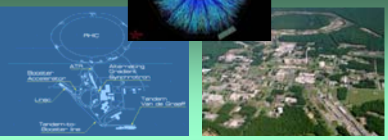
The Electromagnetic Calorimeters at STAR

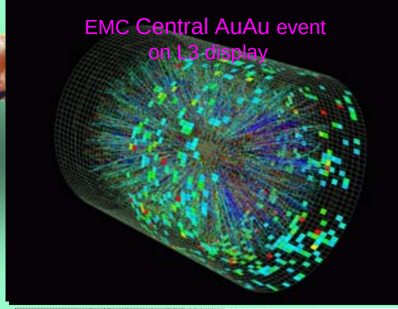
STAR detector is located at RHIC (Brookhaven National Laboratory, USA)

polarized pp collisions

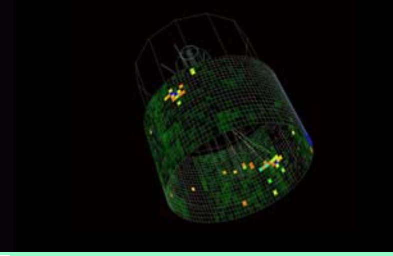
AuAu collisions @ 200 GeV/NN



EMC Central AuAu event on L3 display



EMC DiJet event in dAu



STAR Collaborators/Institutions

Brazil: Universidade de São Paulo

China: IHEP - Beijing, IPP - Wuhan

England: University of Birmingham

France: Institut de Recherches Subatomiques Strasbourg, SUBATECH - Nantes

Germany: Max Planck Institute Munich, University of Frankfurt

India: Institute of Physics - Bhubaneswar, VECC Calcutta, Panjab University - Chandigrarh, University of Rajasthan - Jaipur, Jammu University, IIT -Bombay

Poland: Warsaw University, Warsaw University of Technology

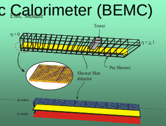
Russia: MEPHI – Moscow, LPP/LHE JINR – Dubna, IHEP - Protvinoh

U.S. Labs: Argonne, Berkeley, and Brookhaven National Laboratories

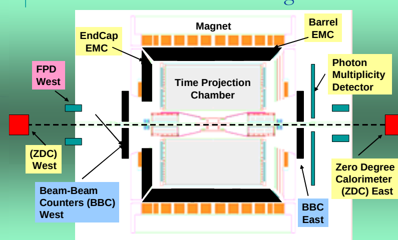
U.S. Universities: Arkansas, UC Berkeley, UC Davis, UCLA, Carnegie Mellon, Creighton, Indiana, Kent State, Michigan State University, CCNY, Ohio State, Penn State, Purdue, Rice, Texas A&M, UT Austin, Washington, Wayne State, Yale

The Barrel Electromagnetic Calorimeter (BEMC)

- Overview
  - $-1.0 < \eta < 1.0$
  - Full azimutal coverage
  - 4800 towers and 36 k SMD strips
  - Radius ~ 2.3 m
  - 120 modules
    - $(\Delta\eta, \Delta\phi)_{module}$ ~ (1.0, 0.1)
    - 40 towers/module
      - Lead/scintilator sample calorimeter
      - 21 X_0
      - $(\Delta\eta, \Delta\phi)_{tower}$ ~ (0.05, 0.05)
      - dE/E ~ 14%/√E
    - Shower max detector
      - Positioned at ~ 5 X_0
      - Better spatial resolution
      - $(\Delta\eta, \Delta\phi)$ ~ (0.007, 0.007)
    - Pre-shower detector
      - First two layers of scintilator
      - 2 X_0.



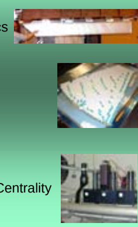
STAR Detector: 2005 Configuration



Stephen Trentalange UCLA DIS04

Calorimeters

- Barrel Electromagnetic
- Heavy ION and pp Spin Physics
  - 0.001 < occupancy < 0.03 for d-Au
  - 0.00015 < occupancy< 0.01 for p-p
- EndCap Electromagnetic
- Primarily pp Spin Physics
- FPD Electromagnetic
- pp Spin Physics
- ZDC Neutrons
- Primarily Heavy Ion Trigger / Centrality



Endcap Calorimeter

- 12 PMTs per box, one 68 sector of towers
- PMT housings built in Dubna
- CW bases from Dubna
- Box structure Texas A&M
- MAPMT testing and LEDs at KSU
- Assembly of PMT boxes to Valpo. U.
- All 720 channels installed
- ~97% fully functional

PMT Boxes

Box lifter for installation and repair

(MA)PMT boxes and electronics on back of poletip

MAPMT Boxes

Internal Fiber Harness

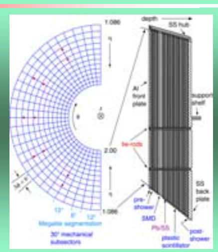
PMT Box

MAPMT, CW base and 16 ch. FEE

- SMD and pre/post-shower
- 12 MAPMTs (16 ch) per box
- 192 ch. FEE internal to box
- 4 Sectors - ~3000 ch. inst.
- 99.5% working

The Endcap Electromagnetic Calorimeter (EEMC)

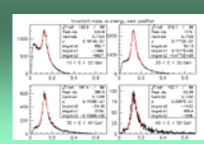
- 2 half annuli - 1 < η < 2
- Stainless steel structure
- Radiators
  - 23 layers
  - Pb/SS lamination
  - 21 radiation lengths
- 720 projective towers
  - 24 layers
  - 68 and 128 megatiles
  - Essentially 100% coverage
- Depth segmentation
  - 2 preshower layers
  - High position resol. SMD
  - Postshower (24th layer)
- Will provide high-pt level 0 trigger similar to the barrel



Alexandre A. P. Suaide, University of São Paulo - Brazil   FEMC03 - march 2003

EEMC Shower Max Detector

- EEMC Features Modular, Gapless, Fast Plastic Scintillator Shower-Max Detector
  - Extruded strips of triangular cross section improve shower profile stability (hence, γ/π0 discrimination), plus position resolution for MIP's
  - Two ⊥ planes per 30° sector, one overlaps adjacent sector
    - continuous φ coverage in 36 mm total depth
  - Readout via axial WLS fibers and multi-anode PMT's
    - 4-8 pe/MIP traveling through apex-to-base height
- Located 5 radiation lengths deep in detector
- ~7000 individually read out scintillating strips
- U and V plane in each 30° sector
- Prototype tested at STAR during last pp run as a FPD



Data from Test in Forward Pion Detector

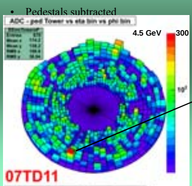
Endcap Megatiles

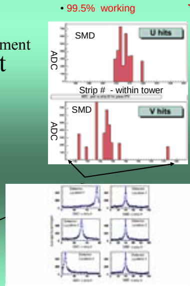
Cluster Finder under Development

- Real Au-Au event

triggered on EEMC HT

- Database has mapping ch -> det
- Association between towers and SMD
- Pedestals subtracted

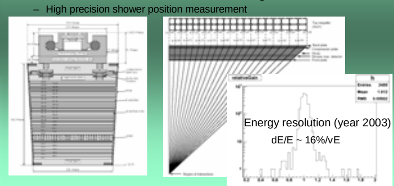




SLAC Test-Beam Data for Comparison

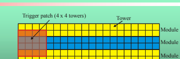
The BEMC Module

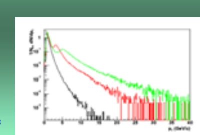
- 21 layers of lead/scintilator
  - 5 mm Pb + 5 mm (6 mm for PSD) Sci (Kuraray SCSN81)
  - First 2 layers have separate readout -> pre-shower detector
  - Light cross talk between towers < ½%
- Gaseous Shower Max detector at ~ 5X_0
  - High precision shower position measurement



BEMC (L0) trigger

- High-p_t trigger
  - Photons, electrons and π^0
  - 150 (half of BEMC) trigger patches
    - 4 x 4 towers
    - $(\Delta\eta, \Delta\phi)$ ~ (0.2, 0.2)
    - Highest tower in patch (HT)
      - 0.5 GeV energy resolution
- High Tower trigger
  - Highest tower in patch
- Patch sum trigger
  - Sum over 16 towers
  - 16 bits->6 bits convertion
    - Linear lookup table
      - Extremely high threshold
- Jet trigger
  - Sum over patches in 10 modules
  - Under commissioning





Alexandre A. P. Suaide, University of São Paulo - Brazil   FEMC03 - march 2003

SMD

AuAu y2004

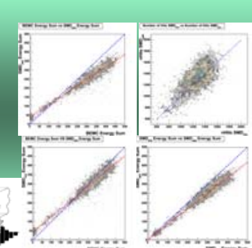
Blue – 1:1 ratio

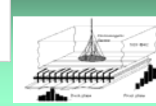
Red – actual ratio

Ratio of energies in SMD ϕ, η planes

Test beam: 0.9

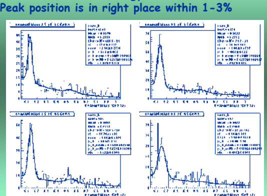
Data: 0.8





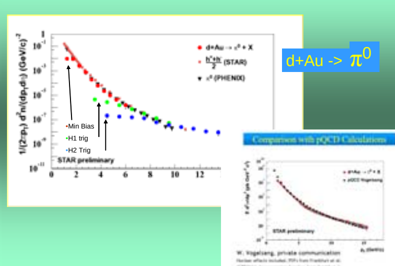
BEMC π^0 reconstruction from pp data (mass spectra)

- π^0 in pp events
  - SMD information for shower position
  - Tower clusters for energy measurements
  - Peak position is in right place within 1-3%



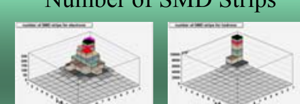
Alexandre A. P. Suaide, University of São Paulo - Brazil   FEMC03 - march 2003

Comparison with former Measurements



Electron ID: Cut on Number of SMD Strips

UCLA

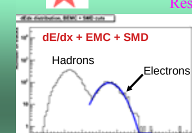


- Best knowledge electron sample (dE/dx, P/E, distance cut and one-to-one association)
- Most hadrons cause small size shower if they do cause any

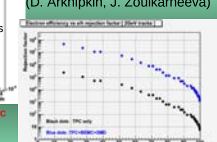
Electron/Hadron Discrimination Results dAu

dAu y2003

(D. Arkhipkin, J. Zoulkarneeva)



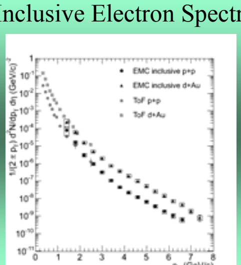
Electron Peak for p >1.5 GeV/c hadron suppression ~10^5 purity > 90%



Hadron Suppression versus Electron efficiency

Alexander Stolpovsky Feb 18 2004 CALTECH

Inclusive Electron Spectra

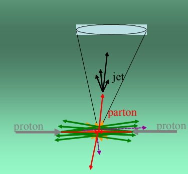


Jet Finder

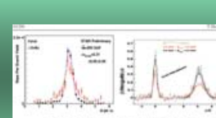
(Mike Miller/Thomas Henry)

For this Analysis, Jets are defined as a grouping of one or more (charged) Tracks measured in the TPC and satisfying the following requirements:

- Using an Iterative, Midpoint, Cone Algorithm
- Cone Angle = 0.7 in η-ϕ
- Seed Energy = 0.5 GeV
- pT Track > 0.1 GeV
- pT Jet > 5 GeV
- Z = +/- 75 cm
- Jet Eta Range = 0.2- 0.8



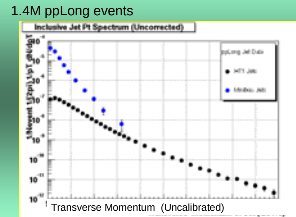
J. Phys. G. Nucl.Part. Phys.30 (2004) S1287-S1290



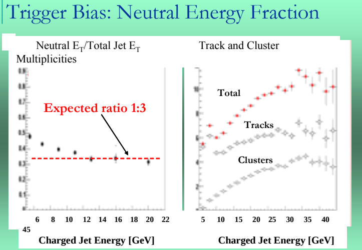
The left panel shows the d+Au di-jet delta phi distribution at root s = 200 GeV. The right panel shows di-hadron delta phi.

Jet Yield vs. p_T

1.4M ppLong events

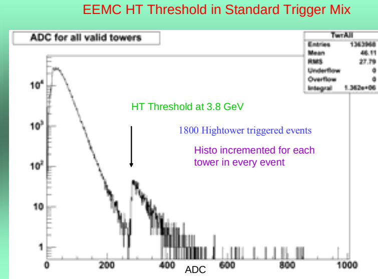


Trigger Bias: Neutral Energy Fraction



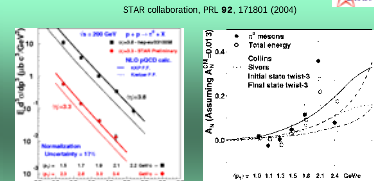
Stephen Trentalange UCLA DIS04

EEMC HT Threshold in Standard Trigger Mix



Forward π^0 Production

STAR collaboration, PRL **92**, 171801 (2004)



- pQCD calculations consistent with measured large-η π^0 cross sections
- Large transverse single-spin effects observed for √s = 200 GeV *pp* collisions

Collins effect ⇒ transversity   Sivers effect ⇒ orbital angular momentum

Additional measurements required to disentangle contributions

Conclusions

- EEMC is complete, BEMC is 75% complete
- Working on including PSD in the data stream
- Important trigger for data taking
  - HighTower – working since last run
  - JetPatch – is being tested and expected to work this run
- Analysis
  - electron analysis
  - Jet yield is measured and being compared to MC
  - corrections for π^0 p_t spectrum understood but need embedding

- *π^0-gated di-hadron correlations in 62 and 200 GeV Au+Au (quenching of q vs. g jets)*
- *Evaluation of efficiency & bias for different jet triggers, + extended coverage for A_{LL}(jets) in 200 GeV p+p*
- *Search for high-pT direct photon yield in p+p and ALL(π0) in 200 GeV p+p (sensitivity to ΔG in proton)*
- *Au+Au*