Proton break-up in pp at RHIC

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Contents

- Why to study pp?
- Some model ideas
- High multiplicity events
- Multi-strange (anti-)baryons
- Conclusions

Why pp is interesting

- Clean environment
  $\rightarrow$ No Flow, No re-scattering, no bulk
- Open Questions:
  Rapidity correlations
  Charged particle fluctuations
  Cluster/Clan Production
  Anti-baryon enhancement

Tools

HIJING:

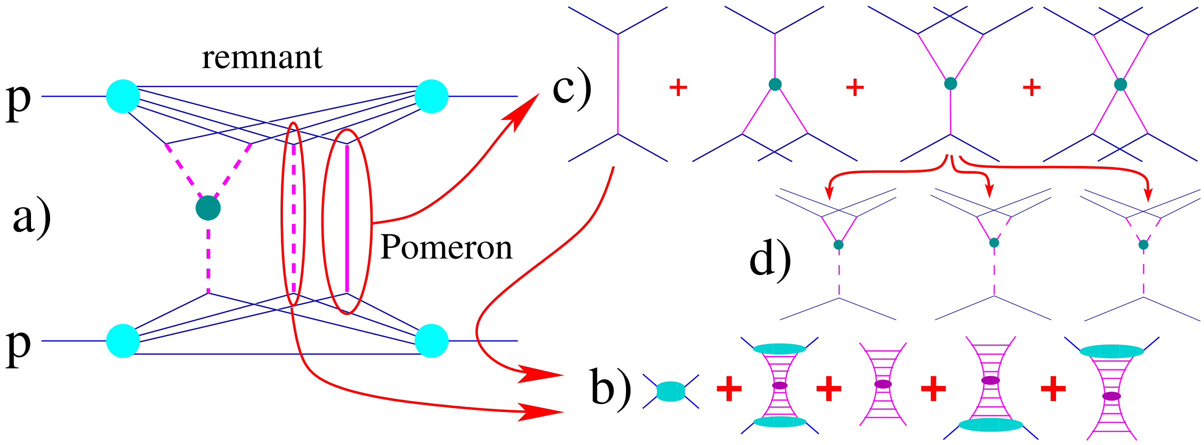
- pQCD hard scattering
- soft interactions ala PYTHIA (longitudinal excitation)
- multiple hard interactions
- high multiplicity due to jets
  $\rightarrow$ in central pp: LOW parton densities

NEXUS:

- pQCD hard scattering
- multiple hard and soft interactions
- based on Pomeron exchange (Color exchange model)
- high multiplicity due to multiple Pomeron exchange
  $\rightarrow$ central pp: HIGH parton densities

Nexus

- The diagrams

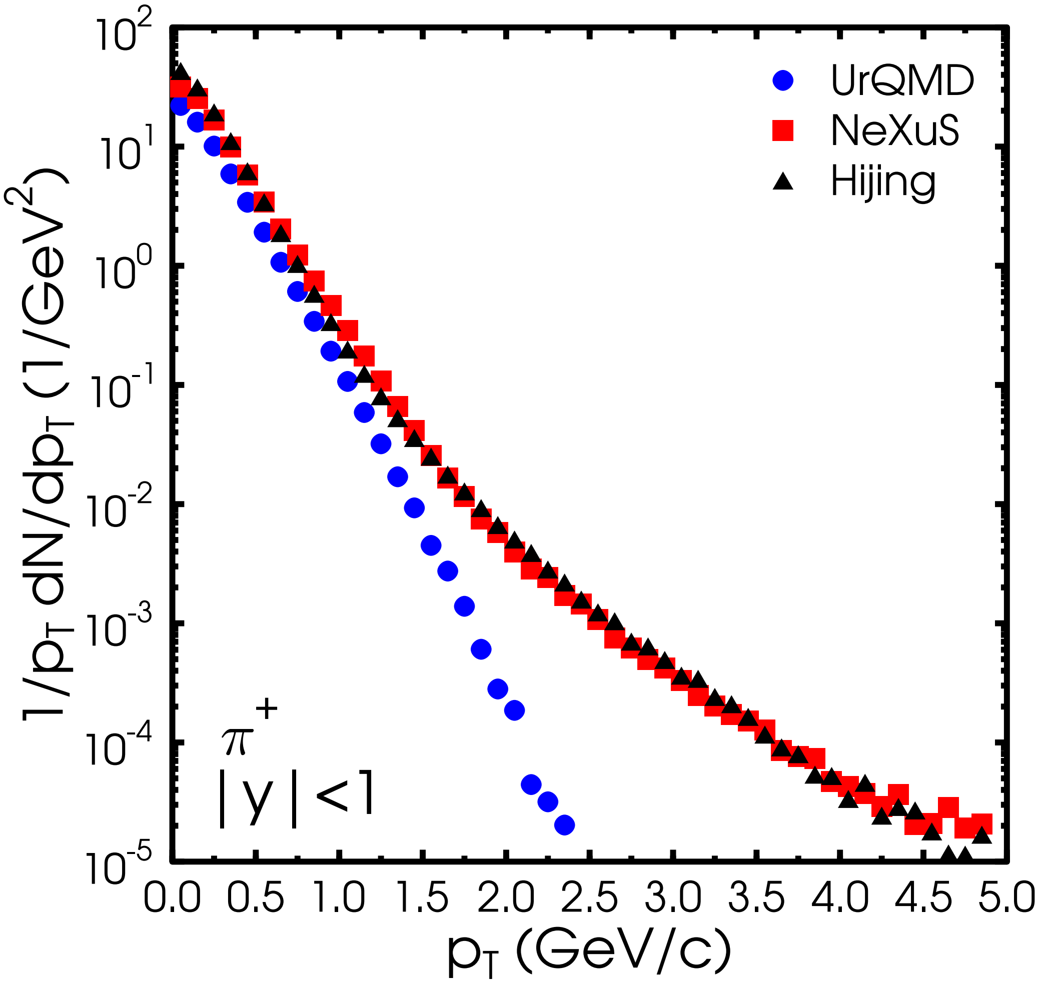


- based on multiple P exchange

see T. Pierog et al., hep-ph/0211202 for details

pp @ 200 GeV

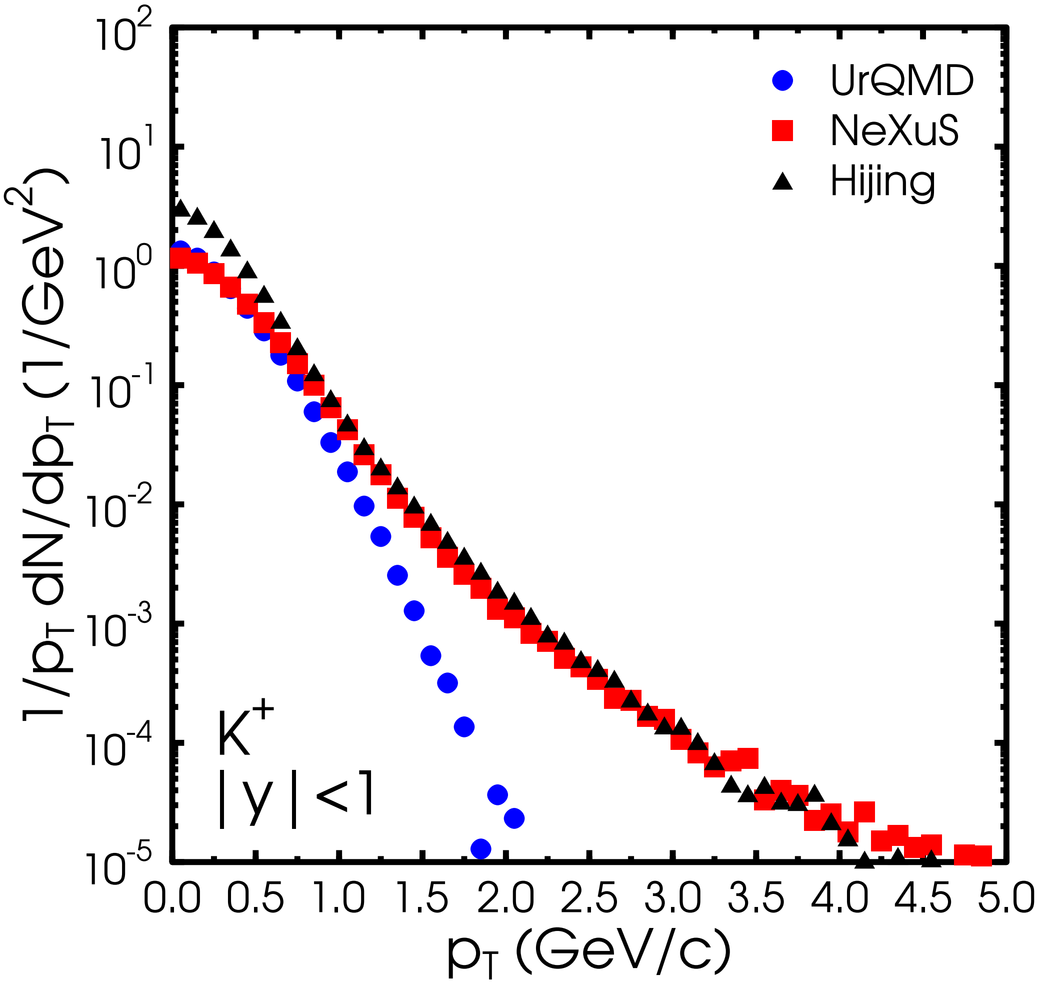
- Pion transverse momentum spectra



- pQCD power law from 1.5 GeV on
- Hijing and Nexus identical

pp @ 200 GeV

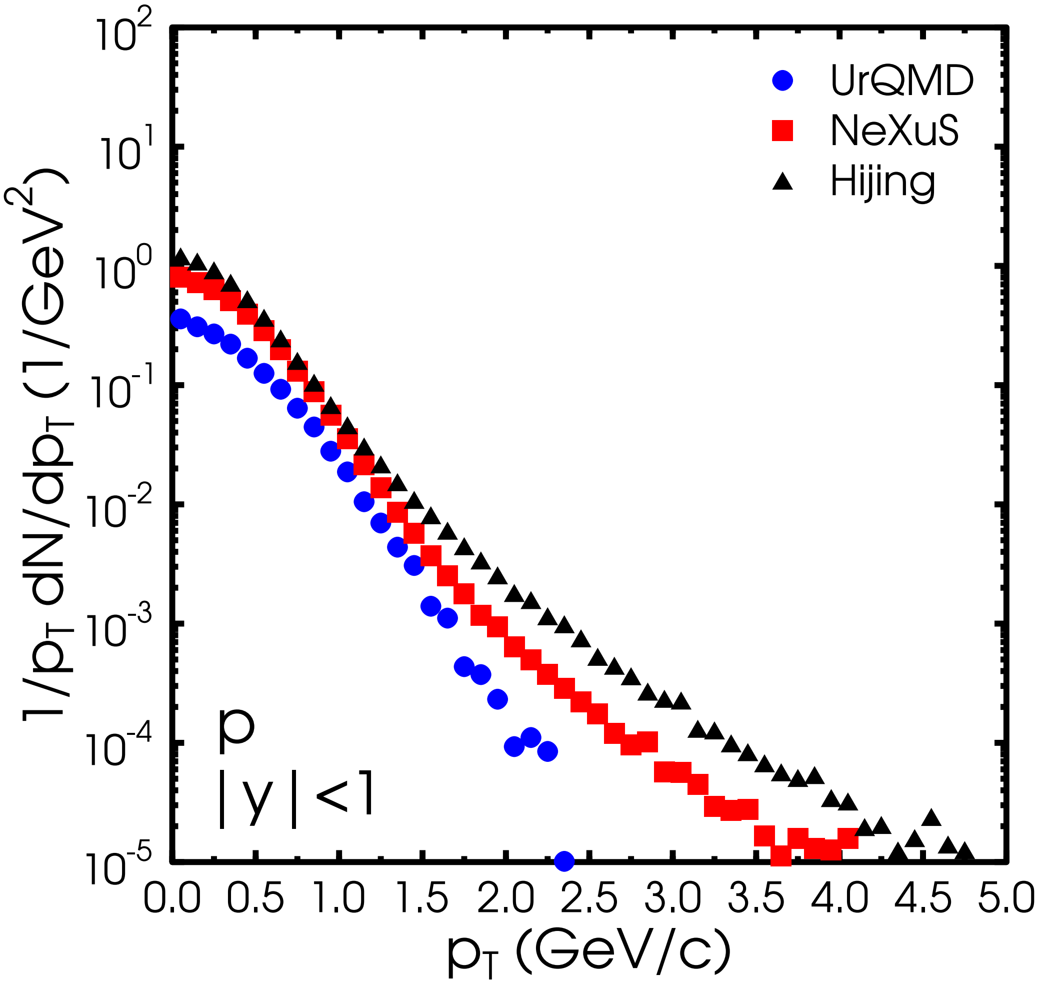
- Kaon transverse momentum spectra



- pQCD power law from 1.5 GeV on
- Factor 2-3 difference at low p_T

pp @ 200 GeV

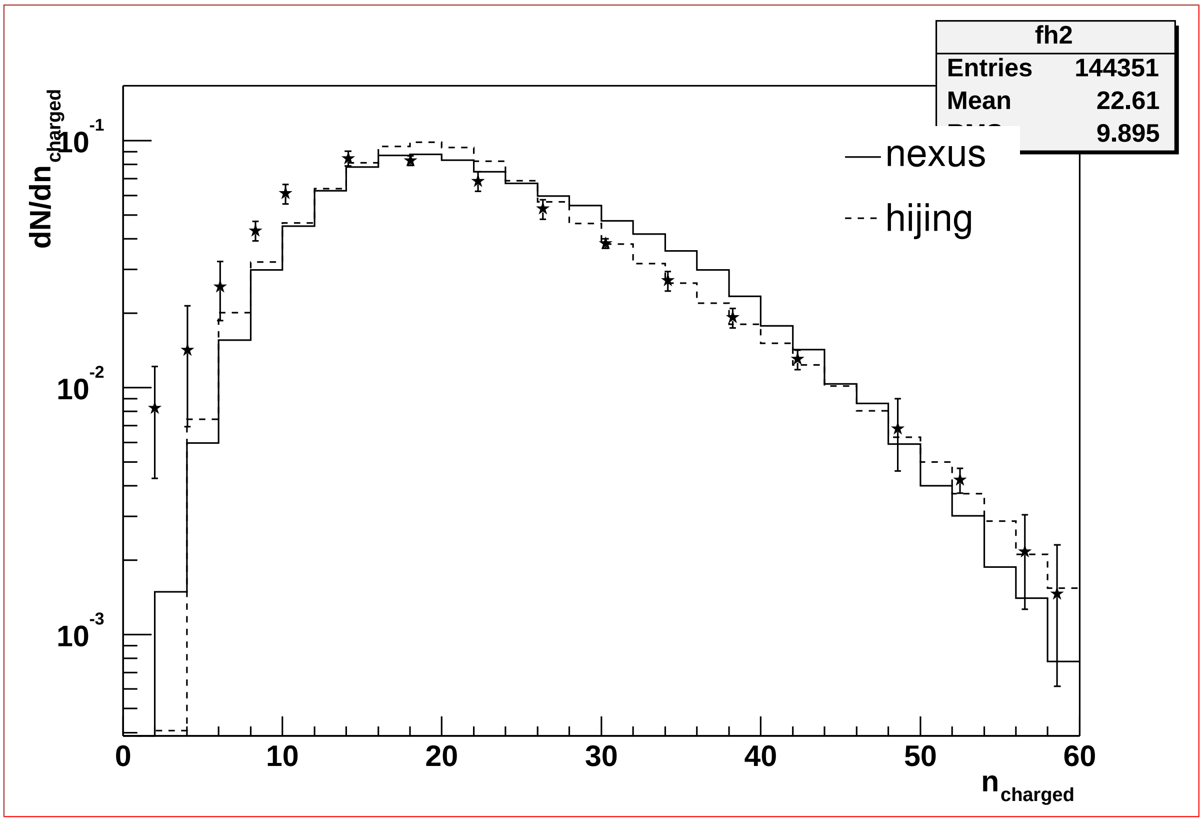
- Proton transverse momentum spectra



- pQCD power law from 1.5 GeV on
- Large difference at high p_T

$p\bar{p}$ @ 200 GeV

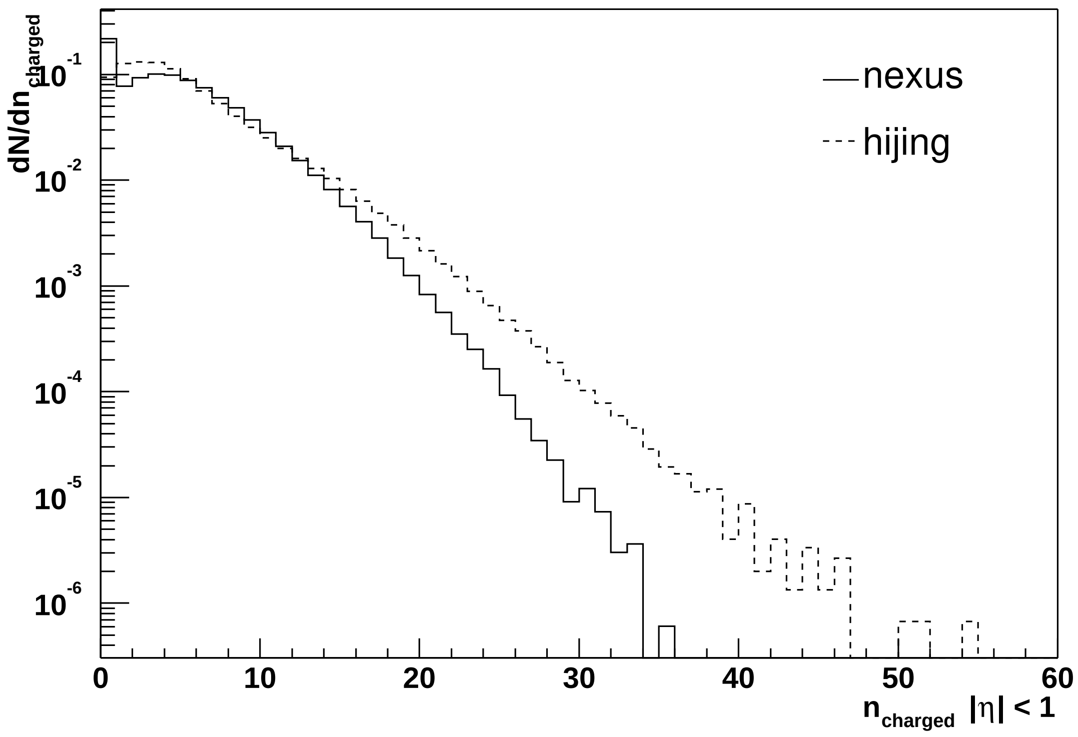
- Charged particle fluctuations: UA1



- Both models do a good job
- High multiplicity: Jets vs. multiple P exchange

pp @ 200 GeV

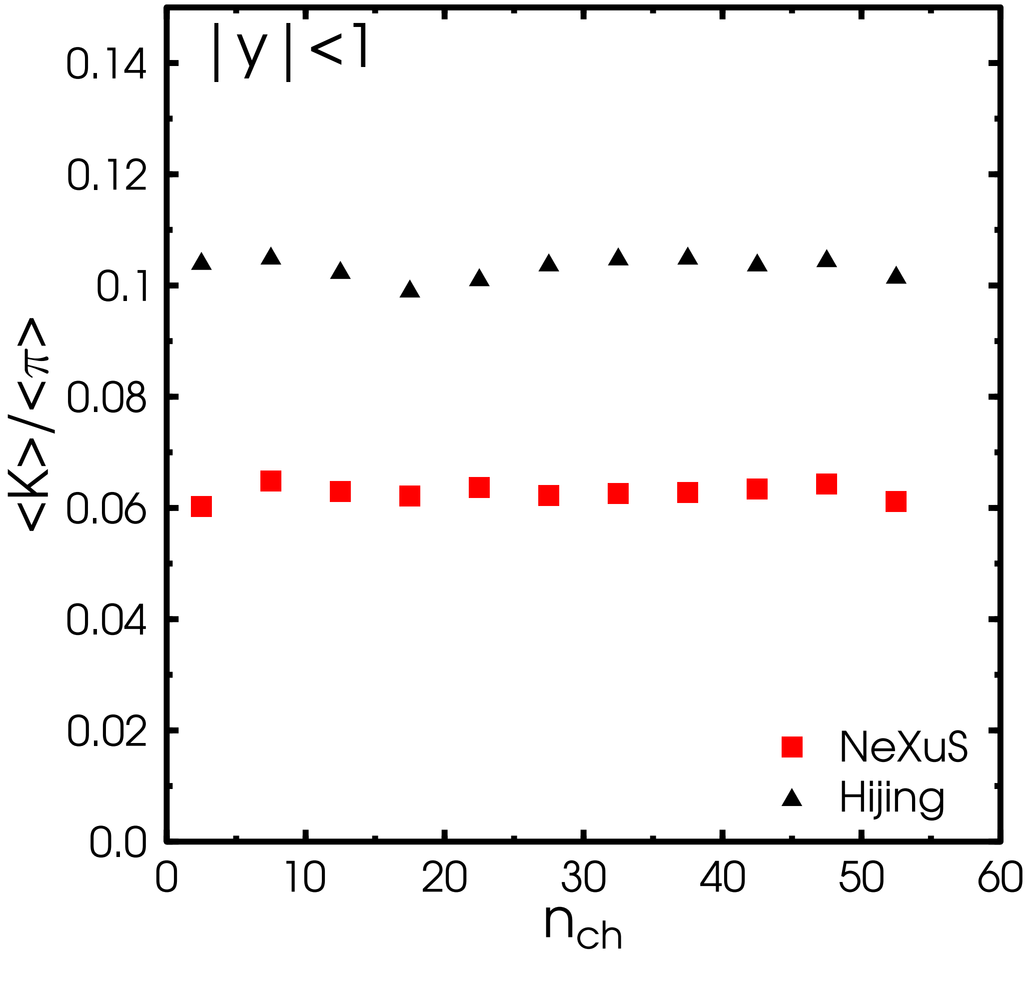
- Charged particle fluctuations: RHIC



- High multiplicity: Jets vs. multiple P exchange
- Less high n_{ch} events in the multiple scattering approach

pp @ 200 GeV

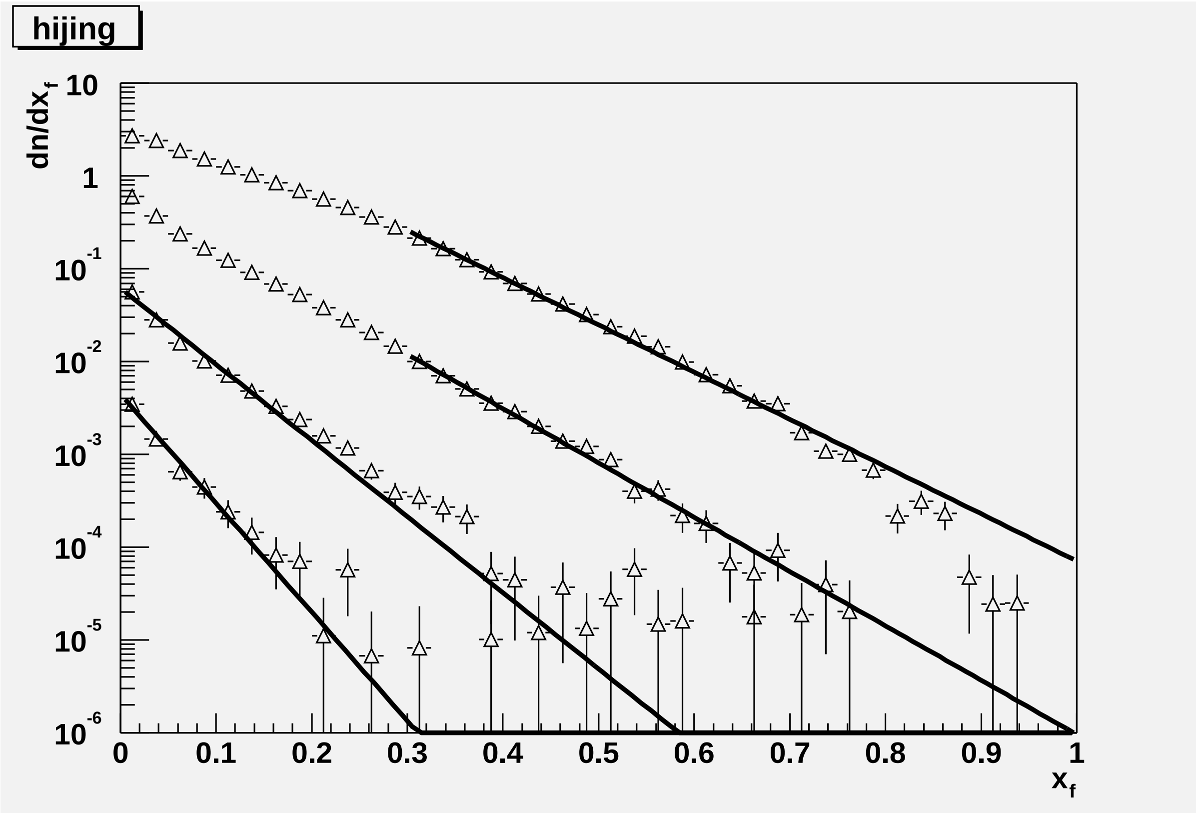
- E-by-E particle ratios



- Ratios do not depend on n_{ch}
- Difference due to different K yields

pp @ 200 GeV

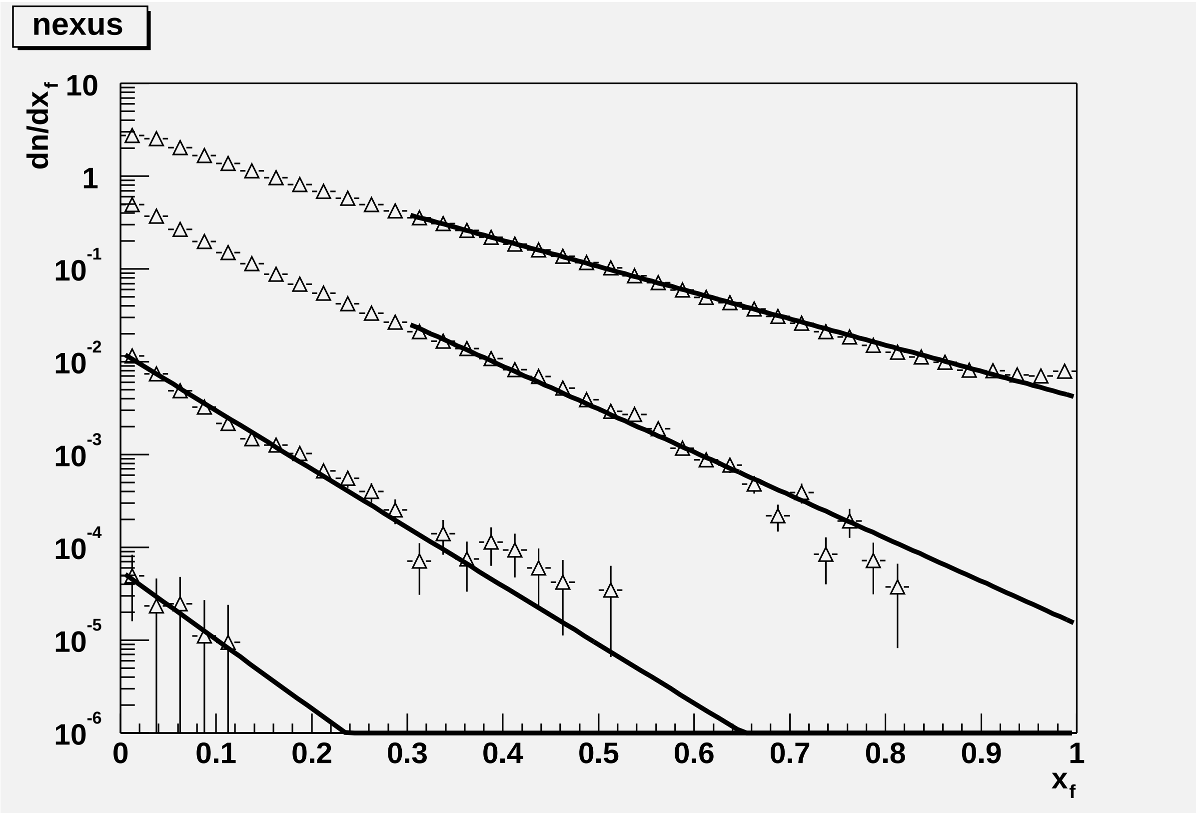
- HIJING: Feynman x spectra of charged pions
- Different n_{ch} bins: $\Delta n_{ch} = 10$



- Two slope behavior
- Lines are exponential fits

pp @ 200 GeV

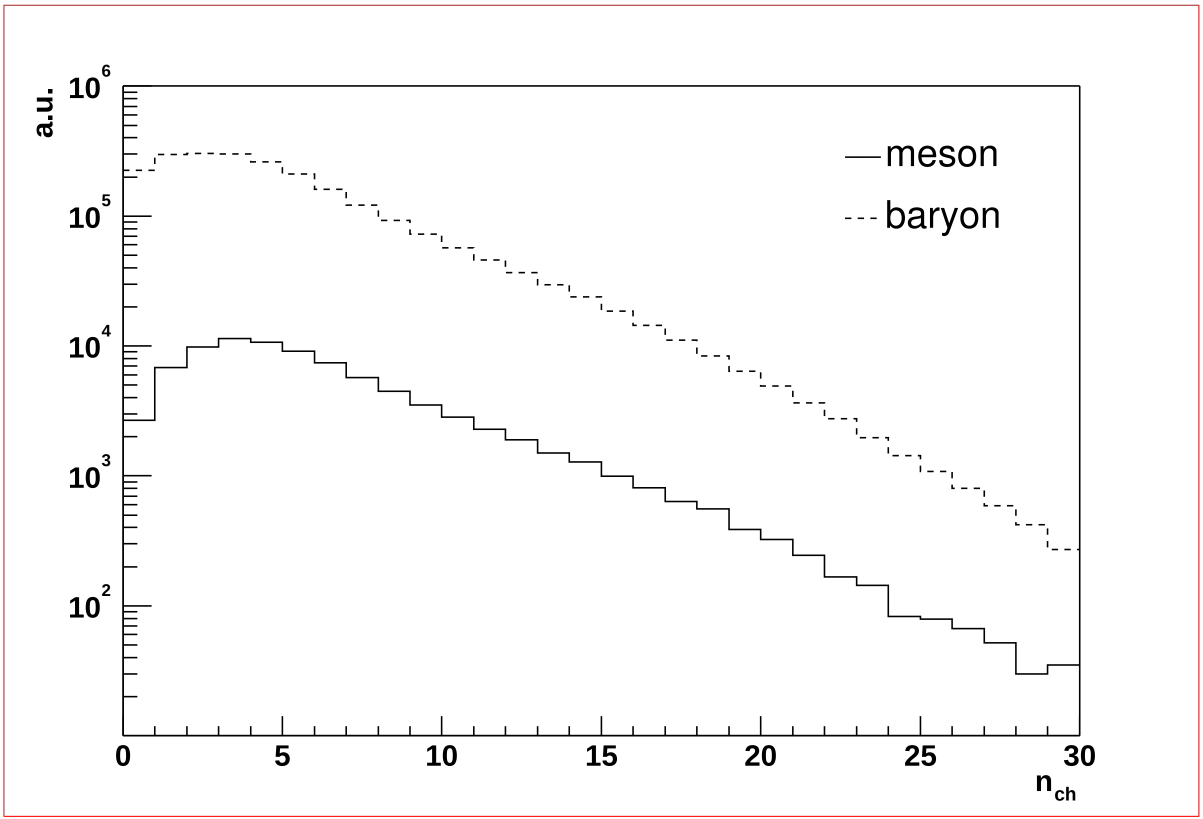
- NEXUS: Feynman x spectra of charged pions
- Different n_{ch} bins: $\Delta n_{ch} = 10$



- Only one slope

pp @ 200 GeV

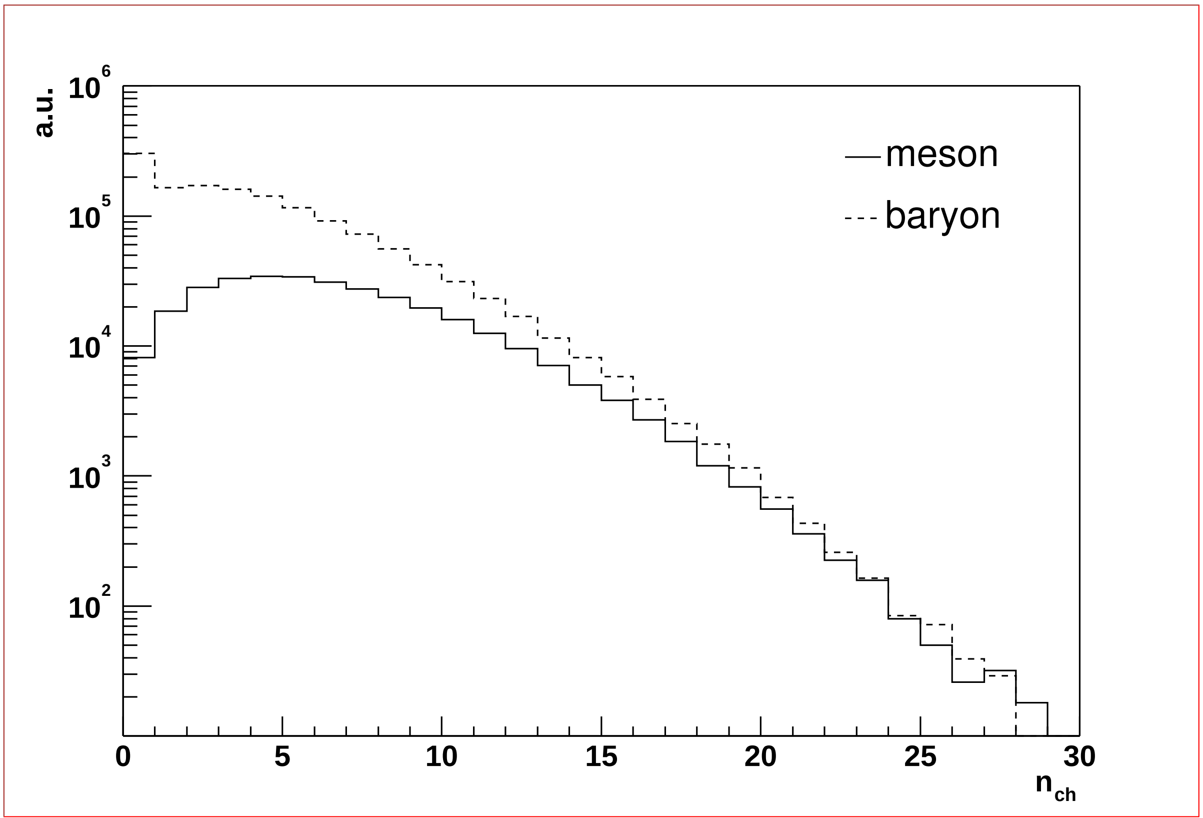
- HIJING: Type of 'fastest' particle (largest x_f)



- Fraction of fast $B \gg m$
- Fraction is independent of n_{ch}

pp @ 200 GeV

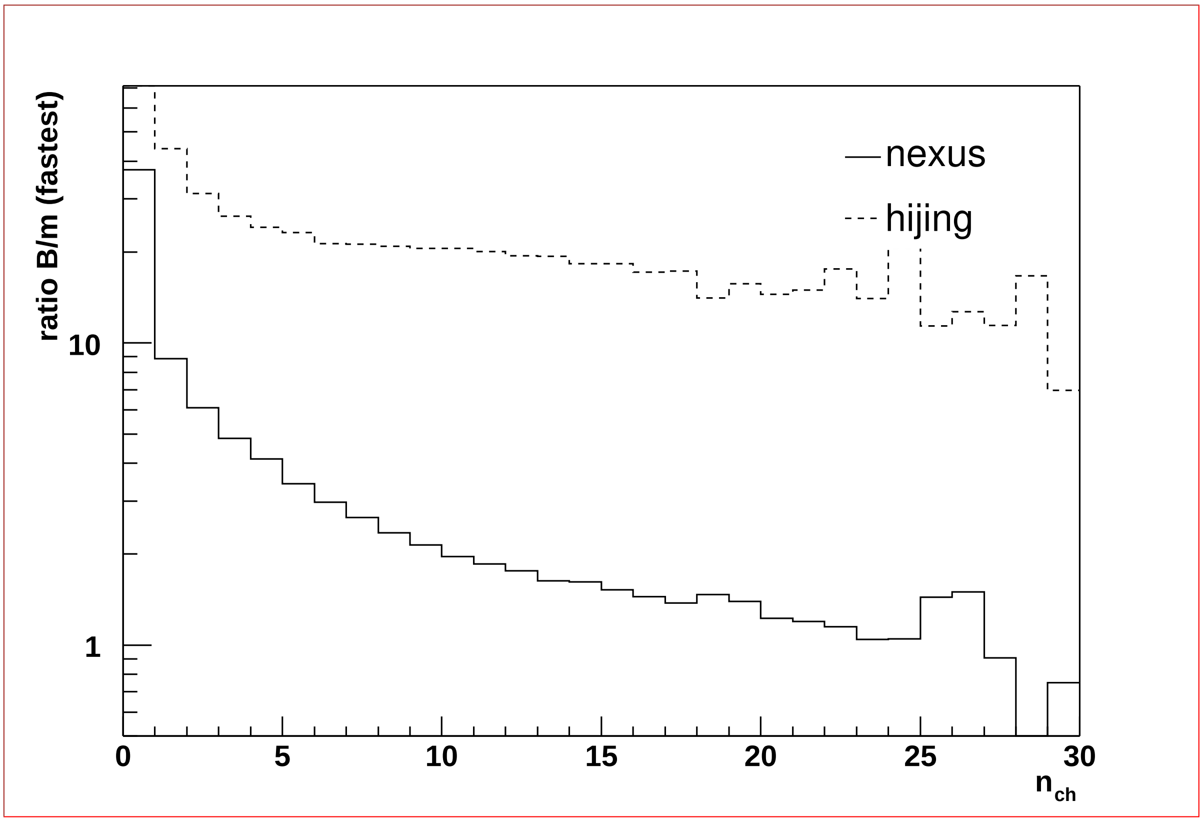
- NEXUS: Type of 'fastest' particle (largest x_f)



- Fraction of fast B approaches fraction of m with increasing n_{ch}
- Proton is destroyed due to multiple interactions

pp @ 200 GeV

- Type of 'fastest' particle (largest x_f)



- HIJING predicts flat ratio of leading Baryon/Meson
- NEXUS predicts strong decrease of the baryon contribution to the leading particle

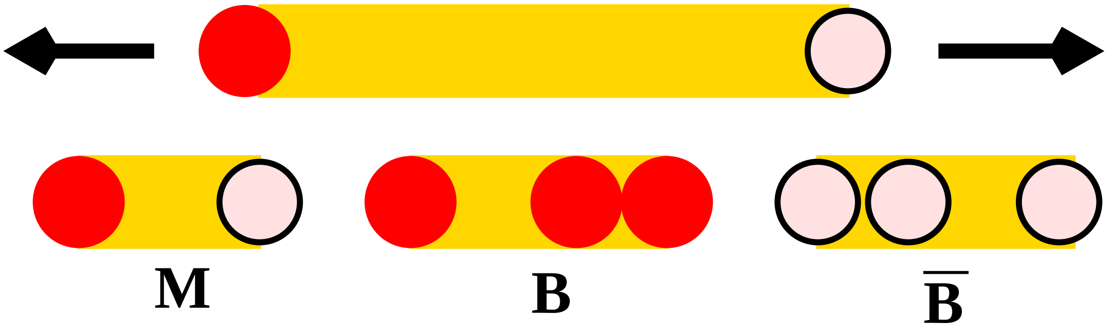
Conclusion I

- Studying the leading particle allows to distinguish multiplicity increase from jets from multiple Pomeron exchange.

- High multiplicity pp events might have the same parton density as central Au+Au

e^+e^-

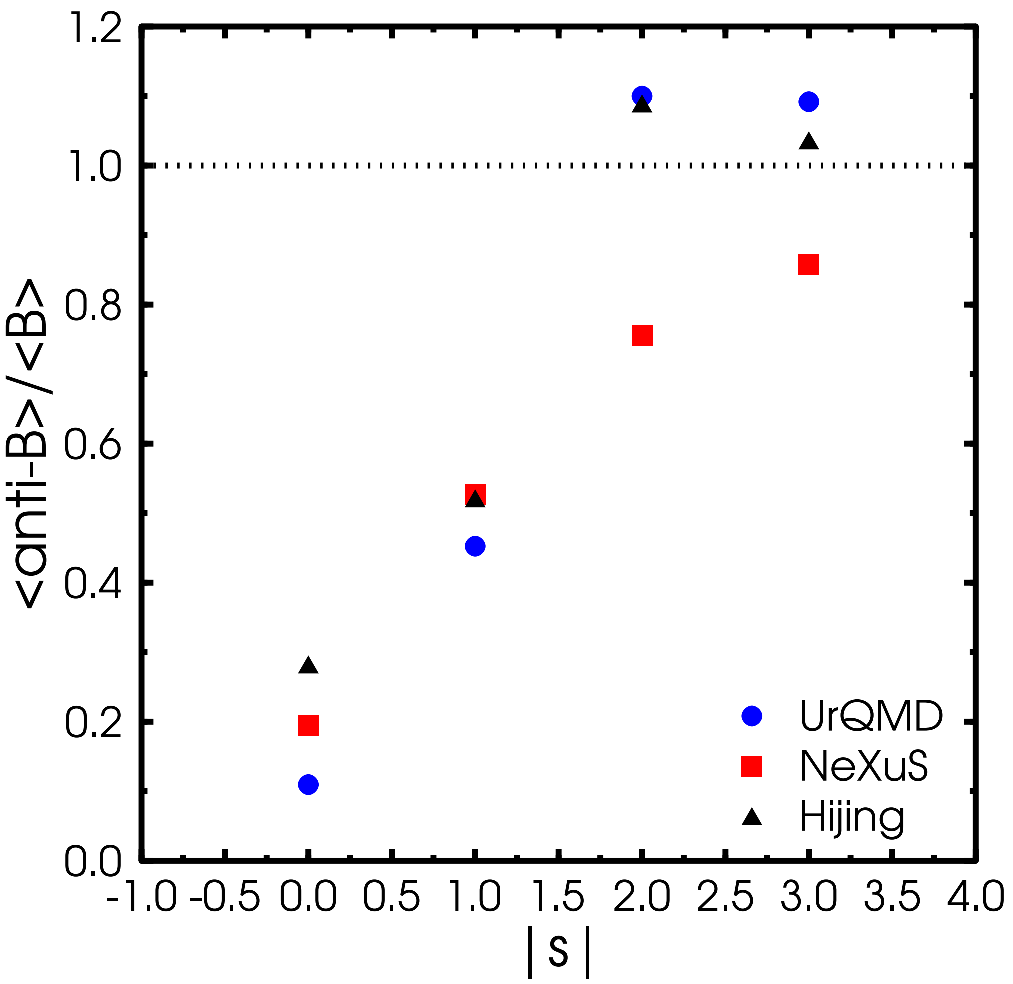
- Fragmentation in $e^+e^- \to \gamma^* \to q\bar{q}$



- Symmetric with respect to charge and baryon number
- Well tested, works nicely
- But what in pp?
- Create q-qq string? junctions? something else?

pp @ 200 GeV

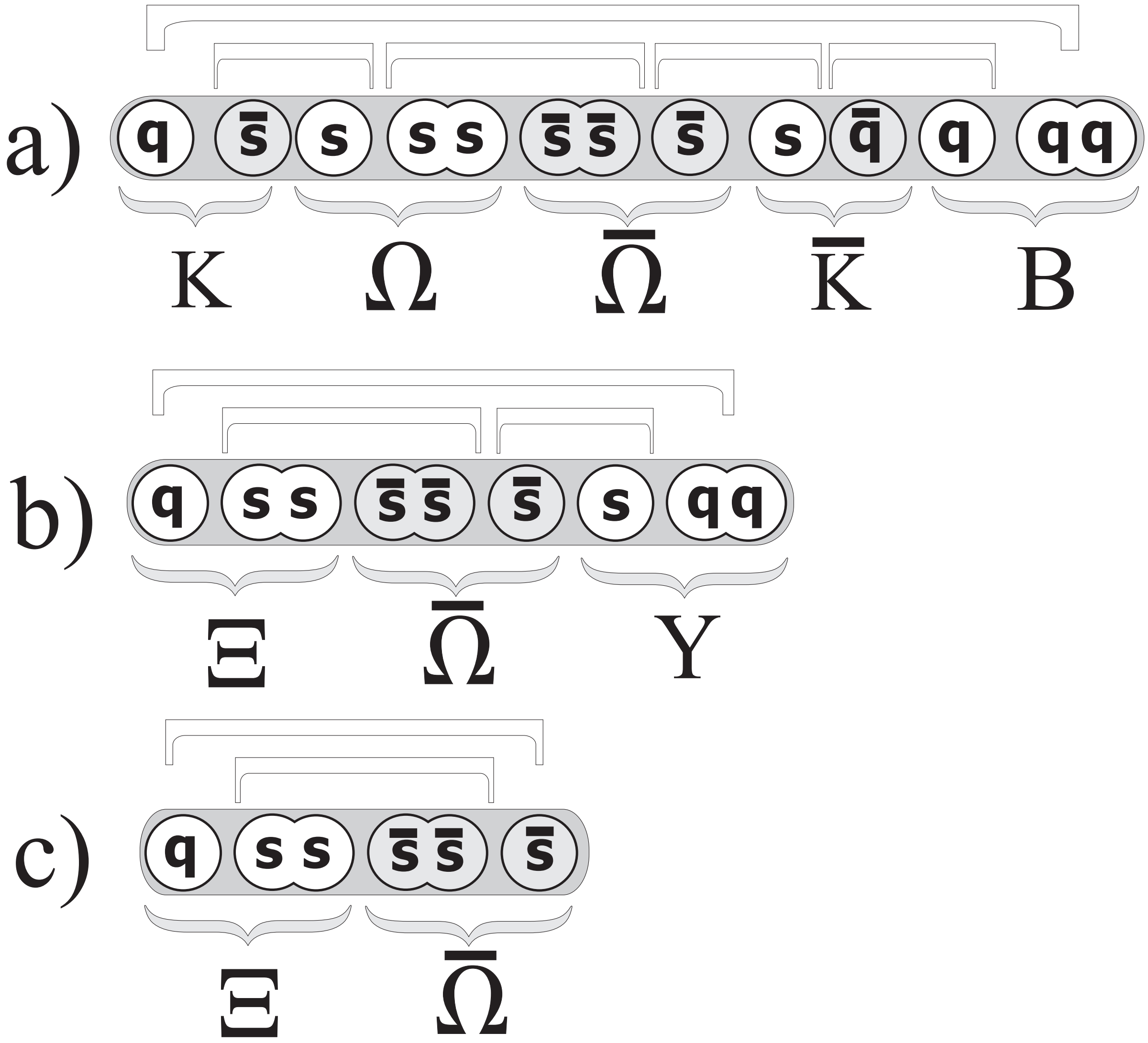
- Anti-baryon / Baryon ratios



- Di-quark string models yield ratio above 1
- Pomeron/Remnant configurations yield ratio below 1
  (Thermal models are by definition below 1)

A sketch of the fragmentation

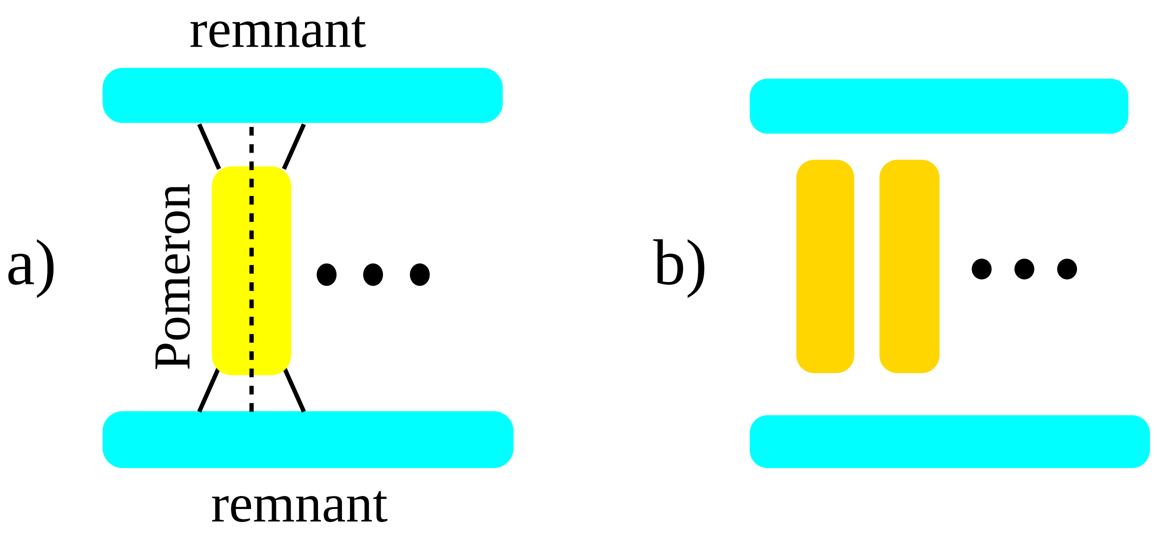
- Anti-baryon / Baryon asymmetry



- Ω suppression near string ends
  $\rightarrow \overline{\Omega}/\Omega > 1$

How to avoid $\overline{B}/B > 1$

Assume that (soft) Pomerons couples only to sea-quarks

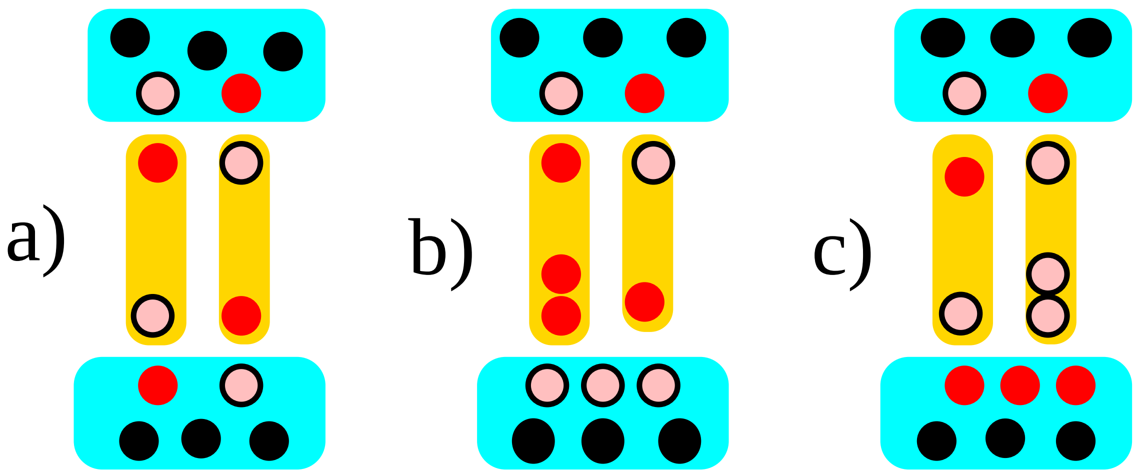


- Arbitrary number of Pomerons
- Soft Pomeron: Couples to sea-quarks
- Cut Pomeron $\rightarrow$ 2 strings

for details see: Phys. Rev. D67, 034011 (2003)

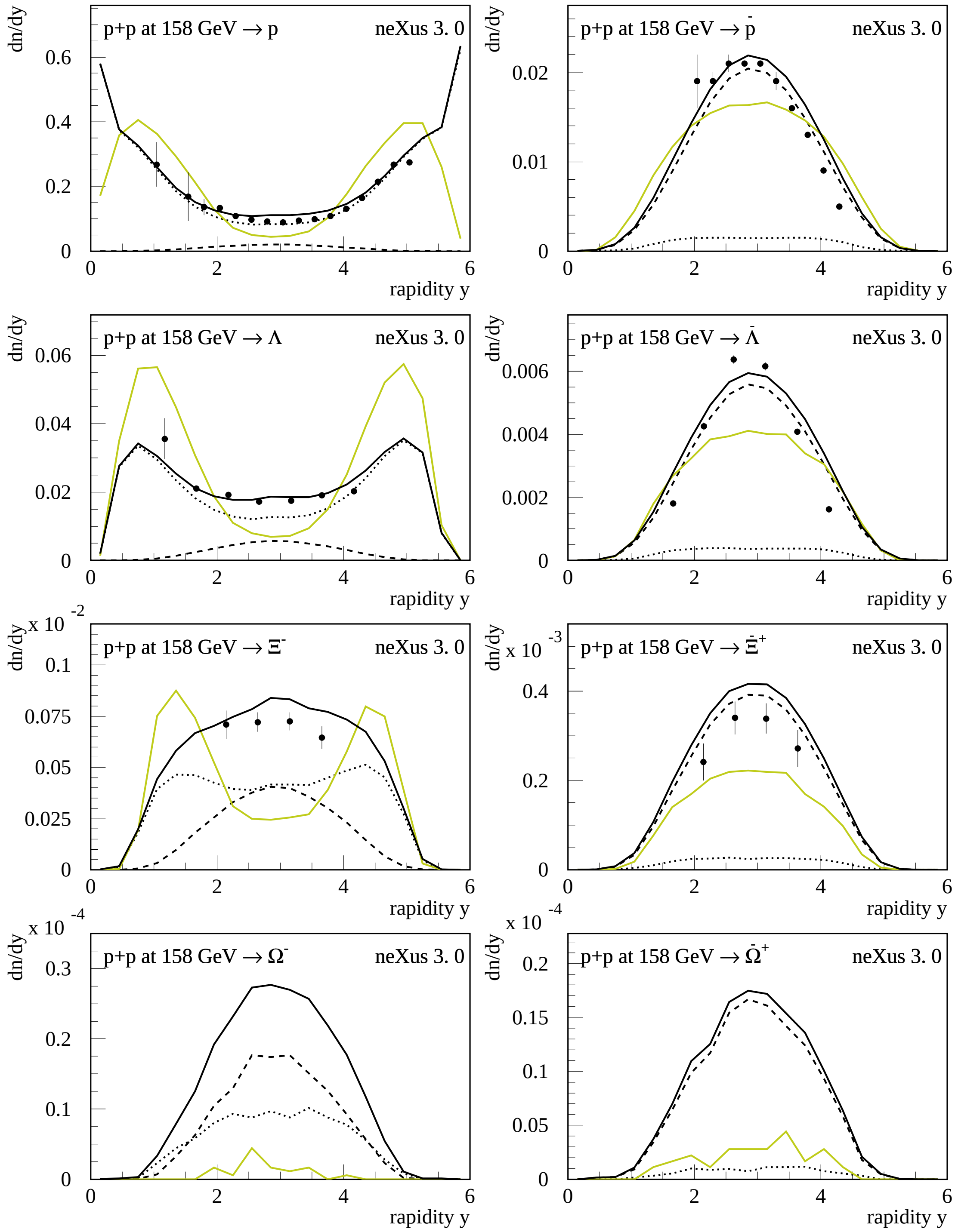
Novel string model

- Remnants and Pomerons



- Different types of strings are created
- Parameters: $P(q), P(s)$

pp @ 18 GeV



- Good description of the data
- Check at RHIC

Summary

- High parton densities might be the origin of high multiplicity events
- Parton densities in pp might be as high as in Au+Au
- Signal of high parton density: break-up of the leading proton

- String formation in pp, not clear
  maybe, remnants and Pomerons,
  $\rightarrow$ no simple $q - qq$ strings!

Many thanks to . . .

- Tanguy Pierog
- Adrian Dumitru
- Hajo Drescher
- Klaus Werner
- Xin-Nian Wang