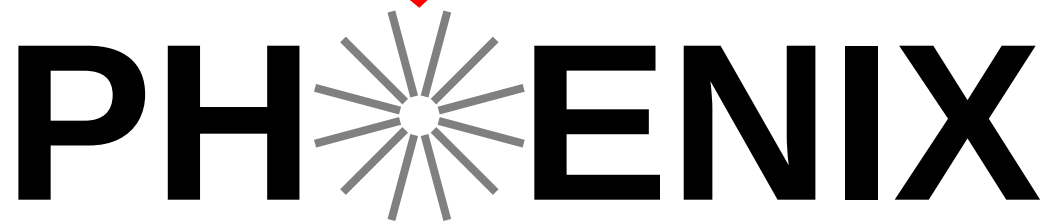
Future Possibilities for Measuring Low Mass Lepton Pairs in



Christine Aidala for the PHENIX Collaboration

Quark Matter 2002, Nantes

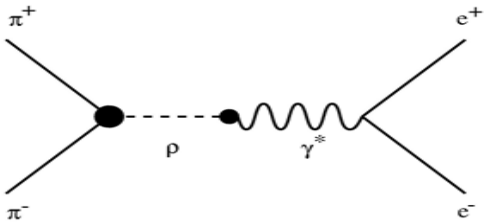
Why measure low mass lepton pairs?

In heavy ion collisions, low mass lepton pairs provide a clean signal for studying

- thermal radiation from the hadron gas
- in-medium effects on low mass vector mesons
- open charm
  - cross section at RHIC appears to be large!

Thermal radiation from HG — ππ annihilation: $\pi^+\pi^- \rightarrow \gamma^* \rightarrow e^+e^-$

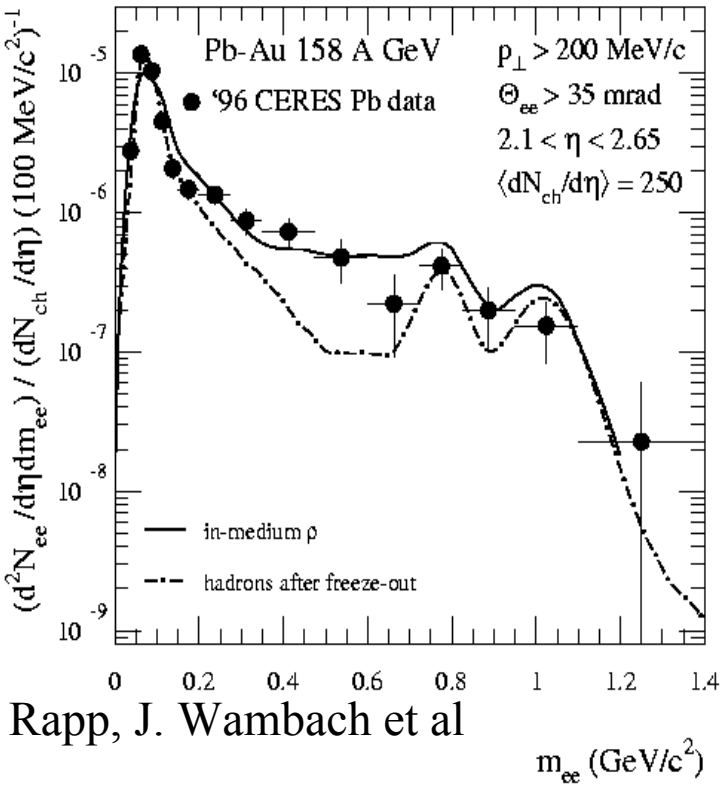
Cross section dominated by pole at the ρ mass of the π em form factor:



$$F_\pi^2(m) = \frac{m_\rho^4}{(m_\rho^2 - m^2) + m_\rho^2 \Gamma_\rho^2}$$

In-medium effects —

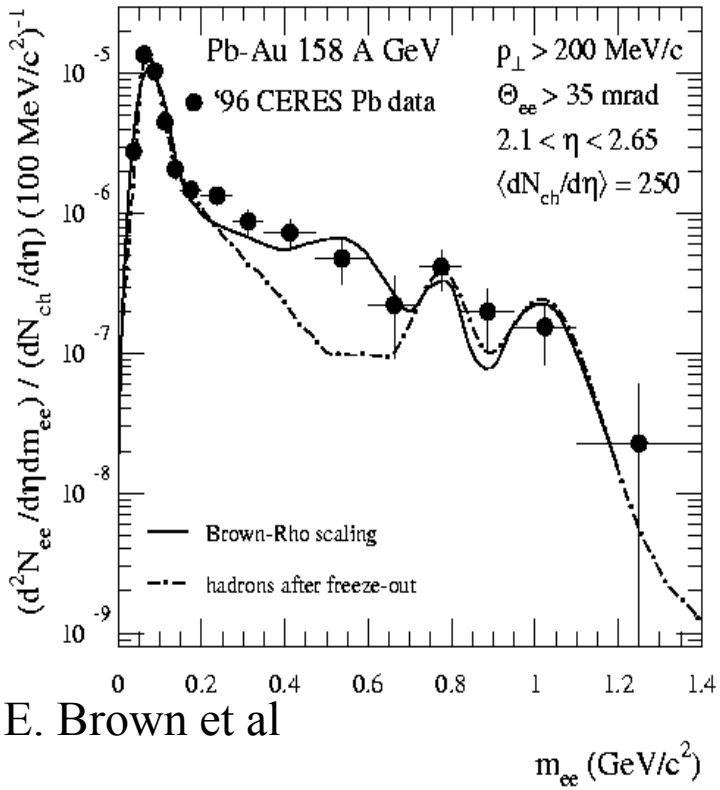
ρ-meson broadening



R. Rapp, J. Wambach et al

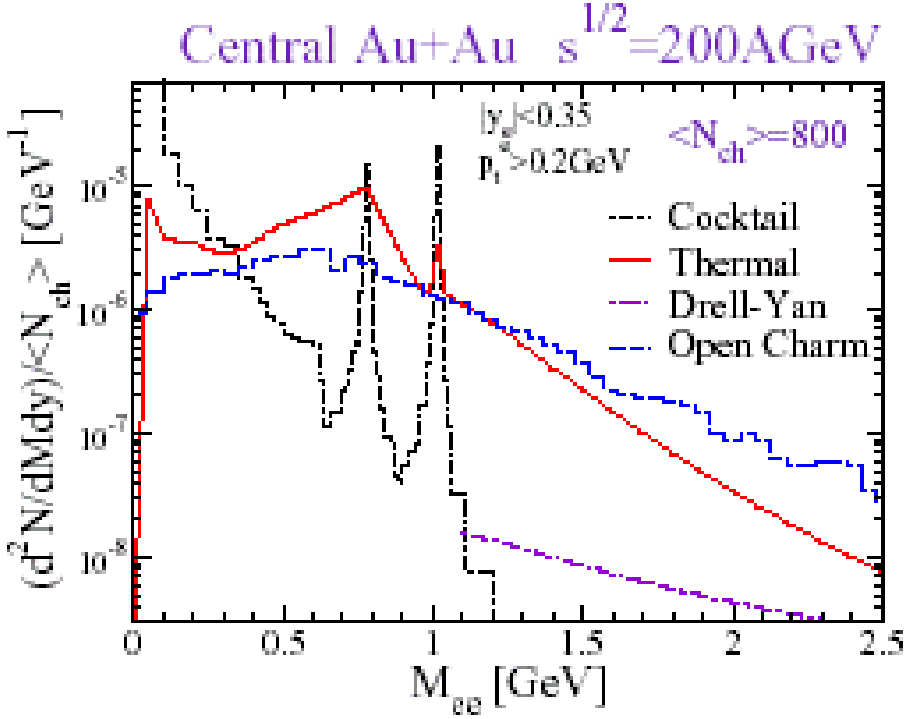
OR

Dropping ρ-meson mass



G.E. Brown et al

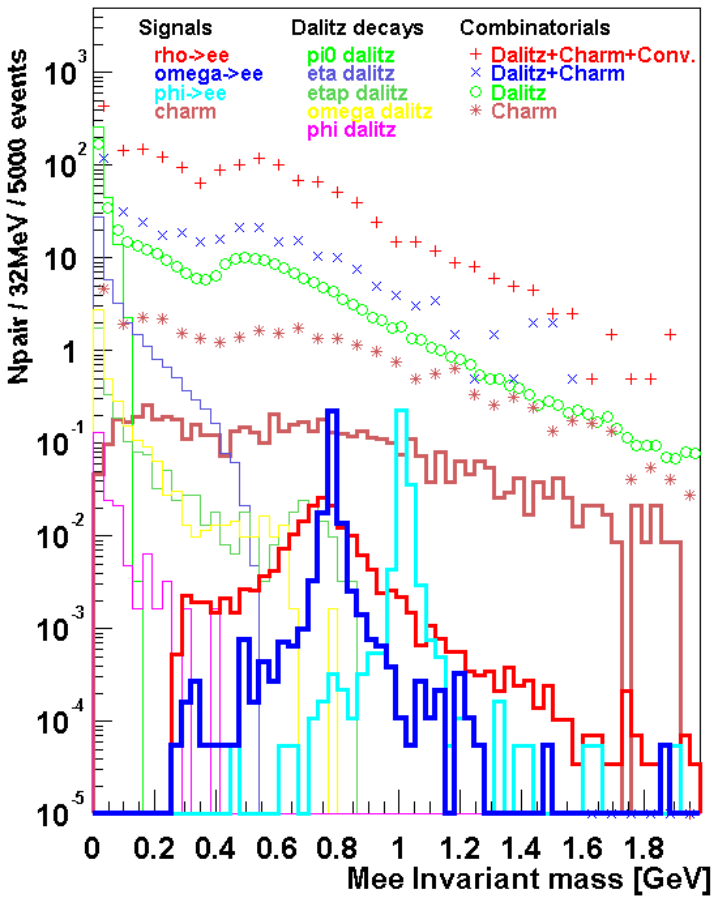
Electron pairs from theory . . .



R. Rapp

Invariant mass distribution of electron pairs at RHIC

$\sqrt{s_{NN}} = 200GeV$



K. Ozawa

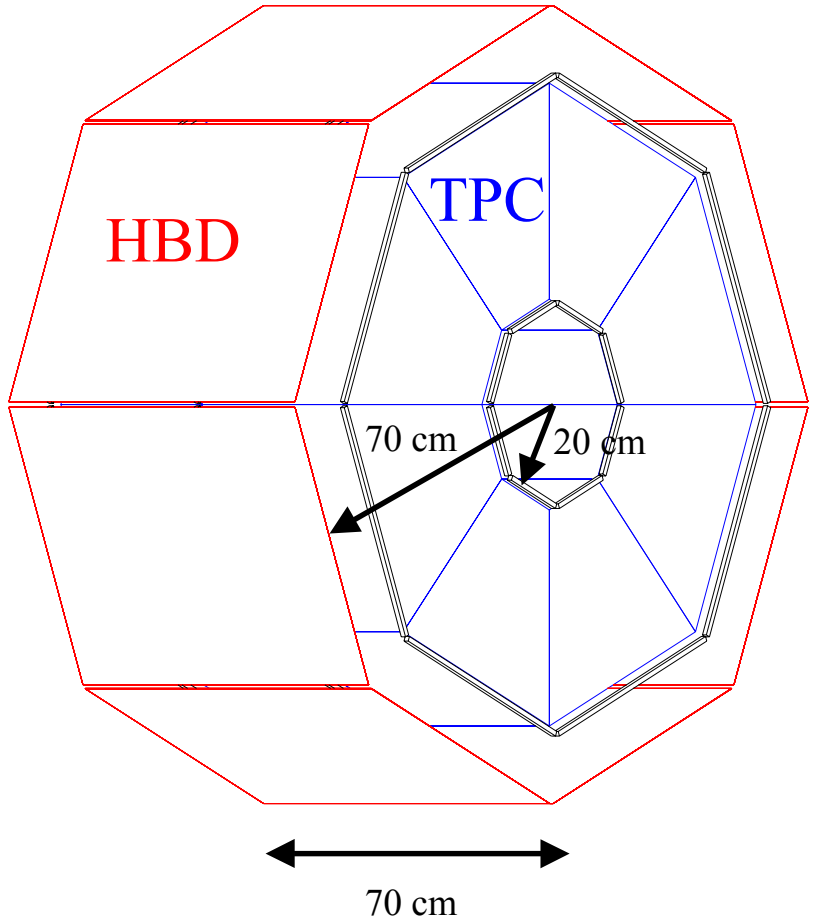
Simulated electron pair spectrum and combinatorial background in PHENIX

$s_{charm} \sim 650$ mb $\Rightarrow$ 15.8 $c\bar{c}$/event

How to lower the background?

Proposed New Detector: Combined TPC/HBD

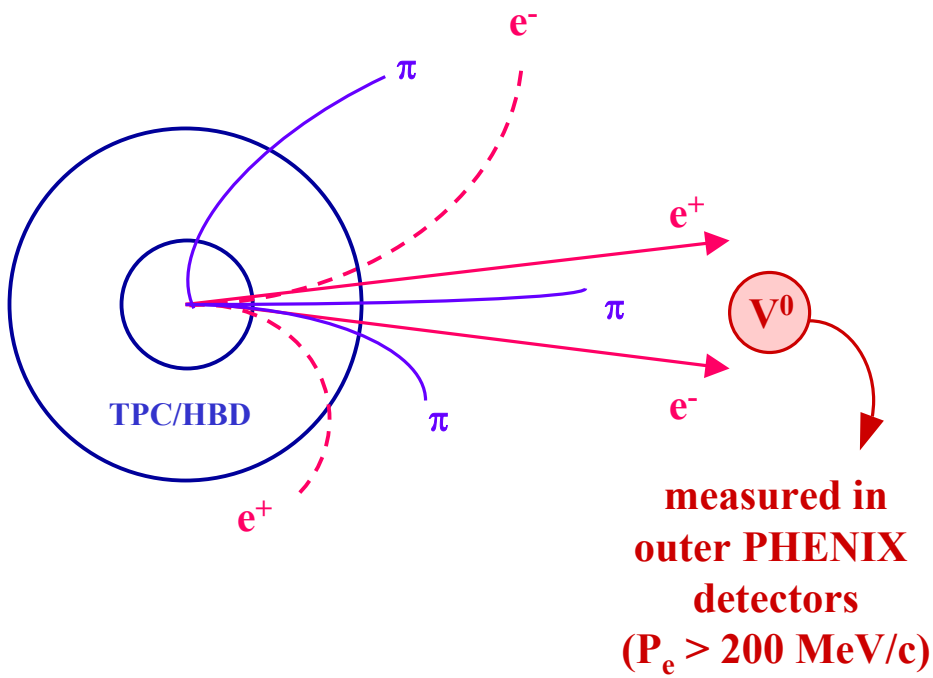
- Fast, compact Time Projection Chamber, encircled by "Hadron Blind" photocathode layer sensitive to light from Cerenkov radiation
  - "Hadron Blind Detector": choose radiator gas such that only electrons produce Cerenkov radiation
- Joint R&D effort with STAR



Strategy for identification and rejection of background electrons

- Run with low inner magnetic field—optimize measurement of low momentum tracks
- Electron ID for signal electrons (vector mesons, low mass pairs) from outer PHENIX detectors
- Electron ID for low momentum electrons (p < 200 MeV/c) from Cerenkov blob on HBD, dE/dx in TPC
- Reconstruct invariant mass of opposite sign pairs identified as electrons

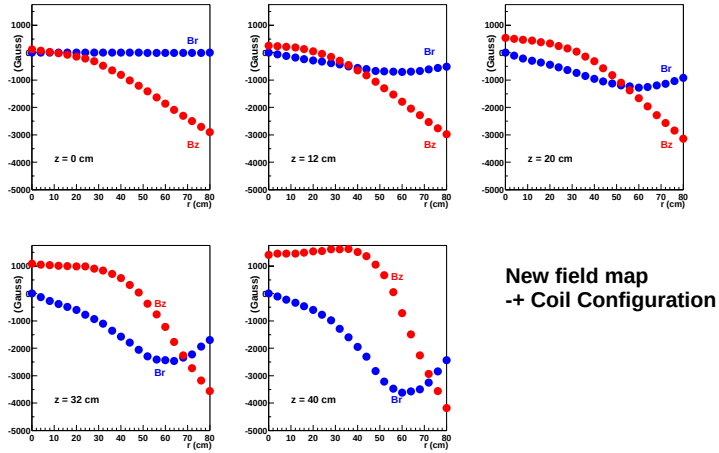
  ($\varepsilon_e > 90\%$, $\pi_{rej} > 200{:}1$ for particles outside PHENIX acceptance)



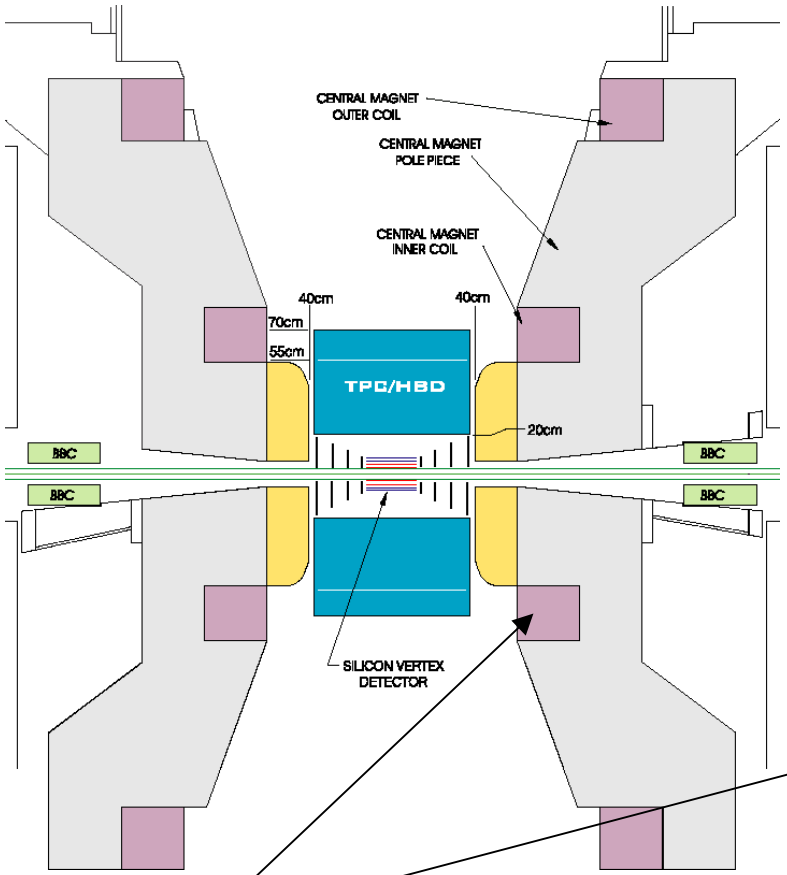
Reject pairs which reconstruct to an invariant mass < ~130 MeV/c^2

A new inner field coil creates the low-field inner tracking region needed

Not a field-free region



New field map
-+ Coil Configuration



Inner Coil creates a zero-field integral (∫Bdl = 0) region inside the Central Magnet

TPC/HBD Proposal: Added bonuses to PHENIX!

- 2π tracking
- greater particle ID capabilities
- inner coil can also enhance outer field: improved momentum resolution for high p_t tracks

R & D

Gas requirements

Use **single** gas as

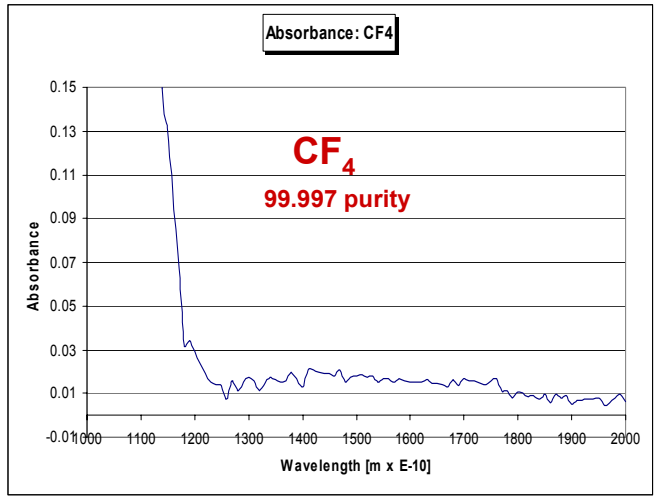
- TPC drift gas
- HBD radiator gas
- operating gas for readout detector
  - must be fast, VUV transparent, work well in readout detector:

CH_4, CF_4,…

Currently studying:

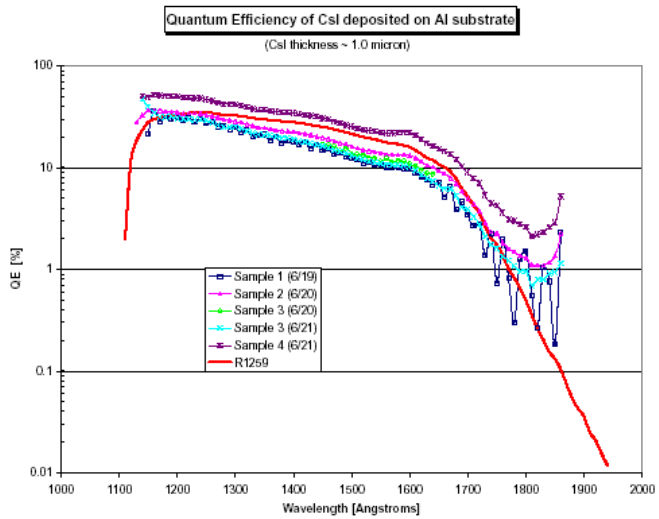
- Drift velocity, diffusion, dE/dx
- Gas scintillation and timing
- Different gas mixtures

Absorbance of CF_4



B. Azmoun

Quantum efficiency of CsI



Transparency of CF_4 down to wavelengths of ~120 nm allows more photoelectrons to be produced on the CsI—region of highest Q.E.

Detector Readout

Micropattern readout detector:

Gas Electron Multiplier (GEM) or possibly μMegas

Use for both TPC and HBD readout

Currently studying:

- Gain of GEM for stable operation
- Aging properties of GEM
- Response to electrons and hadrons (N_{pe} per electron and per MIP)

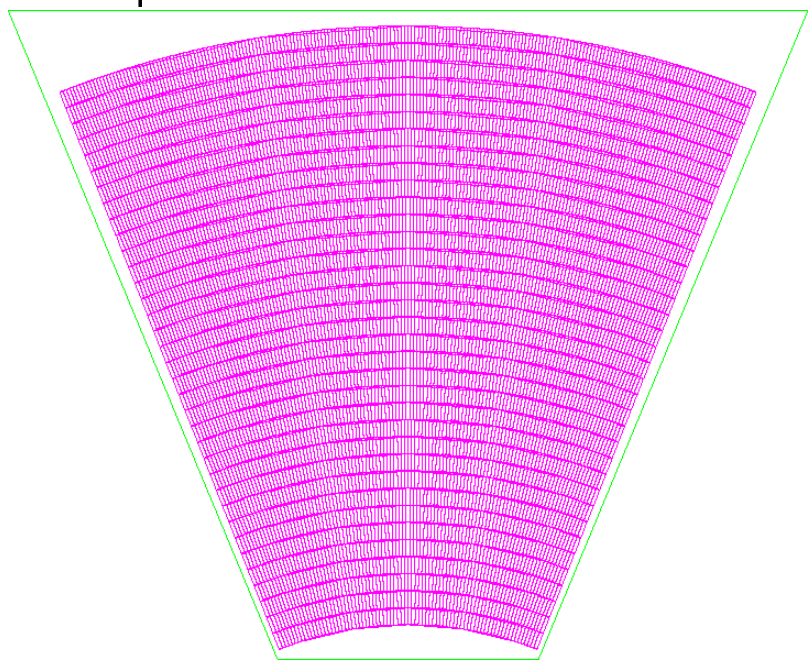
Axial drift in TPC: readout on two endplanes

35 TPC pad rows

Pad size:

dr ~ 1 cm

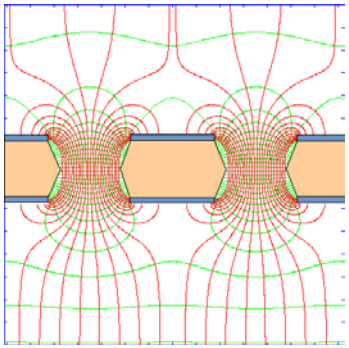
dϕ ~ 2 mm

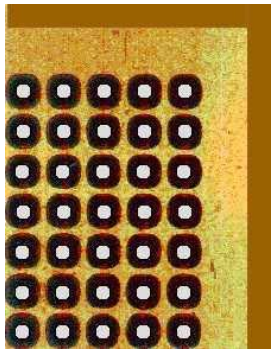


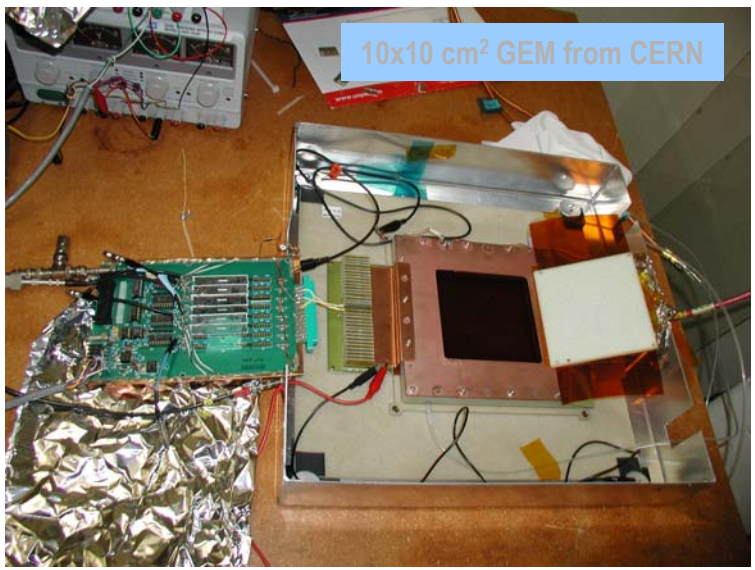
One octant of TPC

What is a GEM and how does it work?

Gas Electron Multiplier





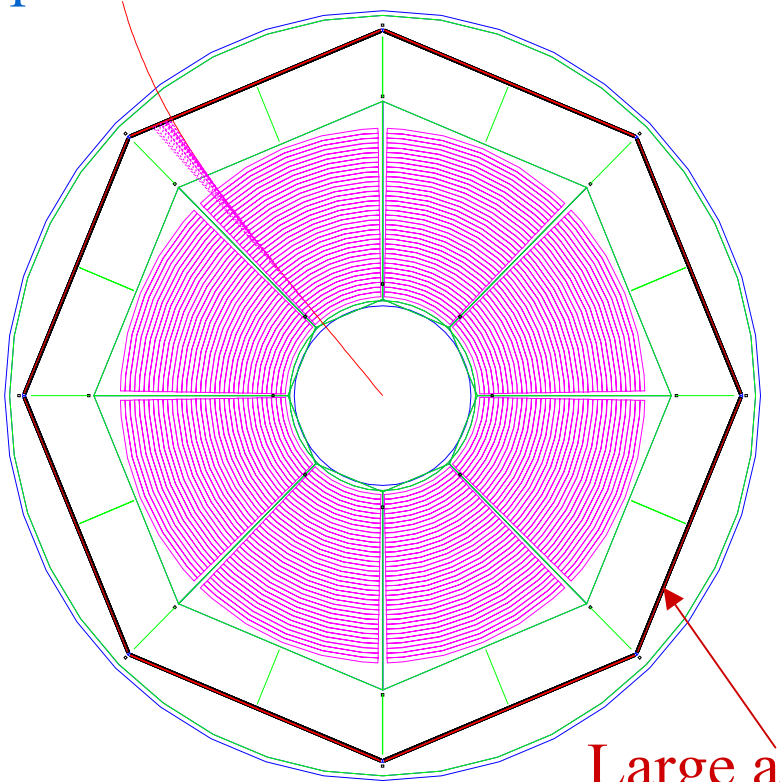


- Cu-coated kapton
- Etched grid of ~40-micron holes
- Potential difference applied across the holes, creating a strong electric field inside each hole
- Electrons avalanche through the holes

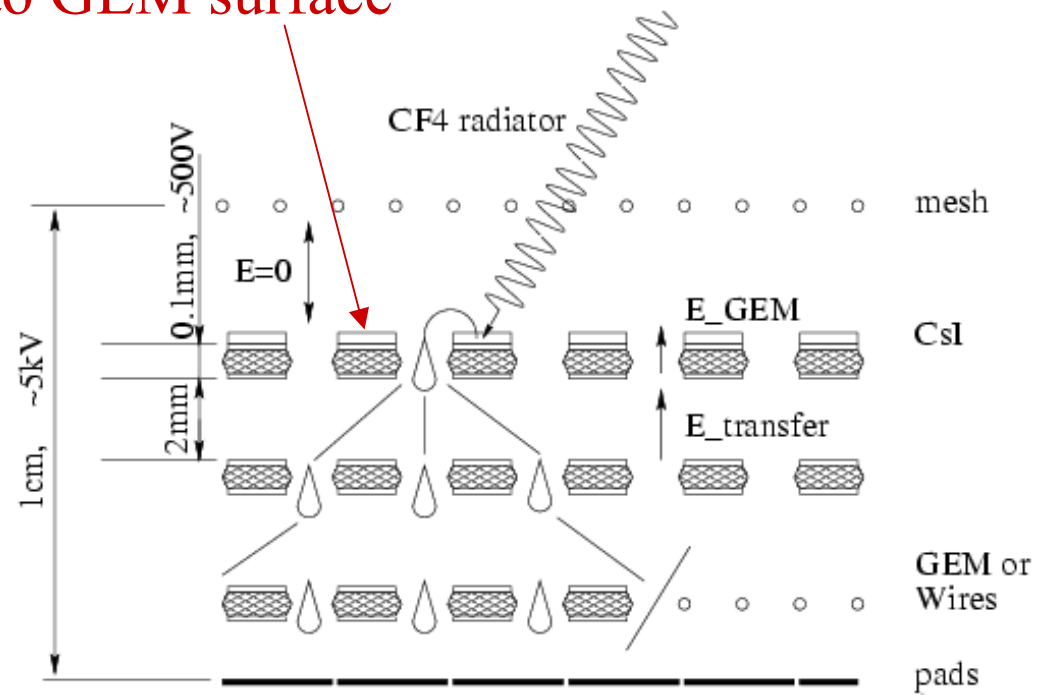
GEM detector studies currently underway

HBD readout

100 MeV electron producing a Cerenkov blob on the HBD image plane



CsI photocathode deposited directly onto GEM surface



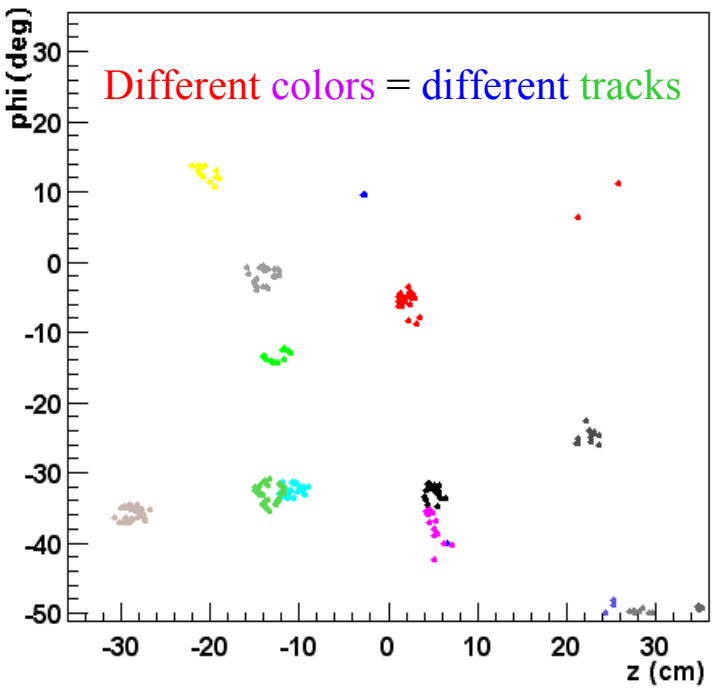
A. Breskin

Large area photocathode: CsI

Simulation Studies

Occupancy of HBD

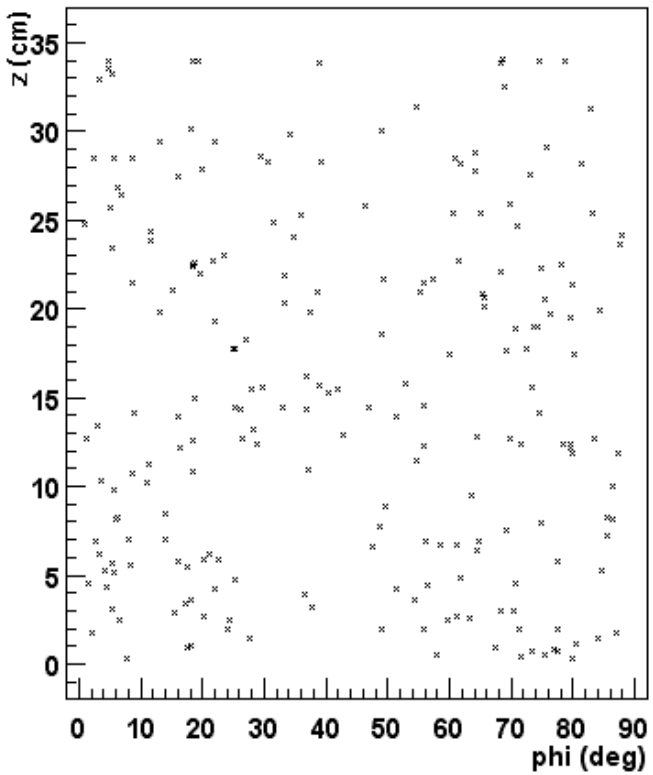
Assuming 4% of a radiation length from proposed silicon vertex detector upgrade (see poster #89, H. van Hecke)



CF_4: ~30 photoelectrons per e^- track

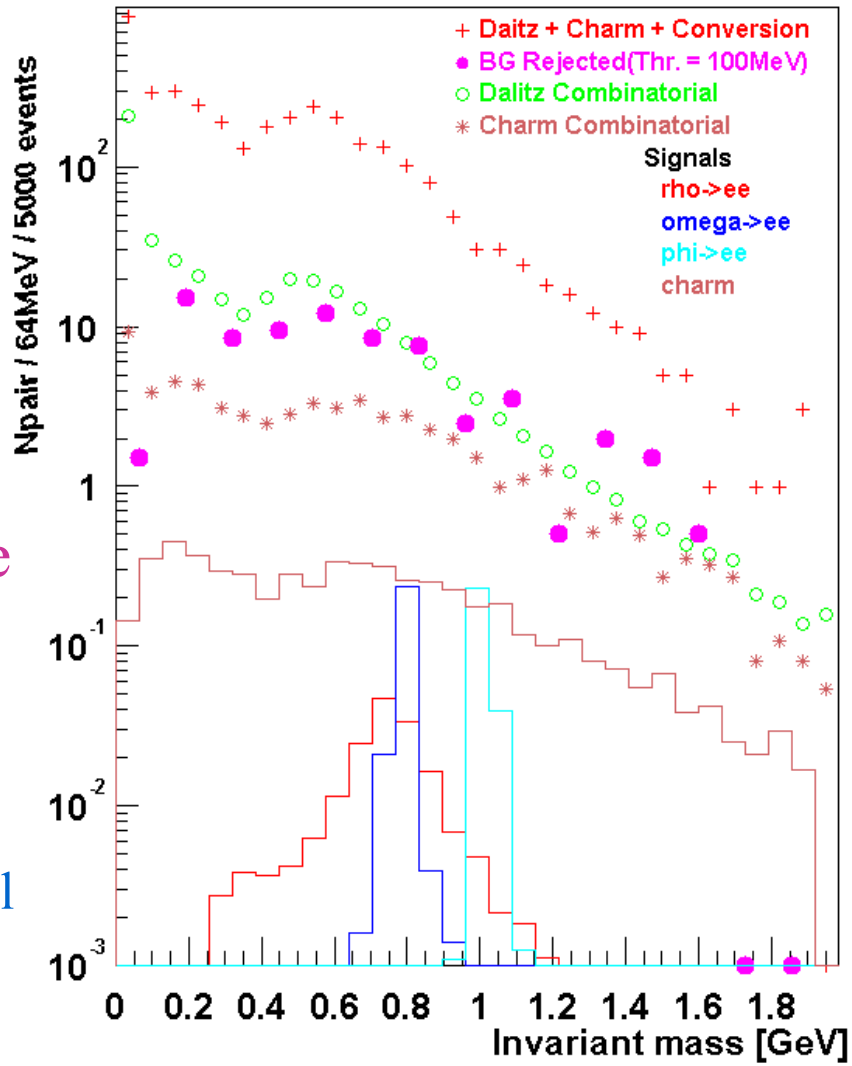
Occupancy of TPC

Innermost pad row (r = 20 cm)
Central Au-Au at 200 GeV



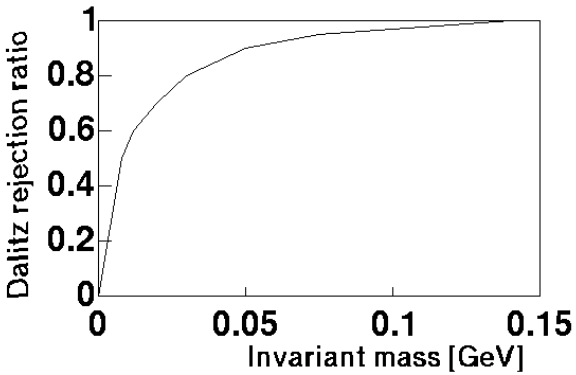
How well can we reduce the electron background from Dalitz decays and conversions?

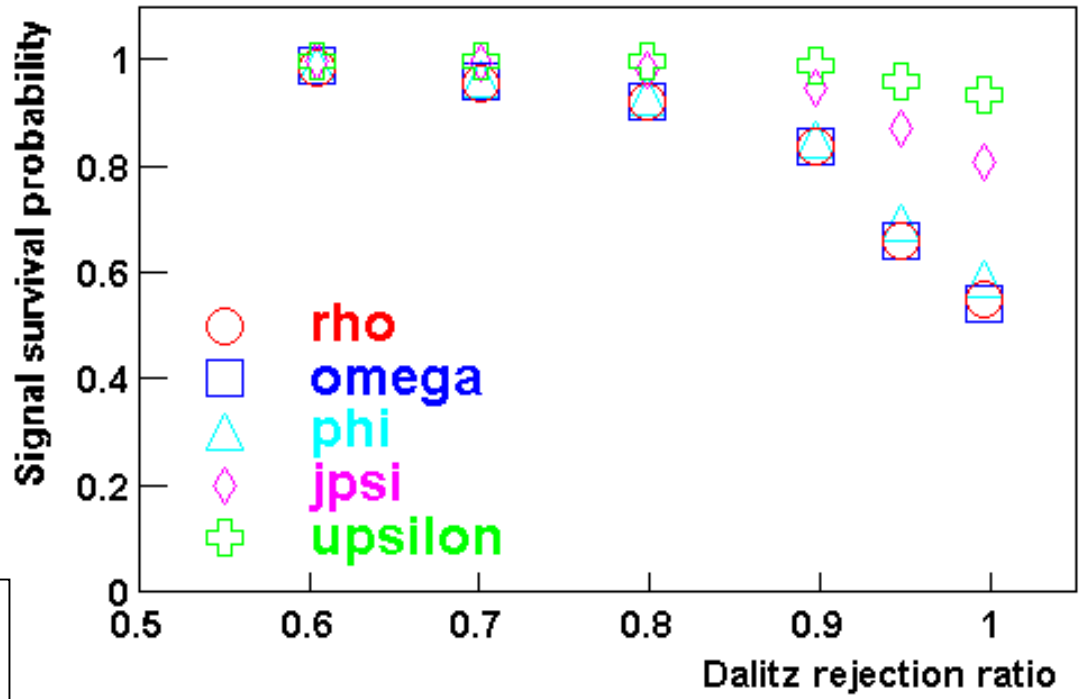
- Central events ($dN_{ch}/dy = 650$)
- Both electrons from vector mesons in PHENIX central arm acceptance ($p_T > 200$ MeV/c, $|h| < 0.33$, $2*|f| < 90^o$)
- p >10 MeV/c for all electrons
- Rejection factor for p's: 1/200 $(1/200)^2$ for p<4 GeV/c in PHENIX central
- 100% electron efficiency
- Perfect momentum resolution



K. Ozawa and C.A.

Dalitz rejection and Survival Probability of Vector Mesons





Survival probability of ρ,ω,ϕ is ~85% for Dalitz rejection ratio of 90%.

K. Ozawa

Conclusions

- The measurement of low mass lepton pairs requires excellent rejection of Dalitz pairs and conversions to reduce the combinatorial background.
- A novel new detector is proposed consisting of a TPC and HBD which can greatly reduce the Dalitz and conversion backgrounds.
- The large charm cross section in heavy ion collisions is another significant source of background which cannot be eliminated by Dalitz rejection. This signal will have to be measured as well in order to fully understand the low mass pair continuum.