EXTENDED LONGITUDINAL SCALING: DIRECT EVIDENCE OF SATURATION

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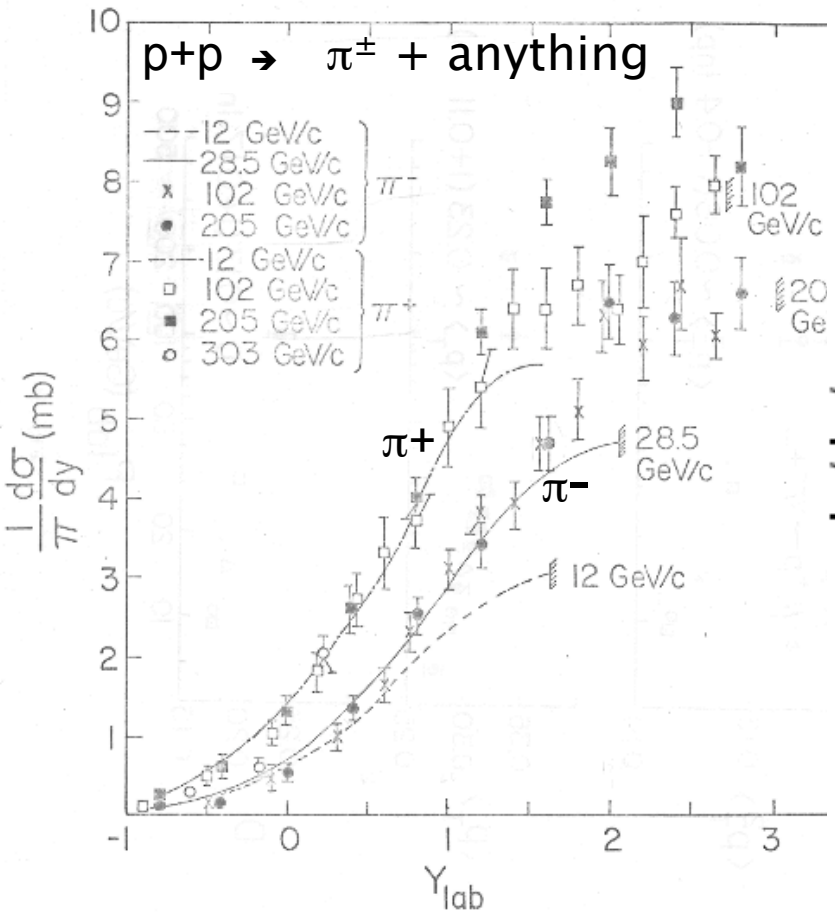
In 1969 Benecke, Chou, Yang and Yen proposed the:

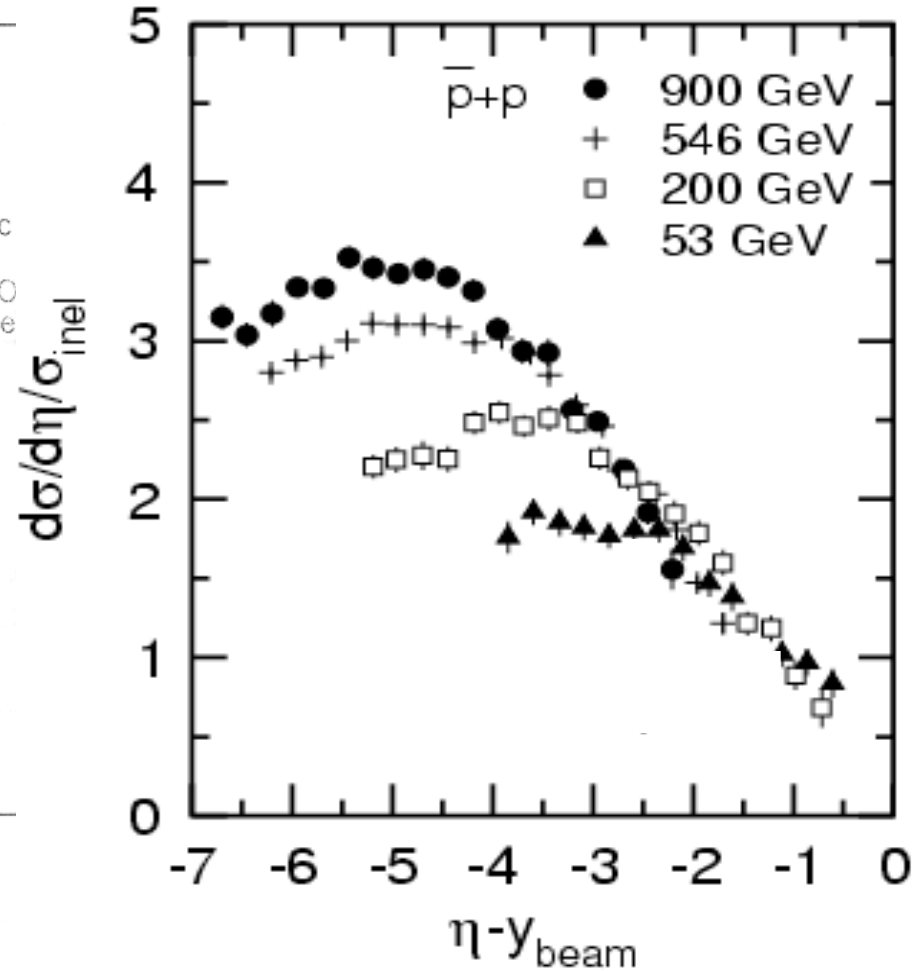
"Hypothesis of Limiting Fragmentation in High Energy Collisions"

It was based on the "two-fireball model" used to explain cosmic ray physics

And the "intuitive picture of a high-energy collision process as two extended objects going through each other, breaking into fragments in the process……"

Hypothesis of limiting fragmentation clearly established in elementary collisions:

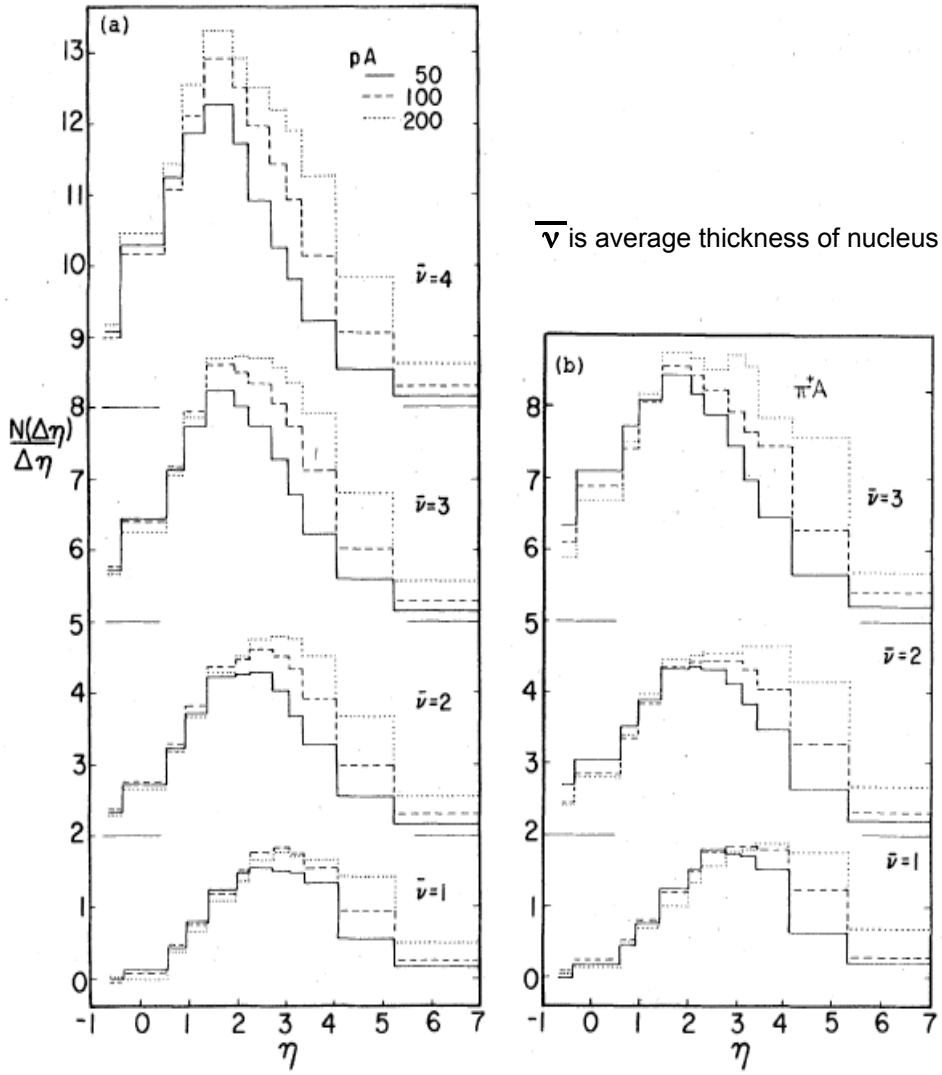




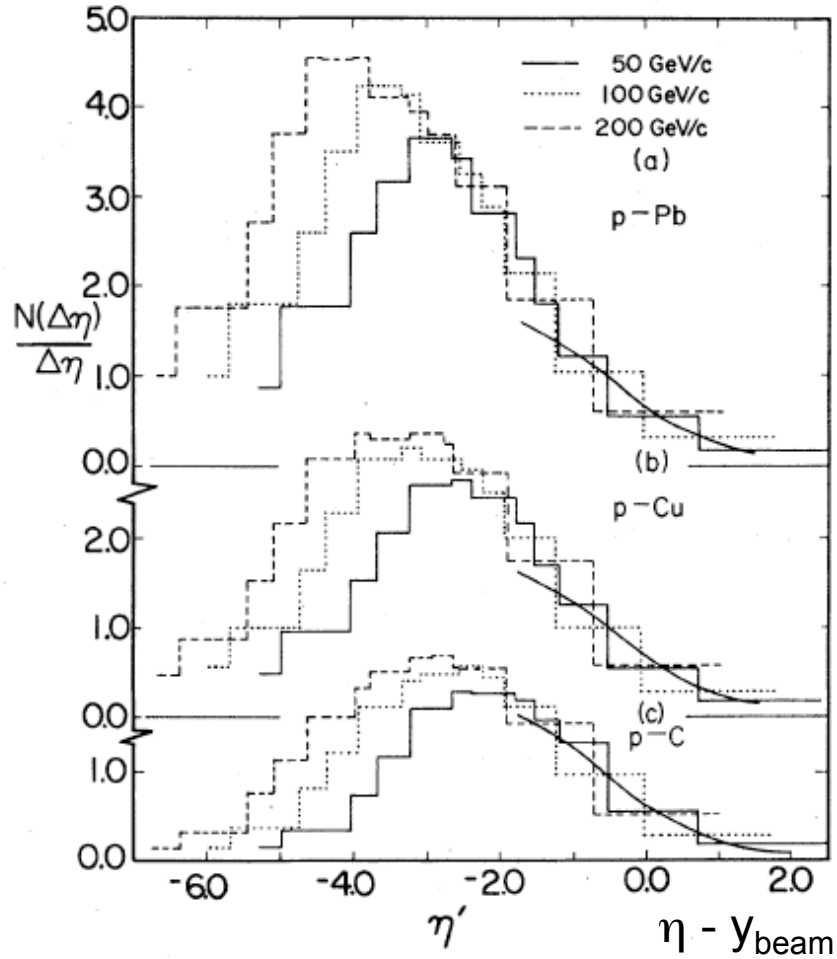
J.Whitmore, Physics Reports 10C (1974)

UA5, ZPC 33(1986); CDF, PRD 41 (1990)

Limiting fragmentation in pA data (Experiment E178) $\sqrt{s_{NN}}$ = 10 - 20 GeV



$\bar{\nu}$ is average thickness of nucleus

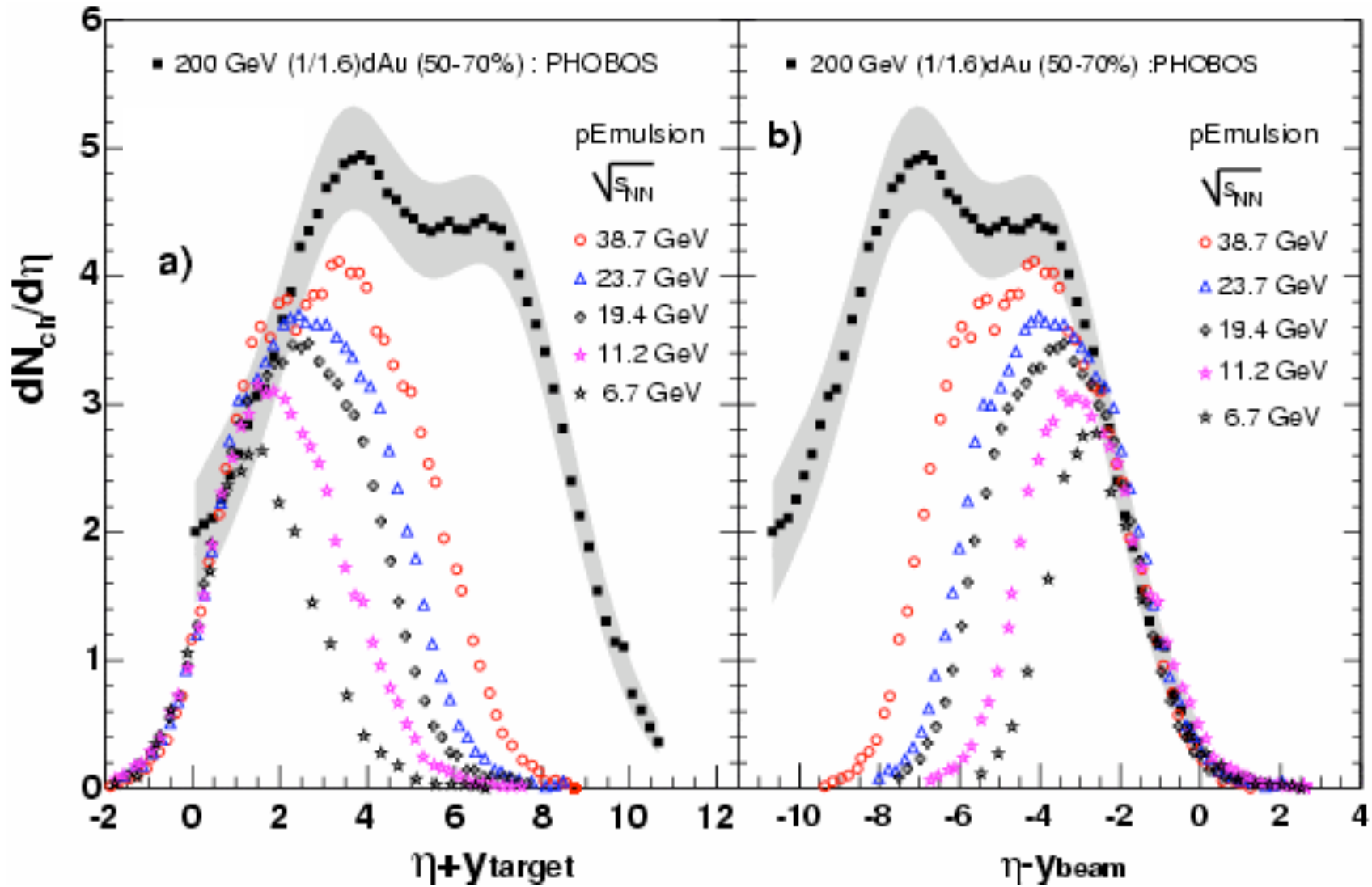


Nucleus rest frame

Projectile rest frame

W.B., J. Elias et al., (E178 B) PR D22 (1980) 13

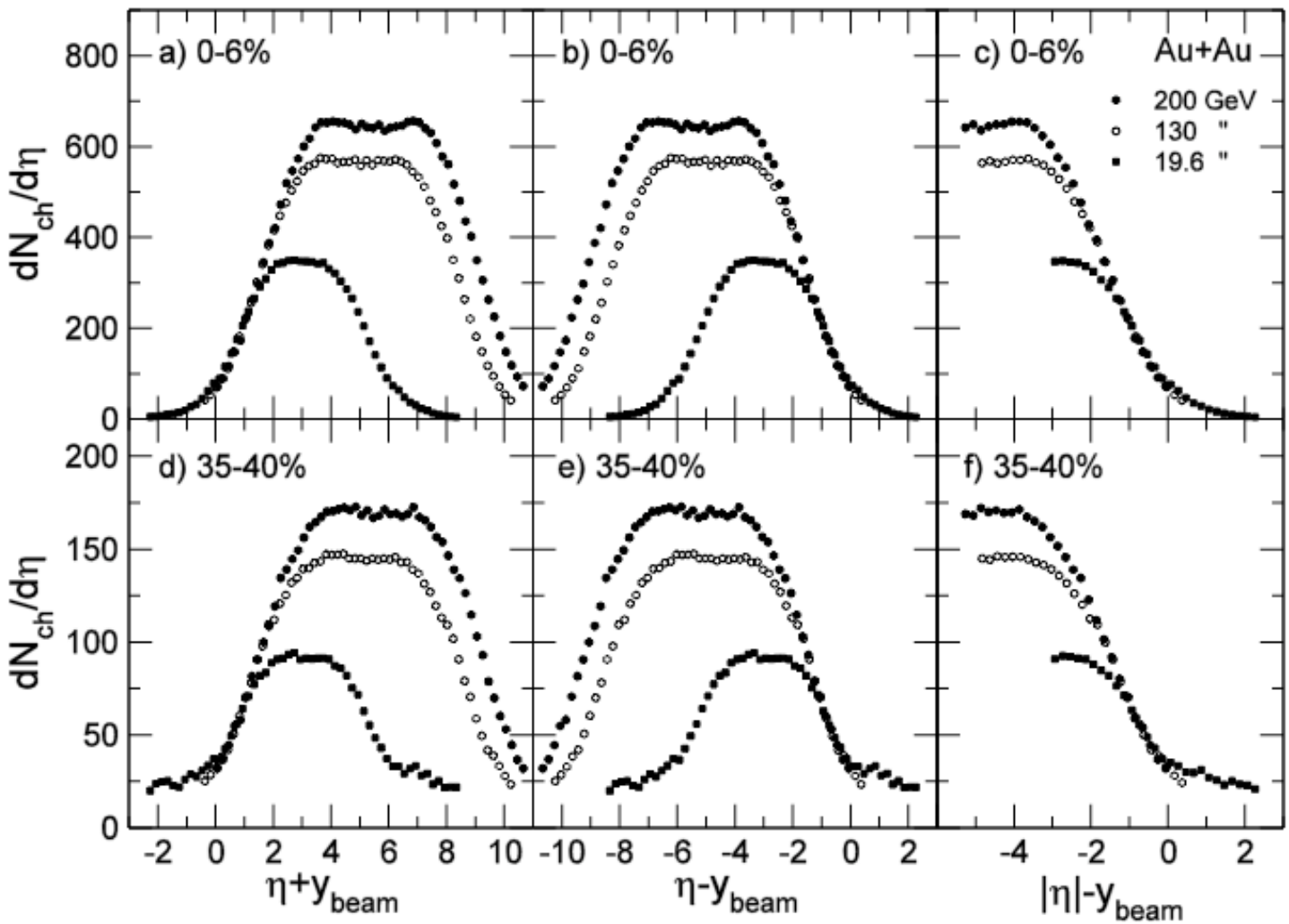
Limiting fragmentation in p(d)+A collisions



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

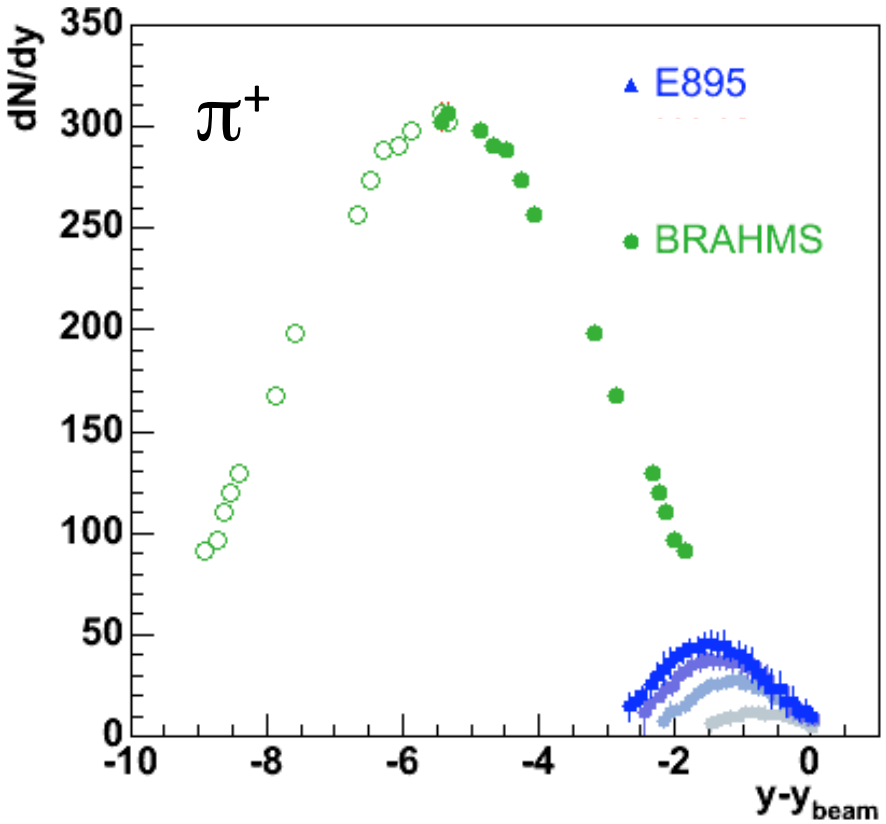
Limiting Fragmentation in AA Collisions

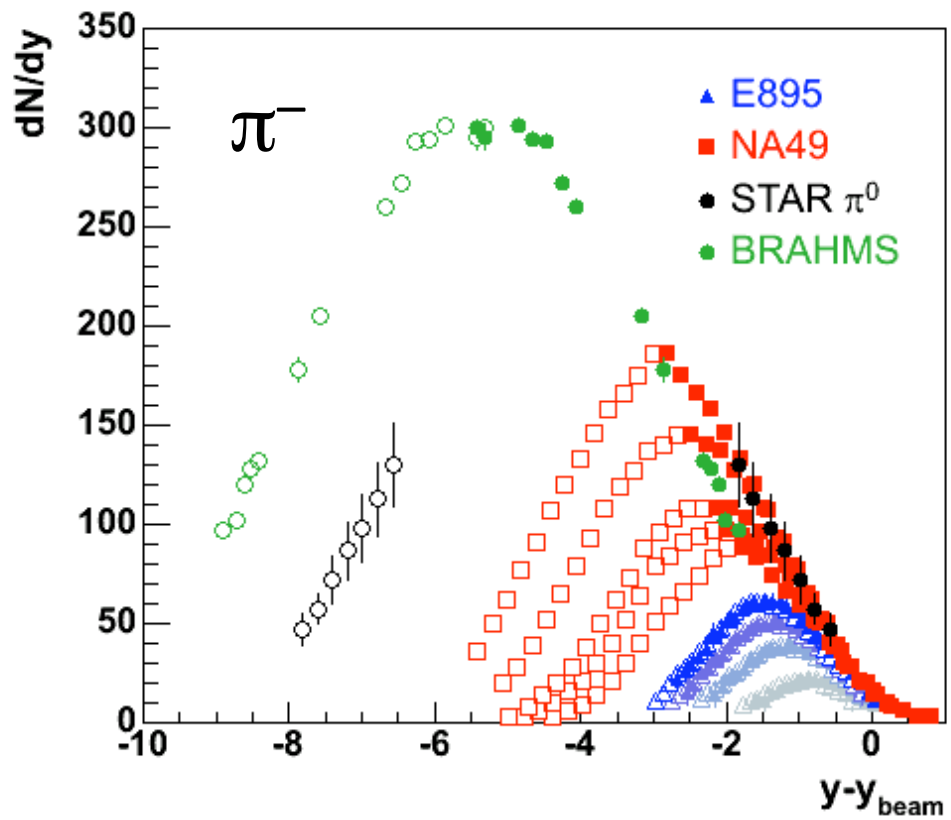
Renamed by PHOBOS "Extended Longitudinal Scaling" because of the broad range in rapidity in which it is seen.



PHOBOS Phys. Rev. Lett. 91, 052303 (2003) / Nucl. Phys. A757, 28 (2005)

Extended Longitudinal Scaling seen in inclusive processes in AA collisions



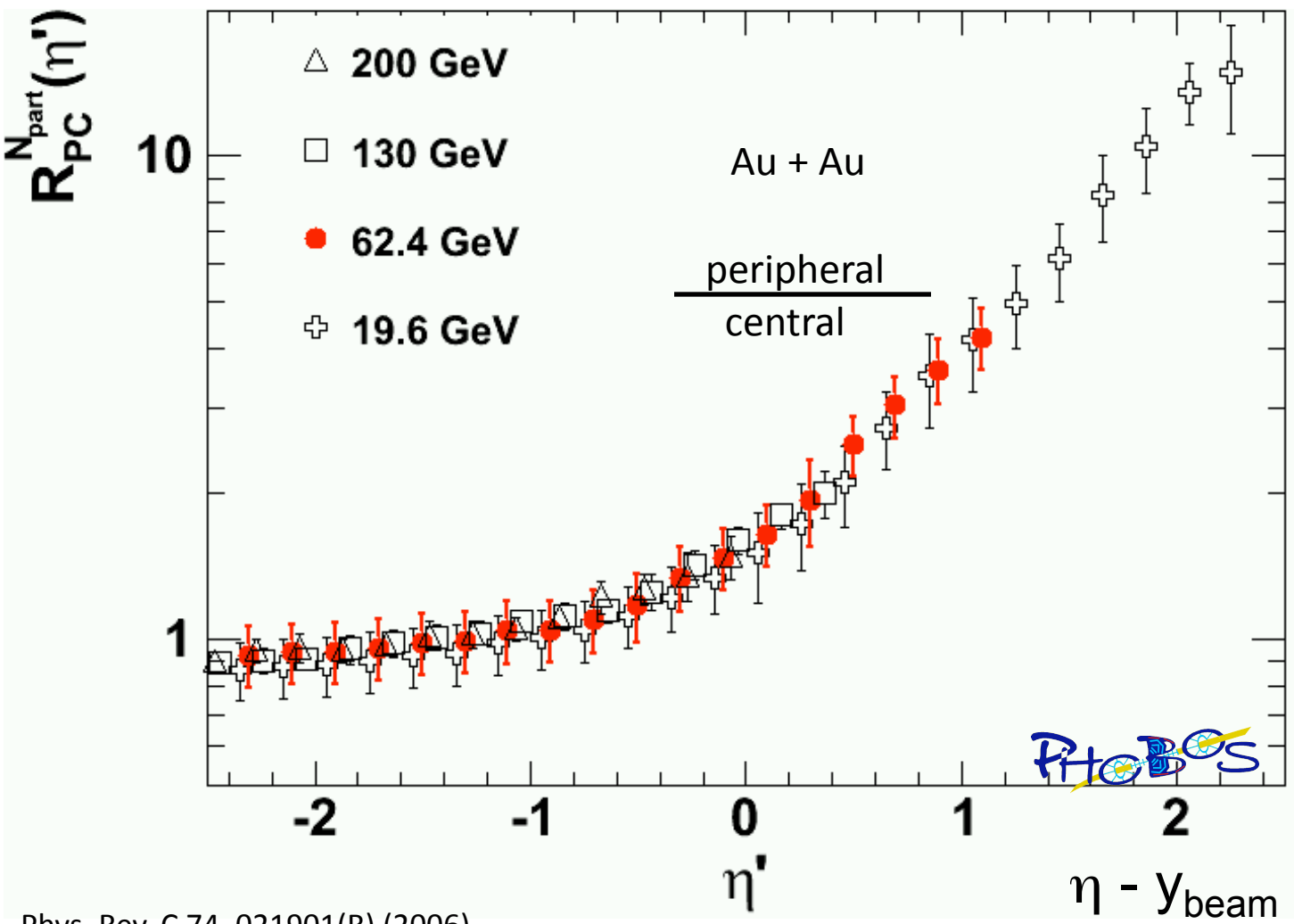


NA49: PRC 66 054902
Brahms: PRL 94 162301 (2005)
E895: PRC 68 054905 (2003)

$\sqrt{s}$=2.63, 3.28, 3.84, 4.29,
6.27,7.62,8.76,12.32,17.27,200 GeV

Au+Au, Pb+Pb

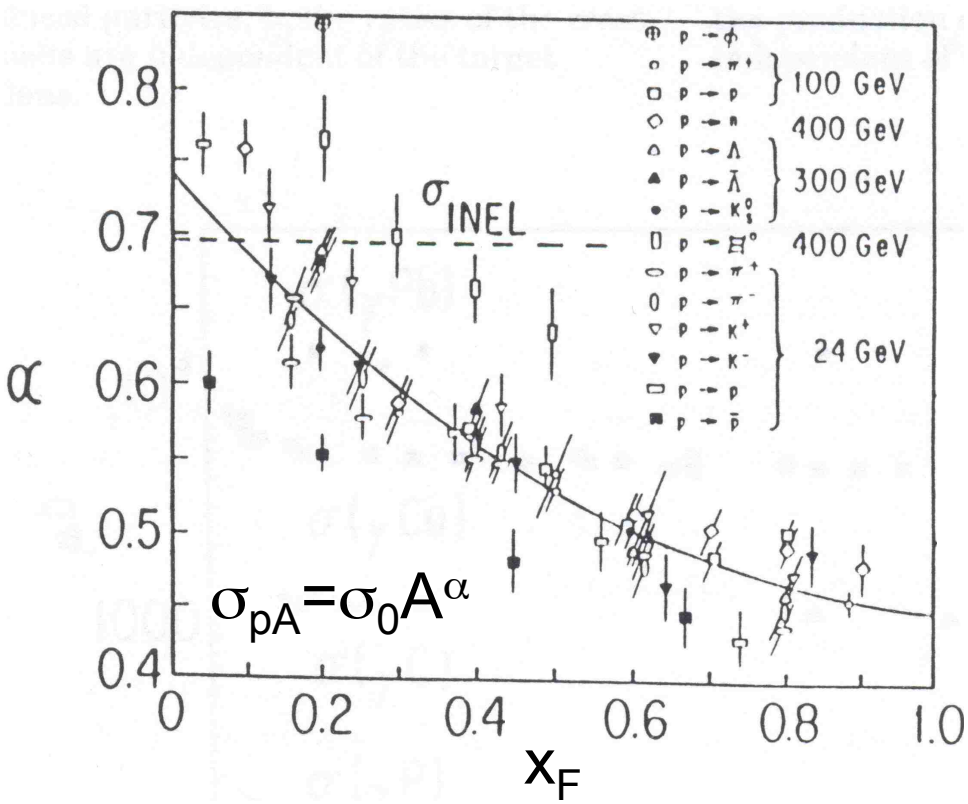
From Gábor Veres QM05



Phys. Rev. C 74, 021901(R) (2006)

arXiv:0709.4008 [nucl-ex]

p+A collisions



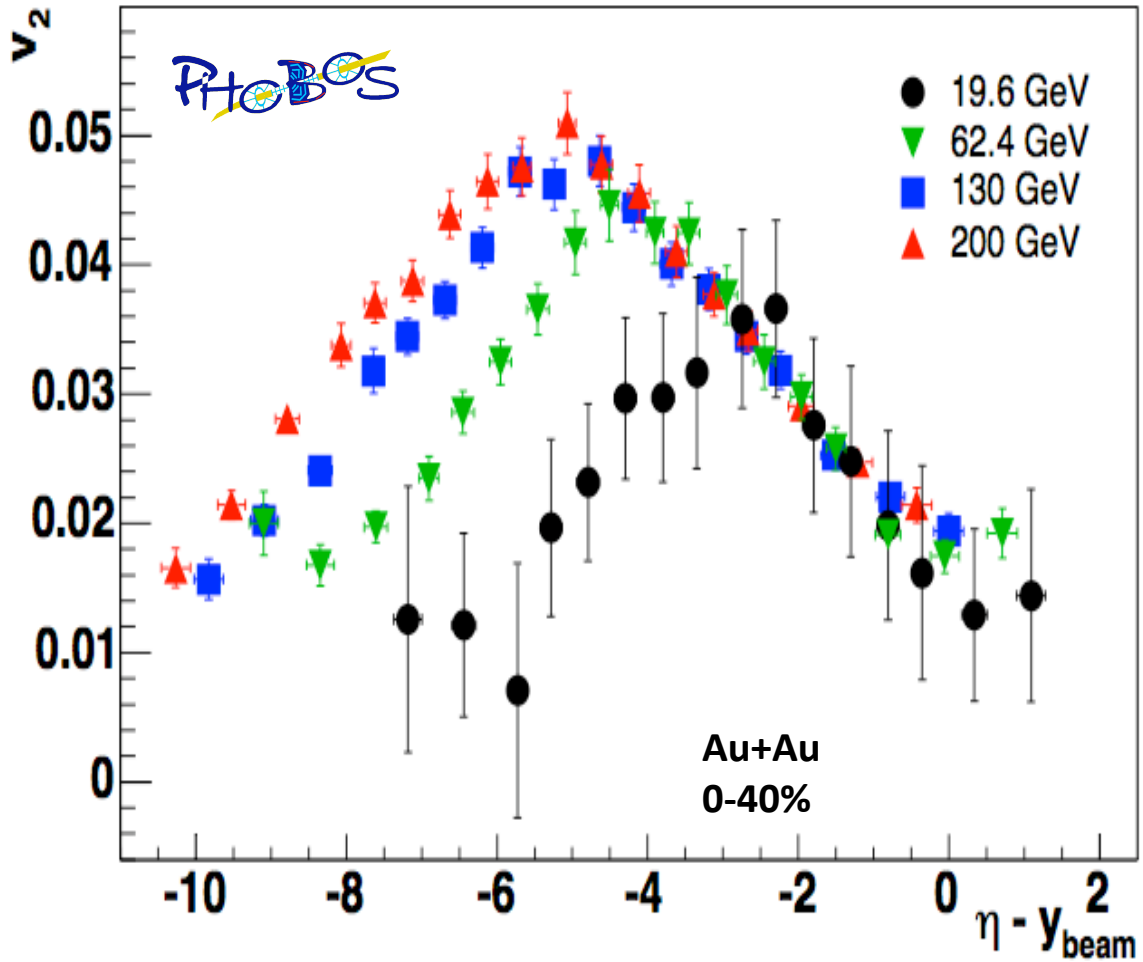
Various final states:
$\phi, \pi^+, \pi^-, p, \bar{p}, n, \Lambda, \bar{\Lambda}, K^0_s, \Xi, K^+, K^-$

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

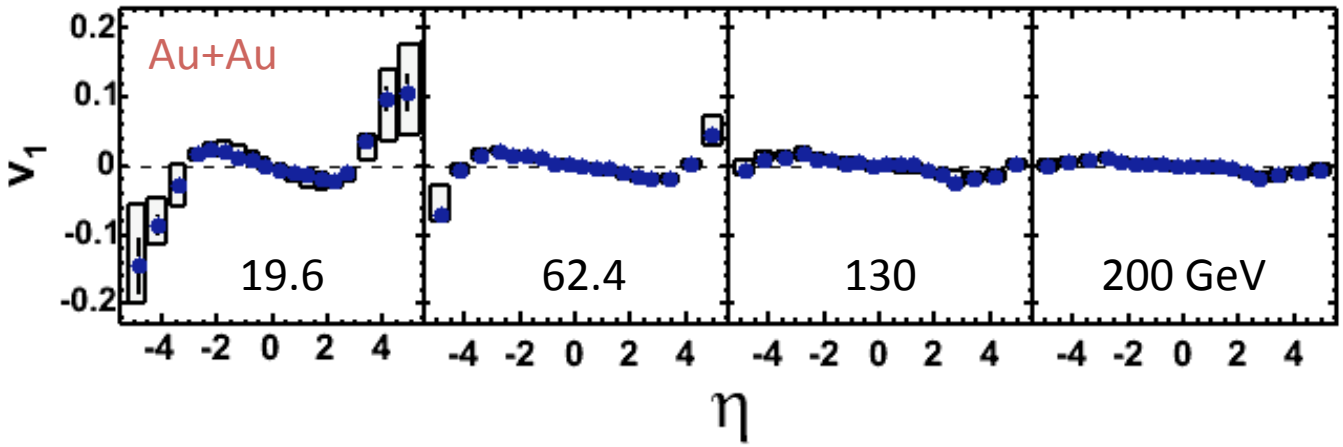
A Dependence in forward fragmentation region independent of energy

W.B. Nucl. Phys. A544:49 (1992)

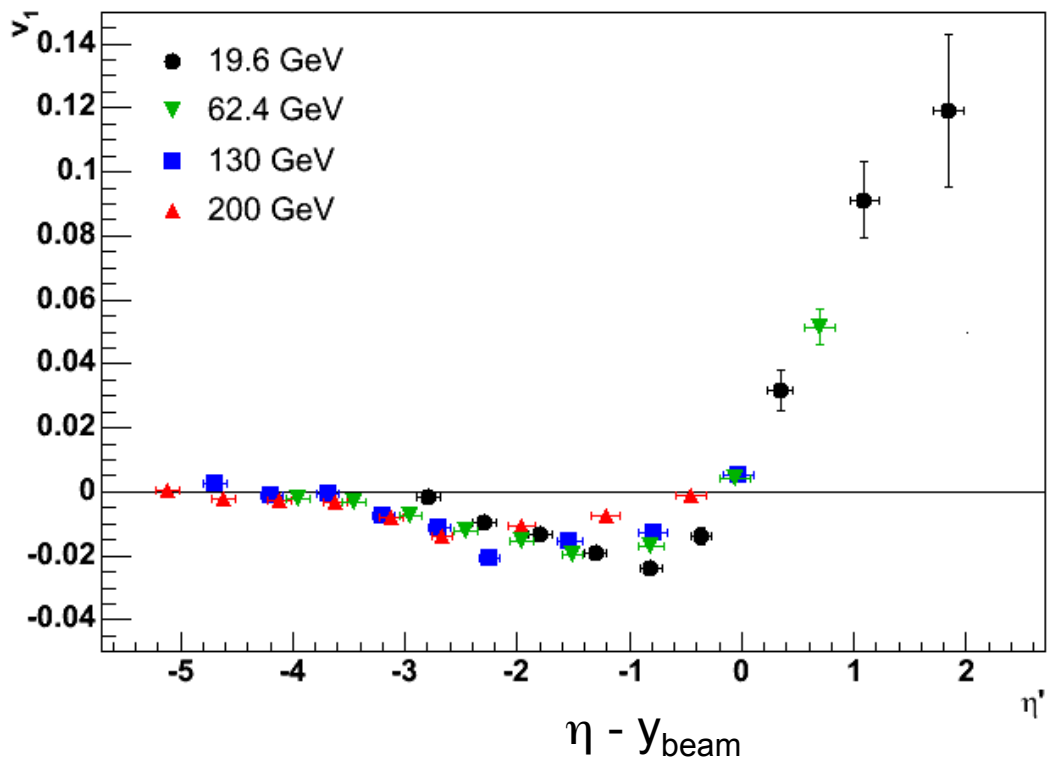
Extended longitudinal scaling seen in transverse properties of produced particles



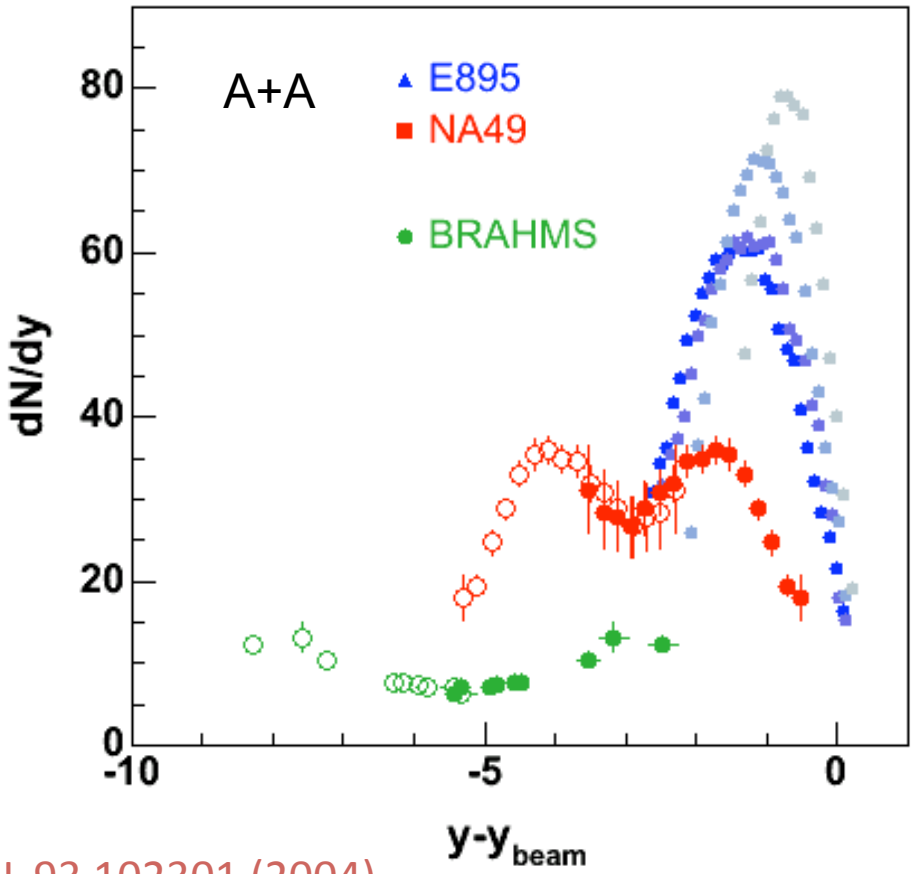
PRL94, 122303(2005)



PHOBOS
0-40% centrality



Energy dependence of net proton production



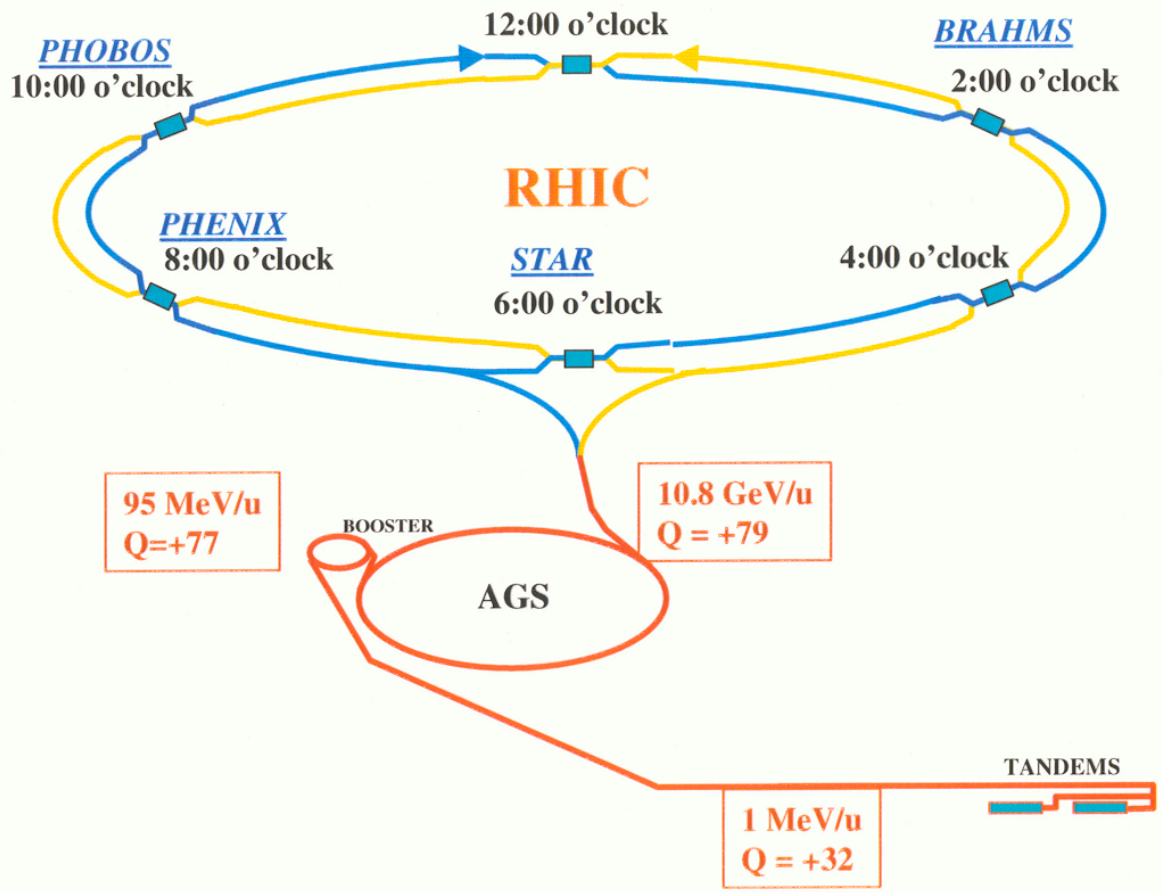
conserved quantity, different from produced particles

↓

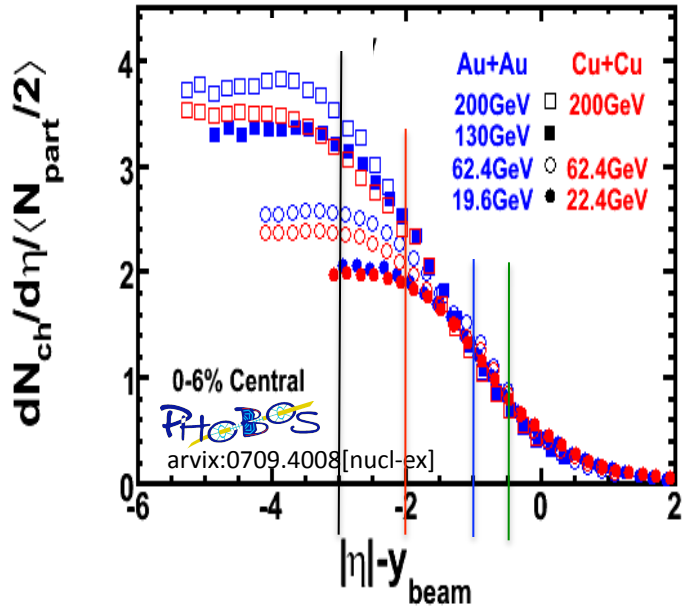
No scaling is observed at high η…

Brahms: PRL 93 102301 (2004)
NA49: PRL 82, 2471 (1999)
E895: PR C66 054905 (2003)

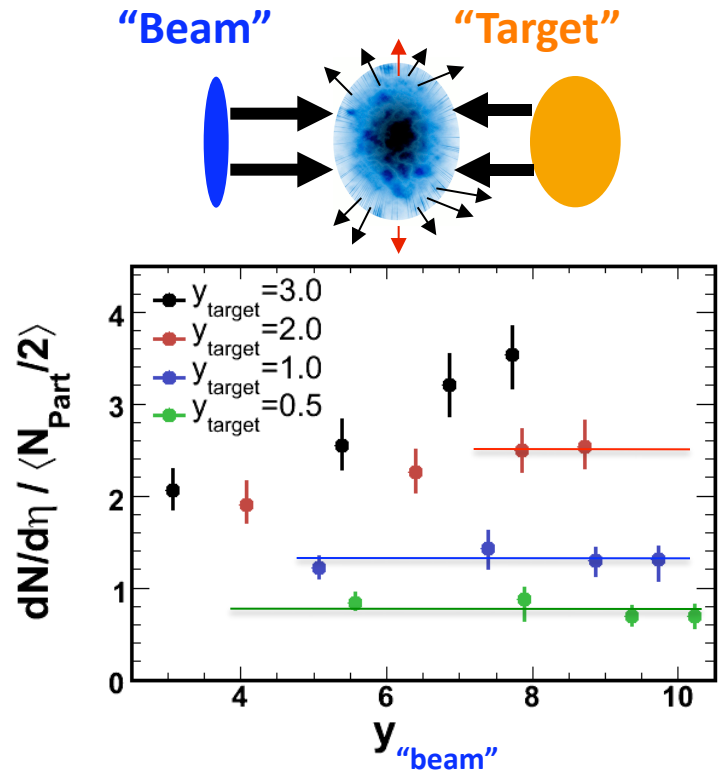
From Gábor Veres QM05

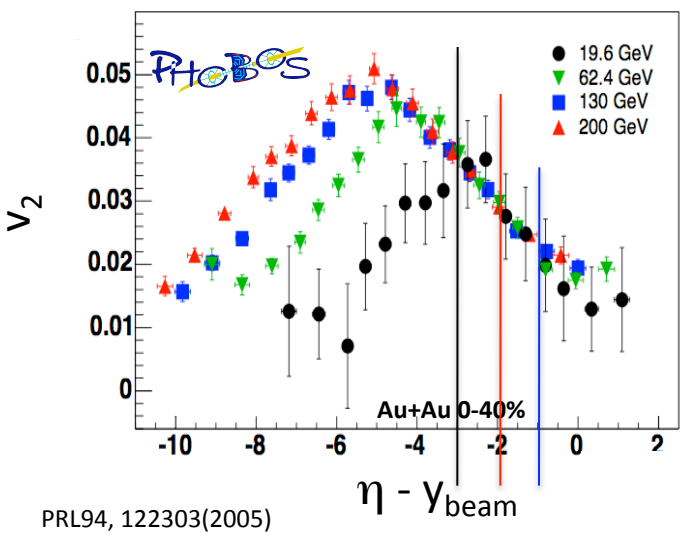

12:00 o'clock
PHOBOS
10:00 o'clock
BRAHMS
2:00 o'clock
RHIC
PHENIX
8:00 o'clock
STAR
6:00 o'clock
4:00 o'clock
95 MeV/u
Q=+77
BOOSTER
AGS
10.8 GeV/u
Q = +79
TANDEMS
1 MeV/u
Q = +32

Direct manifestation of the saturation of particle production

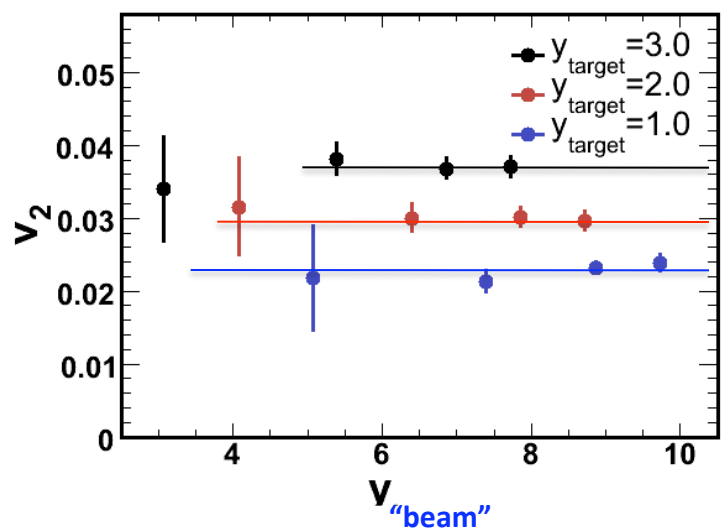


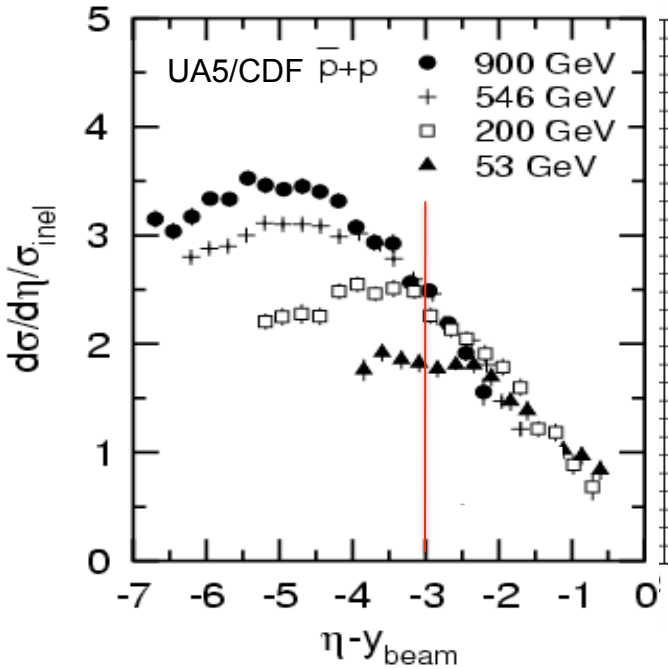
Taking y≈η

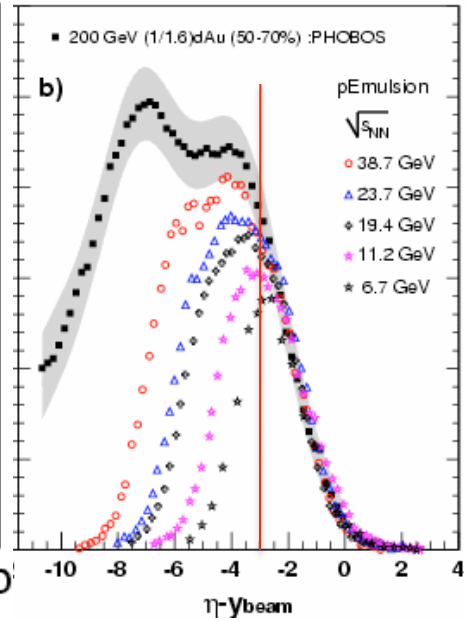


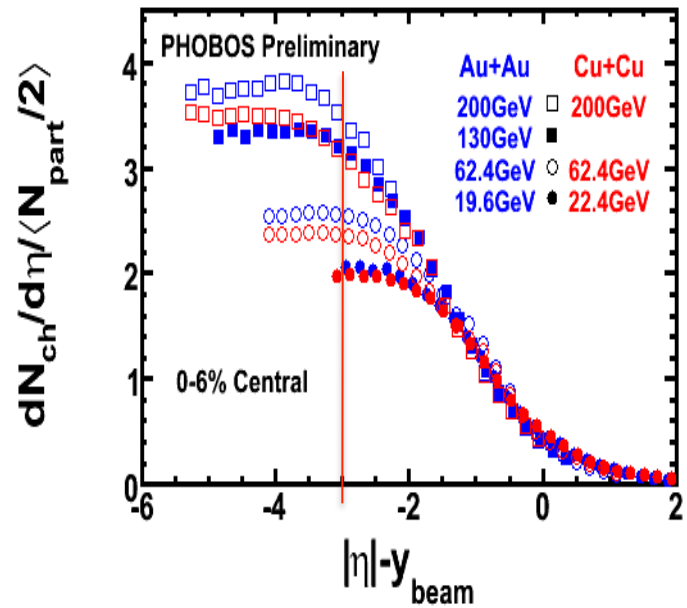


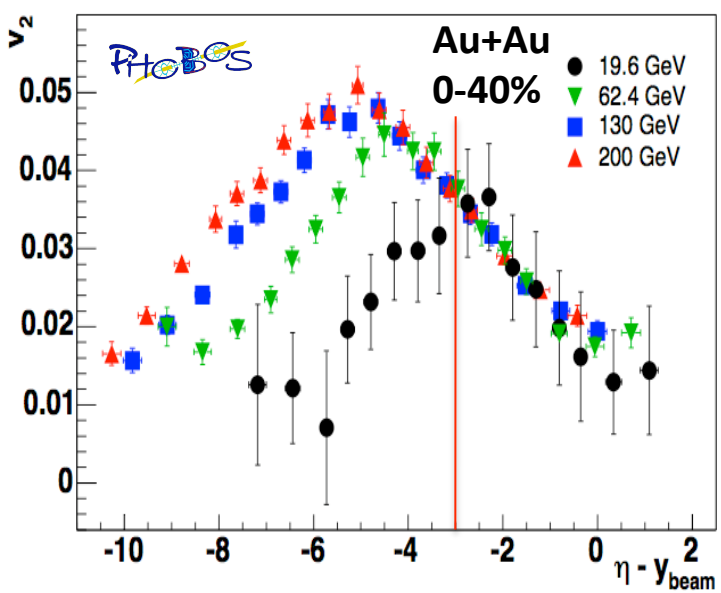
PRL94, 122303(2005)





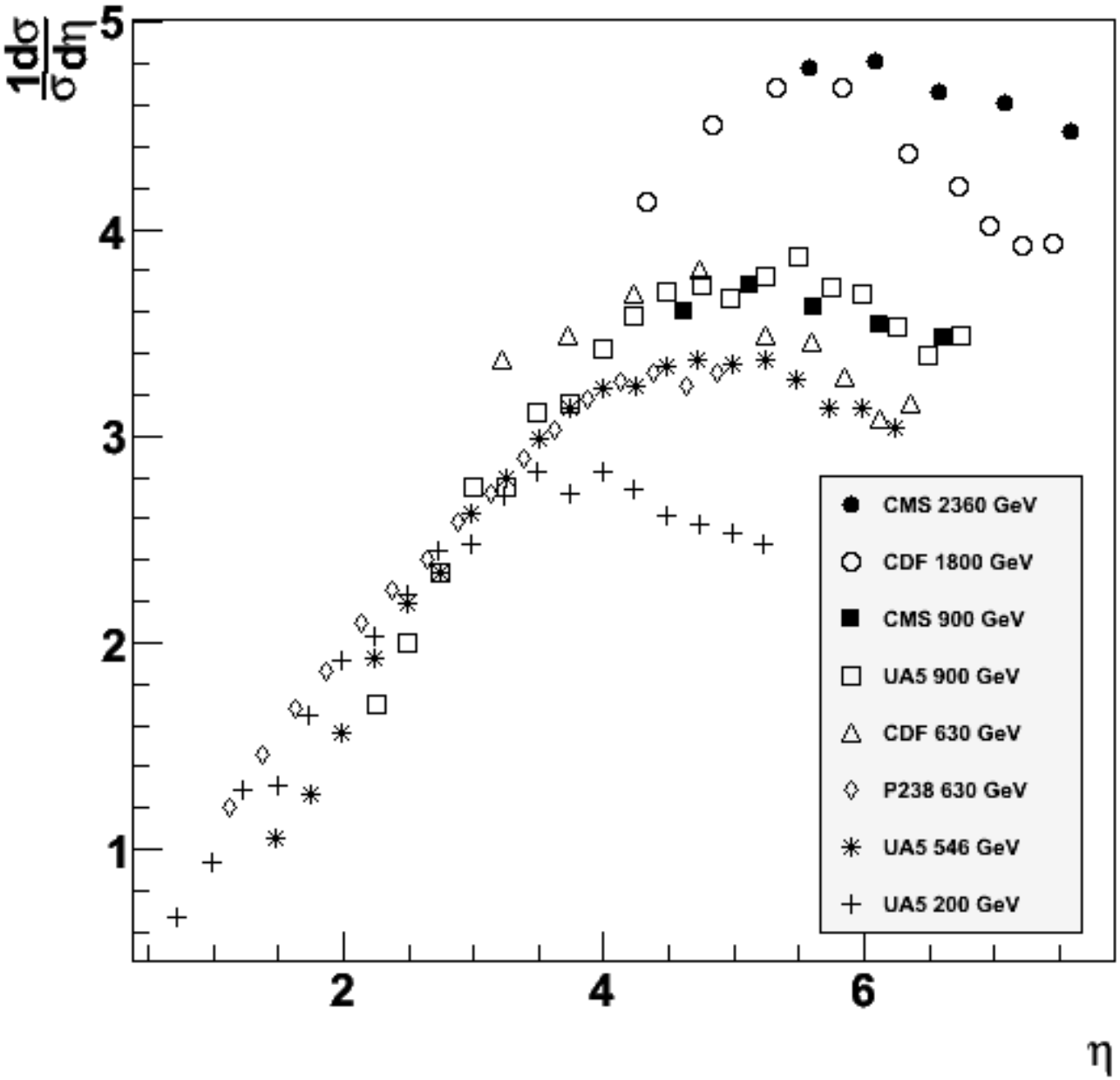




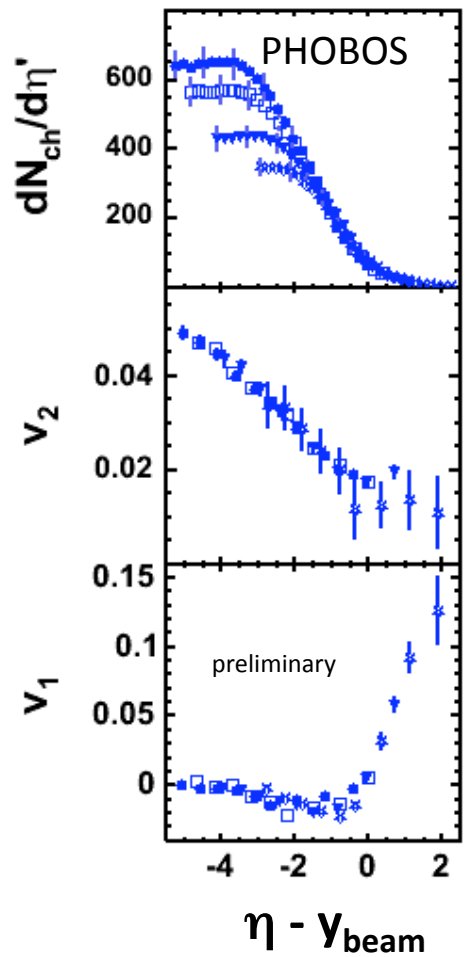


Direct evidence of saturation in pp, pA and AA

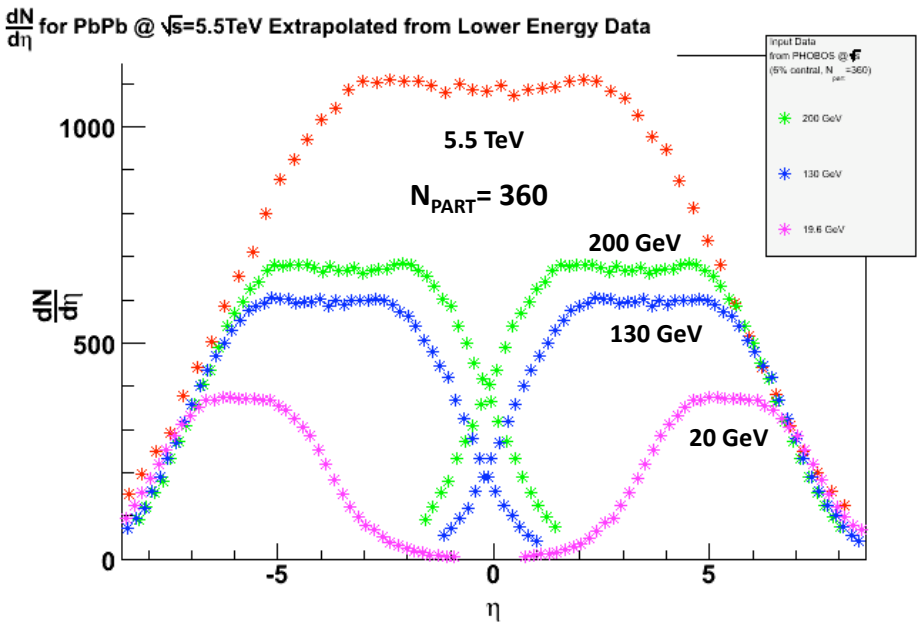
p+p($\bar{p}$) Non-Single-Diffractive

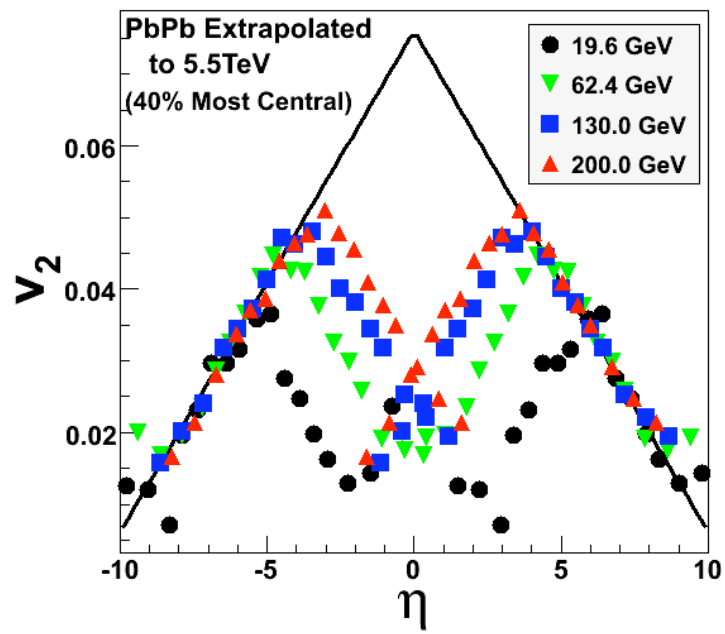


Note: since dn/dη and v2 show saturation, de facto the dn/dη and v2 saturation curves give the results for these quantities that will be obtained in the energy scan at RHIC.



Extrapolation of PHOBOS data to LHC energies will almost certainly fail (at least for dn/dη)





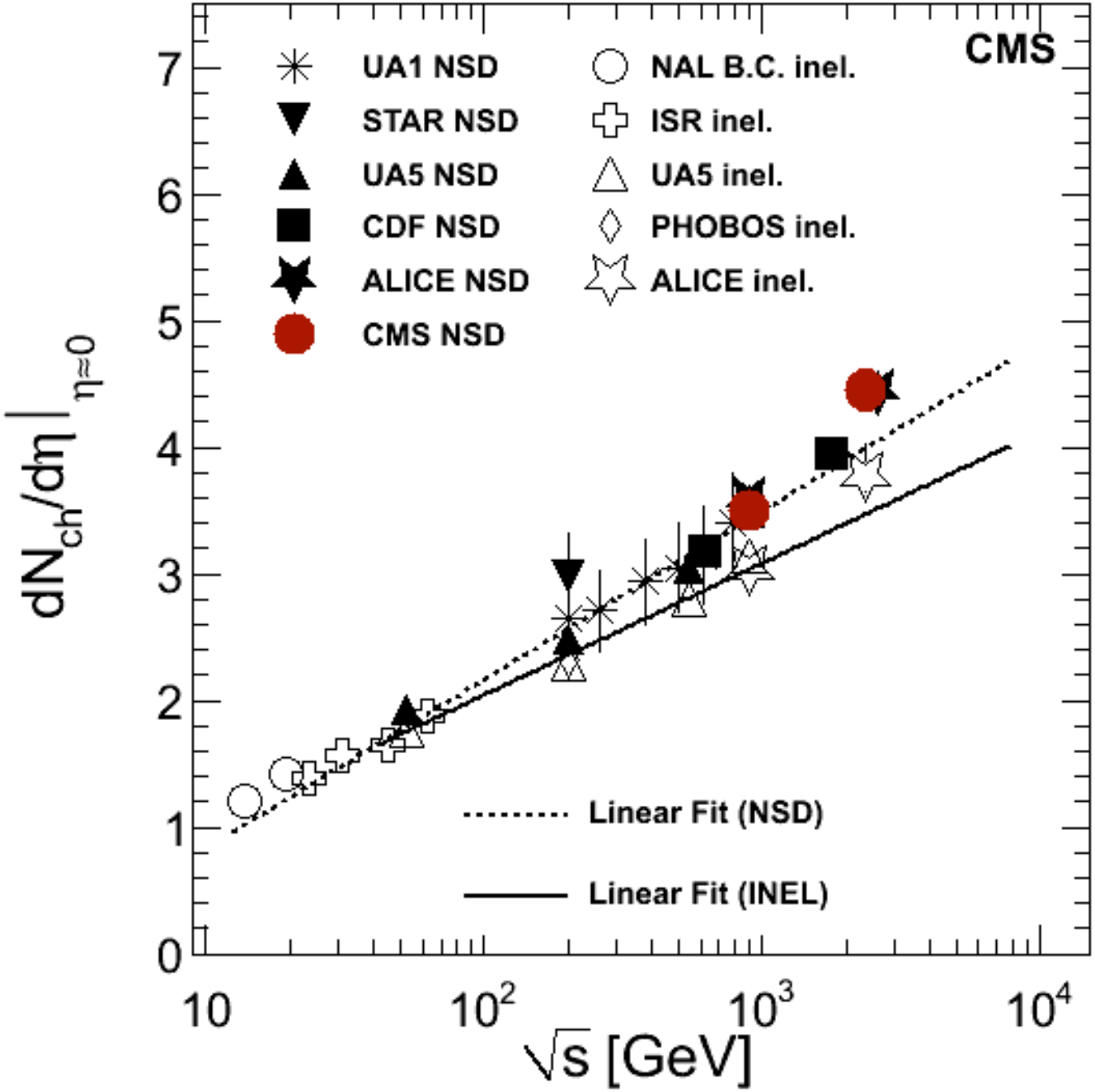
Total charged multiplicity in central (N_{part} = 386) PbPb collisions at $\sqrt{s}$ = 5.5 TeV = 15000 ± 1000

Mid-rapidity dN/dη in central (N_{part} = 386) PbPb collisions at $\sqrt{s}$ = 5.5 TeV = 1200 ± 100

Total charged multiplicity in inelastic pp collisions at $\sqrt{s}$ = 14 TeV (10 TeV) = 60 ± 10 (56 ± 9)

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

Extrapolation: WB J. Phys. G35, 044040 (2008).



Data points from CMS
JHEP 02 (2010)041