



hpDIRC Hits Occupancy



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CUA



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South Carolina



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of Glasgow



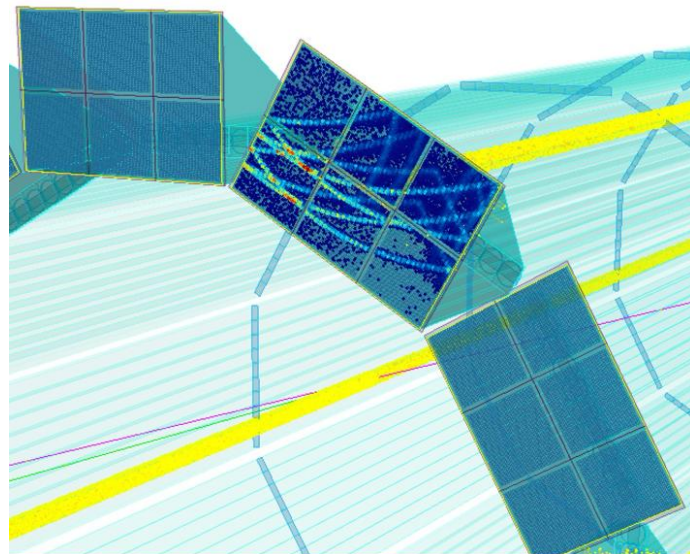
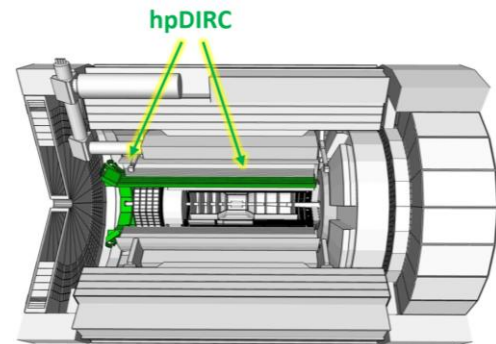
Introduction

❖ First look at the **background occupancy** in hpDIRC from **epic simulation**

❖ On-going study, **results presented are preliminary**

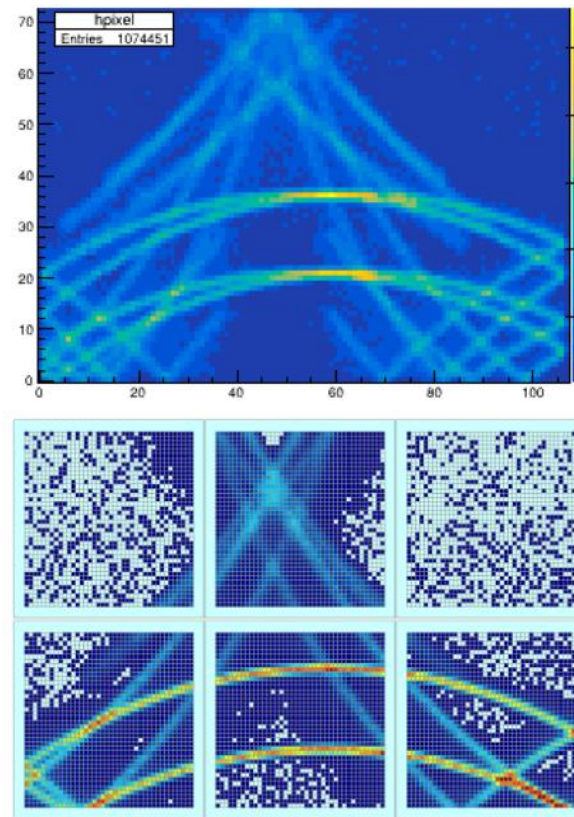
❖ **Two known limitations** that affect the results:

- Fully pixelated detector plane, no gaps or dead areas
- Results were produced before the recent software correction for the treatment of photons generated in the prism



Limitations

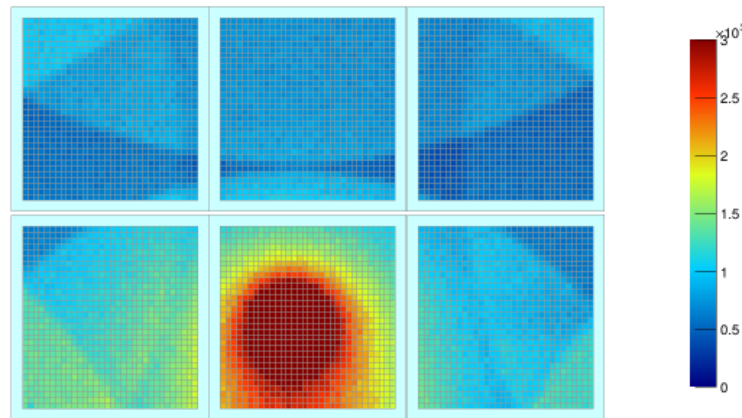
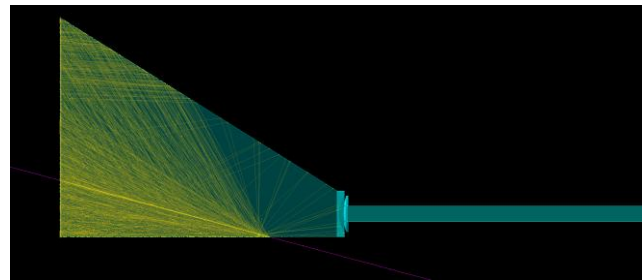
- ❖ Fully pixelated detector plane, no gaps or dead areas
 - Expect occupancy to scale down by $\sim 50\%$ for realistic HRPPD layout and photon detection efficiency
- ❖ Results were produced before the recent software correction for the treatment of photons generated in the prism
 - Current results contain artificial, rare high-multiplicity event anomalies



Results from **standalone simulation**

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Results from **standalone simulation**

Configuration

- ❖ hpDIRC config:
 - **12 readout modules**, each measuring **35.7 cm × 24.3 cm**
 - Each having **9639** pixels of **3 mm × 3 mm** size (idealized detector plane)
- ❖ Background and Signal occupancy estimated for **2 μs time-window**
- ❖ Results obtained for **18 x 275 GeV** beam energy
- ❖ Centrally produced RECO datasets used, obtained from RUCIO

RECO Datasets

❖ Background datasets include:

- `/RECO/26.03.0/epic_craterlake/BACKGROUNDS/SYNRAD/dataprod_rel_1.0.0/18x275` **Synrad**
- `/RECO/26.03.0/epic_craterlake/BACKGROUNDS/BEAMGAS/electron/coulomb/EIC_ESR_Xsuite/dataprod_rel_1.0.1/18x275/10000Ahr/MachineRuntime50s` **Electron coulomb**
- `/RECO/26.03.0/epic_craterlake/BACKGROUNDS/BEAMGAS/electron/touschek/EIC_ESR_Xsuite/dataprod_rel_1.0.1/18x275/10000Ahr/MachineRuntime50s` **Electron touschek**
- `/RECO/26.03.0/epic_craterlake/BACKGROUNDS/BEAMGAS/electron/GETaLM1.0.0-1.1/18GeV` **Electron Brem**
- `/RECO/26.03.0/epic_craterlake/BACKGROUNDS/BEAMGAS/proton/pythia8.306-1.0/275GeV` **Proton BeamGas**

❖ Physics signal datasets:

- `/RECO/26.04.1/epic_craterlake/SIDIS/pythia6-eic/1.2.0/ep_noradcor/18x275/q2_1to10`
- `/RECO/26.04.1/epic_craterlake/SIDIS/pythia6-eic/1.2.0/ep_noradcor/18x275/q2_10to100`
- `/RECO/26.04.1/epic_craterlake/SIDIS/pythia6-eic/1.2.0/ep_noradcor/18x275/q2_100to1000`
- `/RECO/26.04.1/epic_craterlake/SIDIS/pythia6-eic/1.2.0/ep_noradcor/18x275/q2_1000to100000`

Background Rates

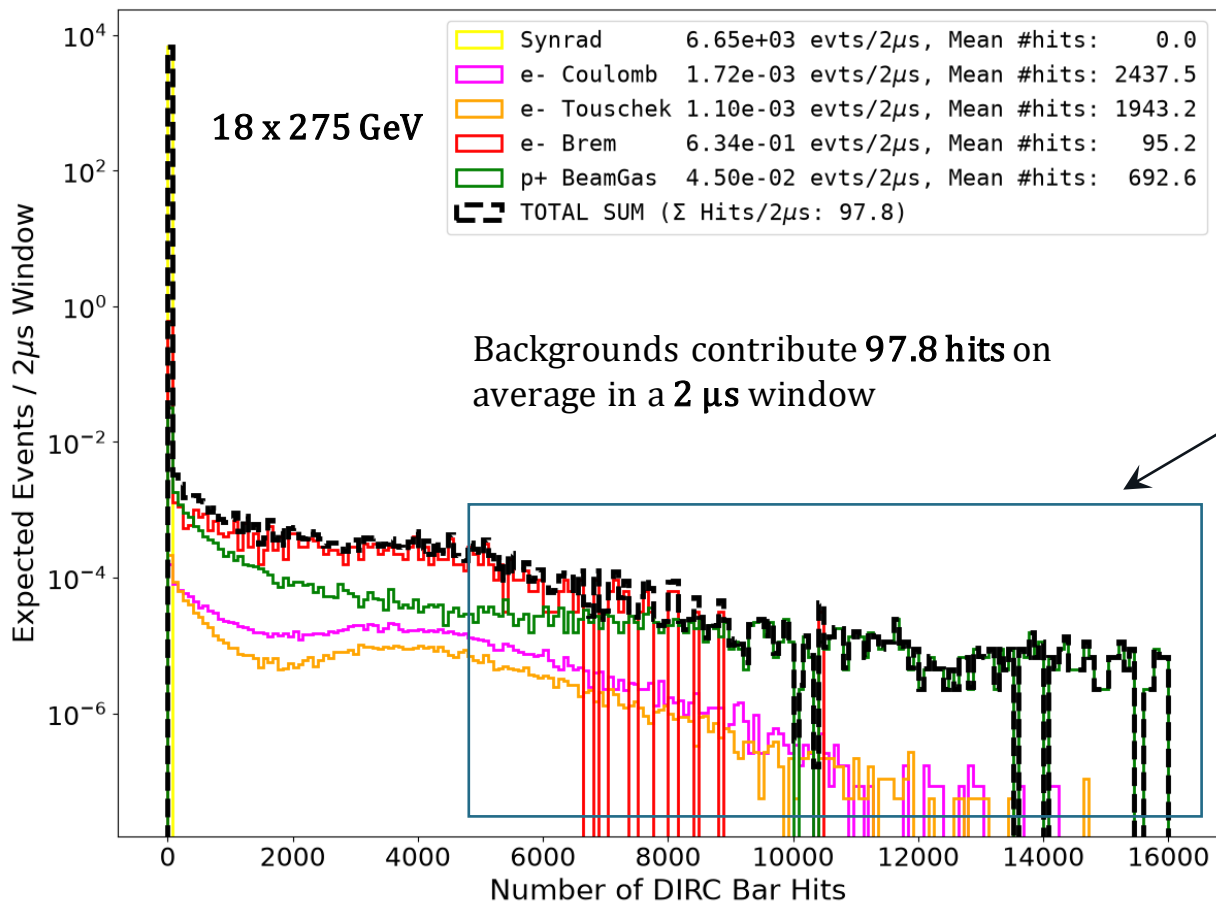
18 x 275 GeV

Background	Rate (kHz)
Synrad	3324000
Electron coulomb	0.86
Electron tousek	0.55
Electron brem	316.94
Proton beam gas	22.5

Background rates obtained from <https://wiki.bnl.gov/>

Background Rate

$$\text{Norm} = \text{Rate} \times 2 \mu\text{s} / \# \text{ sim events}$$

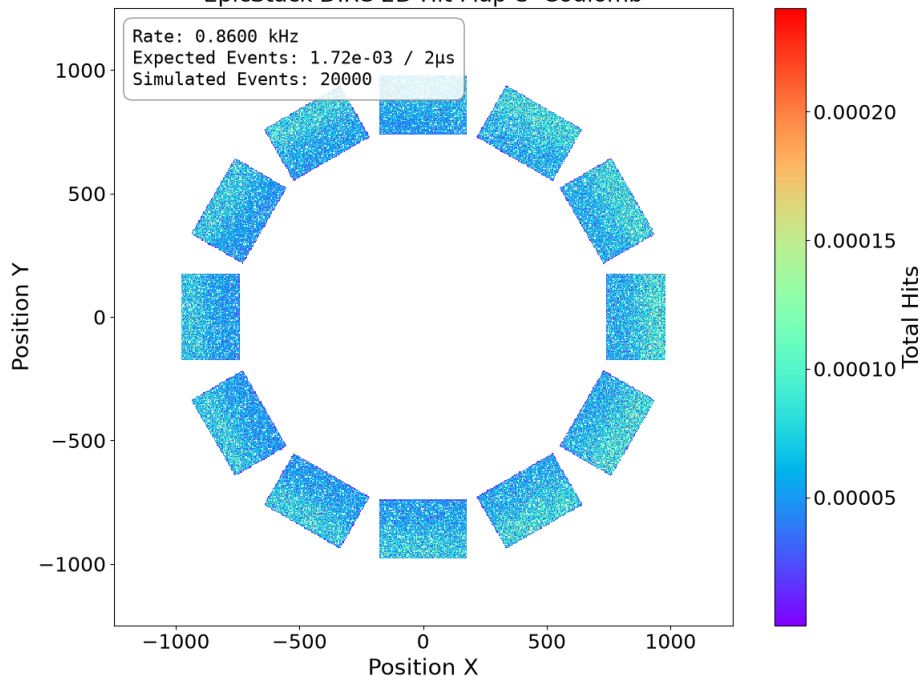


Background Hit Pattern

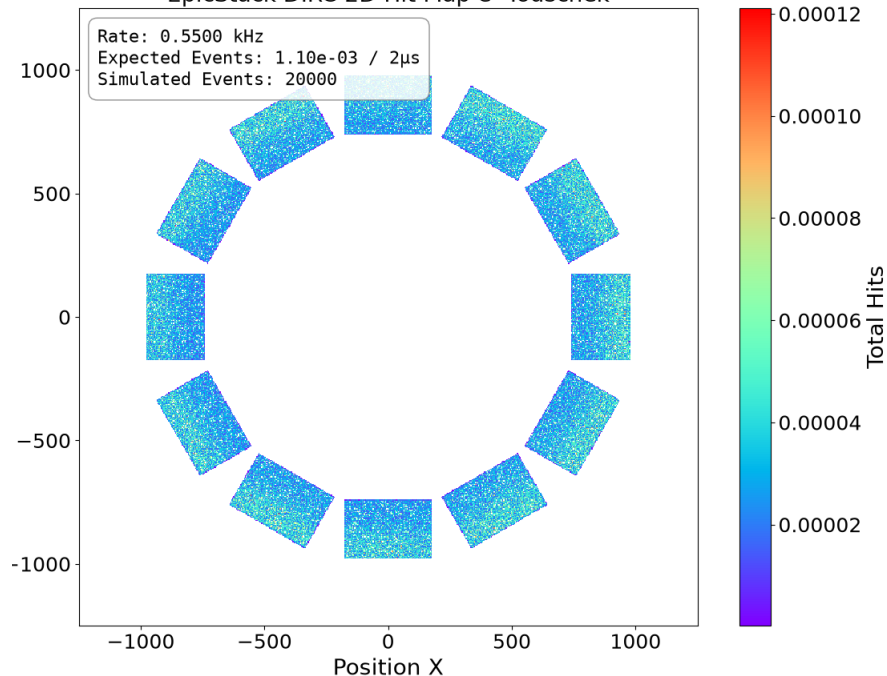
18 x 275 GeV

Z-axis normalized to 2 μ s time: Rate $\times$ 2 μ s / # sim events

EpicStack DIRC 2D Hit Map e- Coulomb



EpicStack DIRC 2D Hit Map e- Touschek



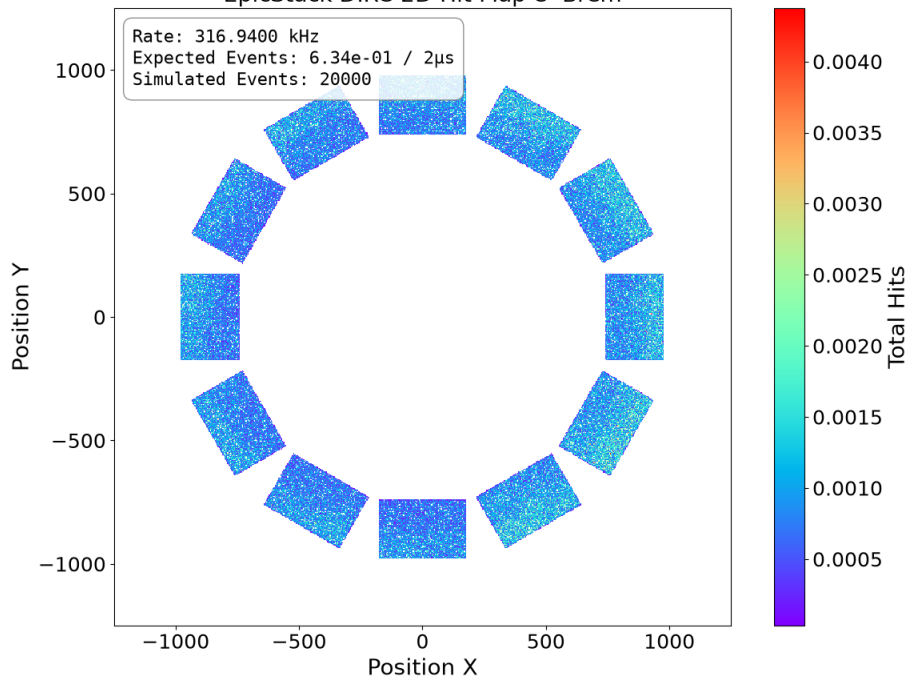
Hit pattern is **consistent across all modules**, exhibiting the same internal variations.

Background Hit Pattern

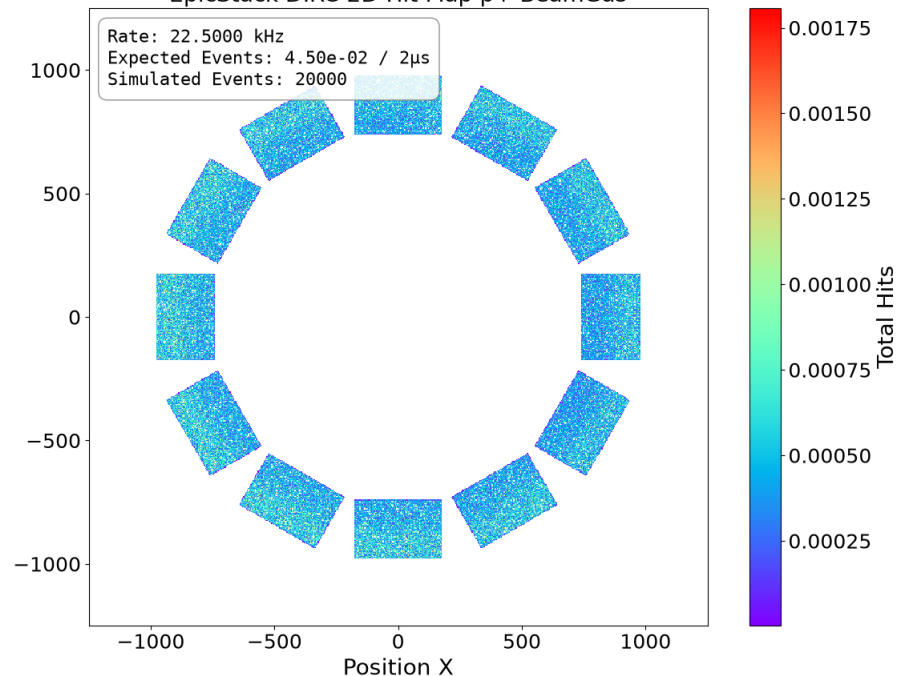
18 x 275 GeV

Z-axis normalized to 2 μ s time: Rate $\times$ 2 μ s / # sim events

EpicStack DIRC 2D Hit Map e- Brem



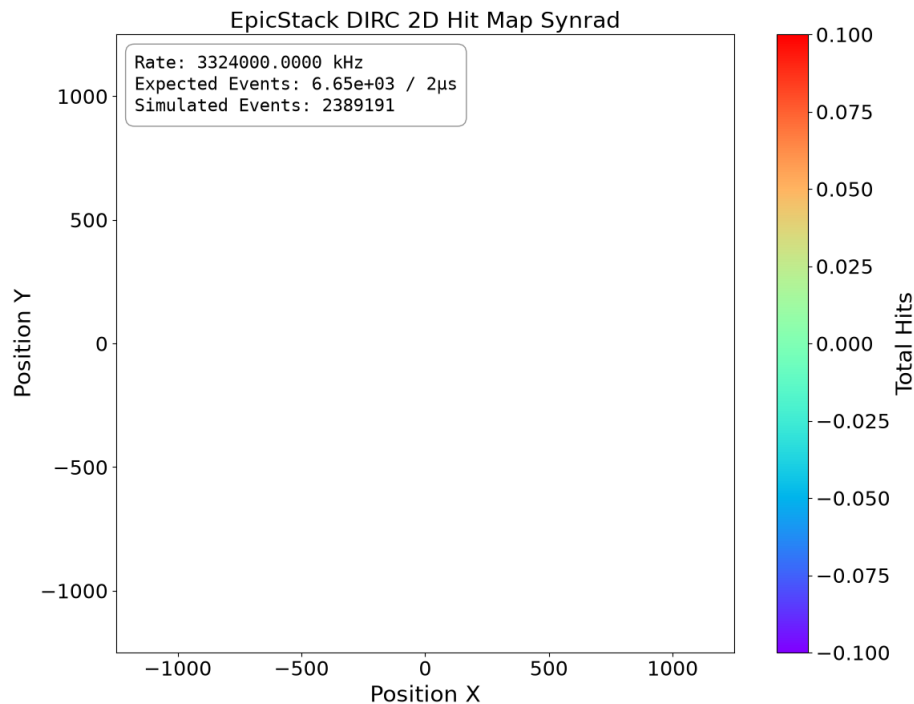
EpicStack DIRC 2D Hit Map p+ BeamGas



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Background Hit Distribution

18 x 275 GeV



Synchrotron radiation has the highest rate among all backgrounds, but it produces zero hits in hpDIRC.

Signal Rates

- ❖ The rate is calculated for an instantaneous luminosity (L) of 5.0×10^{33} as:

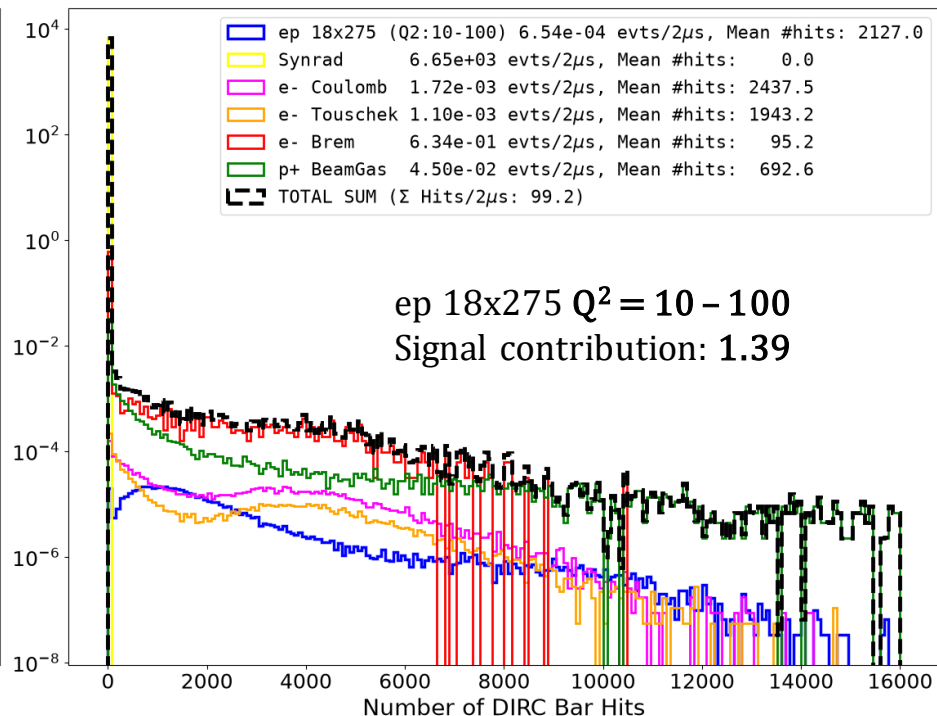
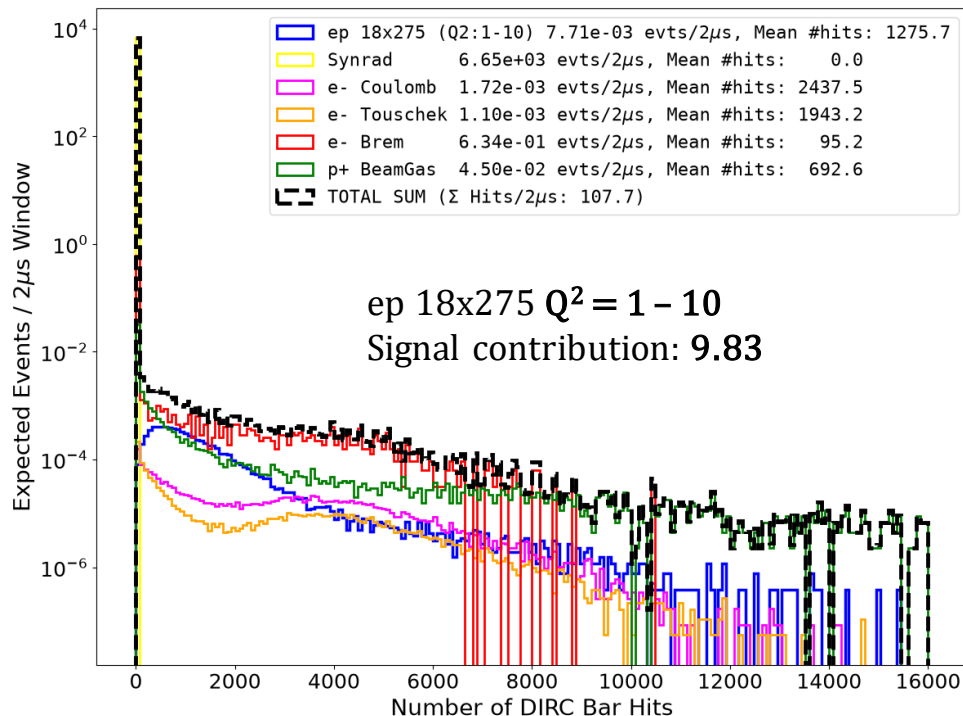
$$\text{Rate} = L \times \sigma$$

σ is the **integrated cross-section** of the signal obtained from the EVGEN/hepmc3 files

Signal	Cross-section (pb)	Rate (kHz)
SIDIS ep 18x275 $Q^2 = 1 - 10$	7.70862×10^5	3.8543
SIDIS ep 18x275 $Q^2 = 10 - 100$	6.54077×10^4	0.3270
SIDIS ep 18x275 $Q^2 = 100 - 1000$	2.61440×10^3	0.0131
SIDIS ep 18x275 $Q^2 = 1000 - 100000$	4.04528×10^1	0.0002

Signal Rates

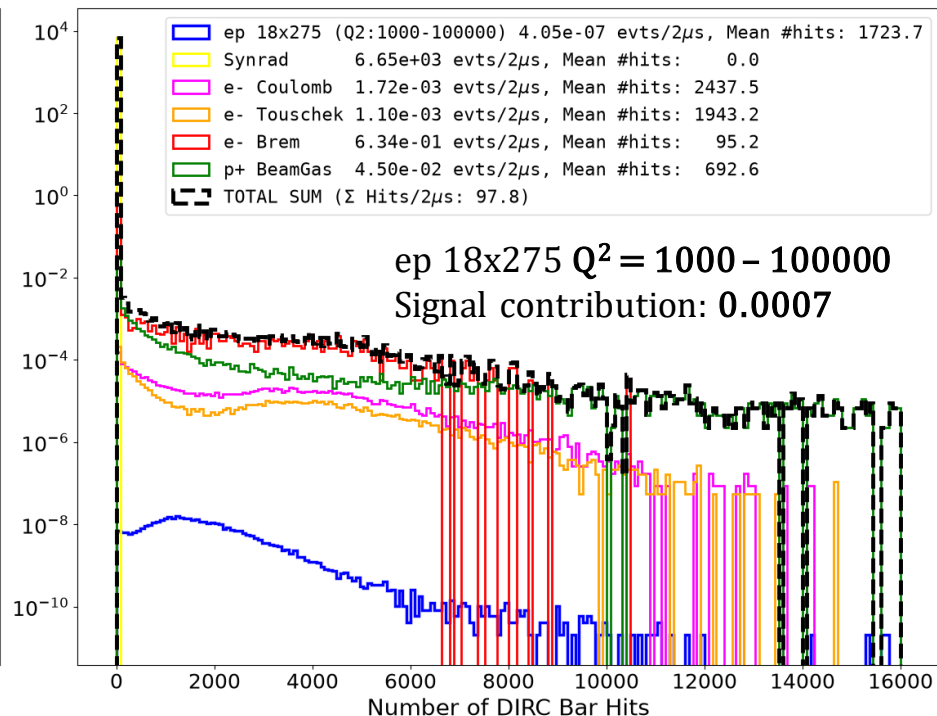
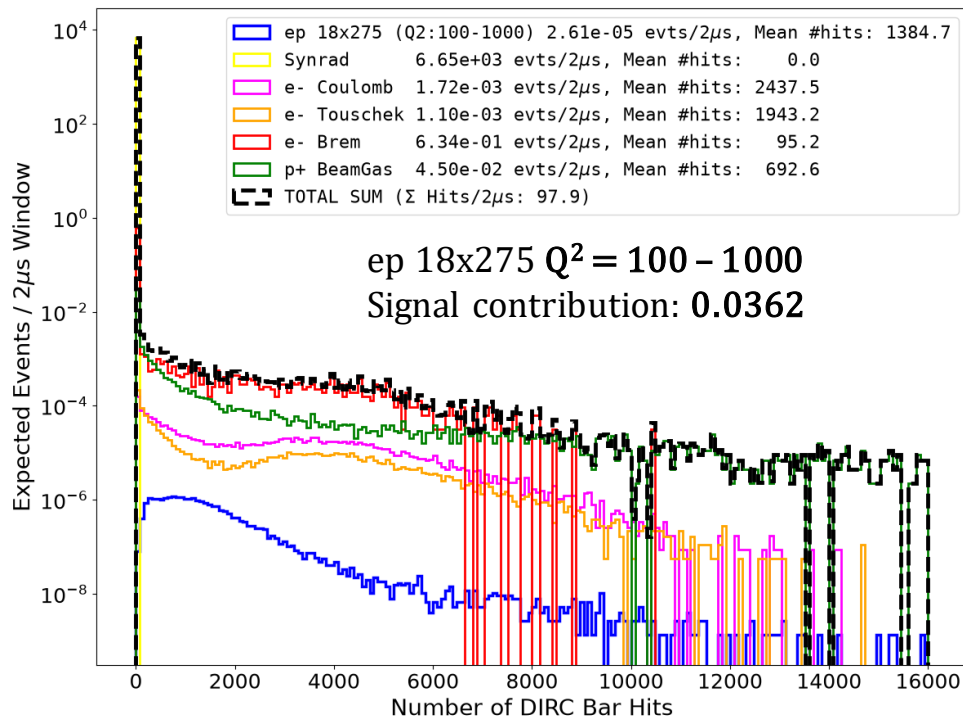
Contribution from backgrounds: **97.8 hits (mean)** in a **2 μ s** window



Norm = Rate $\times$ 2 μ s / # sim events

Signal Rates

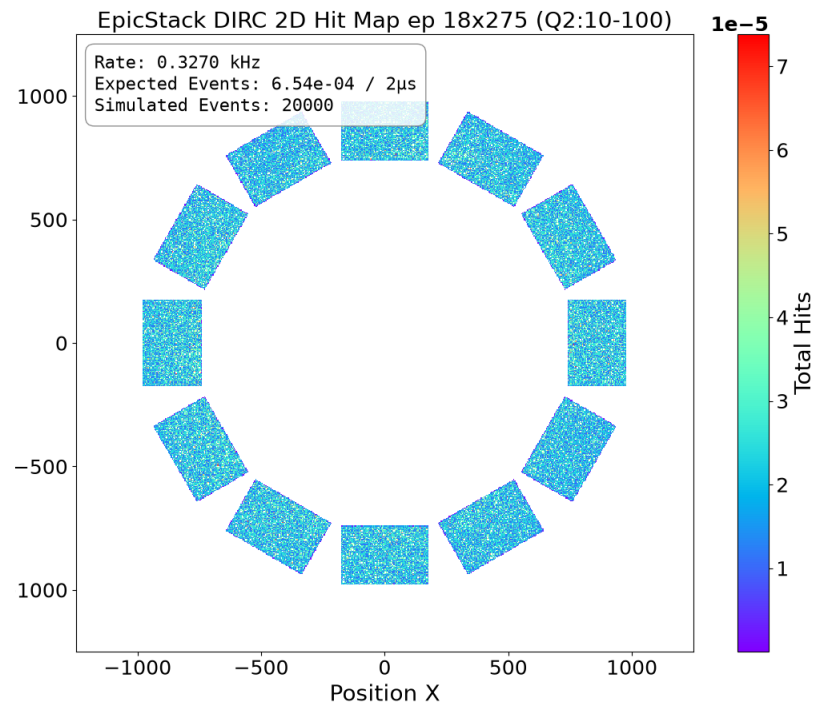
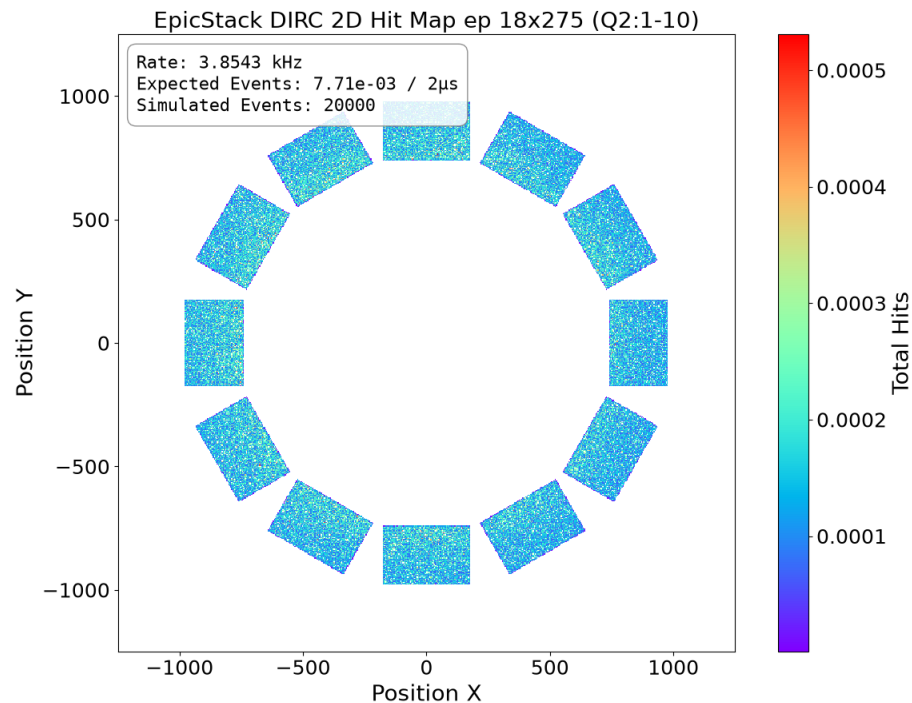
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Signal Hit Pattern

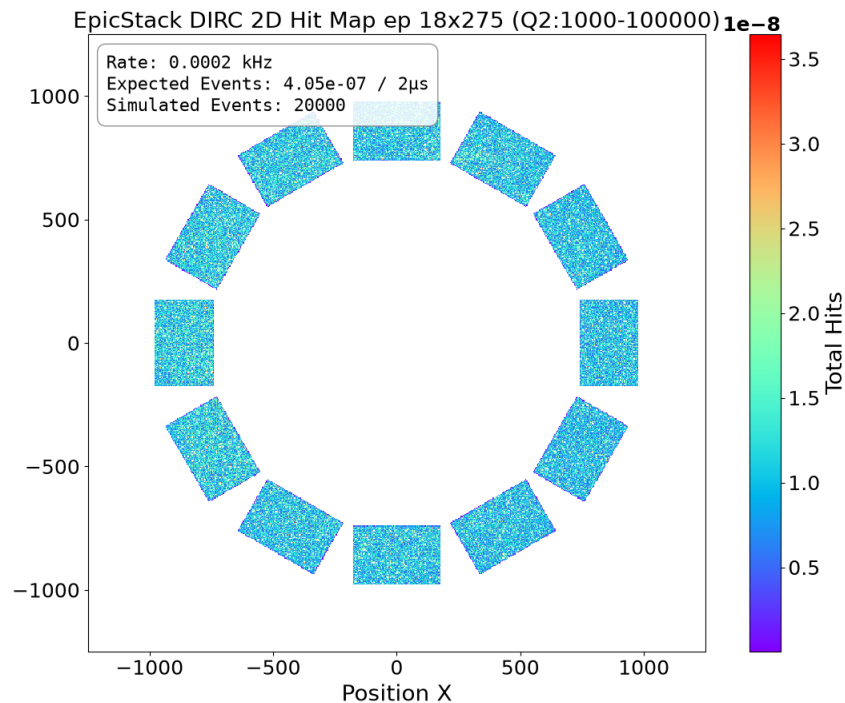
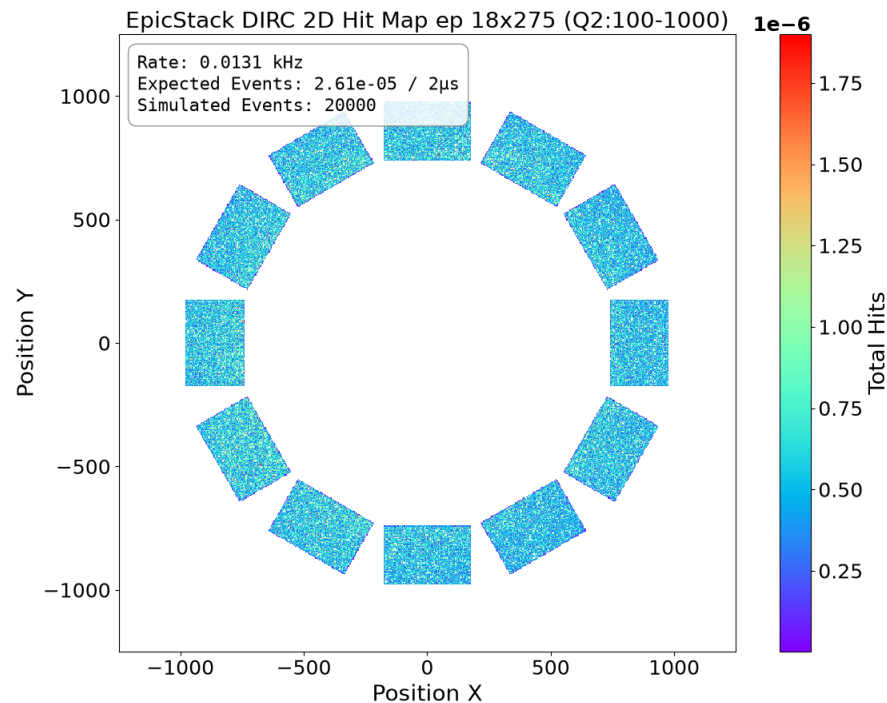
Z-axis normalized to 2 μ s time: $\text{Rate} \times 2 \mu\text{s} / \# \text{ sim events}$



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Hit pattern is **consistent across all modules**, exhibiting the same internal variations.

Mean Signal Hits

Signal	Cross-section (pb)	Rate (kHz)	Mean # Hits
SIDIS ep 18x275 $Q^2 = 1 - 10$	7.70862×10^5	316.94	9.83
SIDIS ep 18x275 $Q^2 = 10 - 100$	6.54077×10^4	0.3270	1.39
SIDIS ep 18x275 $Q^2 = 100 - 1000$	2.61440×10^3	0.0131	0.0362
SIDIS ep 18x275 $Q^2 = 1000 - 100000$	4.04528×10^1	0.0002	0.0007

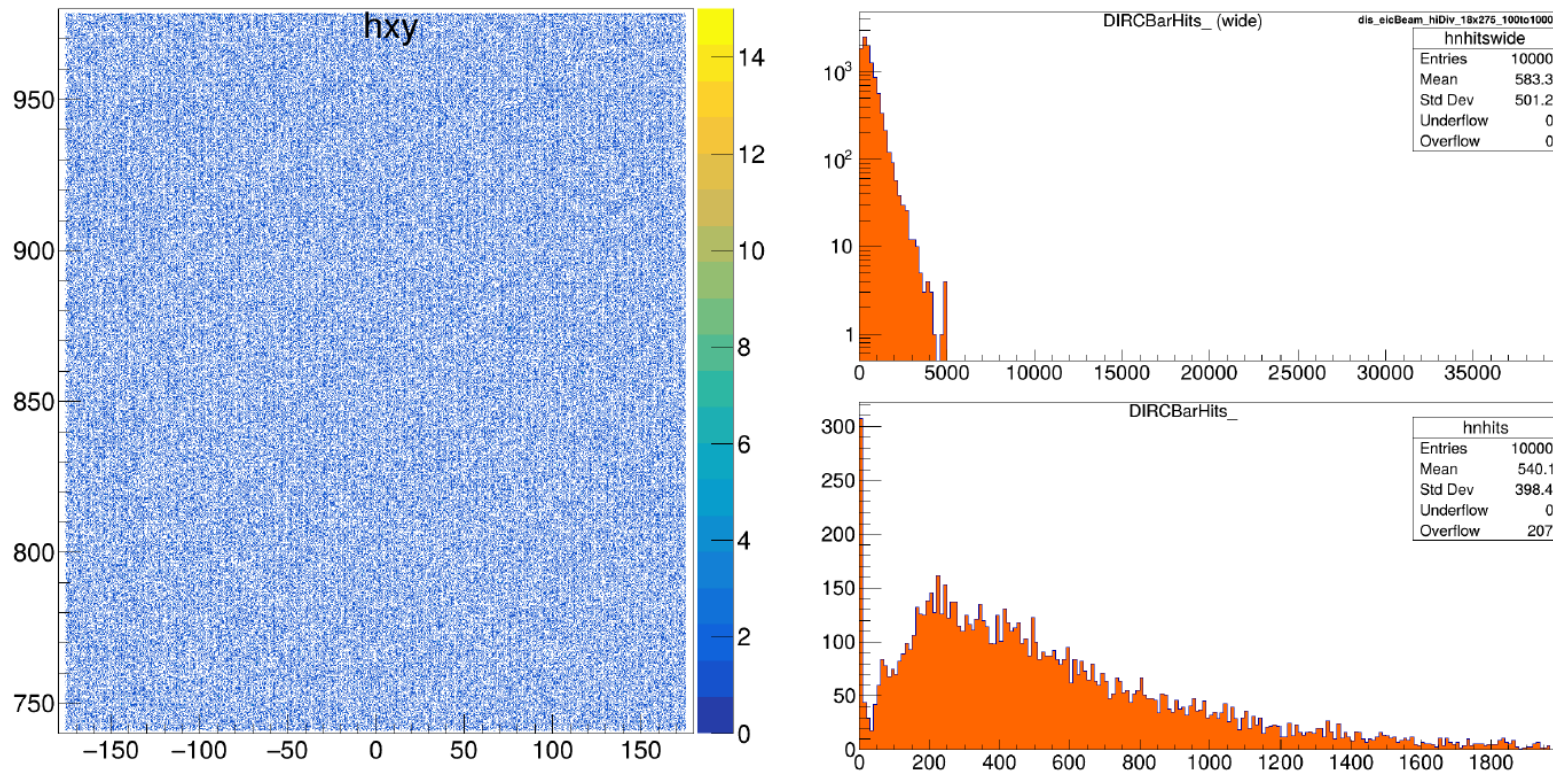
Summary

- ❖ Background occupancies are encouraging as a first estimate for the hpDIRC.
- ❖ Updated simulation will provide:
 - Realistic estimate of occupancies after including detection efficiencies and accounting for dead regions and gaps
 - Maximum hit rates per readout module
 - Revised high-occupancy event frequencies (software correction implemented)
- ❖ **Next step:** Evaluate the impact of backgrounds on hpDIRC PID performance using timing information and the full reconstruction.

BACKUP

Realistic Hit Distribution

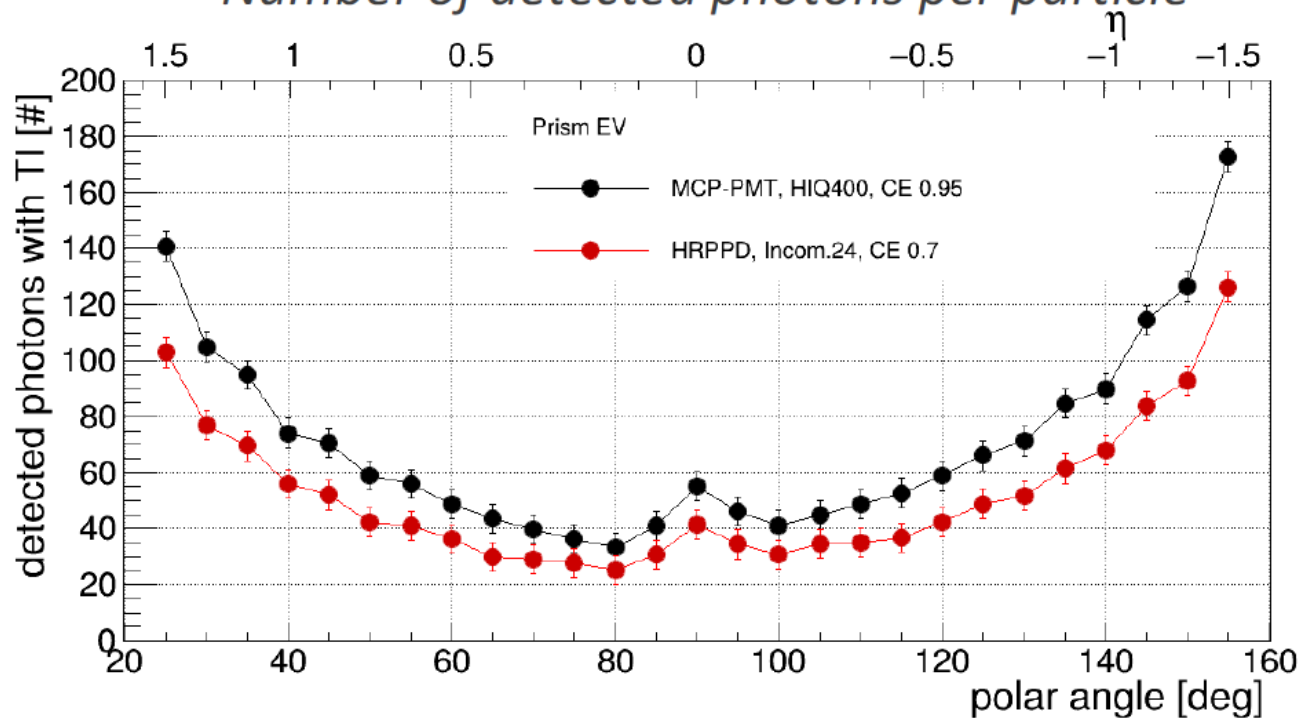
pythia8 DIS, epic, $100 < Q^2 < 1000$



Plots obtained by running npsim over DIS 18x275 hepmc3 datasets produced using pythia8

Number of Photons

Number of detected photons per particle



Results from single 6 GeV/c π /K events from standalone simulation