LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2

WBS NAME	Time Projection Chamber (TPC)

ESTIMATE SOURCE/TYPE (select one or more)	See lower level

BASIS

The cost of the TPC was estimated by using quotes, bottoms-up historical information, in-house manufacturing analysis and engineering judgment. Detail information is contained in the lower WBS levels. Each level used Excel spread sheets to calculate costs based upon specific parameters such as component weight or cost/unit.

For each lower level WBS, a bottoms-up task list for design was generated by starting with an engineering estimate of the required number of drawings. Two estimates for the time required for drawings were used. The first was 24 hours per layout and the second was 20 hours per drawing. This time includes the initial drawing, checking and then drawing corrections. These times are estimated to be valid only after some conceptual design effort has taken place. The amount of engineering or technician required for each design task was then added. For other work, the task duration was estimated and engineering, designer and technician effort was added. In some cases, these estimates were based upon historical data.

These tasks lists and duration become the basis for costs and the TPC schedule.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.1

WBS NAME	Outer Field Cage (OFC)

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4, 6

BASIS

The cost of the OFC was estimated by using quotes, bottoms-up, historical information and engineering judgment. For each lower level WBS, a spreadsheet was generated that estimated the component costs and then personnel effort was determined as described earlier. The spreadsheet for this WBS is "OFC Worksheet".

WBS #	4.2.1.1

WBS NAME	OFC Supporting structure

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,6

BASIS

The nominal dimensions of the outer field cage was entered into the "OFC Worksheet". The area and weight of the various materials was then calculated. Quotes have been received for the aluminum sheet ($3.50/lb), the honeycomb ($3.5/lb), and the adhesive ($7/lb).

The number, size, and weight of the OFC/TOF support rails and cooling pipes was calculated based upon the present estimate of requirements. A quote was received for the OFC/TOF support rails. A non recurring cost ($4.5 k) was added to a $4/lb extruded cost. Additional effort was estimated for work at each end of the extrusions to prepare them for joining to a manifold. The amount of effort was an engineering judgment. Some funds ($2 k) were added for miscellaneous.

The weight of the end flanges was calculated and a cost/lb ($12/lb) was assumed. It was assumed that there were 60 threaded inserts at $2/insert.The method of estimating the task duration and effort was covered in the discussion under the main WBS level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.1.2

WBS NAME	OFC Insulation

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

A quote was received for the mylar ($3.50/lb) and the adhesive ($7/lb). The amount of each was calculated on the Excel spreadsheet "OFC Worksheet".

WBS #	4.2.1.3

WBS NAME	OFC Voltage gradient system

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

A quote was received for copper over Kapton ($7.09/ft^2) and it was assumed that the etching costs would be 3 times this value. The amount required was calculated on the Excel spreadsheet "OFC Worksheet". A power supply costs of $4 k was obtained from a catalogue and the cost of the HV cable and resistor chain was an engineering estimate.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.1.4

WBS NAME	OFC Fabrication equipment

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS
A quote was received for a rail system for the winding headstock. A detailed list of the components required was made and a cost assigned to each one. The list included the total wrapping system, the room modifications and some miscellaneous fabrication equipment. The costs assigned were engineering estimates.

WBS #	4.2.1.5

WBS NAME	OFC Fabrication and test

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

The effort for the fabrication tasks was based upon historical information obtained from ALEPH TPC personnel. Other tasks were assigned labor based upon engineering judgment. The miscellaneous costs were also engineering estimates.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.2
WBS NAME	Central membrane (High voltage plane)
ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

The size, and weight of foam material was calculated on "IFC HV Memb Worksheet". A phone quote was received for foam material. For 1-in thick sheets, the cost is \$0.07/in^2, while for 2-in it is \$0.16/in^2. Additional costs for aluminum stiffeners (\$10/lb), setup and engineering were added. Estimates were also made for the required hangers (\$25/each). These were engineering estimates. A miscellaneous cost of \$1 k was assumed.

WBS #	4.2.3
WBS NAME	Inner field cage (IFC)
ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

The cost of the IFC was estimated by using quotes, bottoms-up and engineering judgment.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.3.1

WBS NAME	IFC Supporting structure

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

The amount of Rohacell foam was calculated on "IFC HV Memb worksheet". A quote of \$0.07/in^2 was received for 1" material. A quote was also received for the adhesive at \$7/lb. The weight of two flanges was estimated and a cost of \$10/lb was assumed. A non recurring cost of \$1 k was estimated for engineering and setup. A cost of 4 seals at \$100/seal was assumed since the seals are a special type. The number of drawings and therefore, effort was an engineering estimate.

WBS #	4.2.3.2

WBS NAME	IFC Voltage gradient system

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

A quote was received for 1 mil al/Kapton. (\$13/ft^2) It was assumed that the etching cost would be 5 times this cost. This high value is based upon discussions with a consultant in the area of aluminum etching. Vendors for etching this large an aluminum/Kapton sheet may not exist. Either the consultant or LBL will have to do the etching. The costs of the HV cable (\$1 k) and the resistor chain (\$0.2 k) were an engineering estimate.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.3.3

WBS NAME	IFC Fabrication equipment

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS
A detailed list of equipment required for the fabrication of the IFC was made. It was assumed that the OFC winder would be the basic tool required. A wrapping drum assembly ($8.8 k) and a laminating system ($8.2 k) was assumed to be needed. The cost was an engineering estimate.

WBS #	4.2.3.4

WBS NAME	IFC Fabrication and test

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS
A bottom-ups task list was made with estimated duration. The amount of engineering, design, and technicians was then added. Some miscellaneous funds were added ($5 k). The effort and cost are engineering estimates. This list is detailed on "IFC HV Memb Worksheet".

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.4

WBS NAME	Sector

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level BOE

BASIS

The cost of completed sectors was based upon quotes, bottoms-up, in-house manufacturing analysis and engineering judgment. The estimated assembly time was then compared to that experienced by the ALEPH TPC personnel. Although the effort appears about the same, it is not clear how much of the ALEPH work was not accounted for.

A detailed task list for the fabrication, assembly and test of a sector was generated with hours as the time unit. After a total/sector was obtained, it was multiplied by 52 which is the number of sectors required plus 4 spares.

Various sector components were considered separately and the unit cost was multiplied by the estimated number of units.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.4.1

WBS NAME	Mechanical structures

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,6

BASIS

A quote was received for the sector casting. A non recurring cost ($4.5 k/pattern) was included in the quote. Each sector casting was quoted at a cost of $418 each. A quote of $80/sector was received for vacuum impregnation of the casting. The outer sector drawings was reviewed by the LBL machine shop and they estimated 20.3 hr/sector. This was broken down into conventional and NC machining (16.8 hr/sector). A shop rate of $38.63/hr was used to get the final machining costs. A $4.5 k quote for outside grinding was obtained.

A blank-off configuration was assumed and the weight calculated. A cost of $12/lb was assumed for fabrication.

The cost of the aluminum wire mounts was based upon previous extrusion quotes. Die costs are about $1/each, and extruded material is $2.79/lb. G-10 wire mounts were estimated to cost $10 each. This was an engineering estimate. Wire costs were based upon the price of recently purchased wire ($0.07/m).

A quote was obtained for the sector cooling tubes of $2.85/m with a non recurring costs of $1.05 k. An additional 20% was added to the total pipe length. The length of a 2-in diameter manifold was estimated and multiplied by a cost of $3.17/ft obtained from the LBL catalogue. An engineering estimate was made for brazing work and pressure testing the final component.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.4.2

WBS NAME	Electrical structures

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,6

BASIS

A quote was received for the multilayer pad plane PC board. This was \$2.71/board with a non recurring cost of \$10 k. An additional cost of \$400/2 sheets of G-10 was added as well as \$25/board for connector soldering. A non recurring costs of \$5 k was assumed. The anode bias board was estimated using a multilayer board cost sheet at \$41.25/each with a non recurring cost of \$485. The feedthroughs were estimated to be \$13 each. A cost of \$194.76 k for the anode power control and supply was based upon historical information. A cost was assumed for the gate PC board (\$1.5 k/each), the gated grid drives (\$1.0 k) and the pulser (\$0.5 k) based upon previous purchases. These costs were multiplied by the number of each required. The cost of the flex PC cables/boards was assumed to be \$20 each. A miscellaneous cost of \$100/sector was assumed. These details are on "Sector Worksheet".

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.4.3

WBS NAME	Sector assembly equipment

ESTIMATE SOURCE/TYPE (select one or more)	2,4,6

BASIS

An engineering estimate was made for effort and material to:

Modify the existing wire winder. Component cost was estimated by using a cost/lb times the estimated weight.

Modify the sector assembly room. A miscellaneous costs of $15 k was assumed to fab a dark room for high voltage testing, clean up the area and to provide miscellaneous room equipment.

Setup and equip the sector assembly stations. A detailed task list was made for assemble of a sector and the equipment required for each task was estimated. It was assumed that 6 modified granite tables ($2 k each) will be required. A total of 12 wire placement fixtures with supports will be required ($1.2 k each). A list of station items to be purchased was made with an estimated cost for each. In addition, a list of equipment to be made at LBL was drafted with an associated cost for each item. A cost of 4 sector covers at $0.5 k each was added as well as 8 stands at $0.2 k each.

These details are on "Sector Worksheet".

WBS #	4.2.4.4

WBS NAME	Sector assemble

ESTIMATE SOURCE/TYPE (select one or more)	2,4,6

BASIS

A bottoms-up task list for sector assembly was made with personnel requirements estimated. A 10% rework effort was assumed. The value obtained was then compared to a top-down estimate by personnel experienced with the EOS TPC. The detailed task list was combined into fewer number of tasks for input to the resource-loaded schedule.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.4.5

WBS NAME	Sector test

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

A bottoms-up task list for sector tests was made with personnel requirements estimated. A 10% retest time was assumed.

WBS #	4.2.5

WBS NAME	Sector support (Wheel)

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

The major item, the wheel, in this WBS was drawn in some detail and sent out for quotes. Several were received with suggestions on method of fabrication. The quoted used included the castings, machining and assemble of four quadrants. The other items in this WBS are based upon engineering estimates.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.5.1

WBS NAME	Wheel

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

A drawing of the wheel was sent to several vendors and quotes was received for wheels made from plates, cast in one piece and an assembly made from four quadrants. The later quote was used for the estimate as it came from a reliable vendor ($193 k). Additional costs were estimated for alignment pins, seals, the cooling distribution lines, and miscellaneous. These costs were engineering estimates except for the cost of cooling pipes which were obtained from the LBL catalogue. A miscellaneous cost of $10 k was assumed. These details are contained in "Wheel Worksheet".

WBS #	4.2.5.2

WBS NAME	TPC/iron support

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

Drawings were made for the components in this WBS and an estimate was made of the weight of the individual parts. This was multiplied by an estimated cost/lb ($10-$12/lb) depending upon the complexity of the part. Additional costs were added for adjustable platforms, bearings and miscellaneous. These were engineering estimates.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.1

WBS NAME	laser beam source

ESTIMATE SOURCE/TYPE (select one or more)	see lower entries

BASIS
see lower entries

WBS #	4.2.6.1.1

WBS NAME	Nd:Yag laser

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS
Vendor quote Dec. 1992, Spectra Physics

WBS #	4.2.6.1.2

WBS NAME	harmonic generator

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS
Vendor quote Dec. 1992, Spectra Physics

WBS #	4.2.6.1.3

WBS NAME	harmonic separator

ESTIMATE SOURCE/TYPE (select one or more)	6

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

BASIS

Vendor quote Dec. 1992 Spectra Physics

WBS #	4.2.6.1.4
WBS NAME	power spit and dump
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of items purchased in 1990 from CVI and NRC

WBS #	4.2.6.1.5
WBS NAME	polarization rotator
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of items purchased in 1990 from NRC

WBS #	4.2.6.1.6
WBS NAME	polarizer for attenuation
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of items purchased in 1990 from NRC

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.1.7
WBS NAME	beam dump
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of parts purchased in 1990 from NRC and estimate of time to construct.

WBS #	4.2.6.1.8
WBS NAME	telescope
ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

Cost of parts purchased in 1990 from NRC, plus estimate of time to do optics calculations.

WBS #	4.2.6.1.9
WBS NAME	motor driven beam steering
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of units purchased in 1990 from NRC

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.1.10
WBS NAME	energy monitor
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

1990 catalogue cost.

WBS #	4.2.6.1.11
WBS NAME	optics breadboard
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Cost of unit purchased in 1990 from NRC

WBS #	4.2.6.1.12
WBS NAME	cover
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate of design and construction labor.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.1.13
WBS NAME	interlock circuitry
ESTIMATE SOURCE/TYPE (select one or more)	6

BASIS

Estimate of design and construction labor

WBS #	4.2.6.1.14
WBS NAME	dry nitrogen connection
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate of effort.

WBS #	4.2.6.1.15
WBS NAME	support structure
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate of design and construction effort.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.1.16
WBS NAME	operational safety procedure document
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Recollection of time required to do this in the past.

WBS #	4.2.6.2
WBS NAME	beam transport
ESTIMATE SOURCE/TYPE (select one or more)	see lower level

BASIS

see lower level

WBS #	4.2.6.2.1
WBS NAME	tubes and flanges
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

WBS #	4.2.6.2.2
WBS NAME	supports for optical mounts
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.2.3

WBS NAME	optics plus kinematic mounts

ESTIMATE SOURCE/TYPE (select one or more)	1&8

BASIS

NRC catalogue cost for hardware: $125
CVI custom order cost for mirror: $290
total cost: $415
cost for 8 items: $3320

WBS #	4.2.6.2.4

WBS NAME	supports for tubes

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

WBS #	4.2.6.3

WBS NAME	laser beam fan out

ESTIMATE SOURCE/TYPE (select one or more)	see lower level

BASIS

see lower level

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.3.1
WBS NAME	custom optics bread board
ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

Cost scaled from a similar previous purchase

WBS #	4.2.6.3.2
WBS NAME	breadboard mounting fixtures
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

WBS #	4.2.6.3.3
WBS NAME	breadboard cover
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.3.4

WBS NAME	entrance reflector

ESTIMATE SOURCE/TYPE (select one or more)	1

NRC catalogue cost for hardware: $125
CVI custom order cost for mirror: $290
total cost: $415
cost for 2 items: $830

WBS #	4.2.6.3.5

WBS NAME	loop, quadrant reference assemblies

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Catalogue cost plus guessed cost for special order UV transparent windows.
quadrant detector: $180
quadrant mount: $80
beam splitter: $290
beam splitter kinematic mount $ 80
kinematic mount support: $80
Total single item cost: $580
Cost for 4 assemblies: $2320

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.3.6

WBS NAME	loop prism assemblies

ESTIMATE SOURCE/TYPE (select one or more)	3

BASIS

Similar prism costs and catalogue costs for support hardware with kinematic mount.

prism: $335

kinematic mount $ 80

kinematic mount support: $80

total single item cost: $495

Cost for 10 assemblies: $4950

WBS #	4.2.6.3.7

WBS NAME	split off assemblies

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

NRC catalogue cost for hardware: $78

CVI custom order cost for mirror: $290

total cost: $368

cost for 12 items: $4416

Mounting bracket machining and design labor is an engineering judgment.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.3.8

WBS NAME	split off quadrant reference assemblies

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

Catalogue costs:

quadrant detector: $80

quadrant mount: $80

beam splitter: $290

beam splitter kinematic mount $ 80

total: $530

Cost for 24 items: $6360

Design and labor for the splitter support is from an engineering judgment.

WBS #	4.2.6.3.9

WBS NAME	windows and ports in the sector wheel

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

Engineering judgment for design and labor, catalogue costs for anti-reflection coated windows.

window cost: $290

Cost of 12 windows: $3480

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	5. In-house manufacturing analysis
2. Bottoms-up	6. Historical information
3. Analogy	7. Parametrics/factors
4. Engineering judgment	8. Other (explain below)

WBS #	4.2.6.4

WBS NAME	laser beam injection

ESTIMATE SOURCE/TYPE (select one or more)	see lower levels

BASIS

see lower levels

WBS #	4.2.6.4.1

WBS NAME	splitter reflectors

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

Penta prism: $600 (cost of similar device)

Cost of 12 prisms: $7200

Cost of mirror: $290 (small quantity cost, so estimate is high)

Cost of 96 mirrors: $27840

Total: $35040

The time for manufacturing and designing a complete reflector by joining the two mirrors is an engineering judgment.

WBS #	4.2.6.4.2

WBS NAME	reflector mounts

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.4.3

WBS NAME	reflector field shaping covers

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

WBS #	4.2.6.5

WBS NAME	quadrant detector readout system

ESTIMATE SOURCE/TYPE (select one or more)	see lower level items

BASIS

see lower levels

WBS #	4.2.6.5.1

WBS NAME	cables

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

lemo cables	detector-amplifier	4 each
lemo cables	amplifier-ADC	4 each
power	amplifier	1 each
Total		9 each
16 detectors		144 cables at $50 each
Total		$7200

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.5.2
WBS NAME	amplifiers
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Guess of 2K$ for 8 channel module or 18K$ for 8 modules + 1 spare.
This will handle 16 quadrant detectors.

WBS #	4.2.6.5.3
WBS NAME	camac ADCs
ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

Use existing modules from Bevatron pool, 0 cost.

WBS #	4.2.6.5.4
WBS NAME	camac crate
ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

From Bevatron pool, 0 cost.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.6.5.5
WBS NAME	Kamax software and camac interface
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Guess 5 k$

WBS #	4.2.6.5.6
WBS NAME	Mac computer
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Guess 5 k$

WBS #	4.2.6.7
WBS NAME	safety interlocks
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This estimate includes personnel effort plus an estimated cost for BNL's standard access control boxes for doors leading into a laser area.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7

WBS NAME	Gas system

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,6

BASIS

See the lower level BOE.

WBS #	4.2.7.1

WBS NAME	Component gas supply

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.1	Component Gas Supply subsystem	1	$10.00	
4.2.7.1.1	Evaporators	2	$1.00	Engr. est.
4.2.7.1.2	Pressure Regulators	7	$0.43	Catalog and Hist. info.
4.2.7.1.3	Air Operated Valves	9	$0.22	Hist. info.
4.2.7.1.4	Misc. Plumbing Components	1	$2.00	Engr. est. and Hist. info.
4.2.7.1.5	Slow Controls Interface	1	$1.00	Engr. est.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.2

WBS NAME	Gas mixer

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.2	Gas Mixer subsystem	1	$18.70	
4.2.7.2.1	Mass Flow Controllers	4	$1.38	Manufacturer est.
4.2.7.2.2	Mass Flow Controller Electronics	1	$7.00	Catalog price and man. est.
4.2.7.2.3	Temperature Controller	1	$2.00	Engr. est.
4.2.7.2.4	Pressure Control	1	$0.50	Hist. info.
4.2.7.2.5	Air Operated Valves	5	$0.24	Hist. info.
4.2.7.2.6	Misc. Plumbing Components	1	$1.50	Engr. est. and Hist. info.
4.2.7.2.7	Slow Controls Interface	1	$1.00	Engr. est.

WBS #	4.2.7.3

WBS NAME	Gas recirculating

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.3	Gas Recirculating subsystem	1	$16.00	
4.2.7.3.1	Special Sealed Blower	1	$8.00	Manufacture est.
4.2.7.3.2	Flow Controller	1	$2.00	Engr. est. and Cat price
4.2.7.3.3	Air Operated Valves	3	$0.67	Hist. info.
4.2.7.3.4	Misc. Plumbing Components	1	$3.00	Engr. est.
4.2.7.3.5	Slow Controls Interface	1	$1.00	Engr. est.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.4

WBS NAME	TPC Pressure regulation

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.4	TPC Pressure Regulation subsystem	1	$9.30	
4.2.7.4.1	Pressure Sensors	3	$1.33	Catalog price
4.2.7.4.2	Control Valve	1	$0.60	Catalog price
4.2.7.4.3	Pump	1	$1.50	Catalog price
4.2.7.4.4	Control Electronics	1	$1.00	Engr. est.
4.2.7.4.5	Air Operated Valves	1	$0.20	Catalog price
4.2.7.4.6	Misc. Plumbing Components	1	$1.00	Engr. est.
4.2.7.4.7	Slow Controls Interface	1	$1.00	Engr. est.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.5

WBS NAME	Gas monitor

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.5	Gas Monitor subsystem	1	$83.60	
4.2.7.5.1	Oxygen Meter	1	$8.00	Engr. est.
4.2.7.5.2	Water Meter	1	$6.00	Engr. est.
4.2.7.5.3	Velocity Test Chamber	1	$15.00	Engr. est. and Hist. info.
4.2.7.5.4	Electron Life Time Test Chamber	1	$25.00	Engr. est. and Hist. info.
4.2.7.5.5	Laser	1	$7.00	Hist. info.
4.2.7.5.6	High Voltage	1	$3.00	Hist. info.
4.2.7.5.7	Pressure Controllers	2	$1.50	Catalog price and Hist. info.
4.2.7.5.8	Flow Controllers	2	$1.00	Catalog price
4.2.7.5.9	Temperature Controllers	2	$1.00	Engr. est.
4.2.7.5.10	Chamber Electronics	2	$0.50	Engr. est. and Hist. info.
4.2.7.5.11	Air Operated Valves	11	$0.24	Hist. info.
4.2.7.5.12	Gas Pumps	3	$1.00	Hist. info.
4.2.7.5.13	Misc. Plumbing Components	1	$3.00	Engr. est.
4.2.7.5.14	Slow Controls Interface	1	$3.00	Engr. est.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.6

WBS NAME	Exhaust

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

4.2.7.6	Exhaust subsystem	1	$4.50	
4.2.7.6.1	Blowers	2	$0.50	Catalog price
4.2.7.6.2	Vent Stacks	2	$1.00	Engr. est.
4.2.7.6.3	Misc. Plumbing Components	1	$1.00	Engr. est.
4.2.7.6.4	Slow Controls Interface	1	$0.50	Engr. est.

WBS #	4.2.7.7

WBS NAME	Gas system building

ESTIMATE SOURCE/TYPE (select one or more)	2,4,6

BASIS

4.2.7.7	Gas System Building	1	$30.00	100/sqft*200+50/sqft*200

WBS #	4.2.7.8

WBS NAME	Slow controls crate and processor

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

4.2.7.8	Slow Controls Crate and Processor	1	$6.00	DAQ est.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.9

WBS NAME	Temporary setup at LBL

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

4.2.7.9	Temp. Setup at LBL	1	$25.00	Engr. est.

WBS #	4.2.8

WBS NAME	Cooling system

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level BOE.

BASIS

The cooling system consists of chillers, tanks, piping, fittings, valves, controls, pumps, FEE cooling plates, slow controls and effort of preassemble and tests the components. A quote was received for a 15-kW chiller ($10 k). This will service one end of the TPC. A tank cost of $1 k was assumed for the two required. Pipe costs were obtained from the LBL catalogue based upon the estimated size and length of runs. A quote of $509 was received for a 2-in SS valve. It was assumed that this valve was used throughout the system. A cost was assumed for the regulator valves ($1 k each), the controls ($5 k each) and the pumps ($1 k each). The cost of the FEE cooling plate was based upon quotes for similar extruded parts.

It was assumed that the slow controls had a thermistor ($22 each) as a transducer with an additional $100 per channel cost. The total number of slow controls was assumed to be 8/sector and 20/end for a total of 416. Ten percent additional channels were added.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.9

WBS NAME	Transport fixtures/shipping

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level BOE.

BASIS

The costs of this WBS was a combination of quotes, bottoms-up and engineering judgments. It was assumed that the TPC will be partially disassembled and the components shipped to BNL in many boxes. The cost of these boxes were estimated. The assembled TPC will be shipped by truck to BNL. A quote was received for shipping a 16-ft high load (including truck height) on an air-ride truck. The weight was not a consideration, but the height of the component was. Whether the TPC is shipped assembled or disassembled, the price of the large truck will be the same due to the height.

WBS #	4.2.9.1

WBS NAME	Transportation fixtures

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

Box sizes were assumed for sectors, cooling system, laser system, and miscellaneous. LBL prices for lumber ($34/sheet) were used to estimate material costs. All other costs were engineering estimates. Several special shock isolation pallets were included. Some funds were added to modify the test stand for shipping.

The personnel effort and schedule were determined by estimating the time to design and fabricate the various boxes.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.9.2

WBS NAME	Shipping

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

A sketch showing the outside dimensions and the weight was sent out to be reviewed by several trucking companies. One estimated the cost to ship the TPC from here to BNL (($23 k). It included all permits, lead car(s), main truck and drivers. The quote was valid for a load height of < 16 ft. If over 16 ft, the price was estimated to be twice the quoted price. The same company also estimated the cost of a covered 48 x 9 x 10 ft truck ($5 k). Costs were added for an engineer to accompany the truck.

WBS #	4.2.10

WBS NAME	Assemble & test

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level BOE.

BASIS

The assembly fixtures in this WBS are not designed. An estimate was made of a typical structure and then a cost/lb assumed based upon the complexity of the part. A large part of this WBS is labor. This effort was estimated by use of a detailed bottoms-up list of expected tasks. The effort for each task was estimated based upon the type of work to be done. The details of these estimates are in "Assembly/test/PM Worksheet".

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.10.1

WBS NAME	Assembly fixtures

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

A rough sketch of a test stand was made and the length of the major members was calculated. Large beams with an assumed weight and cost/lb ($8/lb) were used. A wheel lifting fixture was assumed to weigh 200 lb and cost $8/lb. Sector lifting fixtures were assumed to weigh 50 lb and cost $10/lb.

Using an 8-ton weight for the TPC, the size of an installation beam was calculated. Since this is a lot of steel a cost of $6/lb was assumed. Flanges were assumed to cost $8/lb and the large support stands $6/lb. Miscellaneous funds were added for jacks, blocks and other parts.

WBS #	4.2.10.2

WBS NAME	Sector removal tool

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

The size of the main beam was estimated and a cost/lb ($10/lb) assumed. A cost of $4 k/degree of movement was assumed. It was assumed that the majority of components are off-the-shelf items. Funds were also added for miscellaneous. The size and configuration of this tool was based upon the ALEPH TPC design.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.10.3

WBS NAME	TPC assemble

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

The effort and cost for installation of cable ways was based upon standards obtained from EE integration. Pipe costs were obtained from the LBL catalogue. A miscellaneous cost of $10 k was assumed.

The cost for this WBS is almost all labor. A detailed task list was made and engineers, designers and technicians were assigned as required. Some miscellaneous funds were added to use during assembly. The assumed rate of doing some of the tasks is included in "Assembly/test/PM Worksheet".

WBS #	4.2.10.4

WBS NAME	TPC test

ESTIMATE SOURCE/TYPE (select one or more)	2,4,6

BASIS

The costs for this WBS is almost all labor. A task list was made and engineers, designers and technicians were assigned using engineering judgment. Some funds were added for miscellaneous. The time required for testing is based upon EOS and other experience.

This WBS also includes time for partial disassembly of the TPC. A detailed task list was made and effort assigned to each task.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.11

WBS NAME	TPC project management

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS
The effort and, therefore, the costs were an engineering estimate. Some funds were added as miscellaneous.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4

WBS NAME	Solenoid magnet

ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

See lower level WBS

WBS #	4.4.1

WBS NAME	Conventional coil

ESTIMATE SOURCE/TYPE (select one or more)	8

ESTIMATE TYPE Various , see lower level BOE

BASIS

See lower level WBS

WBS #	4.4.1.1

WBS NAME	Coils

ESTIMATE SOURCE/TYPE (select one or more)	1, 4 & 6

BASIS

The design is based on coil pancakes built for E787 at BNL, scaled from 296cm to 524 cm in diameter. The cost estimate is based on $7 per pound for the finished coil; this was obtained by examining quotes for other large solenoid magnets as well as a quote that has been made for a STAR copper coil.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.1.2
WBS NAME	Coil clamps and indexing equipment
ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

The cost estimate is based on engineering experience using a unit cost of $ 10k per coil package.

WBS #	4.4.1.3
WBS NAME	Coil spacer rings
ESTIMATE SOURCE/TYPE (select one or more)	4 & 7

BASIS

This estimate is based on a conceptual design of the rings using a per pound cost of $2.75 for material, fabrication, and scrap allowance. The estimate also includes shipping and hardware costs.

WBS #	4.4.1.4
WBS NAME	Water manifolds,buss,interlocks
ESTIMATE SOURCE/TYPE (select one or more)	4, 5 & 7

BASIS

This estimate is based on a per pound cost of $3.50 for all copper buss. The estimate is also based on previous engineering experience as well as in house quotes from controls experts.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.2

WBS NAME	Return Steel

ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

Various; see lower level WBS

WBS #	4.4.2.1

WBS NAME	Backleg steel and end rings

ESTIMATE SOURCE/TYPE (select one or more)	4,5, & 6

BASIS

The estimate was based on a preliminary design using a cost per pound for material, machining, and excess scrap allowance to allow for the large diameter end rings. The unit cost was $1.00 per pound for the return yoke and $1.25 per pound for the end rings. The estimate also includes a shipping cost for the entire core package andassembly equipment. The total weight of the return yoke is 588 tons, and each end ring weighs 39 tons.

WBS #	4.4.2.2

WBS NAME	Pole tips

ESTIMATE SOURCE/TYPE (select one or more)	4,5, & 6

BASIS

The estimate was based on preliminary engineering and a conceptual design using a unit cost of $1.50 per pound for materials, fabrication, and an excess material allowance for oversized components. Also included in the estimate is an allowance for assembly equipment. Each endcap weighs 75 tons.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.3

WBS NAME	Power supply and controls

ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

See lower level WBS

WBS #	4.4.3.1

WBS NAME	Power supply

ESTIMATE SOURCE/TYPE (select one or more)	1 & 4

BASIS

Based on discussion and quote from vendor.

WBS #	4.4.3.2

WBS NAME	Controls

ESTIMATE SOURCE/TYPE (select one or more)	3 & 4

BASIS

Engineering judgement based on existing systems

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.3.3

WBS NAME	Power cabling

ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

Based on a 250 foot run of 500MCM locomotive cable, assuming 26 cables at $6 per running foot. $6K has been allowed for connectors.

WBS #	4.4.4

WBS NAME	Magnetic field measuring system

ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

See lower level WBS

WBS #	4.4.4.1

WBS NAME	Modifications to ALEPH Probe Positioning and Readout System

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Both materials and labor were estimated by engineering judgement from previous experience.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.4.2

WBS NAME	Hall Probes

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Both materials and labor were estimated by engineering judgement from previous experience.

WBS #	4.4.4.3

WBS NAME	Data Acquistion and Storage

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Both materials and labor were estimated by engineering judgement from previous experience.

WBS #	4.4.4.4

WBS NAME	Assembly and Test

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Both materials and labor were estimated by engineering judgement from previous experience.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.4.4.5
WBS NAME	Shipping
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Both materials and labor were estimated by engineering judgement from previous experience.

WBS #	4.4.5
WBS NAME	Support system
ESTIMATE SOURCE/TYPE (select one or more)	8

BASIS

See lower level WBS

WBS #	4.4.5.1
WBS NAME	Main yoke support
ESTIMATE SOURCE/TYPE (select one or more)	2,7

BASIS

Preliminary engineering and design using $1.00 per pound for materials and fabrication cost of structural steel with vendor quotes for mechanical hardware. The scaling factor used in this estimate of 1.25 is due to the weight increase in the structure going from a superconducting to a conventional magnet design.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.4.5.2

WBS NAME	Pole tip support

ESTIMATE SOURCE/TYPE (select one or more)	2,7

BASIS

Preliminary engineering and design using $1.00 per pound for materials and fabrication cost of structural steel with vendor quotes for mechanical hardware. The scaling factor used in this estimate of 1.25 is due to the weight increase in the structure going from a superconducting to a conventional magnet design.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.

WBS NAME	Front End Electronics

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS
See lower level BOE

WBS #	4.7.1.2

WBS NAME	TPC Front End Electronics

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS
See lower level BOE

WBS #	4.7.1.2.1

WBS NAME	FEE Boards

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS
See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.1

WBS NAME	TPC Front End Board

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4 & 6

BASIS

The manpower estimates are for the engineering effort required to design the front end board. Provision has been made for a semi-custom IC to provide buffering of the SCA/ADC devices, address comparison on the cable bus, and clock regeneration. The costs for circuit board manufacturing and electronic component are estimated as follows:

PCB	7 in. X 3 in X 4 layers (vendor quote)	$16
diodes	32 @ $.30 ea.	$10
Connectors		$11
Buffer IC, op amp, misc parts		$19
per board total		$56
total FEE cost	5003 boards X $56	$280K

The detector will require 193 bds/sector X 108% (for spares) X 24 sectors = 5003 boards. Other major expenses are the non-recurring engineering (NRE) charges for IC and PCB development, estimated at $30K and $3K, respectively.

Total System Cost: (including NRE charges) $313K

Manpower:

Eng:		EA:	
50m-d	Board Design	30m-d	Build 1st Article
110m-d	ASIC Design	20m-d	Order Tracking
30m-d	ASIC Vendor Liason	60m-d	2 PCB Designs
20m-d	Debug/Doc.		

Tech:

50	m-d	PCB/Order tracking
100	m-d	Kit preparation

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.2

WBS NAME	PASA Integrated Circuit

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS

See lower level BOE

WBS #	4.7.1.2.1.2.1

WBS NAME	PASA IC Development & Production

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4 & 6

BASIS

This WBS entry is for the design and fabrication of the 16 channel preamp/shaper amp IC (PASA IC). The estimate for silicon production costs is derived from the following assumptions:

- 137K channels
- 16 channels/die
- 100 die/wafer
- 75% yield at wafer level, 50% yield after packaging and test
- "Pre-production" run of ~300 ICs to verify design, yields, etc.
- 20% spare die, to yield 10% spare ICs after board production

Silicon costs:

Silicon: 206 wafers @ $505	$104K
Packaging: 15,500 pkgs @ $2	$ 31K
Total Packaged Die Cost:	**$124K**

Fixed, one-time charges (NRE):

Silicon Mask Charges:	$ 24K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

IC Development Submissions: 3 @ $6K		$ 18K
"First article" pre-production run:		$ 30K
"First article" packaging:		<u>$ 2K</u>
Total NRE charges:	$ 74K	

Testing:

Given the expected yield of 50%, we will need to perform on-wafer testing before packaging and then perform a parametric testing of the packaged parts. The IC testing charges are estimated as follows:

Wafer test jig:	$ 12K
ATE programming	$ 18K
Custom IC tester computer: 2 @ $5K	$ 10K
Custom IC tester hardware: 2 @ $5K	$ 10K
Custom IC tester software: 2 @ $6K	$ 12K
Digital Scope (IC waveform analysis)	<u>$ 12K</u>
Total, testing :	$ 74K
Total Cost, PASA IC:	$272K

Manpower:

Eng. (IC Designer)		EA:	
175m-d	IC Design	20m-d	Tester build
45m-d	Tester HW design	10m-d	Tester debug
65m-d	Tester SW design		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.7.1.2.1.2.2

WBS NAME	PASA Integrated Circuit (Test at BNL)

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS estimate is for the manpower to test the PASA integrated circuits at BNL

Manpower:

Tech:

111m-d IC test @ 4 min/IC

WBS #	4.7.1.2.1.3

WBS NAME	SCA/ADC Integrated Circuit

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS

See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.3.1

WBS NAME	SCA/ADC Integrated Circuit

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4 & 6

BASIS

This WBS number is for the design and fabrication of the 16 channels Switched Capacitor Array + Analog to Digital Converter IC (SCA+ADC IC). The estimate for silicon production is derived from the following assumptions:

- 137K channels
- 16 channels/die
- 90 die/wafer
- 70% yield at wafer, 45% yield after packaging and test
- "Pre-production" run of ~300 ICs to verify design, yields, etc.
- 20% spare die, to yield 10% spare ICs after board production

Silicon costs:

Silicon: 254 wafers @ $567	$144K
Packaging: 16,000 pkgs @ $2.75	$ 44K
Total Packaged Die Cost:	**$188K**

Fixed, one-time charges (NRE):

Silicon Mask Charges:	$ 34K
IC Development Submissions: 3 @ $8K	$ 24K
"First article" pre-production run:	$ 32K
"First article" packaging:	$ 2K
Total NRE charges:	**$ 92K**

Testing:

Given the expected yield of 45%, we will need to perform on-wafer testing before packaging and then perform a parametric testing of the packaged parts. The IC testing charges are estimated as follows:

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Wafer test jig:	$ 12K
ATE programming	$ 28K
Custom IC tester computer: 2 @ $5K	$ 10K
Custom IC tester hardware: 2 @ $5K	$ 10K
Custom IC tester software: 2 @ $6K	$ 12K
Total, testing:	**$ 72K**
Total Cost, SCA+ADC IC:	**$352K**

Manpower:

Eng. (IC Designer)		EA:	
175m-d	IC Design	10m-d	Tester debug
45m-d	Tester HW design	20m-d	Tester build
65m-d	Tester SW design		

WBS #	4.7.1.2.1.3.2

WBS NAME	SCA+ADC Integrated Circuit (Test at BNL)

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS estimate is for the manpower to test the SCA+ADC integrated circuits at BNL

Manpower:

Tech:

111m-d	IC test @ 4 min/IC

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.4

WBS NAME	Front End Board assembly.

ESTIMATE SOURCE/TYPE (select one or more)	1, 4

BASIS

This estimate is for the assembly of the TPC Front End Electronics board by an outside assembly house (Promex quote of 9/11/92). The Major Expenses is estimated as follows:

Assembly and test: $36 X 5003 boards	$180K
NRE setup charges:	$ 1K
Total cost, assembled board:	**$181K**

The assumption is that board "kits" are supplied to the assembly house, that a board tester (WBS 4.7.1.2.1.5) is staged at the assembly house for board functional test, and that most vendor liason is performed by Electronic Associates and Technicians.

Manpower:

Eng:		EA:	
10m-d	Vendor Liason	10m-d	Vendor Training
		20m-d	Vendor Liason
		20m-d	Parts Ordering/Tracking
Tech:			
10m-d	Vendor Liason		
40m-d	Parts Kitting		
40m-d	Board QA		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.5

WBS NAME	Tested Front End Boards.

ESTIMATE SOURCE/TYPE (select one or more)	1,4 & 6

BASIS

See lower level BOE

WBS #	4.7.1.2.1.5.1

WBS NAME	Tested Board

ESTIMATE SOURCE/TYPE (select one or more)	1,4 & 6

BASIS

This estimate is for the design of a custom board tester and the purchase of commercial test equipment (hardware and software). The costs are estimated as follows:

Computer: 2 @ 2.5K	$ 5K
Commercial hardware: 2 @ 2.5K	$ 5K
Custom hardware: 2 @ 3K	$ 6K
Commercail software: 2 @ 3K	$ 6K
Total, board testing	**$22K**

Manpower:

Eng:		Tech:	
30m-d	HW design		
60m-d	SW development	10m-d	Parts Ordering/Tracking
20m-d	Debug		

EA:

20m-d Tester Build & Debug

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.1.5.2

WBS NAME	Tested Board (test @BNL).

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS item is for the final test of the FEE board at BNL. Test time is estimated at 5 minutes per board and MTTR is estimated at 30 minutes per board. The total test time estimate takes into account the board test time, MTTR estimates, and a 25% board repair/rework rate.

Manpower:

Tech:

150m-d Board test and repair

WBS #	4.7.1.2.1.6

WBS NAME	FEE Data/Power Cables

ESTIMATE SOURCE/TYPE (select one or more)	1 & 5

BASIS

This estimate is based on the following parts costs and estimates:

Connectors	3 x $6.00	$18.00
Cable	1 ft. x $2.00	$ 2.00
Total		$20.00

Total system cost: 2502 cables x $20.00 **$50K**

The cable assemby time includes assembly and test. Provision is made for construction of a cable tester.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Manpower:

Eng:		EA:	
15m-d	Cable Eval.	20m-d	Build & Debug Tester
10m-d	Design Tester		
5m-d	Documentation		

Tech:

105m-d Assemble & Test Cables

WBS #	4.7.1.2.2

WBS NAME	Readout Board Assembly

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS
See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.2.1

WBS NAME	Readout Board

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4, & 6

BASIS

This WBS number is for the design and construction of the TPC Readout board (RDO). This board sits on the TPC sector and multiplexs the digital data from up to 18 Front End Electronics boards and supplies the data via a T9000-compatible fiber optic link to the DAQ system. There are a total of 13 RDO boards per sector, for a total of 312 on the detector. Allowing for 5% spares, we have 328 boards costed.

Each RDO board contains 9 instances of "zero suppression logic, one instance for each of two FEE boards. This logic consists of a zero-suppression ASIC and appropriate RAM to store pedestal and data information as well as supporting logic. This "zero suppression logic" is costed below:

Zero suppression ASIC	$30
64KB Data RAM	14
64KB Pedestal RAM	14
Fifo + misc. logic	17
FEE Connector	6
Power Monitoring, Control, & Decoupling	12
Total, Zero Suppression Logic	$93

The RDO board is approximately 13" x 17", 6 layers, components both sides, and 4000 holes. The PCB board cost is derived from standard PCB cost calculations and parts costs are derived from catalog or published prices.

Zero suppression logic: 9 @ $93	$ 837
T9000 Transputer	$ 325
T9000 DRAM	$ 70
Housekeeping Circuitry	$ 50
Sequencing & Buffering	$ 100
Xtals	$ 20

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Connectors: power & signal	$ 50
Sockets	$ 20
Decoupling	$ 20
Clock/Trigger Logic	$ 25
Fiber Optic Xmit/Rcvr: 4 @ $25	$ 100
Fiber Optic Cables: 4 @ $50	$ 200
PC Board	$1075
Board Assy.	$ 325
Total cost, Readout Board:	$3217

Total System Cost, RDO Board: 328 @ $3217 $1055K

Manpower:

Eng.		EA:	
75m-d	Initial Design	60m-d	2 layouts PCB
60m-d	Second Design	20m-d	Build/test 1st article
20m-d	Design review	20m-d	Parts Ordering
15m-d	Documentation	20m-d	Parts Tracking
20m-d	Debug	20m-d	Board QA
10m-d	Bd. Assy Supervise	50m-d	Bd. Assy Supervision
180m-d	ASIC design		
30m-d	ASIC Vendor Liason		
30m-d	Evaluate protos		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.2.2

WBS NAME	Tested Readout Board

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

This WBS number is for the design and development of a computer-based stand-alone tester for the Readout board. Included in this costing is the manpower effort to test the Readout boards as well as the manpower needed for tester development.

Tester Development:

Commercial computer:	$2.5K
Commercial hardware:	2.5K
Custom hardware:	3.0K
Commercial software:	3.0K
Total, Tester HW & SW:	**$11K**

The Readout board is assumed to take 30 minutes to test and 120 minutes MTTR. It is assumed that 33% of the Readout boards will need some form of repair. The board test calculation takes these numbers into account.

Manpower:

Eng:		Tech:	
45m-d	Design tester HW	55m-d	Test RDO boards
65m-d	Design tester SW		
20m-d	Debug tester		
EA:			
20m-d	Build tester		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.3

WBS NAME	Front End and Readout Power

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4 & 6

BASIS

See lower level BOE

WBS #	4.7.1.2.3.1

WBS NAME	Power Supplies and Cables

ESTIMATE SOURCE/TYPE (select one or more)	1, 2 & 6

BASIS

The manpower estimates are for the effort required to design the power supply chassis and supervisory logic as well as to fully specify the power supplies. The Major Expense Item are estimated as follows:

Power Cables:

Conn. Body: 2 @ 4.50	$ 9
Power Pins:	$ 20
Other Pins:	$ 5
Cable Clamps:	$ 12
AWG6 Wire:	$114
AWG10 Wire:	$100
Shielding & Sheathing:	$207
Total, Power Cables	**$467**

Power Supply Chassis:

seven volt ps:	8 @ $400	$3200

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

chassis fab		$ 250
Power cables	14 @ $467	$6538
connectors		$ 224
interlocks		$ 50
misc. parts for supervisory logic		$ 50
per chassis total		**$10312**
total system cost	25 X $10312	**$258K**

Note: We have included one power supply chassis as a spare.

Manpower:

Eng:		EA:	
30m-d	Evaluate PS	25m-d	Ordering
30m-d	Super. Logic	20m-d	Build 1st Art.
15m-d	Documentation	25m-d	Assy Supervise
5m-d	Interlock Design	20m-d	Evaluate PS
15m-d	Dummy Loads	5m-d	Build Dummy Loads

Tech:		Laborer:	
75m-d	Build PS Chassis	175m-d	Build Power Cables
24m-d	Test PS	48m-d	Build Chassis
5m-d	Build Dummy Loads		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.3.2

WBS NAME	PS Interlocks & Monitoring

ESTIMATE SOURCE/TYPE (select one or more)	4, 5, & 6

BASIS

The estimate includes costs for the power supply interlock system and monitoring of critical power supply parameters such as air flow, coolant flow, line voltage, etc. It is estimated that the power supply subsystem in 4.7.1.2.3 will occupy 6 racks (4 power supply chassis per rack) and the costing reflects only the 6 racks.

Interlocks	$0750
Local & remote monitoring	$1000
Total cost	$1750
Total system cost: 6 x $1.75K	**$11K**

Manpower:

Eng:
5m-d Design

EA:
10m-d Design
5m-d Test

Tech:
10m-d Construction
10m-d Test

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.4

WBS NAME	On Chamber Mounting and Cooling

ESTIMATE SOURCE/TYPE (select one or more)	3 & 4

BASIS

This WBS estimate is for the manpower for mounting and cooling the Readout boards,and clock/trigger fanout boards within the TPC.

Manpower:

EA:		Tech:	
40m-d	Supervision	48m-d	Mounting & Adjustments

WBS #	4.7.1.2.5

WBS NAME	Interlocks

ESTIMATE SOURCE/TYPE (select one or more)	3 & 4

BASIS

The manpower estimates are for the engineering effort to design and test the interlock system. This estimate is for interlocks external to the power supply interlock system such as clocks, cooling, etc. The power supply interlock system is costed in WBS 4.7.1.2.3.2.

The parts costs for the interlock system are estimated at: **$20K**

Manpower:

Eng.		EA:	
20m-d	Design Interlocks	20m-d	Build 1st article
		20m-d	Supervision
Tech:			
48m-d	Build Interlock Chassis		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.6
WBS NAME	Shipping
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS item covers the cost of shipping IC and boards for assembly and of shipping the ICs and FEE boards between LBL and BNL for test. It also covers shipping the final complement of electronics (FEE and RDO boards) to BNL for final installation.

Estimated shipping charges: $15K

Manpower:

Tech.		Laborer:	
48m-d	Shipment Prep	48m-d	Packing/Unpacking

WBS #	4.7.1.2.7
WBS NAME	Final Debug & Test
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

The manpower estimates for this WBS assumes that physicists will do most of the installation, cabling, and test of the electronics. It also assumes that the power supply chassis have been installed in the racks and cabled. The manpower estimates cover expected debugging and test for final setup at BNL.

Manpower:

Eng:		EA:	
48m-d	Debug	48m-d	Debug
48m-d	Test	48m-d	Test
Tech:			
48m-d	Tech. support		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.8

WBS NAME	Subproject Management

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS estimate is for the engineering time devoted to project management and reporting.

Project Management misc. expenses: $10K

Manpower:

Eng:

440m-d Project Mgmt

WBS #	4.7.1.2.9

WBS NAME	Prototypes

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4, 5, 6

BASIS

See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.9.1

WBS NAME	Prototype Electronics (Sector prototype & Test)

ESTIMATE SOURCE/TYPE (select one or more)	2 & 6

BASIS

This WBS estimate covers the material and manpower costs for development of a sector prototype with functioning electronics. This prototype sector will be used in support of prototype electronics development (WBS 4.7.1.2.9.2) and in support of the DAQ prototype.

Prototype Sector:

Pad Plane PCB:	$ 7.6K
Pad Plane Structural Support:	$ 3.0K
Pad Plane Connectors	$ 2.0K
Connector Assy to Pad Plane:	$ 2.0K
Total, Proto Sector	$ 15 K

Manpower:

Eng:

40m-d Proto PCB

EA:

30m-d Proto PCB specs & ordering

Tech:

30m-d Proto PCB to Support Assy

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.9.2

WBS NAME	Prototype Electronics (boards)

ESTIMATE SOURCE/TYPE (select one or more)	2 & 6

BASIS

This WBS estimate is for the development of prototype electronics in support of the TPC pad plane prototype and the DAQ prototype. We will be building 40 FEE prototype boards and 2 RDO prototype boards in support of early prototype development. The prototype custom ICs are costed as part of the IC development in WBS items 4.7.1.2.1.2.1 and 4.7.1.2.1.3.1. The costs are estimated as follows:

FEE

Proto PCB: 40 @ $100	$ 4.0K
Connectors & Misc. Components: 40 @ 40	$ 1.6K
FPGA, Analog circuitry: 40 @$80	$ 3.2K
FEE Cables: 40 @ $25	$ 1.0K
Total, FEE Protos	**$ 10K**

The prototypes will use FPGA circuitry to implement all the zero-suppression and FEE clocking algorithms and the costing reflects this:

RDO:

Proto RDO PCB: 2 @ $1.5K	$ 3.0K
Zero-suppression logic: 9 @ $200	$ 1.8K
Signal & FO cables:	$ 0.4K
Other logic, conn., etc.: 2 @ $3K	$ 6.0K
Total, RDO Proto	**$ 11K**

The estimate for NRE covers the one-time charges for PCB construction. These are estimated at $3K for the FEE boards and $5K for the RDO boards.

PCB NRE	**$ 8.0K**

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

The power supplies will be commercial units without the final monitoring system installed. Power cables will be built to support the two RDO boards:

Power:

Power supplies: 2 x 7v @ 50A	\$ 2.0K
Power Cables: 2 @ \$1K	\$ 2.0K
Total, Power supplies	**\$ 4.0K**

Some specialized test equipment must be added to test the prototypes. Examples include: optical power meters, digital pattern generators, and some custom test gear (such as a FEE simulator card).

Prototype Test Equipment:

Optical power meter:	\$ 5K
Pattern Generator	\$ 12K
FEE Simulator 4 @ \$500	\$ 2K
Milliohmmeter:	\$ 3K
Arbitrary Waveform Gen.	\$ 12K
Digital Oscilloscope	\$ 18K
Total, Proto test equipment:	**\$ 52K**

Total estimated expenses for prototypes:

FEE	\$10K
RDO	\$11K
PCB NRE	\$ 8K
Power supplies	\$ 4K
Equipment	\$52K
Total, Proto expenses	**\$85K**

Manpower:

Eng:		EA:	
60m-d	FEE proto design	30m-d	FEE Proto 1st article
30m-d	FEE proto debug	30m-d	RDO Proto 1st article

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

90m-d	RDO proto design	40m-d	Parts Ordering/Tracking
45m-d	RDO proto debug		
30m-d	RDO proto SW		
Tech:		Draftsman:	
80m-d	Build FEE protos	40m-d	Drafting support
40m-d	Build RDO proto		
20m-d	Build Power Supply proto		

WBS #	4.7.1.2.10

WBS NAME	Engineering Models

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This WBS number is for the construction of mechanical, electrical, or display models in support of the TPC FEE.

Misc. Materials $ 5K

Manpower:

Eng: EA:

20m-d Model design 30m-d Model Design & Supervision

Tech: Draftsman:

30m-d Model building 40m-d Model drafting

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.11

WBS NAME	System Design Documentation

ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

The manpower estimates are for the engineering and technician effort required to document the TPC electronics. It includes such global documentation as chassis configurations, cable layouts, system descriptions, safety procedures, etc.

Manpower:

Eng:		EA:	
100m-d	Documentation	60m-d	Documentation
Draftsman:			
20m-d	Drafting		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.12

WBS NAME	Clock/Trigger Distribution

ESTIMATE SOURCE/TYPE (select one or more)	1, 4 & 6

BASIS

The WBS estimate is for the engineering effort required to design the fanout module and for the technician time required for PCB layout and assembly. There are 13 fanout modules required per endcap: one on each sector and one to fanout the signals to the sectors. The costing reflects a total of 28 modules being built, with 2 modules allocated as spares. The total system cost includes an estimated $3K for PCB NRE charges. The cost is estimated as follows:

PCB	$125
Drivers & Receivers	$195
Cables & Conn	$370
Misc.	$042
Bd. Assy	$125
Total	$857

Total board cost: 28 x $857 **$24K**

Total system cost: (including NRE charges) **$27K**

Manpower:

Eng:		EA:	
20m-d	Design	15m-d	PCB layout
5m-d	Debug	5m-d	Build 1st Article
10m-d	Review & Doc.	5m-d	Order Supervision

Tech:

5m-d	Parts ordering
28m-d	Construction
28m-d	Build & Test Cables

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.13

WBS NAME	Slow Controls Interface

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 3 & 4

BASIS

This WBS estimate is for the materials and manpower needed to provide the interface int the Slow Controls system. The materials cost is estimated as follows:

Allen-Bradley ADC System	$ 1.5K
16 Channel Expansion: 50 @ $180	$ 9.0K
GPIB Intf: 2 @ $2K	$ 4.0K
Scanning Voltmeter: 2 @ $1K	$ 2.0K
Misc. VME/VXI Modules: 4 @ $1.5K	$ 6.0K
Total, SC Hardware	$22.5K
Slow Controls Interface:	**$23K**

Manpower:

Eng:		EA:	
40m-d	Design Intf	30m-d	Installation
20m-d	Documentation		
90m-d	Software & Alarms Intf		

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.1.2.14
WBS NAME	Engineering Workstations
ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

This WBS number is for the purchase of two workstations to be used for engineering design of the FEE board and RDO board, IC development, and PCB layout.

Sun Sparcstation LX	$6.5K
(19" color monitor, 16MB RAM, disk)	
Add'l RAM	.5K
Add'l disk	1.5K
Workstation Total Cost	$8.5K
Total cost, 2 workstations	**$17K**

Manpower:

Eng:

10m-d Software setup

EA:

60m-d Support/backups, etc.

Source: Sun official price list (Nov. 1992)

40% discount from list

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2

WBS NAME	DAQ

ESTIMATE SOURCE/TYPE (select one or more)	See lower level BOE

WBS #	4.7.2.1

WBS NAME	DAQ Receiver Crate System

ESTIMATE SOURCE/TYPE (select one or more)	see lower level BOE

WBS #	4.7.2.1.1

WBS NAME	VME crates

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

COMPONENTS		
Crate + power supply*	$5000	
CPU board (68040/Ethernet/SCSI)	3000	
Total each crate		$8000
*source of crate/power supply price: recent purchases of similar VME crate		
Crates (5, as above)		$40.0K
Memory cards 2@$4K		8.0K
TOTAL COMPONENTS		$48.0K
MANPOWER		
Parts ordering		15 MD [TE]
Test		15 MD [TE]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.1.2

WBS NAME	VME Event Builder Boards

ESTIMATE SOURCE/TYPE (select one or more)	bottom up

BASIS

COMPONENTS

T9000 (8@$325)	$2600
RAM 1.5 MByte (8@$60)	480
RAM sockets (32@$4)	128
T9000 decoupling (8@$5)	40
Optical daughterboard PCB (8@$25)	200
Optical DB connector (8@$20)	160
Optical xmtr (16@$20)	320
Optical xmtr drive electronics (16@$5)	80
Optical rcvr (16@$20)	320
Optical rcvr circuitry, AGC (16@$5)	80
C104 routers (2@$250)	500
VME connectors (2)	25
Bus interface	200
Misc (LEDs, switches)	30
Decoupling	25
PC board (6x17 in @$4.00/sq.in.)	400
Total components	$5588

NRE charges:

PCB NRE	$ 5K
Prototypes	12K
Total NRE charges	17K

MANPOWER

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Manufacturing Labor

Assembly	3	MD [TE]
Test	0.5	MD [TE]
Incoming parts testing	1	MD [TE]
Total labor per board	4.5	MD [TE]

Development manpower:

Initial design	60 MD [EN]
Second iteration	45 MD [EN]
Design review	20 MD [EN]
Diagnostics	45 MD [EN]
Documentation	15 MD [EN]
Total engineering manpower	185 MD
Two design iterations PCB layout	60 MD [TE]
Build hand prototype	10 MD [TE]
Parts ordering	20 MD [TE]
Total technician manpower	90 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.2

WBS NAME	Tape System

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Source: Sony published price list (Sept 1992)	
8 MByte/sec tape drive Model DIR-1000L:	$95K
Source: Tri-Plex Systems Corp (Sept, 1992)	
VME interface to Sony drive TSC4X4S	20K
Tape system (2 required - one for spare))	$115K

WBS #	4.7.2.3

WBS NAME	Fileserver

ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Source: official Sun price list (11/92)	
40 per cent discounted from list prices	
690MP server model S690-41-128-P63	$61K
includes:	
1 CPU (96 MIPS)	
128 MByte RAM	
8 Gbyte disk	
5 GByte 8mm tape	
Sun operating system	

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.4
WBS NAME	Network Interface
ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Source : Interphase price list (Nov 1992)

Peregrin II single attach VME-FDDI interface Model 5211	$4700
	(2 required - one for spare)

WBS #	4.7.2.5
WBS NAME	Workstations
ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Source : Sun official price list (Nov 1992)
(40 per cent discounted from list prices)

Sparcstation LX	$6500
19 inch Trinitron color monitor	
16 MByte RAM	
454 MByte internal disk	
Additional 16 MByte RAM	450
Internal 1.2GByte disk (from BNL stores)	1600
Workstation total cost	8550

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.6

WBS NAME	Software

ESTIMATE SOURCE/TYPE (select one or more)	lower level BOE

WBS #	4.7.2.6.1

WBS NAME	Event Builder Software

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

MATERIALS

Inmos debugging tools (estimate, see below)	$15K
VxWorks development license (recent vendor quote)	25K
MODSIM simulator (recent quote from vendor)	10K
Materials Total:	$50K

* Debugging tools based on prices charged for similar products by vendor

MANPOWER

Software design/review	60 MD [EN]
Software testing	150 MD [EN]
Documentation	40 MD [EN]
Software implementation	200 MD [EN]
Total Manpower	450 MD [EN]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.7.2.6.2

WBS NAME	Readout Board Software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

MANPOWER

Preliminary software design/review	50 MD [EN]
Software testing	60 MD [EN]
Documentation	40 MD [EN]
Software implementation	90 MD [EN]
Total Manpower	240 MD [EN]

WBS #	4.7.2.6.3

WBS NAME	Command Interface Software

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

MATERIALS

Graphical User Interface generator	$12K
Source: verbal quote from CenterLine Software, Inc, for their ViewCenter and ObjectCenter products (2 licenses each)	

MANPOWER

Software design/review	60 MD [EN]
Software testing	110 MD [EN]
Documentation	60 MD [EN]
Software implementation	220 MD [EN]
Total Manpower	450 MD [EN]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.6.4
WBS NAME	Network Interface Software
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

MANPOWER

Preliminary software design/review	110 MD [EN]
Software testing	240 MD [EN]
Documentation	60 MD [EN]
Software implementation	340 MD [EN]
Total Manpower	750 MD [EN]

WBS #	4.7.2.6.5
WBS NAME	Tape System Software
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

MANPOWER

Preliminary Software design/review	100 MD [EN]
Software testing	80 MD [EN]
Documentation	30 MD [EN]
Software implementation	110 MD [EN]
Total Manpower	320 MD [EN]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.6.6

WBS NAME	Controls Interface Software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

MATERIALS	
Database management system	$27K
Source: Oracle quote for 16-user license	
(October, 1992)	
MANPOWER	
Software design/review	80 MD [EN]
Software testing	100 MD [EN]
Documentation	60MD [EN]
Software implementation	160 MD [EN]
Total Manpower	400 MD [EN]

WBS #	4.7.2.6.7

WBS NAME	Prototype DAQ Software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

MANPOWER	
Software testing	100 MD [EN]
Documentation	20 MD [EN]
Prototype command interface	80 MD [EN]
RO board software implementation	80 MD [EN]
Rcvr board software implementation	120 MD [EN]
Total Manpower	400 MD [EN]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.2.7

WBS NAME	DAQ Management

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Source: Agreement with LBL concerning charges for Engineering Management

MANPOWER

DAQ Engineering Management	350 MD [EN]
Total Manpower	350 MD [EN]

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3

WBS NAME	Trigger Systems

ESTIMATE SOURCE/TYPE (select one or more)	see below

BASIS
See lower level BOE.

WBS #	4.7.3.1

WBS NAME	Interaction Detector (VPD)

ESTIMATE SOURCE/TYPE (select one or more)	see below

BASIS
See lower level BOE.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.1

WBS NAME	VPD Radiators

ESTIMATE SOURCE/TYPE (select one or more)	1, 4, 6

BASIS

This BOE covers the Pb-quartz radiators that mount to the VPD PMTs.

MANPOWER

Engineer: 5 days

(design VPD lead and quartz radiator pieces, holding assembly, supervise)

Draftsman: 5 days

(make drawings of pieces per engineer's specifications, place orders)

Technician: 20 days

(manufacture quartz and lead Radiators, assemble)

Laborer: 25 days

(chase orders, deliver parts and drawings, open boxes, mount radiators to PMTs, test)

MATERIALS

55 quartz radiators, $ 20 / each

55 Pb converters, $2 / each

misc. hardware (screws, aluminum, etc), $2 / each

total: $2 K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.2

WBS NAME	VPD Phototubes

ESTIMATE SOURCE/TYPE (select one or more)	1, 4, 6

BASIS

This BOE covers the cost of the VPD phototubes.

MANPOWER

Engineer: 5 days

(design wrapping, write database program, supervise)

Laborer: 7 days

(order and unpack PMTs, wrap PMTs, gain characterize PMTs)

MATERIALS

Quote from Raymond Muller at Hammamatsu of hundreds quantity R2490-05 PMT of $1036 / PMT. This is the same PMT used in the CTB. There are 50 PMTs in the VPD, 5 PMTs are allocated as spares.

55 PMTs @ $1036 / PMT = $57 K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

BASIS

PMT Base design is derived from existing design with minor modifications.

MANPOWER

Engineer: 60 days.

(modify Base design for 16 stage base, modify TDC design for base mounting, supervise)

Engineer Associate: 20 days.

(modify existing PC layout to engineer's specs.)

Technician: 5 days.

(machine mechanical pieces for base)

Laborers: 65 days.

(fill and solder PC boards, assemble bases @ 1 day/ base, test and fix bases, 10 days)

MATERIALS

Hardware:

110 PC boards: $20 / each

electrical components including 2 FADCs and CW : $255 / base

optical communication components : $110/base

slow communication components : $25/base

mechanical components: $2 / base

connectors: $6 / base

per base cost = $418

55 bases @ $418 / base = $22990

total: $23 K

WBS #	4.7.3.1.3

WBS NAME	VPD Phototube Bases

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.4

WBS NAME	VPD Cables

ESTIMATE SOURCE/TYPE (select one or more)	1, 3, 4, 6

BASIS

This BOE covers the cost for low voltage and fiber optic cables and jumpers that run from the VPD detectors to the signal processing crates.

MANPOWER

Engineer Associate: 5 days

(design panels & labels, figure cable runs, place orders)

Technician: 10 days

(manufacture panels, shop time)

Laborer: 10 days

(open boxes, apply labels, assemble panels)

MATERIALS

LV Cables (20'), $ 10 / each

Fast fiber (100'), $ 35 / each

Slow fibers (100'), $20/each

total cables: $65 / PMT

55 PMT cables @ $65 = $3575

total $4 K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.5

WBS NAME	VPD Slow Controls

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

BASIS

This BOE covers the cost of designing the VPD slow control system used to set and monitor PMT high voltage.

MANPOWER

Engineer: 5 days

(interface to slow controls group and PMT base design, supervise)

Engineering Associate: 5 days

(make drawings, submit jobs to shops)

Technician: 10 days

(assemble and test control unit)

Laborer: 10 days

(deliver drawings, chase orders, pick up and deliver pieces)

MATERIALS

Hardware: total $ 2 K

(aluminum, screws, bolts, etc.)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.6

WBS NAME	VPD Mounting Fixture

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

BASIS

This BOE covers the cost of designing the VPD mechanical support pieces used to mount the VPD detectors to the beam pipe at RHIC.

MANPOWER

Engineer: 20 days

(design mounting fixture, supervise)

Engineering Associate: 10 days

(make drawings, submit jobs to shops)

Technician: 30 days

(manufacture fixture pieces, assemble detector)

Laborer: 3 days

(deliver drawings, chase orders, pick up and deliver pieces)

MATERIALS

Hardware: total $ 3 K

(aluminum, screws, bolts, etc.)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.7

WBS NAME	VPD Assembly and Testing

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

BASIS

This BOE covers the cost of the assembly and testing the VPD in place at RHIC. A majority of the operational checkout of the detector will be performed by physicists whose time is not costed here.

MANPOWER

Engineer: 20 days

(supervise assembly, test completed system, troubleshoot at system level, travel time to BNL)

Draftsman: 5 days

(generate simple assembly drawings)

Technician: 20 days

(perform higher level assembly)

Laborer: 10 days

(perform lower level assembly)

MATERIALS

misc. hardware (tie-wraps, nuts, bolts, etc.)

total: $ 3 K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.1.8

WBS NAME	VPD Project Management

ESTIMATE SOURCE/TYPE (select one or more)	1, 4, 6

BASIS

This BOE covers the cost of the NIM modules and other logic components will be needed to provide VPD TDC strobes, busy circuts and other required low level logic functions.

MANPOWER

Engineer: 20 days

(analyze VPD trigger logic, determine needed modules, place orders, assemble and test)

Laborer: 40 days

(follow orders, open boxes, etc.)

MATERIALS

WBS #	4.7.3.2

WBS NAME	Central Trigger Barrel (CTB)

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

See lower level B.O.E.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.1.

WBS NAME	CTB radiators

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of the CTB radiators, that mount to the PMTs in trays.

MANPOWER

Engineer: 5 days

design radiators, place orders, supervise assembly check test

Technician: 30 days

assemble radiators and Ponts

Laborer: 150 days

chase orders, wrap radiators, aid in assembly

MATERIALS

250 scintillators at $250/each

misc. hardware

total: $ 63k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.2

WBS NAME	CTB phototubes

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of the CTB phototubes.

MANPOWER

Engineer: 5 days

(design wrapping, write database program, supervise)

Laborer: 50 days

(order and unpack PMTs, wrap PMTs, gain characterize PMTs)

MATERIALS

Quote from Raymond Muller at Hammamatsu of hundreds quantity R2490-05 PMT of $1036/ PMT. There are 240 PMTs in the VPD, 10 PMTs are allocated as spares.

250 PMTs @ $1036/PMT =$259K

misc. hardware

total: $ 261k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.3.

WBS NAME	CTB PMT Bases

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of making the CTB PMT Bases.

MANPOWER

Engineer: 80 days
design base with APC, supervise fabrication check test
Engineer Aid: 60 days
make drawings, modify existing design for HV and Slow control sections
Technician: 40 days
machine mechanical pieces for base, set up test
Laborer: 150 days
fill and solder PC boards, assemble bases at 2/day test and fix bases

MATERIALS

Hardware:
110 PC boards: $20/each
electrical components including 2 FADCs and CW: $255/ base
mechanicalcomponents: $2/ base
connectors: $6/ base
per base cost=$418
55 bases @ $418 a base = $22990
total: $ 80k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.4

WBS NAME	CTB Cables

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of the CTB Cables.

MANPOWER

Engineer: 5 days
(design cable runs, place orders)
Technician:10 day
(perform higher level assembly and test)
Laborer: 30 days
(apply lables, route cables)

MATERIALS

LV cables(20'),$10/ each
Fast fibers (100'), $35/ each
Slow fibers (100') , $20/ each

total: $ 25k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.5

WBS NAME	CTB Slow Controls

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of the CTB slow controls.

MANPOWER

Engineer: 20 days
(interface to slow controls group and PMT base design, supervise)
Engineer Aid: 20 days
(make drawings, submit jobs to shops)
Draftsmen: 5 days
(generate simple drawings)
Technician: 10 days
(assemble and test control unit)
Laborer: 10 days
(deliver drawings, chase orders, pick up and deliver pieces)

MATERIALS

misc. hardware
total: $ 5k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.6

WBS NAME	CTB Mechanical Support

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the CTB mechanical Support including trays and cooling.

MANPOWER

Engineer: 75 days

(design mounting trays with cooling, supervise fabrication)

Engineer Aid: 25 days

(make drawings, aid design details)

Technician: 60 days

(perform higher level assembly and test)

Laborer: 145 days

(assemble radiators in trays, prepare for shipment to BNL)

MATERIALS

misc. hardware

total: $ 39k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.7

WBS NAME	CTB Assembly and Testing

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of the CTB Assembly and Testing.

MANPOWER

Engineer: 15 days
(supervise assembly and test, trouble-shoot at system level)
Draftsmen: 5 days
(generate assembly drawings)
Technician: 20 days
(perform higher level assembly and test)
Laborer: 30 days
(perform lower level assembly)

MATERIALS

misc. hardware (tie-wraps, nuts, bolts, etc.)
total: $ 3k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.2.8

WBS NAME	CTB Project Management

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of the CTB Project Management.

MANPOWER

Engineer: 40 days

(follow costs and schedule)

Laborer: 50 days

(chase orders, document progress)

WBS #	4.7.3.3

WBS NAME	Veto Calorimeter

ESTIMATE SOURCE/TYPE (select one or more)	see below

BASIS

see lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.1

WBS NAME	VC radiators

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of making the VC radiators.

MANPOWER

Engineer: 5 days
(design radiators, fiber routing, supervise fabrication, place orders)
Draftsmen: 5 days
(generate simple drawings)
Technician: 30 days
(perform higher level assembly and test)
Laborer: 30 days
(chase orders, wrap radiators)

MATERIALS

BC 420 scintillator, 30 cm X 40 cm X 2 cm, $250/each
BC 420 scintillator, 15 cm X 40 cm X 2 cm, $150/each
misc. hardware
total: $ 15k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.2

WBS NAME	VC phototubes

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of the VC phototubes.

MANPOWER

Engineer: 5 days

(design fiber bundle end, mount, supervise)

Laborer: 7 days

(order and unpack PMTs, wrap PMTs, gain characterize PMTs)

MATERIALS

Quote from Raymond Muller at Hammamatsu of hundreds quantity R2490-05 PMT of $1036/PMT. This is the same PMT used in the CTB and VPD. There are 4 PMTs in the VC, 1 PMT allocated as spare.

5 PMTs @ $1036 / PMT = $5.7K

total: $ 6k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.3

WBS NAME	VC absorbers

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of making the VC absorbers.

MANPOWER

Engineer: 5 days
(design absorbers, place orders)
Technician: 30 days
(perform higher level assembly and test)
Laborer: 30 days
(open boxes, check pieces)

MATERIALS

Steel pieces 30 X 40 X 5 cm, $150 each
Steel pieces 15 X 40 X 5 cm, $100 each
misc. hardware
total: $ 10k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.4

WBS NAME	VC cables

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of making the VC cables.

MANPOWER

Engineer: 5 days
(design cable runs, place orders)
Technician: 5 days
(install and test)
Laborer: 10 days
(label and install)

MATERIALS

Fast fibers, (150'), $50/each
Slow fibers, (150'), $40/each
misc. hardware
total: $ 1k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.5

WBS NAME	VC mounting

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the VC mounting

MANPOWER

Engineer: 10 days
(design mount, integrate with RHIC, supervise fabrication)
Draftsmen: 5 days
(generate simple drawings)
Technician: 10 days
(machine parts, perform higher level assembly)
Laborer: 10 days
(perform lower level assembly)

MATERIALS

misc. hardware
total: $ 10k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.6

WBS NAME	VC Assembly

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of VC assembly.

MANPOWER

Engineer: 10 days
(design VC boxes, fiber router, supervise fabrication and system level tests)
Draftsmen: 5 days
(generate simple drawings)
Technician: 30 days
(perform higher level assembly and test)
Laborer: 10 days
(perform lower level assembly)

MATERIALS

Blue Giant remote control hydraulic positioning tables, $5k/each
misc. hardware
total: $ 30k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.3.7

WBS NAME	VC Project Management

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of VC Project Management

MANPOWER

Engineer: 25 days
(follow costs and schedule)
Laborer: 25 days
(document design, orders and tests)

WBS #	4.7.3.4

WBS NAME	TPC endcap (MWPC)

ESTIMATE SOURCE/TYPE (select one or more)	see below

BASIS

See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.4.1

WBS NAME	MWPC FEE

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the MWPC FEE.

MANPOWER

Engineer: 20 days
(design ADC control, integration with existing TPC electronics)
Engineer Aid: 30 days
(modify existing designs for preamps and shaper and ADC)
Draftsmen: 10 days
(generate simple drawings)
Technician: 60 days
(assemble FEE cards, set up tests)
Laborer: 30 days
(load cards, test final boards)

MATERIALS

PC card, connector, LED (250MHz), FADC, pre/shaper amps, $200/card
misc. hardware
total: $ 20k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.4.2

WBS NAME	MWPC Cables

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

This basis covers the cost of making the MWPC Cables

MANPOWER

Engineer: 5 days
(design cable runs, place orders)
Technician: 30 days
(assembly, routing, and test)
Laborer: 30 days
(open boxes, label and install cables)

MATERIALS

Fast fiber, (100'), $35/each
Slow fibers, (100'), $20/each
misc. hardware
total: $ 22k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.4.3

WBS NAME	MWPC Assembly and Test

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of MWPC Assembly and Test.

MANPOWER

Engineer: 10 days

(design integration with TPC, supervise assembly, test at system level)

Draftsmen: 10 days

(simple assembly drawings)

Technician: 20 days

(assemble onto TPC and test)

MATERIALS

misc. hardware

total: $ 10k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.4.4

WBS NAME	MWPC Project Management

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of MWPC Project Management

MANPOWER

Engineer: 25 days

(follow project cost and schedule)

Laborer: 25 days

(document designs, orders and tests)

WBS #	4.7.3.5

WBS NAME	Trigger Controller

ESTIMATE SOURCE/TYPE (select one or more)	see below

1. Vendor	5. In-house manufacturing analysis
2. Bottoms-up	6. Historical information
3. Analogy	7. Parametrics/factors
4. Engineering judgment	8. Other (explain below)

BASIS

see lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.1

WBS NAME	Trigger Processor

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the Trigger Processor

MANPOWER

Engineer: 100 days

(work with physicists on design and specification, supervise fabrication and preform system tests)

Engineer Aid: 40 days

(drawings, design standard VME commumications and slow communications)

Technician: 25 days

(fabricate mechanical pieces, assemble and test modules)

Laborer: 25 days

(load, solder PC boards, test components)

MATERIALS

misc. hardware

total: $ 10k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.2

WBS NAME	RAM-FPGA board

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the RAM-FPGA board.

MANPOWER

Engineer: 120 days

(work with physicist to design and specify, supervise fabrication and perform system level tests)

Engineer Aid: 40 days

(make drawings, design VME control and address strobe)

Technician: 40 days

(make mechanical parts for modules, assemble, test)

Laborer: 60 days

(load, solder boards, test)

MATERIALS

16-250 mHz recivers @ $100

2- 250 mHz transmitters @ $100

1-Clock Address Strobe @ $25

32- 1 Kby dual ported memory @ $10

1- 300 pin FPGA @ $70

misc. hardware

total: $ 60k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.3

WBS NAME	RHIC strobe distribution

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the RHIC strobe distribution that is sent to each detector and each trigger modulator.

MANPOWER

Engineer: 10 days

(design distribution system, supervise fabrication, perform system level tests)

Engineer Aid: 10 days

(draw, modify existing distribution designs)

Technician: 30 days

(make mechanical pieces, set up test)

Laborer: 5 days

(load, solder boards, chase orders)

MATERIALS

misc. hardware

total: $ 9k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.4

WBS NAME	TP CPU

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of TP CPU, the two interactive consoles that control the trigger processors.

MANPOWER

Engineer: 5 days

(specify, order, supervise installation)

Technician: 10 days

(install on net, system setup)

MATERIALS

misc. hardware

total: $ 20k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.5

WBS NAME	LED Pulser

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the LED Pulser to test all STAR PMTs

MANPOWER

Engineer: 20 days

(design LED source, pulser, and disribution, supervise fabrication and perform system level tests)

Engineer Aid: 10 days

(make drawings, design diffuser and monitor)

Technician: 20 days

(make mechanical parts, asemble source parts)

Laborer: 10 days

(chase orders, assemble distribution system)

MATERIALS

misc. hardware

total: $ 19k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.6.

WBS NAME	VME Electronics

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of VME Electronics, including crates and controllers

MANPOWER

Engineer: 5 days
(work with physicist to design system, specify crates and associated modules, test at system level)
Technician: 5 days
(perform higher level assembly and test)
Laborer: 30 days
(chase orders, test systems)

MATERIALS

misc. hardware
total: $ 40k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.7.

WBS NAME	NIM electronics

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of NIM electronics.

MANPOWER

Engineer: 5 days
(work with physicist to design and specify analog logic and test modules)
Technician: 5 days
(perform higher level assembly and test)
Laborer: 30 days
(chase orders, setup and test systems)

MATERIALS

misc. hardware
total: $ 20k

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.8

WBS NAME	System Software

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of System Software.

MANPOWER

Engineer: 120 days

(work with physicist to design and specify software system, supervise code development)

Technician: 120 days

(write system level software)

Laborer: 120 days

(write user interface software)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.3.5.9.

WBS NAME	Assembly

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of making the TC Assembly.

MANPOWER

Engineer: 10 days
(work with physicist to design system and supervise assembly)
Technician: 30 days
(perform higher level assembly and test)

WBS #	4.7.3.5.10

WBS NAME	Project Management

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

This basis covers the cost of TC Project Management.

MANPOWER

Engineer: 40 days
(monitor tests and schedule)
Laborer: 25 days
(chase orders, document)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4

WBS NAME	Slow Controls

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS
See lower level BOE

WBS #	4.7.4.1

WBS NAME	Slow Controls Hardware

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS
See lower level BOE

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.1.1

WBS NAME	Commercial Worstation

ESTIMATE SOURCE/TYPE (select one or more)	1, 6

BASIS

This BOE is for the purchase of a commercial, low-cost Unix workstation for development of the slow controls software and control of the VME crates that implement the hardware base for slow controls control of other subsystems. The workstation is costed as follows:

Workstation		$10.0K
Add'l Memory		$ 1.2K
Add'l disks	2 @ 2.9K	$ 5.8K
Misc. supplies		$ 1.0K
Total		$17.0K

The manpower estimate was derived as follows:

Manpower:

EA:	10	m-d	HW Setup
	10	m-d	Add options

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.1.2

WBS NAME	Slow Controls VME Crates

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 6

BASIS

This BOE is for the purchase of commercial VME crates and processors. VME crates and commercial CPUs for the operating basis for EPICS and VxWorks, the major software base for slow controls development. A VME crate is costed as follows:

VME Crate + PS		$2.5K
Comm. CPU	$2.5K	
Expansion Front Panel		$ .5K
Total, per crate		$5.5K

There are a total of 6 VME crates costed in the baseline Slow Controls system. These are:

Magnet	1
TPC	1
TPC Power	1
DAQ	1
Trigger	1
Spare	1
Total, VME crates	6
Total, VME crate cost	**$33K**

The manpower estimates are as follows:

Manpower:

Eng:			EA:		
6	m-d	Checkout	20	m-d	Ordering/Tracking
20	m-d	Config.	20	m-d	Config.
Tech:					
6	m-d	Crate Setup			

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.2

WBS NAME	Software

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS

The software development for Slow Controls has been determined to be based on EPICS, with a VxWorks kernel running in the processor at each VME crate. EPICS (Experimental Physics and Industrial Control System) is designed to be a fast, easy interface to instrumentation for data acquisition, supervisory control, and steady-state control through a table entry database. It runs under Unix on commercial workstations and is designed to control interact with processors running VxWorks in a VME or VXI environment.

WBS #	4.7.4.2.1

WBS NAME	Commercial Software

ESTIMATE SOURCE/TYPE (select one or more)	1, 6

BASIS

This BOE entry is for the purchase of commercial software in support of Slow Controls. EPICS itself is free but other pieces are not. The costed items are:

Commercial Database	$12.0K
VxWorks Licenses (6 @ $1.2K)	$ 7.2K
Total, Comm. Software	$19.2K
Maintenance (5 yrs x 25%/yr)	$23.4K
Total Software cost	**$43K**

The manpower estimate is derived as follows:

Eng:	5	m-d	OS Install
	10	m-d	Database Install

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.2.2

WBS NAME	Custom Software

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS

A significant amount of custom software will need to be developed using EPICS to support Slow Controls. This development is broken in two parts: a component at LBL and a component at our collaborator's site (most probably Creighton State University).

WBS #	4.7.4.2.2.1

WBS NAME	Custom Software (LBL)

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This BOE estimate is for the custom software development and support at LBL. It is anticipated that LBL's involvement with Slow Controls will be in the role of training in the use and administration of the EPICS package and custom VxWorks development not possible at Creighton State.

Misc. Supplies $5K

The manpower estimate is for 20% time for an engineer for the life of the project.

Eng: 110 m-d EPICS & VxWorks support

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.2.2.2

WBS NAME	Custom Software (Creighton State)

ESTIMATE SOURCE/TYPE (select one or more)	4, 8

BASIS

This BOE estimate is derived from the available contributed effort available from Creighton State. The professional effort (40% time) and the student effort (50% time) is deemed to be adequate for the anticipated development effort.

Misc. Supplies: $5K

Manpower:

Eng:	448	m-d	EPICS development (40% time)
Tech:	504	m-d	Software development (Student 50% time)

WBS #	4.7.4.3

WBS NAME	Slow Controls Integration

ESTIMATE SOURCE/TYPE (select one or more)	See below

BASIS

This BOE covers integration of Slow Controls with the other detector subsystems. It covers items such as: shipping, setup at BNL, system integration.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.3.1

WBS NAME	Shipping

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

BASIS

This BOE covers the cost of shipping the slow controls hardware from the collaborator's site to LBL or BNL, as needed.

Shipping (2 trips @ $2.5K) $5K

Manpower:

Tech:	10m-d	Assembly/Disassembly
Laborer:	10m-d	Assembly/Disassembly

WBS #	4.7.4.3.2

WBS NAME	Setup at BNL

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This BOE covers the estimated setup period of Slow Controls at BNL.

Manpower:

Eng:	10m-d	System Installation
Tech:	10m-d	System Installation

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.7.4.3.3

WBS NAME	System Integration

ESTIMATE SOURCE/TYPE (select one or more)	4, 6

BASIS

This BOE covers the system integration of Slow Controls with the other detector subsystems.

The manpower estimate is derived as follows:

Eng:	10	m-d	General Test
	10	m-d	TPC Test
	5	m-d	Magnet Test
	10	m-d	Trigger Test
Tech:	20	m-d	Detector Tests

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8
WBS NAME	Computing
ESTIMATE SOURCE/TYPE (select one or more)	
BASIS	See lower level BOE

WBS #	4.8.1
WBS NAME	Hardware
ESTIMATE SOURCE/TYPE (select one or more)	
BASIS	See lower level BOE

WBS #	4.8.1.1
WBS NAME	Code Development Worksystem
ESTIMATE SOURCE/TYPE (select one or more)	1,4,6
BASIS	See lower level WBS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	5. In-house manufacturing analysis
2. Bottoms-up	6. Historical information
3. Analogy	7. Parametrics/factors
4. Engineering judgment	8. Other (explain below)

WBS #	4.8.1.1.1

WBS NAME	Code Development shared central computer

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

File server compute server functions provided by a SPARCcenter 2000 system. Note the BNL has a site license for most of the applicable software products.

Base system - 2 processors, 4 GB disk, 8mm tape, CD-ROM SCSI, Ethernet, 64MB memory		95000
2 expansion boards, each with two processors and 64MB	2 x 34,200	68400
Disk expansion unit - 6 x 2GB disks		27800
FDDI single attach card		3500
2 add. 8mm tapes		8000
laser printer		5000
	list price	207700
	less 40% discount subtotal	124620
Maintenance and purchased software - 4 years		4000
	Total	164620

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.1.2

WBS NAME	Two-user Workstations (5)

ESTIMATE SOURCE/TYPE (select one or more)	1,4,6

BASIS

Estimate based on recent purchases of workstations from three vendors, Hewlett Packard, Digital Equipment and Silicon Graphics Corp and recent announcements of future prices.

ESTIMATE $15K per workstation. Purchase price includes network interface, first year maintenance, adn software licenses.

Example: SUN Sparc 10 model 41 is 24995 list, 14997 BNL net.

WBS #	4.8.1.1.3

WBS NAME	Code Development System Support

ESTIMATE SOURCE/TYPE (select one or more)	4,6

BASIS

80 man-days of engineering and 250 man-days of programmer effort are included for installation and system support of this system. This corresponds to about 0.25 FTE for a four year code development period. An additional 50 man-days of TE effort are added for the documentation. These estimates are based on experience with BNL HENP support of the RHIC batch complex including three different RISC-UNIX computing platforms sharing NFS mounted disks.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.2

WBS NAME	On-line hardware monitoring systems

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS
See lower level WBS

WBS #	4.8.1.2.1

WBS NAME	SVT Hardware Monitoring systems

ESTIMATE SOURCE/TYPE (select one or more)	

WBS #	4.8.1.2.2

WBS NAME	TPC Hardware Monitoring systems

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
This item must be specified in more detail in consultation with DAQ and TPC designers. Present estimate is physicist judgment. ESTIMATE: Hardware cost $100K. This is for two or three computers with interfaces to mini-DAQ equipment. Support manpower 50 days tech specialist level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.2.4

WBS NAME	Magnet Hardware Monitoring Systems

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

This item must be specified in more detail in consultation with DAQ and Magnet designers. Present estimate is physicist judgment. ESTIMATE hardware cost #10K. This is for a small workstation with a crate of sensing electronics. Support Manpower 0.1 FTE at Tech Specialist level.

WBS #	4.8.1.2.5

WBS NAME	Hardware Monitoring Systems

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

WBS #	4.8.1.2.6

WBS NAME	Hardware Monitoring Systems

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.3

WBS NAME	On-line Physics Monitoring System

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS See lower level WBS

WBS #	4.8.1.3.1

WBS NAME	Event Server computer

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

The computer, disks and network interface are from the Sun Sparcenter 2000 enterprise server announcement. Systems deliverable after 1Q 93. The DAQ compatible is a phone quote from TRI-PLEX systems for an interface and controller. The drive itself will be the spare from the two ordered for DAQ. The total estimate is $98K for hardware and licenses consisting of:

$60K for computer system with 10 GB disks
18K for additional disks and I/O bus
20K for DAQ compatible interface only

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.3.2

WBS NAME	Event analysis compute server system

ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

The estimate is $103k for five dual processor trays inserted in a SUN Sparcenter 2000 cabinet. This brings the vendor's claimed CPU capacity to 228 Mflops, about 90% of the requirement for this system. However, this capacity is not required until RHIC turn on and would not be added to the base system (WBS 4.8.1.3.1) until needed. By that time we estimate at least a factor of two improvement in cost/Mflop.

WBS #	4.8.1.3.3

WBS NAME	Graphical User Interface Workstations

ESTIMATE SOURCE/TYPE (select one or more)	1, 4

BASIS

Cost is based on recent workstation purchases from a number of vendors, with vendor price lists used to estimate augmented graphics capability and network interface costs. Each workstation is estimated at $20k.

WBS #	4.8.1.3.4

WBS NAME	High speed networking hardware

ESTIMATE SOURCE/TYPE (select one or more)	1, 4

BASIS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Based on devices recently installed in the BNL Physics building to expand the local network and support the large RHIC experiment and Physics compute server systems. These include a CISCO AGS+ router/Bridge and a DEC DEFCN FDDI concentrator with FDDI cards for each graphical user workstation (4.8.1.3.3) and multiple ethernet cards, a total cost of $37k.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.3.5

WBS NAME	Management, Engineering, Procurement, and Documentation

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Procurement, quality assurance, installation, and checkout are estimated at 90 man-days. Management, hardware and software engineering and documentation at 0.5 FTE to commence two years before RHIC turn-on, an additional 250 man-days. The estimate is based on experience in managing and installing computing facilities in the experimental areas of the AGS (this facility should be located in the experiment support building at the detector).

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.4

WBS NAME	Off-line Event Processing Systems

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Since this computing capacity is expected to be provided by a facility outside the STAR budget, it is included here only to provide a complete specification of the computing needs. The estimate is for a part of the system proposed in RHIC detector note #8, a report of an ad-hoc committee with members from all the proposed RHIC experiments. That report included an estimate of costs based on the experience of the committee members.

ESTIMATE

.1	Three host event server computers	$ 300k
.2	Two DAQ compatible tape systems	230k
.3	100 SCSI disk drives	200k
.4	Networking FDDI and Ethernet Hdw.	100k
.5	Nine 8mm tape drives	50k
.6	300 event analysis nodes	4000k
.7	Ten FTE engineer level commencing 1 year before RHIC turn on.	

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.1.5
WBS NAME	Off-line Physics Analysis Workstations
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate is a judgment based on unit costs for current computer workstation hardware. Since expenditures for this WBS do not occur until the year before RHIC turn on, the actual capability of the hardware should be four to ten times present workstations, based on projections of current improvement rate. Unit costs are expected to be similar, however, and manpower needs for support functions will remain similar. We estimate $200k for computer hardware over the last two years before RHIC turn on with 0.2 FTE effort for a system manager for those two years, 100 man-days.

WBS #	4.8.2
WBS NAME	Computing software
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS

WBS #	4.8.2.1
WBS NAME	System Definition and Specification
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.1.1
WBS NAME	Software Requirements Specification
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 125 man-days physicist, 30 man-days engineer.

WBS #	4.8.2.1.2
WBS NAME	System Architecture
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 50 man-days physicist. 80 man-days engineer.

WBS #	4.8.2.1.3
WBS NAME	Data dictionary
ESTIMATE SOURCE/TYPE (select one or more)	3,4

BASIS

Estimate based on analogy with the data dictionary used for EOS and engineering judgement. 500 man days physicist. 50 man days engineer. 80 man days tech.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.1.4
WBS NAME	User interface
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man days physicist. 40 man days engineer.

WBS #	4.8.2.1.5
WBS NAME	Graphical interface
ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

Estimate for purchased software basedupon verbal quote from one vendor. Estimate for labor based on engineering judgement. $10K purchased software (2 licenses for UIM/X). 100 man days physicist. 40 man days engineer.

WBS #	4.8.2.1.6
WBS NAME	Software integration and programmer interfaces
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 500 man days physicist. 80 man days engineer.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.1.7
WBS NAME	Messaging Service
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 150 man days physicist. 40 man days engineer.

WBS #	4.8.2.1.8
WBS NAME	Code library specifications
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 20 man days physicist. 20 man days engineer.

WBS #	4.8.2.1.9
WBS NAME	Detector specifications
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 250 man days physicist. 20 man days engineer.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.1.10

WBS NAME	On-line operations system

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 100 man days physicist. 80 man days engineer.

WBS #	4.8.2.1.11

WBS NAME	Data management system

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 100 man days physicist. 60 man days engineer.

WBS #	4.8.2.2

WBS NAME	Event generators

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 600 man days physicist effort. 400 man days student level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.3
WBS NAME	Detector specific software
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS.

WBS #	4.8.2.3.2
WBS NAME	Time projection chamber
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS.

WBS #	4.8.2.3.2.1
WBS NAME	TPC stimulator
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 750 man-days physicist effort. 150 man-days student level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.3.2.2
WBS NAME	TPC Event
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 750 man-days physicist effort. 230 man-days student level.

WBS #	4.8.2.3.2.3
WBS NAME	TPC Monitor Program
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 750 man-days physicist effort. 150 man-days student level.

WBS #	4.8.2.3.2.4
WBS NAME	TCP Calibration Program
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 750 man-days physicist effort. 250 man-days student level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.3.2.5

WBS NAME	TPC Design tools

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 400 man-days physicist effort. 80 man-days tech level.

WBS #	4.8.2.3.2.6

WBS NAME	TPC Software Documentation

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 200 man-days physicist effort.

WBS #	4.8.2.3.2.7

WBS NAME	TPC Control Program

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS
Estimate based on engineering judgement. 200 man-days physicist effort.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.3.4

WBS NAME	Solenoid Magnet (SMS) Software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 330 man-days physicist effort. 50 man-days tech level.

WBS #	4.8.2.3.7

WBS NAME	Trigger Device software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

500 man-days physicist effort. 250 man-days student level.

WBS #	4.8.2.4

WBS NAME	Global Event Reconstruction

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 2000 man-days physicist effort. 1000 man-days student level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.5
WBS NAME	Software Management Tools
ESTIMATE SOURCE/TYPE (select one or more)	1,4

BASIS

Estimate based on vendor quote for purchased software and engineering judgement for labor. $20K purchased software (program development tools). 700 man-days physicist effort. 100 man-days engineer. 550 man-days tech level.

WBS #	4.8.2.6
WBS NAME	Processor Farm Control System
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 400 man-days physicist effort. 60 man-days engineer. 200 man-days tech level.

WBS #	4.8.2.7
WBS NAME	Analysis Shell
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.7.1
WBS NAME	Prototype Analysis shell
ESTIMATE SOURCE/TYPE (select one or more)	3

BASIS

Estimate based on analogy with EOS analysis shell. The prototype analysis shell is a modified version of the EOS analysis shell. 30 man-days physicist effort.

WBS #	4.8.2.7.2
WBS NAME	First Prototype Software Bus
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate is based on engineering judgement. 30 man-days physicist effort. 30 man-days engineering effort. 30 man-days tech level.

WBS #	4.8.2.7.3
WBS NAME	Second Prototype Software Bus
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate is based on engineering judgement. 30 man-days physicist effort. 50 man-days engineer. 30 man-days tech level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.7.4

WBS NAME	User interface

ESTIMATE SOURCE/TYPE (select one or more)	3,4

BASIS

Estimate based on analogy with EOS analysis shell user interface and engineering judgement. 60 man-days physicist effort.

WBS #	4.8.2.7.5

WBS NAME	Data I/O Module

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist effort. 50 man-days engineer effort. 50 man-days tech level.

WBS #	4.8.2.7.6

WBS NAME	Graphics module

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist effort. 50 man-days tech level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.2.7.7

WBS NAME	Event processing module

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate base on engineering judgement. 150 man-days physicist.

WBS #	4.8.2.7.8

WBS NAME	Software bus-based analysis

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist effort. 50 man-days tech level.

WBS #	4.8.2.8

WBS NAME	Magnet measurement software

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist effort. 50 man-days tech level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.9
WBS NAME	On-line operations system
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

See lower level WBS.

WBS #	4.8.2.9.1
WBS NAME	Experiment control
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 200 man-days physicist. 30 man-days engineer.

WBS #	4.8.2.9.2
WBS NAME	Event server
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 130 man-days physicist. 60 man-days engineer. 60 man-days tech level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.9.3
WBS NAME	Error logger
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 50 man-days physicist. 30 man-days engineer.

WBS #	4.8.2.9.4
WBS NAME	Experiment parameter log database
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist. 30 man-days engineer.

WBS #	4.8.2.9.5
WBS NAME	Configuration manager
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate is based on engineering judgement. 100 man-days physicist. 30 man-days engineer.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.9.6
WBS NAME	Configuration database
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist. 30 man-days engineer.

WBS #	4.8.2.9.7
WBS NAME	State manager
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist. 50 man-days engineer.

WBS #	4.8.2.9.8
WBS NAME	Detector Performance History Database
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 100 man-days physicist. 50 man-days engineer.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.8.2.10
WBS NAME	Data Management System
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

WBS #	4.8.2.10.1
WBS NAME	Database Software
ESTIMATE SOURCE/TYPE (select one or more)	1

BASIS

Estimate based on quote from one vendor. $50K for database engine and program development tools for 32 users on a Sparcstation 10 Model 54 class computer. $20K for runtime licenses and network connection software for 20 workstations. Total purchase $70K.

WBS #	4.8.2.9.10.2
WBS NAME	Data Management Software
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Estimate based on engineering judgement. 200 man-days physicist. 100 man-days engineer. 200 man-days tech level.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9
WBS NAME	Detector Conventional Facilities
ESTIMATE SOURCE/TYPE (select one or more)	See lower level

BASIS

The design of the detector conventional facilities System (CFS) is in the conceptual stages. Cost was estimated by several methods depending on the system level of design details. Vendor catalogues, bottoms-up historical information and engineering judgment were used. Detailed information is contained in the lower WBS levels.

WBS #	4.9.1
WBS NAME	Mechanical Utilities
ESTIMATE SOURCE/TYPE (select one or more)	See lower level

BASIS

The cost was estimated by several methods depending on the system level of design details. Vendor catalogues, bottoms-up historical information and engineering judgment we used. Detailed information is contained in the lower WBS levels.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.1.1
WBS NAME	Modified Chilled Water System
ESTIMATE SOURCE/TYPE (select one or more)	1,2,3,4

BASIS

Cost of the MCHW system is based on preliminary design data. Pipe sizes were estimated based on maximum available system pressure of 100 psi. The circulation pumps were sized based on 2-100% flow capacity for redundancy purpose. Isolation and flow control valves are includes for ease of operation control and maintenance. A worksheet was prepared to inventory system components such as valves tubes and fittings. Cost data of components are based on analogy to similar equipment.

Engineering and labor time is calculated based on the estimated number of engineering drawings required to complete the job. It was estimated that 10 drawings including (instrumentation/control drawings) are required. The average engineering and design time per drawing is 7 and 4 days respectively.

WBS #	4.9.1.1.1
WBS NAME	Piping and Fittings
ESTIMATE SOURCE/TYPE (select one or more)	1,2,3,4

BASIS

Detailed information is contained in the lower WBS levels.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.9.1.1.1.1
WBS NAME	Distribution Pipes
ESTIMATE SOURCE/TYPE (select one or more)	2, Construction Cost Book

BASIS

Material cost was calculated from industry and Construction catalogues. 4" pipe 28.38 $/ft, 3" is 18.85 $/ft, 2" is 13 $/ft, 1" is 4.72 is $/ft. Insulation cost varies from 4.44 $/ft to 1.41 $/ft depending on the size. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.1.2
WBS NAME	Fittings and Bracket
ESTIMATE SOURCE/TYPE (select one or more)	2, 4,7

BASIS

Material cost was calculated 20% of piping cost. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.1.3
WBS NAME	Dielectric Union and Flanges
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on a vendor quote of stock at hand. 4 " flange is $105, 2" is $25.39, 1.5 " is $18.12, 1" is 7.39. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.1.1.2
WBS NAME	Valves
ESTIMATE SOURCE/TYPE (select one or more)	1,2, 4

BASIS

Detailed information is contained in the lower WBS levels.

WBS #	4.9.1.1.2.1
WBS NAME	Shutoff Valves
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on a vendor Catalogues. 4" is $314, 3" is $215, 2" is $172, 1.5" is $147, 1" is $92. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.2.2
WBS NAME	Motorized Flow Control Valves
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on a vendor Catalogues. 4" is $1,068, 3" is # 750, 2" is $625. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.9.1.1.3
WBS NAME	Circulation Pumps, Complete Skid
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on a Construction Catalogues. The skid unit comes complete and assembled for $ 16,376. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.4
WBS NAME	ASME Rated 31 Gal Expansion Tank
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on a Construction Catalogues. Unit is assembled fro $1,260. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.5
WBS NAME	Water to Water Heat exchanger
ESTIMATE SOURCE/TYPE (select one or more)	1,2

BASIS

Material cost is based on vendor quotes. Plate heat exchangers are $6,500, tube and shell $7,200. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.1.1.6
WBS NAME	Instrumentation and Control
ESTIMATE SOURCE/TYPE (select one or more)	2,3,4

BASIS

See lower WBS for cost details

WBS #	4.9.1.1.6.1
WBS NAME	Sensors
ESTIMATE SOURCE/TYPE (select one or more)	2,3,4

BASIS

Material cost is based on engineering judgments. Sensors are $700 each. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.6.2
WBS NAME	Computer
ESTIMATE SOURCE/TYPE (select one or more)	3,4

BASIS

Material cost is based on engineering judgments. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.1.1.6.3

WBS NAME	Software

ESTIMATE SOURCE/TYPE (select one or more)	3,4

BASIS

Material cost is based on engineering judgments. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.1.6.4

WBS NAME	Sensors

ESTIMATE SOURCE/TYPE (select one or more)	1,2,3,4

BASIS

Material cost is based on vendor catalogues and engineering judgments. Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.1.2

WBS NAME	Conditioned Air System

ESTIMATE SOURCE/TYPE (select one or more)	3,4

BASIS

The conditioned air system is in the conceptual design stage.

The cost of detector HVAC system is based on a rough engineering estimate. Better estimate will be completed when the magnet return iron final design is available.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.1.3

WBS NAME	Industrial Cooling Water (ICW)

ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

The source of the ICW system heat load is the TPC chiller. It is about 30 KW. The cost of the ICW equipment is generated based on analogy to similar systems. Engineering and design time is based on the number of drawings required to complete the job.

WBS #	4.9.2

WBS NAME	Electrical Utilities

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

The design of the Electrical Utilities system is in the conceptual stage. Cost was estimated by several methods depending on the details. Industry and vendor catalogs, bottom-up, in-house analysis, and engineering judgement were used. For all the utilities, the estimate of engineering time covered design documentation, review, coordination, inspection of hardware, and planning. Drafting time was for preparation and drafting. Technican time was for fabrication.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.1

WBS NAME	Filtered Power

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Cost was estimated by several methods depending on the details. Industry and vendor catalogs, bottom-up, in-house analysis, and engineering judgement were used.
Detailed information is contained in the basis for lower WBS levels.
Filtered power is derived from Clean power. Detailed basis of costs is contained in the lower level WBS.

WBS #	4.9.2.1.1

WBS NAME	Distribution

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Power on 208 V from the main breaker in the assembly hall is taken to a filter and surge suppressor and then to a distribution panel in the operations room. Here it is routed to the workstations DAQ computers and tape loggers using IMT conduit and terminated in 120 V and 208 V outlets.
A similar circuit is used for the Computer room.
The Clean room and the Electronics shop use a common surge suppressor and Distribution panel, which is located next to the Clean room.
The calculations for costs are shown in two lower level WBS numbers.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.1.1.1

WBS NAME	Cables, and conduit

ESTIMATE SOURCE/TYPE (select one or more)	1, 2, 4, 5

BASIS

Costs are calculated based on linear feet for cables and conduits. and on a per item basis for components and fixtures. The cost for wireways and cables were obtained from cost data catalogs used in industry. A worksheet was prepared.

The cost of materials for conduit and cabling is $5417, and is obtained as follows:

Cost of 800 ft. of 2" IMT conduit @ $9.60 per ft.	= $ 2928
Cost of 800 ft. of # 12 cable @ $.53 per ft.	= $ 422
Cost of 10 fittings for conduit @ $ 82.80 each	= $ 828
Cost of 50, 120 V outlets with covers @ $ 7.74 each	= $ 387
Cost of 10, 208 V outlets with covers @ $ 13.56 each	= $ 136
Cost of misc. wiring boxes, conduit supports	= $ 716
TOTAL COST	= $ 5417

Engineering time for the conduit and cables	= 10 MD
Engineering time for the outlets, and wiring boxes	= 6 MD
Drafting ime for the conduit and cables	= 7 MD
Fabrication time	= 4 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.1.1.2

WBS NAME	Distribution panels

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are estimated based on a per item basis for components and fixtures. The cost was obtained from vendor and cost data catalogs used in industry.

The total cost of materials is $ 8476 and includes Panelboards, and filters and surge suppressors. It is obtained as folows:

Cost of 2 Panel boards (225 A main breaker, 208 V/120 V, and 7 branch circuits) @ $1404 each	= $ 2808
Cost of 1 Panel board (400 A main breaker, 208 V/120 V, and 7 branch circuits) @	= $ 2418
Cost of 2, 200 A surge suppressors @ $ 1000 each	= $ 2000
Cost of 1, 300 A surge suppressor	= $ 1250
TOTAL COST	= $ 8746
Engineering time for 2, 225 A Panel boards	= 8 MD
Engineering time for 2, 225 A Panel boards	= 6 MD
Engineering time for the surge suppressors	= 8 MD
Drafting time for 2, 225 A Panel boards	= 3 MD
Drafting time for 2, 225 A Panel boards	= 3 MD
Drafting time for the surge suppressors	= 4 MD
Fabrication time	= 6 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.2

WBS NAME	Clean Power

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Cost was estimated by several methods depending on the details. Industry and vendor catalogs, bottom-up, in-house analysis, and engineering judgement were used.
Detailed information is contained in the basis for lower WBS levels.
The estimate of engineering time was covered design documentation, review, coordination, inspection of hardware, and planning. Drafting time was for preparation and drafting Technican time was for fabrication.

WBS #	4.9.2.2.1

WBS NAME	Distribution

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Power is provided by BNL as 3 phase 208 V. This power is routed to the trolley using Busway, and taken to a main distribution panel in the trolley. Trolley power is carried in 6" wireways and distributed to eight rows of eight racks. Each row has a distribution panel with 20 A circuit breakers. A power conditioner is used in each of four rows.
Clean power is also taken to a distribution panel in the Operations room. From there it is routed to a distribution panel with 20 A circuit breakers. The panel feeds a row of ten racks with 208 V and 120 V. This row has a distribution panel that povides power to each rack via breakers that are rated at 20 A.
The calculations for costs are shown in four lower level WBS numbers.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.2.1.1

WBS NAME	Cables and wireways

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are calculated based on linear feet for cables wireways and conduits. and on a per item basis for components and fixtures. The cost for wireways and cables were obtained from cost data catalogs used in industry.

The cost of materials for conduit and cabling is $15,159, and includes 400 A trolley distribution circuits, 20 A distribution circuits in the racks, and fittings for connecting up the trolley power to the Main Busway circuit.

The costs were obtained as follows:

Cost of 700 ft. of 2,# 4 cable and Neutarl @ $ 2.88 per ft.	= $ 2016
Cost of 200 ft. of 6"x6" wireways @ $ 10.38 per ft.	= $ 2076
Cost of 2270 ft. of #12 cable in racks @ $ .53 per ft.	= $ 1199
Cost of 2 Switch board stub @ $1002 each	= $ 2004
Cost of 2 Cable tap boxes @ $ 1600 each	= $ 2004
Cost of 12 ft of 300 MCM copper cable	
and Greenfield @ $252 per ft	= $ 3024
Misc. fittings, and supports	= $ 1000
TOTAL COST	= $ 15, 159

Engineering time for the 400 A distribution circuits	= 13 MD
Engineering time for the 20 A distribution circuits	= 12 MD
Engineering time for the trolley connection circuit to the	= 5 MD
Drafting time for the 400 A distribution circuits	= 6 MD
Drafting time for the 20 A distribution circuits	= 5 MD
Drafting time for the trolley connection circuit to the	= 5 MD
Fabrication time	= 8 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.2.1.2

WBS NAME	Busways

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are calculated based on linear feet for Busways. The cost for busways was obtained from cost data catalogs used in industry.

The cost of materials for is $4,3740

A calculation for the busway is illustrated here:

Cost of 90 feet of 2500 A busway @ $486/linear foot	= $43,740
Engineering time	= 5 MD
Drafting time	= 2 MD
Fabrication time	= 2 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.2.1.3

WBS NAME	Distribution panels

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are estimated based on a per item basis for components and fixtures. The cost was obtained from vendor and cost data catalogs used in industry. A worksheet was prepared and reviewed by Plant Engineering.

The total cost of materials is $19,290. This includes the Main power Panelboards in the trolley, panelboards for distributing power in the rack, and a panelboard for the Operations room.

Cost of 2 Panel boards (1200 A main breaker,	
208 V/120 V, and 4 branch circuits) @ $3600 each	= $ 7,200
Cost of 5 Panel boards (1200 A main breaker,	
208 V/120 V, and 18 branch circuits) @ $2418 each	= $ 12,090
TOTAL COST	= $19,290
Engineering time for 2, 1200 A Panel boards	= 8 MD
Engineering time for 5, 400 A Panel boards	= 8 MD
Drafting time for 2, 1200A Panel boards	= 4 MD
Drafting time for 2, 400 A Panel boards	= 5 MD
Fabrication time	= 6 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.2.1.4

WBS NAME	Power conditioners

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are estimated based on a per item basis. The cost was obtained from vendor quotes and catalogs used in industry. Four conditioners are used in the trolley, and one in the control room.

The cost 5 conditioners @ $ 7200 each is $36,000.

Engineering time for 5 Power conditioners	= 4 MD
Engineering time for 5 Power conditioners	= 2 MD
Fabrication time	= 2 MD

WBS #	4.9.2.3

WBS NAME	Uninterrupted Power

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Cost was estimated by using vendor catalogs and engineering judgement.
Detailed information is contained in the basis for lower WBS levels.
The estimate of engineering time was covered design documentation, review, coordination, inspection of hardware, and planning. Drafting time was for preparation and drafting Technican time was for fabrication.
Detailed information is contained in the basis for lower WBS levels.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. *Vendor*	5. *In-house manufacturing analysis*
2. *Bottoms-up*	6. *Historical information*
3. *Analogy*	7. *Parametrics/factors*
4. *Engineering judgment*	8. *Other (explain below)*

WBS #	4.9.2.3.1

WBS NAME	Distribution

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Uninterrupted power uses a 1 KVA Uninterrupted power system for the Trolley, and a 2.5 KVA system for the Operations room.
The calculations for costs are shown in a lower level WBS number.

WBS #	4.9.2.3.1.1

WBS NAME	Back-up units, fittings

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are estimated based on linear feet for cables, and on a per item basis for components and fixtures.

The total cost of materials is $4000.

Cost of a 1 KVA Uninterrupted Power system	= $ 1000
Cost of a 2.5 KVA Uninterrupted Power system	= $ 2500
Cost of misc. fittings	= $ 500
TOTAL COST	= $ 4000
Engineering time	= 6 MD
Drafting time	= 5 MD
Fabrication time	= zero

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.4

WBS NAME	Emergency Power

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Cost was estimated by using industry catalogs, and engineering judgement. Detailed information is contained in the basis for lower WBS levels.
The estimate of engineering time was covered design documentation, review, coordination, inspection of hardware, and planning. Drafting time was for preparation and drafting Technican time was for fabrication.

WBS #	4.9.2.4.1

WBS NAME	Distribution

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

This power is used for emergency lighting within the detector during assembly and repairs, and for a few miscellaneous areas. The power will be taken on #12 gauge cable to the detector . The calculations for costs are shown in a lower level WBS number.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.4.1.1

WBS NAME	Cables and conduit

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7

BASIS

Costs are estimated based on linear feet for cables, and an allowance is made for msicellaneous fittings and supports.

The total cost of materials is $536.

Engineering time	= 2 MD
Drafting time	= 2 MD
Fab time	= 5 MD

WBS #	4.9.2.7

WBS NAME	Signal Distribution system

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Cost was estimated by several methods depending on the details. Industry and vendor catalogs, bottom-up, in-house analysis, and engineering judgement were used.
The estimate of engineering time was covered design documentation, review, coordination, inspection of hardware, and planning. Drafting time was for preparation and drafting Technican time was for fabrication.
Detailed information is contained in the basis for lower WBS levels.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1

WBS NAME	Distribution

ESTIMATE SOURCE/TYPE (select one or more)	See the lower level WBS

BASIS

Signals are taken from the Detector to the Trolley, from the trolley to the Operations room, and the Detector to the Operations room via the trolley. They are carried on copper and fiber-optic cables, that are contained within wireways. Only the baseline signals and racks are costed.
Racks are provide to house the electronics. These racks are cooled by a Chilled Air system.
The calculations for costs are shown in four lower level WBS numbers.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1.1

WBS NAME	Cable distribution: detector to trolley

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,6,8

BASIS

Costs are estimated based on linear feet for cables, and on a per item basis for components and fixtures.

Cables from the detector are of both Copper and fiber optics.

There are 3100 copper conductors, and 2000 fiber optic cables that need to be carried from the detector and the trolley, for the baseline detector. These cables are carried on wireways that go through the shielding wall to the trolley on the other side. They are carried on eight 12"x12" wireways, which are supported on unistrut hangers.

The total cost of materials is $17020, and is obtained as follows:.

Cost of 450 ft. of 12"x12" wireways @ $ 13.44 per ft.	= $ 6048
Cost of 500 ft. of 6"x6" wireways @ $ 110.38 per ft.	= $ 5190
Cost of 150 Unistrut hangers @ $9.6 each	= $1440
Cost of 25 Unistrut hangers @ $9.6 each	= $1440
Cost of 25 12 " elbows, tees etc. @ $63.30 each	= $ 1590
Cost of 45 6" elbows, tees etc. @ $56.40 each	= $ 2538
Cost of 12 Pull boxes	= $ 214
TOTAL COST	= $ 17020

Engineering time for 12' wireway routing	= 20 MD
Engineering time for 6" wireway routing	= 15 MD
Engineering time for connecting up 6"and 12" wireways	= 15 MD
Drafting time for 12' wireway routing	= 8 MD
Drafting time for 6" wireway routing	= 8 MD
Drafting time for connecting up 6"and 12" wireways	= 15 MD
Fabrication time	= 8 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1.2

WBS NAME	Cable distribution in trolley

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7,8

BASIS

Costs are estimated based on linear feet for cables, and on a per item basis for components and fixtures.

The copper and fiber optic conductors that are carried on 8, 12"x12" wireways to the trolley, are then routed in wireways within the sub-floor of each deck of the trolley, and between floors. The total length of the wireways is 240 ft.

The total cost of materials is $ 4570, and is obtained aas follows:

Cost of 240 feet of 12" wireways in trolley sub-floor @ $ 13.44 per foot = $ 3226

Cost of 100 feet of 12" wireways to the upper floor @ $ 13.44 per foot = $ 1344

TOTAL COST = $ 4570

Engineering time for 12' wireway routing = 9 MD

Drafting time for 12' wireway routing = 4 MD

Fabrication time = 4 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1.3

WBS NAME	Cable distribution: trolley to operations room

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,6,8

BASIS

Costs are estimated based on linear feet for cables, and on a per item basis for components and fixtures.

Copper fiber optic cables are carried on 2, 6"x6" wireways from the trolley to the operations room. These are only for the baseline detector. The cables also carried in a cable carrier made up of links that permit it to be bent in a controlled manner. This wireways would act as a trough to guide and support. The cable carriers allow the cables to stay connected in place when the trolley is moved beween the assembly and experimental hall.

The total cost is $ 3557 and is obtained as follows:

Cost of 150 feet of 6" wireways @ $ 10.38 per foot	= $ 1557
Cost of 40 feet of cable carrier @ $50 per ft	= $ 2000
TOTAL COST	= $ 4557
Engineering time for 6" wireway routing	= 5 MD
Engineering time for cable carrier	= 5 MD
Drafting time for 6" wireway routing	= 2 MD
Drafting time for cable carrier	= 3 MD
Fabrication time	= 7 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1.4

WBS NAME	Cable distribution in operations and control rooms

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7,8

BASIS

Costs are estimated based on linear feet for cables, and on a per item basis for components and fixtures.

The copper and fiber optic cables that are carried to the operations room go to racks and the DAQ computer. These cables include requirements for future upgrades. They are arrive on two 6" x6"wireways. The cables between the multiport tranceivers in the FDDI ring, and the workstations are carried in 6"x6" wireways and routed to the workstations.

The total cost for 350 feet of 6" wireway @ $10.38 per foot = $3633

Engineering time for 6 "wireway routing	= 5 MD
Drafting time for 6' wireway routing	= 2 MD
Drafting time for cable carrier	= 3 MD
Fabrication time	= 7 MD

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.2.7.1.5

WBS NAME	Racks and Chilled Air system

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4,5,7,8

BASIS

Costs are estimated based on a per item basis for components and fixtures. Vendor quotes were obtained for the racks, and engineering judgement for the chilled air system, which is in a conceptual stage of design.

The total cost of materials is $35,480, and is obtained as follows:

Cost of 10 racks @ $2000 each	= $ 20,000
Cost of 10 chilled units @ $ 1500 each	= $ 15,000
Cost of outlet strips	= $ 480
TOTAL COST	= $ 35,480
Engineering time for racks	= 12 MD
Engineering time for Heat Exchanger, & ducts	= 15 MD
Drafting time for racks	= 6 MD
Drafting time for Heat Exchanger, & ducts	= 5 MD

WBS #	4.9.3

WBS NAME	Detector Integrated Safety Systems.

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

The cost of this system is based on a rough engineering judgment. It is based on scaling of other similar systems such as the SDC detector. Future estimate will be based on a bottoms-up approach..

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.4

WBS NAME	Electronics Trolley

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

The conceptual design of the electronics trolley were completed. The Cost is based on bottoms-up approach. Table of material (dimensions and weights) were prepared. Detailed estimate in lower WBS

WBS #	4.9.4.1

WBS NAME	Structure System

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

The conceptual design of the electronics trolley were completed. The Cost is based on bottoms-up approach. Table of material (dimensions and weights) were prepared. Detailed estimate in lower WBS

WBS #	4.9.4.1.1

WBS NAME	Structure Steel

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

50,000 lb at 1.5 $/lb. Prefab steel. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.4.1.2
WBS NAME	Lexan and Windows
ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

1/ thick Lexan 3.75 $/ft2. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.4.1.3
WBS NAME	Doors
ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

2 doors $1,600 each. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.4.1.4
WBS NAME	Internal Stairs
ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

steel prefab. $3,200. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.4.1.4
WBS NAME	External Stairs
ESTIMATE SOURCE/TYPE (select one or more)	2,4

BASIS

Stairs on Casters, steel . $1600 steel prefab. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.4.2
WBS NAME	Hilman Rollers
ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

15,000 tons rollers $300 each, 4 requiredfor the trolley, additional roller for lower shield blocks . The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.4.3
WBS NAME	Electrical and Lights
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Engineering judgment. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.4.4

WBS NAME	Ventilation HVAC

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Engineering judgment. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.4.5

WBS NAME	Fire Protection and Sprinkler System

ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Engineering judgment. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.5

WBS NAME	Access Systems

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

See lower WBS for details

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.5.1

WBS NAME	Detector Access Systems

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

Vendor quotes for Fiberglas scaffolds, fiberglas , $3,700 . The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.5.2

WBS NAME	Task Specific Access Systems

ESTIMATE SOURCE/TYPE (select one or more)	1,2,4

BASIS

Material cost is based on: Conceptual design and engineering judgment of a library type ladder around the return iron to access PMT's. The Labor calculated based on number of drawings (4 days engineering and 4 days draftsman time per drawing)

WBS #	4.9.6

WBS NAME	Area Shop Equipment

ESTIMATE SOURCE/TYPE (select one or more)	2,3,4

BASIS

A list of equipment required for the mechanical and electrical area shops were prepared based on similar shops at LBL. Cost of machines were obtained by analogy with LBL area shop. $2k of stock inventory was -added to each shop.

See lower level for details

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.9.6.1

WBS NAME	Mechanical Shop

ESTIMATE SOURCE/TYPE (select one or more)	2,3,4

BASIS

A list of equipment required for the mechanical area shop were prepared based on similar shops at LBL. Cost of machines were obtained by analogy with LBL area shop. $2k of stock inventory was -added to each shop.

WBS #	4.9.6.2

WBS NAME	Mechanical Shop

ESTIMATE SOURCE/TYPE (select one or more)	2,3,4

BASIS

A list of equipment required for the electrical area shop were prepared based on similar shops at LBL. Cost of machines were obtained by analogy with LBL area shop. $2k of stock inventory was -added to each shop.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.11

WBS NAME	Installation & Test

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

See lower level BOE

WBS #	4.11.1

WBS NAME	Installation

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

This element includes the cost of all labor used in the hall for subsystem assembly and installation, as well as miscellaneous expense items incurred during these activities.

The EDIA (EN, EA, DR & AD) portion of the cost is for a continuation of engineering support, from the institution that provided the original construction support, during the final assembly (if necessary), installation and test phase. In other words, funds for an engineer who was involved in the design and fabrication effort to spend time at BNL during that subsystems installation.

The element includes the cost of day to day installation activity management by the lead installation engineer and installation coordinator.

Implicit in the labor portion of the cost estimate for installation is that a good deal of the signal cable pulling efforts will be done by project physicists, post-docs, grad students, and other "free" labor. All cables carrying relatively hi-voltage or hi-current will be installed by BNL/RHIC electricians, not by physicists.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

The details of the installation technical manpower estimates can be found in the spreadsheet "Install worksheet". This spreadsheet includes a detailed breakdown of the installation tasks (the next level WBS element) by the following labor categories: Rigger, Electrician, Plumber, ME Tech, EL Tech, Alignment, and Laborer. Some of these estimates were made in conjunction with the subsystem lead engineers, some were made using engineering judgment and a vague knowledge of the efforts involved in performing these tasks. The contingency % applied shows which is which.
Engineering and Engineering assistant estimates were made by estimating the duration of the task and allowing for the engineer to be there to set up and stay for a good fraction of the activities. Draftsman estimates were scaled from the Engr'g effort; typically 10% of EN effort. These efforts are added to support the engineer in making last minute revisions to drawings and documentation, to correct interface problems with supports or utility connections. The effort to make "as built" corrections to drawings after the element installation is complete is in the subsystem cost estimates.

WBS #	4.11.2

WBS NAME	Test

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

The details of the test support technical manpower estimates can be found in the spreadsheet "Install worksheet". This spreadsheet includes a breakdown of the testing tasks by the following labor categories: Rigger, Electrician, Plumber, ME Tech, EL Tech, Alignment, and Laborer. Some of these estimates were made in conjunction with the subsystem lead engineers, some were made using engineering judgment and a vague knowledge of the efforts involved in performing these tasks. The contingency % applied shows which is which.
Engineering and Engr'g. Assist. estimates were made by estimating the duration of the task to be performed and the QA documentation or test reports required at completion of the tests. Draftsman estimates were scaled from the Engr'g effort; typically 10% of EN effort. These efforts are added to support the engineer in making last minute revisions to documentation, to aid in the performance of tests and to document test results.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.11.3

WBS NAME	General Purpose Installation & Test Equipment

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

This element includes the cost of specifying or designing and fabricating or procuring commonly used equipment associated with installation & test.
The element includes the cost of procuring or renting general purpose installation hardware such as:

- man-lifts
- fork trucks
- "coat hangers" and spreader bars
- standard rigging hardware (hoist rings, cables and slings)
- hand tools
- cribbing blocks

The element includes general purpose test equipment such as:

- volt-amp meters
- test power supplies
- test cables
- temporary use data loggers

This element does not include special lifting and handling devices, and insertion hardware which is specific to a single subsystem such as the TPC installation fixturing (beam or beams). It also does not include special test equipment and devices which are specific to a single subsystem such as the solenoid field mapping equipment.
This is an engineering estimate of the engineering, design and tech effort to research requirements, design, build or procure this hardware. Estimates for manlifts and forklifts were gotten from catalogs on such equipment and were included as the following:

Man-lift, fiberglass - $11K
Fork-lift truck - $35K
1 large and 1 small "coat-hanger" - $40K
Supply of standard rigging hardware - $15K
Cribbing materials, jacks and chains - $5K
Hand and power tools - $4K
Electronic test equipment - $10K
Lease of a truck for the 3 year duration - $10K
Misc. equipment - $20K TOTAL - $150K

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.11.4

WBS NAME	Installation & Test Activities Management

ESTIMATE SOURCE/TYPE (select one or more)	

BASIS

This element includes the cost of coordination and management of the day to day installation activities. Included is the cost of an on-site installation manager or coordinator and some clerical support. This person will coordinate the daily activities of all personnel in the assembly and interaction halls and the operations building, insuring that work runs smoothly, that when special support equipment or people are needed they are there, and that the overall installation plan is being implemented in a timely way.

Installation Manager - 0.85 FTE for the duration: 2 yrs, 8 mo. - 597 m-days
Admin. Support at ~20% - 100 m-days

Material estimate is for the procurement of a computer and software, and for setting up the installation mgm't office at the beginning of the task.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.12

WBS NAME	Project Management

ESTIMATE SOURCE/TYPE (select one or more)	See lower level WBS elements

WBS #	4.12.1

WBS NAME	Planning

ESTIMATE SOURCE/TYPE (select one or more)	2 , 6 & 8

BASIS

Recent related experience on other large experiments such as SDC and D-Zero.

Materials -

$12K in FY '93: Computer and software for planning and tracking activities plus additional expenses related to setting up the STAR project office.

$60K in FY '95-'97: Off-site relocation and living expenses for the Proj. Manager. It is planned that the PM will relocate to BNL for the approximately 3 years of installation activities. This estimate is based on information received from LBL travel personnel.

Labor estimate -

1 EN, 0.5 EA and 0.5 AD, FY '93: This is to cover the cost of the Project Manager, 50% the cost of the Project Administrator (PA), and 50% of a secretary to support the PM and Project Director. The first year of the project is the time that most of the development of schedules, cost estimates, report formats, etc. takes place and therefore a good portion of the PA is costed here. In out years, the PA shows up more significantly in tracking and in TPC planning and tracking.

1 EN, 0.2 EA and 0.5 AD, FY '94-'97: This is to cover the cost of the Project Manager, 20% the cost of the Project Administrator (PA), and 50% of a secretary to support the PM and Project Director. After the initial development of schedules, cost estimates, report formats, etc. takes place , this effort is seen more as maintenance and reporting and therefore requiring less of the PA. As

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

discussed above, in the 3 years planned for STAR installation at BNL, the PM will relocate to help plan and trouble shoot the installation process.

WBS #	4.12.2

WBS NAME	Tracking

ESTIMATE SOURCE/TYPE (select one or more)	2 & 6

BASIS

Engineering judgment based on past similar experience with large DOE/DOD programs.

Materials -

$6K in FY '93: Additional expenses related to setting up the STAR project office.

Labor estimate -

0.5 EA and 0.5 AD, FY '93: This is to cover 50% the cost of the Project Administrator (PA), and 50% of a secretary to support the PM and Project Director. The first year of the project is the time that most of the development of tracking procedures and report formats takes place.

0.5 EA and 0.5 AD, FY '94-'97: This is to cover 50% the cost of the Project Administrator (PA), and 50% of a secretary to support the PM and Project Director. After the initial development of tracking procedures and report formats takes place, this effort is seen more as maintenance and reporting.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.12.3

WBS NAME	Document Control

ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

Recent related experience on other large experiments such as SDC and D-Zero.

Materials -

$7K in FY '93 for a computer and software (filemaker, Word, etc.) to store and retrieve STAR Project notes and documents. Not for storage of STAR CAD drawings - bit probably for storage of the drawing list (no's., titles, etc.).Labor estimate -

50% time secretary to set up and maintain the document files at BNL. This is supplemented at LBL by 2 other secretaries working part time on Doc. Control. All STAR documents will be kept at 2 locations minimum (in some cases 3).

In FY '97, this secretary will be at full time to supervise the transfer of all original files to BNL (ie, the originals will no longer be kept at LBL).

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.12.4
WBS NAME	Quality Assurance (QA) Program
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Given the current environment, its state of flux, and the fact that if QA is going to be effective it needs to be well integrated from the very beginning of a project, we are planning to bring a BNL QA engineer onto the project as soon as possible.

Materials -

$6K in FY '93 for a workstation/computer and software.

Labor estimate -

0.5 FTE Eng'r for the duration, 0.1 FTE Admin. support: The 50 % time QA engineer will help us develop a QA plan with RHIC. This person will be responsible for training the relevant subsystem people to write plans and reports. This person will get actively involved in planning and reviewing both system and subsystem level QA documents and reviews. It is hoped that the other 1/2 of this person would either serve the same purpose in the Phoenix organization or fill the other 1/2 time role in EH&S below.

WBS #	4.12.5
WBS NAME	Environmental Health and Safety
ESTIMATE SOURCE/TYPE (select one or more)	4

BASIS

Given the current environment, its state of flux, and the fact that if EH&S requirements are going to be applied effectively they need to be well integrated from the very beginning of a project, we are planning to bring a BNL EH&S engineer onto the project as soon as possible.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

Materials -

$6K in FY '93 for a workstation/computer and software.

Labor estimate -

0.5 FTE Eng'r for the duration, 0.1 FTE Admin. support: The 50 % time EH&S engineer will help us develop a EH&S plan (Safety Analysis Reports, etc.) with RHIC. This person will be responsible for training the relevant subsystem people to write plans and reports. This person will get actively involved in planning and reviewing both system and subsystem level Safety documents and reviews. It is hoped that the other 1/2 of this person would either serve the same purpose in the Phoenix organization or fill the other 1/2 time role in QA above.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.13

WBS NAME	Systems Integration

ESTIMATE SOURCE/TYPE (select one or more)	See lower level BOE.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.13.1
WBS NAME	Mechanical Integration
ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

Recent related experience on other large experiments such as SDC and D-Zero.

Materials estimate -

$15K in first year for purchase of a 3-d CAD workstation and HP-ME30 software.

$20K in years 3,4,5 for additional travel related expenses. It is expected that the individual will need to spend a couple of weeks several times during each of the 3 years of installation at BNL aiding in the planning and management of installation activities.

Labor estimate -

2 FTE Engineers in '93: Recent related experience (STAR FY '92). There is an extensive list of tasks that must be completed in '93; they include documenting facilities and utility requirements for the Title1/2 design activities by BNL Plant Engr'g, developing and documenting a complete picture of the detector (incl. space for cables and utilities, structural support, assembly access, etc.) so that subsystems can begin preliminary and detail design activities, and beginning the conceptual design and cost estimates and schedule planning for the Conventional Systems (WBS 4.9) hardware.

1FTE Engineer in '94 & '95: It is expected that mechanical integration activities will taper off somewhat in out years. As the detector overall design becomes firm - which it must if detailed design activities on subsystems is to begin on schedule, the mechanical integration activities will become more maintenance and documentation upkeep related. This activity from here on is planned as level of effort.

0.5 FTE in '96 & '97: As detector installation activities proceed and installation management personnel become more familiar with the detector design, the need for support from integration personnel will decrease. The 1/2 time support is seen as necessary to answer questions, help in installation planning activities, put out fires, etc.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.13.2

WBS NAME	Electrical Integration

ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

Part-time level of effort task. Engineering judgment based on recent similar experience on SDC and D-Zero.

Materials estimate -

$6K in first year for purchase of a workstation and software.

$20K in years 3,4,5 for additional travel related expenses. It is expected that the individual will need to spend a couple of weeks several times during each of the 3 years of installation at BNL aiding in the planning and management of installation activities.

Labor estimate -

0.75 FTE Engineer in '93: Full time Eng'r for the first 6 mo. and 0.5 time for the last 6. There is a fairly extensive list of tasks that must be completed in '93; they include documenting facilities and utility requirements for the Title1/2 design activities by BNL Plant Engr'g, developing and documenting a complete list of the detector cable cross section and routing, and beginning the conceptual design and cost estimates and schedule planning for the Conventional Systems (WBS 4.9) hardware (e.g., help plan the layout of the electronics trolley).

0.5 FTE Engineer in '94 & '95: It is expected that electrical integration activities will taper off somewhat in out years. As the detector overall design becomes firm - which it must if detailed design activities on subsystems is to begin on schedule, the electrical integration activities will become more maintenance and documentation upkeep related. This activity from here on is planned as level of effort.

0.5 FTE in '96 & '97: As detector installation activities proceed and installation management personnel become more familiar with the detector design, the need for support from integration personnel will decrease. The 1/2 time support is seen as necessary to answer questions, help in installation planning activities, put out fires, etc.

LEGEND FOR ESTIMATE SOURCE/TYPE:

1. Vendor	*5. In-house manufacturing analysis*
2. Bottoms-up	*6. Historical information*
3. Analogy	*7. Parametrics/factors*
4. Engineering judgment	*8. Other (explain below)*

WBS #	4.13.3

WBS NAME	Facilities Integration

ESTIMATE SOURCE/TYPE (select one or more)	4 & 6

BASIS

Part-time level of effort task. Engineering judgment scaled from recent similar experience on SDC.

Materials estimate -

$7K in first year for purchase of a CAD workstation and software.

Labor estimate -

0.5 FTE Engineer in '93: This is planned to be a BNL engineer, who can work closely with BNL Plant Engineering, and RHIC detector engineering management. The list of tasks that must be completed in '93 include helping to document, transfer and explain facilities and utility requirements for the Title1/2 design activities by BNL Plant Engr'g, and beginning to understand the requirements of the Conventional Systems (WBS 4.9) hardware so that in future years BNL engineering personnel can perform detail design and procure this equipment.

0.5 FTE Engineer in '94 & '95: It is expected that this effort will be a continuation of working closely with BNL Plant Engineering to oversee the completion of Title 2 design, bid, and construction activities. There may also be a component of organizing and managing Conventional Systems (4.9) hardware design and procurement. This activity from here on is planned as level of effort.

0.5 FTE in '96 & '97: This effort is expected to be related to planning of installation activities for Conventional Systems (4.9) hardware. The 1/2 time support is also seen as necessary to answer general questions and to put out fires.