

PHENIX Run-15

Goals and Status

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For the PHENIX Collaboration



“It was the best of times, it was the worst of times...”

- Charles Dickens: *A Tale Of Two Cities* (1859)



Run-15 BUP

...it was the age of wisdom...

- **p+p @ 200 GeV** with transverse polarization for 9 weeks [Physics driven goal is **50 pb^{-1}** recorded within **$|z| < 40 \text{ cm}$** and **$\langle P \rangle = 60\%$**]
- **p+Au @ 200 GeV** with transverse polarization of the proton for 5 weeks [Physics driven goal is **190 nb^{-1}** sampled within **$|z| < 40 \text{ cm}$** and **$\langle P \rangle = 60\%$** .]
- **p+Al @ 200 GeV** with transverse polarization of the proton for 2 weeks [Physics driven goal is **450 nb^{-1}** sampled within **$|z| < 40 \text{ cm}$** and **$\langle P \rangle = 60\%$**]



Why p+p at 200 GeV?

- p+p runs have, generally two physics purposes at PHENIX:
 - A baseline for the understanding of heavy-ion physics.
 - Since they can be polarized, one can investigate spin physics phenomena at the same time.
- But, have already run 200 GeV p+p in:
 - Run 5 (long. and trans. 29.5 pb⁻¹),
 - Run 6 (long. and trans. 88.6 pb⁻¹),
 - Run 8 (trans. 38.4 pb⁻¹),
 - Run 9 (long. 114 pb⁻¹), and
 - Run 12 (trans. 74 pb⁻¹)!
- Have > 100 pb⁻¹ of transversely polarized p+p data.
- **Why do we need more?**



We have new instrumentation

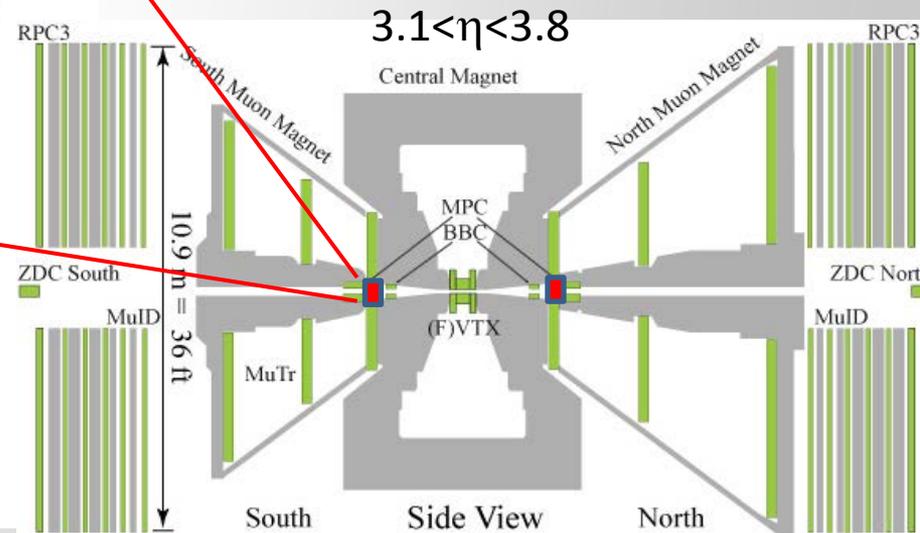
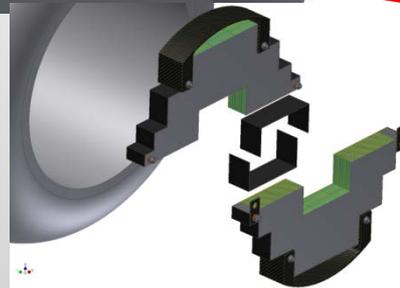
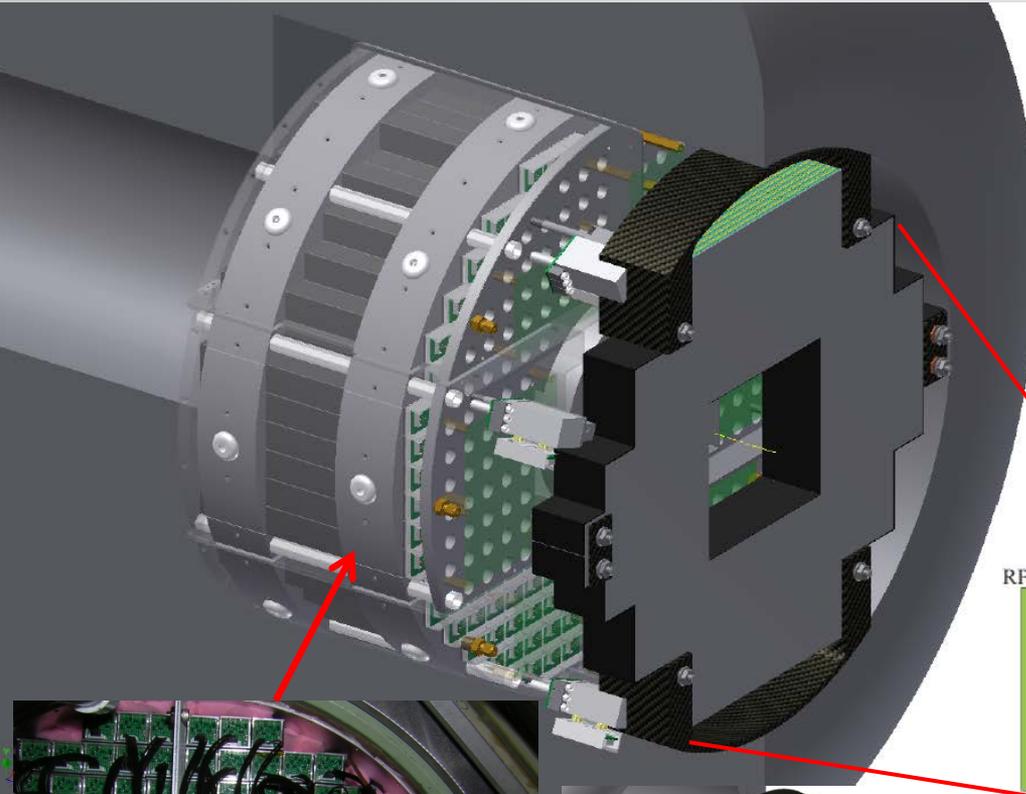
- New instrumentation provides access to previously unmeasured kinematic regions and physics processes.
 - In Run-15, PHENIX had the MPC-EX for the first time, giving access to direct photons at forward rapidities.
 - We had a fully working FVTX, and VTX for the first time during 200 GeV p+p and p+A running, enhancing our heavy flavor program at forward and central rapidities.



The MPC-EX Detector

A combined charged particle tracker and EM pre-shower detector – dual gain readout allows sensitivity to MIPs and full energy EM showers.

- π^0 rejection (direct photons)
- π^0 reconstruction out to $>80\text{GeV}$
- Charged track identification

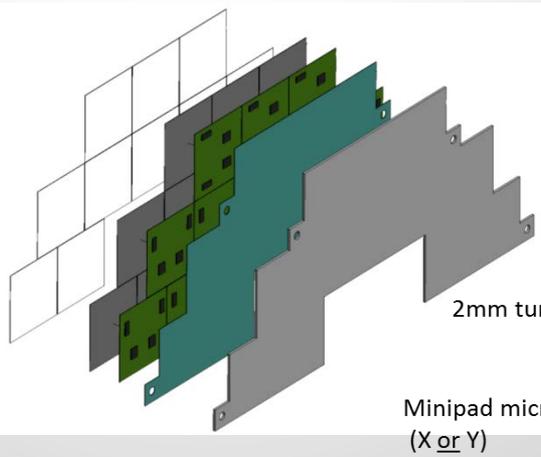
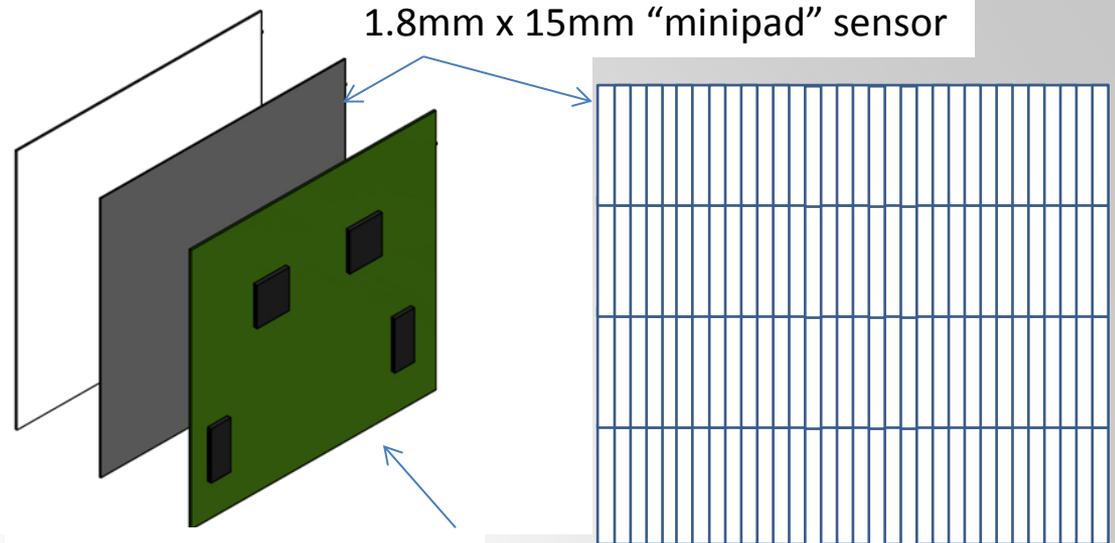
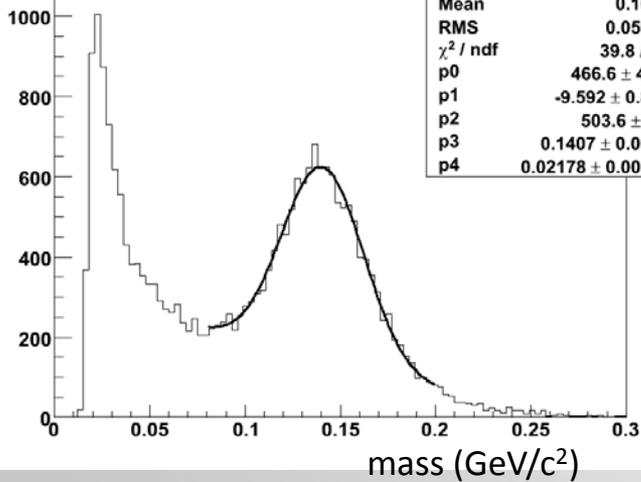


Minipad Sensors

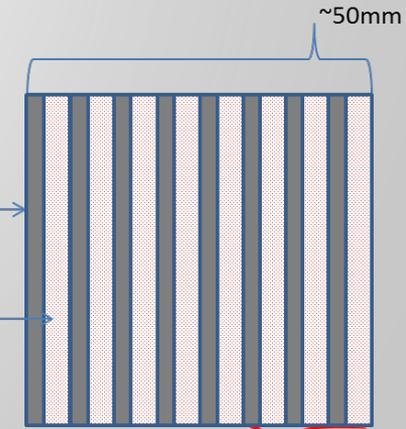
Detector elements are Si “minipad” detectors, one layer per tungsten gap, oriented in X and Y (alternating layers).

Simulated π^0 mesons reconstructed in p+p jet events ($E > 20\text{GeV}$) using energy splitting.

Single-Track Pizero Candidates



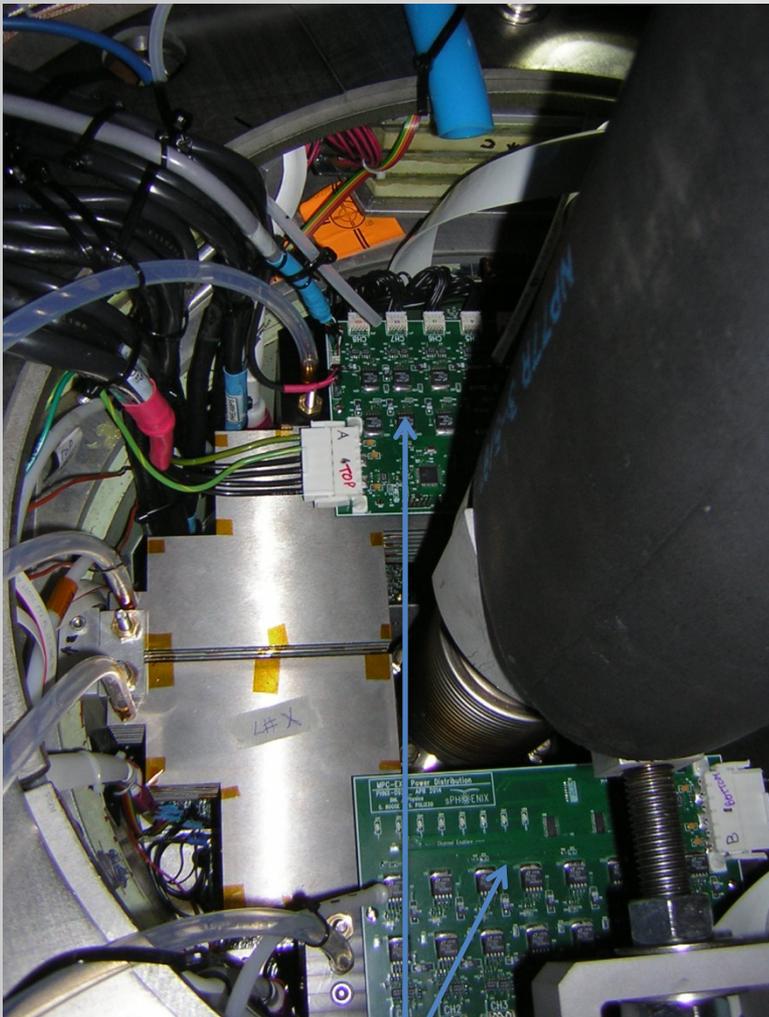
Cross-Section View:



MPC-EX in Run 15

*...it was the age of foolishness,
it was the epoch of belief...*

- Both North and South MPC-EX detectors were installed a few weeks before the run began.
- Work on the readout continued into the second half of the p+p run.
- Successfully began collecting data on March 17.
- Offline analysis is on-going.

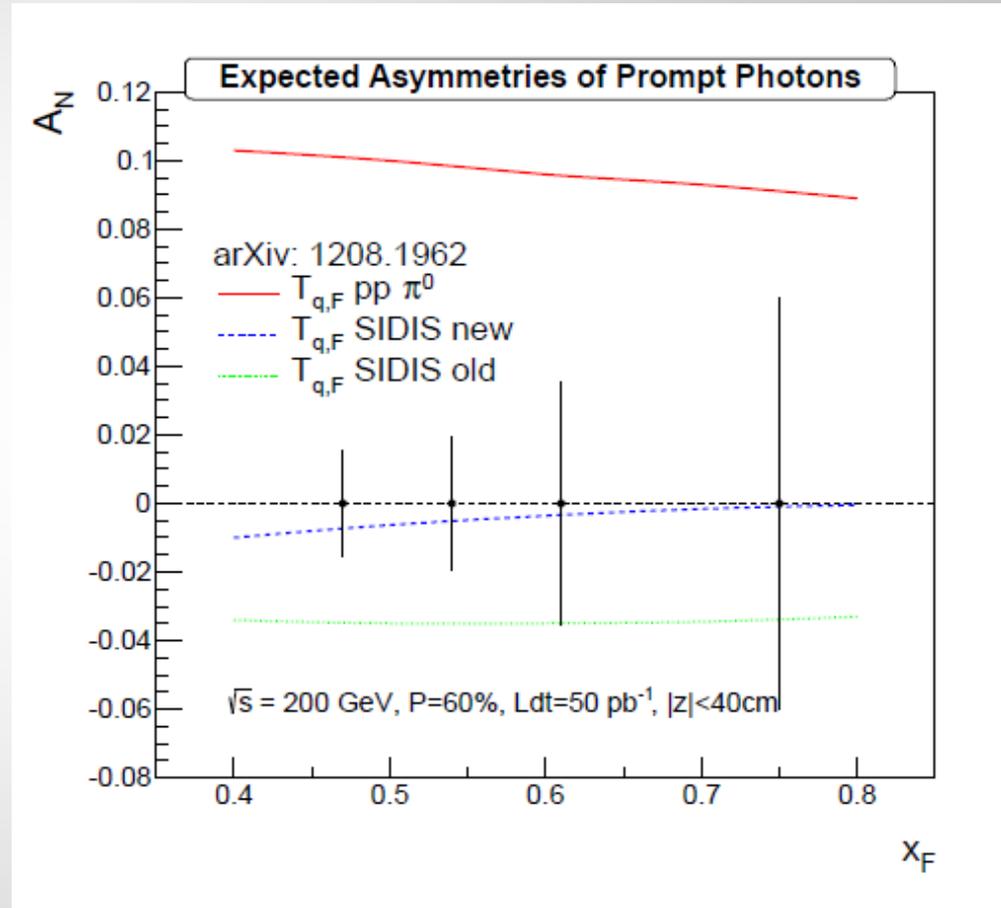


LV Distribution Boards



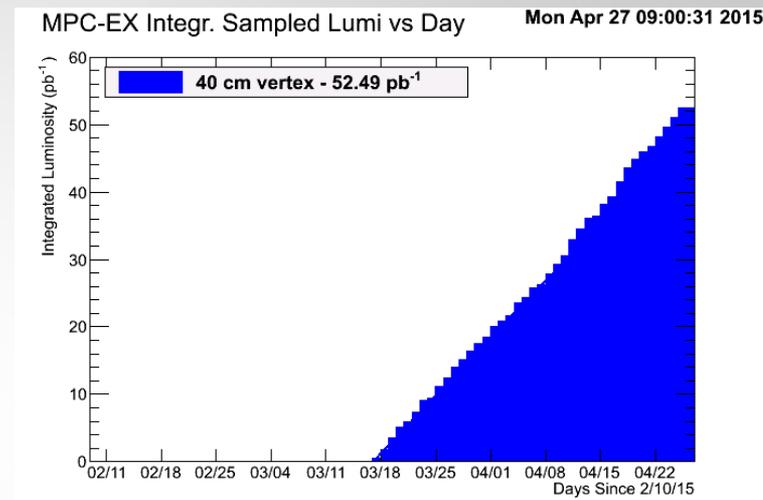
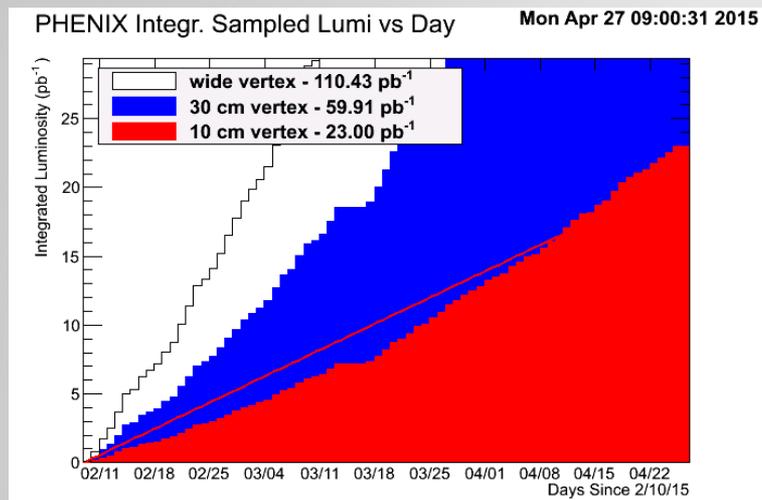
MPC-EX Physics

- Utilize unique capabilities of MPC-EX upgrade.
- Direct photon with no final state interactions.
- Uncertainties clearly resolve sign disagreement for $T_{q,F}$.

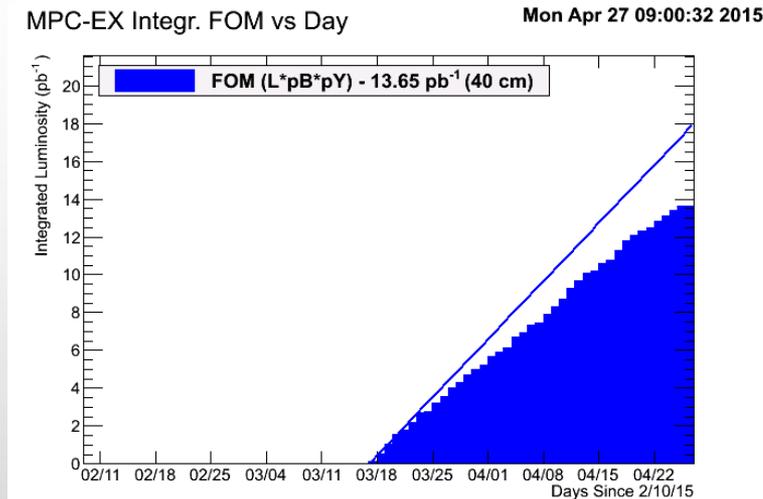
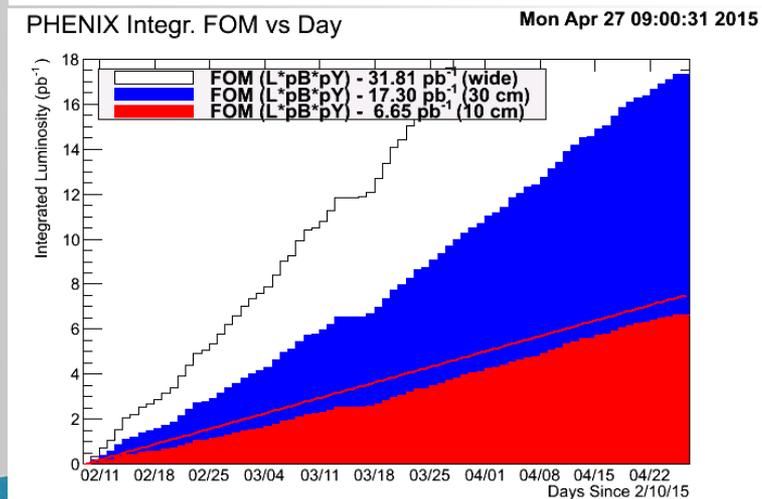


p+p Luminosity and FoM Goals

...it was the epoch of incredulity...



Lumi



FoM

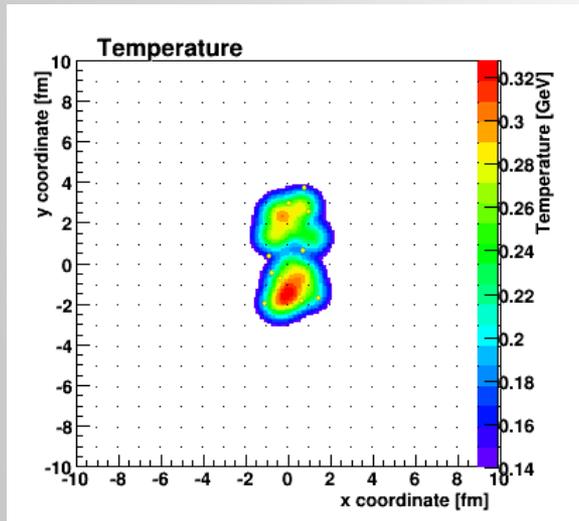
Why p+A at 200 GeV?

- In the past, we have had several d+A runs.
 - A baseline for the understanding of heavy-ion runs.
 - The deuteron beam was not polarized.
- But even if with a polarized proton beam, what would we look for?



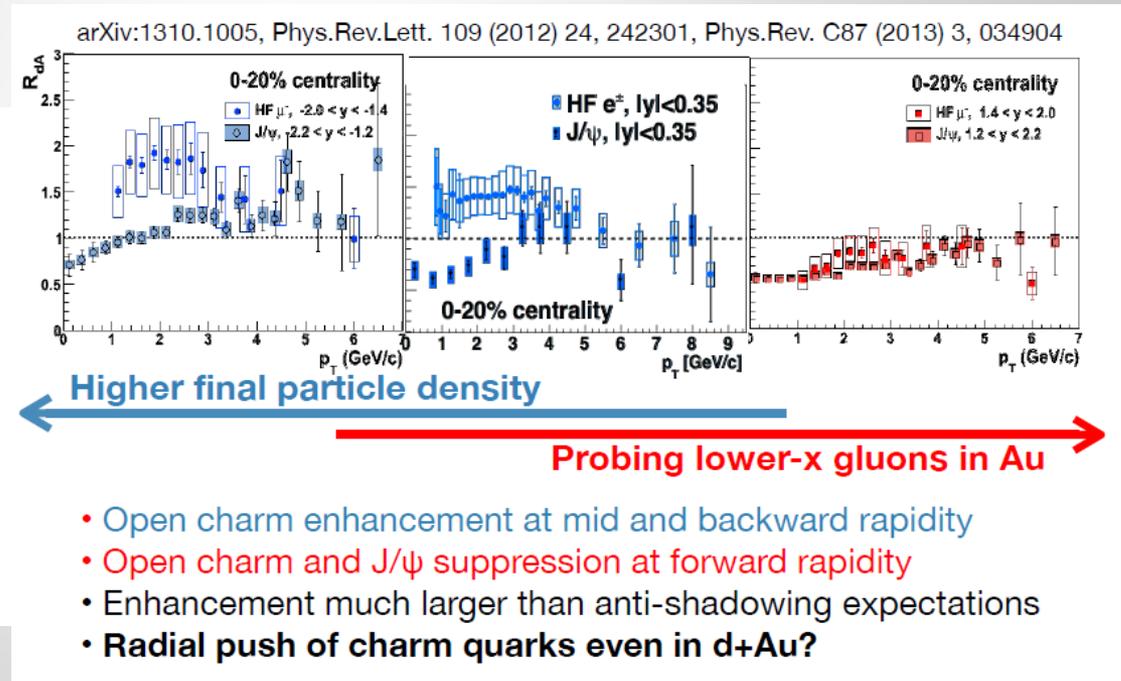
Protons are smaller

- d+Au collisions may have a remaining flow effect from multi-parton collisions, that may be smaller in p+Au.
- And, that flow might explain larger than expected charm enhancement in d+Au.



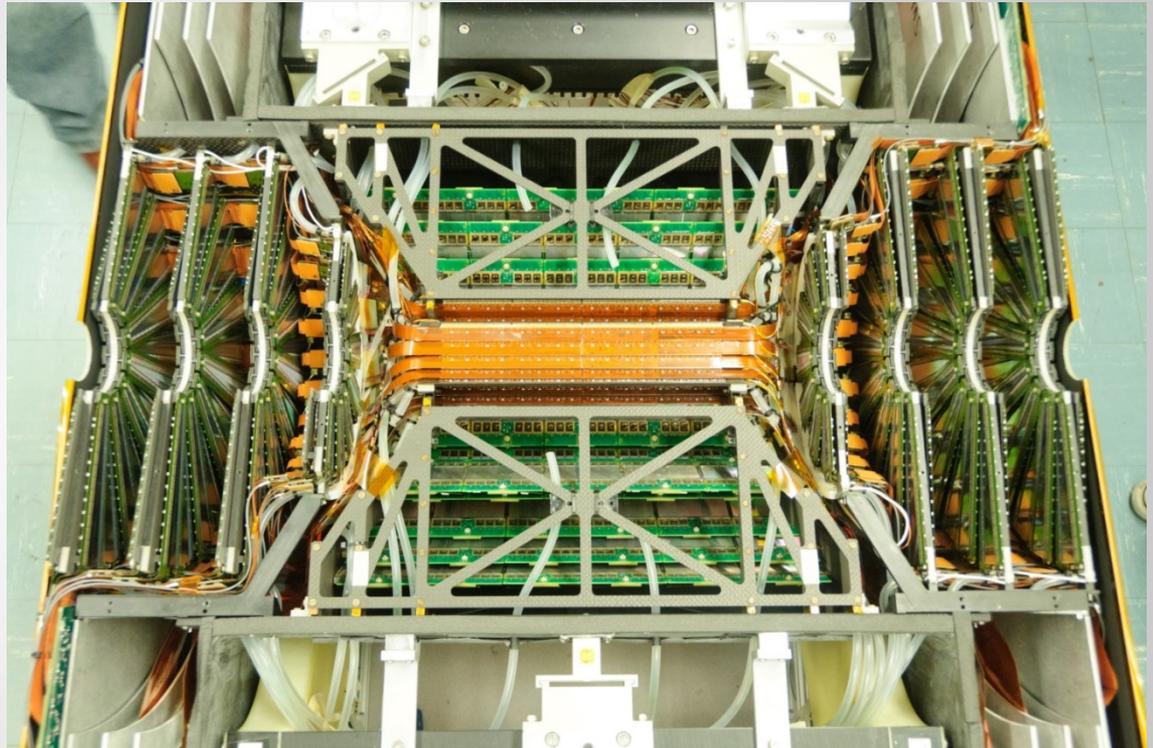
Gold-going direction

Deuteron-going direction



Refurbished F/VTX

- VTX pixels and Strip-pixels were refurbished for Run 14.
- Improved cooling, environment containment, etc.
- FVTX ran well for Run 15.
- Together, provides heavy flavor program in PHENIX (DCA).
- And...



FVTX Multiplicity Trigger

Game Change: the “ridge” in pp collisions

Opportunity of studying novel QCD phenomena opened up by the LHC

September, 2010



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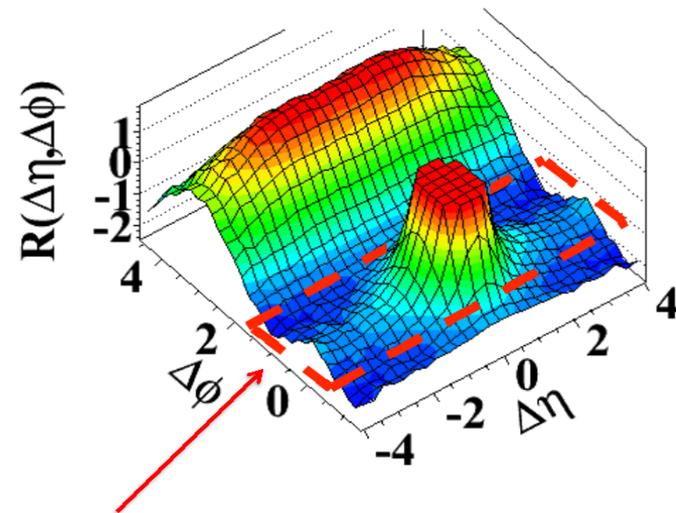
Observation of long-range, near-side angular correlations in proton-proton collisions at the LHC

The CMS collaboration

ABSTRACT: Results on two-particle angular correlations for charged particles emitted in proton-proton collisions at center-of-mass energies of 0.9, 2.36, and 7 TeV are presented, using data collected with the CMS detector over a broad range of pseudorapidity (η) and azimuthal angle (ϕ). Short-range correlations in $\Delta\eta$, which are studied in minimum bias

Two-particle $\Delta\eta$ - $\Delta\phi$ correlation

pp $N > 110$, $1 < p_T < 3$ GeV/c



Unexpected ridge-like correlations in high multiplicity pp!

Slide from Wei Lei, Rice University

3

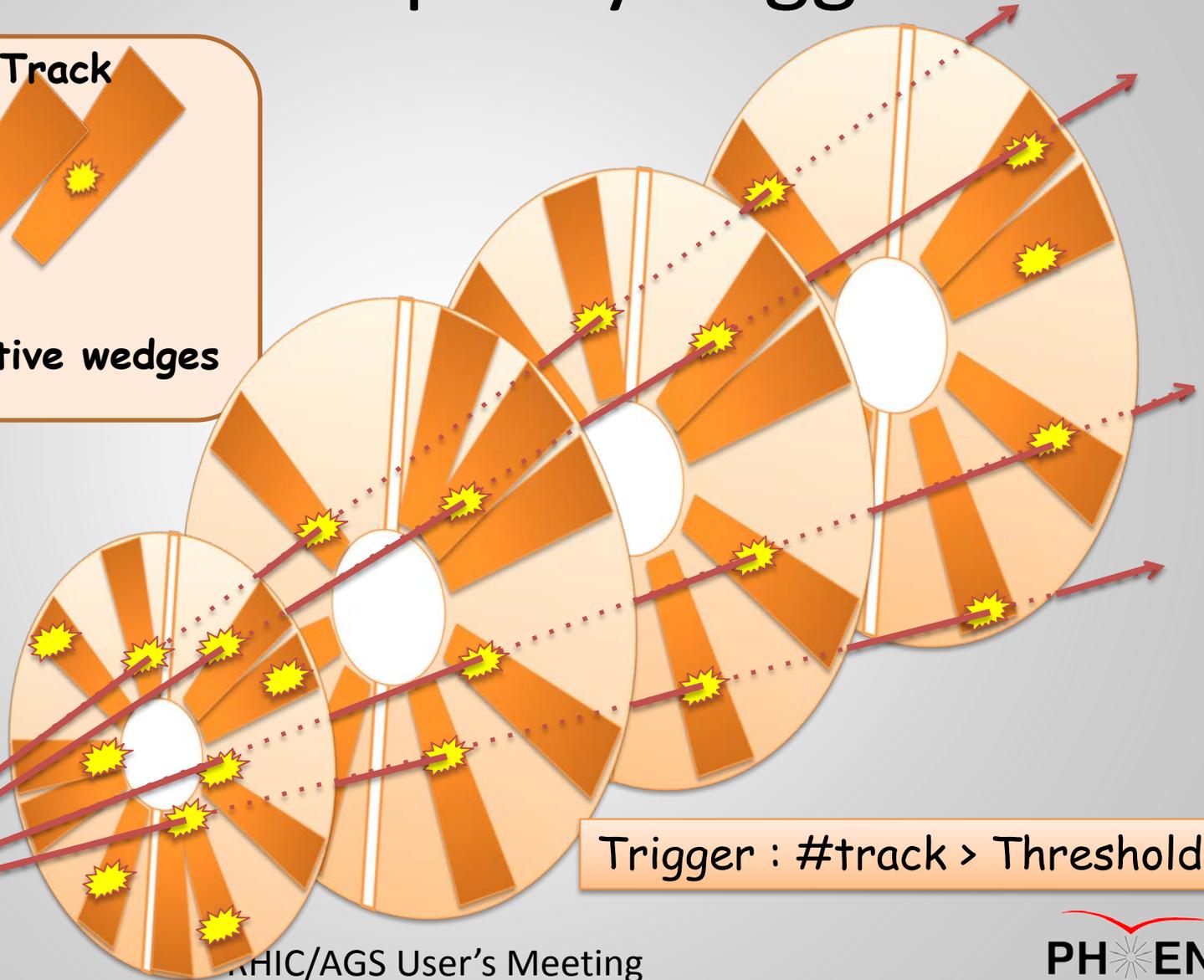


FVTX Multiplicity Trigger

Online Coarse Track



~ 3/4 active wedges

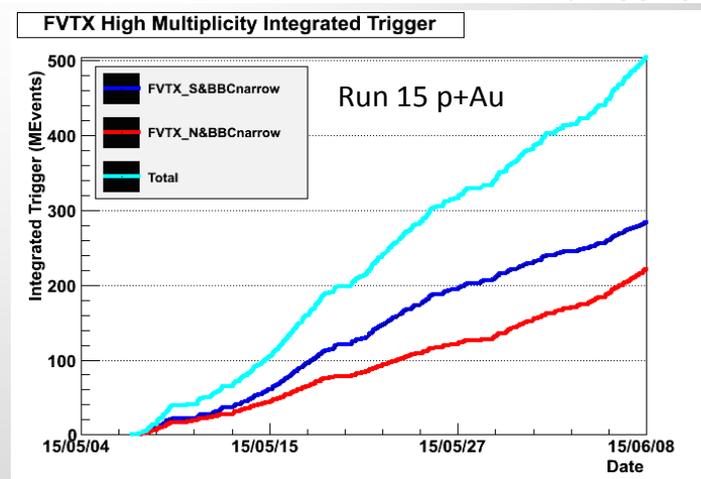
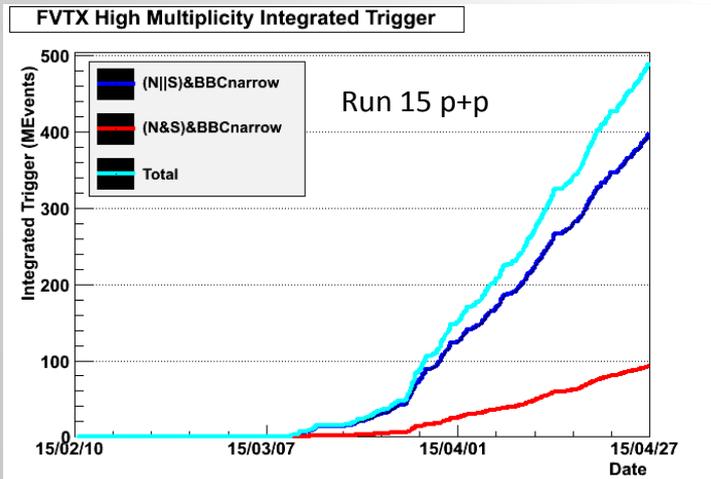
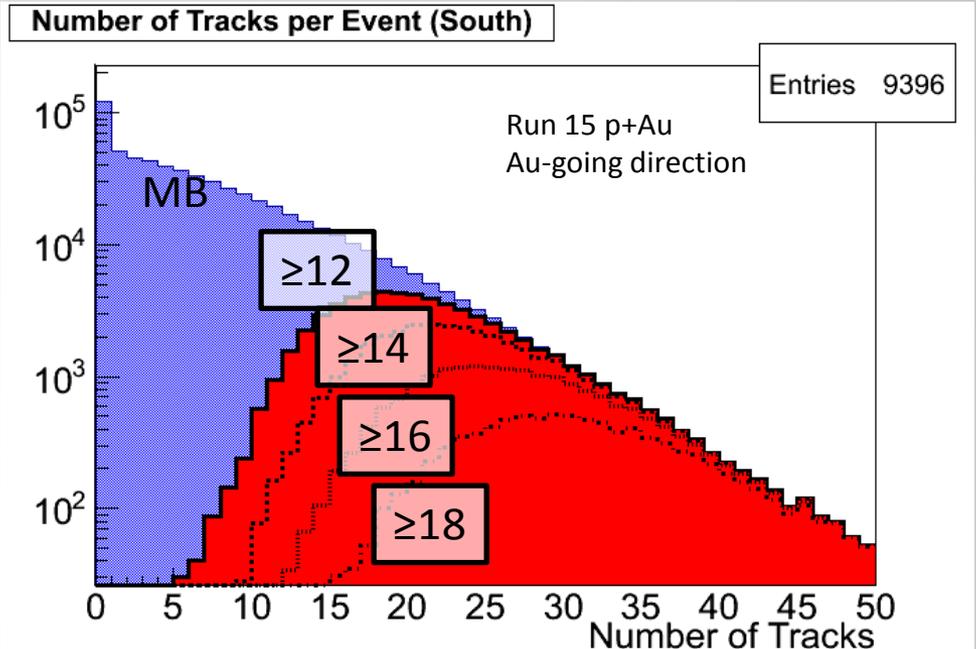


Trigger : #track > Threshold



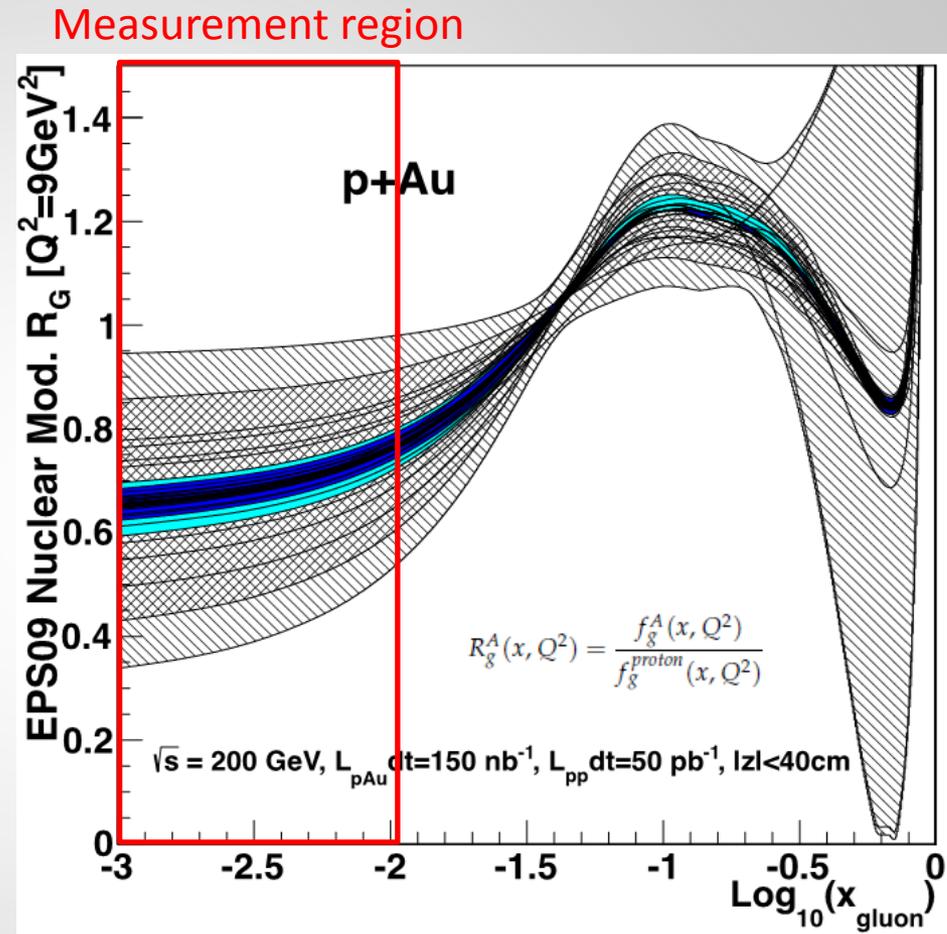
FVTX Multiplicity Trigger

- Has the ability to tune for rejection and purity.
- Collected sufficient triggers in both p+p and p+Au.



EPS09 Limits from Prompt Photons

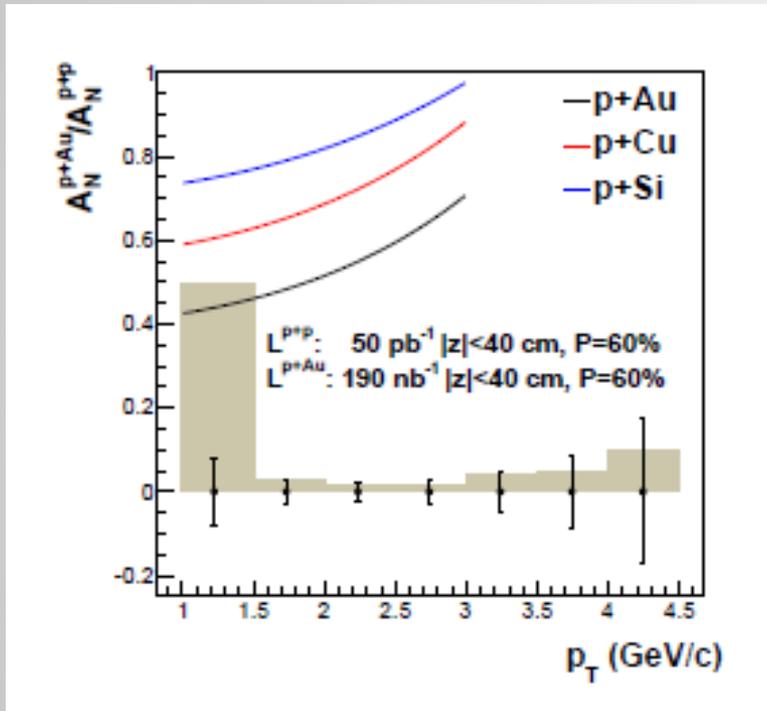
- Outer hatched lines are the 90% confidence level envelope of all the EPS09 curves.
- Assume the R_{pAu} value we measure corresponds to the EPS09 central value.
- Light blue corresponds to 90% C.L. of simulated measurements.
- Dark blue represent the 1-sigma limits.



Prompt photons in MPC-EX -> Precise Measurement of Gluons at Low-x



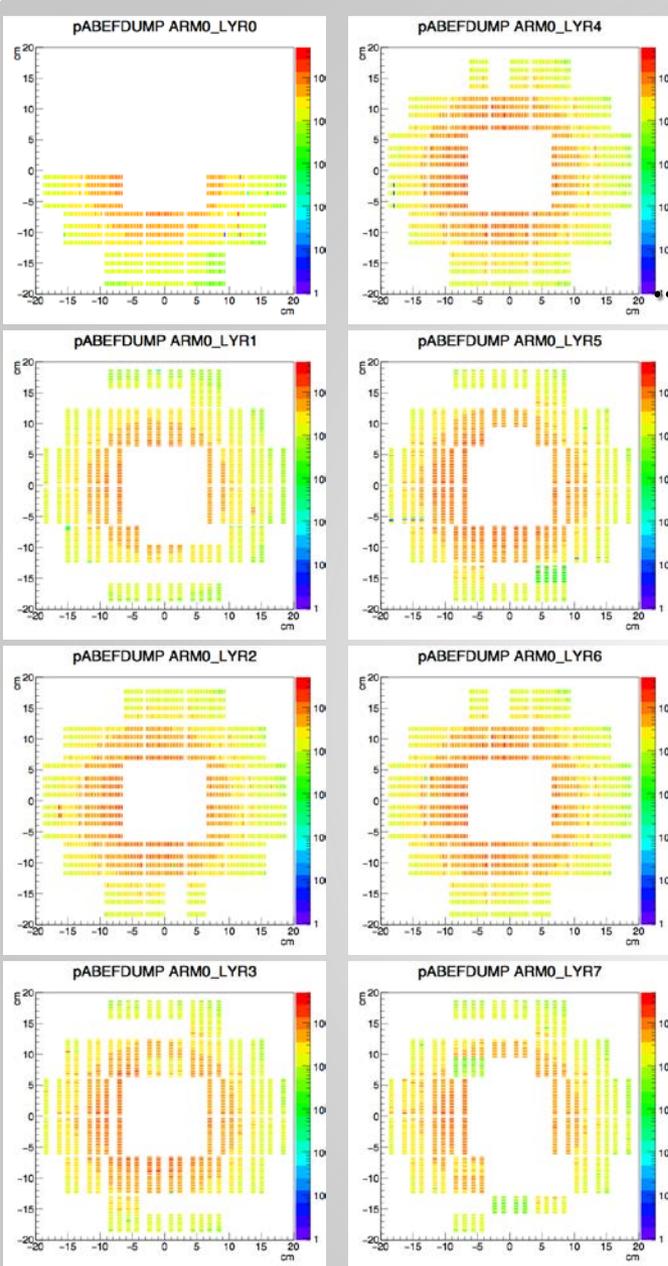
Transverse Single-Spin Asymmetries in polarized p+A Collisions



- Transverse polarization A_N in p+A scales with the saturation scale for $p_T < Q_s$. Completely unique RHIC access to saturation physics.
- p+Au measurement with projected uncertainties in $190 \text{ nb}^{-1} |z| < 40 \text{ cm}$
- Testing geometric scaling with Si target nuclei, comparable uncertainties with 2 week runs.

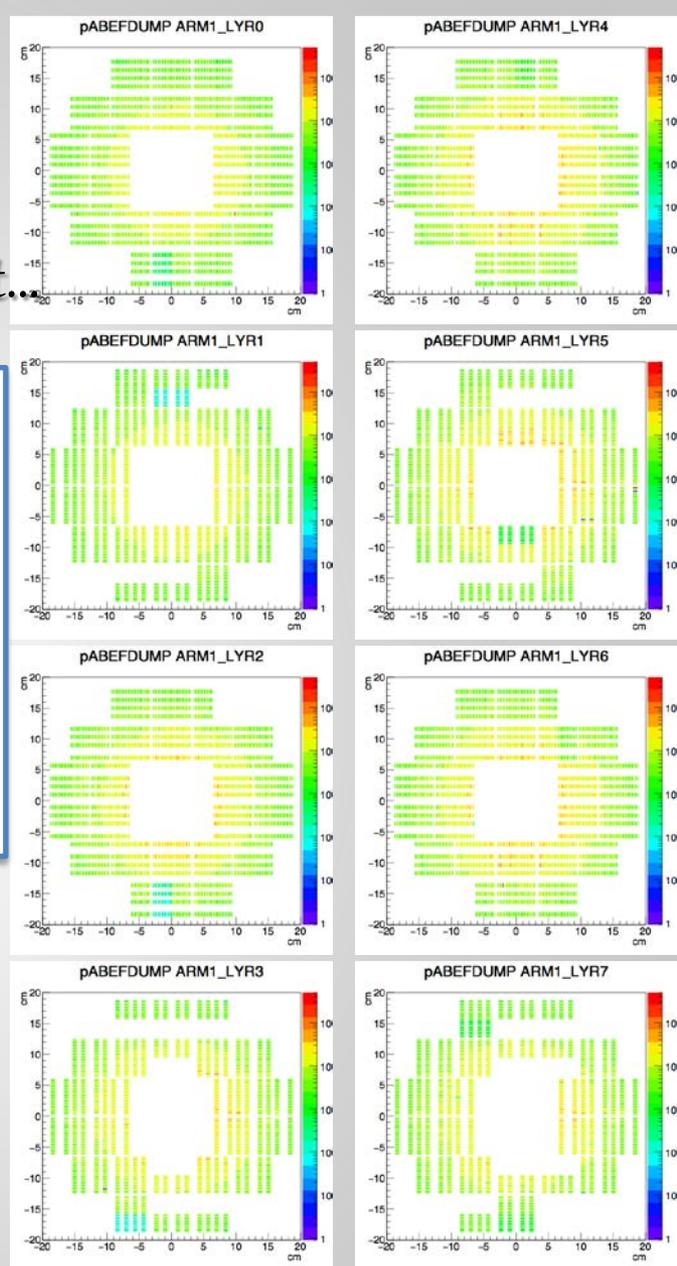
MPC-EX

...it was the season of Light...



South: Au going direction

North: p going direction



MPC Damage

...it was the season of Darkness...

Store

19050

19116/18

19134

May 11

May 28

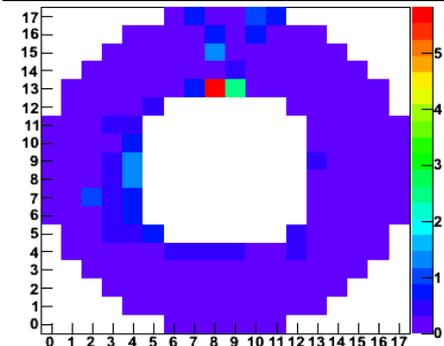
June 1

Damaged South
Impacted North

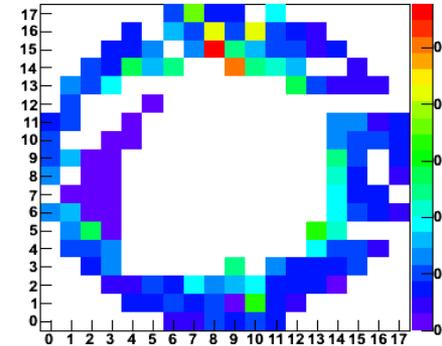
We got lucky
No add't'l damage

The end of the
MPC in Run 15

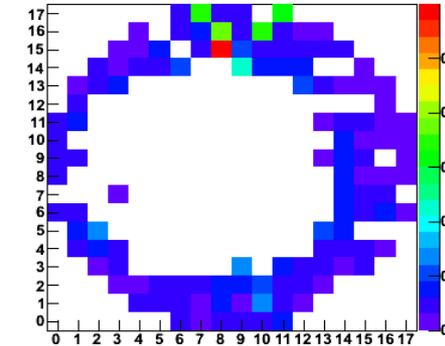
Energy Per Crystal, SMPC Trigger 0



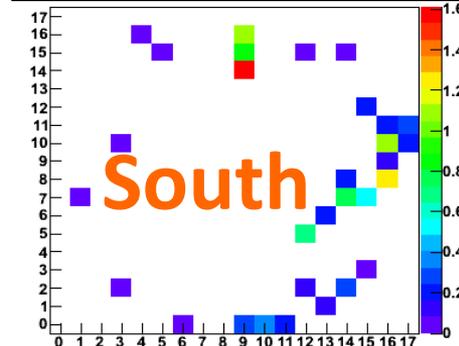
Energy Per Crystal, SMPC Trigger 0



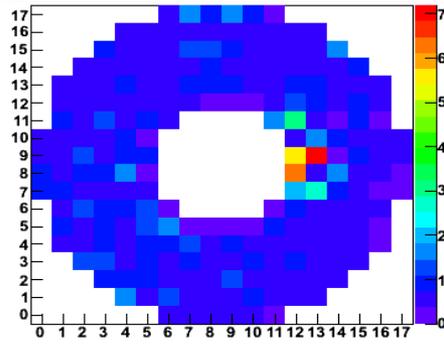
Energy Per Crystal, SMPC Trigger 0



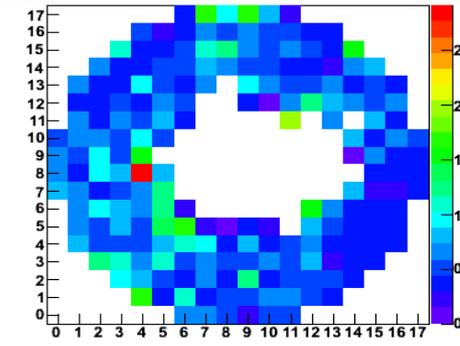
Energy Per Crystal, SMPC Trigger 0



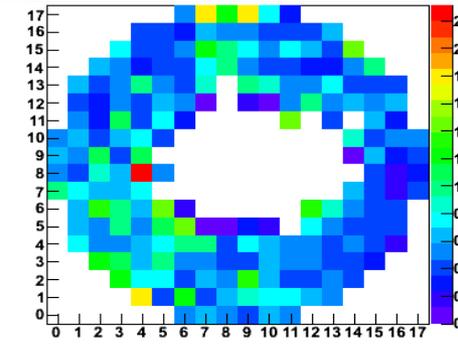
Energy Per Crystal, NMPC Trigger 0



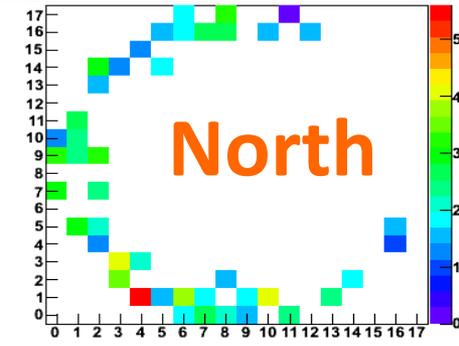
Energy Per Crystal, NMPC Trigger 0



Energy Per Crystal, NMPC Trigger 0



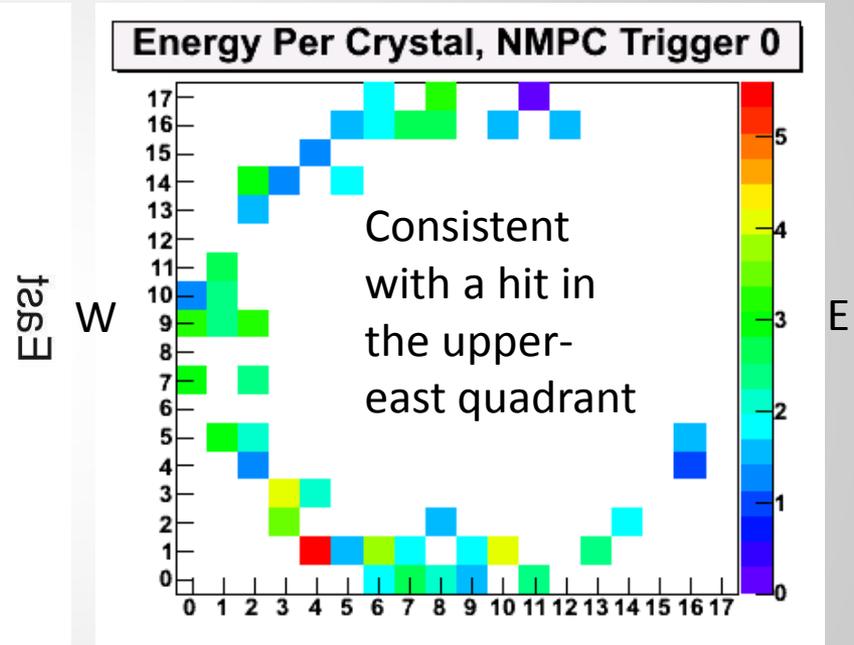
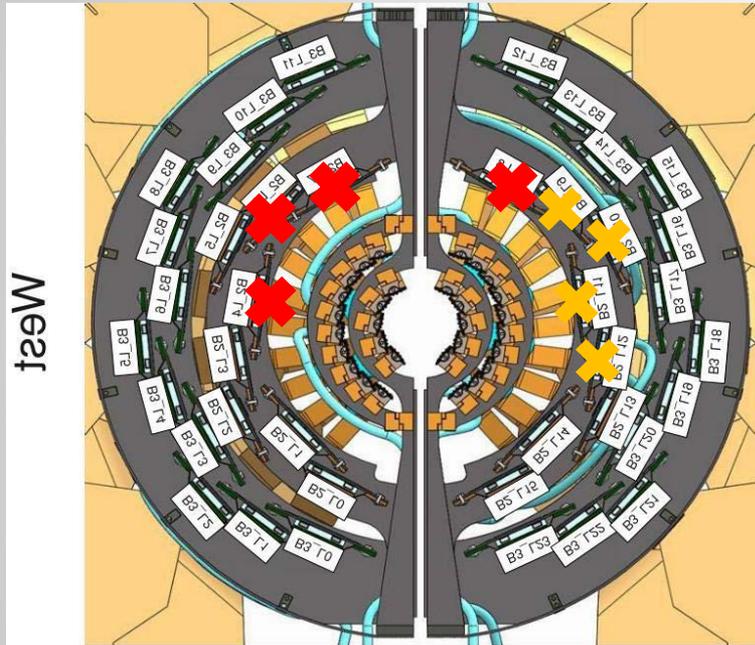
Energy Per Crystal, NMPC Trigger 0



Silicon

...it was the spring of hope, it was the winter of despair...

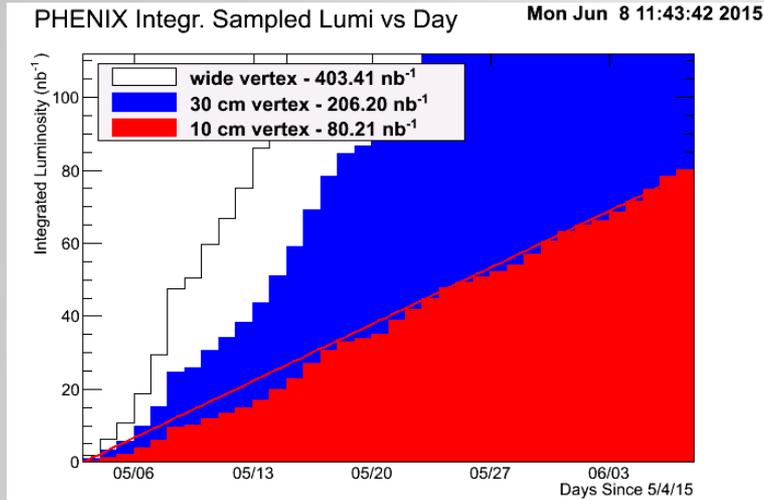
- Barrel 2 ladders 4,7,8,9,10, and 11 have been impacted



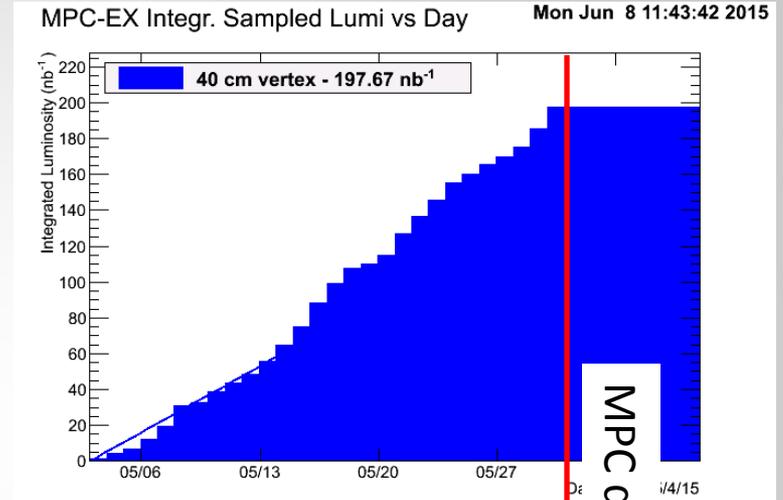
- After a further event, we have turned off the FVTX and VTX...



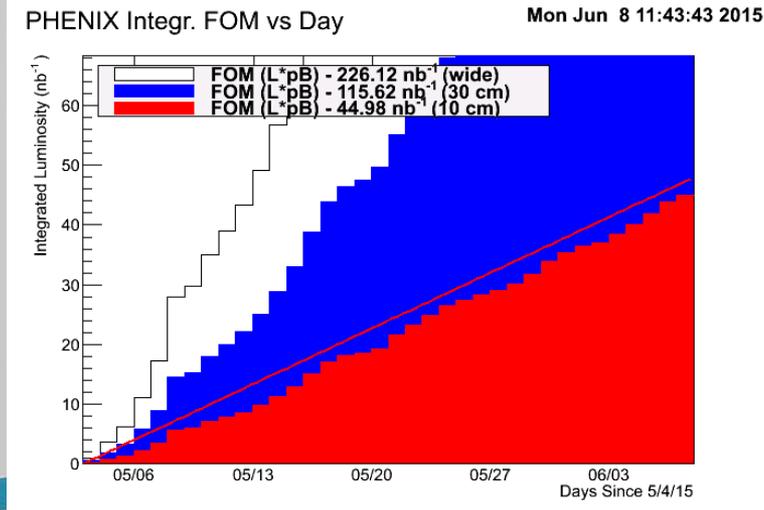
p+Au Luminosity and FoM Goals



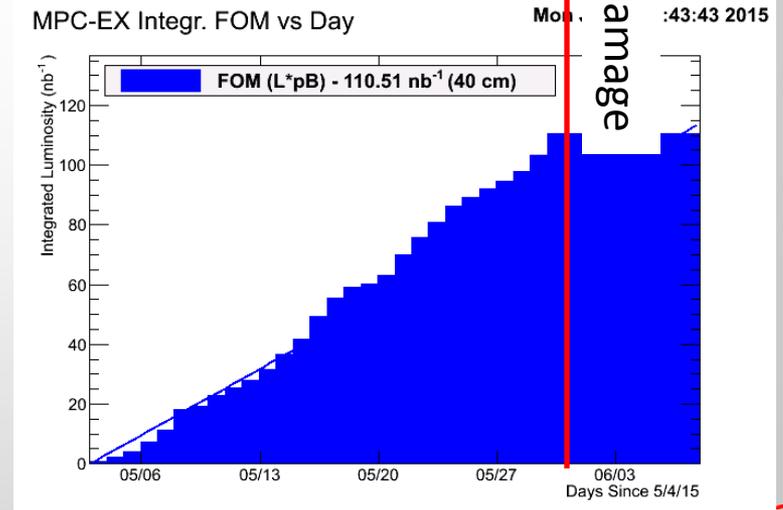
Lumi



MPC damage

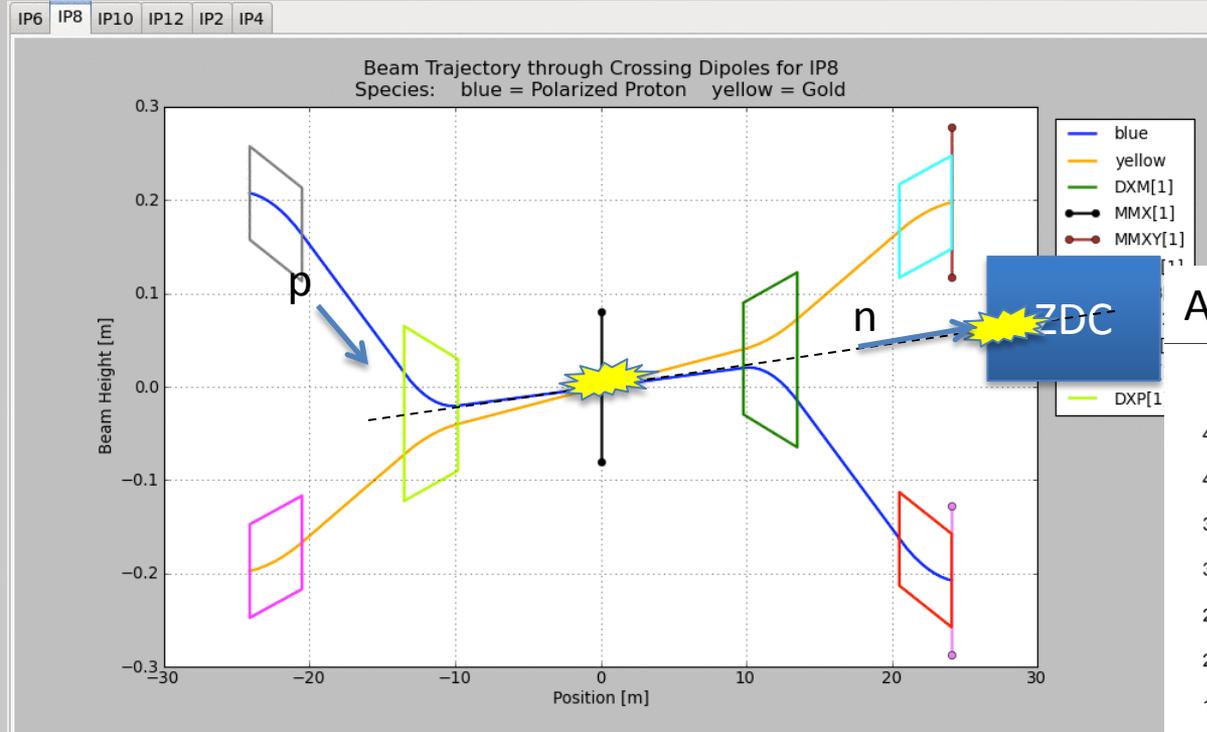


FoM

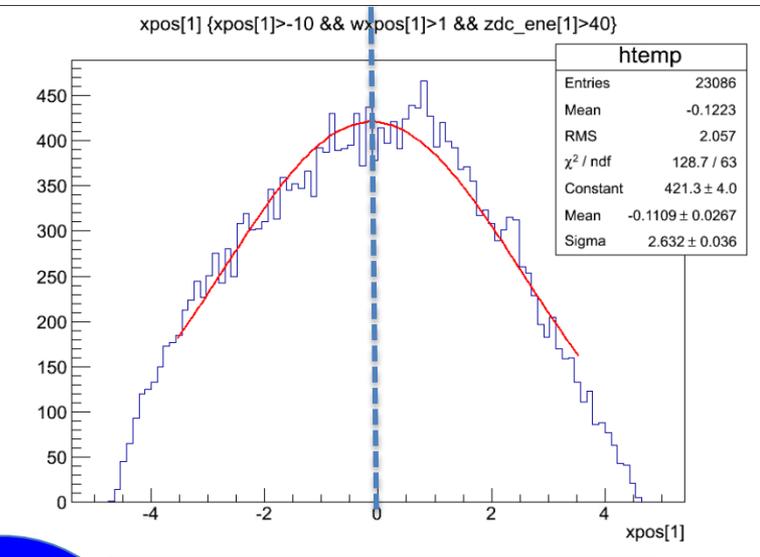


MPC damage

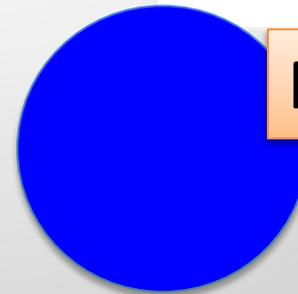
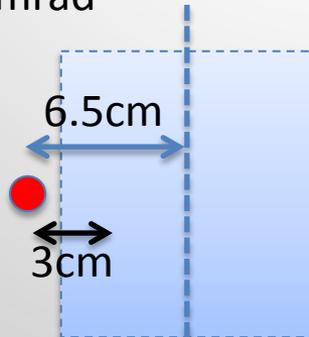
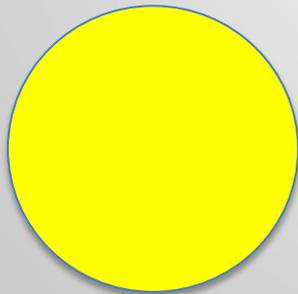
Local Polarimeter



Analysis by Minjung Kim (SNU/RIKEN)



Blue beam angle : 1.66 mrad (3.6mrad in physics runs)
 Angle btwn Blue and Yellow : 2mrad



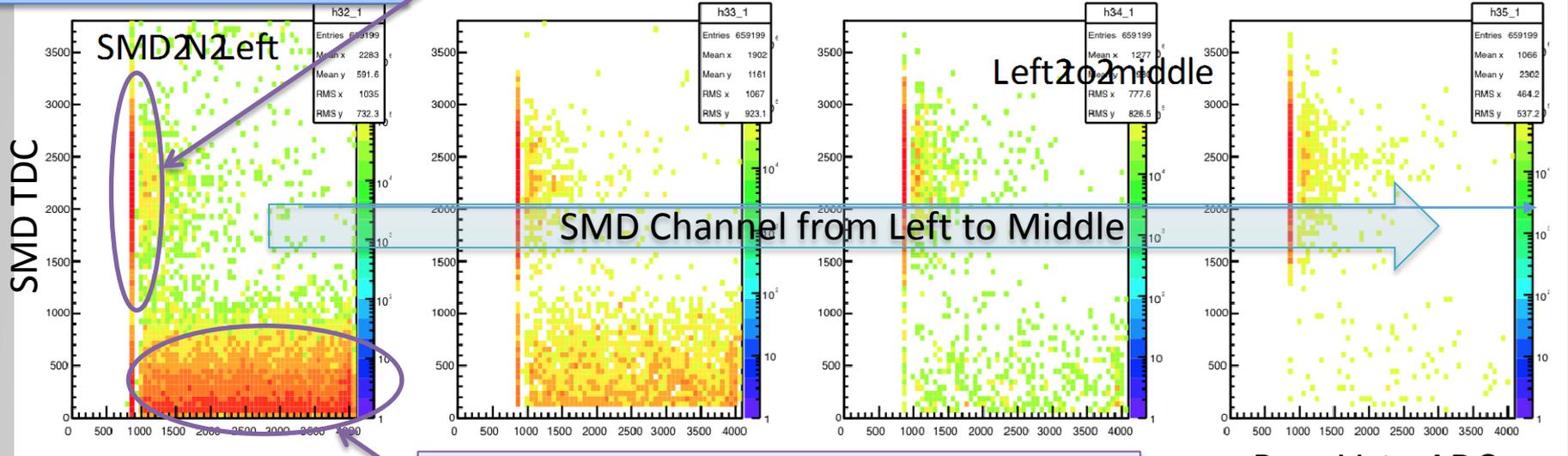
Nicely centered!



Dedicated runs

1st Attempt (May 21st)

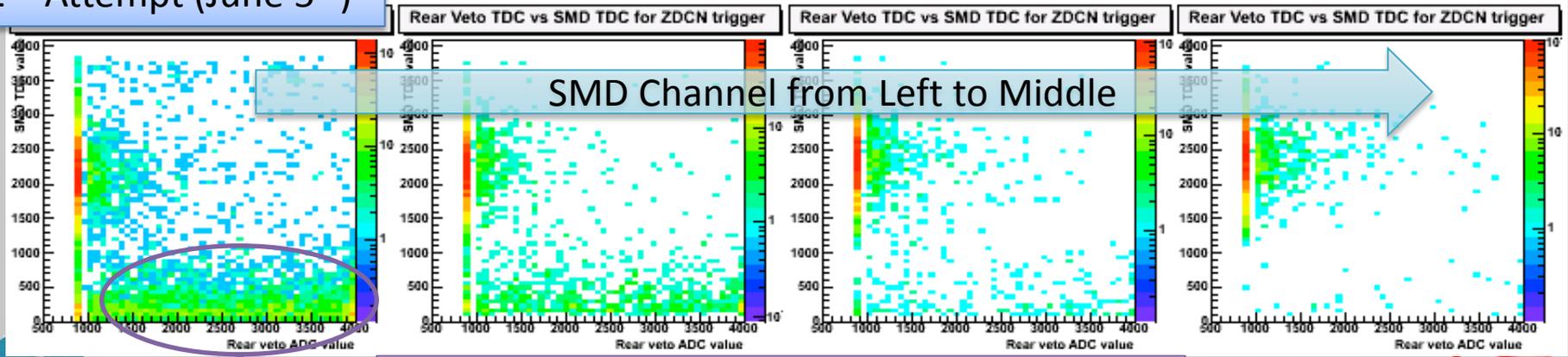
Neutrons from collision



SMD Channel from Left to Middle

Charged backgrounds from Yellow beam

2nd Attempt (June 5th)



SMD Channel from Left to Middle

Charged backgrounds are relatively smaller !!

p+Al

*... we had everything before us,
we had nothing before us...*

- No MPCEX physics.
- Will get limited flow observables (the loss of the MPC and the FVTX will leave us only the BBC to determine the reaction plane).
- Will not get heavy flavor (the loss of the F/VTX means no DCA analysis).
- Will look at the forward neutron asymmetry in p+Al, to look for systematic changes in asymmetry from p+p to p+Au to p+Al.



Summary

- Run 15 p+p was very successful, despite a delayed start with our new detector MPC-EX.
- Run 15 p+Au was also successful, despite the loss of the MPC South early in the run and both MPCs later.
- We will take whatever we can get from Run 15 p+Al, but have lost most of our more unique physics opportunities.



Thanks

- Many thanks to Itaru Nakagawa (Spin Coordinator), our period coordinators, and the entire BNL/PHENIX tech crew!
- The most sincere thanks to the CAD crew for their hard work and dedication.

...we were all going direct to Heaven, we were all going direct the other way - in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or for evil, in the superlative degree of comparison only.

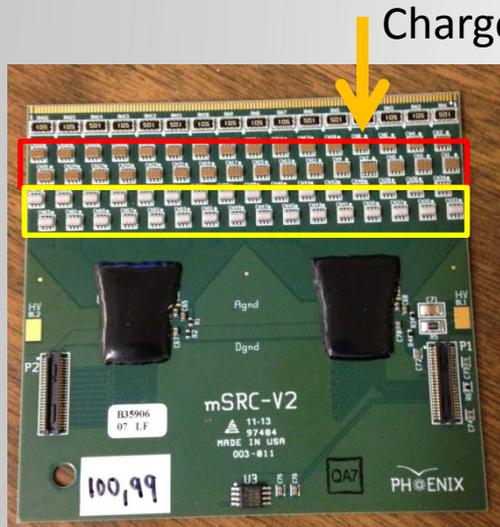
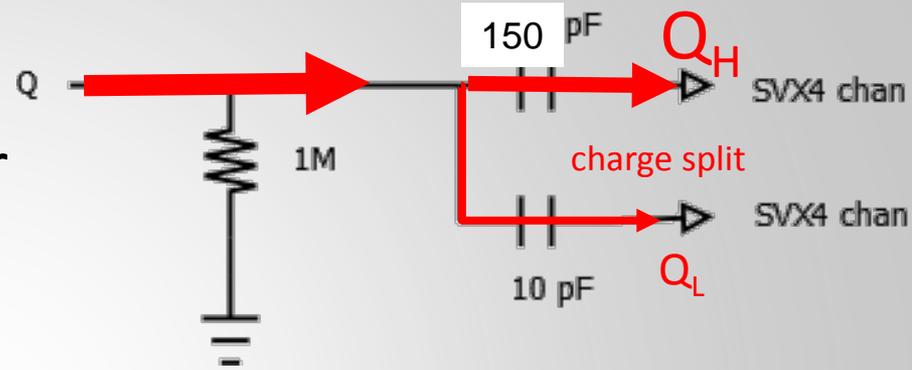


Backup



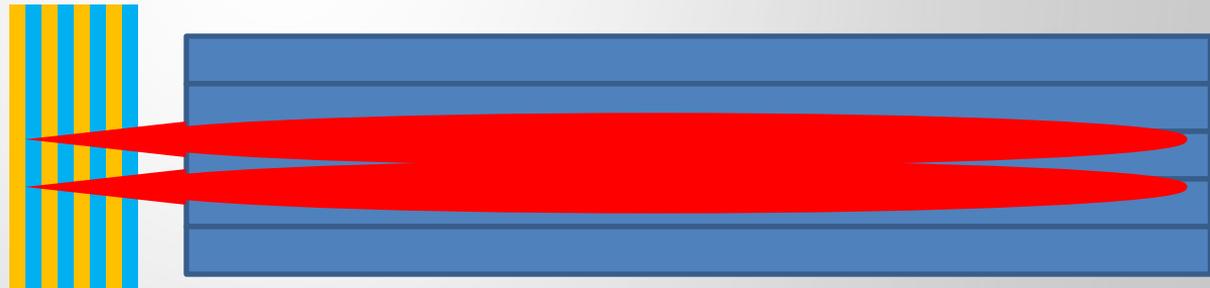
Tracking through the layers

- Need to be:
 - Sensitive to MIPs in first layer
 - Not saturated at last layer



MPC-EX

MPC

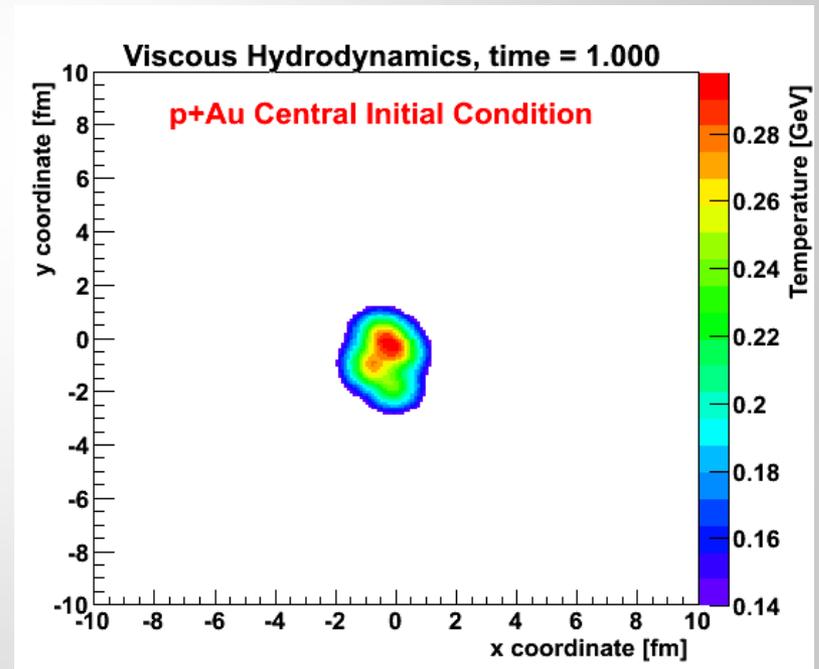
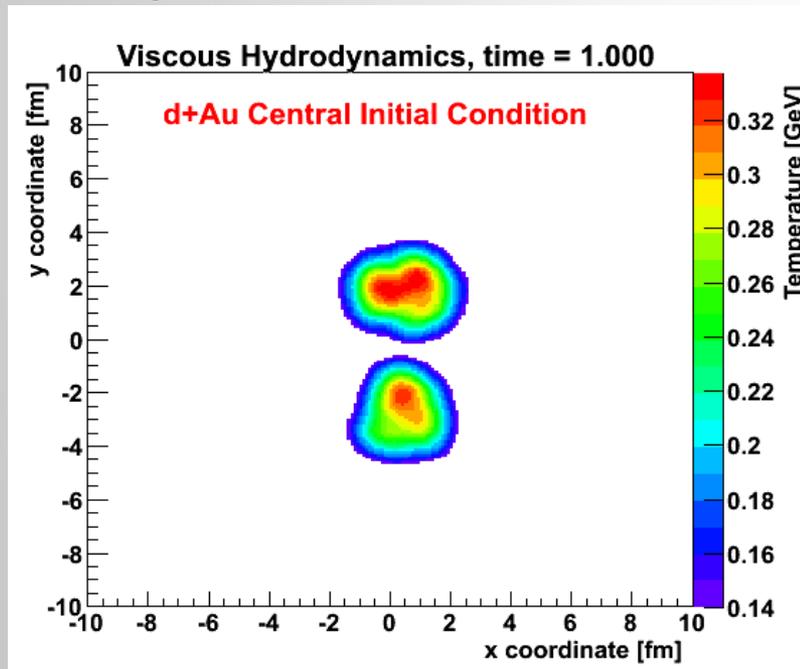


128 minimipads become 256 channels

RHIC/AGS User's Meeting

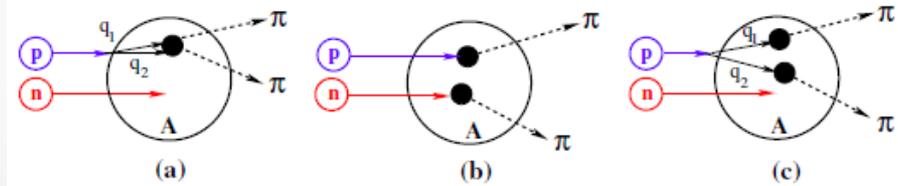
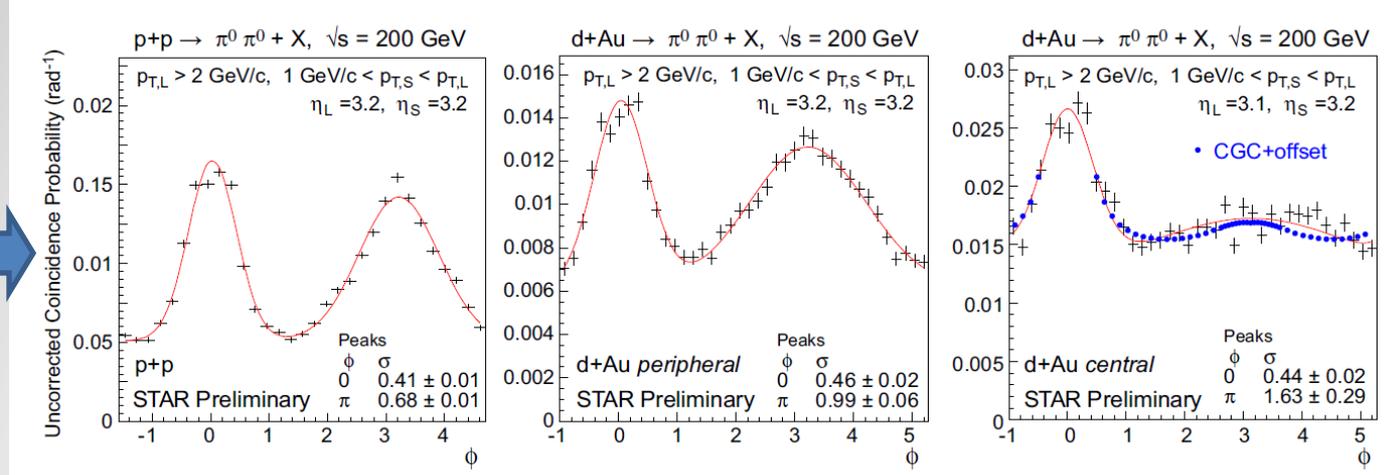
Protons are smaller

- d+Au collisions may have a remaining flow effect from multi-parton collisions, that may be smaller in p+Au.

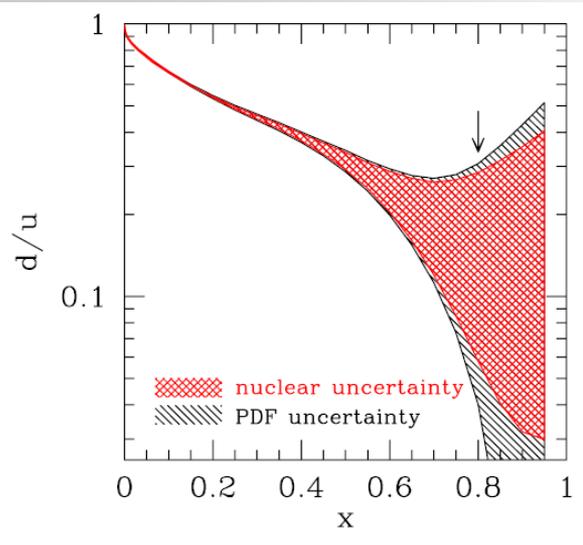


Why p+A instead of d+A?

Multi-parton interactions can contribute to the suppression of the away-side correlation strength.



Phys. Rev. D 84 014008 (2011)



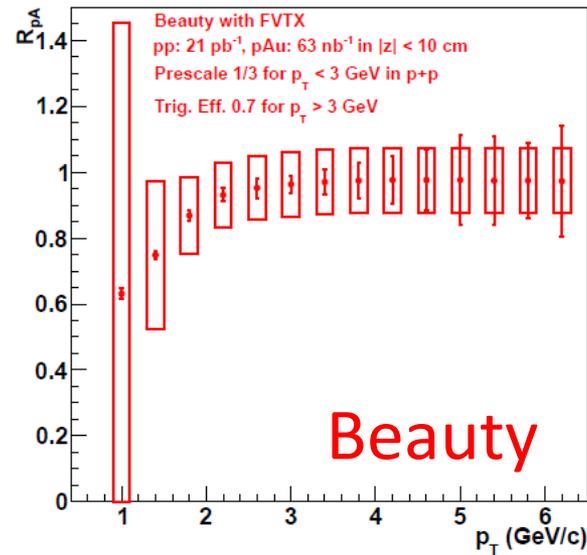
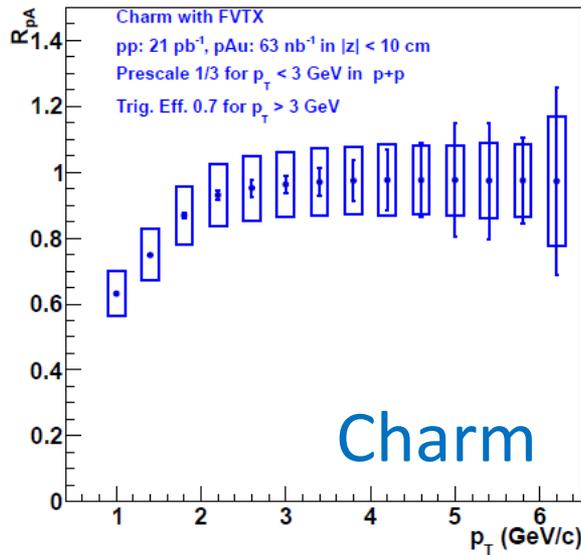
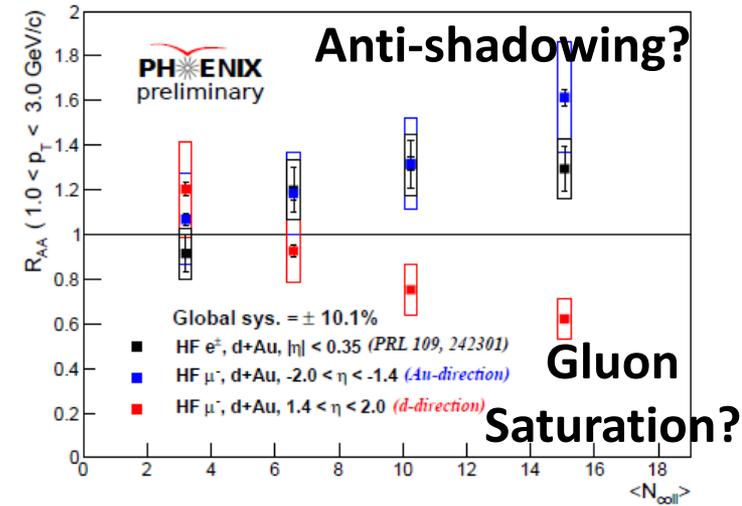
Forward rapidity corresponds to *high-x* in the projectile nucleon (d or p). Nuclear corrections at high-x are large for the deuteron, which may necessitate d+p running for proper comparison.

...and you can't polarize the deuteron at RHIC...

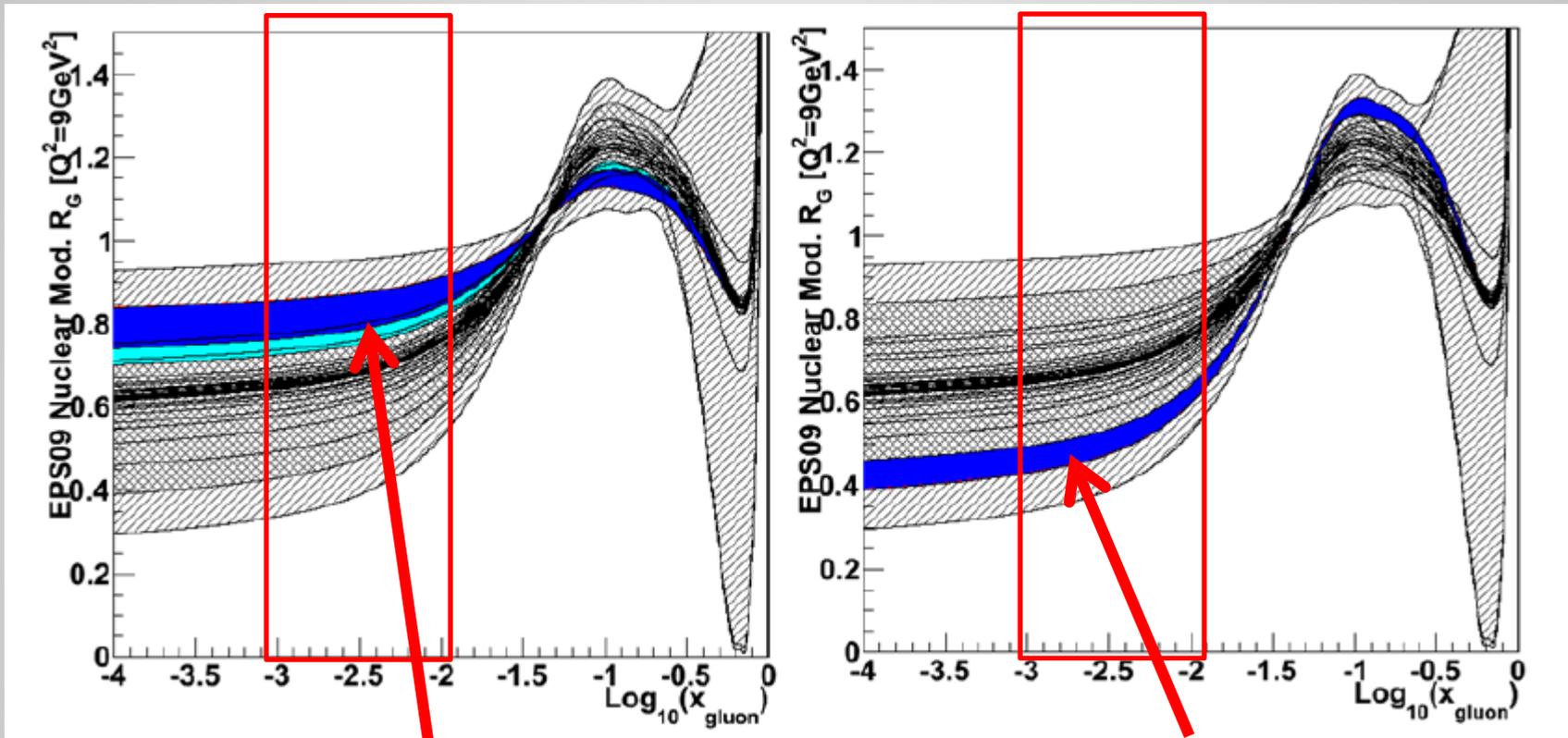
Open Heavy Flavor Probes of nPDFs and More

Another handle on gluon nPDF and critical baseline for quarkonia

Measure open charm and beauty at forward/backward rapidity with FVTX



Upper and Lower Limits from EPS09



assuming EPS09 upper curve

assuming EPS09 lower curve

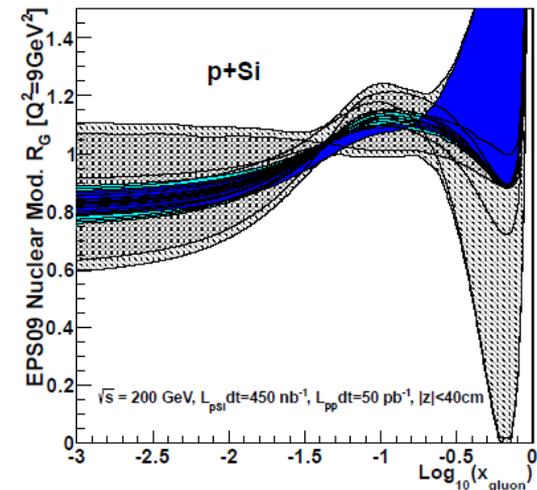
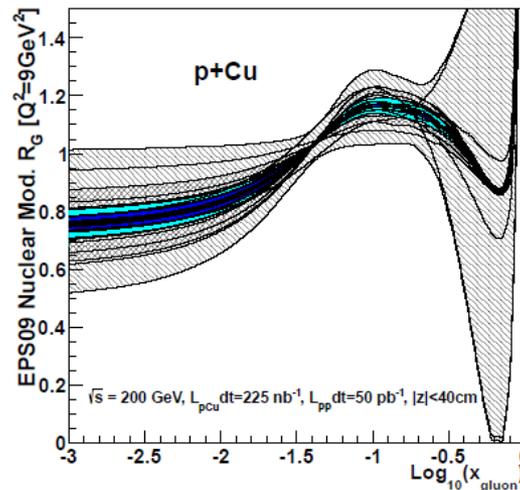
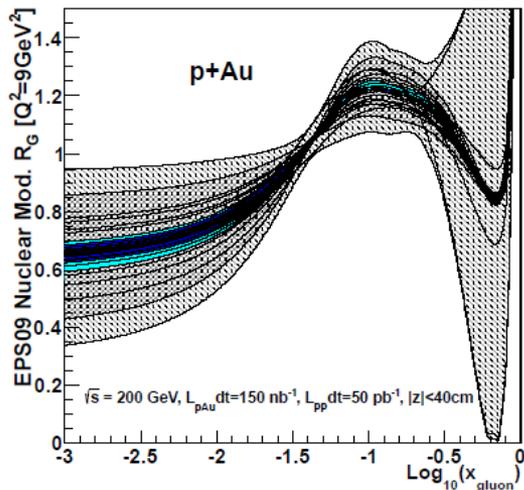
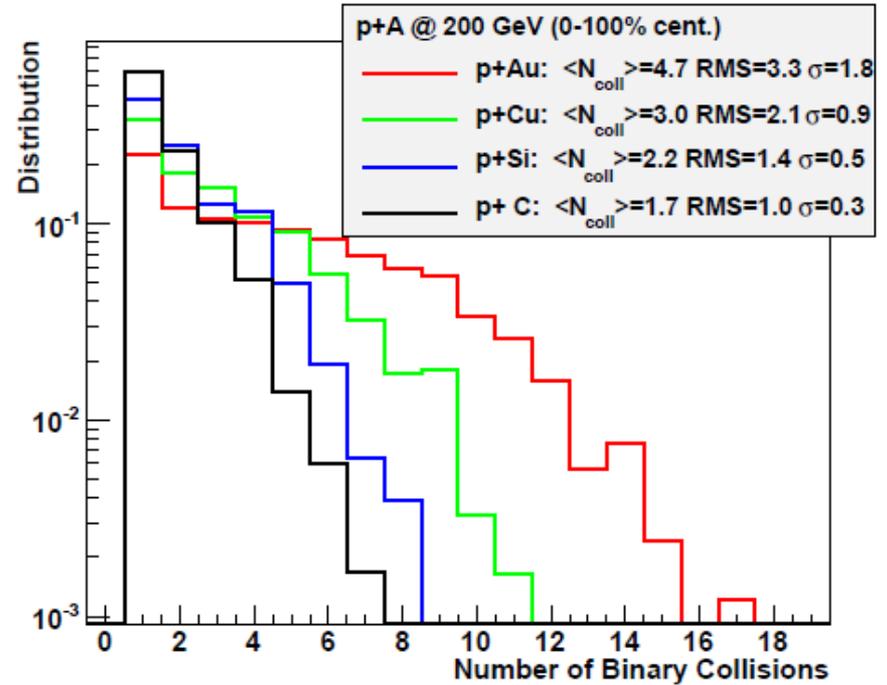
Ultimate sensitivity depends on the measurement and a full NLO fit.

Geometry Test

DIS measures give geometry averaged nPDF

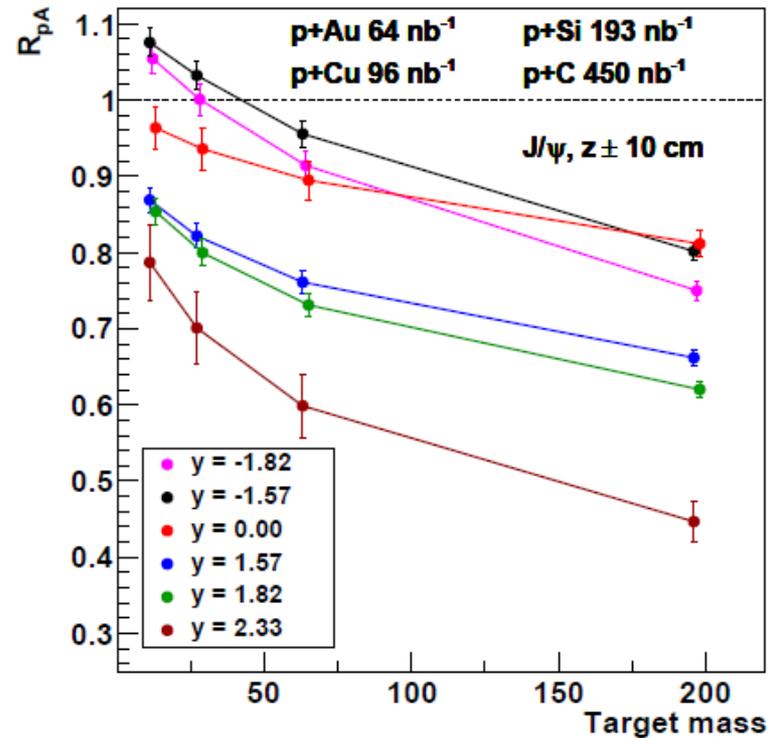
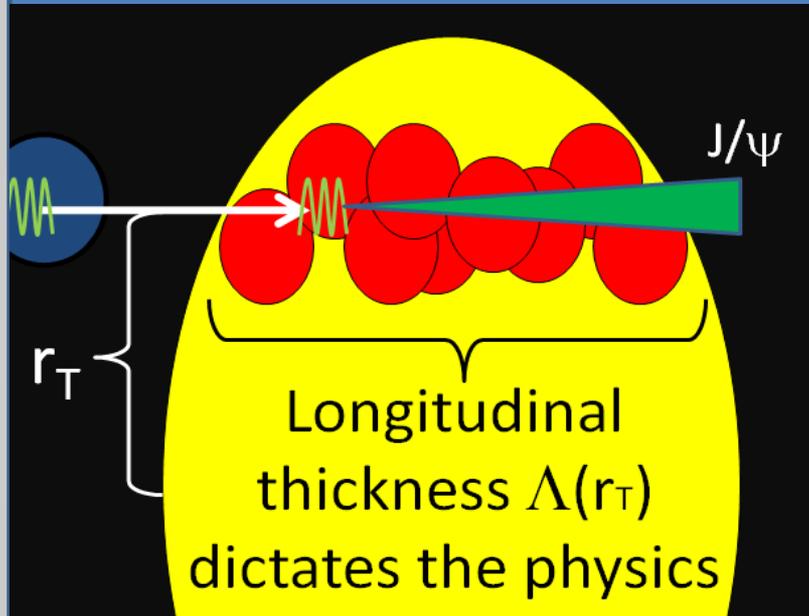
Utilized d+Au centrality measures to date...

Excellent opportunity to validate with direct photons nPDF of different nuclei



Quarkonia in Medium (Cold or Hot)

J/ψ and ψ' are hard to explain w/ nPDF & σ_{breakup}



Instead of d+Au centrality selection, another method to change nuclear density is with different targets

Also combined with improved S/B and for the first time ψ' at forward and backward rapidity (FVTX)



Yellow Pre-fires, etc.

- Store 18969?, April 30 - ???
 - Tripped LV/HV in MPC-EX, 20% increase in bias current, MPC was off.
- Store 19050, May 11 - Pre-fire 111x111
 - MPC South mostly gone, MPC North damaged
- Store 19116, May 28 - Pre-fire 12x12 store
 - No additional damage
- Store 19118, May 28 - Pre-fire 111x111
 - No additional damage
- Store 19134, June 1 - Pre-fire 111x111
 - Killed remaining MPC both sides
- Store 19139, June 2 - ???
 - Tripped 3 out of 4 MPC-EX LV modules and all HV

