Is Strangeness production different in the Bulk and in Jets ?

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Soft Physics Workshop
Strasbourg, 19 Juin 2009

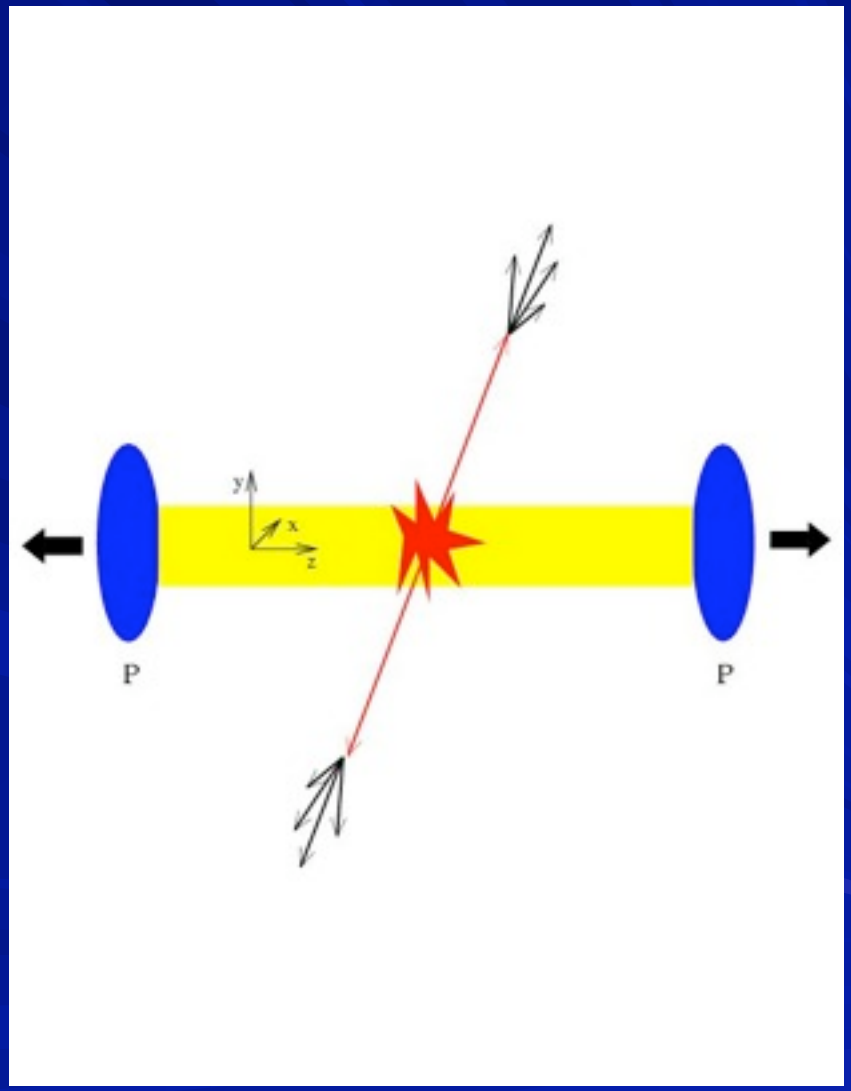
Summary

- What are jets?
- EPOS Event Generator
- The observable of lambda/k0S
- Is this ratio different in the bulk and in jets ?

What are jets ?

Asked to a theoritician

A collimated flux of particle coming from the fragmentation of a hard parton



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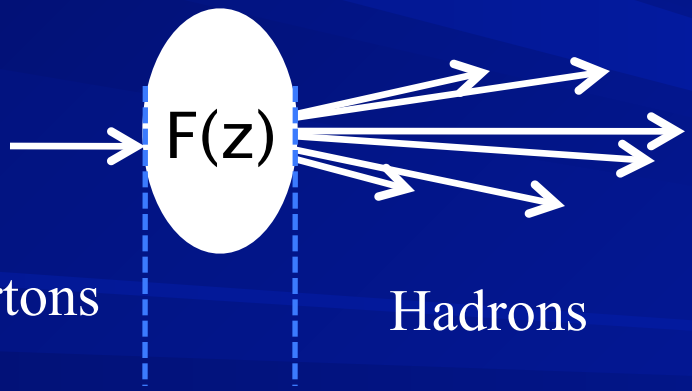
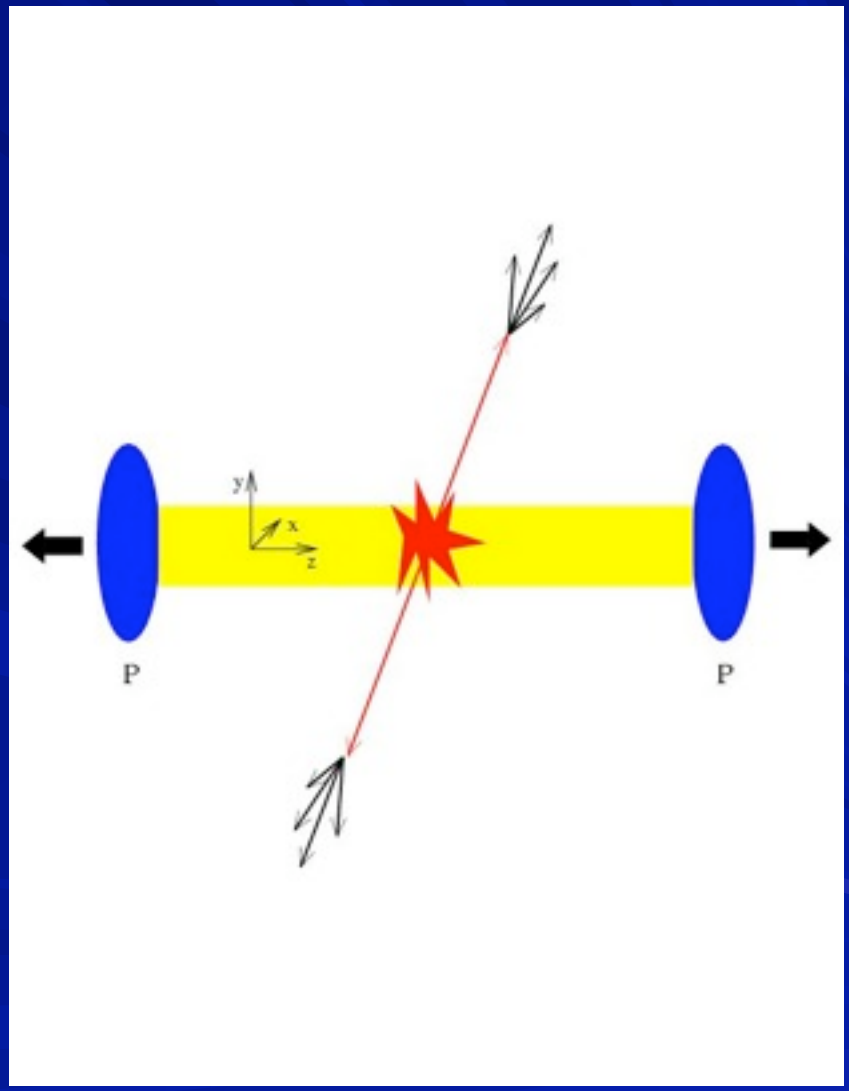
Fragmentation Function

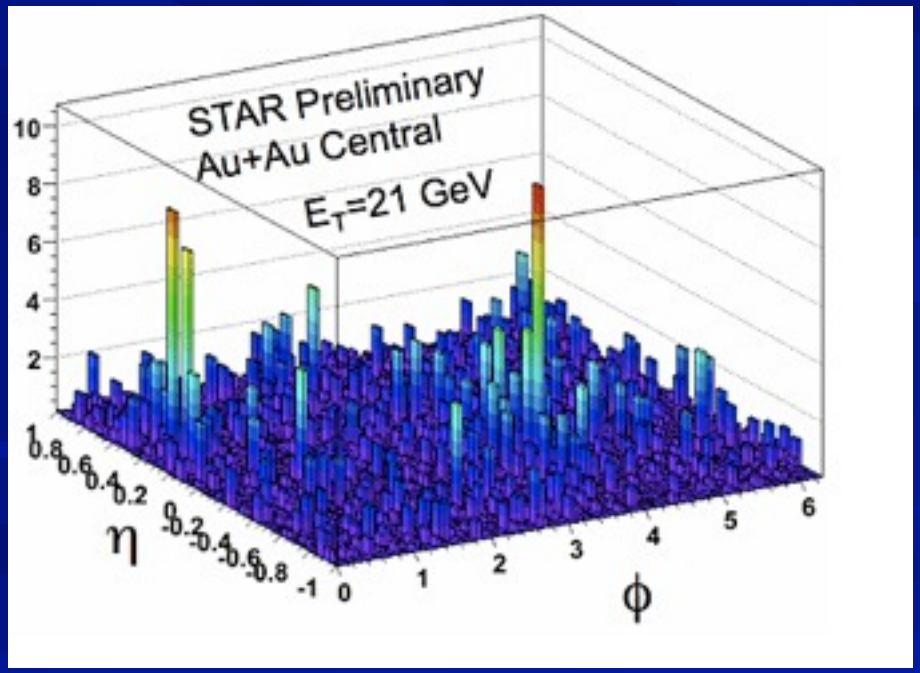




What are jets ?

Asked to Experimentalist (from heavy ion communitty)

- A collimated flux of particle coming from the fragmentation of a hard parton
- Swallowed up in particles coming from the underlying event
- Identified by a jet finder algorithm for a defined Radius



http://www.bnl.gov/rhic/news/102108/story2.asp

21 GeV di-jet reconstructed from a central Au+Au event at $\sqrt{s_{NN}}$=200 GeV in the STAR detector.

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EPOS MODEL

- Quantum mechanical multiple scattering approach based on partons and strings

S.Ostapchenko, T.Pierog, K.Werner, H.J.Drescher, M.Haldik , Phys. Rep, 350, 2001.
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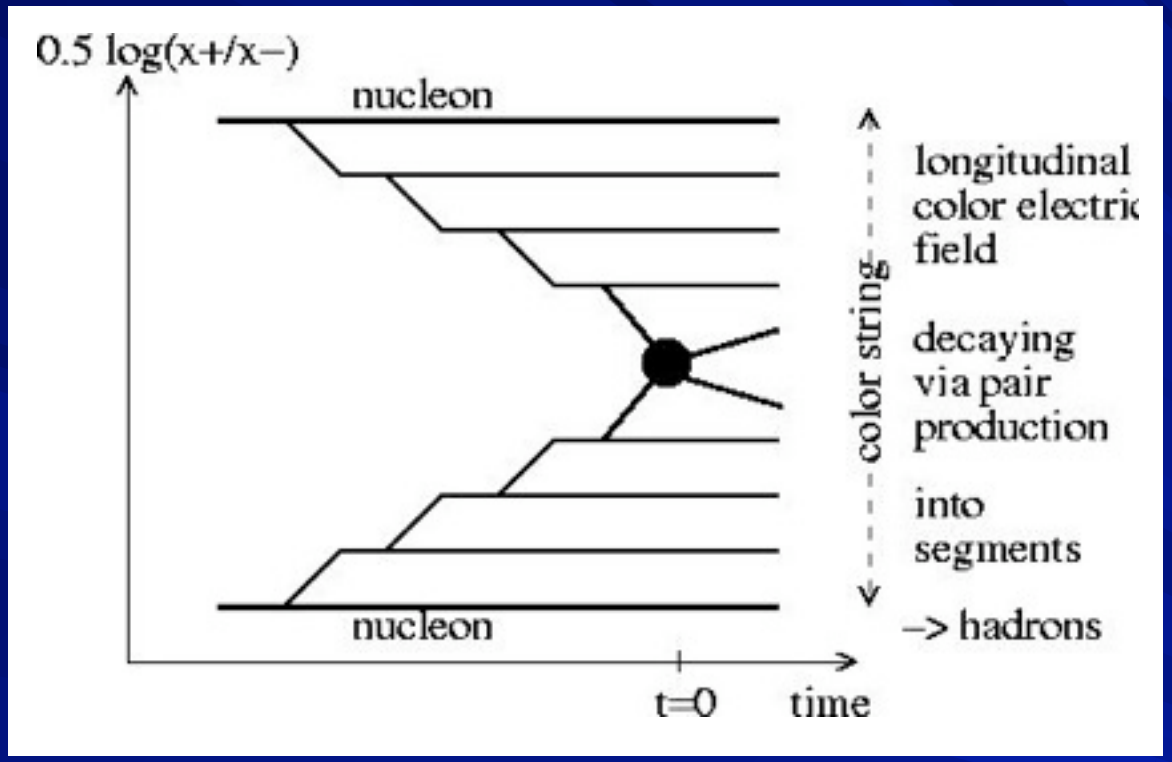
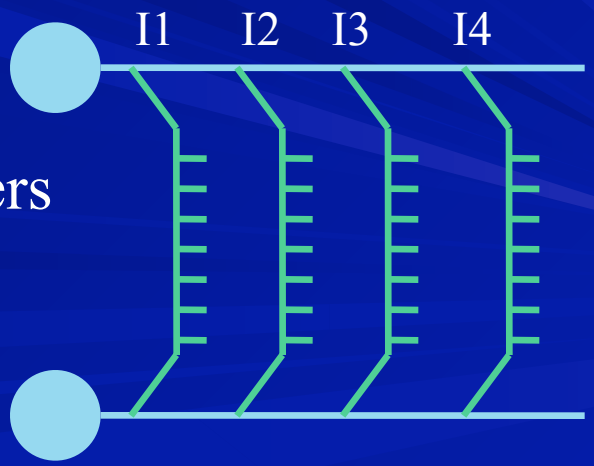


Parton ladders : soft or hard interaction

Multiple interaction : exchange of parton ladders in parallel with care of energy conservation



Parton Ladder

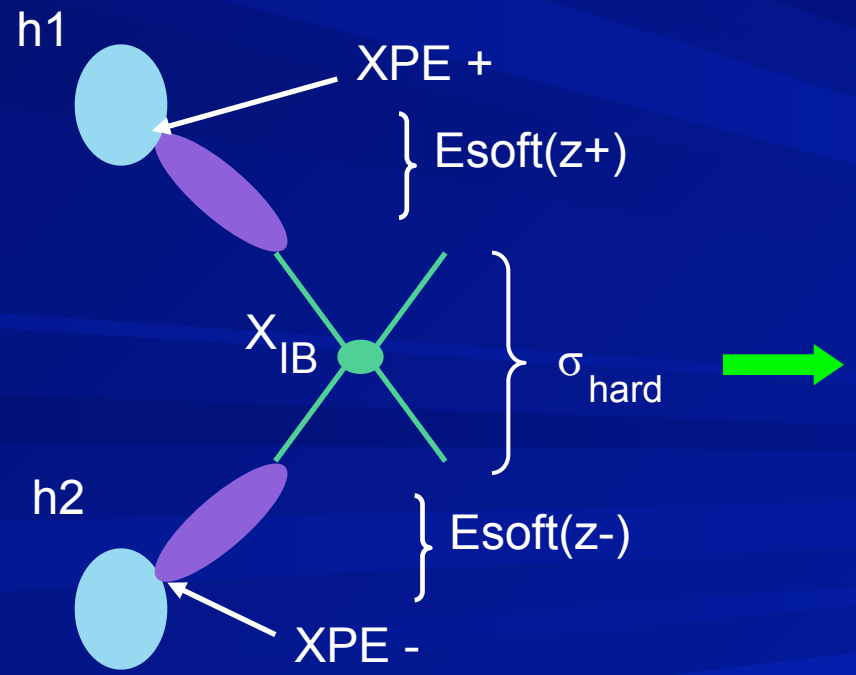
Proba of an interaction with b (impact parameter)

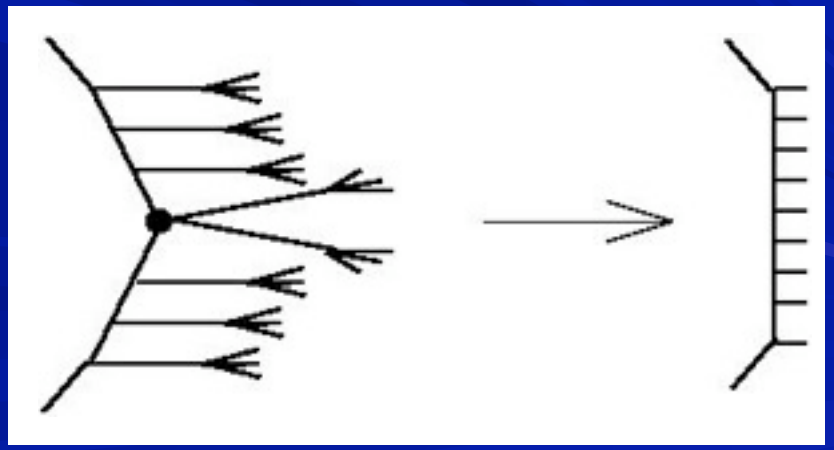
Moment distribution of parton (i,j) in soft part

pQCD, parton-parton cross-section (parton model)

Entering the ladder, proba of a parton with x+-

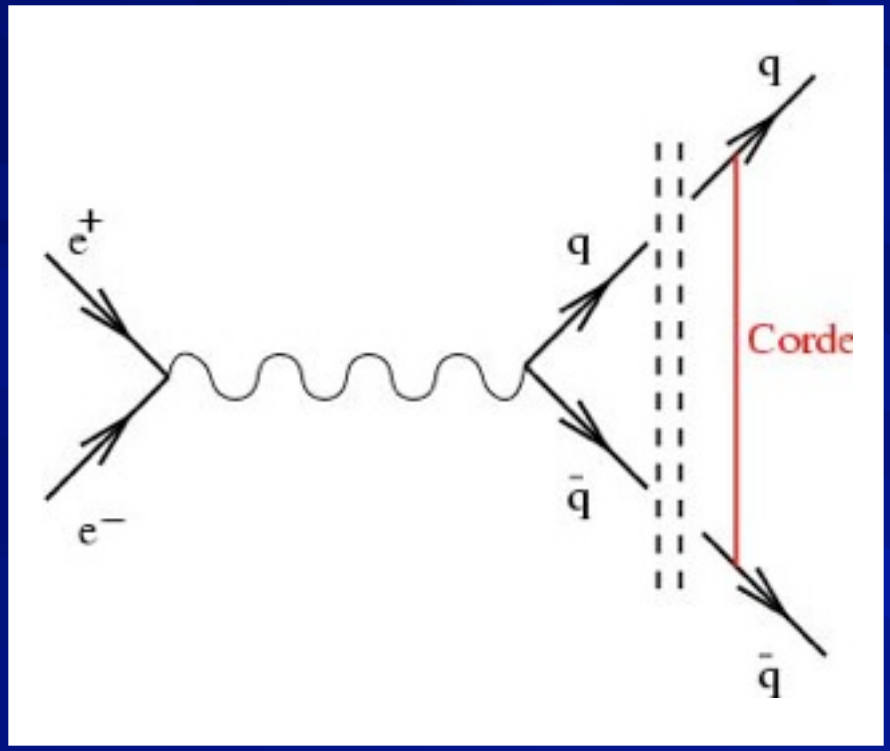
$$G^{h1h2}_{sea-sea}(x^+,x^-,s,b) \propto \int_0^1 dz^+ \int_0^1 dz^- \sum_{i,j} E^i_{soft}(z^+) E^j_{soft}(z^-) \sigma^{ij}_{hard}(z^+ z^- \hat{s}, Q_0^2) F^{h1}_{part}(x^+) F^{h2}_{part}(x^-)$$





Particle Production : String Model

Phenomenological model to describe hadronisation



The basic feature of the String Model ;

Existence of a color field between the 2 outgoing quarks

A string is formed with the string tension

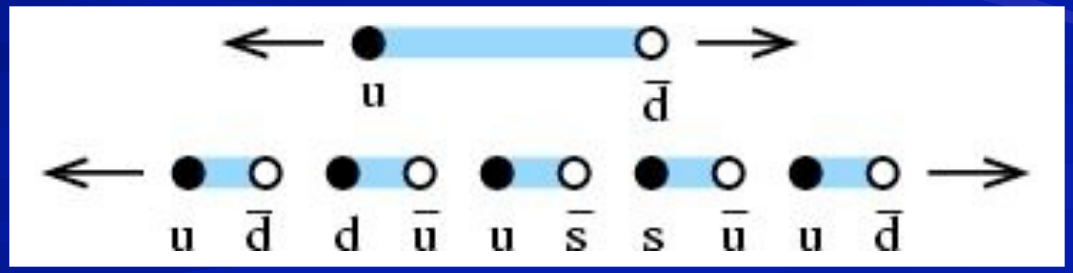
$$k \approx 1 GeV / fm$$

the quantity of energy per unit length

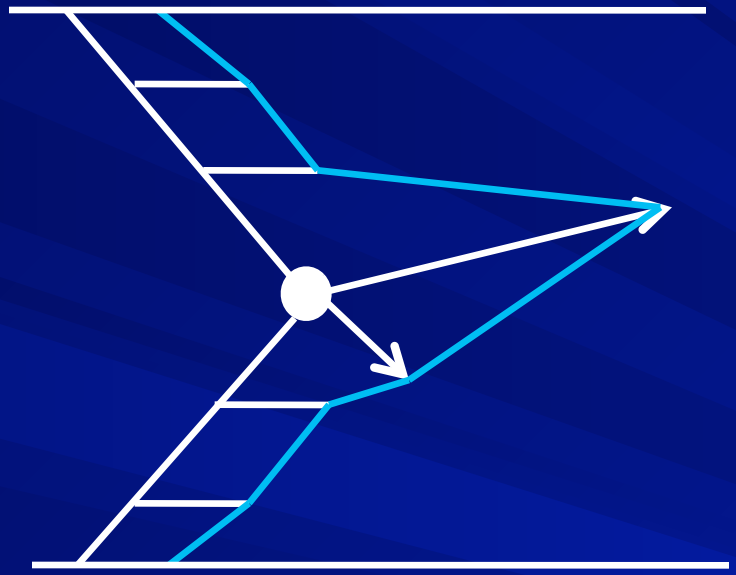
String fragmentation :

String breaks up via color singlets

Segments identified as hadrons



String Model in EPOS



Strings are formed between quarks,
Gluons act as a kink

➡ Kinky strings produce hadrons with pt

- Particles produced all along the string
  For semi-hard ladders : no reason that they all belongs to a jet

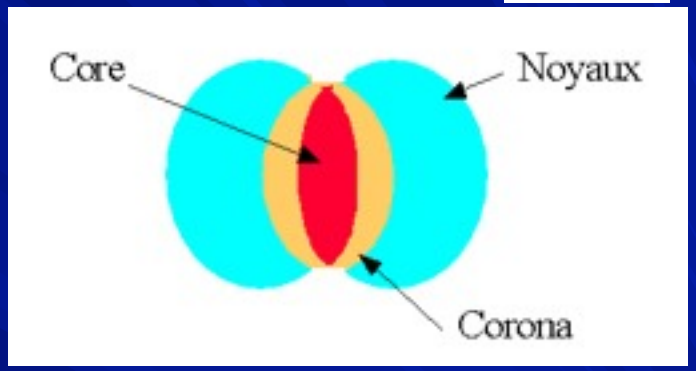
- As for an experiment, needs a definition : leading particles, Radius of the cone

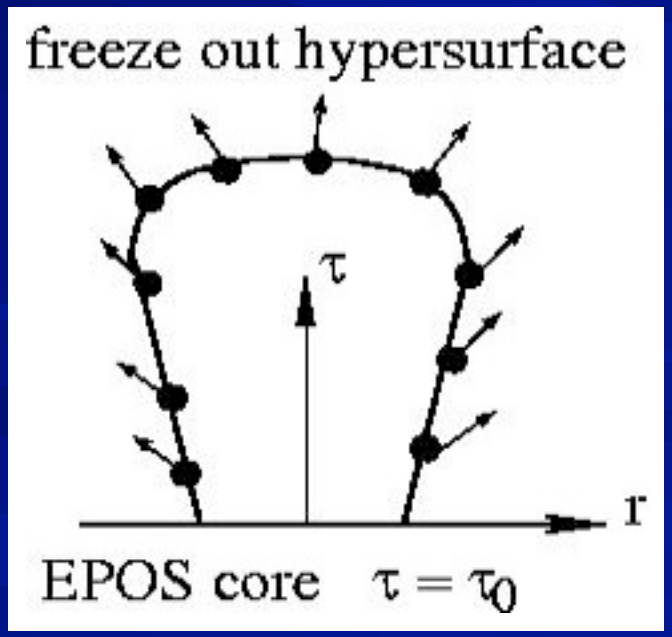
Collective Effect of a dense core

Here : not the hydro klaus talked about, the previous toy model

Modification of the string procedure :

- Corona = low density, classical EPOS particle production
- Core = high density, hydro expansion





One define a freeze-out surface : transition from strongly interacting matter to free hadrons.

Parametrisation of the freeze out hypersurface.

Already available in pp interactions.

Summary

- What are jets?
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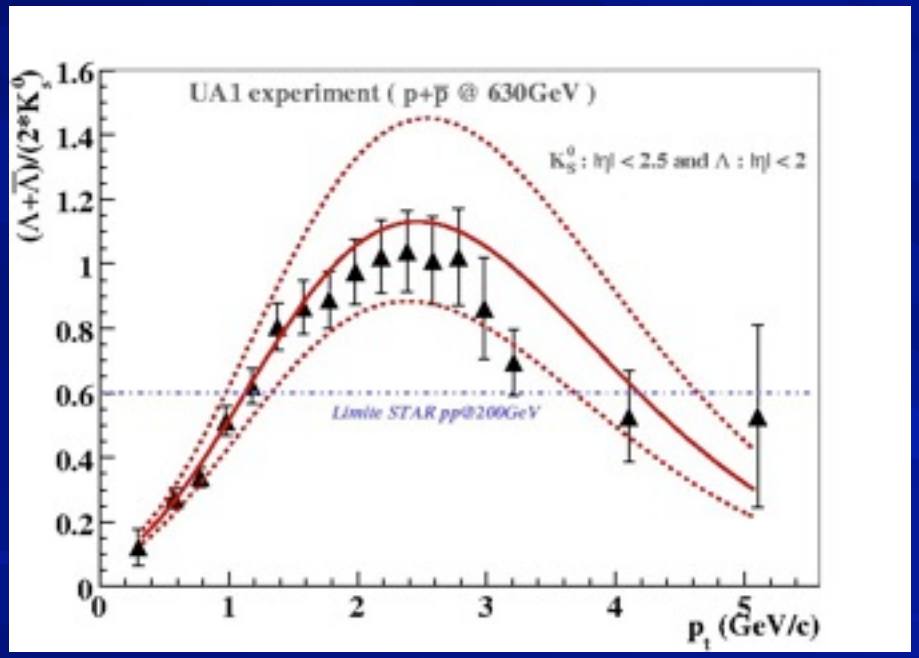
- The observable of lambda/k0S
- Is this ratio different in the bulk and in jets ?

Ratio lambda/k0s

A signature of the Quark Gluon Plasma in heavy ion collisions

In pp collisions at sqrt(s)=200 GeV : flat ratio and remainded below unity

With increasing energy : the behaviour changes!



See talk by Hélène

Is this ratio the same if we look at the bulk, if we look at jets ?

Ratio lambda/k0s

In EPOS, look at this ratio in pp collisions for :

- "The Bulk" : here everything, no trigger on particles origin, effects from collectivity

- "Jets" : all particles coming from semi-hard ladders jet disconnected from the medium

Preliminary study to see what could be done at LHC

Summary

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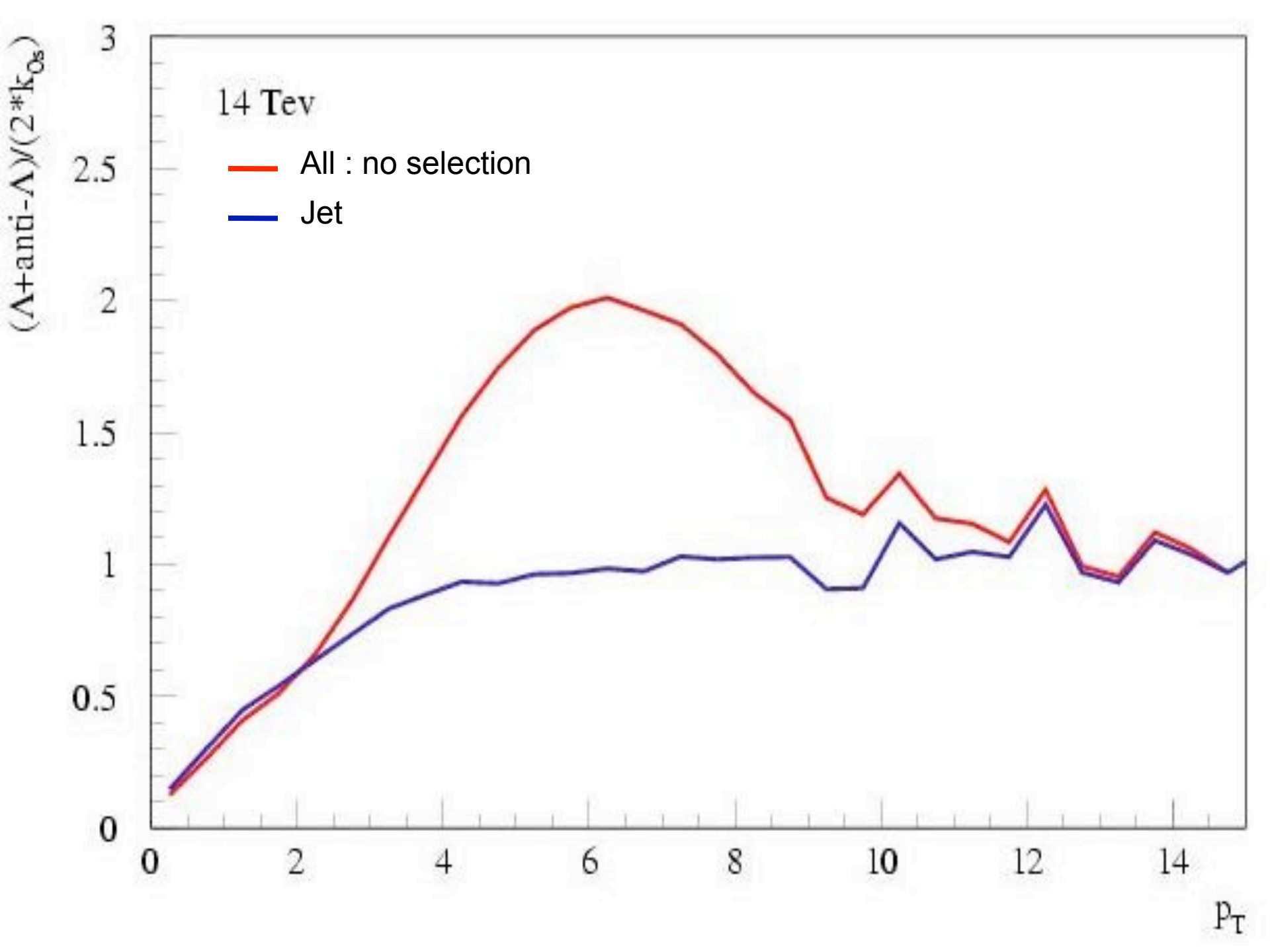
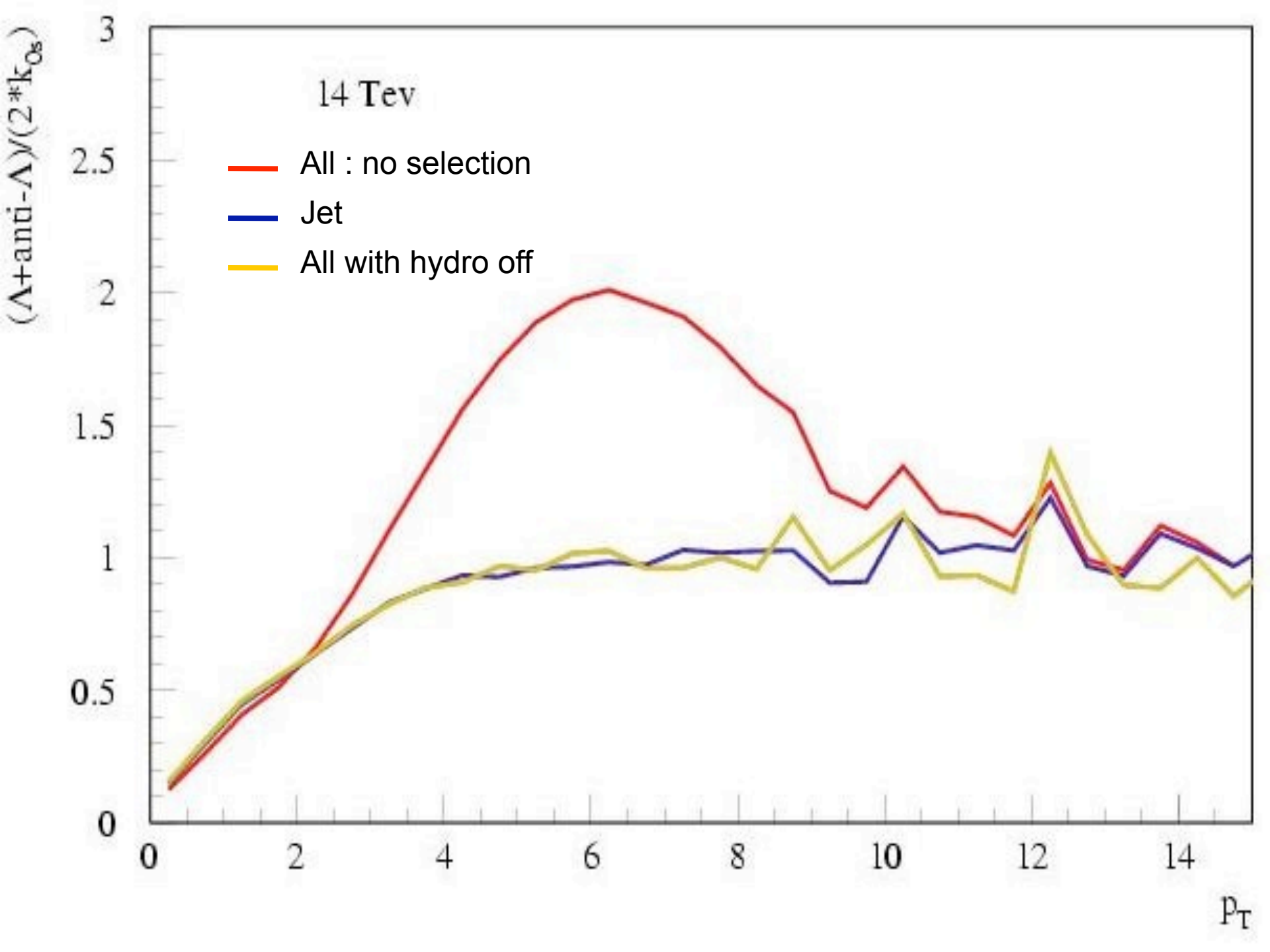
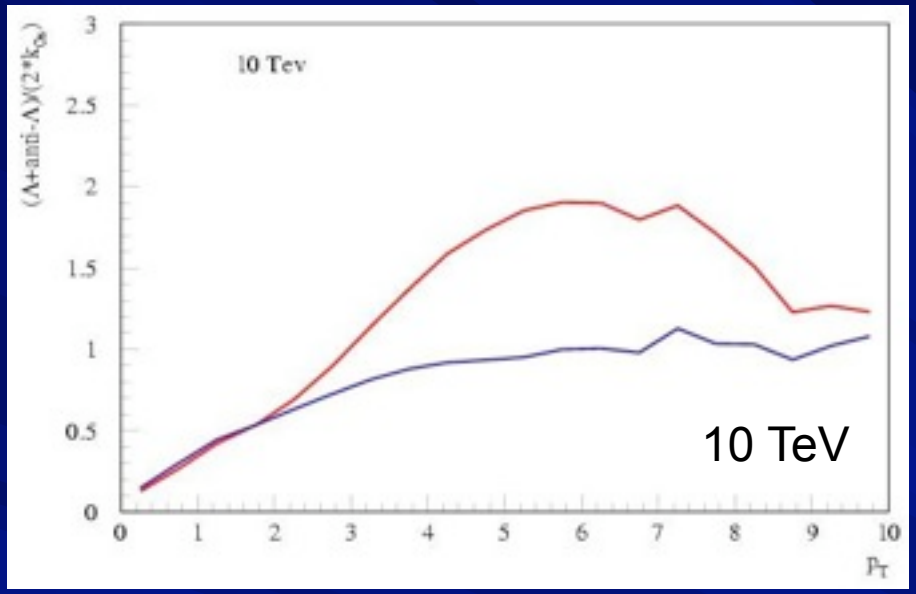
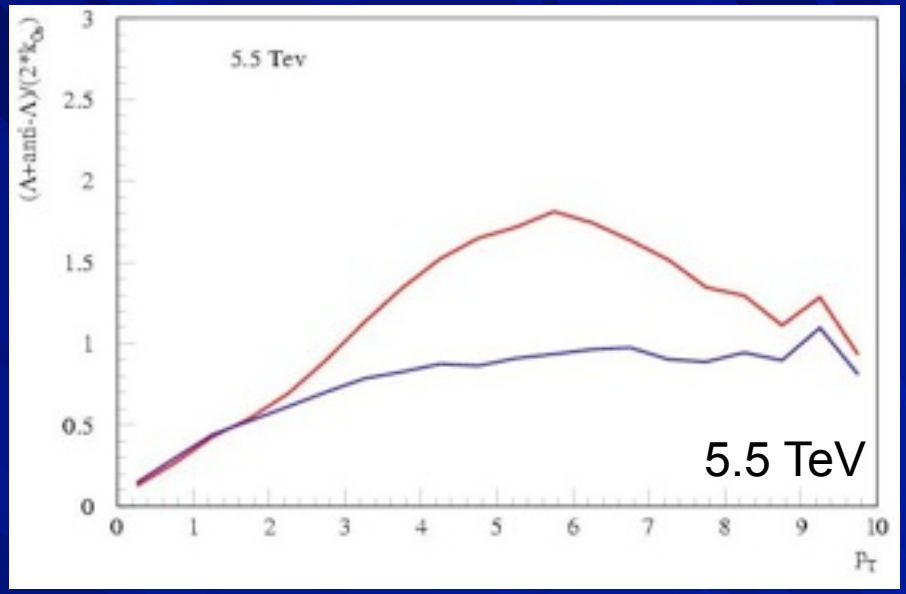
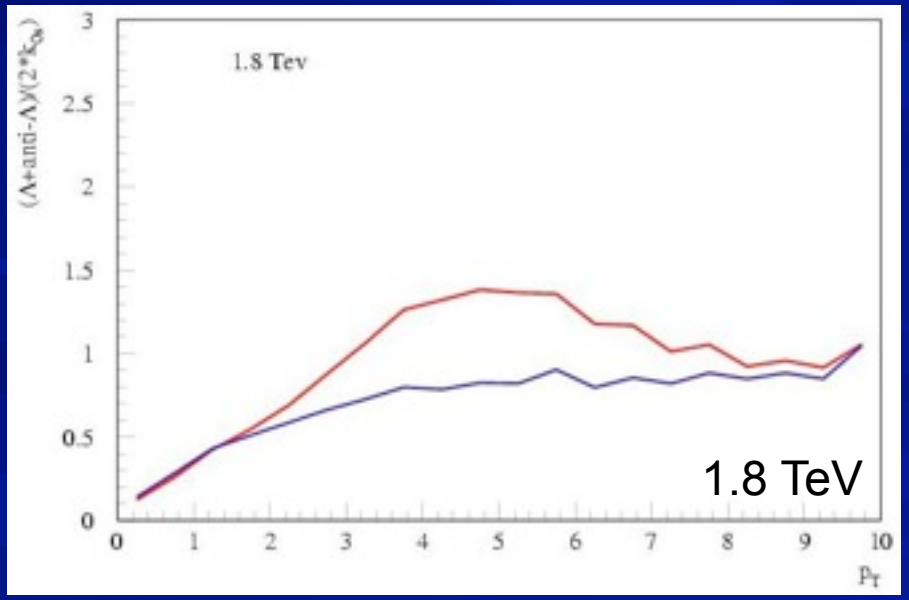

14 Tev
All : no selection
Jet
$(\Lambda+\text{anti-}\Lambda)/(2*k_{0s})$
p_T
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14

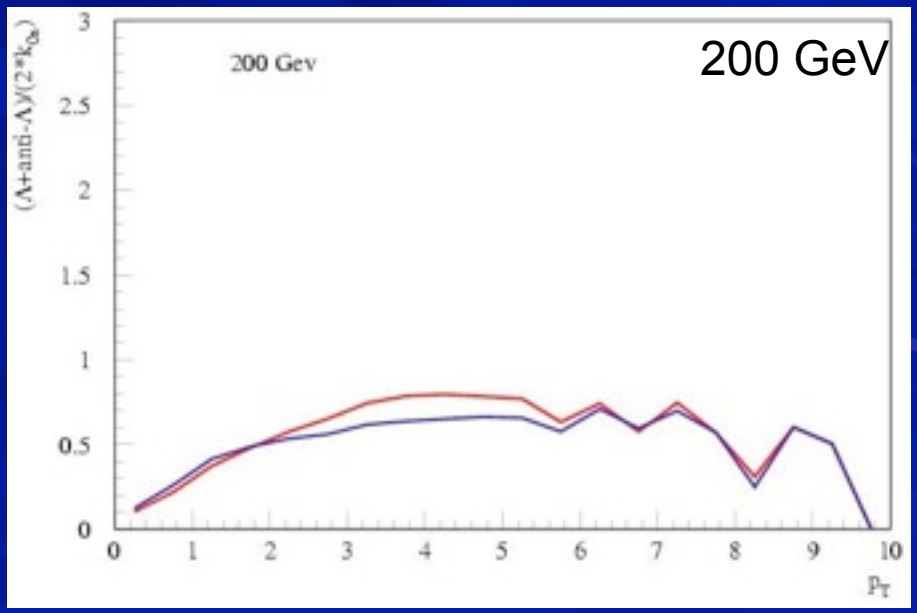

14 Tev
All : no selection
Jet
All with hydro off
(Λ+anti-Λ)/(2*k0s)
pT
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14

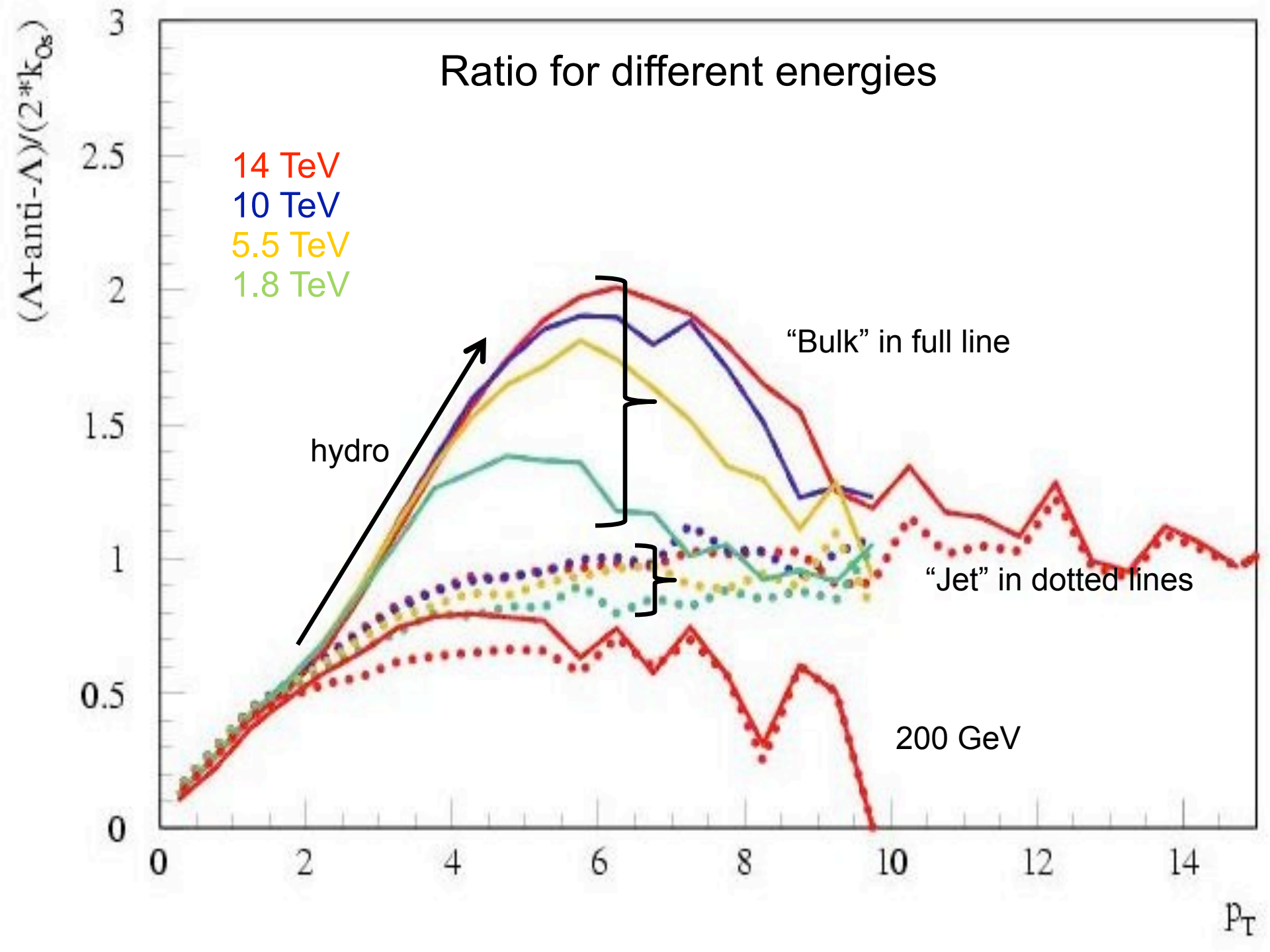


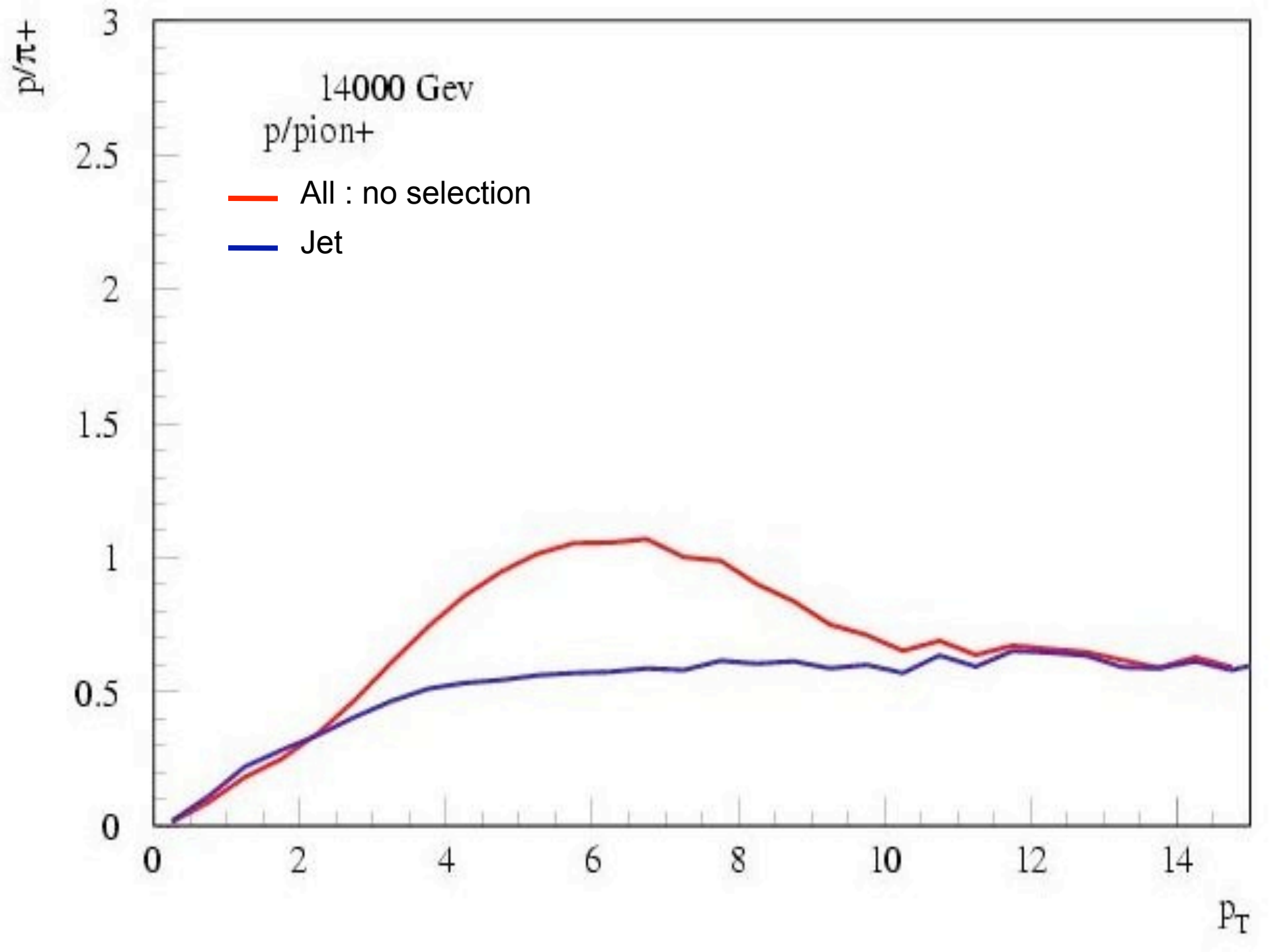


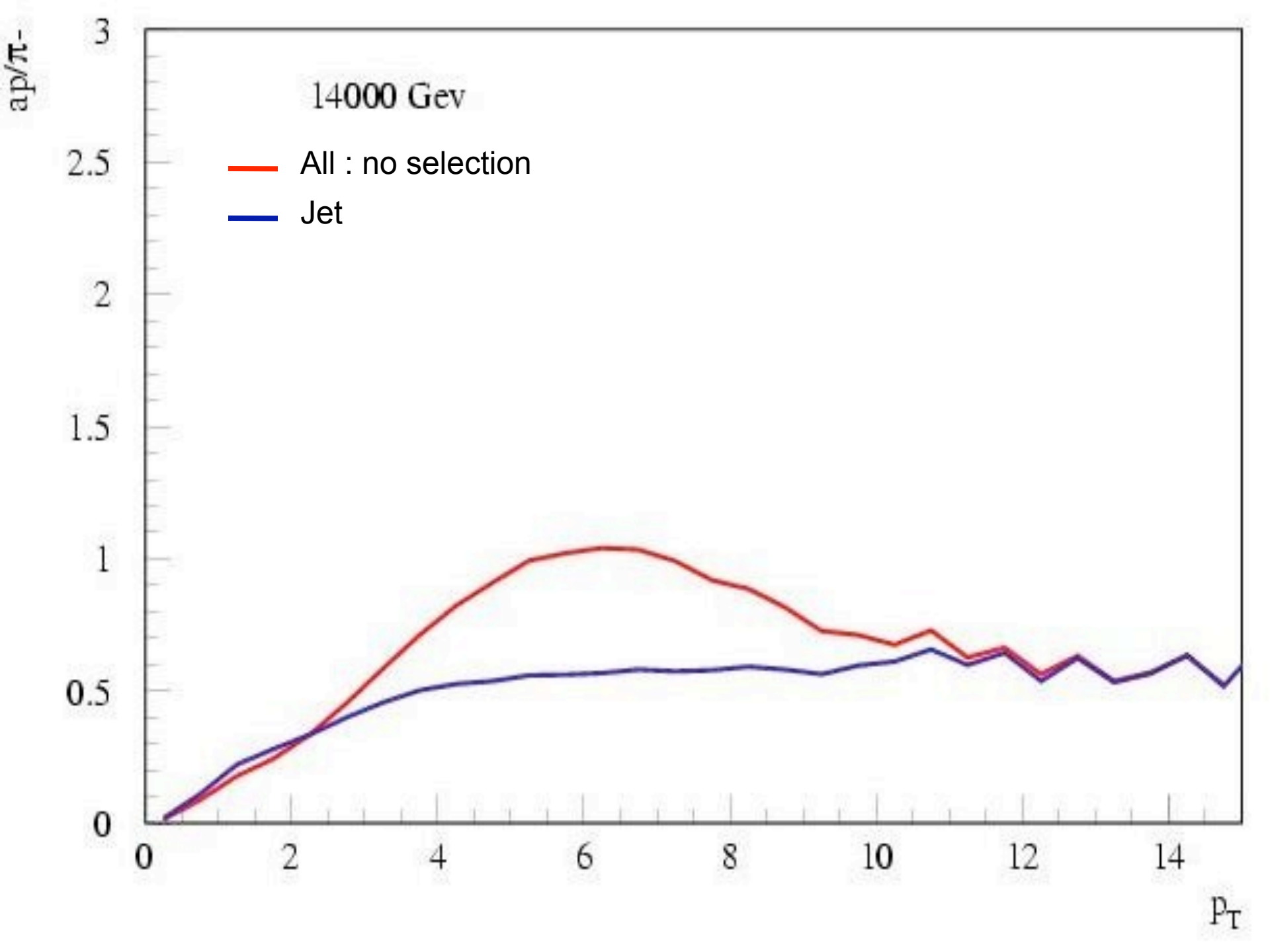
For different energies : from RHIC to LHC






Ratio for different energies
14 TeV
10 TeV
5.5 TeV
1.8 TeV
hydro
"Bulk" in full line
"Jet" in dotted lines
200 GeV
(Λ+anti-Λ)/(2*k0s)
pT
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14


p/π+
14000 Gev
p/pion+
All : no selection
Jet
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
p_T


ap/π-
14000 Gev
All : no selection
Jet
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
p_T

Informations we get

- Ratio Lambda/k0s different in the “bulk” and in “jets”
- Difference of fragmentation in jet and the bulk
  - In jets : the usual string model
  - In the bulk : collectivity
- This difference grows with energy : collectivity more and more important
- Relative difference between bulk and jet different with p/pion
- In pp : should clearly see this effect
- A way to understand
  - Hydro part/ Jet part, Soft/Hard
  - Difference between medium and jet fragmenation
  - Difference with Strangeness production

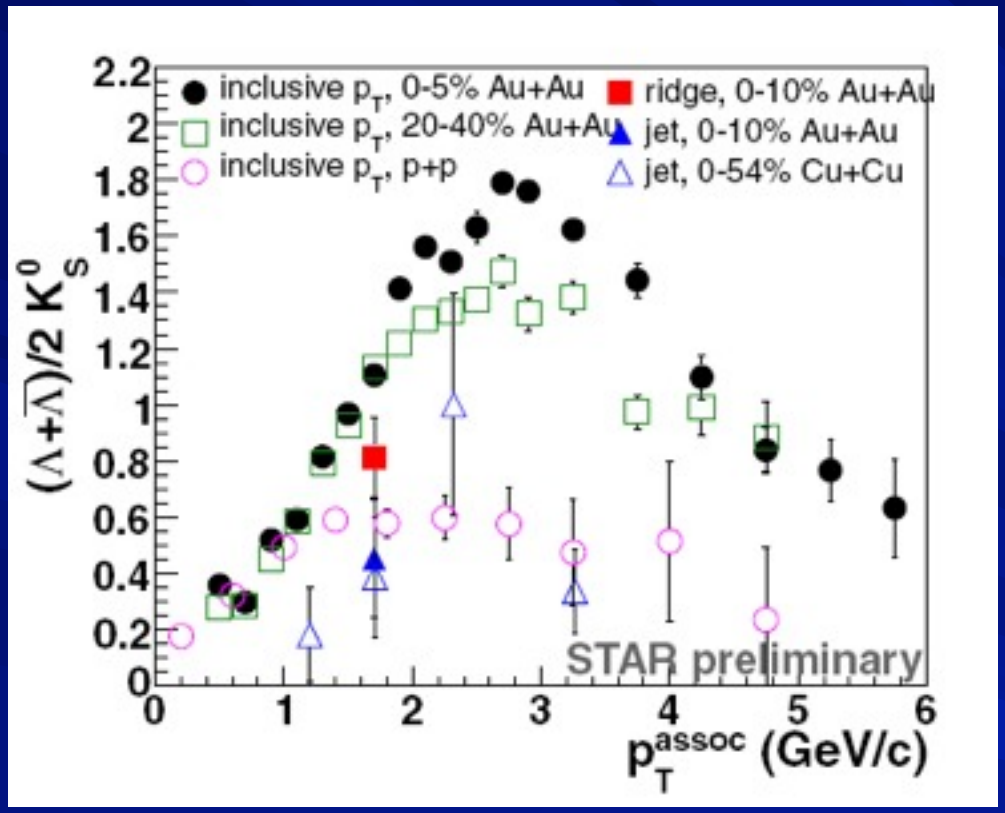
Conclusions

- Epos : goal to be a generator of complete event
  - One experimental event = one generator event
  - Soft, hard, multiple interactions and collective effects in the same event
- Ratio lambda/k0s
  - Different behavior of this observable in “jets” and in the “bulk”
  - In EPOS due to collectivity : difference in fragmentation : string vs. hydro
- Preliminary study

Interesting for the complete understanding of an event

Should be done with same criteria as in experiment : jet finder, R, …

Open Questions to Experimentalist !



C.E.Nattrass, J. Phys.G 35 104110, 2008

Already some arguments in this sense at RHIC for Heavy ion

Leading hadrons?, full jet reconstruction?, jet finder?, R? : WICH CONDITIONS?

Importance of the underlying event : definitions?

R. D. Field, Studying the underlying event at CDF, 2006

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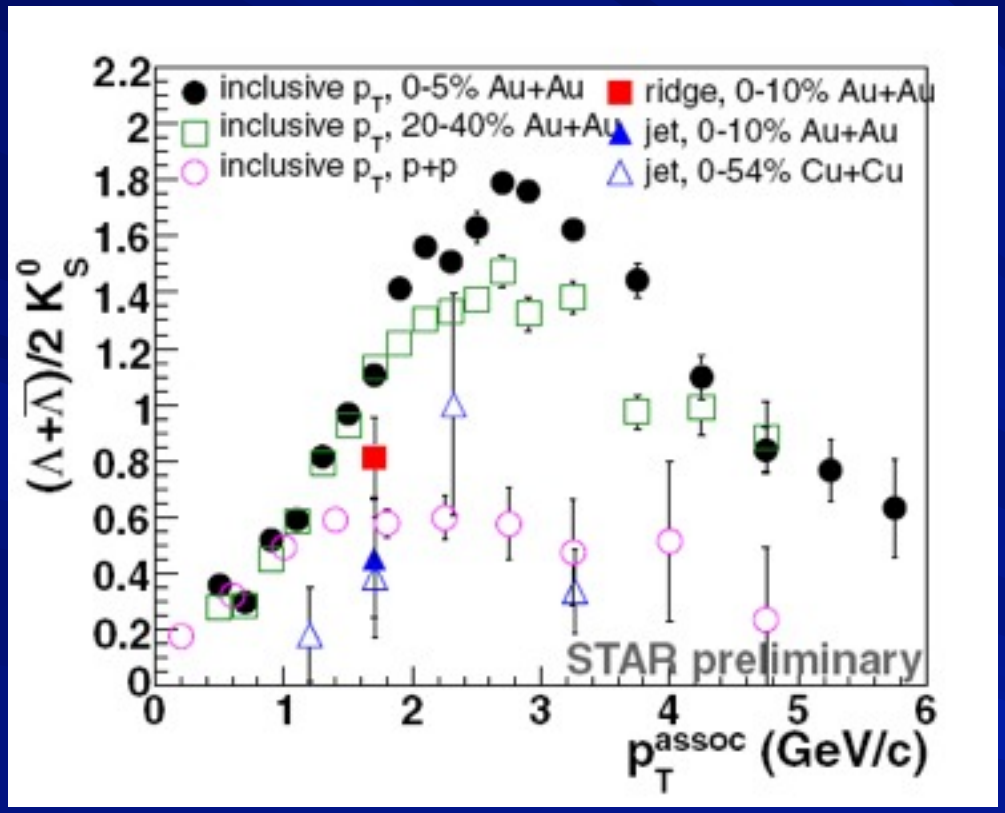

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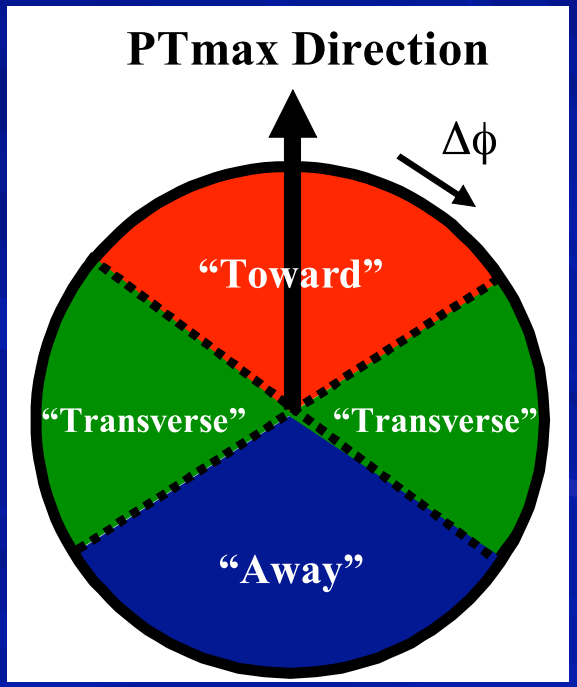

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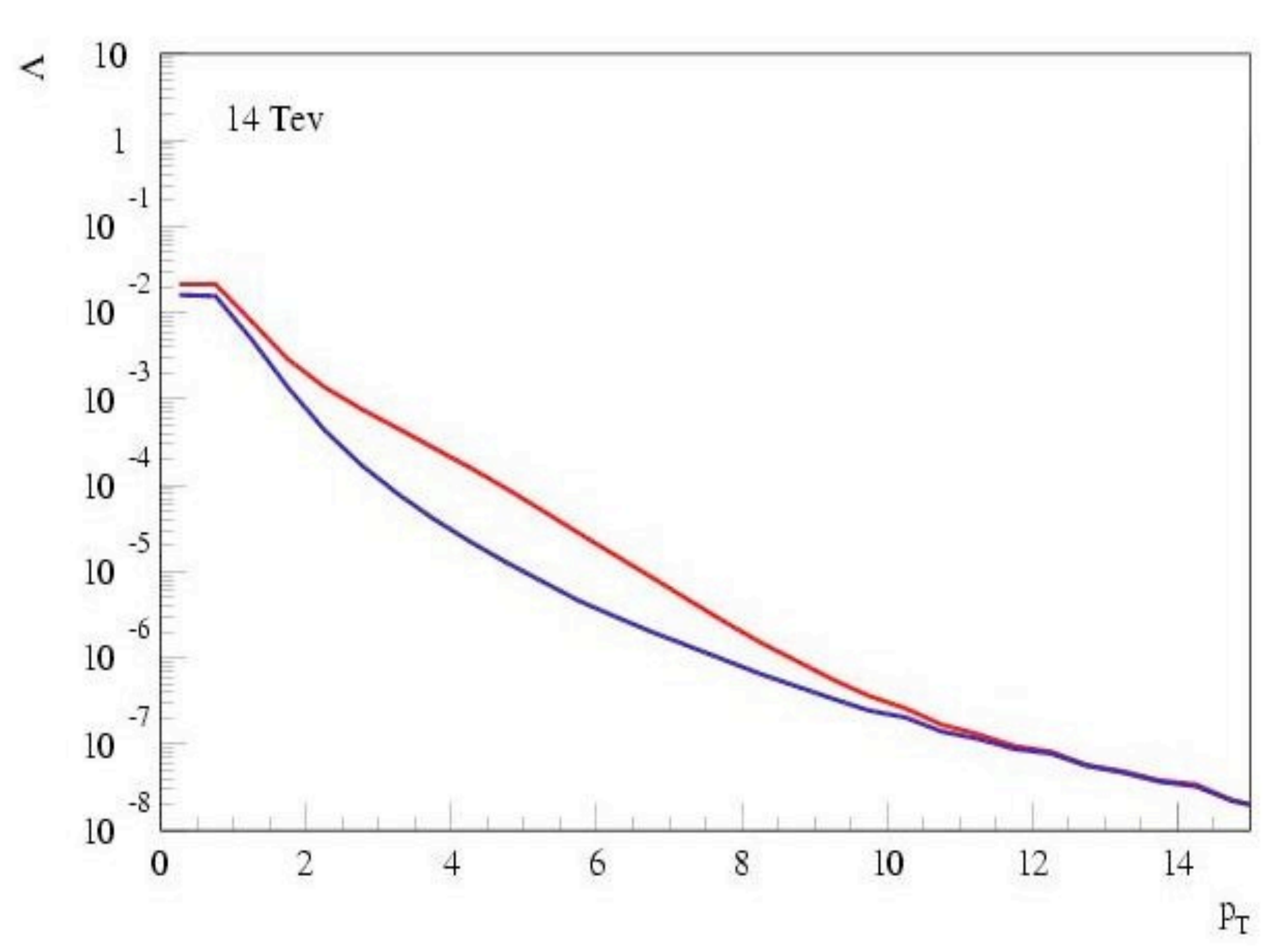
Thanks

EPOS

Energy conserving quantum mechanical multiple scattering approach

Based on

- Partons, parton ladders, strings
- Off-shell remnants
- Splitting of parton ladder


14 Tev
10
1
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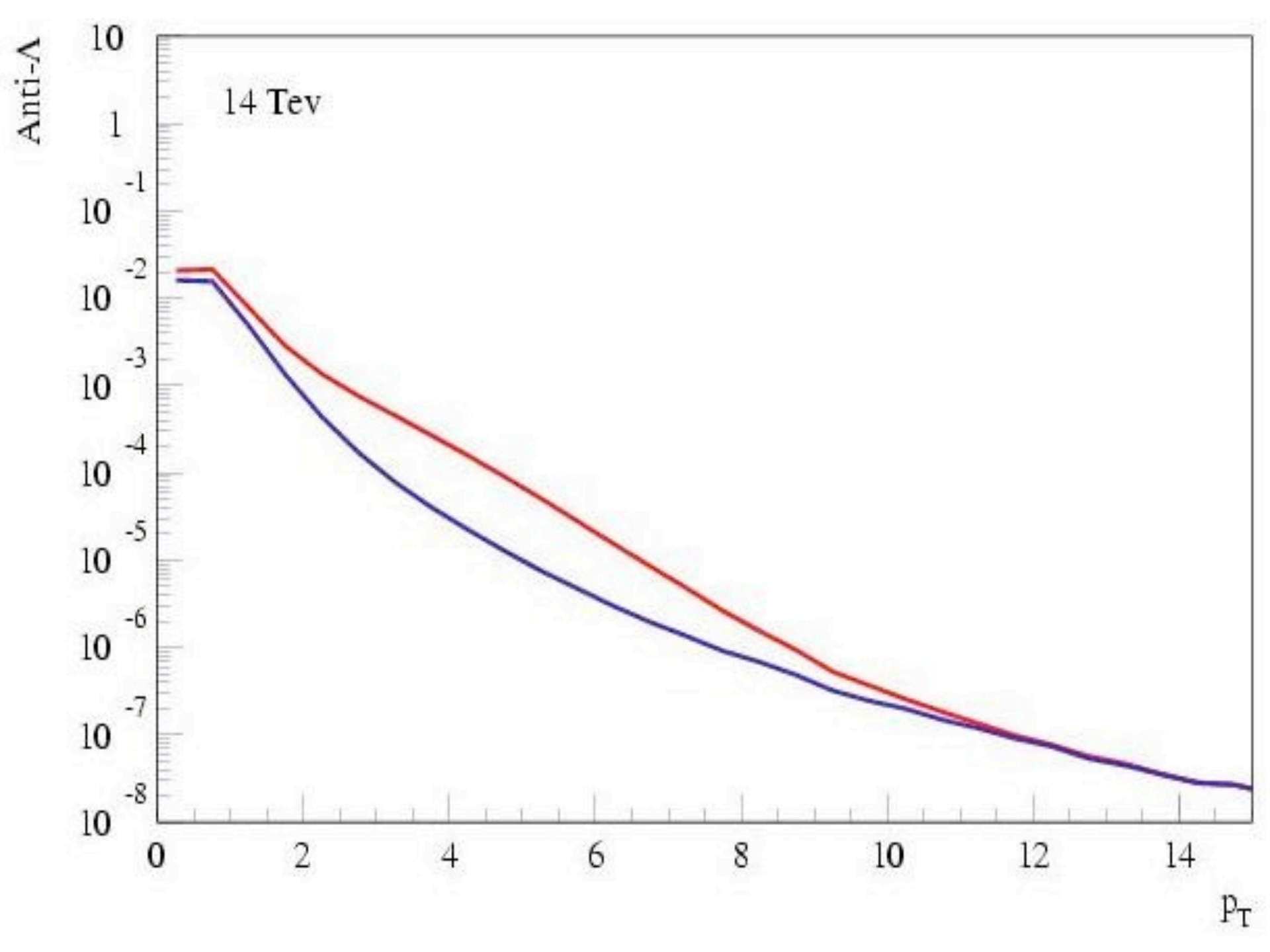
p_T


Anti-Λ
14 Tev
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-2
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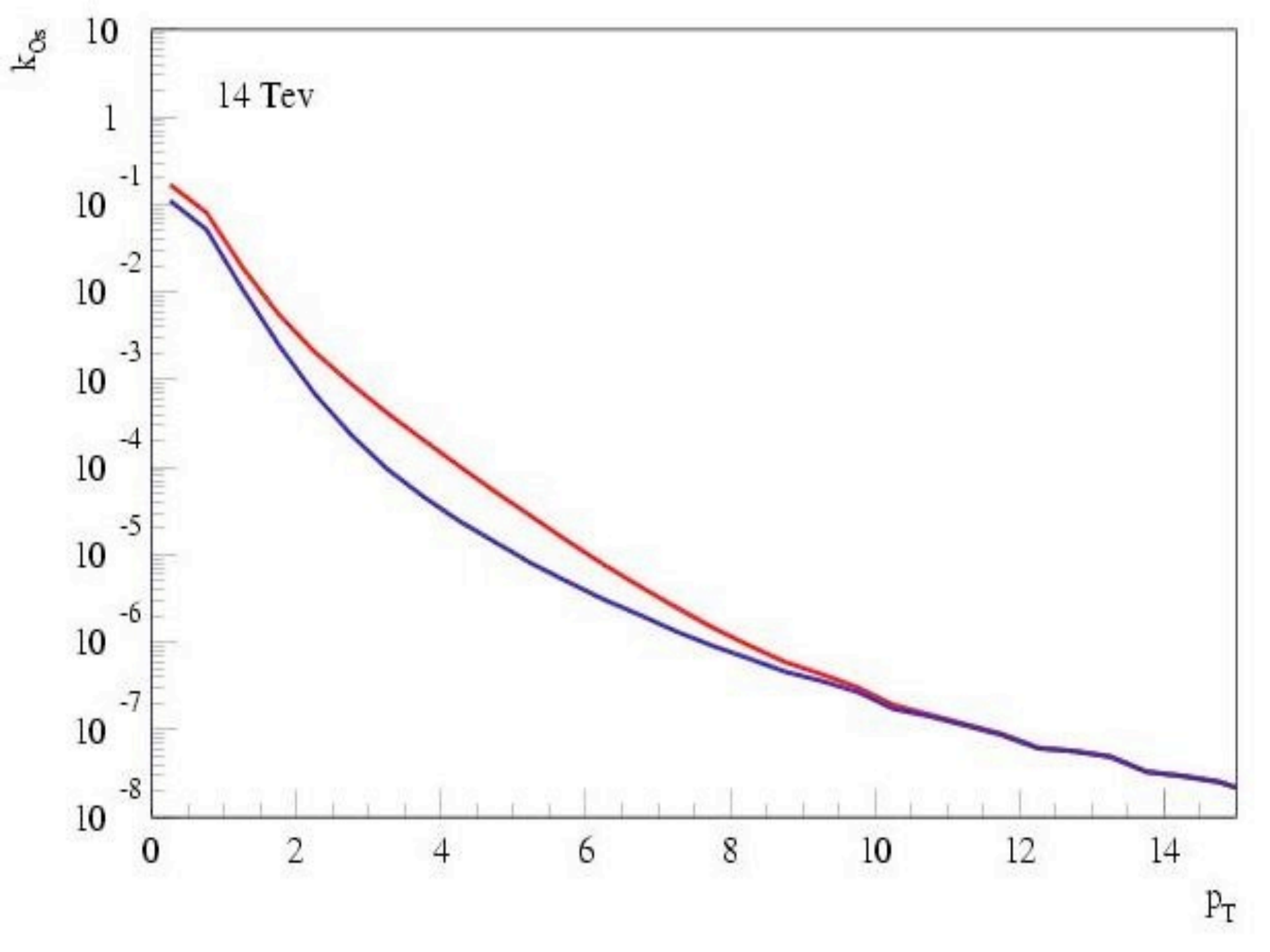
p_T


k_{Os}
14 Tev
10^{1}
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10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
0
2
4
6
8
10
12
14
p_T