e^+e^- production from p-Be to Pb-Au

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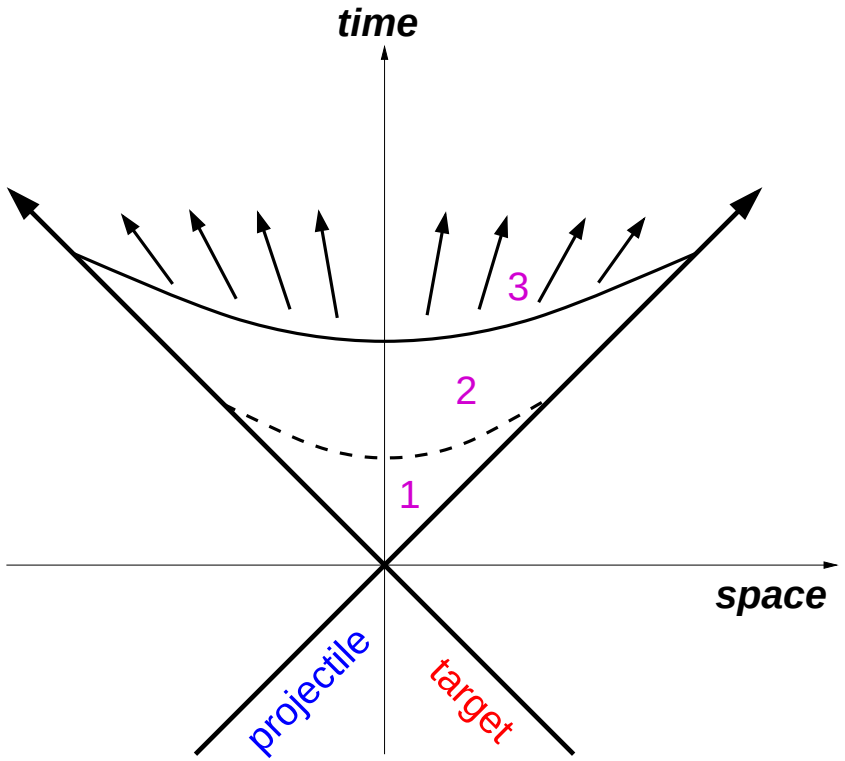
for the

CERES Collaboration

e^+e^- production from p-Be to Pb-Au

- **Introduction**
- **The CERES experiment at the SPS**
- **Electron pair analysis**
- **Recent results from run2000 158 AGeV/c Pb-Au**

Electromagnetic Radiation



1) formation phase

DY, qg…

2) hot and dense medium

thermal radiation,

medium modifications (ρ)…

3) hadron decays

π^0,η,ω,ϕ..

Penetrating probes

…but $\alpha^2 \sim 10^{-5}$

1) and 3) also in pp, new physics in 2)

Dilepton mass spectrum (schematic)

NA50, NA60 (μ pairs):

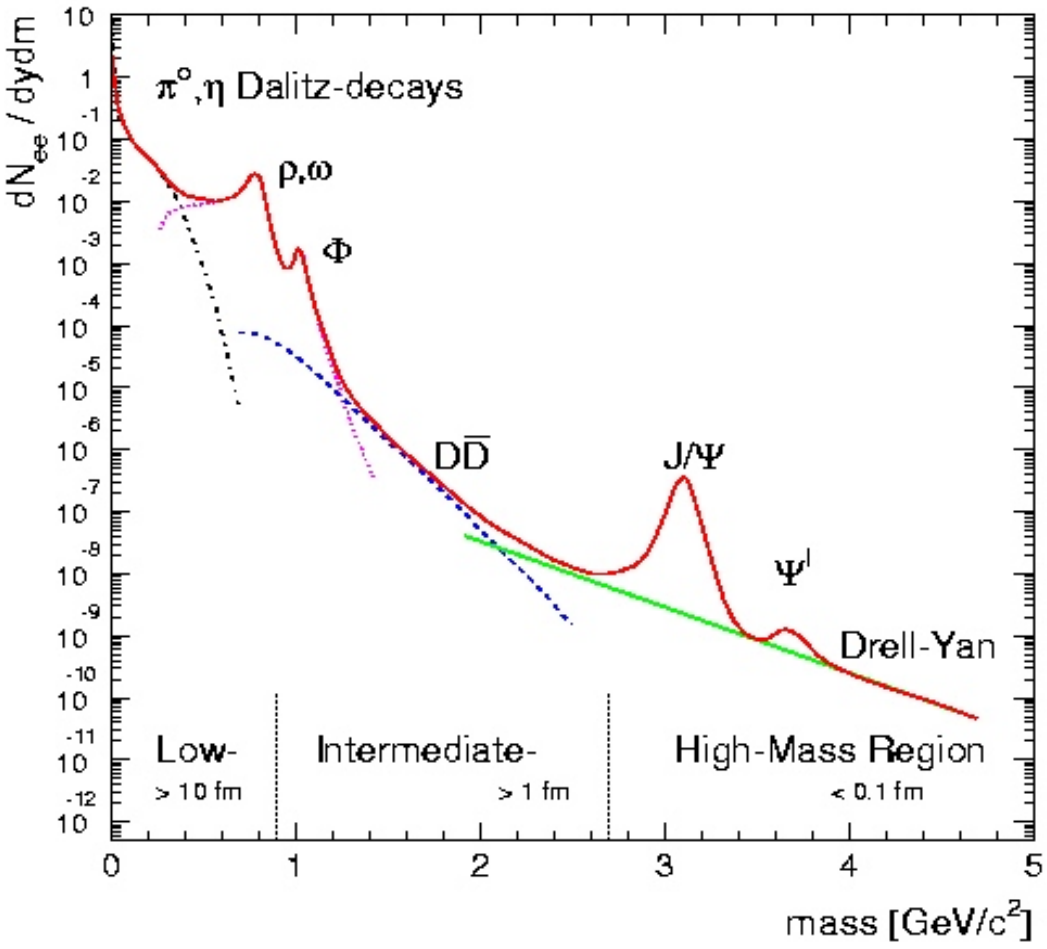
HMR and IMR:

- **J/ψ suppression**
- **open charm enhancement…**
- **NA60: + low mass**

CERES (*e* pairs):

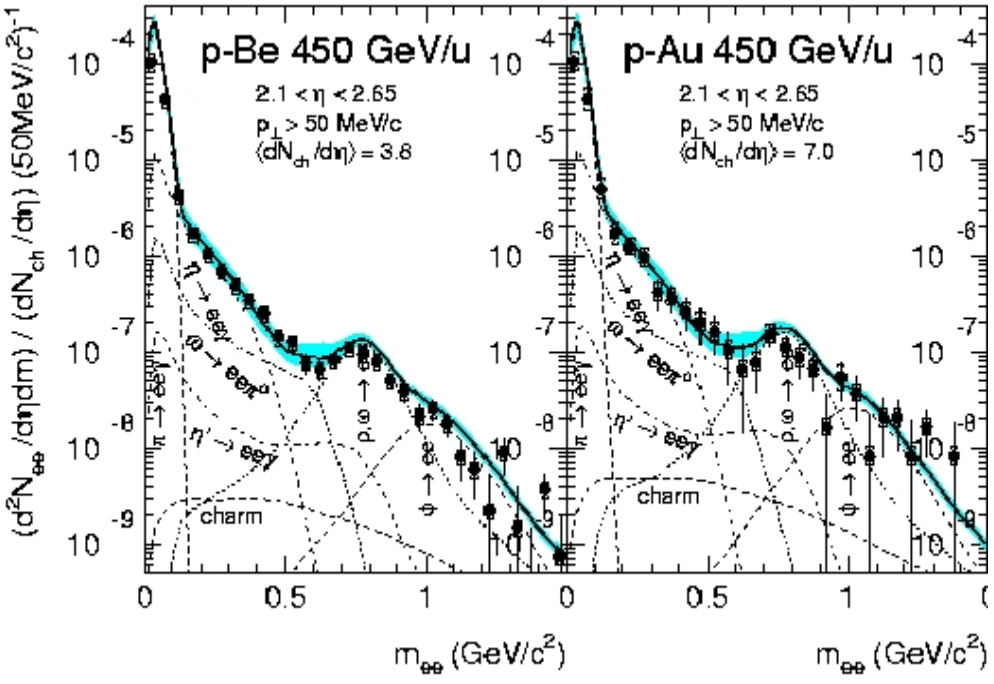
Low mass region, ρ,ω,ϕ:

- **chiral symmetry restoration**
- **thermal radiation…**



CERES history

Eur.Phys.J. C4 (1998) 231, 249



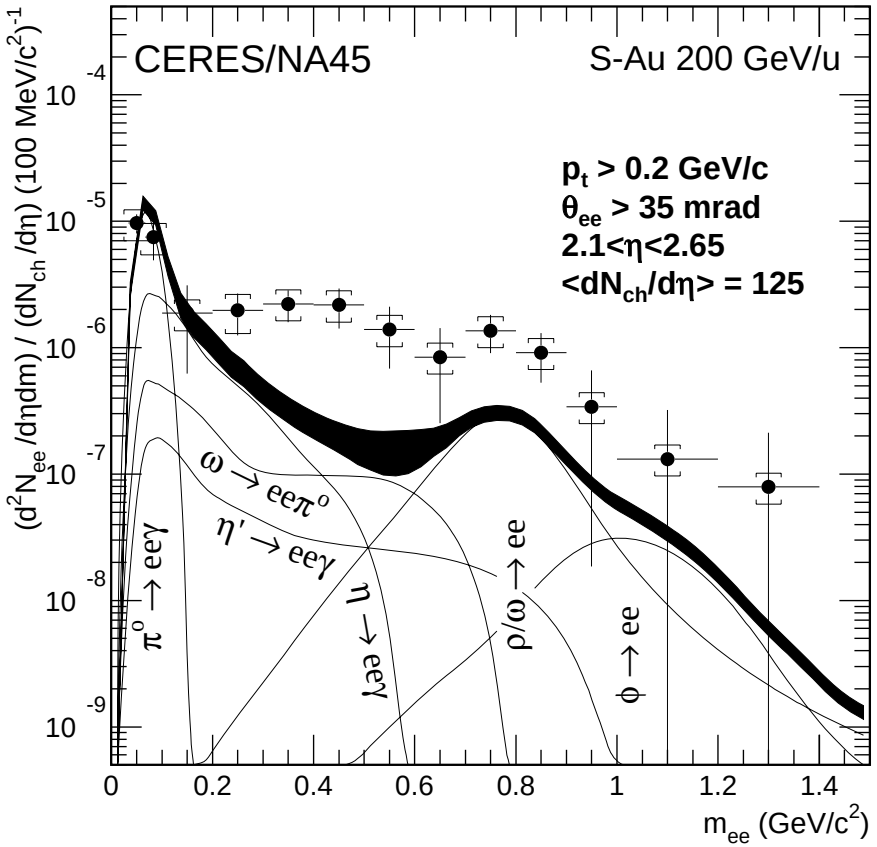
p-induced reactions:

- **consistent with expectations from known hadronic sources**
- **the *hadronic cocktail:***

  our best knowledge of cross sections, form factors, branching ratios…
  in the absence of new physics,
  folded with detector acceptance and resolution

CERES history

Phys. Rev. Lett. 75 (1995) 1272

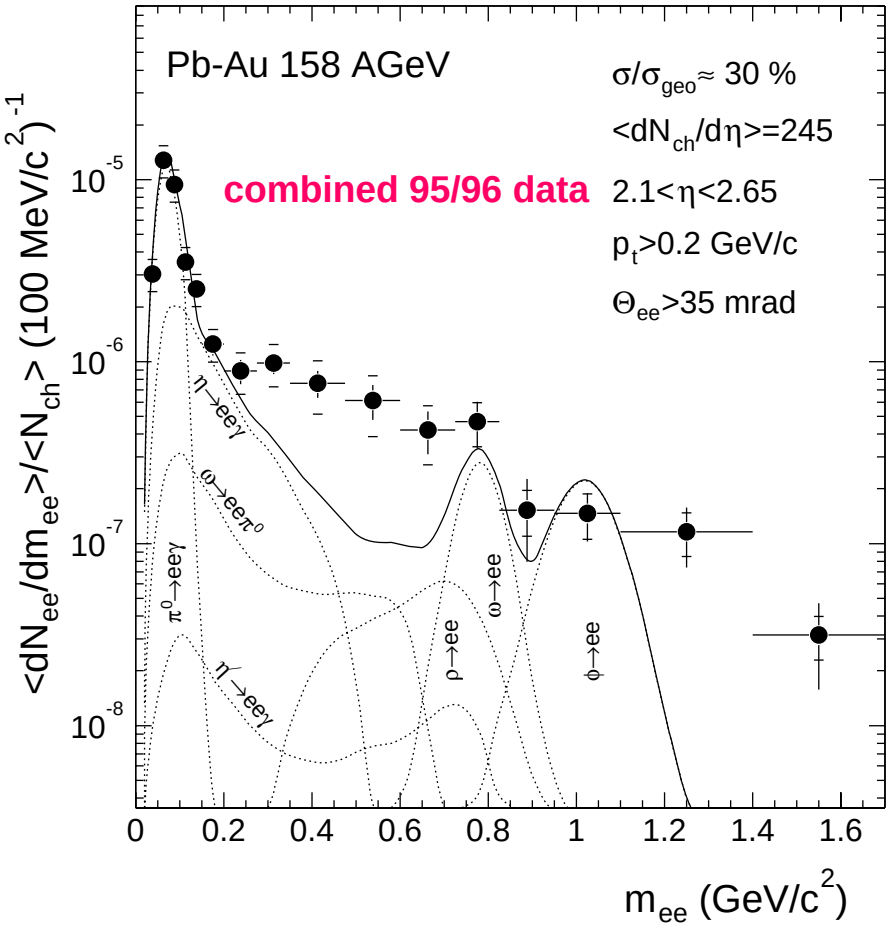


HI-induced reactions:

- **significant enhancement in the low mass region**
- ***E* = 5.0 +/- 0.7(*stat*) +/- 2.0 (*syst*) for m_{ee}>0.2 GeV/c^2**

CERES history

CERES coll. NPA 661(1999),
PLB 422(1998), NPA 715 (2003)



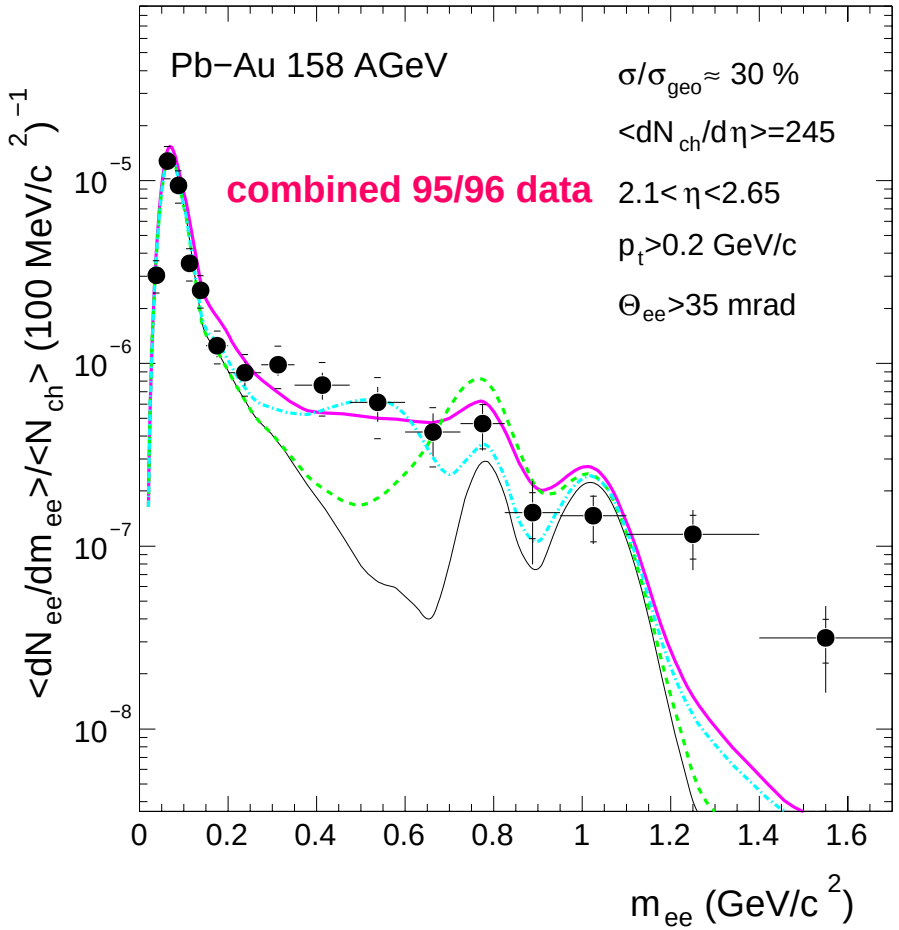
Pb-Au at 158 AGeV/c:

- ***E* = 2.4 +/- 0.2(*stat*) +/- 0.6(*syst*)**
  for m_{ee}>0.2 GeV/c^2

w.r.t. *HI-cocktail*

thermal particle yields *(φ!)* and mass dependence of flow

CERES history



Pb-Au at 158 AGeV/c:

enhanced vacuum-ρ due to ππ-annihilation

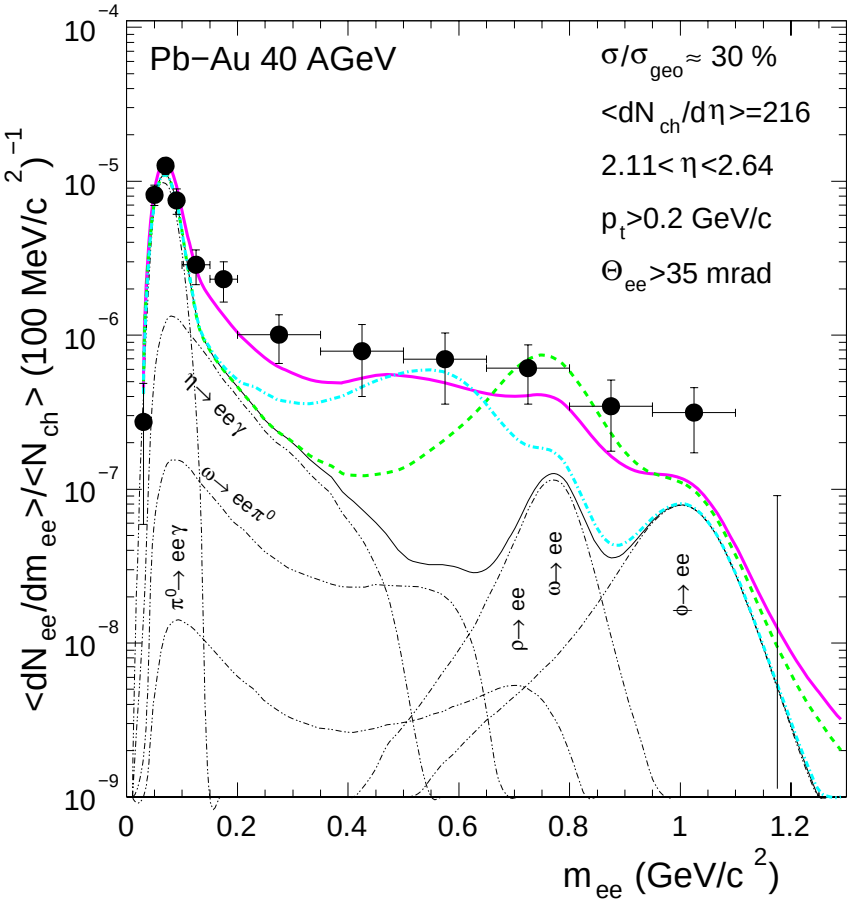
modified ρ-spectral function

Brown-Rho scaling

calculations: R. Rapp

CERES history

CERES coll. PRL 91 (2003) 042301



with TPC (Run1999):

Pb-Au at 40 AGeV/c

***E* = 5.9 +/- 1.5 (*stat*) +/- 1.2 (*syst*)+/- 1.8 (*decays*)**

for m_{ee}> 0.2 GeV/c^2

enhanced vacuum-ρ due to ππ-annihilation

modified ρ-spectral function

Brown-Rho scaling

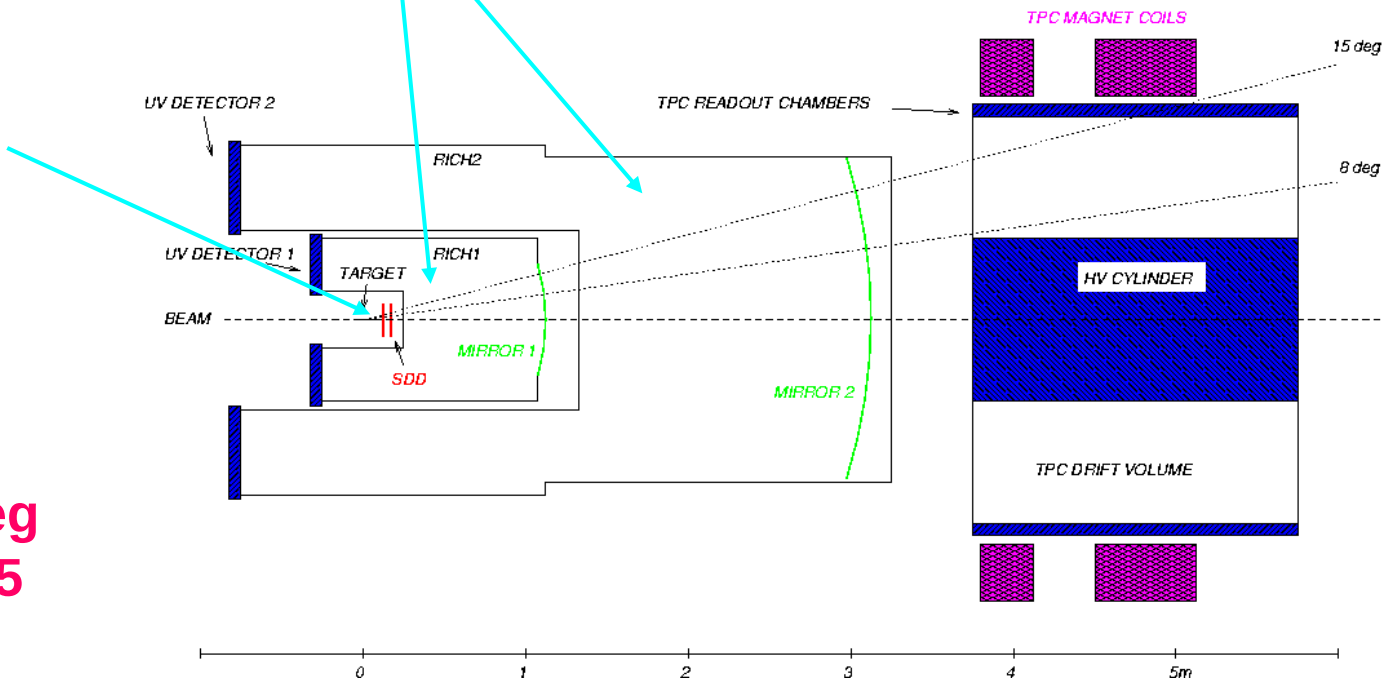
T vs. μ_B effects?

The upgraded CERES experiment

Radial TPC

RICHes

Silicon Drift Detectors

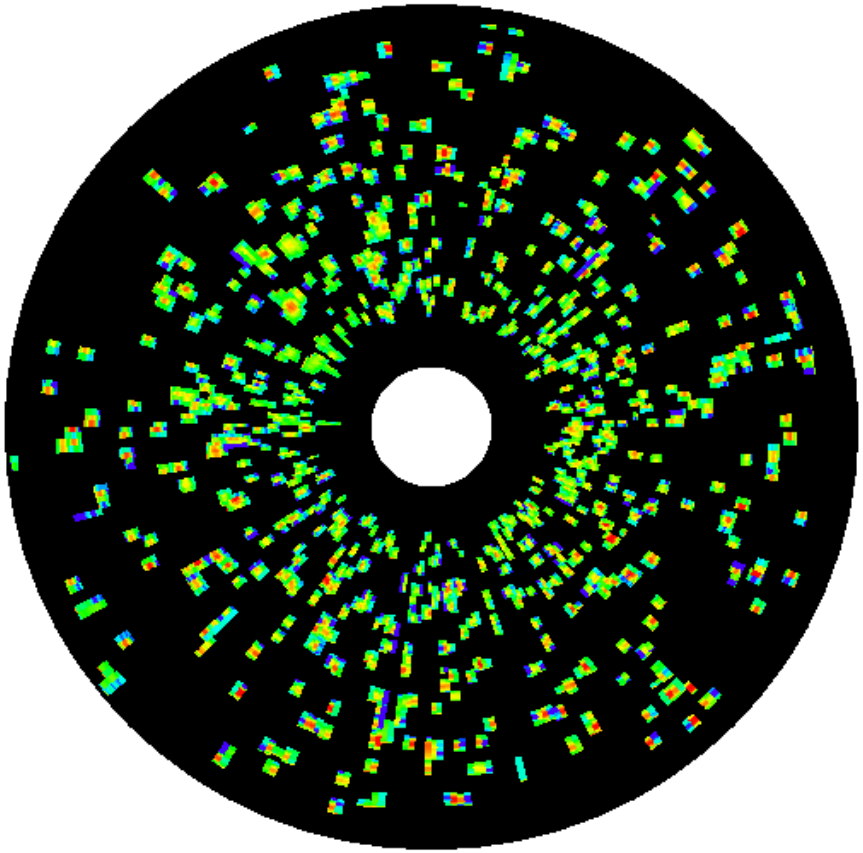


acceptance:

$8 < \theta < 15$ deg

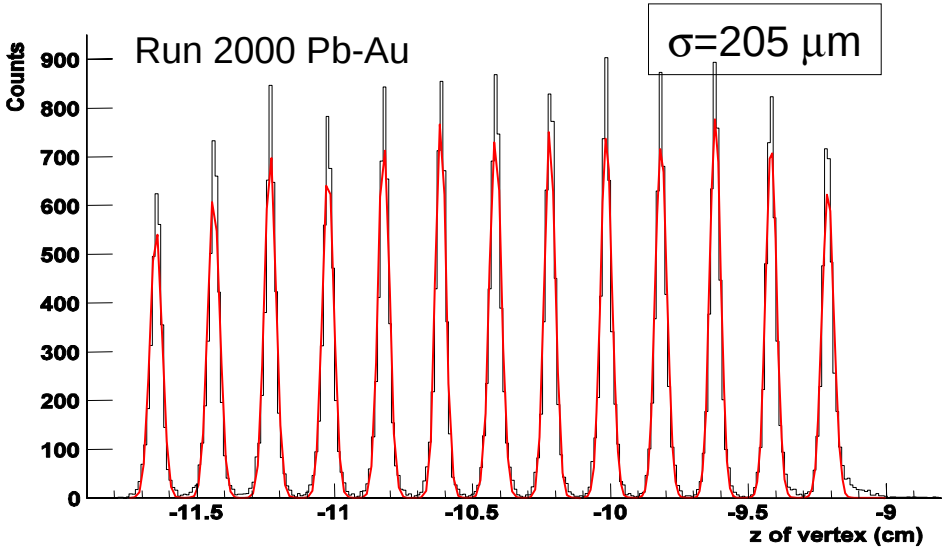
$2.1 < \eta < 2.65$

Silicon Drift Detectors

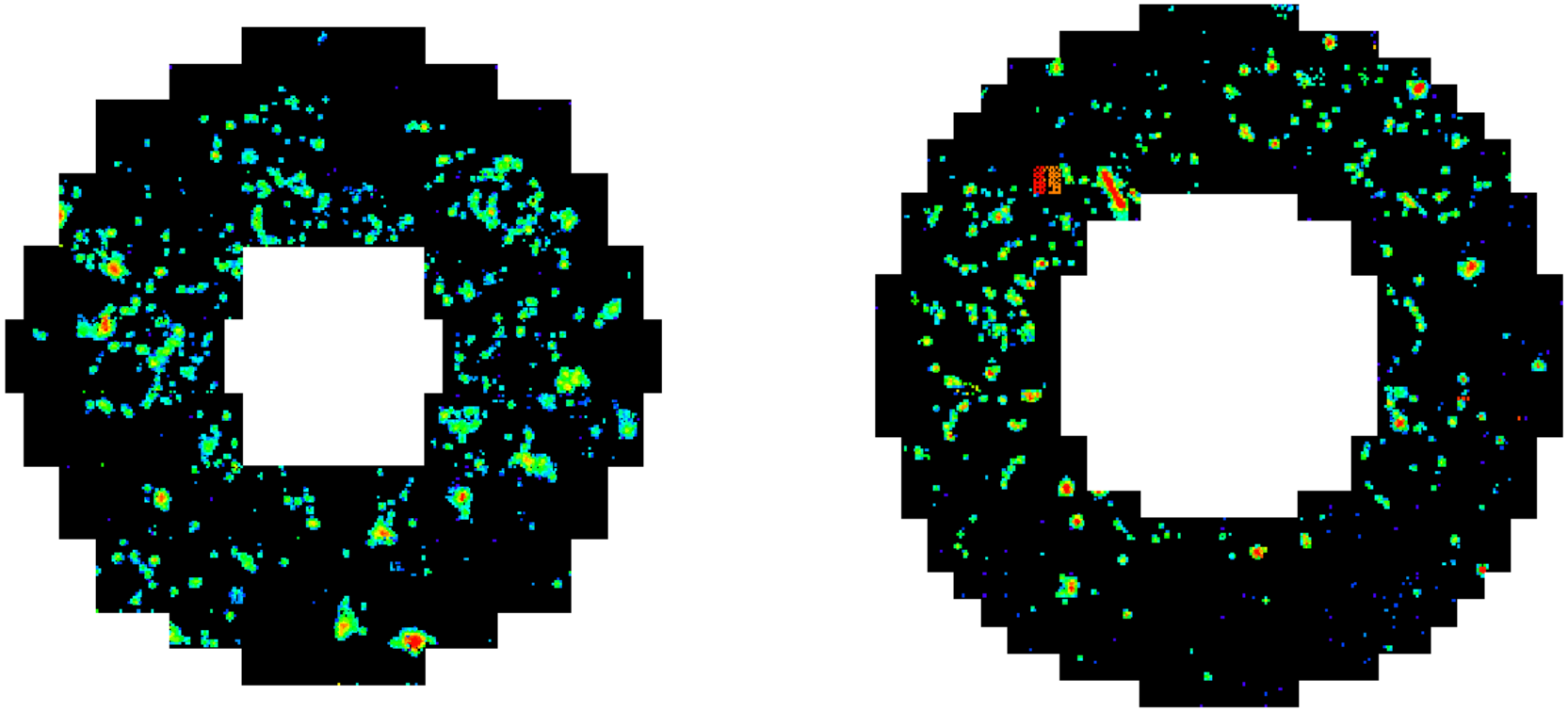


SDD1 and SDD2:

- **charged particle tracking**
- **vertex reconstruction**



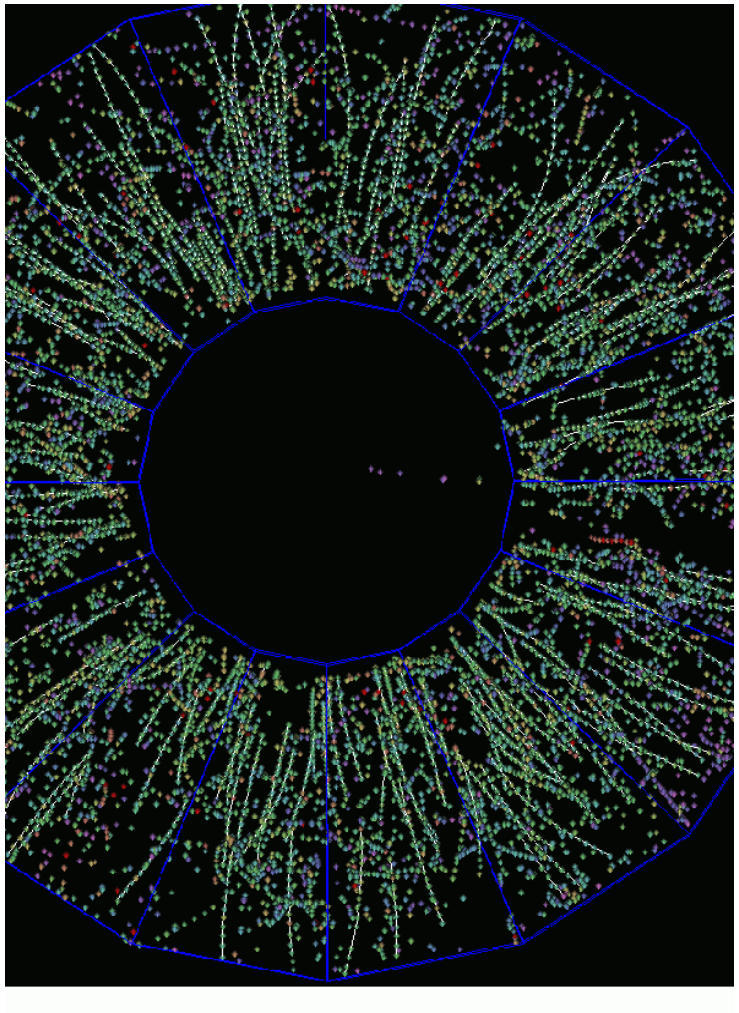
RICH



RICH1 and RICH2: electron ID via ring signature

field-free operation allows combined mode

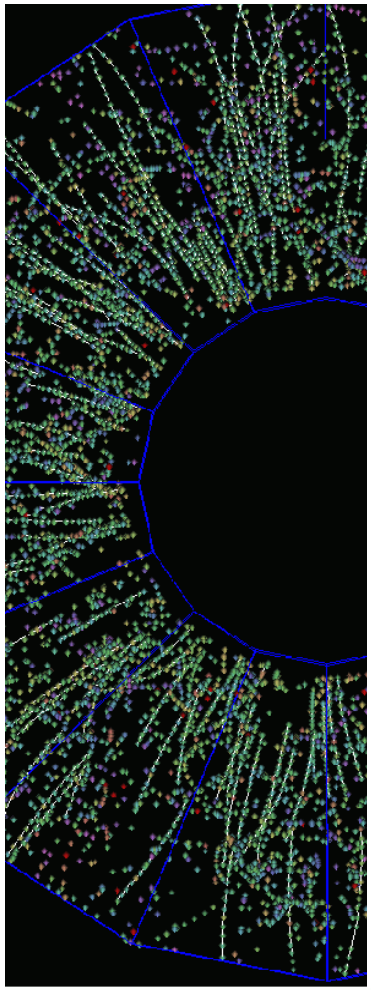
Time Projection Chamber



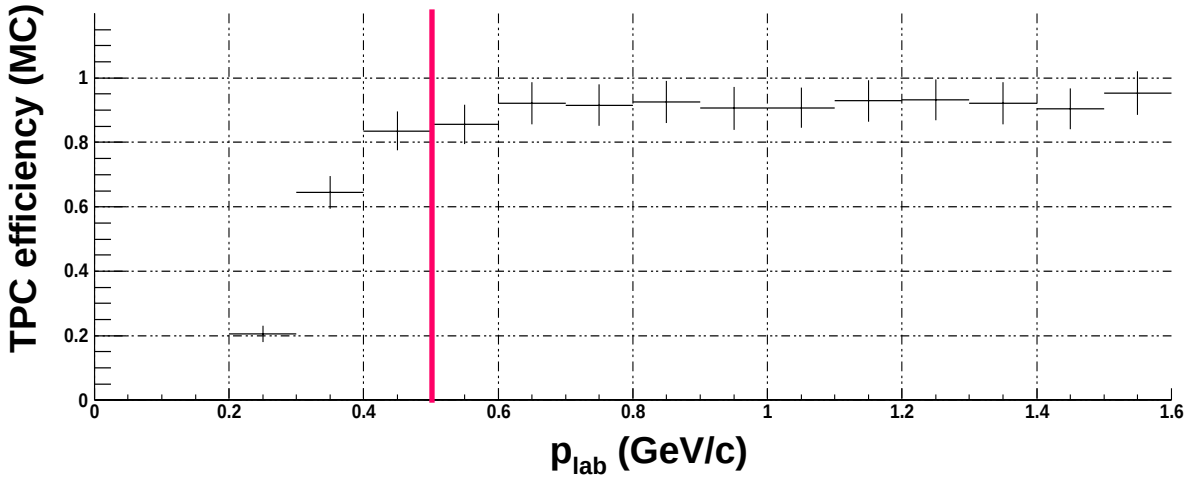
radial TPC:

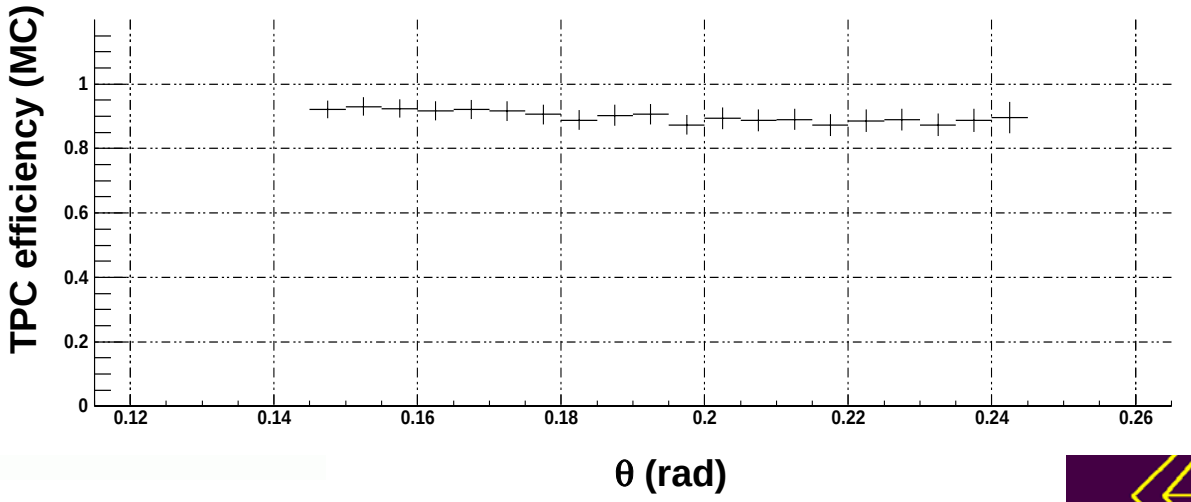
- **charged particle tracking**
- **momentum determination**
- **electron ID via dE/dx**

TPC tracking efficiency

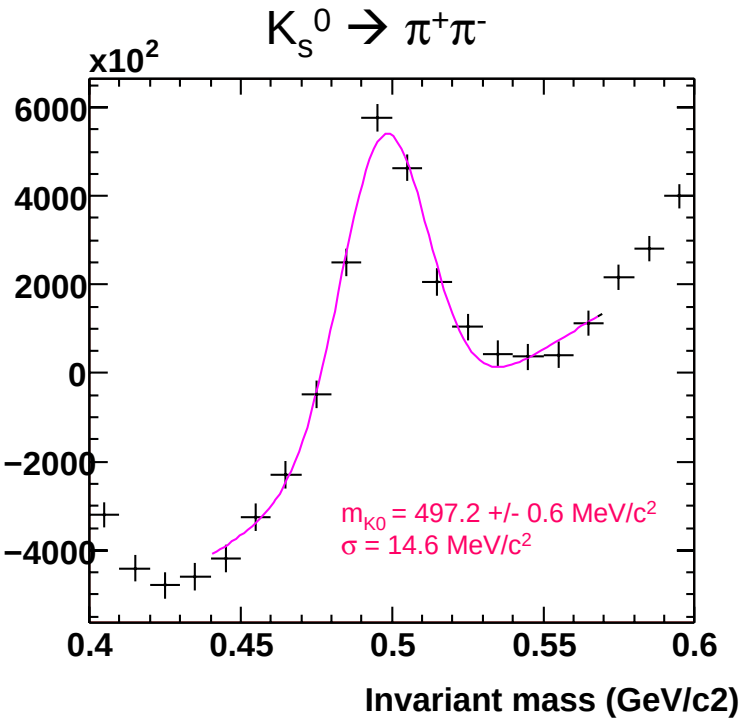


p_t ~ 0.1 GeV/c





Momentum and mass resolution



mass resolution ~4% at ϕ

Electron pair analysis

Data set from Run 2000:

Pb-Au 80 AGeV/c σ/σ_{geo}= 30% 0.5M Events

Pb-Au 158 AGeV/c σ/σ_{geo}= 30% 3.0M Events

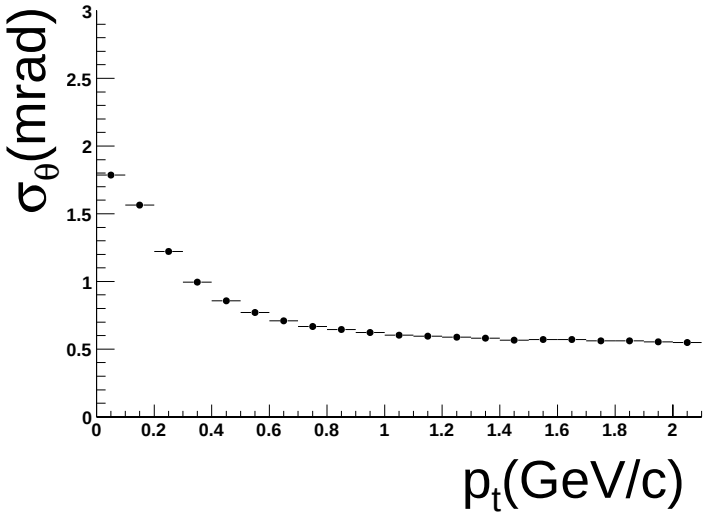
Pb-Au 158 AGeV/c σ/σ_{geo}= 8% 30.0M Events

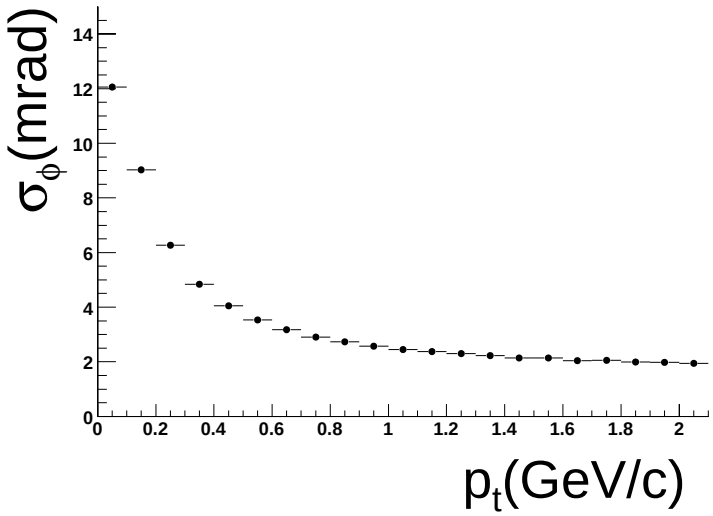
Electron pair analysis

1. **charged particle tracking**
2. **electron identification**
3. **rejection of combinatorial background**

Charged particle tracking

Angular matching of TPC and SDD tracks





vertex condition suppresses late conversions

Charged particle tracking

Angular matching of TPC and SDD tracks

→ Study of hadronic observables:

$\phi \rightarrow KK$, $\Lambda \rightarrow p\pi$, $K^0 \rightarrow$ …

$D \rightarrow K\pi$, $\rho \rightarrow \pi\pi$

HBT

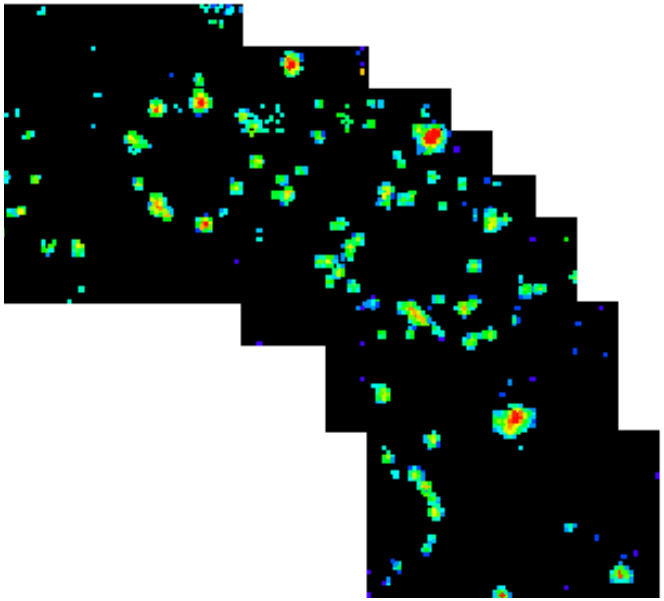
event-by-e… …ations

azimu… …opies

NOT IN THIS TALK!!!

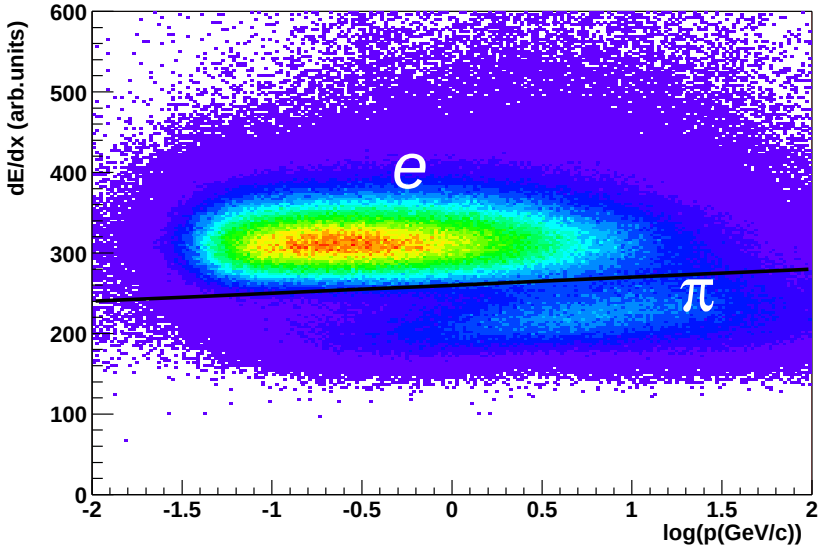
Electron identification

Ring signature in RICH:



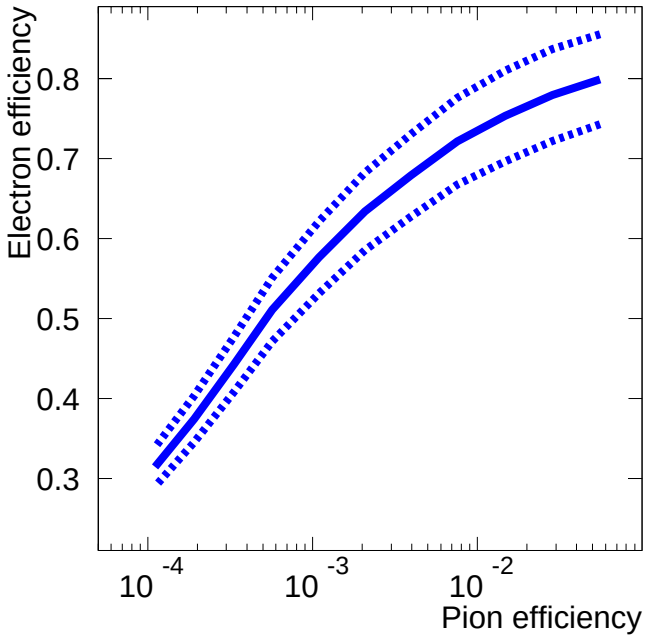
Energy loss dE/dx in TPC:

$\sigma(dE/dx) / (dE/dx) = 10\%$

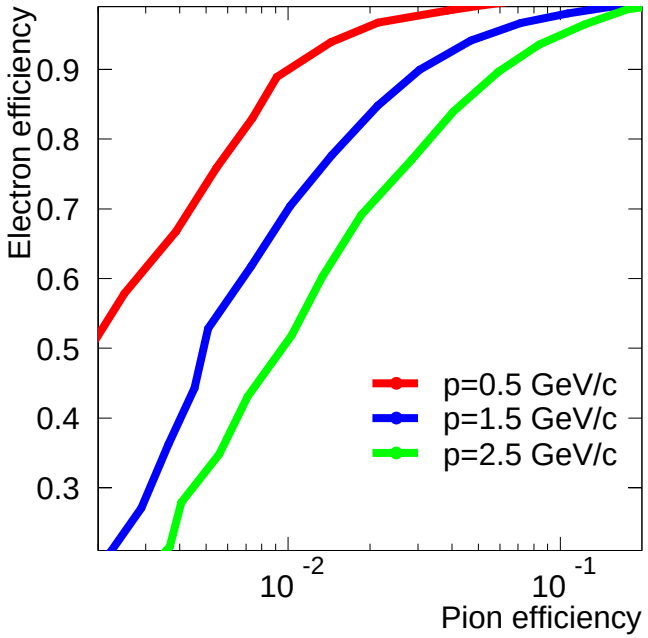


Electron identification

RICH



TPC



e.g. at 1.5 GeV/c: 0.03 (TPC) x 0.003 (RICH) = 10^{-4} π-efficiency
at 0.9 (TPC) x 0.65 (RICH) = 60% e-efficiency

Background rejection

Dominant sources are π^0-Dalitz and γ-conversions

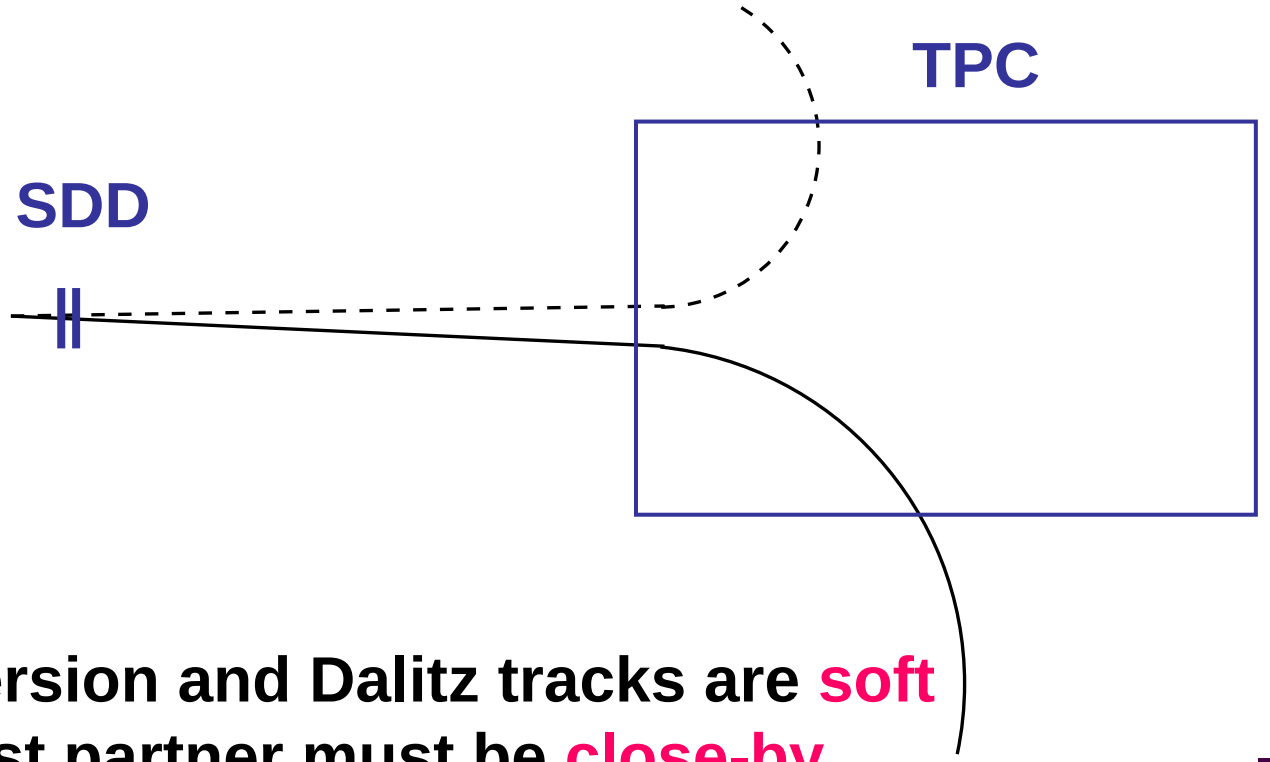
1. Dalitz recognition:

- **Rejection of tracks which form a pair $\Theta_{ee} < 35$ mrad**
- **Tracks which form a pair $m_{ee} < 0.2$ GeV/c^2 excluded from further pairing**

…still a large number of tracks remaining from unrecognized π^0-Dalitz pairs and γ-conversions!

Background rejection

2. on the remaining tracks: kinematical and topological cuts



- **conversion and Dalitz tracks are soft**
- **the lost partner must be close-by**

Background rejection

2. on the remaining tracks: kinematical and topological cuts

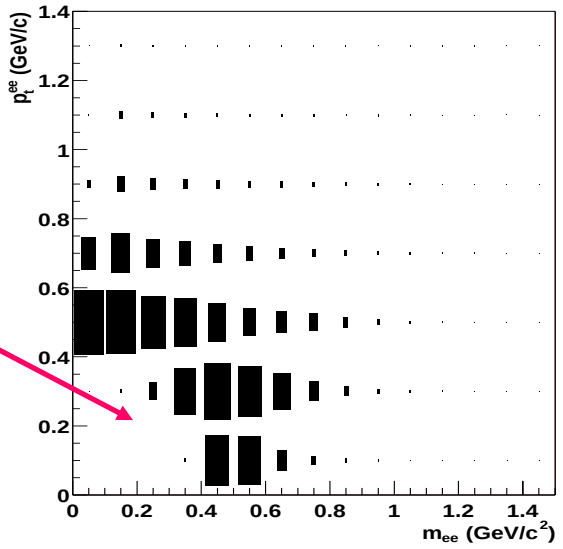
- **p_t-cut: limits acceptance at low mass and pair p_t**

traditional: p_t>0.2 GeV/c

→ $m_{t,ee}$ > 0.4 GeV

better: p_t>0.1 GeV/c

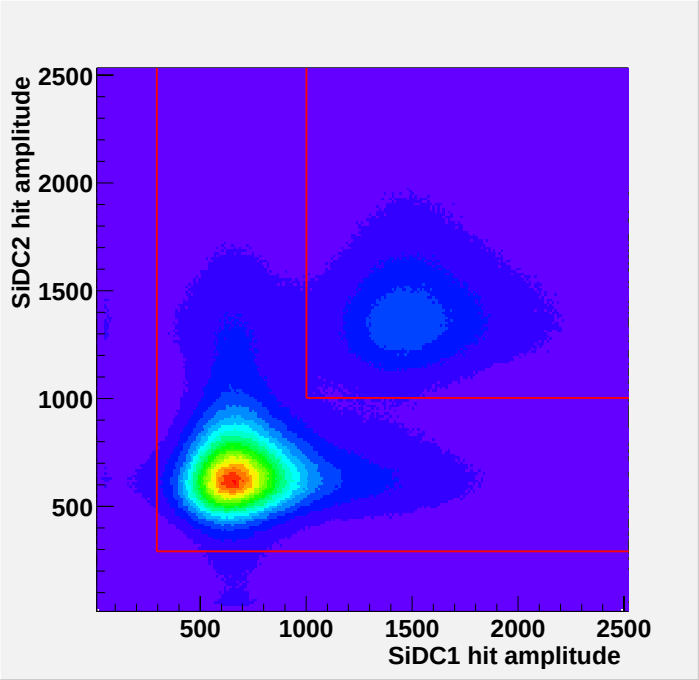
→ $m_{t,ee}$ > 0.2 GeV



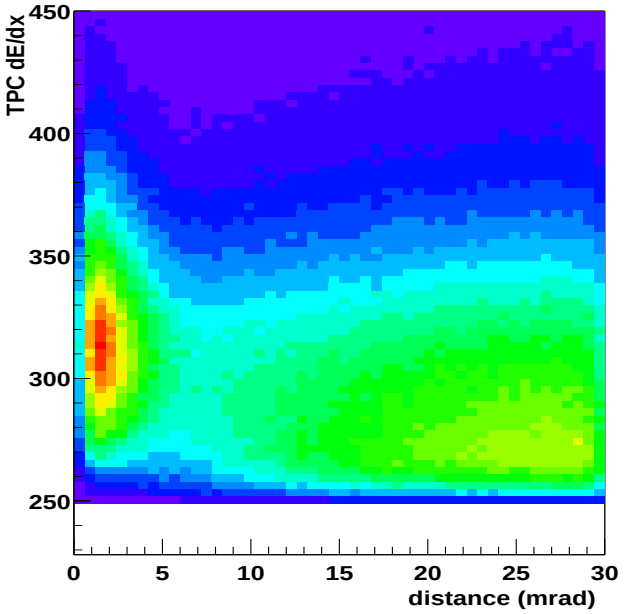
Background rejection

2. on the remaining tracks: kinematical and topological cuts

- **energy loss in SDD:**

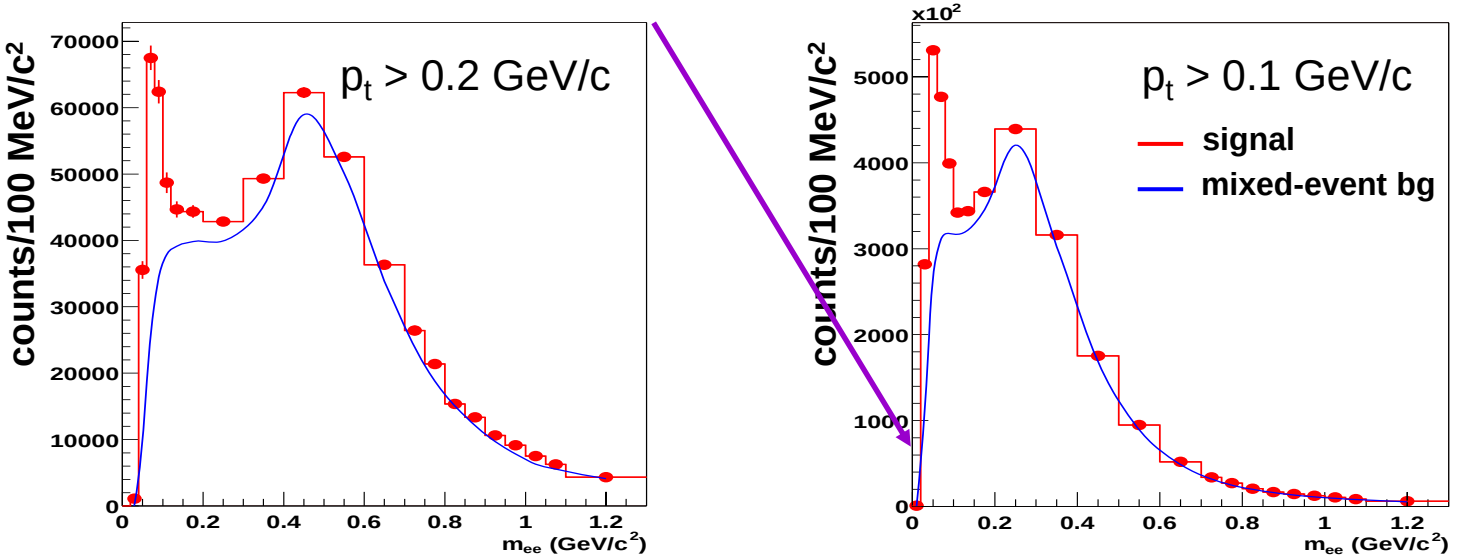


- **V-track signature in TPC:**



Invariant mass distributions

~1.8x10^7 Pb-Au events at 158 AGeV/c:



p_t>0.2 GeV/c

m_{ee}<0.2 GeV/c^2:

S = 2844+/- 113, B/S = 1.8

m_{ee}>0.2 GeV/c^2:

S = 2174+/-182, B/S = 13

p_t>0.1 GeV/c

m_{ee}<0.2 GeV/c^2:

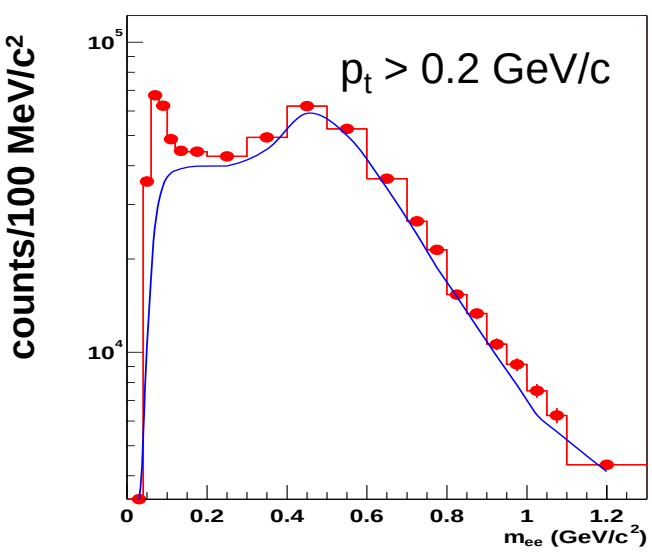
S = 18030+/-347, B/S = 2.8

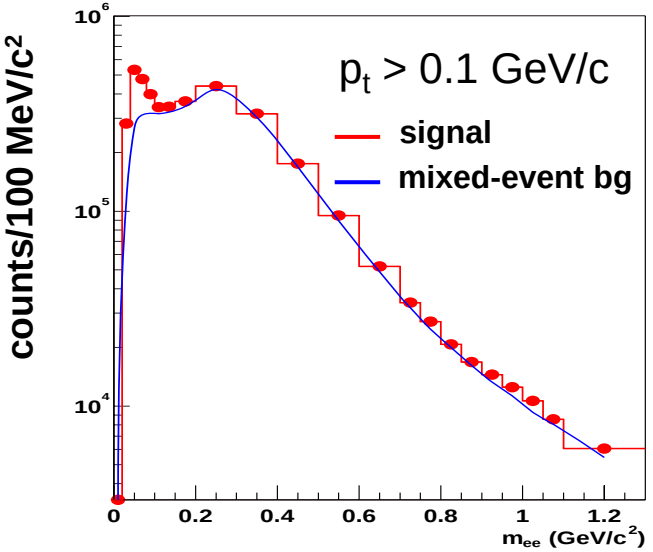
m_{ee}>0.2 GeV/c^2:

S = 5511+/-351, B/S = 20

Invariant mass distributions

~1.8x10^7 Pb-Au events at 158 AGeV/c:





p_t>0.2 GeV/c

m_{ee}<0.2 GeV/c^2:
S = 2844+/- 113, B/S = 1.8

m_{ee}>0.2 GeV/c^2:
S = 2174+/-182, B/S = 13

p_t>0.1 GeV/c

m_{ee}<0.2 GeV/c^2:
S = 18030+/-347, B/S = 2.8

m_{ee}>0.2 GeV/c^2:
S = 5511+/-351, B/S = 20

Electron pair analysis

Signal *S:*

- **combination of unlike-sign pairs from the same event**

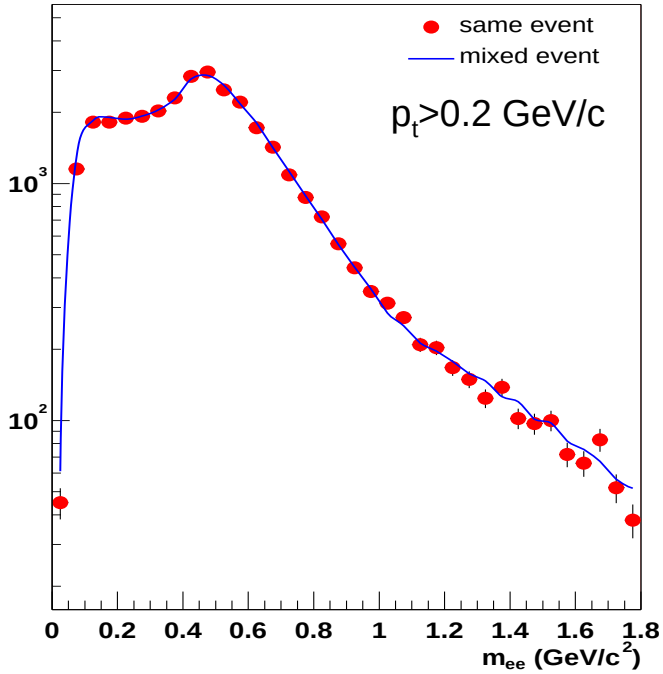
Background *B:*

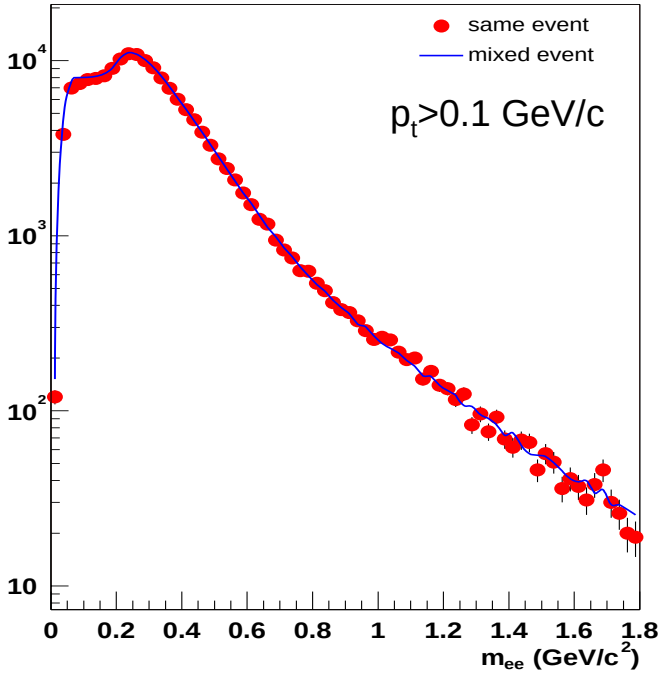
- **like-sign combinations from the same event**
  - **(+) same-event correlations (partially) contained**
  - **(–) if not S>>B, finite statistics contributes**

- **unlike-sign (or like-sign) combinations from mixed events**
  - **(+) no statistical limitation**
  - **(–) normalization, no correlation**

Electron pair analysis

combinatorial background





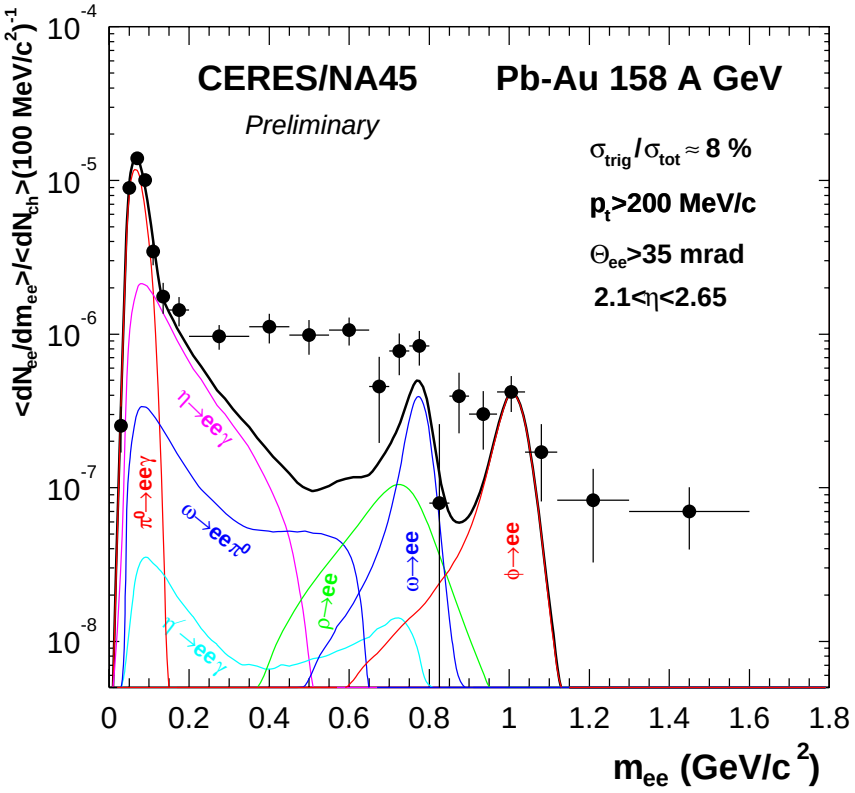
for subtraction:

same-event BG for m_{ee}< 0.2 GeV/c

normalized mixed-event BG for m_{ee}> 0.2 GeV/c

Mass spectrum

Run 2000 Pb-Au 158 AGeV/c:



A.Marin (QM04) J.Phys.G30 (2004)

- mixed-event background
- normalization to cocktail at π^0-Dalitz

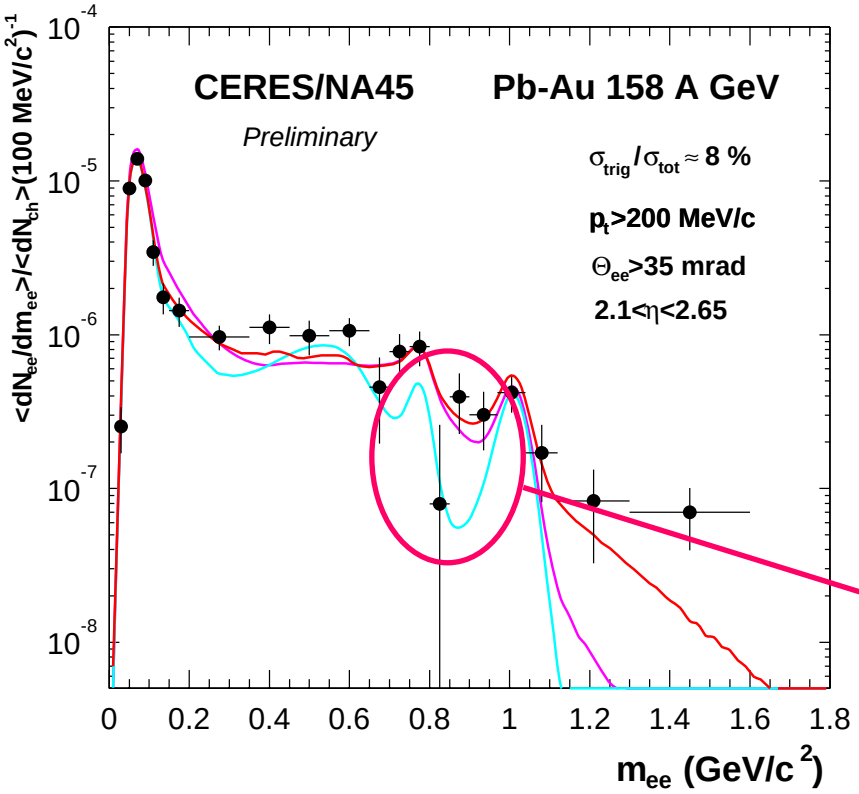
Enhancement for m_{ee}>0.2 GeV/c^2:

***E* = 3.3 +/- 0.3 (*stat*)**

…no systematic errors yet!

Mass spectrum

Run 2000 Pb-Au 158 AGeV/c:



modified ρ-spectral function (Rapp, Wambach)

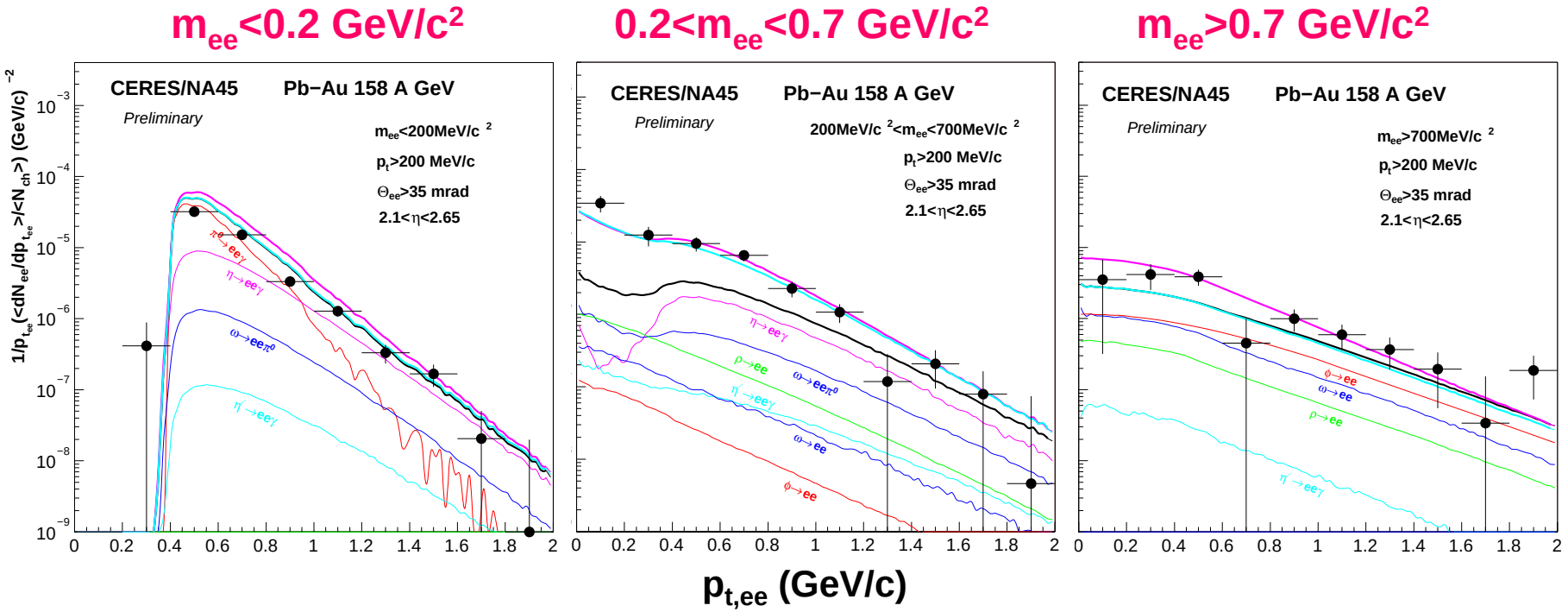
Brown-Rho scaling

thermal radiation (Kämpfer et al.)

discrimination soon possible

A.Marin (QM04) J.Phys.G30 (2004)

Transverse momentum spectra



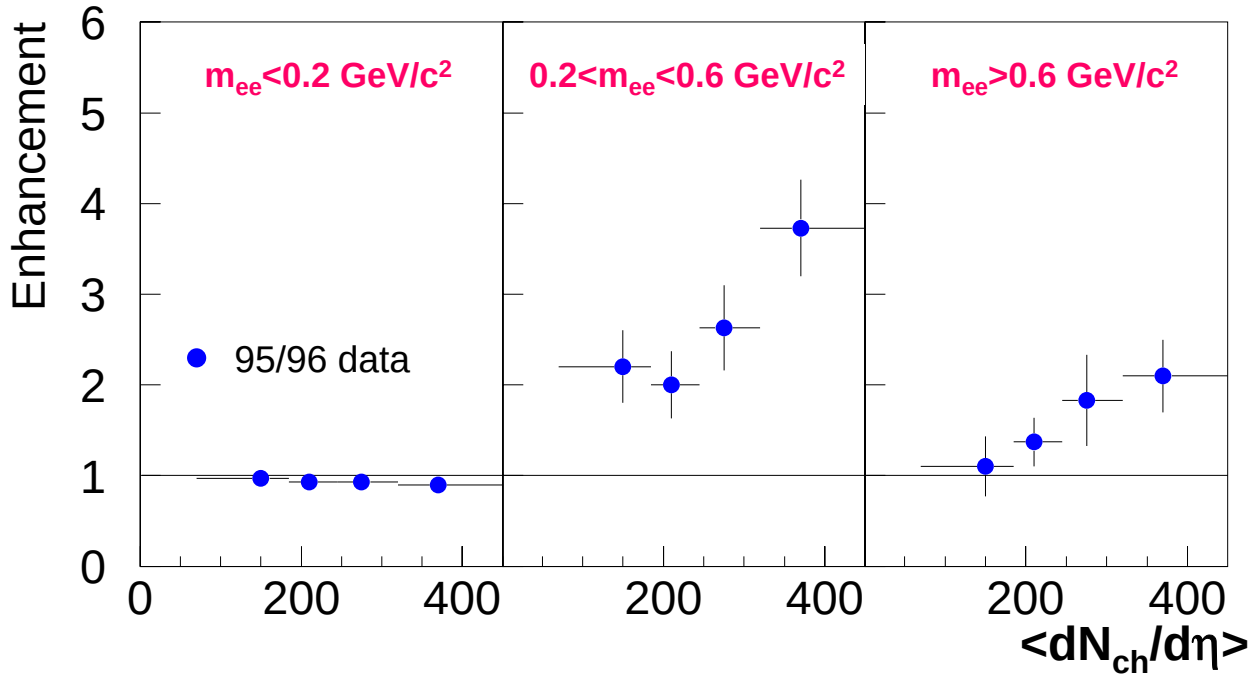
S. Yurevitch, PhD in preparation

modified ρ-spectral function

Brown-Rho scaling

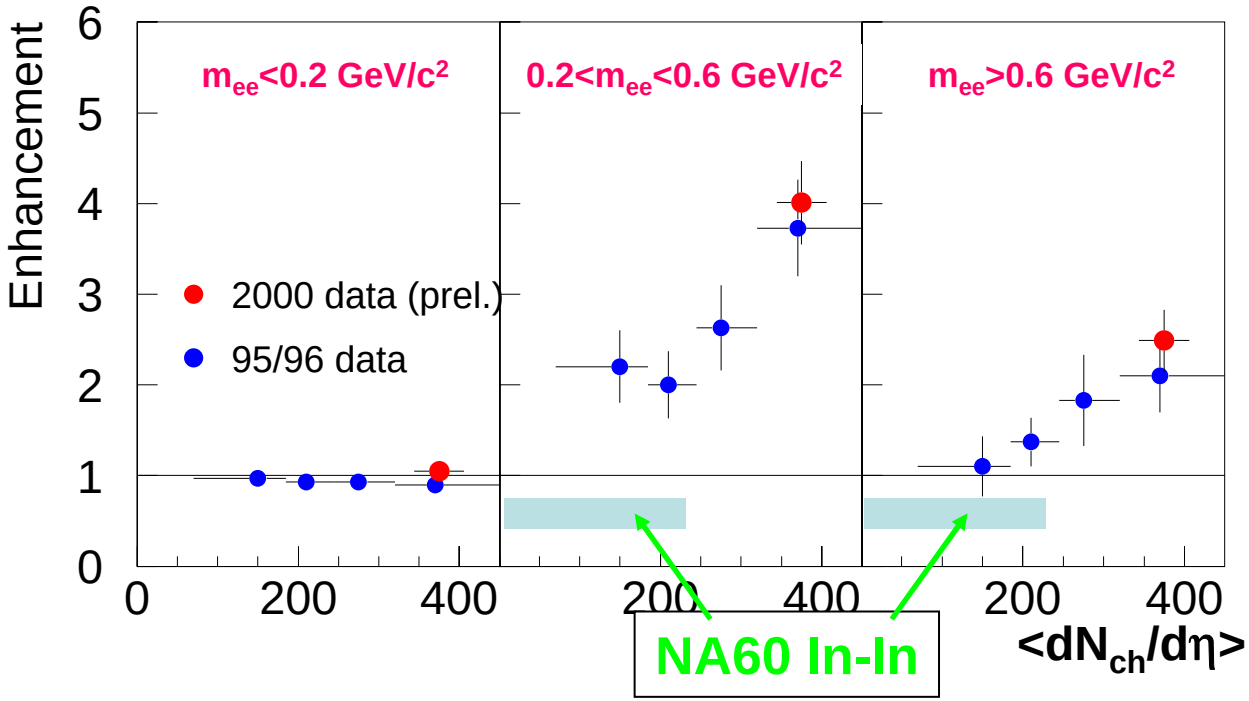
- **enhancement located at low pt (known from 95/96)**

Centrality dependence



- **pair yield increases stronger than linear with <N_{part}>**

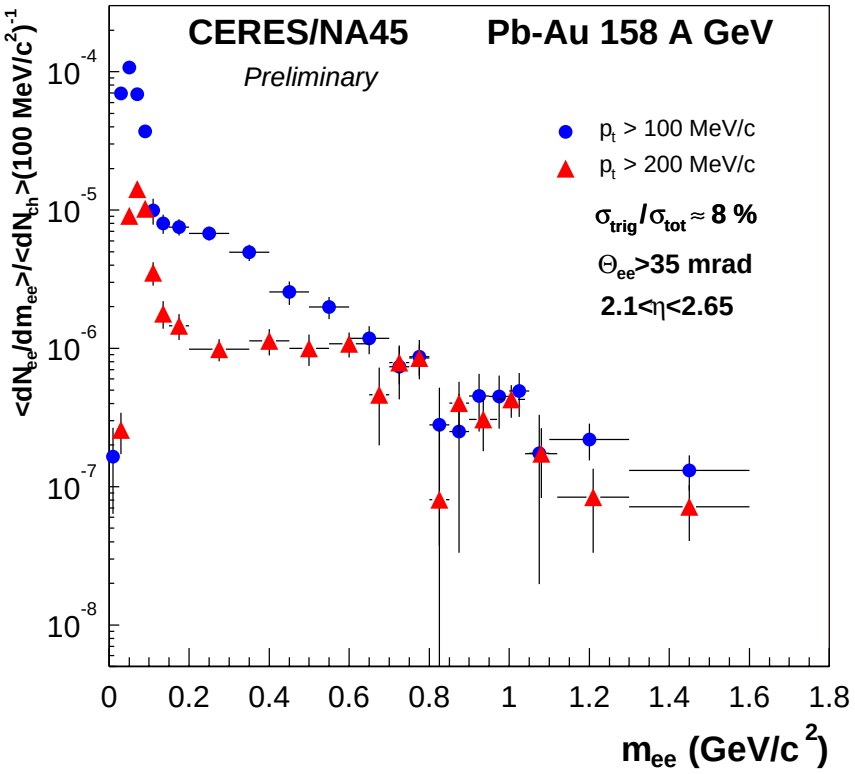
Centrality dependence



- **pair yield increases stronger than linear with <N_{part}>**
- **most central point confirmed by 2000 data**

p_t>0.1 GeV/c mass spectrum

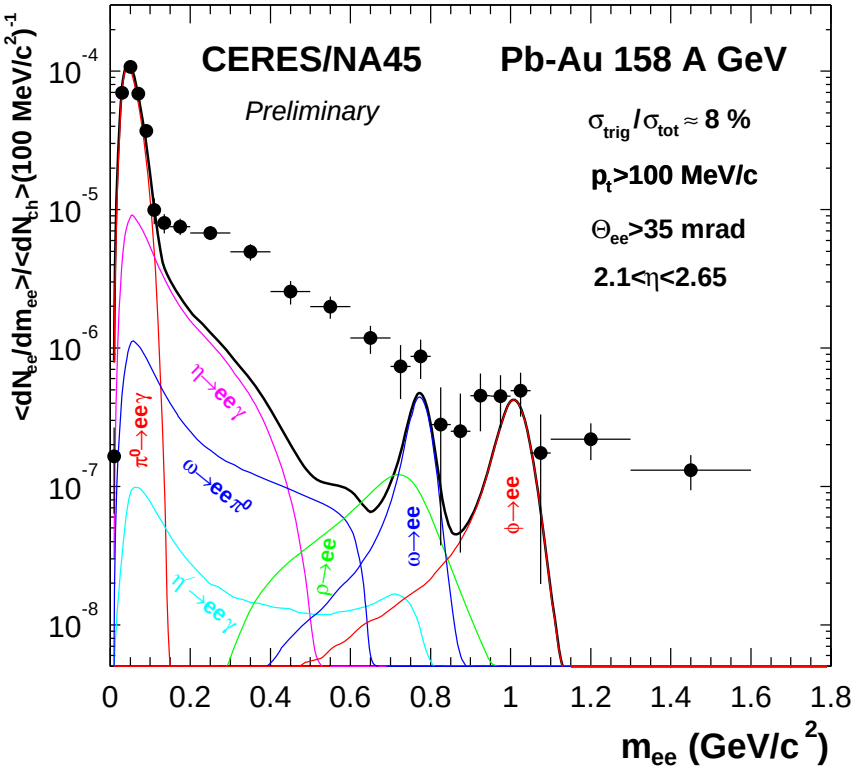
Run 2000 Pb-Au 158 AGeV/c:



- **both spectra normalized to π^0-Dalitz**
- **spectra agree for m_{ee}>0.7 GeV/c^2**
- **p_t > 0.1 GeV/c adds sensitivity to low masses and pair p_t (m_t>0.2 GeV)**

Mass spectrum and hadronic cocktail

Run 2000 Pb-Au 158 AGeV/c:



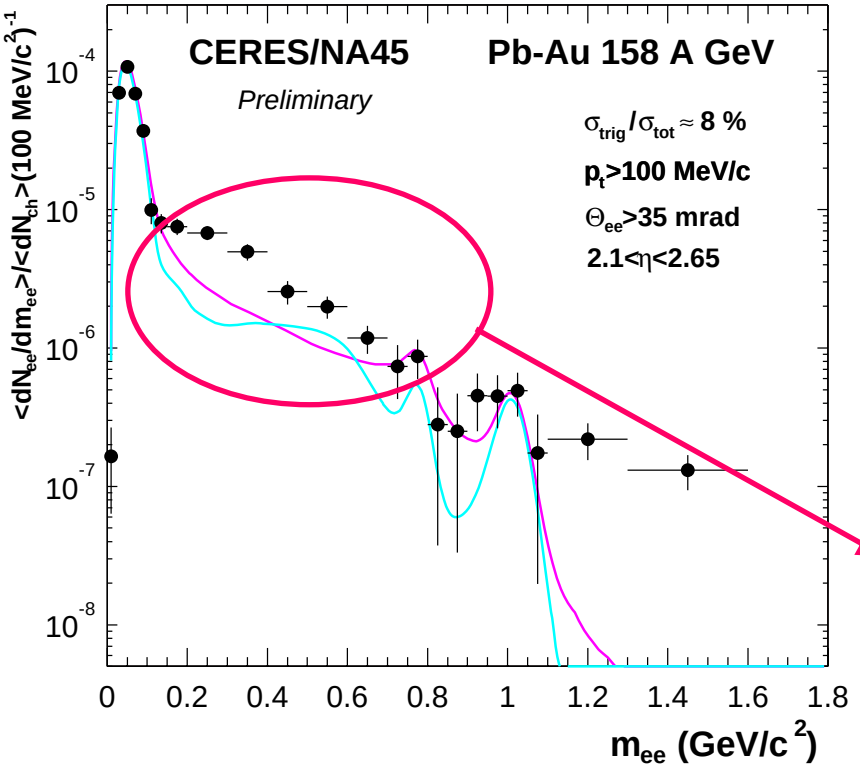
S. Yurevitch, PhD in prep.

with p_t>0.1 GeV/c selection:

- **Enhancement extends to π^0-peak**
- ***E* = 5.6 +/- 0.4 (*stat*)**
  for m>0.2 GeV/c^2

Mass spectrum and models

Run 2000 Pb-Au 158 AGeV/c:



modified ρ-spectral function

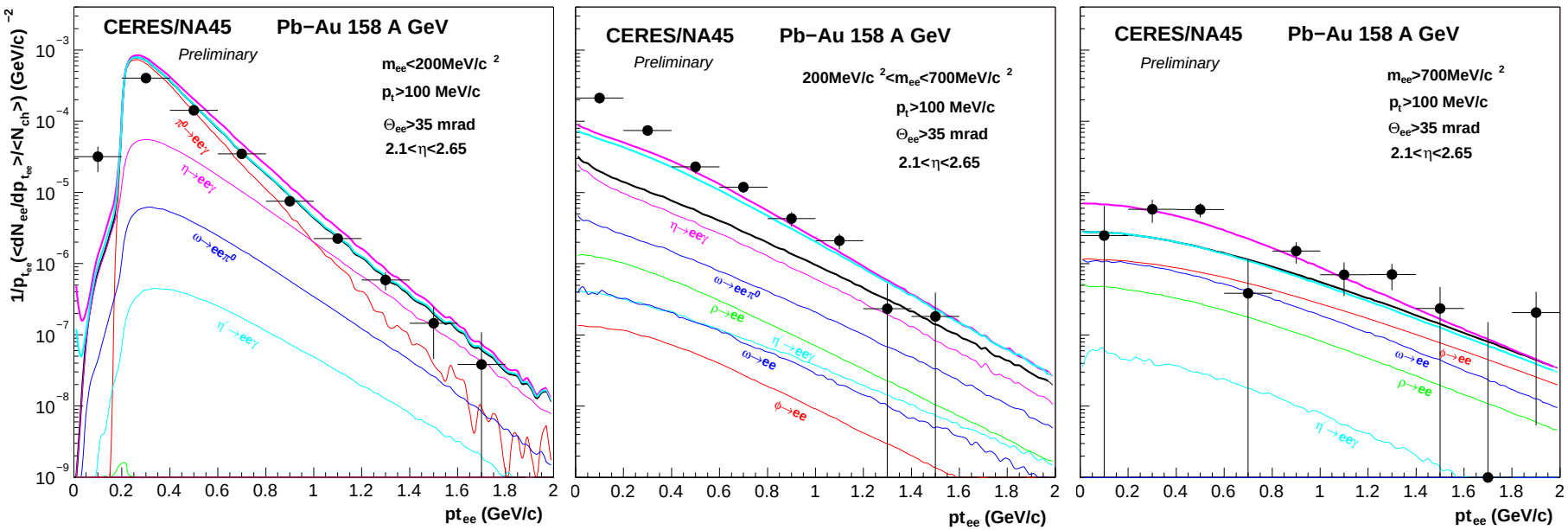
Brown-Rho scaling

Low-mass enhancement over models?

S. Yurevitch, PhD in prep.

Transverse momentum spectra

m_{ee}<0.2 GeV/c^2 | 0.2<m_{ee}<0.7 GeV/c^2 | m_{ee}>0.7 GeV/c^2



modified ρ-spectral function

Brown-Rho scaling

S. Yurevitch, PhD in preparation

- **Enhancement located at low p_t**
- **Larger enhancement due to improved low p_t acceptance**

Summary and outlook

- **preliminary results of e+e- production in 158 AGeV/c Pb-Au from run2000 have been presented**
- **low mass enhancement with p_t>0.2 GeV/c consistent with highest centrality in 95/96**
- **larger enhancement observed with p_t>0.1 GeV/c selection**
- **new data production just finished – larger significance expected (ρ/ω, ϕ)**
- **evaluation of efficiency and systematic errors**

CERES Collaboration

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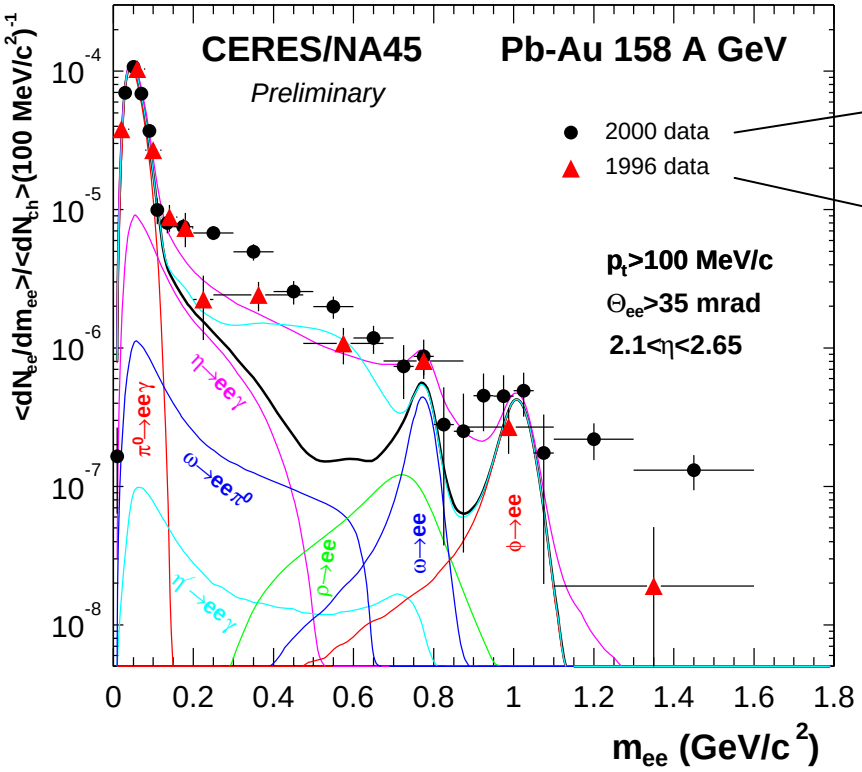
Mass spectrum

Comparison to 96 data:



σ/σ_{tot} = 8%

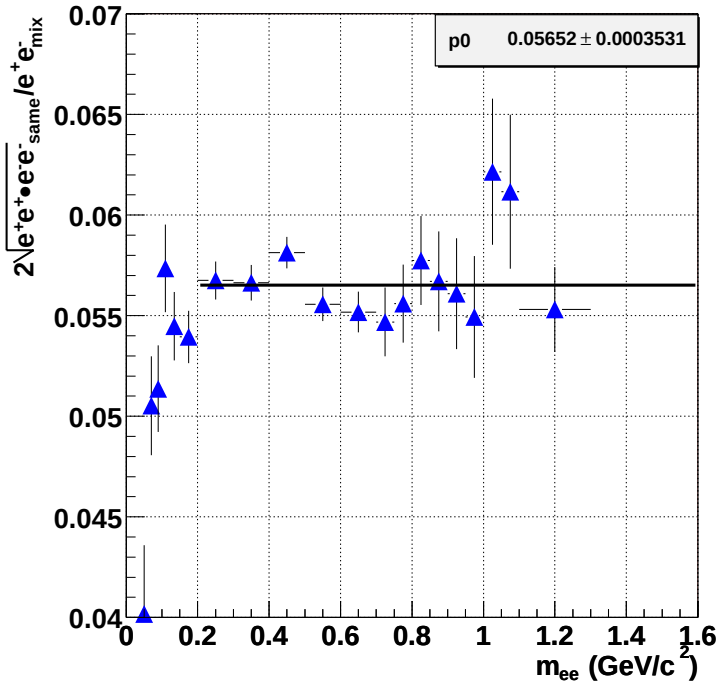
σ/σ_{tot} = 30%

***E*(96) = 3.7 +/- 1.0 (*stat*) +/- 1.5 (*syst*)**
***E*(00) = 5.6 +/- 0.4 (*stat*) +/- ?**

96 data: G. Hering, PhD thesis, nucl-ex/0203004

Estimate of combinatorial background

p_t > 0.2 GeV/c



p_t > 0.1 GeV/c