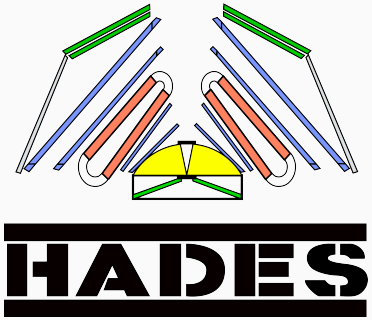


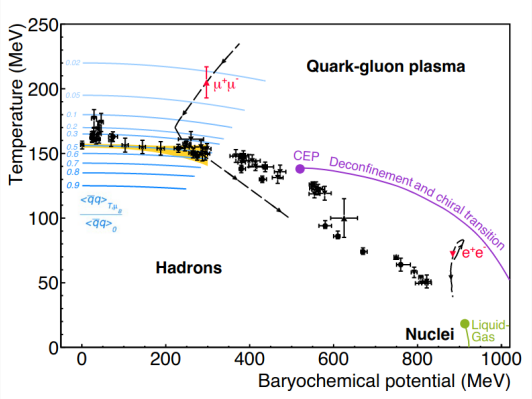
Virtual Photon Measurements with the HADES at GSI

DiElectron reconstruction in Ag+Ag collisions at $\sqrt{s_{NN}} = 2.55\,GeV$
PANIC 2021, 05.09.-10.09.

Jan-Hendrik Otto for the HADES collaboration, JLU Gießen

September 5, 2021

Physics at HADES



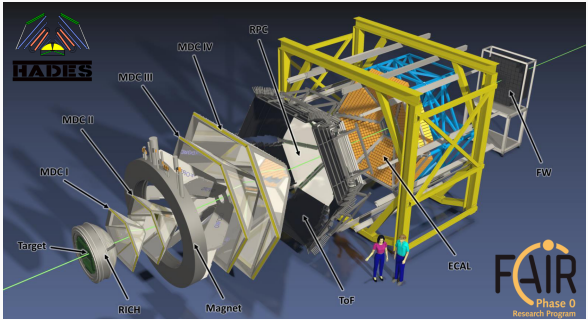
Nature Physics volume 15, pages 1040–1045 (2019)

- Explore high-μ_B region of the QCD phase diagram
- Focus on rare and penetrating probes $\rightarrow$ DiElectrons
- Address various aspects of baryon-meson coupling

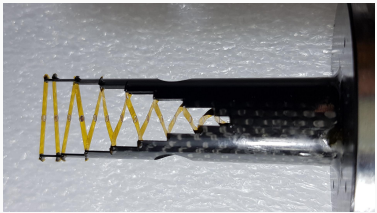
3 stages of heavy ion collision where DiElectrons are produced:

- Intitial NN collisions
- Fireball
- Decay of hadronic resonances

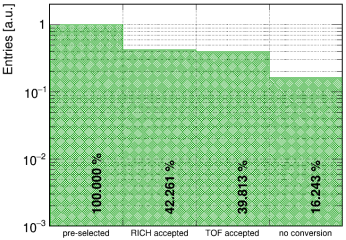
The High Acceptance DiElectron Spectrometer

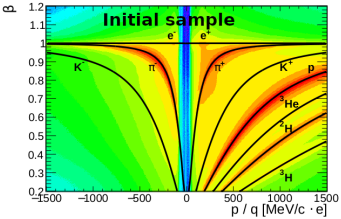


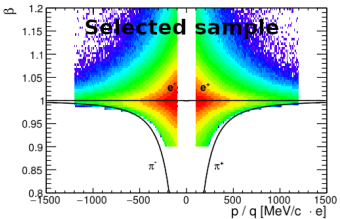
- Fixed target experiment at SIS18 (GSI, Germany)
- Magnet spectrometer
- Low mass Mini-Drift-Chambers (MDCs)
- Time of flight walls RPC and ToF
- upgraded RICH detector and new ECal for electron and photon detection
- Almost full azimuth angle coverage and polar angles between $18^\circ - 85^\circ$
- 15-fold ($25\ \mu m$, $\Delta z = 3.7\ mm$) segmented target



Electron identification

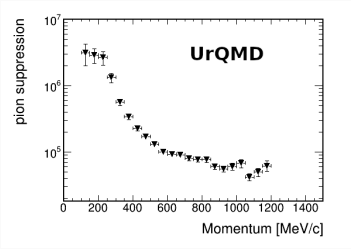


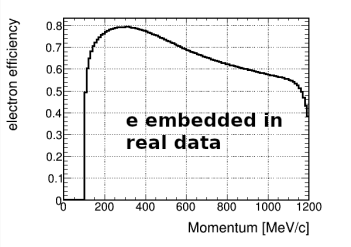




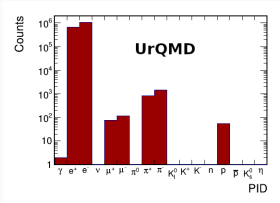
- $4.55 \cdot 10^9$ Ag+Ag collisions analysed (0 – 40% centrality)
- RICH (and TOF) criteria for lepton identification
- New: Highly efficient physical background (conversion) rejection based on the RICH

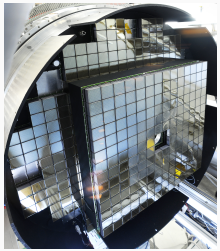
Electron identification in AgAg at $\sqrt{s_{NN}}$





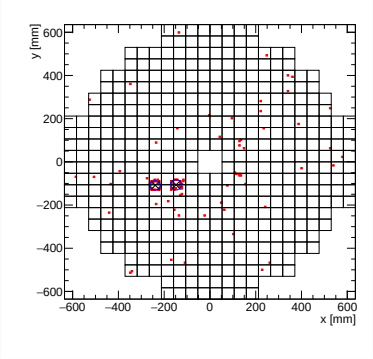
- HADES (RICH detector) combines high efficient electron identification with high pion and conversion suppression
- $\rho \to \pi\pi$ ($\sim 100\%$) vs. $\rho \to ee$ ($\sim 4.72 \cdot 10^{-3}\%$)
- Integrated electron purity of $P \sim 99.9\%$ (UrQMD simulation, RICH rotation technique)
- Efficiency calculation based on $e^{\pm}$ embedded in real data
- HADES electromagnetic calorimeter might even further improve



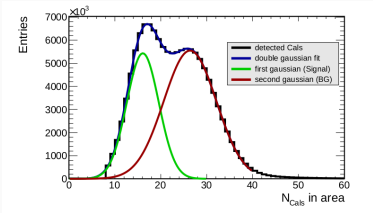


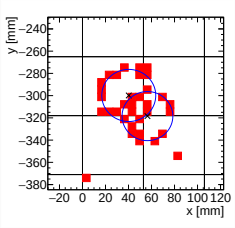
The HADES RICH - conversion suppression

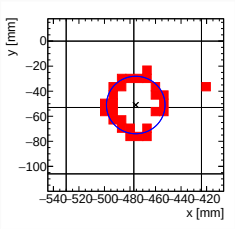
Upgrade of the HADES RICH (in cooperation with CBM)



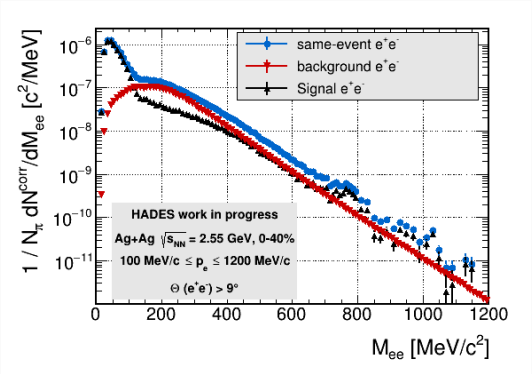
- On average 16 photons/ring
- Negligible background level - timing cuts enable high level noise rejection
- Excellent conversion recognition even at vanishing opening angles by counting converted Cherenkov photons (Cals)





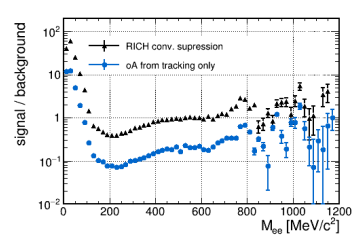


DiElectron formation

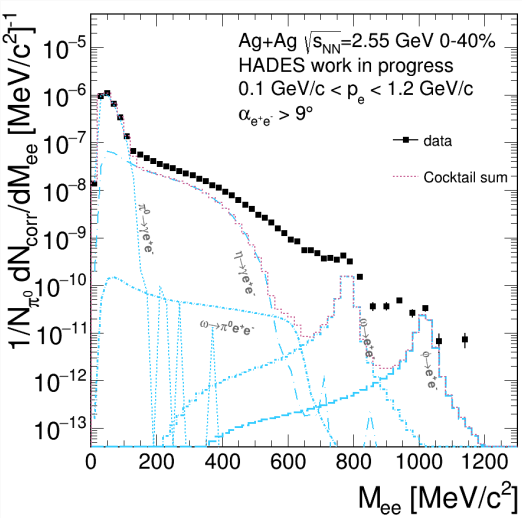


M_{ee} [MeV/c^2]	0 -150	150 - 450	450 - 750	750 - 1200
N^{raw}_{pairs}	$0.141 \cdot 10^6$	$0.607 \cdot 10^5$	$0.590 \cdot 10^4$	556
$N^{corr.,\,CB\,sub.}_{pairs}$	$1.546 \cdot 10^6$	$1.752 \cdot 10^5$	$1.318 \cdot 10^4$	1500

- Efficiency correction based on single electron simulation embedded into real data (in p, θ, ϕ)
- $< BG_{+-} >= 2k\sqrt{< FG_{++} >< FG_{--} >}$
- BG from mixed-event technique for $M_{ee} > 300\,MeV/c^2$
- $S/B\,(M_{ee} = m_\omega) \approx 3$
- $S/B > 1$ for $M_{ee} > 400\,MeV/c^2$



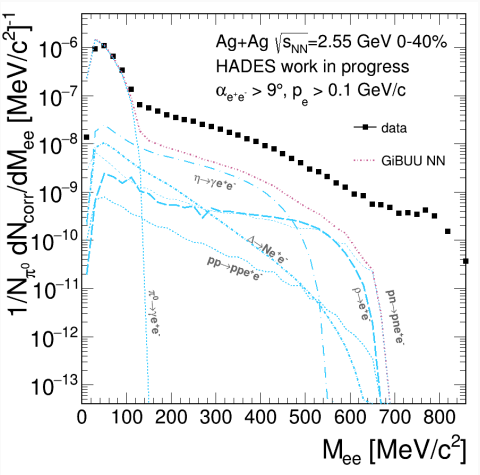
Cocktail simulation



- π^0 extrapolated from π^+ and π^- measurement; π^0 analysis in $\pi^0 \to \gamma\gamma$ and $\pi^0 \to \gamma\gamma \to 4e$ currently performed
- η from TAPS systematics (Phys. Rev. C84(1 2011)); analysis via conversion channel also currently performed
- ω and ϕ from thermal models; good agreement with extrapolation from high momentum data to full phase space in ω
- clear excess above final freezeout hadrons

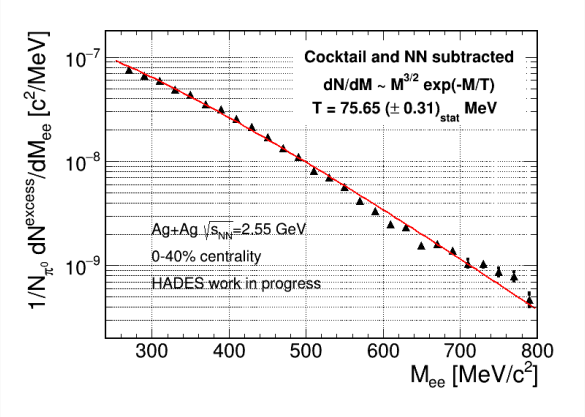
	Mult/$\langle A_{part}\rangle$	0 — 40 % centrality
$\langle A_{part}\rangle$		102
$Mult_{\pi^0}$	0.08	8.01
$Mult_{\eta}$	$2 \cdot 10^{-3}$	0.20
$Mult_{\omega}$	$3.50 \cdot 10^{-5}$	$3.57 \cdot 10^{-3}$
$Mult_{\phi}$	$3.00 \cdot 10^{-7}$	$3.06 \cdot 10^{-5}$

NN Reference



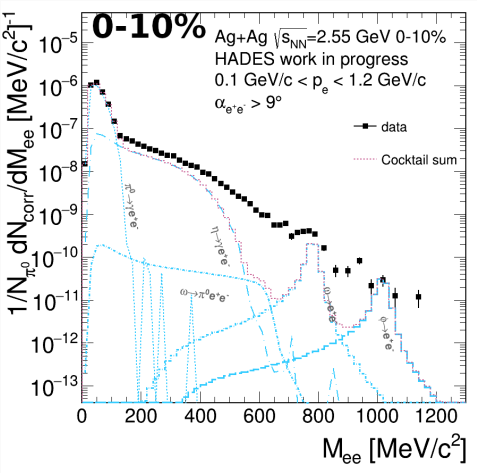
- No NN reference measured by HADES at $\sqrt{s_{NN}} = 2.55\,GeV$
- pp and pn simulated using GiBUU 2021 release (analogue to Physical Review C, 6, 102.064913) modeling $NN = 0.54\,pp + 0.46\,pn$
- Uncertainties especially in the pn-bremsstrahlung contribution dominant for $M_{ee} > 500\,MeV/c$

Excess radiation

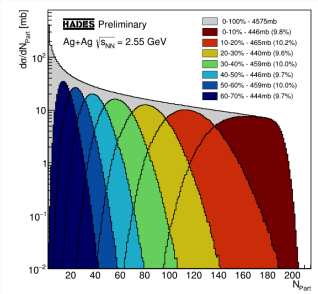


- Subtraction of hadronic cocktail and GiBUU NN reference reveals fireball radiation
- Acceptance correction based on PLUTO simulation
- Only statistical errors shown

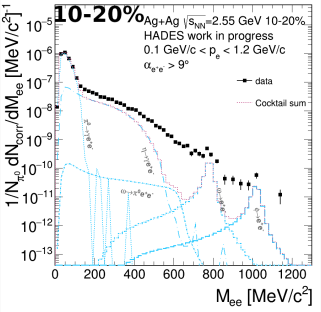
Centrality dependent analysis

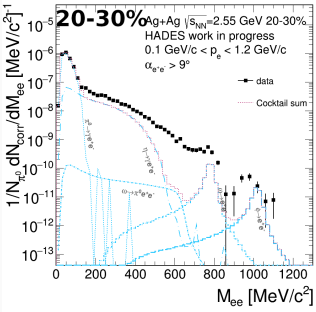


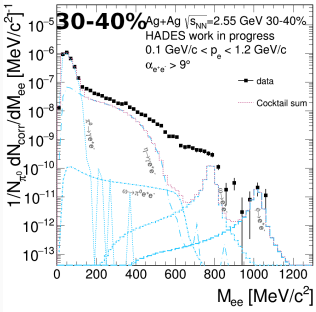
- Centrality estimation based on the Glauber MC model (analogue to published AuAu data, Eur. Phys. J. A 54, 1434-601X)
- Linear scaling with $\langle A_{part} \rangle$ assumed for π^0 and η
- $\langle A_{part} \rangle^{4/3}$ scaling assumed for ω and ϕ



Centrality dependent analysis

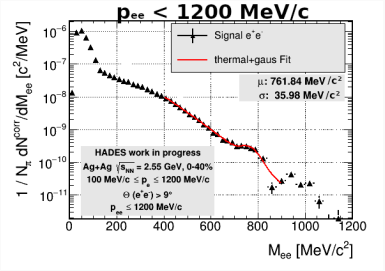


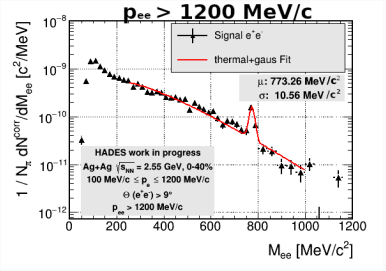




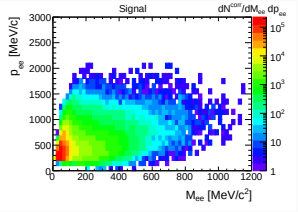
All centrality classes compare well → assumptions on hadron production seem reasonable

Pair momentum dependent analysis



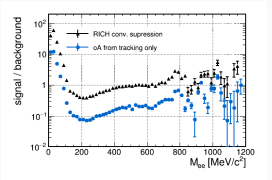


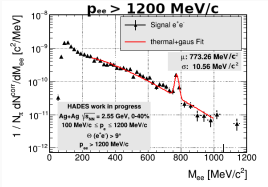
- Clear hints to in-medium modification of the ω (similar to previous HADES p+Nb measurement, *Phys. Let. B 8 (2012), 10.1016*) - now seen in AgAg
- ω multiplicity estimation possible for high momenta

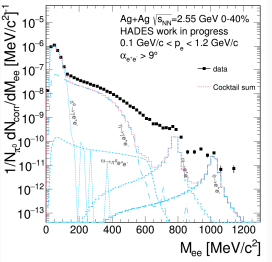


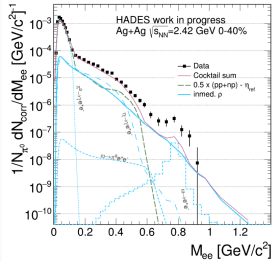
Summary

- High quality AgAg data at $\sqrt{s_{NN}} = 2.55\,GeV$ and $\sqrt{s_{NN}} = 2.42\,GeV$ taken by HADES
- The upgraded spectrometer allows for high efficient electron identification paired with high pion suppression and conversion recognition: Unprecedented quality of DiElectron spectra
- Hints for in-medium modification of the ω meson comparing low and high momentum data
- Decomposition of the DiElectron spectrum and comparison to NN reference (GiBUU) enables temperature estimation (as in AuAu, Nature Physics volume 15, pages 1040–1045 (2019))









The HADES collaboration