MULTIDIFFERENTIAL ANALYSIS OF DIELECTRON SPECTRA IN AG+AG COLLISIONS AT 1.23A GEV

Master‘s Thesis Proposal

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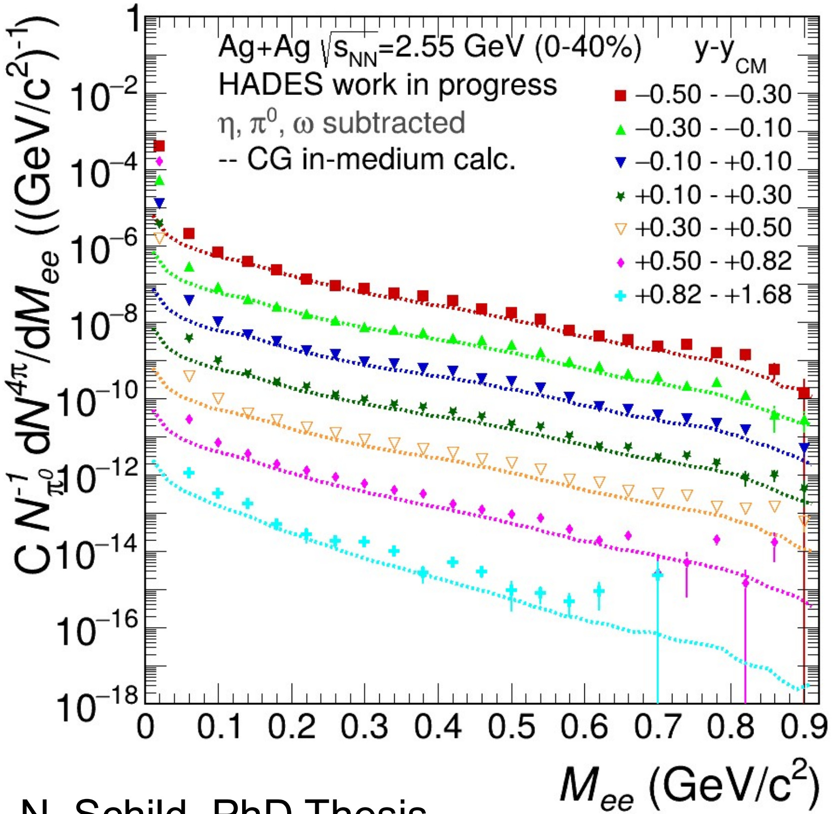
MOTIVATION AND GOALS

- Multidifferential spectra produced by N. Schild for Ag+Ag @ $\sqrt{s_{\mathrm{NN}}}$=2.55 GeV

→Achieve multidifferential analysis of the dielectron data measured in Ag+Ag @ $\sqrt{s_{\mathrm{NN}}}$=2.42 GeV

→ Expand existing analysis procedure from integrated $\mathrm{M_{ee}}$-spectra to multidifferential $\mathrm{M_{ee}}$-, $\mathrm{p_T}$- and y-spectra

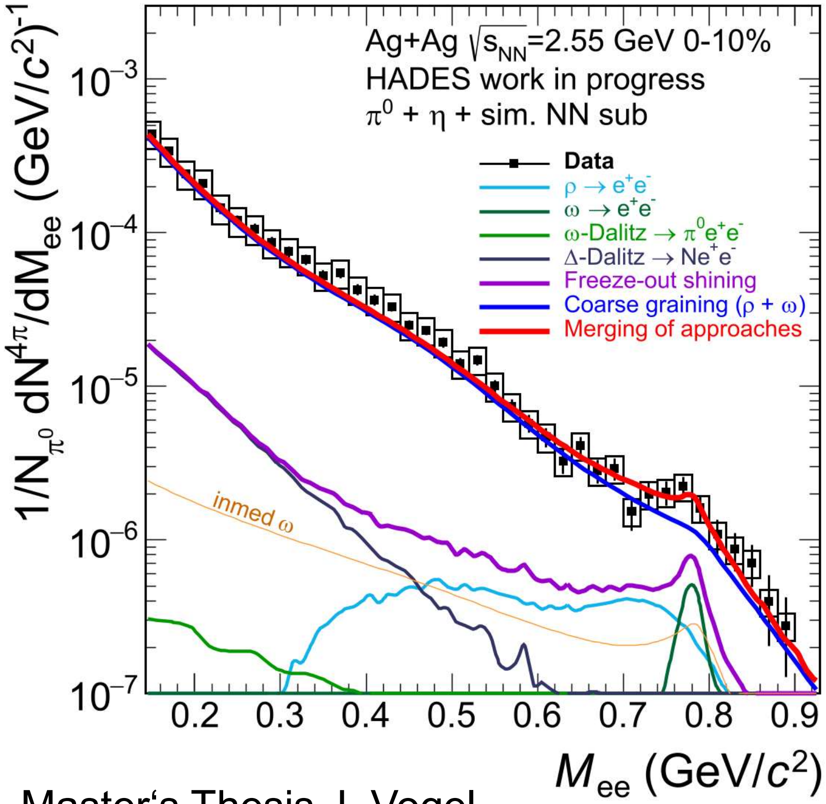


N. Schild, PhD Thesis

MOTIVATION AND GOALS

- Use multidifferential Ag+Ag @ $\sqrt{S_{\mathrm{NN}}}$=2.42 GeV dielectron spectra to compare to merged model calculations established by J. Vogel in her master‘s thesis

- Merged model approach: Combination of shining model and coarse-grained UrQMD to investigate the thermalised medium

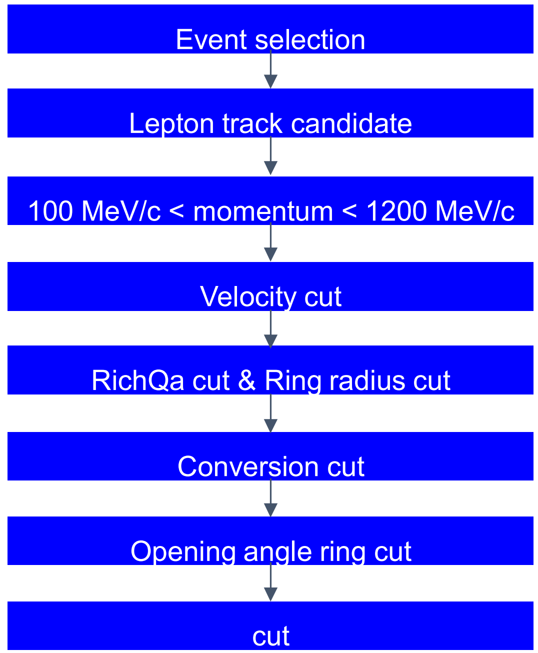


Master‘s Thesis J. Vogel

PARTICLE IDENTIFICATION

- Difficulties of using dielectrons as probes:
  - Rare
  - Charged hadrons contaminate the data
  - Conversion pairs

- A multitude of cuts is applied to the data for particle identification and filtering



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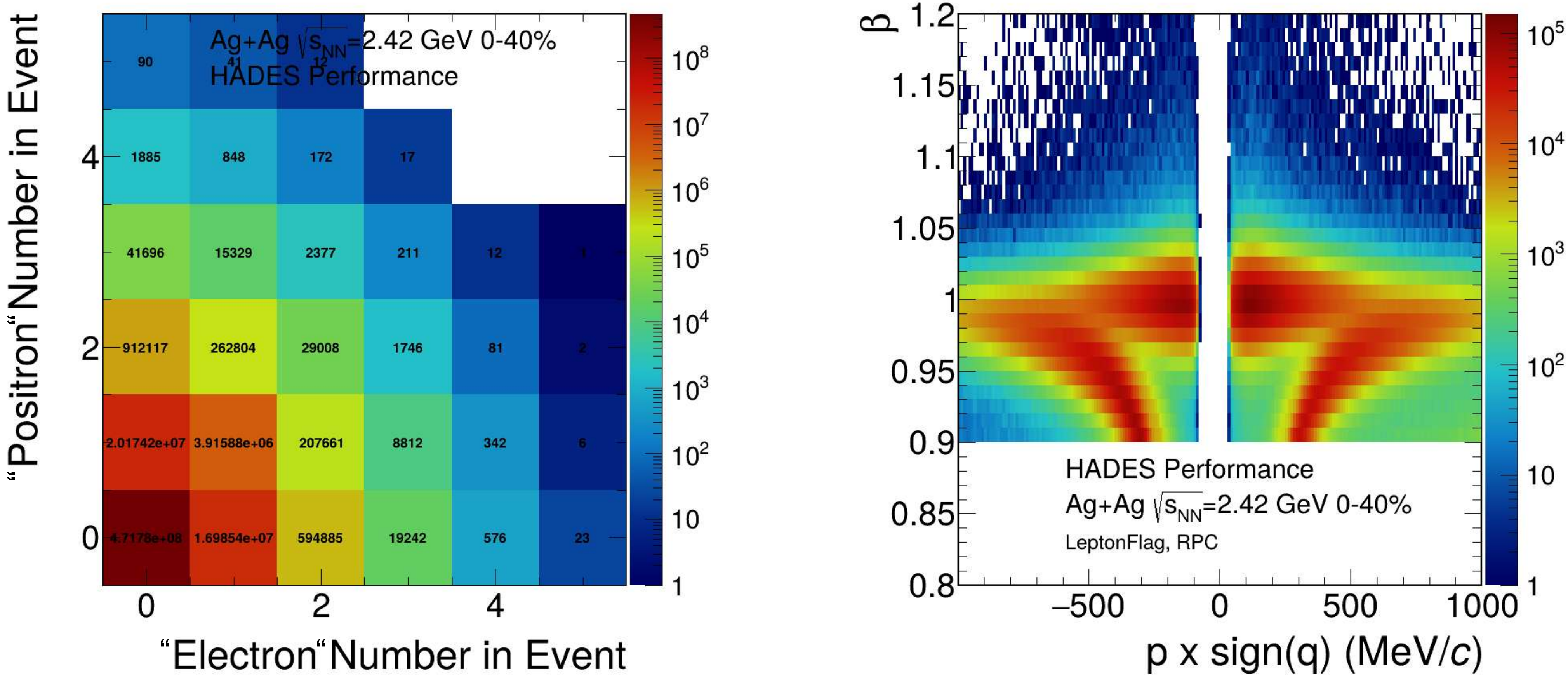
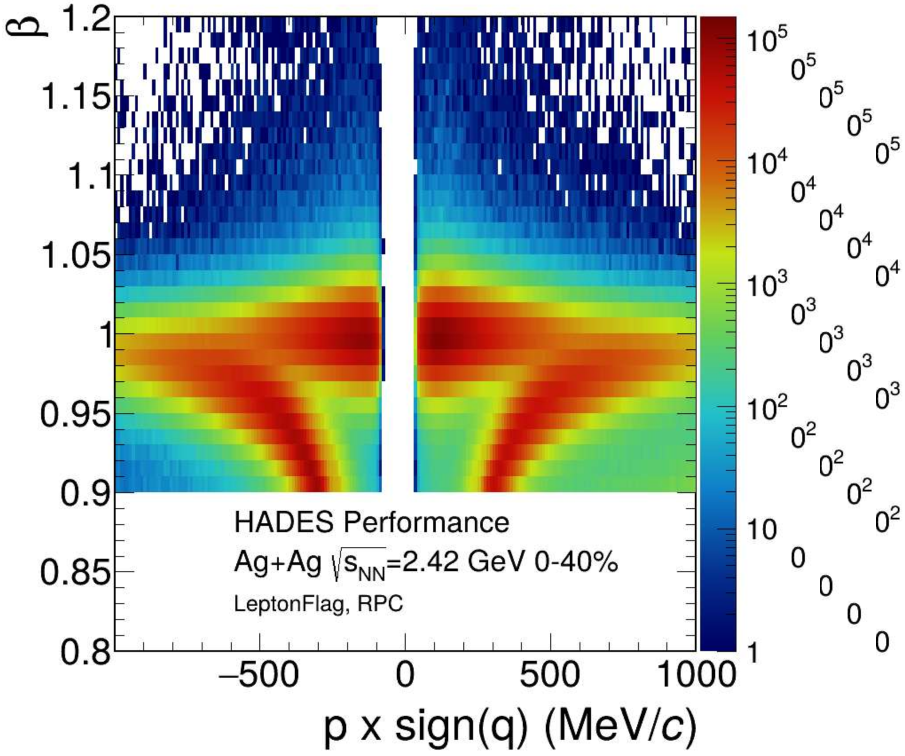


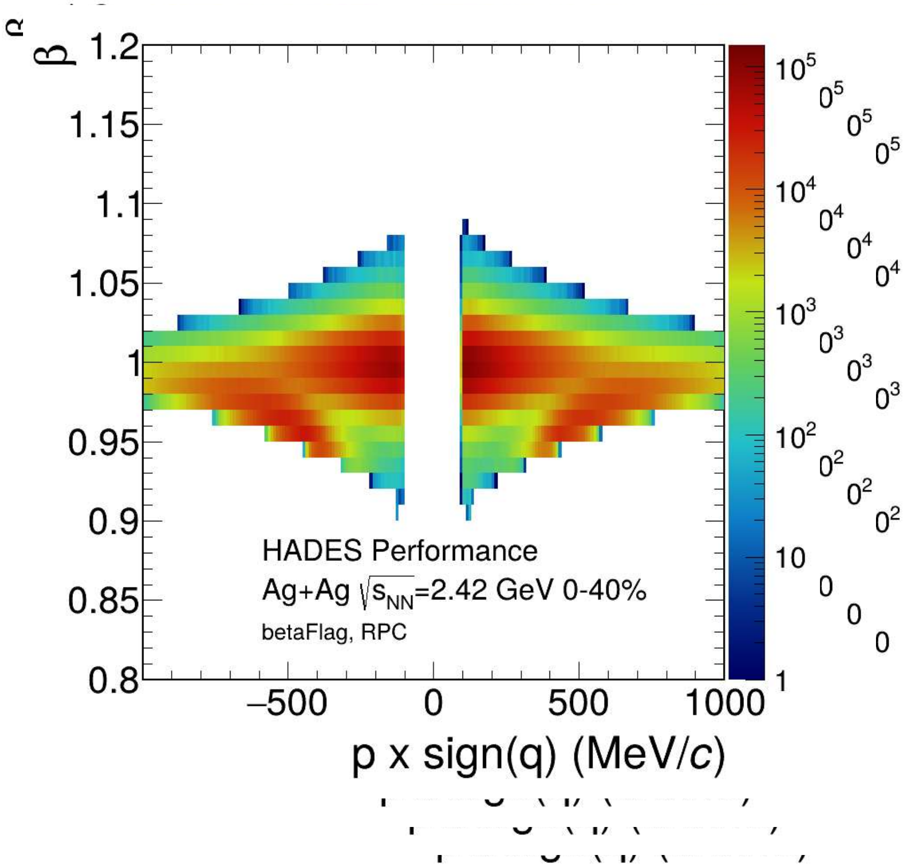
PARTICLE IDENTIFICATION

- Cut used:
- kIsLepton Flag
  - All lepton track candidates
  - $\beta > 0.9$
  - Track fit quality $\chi^2_{\mathrm{RK}} < 1000$
  - META hit
  - RICH ring associated with track



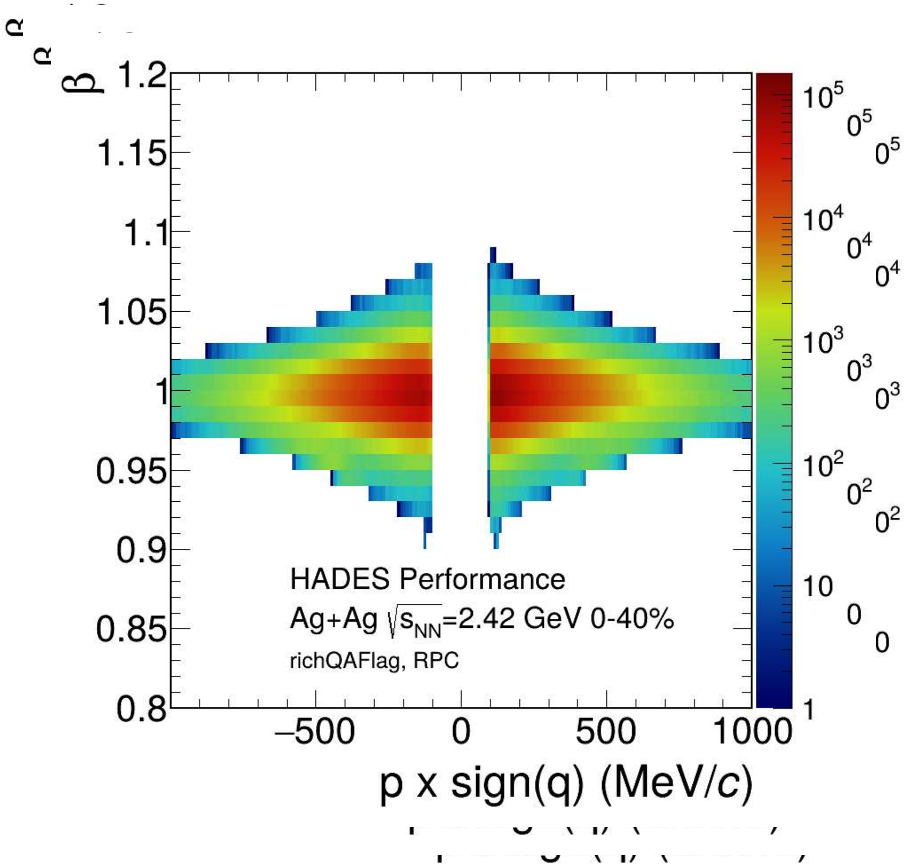
PARTICLE IDENTIFICATION

- Cuts used:
- Acceptance:
  - 100 MeV/c < p < 1200 MeV/c
  - 16° < θ < 83°
- β Flag
  - Momentum dependent β Cut
  - β window evolves with $e^{2-0.0017 \cdot p}$
  - At low momenta this still includes 98% of all candidates
  - At highest momenta it includes 68% of all candidates



PARTICLE IDENTIFICATION

- Cut used:
- richQA Flag
  - Tighter constraints on RICH ring matching
  - Momentum dependent cut on $\Delta\theta$ and $\Delta\phi$
  - Also cut on ring radius: 20.47mm < R < 26.06mm



HADES

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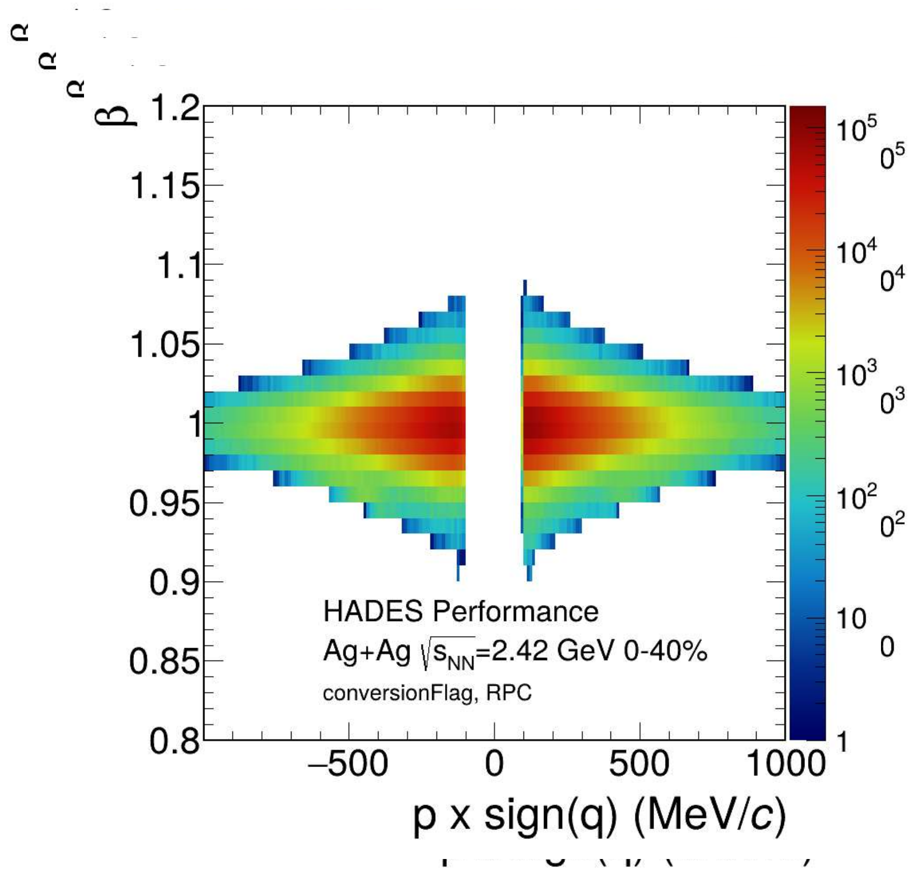
CONVERSION REJECTION

- Cuts used:
- Conversion rejection
  - Candidates with unusually many or unusually placed RICH hits are excluded
  - The could correspond to double ring → conversion in RICH
- oARing Flag
  - Take angle between ring center of given candidate and another in same event
  - If angle < 9°: reject candidate



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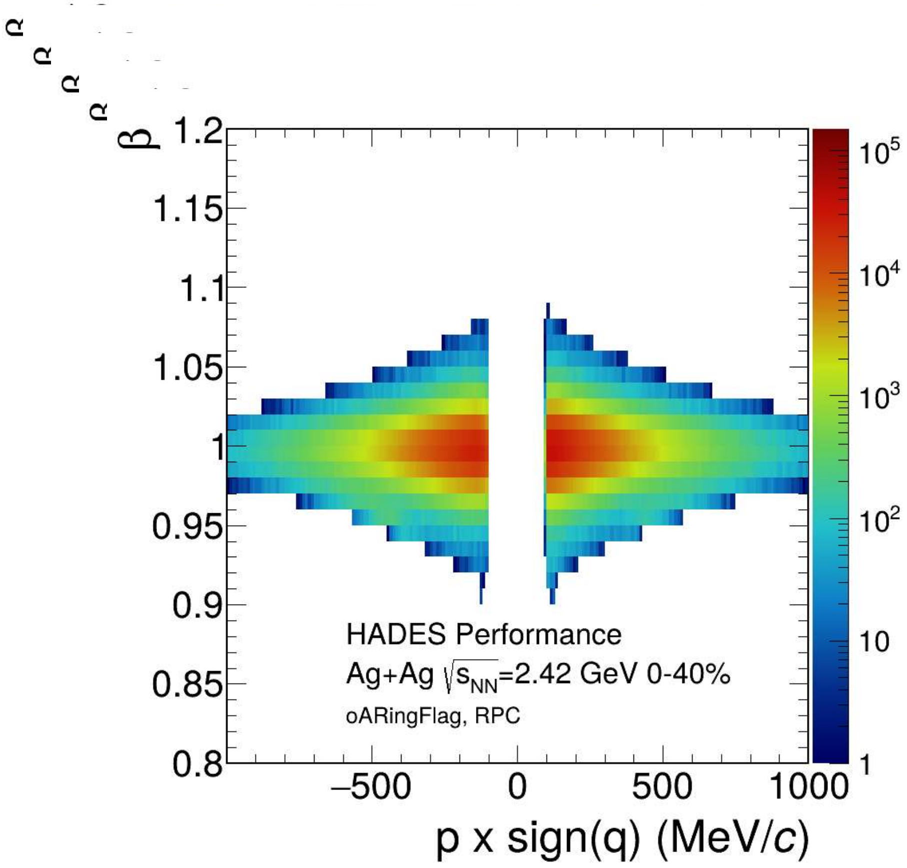

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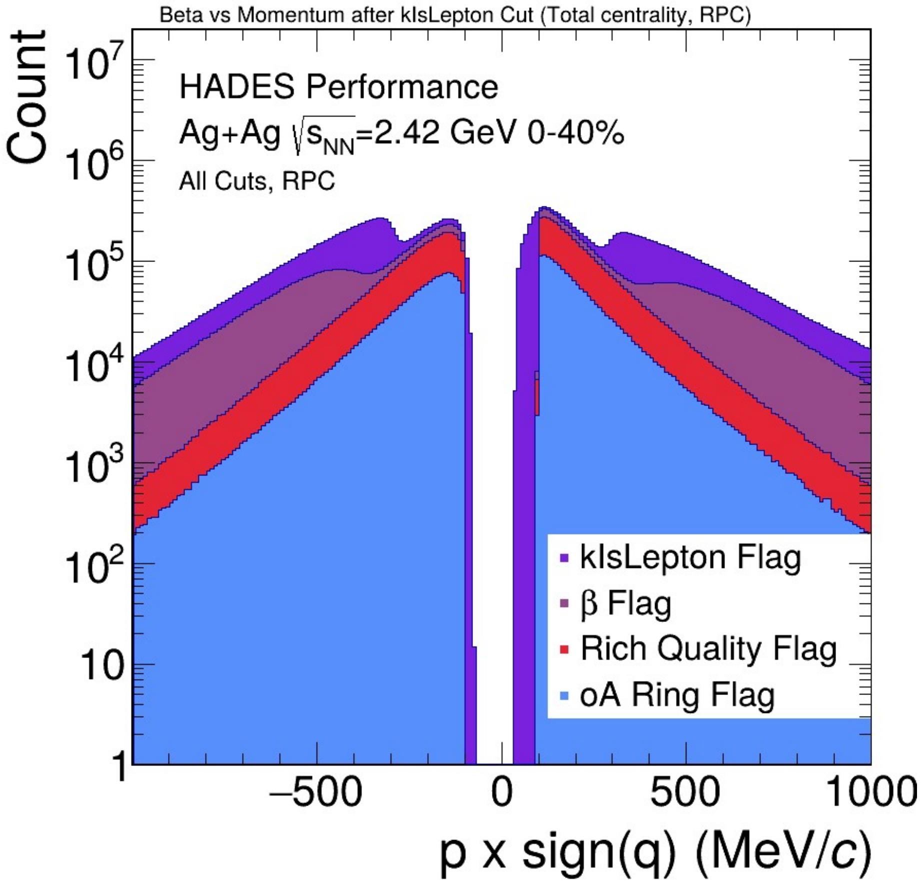

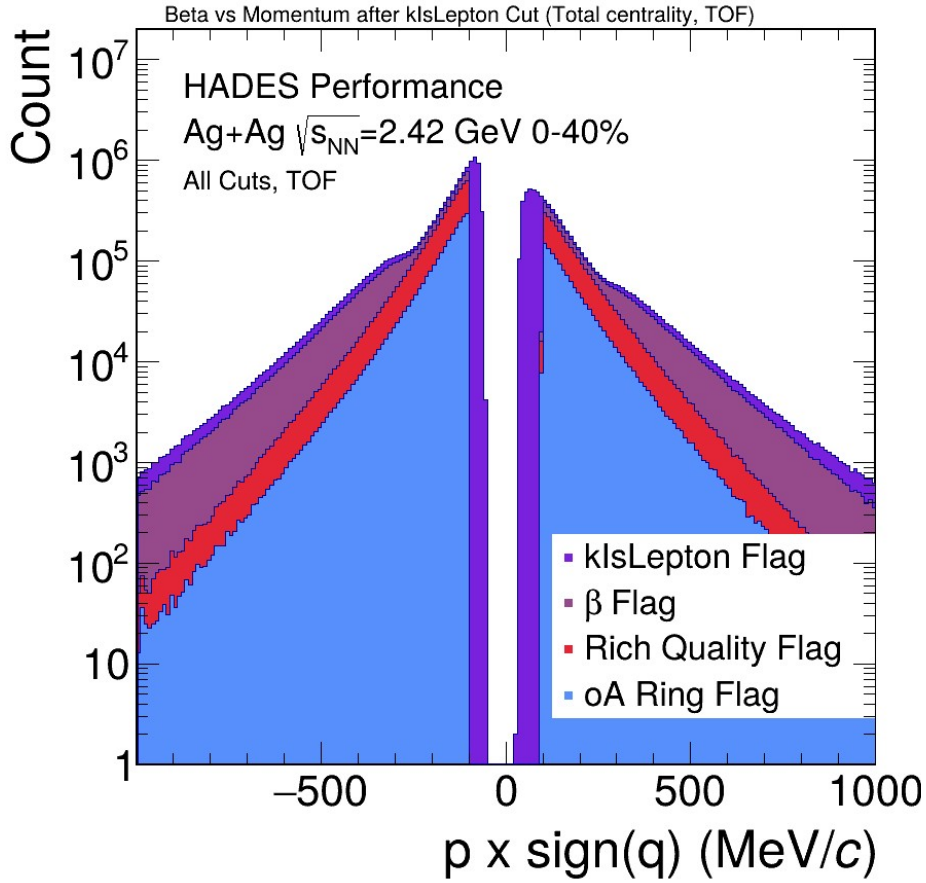

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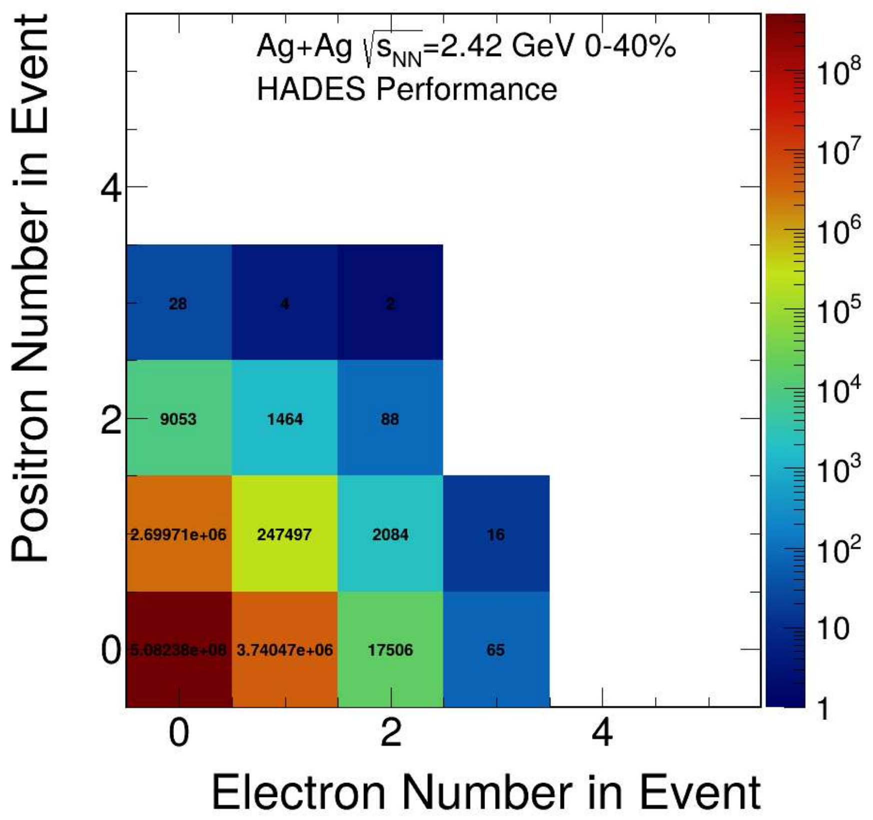
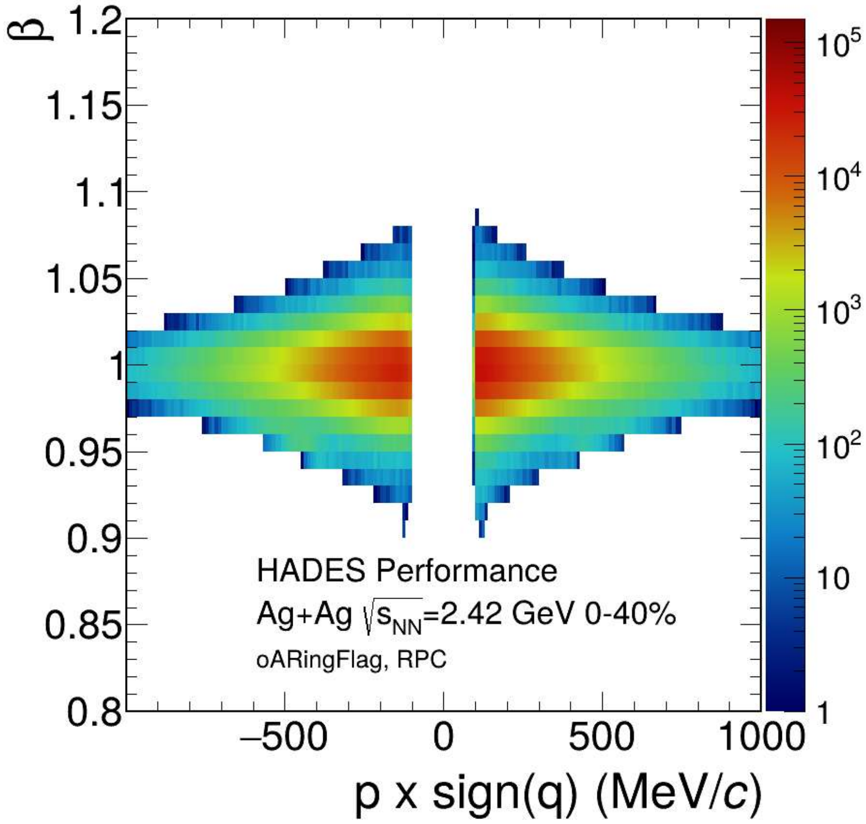




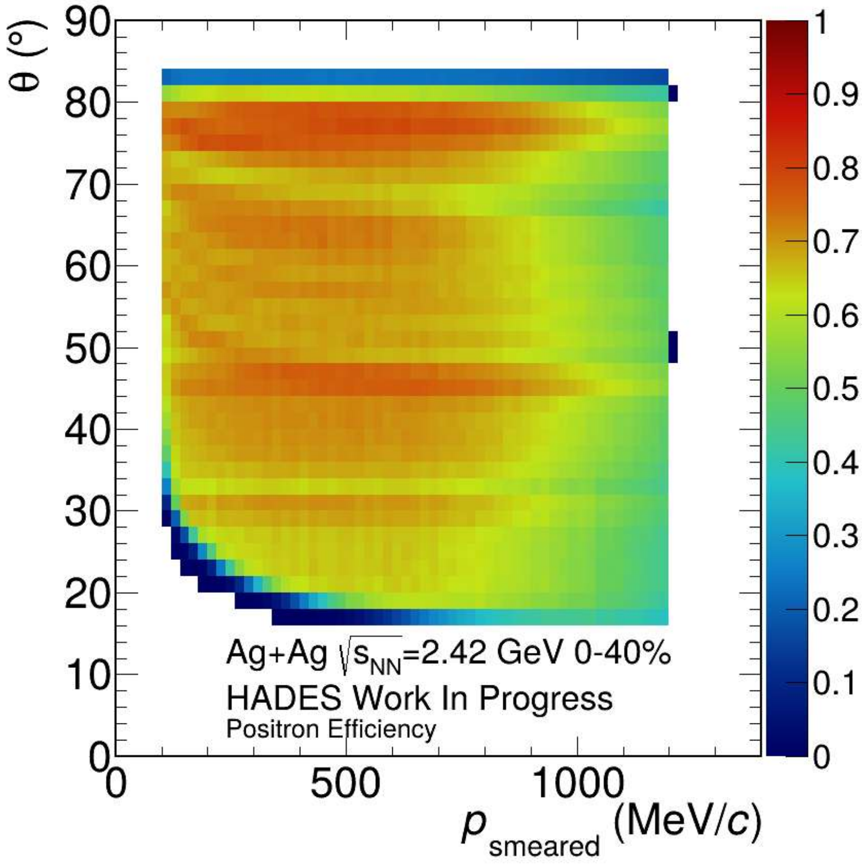
→ Significant reduction in hadron contamination

EFFICIENCY CORRECTIONS

- Single lepton efficiency is estimated using embedded data approach using „white“ leptons (evenly distributed in (p, θ, φ))
- Pair efficiency is estimated by:

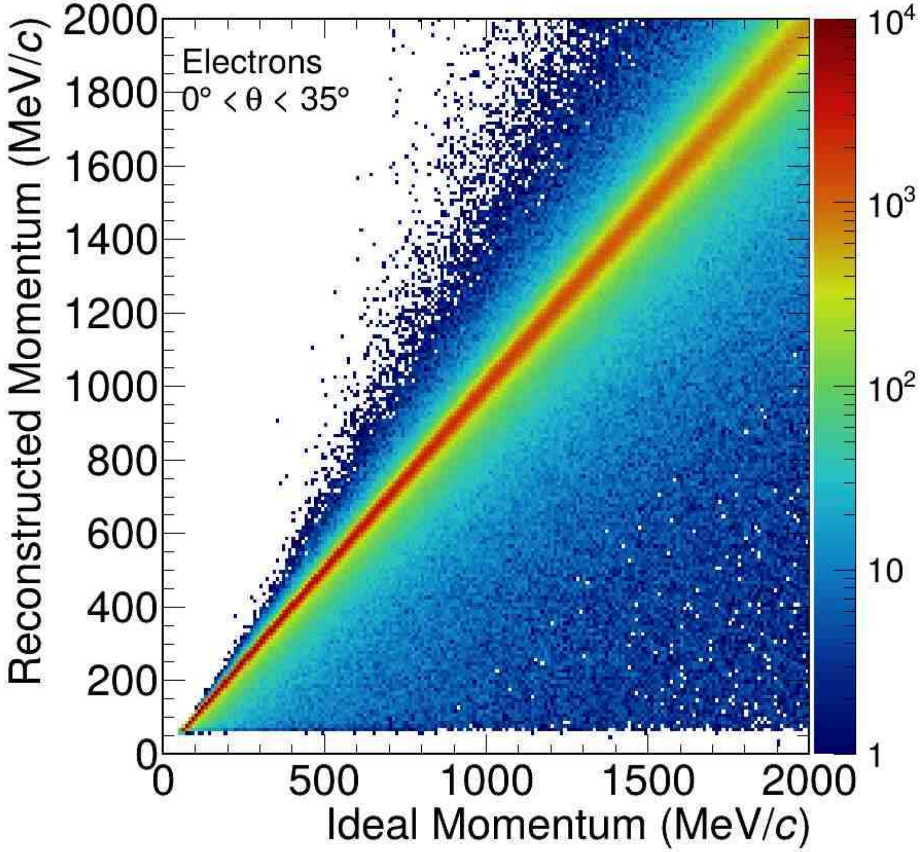
$$\varepsilon_{ee} = \varepsilon_{e} \cdot \varepsilon_{e'}$$

- Efficiency correction is applied while filling M_{ee}, $p_{T,ee}$ and y_{ee} histograms weighting with $1/\varepsilon_{ee}$



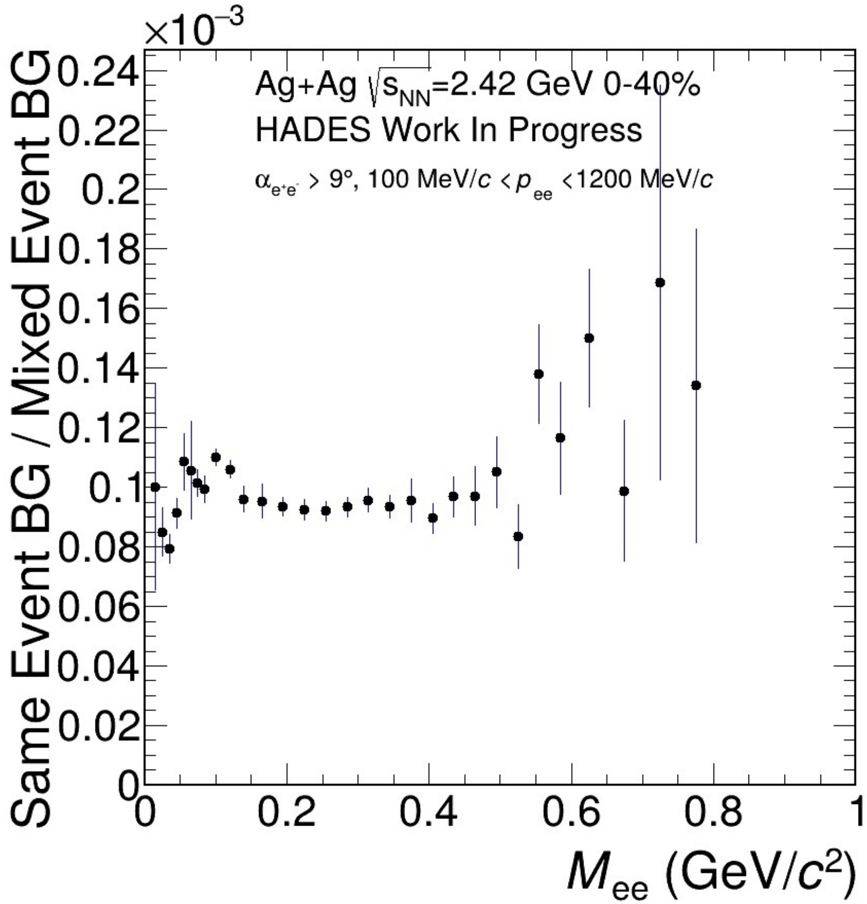
MOMENTUM SMEARING

- Kine particle momenta are „smeared“ using one of four matrices depending on θ-angle
  - 0°-35°
  - 35°-55°
  - 55°-70°
  - 70°-90°
- In the following analysis, efficiency matrices with smeared momenta where used



CB ESTIMATION

- Recap on dielectron signal extraction:
- $N^{\text{Signal}} = N_{\text{SE}}^{+-} - N^{\text{CB}}$
- $N^{\text{CB}} = \begin{cases} N_{\text{SE}}^{+-} = 2\text{k}\sqrt{N_{\text{SE}}^{++} \cdot N_{\text{SE}}^{--}} \\ N_{\text{ME}}^{+-} = 2\text{k}\sqrt{N_{\text{ME}}^{++} \cdot N_{\text{ME}}^{--}} \end{cases}$



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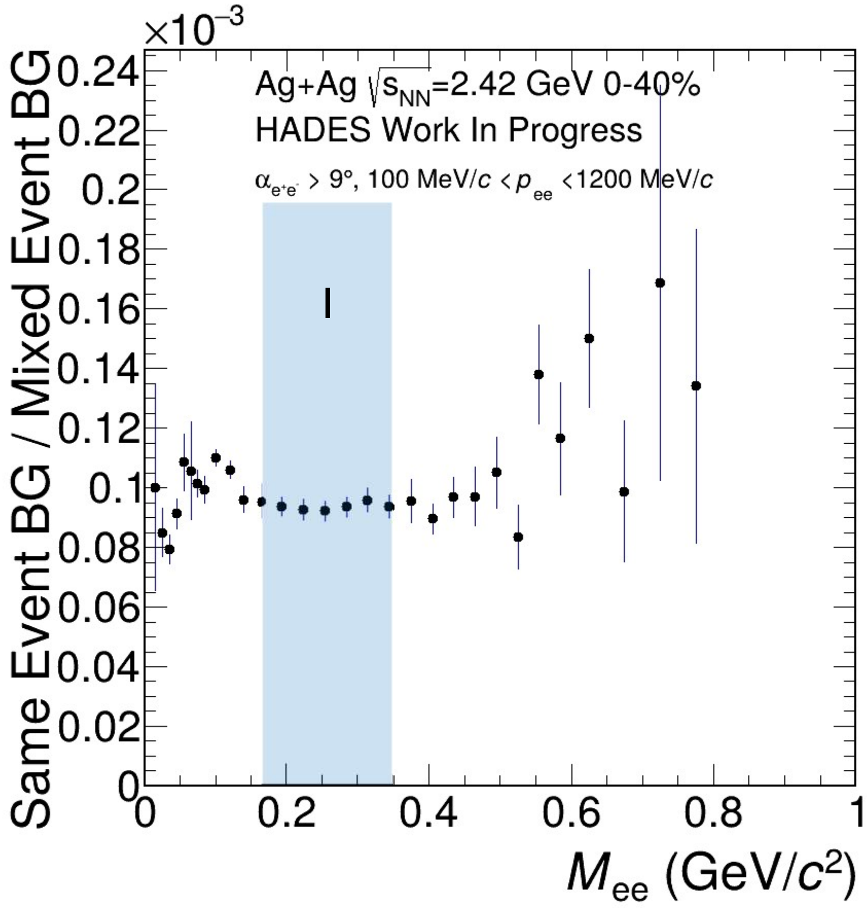
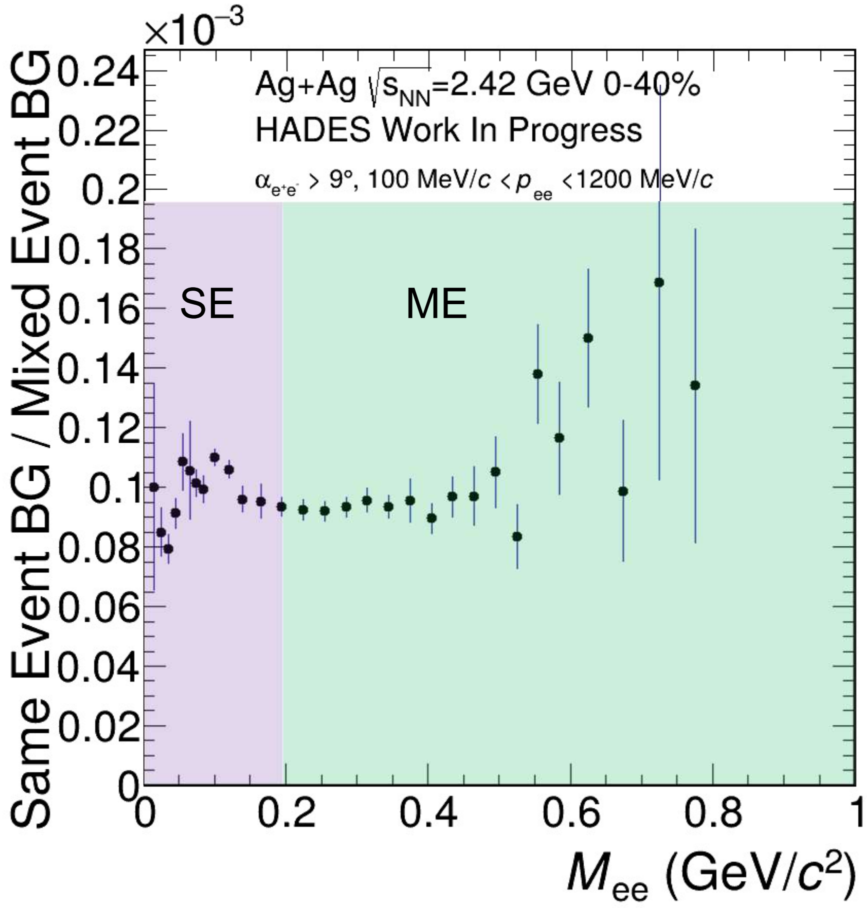
CB ESTIMATION

- Recap on dielectron signal extraction:
- Use Interval I to extract a mixed event scaling factor
- Scaling = $\dfrac{\sum_I N_{\mathrm{SE}}^{\mathrm{CB}}}{\sum_I N_{\mathrm{ME}}^{\mathrm{CB}}}$

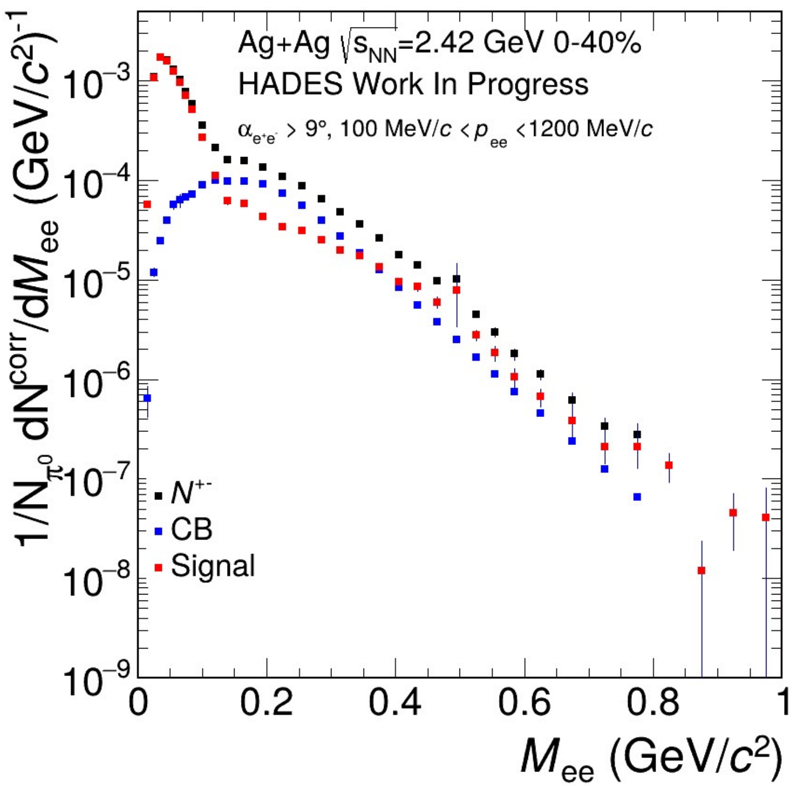


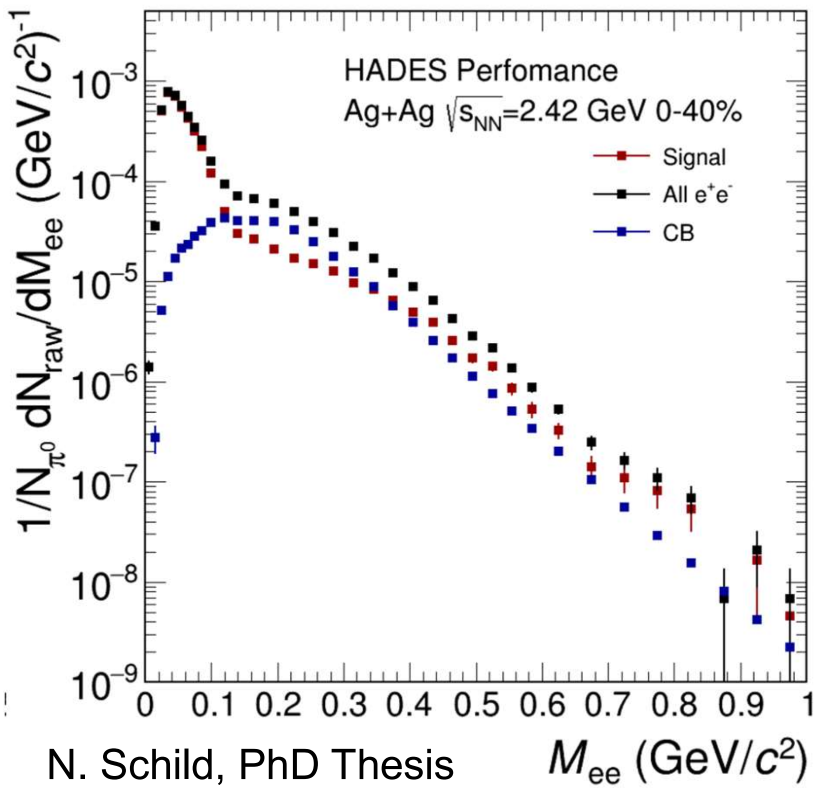
CB ESTIMATION

- Recap on dielectron signal extraction:
- Apply SE-BG in π^0dominated, correlated background region up to 0.18 GeV/c² (highlighted in purple)
- Apply ME-BG uncorrelated background region starting at 0.18 GeV/c² (highlighted in green)
- Apply same factor for multidifferential p_{T}- and y-spectra CB estimation



DIELECTRON SIGNAL EXTRACTION





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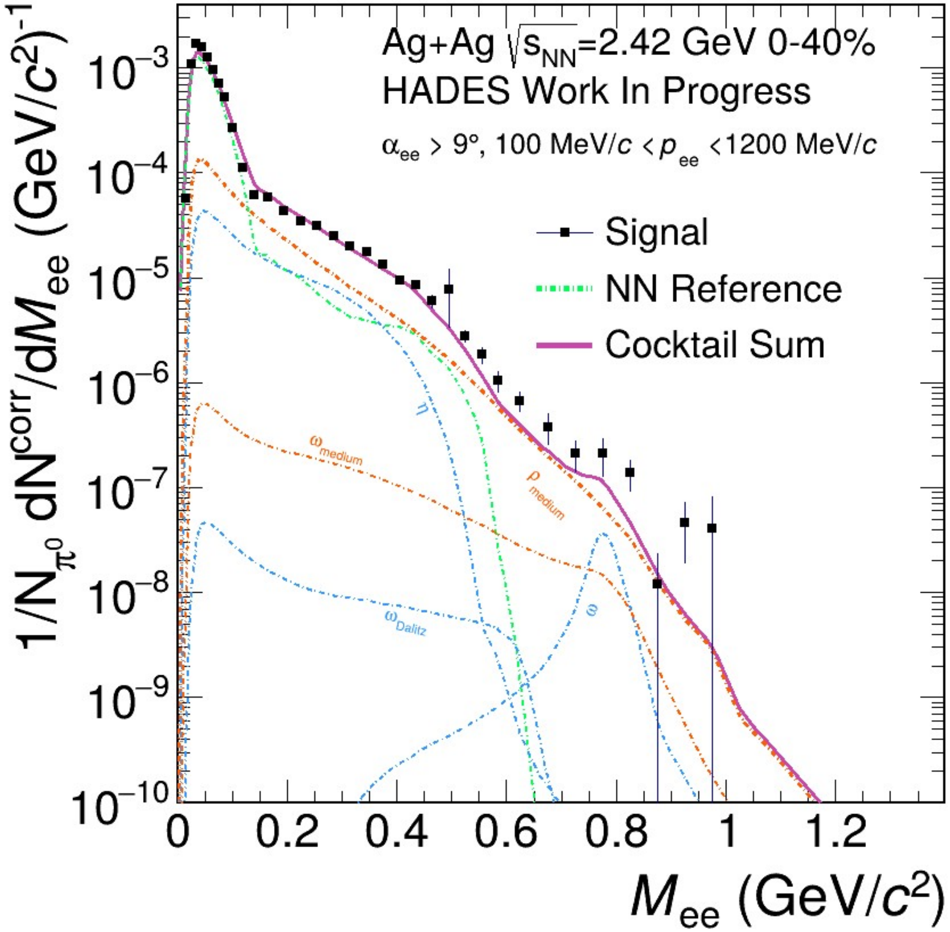
COMPARISON TO SIMULATION

- NN reference data provides first-chance NN collision contributions, including π^0
- Pluto simulations provide freeze-out contributions:
  - ω
  - ω_{Dalitz}
  - η
- Coarse-grained UrQMD simulations provide medium contributions:
  - In medium ρ
  - In medium ω



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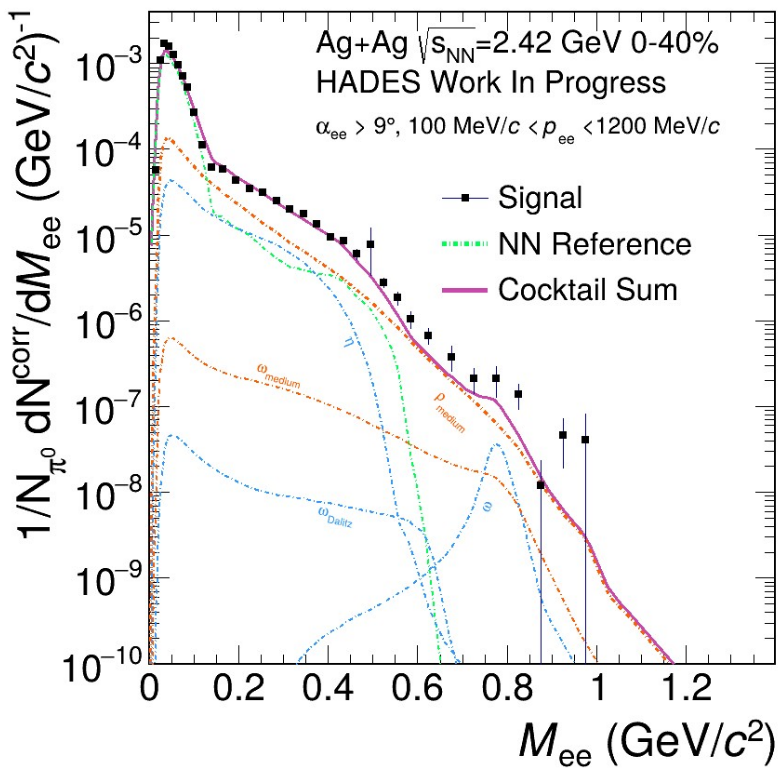

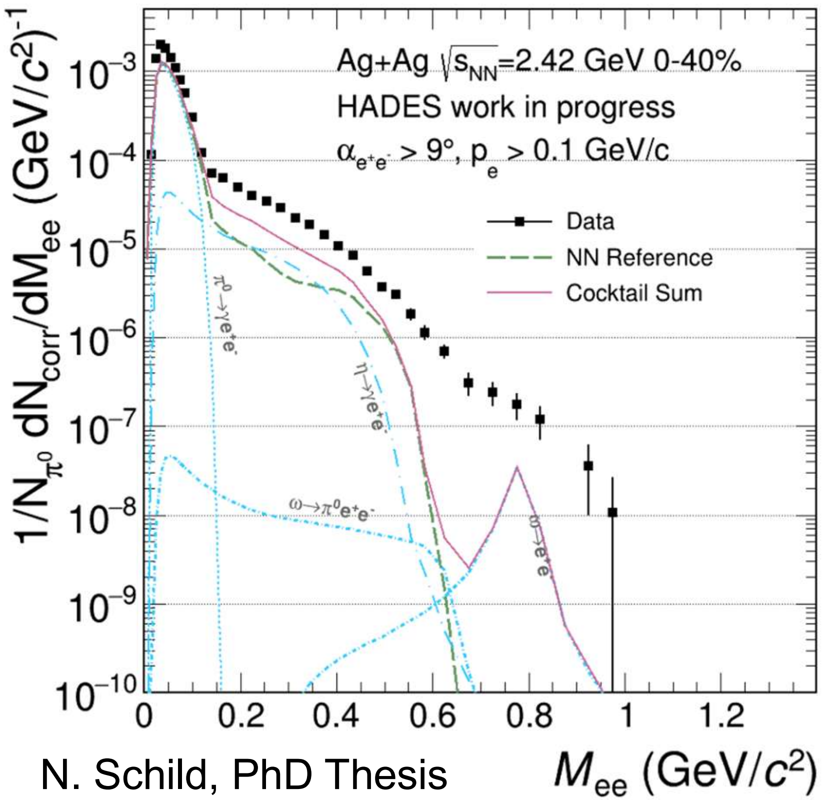

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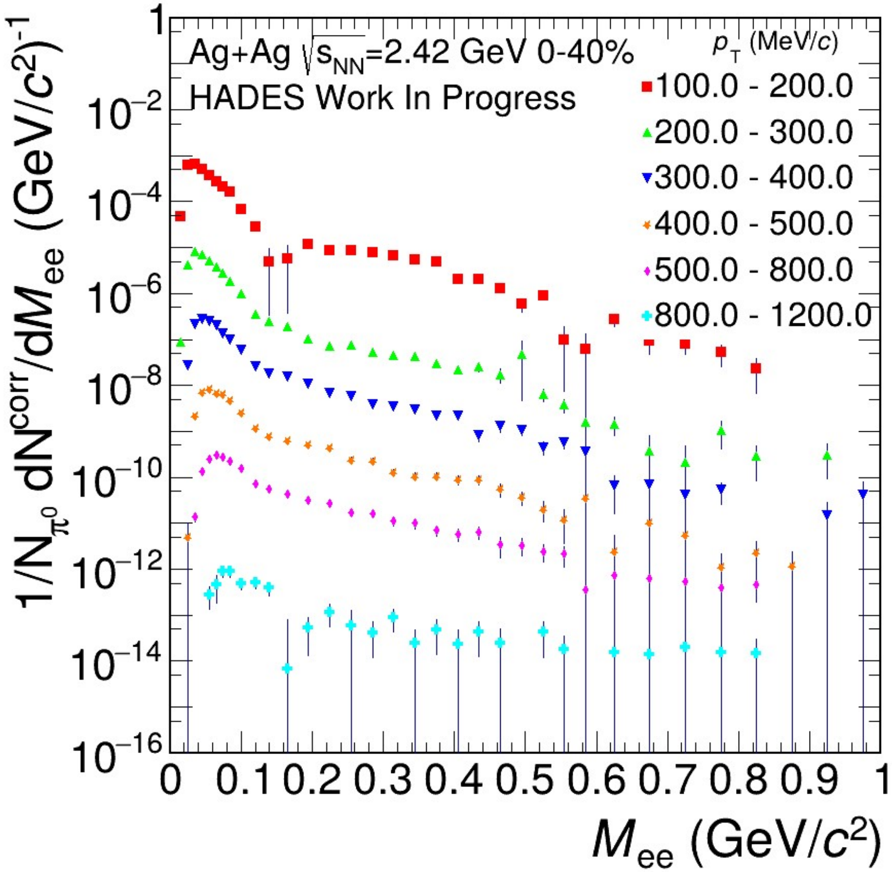
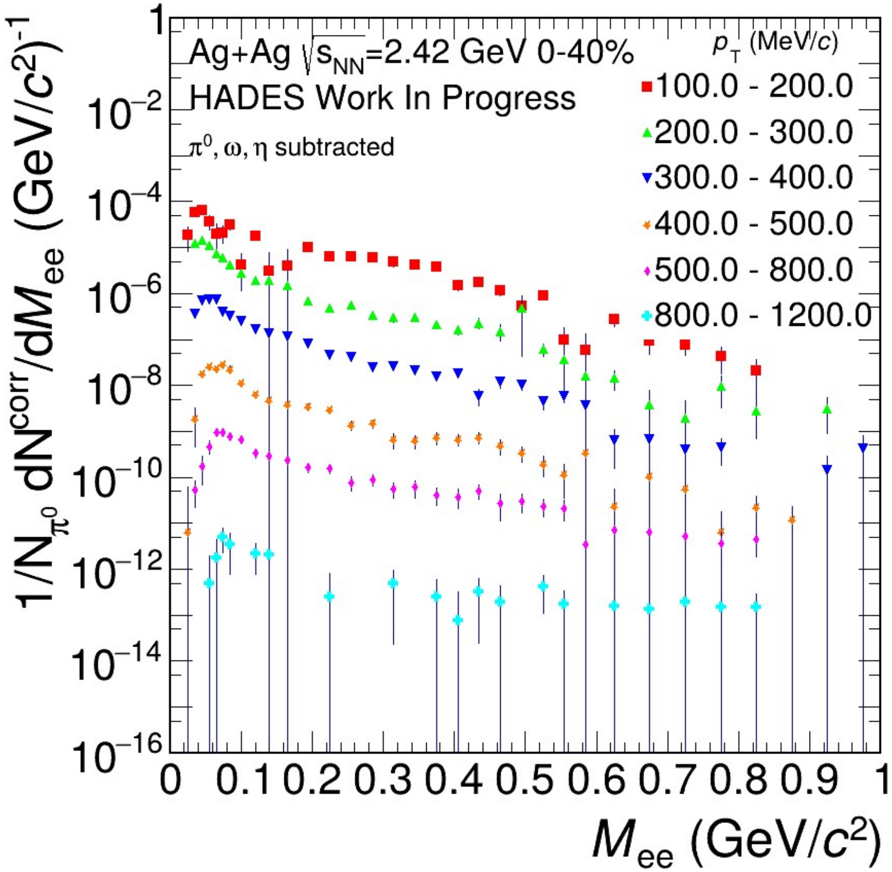
TRANSVERSE MOMENTUM

- Multidifferential $\mathrm{M_{ee}}$-spectra for varying p_T
- Each scaled by an additional factor of 10^{-1} to keep visually distinct



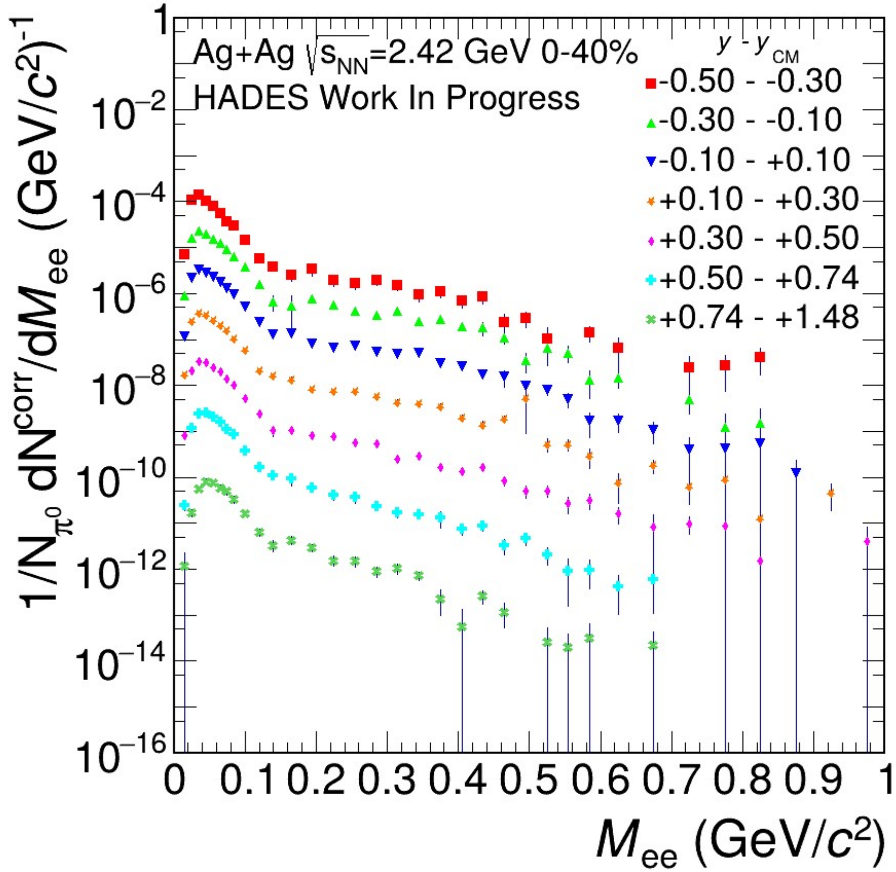
TRANSVERSE MOMENTUM

- Multidifferential $\mathrm{M_{ee}}$-spectra for varying p_T
- π^0-, ω-, and η-contributions subtracted
- Each scaled by an additional factor of 10^{-1} to keep visually distinct



RAPIDITY

- Multidifferential $\mathrm{M_{ee}}$-spectra for varying y
- Each scaled by an additional factor of 10^{-1} to keep visually distinct



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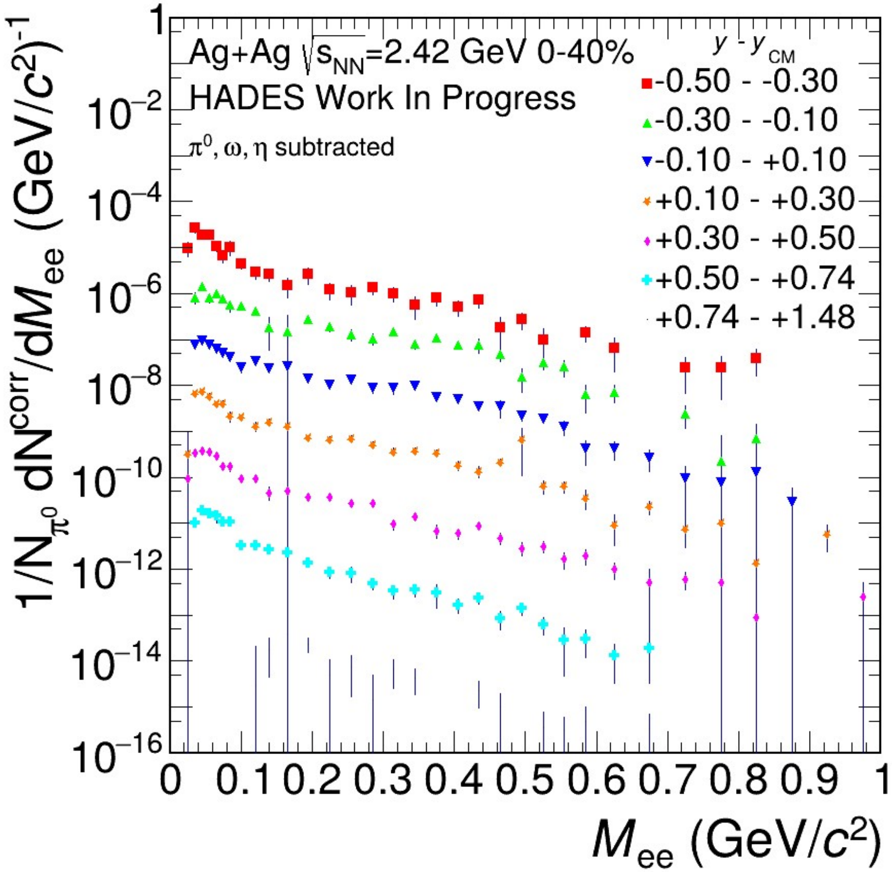
RAPIDITY

- Multidifferential $\mathrm{M_{ee}}$-spectra for varying y
- π^0-, ω-, and η-contributions subtracted
- Each scaled by an additional factor of 5^{-2} to keep visually distinct



MULTIDIFFERENTIAL SPECTRA

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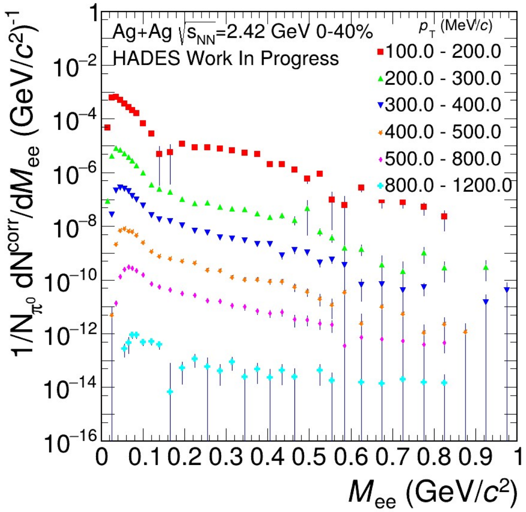

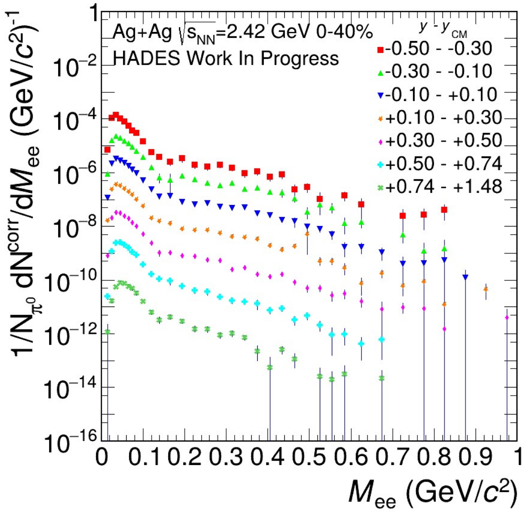

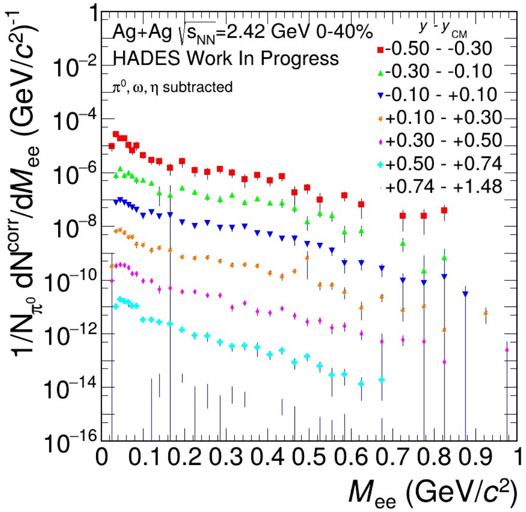

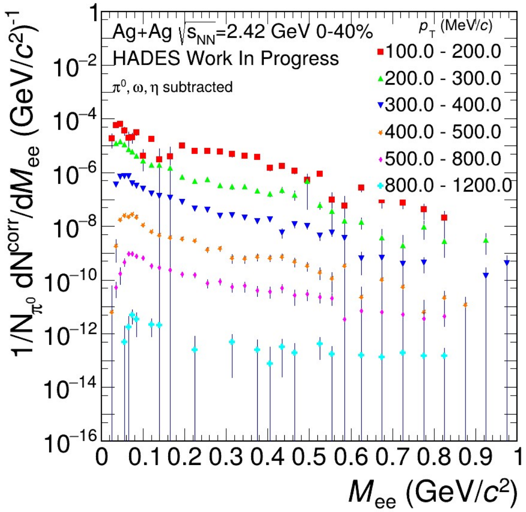

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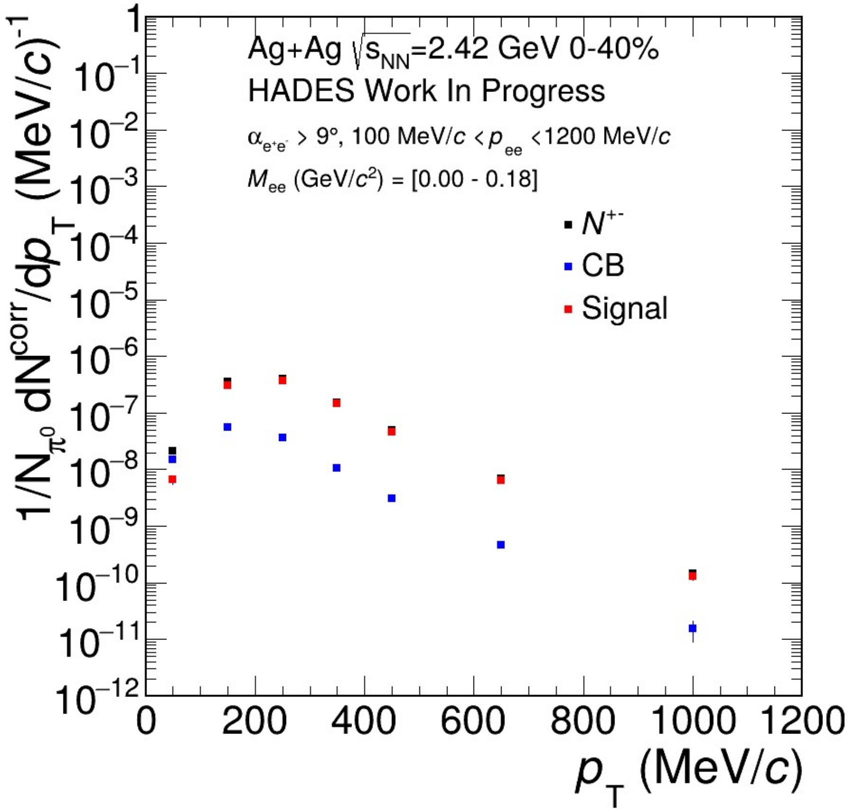

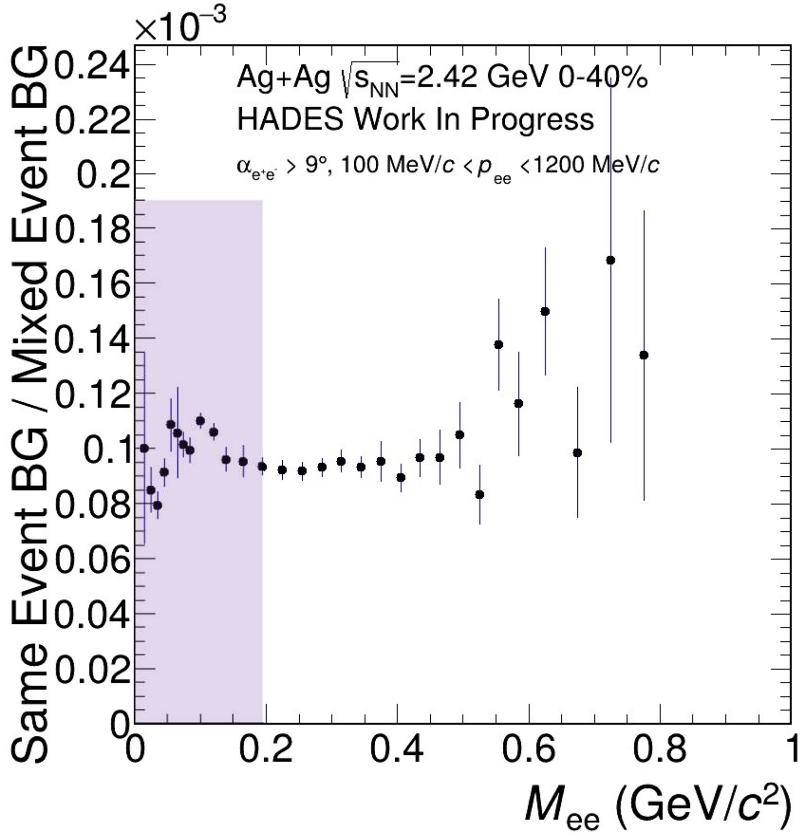

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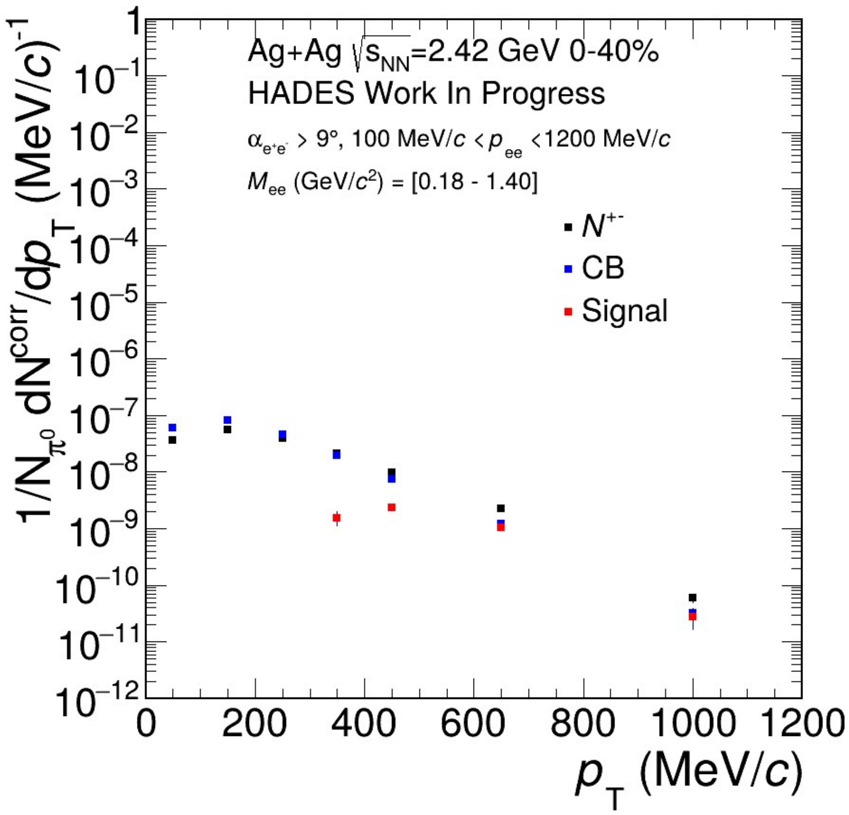

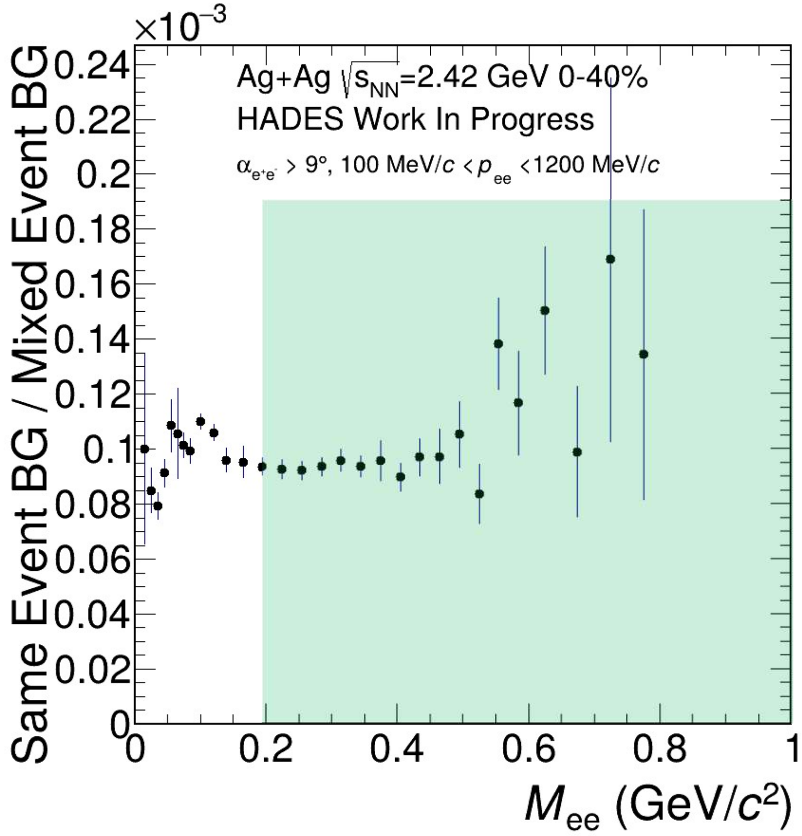

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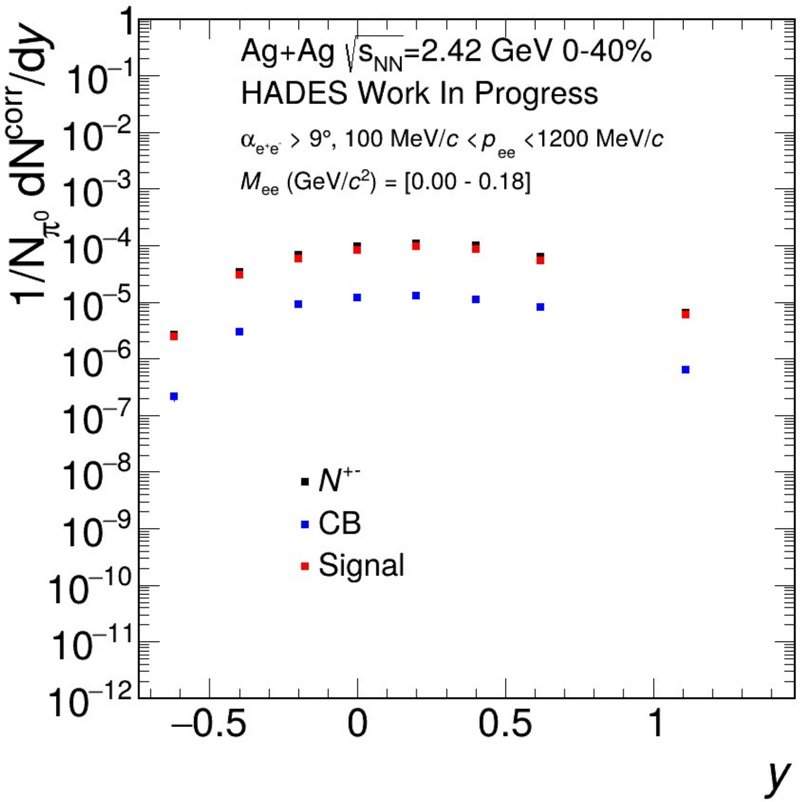

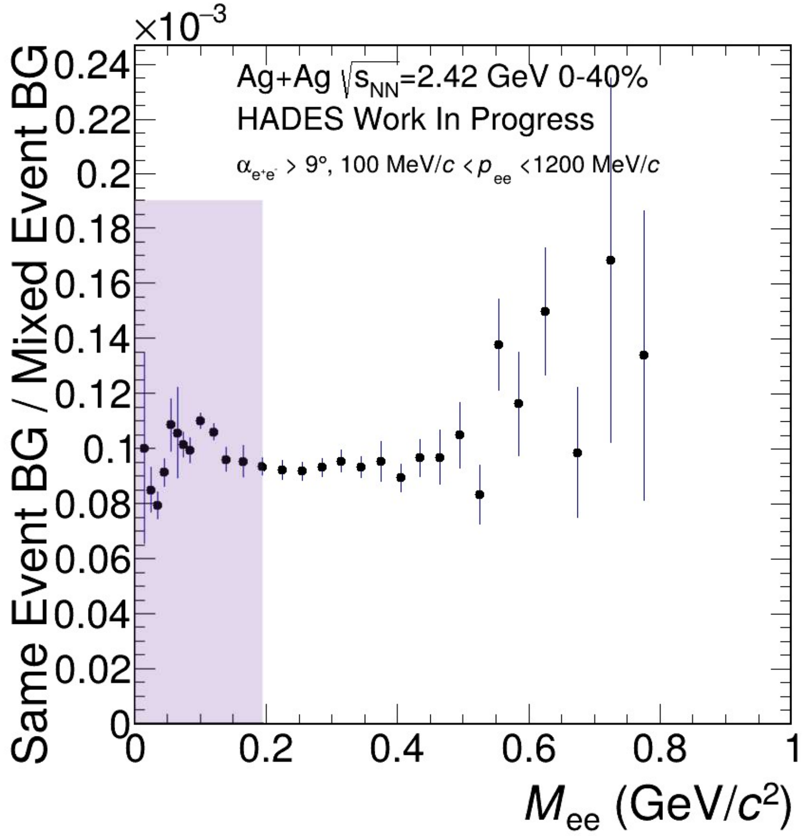

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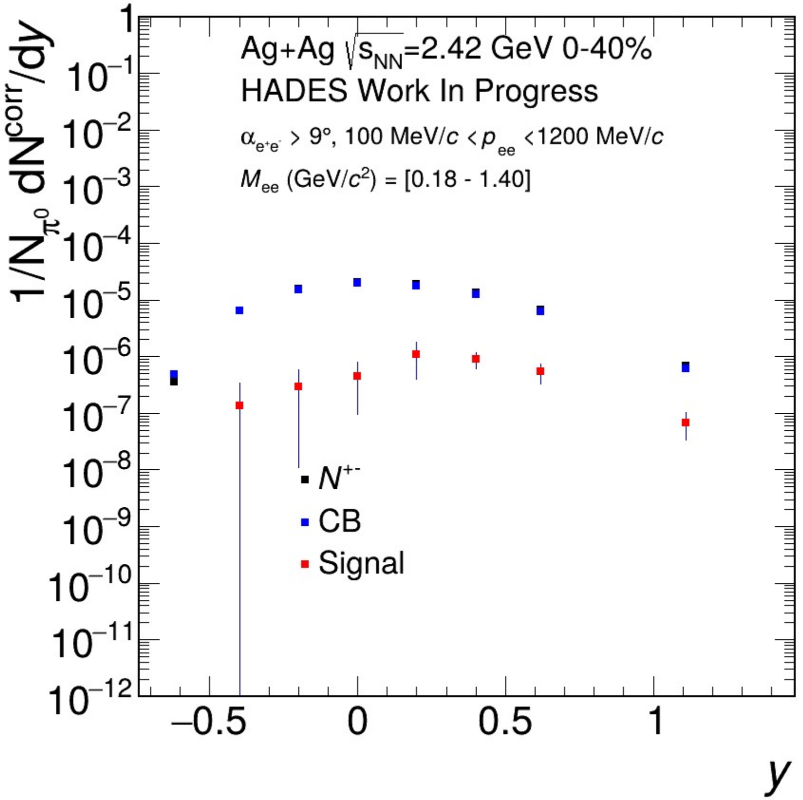
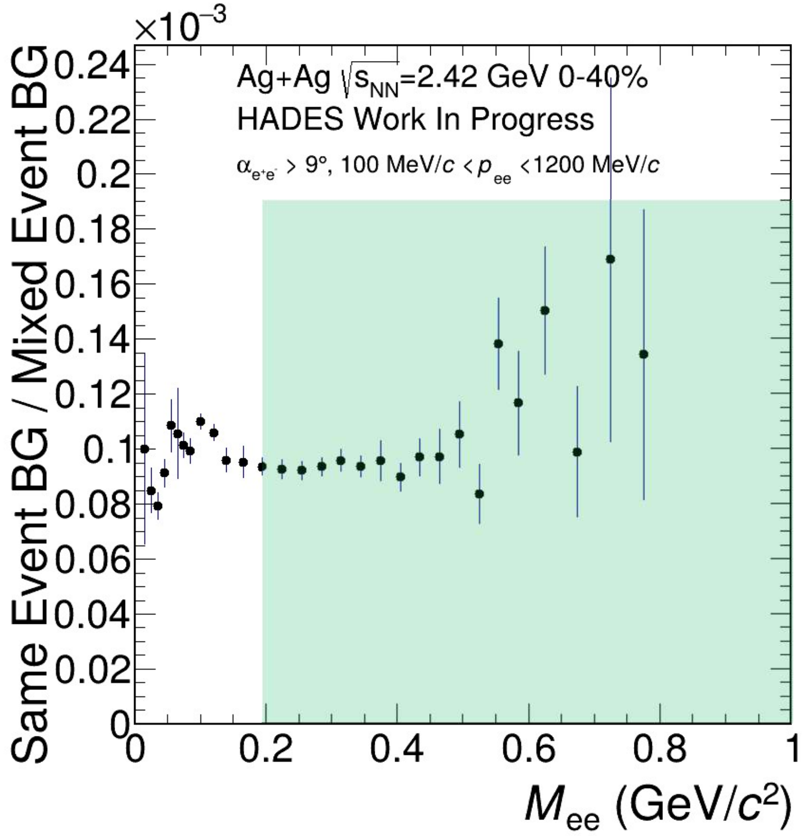
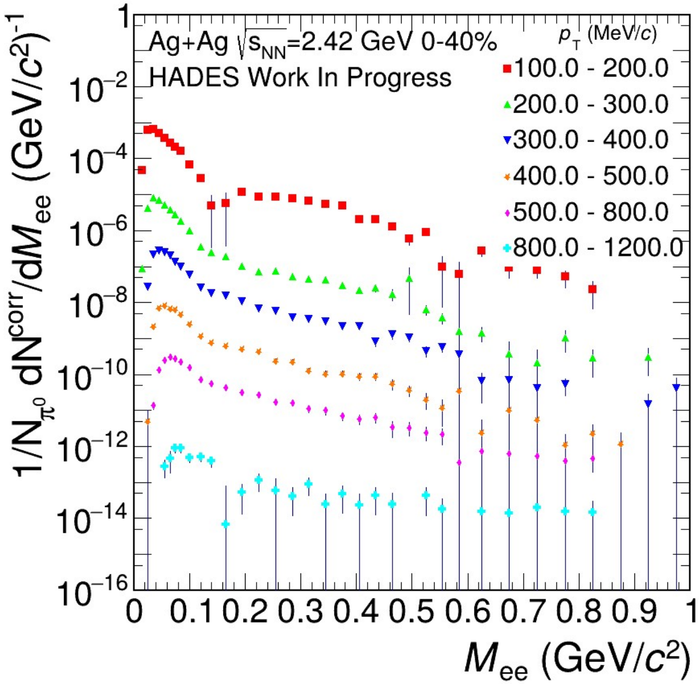
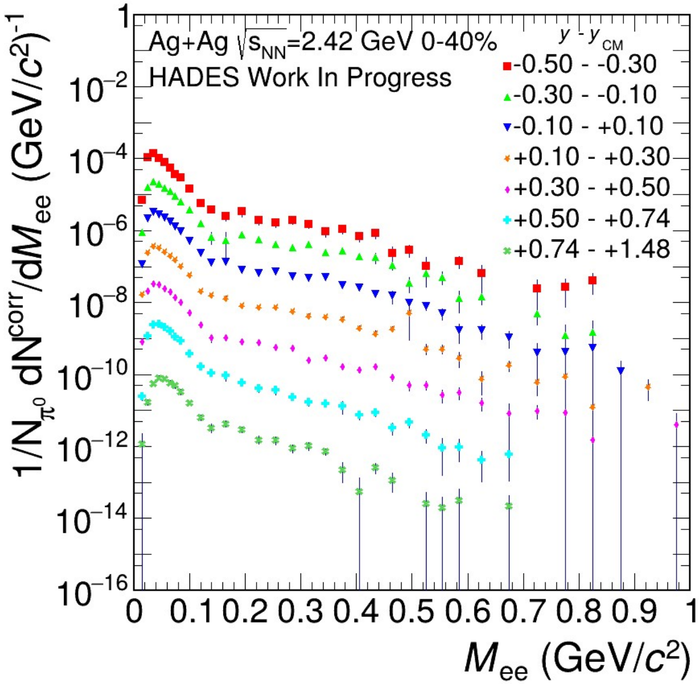




SUMMARY

- Multidifferential analysis procedure has been established for Ag+Ag @ $\sqrt{s_{NN}}$=2.42 GeV dielectron data





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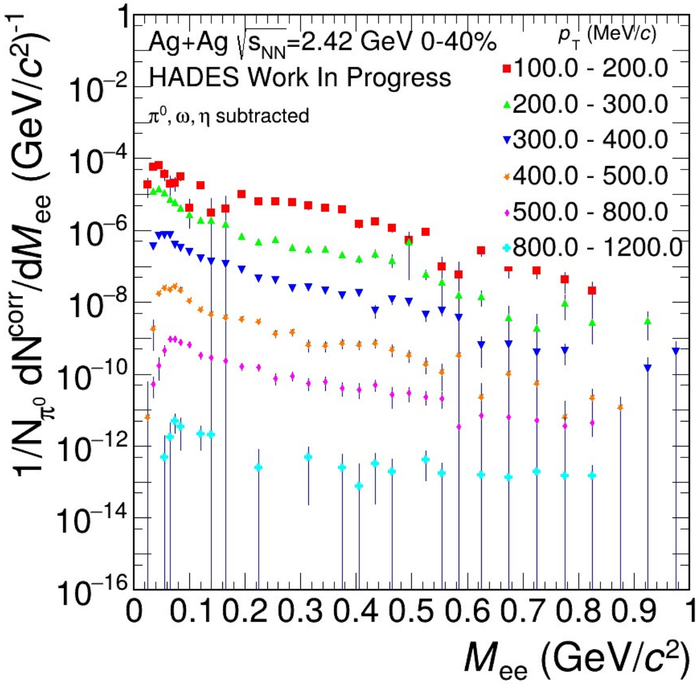

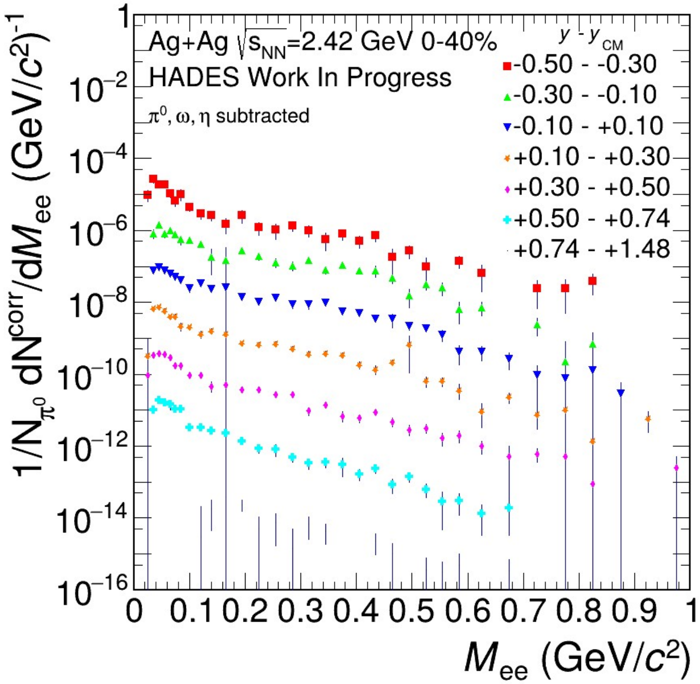

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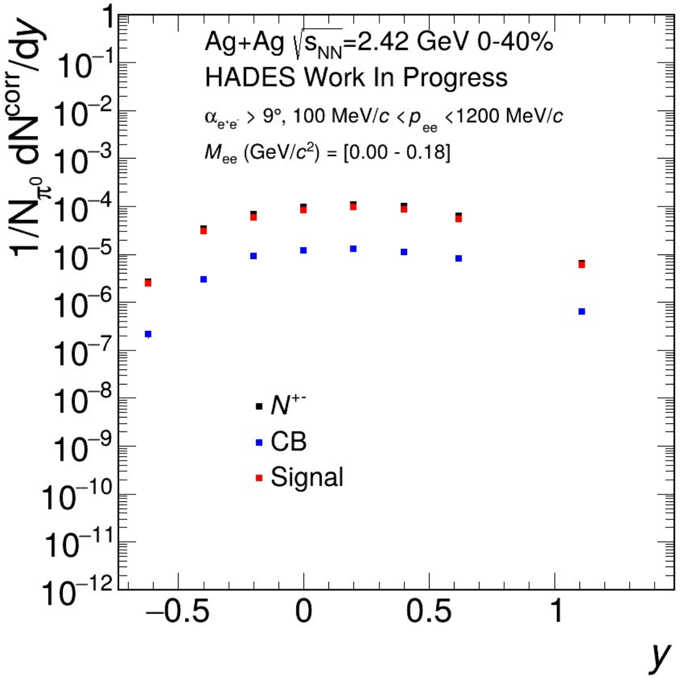
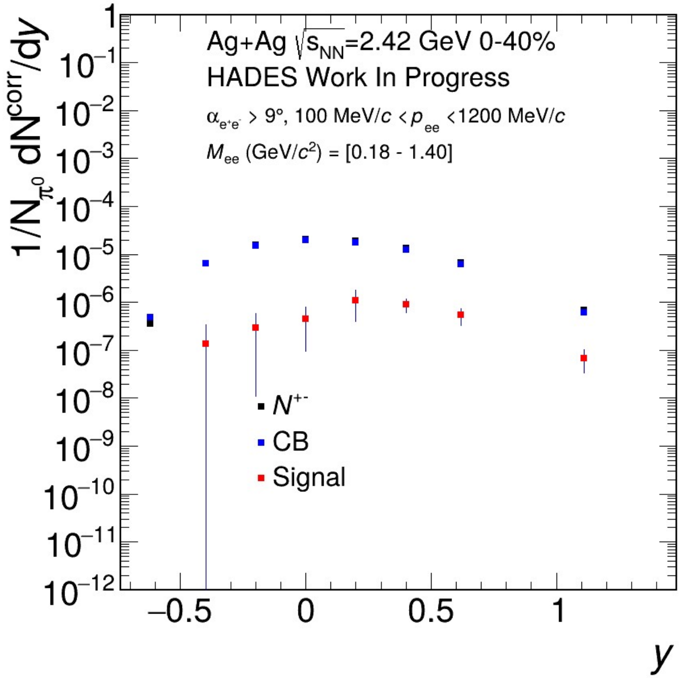
SUMMARY

- p_T- and y-spectra have been produced in two mass ranges corresponding to
  - Correlated CB regime (π^0 dominated)
  - Uncorrelated CB regime





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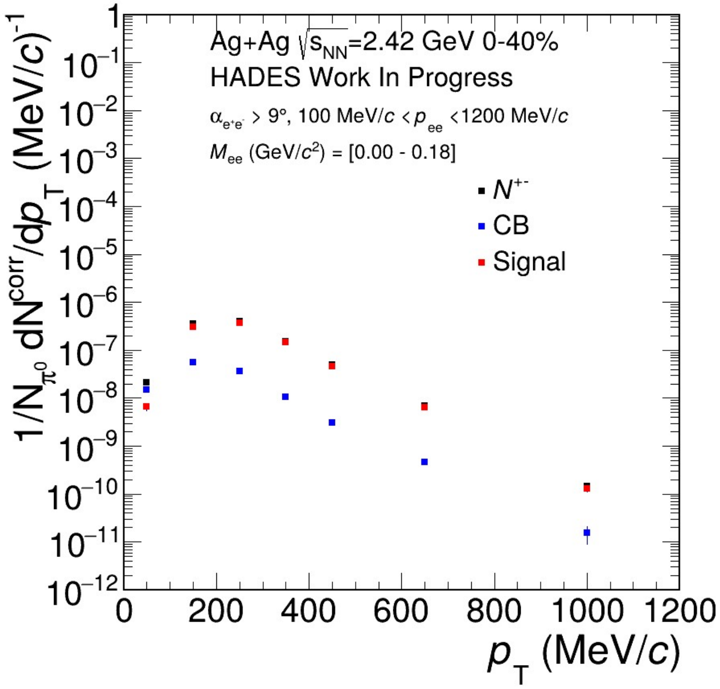
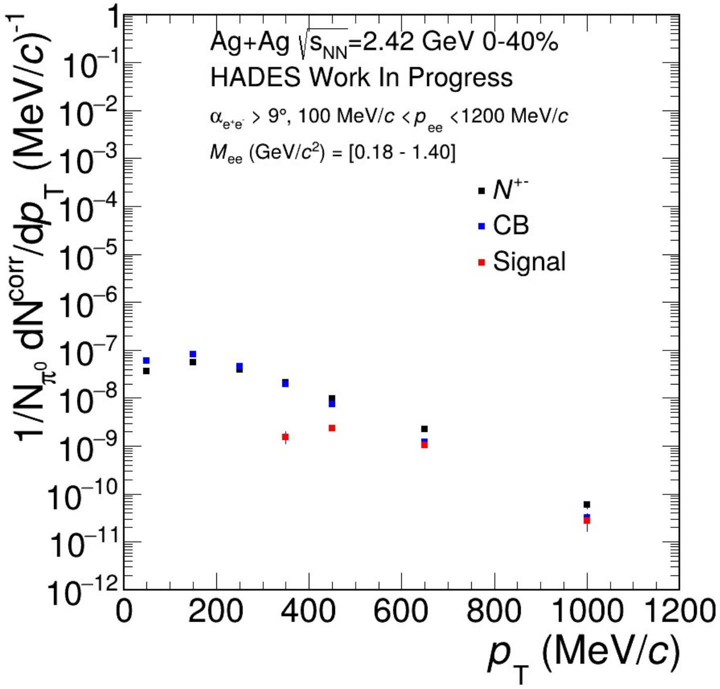
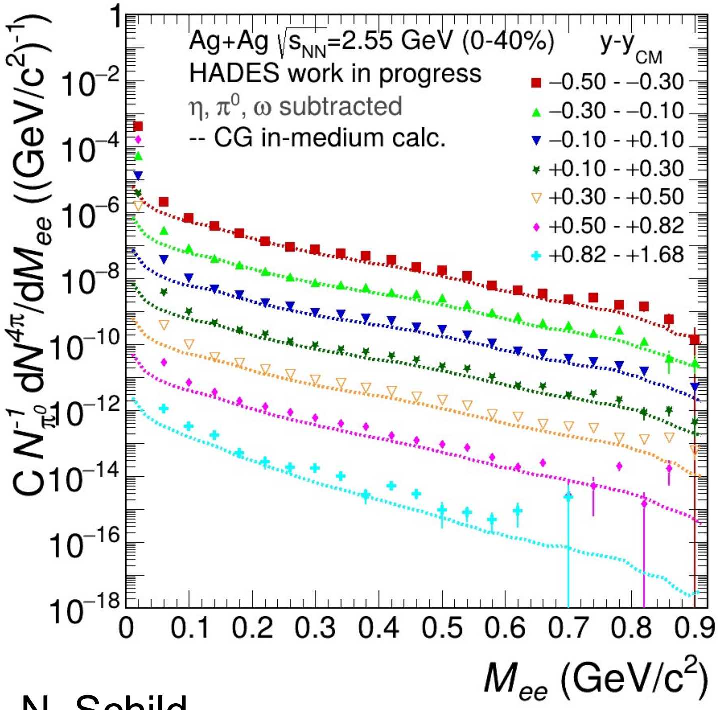




OUTLOOK

- Finalize multidifferential analysis procedure by
  - Trying out different binnings
  - Evaluating systematic uncertainties
  - Make results comparable to simulations



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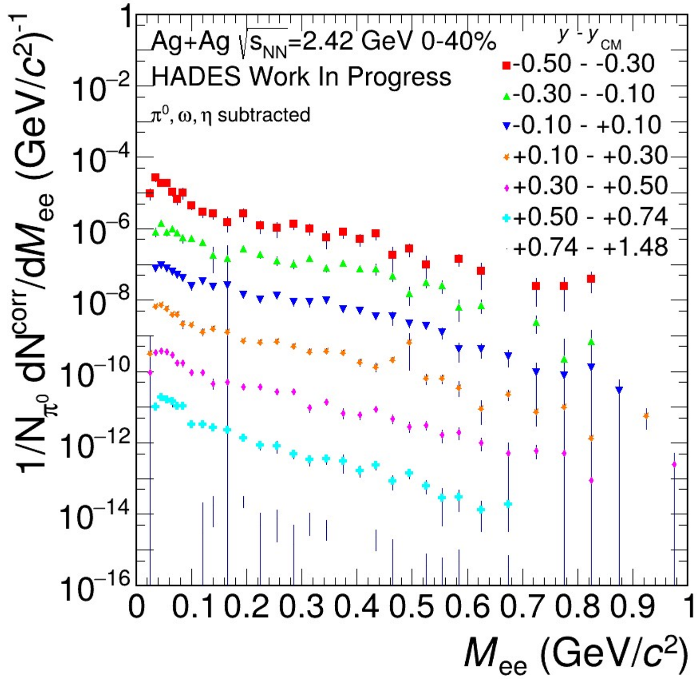
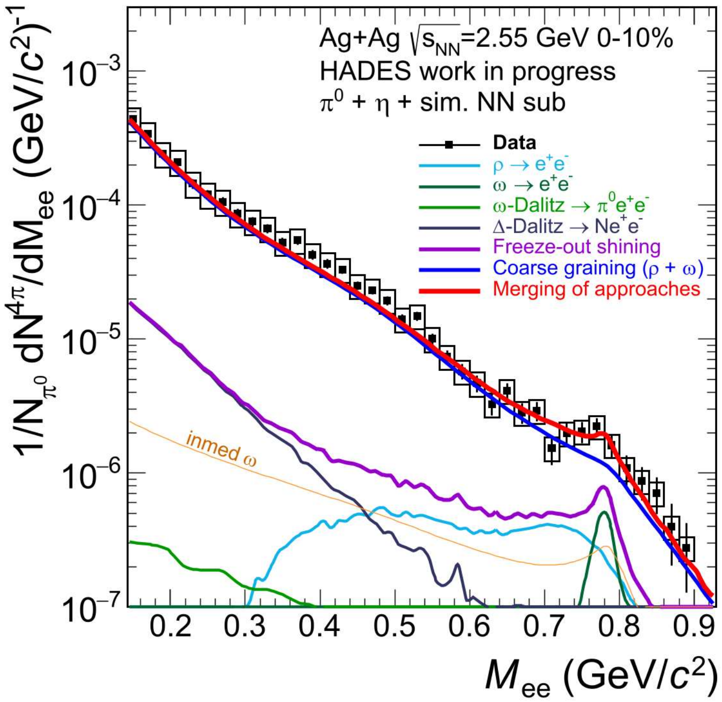


OUTLOOK

- Extract necessary multidifferential excess yield spectra
- Compare to merged model calculations presented in J. Vogels work



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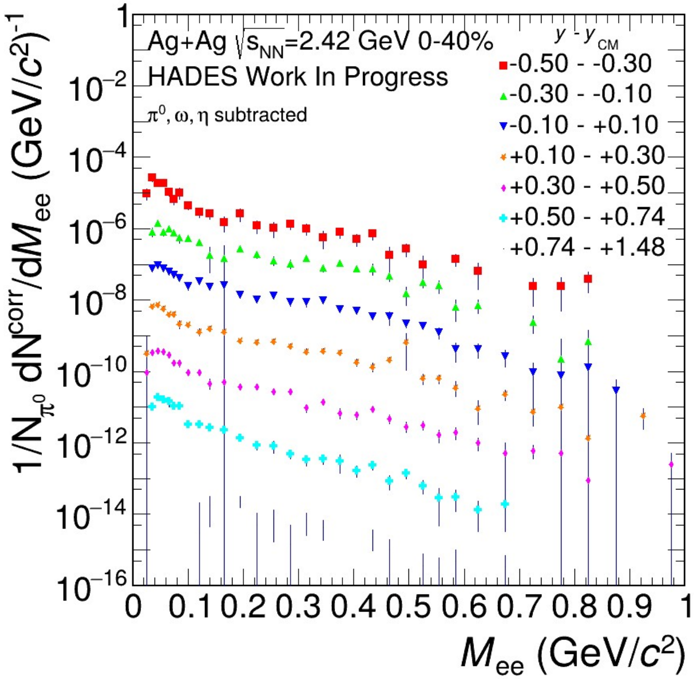
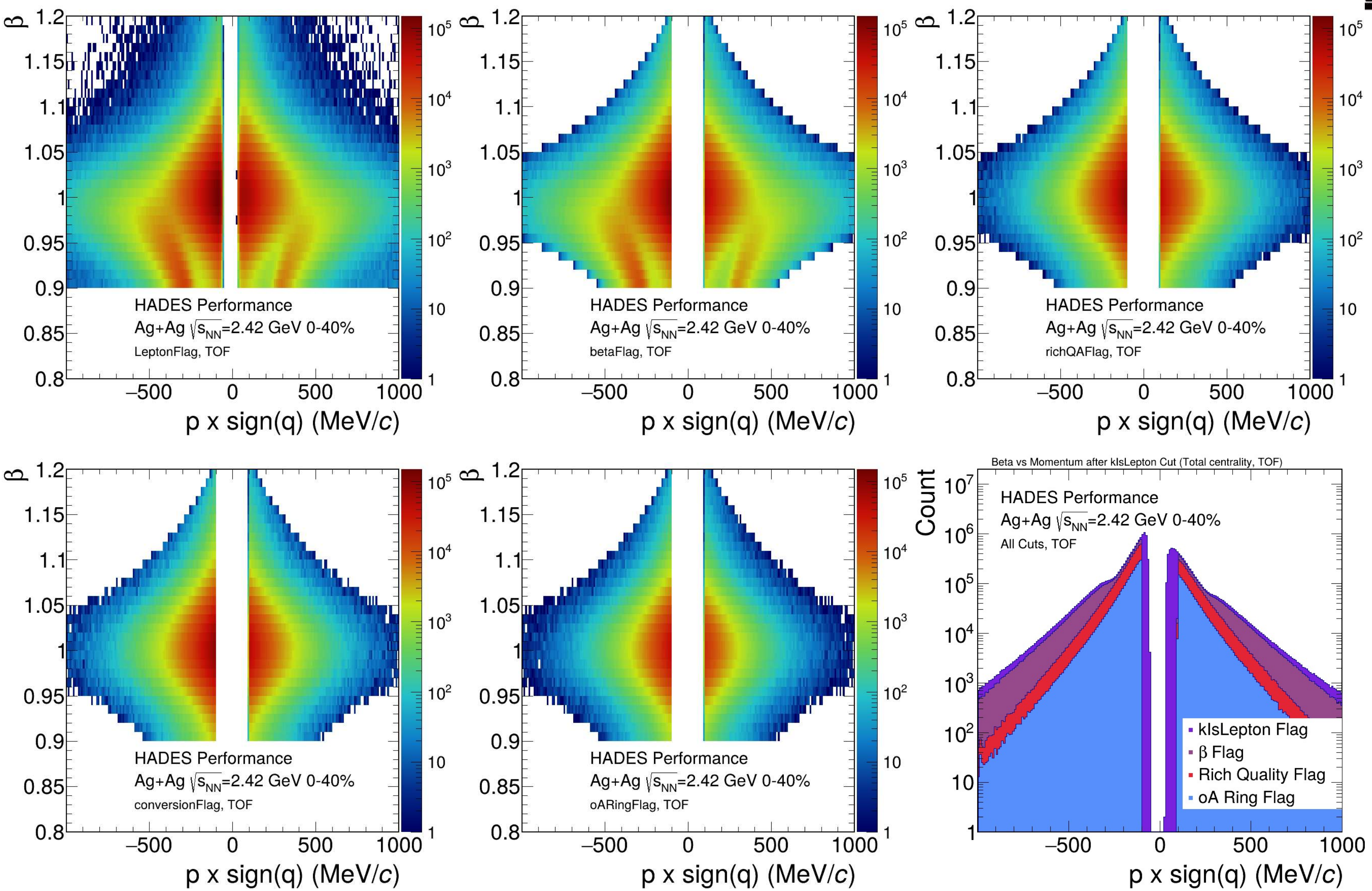
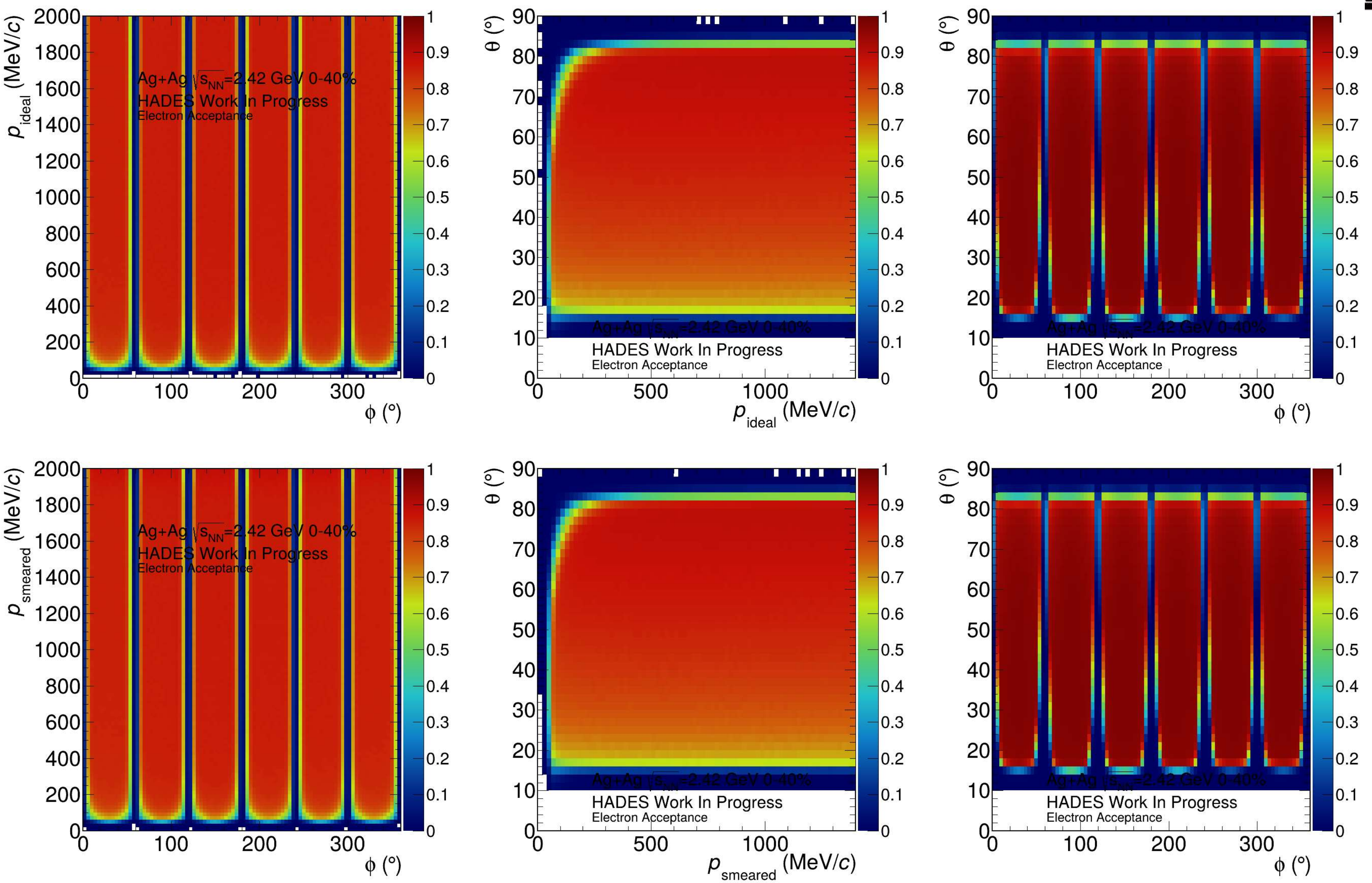


THANK YOU!

ADDITIONAL: PERFORMANCE



ADDITIONAL: POSITRON ACCEPTENCE



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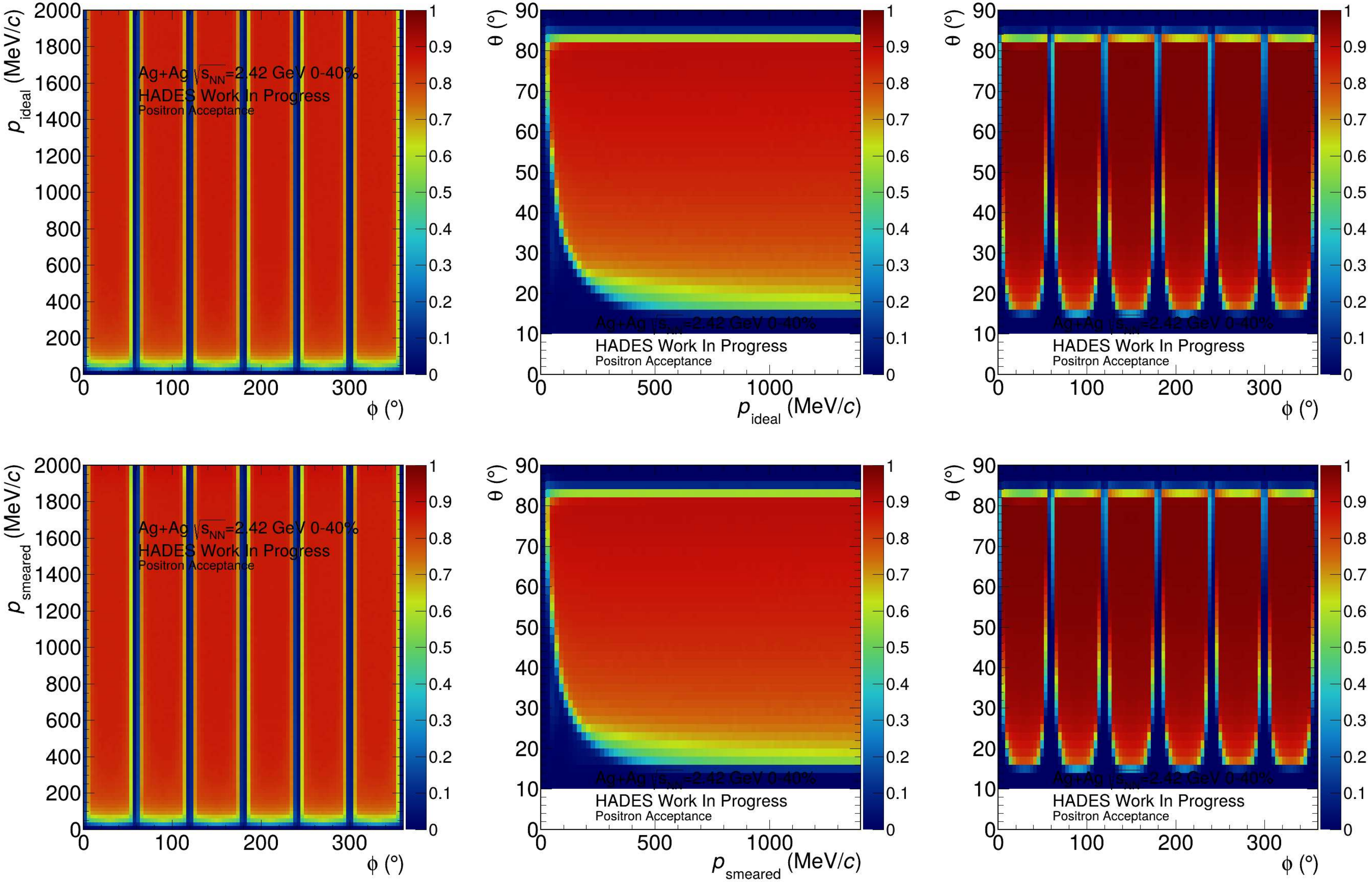

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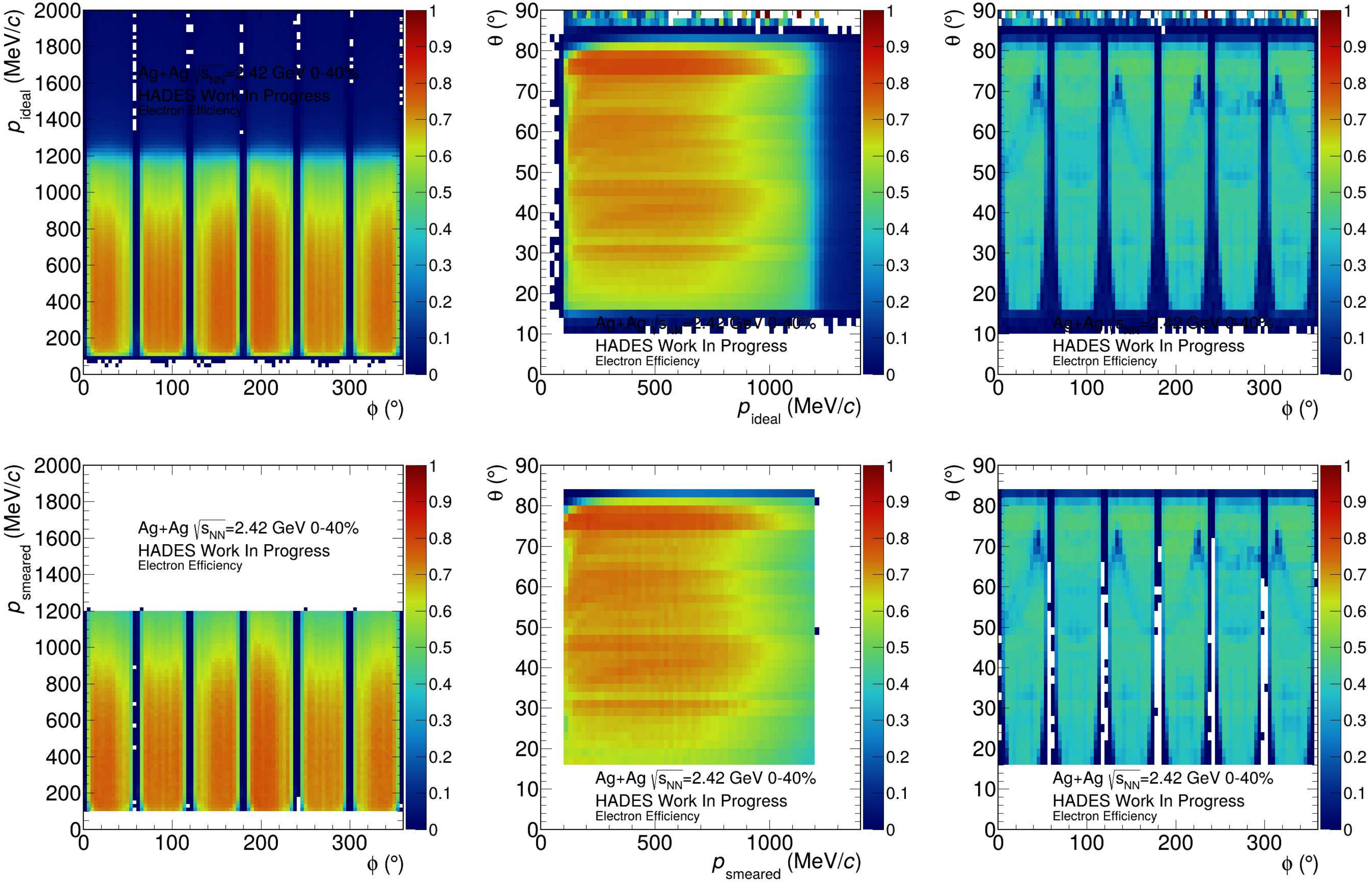
ADDITIONAL: ELECTRON EFFICIENCY



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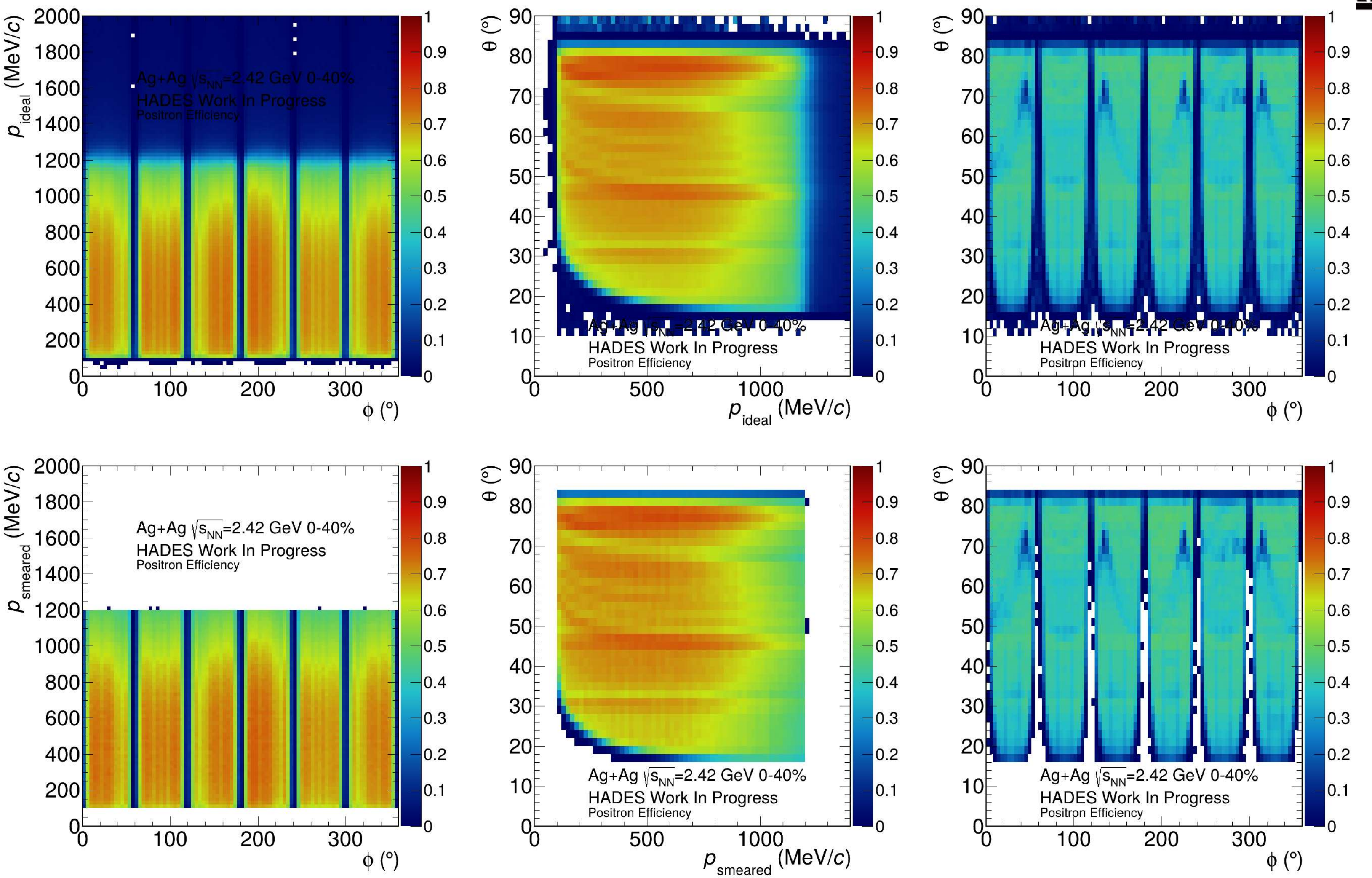
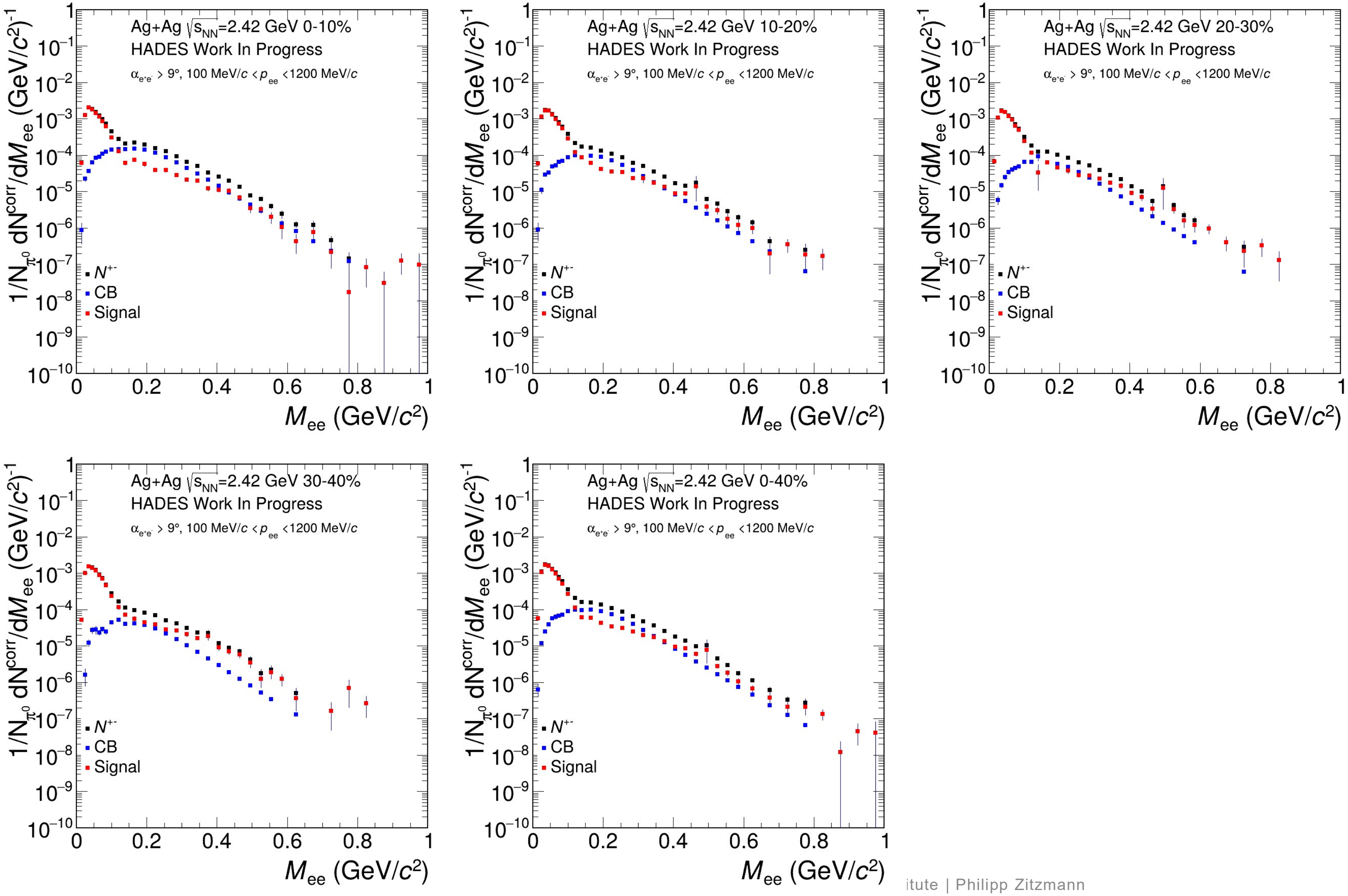
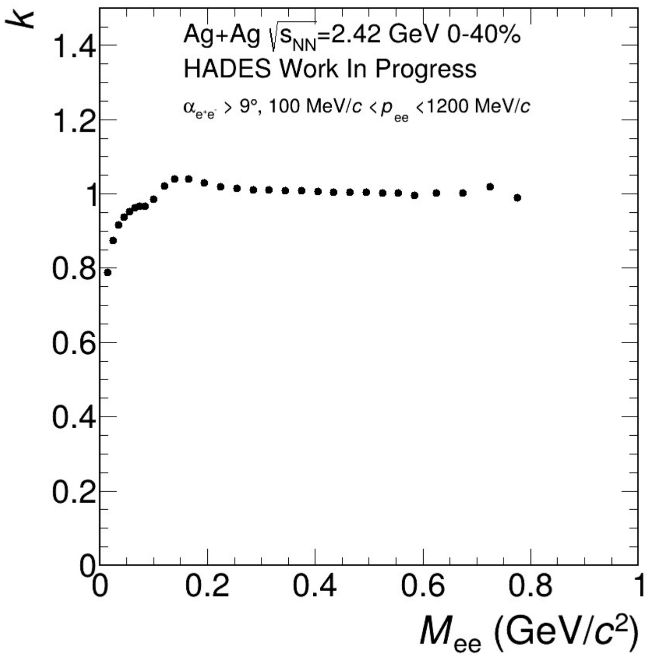
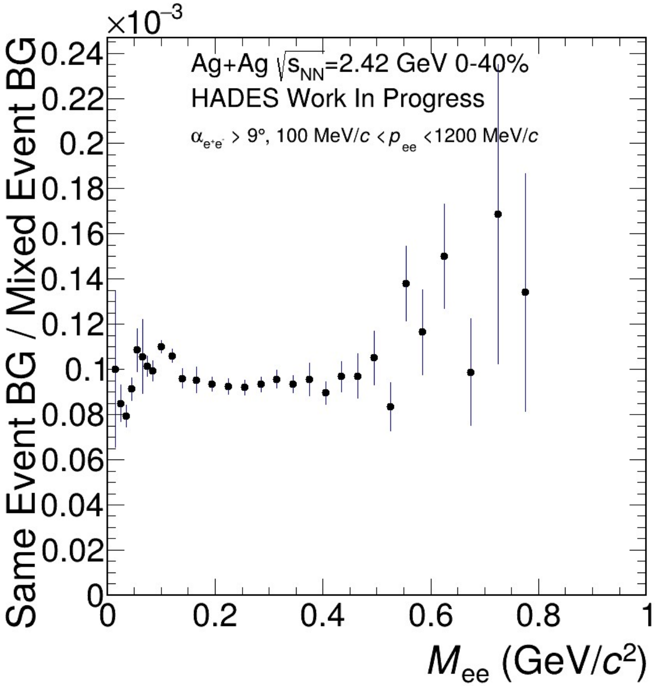


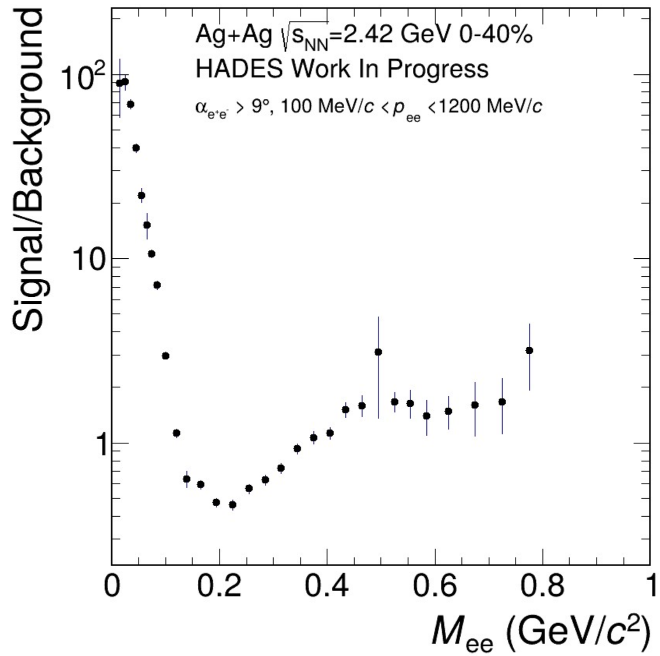
ADDITIONAL: INVARIANT MASS



ADDITIONAL: INVARIANT MASS







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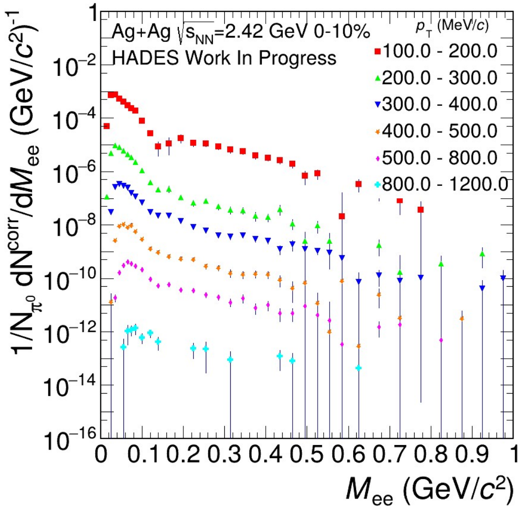

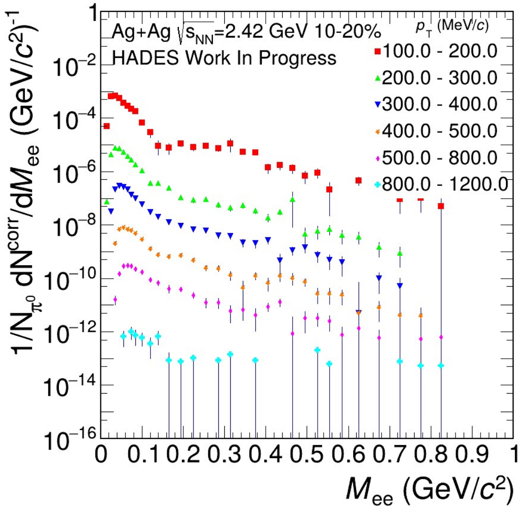

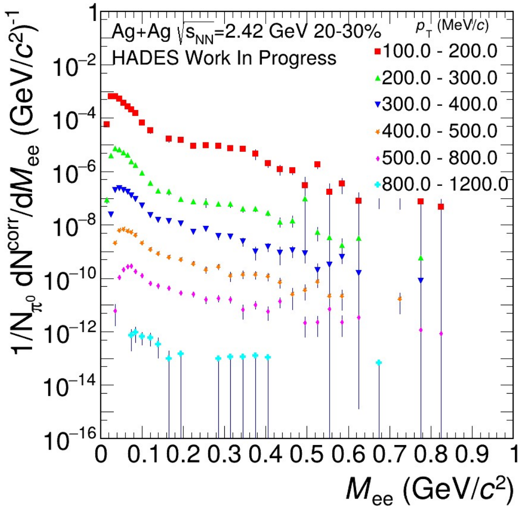

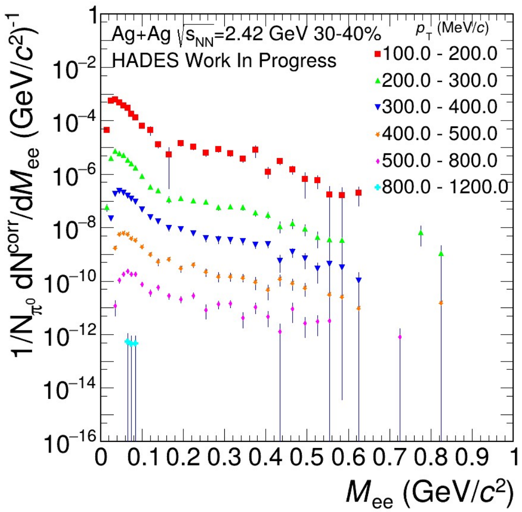

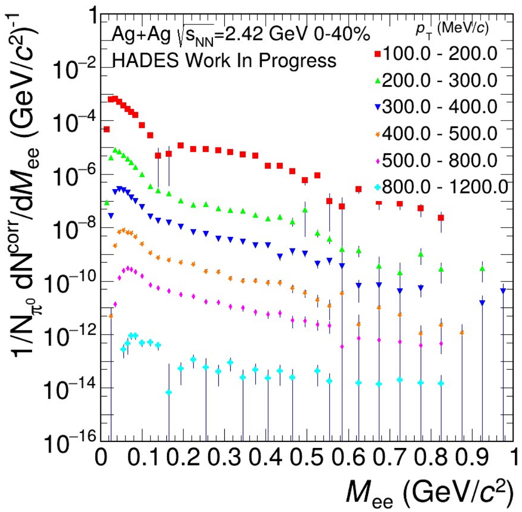

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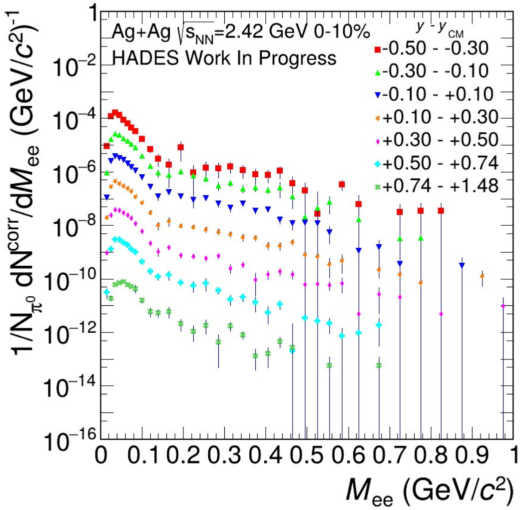

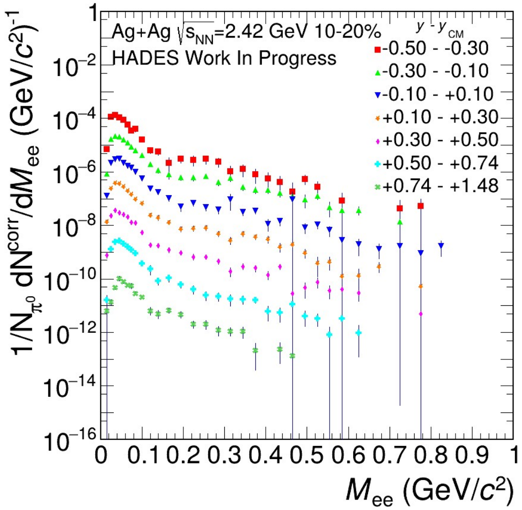

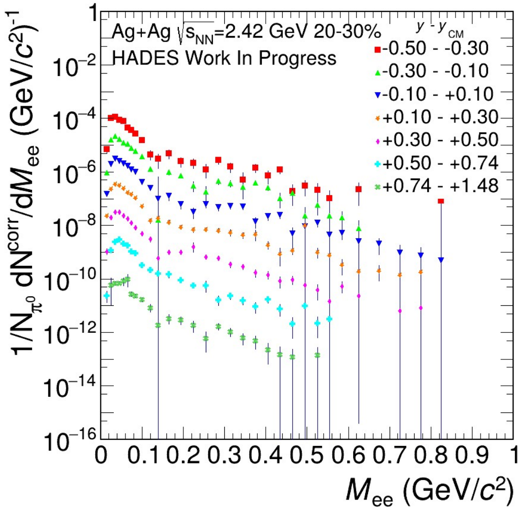

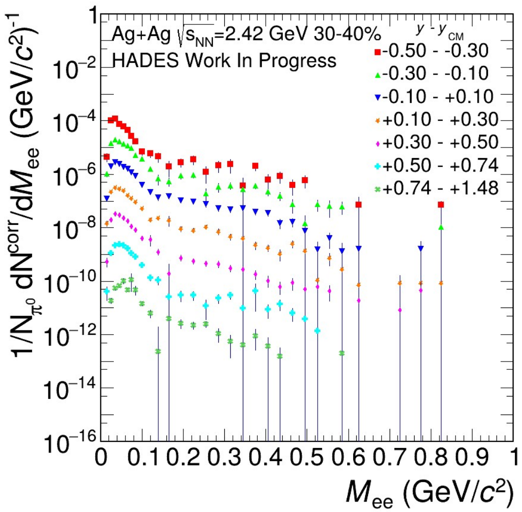

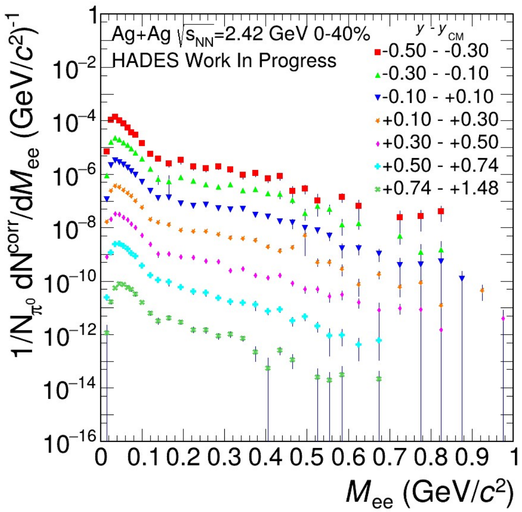

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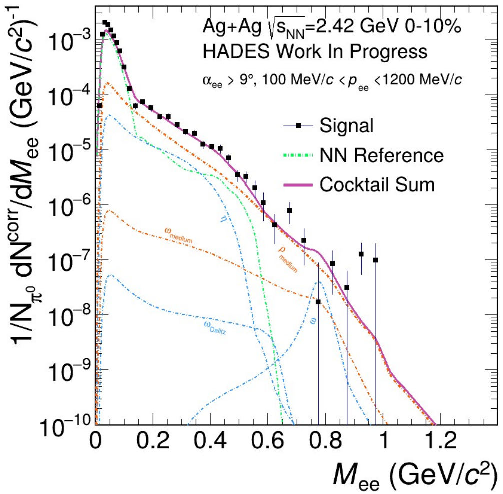

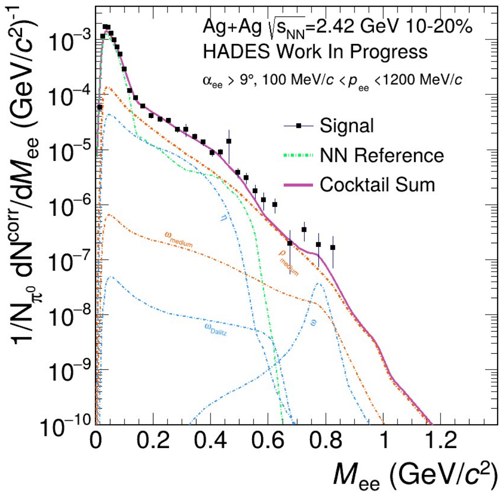

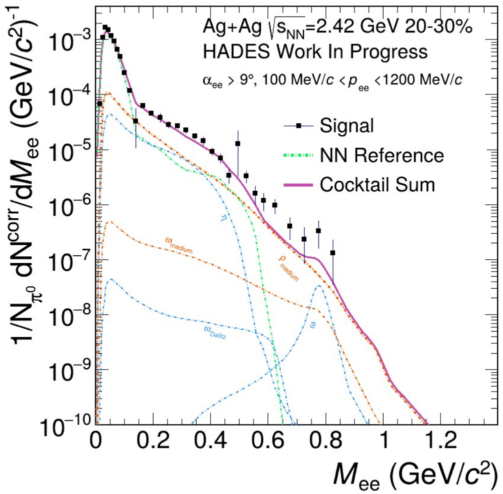

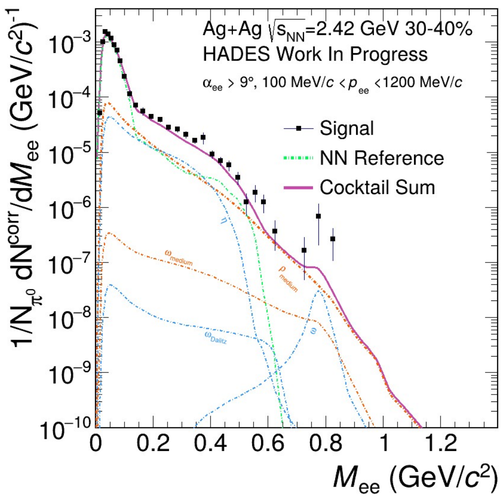

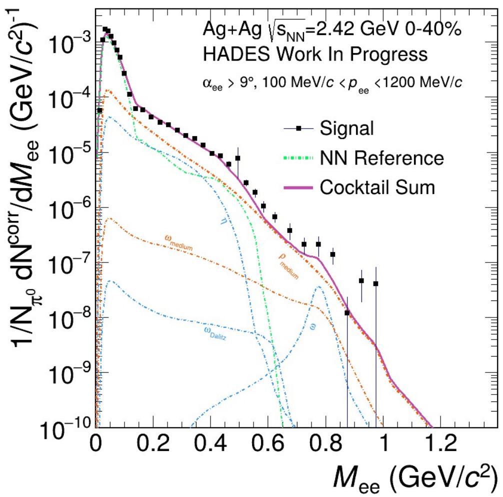

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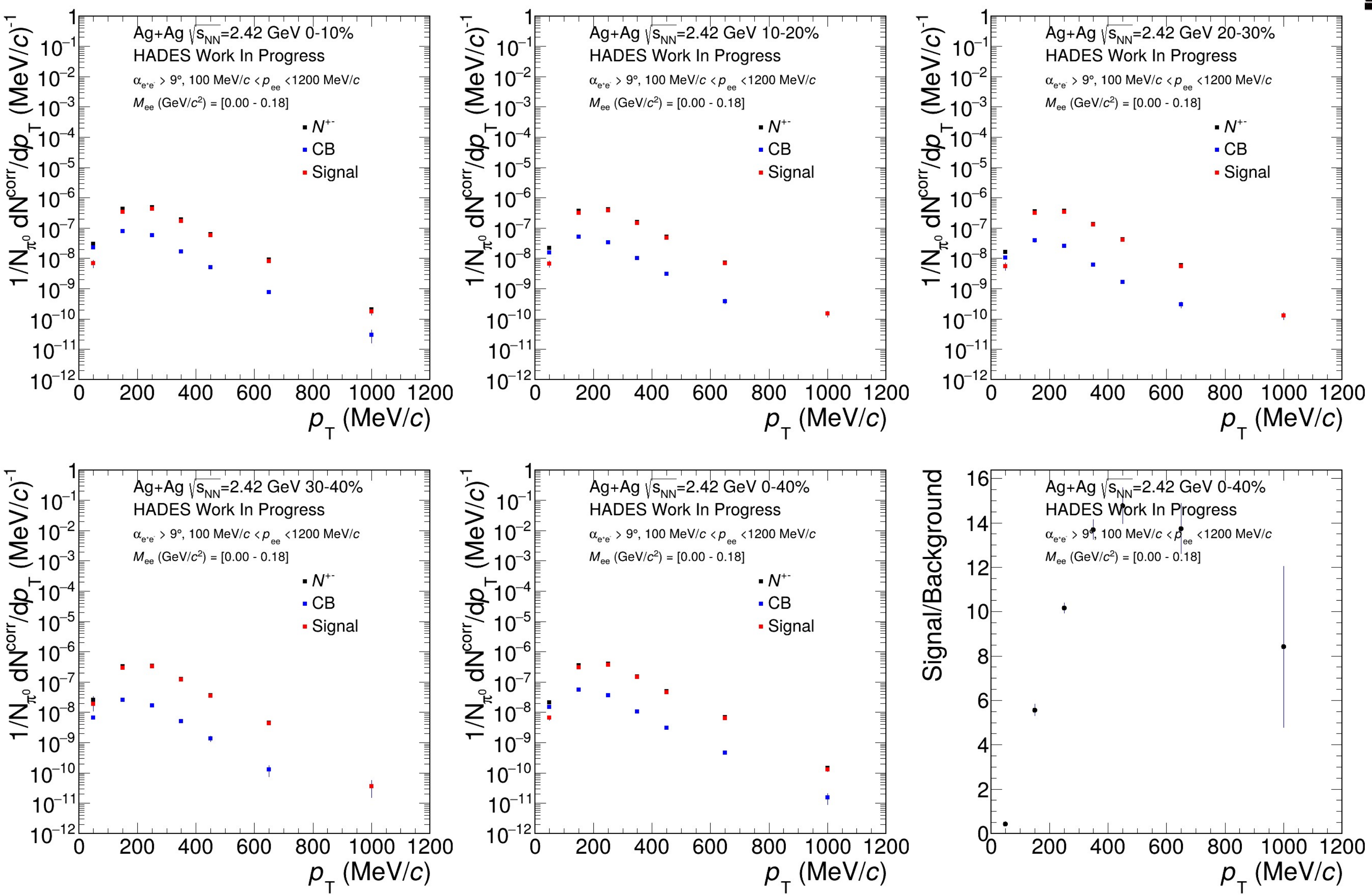

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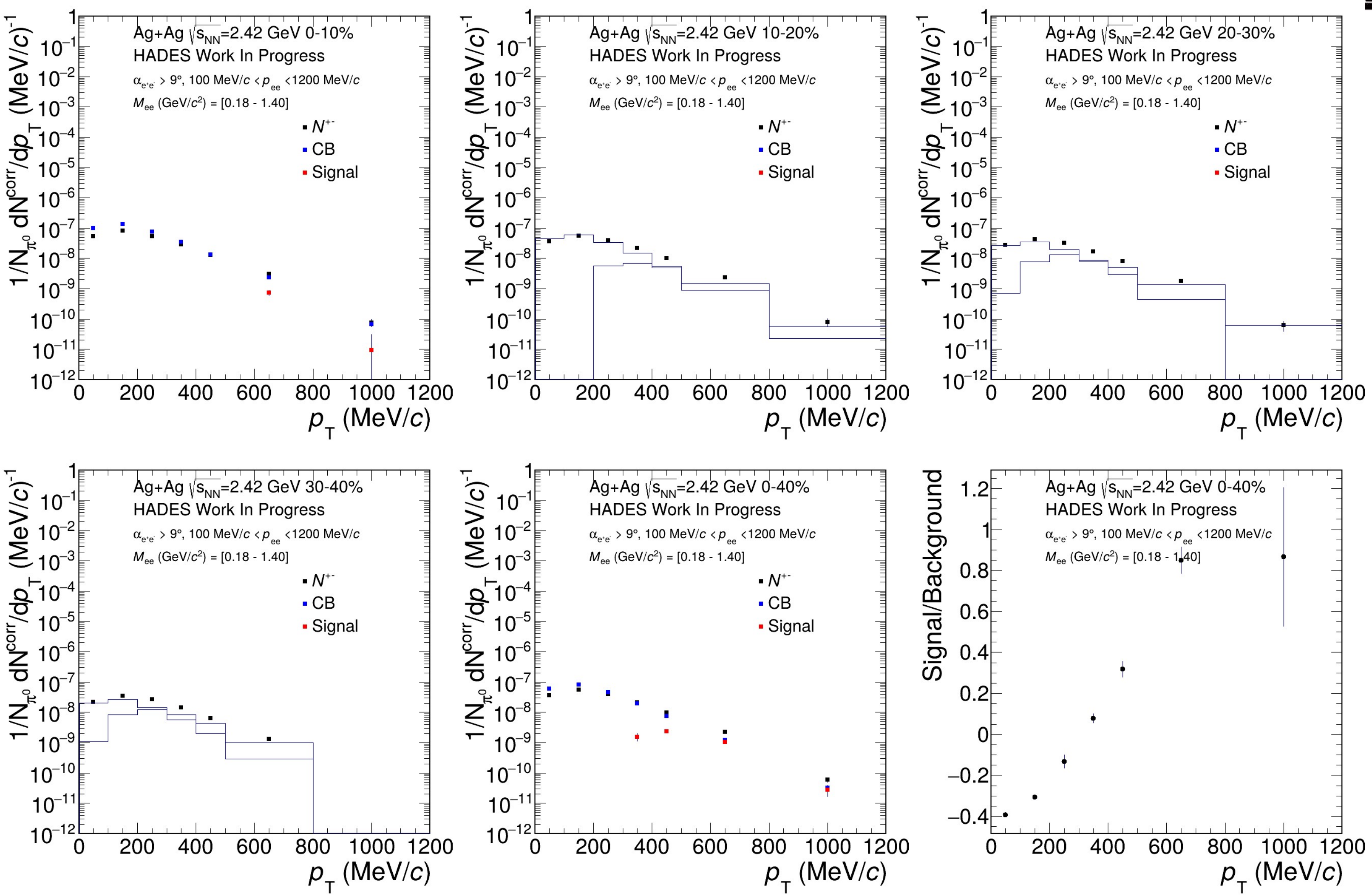

ADDITIONAL: RAPIDITY

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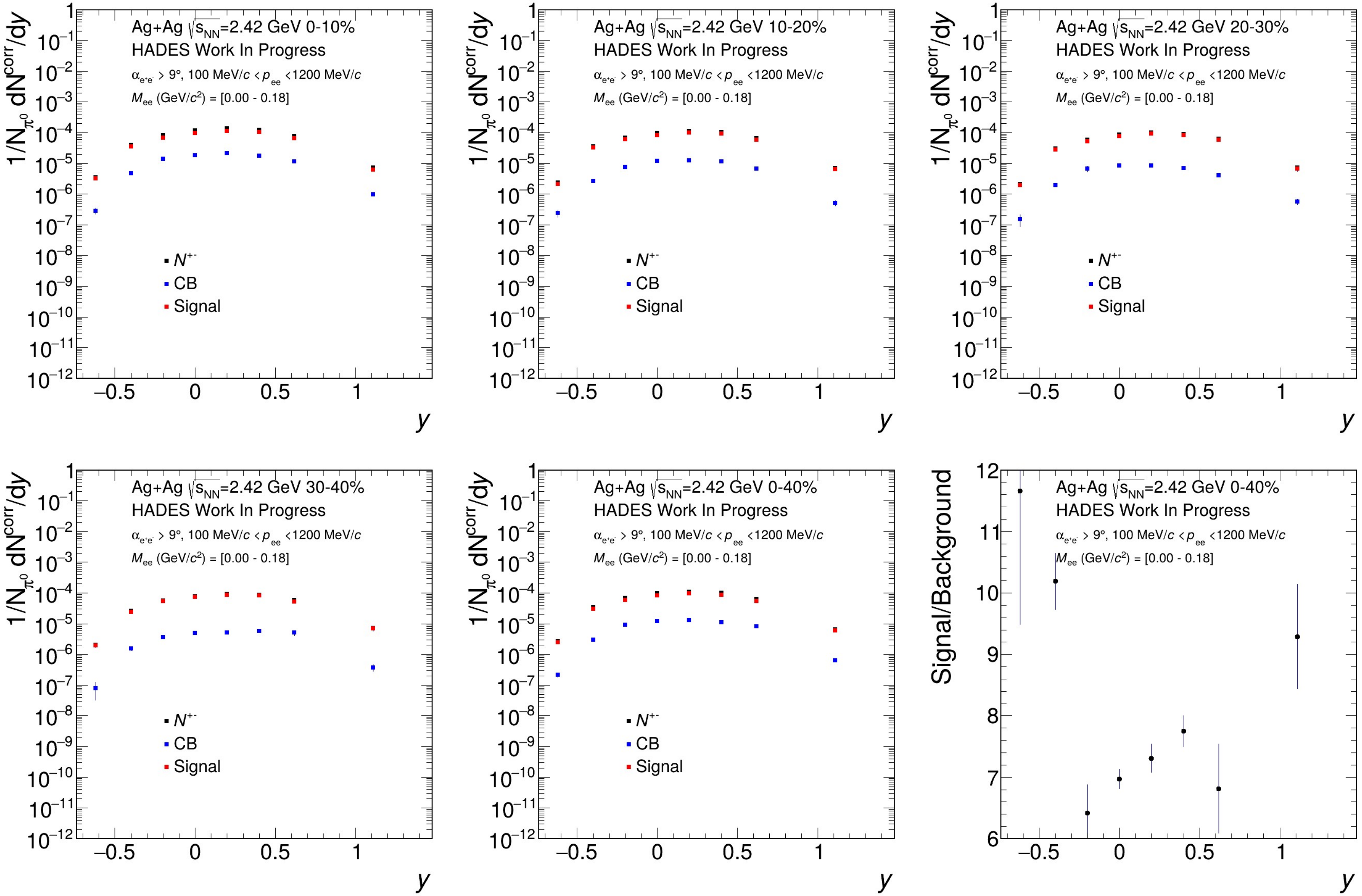

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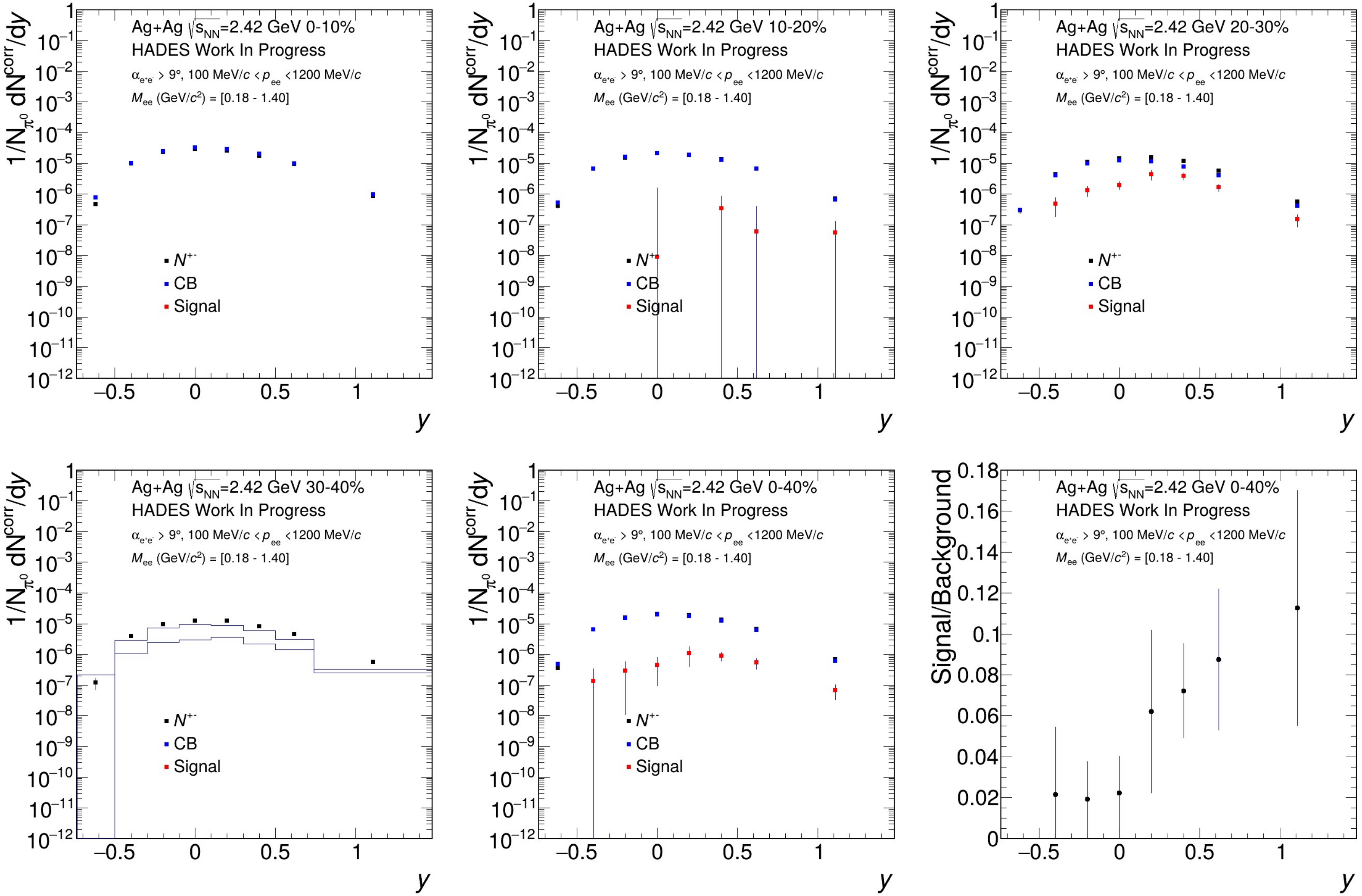

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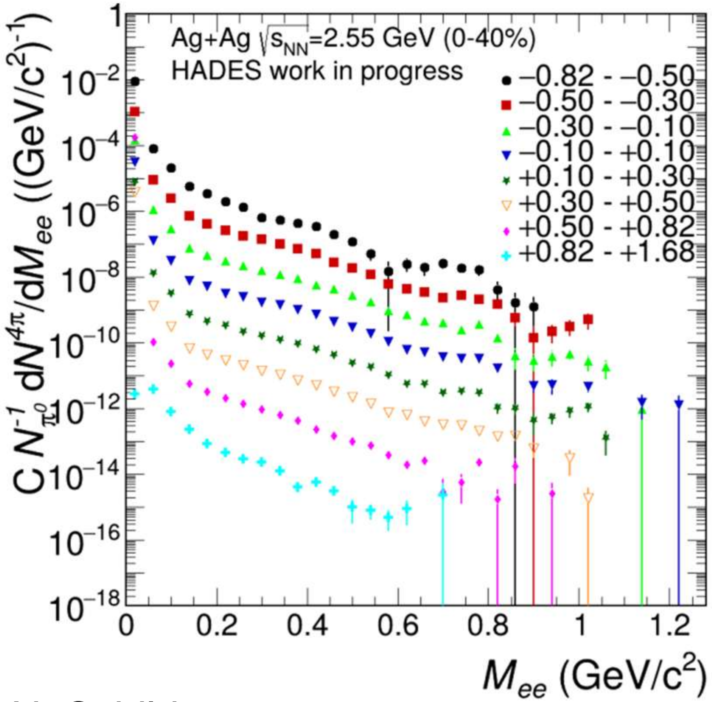
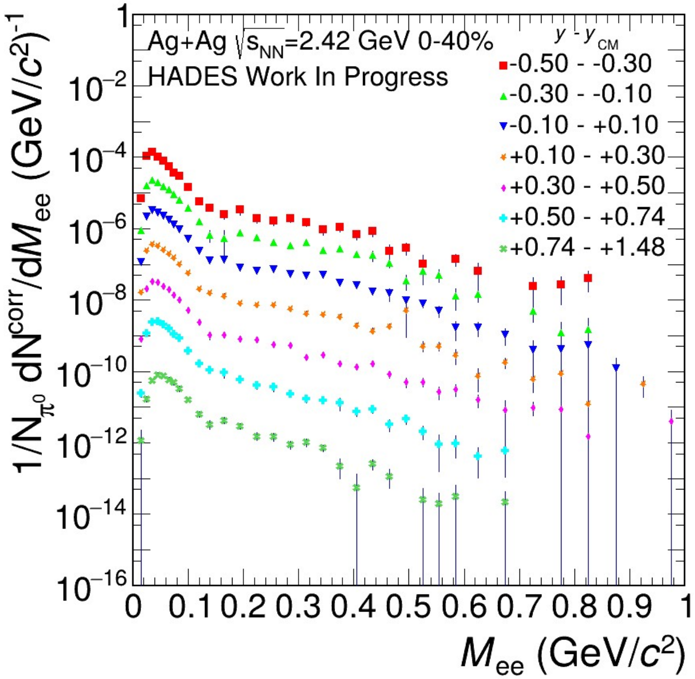


N. Schild



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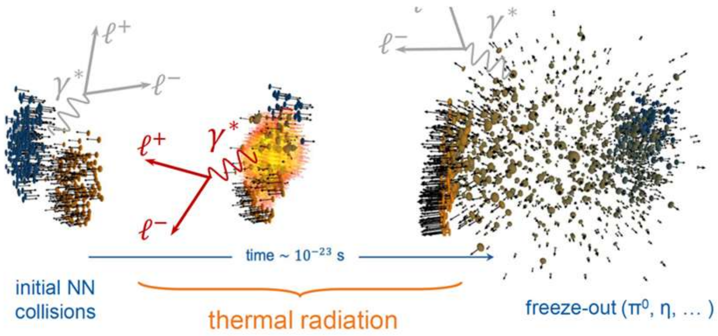
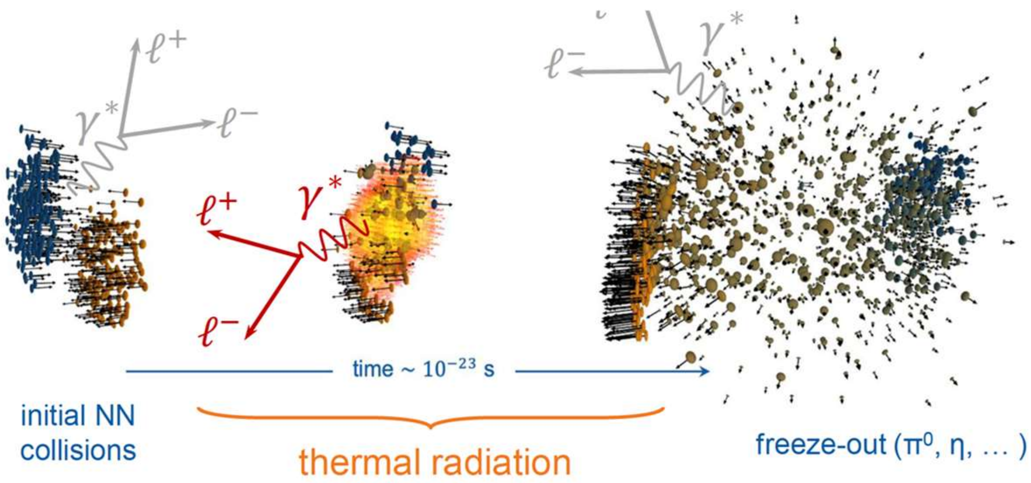
USING DILEPTONS TO PROBE HOT AND DENSE MATTER

- Dileptons do not interact via the strong force
- Dileptons are produced at every stage of heavy ion collisions:
  - First chance NN collisions:
    Δ Dalitz decay and Bremsstrahlung
  - Hot and dense fireball:
    ρ,ϕ and ω Vector mesons are produced
  - Freeze out:
    π^0 and η dominate
- ρ-meson decays inside the fireball because of decay width of 1.3 fm/c being smaller than that of the fireball of about 15 fm/c
- Dileptons can be used to:
  - Acquire lifetime or volume of the fireball
  - Study collectivity (flow)
  - Study in medium modifications and connect to chiral symmetry restoration



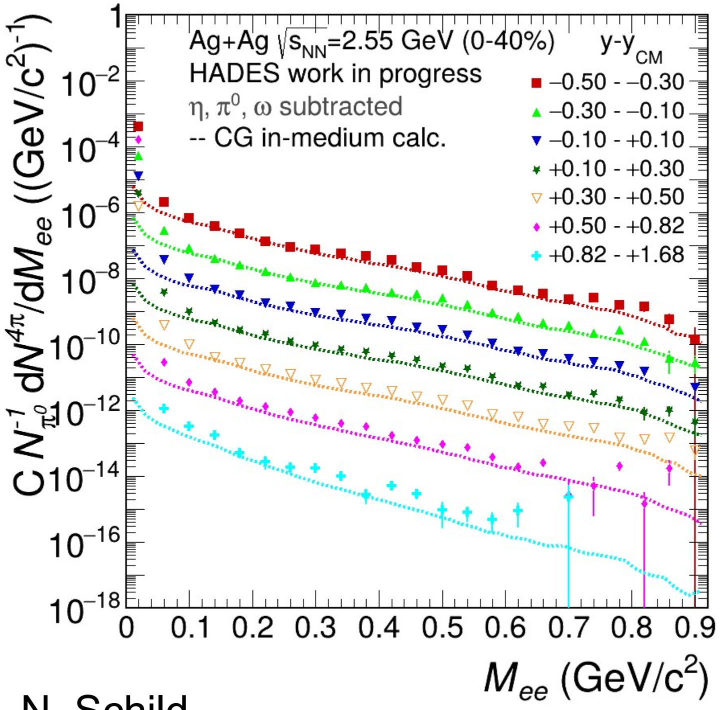
USING DILEPTONS TO PROBE HOT AND DENSE MATTER

- Dileptons are emitted during every stage of the collision
- After creation they no longer interact with the medium
- Good probes for studying:
  - Fireball temperature, expansion, volume, etc.
  - Characteristics of the hot and dense medium



OUTLOOK

- Play around with binnings for multidifferential analysis procedure
- Evaluate systematic uncertainties



N. Schild