XIV International Conference on Hadron Spectroscopy HADRON 2011

Neutral kaon production in p+p and p+Nb collisions

Kirill Lapidus for the HADES collaboration

Excellence Cluster “Universe”

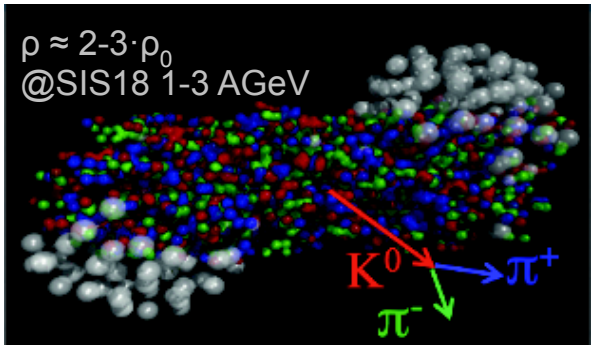
TU Munich

Munich
June 2011

Outline of the talk

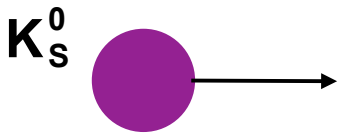
1. Physics motivation.
2. K^0_S results in the p+p experiment.
3. First K^0_S spectra from the p+Nb experiment.
4. Summary.

Kaon-nucleon interaction

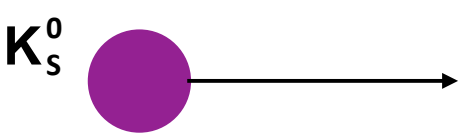


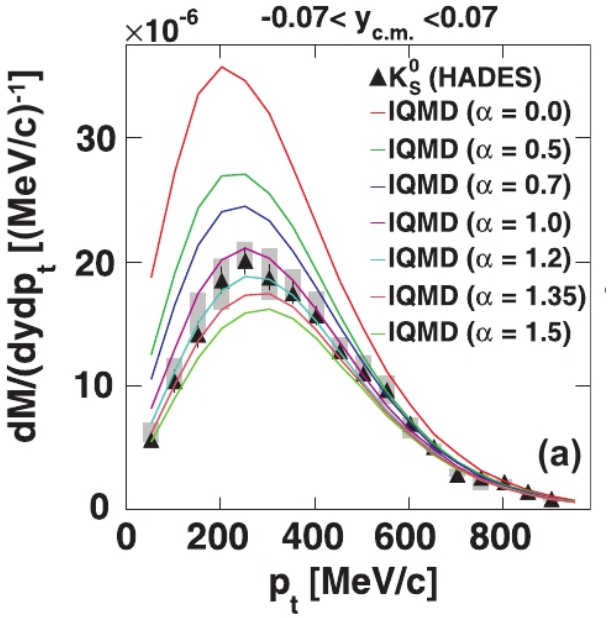
UrQMD-Goethe Universität Frankfurt

Without potential



With repulsive potential

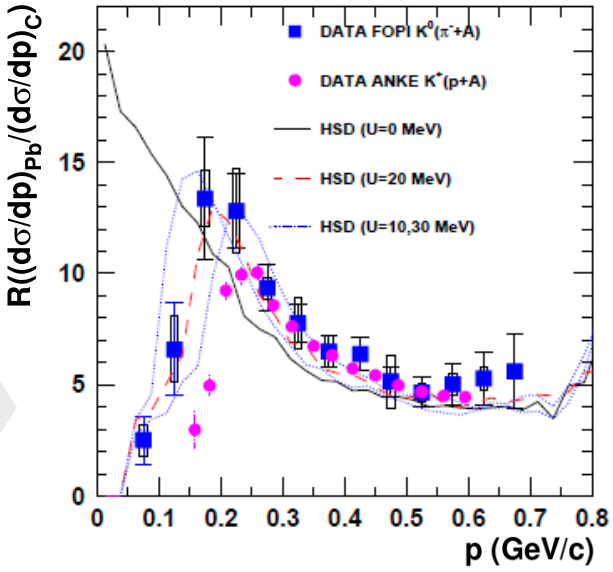




Agakishiev et al. Phys. Rev. C 82(2010), 044907

HADES (Ar+KCl@1.76AGeV)
Repulsive KN potential: **39 MeV**

FOPI (π^-+A@1.15GeV)
ANKE (p+A@2.3GeV)
Repulsive KN potential: **20 MeV**



Benabderrahmane et al. Phys. Rev. Lett. 102, 182501 (2009)
Büscher et al. Eur. Phys. J. A 22, 301-317 (2004)

Motivation for our study

Goal:

- Comparison of the K^0_S production in proton-nucleus ($p + {}^{93}Nb$) and elementary ($p + p$) collisions.

Features:

- High acceptance for the low p_t region.
- No Coulomb interaction for the K^0_S .

Limitation of this measurement:

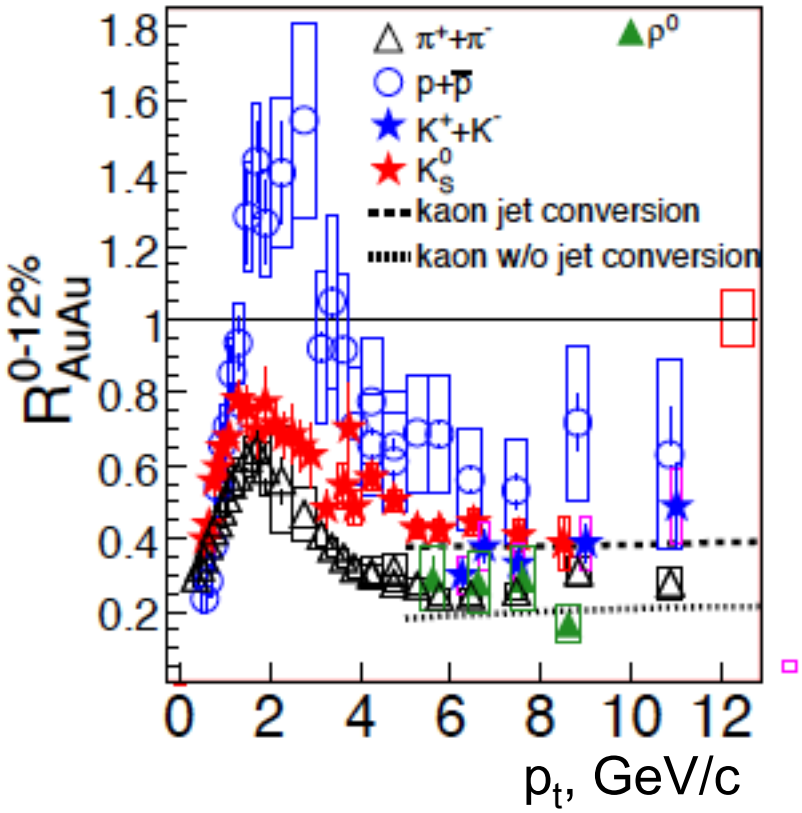
- Higher kinetic beam energy with 3.5 GeV (previous measurements: ~1-2.3 GeV).
- p+p as a reference — doesn't take into account nuclear effects: p+n reactions, absorption, two-step production.

see M. Nanova's talk

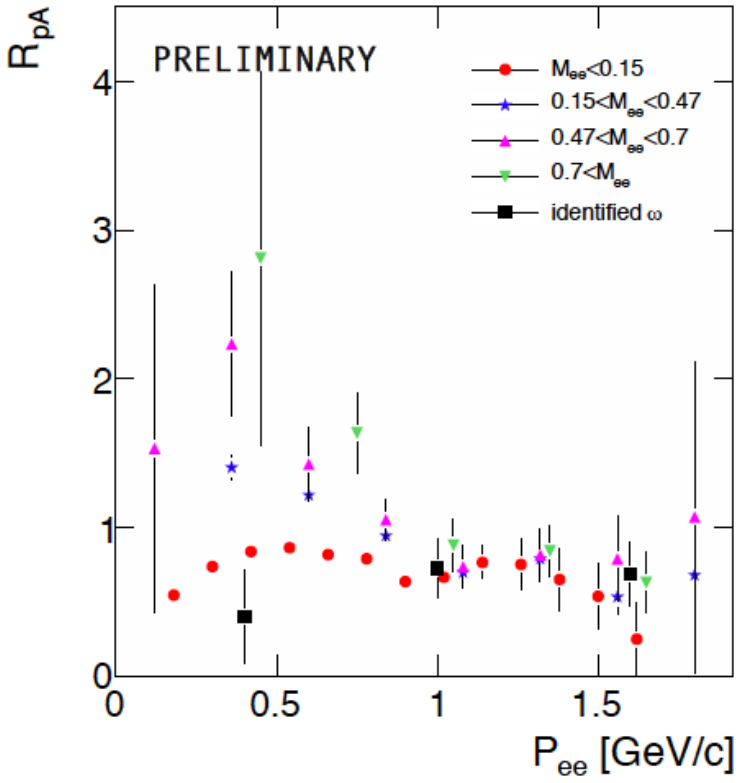
Nuclear modification factor

$$R_{pA} = \frac{2 \cdot \left(dN/dp_t\right)_{pNb}}{A_{part}^{pNb} \cdot \left(dN/dp_t\right)_{pp}}$$

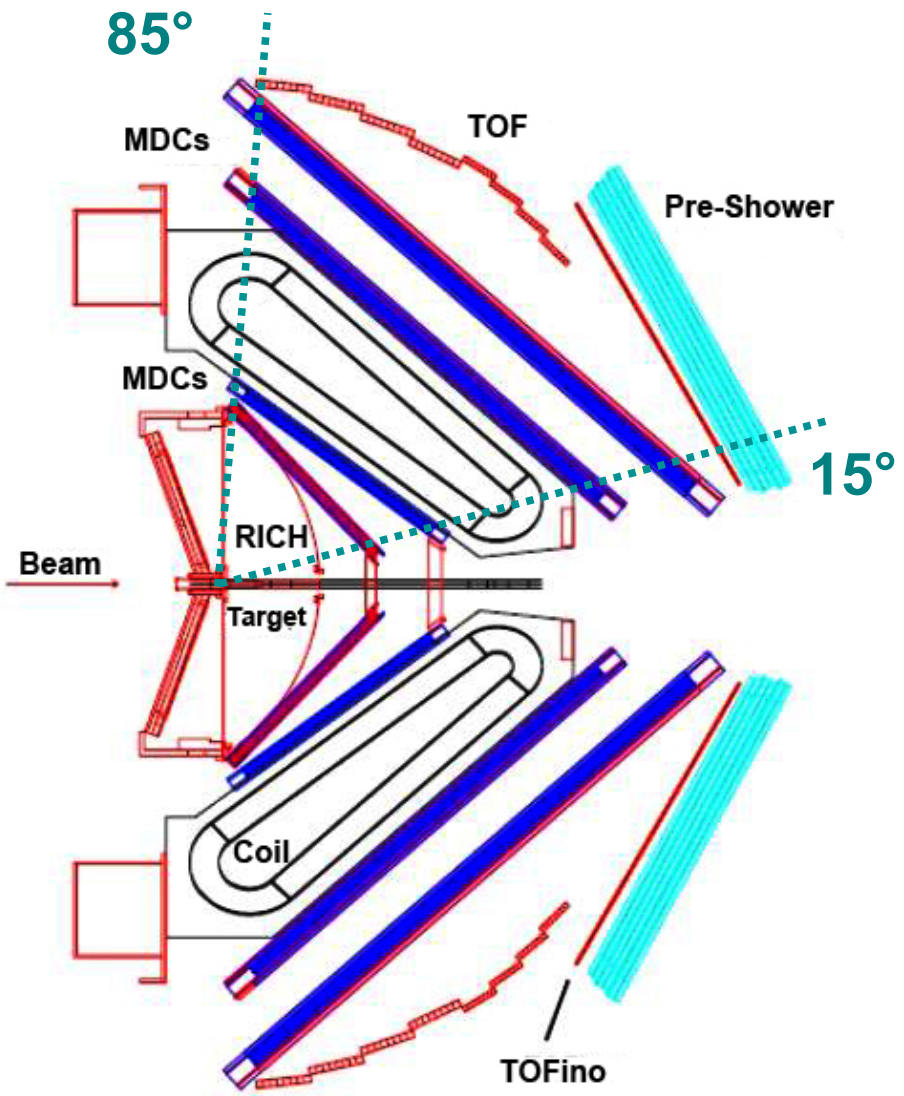
STAR data arXiv:0907.4644v2



HADES data M. Weber talk



The HADES detector

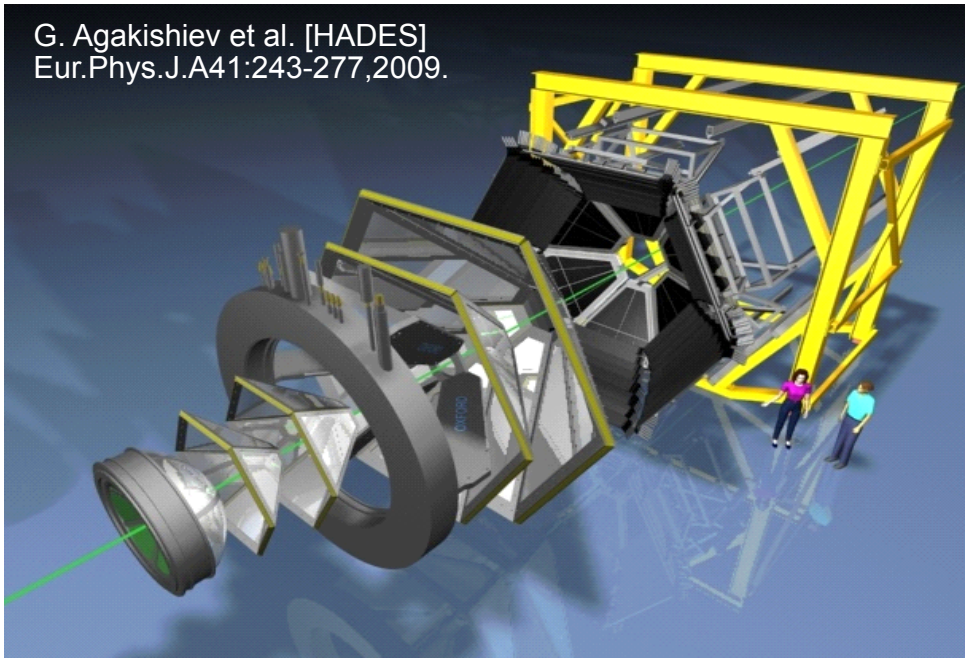


High **A**cceptance **D**i-**E**lectron **S**pectrometer:

- Momentum resolution ≈ 1-5 %
- Particle identification via dE/dx & TOF
- $1.2 \cdot 10^9$ events in p+p
- $4.2 \cdot 10^9$ events in p+Nb

} 3.5 GeV beam

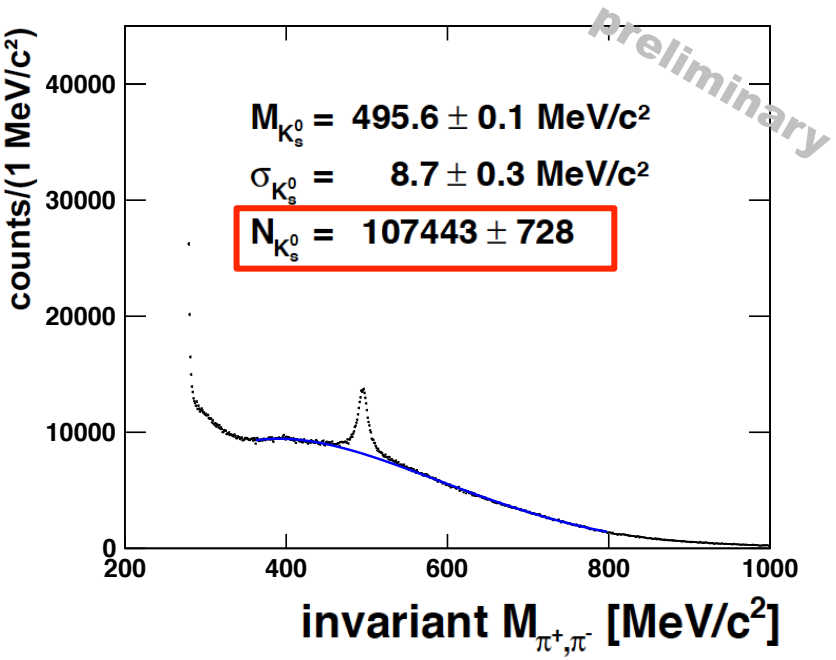
- M ≥ 3 LVL1 trigger for both runs



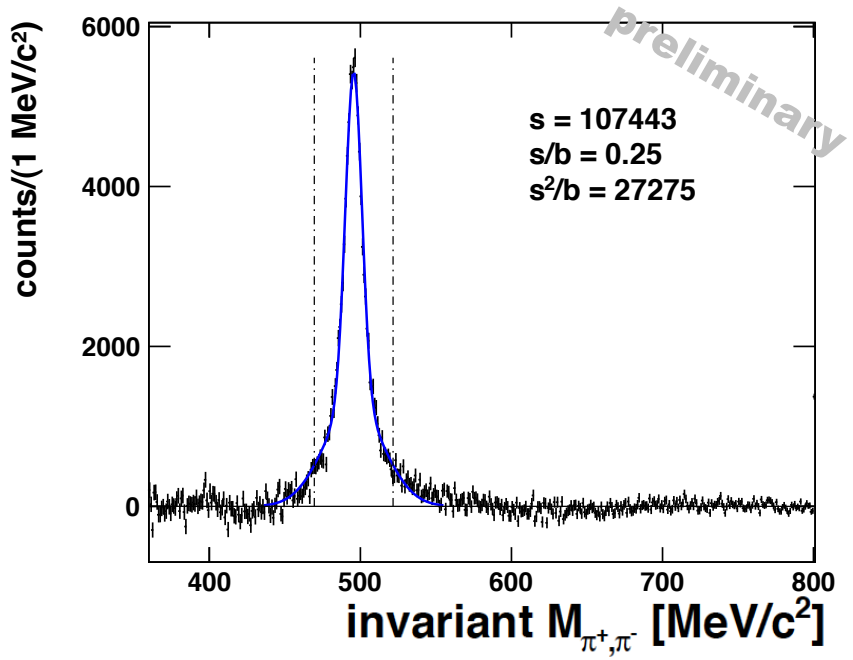
Results from the p+p experiment

K^0_S in p+p collisions

Invariant mass $\pi^+\pi^-$ after applying cuts



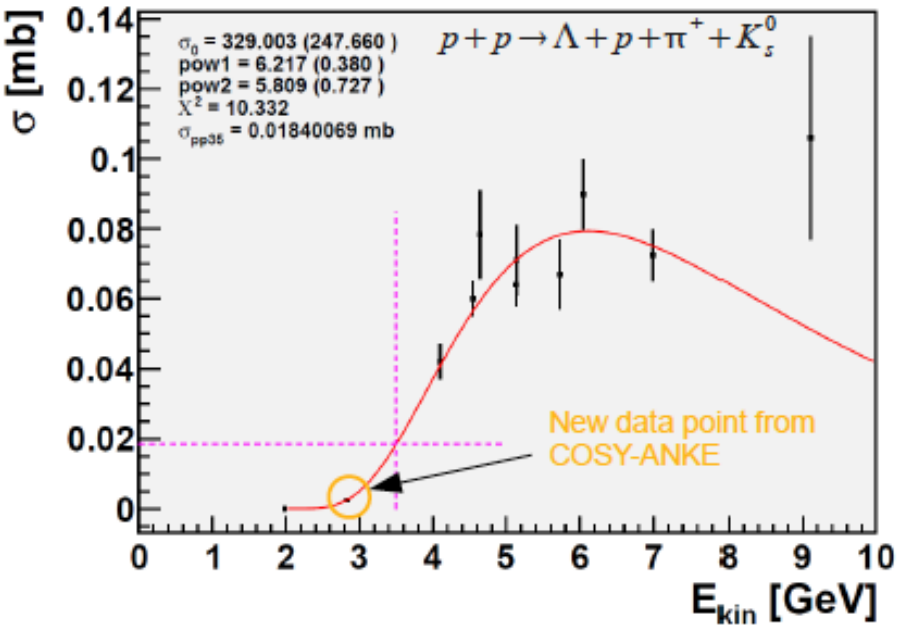
Background subtracted invariant mass $\pi^+\pi^-$



- Primary and secondary vertex cuts applied.
- Background reconstruction via mixed event method not possible due to correlated pions.
- Fitting curve: polynomial Landau fit (polynom of 3rd order).

PLUTO simulations

- Simulation of 13 K_s^0 production channels for p + p @ 3.5 GeV (91% of σ_{tot})
- $\sigma_{tot} = 0.10527$ mb



Phase space fit:

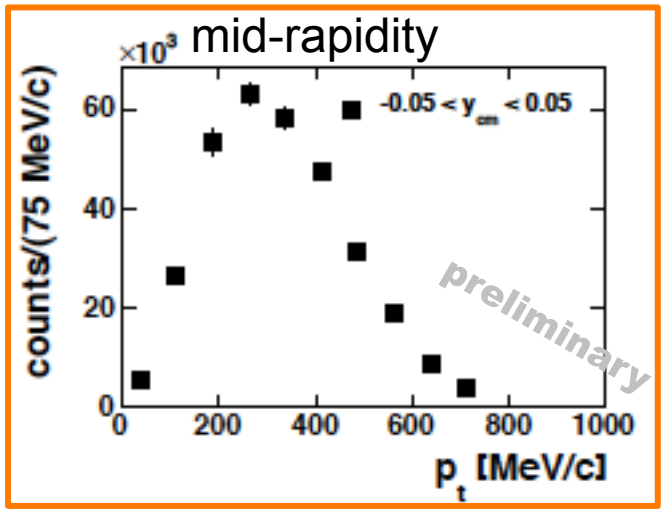
$$y = \sigma_0 \left(1 - \frac{s+2m}{x+2m}\right)^a \left(\frac{s+2m}{x+2m}\right)^b$$

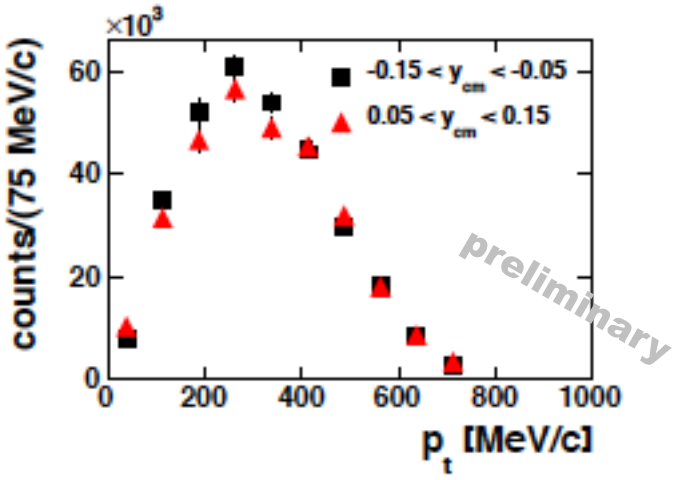
Reaction	σ [mb]
$p+p \to \Sigma^+ + p + K_s^0$	0.02128536
$p+p \to \Lambda + p + \pi^+ + K_s^0$	0.01840069
$p+p \to \Sigma^0 + p + \pi^+ + K_s^0$	0.01238090
$p+p \to p + n + K^+ + K_s^0$	0.00757802
$p+p \to \Sigma(1385)^+ + p + K_s^0$	0.00531218
$p+p \to \Lambda + n + \pi^+ + \pi^+ + K_s^0$	0.00508021
$p+p \to \Sigma^+ + n + \pi^+ + K_s^0$	0.00453141
$p+p \to \Lambda + \Delta^{++} + K_s^0$	0.00446818
$p+p \to \Lambda + p + \pi^+ + \pi^0 + K_s^0$	0.00446203
$p+p \to \Sigma^+ + p + \pi^0 + K_s^0$	0.00406263
$p+p \to \Sigma^- + p + \pi^+ + \pi^+ + K_s^0$	0.00375049
$p+p \to \Sigma^+ + p + \pi^+ + \pi^- + K_s^0$	0.00225889
$p+p \to p + p + \pi^+ + K_s^0 + K^-$	0.00202397

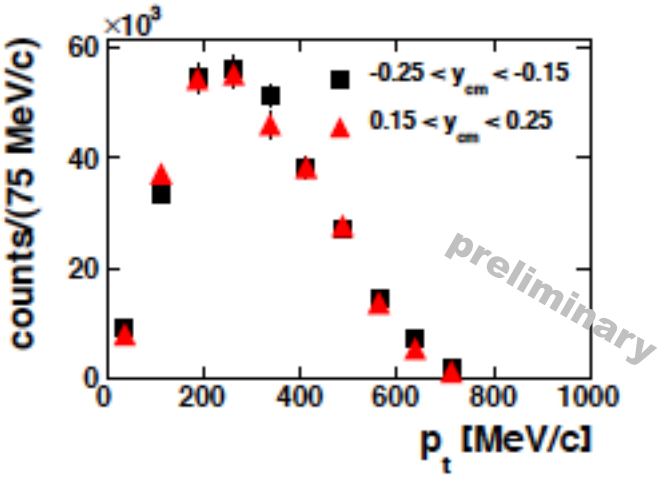
I. Frohlich et al. [HADES] PoS ACAT2007:076,2007.

p_t-spectra in p+p

Acceptance & efficiency corrected p_t-spectra

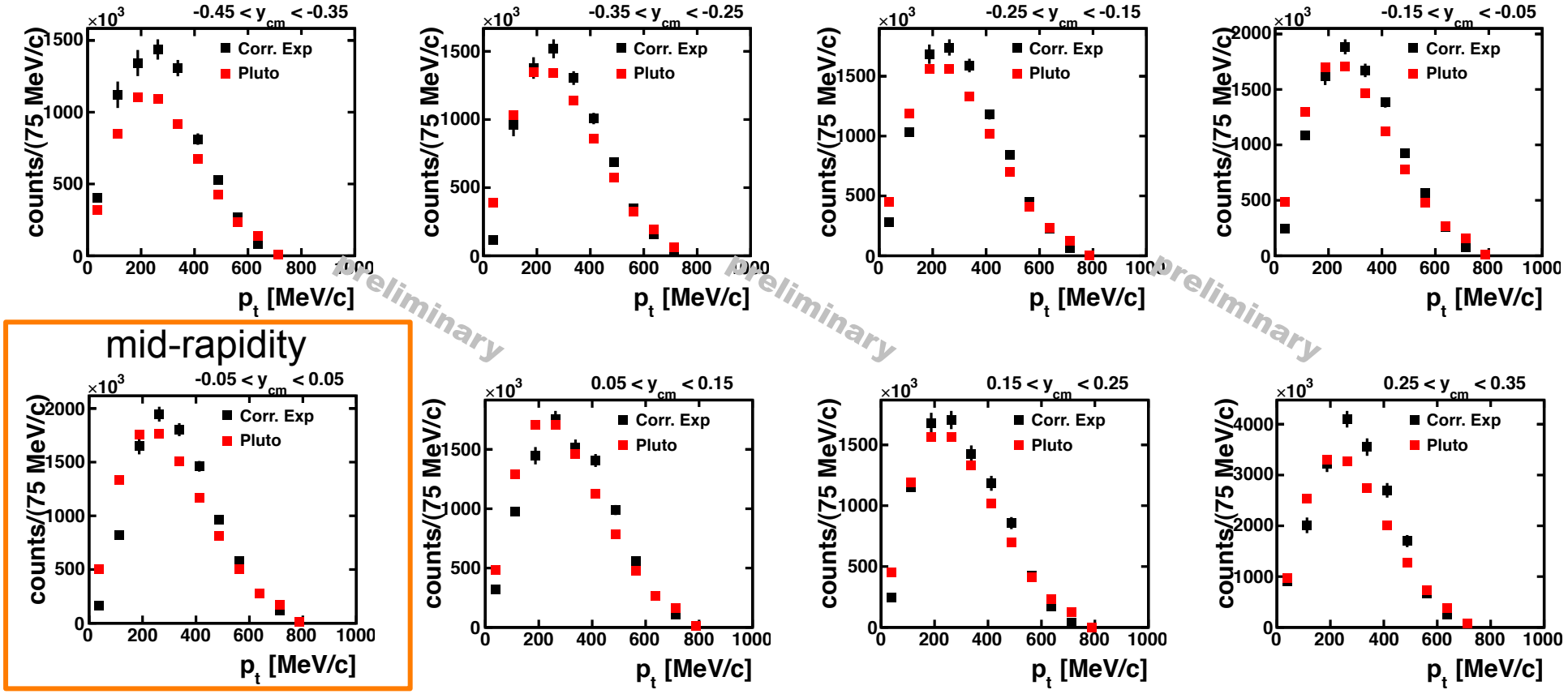






- High statistics obtained for the low-p_t region.
- Spectra show symmetry w.r.t. mid-rapidity (maximal deviation 10%) ➔ acceptance and efficiency corrections under control.

p_t-spectra in p+p: comparison with PLUTO simulations

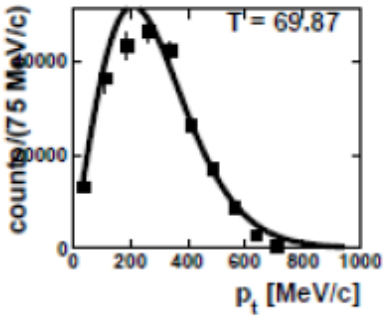


- Single normalization factor (from midrapidity).
- Spectra show good overall agreement.

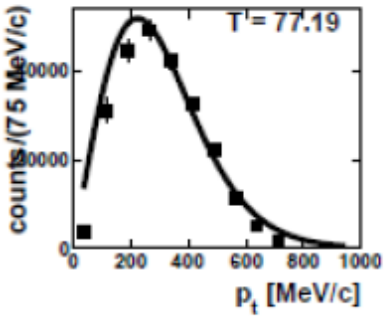
p_t-spectra in p+p and Boltzmann fits

- Fit in the region 200-750 MeV/c.

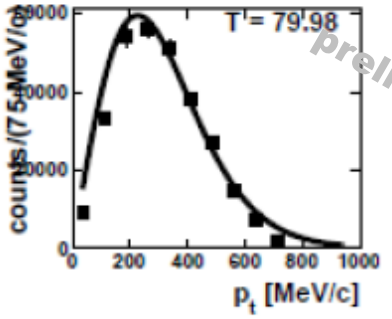
-0.45 < y_{cm} < -0.35



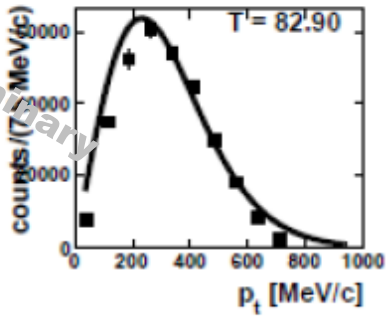
-0.35 < y_{cm} < -0.25



-0.25 < y_{cm} < -0.15

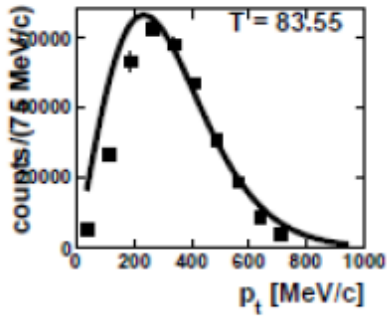


-0.15 < y_{cm} < -0.05

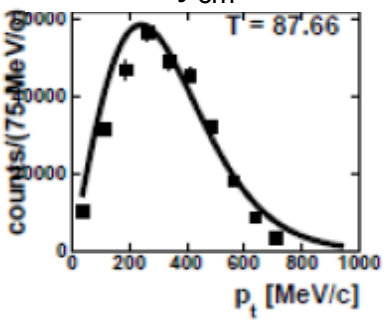


preliminary

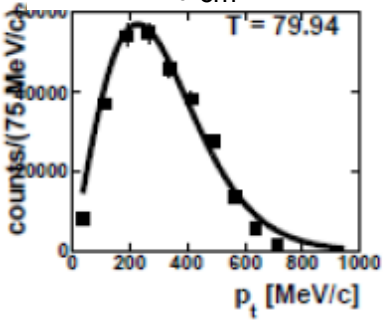
mid-rapidity



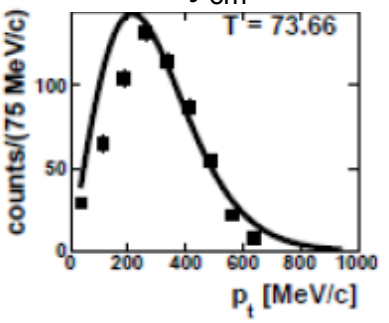
0.05 < y_{cm} < 0.15



0.15 < y_{cm} < 0.25



0.25 < y_{cm} < 0.35



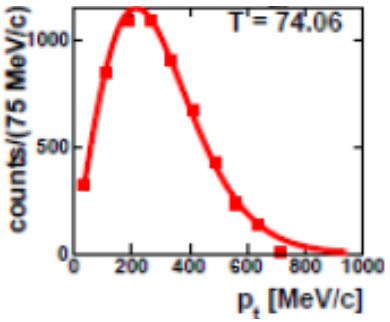
Boltzmann distribution for p_t

$$\frac{dN}{dp_t dy} = A \cdot p_t \cdot \sqrt{p_t^2 + m^2} \cdot \exp\left(-\frac{\sqrt{p_t^2 + m^2}}{T_B}\right)$$

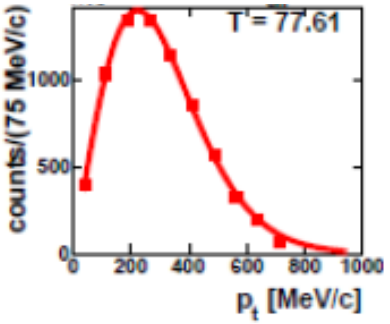
p_t-spectra in p+p (PLUTO simulation) and Boltzmann fits

- Fit in the region 200-750 MeV/c.

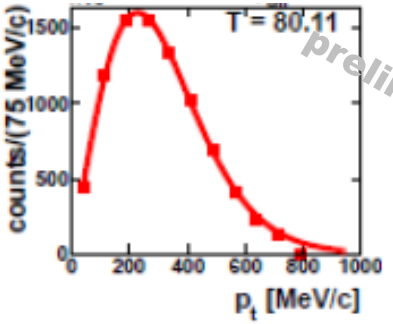
-0.45 < y_{cm} < -0.35



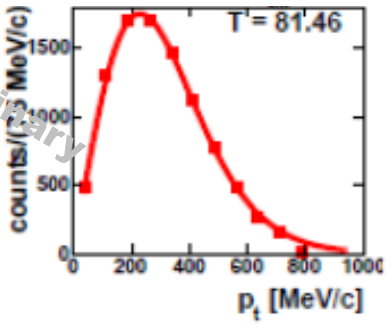
-0.35 < y_{cm} < -0.25



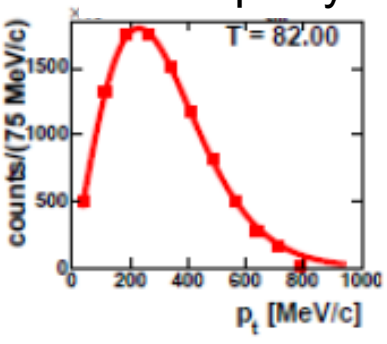
-0.25 < y_{cm} < -0.15



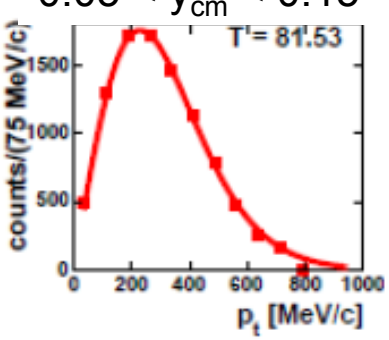
-0.15 < y_{cm} < -0.05



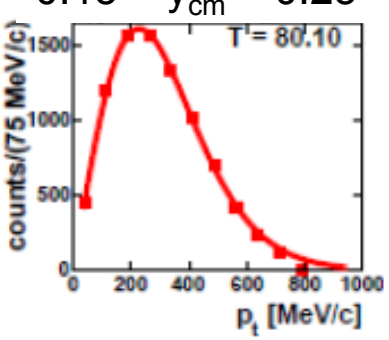
mid-rapidity



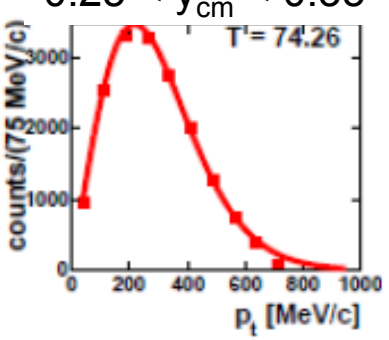
0.05 < y_{cm} < 0.15



0.15 < y_{cm} < 0.25



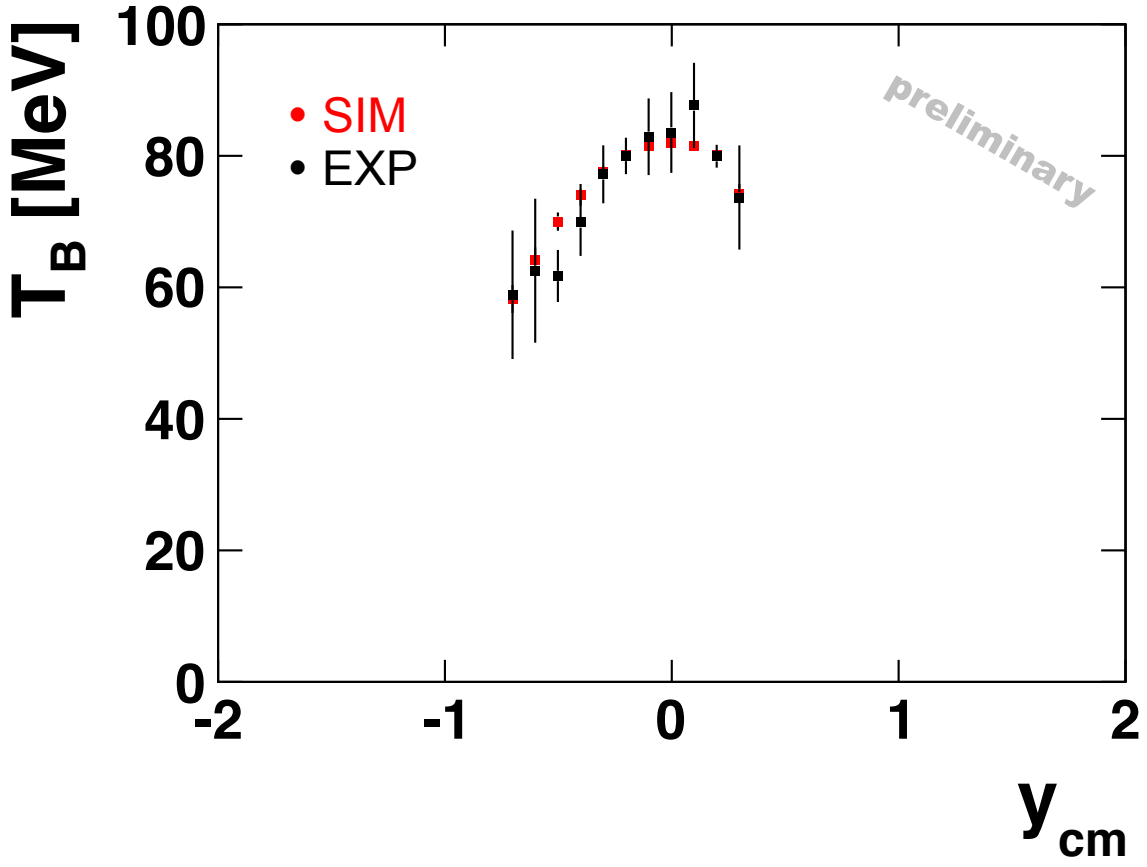
0.25 < y_{cm} < 0.35



Boltzmann distribution for p_t

$$\frac{dN}{dp_t dy} = A \cdot p_t \cdot \sqrt{p_t^2 + m^2} \cdot \exp\left(-\frac{\sqrt{p_t^2 + m^2}}{T_B}\right)$$

Boltzmann slope parameters: experiment versus simulation

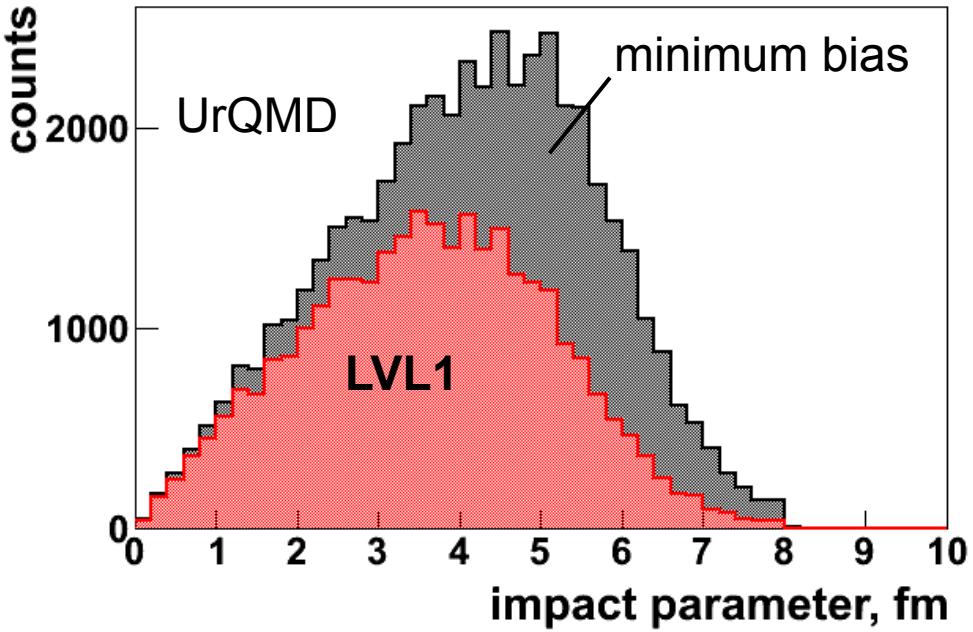


- Systematics from the variation of the fit range (±50 MeV/c).
- Good agreement between experiment and simulation for extracted slopes.
- Further studies with PYTHIA simulations.

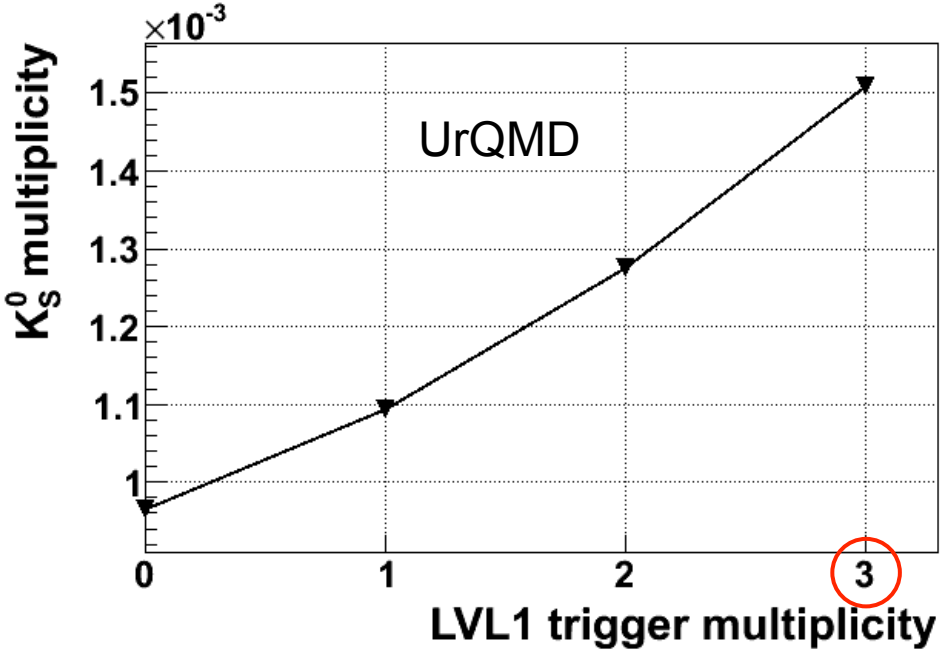
Results from the p + Nb experiment

p+Nb experiment: trigger issues

Centrality selection with LVL1 trigger



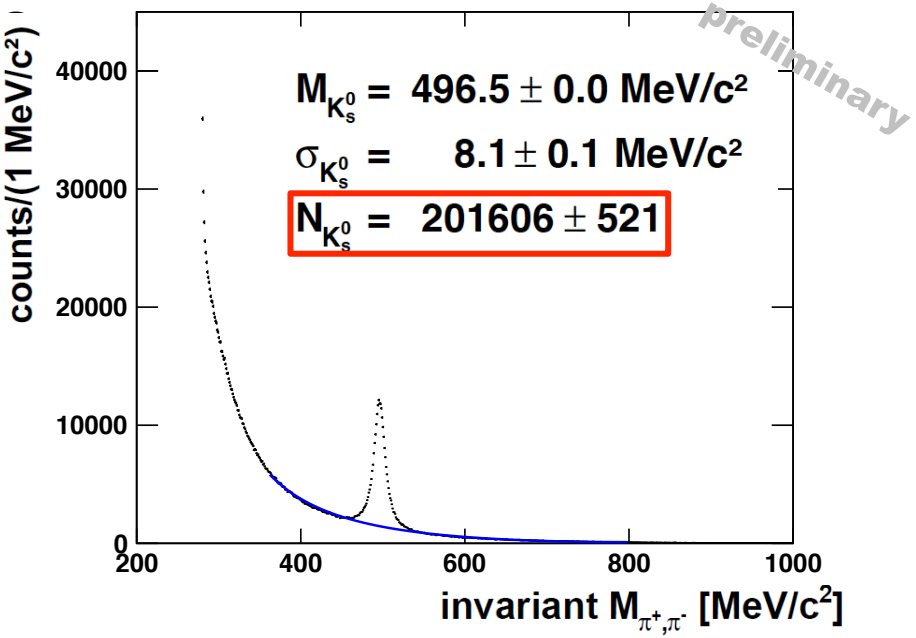
K^0_S multiplicity per event in the HADES acceptance versus LVL1 trigger mult.



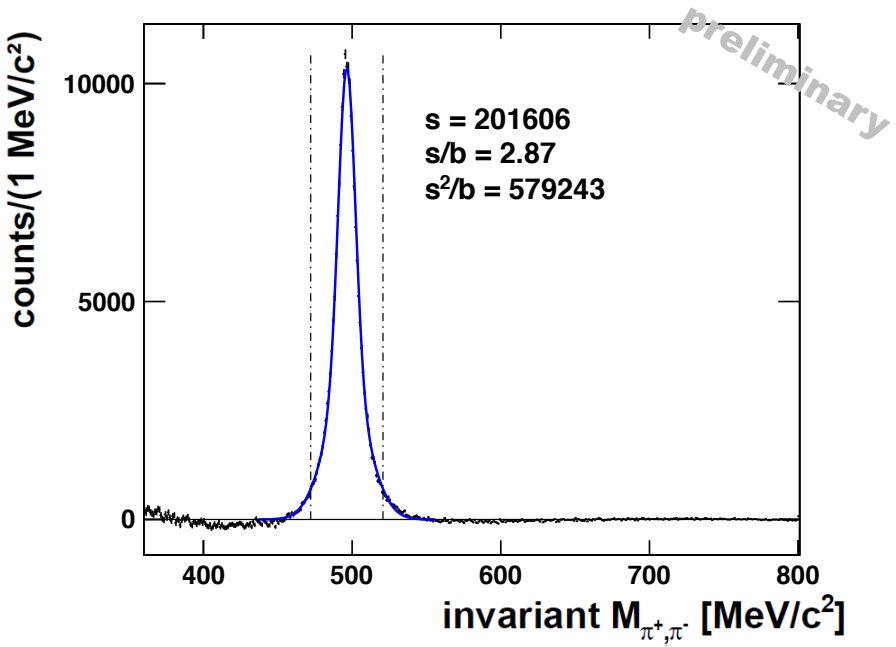
- M ≥ 3 LVL1 trigger was used.
- $\langle A_{part} \rangle \approx 2.7$.
- Ratio M3/minimum bias in the HADES acceptance **1.57.**

K^0_S signal in p+Nb

Invariant mass $\pi^+\pi^-$ after applying cuts



Background subtracted invariant mass $\pi^+\pi^-$

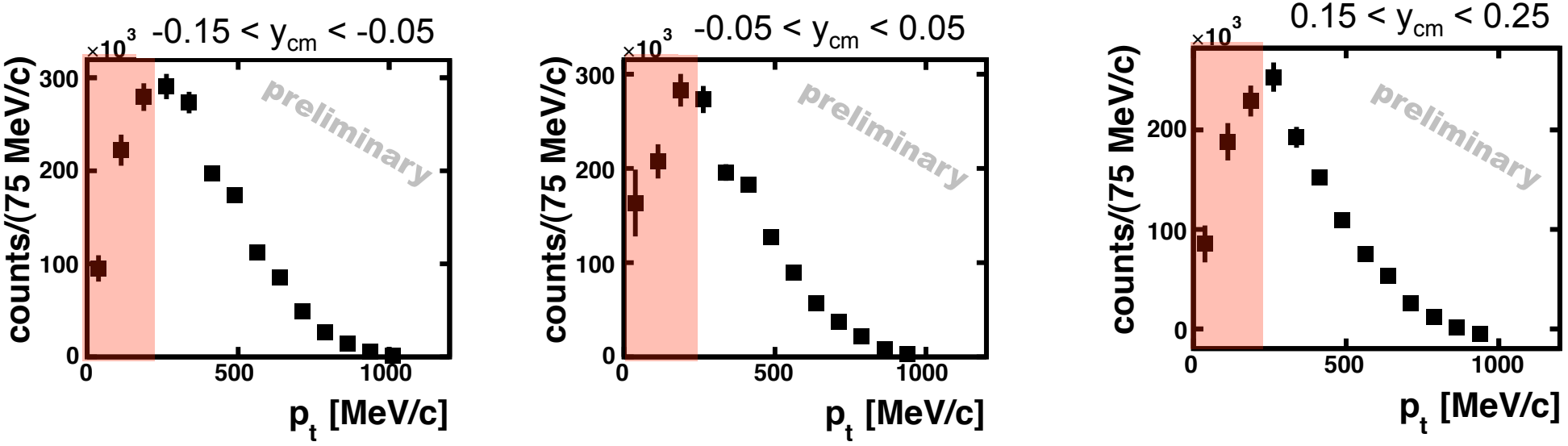


- Analysis strategy very similar to the p+p case.
- Background via polynomial landau fit.
- Mixed event background shown to give consistent results.

First p_t-spectra in p+Nb

Acceptance & efficiency corrected p_t-spectra

mid-rapidity



- Efficiency correction with the simulated tracks embedded into the real data.
- High statistics obtained for the low-p_t region.

Comparison

p + p experiment:

- Corrected p_t (m_t) spectra → high statistics in low p_t.
- Obtained p_t spectra are symmetric w.r.t. midrapidity → acceptance and efficiency corrections under control.
- Description of the low-p_t component:
  - Simulations with Pythia, GiBUU.

p + Nb experiment — cold nuclear matter:

- Corrected p_t spectra → high statistics in low p_t.
- Analyze p_t spectra with GiBUU.
- Extract pNb/pp ratio, analyze with transport models (GiBUU, HSD).

The HADES Collaboration

G. Agakishiev, A. Balanda, D. Belver, A. Belyaev, A. Blanco, M. Böhmer, J. L. Boyard, P. Cabanelas, E. Castro, J.C. Chen, S. Chernenko, J. Díaz, A. Dybczak, E. Epple, L. Fabbietti, O. Fateev, P. Finocchiaro, P. Fonte, J. Friese, I. Fröhlich, T. Galatyuk, J. A. Garzón, A. Gil, M. Golubeva, D. González-Díaz, F. Guber, M. Gumberidze, T. Hennino, R. Holzmann, P. Huck, A. Ierusalimov, I. Iori, A. Ivashkin, M. Jurkovic, B. Kämpfer, T. Karavicheva, I. Koenig, W. Koenig, B. W. Kolb[4], A. Kopp[8], G. Korcyl, G.K. Kornakov, R. Kotte[5], A. Kozuch, A. Krása, F. Krizek[14], R. Krücken[11], H. Kuc, W. Kühn, A. Kugler, A. Kurepin, A. Kurilkin, P. Kurilkin, P. Kähltz[5], V. Ladygin[6], R. Lalik, J. Lamas-Valverde, S. Lang, K. Lapidus, T. Liu, L. Lopes, M. Lorenz[7], L. Maier, A. Mangiarotti[2], J. Markert, V. Metag, B. Michalska, J. Michel, C. Müntz[7], R. Münzer, L. Naumann, Y. C. Pachmayer[7], M. Palka, Y. Parpottas, V. Pechenov[4], O. Pechenova, J. Pietraszko, W. Przygoda[3], B. Ramstein, A. Reshetin, J. Roskoss[8], A. Rustamov, A. Sadovsky, P. Salabura[3], A. Schmah, J. Siebenson, Yu. G. Sobolev[14], S. Spataro, H. Ströbele, J. Stroth, C. Sturm[4], A. Tarantola[7], K. Teilab[7], P. Tlusty[14], M. Traxler, R. Trebacz, H. Tsertos, T. Vasiliev[6], V. Wagner[14], M. Weber[11], J. Wüstenfeld[5], S. Yurevich, Y. Zanevsky[6]