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

\[ \Delta \text{ Distribution} \ (\Delta \equiv y - y_p) \]

\[ \text{No Feynman scaling} \]

\[ \text{No limiting fragmentation} \]

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

\[ \langle y \rangle = \frac{2}{N_{\text{part}}} \int_0^{y_p} y \frac{dN_{B-\bar{B}}(y)}{dy} dy \]

- 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**

- **Example:**
  - \(u\) \(u\) \(d\)
  - **pion** \(\rightarrow\) **baryon**
  - \(\frac{1}{3}\) **proton** \(\rightarrow\) \(\frac{2}{3}\) **\(\Delta^+\)**
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.
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
    - $pp \rightarrow AA$ collisions
    - net-baryon $\rightarrow$ net-proton
    - strange baryons contribution
Comparison with Data

Assuming that:

\[ \frac{dN}{dy}_{A-A} \approx \frac{1}{2} N_{part} \times \frac{dN}{dy}_{p^*-p^*} \]

\( p^* \) - 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:

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

$$Q_0^2 = \frac{0.30^{+0.05}_{-0.01}}{}$$
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
Centrality Dependence

Minimum Bias vs Central Collisions