Latest results from CERES

Ana Marín

for the CERES/NA45 Collaboration

Quark Matter 2004
Oakland, January 11 - 17, 2004

- **CERES setup**
- **Old/new calibration**
- **Preliminary electron results**
- ϕ **puzzle**
- **Event-by-event mean** p_T **and net-charge fluctuations**
- **Conclusions and outlook**

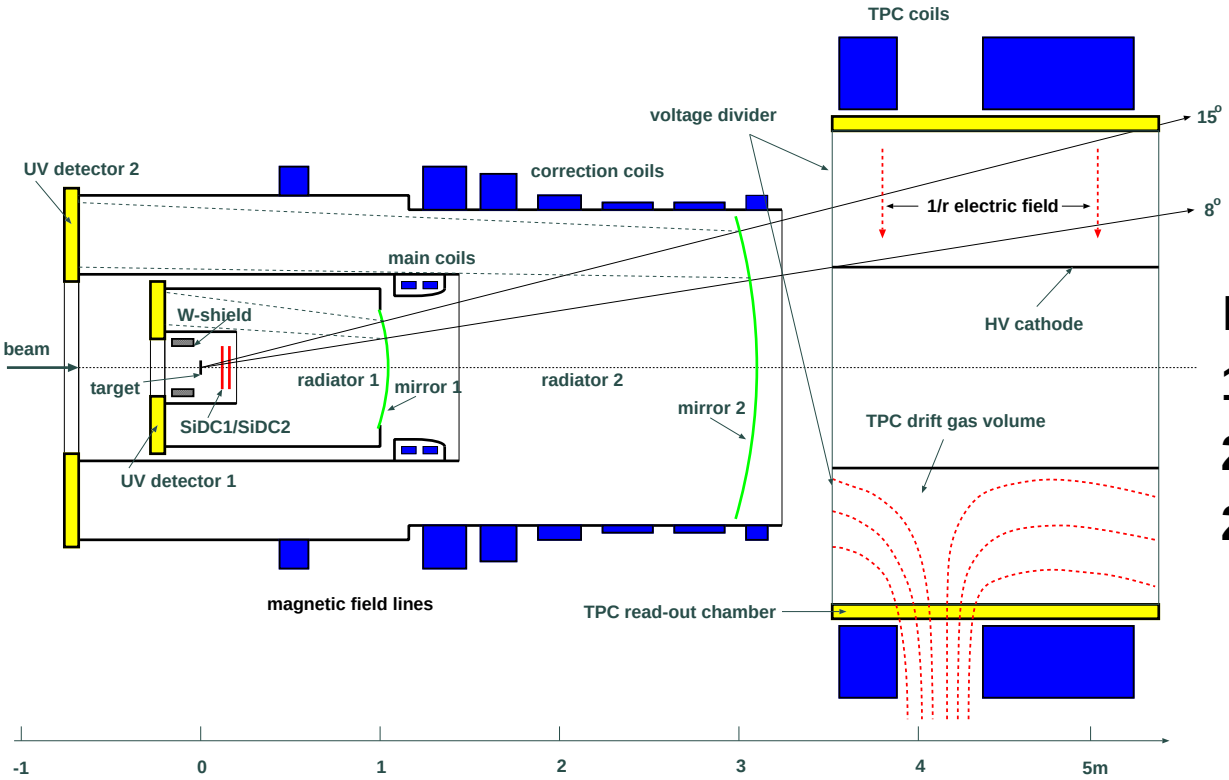
Goals

- **CERES has established in previous runs low mass enhancement**
- **enhancement is most likely due to strong in-medium modifications of ρ meson $\leftrightarrow$ link to chiral symmetry restoration ?**

Open questions:

- **fate of other vector mesons?**
- **are they visible with better resolution?**
- **modification in yield, mass , width? (ϕ puzzle)**
- **Difference observed in yields and slope:** **NA49:** $\phi \rightarrow K^+K^-$ **NA50:** $\phi \rightarrow \mu^+\mu^-$
- **Difference could be physics: in-medium ϕ vs thermal freeze-out ϕ**

Experimental setup



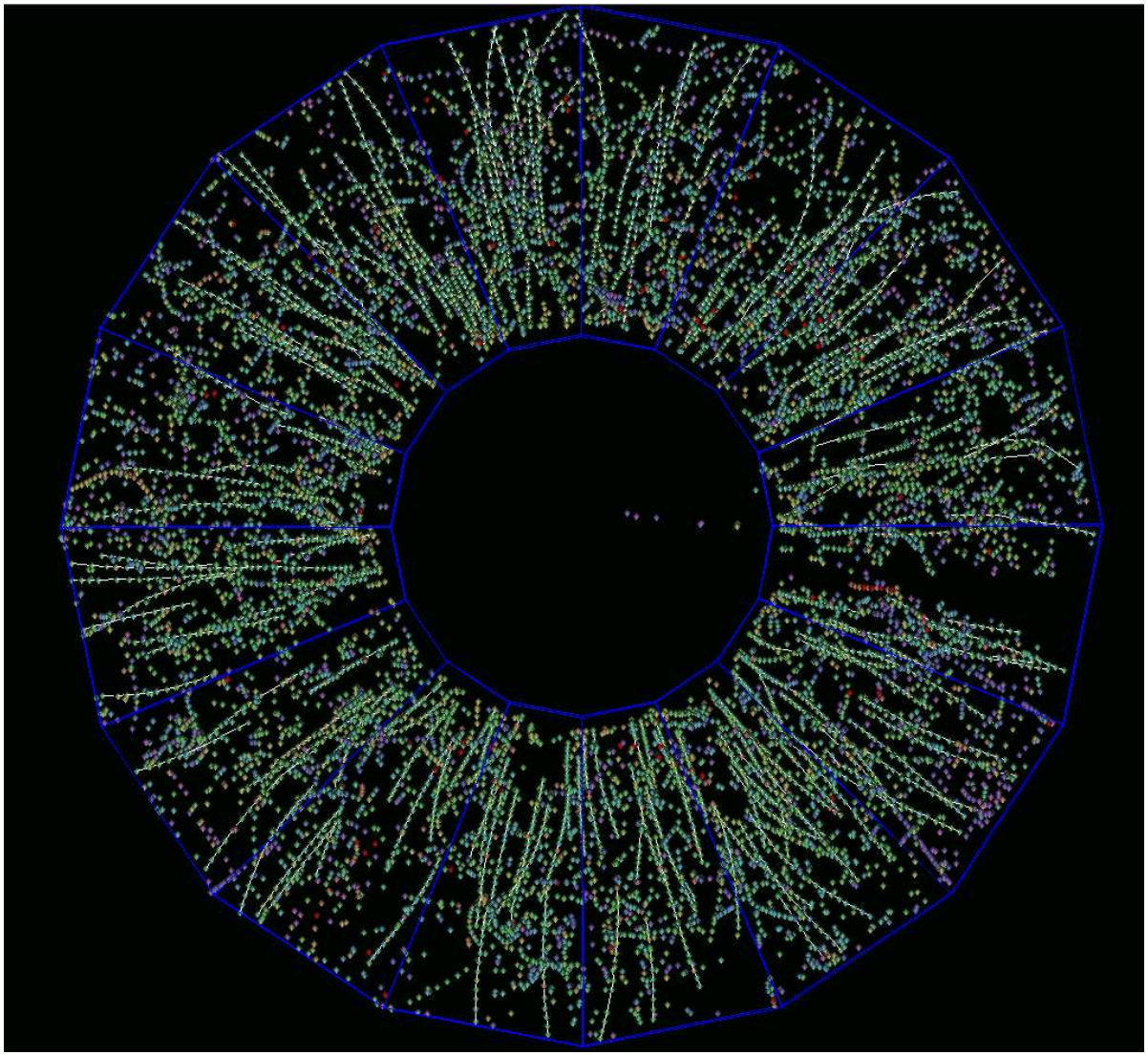
Data sets (Pb+Au)

RUN	p_{beam}	σ/σ_{geo}	Events
1999	40 AGeV	30%	8 M
2000	80 AGeV	30%	0.5 M
2000	158 AGeV	8%	33 M

- **Sidc1/2:** **vertex reconstruction and angle measurement**
- **Rich1/2:** **electron ID**
- **TPC:** **momentum determination, additional PID via dE/dx**

  Improved mass resolution

CERES TPC

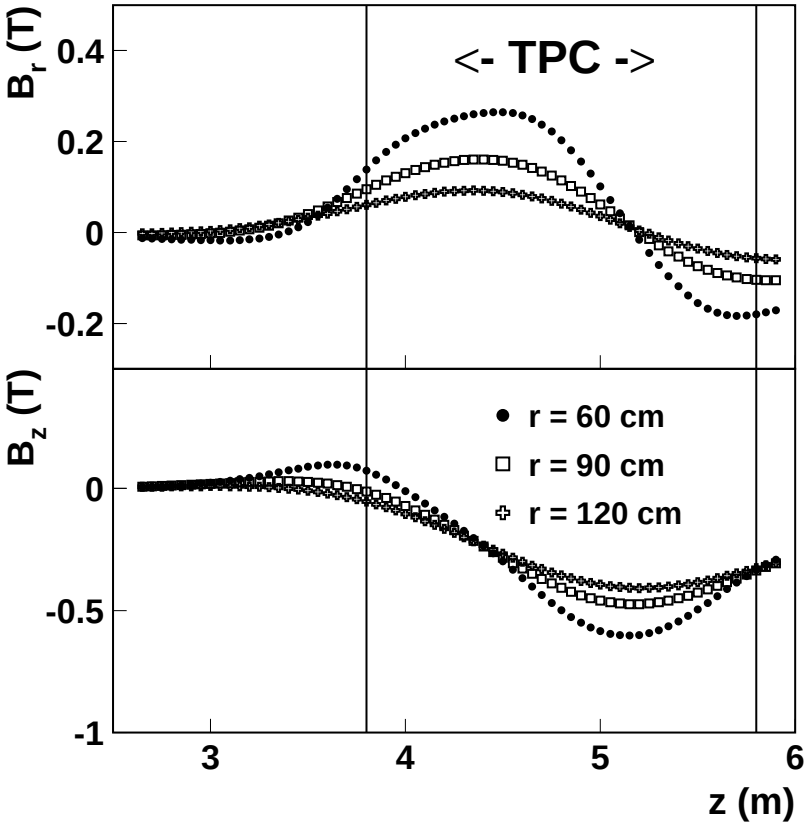


Pb+Au at 158 AGeV

TPC calibration

Old calibration	New calibration
Ideal B field	Measured B field
Ideal E field + empirical correction	Full E field calculation including field cage features
Drift stops at gating grid	E field/drift calculated up to cathode wires
Changes in E field due to geometry ignored	E field due to geometry
Drift based on Magboltz drift formula	Difference between Magboltz and Monte-Carlo drift included
Mobility vs E field is fixed and scaled	Mobility based on slow control parameters in 1 hour intervals
	Correction map of final distortions
Momentum fit constant in ϕ	Momentum fit ϕ dependent

Magnetic field



- **Magnetic field has two main components B_z and B_r varying with z and r**
- **Measured magnetic field included as a correction on top of the calculated Poisson map**

$\Downarrow$

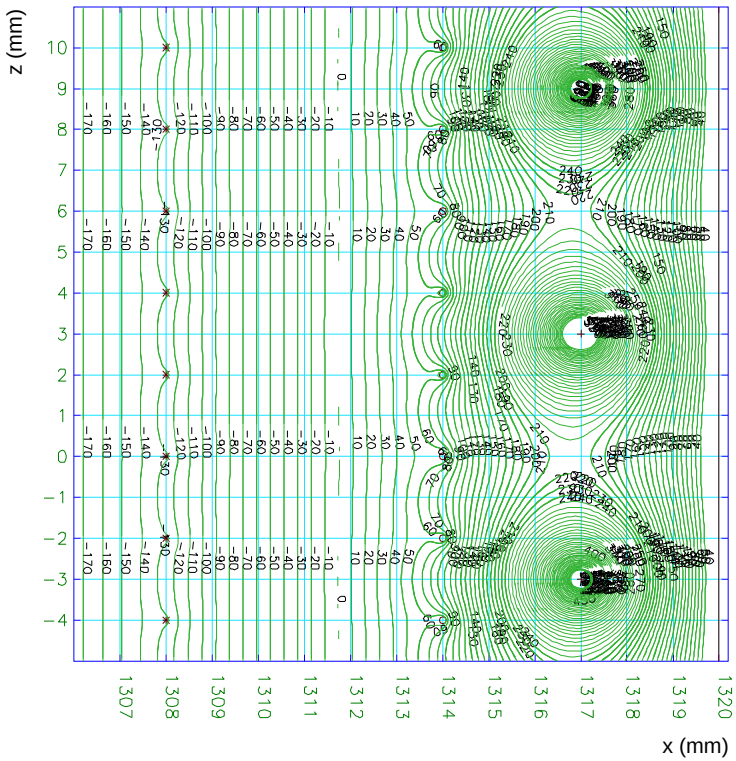
influences both drift and momentum measurement

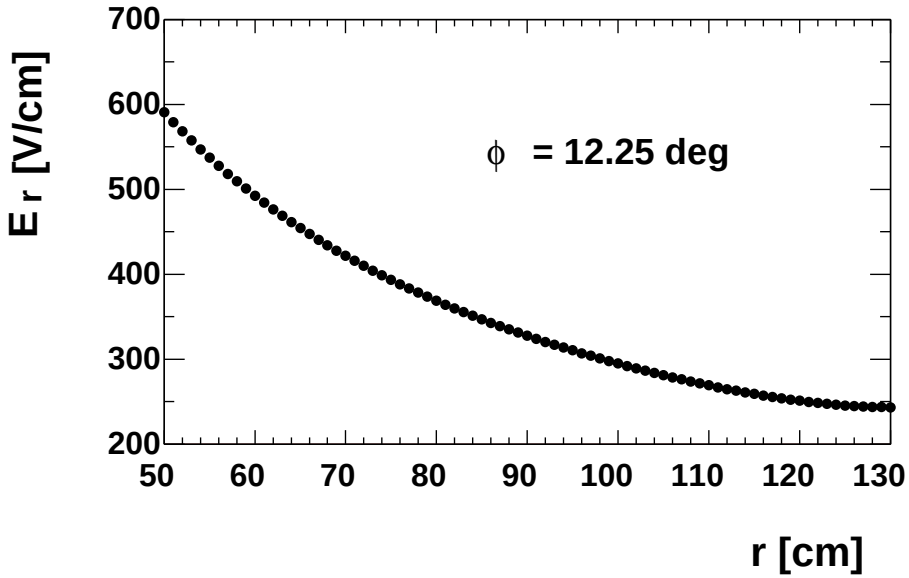
Electric field I

- **Self made calculation of E field: better accuracy than finite elements programs + knowledge of all features of the field cage included**

  GSI Scientific Report 2002, p. 230

- **E field calculation in the wire plane region (gating grid to cathode wires) and its influence on the drift region: very important to properly account for the Lorentz angle.**

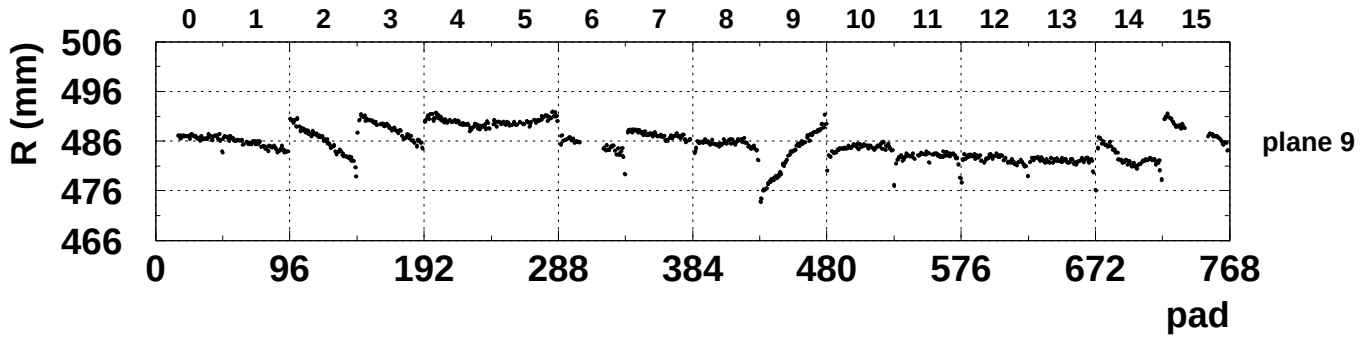




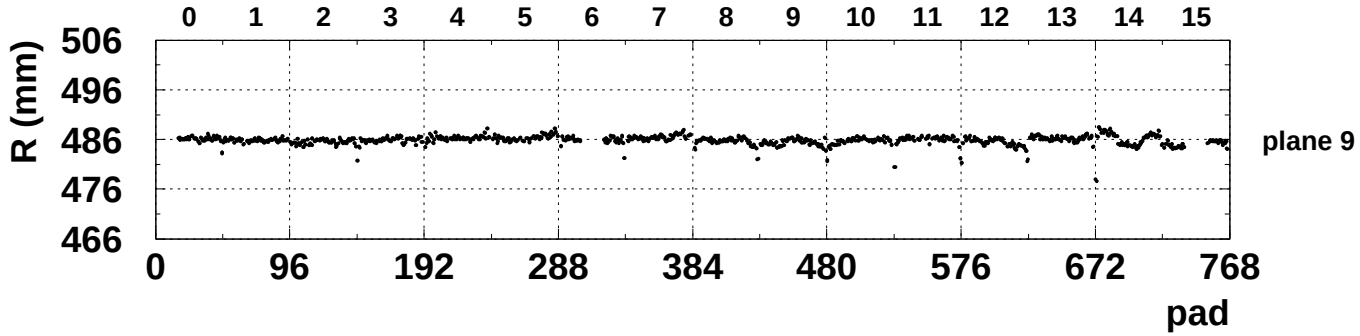
Electric field II

- **Electric field due to geometrical calibration calculated in 2D and added to the 3D field.**
- **Reconstructed radius of the inner drift electrode**

before geometrical calibration:

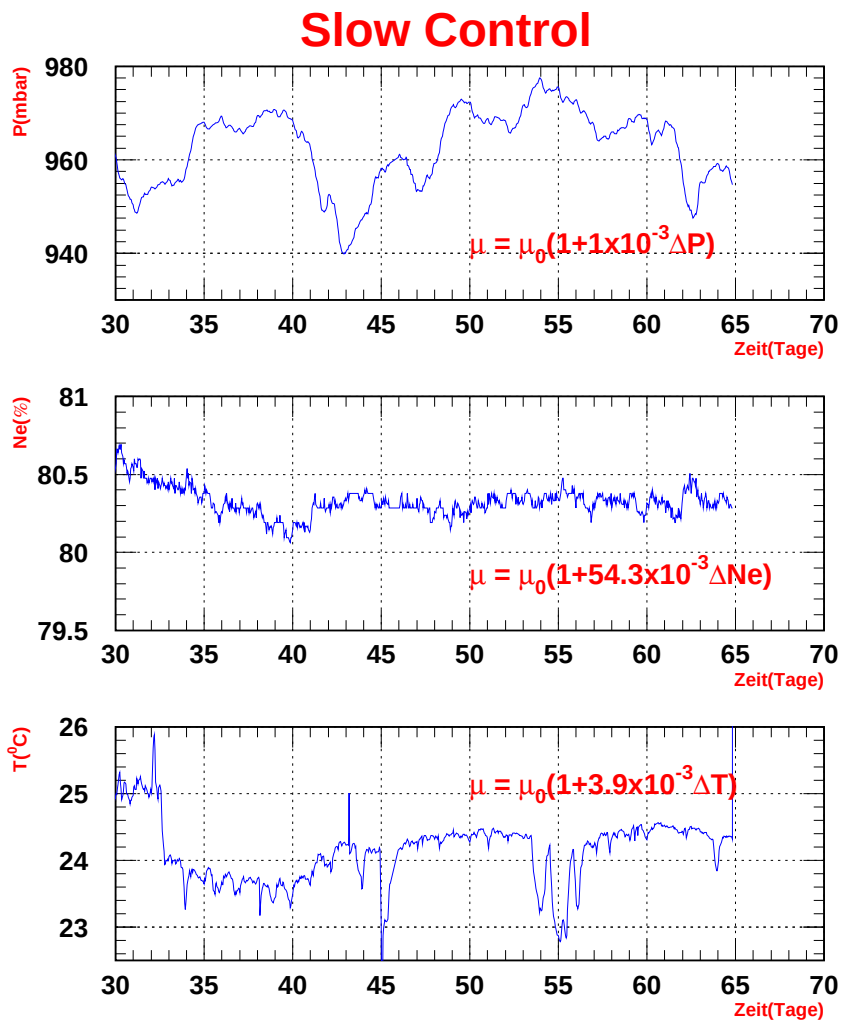


after geometrical calibration:



Slow control data and automatic calibration

- Main parameters of the drift gas (pressure P, Ne concentration, temperature T) are recorded by the slow control system
- During the analysis a prediction for mobility μ is done
- Precision obtained for v_D with the slow control is 0.5%
- Residual corrections based on charge step in time spectra are applied



Drift velocity vector for a given $\vec{E}$, $\vec{B}$ and μ

- **Transformation (pad,time,plane) $\rightarrow$ (x,y,z):**
  - **drift trajectory is calculated using Runge-Kutta**
  - **drift velocity vector is given by:**

$$\vec{v}_D = \mu \frac{1}{1+(\mu|B|)^2}(\vec{E} + \mu(\vec{E}\times\vec{B}) + \mu^2(\vec{E}\cdot\vec{B})\vec{B})$$

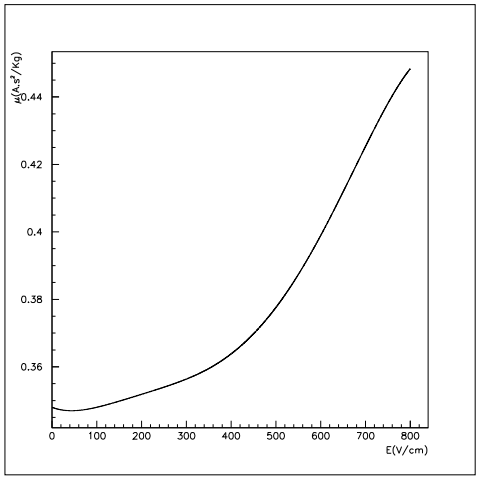
- **Difference between Magboltz Monte-Carlo drift and $\vec{v}_D$ accounted for with a correction**

$\vec{v}_p$ **:** $\vec{v}_D$ ***//*** $\vec{E}$ $\qquad$ $\vec{v}_p \cdot$ **p$_0$(plane)**

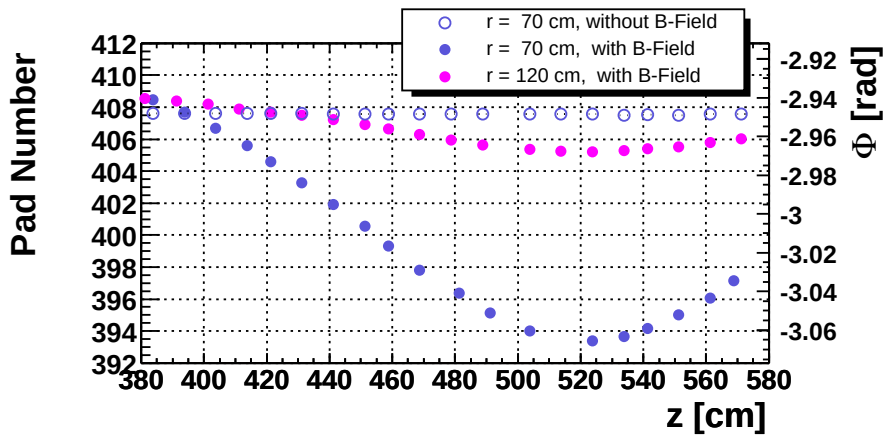
$\vec{v}_c$ **:** $\vec{v}_D$ ***//*** **(**$\vec{E}\times\vec{B}$**)** $\qquad$ $\vec{v}_c \cdot$ **(p$_0$+p$_1$ ·E)**

$\vec{v}_t$ **:** $\vec{v}_D \perp$ **(**$\vec{E}\times\vec{B}$**)**

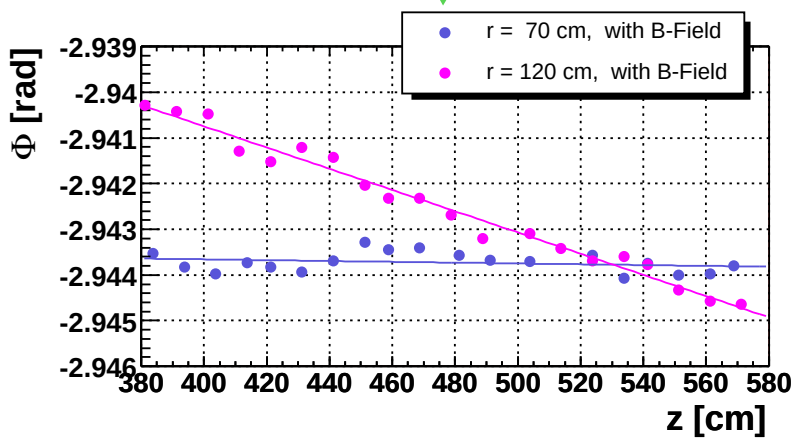
- **Mobility obtained from calibration using laser data**



(Pad,time) to (x,y,z) transformation



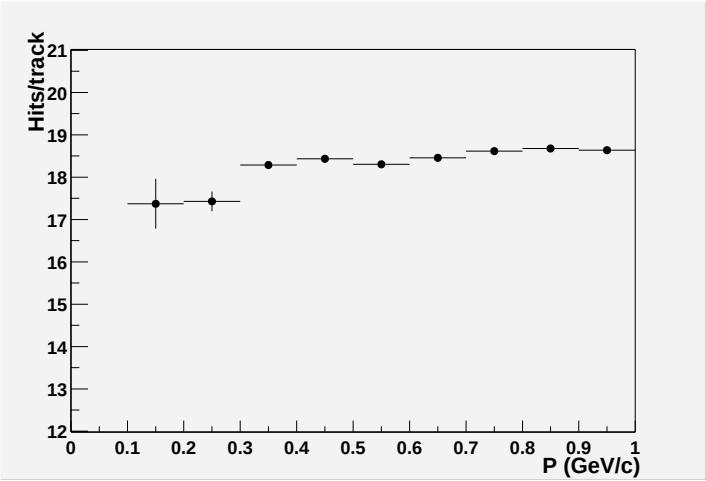
TPC Coordinates → Space Coordinates using $\vec{v}_{drift}$

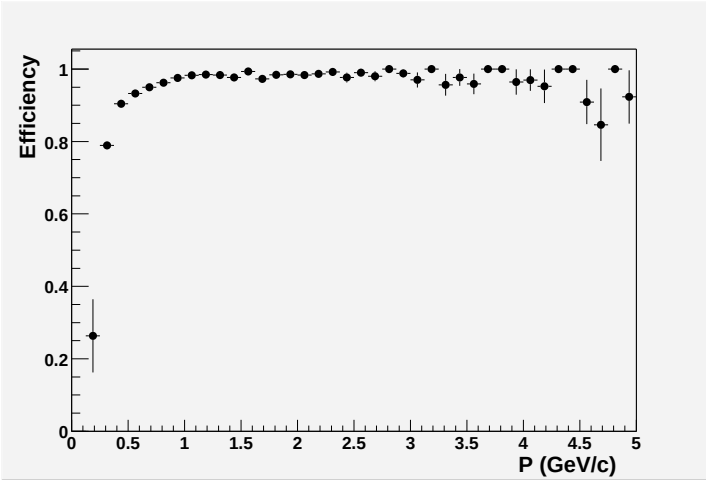


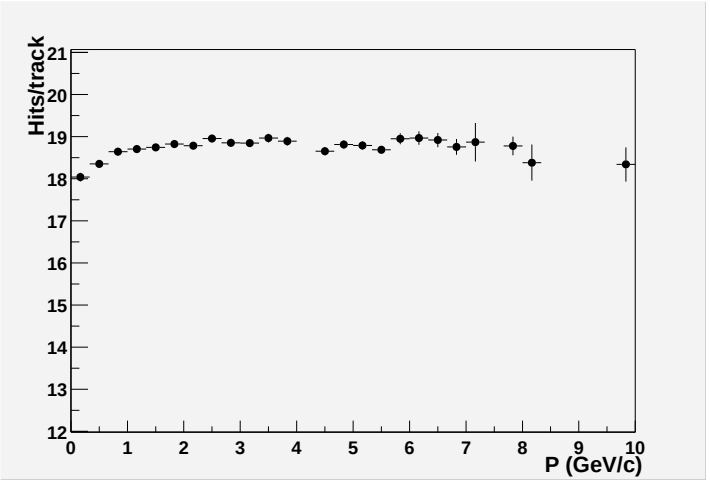
- **Laser provides straight tracks**
- **Displacements in rϕ due to Lorentz angle up to 16 cm**

Particle Tracks

- **18 hits/track down to p = 0.5 GeV/c**
- **80% efficiency down to p = 0.3 GeV/c**

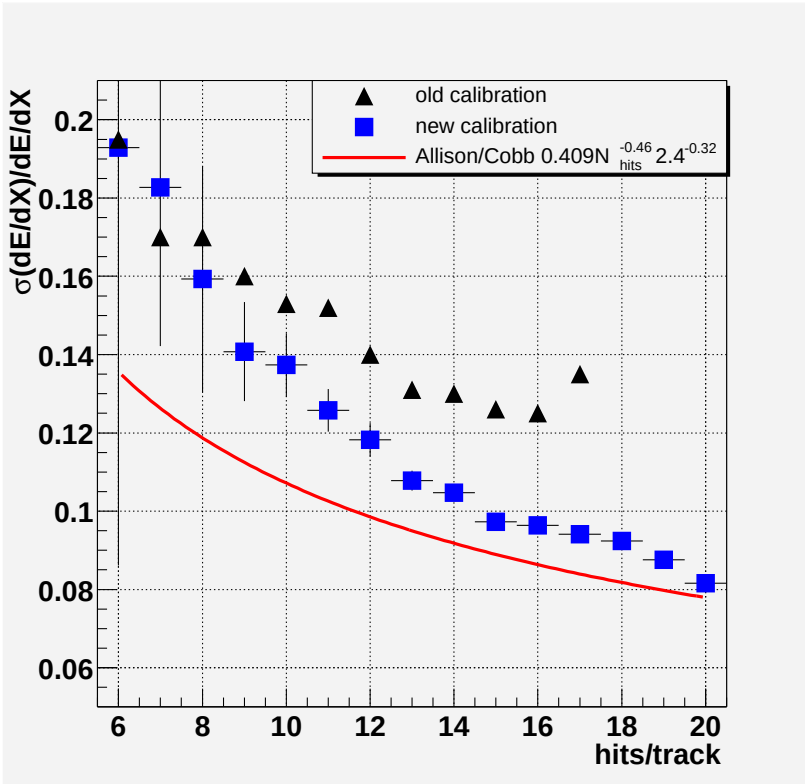






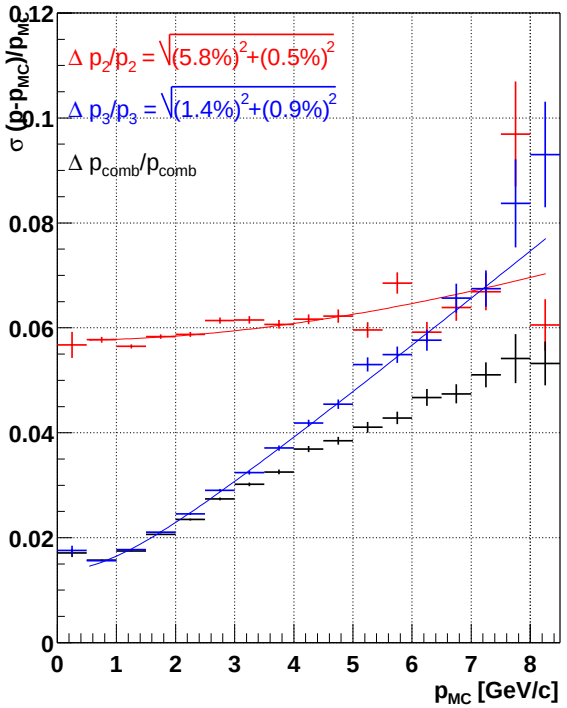
dE/dx resolution

- **Pad-to-pad calibration based on total amplitude in the pad of maximum amplitude**
- **Correction of undershoot after each pulse included**
- **Attachment correction done taking into account the population of different particles in polar angle θ**

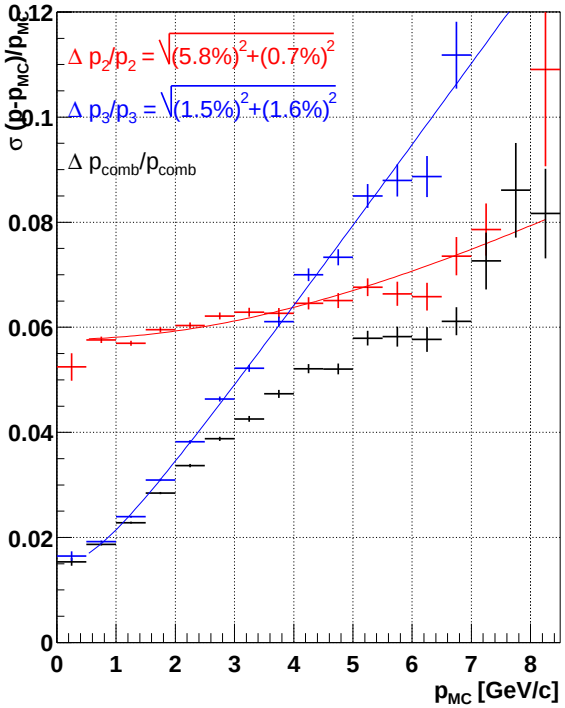


Momentum resolution based on MC

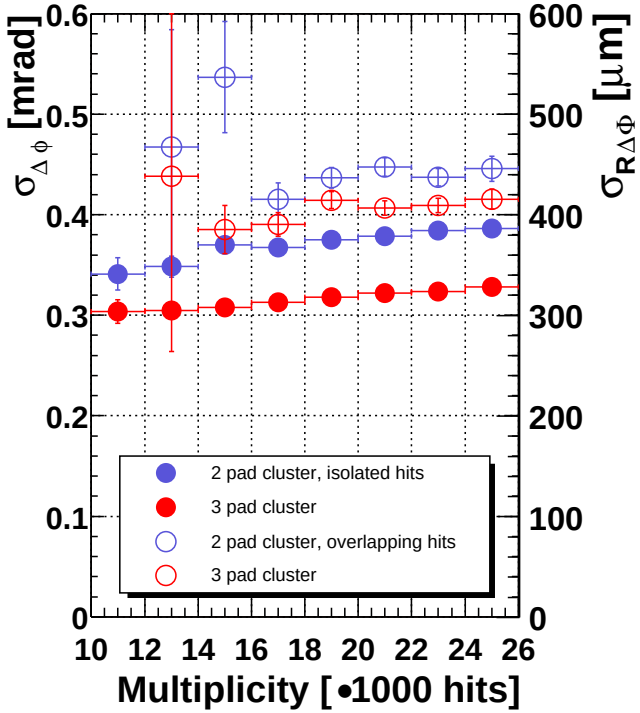
MC design resolution (N_{hits}>=19)



MC additional smearing (N_{hits}>=19)



300 < Amp < 350



- **2-parameter fit assumes tracks come from vertex**
- **3-parameter fit takes into account multiple scattering**
- **combined momentum fit**
- **Mass resolution ~4% at the ϕ**

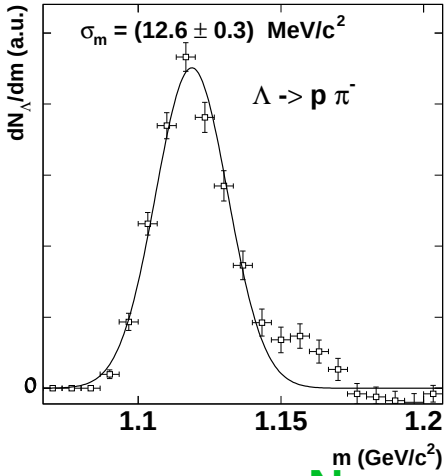
$$\sigma_2^2 = \sigma_{20}^2 + \sigma_{21}^2 \cdot p^2$$

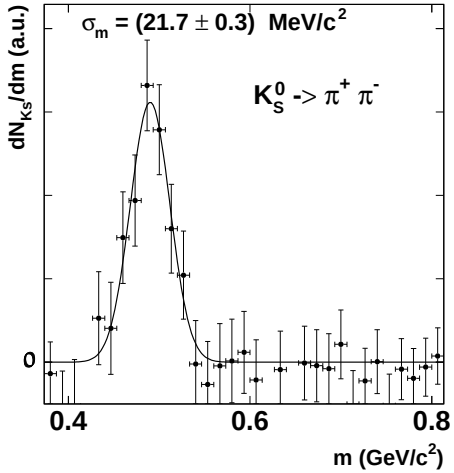
$$\sigma_3^2 = \sigma_{30}^2 + \sigma_{31}^2 \cdot p^2$$

$$p_{comb} = \frac{\frac{p_{cor2}}{\sigma_2^2} + \frac{p_{cor3}}{\sigma_3^2}}{\frac{1}{\sigma_2^2} + \frac{1}{\sigma_2^2}}$$

Λ and K_s^0: comparison of old/new calibration

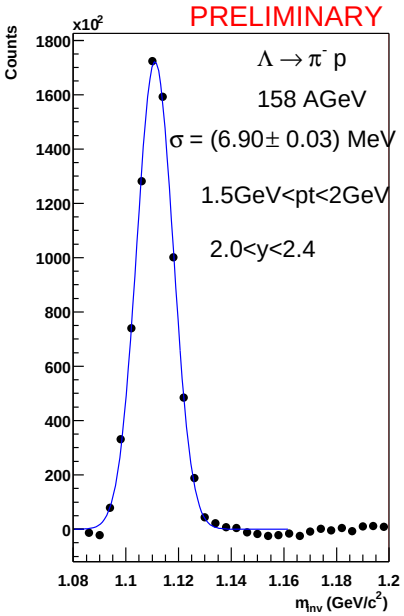
Old calibration

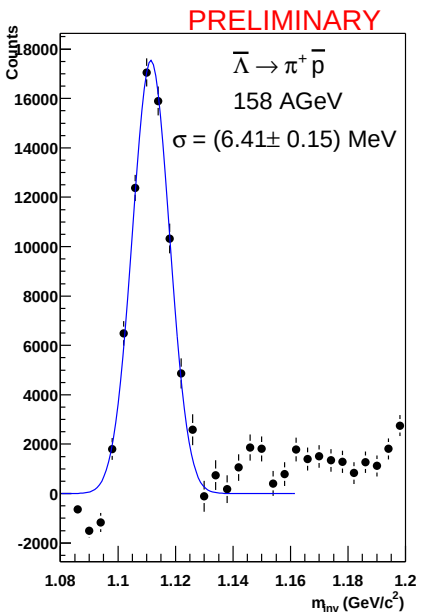


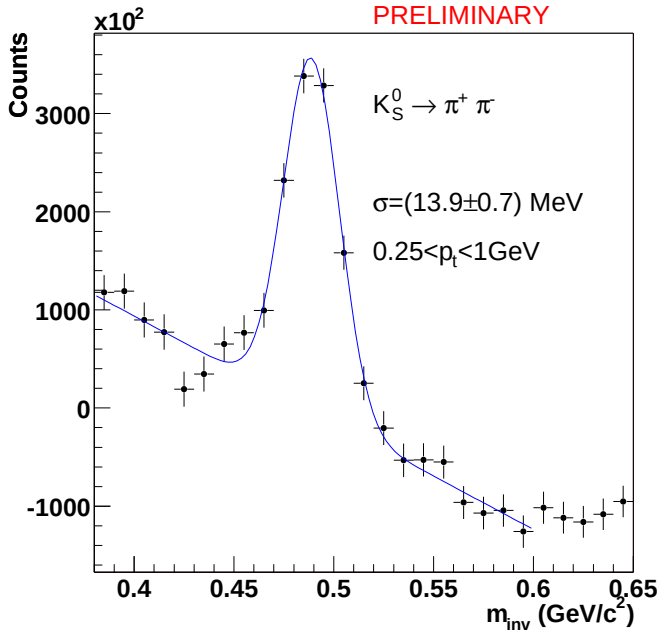


Detailed calibration improves the mass resolution by a factor of 1.7

New calibration







Main experimental difficulties in low e^+e^- mass region

$N_{e^+e^-}/N_{ch} \sim 10^{-5}$: electromagnetic decays are rare

- **Ring Imaging Cherenkov detectors** $\gamma_{th} \sim 31$
- **Additional PID via TPC dE/dx vs momentum**

$N_{e^+e^-}/N_{\gamma} \sim 10^{-5}$: large γ background

- **Minimize radiation length in acceptance**
  ($X/X_{\circ} < 1\% \rightarrow N_{e^+e^-} / N_{e^+e^- \rightarrow \gamma} \sim 10^{-3}$)

Still large combinatorial background

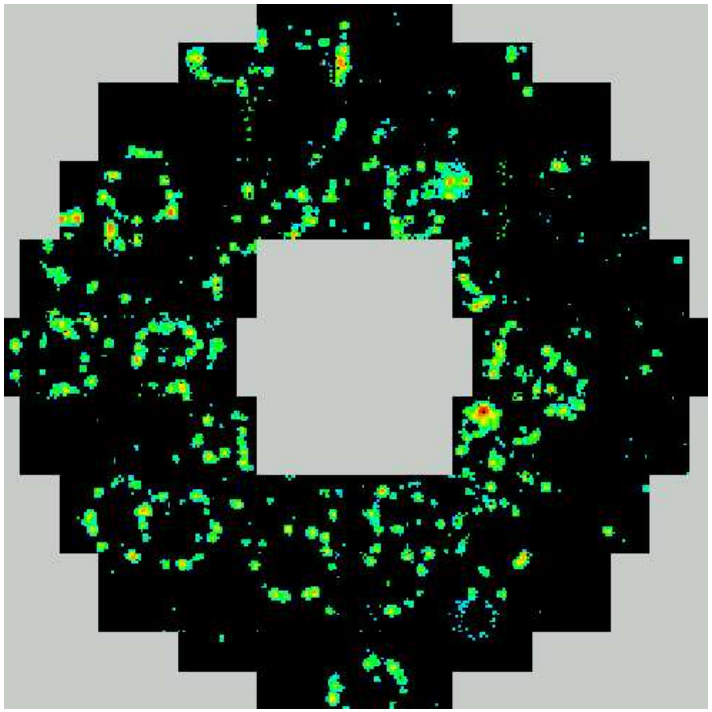
- $\gamma \rightarrow e^+e^-$
- $\pi^{\circ} \rightarrow e^+e^-\gamma$
- **Reconstruction of pairs with small opening angle important**

Reconstruct invariant mass $m_{e^+e^-} = \sqrt{2 \cdot p_{e^+} \cdot p_{e^-} \cdot (1 - \cos\theta_{e^+e^-})}$

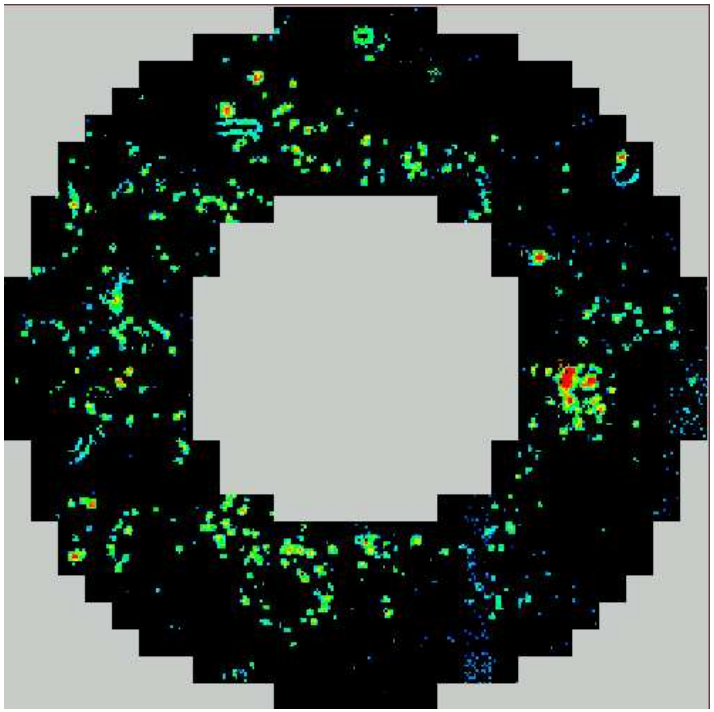
Substract background from like-sign pairs

Electron identification with RICH

RICH1

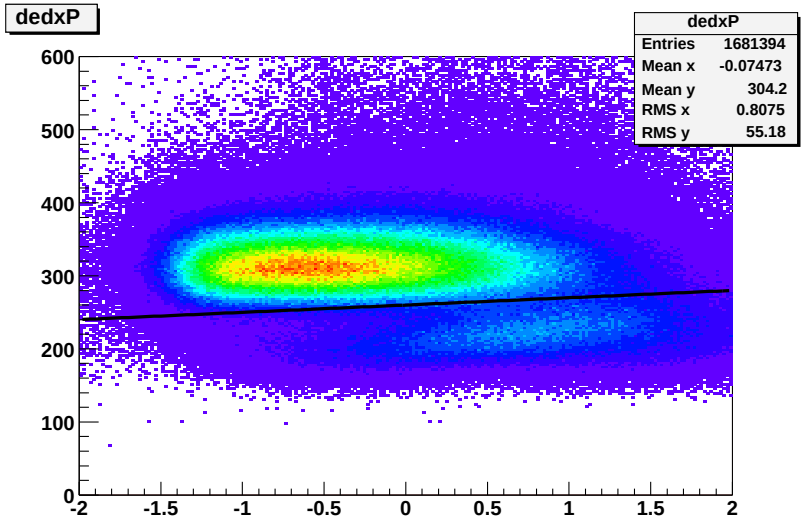


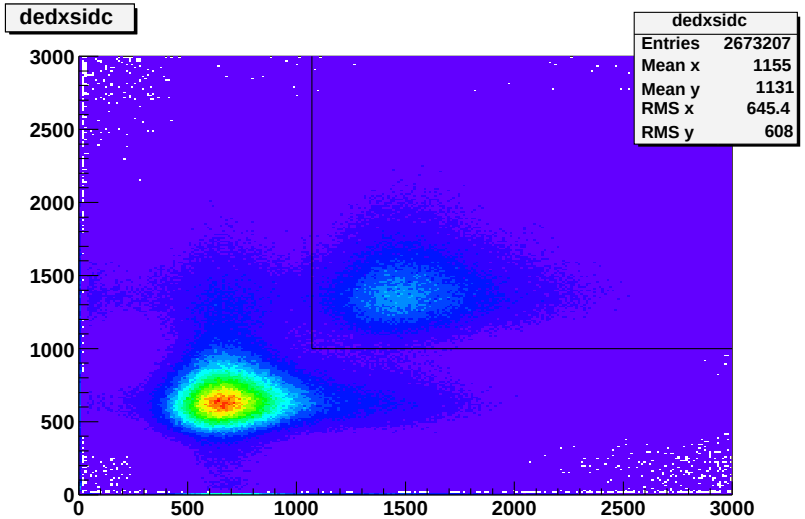
RICH2



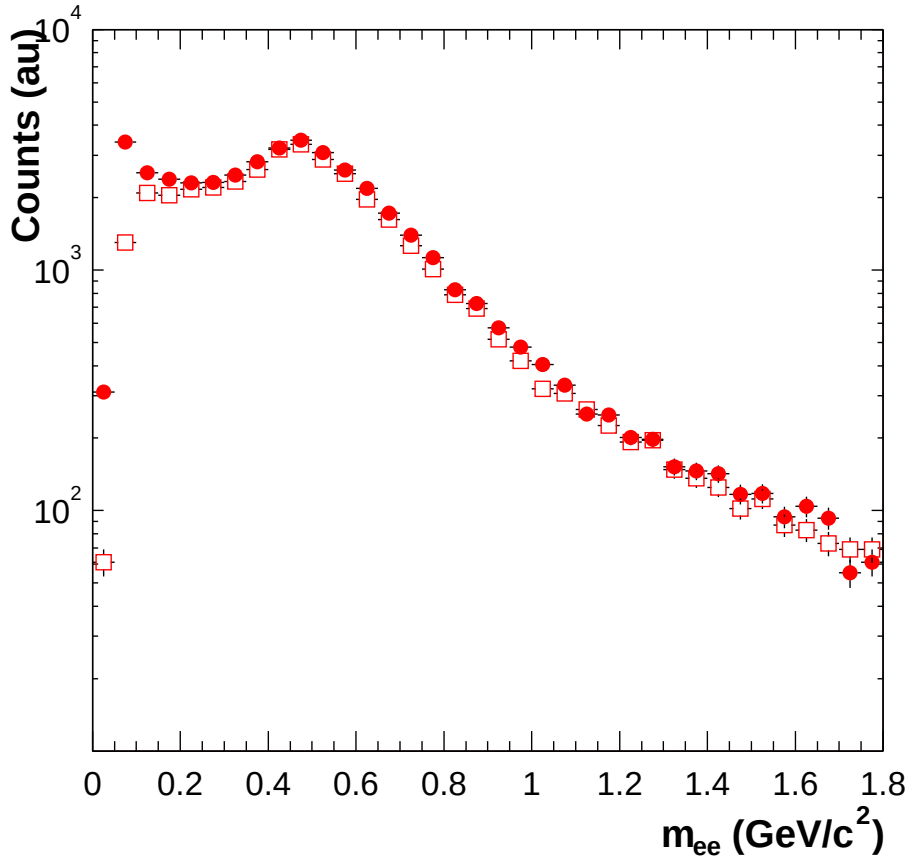
Pb+Au collision from run 1303, burst 332

Electron analysis



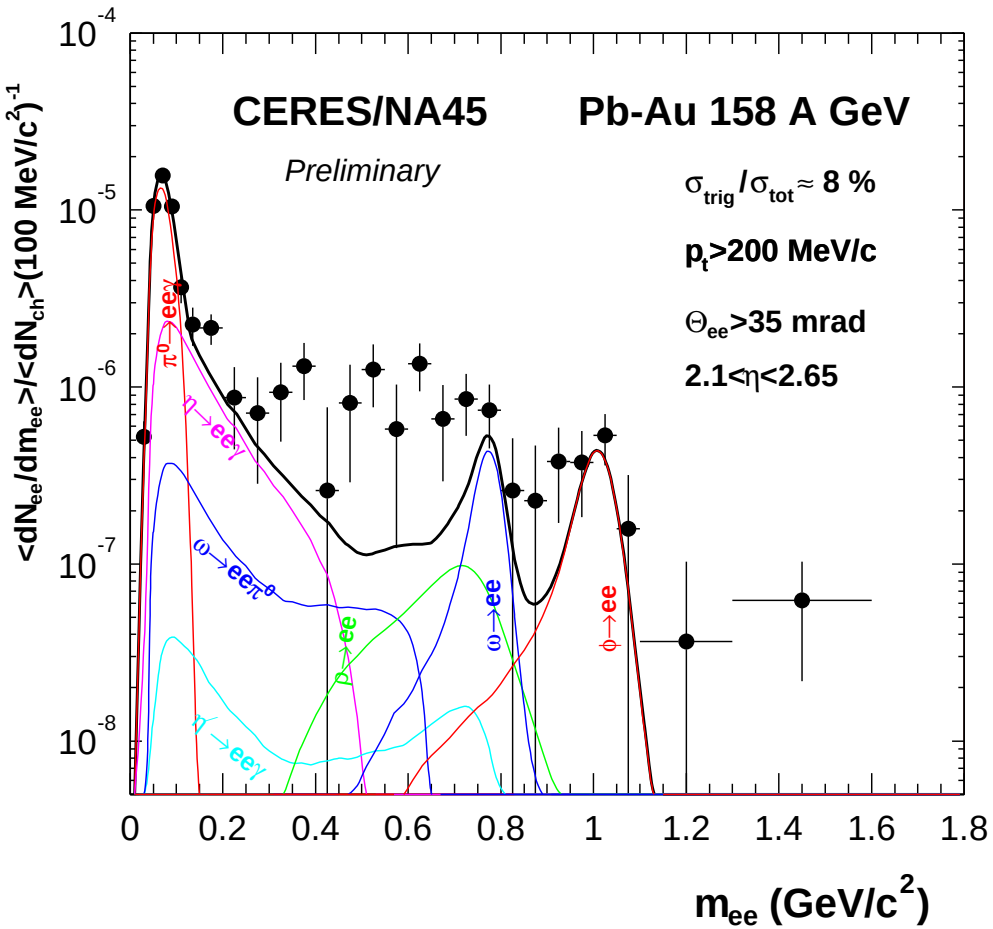


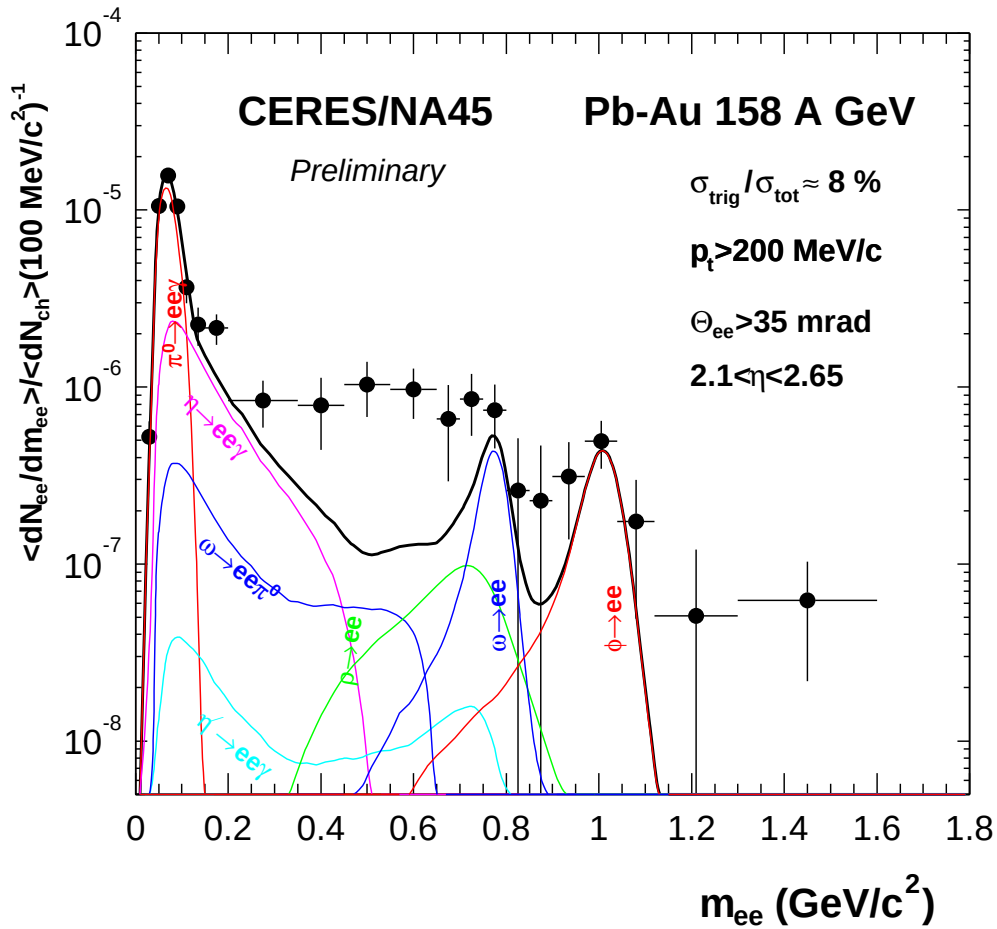
unlike/like-sign invariant mass



Talk of A. Cherlin and S. Iourevitch in parallel session on Tuesday afternoon

Preliminary results on electrons



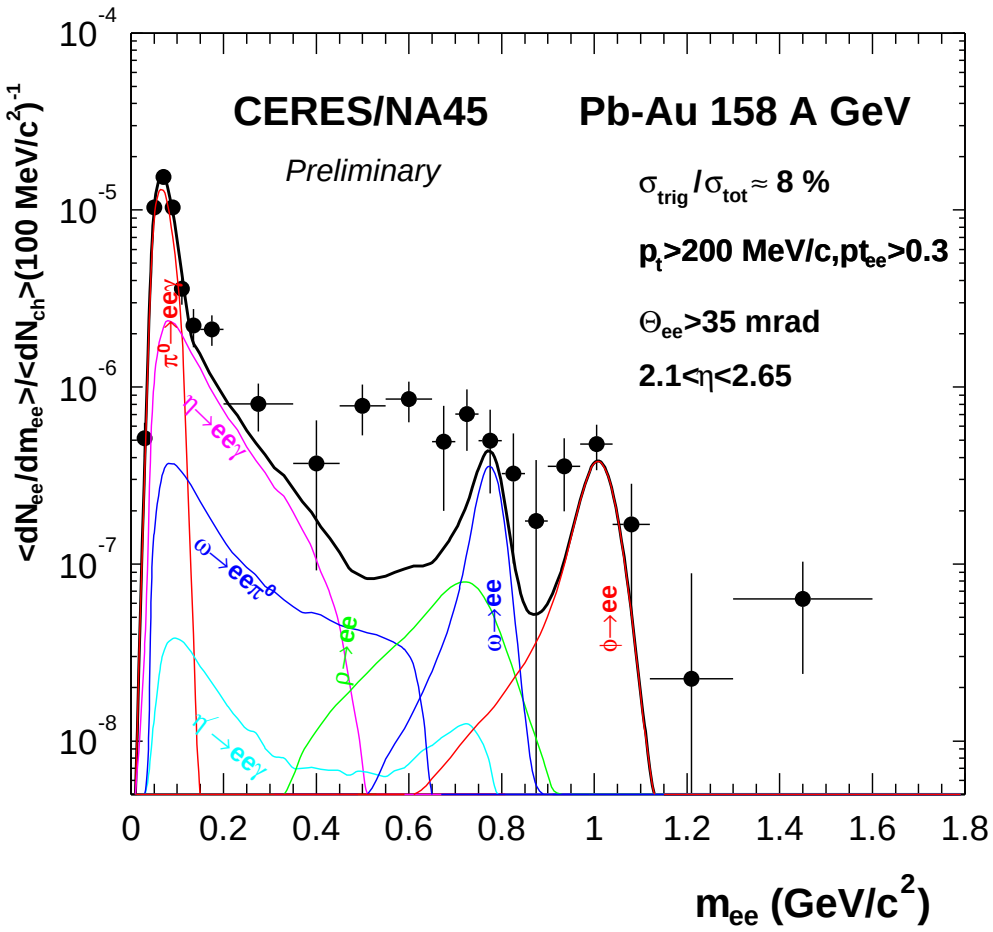


mass range	# of pairs	S/B
$m_{ee} < 0.2$ GeV/c^2	3135±118	1/1.75
$m_{ee} > 0.2$ GeV/c^2	2037±256	1/15.7
$0.9 < m_{ee} < 1.11$ GeV/c^2	222±66	1/7.5

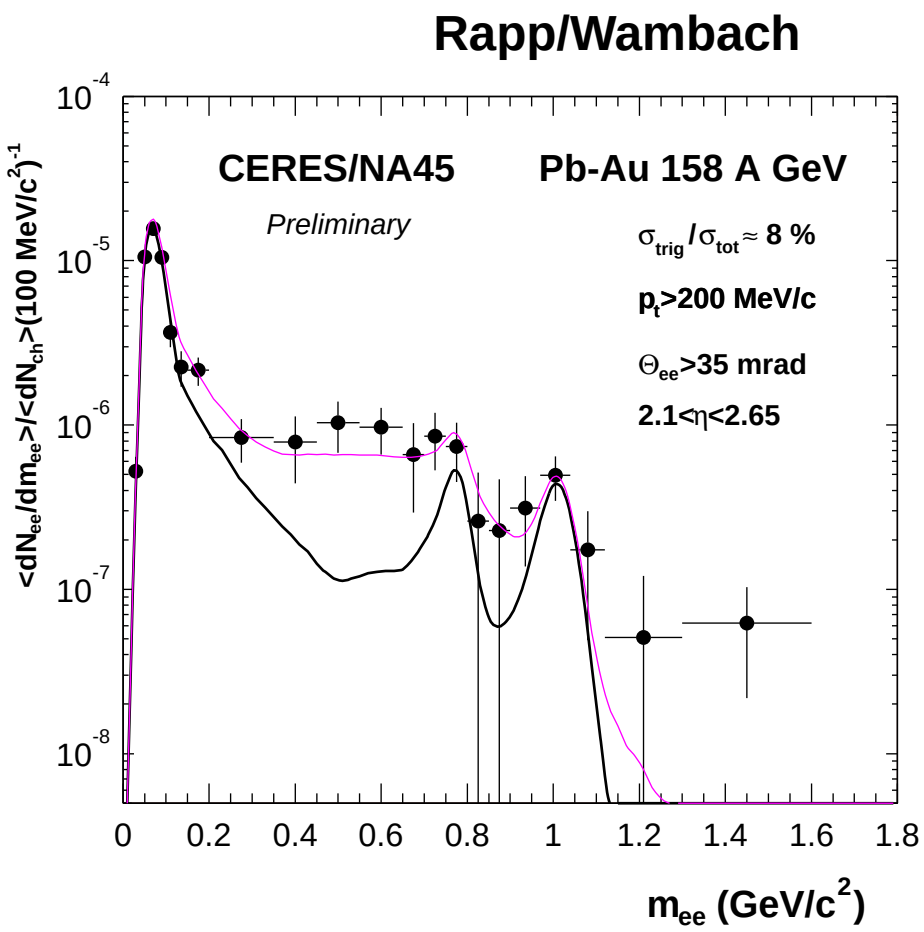
normalization to π_0 Dalitz, no systematic errors

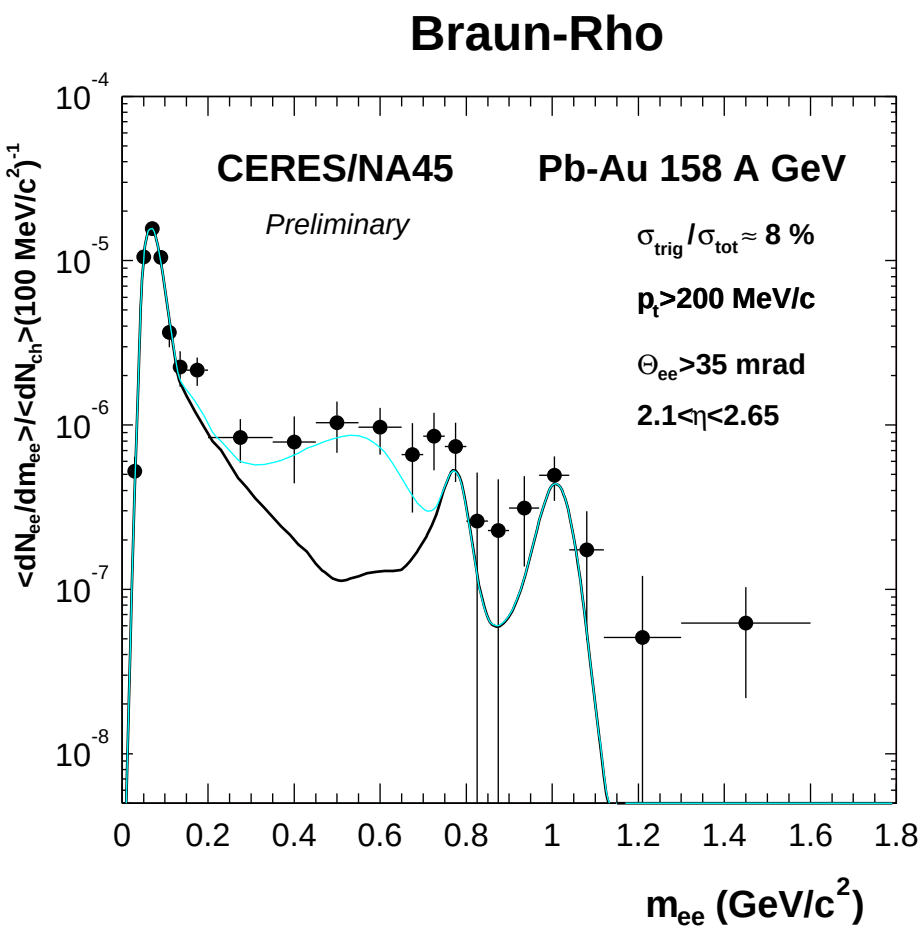
- particle ratios: therm. model fit to Pb+Pb data
- y and p_T distributions from Pb+Pb systematics
- enhancement for $m_{ee} > 0.2$ GeV/c^2 compared to hadronic cocktail: 2.8±0.4

Preliminary results on electrons

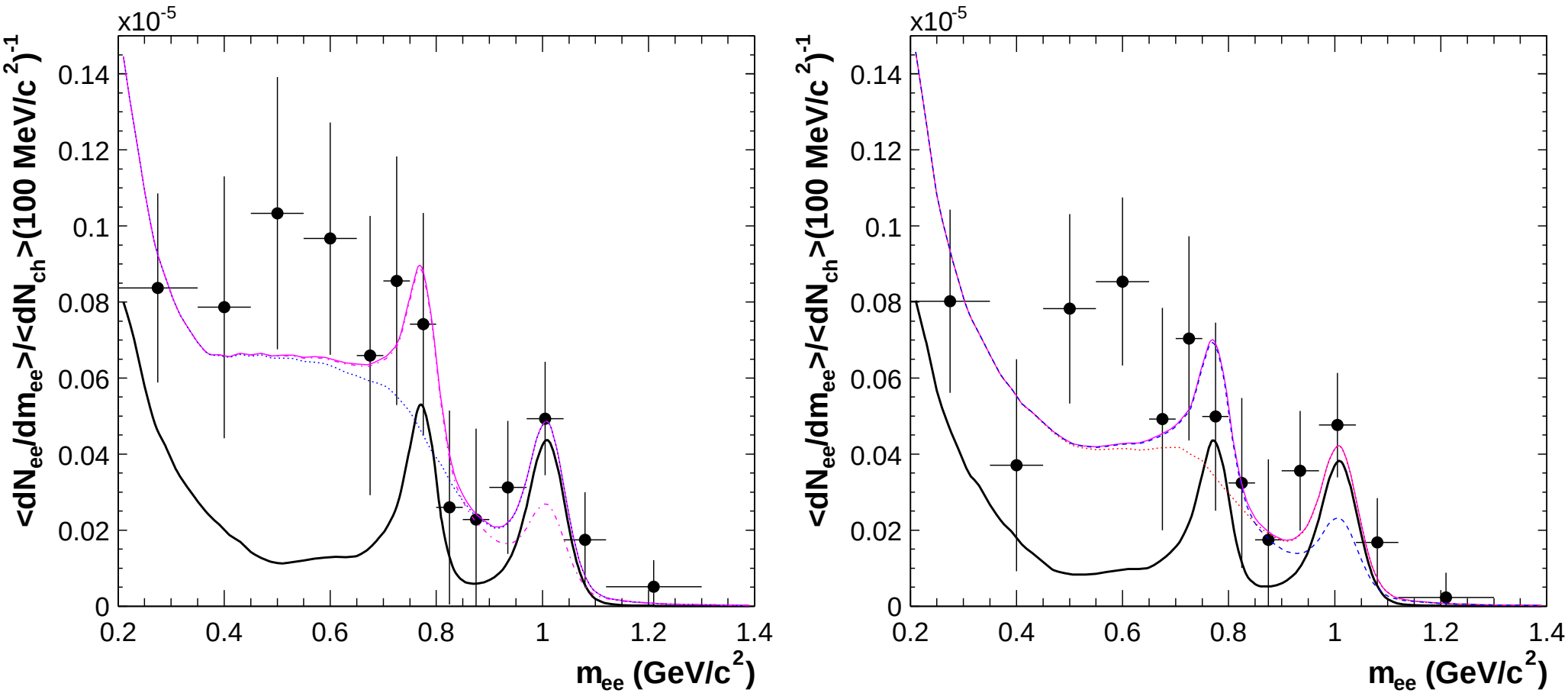


Comparison to models



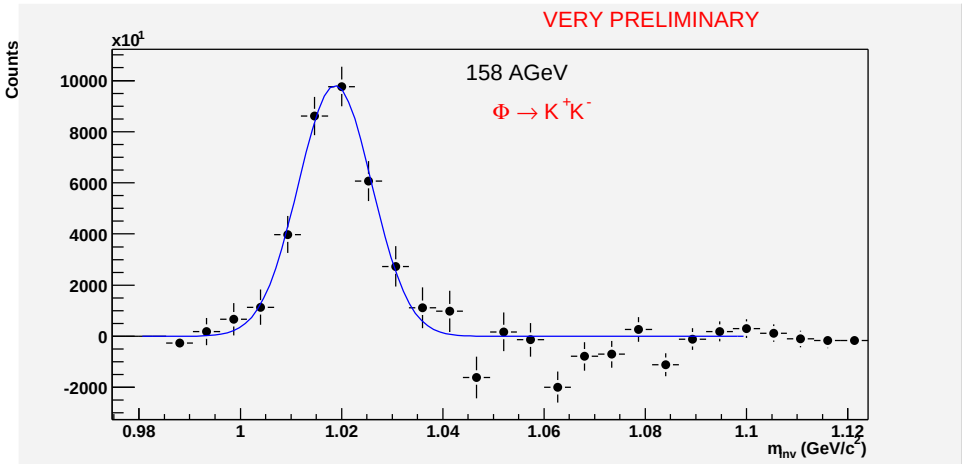


ϕ meson yields

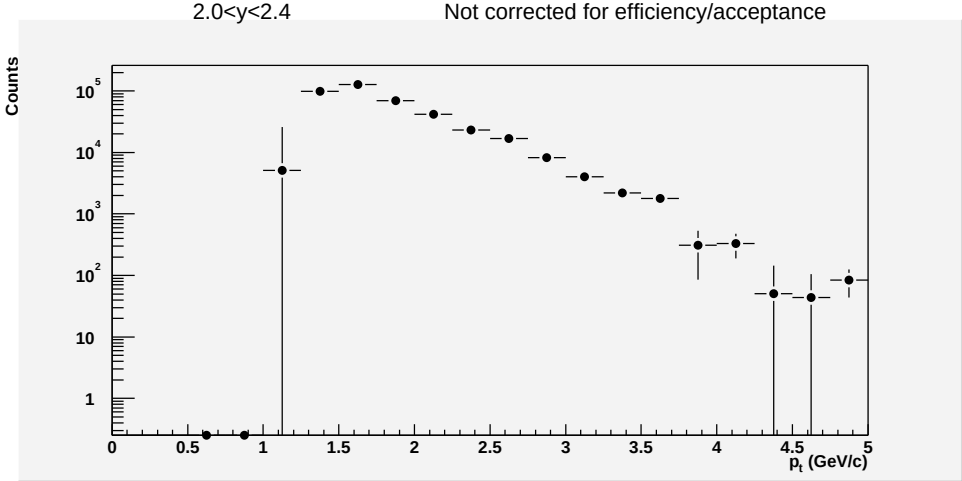


		p_t>0.2 GeV	+p_t^{ee}>0.3GeV
thermal ϕ yield	$N(\phi^{exp})/N(\phi^{model})$	**1.2±0.4**	**1.3±0.4**
ϕ reduced to 50%	$N(\phi^{exp})/N(\phi^{model})$	**2.6±0.8**	**2.9±0.8**

The ϕ puzzle



2.0<y<2.4 Not corrected for efficiency/acceptance



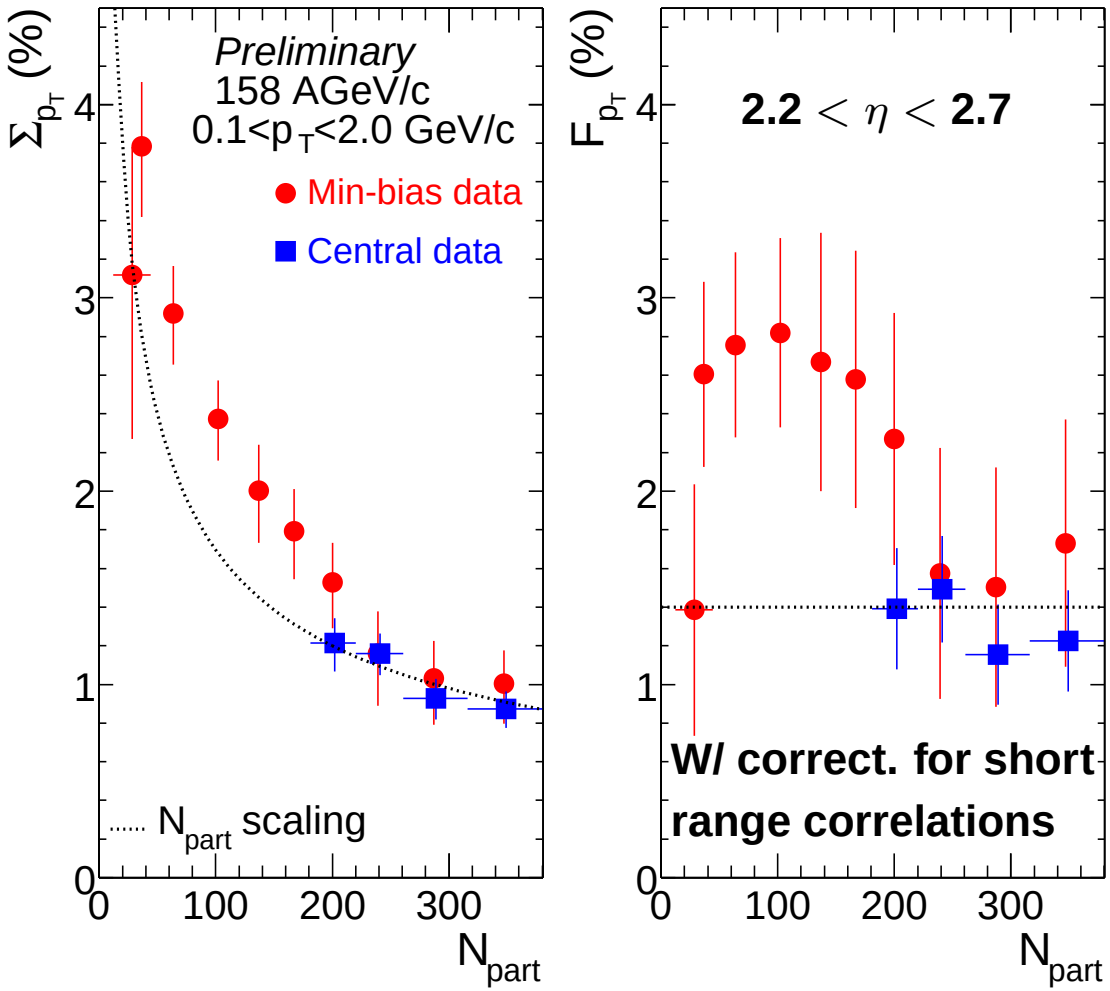
- **ϕ meson can be identified in the K^+K^- channel**

Measurement of both decay channels in the same experiment

Event-by-event mean p_T fluctuations at 158 AGeV/c

Talk of H. Sako in parallel session on Friday afternoon

- **Centrality dependence of fluctuations in new analysis of minimum bias data**
- **non-monotonic dependence and enhancement over p+p extrapolation in semi-central events observed**

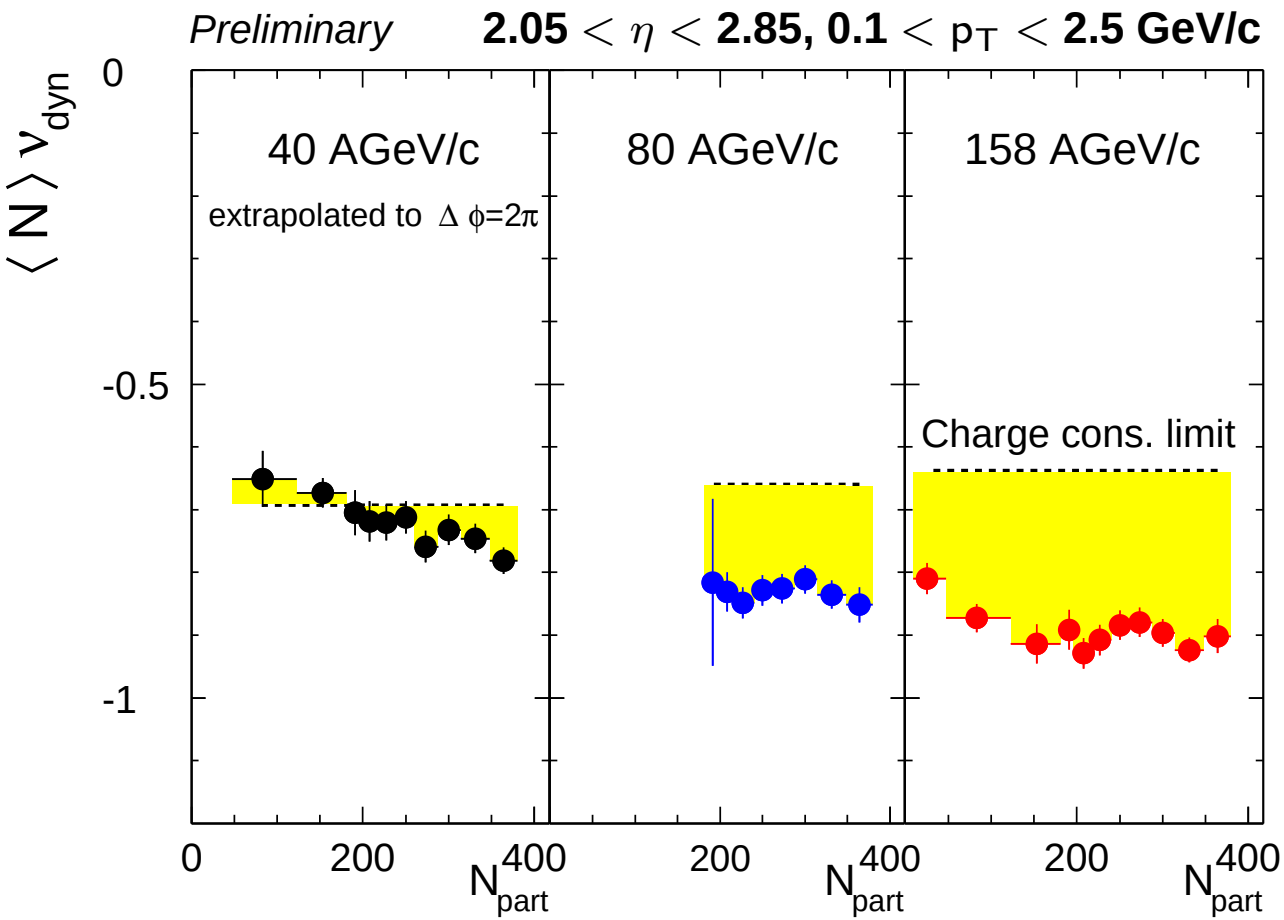


Event-by-event net-charge fluctuations at 40, 80, and 158 AGeV/c

Talk of H. Sako in parallel session on Friday afternoon

Centrality and collision energy dependence

- **smaller fluctuations than charge conservation limit**
- **decrease in centrality and collision energy observed**



Conclusions and outlook

- **Preliminary results on electrons from 2000 run with mass resolution of $\approx$ 4% have been shown**
  $\longrightarrow$ *Talk of A. Cherlin and S. Iourevitch in parallel session on Tuesday afternoon*
- **Work to be done:**
  - **Improvement of signal to background in progress**
  - **Absolute normalization**
  - **Systematic errors**
- **New algorithm of electron identification under development**
- **CERES will measure ϕ to K^+K^- channel $\Rightarrow$ light on the ϕ puzzle**
- **CERES has observed non-statistical fluctuations both in mean p_T and net-charge:**
  - **similar features to observations at RHIC**
  - **no indication for the critical point**

  $\longrightarrow$ *Talk of H. Sako in parallel session on Friday afternoon*
- **More results will come with the 2000 large data sample**

CERES/NA45 Collaboration

D. Adamová, V. Kushpil, M. Šumbera
NPI ASCR, Řež, Czech Republic

G. Agakichiev, D. Antonczyk,
A. Andronic, H. Appelshäuser,
P. Braun-Munzinger, O. Busch,
A. Castillo, C. Garabatos, G. Hering,
J. Holeczek, A. Maas, S. Sedykh,
A. Marín, D. Miśkowiec, J. Rak,
G. Tsiledakis, H. Sako
GSI Darmstadt, Germany

J. Bielčíková, S. Damjanović, T. Dietel,
L. Dietrich, S. I. Esumi, K. Filimonov,
P. Glässel, W. Ludolphs, J. Milošević,
V. Petráček, W. Schmitz, H. J. Specht,
J. Stachel, H. Tilsner, T. Wienold,
B. Windelband, S. Yurevich
Heidelberg University, Germany
J. P. Wessels
Münster University, Germany

V. Belaga, K. Fomenko, Yu. Panebrattsev,
O. Petchenova, S. Shimansky, V. Yurevich
JINR Dubna, Russia

A. Cherlin, Z. Fraenkel, A. Gnaenski,
A. Milov, I. Ravinovich, I. Tserruya, W. Xie
Weizmann Institute, Rehovot, Israel

A. Drees, F. Messer
SUNY at Stony Brook, U.S.A.

B. Lenkeit, A. Pfeiffer, J. Schukraft
CERN, Geneva, Switzerland

P. Rehak
BNL, Upton, U.S.A.

J. P. Wurm
MPI, Heidelberg, Germany

We would like to acknowledge the support from CERN IT team for data processing.