Strangeness production at the CERN SPS energies

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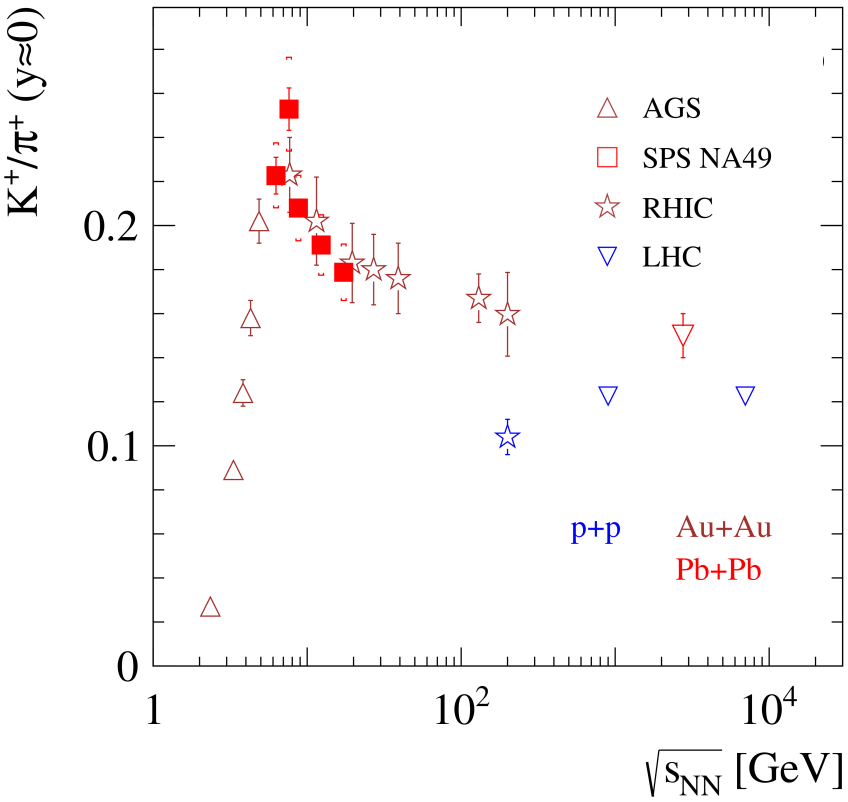
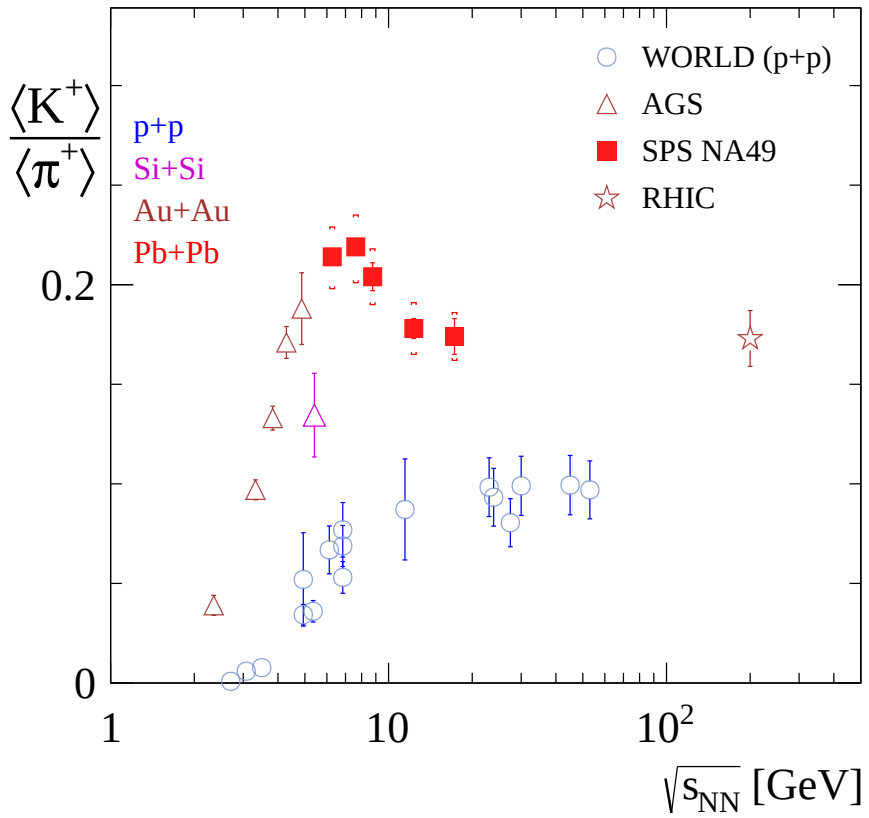
Outline

Motivation for NA61/SHINE measurements



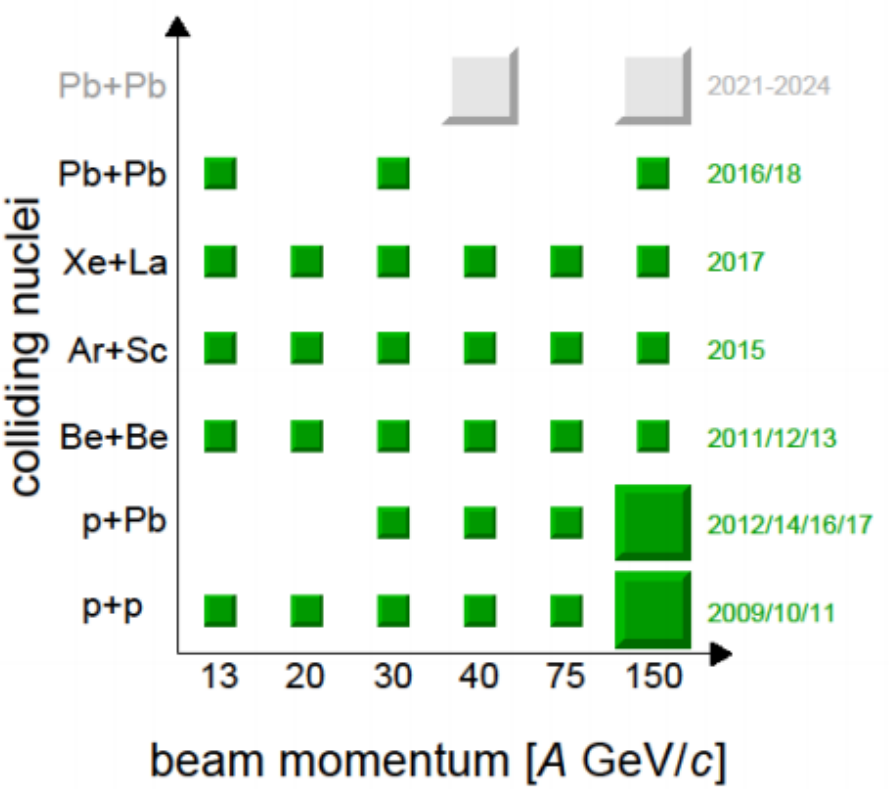


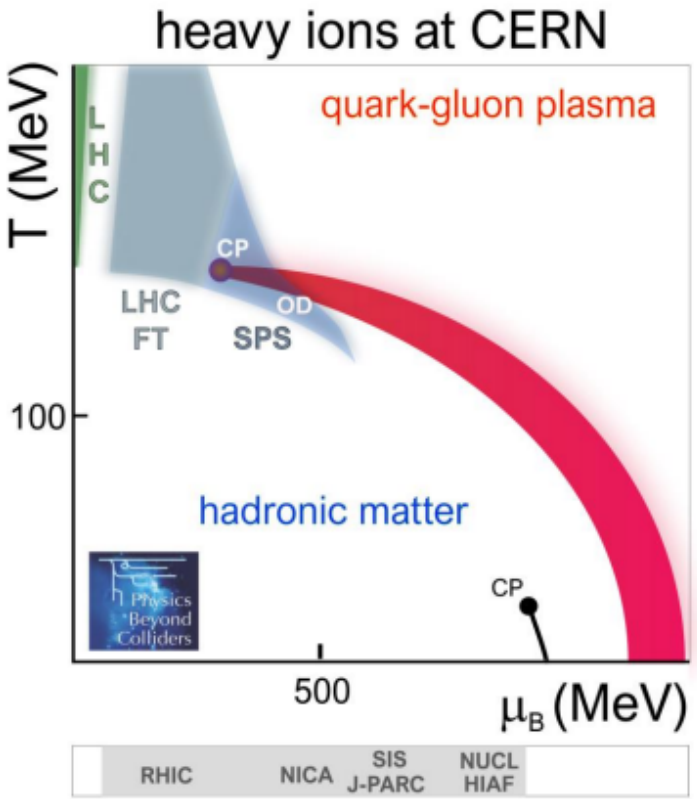
- Rapid change in the K^+/π^+ ratio - HORN - was observed in Pb+Pb collisions (NA49). Predicted as a signature of the onset of deconfinement
- Before NA61/SHINE no precise data on system size dependence of particle production at SPS energies

NA49, *PRC* **66**, (2002), NA49, *PRC* **77**, (2008); M. Gaździcki, M.I. Gorenstein, *A. Phys. Pol.* **B30**, 2705 (1999)

NA61/SHINE 2D scan

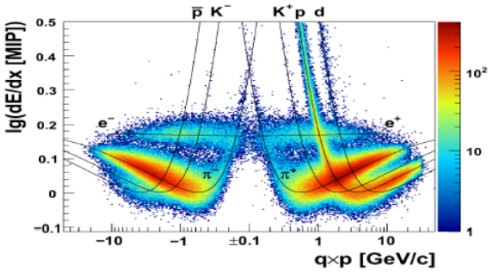
- NA61/SHINE performed unique, two-dimensional scan in collision energy and nuclear mass number of colliding nuclei
- Data cover unique range in the phase diagram of strongly interacting matter

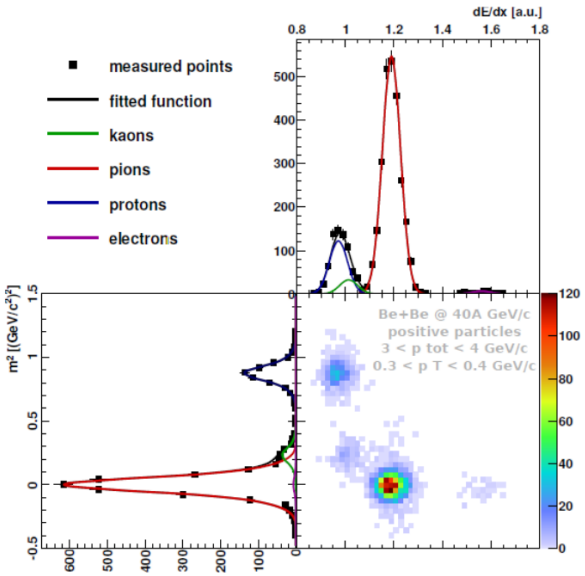




Charged particle identification

Final results stand for primary particles produced in strong and electromagnetic processes, they are corrected for detector geometrical acceptance and reconstruction efficiency as well as weak decays and secondary interactions.

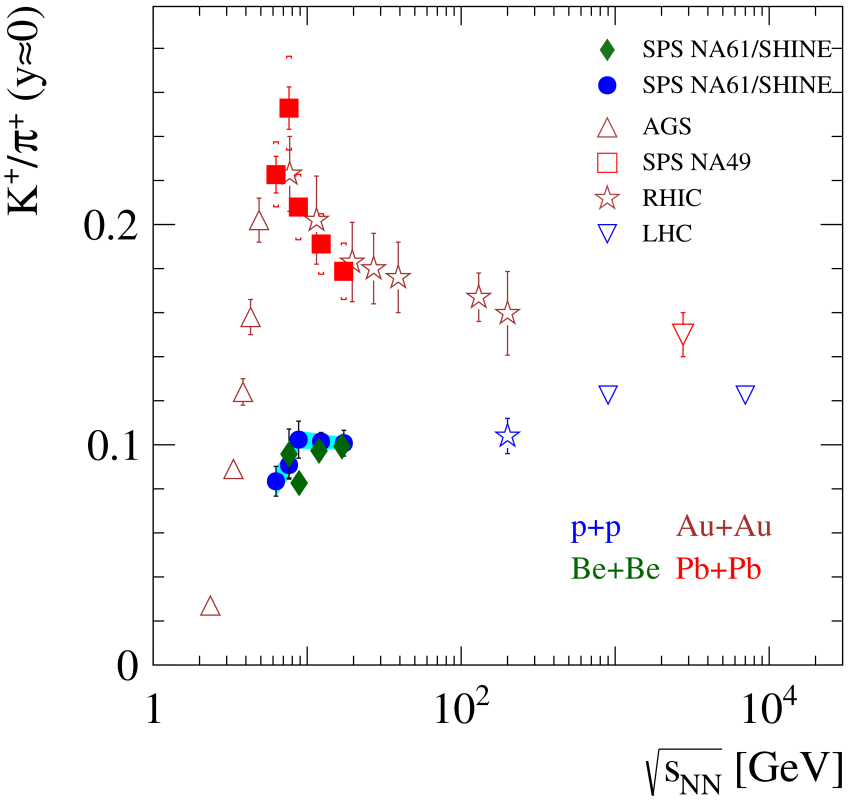


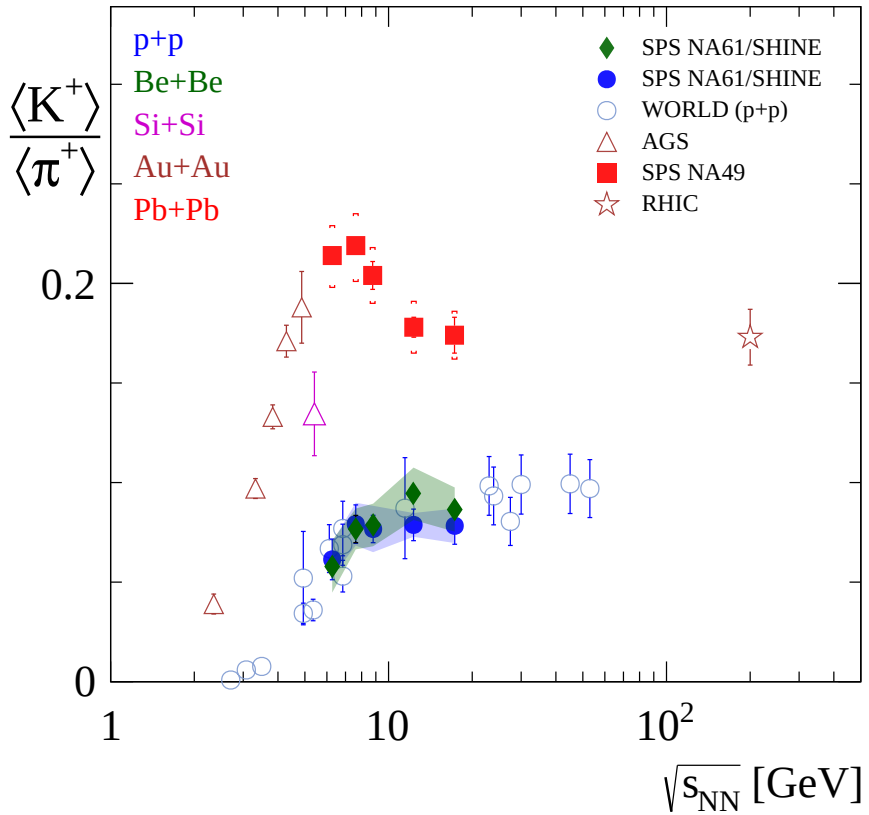


- **tof-dE/dx** analysis estimates number of π, K, p using an energy loss and particle time of flight measurements
- **dE/dx** analysis uses TPC energy loss information to identify particles
- h^- **analysis** - is based on the fact that the majority of negatively charged particles are π^- mesons

Strangeness production in small collision systems

Onset of deconfinement: horn





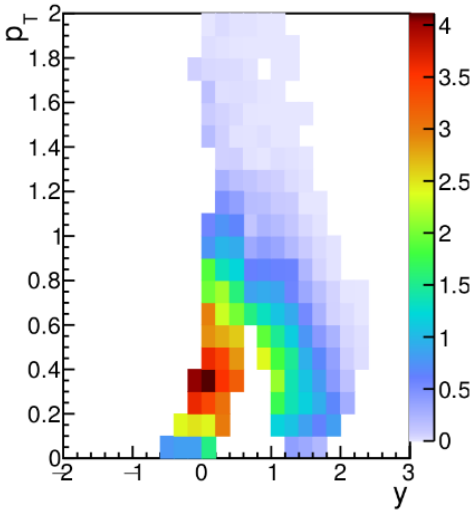
- Rapid change in the K^+/π^+ ratio in Pb+Pb collisions at the CERN SPS (NA49)
- Plateau like structure visible in p+p interactions (NA61/SHINE)
- Be+Be close to p+p reactions (NA61/SHINE preliminary)

NA49, *PRC* **66**, (2002), NA49, *PRC* **77**, (2008), NA61/SHINE, *EPJC* **74** (2014), NA61/SHINE, *EPJC* **77** (2017)

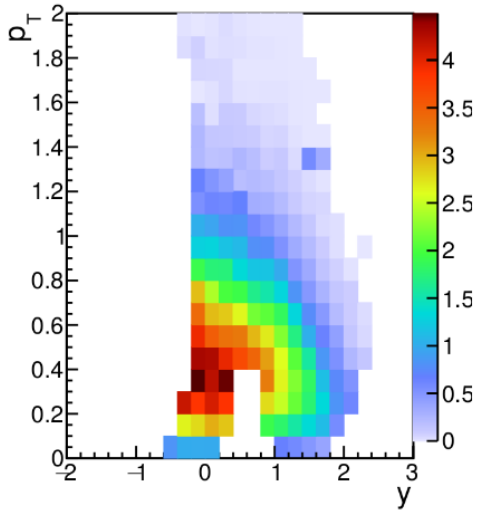
New preliminary results on strangeness production in intermediate size collision systems

K^+ in central Ar+Sc collisions

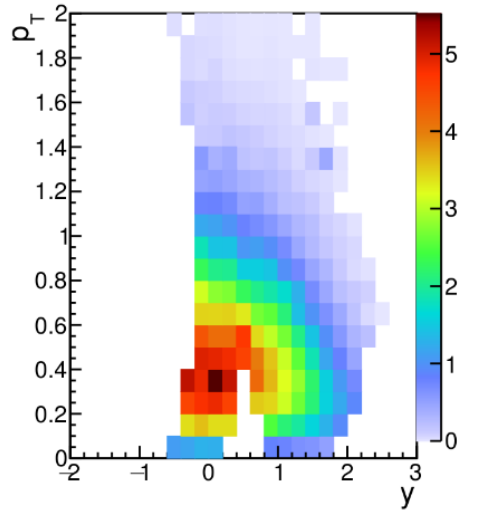
19A GeV/c



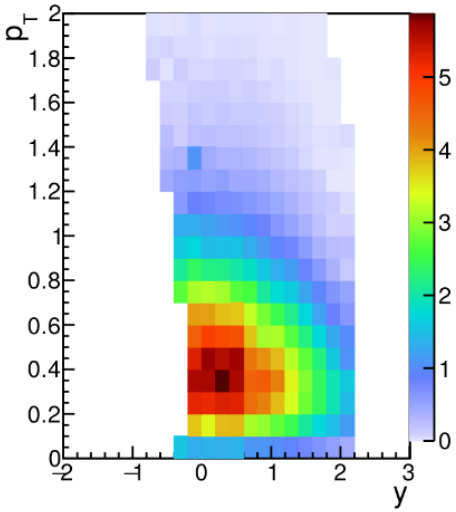
30A GeV/c



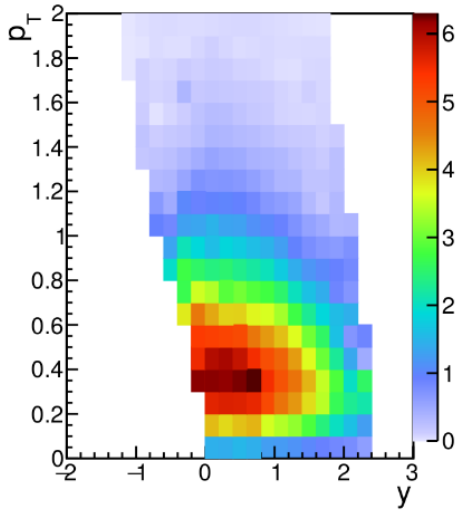
40A GeV/c



75A GeV/c



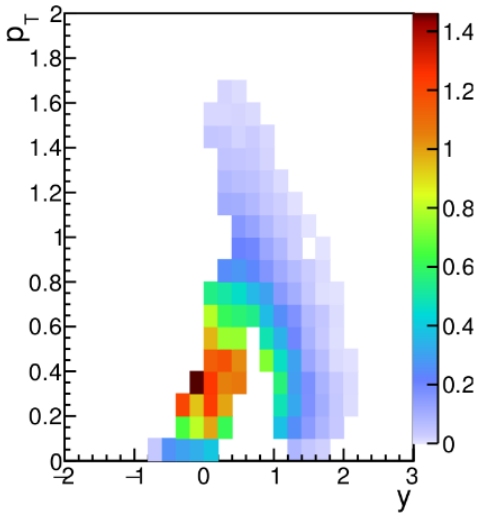
150A GeV/c



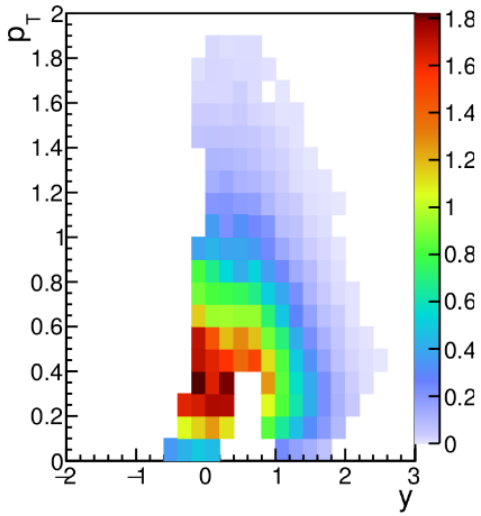
- 2D spectra in 0-10% centrality
- centrality selected by forward energy measurement

K^- in central Ar+Sc collisions

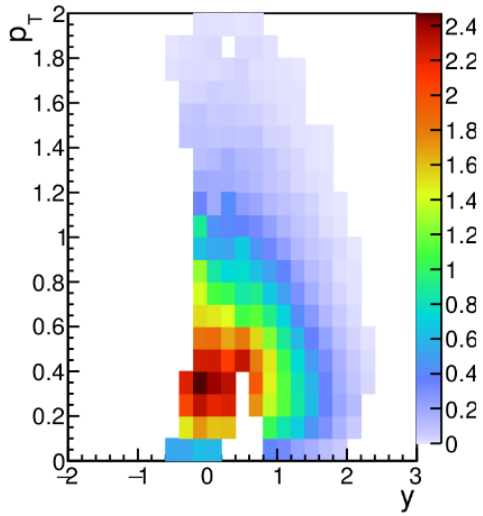
19A GeV/c



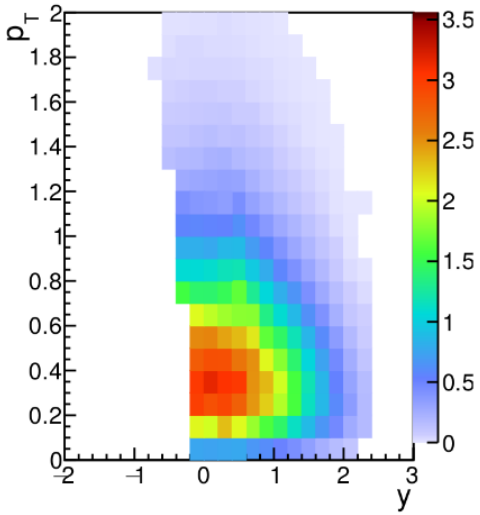
30A GeV/c



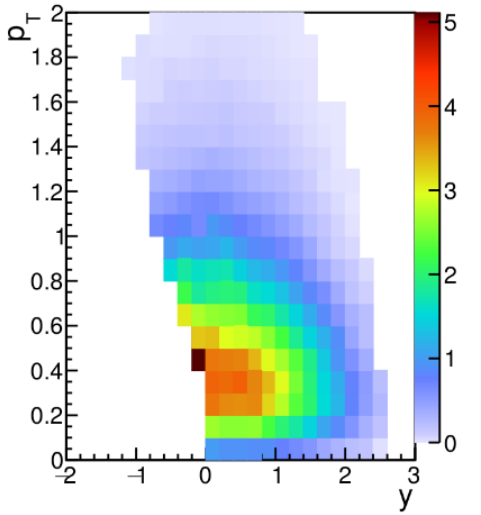
40A GeV/c



75A GeV/c



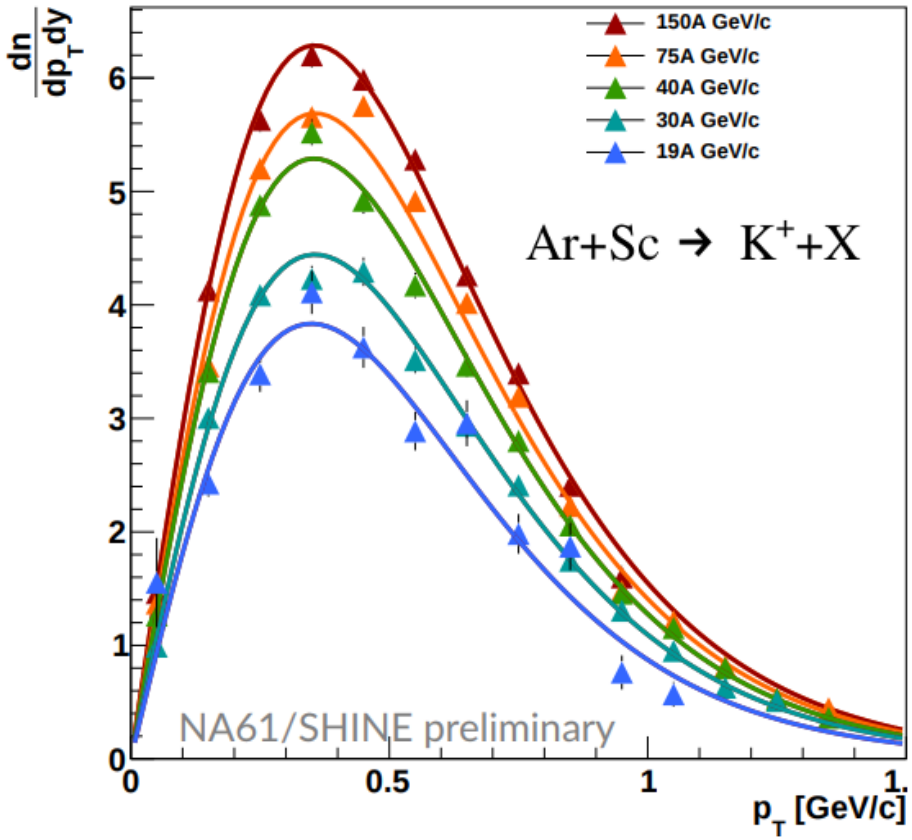
150A GeV/c

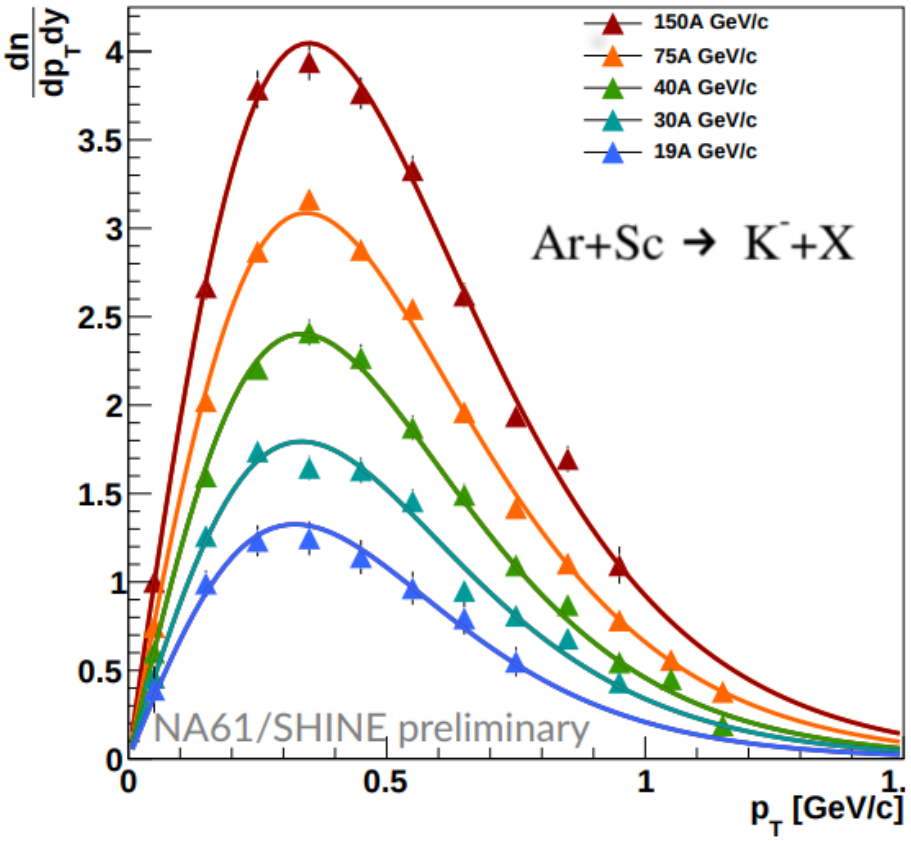


- 2D spectra in 0-10% centrality
- centrality selected by forward energy measurement

Closer look at mid-rapidity: p_T spectra of $K^{\pm}$

0-10% central Ar+Sc collisions

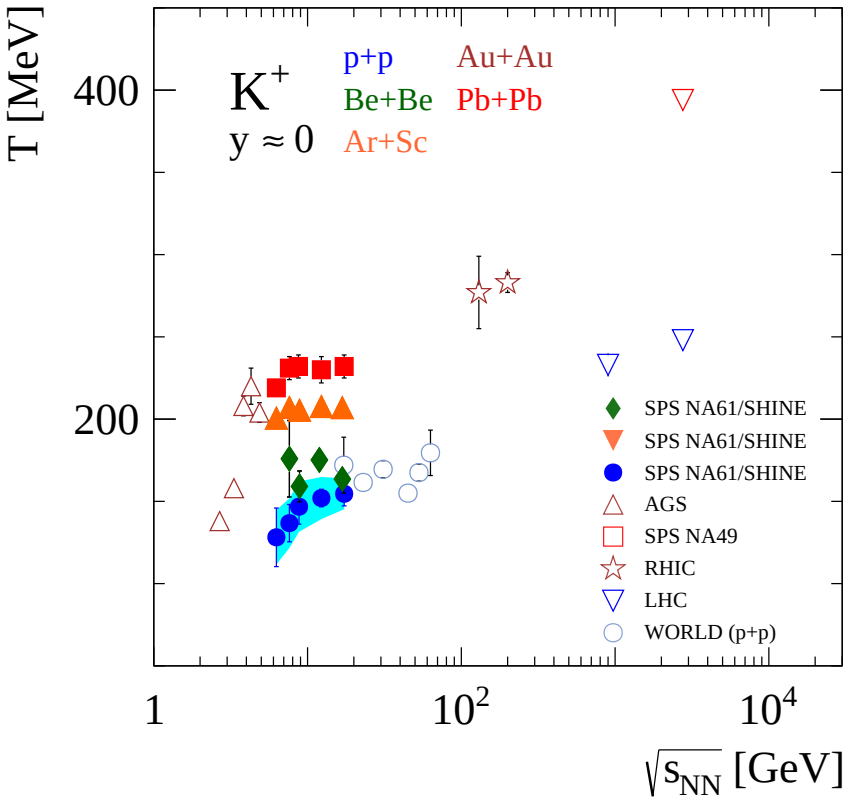


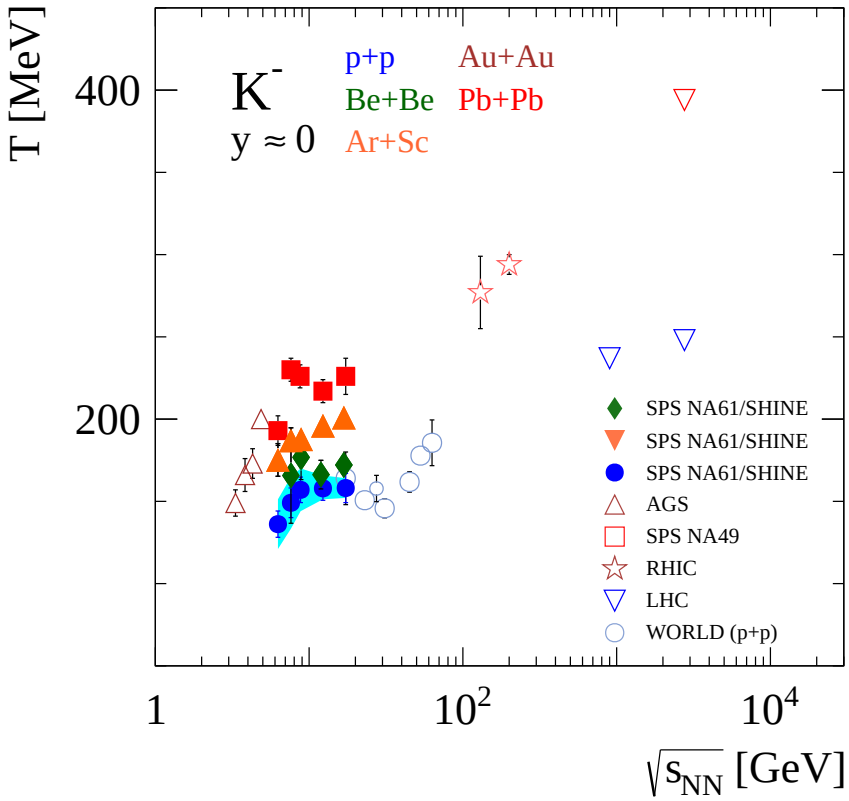


fitted function:

$$\frac{d^2n}{dp_T dy} = \frac{Sp_T}{T^2+Tm_K} exp\left(-\frac{\sqrt{p_T^2+m_K^2}}{T}\right)$$

Onset of deconfinement: step





- Intermediate plateau in the increase with $\sqrt{s_{NN}}$ of the inverse slope parameter of $K^{\pm}$ spectra in Pb+Pb is observed
- Predicted due to mixed phase of hadron gas and QGP (*APP* **B30**, 2705 (1999))
- Similar structures are visible in other systems
- Level of plateau grows with system size

NA49, *PRC* **66**, (2002), NA49, *PRC* **77**, (2008), NA61/SHINE, *EPJC* **74** (2014), NA61/SHINE, *EPJC* **77** (2017)

Extraction of rapidity spectra and mean multiplicities

Measured dn/dy yields ($\approx 99\%$) are extrapolated beyond the analysis acceptance

- exponential dependence in p_T is fitted:

$$\frac{d^2n}{dp_T dy} = \frac{Sp_T}{T^2 + Tm_K} exp\left(-\frac{\sqrt{p_T^2 + m_K^2}}{T}\right) \quad (1)$$

- the function integral outside the acceptance region is added to the measured data points

Measured rapidity distribution is extrapolated beyond analysis acceptance:

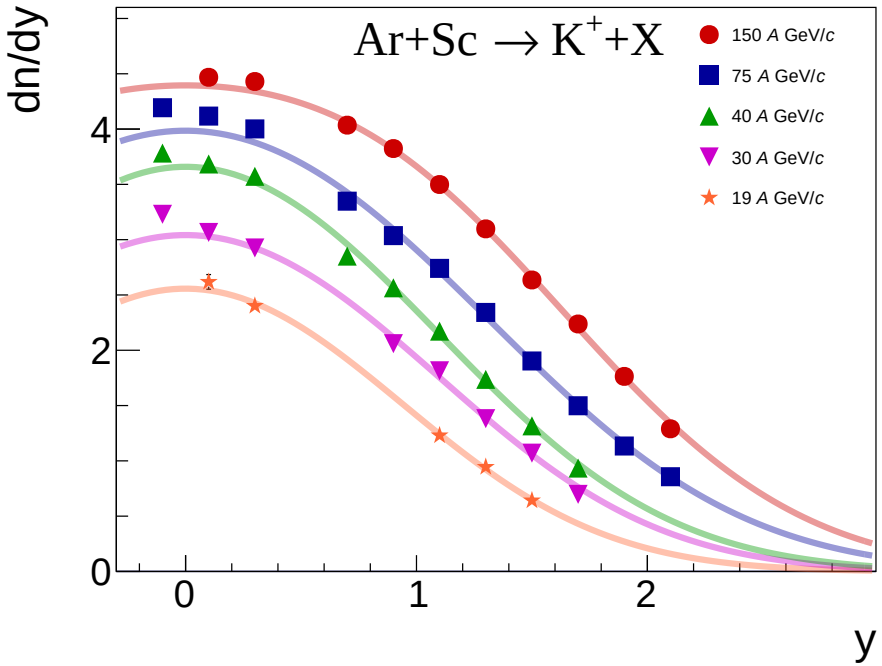
- gaussian dependence in y is fitted:

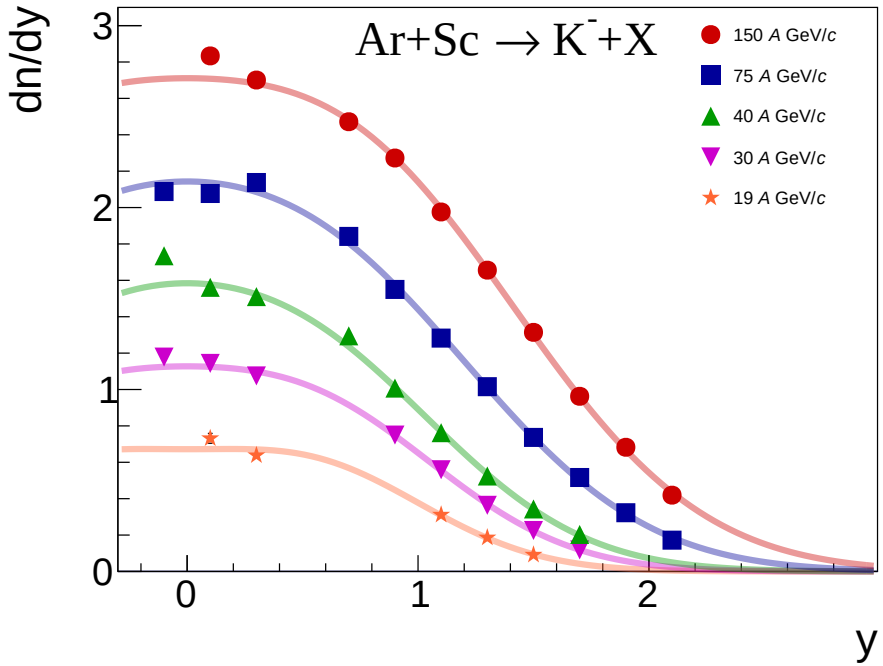
$$f_{fit}(y) = \frac{A}{\sigma_0\sqrt{2\pi}} exp\left(-\frac{(y-y_0)^2}{2\sigma_0^2}\right) + \frac{A}{\sigma_0\sqrt{2\pi}} exp\left(-\frac{(y+y_0)^2}{2\sigma_0^2}\right) \quad (2)$$

- the function integral is taken as a mean multiplicity

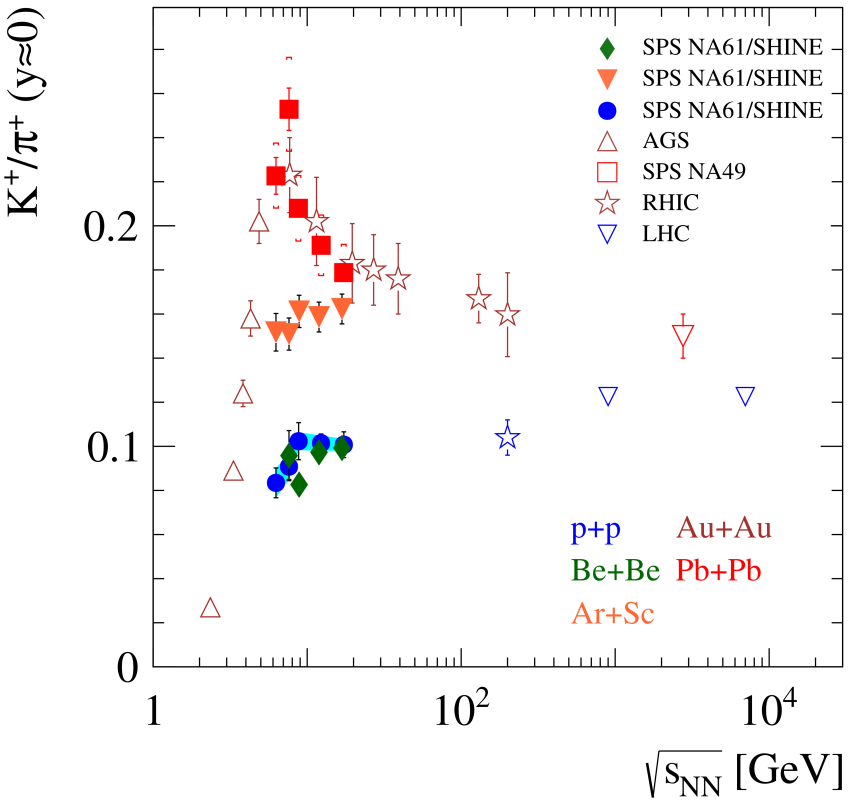
Rapidity spectra of $K^{\pm}$ produced in Ar+Sc collisions

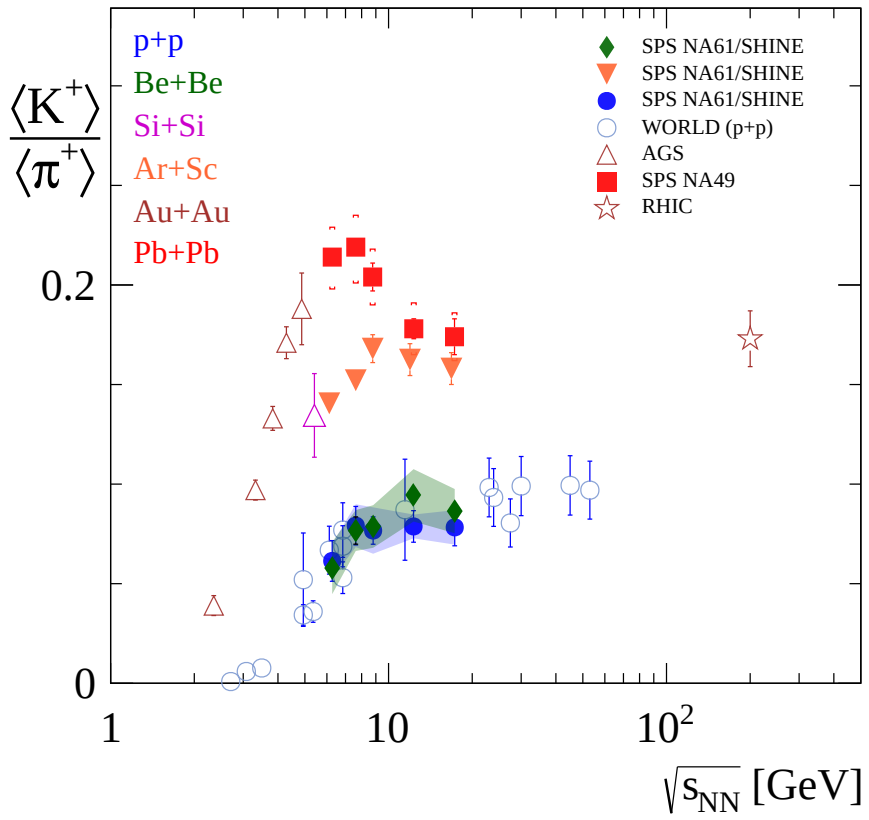
0-10% central Ar+Sc collisions





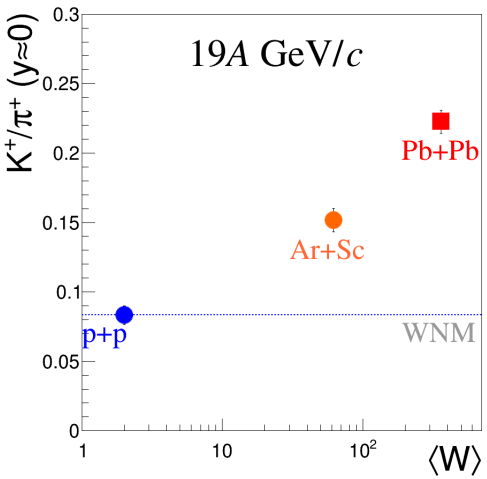
Onset of deconfinement: horn

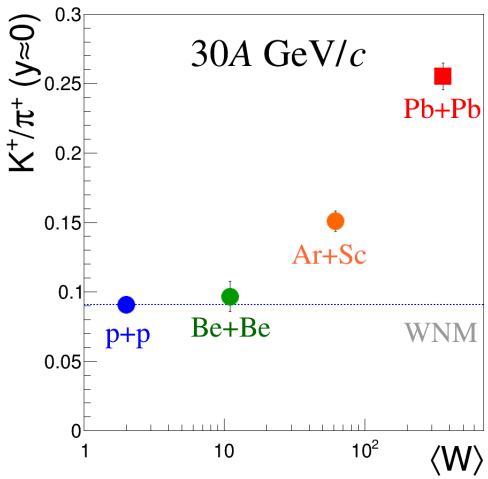


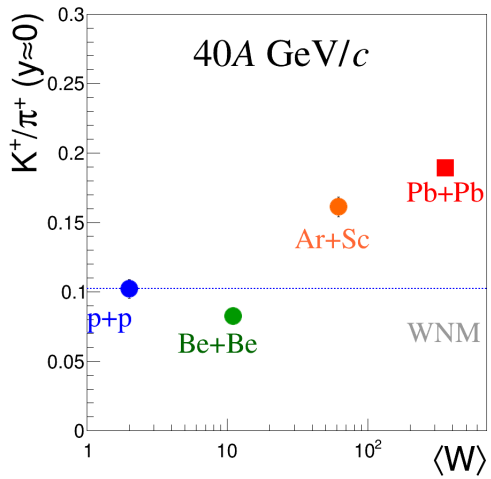


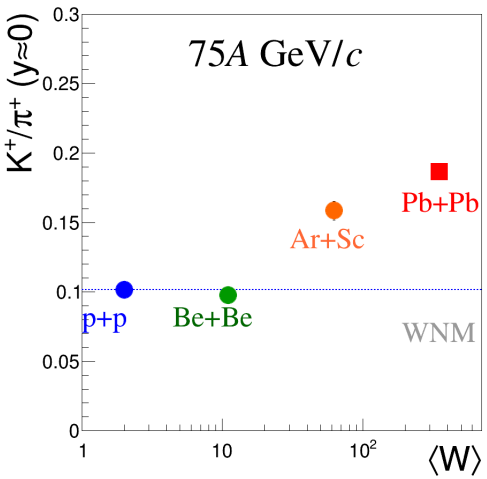
- Rapid change in the K^+/π^+ ratio in Pb+Pb collisions (NA49)
- Plateau like structure visible in p+p interactions (NA61/SHINE)
- Be+Be close to p+p interactions (NA61/SHINE)
- Ar+Sc show dependence on collision energy qualitatively similar to p+p
- No indication of horn structure in Ar+Sc data

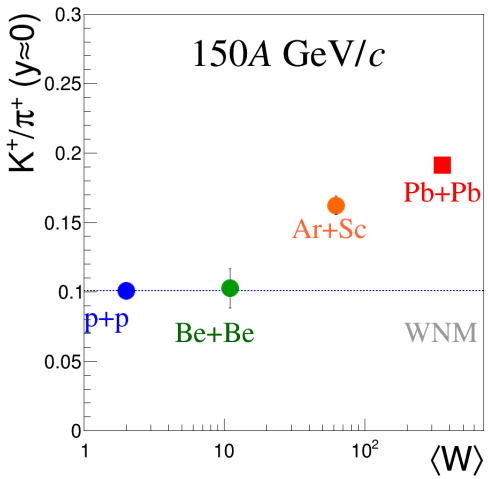
K^+/π^+ ratio at mid-rapidity as a function of system size







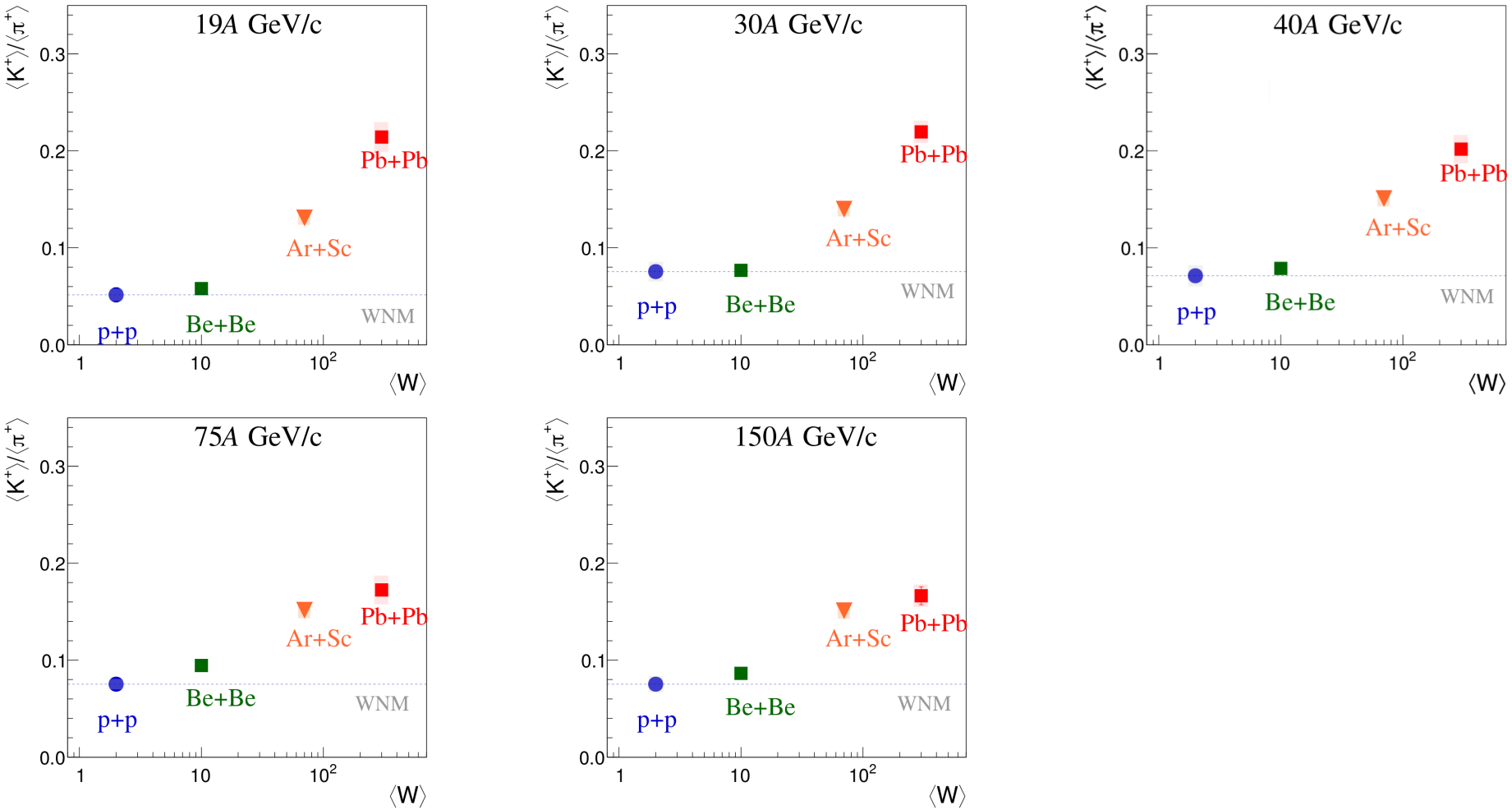




- Ar+Sc data are significantly higher than p+p≈Be+Be results
- Ar+Sc is closer to Pb+Pb, than to smaller system results
- Difference between Ar+Sc and Pb+Pb results is smaller for higher beam momenta

Wounded Nucleon Model: A. Bialas, M. Bleszynski, W. Czyz, *Acta Phys.Polon.* **B8** (1977)

$\langle K^+ \rangle / \langle \pi^+ \rangle$ ratio in 4π acceptance as a function of system size



Similar as at mid-rapidity:

- Ar+Sc data are significantly higher than p+p≈Be+Be results
- Ar+Sc is closer to Pb+Pb, than to smaller system results
- Difference between Ar+Sc and Pb+Pb results is smaller for higher beam momenta

Wounded Nucleon Model: A. Bialas, M. Bleszynski, W. Czyz, *Acta Phys.Polon.* **B8** (1977)

Summary

The new preliminary results on kaon transverse momentum and rapidity spectra in Ar+Sc collisions at five beam momenta (19A-150A GeV/c) in 0-10 % centrality were presented:

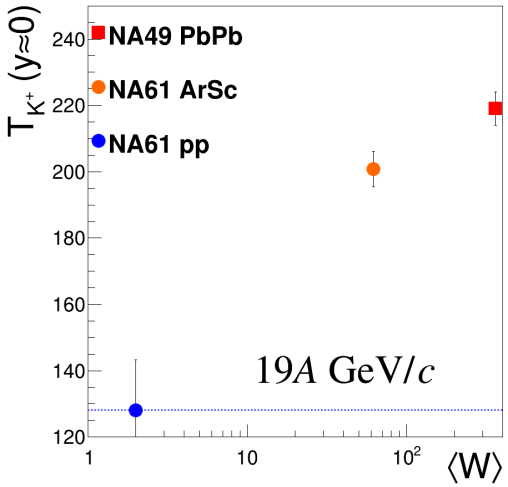
- Inverse slope parameter T of $K^{\pm}$ at mid-rapidity
  - between p+p≈Be+Be and Pb+Pb
  - shows similar energy dependence to other systems (p+p≈Be+Be and Pb+Pb)

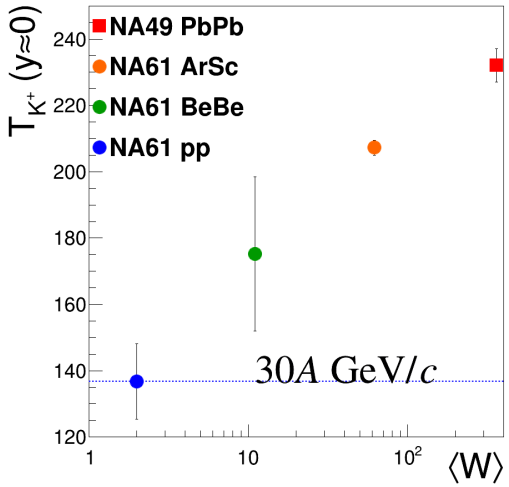
- $\langle K^{+} \rangle / \langle \pi^{+} \rangle$ and $K^{+}/\pi^{+}(y \approx 0)$ ratios
  - between p+p≈Be+Be and Pb+Pb.
  - shows similar energy dependence to p+p≈Be+Be
  - no horn structure is visible
  - difference with respect to Pb+Pb is smaller for higher collision energies

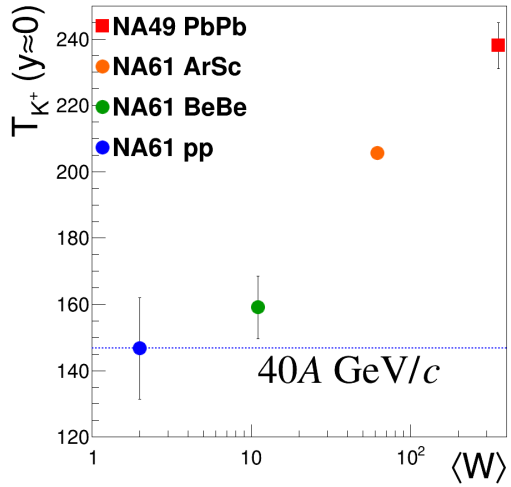
Thank You!

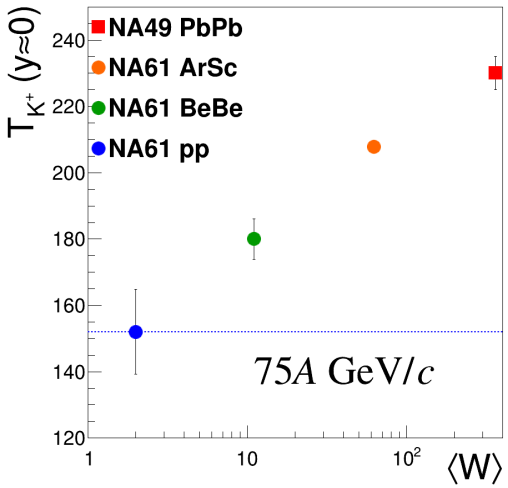
Backup slides

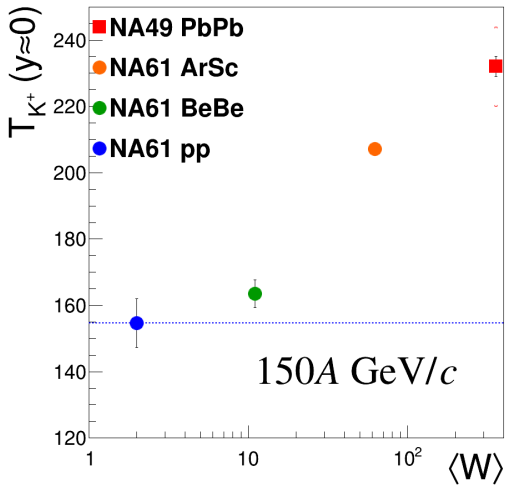
System size dependence of inverse slope parameter T of K^+ p_T spectra at mid-rapidity











System size dependence of inverse slope parameter T of K^- p_T spectra at mid-rapidity