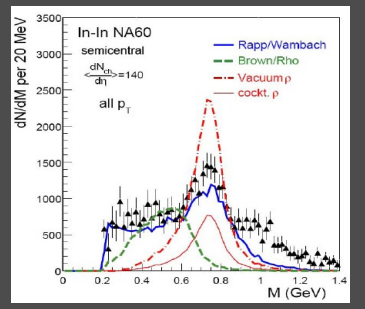
Reconstruction of the e^+e^- signal in p+Nb collisions at 3.5 GeV

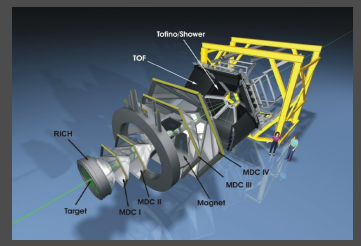
M.Lorenz for the HADES collaboration

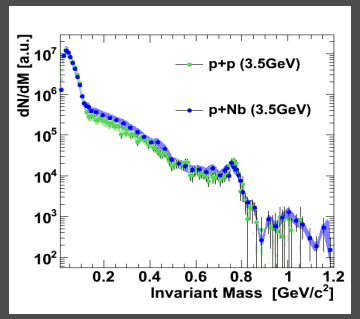
EMMI mini-Workshop on
Vector mesons in cold nuclear matter

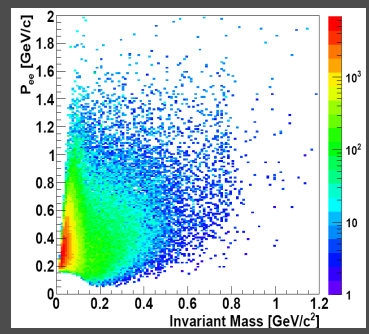
Outline:

- General remarks on the measurement
- Reconstruction of e^+e^- pairs
- Comparison of p+p and p+Nb data
  - Kinematical observables
  - Slow and fast vector mesons
- Conclusions and open questions



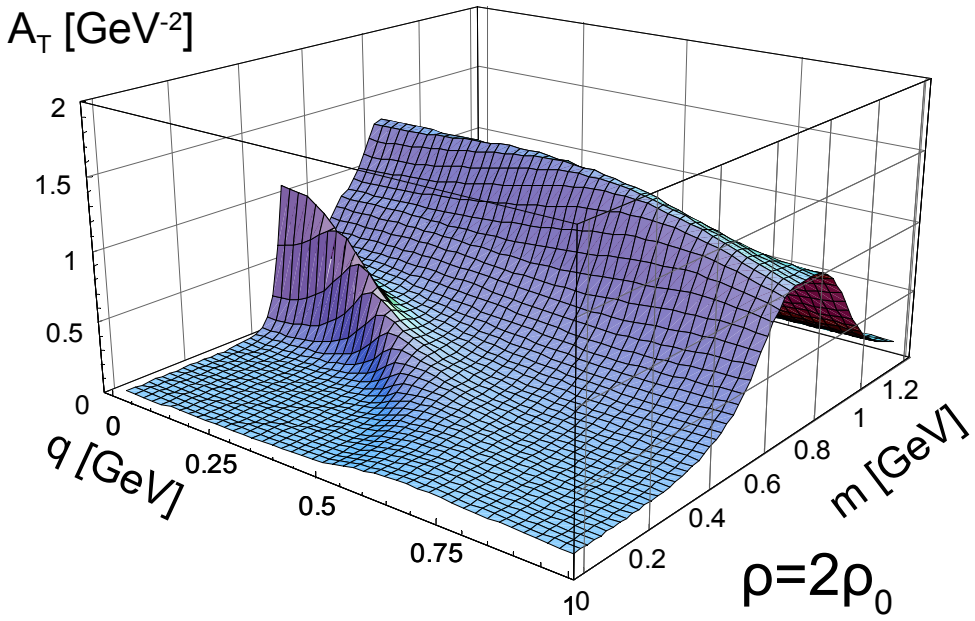




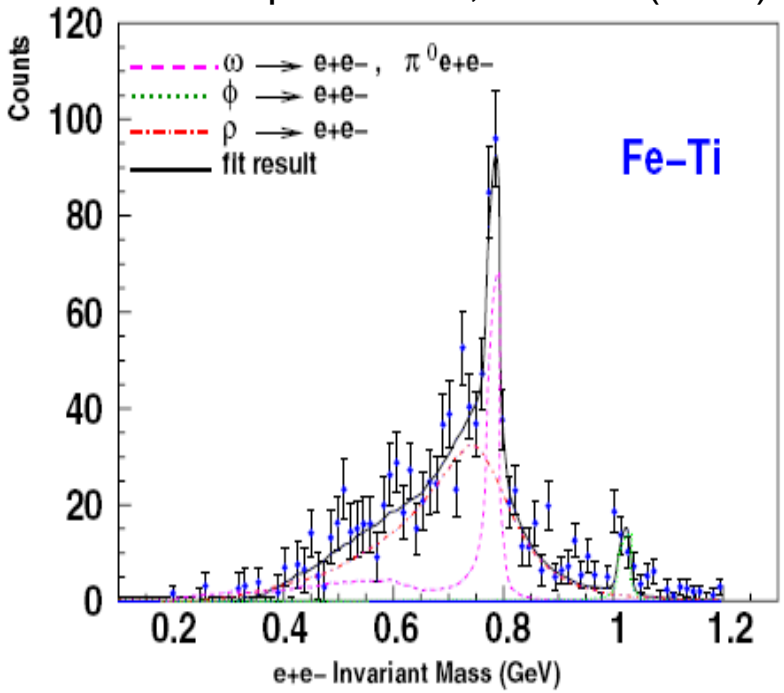


General remarks

M. Post et al., NPA 741 (2004) 81



Nasseripour et. al., PRL 99 (2007)



- Change in line shape: decay inside the medium

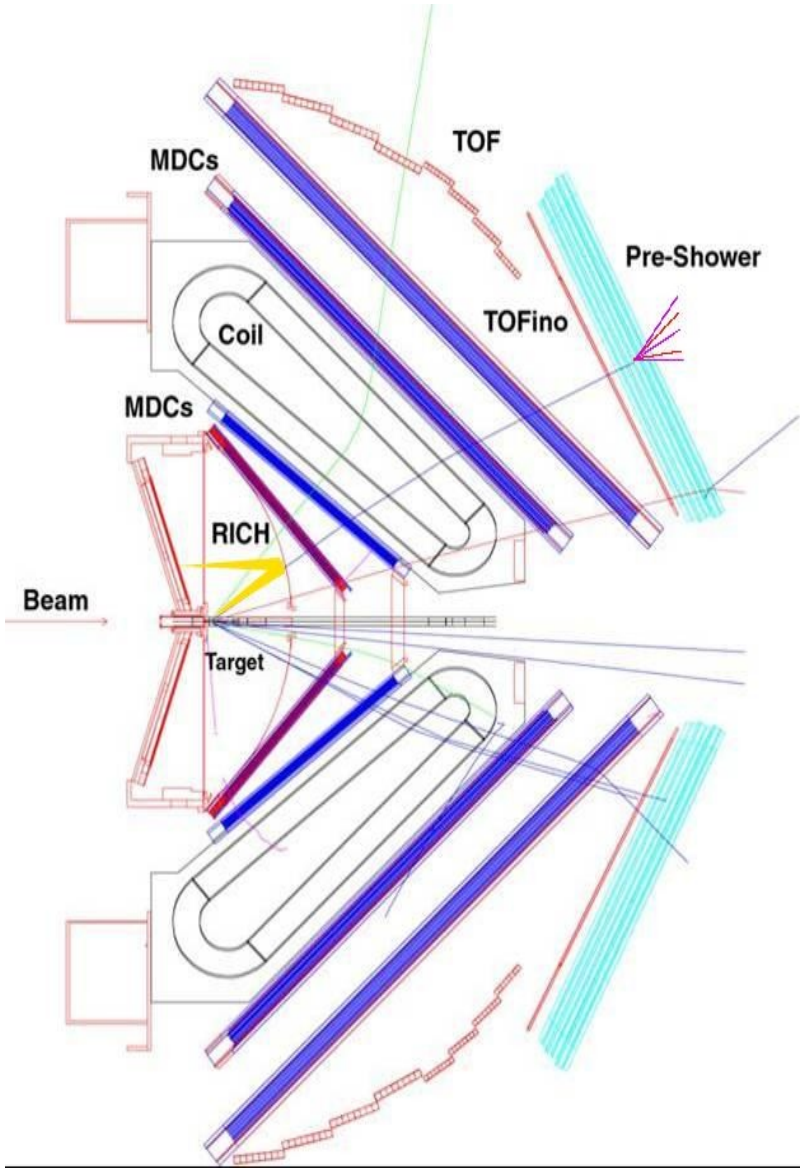
- Hadronic models: modification in the spectral function most pronounced for low relative momenta

→ good acceptance of low momenta pairs

- in dilepton spectra always contributions from ρ and ω mesons

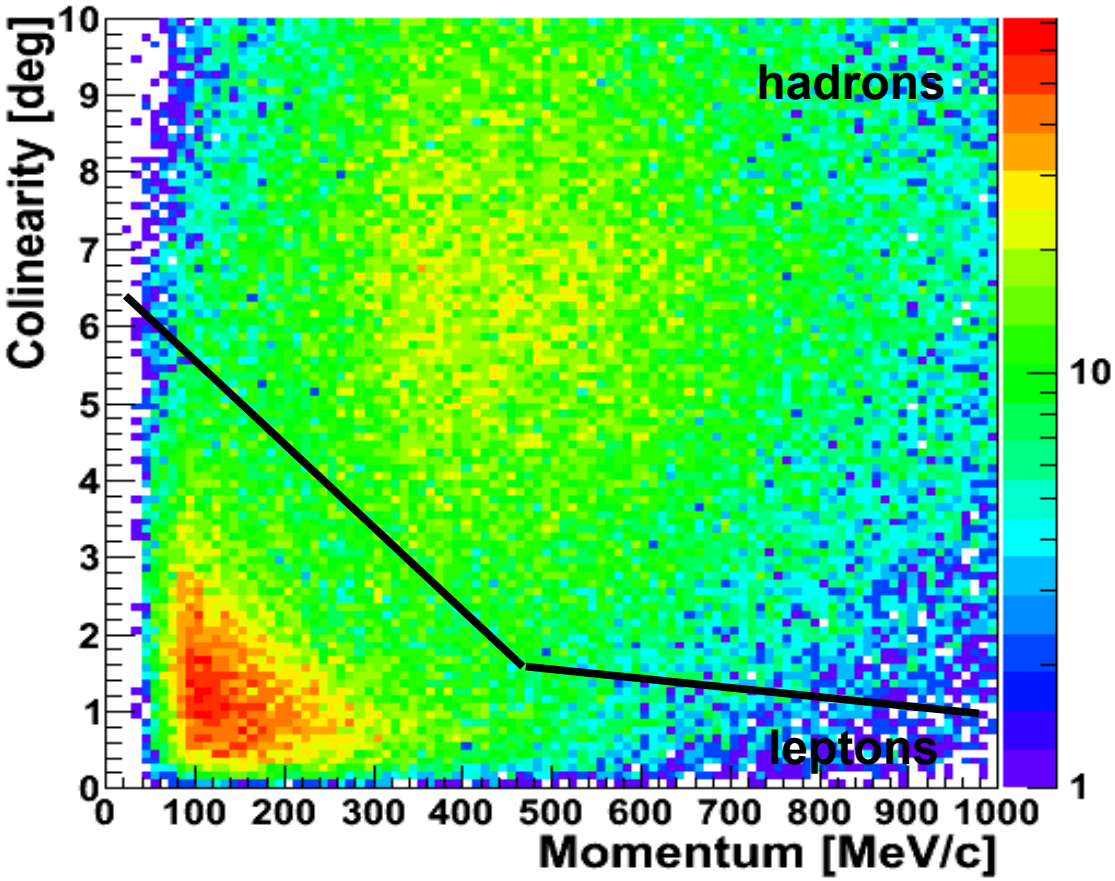
→ how to distinguish between a broad ω and a vacuum ρ contribution?

Electron identifcation



Electron identification:
- RICH
- SHOWER
- dEdx (MDC + TOF-walls)

decision based on a neural network



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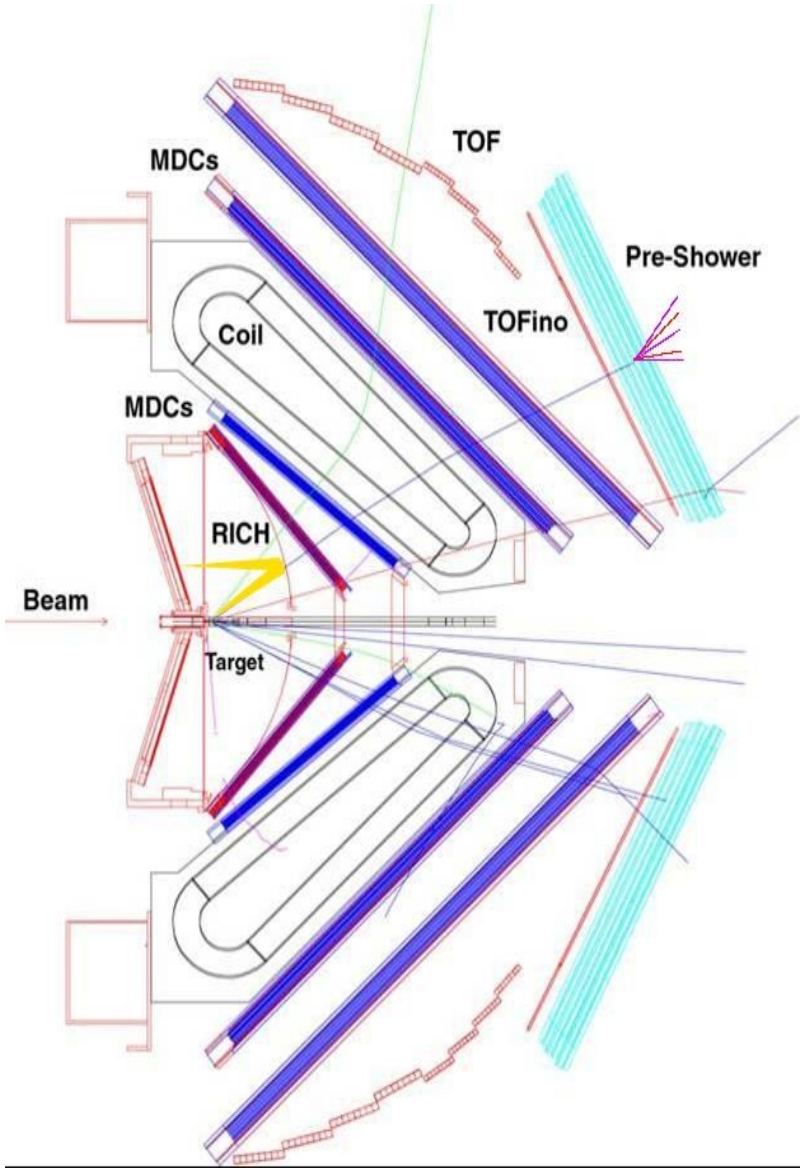

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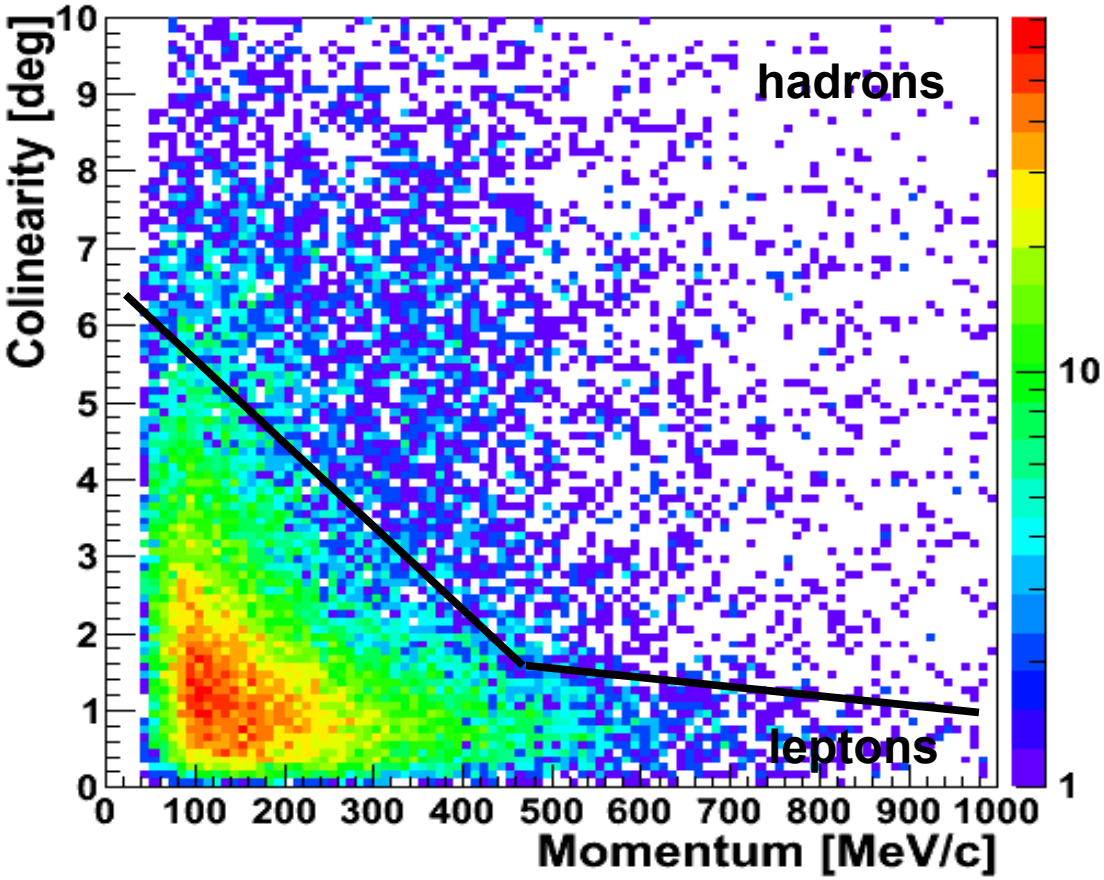
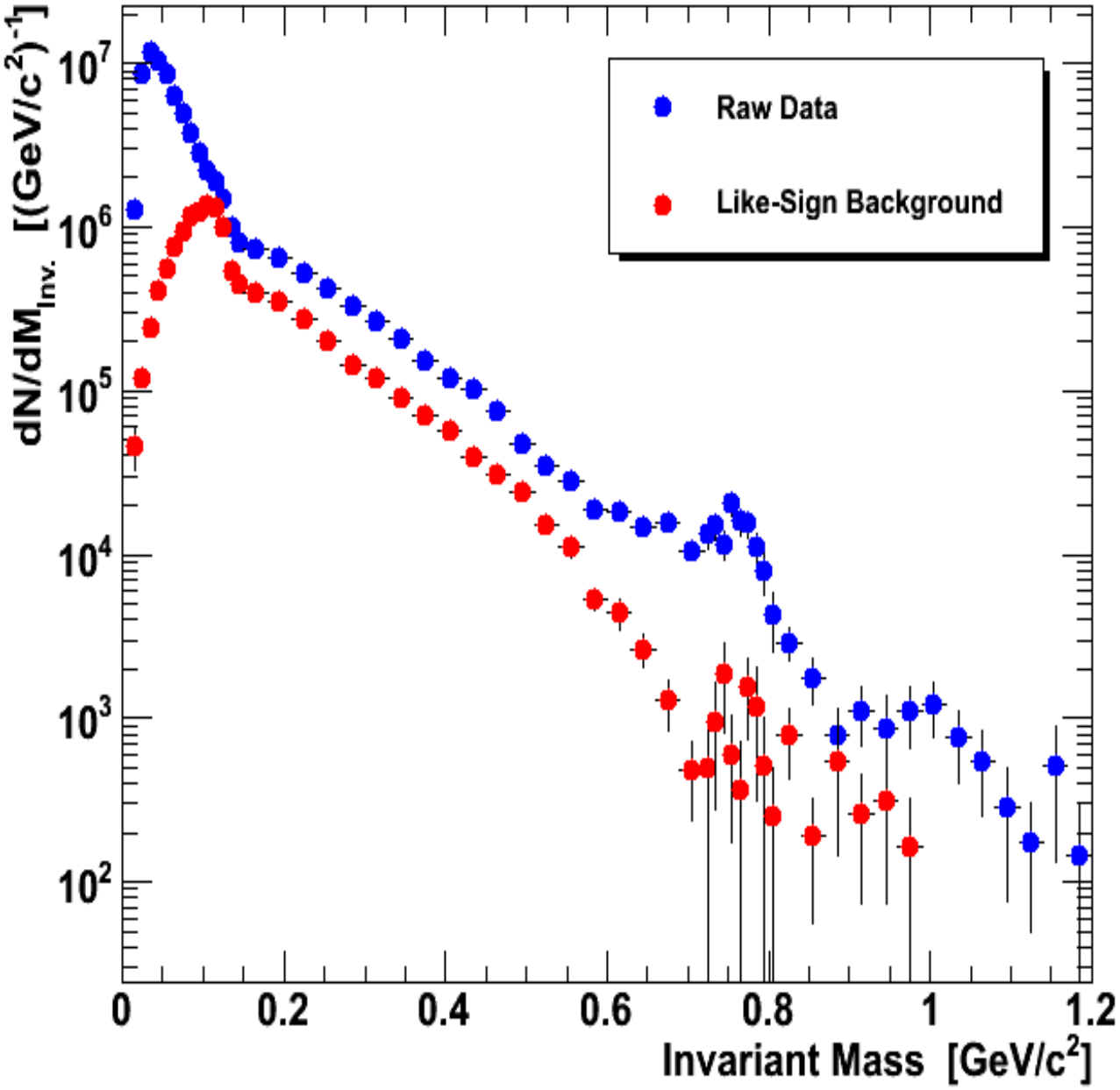
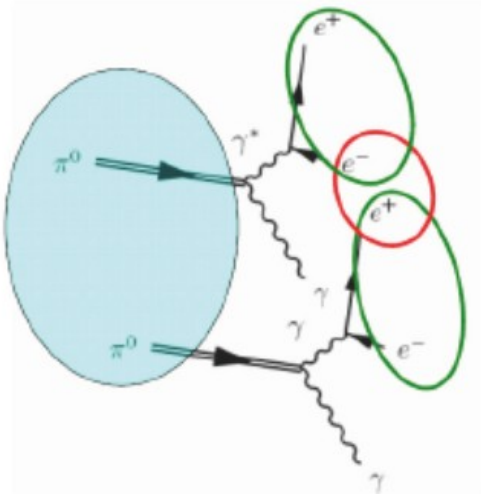


e^+e^- pair reconstruction

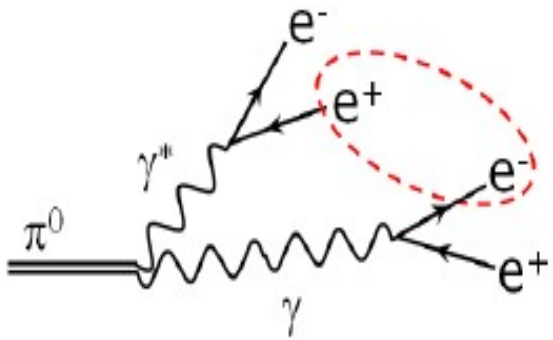


Background sources:

uncorrelated

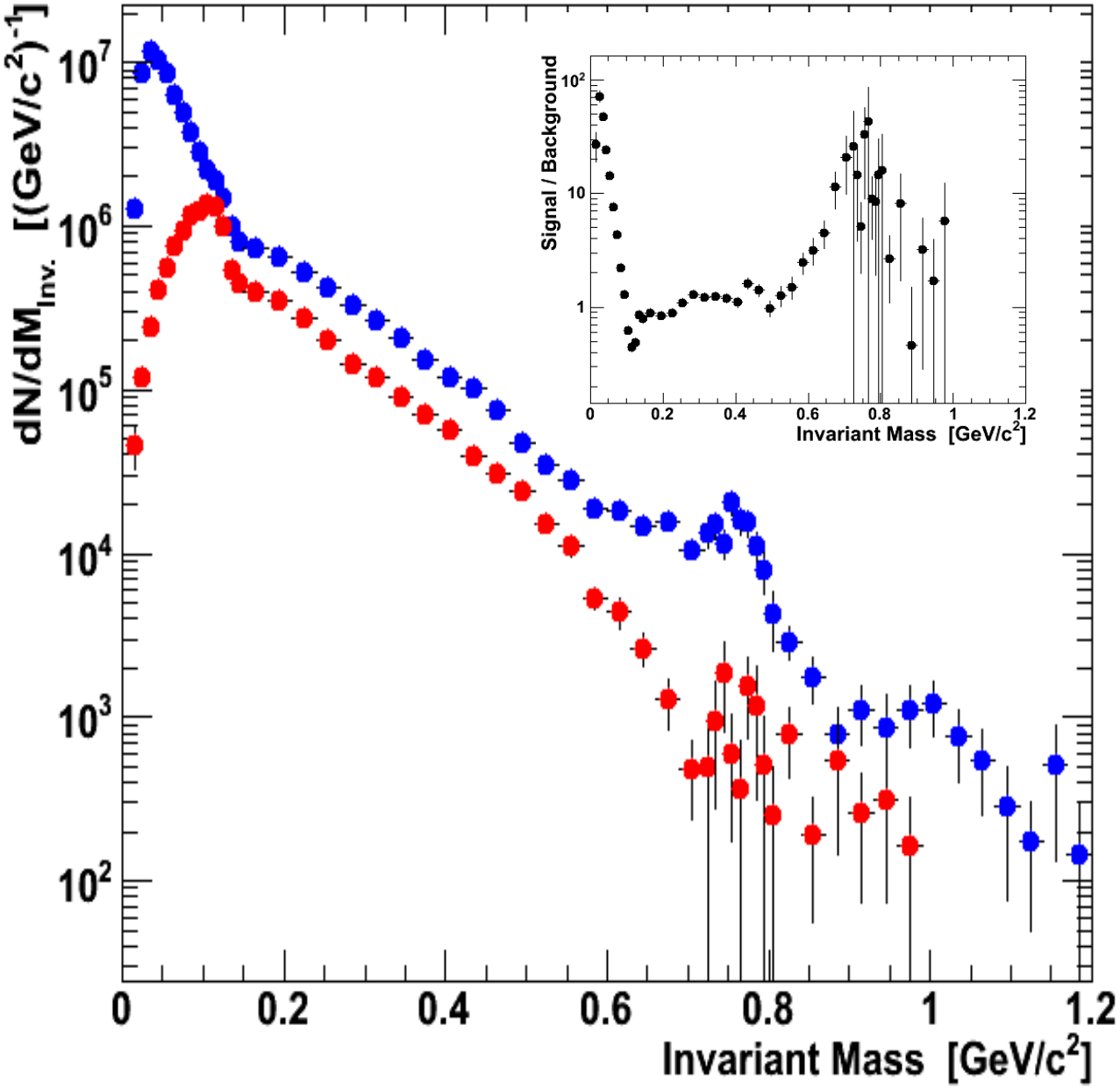


correlated



$U = N_{++} + N_{--}$

e^+e^- pair reconstruction



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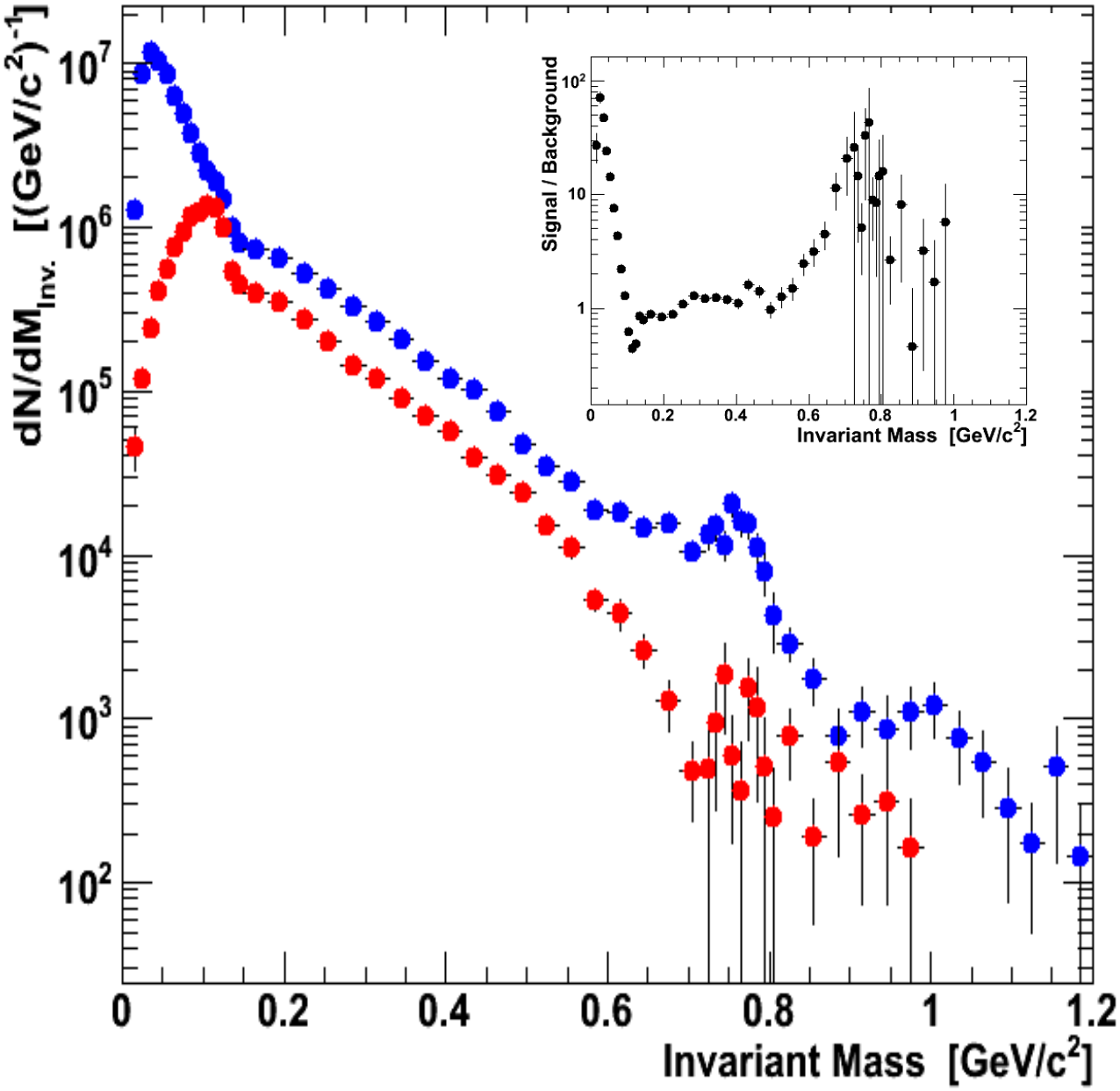


Needed precision of measurement: 10%

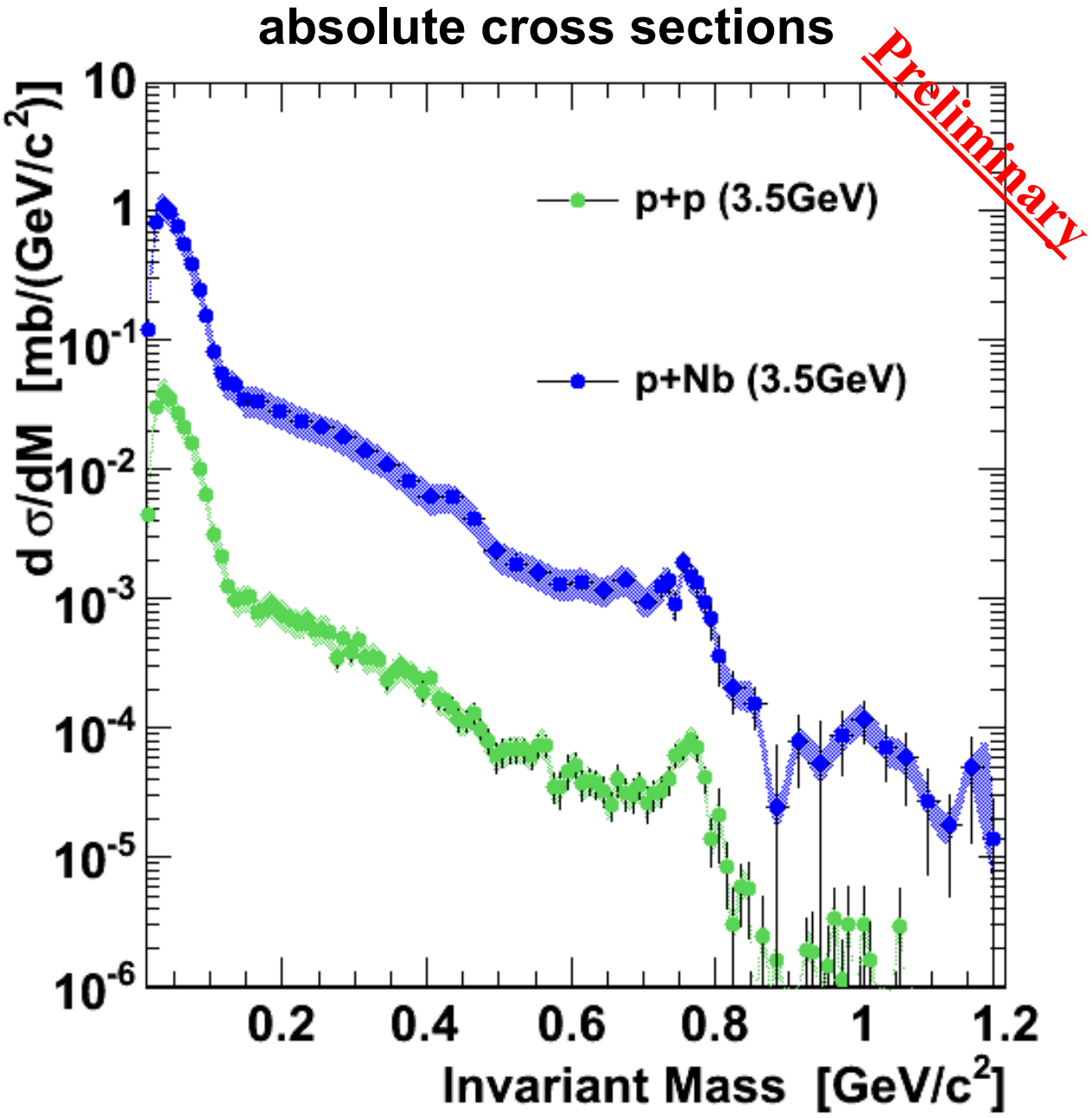
S/B= 1
accuracy of background estimation 10%

S/B= 0.1
accuracy of background estimation 1%

S/B= 0.01
accuracy of background estimation 0.1%

Comparison of p+p and p+Nb data

Comparison of the spectra



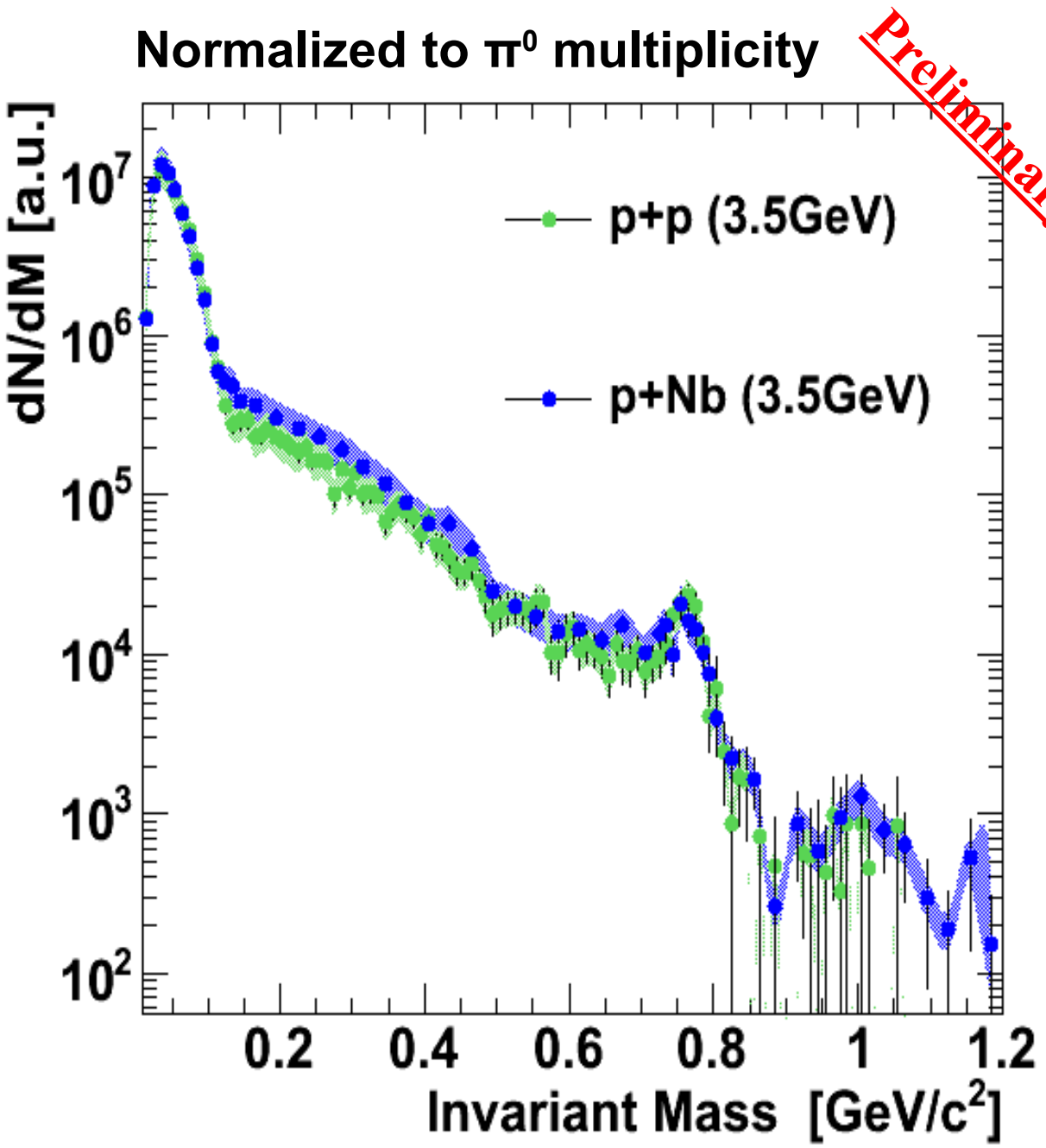
Systematical errors (bands):

Efficiency correction ≈ 15%
Normalization ≈ 20%
Analysis ≈ 5% (≈ 20% for Y)

Total ≈ 30%

Comparison of line shape:
→ norm to π^0 multiplicity

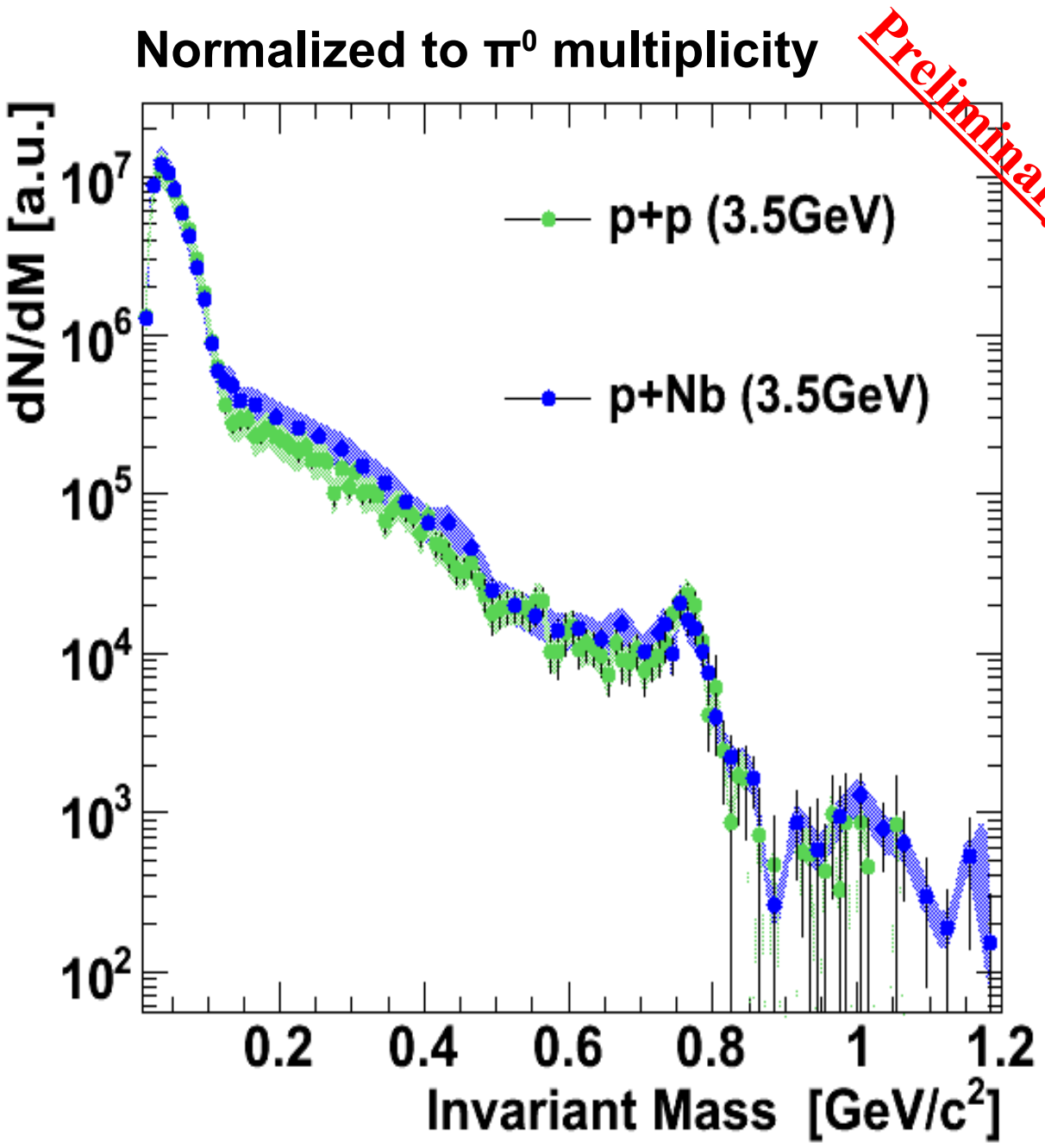
Comparison of the spectra



Higher rates in η region but no significant difference in ω region

Additional information needed:
→ compare different kinematical observables (p_t,Y,P..)

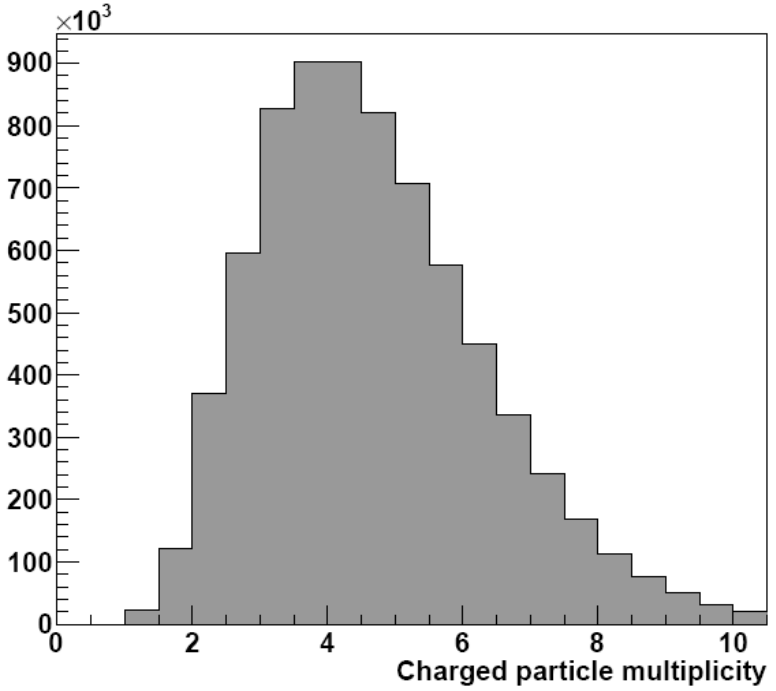
Comparison of the spectra



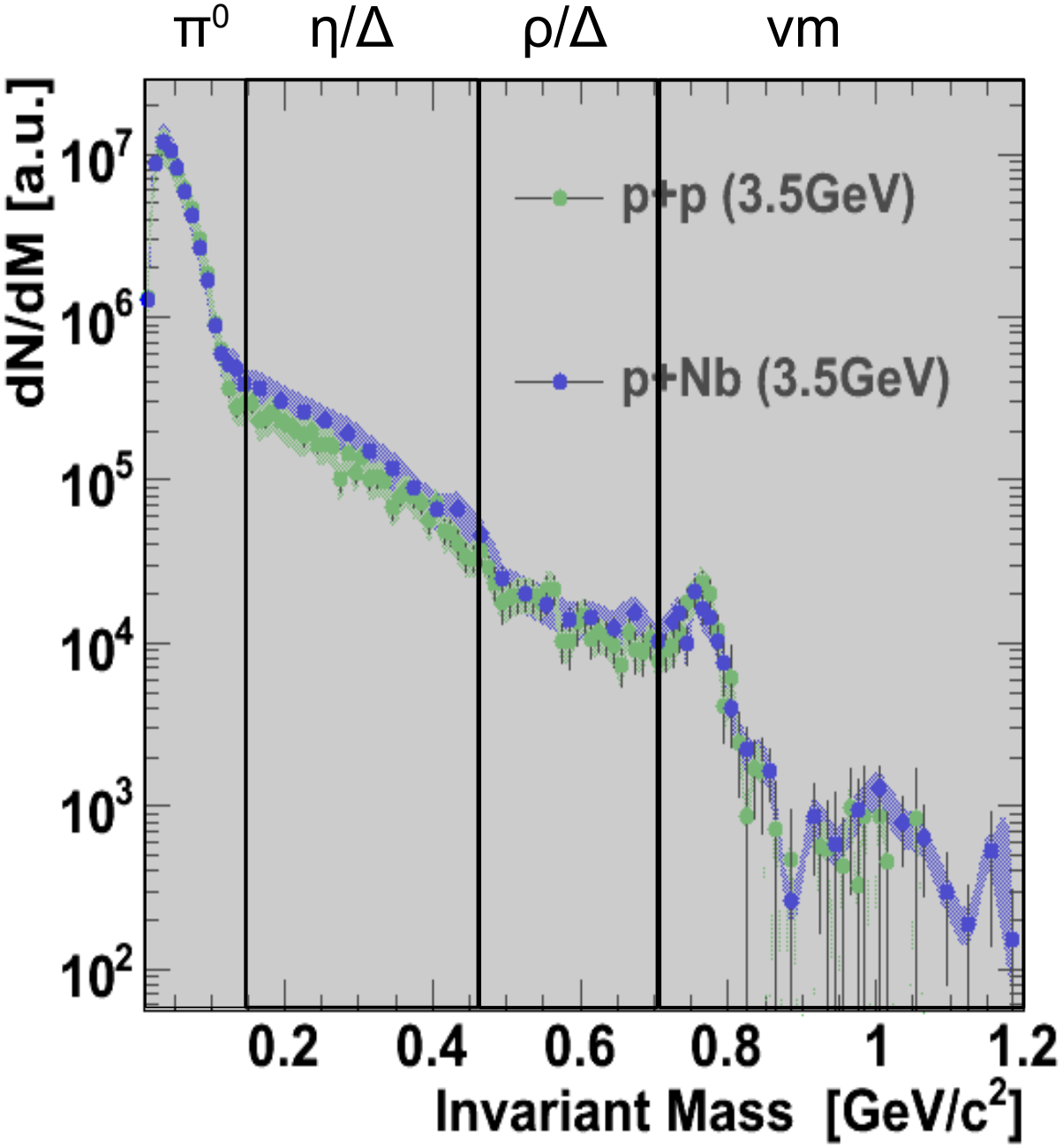
Higher rates in η region but no significant difference in ω region

Additional information needed:
→ compare different kinematical observables (p_t,Y,P..)

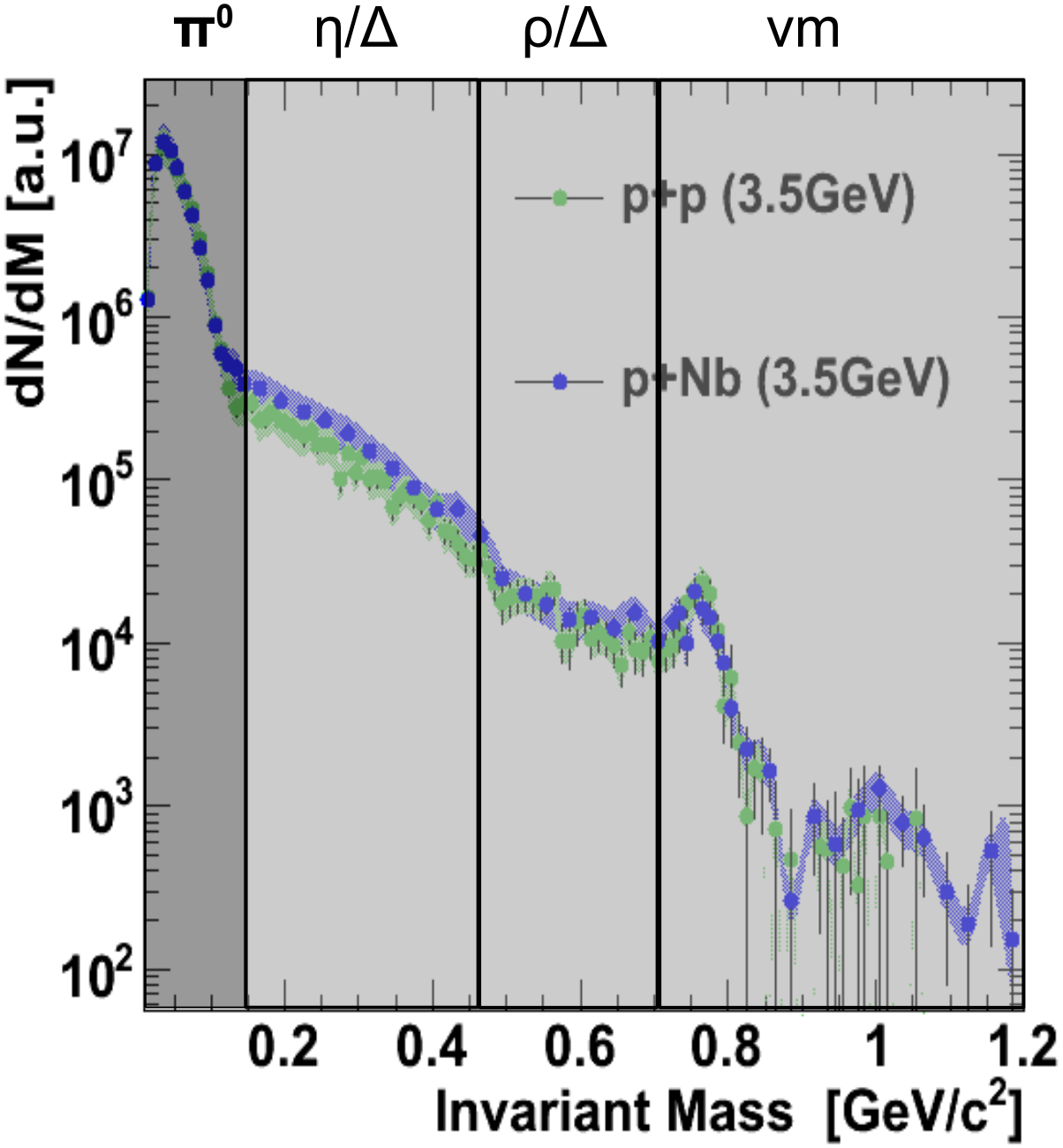
→ make use of charged particle multiplicity (correlation with impact parameter??)



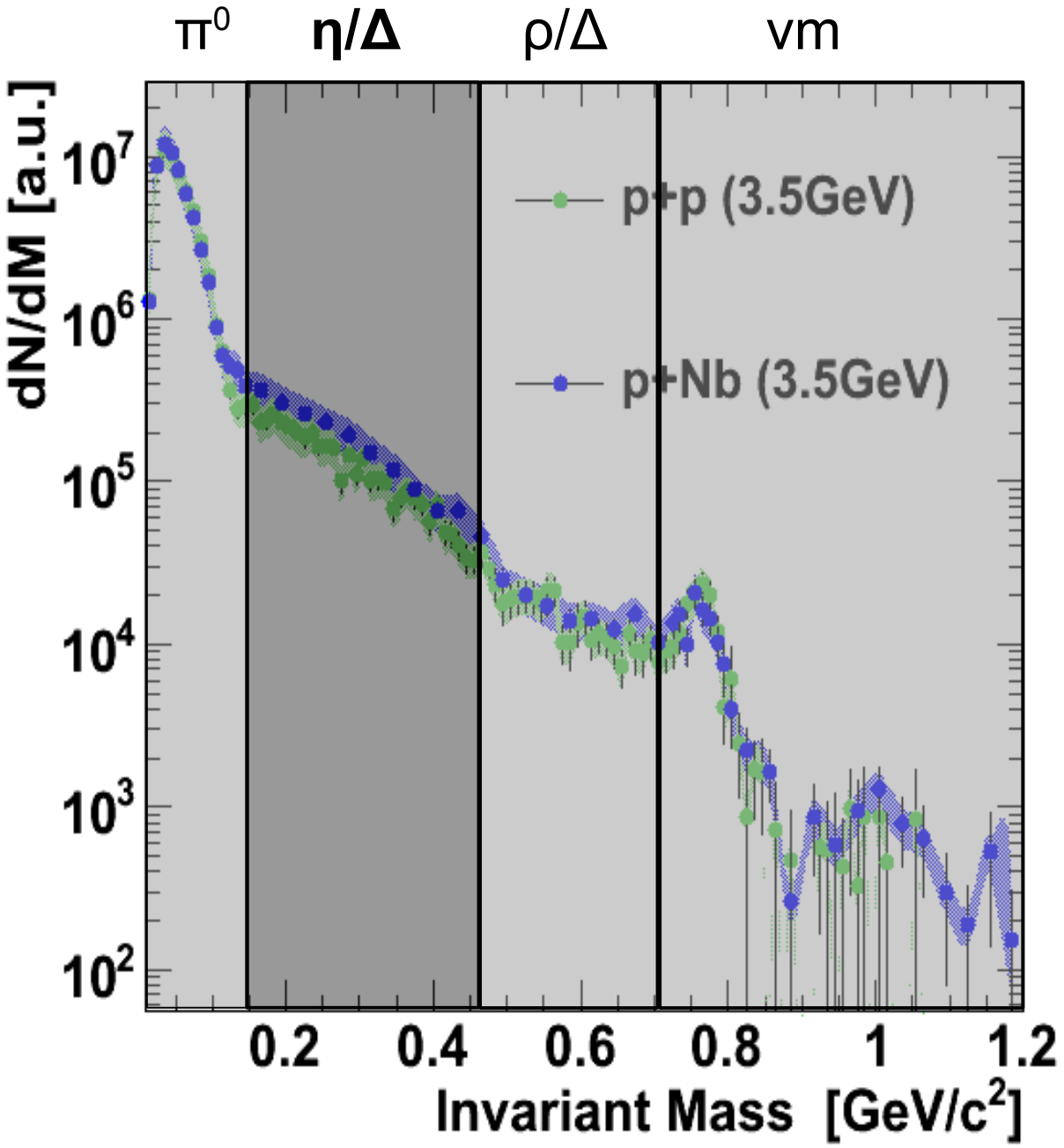
kinematical observable



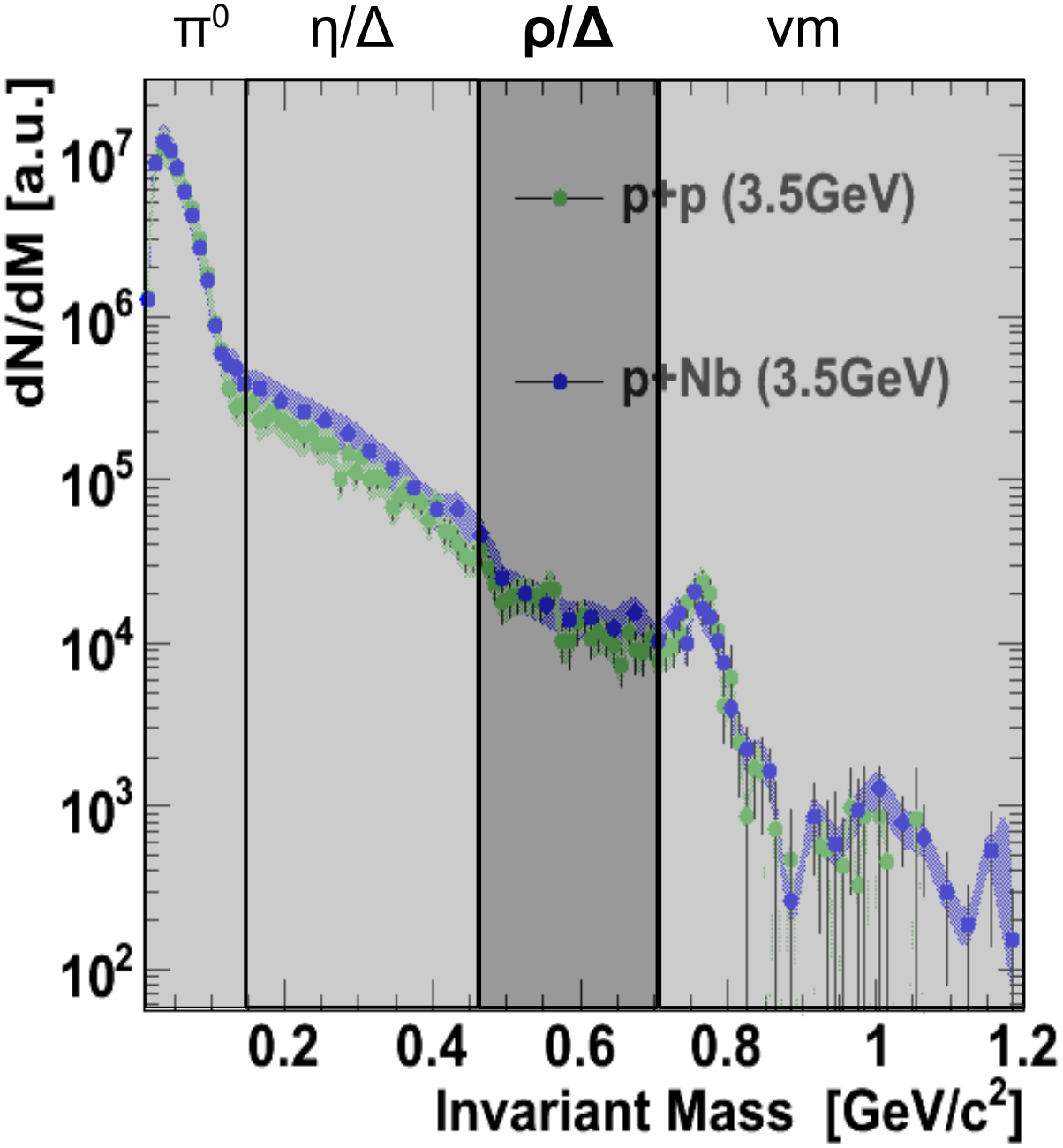
kinematical observable



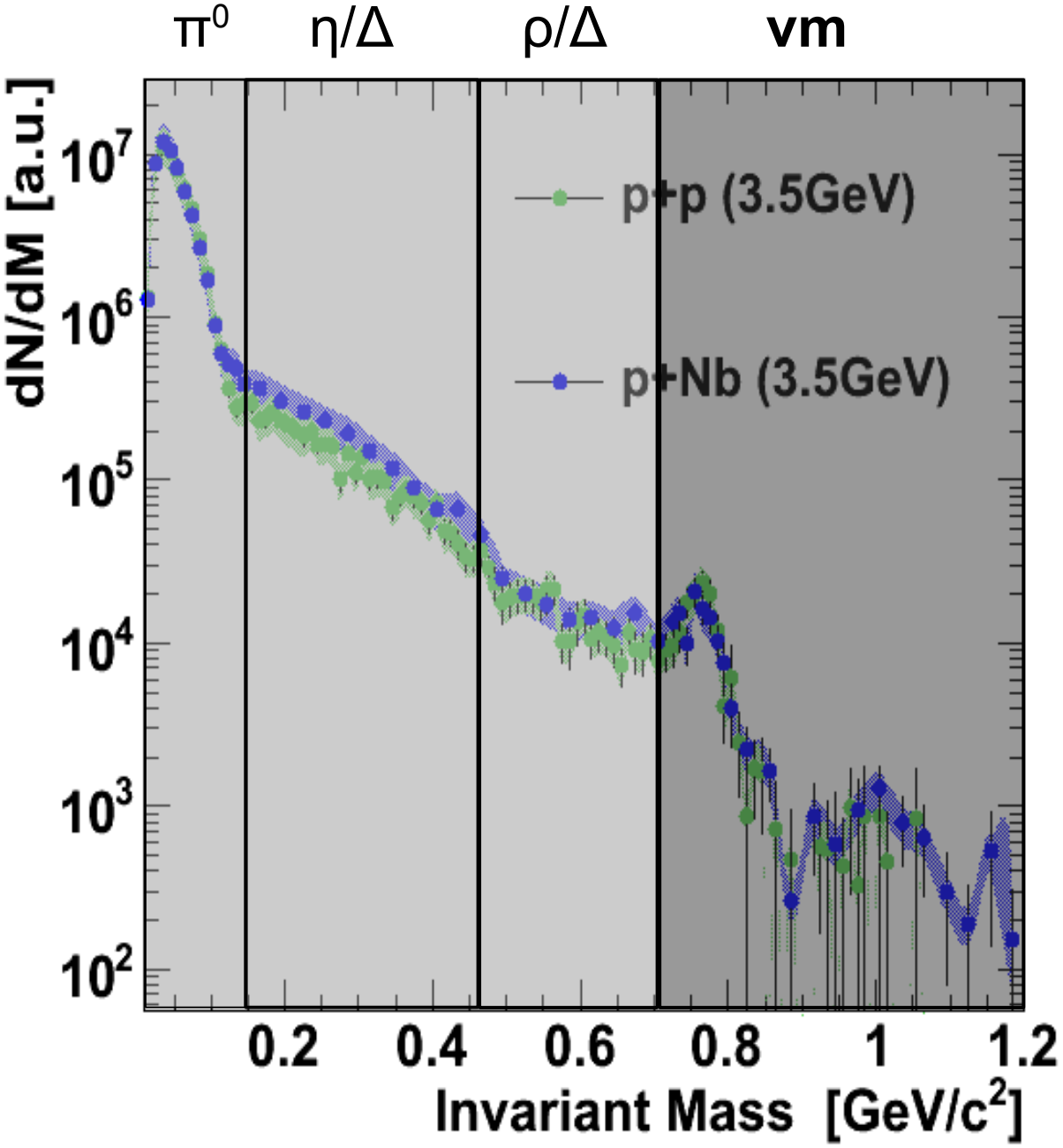
kinematic observable



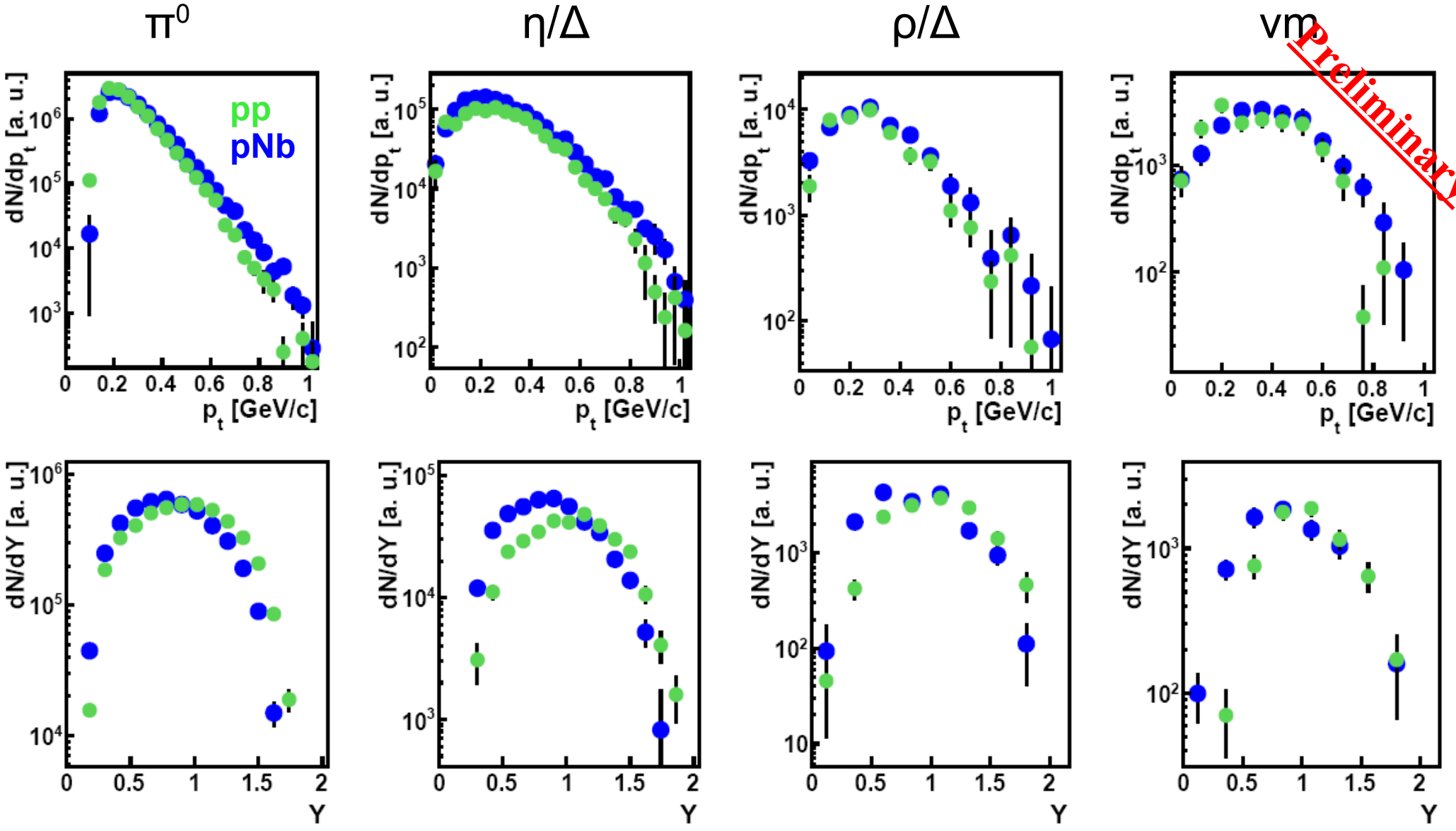
kinematical observable



kinematical observable

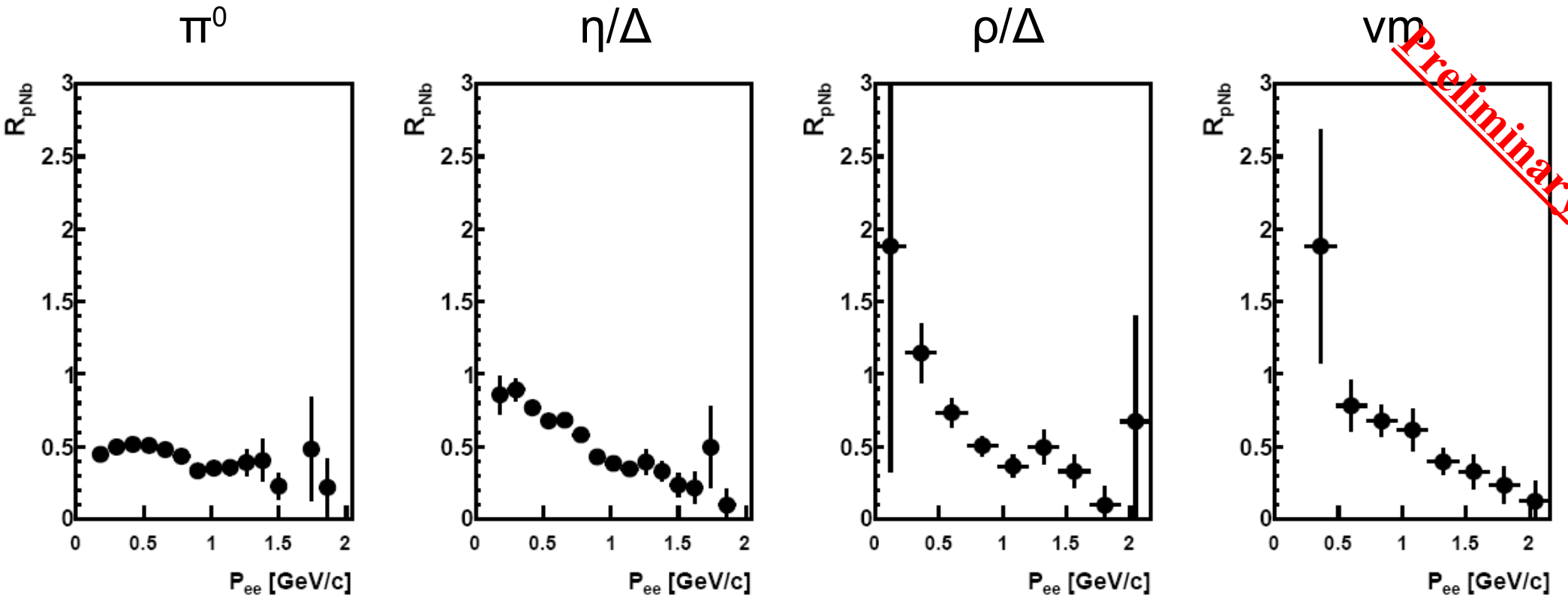


kinematical observable I: p_t and Y



- shift to target rapidity and slightly higher transverse momenta

kinematical observable II: P_{ee}

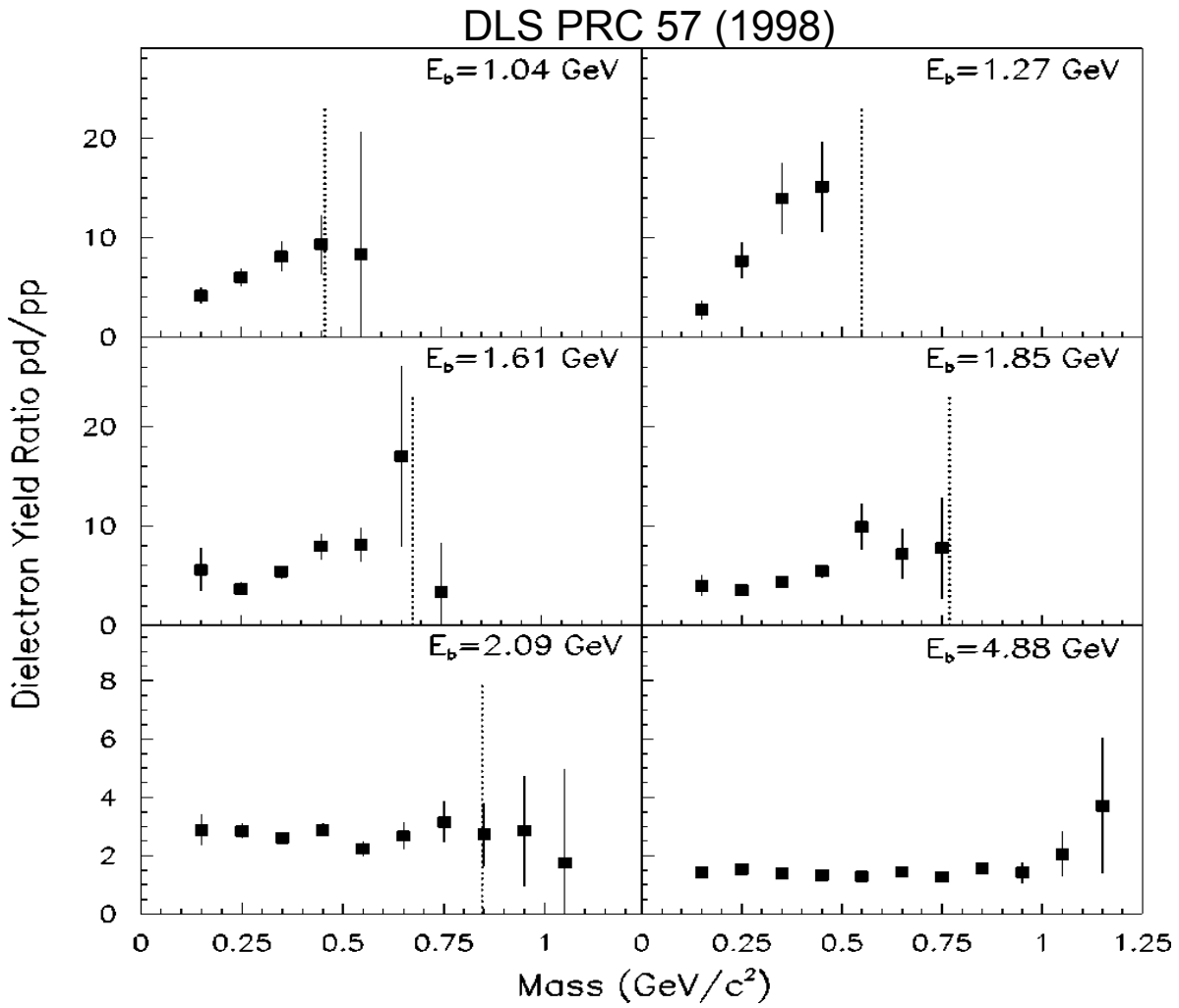


- constant ratio in π^0 region
- strong momentum dependence for other regions
- higher values at low momenta: secondary production stronger than absorption?
Isospin effect important for secondary production?

$$R_{pNb} = \frac{dN/dp^{pNb}}{A_{part} \cdot dN/dp^{pp}}$$

A_{part}= 2.7 (from Glauber model)

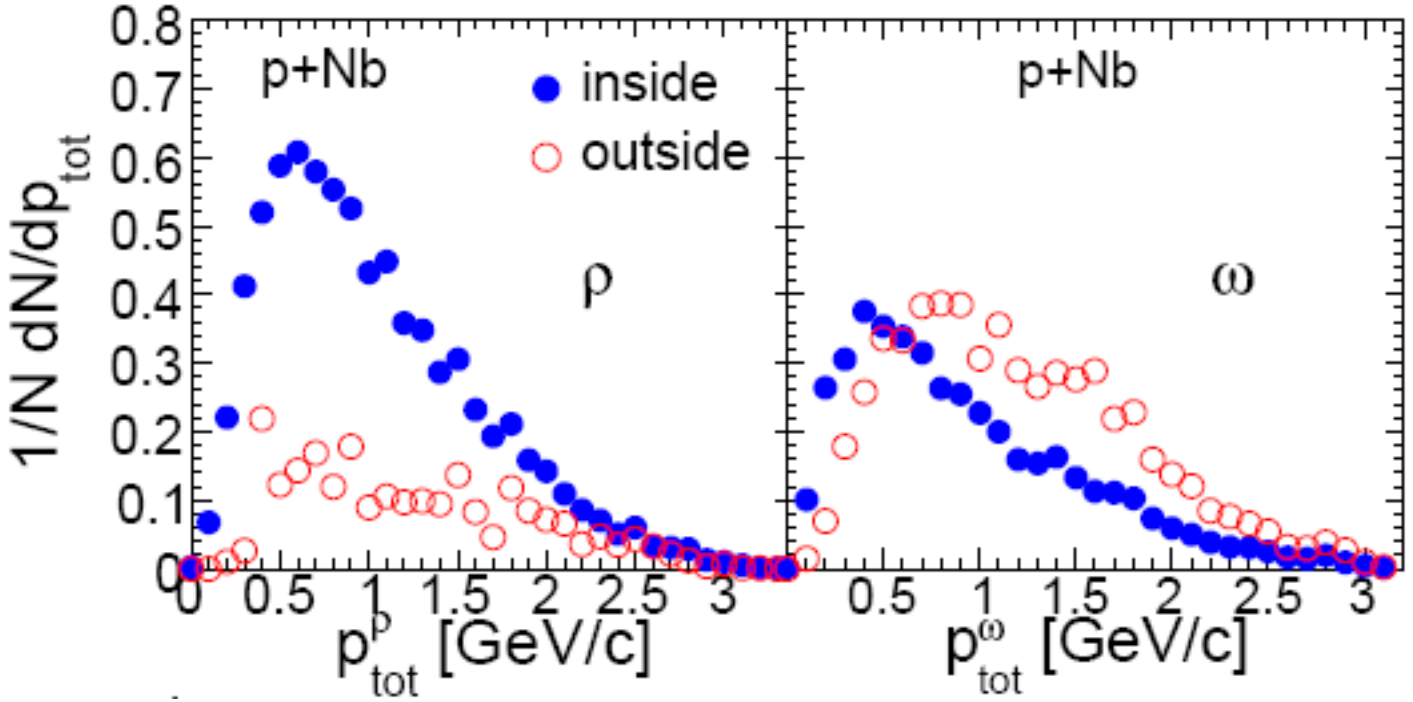
Secondary production and isospin effect



In secondary collisions √s is lower than 3.18GeV, isospin effects might become important. **How strong is the contribution of secondary collisions, what is the average √s of this reactions?**

Vector mesons

HSD calculation from beam time proposal



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- Hadronic models: modification in the spectral function most pronounced for low relative momenta

Vector mesons

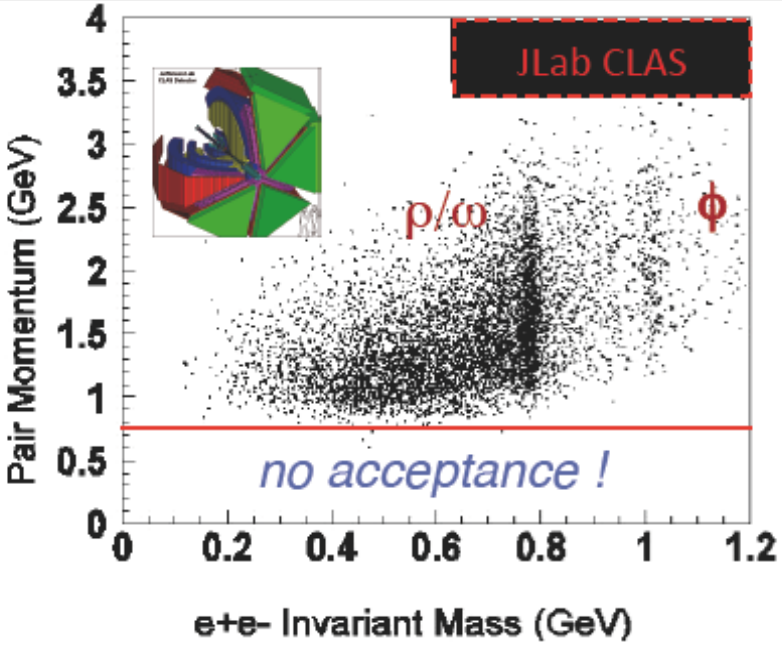
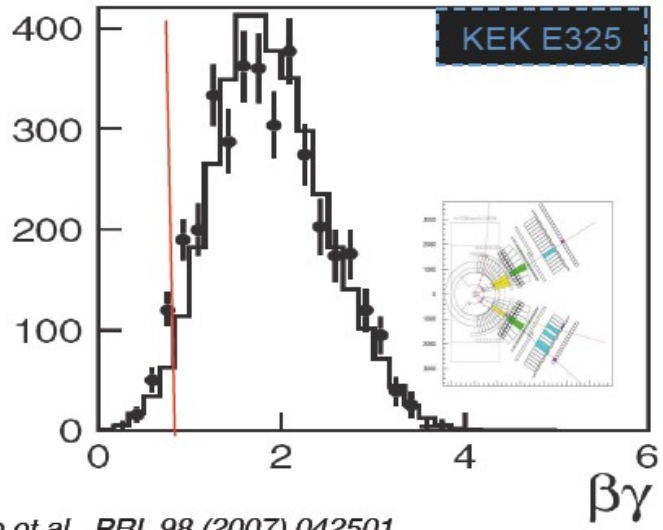
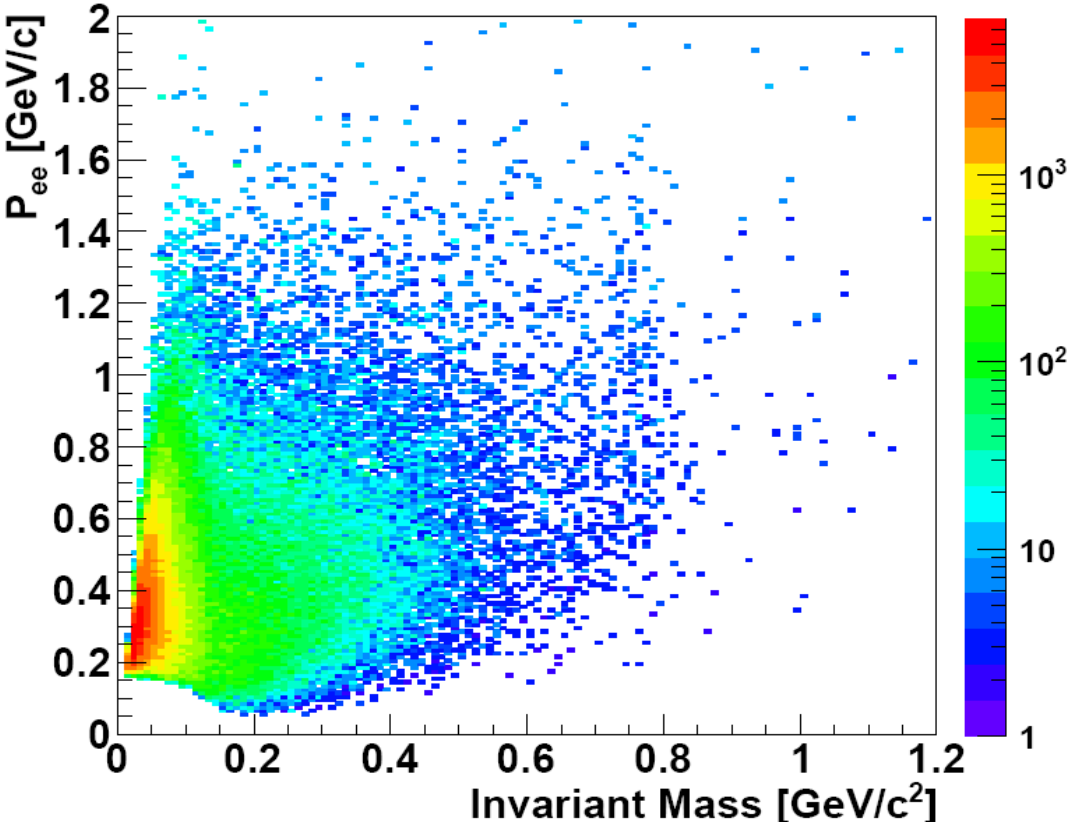


Fig. from S.Leupold et al., nucl-th 0907.2388

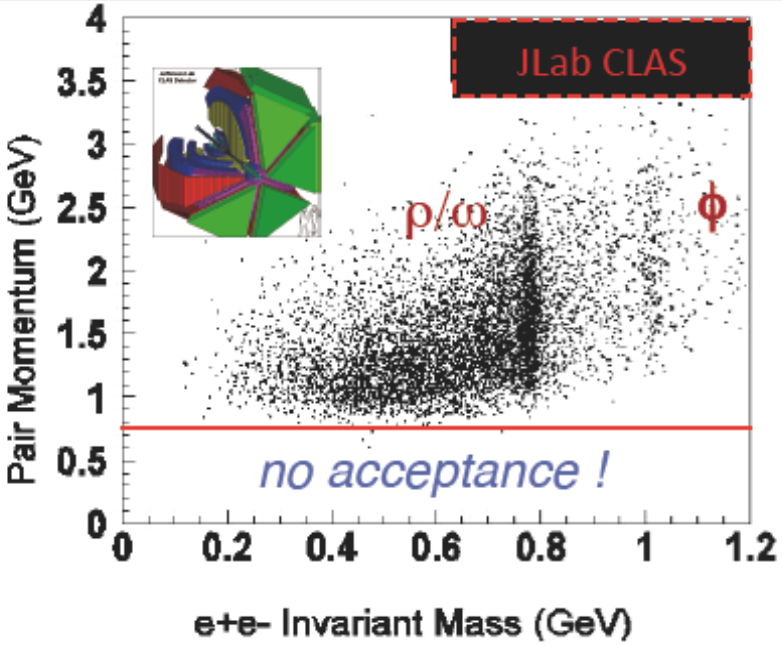


R.Muto et al., PRL 98 (2007) 042501



Compared to CLAS and KEK-E325 better coverage of slow vector mesons

Vector mesons



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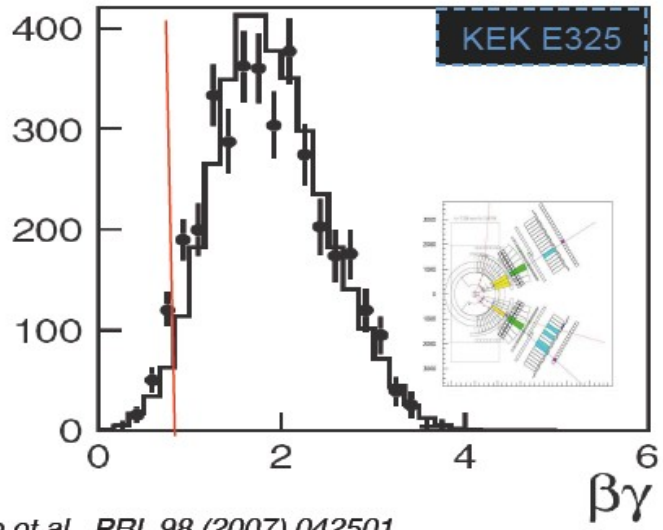
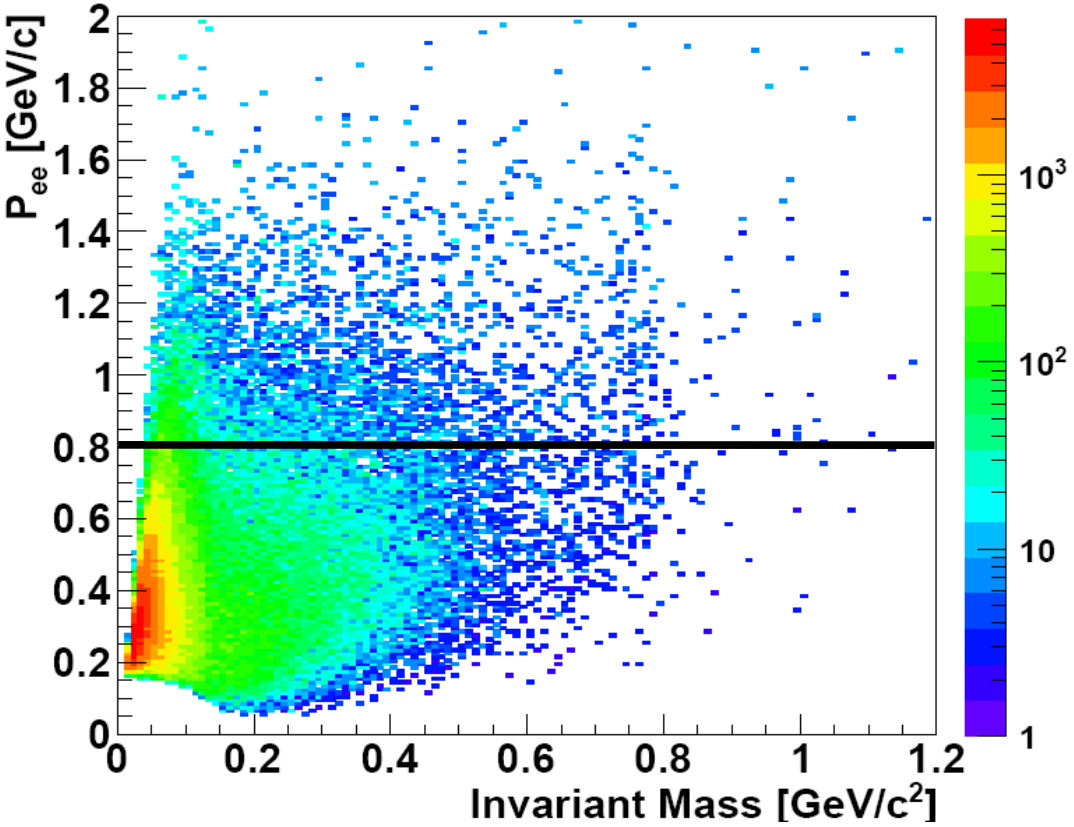
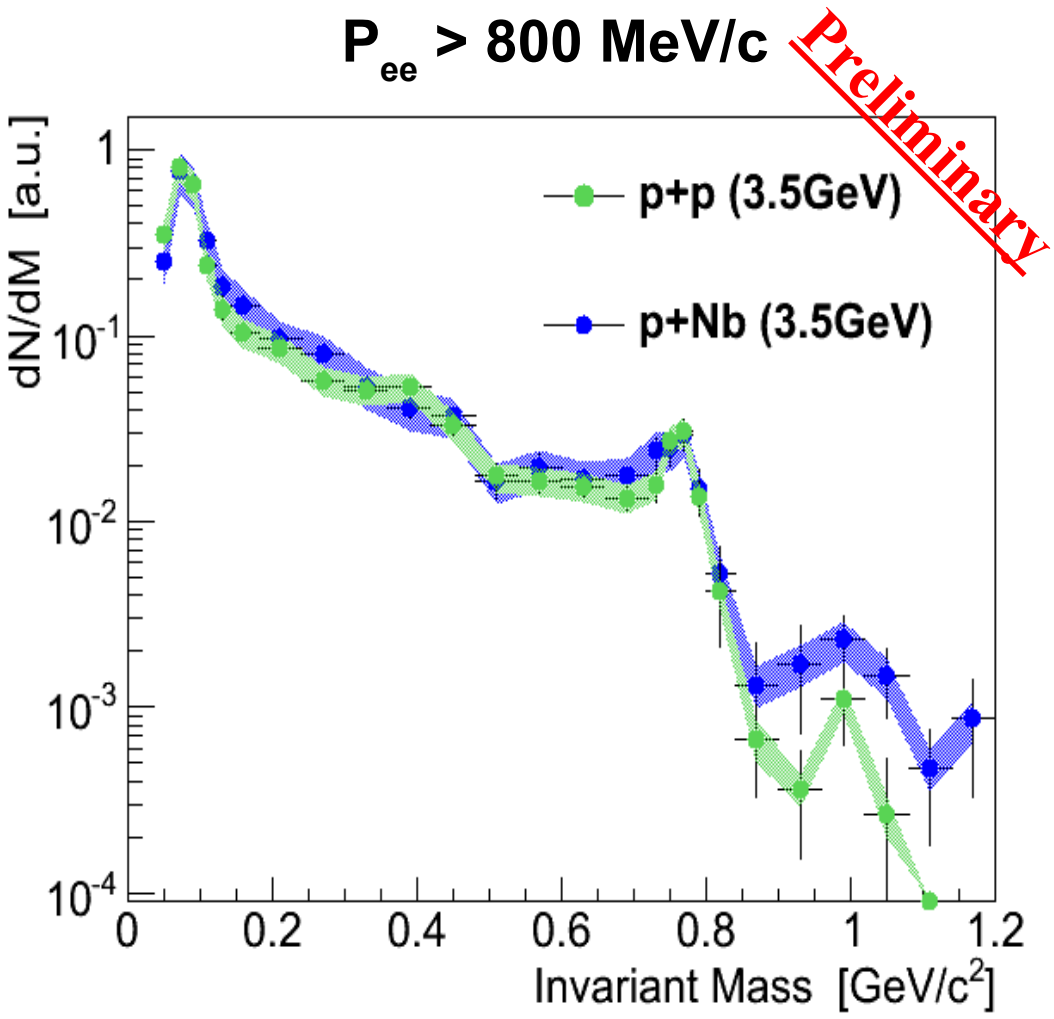


R.Muto et al., PRL 98 (2007) 042501



Compared to CLAS and KEK-E325 better coverage of slow vector mesons
→ compare slow and fast ω with pp reference

Vector mesons



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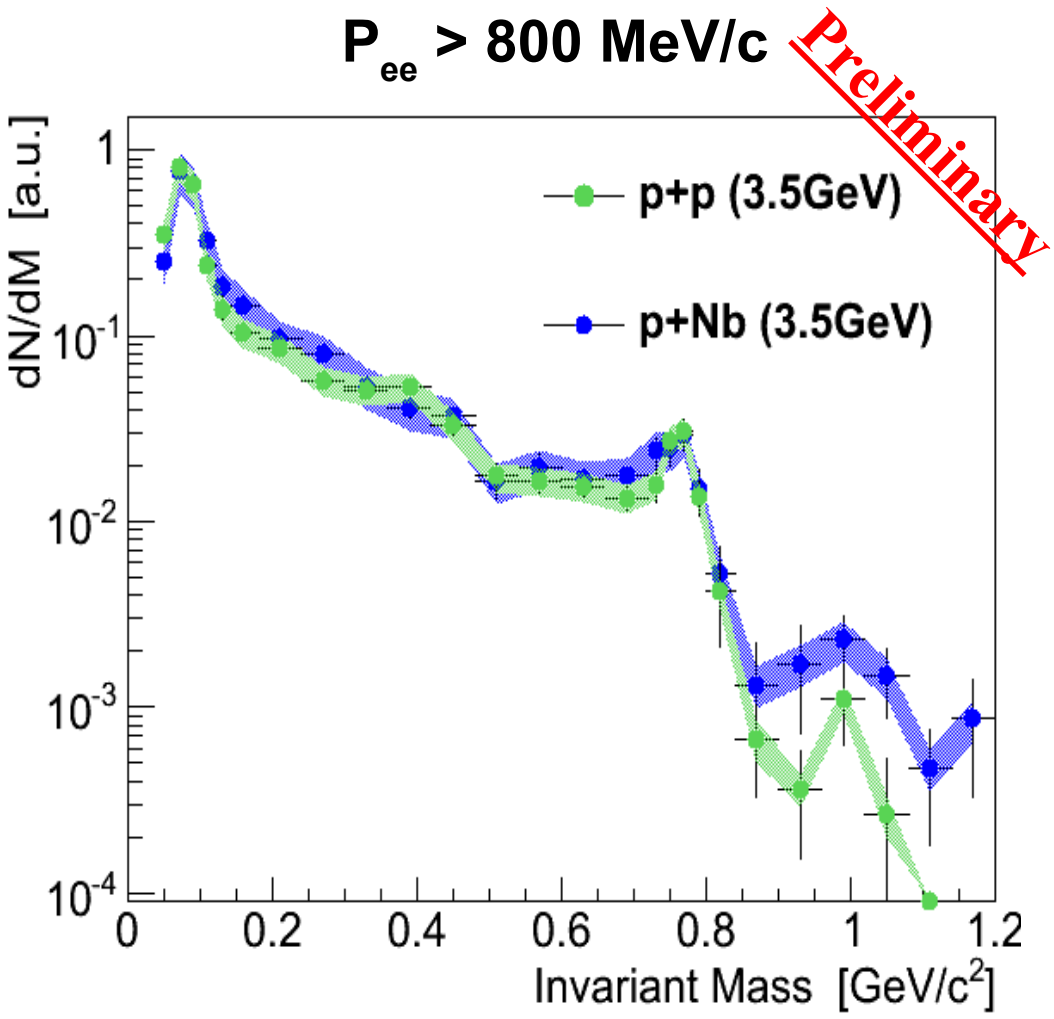

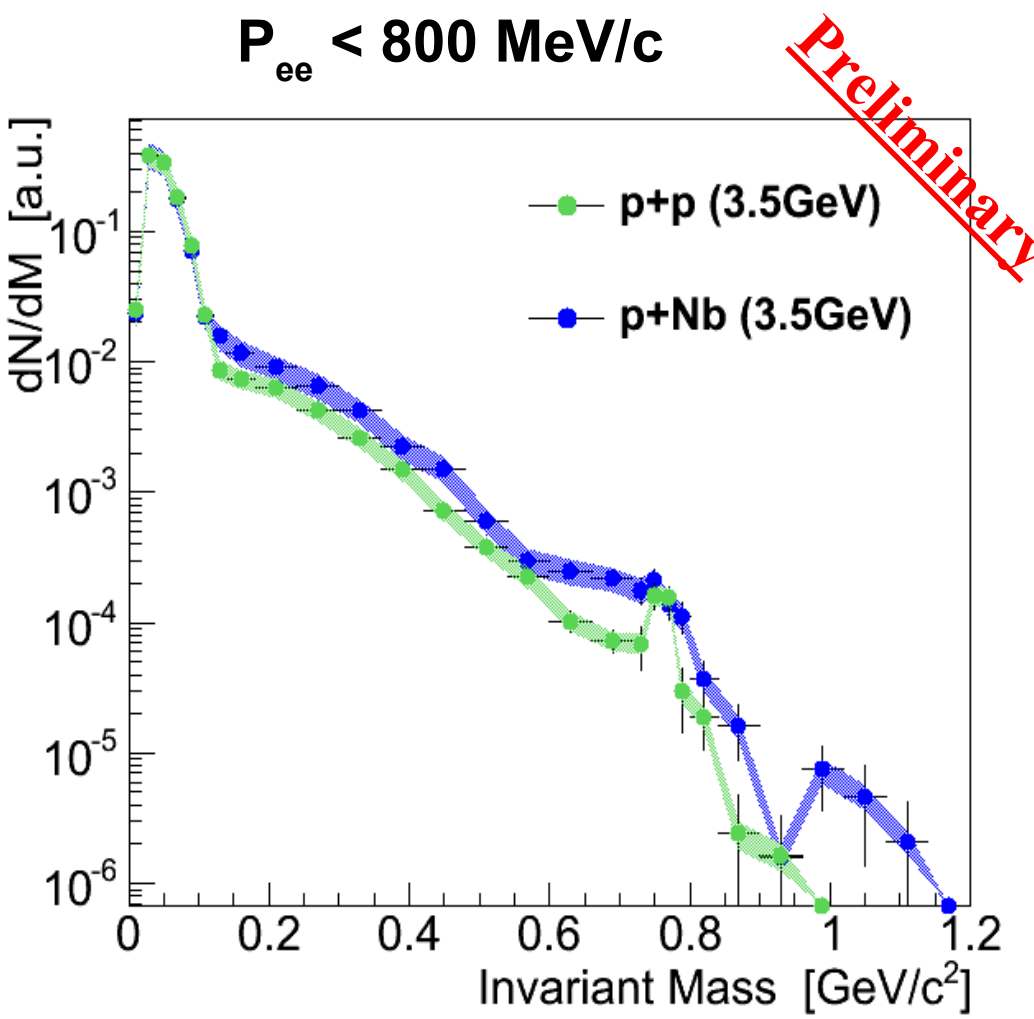

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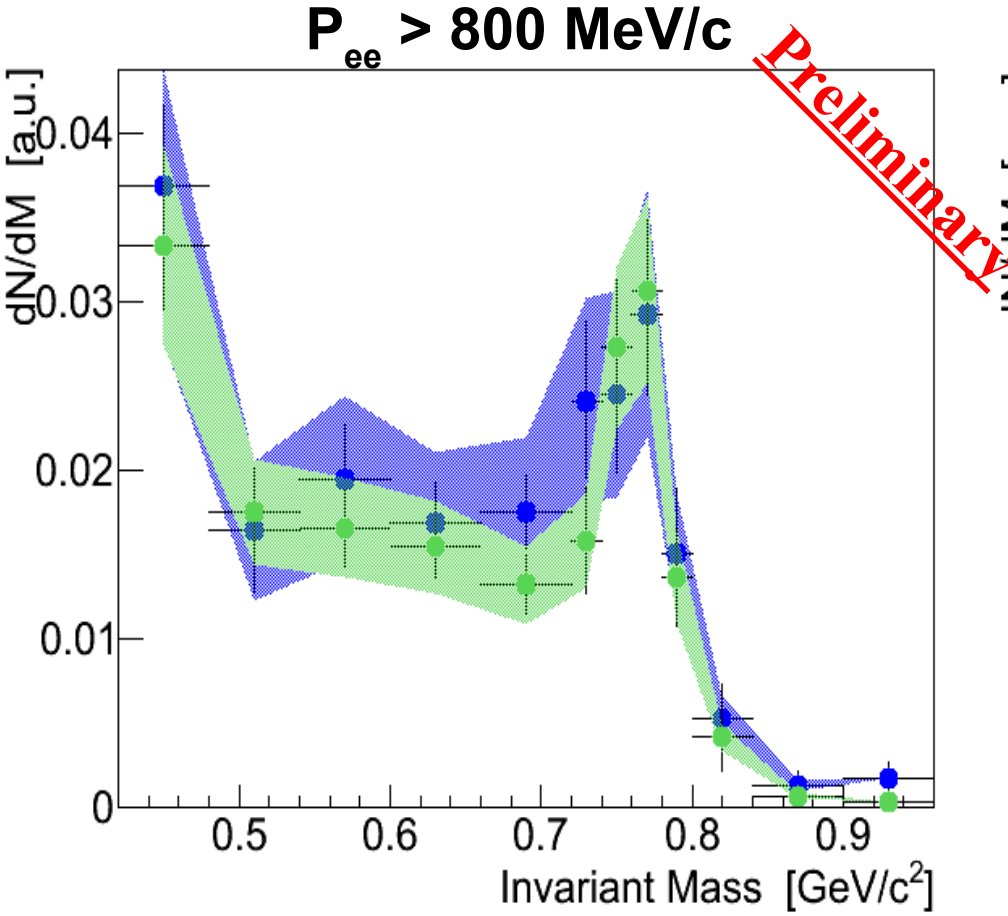
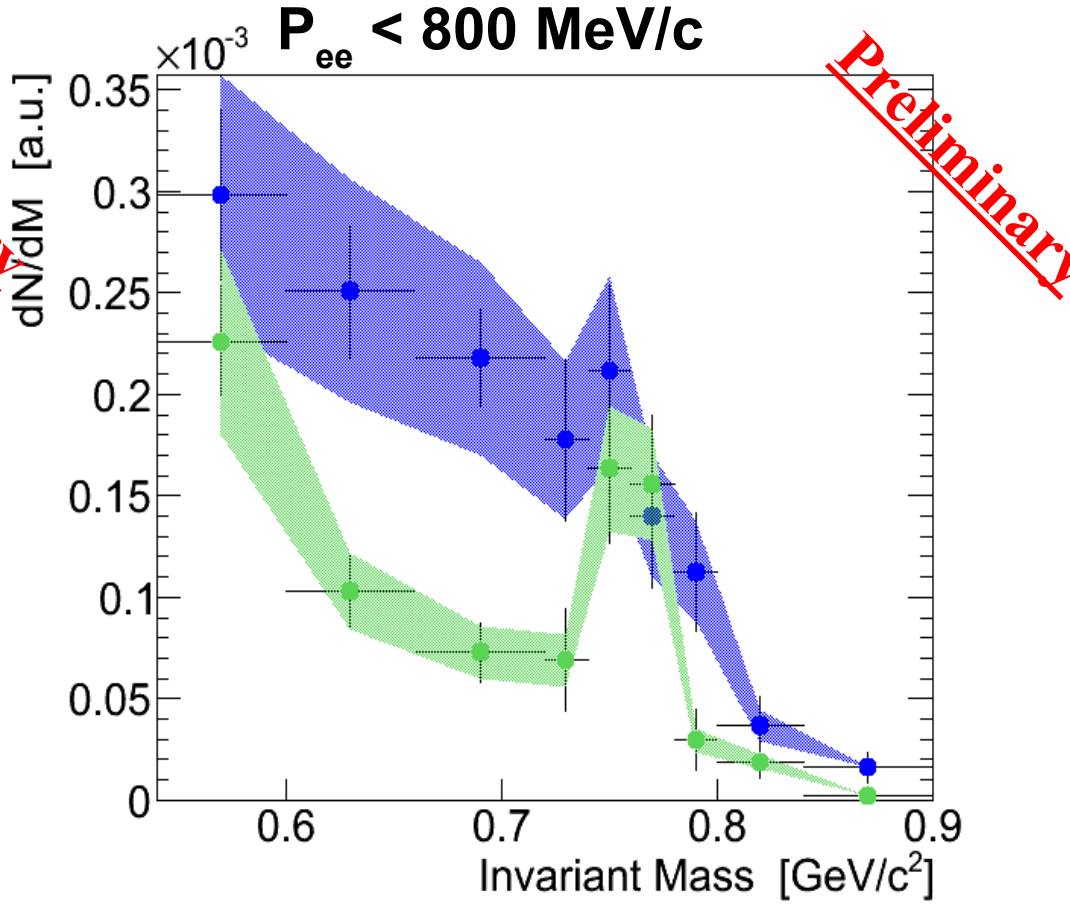
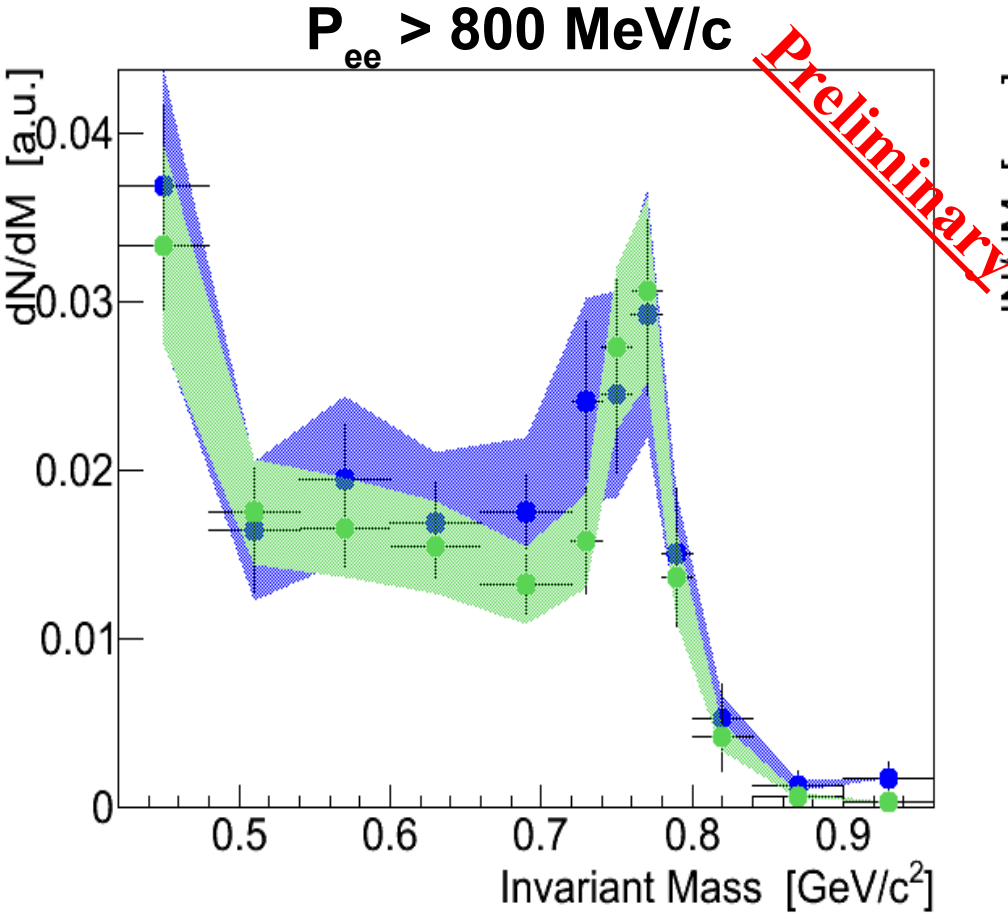
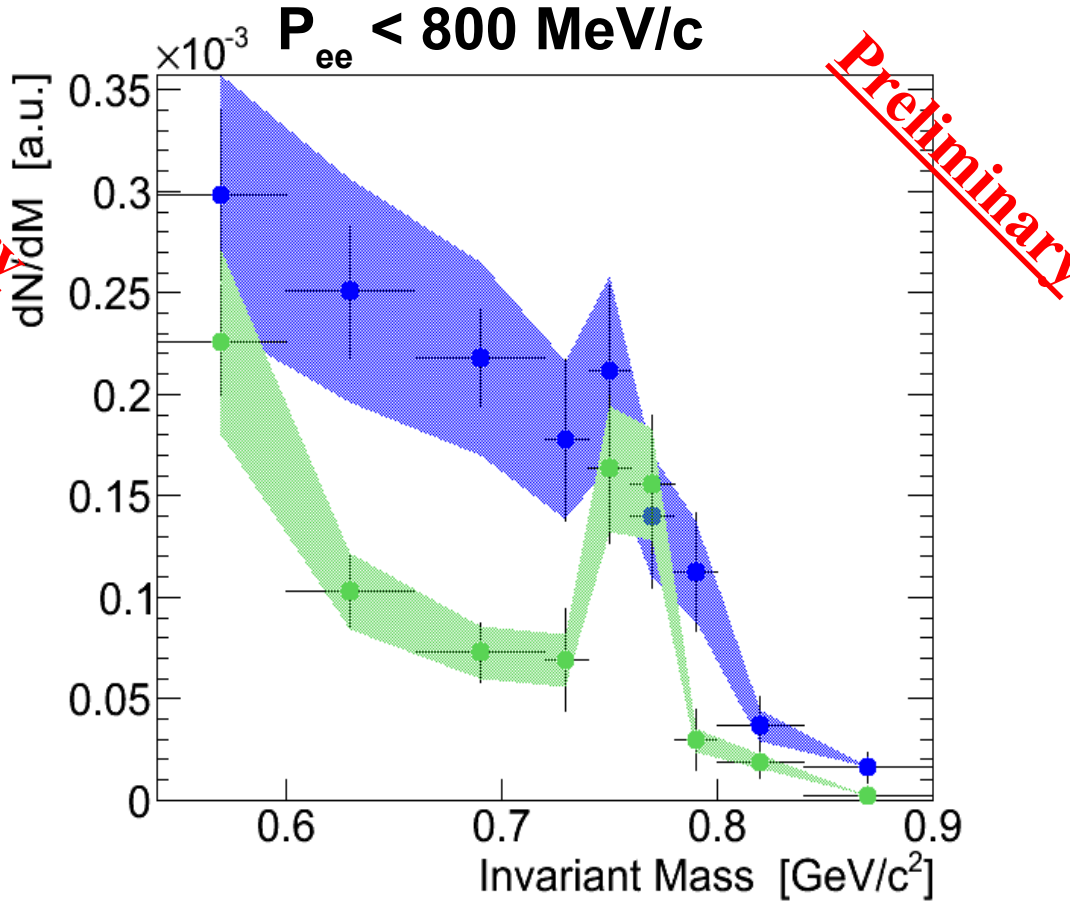




- strong difference in spectral function for slow pairs in the vm region

Vector mesons





- strong difference in spectral function for slow pairs in the vm region

- two effects:

  enhanced ρ-like contribution → role of secondary collisions (isospin effect)?

  ω-absorption → in-medium broadening (consistent with CBELSA/TAPS?)

Conclusion and questions

➔ R_{pA} strongly momentum dependent (except for pion region), higher values at low momenta (secondary collisions)

• strong difference in spectral function for slow pairs in the vm region compared to pp possible explanation:

ω-absorption → in-medium broadening (consistent with CBELSA/TAPS?)

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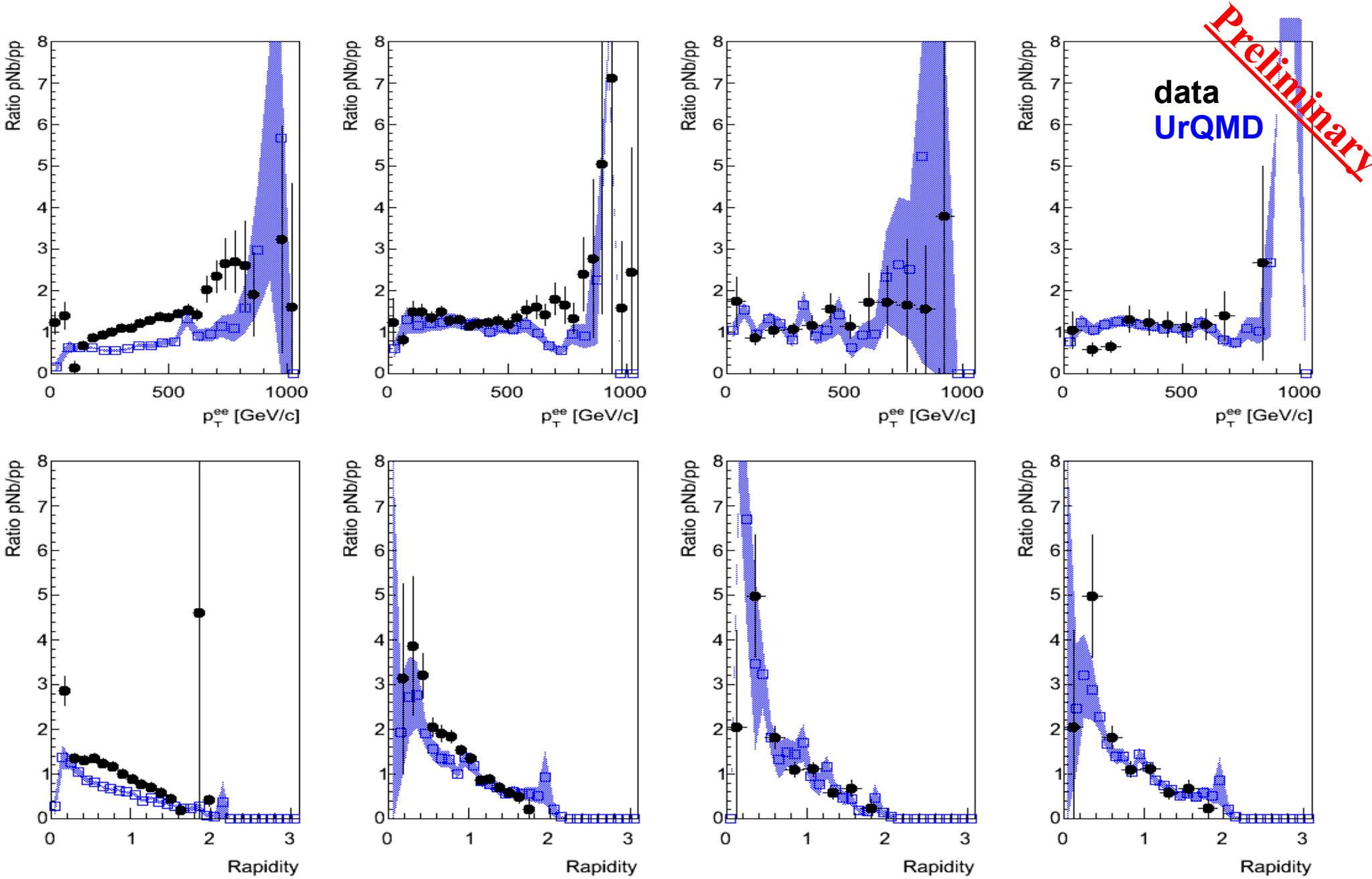
Thank you for your attention!

The HADES Collaboration

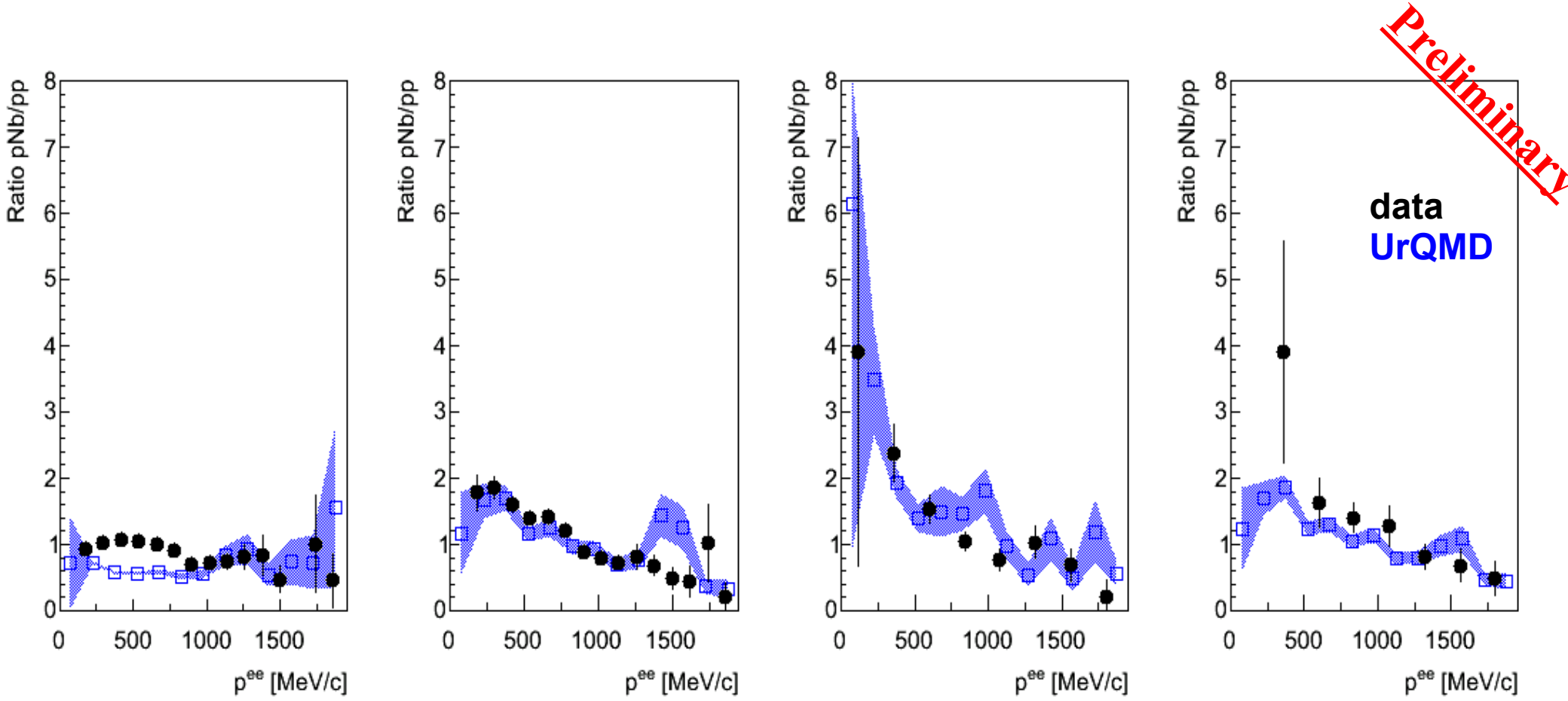
G. Agakishiev[8], C. Agodi[1], A. Balanda[3,e], G. Bellia[1,a], D. Belver[15], A. Belyaev[6], A. Blanco[2], M. Böhmer[11], J. L. Boyard[13], P. Braun-Munzinger[4], P. Cabanelas[15], E. Castro[15], S. Chernenko[6], T. Christ[11], M. Destefanis[8], J. Díaz[16], F. Dohrmann[5], A. Dybczak[3], T. Eberl[11], E. Epple[11], L. Fabbietti[11], O. Fateev[6], P. Finocchiaro[1], P. Fonte[2,b], J. Friese[11], I. Fröhlich[7], T. Galatyuk[4], J. A. Garzón[15], R. Gernhäuser[11], C. Gilardi[8], M. Golubeva[10], D. González-Díaz[4], E. Grosse[5,c], F. Guber[10], M. Heilmann[7], T. Hennino[13], R. Holzmann[4], A. Ierusalimov[6], I. Iori[9,d], A. Ivashkin[10], M. Jurkovic[11], B. Kämpfer[5], K. Kanaki[5], T. Karavicheva[10], D. Kirschner[8], I. Koenig[4], W. Koenig[4], B. W. Kolb[4], R. Kotte[5], A. Kozuch[3,e], F. Krizek[14], R. Krücken[11], W. Kühn[8], A. Kugler[14], A. Kurepin[10], J. Lamas-Valverde[15], S. Lang[4], J. S. Lange[8],K. Lapidus[10], L. Lopes[2], M. Lorenz[4], L. Maier[11], A. Mangiarotti[2], J. Marín[15], J. Markert[7], V. Metag[8], B. Michalska[3], D. Mishra[8], E. Morinière[13], J. Mousa[12], C. Müntz[7], L. Naumann[5], R. Novotny[8], J. Otwinowski[3], Y. C. Pachmayer[7], M. Palka[4], Y. Parpottas[12], V. Pechenov[8], O. Pechenova[8], T. Pérez Cavalcanti[8], J. Pietraszko[4], W. Przygoda[3,e], B. Ramstein[13], A. Reshetin[10], M. Roy-Stephan[13], A. Rustamov[4], A. Sadovsky[10], B. Sailer[11], P. Salabura[3], A. Schmah[4], J. Siebenson[11], R. Simon[4], S. Spataro[8], B. Spruck[8], H. Ströbele[7], J. Stroth[7,4], C. Sturm[7], M. Sudol[4], A. Tarantola[7], K. Teilab[7], P. Tlusty[14], M. Traxler[4], R. Trebacz[3], H. Tsertos[12], I. Veretenkin[10], V. Wagner[14], H. Wen[8], M. Wisniowski[3], T. Wojcik[3], J. Wüstenfeld[5], S. Yurevich[4], Y. Zanevsky[6], P. Zumbruch[4]

Backup

p+Nb: kinematic observables I

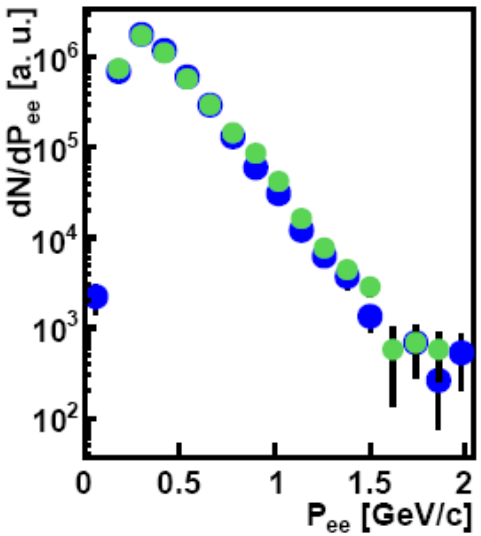


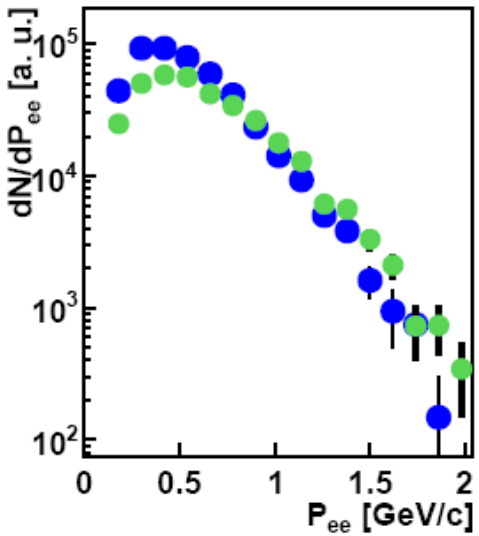
p+Nb: kinematic observables II

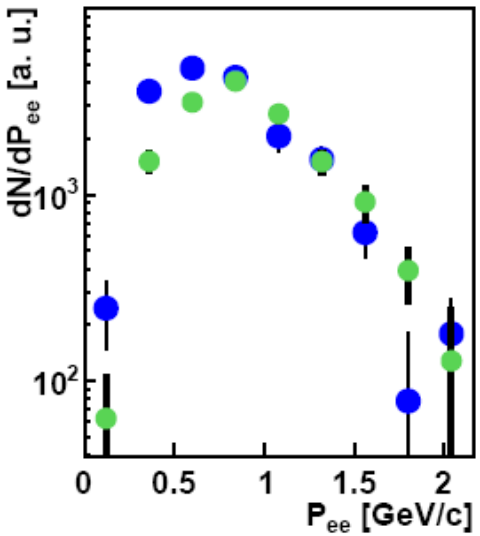


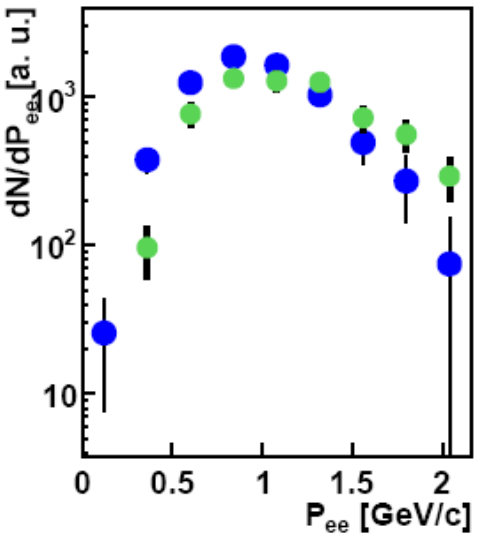
Higher yield in low momenta region except for π^0 region

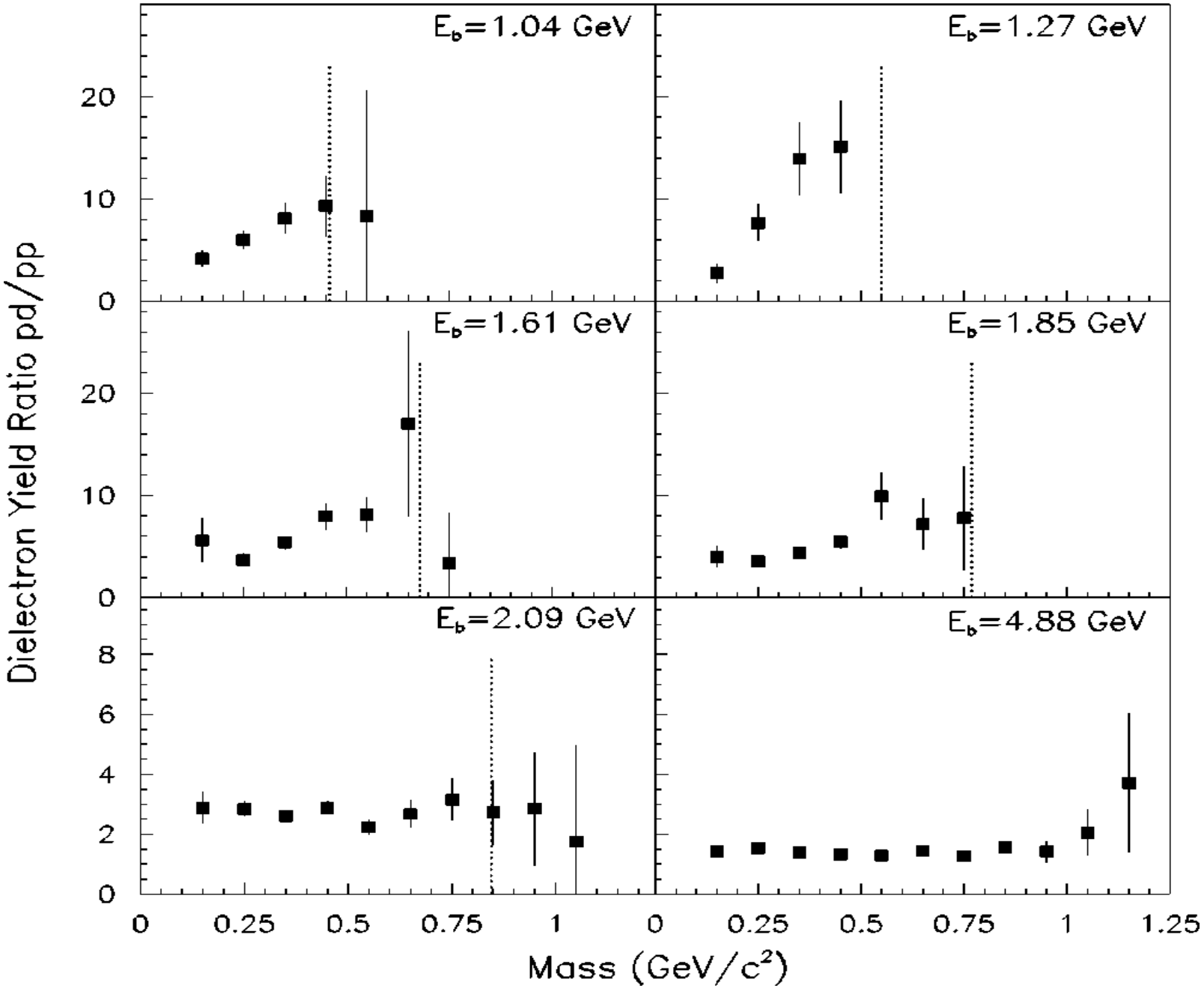
p+Nb: kinematic observables P_{ee}

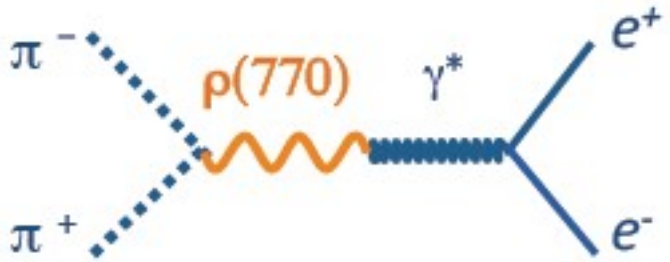









E_b=1.04 GeV
E_b=1.27 GeV
E_b=1.61 GeV
E_b=1.85 GeV
E_b=2.09 GeV
E_b=4.88 GeV
Dielectron Yield Ratio pd/pp
Mass (GeV/c^2)
0
10
20
2
4
6
8
0.25
0.5
0.75
1
1.25



Low Mass
M ≤ 1 GeV

$$\mathrm{Im}\,\Pi_{em} \sim [\mathrm{Im}\,D_\rho + \frac{1}{9}\mathrm{Im}\,D_\omega + \frac{2}{9}\mathrm{Im}\,D_\phi]$$

ρ – meson dominated

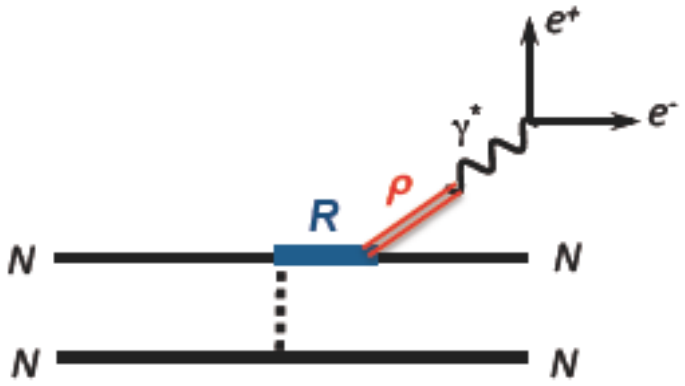
$$\mathrm{Im}\,\Pi_{em} \sim \mathrm{Im}\,D_\rho$$

Spacelike $q^2>0$

Measured

Momentum transfer

$e^+e^- \rightarrow \pi^0$

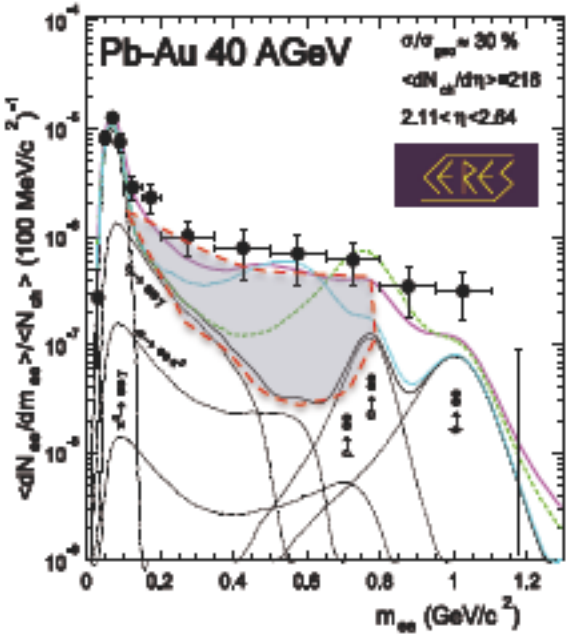


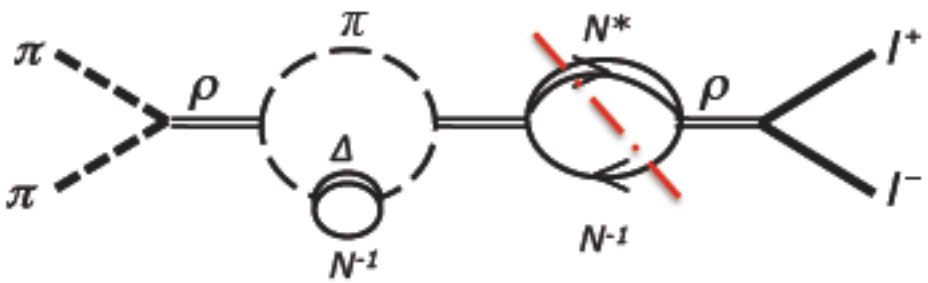
timelike $q^2<0$

Not measured

Energy transfer

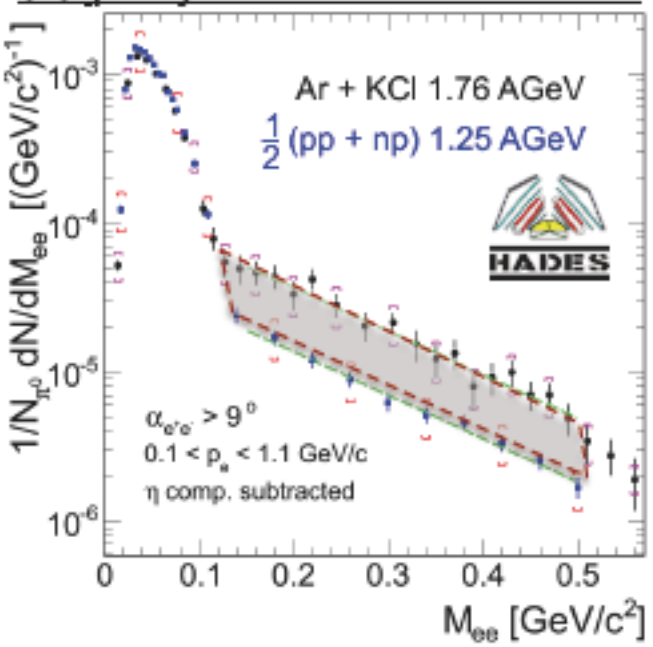
CERES: Phys. Rev. Lett. 91 (2003) 042301

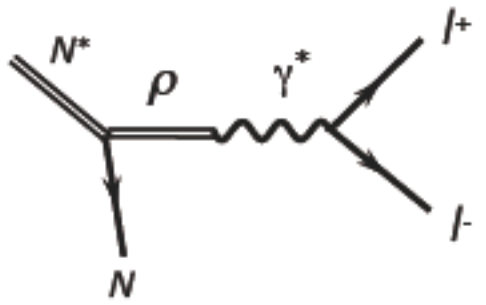




- Main source: $\pi^+\pi^- \rightarrow \rho \rightarrow e^+e^-$
- Strength of dilepton yield at low masses is due to coupling to baryons!

e^+e^- pair yield Ar+KCl 1.76 GeV/u





- Dalitz decays of baryonic resonances - dominant source at low beam energies.

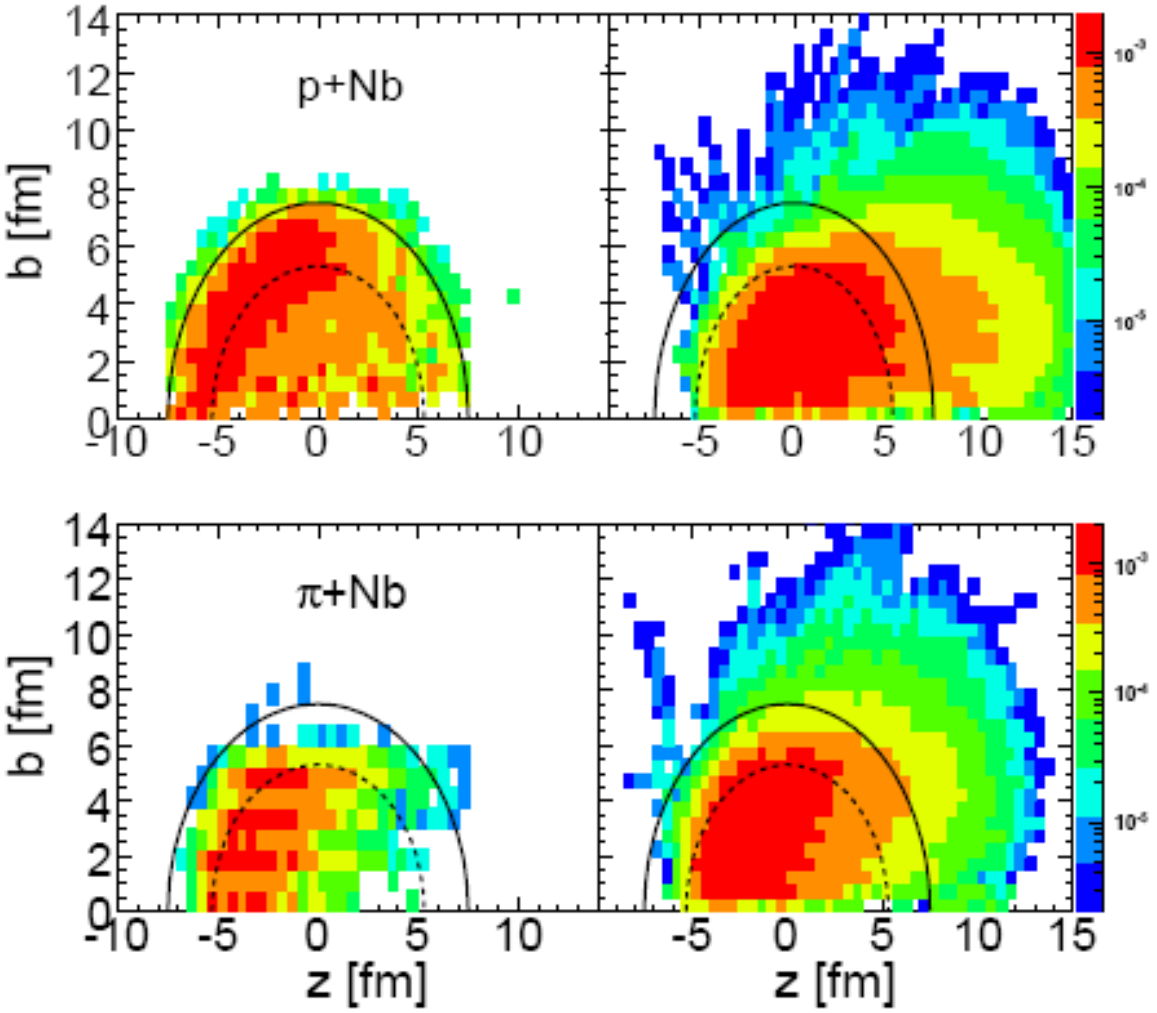
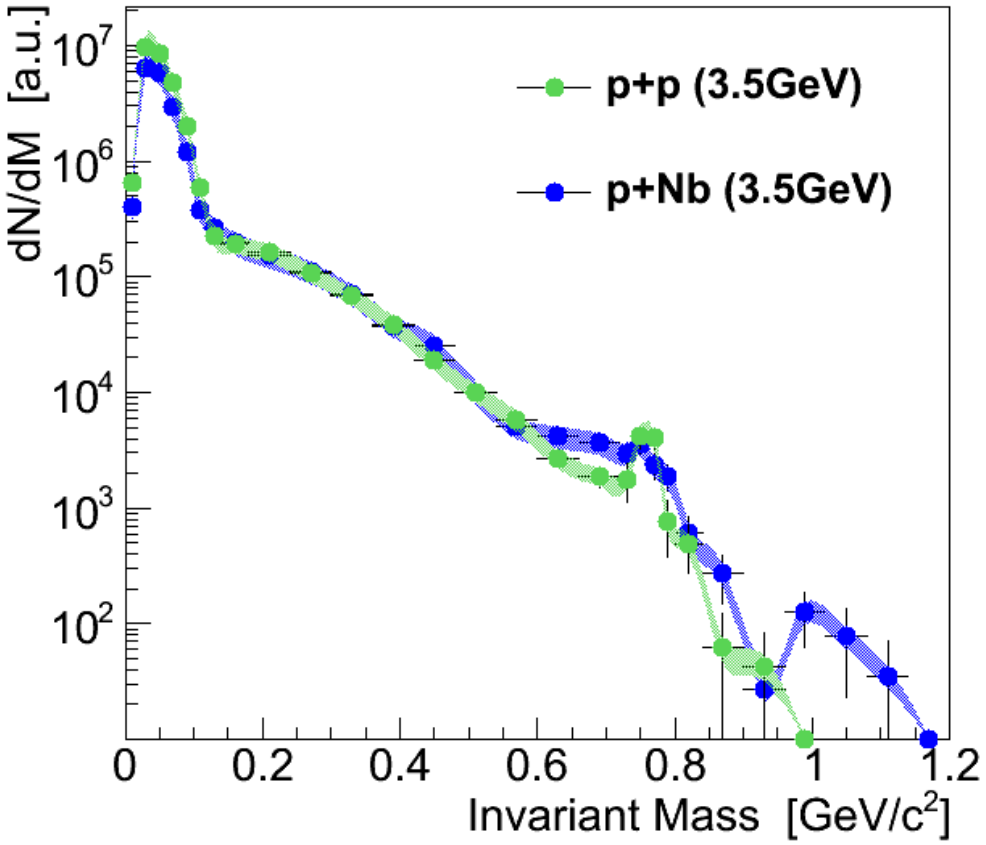
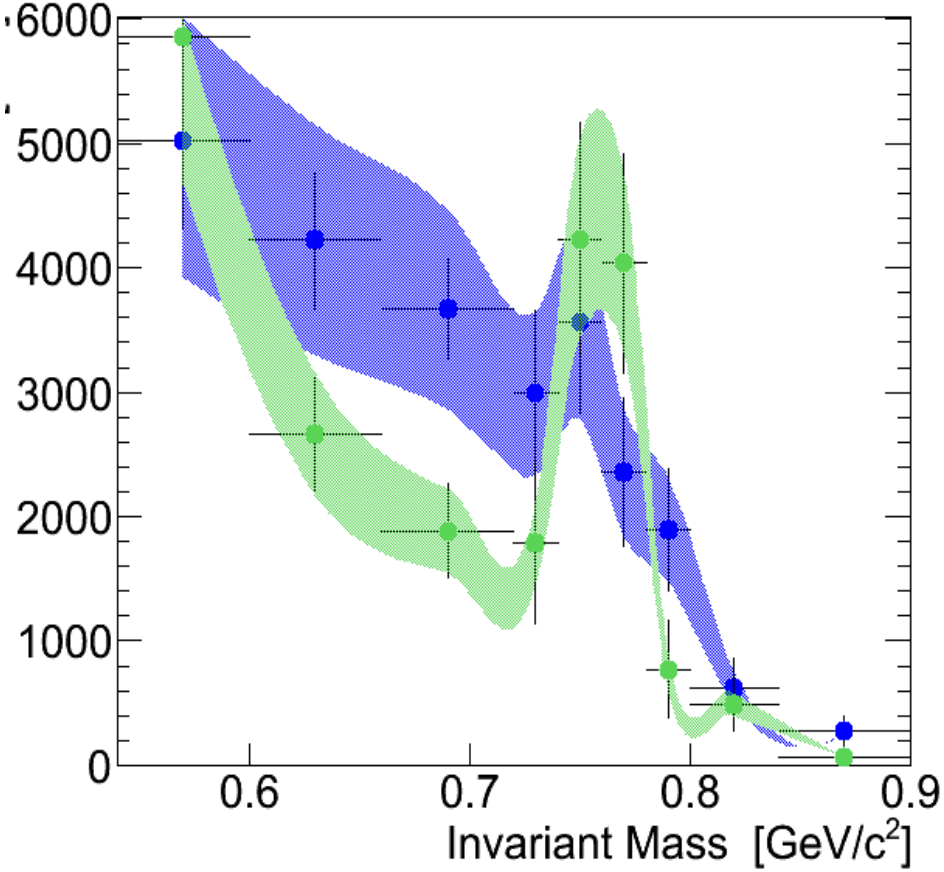


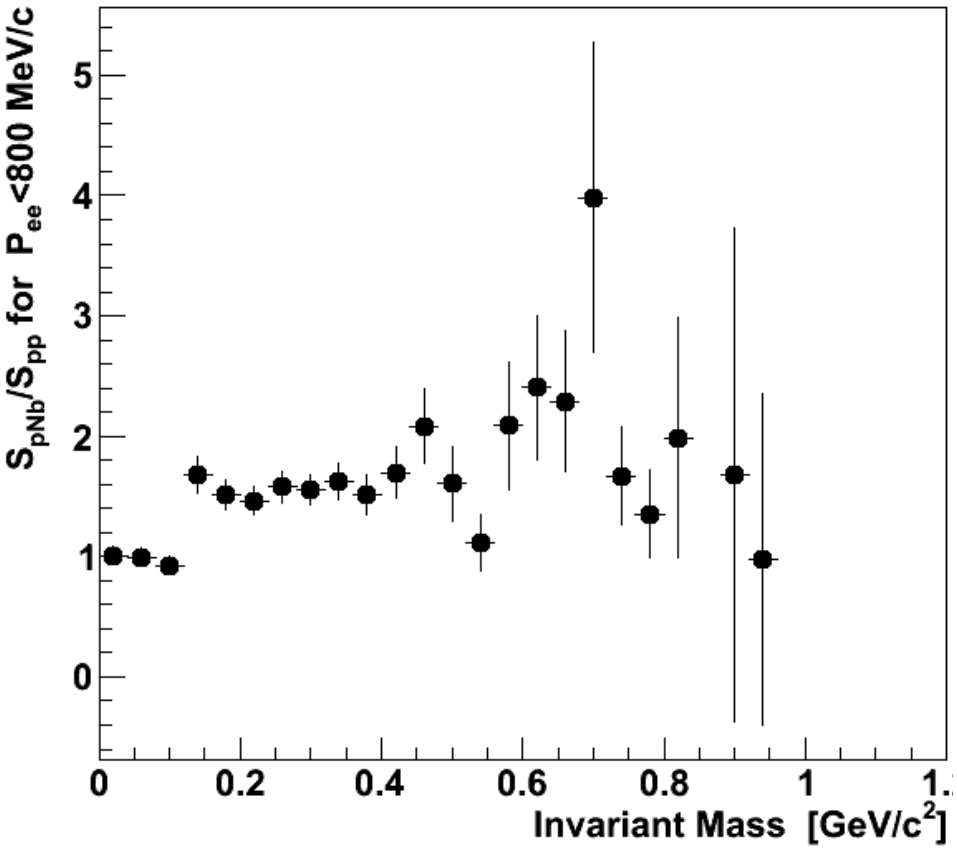
Figure 6: Radial (b=$\sqrt{x^2+y^2}$) vs. longitudinal coordinate (z) of the ω production and decay (left and right panels, respectively). The upper panels show the results for pNb reactions at 3.5 GeV and lower ones for πNb reactions at 1.17 GeV. The full and dashed half-circles correspond to 10% and 90% of the nuclear density, respectively.


dN/dM [a.u.]
10^7
10^6
10^5
10^4
10^3
10^2
p+p (3.5GeV)
p+Nb (3.5GeV)
0
0.2
0.4
0.6
0.8
1
1.2
Invariant Mass [GeV/c^2]

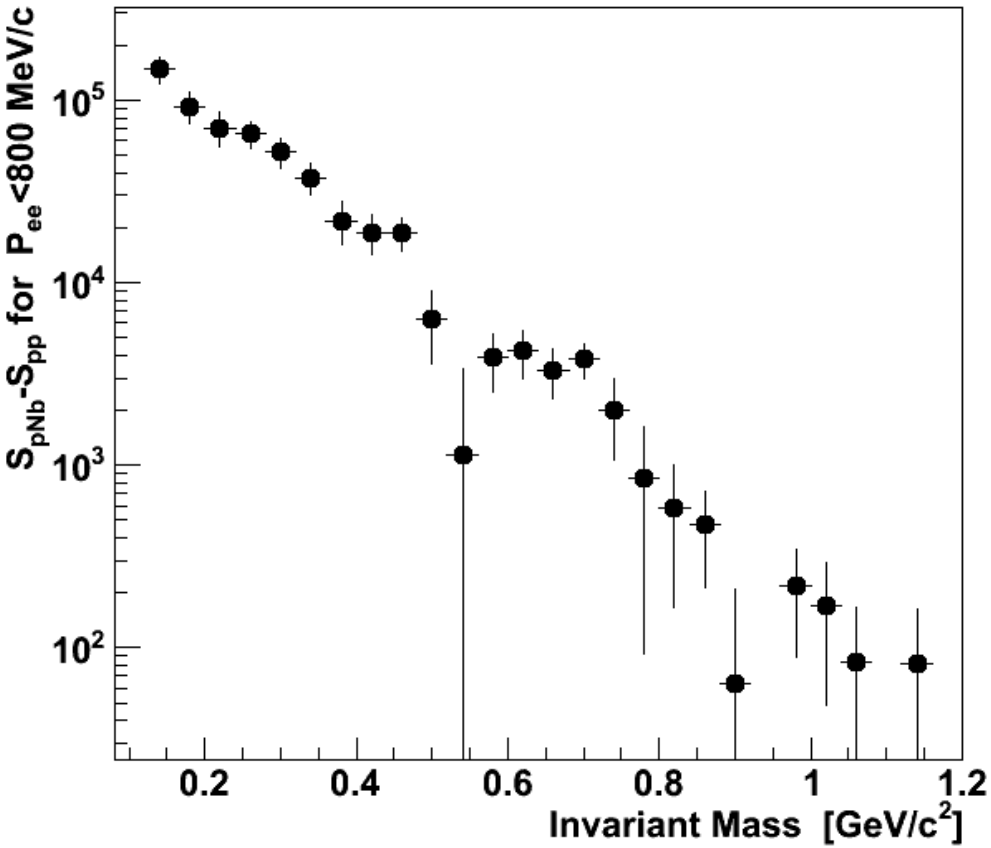

6000
5000
4000
3000
2000
1000
0
0.6
0.7
0.8
0.9
Invariant Mass [GeV/c^2]

Vektormesonen

Verhältnis S_{pNb} / S_{pp}



Differenz S_{pNb} - S_{pp}



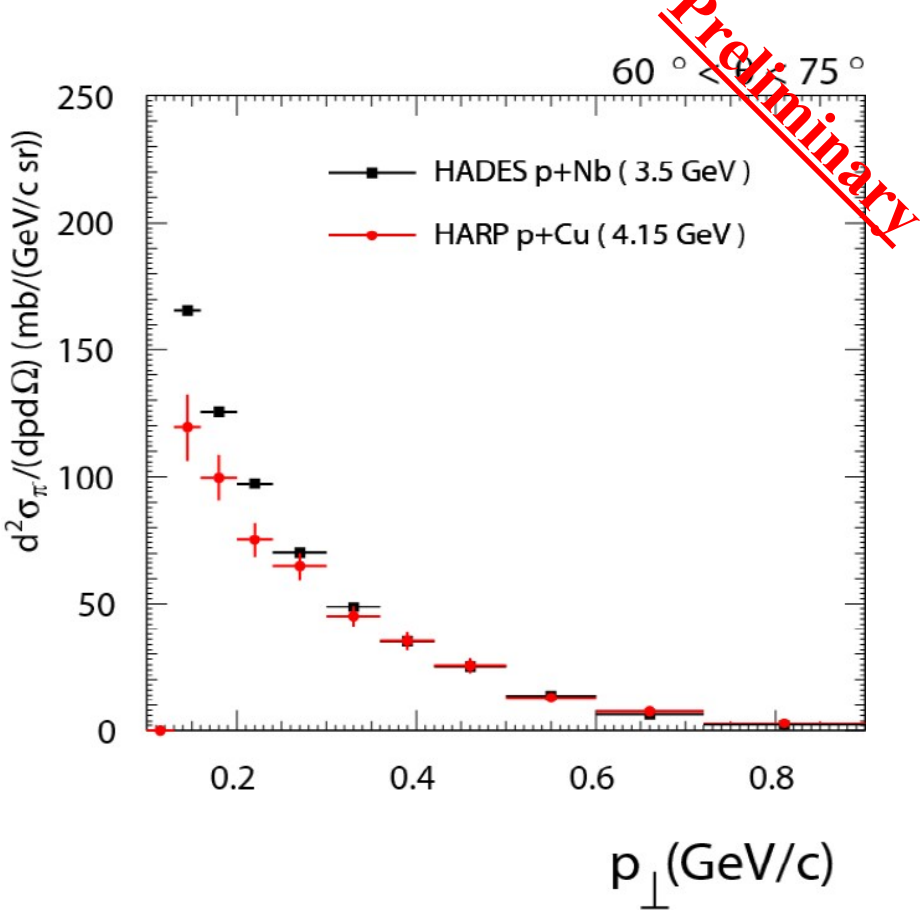
p+Nb cross section

p+p normalized to number of elastic pp collisions

Kammerud et al. Phys. Rev. D 4 (1971),

p+Nb normalized to HARP π^- data in p+Cu at 4.15 GeV (p_t>0.3 GeV)

Eur.Phys.J.C70:573-633,2010.



Analysis by M.Weber, P.Tlusty