K^*/K ratio and the time between freeze-outs for intermediate-mass Ar+Sc system at the SPS energy range

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Motivation

- K^* lifetime (≈ 4 fm/c) is comparable with time between freeze-outs → some resonances may decay inside the fireball; momenta of their decay products can be modified due to elastic scatterings → problems with experimental reconstruction of resonance via invariant mass → suppression of the observed K^* yield

Assuming no regeneration processes (Fig.) time between freeze-outs can be determined from (STAR, Phys.Rev.C 71, 064902, 2005; C. Markert, G. Torrieri, J. Rafelski, AIP Conf.Proc. 631, 533, 2002):

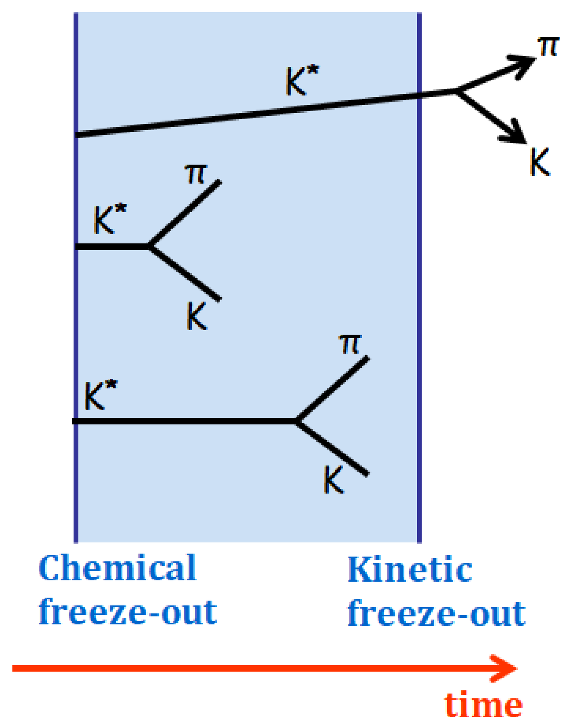
$$\frac{K^*}{K}|_{kinetic} = \frac{K^*}{K}|_{chemical} \cdot e^{-\frac{\Delta t}{\tau}} \qquad (1)$$

$\frac{K^*}{K}|_{chemical}$ – K^*/K ratio in inelastic p+p collisions

$\frac{K^*}{K}|_{kinetic}$ – K^*/K ratio in central Ar+Sc collisions

τ – $K^*(892)^0$ lifetime = 4.17 fm/c

Δt – time between chemical and kinetic freeze-outs (in K^* rest frame)

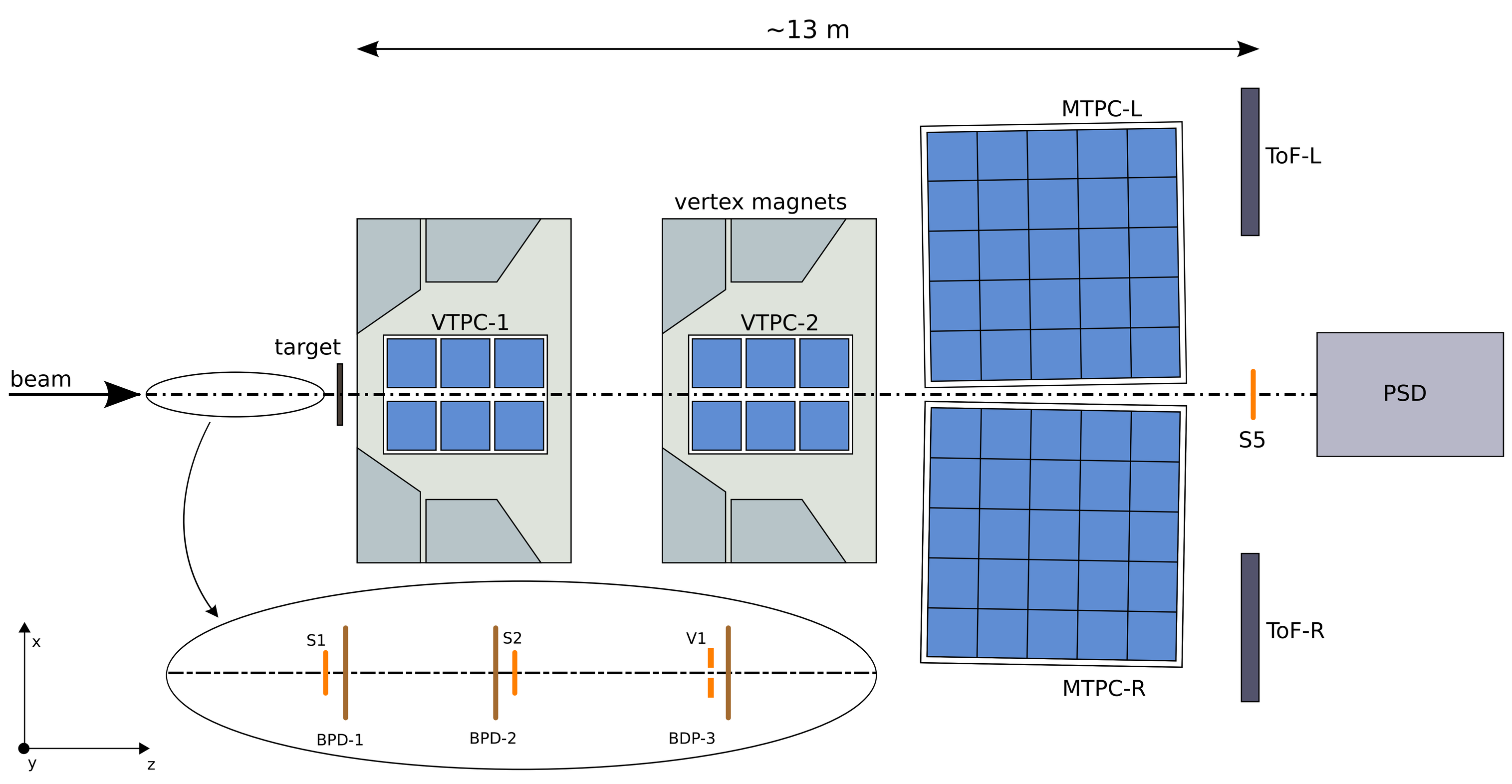


The picture assumes that conditions at chemical freeze-out of p+p and Ar+Sc are the same

- K^* spectra and yields are also used as input data to Blast-Wave and Hadron Resonance Gas models

NA61/SHINE experiment

NA61/SHINE is a multipurpose, fixed-target experiment located at the CERN Super Proton Synchrotron (SPS). The main goal of its strong interaction program is to study the properties of the onset of deconfinement and search for the critical point of strongly interacting matter



NA61/SHINE layout used in Ar+Sc data taking

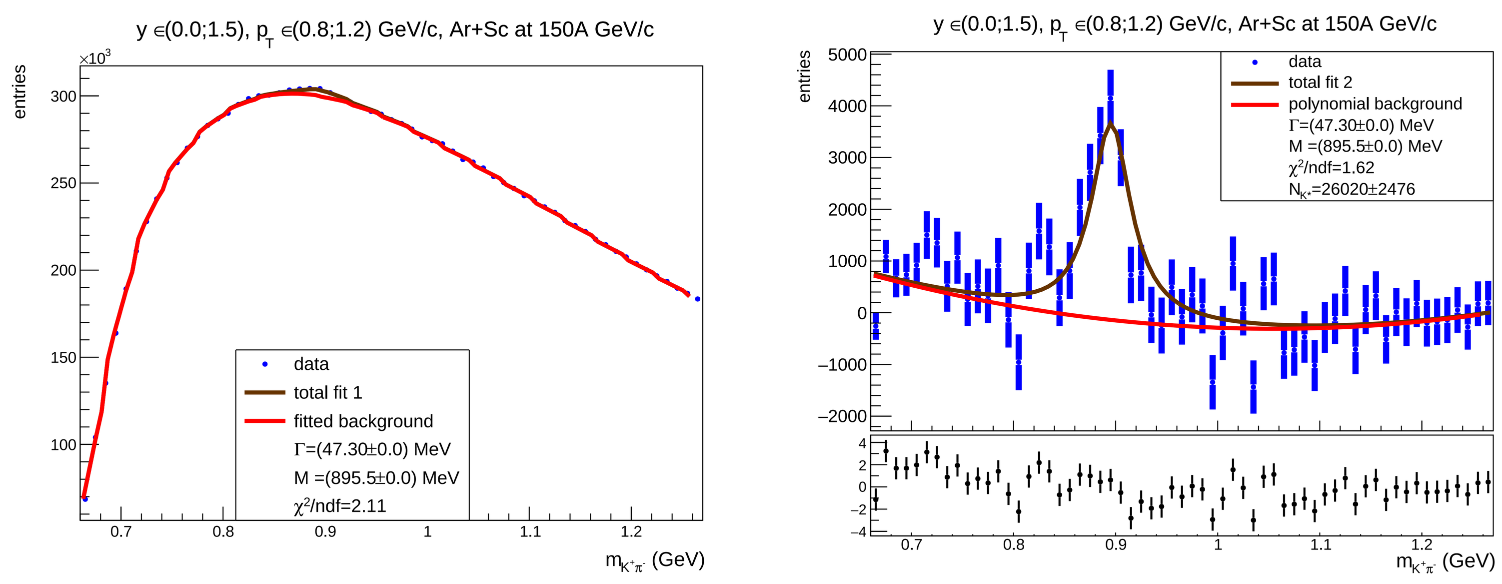
Methodology

$K^*(892)^0$ signal is obtained by using template method (NA61/SHINE, Eur.Phys.J.C 80, 460, 2020)

Invariant mass spectra are fitted with function:

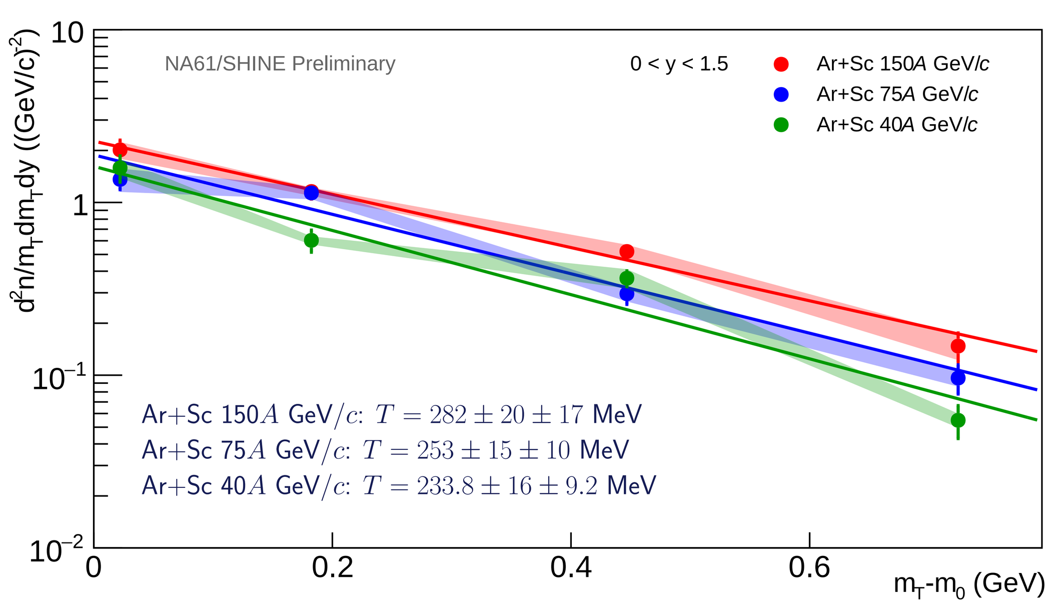
$$f(m_{K^+\pi^-}) = a \cdot T^{MC}_{res}(m_{K^+\pi^-}) + b \cdot T^{DATA}_{mix}(m_{K^+\pi^-}) + c \cdot BW(m_{K^+\pi^-}) \qquad (2)$$

- $T^{DATA}_{mix}(m_{K^+\pi^-})$ – background estimated using mixing method
- $T^{MC}_{res}(m_{K^+\pi^-})$ – resonance background estimated using reconstructed Monte Carlo data (combination of tracks that come from decays of resonances different than $K^*(892)^0$ and combination of tracks where one comes from the decay of resonance and one comes from direct production in primary interaction)
- $BW(m_{K^+\pi^-})$ – Breit-Wigner distribution
- a,b,c - normalisation factors

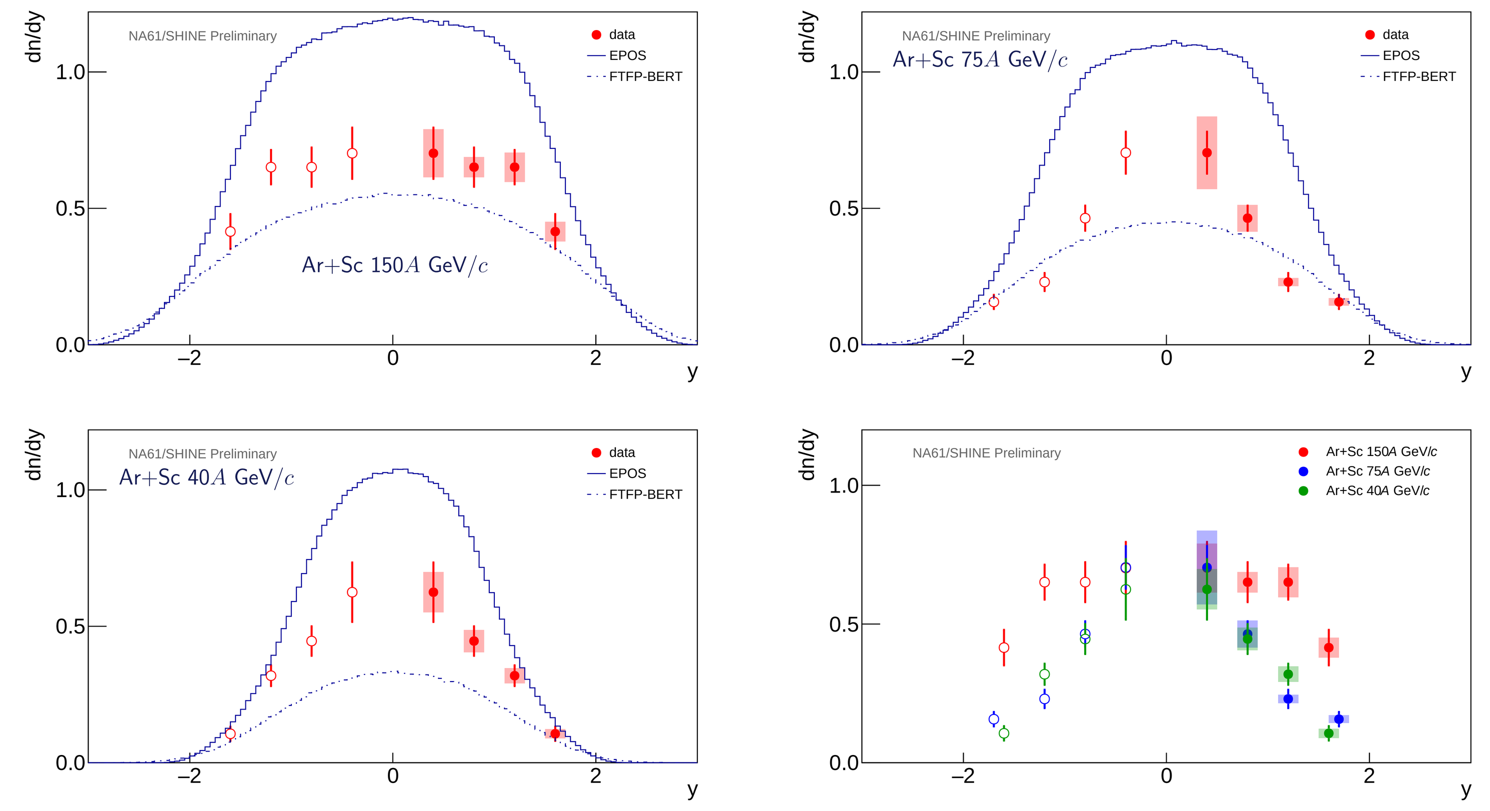


Left: invariant mass spectrum (blue dots) fitted with Eq. 2 (brown line). The red line shows background estimated using mixing method and reconstructed Monte Carlo data. Right: invariant mass spectrum after background subtraction. The red line is residual background described by second-order polynomial curve

Transverse mass spectra of $K^*(892)^0$ in 0-10% Ar+Sc collisions



Rapidity spectra and multiplicities of $K^*(892)^0$ in 0-10% Ar+Sc collisions



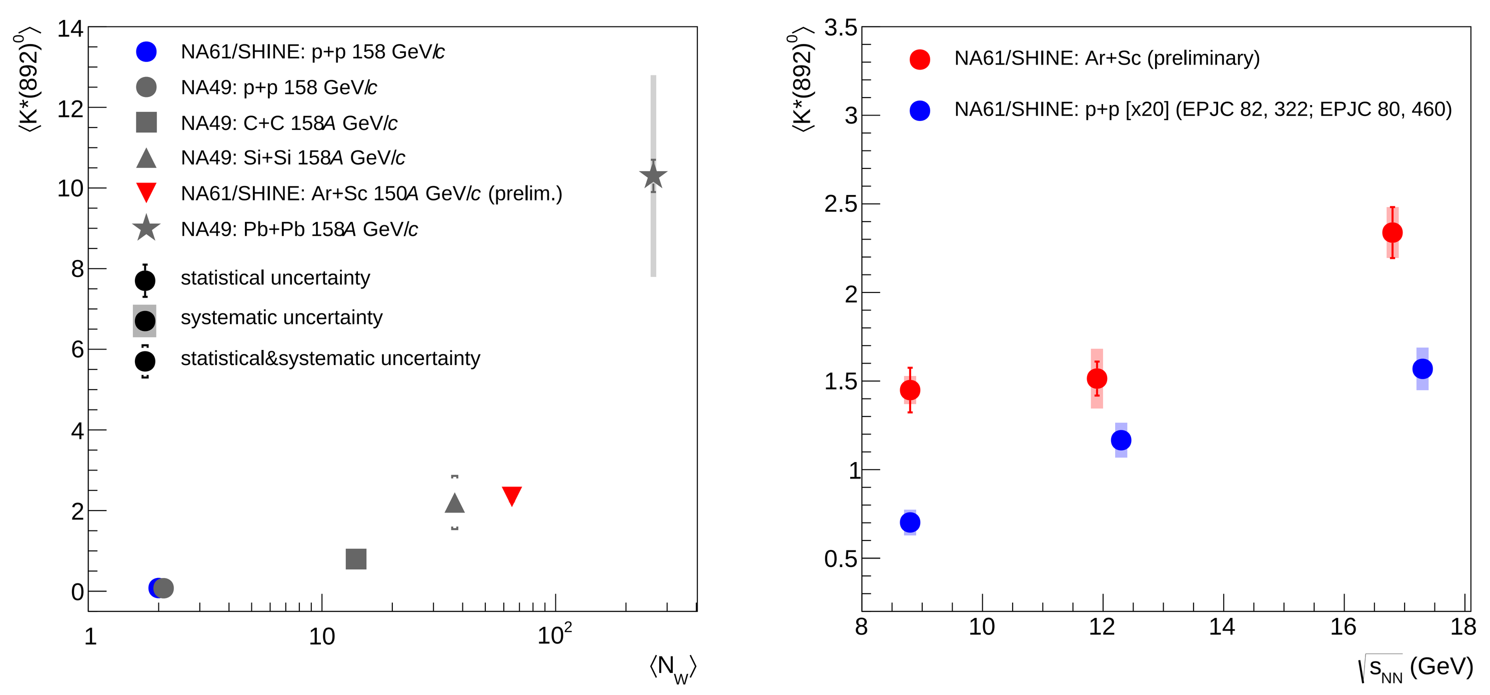
Full symbols represent the measurements, open symbols were obtained by reflection around mid-rapidity. Rapidity spectra in 0-10% central Ar+Sc collisions are compared with EPOS 1.99 and FTFP-BERT

Ar+Sc at 150A GeV/c: $\langle K^*(892)^0 \rangle = 2.34 \pm 0.14$ (stat) ± 0.14 (sys)

Ar+Sc at 75A GeV/c: $\langle K^*(892)^0 \rangle = 1.514 \pm 0.096$ (stat) ± 0.17 (sys)

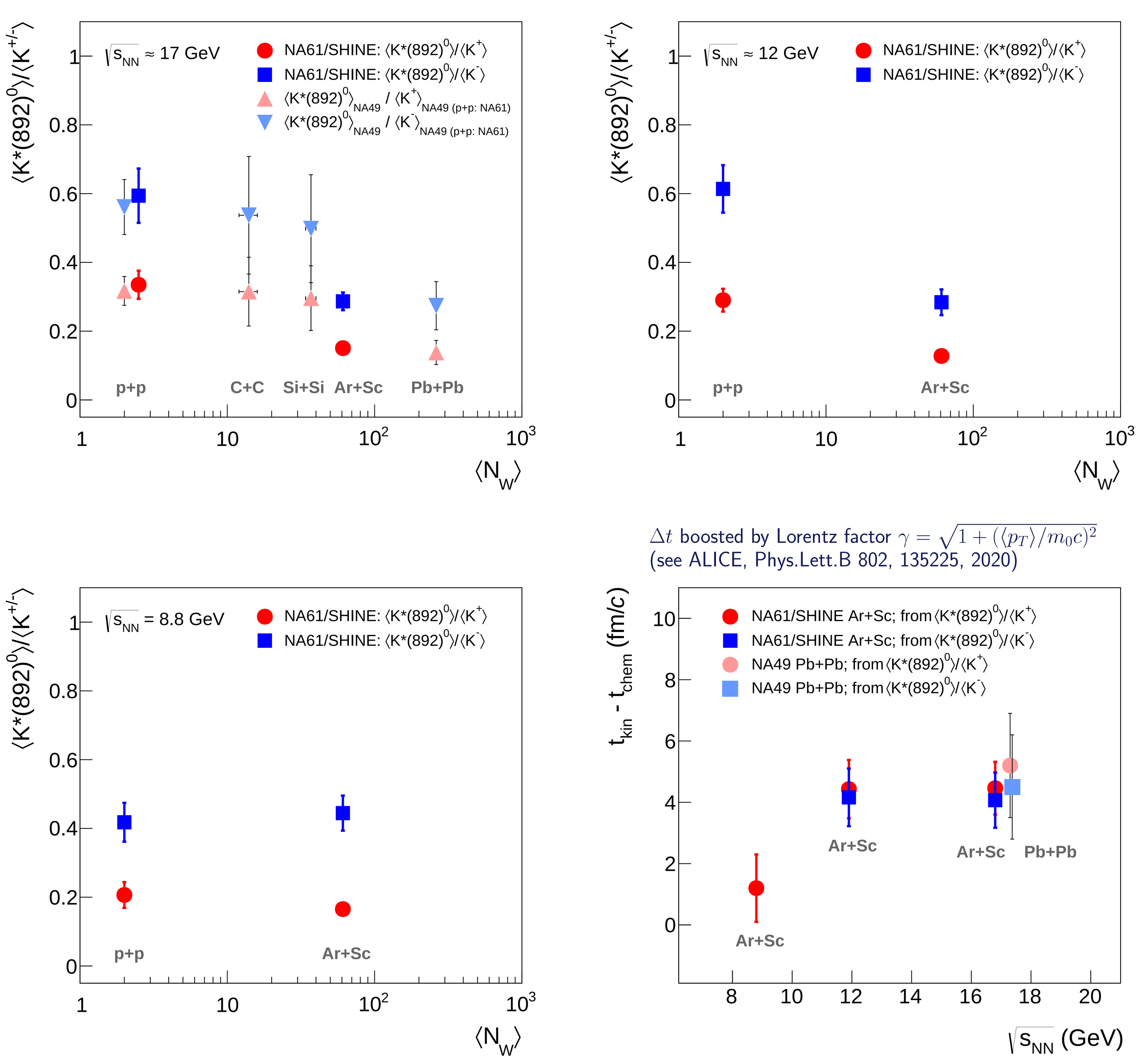
Ar+Sc at 40A GeV/c: $\langle K^*(892)^0 \rangle = 1.449 \pm 0.13$ (stat) ± 0.079 (sys)

Multiplicities of $K^*(892)^0$



Plots prepared based on data from: NA49, Phys.Rev.C 84, 064909, 2011; NA61/SHINE, Eur.Phys.J.C 80, 460, 2020, Eur.Phys.J.C 82, 322, 2022

K^*/K ratios and time between freeze-outs



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NA49, Phys.Rev.C 84, 064909, 2011, Phys.Rev.C 66, 054902, 2002, Phys.Rev.Lett. 94, 052301, 2005;
NA61/SHINE p+p: Eur.Phys.J.C 80, 460, 2020, Eur.Phys.J.C 82, 322, 2022, Eur.Phys.J.C 77, 671, 2017;
NA61/SHINE Ar+Sc: Eur.Phys.J.C 84, 416, 2024

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