Dimuon Production from Au-Au Collisions at $\sqrt{s_{NN}} = 200\ GeV$

Ming Xiong Liu

Los Alamos National Laboratory

(for the PHENIX Collaboration)

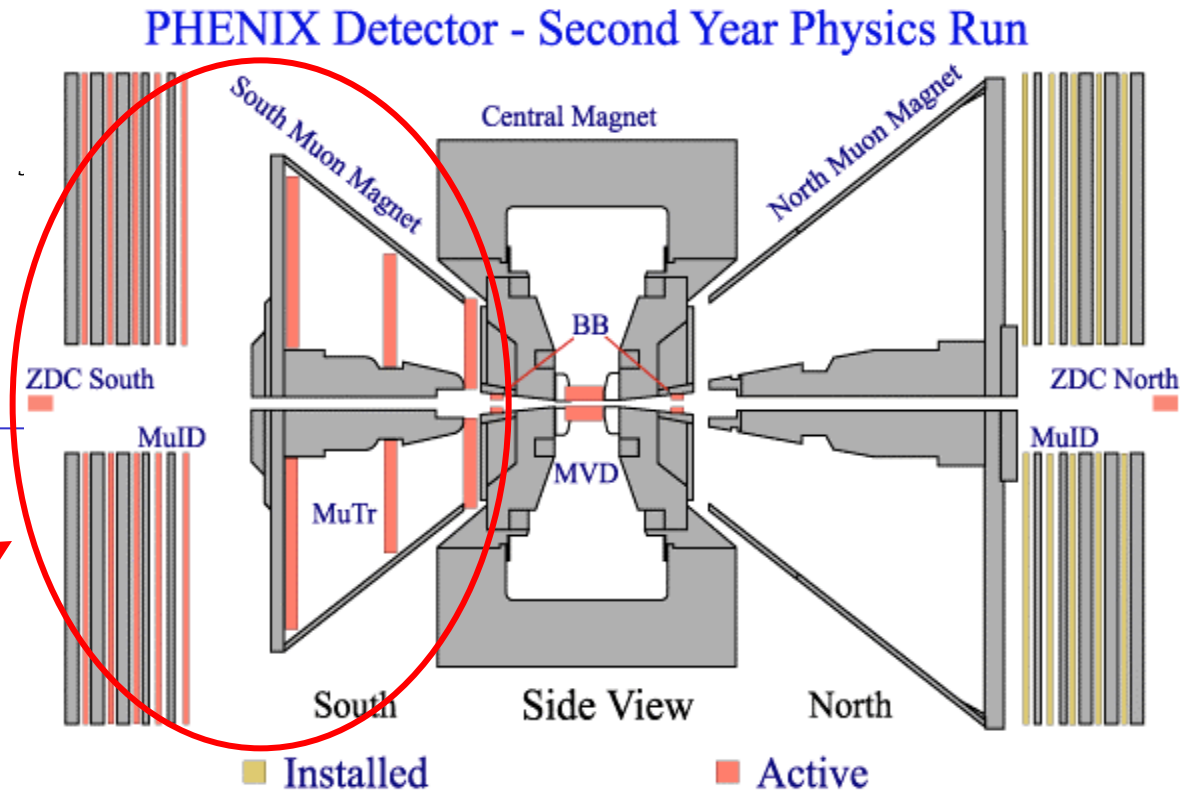
- Introduction
- Detector performance and key parameters
- Monte Carlo simulations
- Dimuons from a small sample of Run-2 data

Introduction

Among RHIC experiments, PHENIX has the unique capability to measure muons from high energy collisions. Muons from heavy ion collisions carry important information of the collision dynamics. The first muon detector (south muon arm) was installed in the late 2001 and commissioned during 2001-2002 RHIC run.

Of particular interest, the J/Ψ production is considered as one of the sensitive probe of the QGP formation in heavy ion collisions. The decay channel $J/\Psi \rightarrow \mu^+\mu^-$ provides a clean experimental measurement of J/Ψ production in heavy ion collisions.

We discuss the muon detector performance and our first analysis effort to measure the dimuon production with about 1 million minimum bias triggered events (~1% of total Run-2 Data set) that were collected by PHENIX in RHIC Run-2 (2001-2002).

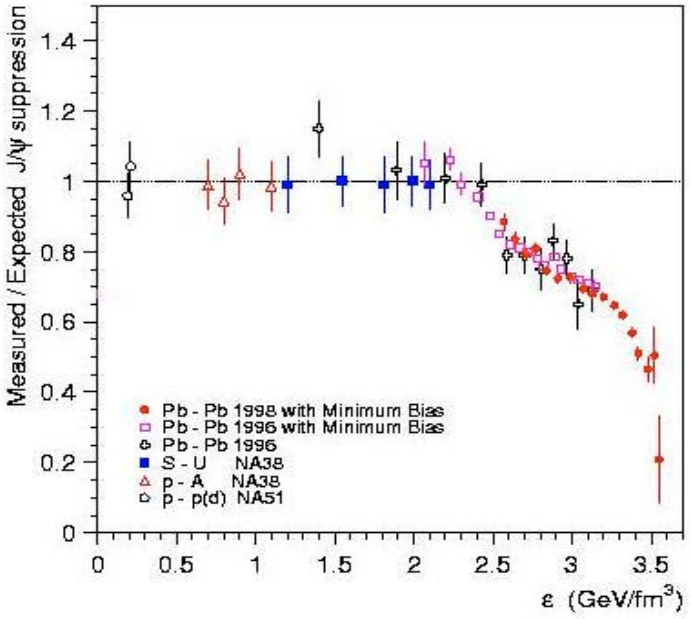


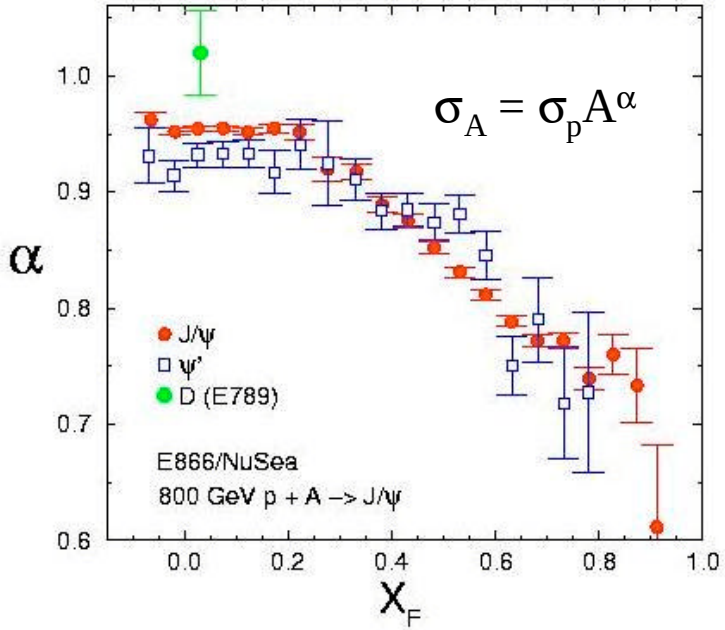
South Muon Detector

Dimuon Physics - Vector Meson Suppression?

A predicted signature of Quark-gluon plasma (QGP) is the suppression of J/Ψ production. The formation of J/Ψ's in a QGP is predicted to be inhibited by color-screening

But J/Ψ's are also suppressed by non-QGP effects such as absorption, shadowing, etc; as seen in the results from E866/NuSea measurements at Fermilab.



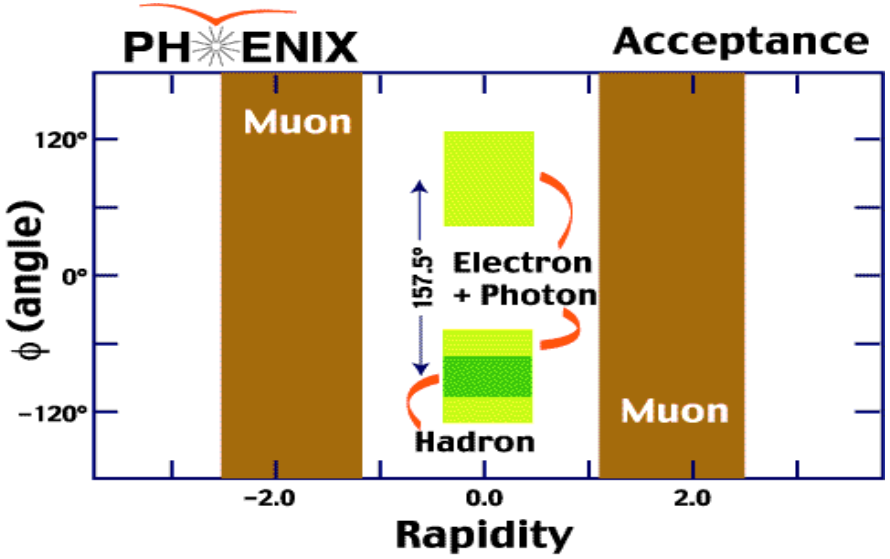


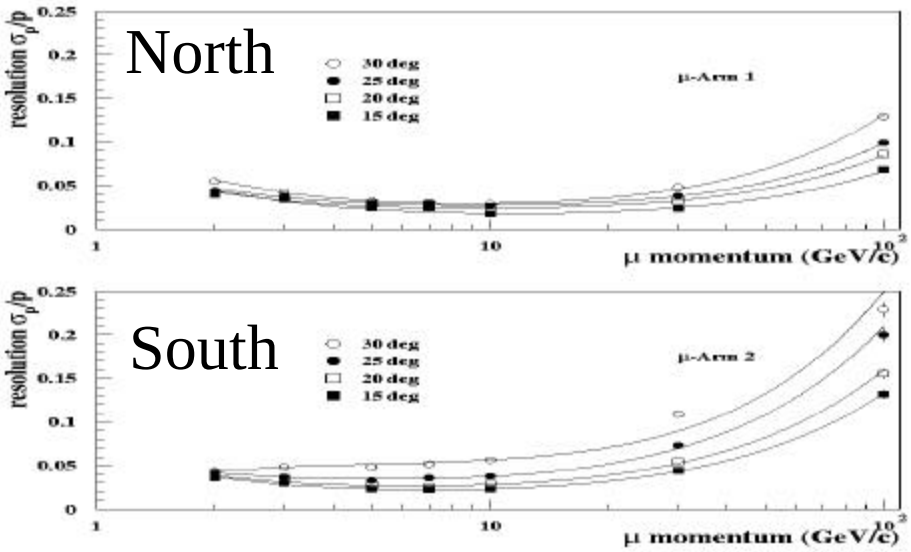
NA50 -- Anomalous J/Ψ suppression. Evidence for QGP??

It is very important to systematically study J/Ψ production in p-p, p-A(or d-A) and AA at RHIC !!! Also see: H. Sato and D. Silvermeyer's posters.

Muon Detector Key Parameters

- Muon Arms
  - $1.2 < |h| < 2.2$ (south)
  - $1.2 < |h| < 2.4$ (north)
  - $\Delta\phi = 2\pi$
- Physics Simulations:
  - ϕ mass resolution 80 MeV/c^2
  - J/ψ mass resolution 110 MeV/c^2
  - Υ mass resolution 200 MeV/c^2
  - W/Z decays $?p/p \sim 15\%$
  - $?p/p \sim 3\%$ (@3~10GeV/c for J/Ψ events)

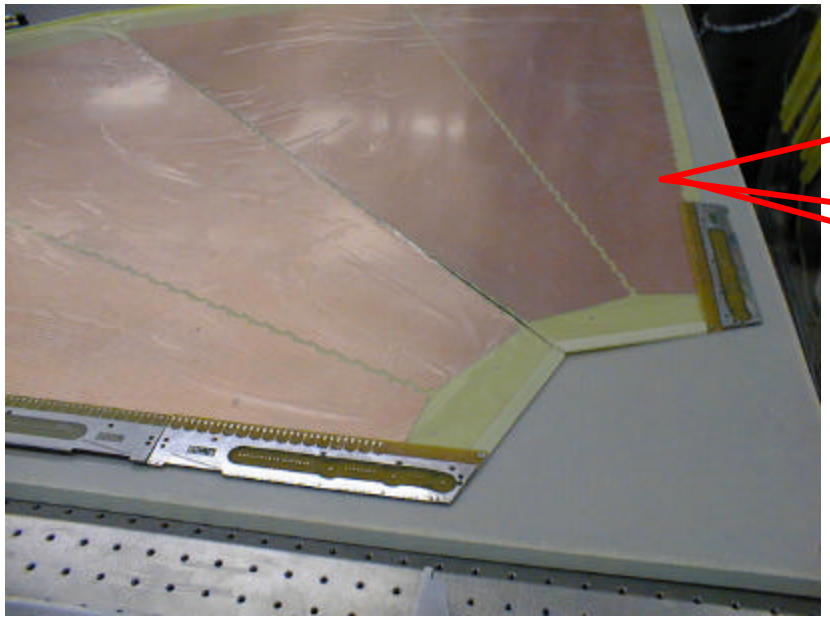


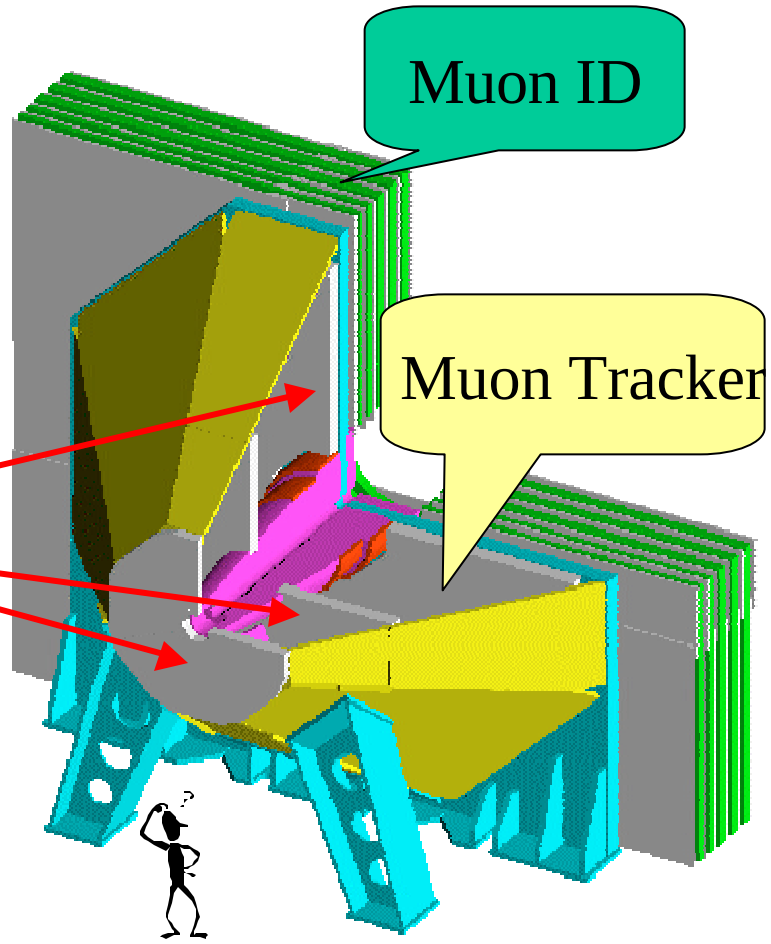


South Muon Detector

See K. Read's poster for details

- Muon Identification Panel
- Muon Tracking Chamber
  - 0.5cm spacing cathode strips
  - read out every other strips
  - handle data at high multiplicity and high collision rate





High Speed Multi-Sample Readout

- Low noise and high speed

$$resolution: 100mm = x \cdot 1cm \Rightarrow x = 1\%$$

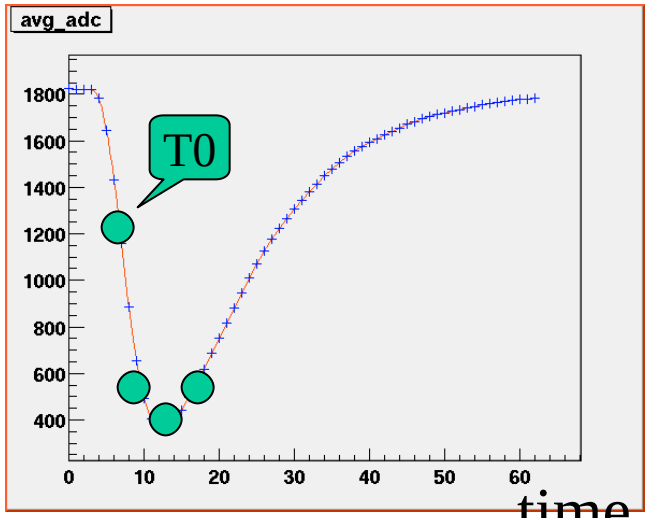
$$noise: Q' = 80\,fC \cdot 1\% = 0.8\,fC$$

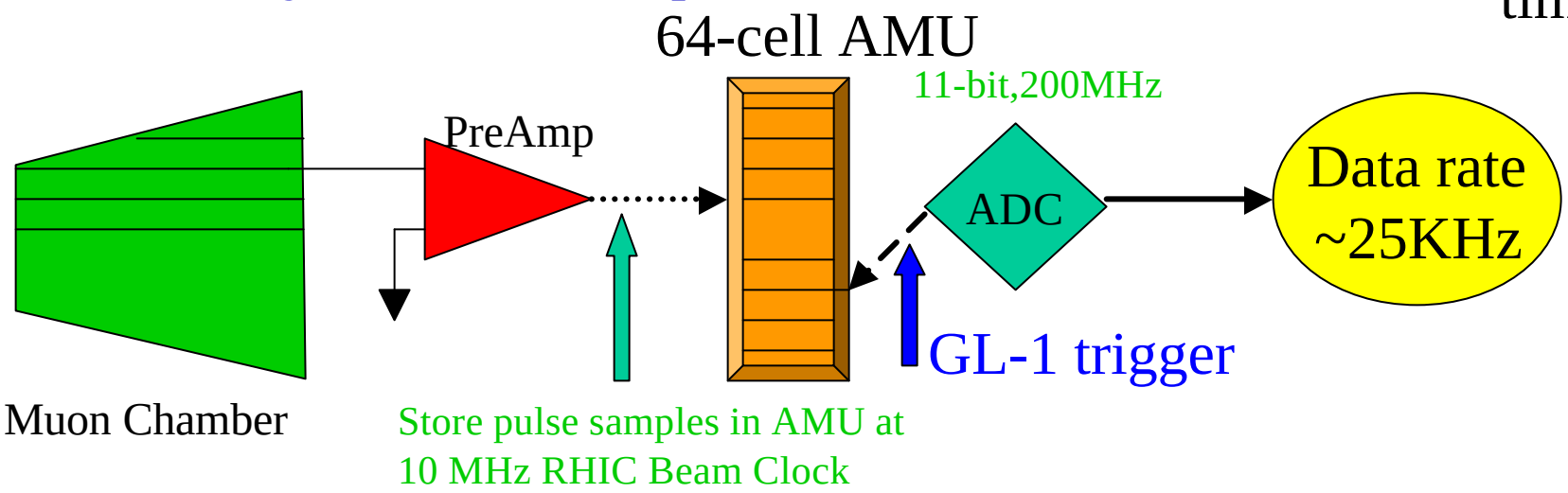
$$Thermal\ noise:$$

$$\frac{1}{2}\frac{Q_{thermal}^{\ 2}}{C_{\det}} = \frac{1}{2}kT \Rightarrow Q_{thermal} = 0.65\,fC$$

- T0 -> reject out of time pulse

4-samples per pulse to improve signal/noise

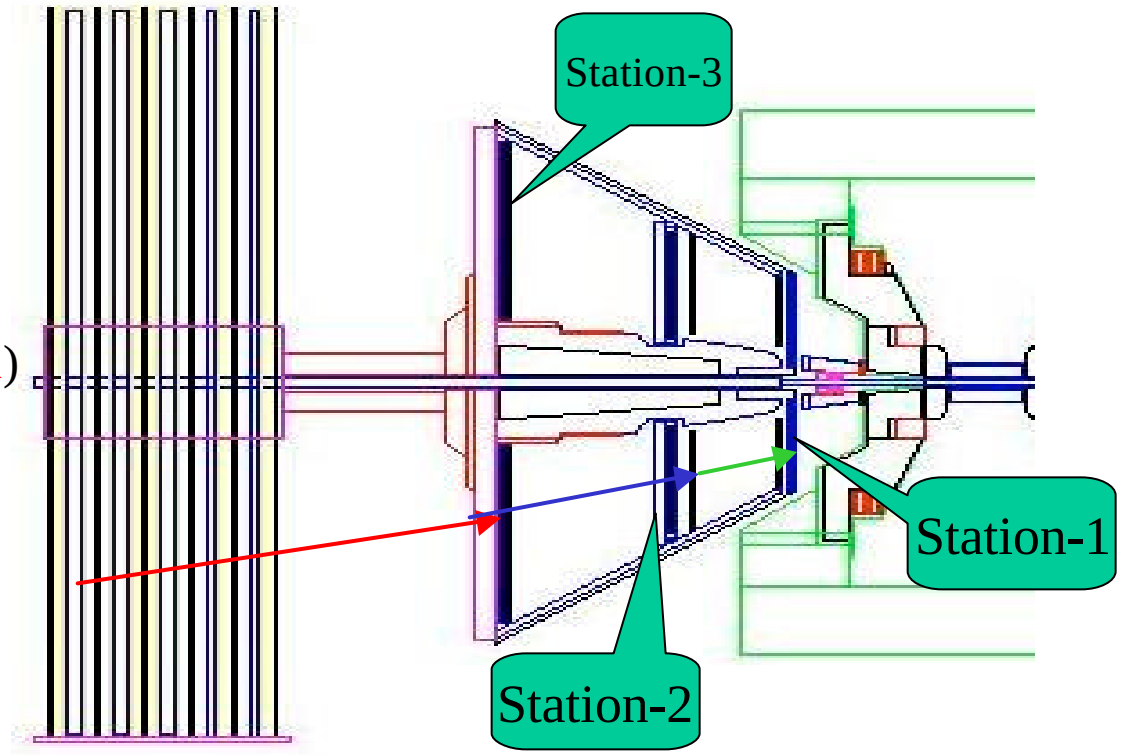




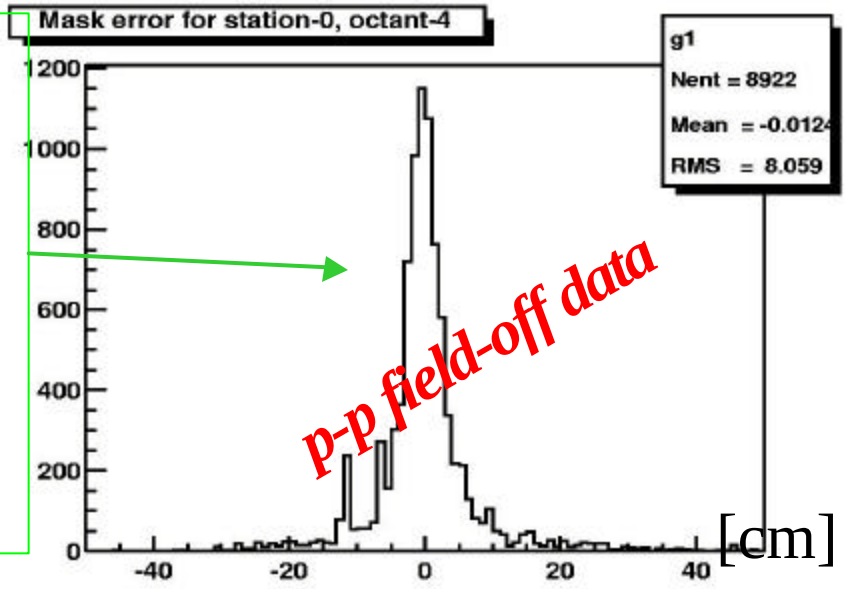
Track Finding

- Start with a good muon candidate from Muon ID panel (red vector = muid road)
- Combine muID road with station-3 hits and swim it to staion-2(blue vector)
- Repeat same procedure at station-2 and station-1
- Refit all hit candidates
- Parameters are tuned with MC simulations
- Challenge: in Au-Au collisions, high multiplicity produces many combinatory ghost tracks.

See J. Newby's poster for details



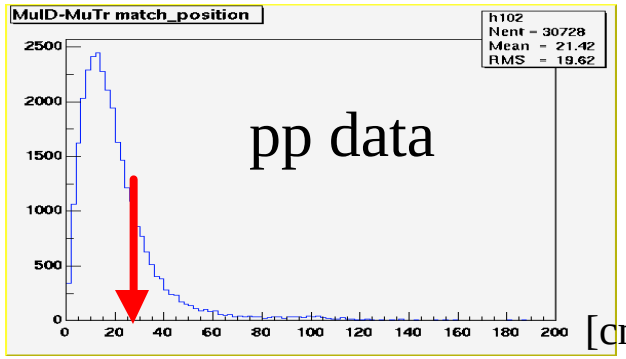
Projection from station-2 to station-1. The distribution width is dominated by the multiple scattering of low momentum particles

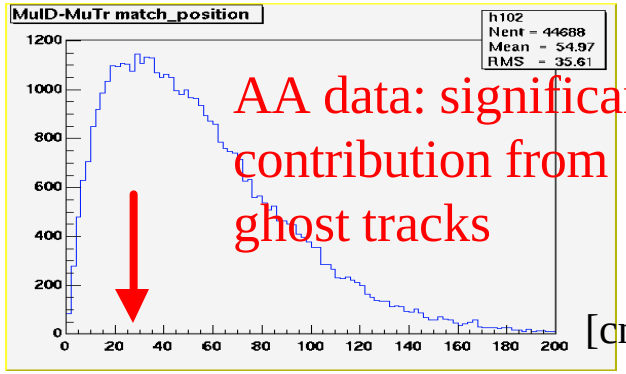


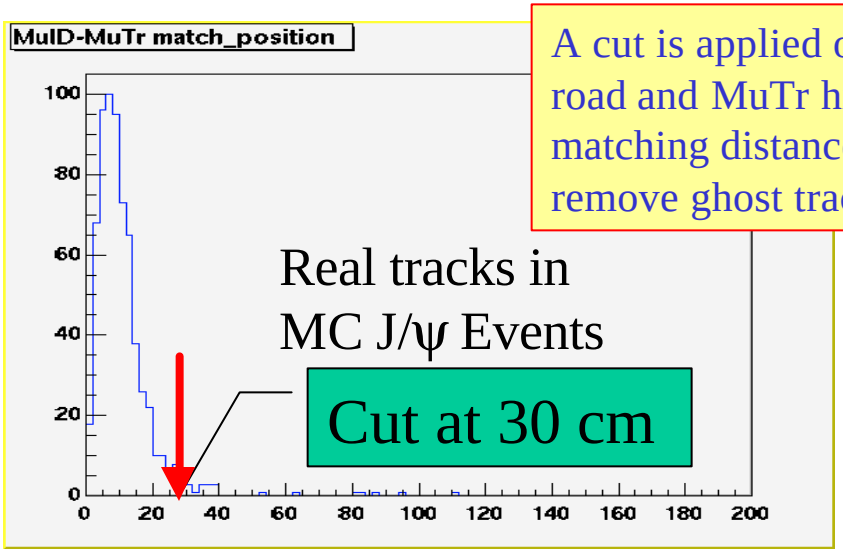
Tracking - ghost track removal

Reconstructed muons suffer from a large number of ghost tracks in the AuAu events as very loose cuts were used in the pattern recognition to keep a high track finding efficiency

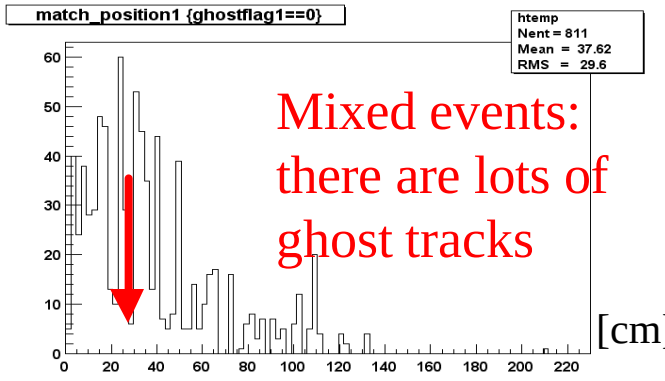
- To remove ghost tracks:
  - apply global track fitting quality cuts
  - require muon ID and muon tracker match
- Use MC tune cuts
  - J/ψ signals
  - J/ψ mixed w/ AuAu data







A cut is applied on muID road and MuTr hits matching distance to remove ghost tracks



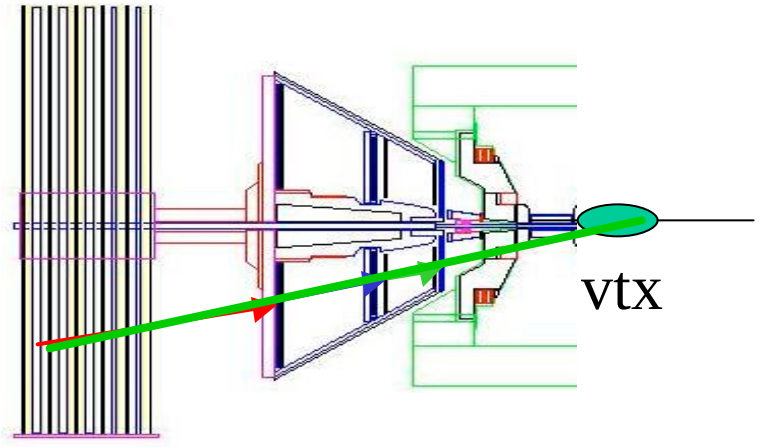
MuID road and MuTr matching distance

Expectations from MC Simulation

- Vertices for single-muon are peaked at locations farther from south muon arm as expected for muons from pion and kaon decays

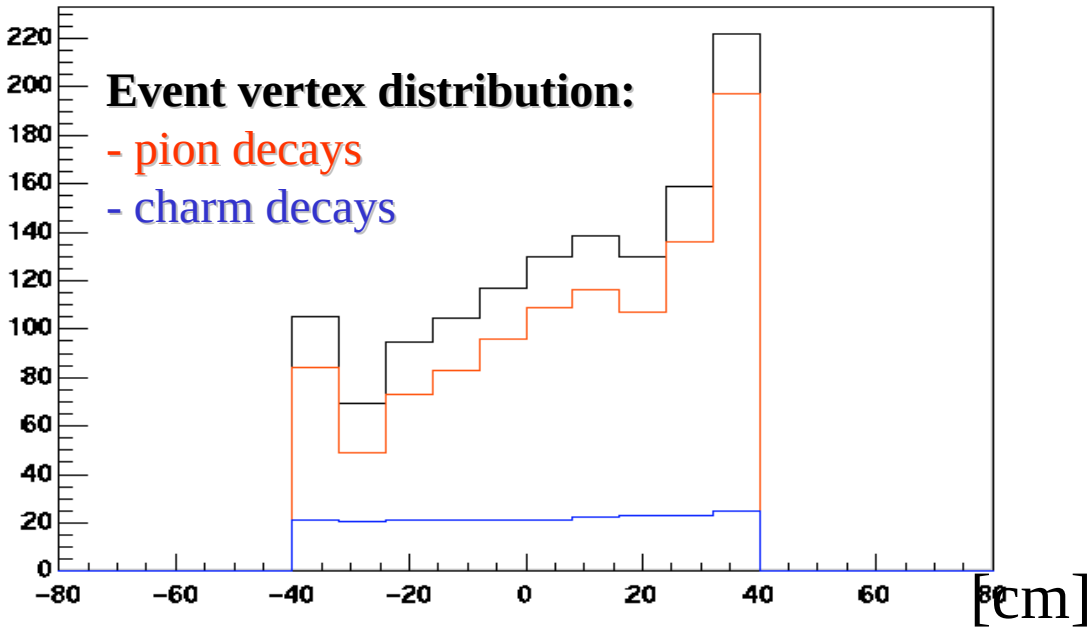
- Muons from heavy quark decay are independent of vtx position

- Many pions and kaons are produced in Au-Au collisions at RHIC



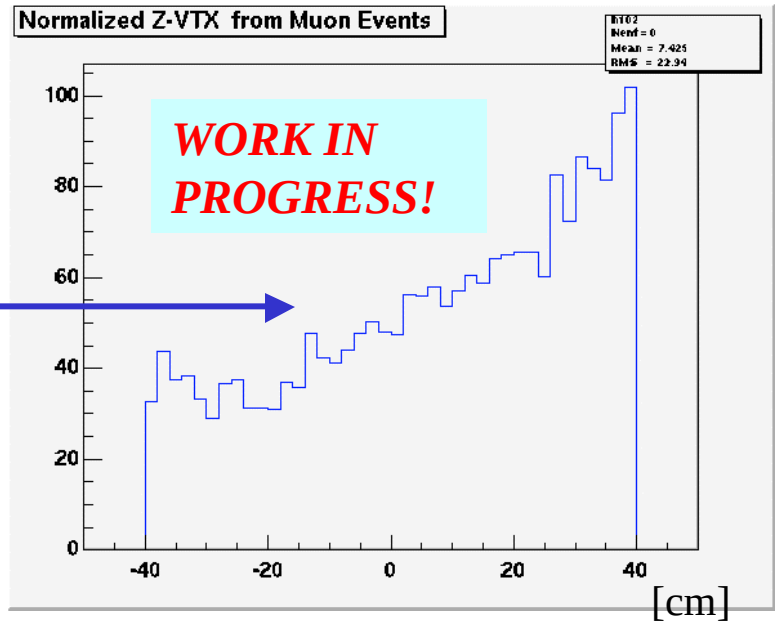
$$Br(p^+ \rightarrow m^+ n) = 99.99\%$$
$$ct(p^\pm) = 7.80m$$

$$Br(K^+ -> m^+ n) = 63.5\%$$
$$ct(K^\pm) = 3.71m$$

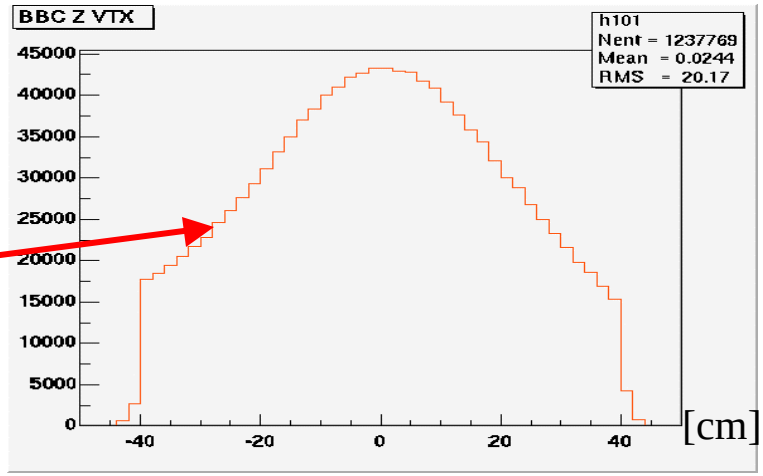


Muon Event VTX from Real Data

- Applied track quality cuts to select events with good muons.
- Normalized Z vertex distribution from events that have at least one good muon candidate.
- As expected, a significant contribution of muons from K/pi decays is observed



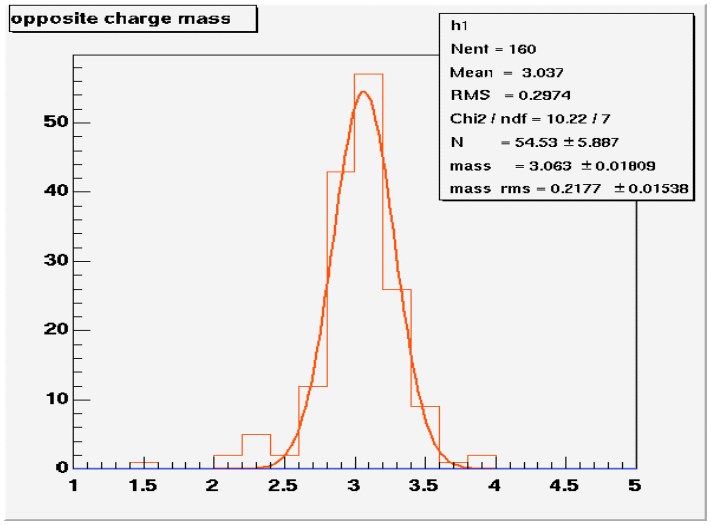
Collision Z vertex distribution from minimum bias triggered events



MC J/ψ Embedded into Au-Au Data

- Simulation used real gain and noise to match real data
- Mixed signal with real Au-Au event at 1:1 ratio to check J/ψ reconstruction efficiency. (Note: expect ~O(1) J/ψ events from 1 million minimum bias triggered events)
- Reconstructed events as "real data"

Input MC J/ψ signal

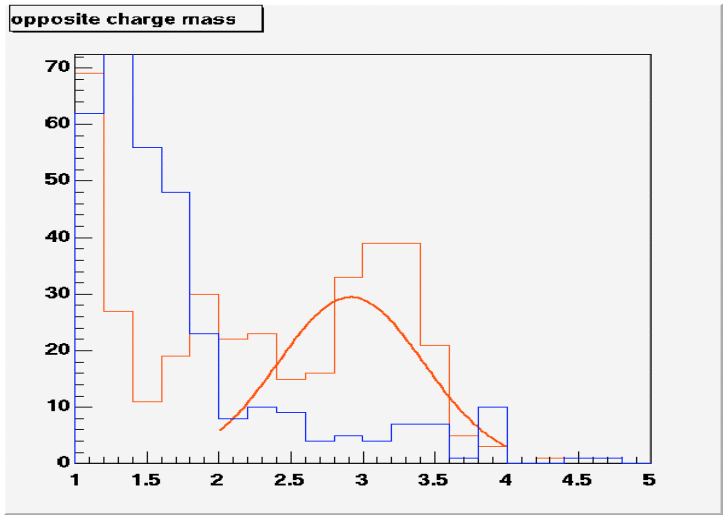


Dimuon mass (GeV)

MC J/ψ Mixed with AA data

RED: opposite signed pairs

BLUE: same signed pairs

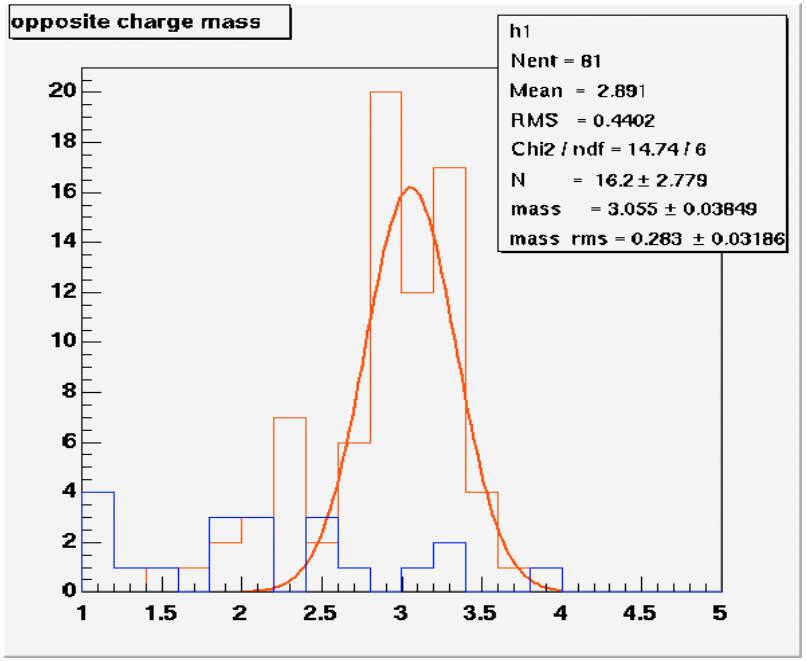


Dimuon mass (GeV)

Apply quality cuts to both mixed and background AA events

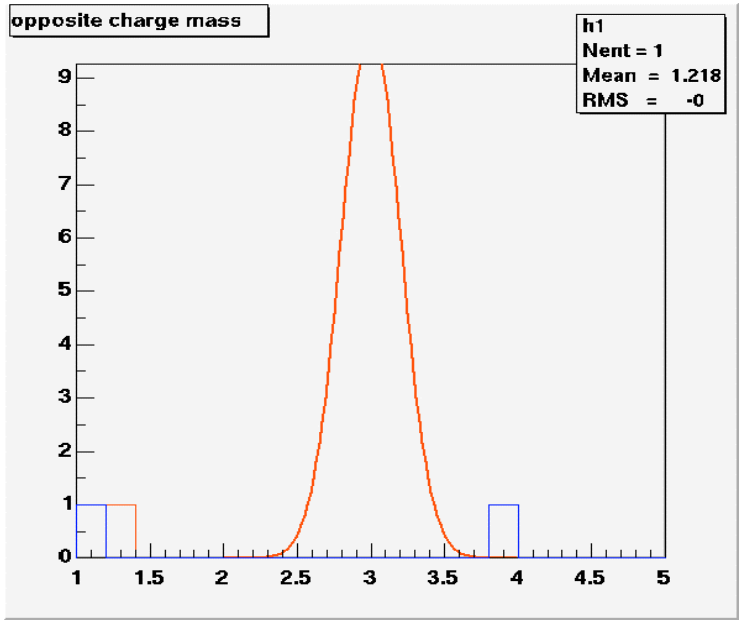
Effectively removes most of the ghost tracks

Dimuon mass from mixed events. J/ψ can be cleanly reconstructed by the offline code in the high multiplicity mixed events.



Dimuon mass (GeV)

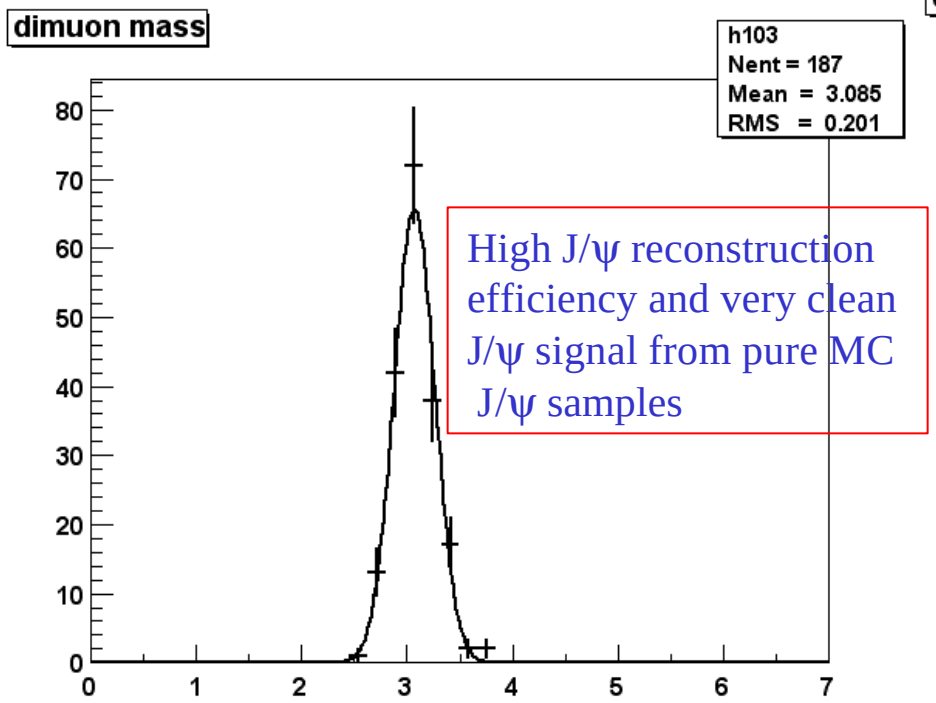
Dimuon mass from background AA events used in the embedding analysis. No events are found in the J/ψ mass region



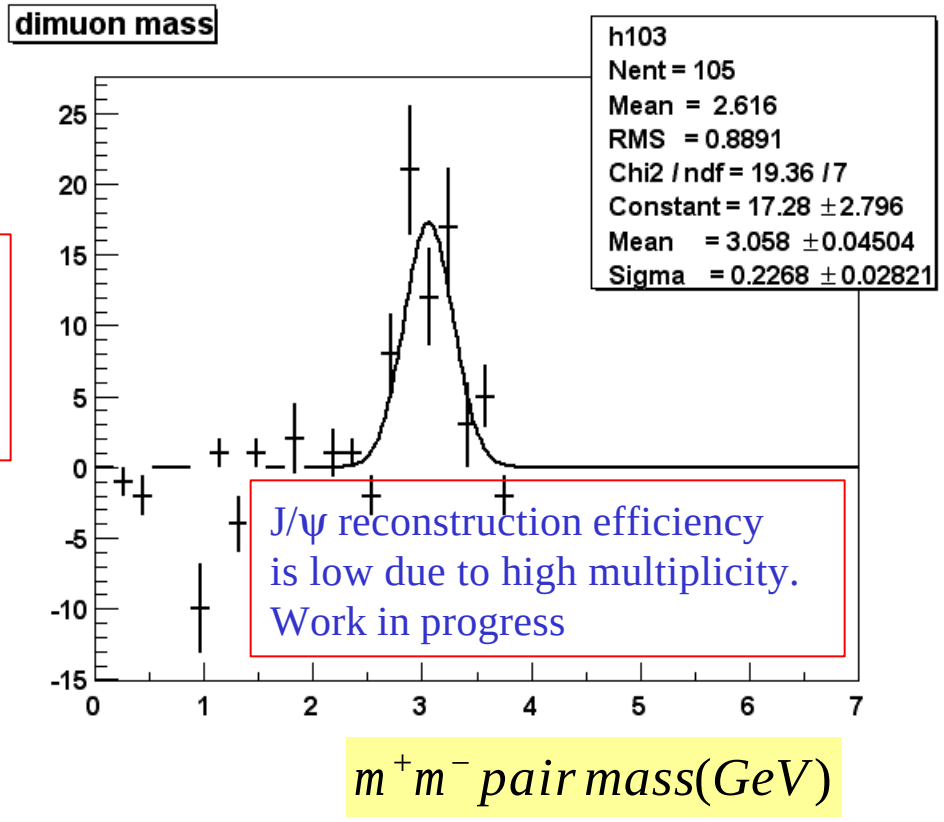
Dimuon mass (GeV)

Background subtracted MC J/ψ signal

- Input MC J/ψ signals

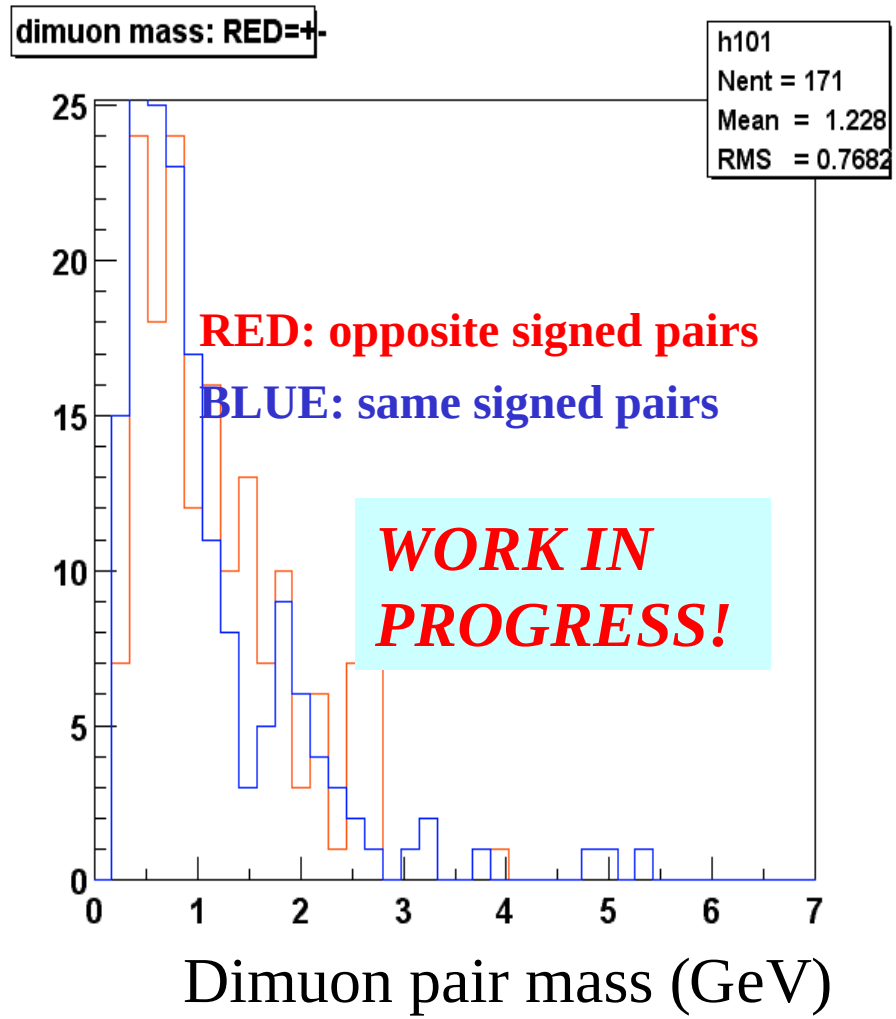


- MC J/ψ + real Au-Au



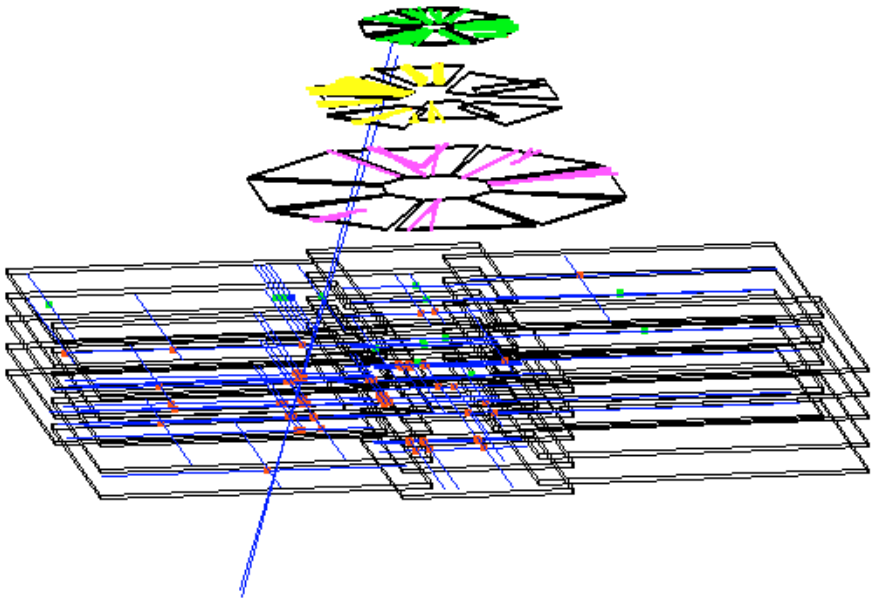
Dimuon mass from real data

- Analyzed ~ 1 million Au-Au minimum bias triggered events
- Expected J/ψ ~ O(1) if scaled with binary collisions
- Need more statistics (we do have x100 data on tape!)
- See H. Sato's poster for p-p data where event multiplicity is much lower.



Summary and Outlook

First Au-Au collision events were observed on 07/18/2001



- Successfully installed and commissioned muon detector in the PHENIX
- Analyzed ~ 1 Million (1%)Au-Au events collected in Run-2
- Lots of progress in understanding muon track reconstruction and ghost rejection
- Processing of the whole data set is in progress