Background and track reconstruction studies

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Outline

Backgrounds at the EIC

- Synchrotron radiation

- Primary collisions
  - Ionization radiation
  - Low Energy Neutron Radiation

- Beam-gas induced
  - Electron-gas interactions
  - Hadron-gas interactions

Wiki page to document background studies

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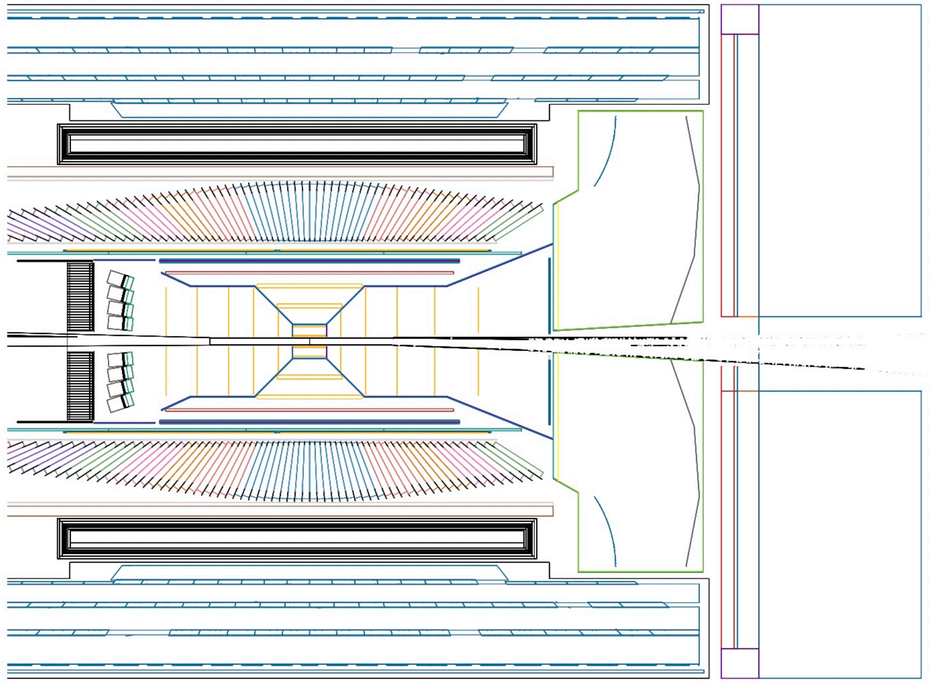

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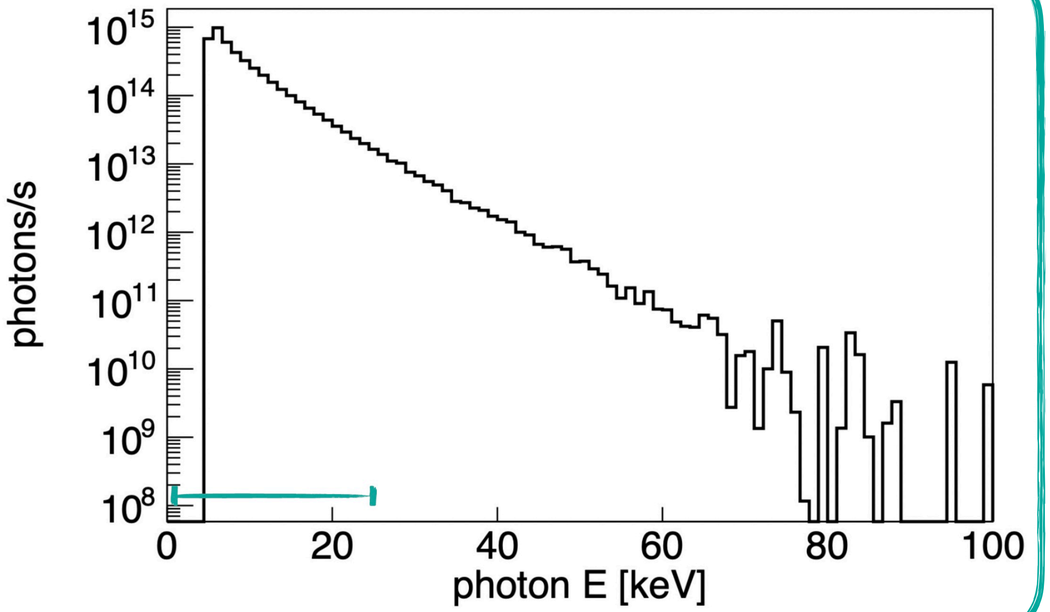
Synchrotron radiation

- Caused by quads and bending magnet upstream of IP

Simulations based on Synrad+ (by M. Stutzman)

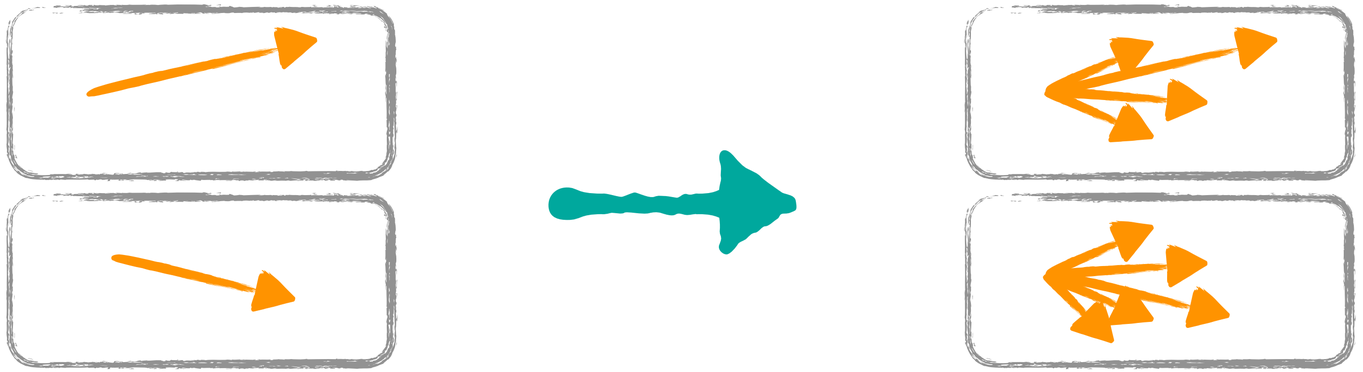
- virtual cylinder placed just inside the IR beampipe
- Electrons are propagated through B field
- resulting photons passing through cylinder are recorded

Output: hepmc file with single-photon “events” containing information related to photon vertex, momentum, and weight corresponding to equivalent photons / sec



Have

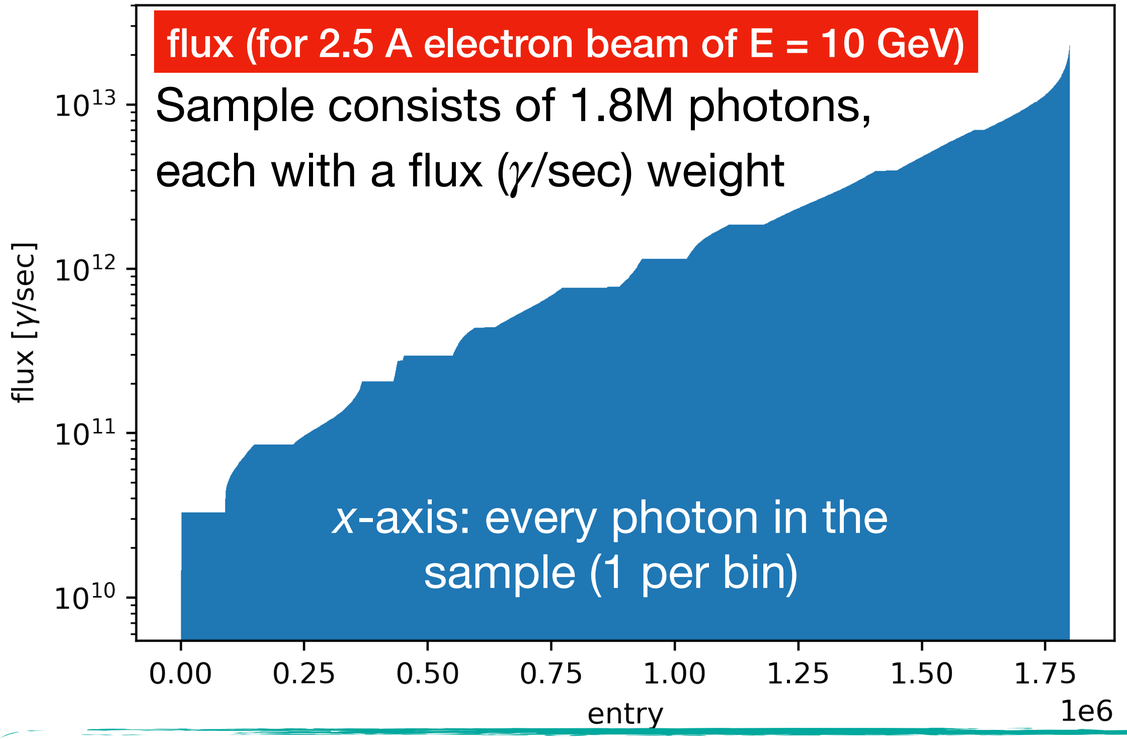
A series of single-photon events from a Synrad+ simulation.



Need

A series of events with many photons corresponding to a time integration window.

Synchrotron radiation event generator

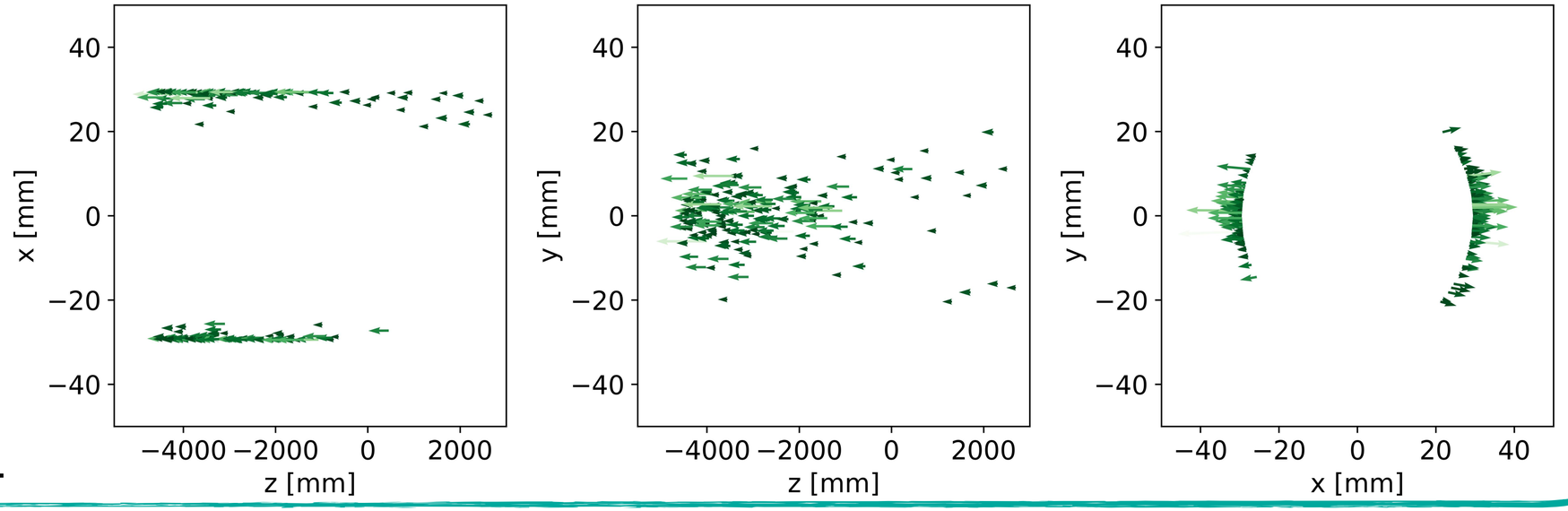


Define an integration window (IW)

```
integral = 0
while integral < IW:
    Randomly sample photon, add it to event
    integral += 1/flux
return event
```

Sample as many photons as fit in the defined time integration window

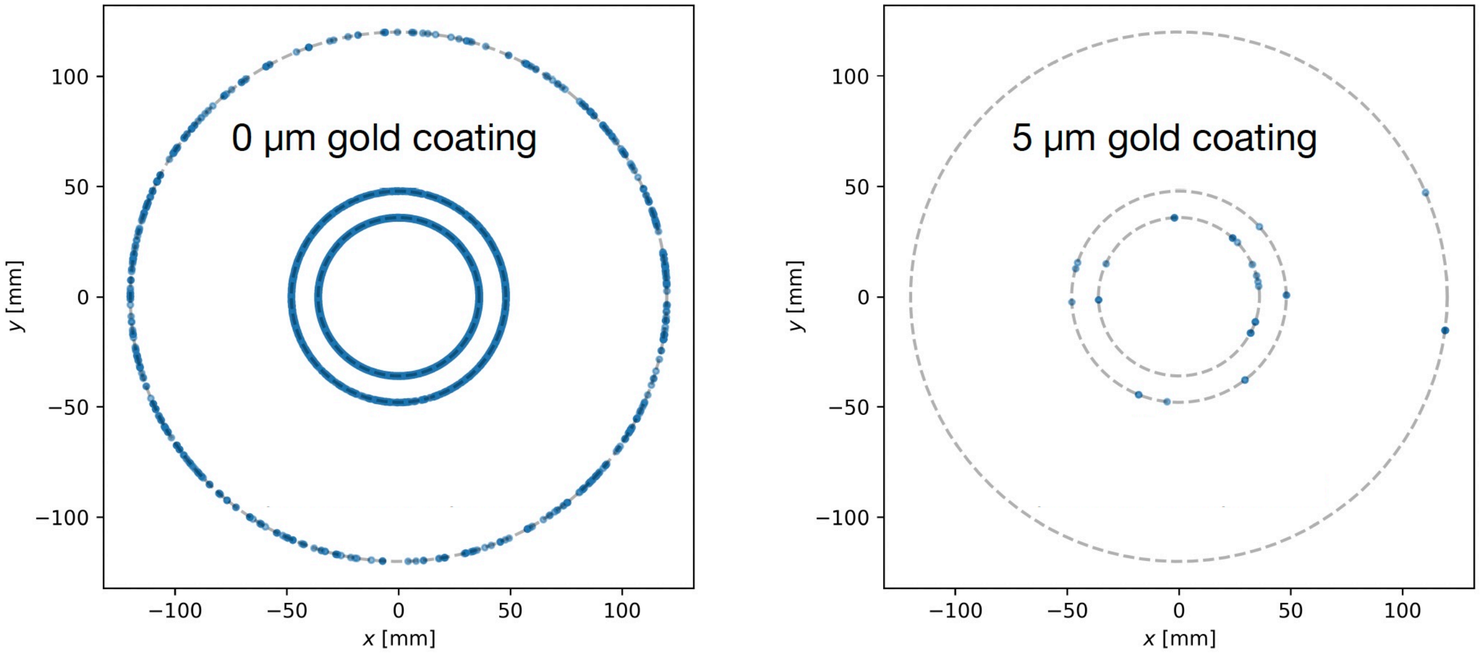
Sample event for a 100 ns time integration window



Study by Ben Sterwerf, **RCT**, et al.

Synchrotron radiation results

Impact of gold coating in the beampipe



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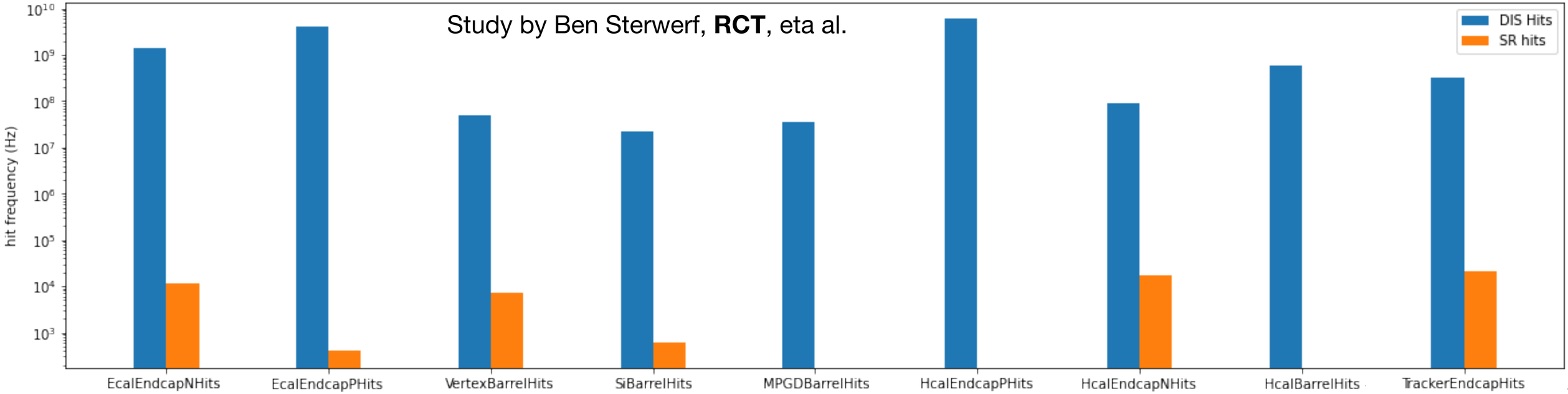
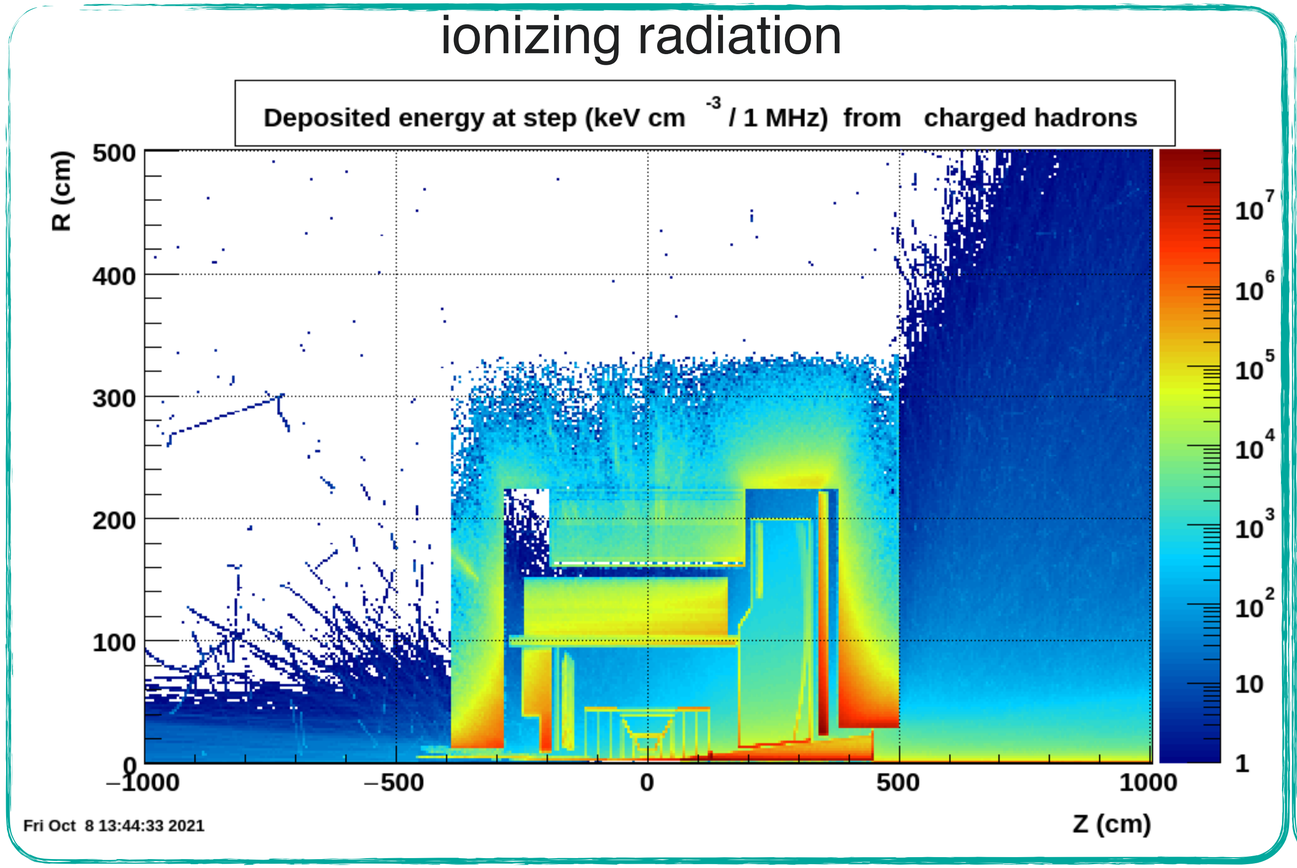


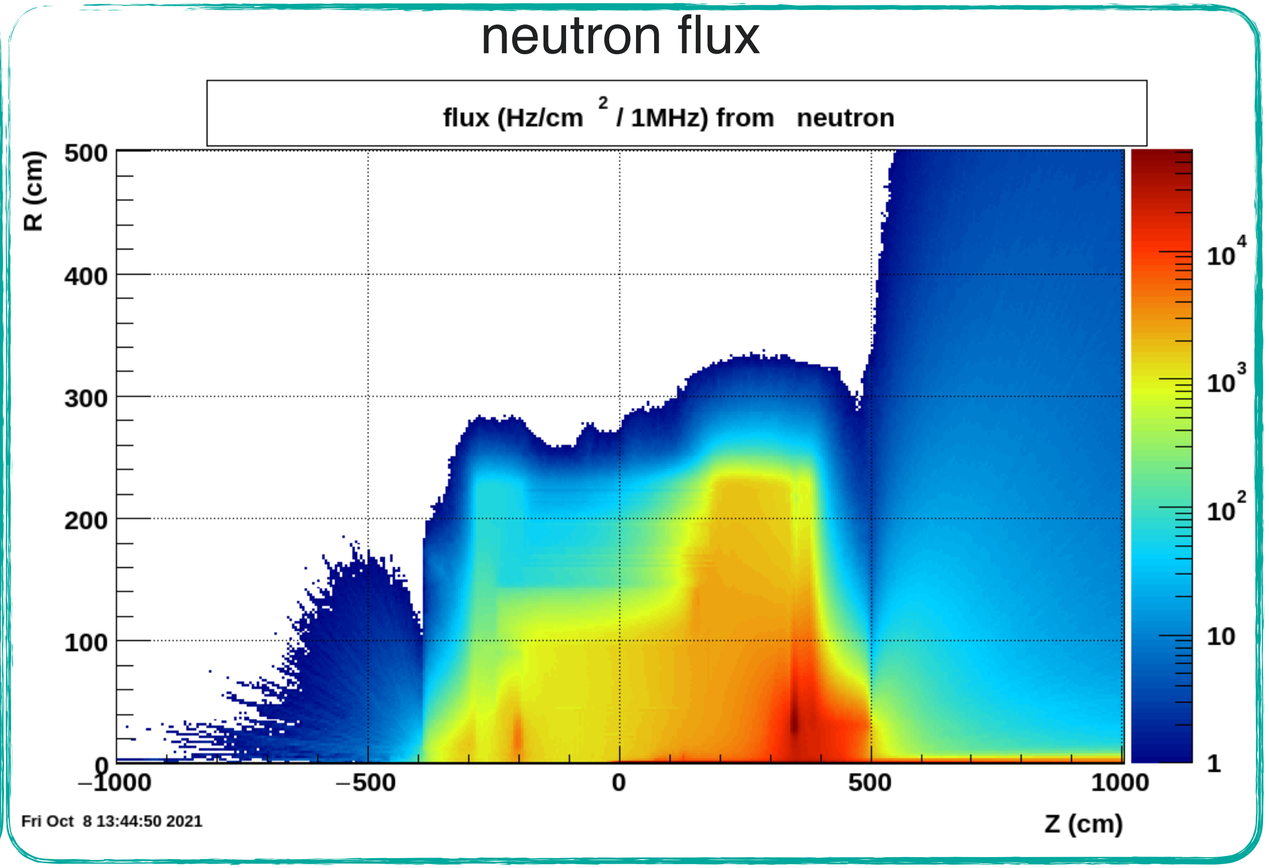
Primary Collisions

- Primary collisions → substantial fraction of ionizing radiation and low-energy neutron flux in the hall
- Simulations based on Pythia 6 tuned to HERMES, COMPASS and HERA with $Q^2 > 10^{-9}$ GeV^2

ionizing radiation



neutron flux



Plots by Alex Jentsch

ATHENA detector - update in progress

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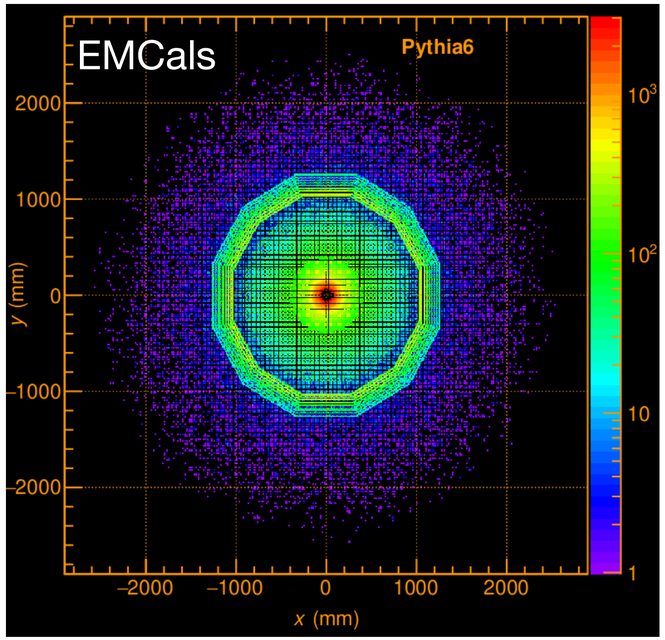
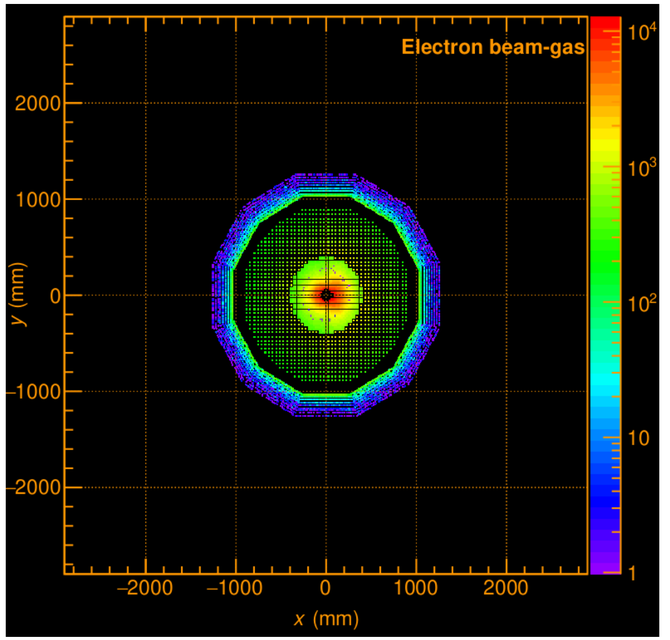
Electron Beam-Gas interactions

vacuum after 10000 Ah (running of 5 month at 10^{34} cm^2s^{-1})

Interaction of beam particles with residual gas molecules in the beam pipe can impact detector performance and/or mimic physics signals

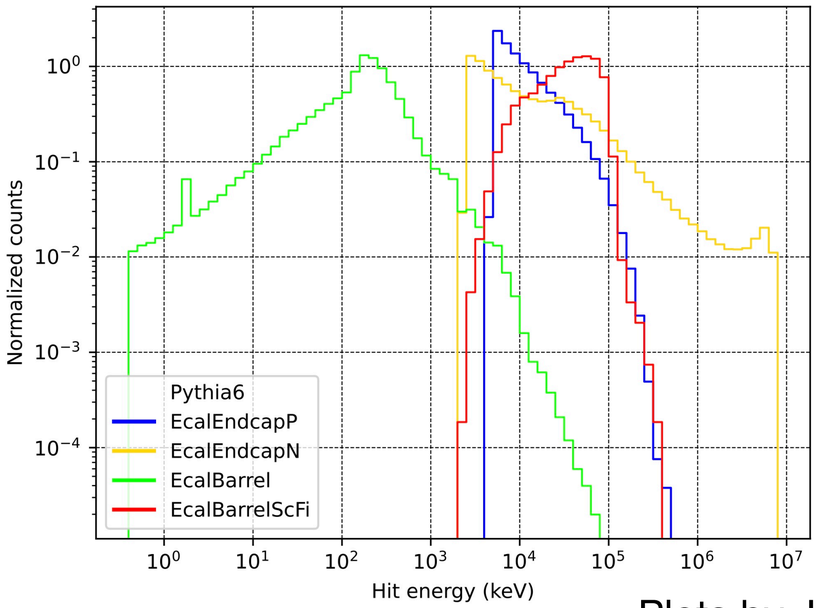


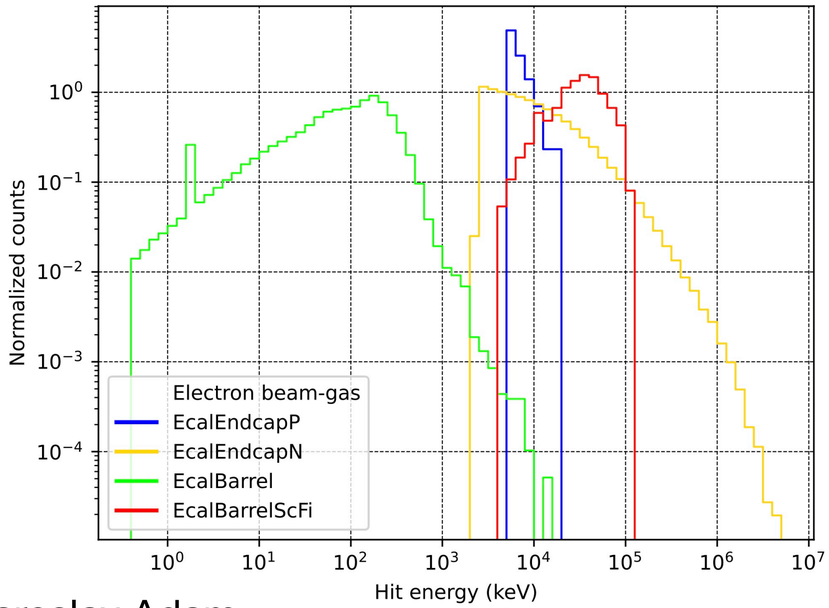


- off-momentum electrons will be shielded by collimators (detailed simulations of collimation system are underway)

- main contribution to detector background are from Bethe-Heitler process:

$$e_{\text{beam}} + \mathrm{H}^2_{\text{rest gas}} \rightarrow e' + \gamma + \mathrm{H}^2_{\text{rest gas}}$$





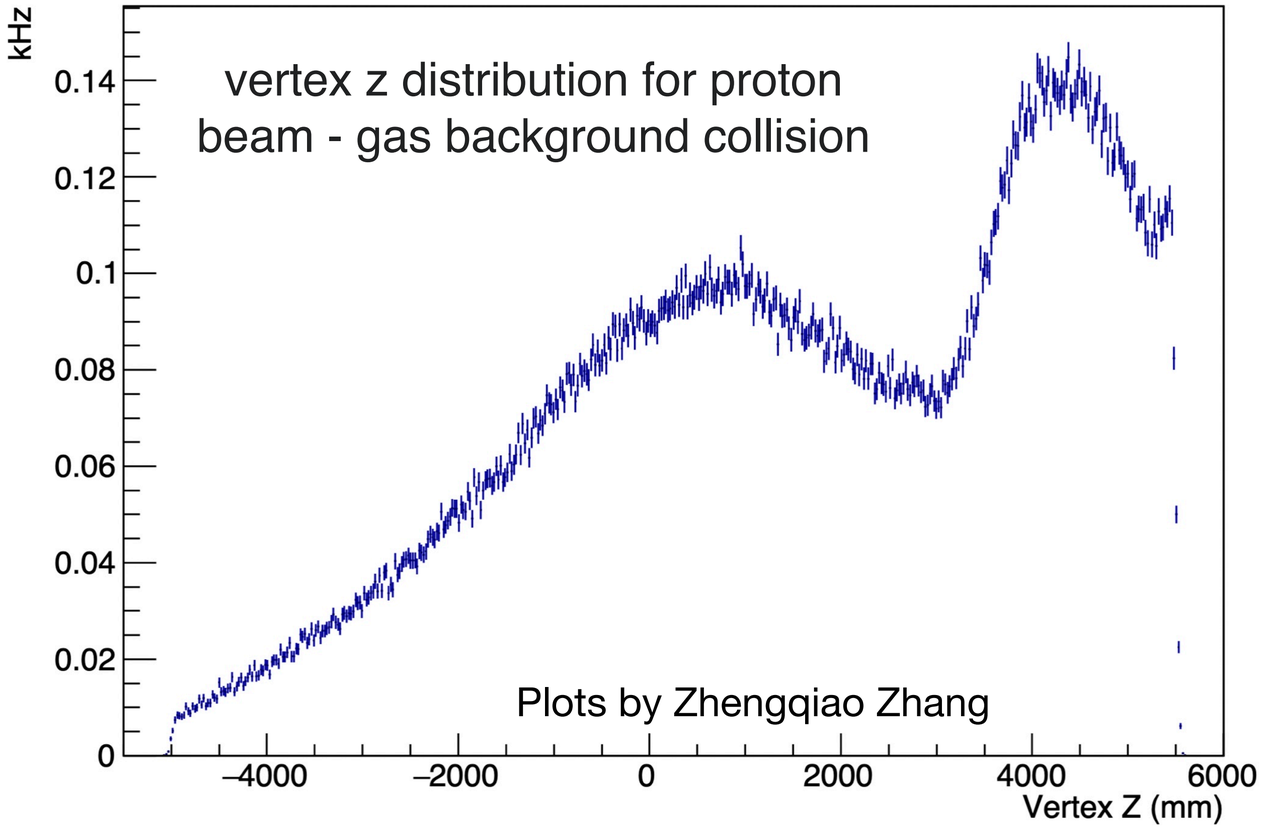
Plots by Jaroslav Adam

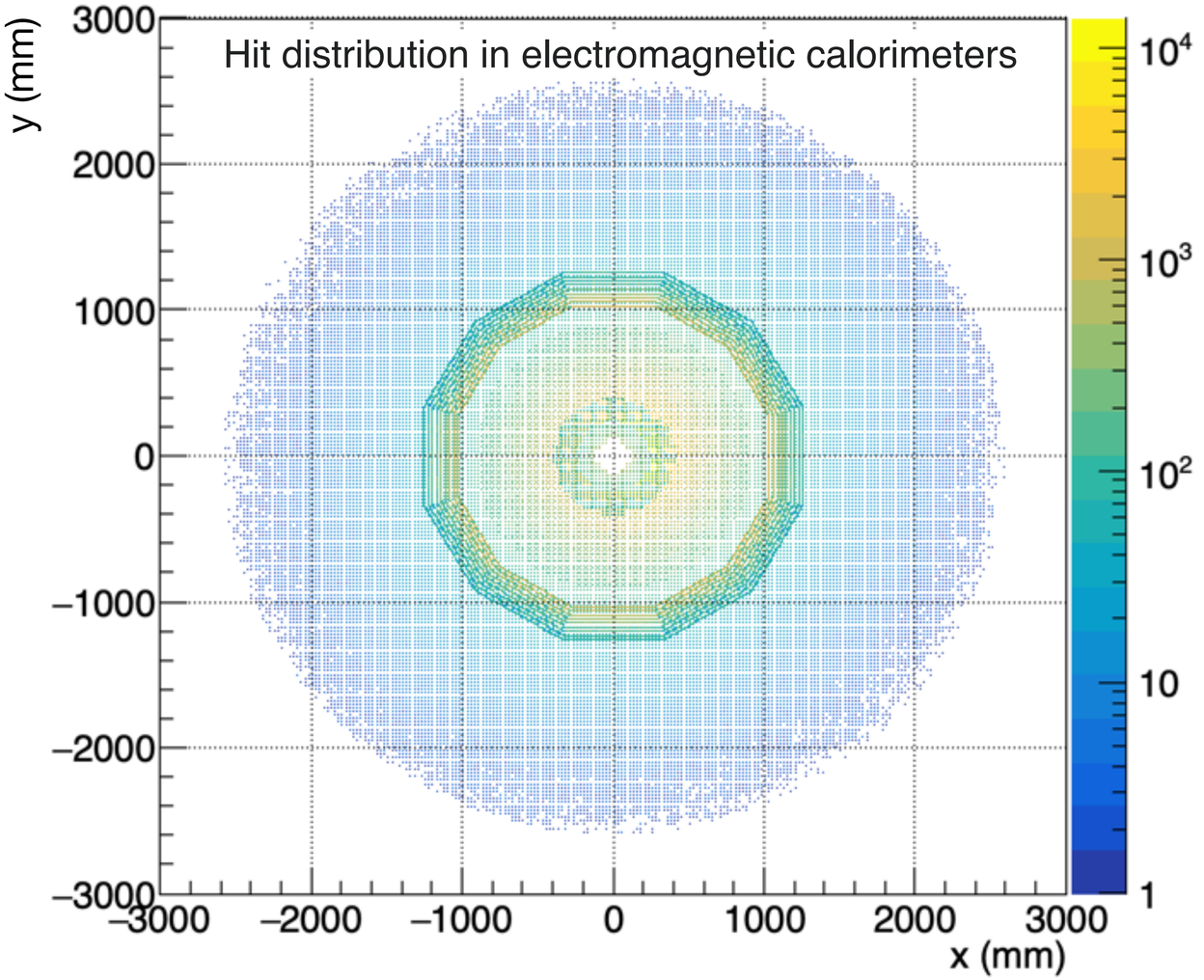
ATHENA detector - update in progress

Hadron Beam-Gas interactions

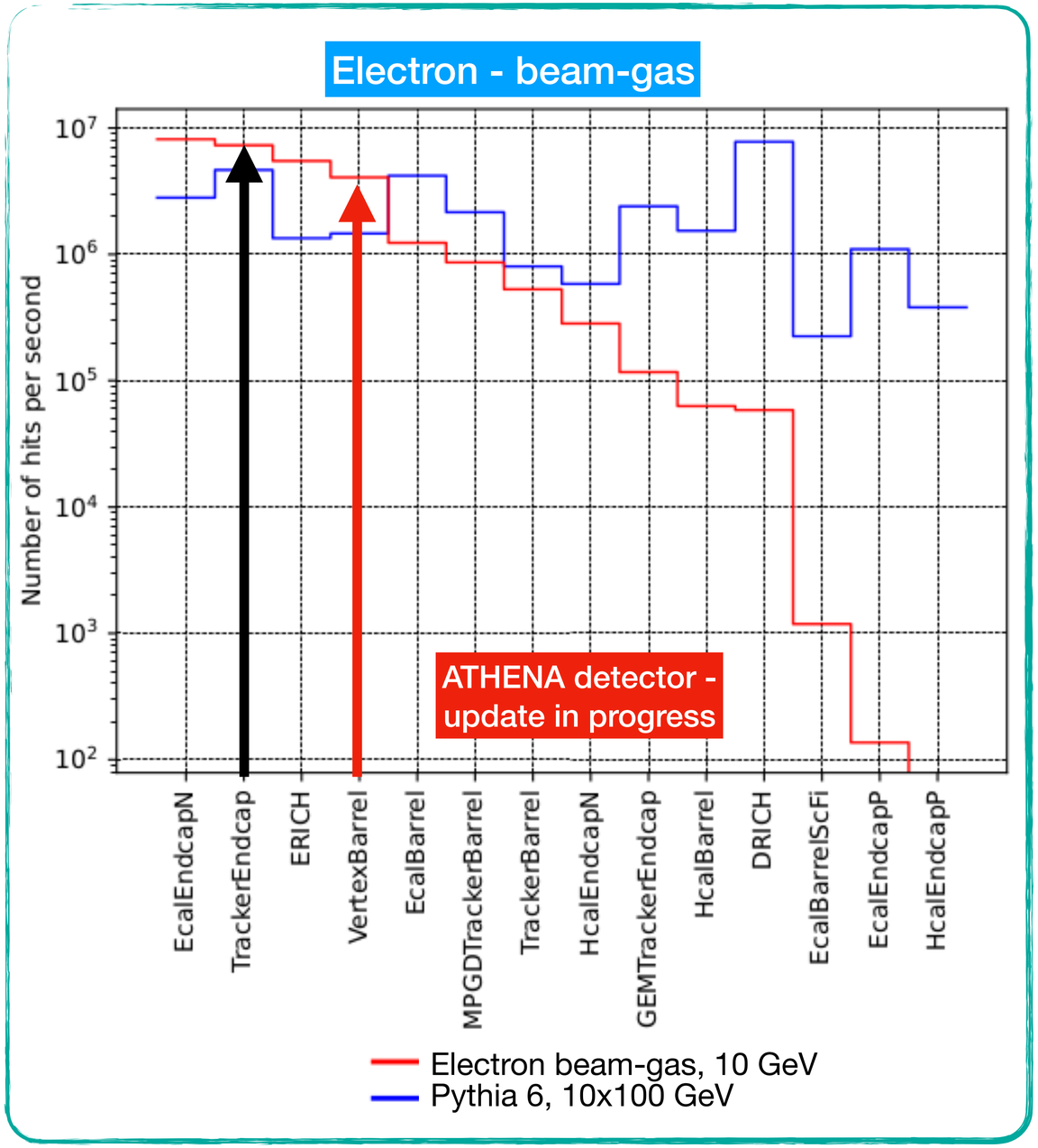
vacuum after 10000 Ah (running of 5 month at 10^{34} cm^2s^{-1})

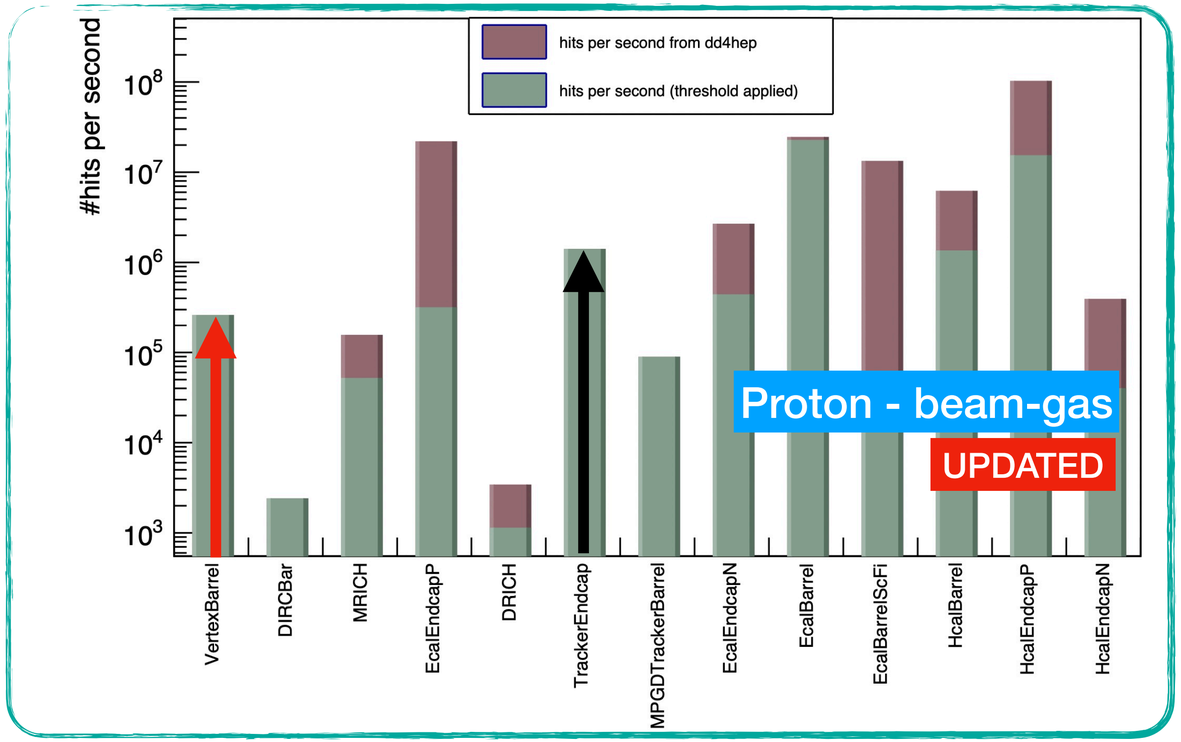
- concerning large hadronic cross section of the $p/A_{\mathrm{beam}} + \mathrm{H}^2_{\mathrm{rest\ gas}}$ interactions
- Secondary interactions of produced particles with detector components is one of the main sources of neutrons that thermalize within the detector hall

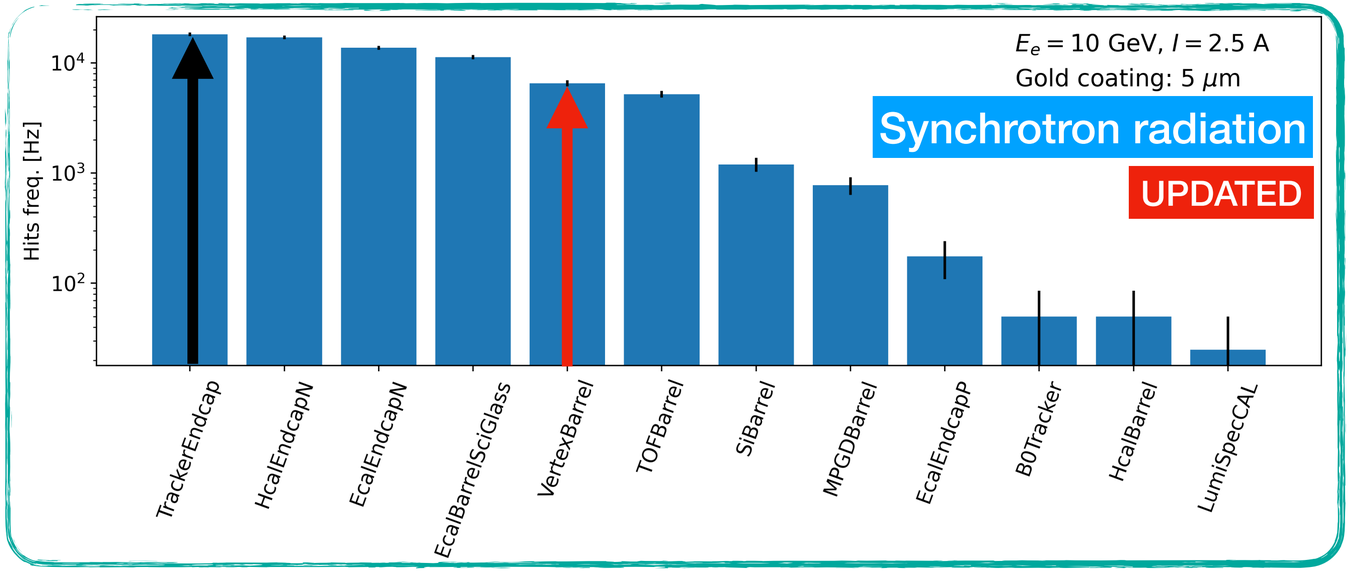




Background comparisons







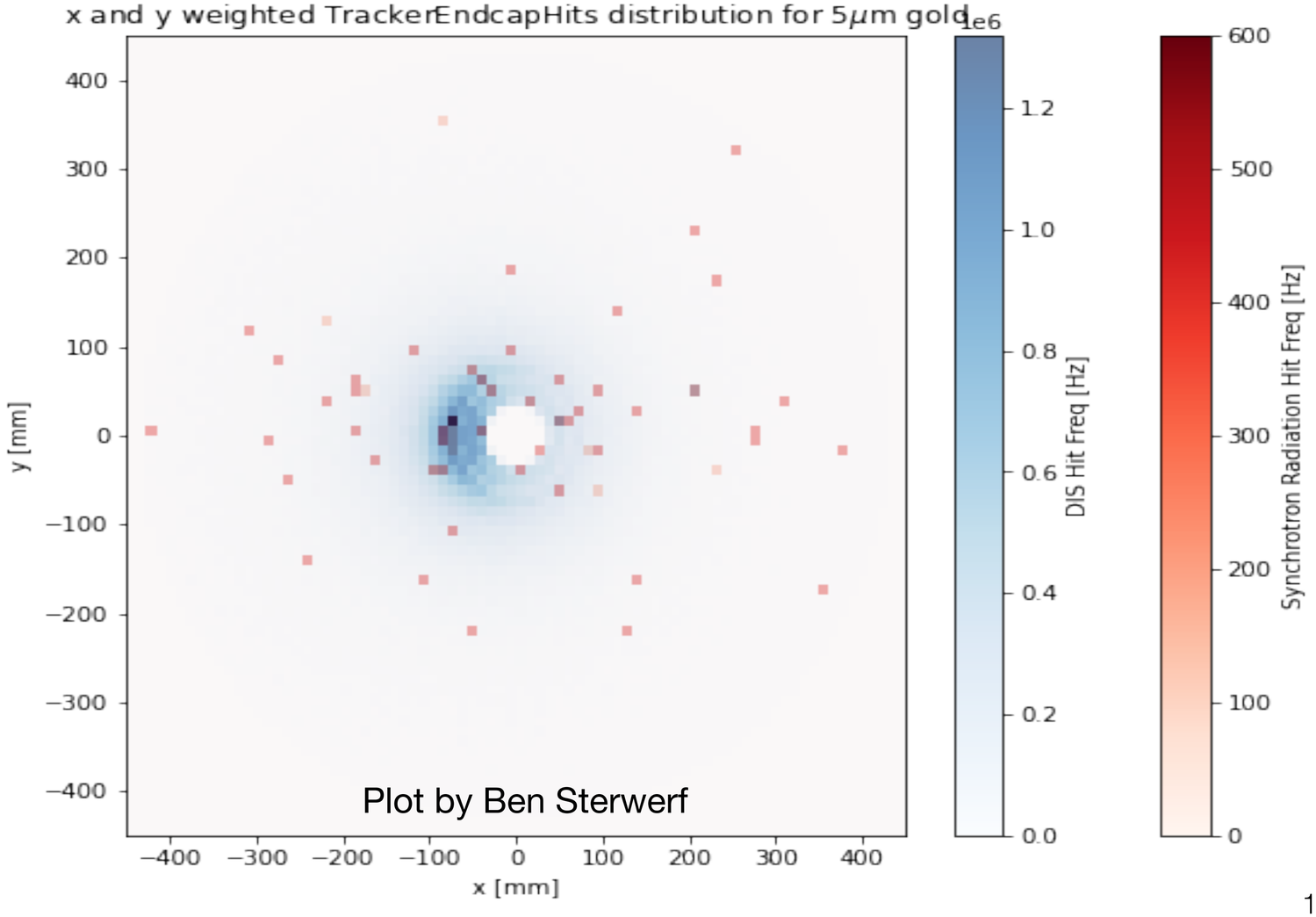
Testing background impact

Need to simulate dataset that emulates true EIC environment as precisely as possible
- mix signal and background sources
- propagate sample through GEANT simulation to assess impact on detector performances

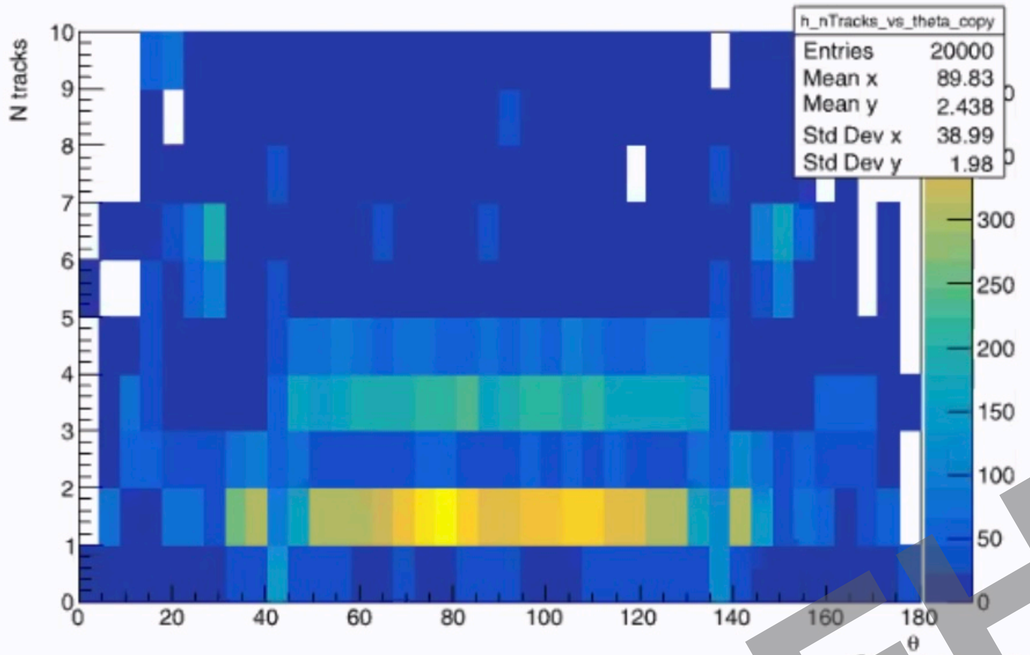
Work by Kolja Kauder, David Lawrence, et al. to implement functionality to mix

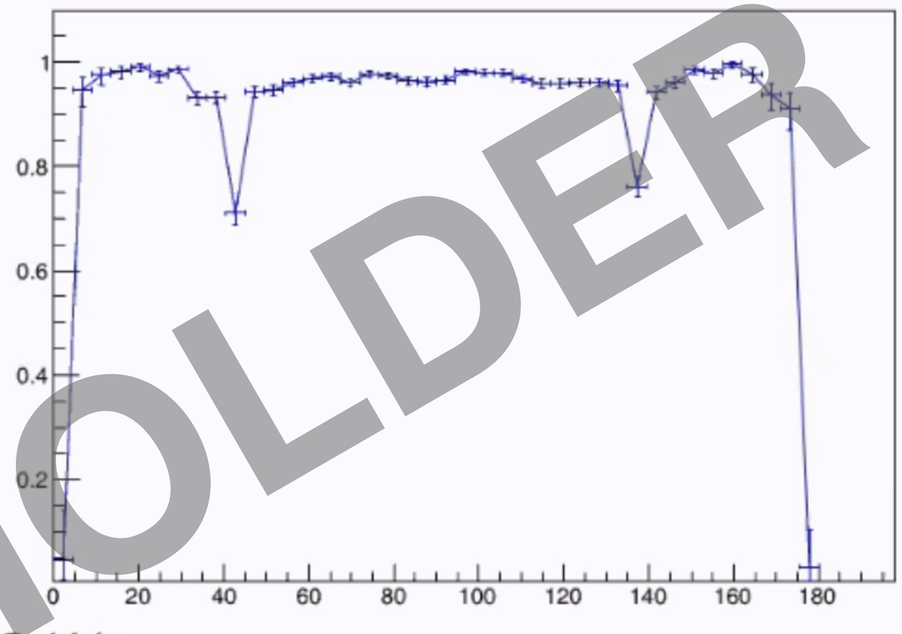
$$\text{signal} + \sum_{i=1}^{N} \text{background}_i$$

After mixing, we also need realistic measurement conditions, e.g. track reconstruction not based on truth seeding



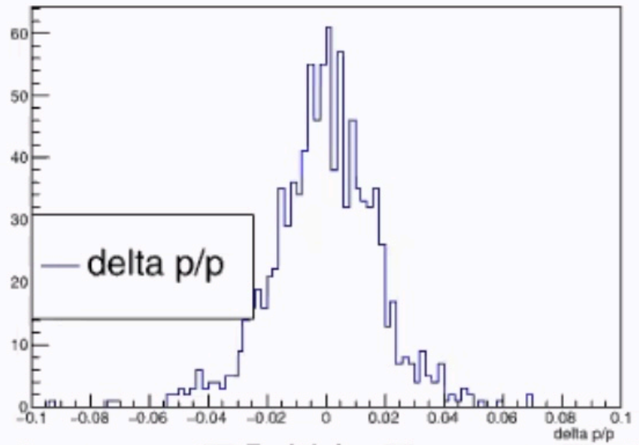
Progress on track reconstruction





$1 < p < 2$ GeV/c

- Juggler/ACTS 19.9 version, using ACTS' binned seeder
- Maximum seeds per space point middle set to 2 (minimum not yielding a poor efficiency)
- Mostly 1 seed/track, but some 3 or 4 seeds/track
- $\approx$ 2% of seeds fail due to issues with binned seeder
- Forward $\Delta p/p$ slightly deteriorated vs. truth seeding, but in the ball park



$1 < p < 2$ GeV/c, $2 < \eta < 2.5$

Summary and Conclusions

- Several background sources have been identified and studied. Recently, a background task force was formed

- Synchrotron radiation studies have been updated with newest EPIC detector version

- Other backgrounds were studied with ATHENA detector and details need to be updated

- Largest background source expected to be beam - gas interactions

- Currently working on functionality to combine backgrounds and signal

- Next step will be to study background impact on detector performance and physics, e.g. impact on track reconstruction

- Realistic track finding is underway

Thanks for your attention