Status Report HADES

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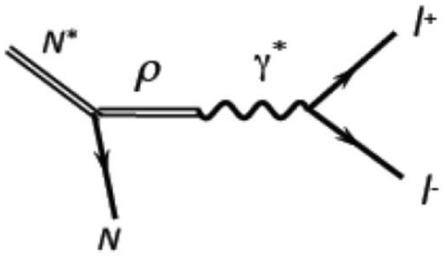
Bild: Hosan

Physics goals

Investigation of hadrons in vacuum and in medium at high net-baryon densities:

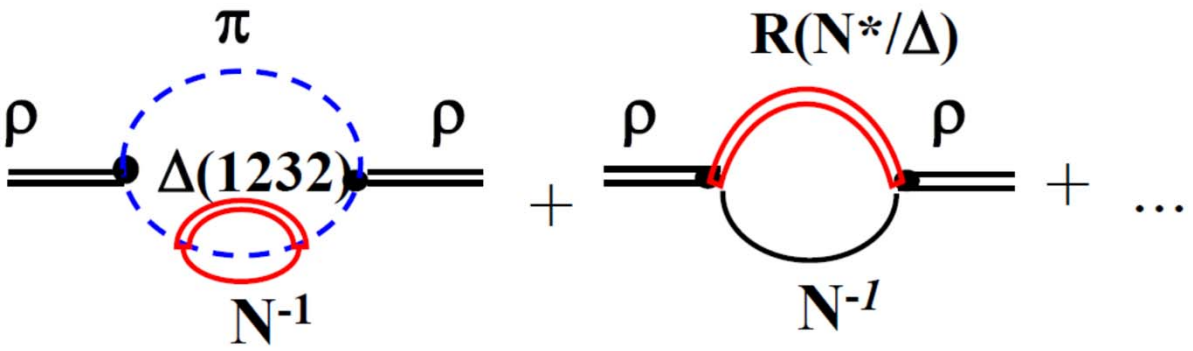
- Electromagnetic structure of Baryons and Mesons: Baryon electromagnetic transitions, Bremsstrahlung, Dalitz decays
- Test Vector Meson Dominance model in elementary reactions, pion beams
- Study high μ_B region of phase diagram
- Properties of matter as occuring in neutron star mergers



R→ Ne+e- (Dalitz decays)

R-ρ coupling in elementary interactions

In medium ρ spectral funtion



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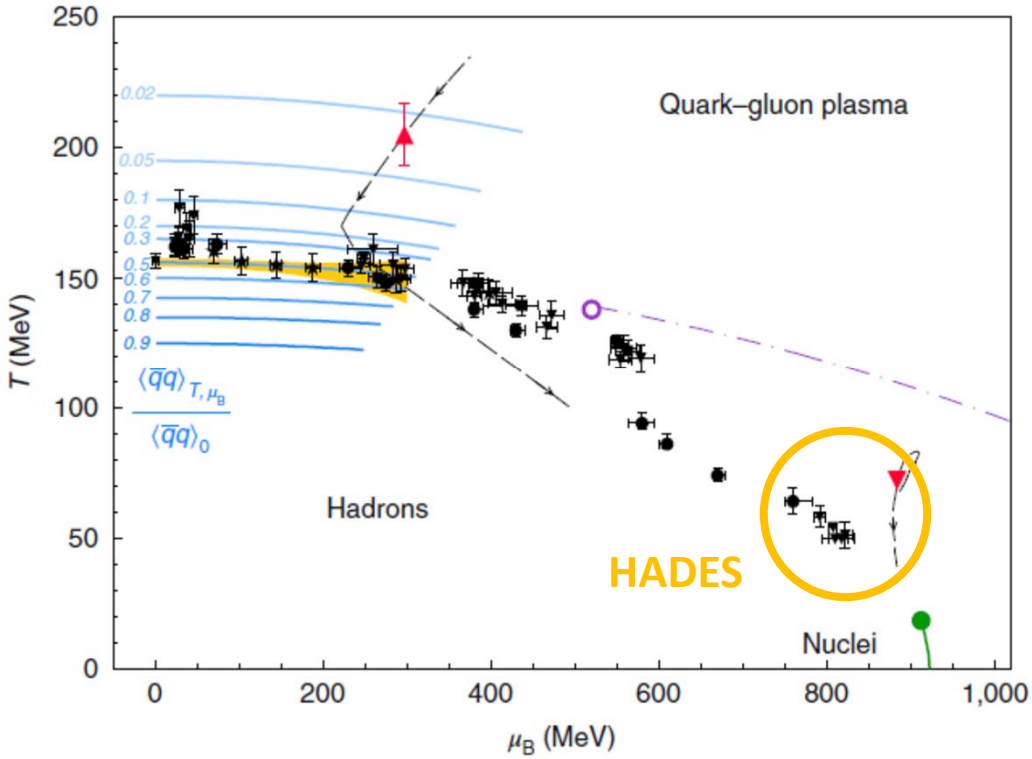

HADES; Nature Physics 15 (2019) 10, 1040-1045

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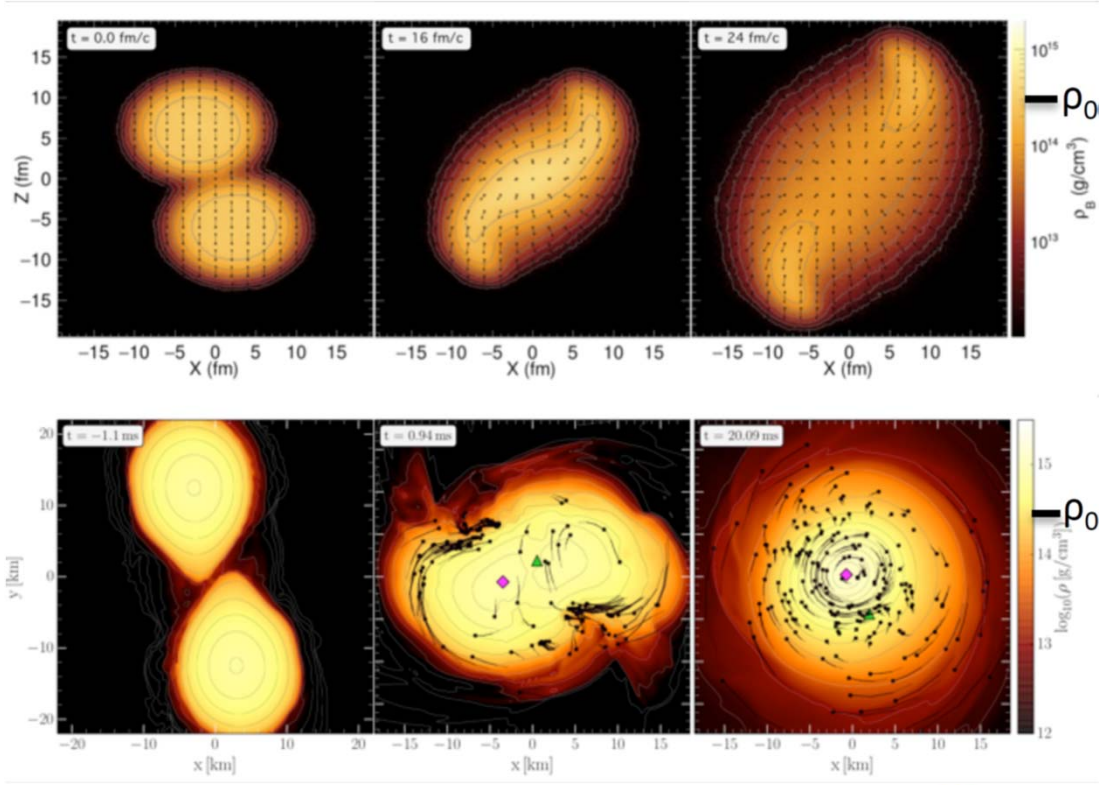
Central Au+Au collisions,
$\sqrt{s_{NN}} = 2.4\ GeV$

T < 70 MeV, $\rho \approx 3\rho_0$ in both cases

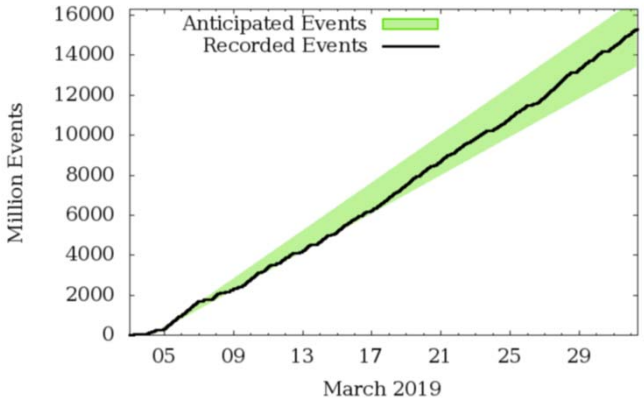
Neutron Star Merger

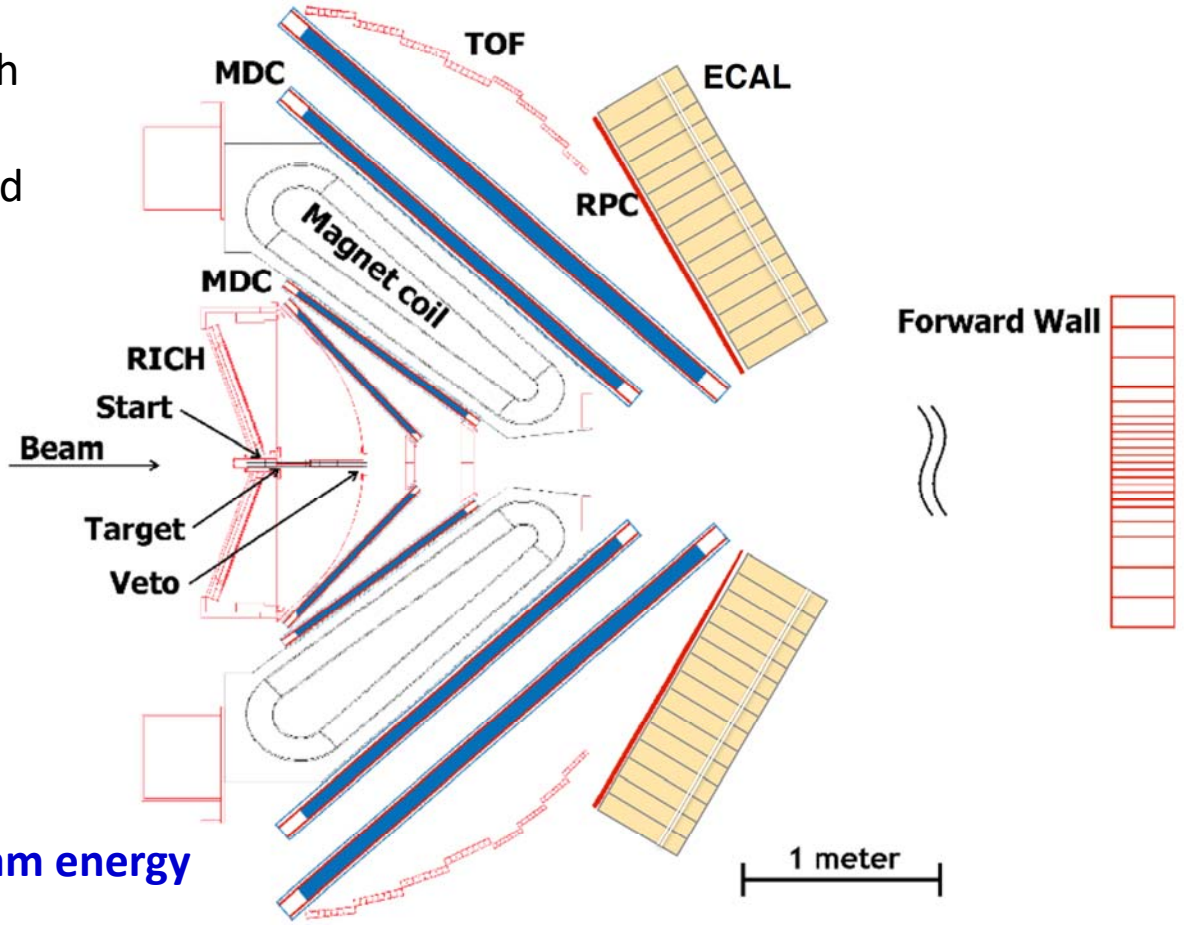


M. Hanauske, J.Phys.: Conf. Series878 012031 (2017)
L. Rezzolla et. al. PRL 122, n0.6, 061101 (2019)h
Au+Au simulation UrQMD: S. A. Bass et al., Prog. Part. Nucl. Phys. 41, 255 (1998).
Fig. credit T. Galatyuk & Florian Seck

The HADES experiment – status & future

- Running succesfully since 2002
- Last major upgrade 2018/2019
  - RICH upgrade (coop. with CBM)
  - ECAL addition
- Succesful beamtime 2019 with Ag+Ag collisions:
  - 15 billion events collected
  - 16-18 kHz event rate
- FAIR Phase-0 program!





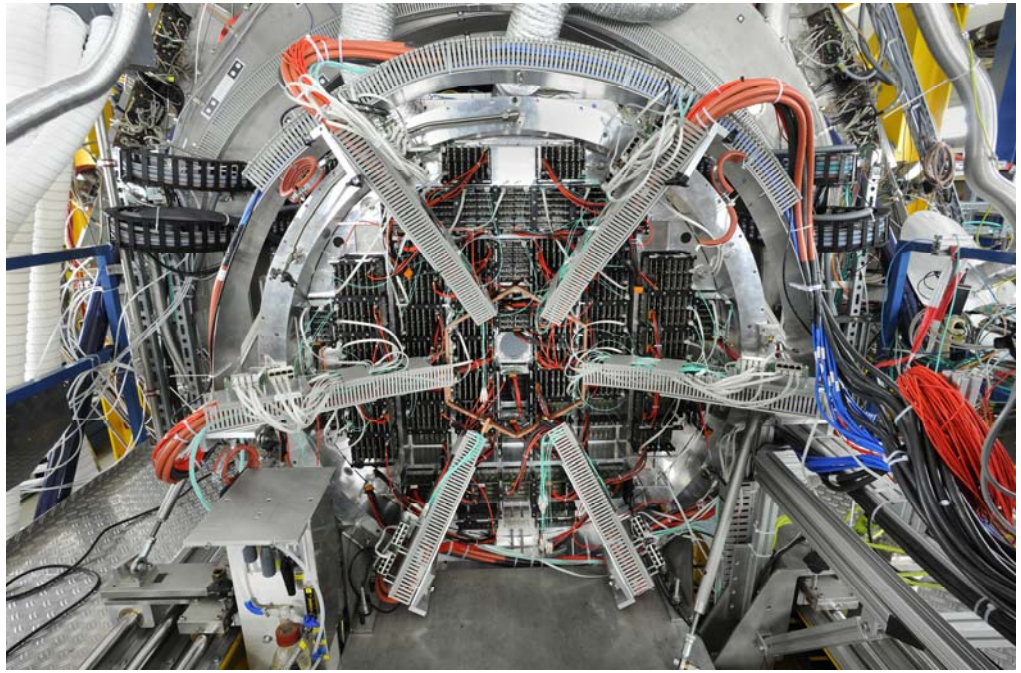
Ag+Ag collisions at 1.58 AGeV beam energy ($\sqrt{s_{NN}}$=2.55 GeV)

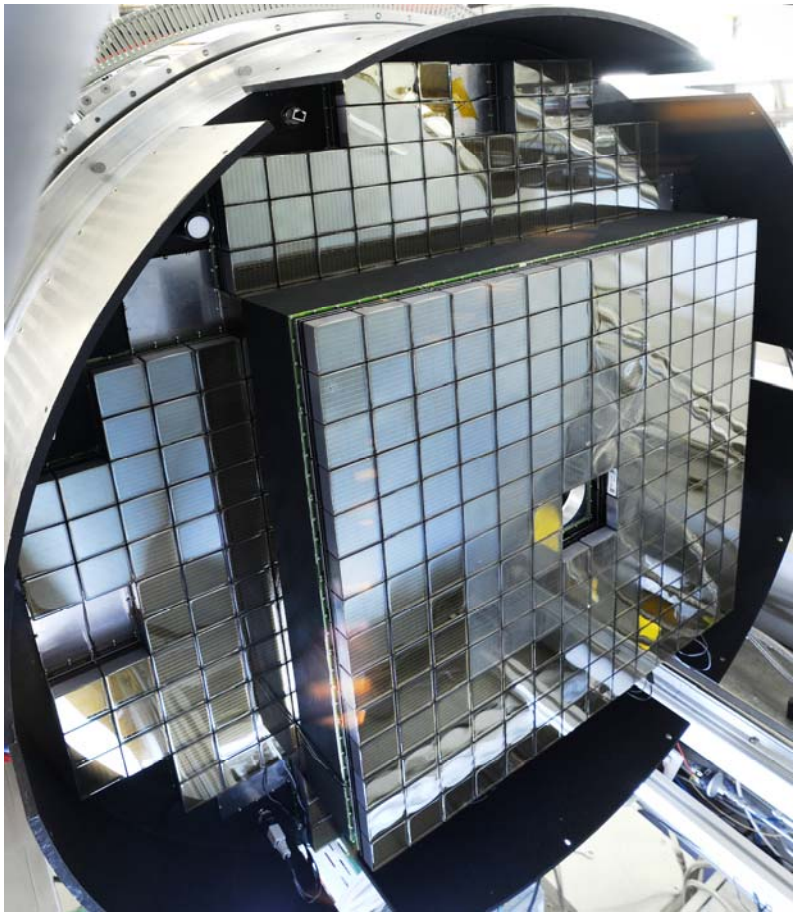
RICH upgrade

RICH upgrade

- Photon detector replaced by 428 H12700 MAPMTs (~ ½ of CBM MAPMTs)
- New readout electronics developed based on the „DiRICH“ family, FPGA-TDCs with ToT inf.
- Average timing precision ~225 ps
- 15-19 measured photoelectrons / ring

Participating institutions: TU München, JLU Giessen, BU Wuppertal, GSI





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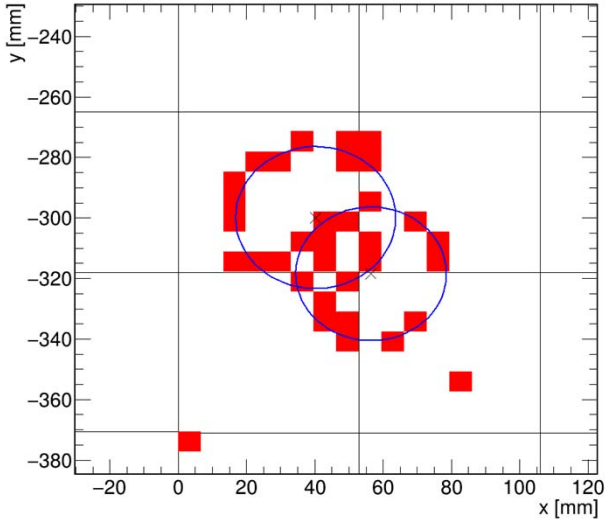
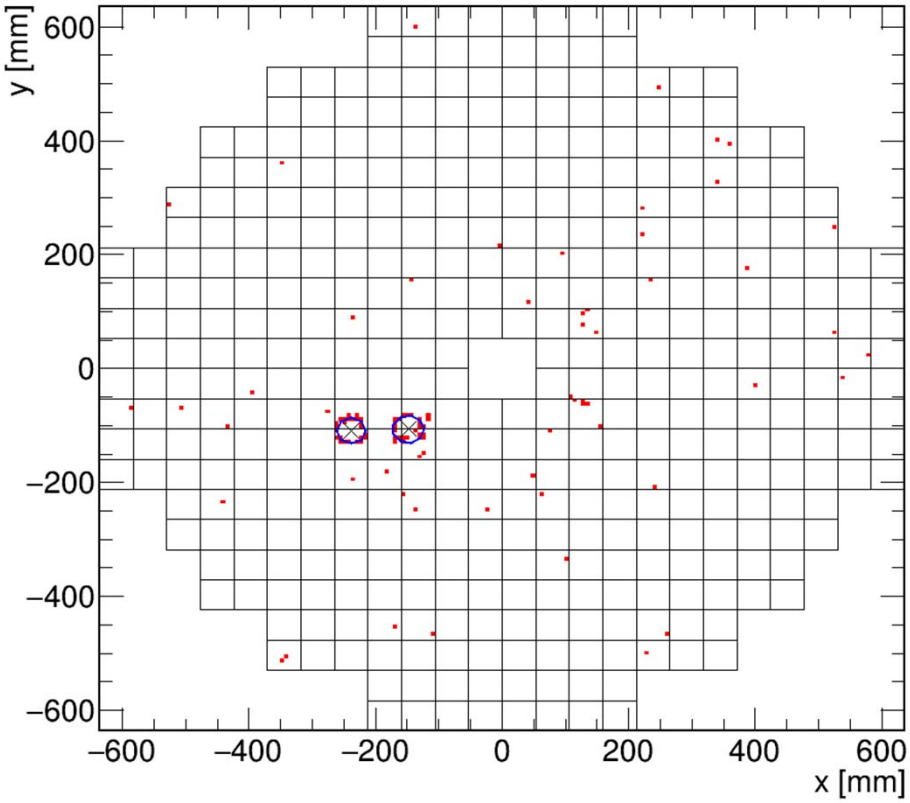


Ring finder integrated efficiency > 98%
Electrons Integrated purity > 99.5%

Very low noise and clear rings!

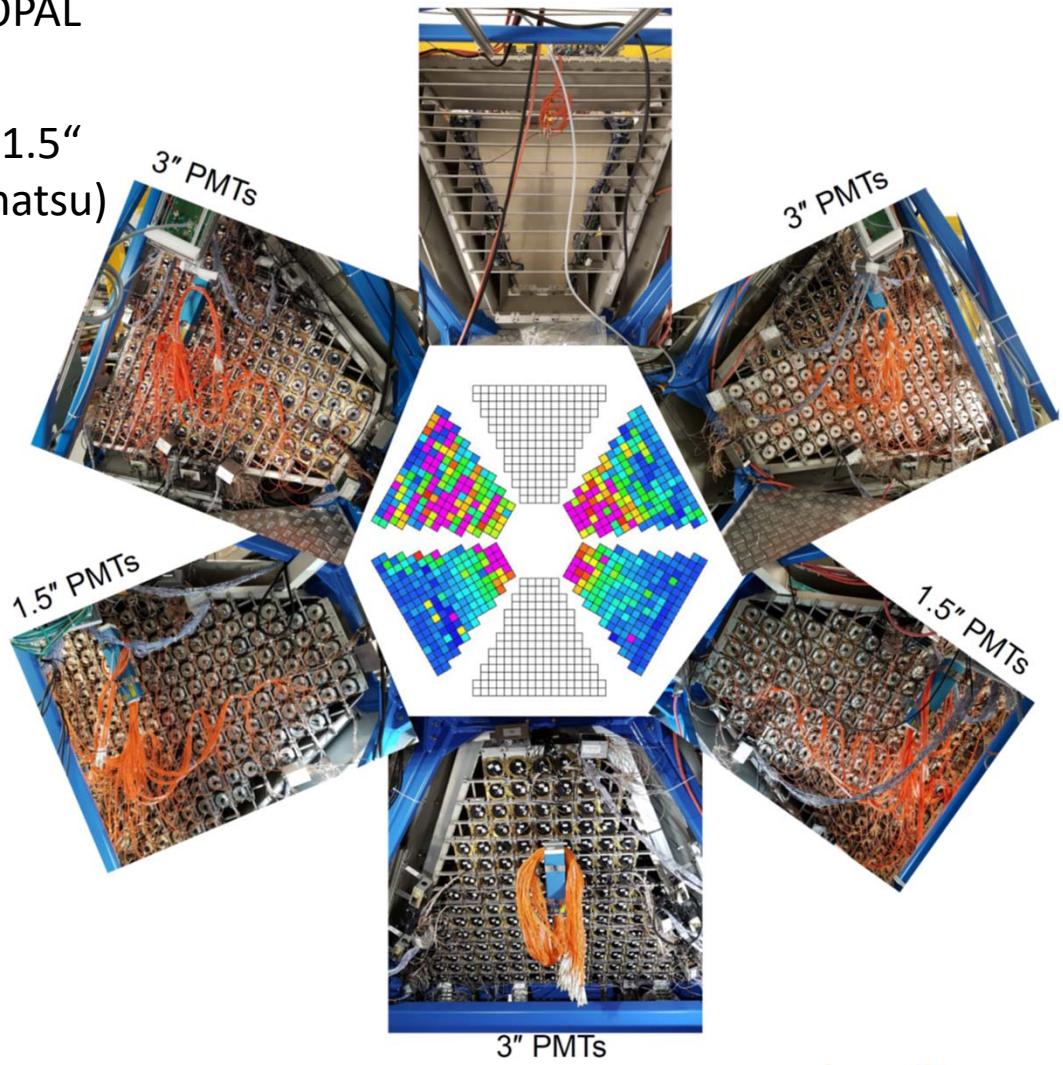


ECAL

ECAL replacing the pre-shower detectors

Participating institutions: JU Krakow, INR Moscow, MPI Rez, GSI, TU Darmstadt

- 978 lead glass modules recycled from OPAL
- 6 sectors, 10°<θ<45°
- PMT readout with two different types (1.5“ recovered from WA98, 3“ R6091 Hmamatsu)
- 4 sectors ready for beamtime 2019
- 5th ready now, 6th Q1 2022



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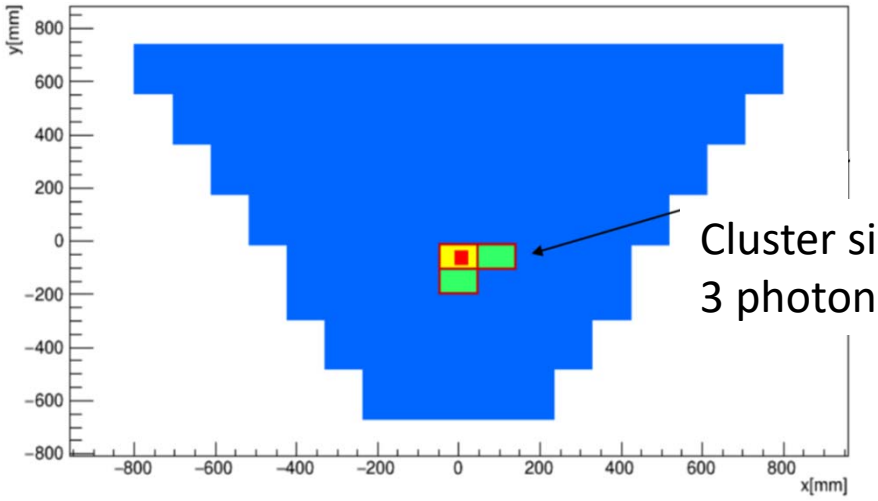
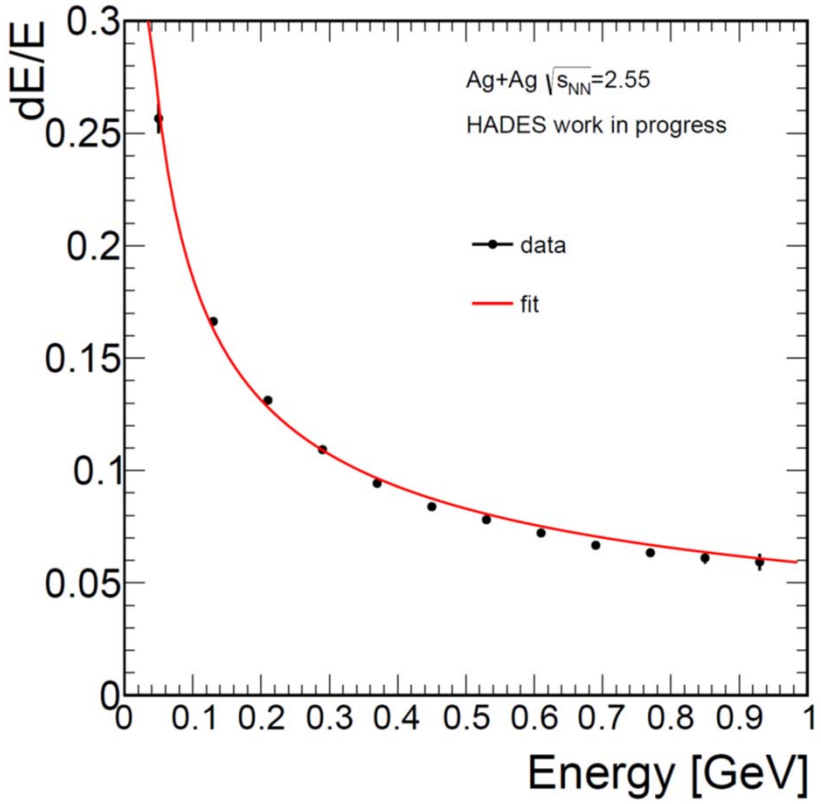


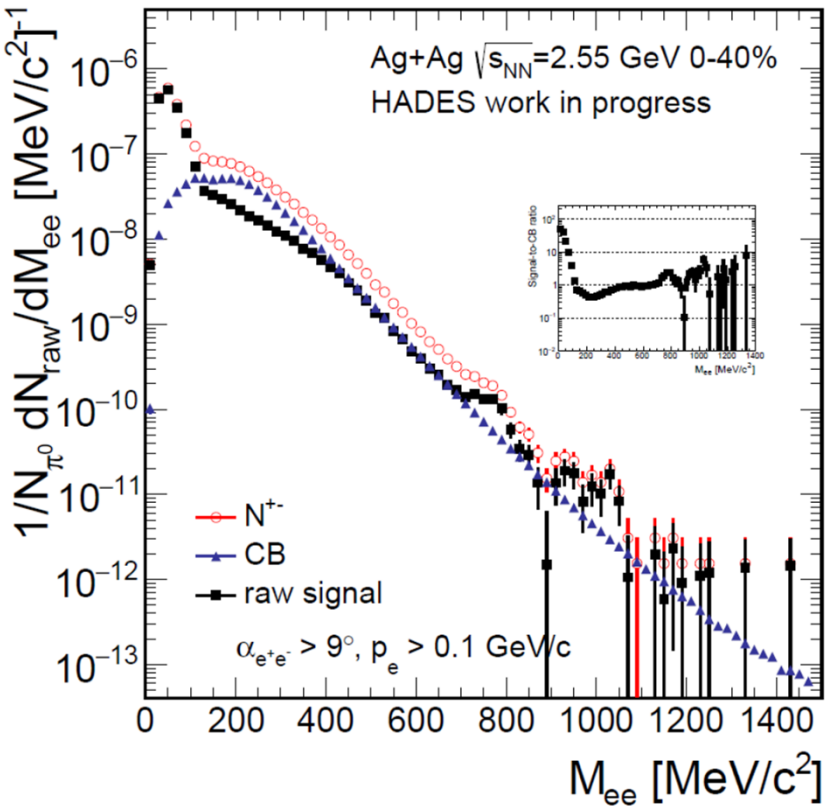
5.2 % energy resolution
205 ps timing resolution

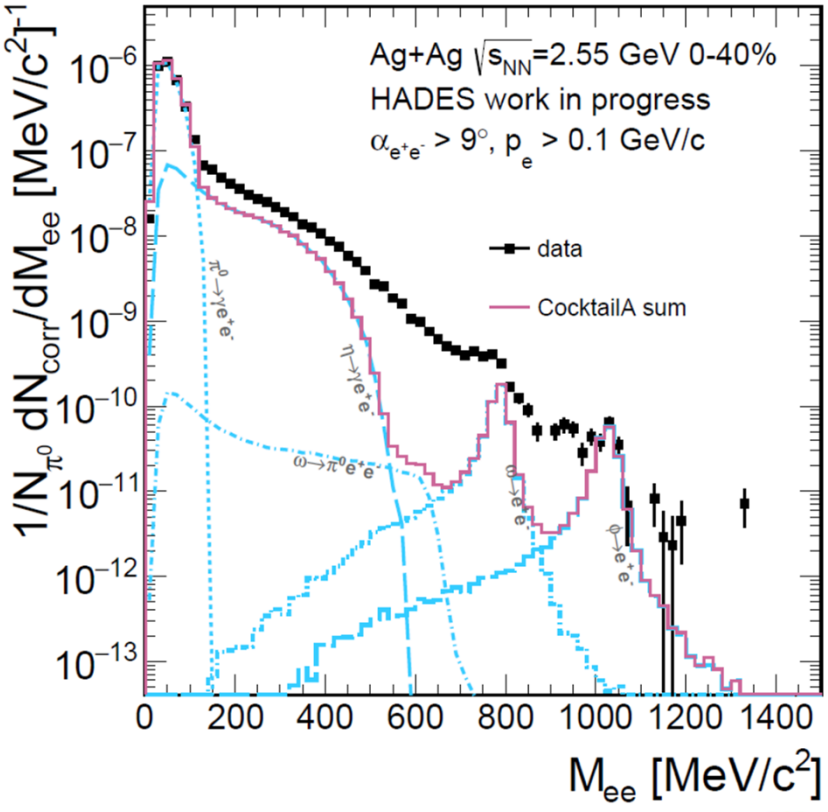


Di-electrons

Di-electron analysis in particular exploiting the close-pair rejection capability of the new RICH!

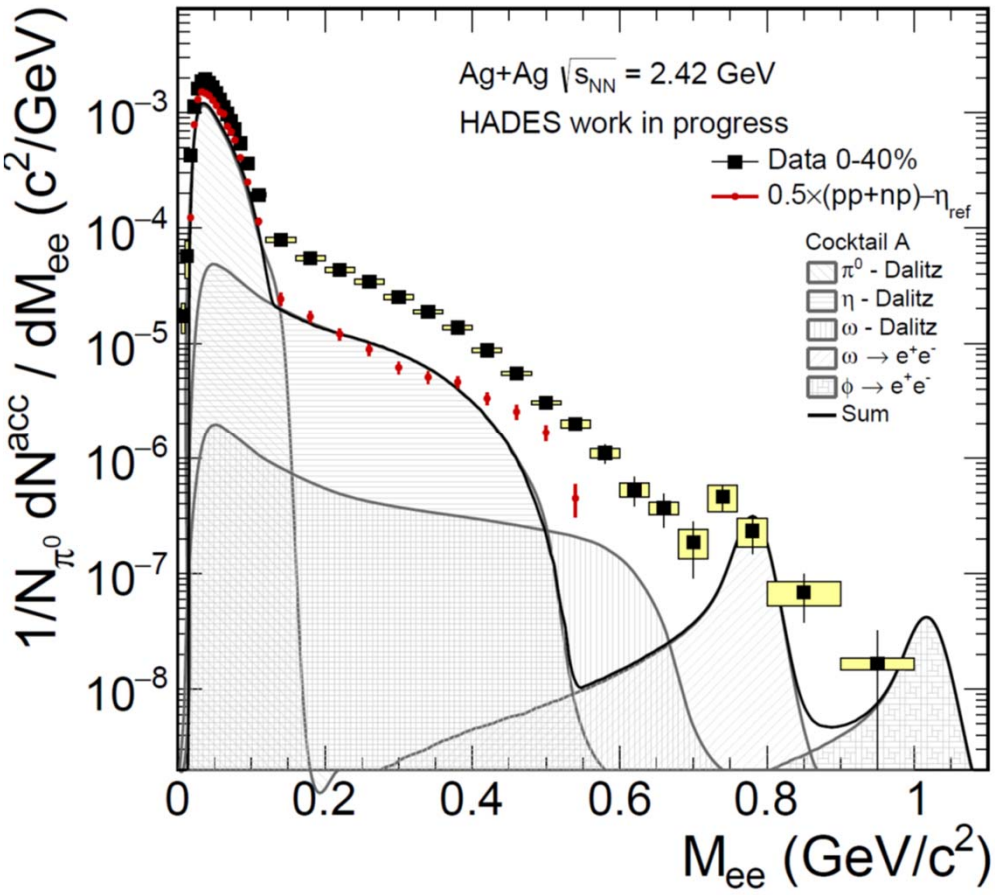
- S/B ratio ≅ 1 for masses around 300 MeV; … of ≅ 3 in the ω-region
- Raw yield of pairs: $1.6 \cdot 10^4$ for 450 MeV – 700 MeV
  918 for 700 MeV – 1020 MeV
  35 for > 1020 MeV





Di-electrons

…. And this could be achieved with just 3 days of beam (Ag+Ag lower energy, same as Au+Au data

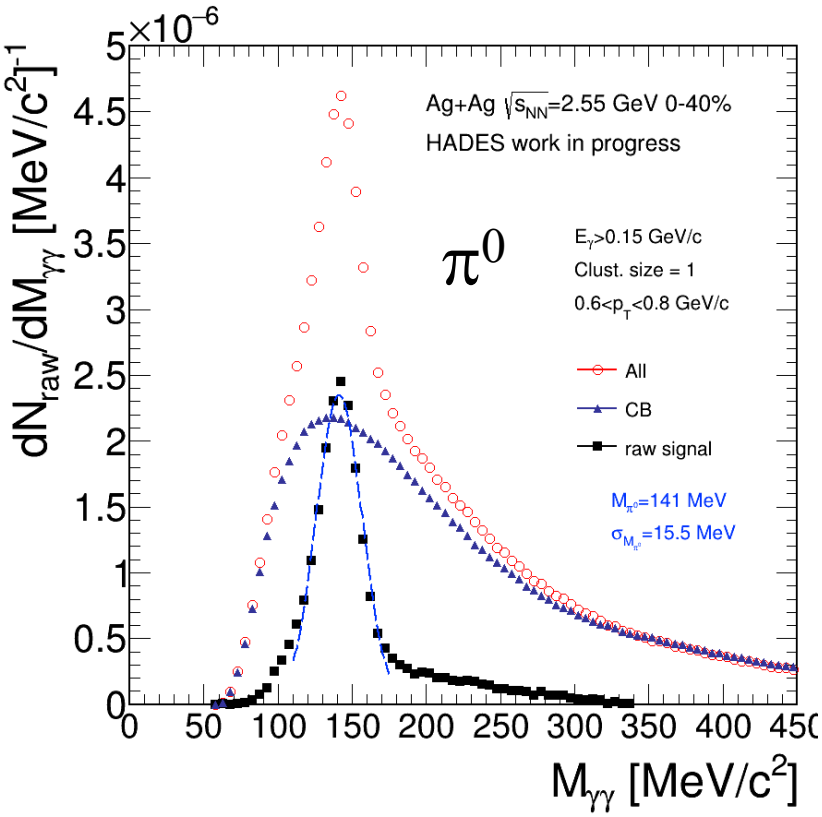


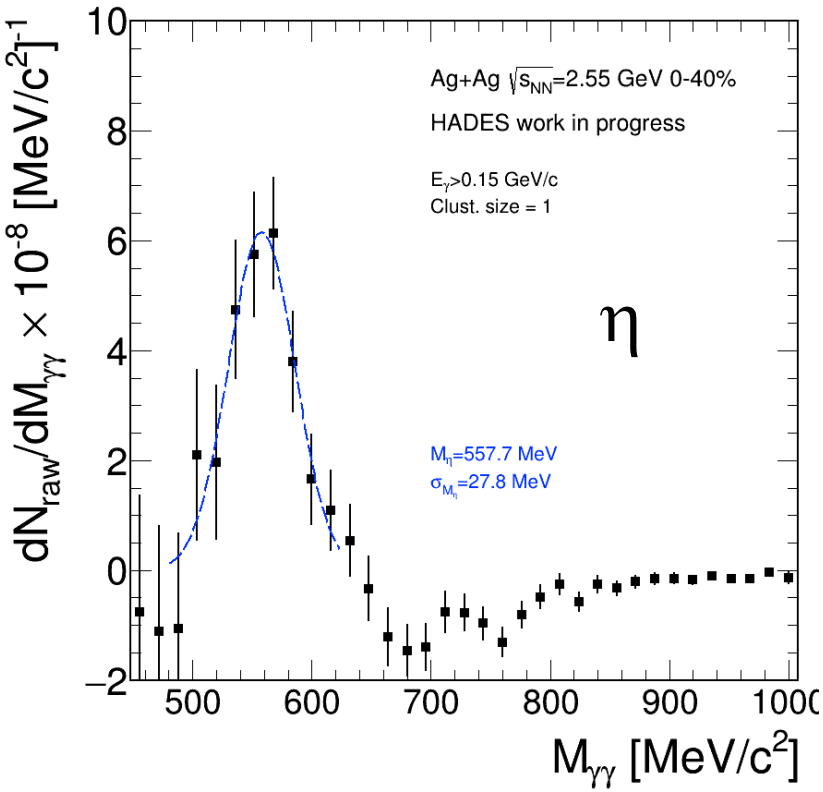
Lower statistics data set
Ag+Ag collisions at
1.23 AGeV beam energy

Di-Photons

ECAL analysis with photons

- Cluster size 1 photons selected, Energy > 150 MeV
- $\beta > 0.95$, no track matched
- 0-40% centrality





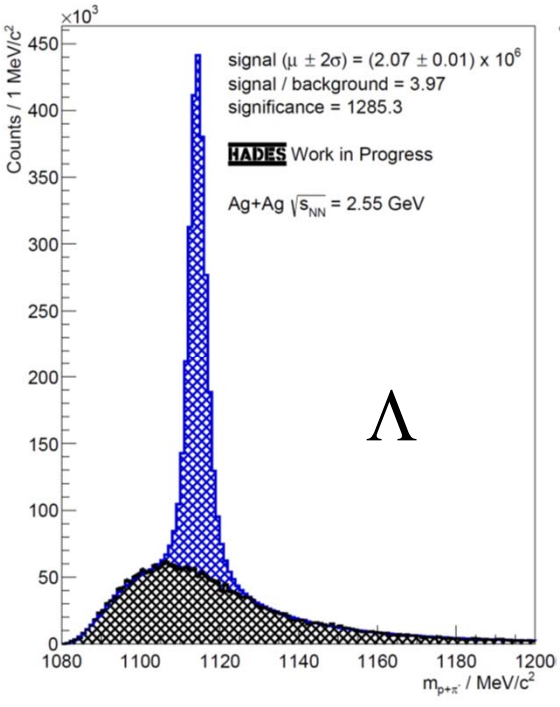
Hadrons in Ag+Ag collisions

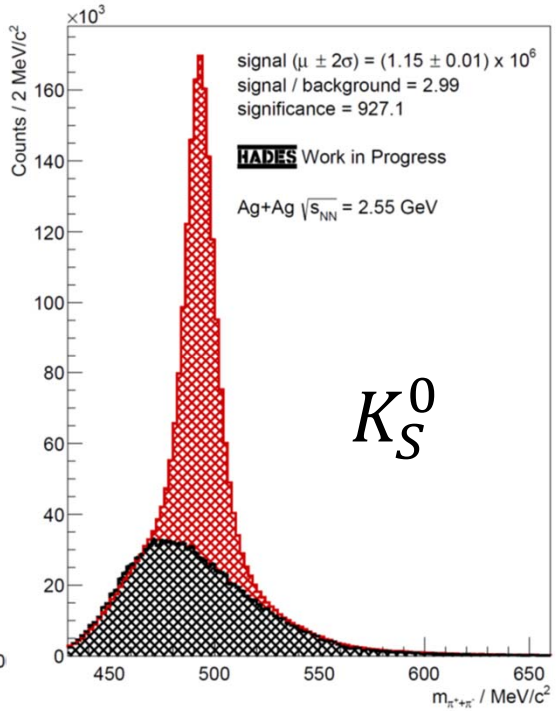
- Although strangeness production is just at/ below threshold in NN

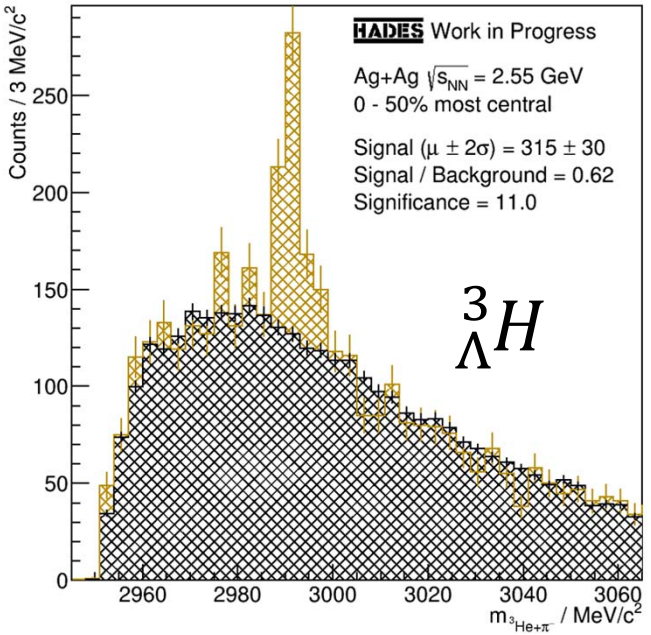
  $NN \rightarrow N\Lambda K^+ \ \sqrt{S_{NN}} = 2.55\ AGeV$

  $NN \rightarrow NNK^+K^- \ \sqrt{S_{NN}} = 2.86\ AGeV$

  → many strange hadrons produced (K^+, K^-, K^0, Λ, ϕ already seen, Ξ^- work in progress)
- ${}^3_\Lambda H$ seen in ${}^3He + \pi^-$ channel







HADES Highlights 2020

Publications in 2020:

- e-Print: 2005.12217 [nucl-ex], accepted by PRL:
  Directed, elliptic and higher order flow harmonics of protons, deuterons and tritons in Au+Au collisions at $\sqrt{s_{NN}}$ = 2.4 GeV
- e-Print: 2010.06961 [nucl-ex]:
  Production and electromagnetic decay of hyperons: a feasibility study with HADES as a Phase-0 experiment at FAIR
- Eur.Phys.J.A 56 (2020) 10, 259:
  Charged pion production in in *Au+Au collisions at $\sqrt{s_{NN}}$ = 2.4 GeV*
- Phys.Rev.C 102 (2020) 2, 024001: --- PDG entries ---
  Two-Pion production in the second resonance region in $\pi^- p$ collisions with HADES
- Phys.Rev.C 102 (2020) 2, 024914: --- editors highlight ---
  Proton-number fluctuations in $\sqrt{s_{NN}}$ = 2.4 GeV Au + Au collisions studied with the High-Acceptance DiElectron Spectrometer (HADES)
- Eur.Phys.J.A 56 (2020) 5, 140:
  Identical pion intensity interferometry at $\sqrt{s_{NN}}$ = 2.4 GeV

… and the highlight from 2019:

- Nature Physics 15 (2019) 10, 1040-1045:
  Probing dense baryon-rich matter with virtual photons

HADES Highlights 2020

New PDG entries:

4 first entries: BR(Nρ)

4 additional entries: BR(Δπ),BR(Nσ)

$$\pi^- p \to \pi^+ \pi^- n$$

$$\pi^- p \to \pi^0 \pi^- p$$

Phys. Rev. C 102, 024001 (2020):

Two-pion production in the second resonance region in πp collisions with HADES

PDG Verification

particle data group

Send Feedback
Help

PDG verification for: PR C102 024001 (ADAMCZEWSKI-MUSCH 2020)
Verifier: SARANTSEV

Back to SARANTSEV verifications

$\Gamma(N(1520) \to \Delta(1232)\pi , S-wave)/\Gamma_{total}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
12.1 ±2.1	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1520) \to \Delta(1232)\pi , D-wave)/\Gamma_{total}$ Γ_6/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
6 ±2	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1520) \to N\rho , S=3/2 , S-wave)/\Gamma_{total}$ Γ_8/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
11.8 ±1.9	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1520) \to N\rho , S=1/2 , D-wave)/\Gamma_{total}$ Γ_9/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
0.4 ±0.2	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1520) \to N\sigma)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
7 ±3	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1535) \to \Delta(1232)\pi , D-wave)/\Gamma_{total}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
3 ±1	ADAMCZEWSKI- 2020 M..	DPWA	Multichannel

$\Gamma(N(1535) \to N\rho , S=1/2)/\Gamma_{total}$ Γ_7/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
2.7 ±0.6	ADAMCZEWSKI- 2020	DPWA	Multichannel

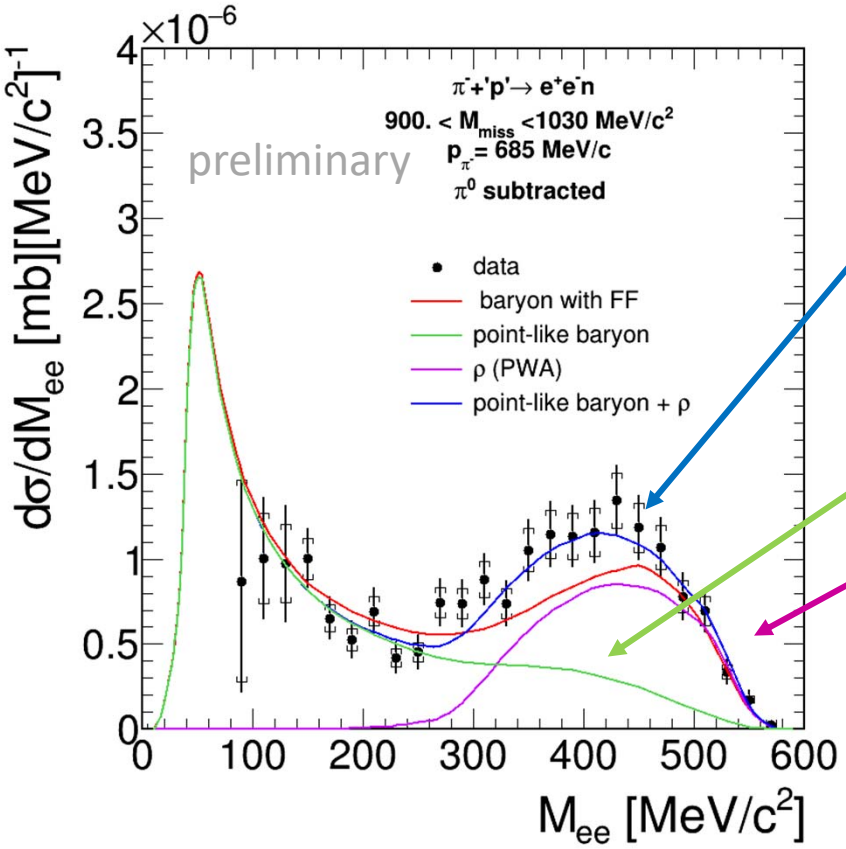
$\Gamma(N(1535) \to N\rho , S=3/2 , D-wave)/\Gamma_{total}$ Γ_8/Γ

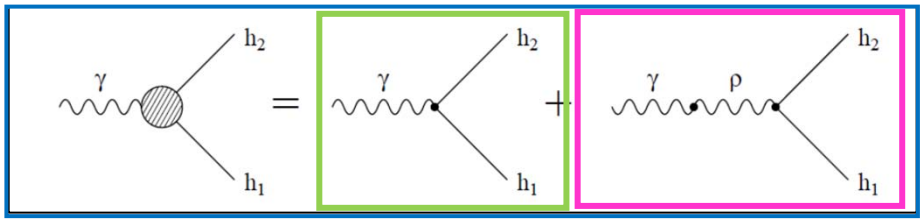
VALUE (%)	DOCUMENT ID	TECN	COMMENT
0.5 ±0.5	ADAMCZEWSKI- 2020 M	DPWA	Multichannel

Baryon Dalitz decays

Exclusive analysis of $\pi^- p \to e^+ e^- n$

N*(1520) dominant





combined approach

Vector Meson Dominance model

Point like description

The HADES experiment – status & future

Further upgrades ongoing:

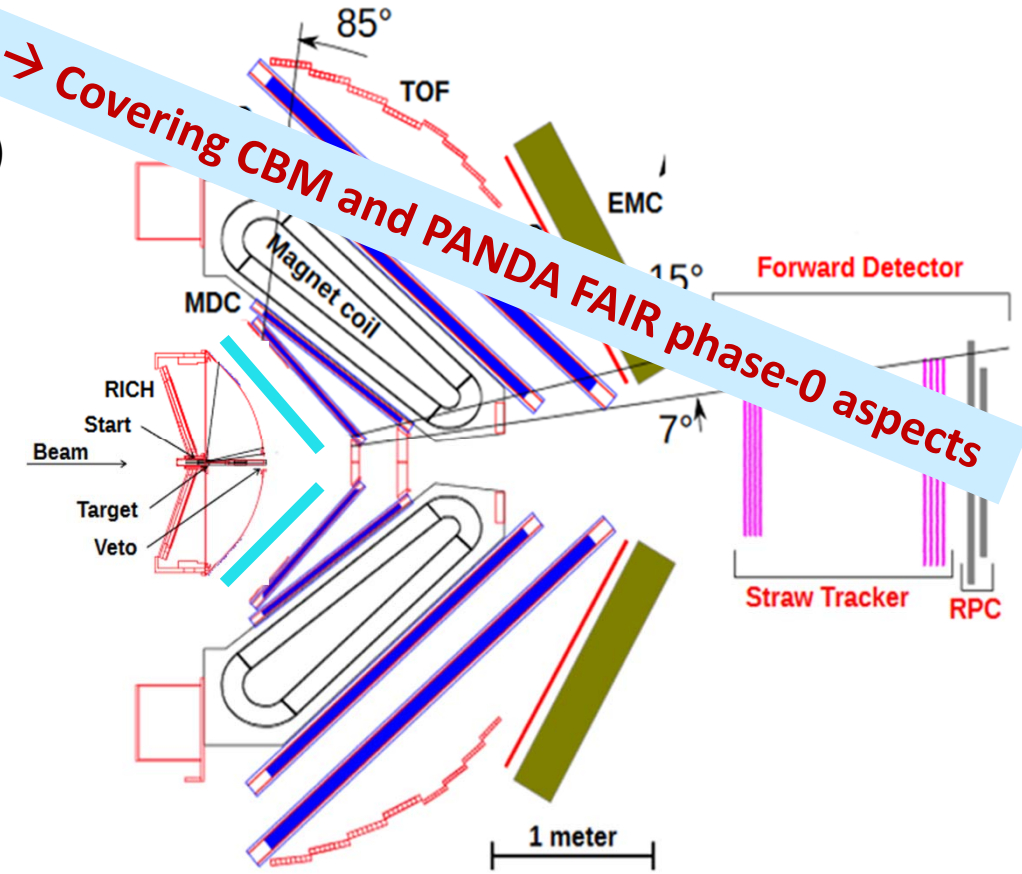
- Forward detector (coop. with PANDA)
- InnerTOF system
- T0 system based on LGAD

On top of upgrades of MDC FEE, DAQ necessary to keep HADES an up-to-date hadron & heavy-ion experiment

Next beamtime early 2022:
p+p collisions at 4.5 GeV

- Hyperon decays (em & hadronics)
- double & hidden strangeness
- Hadrons & dileptons as reference for pA and AA

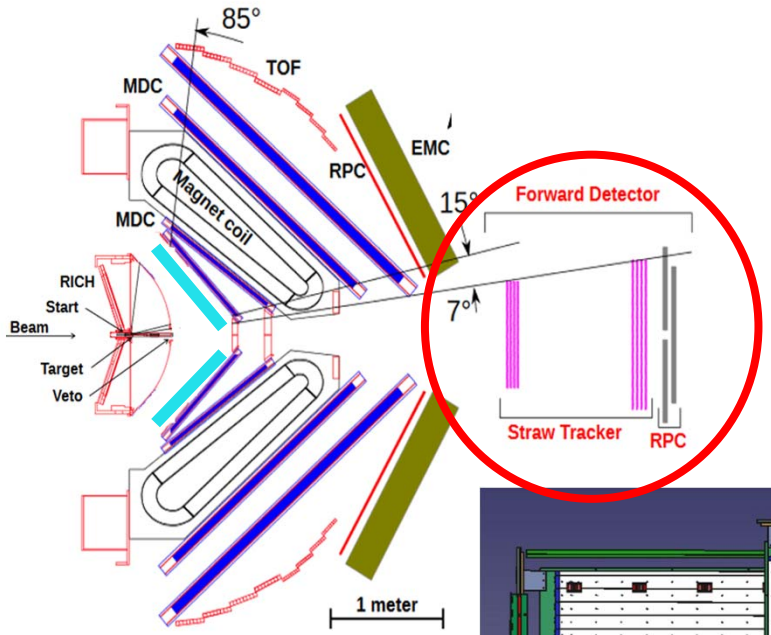
beamtime spring 2022:
Low energy scan of Au+Au collisions



Further beamtime applications highly rated but postponed due to time restrictions:
Pion beam, medium effects in pA, NN Bremsstrahlung & Dibaryon

HADES upgrades

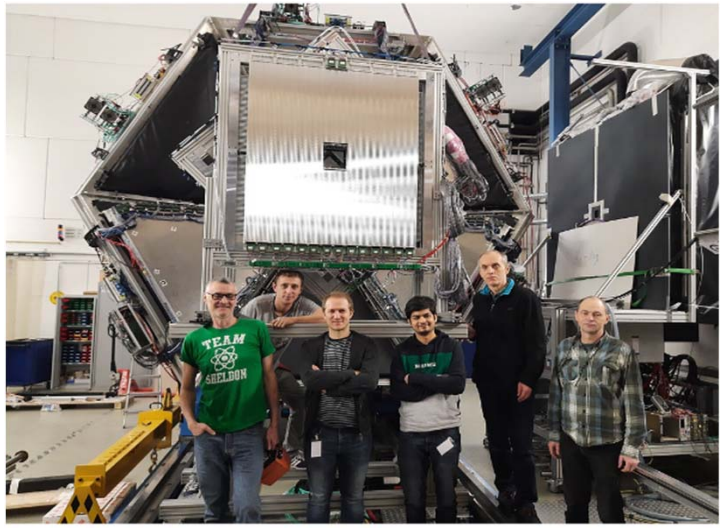
Forward detector to track charged hadrons at θ<7°
2 straw trackers, 1 forward RPC

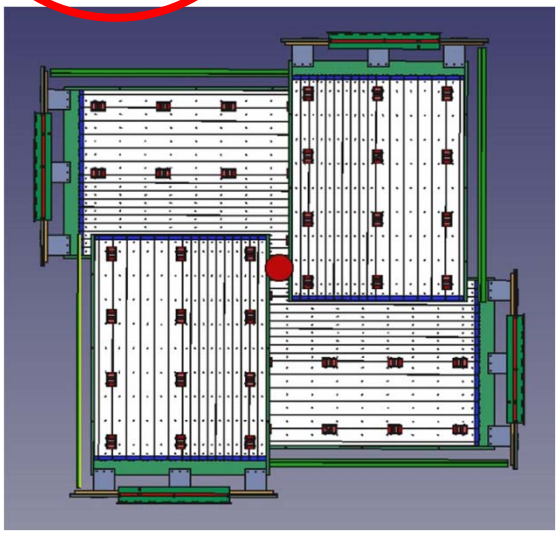


STS 1 installed

Participating institutions:
FZ Jülich,
JU Kraków,
IPNO Orsay,
LIP Portugal

STS 2 installed





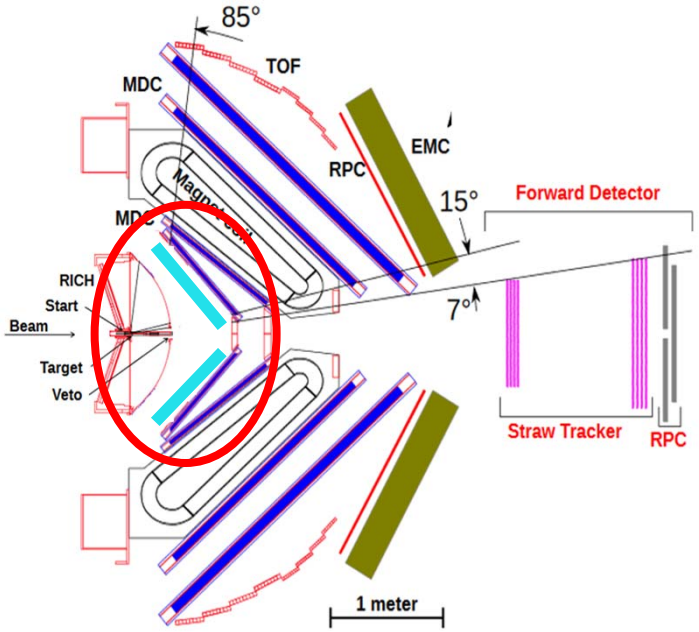
FRPC
Installation Q1/2021

Feasibility studies for S518 experiment published:
HADES and PANDA Collaborations, arXiv:2010.06961 [nucl-ex]

HADES upgrades

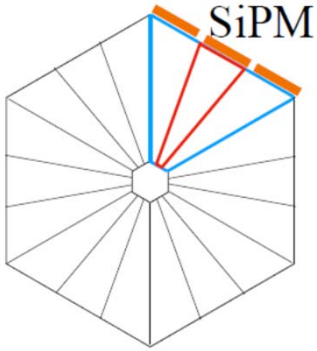
InnerTOF Trigger System

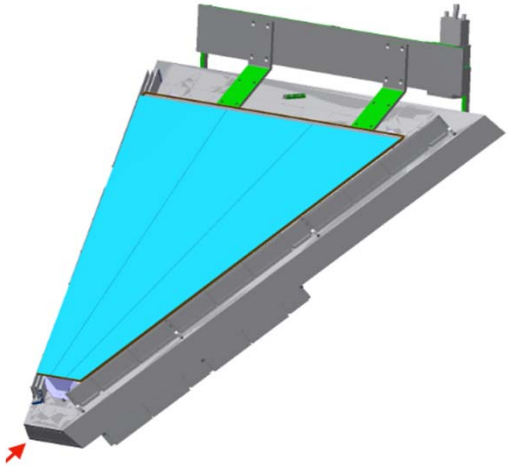
Trigger selectivity improvement by a factor 2 expected



Single sector of InnerTOF system

- Three plastic scintillators
- Thickness of 7mm





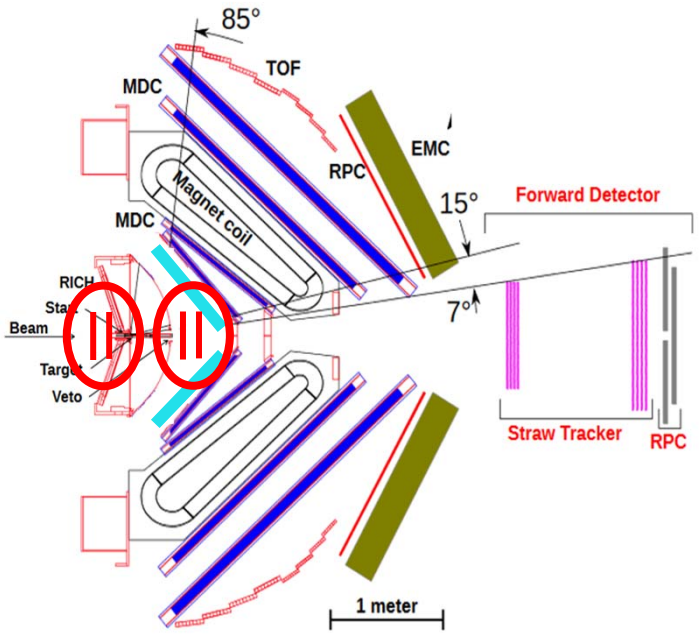
- 2 sectors ready in Q1/2020
- Full system ready Q3/2021

Participating institutions: FZ Jülich

HADES upgrades

T0 system based on LGAD

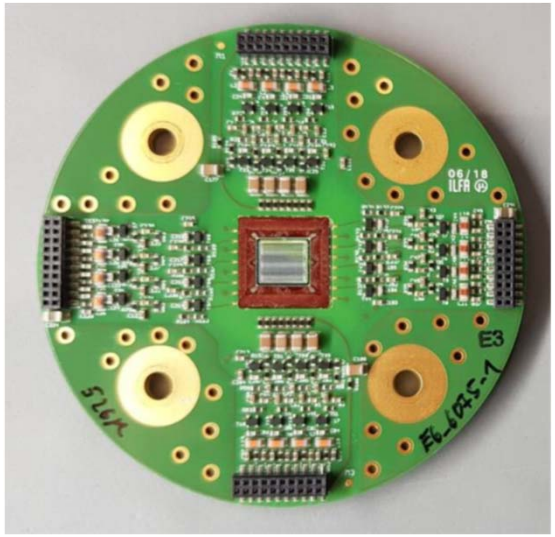
T_0 & vertex determination, beam monitoring



Low Gain Avalanche Detectros for the HADES reaction time (T_0) detector upgrade:
J. Pietraszko et al, Eur.Phys.J.A (2020) 56:183

T0 detector key requirements:

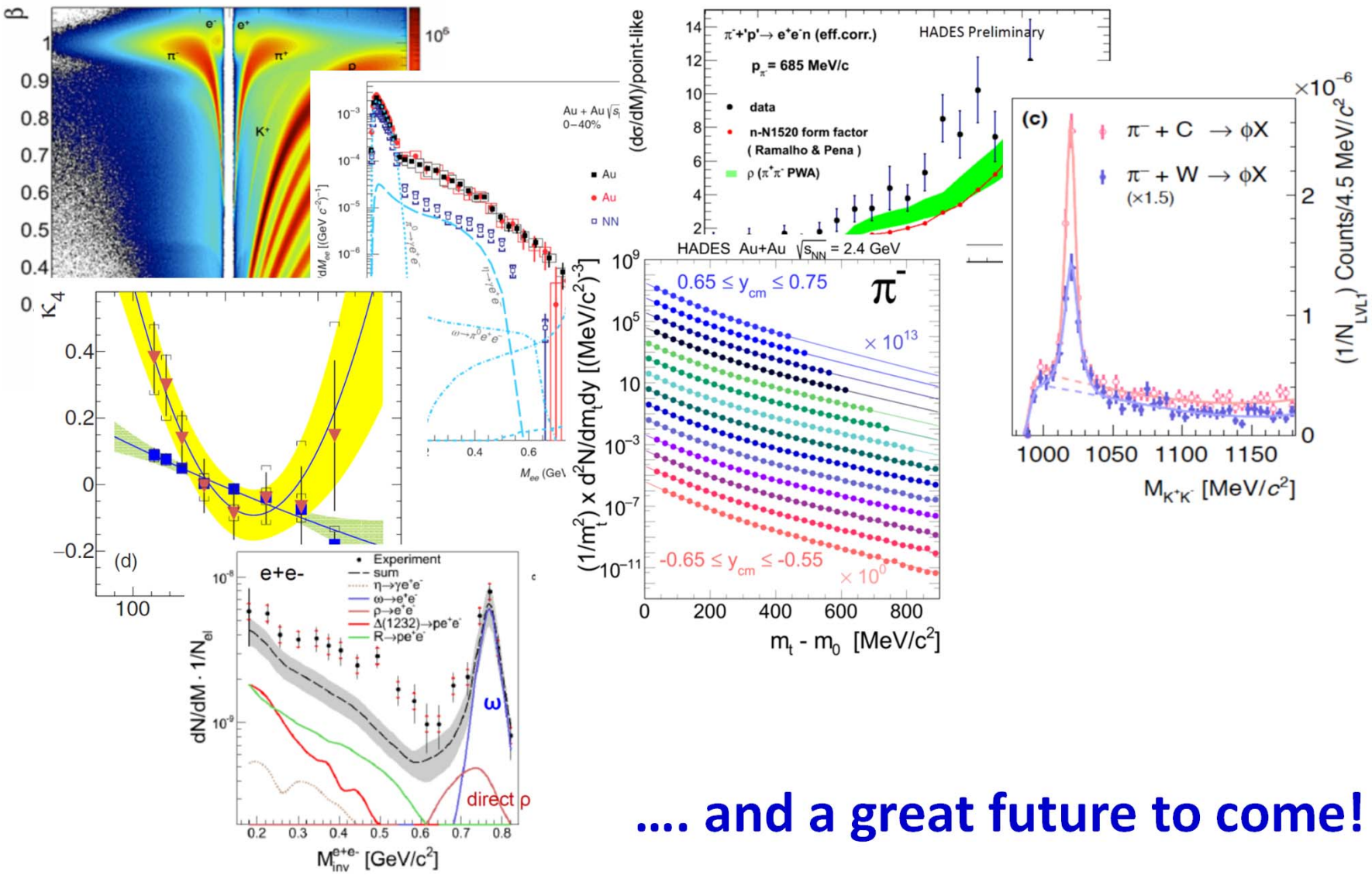
- Time precision < 50ps
- Rate capability of 100 MHz/cm^2
- Vacuum operation



- Q4 2020 readout system readiness
- Sensor production started (FBK), delivery Q2/Q3 2021

Participating institutions: GSI, TU Darmstadt, GU Frankfurt, JU Krakow, part of the „High-D“Consortium ErUM BMBF Collaboration with Fondazione Bruno Kessler (FBK, Trento, Italy), INFN Torino, Italy

HADES status



…. and a great future to come!