Current Status of Di-Electron Analysis

Implementation of Random Event Techniques to simulate enhanced Background

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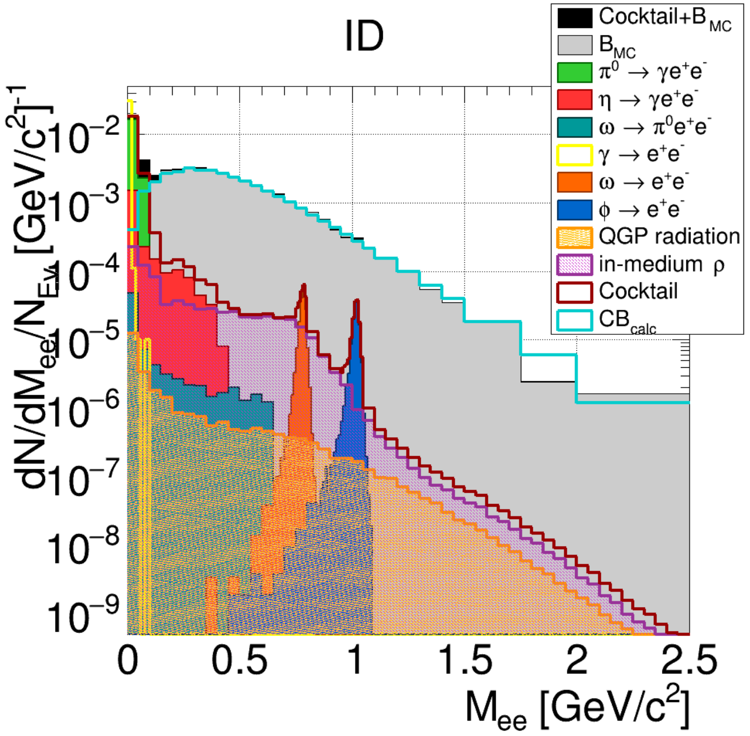
Current Status of Di-Electron Analysis

Ratio S/BG ≈ 1/100, not possible to see any peaks in BG+Cocktail spectrum.

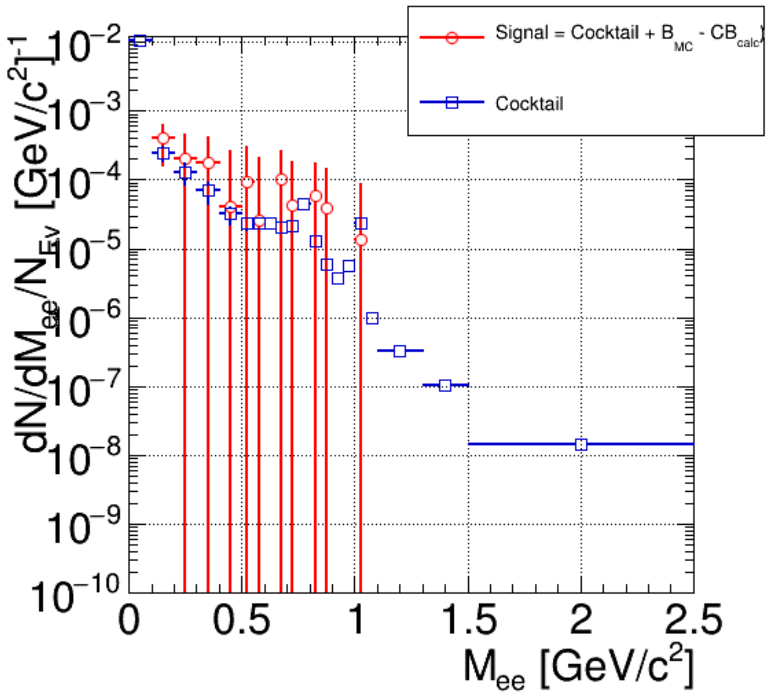
→ Describe background with mathematical expression (CB_{calc}) and subtract it from complete e+e- spectra.

→ Problem in our simulations: Two large numbers are subtracted – Not sufficient statistics → large fluctuations in calculated signal

→ Idea: Enhance statistics by implementing Fast Simulation techniques (Random Events)



Invariant mass spectrum after electron-ID. The signal-to-background-ratio is about 1/100.

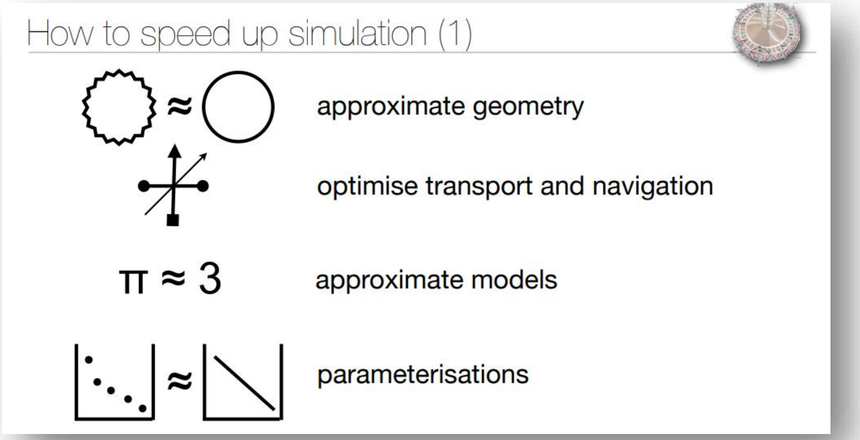


Signal (red), calculated from the calculated Combinatorial Background (CB_{calc}) which is subtracted from the e+e- yield, compared with the MC-true-cocktail (blue) after the electron-ID cut. To achieve an error of only 10 % for the signal, the background must be known with per-mill precision.

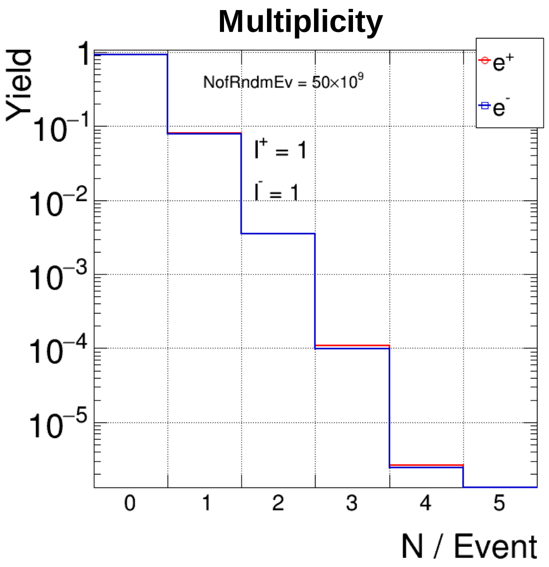
Implementation of a Fast Simulation (Random Event) Procedure

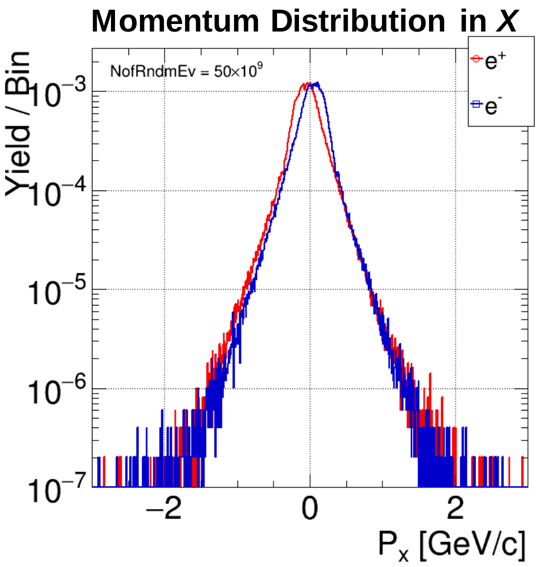
- Fast Simulation procedures were implemented in several Experiments (e.g. ATLAS, ALICE, CMS, …)
- Fast Simulations are based generally on approximations of geometry / models and parametrisations of outputs.
- Here: use output of „Slow Simulations“ as basis to create large numbers of randomly generated distributions (events) via using `GetRandom()`, seperate for each particle (charge).
- Here: **Four values** per particle (charge) are used to construct random events:
  - **Multiplicity:** Occurence of a particle (charge) per event after electron-identification
  - **3D Momentum** distribution of that particle (charge)

[Andreas Salzburger: *Fast Simulation in ATLAS*; talk; 2013]

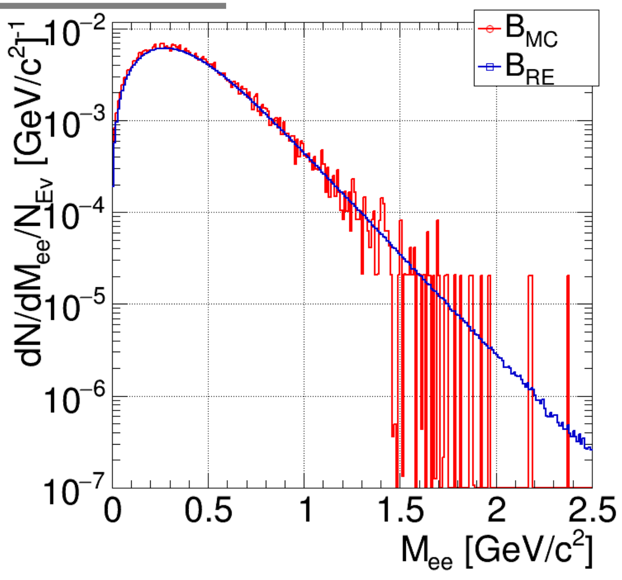


Implementation of a Fast Simulation (Random Event) Procedure





- Pair e+e-
- Calc. m_{inv}
- Fill histo



M_{inv} spectra from analysis and Random Events.

Procedure:

i) In analysis, fill histograms with **multiplicity** and **3D momentum** distributions.

ii) For random events, use those histograms as basis to create random events via getting random **multiplicity** and **3D momentum** distributions via `GetRandom()`.

iii) Pair all combinations of **e+** and **e-** tracks.

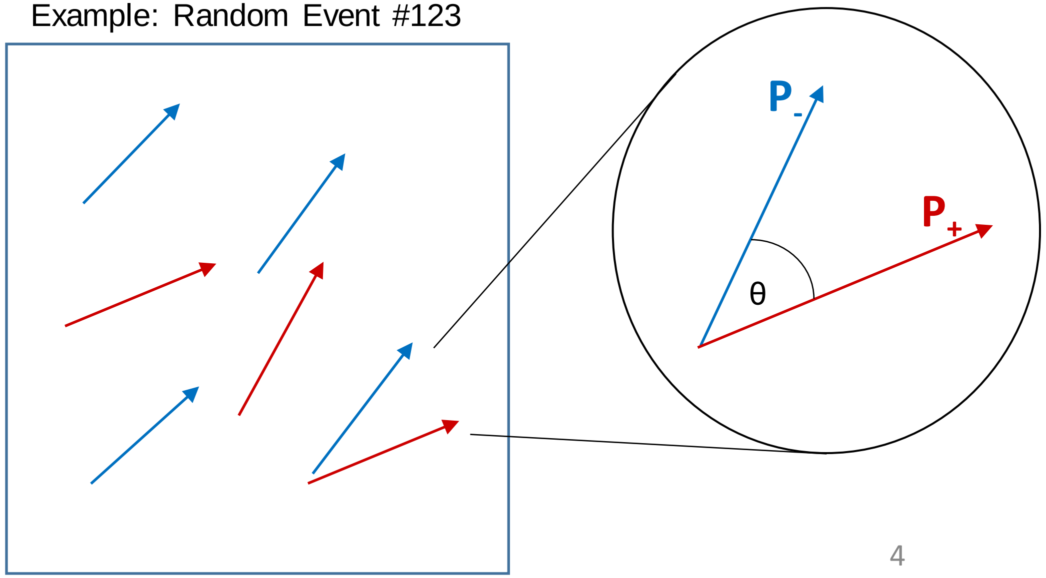
iv) Calculate m_{inv} and fill histogram.

} Same procedure as in analysis

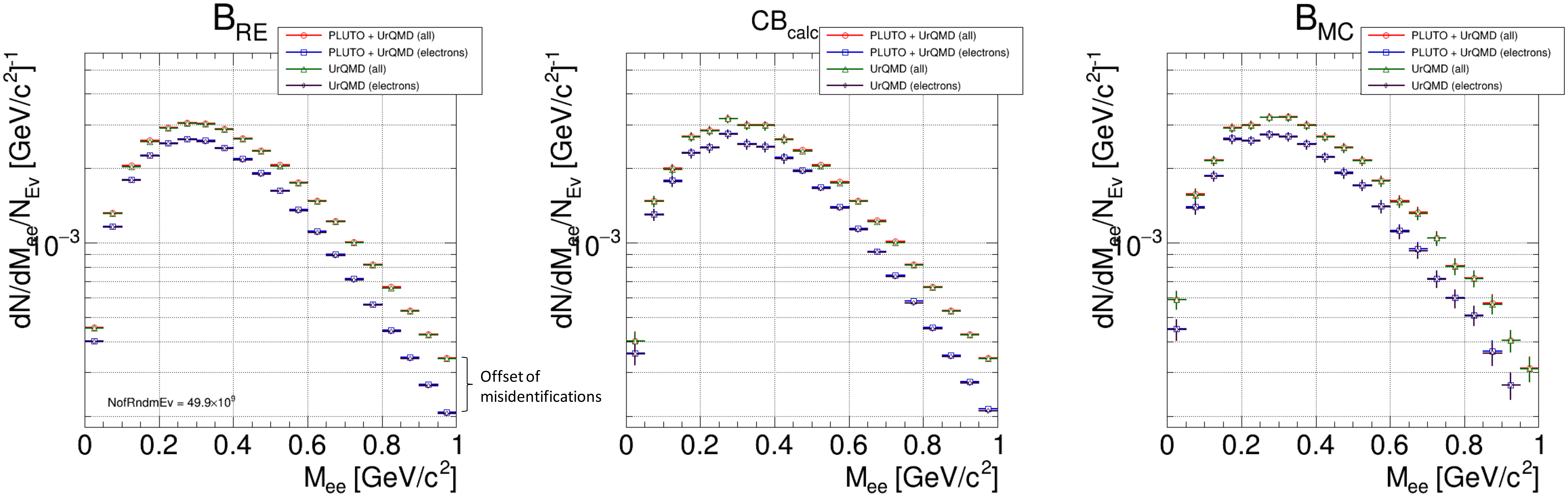
$$m_{\text{inv}} = 2\sqrt{P_+ \cdot P_-} \cdot \sin\left(\frac{\vartheta}{2}\right)$$

[freepik.com]

Example: Random Event #123

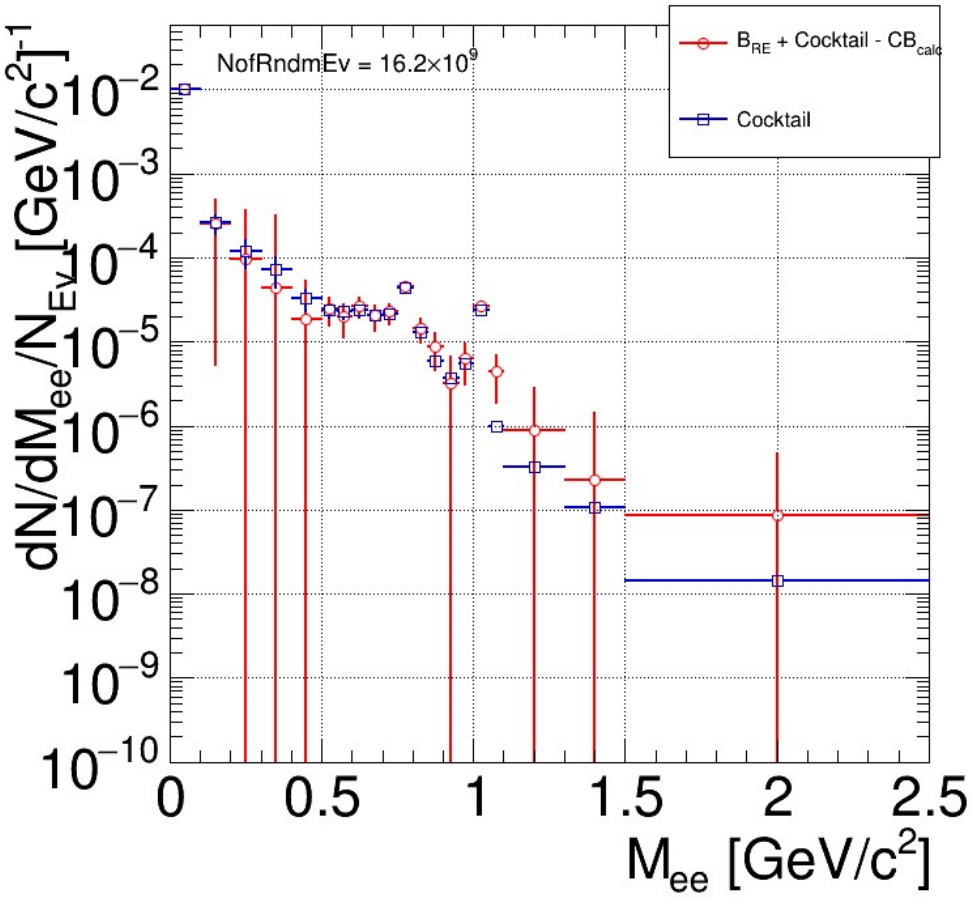


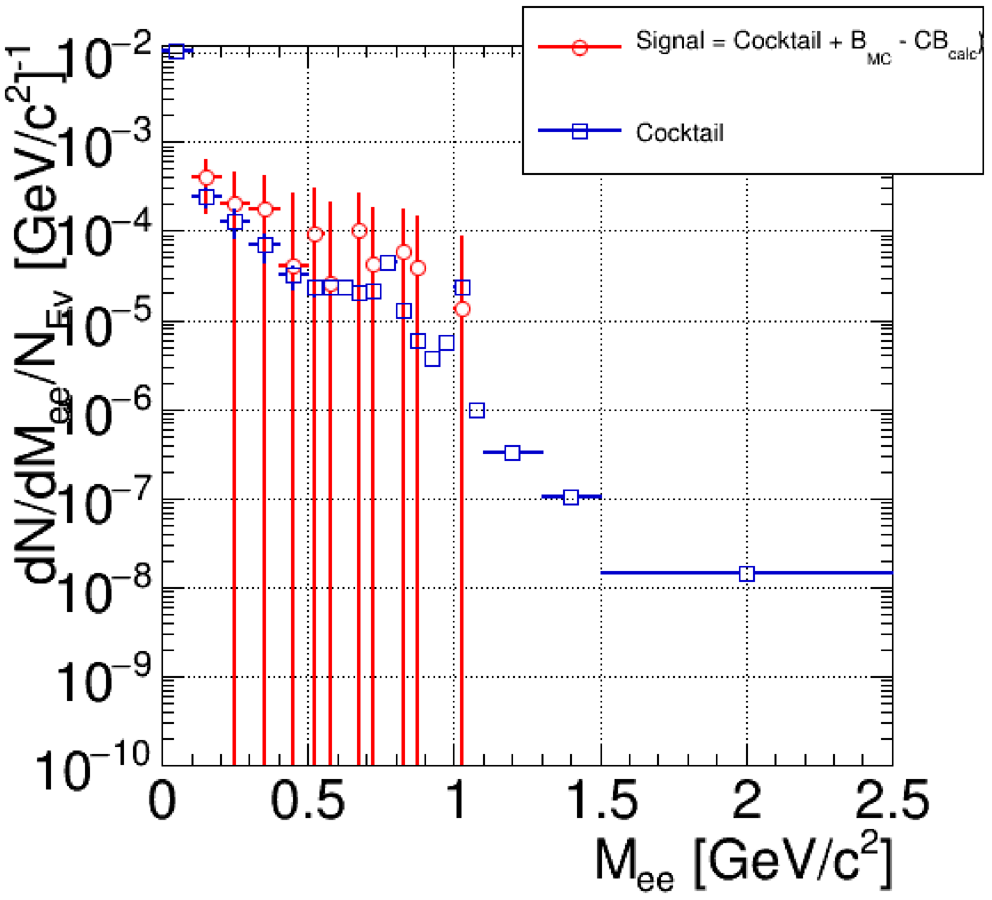
Background obtained from different Procedures



B_{RE} (left) in comparison to the calculated Combinatorial Background (center) and the MC-background (right) for various categories. Data are taken after electron-ID step.

Result

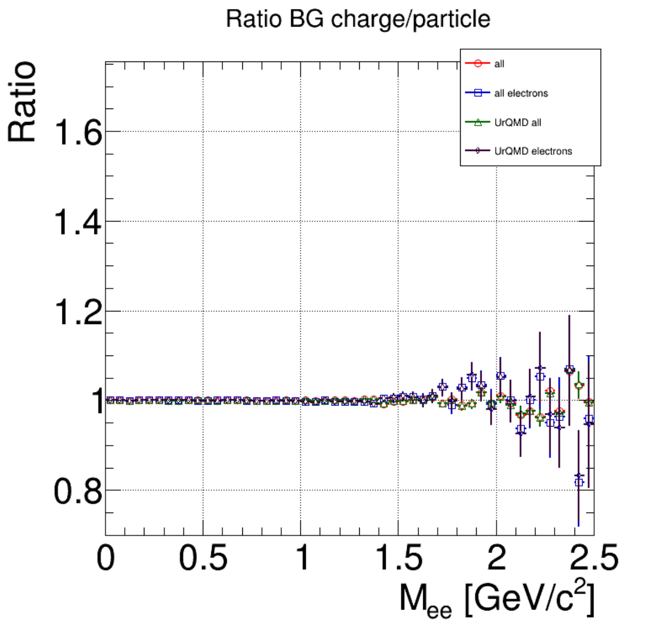




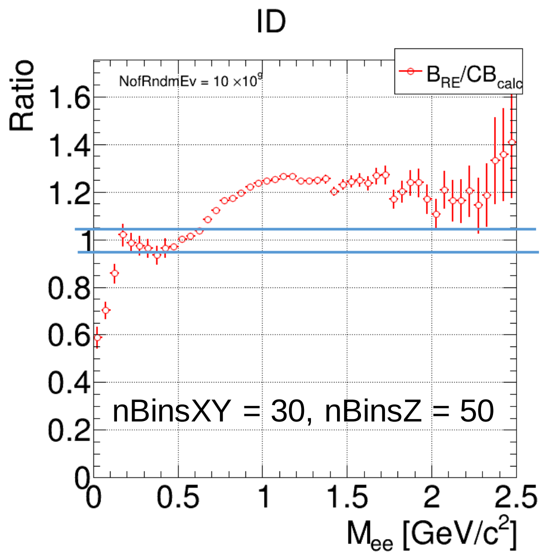
Signal (red), obtained by Random Event techniques (left) and by subtracting the calculated Combinatorial Background from the e+e- yield (right), resp., in comparison to the MC cocktail (blue).

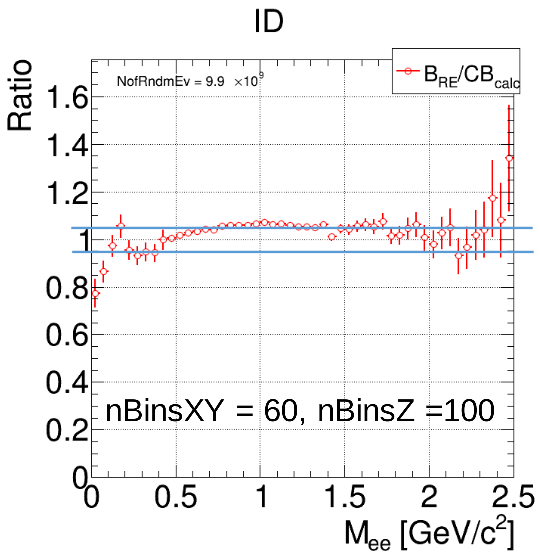
Technical Details

- Parameters were collected seperately for: e_{Signal}, e_{γ}, e_{η}, $e_{\pi 0}$, e_{Other}, $\pi^{+/-}$, protons, $other^{+/-}$ (**15 particle species**) → changed to split up into basically **2** species: positive and negative charges (figure right: ratio of BG obtained from both procedures)
- **Time** per randomly generated event: ≈ 8 μs → <10 minutes for $20x10^9$ events when running parallel on batch farm
- **3D Momentum** histograms: from **TH3D** to **THnSparseD**
  - Advantage: THnSparse occupies disk space only for filled bins
  - Before only 1-2 % of bins were filled → saves a lot memory
  - Bin precision is very important for accuracy. Now: 1000 bins per axis (≈ 4 MB/hist)



Ratio of background yields obtained by charge-based and particle-based Random Event procedure for different categories.



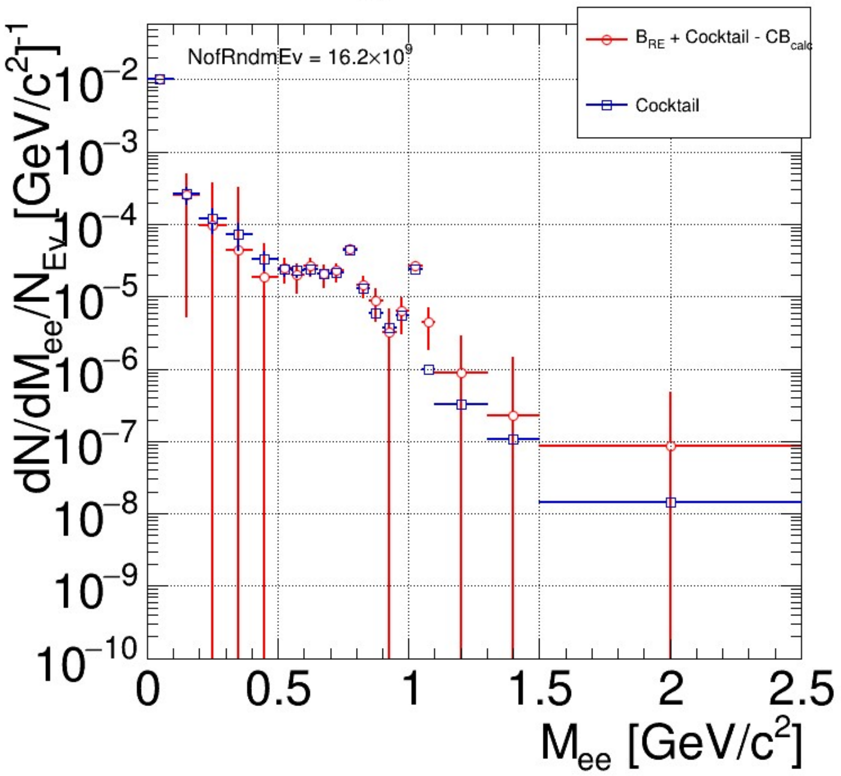


Left: Ratios B_{RE} / CB_{calc} for different number of bins of the 3D momentum histograms [1]. The blue lines indicate a range of ± 5 %.

[1] PLUTO particles contributed with wrong counting in these plots.

To do

An update of the CB_{calc} is to be implemented with the possibility of a larger mixing depth for mixed events (until now: mixing depth = 1000) to decrease the errors at masses > 1 GeV.



Thank you for your attention!