2026 RHIC/AGS ANNUAL USERS'S MEETING
AND RHIC SCIENCE SYMPOSIUM

Thesis Award Flash Talk

e^+e^- Pairs as a QCD Probe

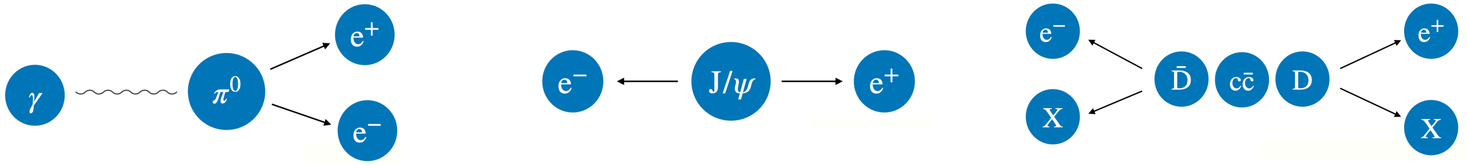
Vassu Doomra
CFNS & UC Berkeley

Center for Frontiers in Nuclear Science

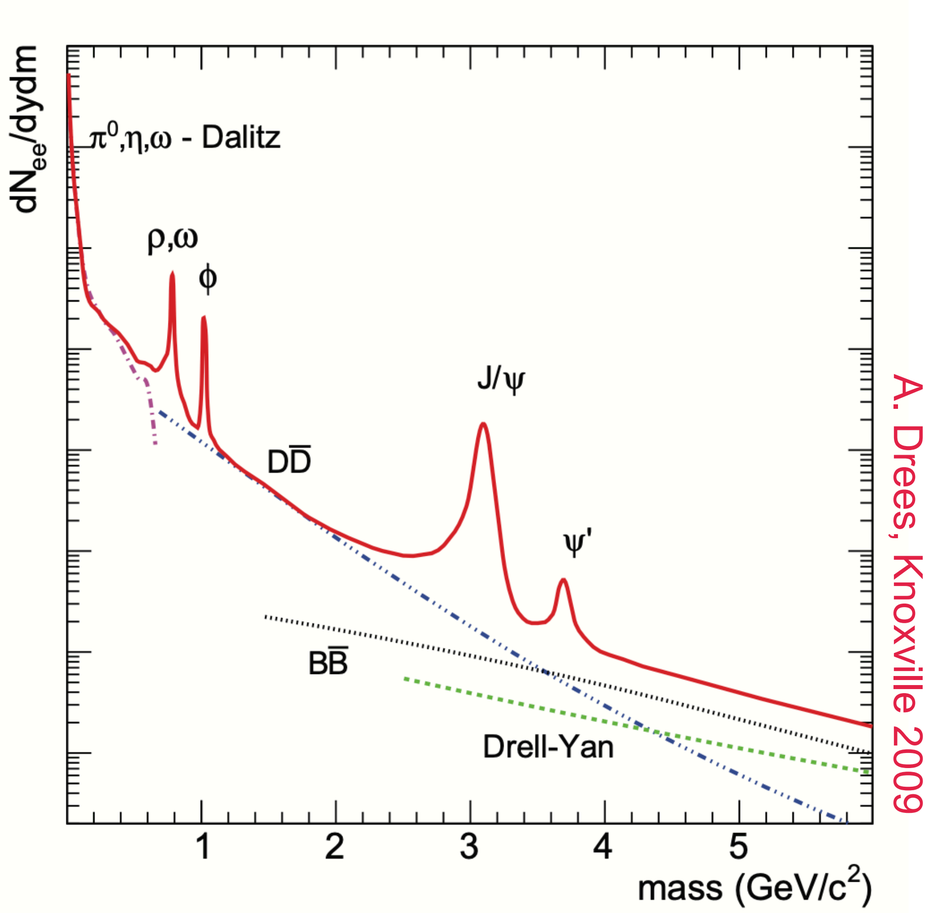
PHENIX

Berkeley
UNIVERSITY OF CALIFORNIA

Why Dileptons?

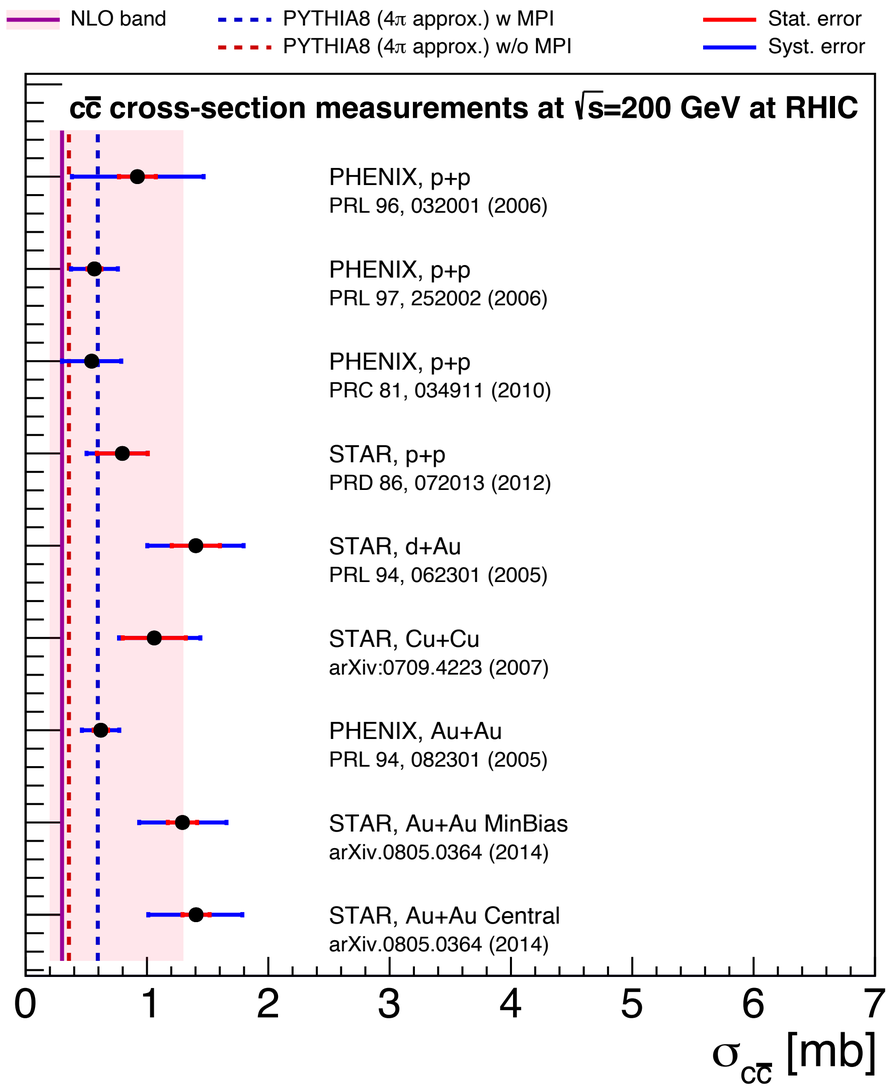


- In p+p collisions, at RHIC energies, the main physics signal in the intermediate mass region originates from semileptonic decays of open heavy-flavor mesons (off-vertex or non-prompt component).
- Small contribution from Drell-Yan as well.
- Vertex detector is required to statistically identify the semi-leptonic or the non-prompt component.
  - PHENIX installed a Silicon Vertex Tracker (VTX) in 2011.
  - VTX, however, presents a huge photon conversion background.



A. Drees, Knoxville 2009

What do we know so far?



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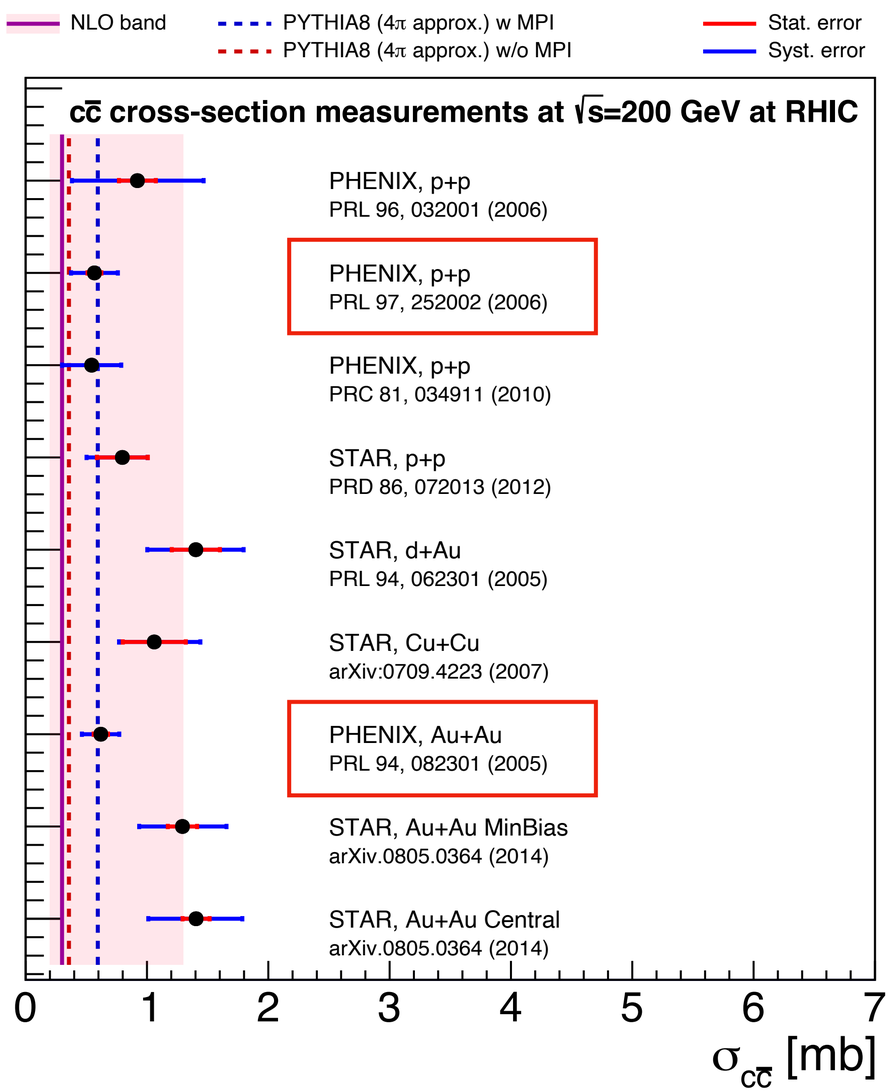

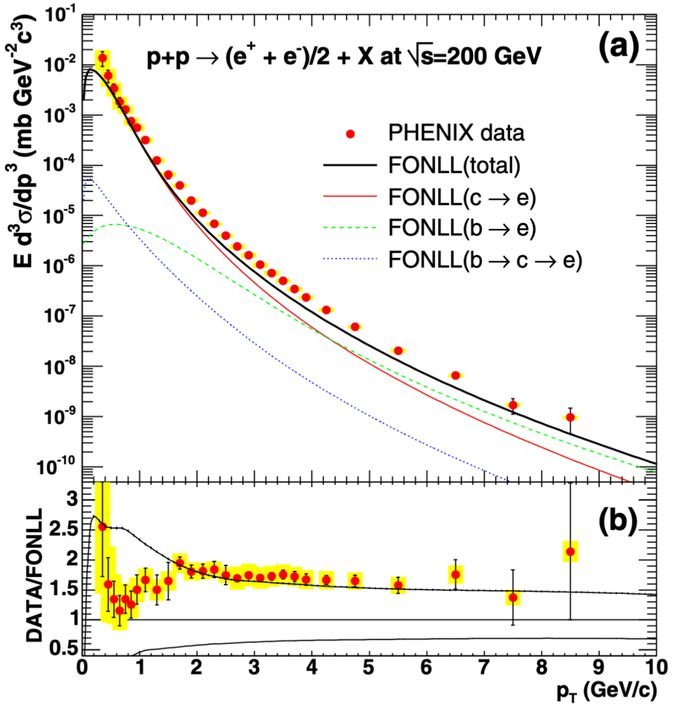

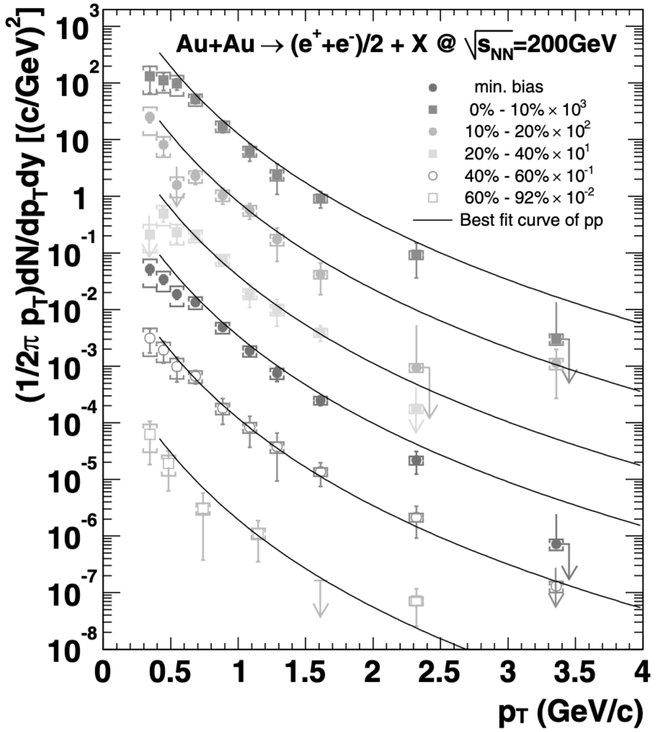

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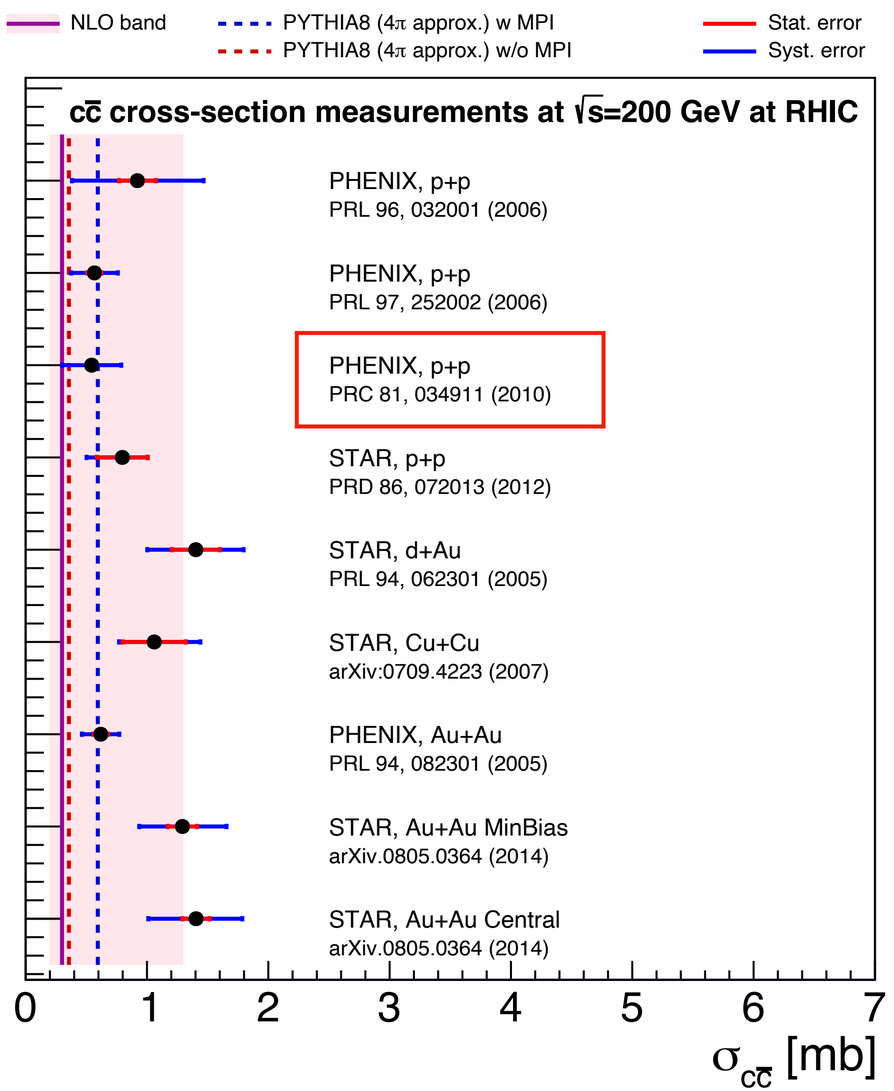

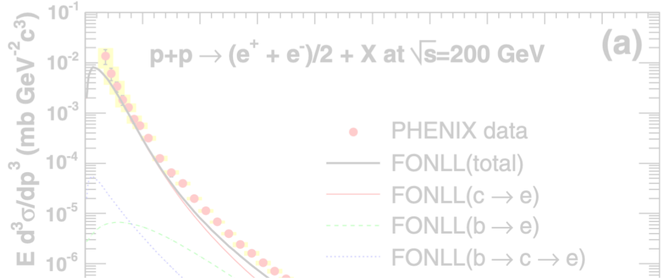

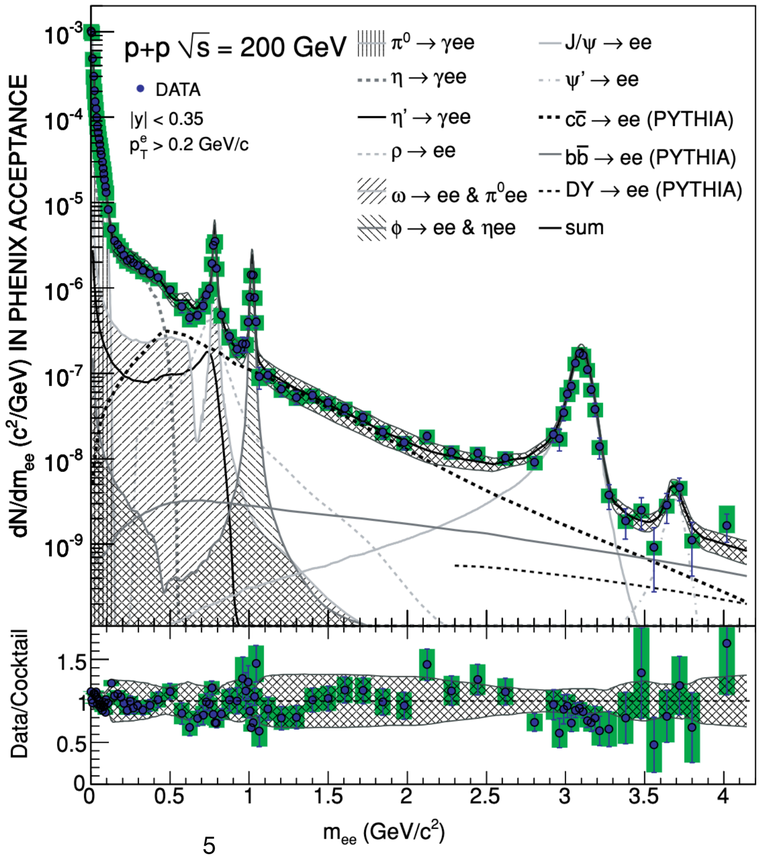

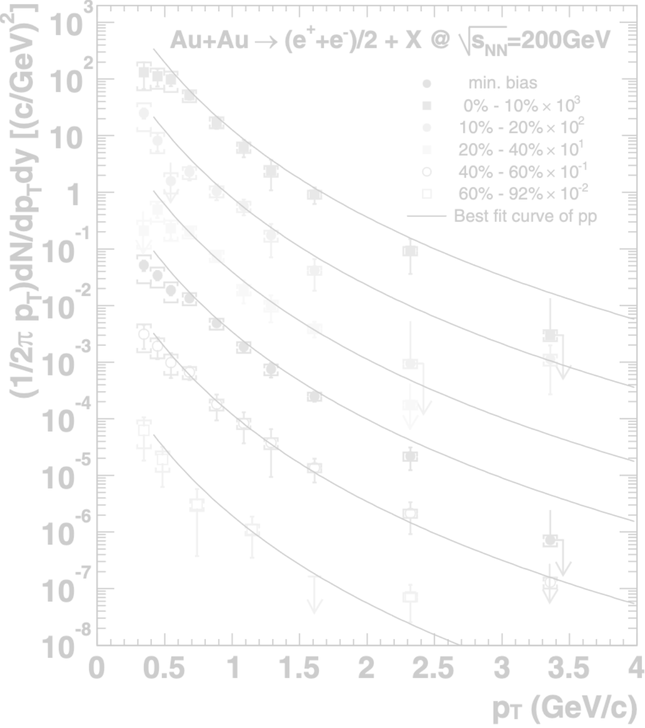

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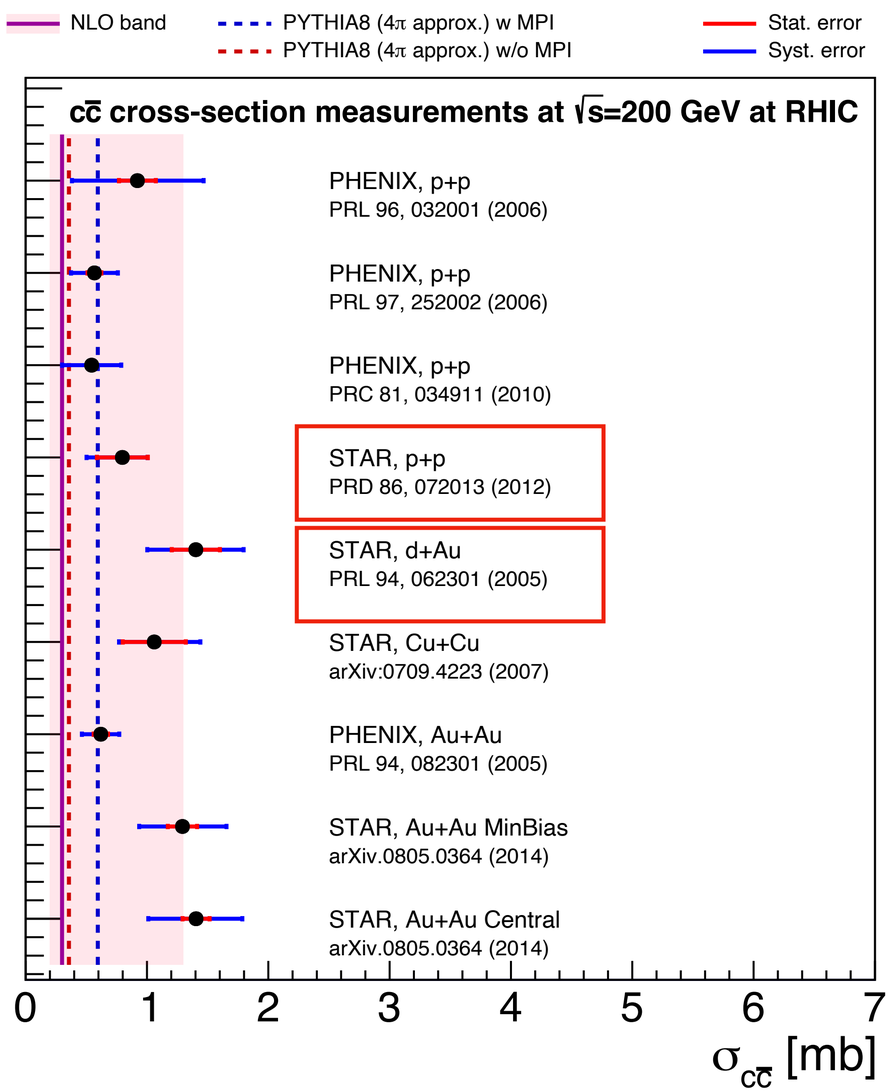

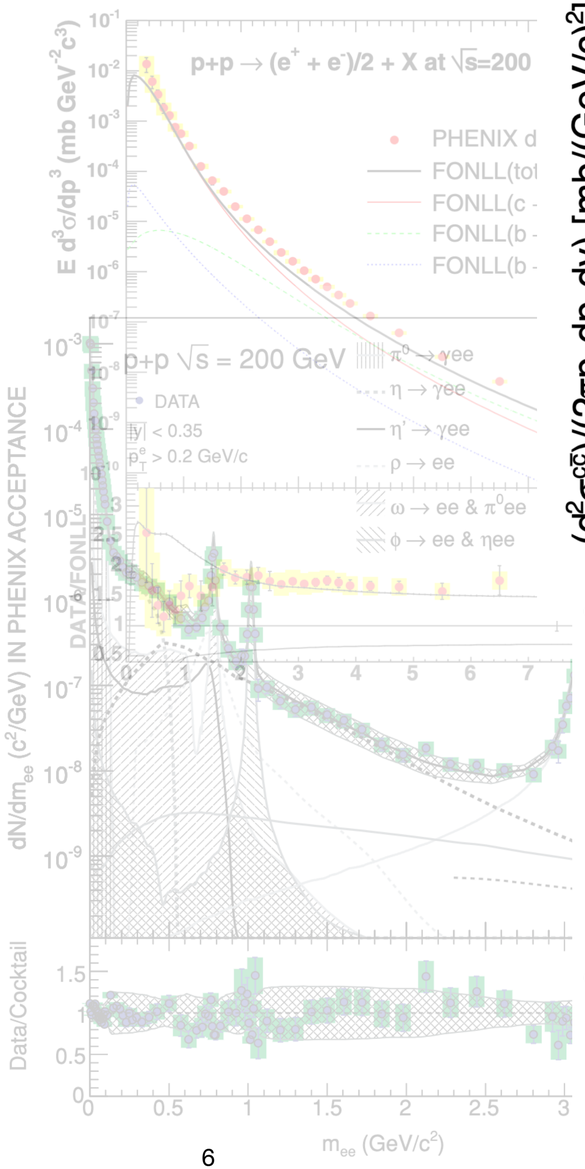

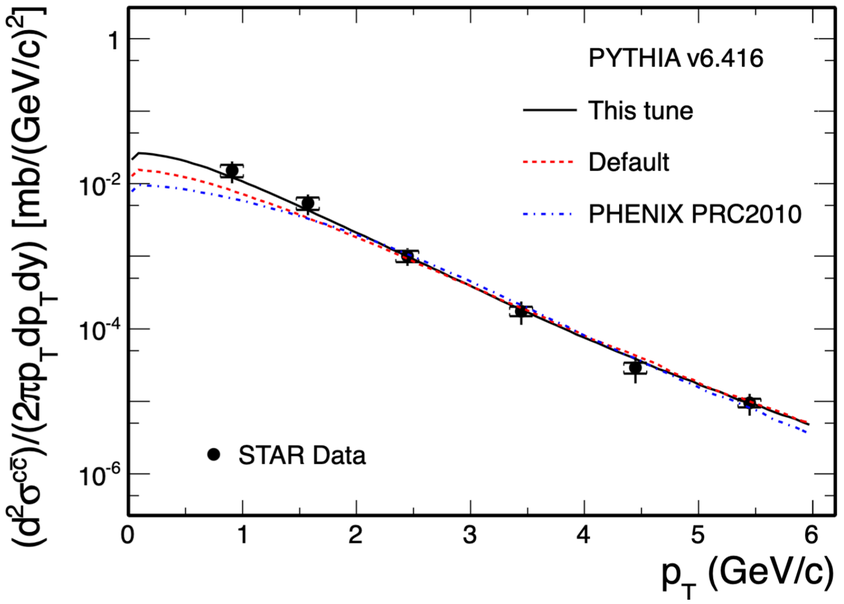

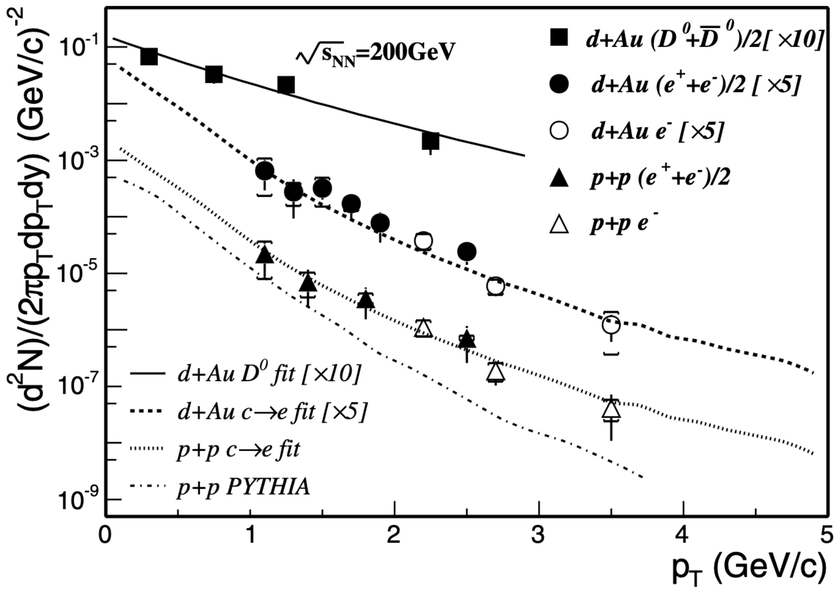

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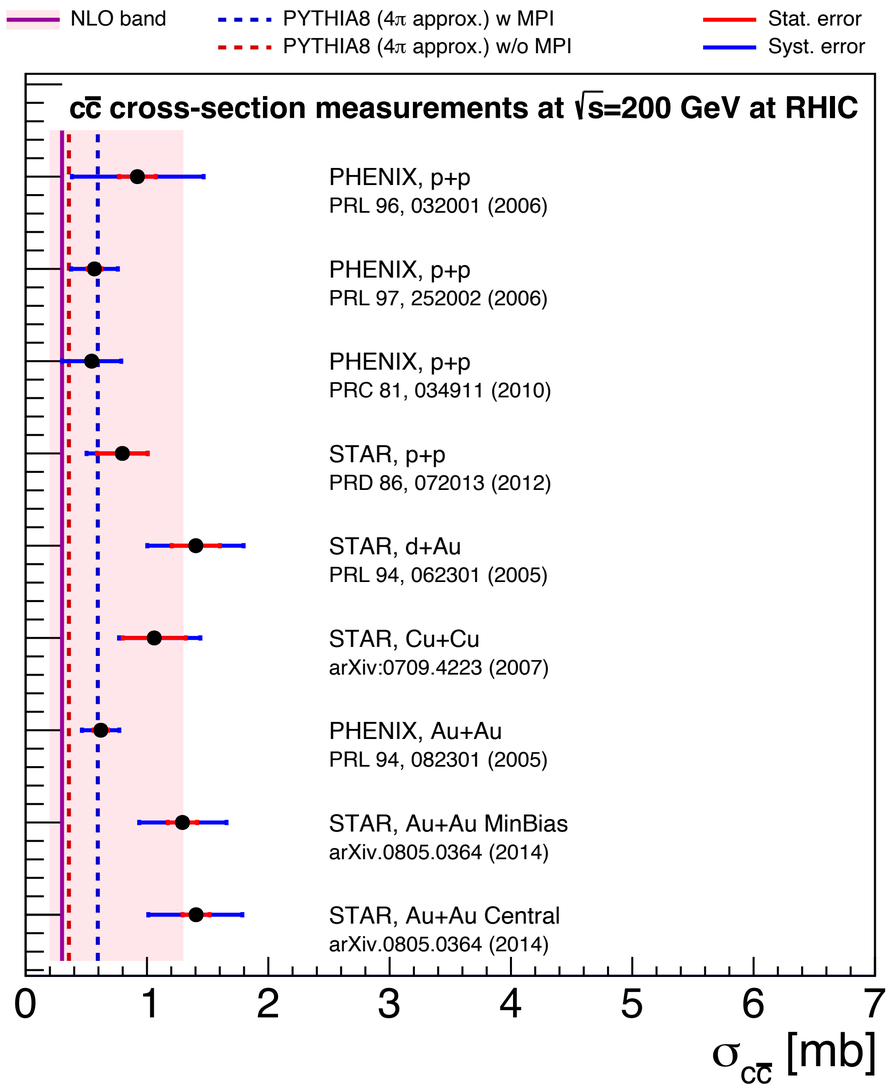
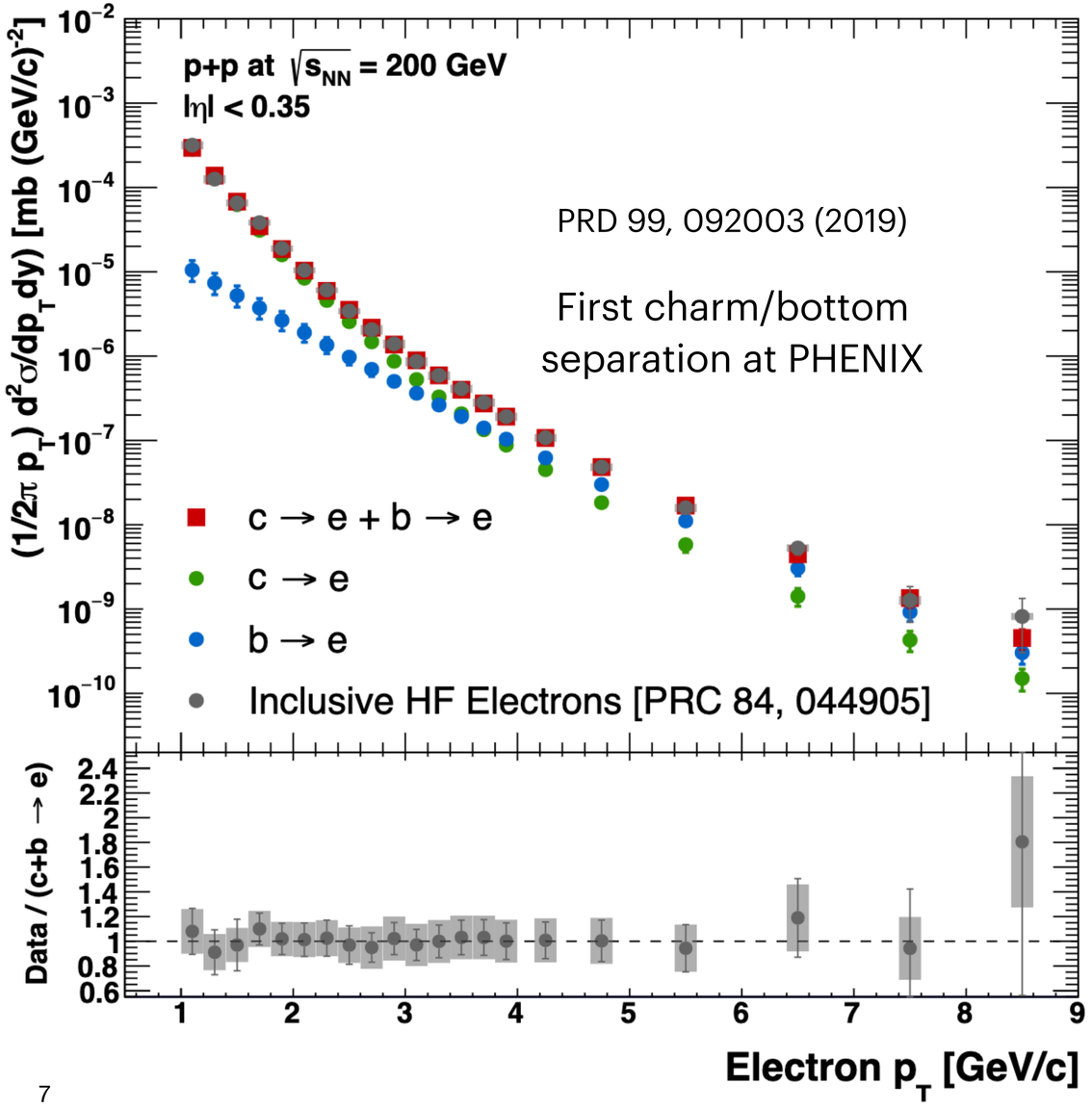




Why is the measurement challenging?

Background dominated

- Large photon conversion background
- High material budget (~15% X_0)

Limited acceptance

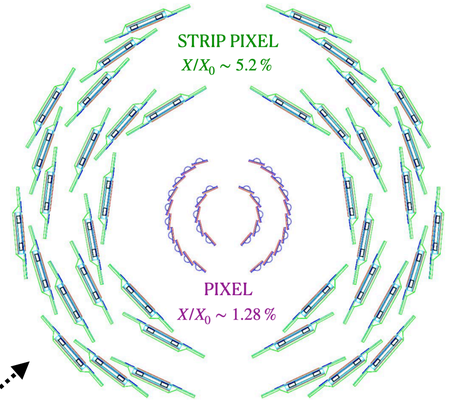
- Two-arm geometry → reduced pair efficiency

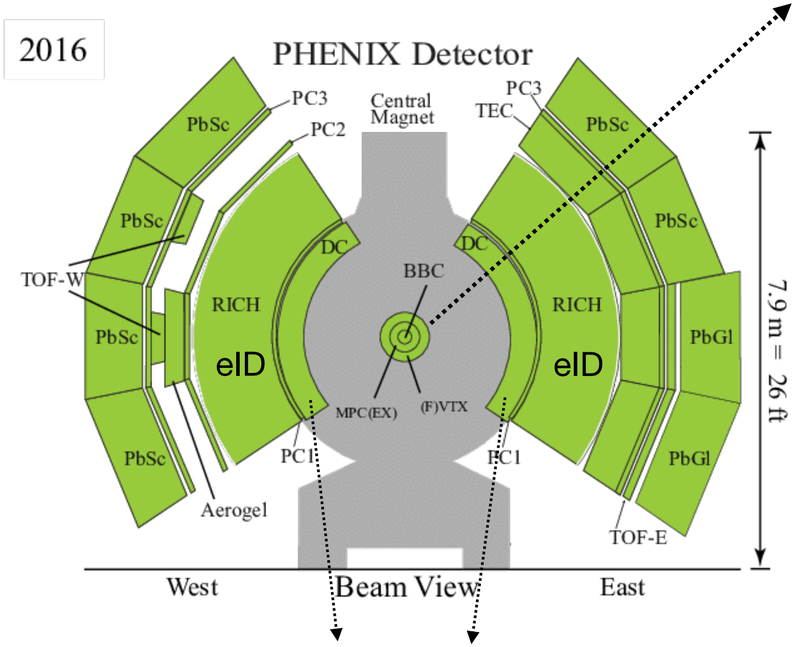
Low signal

- Small c → e branching (~10%)

Detector limitations

- Reduced VTX performance at high luminosity
- Dead regions in VTX (~60% live area in outer layers, 2015)





Tracking Detectors

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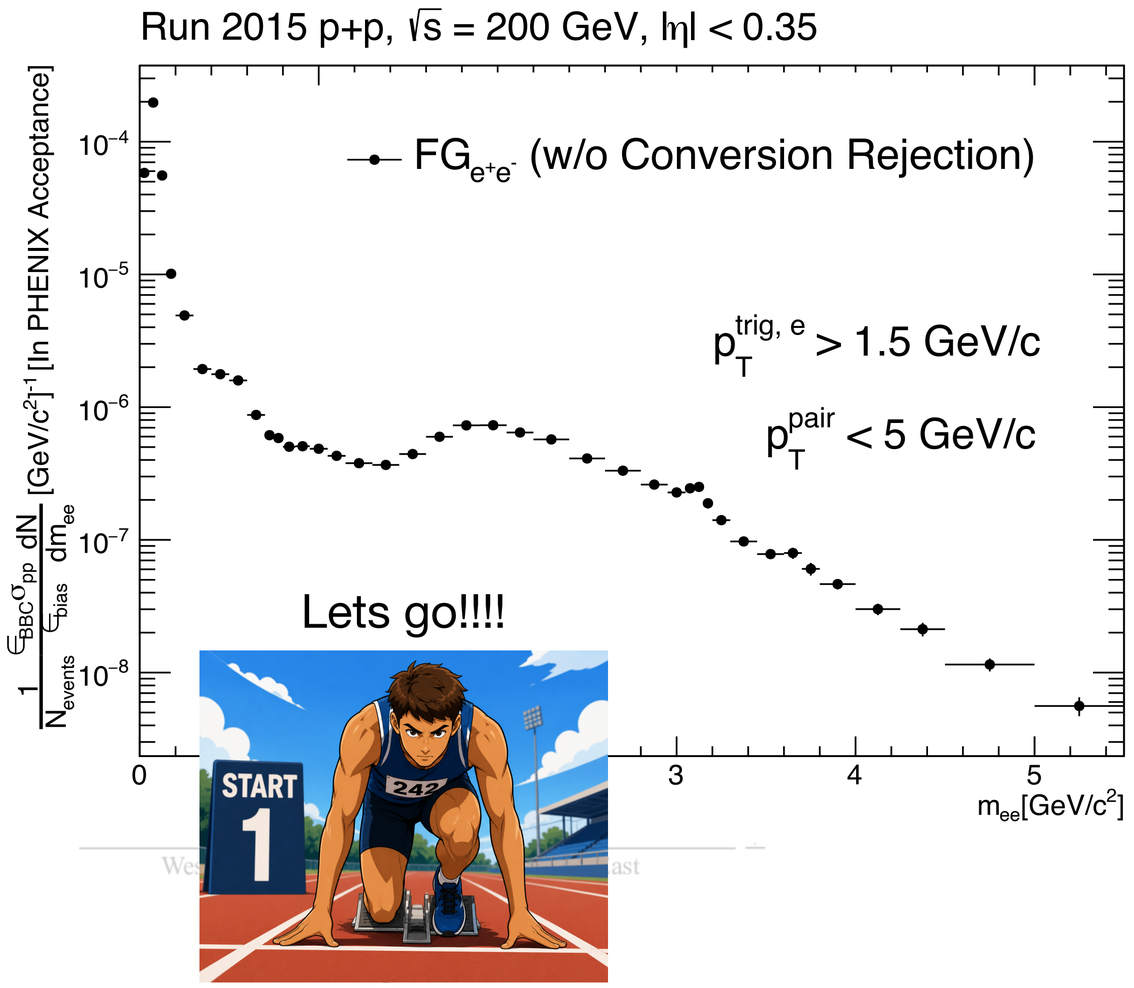

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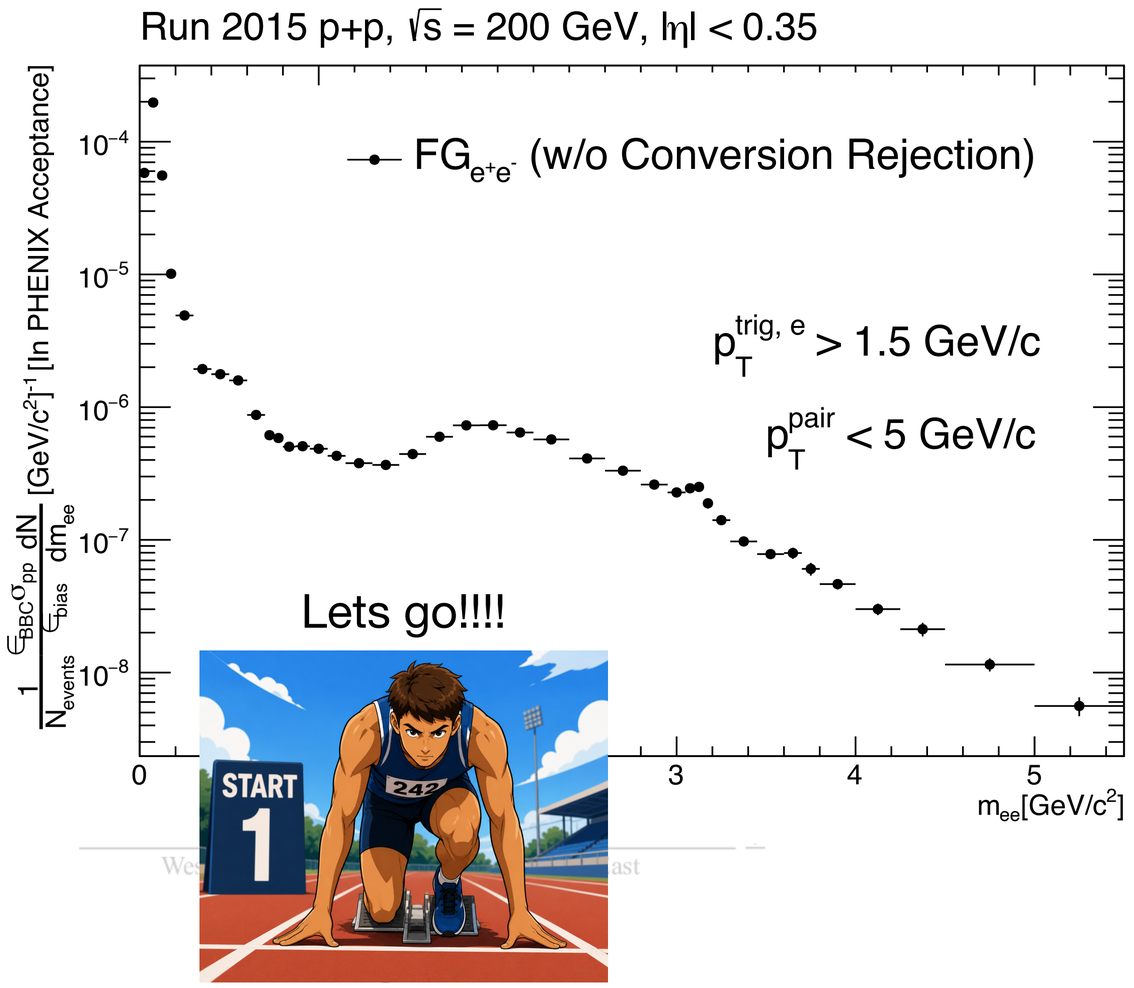

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- A dedicated photon conversion rejection algorithm was developed by requiring each track to have an innermost VTX hit, rejecting approximately 99% of conversion tracks.

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- Distorted z-vertex reconstruction observed for most events at high luminosity.

- Data-driven z-vertex recalculation recovers 60–70% of the lost statistics in this regime.

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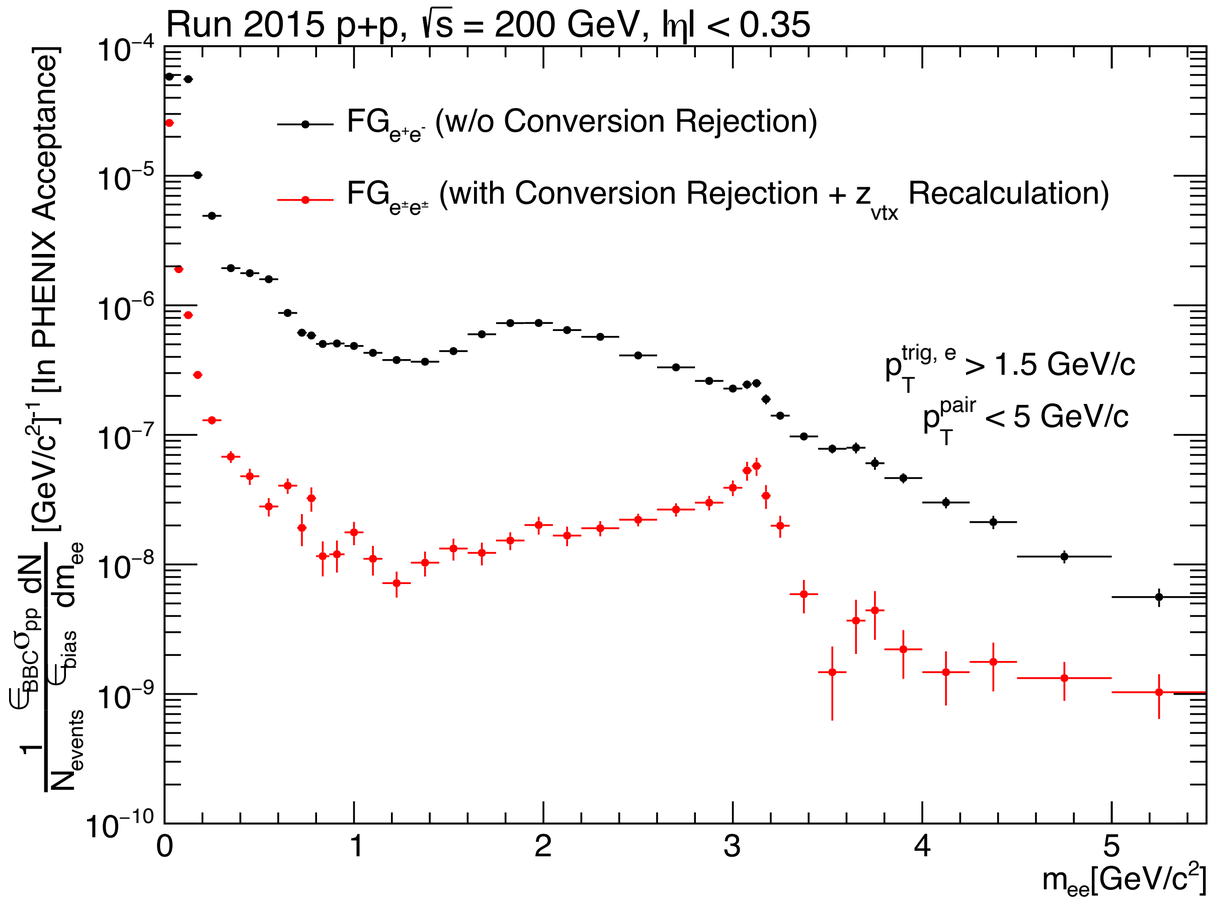
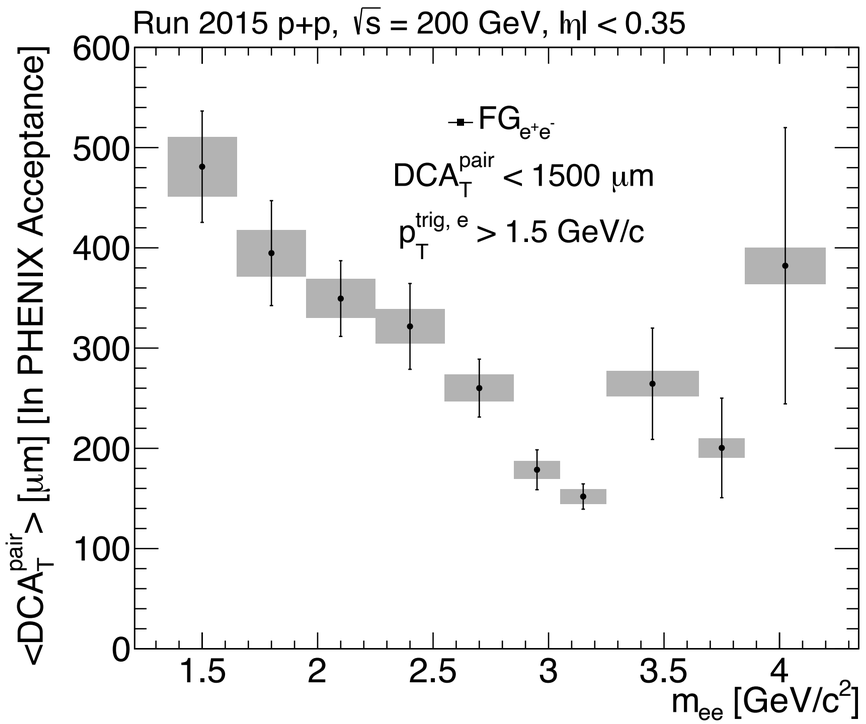
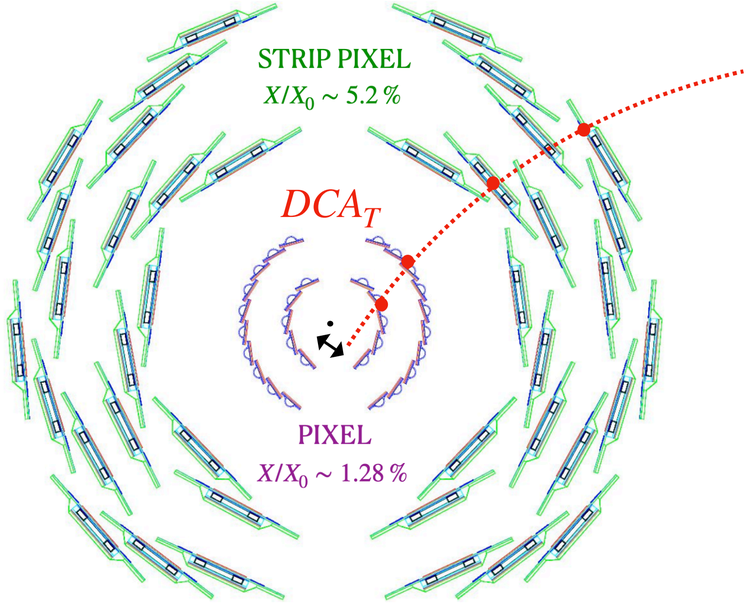


Measurements in the DCA Space

We calculate a transverse DCA of the central arm tracks to the interaction vertex determined by the VTX given by

$$DCA_T = L - R$$



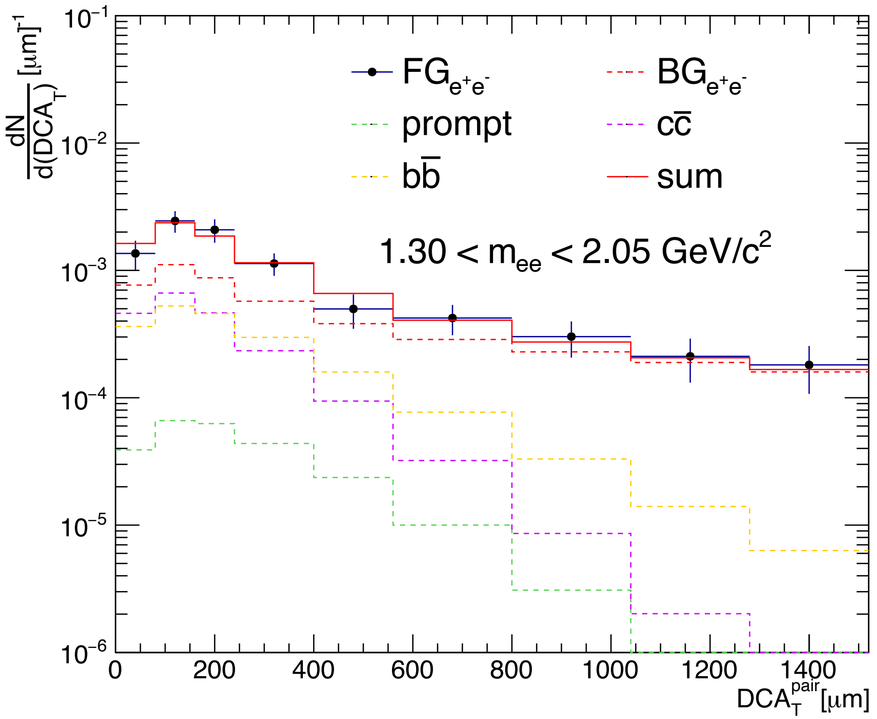


From the single track $\mathrm{DCA_T}$ we define a pair DCA as:

$$DCA_T^{pair} = \sqrt{|\,DCA_{e^-}^2 - DCA_{e^+}^2\,|}$$

DCA Template fits to extract *c* and *b*

- Stepwise procedure with a sliding window in invariant mass used for DCA template fits.
- Separates background, charm, and bottom contributions.



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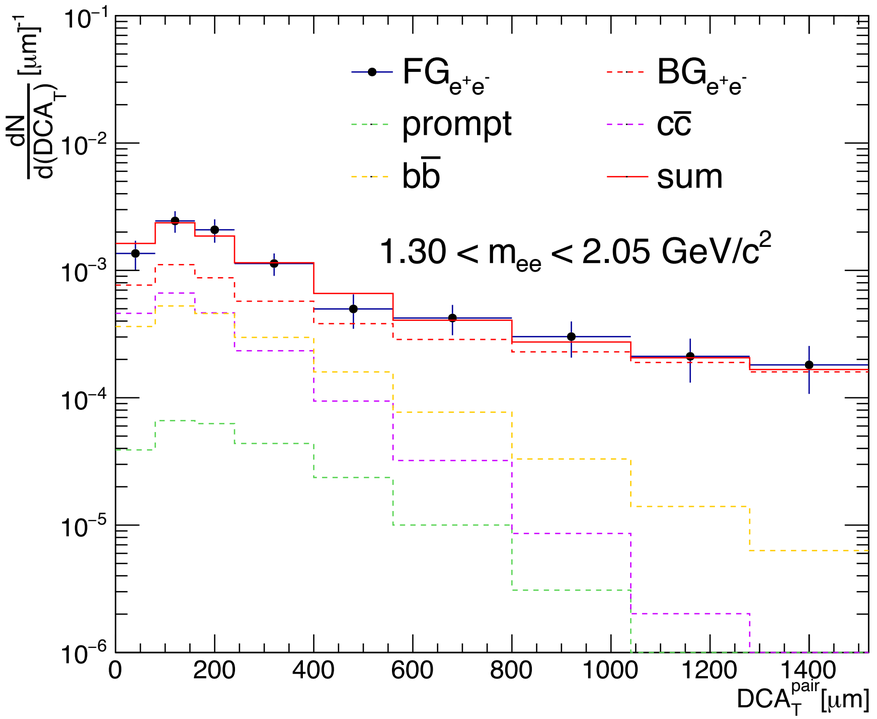

Background pretty much fixed by the high-DCA_T^{pair} region

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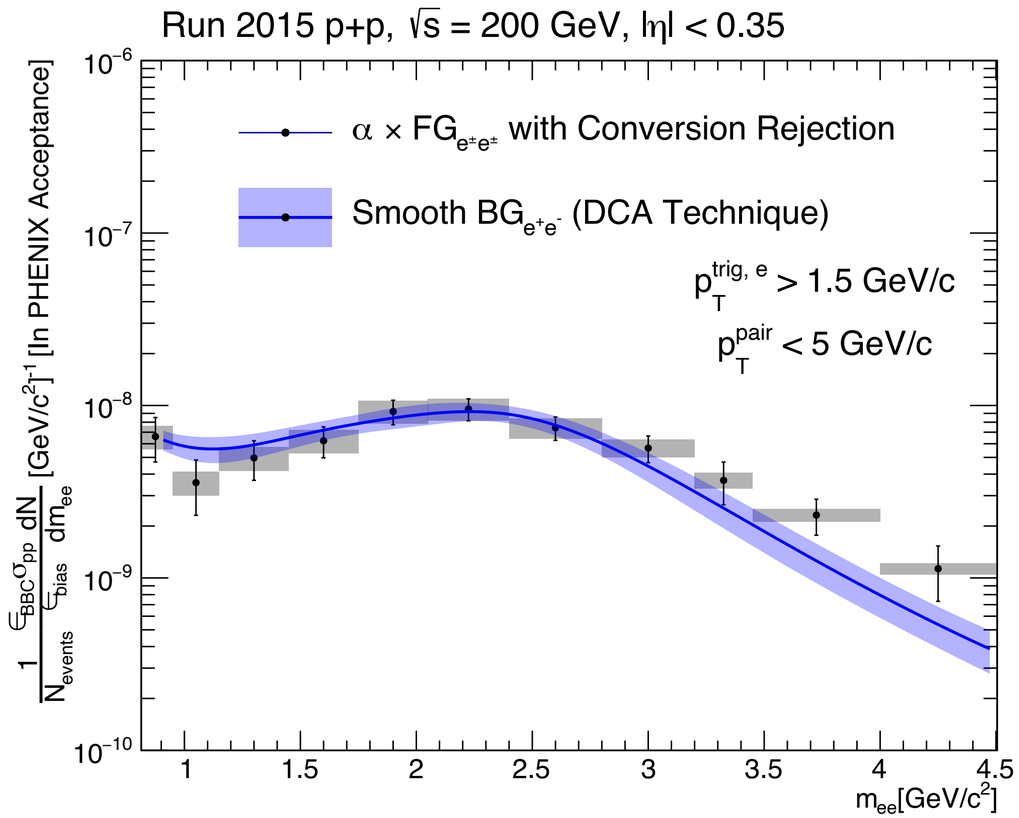
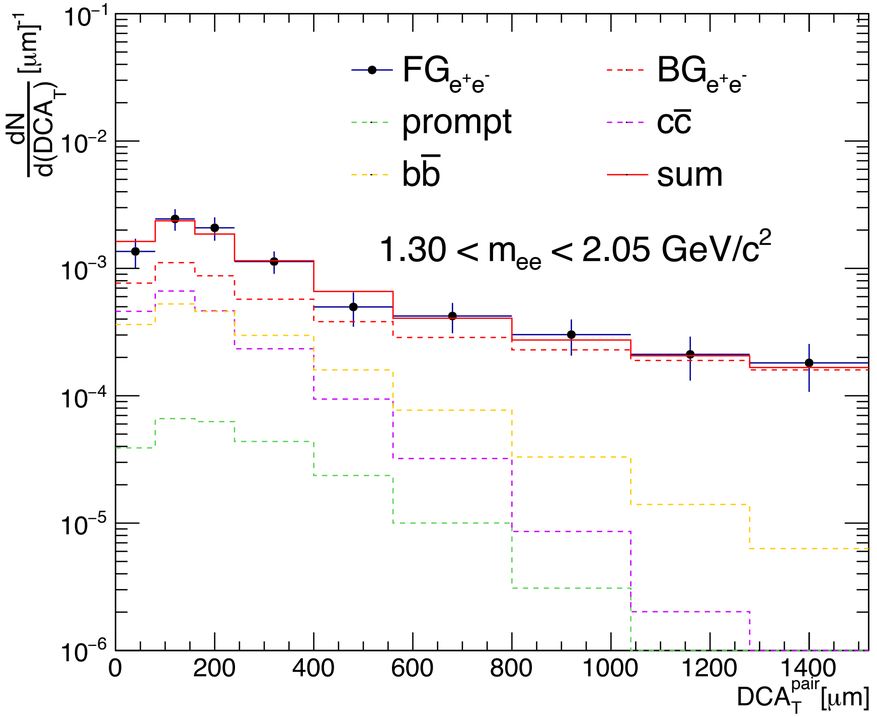
DCA based extraction of BG shows excellent scale agreement with the acceptance corrected like-sign mass spectrum!





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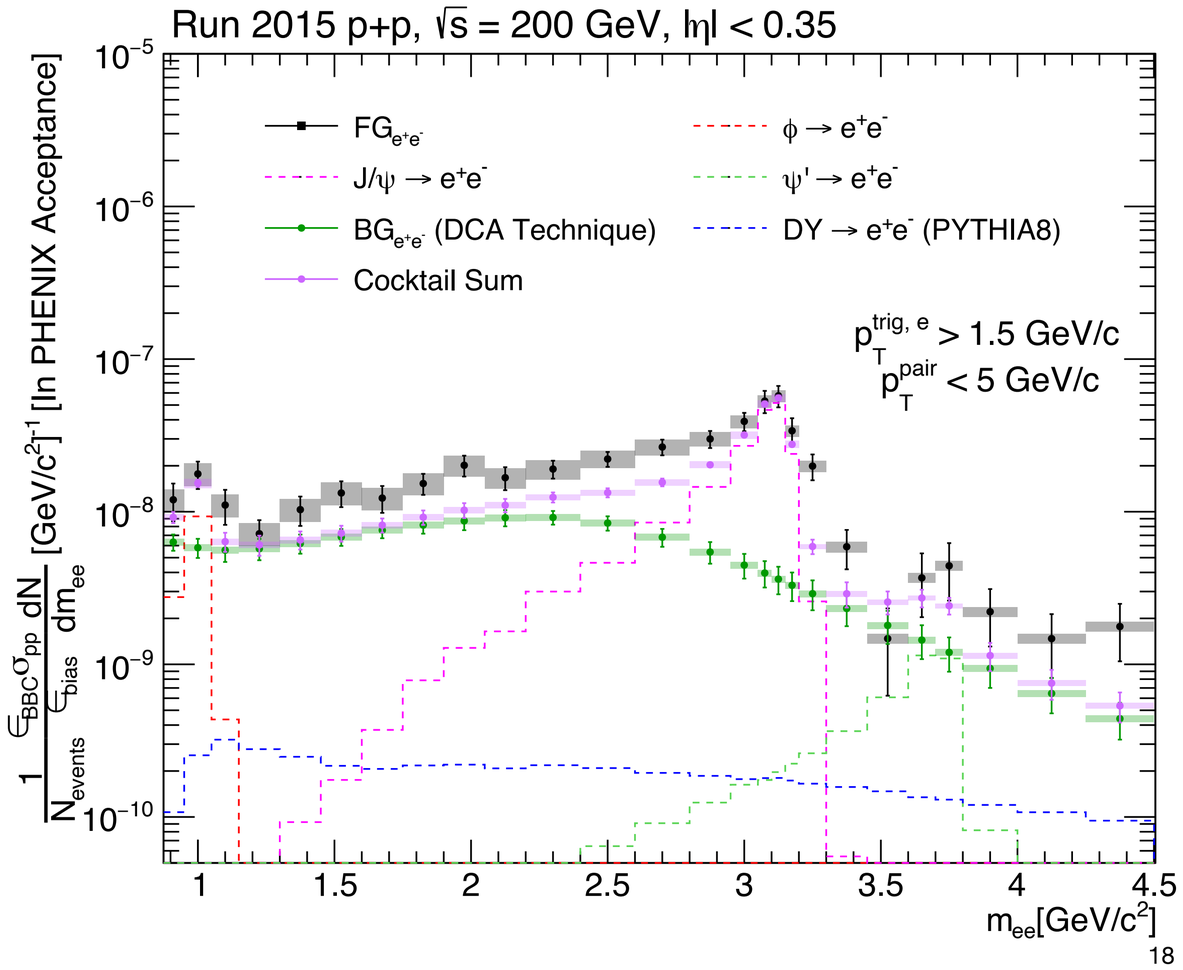

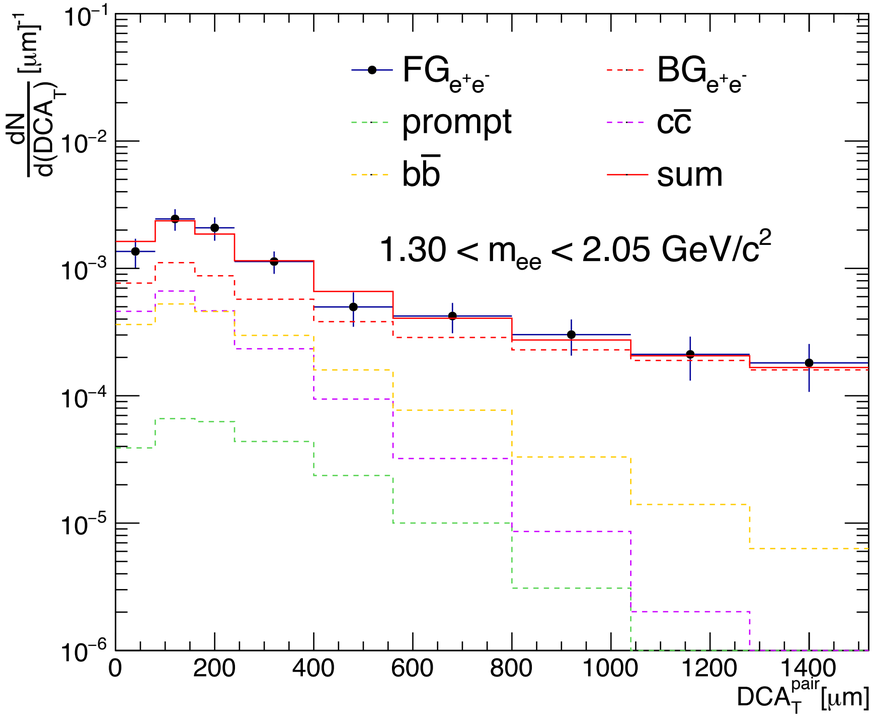

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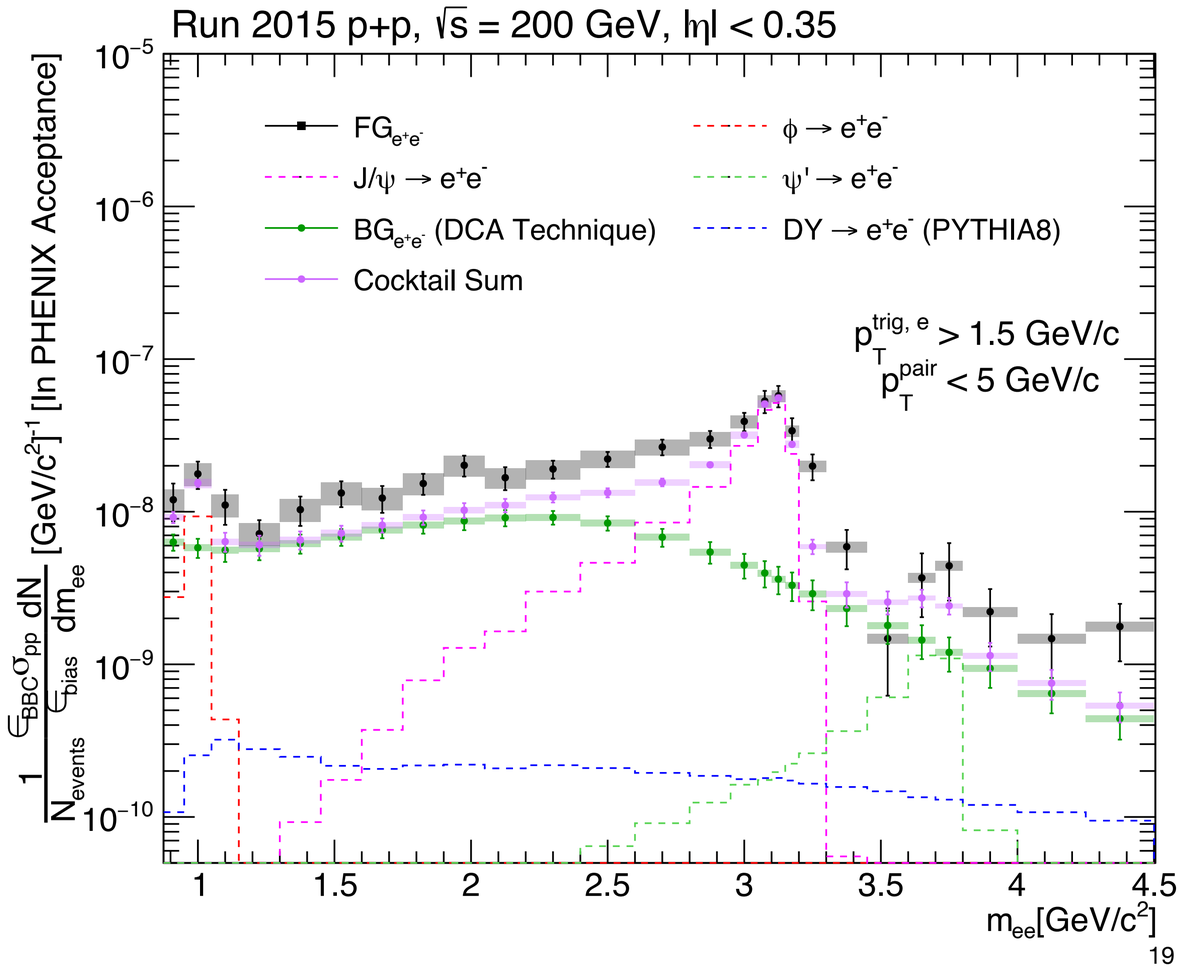

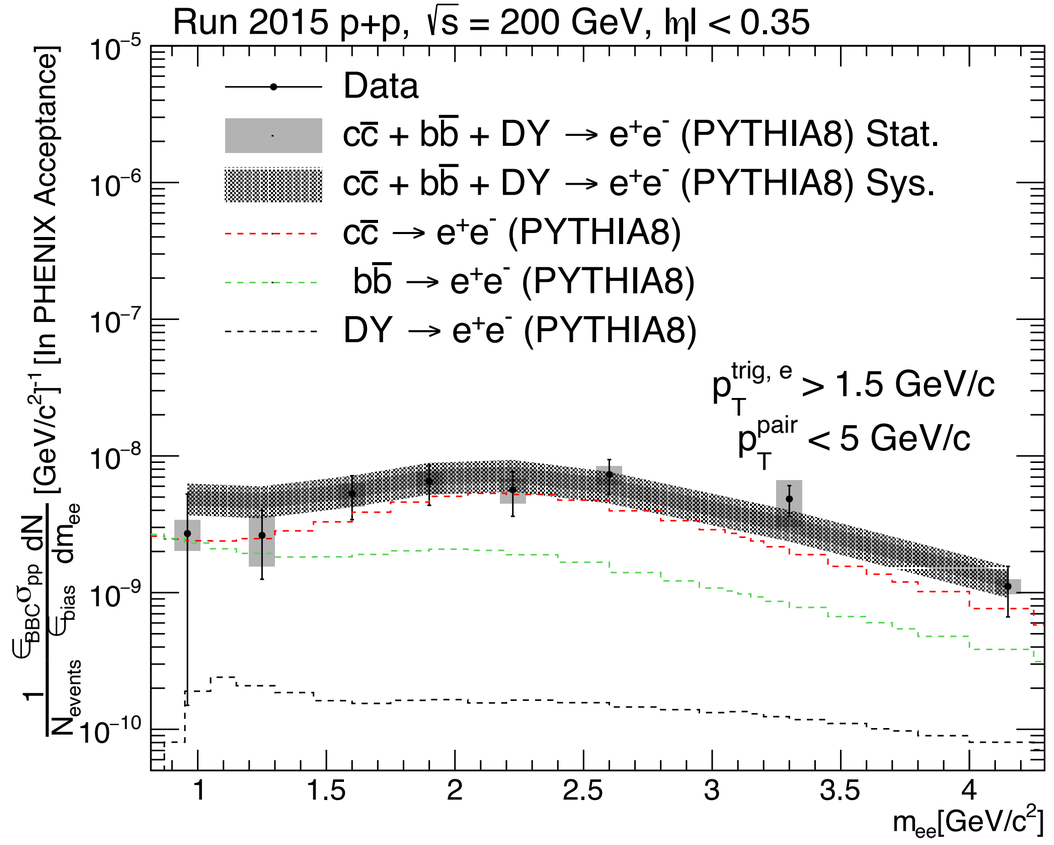

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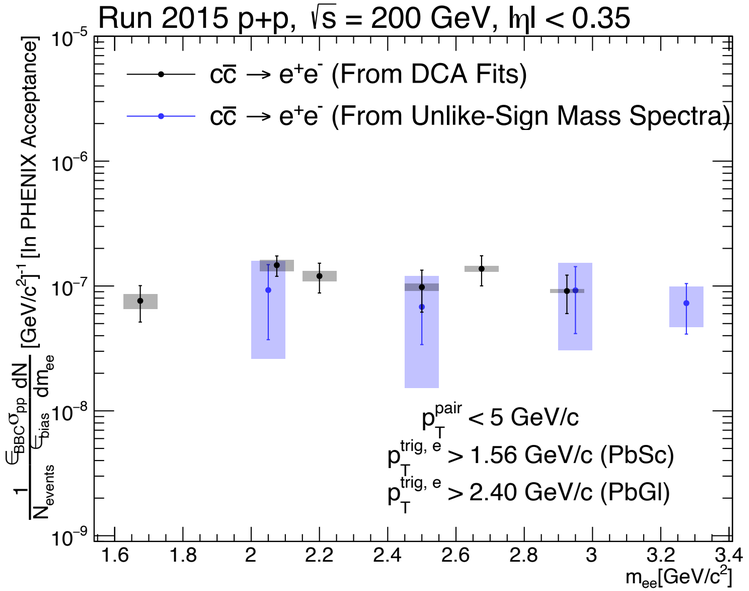

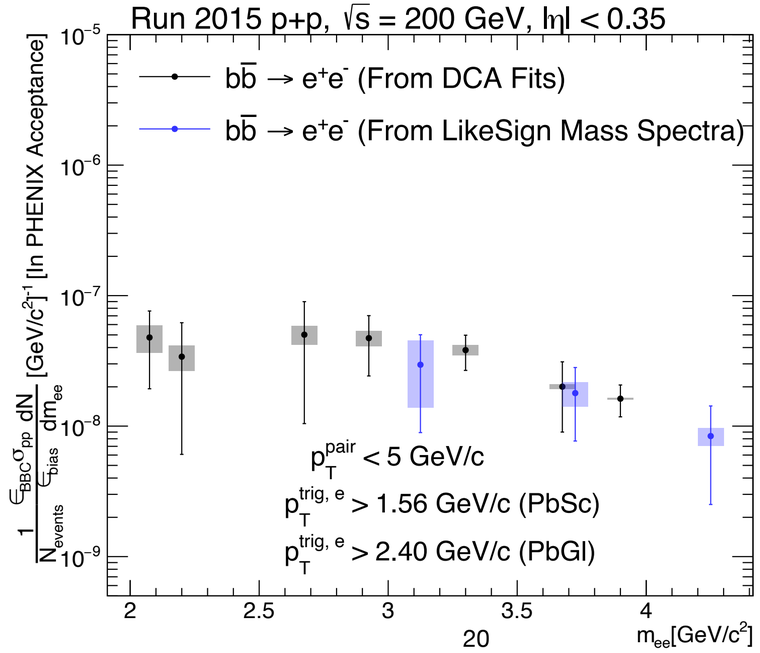

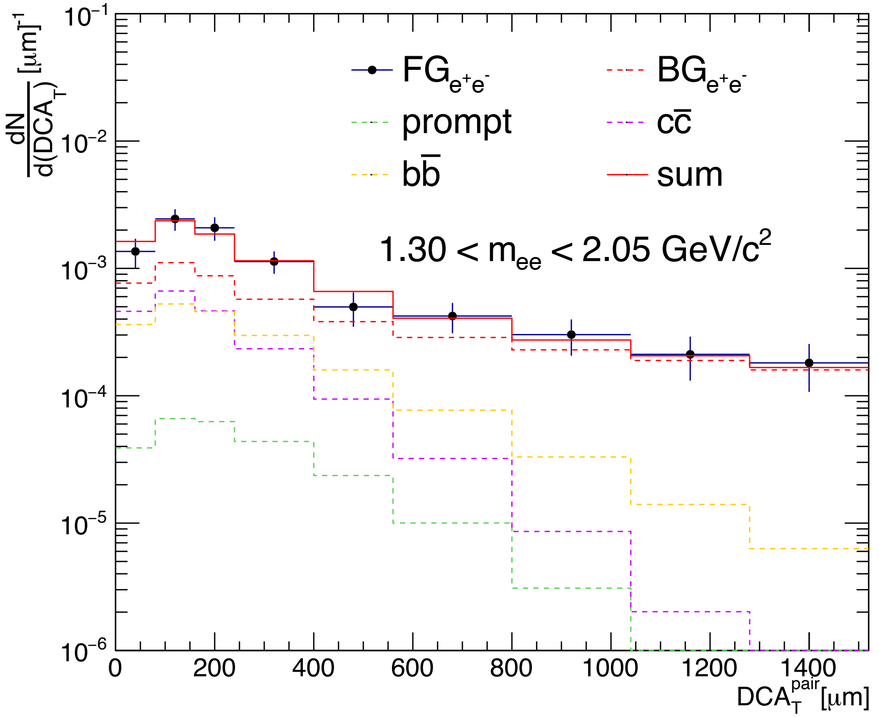

Impact

- First empirical separation of charm and bottom in the intermediate dilepton invariant mass region at RHIC.

- Developed techniques are broadly applicable.

- Provides a baseline for heavy-ion measurements.

- Most precise charm production cross-section measurement to date.