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Mechanical Integration Plan for the Baseline STAR Detector

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Introduction

This document (STAR Note 0076) describes the integration plan for the STAR preliminary design phase. Listed are a set of tasks and associated reports and drawings which will be produced by the integration group for STAR; they will form the basis of the System Integration Review (SIR).

Chapters 5 and 6 of the STAR Conceptual Design Report (CDR), published July 1992, contain the latest mechanical integration information. The efforts outlined in this plan utilize the STAR-CDR as a starting point and will address the outstanding mechanical integration issues to arrive at a more refined and detailed baseline detector design. This note outlines a methodology and schedule to complete these tasks.

The conventional facilities/utilities requirements will be listed in a Preliminary Resource Requirement Report (RRR) to be issued prior to the STAR Facilities Title 1 start date. This report will describe new building requirements, and the facilities/utilities upgrades needed. The final RRR will be issued prior to the Title 2 start date.

List of Integration Tasks

1. Resolving current Integration Issues

The primary task of the integration group is to find and facilitate the resolution of technical conflicts and issues that impede the progress of the design. The group will maintain close contact with associated subsystem groups and work with them to resolve outstanding issues. The integration group may require specific analyses to be performed in a timely manner by the subsystem groups in order to resolve issues. The integration group will make recommendations to the Technical Director as to where difficult decisions must be made to resolve conflicts between subsystems. The major outstanding technical issues are discussed in the following sections of this note.

1.1 Return Iron and Support Structure Design (RISS)

The design of this subsystem is a critical path item for STAR. The integration and conventional facilities needs are highly dependent on the design of these subsystems. The integration group will work closely with the magnet return iron design group at BNL to formulate a design for these subsystems.

Present RISS conceptual design assumes that a 60,000 sq cm cross-sectional area normal to flux lines is needed for proper flux return. This area is divided into 60 barrel return iron segments (BRI), each of which is 25 cm by 40 cm in cross section. Each segment serves as a strong back for a complete group of EMC segments (at constant phi), which together form a single BRI/EMC module. The advantage of this design is that the total weight of each BRI/EMC module is about 10 tons which is fairly manageable during handling and assembly. The conceptual design also allows individual change out of BRI/EMC modules.

Detailed stress analysis of the RISS has not yet been completed. The return iron segments are bolted tightly to the end iron rings forming a solid structure; however it is not clear at this point whether additional stabilization of the resulting structure will be required. Asymmetric forces transverse to the beamline due to alignment or from rolling along the floor rails may not be adequately sustained by the bolted-up structure. These loads must be estimated conservatively, and the structure analyzed to determine whether additional stabilization is needed. The conceptual design shows two large longitudinal beams connecting the detector support cradles together for lateral stability. It is not clear whether these beams are needed or whether there are better, cheaper solutions.

Preliminary stress analysis shows that simply supported BRI/EMC modules at the 3 and 6 o'clock positions will have approximately 0.180 inch deflection in the vertical direction at midpoint. This deflection is of concern to the EMC group as there is little clearance between EMC segments in the phi direction. As such, the danger of crushed fibers occurring during assembly must be addressed. New design concepts to reduce the deflection will be considered, i.e., new return iron cross section configurations, or perhaps tie plates can be used to hold all the return iron segments together at various points along their length. These tie-plates may also act as lateral stabilizers.

The following list contains information required to complete a preliminary design integration of the RISS system:

1) A choice of conventional or superconducting magnet technology needs to be made promptly. A basic design concept for the RISS for a conventional conducting coil does not exist at this time, only a conceptual cross-section for the detector. This cross-section shows that there is (barely) sufficient room to allow the detector to be moved into the hall; preliminary magnet and RISS design is necessary to verify that this detector will fit through the door to the Wide Angle Hall. Additional modifications to the currently proposed assembly hall may be necessary to accommodate a conventional coil design, due to the coil weight of approximately 80 tons. It should be noted that a conventional magnet choice will

have major impact on the integration efforts; cabling plan, assembly procedures as well as utility and conventional facilities upgrade requirements will need to be redefined. The integration plan schedule attached to this document is based on the assumption that the present baseline detector has a superconducting coil. A revised schedule will be issued if a decision is made to go with a conventional coil or if there are any other major subsystem design changes.

Once a magnet technology choice has been made, the following magnet design data is required:

- coil dimensions including all correction coils and tolerances for fabrication, installation, alignment, cooldown, and operation
- flux return and poletip shape requirements
- coil mount design
- coil lifting and installation method
- magnetic force distribution
- field mapping integration requirements estimated weight
- utilities needs.

2) The RISS design is heavily dependent on the final design configuration of the EM calorimeter. Data required from the EMC group is:

- number of EMC segments and dimensions
- alignment tolerances, and procedures
- service plan
- upgrade plan, including endcap EM
- assembly plan and schedule (for both individual modules and entire EMC).

Discussion with the EMC group to address these concerns has begun. Upon receiving the EMC and coil design data, RISS design concepts will be developed by BNL with the aid of the integration group. Once the design concepts are approved by STAR, the RISS detailed engineering design tasks will begin. The integration group will monitor the ongoing progress of the design to insure that RISS design efforts are properly addressing the subsystem needs, and the assembly/service and conventional facilities requirements of STAR.

1.2 TPC/EMC Coverage Problem

Preliminary radiation length ray trace analysis indicates that the end flanges of the TPC outer field cage and pad plane support wheel obscure the EMC segments from | eta | = 0.9-1.05. The EMC group is aware of this and must decide whether this is acceptable, and if not, how much radiation length is allowable. The TPC group is considering alternate designs to reduce this problem. The coil and its cryostat are designed to have a low radiation length up to | eta | = 1.037 or better. If the mass in front of the EMC mass is unacceptable beyond | eta | = 0.9, then cost reductions in the coil and steel may be possible through design optimization. The integration group will facilitate discussion between these groups (CTB/TOF may also be involved) and help set a timetable for resolution of this problem.

1.3 Subsystem Supports

The integration group will coordinate the designs of subsystems supports to insure that the detector can be assembled and serviced according to a prescribed plan. Special attention should be given to make certain that subsystem design includes the effects of loading from other subsystems. Presently, the following support concepts are being considered: The magnet conceptual design calls for 12-point radial and axial support for each end of the magnet cryostat. The support points are located on the end return iron rings.

The TPC/CTB/TOF/SVT subassembly is supported at two points on each end by the cryostat flange; the mounts are offset to allow removal of CTB/TOF modules from at least one end. The magnet cryostat must be properly designed to account for the localized load from this subassembly.

The SVT is supported by composite cones which, in turn, are supported on the inner flange of the pad plane support wheel.

1.4 Uniform Temperature Around the TPC

The TPC has extremely tight temperature control requirements for all of its vessel walls. The TOF upgrade requires electronics and PMTs to be mounted directly on the outer field cage of the TPC. The integration group will insure that TOF cooling is compatible with the TPC temperature control requirements.

2. <u>Dimension Control Plan for Subsystems</u>

The aim of this effort is to show that the detector can easily be assembled, aligned and operated without interferences. The integration group will define a detector configuration which will facilitate proper subsystem design. Maximum dimensions for subsystems, their support structures and utility interfaces will be dearly

defined and documented in engineering drawings and notes. Once these dimensions and drawings are incorporated into the baseline design, any changes will need to be submitted for approval to the STAR Change Control Board (CCB).
Each subsystem will be responsible for producing a report which addresses the issues related to subsystem dimensions control. These issues will include: space needed for electronics, cabling and piping, nominal dimension tolerances, out-of-roundness due to deflection, manufacturing tolerances, deflections due to subsystem mounting, assembly stack-up tolerances, required assembly clearances, thermal expansion/contraction, etc.

3. Cabling and Piping Plan

This effort will be directed toward developing a detailed cabling layout beginning with detector subsystems and ending with data acquisition and computing. All cables and pipes will be inventoried and listed at various stages along the path and submitted for review. The integration group will gather the necessary information from the Electronics Integration Group Leader to determine overall detector system needs. Appropriate contingency space will be determined to allow for design uncertainties. Assembly drawings, both 2-D and 3-D, will show the routing. Conceptual design of cable trays and other cabling equipment will be performed by the integration group as necessary, to facilitate the preliminary and final design which will be performed by the STAR conventional systems design group.

Signal cables and utility lines to and from the SVT, TPC, CTB/TOF penetrate the detector at each end, between the poletip and end return iron ring. Cryogenic feedthroughs, signal cables, and utility lines to and from the solenoid and EMC penetrate the barrel return iron between segments, with some segments being cut away where necessary. Space allocated for cable routings should not interfere with the space required to retract the magnet pole tips when servicing the detector and should not occupy space allocated for a possible EMC/endcap upgrade. Serviceability of some EMC barrel modules may be affected by solenoid cryogenic pipes and feedthroughs.

At present, preliminary cable and utility line sizes and numbers have been provided to the integration group by subsystem group leaders. STAR integration drawings in the CDR show the present routing schemes. The next step is to accurately define the cable routing both inside and outside the detector through additional design iteration. To be able to complete this task, the following data will be gathered from subsystem group leaders.

TPC

- Electronics card and utility manifold layouts:
  At the present time, it is assumed that the interface between the manifolds and cabling trays extend 18 inches outward from the pad planes. More detailed dimensions are required to be able to do a more realistic routing layout, namely:

- update the number, size, and type of cables and cooling pipes

- show a layout of the cooling system

- provide TPC gas flow circuit diagram.

SVT

Location and size of SVT electronics has not yet been well defined. Presently it is assumed that the SVT front end electronics will be located on a tube extending from the support cone. These electronics may obscure the XTPC upgrade detectors and needs to be further investigated. Cable routing will be designed to insure minimum interference with the TPC. The SVT group should provide the following data:

- update the number, size, and type of cables and cooling pipes

- show a layout of the cooling system

- provide inert gas requirement.

CTB/TOF

The trigger system will be designed to easily accommodate future upgrades. Phase 1 trigger detectors consist of the Central Trigger Barrel (CTB), Vertex Position Detectors (VPD), Multi-Wire Proportional Chambers (MWPC) and Veto Calorimeters (VC). The CDR does not contain trigger mechanical design parameters. The system that has the most significant impact on the integration effort is the CTB which is an array of 200 scintillator slats mounted on the TPC outer barrel, with a total of 200 PMT's at each end. The integration effort will provide adequate and accessible space for the PMT's without interfering with the TPC supports. The TOF, which will replace the CTB in a future upgrade, could have as many as 7776 PMT's located on the barrel. Fiber optic cables will run from the PMT's to the electronics racks outside the detector through slotted passageways in the end return iron ring. Modified chilled water (MCW) for PMT electronics will be necessary. The following data is required from the trigger group:

- layout of the CTB design concept
- layout of the CTB PMT's (size, orientation, shielding and cooling requirements)
- layout of the VPD system
- layout of TOF upgrade cooling manifold
- service and upgrade schedule and plan.

Superconducting Magnet

Presently, it is assumed that the superconducting magnet has the following services:

two 4-inch refrigeration ports
two 2-inch main magnet leads
one 3-inch correction coil lead
one 4-inch vacuum port
six 1-inch instrumentation ports.

All magnet service lines will be located on the top of the cryostat at one end only. The cables and pipes will be routed through slotted holes located at the ends of the EMC and return iron. As the design of the magnet cooling scheme evolves, the routing requirements may be changed. The magnet helium supply source can either be RHIC's helium distribution system or a local 300 watt refrigeration plant. A detailed cryogenic pipe routing plan from the control dewar and beyond will be completed by the integration group when the magnet group defines the helium supply source.

EMC

The EMC cabling requirement does not present major difficulties at this time. Future upgrade plans call for connecting the shower max optical fibers to (new) shower-max PMT's outside of the return iron. The fibers will be routed from both ends of the wedges through the gaps between the return iron segments. The data required from the EMC design group is listed in section 1.1.

4. Assembly and Service Plan

This effort will be directed toward describing, in more detail, the assembly process and various servicing scenarios. Information about required time, manpower, space and fixtures will be integrated into the sequence. Conceptual assembly and service scenarios were presented in the CDR. The integration group will produce both 2-D and 3-D CAD drawings of detailed assembly and service scenarios to be included in the SIR. During the installation phase, it is expected that the integration group will spend extended periods of time at BNL working closely with installation personnel to insure that the detector assembly operations proceed as planned.

The integration group will coordinate each subsystem group's efforts in designing special assembly/disassembly fixtures and beams to insure proper system integration and installation.

5. Detector-Specific Utilities Requirements

The mechanical integration group will coordinate with the electronics group to publish a detector Resource Requirements Report (RRR) in time for initiation of Title 1 activities for the facilities. The RRR will include detector-specific electric power and cooling requirements. This document will be updated and published as the Baseline STAR RRR prior to initiation of Title 2 activities. Later modification will be controlled by the STAR Change Control Board.

Subsystem cooling needs are calculated based on the number of channels, the estimated power per channel and power supply efficiencies. The CDR contains a table detailing STAR cooling requirements. This data is based on an estimated power dissipation on the front end electronics chip of 0.10 watt per channel. Electronics R&D effort may reduce the power requirement by a factor of two, which will significantly reduce the cooling requirement.

The primary sources of the heat load in the interior of the detector are the SVT and TPC electronics and the trigger barrel photo-multiplier tubes. Modified chilled water (MCW) cooling circuits will be designed to remove this heat load and greatly reduce any heat rejection to the interior of the detector. Other detector-specific utilities may include:

- dry conditioned air (or N_2 gas) to maintain uniform temperature inside the interior of the detector and to prevent condensation of water on the electronics heat exchangers or around high voltage lines

- industrial water to cool the helium compressor

- low conductivity water (LCW) for power supplies (at the moment, no LCW is required because power supplies are cooled by either air or MCW; a conventional solenoid coil would use LCW for cooling)

- special gases (TPC gas distribution system will be provided by the TPC group).

The MCW system will have its own circulation equipment to control both pressure and temperature. The MCW will be delivered to subsystem distribution manifolds located on the detector, the electronics trailer and the DAQ/computer room. The integration group will be responsible for estimating the cooling load and layout of the MCW circulation system up to the subsystems distribution manifolds. The detailed design of the chilled water (CHW) system will be the responsibility of RHIC Conventional Systems design group. STAR subsystem engineers will be responsible for designing their individual heat exchangers and supply and return manifolds, e.g., the TPC group will design the cooling circuits for the electronics and the outer field cage including the manifold system. The location of individual manifolds will be integrated into the cable routings layout scheme to insure that access to other subsystems will not be adversely impacted. The detector HVAC system will serve several functions:

- to eliminate (or reduce) temperature gradient and fluctuation inside the detector

- to insure that the humidity level is low enough to avoid water condensation on electronics heat exchangers

- to create a low-oxygen environment (if prescribed by the STAR safety coordinator) for fire protection.

Detailed determination of the HVAC flow rate and distribution system has not yet been completed. The HVAC flow rate must satisfy both safety and any cooling requirements not covered by water cooling. It is assumed that safety requirements are met by providing 8 changes per hour, or 150 CFM for the detector interior space. HVAC, however, has limited capacity for heat removal. If we assume 90% subsystem MCW heat exchanger effectiveness, the heat load rejected to the interior space of the detector will be approximately 6 kwh. At a temperature difference (between the inlet and outlet plenums) of 2.5°F, the flow rate required is 7,500 CFM. This is much too high, due to flow-induced vibration and high pressure differentials. Therefore, it is essential to insure the MCW subsystem cooling is capable of removing close to 100% of the heat generated.

The integration group will coordinate the effort between the magnet group and RHIC's cryogenic group to provide cryogens to the STAR superconducting magnet. There are several design concepts by which helium from RHIC's facilities can be delivered to the detector. The integration group will help insure that STAR cryogenic needs are satisfied during the testing and operations phases. A joint STAR/RHIC report describing the proposed cryogenic system design and interface will be included in the SIR.

6. <u>Conventional Facilities Requirements</u>

At the present time, the integration group provides the interface with BNL's conventional systems design group and will help formulate STAR's conventional facilities requirements. These requirements will be listed in the RRR and will include the following items, 6.1 - 6.5.

6.1 Wide Angle Hall Upgrade

The integration group will specify modifications to the existing hall which are required for assembling, operating and servicing the detector. BNL will be provided with information on weight, load distribution, and roller track layout. Utilities such as HVAC, electric power and crane capacity will also be specified.

6.2 Assembly Building

An assembly building adjacent to the Wide Angle hall is being proposed for construction, to accommodate the assembly and testing of the STAR detector. The size of this assembly building should be suitable for assembling and testing the detector, and for housing small local shops and a clean room. Based on the preliminary assembly scenario and the size of the detector and its electronics trailer, an assembly hall 120 feet long by 60 feet wide is proposed. The assembly building will have temperature and humidity control equipment, and two complete bridge cranes sharing a set of rails.

6.3 Electronics/Operation Building

The electronics/operation building floor space requirement and layout will be specified by STAR deputy spokesman, Tim Hallman. The integration group will specify the building utility needs and cable routing preliminary layout.

6.4 Electronics Racks Moving Platform

Racks for subsystem power supplies and some electronics will be located on a platform that is transported on rollers with the detector between the assembly building and the Wide Angle Hall. The platform will be designed to house the racks, utility (electric power and coolants) distribution manifolds, cable trays and diagnostic equipment. At least 3 feet of unoccupied space between racks will be required for assembly and repair. It may be necessary to build a plastic enclosure around the platform to keep dirt away from the racks.

A removable shielding wall of heavy concrete, 4-feet wide, will be erected between the detector and the platform. The bottom part (close to the floor) of the shielding wall will have non-projective passageways to route cables and pipes; it may be constructed as part of the platform to facilitate movement in and out of the hall. The platform height is limited by the door opening between the assembly building and the Wide Angle Hall.

The CDR shows a conceptual layout of the platform. The present platform design can house approximately thirty racks on 2 decks. Final platform design specification will be based on the actual number of racks that must be housed near the detector.

The final design details, based on specifications from the integration group, will be performed by the BNL group responsible for the return iron and structure support systems design or the conventional system design group. Facilities upgrade required to accommodate the electronics platform will be included in the RRR.

6.5 RHIC/STAR Interface

The integration group will work closely with BNL/RHIC engineering to identify and specify accelerator/detector system interfaces. Technical issues to be resolved include:

- configuration of beampipe and its supports
- configuration of accelerator vacuum system
- cryogenic system interface
- conventional facilities interface
- safety system interface
- accelerator/detector operating procedures
- design of radiation shields and interlocks.

7. Safety Review

The integration group will work together with the STAR safety coordinator and each of the subsystem groups to insure that each subsystem, and the detector as a whole, undergo thorough safety analysis; that all safety issues are addressed; and that the STAR detector passes all DOE/ RHIC safety reviews. A member of the integration group will be on the internal STAR Safety Committee.

8. Schedule and Milestones

The schedule for completing the integration tasks is attached to this document. As previously discussed, it is based on the assumption that the present baseline detector contains a superconducting coil. If a decision is made to use a conventional "warm" coil or if a subsystem undergoes major design changes that may significantly impact the integration effort, the schedule will be revised accordingly and reissued. The following is a list of major integration milestones and due dates:

Milestone	Due Date
Subsystem group leaders review and update Parameters Notebook and the worksheets	8/20/92
Integration group set updated baseline mechanical parameters for the detector	10/12/92
Integration group publish STAR Final Parameters Notebook	1/13/93
Integration group publish Facilities Requirement Draft Report (RRR)	1/14/93
BNL publish document for Title 1 activities	2/1/93
Integration group publish System Integration Preliminary Report (SIR)	3/3/93
Integration group publish Final RRR	6/1/93
BNL publish document for Title 2 activities	6/1/93
Integration group publish Final SIR	6/30/93
BNL publish Return Iron and Support System Design Report	6/30/93

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