Antibaryon to Baryon Production Ratios in Pb-Pb and p-p collision at LHC energies of the DPMJET-III Monte Carlo

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Genf, 30. Mai 2007

Abstract

A sizable component of stopped baryons is predicted even for Pb-Pb and p-p collisions at LHC energies.
Based on an analysis of RHIC data within framework of our multichain Monte Carlo DPMJET-III the LHC predictions for *pp* and *PbPb* of the model are presented.

Talk at the workshop: Heavy Ion Collisions at the LHC, Last Call for Predictions 2007

What is the idea of the talk?

The presentation is meant as an addendum to Ranft's talk in the multiplicity section about the main DPMJET III prediction.

It addresses baryon stopping in the framework of this pure "initial state model".

Most interesting we consider the component without leading quarks. Where the flavor decomposition is not dominated by final state interactions the quarkless component can be enhanced by considering strange baryon ratios.

Net baryon flow and “initial state models”

One motivation from looking for a baryon stopping component with a flatish rapidity distribution comes from color evaporation models.
In color evaporation models soft gluons can freely rearrange colors.
A color configuration can be arranged, in which the baryonic charge somehow ends up moved to the center. The actual transport is then just an effect of the orientation of the color-compensation during the soft hadronisation.

This transport mechanism can appear in many scenarious. In realistic QGP models, which local equilibration, such a global effect seems difficult. Other ideas about fast baryon stopping exist but to have it as part of the initial process is an attractive option.
Such an initial state model is considered here.

How to treat baryon exchanges?

The phenomenology of such baryon processes in “Dual” models was developed 30 years ago in a ‘Topological” framework
(see p.e. Rossi & Veneziano).
Critical are various baryonium intercepts

$$\alpha^{2}_{Barionium},\ \alpha^{1}_{Barionium},\ \text{or}\ \alpha^{0}_{Barionium}$$

which respectively contain 0, 1 or 2 quark pairs.
These intercepts were estimated using the energy dependence of cross sections and the inclusive baryonic charge stopping.
Some ambiguity remains for the long range component and a confirmation of the flat distribution indicated by RHIC data at LHC would be helpful.

Why is baryon slowing interesting? Introduction

Today such baryon processes are of fundamental interest. One is nowadays convinced that under certain conditions very high energy hadronic scattering can be understood with BFKL Pomeron exchanges described by ladders of dispersion graphs. In these graphs soft effects are contained in effective gluon amplitudes. These include in principle the color compensating mechanism usually modelled as two strings neutralizing triplet colors.

In string phenomenology it is assumed that these predictions somehow apply to minimum bias physics. The idea is that BFKL QCD calculations extrapolate smoothly into the minimum bias region and offer in this way a stringend guidance for modeling the non-perturbative region.

Also for high energies minimum bias events involve string ends with respectable $O(1GeV)$ transverse momenta closely neighboring the perturbative range. The seperation of soft and hard processes is often exaggerated.

Why is baryon slowing interesting?

Beside Pomerons this theory predicts

Odderons

It is a necessary ingredient of this approach. In comparison to the Pomerons they have a similar, somewhat lower intercept and presumably a much smaller coupling.

The central observation is that in inelastic exchanges Odderons can contribute three strings with an exchange of baryon charge. To conclude there is rather solid theoretical support for a rather flat net baryon contribution. The difference between the soft and hard Odderon is of couse unknown but it should be in a similar range as that of the soft and hard Pomeron.

What is the situation at available energies?

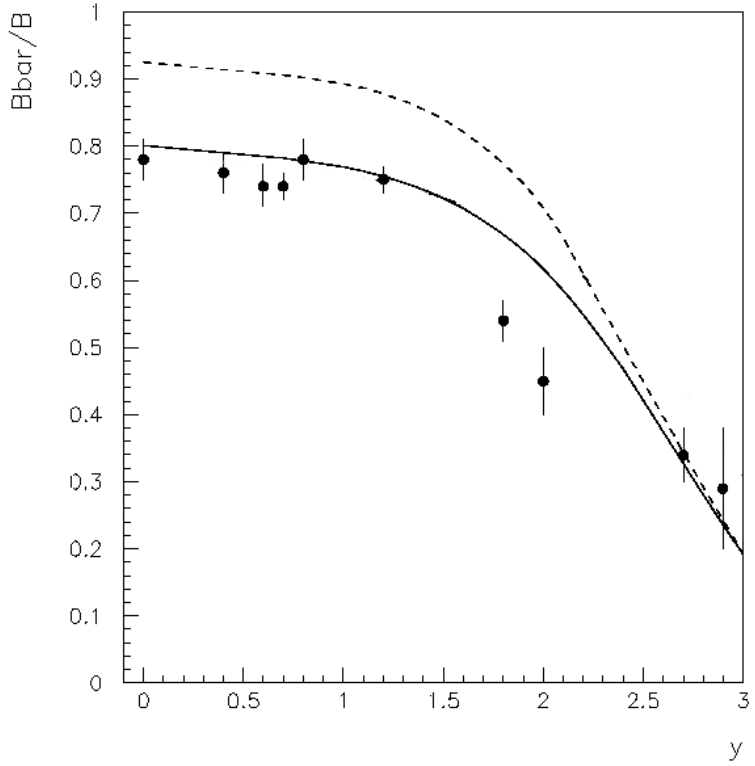
The first indication for a flat component came from never finalized preliminary ZEUS data at HERA.

As RHIC runs *pp* or *heavy ions* instead of $p\bar{p}$
this question could be addressed much better than before in hadronic colliders.

The data seem to require a flat contribution:

RHIC data seen from the Quark-Gluon-String model:

RHIC BRAHMS *pp* Data are compared to an approximation of the model with a simplifying factorisation.
The fit required diquarks with a probability of $\epsilon = 0.024$ to involve a quarkless vortex line with a slope $\alpha_{\{SJ\}} = 0.9$. Unity would correspond to a flat distribution.



At LHC the rapidity extends two units more, allowing considerable clarification

Baryon Transport in DPMJET III

There are several components affecting the position of the net baryon charge:

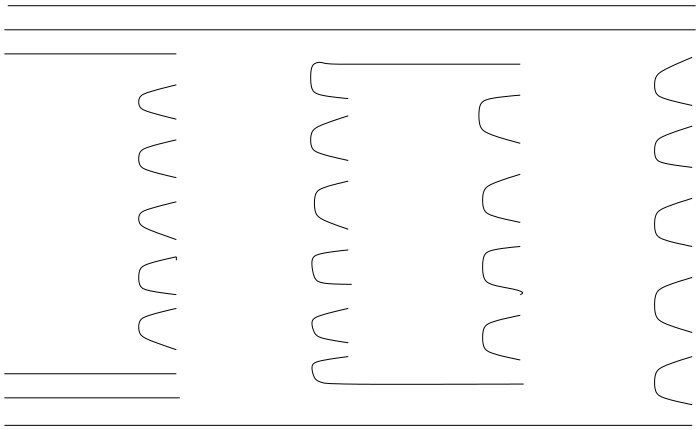
initial diquark structure function
during the string decay: $qq \rightarrow qq$+meson
during the string decay: $qq \rightarrow qq$+baryonium
string fusion effects

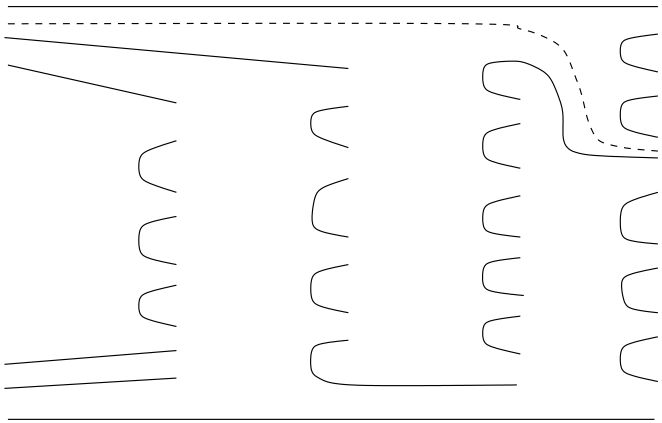
The baryonium is just a wide two meson state.
To obtain a long range baryon transport we introduced a new string interaction flipping the standard string configuration in a certain way. Two cases are thereby considered

string rearangements with glauber sea quarks
string rearangements with unitary sea quarks

The String Rearangement Mechanism

A sea quark which would normally end up on a meson string (upper picture)





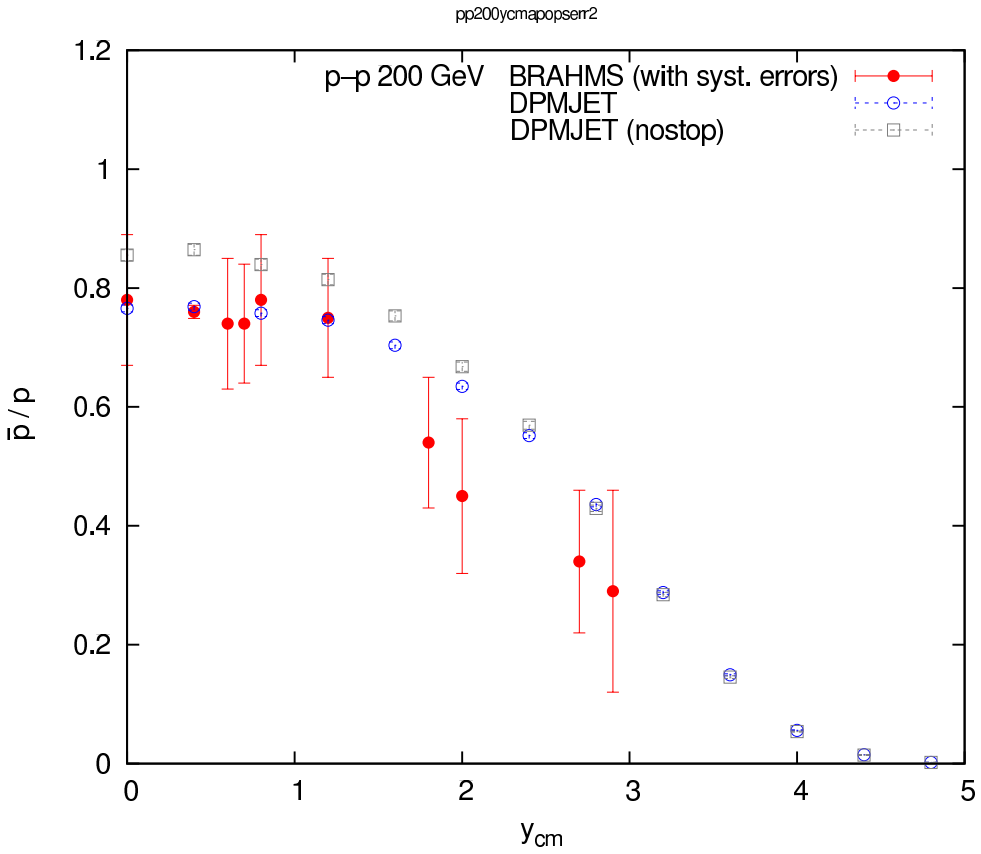
can also pick up a vortex line (lower picture) and flip the structure as shown.

Asymptotically the vortex line picks up the intercept of the sea quarks. In DPMJET III it is presently only 0.5 and not 0.9 of the QGS consideration.

RHIC data seen from the DPMJET III Monte Carlo

The ratio $\bar{p}/p$ as function of y_{cm} compared with BRAHMS data.

At this energy the contribution mainly comes from non flipping effects.

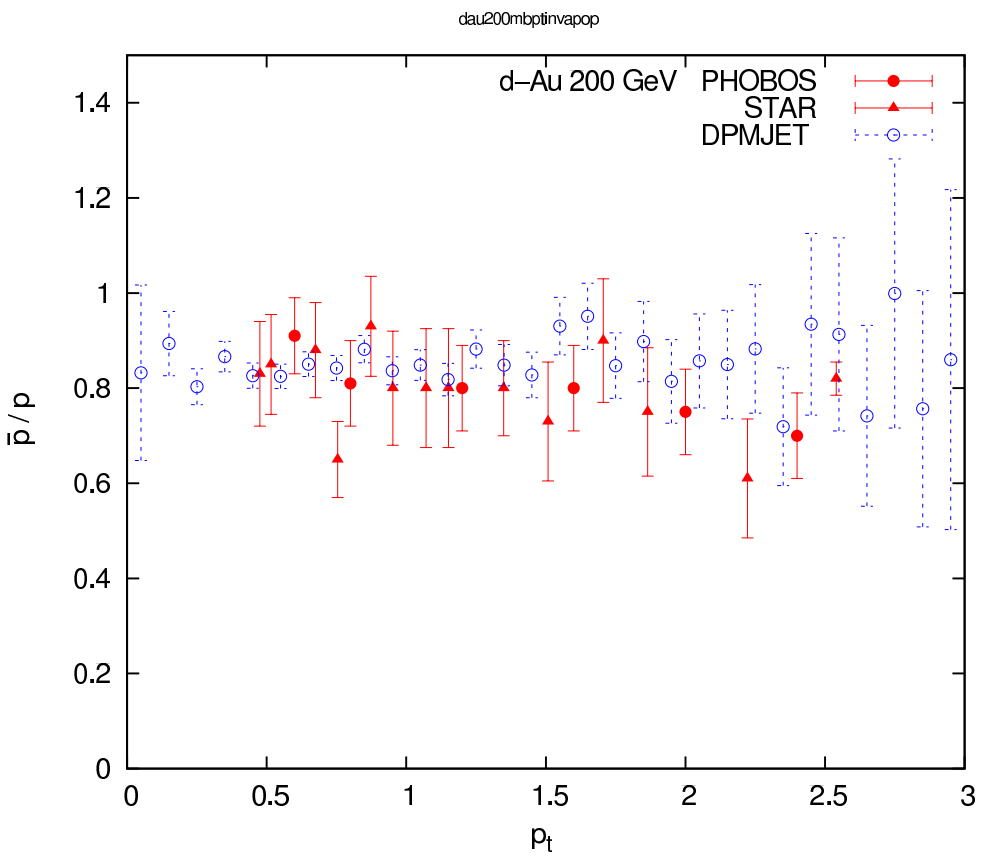


RHIC data seen from the DPMJET III Monte Carlo

The ratio $\bar{p}/p$
as function of $p_\perp$
compared with
PHOBOS and STAR data.

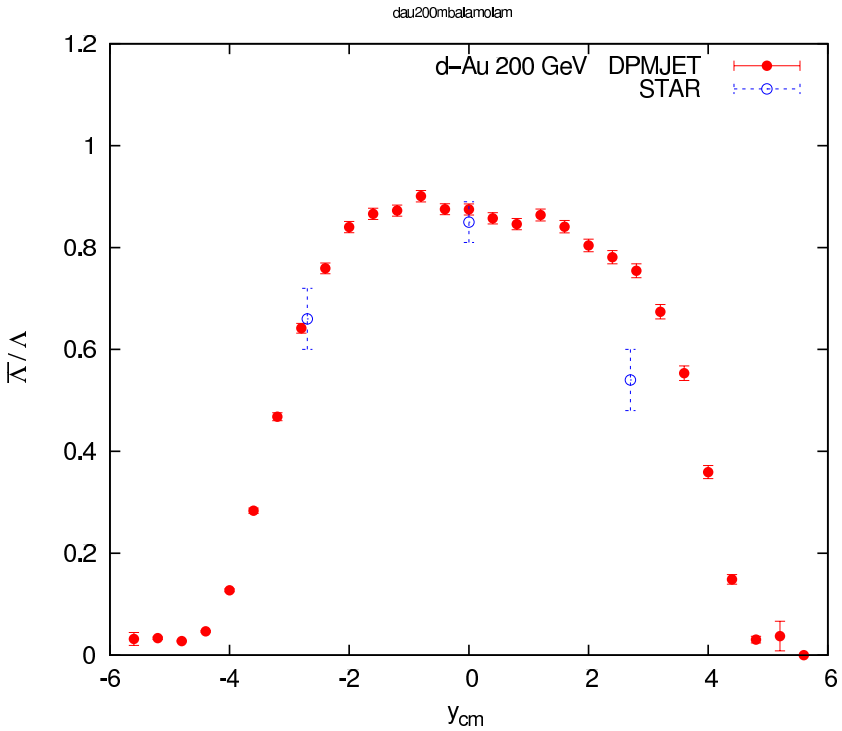
There is no visible $p_\perp$
dependence in the
considered soft range

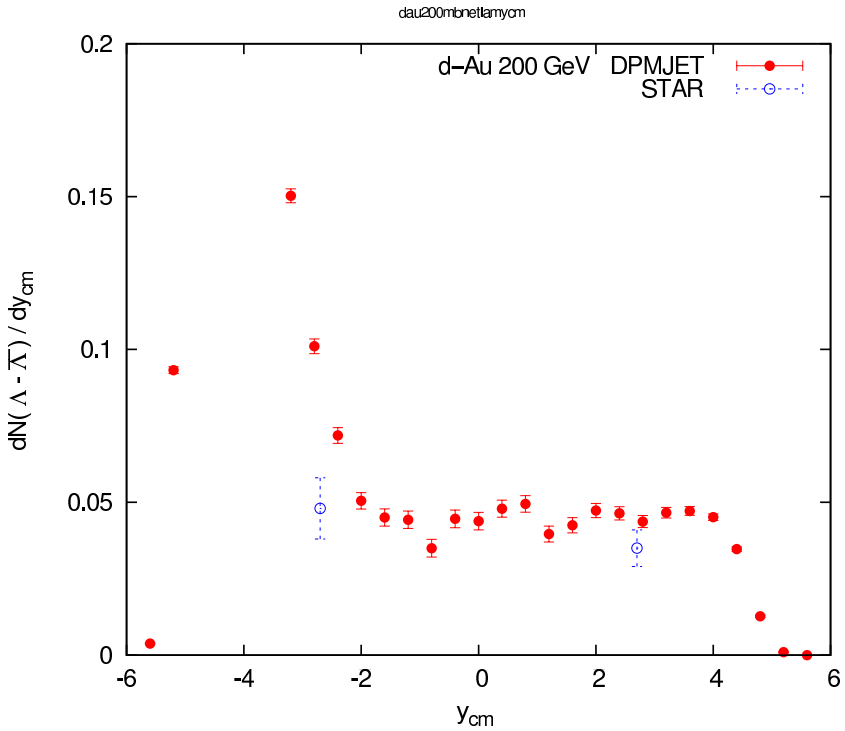
The same applies to the
centrality dependence.



RHIC data seen from the DPMJET III Monte Carlo

Data on Λ's of the STAR collaboration are also reproduced:

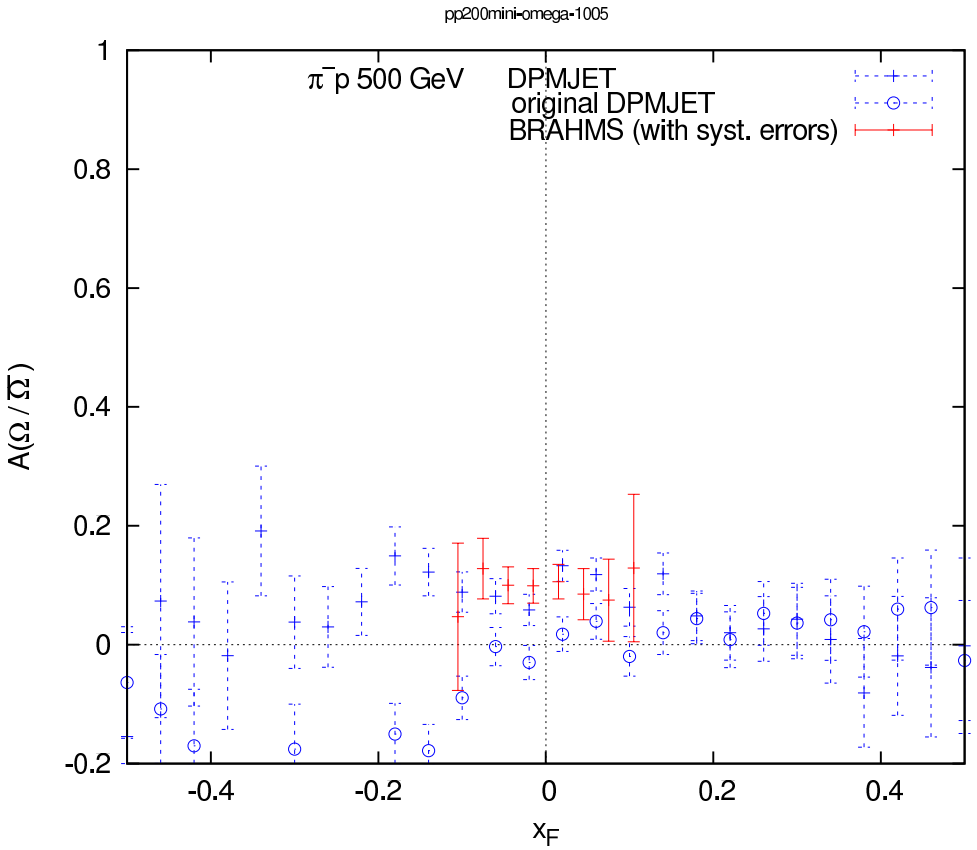




RHIC data seen from the DPMJET III Monte Carlo

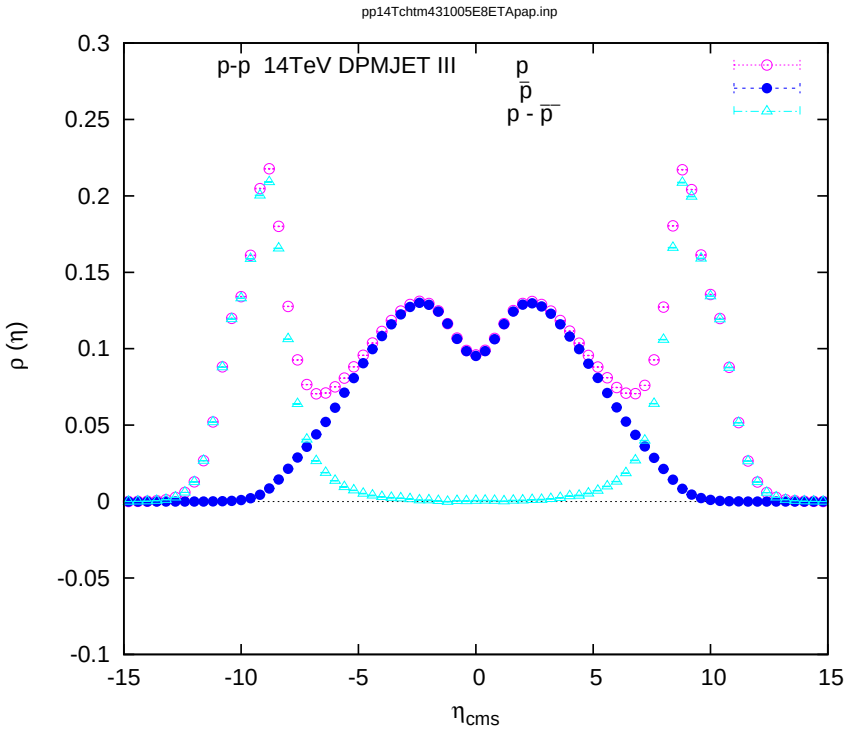
The baryonium production is adjusted from the blue circles to the blue crosses to reproduce the Ω-asymmtry measured by the E798 collaboration in πp scattering.

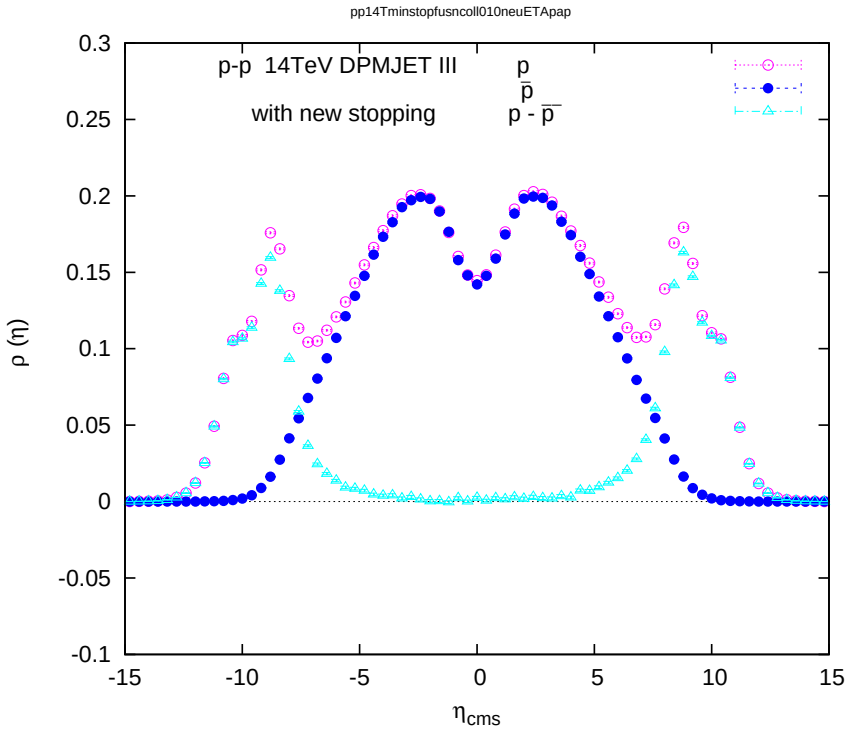
The Ξ asymmetry with an backward peak is not reproduced.



DPMJET III prediction for *pp* LHC

The string-flipping baryon stopping and the string fusion is now considerable effect also for *pp* scattering .

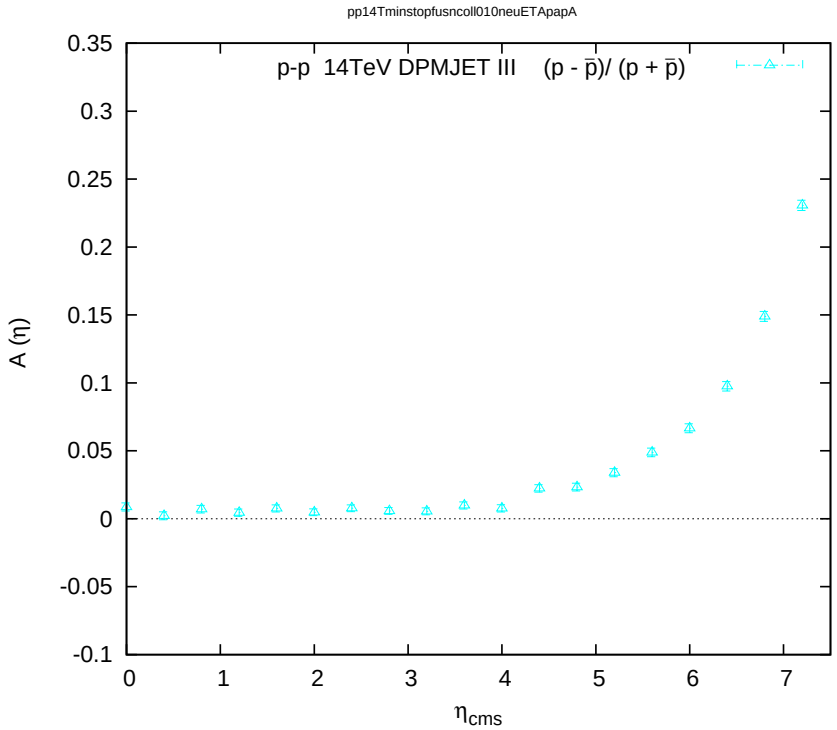




DPMJET III prediction for *pp* LHC

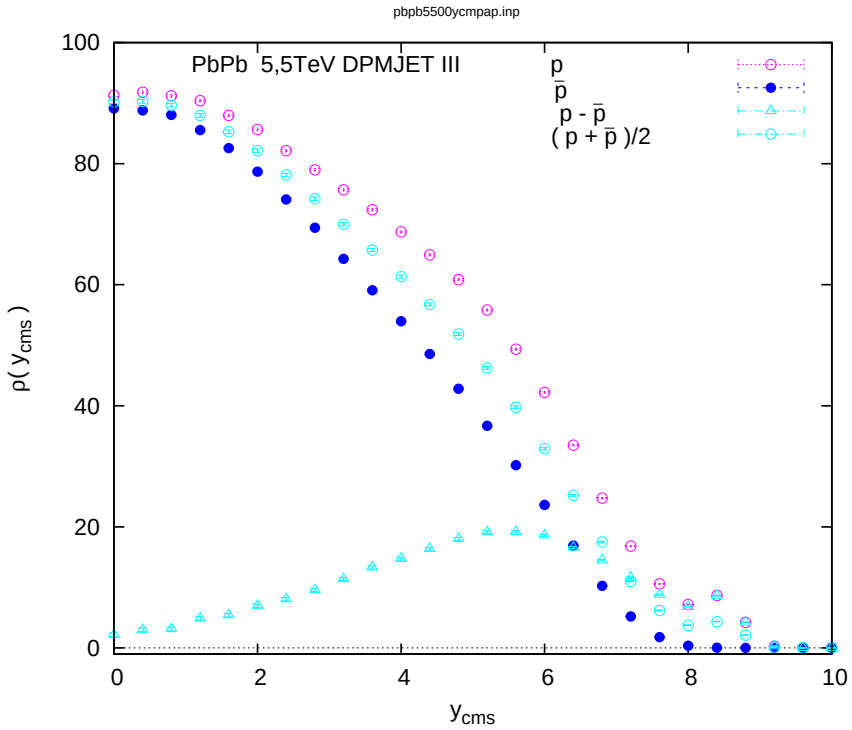
With stopping the prediction for asymmetry is in the percent region.

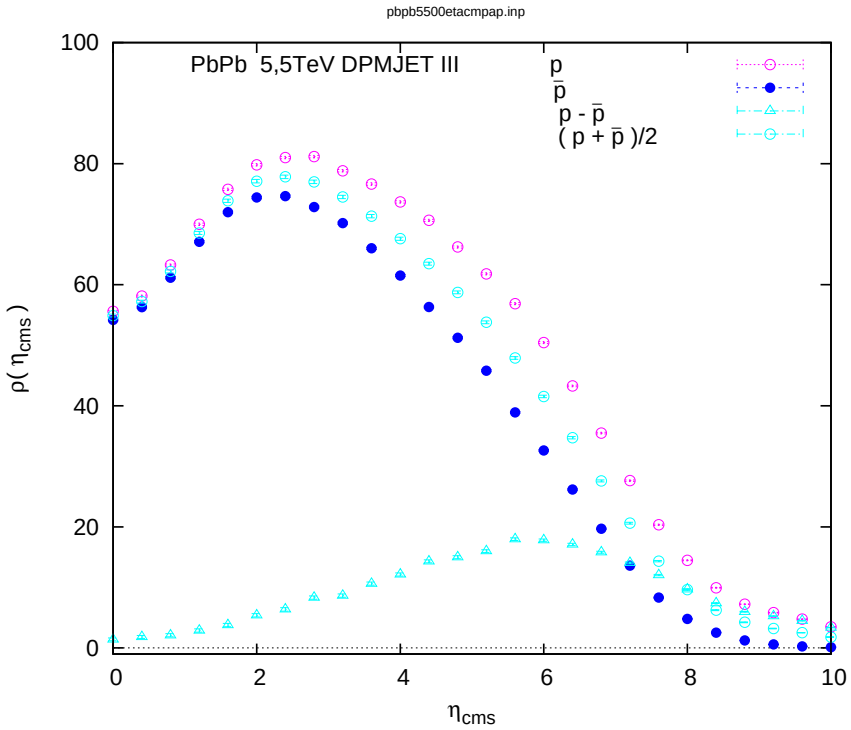
Of course, with the effective intercept of 0.5 the present implementation of the baryon stopping is a rather conservative estimate.



DPMJET III prediction for central *PpPp* LHC

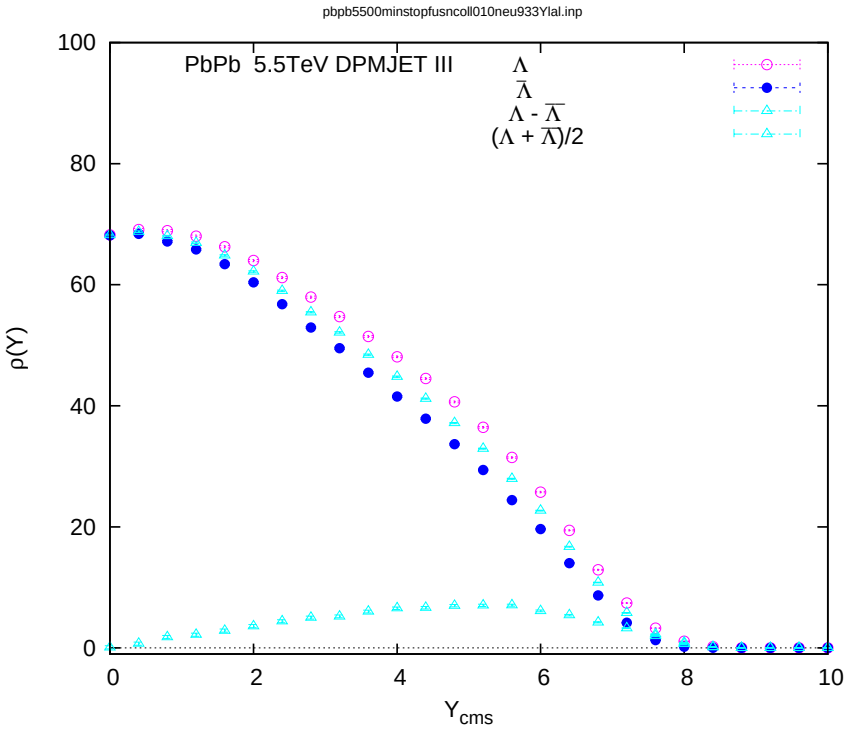
For the most central 10% of the heavy ion events the rapidity and pseudorapidity proton distributions are:

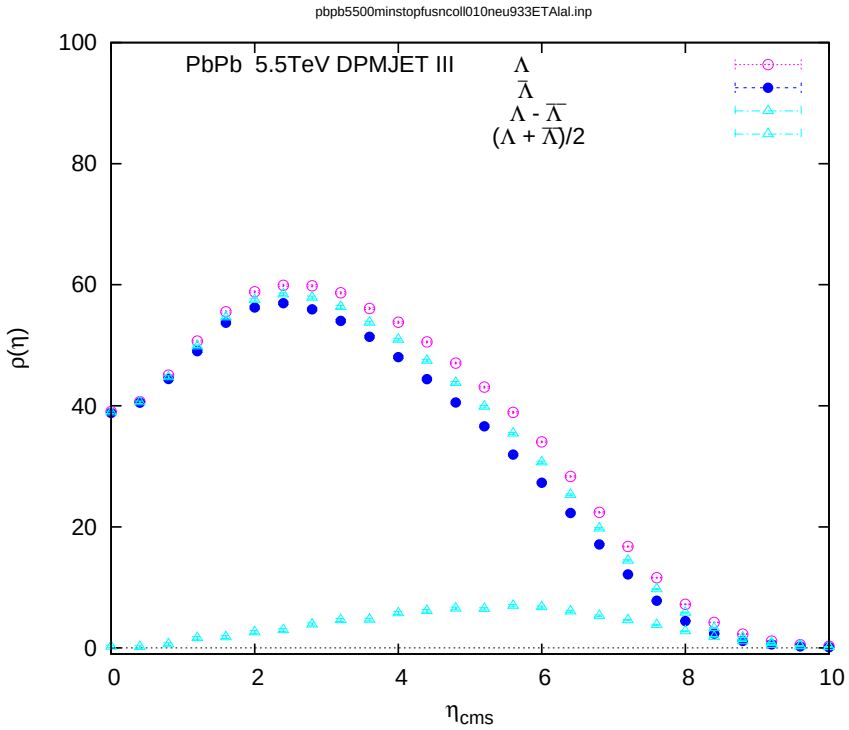




DPMJET III prediction for central *PpPp* LHC

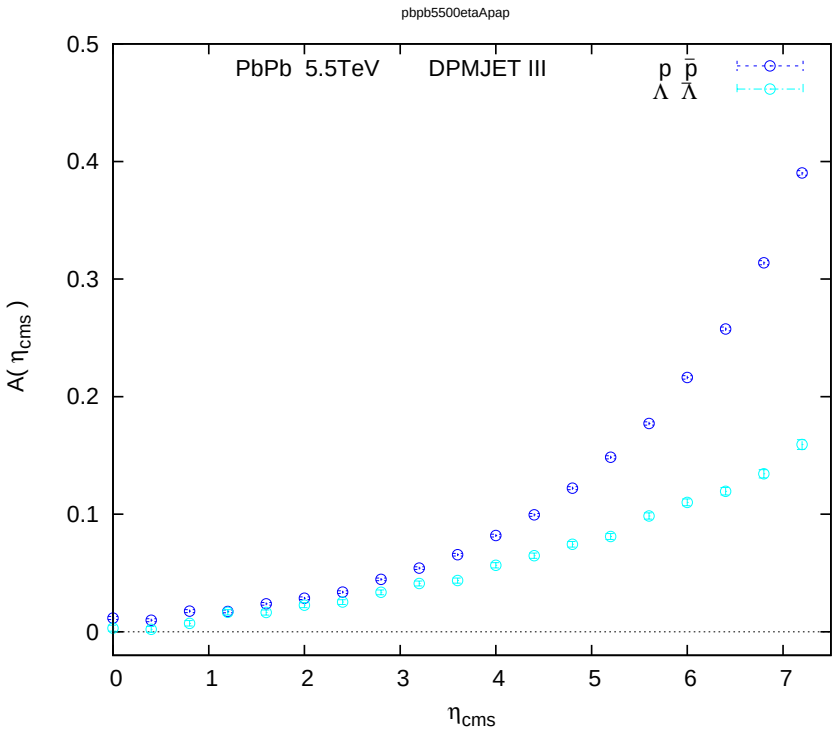
For the most central 10% of the heavy ion events the rapidity and pseudorapidity Λ distributions are:





DPMJET III prediction for central *PpPp* LHC

For the most central 10% of the heavy ion events the asymmetries for p and Λ are then:



This concludes my presentation.

The String Rearangement Mechanism (continued)

The mechanism requires multiple chains.

The model incorporates *unitarity* requiring multiple chains.
For $p - p$ LHC the effect is important, while at $p - p$ RHIC the energy is too small for a significant effect.

In heavy ion scattering a single nucleon has multiple interactions (*Glauber mechanism*).
Multiple strings originating in interactions with seperate nucleons on the other side lead to a significant effect at RHIC for (light or heavy ion)-(heavy ion) scattering.