CERES measurement of strangeness production at top SPS energy

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Strangeness in Quark Matter
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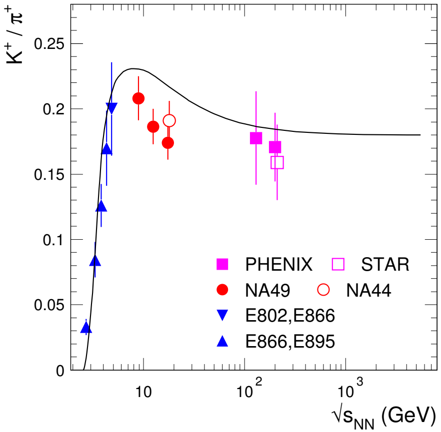
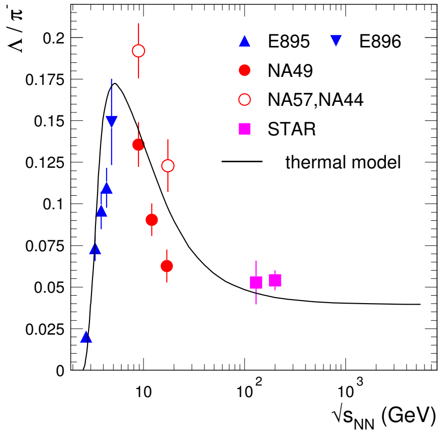
motivation

- Termal model describes particle ratios from AGS up to RHIC energies
- Deviations are observed in the strange sector at SPS
  - some models attribute that to the phase transition
  - is this a real physics effect or experimental artifact?
- Discrepancies in the experimental data – from NA49 and NA57
  - for kaons are at the level of 30%.
  - for Λ around 70%

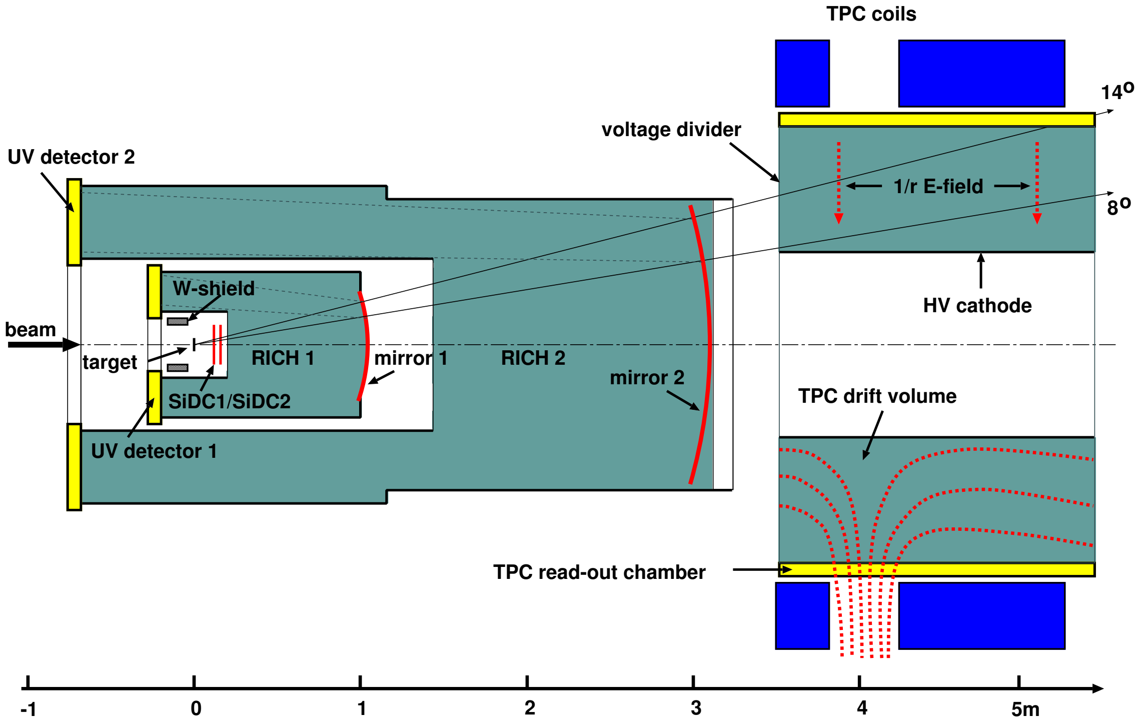


- The strangeness production at top SPS energy was addressed by the CERES experiment with the measurement of:
  - K_s^0, Λ, K^{+-}
- The production of K_s^0 measures the number of s and $\bar{s}$ quarks.

$$K_s^0 = 0.5(K^+ + K^-)$$



experimental setup



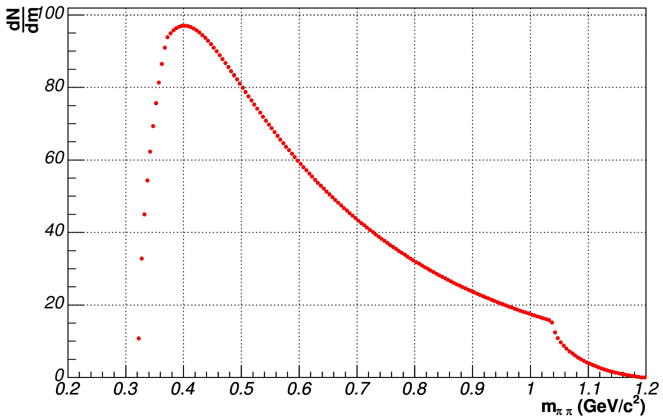
- The setup consist of radial TPC, Silicon Detectors, RICH and a Multiplicity Counter
- Momentum is measured using push-pull magnetic field
- The CERES experiment collected around 30M central PbAu events in year 2000

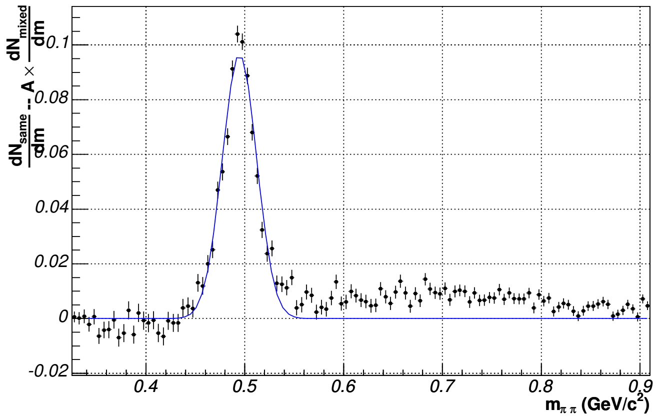
reconstruction strategy

- Kaons are reconstructed as a peak in the invariant mass spectrum of the pion pairs.

$$K_s^0 \to \pi^+\pi^-$$

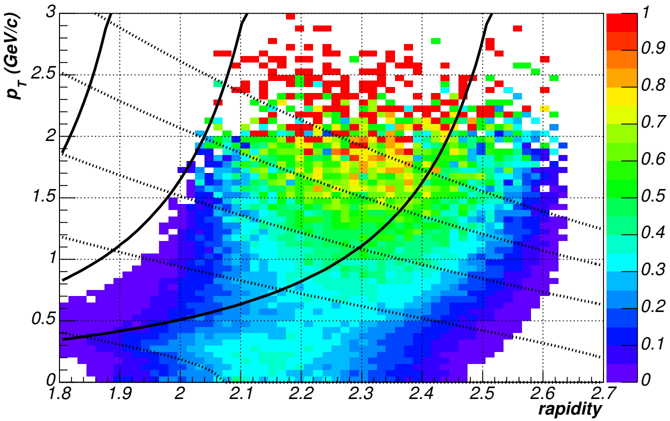
- The acceptane starts at $p_T = 0$ GeV/c
  - no error due to exptapolation of p_T spectrum
- No topological cuts are applied
  - reduces uncertainty of the efficiency correction
- Small signal/background ratio $S/B = 1/1000$
  - compensated by a large statistics
  - precisely estimated using mixed events (10^{-4})
- Contributions from Λ and residual correlations were removed using Armenteros cut

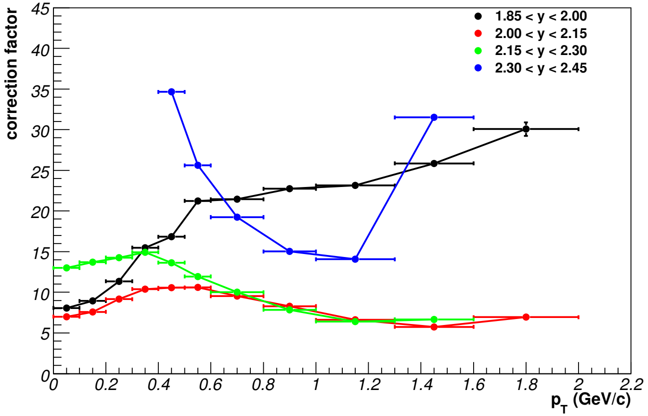




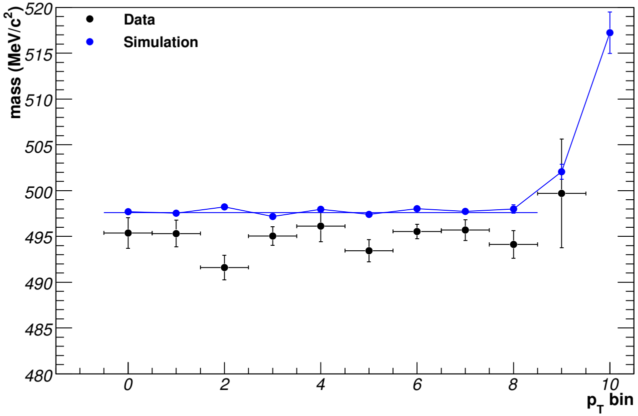
efficiency study

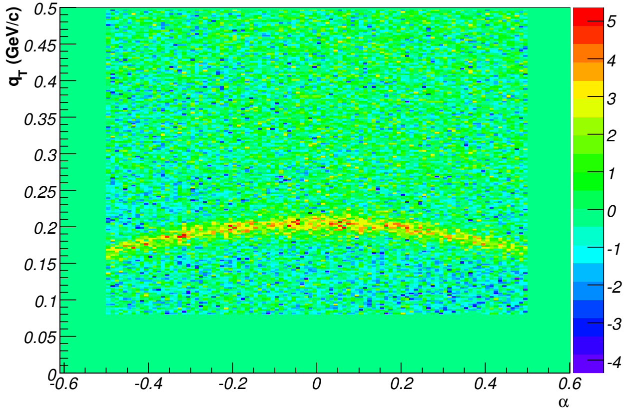
- The geometric acceptance and efficiency was studied with a GEANT based simulation.
- The detector covers rapidity range $2.0 < y < 2.6$, this space was divided into four rapidity bins of 0.15 unit each
- Transverse momentum acceptance starts at:
  - $p_T = 0$ GeV$/c$ for $2.0 < y < 2.45$
  - $p_T = 0.4$ GeV$/c$ for $2.45 < y < 2.6$
- The total efficiency is dominated by the geometrical shape of the detector.
  - p_T dependence of the correction factors differ in rapidity bins
  - smoothest is the bin $2.15 < y < 2.30$
  - small number of cuts keeps the correction factor small and transparent

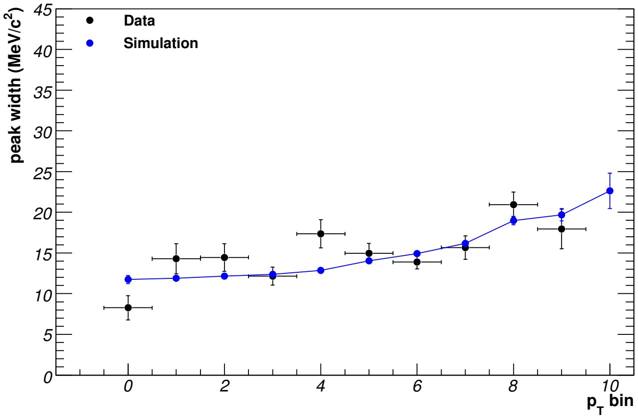




Control Plots

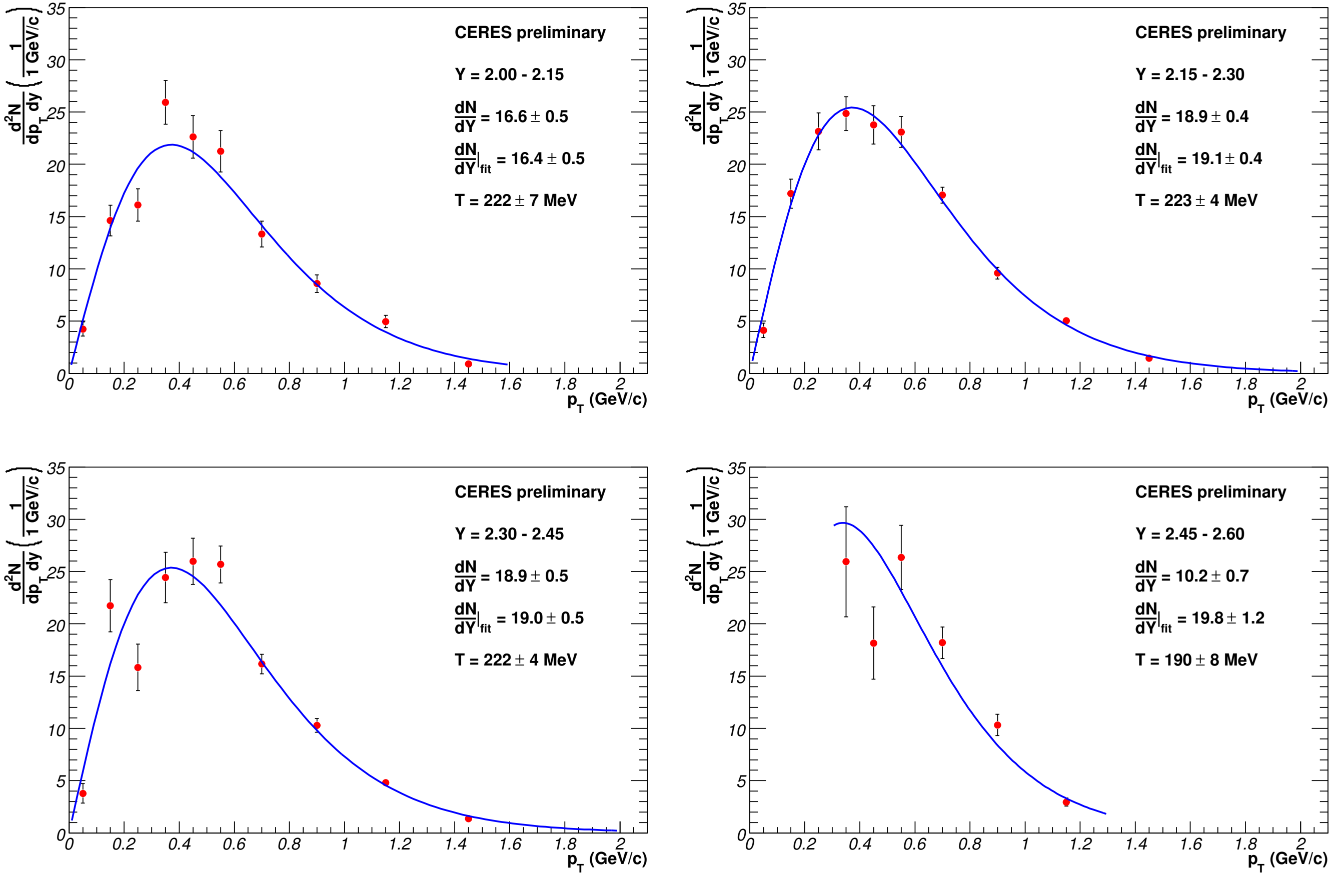






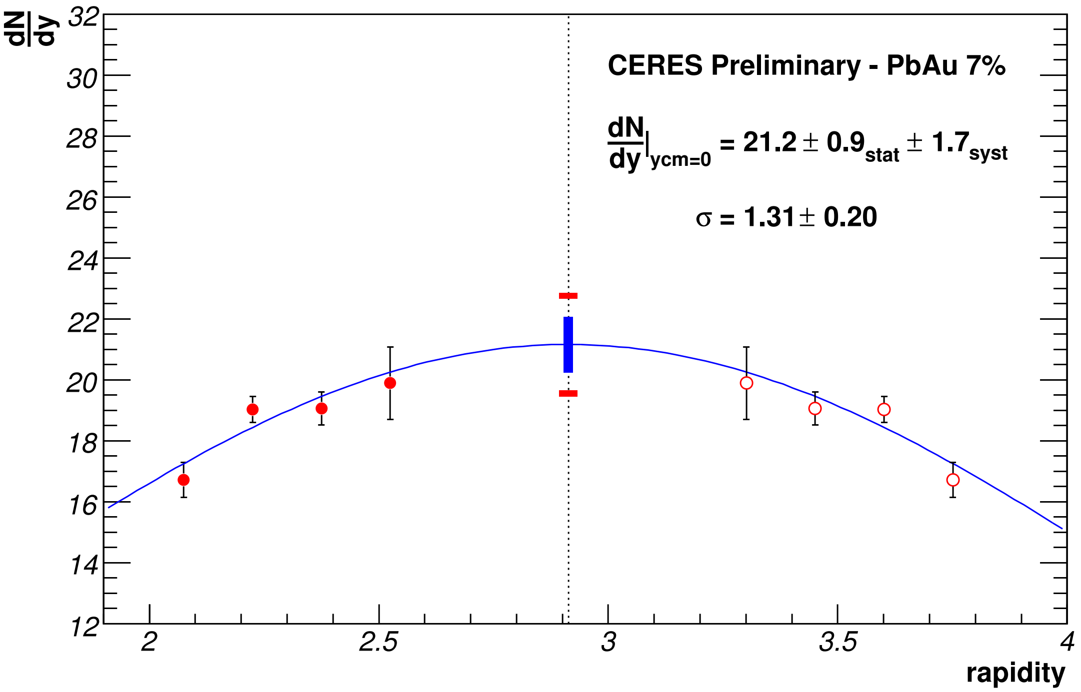
- Reconstructed mass 2 MeV/c^2 below PDG value
- Peak resolutions are correctly reproduced in the simulation
- Armaneteros Plot $(S - B)/\sqrt{B}$

transverse momentum spectrum



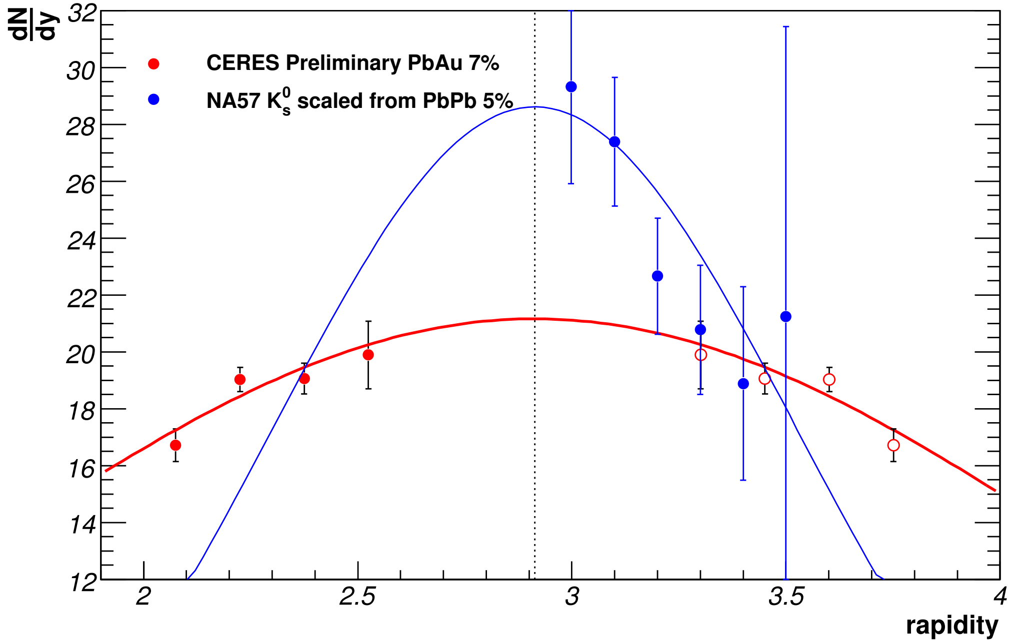
$$\frac{d^2N}{dy * dp_T} = \frac{N}{T(m_0 + T)\exp(-m_0/T)} * p_T \exp(-m_T/T)$$

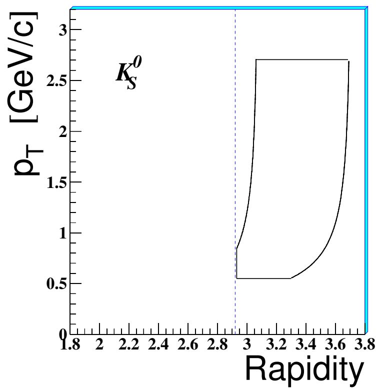
rapidity spectrum



- The points were reflected about midrapidity (open symbols)
- The spectrum was fit with a Gaussian, the blue box represents statistical error
- The systematic error (red lines) was estimated changing the cuts in data and simulation.
- Systematic error includes uncertainty in extrapolation

comparison – K_s^0 by NA57

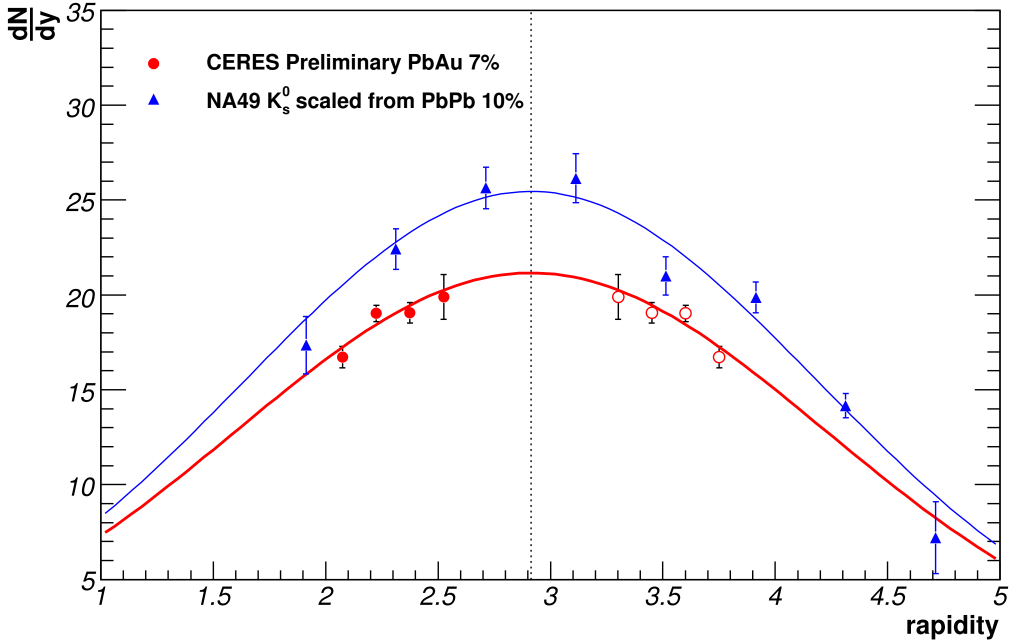




F. Antinori, *et. al.* (NA57 Collab.)
J. Phys. G31 (2005) 1345

- CERES measurement has better statistical precision thanks to direct measurement of the yield.
- In the area of common acceptance data points are in a good agreement.
- The rapidity spectrum fits are different

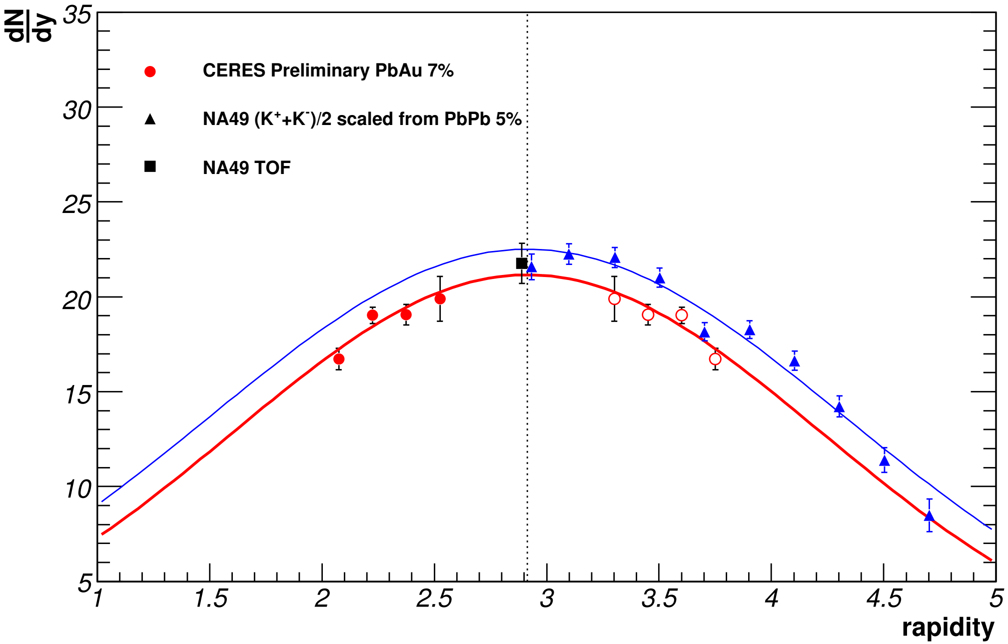
comparison – K_s^0 by NA49 (preliminary)



- Good agreement in the shape of the rapidity spectum
- Difference in the absolute normalization by 3σ of the combined statistical error
- The NA49 data does not have systematic error assigned

A. Mischke *et. al.* (NA49 Collab.)
Nucl. Phys. A715 (2003) 453c

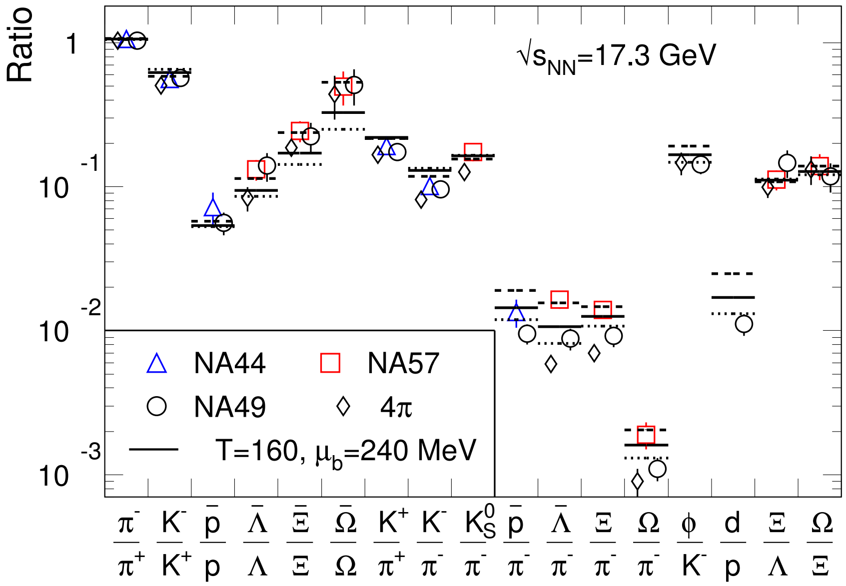
comparison



S. V. Afanassiev *et. al.* (NA 49 Collab.)
Phys. Rev. C66:054902, 2002

- Comparing fits
  - Very good agreement of the rapidity spectrum shape
  - Agreement of the normalization within 1σ
- Comparing point-to-point in overlaping acceptance
  - difference is systematic but within systematic errors

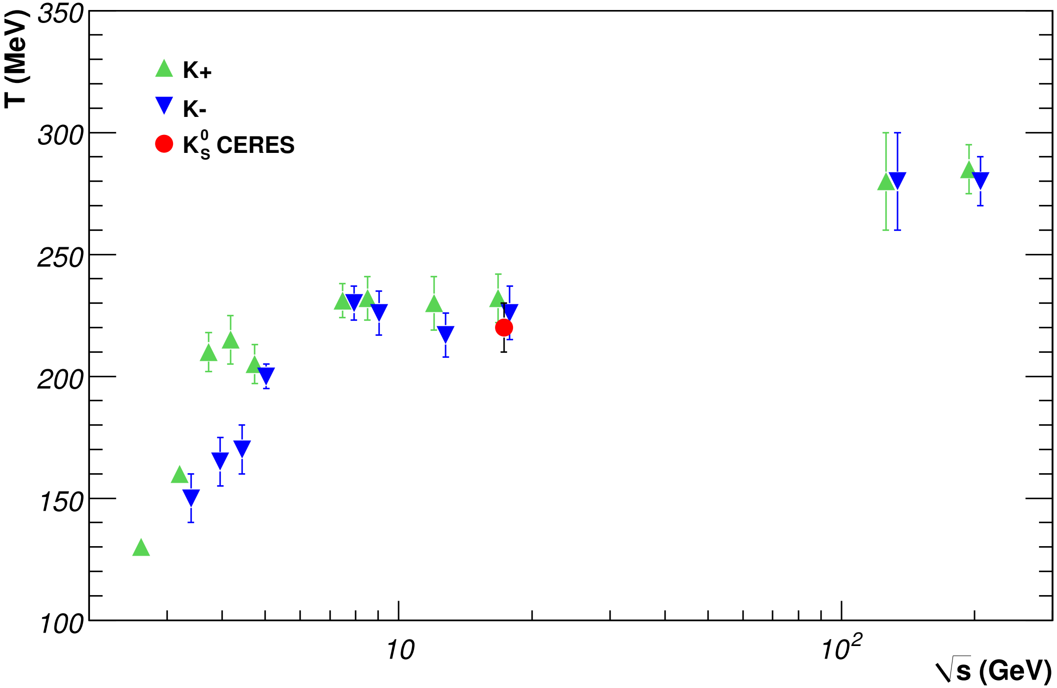
comparison to thermal model



A. Andronic, P. Braun-Munzinger, J. Stachel
Nucl.Phys.A772:167-199,2006.

- Thermal model predicts number of K_s^0 within 1 unit of rapidity $N = \int_{-0.5}^{0.5} \frac{dN}{dy} dy$
- Prediction of the thermal model for $n_p = 340$ participants is $N = 23.9$.
- This measurement: $N = 20.6 \pm 0.9_{STAT} \pm 1.6_{SYST}$.
- The numbers differ by 16% within 2σ of combined error of 9%.

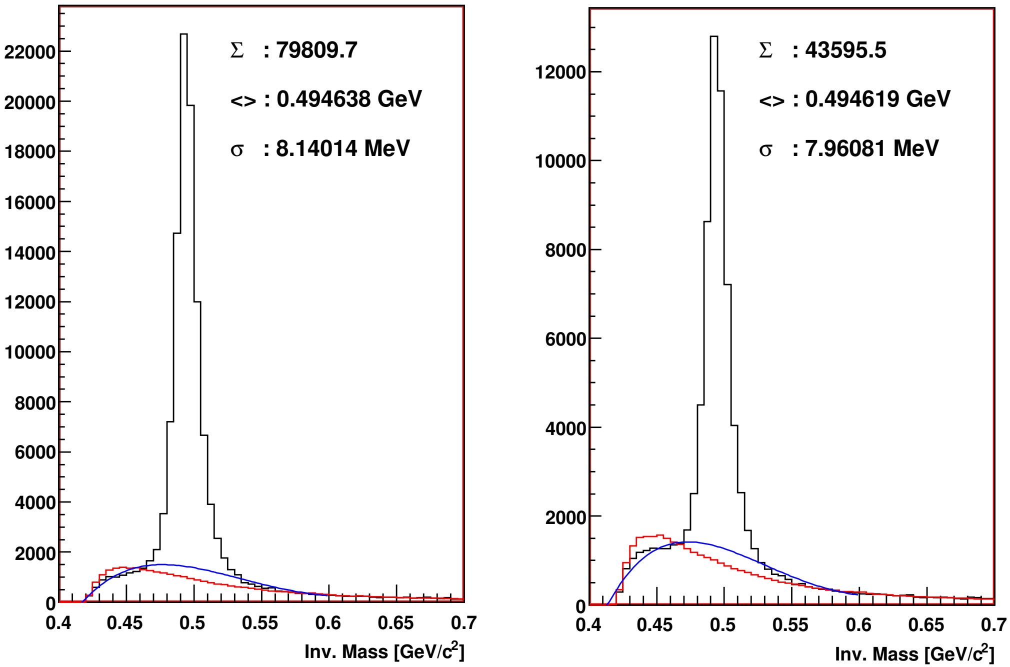
transverse momentum spectrum



R. Stock, J. Phys. G30 (2004) S644-S648

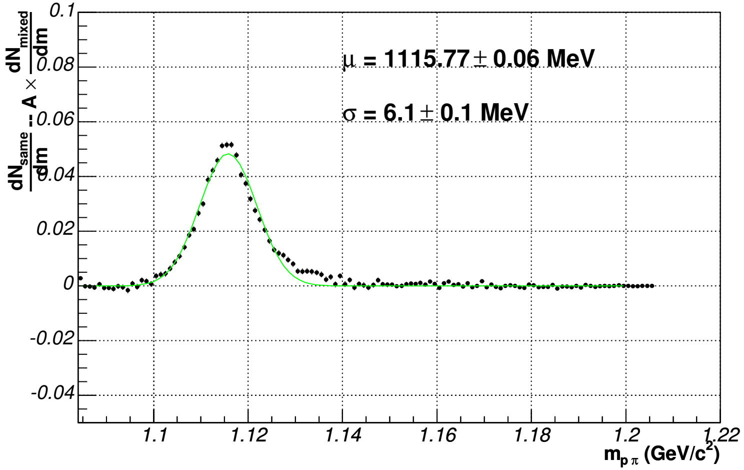
- The reconstructed temperature is $T = 220 \pm 3_{stat} \pm 10_{syst}$ MeV.
- This value fits into the global systematics

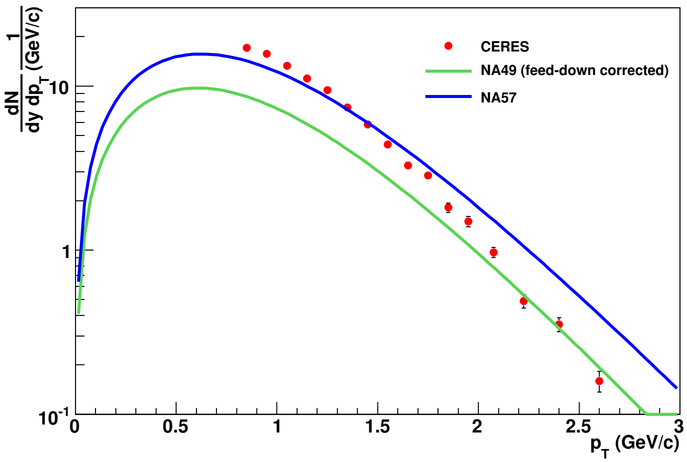
charged kaons (Matusz Kalisky, GSI)



- Charged kaons are reconstructed using tau-decay
  - $K^+ \to \pi^+\pi^+\pi^-$
  - the signature is very clean
  - the systematics is very different than in K_s^0
- Open Issues
  - estimation of the combinatorial background
  - effiency correction is more involved than for K_s^0

Lambda





- Lambdas have similar decay topology to K_s^0 but the acceptance starts at $p_T > 700$ MeV/c
  - total yield depends on p_T extrapolation
- The yield in limited the p_T range is compared to fits from NA49 and NA57
  - no feed-down correction was applied
  - the yield agree with NA57 at mid-momentum range
  - the yield areee w NA49 at high p_T
- Ongoing effort on low-p_T tracking can help solving the Λ puzzle

conclusions

- Precision measurement of the K_s^0 was performed.
- The measurement is weakly dependent on the Monte–Carlo simulations.
- The result shed light on SPS K_s^0 puzzle.
- The obtained yield is below the prediction of the thermal model by 16%, with statistical significance of 2σ.
- Temperature fits into the global systematics.
- First glimps of charged Kaons and Lambda was presented

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