PHENIX Run-12 Heavy Ion Report

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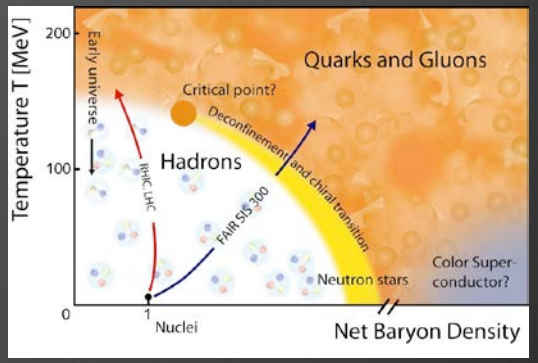
Story Line

- Run-12 Heavy Ion Physics Goals
- What were the PHENIX plans?
- How did PHENIX do?

Study QCD Matter in Difference Phases



Cast and Crew

Heavy Ion Physics Goals

Study QCD Matter Properties at
Extreme High Temperature and Density

Recent and Future RHIC Run Summary

Run	Species	√s	Wks	±30 cm	±10 cm	Pol	Comments
11	p+p	500	10	27 pb^{-1}		50%(L)	W program + ΔG
	Au+Au	19.6	1.5	13.7M MB evts			energy scan
	Au+Au	200	7	915 μb^{-1}	790 μb^{-1}		heavy flavor (VTX)
	Au+Au	27	1	5.2 μb^{-1}			energy scan
12	p+p	200	4.4	9.2 pb^{-1}	2.9 pb^{-1}	~60%(T)	HI ref. + transv. spin
	p+p	510	4.9	30.0 pb^{-1}	9.9 pb^{-1}	50%(L)	W program + ΔG
	U+U	193	2.9	171.2 μb^{-1}	89.9 μb^{-1}		explore geometry
	Cu+Au	200	5.5	**2.9nb^{-1}**	**2.4 nb^{-1}**		control geometry
13	p+p	510	15	250 pb^{-1}		60%(L)	W program
	p+p	200	~5	20 pb^{-1}	5.5 pb^{-1}	60%(T)	HI ref. + transv. spin
14	Au+Au	200	6-8	1.7 nb^{-1}	1.0 nb^{-1}		high bandwidth
	d+Au	200	rest	260 nb^{-1}	150 nb^{-1}		CNM

PHENIX Beam Use Proposal for Run-13 & Run-14 was recently submitted.

Run-12 Heavy Ion Program

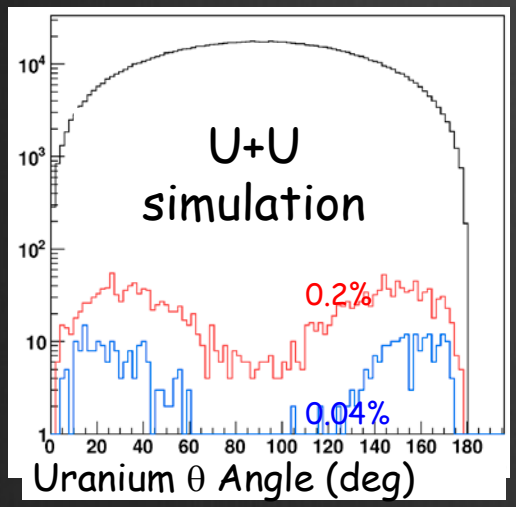
- p+p collisions at 200 GeV: Heavy ion reference measurements for separating charm and beauty.
- U+U at 193 GeV: Exploring colliding geometry.
- Cu+Au at 200 GeV: Use the unique geometry (core vs corona and asymmetric peripheral) of the colliding system

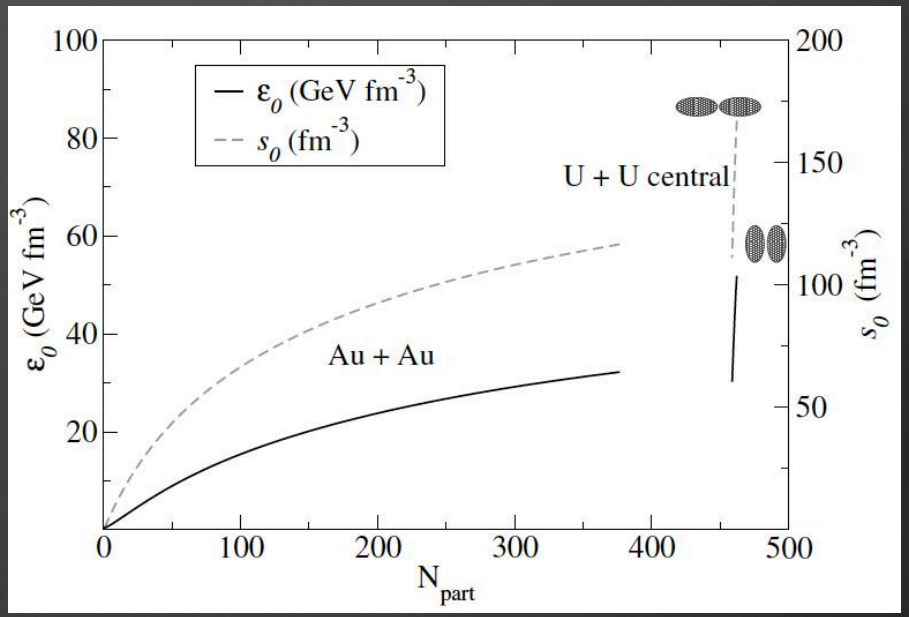
Projected Goals

Species	sqrt(s_NN)	Weeks	Int L dt (|z| <10 cm)
p+p	200 GeV	4	3.8 pb^{-1}
U+U	193 GeV	3	60 μb^{-1}
Cu+Au	200 GeV	5	2.4 nb^{-1}

U+U Collisions

Allow us to explore early time dynamics and thermalization: a) varying the eccentricity for flow studies; b) varying path length for parton suppression studies.





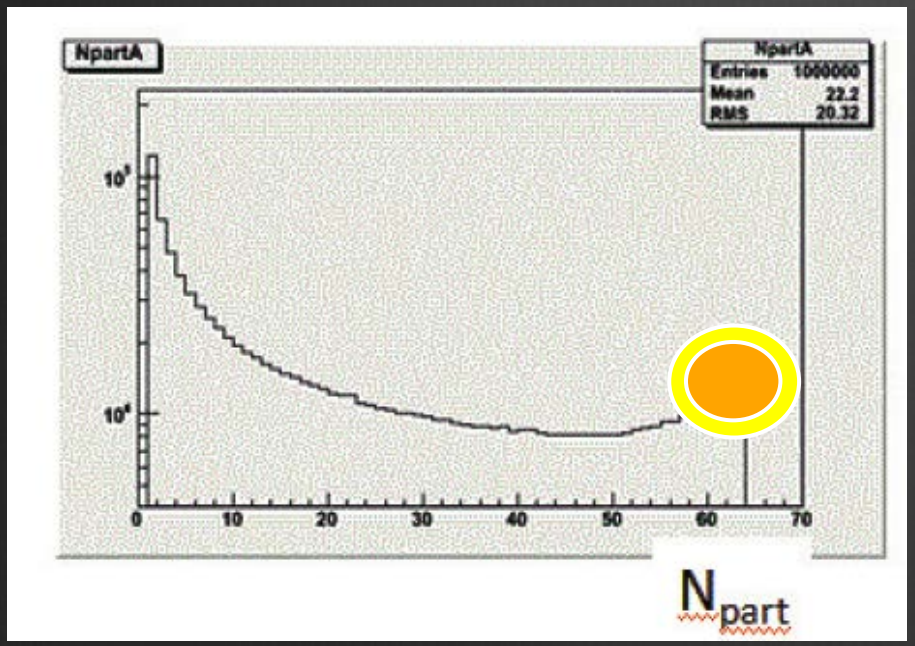
U. Heinz

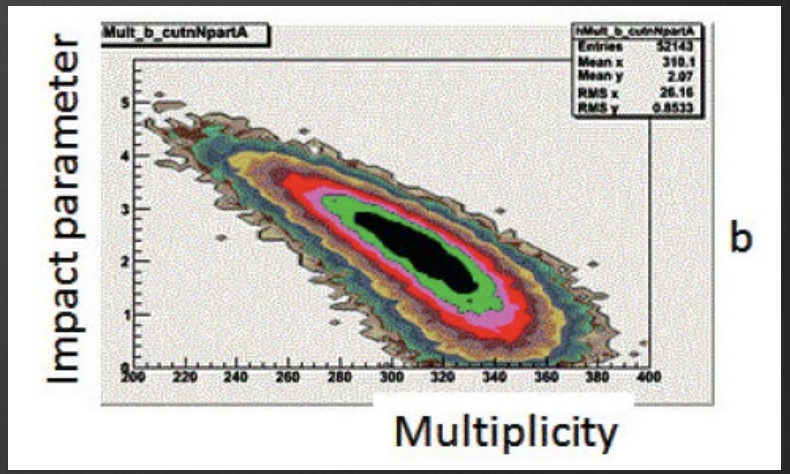
U+U energy density (65% larger than Au+Au for tip-tip)

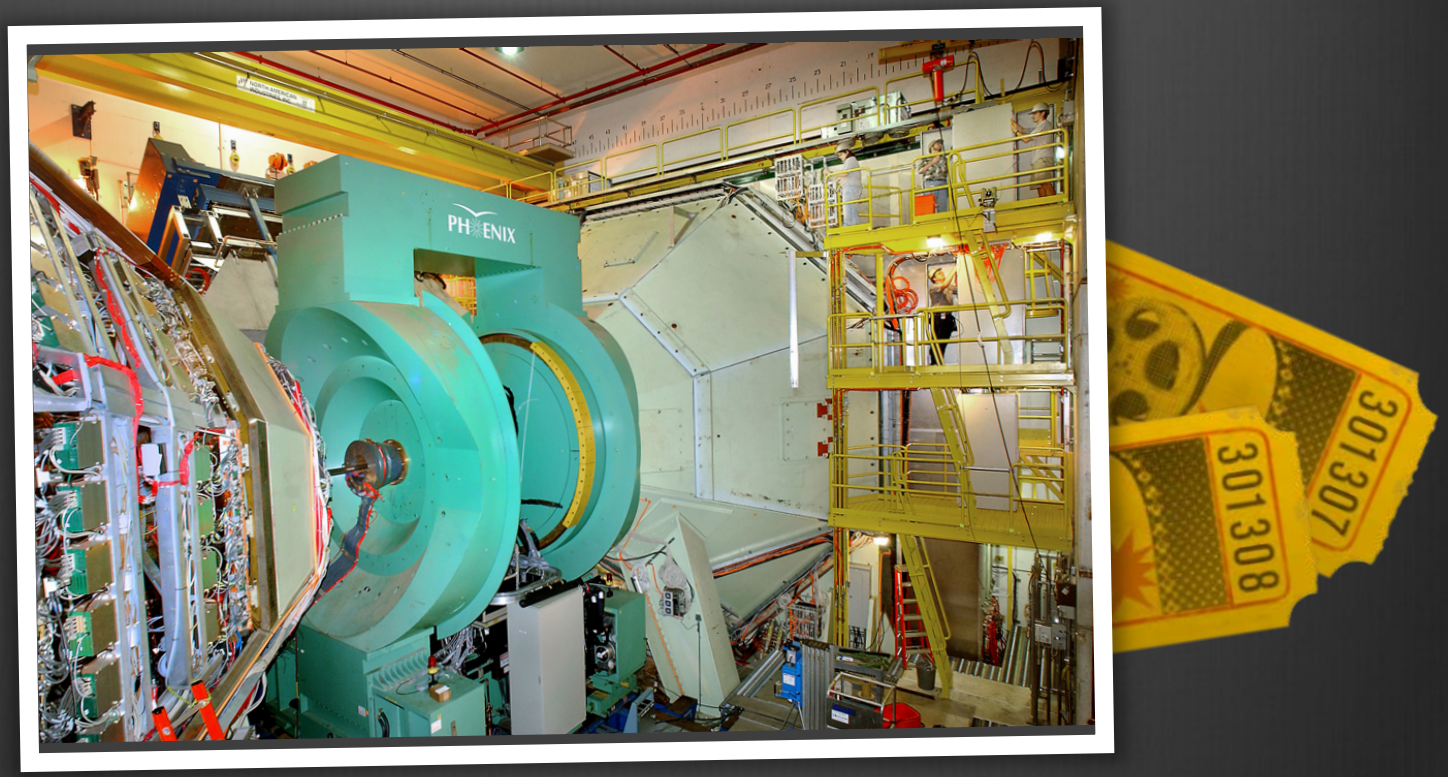
The key to utilizing UU collisions for these purposes is the ability to disentangle the various geometries of the individual interaction !!!

Cu+Au Collisions

- Cu buried inside Au for most central collisions
  - Minimize effects of the surface on hard probes
  - Select top 3% centrality class for this study
- Eccentricity w/o left/right symmetry for non-central collisions
  - Non-fluctuation source of odd harmonics.







PHENIX Detectors

Emphasize newly commissioned detectors

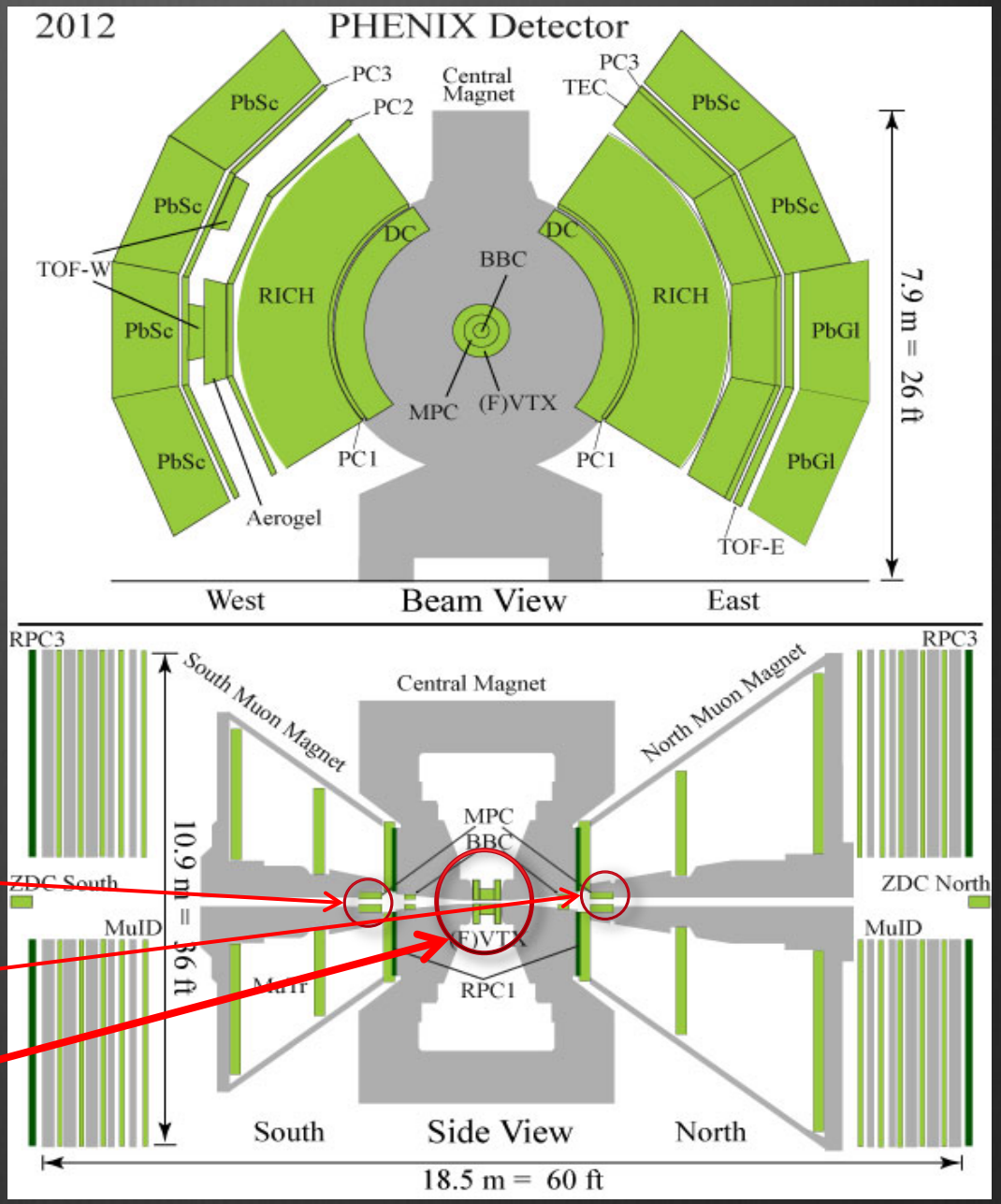
Central Arms:
- hadrons, photons, electrons
- $|\eta| < 0.35$
- $\Delta\varphi = \pi$ (2 arms x $\pi/2$)

Global Detectors:
- Beam-Beam Counter (BBC)
- Zero Degree Calorimeter (ZDC)

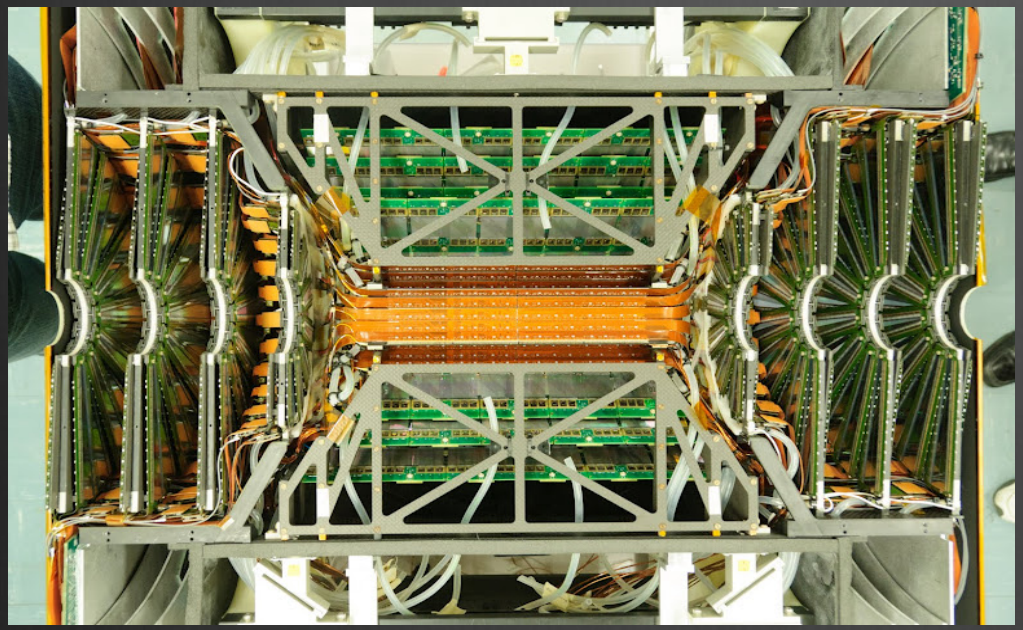
Muon Arms:
- muons
- $1.2 < |\eta| < 2.2$
- $\Delta\varphi = 2\pi$

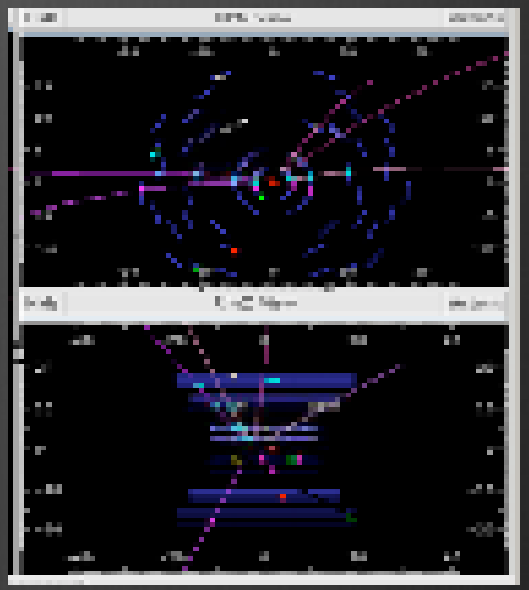
MPC:
- $3.1 < |\eta| < 3.9$
- $\Delta\varphi = 2\pi$

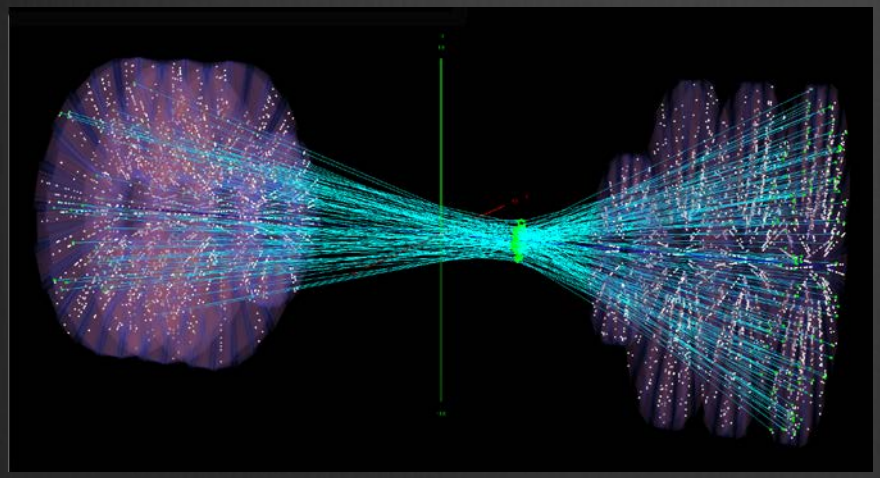
VTX/FVTX

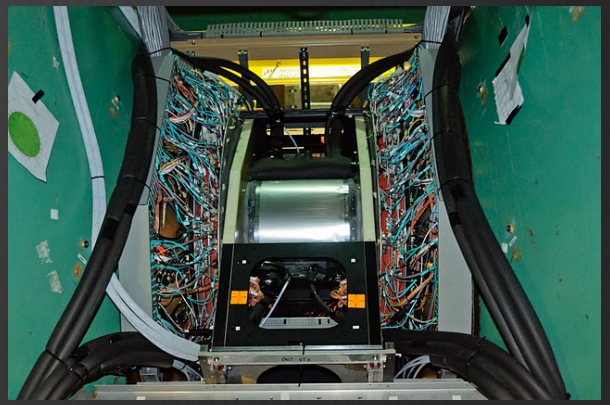


New detector, better precision physics measurement, with new challenges too.



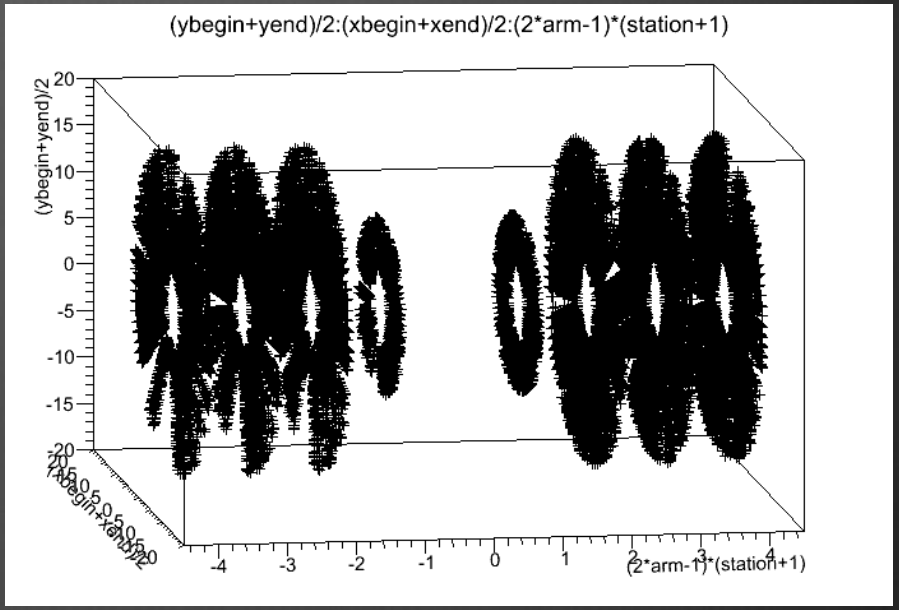




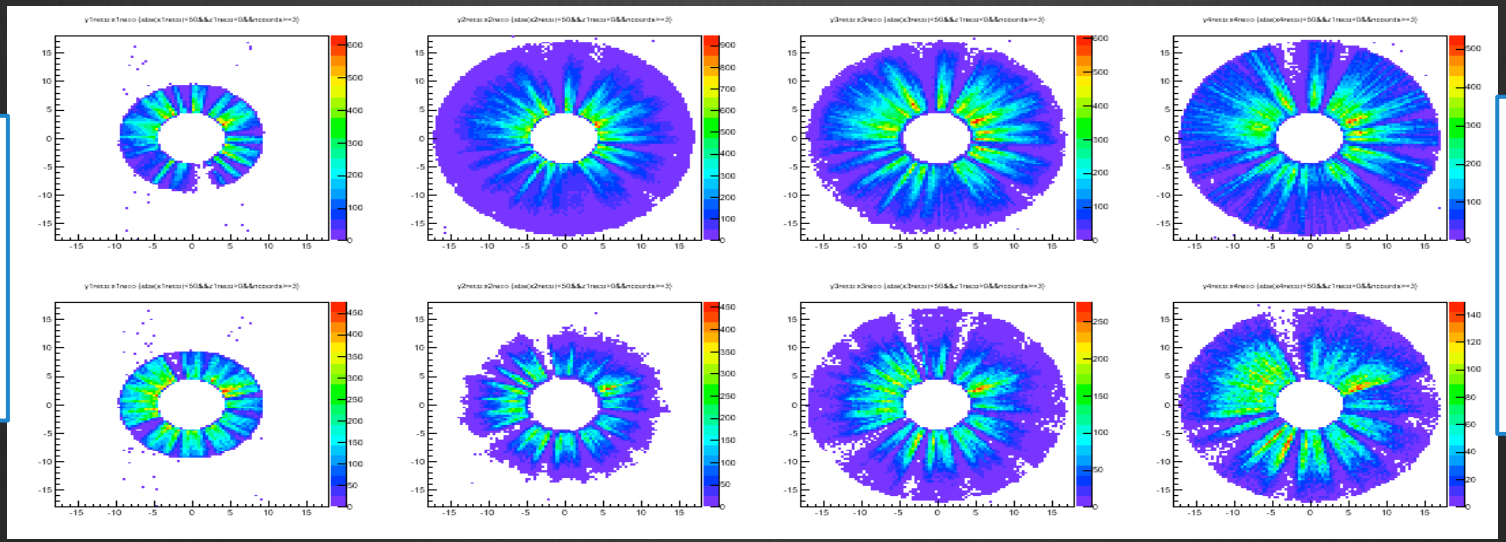


FVTX

Detector Commissioning + Software Development

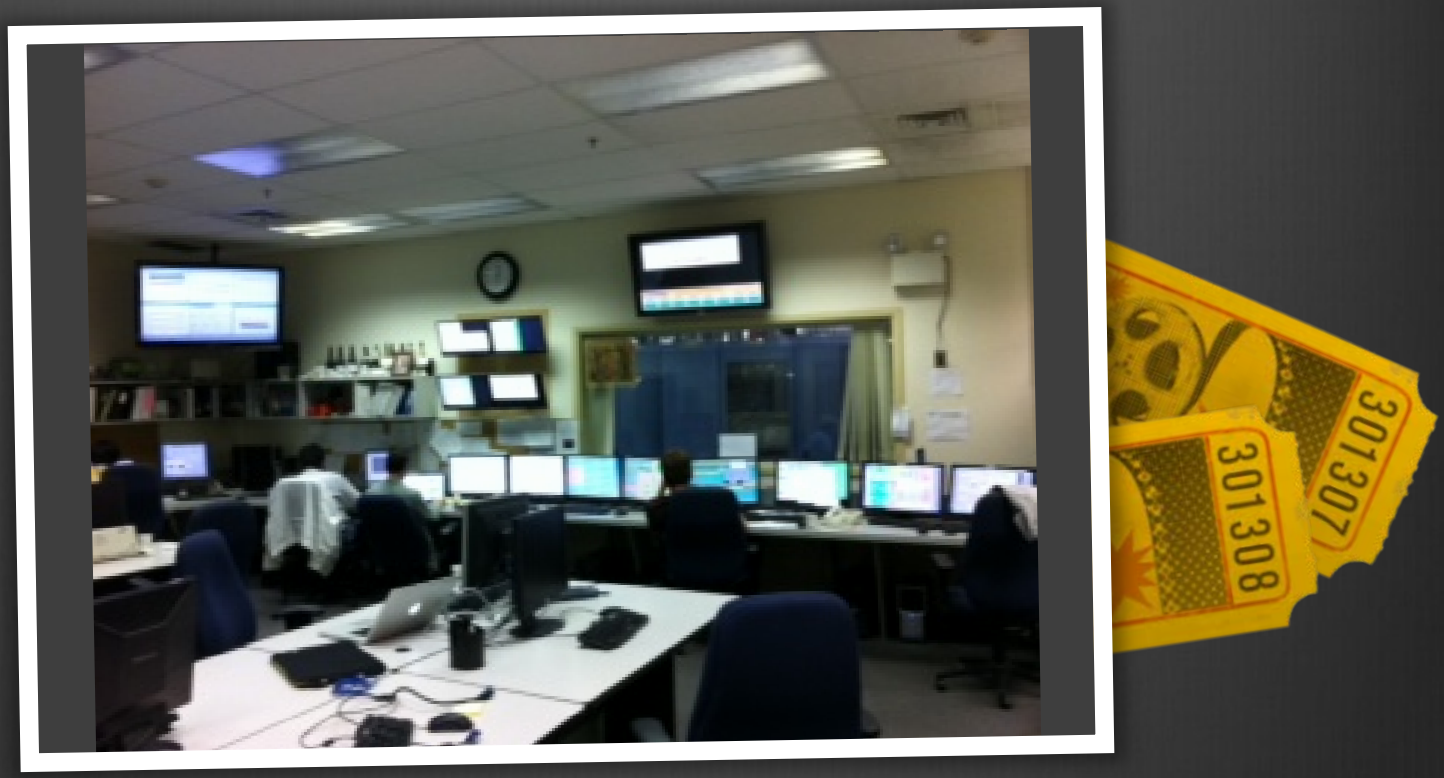


Close to IR



Away from IR

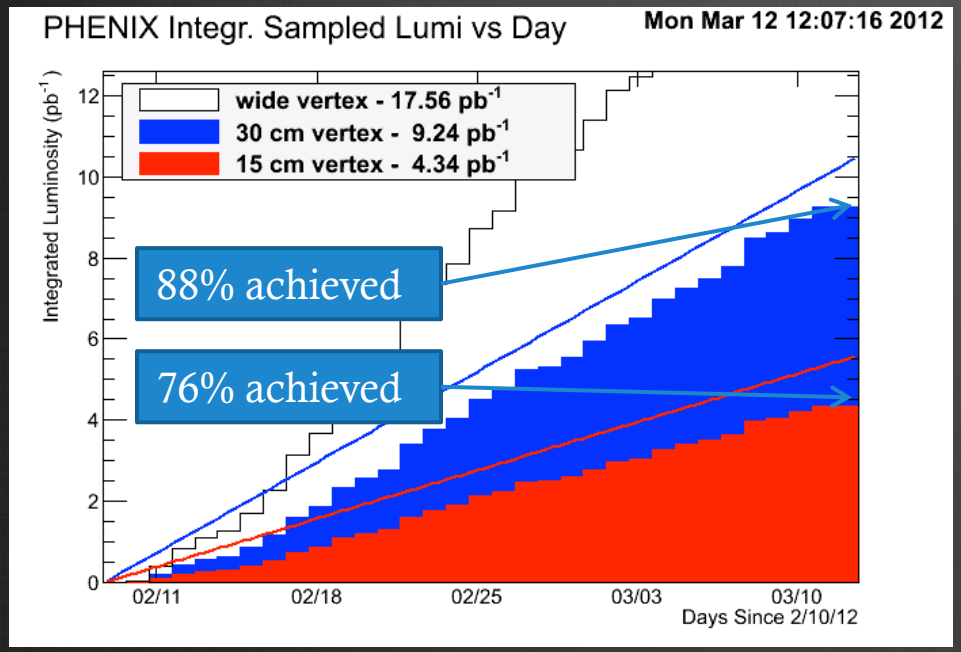
Hits distribution from matched tracks from existing muon spectrometer



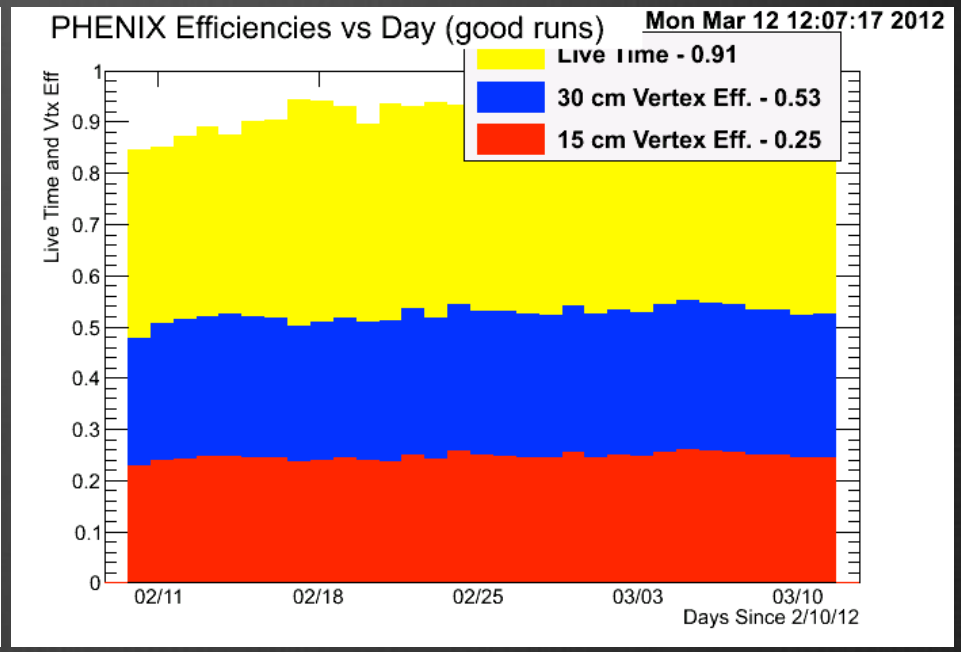
PHENIX Data Taking

Comparison Measurement 200 GeV p+p (polarized protons)

Integrated Sampled Luminosity



Collision Vertex Distributions

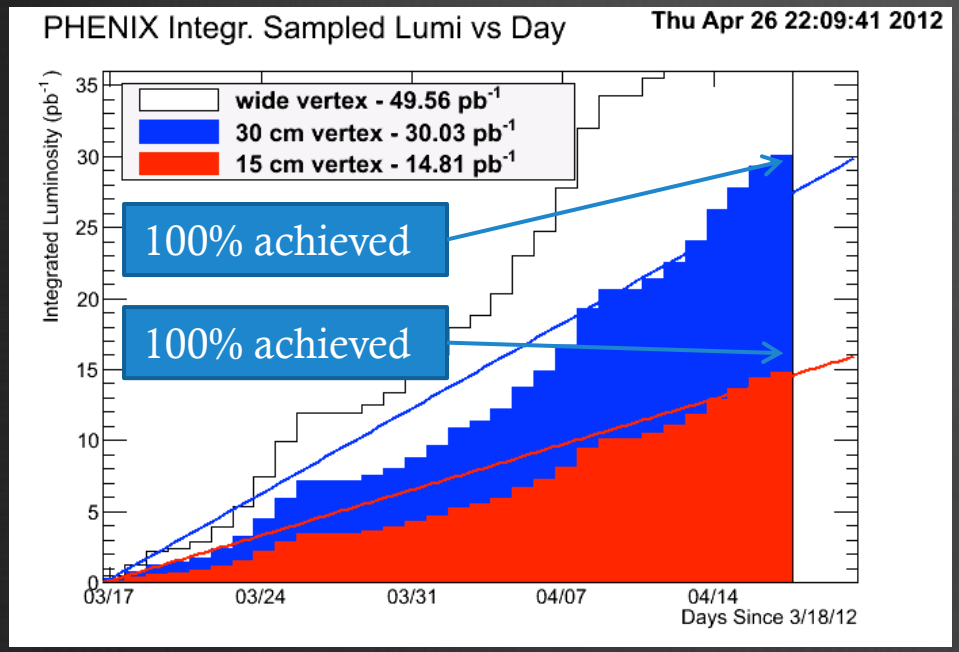


Goal: 10.5 pb^{-1} for $|z|<30$ cm & 3.8 pb^{-1} for $|z|<10$ cm

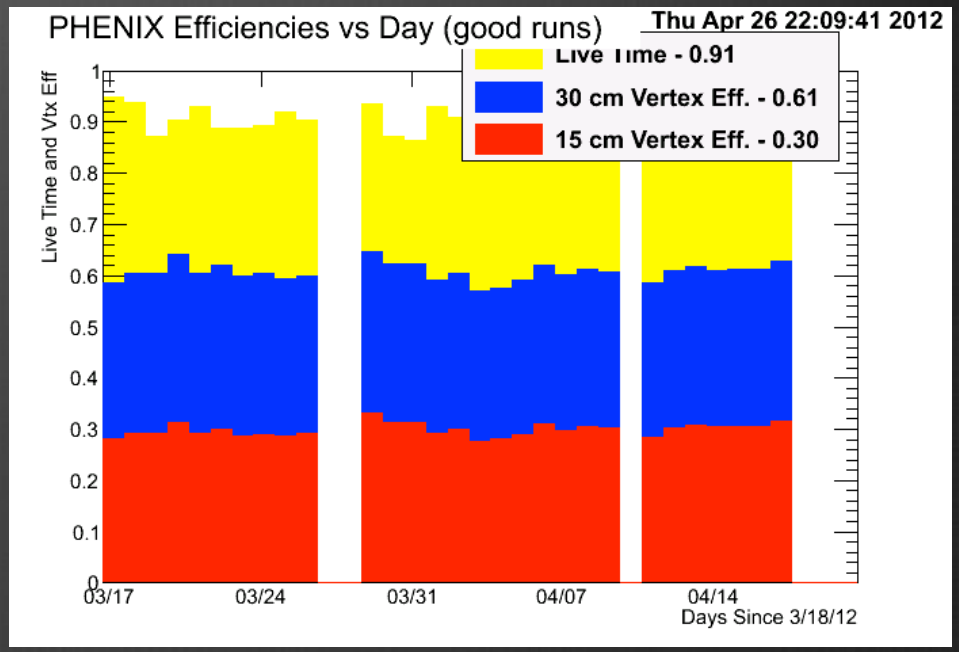
We collected over 4.5 billion physics events !!!

W Physics Program
510 GeV p+p (polarized protons)

Integrated Sampled Luminosity



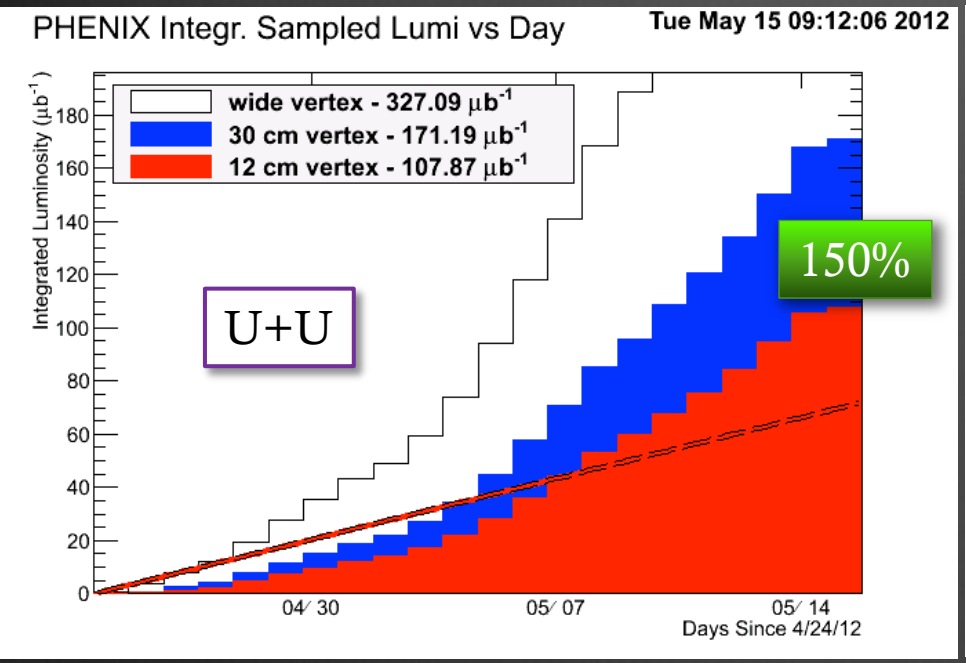
Collision Vertex Distributions

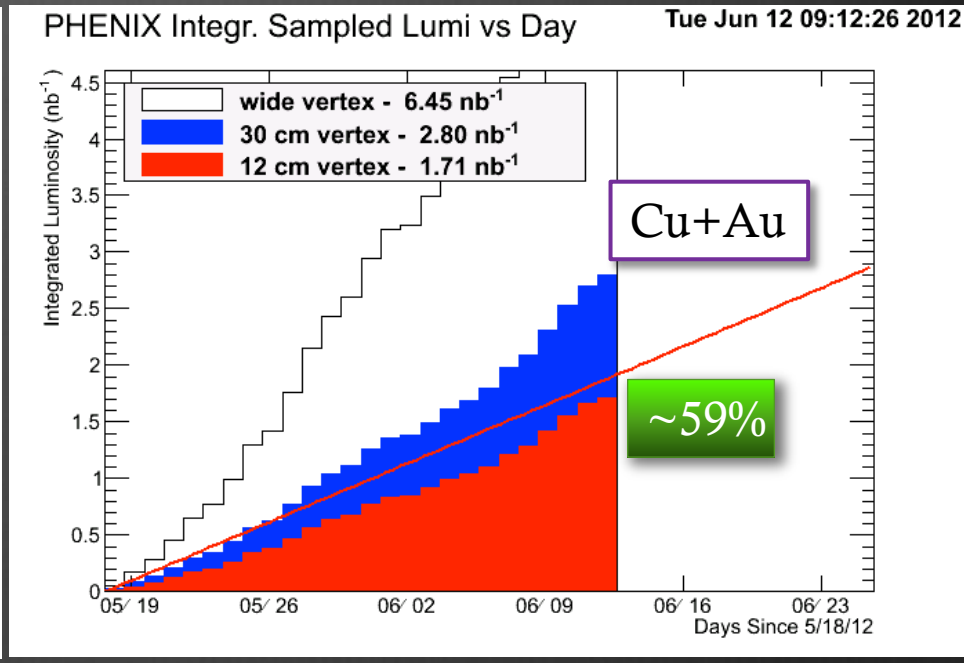


Goal: 30 pb^{-1} for $|z|<30$ cm & 10 pb^{-1} for $|z|<10$ cm

We collected over 4.2 billion physics events !!!

Sampled Luminosity (U+U & Cu+Au)





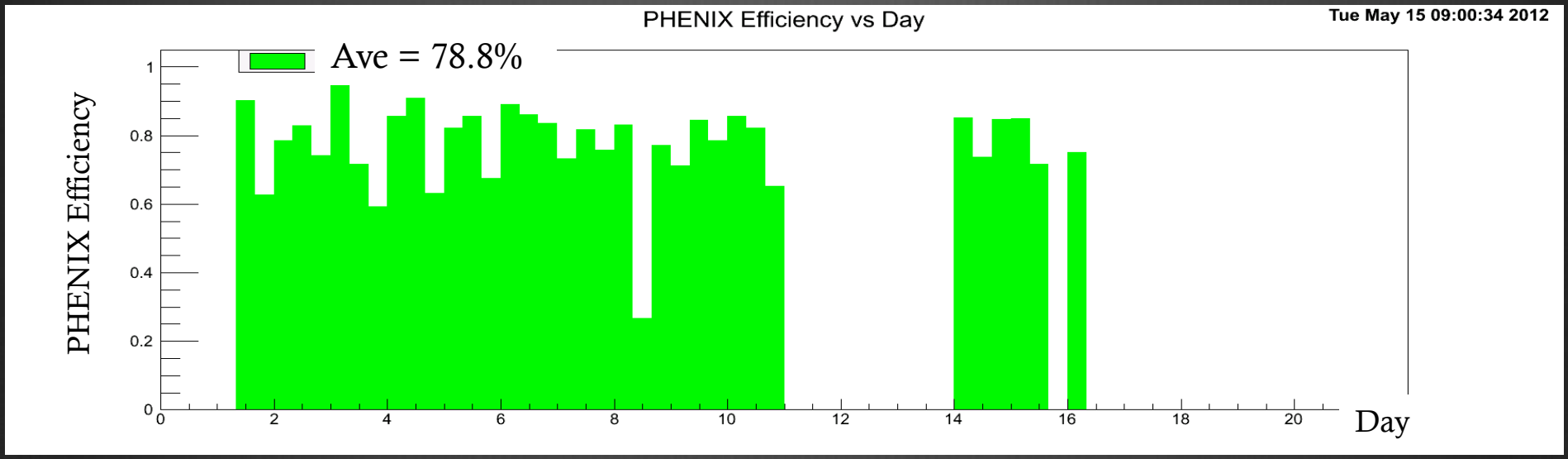
Goal: 60 μb^{-1} for $|z|<10$ cm

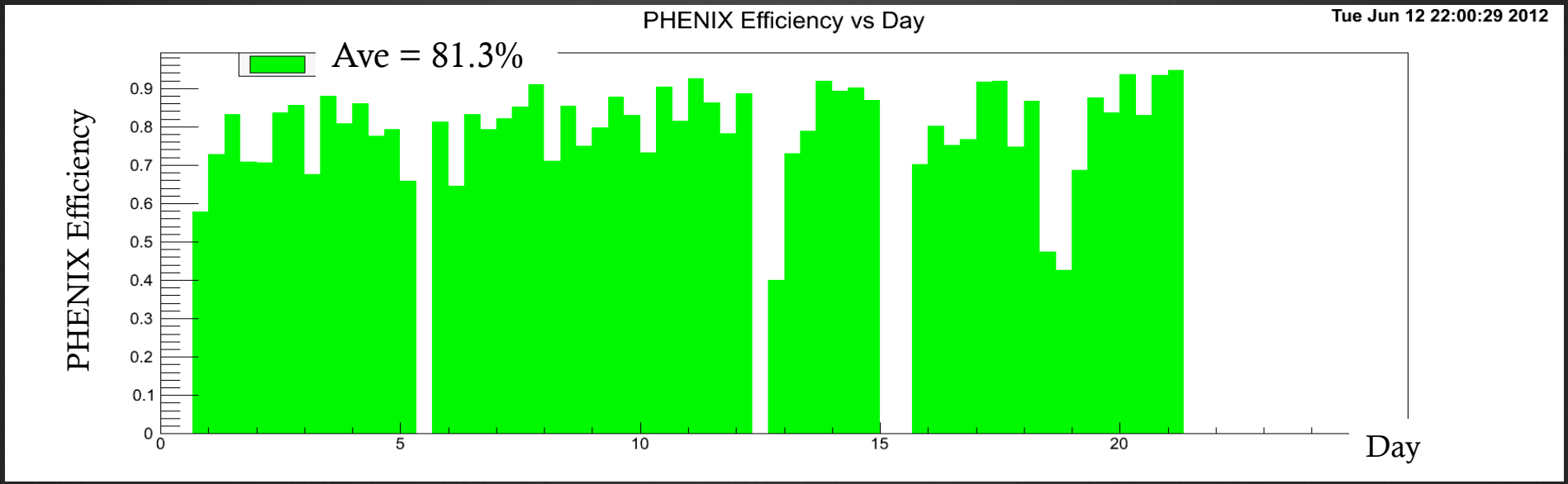
Goal: 2.4 nb^{-1} for $|z|<10$ cm

Collected over 3 billion events (4/25 – 5/15). Far exceeded the requested goal !!!

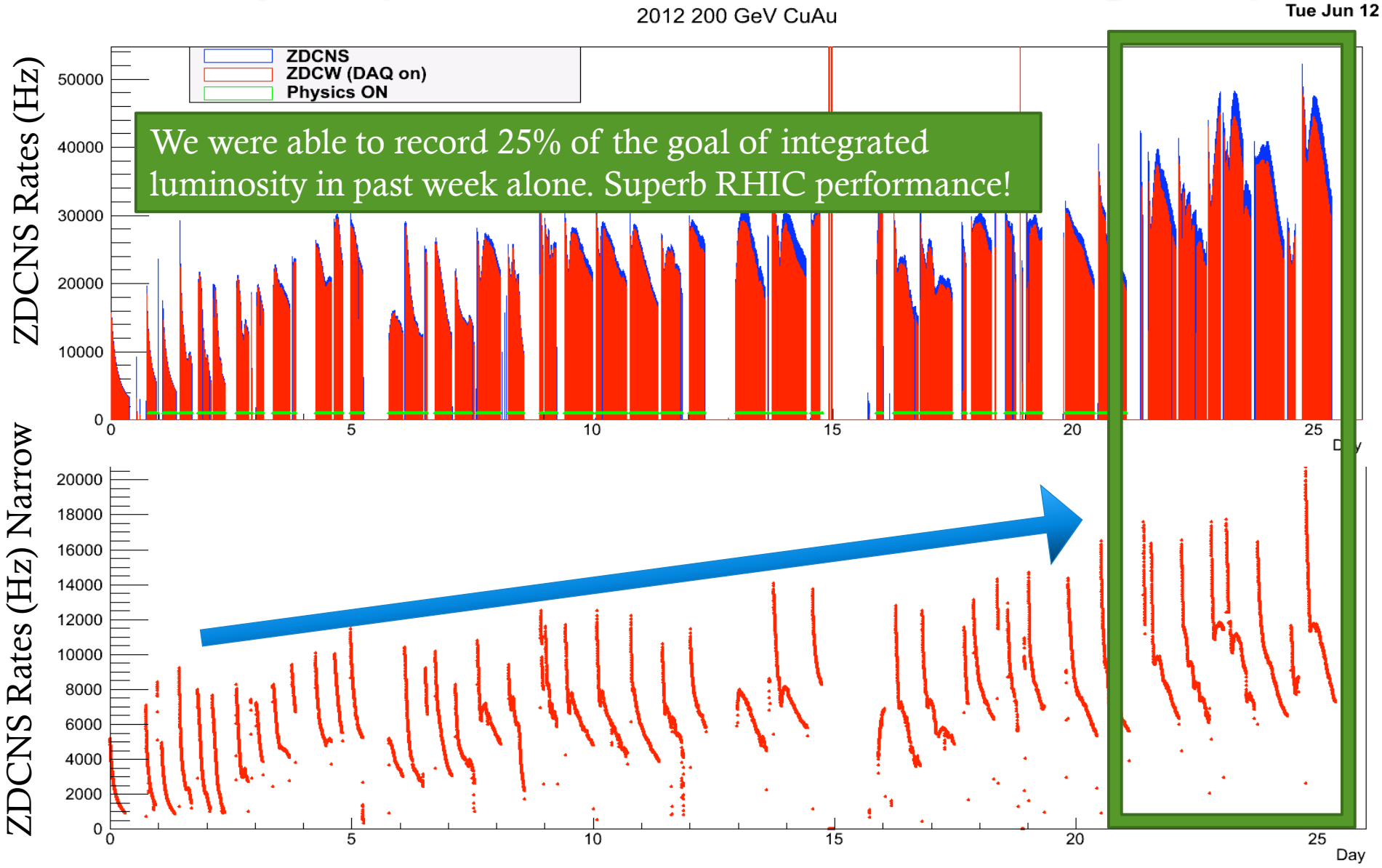
Collected over 6.8 billion events already, data taking is ongoing until 8am, June 25. Started on 5/18.

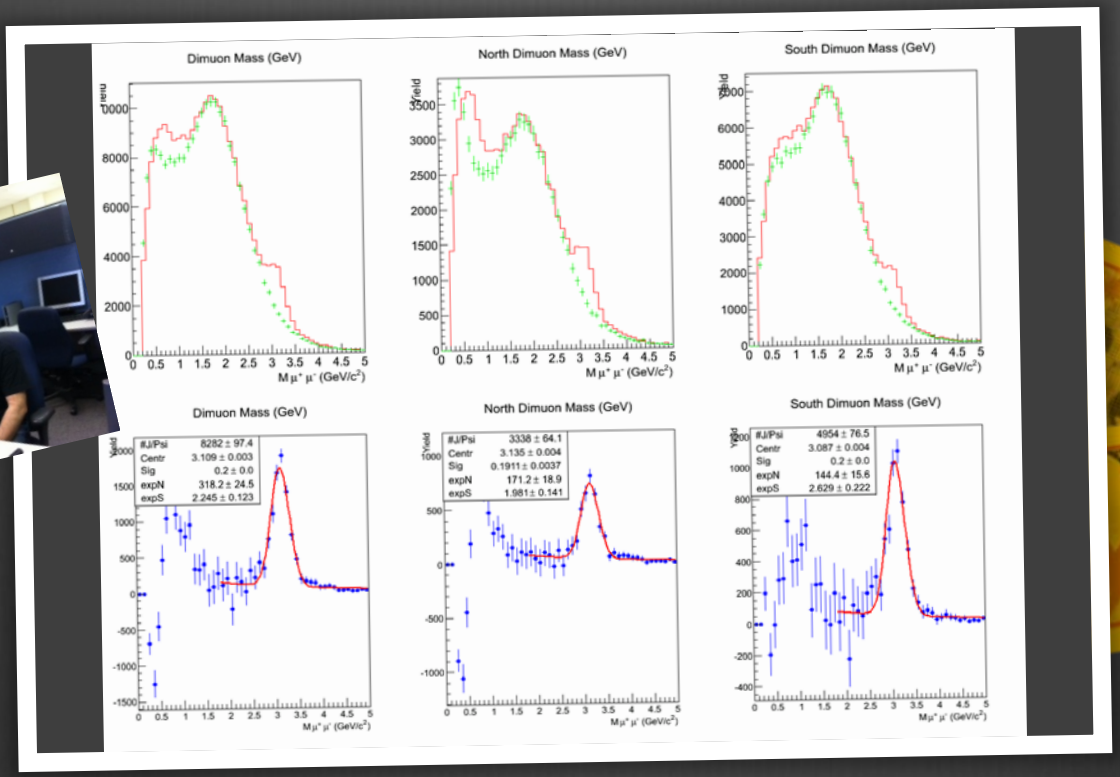
Data Taking Efficiency (U+U, Cu+Au)

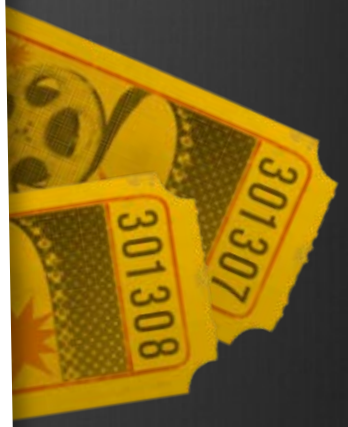




Everyday is a record breaking day



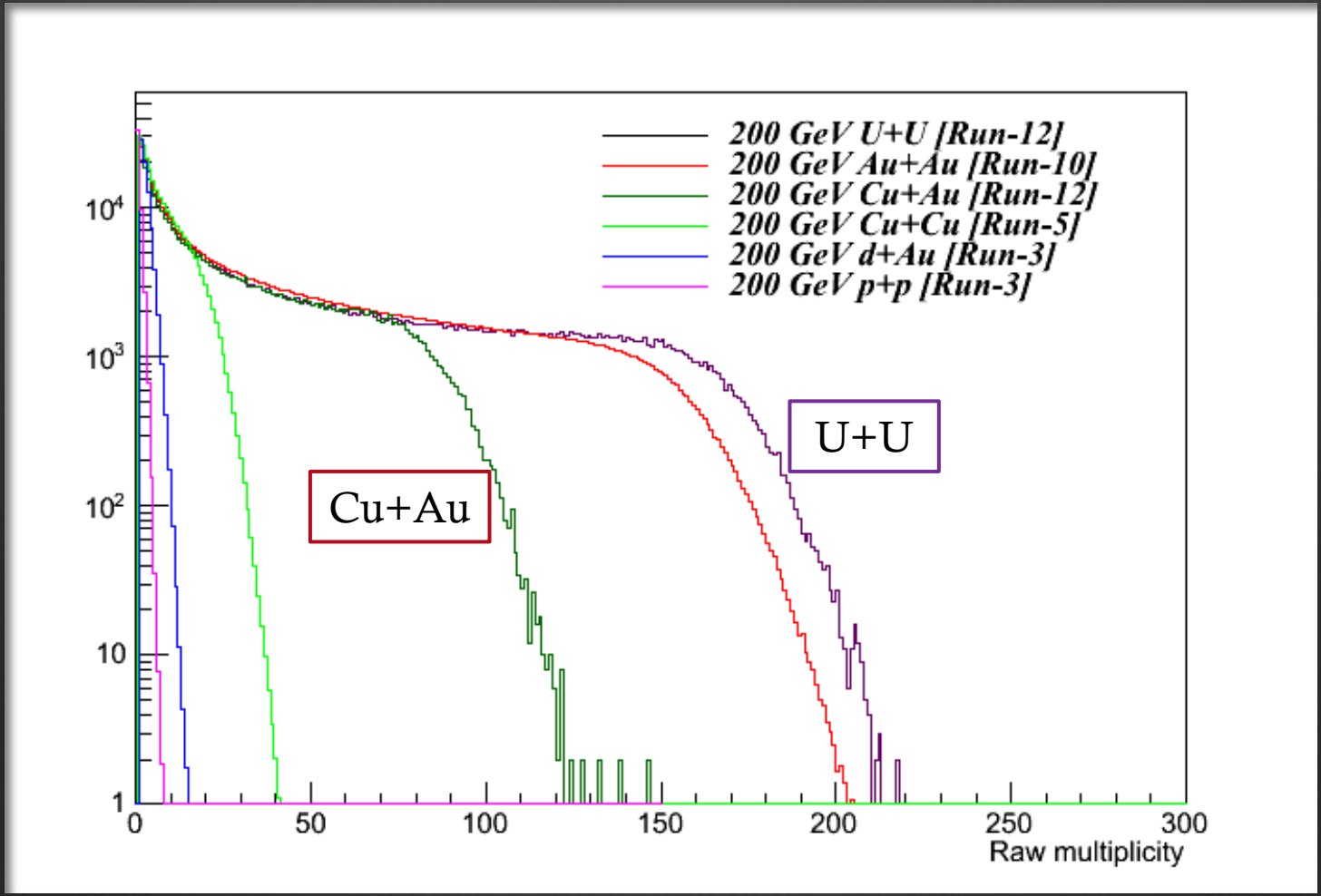




Fast Data Analysis

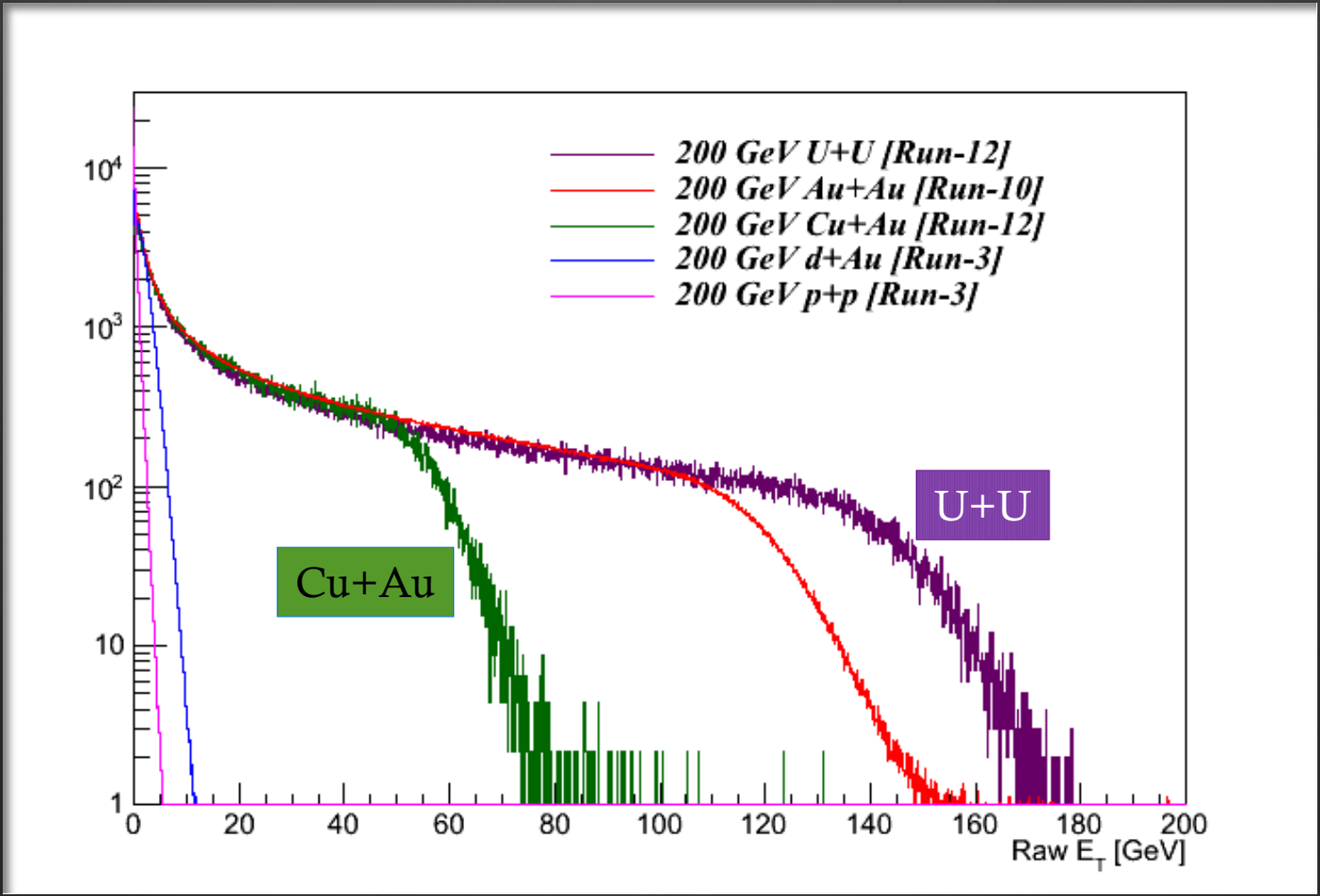
Provide near real-time feedback of detector performance and data quality

Multiplicity Distributions



These are all raw values. No corrections for acceptance, efficiency, etc. have been applied.

E_T Distributions



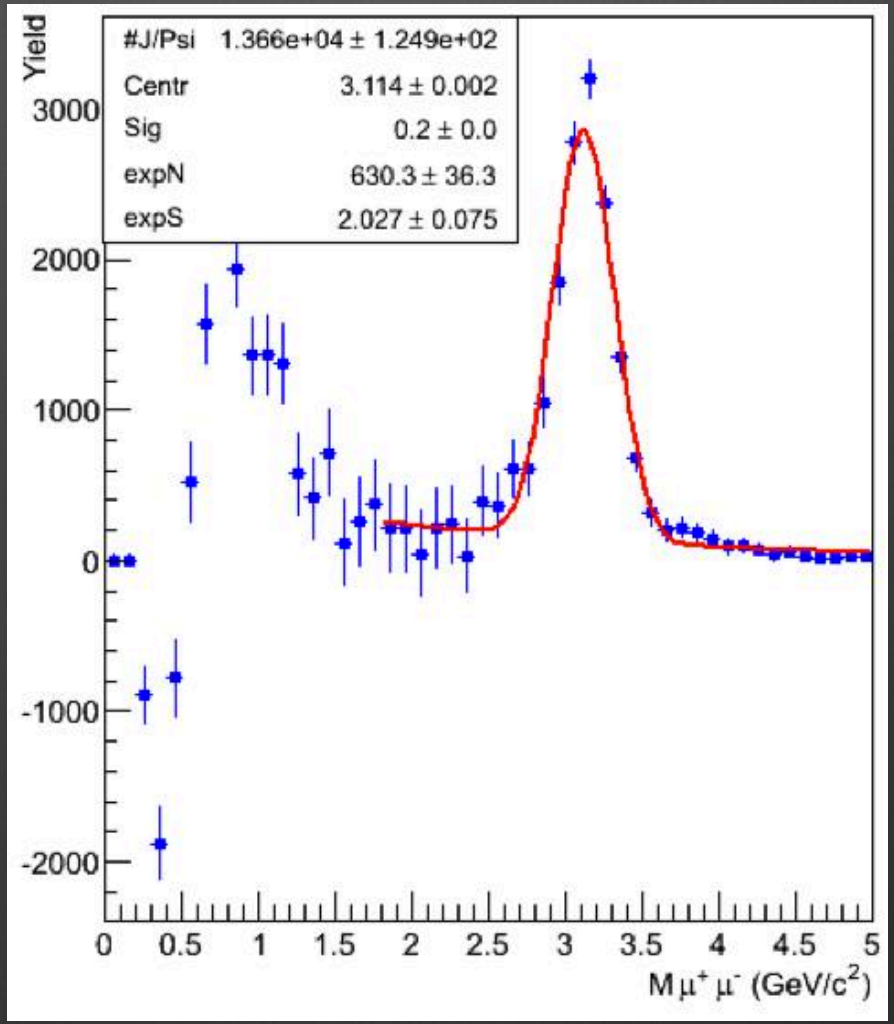
These are all raw values. No corrections for acceptance, efficiency, etc. have been applied.

J/ψ Measurements (Cu+Au)

J/ψ yields from the PHENIX Muon Arms for Cu+Au Collisions

Run12 Cu+Au expectation: 62k J/ψ - for PHENIX wide-vertex luminosity goal of 4.6 nb^{-1}

We are only able to process less than 20% of the incoming data in the counting house before sending data to RCF HPSS



More J/ψ are sampled which allows us to make collision geometry dependent study!!!

Operational Lessons

- We had great support from CA-D for periodic detector repairs.
- Having a pre-planned/fixed CA-D run schedule made running the experiment much smoother.
- In the future, we need to plan ahead and agree on the balance between the machine studies and physics measurements.

Summary

- PHENIX Run-12 heavy ion run is a huge success.
- RHIC has demonstrated beautifully its versatile colliding capability of different species and energies in a single run-year: 200 and 510 GeV polarized p+p; U+U and Cu+Au collisions with increasing luminosity.
- RHIC computing facility is also a bright spot in Run-12, which supported a record-breaking data storage rates and provides efficient computing power for a fast physics data analysis.
- Great communication and feedback between CA-D and PHENIX.

Acknowledgement

PHENIX would like to thank CA-D for the record-breaking performance in Run-12. I would also like to thank Bill Christie from STAR for his support of many PHENIX-driven priorities

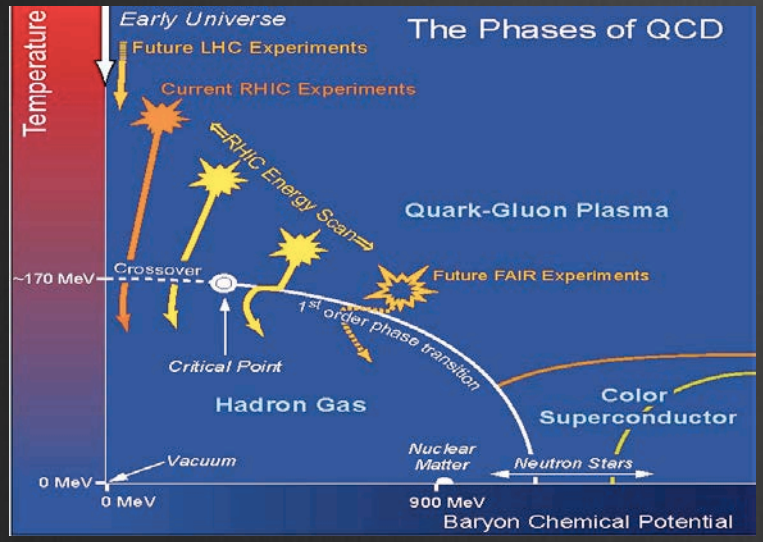
Update From RHIC Run 12:

One World Record, Three World Firsts

Roger Stoutenburgh D2800512

Run 12 at RHIC provides world's highest beam energy for polarized protons, uranium-uranium collisions, increasing luminosity for colliding uranium beams, and copper-gold collisions

Backups


Temperature
Early Universe
Future LHC Experiments
The Phases of QCD
Current RHIC Experiments
RHIC Energy Scan
Quark-Gluon Plasma
~170 MeV
Crossover
Future FAIR Experiments
1st order phase transition
Critical Point
Hadron Gas
Color Superconductor
Vacuum
Nuclear Matter
Neutron Stars
0 MeV
0 MeV
900 MeV
Baryon Chemical Potential

301307
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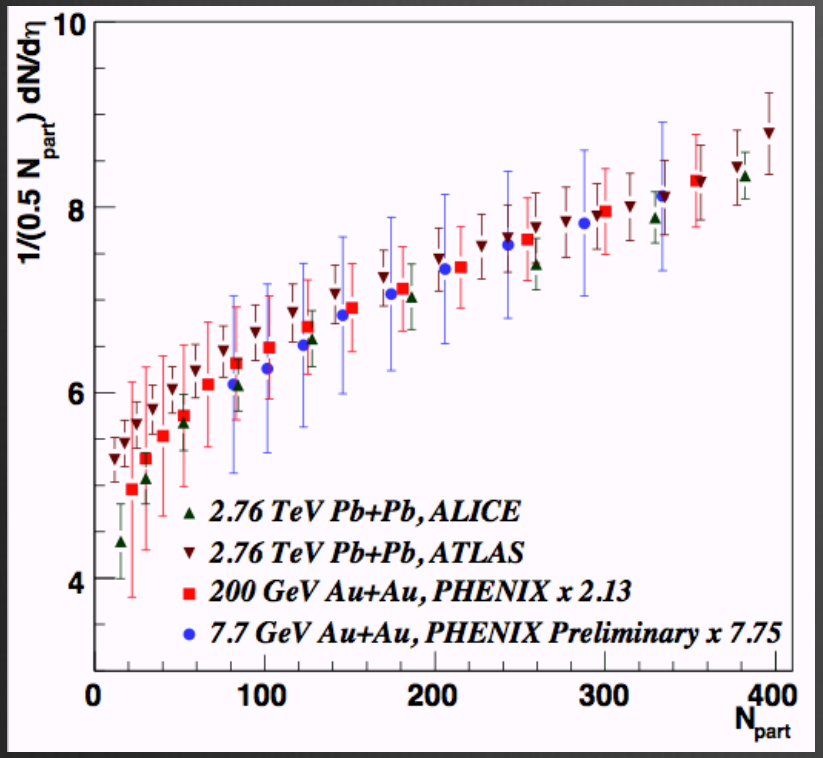
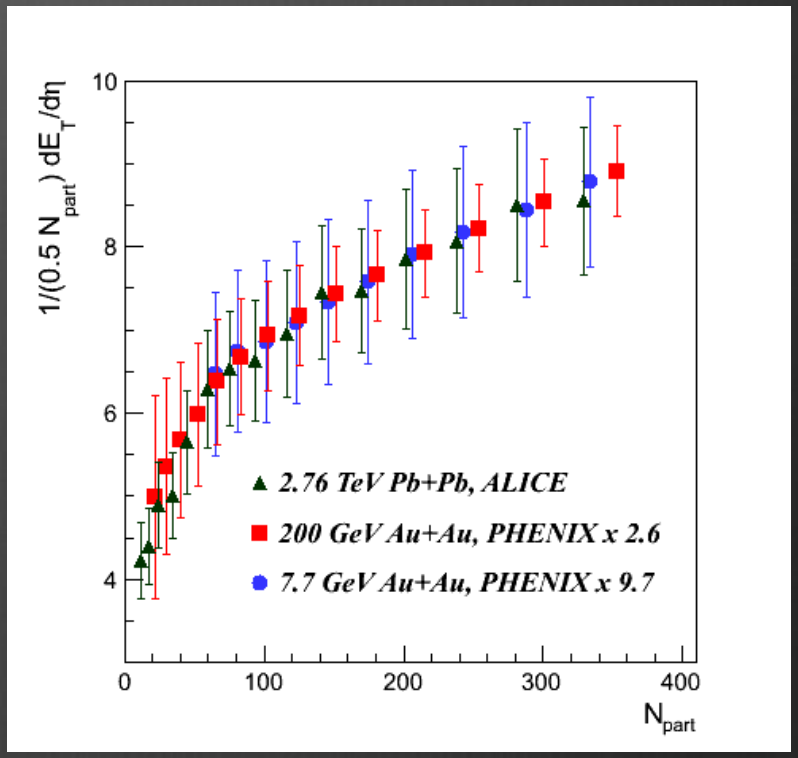
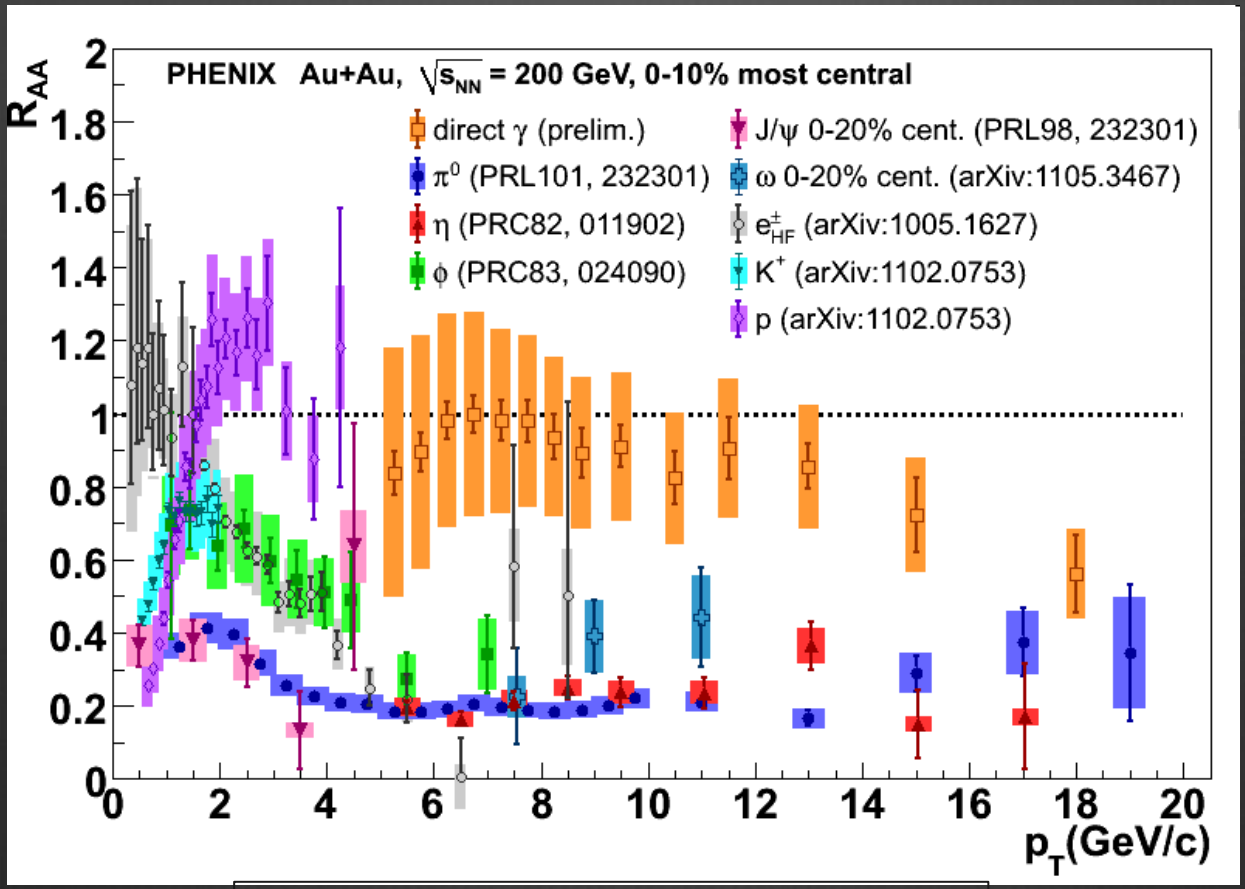
Explore Colliding Geometry





The near identical shape of distributions of multiplicity and ET indicates a nuclear-geometrical effect. The geometry if the number of quark/nucleon participants.

Nuclear Modification Factor



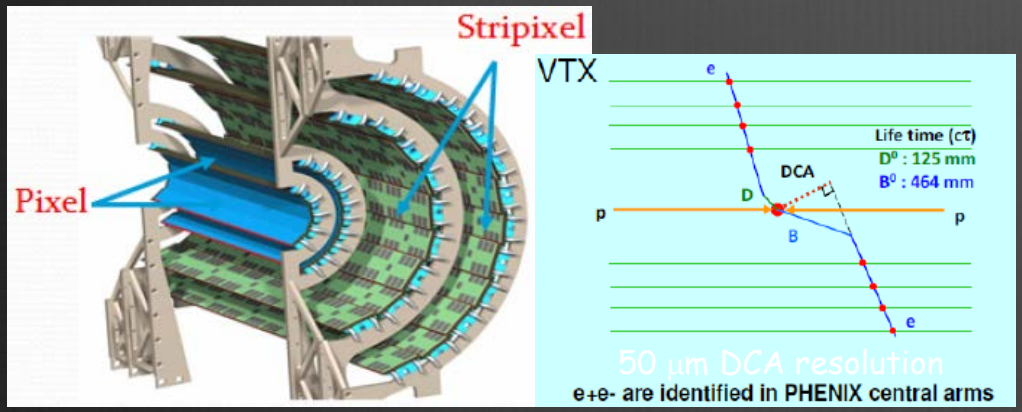
$$R_{AA}(p_T) = \frac{\frac{1}{N_{AA}^{evt}} \frac{d^2 N_{AA}}{dp_T dy}}{<T_{AA}> \frac{d^2 \sigma_{pp}}{dp_T dy}}$$

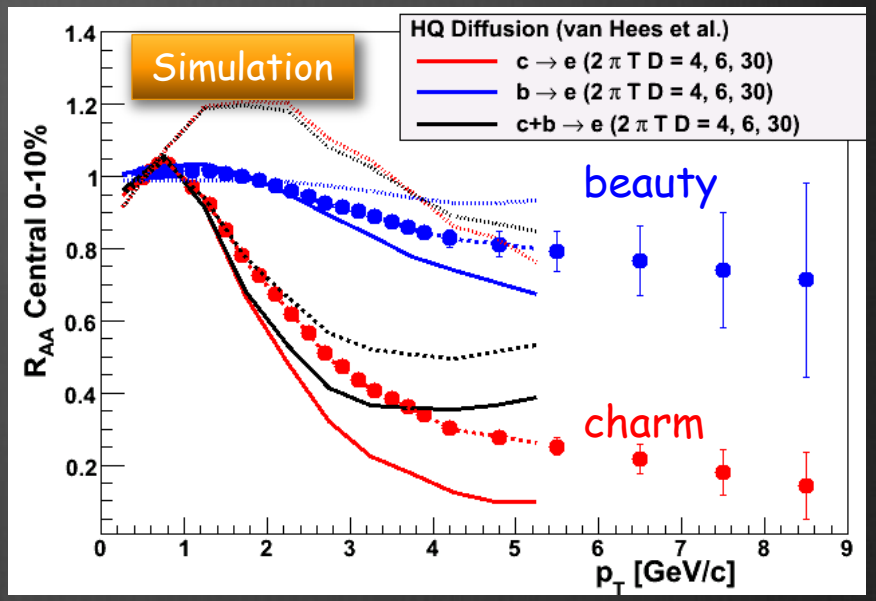
Probing the sQGP with Heavy Quarks

for 4.3 nb^{-1} (Au+Au), 14.8 pb^{-1} (p+p)

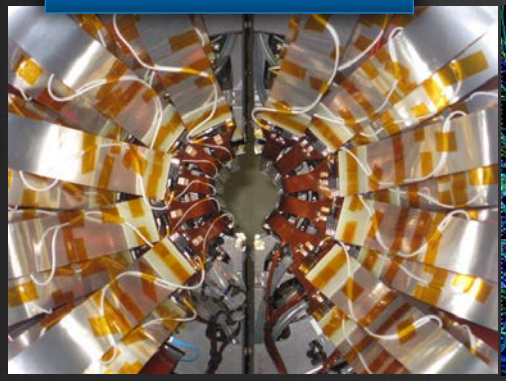
Silicon VerTeX Detector (VTX)

- Commissioned in Run-11
- Separate charm and beauty

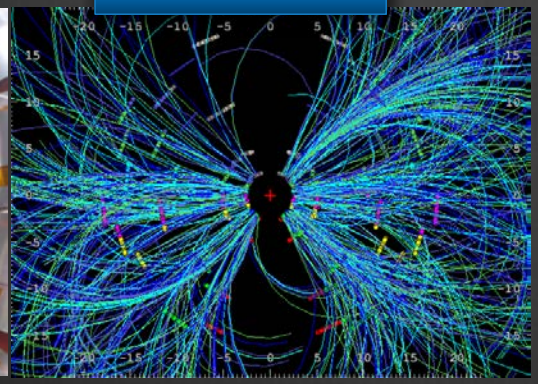


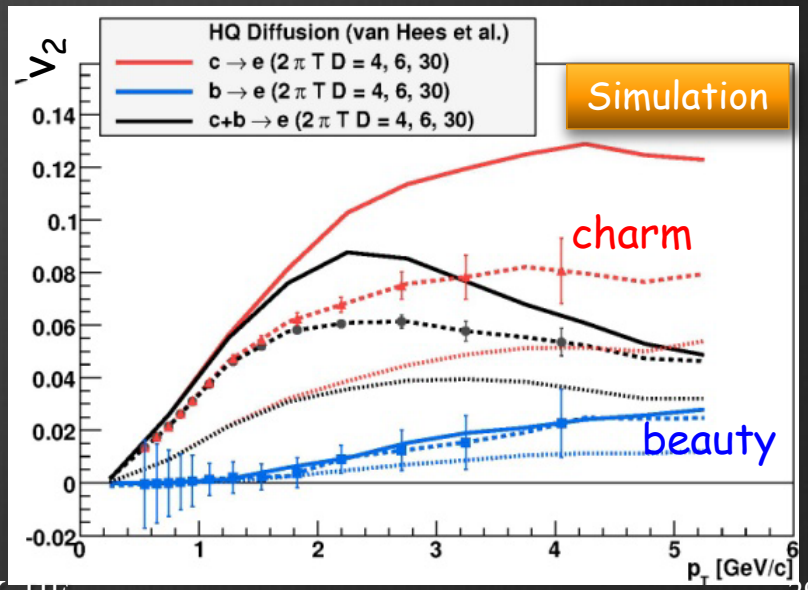


end view of VTX



Au+Au event

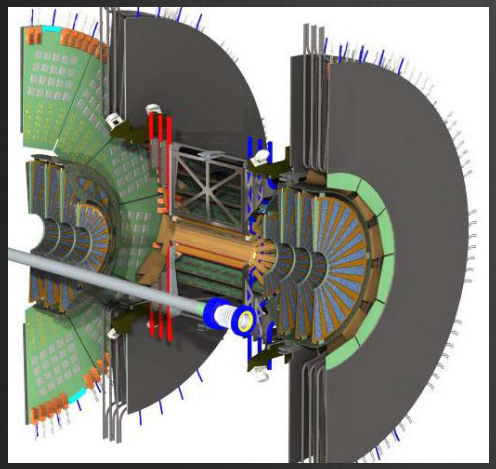


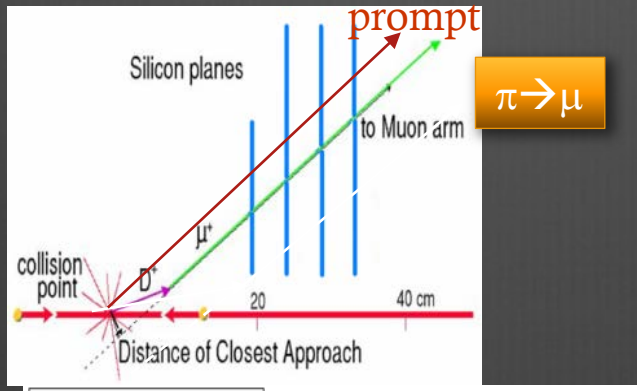
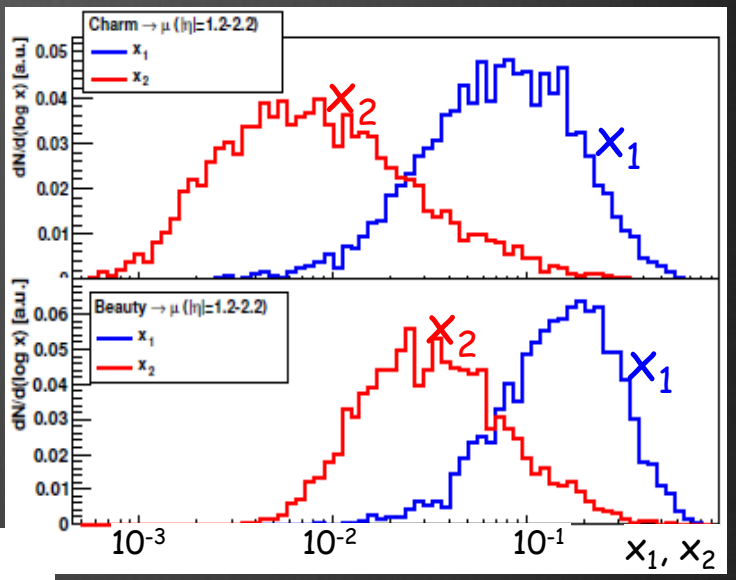
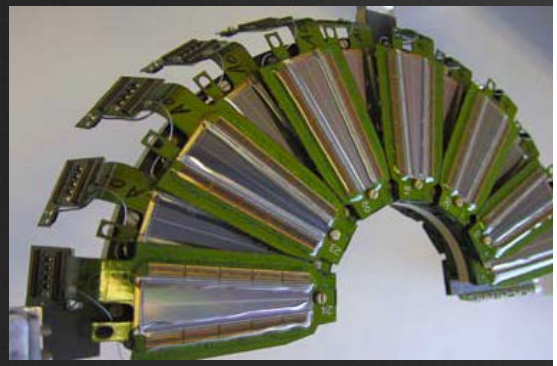
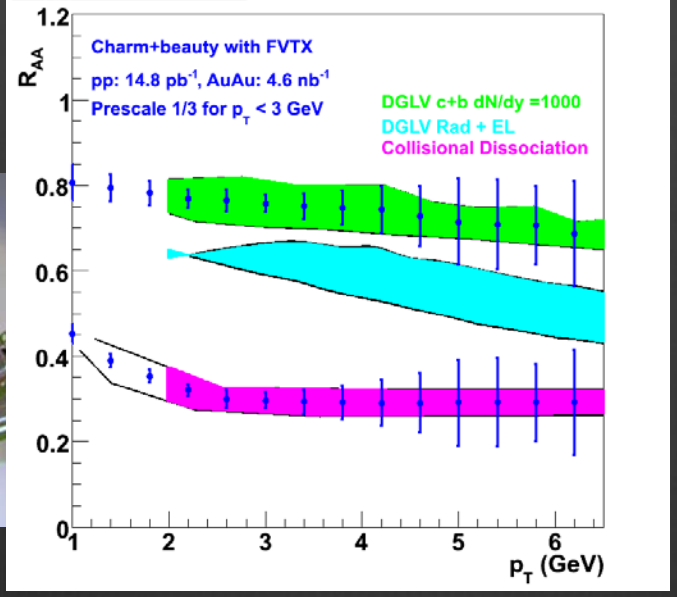
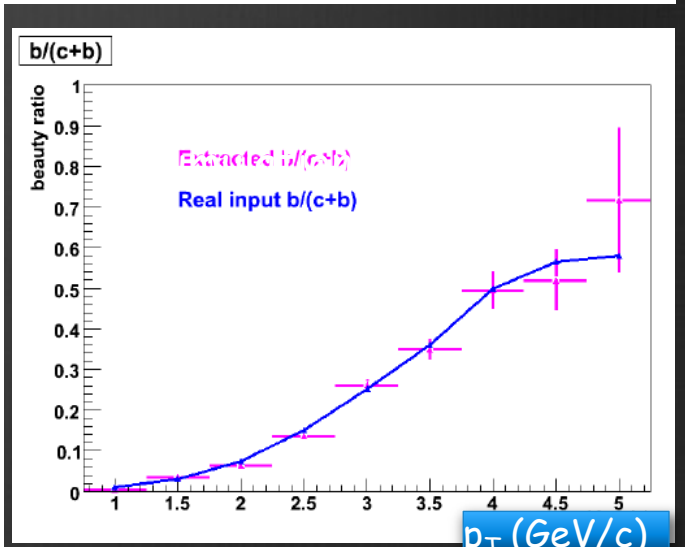


Probing the sQGP with Heavy Quarks

Forward silicon vertex detector (FVTX)

- Commissioned in Run-12
- Separate charm and beauty
- Improve ψ' measurement





FVTX c,b x-coverage