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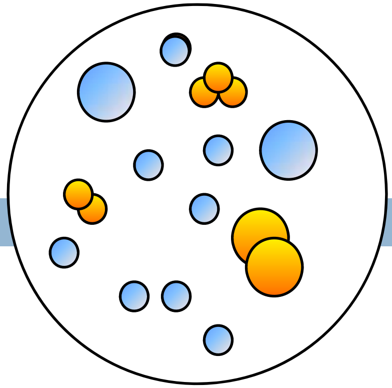
NET-BARYON PHYSICS

LIP

Basic Mechanism

Introduction I



- Net-Baryon = (Baryons - Anti-Baryons)
- As the baryon number is conserved, the net-baryon keeps track of the energy-momentum carried by the incoming particles
- At very high energy it is assumed that sea quarks dominate over the valence
- How does the fraction of energy carried by the net-baryon evolve as a function of the centre-of-mass energy per nucleon?

Introduction II

- The net-baryon has not been fully studied by Experiments
- In Monte Carlo hadronic models the physics of net-baryon production is very much obscured by the complexity of extensive and detailed codes

- Build a simple model to explain net-baryon data and predict the behaviour at higher energies

What we know…

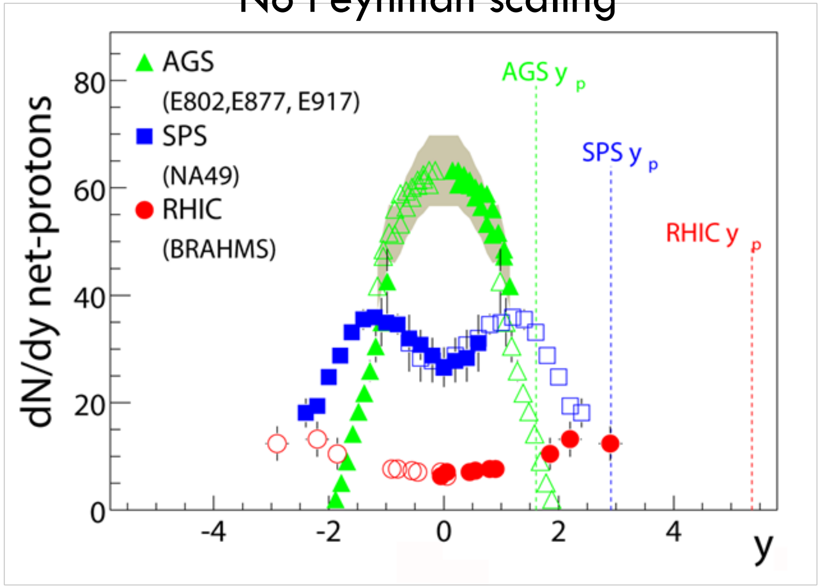
- Experimental Data
  - AGS
  - NA49
  - RHIC – (BRAHMS)
- Current Model Predictions
  - EPOS 1.61
  - QGSJET-II.03

Net-Proton Data

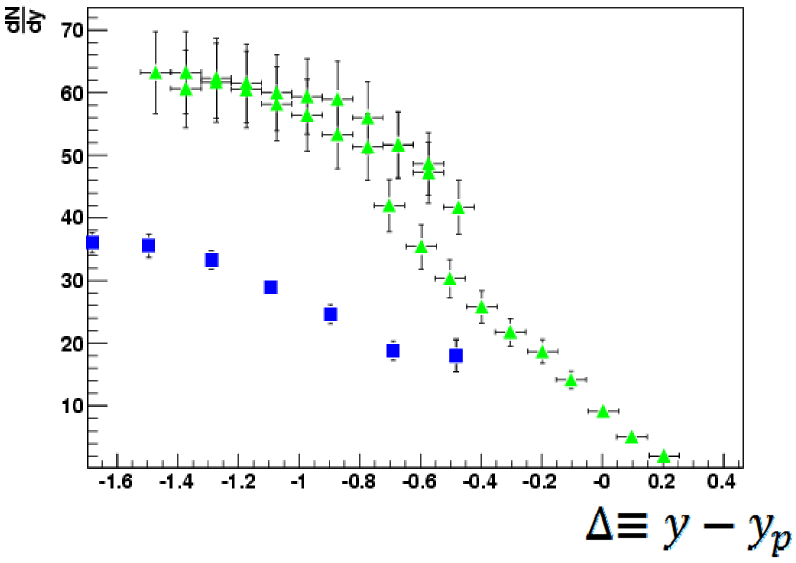
Rapidity Distribution

Δ Distribution ($\Delta \equiv y - y_p$)

No Feynman scaling



No limiting fragmentation



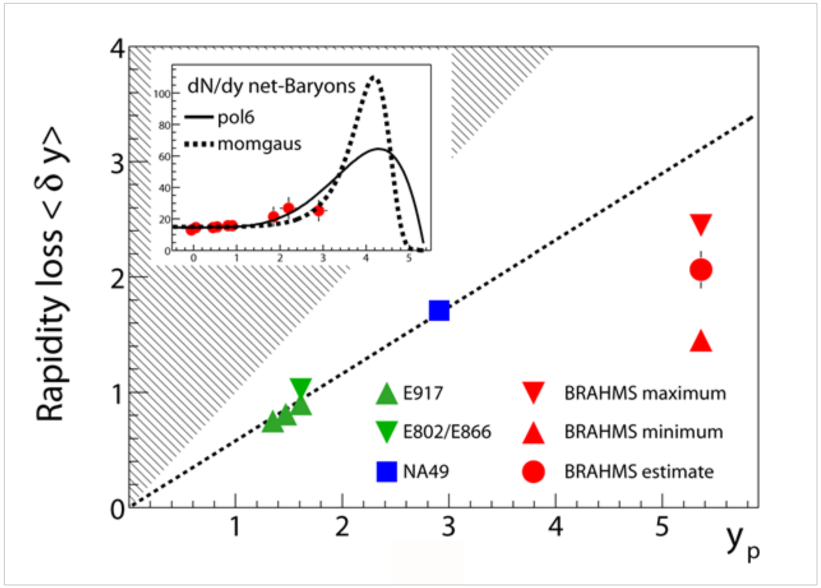
5% most central collisions

Data have been corrected for weak decays

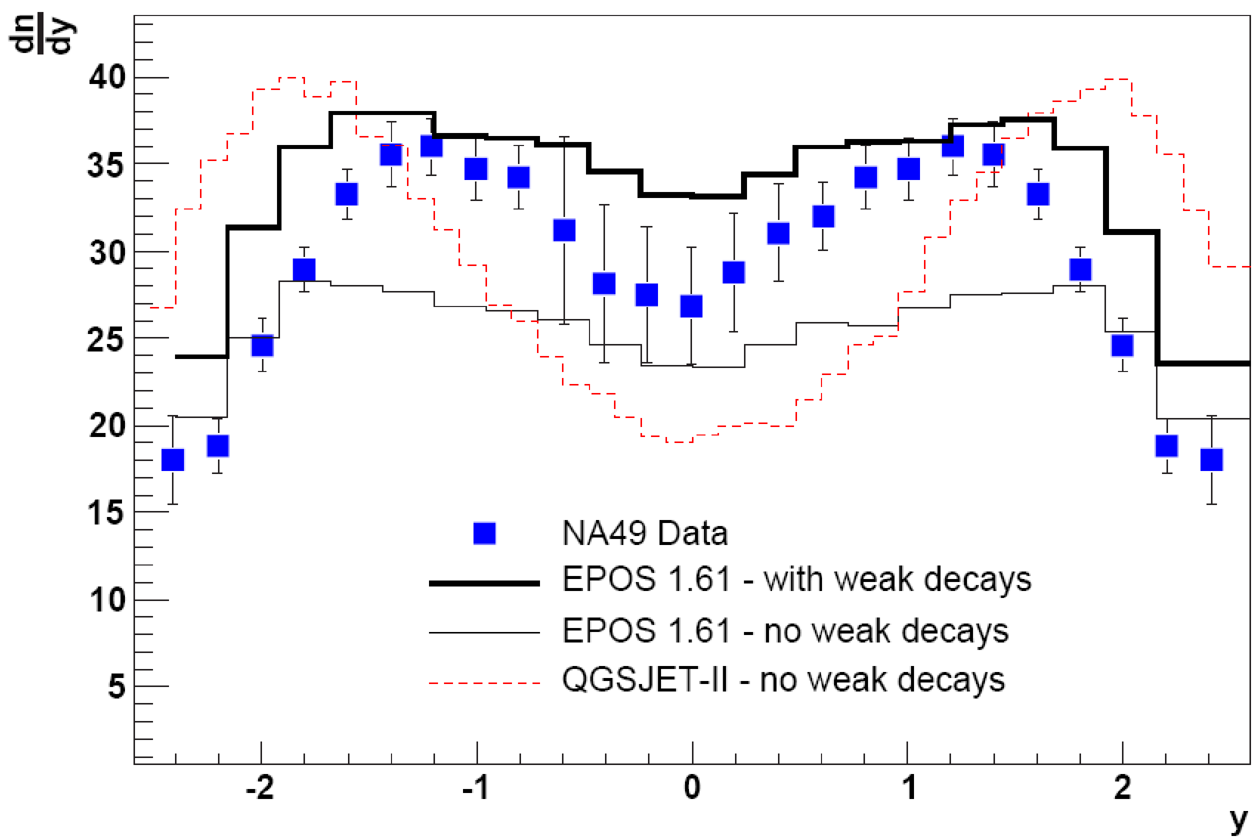
Experimental Data

- Rapidity loss given by
  - $\langle \delta y \rangle = y_p - \langle y \rangle$
    - y_p is the beam rapidity
    - $\langle y \rangle = \frac{2}{N_{part}} \int_0^{y_p} y \frac{dN_{B-\bar{B}}(y)}{dy} dy$
- Scarce Data
- Large uncertainties

Net-Baryon Rapidity Loss



Model Predictions (Pb-Pb at 17 GeV)



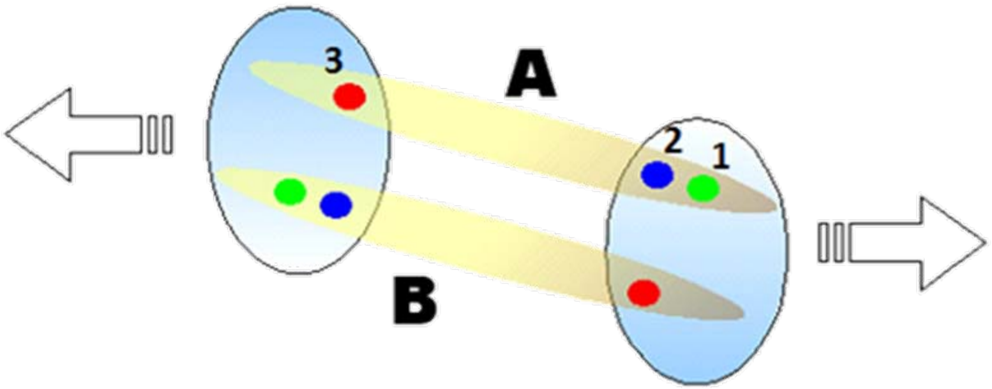
- Weak decay Corrections Applied to Data
- QGSJET-II is not expected to perform very well at such low energies

Our Simple Model

- Description of the model
- Comparison with data
- Predictions for higher energies

Model – String Formation

- Formation of extended color fields or strings
  - Quark Combinatorial
- The string gets its energy-momentum from the valence quarks PDFs
  - Dependency of Q^2
  - CTEQ6
  - Nuclear effects taken into account (EKS98)



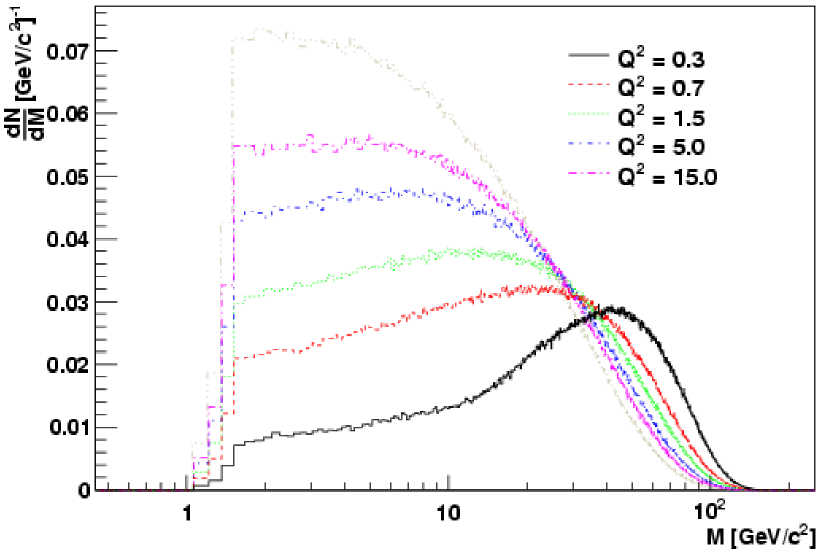
$$E_A = (x_1 + x_2 + x_3)\frac{\sqrt{s}}{2}$$

$$P_A = (-x_1 + x_2 + x_3)\frac{\sqrt{s}}{2}$$

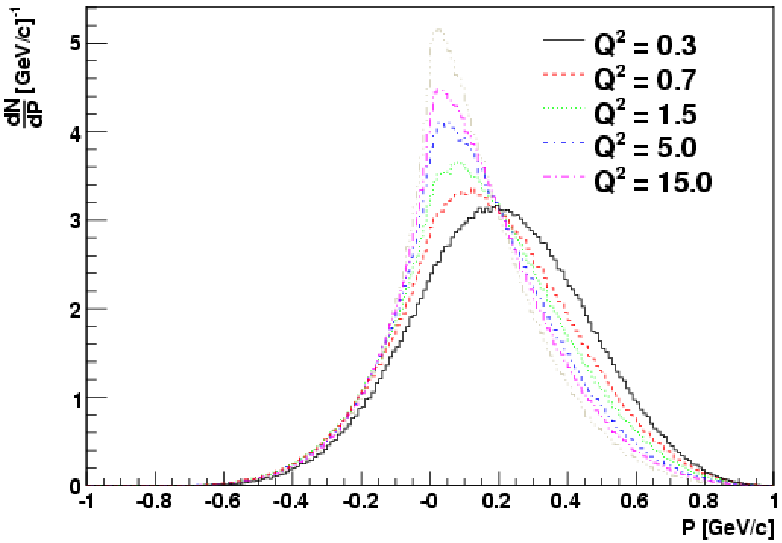
$$M = \sqrt{E^2 - P^2} = \sqrt{x_1\,(x_2 + x_3)\,s}$$

String Characteristics (200 GeV)

Mass Spectrum of strings



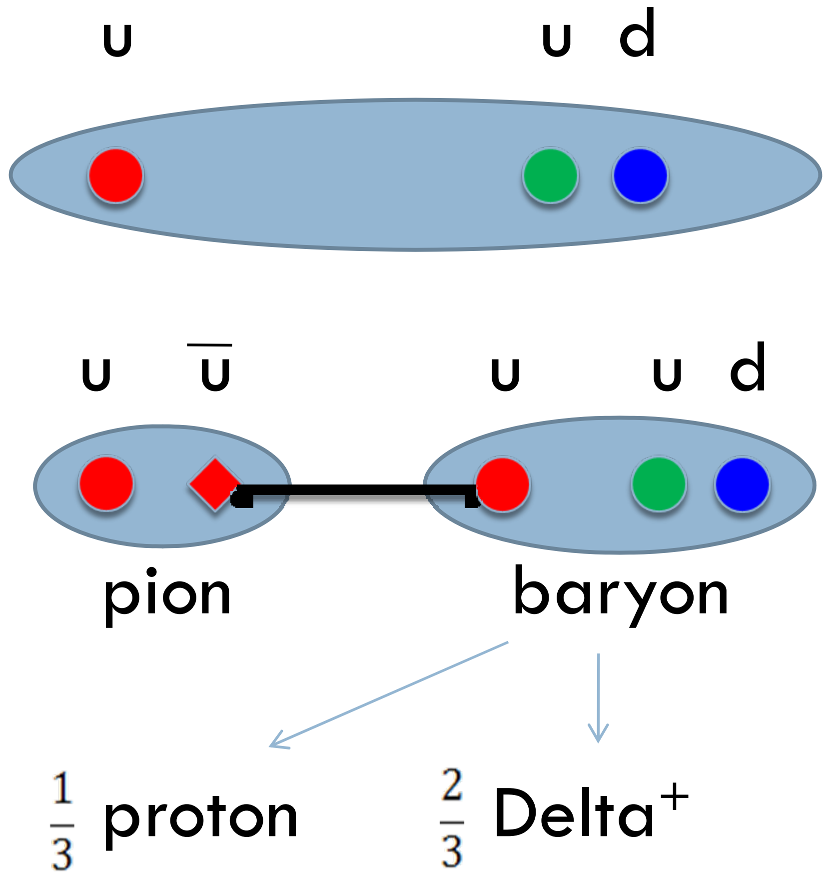
Momentum of string A



Model – String Fragmentation

- Mechanism of String Fragmentation:
  - It is assumed that the string decays into a baryon and a meson
  - Kinematic Constraints
  - Both fundamental and excited states were considered taking spin-dependent weights (2j+1)
  - Unstable baryon were forced to decay in order to enter in net-baryon calculations
  - The contribution of s quarks was not considered at this point

- Example



Model – String Fragmentation II

- Mechanism of String Fragmentation:
  - The baryon produced will have the direction of the two nearest quarks in momentum
    - Diagram 1 is predominant at low energies
    - At high energies Diagram 2 will be as important as Diagram 1
- Can reproduce some features of string baryon junction and pop corn

$$x_3 < x_2 < x_1$$

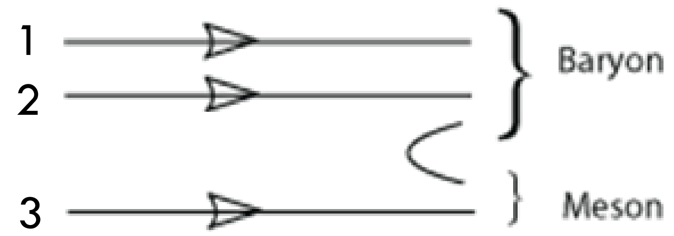


Diagram 1

$$x_1 - x_2 < x_2 - (-x_3)$$

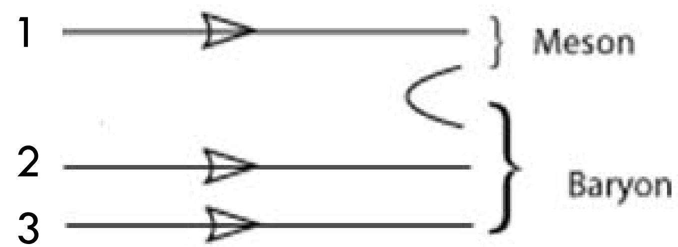
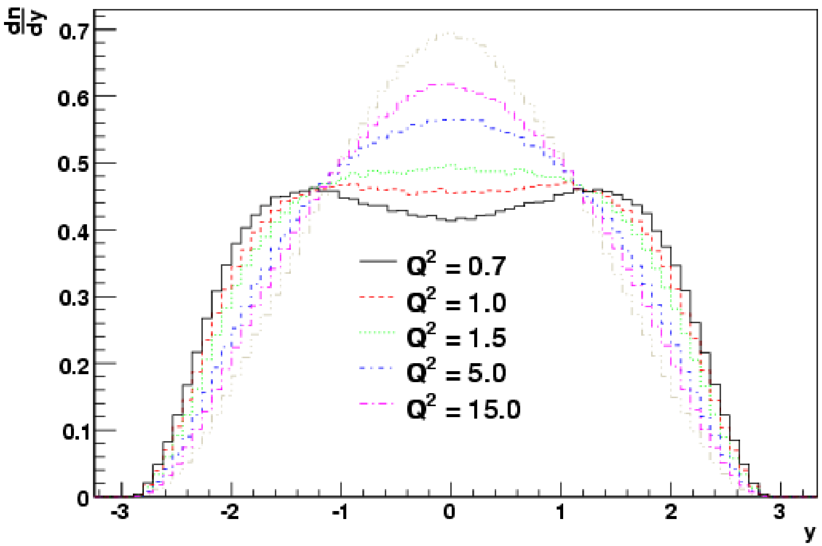


Diagram 2

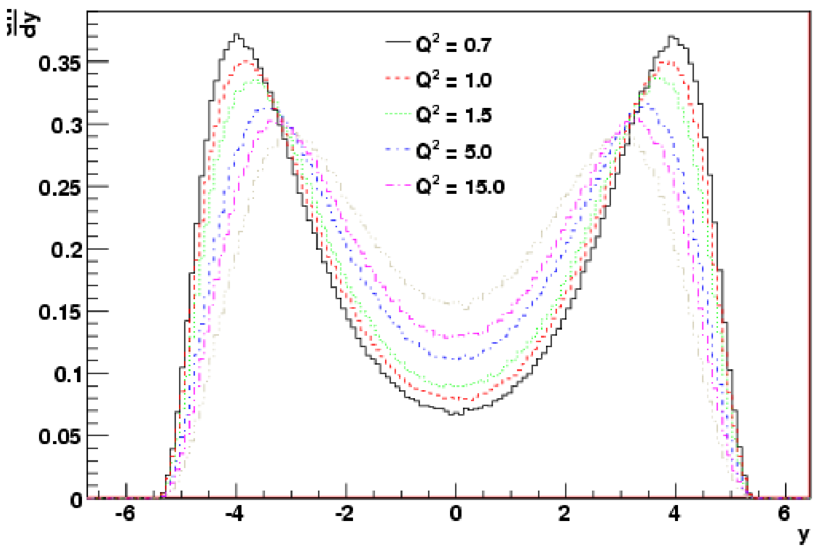
$$x_1 - x_2 > x_2 - (-x_3)$$

Net-Baryon Rapidity

17 GeV



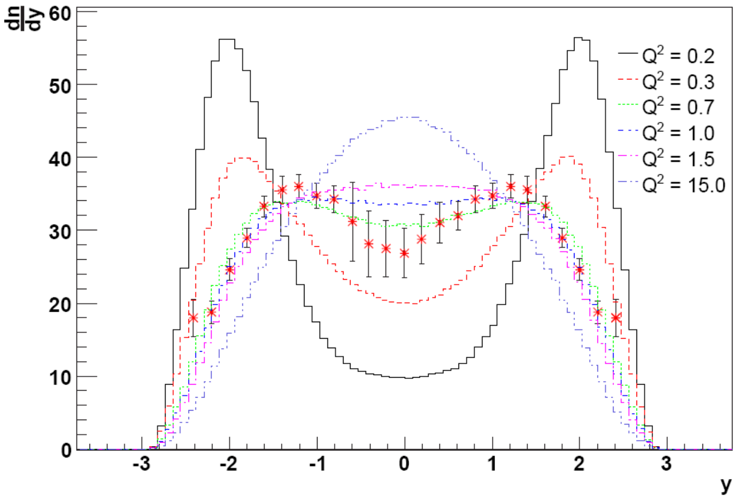
200 GeV

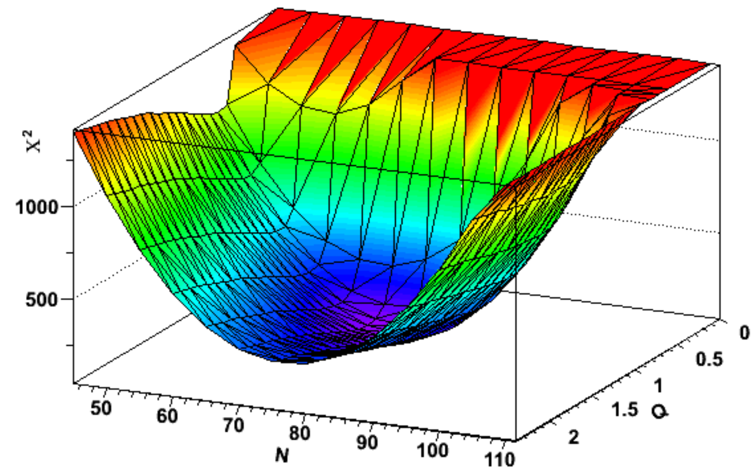


Evolution with energy is a consequence of QCD evolution of the PDFs and kinematic constraints in the string fragmentation

Effective Q^2 – Data Fits

- Effective Q^2 as quark PDFs input
- Fits were performed to the available net-proton data
  - Q^2
  - Normalization factor
    - pp → AA collisions
    - net-baryon → net-proton
    - strange baryons contribution

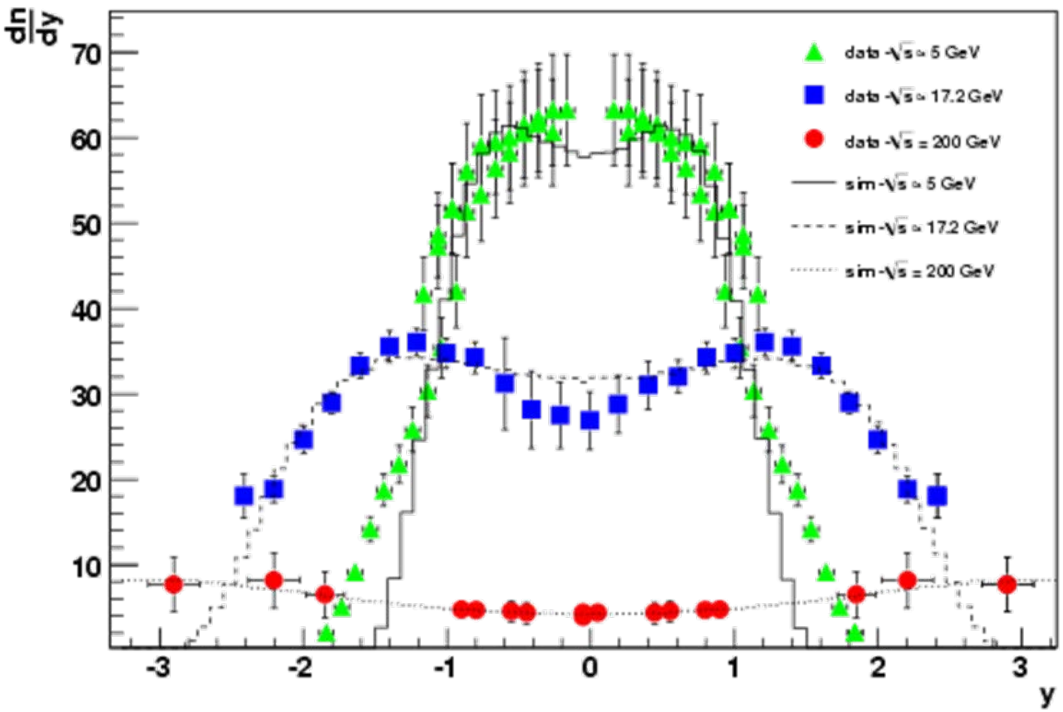




Comparison with Data

Assuming that:

$$\left.\frac{dn}{dy}\right|_{A-A} \simeq \frac{1}{2} N_{part} \times \left.\frac{dn}{dy}\right|_{p^*-p^*}$$



p^* - proton pdfs with nuclear corrections

Evolution with collision energy $\sqrt{s}$

Relate effective Q^2 with collision energy using

$$Q^2 = Q_0^2 \left(\frac{\sqrt{s}}{\sqrt{s_0}} \right)^{\lambda_v} \; [GeV^2]$$

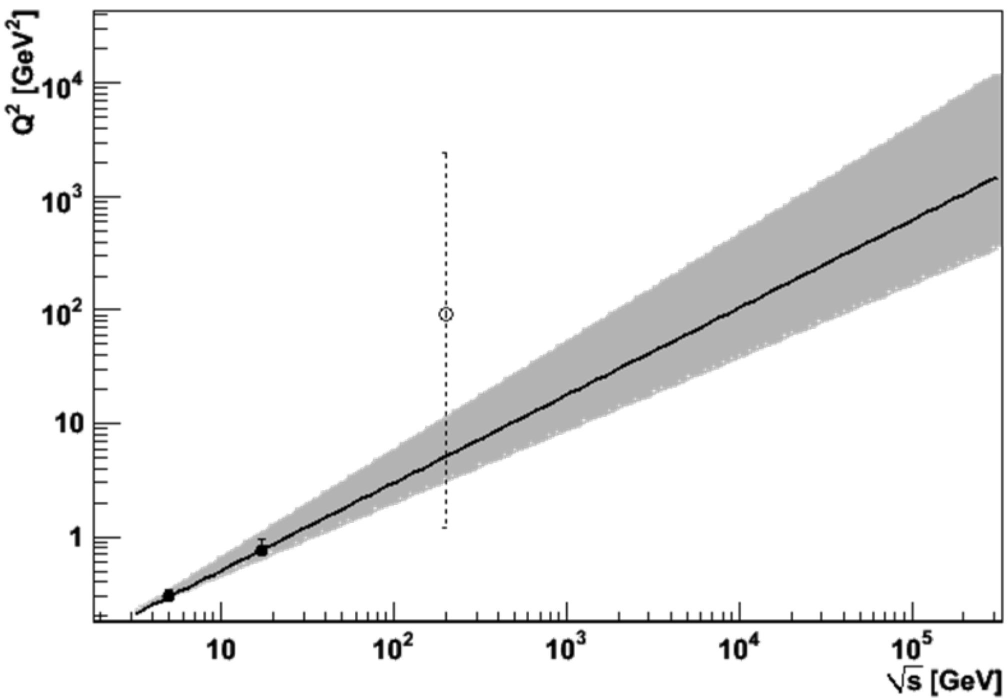
Taking $\sqrt{s_0}$ = 5 GeV

We obtain:

$$\lambda_v = 0.77^{+0.18}_{-0.13}$$

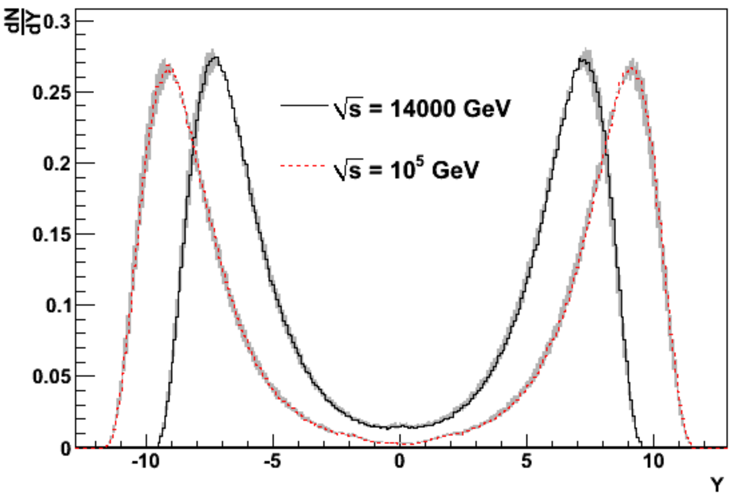
$$Q_0^2 = 0.30^{+0.05}_{-0.01}$$

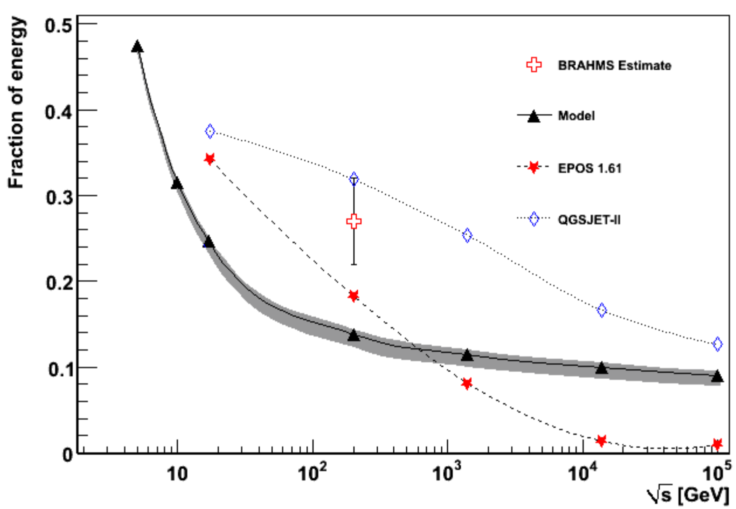
$\sqrt{s}$ (GeV)	Collision	Q^2 (GeV^2)	N_{part}
5	Au-Au	$0.30^{+0.04}_{-0.01}$	$269.9^{+10.4}_{-9.0}$
17	Pb-Pb	$0.77^{+0.18}_{-0.04}$	$299.6^{+9.7}_{-7.7}$

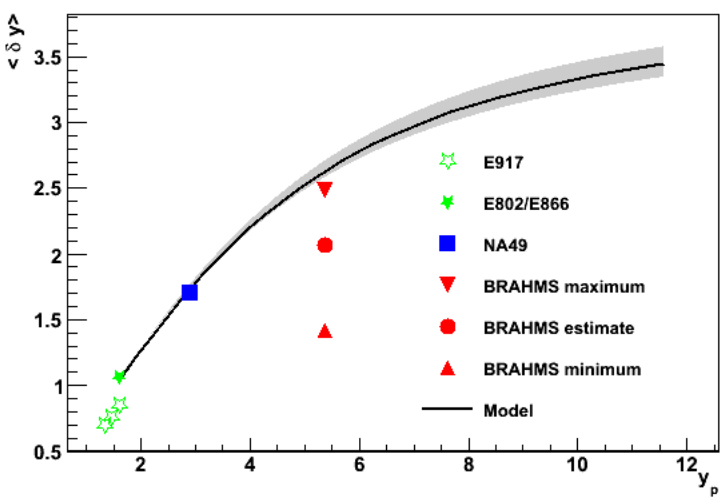


Net-Baryon Predictions

- Rapidity distribution
- Rapidity Loss
- Fraction of energy carried



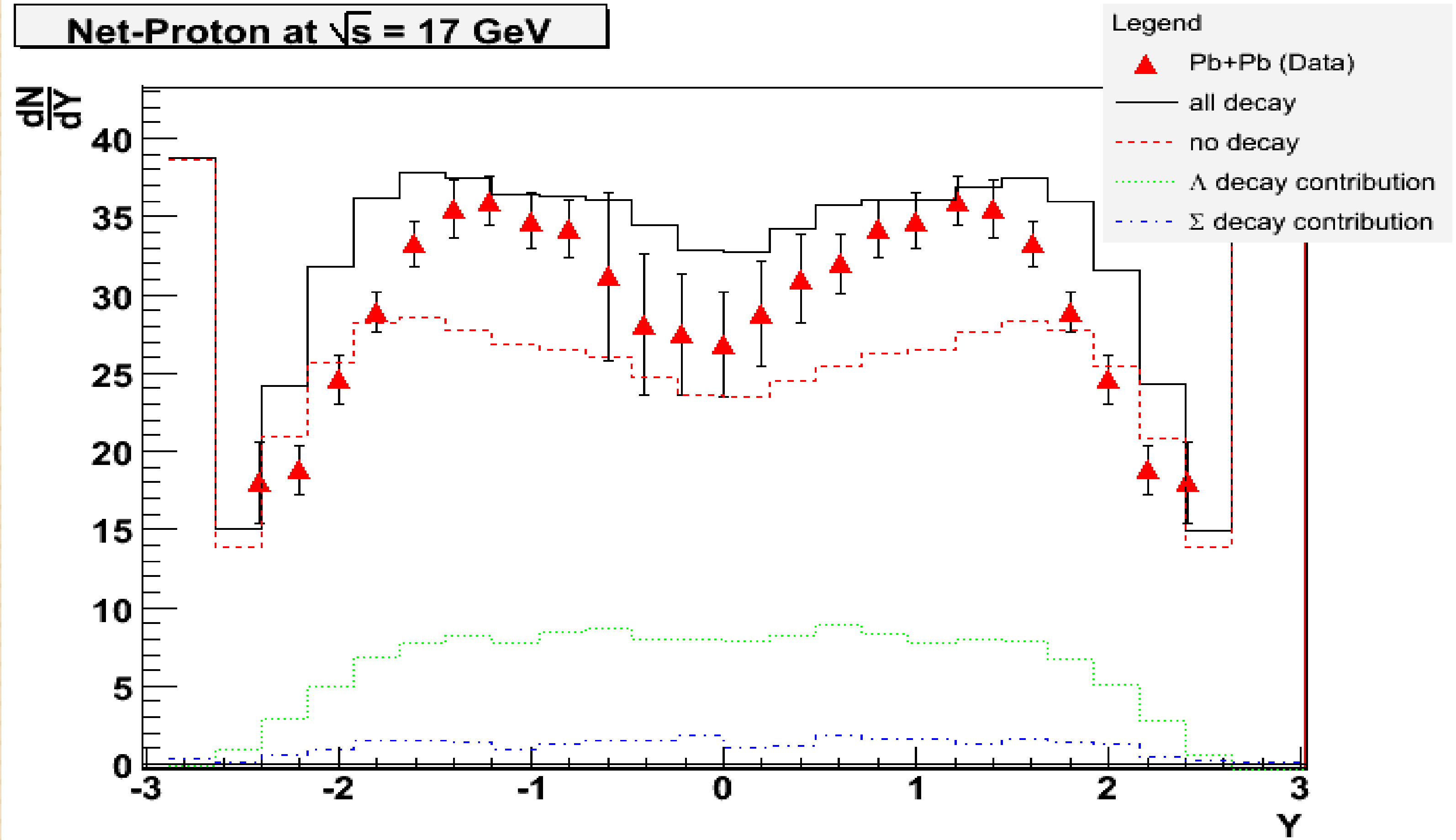




Conclusions

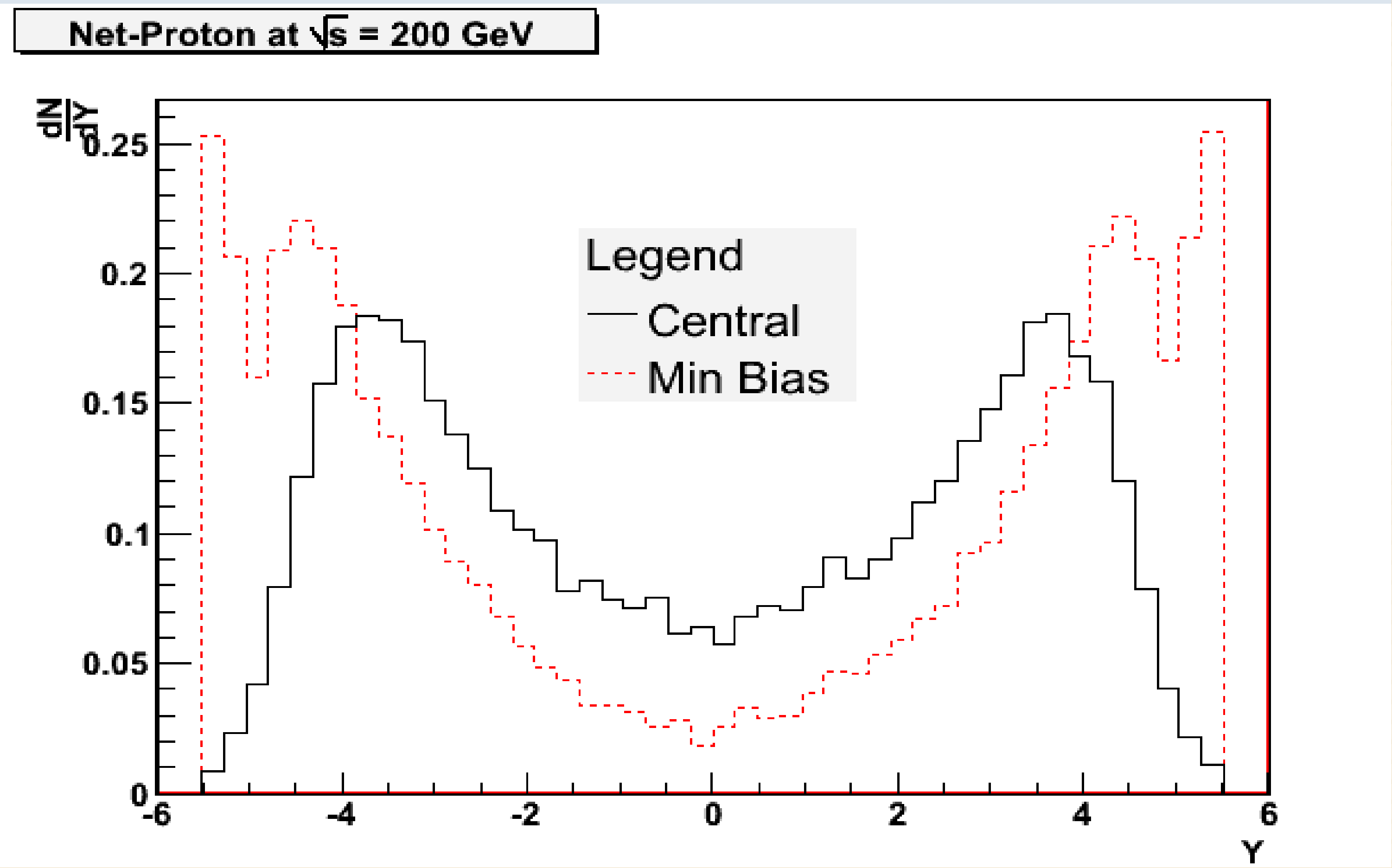
- We believe that the role of the Net-Baryon is not negligible
- EPOS 1.61 and QGSJET-II have problems in reproducing the Net-Baryon data at low energies
- Simple Model can reproduce the Net-Baryon's main features
- Centrality dependence is under study
- New (and forward) data needed!!

Backup slides



Weak decays

EPOS 1.61



Centrality Dependence

Minimum Bias vs Central Collisions

EPOS 1.61