V^0 Reconstruction in Au+Au at 1.23 AGeV with HADES

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Outline

- Strangeness Production at SIS energies
- Au+Au at 1.23 AGeV with HADES
- Reconstruction of weakly decaying hadrons Λ and K_S^0
  - Off-Vertex reconstruction (V^0)
  - Differential analysis in m_t-y
  - Preliminary results of corrected m_t spectra

Strangeness Production @ SIS Energies

Elementary collisions (nucleon - nucleon)

$$
\begin{aligned}
NN &\rightarrow K^+ \Lambda N && (E_{kin} = 1.58\ AGeV)\\
NN &\rightarrow K^0_S \Lambda N && (E_{kin} = 1.59\ AGeV)\\
NN &\rightarrow K^+ K^- NN && (E_{kin} = 2.49\ AGeV)\\
NN &\rightarrow \phi NN && (E_{kin} = 2.59\ AGeV)
\end{aligned}
$$

Heavy-Ion collisions (nucleus - nucleus)

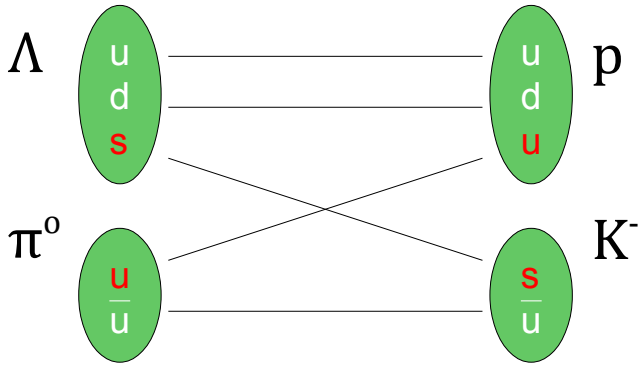
1

Accumulation of energy in secondary collisions

$$NN \rightarrow N\Delta \qquad NN \rightarrow N\Delta$$
$$N\Delta \rightarrow NNK^+K^- \qquad N\Delta \rightarrow NK^+\Lambda$$

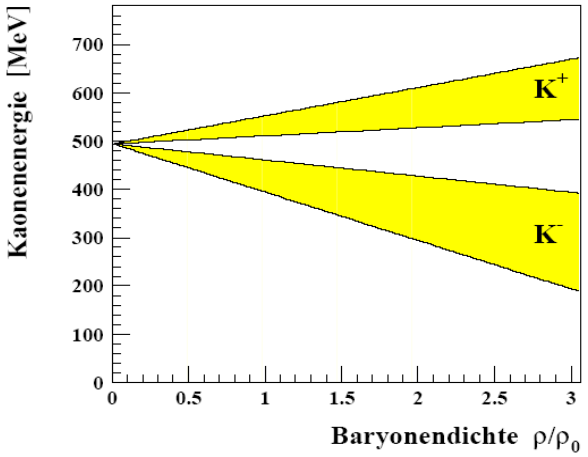
2

Strangeness exchange



3

Effective Kaon potentials

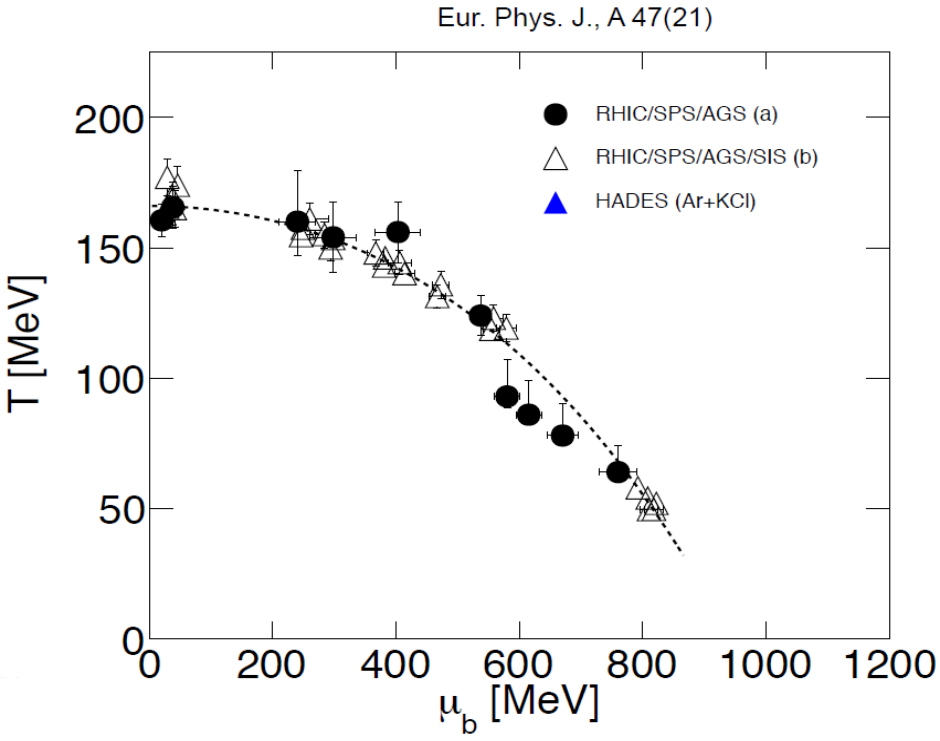


Calculation by J. Schaffner-Bielich

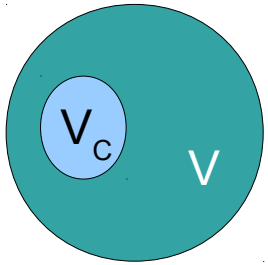
Statistical Model

- Determination of particle production yields coming from a thermal source (volume V, temperature T and chemical potential μ)

$$Z_i^1 = \pm \frac{g_i}{2\pi^2} \int_0^\infty p^2 dp \ln\left[1 \pm \exp\left(\frac{\vec{q}_i\vec{\mu} - E_i}{T}\right)\right]$$



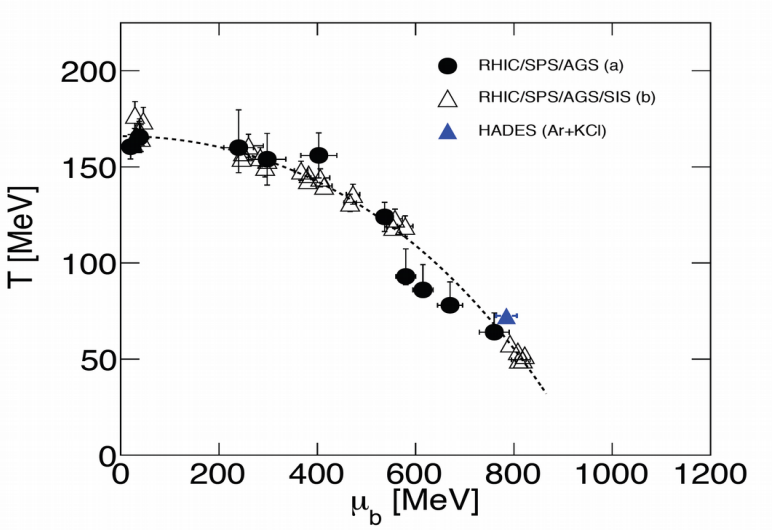
- (Strangeness-)canonical ensemble for SIS energies (1-2 AGeV):
  - Number of particles carrying quantum number (strangeness) is small
    → exact strangeness conservation over sub-volume with R_C in Au+Au at 1.23 AGeV needed

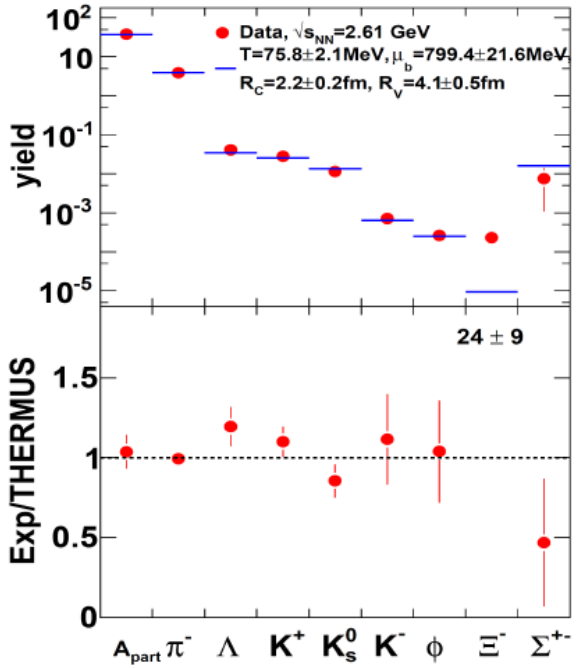


Hadron Production with HADES

- Ar+KCl at 1.76 AGeV: complete set of strange hadron yields measured/determined
- Description of particle production yields with Statistical Hadronization Model (SHM) in good agreement with data

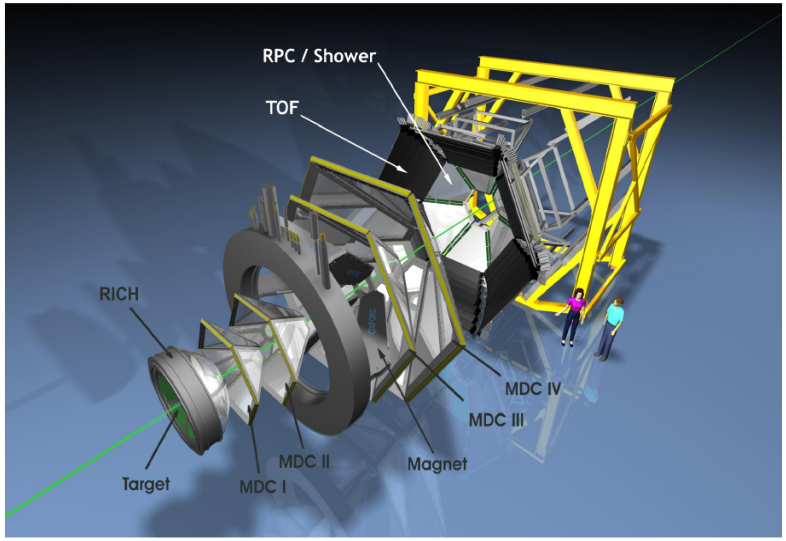
Particle	Multiplicity	T_{eff} [MeV]
π^-	$3.9 \pm 0.1 \pm 0.1$	$82.4 \pm 0.1^{+9.1}_{-4.6}$
$\Lambda + \Sigma^0$	$(4.09 \pm 0.1 \pm 0.17^{+0.17}_{-0.37}) \times 10^{-2}$	$95.5 \pm 0.7 + 2.2$
K^+	$(2.8 \pm 0.2 \pm 0.1 \pm 0.1) \times 10^{-2}$	$89 \pm 1 \pm 2$
K^0_S	$(1.15 \pm 0.05 \pm 0.09) \times 10^{-2}$	92 ± 2
K^-	$(7.1 \pm 1.5 \pm 0.3 \pm 0.1) \times 10^{-4}$	$69 \pm 2 \pm 4$
ϕ	$(2.6 \pm 0.7 \pm 0.1 - 0.3) \times 10^{-4}$	84 ± 8
Ξ^-	$(2.3 \pm 0.9) \times 10^{-4}$	-
$\Sigma^+ + \Sigma^-$	$(0.75 \pm 0.65) \times 10^{-2}$	-





G. Agakishiev et al., (HADES Collaboration), Eur. Phys. J. A 47, 21 (2011)

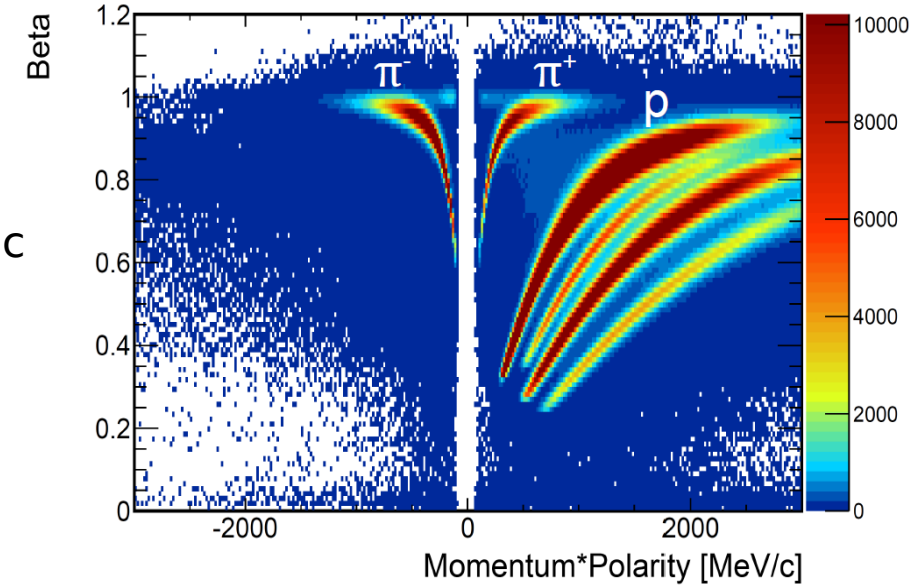
Au+Au Collisions at 1.23 AGeV with HADES



- High geometrical acceptance optimized for e^+/e^- pairs
- Full azimuthal coverage ϕ
  Polar angle θ = 18°-85°
- Multi-Wire Drift Chambers (MDC) +
  Magnetic field: Track reconstruction (incl. p)
- Hadron identification:
  energy-loss in MDC/TOF
  time-of-flight walls: TOF & RPC

Au+Au in April 2012

- 557 hours of beam
- Beam Rate: 1.2 – 1.5 x 10^6 ions / sec
- Trigger Rate: 8 kHz (200 Mbyte/s)
  → 7.4 x 10^9 events recorded
- $\langle A_{part} \rangle \approx 174$



Weak Decays

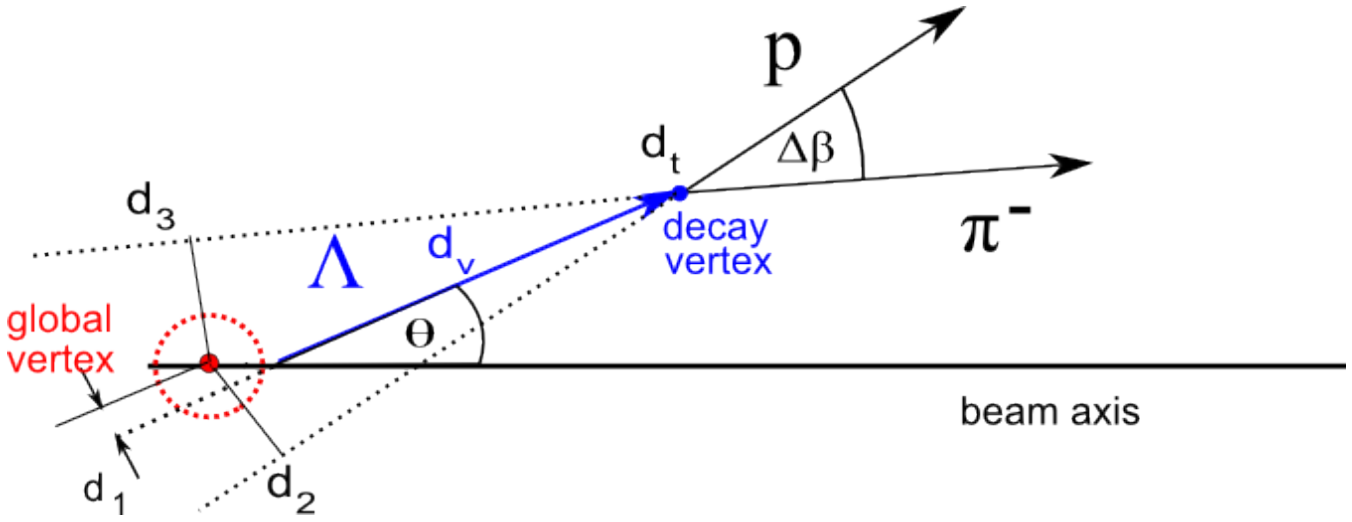
	Decay Length $c\tau$ [cm]	BR [%]	$\sqrt{s_{tr}}$ [GeV]	$\sqrt{s} - \sqrt{s_{tr}}$ [GeV]
$K_s^0((d\bar{s} + \bar{d}s)\sqrt{2}) \to \pi^+\pi^-$	**2.68**	**69.2**	**2.55**	**-0.14**
$\Lambda(uds) \to p\pi^-$	**7.89**	**63.9**	**2.55**	**-0.14**

- reconstruction via invariant mass of charged particles

$$m_{inv} = \sqrt{(m_1^2 + m_2^2) + 2 \cdot \left(\sqrt{m_1^2 + (\vec{p}_1 c)^2}\sqrt{m_2^2 + (\vec{p}_2 c)^2} - |\vec{p}_1|\,|\vec{p}_2|\,c^2 \cos\theta_{1,2}\right)}$$

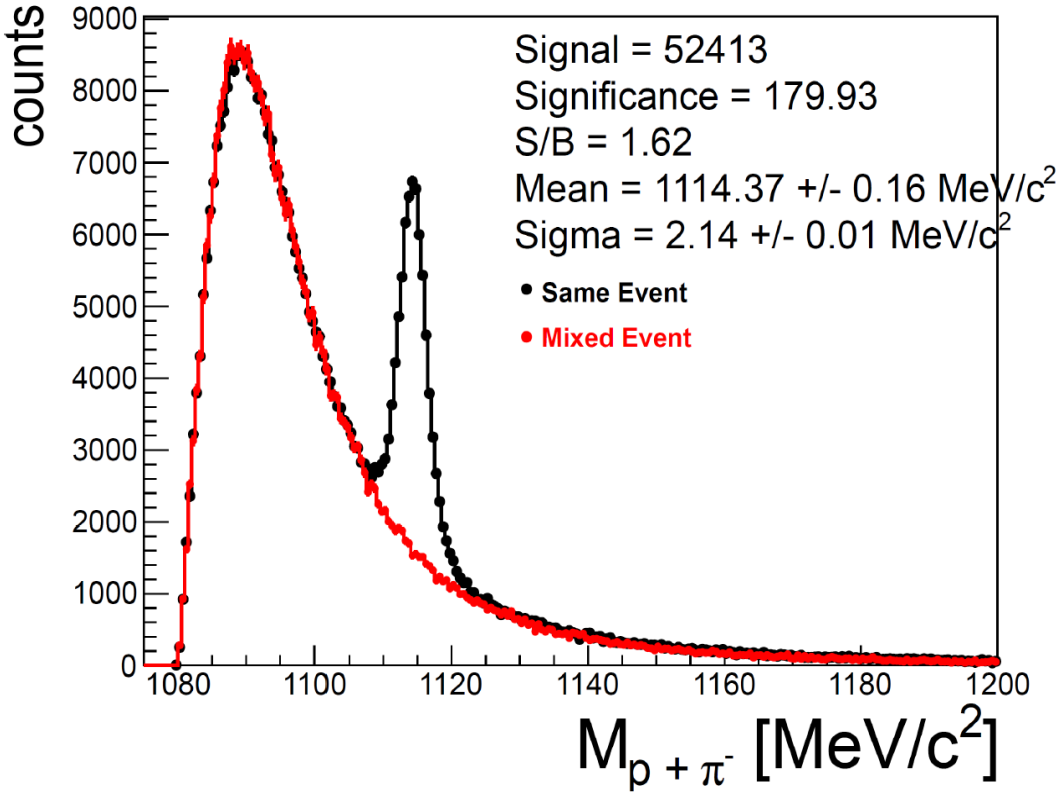
- long life-times allow for secondary vertex reconstruction
- Au-Au @ 1.23 AGeV: all strange particles produced below their NN threshold
- More sub-threshold strange hadron production (K^+,K^-,Φ):
  see talk H. Schuldes

Background Suppression



d_1: dist. primary particle track – prim. Vertex
d_v: dist. prim. vertex – decay vertex
d_2: min. dist. prim. vertex – daughter$_1$ track
d_3: min. dist. prim. vertex – daughter$_2$ track
d_t : distance of closest approach of daughter particles

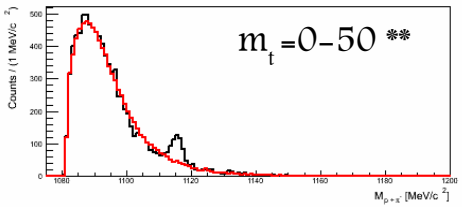
Δβ: opening angle

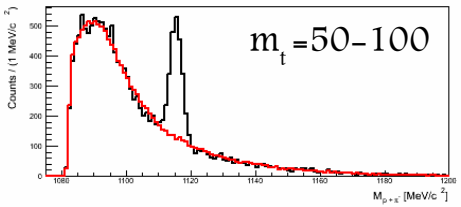


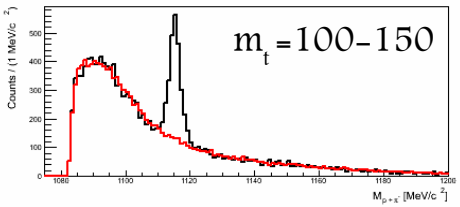
- First observation of sub-threshold Λ production
- Highly significant data sample comparable to Ar+KCl
- Background description via Mixed Event method
- Sufficient statistics for differential analysis as a function of m_t and y

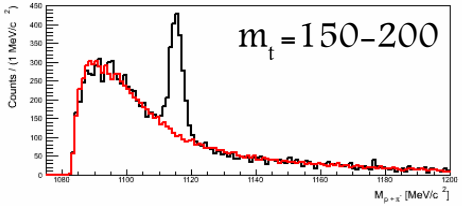
Differential Phase Space Analysis (*e.g. 0.7 < y < 0.8*)

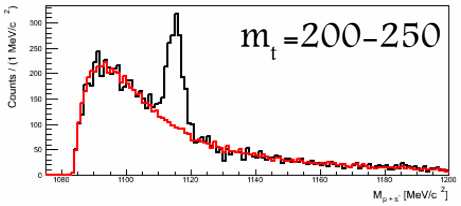
$\Lambda \rightarrow p\pi^-$

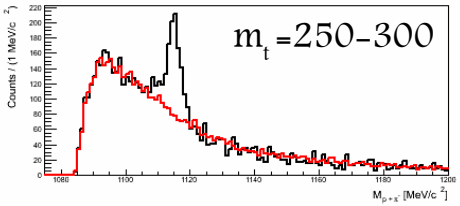


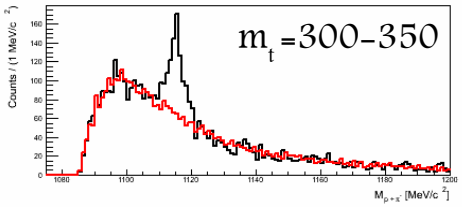


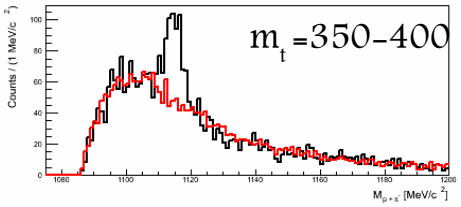


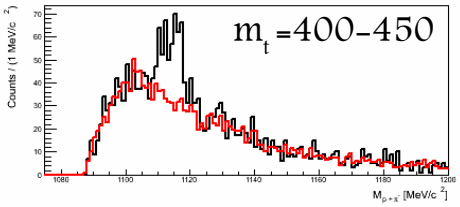


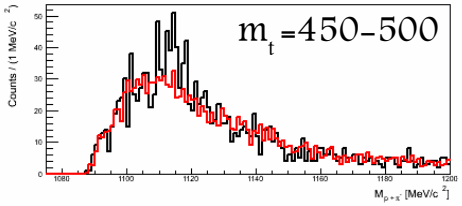


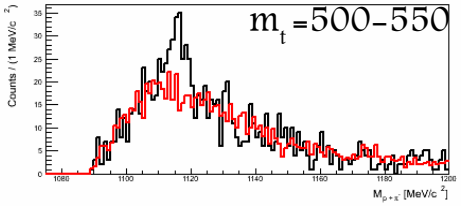


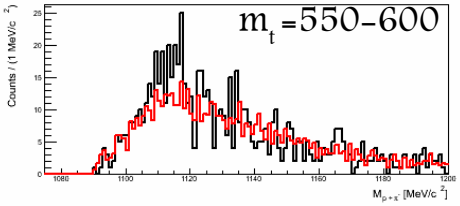












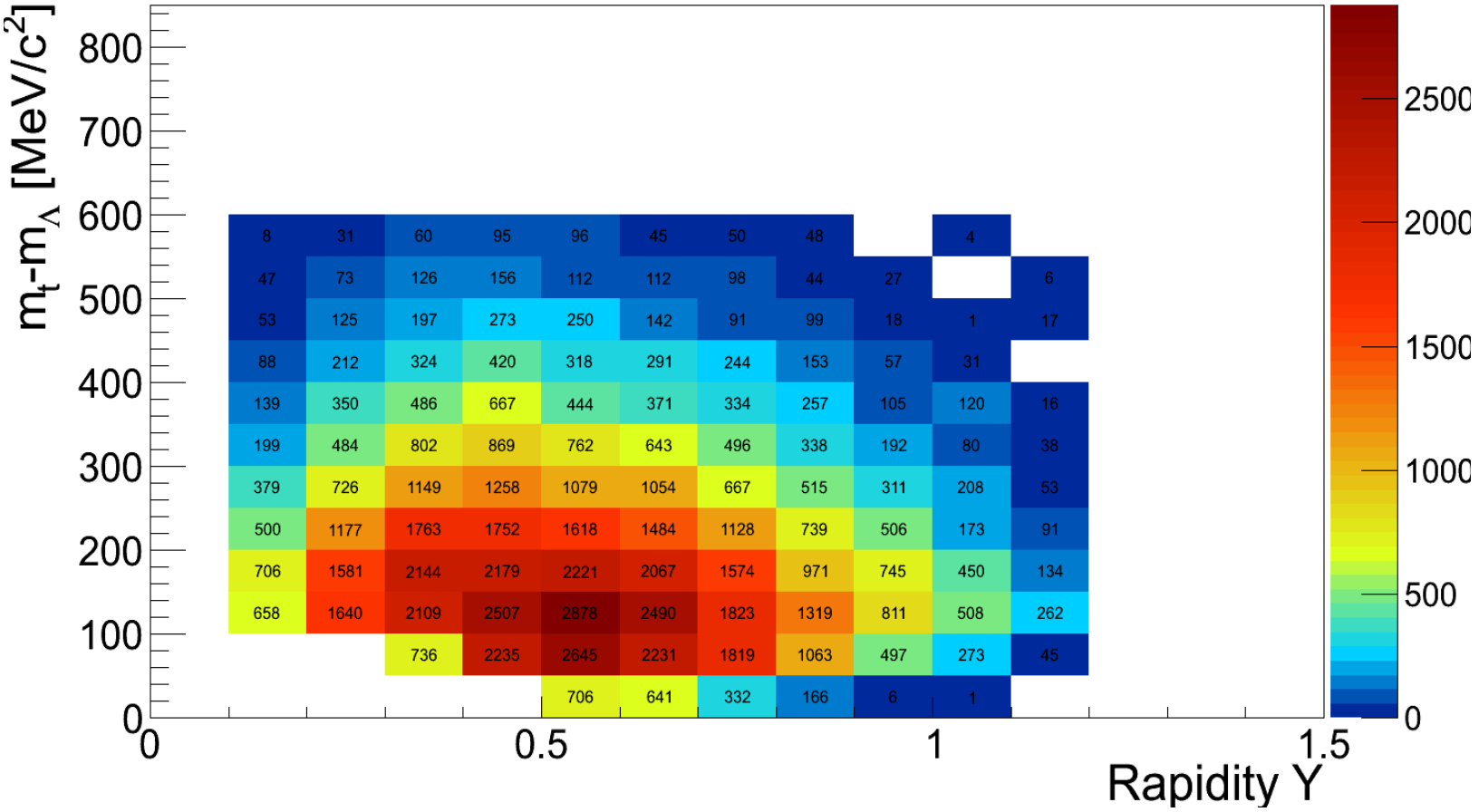
** in [MeV/c²]

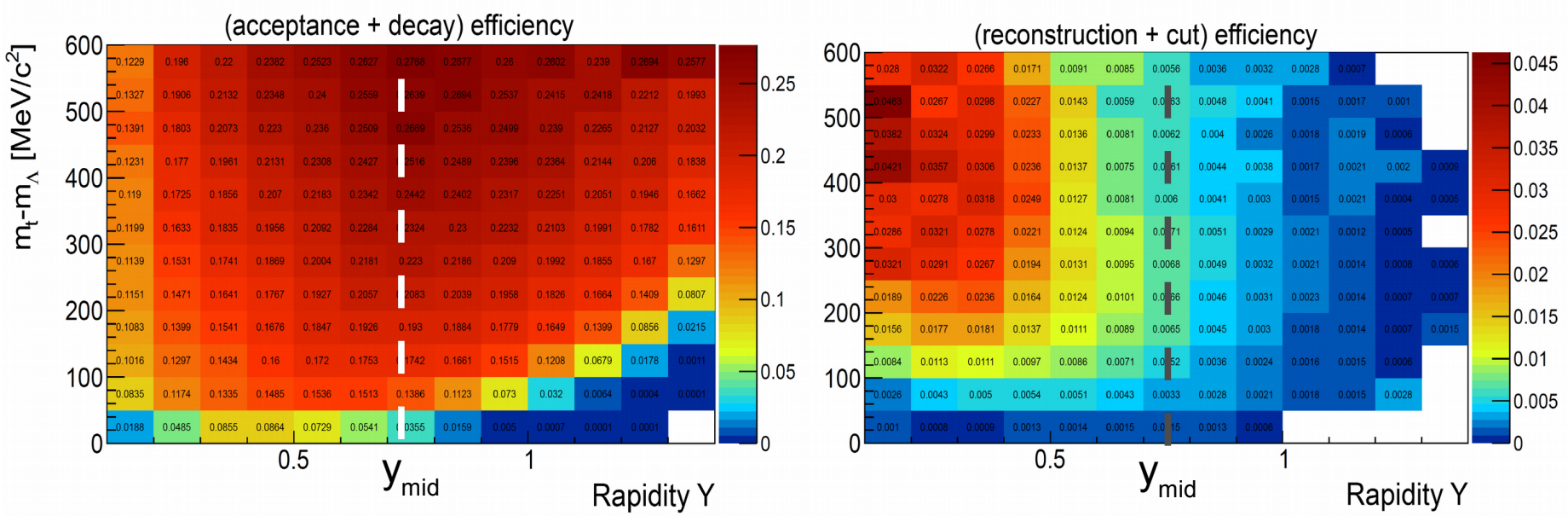
data

mixed event

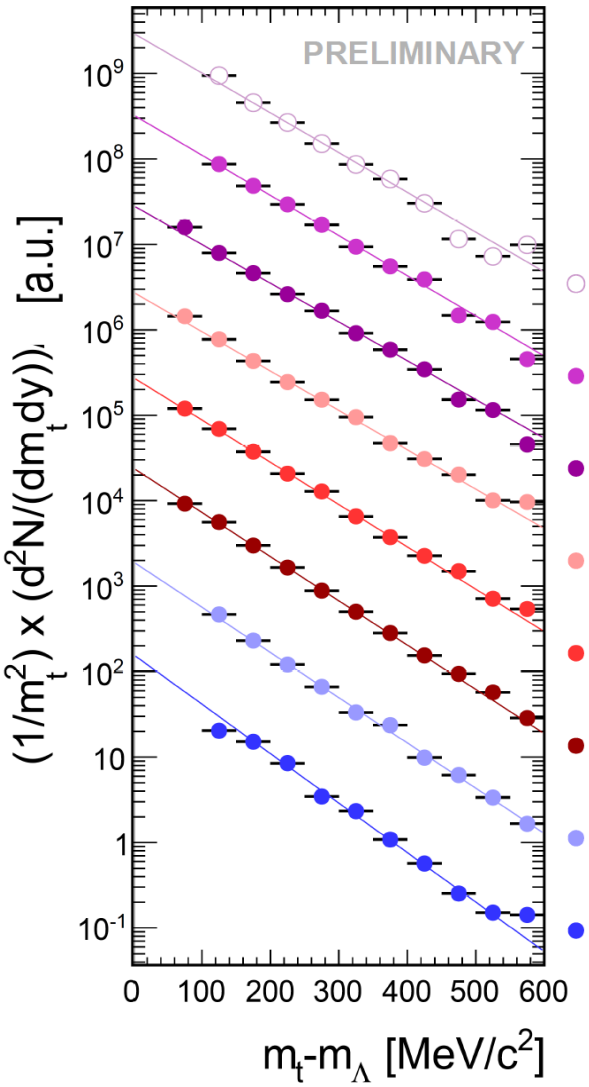
Differential Phase Space Analysis (*e.g. 0.7 < y < 0.8*)

$\Lambda \rightarrow p\pi^-$





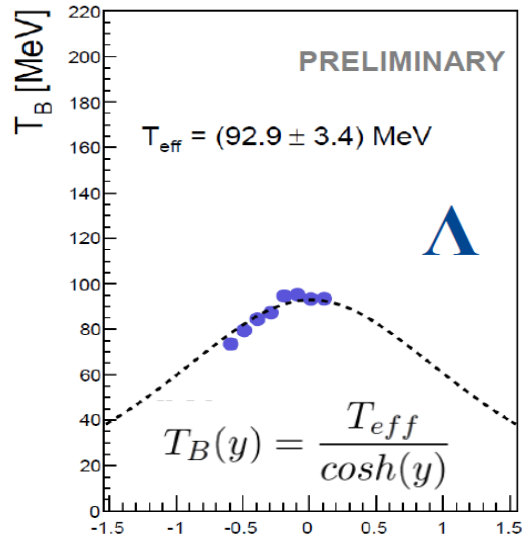
- Particles produced in Monte Carlo Simulation (Pluto) and propagated through GEANT
- Acceptance around 15-25%
- Reconstruction efficiency an order of magnitude lower due to strong off vertex constraints

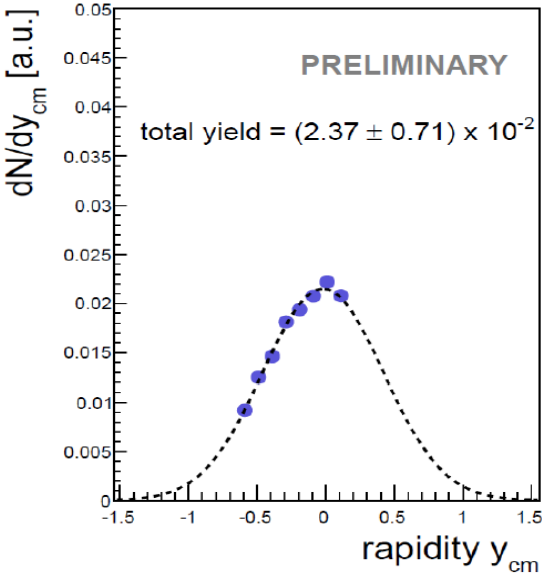


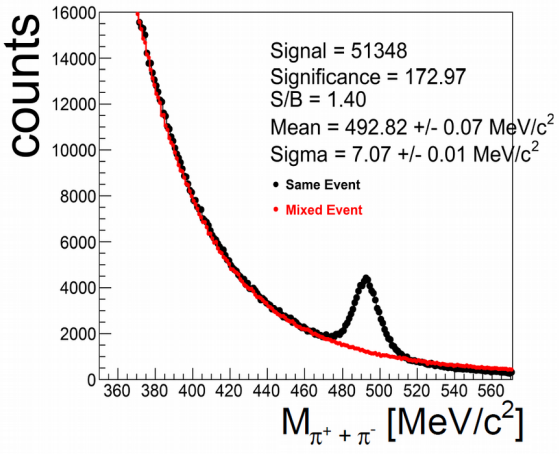
fit function

$$\frac{1}{m_t^2}\frac{d^2N}{dm_t dy} = C(y) \cdot exp\left(-\frac{(m_t - m_0)c^2}{T_B(y)}\right)$$

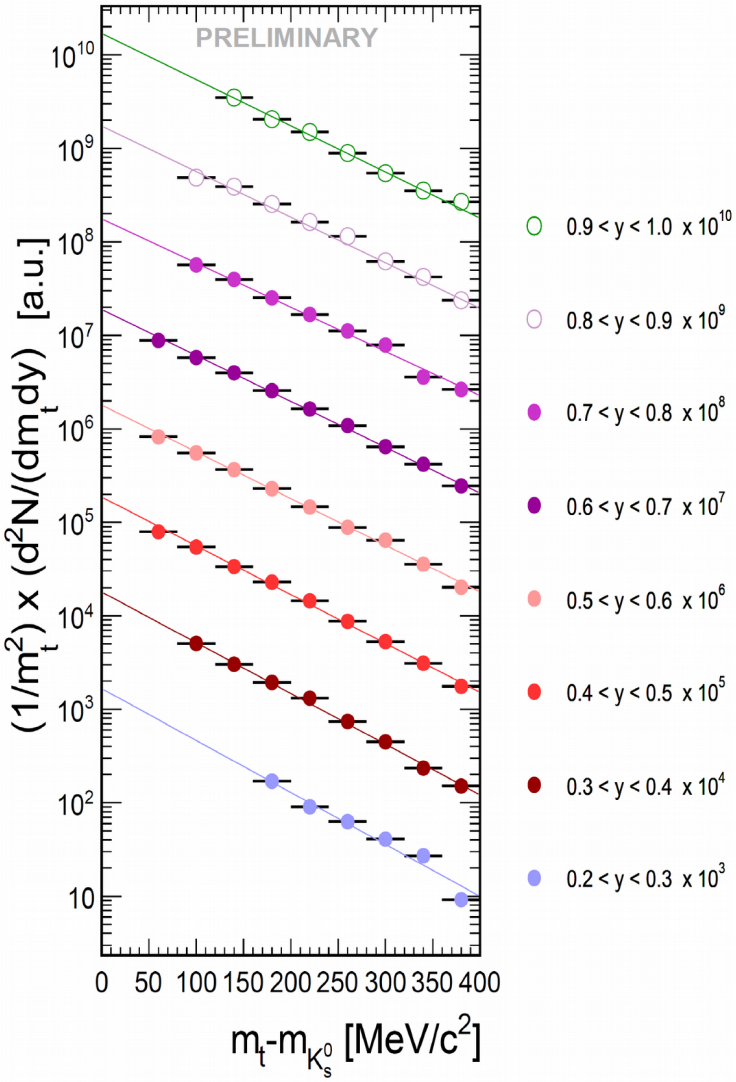
- 0.8 < y < 0.9 x 10^9
- 0.7 < y < 0.8 x 10^8
- 0.6 < y < 0.7 x 10^7
- 0.5 < y < 0.6 x 10^6
- 0.4 < y < 0.5 x 10^5
- 0.3 < y < 0.4 x 10^4
- 0.2 < y < 0.3 x 10^3
- 0.1 < y < 0.2 x 10^2

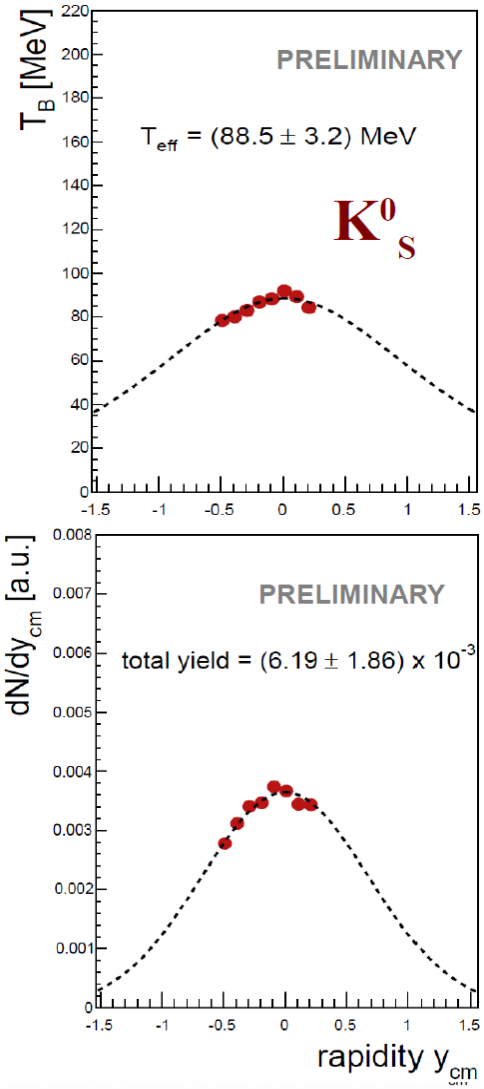




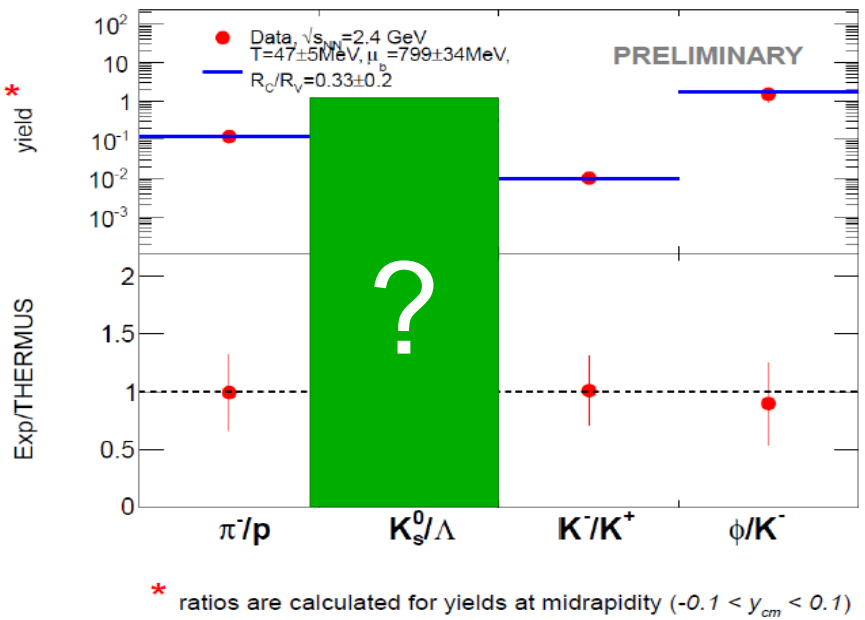


$K_S^0 \rightarrow \pi^+\pi^-$



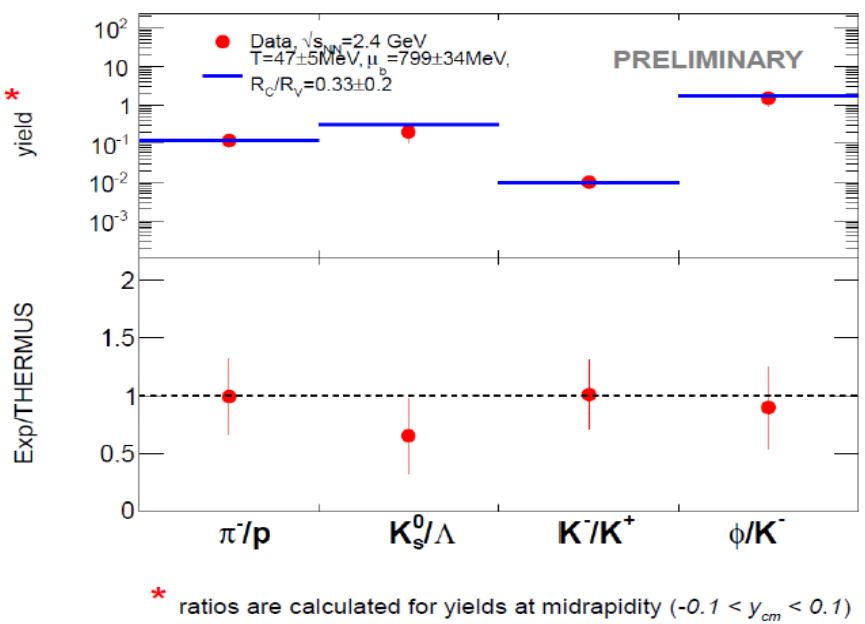


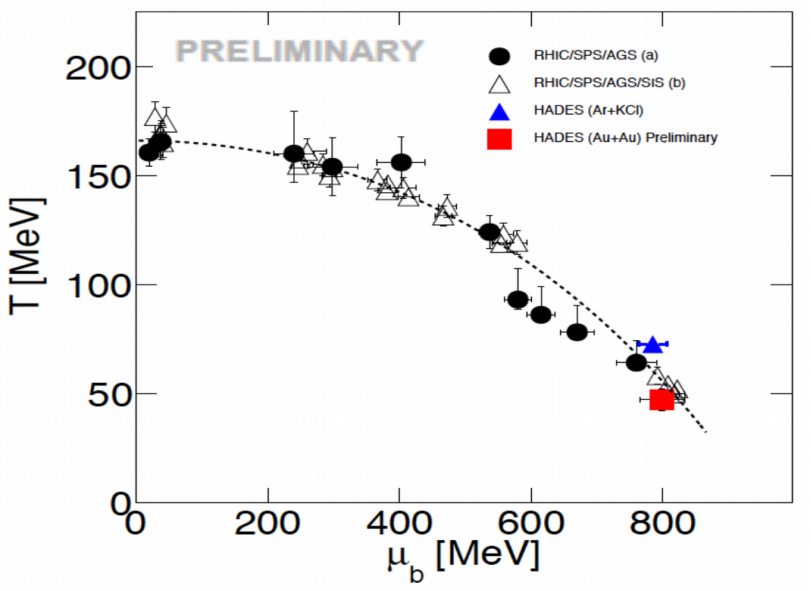
Statistical Model Fit in Au+Au



* ratios are calculated for yields at midrapidity ($-0.1 < y_{cm} < 0.1$)

Statistical Model Fit in Au+Au





- First attempt of statistical model fit gives reasonable values:

$T = 47 \pm 5$ MeV

$\mu_B = 799 \pm 34$ MeV

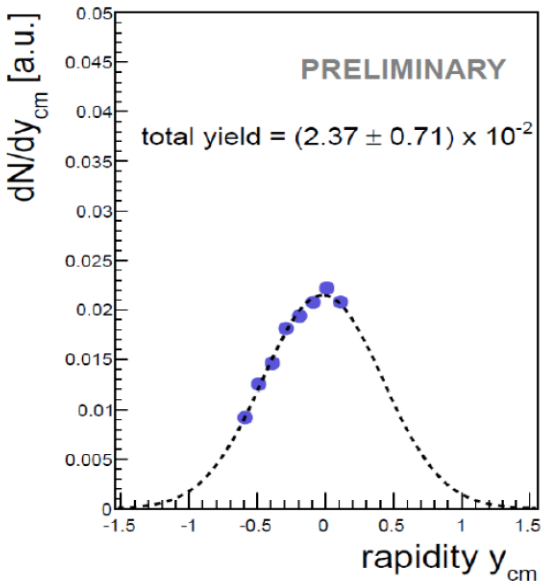
$R_C/R_V = 0.3 \pm 0.2$

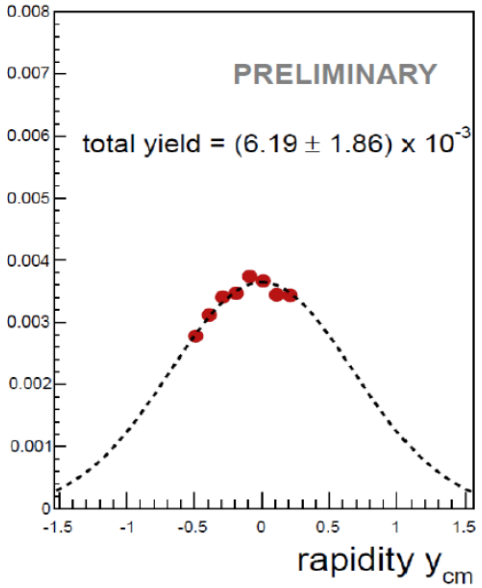
Summary

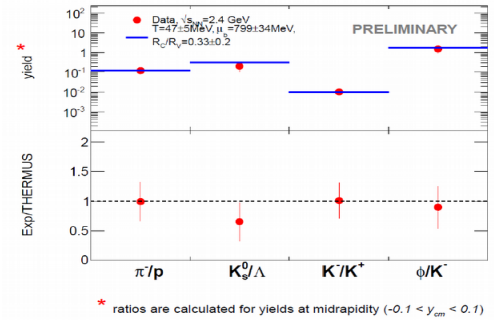
- Successful Au+Au run with HADES
- Sufficient statistics for differential analysis in terms of m_t – y
- Preliminary corrected m_t, dN/dy, T_B spectra presented
- Preliminary ratios consistent with statistical model

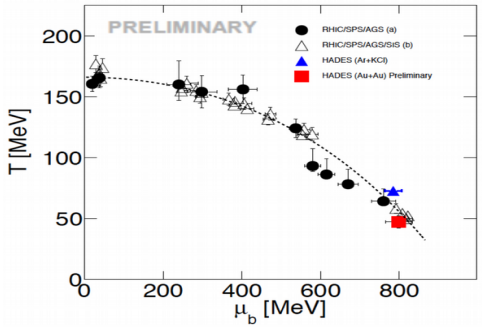
Outlook

- Finalizing results
- Search for deep subthreshold particle states









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