New Trigger Logic for the Forward Meson Spectrometer (FMS)

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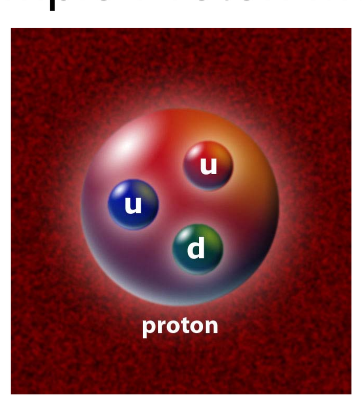
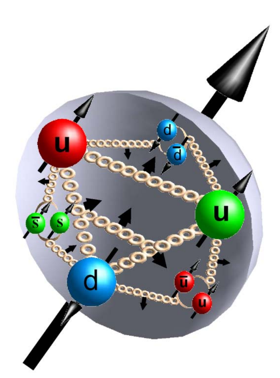
Introduction

The Forward Meson Spectrometer (FMS) is part of the STAR Experiment at the Relativistic Heavy Ion Collider (RHIC) in Brookhaven New York. STAR is investigating the quark and gluon structure of the proton. Particularly the origin of: proton mass, proton spin, and of large transverse single-spin asymmetries in p+p collisions. STAR is also studying phases of matter, under extreme conditions, such as the quark gluon plasma, which exits at high densities, and extremely high temperatures. The FMS is able to detect particles at high pseudo-rapidity increasing the acceptance of the STAR detector in the forward region.

Simple Proton Model



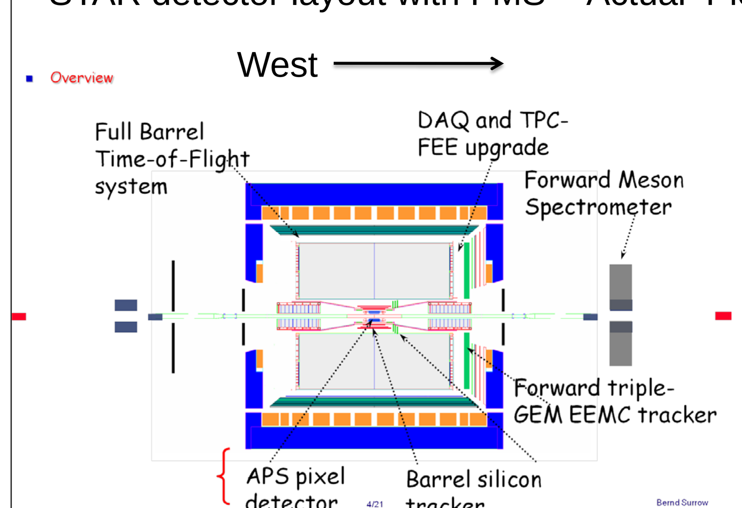
Complex Proton Model



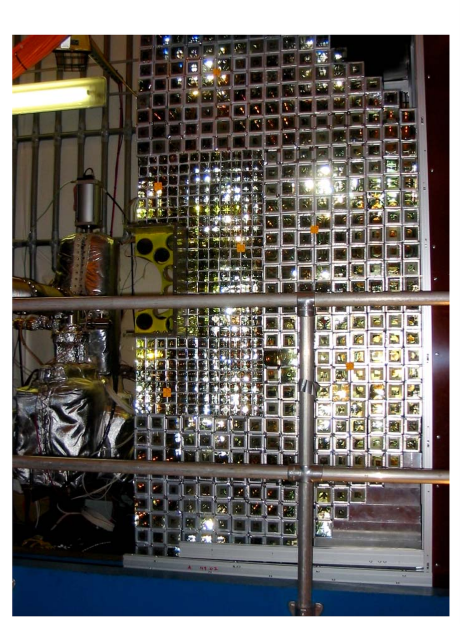
The FMS Detector

The FMS is an electromagnetic calorimeter, and a STAR subsystem. The FMS is an array of lead-glass, Pb-gl detectors; located 706 cm down beam, to the west, of the main STAR detector.

STAR detector layout with FMS



Actual Picture of the FMS North Half



The FMS provides full azimuthal coverage in the $2.5 < \eta < 4$ Pseudo-rapidity space.

Physics with the FMS

The FMS was designed with three Physics goals in mind.

1. Measure gluon distributions xg(x) in protons and gold nuclei from $0.001<x<0.1$

Check universality of xg(x) in region of overlap with DIS ($0.02<x<0.1$)

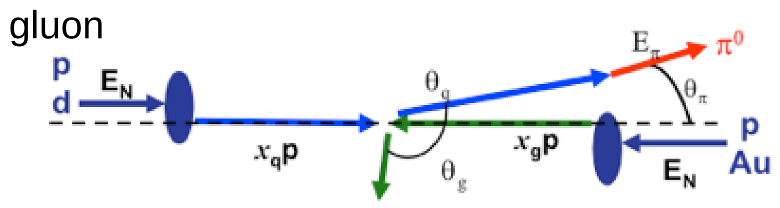
2. Characterize correlated pion distributions as a function of Q^2 to search for onset of saturation effects

Is Au a Color Glass Condensate (CGC)?

3. Resolve the origin of large transverse spin asymmetries in $p_\uparrow+p \to \pi^0+x$ for forward π^0 production

Preliminary results are available for correlated pion distributions (related to goal 2.)

Illustration of d+Au collision used to measure the gluon distribution g(x)



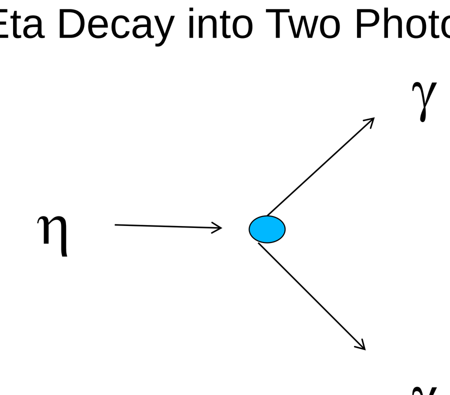
The large spin asymmetries mentioned in goal 3 have been observed

Two different explanations have been proposed the Sivers effect: An initial-state phenomenon related to quark or gluon orbital motion, and the Collins effect: A final-state phenomenon related to quark transverse polarization

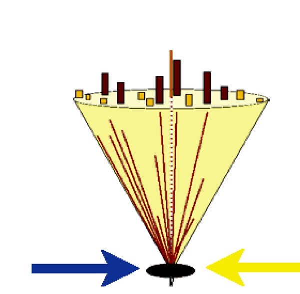
2009 FMS Trigger Logic

The 2009 trigger logic fired on clusters around a local high energy event. This made it very efficient at triggering on energetic photons, π^0 's, and other localized events. This trigger's success in triggering on local events came at the cost of making it less efficient at triggering on more spread out events, such as particle jets, or energetic η (eta) decays. The trigger did not work as well for these events because it saw the energy as being deposited in distinct clusters, causing energetic events like η decays and jets to appear as multiple less energetic events, though they come from single highly energetic events.

Eta Decay into Two Photons



Jet Like Event



My Involvement with the FMS

My assignment regarding the FMS was to develop a new trigger algorithm.

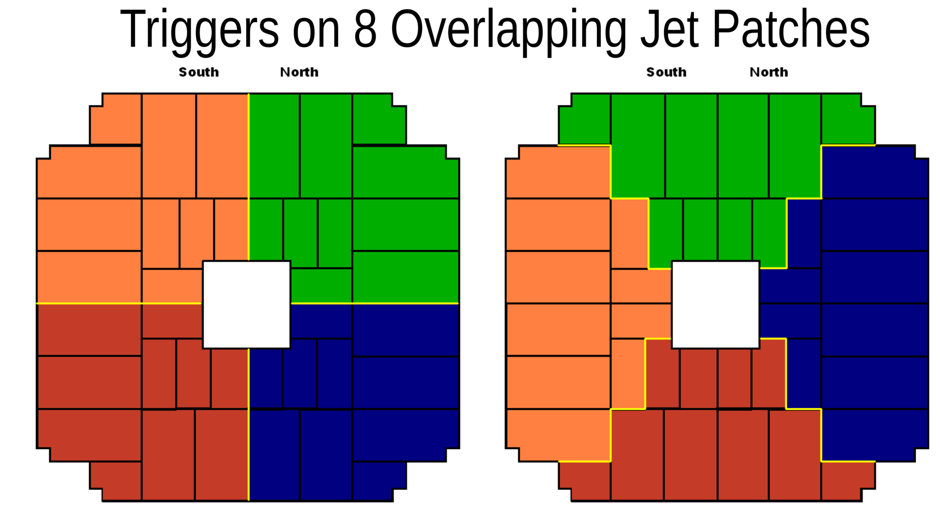
The new algorithm is intended to increase the versatility of the FMS by allowing it to trigger on events in 1 of 8 overlapping jet patches or a board sum . (Jet Patch defined later)

Once the new logic scheme had been worked out, it needed to be tested, so I modified the simulation code for the old trigger algorithm to reflect the new algorithm.

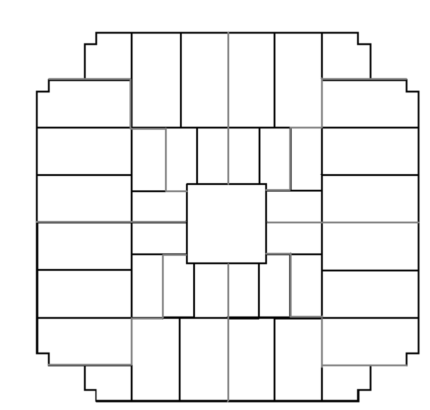
After the simulation code was complete we ran several simulations over the equivalent of 2.6B p+p collisions at 200 GeV and 50M p+p collisions at 500 GeV, to analyze the behavior of the new trigger.

New FMS Trigger Logic for 2011

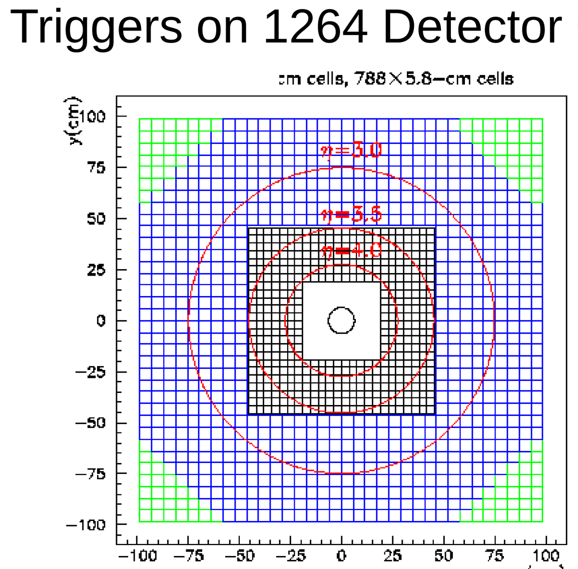
Triggers on 8 Overlapping Jet Patches



Triggers on 40 QT Boards



Triggers on 1264 Detector Cells



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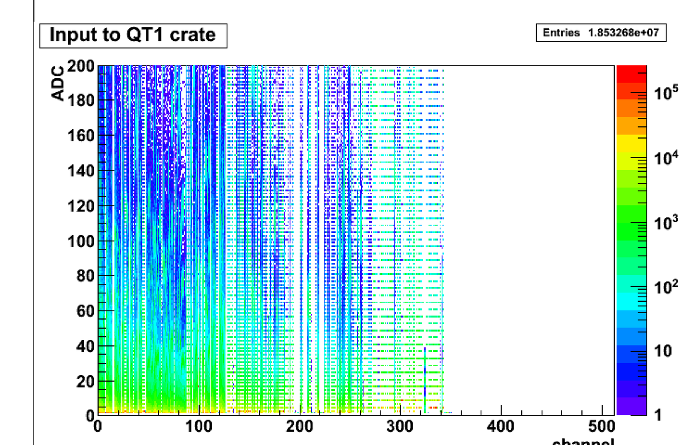
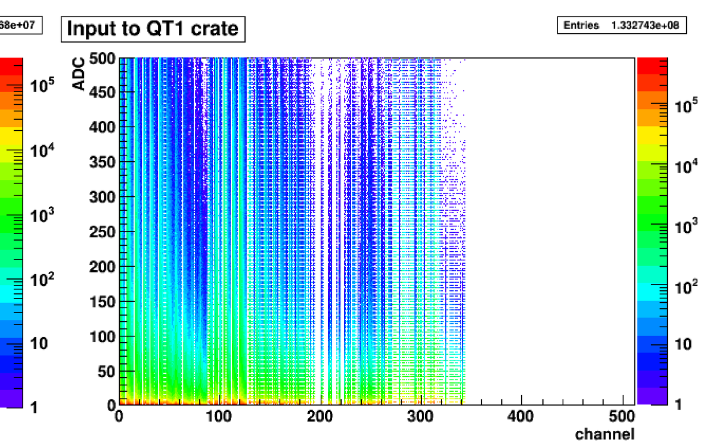
Results and Conclusions

Here is a comparison between the actual data from 2009 and that generated by the simulator.

2009 Data 200 Gev

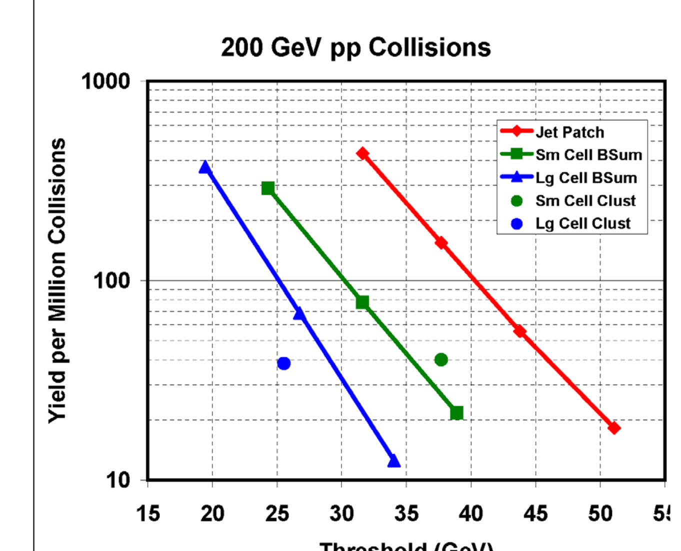


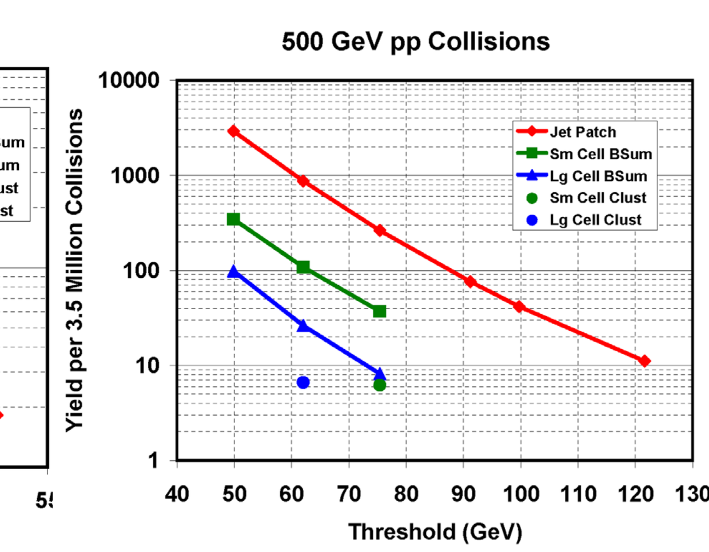
Simulation 200 GeV



The simulation qualitatively reproduced the data from 2009, these diagrams depict the data seen by the detector.

The simulated data were then input to the Jet Patch trigger simulator, and the results were used to predict rates for the Jet Patch and Board Sum Triggers.





The Jet Patch Trigger appears to be functioning as intended, and shows improved efficiency over the Cluster Trigger.

The Higher firing rate for the JP Trigger compared to the Cluster Trigger indicates that there are significant numbers of events like jets and η's where the energy is too spread out to fire the Cluster Trigger, but are energetic enough to fire the JP Trigger.

The Board Sum Trigger rate exceeds that of the Cluster Trigger in the large cells, but is lower in the small cells. However the ability to trigger on clusters does not appear to be significantly reduced.

A Di-jet trigger also works, though implementation depends on the logic capabilities of the actual hardware in the detector.

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