Studying properties of hot and dense baryonic matter with the HADES experiment

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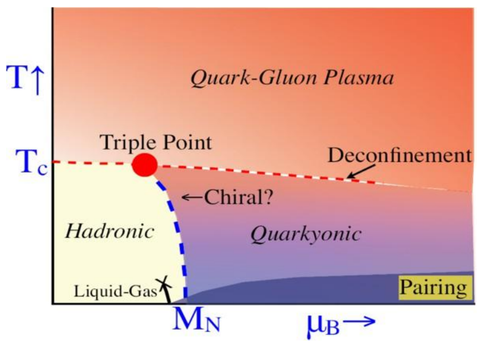
QCD at high net baryon density



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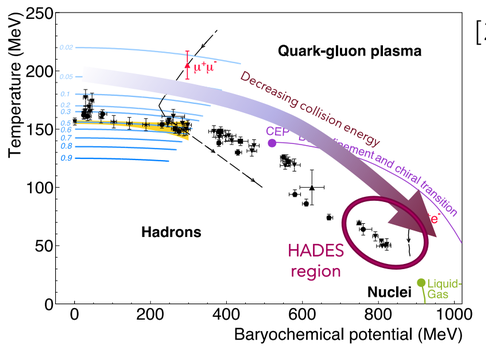
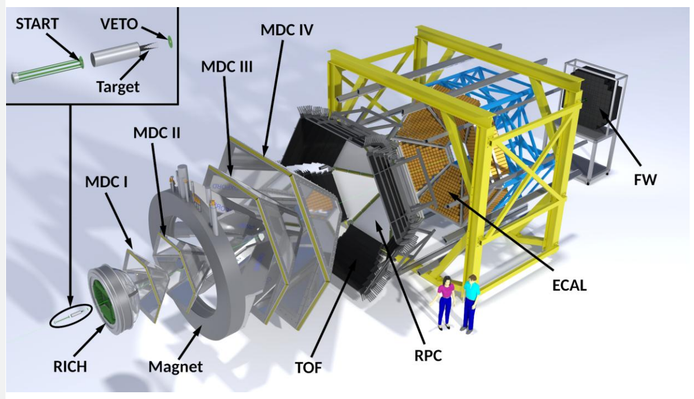
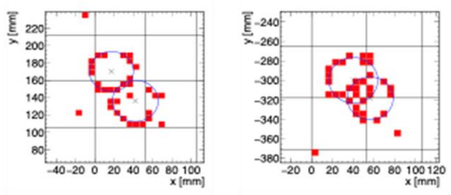


[2-3]

- Region of the QCD phase diagram complementary to studies at LHC
- Conjectures of a rich phase structure

High Acceptance Di-Electron Spectrometer





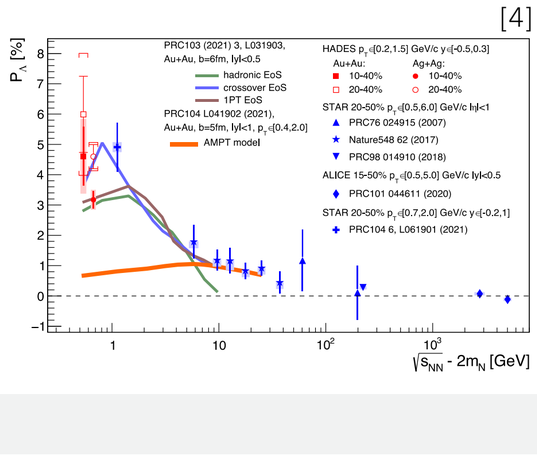
Close pair reconstruction in RICH

- Multi-purpose detector
- Optimized for p+p and A+A collisions at SIS18 energies (E_{kin}/A = 1-2 GeV)
- Specialized for di-electrons, well capable to detect all charged particles

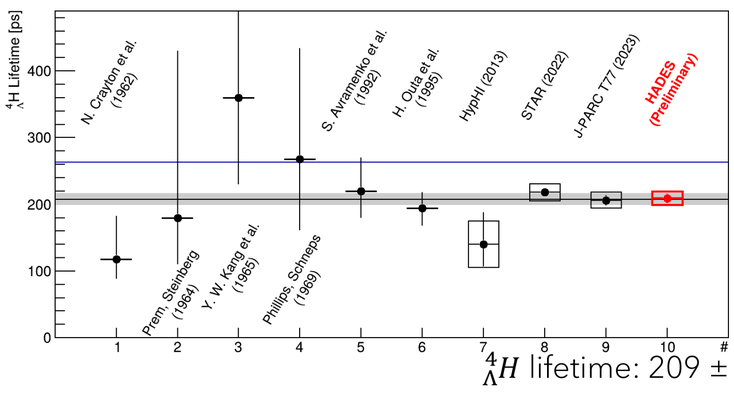
Global spin polarization

- Accessed via Λ baryon polarization
- What is the mechanism of converting $\vec{L}$ to $\vec{S}$?
- Why the polarization is the largest at the lowest energies?
- What will happen at $\sqrt{s_{\mathrm{NN}}}$ from 2 to 9 GeV?

[4]



Measurement of hypernuclei lifetime



$^4_\Lambda H$ lifetime: 209 ± 7 ± 10 ps

- HADES results consistent with world data
- Contribute with high precision

* $^4_\Lambda H$ measured as well

Hadron flow sensitivity to the EoS

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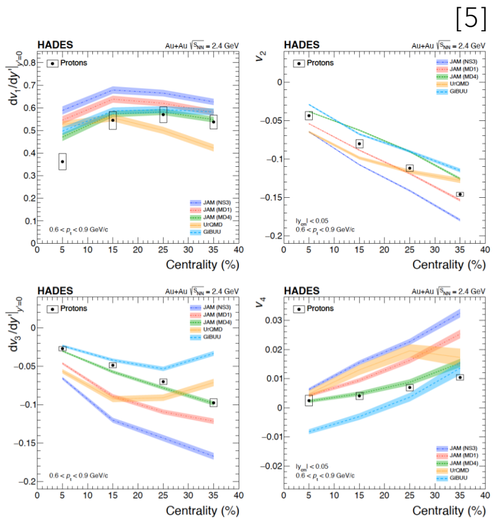


- $\frac{dN}{d(\phi-\Psi_{\mathrm{EP}})} \propto 1 + 2\sum_{n=1}^{\infty} v_n \cos(n(\phi - \Psi_{\mathrm{EP}}))$
- Nuclear potential in transport models:

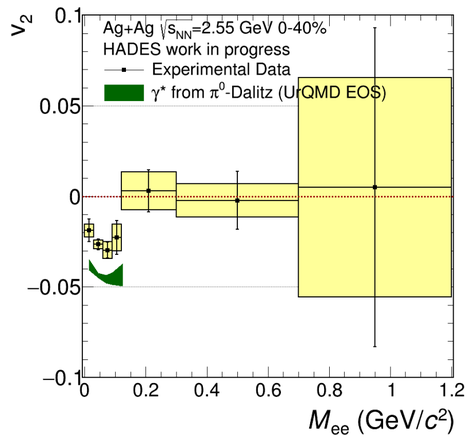
$$V_{sk} = \alpha\left(\frac{\rho_{int}}{\rho_0}\right) + \beta\left(\frac{\rho_{int}}{\rho_0}\right)^{\gamma}$$

which can have "harder" or "softer" energy dependence

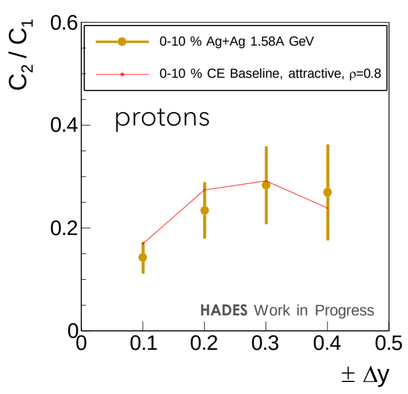
- Consistent description of all v_n, for different phase-space regions and centrality classes is not yet there

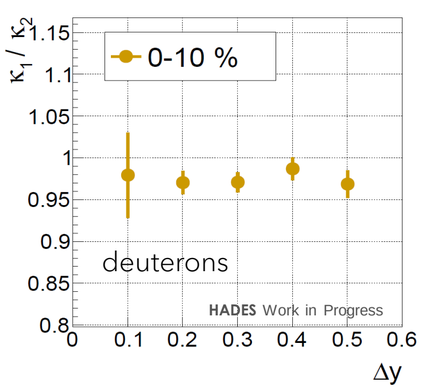
Dilepton azimuthal anisotropy

- At low M_{ee} v_2 similar to $\pi^{\pm}$:
  - Dominated by $\pi^0 \rightarrow \gamma e^+e^-$
  - Attenuation due to missing momentum of the real photon (?)
  - Freeze-out emission
- At higher M_{ee}, v_2 closer to 0:
  - Dileptons don't "feel" the squeeze-out – early emission



Baryon number fluctuations



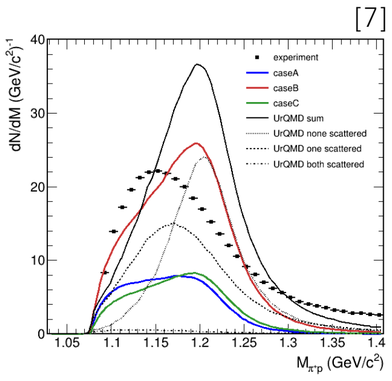


- Protons trend described by the proper Canonical baseline [6] accounting for correlations and attractive potential
- Deuterons closer to the Poisson limit

Correlated πp pair spectra

- Dominated by Δ(1232) at HADES energies
- Comparison with kinetic transport (UrQMD):
  - When daughters not scattered – spectrum similar to thermal model (freeze-out)
  - When at least one daughter scattered – spectrum similar to experimental data
  - Decay products should be scattered for most of the pairs – scattering likely too low in the transport

[7]



References

[1] NPA **830** (2009) 709c-712c
[2] JHEP **1009** (2010) 073, PRD **100** (2019) 074011, PLB **820** (2021) 136584, JHEP **11** (2021) 141, NPA **796** (2007) 83, EPJA **58** (2022) 12, 247
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[4] HADES, PLB **835** (2022) 137506
[5] HADES, EPJA **59** (2023) 4, 80
[6] NPA **1008** (2021) 122141, PRC **110** (2024) 6, 064910
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