Rapidity and transverse momentum dependence of $\pi\pi$ Bose-Einstein correlations measured at 20, 30, 40, 80 and 158 AGeV beam energy

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Outline

- **Introduction**
  - → **measurement**
  - → **corrections**
- **New NA49-results at 20 and 30 AGeV**
- **Energy dependence of HBT-radii**
  - → **NA49 : 20,30,40,80 and 158 AGeV**
  - → **HBT from AGS to RHIC**

Introduction

Objective: **Determine spatial and temporal characteristics of the source by means of two particle Bose- Einstein- correlations**

$$Two-Particle-Corr. \Leftrightarrow P(p_1)\cdot P(p_2) \neq P(p_1, p_2)$$

Measurement:

$$C_2(q, p_1, p_2) = \frac{P(p_1, p_2)}{P(p_1)P(p_2)} = N \cdot \frac{S(q, p_1, p_2)}{B(q, p_1, p_2)} \cdot Corr.$$

pairs from the same event

pairs from different events

Pratt-Bertsch-Parametrisation:

$$C_2(q, p_1, p_2)_{BP} = 1 + \lambda \cdot \exp\left(-q_{side}^2 R_{side}^2 - q_{out}^2 R_{out}^2 - q_{long}^2 R_{long}^2 - 2 q_{out} q_{long} R_{outlong}^2 \right)$$

Measurement

Fit - function: $$C_2(q,k)_f = p\cdot\left(W(q,r_m)\cdot C_2(q,k)_{BP}\right)+\left(1-p\right)$$

Bose Einstein CF: $$C_2(q,k)_{PB} = 1+\lambda(k)\cdot\exp(-q_{side}^2\cdot R_{side}^2 - .....)$$

Purity (h^-h^-): p : **not identical pairs, long lived resonances, weak decays (determined by a simulation)**

Coulomb interaction : $W(q,r_m)$ **(Sinyukov et.al. Phys. Lett. B 432(1998)248-257)**

r_m **: „mean pair separation“**

Fit procedure: **calculate** r_m **using extracted HBT-radii**

iterative procedure

New 20 and 30 AGeV NA49 results

Measurement of the CF for h^-h^- pairs in the LCMS in bins of :

Mean transv. momentum: $$k_t = \frac{1}{2} | \vec{p}_{t,1} + \vec{p}_{t,2} |$$

Pair rapidtiy: $$Y = \frac{1}{2} \ln \left(\frac{E_1 + E_2 + p_{z,1} + p_{z,2}}{E_1 + E_2 - p_{z,1} - p_{z,2}} \right)$$

bin - size : k_t : 0.1 GeV/c

Y_{cm}: 0.4 units (starting at mid rapidity)

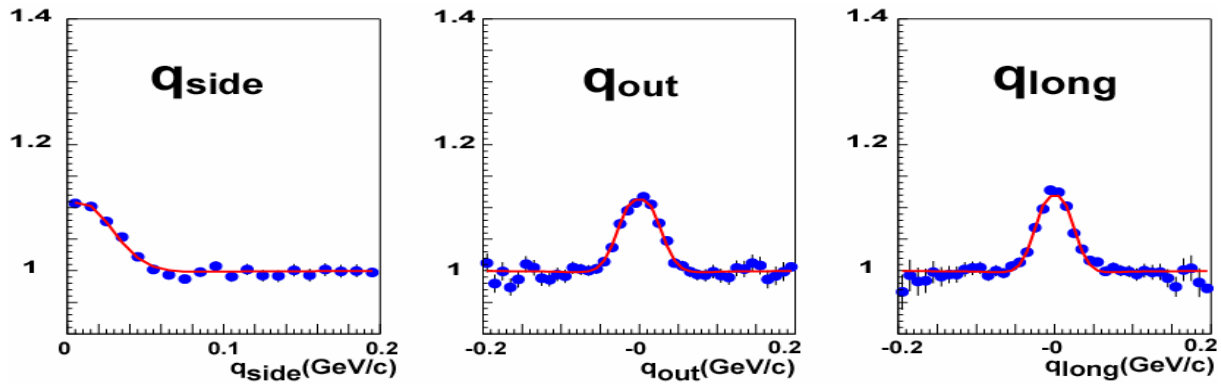
20/30 AGeV Results

Projections of the 3-dim CF : (proj. range : 30MeV/c)

20 AGeV

Y_{cm} = 0.0 - 0.4

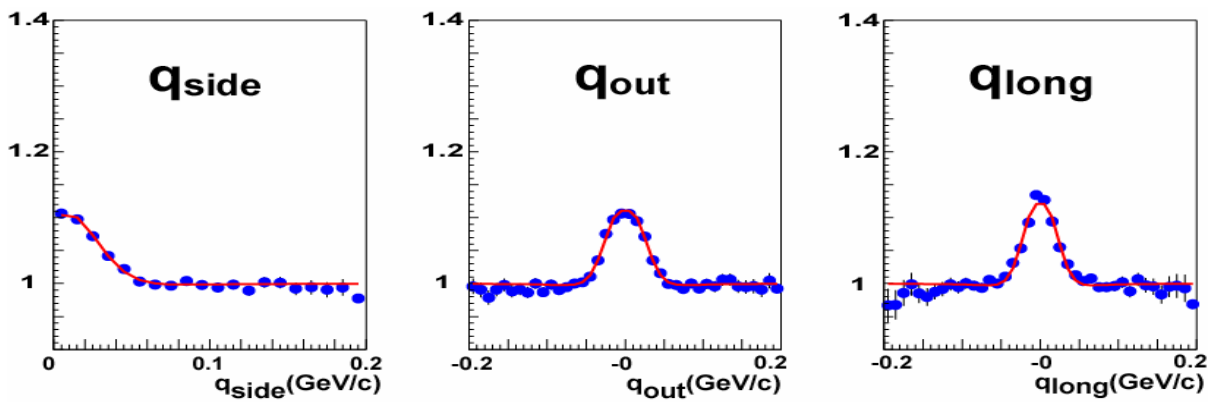
k_t = (0.0 - 0.1) GeV/c



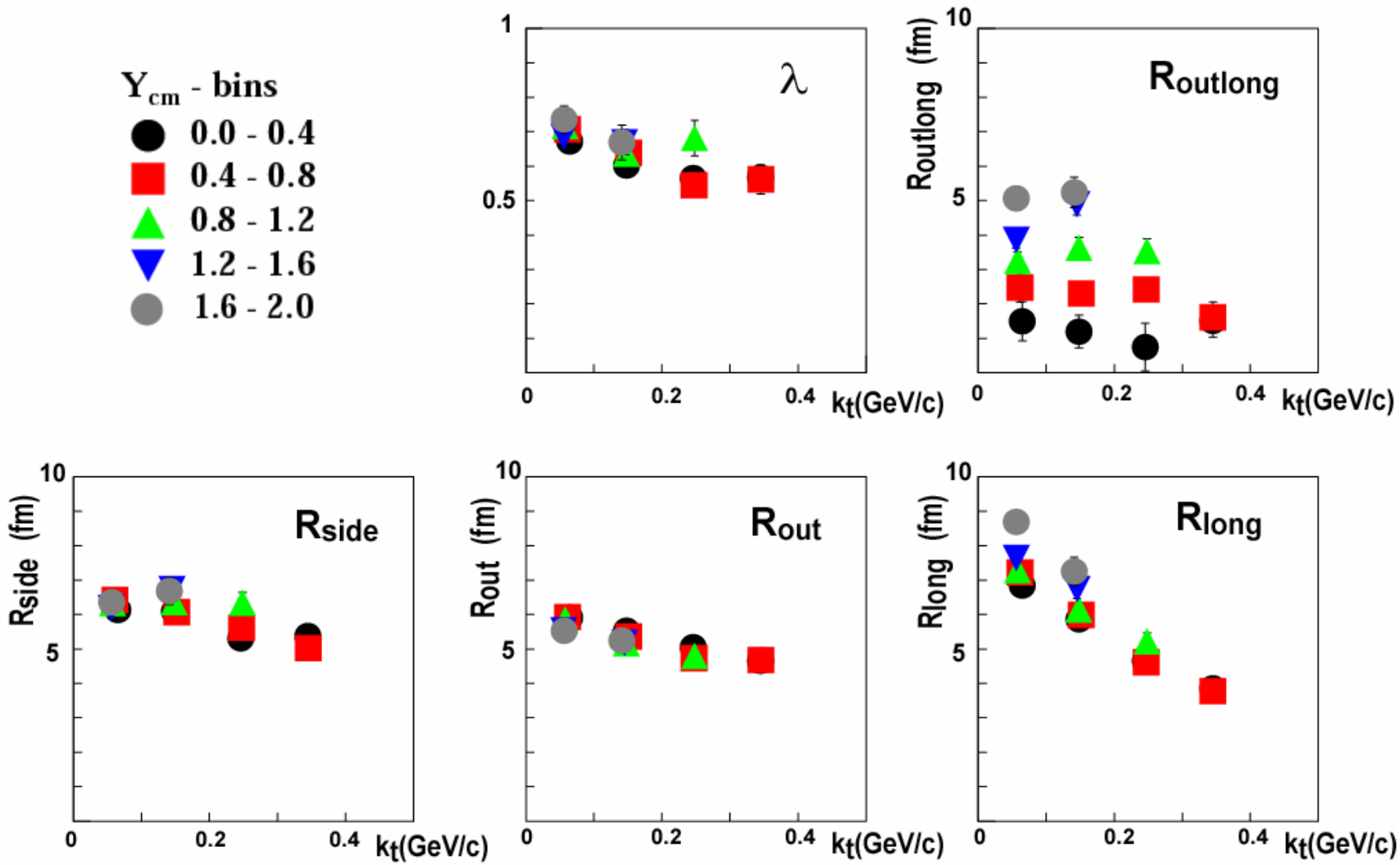
30 AGeV

Y_{cm} = 0.0 - 0.4

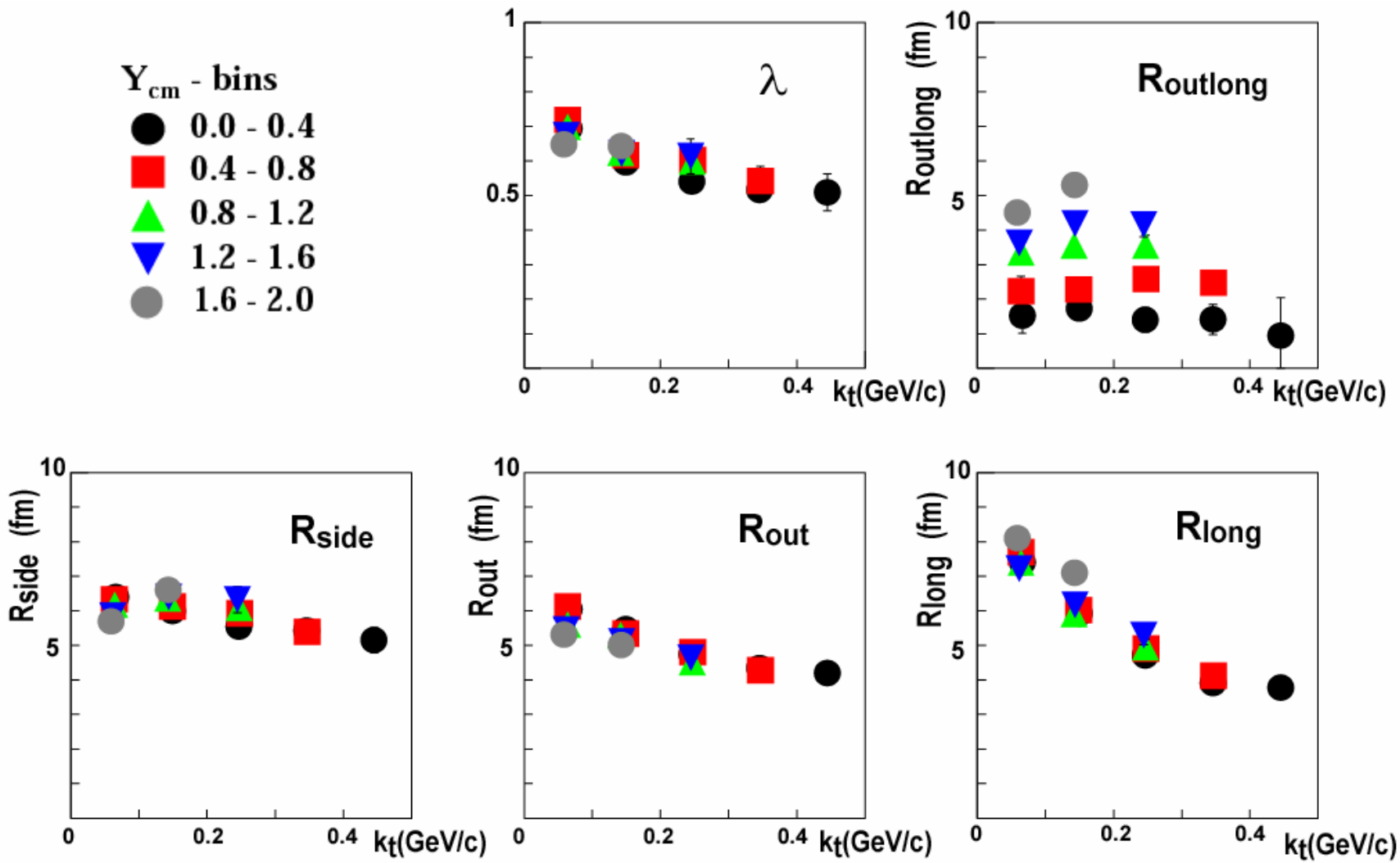
k_t = (0.0 - 0 .1) GeV/c



New 20AGeV results



New 30AGeV results



Energy dependence of HBT radii

- New 20 , 30 AGeV NA49 results

  40 , 80, 158 AGeV NA49 (reanalysis).

  preliminary

  → extract source quantities from k_t- dependence of the radii for each energy (sys. error on radii ≈ 0.5 fm)

- Energy dependence AGS to RHIC

R_{long} (mid rapidity)

longitudinal boost- inv. expansion :

(Nucl. Phys. A 498(1988)151c)

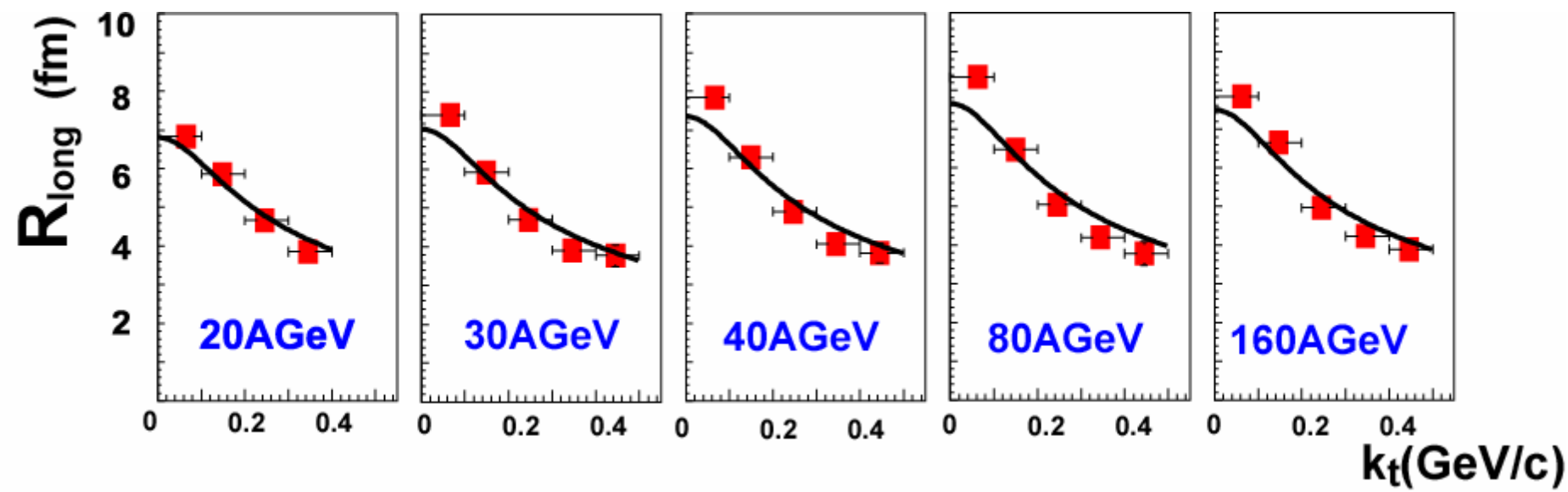
$$R_{long} = \tau_f (T_f / m_t)^{1/2}$$

τ_f : „lifetime“ (fm/c)

T_f = 120MeV

$m_t = \sqrt{m_\pi^2 + k_t^2}$

τ_f : **7.3±0.3** **7.6±0.3** **7.9±0.3** **8.3±0.3** **8.1±0.3** **(fm/c)**



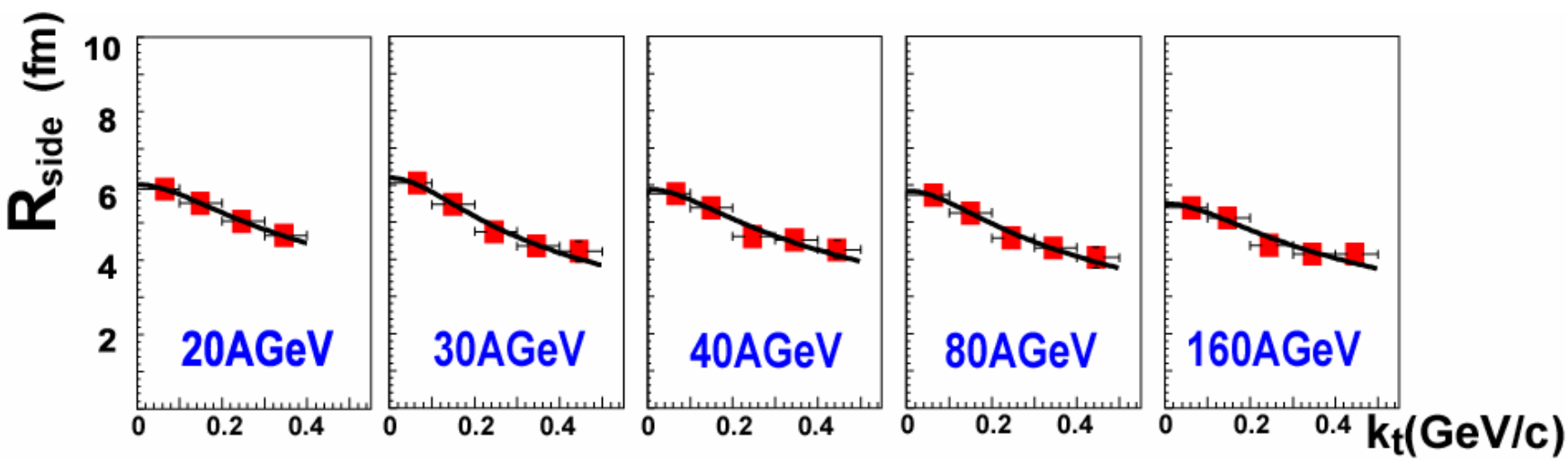
R_{side}(mid-rapidity)

$$R_{side} = R_{geo} / \left(1 + m_t \cdot \eta_f^{\,2} / T_f\right)^{1/2}$$

η_f : flow rapidity

R_{geo} : geometrical radius (fm)

results	20AGeV	30AGeV	40AGeV	80AGeV	160AGV
$R_{geo}\,(fm)$	7.9±1.3	9.7±2.2	7.9 ±1.1	8.4 ±1.4	7.3 ±0.8
$\eta_f^2/T_f\,(1/MeV)$	5.5±3.0	10.3±6.6	5.9±2.7	7.8±4.0	5.3±2.0

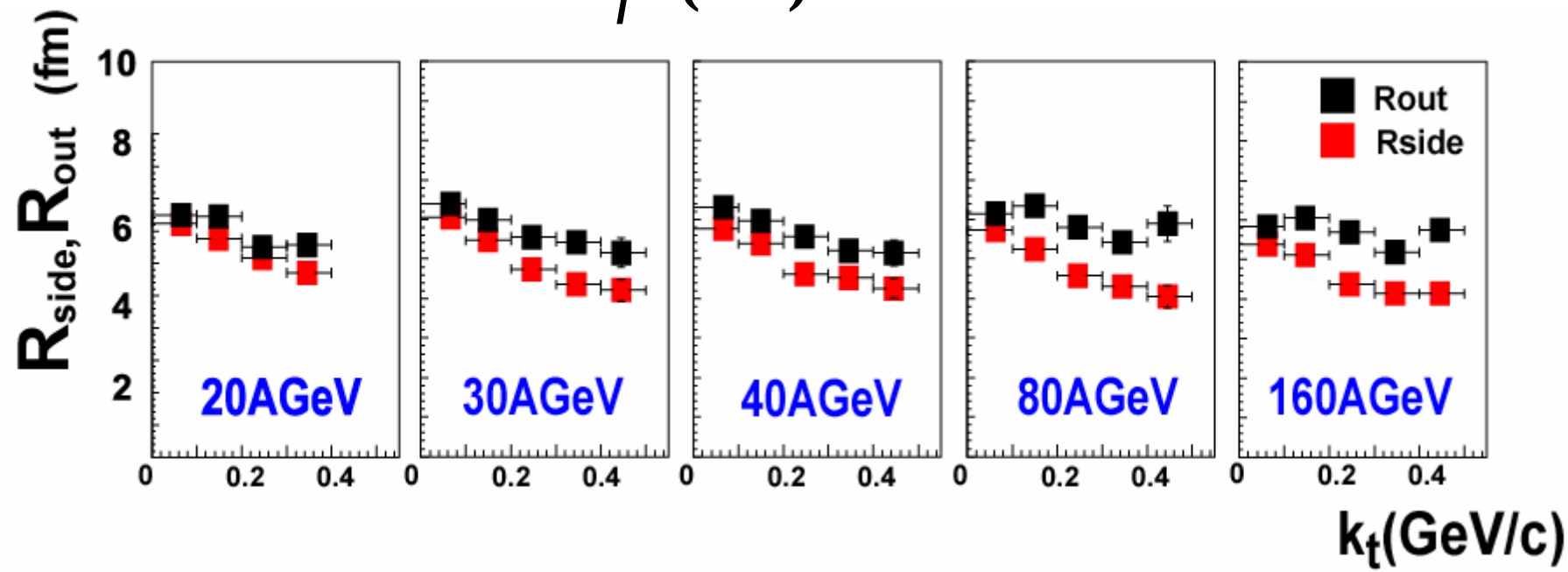


R_{out} - R_{side} (mid rapidity)

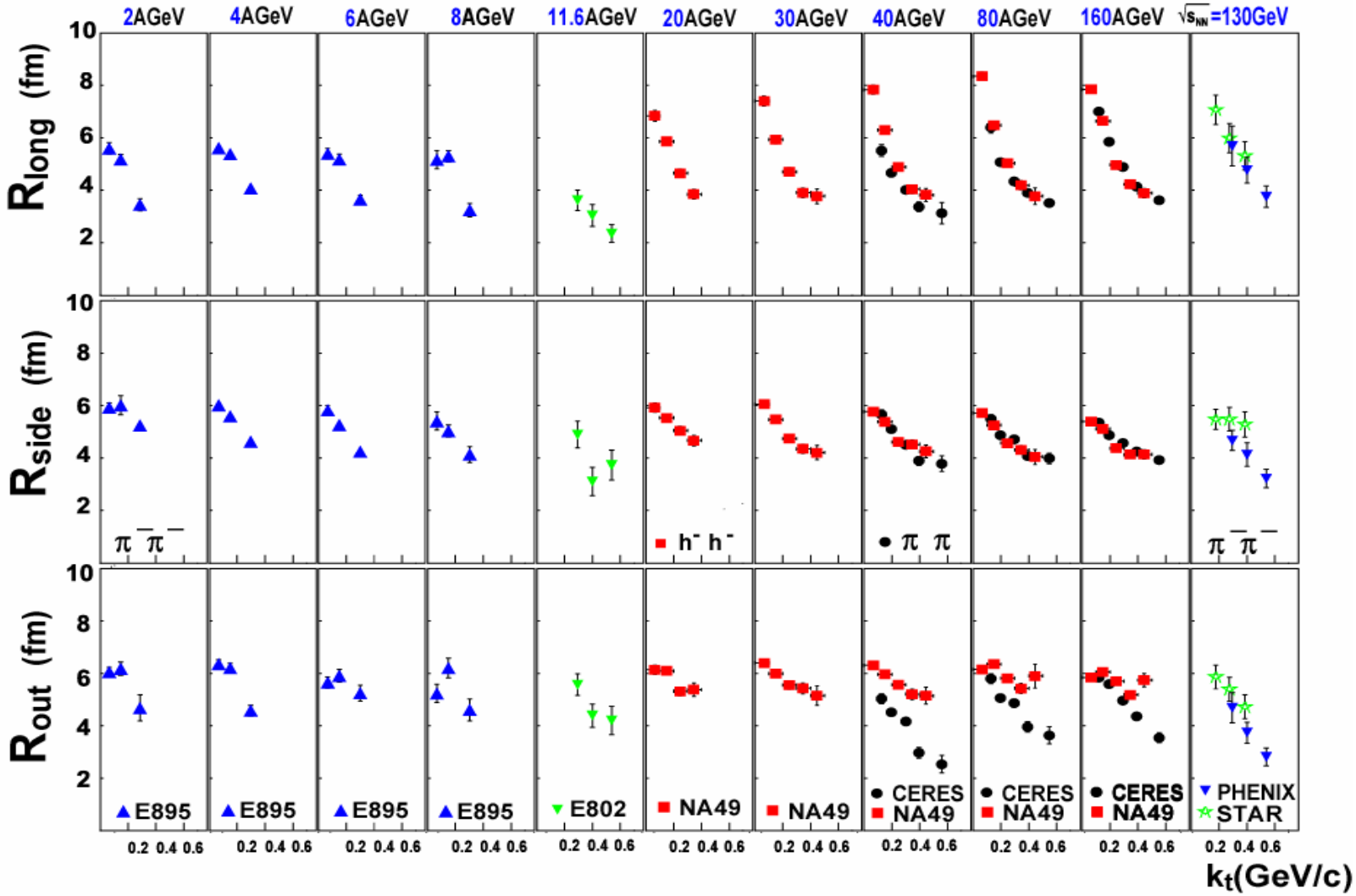
Duration of emission

$$\Delta\tau_f^2 = \frac{1}{\beta_t^2}\cdot\left(R_{out}^2 - R_{side}^2\right) \qquad \beta_t \approx \frac{k_t}{m_t}$$

$$\Delta\tau_f \approx (3\text{-}4)\,\text{fm/c}$$

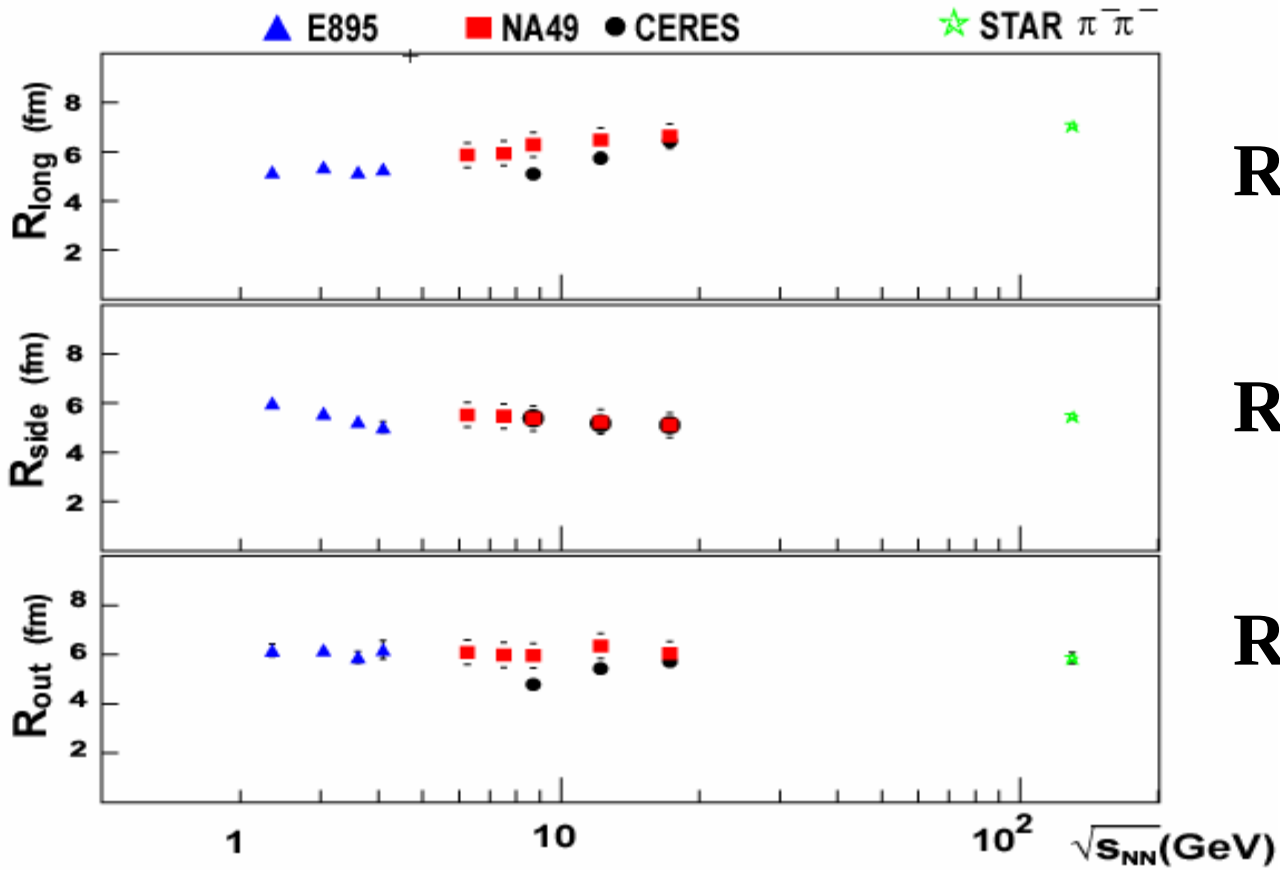


HBT from AGS to RHIC



Energy dependence: $k_t \approx$ 0.15 GeV/c

weak energy dependence



R_{long} : increases

$R_{side} \approx$ const.

$R_{out} \approx$ const.

Conclusion

Only weak energy dependence of

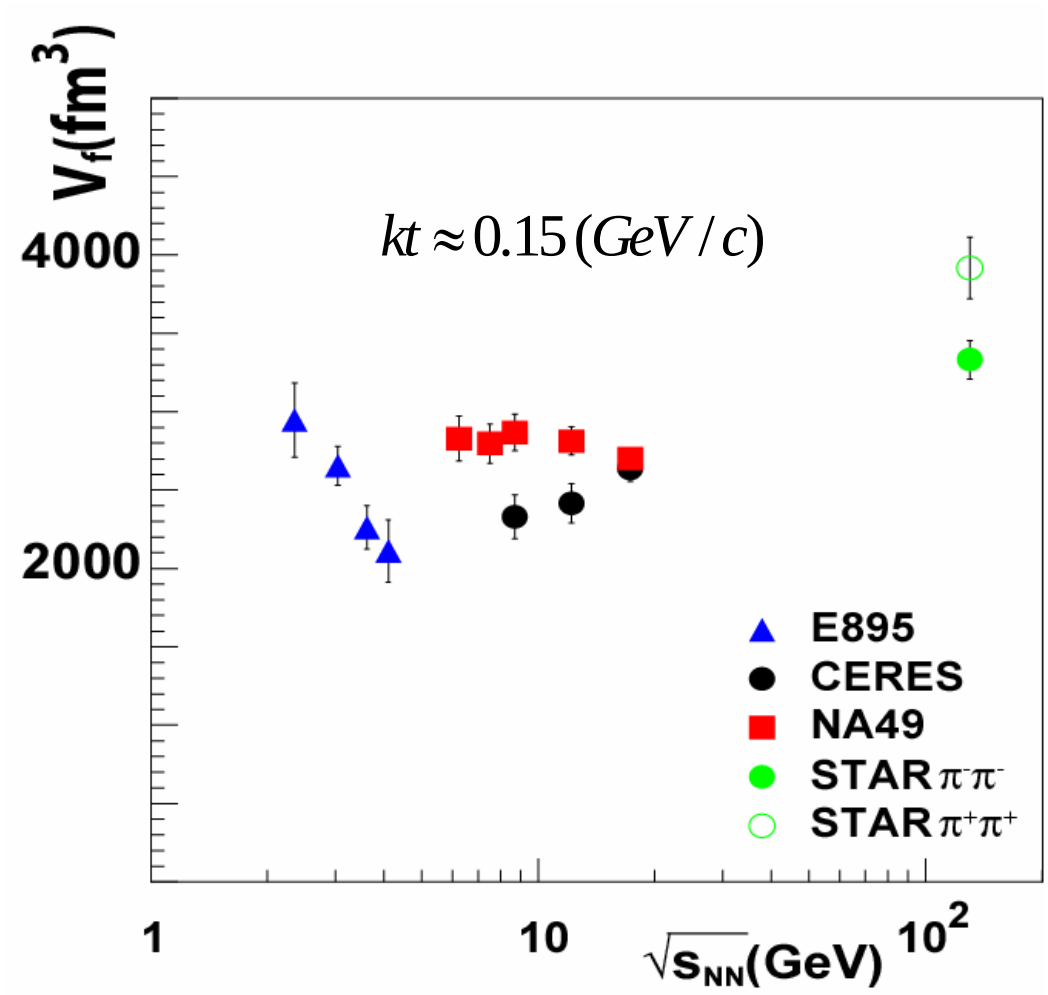
HBT- radii observed at NA49

R_{long}<10% , R_{side}<5% , R_{out}<5%

R_{out}>R_{side}

Backup

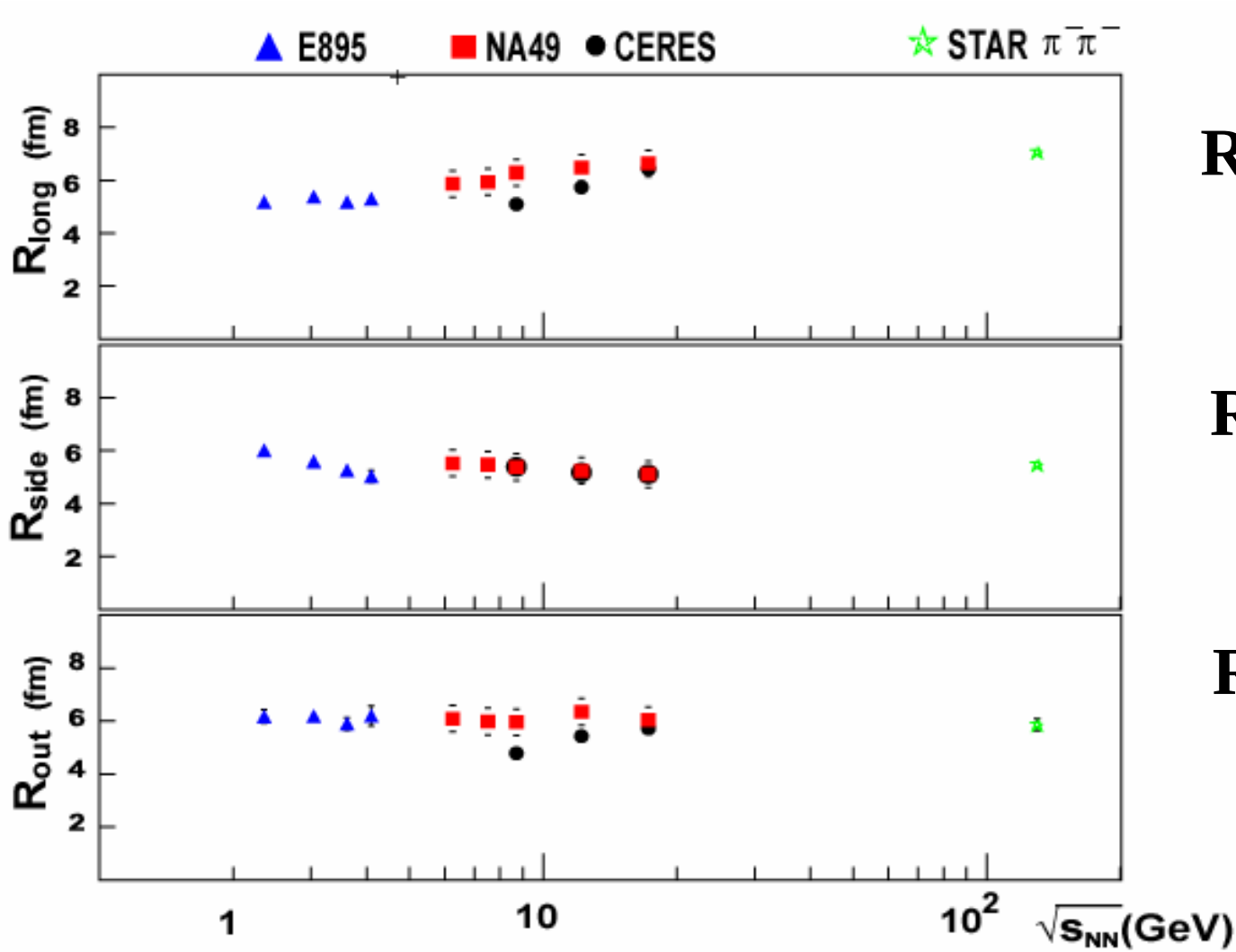
freeze-out volume V_f



$$V_f = (2\pi)^{3/2} Rlong \cdot R^2 side$$

No significant energy depenence observed at NA49

Energy dependence $k_t \approx$ 0.15 GeV/c

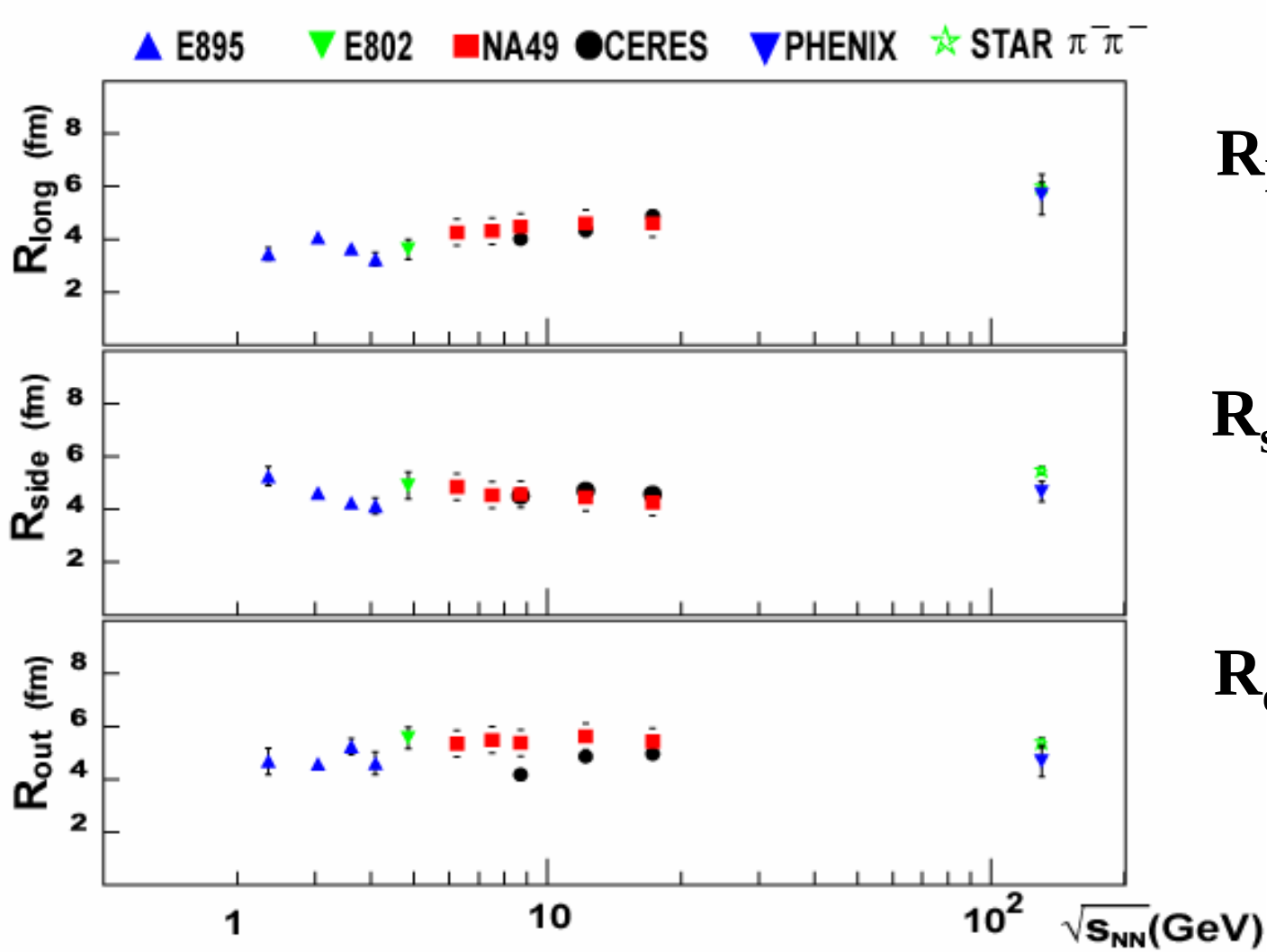


R_{long} : increases

$R_{side} \approx$ const

$R_{out} \approx$ const

Energy dependence $k_t \approx$ 0.3 GeV/c



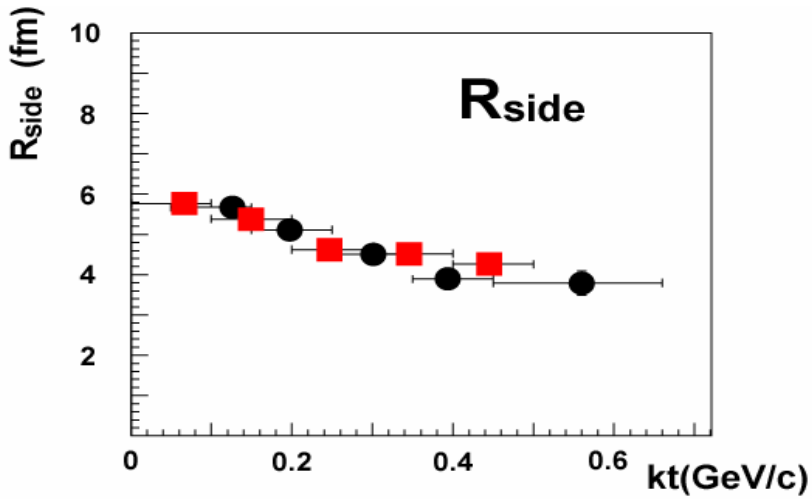
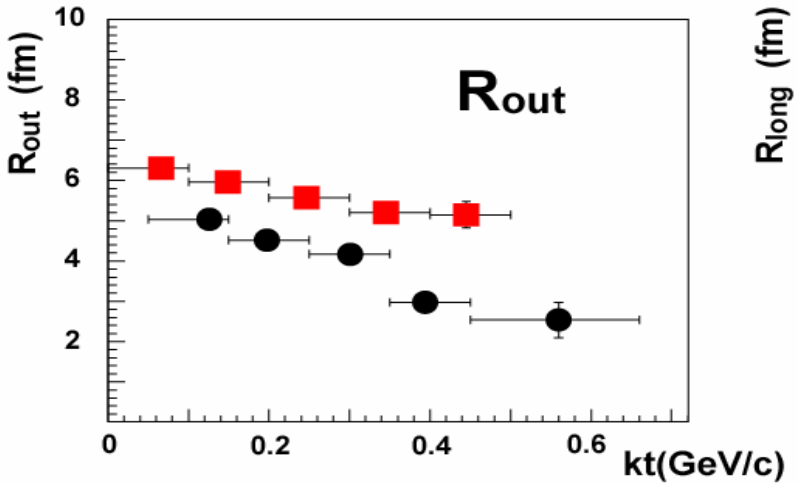
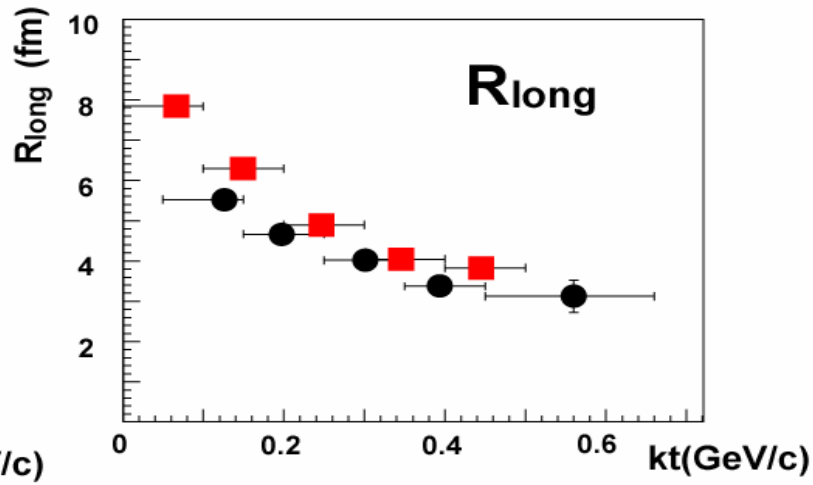
R_{long} : increases

$R_{side} \approx$ const

$R_{out} \approx$ const

Comparison to CERES at 40 AGeV

- CERES :Y(1.98-2.48)
- NA49 :Y(2.2-26)

Differences due to:

- Momentum resolution (Rout)
- Coulomb-interaction (Rout/Rlong)