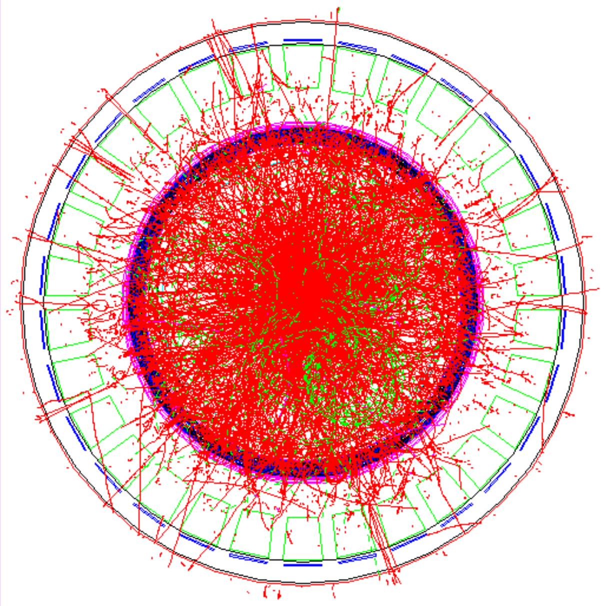
The Muon Telescope Detector (MTD): Opening New Capabilities at STAR



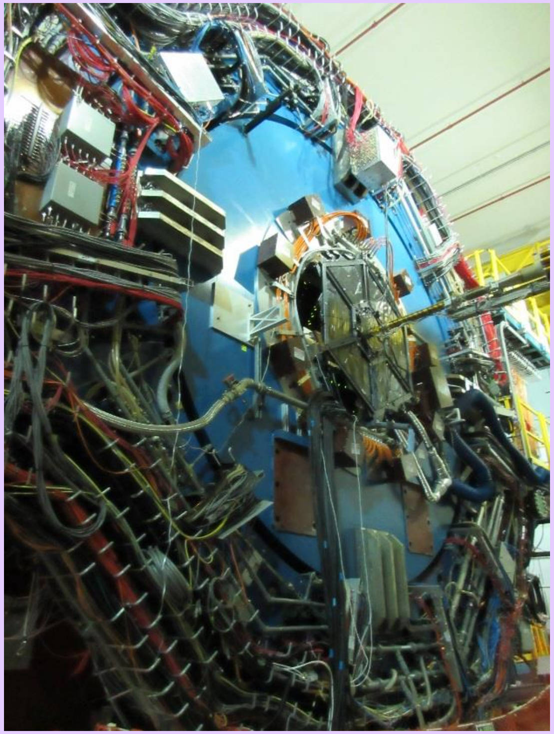
Kathryn Meehan *for the STAR Collaboration*

UC Davis

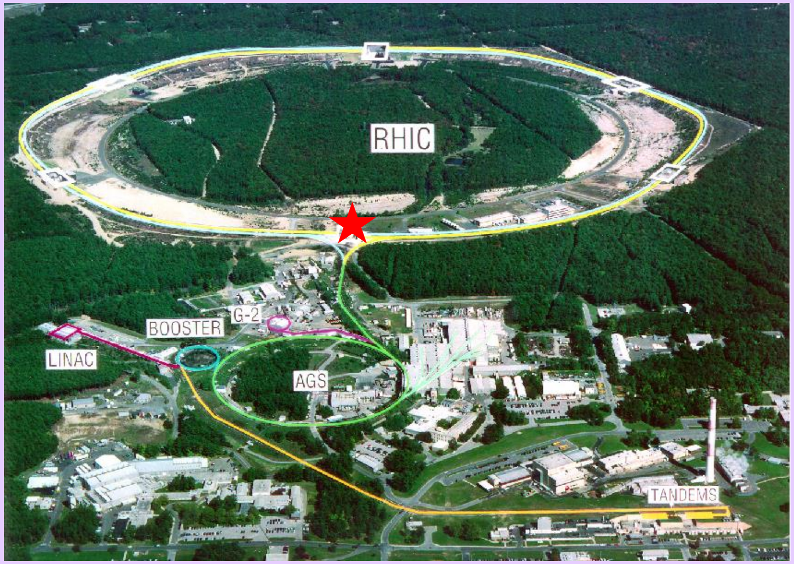
APS Far West Section Meeting

Oct 25, 2014

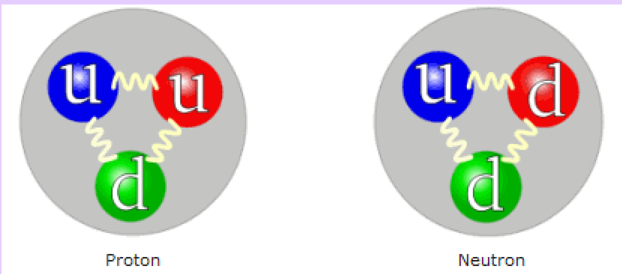
STAR: Solenoidal Tracker at RHIC



RHIC = Relativistic Heavy Ion Collider

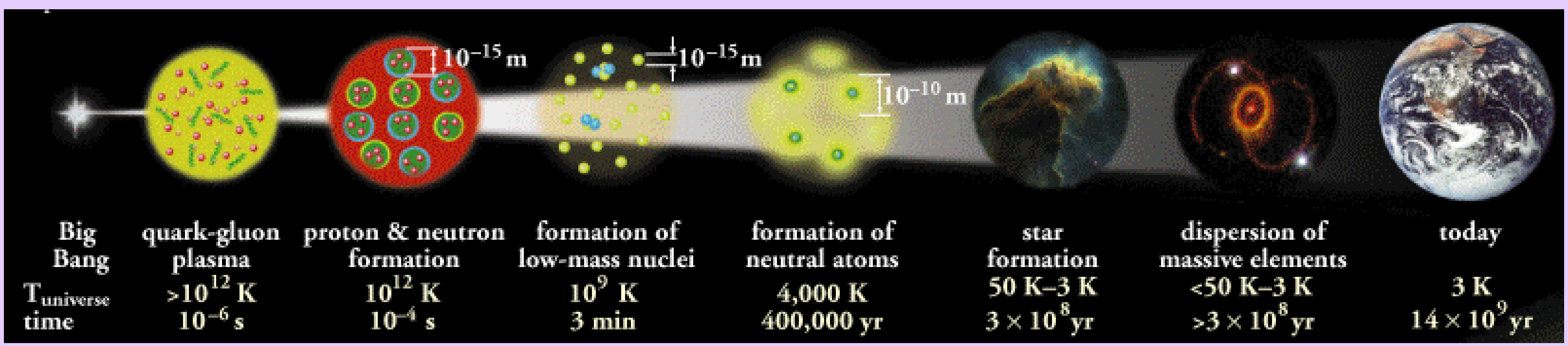


QGP: A New State of Matter

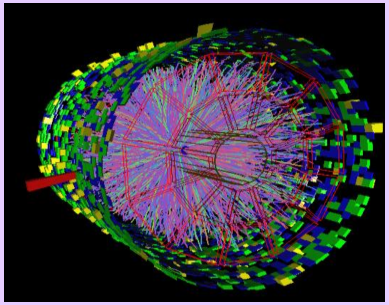


Quark composition of a proton and a neutron (diagrams from *Wikipedia*)

- Over 250,000 times hotter than center of the sun!
- About trillionth of a cm across and lasts about 10^{-23} s
- Only high-temperature system to study strong interaction

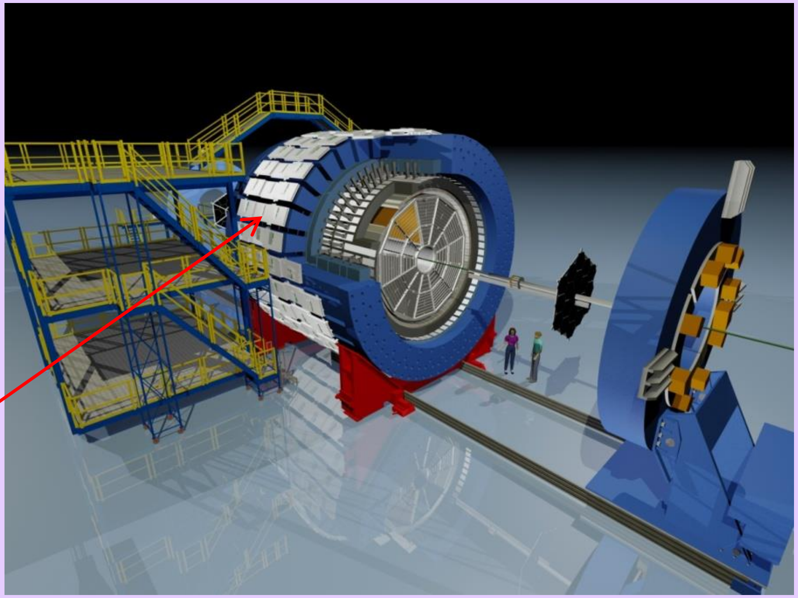


Detectors of STAR



From innermost to outermost layer:

1. Beam pipe
2. Silicon detectors for particle tracking
3. Time Projection Chamber (tracking and particle id)
4. Time of Flight (TOF) Detector (extends particle id)
5. Electromagnetic Calorimeter (measures energy)
6. Magnet $B_{solenoid}$=0.5 T, $B_{return\ bar}$~1.26 T
7. Muon Telescope Detector

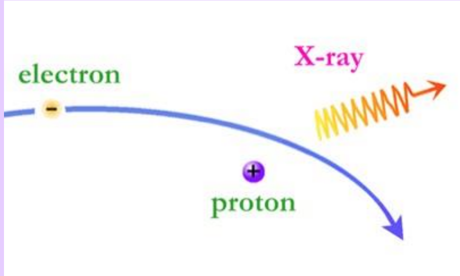


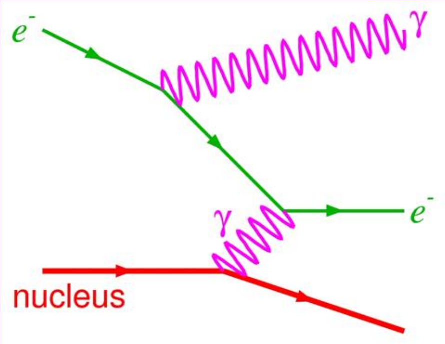
Motivation for MTD

Can study QGP through the "muon channel":

- easier to select which events to study
- less energy loss in detector

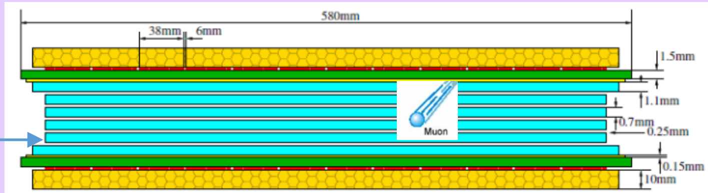
$$\frac{dE_{rad}}{dx} \sim \frac{1}{m^2} \qquad \frac{m_\mu}{m_e} \sim 200$$



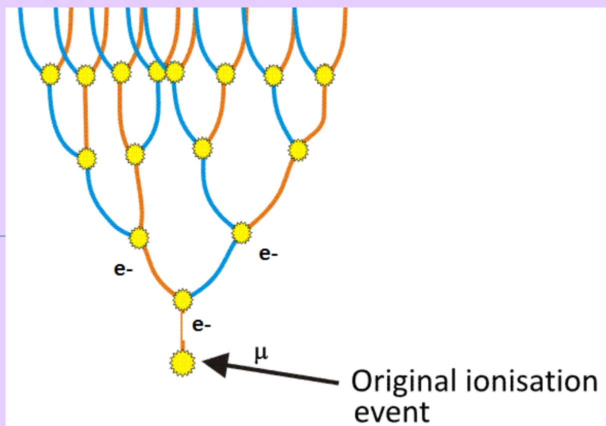


Cartoon and Feynman diagrams of Bremsstrahlung radiation

The Muon Telescope Detector



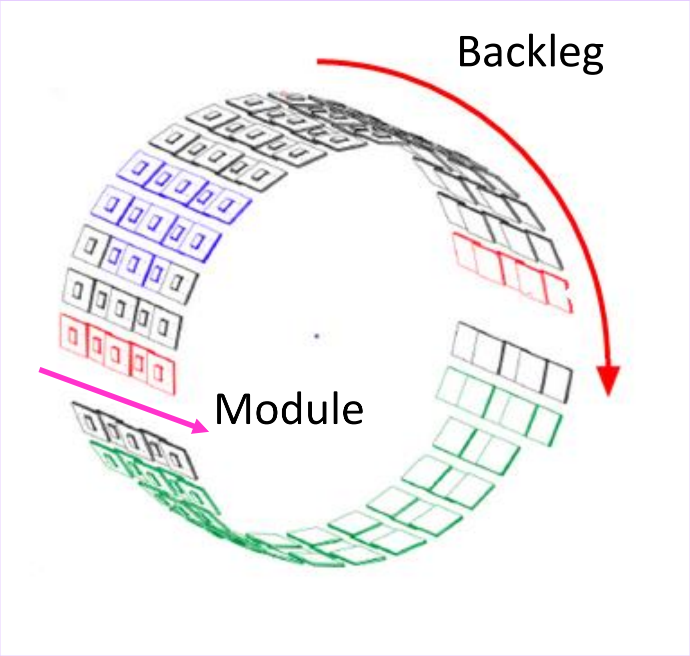
Multi-gap Resistive Plate Chamber (MRPC)

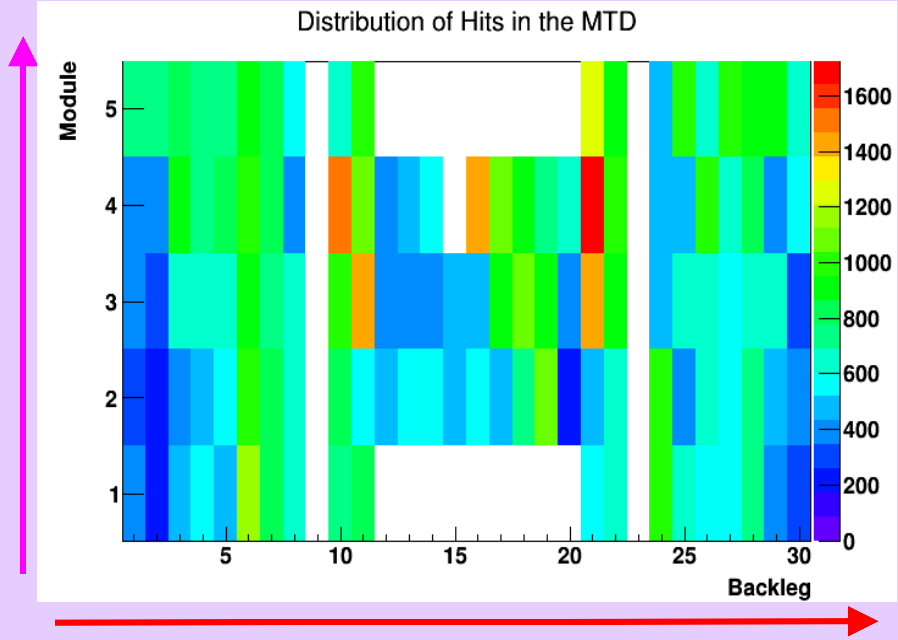


- MTD uses MRPCs to record hits
- Combined with timing and energy information from other detectors we can select events of physics interest

MTD Acceptance

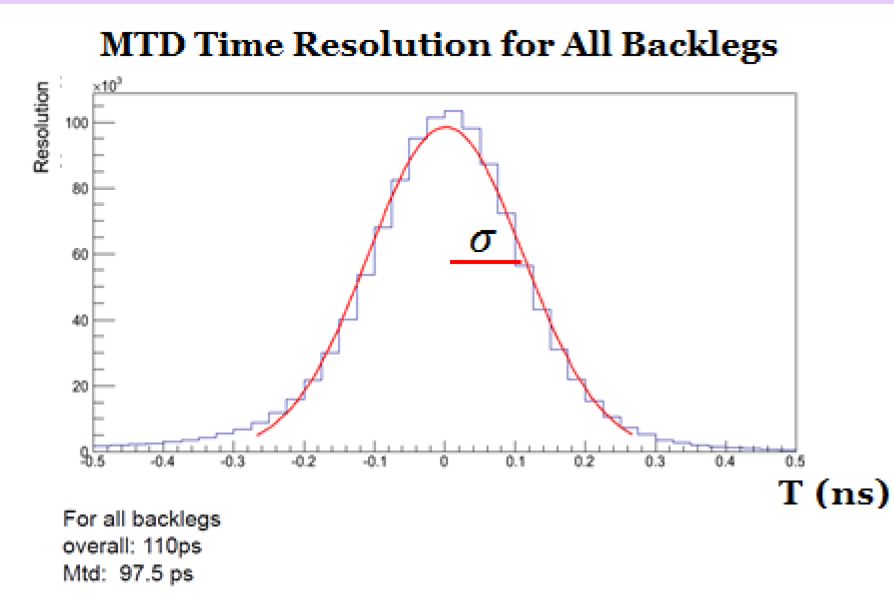
Acceptance is 45% in azimuth with a pseudo-rapidity range of $|\eta|<0.5$

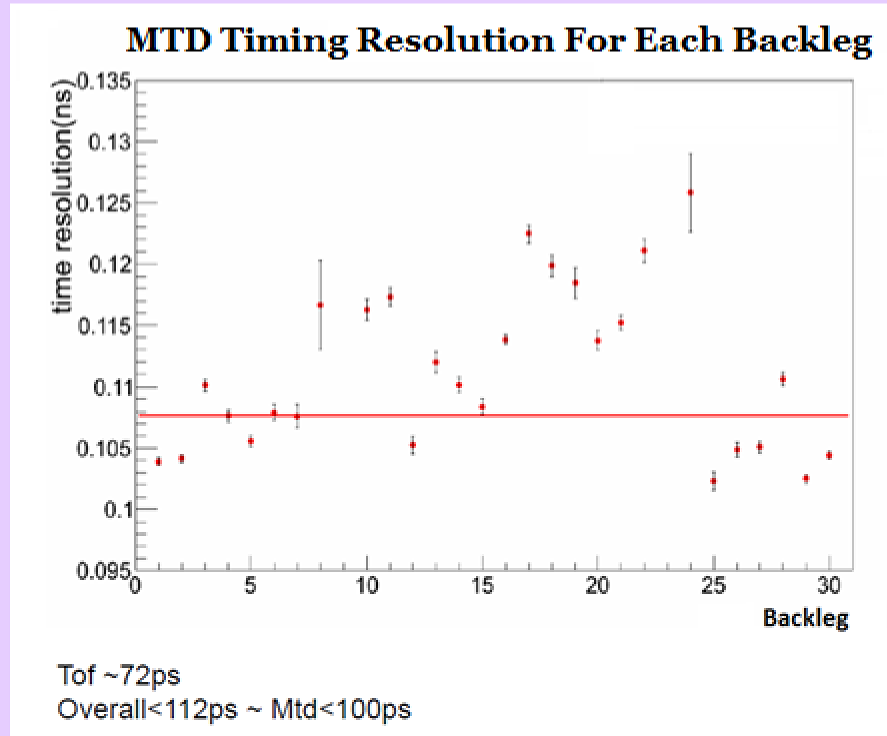




Cosmic Ray MTD Calibration

- timing resolution: ~100 ps





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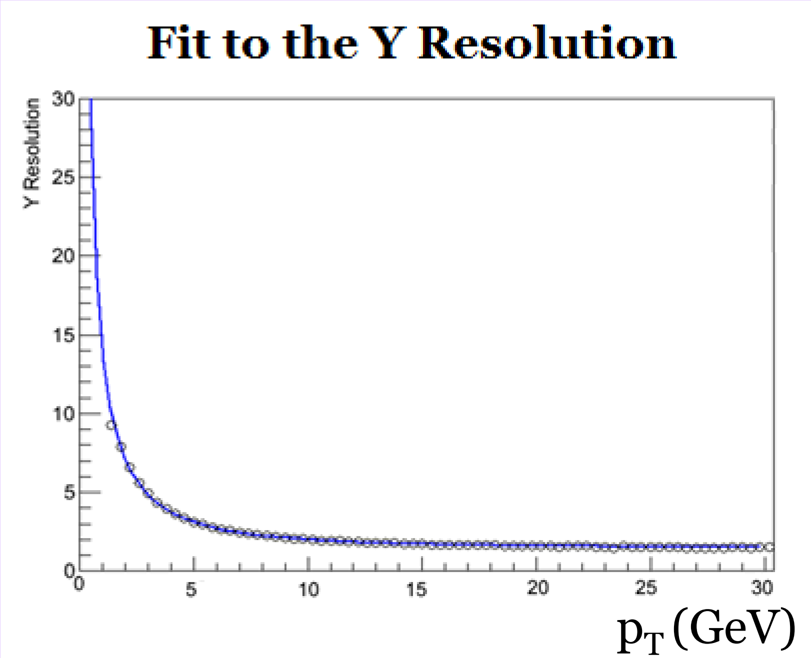
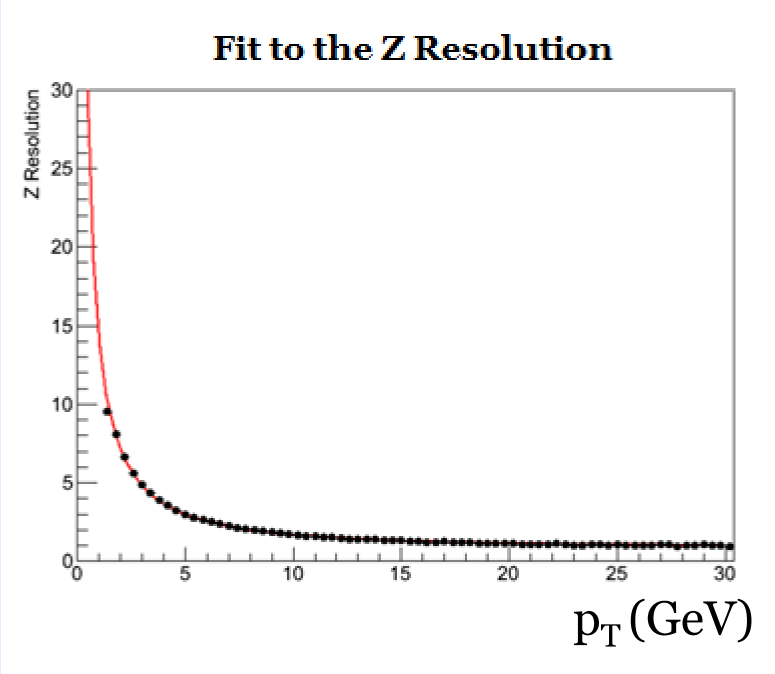
MTD Spatial Resolution: ~1-2 cm



$$\sigma_{\Delta y}(p_T) = \sqrt{(p0/{p_T}^2) + p1}$$

$\sqrt{p1}$ is the spatial resolution of MTD in absence of multiple scattering



Overall spatial resolution:

Y-direction: ~1.5 cm
Z direction: ~1 cm

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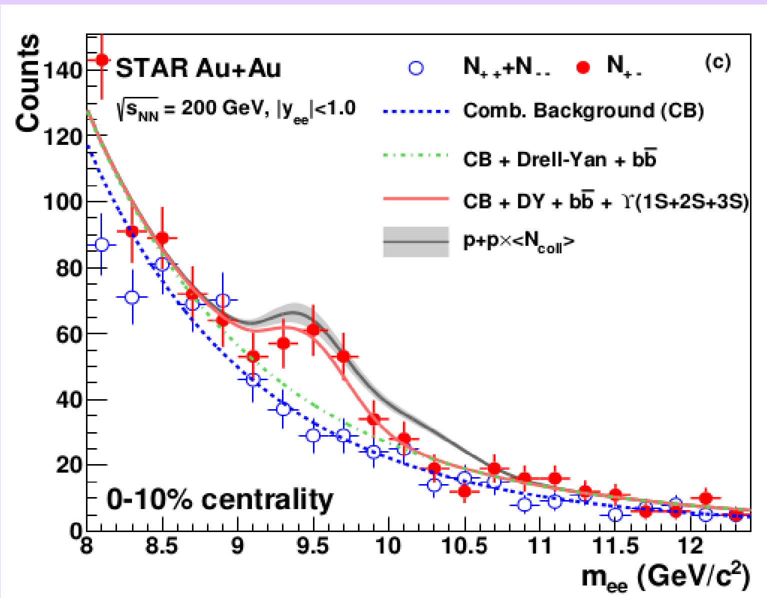
Predicted MTD Performance

Current Dielectron Spectrum



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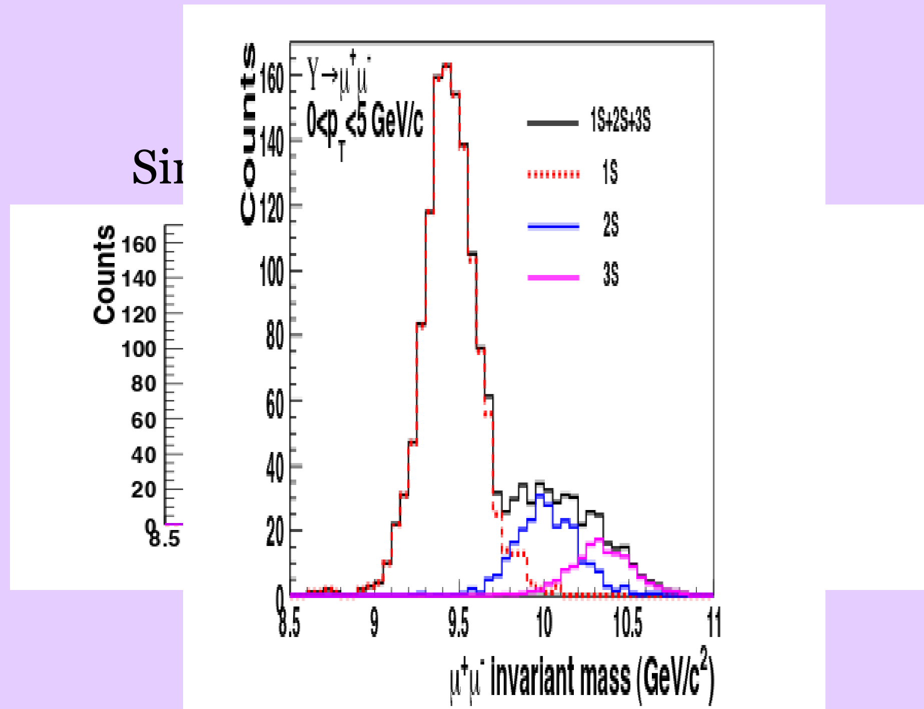
Integrated luminosity =1.08 nb^{-1}
ϒ(1S+2S+3S) Counts (0-10%) =66±17
Total ϒ Counts ~250



Integrated luminosity ~26 nb^{-1}
Expected ϒ Counts~9300

Conclusion

- MTD fully installed and took first data in Run 2014
- Cosmic ray calibration performed:
  - spatial resolution of ~1-2 cm
  - time resolution of ~100ps
- STAR now has a new channel open for studying heavy flavor physics!
  - J/Ψ analysis
  - ϒ analysis
  - μ-e correlations