# *Azimuthal isotropic expansion in "highly central" collisions*

*C. Andrei and A. Herghelegiu*

- *Motivation*

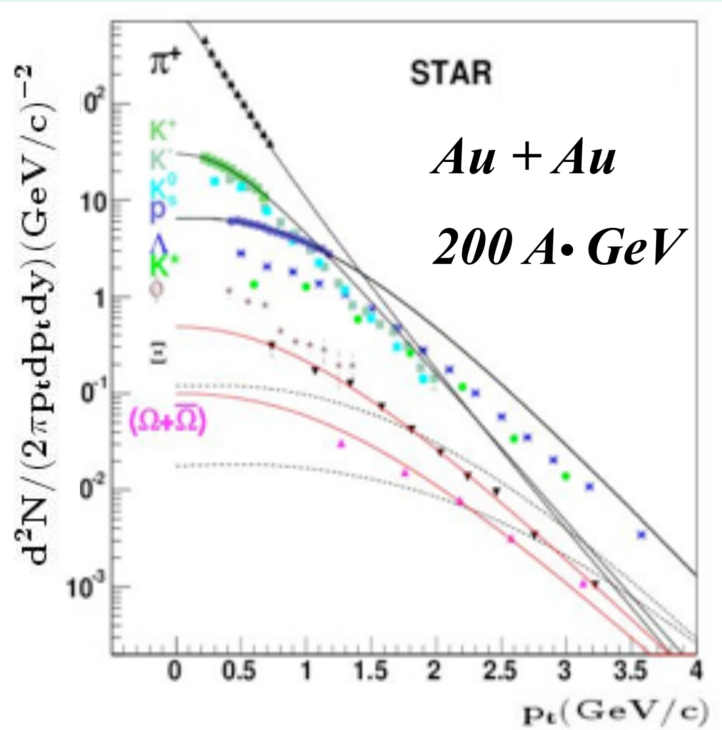
- *p+p at 900 GeV*
  - *PHYTHIA and PHOJET*
  - *Primary and reconstructed $p_t$ distributions and $<p_t>$*
  - *$<p_t>$ vs. mass as a function of multiplicity and directivity*
  - *soft – hard interaction selection*

- *ALICE PID performance*

- *Outlook*

# *Transverse Flow*

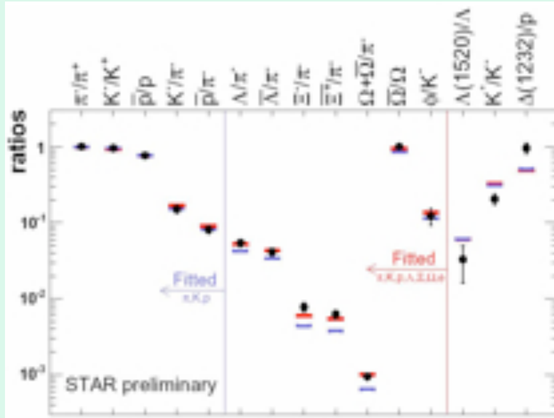
**0403014nucl-ex/**



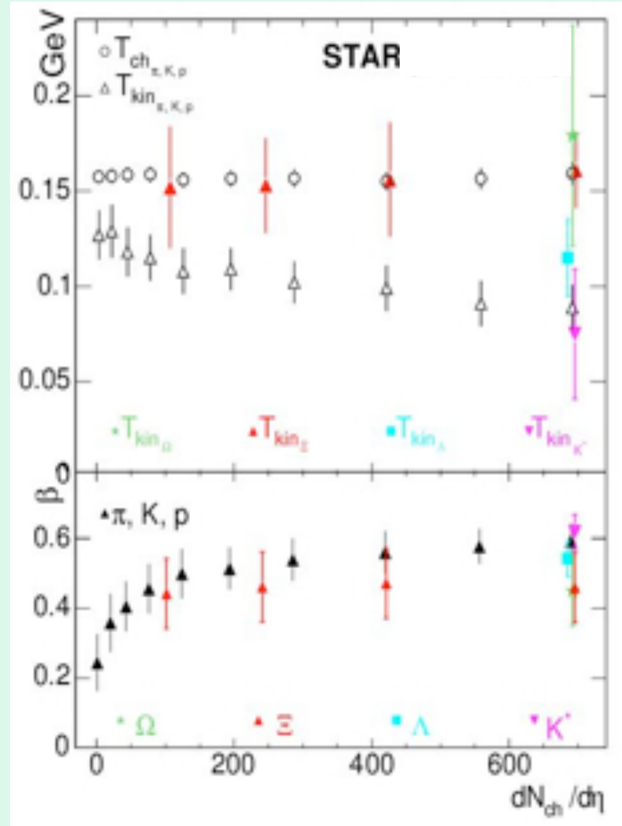

$$\frac{d^2N}{p_t dp_t} \sim \int_0^R r dr m_t I_0\left(\frac{p_t sinh\rho}{T}\right) K_1\left(\frac{m_t cosh\rho}{T}\right)$$

$$\rho = tanh^{-1}\beta_r$$

$$\beta_r(r) = \beta_s\left(\frac{r}{R}\right)^\alpha \quad \alpha = 0.5, 0.7, 1, 2$$

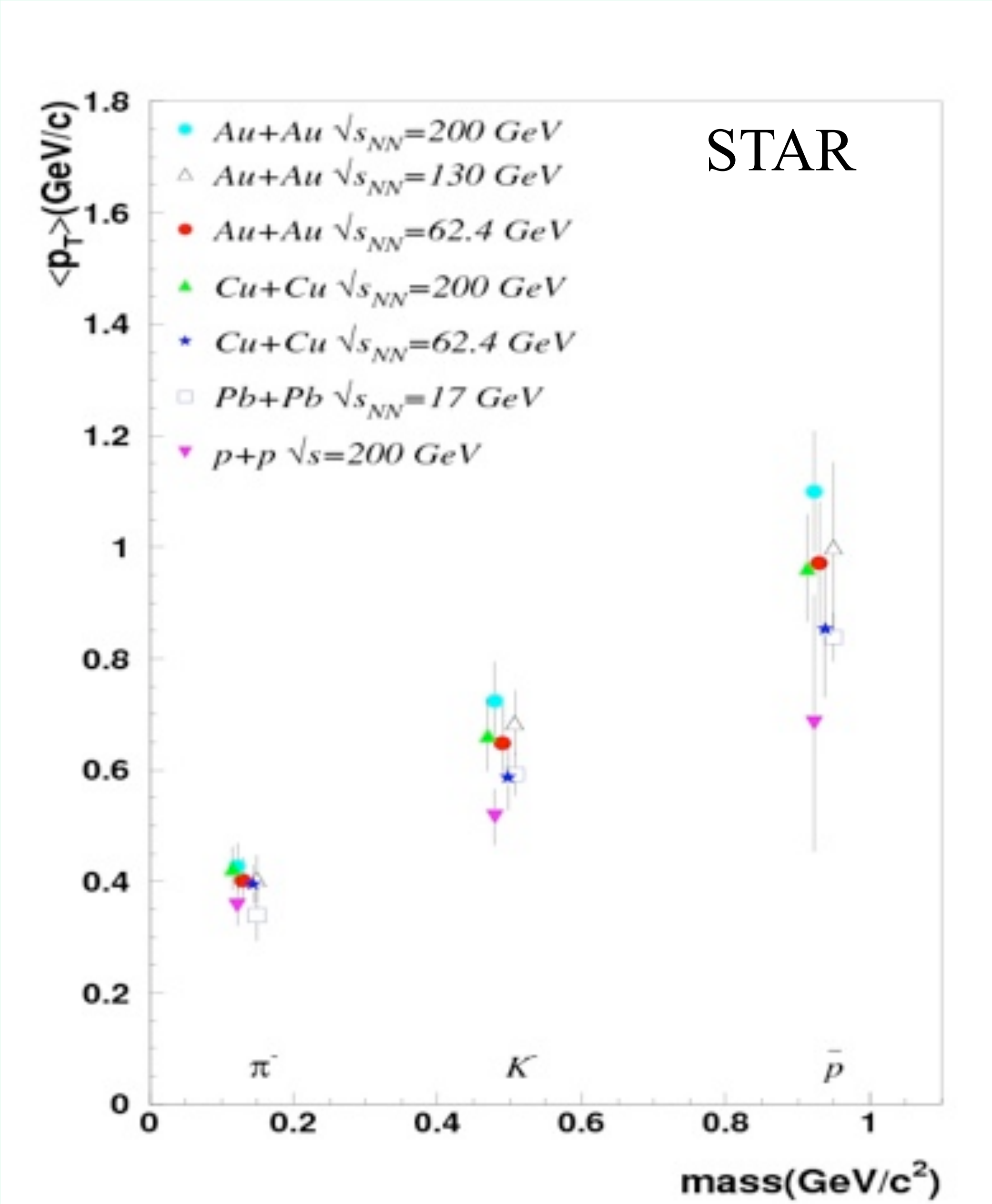



| Particle | $T_{kin}$ (MeV) | $\langle\beta\rangle$ $(c)$ |
|---|---|---|
| $\pi$, $K$, $p$ | $89 \pm 10$ | $0.59 \pm 0.05$ |
| $K^*$ | $75 \pm 35$ | $0.62 \pm 0.05$ |
| $\Lambda$, $\bar{\Lambda}$ | $115 \pm 20$ | $0.54 \pm 0.05$ |
| $\Xi^-$, $\bar{\Xi}^+$ | $161 \pm 20$ | $0.46 \pm 0.10$ |
| $\Omega$, $\bar{\Omega}$ | $179 \pm 60$ | $0.45 \pm 0.10$ |



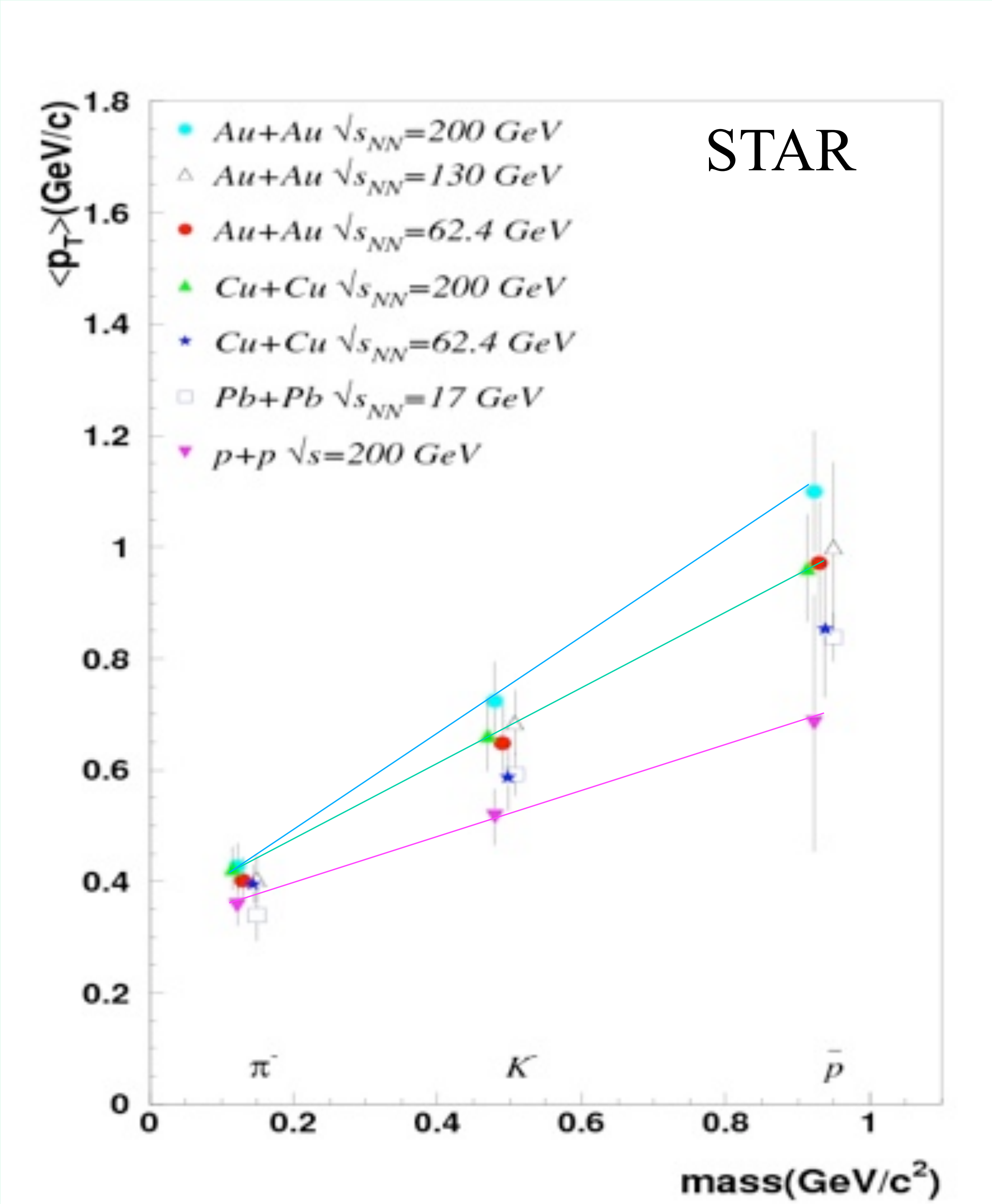

E.Schnedermann, J.Sollfrank,U.W.Heinz, Phys.Rev. C48(1993)2462

# *Transverse Flow from $\langle p_t \rangle$ vs. mass analysis*



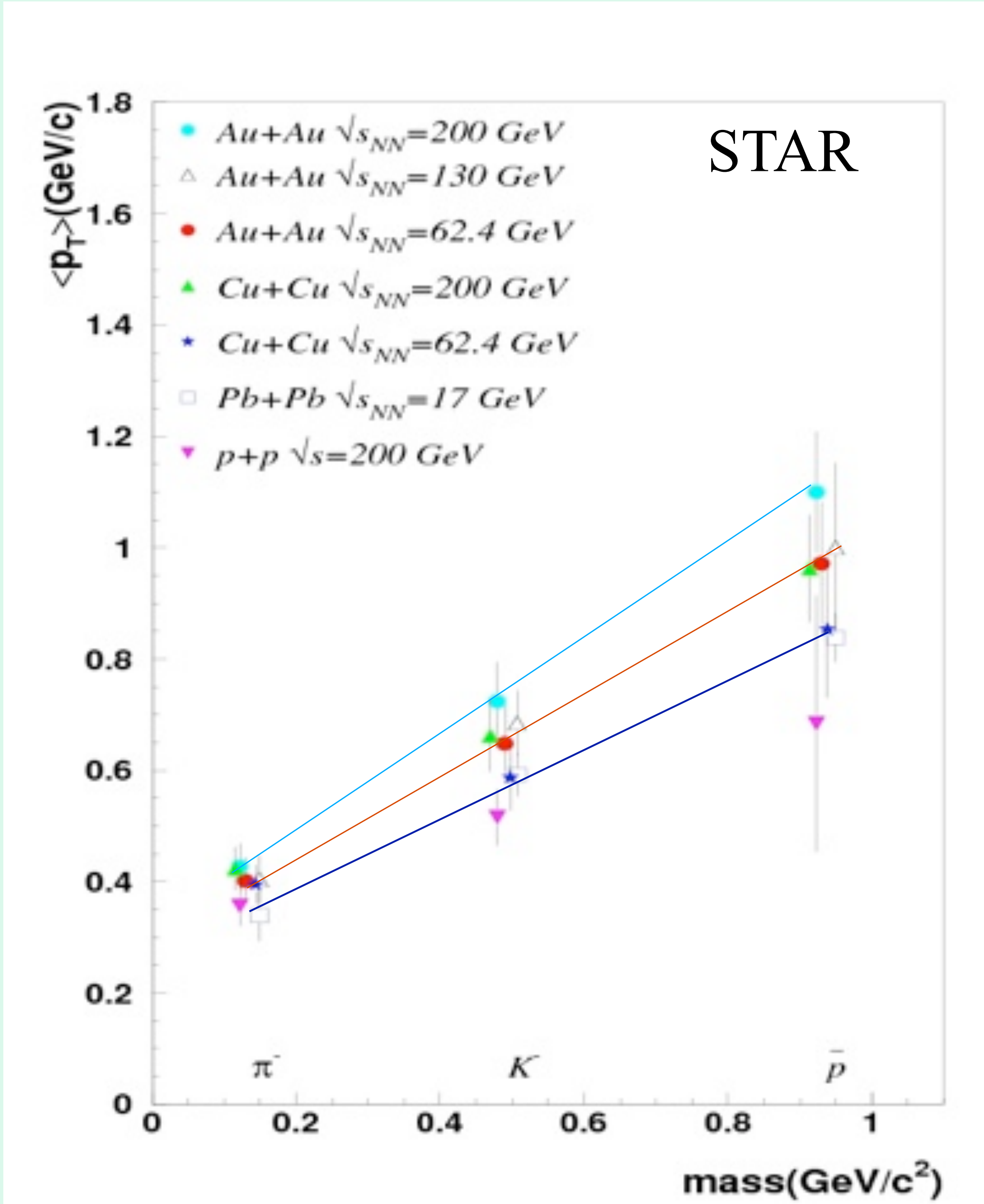

**M. Petrovici, A. Pop**
**arXiv: 0904.3666**

# *Transverse Flow*
# *from $<p_t>$ vs. mass analysis*




M. Petrovici, A. Pop
arXiv: 0904.3666

# *Transverse Flow*
# *from <$p_t$> vs. mass analysis*




**M. Petrovici, A. Pop**
**arXiv: 0904.3666**

# *Boltzmann-Gibbs Blast-Wave*

$$< p_t >= \frac{\int_0^\infty p_t^2 f(p_t) dp_t}{\int_0^\infty p_t f(p_t) dp_t}$$

$$f(p_t) \sim \int_0^R r dr m_t I_0 \left(\frac{p_t sinh\rho}{T}\right) K_1 \left(\frac{m_t cosh\rho}{T}\right)$$

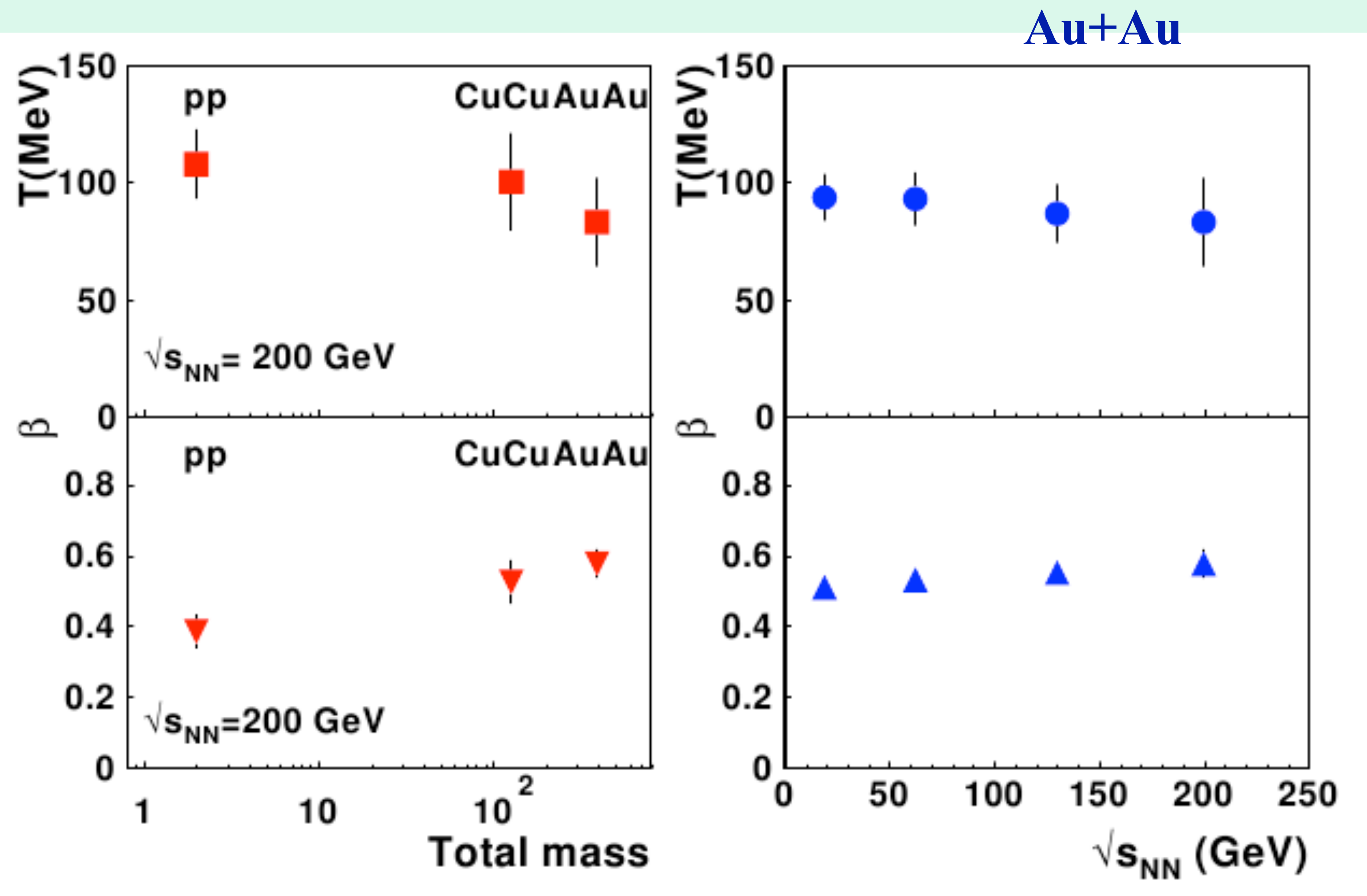
$$\rho = tanh^{-1} \beta_r$$

$$\beta_r(r) = \beta_s \left(\frac{r}{R}\right)^n$$

$$m_t = \sqrt{m^2 + p_t^2}$$

**E.Schnedermann, J.Sollfrank,U.W.Heinz,**
**Phys.Rev. C48(1993)2462**

# *Boltzmann-Gibbs Blast-Wave*




**M. Petrovici, A. Pop arXiv: 0904.3666**

# Tsallis Blast-Wave

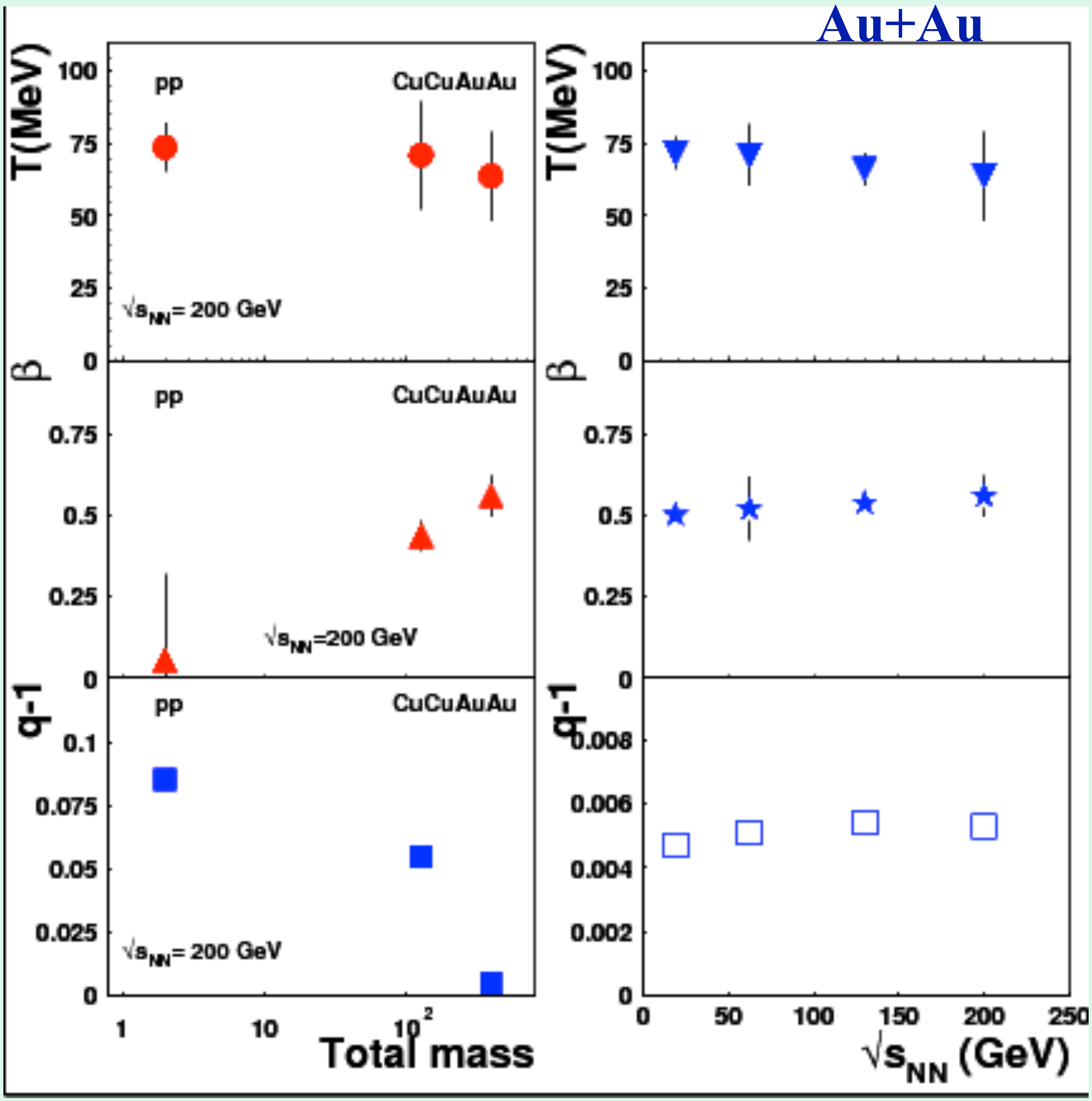
**Tsallis Blast Wave:**

$$f(p_t) = m_t \int_{-Y}^{Y} cosh(y)dy \int_{-\pi}^{\pi} d\phi \int_{0}^{R} rdr(1+\frac{q-1}{T}(m_t cosh(y)cosh(\rho)-p_t sinh(\rho)cos(\phi)))^{-1/(q-1)}$$

$$< p_t >= \frac{\int_0^\infty p_t^2 f(p_t) dp_t}{\int_0^\infty p_t f(p_t) dp_t}$$

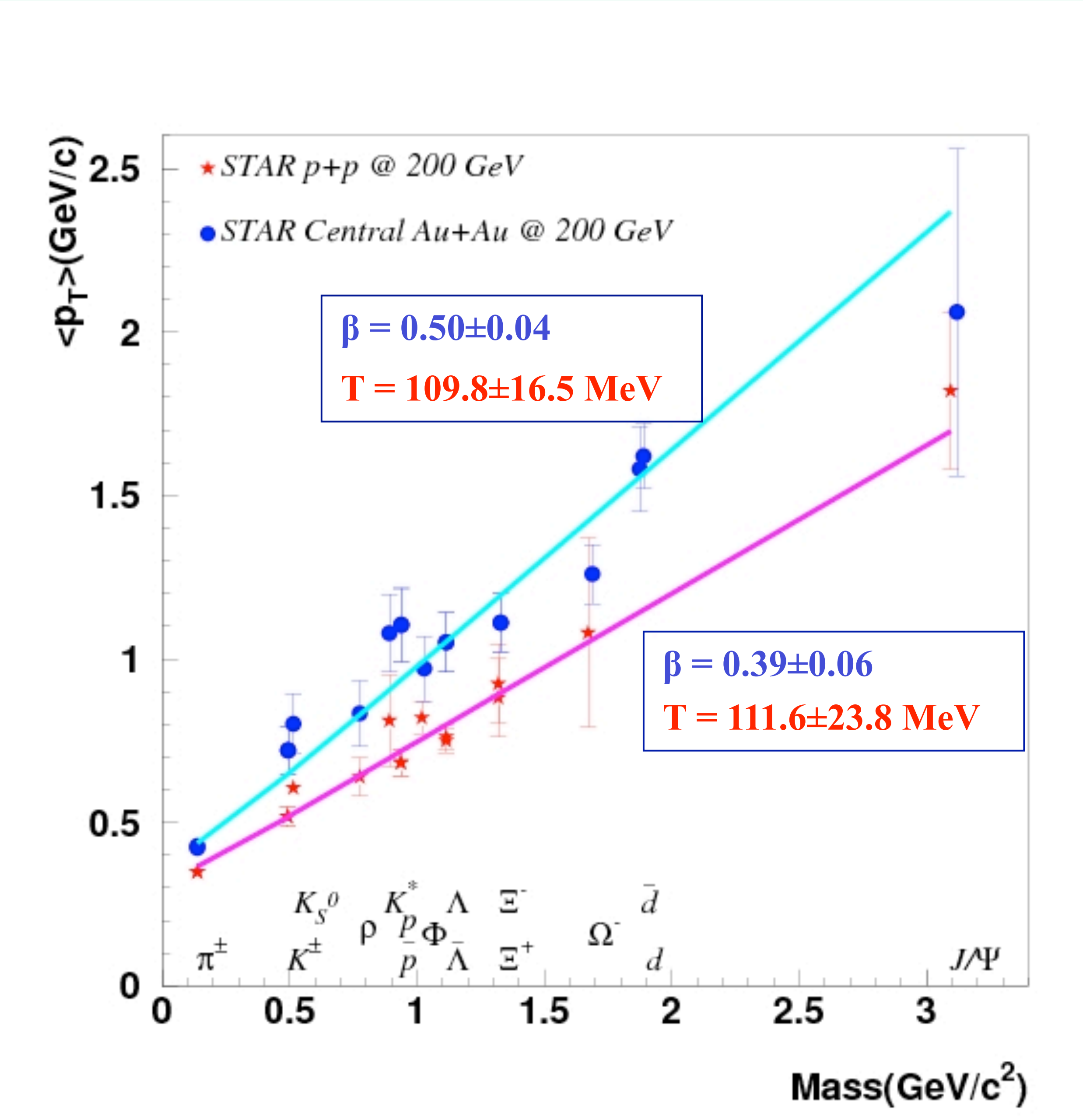
**A. Lavagno, Phys.Lett. A301(2002)13**
**Z. Tang et al, arXiv:0812.1609 nucl-ex**

# *Tsallis Blast-Wave*




M. Petrovici, A. Pop arXiv: 0904.3666

# BGBW vs TBW




$$< p_t >= \frac{\int_0^\infty p_t^2 f(p_t) dp_t}{\int_0^\infty p_t f(p_t) dp_t}$$

$$f(p_t) \sim \int_0^R r dr m_t I_0 \left( \frac{p_t \sinh \rho}{T} \right) K_1 \left( \frac{m_t \cosh \rho}{T} \right)$$

**M.Petrovici and Amalia Pop**
**- AIP Conference Proceedings 972(2008)98**
**- will be published**

# *BGBW vs TBW*

**$\pi^{\pm}$, $K^{\pm}$, $K^*$, $K_s^0$, $\bar{p}$, $\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, d, $\bar{d}$, J/$\psi$**

| System | p + p | p + p | Au + Au | Au + Au |
|---|---|---|---|---|
| Model | BGBW | TBW | BGBW | TBW |
| T [MeV] | 111.6±23.8 | 78.86±10.13 | 109.8±16.5 | 86.8 ±1.54 |
| $\beta$ | 0.39±0.06 | 0.027±0.10 | 0.50±0.04 | 0.48±0.04 |
| q | 1.0 | 1.0874 | 1.0 | 1.0247 |

**$\pi^{\pm}$, $K^{\pm}$, $K^*$, p, $\bar{p}$, d, $\bar{d}$**

| | Au + Au | Au + Au |
|---|---|---|
| | BGBW | TBW |
| T [MeV] | 98.7±19.5 | 79.05±0.04 |
| $\beta$ | 0.54±0.04 | 0.53±0.0005 |
| q | 1.0 | 1.0175 |

**$\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, J/$\psi$**

| | Au + Au |
|---|---|
| | TBW |
| T [MeV] | 198.0±7.6 |
| $\beta$ | 0.32±0.012 |
| q | 1.0247 |

**M. Petrovici, A. Pop arXiv: 0904.3666**

# *BGBW vs TBW*

**$\pi^{\pm}$, $K^{\pm}$, $K^*$, $K_s^0$, $\bar{p}$, $\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, d, $\bar{d}$, $J/\psi$**

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**$\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, $J/\psi$**

| | Au + Au |
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| q | 1.0247 |

**M. Petrovici, A. Pop arXiv: 0904.3666**

# *BGBW vs TBW*

$\pi^{\pm}$, $K^{\pm}$, $K^*$, $K_s^0$, $\bar{p}$, $\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, d, $\bar{d}$, $J/\psi$

| System | p + p | p + p | Au + Au | Au + Au |
|---|---|---|---|---|
| Model | BGBW | TBW | BGBW | TBW |
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| $\beta$ | 0.39±0.06 | 0.027±0.10 | 0.50±0.04 | 0.48±0.04 |
| q | 1.0 | 1.0874 | 1.0 | 1.0247 |

$\pi^{\pm}$, $K^{\pm}$, $K^*$, p, $\bar{p}$, d, $\bar{d}$

| | Au + Au | Au + Au |
|---|---|---|
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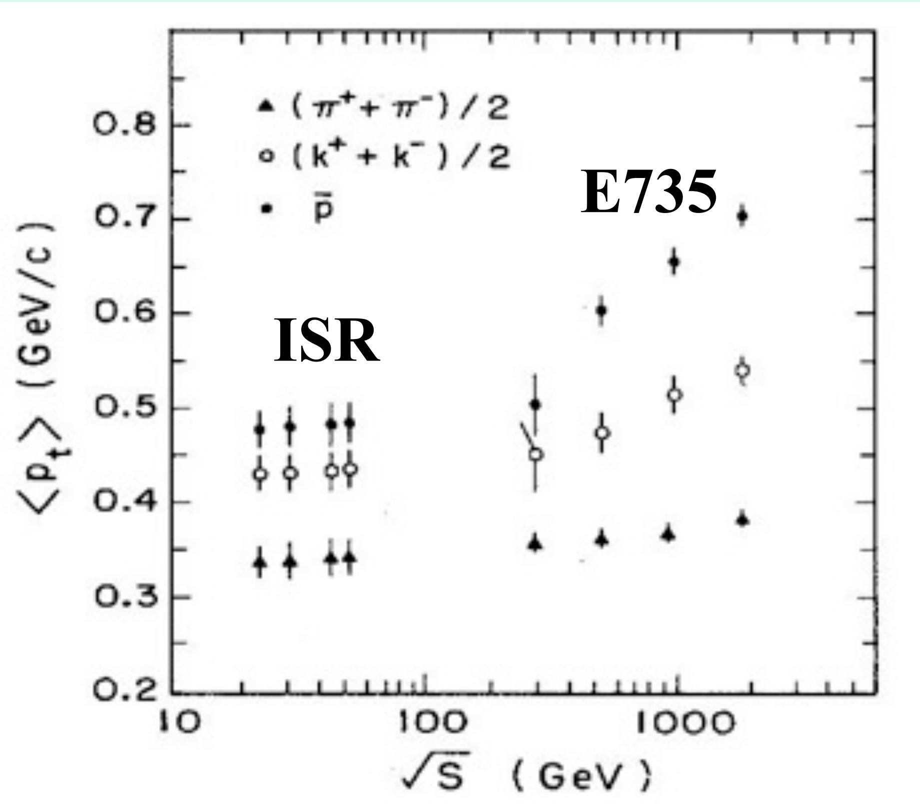
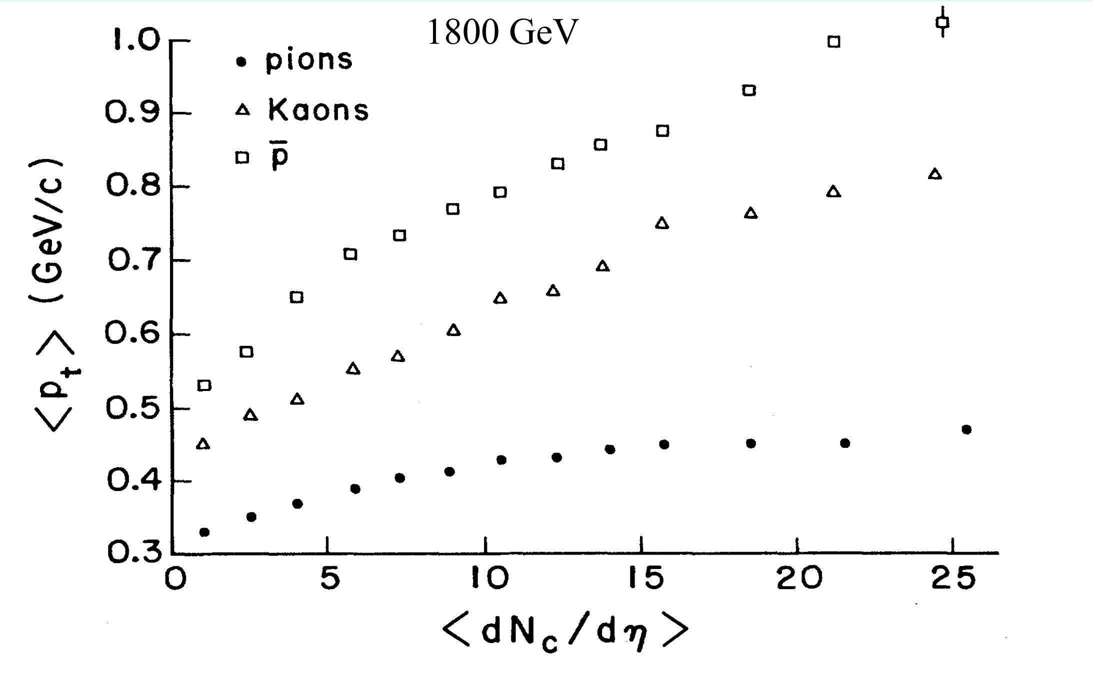
$\Lambda$, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^-$, $J/\psi$

| | Au + Au |
|---|---|
| | TBW |
| T [MeV] | 198.0±7.6 |
| $\beta$ | 0.32±0.012 |
| q | 1.0247 |

**M. Petrovici, A. Pop arXiv: 0904.3666**

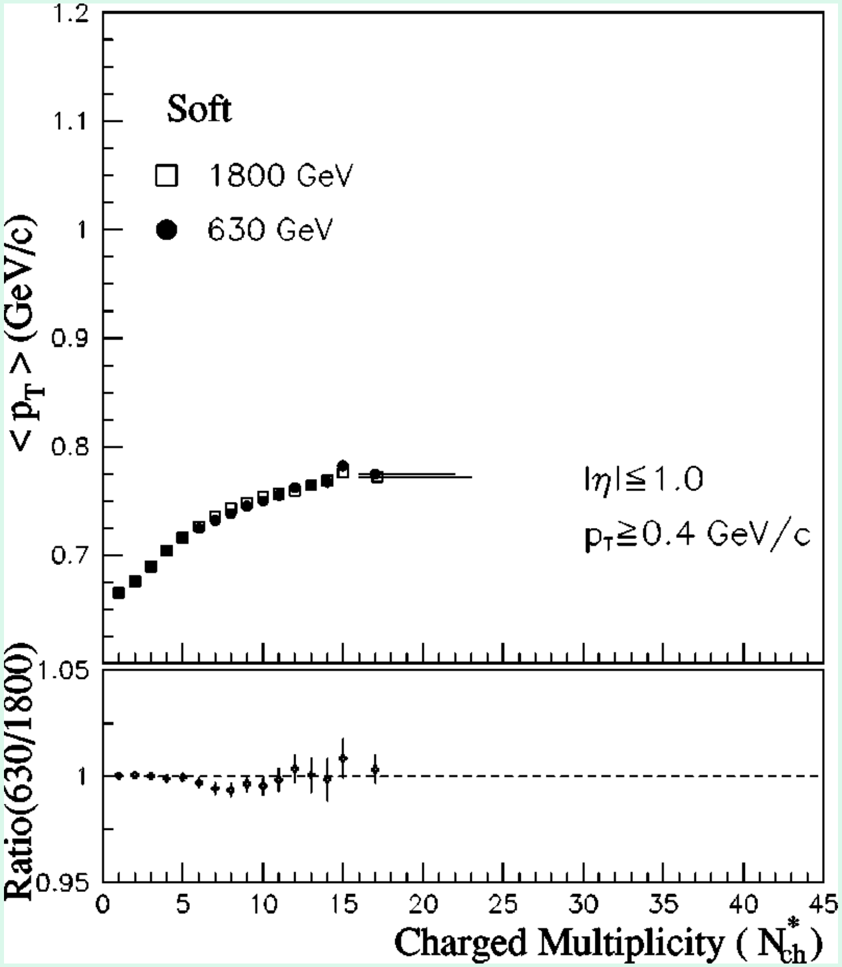
# SPS and Tevatron Results



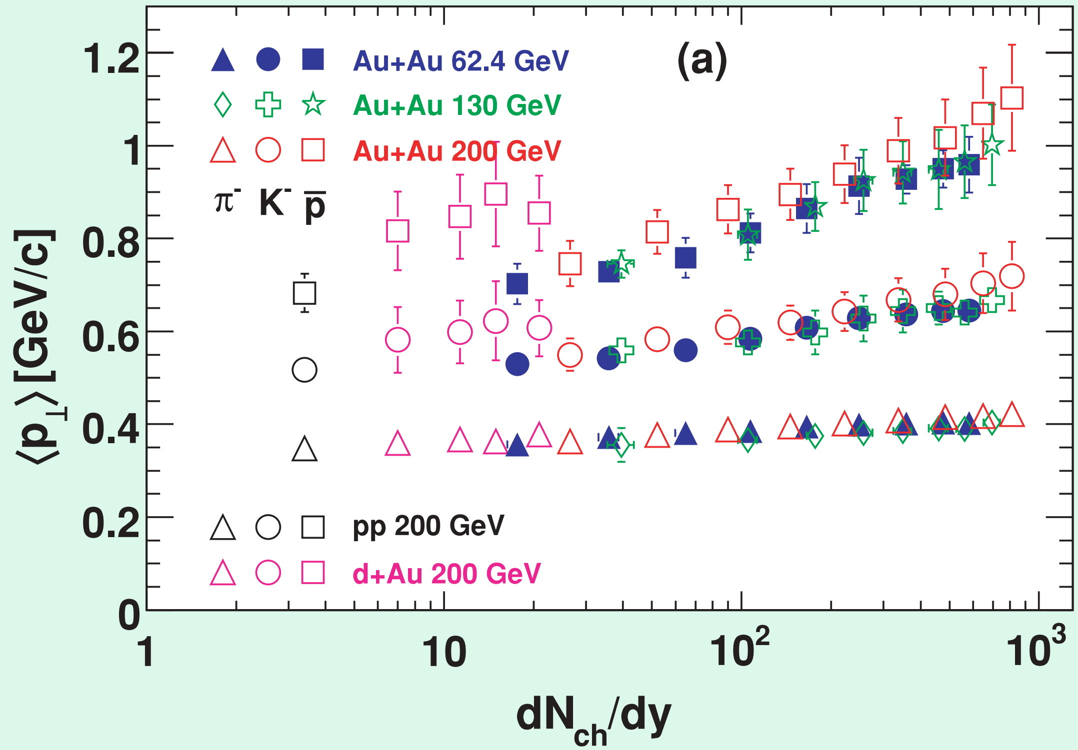




*E735*

# *Charged particle multiplicity scaling*




D.A.Costa – CDF, Phys.Rev. D65(2002)072005




B.I.Abelev – STAR, Phys.Rev. C79(2009)034909

# *Analysis details*

Simulations - PYTHIA Tune6T - LHC10a12, runs: 104825, 104800, 104799, 104793, 104792, 104316, 104157 -> used to determine corrections

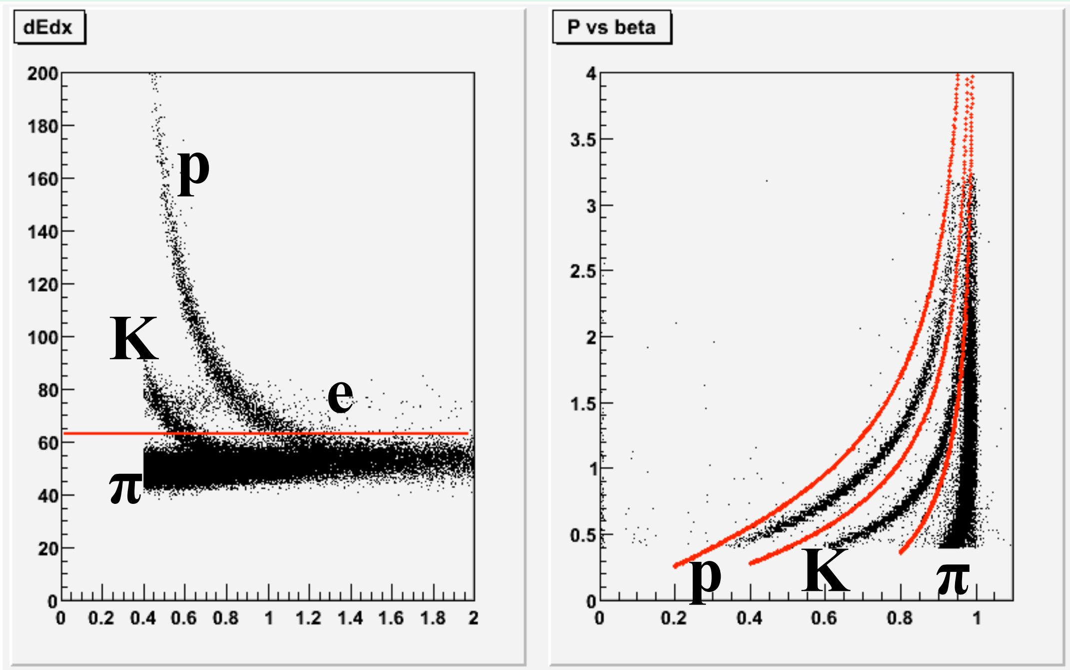
- PYTHIA Tune6T - LHC10a12, run 104824
- PHOJET - LHC10a14, run 104792

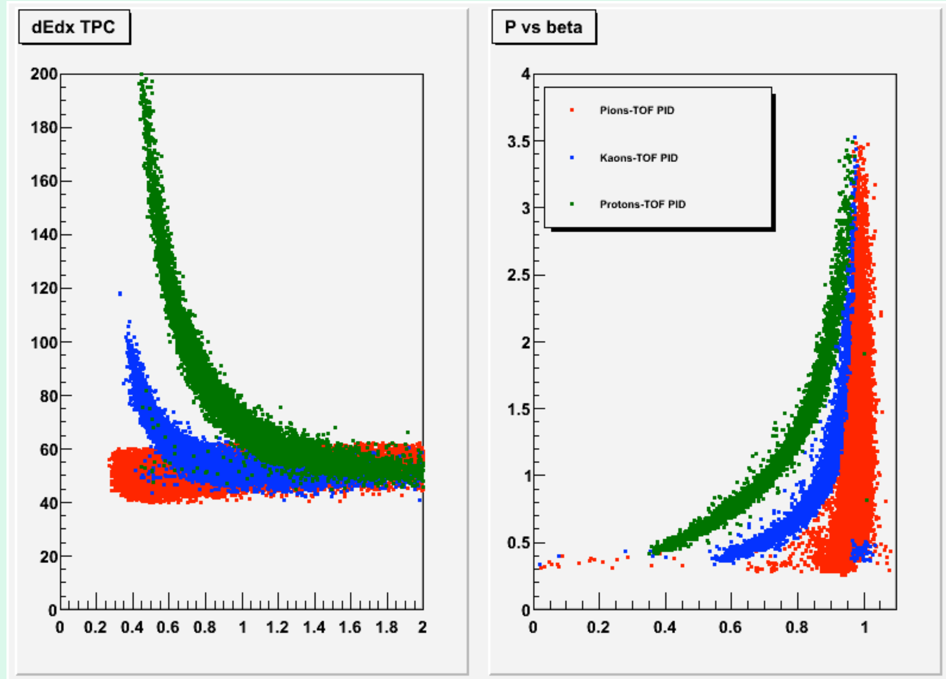
AliPhysicsSelection

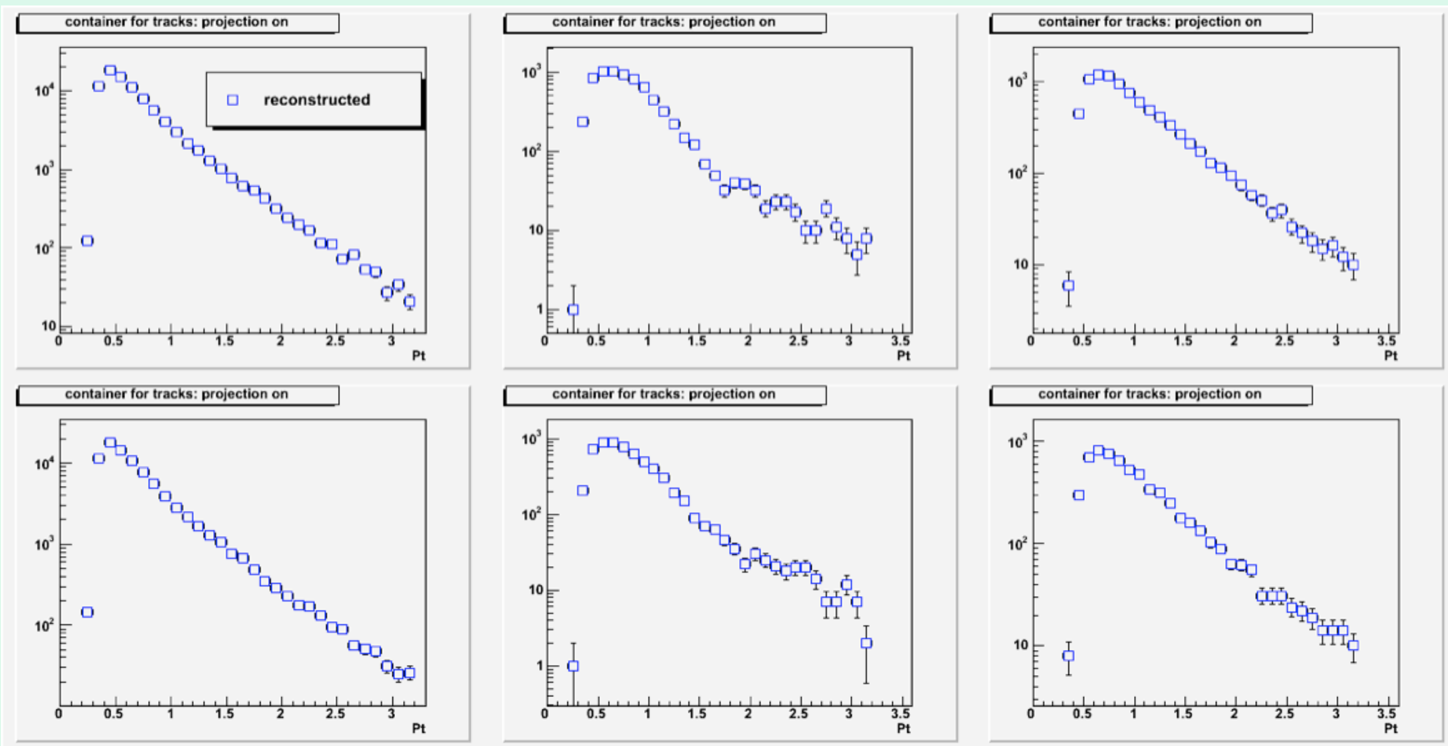
Track cuts:
- $0.2 < p_T < 3.2$ GeV
- $|y| < 0.5$
- min TPC clusters = 80
- $\chi^2$/cluster = 4.0
- no kink daughters
- SetRequireTPCRefit & SetRequireITSRefit
- $|d0| < 7*(0.0050+0.0060/p_T^{0.9})$ cm

PID – the present results are based on what we called "manual PID"

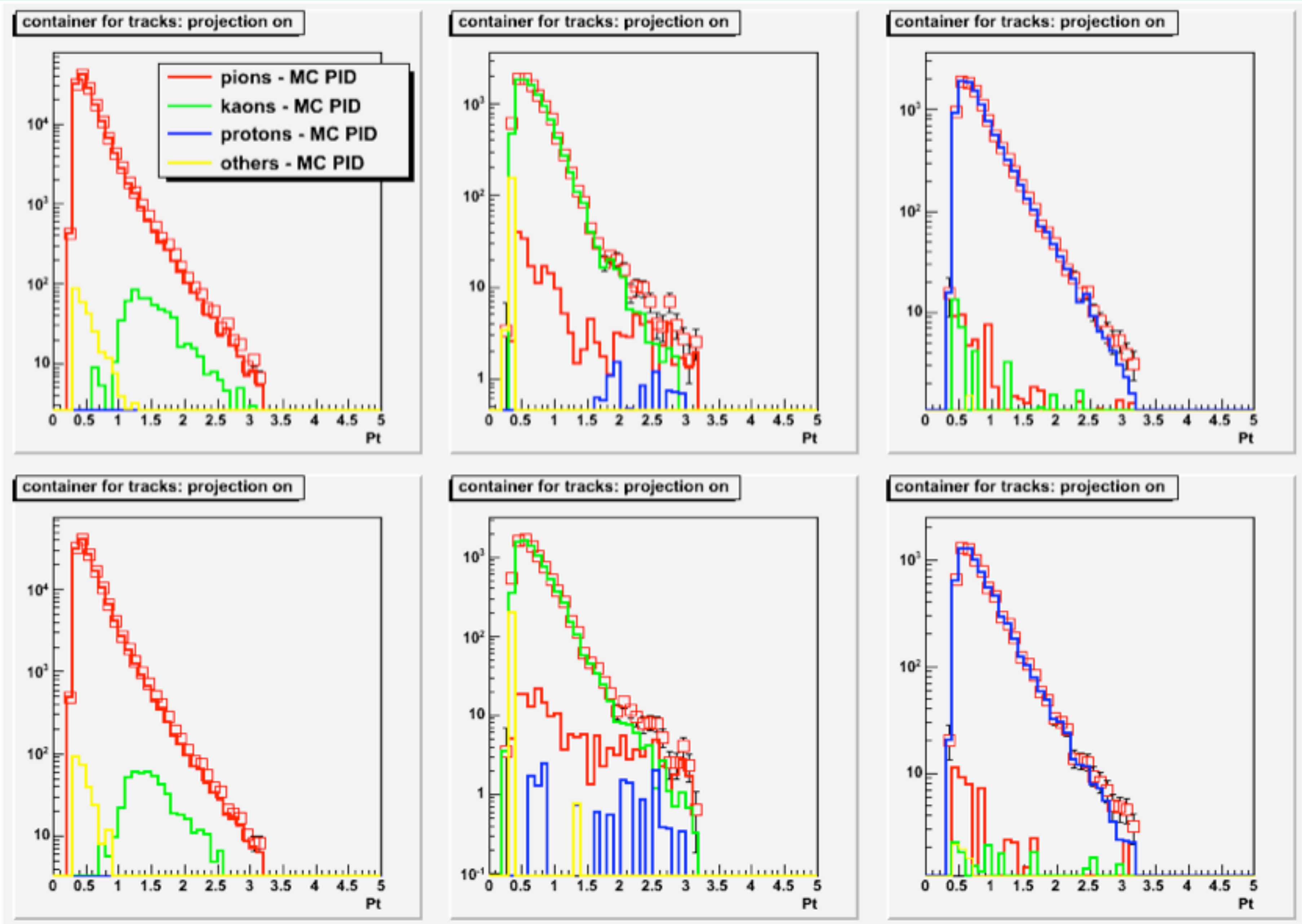
# *corrected spectra - PYTHIA*



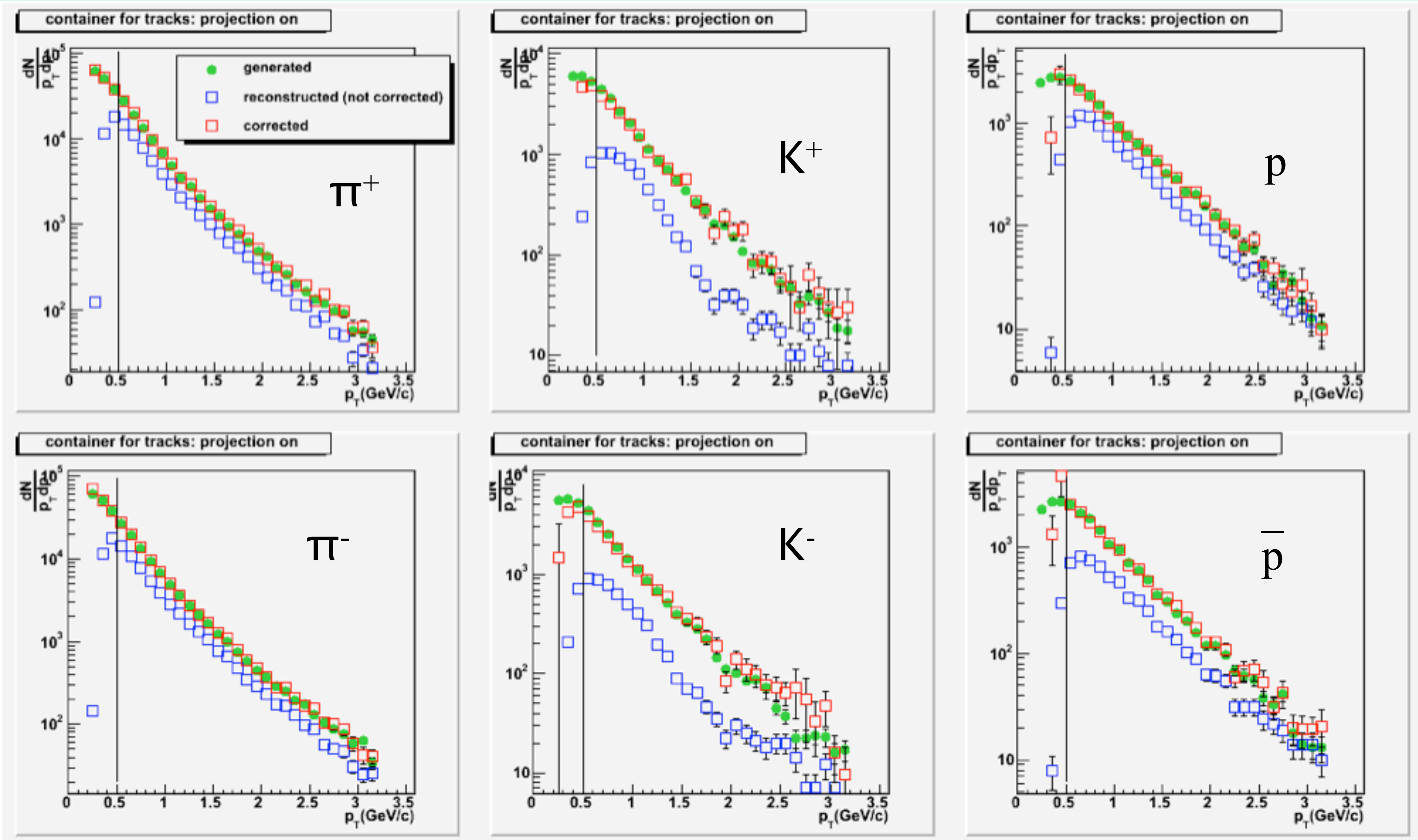



# *Contaminations spectra - PYTHIA*

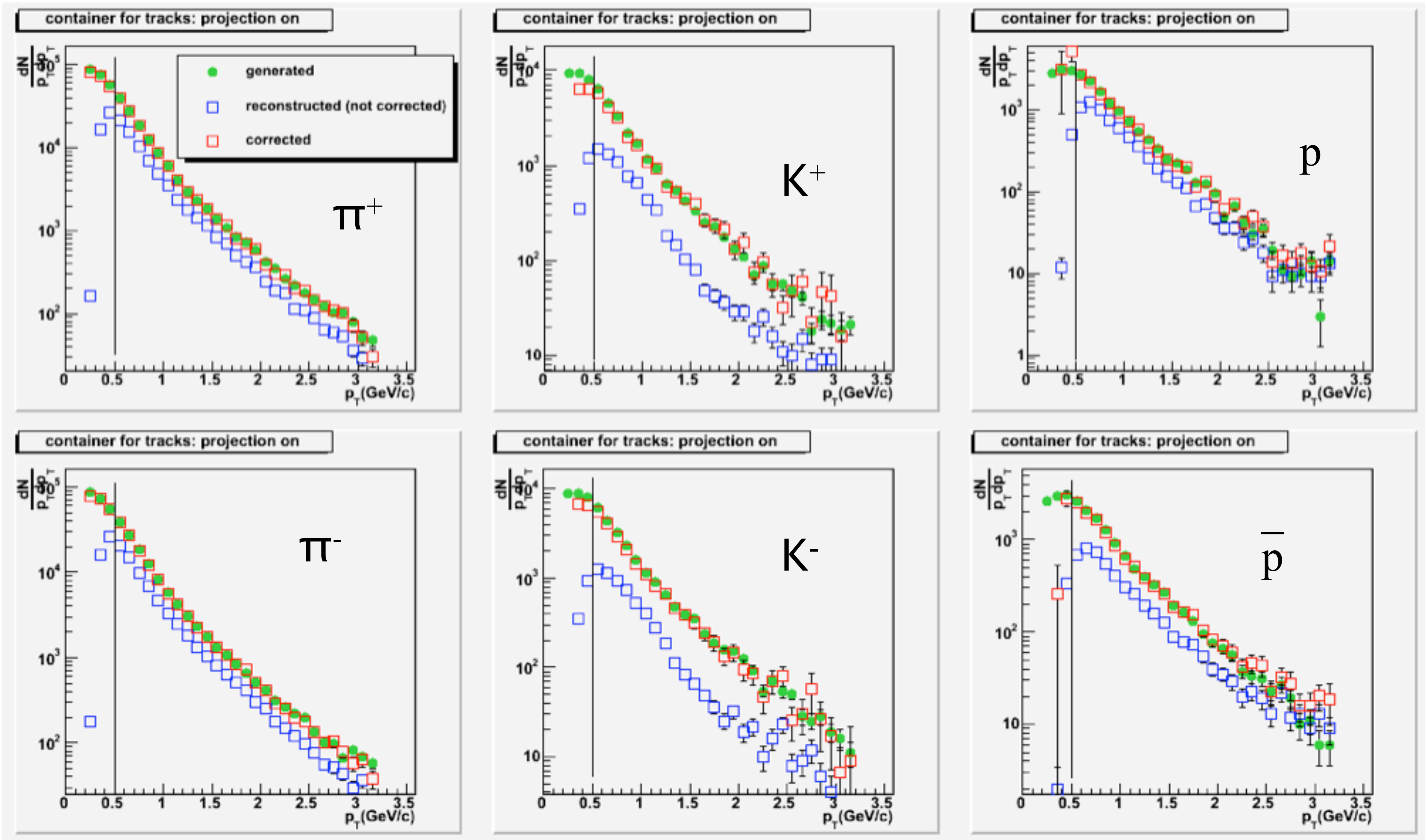


# *PYTHIA*
## *corrected with PYTHIA-EFF*



# *PHOJET*

## *corrected with PYTHIA-EFF*



# *Extrapolation procedures*

**Boltzmann-Gibbs Blast Wave = Boltzmann**

$$f(p_t) \sim \int_0^R r dr m_t I_0\left(\frac{p_t sinh\rho}{T}\right) K_1\left(\frac{m_t cosh\rho}{T}\right)$$

**Boltzmann-Gibbs Blast Wave (explicit rapidity integral) = Boltzmann Rap**

$$f(p_t) \backsim \int_{-Y}^{Y} dy \int_0^R m_t r\, dr\, cosh(y)\, exp\left(\frac{-m_t cosh(\rho) cosh(y)}{T}\right) I_0\left(\frac{p_t sinh(\rho)}{T}\right)$$

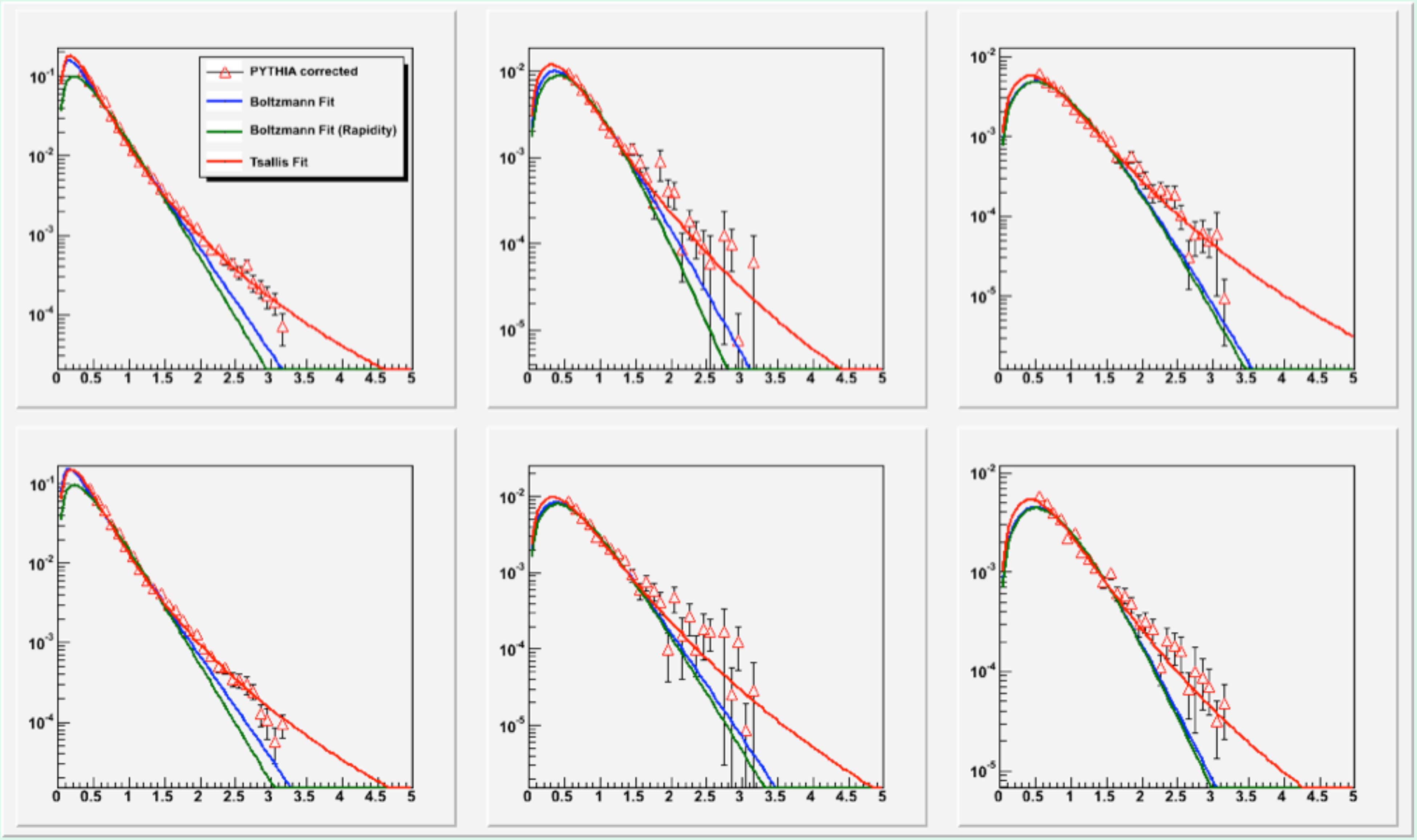
**Tsallis Blast Wave = Tsallis**

$$f(p_t) = m_t \int_{-Y}^{Y} cosh(y) dy \int_{-\pi}^{\pi} d\phi \int_0^R r dr (1+\frac{q-1}{T}(m_t cosh(y) cosh(\rho) - p_t sinh(\rho) cos(\phi)))^{-1/(q-1)}$$

**where:**

$$m_t = \sqrt{m^2 + p_t^2} \qquad \beta_r(r) = \beta_s\left(\frac{r}{R}\right)^n \qquad \rho = tanh^{-1}\beta_r$$

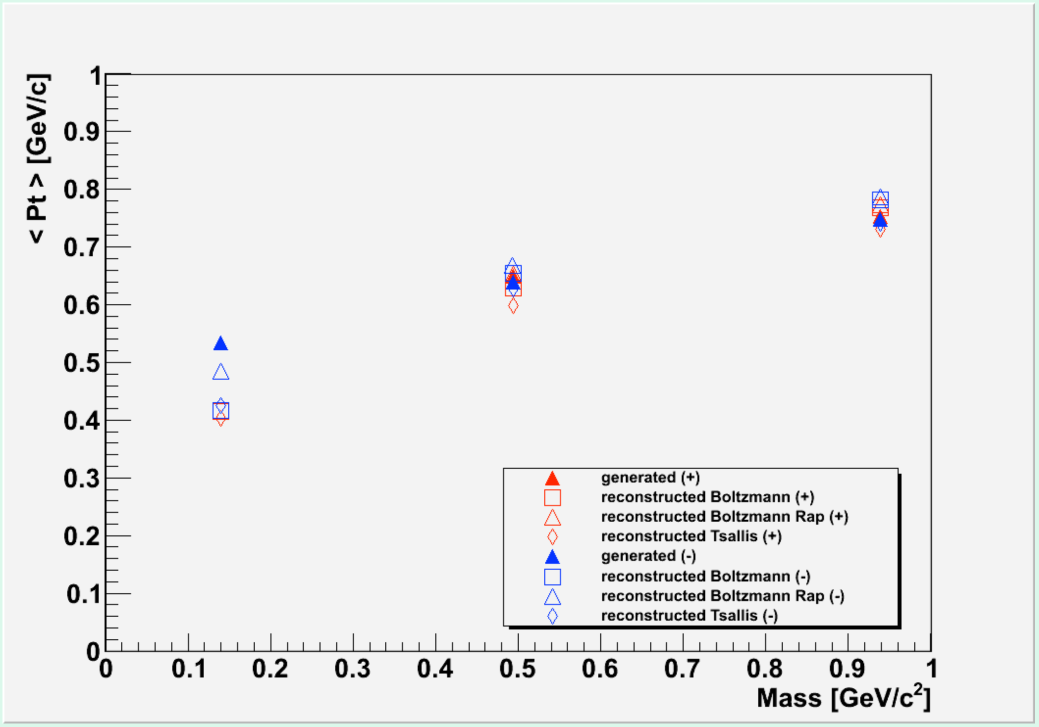
# *PYTHIA - extrapolations compared*



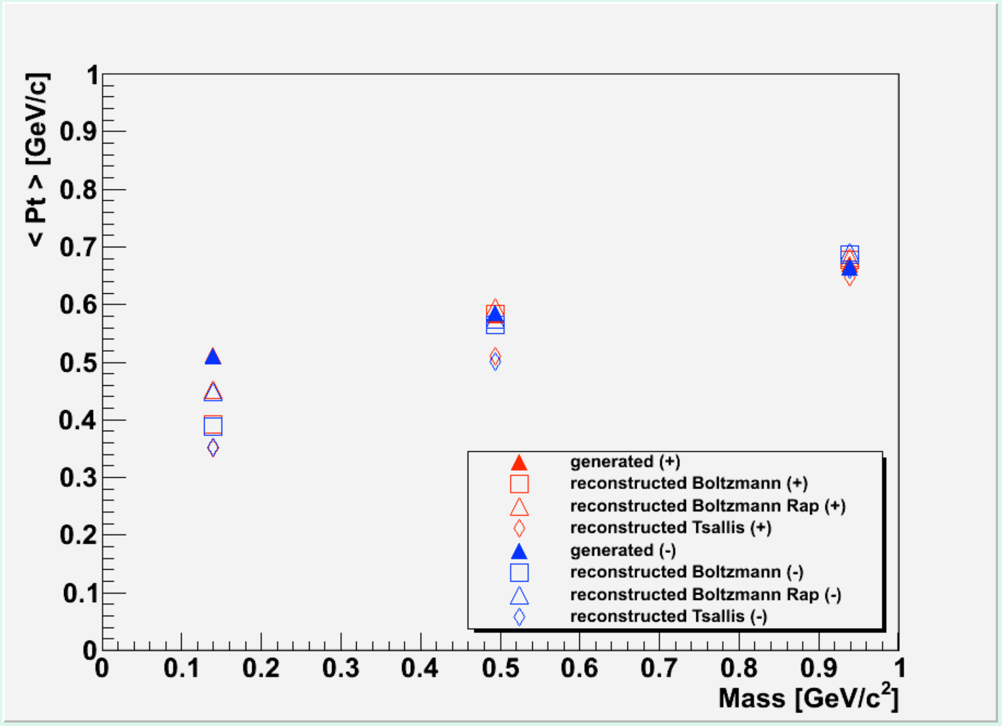
# *Efficiency correction and extrapolation*

## *$|y| < 0.2$*

**PYTHIA (corrected with PYTHIA – eff)**

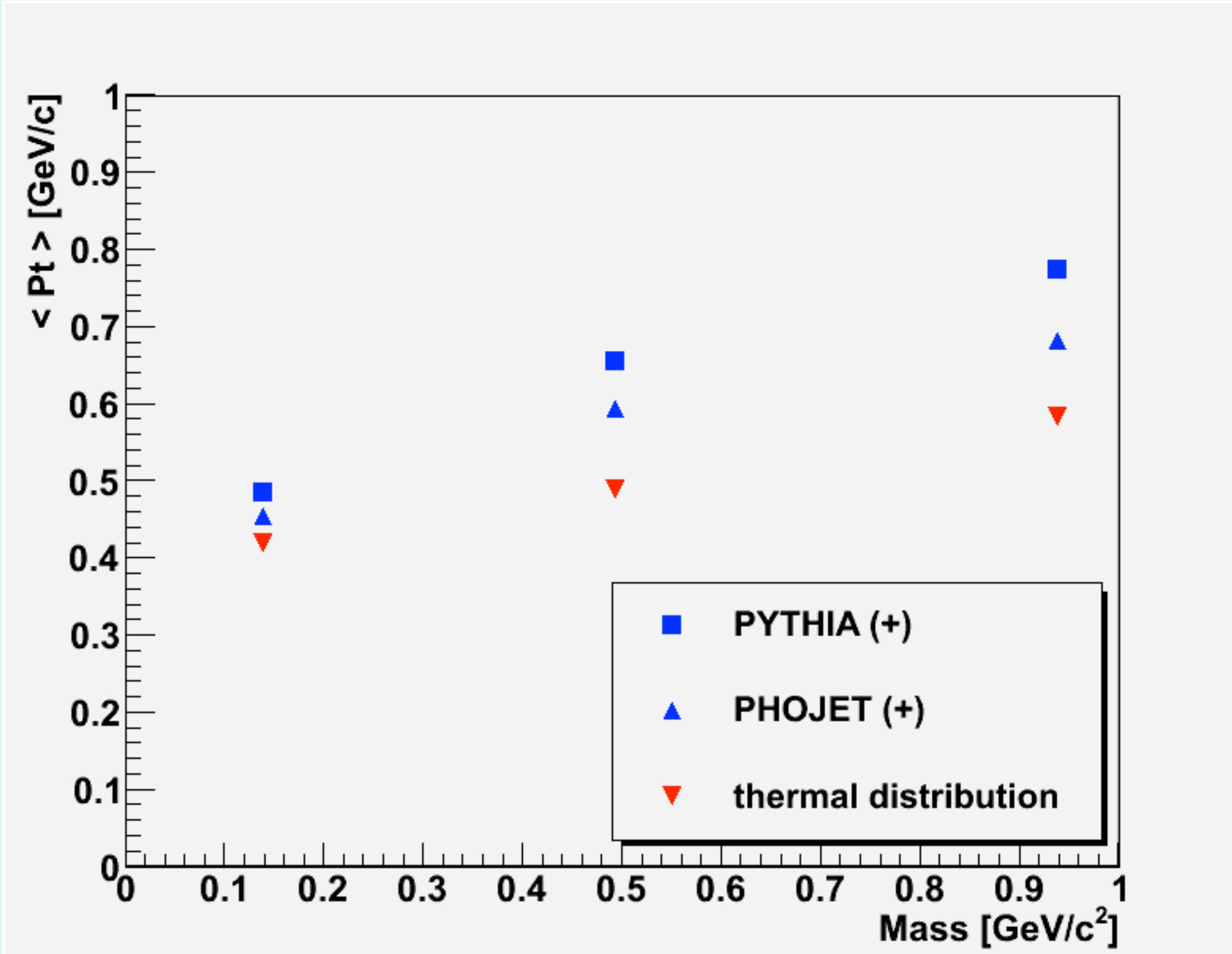



**PHOJET (corrected with PYTHIA – eff)**



# $\langle p_T \rangle$ - MC

## $|y| < 0.2$, Boltzmann Rap

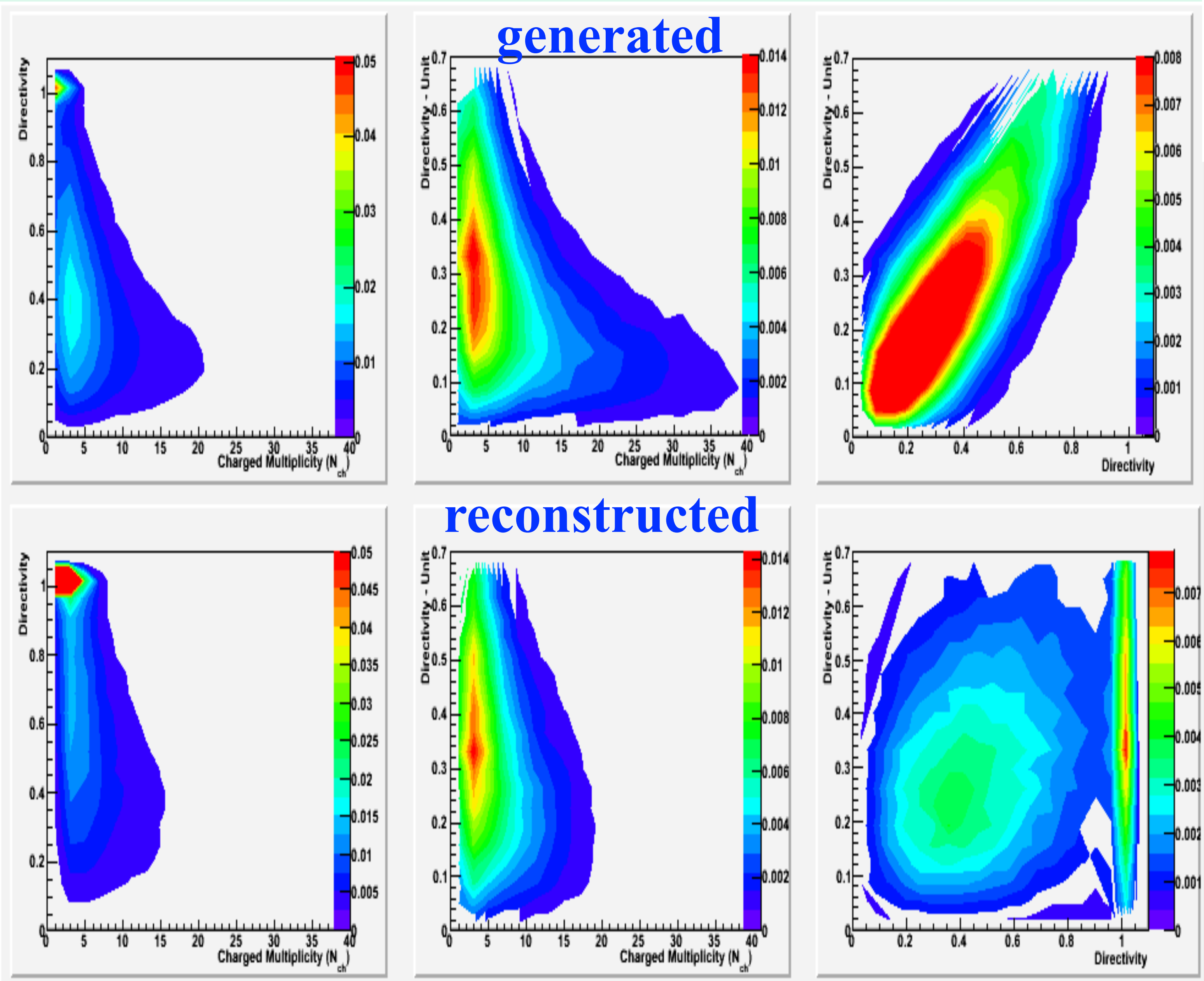



$$\langle p_\perp(m, T)\rangle_{\left\{\substack{\text{Fermi}\\ \text{Bose}}\right\}} = \sqrt{\frac{\pi m T}{2}}\,\frac{\sum_{n=1}^{\infty}(\mp 1)^{n+1} K_{\frac{5}{2}}(n(m/T))}{\sum_{n=1}^{\infty}(\mp 1)^{n+1} K_2(n(m/T))}$$

T = 170 MeV

# *How to select azimuthal isotropic events?*

## *PYTHIA*




$$D = \frac{|\sum_i p_t^i|}{\sum_i |p_t^i|}\Big|_{\eta>0},$$

Multiplicity:
- η: -0.5, 0.5

Directivity:
- η: 0.0, 1.9

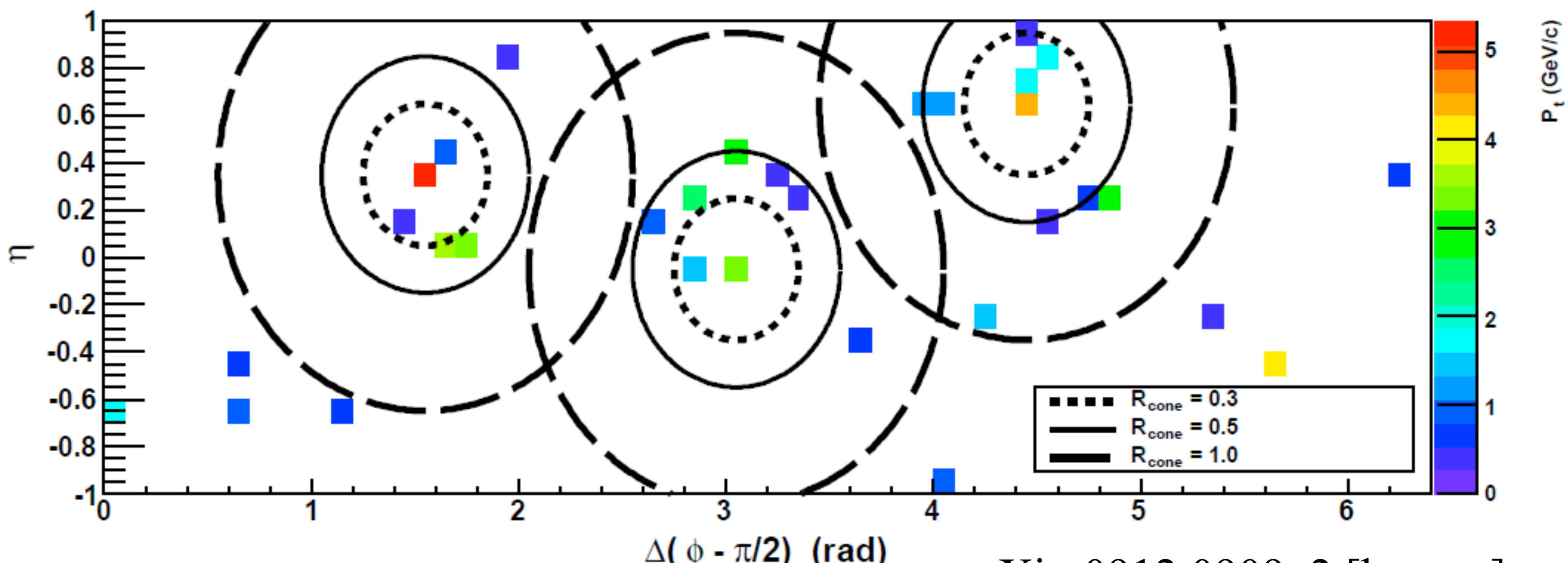
Dir. Unit used:
- SPD tracklets
- SPD φ angle

# *Hard and Soft event selection*

-CDF inspired method:

If a particle with $p_T$>0.7GeV/c and one with $p_T$>0.4GeV/c are separated in (η,φ) by a distance smaller than R=0.7, the event is labeled as “hard”

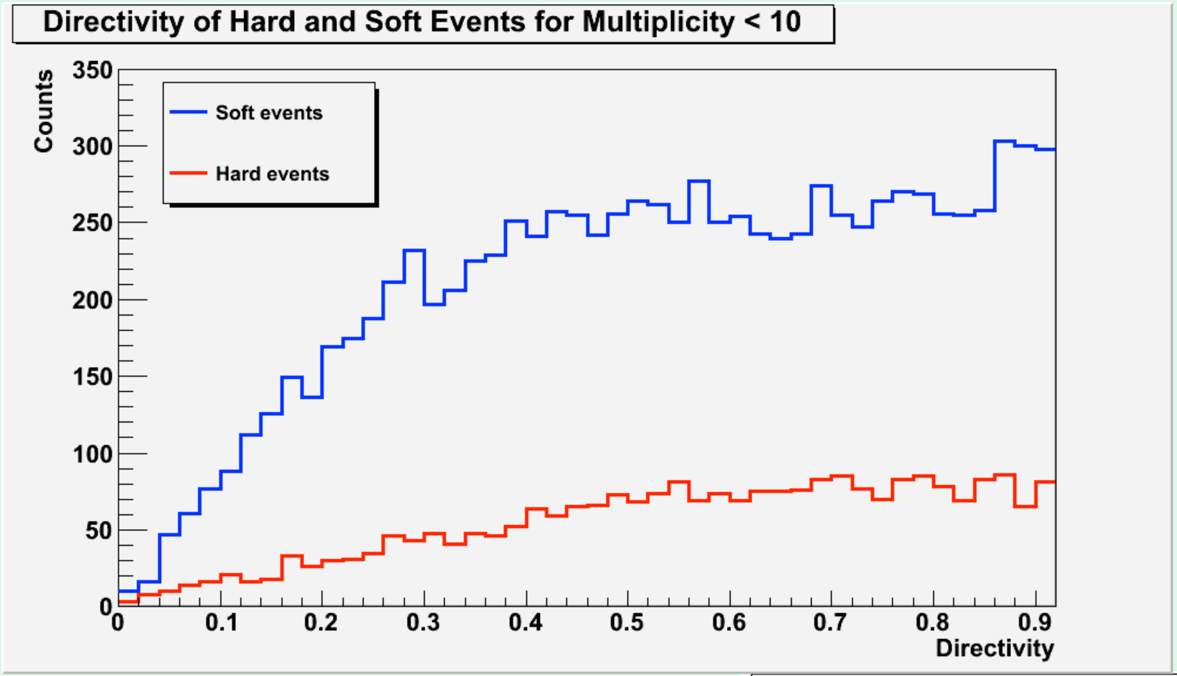
ALICE simulation - 10 TeV

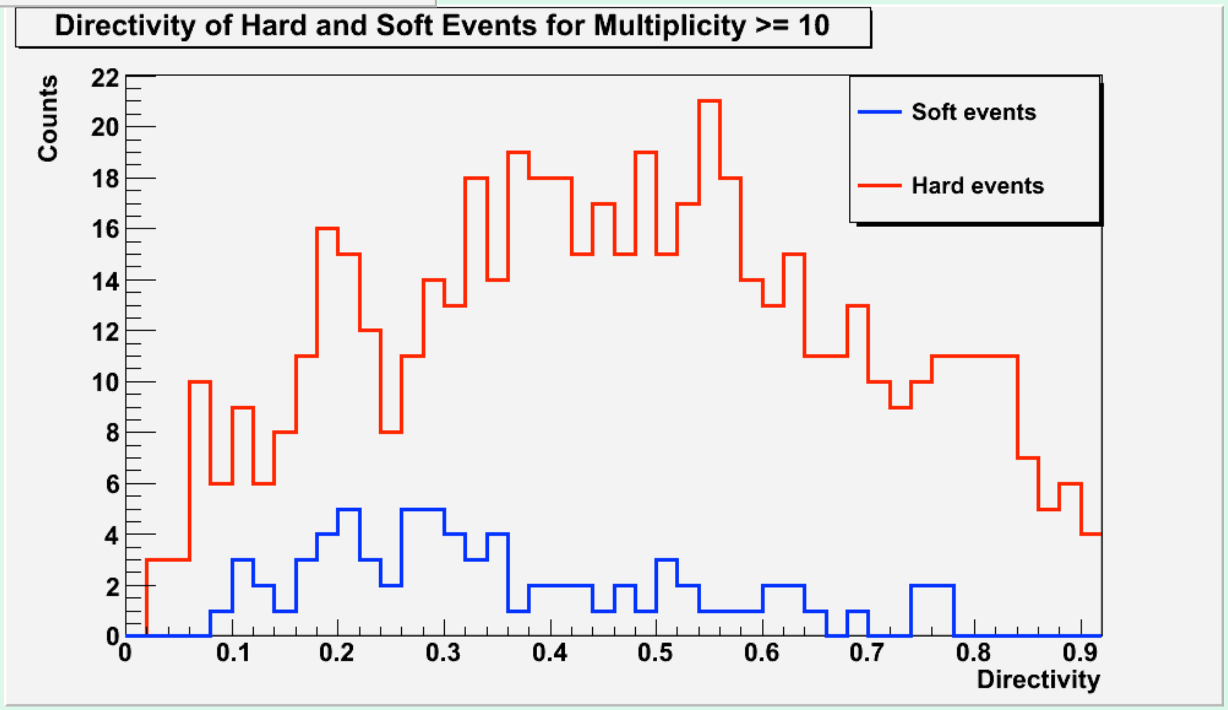



arXiv:0912.0909v2 [hep-ex]

# *Multiplicity dependence of the Directivity distribution*
# *Hard and Soft events*

## *PYTHIA*

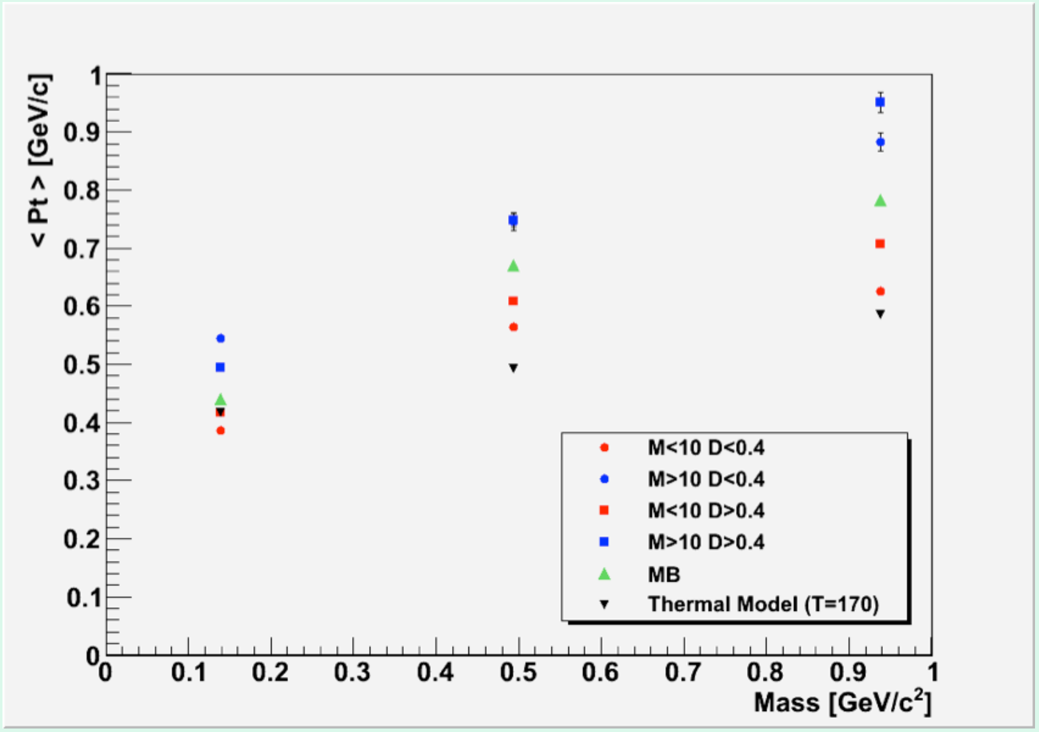


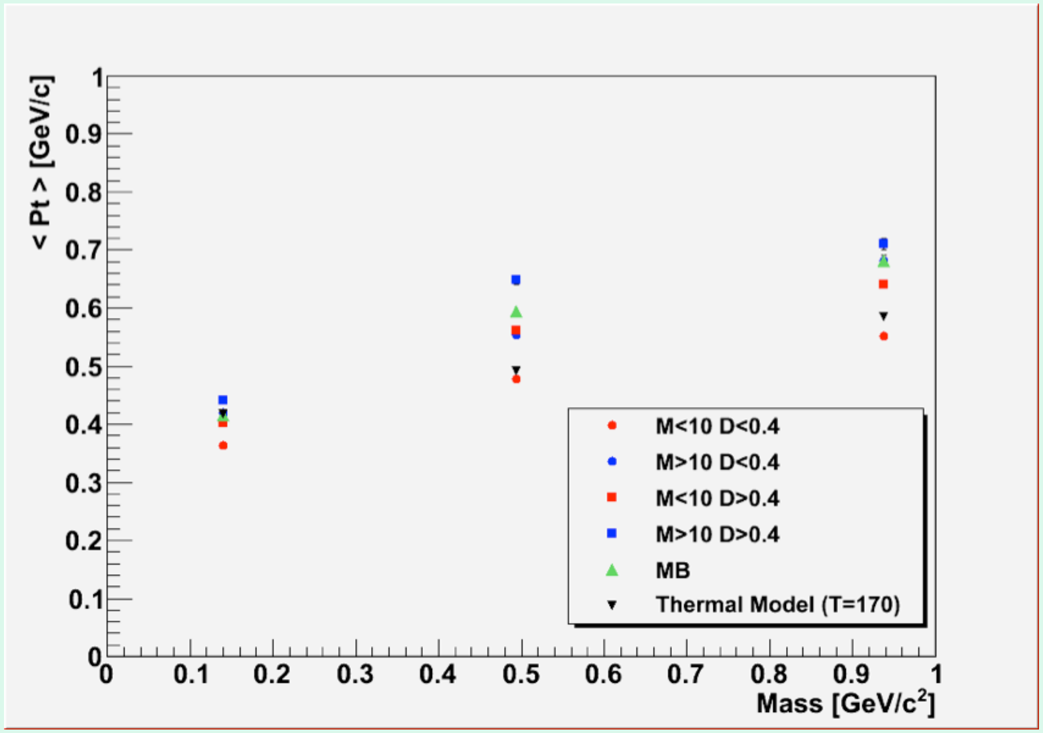
# $<p_t>$ vs mass for different cuts in multiplicity and directivity

## *PYTHIA & PHOJET*

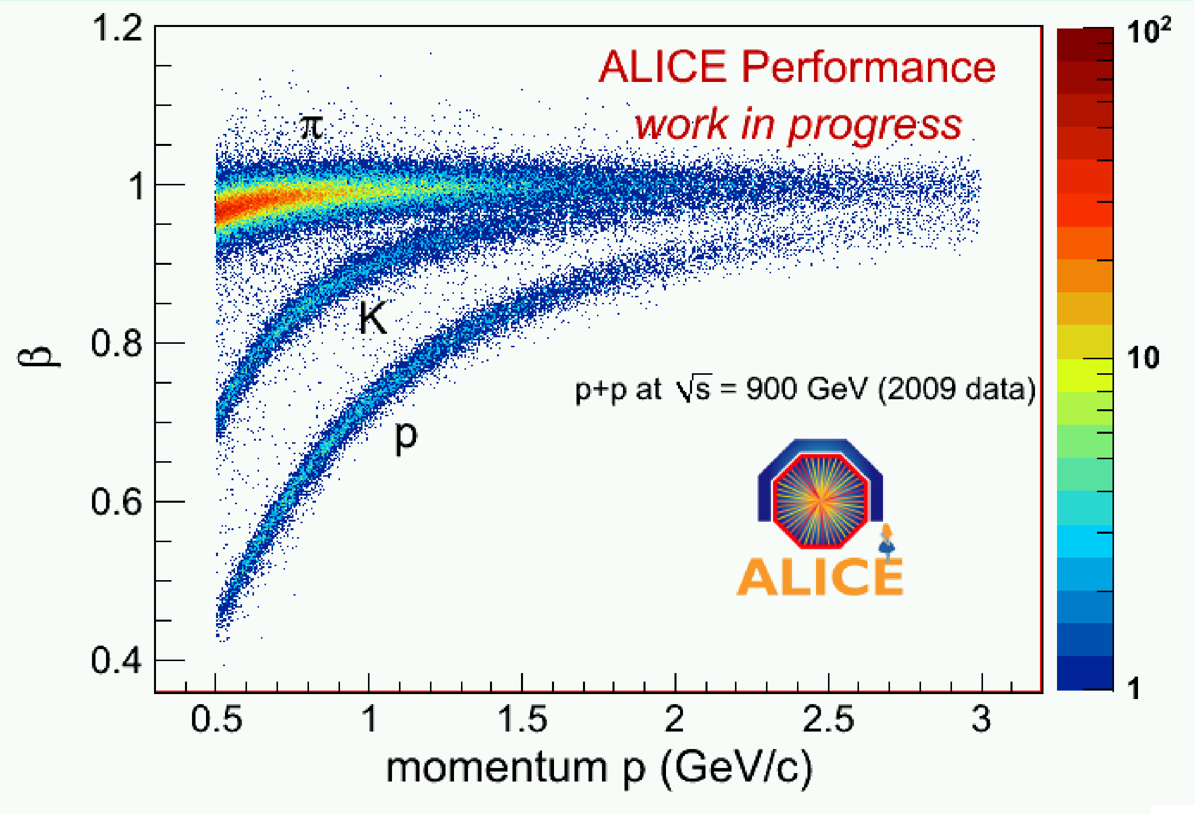
**PYTHIA**

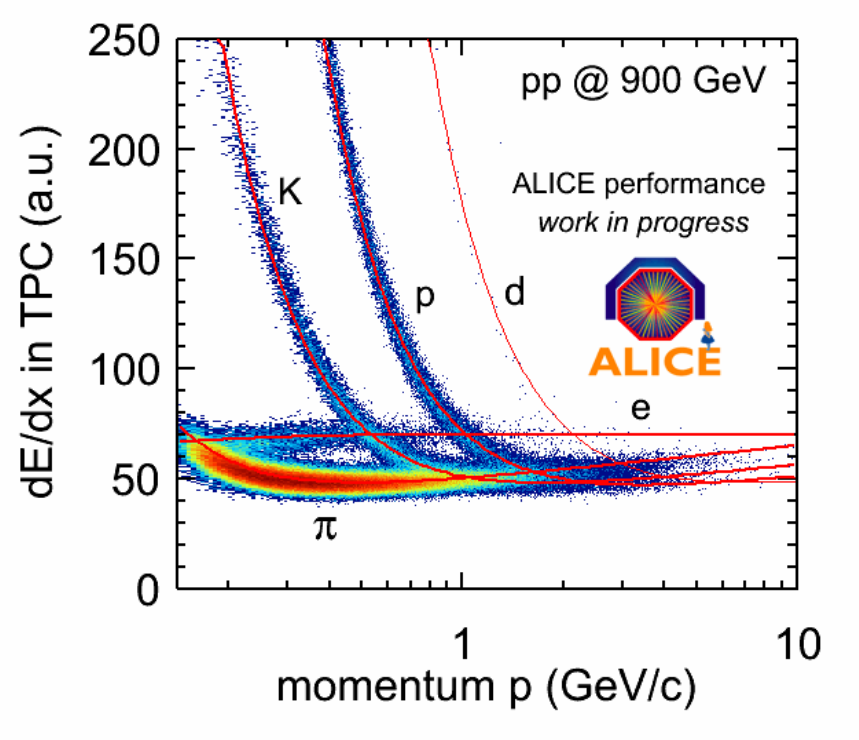


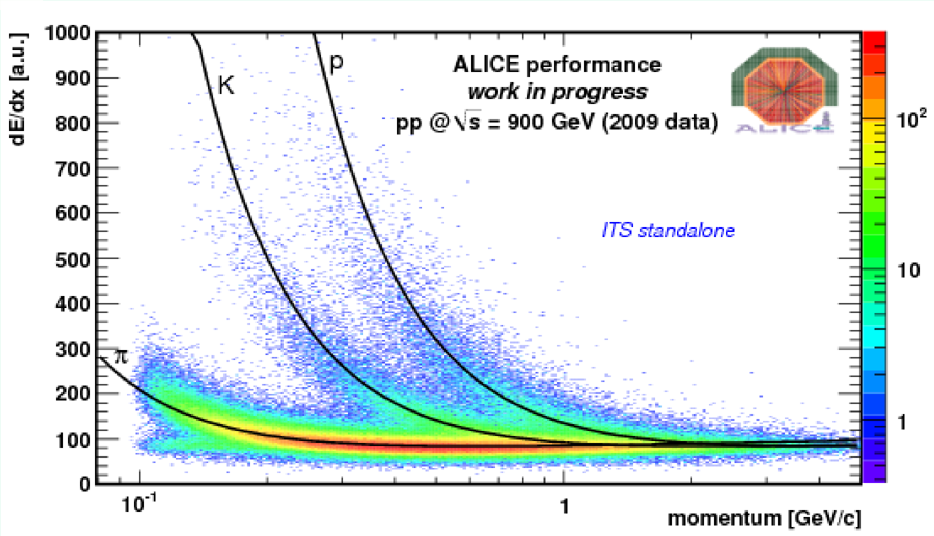

**PHOJET**



# *ALICE PID performance*



# *Next steps*

- Combined PID - MC and Data (0.9 and & 7 TeV)
- the influence of the resonance decay on the $p_t$ spectra
- MC based on EPOS
- Detailed studies on selection procedures for soft and hard processes
- unstable particles (hyperons)
- Preparing the stage for Pb-Pb collisions expected for Fall 2010