Highlights from HADES Au+Au collisions at 1.23 AGeV

Outline

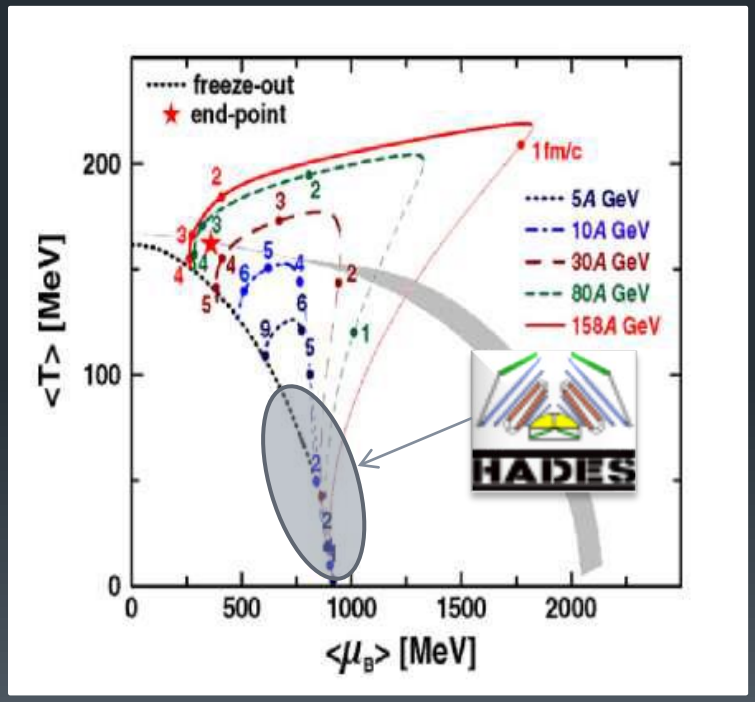
- Which matter?
- HADES and results
  - Strangeness
  - Dileptons
- Future

Christina Deveaux for the HADES collaboration

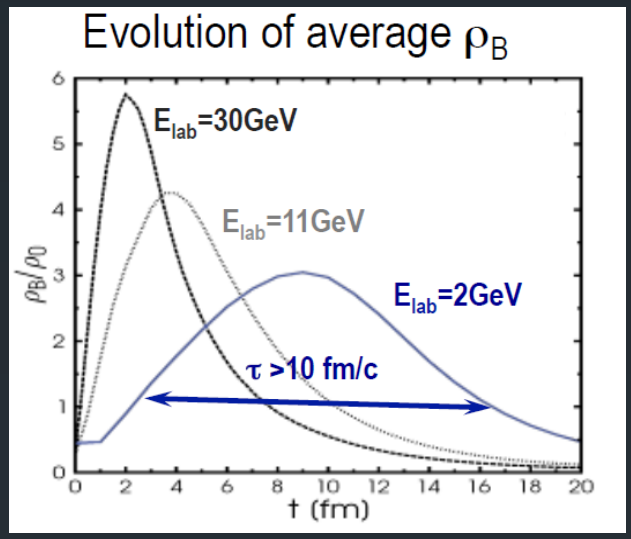
Which matter?

Heavy ion collisions at the few AGeV energy regime offer:

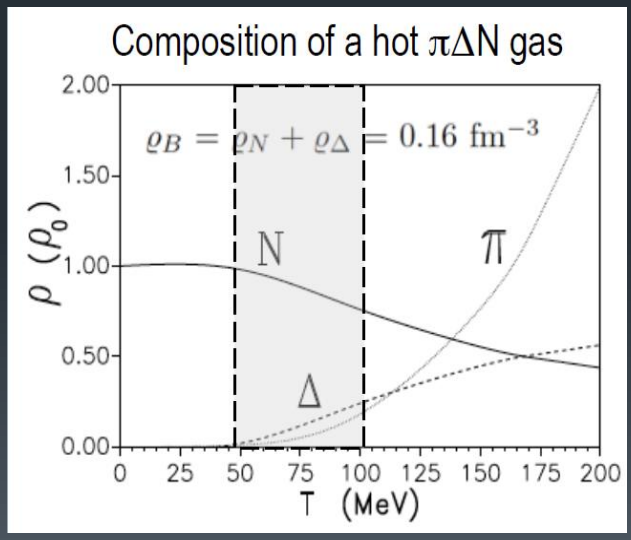
- Access to moderate T, high μ_B
- Long lived, high density medium
- Baryon resonance rich matter



Trajectories: Ivanov et al., PRC 73 (2006)

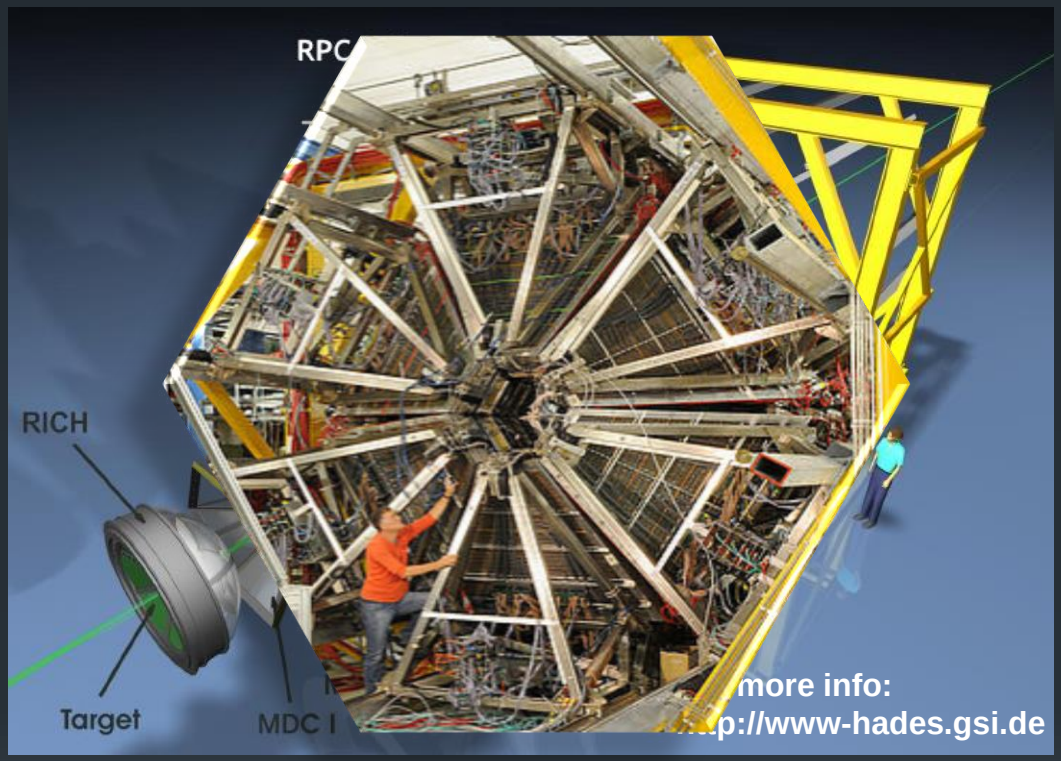


S. Vogel et al. PRC 78 (2008) 044909



Rapp, Wambach, Adv.Nucl.Phys. 25 (2000)

HADES



High Acceptance DiElectron Spectrometer

- Fixed target experiment
- Full azimuthal coverage, 18°-85° in polar
- SIS18, GSI Darmstadt
- 1-2 AGeV for heavy ion
- Proton and pion induced reactions
- 80.000 channels
- 50 kHz event rate (400 Mbyte/s peak data rate)

Physics Focus:

- Explore properties of matter at high baryonic densities
- Excitation function for low mass lepton pairs and (multi) strange baryons and mesons

Italy
- Catania, Milano

Portugal
- Coimbra, Lisboa

Poland
- Cracow

Russia
- Dubna, Moscow

Germany
- GSI Darmstadt, TU Darmstadt, Dresden, Wuppertal, Frankfurt, Giessen, München

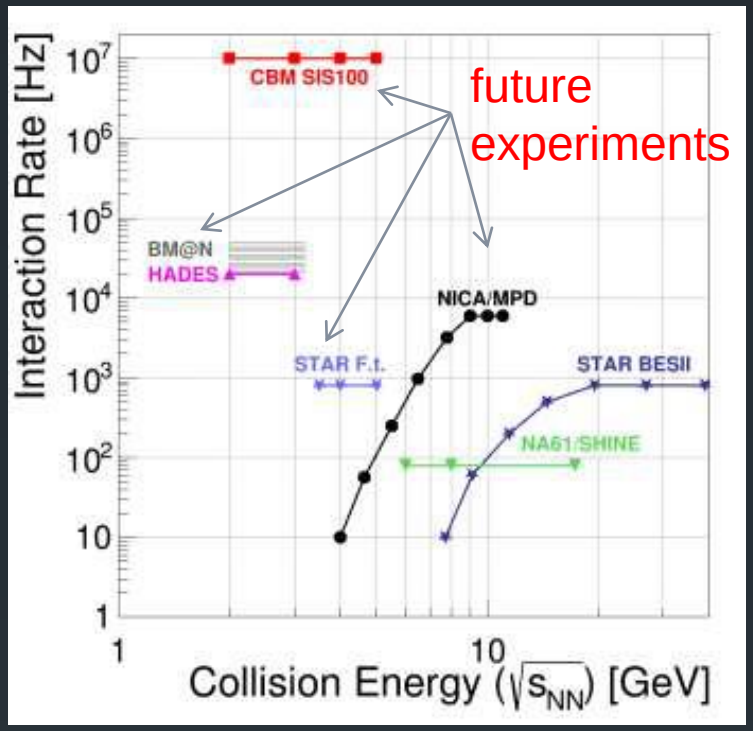
Cyprus
- Nicosia

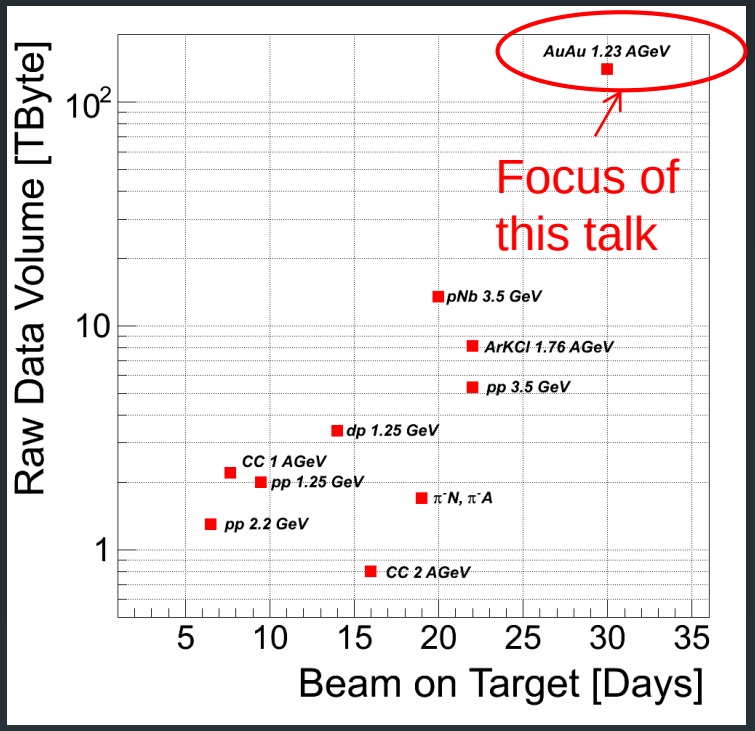
France
- Orsay

Czech Rep
- Rez

Spain
- Santiago de Compostela

HADES Data Sets



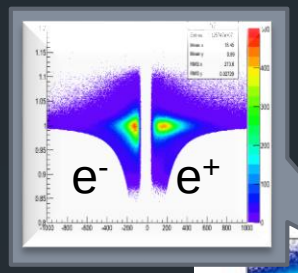


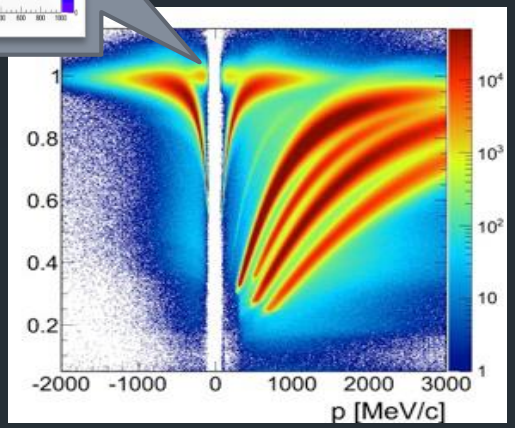
558.3 hours
31 days
7.31×10^9 evts

HADES is a high rate heavy ion experiment at low energies: access to many observables, including rare probes ρ/ω/φ

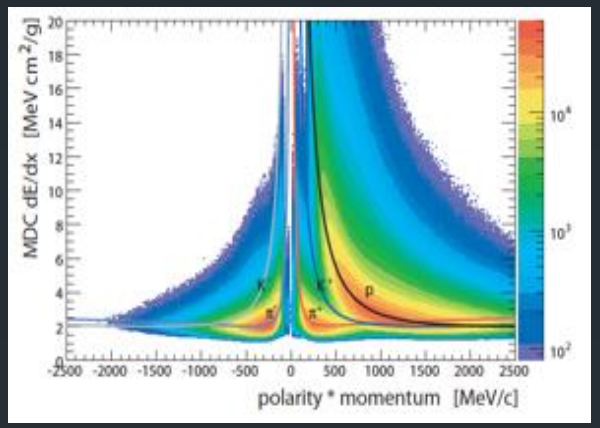
Plethora of runs over several years, see Nuclear Physics A (931) 2014, 41–51 for an overview

Performance

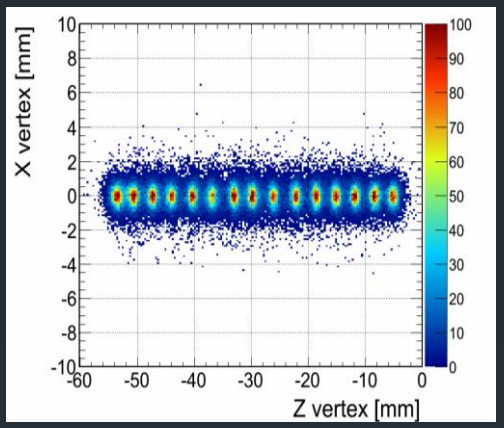




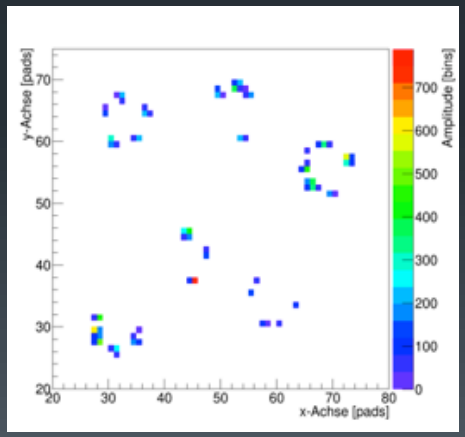
Time-of-Flight



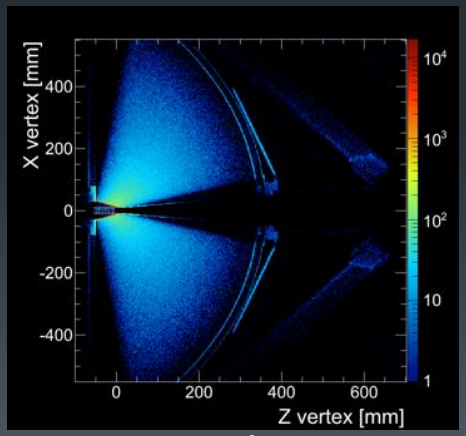
Energy Loss



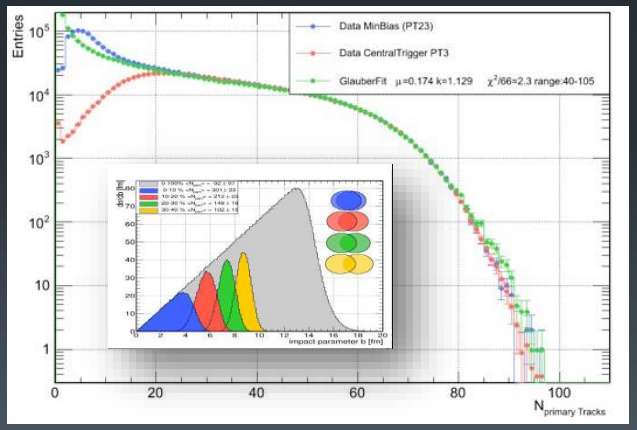
Vertex reconstruction



RICH rings



Low conversion probability ~2%

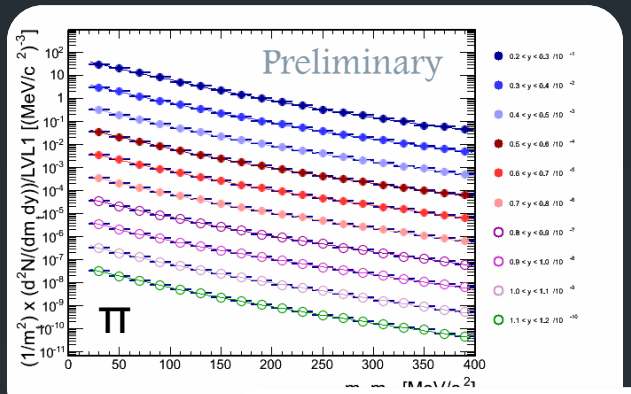


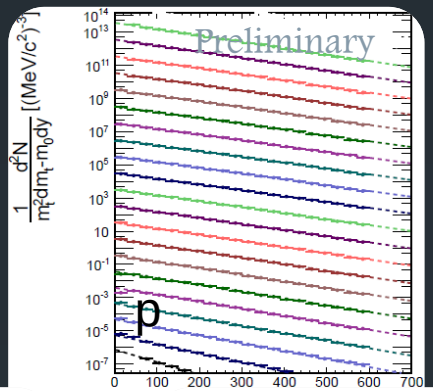
Centrality determination based on Glauber model

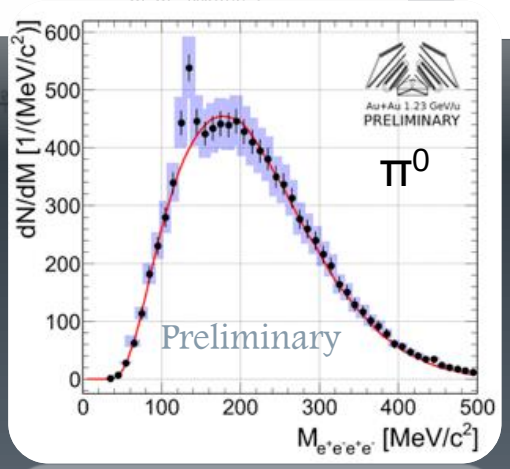
Hadrons

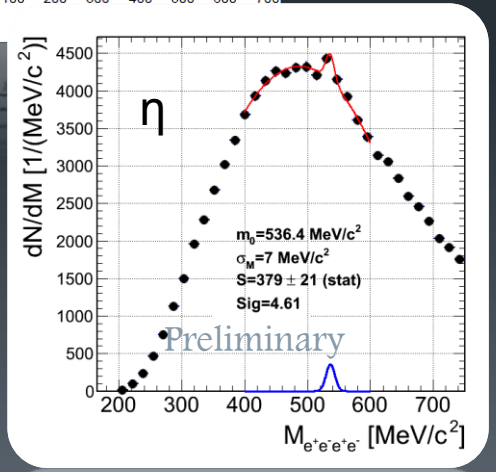
HADES is able to measure many different species of hadrons:

- charged pions
- protons
- π^0 and η





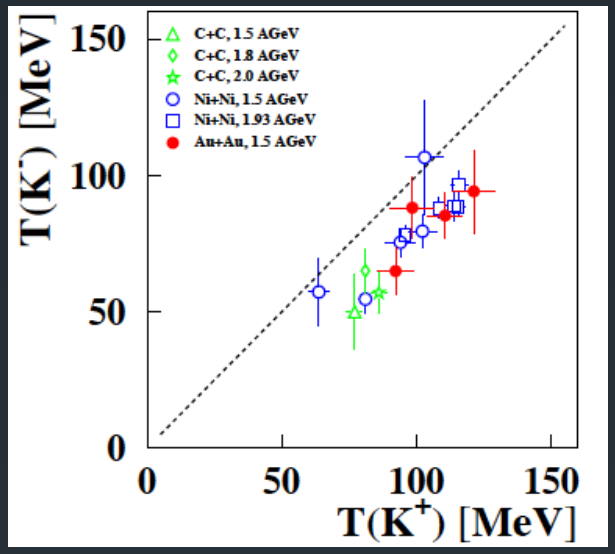




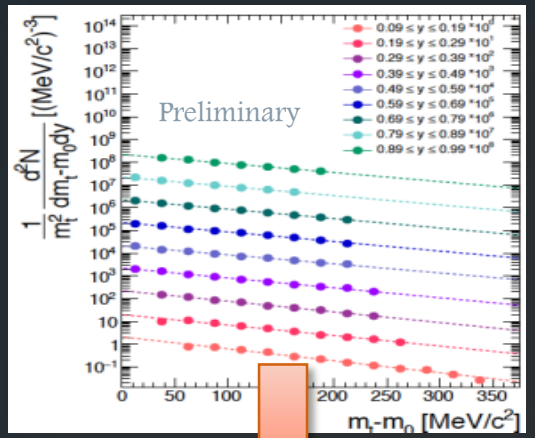
…and strange particles on which this talk will focus.

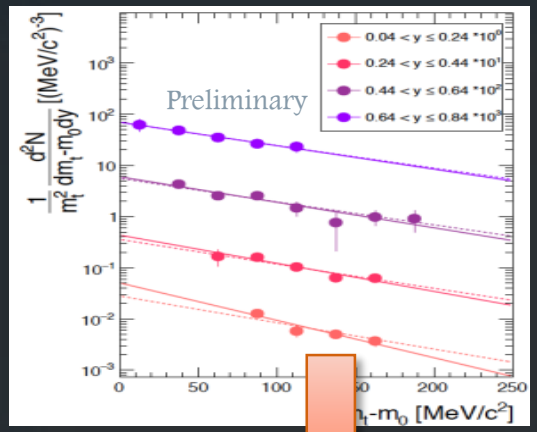
Hadrons : Strangeness

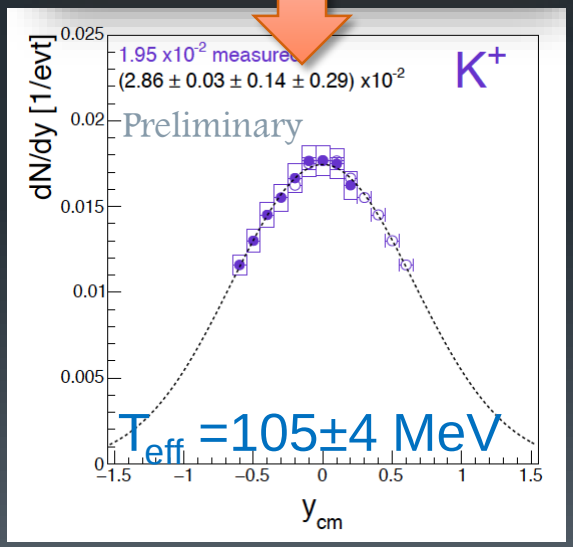
HADES confirms inverse slope of K^- lower than of K^+ with highest quality data available

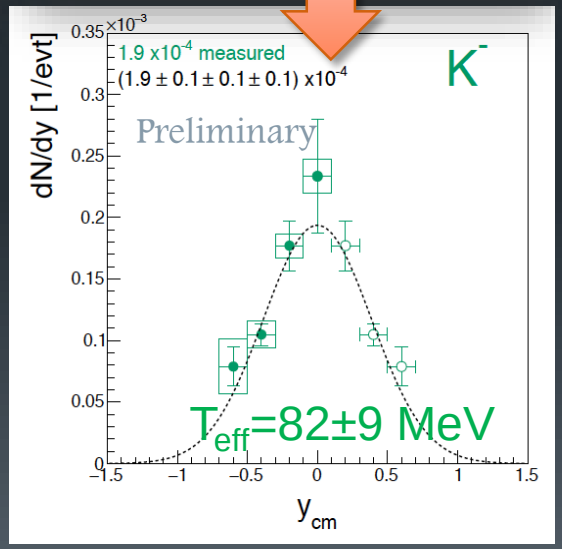


Förster et. al (KaoS)









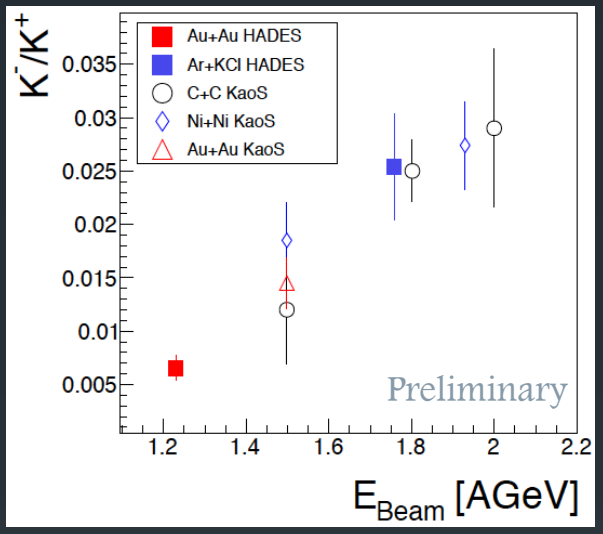
However:
New measurements from HADES question the "classical" interpretation with repulsive/attractive potentials explaining this observation…

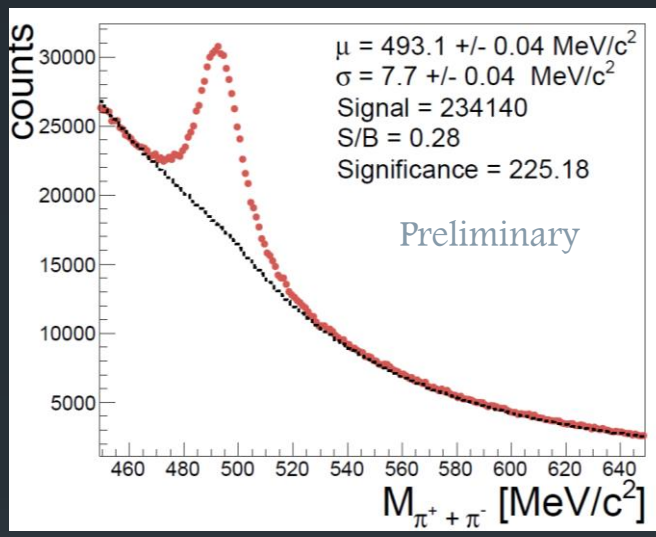
Ph.D. H. Schuldes, Frankfurt

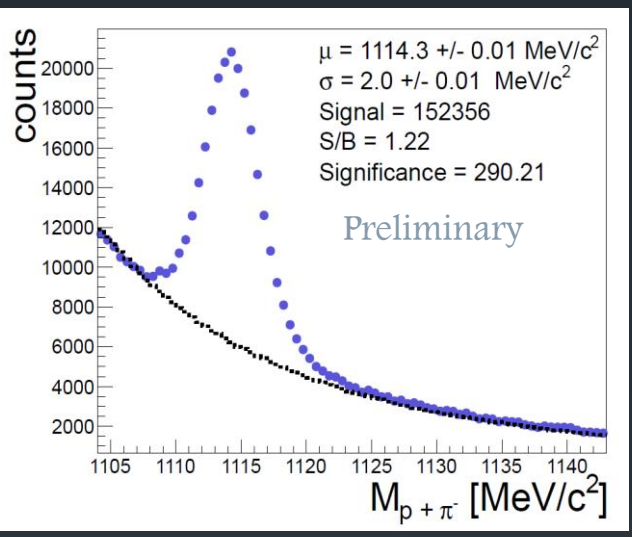
Hadrons : Strangeness

HADES extended knowledge :

- K^- / K^+ ratio energy dependence
- K^0s measurement
- Λ measurement







$NN \rightarrow N\Lambda K^+$ E_{thr} = 1.58 GeV

$NN \rightarrow NNK^+K^-$ E_{thr} = 2.49 GeV

Ph.D. T.Scheib, Frankfurt

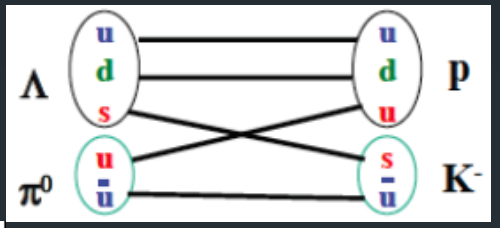
These are all sub-threshold measurements!

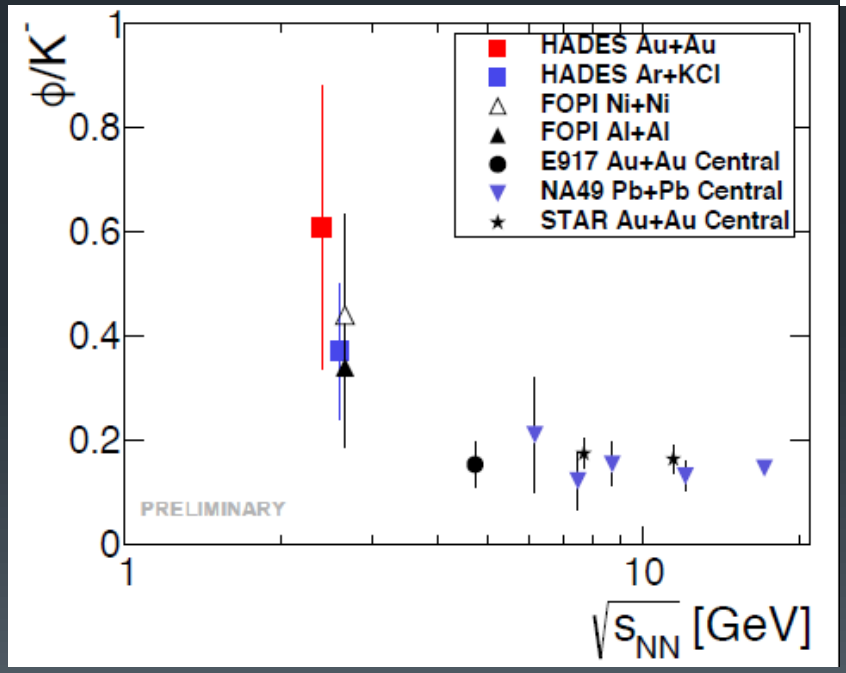
Why is there strangeness at all?

Hadrons : Strangeness

It is ongoing work from theory and experiment to fully understand the origin of strangeness.
However HADES put an important piece in the puzzle :

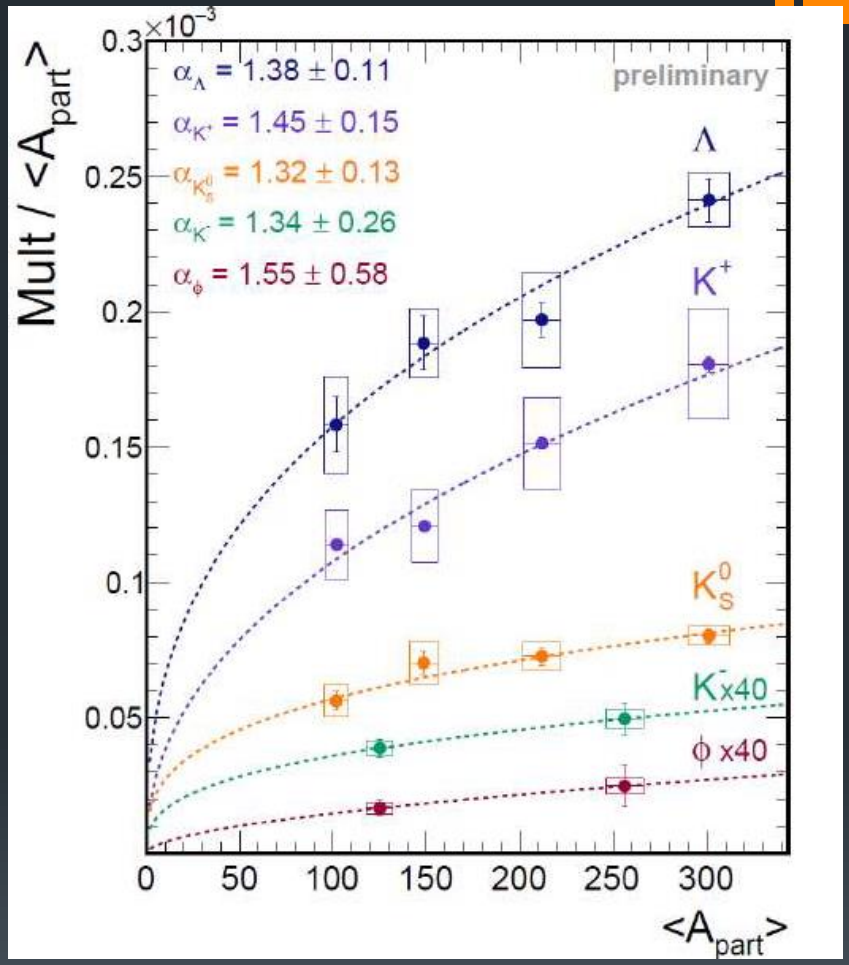
- Enhanced Φ production at low beam energy
  - 30% of K^- result from Φ decays
  - not from strangeness exchange as believed





Hadrons : Strangeness overview

- All strange particles are produced below NN threshold
- Systematic comparison of data
- Particle yields rise with centrality ($M/A_{Part} \sim A_{part}^{\alpha}$,$\alpha>1$)
- Within uncertainties agreement with KaoS and FOPI
- Multiple interactions?
- Multi-step processes?
- In-medium potential?
- Feeddown from higher N* resonances?



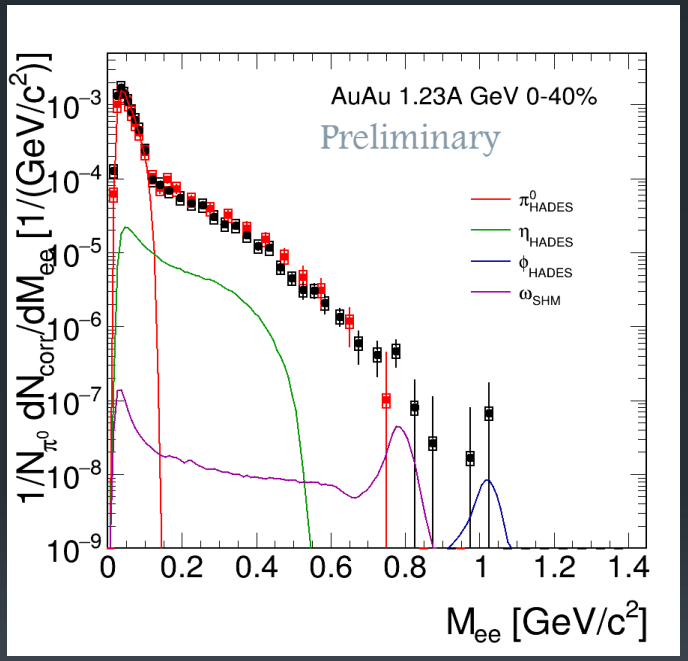
Comparison to models is ongoing…

Dileptons

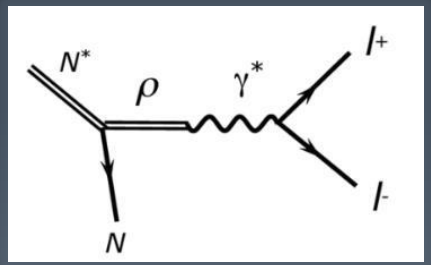
We saw hints of medium modifications from subthreshold strangeness production. Another way to check is to look at dileptons
→ measure their yield

Cocktail:

- π^0 from charged pions multiplicity, cross-checked with HADES measurement (γ-conversion)
- η from HADES measurement (γ-conversion)
- φ from the K+K- channel
- ω from the Statistical Hadronization Model



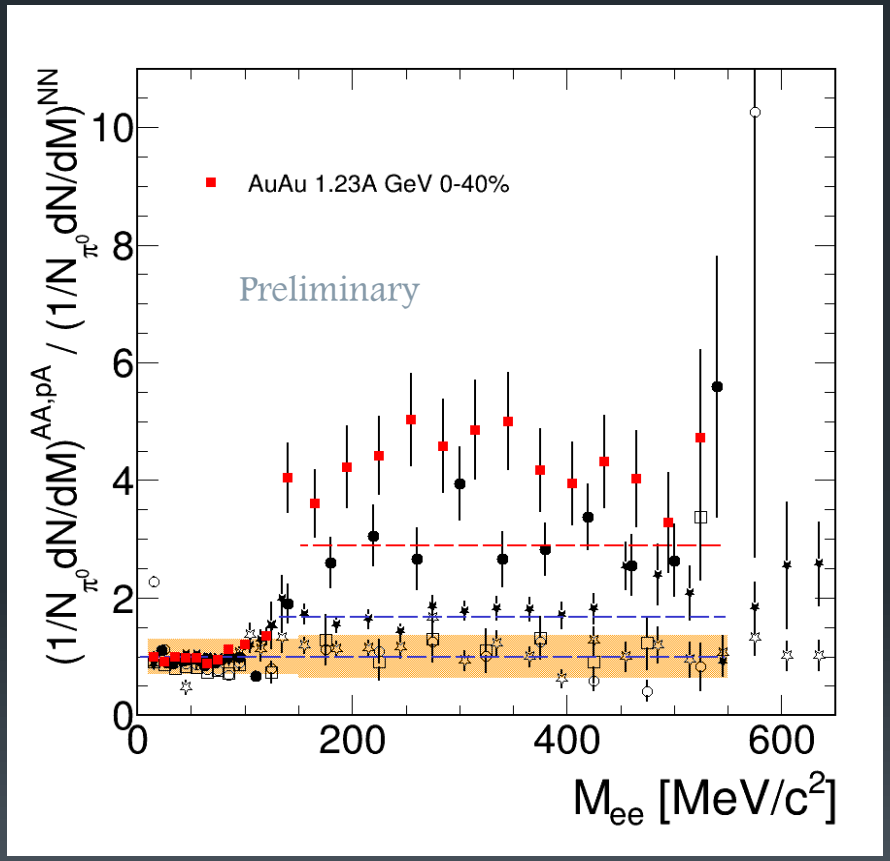
Additional radiation from baryon rich medium compared to naïve vacuum expectations:



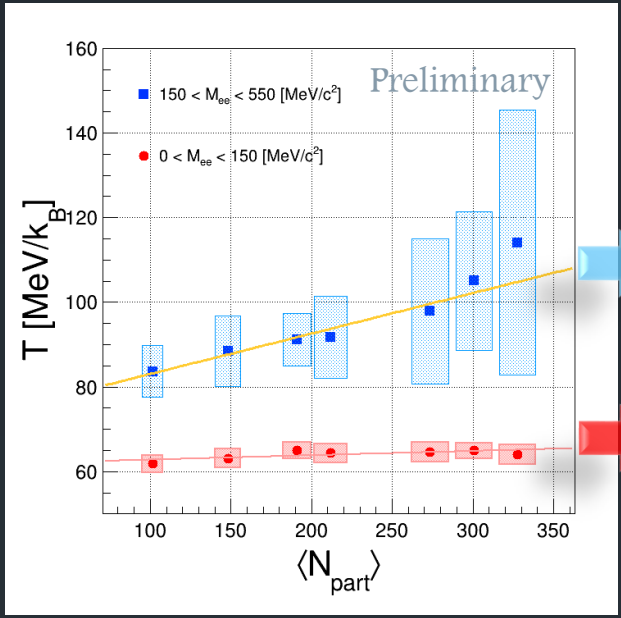
Dileptons

HADES performed a thorough study of various collision systems in the same energy regime.
Freeze-out contributions removed (π^0 by normalization, η by subtraction)
The remaining radiation in C+C is already present in N+N

- Visible enhancement in p+Nb (for slow dileptons, < 800 MeV)
- Much stronger excess in Ar+KCl
- Even stronger excess in Au+Au
  Question of "medium" is about the effects beyond simple superposition of NN collisions
- Regeneration of baryonic resonances

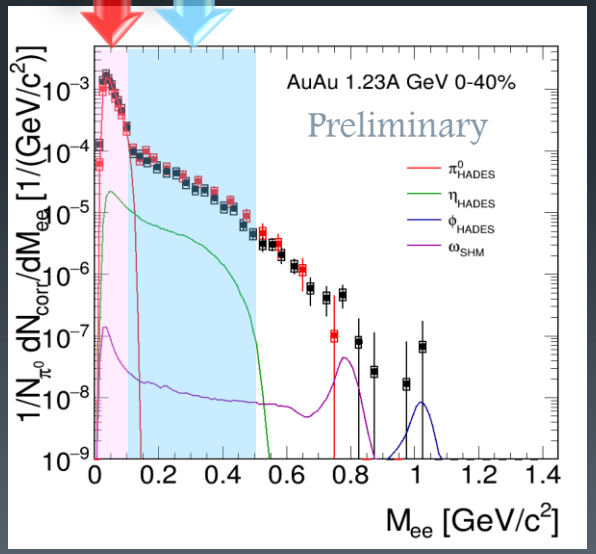


Dileptons

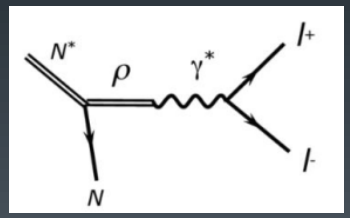


150 < M_{ee} < 550 MeV
medium radiation dominated

0 < M_{ee} < 150 MeV
freeze-out dominated



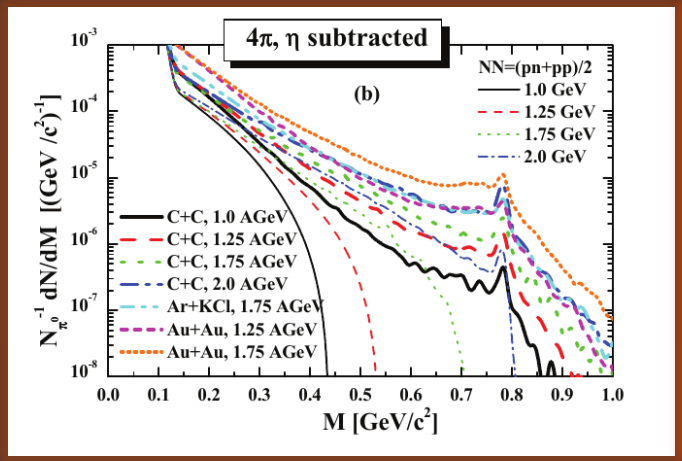
Around the π^0 mass slope is ~constant
Effect from intermediate mass range: radiation!

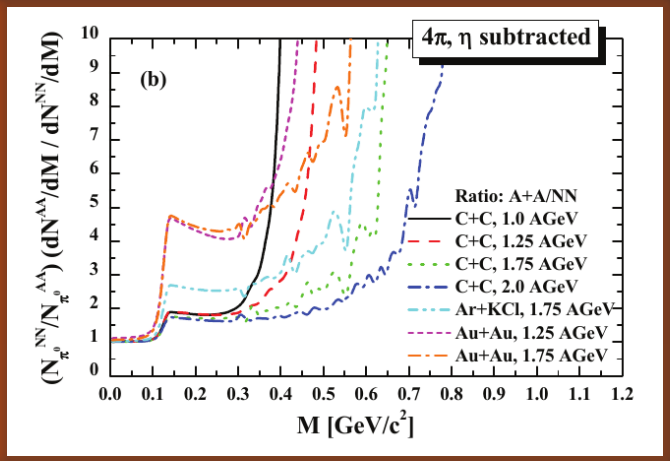


How to understand?
Examine models…

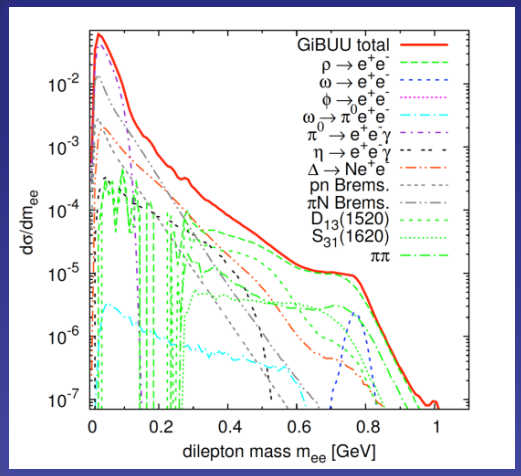
Models' point of view

„System size and energy dependence of dilepton production"
Bratkovskaya, Aichelin, et al., PRC 87 (2013) 064907





In **HSD**:
Dilepton excess above NN mostly due to
Δ regeneration & decay

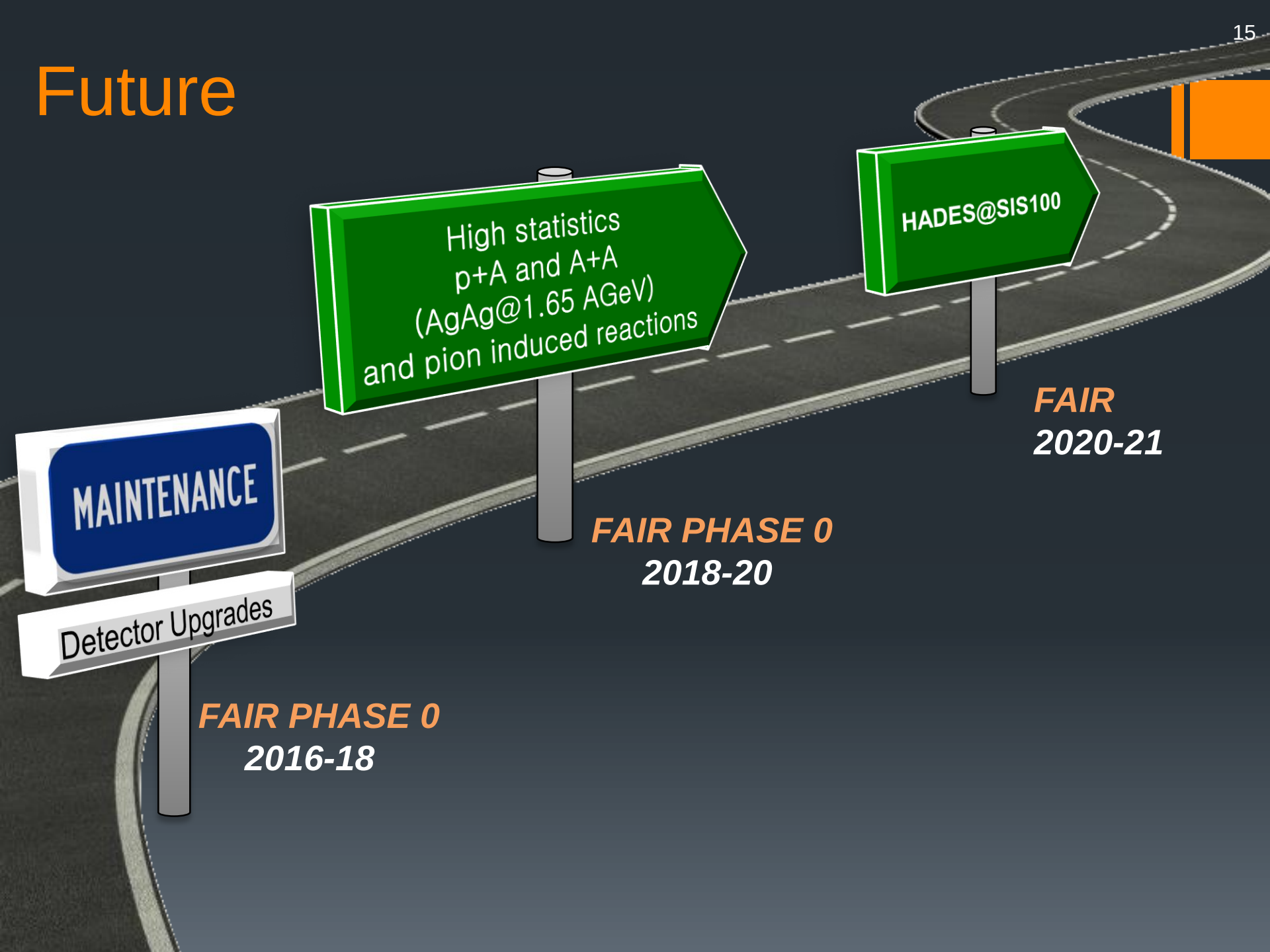


GiBUU: J. Weil et al.

In **GiBUU**:
more baryon resonances are included, e.g. N*(1520)

- comparison with data in preparation

Future

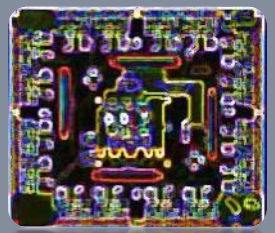


FAIR PHASE 0
2016-18

FAIR PHASE 0
2018-20

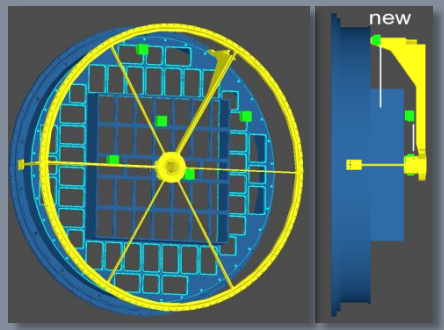
FAIR
2020-21

FAIR Phase 0 : Detector upgrades

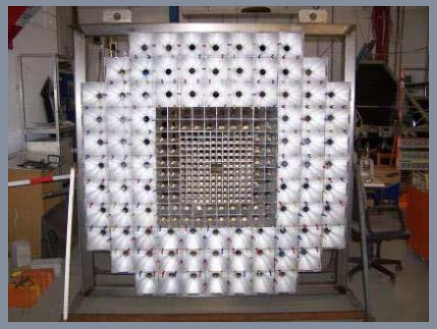


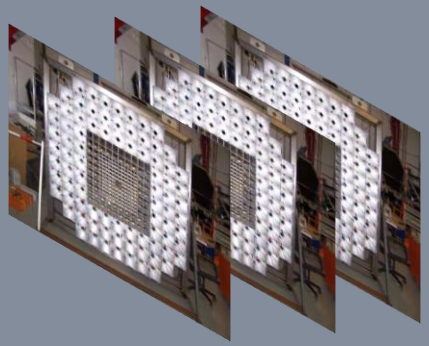
development ongoing…

MDC
electronics upgrade

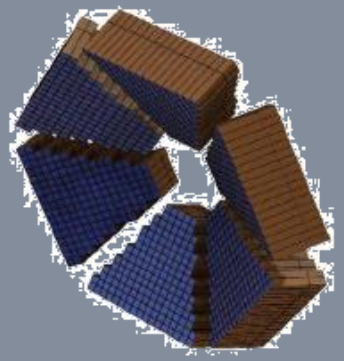


RICH
Photo detector plane with PMTs





FW
Straw tubes →
3 stations



ECAL
New detector!
Lead glass

Summary

Investigation of properties of baryon rich dense matter (in-medium effects) is the purpose of the HADES experiment at GSI.

HADES has measured a large set of energy and system sizes. Preliminary results from recent AuAu@1.23AGeV collisions include:

- Strangeness:
  - yields and inverse slope confirms and complements existing results
  - All strangeness produced in sub-threshold
  - New: enhanced φ production!
- Dileptons:
  - Excess yield in the intermediate mass range
  - particularly pronounced for AuAu system
- Deeper understanding of observed effects needs comparison with models! Ongoing…

HADES @ SIS18/SIS100

Stay tuned ☺