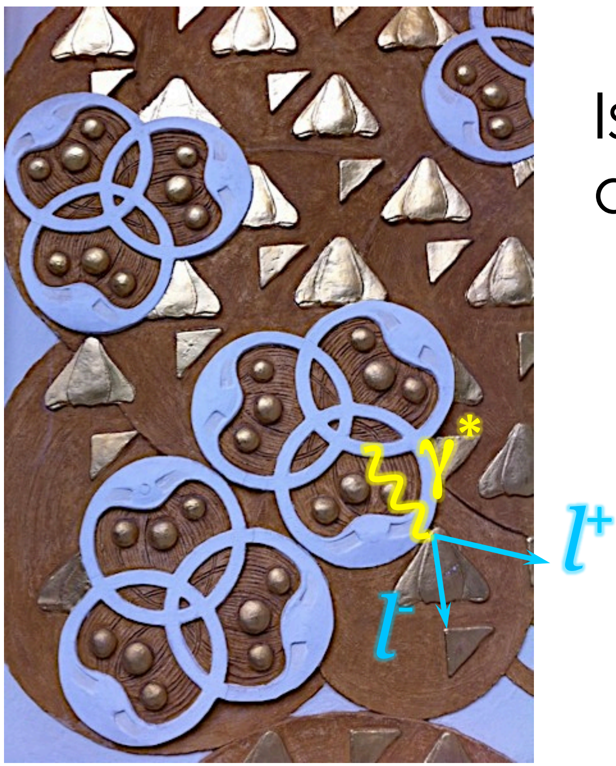


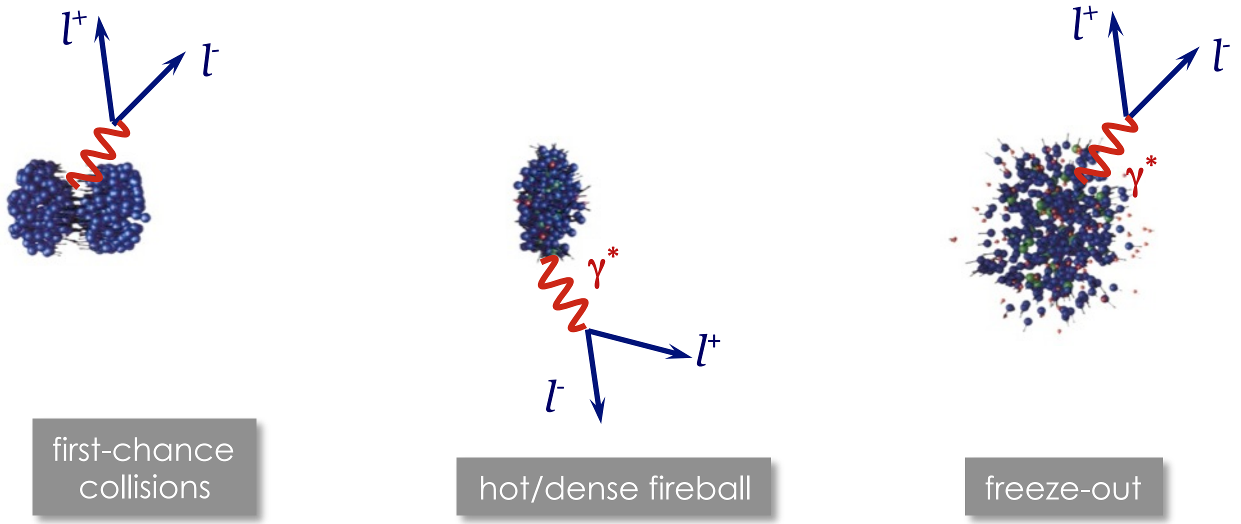

# Isolation of excess pairs an experimental approach

EMMI RRTF
10 October 2013

Tetyana Galatyuk

# Probing EM structure of dense/hot hadronic matter

**Sources of lepton pairs**



# Characteristics of dilepton rates (cocktail)

Characteristic features of dilepton invariant mass spectra

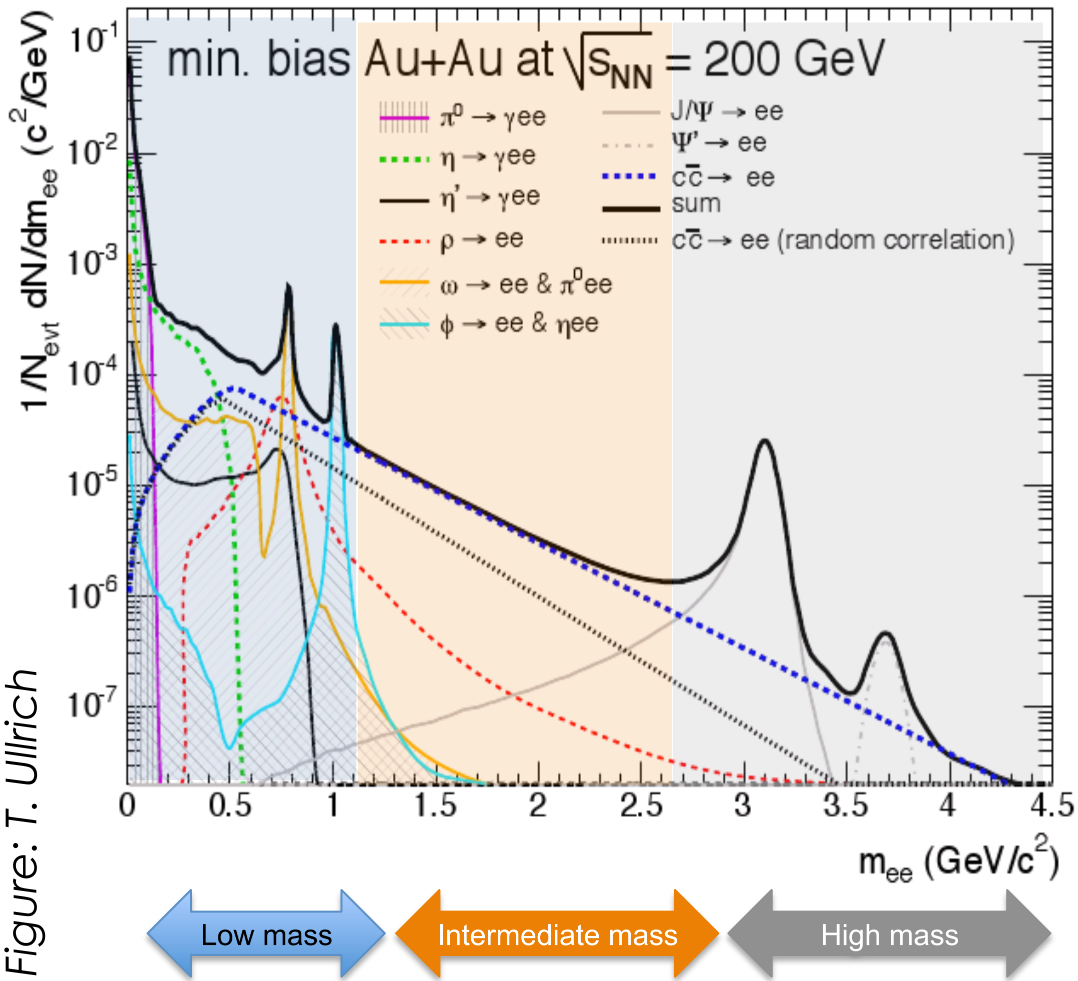



Figure: T. Ullrich

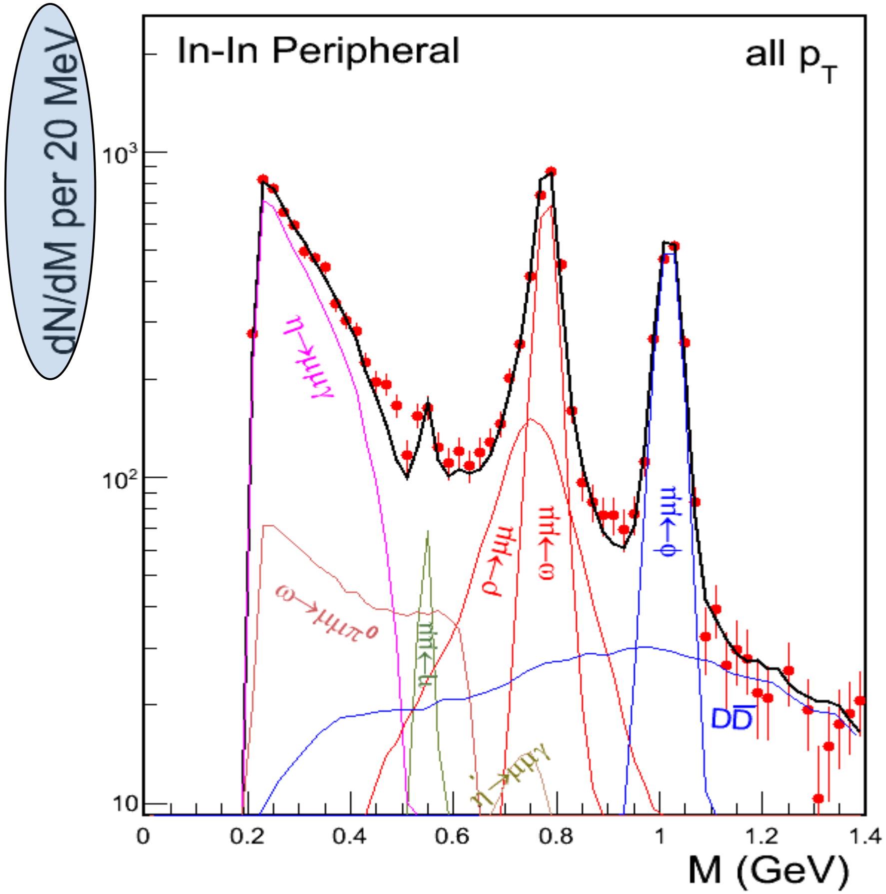
**Low mass:**
- continuum enhancement?
- in-medium modification of vector mesons → link to the chiral symmetry restoration?

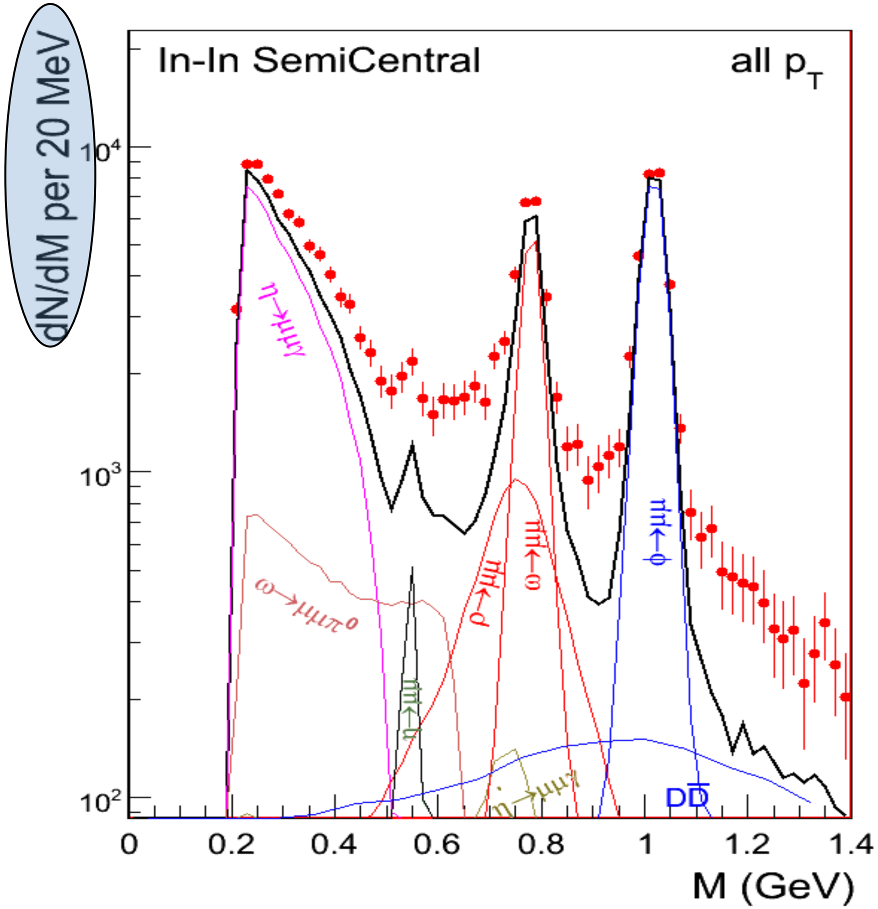
**Intermediate mass:**
- QGP thermal radiation?
- heavy-flavor modification?

**High mass**:
- J/ψ suppression ?
  enhancement ?
- Drell-Yan, primordial emission

# Understanding the mass spectra

S. Damjanovic, Trento 2010



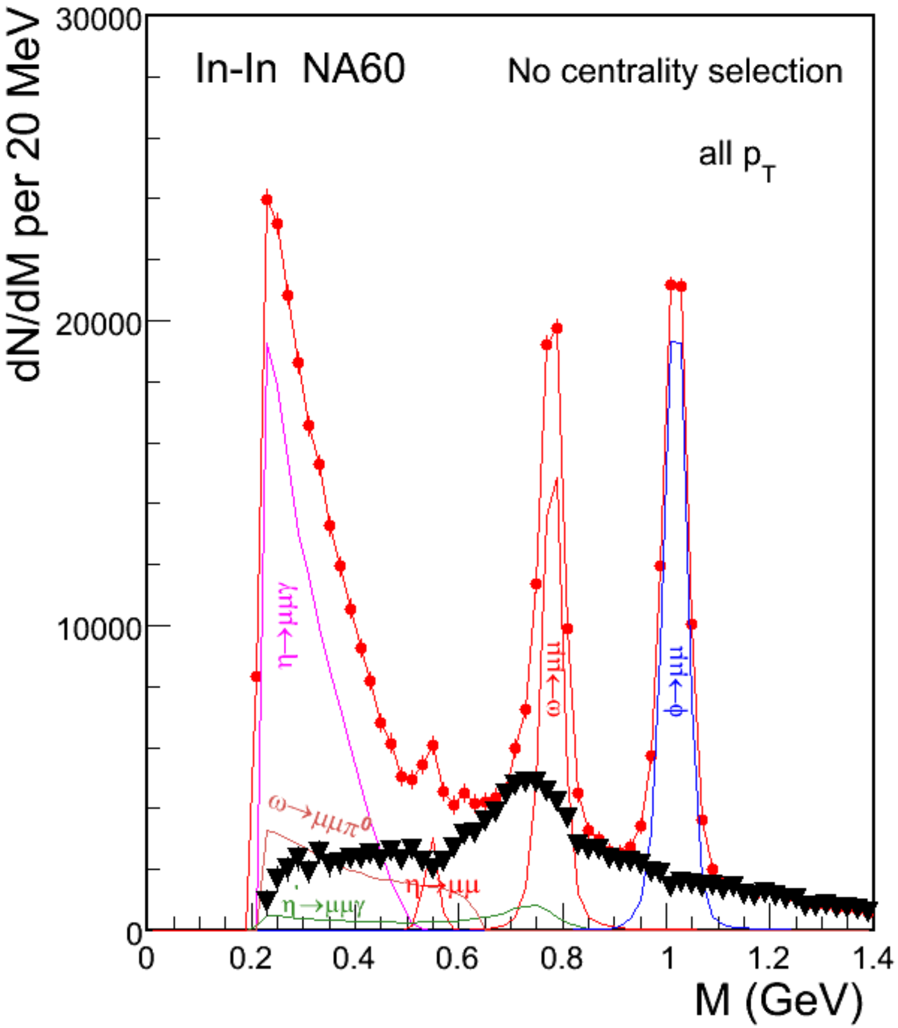

<u>Peripheral data</u>
well described by meson decay 'cocktail' ($\eta$, $\eta'$, $\rho$, $\omega$, $\phi$) and DDbar

<u>More central data</u>
Clear excess of data above decay 'cocktail'. But, what is the spectral shape of the excess?

# Isolation of excess dimuons

S. Damjanovic, Trento 2010

Phys. Rev. Lett. 96 (2006) 162302




ω and f : fix yields such as to get, after subtraction, a smooth underlying continuum

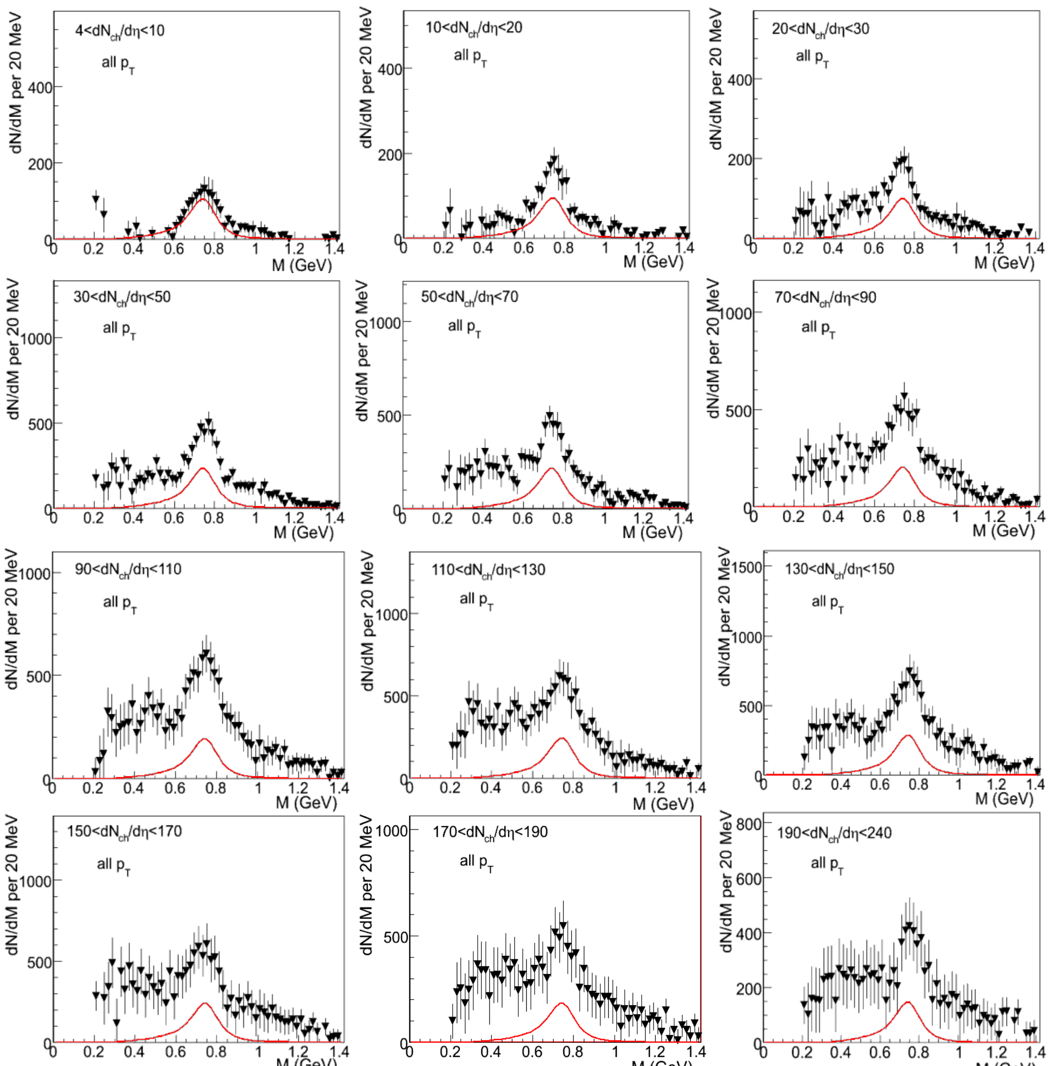
η : fix yield at $p_T$ >1 GeV profiting from the very high sensitivity of the spectral shape of the Dalitz decay to any underlying admixture from other sources; lower limit from peripheral data

accuracy 2-3%, but results robust to mistakes even at the 10% level

# Excess mass spectra in 12 centrality bins

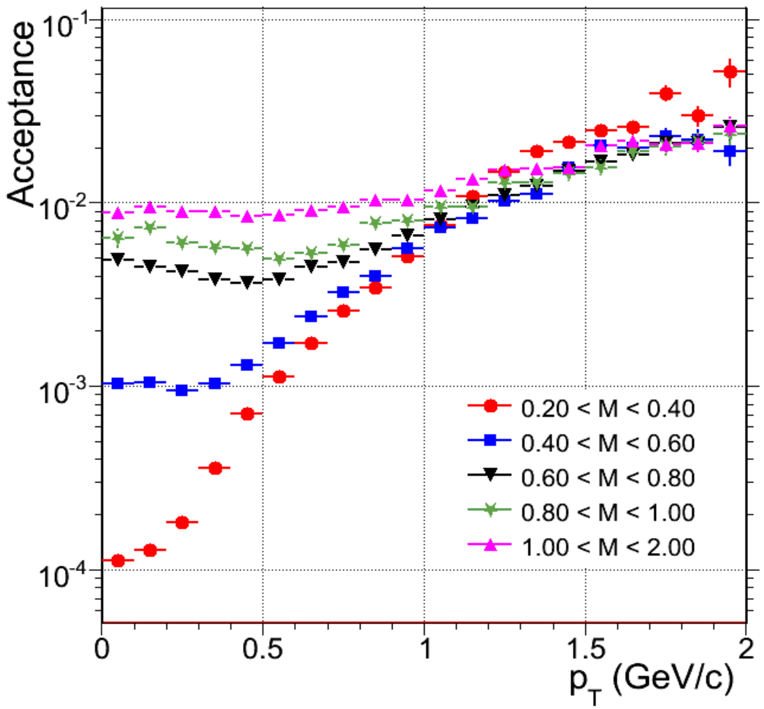
S. Damjanovic, Trento 2010

Eur.Phys.J.C 49 (2007) 235



# Acceptance corrections

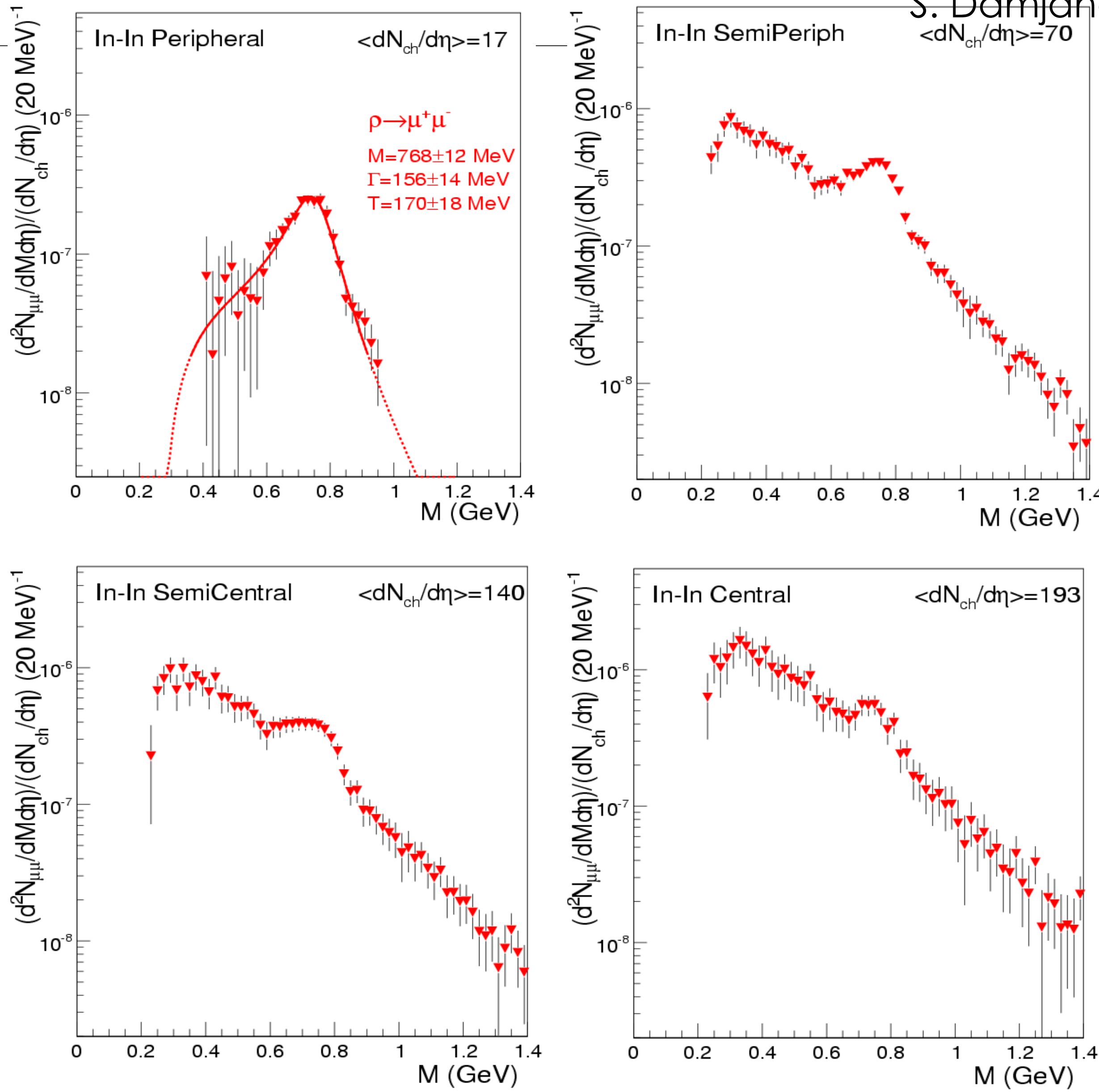
S. Damjanovic, Trento 2010




- reduce 4-dimensional acceptance correction in M-$p_T$-y-cos$\Theta_{CS}$ to (mostly) 2-dimensional corrections in pairs of variables. Example M-$p_T$, using measured y distributions and measured cos$\Theta_{CS}$ distributions as an input; same for other pairs (iteration)
- requires separate treatment of the excess and the other sources, due to differences in the y and the cos$\Theta_{CS}$ distribution
- acceptance vs. M, $p_T$, y, and cos $\Theta$ understood to within <10%, based on a detailed study of the peripheral data

# Centrality dependence of excess mass spectra

S. Damjanovic, Trento 2010



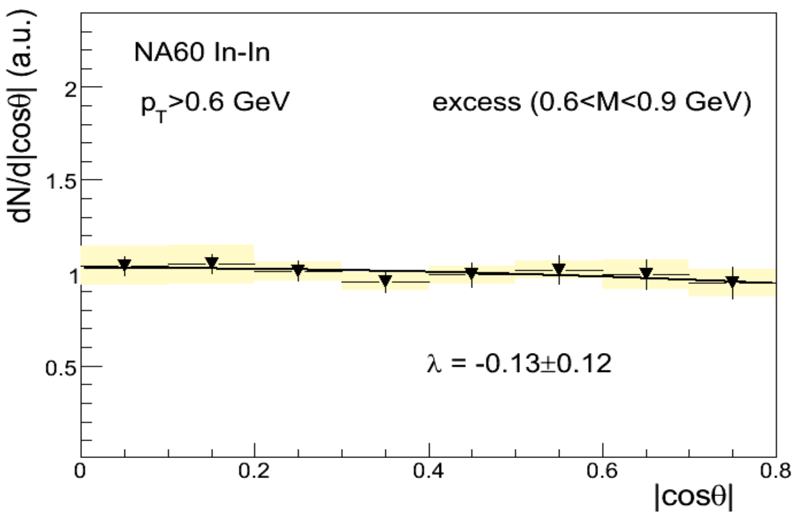

very fast evolution from vacuum $\rho$ to Planck-like spectra

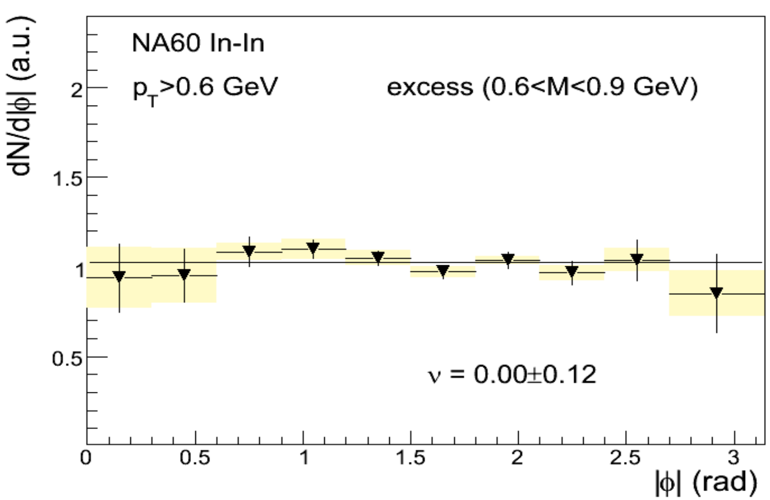
increasing masking of residual freeze-out $\rho$

# Angular distributions

S. Damjanovic, Trento 2010

Phys. Rev. Lett. 102 (2009) 222301



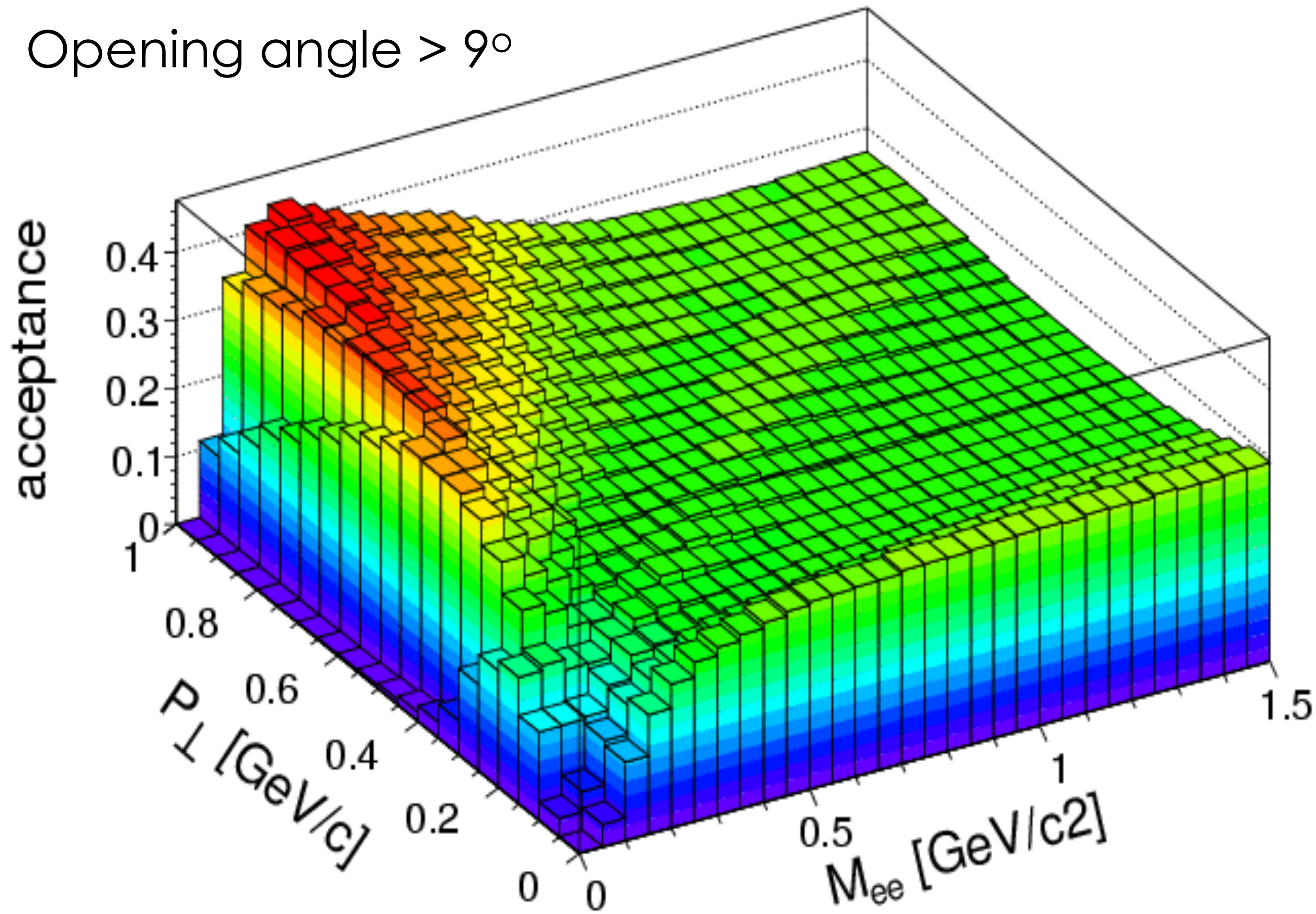




$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta\, d\phi} = \left(1 + \lambda\cos^2\theta + \mu\sin 2\theta\cos\phi + \frac{\nu}{2}\sin^2\theta\cos 2\phi\right)$$

**Zero polarization within errors**

# HADES pair acceptance

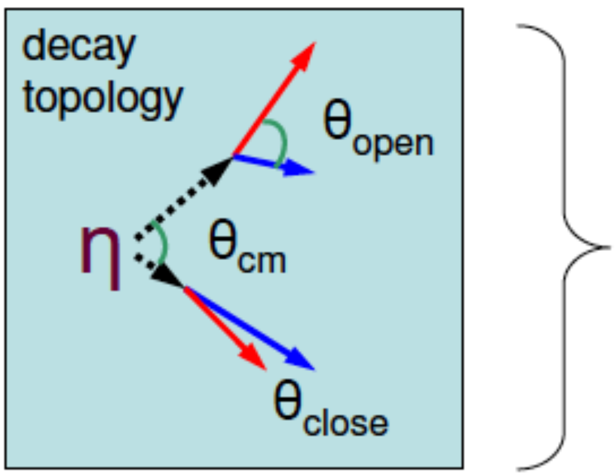
Opening angle > 9°

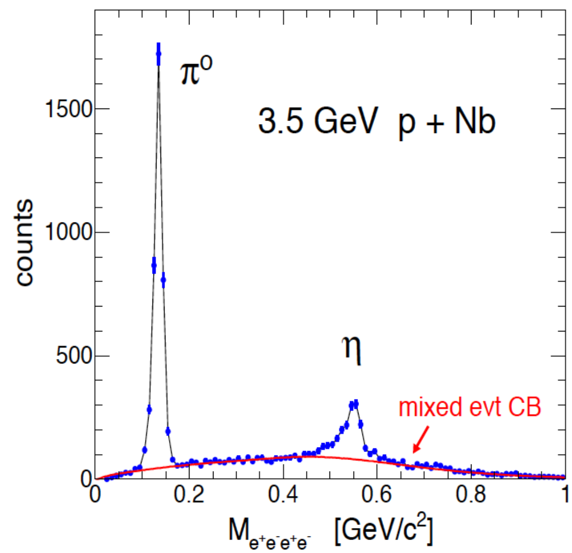


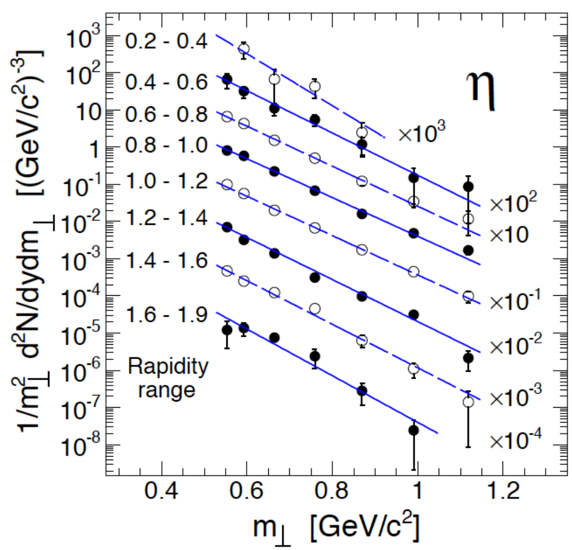
# Reconstruction of $\pi^0$ and $\eta$ decays through conversion

September 2008 run: 3.5 GeV p+Nb: → 9.2 · $10^9$ LVL1 events:

- Meson → $\gamma e^+e^-$ + pair conversion of photon: meson → $e^+e^-$ $e^+e^-$
- Meson → $\gamma\gamma$ + conversion of both photons: meson → $e^+e^-$ $e^+e^-$

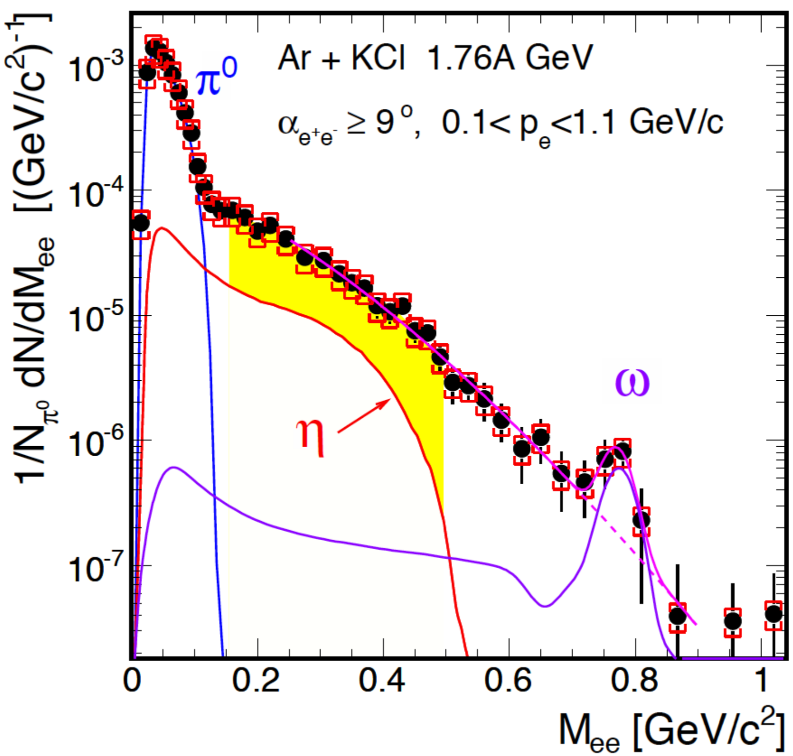


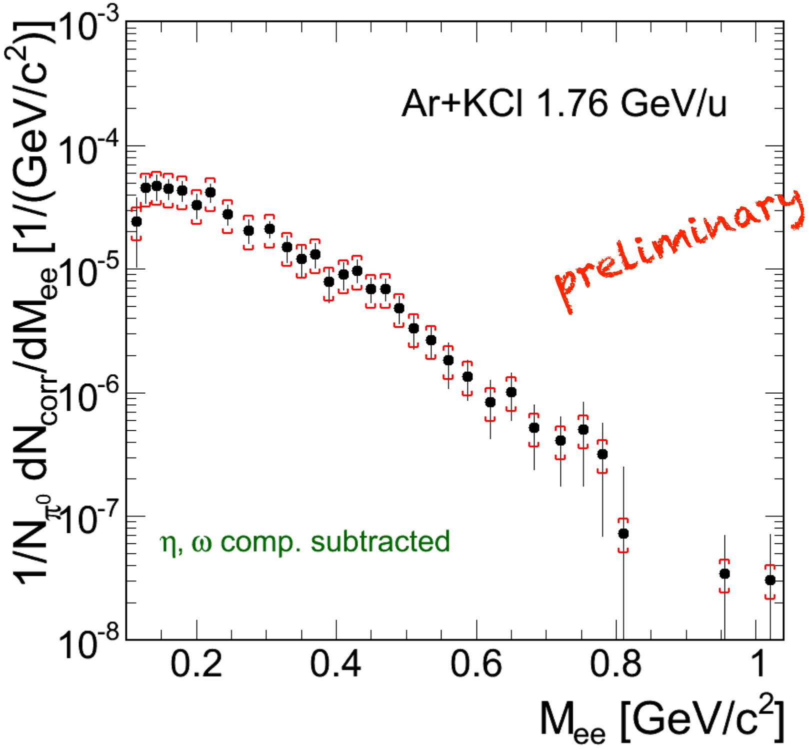




Nearly full phase-space coverage for $\eta$ detection!

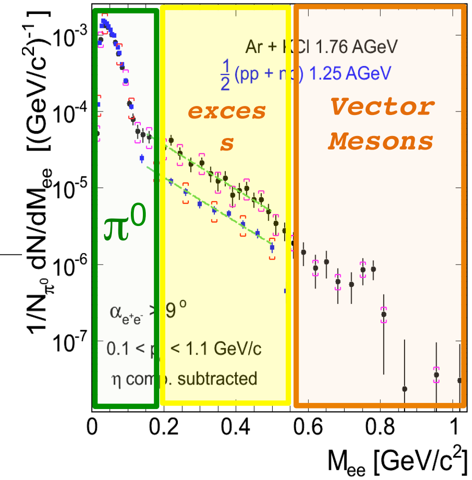
# Ar+KCl data, $E_{kin}$=1.76 GeV/u

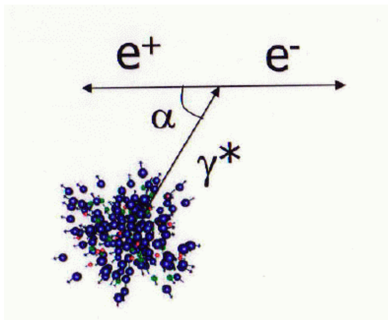


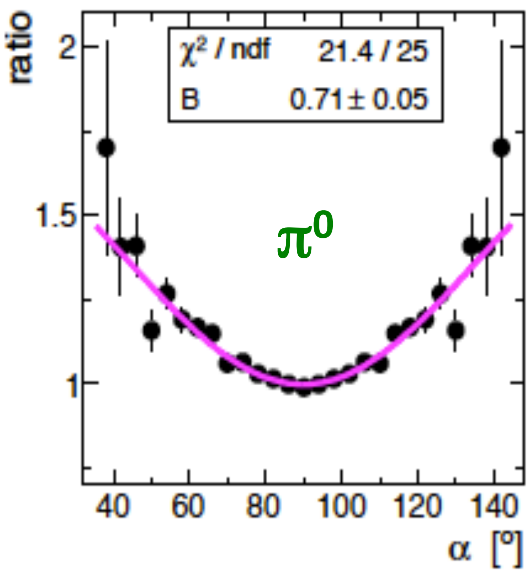

Phys.Rev.C84:014902,2011

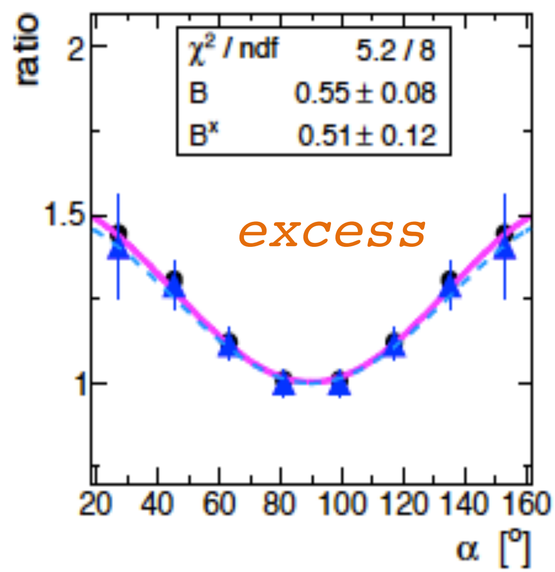
# e+e- angular distributions

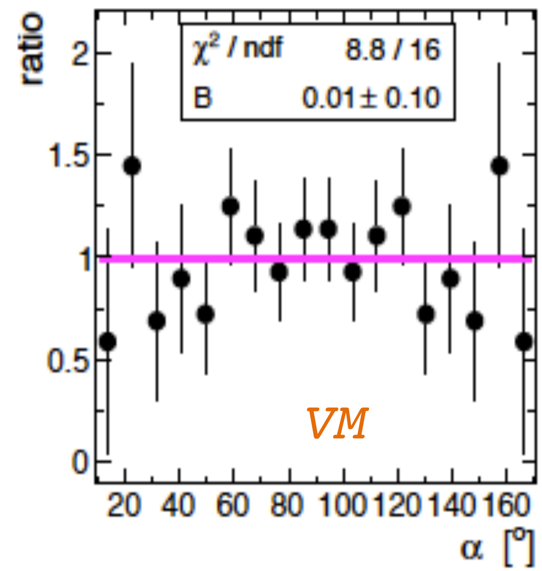



$$\frac{dN}{d\alpha} = A(1 + B\cos^2\alpha)$$



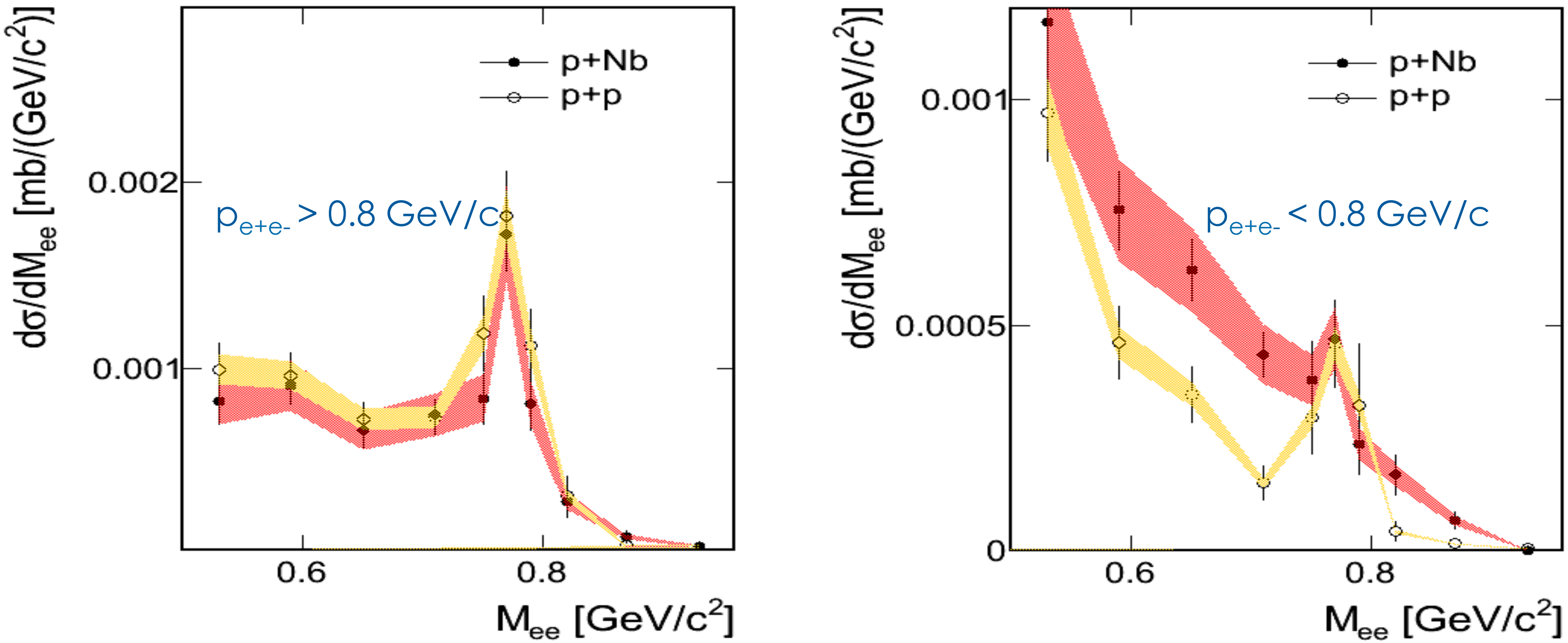




Excess has polarization consistent with Δ

Not clear → need more statistic *(B = 0 at SPS)*

# Omega in cold nuclear matter

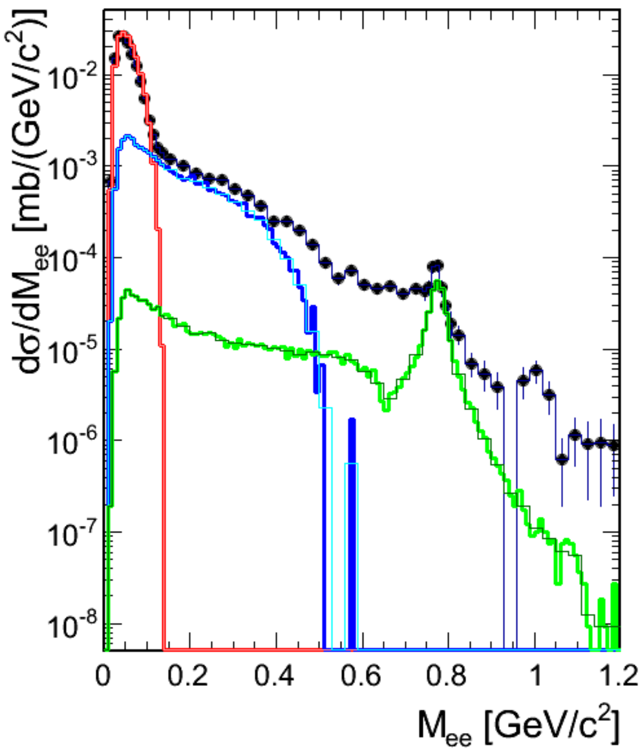
Phys.Lett. B715 (2012) 304-309

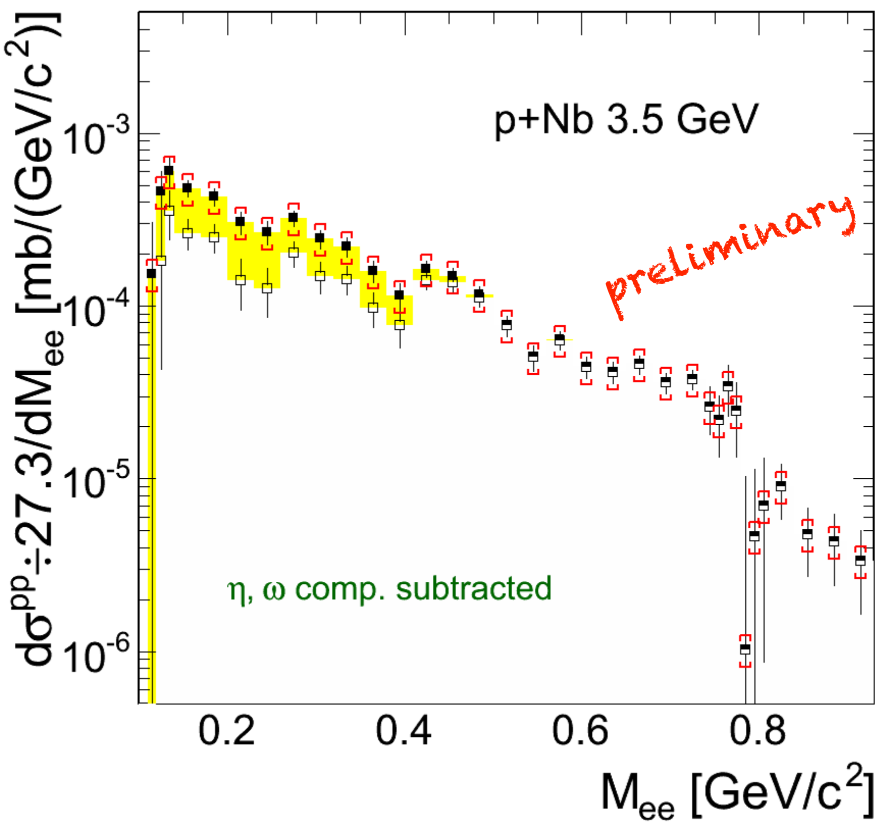



Selection on momentum of the decaying ω meson

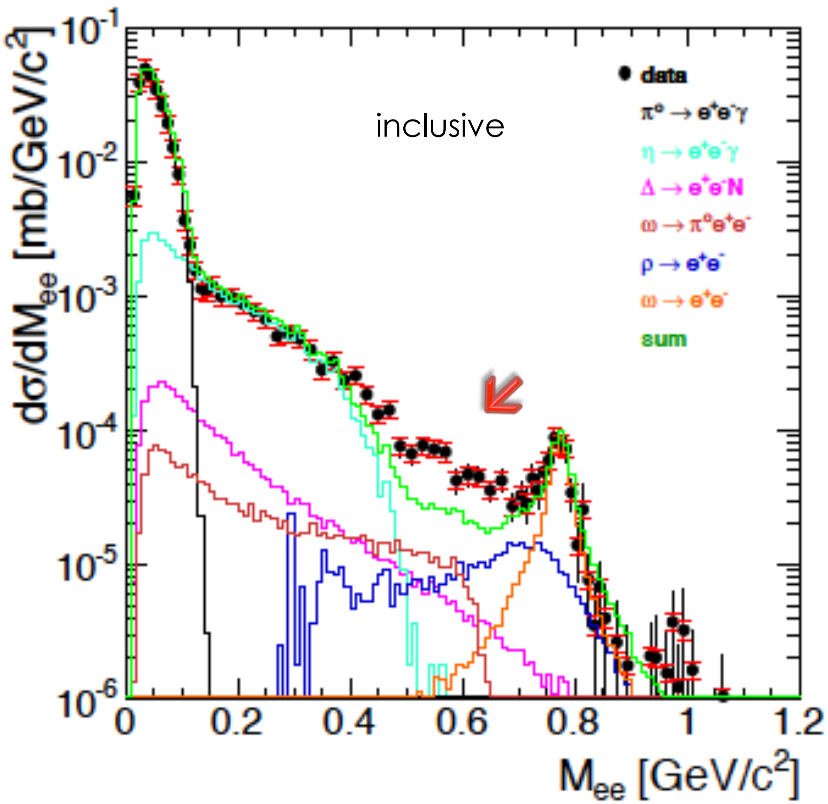
- First measurement of in-medium vector meson decays in the relevant momentum region (high-momentum ω mesons "decouple" from the medium)
- ω suppressed, in-medium decays buried under ρ-like contribution

# p+Nb data, $E_{kin}$=3.5 GeV



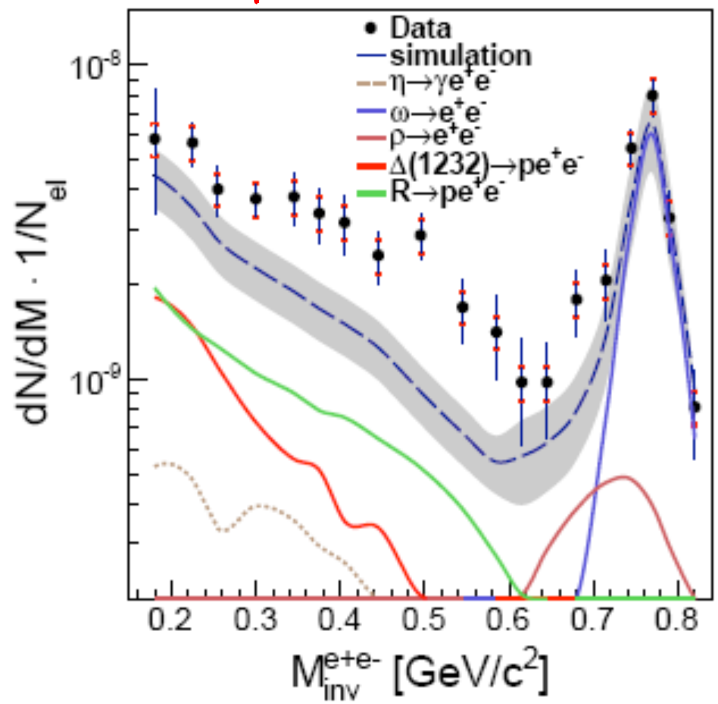
# pp reference




Eur.Phys.J. A48 (2012) 64

To be published

exclusive

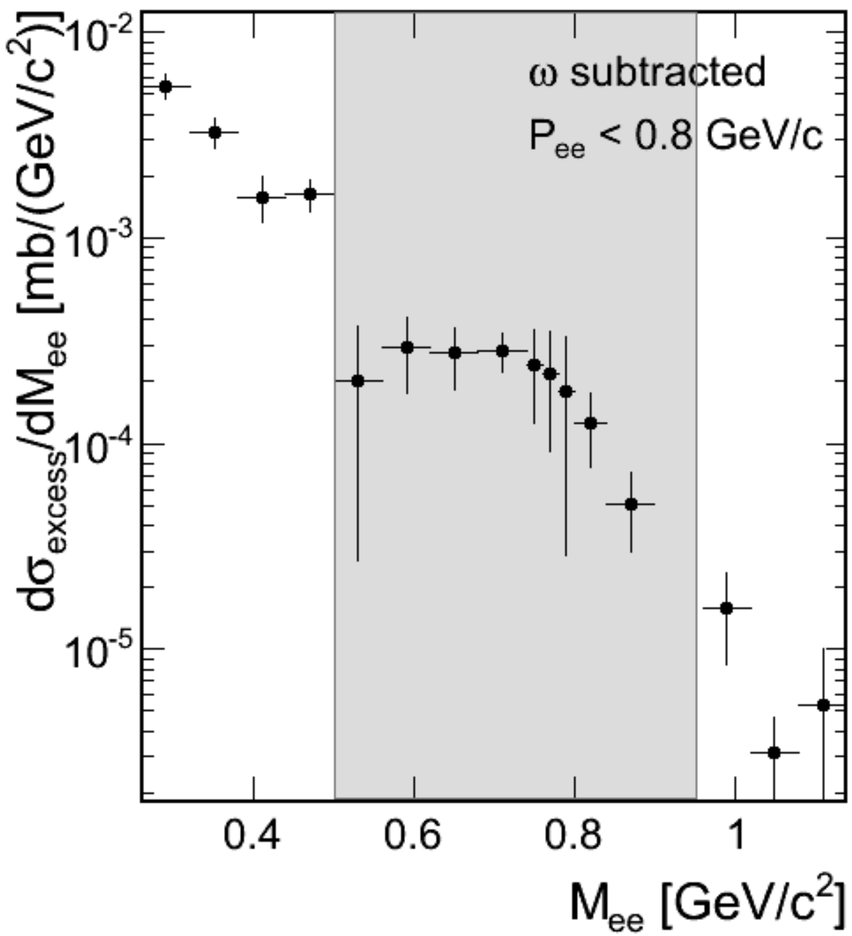



**PDG Enrty 2012**
**BR(h→e+e-) < 5.6x10-6 (90% CL)**

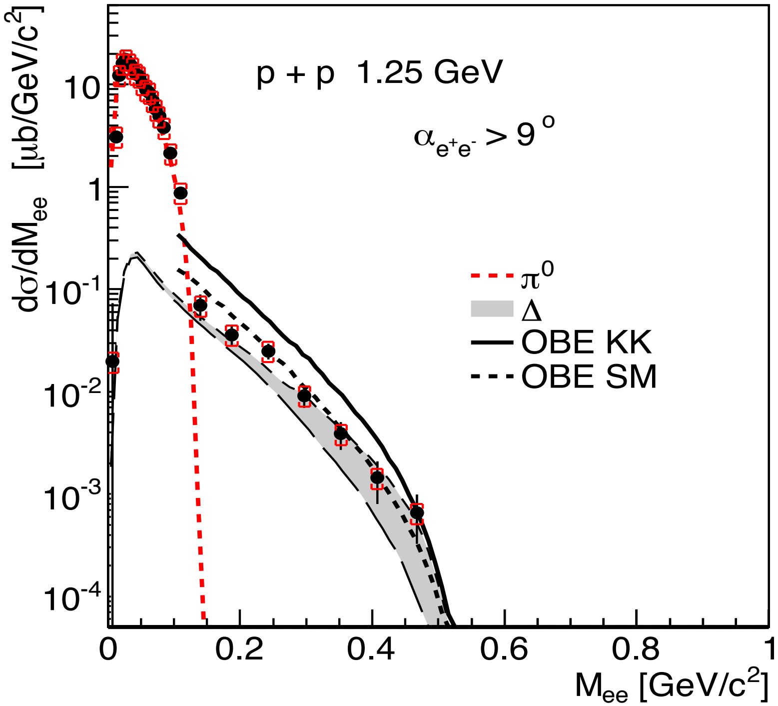
- Coupling of ρ to baryonic resonances
  → Cross check with hadronic final states needed!

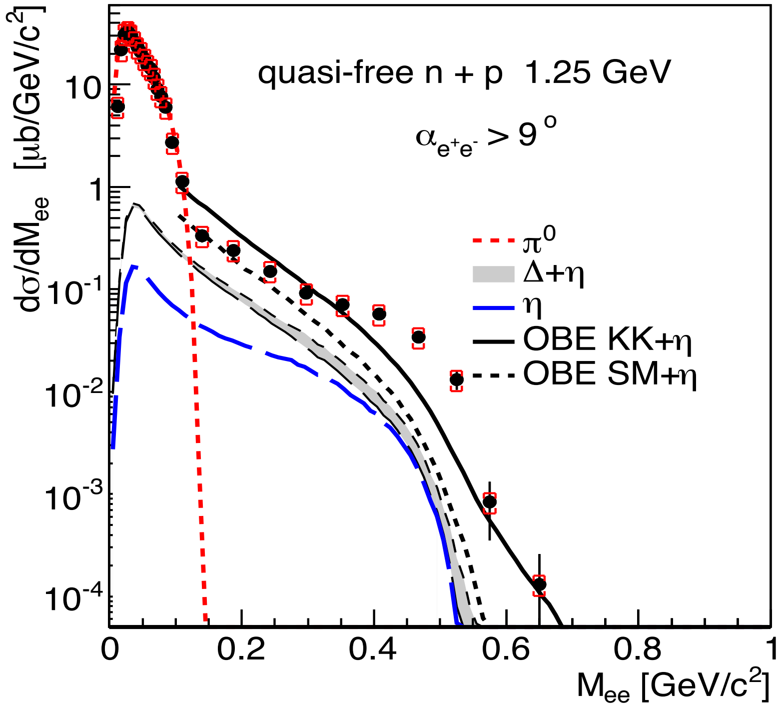
# pNb – pp - ω

Phys.Lett. B715 (2012) 304-309



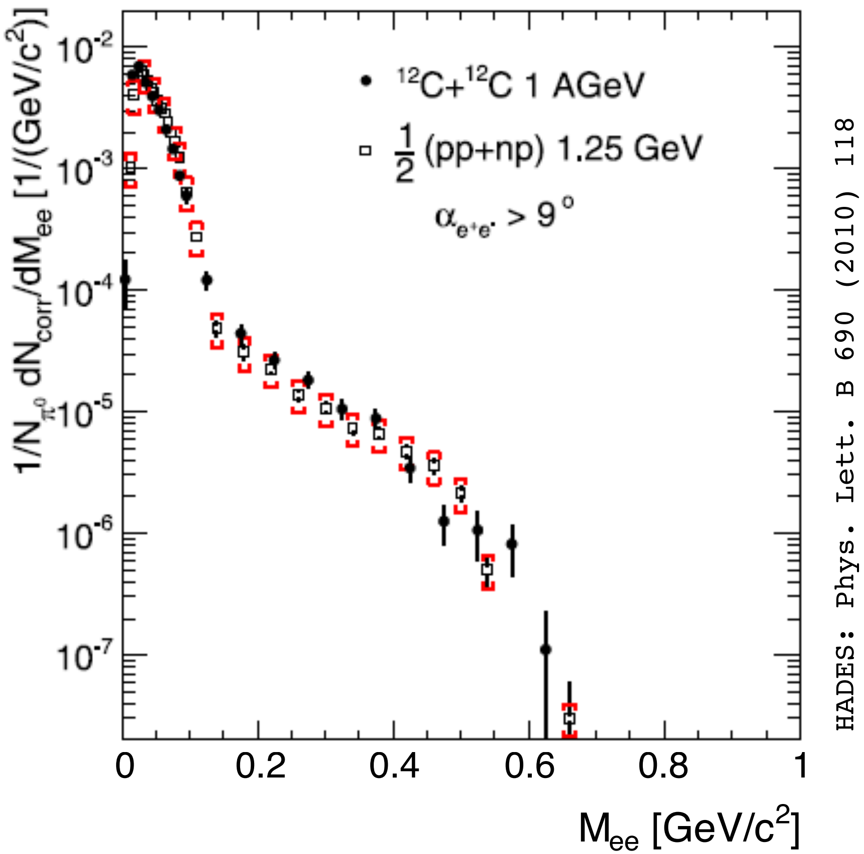
# NN reference

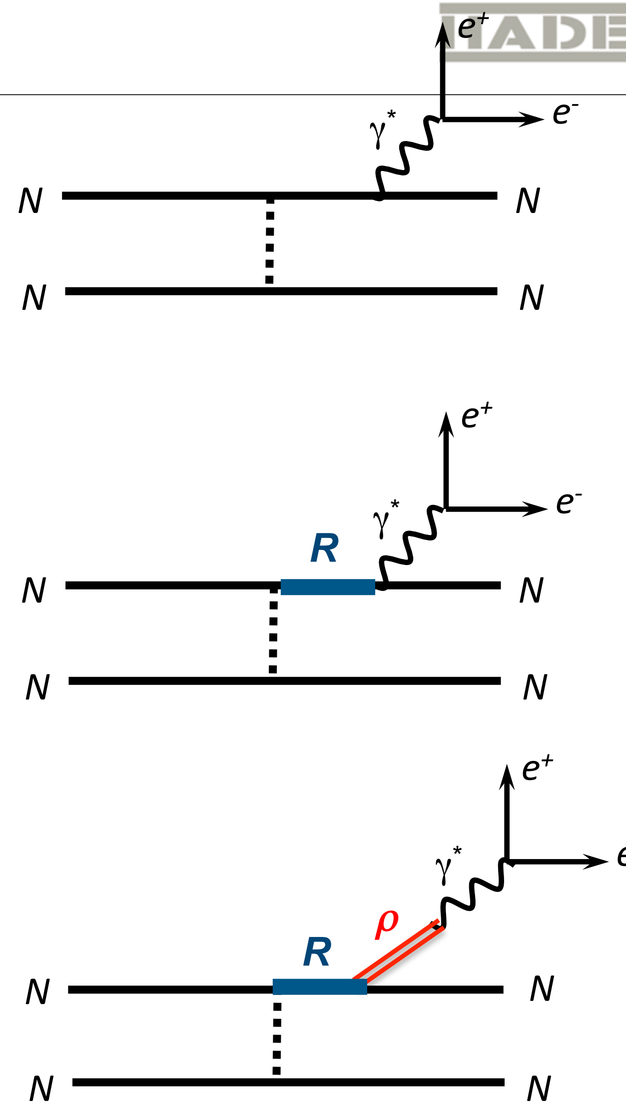



HADES : PLB 690 (2010) 118

# Origin of the low-mass pair excess in C+C collisions



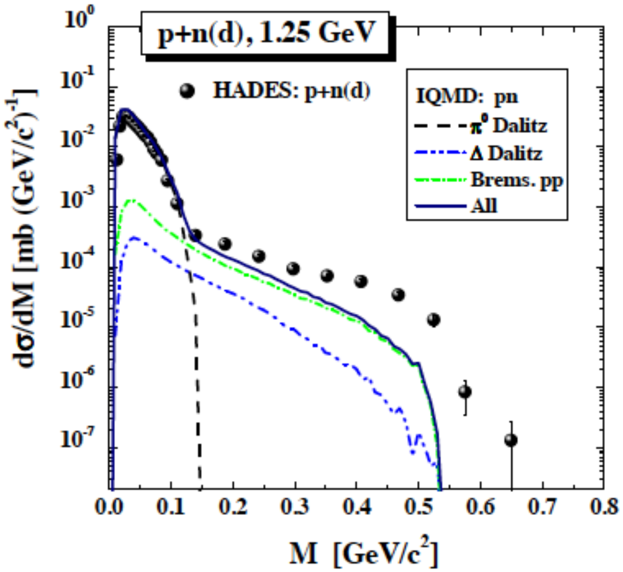



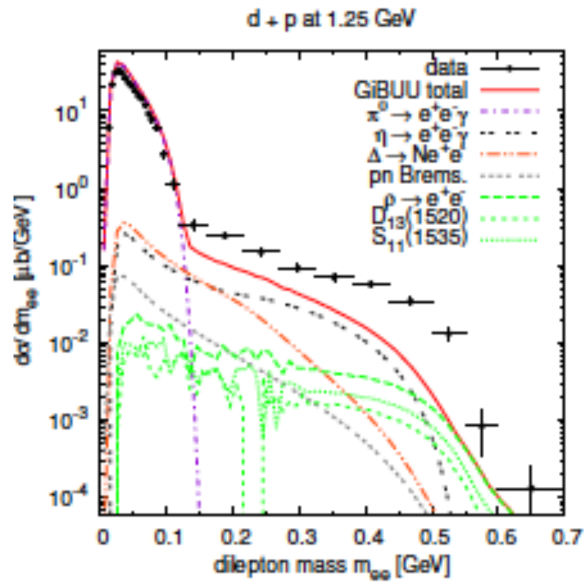

**Baryonic contributions from NN "reference"**

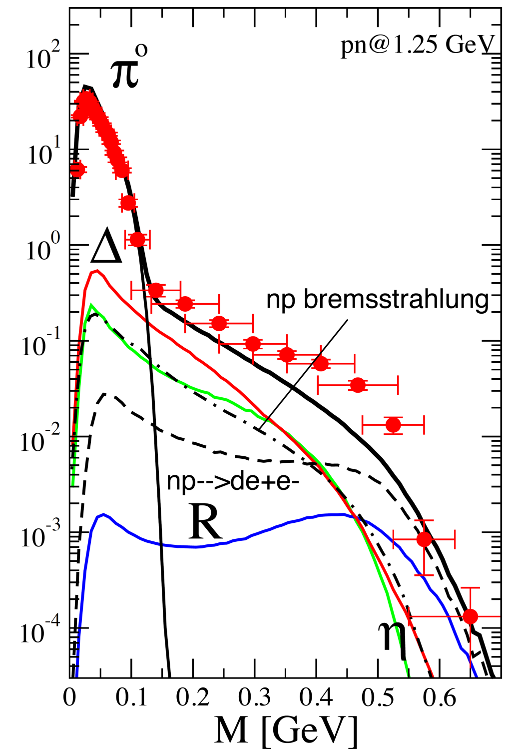


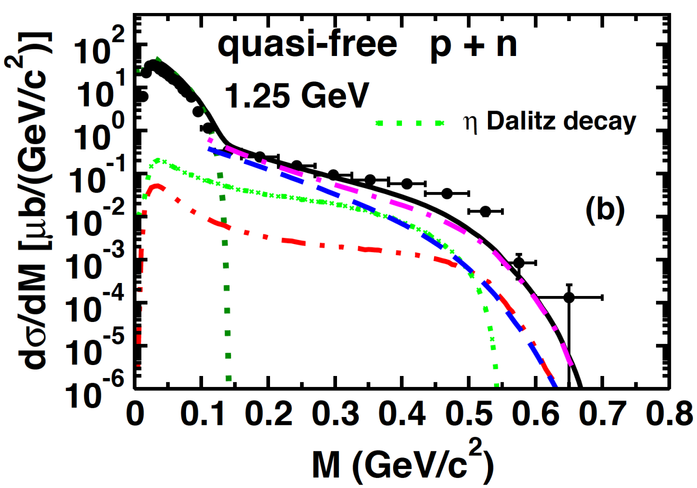
**$R = \Delta, N^*$**

# pn collisions

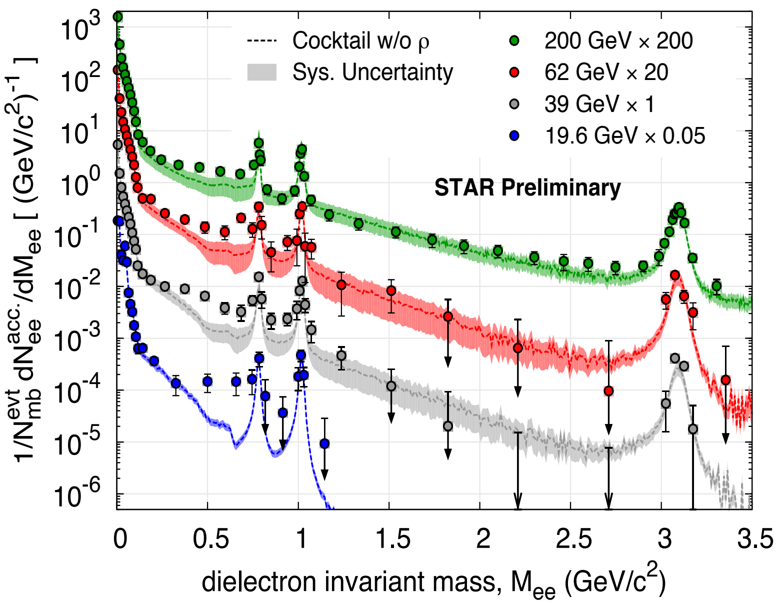


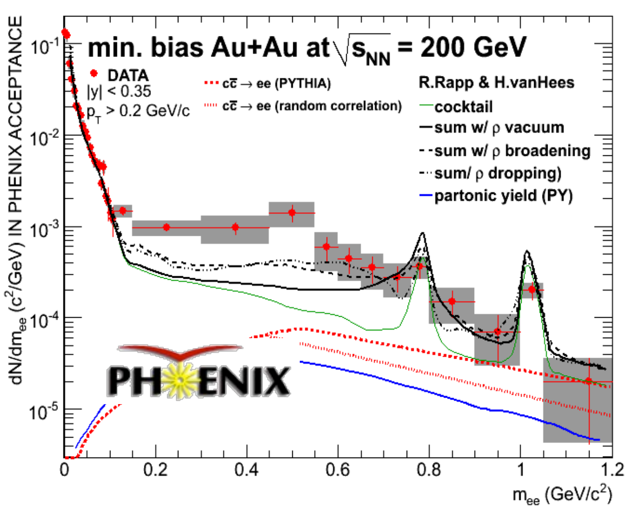



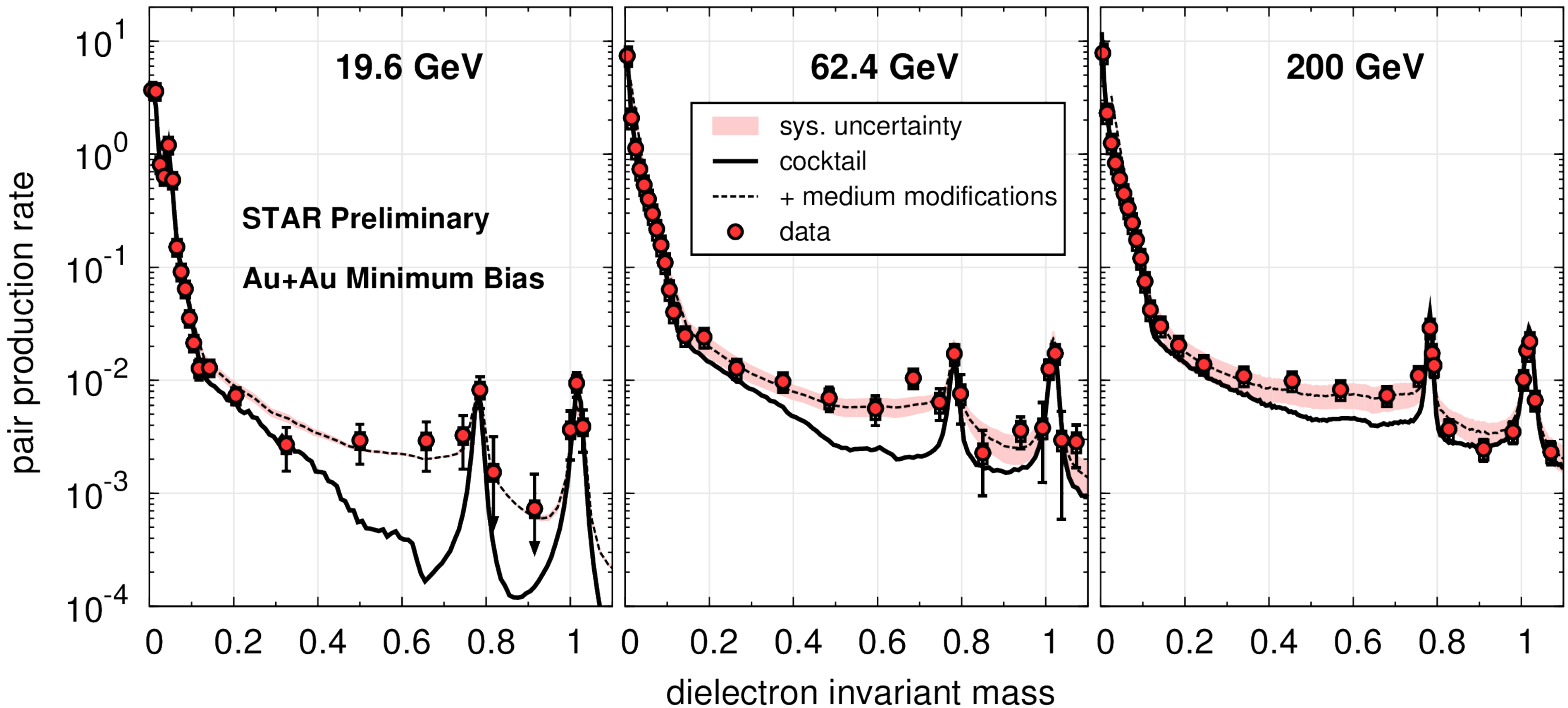
# Dileptons at RHIC and LHC



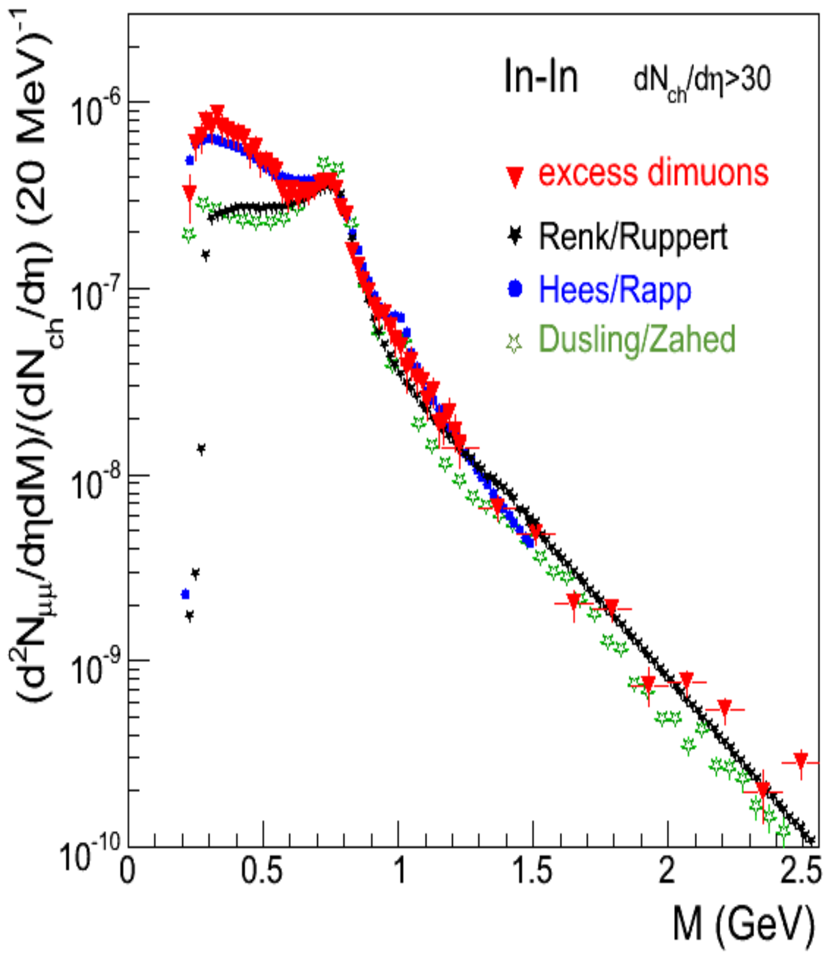

- SPS $\sqrt{s_{NN}} \leq 17.2$ GeV
  - net-baryon density: $\mu_B$~250MeV (at $T_{ch} \approx 160$ MeV)
- RHIC $\sqrt{s_{NN}} = 200$ GeV
  - $\mu_B$<<T, i.e. vanishing net-baryon density
  - **Lattice QCD computations are most powerful!**
- Precision measurement from $\sqrt{s_{NN}}$ = 200GeV is absolutely needed to "calibrate" EM rates
- Wish: excess mass spectrum a-la NA60, i.e. subtracting all know sources, at $\sqrt{s_{NN}}$ = 200GeV
  - High precision measurements of charm
  - Statistic!

# STAR Beam Energy Scan



# Acceptance corrected excess mass spectrum

[Eur. Phys. J. C 59 (2009) 607-623]
CERN Courier 11/ 2009, 31-35
Chiral 2010 , AIP Conf.Proc. 1322 (2010) 1-10




M>1 GeV

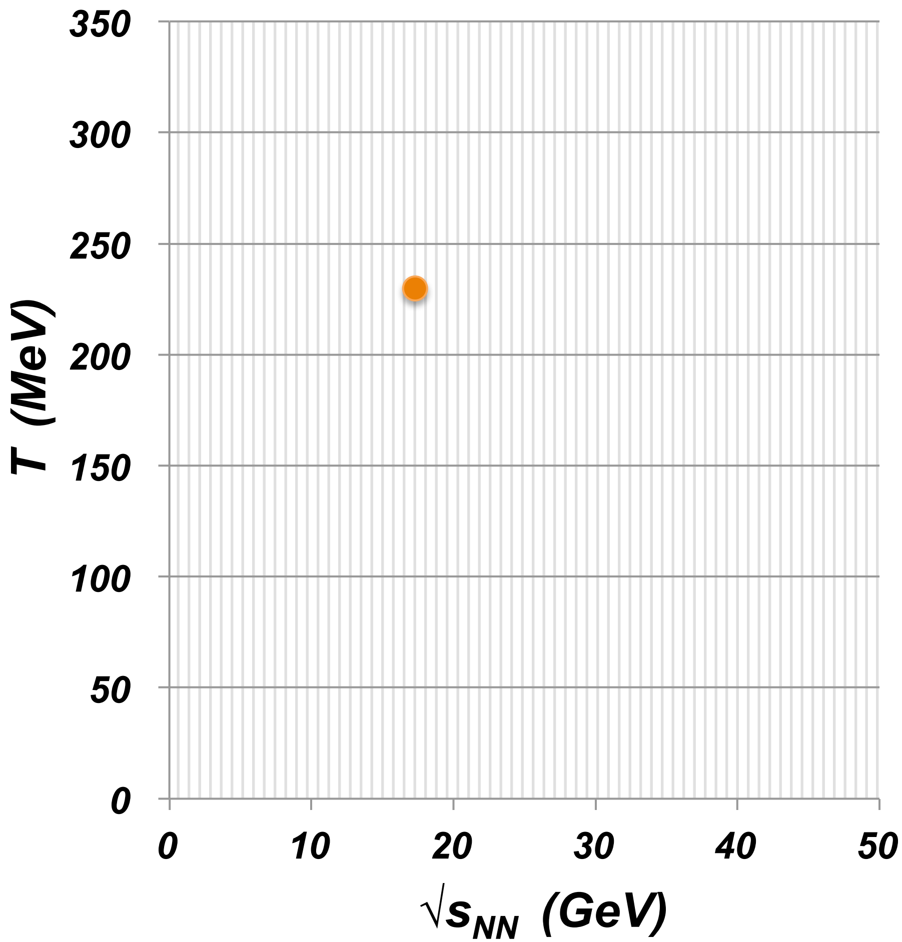
~ exponential fall-off → **'Planck-like'**

fit to $dN / dM \propto M^{3/2} \times \exp(-M / T)$

range 1.1-2.0 GeV: T=205±12 MeV
1.1-2.4 GeV: T=230±10 MeV

**described by R/R, D/Z and H/R models**

# Future explorations




- Look for non-monotonic behavior of T as a function of $\sqrt{s_{NN}}$? (Note, T < $T_{initia}$)
- Appearance (disappearance) of QGP radiation
- What would pp and pA say?