# Studying heavy flavor (charm and beauty) production via dielectrons in p + p and d + Au collisions

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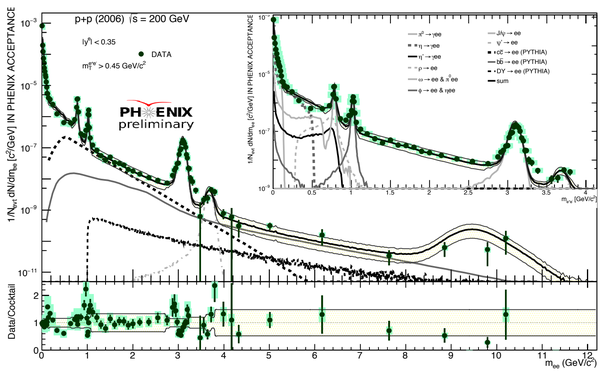
## Motivation

The dielectron mass spectrum is a unique probe to directly access the different stages of a heavy-ion collision. The intermediate ($1 < m_{e^+e^-} < 3$ GeV/$c^2$) and high ($4 < m_{e^+e^-} < 8$ GeV/$c^2$) mass regions are dominated by semi-leptonic decays of open charm and beauty respectively, and so provide information about the heavy flavor dynamics. Utilizing the double differential information in $m_{e^+e^-}$ and $p_T$ space provides sensitivity to the regions where either charm or beauty dominates. This allows separation of $c\bar{c}$ and $b\bar{b}$ contributions, which are then quantified by comparison to **PYTHIA** and **MC@NLO** simulations.

## Dielectron mass spectrum in p + p collisions



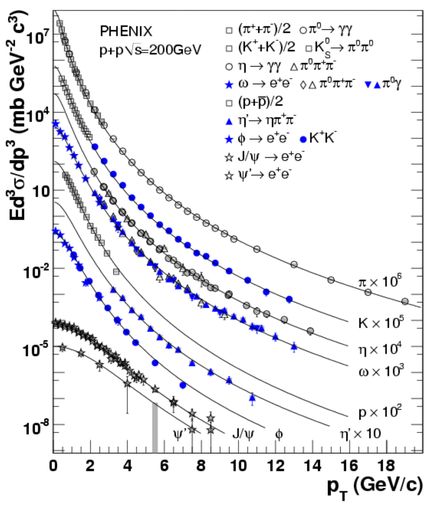

- Good agreement with cocktail.
- Extended mass coverage to 12 GeV/$c^2$.
- Like-sign pairs used for background subtraction after correcting for relative acceptance difference between unlike/like sign.
- Cocktail includes contributions of:
  - Hadrons
  - Heavy flavor
  - Drell-Yan

## Hadronic cocktail

- Parametrize the $\pi^{\pm}$ and $\pi^0$ data for a given collision system

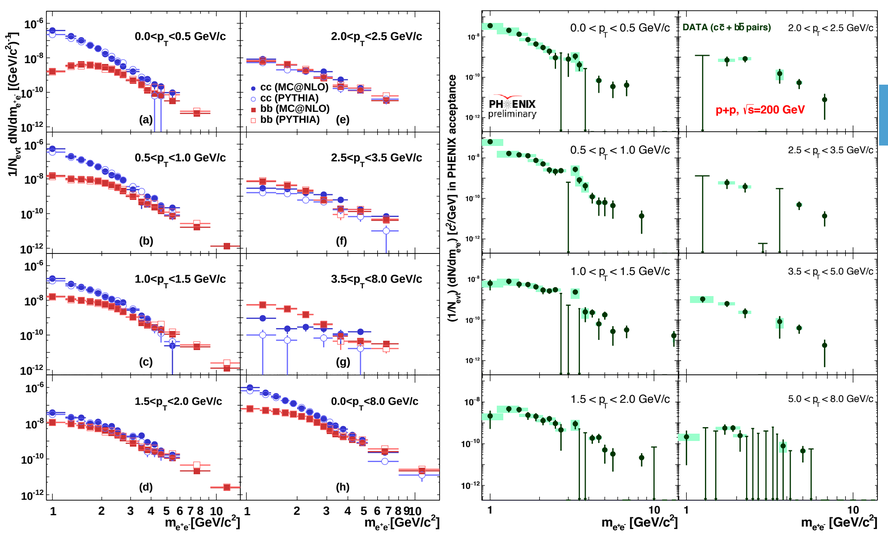
$$E\frac{d^3\sigma}{dp^3} = \frac{A}{(e^{-(ap_T+bp_T^2)}+p_T/p_0)^n}$$

- Use $m_T$ scaling for shape of other hadrons: $p_T \rightarrow \sqrt{p_T^2 - m_{\pi^0}^2 + m_{hadron}^2}$ and fix normalization using the existing data where available.



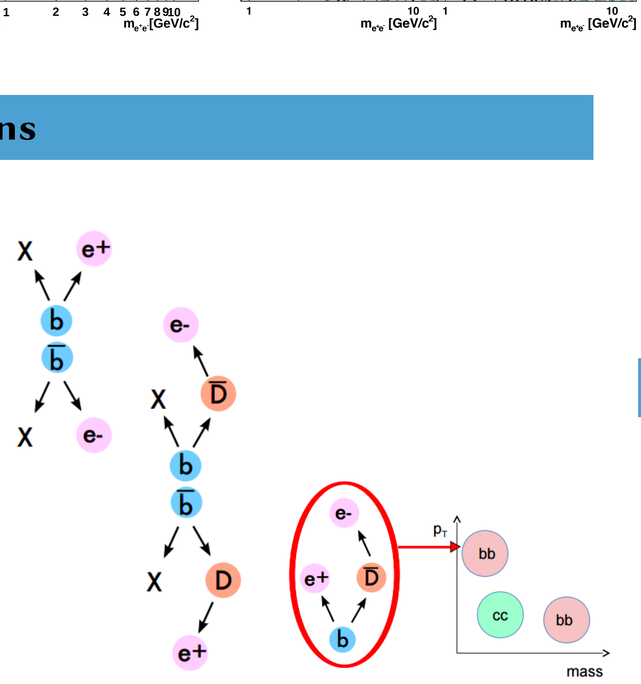

## Heavy flavor yield extraction

- Subtract in mass and $p_T$
  - Vector mesons
  - Pseudoscalar mesons
  - Drell-Yan.
- We are left with open heavy flavor decays
- Fit in $m$, $p_T$ with
  - MC@NLO, an NLO event generator
  - PYTHIA, a LO event generator
- Following general trends observed
  - charm dominates at
    - low $p_T$, low mass
  - beauty dominates at
    - low $p_T$, high mass
    - high $p_T$, low mass

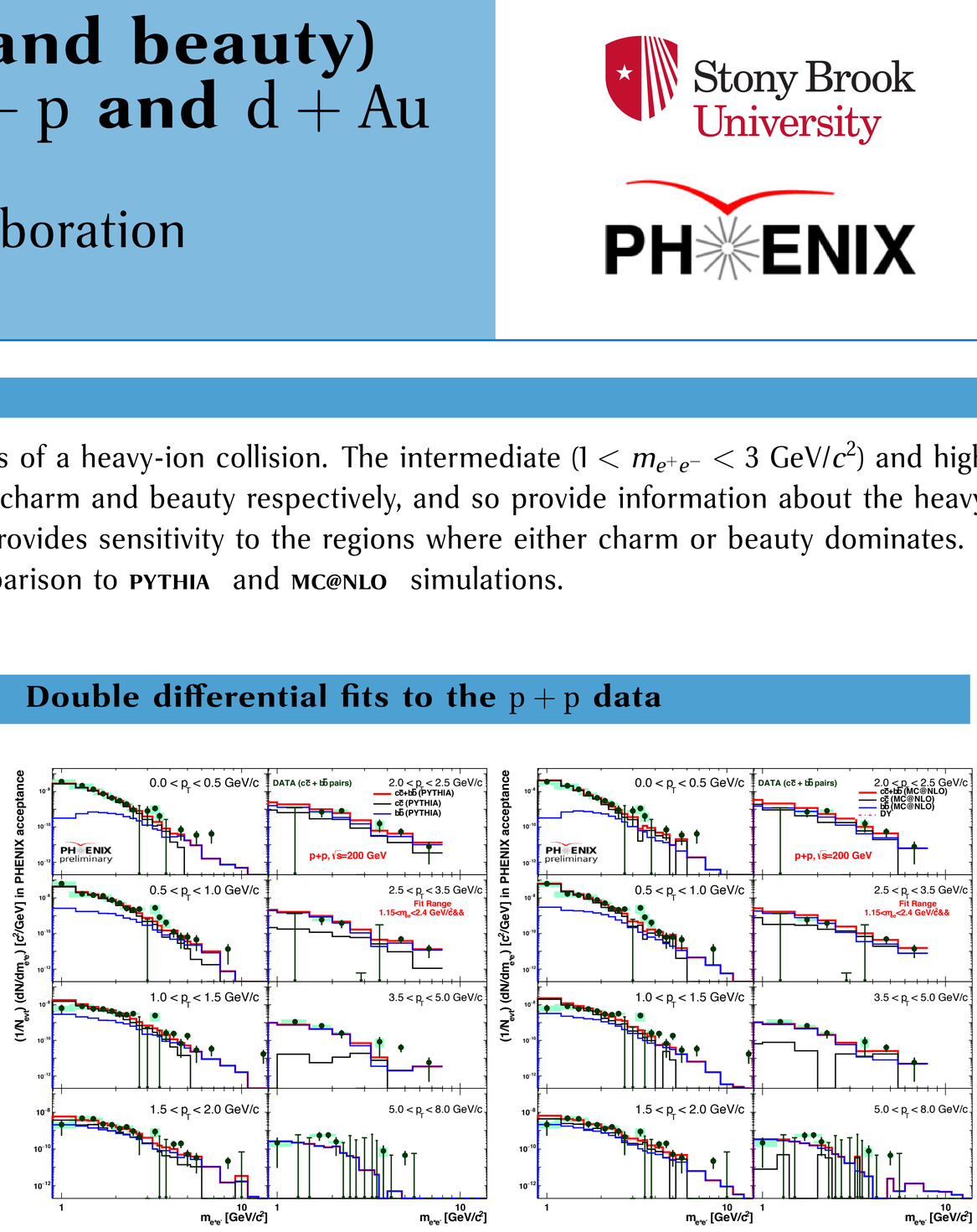



## Separting $c\bar{c}$ and $b\bar{b}$ via dielectrons

- Multiple ways to produce $e^+e^-$ pairs from $b\bar{b}$.
- All contribute similar total pairs.
- But they populate different regions of mass, $p_T$ space.
- At high $p_T$, decays from a single open $B$ meson completely dominate the mass spectrum.
- Due to oscillations, the other decay chains contribute to both like- and unlike-sign pairs.



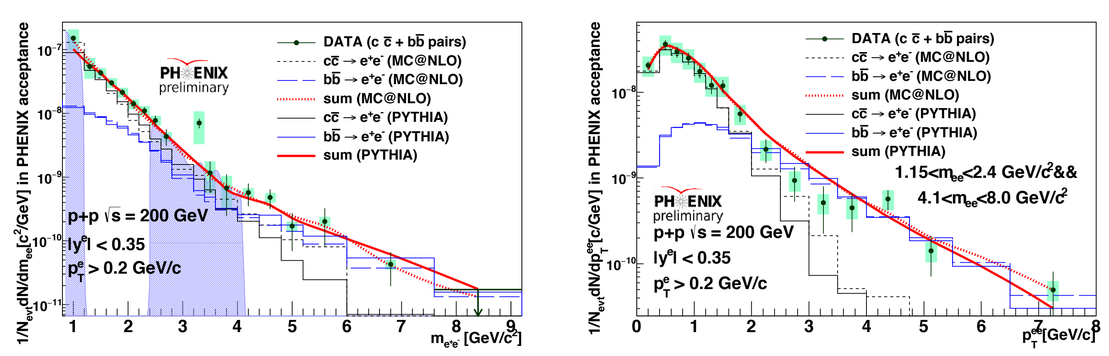

## Double differential fits to the p + p data




**MC@NLO** fits to the data

**PYTHIA** fits to the data

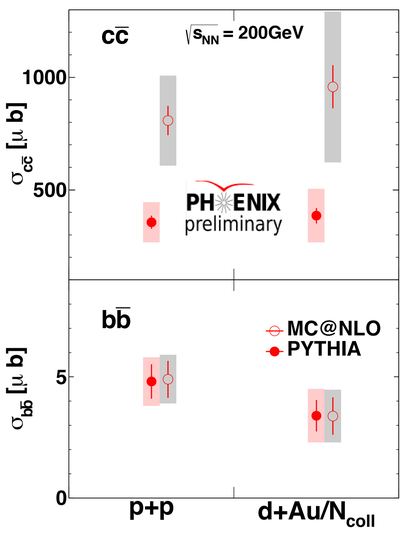
## Integrated mass and $p_T$ spectrum of $c\bar{c}$ + $b\bar{b}$ pairs



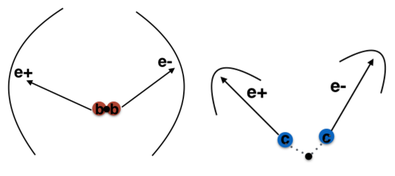

- Highlighted region in blue, in the mass projection, is excluded from the double differentail fits.
- **Both PYTHIA and MC@NLO describe the data equally well.**

## Extracted $\sigma_{c\bar{c}}$ and $\sigma_{b\bar{b}}$ in p + p and d + Au

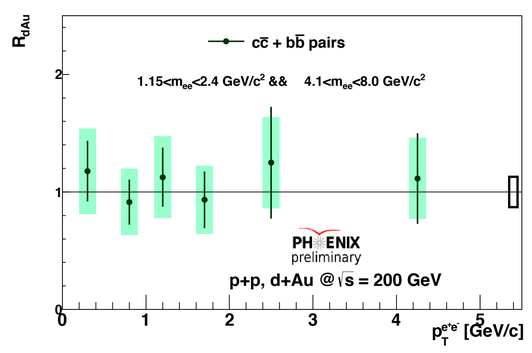
Details of the d + Au results from the same technique can be found in **PRC 91, 014907**




- **Very large model dependence for the $c\bar{c}$ cross-section.**
- **$b\bar{b}$ cross-section comes out to be model independent.**
- If $m_q >> p$, the $e^{\pm}$ decay randomizes the opening angle.




## p + p and d + Au comparison




- No significant modification seen in the heavy flavor pair spectrum in d + Au as compared to p + p.
- Word of caution: However, this is not the typical $R_{dAu}$ plot. These are electron pairs and so they mostly do not come from the same quark.

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