Measurements of di-electron production in Au+Au collisions at RHIC-PHENIX

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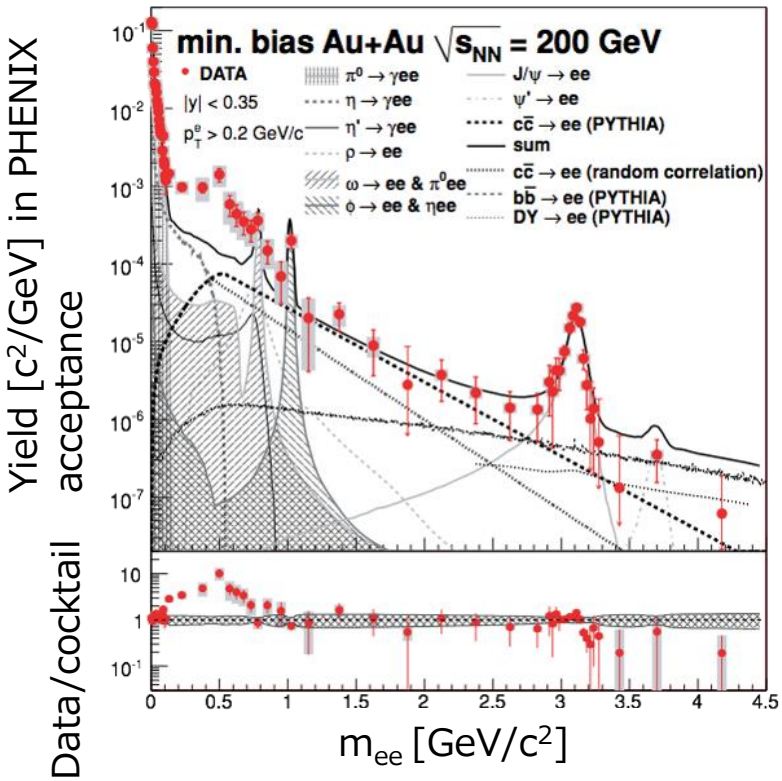
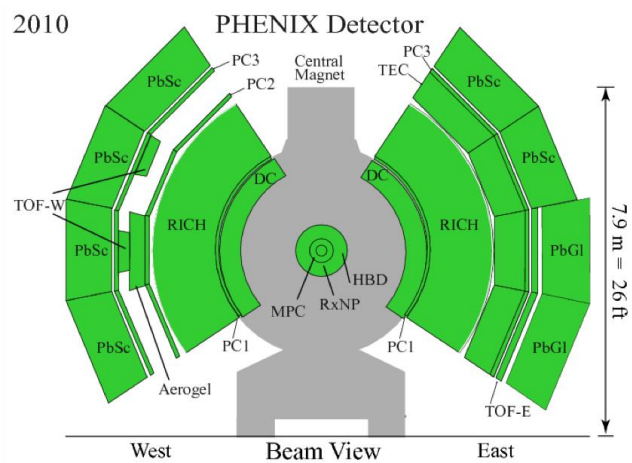
Dielectron measurements in Au+Au collisions

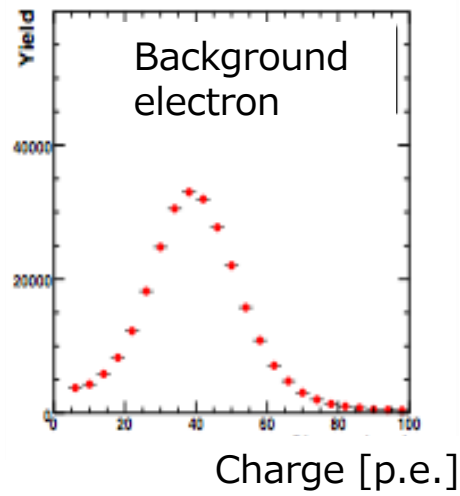


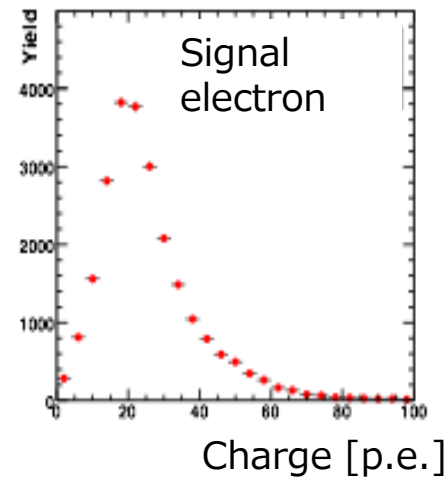
PRC 81, 034911(2010)

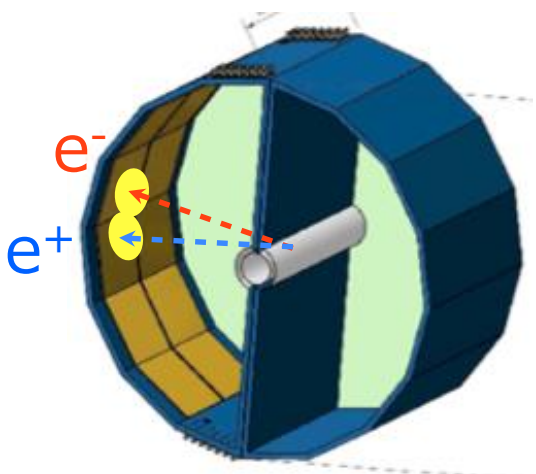
- Low-mass region
  - In-medium modification of light vector mesons are sensitive to partial restoration of chiral symmetry
- Intermediate-mass region
  - Energy loss of heavy flavor quarks in QGP
- High-mass region
  - Quarkonia suppression

PHENIX with HBD



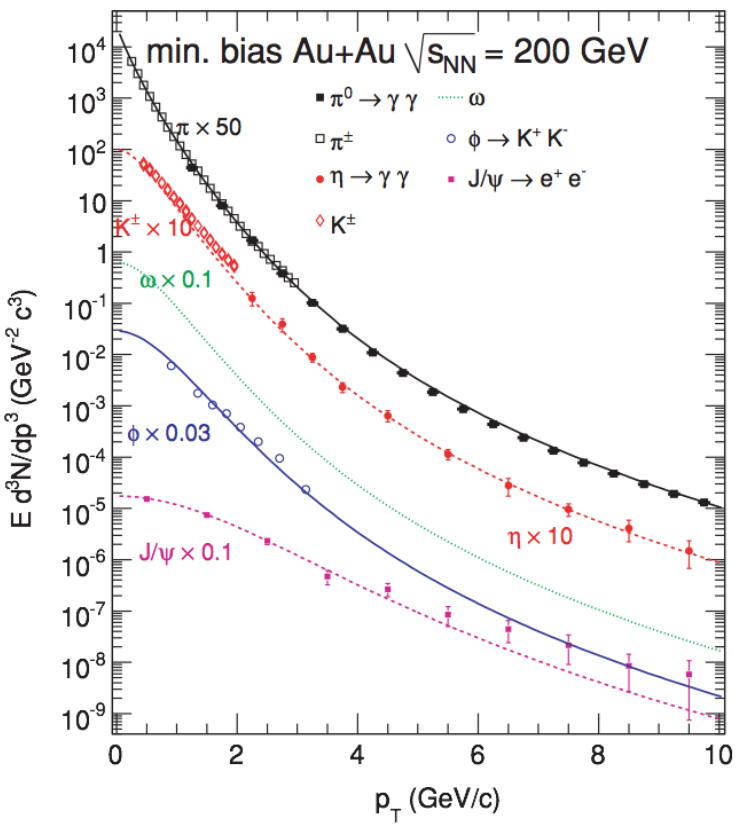






- S/B ~ 1/200
- Major background sources in di-electron measurement are γ conversions inside material + π^0 Dalitz decays
- The opening angle of electron pairs from these sources is very small
- HBD is a Cherenkov detector placed in the field free region extending out to 60cm

Hadronic cocktail



- π^0, π^+, π^- data fit to a modified Hagedorn function

$$E\frac{d^3N}{dp^3} = \frac{A}{\left(e^{-(ap_T+bp_T^2)+p_T/p_0}\right)}$$

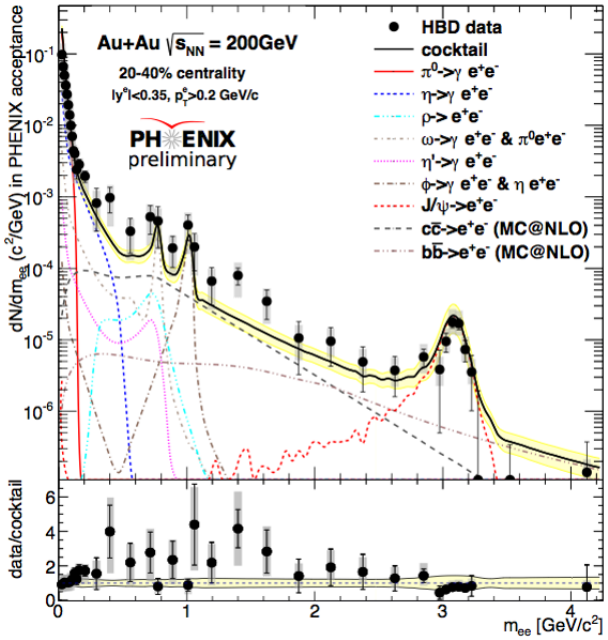
- Other mesons
  - Use mT scaling for the shape:

$$p_T \to \sqrt{p_T^2 + (m_h^2 - m_{\pi^0}^2)}$$

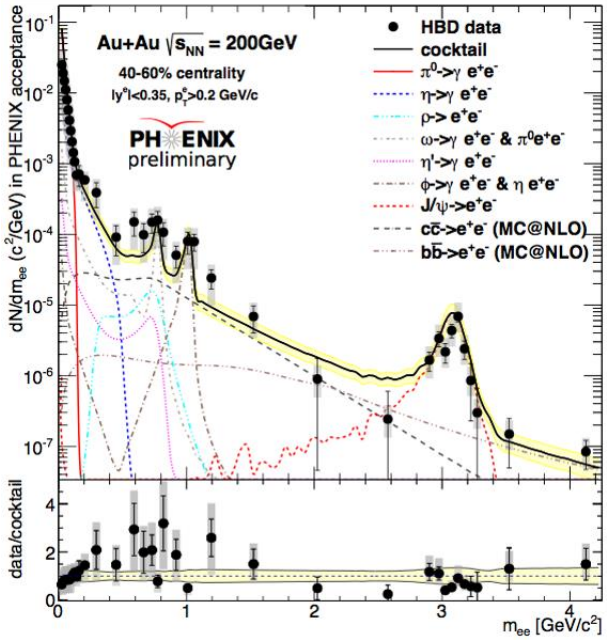
  - Normalize to data at high pT
- Fits are done independently for each particle and for each centrality
- Open heavy flavor (c,b) contributions determined using MC@NLO
- J/Ψ shape from full detector MC. Yield from pp scaled by N_{coll} *R_{AA}

QM 2012 results

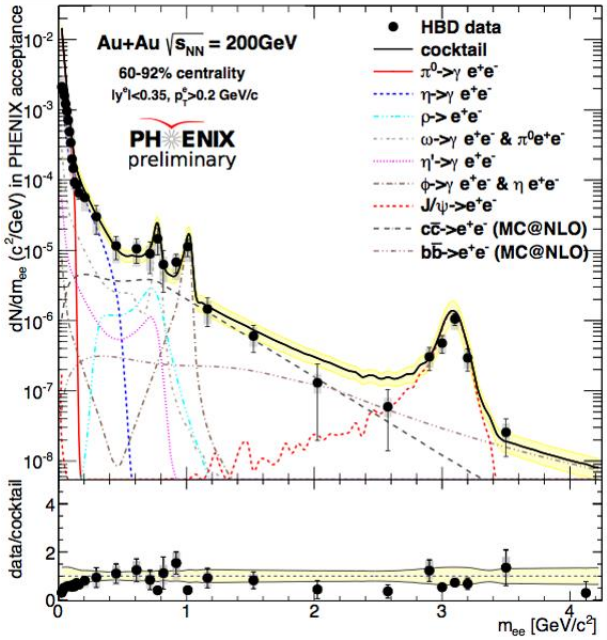
20-40%



40-60%



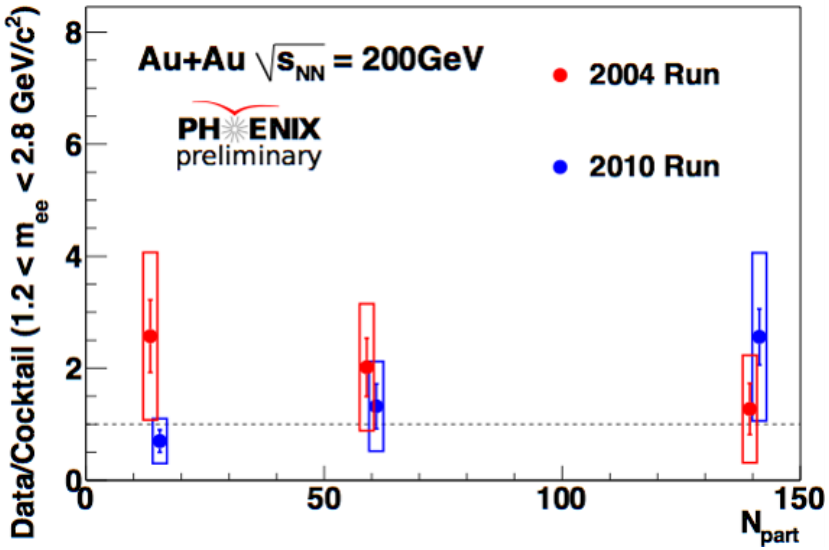
60-92%



Consistent with cocktail within experimental uncertainties.

Intermediate mass region

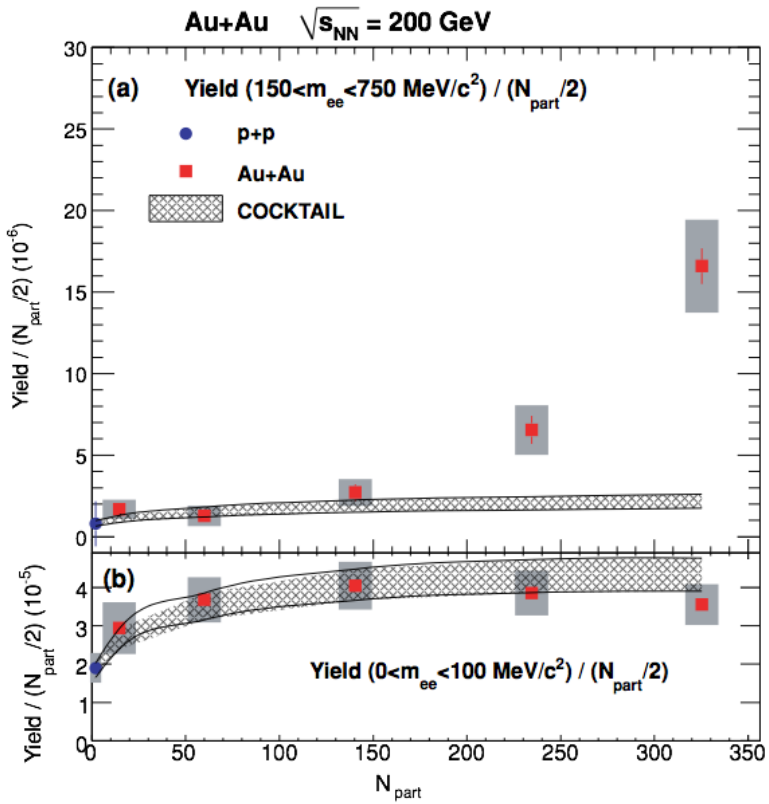
2004 Run: PRC 81 034911(2010)

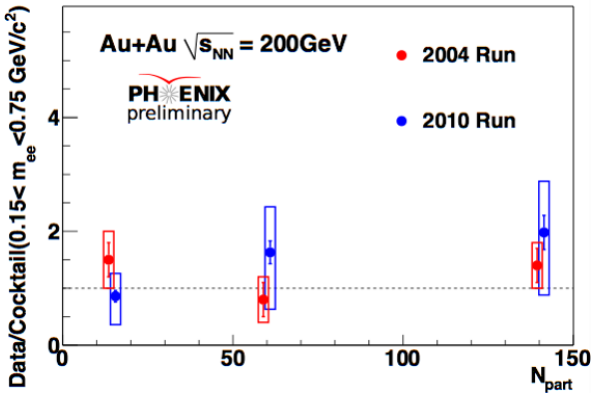


Run10: MC@NLO
Run4: PYTHIA
MC@NLO = 1.16 * PYTHIA

- 2004 results are consistent with N_{coll} scaled PYTHIA in all centrality bins
  - Energy loss of charm vs thermal radiation. Balancing effect?
- 2004 results and 2010 results are consistent within error bars
  - Error bars are large: Strong QA and strong cuts to homogenize the response of the central arm detectors over time
  - How about the most central bins?

Low mass region



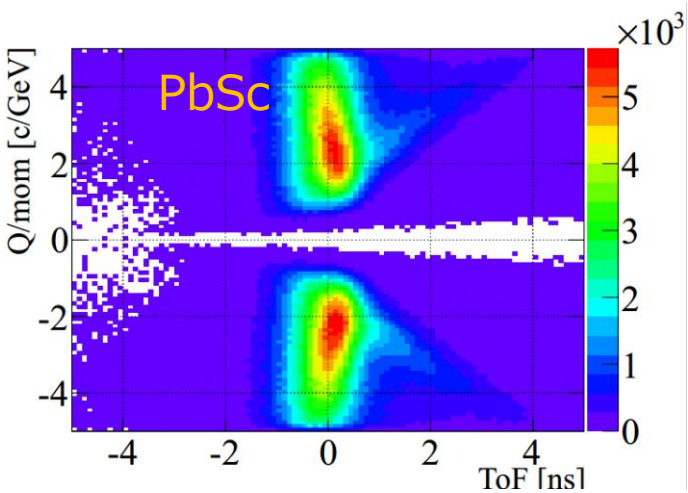


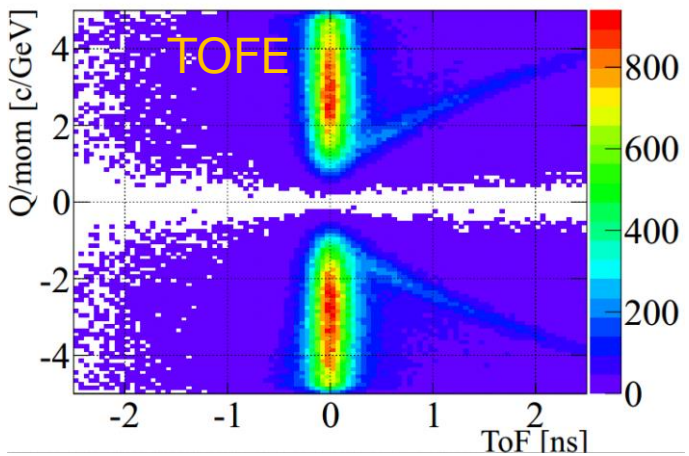
- 2004 results and 2010 results are consistent with each other for mid-central and peripheral bins.
- In 2004 results, huge enhancement is visible only in the most central bins
- Need the results of the most central bins to understand the LMR enhancement observed in 2004.

Improvements since QM 2012

- Improved electron Identification
  - TOF
- Background subtraction
  - Source-by-source subtraction using MC simulations

Electron identification



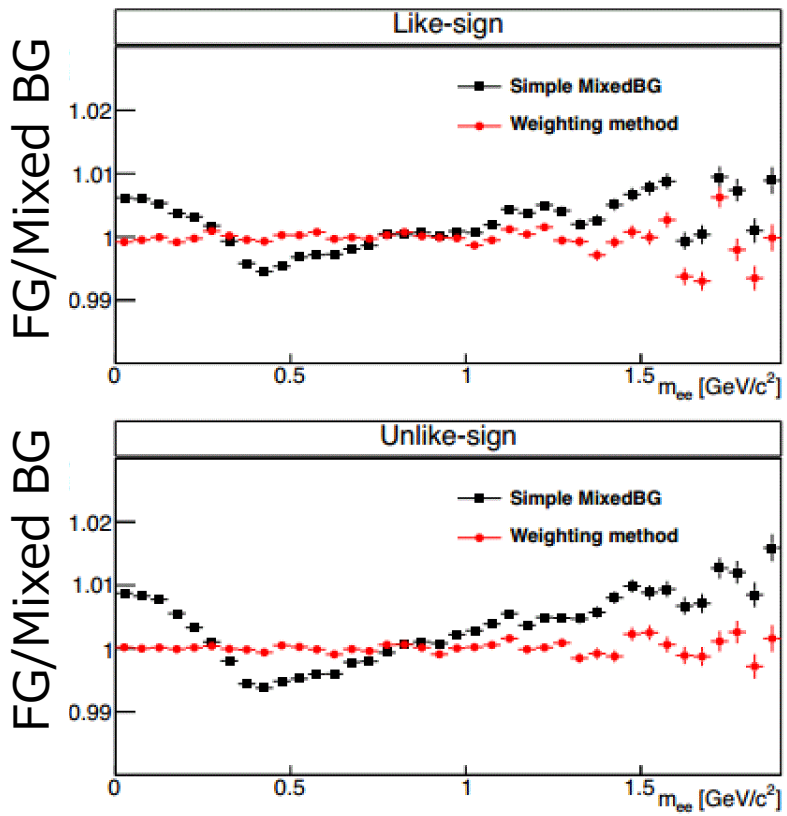


- Include TOF information for hadron rejection
  - EMCal resolution: ~450ps
  - TOFE resolution: ~150ps
- Improved the algorithm of RICH detector
  - Issue: parallel track point to the same ring
  - PMTs fired by electrons are not used by other tracks
- Hadron contamination in the most central bin:
  - ~20% -> ~5%
  - Run-4: ~30%

Background subtraction

- QM 2012
  - Subtract the mixed BG (combinatorial BG)
  - Subtract the acceptance corrected residual like-sign spectrum (correlated BG)
  - Worked well for mid-central and peripheral collisions
  - Not enough precision for the most central bins
- Quantitative understanding of the like-sign spectrum
  - Like-sign = Mixed BG + cross pair + jet (2004 results)
    - Cross pair: e.g. π^0 -> ee γ -> ee ee
  - We could not reproduce the like-sign data
  - Like-sign = Modified mixed BG + cross pair + jet + hidden ghost
    - Mixed BG modified to include flow
    - Hidden ghost: residual detector correlations which cannot be eliminated by the ghost cuts

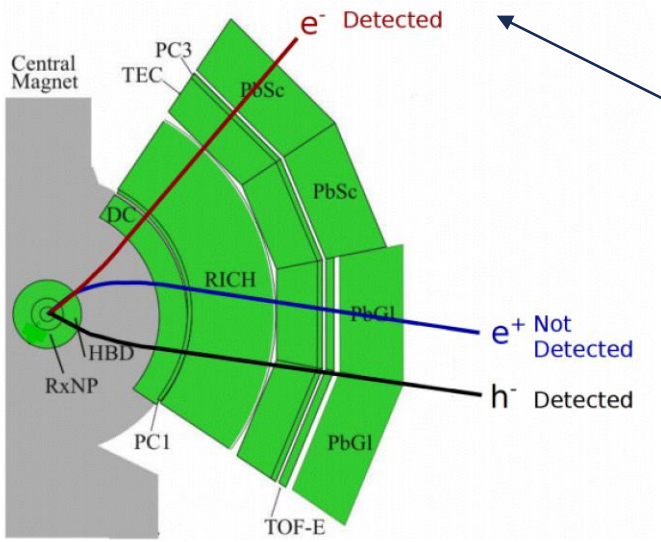
Effect of flow on combinatorial background



TOYMC using single electron v_2 from 20-40% data

- Flow distorts both the shape and the integral of combinatorial background
  - BG+- = 2 √ (BG++* BG--) is broken by a few per mil for the PHENIX acceptance
- Weighting method
  - When we generate mixed background, apply the following weight pair-by-pair.
  - $w(\Delta\varphi) = 1 + 2\, v_2(p_{T,1})\, v_2(p_{T,2}) \cos(2\Delta\varphi)$
  - The weighting factor is derived analytically
  - Estimate single electron v_2 using our own data
  - Weighting method cures both the shape and the integral

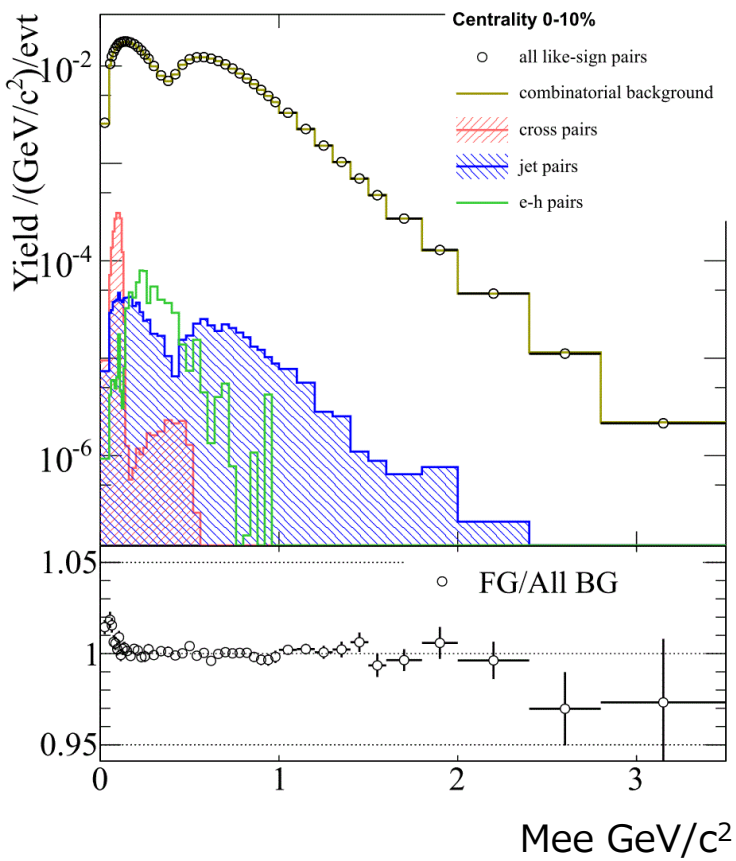
Hidden ghost



Residual correlation

- Pion is parallel to e^+ -> pion is misidentified as electron
- If e^+ and π^- are both reconstructed, the RICH ring sharing cut will reject the event
- If the e^+ is not reconstructed (due to rec. eff. or dead area), the ring sharing is not recognized, and the event has a correlated e^- π^- pair

Like-sign spectra for the most central bin



- Like sign spectrum is quantitatively reproduced with sub-percent accuracy at m > 200 MeV/c^2

Summary

- Significant improvement in both electron identification and background subtraction
- HBD analysis is moving towards completion