Calibration of the Shower Maximum Detector in the Barrel EMC at STAR

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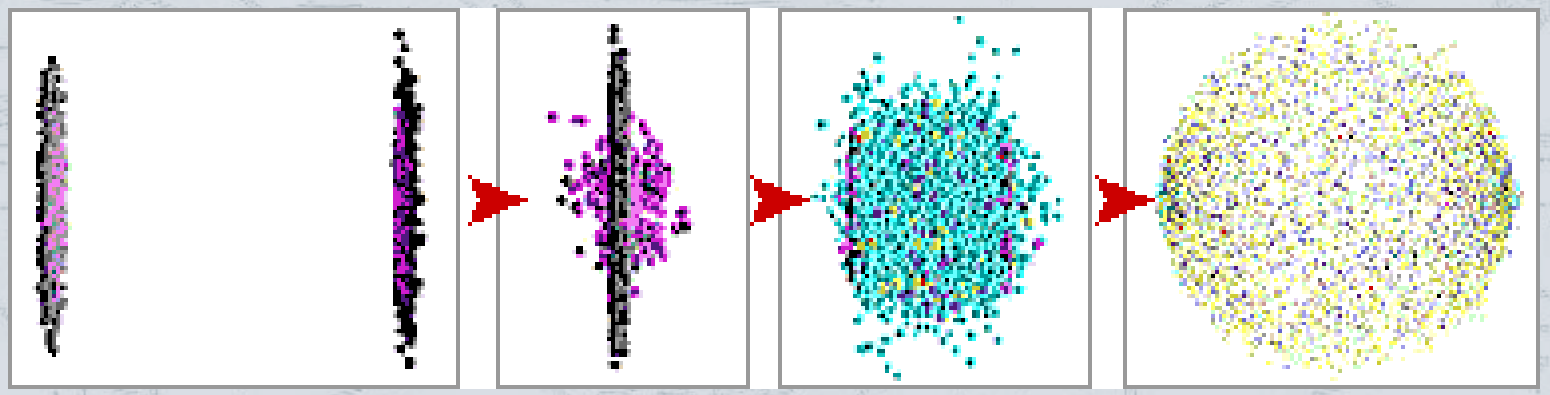
Quark - Gluon Plasma (QGP)

- Form of matter believed to have existed in early universe (hadronized 10μs after Big Bang)
- Quarks and gluons deconfined
  - Unlike hadronic matter - quark-antiquark pairs (mesons) or three quarks (baryons)
- Believed to be recreated in high energy, heavy ion collisions



Heavy Ions (distorted by relativistic effects)

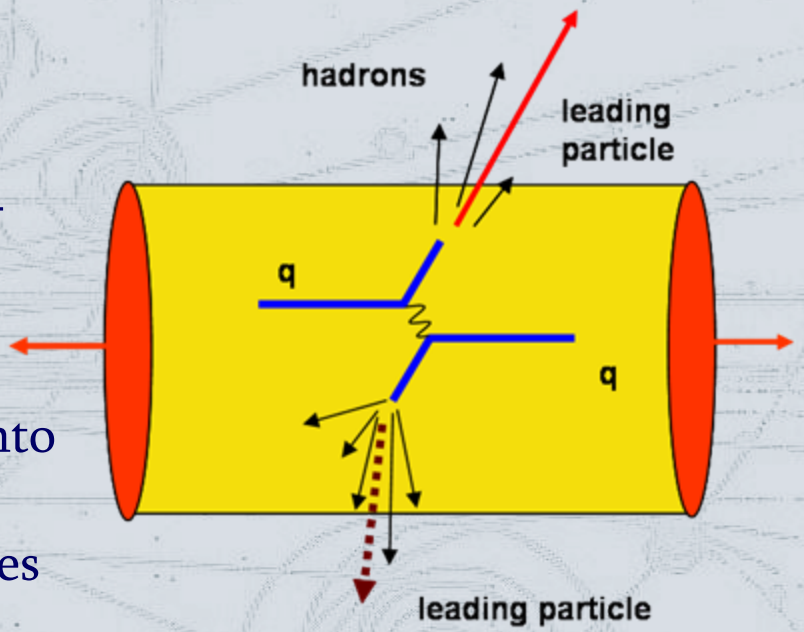
Collision

Deconfined quarks and gluons

Hadronization

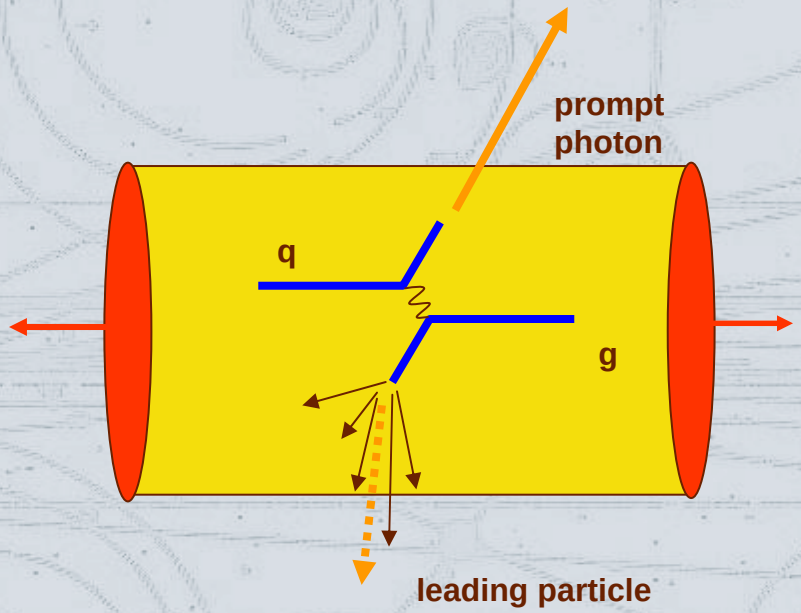
Jets as Probes

- To understand this dense medium - need probe
- Jet
  - A parton (quark or gluon) fragments into a cone of hadrons (= a "jet")
  - Produced from hard scattering processes (between partons)
  - Hard scattering occurs early in heavy-ion collision – scattered parton experiences evolving medium



→ Jet makes ideal probe of medium

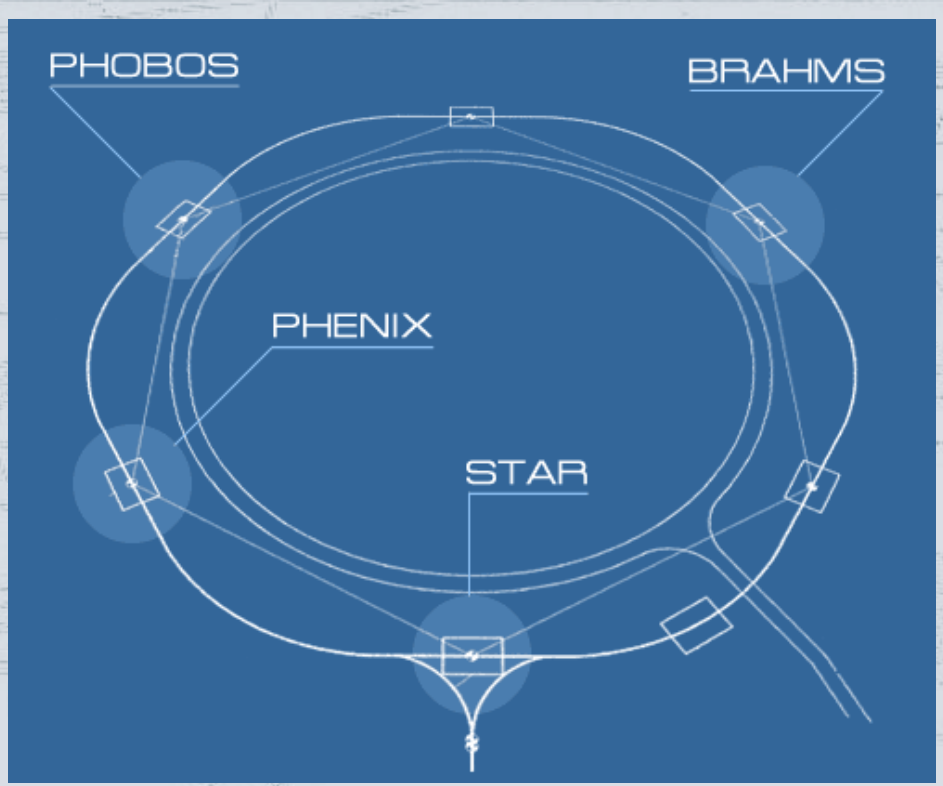
γ- Jet Probe



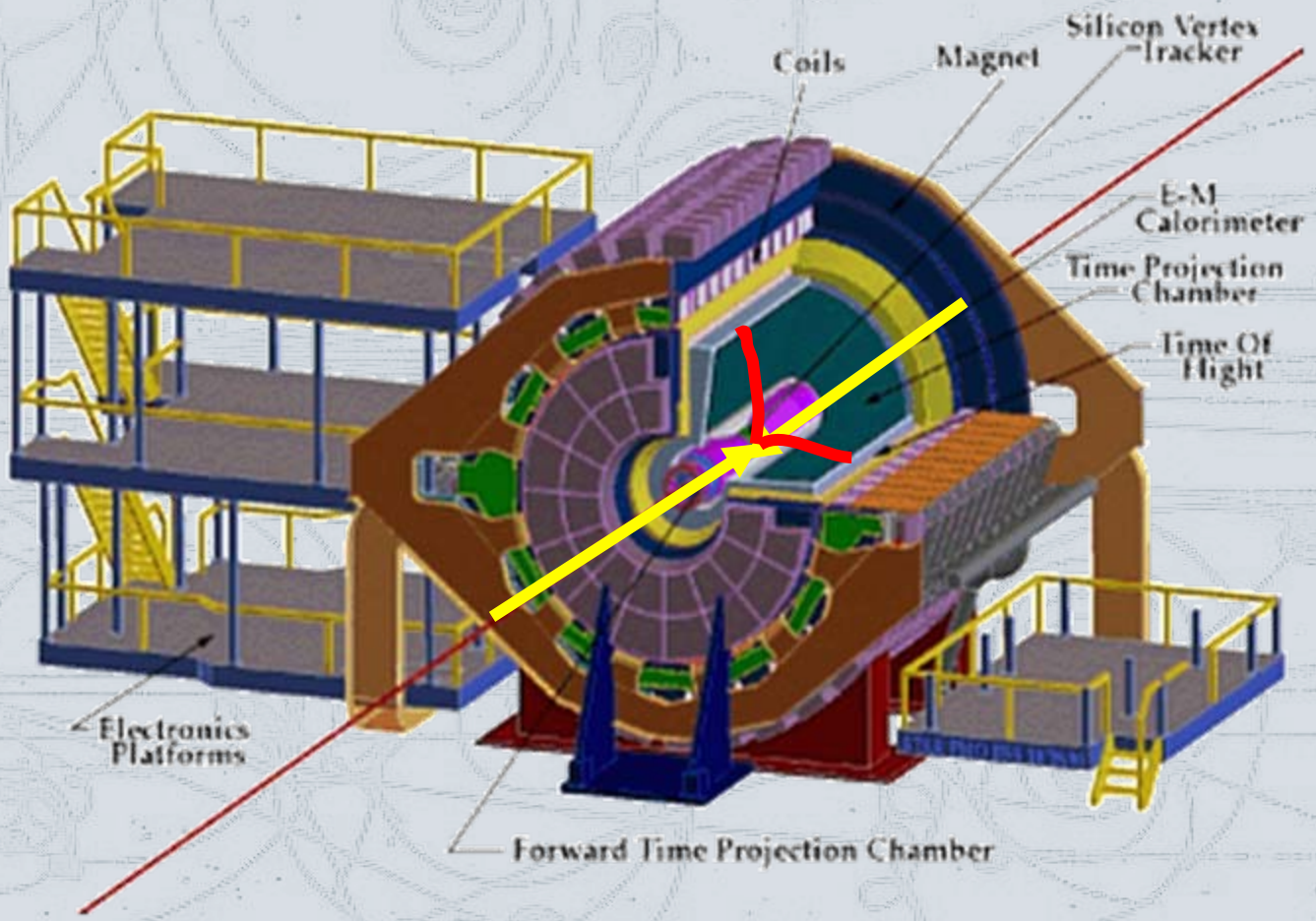
- Jet produced back to back with "direct" photon
- QGP interacts primarily via strong force
  - Photon only interacts via EM force
- Direct photon carries initial energy - not modified by passing through medium
  - "Calibrated" probe
- However, significant number of background photons (e.g. $\pi^0 \rightarrow \gamma\gamma$)

Relativistic Heavy Ion Collider (RHIC)

- Two rings - beams traveling in opposite directions
- Can produce Au+Au collisions at 200 GeV
  - Ideal for creating QGP
- Six interaction points
- Four experiments initially
  - PHOBOS (inactive)
  - BRAHMS (inactive)
  - PHENIX
  - STAR

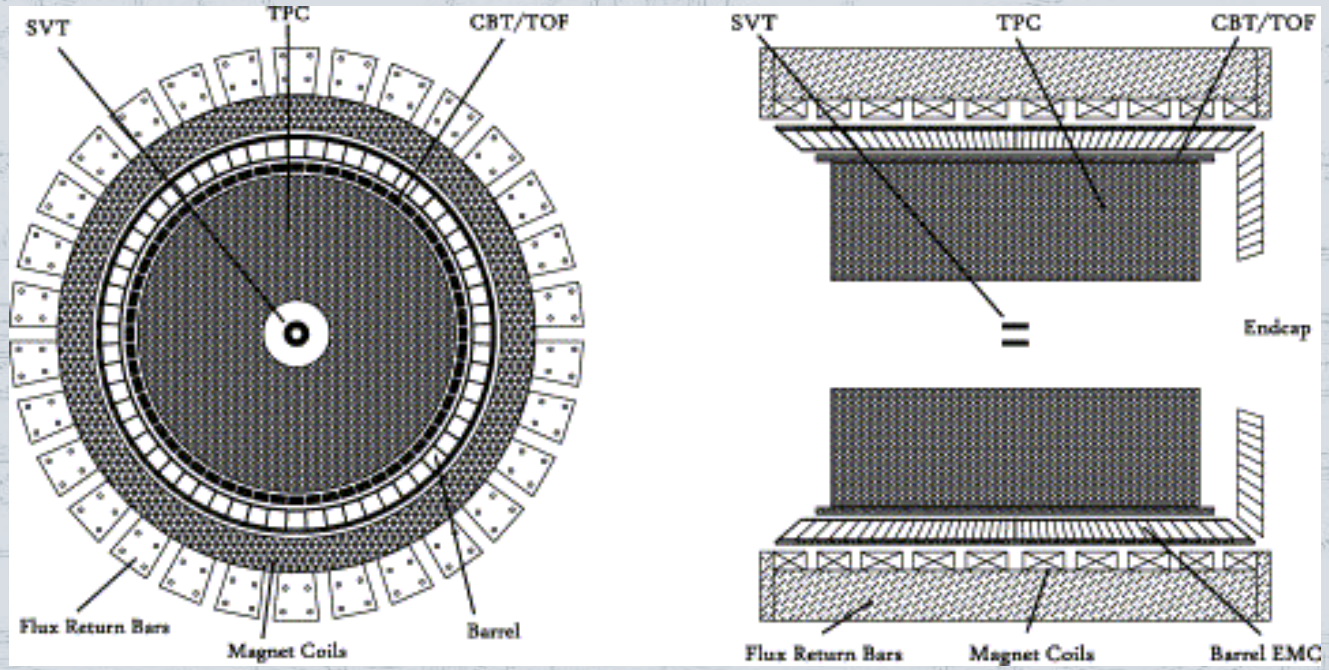


Solenoid Tracker at RHIC (STAR)



- Goals
  - Look for signatures of the QGP
  - Study properties of matter created in these heavy-ion collisions

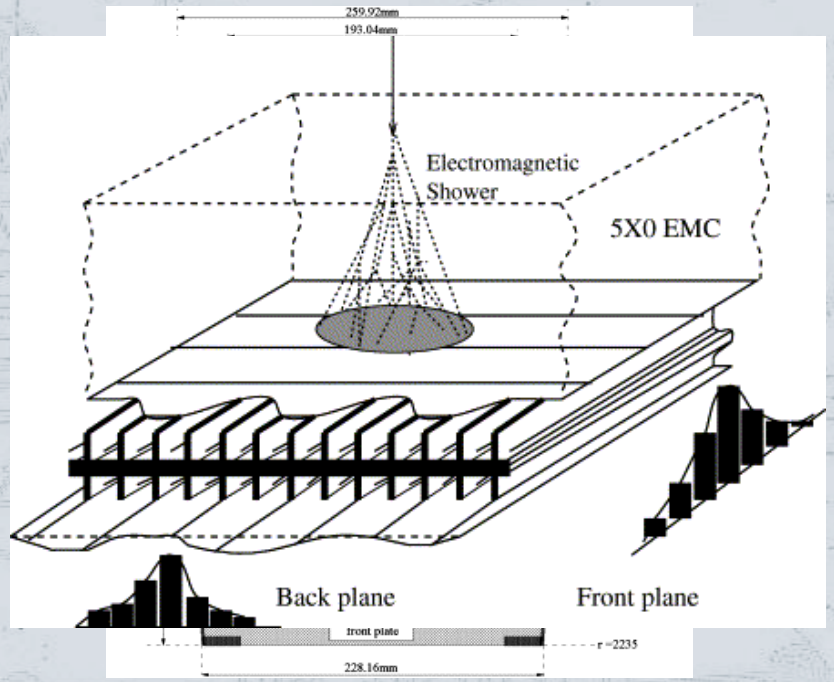
Barrel Electromagnetic Calorimeter (BEMC)



- Used by STAR for energy detection and triggering
- Large acceptance
- Coverage: $-1 < \eta < 1$, $\phi = 2\pi$
- Contains 4800 towers, each with a coverage of $\Delta\phi = 0.05$ rad by $\Delta\eta = 0.05$

Tower and Shower Maximum Detector (SMD)

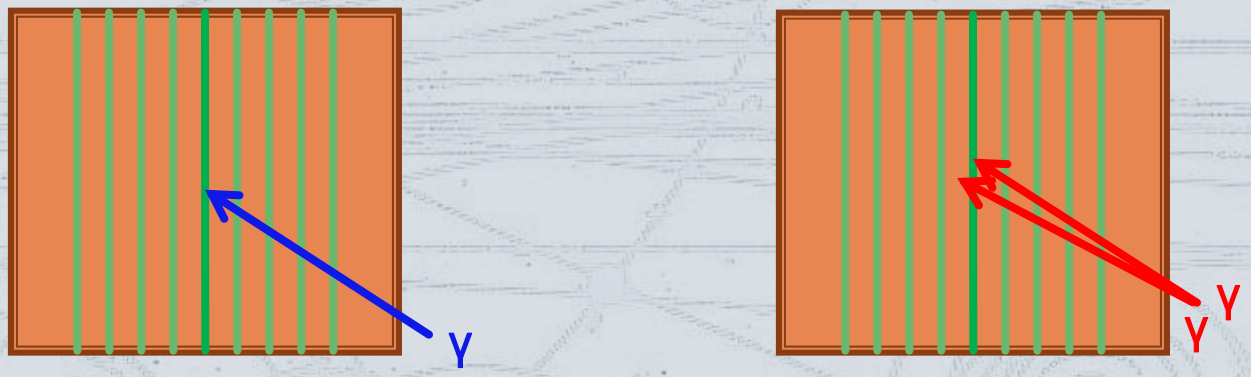
- Contains alternating layers of lead and plastic scintillator
  - 20 layers of 5 mm thick lead (Pb)
  - 21 layers of 5 mm thick scintillator
  - Wire chamber with cathode-strip readout = SMD
- Depth ~ 20 X_0 at $\eta = 0$



- Shower – $e^{\pm}/\gamma$ interacting with Pb, results in cascade of secondary $e^{\pm}/\gamma$
- Shower maximum detector at 5 X_0 (after shower has reached its maximum)
  - Good spatial resolution
  - Perpendicular strips for determining position
  - 18,000 in η and 18,000 in ϕ

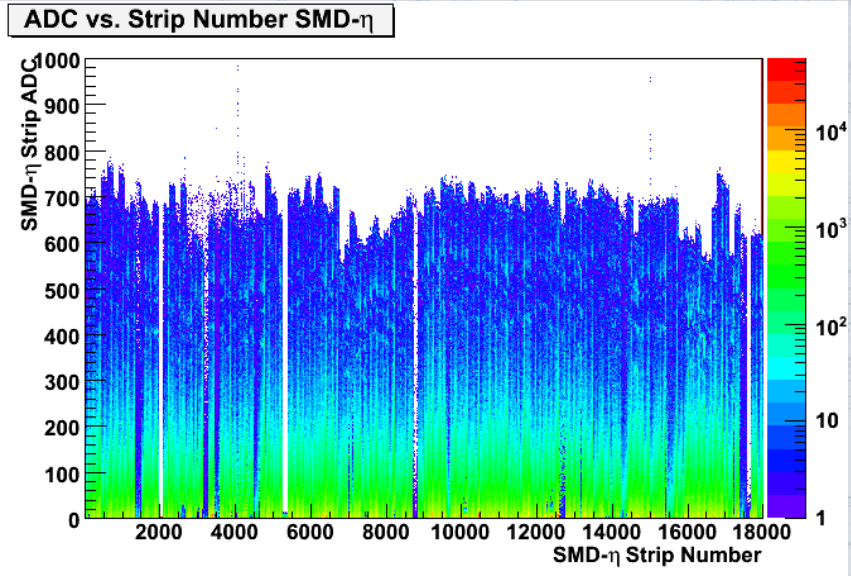
Calibration of SMD

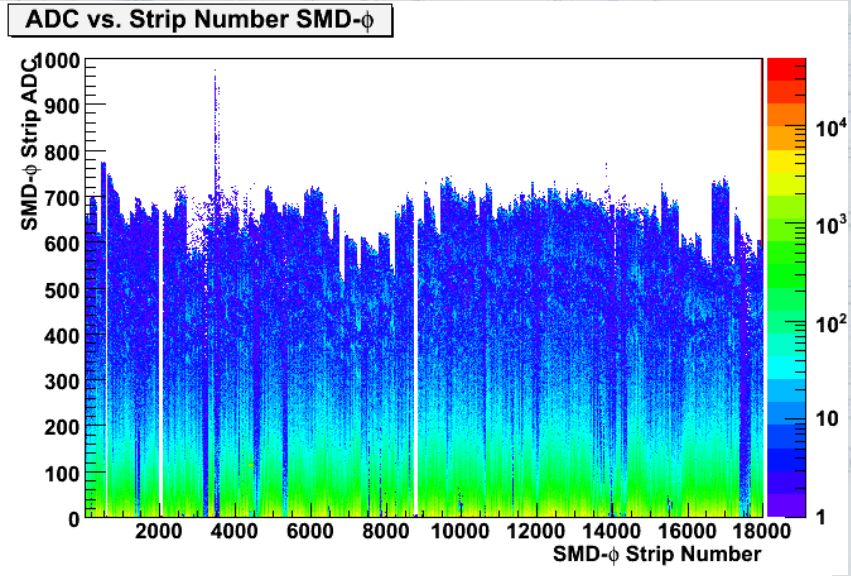
- Main source of background photons = π^0 decays
  - Two photons with narrow opening angle



- Hard to resolve differences in energy distributions
- Calibrate detector for better discrimination ability
  - Calculate gains (amplification of signal from light to energy)
  - Equalize gains
  - Save calibration constants to database for future runs

2D Histograms - Pedestal Subtraction

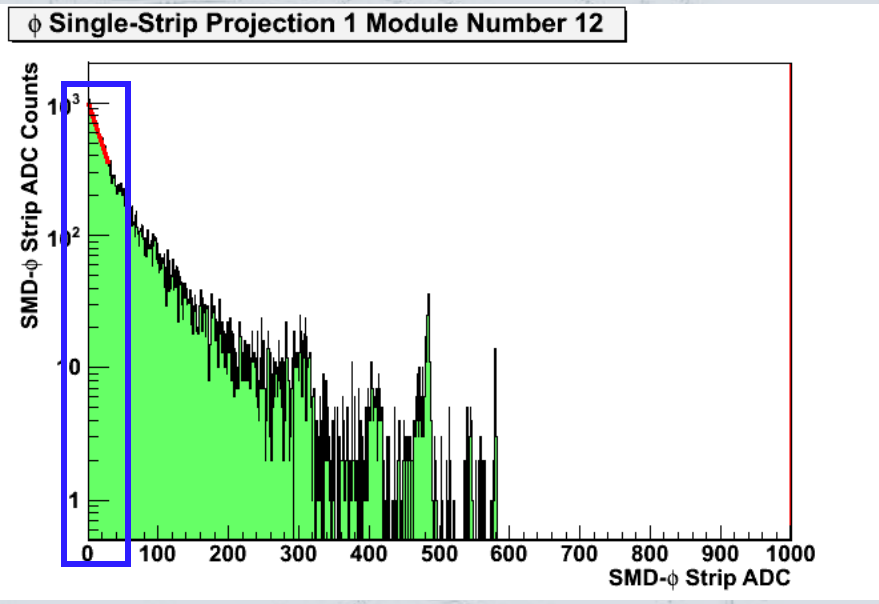


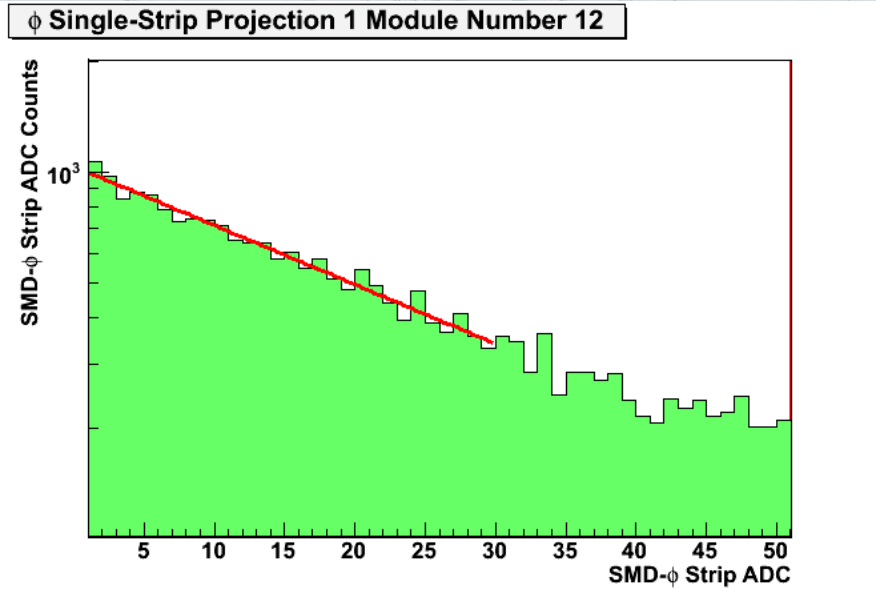


- 3 million minimum biased Au+Au 200 GeV events
- Detector ID number and ADC value saved
- Data zero suppressed - use pedestal run information
- Mean and five time the RMS of the pedestal subtracted
- Mean value of strips not equal

Quality Assurance

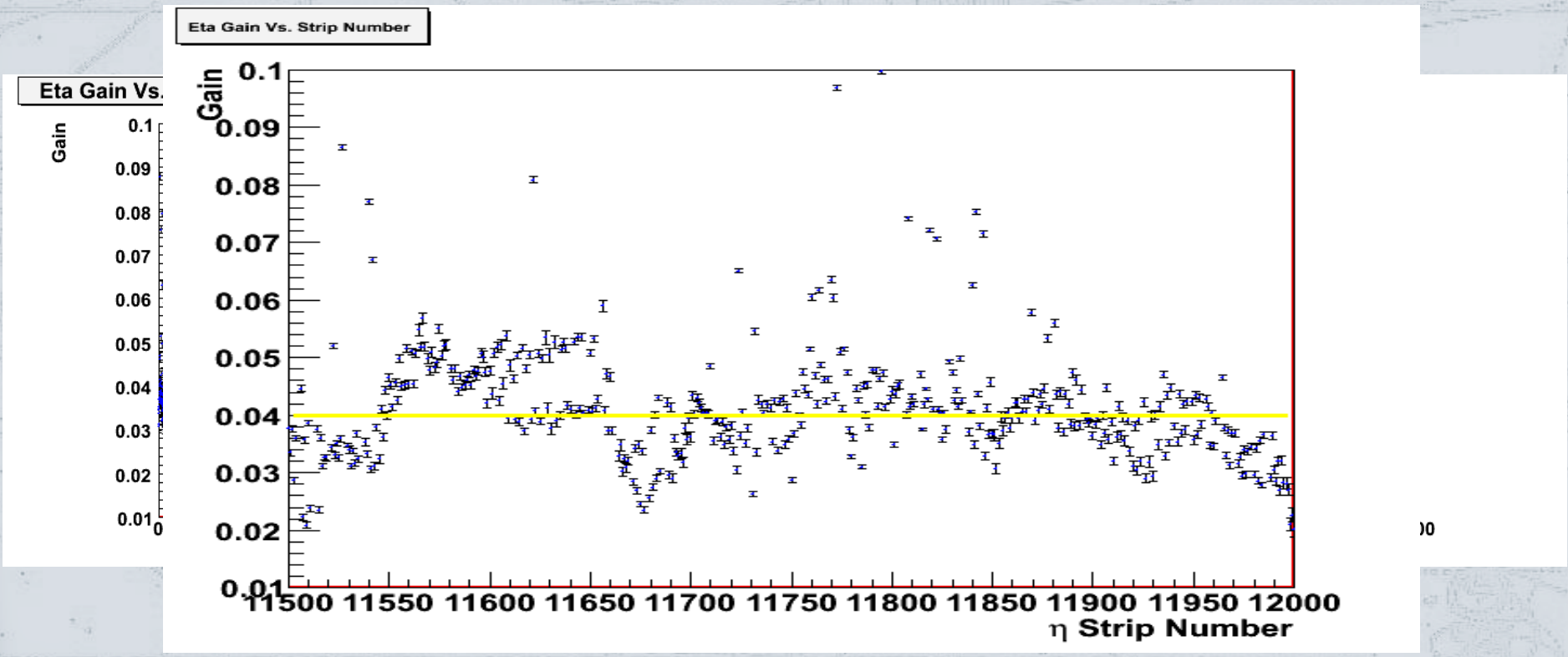
- 2D histograms projected by strip
- Each strip given a status indicator
  - 0 - Dead channel (< 5 entries)
  - 1 - Good channel
  - 3 - Cold channel (number of entries < 1/5 of the average number of entries
  - 4 - Hot channel (number of entries > 5 times the average number of entries
- Each strip then fit with exponential function from ADC values 1 to 30





Gains

- The |slope| vs. the strip number for η is shown below



- The gain of each strip is the variation of its slope with respect to a constant

Calibration Constants

- These multiplicative constants saved to database - to be applied in future

Detector relatively calibrated

- Future
  - Use simulation to complete absolute calibration
  - Absolutely calibrated constants - find energy from raw ADC value

Acknowledgements

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