Background Challenges BIC - Tasks

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Tasks

How to proceed in addressing the background challenges

Answering to 3 families of questions:

a) Impact on detector performance;

b) Impact on data flow, requested bandwidth and potential dead-time;

c) radiation/fluence damages.

Using data from simulation campaigns

Using radiation maps with DIS + background

a) Impact on detector performance

DSC responsibility

- **Progressing in two steps**

1. **Make use of what is at hand**, namely the Feb. 2026 simulation campaign (10 x 100) and related simulation background (probably optimistic concerning beam-gas rates as vacuum after 10000 A-h of running is assumed)
   - Events with background (10μm gold coating on the beampipe): /volatile/eic/EPIC/RECO/26.02.0/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS/NC/10x100/minQ2=1/
   - *Events without background*: /volatile/eic/EPIC/RECO/26.02.0/epic_craterlake/DIS/NC/10x100/minQ2=1/
   - **Obtain subsystem performance**(*) from DIS + the background
   - **Compare the performance** with / without background
2. **Challenge the subsystems with increased background rates**
   - Premature to give now a recipe for the increased background: the outcome of the first step will provide suggestions

See the presentation with the charge:
https://indico.bnl.gov/event/31599/contributions/120324/attachments/68421/117639/TIC_20260223.pdf

a and b) Rates and performance

a) First look into occupancies and rates within BIC (SciFi and AstroPix)
b) Performance studies

ECals

E-resolution (CD: vs p)
efficiency (CD: vs η, p)
π/e separation (CD only: vs p)
angular resolution (CD only)

- Using subsample of scattered electrons
- Wide range energy photons (low energy performance needed)

- Will look into E/p as a first step

- AstroPix based

Start from using MCScatteredElectrons collection of electrons

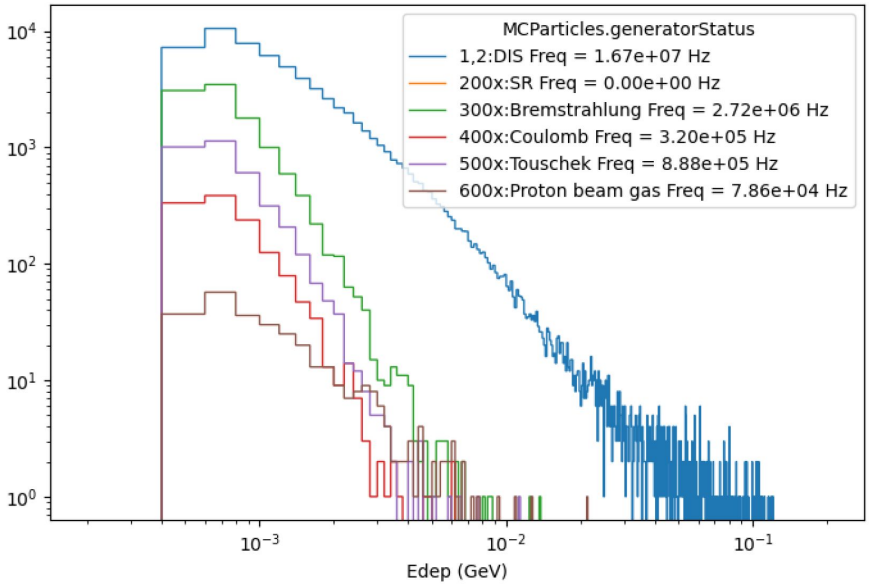
Files used in the study

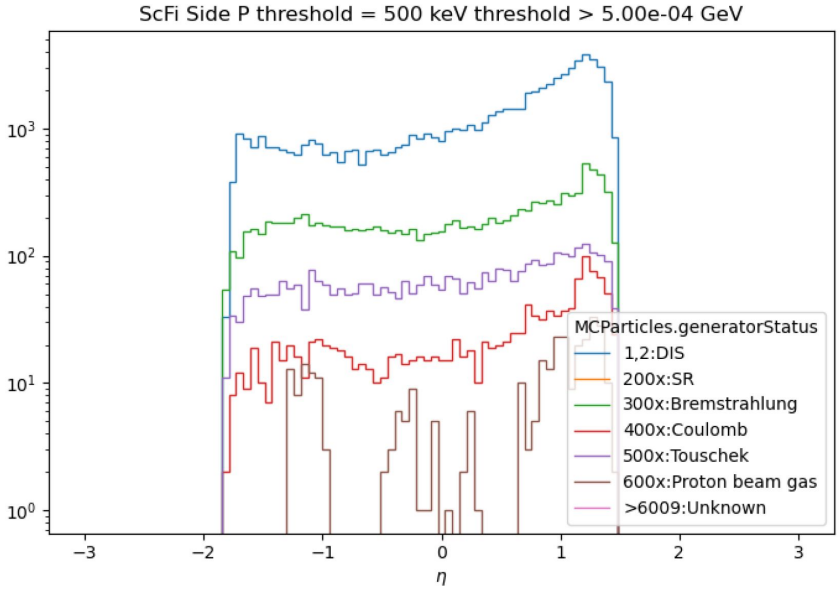
- Files used: root://dtn-eic.jlab.org//volatile/eic/EPIC/FULL/26.02.0/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS/NC/10x100/minQ2=1/
- Used 800 root files, NO events = 162400
  - Total NO background files available : 910
  - 88% total files used.
- Terminology:
  - Hottest-channel: Average rate of the hottest channel.
  - Max-ch: 100% highest number of hits in a single event.

a) Rates and occupancies

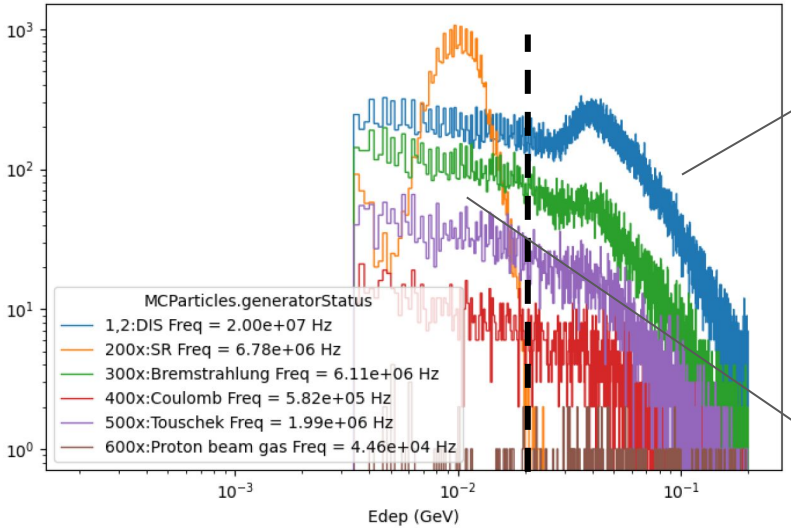
Comprehensive set of slides with occupancies attached to the indico entry

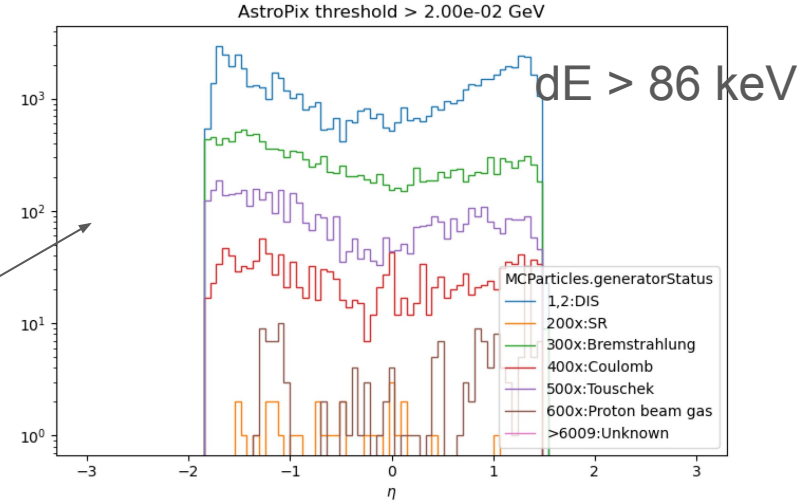
Background origin (SciFi)

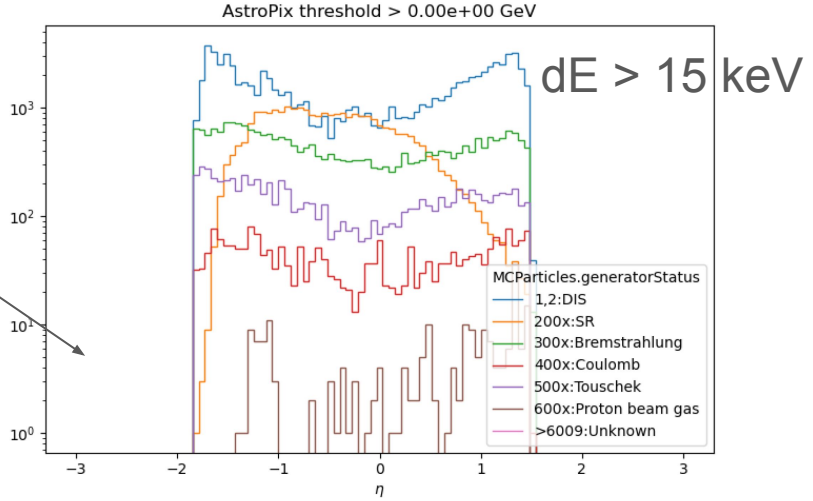




Background origin (AstroPix)

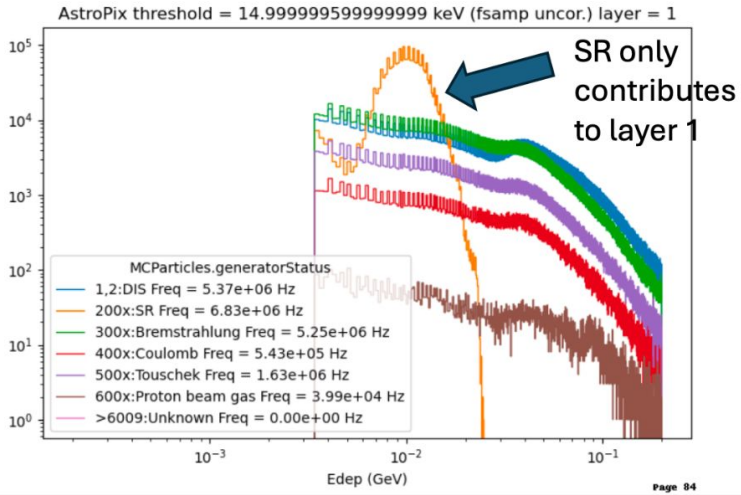


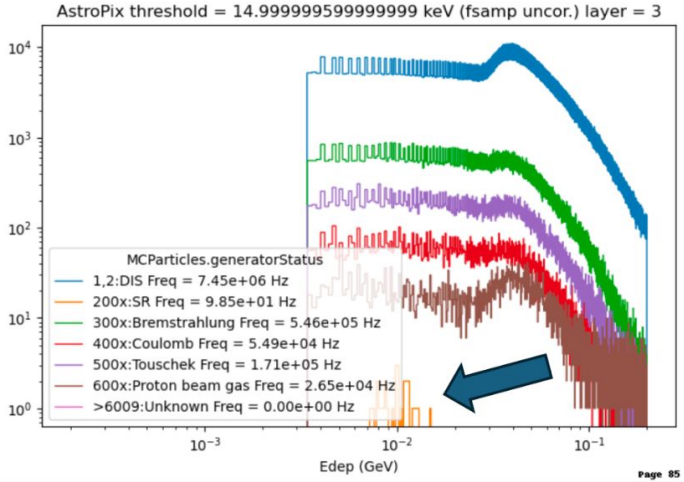




Background origin (AstroPix)

- Significant hits from SR on the first layer.
- SR are easily blocked by any material.
- Stave 1 and 6 got less hits because they are overlapped by nearby sectors.
- Can be eliminated by higher threshold on AstroPix layer 1.

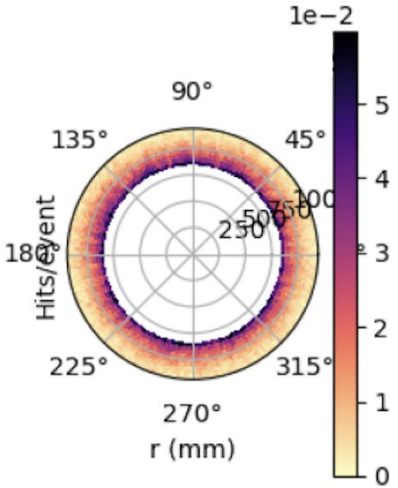




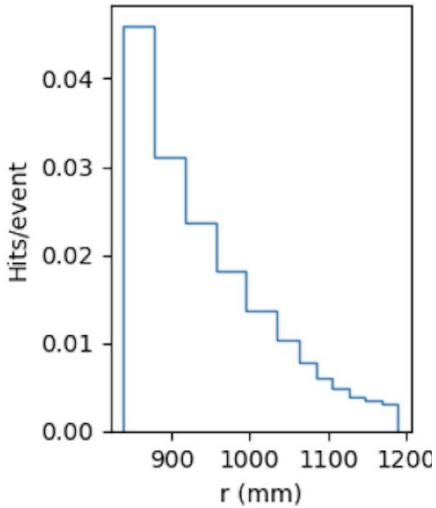
SciFi occupancies and rates

Hit = energy deposit above threshold (5 MeV) originating from a unique primary particle, electron going side presented below

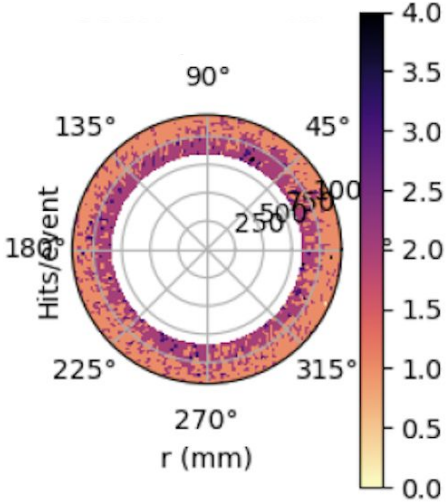
Average nb hits/event per channel



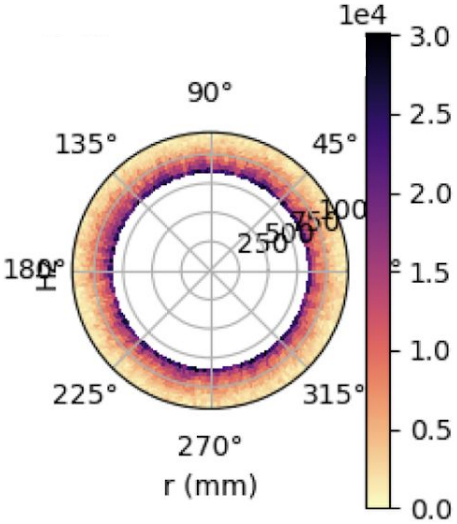
Average nb hits/event per channel



Max nb hits/event per channel

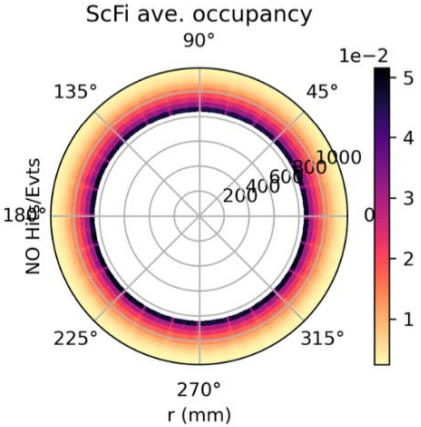


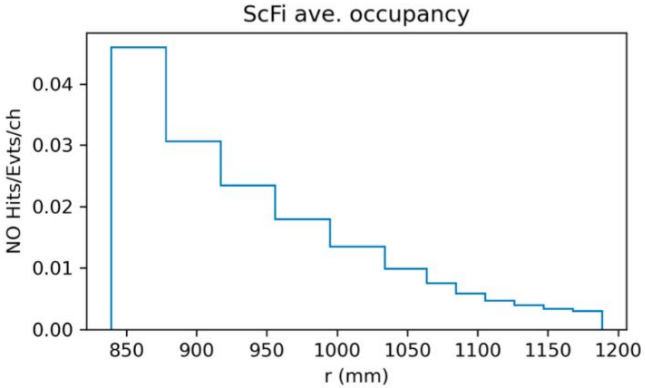
Rate per channel

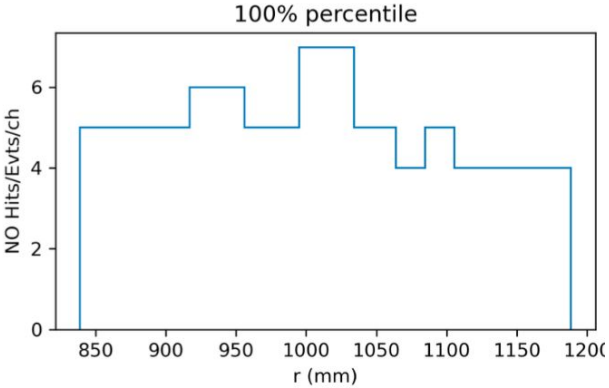


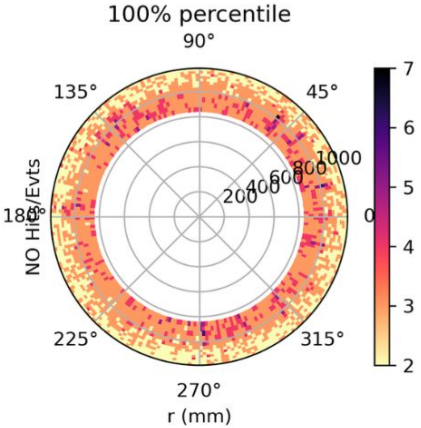
SciFi occupancies and rates

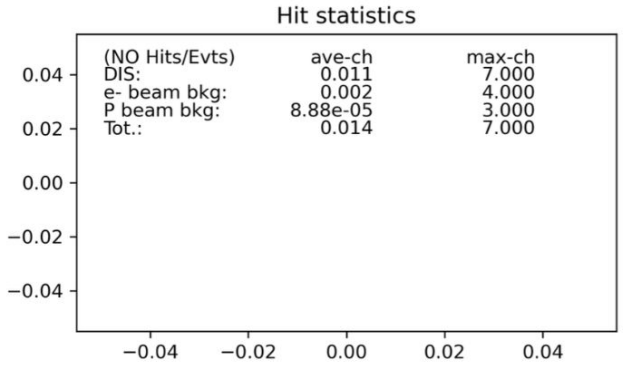
All data, +ve side, Edep > 500 keV, per channel NO Events = 162400

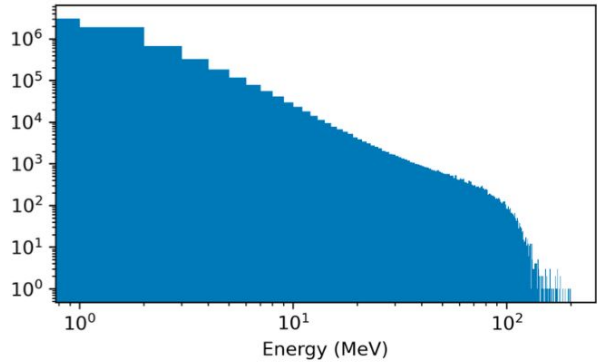








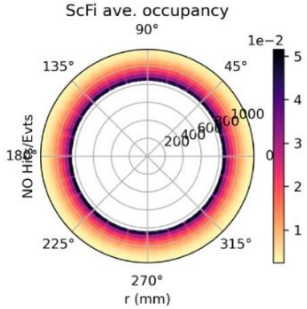


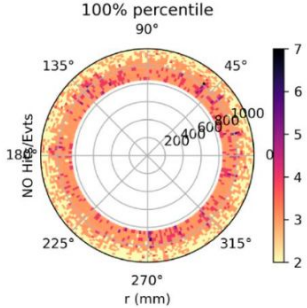


ScFi occupancy
E-Threshold = 500 keV

By channels

+z side

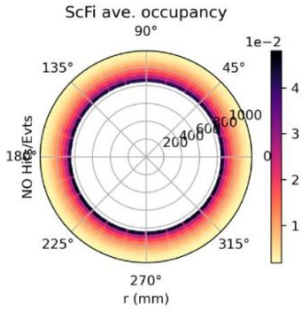


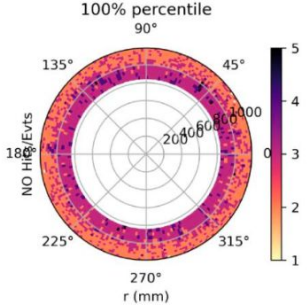


(NO Hits/Evts)	ave-ch	max-ch
DIS:	0.011	7.000
e- beam bkg:	0.002	4.000
P beam bkg:	8.88e-05	3.000
Tot.:	0.014	7.000

(Tot Hz)	all-ch	hottest-ch
DIS:	1.64e+07	1.38e+04
e- beam bkg:	3.04e+06	9.82e+03
P beam bkg:	1.28e+05	1.62e+03
Tot.:	2.04e+07	2.58e+04

-z side



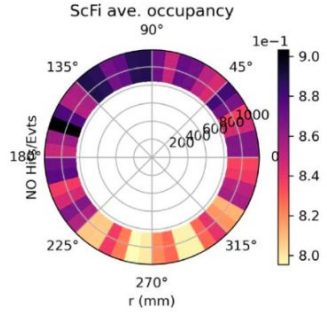


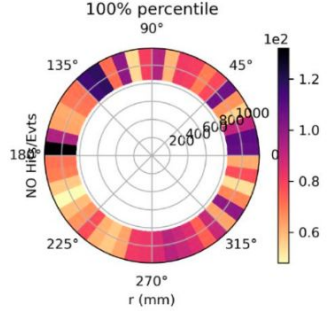
(NO Hits/Evts)	ave-ch	max-ch
DIS:	0.010	5.000
e- beam bkg:	0.002	4.000
P beam bkg:	6.90e-05	3.000
Tot.:	0.012	5.000

(Tot Hz)	all-ch	hottest-ch
DIS:	1.39e+07	1.19e+04
e- beam bkg:	2.66e+06	9.79e+03
P beam bkg:	9.93e+04	1.64e+03
Tot.:	1.74e+07	2.40e+04

By sectors

+z side

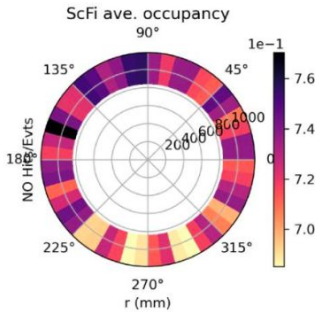


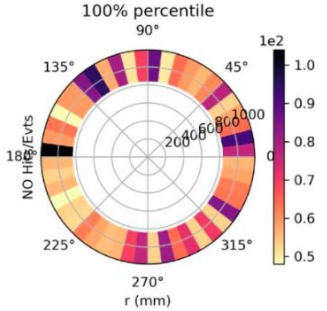


(NO Hits/Evts)	ave-sect	max-sect
DIS:	0.682	132.000
e- beam bkg:	0.127	19.000
P beam bkg:	0.005	32.000
Tot.:	0.849	132.000

(Tot Hz)	all-sect	hottest-sect
DIS:	1.64e+07	3.69e+05
e- beam bkg:	3.04e+06	7.35e+04
P beam bkg:	1.28e+05	1.42e+04
Tot.:	2.04e+07	4.52e+05

-z side





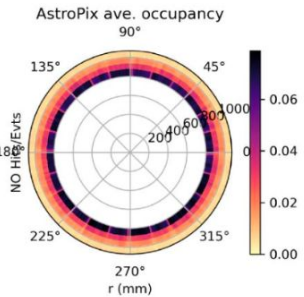
(NO Hits/Evts)	ave-sect	max-sect
DIS:	0.578	104.000
e- beam bkg:	0.111	20.000
P beam bkg:	0.004	31.000
Tot.:	0.725	104.000

(Tot Hz)	all-sect	hottest-sect
DIS:	1.39e+07	3.11e+05
e- beam bkg:	2.66e+06	6.52e+04
P beam bkg:	9.93e+04	1.37e+04
Tot.:	1.74e+07	3.85e+05

AstroPix E-Threshold = 15 keV

By chips by 12 modules

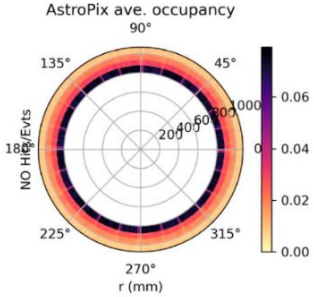
Module <=11



(NO Hits/Evts)	ave-sect	max-sect
DIS:	0.016	153.000
e- beam bkg:	0.012	42.000
P beam bkg:	4.59e-05	18.000
Tot.:	0.029	153.000

(Hz)	all-sect	hottest-sect
DIS:	9.40e+06	3.17e+04
e- beam bkg:	7.19e+06	5.14e+04
P beam bkg:	2.74e+04	1.48e+03
Tot.:	1.76e+07	7.23e+04

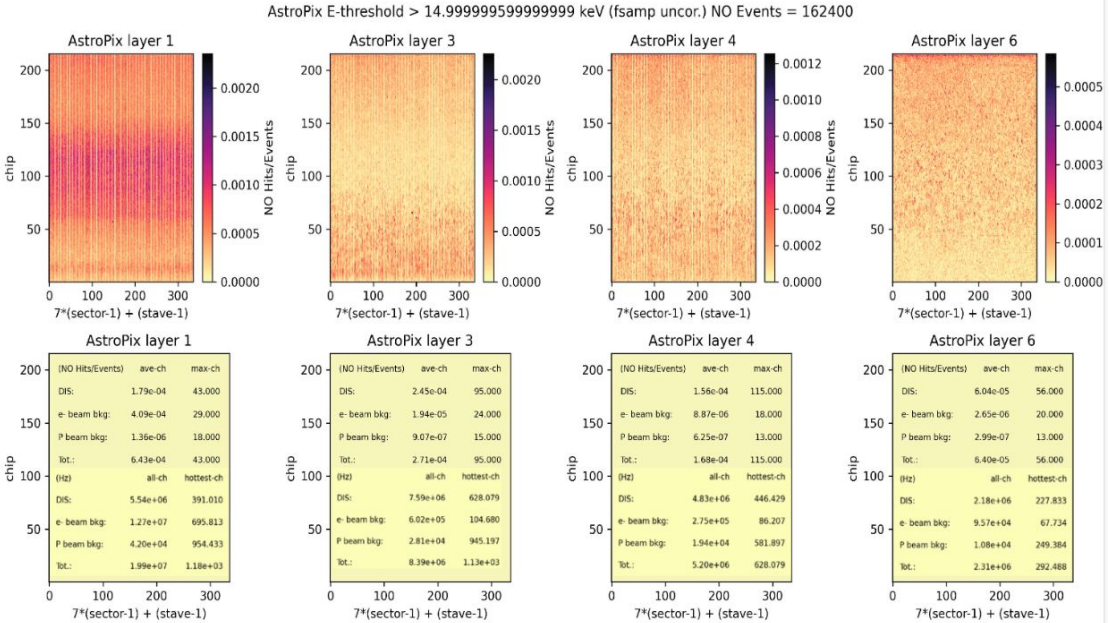
Module >11



(NO Hits/Evts)	ave-sect	max-sect
DIS:	0.018	183.000
e- beam bkg:	0.011	35.000
P beam bkg:	1.22e-04	41.000
Tot.:	0.031	183.000

(Hz)	all-sect	hottest-sect
DIS:	1.08e+07	2.49e+04
e- beam bkg:	6.48e+06	4.37e+04
P beam bkg:	7.28e+04	1.47e+03
Tot.:	1.83e+07	7.38e+04

By chips by sector-stave



(NO Hits/Events)	ave-ch	max-ch
DIS:	1.79e-04	43.000
e- beam bkg:	4.09e-04	29.000
P beam bkg:	1.36e-06	18.000
Tot.:	6.43e-04	43.000
(Hz)	all-ch	hottest-ch
DIS:	5.54e+06	391.010
e- beam bkg:	1.27e+07	695.813
P beam bkg:	4.20e+04	954.433
Tot.:	1.99e+07	1.18e+03

(NO Hits/Events)	ave-ch	max-ch
DIS:	2.45e-04	95.000
e- beam bkg:	1.94e-05	24.000
P beam bkg:	9.07e-07	15.000
Tot.:	2.71e-04	95.000
(Hz)	all-ch	hottest-ch
DIS:	7.59e+06	628.079
e- beam bkg:	6.02e+05	104.680
P beam bkg:	2.81e+04	945.197
Tot.:	8.39e+06	1.13e+03

(NO Hits/Events)	ave-ch	max-ch
DIS:	1.56e-04	115.000
e- beam bkg:	8.87e-06	18.000
P beam bkg:	6.25e-07	13.000
Tot.:	1.68e-04	115.000
(Hz)	all-ch	hottest-ch
DIS:	4.83e+06	446.429
e- beam bkg:	2.75e+05	86.207
P beam bkg:	1.94e+04	581.897
Tot.:	5.20e+06	628.079

(NO Hits/Events)	ave-ch	max-ch
DIS:	6.04e-05	56.000
e- beam bkg:	2.65e-06	20.000
P beam bkg:	2.99e-07	13.000
Tot.:	6.40e-05	56.000
(Hz)	all-ch	hottest-ch
DIS:	2.18e+06	227.833
e- beam bkg:	9.57e+04	67.734
P beam bkg:	1.08e+04	249.384
Tot.:	2.31e+06	292.488

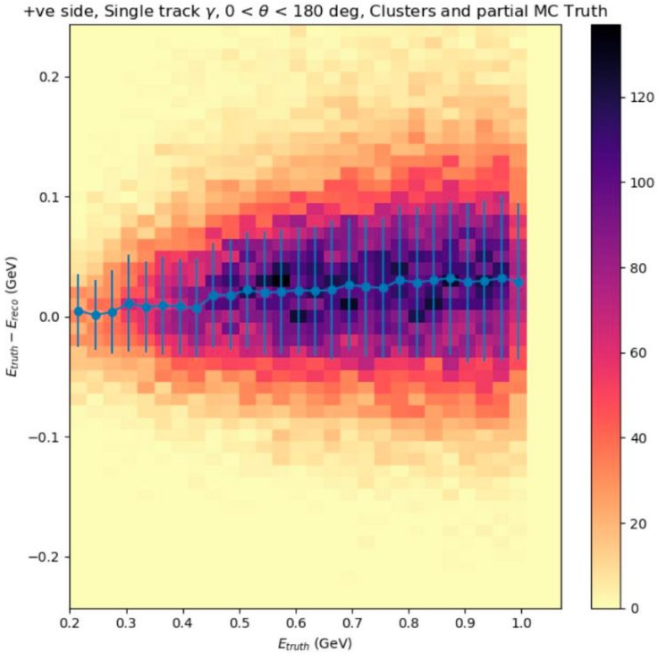
Occupancy summary

	DIS	Electron beam background	Proton Beam Background	All Sources	
ScFi/Pb layers					
Hottest Channel Avg	13.80	9.82	1.64	25.80	kHz
Channel Avg	5.26	0.99	0.04	6.56	kHz
Total	30.30	5.70	0.23	37.80	MHz
Imaging Layers (E > 15 keV)					
Hottest Channel Avg	0.63	0.70	0.95	1.18	kHz
Channel Avg	159.37	109.79	0.79	285.09	Hz
Total	20.14	13.67	0.10	35.80	MHz

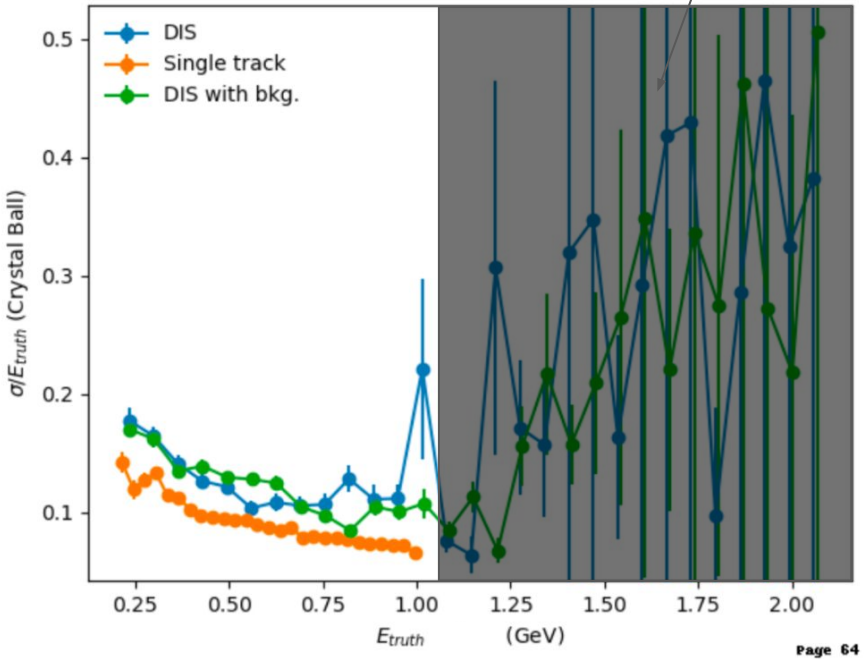
b) Performance

1. Take attenuated hits.
2. Perform attenuated correction with true-z **smeared with gaussian random number**.
   - Only take data from +ve z side of SiPM
3. NPE -> energy by linear fit.
4. Feed the corrected hits to cluster algorithm
   - EcalBarrelScFiRecHits -> EcalBarrelScFiProtoClusters -> EcalBarrelScFiClustersWithoutShapes
5. Use existing truth association
6. Draw Ereco vs Etruth for energy resolution

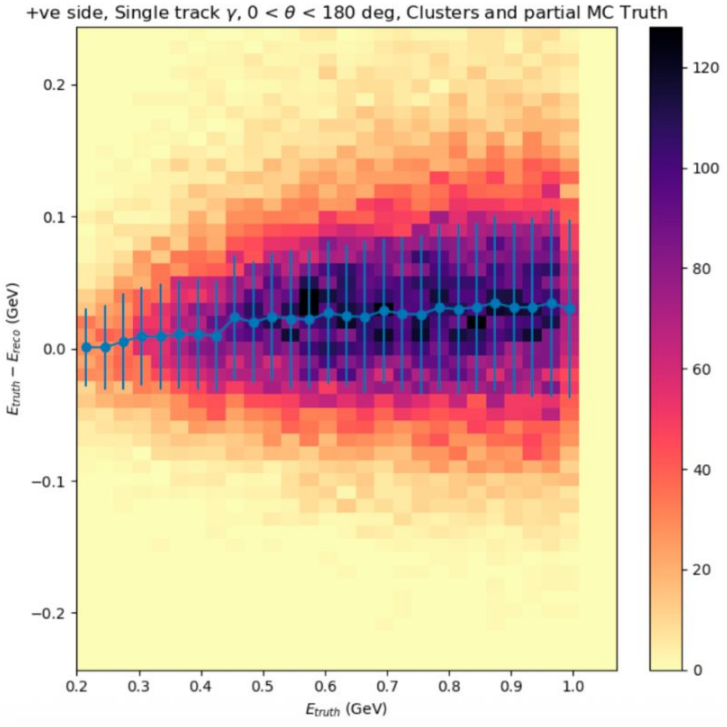
Plotted Etruth – Ereco for resolution
Assumed perfect z-resolution



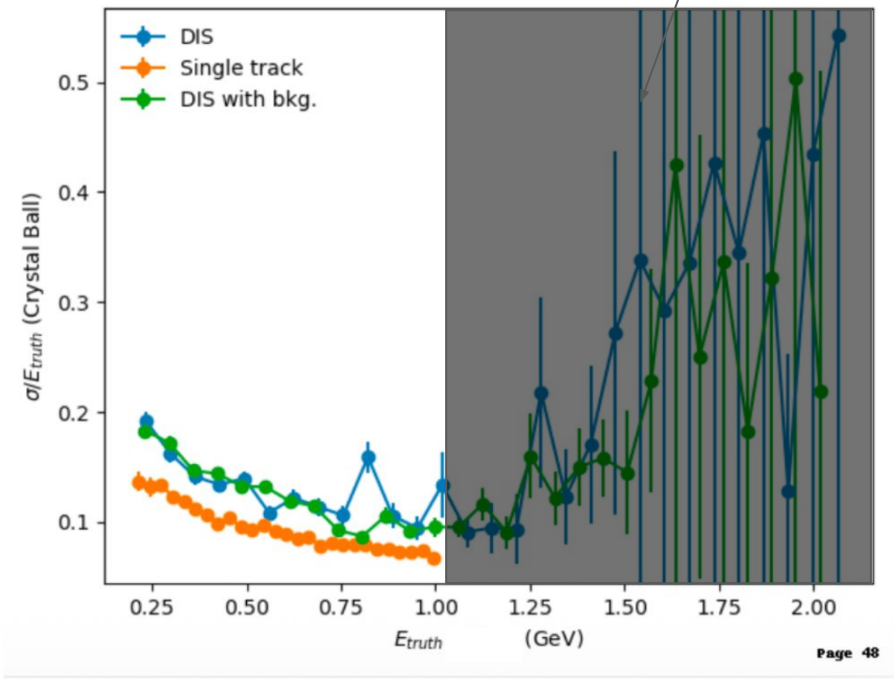
Statistics



Plotted Etruth – Ereco for resolution
Assumed z-resolution = 40 mm



Statistics

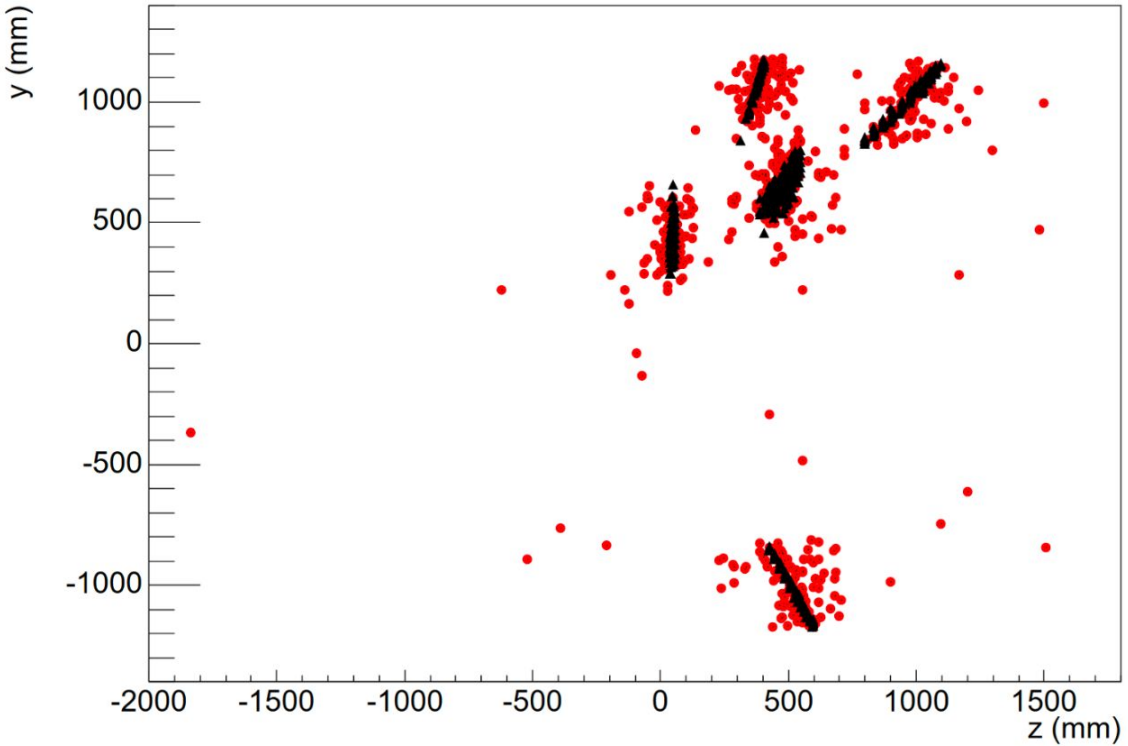


Matching and position resolution

Algorithms

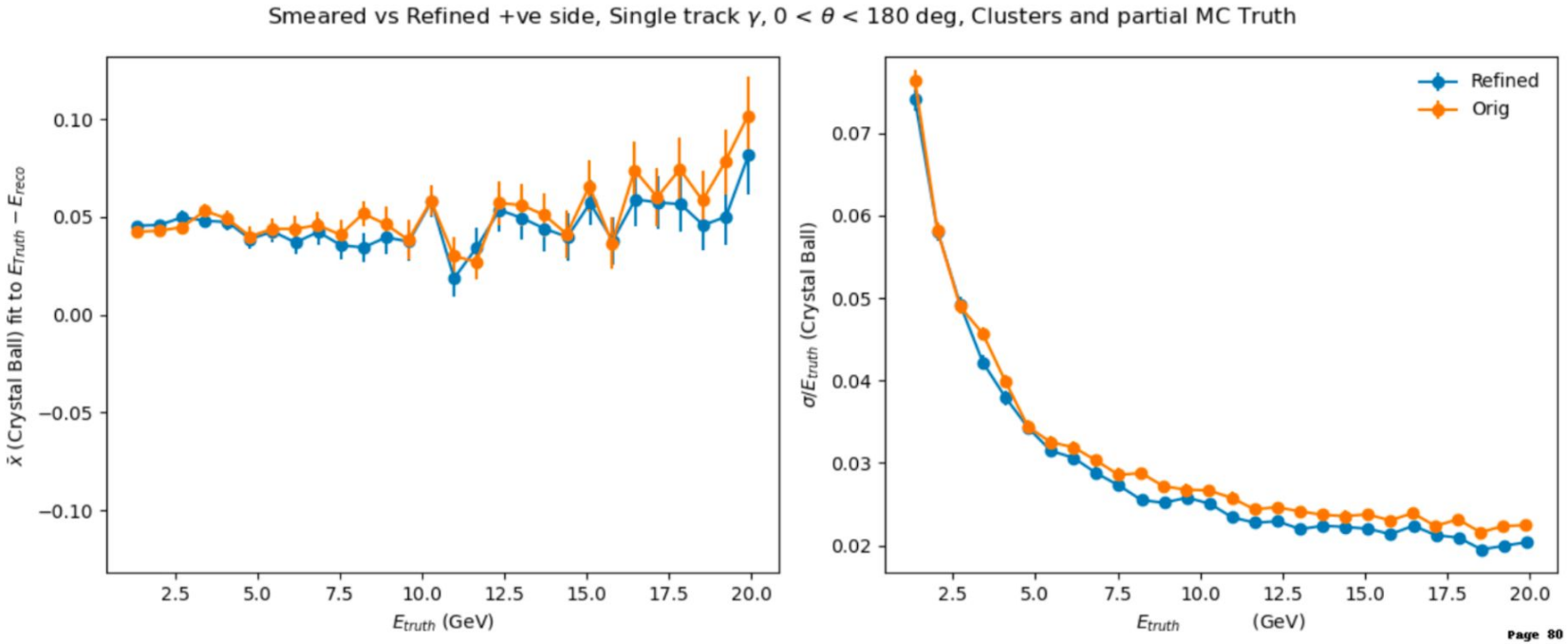
- If there are >= 2 AstroPix hits:
  - Fit a straight line between all AstroPix points.
  - Find the closest point between the straight line and ScFi fiber.
  - Re-calculate attenuation with Z-location from that point.
- If there is only one AstroPix hits:
  - Use shape information from ScFi cluster.
  - Extrapolate AstroPix points with ScFi shape.

Hit position



- Red: z-pos with 100 mm smearing.
- Black: Refined ScFi cluster with AstroPix position.

Energy resolution
z-pos smeared by 100 mm.



c) Radiation/Fluence Damage

New Radiation Doses Files Evaluated - Similar doses to used in the reports below
Wiki page: https://wiki.bnl.gov/EPIC/index.php?title=Radiation_Doses

BIC SiPM performance under irradiation and expected rates:

- https://indico.bnl.gov/event/28900/contributions/110045/attachments/63299/108667/2025-06-4-BIC-SiPMs.pdf
- https://indico.bnl.gov/event/29267/contributions/111742/attachments/63968/109892/2025-08-13-BIC-SiPMs.pdf