Looking Forward for Color Glass Condensate signatures

comparing $\sqrt{s}$=200GeV p+p/d+Au

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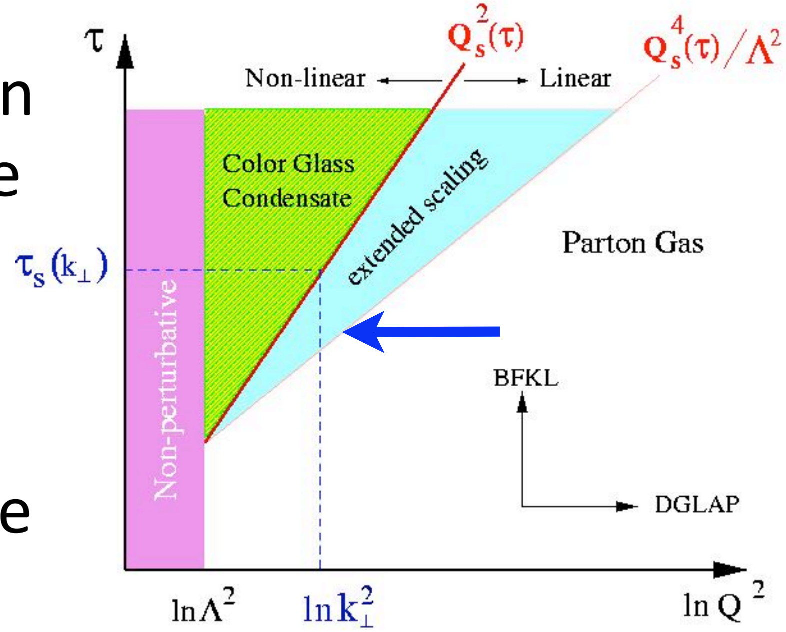
Outline

- Motivation
  - CGC and forward physics
- Run-8 FMS results
  - run-3 FPD emulation
  - $\pi^0+h^\pm$ & $\pi^0+\pi^0$ azimuthal correlation
  - multiplicity dependence
- Conclusions & Outlook

Color Glass Condensate

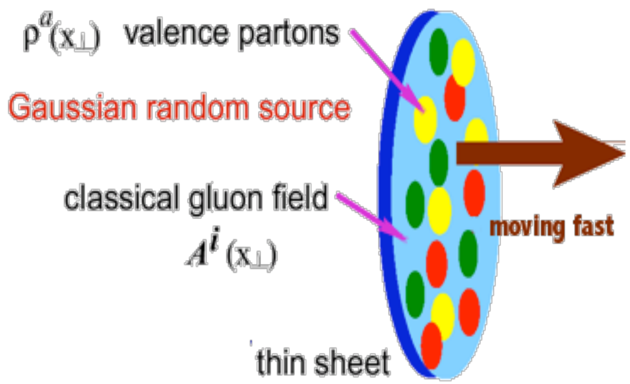
- BFKL and DGLAP divergence for gluon distributions at low-x suggests the presence of non-linear effects (**parton recombination**) to obey unitarity => **SATURATION**
- Color Glass Condensate is an effective field-theory for the low-x component of the hadronic wavefunction
- SATURATION effects are associated with a new phase of the color field



Edmond Iancu and Raju Venugopalan, hep-ph/0303204

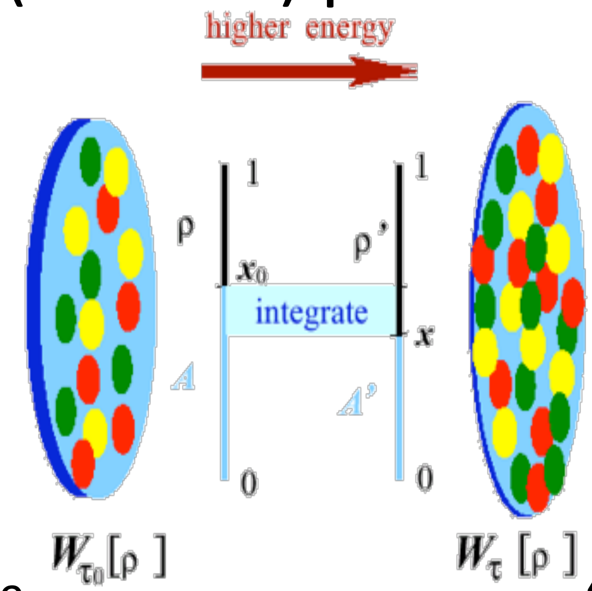
Color Glass Condensate

- Simple kinematic distinction between components: small-x partons are described as classical gluon fields induced by a random source which are the large-x (valence) partons

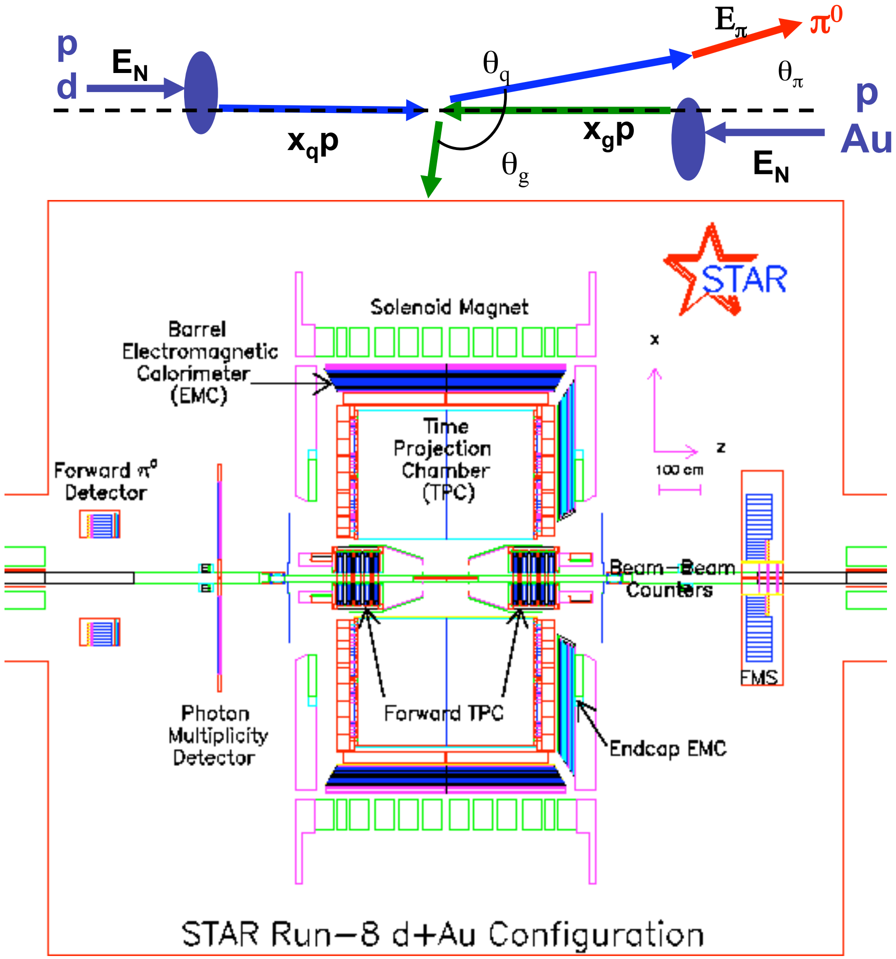


K. Itakura

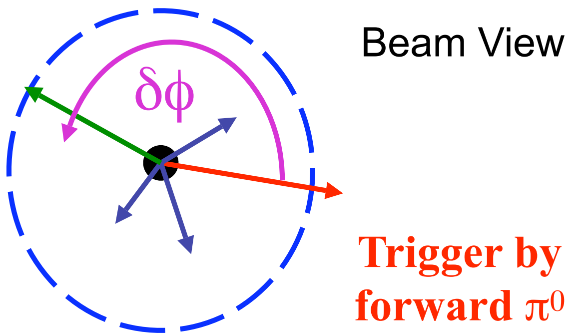
$$\tau \equiv \ln(1/x)$$



Looking forward with mid-η correlations



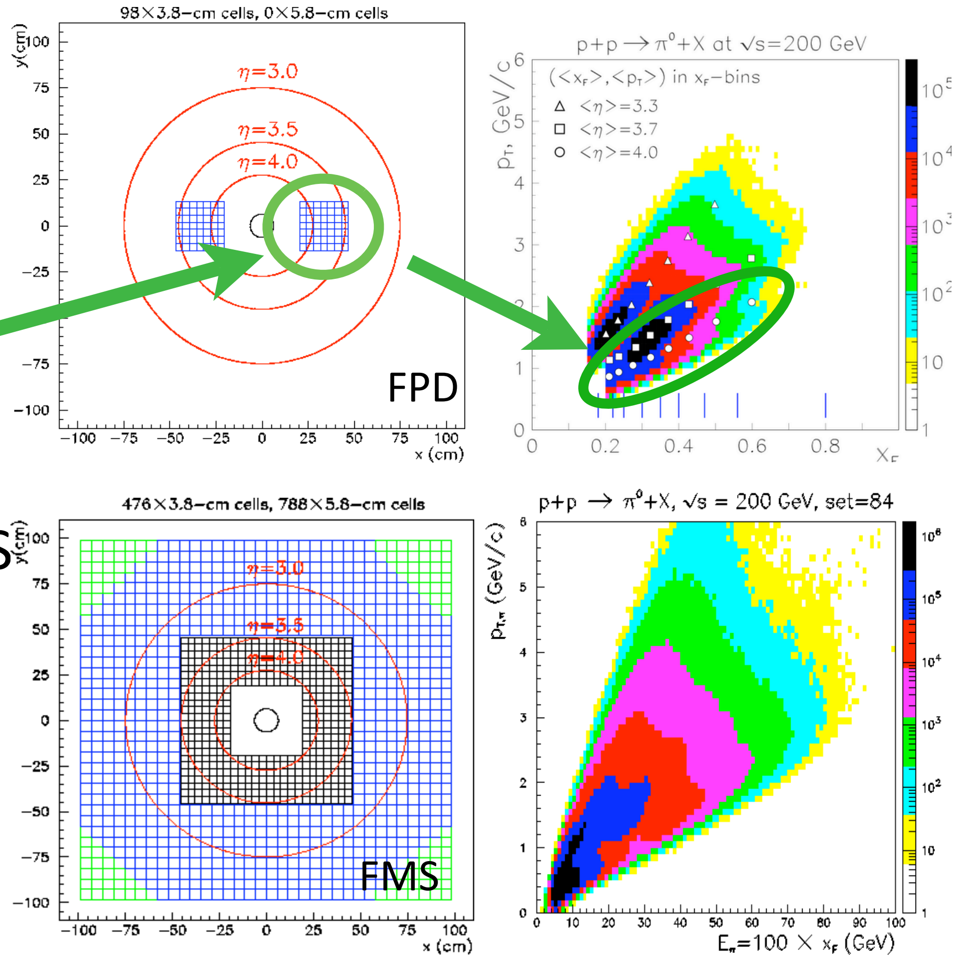
- Enable determination of x_g in 2→2 picture
- Or, are there monojets from CGC?
- High rapidity regions is where gluons start to overlap (saturation)



Looking forward

Phys. Rev. Lett. 97 (2006) 152302

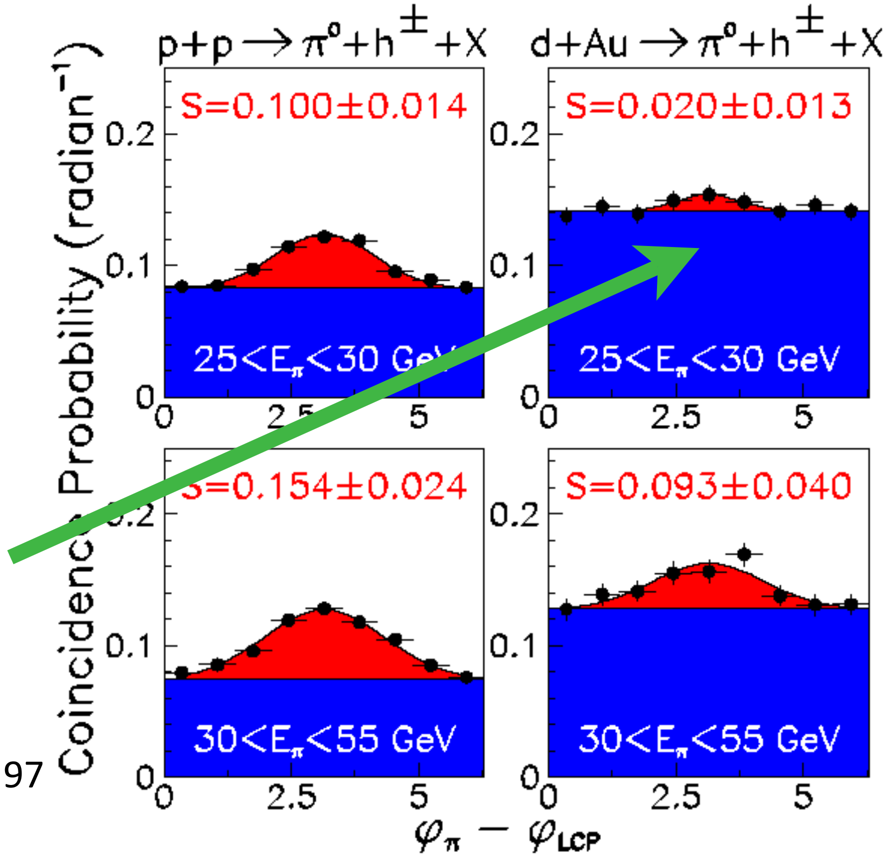
- In d+Au, FPD/FMS faced d beam to see neutral pions produced by large-x partons with low-x nuclear gluons
- Exploratory run-3 measurements: West-South FPD module only
- Run-8 measurements: first FMS run (50x bigger acceptance)
- $L_{run-8}=10*L_{run-3}$



FPD results

published run-3 results

- Di-jet studies with azimuthal correlations (FPD early results)
- Disappearance or broadening of jet-like correlation as expected in saturation models
- Mono-jet picture arising?

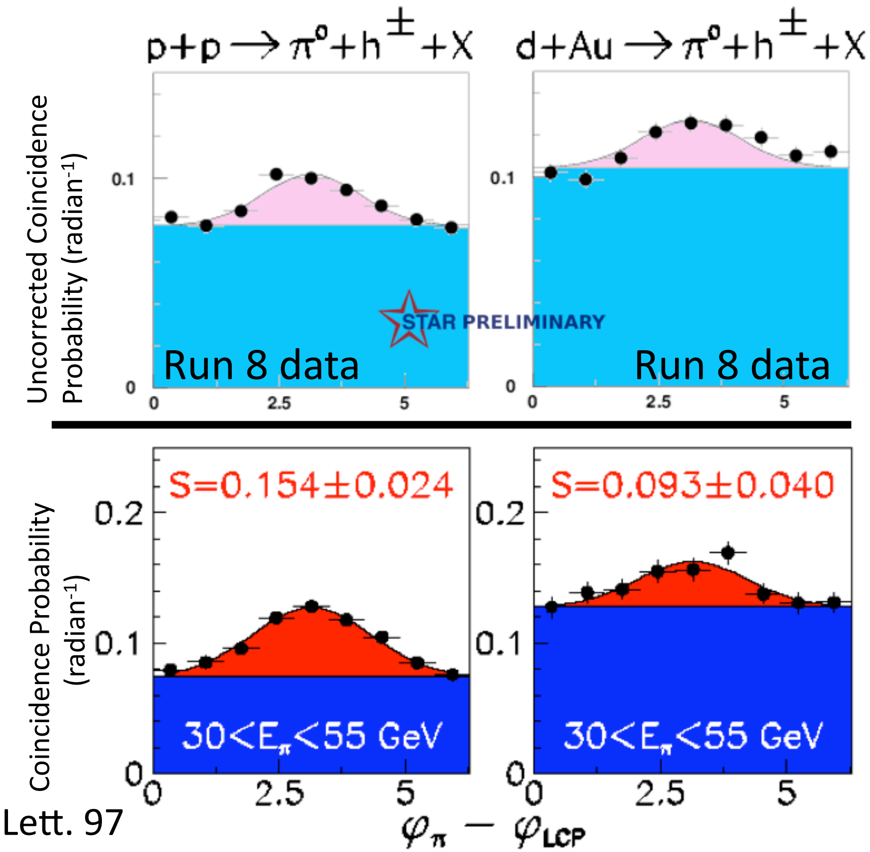


Phys. Rev. Lett. 97 (2006) 152302

FMS – FPD comparison

- Emulate FPD from run-8 FMS:
  - FMS photons: x > 0cm;
  - $|\eta_{TPC}| < 0.75$; $3.8 < \eta_{FMS} < 4.1$;
  - $0.5\text{GeV} < p_T^{(TPC)}$
  - $|\alpha_{FMS}| = |E_1 - E_2|/(E_1 + E_2) < 0.7$;
  - $30 < E_{FMS} < 55$ GeV
  - leading (in p_T) particles considered
- Reproduce gaussian width and many similarities
- Normalization requires more systematic studies:
  - pile-up correction
  - vertex efficiency
  - run-3/run-8 trigger

σ=0.949±0.121 σ=0.965±0.198



Phys. Rev. Lett. 97 (2006) 152302

σ=1.161±0.132 σ=1.073±0.335

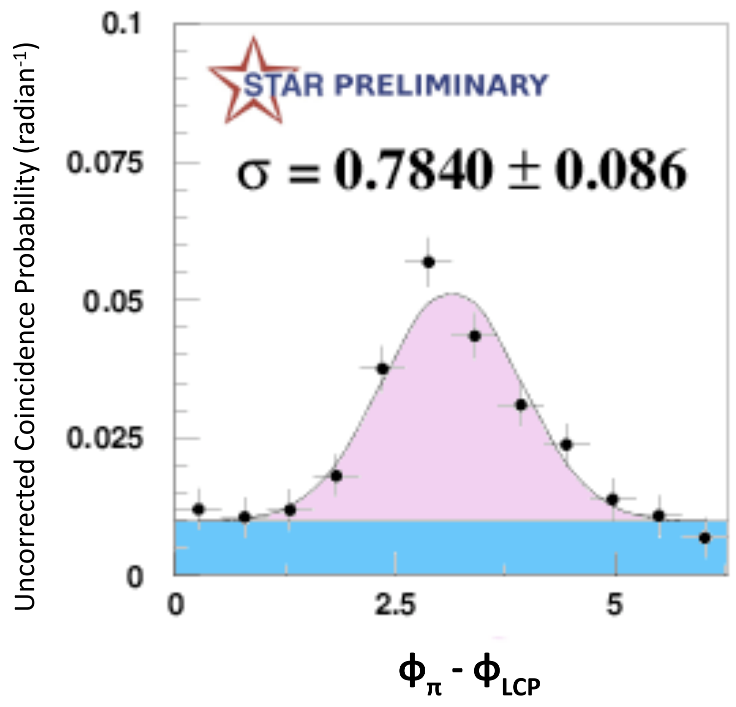
FMS results: $\pi^0+h^\pm$ correlations

- Correlate forward π^0 with a mid-rapidity charged track (TPC)

pQCD inspired "GSV cuts" (Guzey, Strikman and Vogelsang, hep-ph/0407201):

- $|\eta_{TPC}| < 0.9$; $2.8 < \eta_{FMS} < 3.8$;
- $2.5GeV < p_T^{(FMS)}$
- $1.5GeV < p_T^{(TPC)} < p_T^{(FMS)}$;
- $|\alpha_{FMS}| < 0.7$;
- $0.07 < M_{\gamma\gamma} < 0.30$ GeV ;
- only leading particle considered ;
- corrected for pile-up ;
- (as proposed in hep-ex/0502040)

p+p-> π^0+$h^\pm$+X

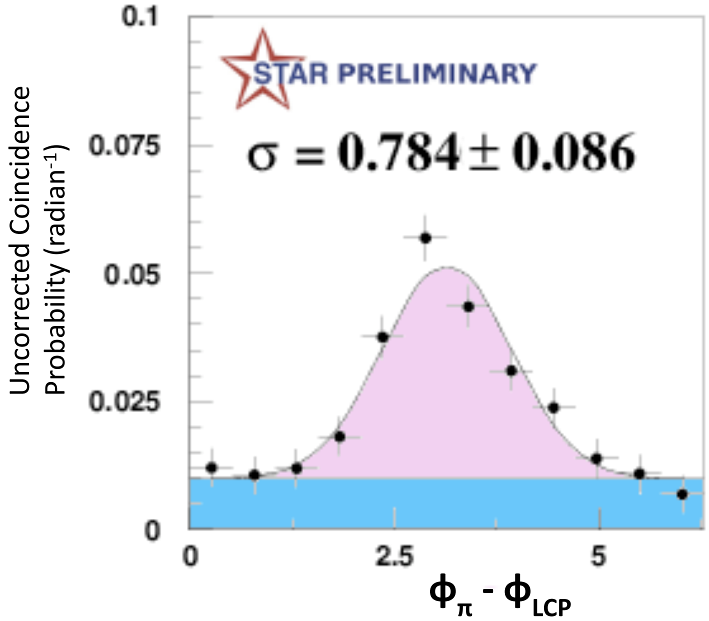


FMS results: π^0+$h^\pm$ correlations

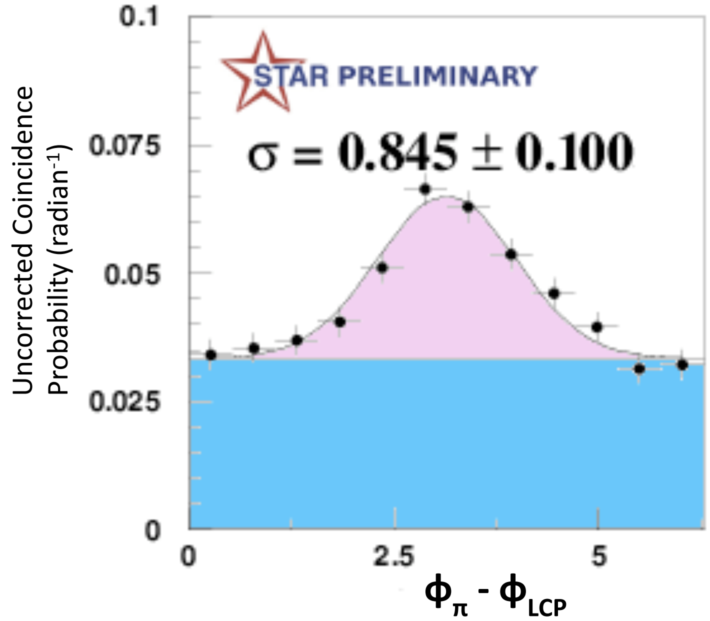
comparison p+p & d+Au

- Same conditions ("GSV cut") were applied in d+Au

p+p-> π^0+$h^\pm$+X



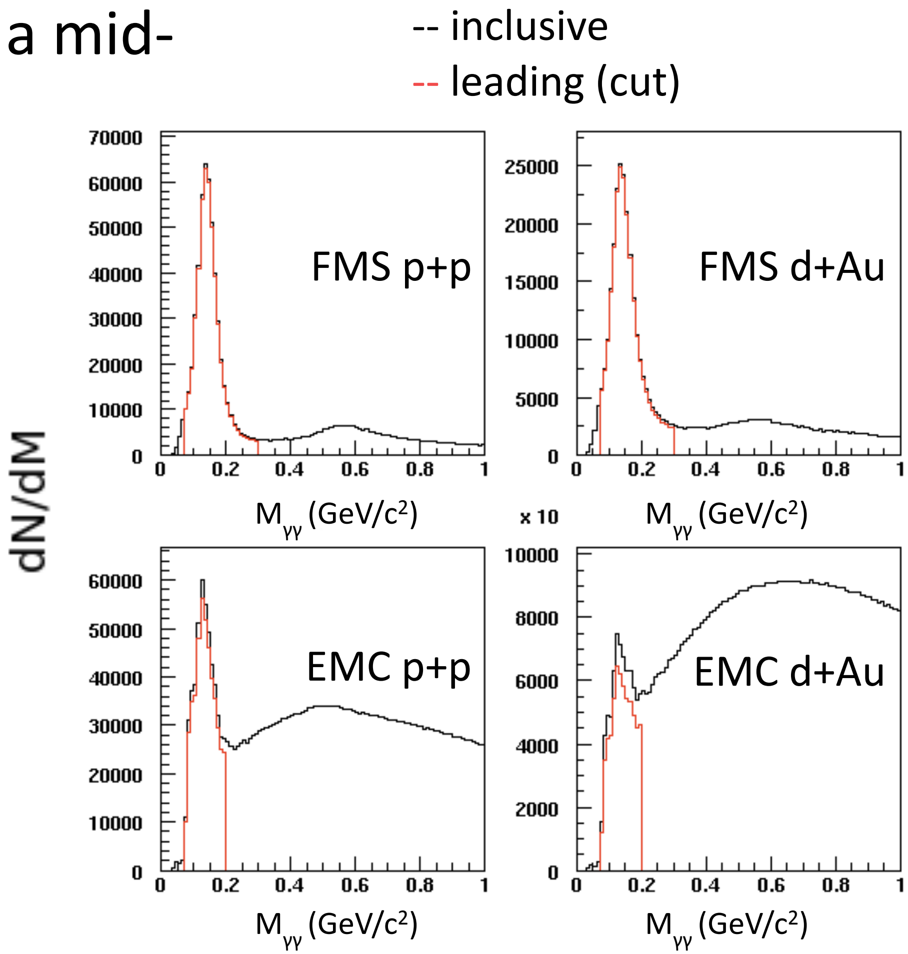
d+Au-> π^0+$h^\pm$+X



- Back to back peaks are evident

FMS results: $\pi^0+\pi^0$ correlations

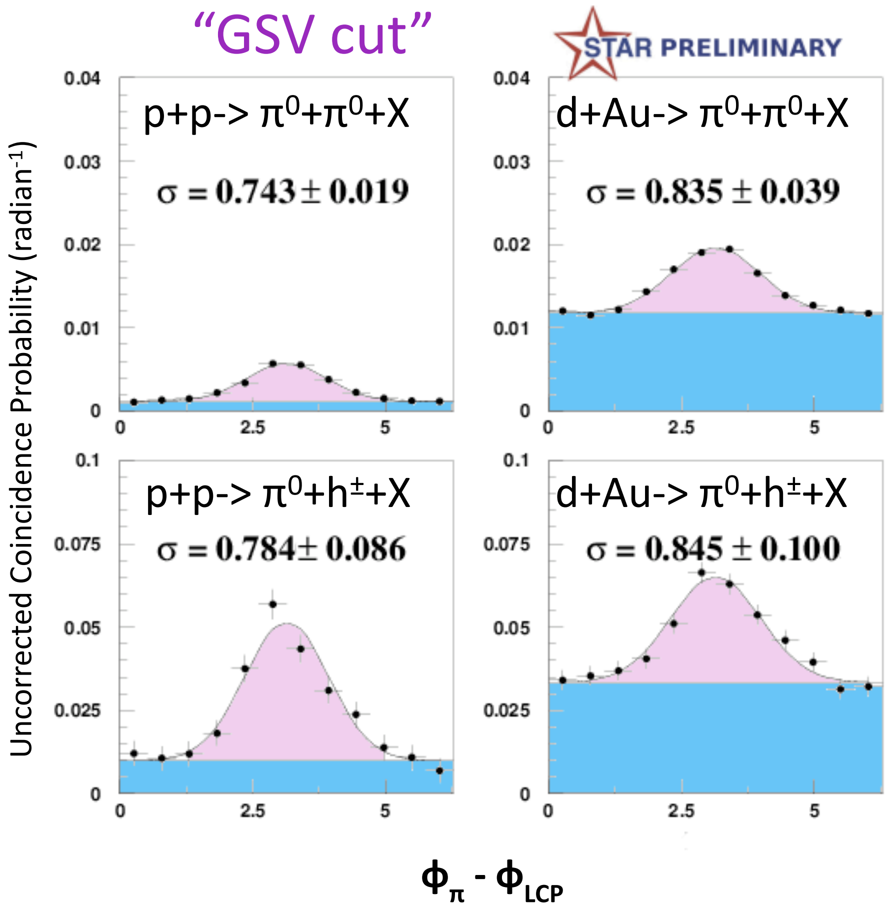
- Correlate forward π^0 with a mid-rapidity π^0 (bEMC)



- $|\eta_{EMC}| < 0.9$;
- $2.8 < \eta_{EMC} < 3.8$;
- $2.5GeV < p_T^{(FMS)}$;
- $1.5GeV < p_T^{(EMC)} < p_T^{(FMS)}$;
- $|\alpha_{FMS/EMC}|<0.7$;
- $0.07 < M_{\gamma\gamma}^{(FMS)} < 0.30$ GeV
- $0.07 < M_{\gamma\gamma}^{(EMC)} < 0.20$ GeV
- Only EMC towers used (no SMD)
- only leading particles considered

FMS results:

π^0+$h^\pm$ & π^0+π^0 comparison



"GSV cut"

(2.5GeV < $p_T^{(FMS)}$; 1.5GeV < $p_T^{(EMC)}$ < $p_T^{(FMS)}$)

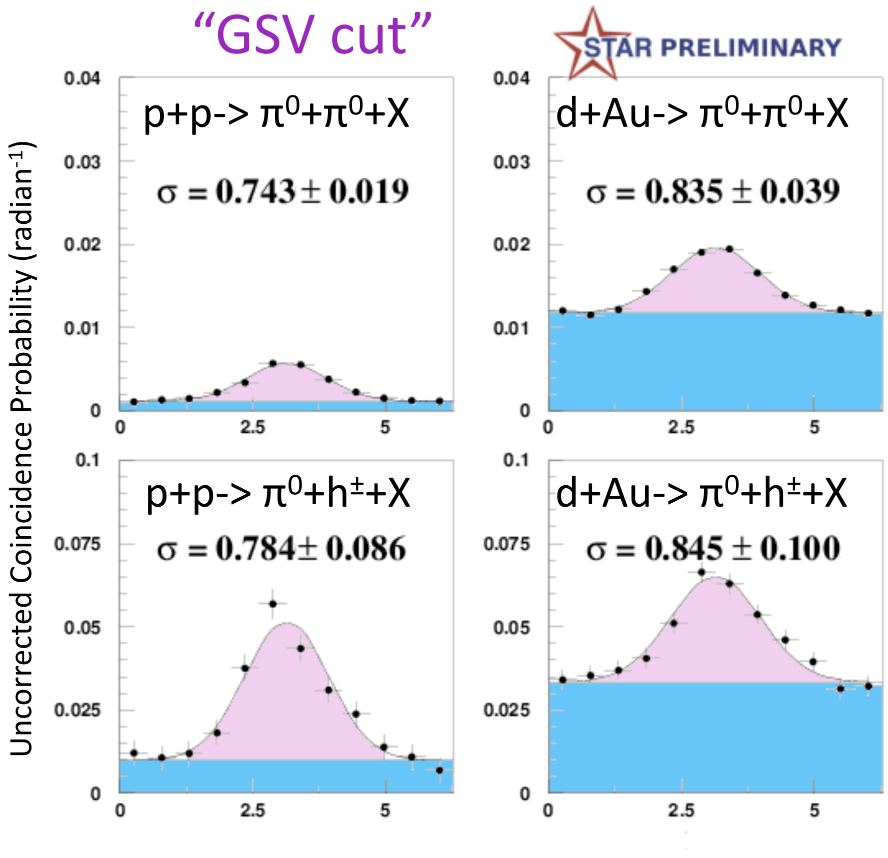
$\sigma_{dAu} - \sigma_{pp} = 0.09 \pm 0.04$

- Correlation in π^0+π^0 shows broadening in signal width from p+p to d+Au
- Correlation in π^0+$h^\pm$ shows signal width consistent with π^0+π^0

FMS results:

$\pi^0+h^\pm$ & $\pi^0+\pi^0$ comparison

"GSV cut"

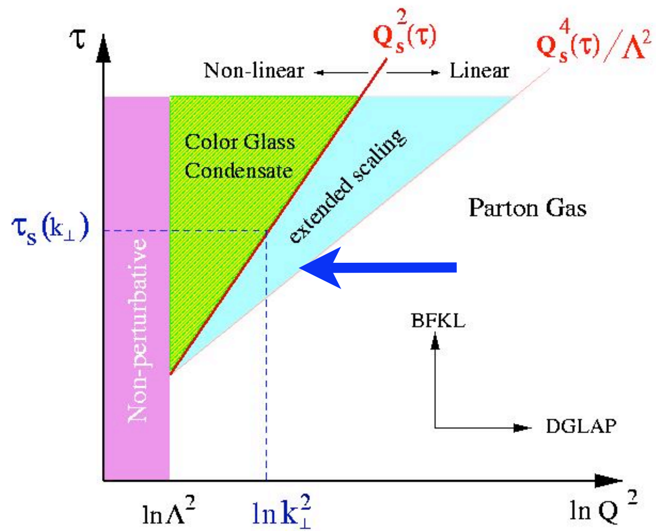


$\phi_\pi - \phi_{LCP}$

"GSV cut"

$(2.5\text{GeV} < p_T^{(FMS)}; 1.5\text{GeV} < p_T^{(EMC)} < p_T^{(FMS)})$

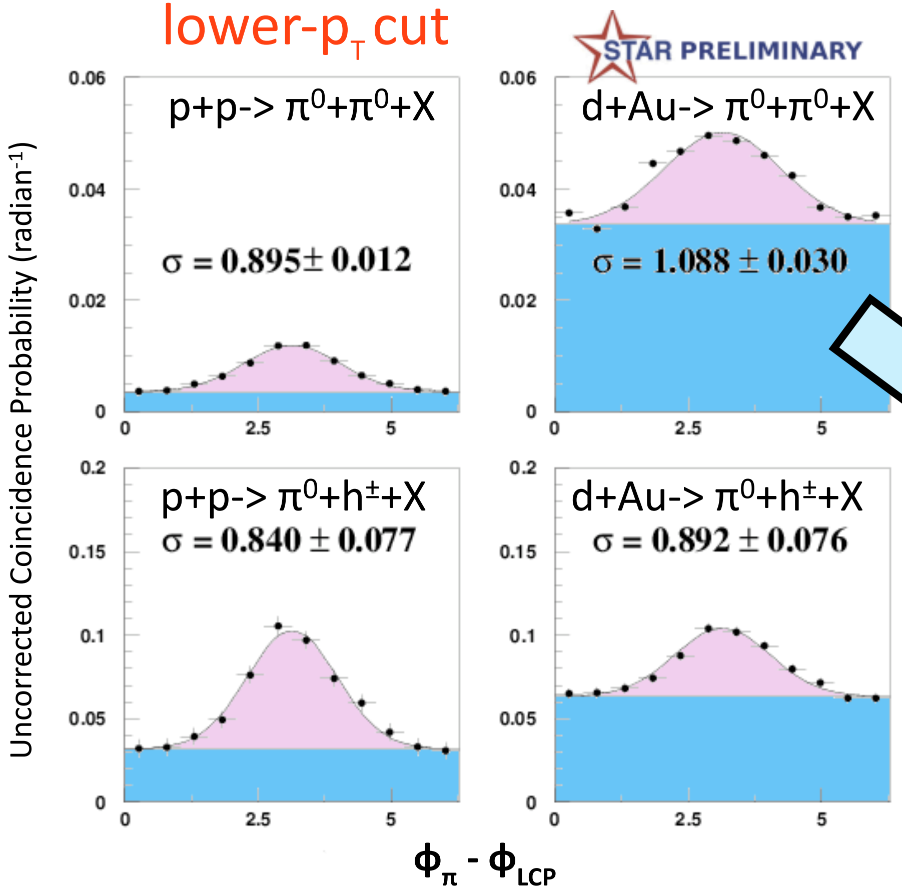
$$\sigma_{dAu} - \sigma_{pp} = 0.09 \pm 0.04$$



FMS results:

π^0+$h^\pm$ & π^0+π^0 comparison

lower-p_T cut



"GSV cut"

(2.5GeV < $p_T^{(FMS)}$; 1.5GeV < $p_T^{(EMC)}$ < $p_T^{(FMS)}$)

$$\sigma_{dAu} - \sigma_{pp} = 0.09 \pm 0.04$$

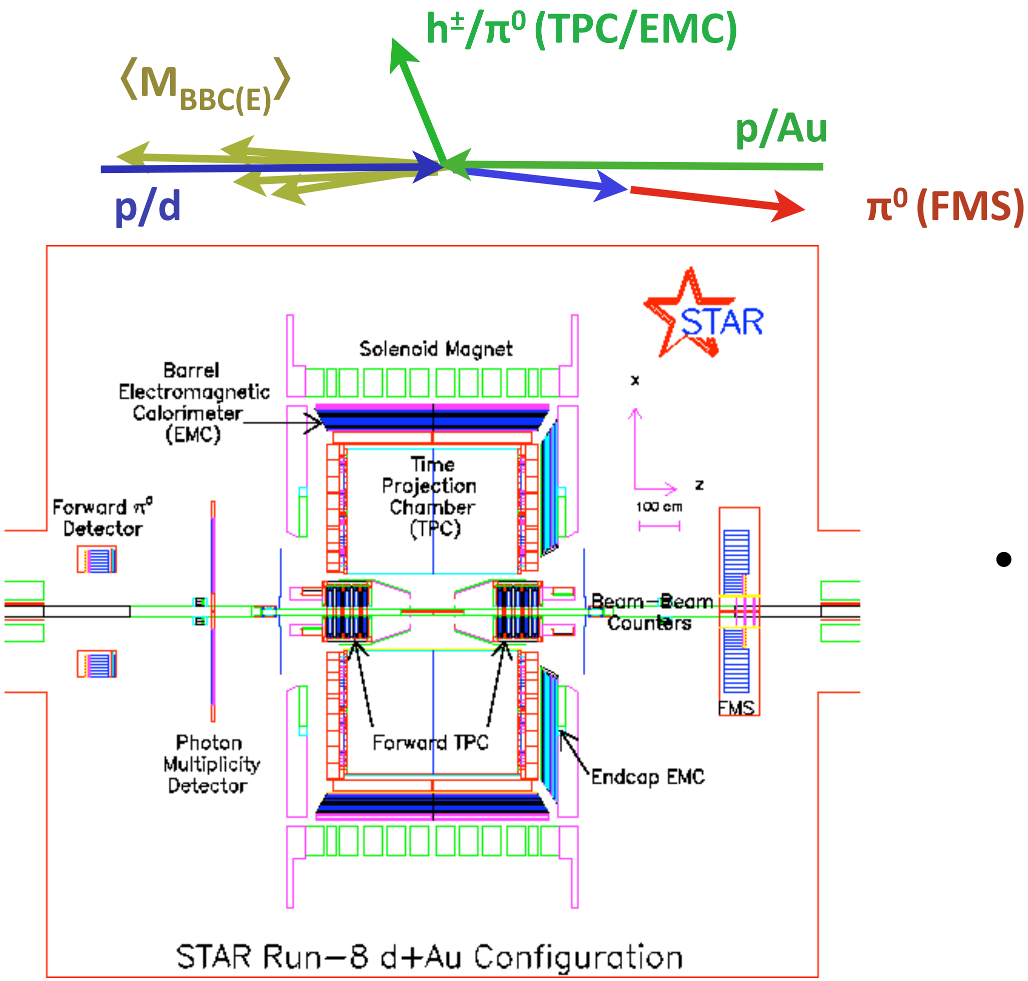
lower-p_T cut

(2.0GeV < $p_T^{(FMS)}$; 1.0GeV < $p_T^{(EMC)}$ < $p_T^{(FMS)}$)

$$\sigma_{dAu} - \sigma_{pp} = 0.19 \pm 0.03$$

- p_T dependent azimuthal signal broadening

Gold-side multiplicity dependence

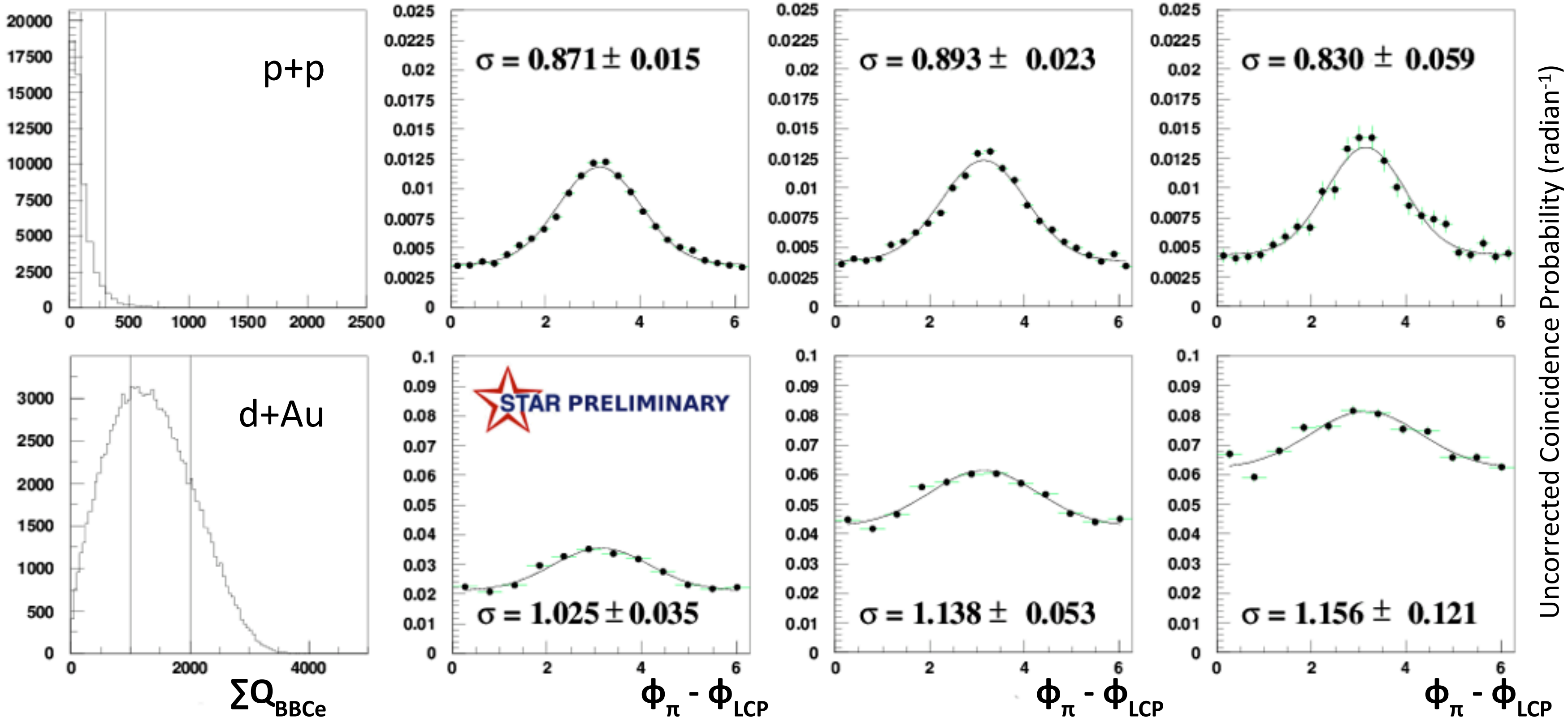


- Selection: charge sum from east (Au side: $-5.0 < \eta_{BBC} < -3.4$) BBC phototubes (18 counts ~ 1MIP)

Gold-side multiplicity dependence

- Modification in background level in d+Au π^0+π^0 correlations

low-p_T cut (2.0GeV < $p_T^{(FMS)}$; 1.0GeV < $p_T^{(EMC)}$ < $p_T^{(FMS)}$)



- Modification in d+Au π^0+π^0 (FMS-EMC) correlations

Conclusions

- STAR Run-8 and FMS, a big success allowing p_T scan;
- FMS reproduces Run-3 FPD gaussian widths;
- Comparison of $\Delta\Phi_{\pi0(FMS)+\pi0(EMC)}$ for pp and dAu indicates azimuthal broadening in dAu;
- Data are qualitatively consistent with a p_T dependent picture of gluon saturation of the gold nucleus.

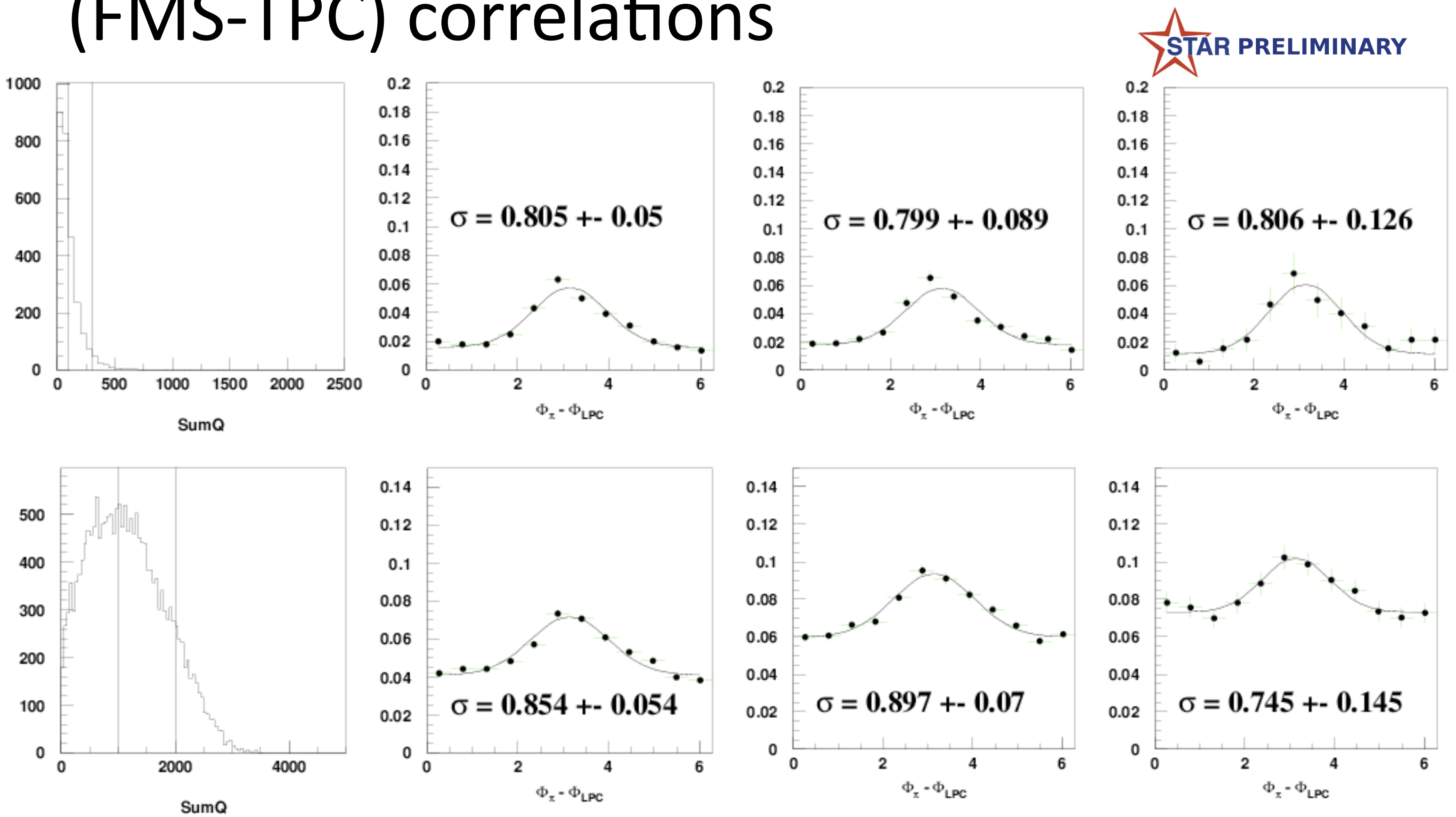
Outlook

- Extract $\Delta\Phi_{\pi0+\pi0}$ for two forward π^0
- Scanning the p_T range (from GSV to run-3)
- Scanning $\Delta\eta$: x dependence of nuclear parton density
- Clustering: towards π^0+jet or jet+jet
- Absolute normalization and systematics studies

Back-up slides

Gold-side multiplicity dependence

- Modification in background level in d+Au π^0+h^+ (FMS-TPC) correlations



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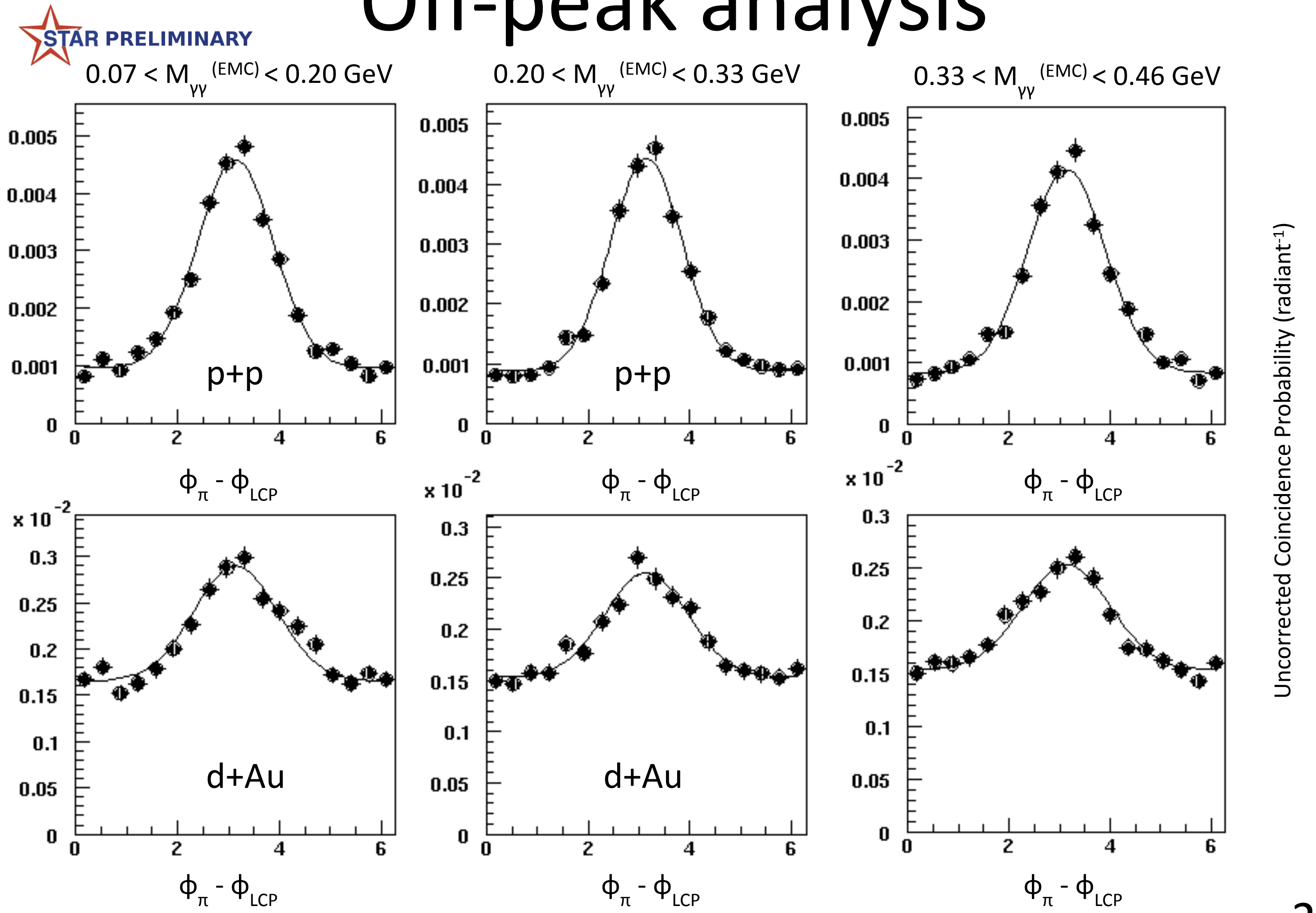
Off-peak analysis



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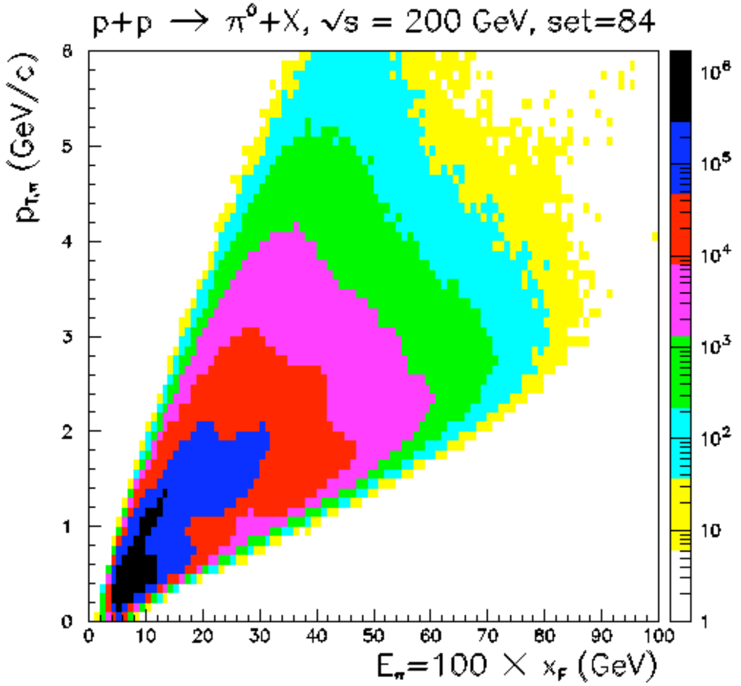
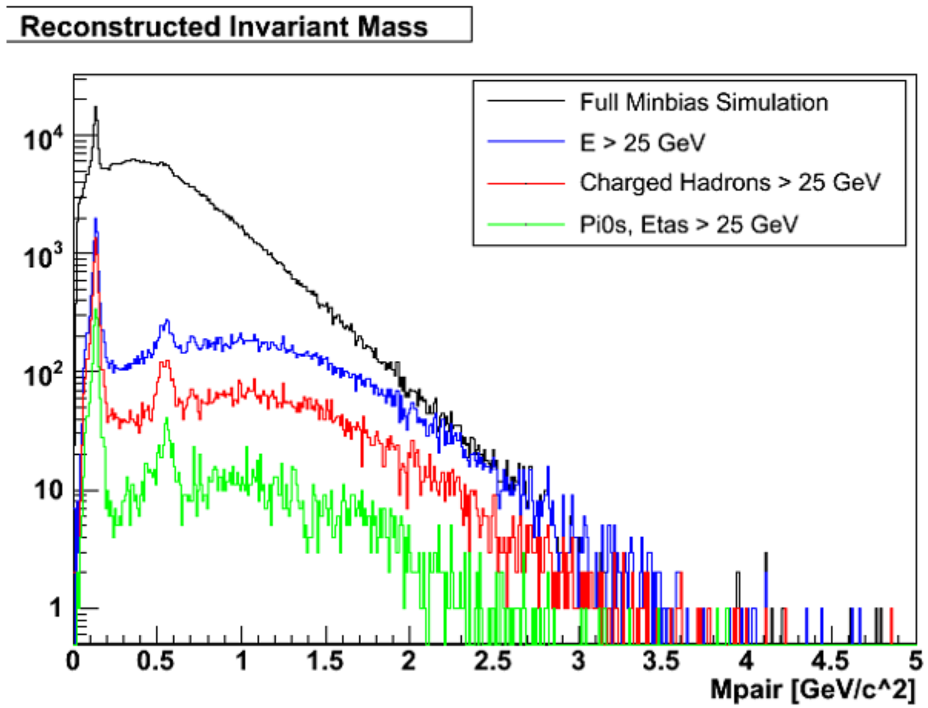
FMS run8



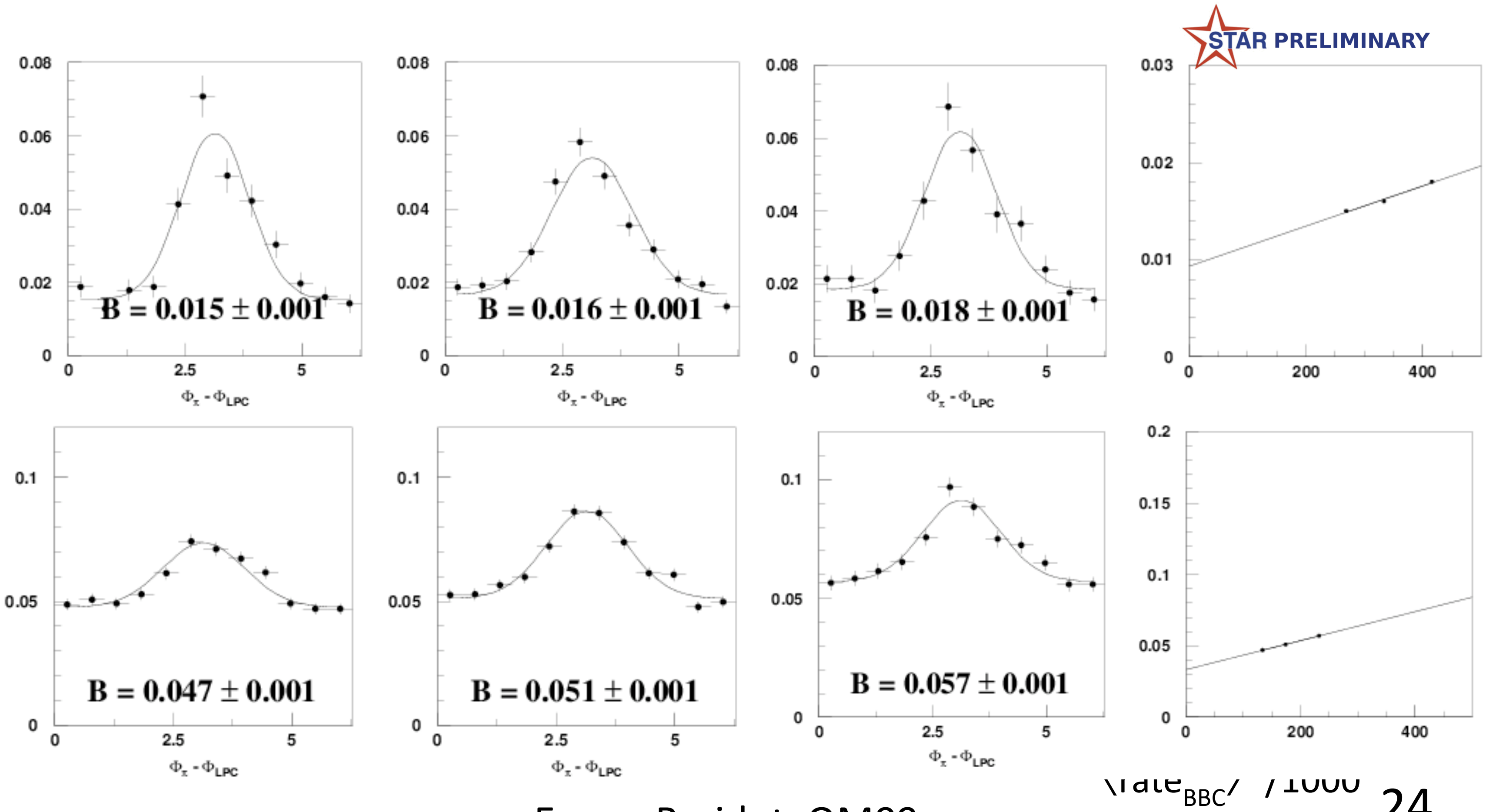
p+p → π⁰+X, √s = 200 GeV, set=84
$p_{T,\pi}$ (GeV/c)
E_π=100 × x_F (GeV)



Reconstructed Invariant Mass
Full Minbias Simulation
E > 25 GeV
Charged Hadrons > 25 GeV
Pi0s, Etas > 25 GeV
Mpair [GeV/c^2]

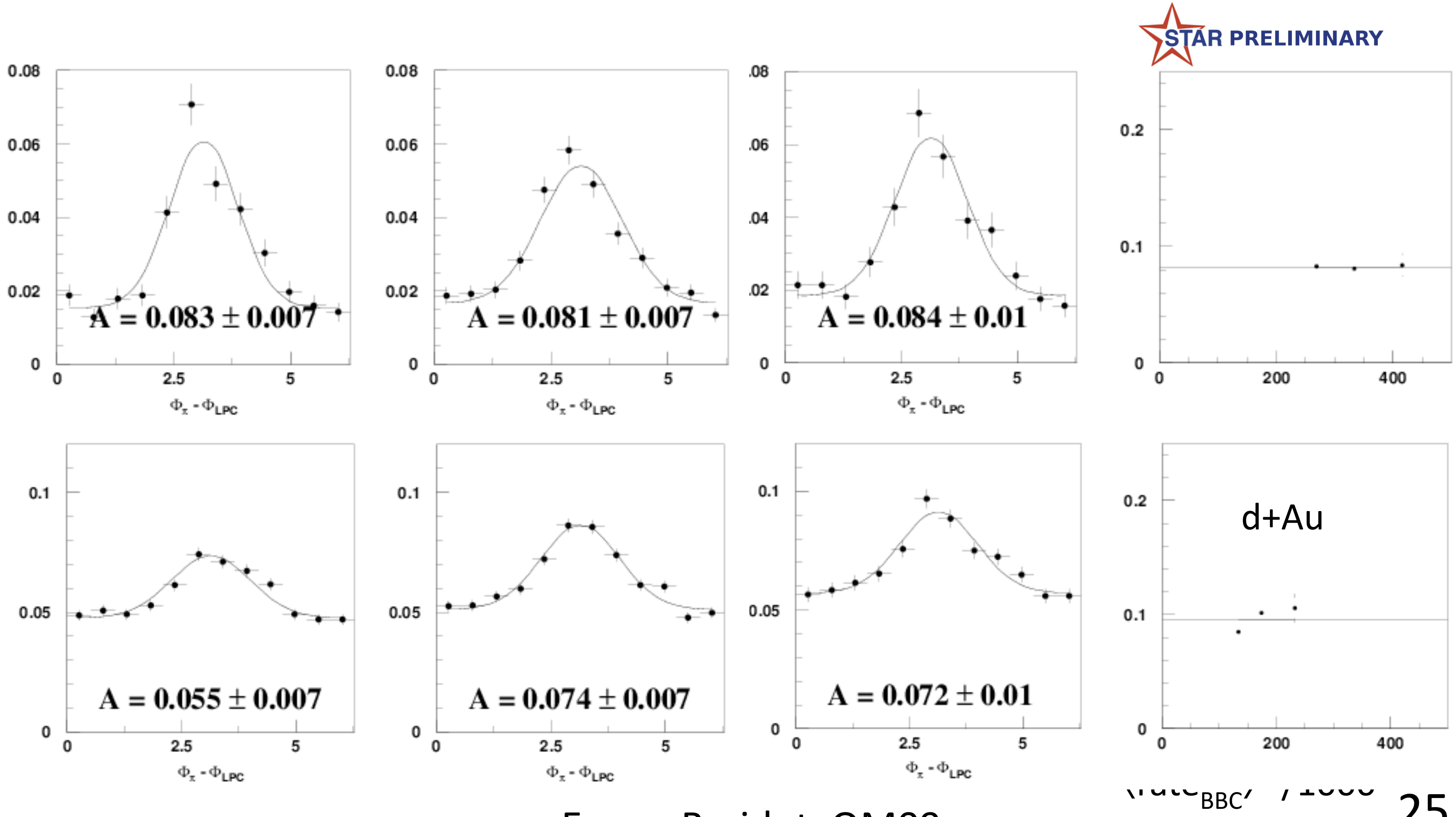
Luminosity dependence I:

check for π^0-$h^\pm$ correlations background ("GSV cuts")



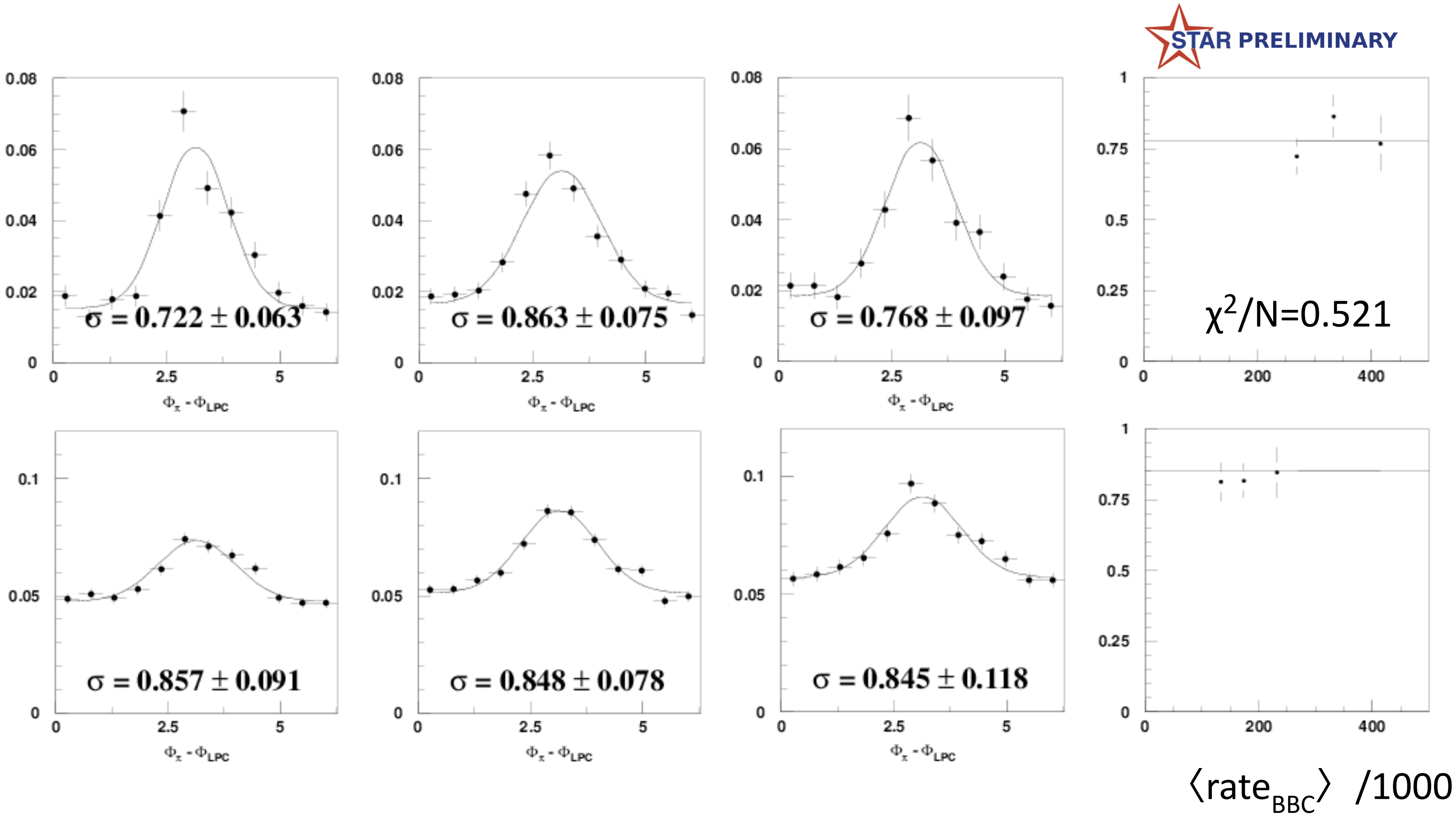
Luminosity dependence II:

check for π^0+$h^\pm$ correlations signal ("CSV cuts")



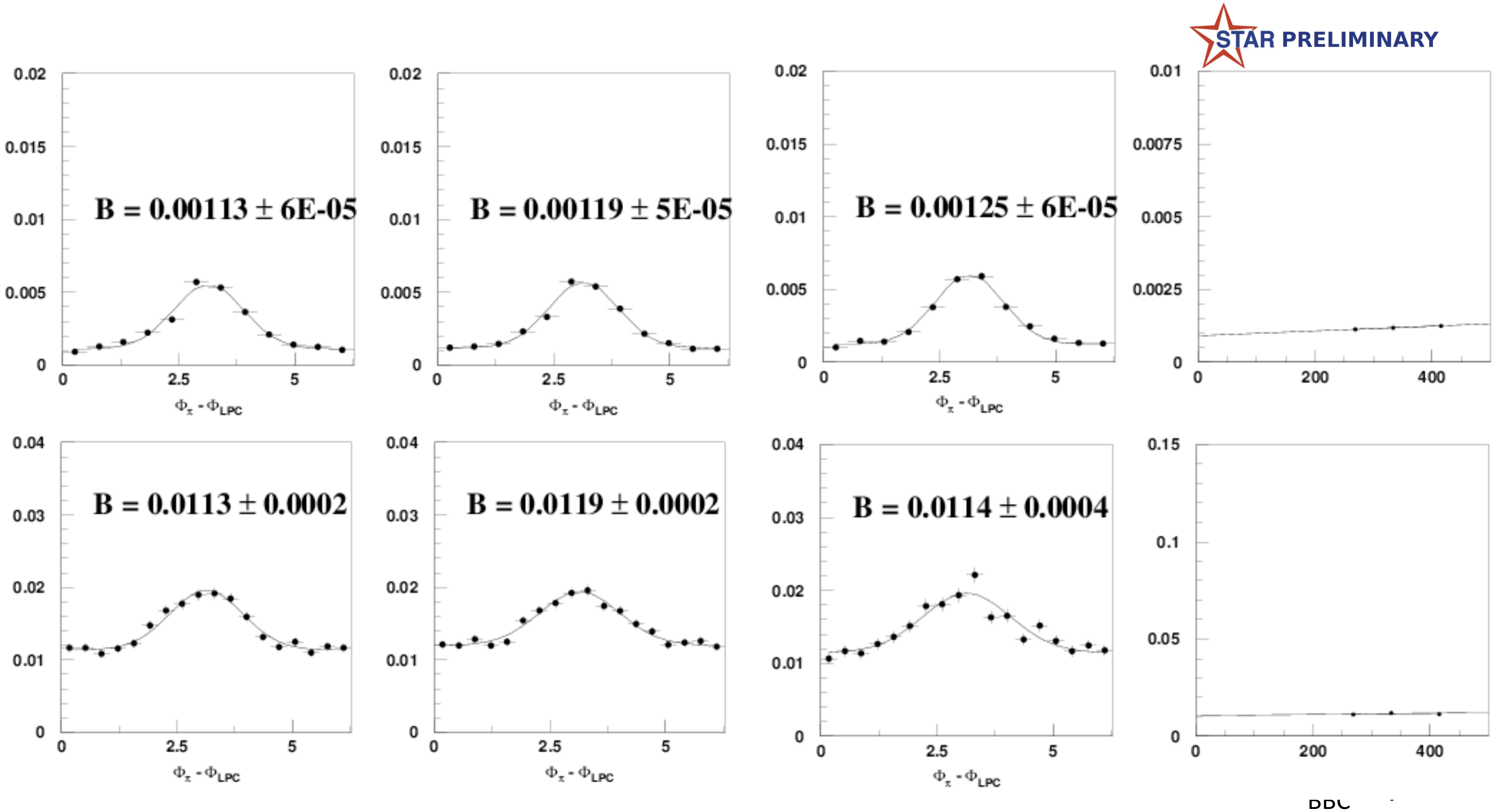
Luminosity dependence III:

check for π^0+$h^\pm$ correlations width ("CSV cuts")



Luminosity dependence IV:

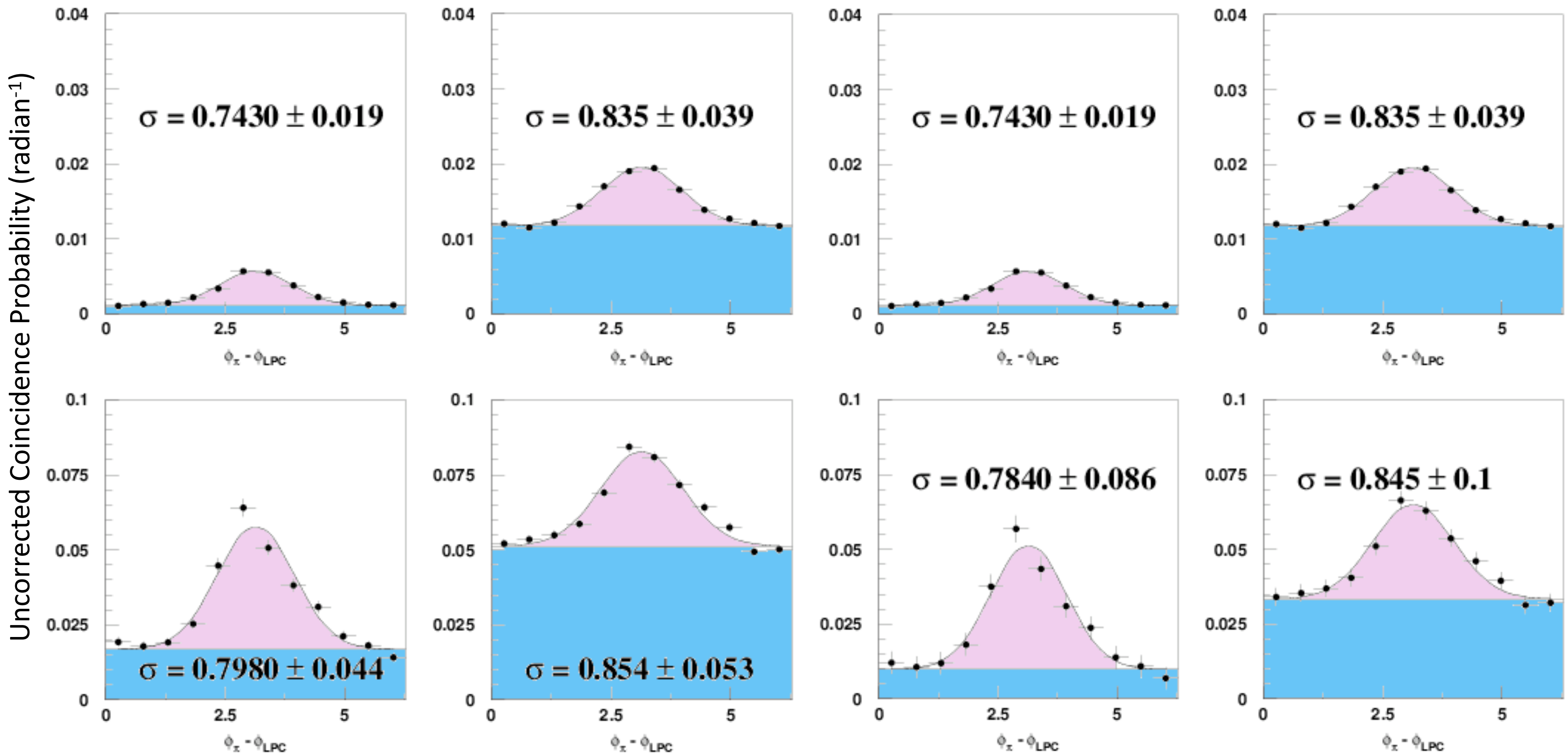
check for $\pi^0+\pi^0$ correlations background ("CSV cuts")



FMS results:

π^0+h$^\pm$ & π^0+π^0 with/without pile-up correction ("CSV cuts")

NO pile-up correction STAR PRELIMINARY pile-up corrected

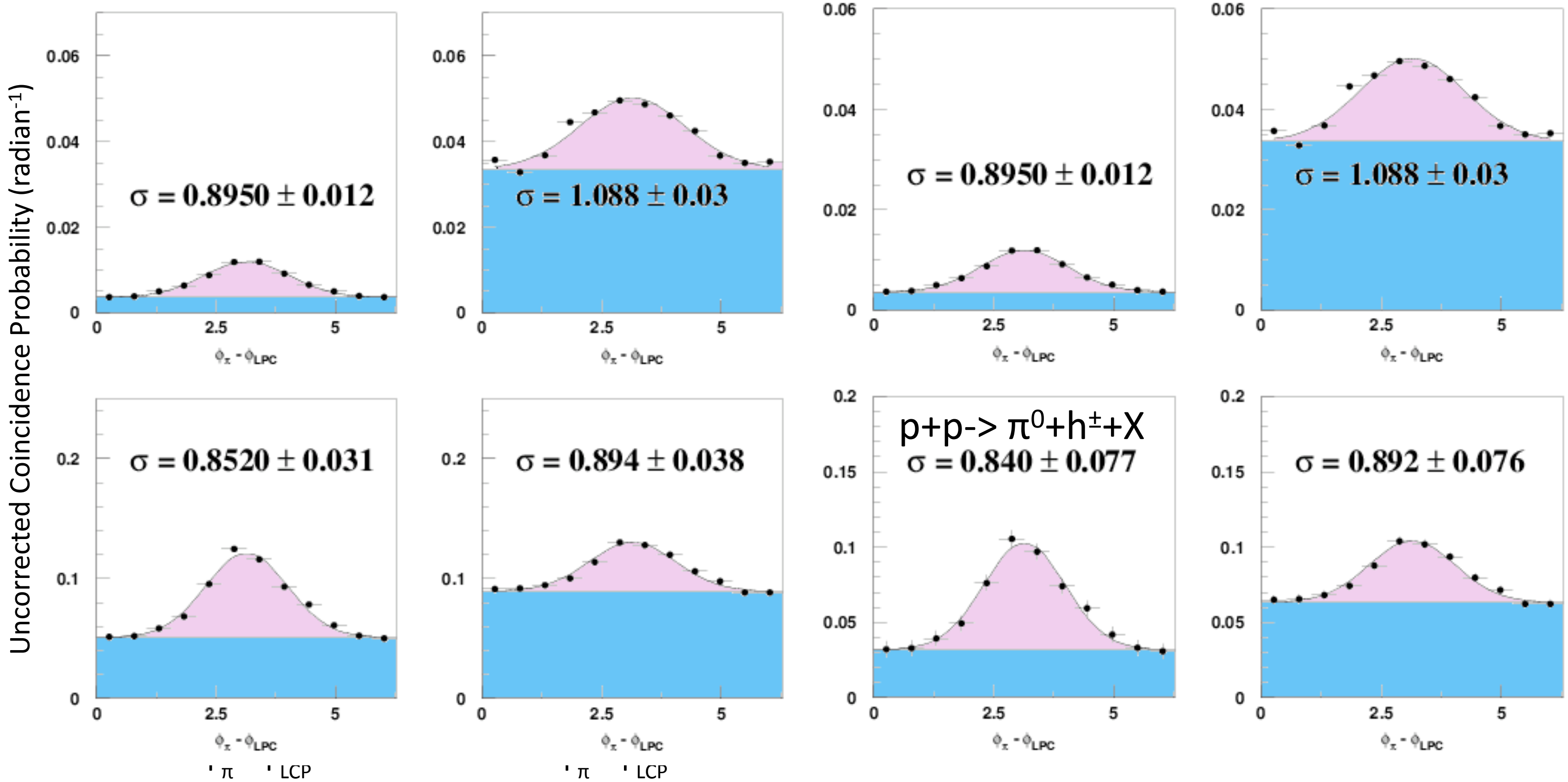


FMS results:

same as previous slide with lower p_T cuts:

$1.0\text{GeV} < p_T^{(EMC/TPC)} < p_T^{(FMS)}$; $2.0\text{GeV} < p_T^{(FMS)}$

NO pile-up correction STAR PRELIMINARY pile-up corrected



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