Synchrotron Radiation Studies - Update

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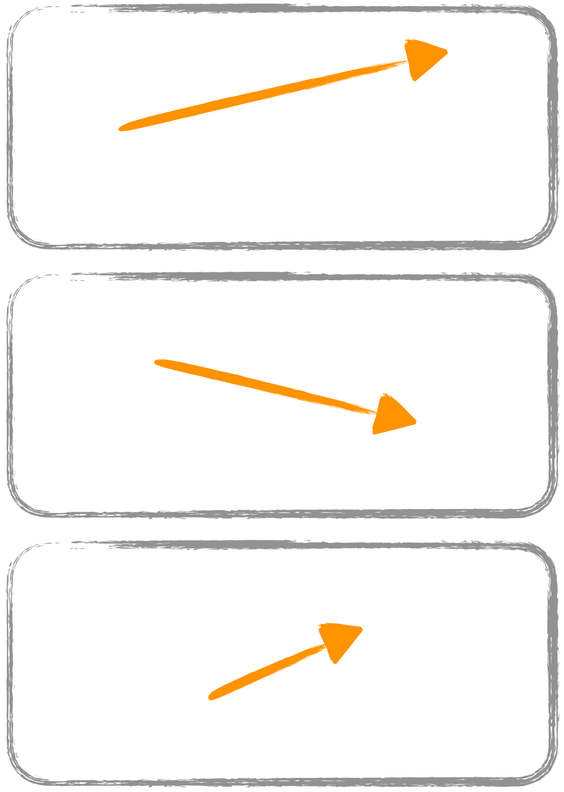
Background Meeting
12/02/2022

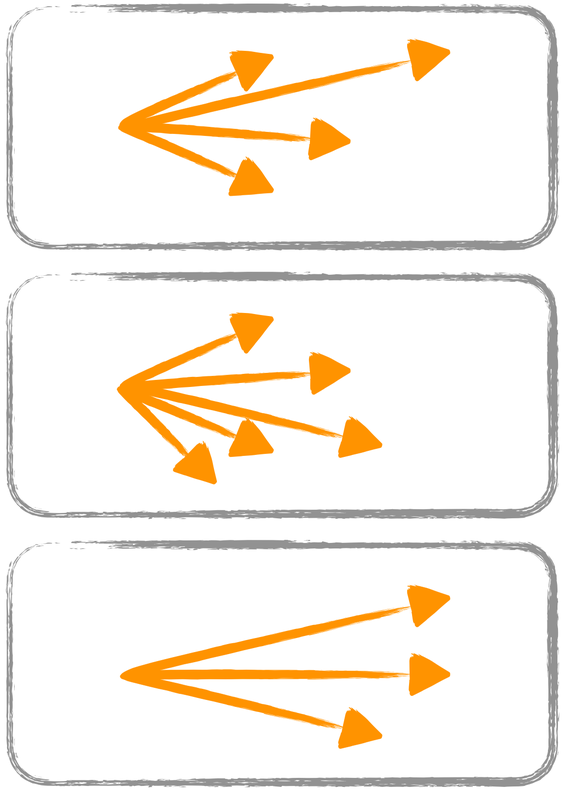
Recap

Have



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

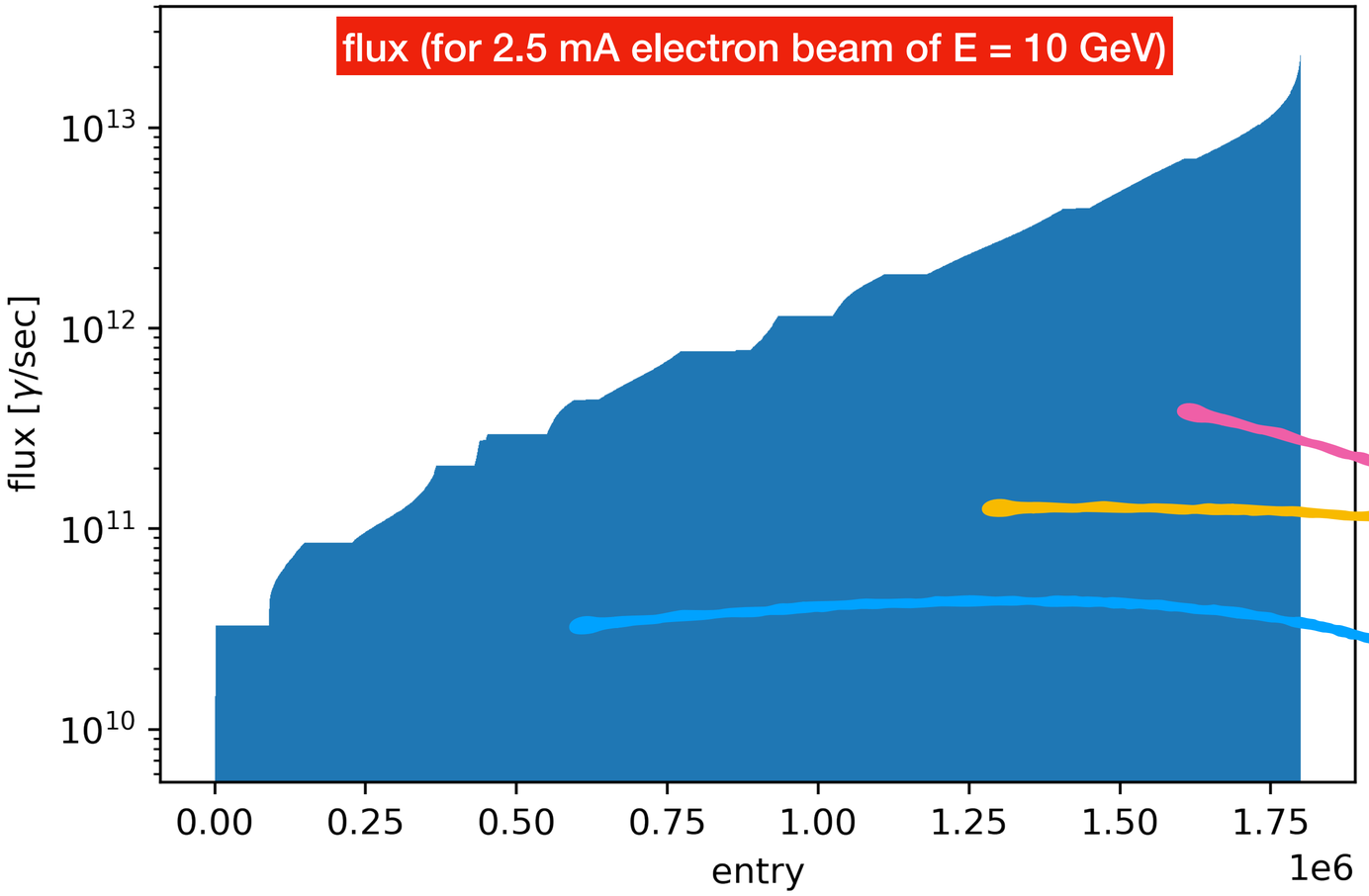
Want



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

Composing an event

Sample consists of 1.8M photons, each with a flux (γ/sec) weight



x-axis: every photon in the sample (1 per bin)

Define an integration window (IW)

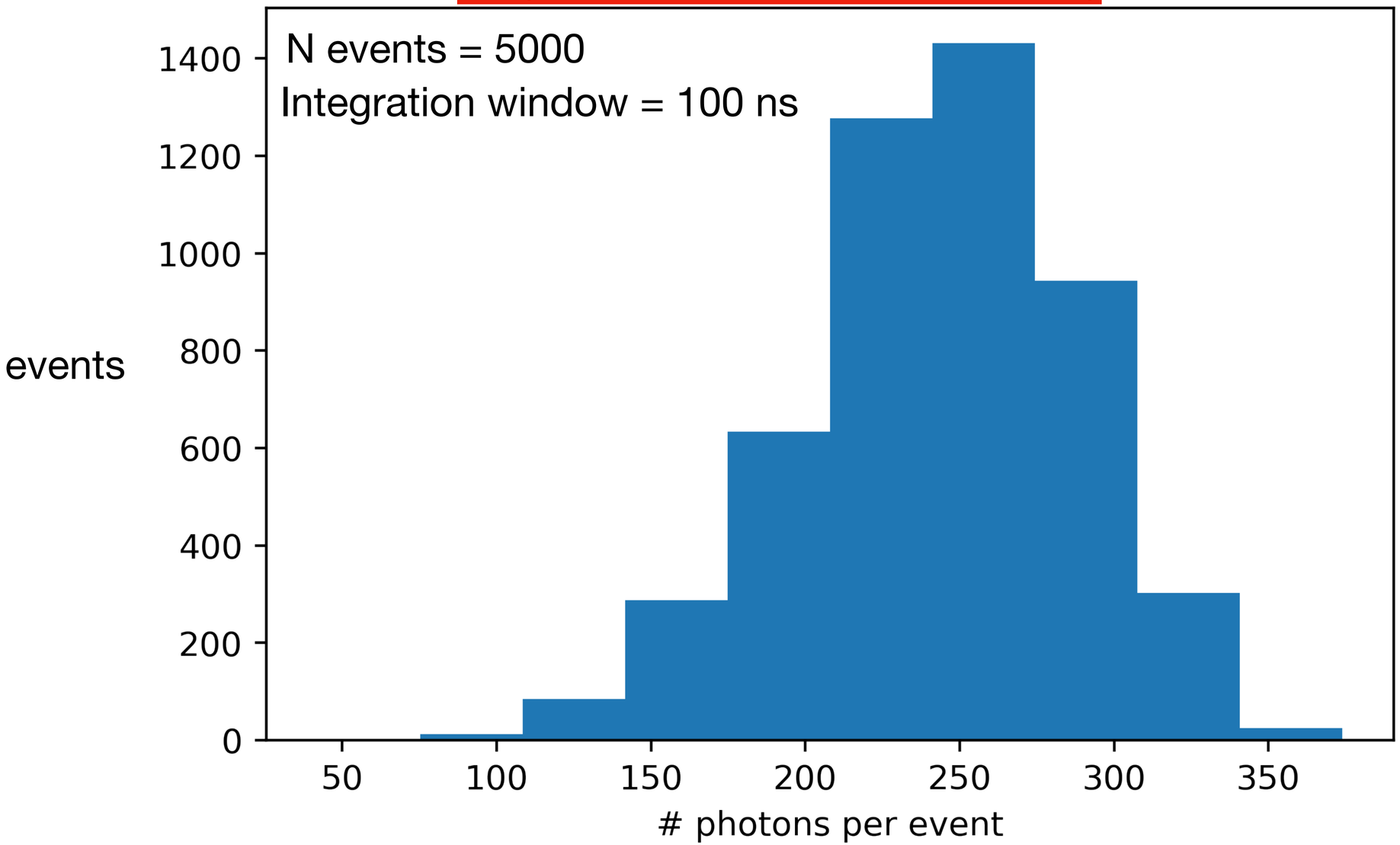
```
integral = 0
while integral < IW:
    Randomly sample photon, add it to event
    integral += 1/flux
return event
```

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

Time integration window

Multiplicity

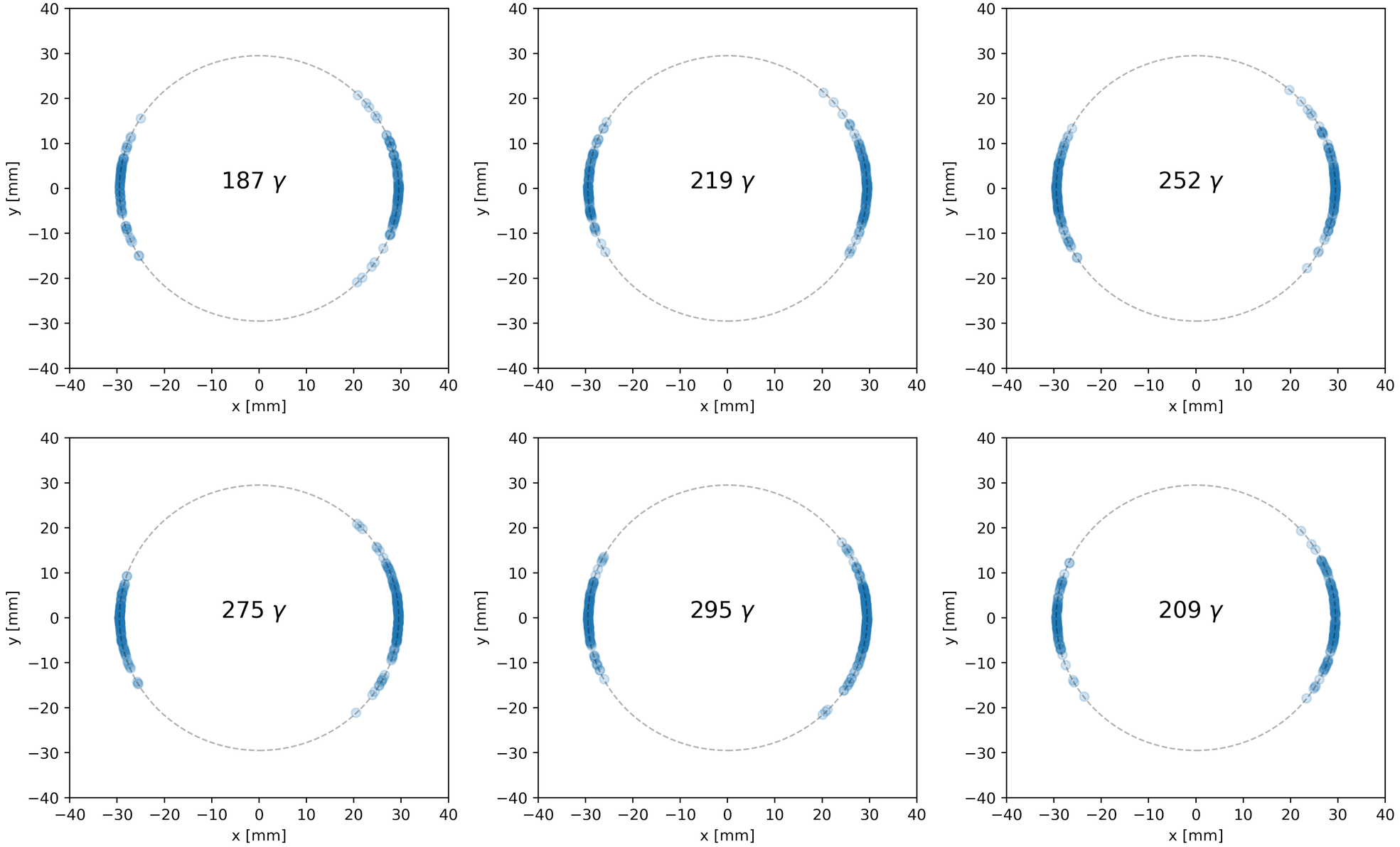
flux (for 2.5 mA electron beam of E = 10 GeV)



before interaction with gold coating

For each photon in the event we have: p_x, p_y, p_z, x, y, z

Sample events

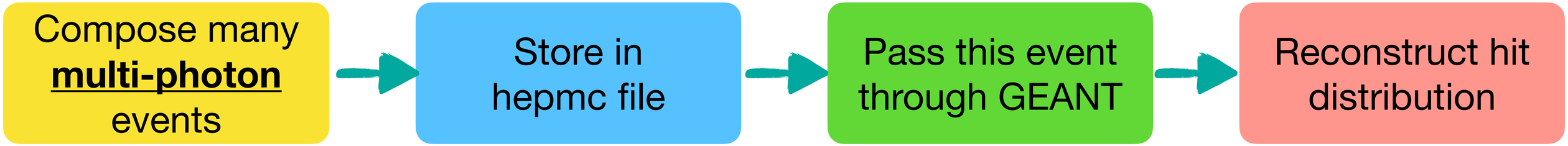


before interaction with gold coating

Integration window = 100 ns

flux (for 2.5 mA electron beam of E = 10 GeV)

What we want(ed) to do



Advantages:

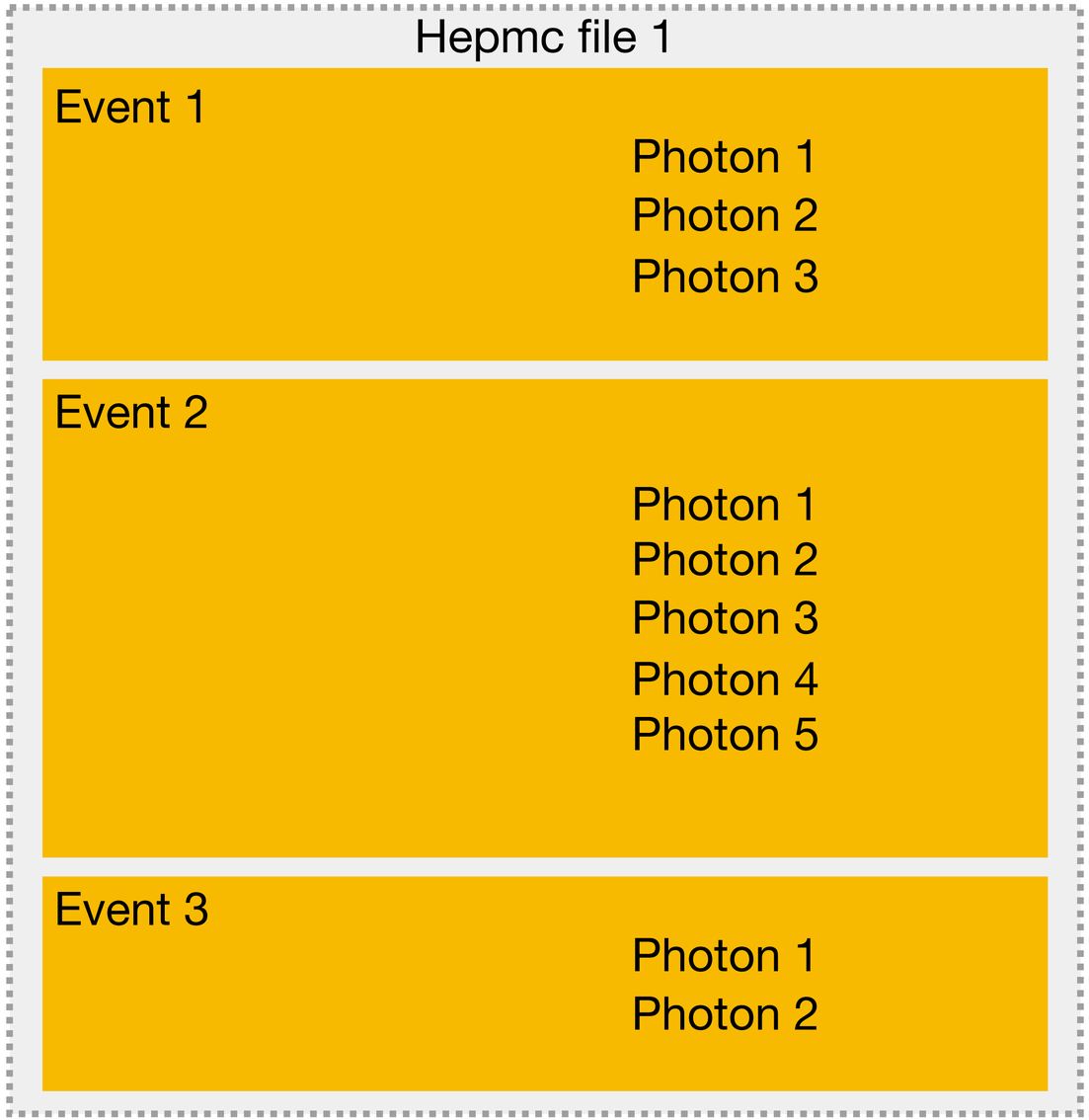
- Simplicity (event generator is a very light python code)
- Requires minimal processing of input photon files
- Portability: can test hepmc files in multiple platforms (DD4HEP, Fun4All, …)
- Can pass same sample over multiple detector configurations (e.g. changing gold coating)

Issues:

- DD4HEP hit distributions reveal that photon momentum vectors are detached from their respective vertices and launched from v = (0,0,0), which produces wrong topology

Alternate method

Instead of:



* Implemented by UC Berkeley undergrad B. Sterwerf

Alternate method

Instead of:

Hepmc file 1

Event 1
Photon 1
Photon 2
Photon 3

Event 2
Photon 1
Photon 2
Photon 3
Photon 4
Photon 5

Event 3
Photon 1
Photon 2

We use:

Hepmc file 1

Event 1	Photon 1
Event 2	Photon 2
Event 3	Photon 3

Hepmc file 2

Event 1	Photon 1
Event 2	Photon 2
Event 3	Photon 3
Event 4	Photon 4
Event 5	Photon 5

Hepmc file 3

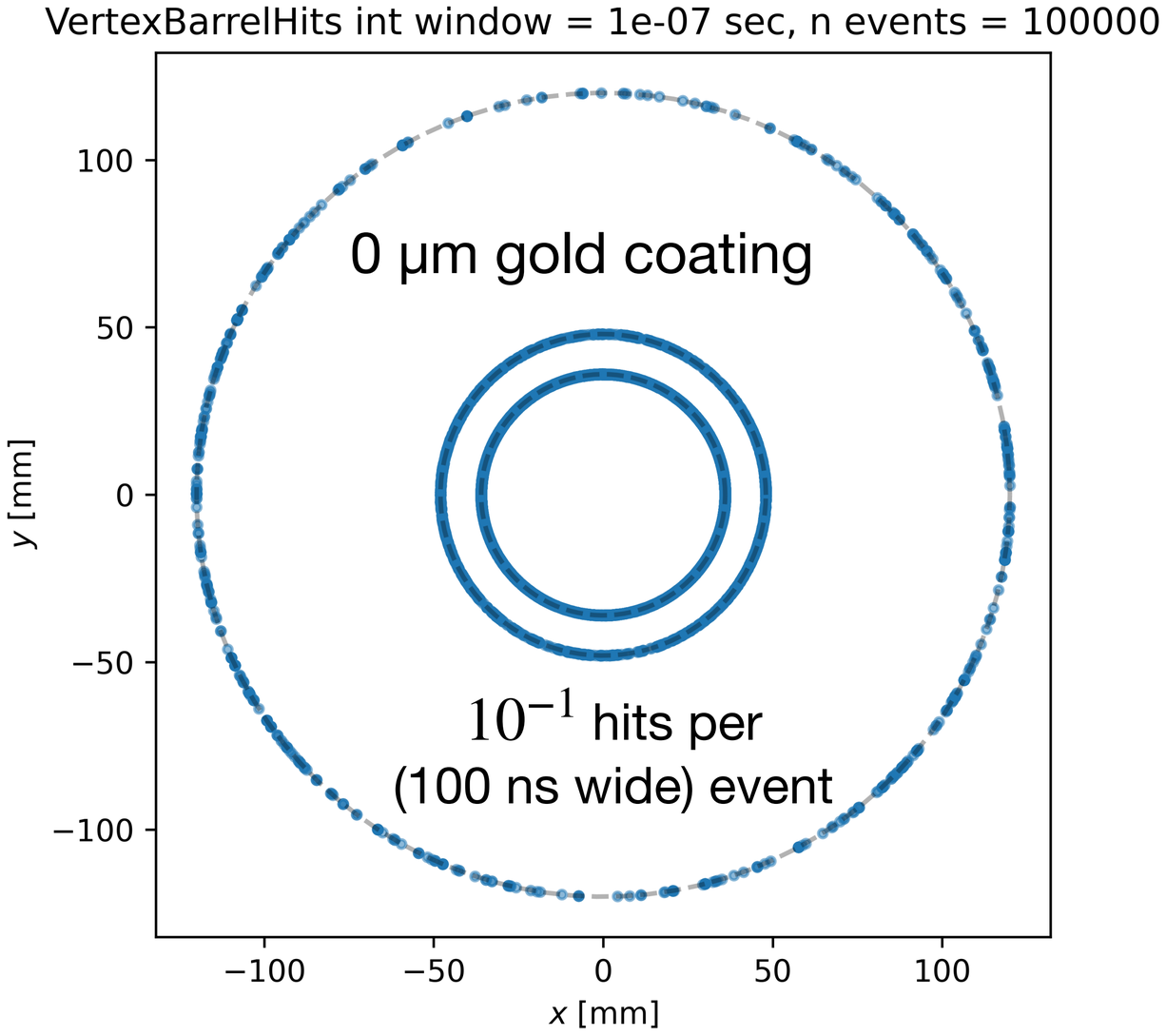
Event 1	Photon 1
Event 2	Photon 2

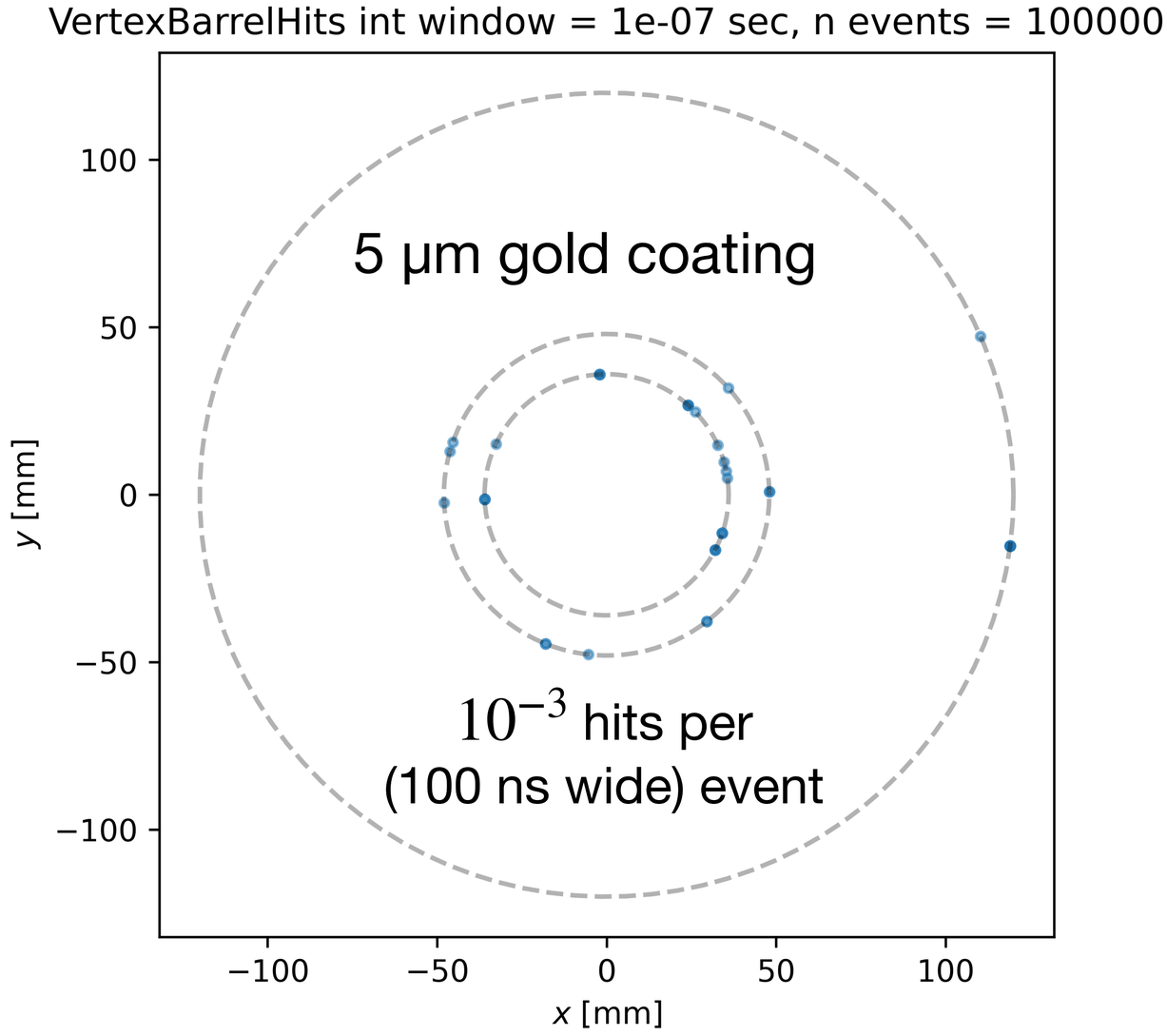
* Implemented by UC Berkeley undergrad B. Sterwerf

Disadvantages with respect to original method

- More convoluted code than event generator that writes to hepmc
- Cannot directly admix an SR event with other signals/backgrounds

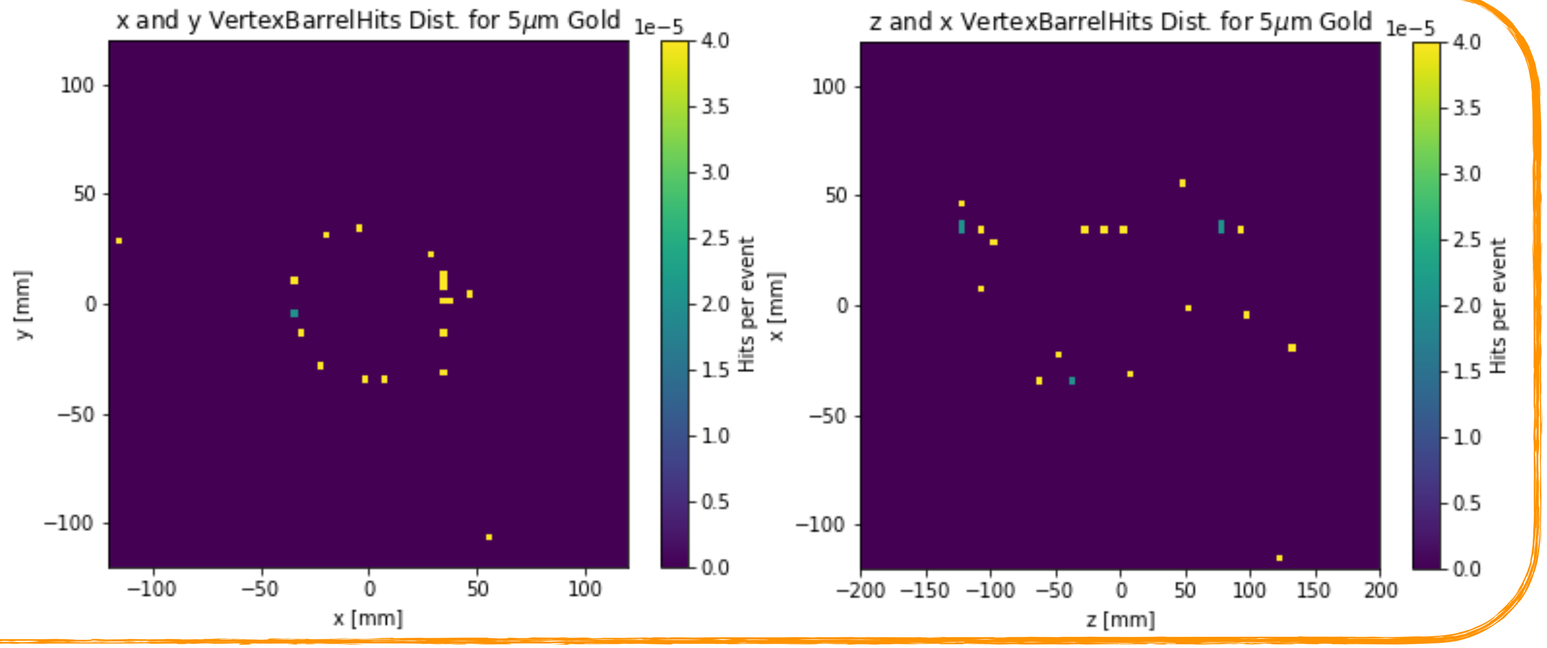
Results


VertexBarrelHits int window = 1e-07 sec, n events = 100000
0 μm gold coating
10^{-1} hits per
(100 ns wide) event
y [mm]
x [mm]
100
50
0
−50
−100
−100
−50
0
50
100

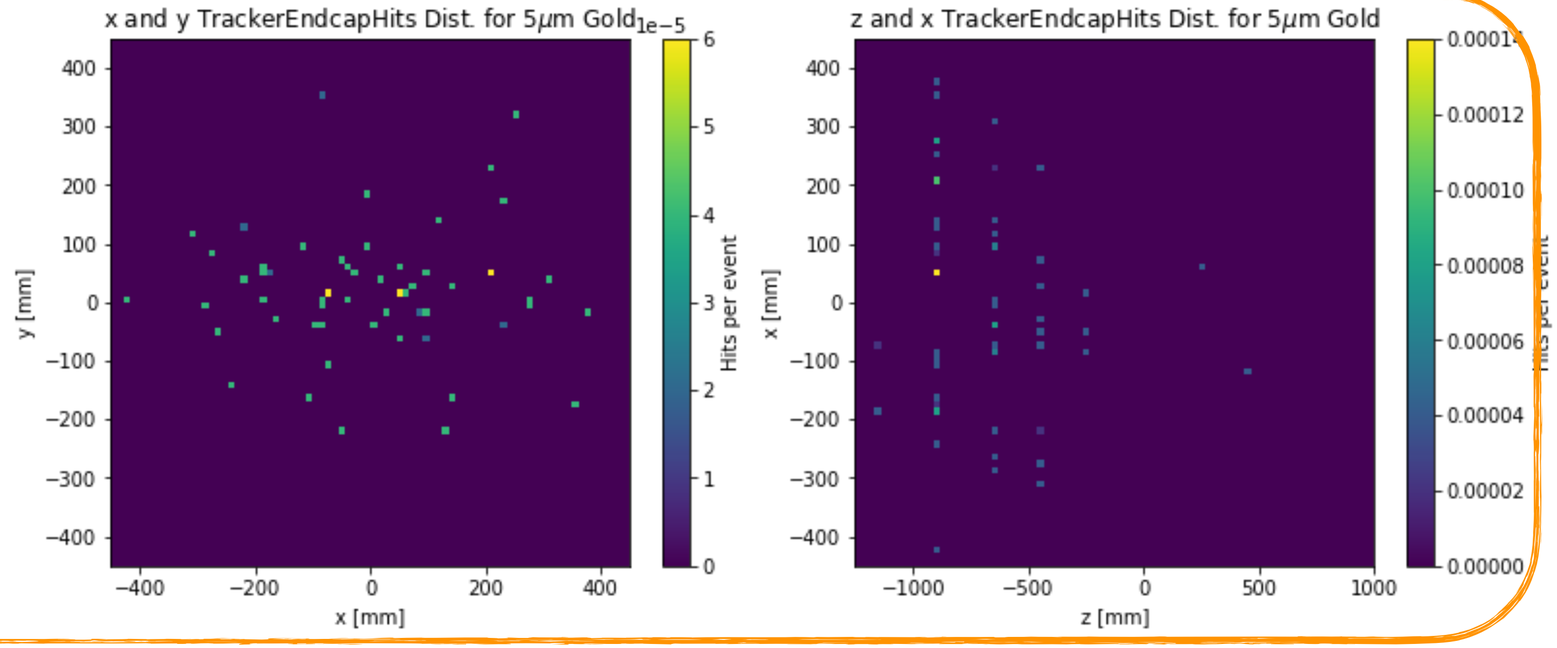

VertexBarrelHits int window = 1e-07 sec, n events = 100000
5 μm gold coating
10^{-3} hits per
(100 ns wide) event
y [mm]
x [mm]
100
50
0
−50
−100
−100
−50
0
50
100

Results with this new method

Vtx layers



Disks

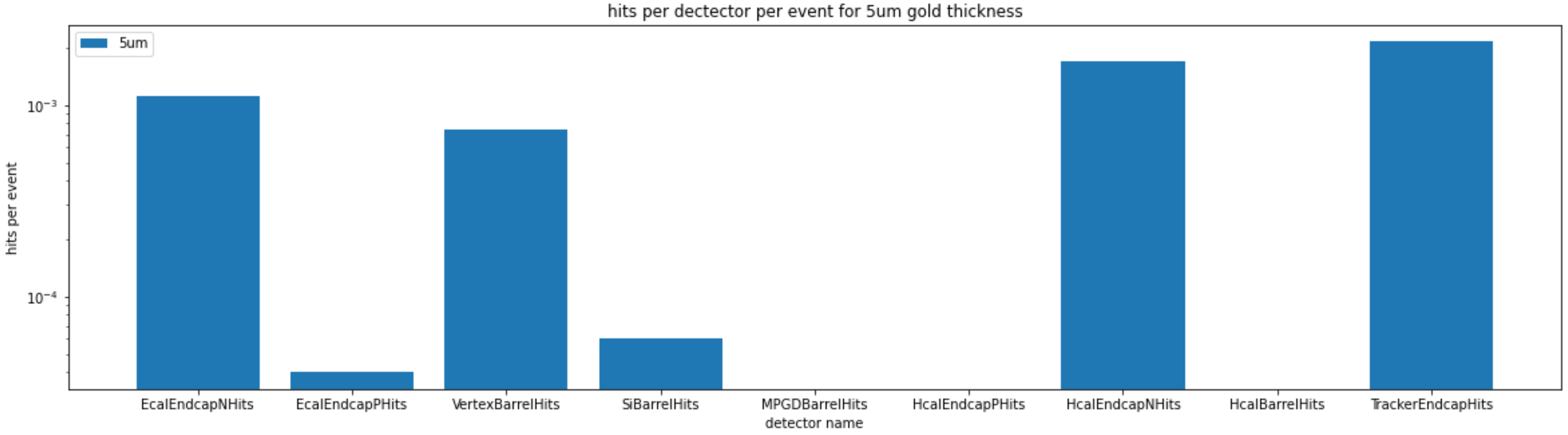


flux (for 2.5 mA electron beam of E = 10 GeV)

* plots by UC Berkeley undergrad B. Sterwerf

Results with this new method

flux (for 2.5 mA electron beam of E = 10 GeV)



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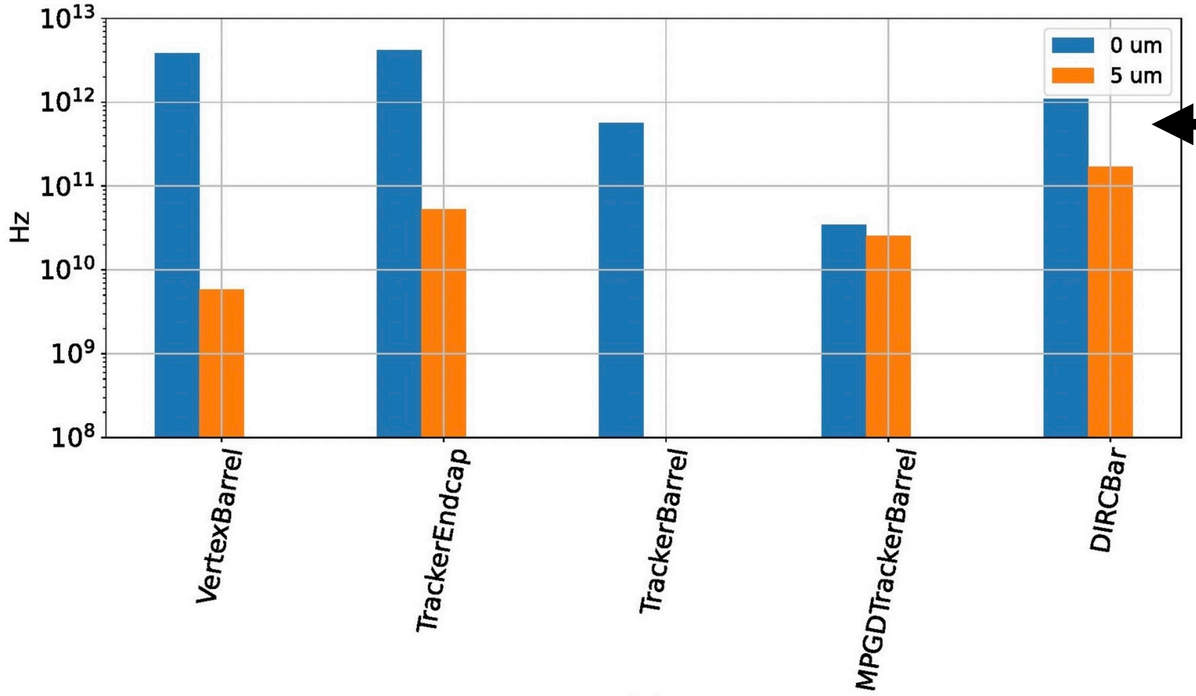
Comparison to previous results

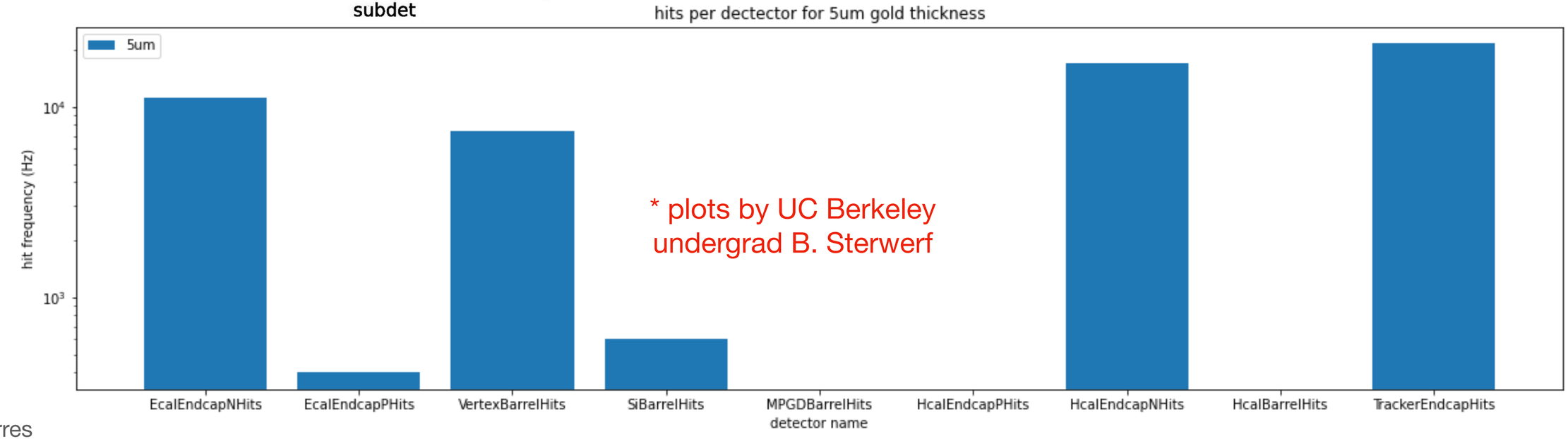
flux (for 2.5 mA electron beam of E = 10 GeV)



Old (biased) method in which we passed all photons through Geant only once and scaled the resulting contribution by the provided weight.

* Keep in mind the detector versions between these plots is different

Compare orange on top to blue on bottom plot



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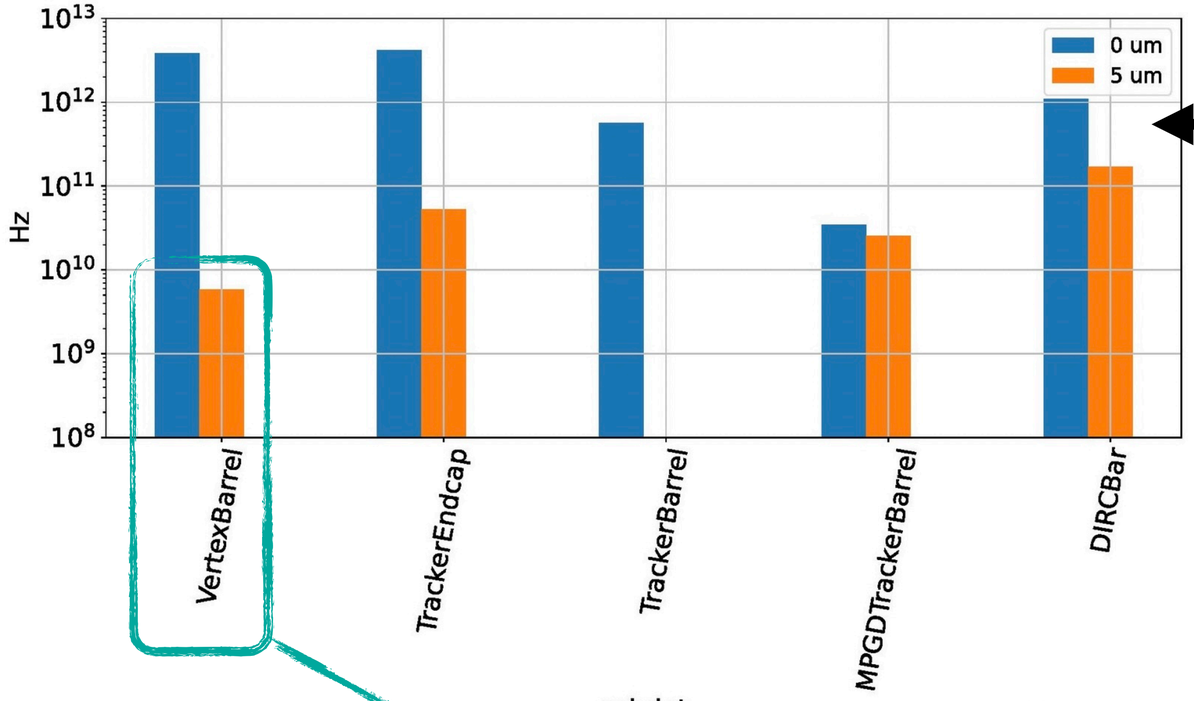

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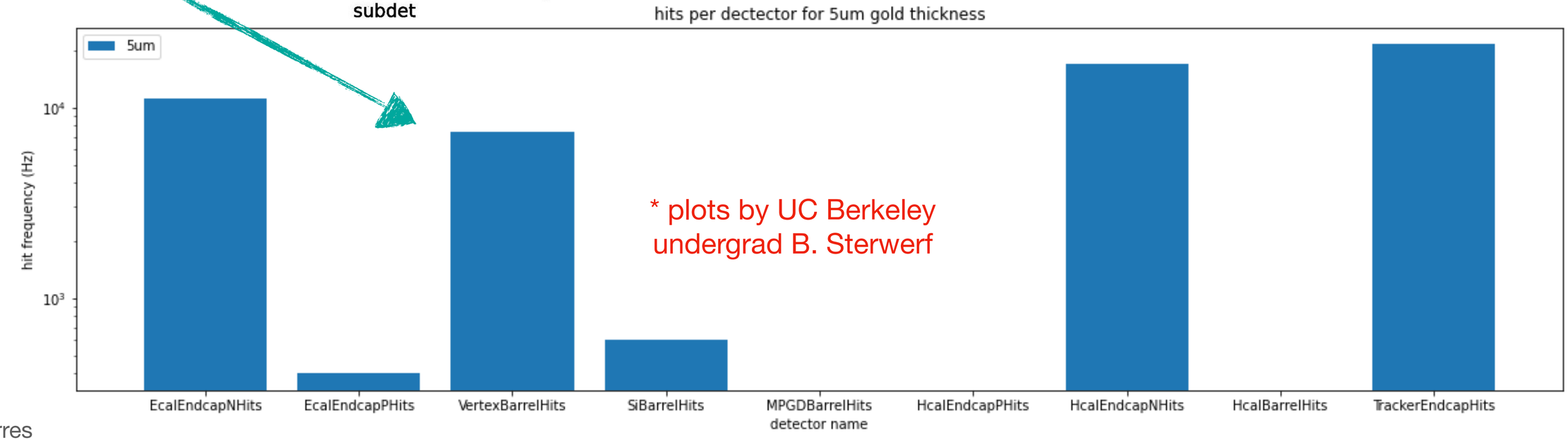

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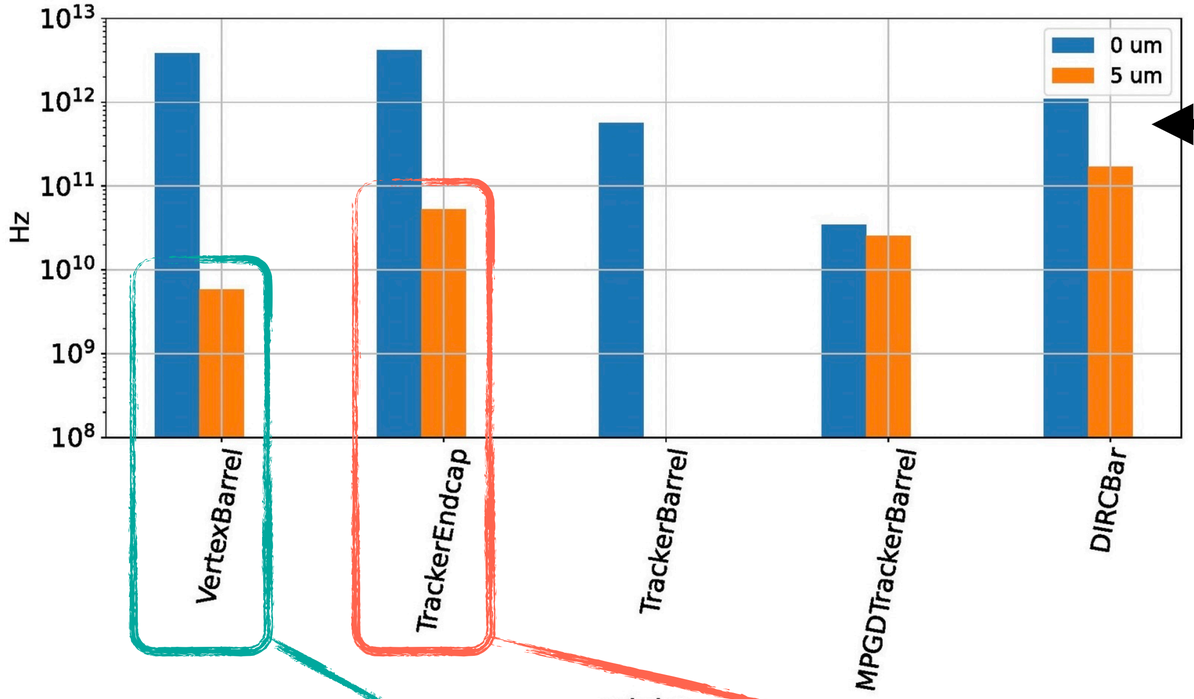

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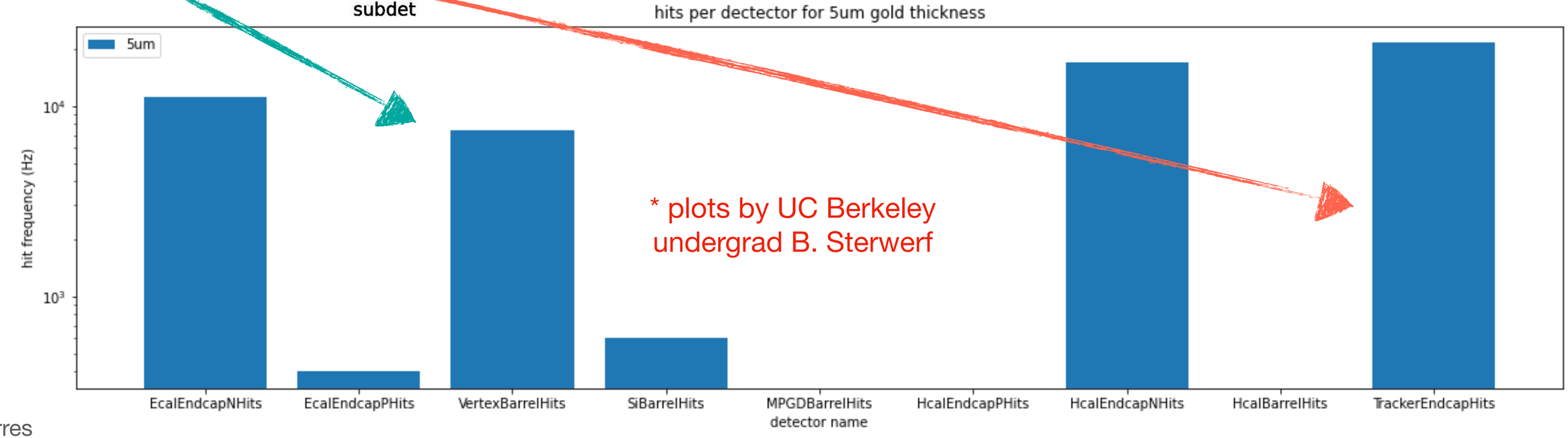

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Digressing (1)

flux (for 2.5 mA electron beam of E = 10 GeV)

Linear scaling to convert to different current

Given that there are three anticipated beam energies it would be useful to get three sets of Synrad+ simulations

Digressing (2)

	entry	subentry	VertexBarrelHits.position.x
0	638790	0	-35.600434
1	691682	0	35.005008
2	691682	1	35.015237
3	2705841	0	-5.263716
4	2705841	1	-5.271909
5	2931962	0	-21.136054
6	2931962	1	-21.143191
7	3643768	0	-18.253366
8	3643768	1	-18.261422
9	3655173	0	-116.376440
10	3655173	1	-116.381387
11	4342408	0	-2.985499
12	4342408	1	-2.978003
13	4424881	0	7.787438
14	4424881	1	7.786447
15	4751829	0	35.237831
16	4751829	1	35.240703
17	5335254	0	47.868574

Double Hits?

Summary

- The SR event generator was composed a while back (independently by RCT and B. Sterwerf).

- There is (was?) a bottleneck with Hepmc/DD4HEP detaching photon momentum vectors from vertices (thanks to K. Kauder for diving into this).

- We implemented an alternate method to work around this issue and developed the software to achieve the same task.

- New results predict smaller synchrotron radiation rates and imply (as expected) that the preliminary results (pre-proposals) were biased by a few photons with very high weights.

Backup slides

VertexBarrelHits int window = 1e-07 sec, n events = 100000