19 June 2007

TO-DAY: ALL YOU WANTED TO KNOW ABOUT HEAVY ION COLLISIONS BUT DID NOT DARE TO ASK

TOMORROW: WHY DATA SEEMS TO BE MUCH SIMPLER THAN THE EXPLANATIONS OF IT?

AND PREDICTIONS FOR LHC

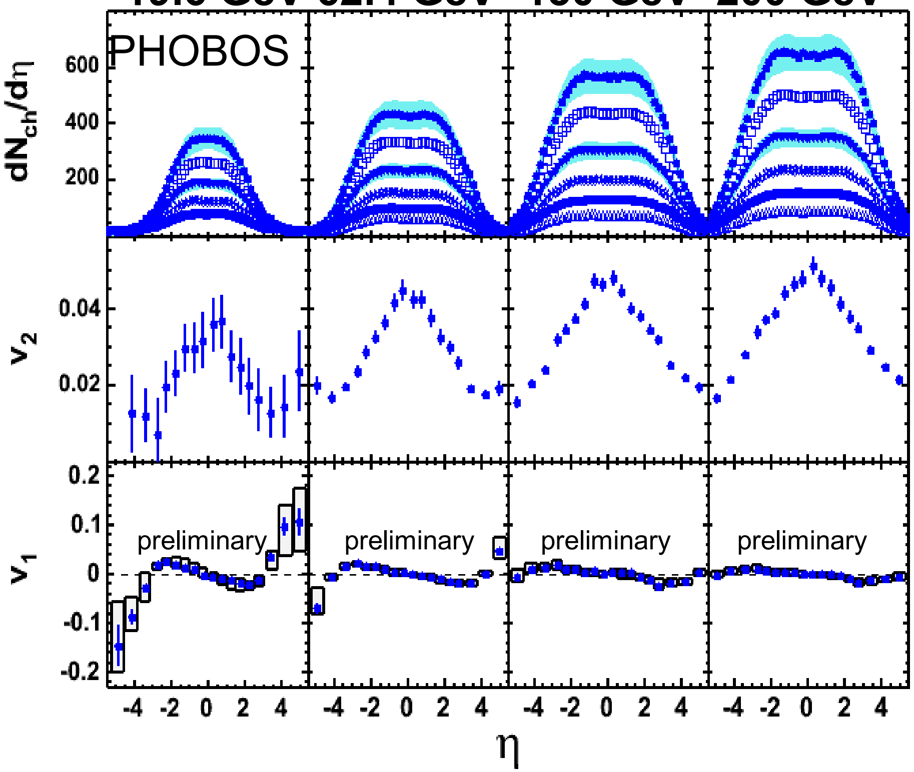
Many thanks to Alex Mott, Yen-Jie Lee and Andre Yoon for help with many of the plots, and Y.Yilmaz for N_{PART} calculations for PbPb at LHC

For a very broad range of energies and geometry of the collision:

- For $\sqrt{S_{NN}}$ from <10 GeV to 200 GeV
- For N_{PART} from 2-350
- And over the entire rapidity range

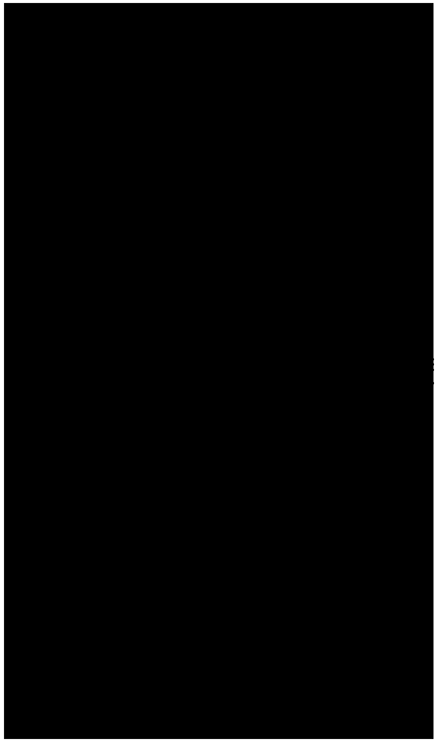
- The global distributions of charged particles produced in pp, pA, AA, and even $e^+ e^-$ collisions show remarkably similar trends, and data is found to factorize into an energy dependent part and a geometry, or incident system dependent part
- The trends allow us to "predict" with high precision several important results that will be seen in PbPb at LHC. More important, an understanding of what happens in AA collisions must include an explanation of these trends and the broad range over which they seem to apply

Au + Au

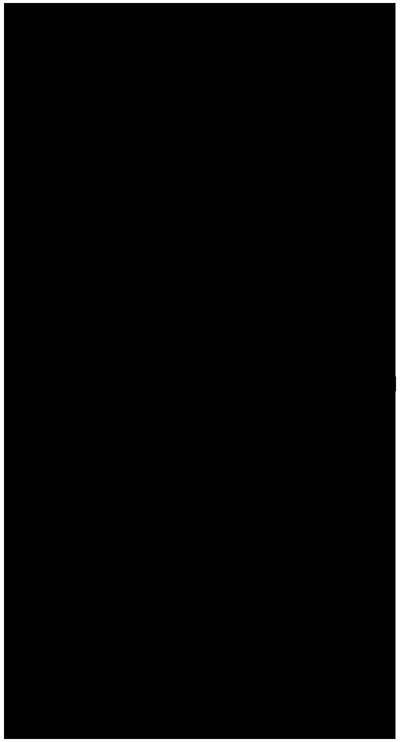


Cu + Cu

62.4 GeV



200 GeV



PHOBOS, Gunther Roland QM 2005

Warning: rapidity y ≠ pseudorapidity η

$$\tanh^{-1}\beta \neq \tanh^{-1}\cos\theta$$

change of reference frame:

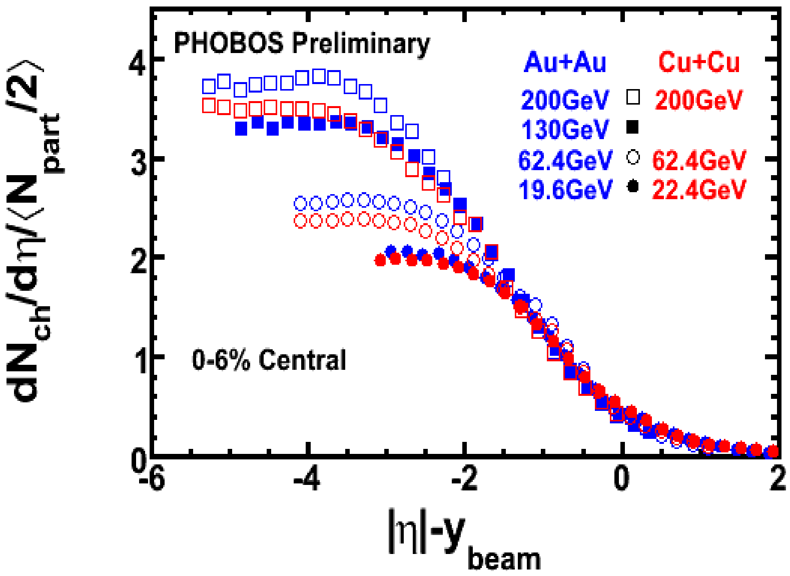
$$y \rightarrow y + \Delta y_{relative}$$

$$\eta \rightarrow \eta + \Delta y_{relative}$$

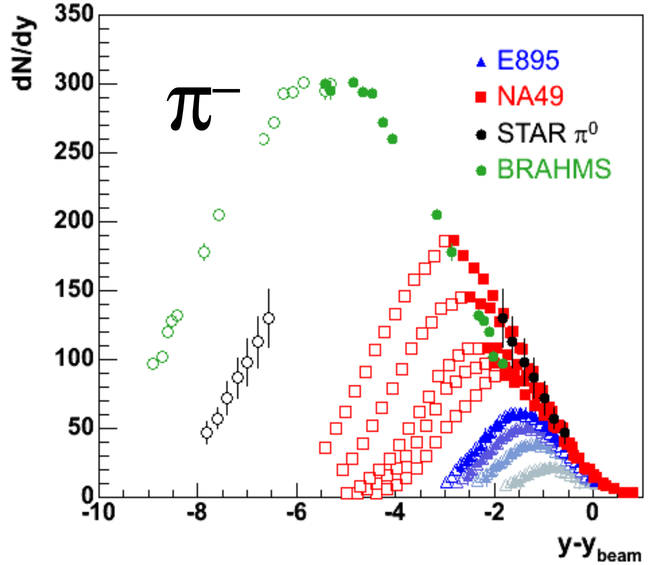
$$\eta - y = \tanh^{-1}\cos\theta - \tanh^{-1}\beta$$

$$\eta - y = \tanh^{-1}\frac{p_l}{p} - \tanh^{-1}\frac{p_l}{E}$$

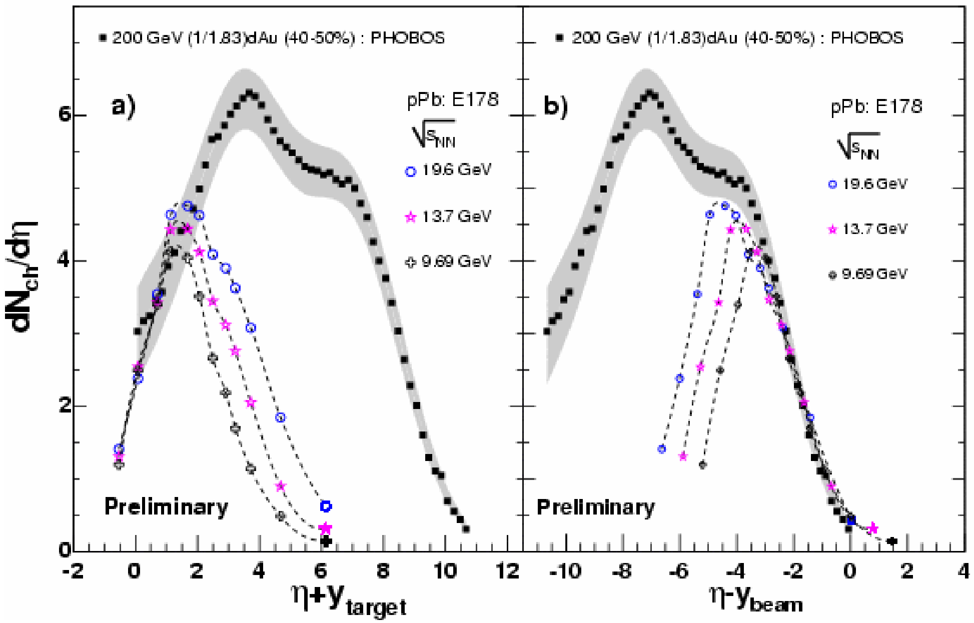
$$\frac{1}{\gamma}$$



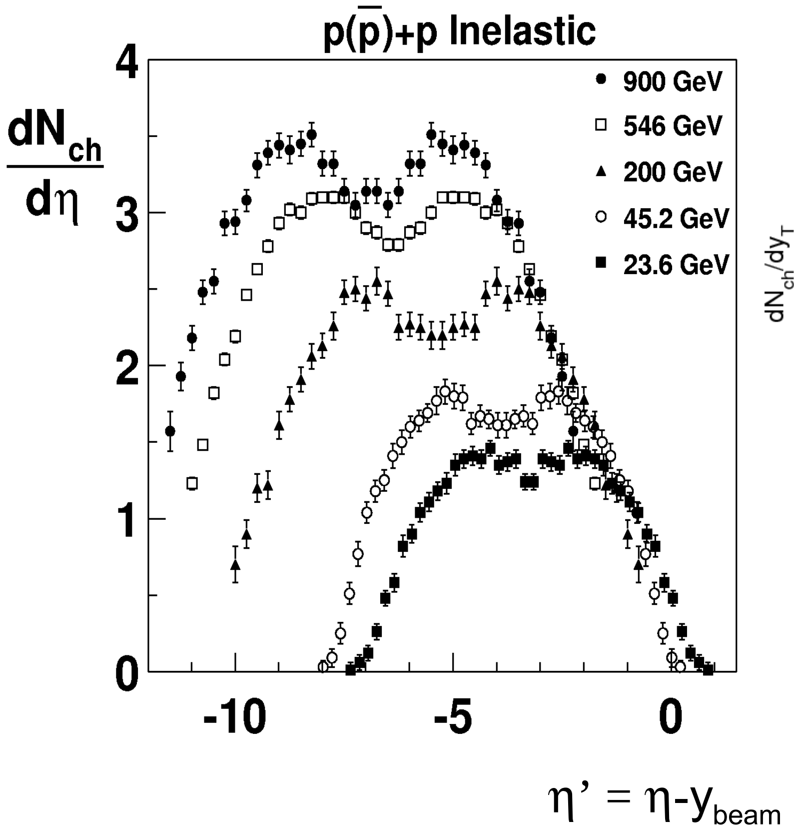
PHOBOS, Hofman, QM2006

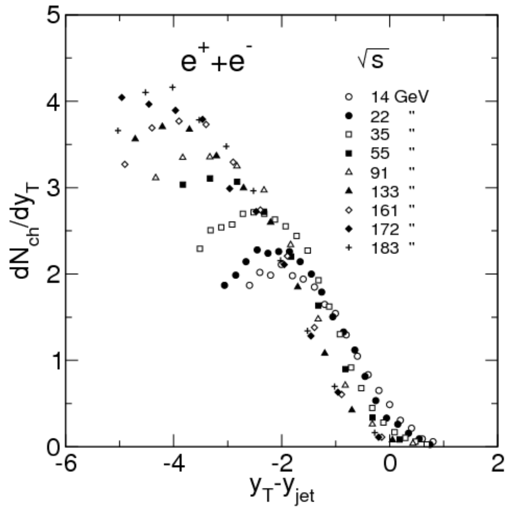


Veres, QM2005

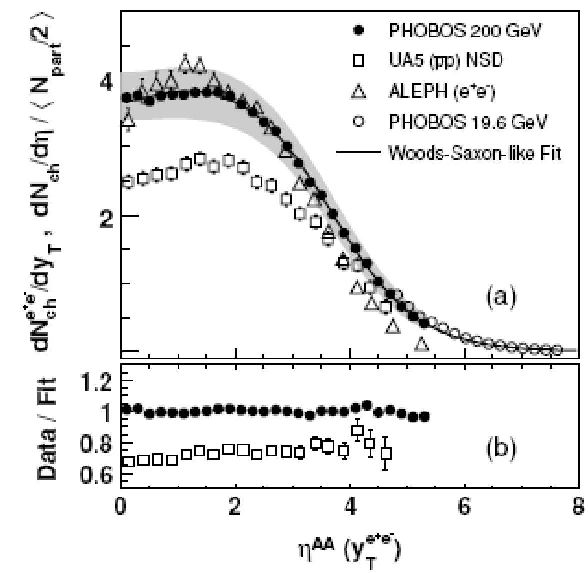


PHOBOS, Nucl. Phys. A 757 (2005) 28.
E178: PRD 22 (1980) 13



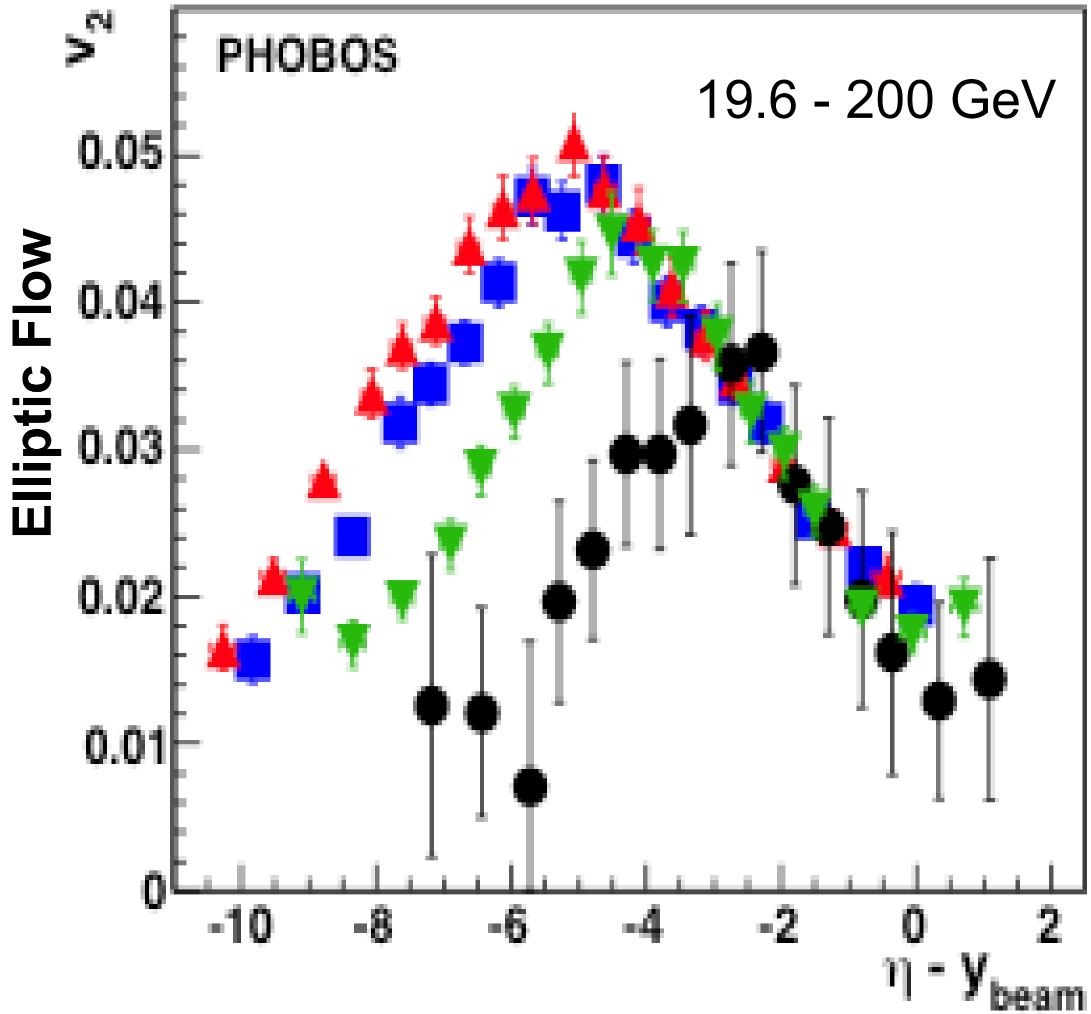


DELPHI, Phys. Lett. B459 397 (1999)



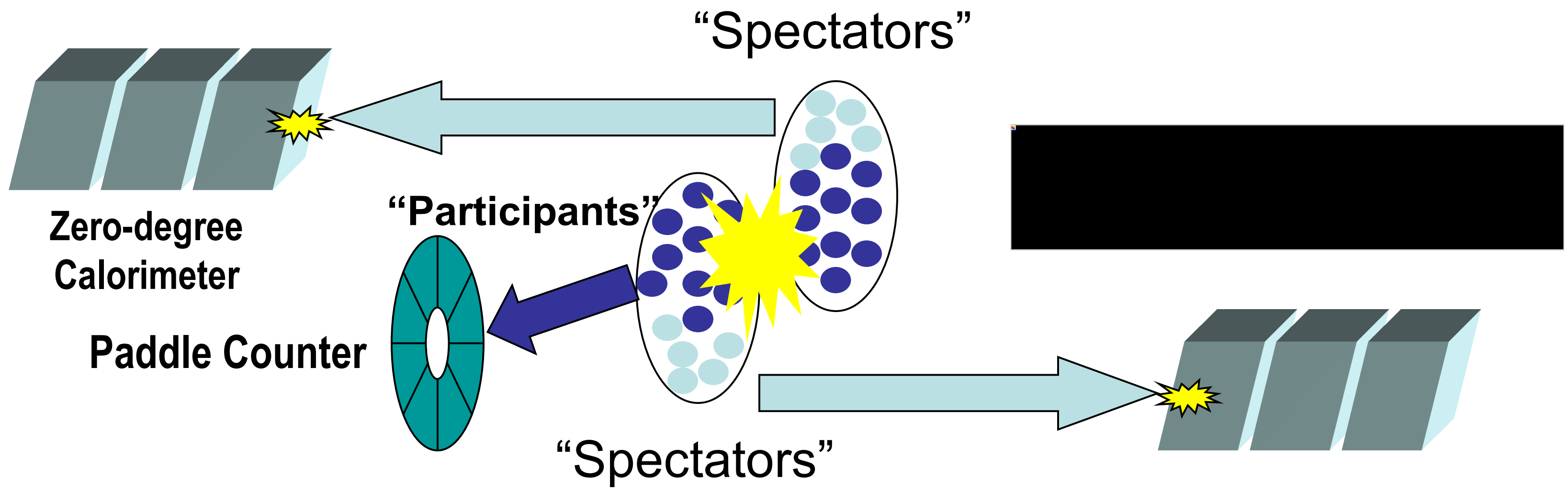
PHOBOS, Phys. Rev. C 74, 021902(R) (2006)

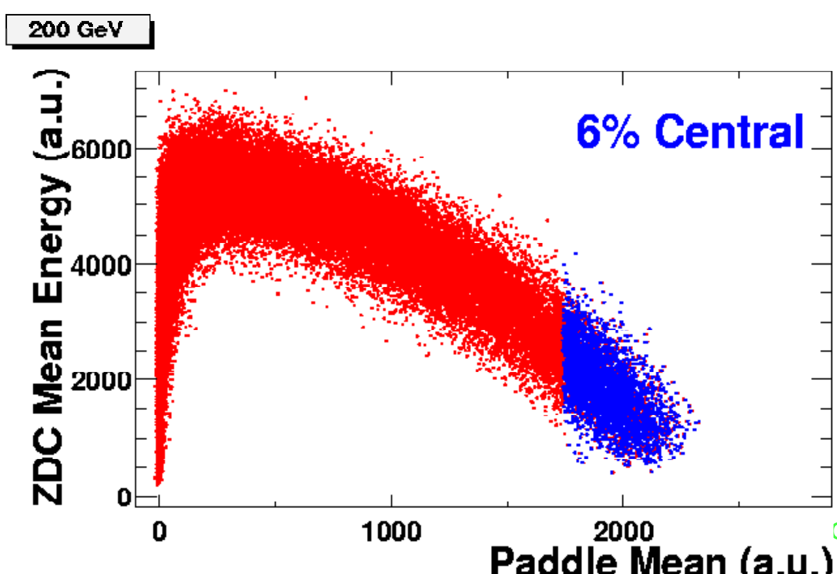
CDF (900) Phys.Rev D 41 (1990) 2330
UA5 (200,546) Z.Phys.C 43 1 (1989)
ISR (23.6,45.2) Nucl.Phys B 129 365 (1977)



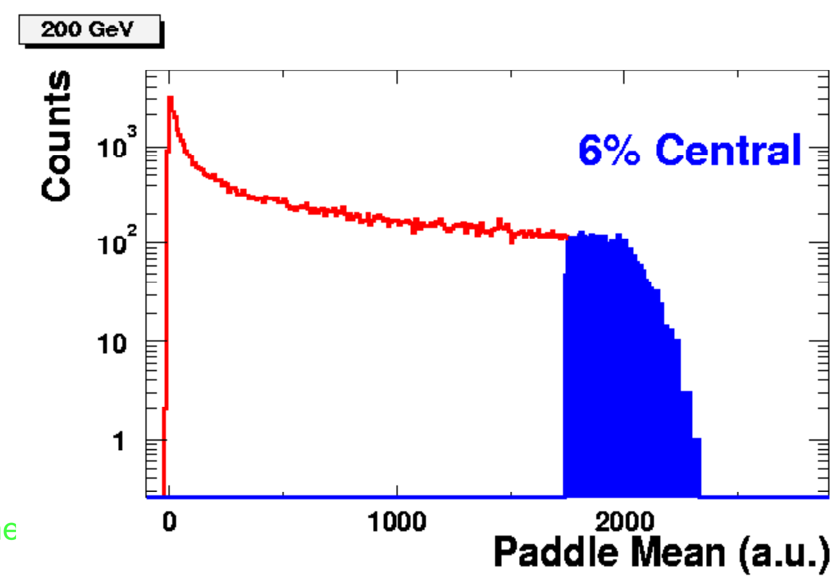
PHOBOS, Nucl.Phys. A757 (2005) 28

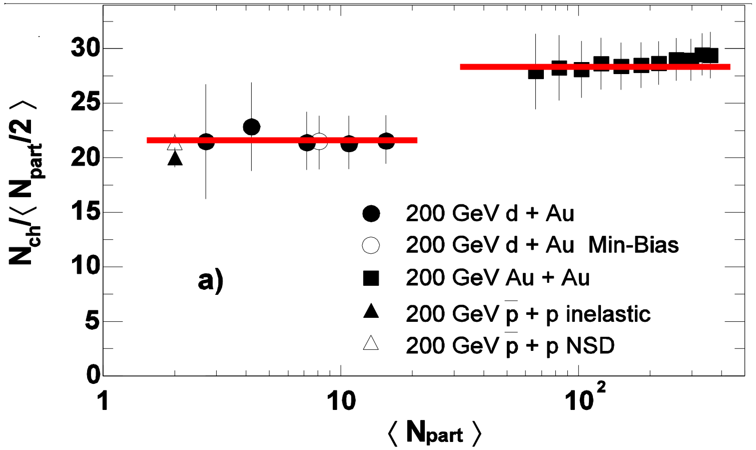
Experimental Control of Centrality or Impact Parameter



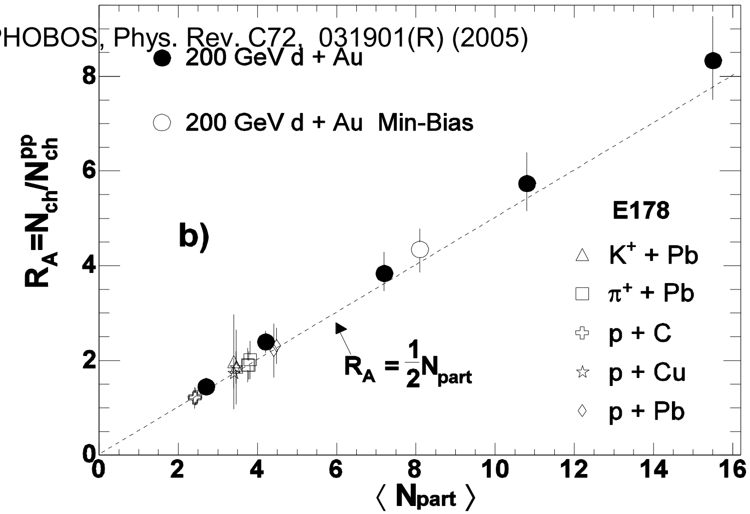


opane

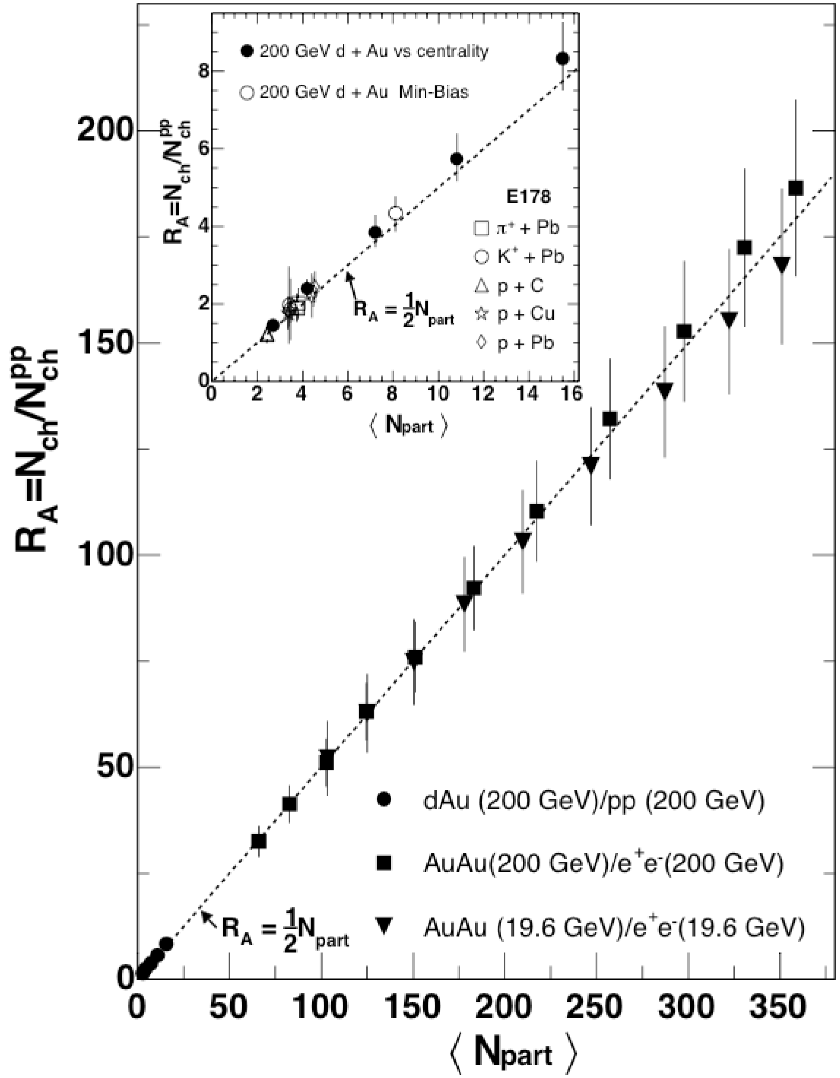




PHOBOS, Phys. Rev. C72, 031901(R) (2005)



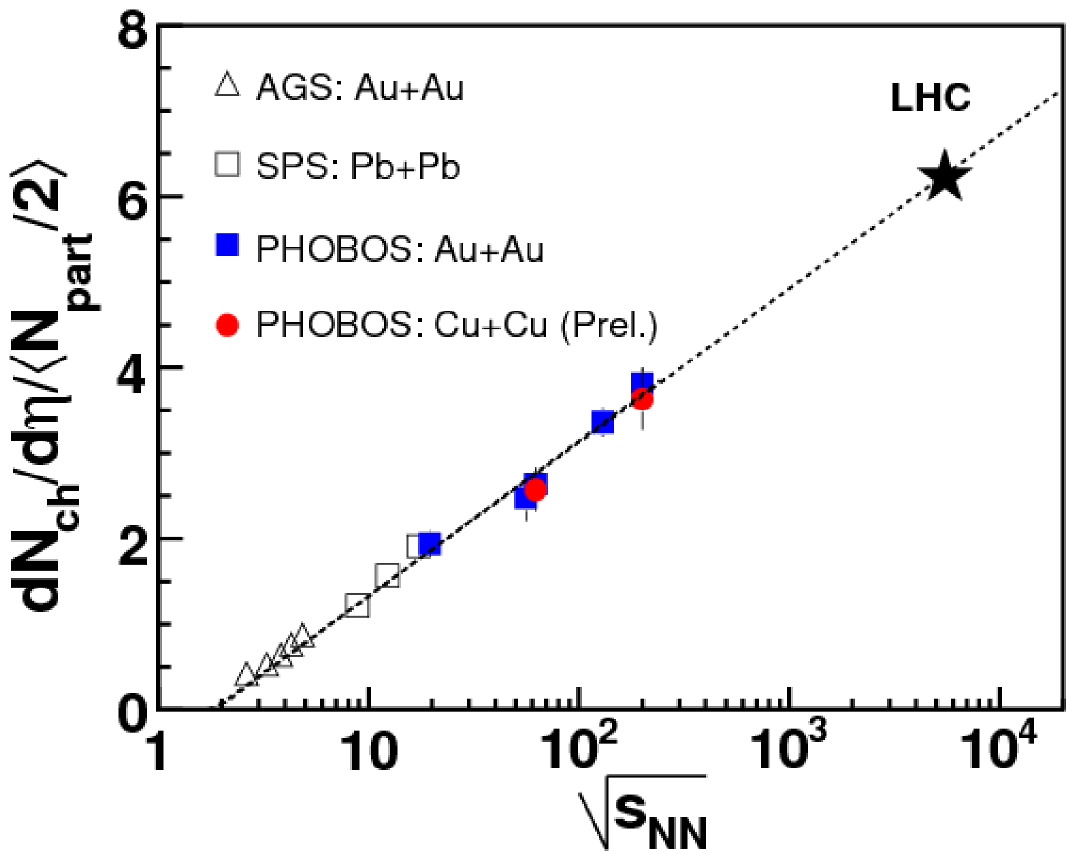
PHOBOS, Phys. Rev. C74 021902 (R) 2006



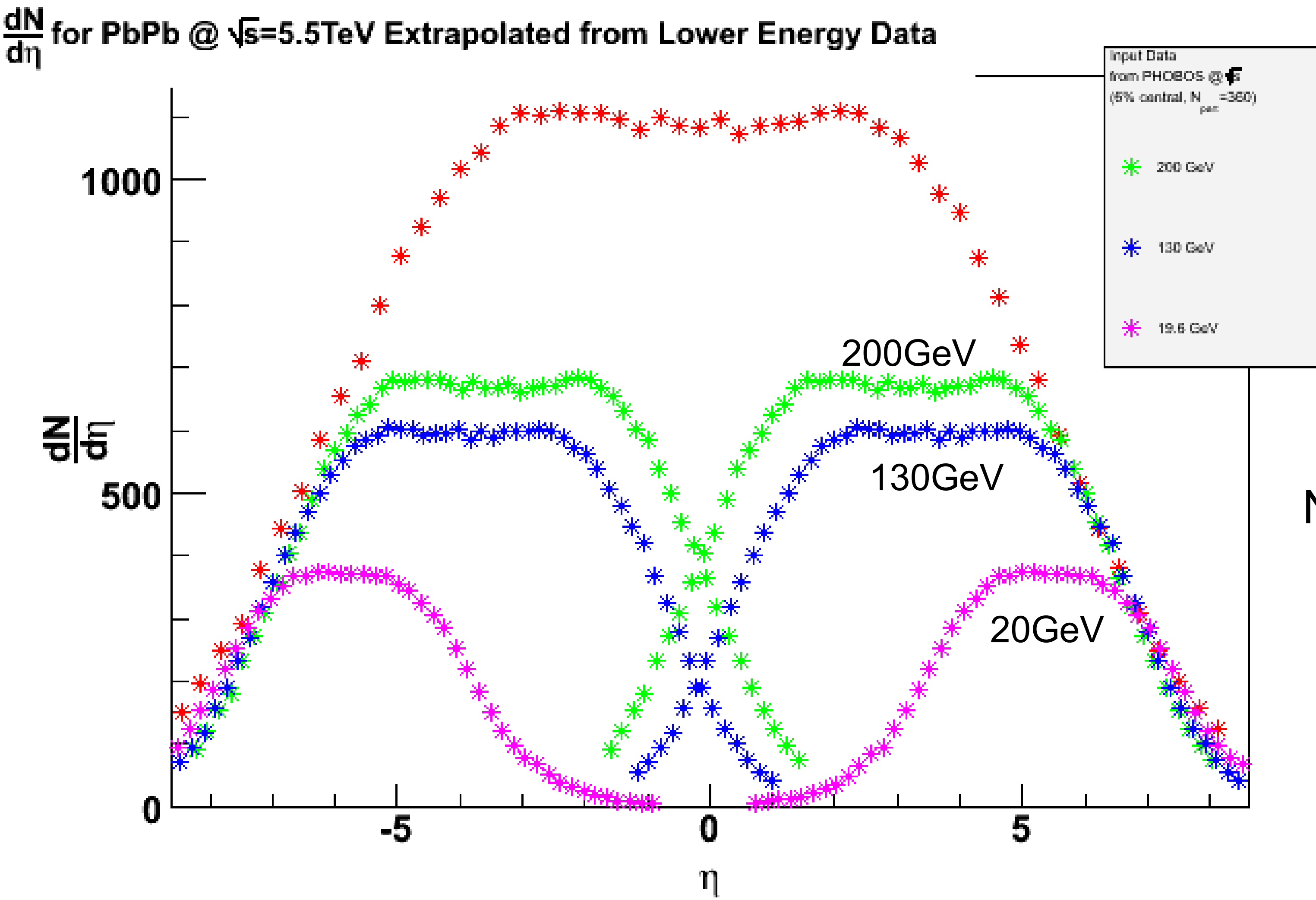
or wounded nucleons*

W. Busza, Acta Phys. Pol. B35 (2004)2873 E178:
W.Busza et al. PRL34 (1975) 836

*A.Biala, M.Bleszczynski, W.Czyz, Nucl.Phys. B111 (1976) 4661

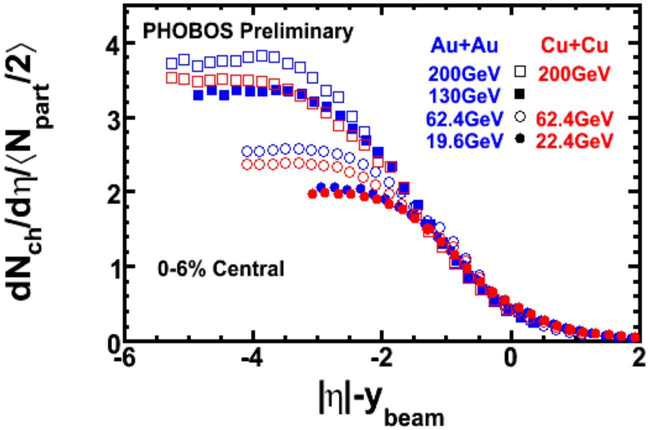


Data compiled by PHOBOS, R. Nouicer, PANIC 05



N_{PART} = 360

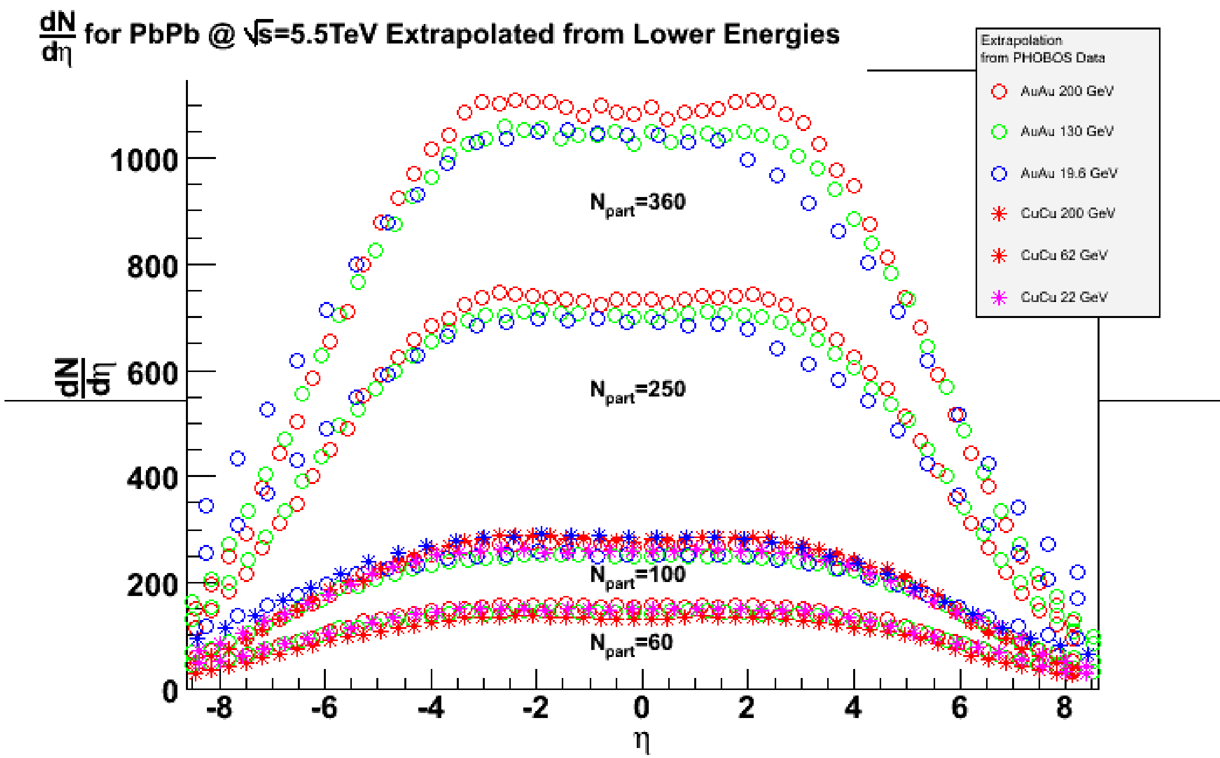
AuAu Data from PHOBOS, Nucl. Phys. A757 (2005) 28



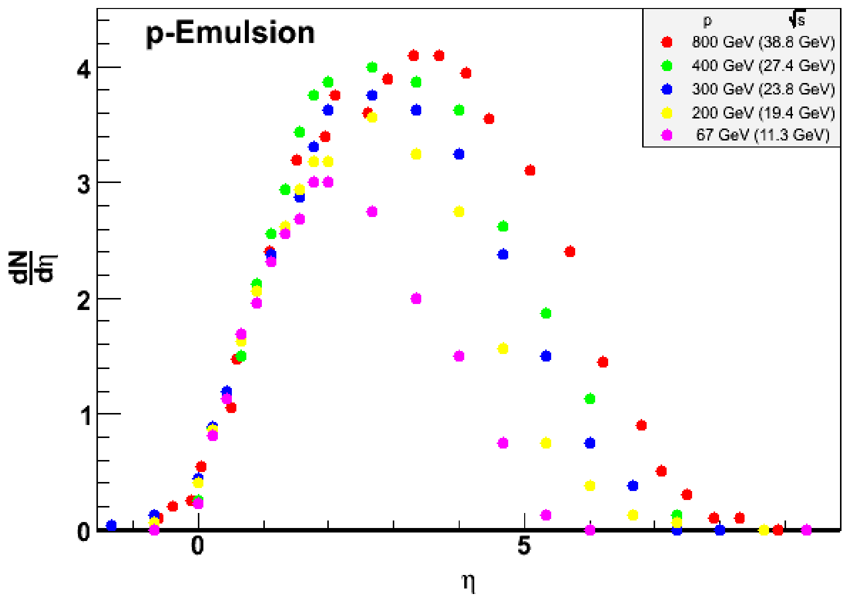
PHOBOS, Hofman, QM2006

Linear scaling in N_{PART}

$\ln\sqrt{s}$ scaling in η and dN/dη

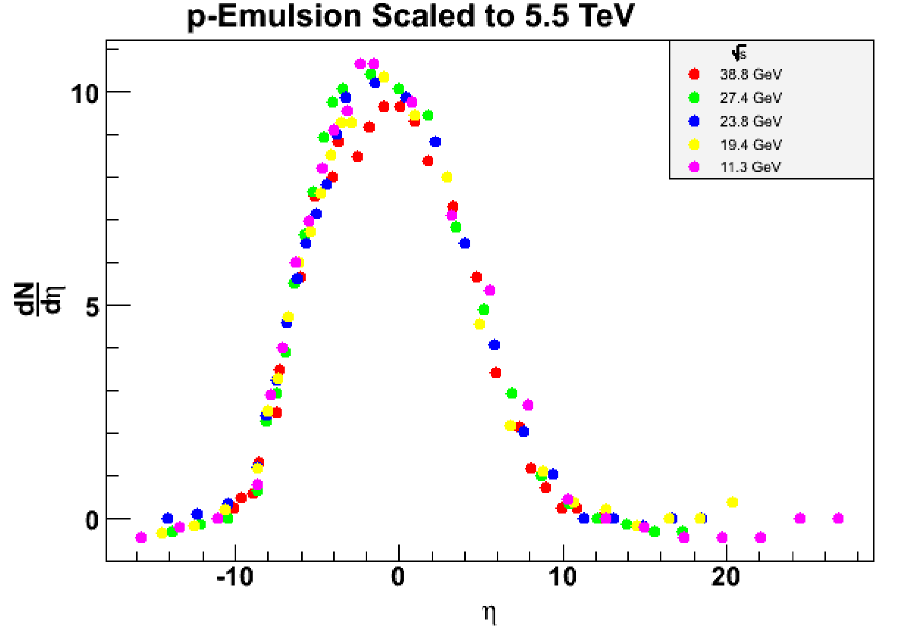


11.3 GeV - 38.8 GeV



Data from compilations in Nucl. Phys. B142 (1978) 445 and Phys. Rev. D35 (1987) 3537

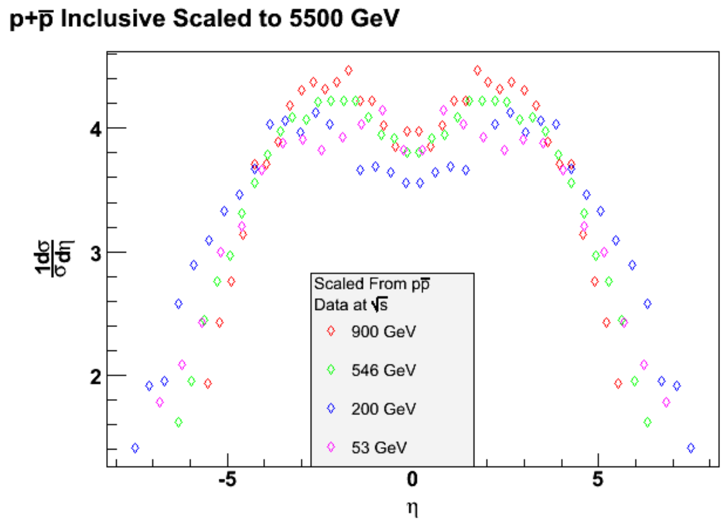
$\ln\sqrt{s}$ scaling in η and dN/dη

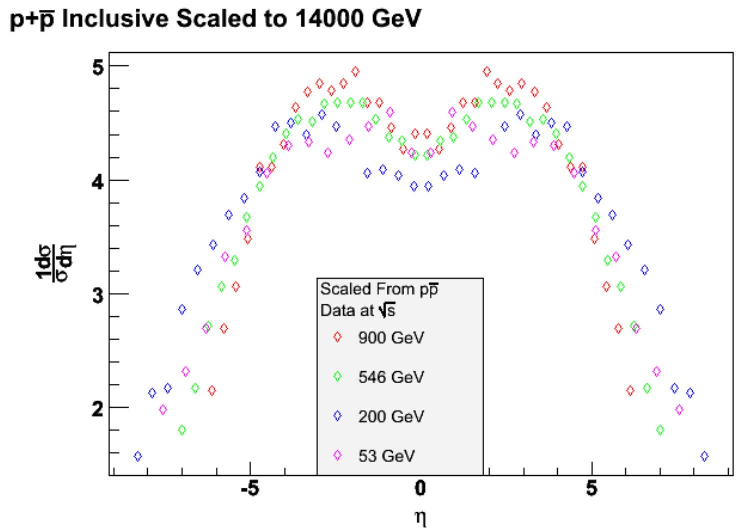


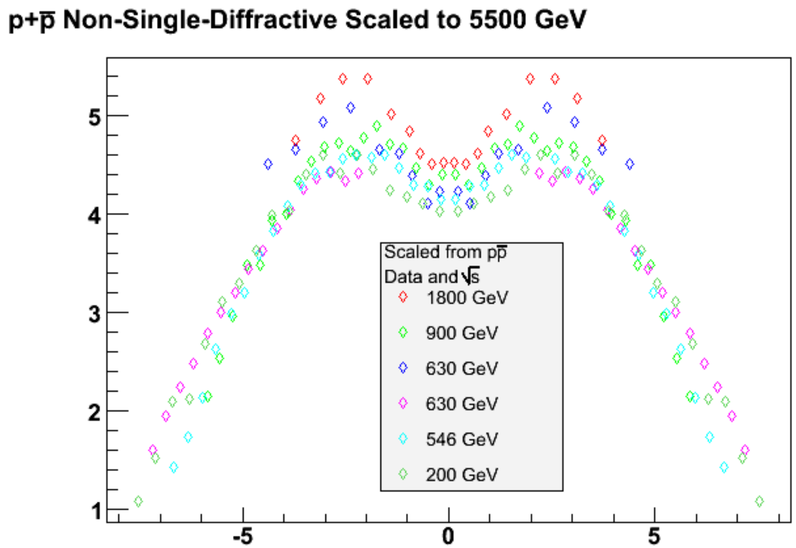
Data from compilations in Nucl. Phys. B142 (1978) 445 and Phys. Rev. D35 (1987) 3537

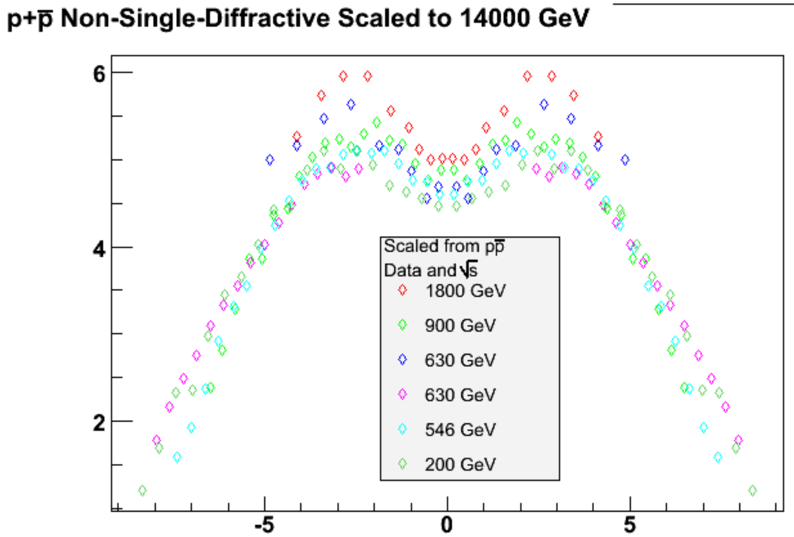
N_{PART} for p-emulsion = 3.4

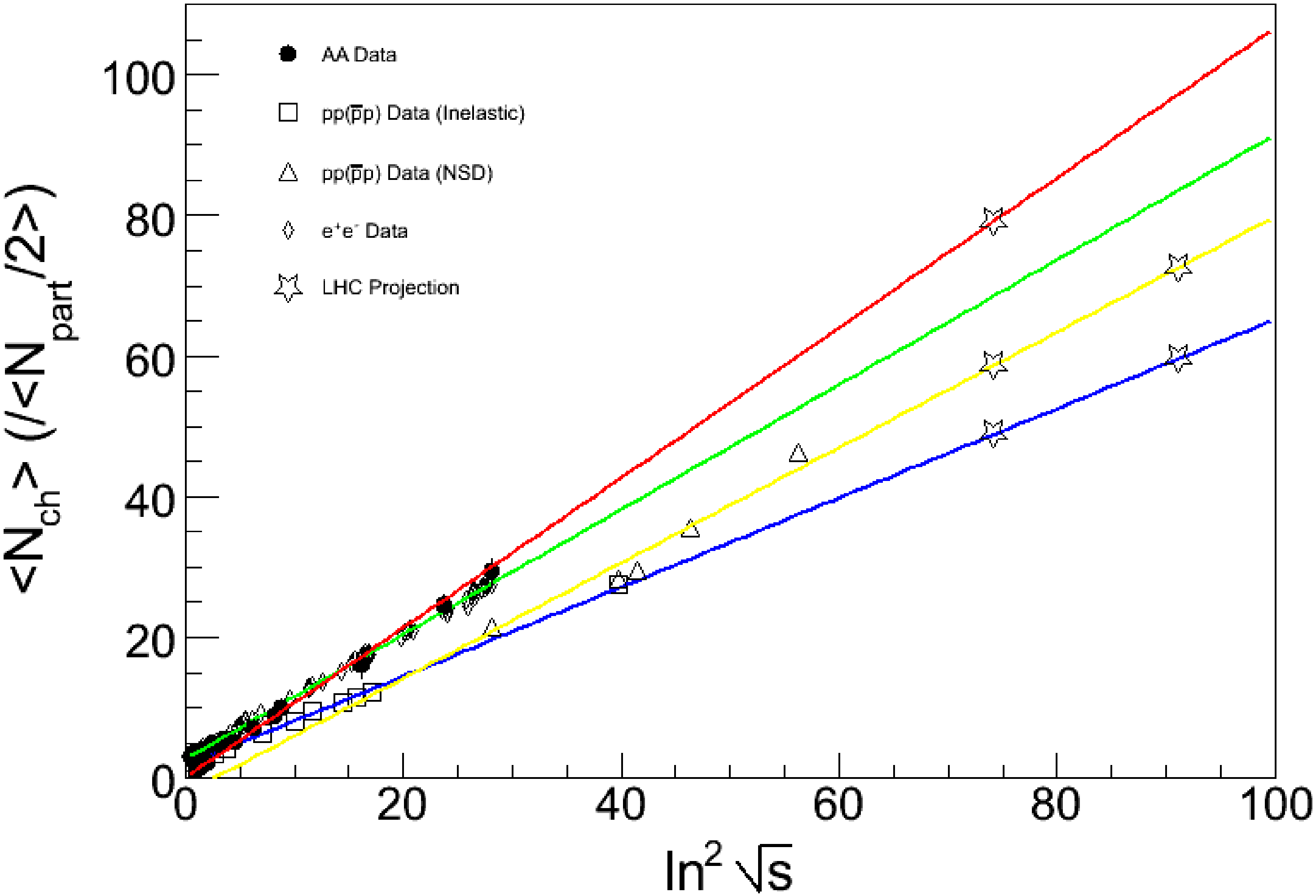
Data from compilation in review of particle physics scaled by $\ln\sqrt{s}$ in η and dN/dη



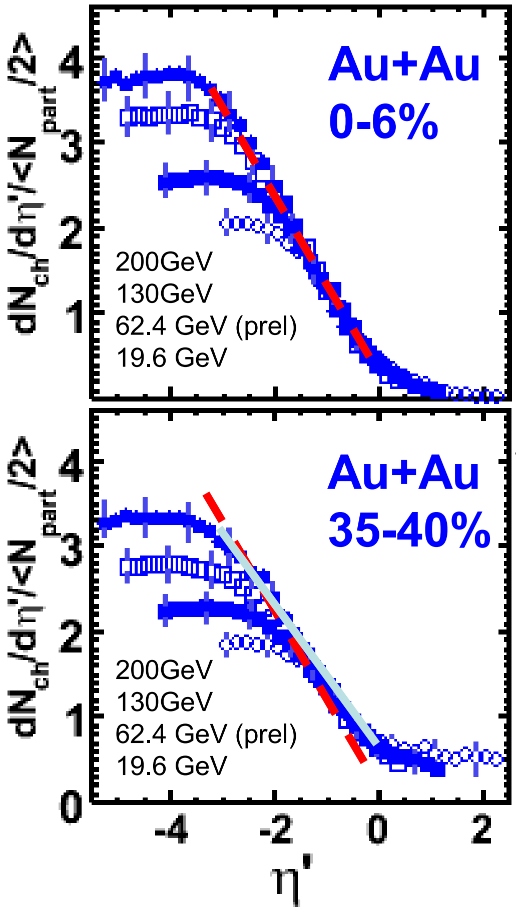




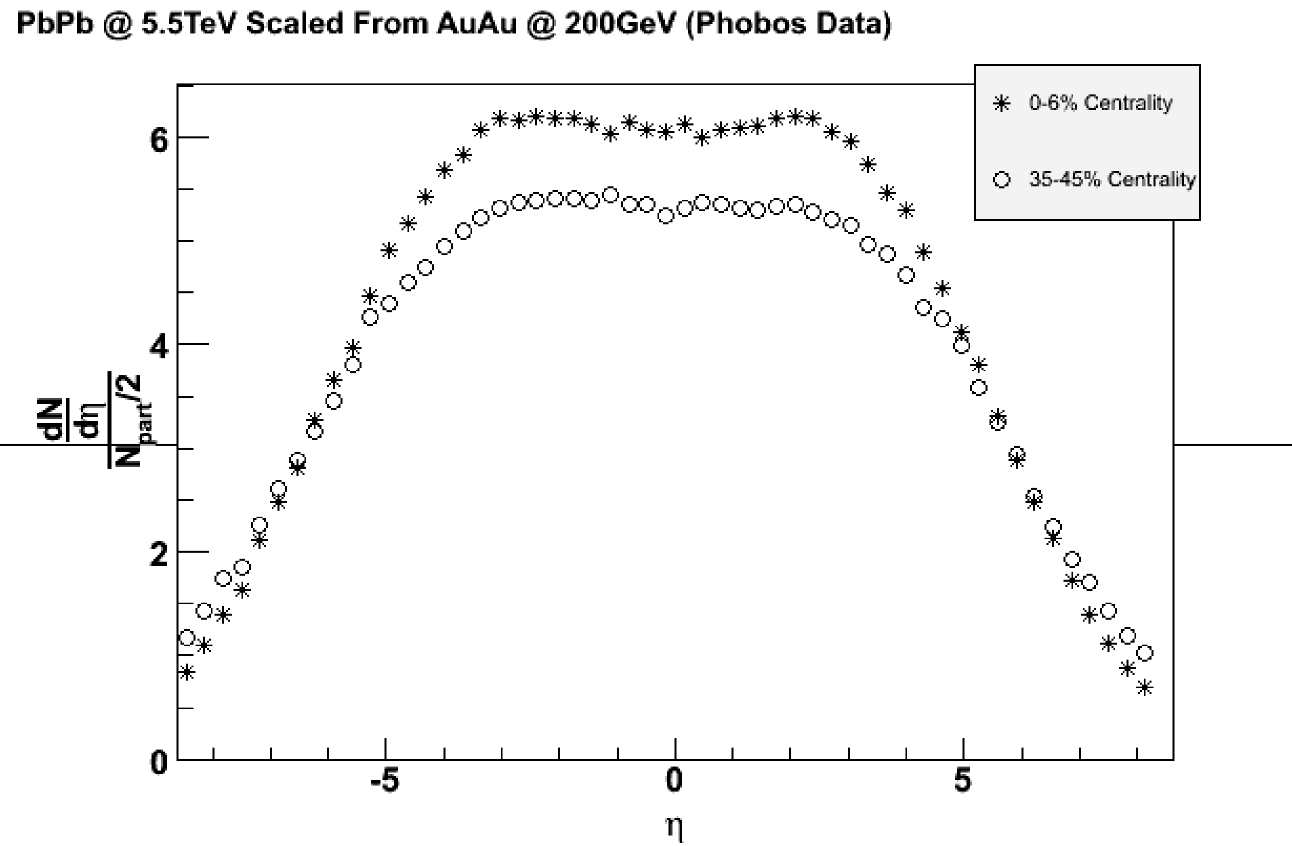




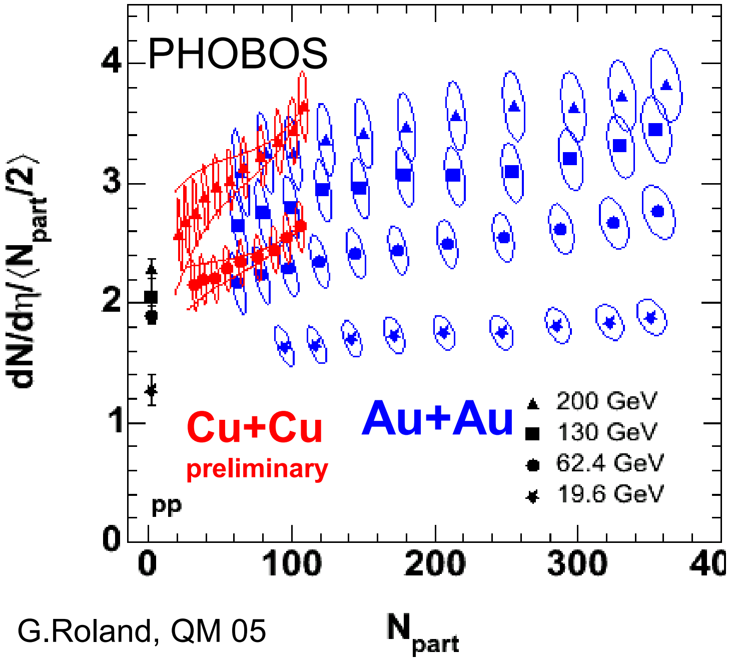
W. Busza, Acta Phys. Pol. B35 (2004)2873



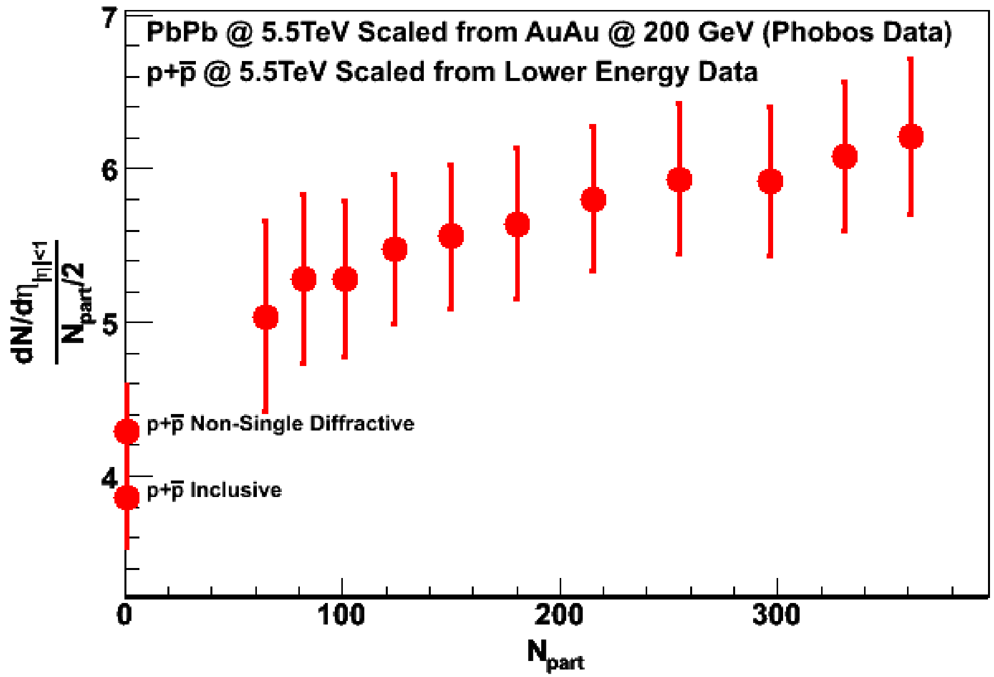
PHOBOS, Phys. Rev. C74 021901 (2006)

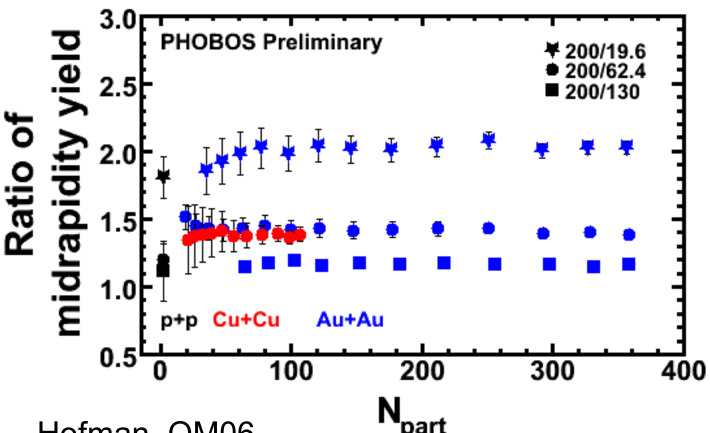


AuAu: PHOBOS, PRL 91 (2003) 052303



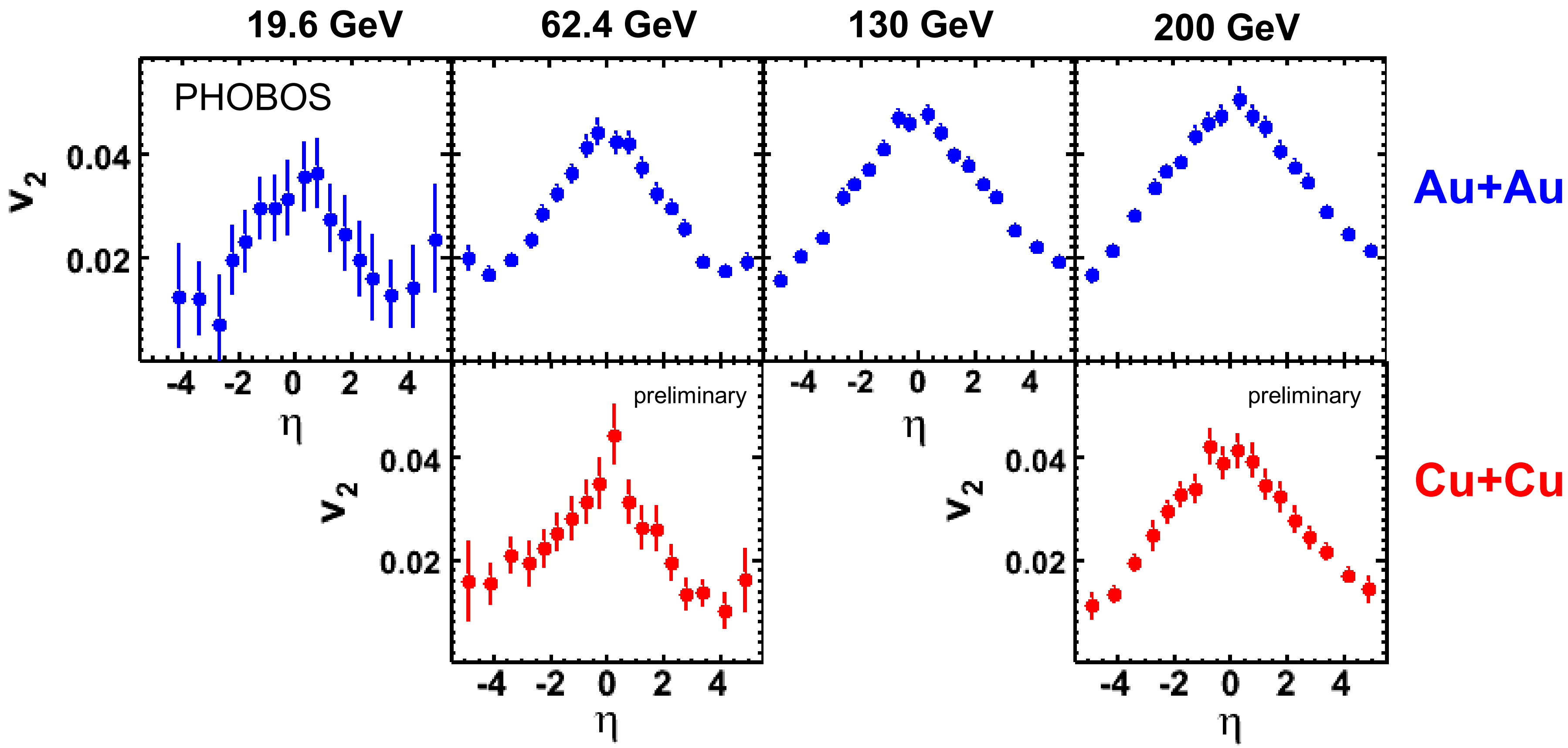
G.Roland, QM 05



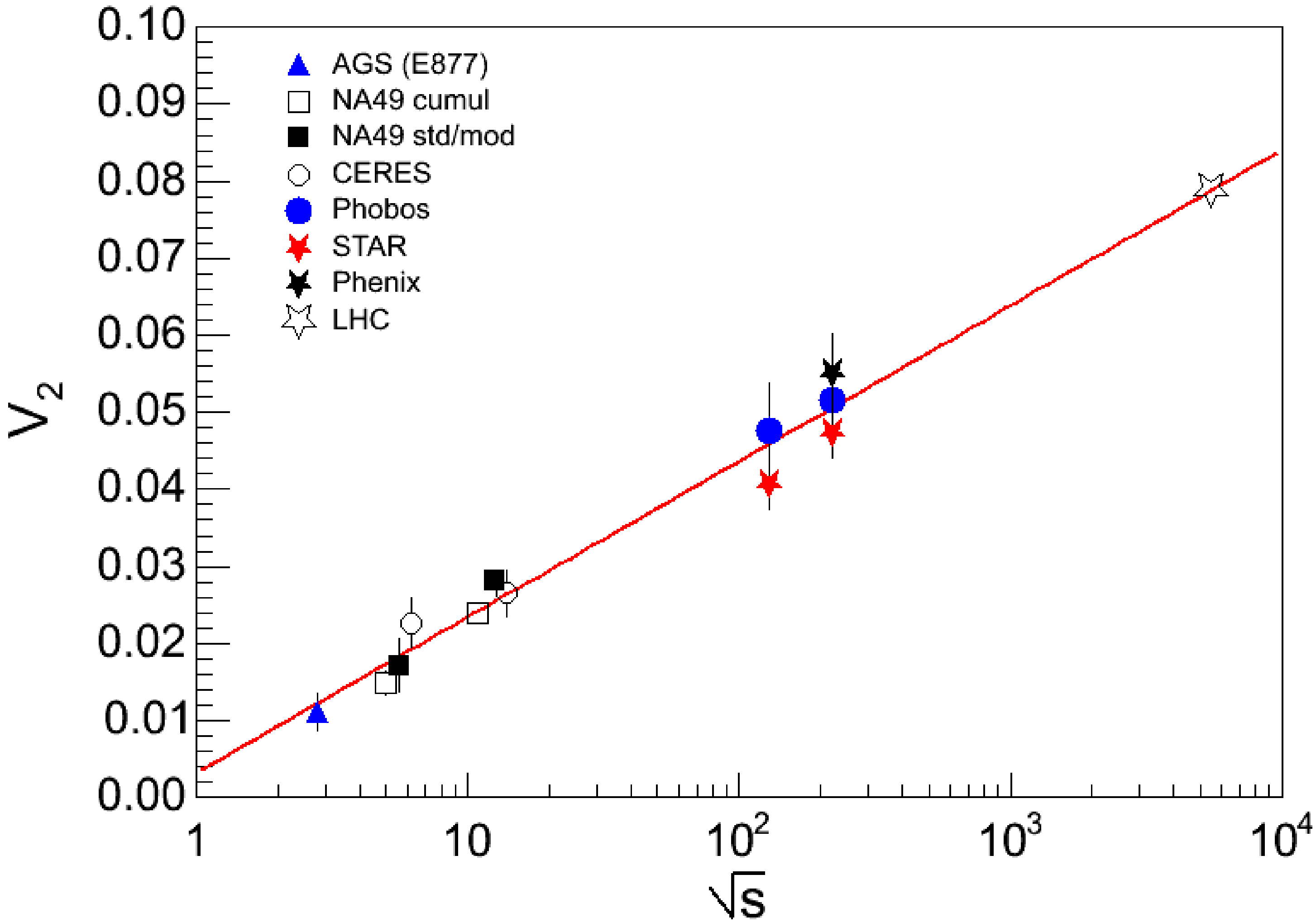


Hofman, QM06

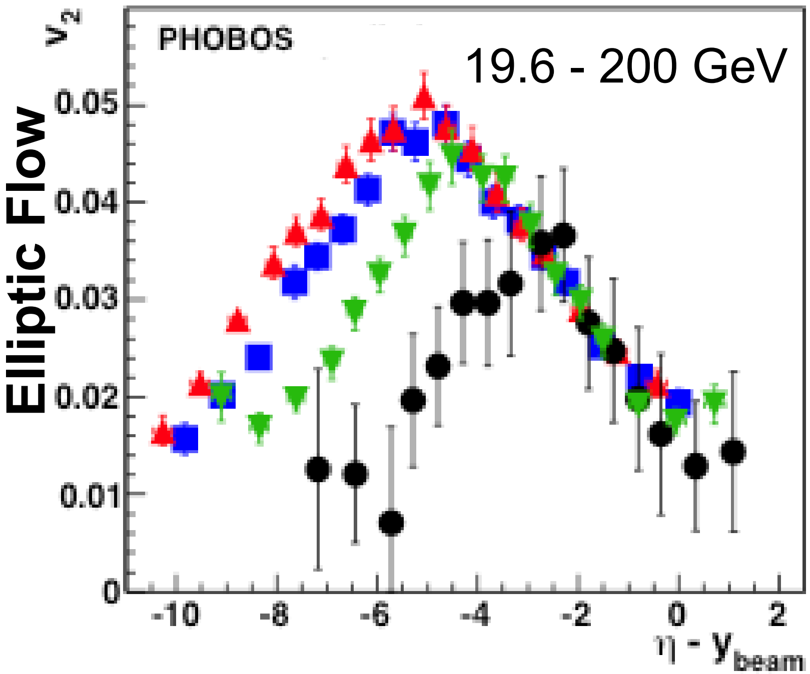
AuAu: PHOBOS data

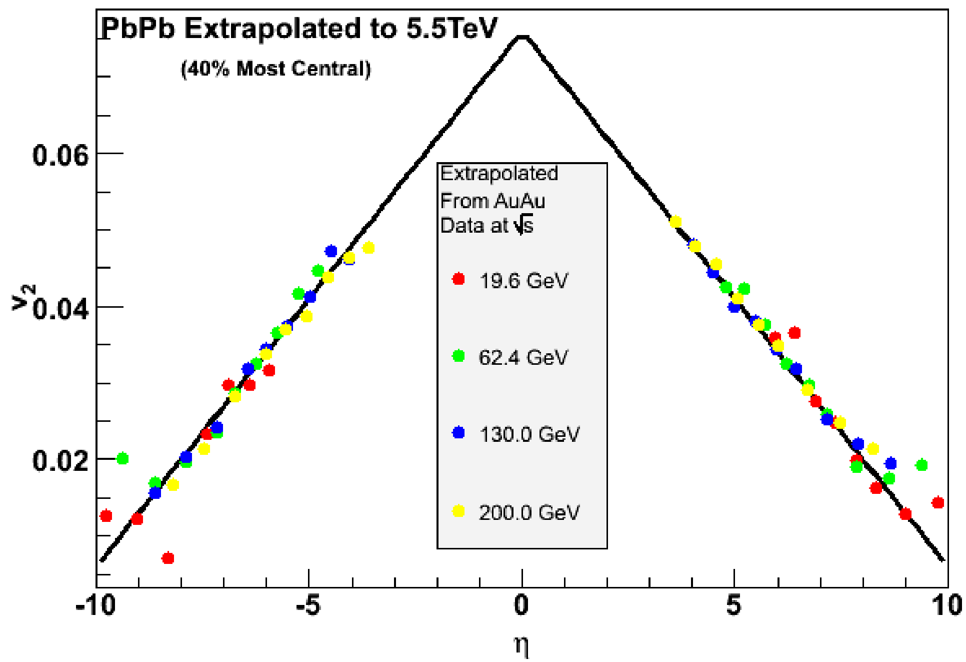


AuAu: PHOBOS: PRL 94 122303 (2005)
CuCu: PHOBOS: PRL accepted for publication



Compilation of data from Phys. Rev. C68 (2003) 034903



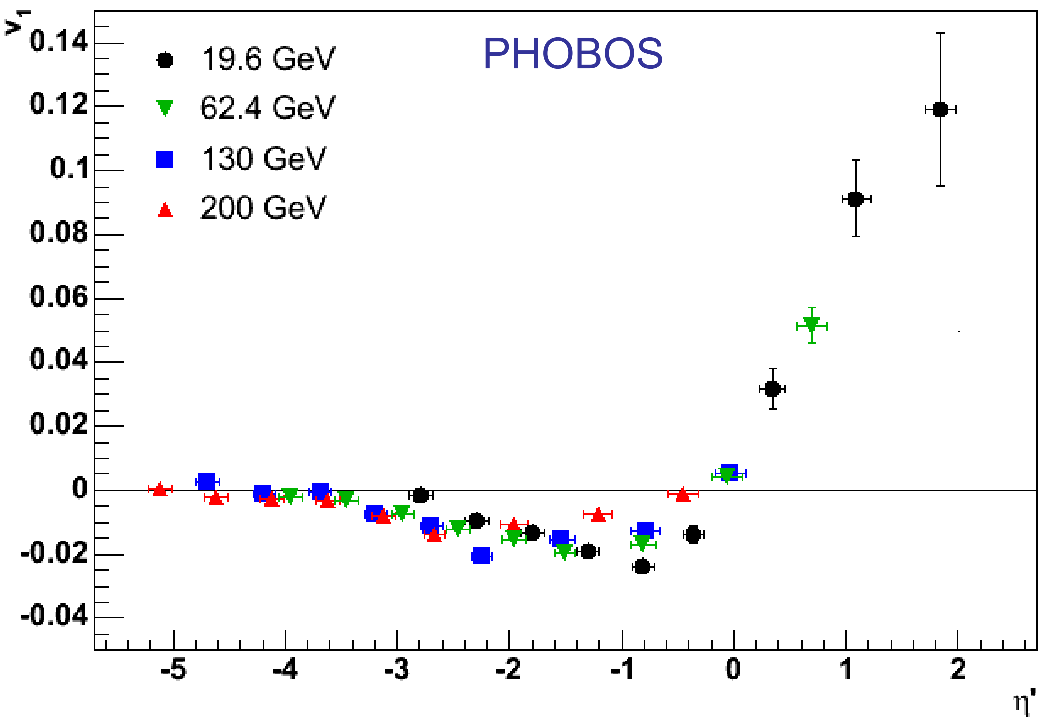


PHOBOS, Nucl.Phys. A757 (2005) 28

G. Roland, PANIC 05

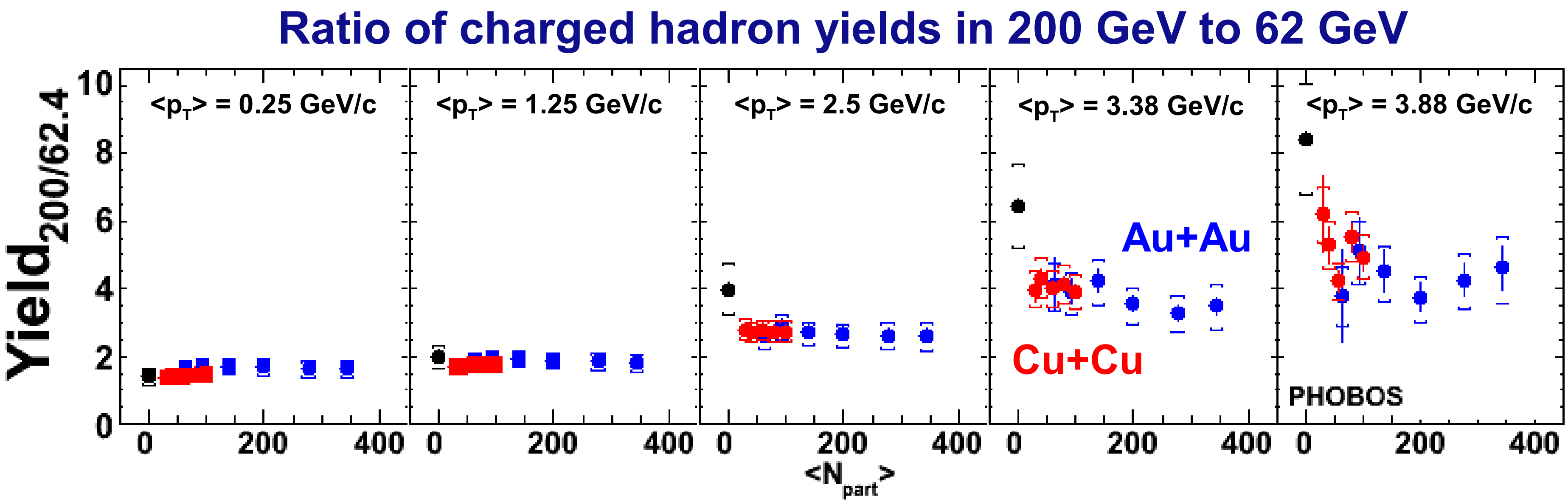
Au+Au

PHOBOS

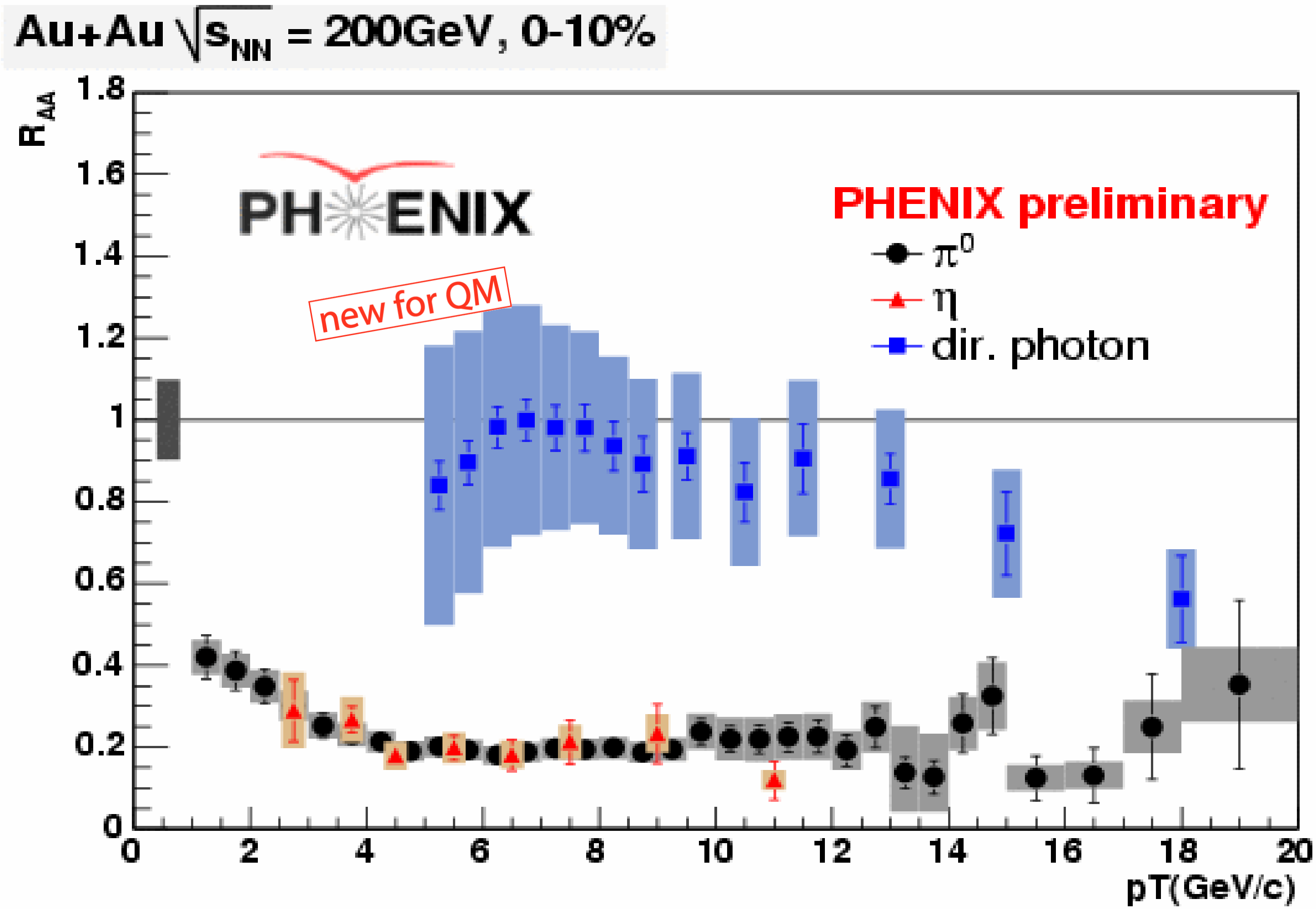


PHOBOS 0-40% centrality:
PRL 97, 012301 (2006)

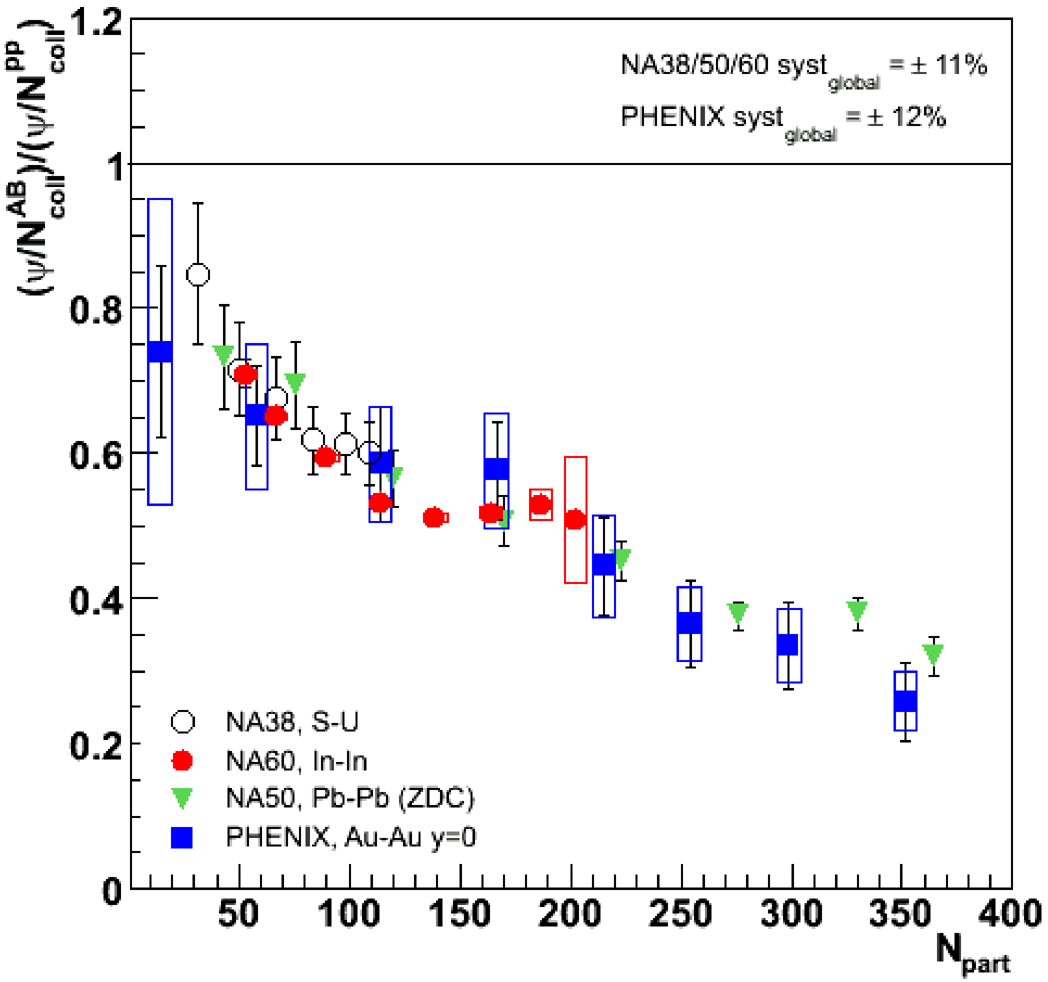
Energy and Geometry Factorization seems to apply to P_T spectra



Au+Au: PHOBOS, PRL 94, 082304 (2005)



B. Sahlmüller, QM06



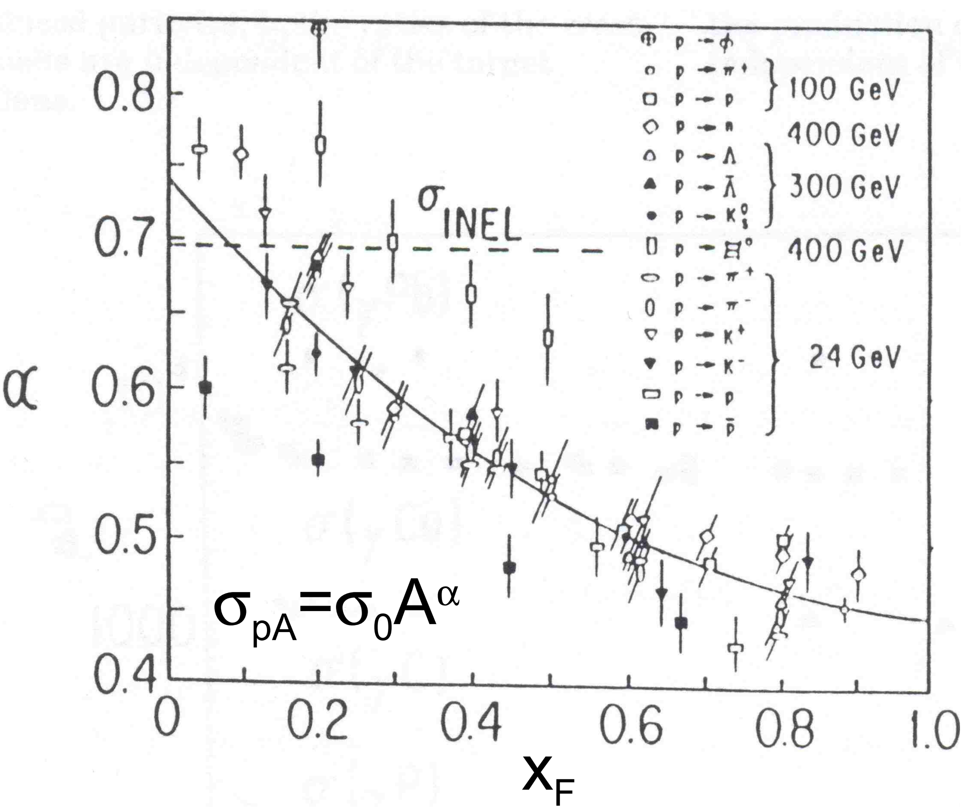
SPS and RHIC suppression looks the same!

(Figs. from Enrico Scomparin)

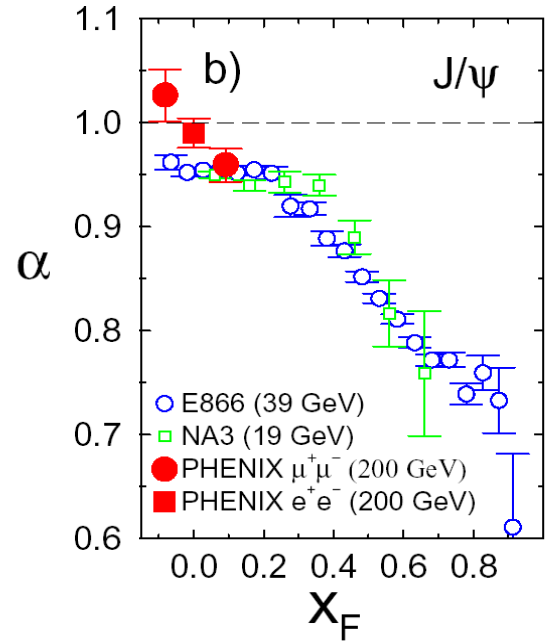
p+A collisions

Various final states: ϕ, π^+, π^-, p, $\bar{p}$, n, Λ, K^0, Ξ, K^+, K^-

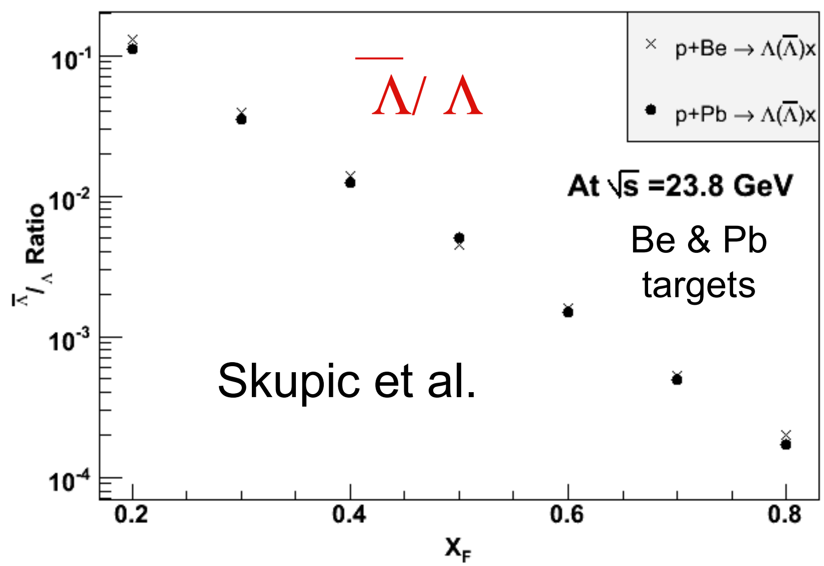
Various beam energies: 24, 100, 300, 400 GeV



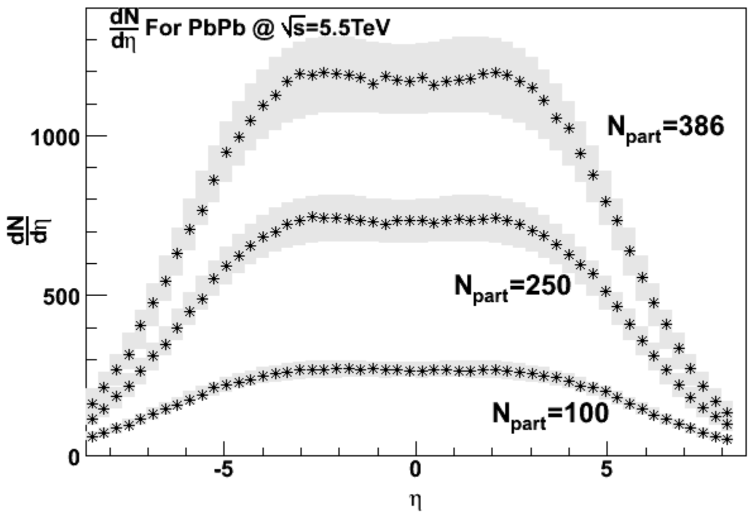
W. Busza, Nucl. Phys. A544:49 (1992)
E451, PRD27 (1983) 2580

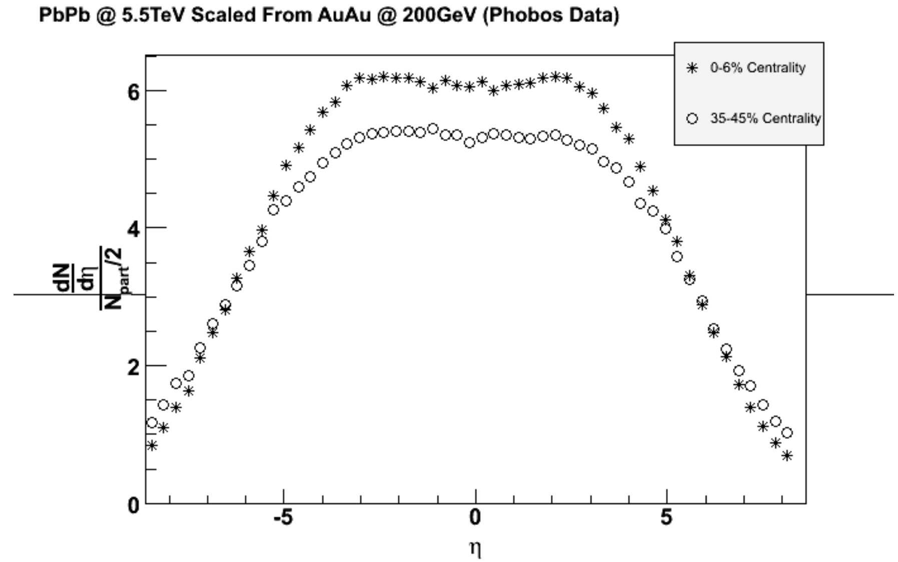


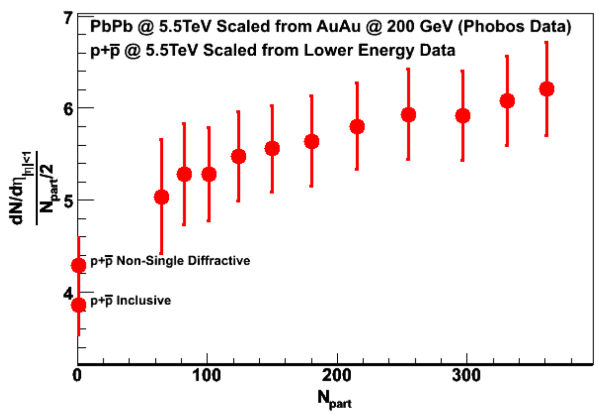
G. Veres, QM05

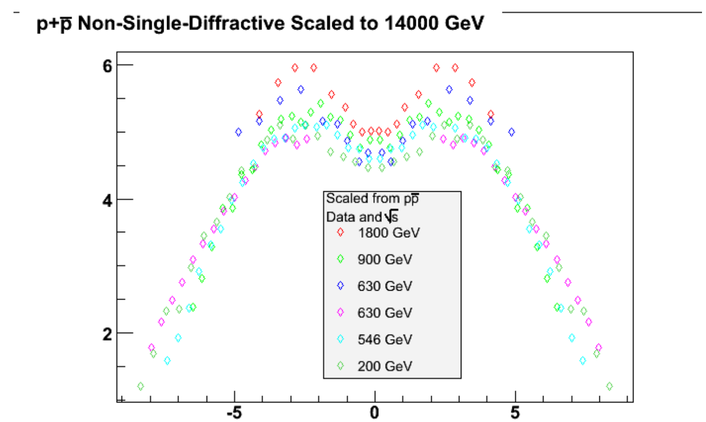


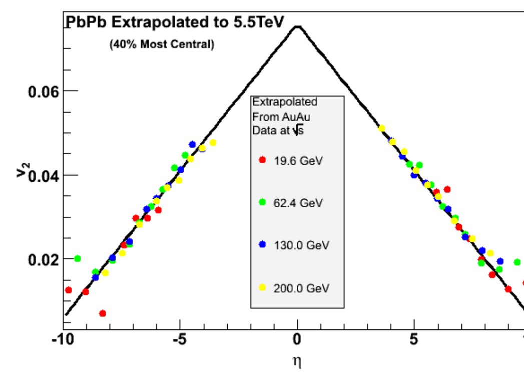
Summary of Main "Predictions"











Total charged multiplicity in central (N_{PART} =386) PbPb collisions at (√s = 5.5 TeV) = **15000 +/- 100**

Total charged multiplicity in NSD pp collisions at (√s = 14 TeV) = **72 +/- 8**

Final Comments

- If these "predictions" turn out to be correct, more than ever, any model which claims to explain the phenomena observed in heavy ion collisions at ultra relativistic velocities, must contain an explanation for the observed trends, as well as the broad range of systems, energies and rapidities over which the trends are observed.

- If these "predictions" turn out to be false, it will be a direct indication of the onset of new phenomena at LHC energies.

- If the observed trends are a consequence of some very general principles, it means that the data on the global properties is not sensitive to the details of the system formed in AA collisions. It then follows that we learn little from models that agree with this data, unless at the same time the models explicitly explain the trends.