Di-electron measurements with HADES at SIS100

HADES

Outline

- ✓ Motivation
- ✓ HADES di-electron results (SIS 18) - summary
- ✓ HADES upcoming programme (SIS 18) - summary
- ✓ Di-electron data understanding and interpretation - remarks
  - Systematic errors (eff. corrections, CB subtraction, pi0 normalization)
  - Knowledge of long-lived sources
- ✓ Preliminary simulation results for di-electrons with HADES at SIS100
  - Acceptance for ω direct decay
  - Invariant mass distributions

Jerzy Pietraszko, GSI Darmstadt

Workshop on Nuclear Matter Physics at SIS100, GSI Darmstadt

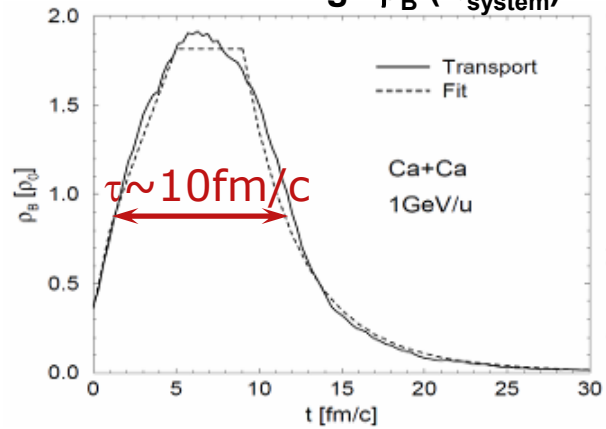
Di-electron measurements - motivation

HADES

How do we study the properties of nuclear matter at high densities and temperatures ?

- ✓ SIS 18 (1-2 AGeV) T < 80 MeV; ρ = 2.0 ρ_0; τ~10fm/c
- ✓ SIS 100 (2-10 AGeV) T < 110 MeV; ρ = 4.0 ρ_0

Evolution of average ρ_B (τ_{system})



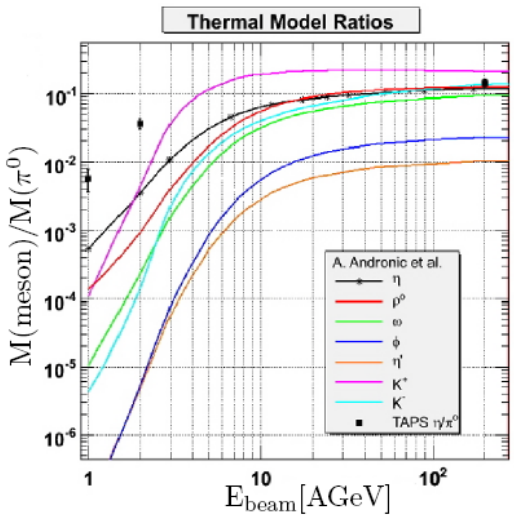
Aim:

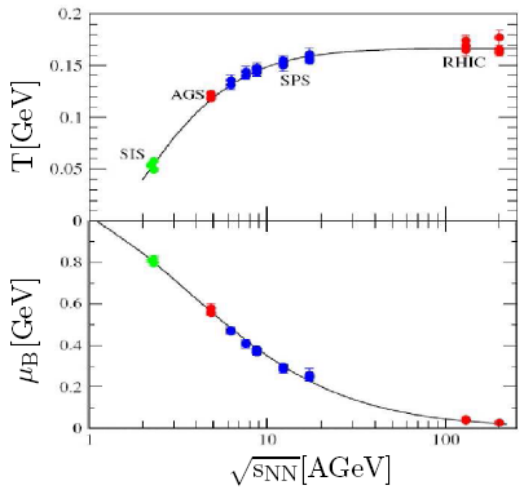
- ✓ Model independent, systematic investigation of radiation from compressed nuclear matter
- ✓ In medium spectral functions of the light VM (φ,ω,ρ)
  → chiral symmetry restoration

How:

Measure dilepton radiation from the collision and subtract contribution emitted at chemical freeze-out.
→ radiation from the early stage of the collision

Precise knowledge of the yield at chemical freeze-out is essential.
SIS 18 (up to 2 AGeV) – TAPS π^0,η
SIS 100 (2 – 40 AGeV) – only models

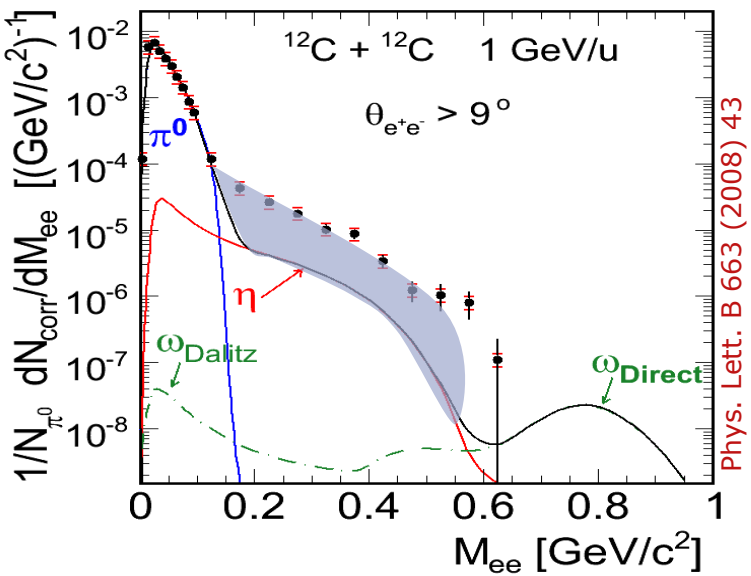


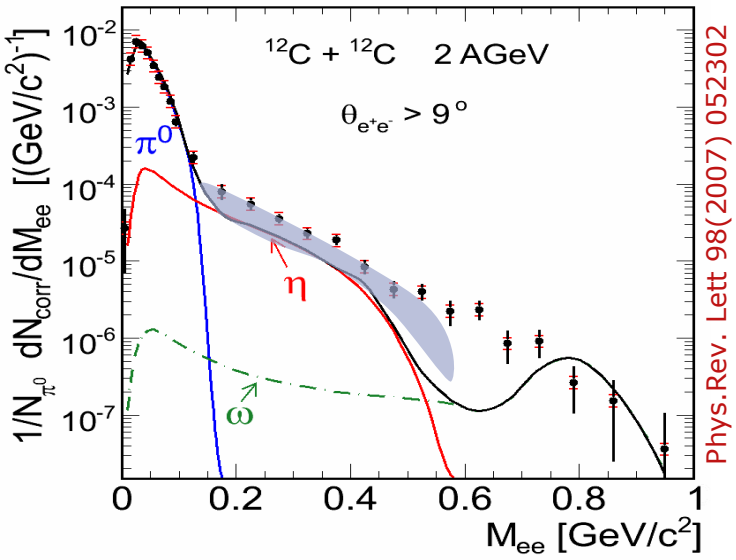


Di-electron results: C+C @ 1AGeV, C+C @ 2AGeV

HADES

HADES di-electron results – C+C system





Normalization: $N_{\pi 0} = ½ (N_{\pi+} + N_{\pi-})$; $\pi^{\pm}$ **from the same data sample**

[arXiv:0902.4377v1[nucl-ex]]

Systematic errors: ~25%, $\sigma_M(\omega) = 9\%$

"hadronic cocktail": thermal source; only long-lived components included,
i.e. π^0, η: **TAPS data,** ω: $m_\perp$ **scaling.**
[I. Froehlich et al.,arXiv:0708.2382]

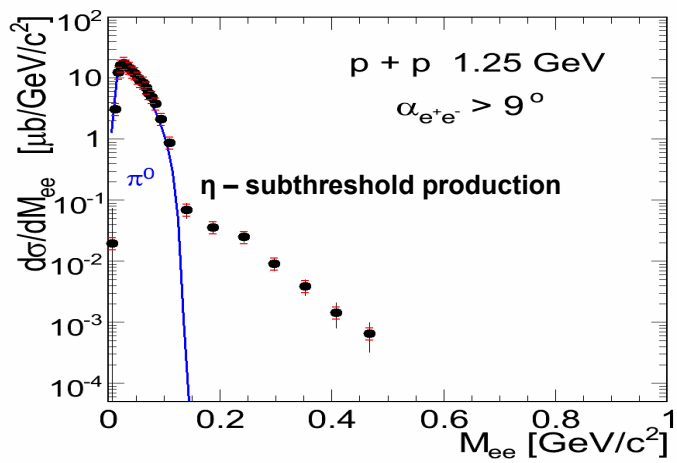
What about Δ-Dalitz and pn-Bremsstrahlung? Not included in the "hadronic coctail"!

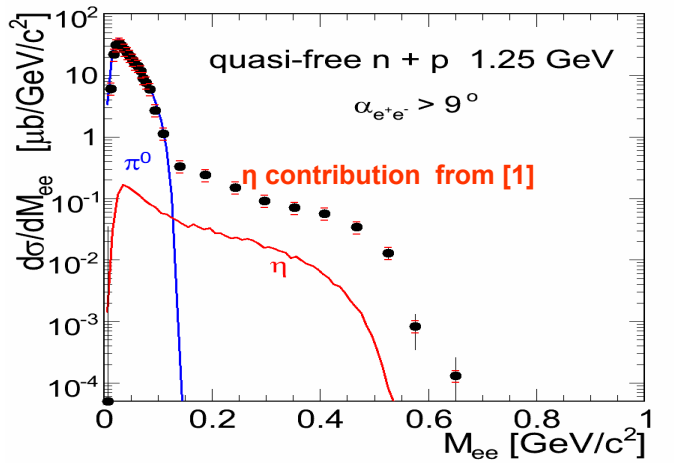
→ measured in p+p, n+p experiments !!!

Di-electron results: p+p, n+p compared to C+C

HADES

HADES di-electron results – p+p, n+p systems





p+p 1.25 GeV, n+p 1.25 GeV

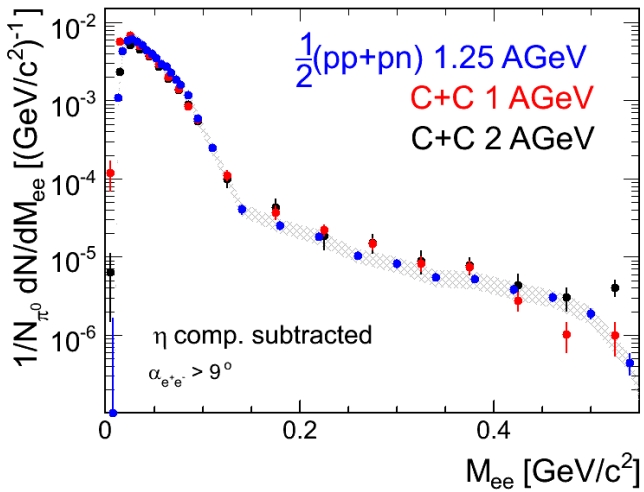
- ✓ π^0 contributions measured by HADES
- ✓ normalized to the elastic scattering

p+p, n+p, C+C di-electron signals comparison

- ✓ e+e- yield in HADES acceptance
- ✓ η contribution subtracted

→ no dependence on beam energy for invariant masses below 0.5 GeV/c^2

→ **"reference data"** for heavier systems



[1] H.Calen et al., Phys.Rev. C 58 (1998), 2667-2670.

Di-electron results: Ar+KCl at 1.76 AGeV

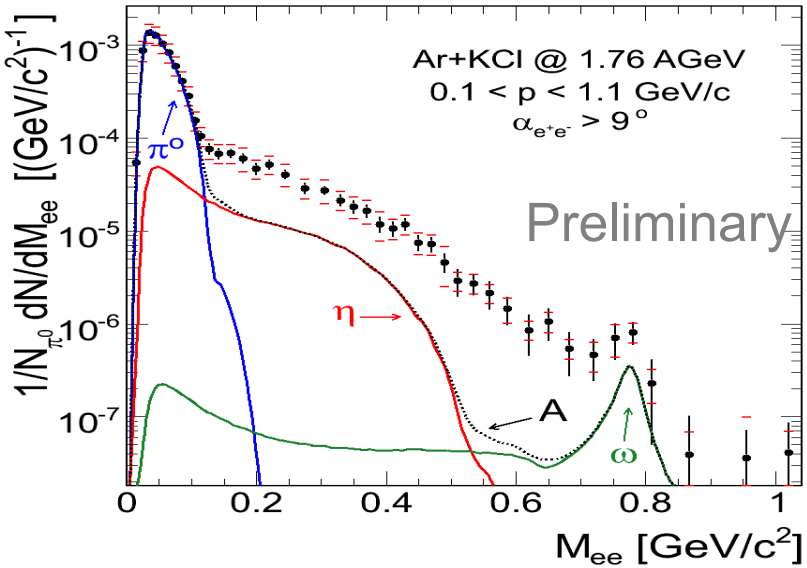
HADES

Ar+KCl 1.76 AGeV

cocktail A (long-lived components at thermal freeze-out, T = 75 MeV)

- ✓ π^0 and η :
  - ✓ mult. constrained by TAPS
    R. Averbeck et al., Z. Phys. A 359 (1997), p. 6573.
    R. Averbeck et al., Phys. Rev. C 67 (2003), 024903.
  - ✓ anisotropic polar angle distribution
- ✓ ω: – mult. from mT scaling
  – isotropic decay pattern

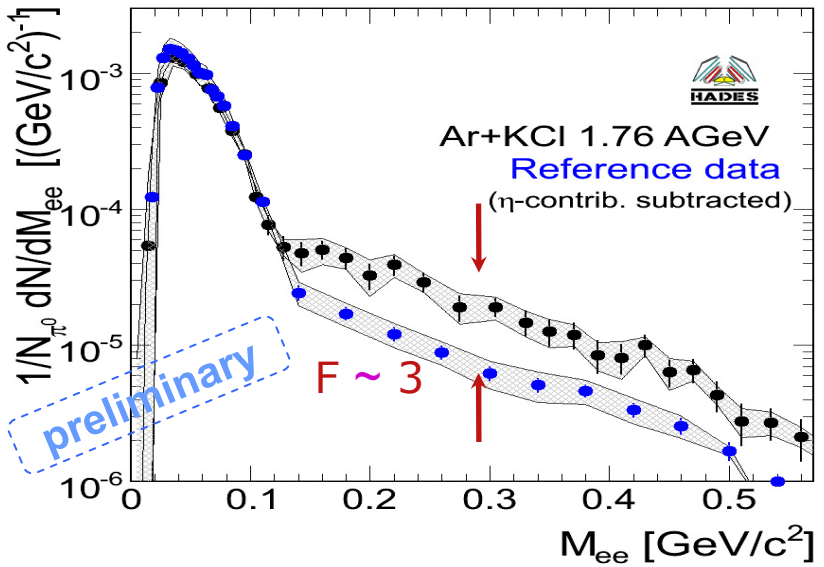
→ Missing part comes from short-lived sources from the early stage of the collision.



Ar+KCl 1.76 AGeV compared to the HADES "Reference data"

- ✓ Excess above the "Reference data" by a factor of about 3

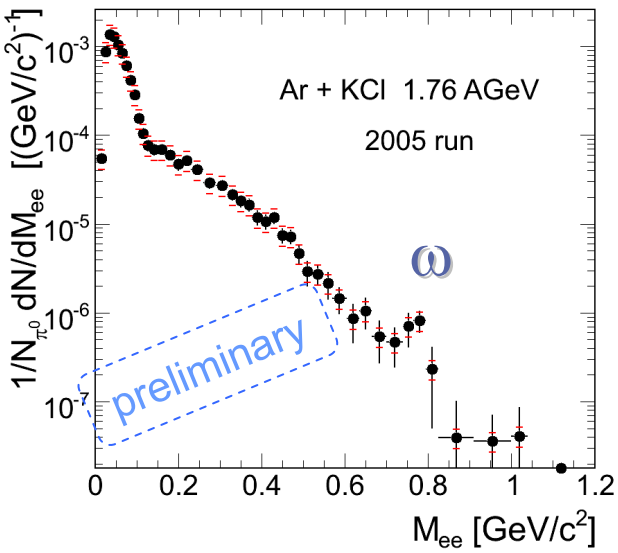
→ radiation from compressed nuclear matter

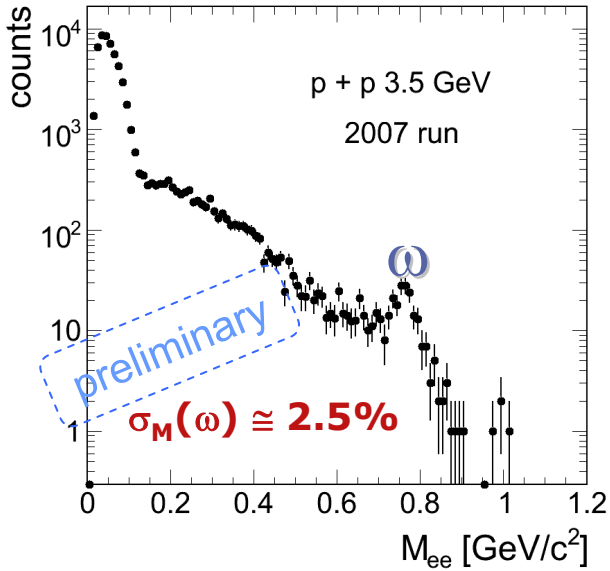


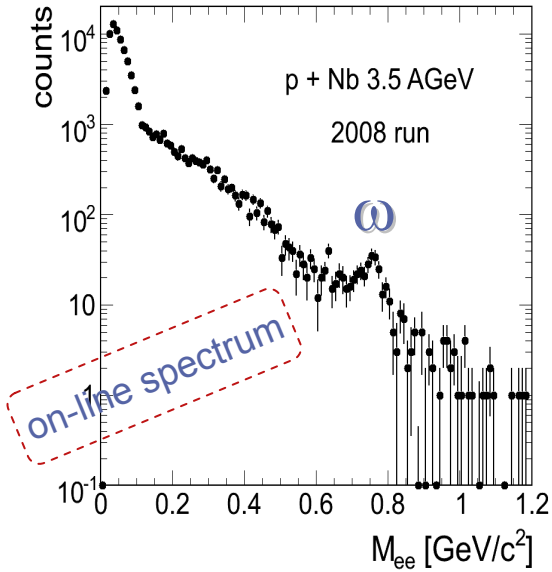
[1] H.Calen et al., Phys.Rev. C 58 (1998), 2667-2670.

Di-electron results: Vector mesons at SIS 18

HADES







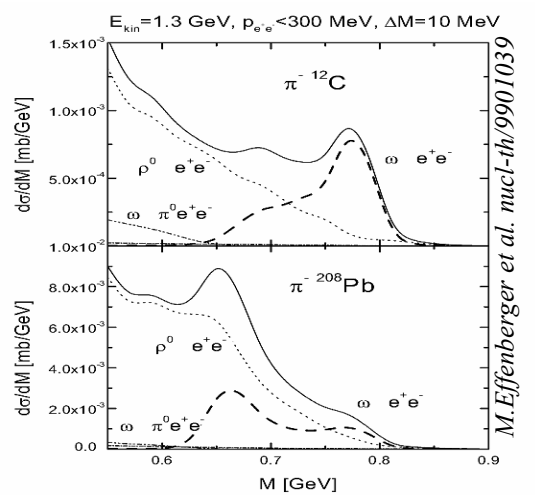
→ First observation of ω production in heavy-ion collisions at SIS energies
→ ω production
→ modification of the ω meson in nuclear matter

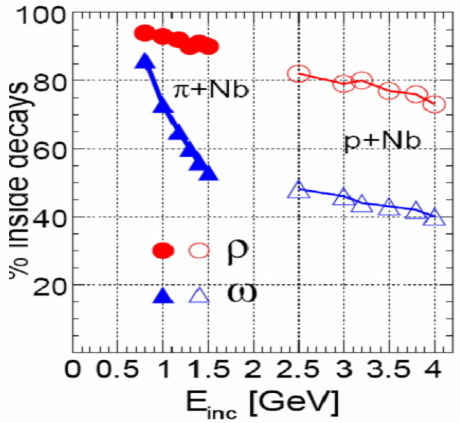
Work in progress !!!

Di-electron plans at SIS18, π⁻- beam

HADES

HADES di-electron measurements at SIS18





π⁻+ A – inclusive ω measurement

$$\pi^- p_{bound} \rightarrow \omega n \rightarrow e^+e^- n;$$

$$p_{e+e-} < 300\ MeV/c; \quad \omega\ „at\ rest"$$

Exclusive measurement

- large cross-section

$$\sigma_{tot}(\pi^- p \rightarrow \omega n) = 2.5mb \qquad @\ p_\pi \approx 1.3GeV/c$$

$$\sigma_{tot}(pp \rightarrow \omega X) \approx 0.4\,mb \qquad @\ p_p \approx 3.5GeV/c$$

✓ **off-shell ρ/ω coupling to $S_{11}(1535)$ and $D_{13}(1550)$**

M.Soyeur et al., nucl-th/0003013

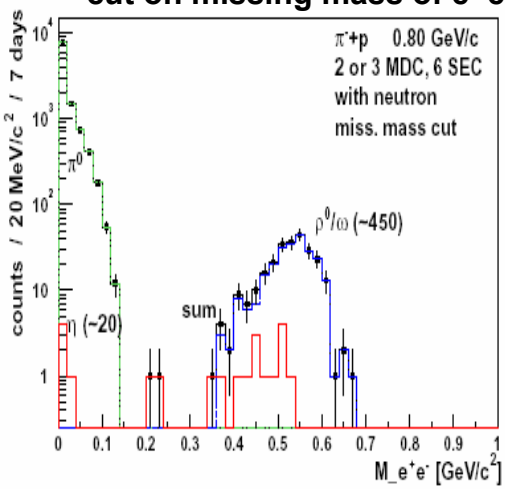
$\pi^- p \rightarrow (\omega/\rho) n \rightarrow e^+ e^- n$

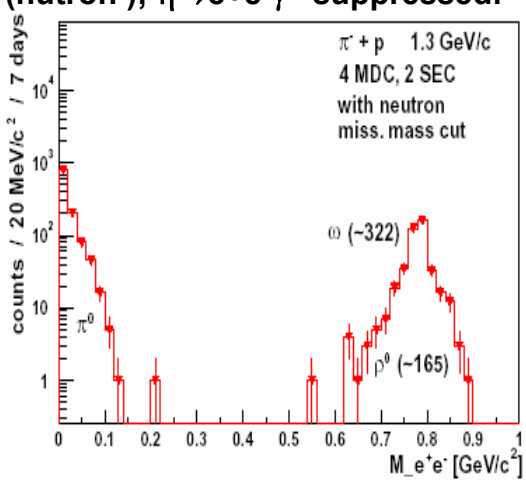
- selection of ρ and ω
- η-> $e^+ e^-$, $\pi^0\pi^0$, ...

suppression by missing mass technique.

Beam particle tracking is essential in preparation

cut on missing mass of $e^+ e^-$ (nutron); η→e+e-γ suppressed!





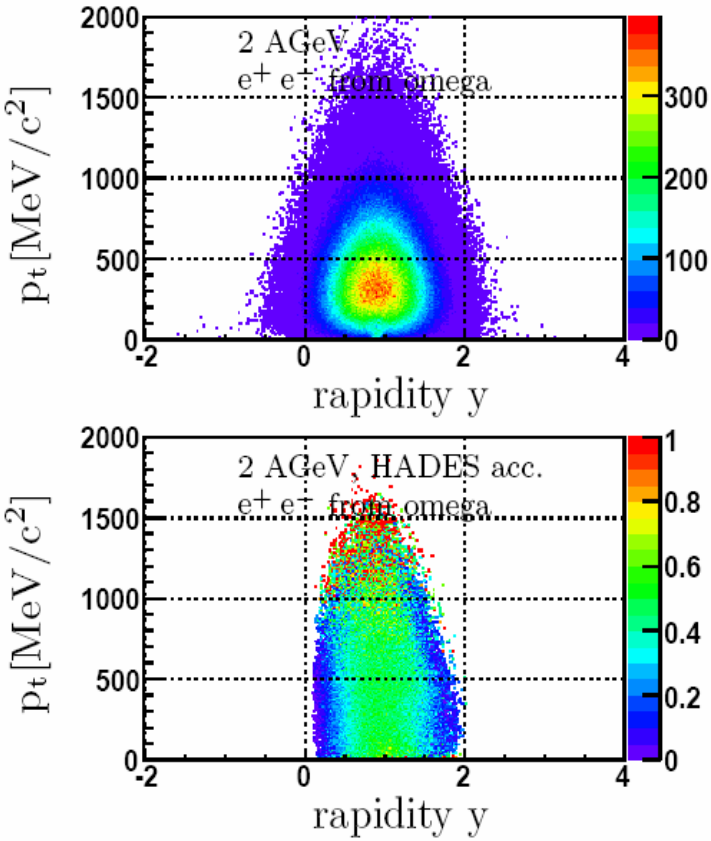
Di-electron plans at SIS18, Au+Au (in 2010)

HADES

Acceptance for di-electrons (2 AGeV)

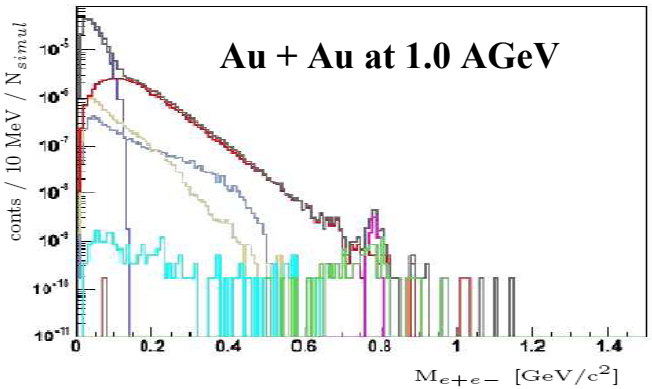
- ✓ Direct ω decay generated by PLUTO
- ✓ ω from thermal model with inverse slope parameter of 89 MeV (2 AGeV)
- ✓ single leptons filtered with HADES acceptance
- ✓ 9^0 opening angle cut was applied

→ **overall acceptance for di-electron pairs: 33-35 %**
→ **the mid-rapidity region covered**



Di-electron cocktail

- ✓ All sources included in the PLUTO
- ✓ Filtered with HADES acceptance
- ✓ Momentum smearing applied



A full HGeant simulation in preparation.

Di-electrons at SIS100 (2-10 AGeV), motivation

HADES

- ✓ **No di-electron data exist in this energy range**
- ✓ **Extension of the HADES physics programme**
- ✓ **Enhance production of Vector Mesons:**

SIS18 → SIS 100
subthreshold production → above threshold
→better signal, precise line shape determination
→reference data for SIS 300

HADES at SIS100:

- running experiment, well understood performance
- currently conducted upgrade will improve stability, DAQ and time resolution of the Spectrometer
- easy transfer to FAIR, experienced crew
- can deliver high quality data

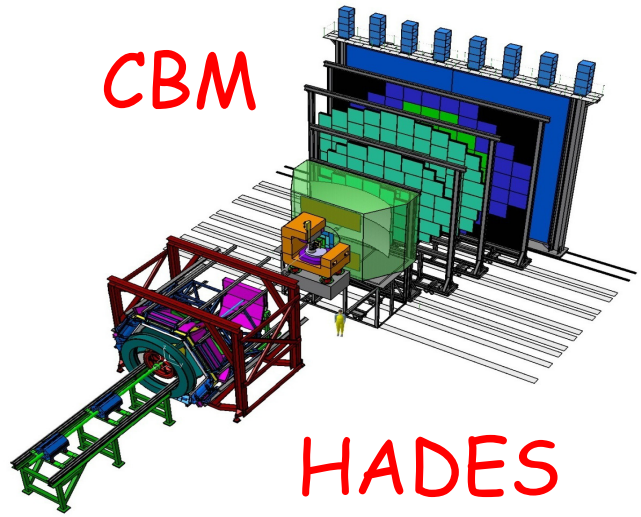
But: for pair excess determination a precise knowledge of the hadronic cocktail is needed (particle yields at chemical freeze-out)

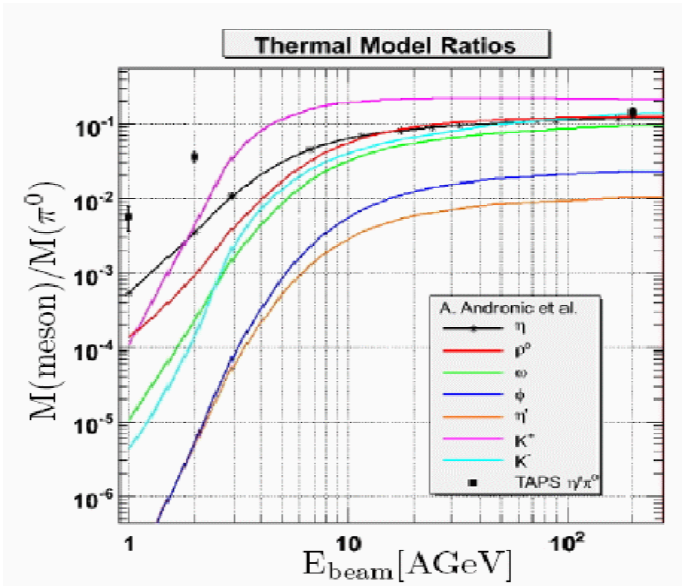
- ✓ At 2-40 AGeV mainly dominated by η-Dalitz
- ✓ Normalization to π^0 (at SIS18 – TAPS data)

→ Calorimeter for HADES

→ π^0, η measurement

→ improved pion suppression





Di-electrons at SIS 100 - $\omega \rightarrow e^+e^-$ acceptance

HADES

Acceptance for di-electrons from ω->e+e−

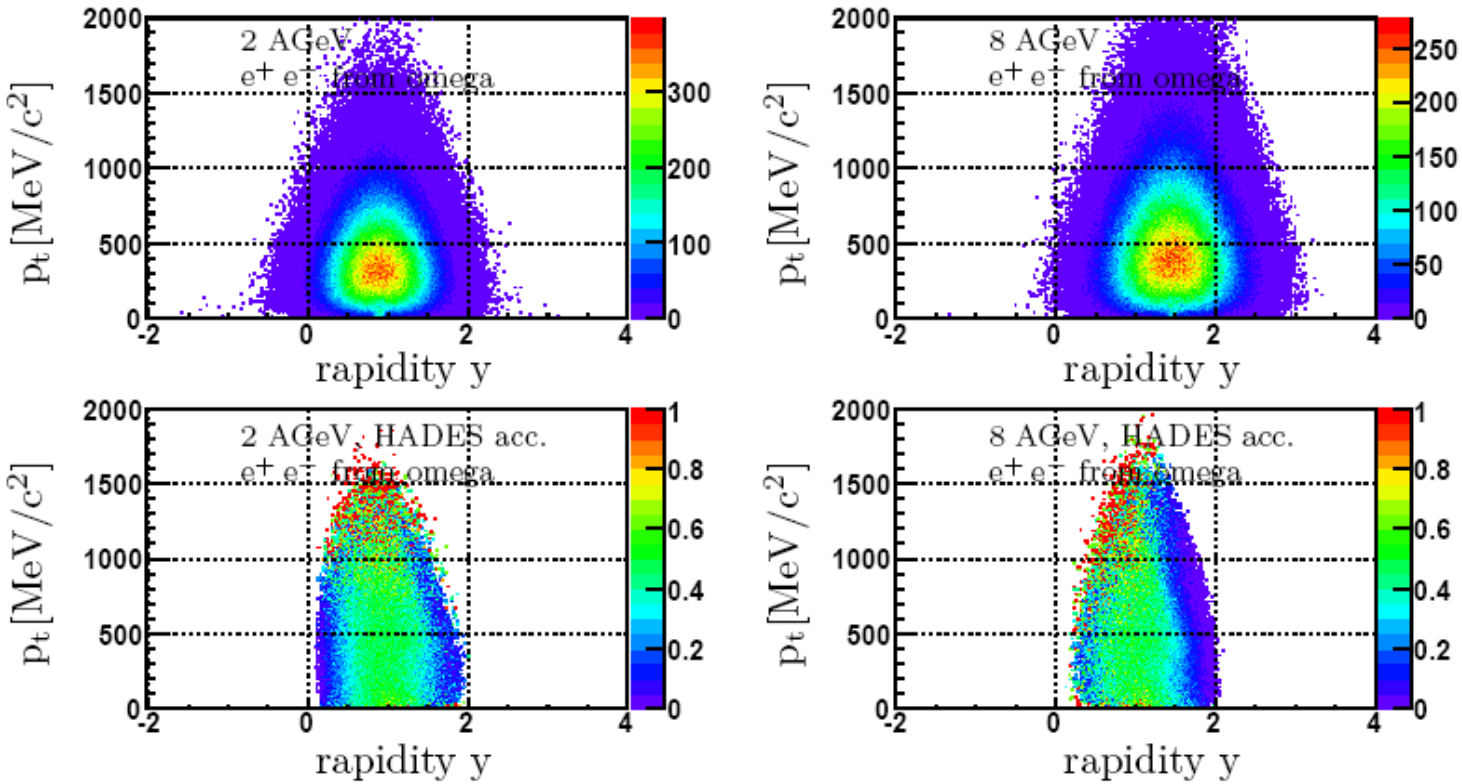
(2 AGeV and 8 AGeV)

- ✓ Direct ω decay: PLUTO, ω from thermal model
- ✓ Single leptons filtered with HADES acceptance
- ✓ 9^0 opening angle cut was applied

Acceptance:

2 AGeV	33 %
8 AGeV	21 %

Number of ω's in acceptance increase by a factor of ~50



Di-electrons at SIS 100 – invariant mass

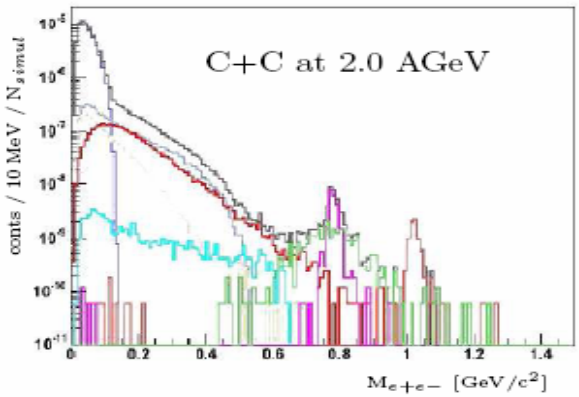
HADES

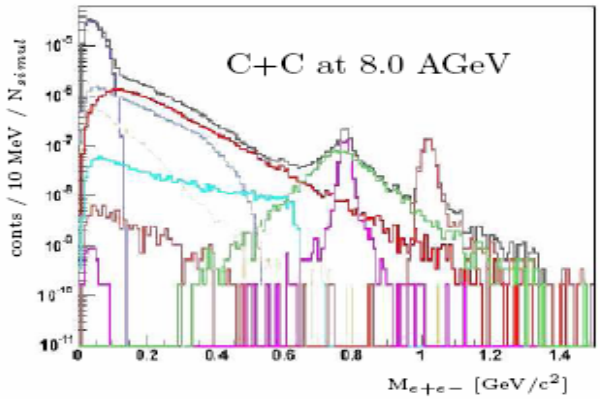
Di-electron invariant mass for various systems:

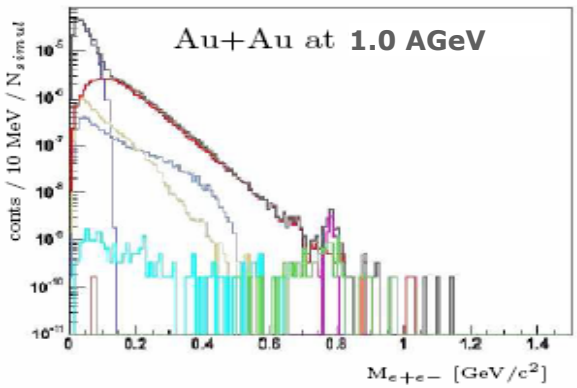
(C+C 2 AGeV and 8 AGeV, Au+Au 1 AGeV and 8 AGeV)

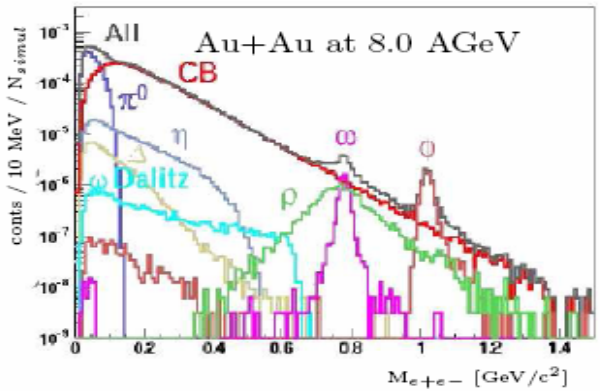
- ✓ All dilepton sources generated by PLUTO, hadronic and electromagnetic decays
- ✓ Single leptons filtered with HADES acceptance
- ✓ Lepton momentums smeared
- ✓ 9^0 opening angle cut was applied

Realistic simulation will be performed !









HADES di-electron measurement at SIS 100 summary

- Di-electron radiation from the collision zone at SIS 18 is being investigated in a very systematic, model independent way.
  - ✓ No medium effects observed for light systems (C+C)
  - ✓ The "reference spectrum" based on elementary reactions established for heavier systems (Ar+KCl)
  - ✓ First VM signal measured at SIS 18 in Ar+KCl collisions
  - ✓ Modification of the ω meson properties in-medium (p+Nb) under investigation
- Interesting physics programme for future proposals of HADES at SIS 18 (Au+Au, π^- beam)
- SIS100 – a natural way of the physics programme extension
  - ✓ Device ready to take high quality data
  - ✓ Easy installation at SIS 100
  - ✓ VM produced above the production thresholds
  - ✓ High acceptance for direct decays of VM over whole energy regions of SIS 18 and SIS100 (from 33 % at SIS 18 to 22 % at SIS100)
- Realistic simulation for heavier systems in preparation.

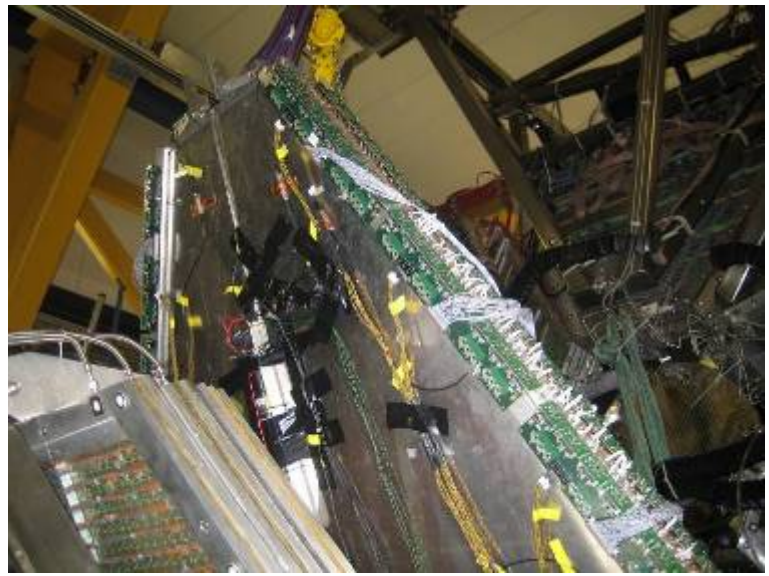
Thank you

The HADES upgrade project, ready in 2010

Ready for SIS18 heavy systems and for SIS 100

- Cope with multiplicities of Au+Au 1.5 AGeV
- Accept up to 20 KHz trigger rate
- Measures:
  - Replace TOFINO with high-granularity RPC
  - Add forward hodoscopes
  - Upgrade DAQ (new Trigger and Read-out Board)
  - Extend RICH radiator
  - Replace plane I of tracking chambers

- RPC full size prototype successfully commissioned in November 2007.
- Expected resolution below 80 ps.



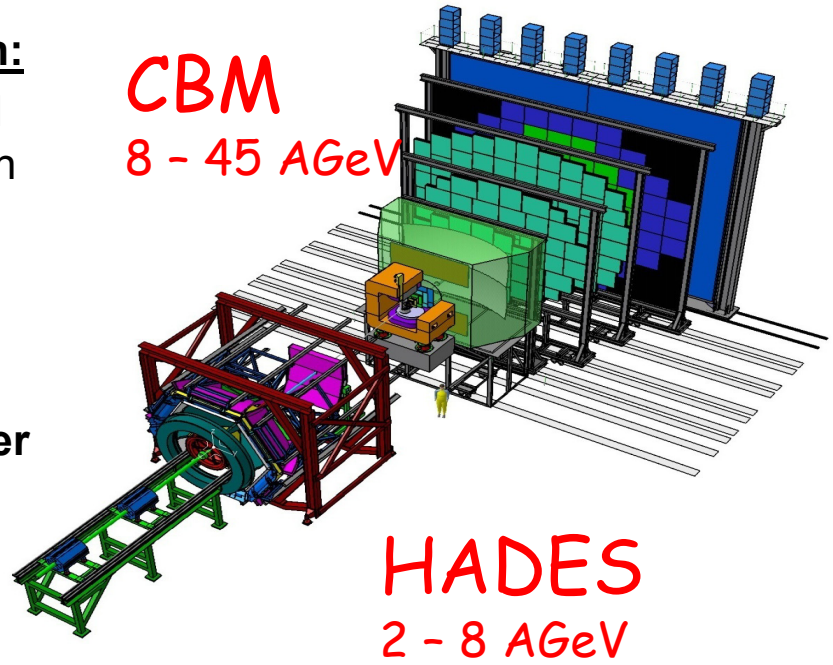
HADES at SIS100
di-electrons from 2-8 AGeV A+A

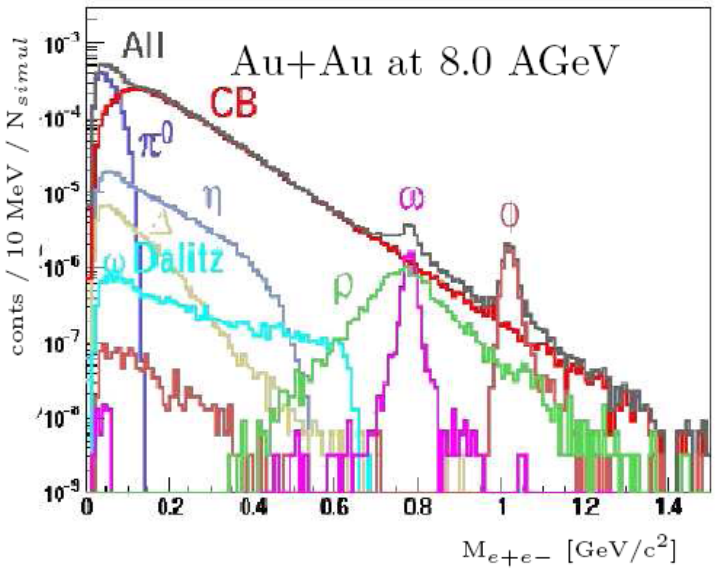
HADES

HADES at FAIR

Dielectron sources form in medium radiation:

- ✓ SIS18 (1-2 AGeV): decays of the short-lived baryonic baryonic resonances, Δ, N* and p-n breamsstrahlung.
- ✓ SPS or RHIC: pion anihilation via the rho resonance above πo- Dalitz region
- ✓ **Dilepton spectroscopy at energies 2-40 AGeV, "terra incognita", HADES will cover 2-8 AGeV.**





HADES at FAIR:

- ✓ Running experiment, well-understood performance
- ✓ Easy transfer to FAIR, experienced crew
- ✓ High acceptance for leptons and hadrons at 8GeV
- ✓ Particle occupancies and background comparable to SIS18 (Au+Au at 1.5 AGeV ←→ Ni+Ni at 8 AGeV)
- ✓ Huge increase in the yield from direct ω, φ decays by factors of 19, 73 respectively compared to SIS18