Virtual photons and rare strange probes in resonance matter

Manuel Lorenz for the HADES Collaboration

Goethe-Universität Frankfurt, Germany

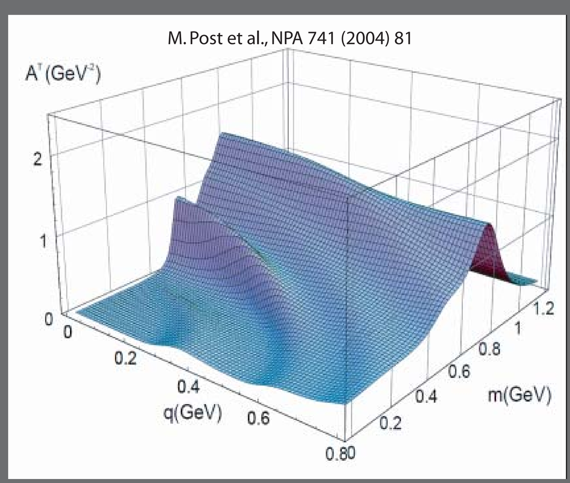
GOETHE UNIVERSITÄT FRANKFURT AM MAIN

HADES

Goethe-Universität Frankfurt

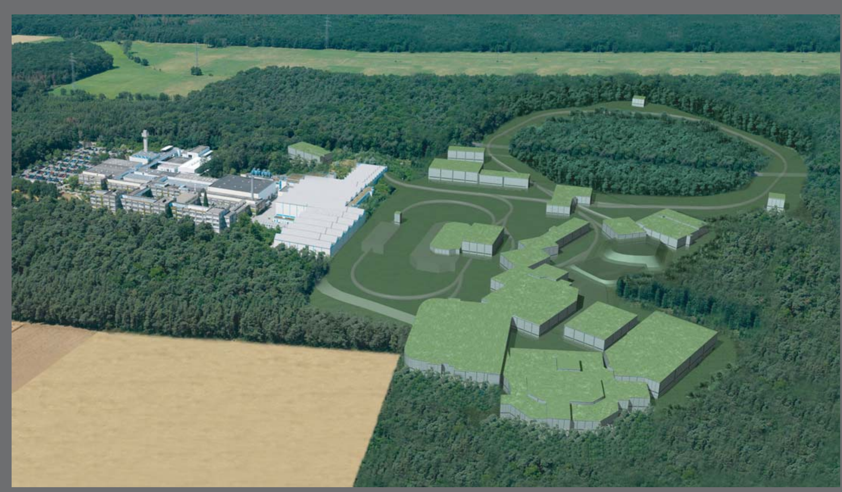
MISSION and APPARATUS

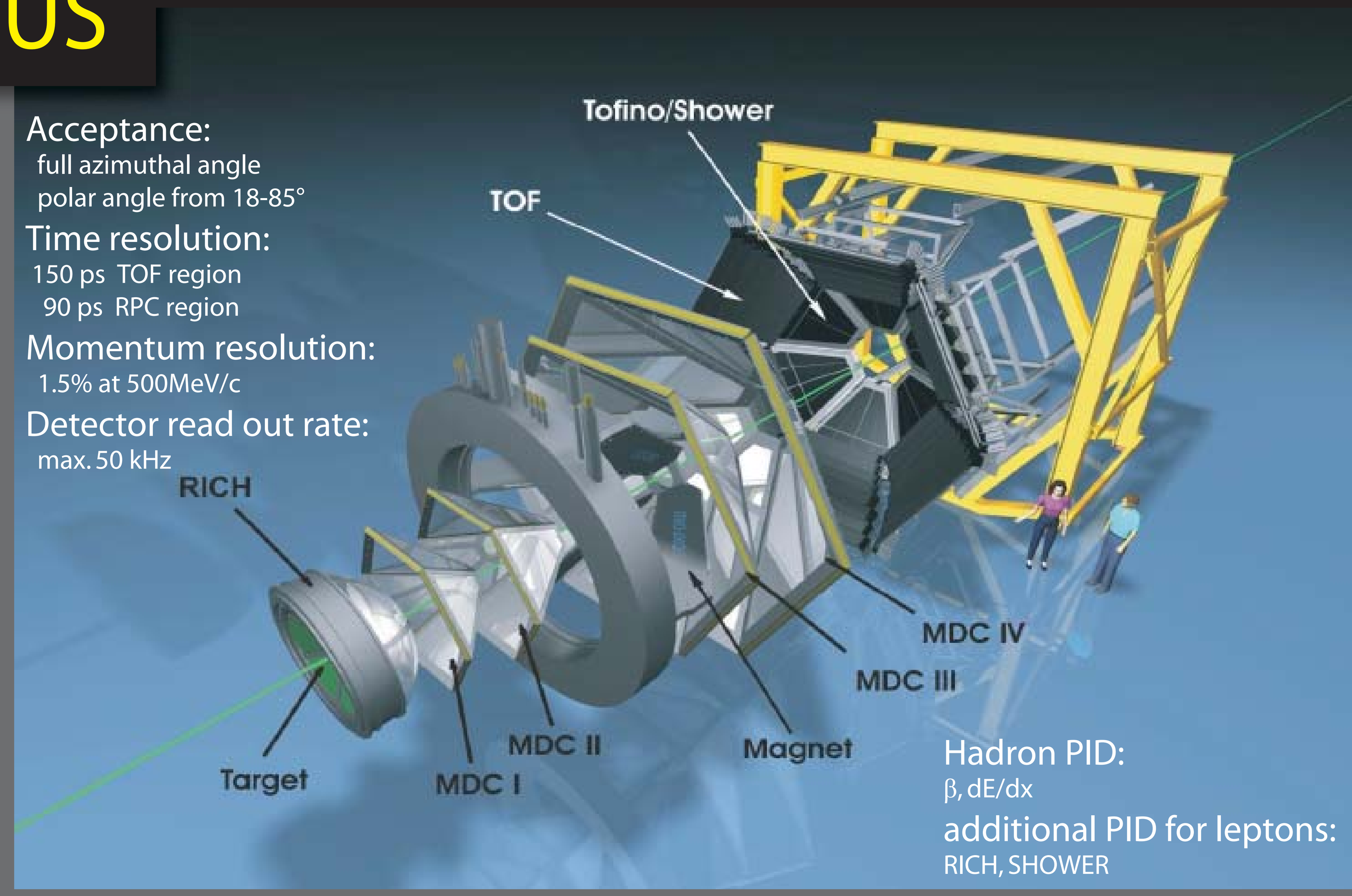
While the Higgs mechanism is responsible for the creation of the quark masses most of the mass of hadrons is generated dynamically by QCD. This generation of mass can be studied systematically by changing the underlying vacuum structure using elementary (cold nuclear matter) or heavy-ion collisions (hot and dense matter). According to hadronic models the ρ meson is most sensitive to those changes of the vacuum.



A very promising observable is hence its decay via a virtual photon to a dilepton pair, as the decay products experience only small final state interaction and deliver the undistorted information to the detector.

The Helmholtzzentrum für Schwerionenforschung (GSI) in Darmstadt provides already now with the SIS 18 accelerator high intensity ion (10^8 ions/s) and proton beams at energies up to 3.5 GeV which will be extended to higher beam intensities (up to 10^{12} ions/s) and energies (35 A GeV) with the upcoming FAIR facility.



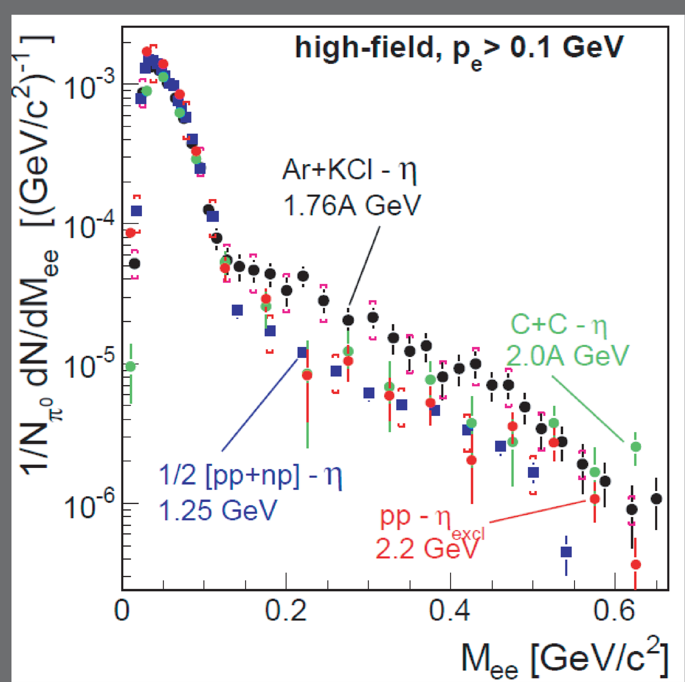


HADES at GSI is a fixed target high acceptance multi-propose spectrometer capable of measuring dielectrons as well as hadron observables. The physics program ranges from HIC over elementary n+p and p+p collisions up to pion and proton induced reactions on heavy nuclei.

HADES: G. Agakishiev et al. (HADES Collaboration), Eur. Phys. J. A 41, 243 (2009).

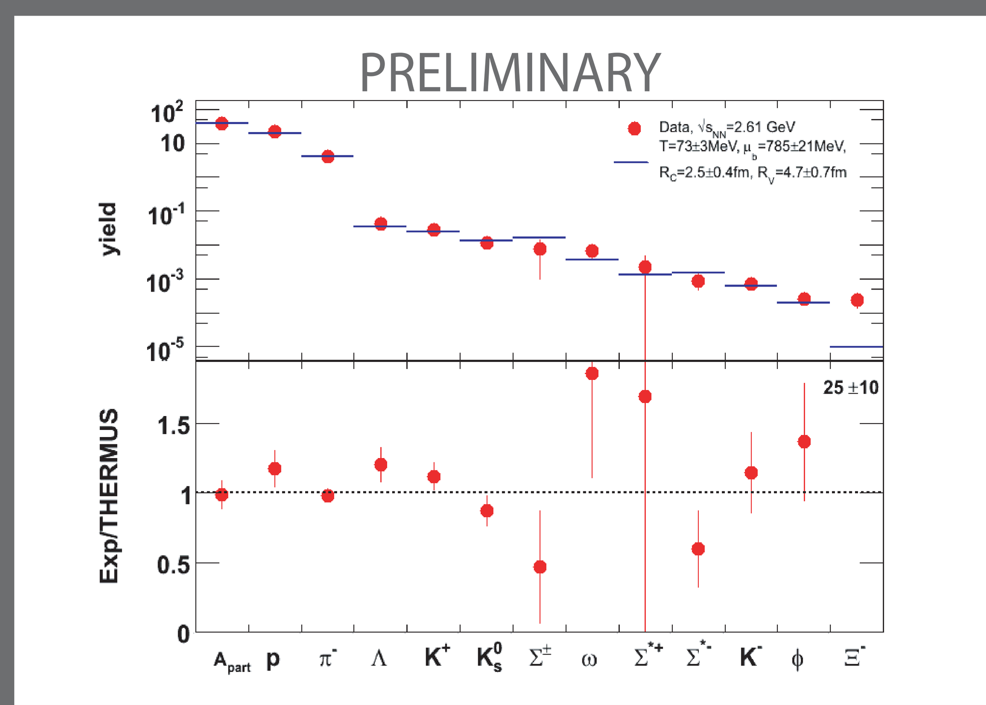
HEAVY-ION COLLISIONS

At bombarding energies of 1-2 A GeV, nuclear matter is compressed to densities of 2-3 times ρ_0 and heated to temperatures of up to 100 MeV. The generated systems stays for a rather long time of about 10 fm/c in the dense phase allowing for a noticeable amount of particle decays inside the medium and their consequent decay to dielectron pairs. Comparing the dielectron yield from Ar+KCl collisions at 1.76 A GeV, normalized to the neutral pion multiplicity, in the invariant mass region between 0.15 GeV/c^2 and 0.5 GeV/c^2 to various references spectra a strong excess is observed (note that the energy dependence is taken out to some extent due to the normalization). In the same invariant mass range experiments reported an excess at higher beam energies, which can be explained by a modification of the rho spectral function in the medium.



At our energies this is not so straight forward due to the stronger contribution of baryonic resonances which couple strongly to ρ meson.

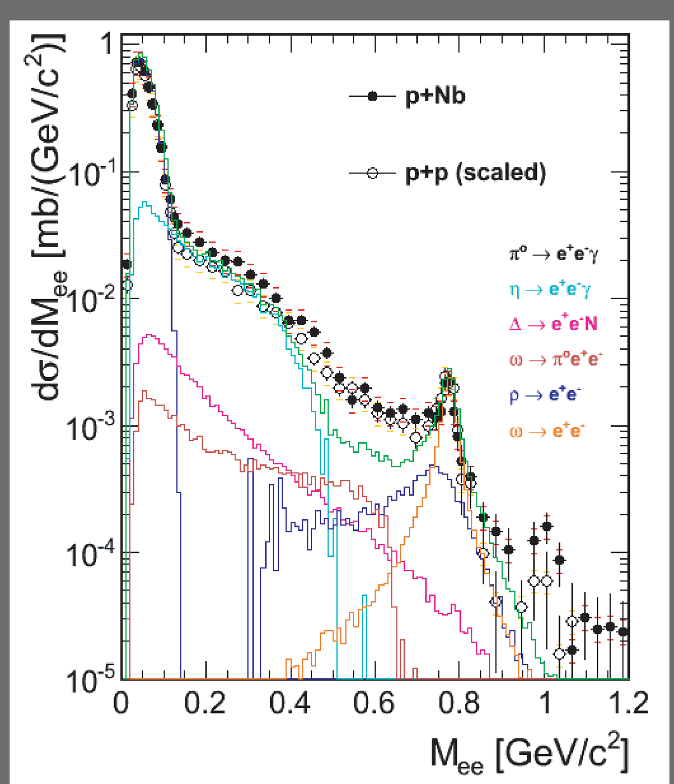
According to vector meson dominance there is then no distinction between the direct Dalitz decay of baryonic resonances (N*⟶Nγ*) and the intermediate coupling to the ρ meson decay (N*⟶Nρ ⟶Nγ*).



Aside from dileptons also various hadron yields have been measured, which can be compared to a statistical hadronization model (THERMUS*). All particles are described with fair agreement apart from the double strange Ξ hyperon, which is produced deep subthreshold at these energies.

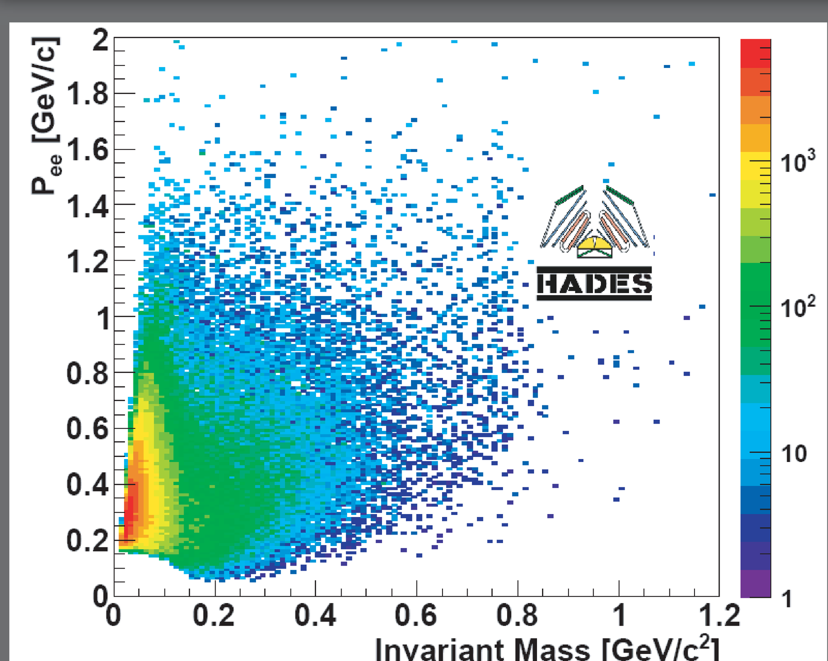
HADES data: G. Agakishiev et al. Phys. Rev., C84(014902), 2011.
G. Agakishiev et al. Phys. J., A 47(21), 2011.
*S. Wheaton, J.Cleymans:Comput.Phys.Commun.180:84-106,2009.

COLD NUCLEAR MATTER

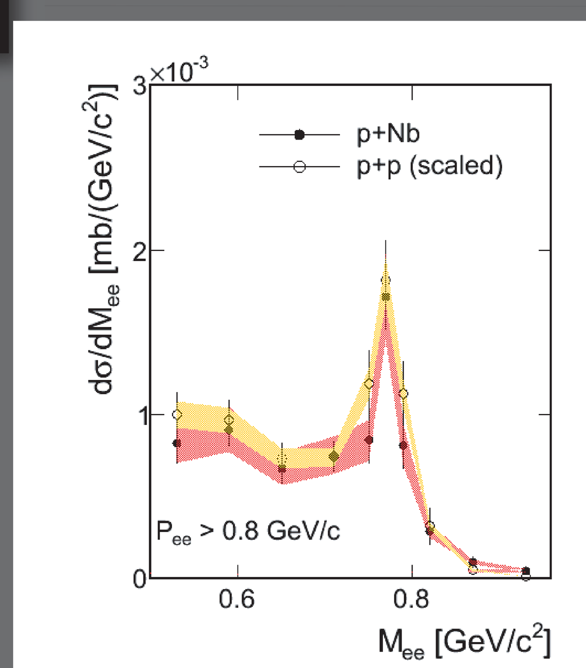


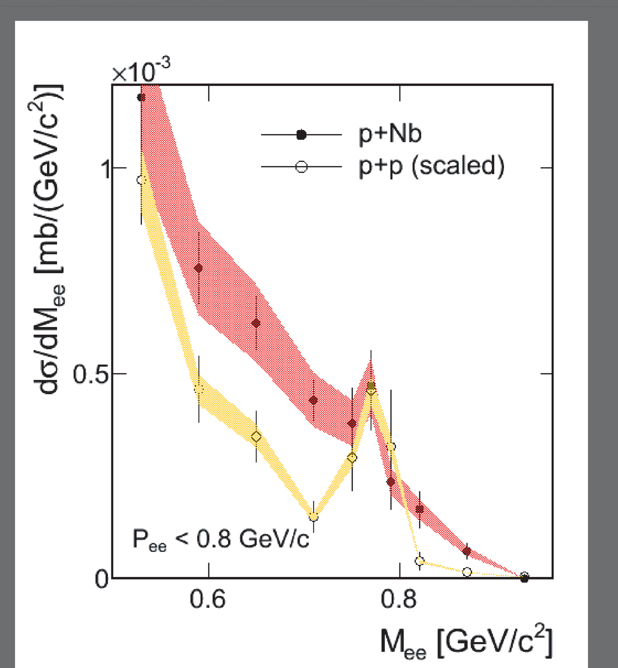
Already in elementary p+p collisions at 3.5 GeV the ρ meson shows deviations from a pure Breit-Wigner shape as illustrated by the HPhythia cocktail.

The shape of the p+p dielectron invariant mass spectra scaled with the total production cross section and the number of participants shows no strong deviations compared to the one obtained from p+Nb reactions at the same beam energy.



However, according to hadronic models possible modifications should be most pronounced for relative momenta to the medium smaller 0.8 GeV/c. The coverage for these low momentum pairs is one of the big advantages of HADES compared to other cold matter dilepton experiments.





We compare the shape of the invariant mass spectrum in the vector meson region separately for P_{ee} > 0.8 GeV/c and P_{ee} < 0.8 GeV/c. While we observe no difference for the high momentum pairs, for slow pairs a strong modification of the dielectron line shape, due to additional ρ-like contribution and reduction of strength in the ω peak signal, is observed.

HADES dtata: G. Agakishiev et al. Eur.Phys.J. A 48 64 (2012).
http://arxiv.org/abs/arXiv:1205.1918

Supported by

GSI · HIC for FAIR Helmholtz International Center · EMMI · Bundesministerium für Bildung und Forschung

Contact:
Manuel Lorenz
Max-von-Laue Str.1
Goethe-Universität Frankfurt
m.lorenz@gsi.de