

EXAMINATION OF HEAVY-ION COLLISIONS USING EPOS MODEL IN THE FRAME OF BES PROGRAM

Maria Stefaniak

Under supervision of: Hanna Zbroszczyk & Klaus Werner



**Wydział
Fizyki**

POLITECHNIKA WARSZAWSKA



EPOS3

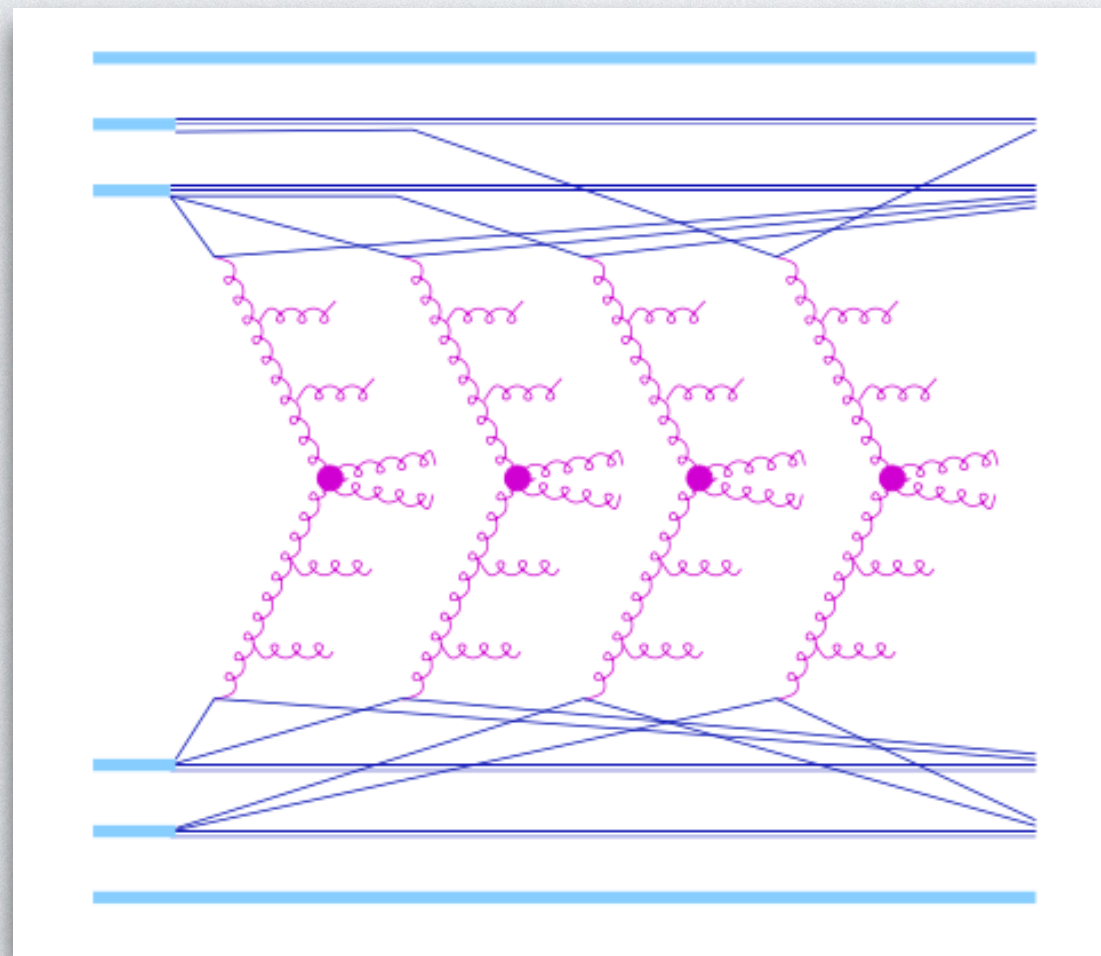
EPOS3

Gribov-Regge multiple scattering approach

- Pomerons
- Parton ladders
- Strings

Core-Corona approach

Viscous hydrodynamic expansion

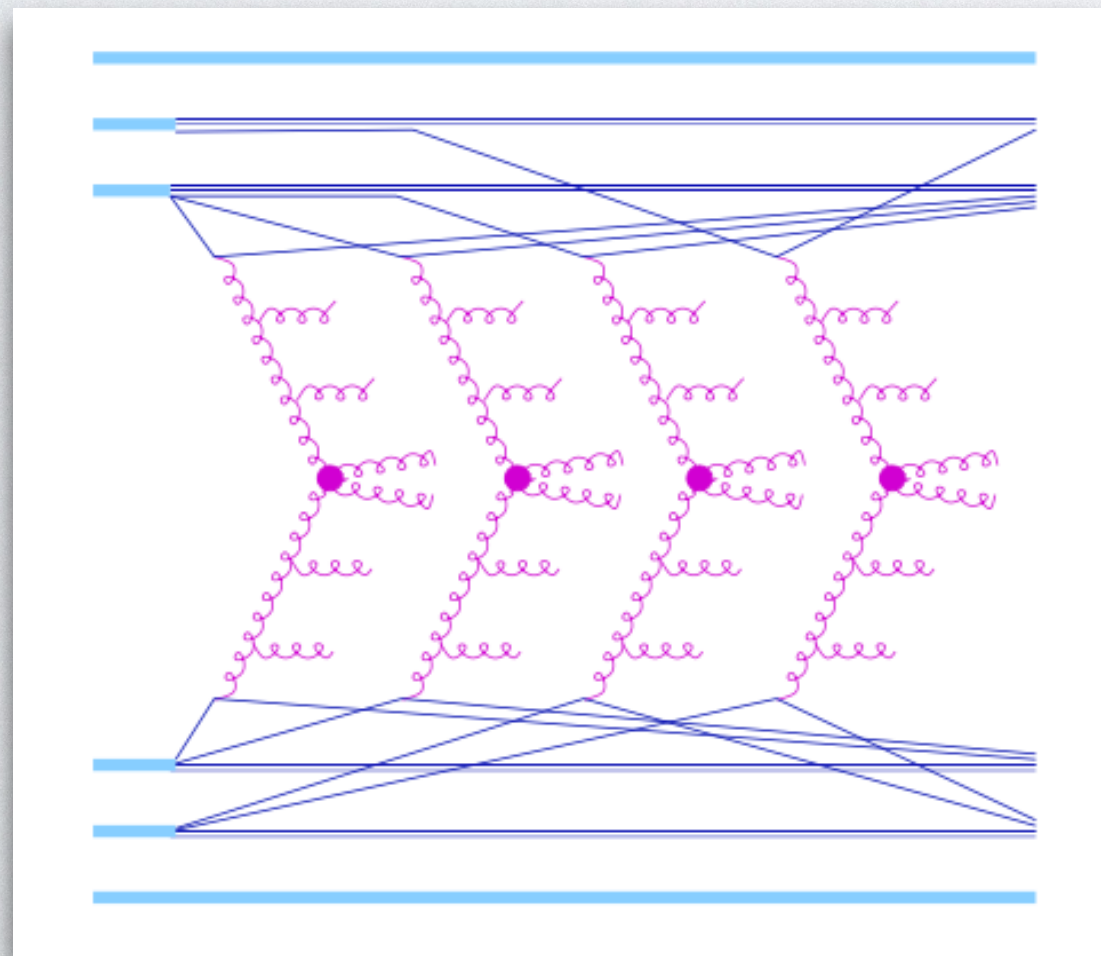


J. Phys.: Conf. Ser. **736** 012009

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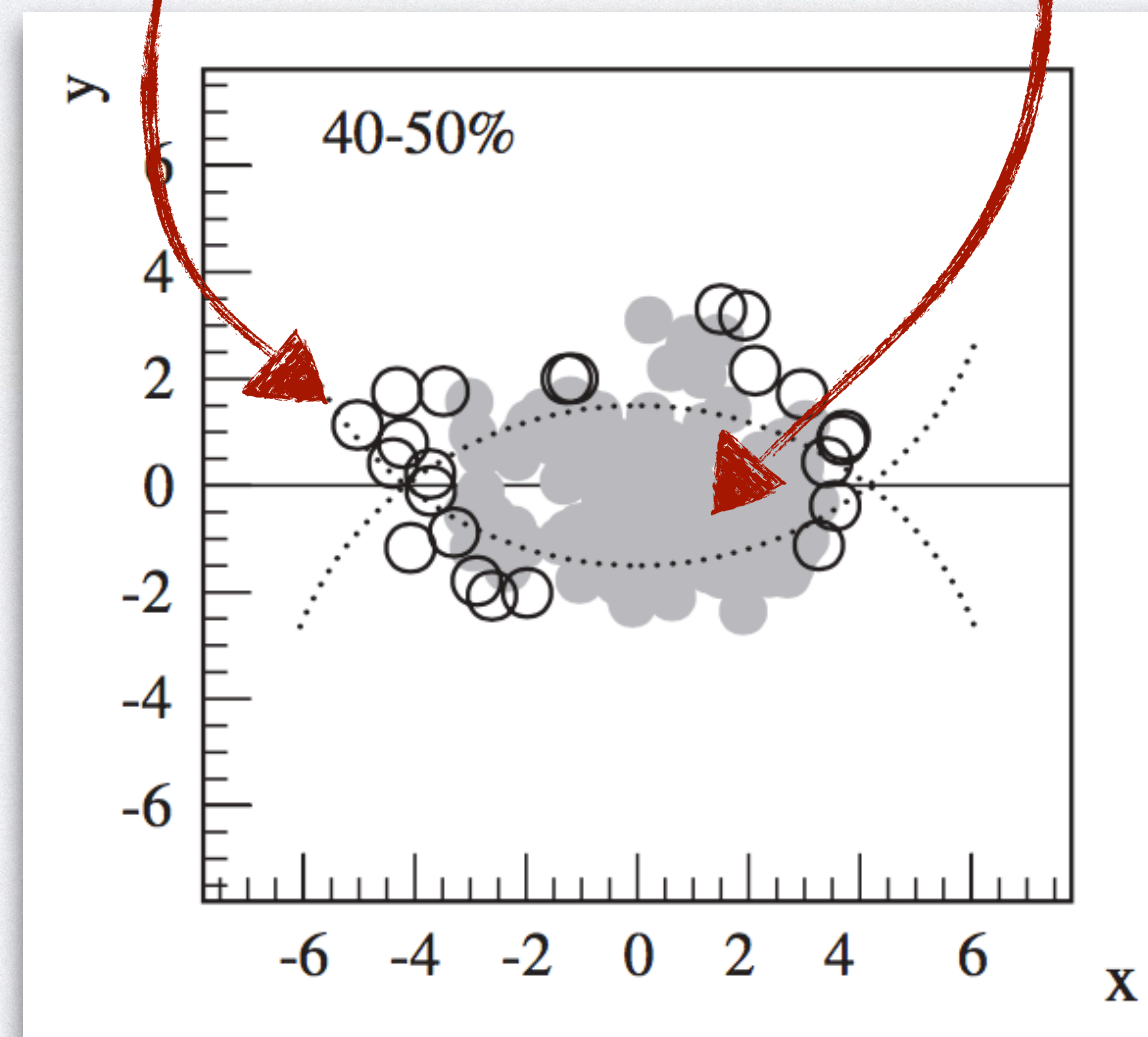


J. Phys.: Conf. Ser. 736 012009

Core-Corona approach

Strings segment in:

- Core - high density area
- Corona - low density



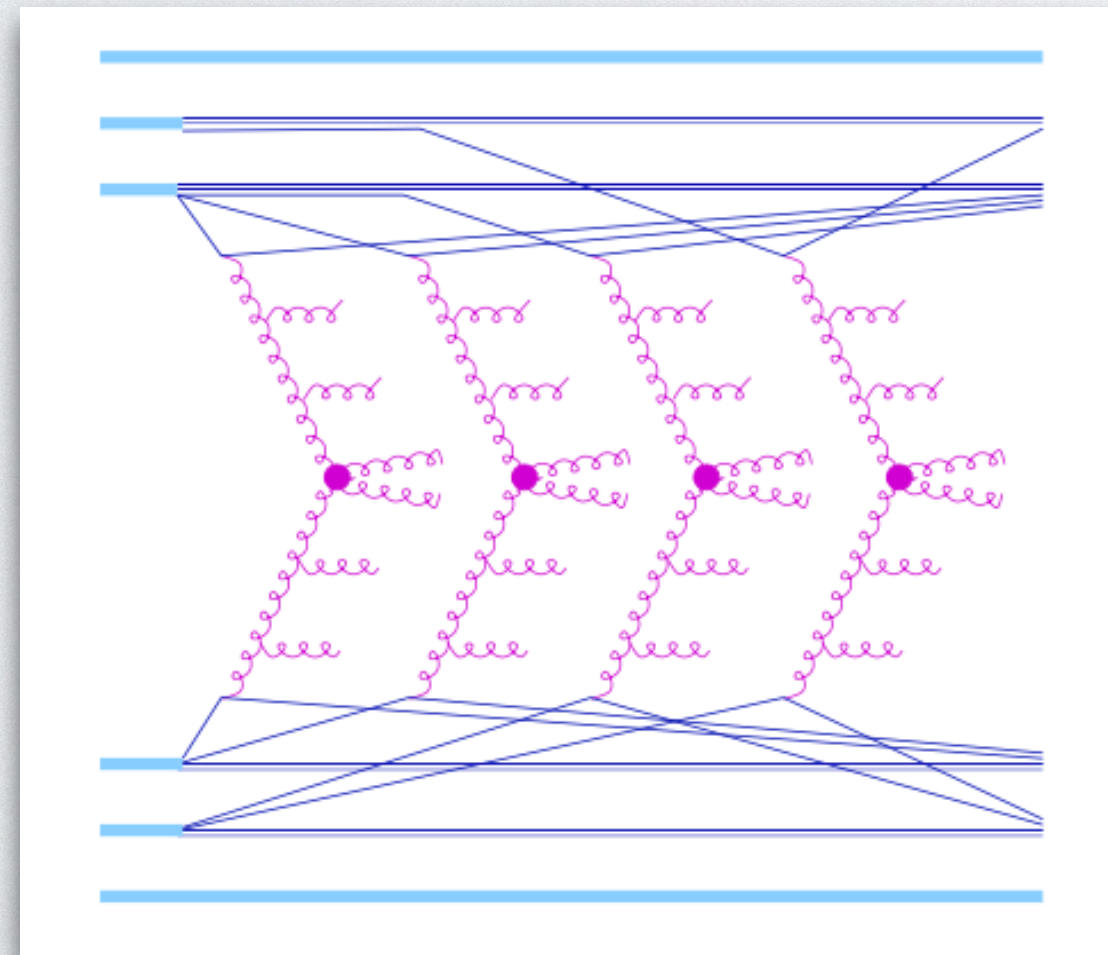
PhysRevLett.98.152301

Viscous hydrodynamic expansion

EPOS3

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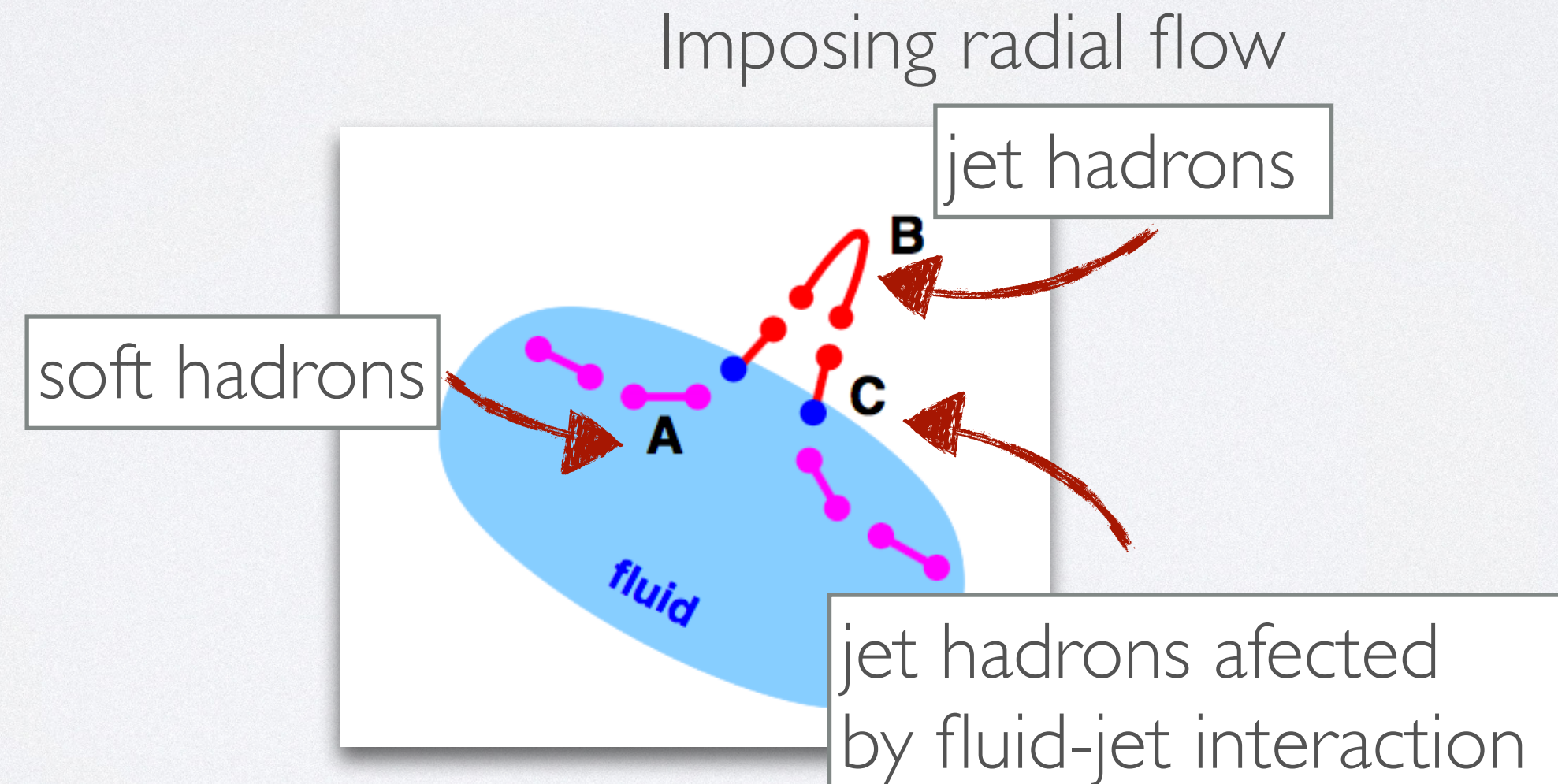


J. Phys.: Conf. Ser. 736 012009

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- Proton-proton scattering



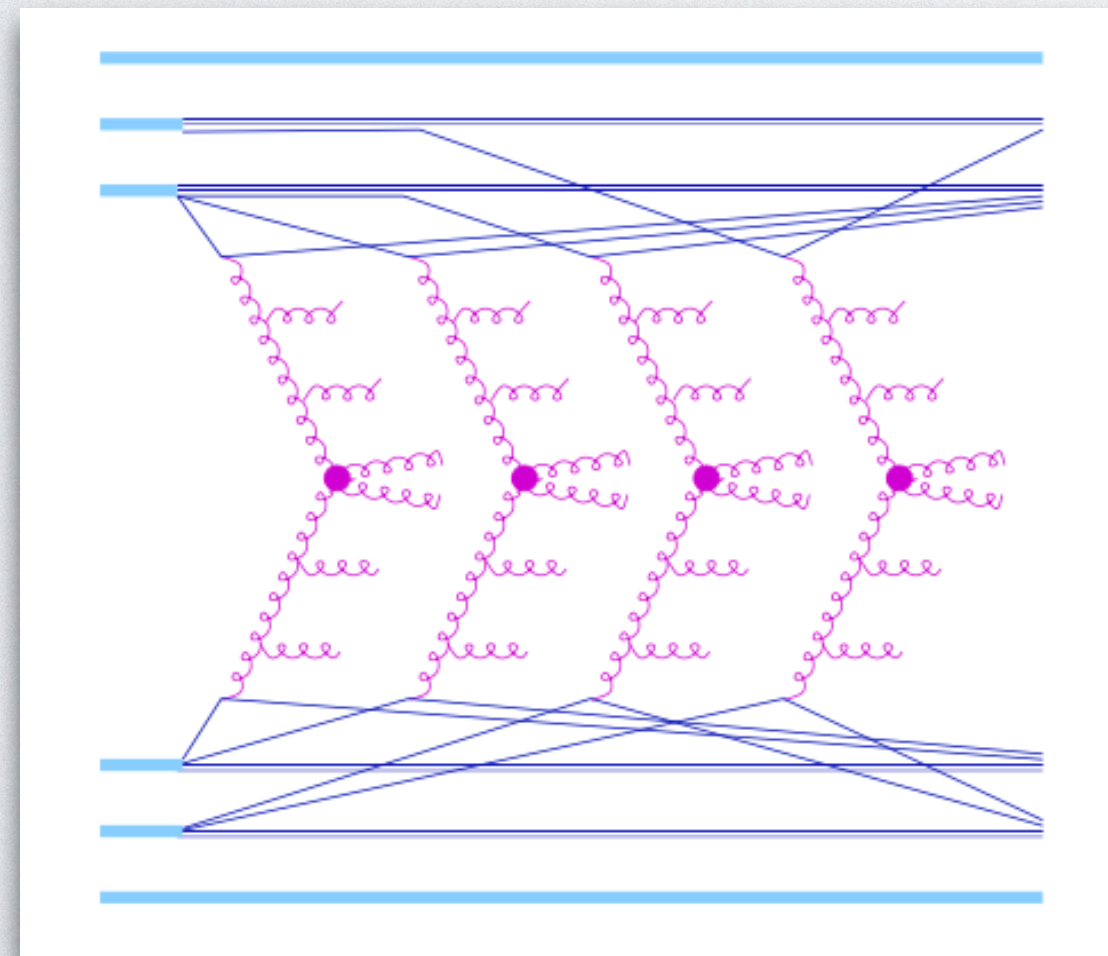
Journal of Physics: Conference Series 422 (2013) 012001

Viscous hydrodynamic expansion

EPOS3

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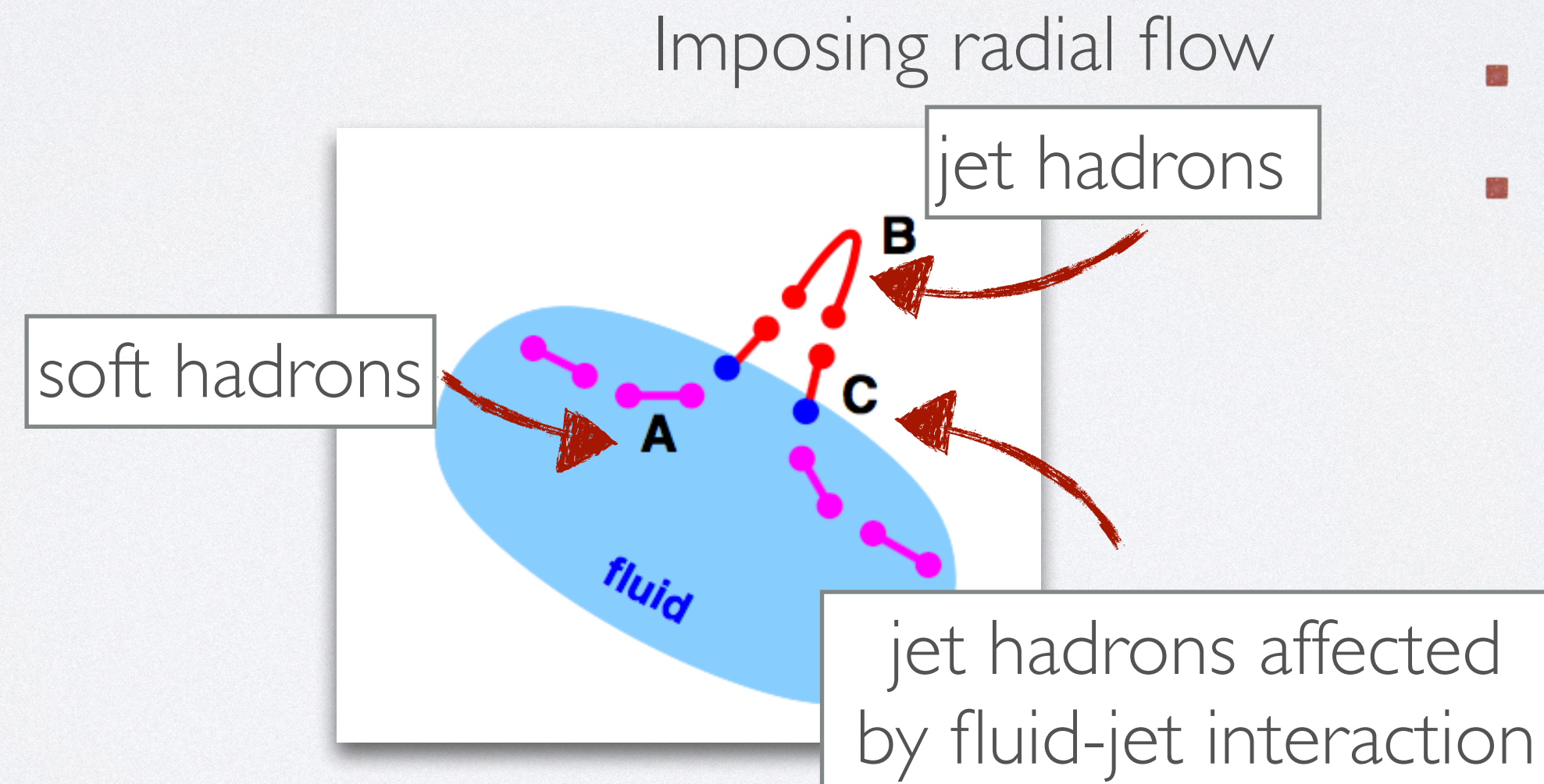


J. Phys.: Conf. Ser. **736** 012009

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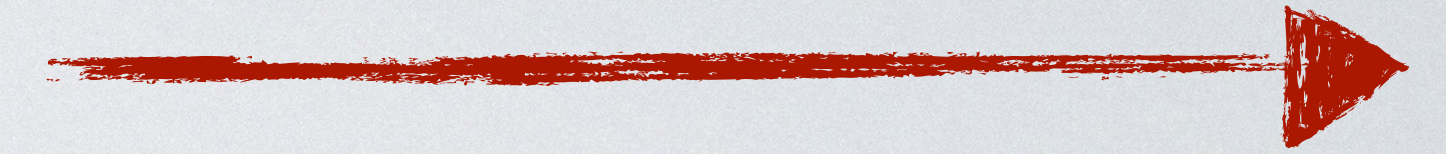
Journal of Physics: Conference Series **422** (2013) 012001

Viscous hydrodynamic expansion

- Initial time τ_0
- Evolution of system according to the eq. of relativistic viscous hydrodynamics
- $\eta/s = 0.08$
- cross-over equation-of-state, compatible with lattice QCD

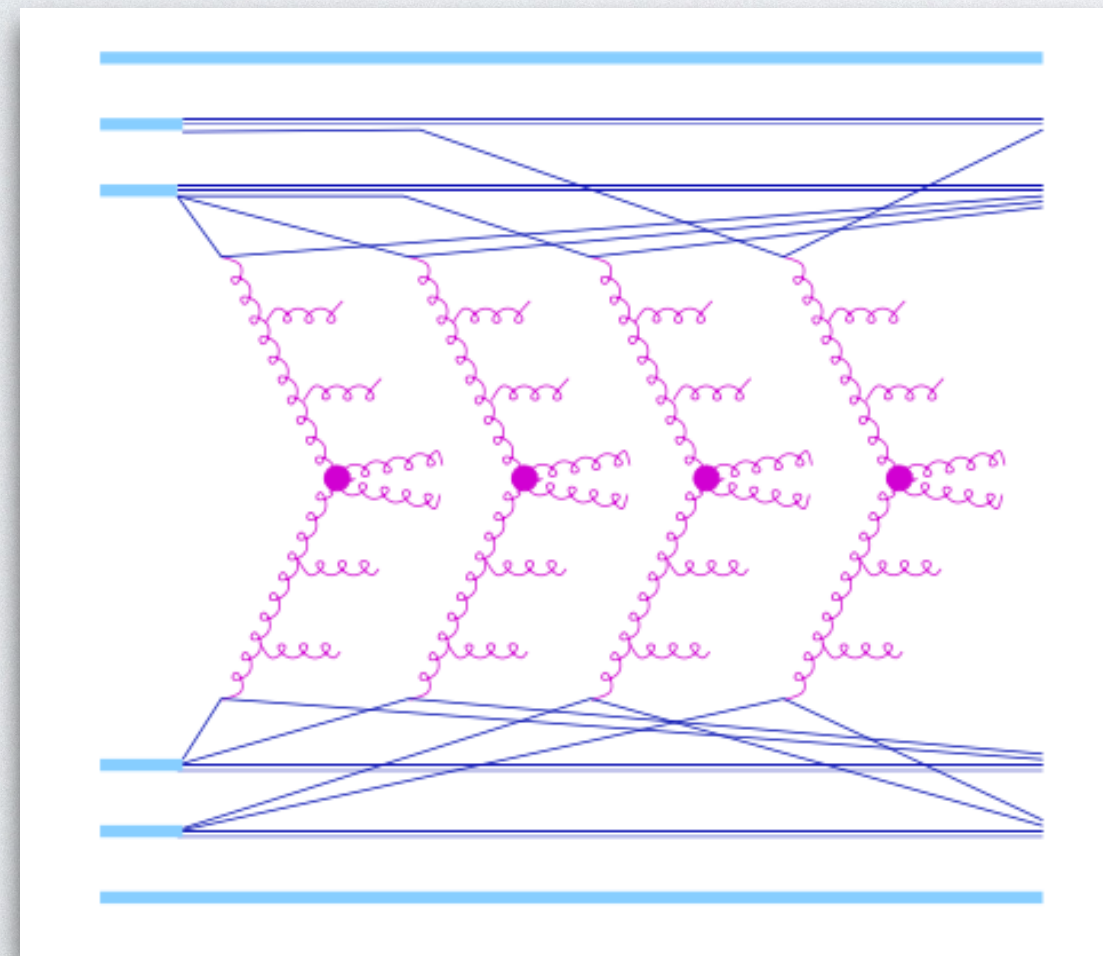
J. Phys.: Conf. Ser. **736** 012009

EPOS3



Gribov-Regge multiple scattering approach

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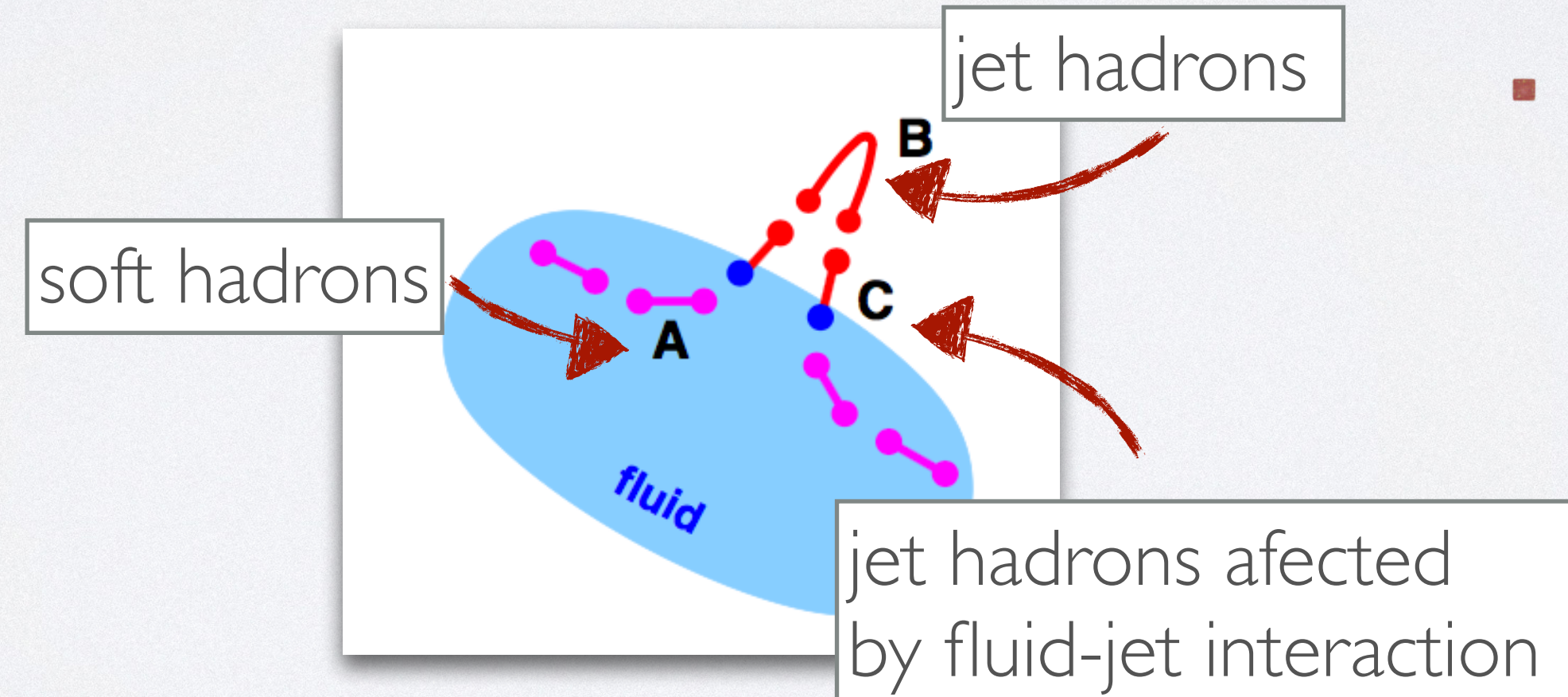
J. Phys.: Conf. Ser. **736** 012009

Core-Corona approach

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- Proton-proton scattering

Imposing radial flow



Journal of Physics: Conference Series **422** (2013) 012001

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- $\eta/s = 0.08$
- cross-over equation-of-state, compatible with lattice QCD

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EPOS3

Statistical hadronization

Core matter:

- hadronization on hypersurface with constant T_H
- Cooper-Frye procedure

Phys. Rev. C 83, 044915 (2011)

Final state Hadronic Cascade

EPOS3

Statistical hadronization

Core matter:

- hadronization on hypersurface with constant T_H
- Cooper-Frye procedure

Phys. Rev. C 83, 044915 (2011)

Final state Hadronic Cascade

If hadron density big enough

hadron-hadron rescattering

URQMD model

J. Phys. G25 (1999) 1859,

Phys. Rev. C78 (2008) 044901

With Hadronic Cascades

EPOS3

NO Hadronic Cascades

Statistical hadronization

Core matter:

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- Cooper-Frye procedure

Phys. Rev. C 83, 044915 (2011)

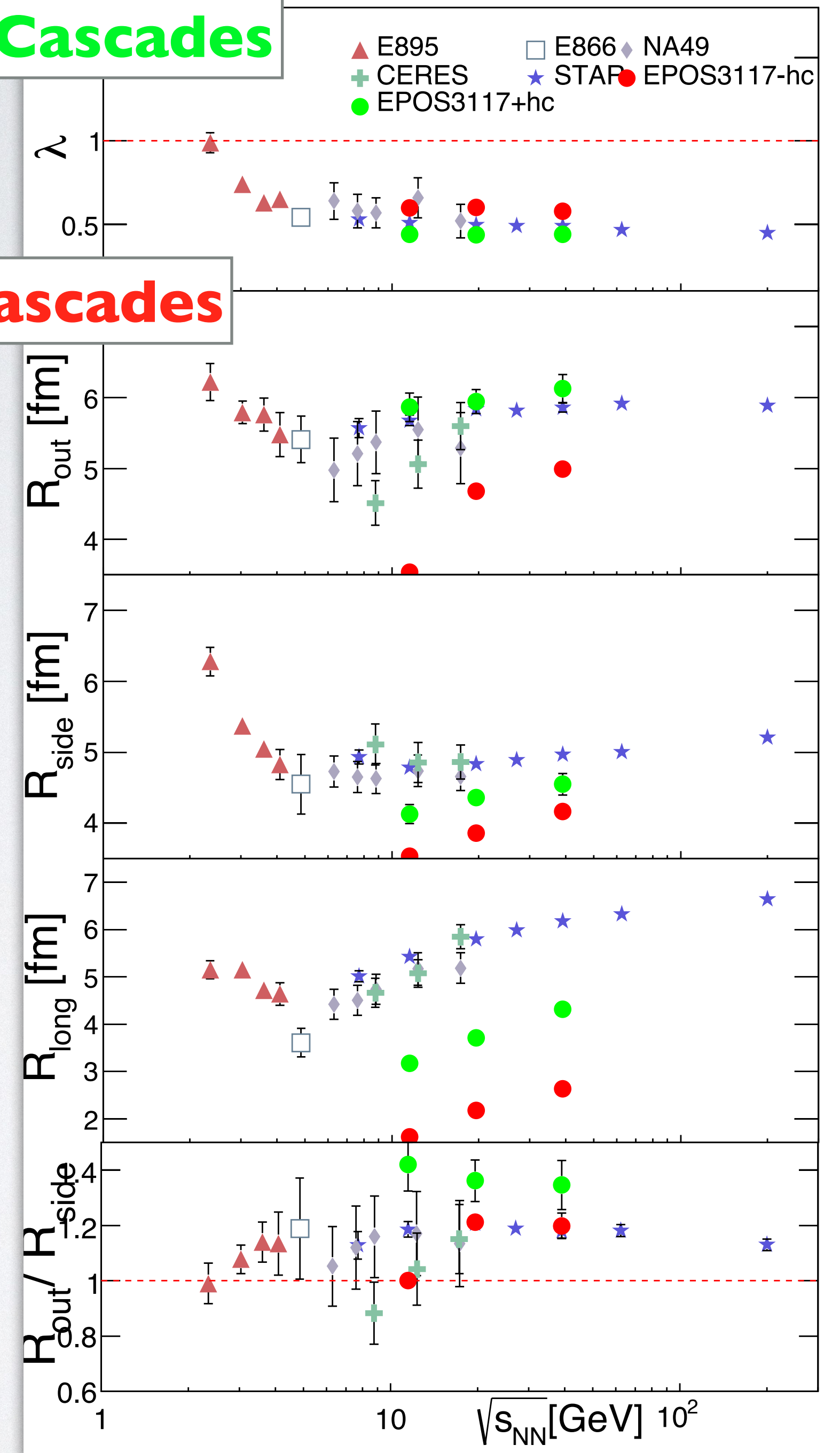
Final state Hadronic Cascade

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URQMD model

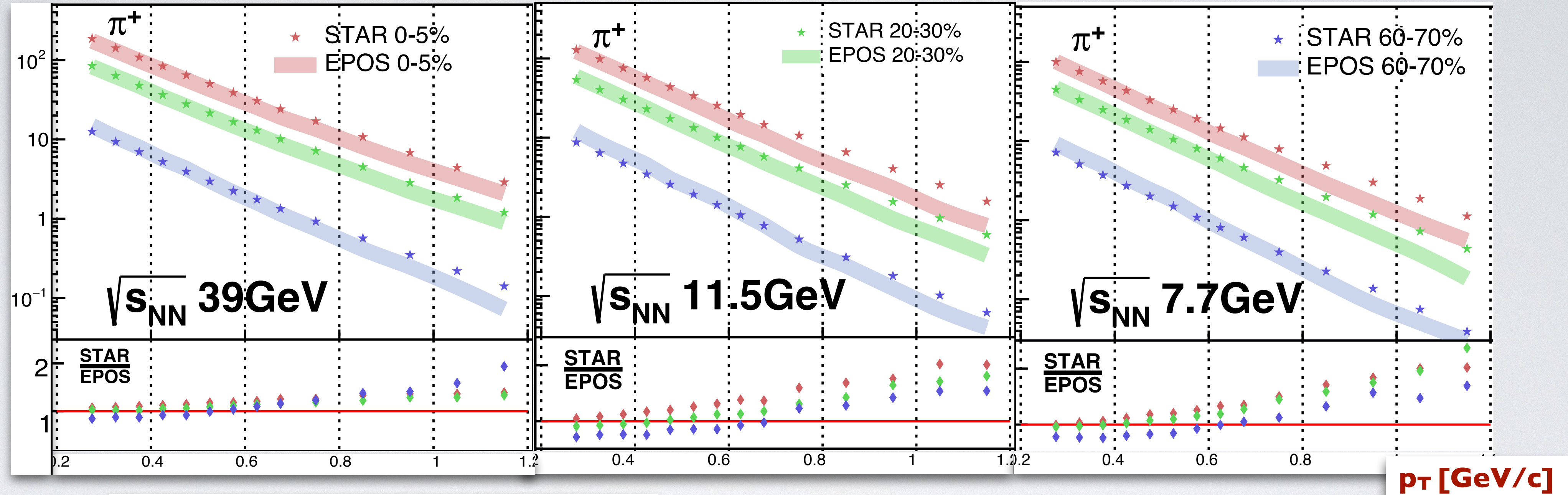
Experimental data: Phys.Rev. C92 (2015) no.1, 014904



SPECTRA $P_T \pi^+$

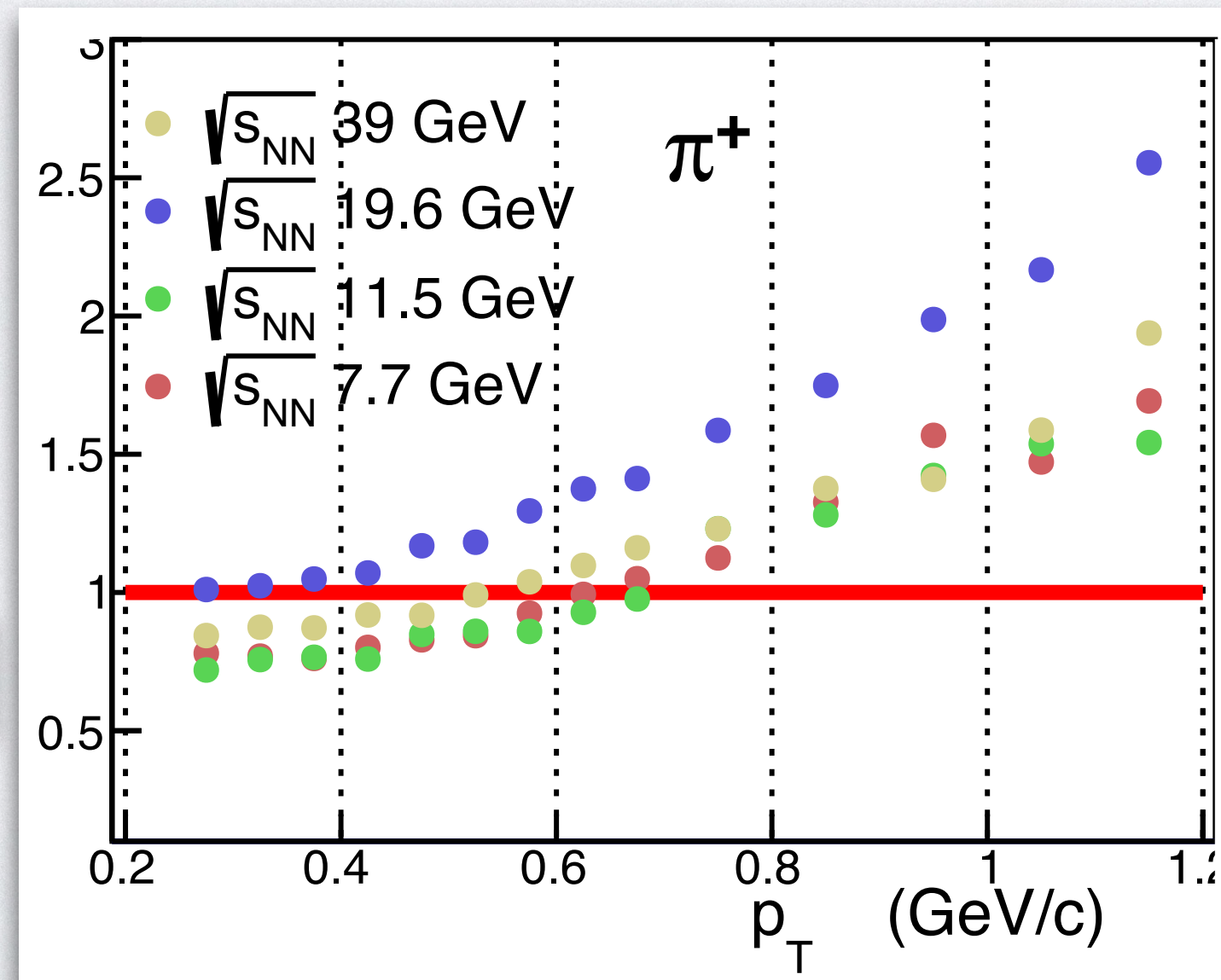
arXiv:1701.07065 **Au+Au**

$$\frac{d^2N}{2\pi p_T d\eta dp_T}$$



STAR
EPOS

Centrality: 60-70%



- Small differences, for **39 GeV in the range of expectations!**
- In **peripheral collisions** visible discrepancies of **slope** for all energies in whole p_T range

SPECTRA P_T K^+

Au+Au

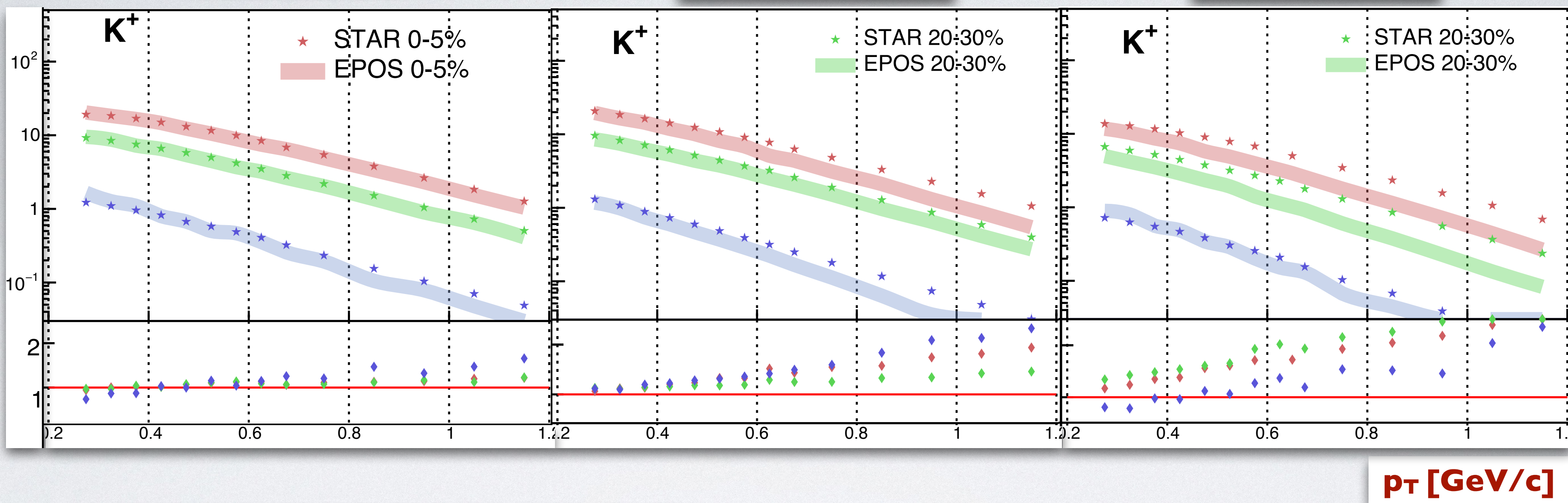
$\sqrt{s_{NN}}$ 39 GeV

$\sqrt{s_{NN}}$ 19.6 GeV

$\sqrt{s_{NN}}$ 7.7 GeV

$\frac{d^2N}{2\pi p_T d\eta dp_T}$

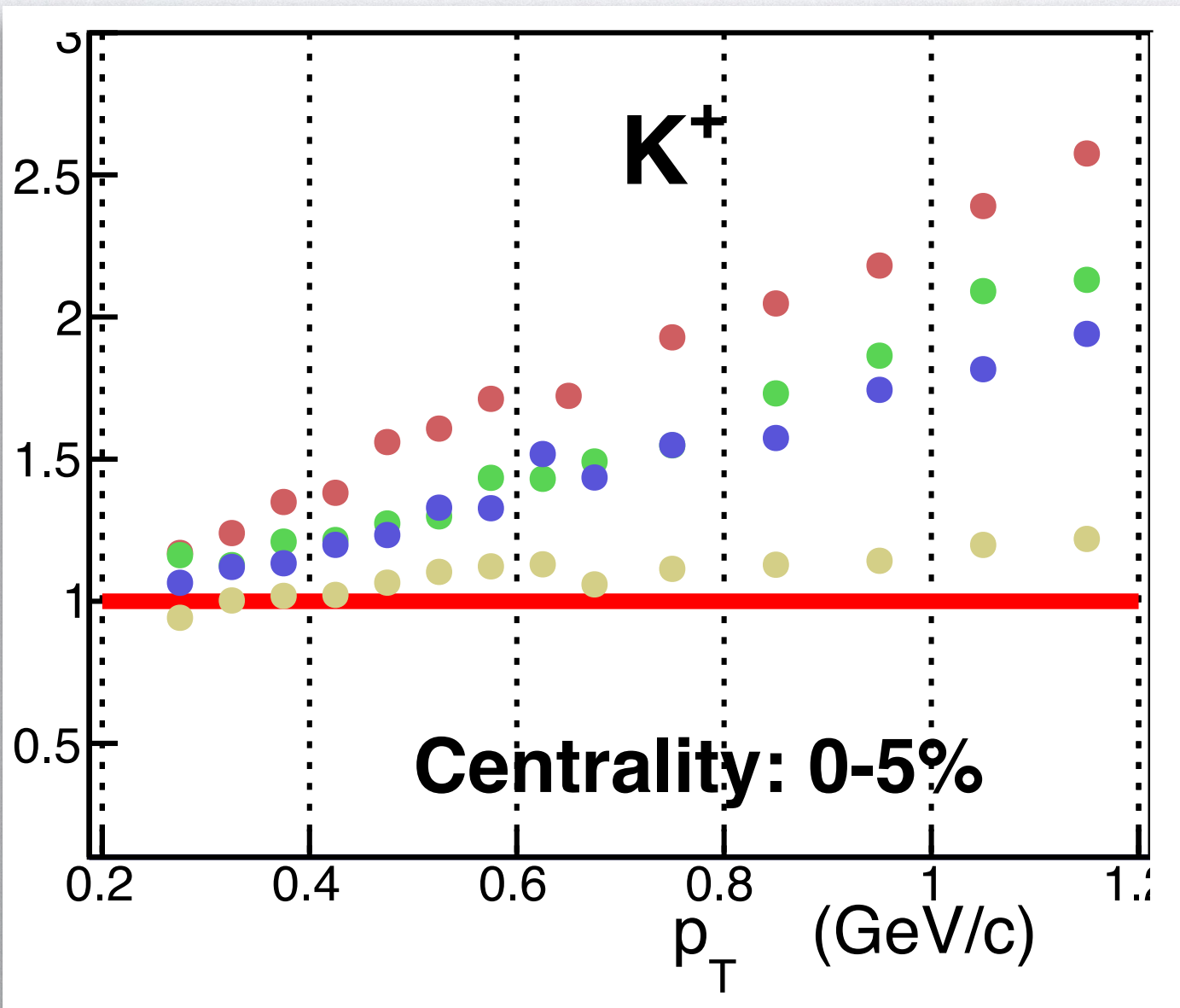
STAR
EPOS



arXiv:1701.07065

STAR
EPOS

● $\sqrt{s_{NN}}$ 39 GeV
● $\sqrt{s_{NN}}$ 19.6 GeV
● $\sqrt{s_{NN}}$ 11.5 GeV
● $\sqrt{s_{NN}}$ 7.7 GeV



- Increasing with p_T difference in **slope**
- Size of discrepancies depend on **energy**
- K not from resonances

SPECTRA P_T (ANTI) PROTONS

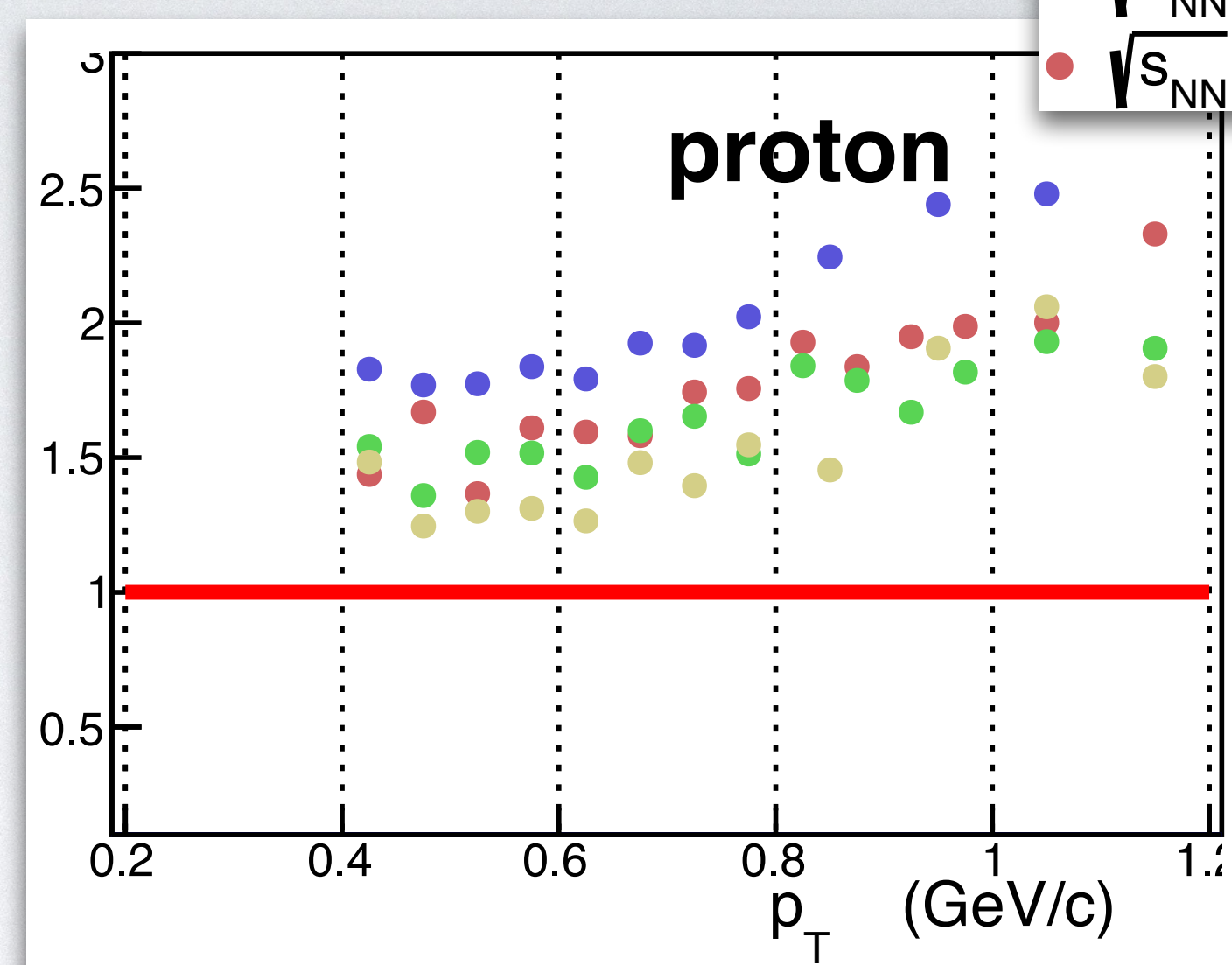
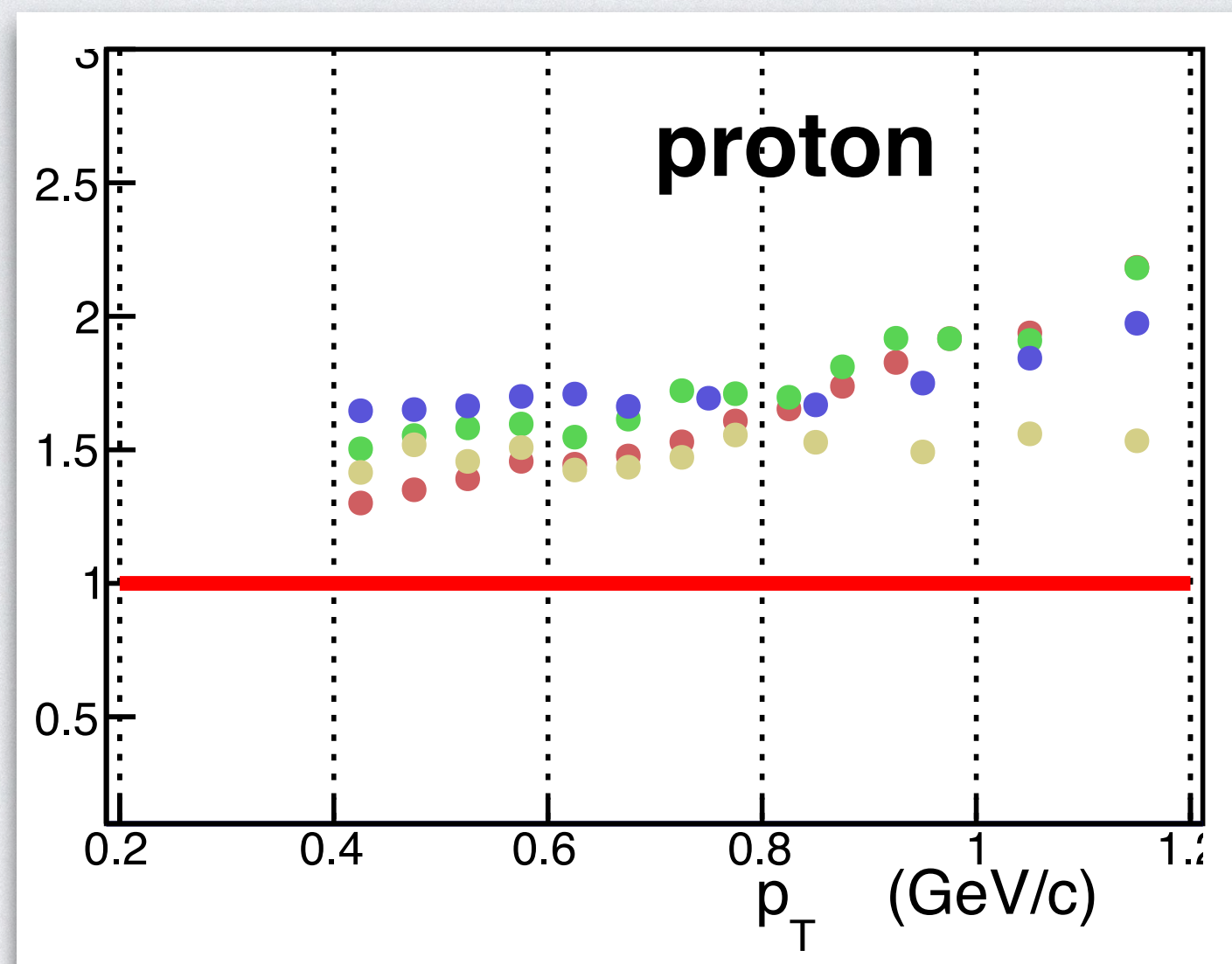
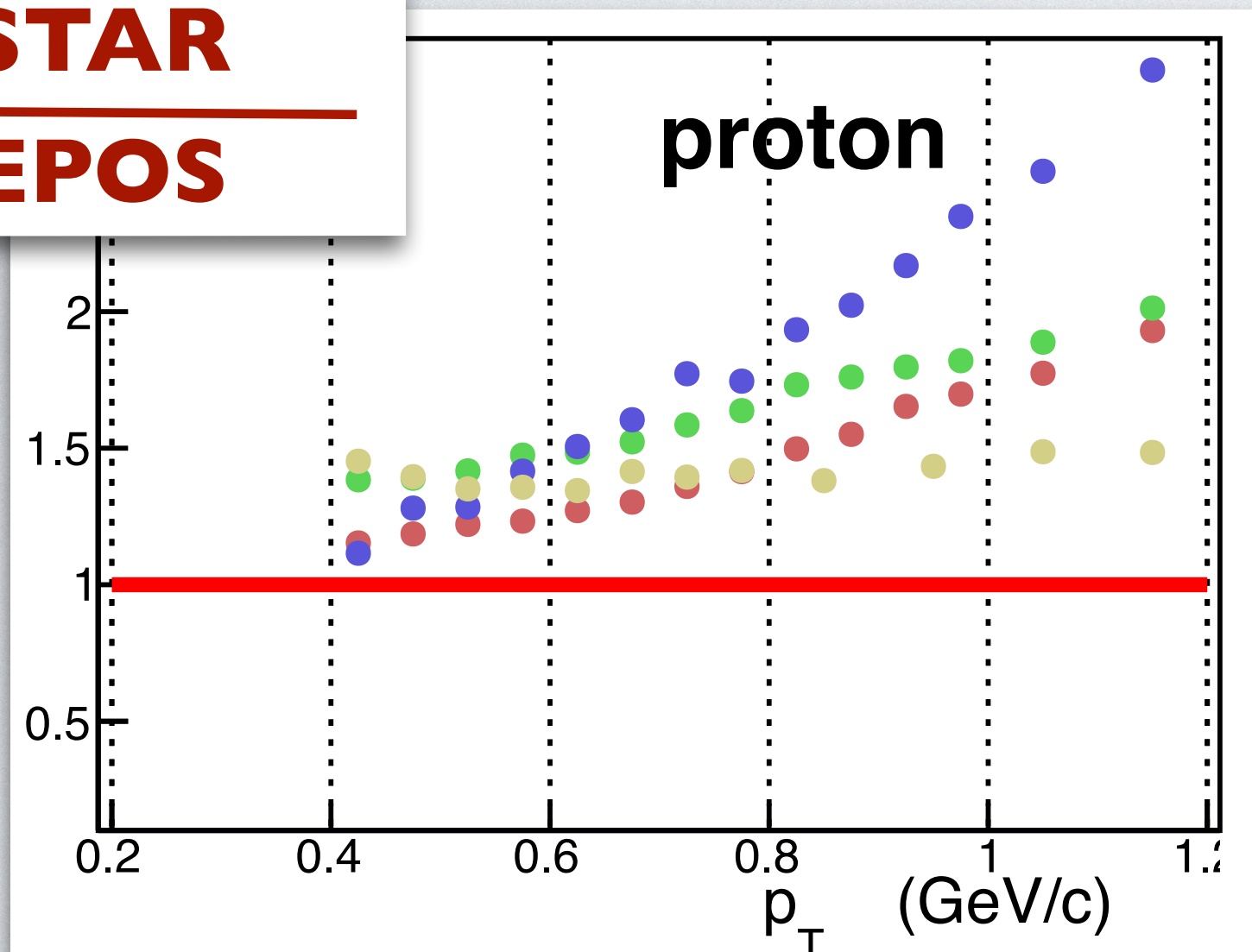
$\sqrt{s_{NN}}$ 39 GeV
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 $\sqrt{s_{NN}}$ 7.7 GeV

Centrality: 0-5%

Centrality: 20-30%

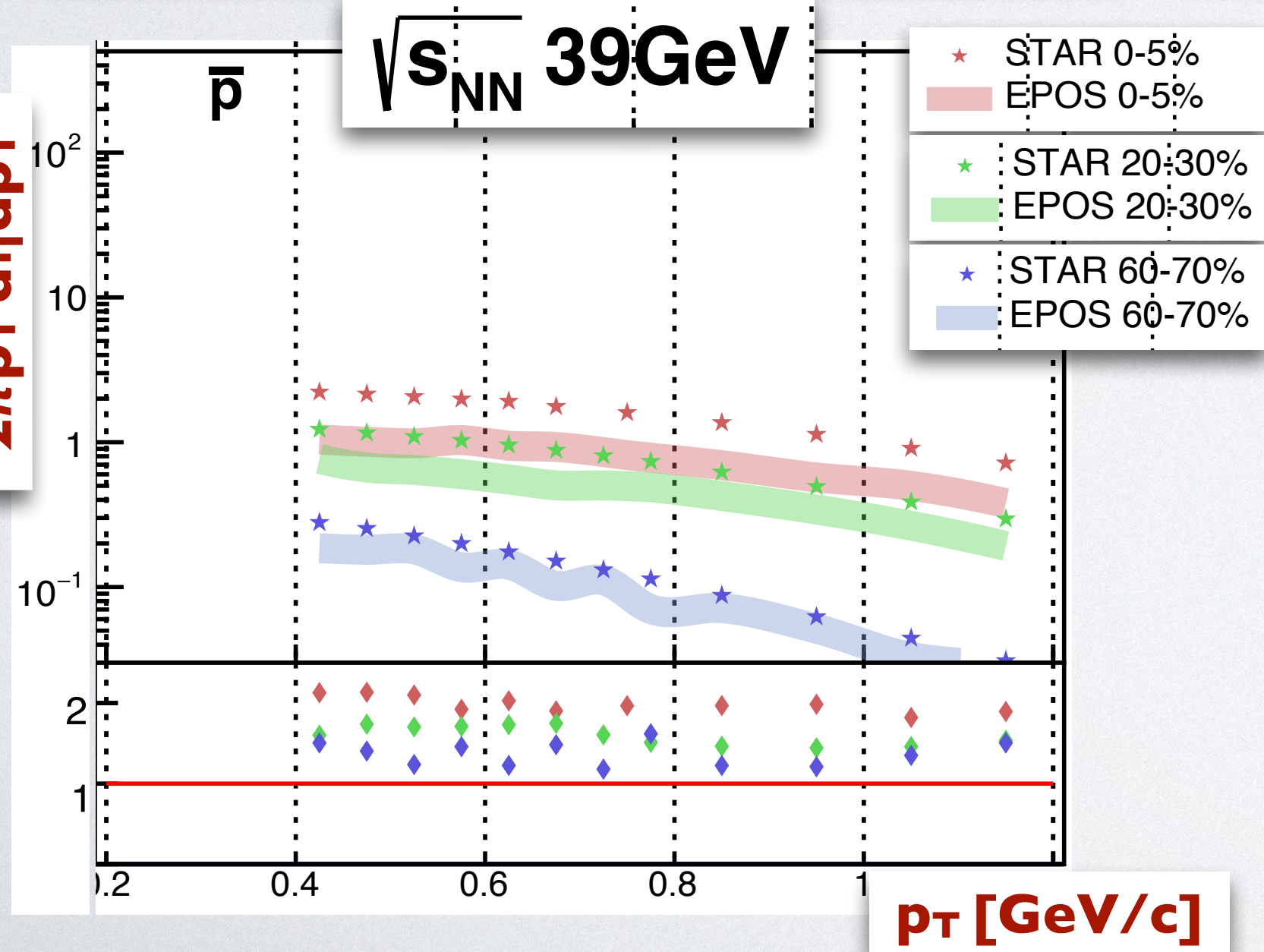
Centrality: 60-70%

STAR
EPOS



$\frac{d^2N}{2\pi p_T d\eta dp_T}$

$\sqrt{s_{NN}}$ 39 GeV

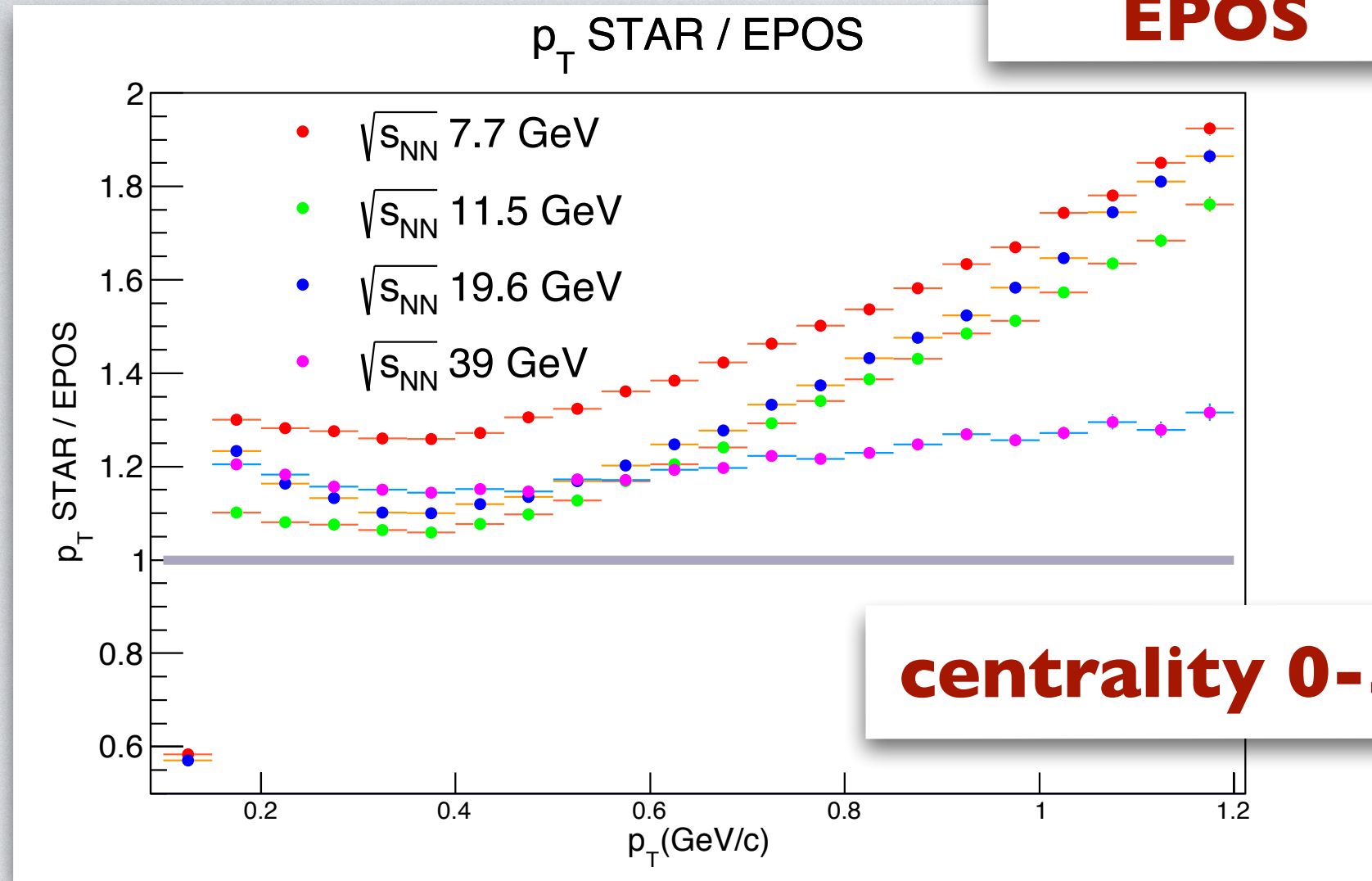


arXiv:1701.07065

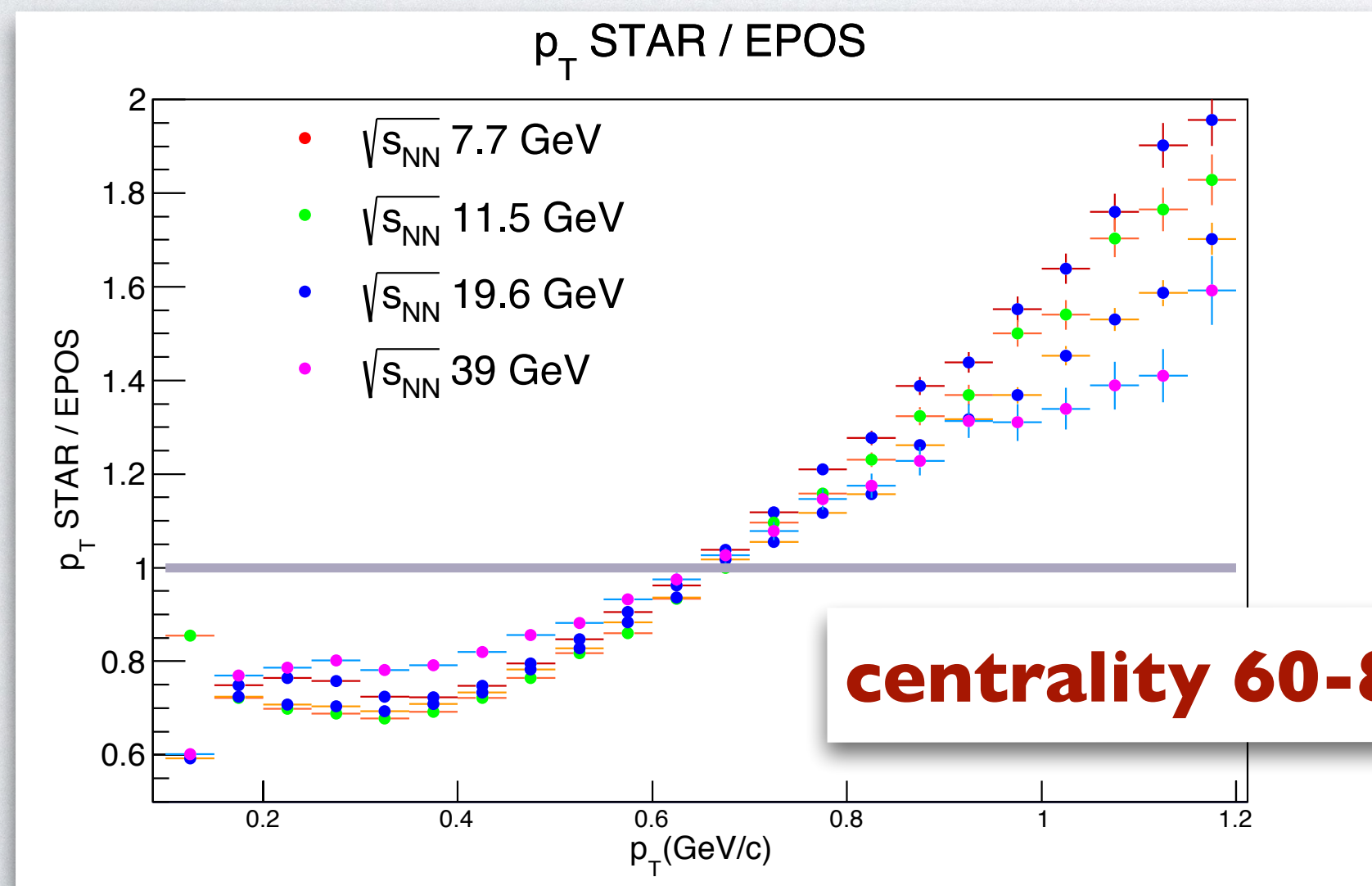
- **p: slope** differences depend on **centrality**
- **p:** differences does **not** depend on **energy**
- **p-bar: slopes agreeable!**

$$\frac{h^+ + h^-}{2}$$

STAR
EPOS



centrality 0-5%



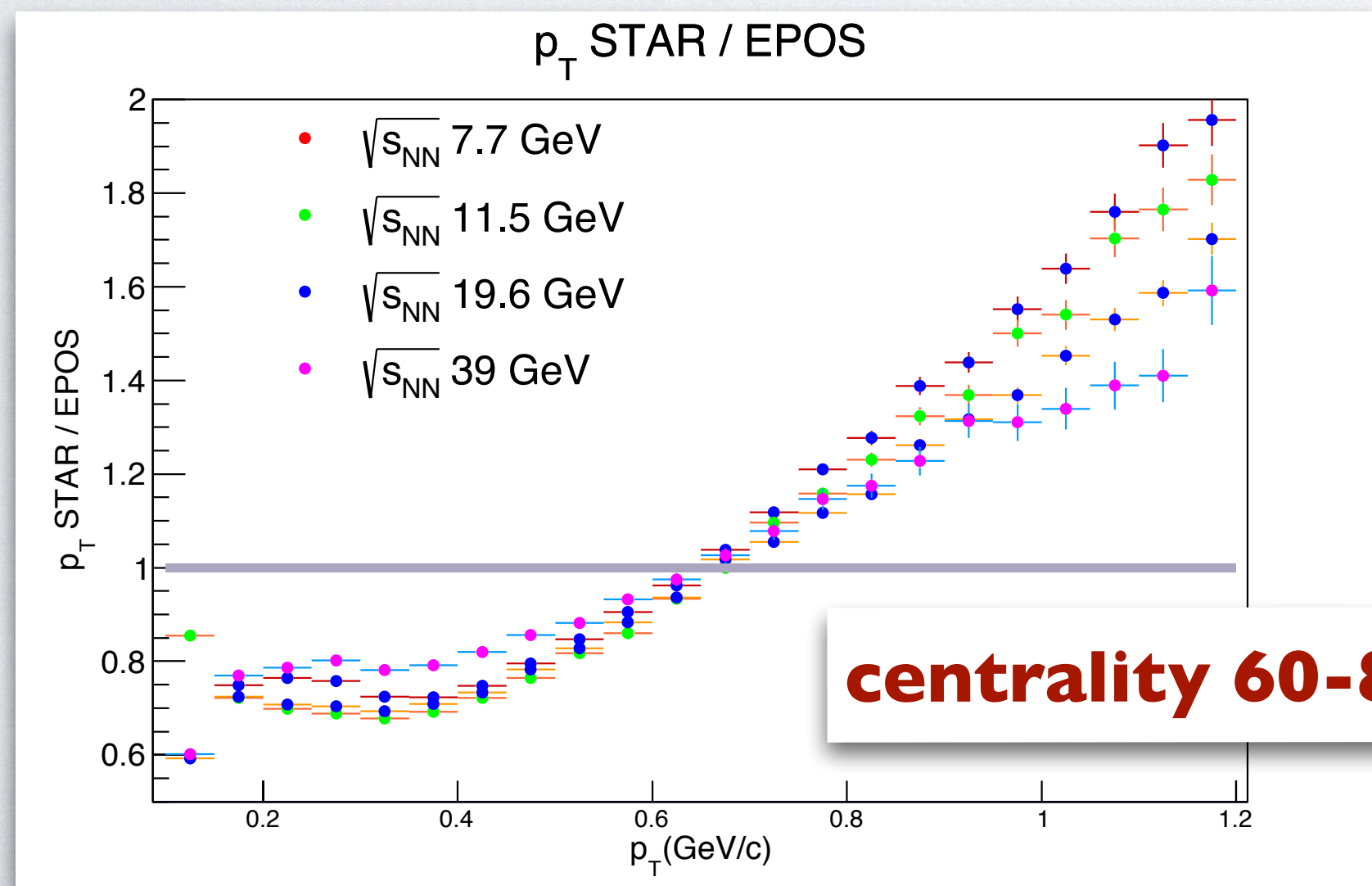
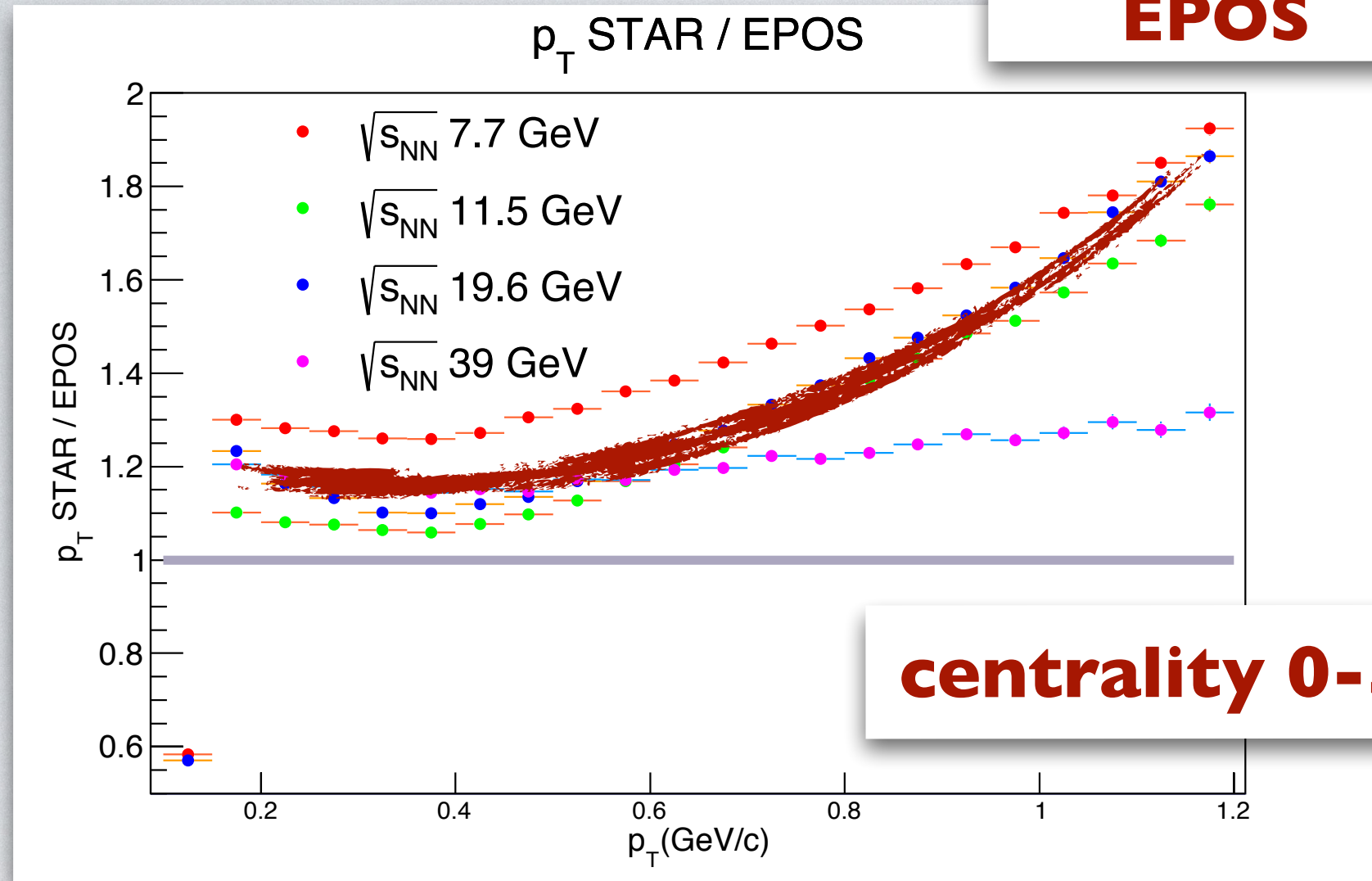
centrality 60-80%

Impact of **core**

SPECTRA P_T

$$\frac{h^+ + h^-}{2}$$

STAR
EPOS

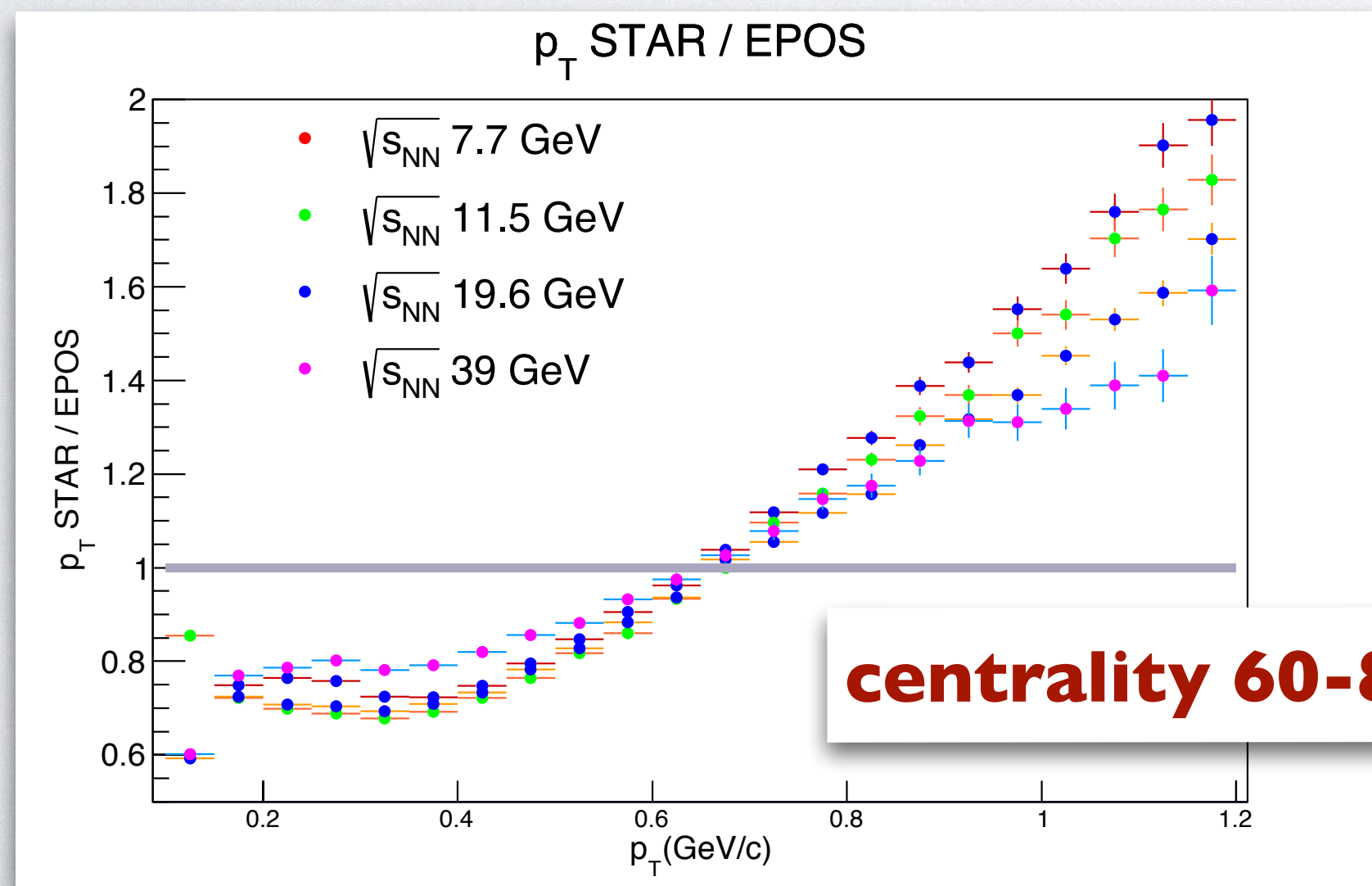
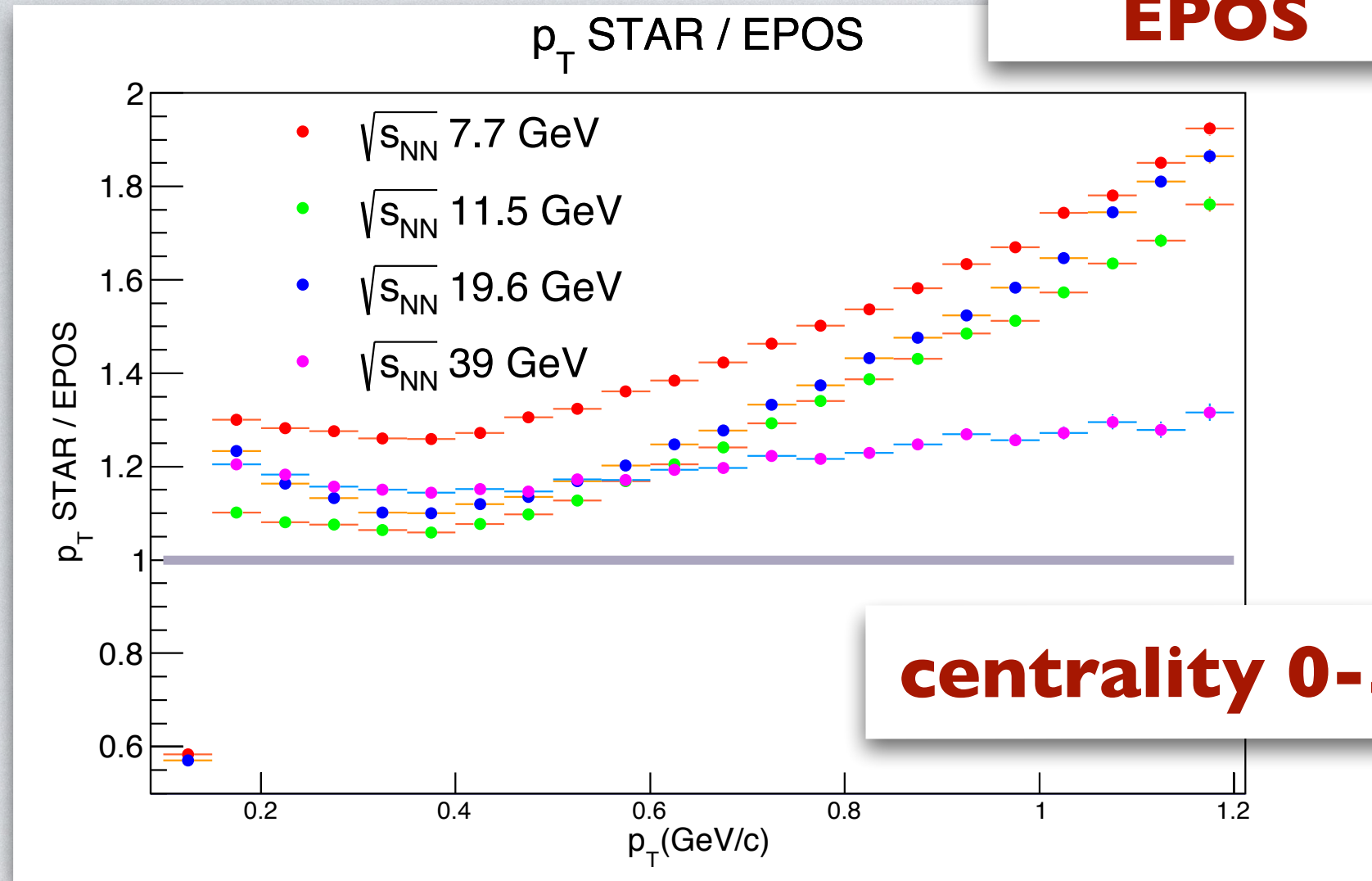


Impact of **core**

SPECTRA P_T

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STAR
EPOS

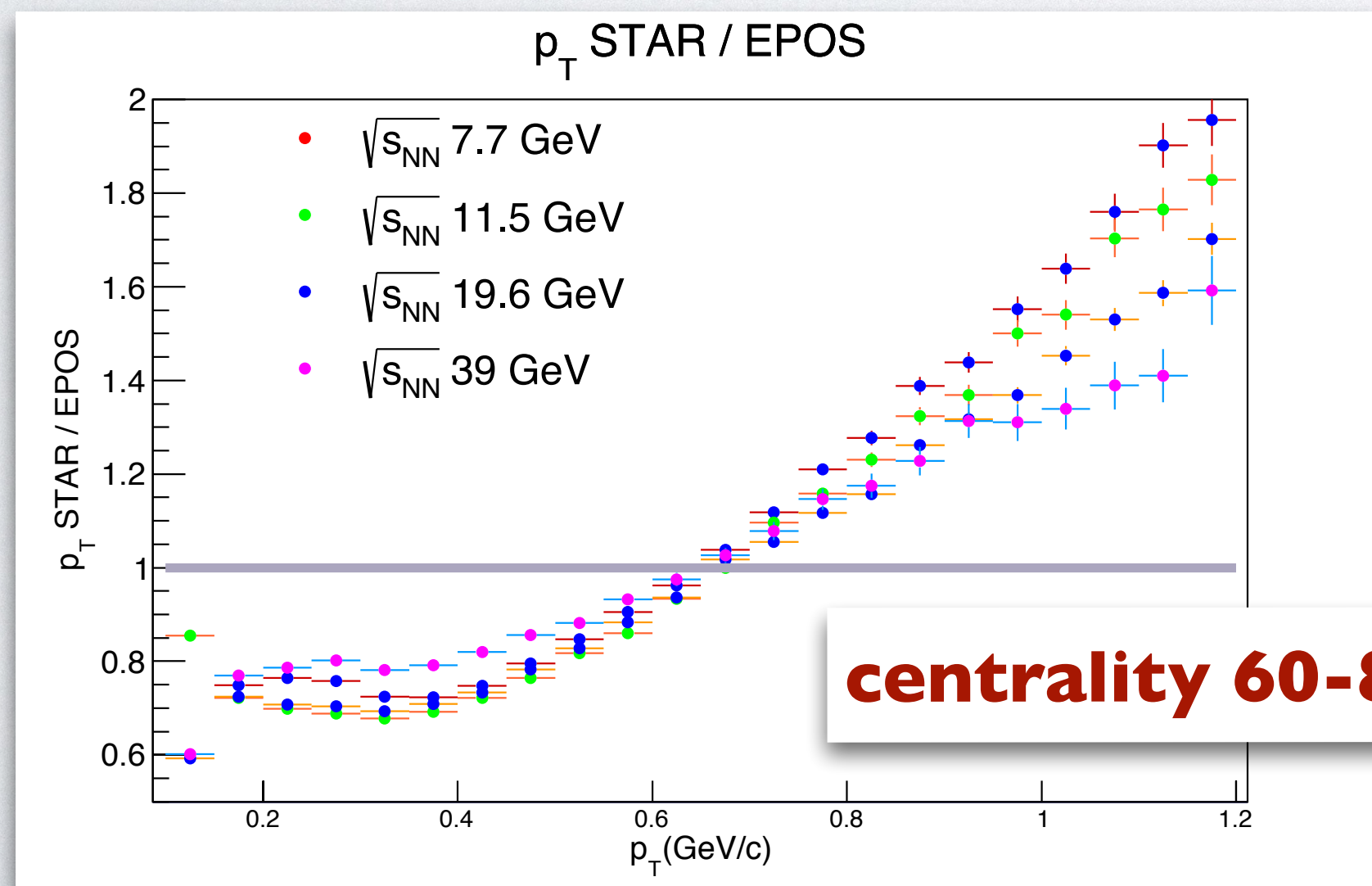
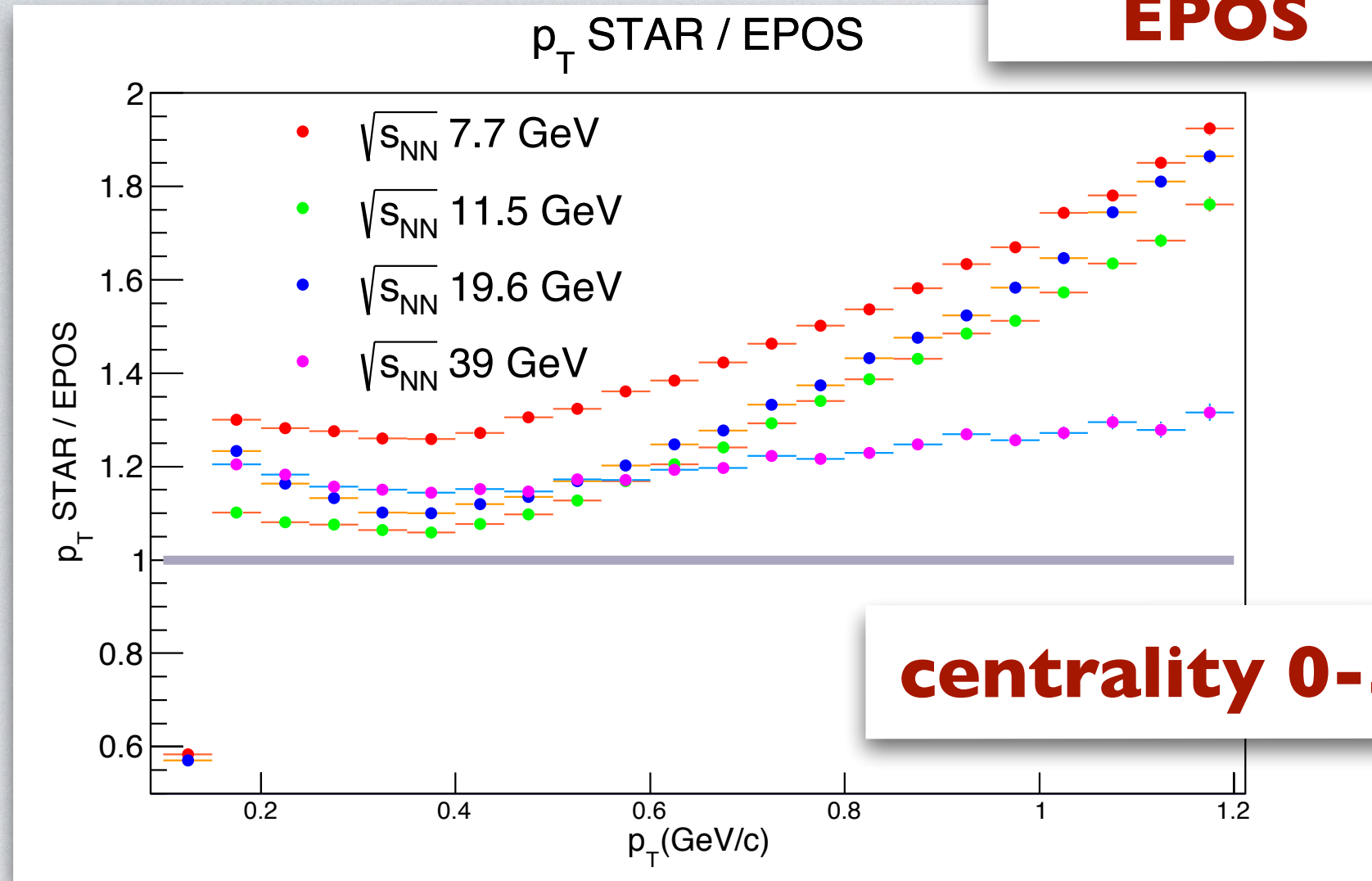


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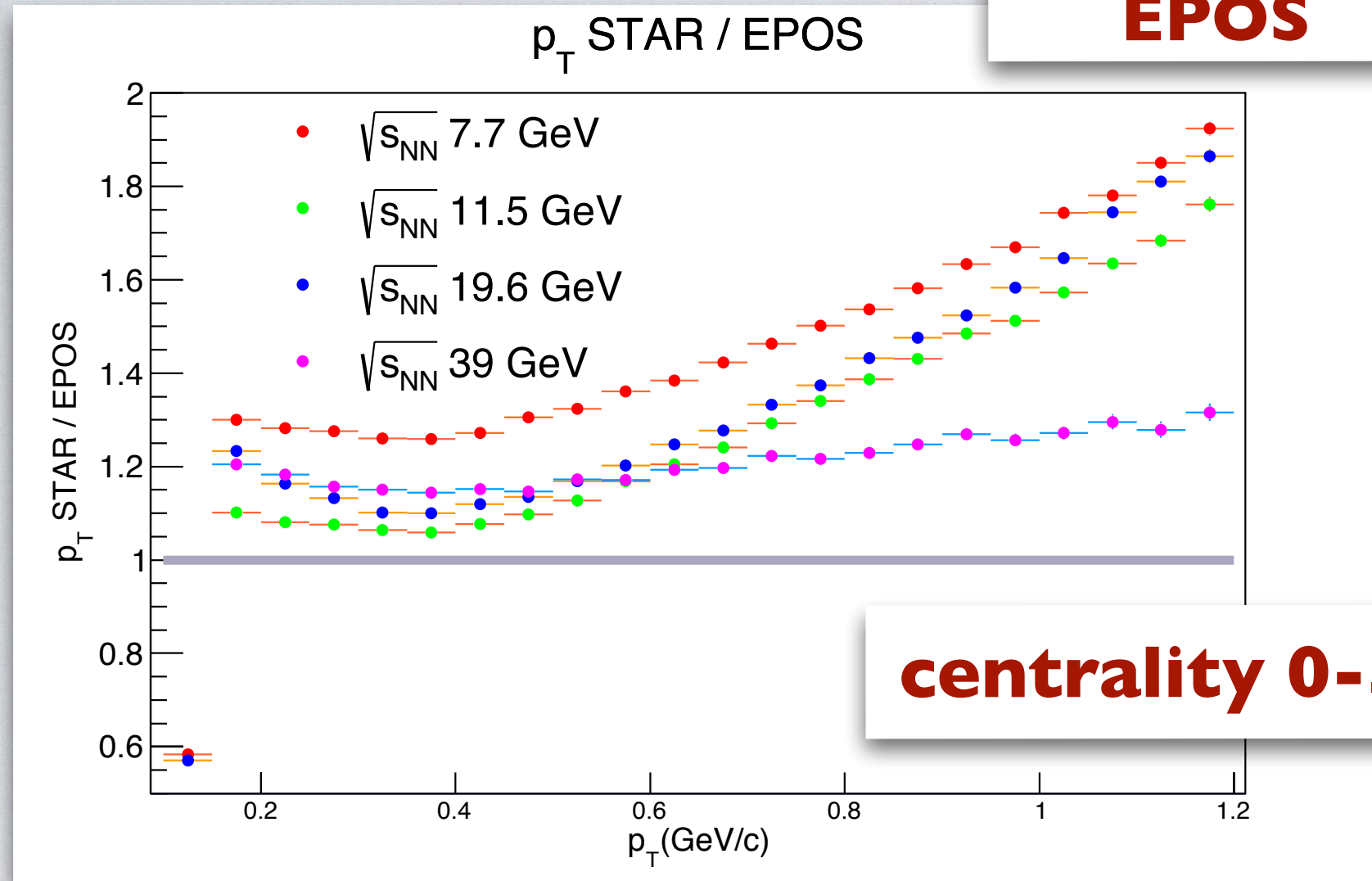


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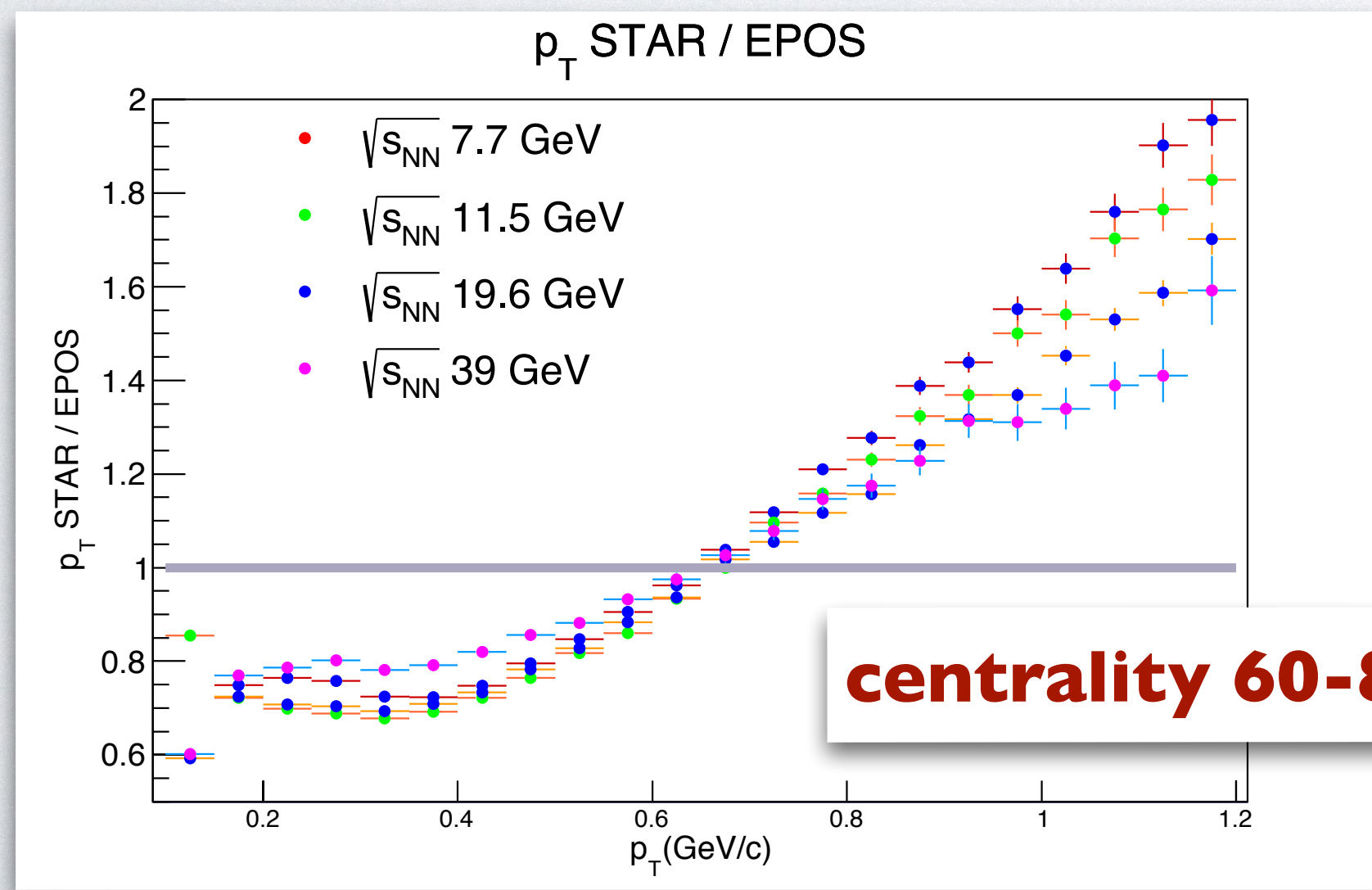
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STAR
EPOS



centrality 0-5%



centrality 60-80%

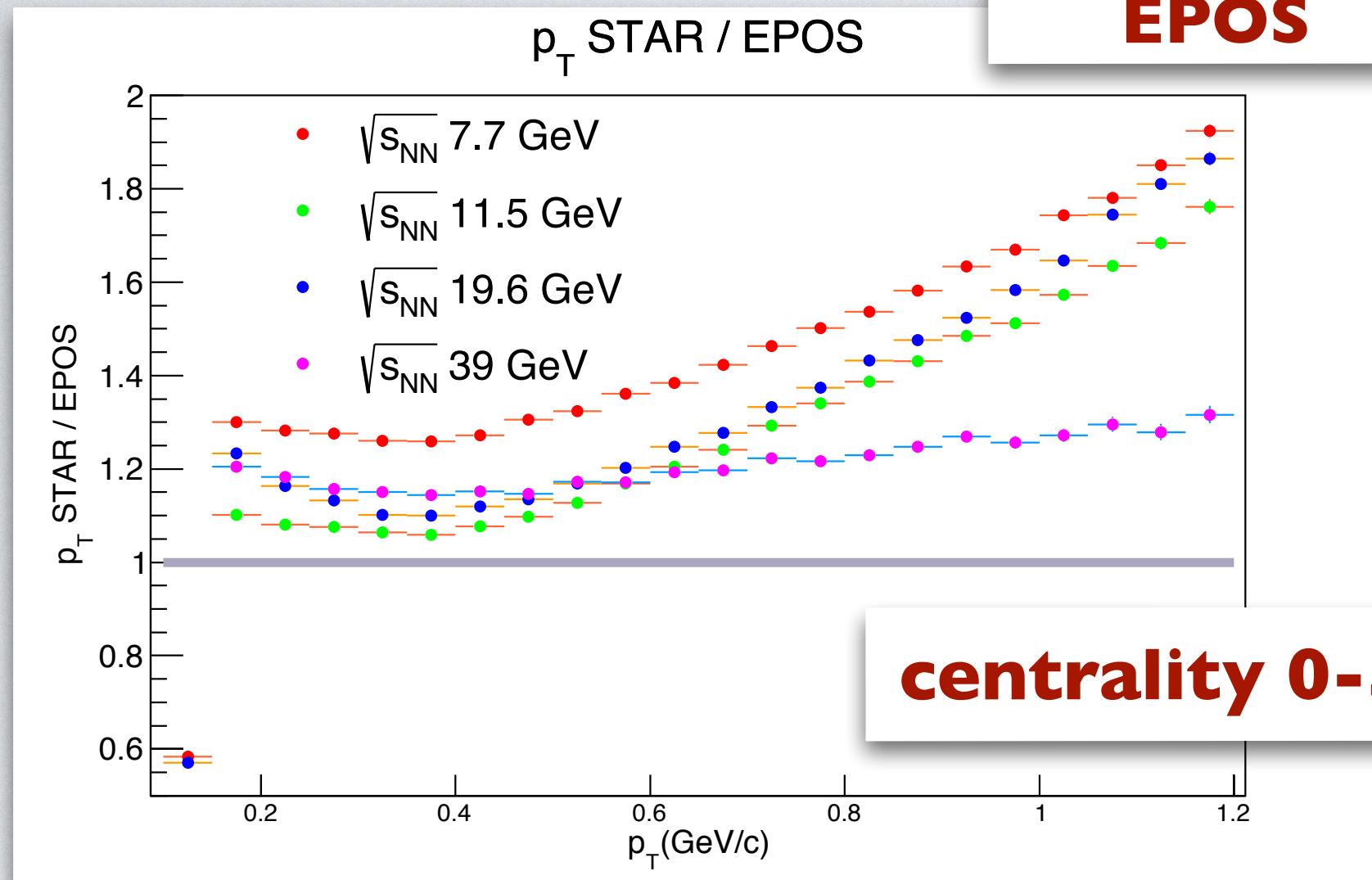


Impact of **core**

SPECTRA P_T

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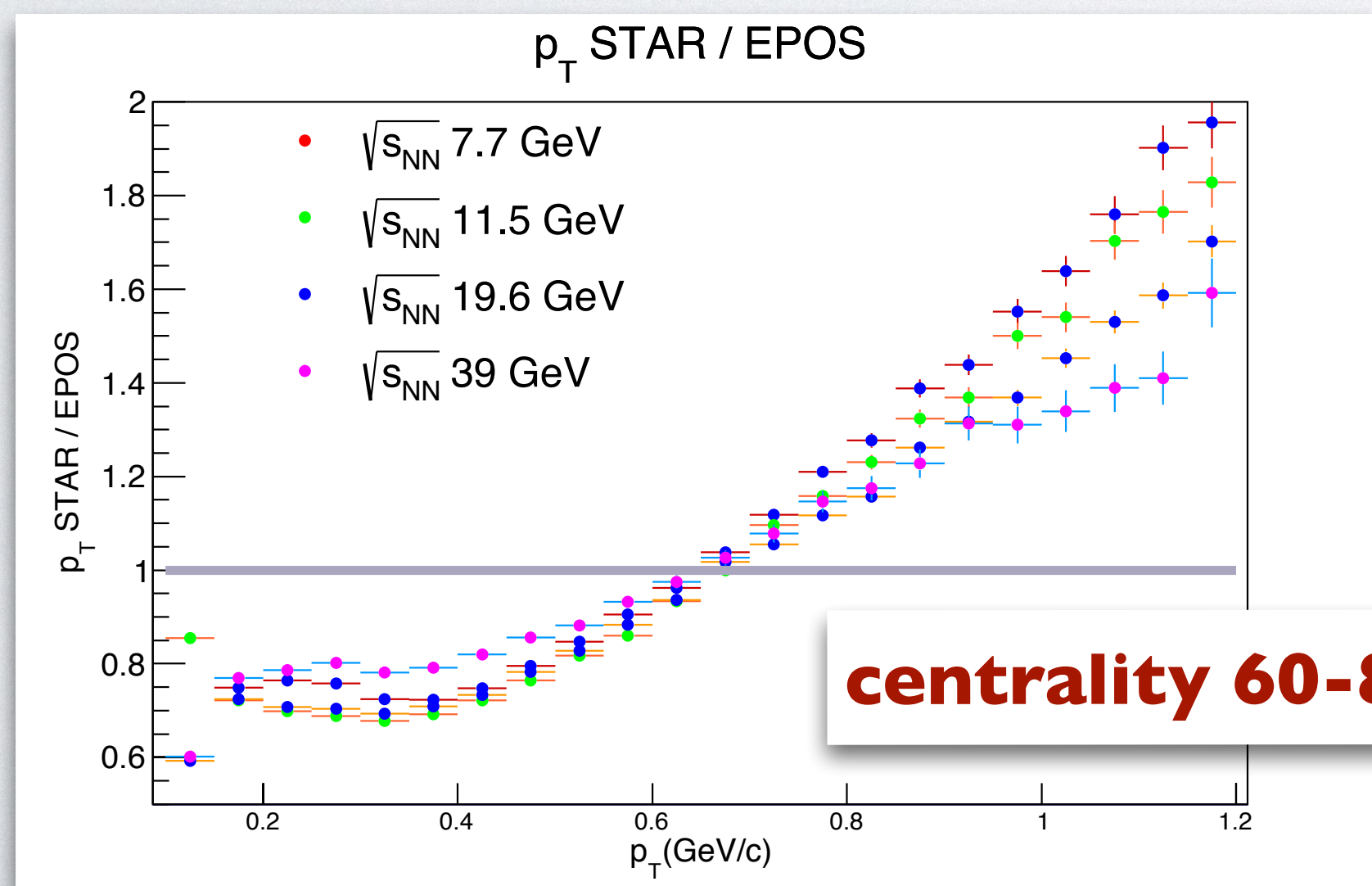
STAR
EPOS



centrality 0-5%



more Particles origin in fluid



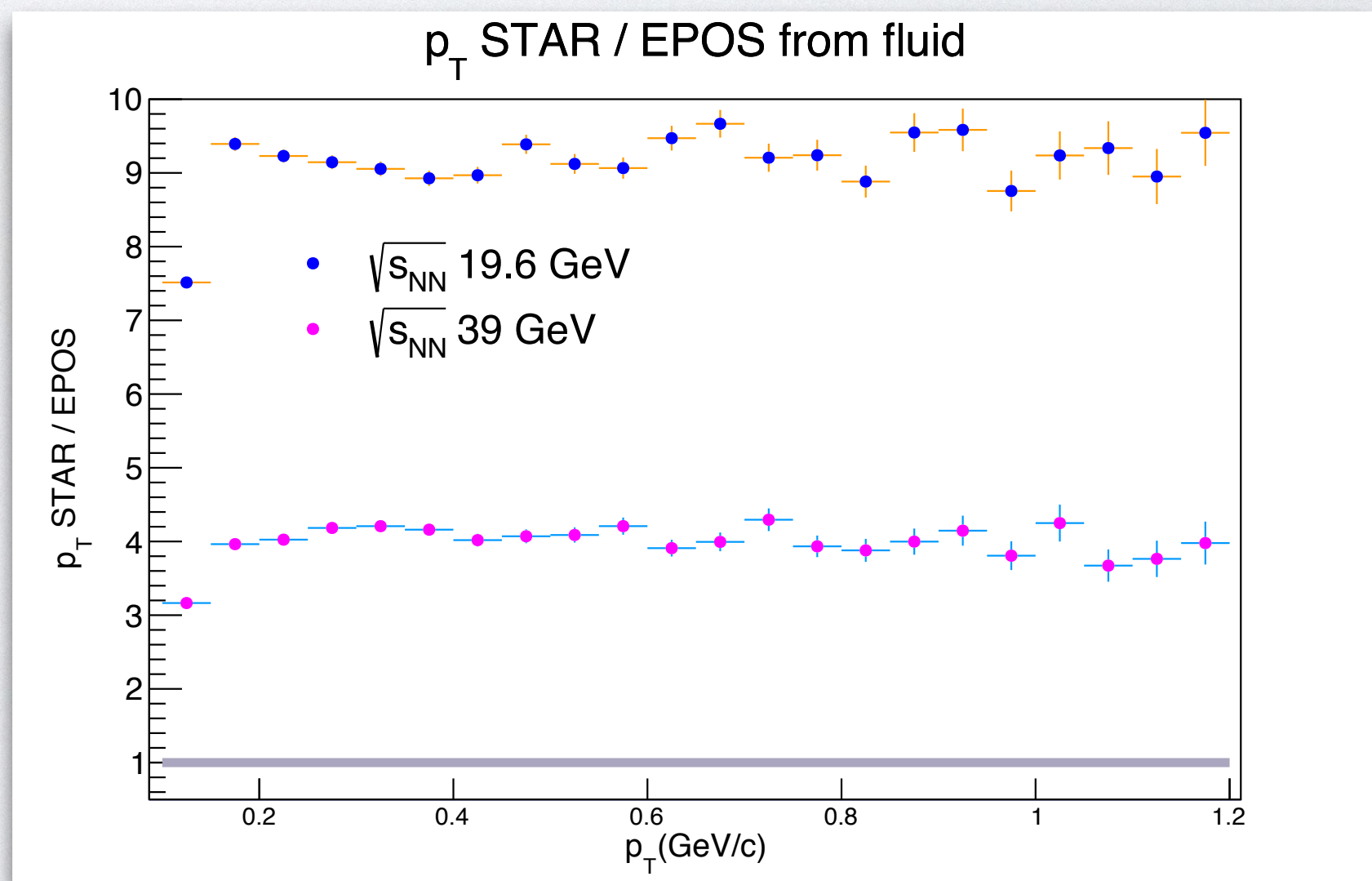
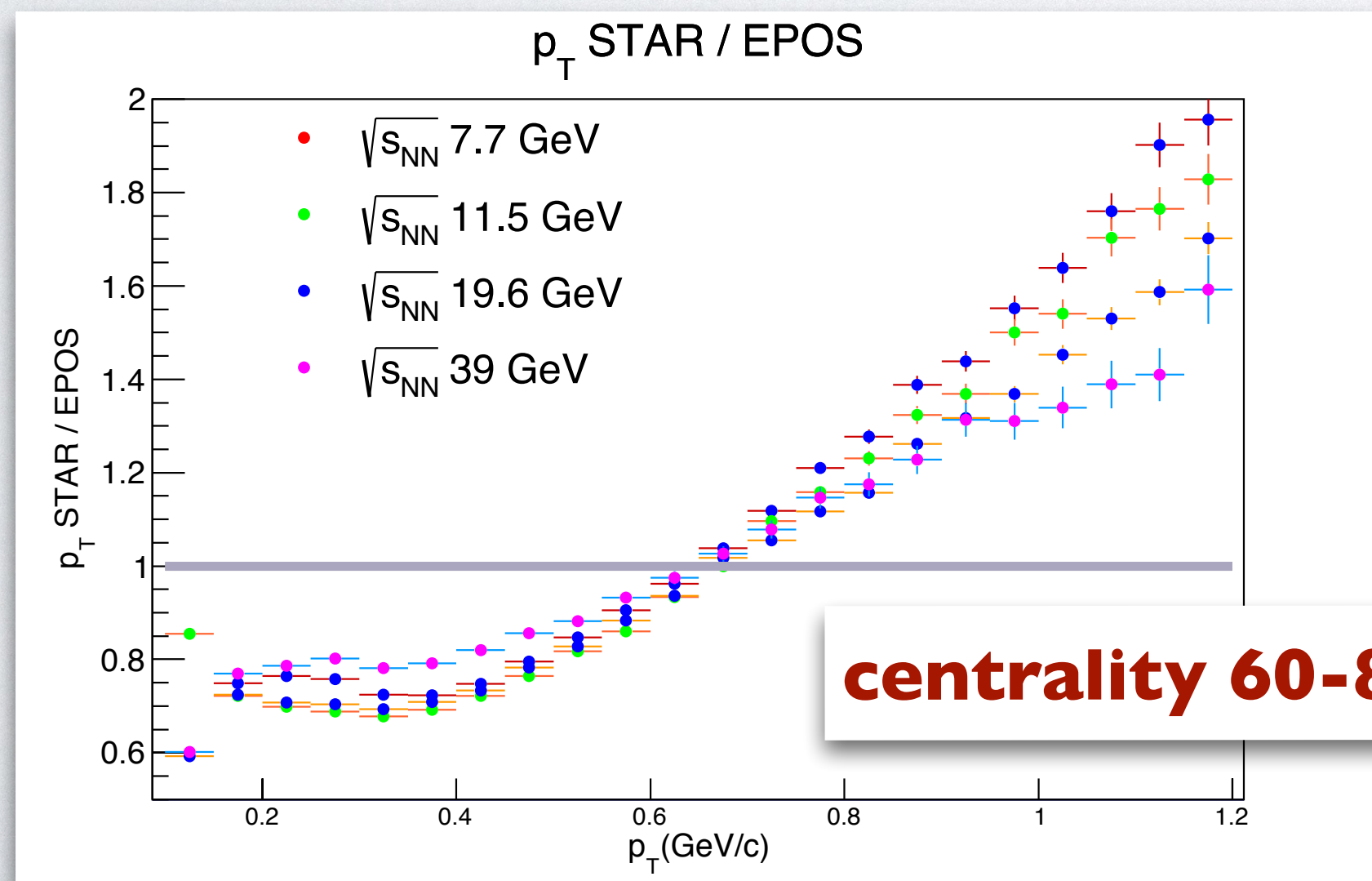
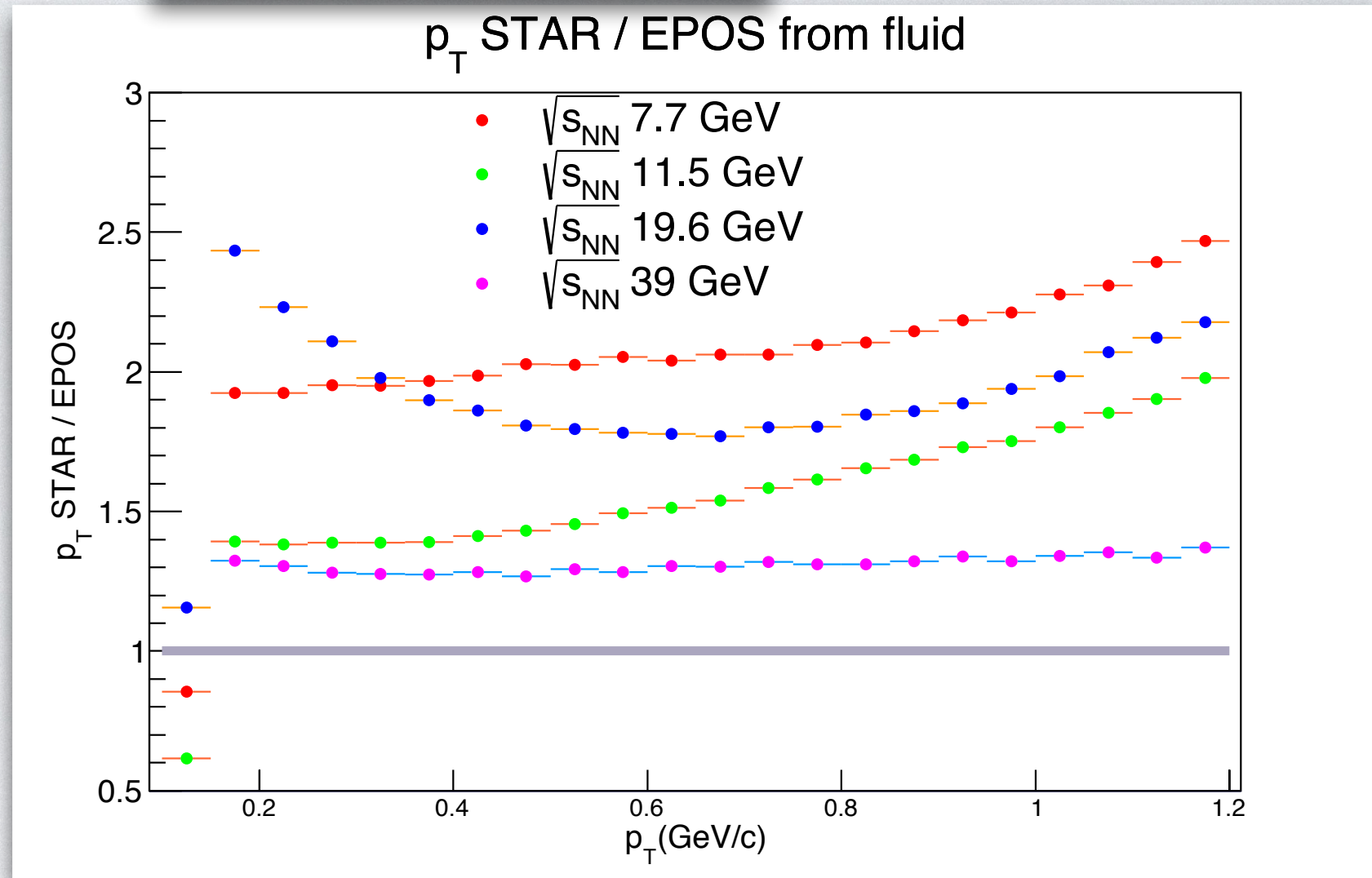
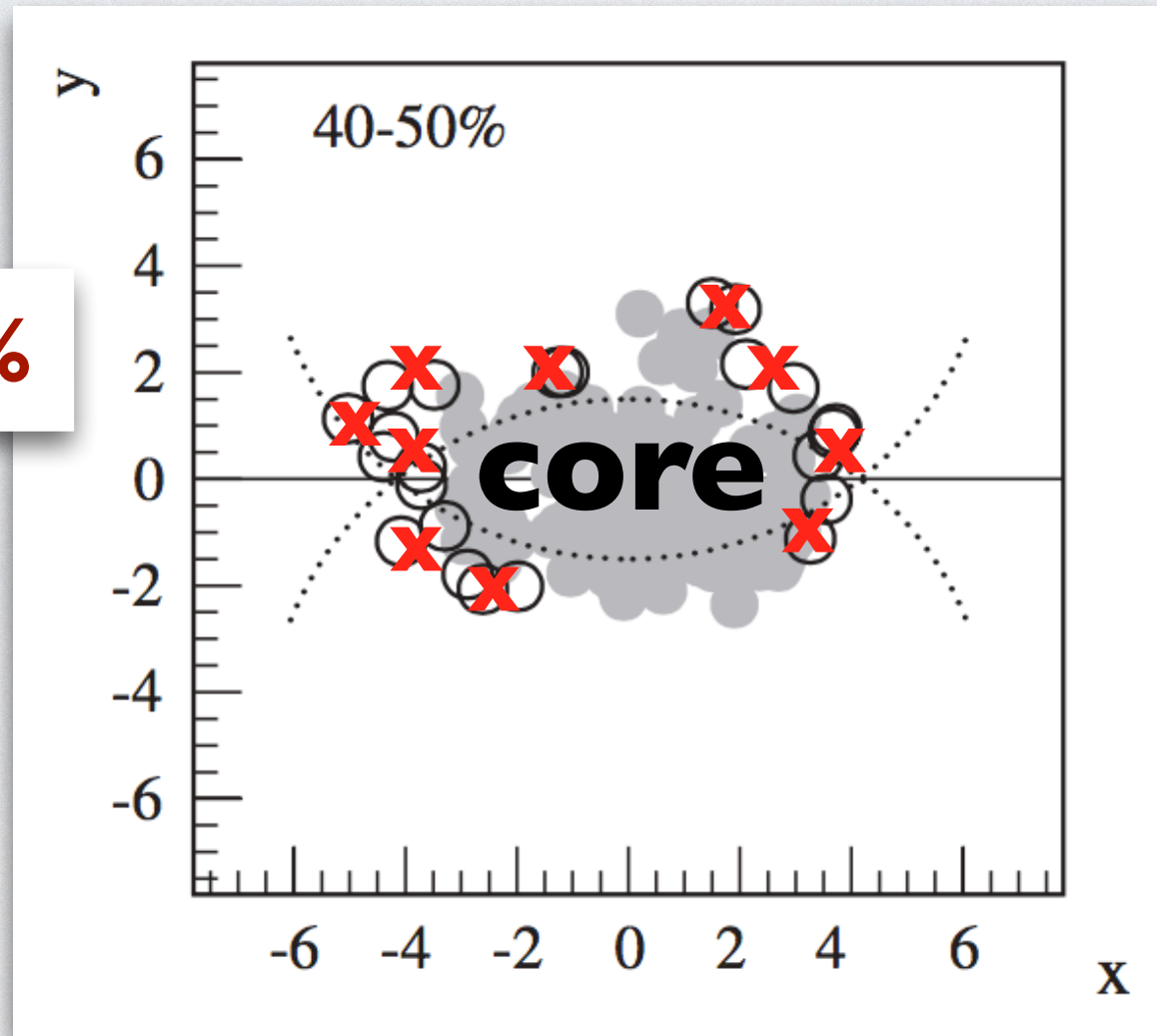
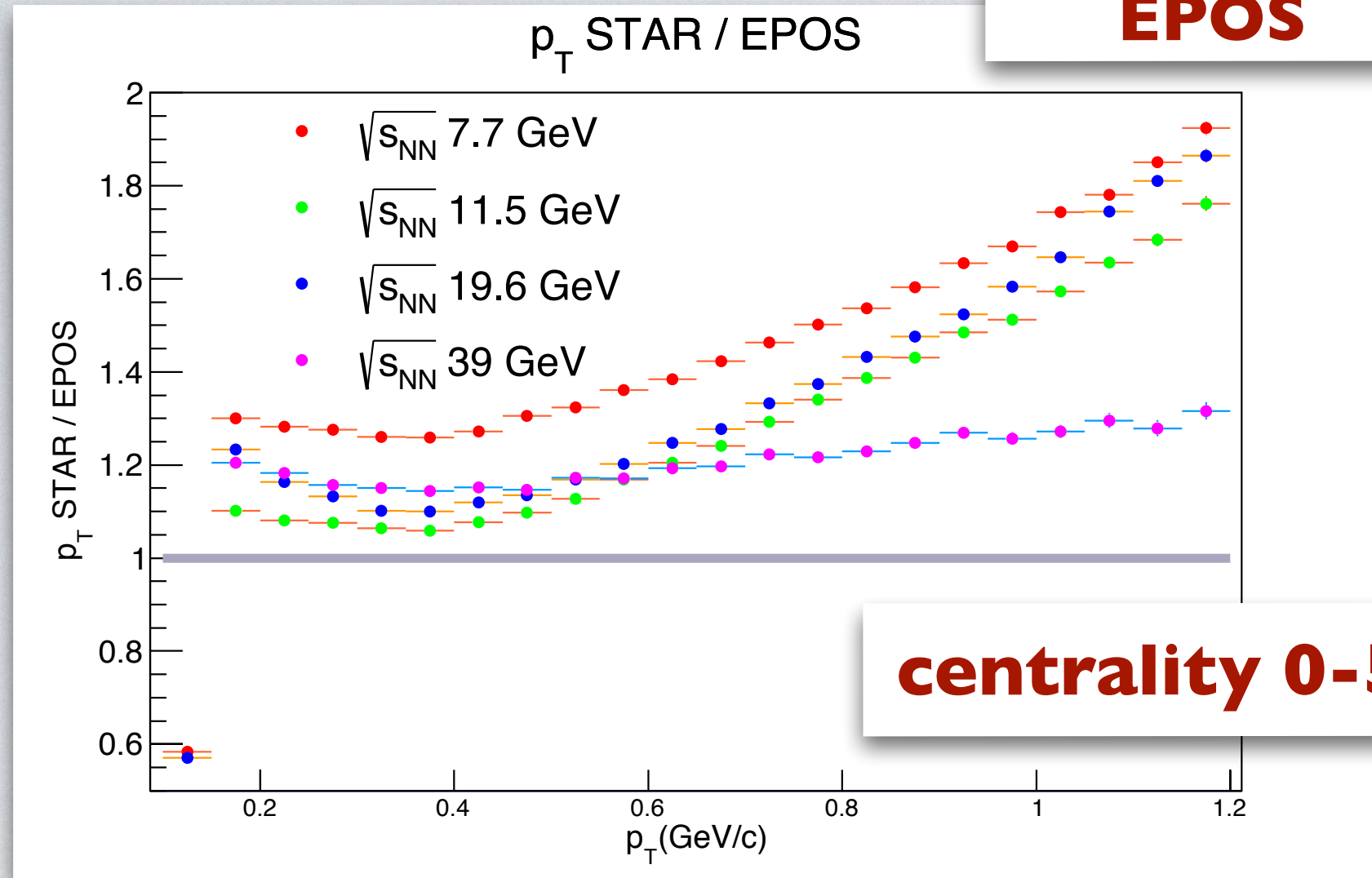
centrality 60-80%

Impact of **core**

SPECTRA P_T

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STAR
EPOS



Decrease of energy:

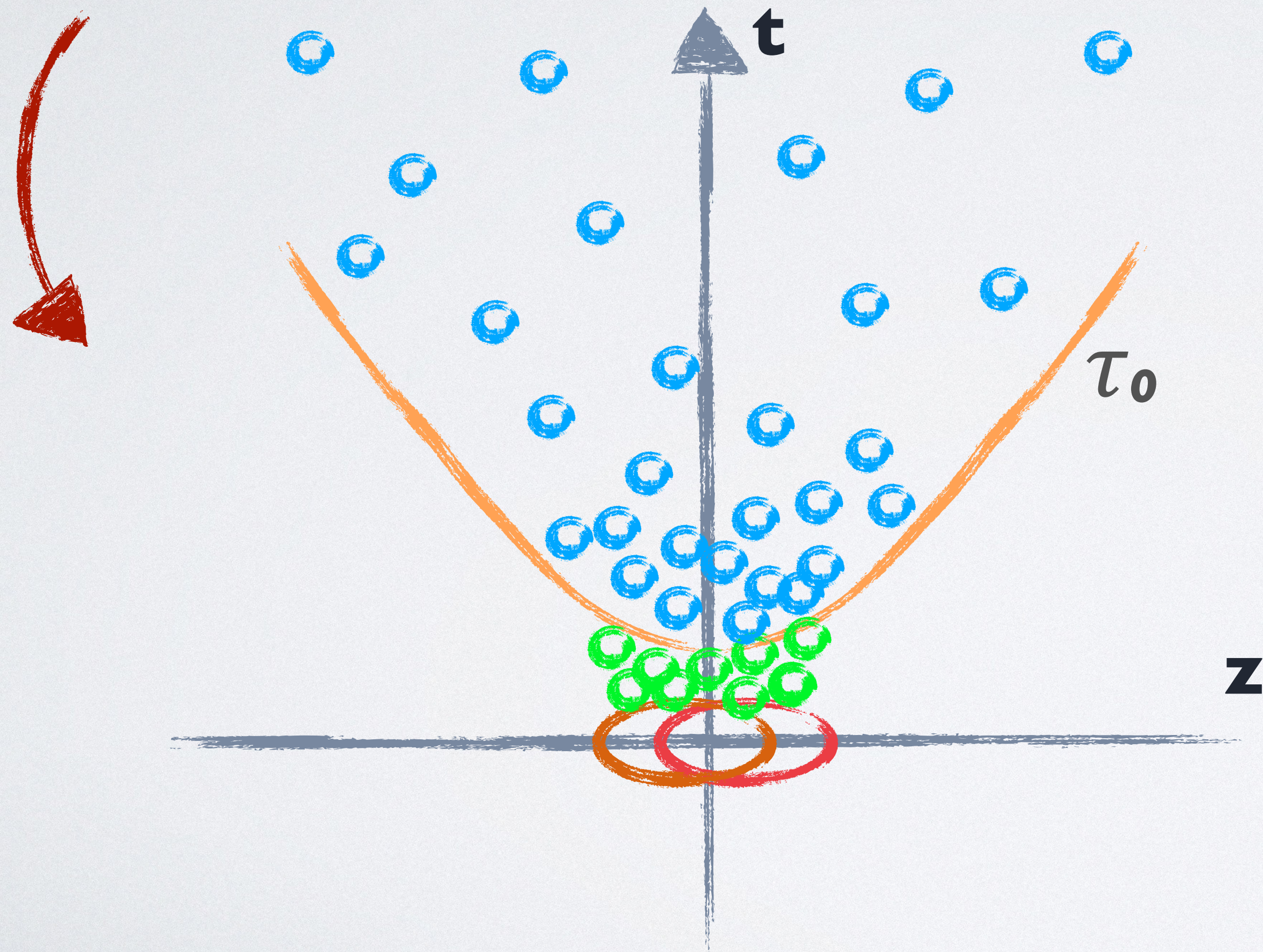
- Initial time
- Equation o state
- ...

INITIAL TIME τ_0

- Core fraction starts at some early proper **initial time τ_0**
- The fluid (**core**) is separated & the hadrons are escaping (also hadron jets - **corona**)

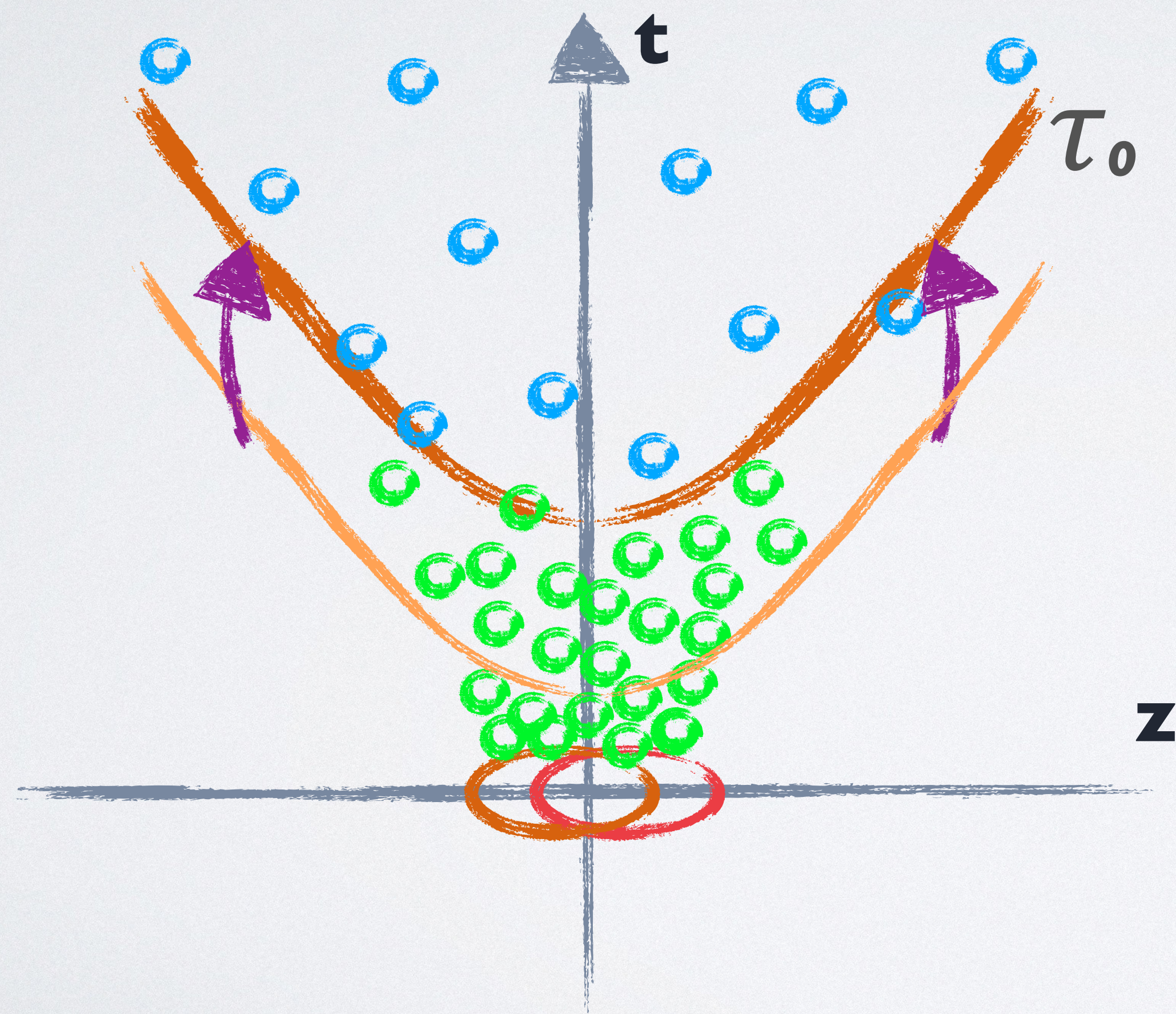
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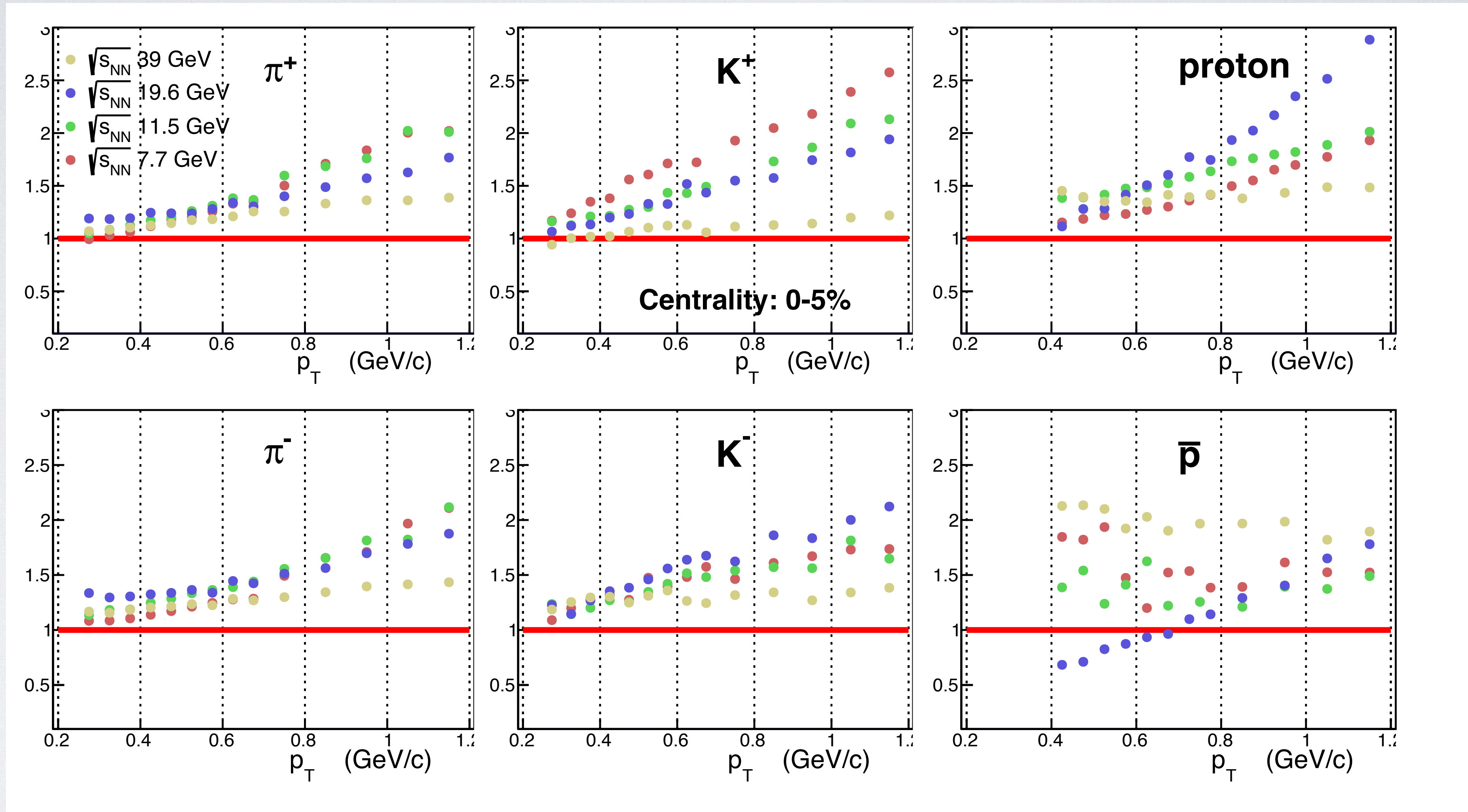
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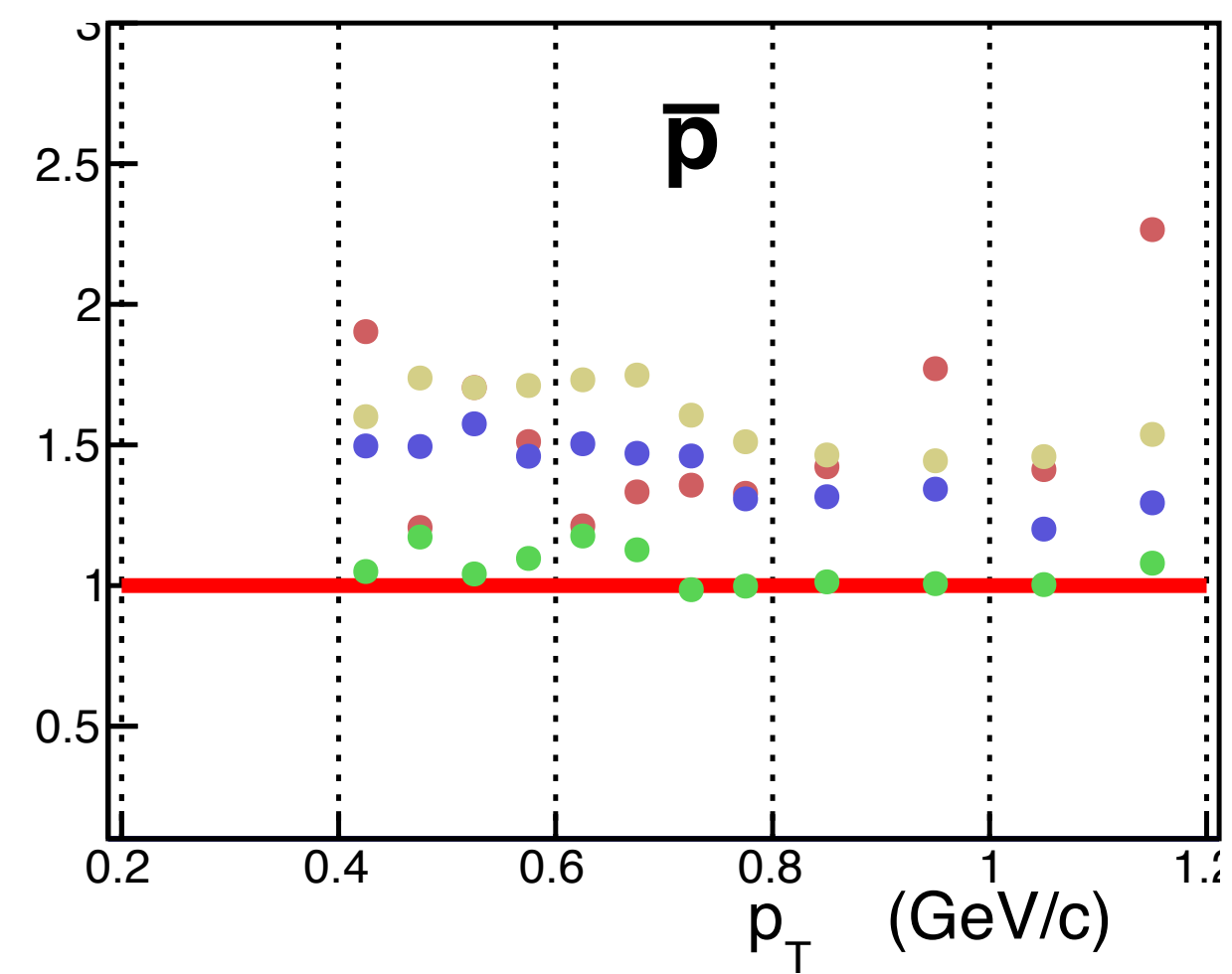
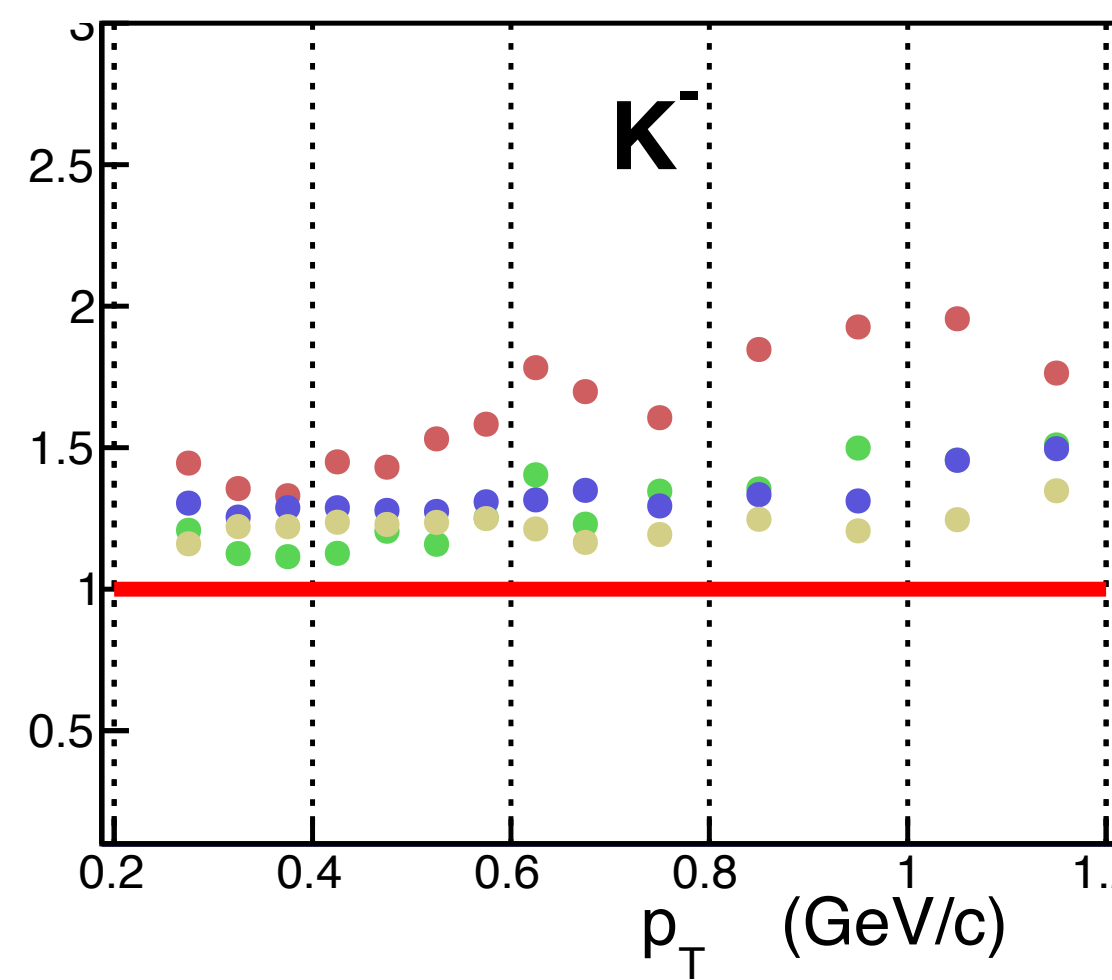
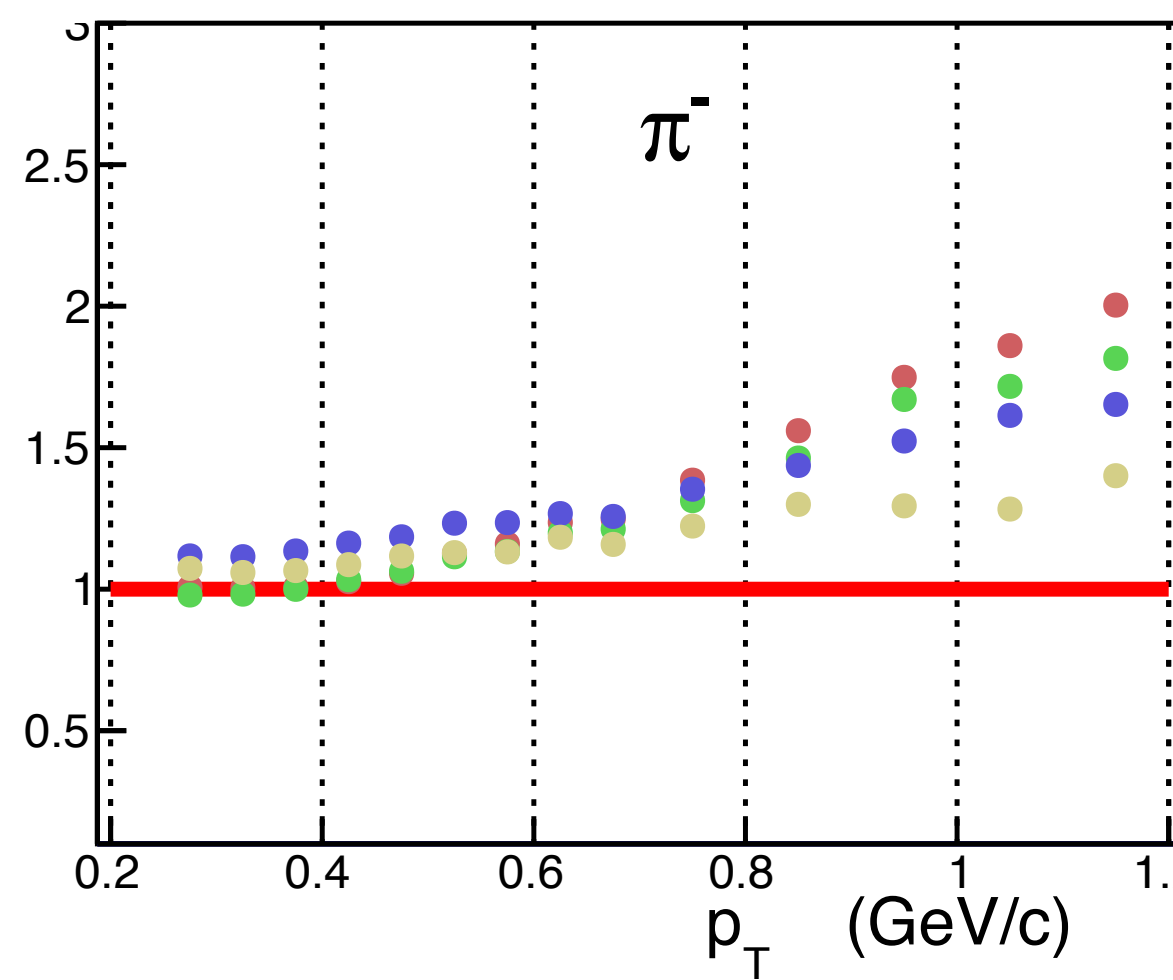
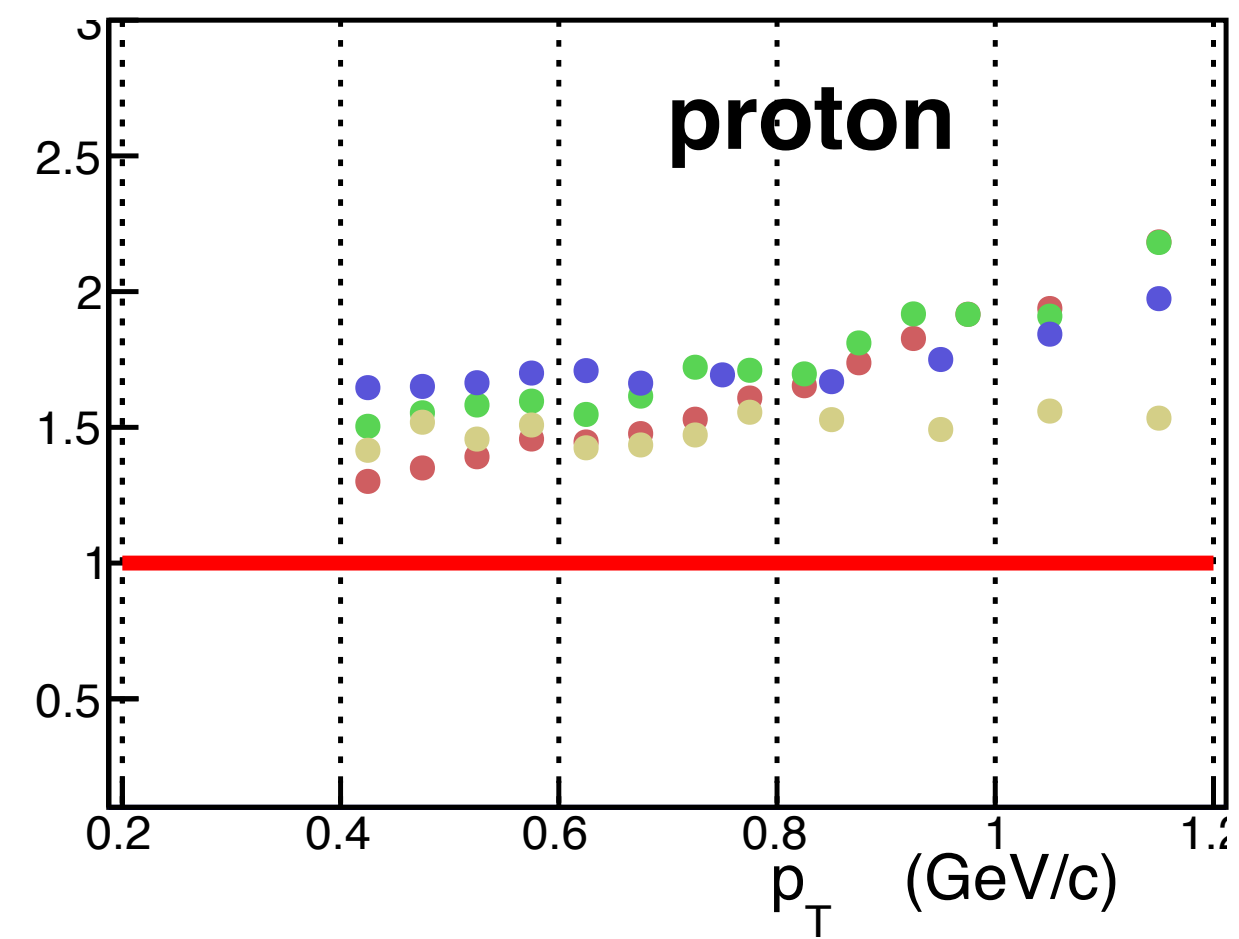
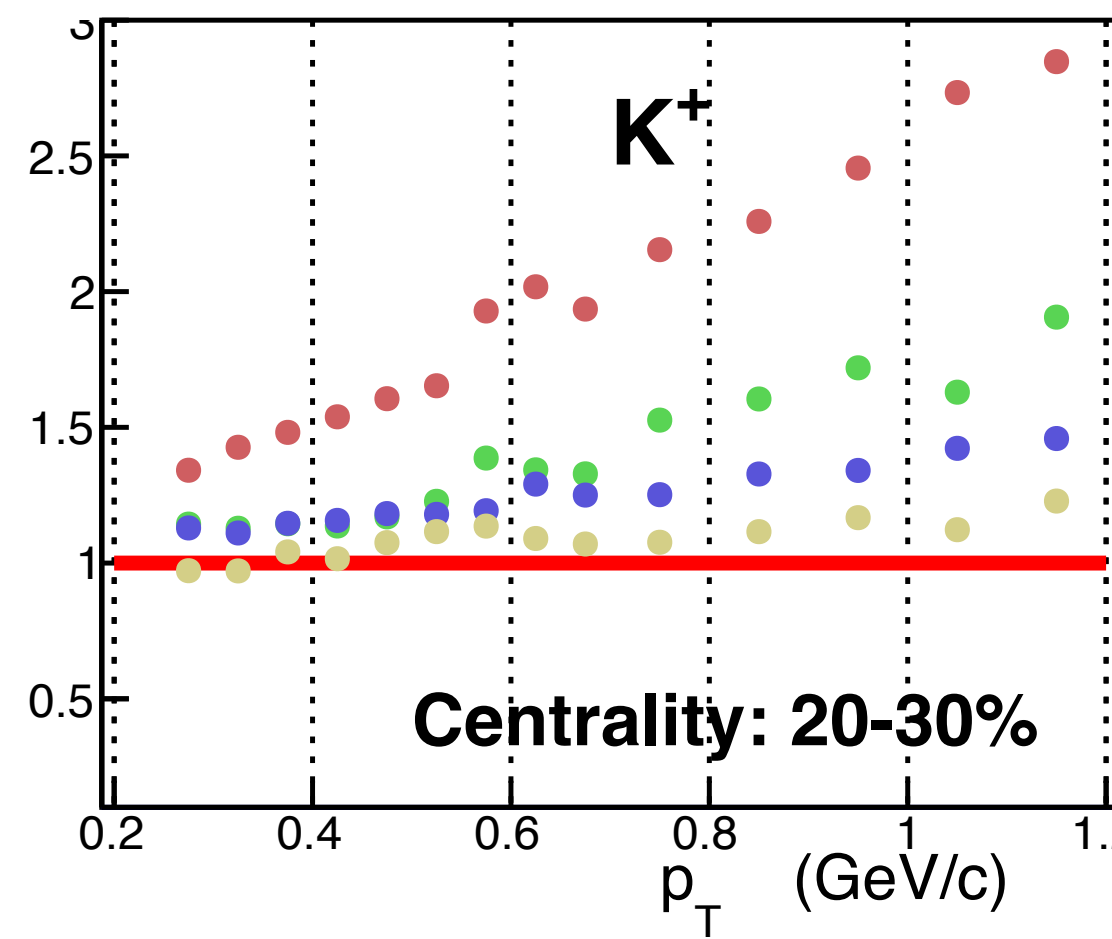
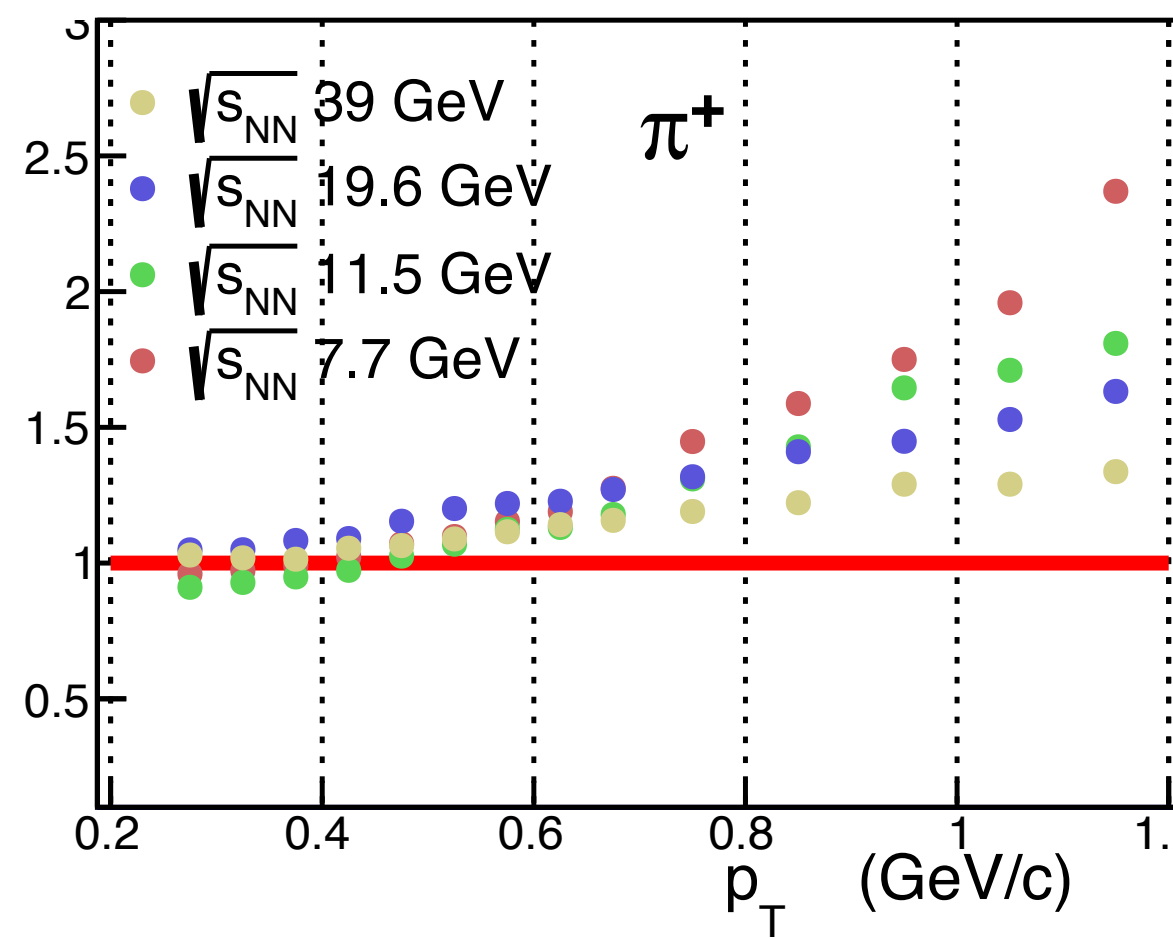
Work in progress

THANK YOU for your attention!

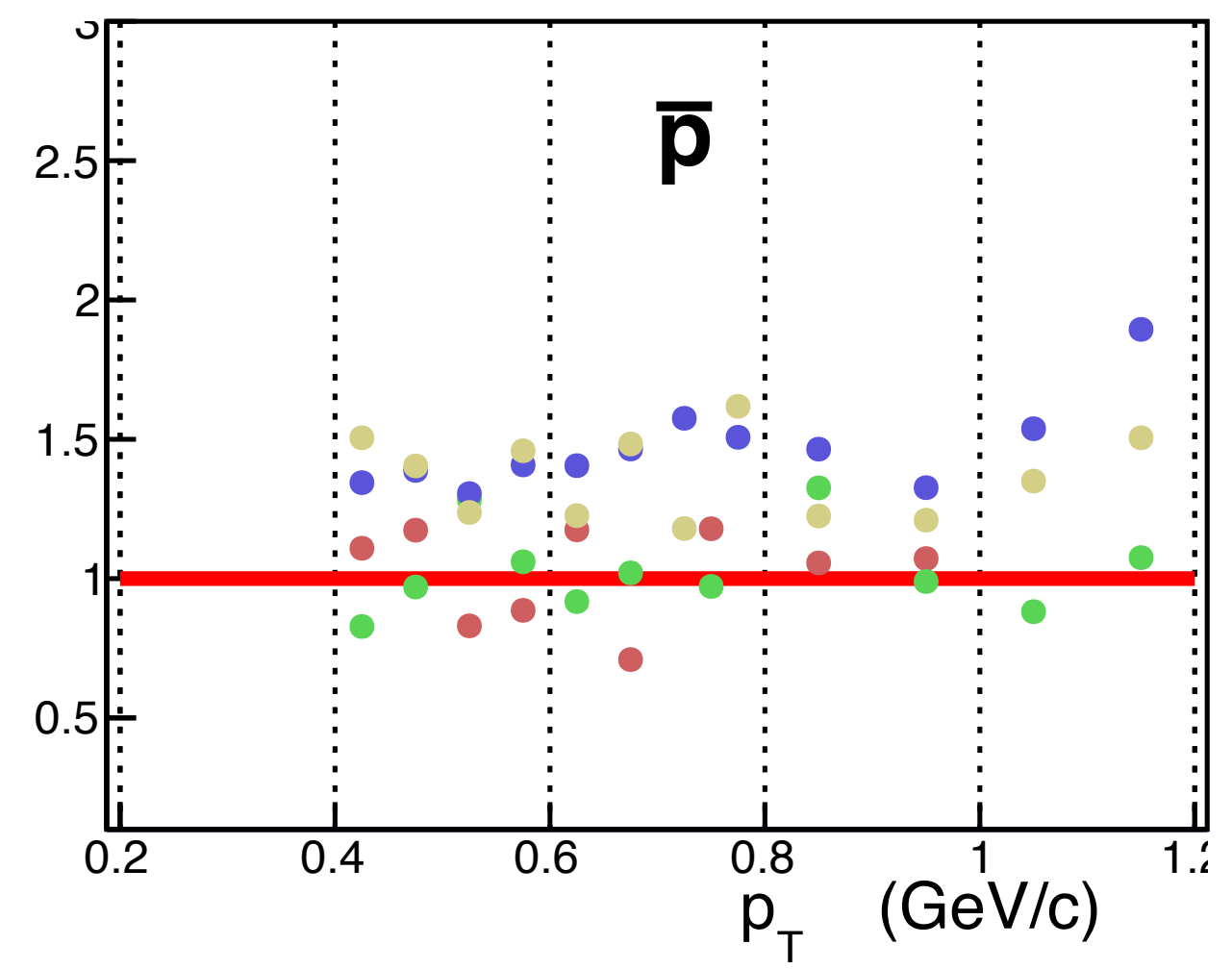
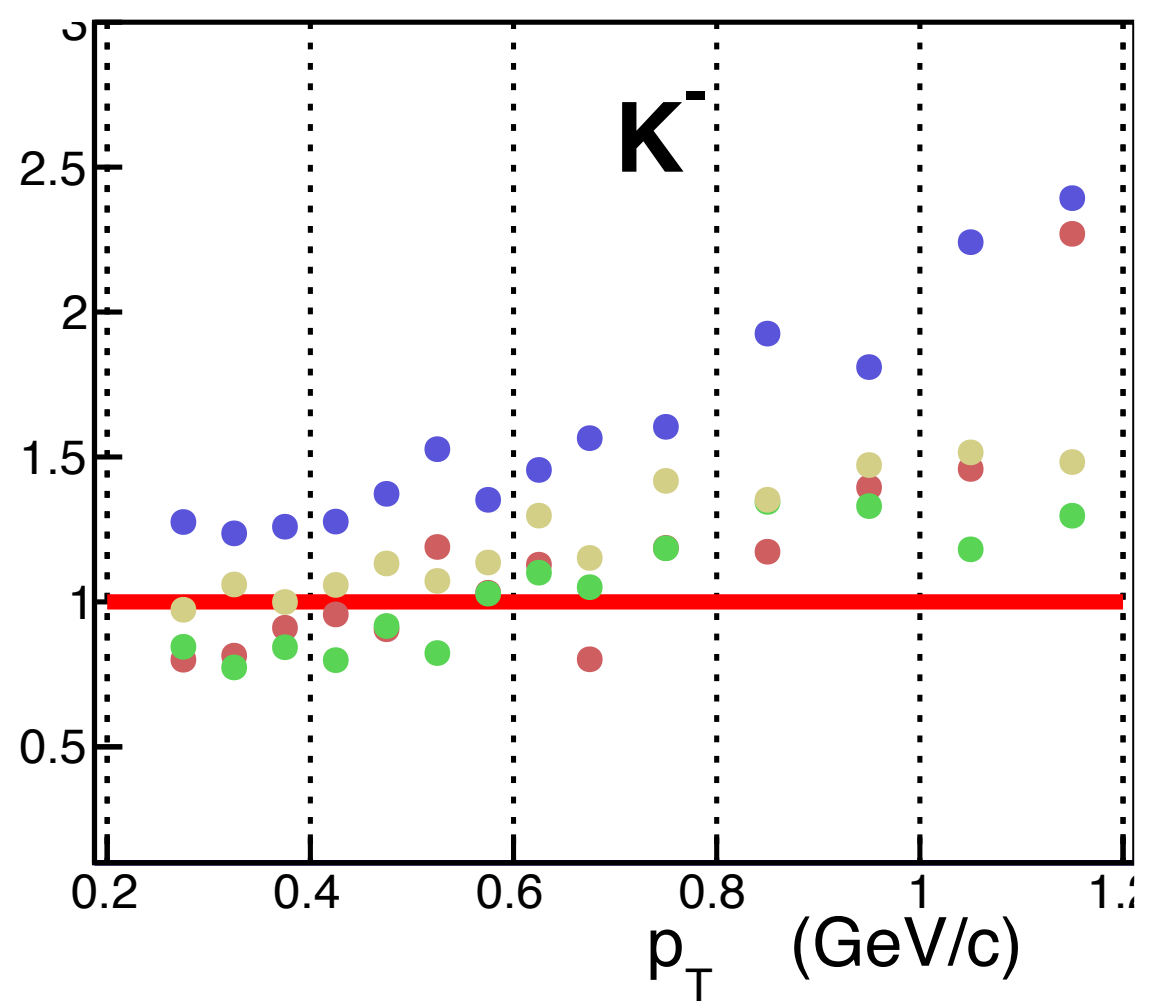
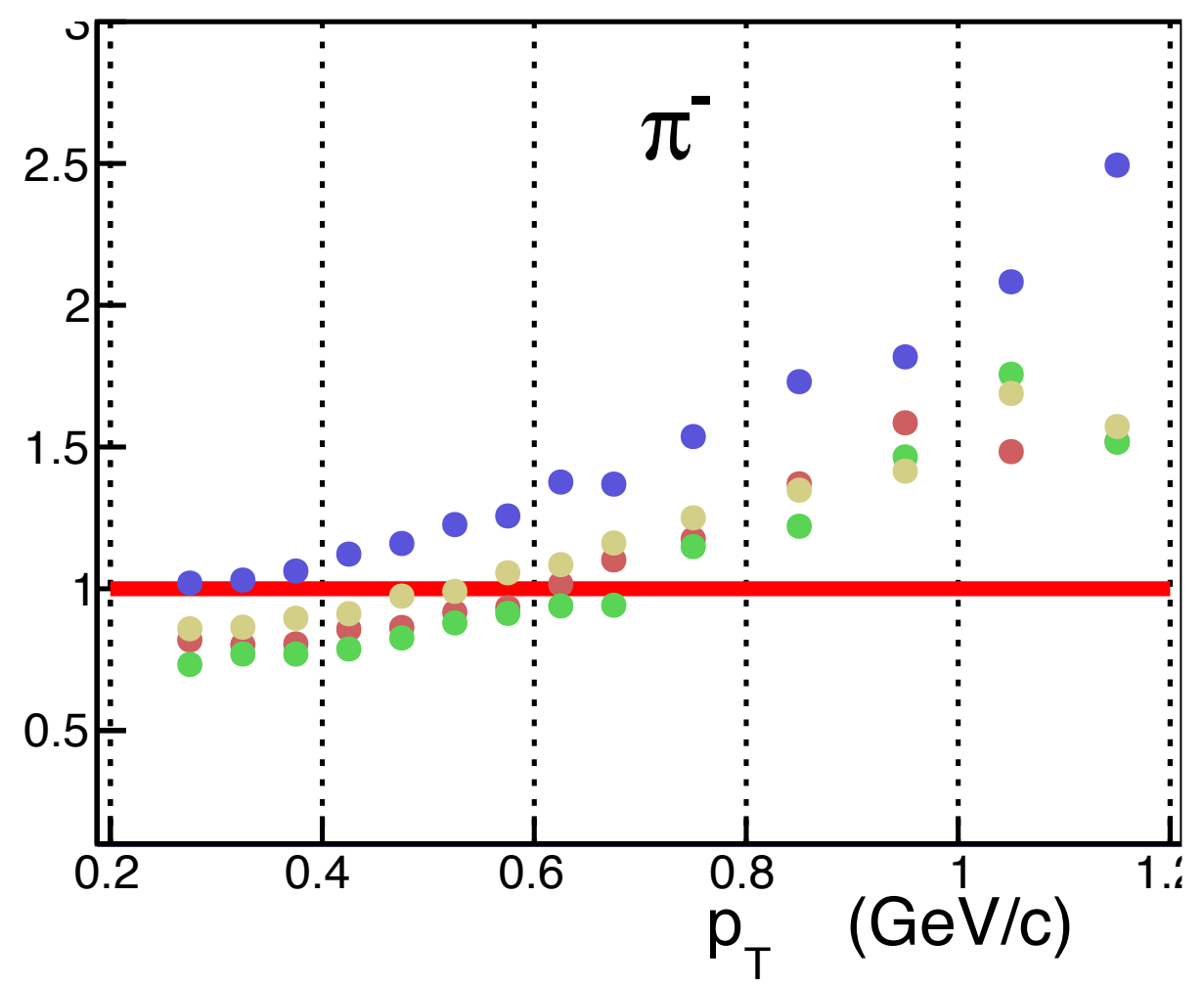
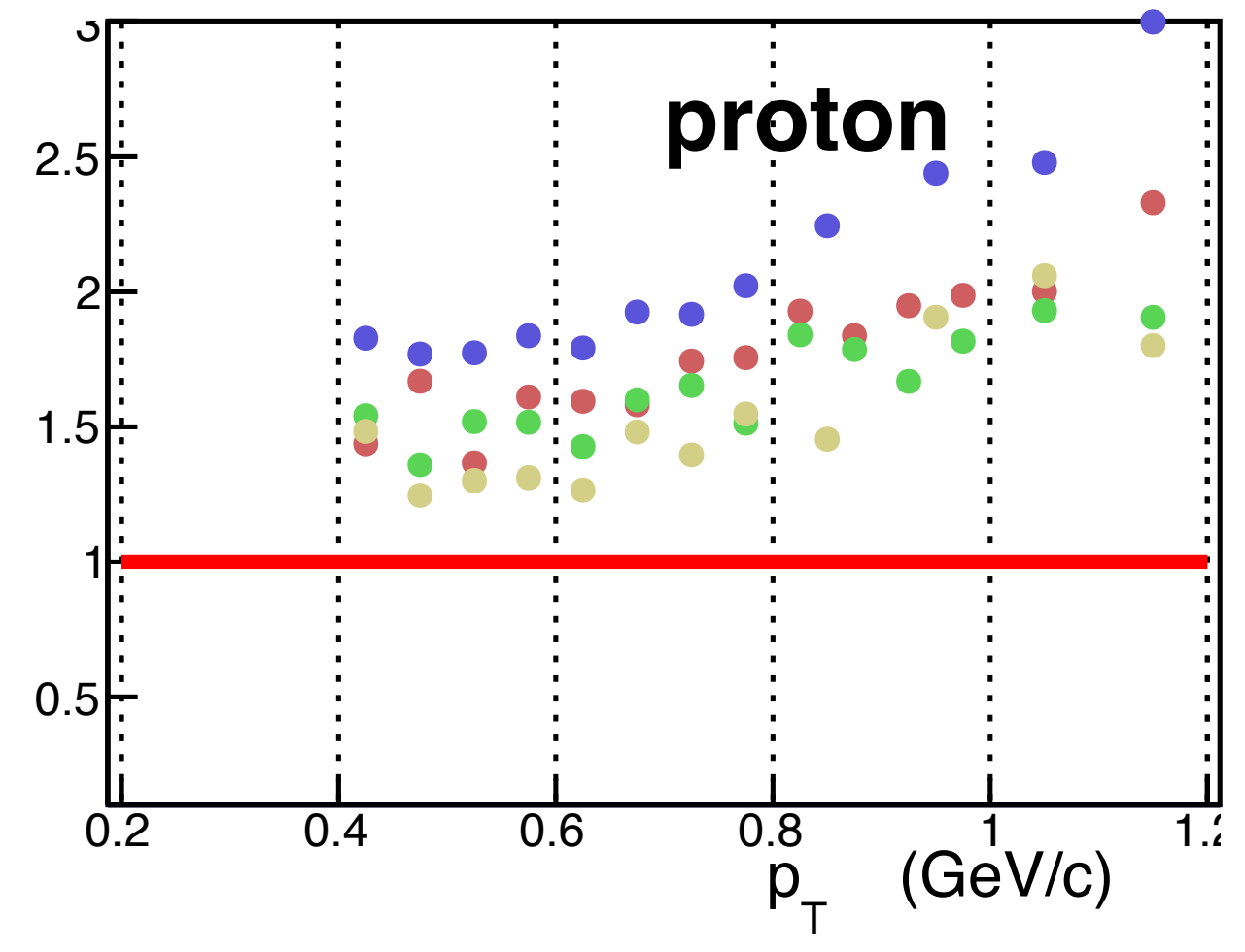
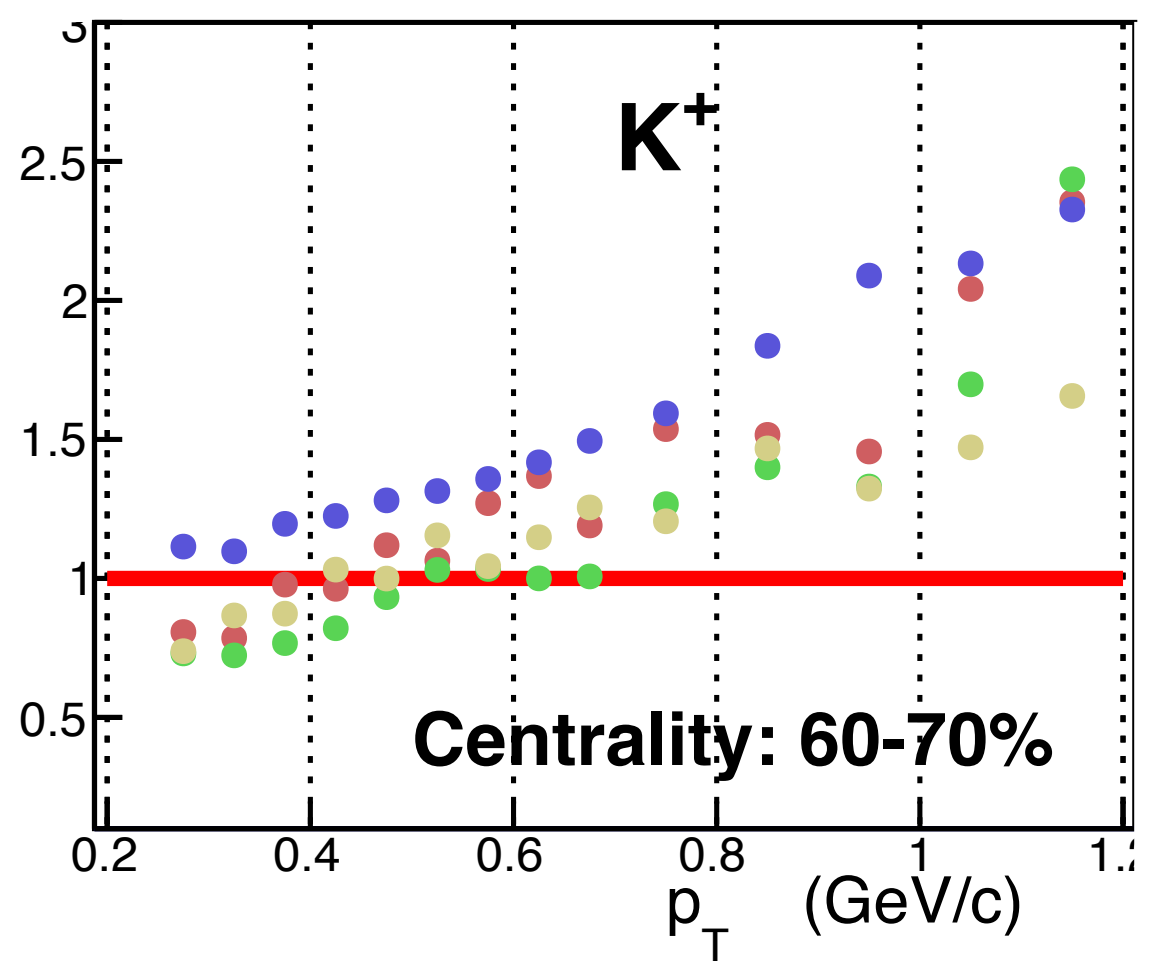
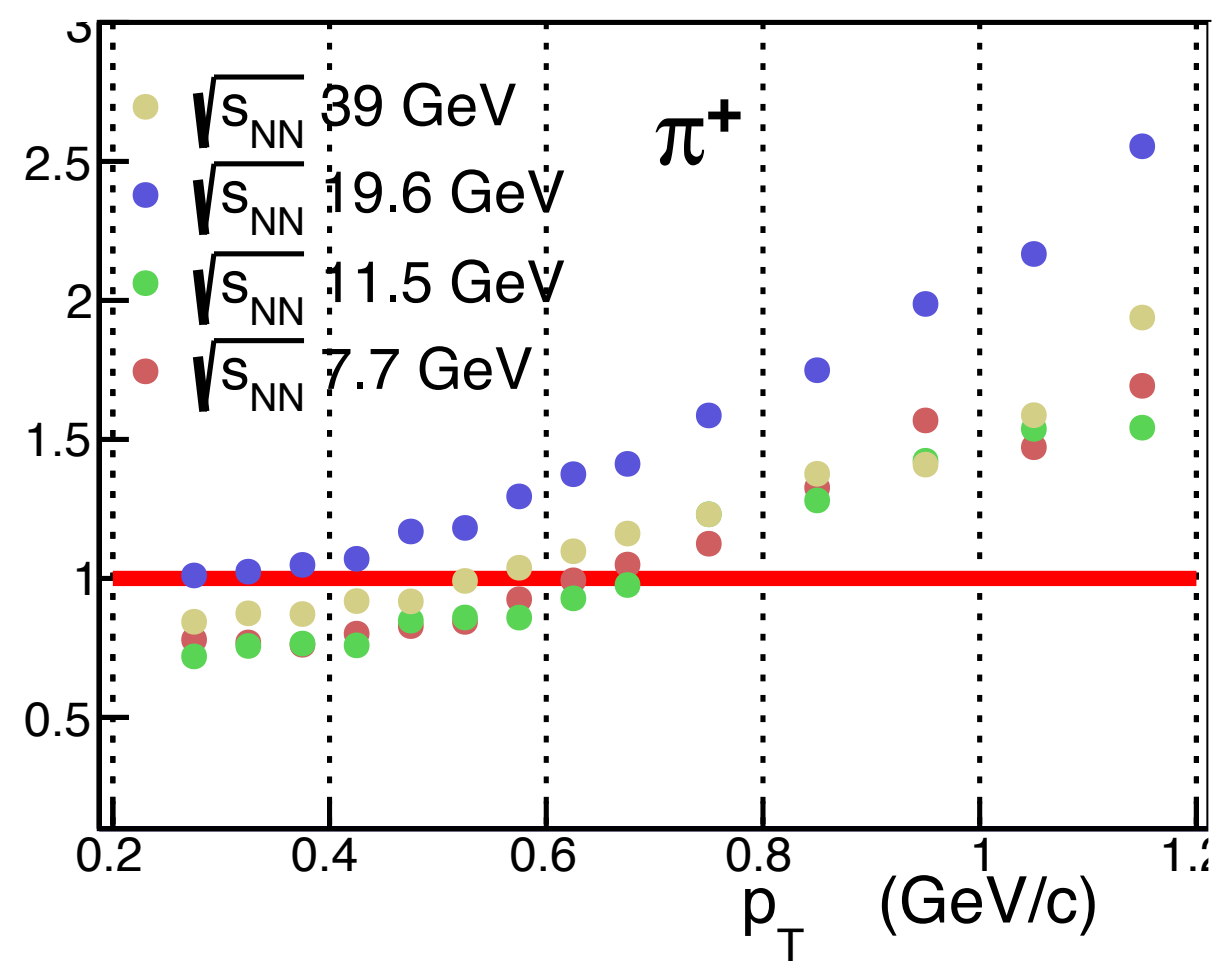
BACK UP



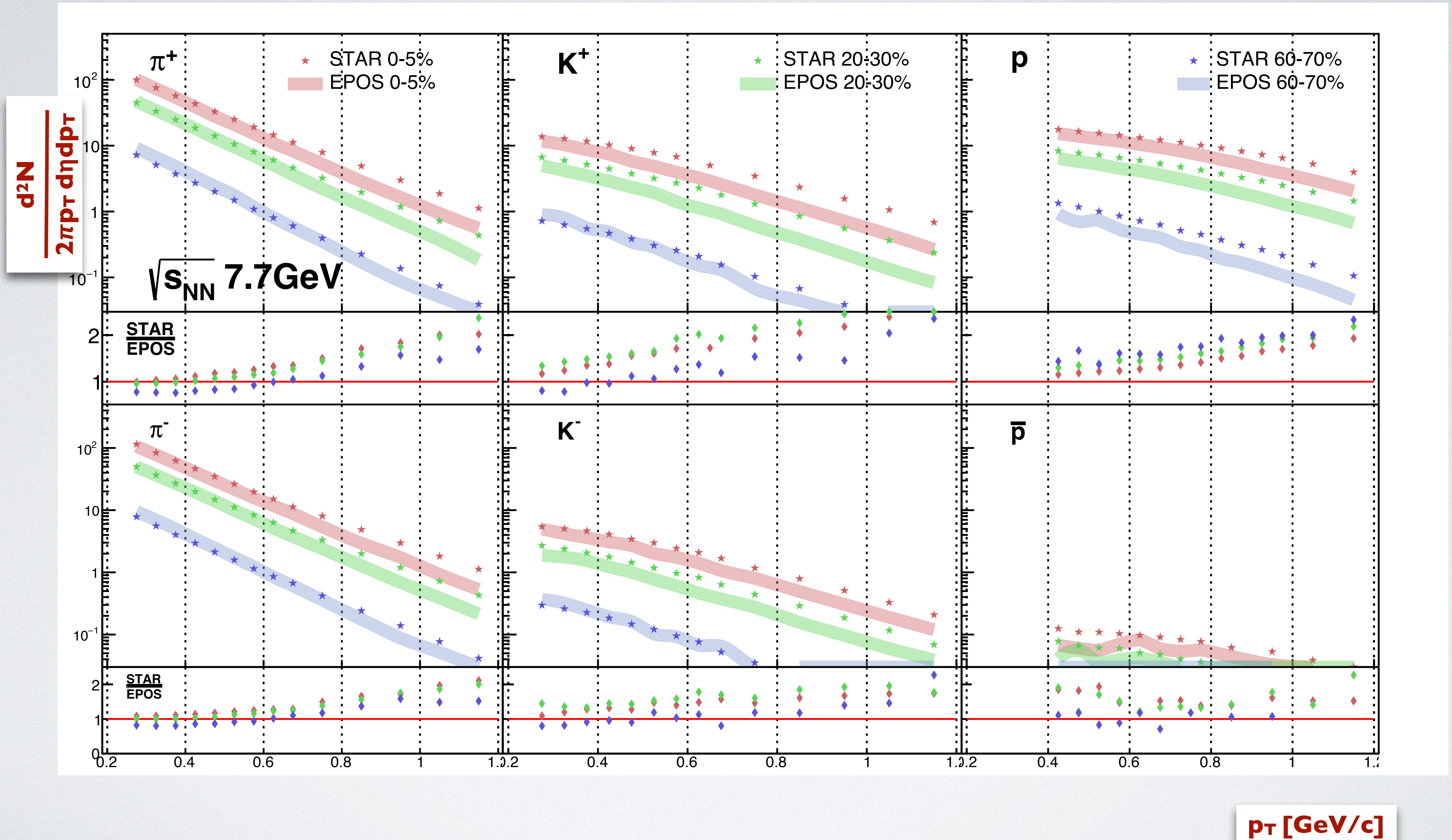
p_T [GeV/c]



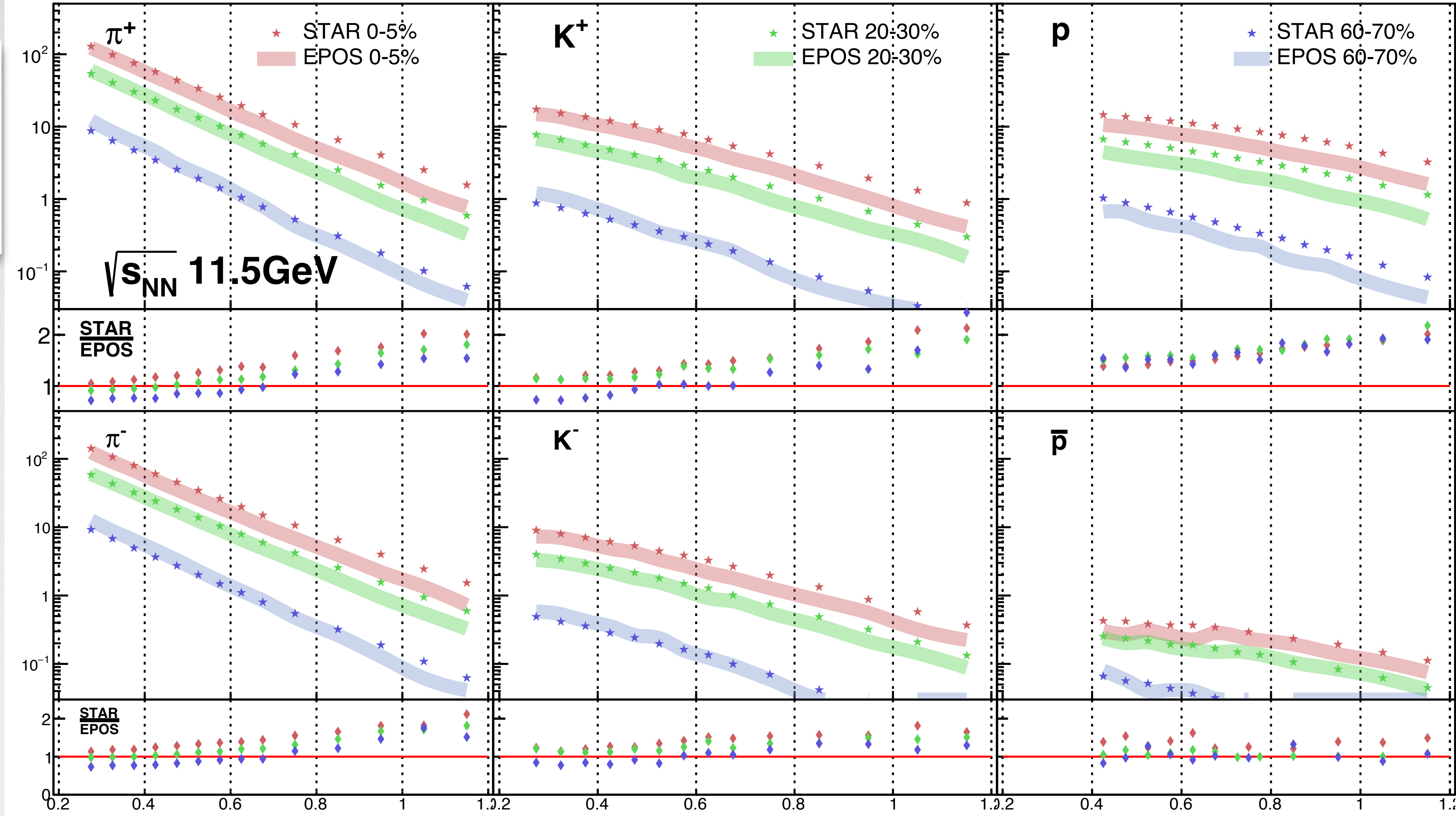
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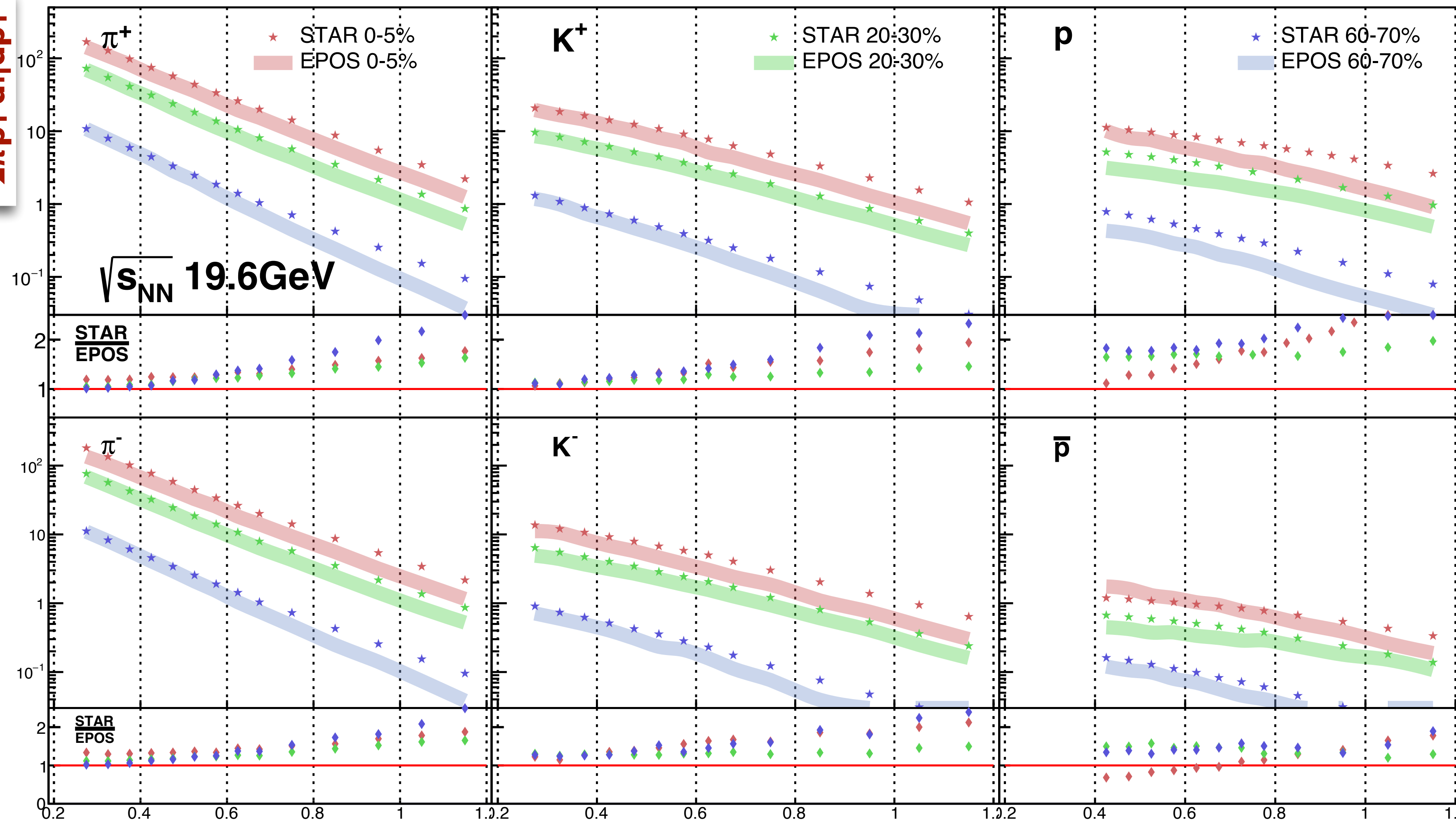


$$\frac{d^2N}{2\pi p_T d\eta d p_T}$$



p_T [GeV/c]

d^2N
 $2\pi p_T d\eta dp_T$



$p_T \text{ [GeV/c]}$

$\frac{d^2N}{2\pi p_T d\eta d p_T}$

