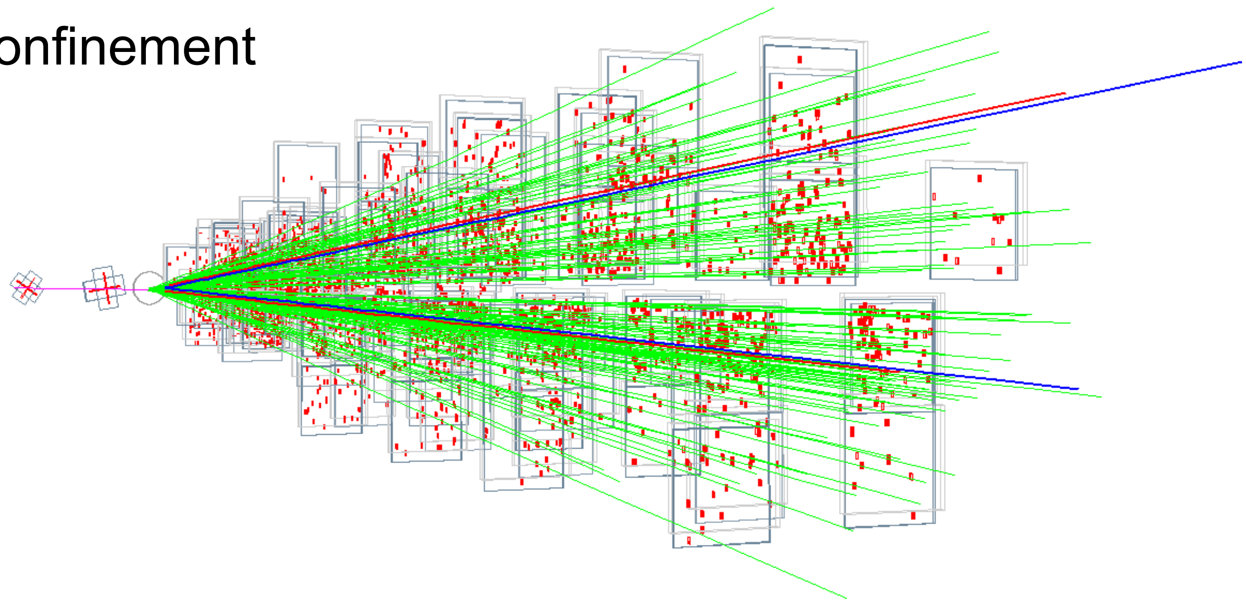
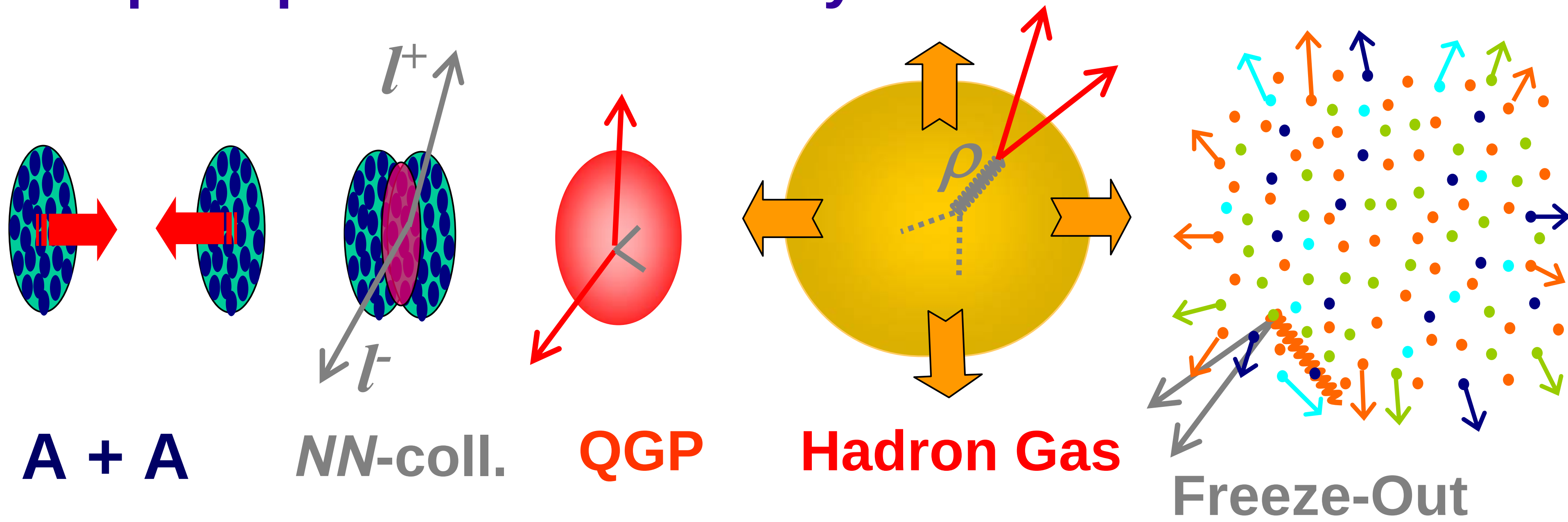
Electromagnetic probes in nuclear collisions: low and intermediate mass dileptons at the SPS

- Motivation
- ω, η Dalitz form factors
- ρ spectral function and chiral restoration
- Radial flow and deconfinement
- New measurements



G. Usai – INFN and University of Cagliari (Italy)

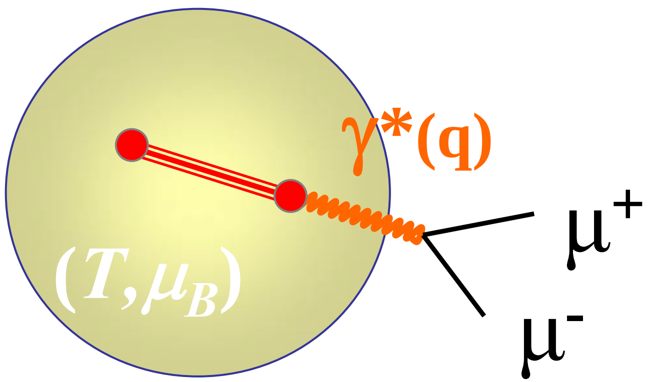
Dilepton production in heavy ion collisions



Sources of Dilepton Emission:

- primordial (Drell-Yan) $q\bar{q}$ annihilation: $NN \to l^+l^-X$
- **emission from equilibrated matter (thermal radiation)**
  - **Quark-Gluon Plasma:** $q\bar{q} \to l^+l^-, \ldots$
  - **Hot+Dense Hadron Gas:** $\pi^+\pi^- \to l^+l^-, \ldots$
- final-state hadron decays: $\pi^0, \eta \to \gamma l^+l^-, D, \bar{D} \to l^+l^- X, \ldots$

Dilepton Rate in a strongly interacting medium



Dileptons produced by annihilation of thermally excited particles:

$q\bar{q}$ in QGP phase

$\pi^+\pi^-$ in hadronic phase

Boltzmann factor

photon self-energy

$$\frac{dR_{l^+l^-}}{dq^4} = -\frac{\alpha^2}{\pi^3 M^2} f^B(q_0;T)\, Im\Pi_{em}(q_0,\vec{q})$$

$$Im\Pi_{em}(s) = \begin{cases} \dfrac{-s}{12\pi} N_c \sum\limits_{u,d,s} (e_q)^2 \left[1 + \dfrac{\alpha_S(s)}{\pi} + \cdots\right] & \text{Partonic phase} \\ \sum\limits_{\rho,\omega,\phi} \left[\dfrac{m_V^2}{g_V}\right]^2 Im\, D_V(s) & \text{Hadronic phase: Vector-Meson Dominance} \end{cases}$$

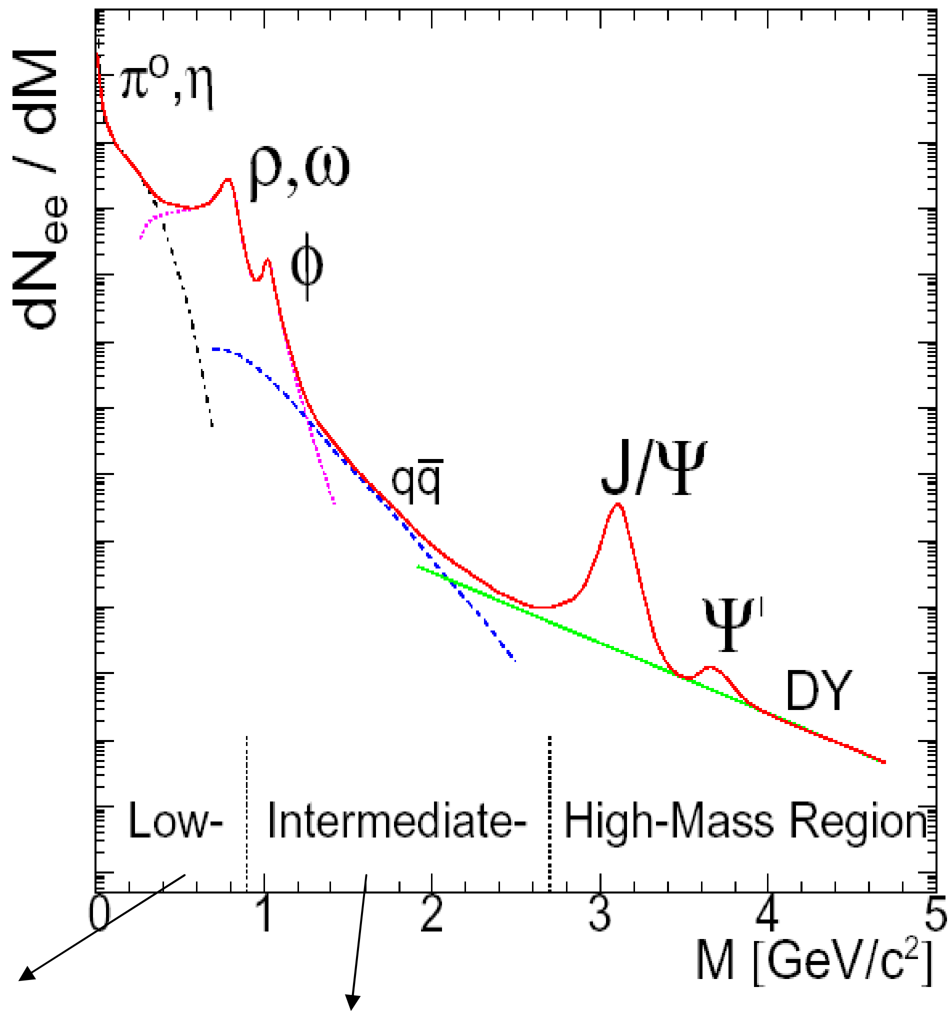
Partonic phase

Hadronic phase: Vector-Meson Dominance

spectral function

Schematic dilepton spectrum in heavy ion collisions

Characteristic regimes for different mass intervals:



Hadron gas
(dominated by ππ)

QGP and/or hadron gas
(multipion)

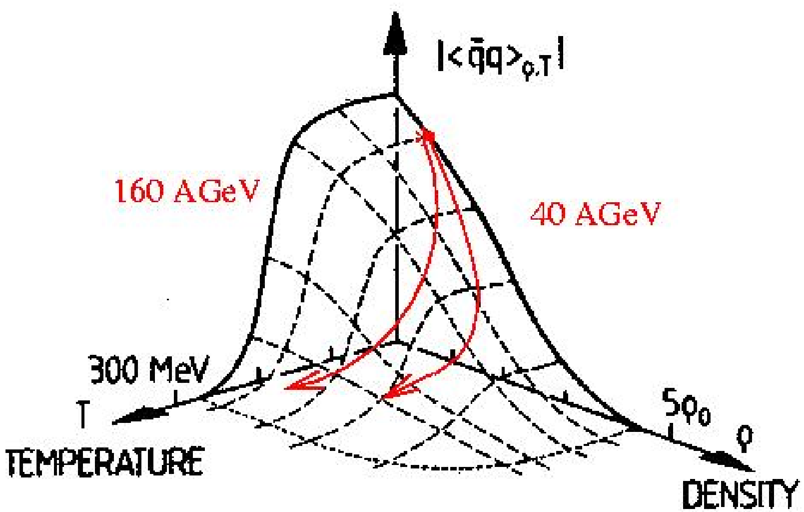
ρ spectral function in hot and dense hadronic matter

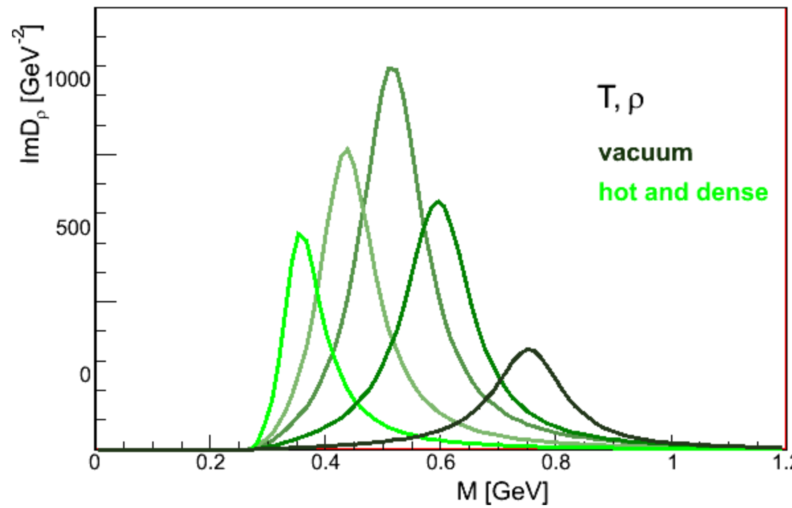
Dropping mass scenario   Brown/Rho et al., Hatsuda/Lee

explicit connection between hadron masses and chiral condensate

universal scaling law

$$m_\rho^* / m_\rho^0 = \langle \bar{q}q \rangle_{\rho,T}^{1/2} \Big/ \langle \bar{q}q \rangle_0^{1/2}$$





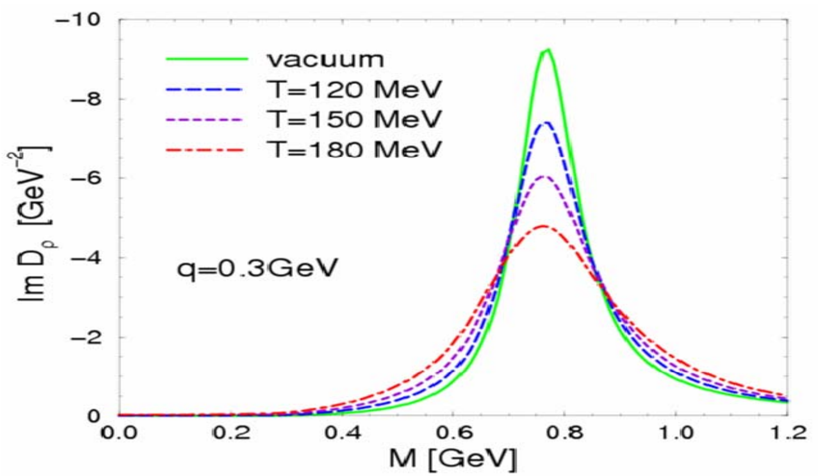
$$\langle \bar{q}q \rangle_{\rho,T}^{1/2} \Big/ \langle \bar{q}q \rangle_0^{1/2} = (1 - C\frac{\rho}{\rho_0})(1-(T/T_c^\chi)^2)^\alpha$$

continuous evolution of pole mass with T and ρ ; broadening at fixed T,ρ ignored

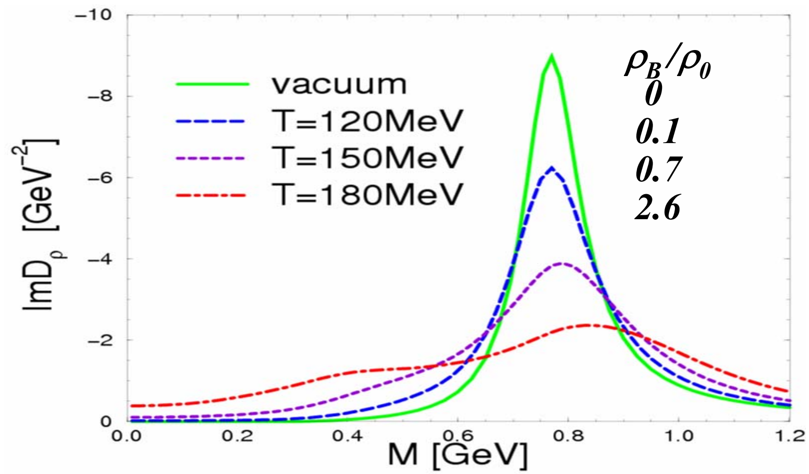
ρ spectral function in hot and dense hadronic matter

Hadronic many-body approach   Rapp/Wambach et al., Weise et al.

hot matter



hot and baryon-rich matter



$$D_\rho(q^2;\mu_B,T) = \left(q^2 - m_\rho^2 - \Pi_{\rho\pi\pi} - \Pi_{\rho B} - \Pi_{\rho M}\right)^{-1}$$

ρ is dressed with:

hot pions $\Pi_{\rho\pi\pi}$,

baryons $\Pi_{\rho B}$ (N,*Δ* ..)

mesons $\Pi_{\rho M}$ (K,a_1..)

ρ "melts" in hot and dense matter

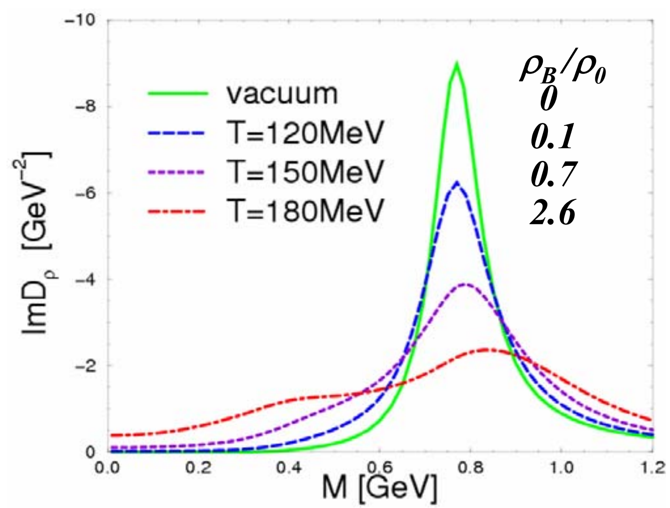
- pole position roughly unchanged
- broadening mostly through baryon interactions

Experimentally observable mass spectrum

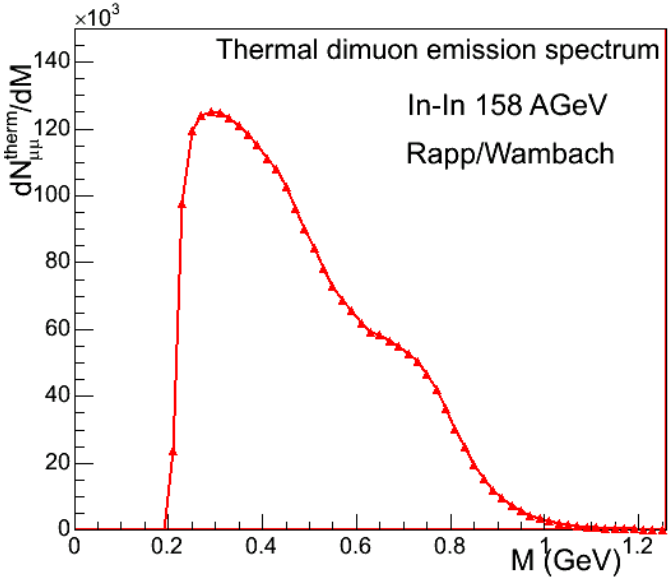
continuous emission of thermal radiation during life time of expanding fireball → integration of rate equation over space-time and momenta required

$$\frac{dN_{\mu\mu}^{therm}}{dM} = \int_{\tau_0}^{\tau_{fo}} d\tau V_{FB}(\tau) \int \frac{Md^3q}{q_0} \frac{dN_{\mu\mu}^{therm}}{d^4x d^4q}(M, q; T, \mu_i)$$

example: broadening scenario



→



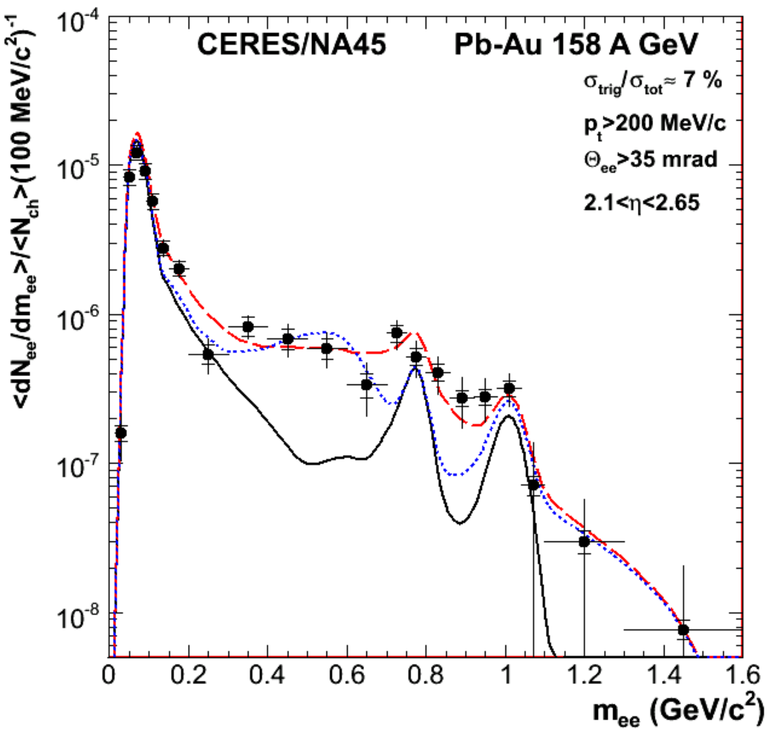
→ Spectral function accessible through rate equation, integrated over space-time and momenta

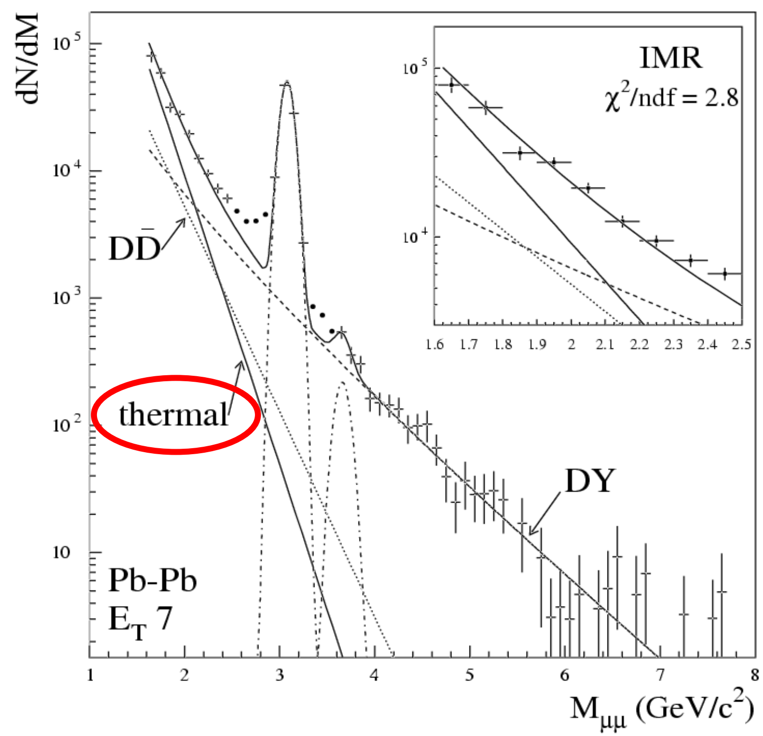
$$dN_{\mu\mu}/dM \approx f(M) \times \langle \exp(-M/T) \rangle \times \langle spectral\ \ function \rangle$$

Experimental landscape in dilepton measurements in 2000

Strong excess below 1 GeV in e^+e^- mass spectrum dominated by ρ meson:
Which in-medium properties?
Connection with chiral symmetry restoration?

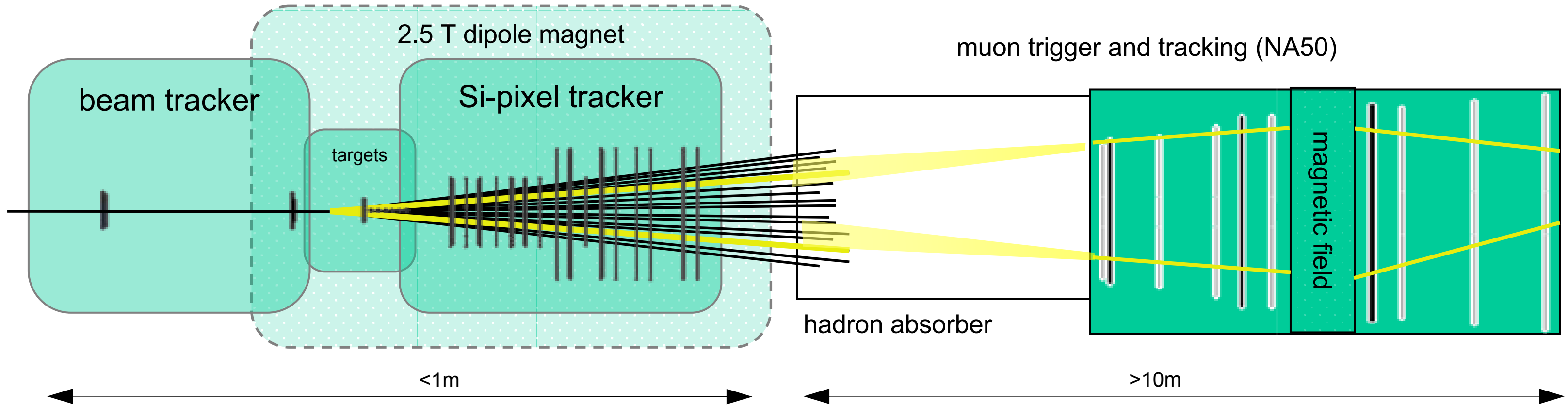
Strong excess in $\mu^+\mu^-$ mass spectrum above 1 GeV:
Thermal dimuons or enhanced open charm?



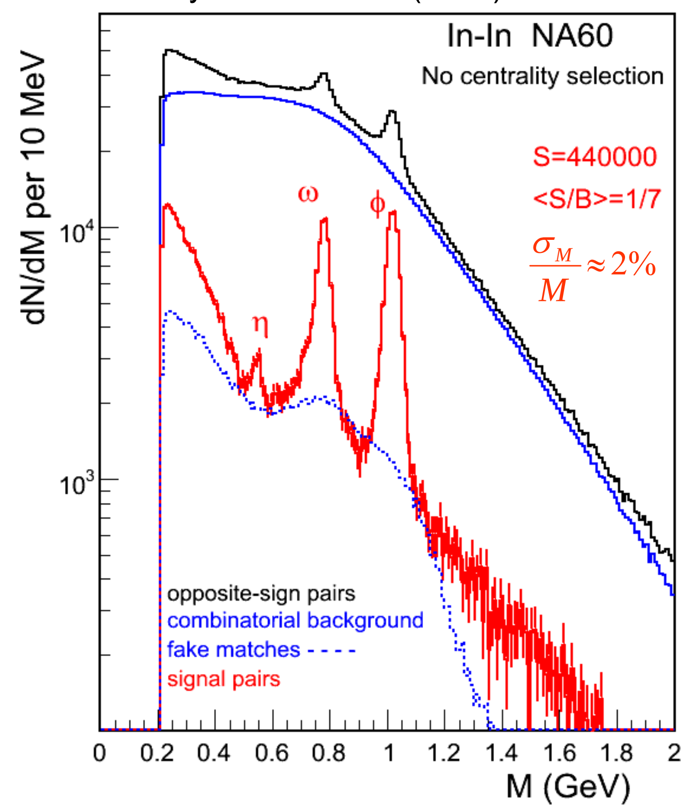


Measurements with higher statistics and resolution were needed

The NA60 concept



Phys.Rev.Lett. 96 (2006) 162302



Track matching in coordinate <u>and</u> momentum

- Improved dimuon mass resolution
- Distinguish prompt from decay dimuons

Additional bend by the dipole field

- Dimuon coverage extended to low p_T

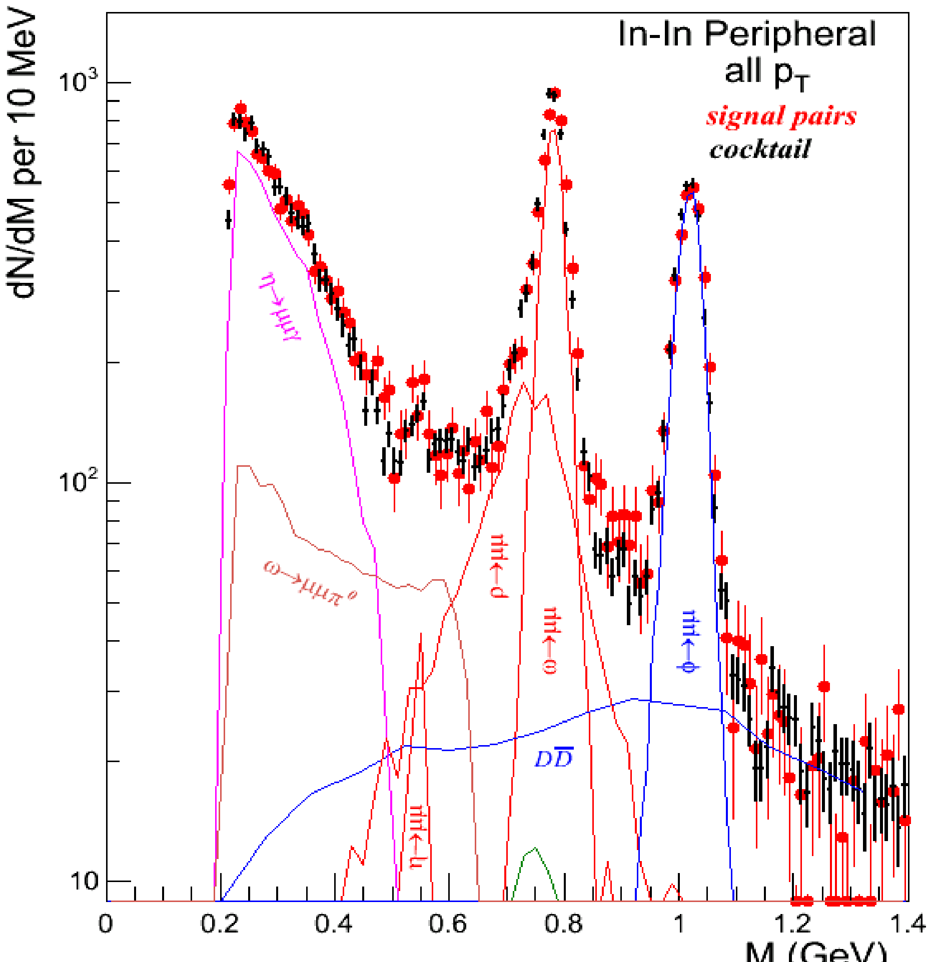
Radiation-hard silicon pixel detectors (LHC development for ALICE and ATLAS)

- High luminosity of dimuon experiments kept

NA60 LMR data: peripheral (Nch<30) In-In collisions

Well described by meson decay 'cocktail': η, η', ρ, ω, f and $D\overline{D} \rightarrow \mu\mu$ contributions (Genesis generator developed within CERES and adapted for dimuons by NA60).

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



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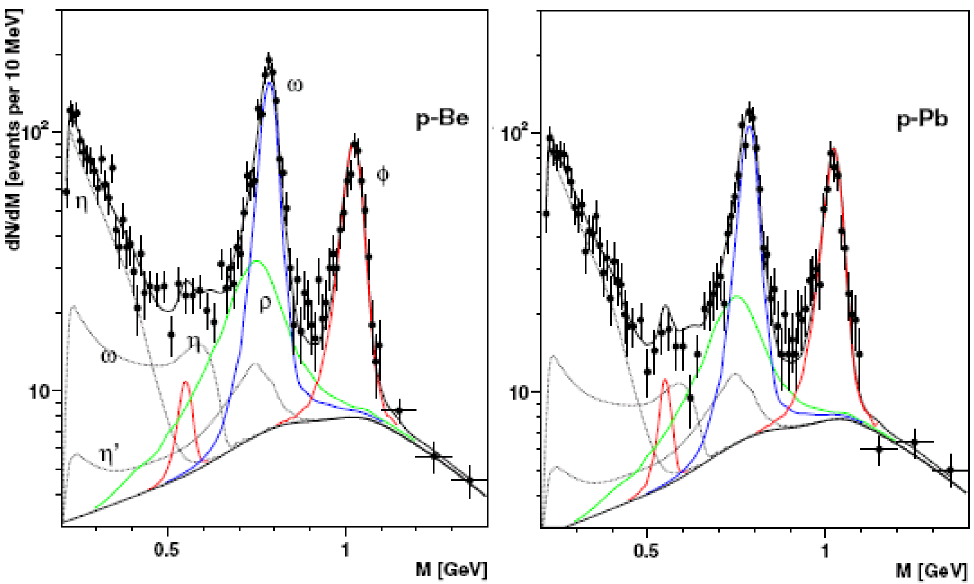
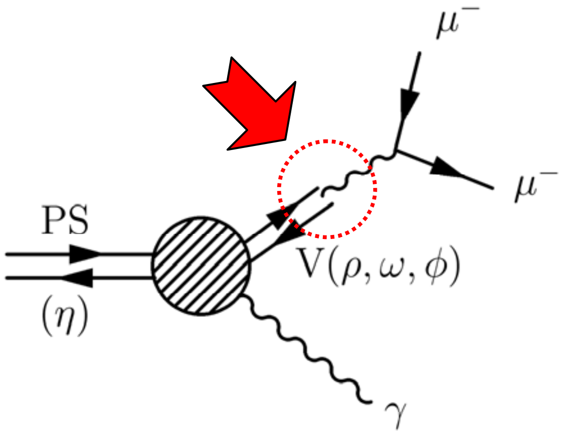
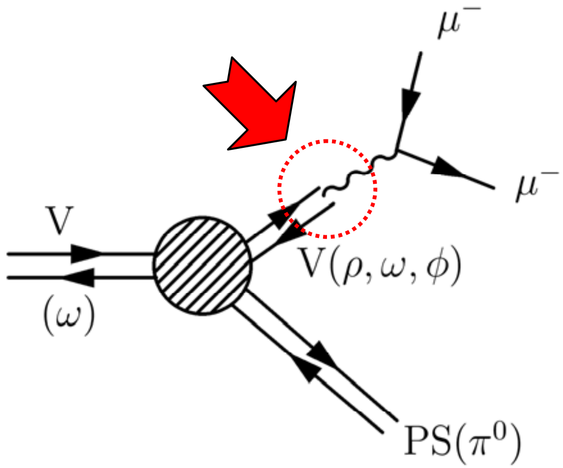


Similar cocktail describes NA60 p-Be,In,Pb 400 GeV data

EM transition form factors $\eta\to\mu\mu\gamma$ - $\omega\to\mu\mu\pi$

Vector Meson Dominance Model (VDM): Photon-hadron interactions proceed via a transition to a vector meson





VMD model provides a description of the electromagnetic form factor

$$F(M) = \frac{\sum_{V=\rho,\omega,\phi}\left[g_{ABV}/2g_{V\gamma}\right] m_V^2 \frac{1}{m_V^2 - M^2 - i\Gamma_V m_V}}{\sum_{V=\rho,\omega,\phi}\left[g_{ABV}/2g_{V\gamma}\right]}$$

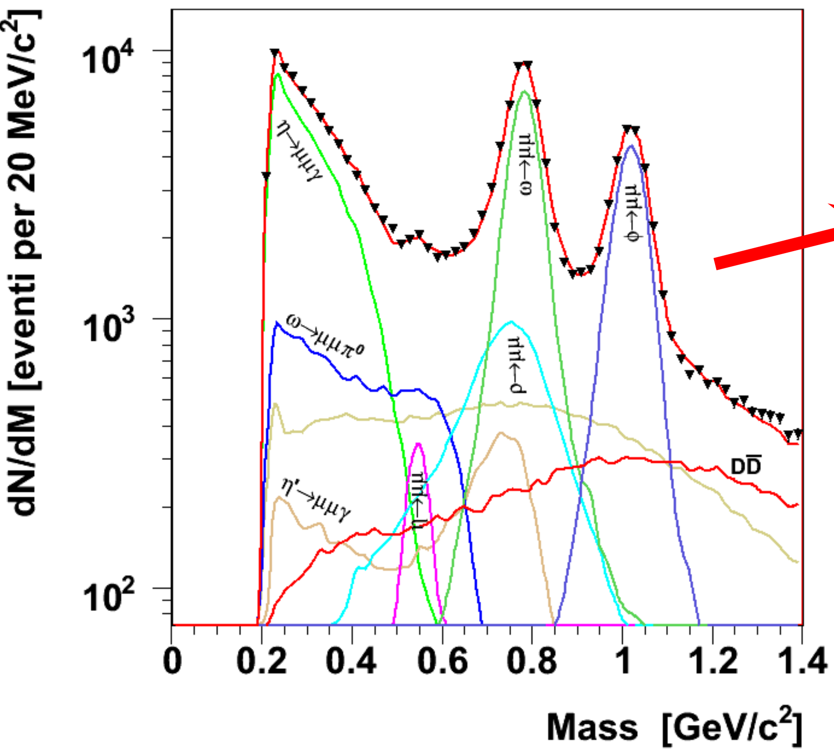
Pole approximation: $\left|F(m_{\mu\mu}^2)\right|^2 = \left(1 - m_{\mu\mu}^2/\Lambda^2\right)^{-2}$

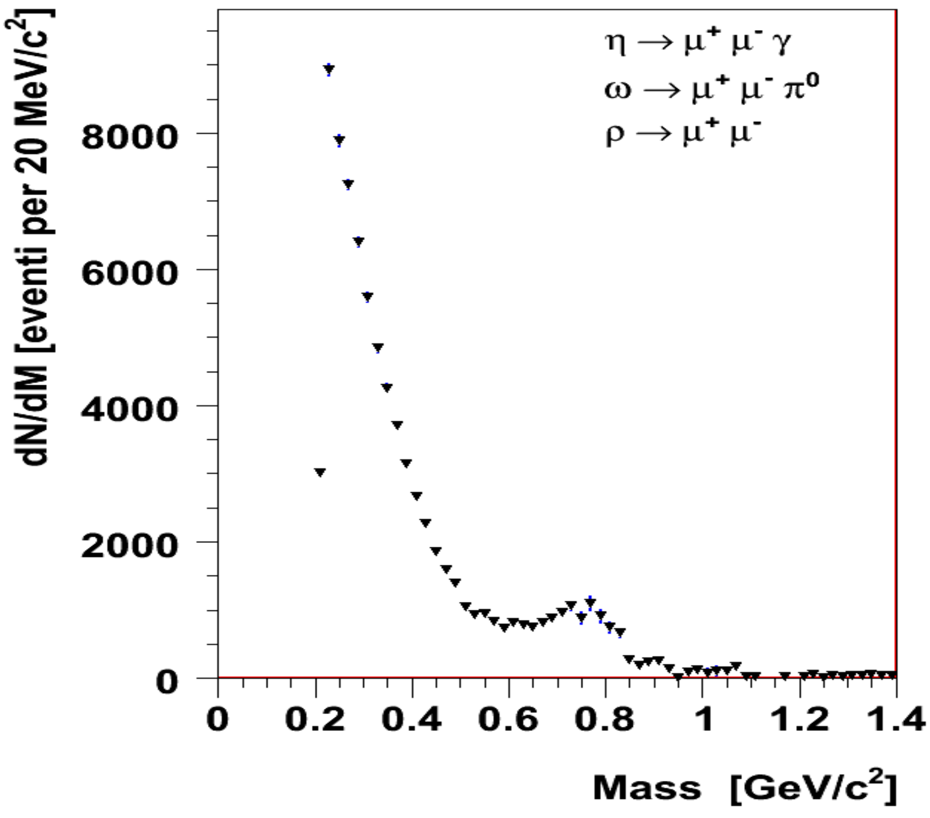
Isolation of Dalitz decays

Fit expected sources:

- **2-body** and **Dalitz** decay of the neutral mesons **η**, **ρ**, **ω**, **η'**, **ϕ**
- open charm contribution

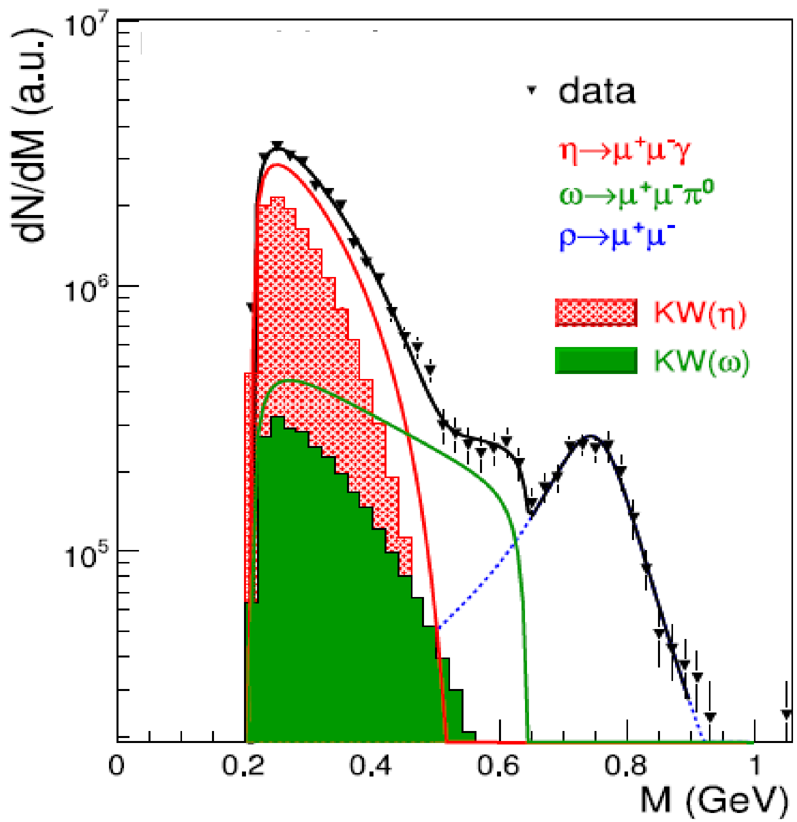
Isolation of Dalitz and ρ decays by subtraction of other sources



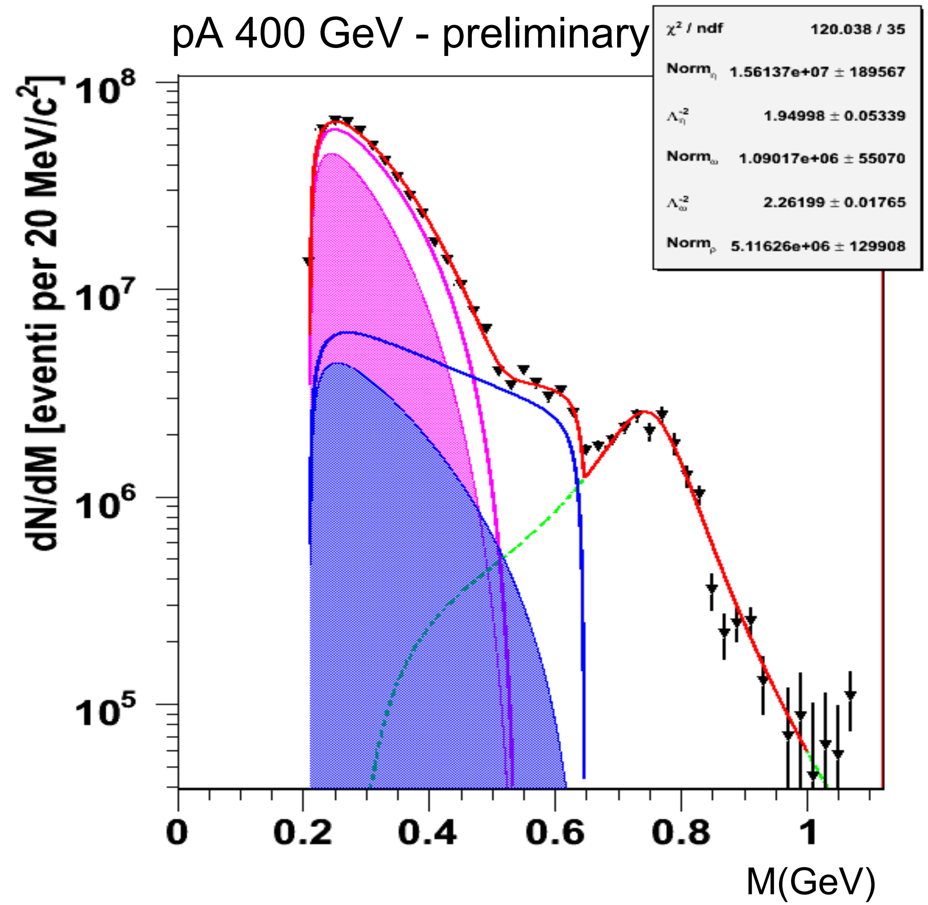


Acceptance corrected spectra

In-In peripheral PLB 677 (2009) 260



pA 400 GeV - preliminary



Rho 2-body decay: line shape characteristic for hadro-production

$$\frac{dR(\rho\to\mu^+\mu^-)}{dM}=\frac{\alpha^2 m_\rho^4}{3(2\pi)^4}\frac{\left(1-\frac{4m_\pi^2}{M^2}\right)^{3/2}\left(1-\frac{4m_\mu^2}{M^2}\right)^{1/2}\left(1+\frac{2m_\mu^2}{M^2}\right)}{\left(M^2-m_\rho^2\right)^2+M^2\Gamma^2}(2\pi MT)^{3/2}e^{-\frac{M}{T}}$$

Dalitz processes: Kroll-Wada times form-factor

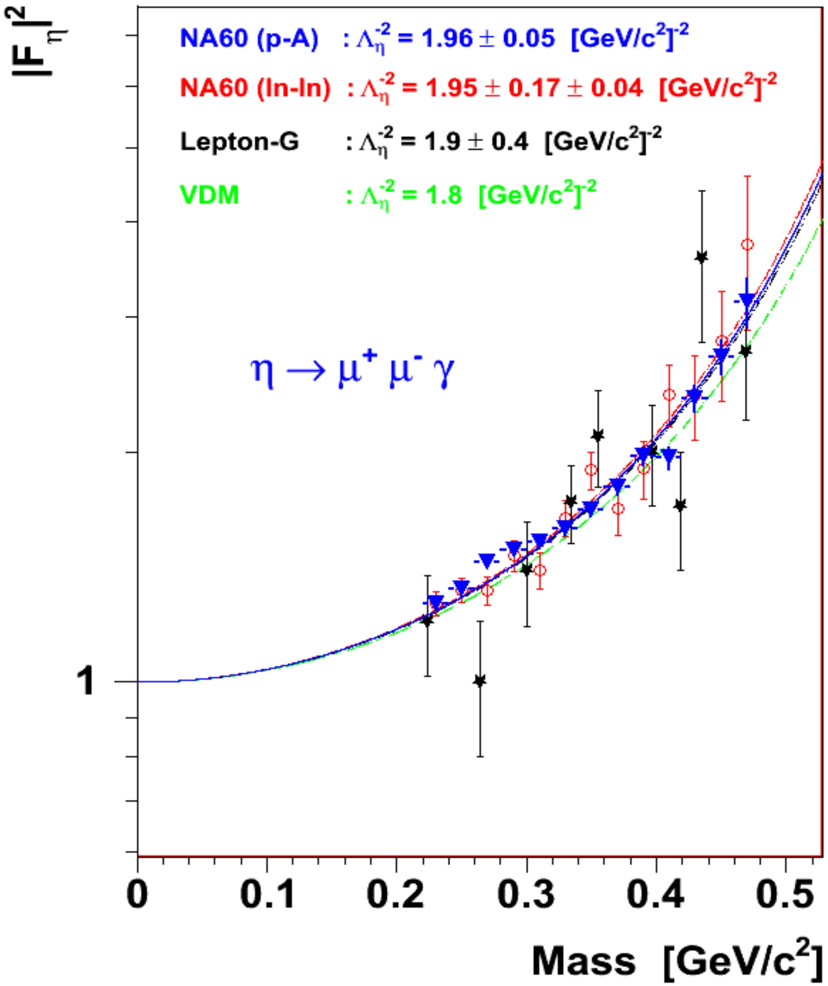
$$\frac{d\Gamma(\eta\to\mu^+\mu^-\gamma)}{dm_{\mu\mu}^2}=\frac{2\alpha}{3\pi}\frac{\Gamma(\eta\to\gamma\gamma)}{m_{\mu\mu}^2}\left(1-\frac{m_{\mu\mu}^2}{m_\eta^2}\right)^3\left(1+\frac{2m_\mu^2}{m_{\mu\mu}^2}\right)\left(1-\frac{4m_\mu^2}{m_{\mu\mu}^2}\right)^{1/2}\times\left|F_\eta(m_{\mu\mu}^2)\right|^2$$

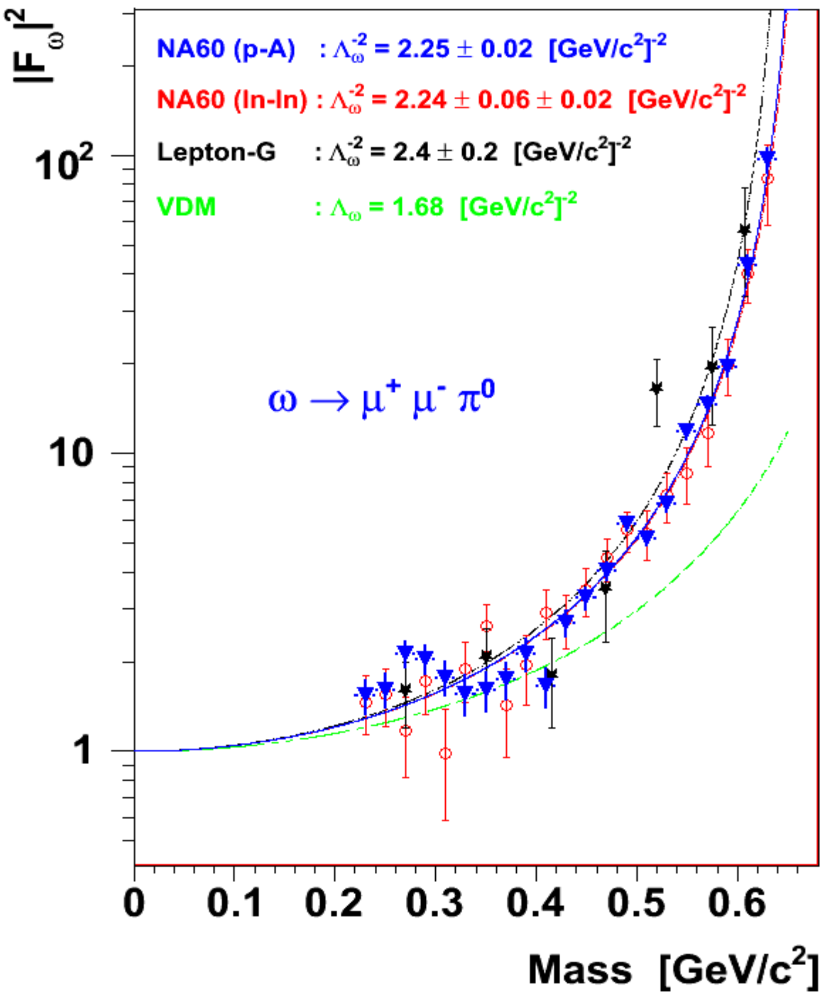
$$\frac{d\Gamma(\omega\to\mu^+\mu^-\pi^0)}{dm_{\mu\mu}^2}=\frac{\alpha}{3\pi}\frac{\Gamma(\omega\to\pi^0\gamma)}{m_{\mu\mu}^2}\left(1+\frac{2m_\mu^2}{m_{\mu\mu}^2}\right)\left(1-\frac{4m_\mu^2}{m_{\mu\mu}^2}\right)^{1/2}\left[\left(1+\frac{m_{\mu\mu}^2}{m_\omega^2-m_{\pi^0}^2}\right)^2-\frac{4m_\omega^2 m_{\mu\mu}^2}{m_\omega^2-m_{\pi^0}^2}\right]^{3/2}\times\left|F_\omega(m_{\mu\mu}^2)\right|^2$$

Form factors

In-In peripheral PLB 677 (2009) 260

pA 400 GeV - preliminary

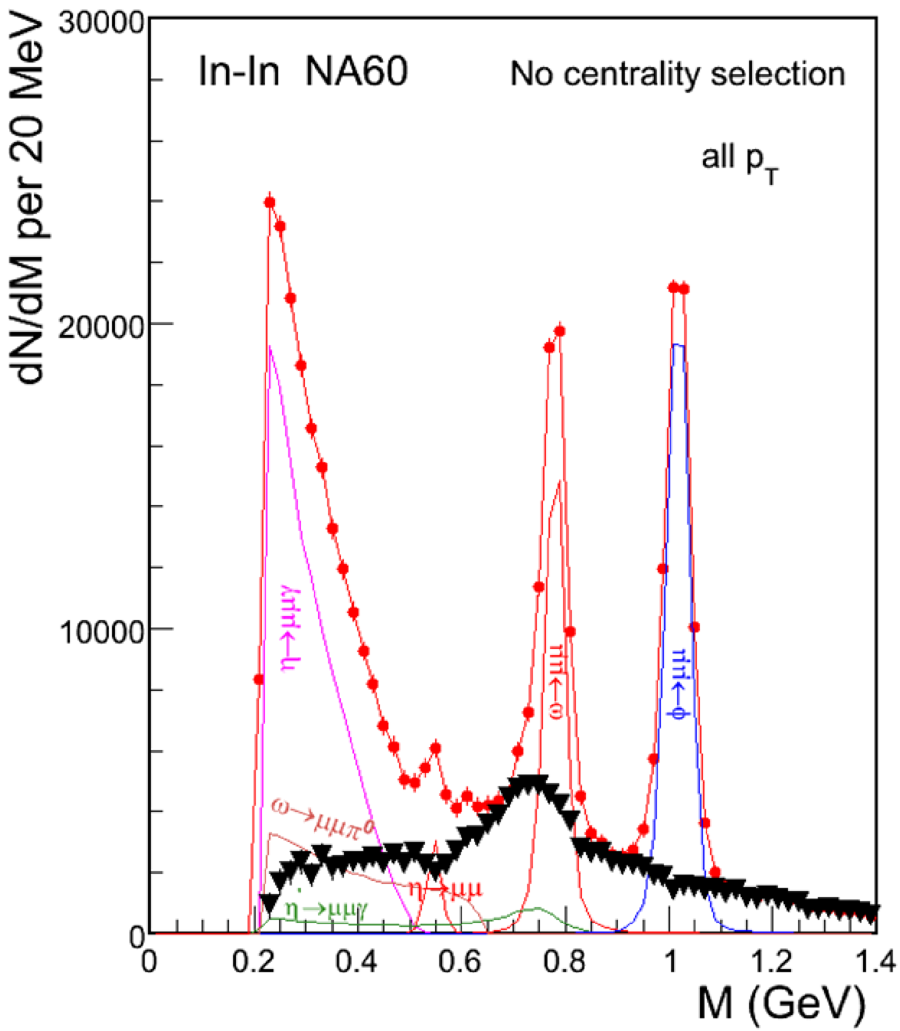




- Confirmed anomaly of F_ω wrt the VDM prediction
- Significantly improved errors wrt the Lepton-G results
- Form factor ambiguity in the hadron cocktail removed

Excess dimuons in In-In collisions at the SPS

Phys. Rev. Lett. 96 (2006) 162302



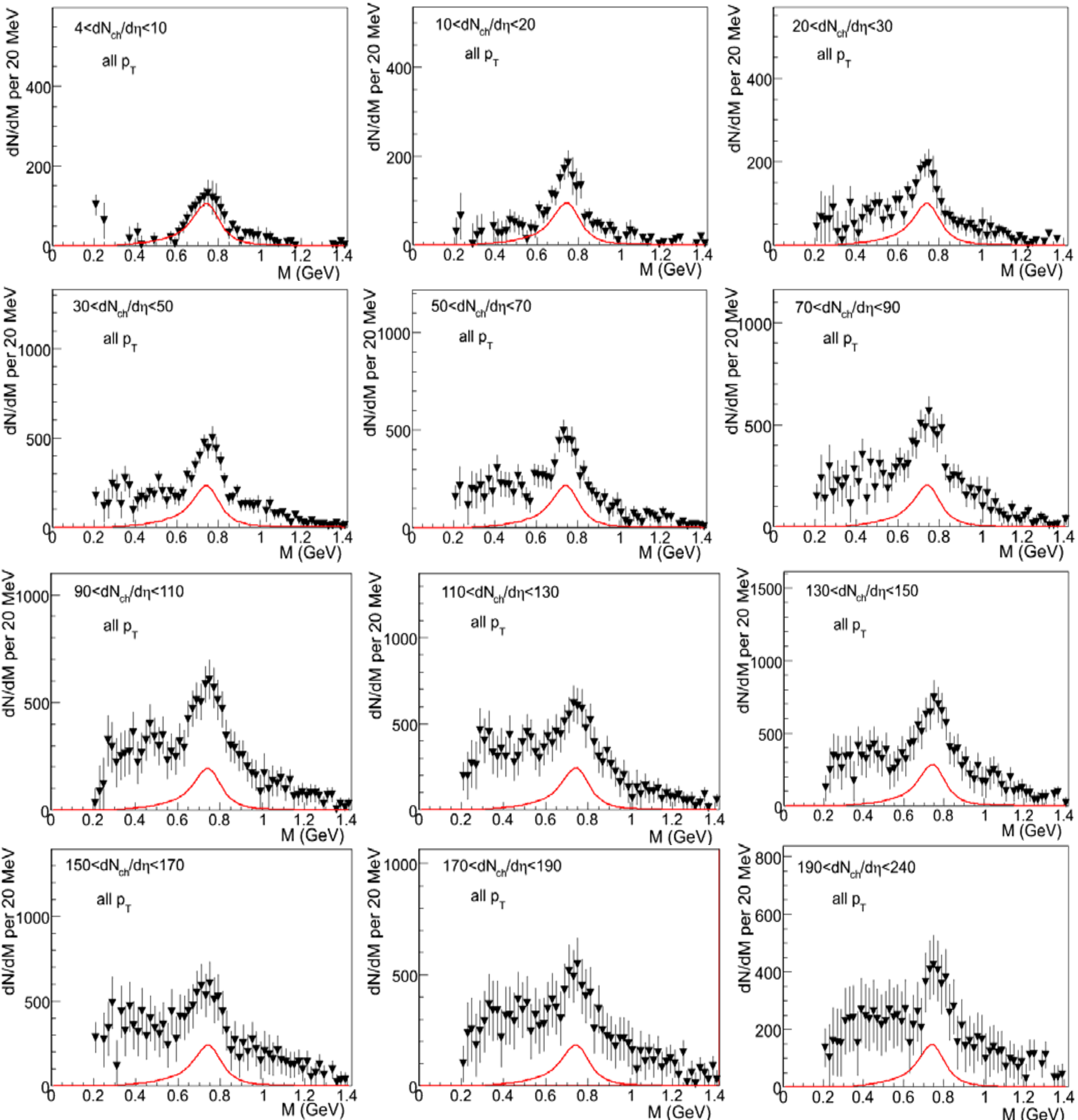
Peripheral data: well described by meson decay cocktail (η, η’, ρ, ω, ϕ) and DD

More central data (shown): existence of excess dimuons

isolation of excess by subtraction of the measured decay cocktail (without ρ), based solely on local criteria for the major sources η Dalitz, ω and ϕ

Excess vs centrality

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

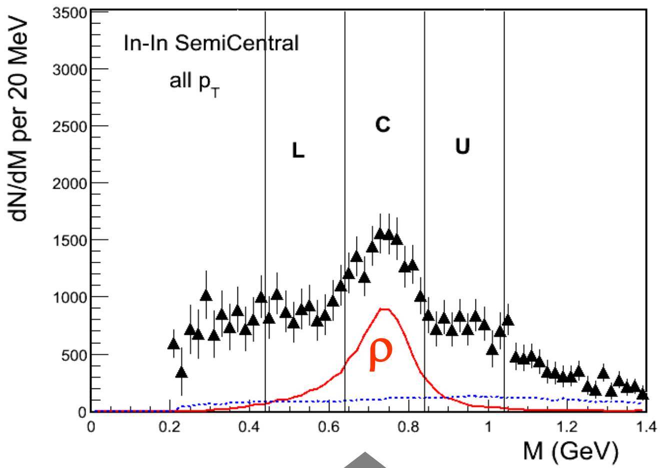


- Excess above the cocktail ρ (bound by ρ/ω=1.0), centered at nominal ρ pole
- Monotonically rises and broadens with centrality

By coincidence, NA60 acceptance roughly removes the phase-space factor
⇒ **ρ spectral function** convoluted over the fireball evolution is directly measured

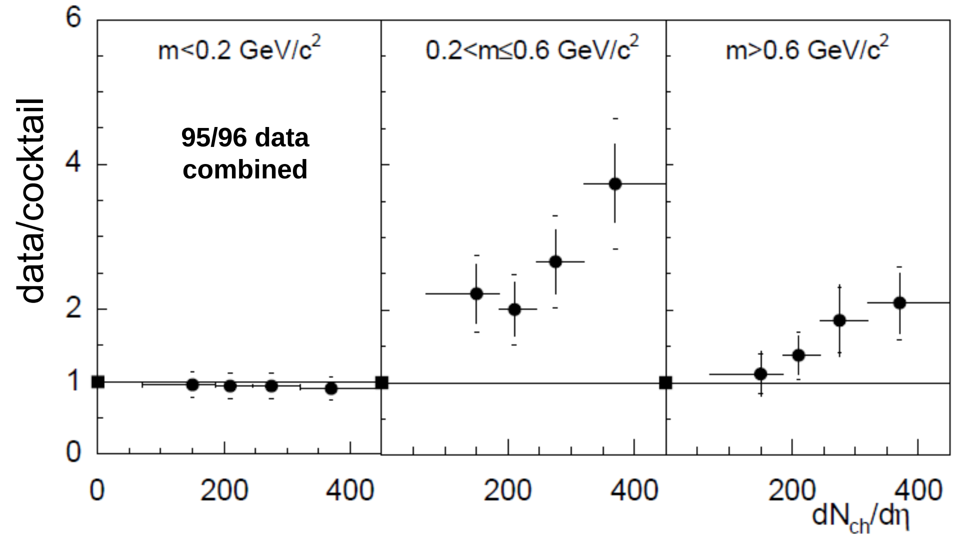
Centrality dependence of excess yields

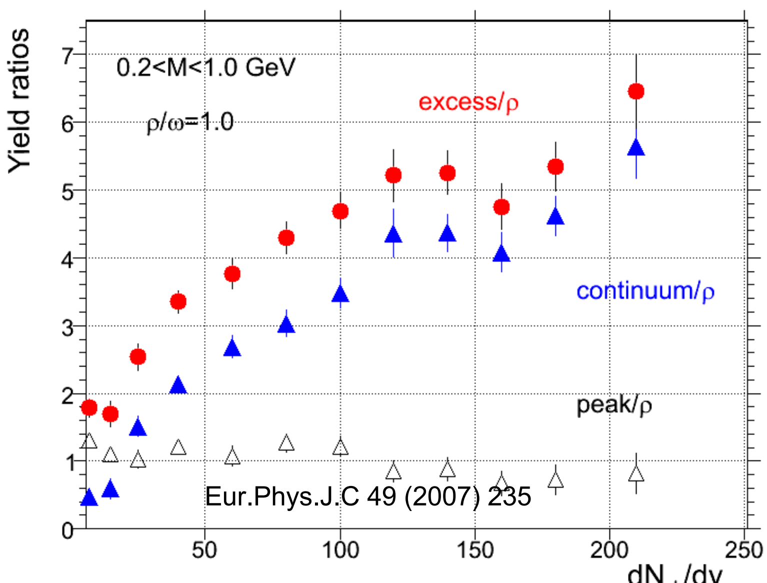
NA60, In-In 158A GeV



peak: R=C-1/2(L+U) continuum: 3/2(L+U)
cocktail ρ is fixed by ρ/ω=1.0

CERES, Pb-Au 158A GeV





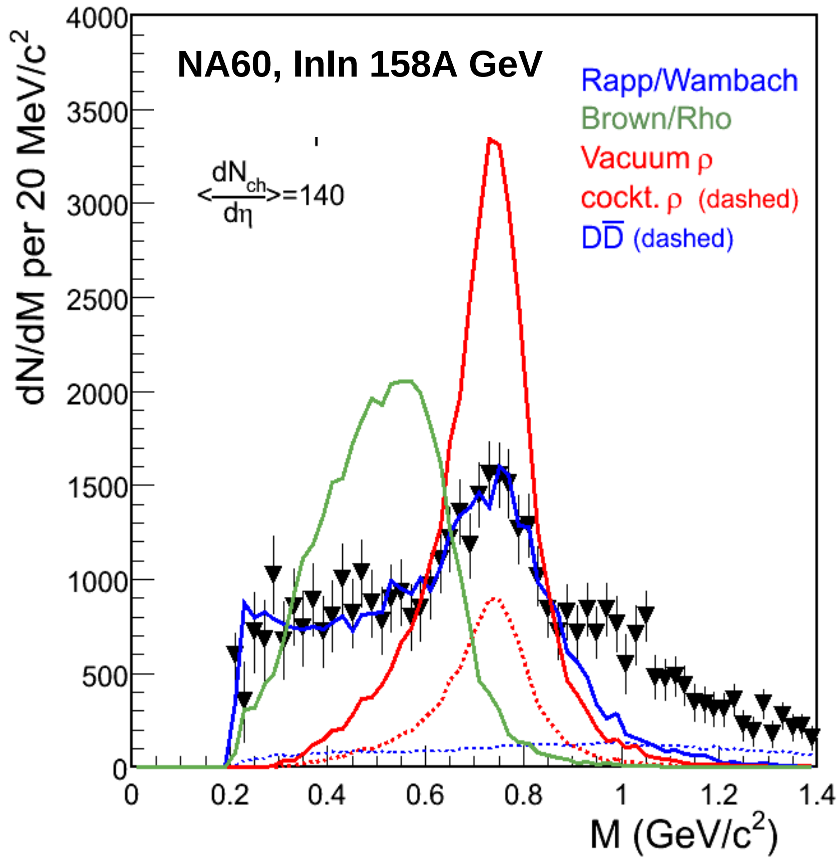
rapid initial increase of total - already 3 at dNch/dh=Npart=50

Total excess wrt "cocktail" r: indicative of the number of r generations: (ρ – clock)

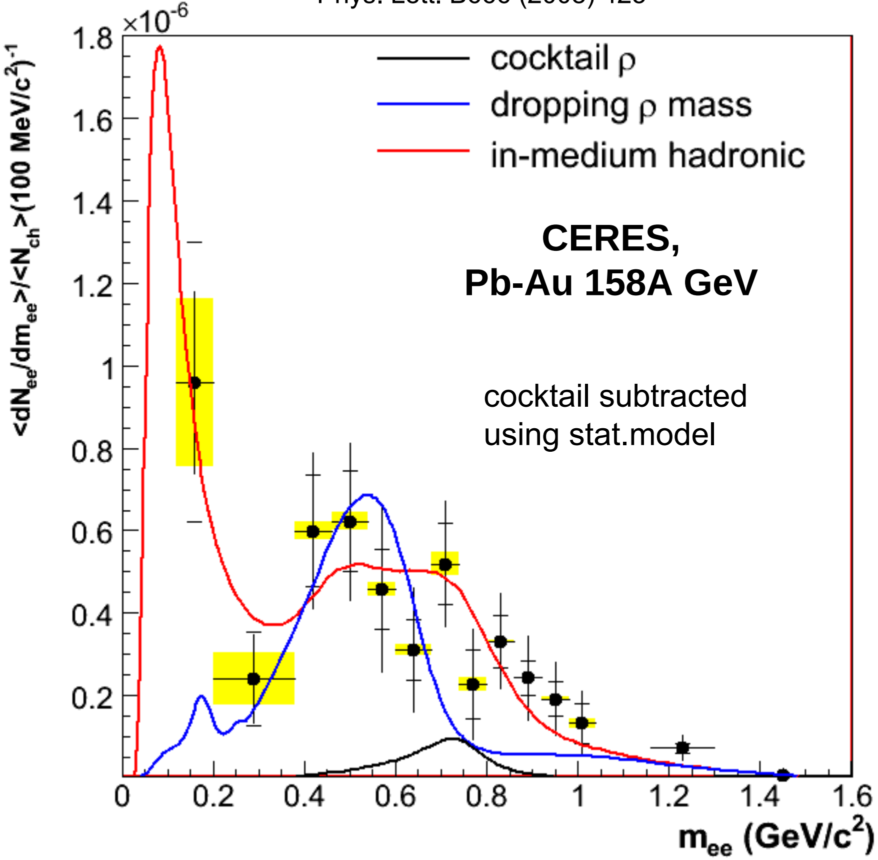
strong increase of continuum (by a factor of >10)

Comparison of data to RW, BR and Vacuum ρ

Phys. Rev. Lett. 96 (2006) 162302



Phys. Lett. B666 (2008) 425



Predictions by Rapp (2003) for all scenarios

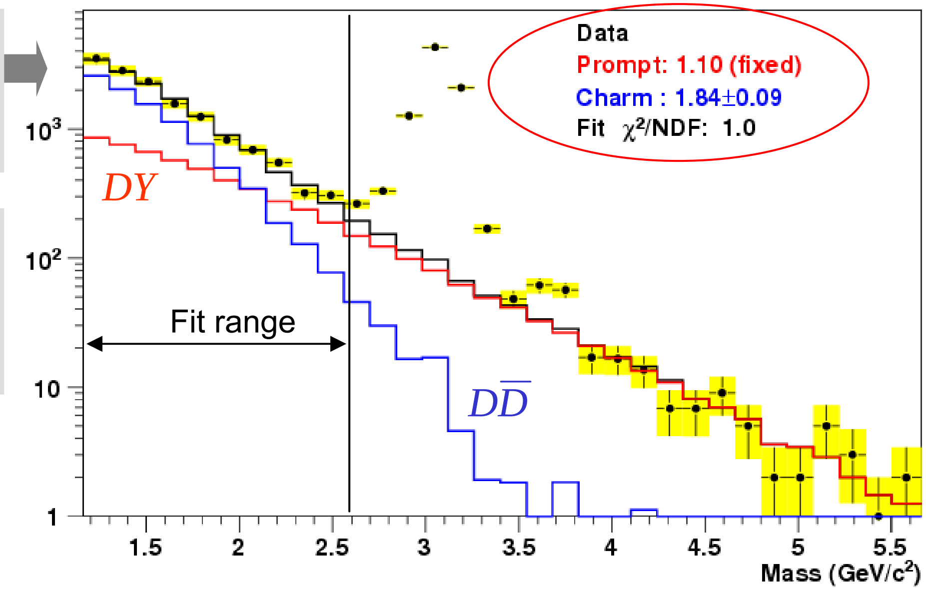
Theoretical yields normalized to data for M<0.9 GeV

Only broadening of ρ (RW) observed, no mass shift (BR)

Extension to intermediate mass region

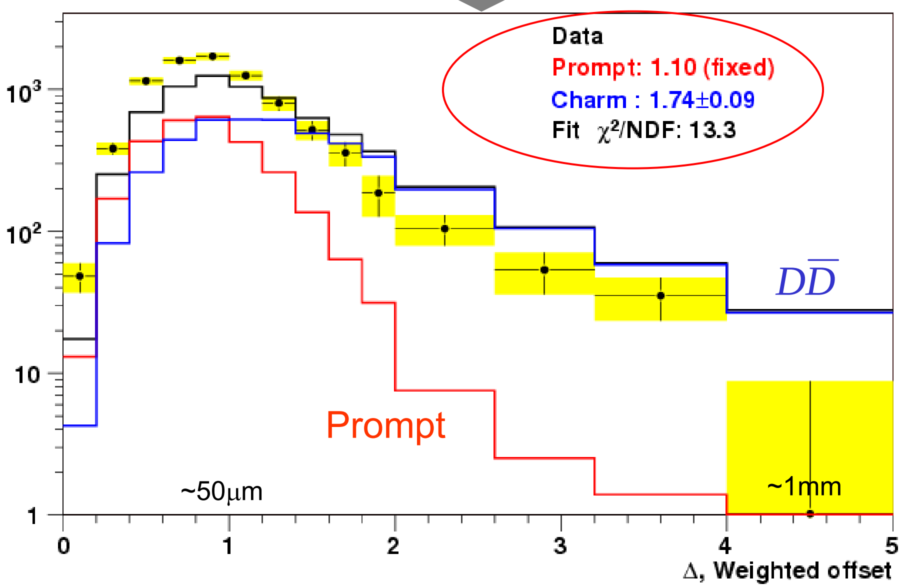
Eur.Phys.J. C59 (2009) 607

Mass spectrum is similar to NA50:
Good description by Drell-Yan + ~2×Open Charm
(extrapolated from pA data)

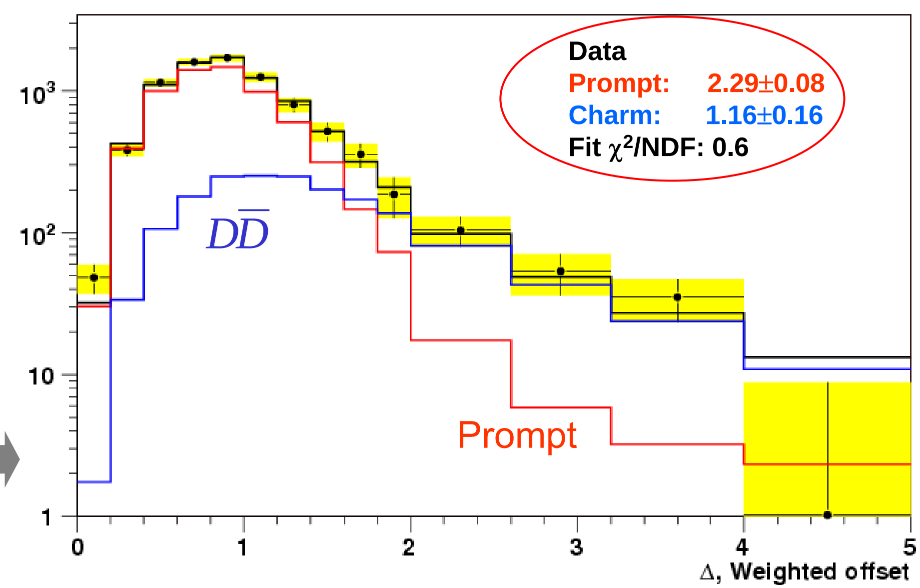


Such explanation is rejected by the spectra of dimuon **offsets** wrt the interaction vertex!

$$\Delta_{\mu} = \sqrt{(\Delta x^2 V_{xx}^{-1} + \Delta y^2 V_{yy}^{-1} + 2 \Delta x \Delta y V_{xy}^{-1})/2} \qquad \Delta_{\mu\mu} = \sqrt{(\Delta_{\mu 1}^2 + \Delta_{\mu 2}^2)/2}$$



Offset fit shows that the enhancement is not due to Open Charm ⇒ **the excess is prompt**

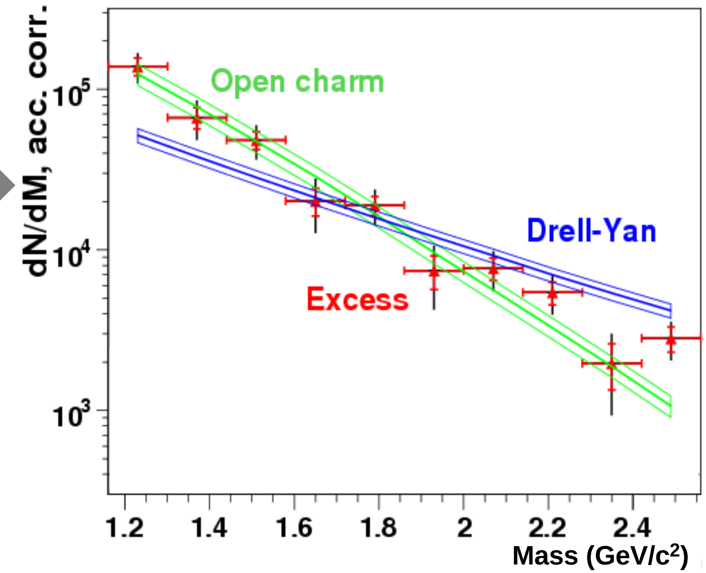


NA60 IMR excess ($1.16 < M < 2.56$ GeV/c^2)

Mass shape and yield close to Open Charm

$D\overline{D}$ contribution measured agrees within ~20% with NA50 pA data (same kinematical domain $|\cos\theta_{CS}|<0.5$)

$\Rightarrow$ no strong $D\overline{D}$ modifications.



Scales with centrality faster than Drell-Yan (~$N_{bin.coll}$), but less faster than $N^2_{participants}$

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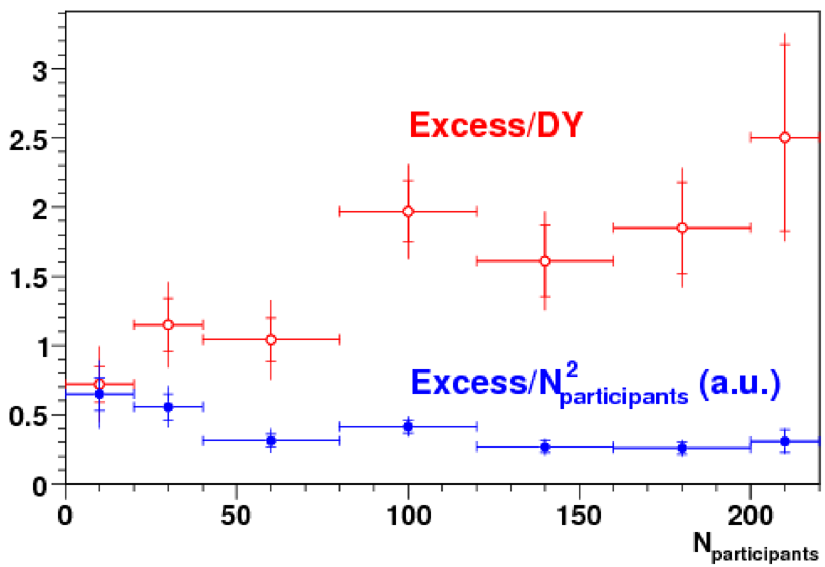
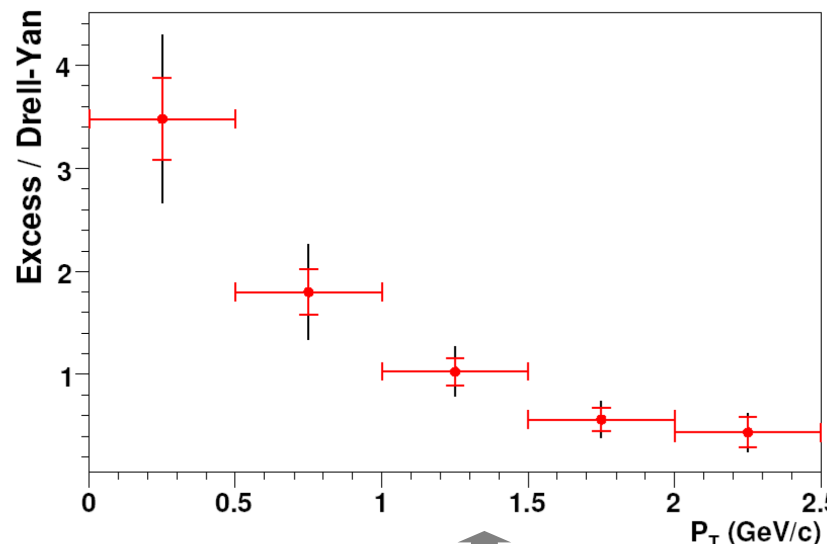




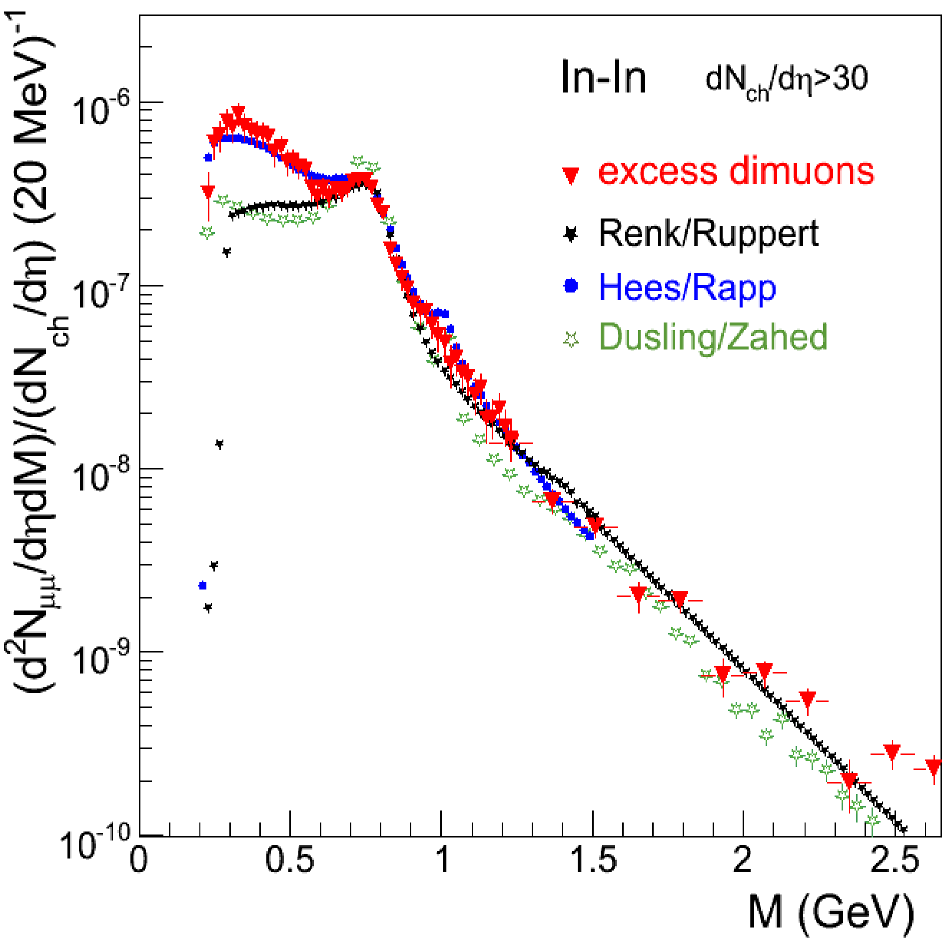
Much softer in p_T than Drell-Yan: rules out higher-twist DY? [Qiu, Zhang, Phys. Lett. B 525, (2002) 265]20

Excess mass spectrum up to 2.5 GeV

All known sources (hadro-cocktail, open charm, DY) subtracted

Acceptance corrected spectrum (p_T>0.2 GeV)

Absolute normalization → comparison to theory in absolute terms!



thermal $\pi\pi \rightarrow \gamma \rightarrow \mu\mu$ (M<1 GeV)

&&

thermal $qq \rightarrow \gamma \rightarrow \mu\mu$ (M >1 GeV)
suggested dominant by T_{eff} vs M
(supported by R/R, D/Z)

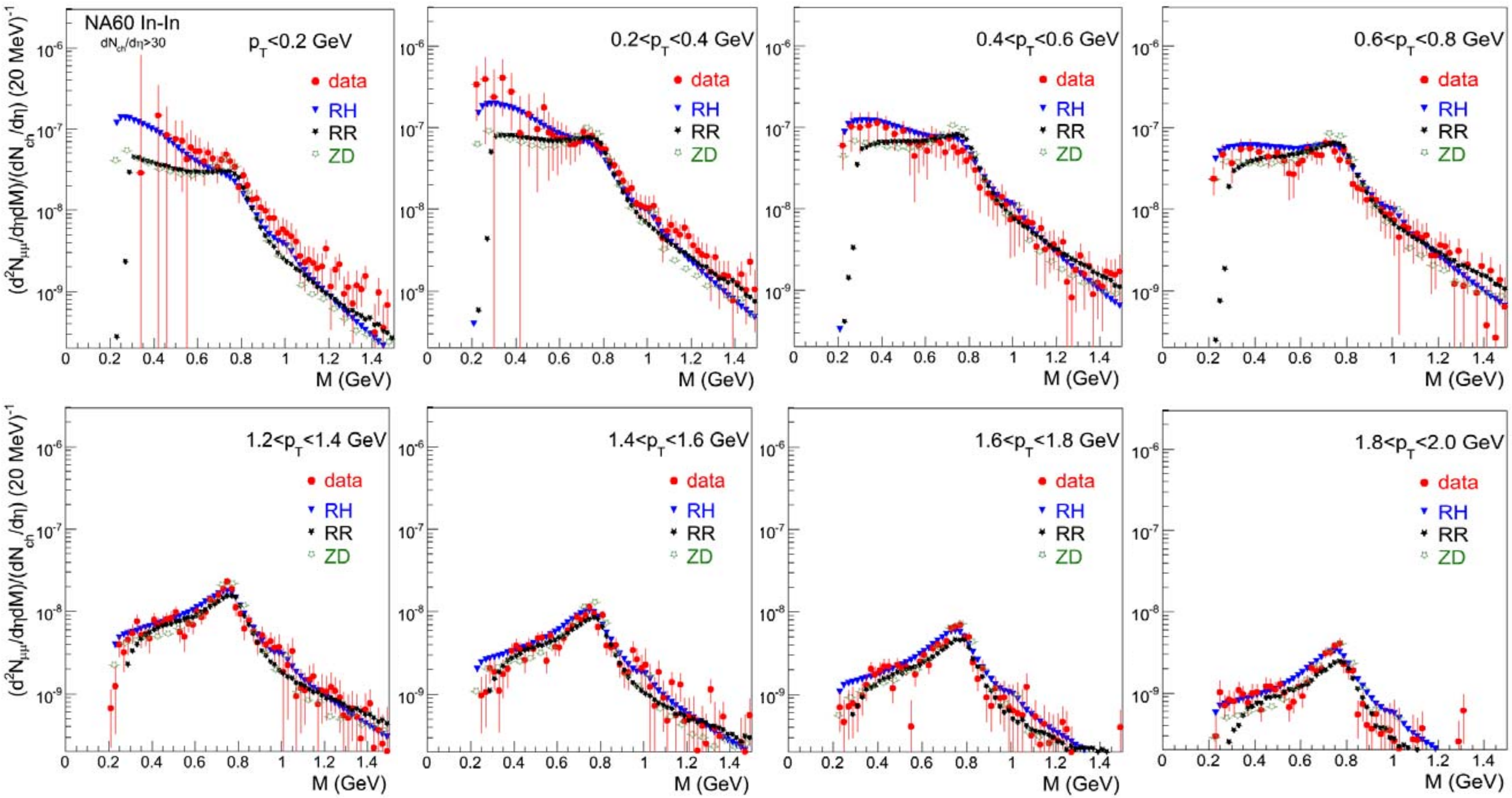
also multipion processes (H/R)

Planck-like mass spectrum; falling exponentially

Agreement with theoretical models up to 2.5 GeV!

NA60 excess vs p_T: comparison to theory

Eur. Phys. J. C 61 (2009) 711



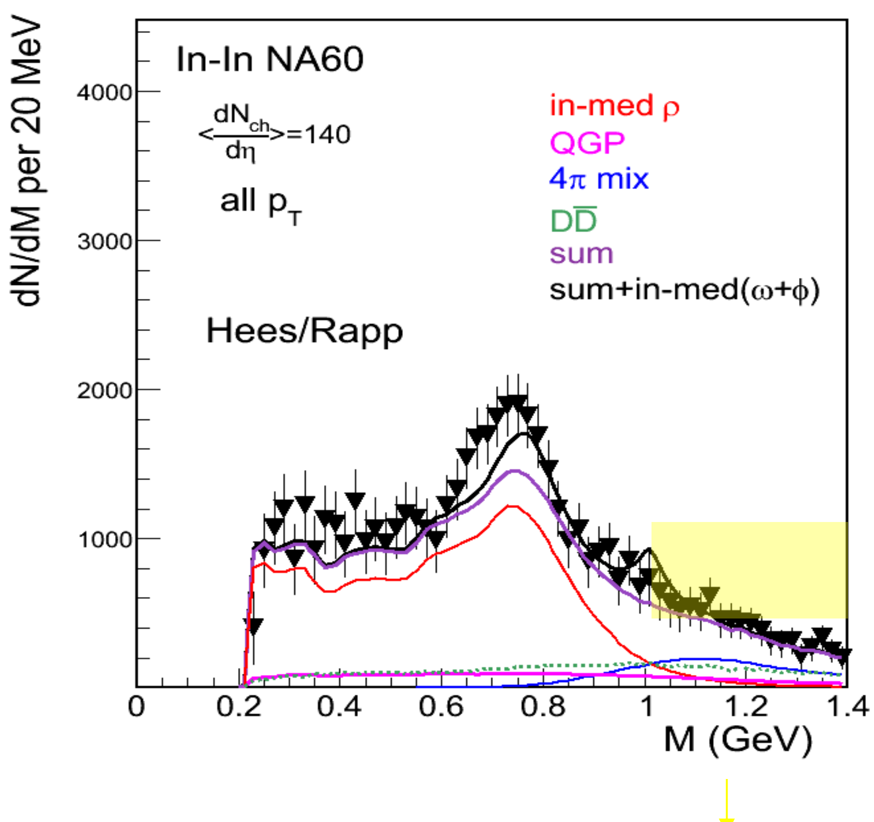
Absolute normalization both for theory and data

Differences at low masses reflect differences in the tail of ρ spectral function

Differences at high masses, p_T reflect differences in flow strength

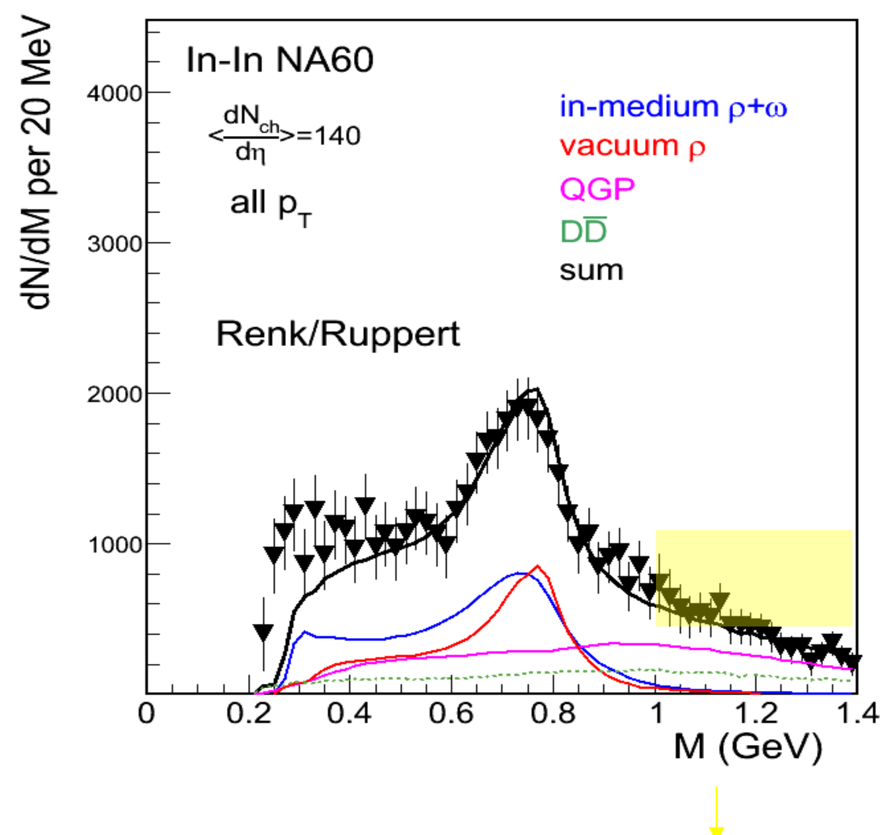
Hadron-Parton Duality for M >1 GeV

Hees/Rapp Phys.Rev.Lett. (2006)



Mass region above 1 GeV described in terms of hadronic processes, 4π …

Renk/Ruppert, hep-ph/0702012



Mass region above 1 GeV described in terms of partonic processes, $q\bar{q}$…

How to distinguish?

Radial flow and p_T spectra

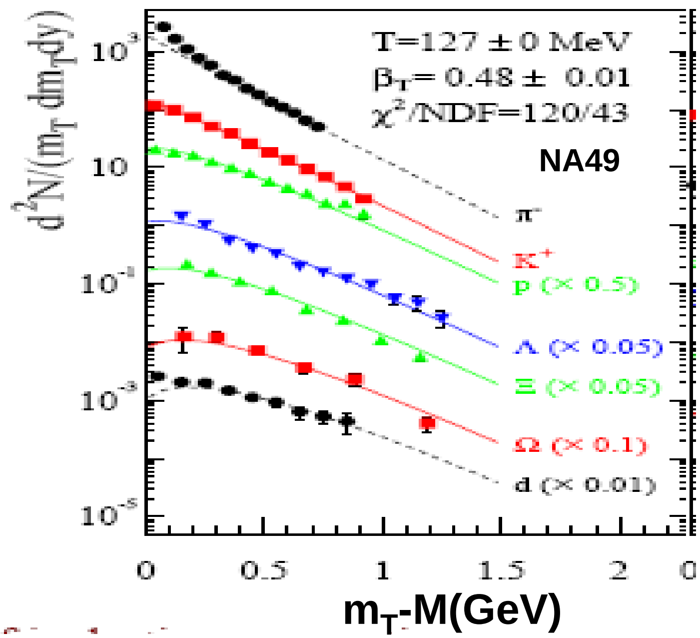
thermalization due to interactions

collective (flow) velocity v_T same for all particles

two components in p_T spectra: thermal and flow

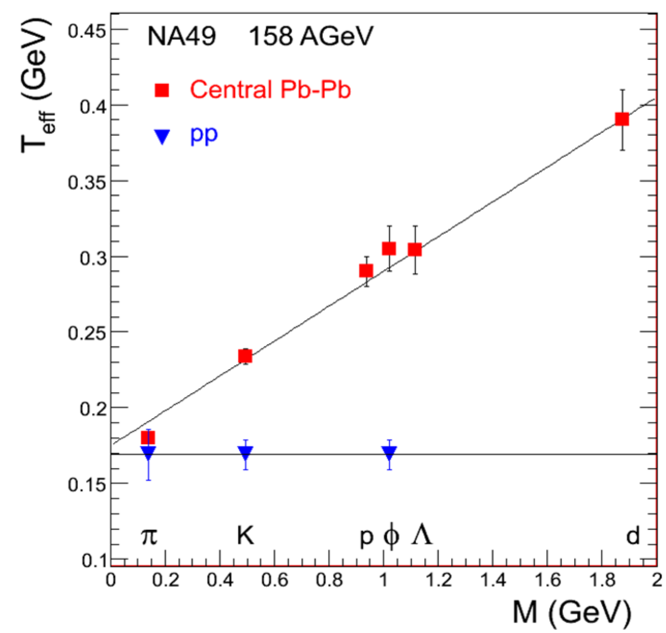
$p_T = p_T^{th} + M\, v_T$

hadron p_T spectra: determined at freeze-out → mass ordering



$$\frac{dN}{m_T dm_T} \propto e^{-m_T / Teff}$$

$$T_{eff} \approx T_f + m\langle v_T \rangle^2$$

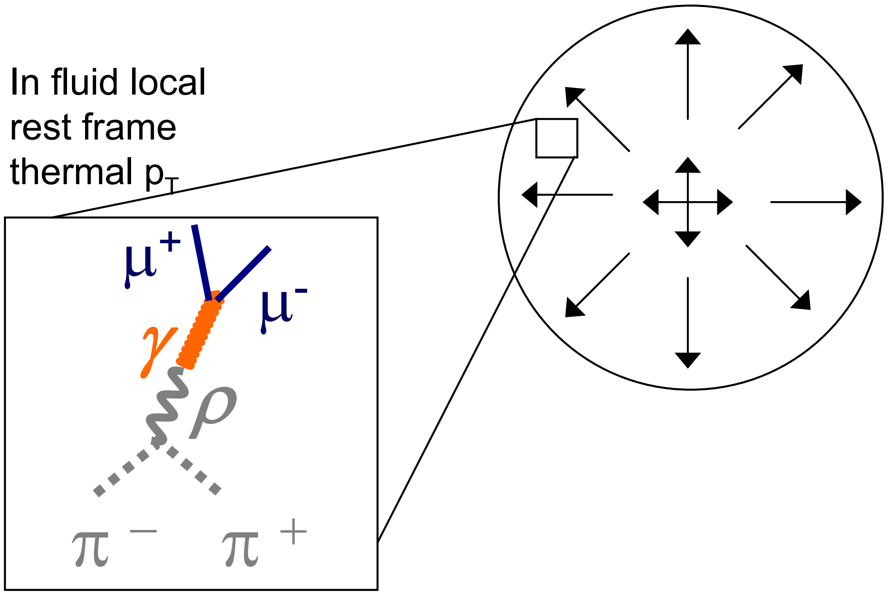


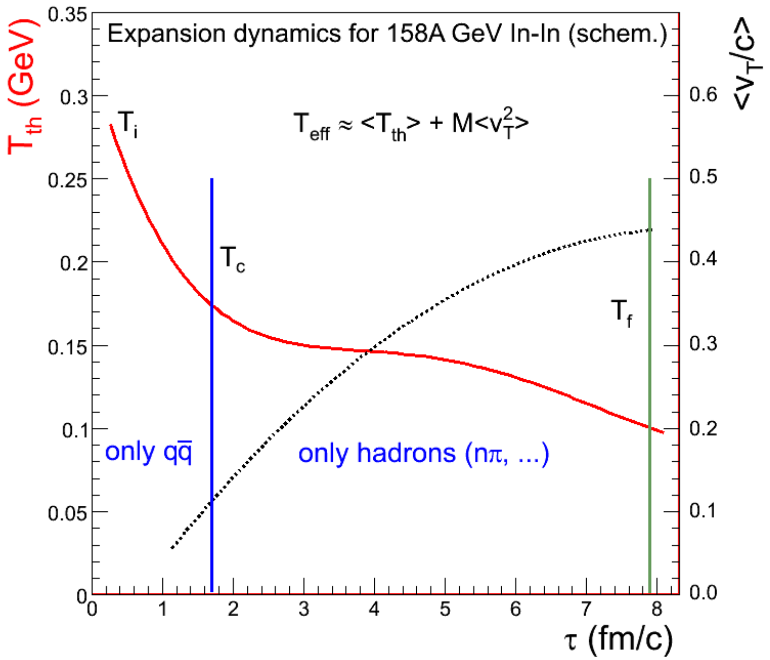
2-parameter fits → T_f, v_T

1-parameter fits → T_{eff}

Lepton pair emission and radial flow

Muon pairs coming from ρ decay or other in-medium processes: continuum emission during the full fireball lifetime (4-dim volume)





T - dependence of thermal distribution of “mother” hadrons/partons

M - dependent radial flow (v_T) of “mother” hadrons/partons

p_T - dependence of spectral function, weak (dispersion relation)

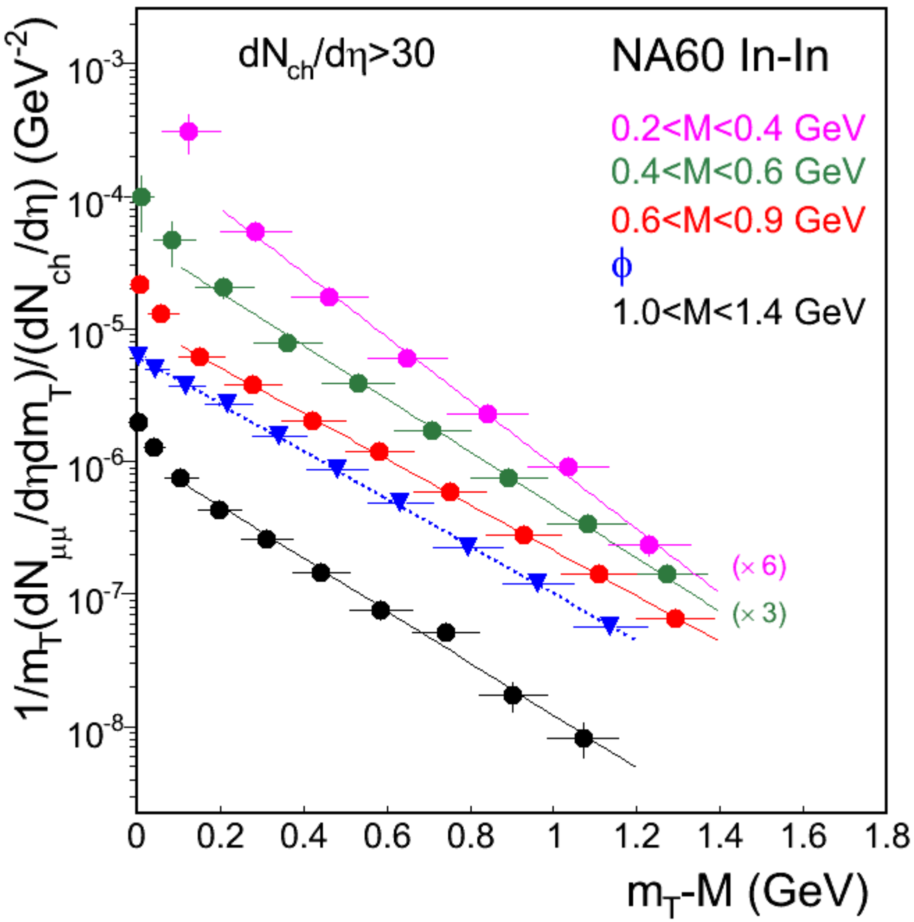
⇒ emission of lepton pairs senses:

- large T and small v_T at early times
- small T and large V_T at later time

handle to distinguish between emitting source

Centrality-integrated excess m_T spectra

Phys. Rev. Lett. 100 (2008) 022302



transverse mass: $m_T = (p_T^2 + M^2)^{1/2}$

absolute normalization

steepening at low m_T; not observed for hadrons (like ϕ)

monotonic flattening of spectra with mass up to M=1 GeV, followed by a steepening above

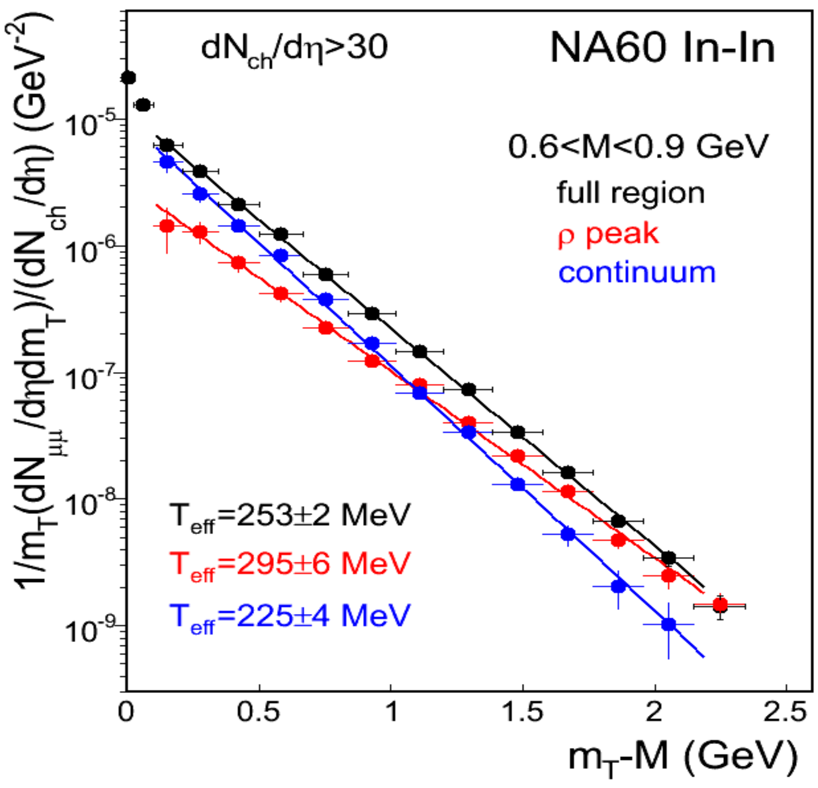
fit m_T spectra for p_T>0.4 GeV with

$$\frac{1}{m_T}\frac{dN}{dm_T} \sim \exp\left(-m_T / T_{eff}\right)$$

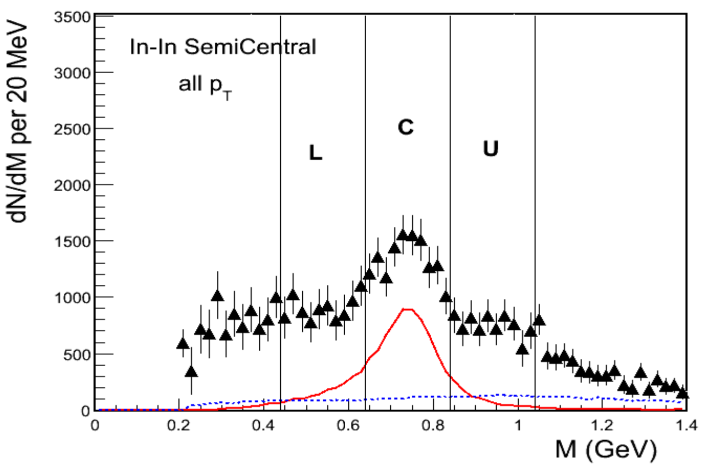
signs for mass-dependent radial flow?

Shape analysis and p_T spectra

identify the ρ peak with the freeze-out ρ in the dilute final stage, when it does not experience further in-medium influences.



use side-window subtraction method



peak: C-1/2(L+U)

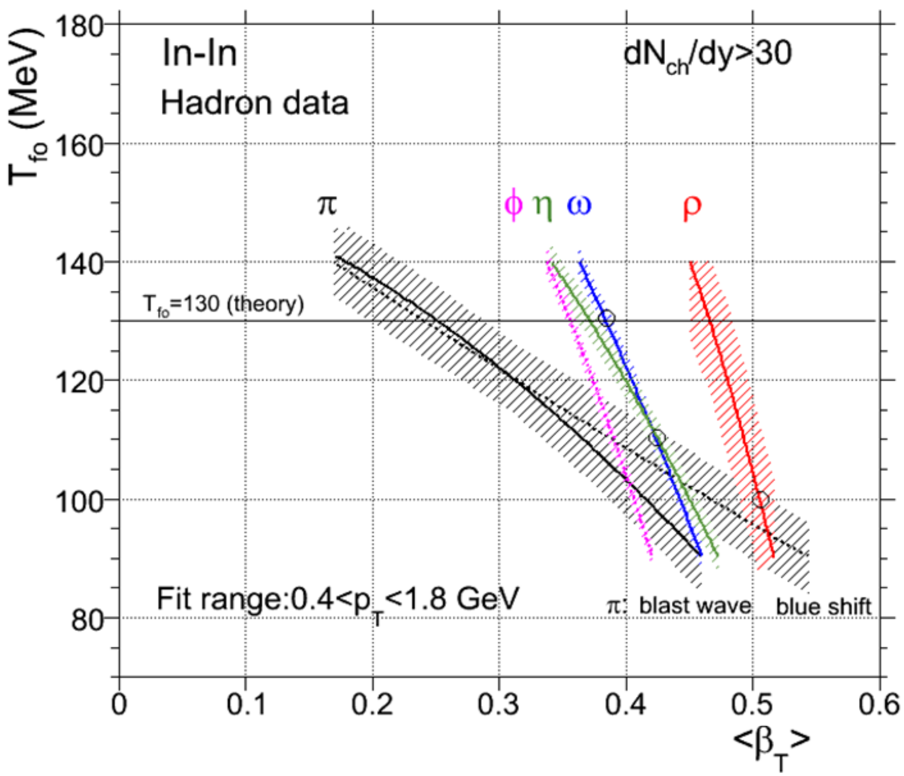
continuum: 3/2(L+U)

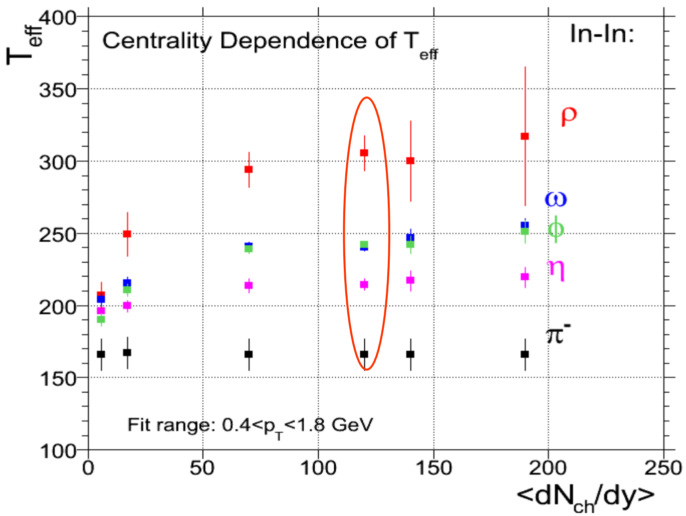
m_T spectra very different for the ρ peak and continuum:

T_{eff} of peak higher by 70+-7 MeV than that of the continuum !

all spectra pure exponential, no evidence for hard contributions

NA60 hadron measurements: hierarchy in hadron freeze-out





large difference between ρ and ω (same mass)

← use of Blast wave code

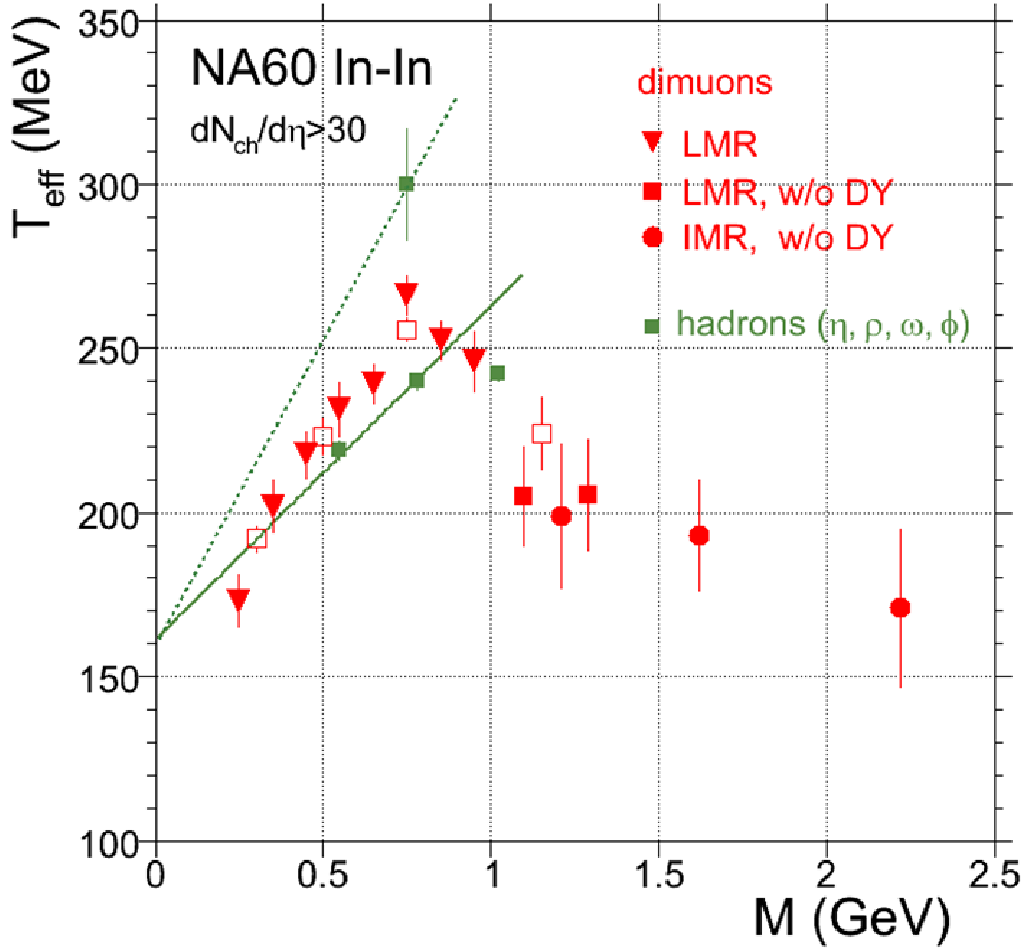
for a given hadron M, the measured T_{eff} defines a line in the T_{fo}-v_T plane

crossing of hadrons with π defines T_f, v_T max reached at respective hadron freeze-out

different hadrons have different coupling to pions (ρ maximal)
→ clear hierarchy of freeze-out (also for light-flavored hadrons)

The rise and fall of radial flow of thermal dimuons

Phys. Rev. Lett. 100 (2008) 022302



Strong rise of T_{eff} with dimuon mass, followed by a sudden drop for M>1 GeV

Rise consistent with radial flow of a hadronic source (here $\pi\pi\rightarrow\rho\rightarrow\mu\mu$) , taking the freeze-out ρ as the reference

Drop signals sudden transition to low-flow source, i.e. source of partonic origin (here $qq\rightarrow\mu\mu$)

Combining M and p_T of dileptons seems to overcome hadron-parton duality

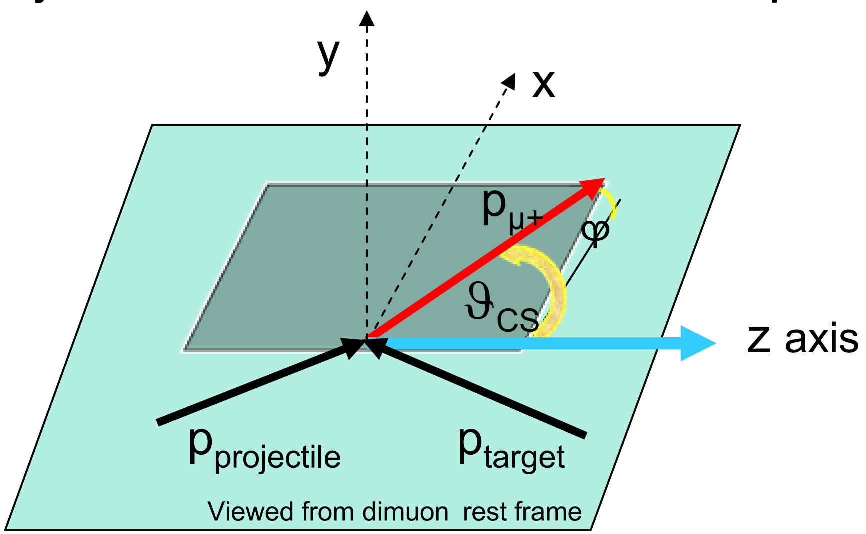
Angular distributions

General formalism for the description of an angular distribution

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta\, d\phi} = \left(1+\lambda\cos^2\theta+\mu\sin2\theta\cos\phi+\frac{\nu}{2}\sin^2\theta\cos2\phi\right)$$

$d\sigma/d\cos\theta\, d\phi$ is the differential decay angular distribution in the rest frame of the virtual photon γ^* with respect to a suitably chosen axis

λ, μ, ν are structure functions related to helicity structure functions and the spin density matrix elements of the virtual photon



Collins Soper (CS) frame

θ is the angle between the positive muon $\mathbf{p}_{\mu+}$ and the z-axis.

The z axis is the bisector between $\mathbf{p}_{proj}$ and $-\mathbf{p}_{target}$

30

What can we learn from angular distributions?

Analysis in the mass region M<1 GeV:

$\Rightarrow$ excess dileptons produced from annihilation of pions

However, pions are spinless:

$\Rightarrow$ Don't we expect to find a trivial result for λ, μ and ν?

The answer is no!

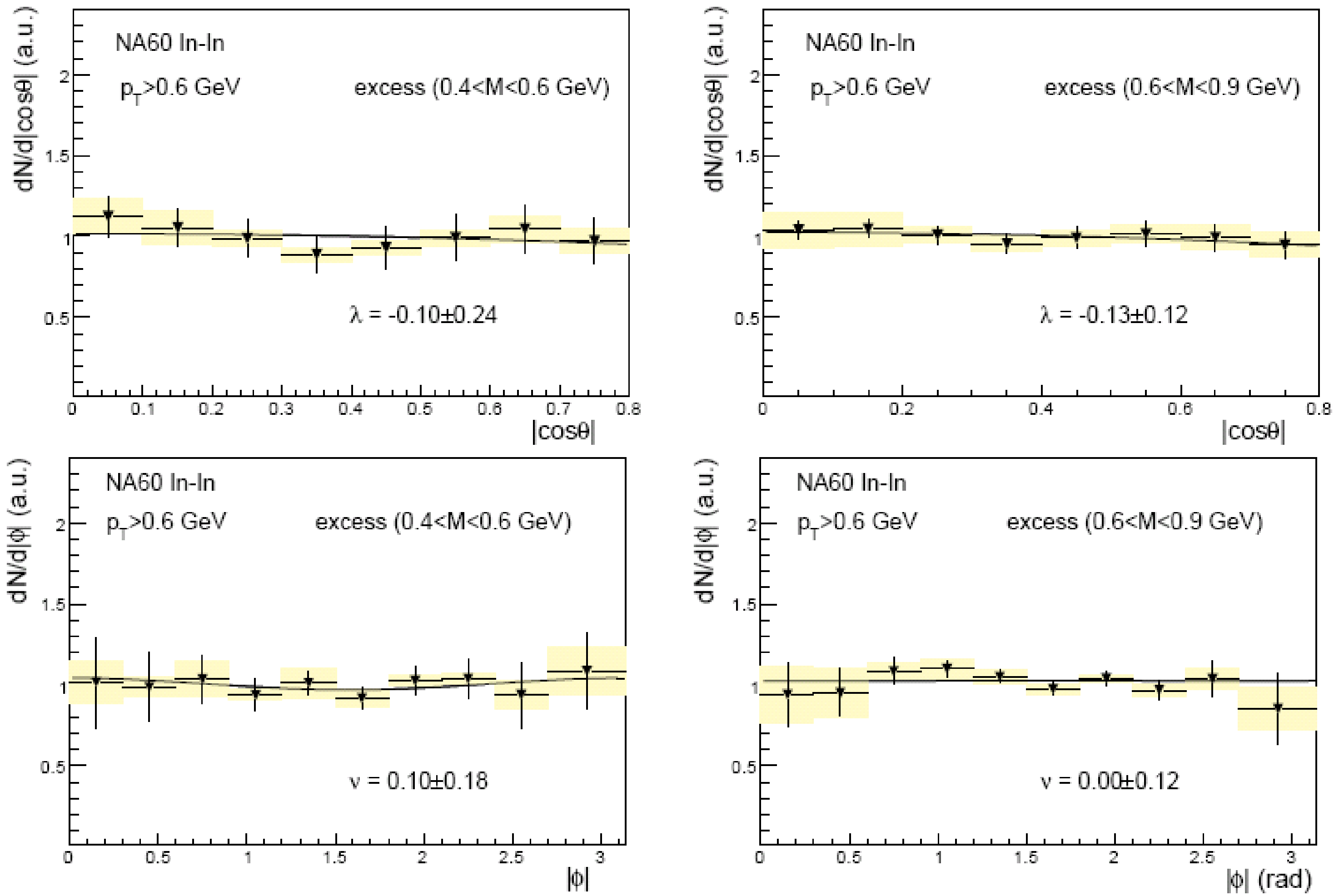
Even for annihilation of spinless particles, like $\pi\pi$ annihilation, the structure function parameters can have any value $\lambda, \mu, \nu \neq 0$

$\Rightarrow$ for collinear pions along z axis $\lambda = -1 \rightarrow$ longitudinal polarization of the virtual photon

However, a completely random orientation of annihilating pions in 3 dimensions would lead to $\lambda, \mu, \nu = 0$

Polarization of excess dileptons

PRL 102 (2009) 222301



Lack of any polarization in excess (and in hadrons) supports emission from a thermalized source

What we have learned from SPS data

Ample evidence of thermal radiation:

- M<1 GeV: $\pi\pi \rightarrow \rho \rightarrow \mu\mu$

- M>1 GeV: partonic radiation and/or multipion processes

Quantitative characterization:

- Planck-like exponential shape of mass spectra (for flat spectral function)

- m_T scaling of transverse momentum spectra

- Absence of any polarization in angular distributions

- Agreement between data and thermal models in yields and spectral shapes

New measurements at lower energies and further investigation of open points

Past NA60 runs:

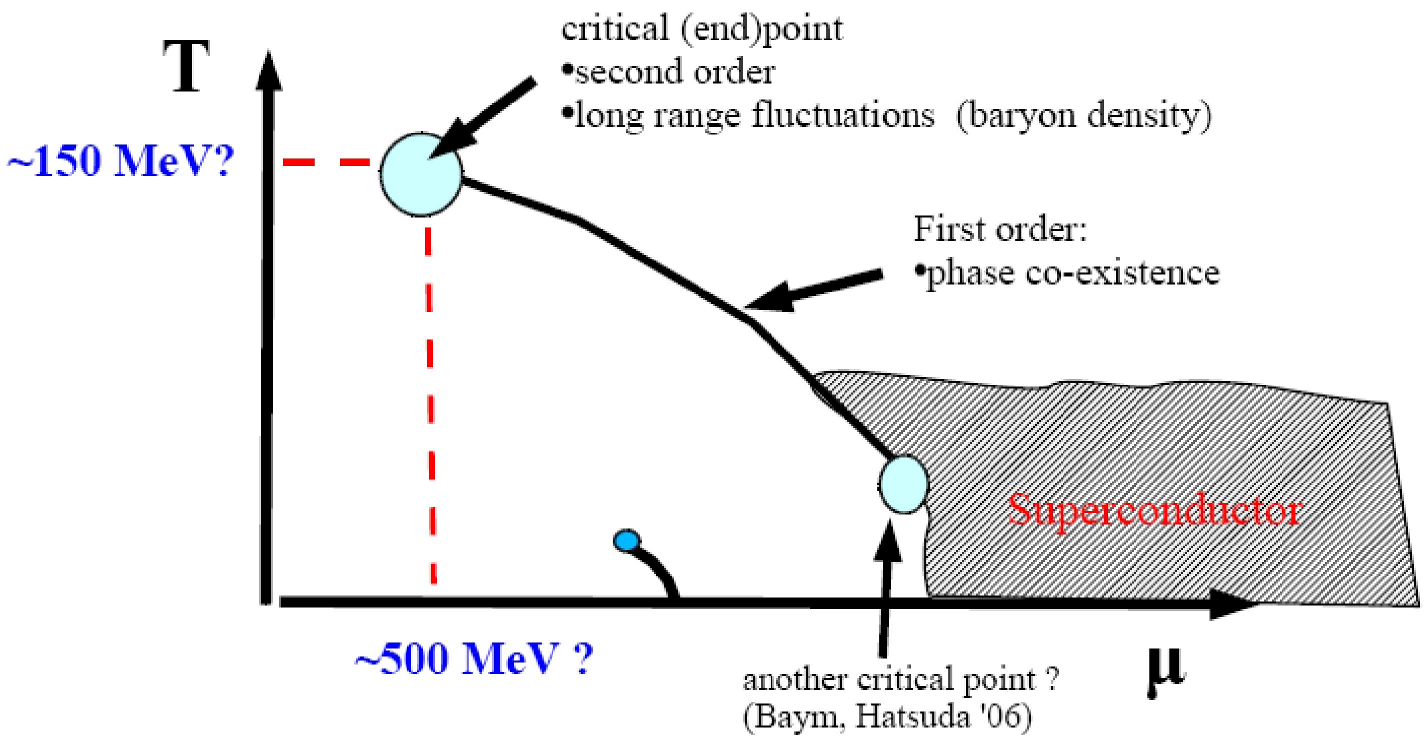
- 2003 Indium run (230 million triggers) – fully reconstructed and analysed
- 2004 proton run (100 million triggers) – analysis in progress

Original part of the program but not done:

- 2002 Lead run

The QCD phase diagram

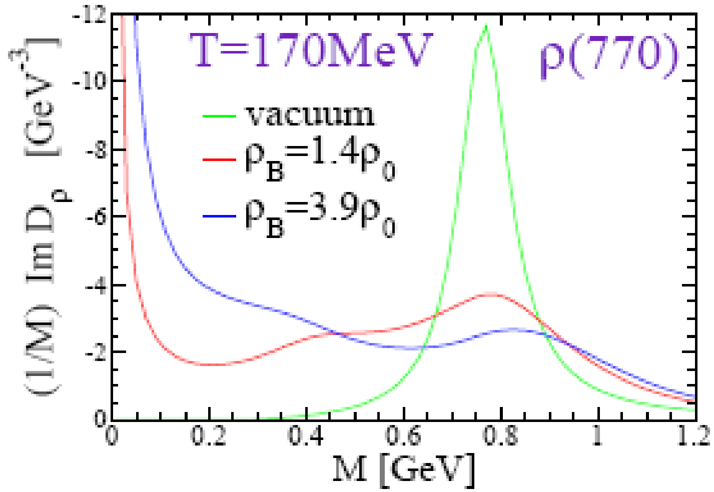
QCD phase diagram poorly known in the region of highest baryon densities and moderate temperatures – is there a critical point?



N.B.: Critical point of water: T_c=647.096 K, p_c = 22.064 MPa, ρ_c = 322 kg/m3

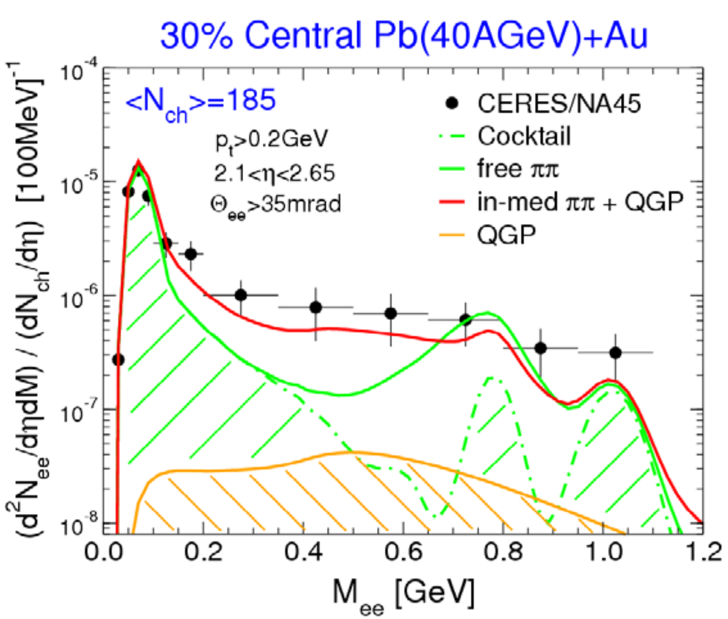
Dilepton measurements?

Low mass dileptons: top to lower energies at SPS



Decrease of energy 160 to 40 AGeV:

predicted net ρ in-medium effects, in particular for M<0.4 GeV, increase by a factor 2 because of baryons!



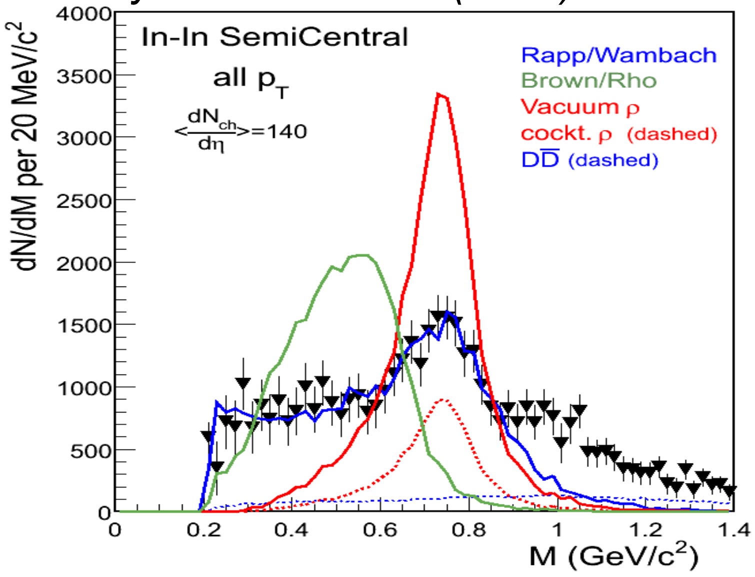
Pioneering measurement by CERES at 40 AGeV: enhancement increases! Seems to confirm importance of baryonic effects

Might not be just coincidental with expectation of emergence of CP

Compelling to continue research into the regime of maximal baryon density experimentally accessible

Low mass dileptons: chiral symmetry restoration

Phys. Rev. Lett. 96 (2006) 162302



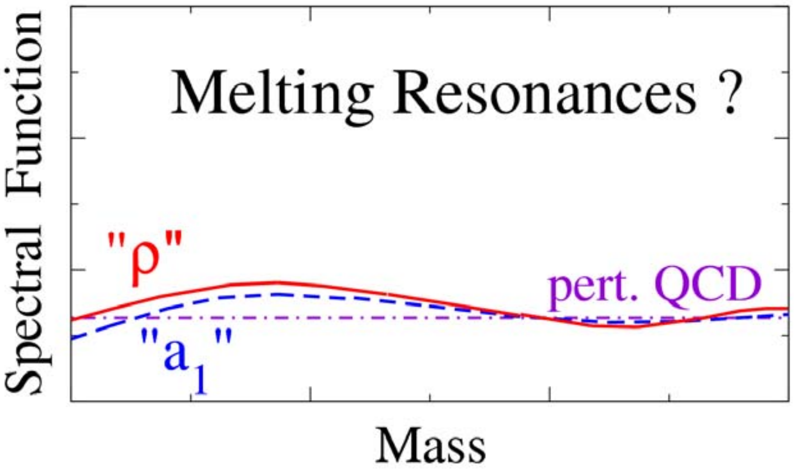
Theoretical yields normalized to data for M<0.9 GeV

Only broadening of ρ (RW) observed
Brown-Rho scaling ruled-out

→ which connection with chiral symmetry restoration?

Chiral restoration at T_c: vector and axial vector spectral functions expected to become degenerate

At CP extended lifetime close to T_c : higher sensitivity to chiral restoration?

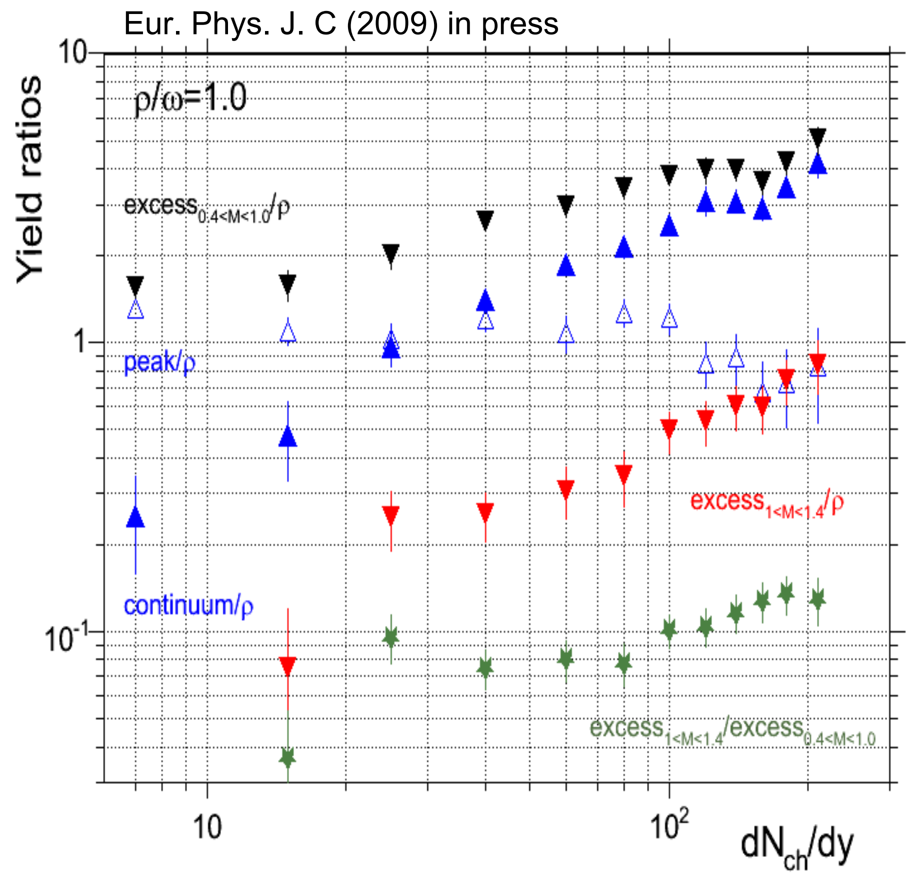


Requires independent measurement of axial-vector spectral function ($a_1 \rightarrow \pi\gamma$) or detailed theoretical modelling of axial spectral function and mixing

Low mass dileptons: constraints in fireball lifetime

NA60 precision measurement of excess yield (ρ-clock):

provided the most precise constraint in the fireball lifetime (6.5±0.5 fm/c) in heavy ion collisions to date!



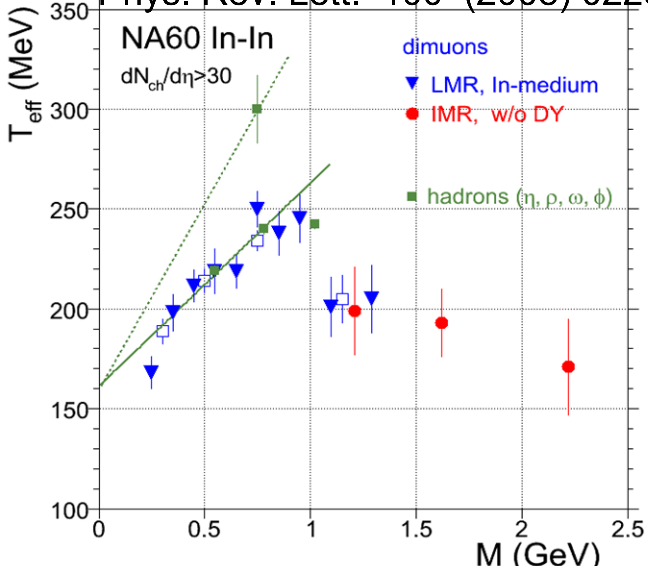
Crucial in corroborating extended lifetime due to soft mixed phase around CP:

if increased τ_{FB} observed with identical final state hadron spectra (in terms of flow) → lifetime extension in a soft phase

Nice example of complementary measurements with NA61

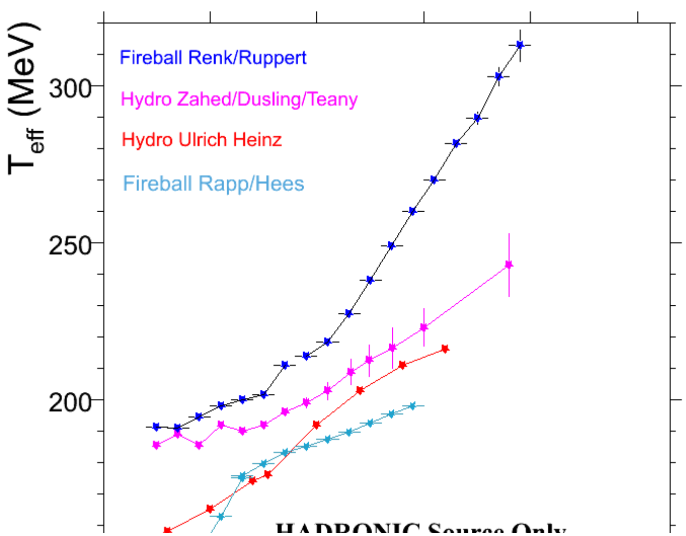
NA60 results on p_T spectra for in-medium excess

Phys. Rev. Lett. 100 (2008) 022302



M>1 GeV:
sudden fall of radial flow of thermal dimuons naturally explained as a transition to a qualitatively different source, i.e. mostly partonic radiation,

$qq \rightarrow \gamma \rightarrow \mu\mu$



HADRONIC source alone ($2\pi+4\pi+a_1\pi$) (in HYDRO and other models of fireball expansion) → continuous rise of T_{eff} with mass, no way to get a discontinuity at M=1 GeV

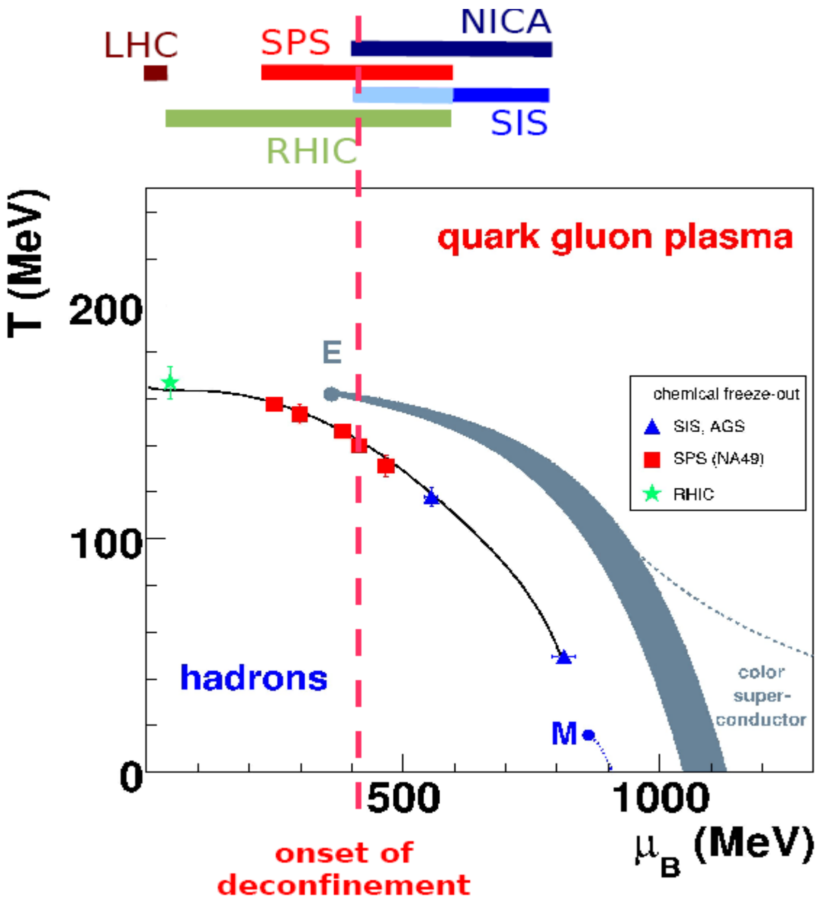
Uncertainty in fraction of QGP: 50%, 60%, 80%, …. but a sizeable contribution of partonic source needed to get a discontinuity in T_{eff}

Lower energies: will the drop disappear or reduced if partonic radiation really important at 158 AGeV? Pb-Pb at 158 GeV?

QCD critical point search – experimental landscape

partly complementary programs
BNL RHIC 2010
DUBNA NICA 2013
GSI SIS-CBM 2016

Heavy ion beams planned at CERN SPS 2011

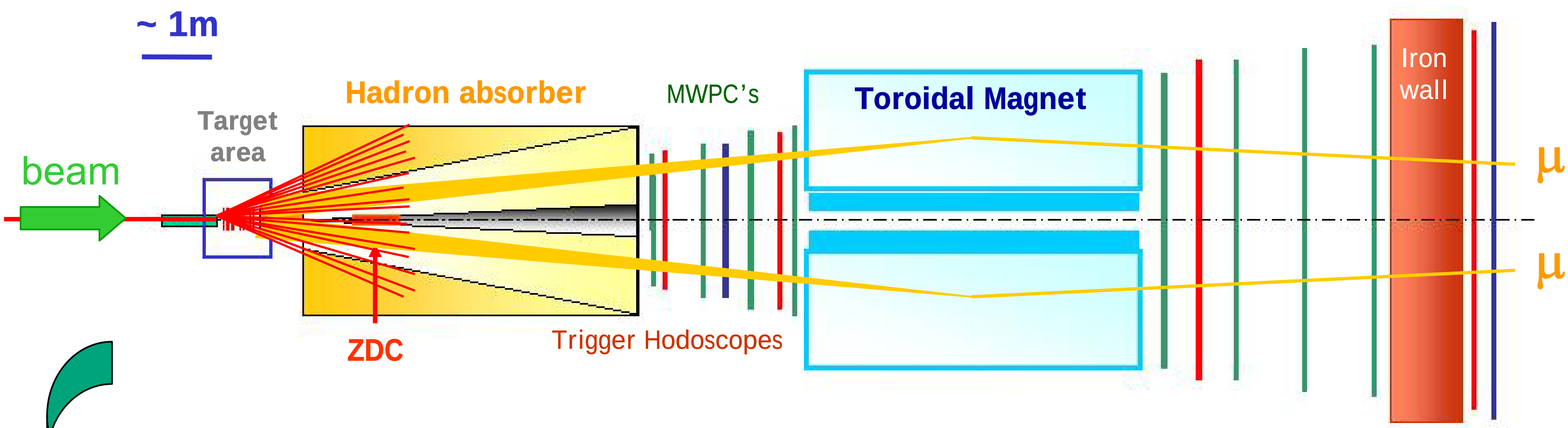


NA60-like experiment:

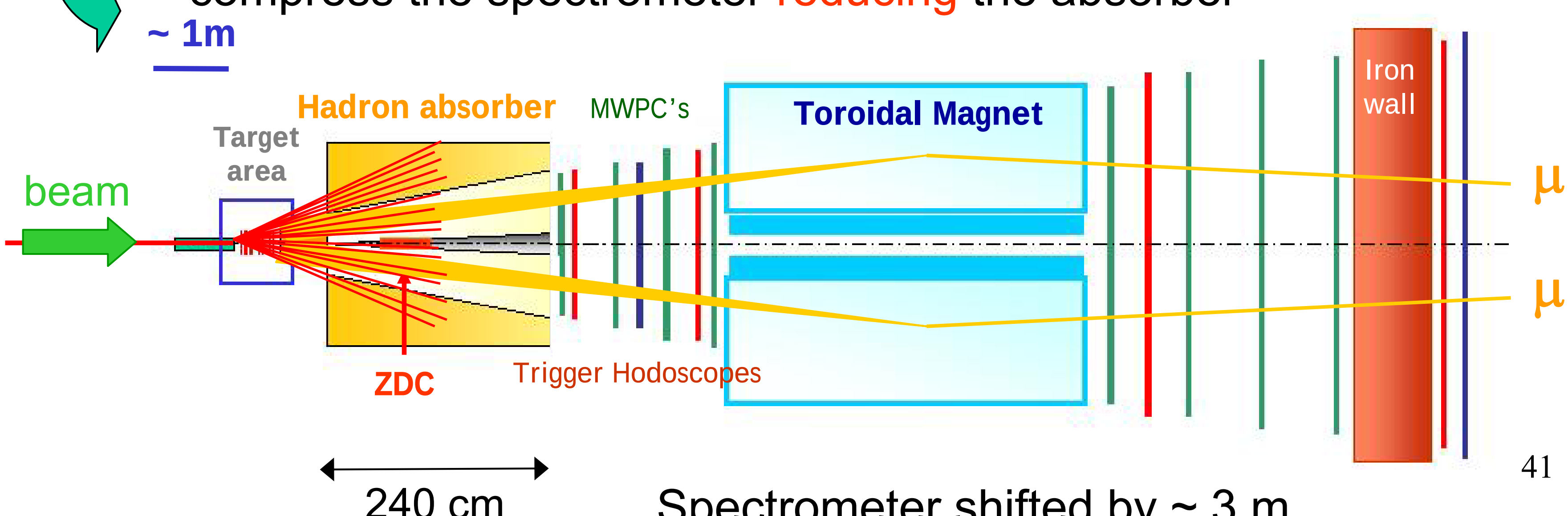
- Dilepton measurements in region not covered by other experiments
- High precision muon pair measurements:
  - high luminosity → statistics
  - very good mass resolution
  - acceptance down to low p_T
  - background subtraction much easier than in e^+e^-
- Flexibility to change energy (and A)
- Complementary to NA61

Apparatus layout: first ideas for lower energies

NA60 muon spectrometer covers the y range 0-1 in the cms system @ 158 GeV

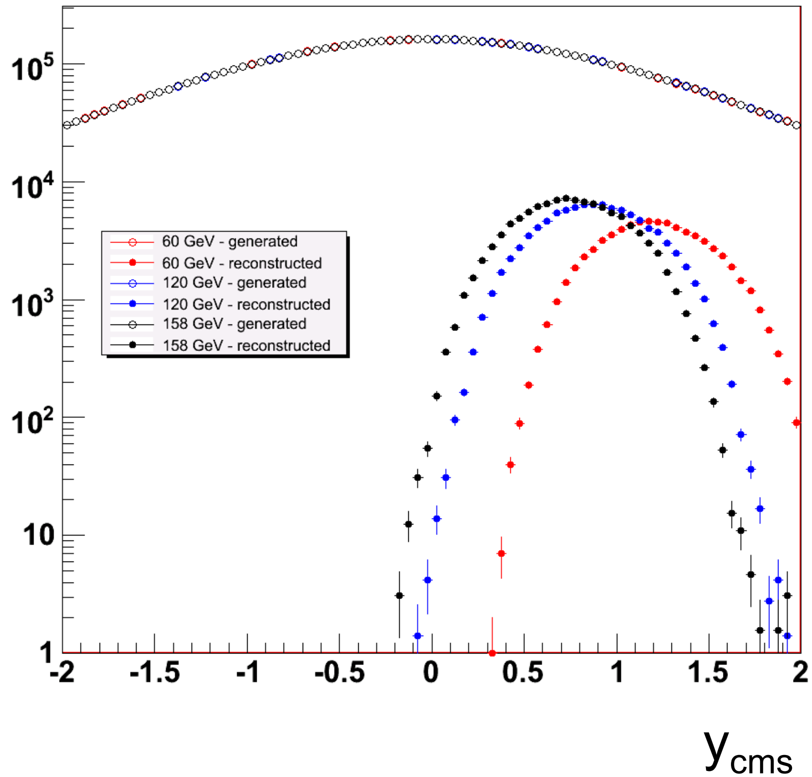


compress the spectrometer reducing the absorber

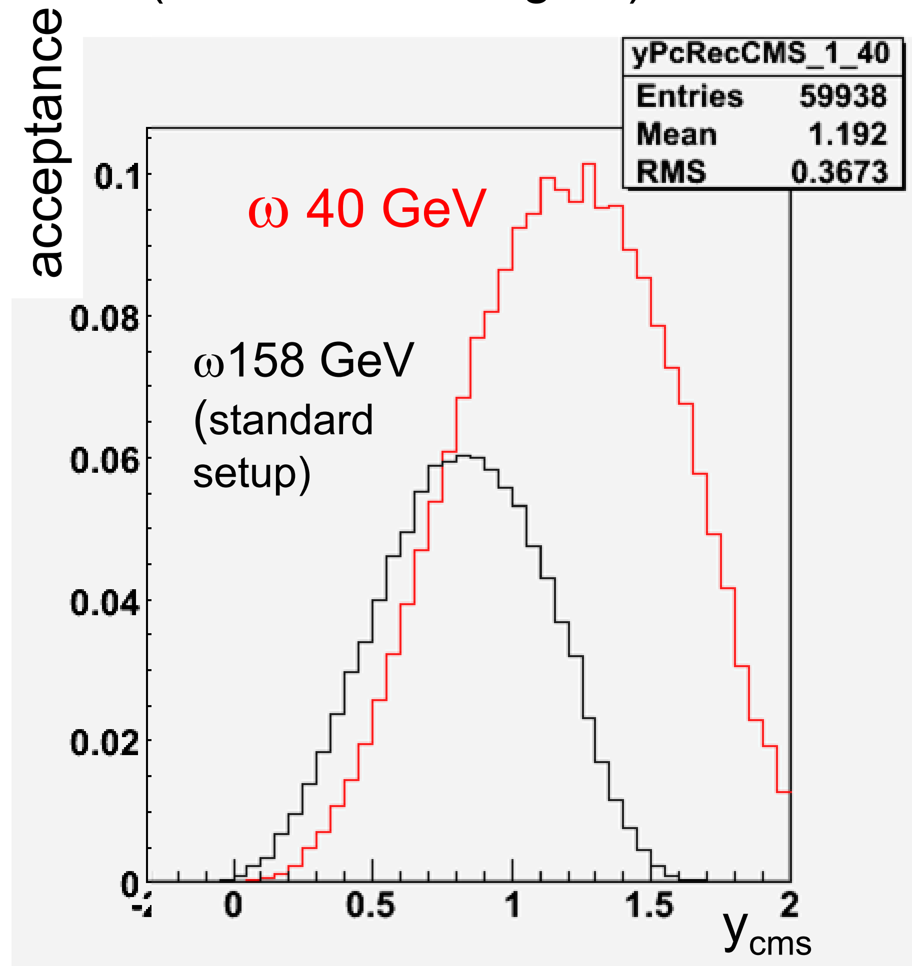


Spectrometer shifted by ~ 3 m

standard NA60 spectrometer
ω simulation



compressed spectrometer
(and shorter magnet)



$\langle y_{lab} \rangle_{158} = 2.91 \quad \Delta y = 0.76$

$\langle y_{lab} \rangle_{120} = 2.77 \quad \Delta y = 0.9$

$\langle y_{lab} \rangle_{60} = 2.43 \quad \Delta y = 1.24$

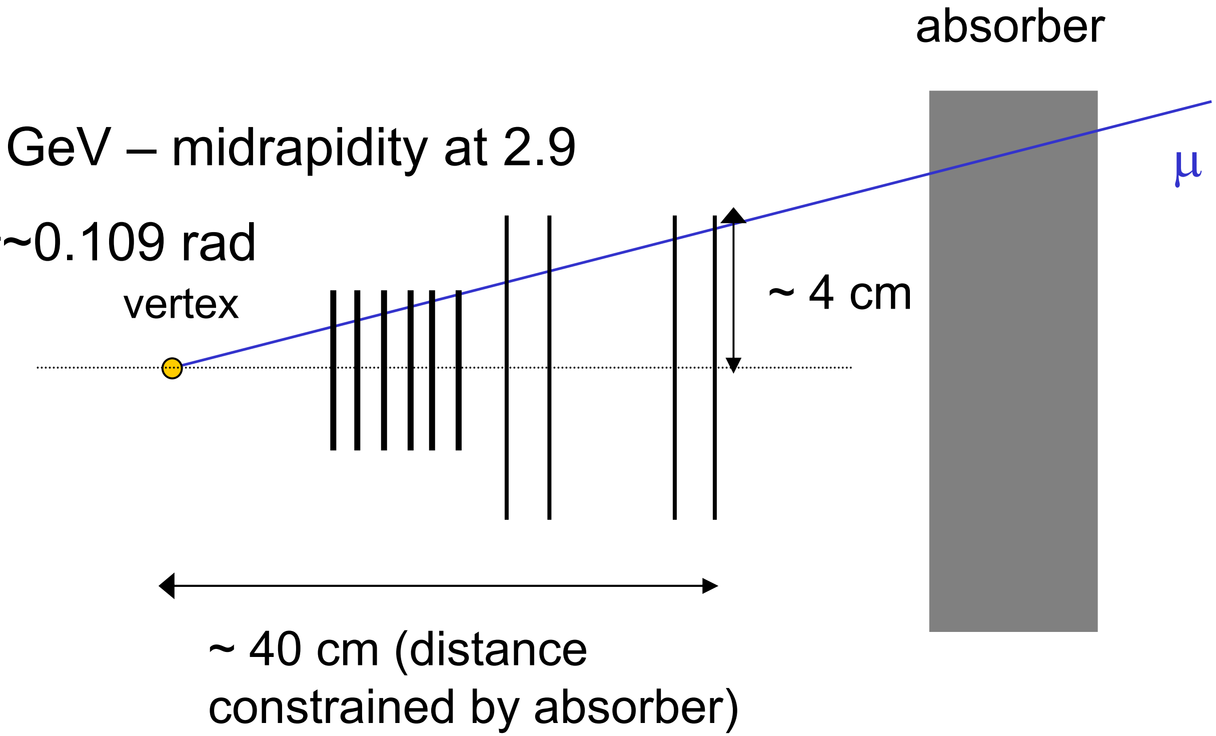
Lowering the energy, the apparatus covers more and more forward rapidity

Rapidity coverage down to mid-rapidity at 40 GeV similar as with standard setup at 158 GeV ...

Rapidity coverage of the pixel telescope

158 GeV – midrapidity at 2.9

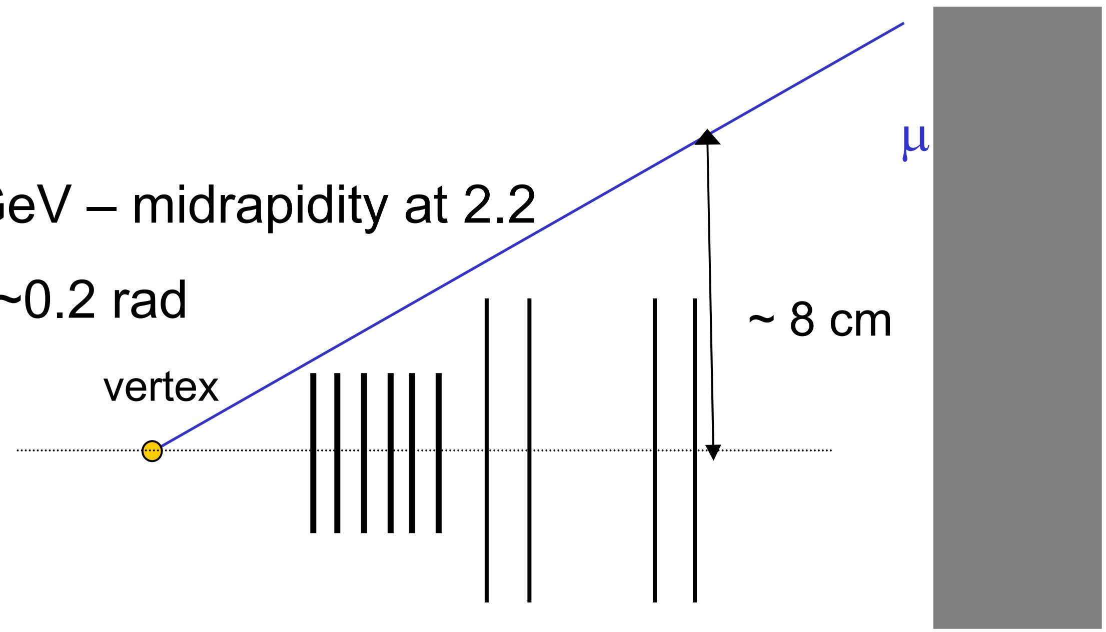
⇒ ϑ~0.109 rad



At 40 GeV particles are emitted in a much wider cone

40 GeV – midrapidity at 2.2

⇒ ϑ~0.2 rad

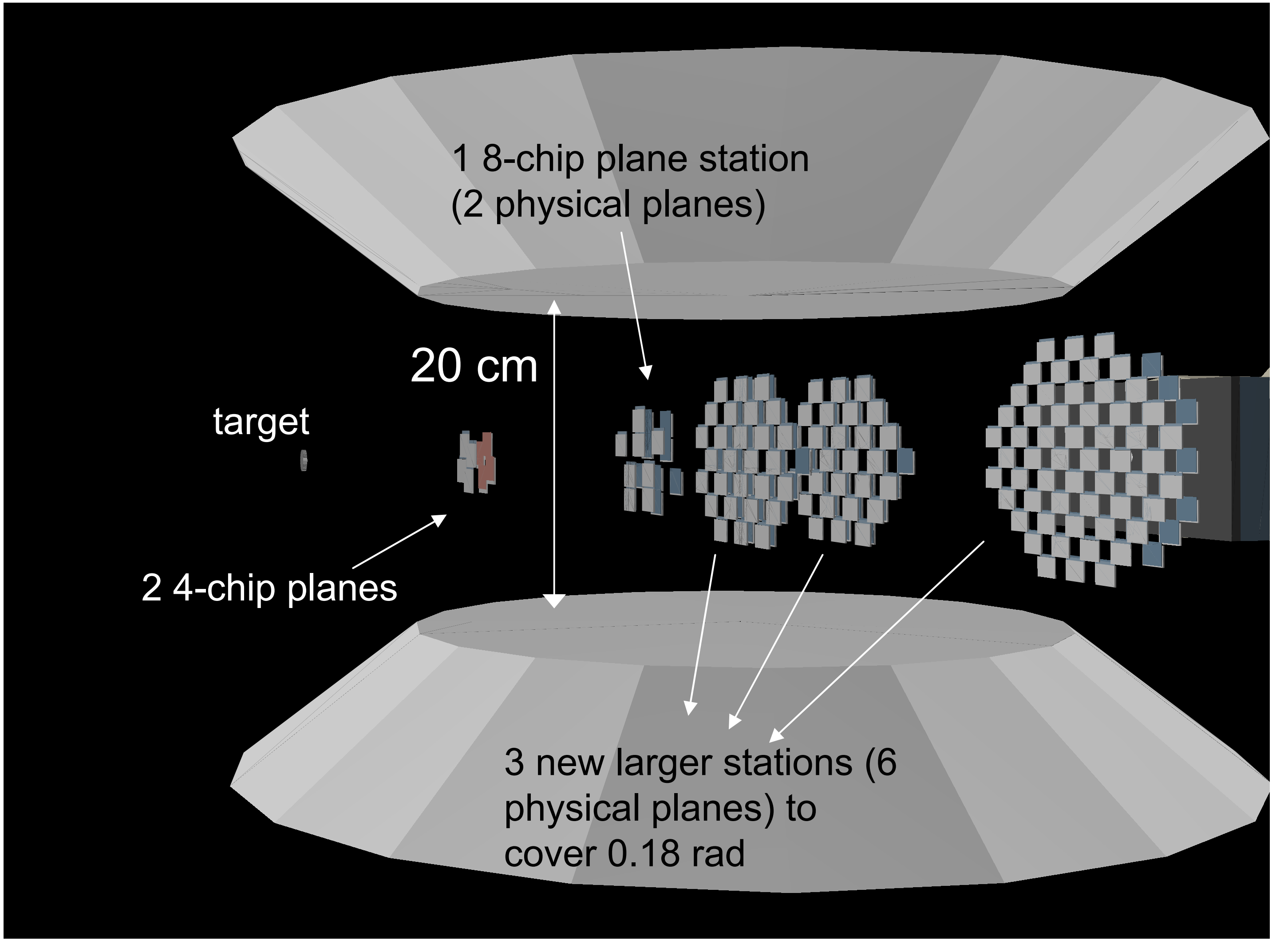


The old pixel telescope does not provide sufficient coverage

A new pixel telescope setup – first ideas

PT7-like larger dipole magnet: 2.5 T – ~20 cm gap

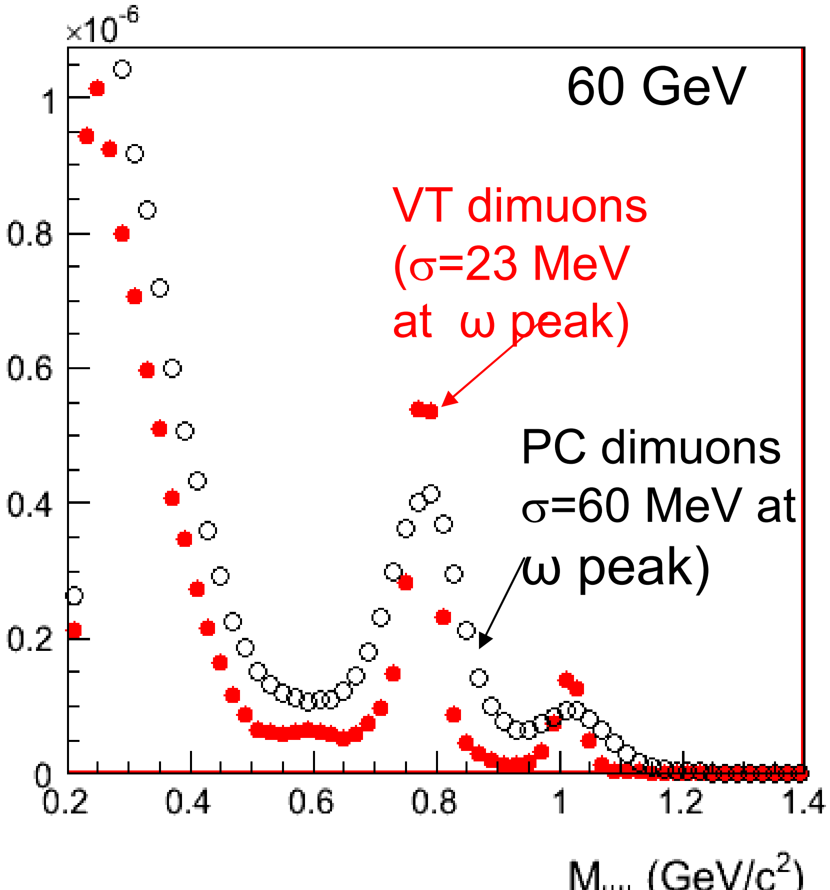
y covering requires 240 ALICE chips (~ 3 times more than previous telescope)

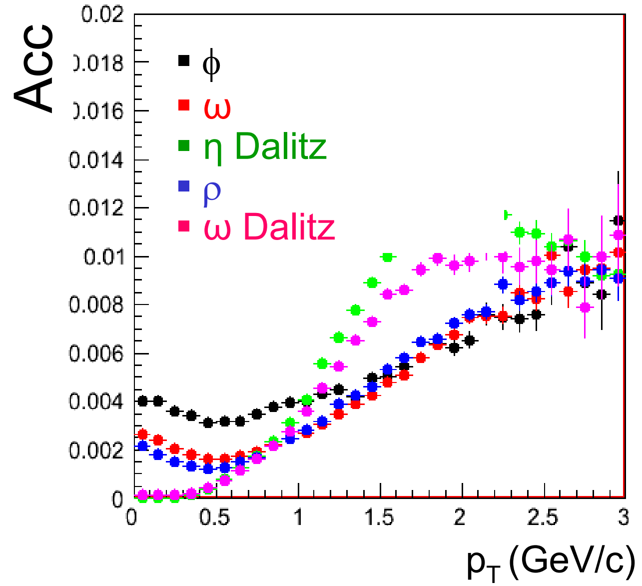


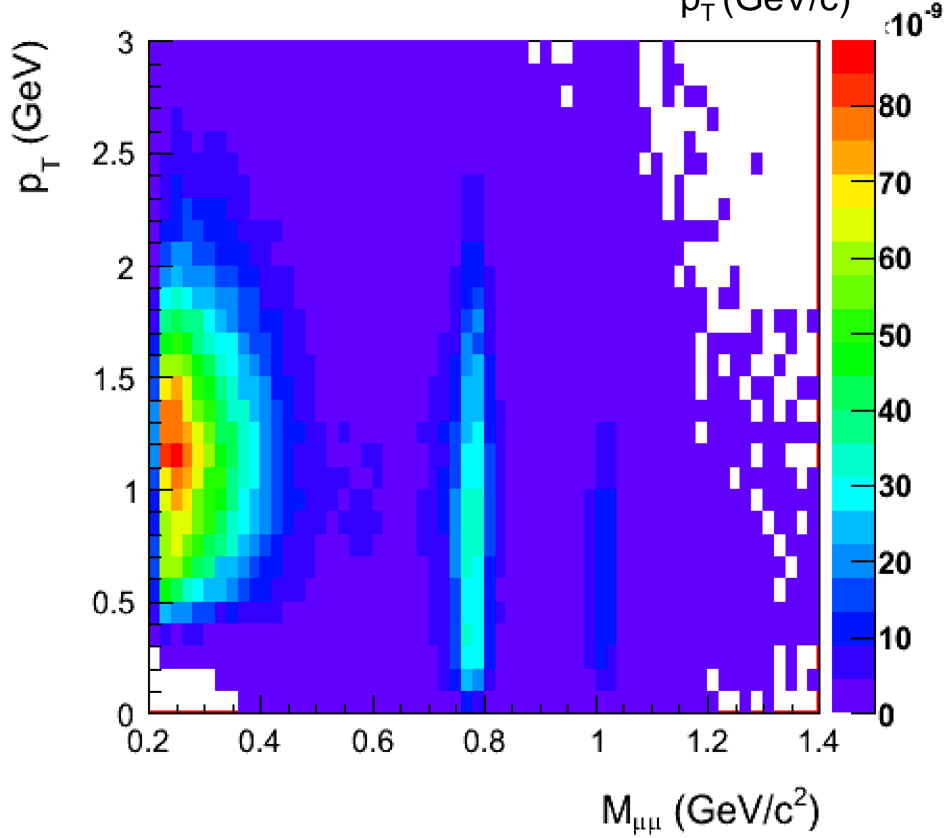
Dimuon reconstruction

Hadron cocktail generated and propagated through new muon spectrometer and new pixel telescope

Dimuon Matching rate ~ 70 %







Future plans

- Heavy ion beams should be available at the SPS again from 2011

- Feasibility of new measurements being studied
  → See G. Usai, presentation at "New Opportunities in the Physics Landscape at CERN" workshop, May 2009

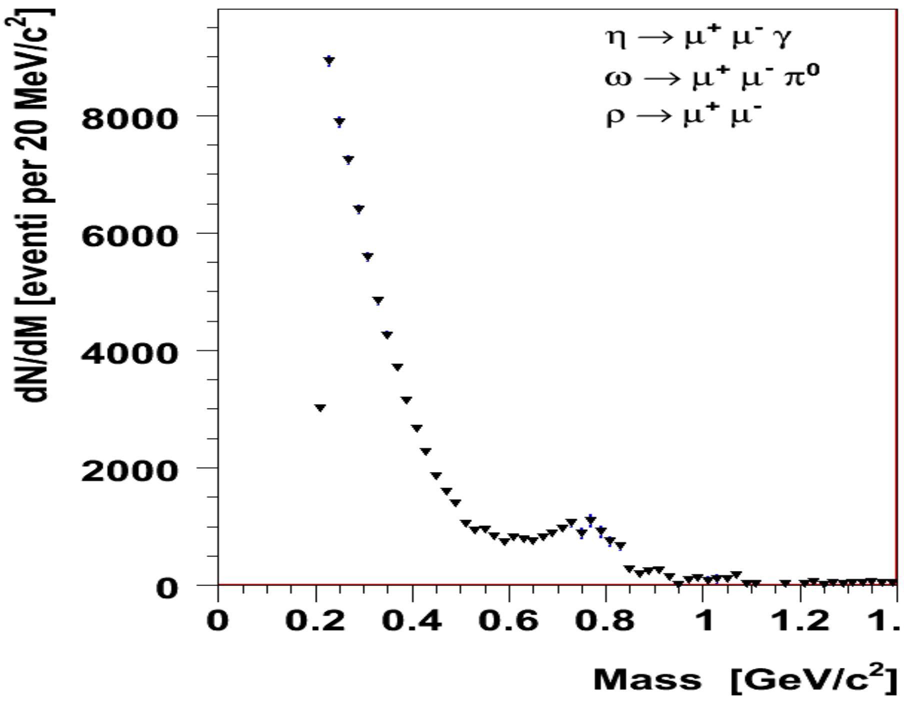
- Discussions with accelerator people on experiment location have started

- Contacts with theorists for the preparation of a letter of intent

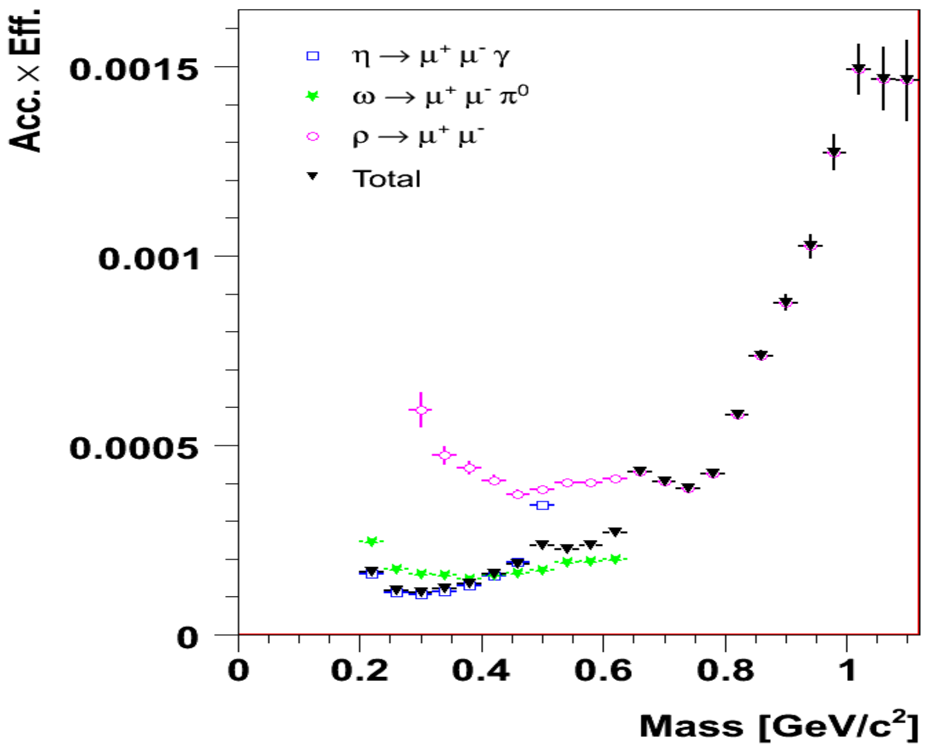
Backup

Isolation of Dalitz decays: acceptanca correction

Isolation of Dalitz and ρ decays



Acceptance correction



Running conditions

Energy scan

tentatively: ~ 40-60-80-120-160 AGeV

Ion beams

Maximization in-medium effects better with small surface-to-volume ratio ions, i.e. Pb or Au

→ suppression of freeze-out ρ (also lower energy helpful to reduce open charm, Drell-Yan and freeze-out ρ) maximizes possible J/ ψ suppression

Complete systematics: running with intermediate A nucleus as indium

→ i.e. important for understanding scaling variable behind J/ψ suppression

Proton beams

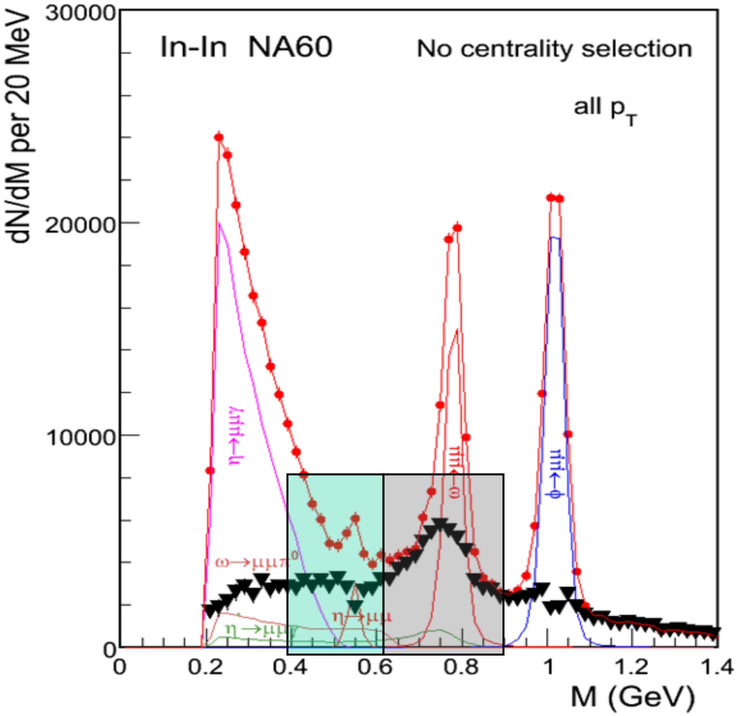
Needed for reference measurements (charm study for instance)

Beam intensities

Ions: 10^7-10^8/s on a 15-20% λ_I nuclear target

protons: 10^9-10^{10}/s on a 15-20% λ_I nuclear target

Angular distributions in the low mass region

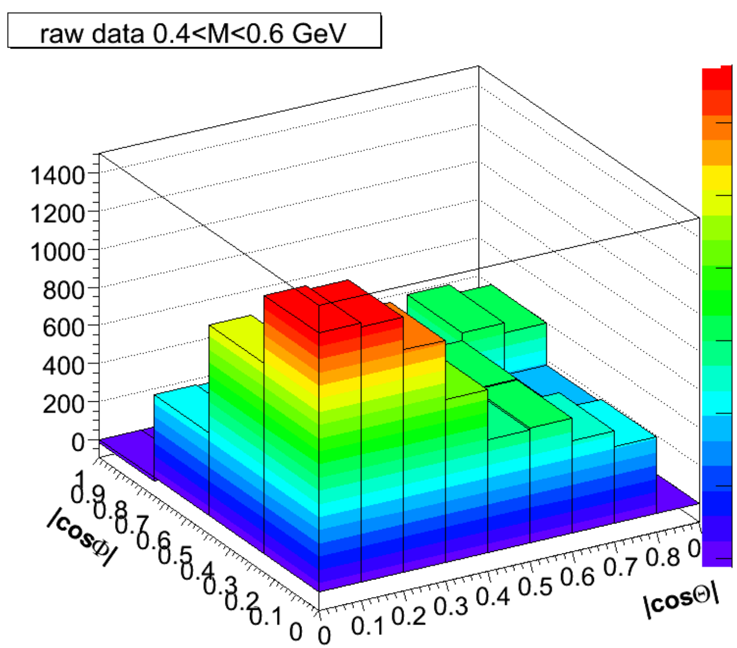


Results on centrality integrated data with p_T>0.6 GeV for:

- Excess dileptons in 2 mass windows:

  0.4<M<0.6 GeV (~17600 $\mu\mu$ pairs)
  0.6<M<0.9 GeV (~36000 $\mu\mu$ pairs)

- Vector mesons ω and ϕ (~73000 $\mu\mu$ pairs)



Analysis done in cosθ -ϕ space with different binnings in [dN/dcosθdϕ]$_{\mathbf{m\ x\ n}}$ to study the systematics

Steps followed for each of the [m x n] bins:
1) Combinatorial background subtraction
2) Assessment of fake matches
3) Isolation of excess by subtraction of the known sources
4) Acceptance correction in 2-dim cosθ-ϕ space or in 1-dim