The MPC-EX Detector in PHENIX

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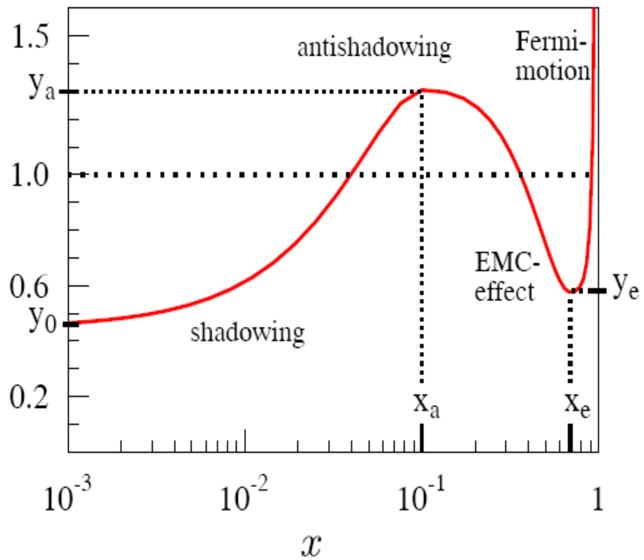
Columbia University

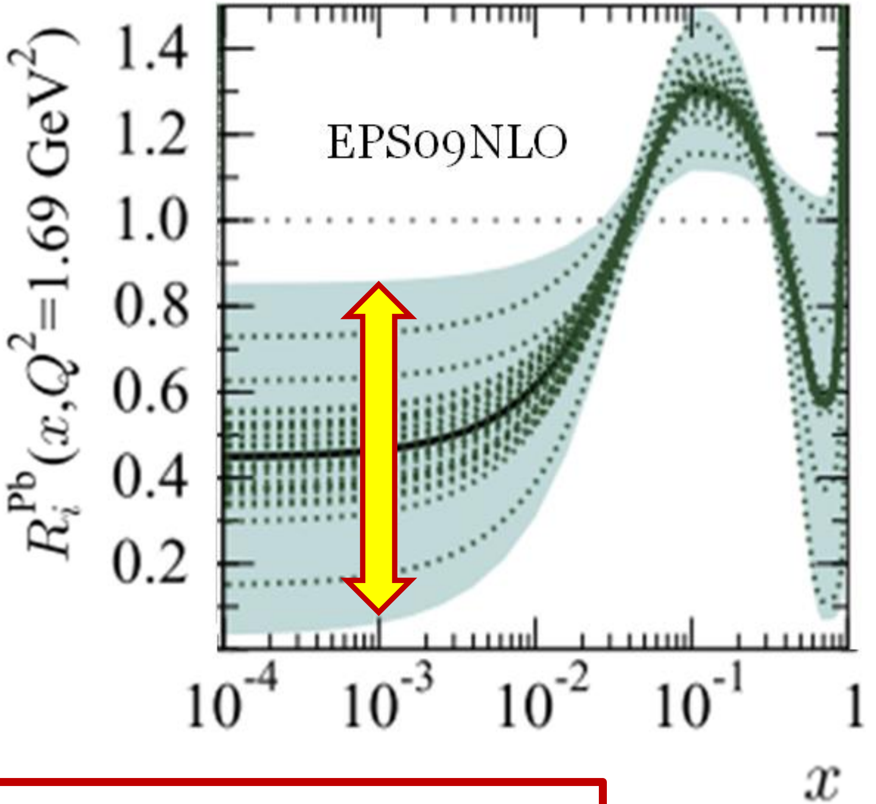
Shadowing/Saturation in Nuclei

- What is the gluon shadowing/saturation in heavy nuclei at low-x?



Fit data on nuclei:
SLAC, NMC, EMC
DIS+DY+PHENIX
midrapidty π^0

Eskola , Paukkunen, Salgado, JHP04 (2009)065

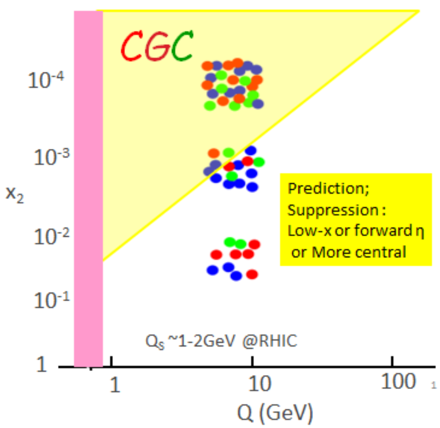


Large uncertainties in gluon nPDF at low-x
→ Lack of data at low-x

Two pictures of Cold Nuclear Matter

Color Glass Condensate

- High gluon density
  - Treat classically
- Weak coupling, $\alpha_S(Q_{Sat})$ small
- Saturation scale: Q_{sat}



Equivalence

F Dominguez, C. Marquet, B-W. Xiao, F. Yuan PRD 83 (2011) 105005

???

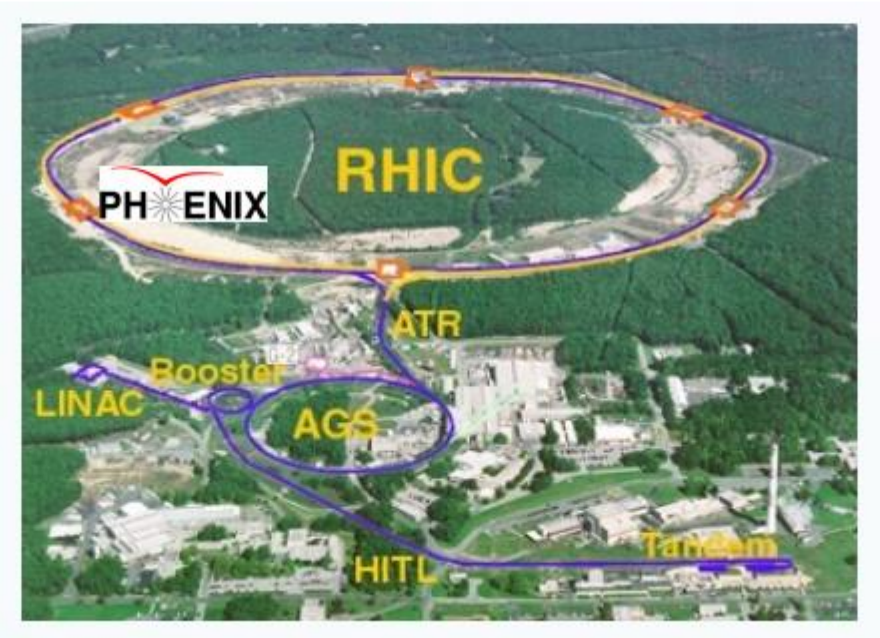
Non-perturbative extensions to pQCD

- Transverse momentum (k_T) dependent PDFs at low-x
  - G^1, G^2
- Higher twist shadowing effects
- Initial state energy loss
- Absorption
- Modified structure functions
- Coherent effects

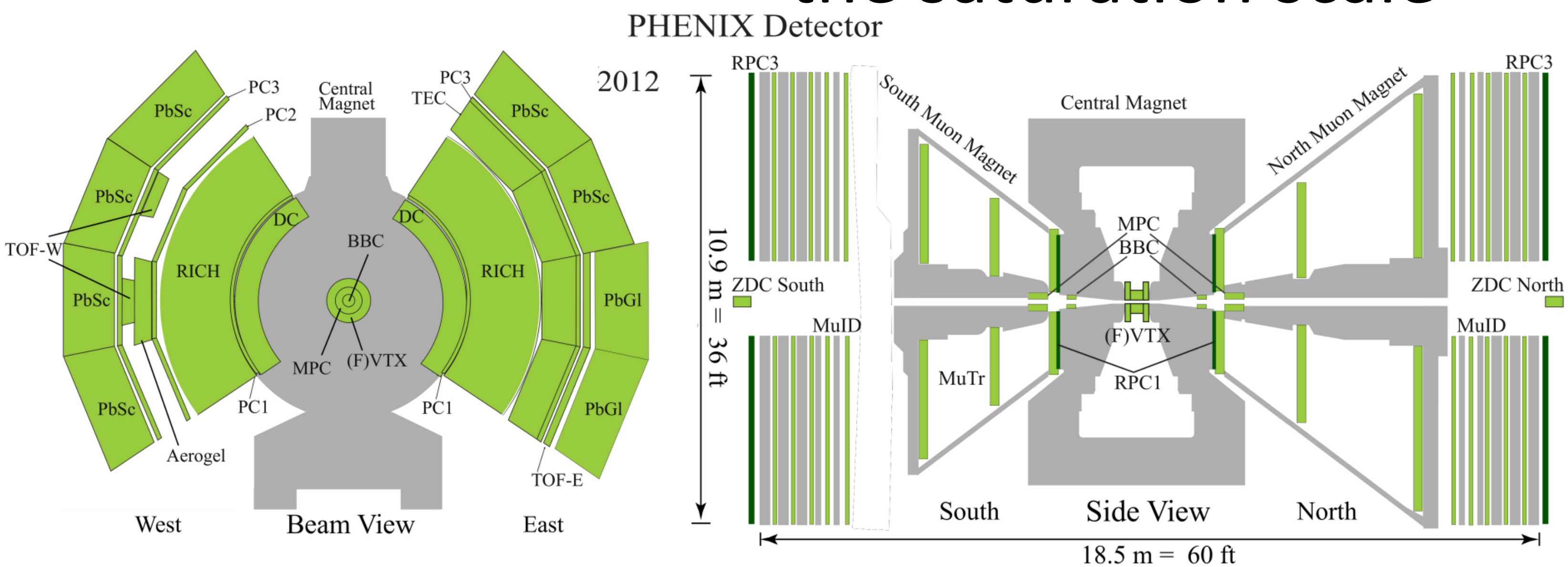
Important:

- Fundamental understanding of partonic processes in nuclei
- Initial conditions at RHIC and the LHC

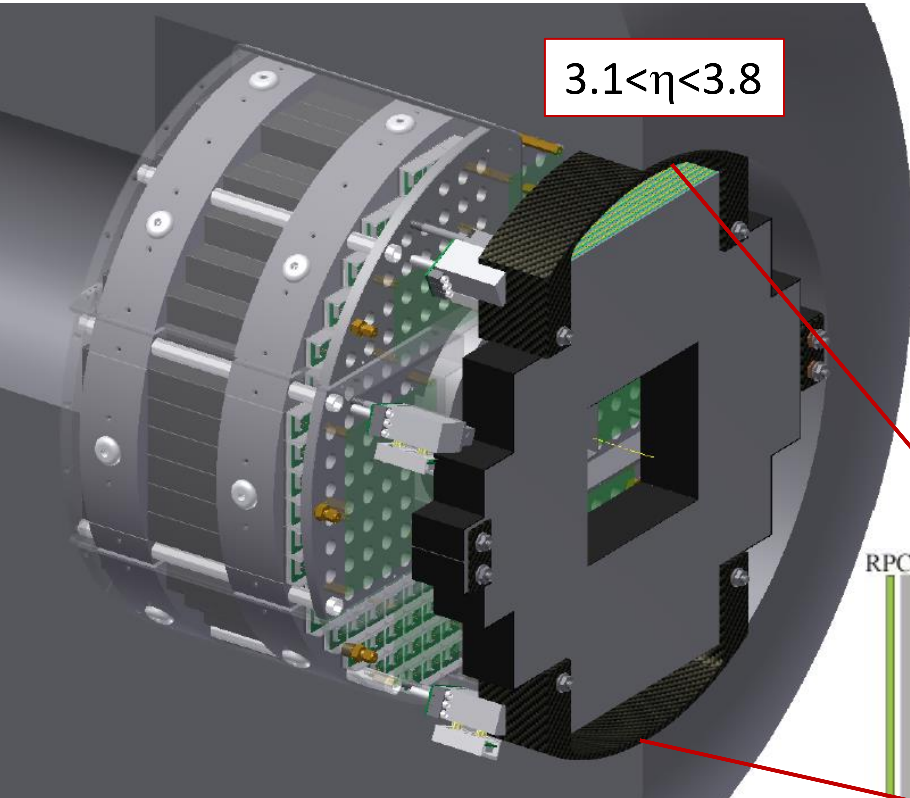
PHENIX at RHIC



- Collision species: Au+Au, Cu+Cu, U+U, Cu+Au, He^3+Au, d(p)+Au, p+Al, p+p
- RHIC is in a position to measure above and below the saturation scale

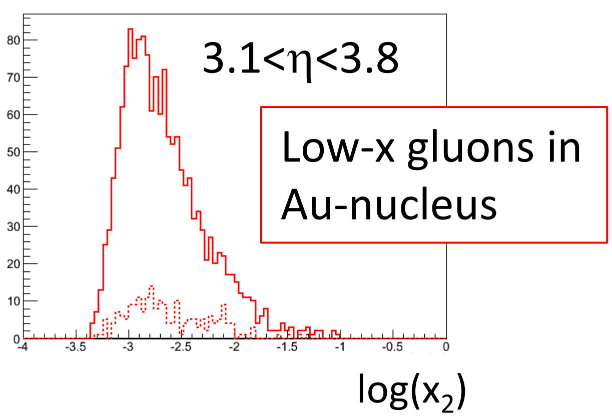


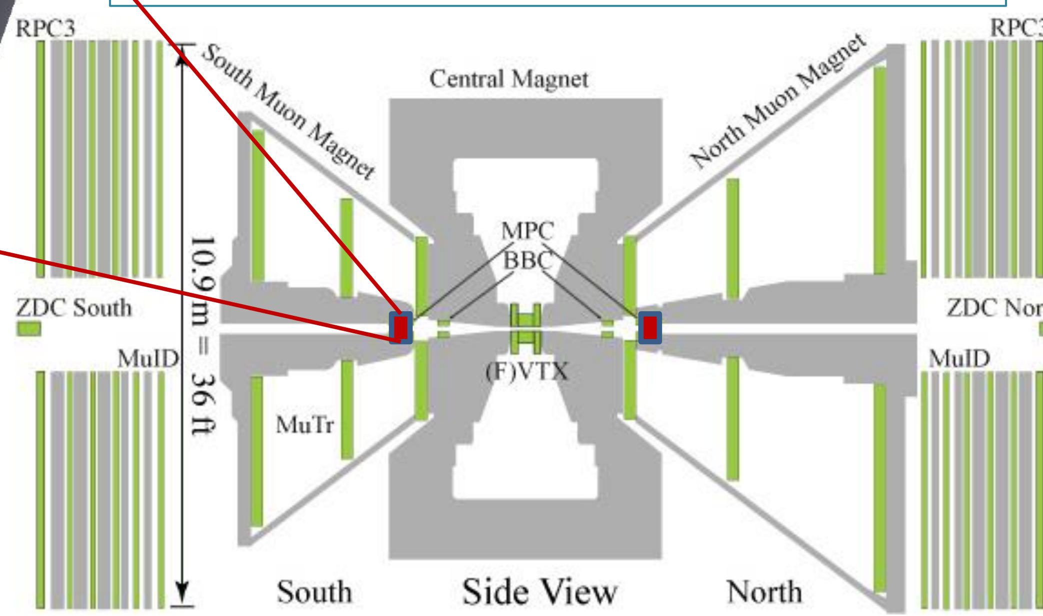
The MPC-EX Detector



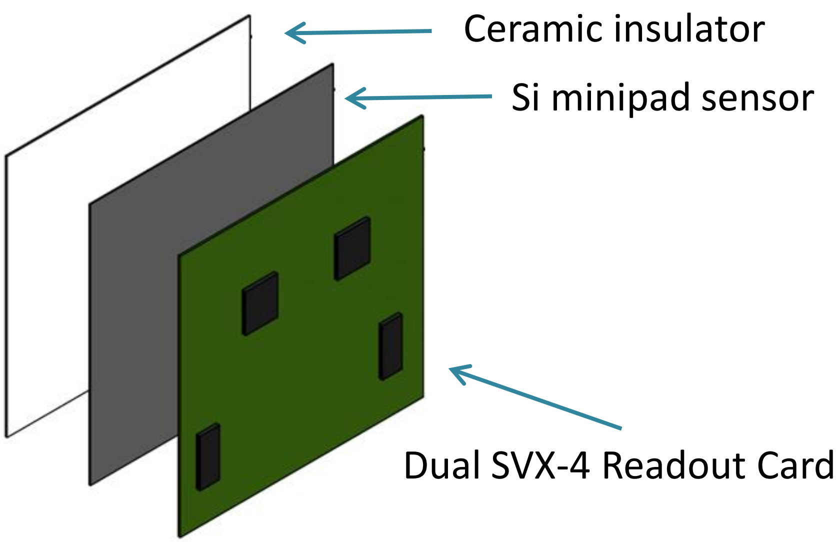
A combined charged particle tracker and EM preshower detector – dual gain readout allows sensitivity to MIPs and full energy EM showers.

- π^0 rejection (prompt photons)
- π^0 reconstruction out to >80GeV
- Charged track identification

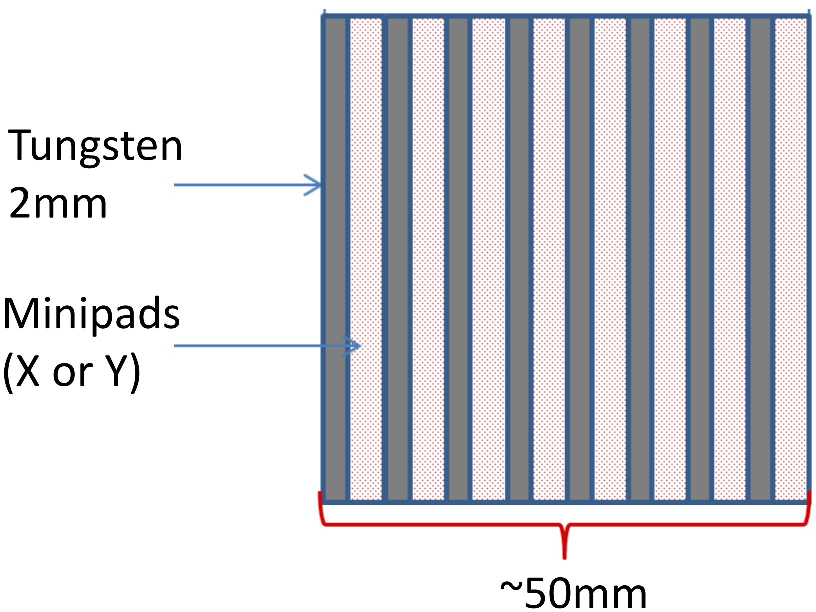


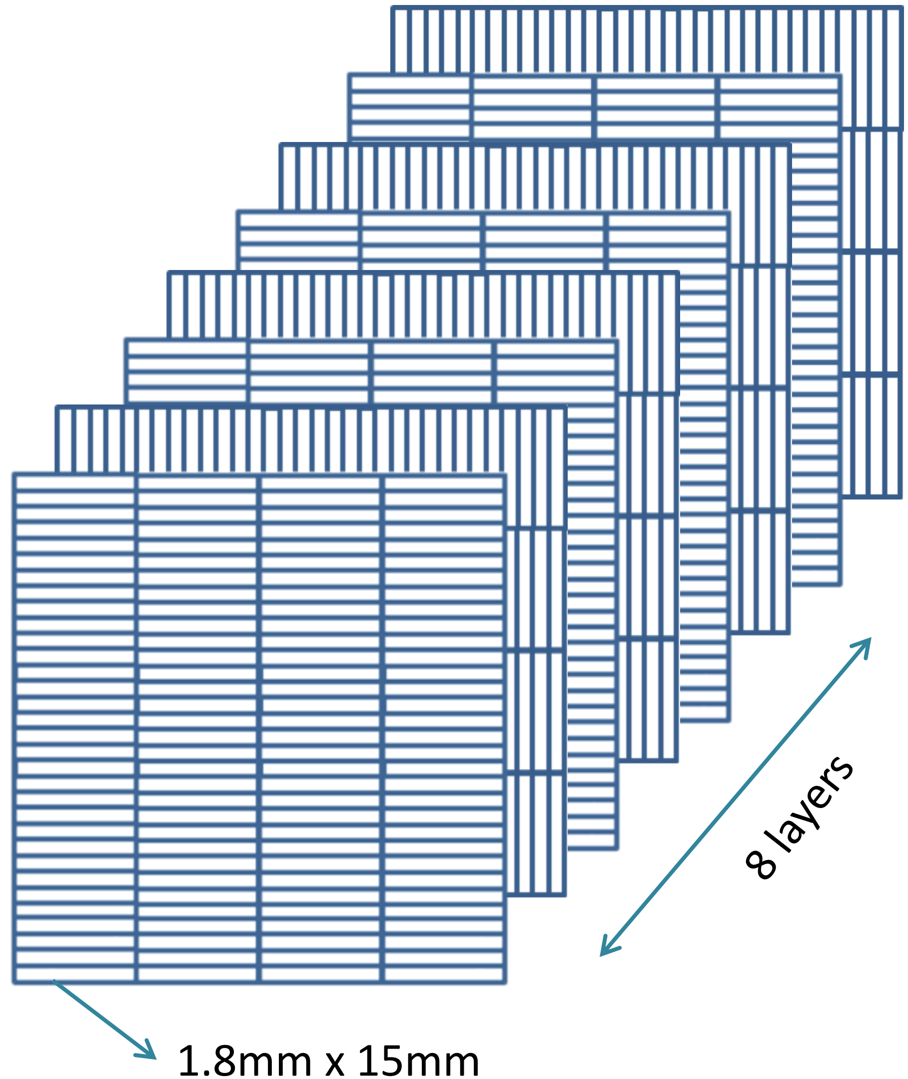


Minipad Sensors



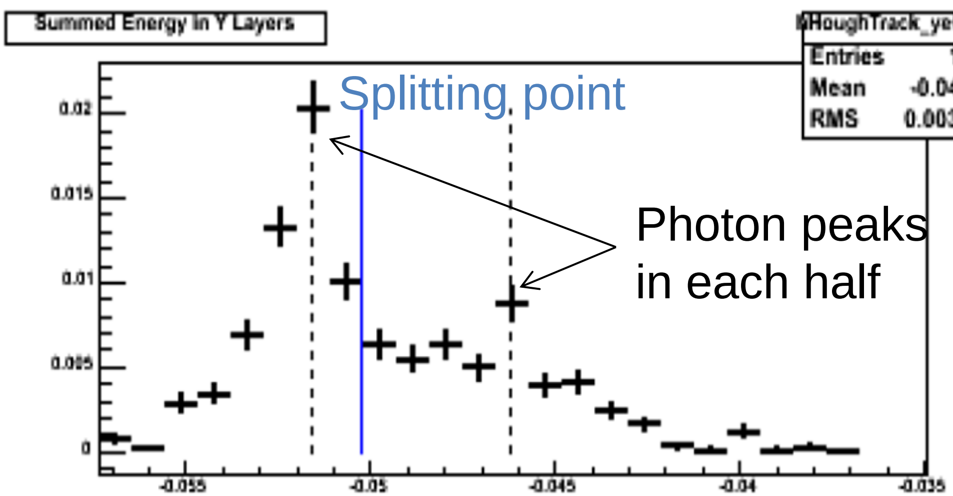
Cross-Section View:

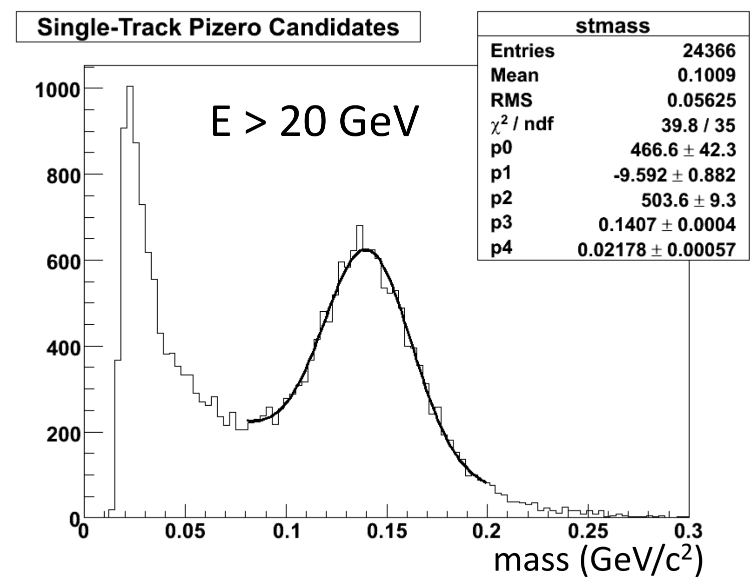




π^0 rejection

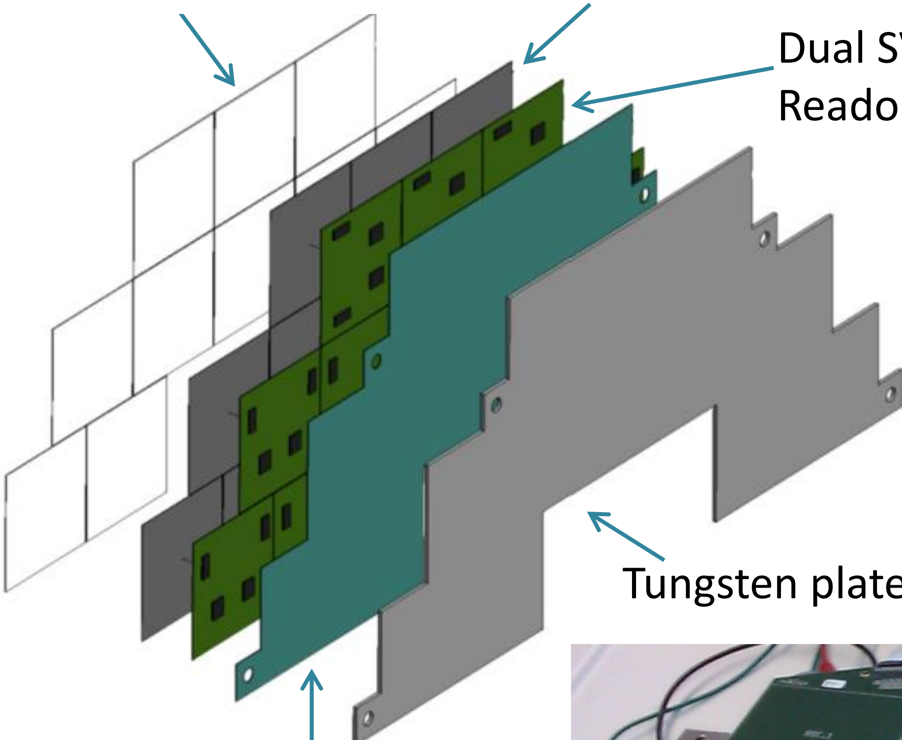
- At E > 20 GeV, π^0s in one track in MPC-EX
- Split energy distributions into two parts
  - Iterate until find stable splitting point
  - Find energy of the halves
- Calculate mass from two halves

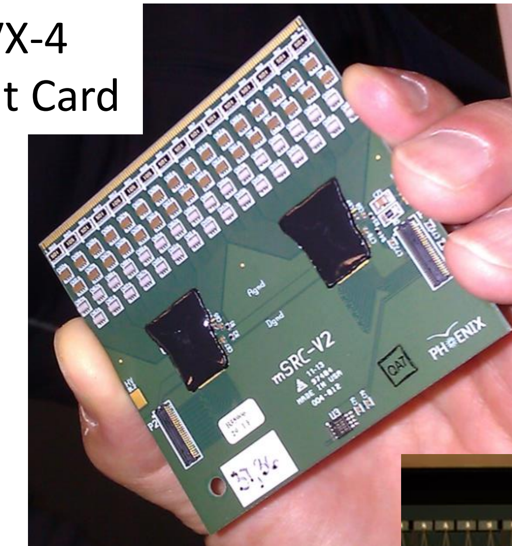




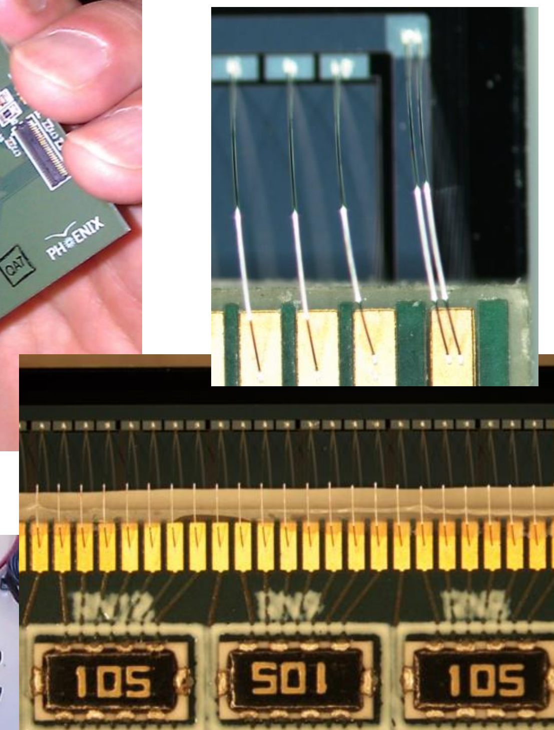
- Able to separate π^0 and γ out to E > 80 GeV

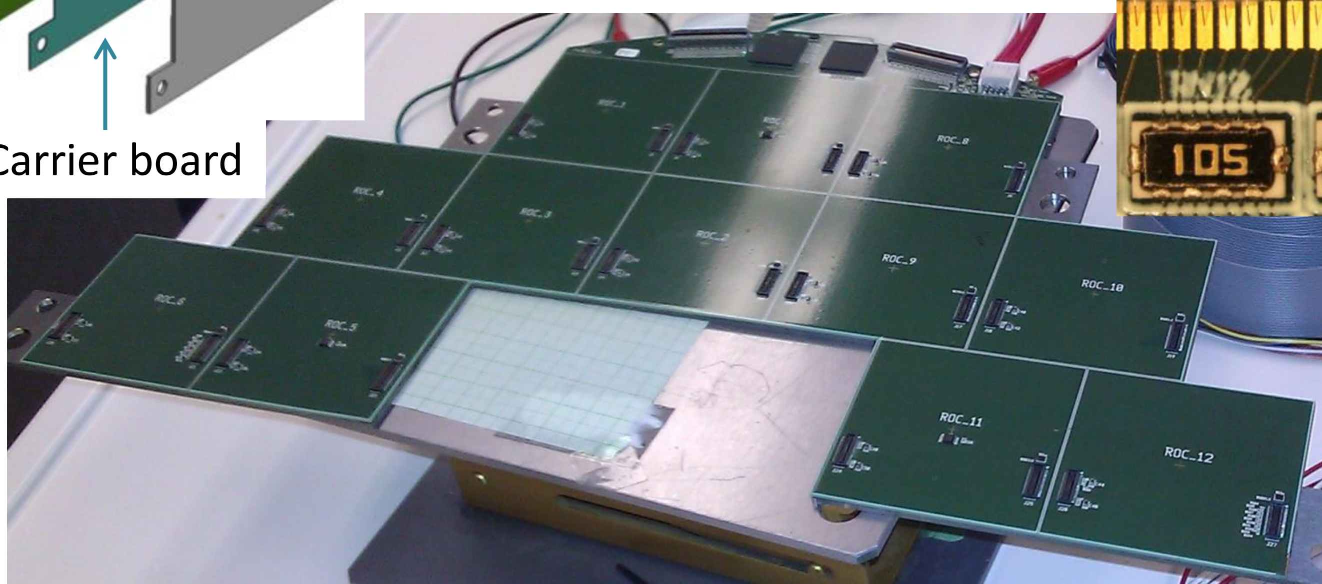
Carrier board assembly





Minipad wired bonded
to readout card

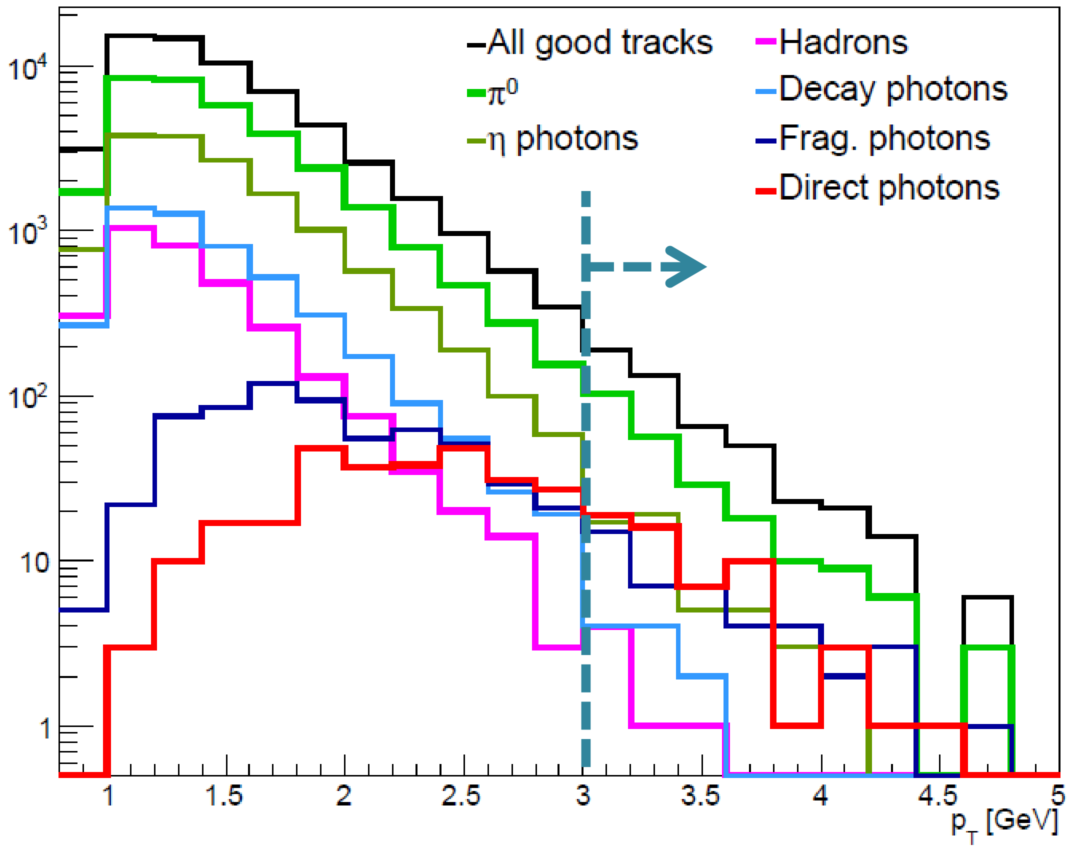


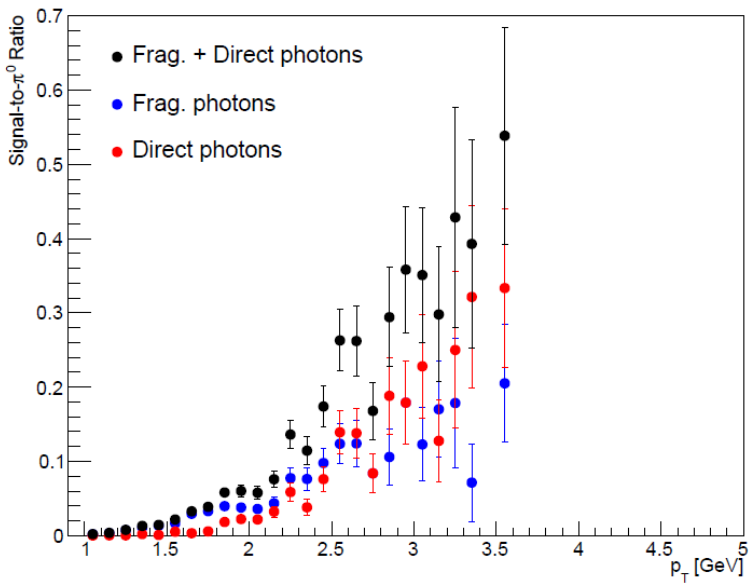


Signal photon simulations

868 million MB p+p Pythia events

–16.5 GeV MPC trigger, +/- 50 cm vertex cut





Signal photons = direct + frag. photons

43% signal-to-π^0 ratio

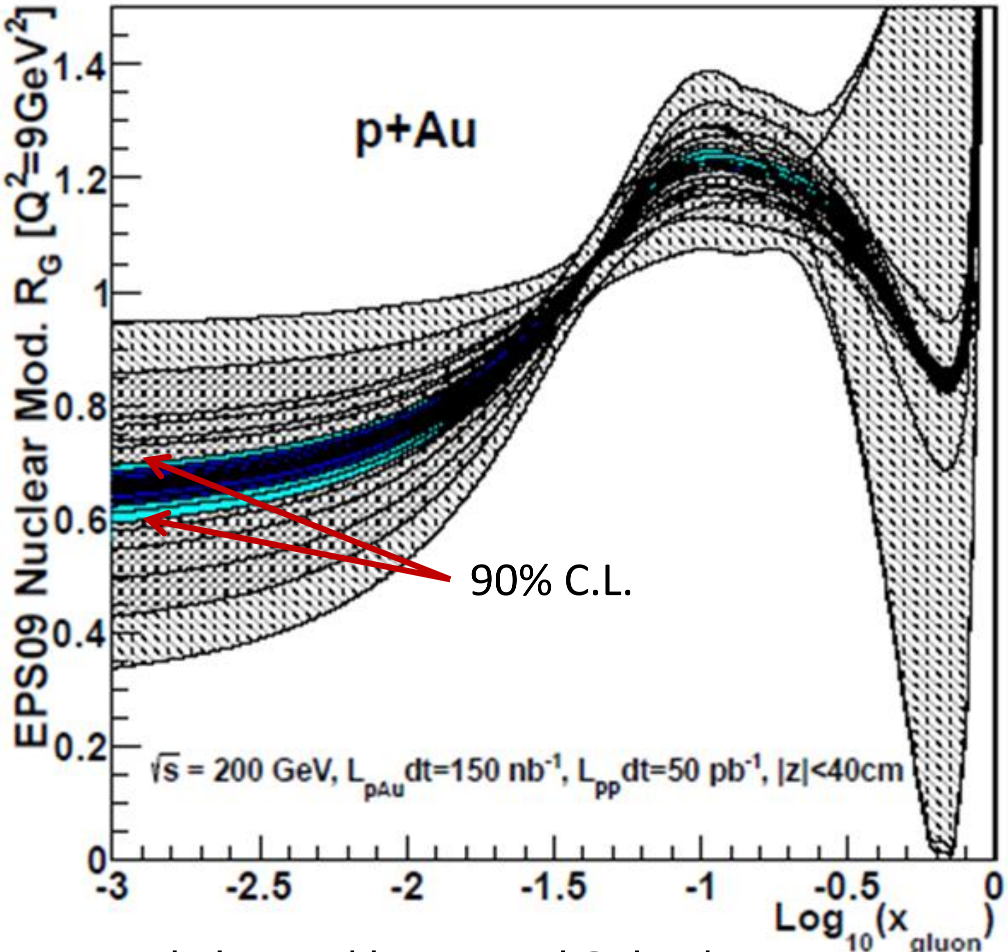
57.4% direct-to-signal ratio

30% signal γ efficiency

3% π^0 efficiency

EPS09 Limits from Prompt Photons

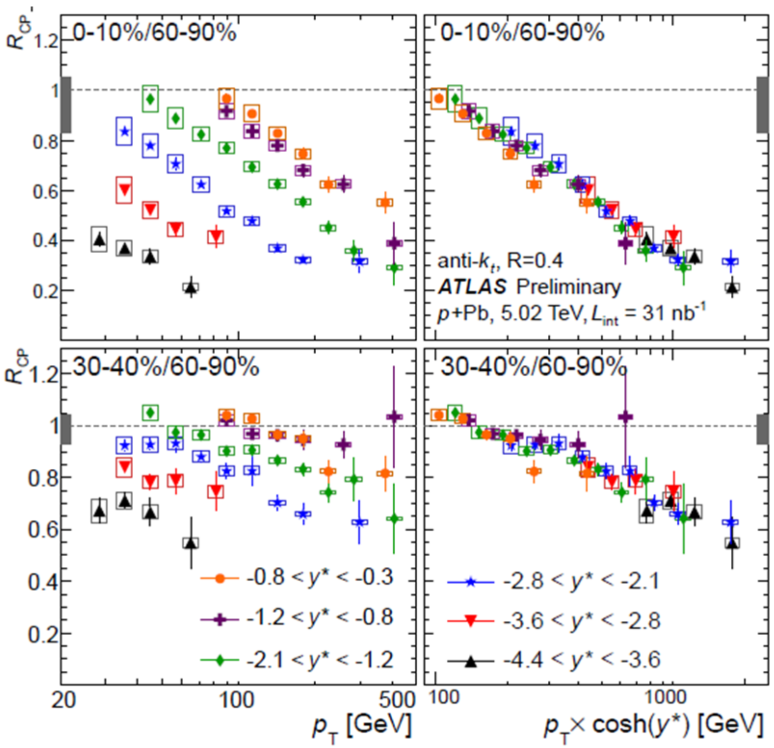
- Weight events in x, Q^2 according to EPS09 to generate R_{pAu} for each curve
- Assume the R_{pAu} value we measure corresponds to the EPS09 baseline
- Vary R^{pp}_{γ}, R^{pAu}_{γ}, γ^{pAu}_{incl} and γ^{pp}_{incl} within 3-sigma systematic errors
- Evaluate EPS09 curves to see which are consistent within 90% C.L.



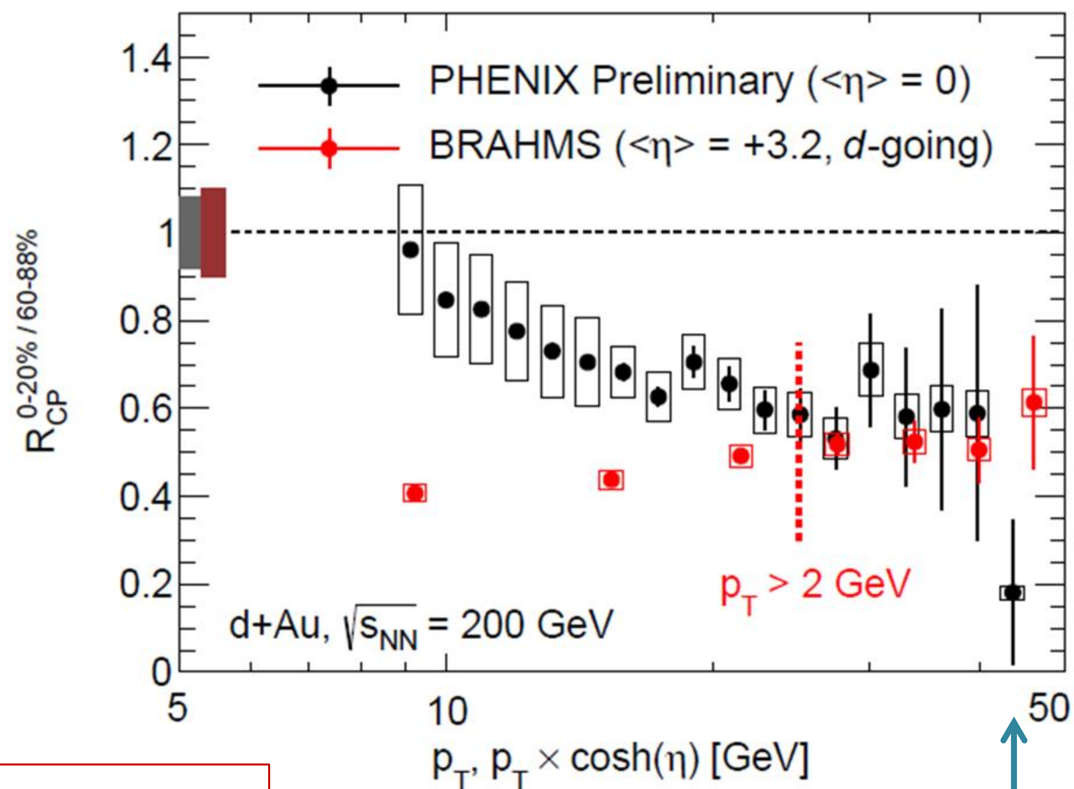
Eskola, Paukkunen and Salgado
2009 *JHEP* 0904:0652

Prompt photons in MPC-EX -> Precise Measurement of the Nuclear Gluon PDF

p+A Baseline for jets at RHIC



Plot from Dennis Pereplitsa's BNL seminar



3 GeV*cosh(3.5) = 49.7 GeV

γ_{Prompt} and π^0 in MPC-EX will be able to disentangle initial state & frag. effects

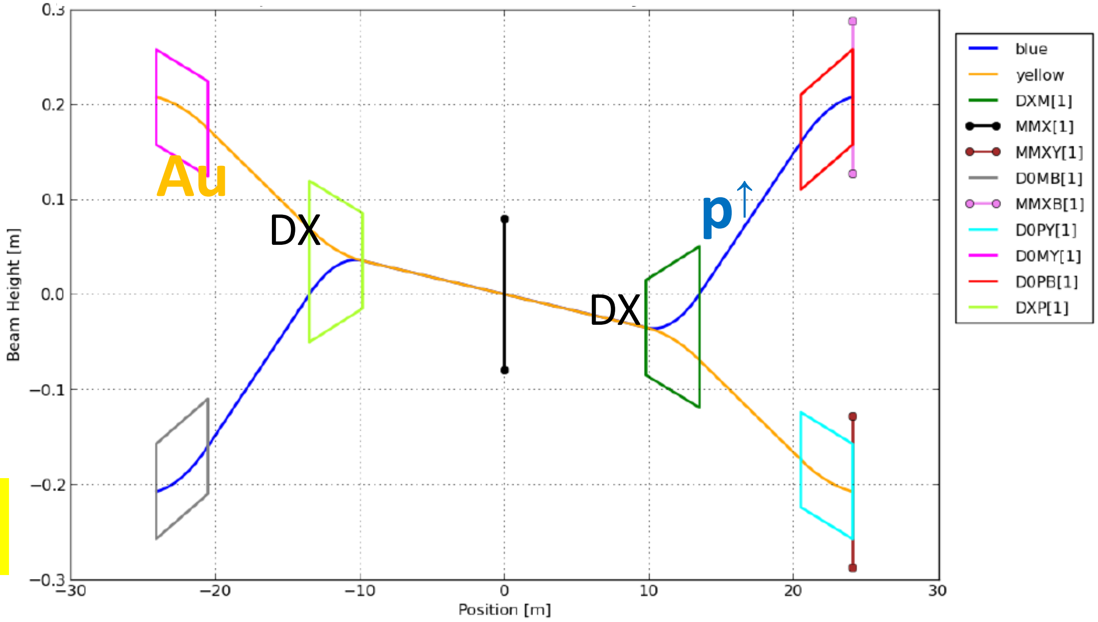
Polarized p+A at RHIC

RHIC was designed to accommodate asymmetric collisions *including* p+Au

For p+A: 3.58 mrad common angle through IP will provide high luminosity head-on collisions

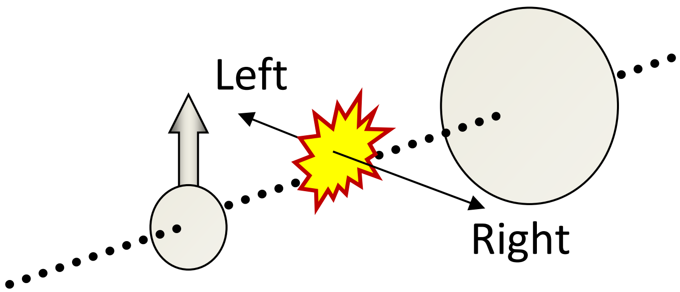
A unique capability of RHIC!

Beam trajectory though crossing dipoles for IP6



Pion asymmetries in p↑+A Collisions

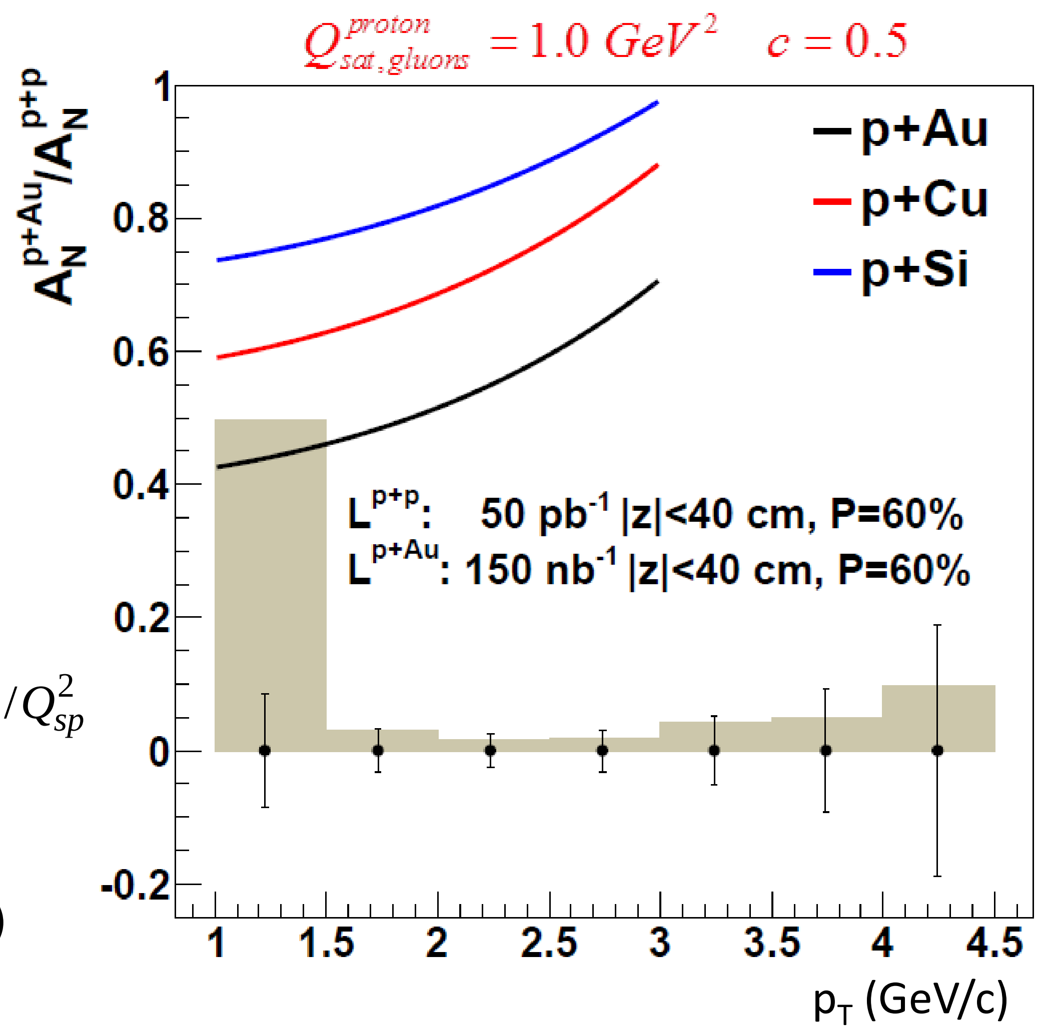
$$Q^2_{sat,A} = cA^{1/3} Q_{sat,proton}$$



$$A_N = \frac{1}{P}\frac{\sigma^\pi_L - \sigma^\pi_R}{\sigma^\pi_L + \sigma^\pi_R}$$

$$\left.\frac{A_N^{pA\to h}}{A_N^{pp\to h}}\right|_{P^2_{h\perp} << Q^2_{sA}} \approx \frac{Q^2_{sp}}{Q^2_{sA}} e^{P^2_{h\perp}\delta^2/Q^2_{sp}}$$

Kang and Yuan, PRD 84 034019 (2011)
(asymmetries modeled as Collins)



- Dependence of $Q_{sat,A}$ on A, centrality

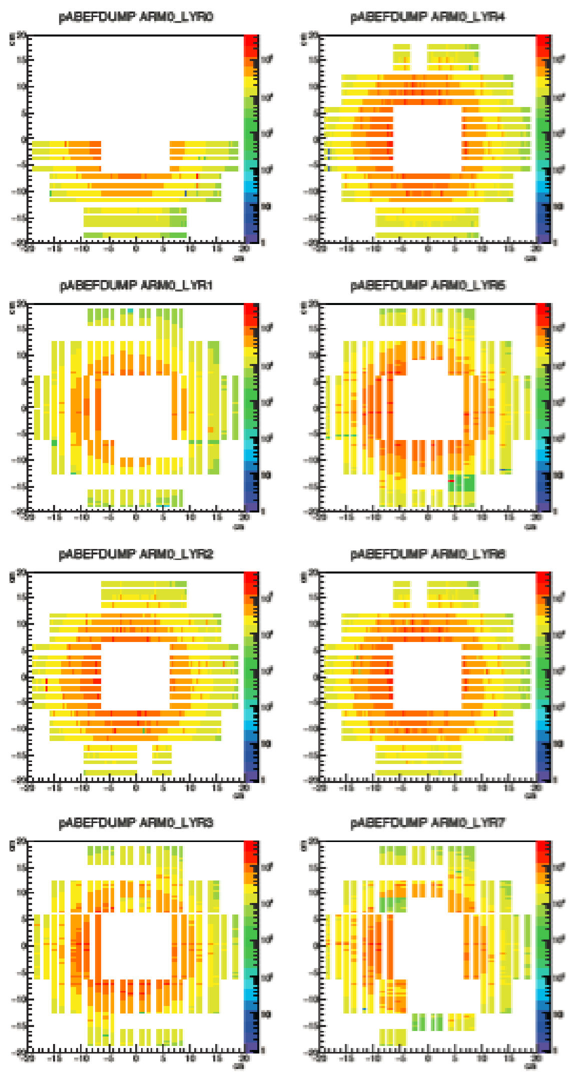
Single spin asymmetries can probe the saturation scale.

Installed in PHENIX

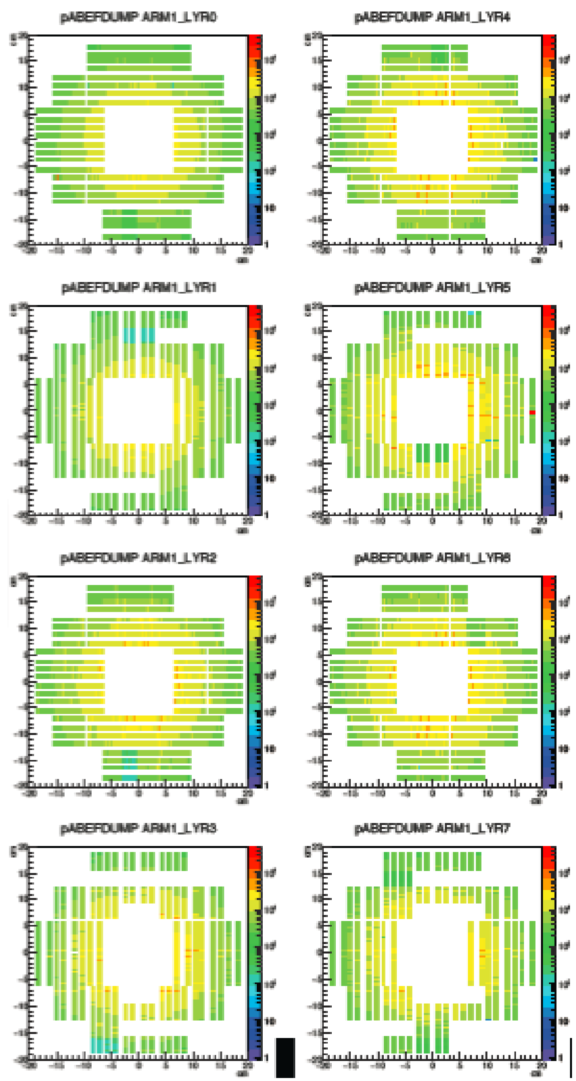
First successful data taking from January – June 2015

A first look at the data

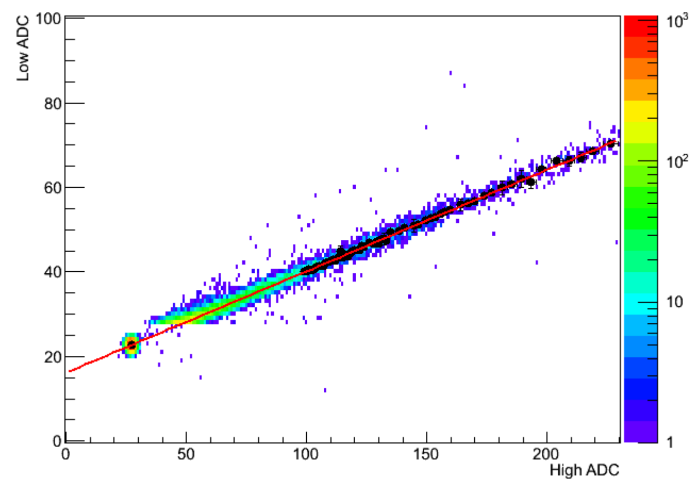
South Hit Map



North Hit Map



Use low-high slope to calibrate lowADC MIP from highADC MIP



highADC MIP calibration in progress

Conclusions

- **RHIC "straddles" $Q_{sat,A}$**
  - RHIC can make measurements both above and below the saturation scale (rapidity, centrality, and energy?)
- **p+A can explore nuclear shadowing/saturation**
  - Flexibility of RHIC to run p+A with various *A* species → dependence on nuclear size
  - Signatures include:
    - **Prompt photons at low-x as a direct probe of the gluon density**
    - **Suppression of hadrons, correlation and even flow**
- **Polarized p+A collisions offer a unique, fundamentally new observable**
  - **SSA's can probe Q_{sat}, nuclear dilution factor**
- **Looking at new data from 2015 RHIC run!**