# Protons and Light Nuclei in Au+Au Collisions at 1.23A GeV with HADES

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## Introduction

- Highest baryochemical potential at freeze out
- Clear baryon domination and hierarchy in hadron multiplicity:
  $M_p \approx 100$, $M_\pi \approx 10$, $M_{K+} \approx 10^{-2}$, $M_{K-} \approx 10^{-4}$
- About 50 % of baryons are bound in light nuclei, important to study in order to extract bulk properties

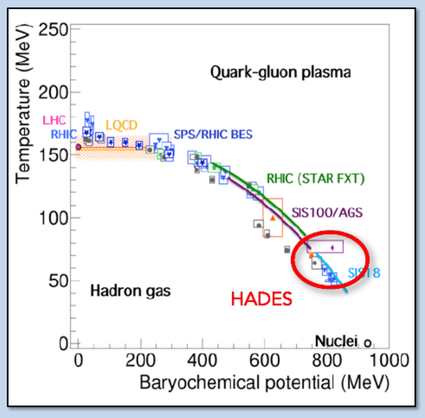



FIG. 1: Phase diagram of nuclear matter in the temperature T and baryochemical potential $\mu_B$ representation. The data points are estimated from a statistical model fit to measured particle yields.

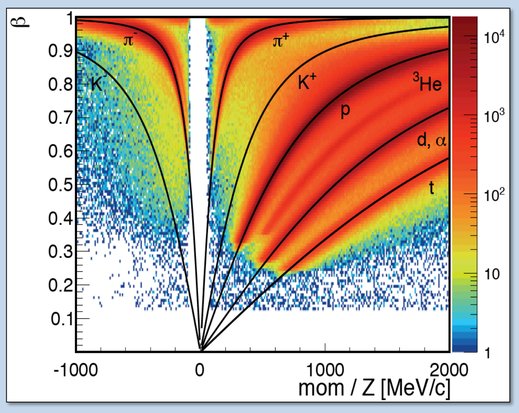



FIG. 2: Correlation between measured time-of-flight (β) and particle momentum. Black lines correspond to the expected values of the different particles.

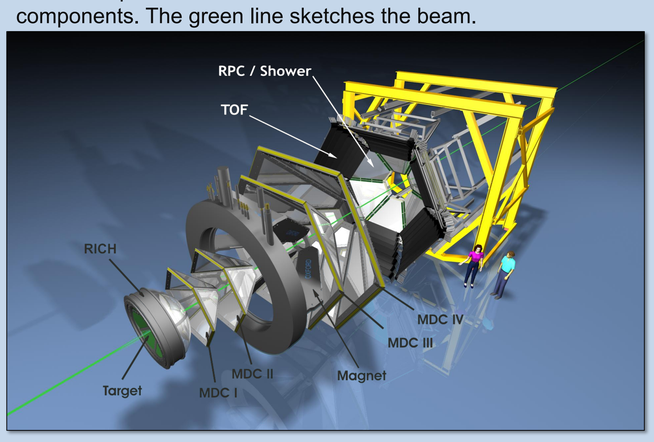
The **H**igh **A**cceptance **DiE**lectron **S**pectrometer [1]

- is a fixed target experiment
- has a large acceptance and trigger rate up to 8kHz
- Au + Au collisions at 1.23A GeV ( $\sqrt{s_{NN}} = 2.4$ GeV) in 2012
- $7.3 \times 10^9$ events for 0-40 % most central collisions

Particles are mainly identified by

- Time-of-flight
- Energy-loss measured in the TOF detector and drift-chambers (MDC)

FIG. 3: Expanded view of the HADES detector with its main components. The green line sketches the beam.




## Analysis

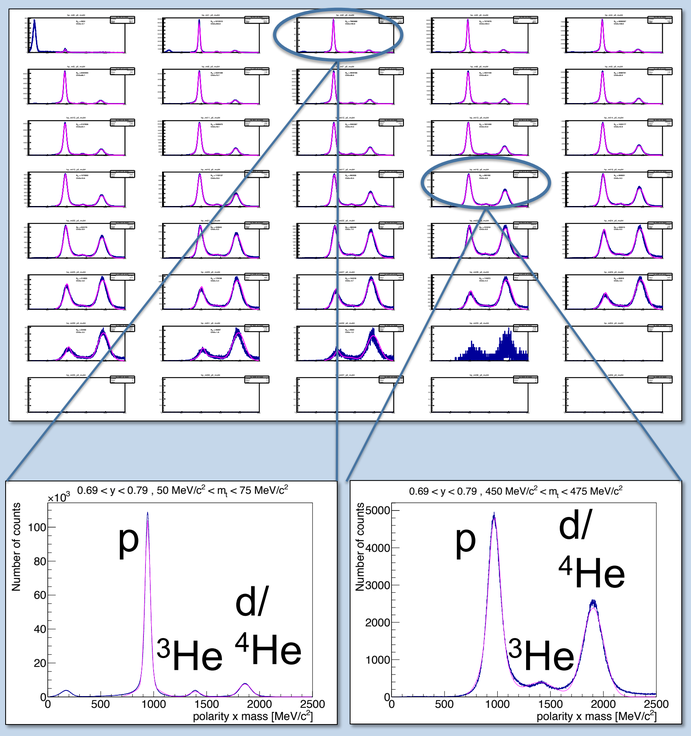



FIG. 4: The different transverse mass bins for the midrapidity slice are shown. Detailed view for two randomly selected bins.

- Identification of protons and light nuclei within each cell of the phase space divided along the rapitidy and transverse mass axis
- Substraction of background contamination by multicomponent fit
- Fully corrected reduced transverse mass spectra are fitted and extrapolated using a blast wave function [2] with linear flow velocity $\beta = \beta_s \left(\frac{r}{R}\right)^n$, n=1

$$\frac{dN}{p_T dp_T} \propto \int_0^R r\, dr\, m_T\, I_0\left(\frac{p_T \sinh\rho(r)}{T_{kin}}\right) \times K_1\left(\frac{m_T \cosh\rho(r)}{T_{kin}}\right)$$

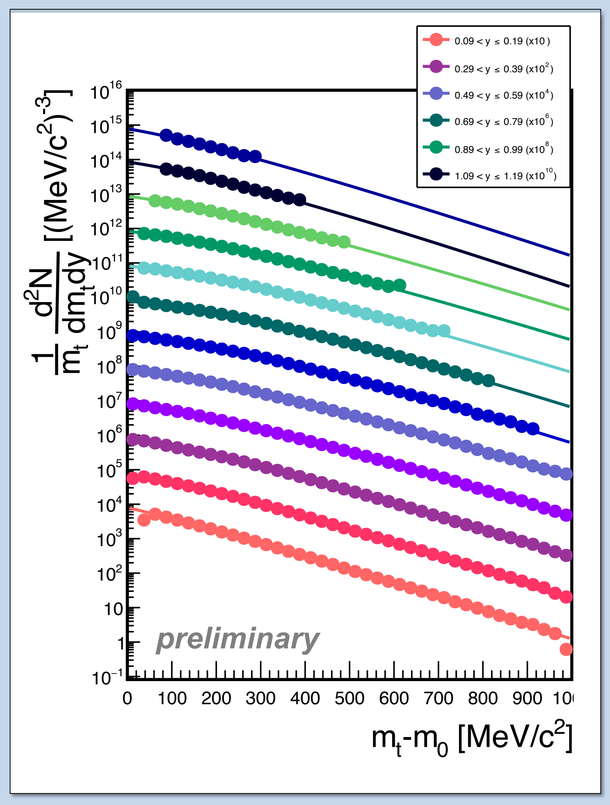



FIG. 5: Corrected reduced transverse mass spectra of protons for the 0-40% most central events, scaled by $1/m_t$. Each spectrum is multiplied by a power of 10 and extrapolated with a blast wave fit.

## Results

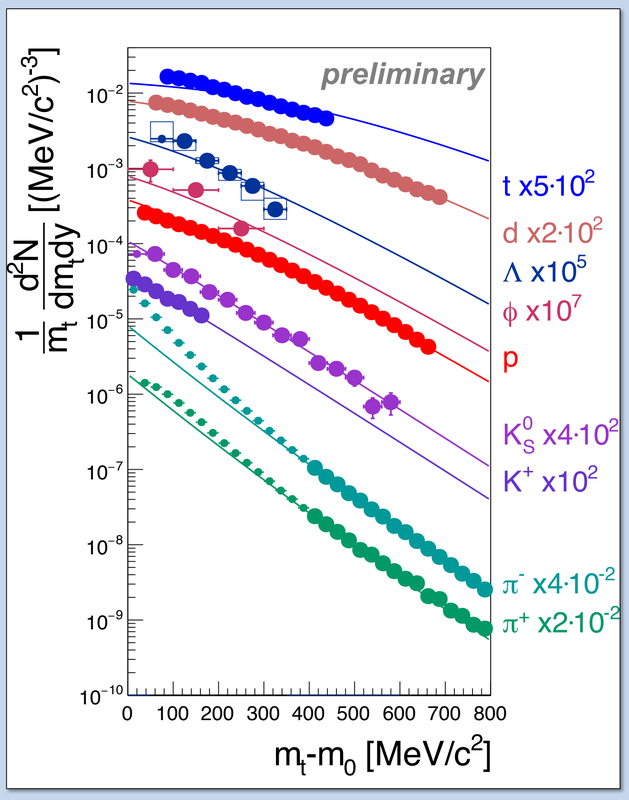



FIG. 6: Simultaneous blast wave fit for 0-10 % most central collisions. Only big points are included in the fit.

- Proton, Kaon, Pion and light nuclei spectra are well described by simultaneous blast wave fit with global parameters:

$$T_{kin} = 66 \pm 8 \text{ MeV}$$
$$\beta = 0.34 \pm 0.04$$

- Λ and ϕ steeper spectra: prefer static & hot thermal source
- $K^-$ not taken into account because of ϕ feeddown [3]
- Low momentum pions are not considered by the fit due to the Coulomb interaction

- Global freeze-out parameters T and β fit well into trend of world data (collection of data taken from [4])

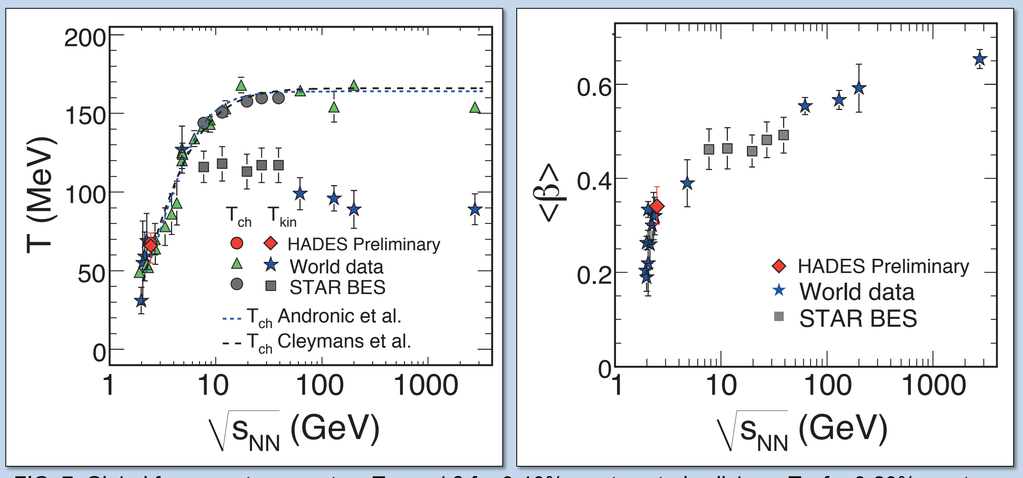



FIG. 7: Global freeze-out parameters $T_{kin}$ and β for 0-10% most central collsions, $T_{ch}$ for 0-20% most central collisions.

**References**

[1] G. Agakishiev et al. [HADES Collaboration], Eur. Phys. J. A 41 (2009) 243-277
[2] E. Schnedermann, J. Sollfrank, and U. Heinz , Phys.Rev. C 48 (1993) 2462
[3] J. Adamczewski-Musch et al. [HADES Collaboration], Phys.Lett. B778 (2018) 403-407
[4] L. Adamczyk [STAR Collaboration], Phys.Rev. C 96 (2017) no.4, 044904

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