PBR simulation update

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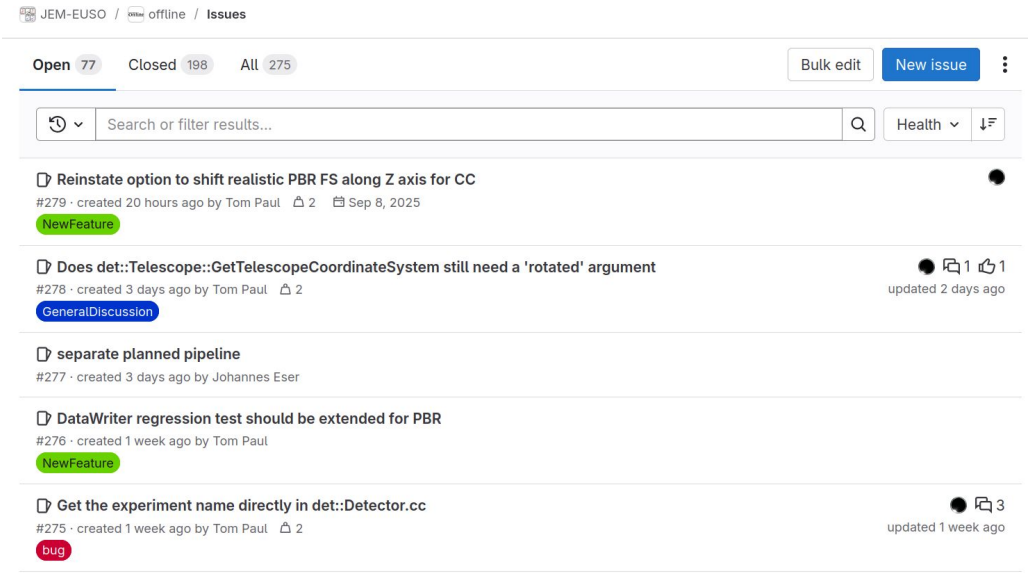
On behalf of Offline simulation contributors
37’th JEM-EUSO Collaboration Meeting
31 May - 6 June 2025, Paris

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

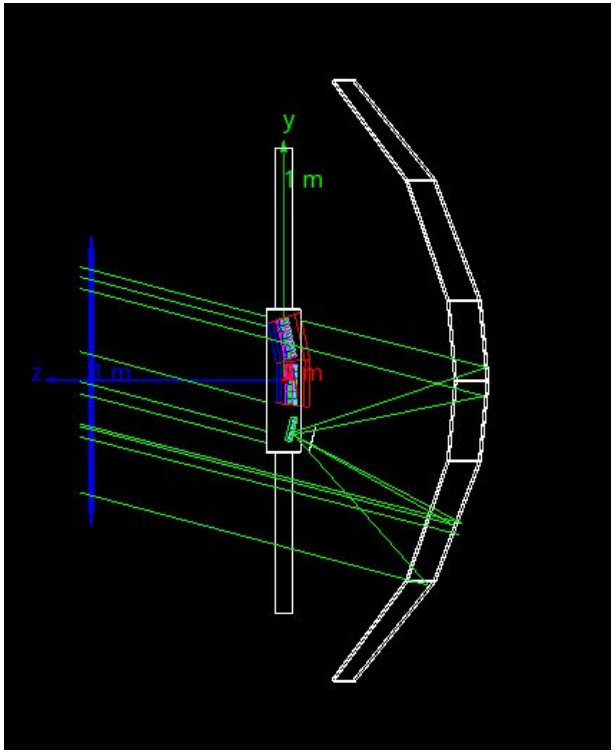
Take home

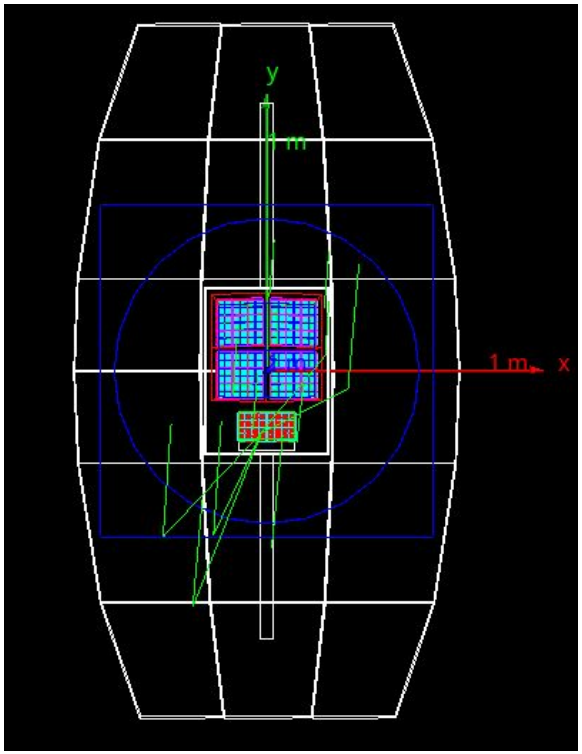
- I'll summarize progress since last meeting (Chicago)
  - Several ongoing projects, not all completed yet
- Pending simulation items
- Solicit your ideas/requests for projects to add to our list
  [add your ideas here at any time]

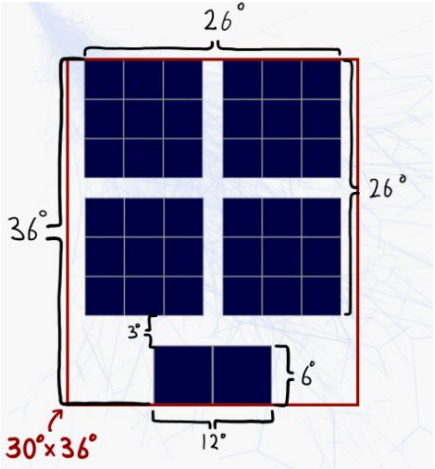


Brief reminder

1.1m aperture, ACP, flatteners, BG3, FC, CC (almost), mirror, bifocalizer pending





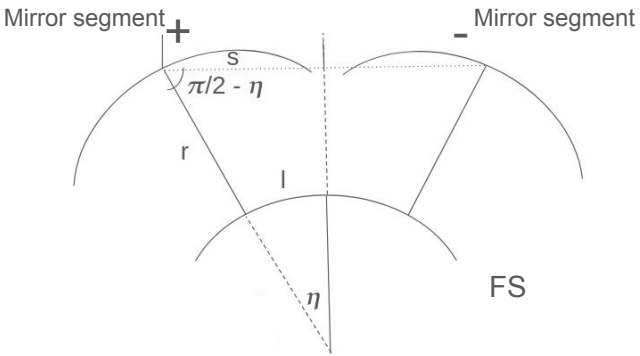


Some items developed since Chicago meeting

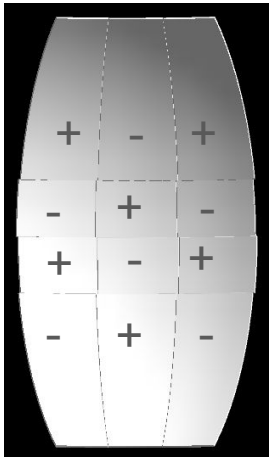
Bifocalization

- OA status
- Possible backup? Bifocalize with mirrors
  - Mirror bifocalizer is NOT our 1’st choice
    (ie at conferences, don’t say this is how we will do it, please)

Mirror bifocalizer



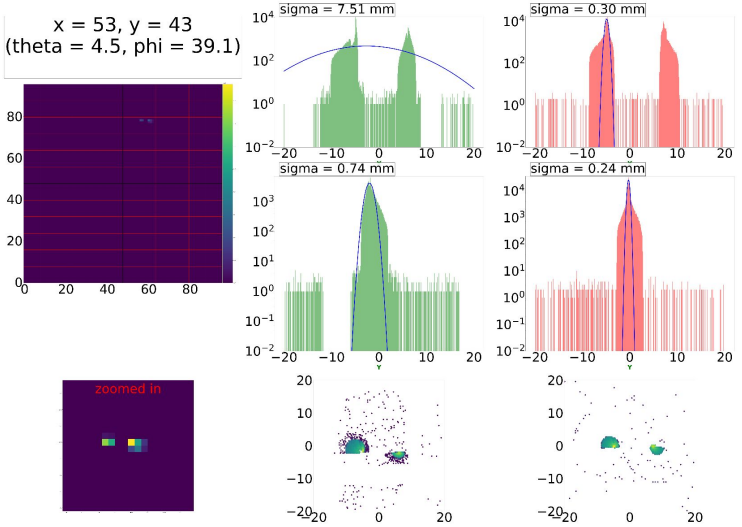
Problem: triggered event rate reduced to ~60-70% of original rate (less light / pixel)



“Checkerboard” configuration

Every other segment goes on a different sphere.

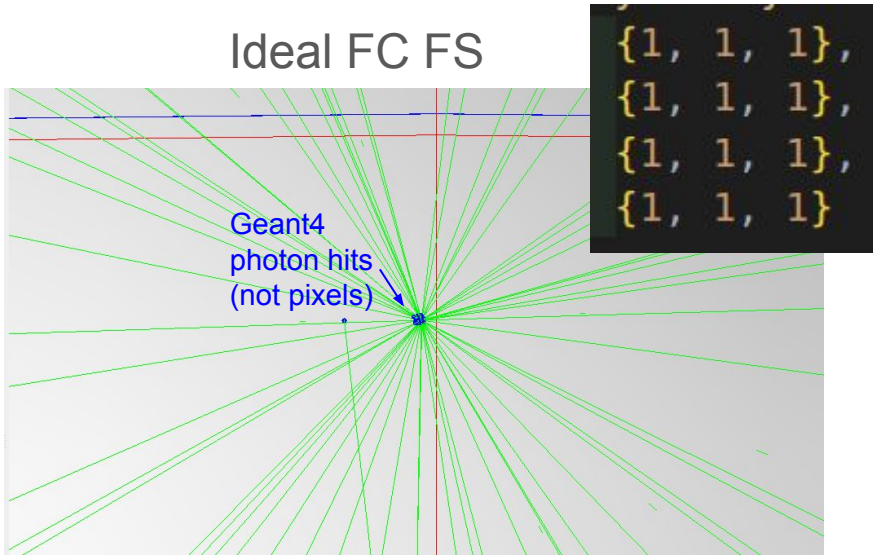
Realistic FC FS Ideal FC FS

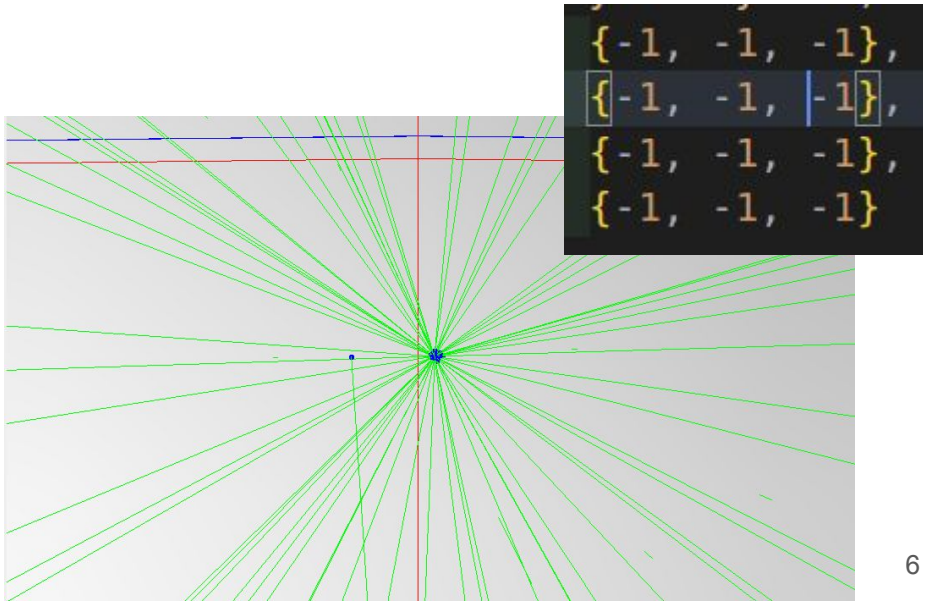


“Generic” mirror bifocalizer

- Each mirror can be independently placed on its own sphere.
- Idea: maybe if we don’t checkerboard the whole mirror, the effect on FC trigger can be reduced while still bifocalizing CC acceptably

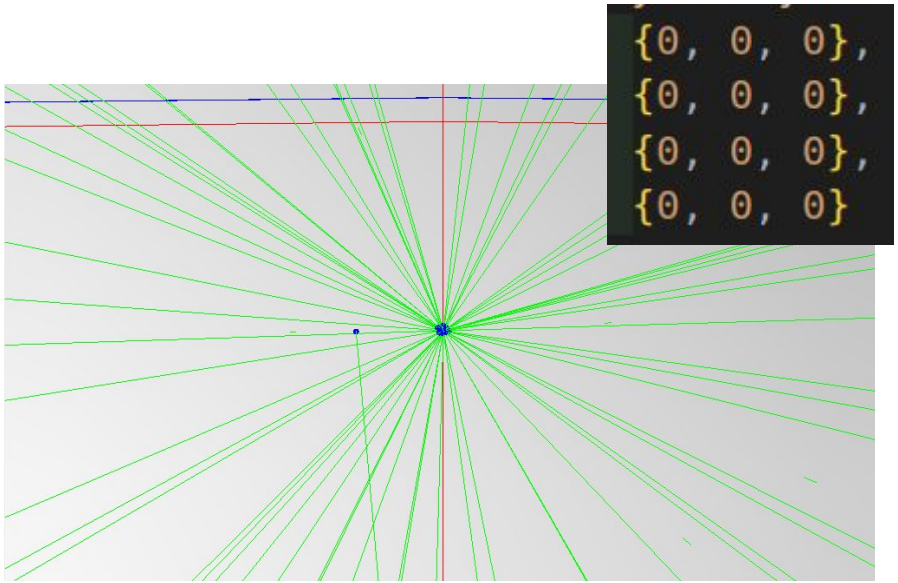
Ideal FC FS

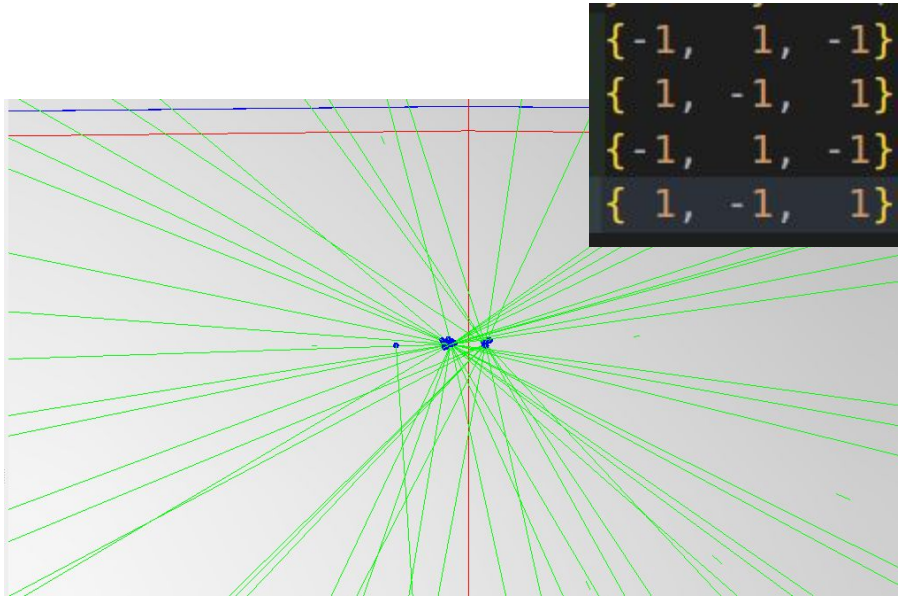




Mirror bifocalizing examples

0 → aiming a center, hits center, ±1 → shift by desired offset



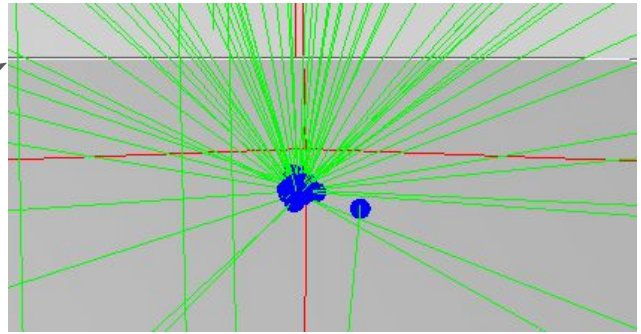


Does it work?

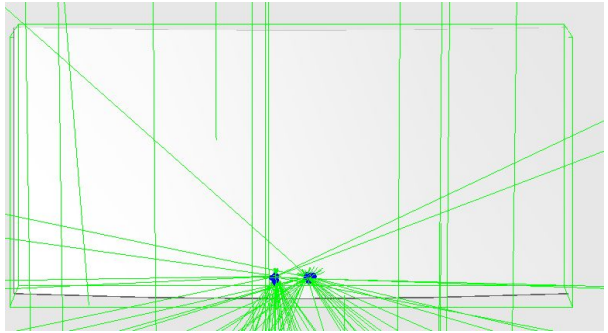
Only checkerboard lower two rows of mirrors
(more light to CC comes from lower parts of mirror)

```
{ 0, 0, 0},
{ 0, 0, 0},
{-1, 1,-1},
{ 1,-1, 1}
```

Top of FC



Bottom of CC



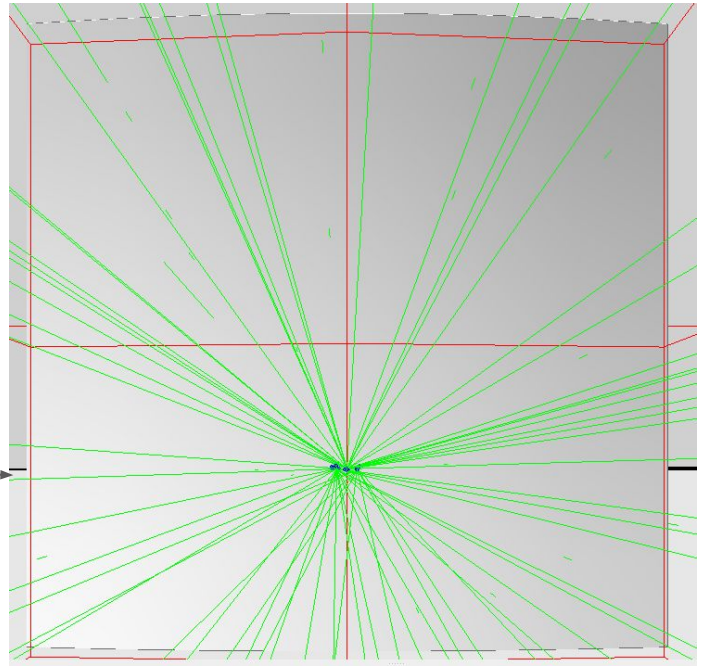
Does it work?

Sort of. 😕

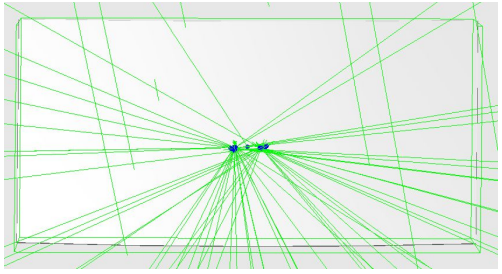
Not a clean on/off for FC or CC by isolating checkerboard

```
{ 0, 0, 0},
{ 0, 0, 0},
{-1, 1,-1},
{ 1,-1, 1}
```

Middle of FoV →



CC



How do different checkerboard patterns work for FC, CC

Definitive answer pending.

George is checking if it is go/no-go from FC trigger point of view

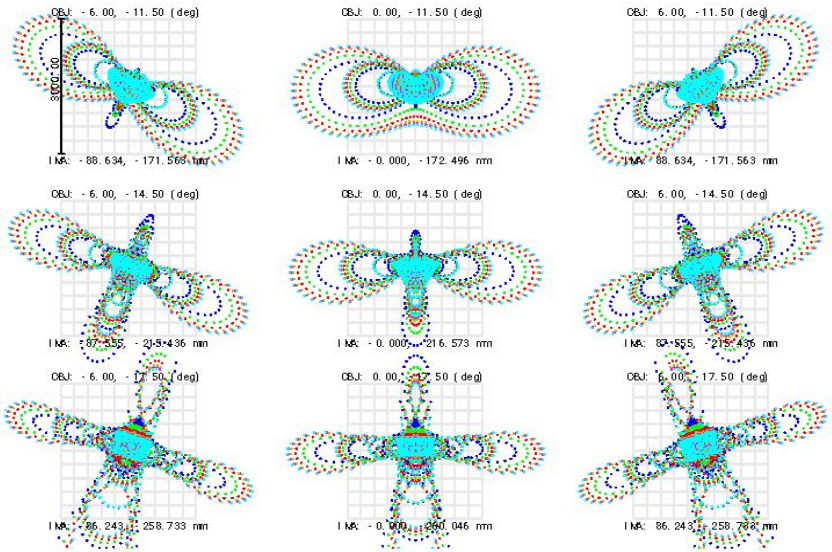
Alex and I are checking if it is go/no-go from CC point of view

Will post results on simulation slack channel when we have them

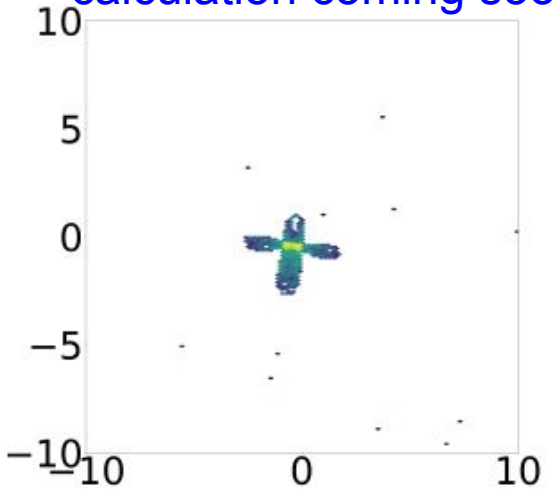
But good news:

Eric Mentzell (optics Engineer at Goddard) is working on OA (zemax sims)
(Thanks John and Toni!)

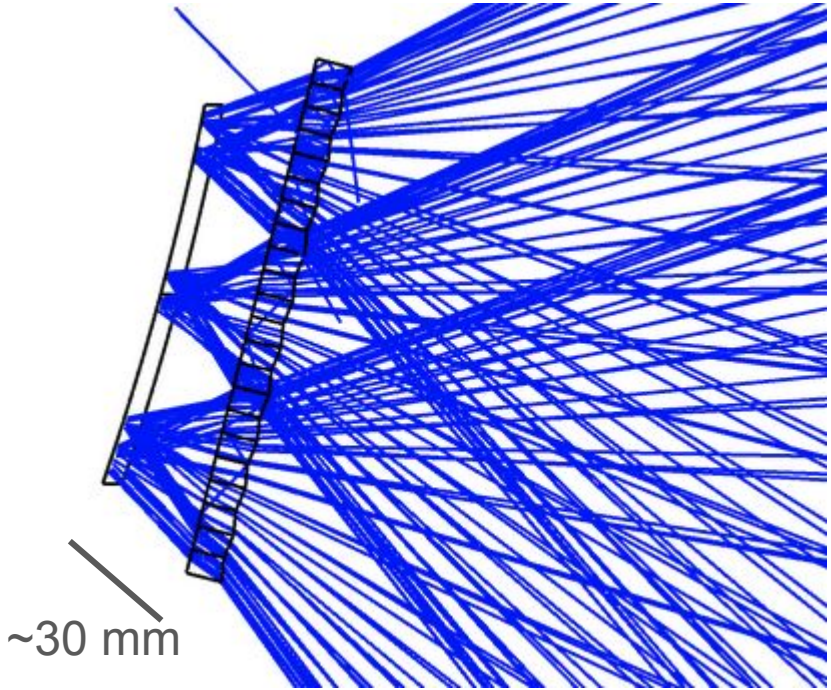
CC PSF's (no OA)



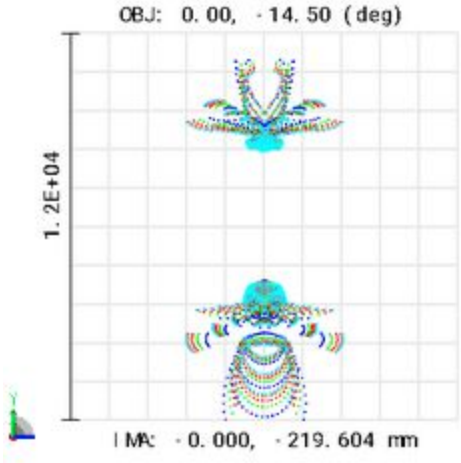
G4 CC sim PSF
(energy containment calculation coming soon)



OA in Eric's model



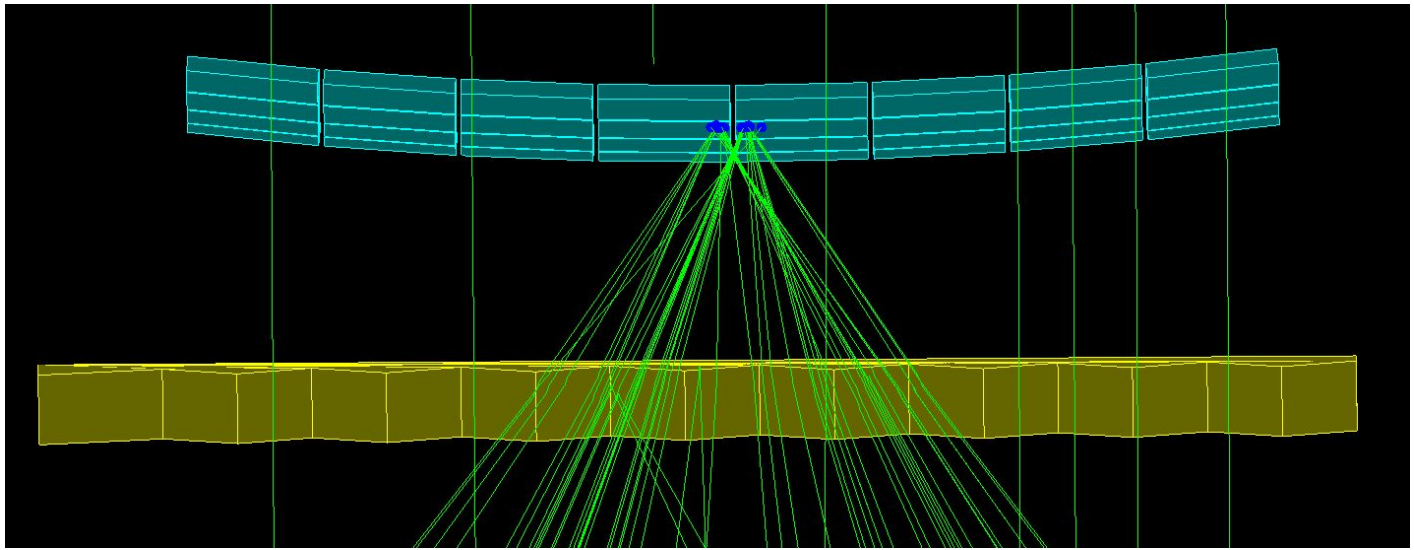
PSF with OA



~6 mm separation

Note: split here is vertical
Horizontal split pending

Preliminary OA model in Geant4

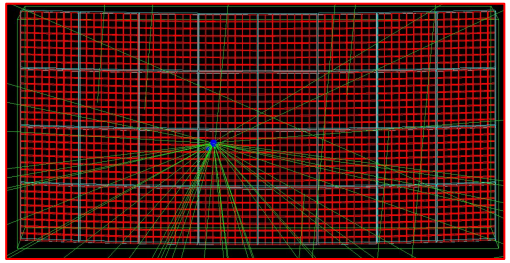


Qualitatively does the correct thing
Will tune to Eric's model once complete (with horizontal split)

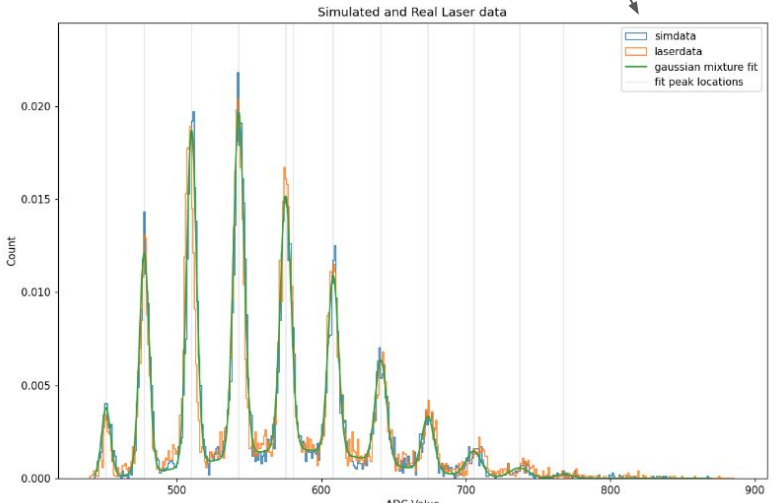
CC Electronics

Isaac, Beatrice

G4 up to hits



Electronics sim



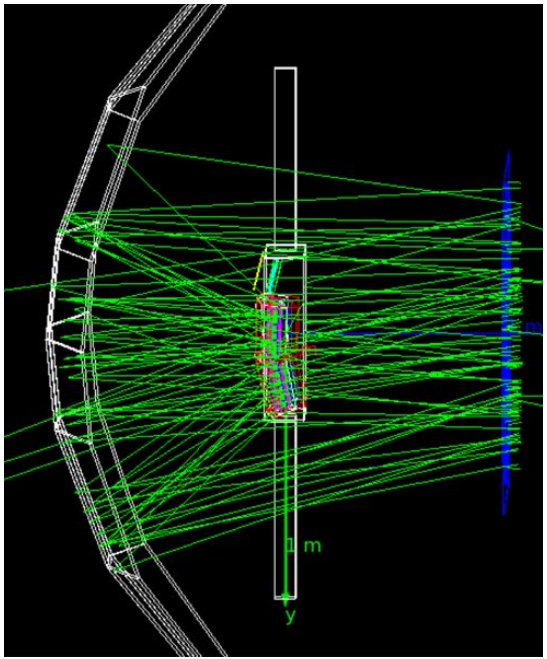
- Light releases PE in SiPM
- PE → avalanche breakdown in a microcell
  - 3584 microcells / pixel
  - Gain (ADC/PE) ≃ digitized integral current from 1 breakdown
  - Details: crosstalk, afterpulses, multiple avalanches

Sim implementation options in offline

- Record variance of ADC per PE
  - Fast
  - Noise treated to 1’st order
- Individually treat each contribution to ADC
  - Closer to real life
  - Fewer parameters from calibration
  - Correct contributions to ADC variance arise naturally

Background simulation

Isotropically injected photons



Enzio, Alex

Start from 400 photons/m^2/st/ns

- removing the shelf
  $\rightarrow N_h = 5100\ (+1000)$
- increasing the injection solid angle to $\Omega = 0.99\,\mathrm{sr}$
  $(N = 378\,\mathrm{ph}\cdot\mathrm{ns}^{-1})$
  $\rightarrow N_h = 4500\ (+400)$
- both (plots)
  $\rightarrow N_h = 5700\ (+1600)$

5000 hits/us / 8192 pixels ≈ 0.5 G4 hits/pixel/us
(lower than George's estimate of 1 hit/pixel/us)

Items not yet addressed (as far as I’m aware)

- CC trigger simulation
- CC event format that will be stored to disk (currently using an old SPB2 format)
- Dark box
- Direct hits simulation (eg. GCR)

- Your ideas here

To participate

Please see the Simulations Wiki

- You'll find mailing list (for meeting announcements)
- Materials from talks, CAD files, documentation, instrument measurements

To post specific simulation issues, see the Offline gitlab page

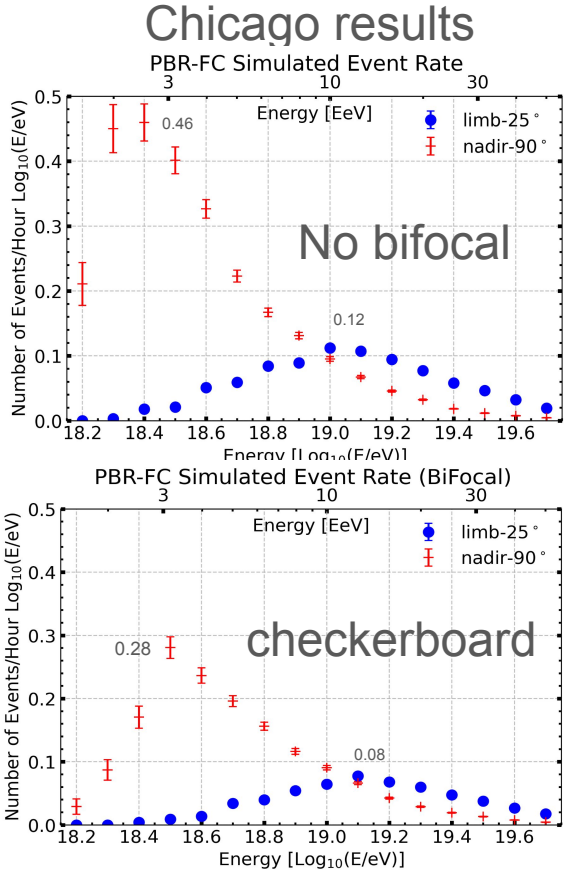
- Both the code and project management tools live there
- You can post simulation ideas for discussion and coding
- And report bugs too…

The End

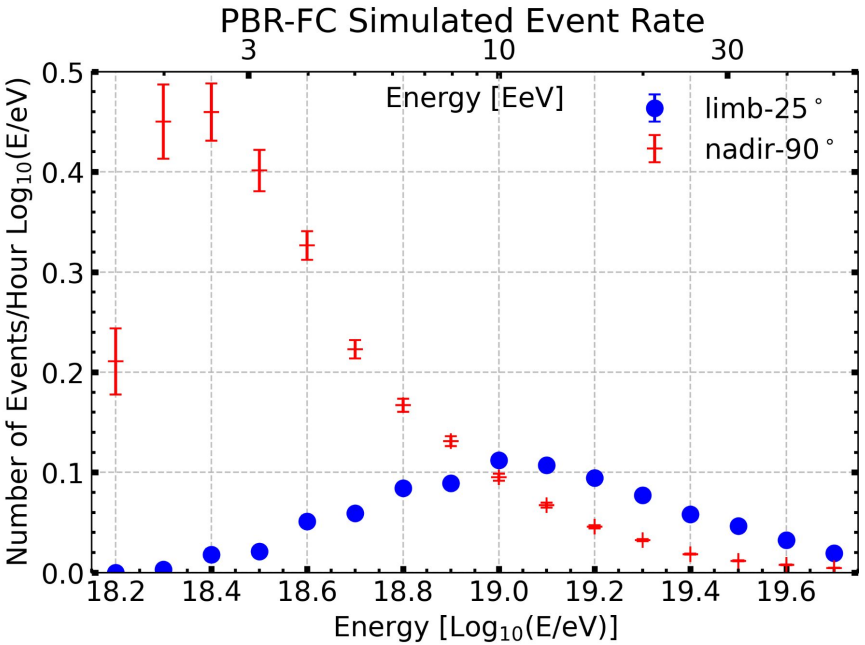
thanks

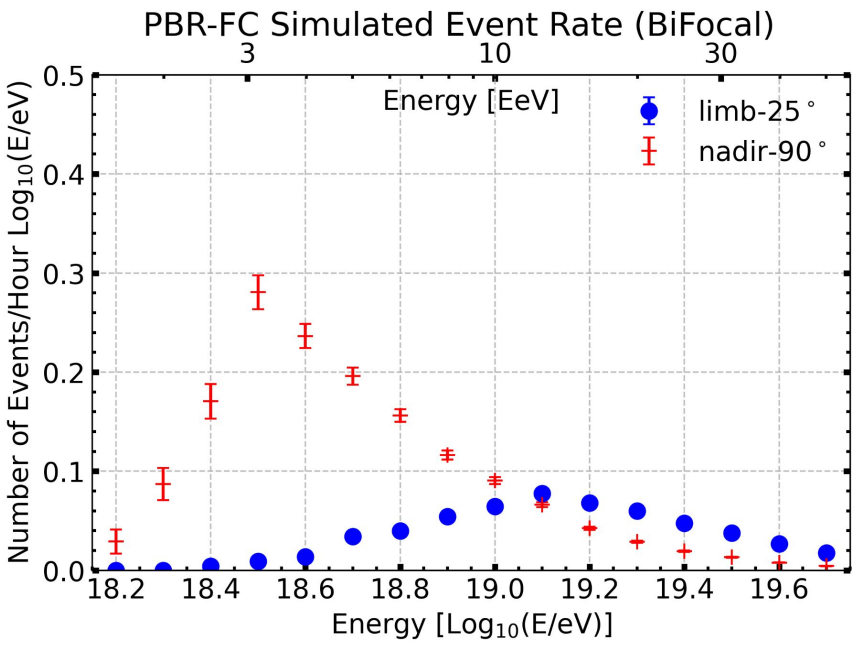
Extras

Previous bifocal



Effect of mirror biocalization on trigger rate





Bifocalizing using “reduced” checkerboard

Perlmutter

	Status	Details
Perlmutter	Down	**Unavailable** - 2025-06-01 23:02 – 9999-01-01 01:01 PST, Unavailabl An issue with the Lustre file system has been identified. Engineers are investigating.