Corrections for mask system reconstruction

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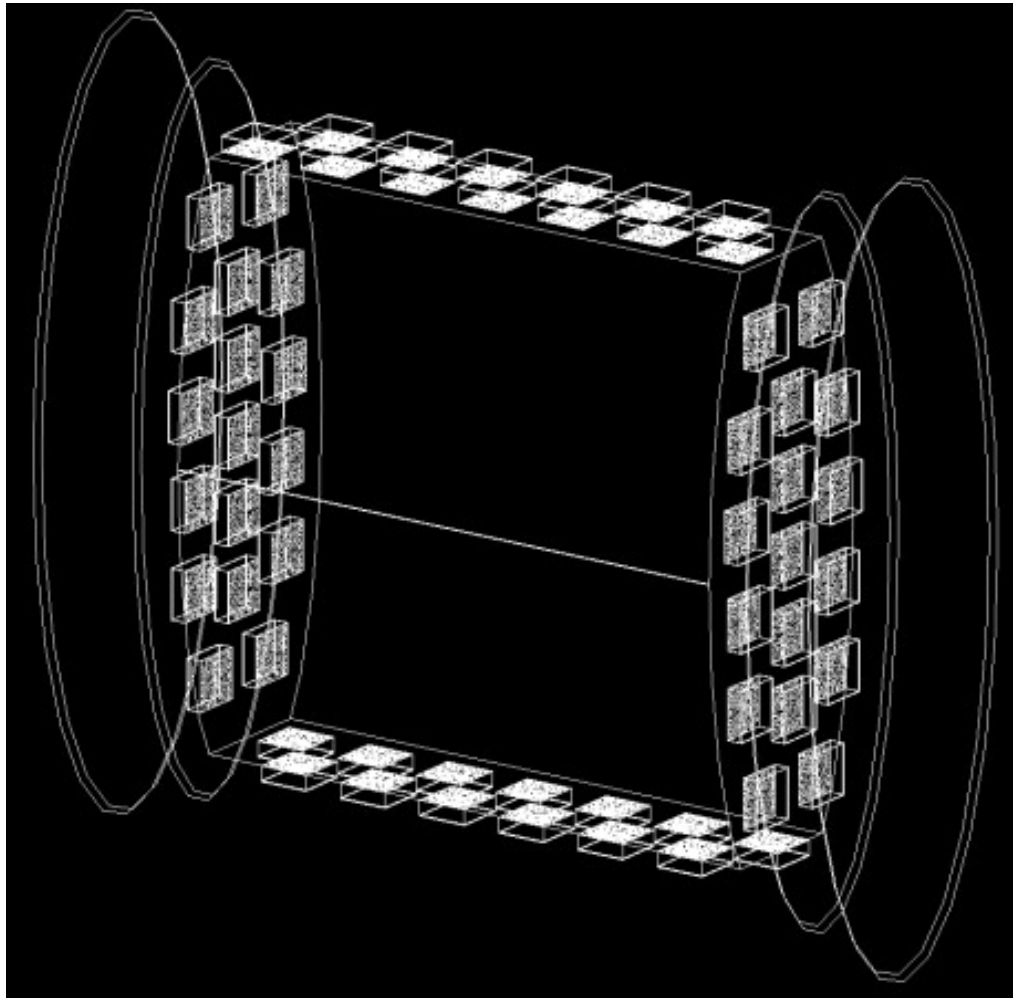
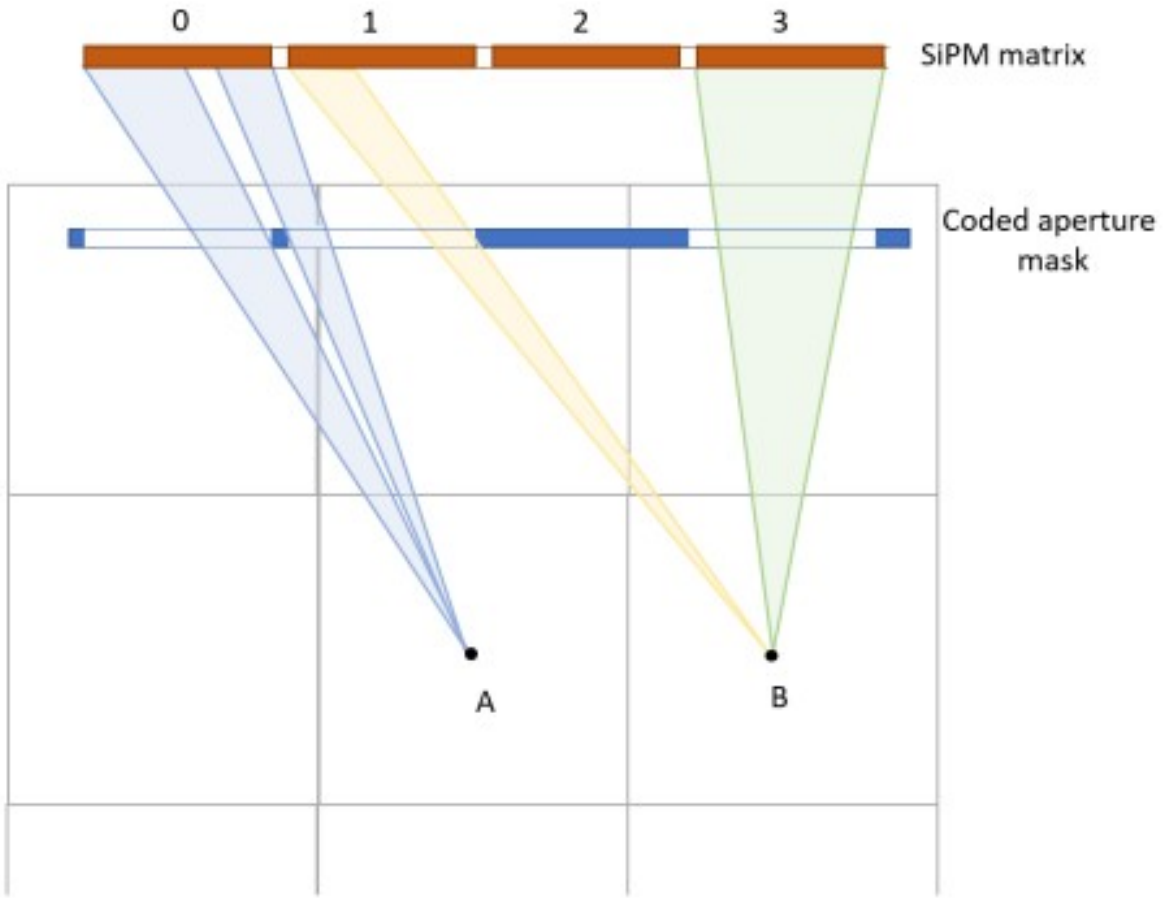
GRAIN geometry





Probability matrix

Probability for a sensor *s* to detect a photon emitted in a voxel *j*:

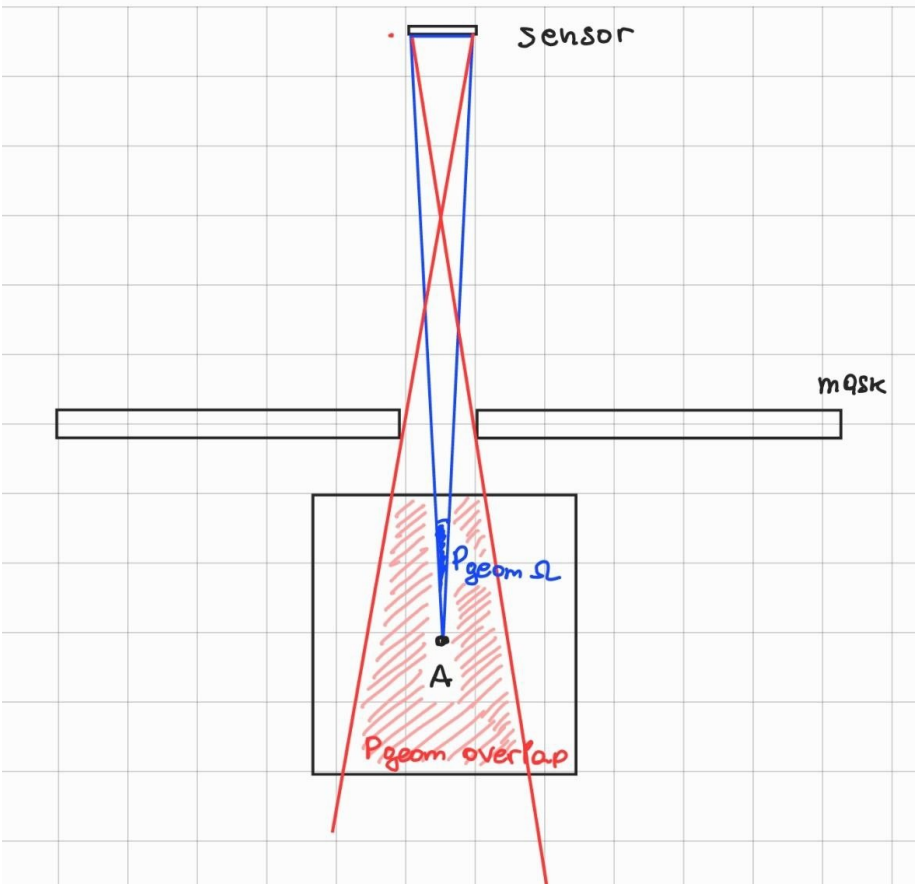
$$P(j,s) = P_{geom}(j,s) * P_{LAr}(d_{j,s}) * P_{sensor}(s)$$

Where

- $P_{geom}(j,s) \approx \Omega/4\pi$, with Ω being the solid angle subtended by the detector area, with origin in the voxel centre.
- $P_{LAr}(d_{j,s})$ takes into account photon attenuation in the medium and depends only on the distance $d_{j,s}$ between sensor and voxel.
- $P_{sensor}(s)$ represents the detection efficiency of the sensor (constant for every sensor).

Overlap correction to geometrical factor

The solid angle Ω is always referred to the voxel center, but some voxels are not fully “visible” by the sensor, through the mask hole. Thus, we are interested in finding which is the fraction $P_{overlap}$ of visible volume.



We estimate $P_{overlap}$ by dividing each voxel in 15x15x15 **minivoxels**, than check how many are within the “view” of the sensor and take the ratio. This computation is performed with GPU, together with the rest of the probability matrix.

The corrected geometrical factor will be

$P_{geom\_corr} = P_{geom} * P_{overlap}$

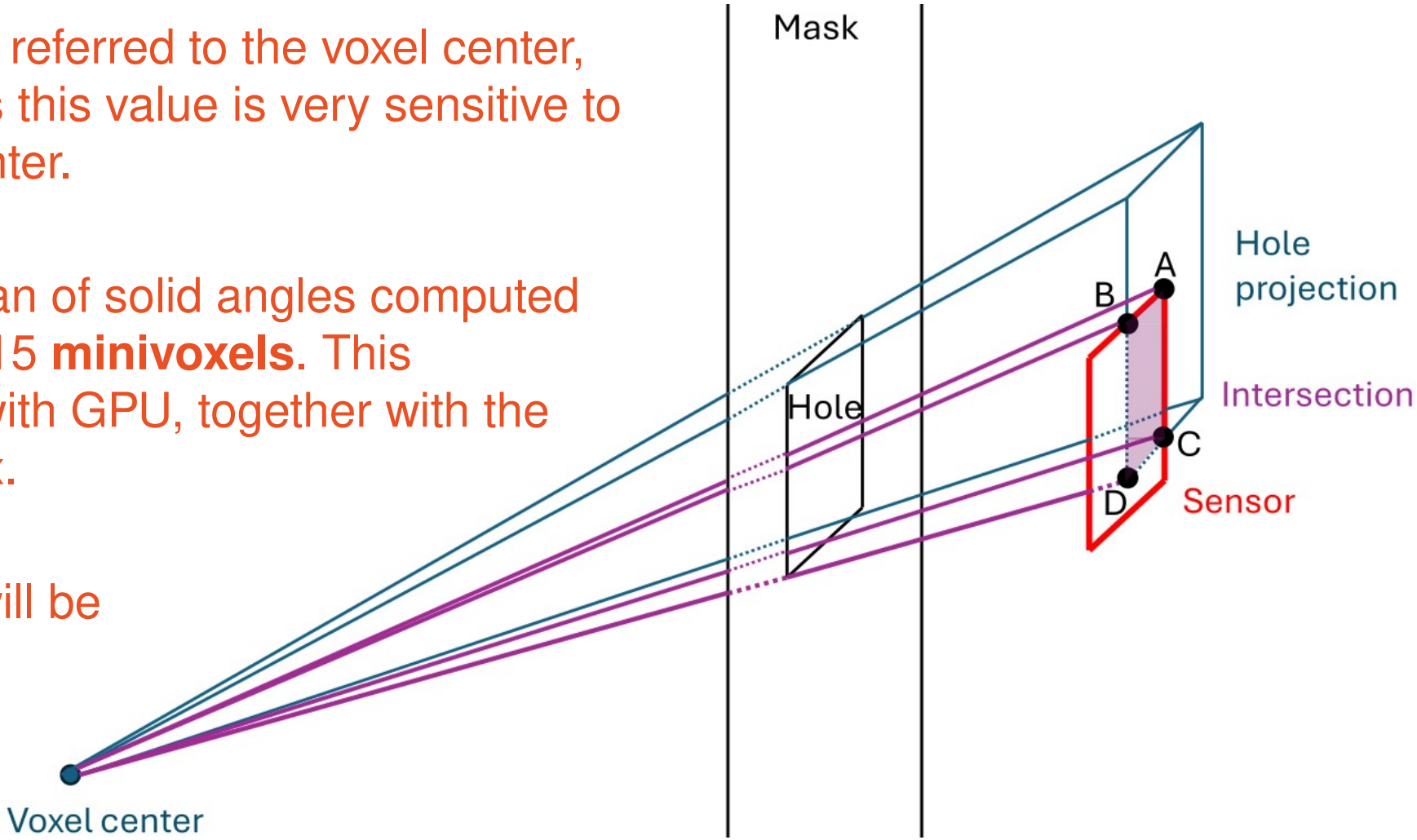
Correction to solid angle

The solid angle Ω is always referred to the voxel center, but for voxels near cameras this value is very sensitive to the position of the voxel center.

Thus, we take Ω as the mean of solid angles computed for each one of the 15x15x15 **minivoxels**. This computation is performed with GPU, together with the rest of the probability matrix.

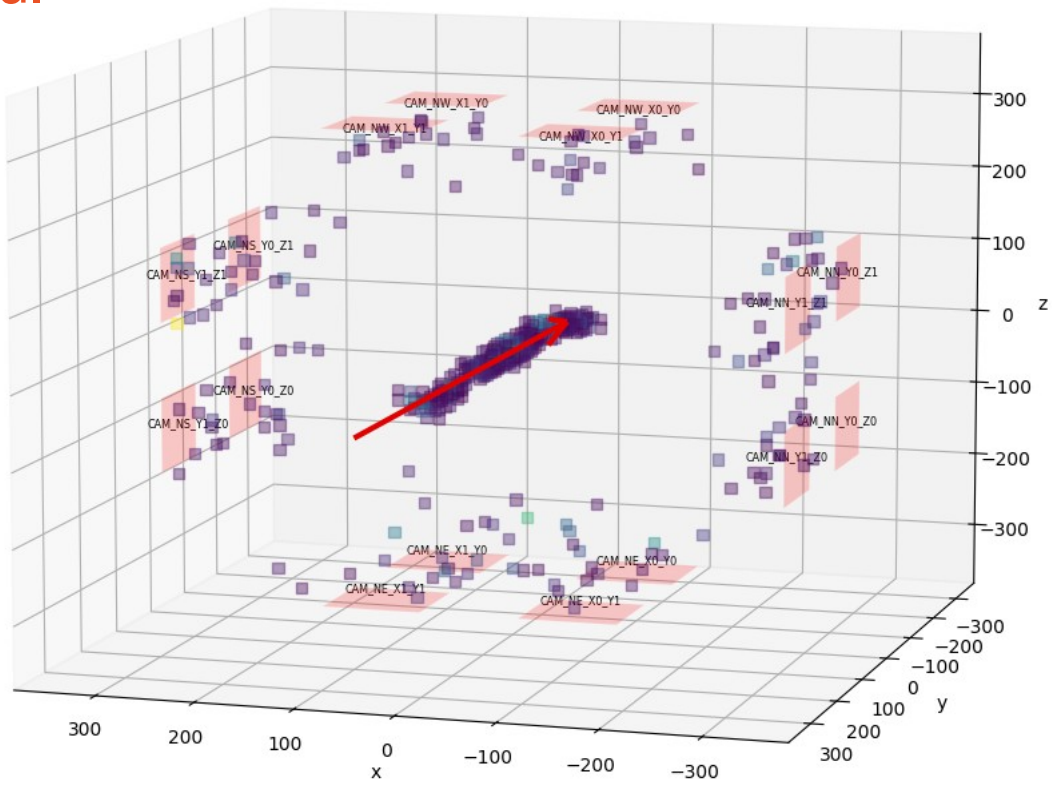
The corrected solid angle will be

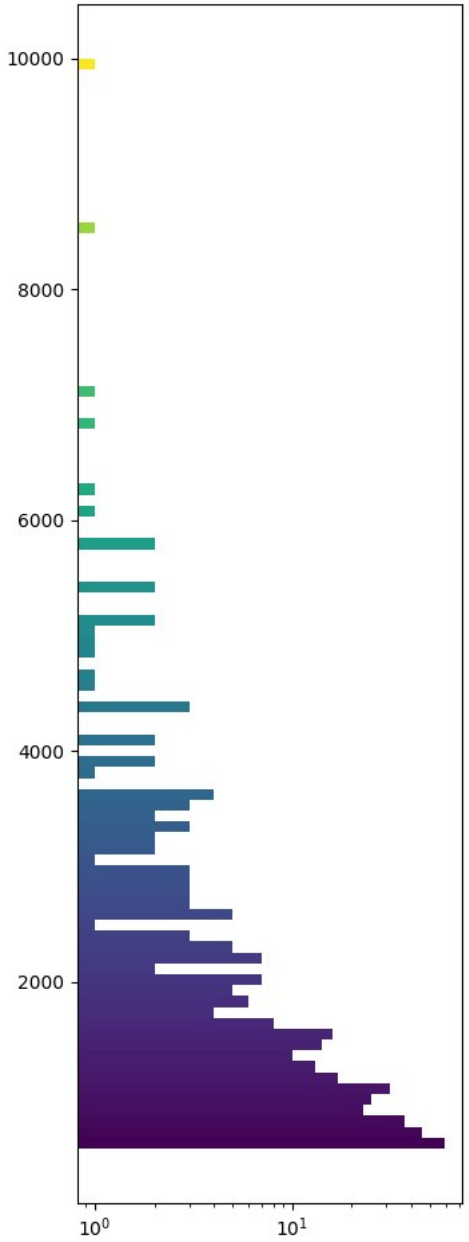
$$\Omega_{corr} = \frac{1}{N} \sum_{i=1}^{i=N} \Omega_i$$



Without corrections

Cut with score > 600 a.u.
for visualization

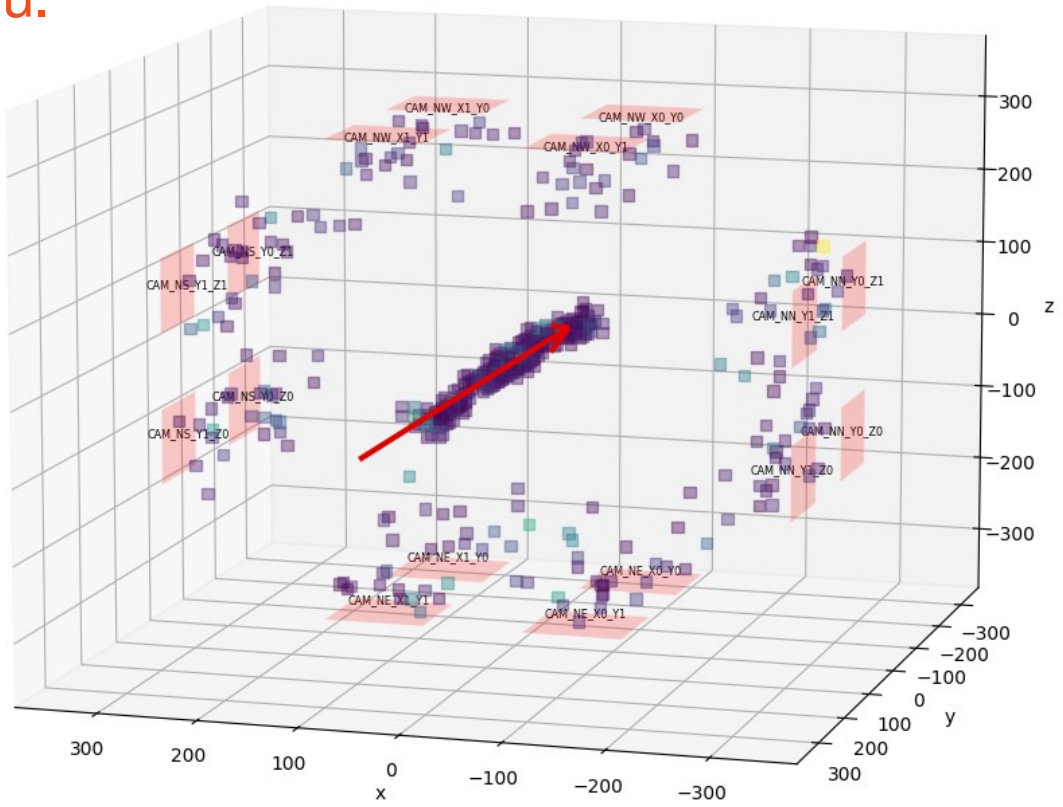


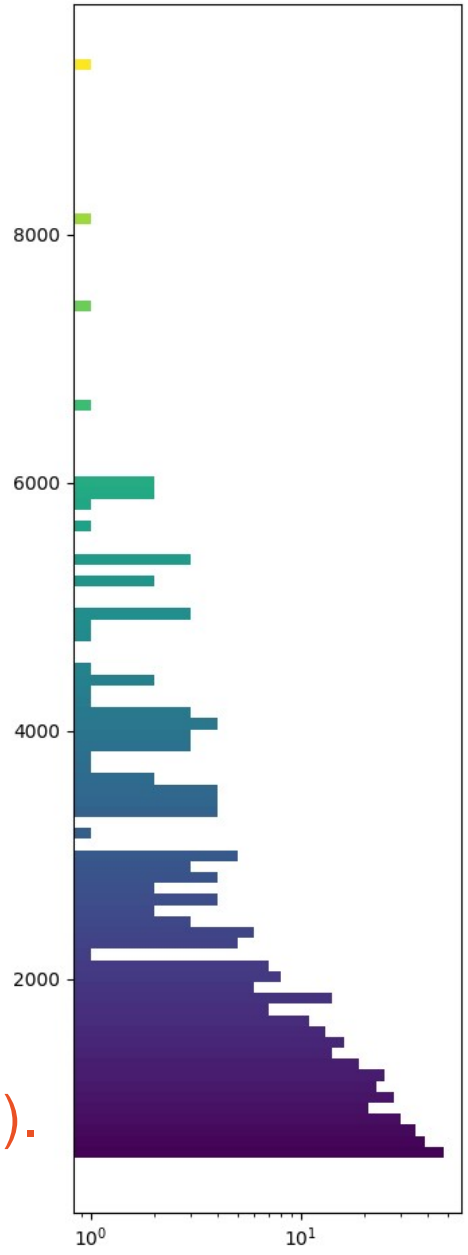


Display of reconstructed voxels in a GEANT muon event (axis in mm).
This is a 4x4 cam simplified geometry.

After overlap corrections

Cut with score > 600 a.u.
for visualization

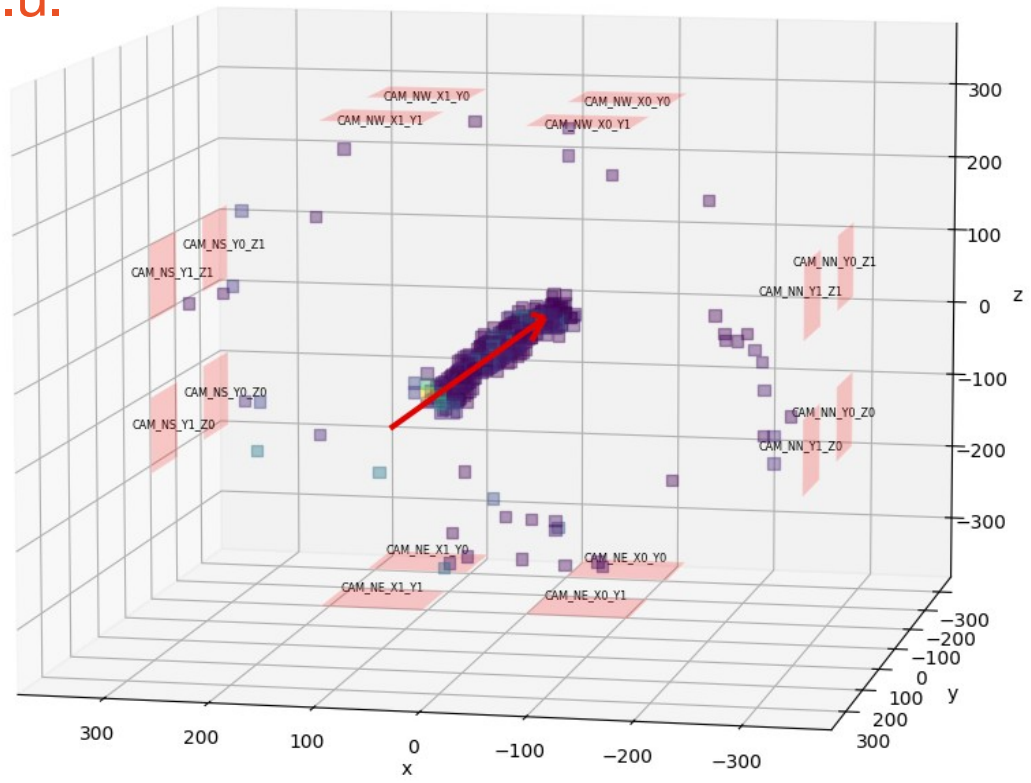


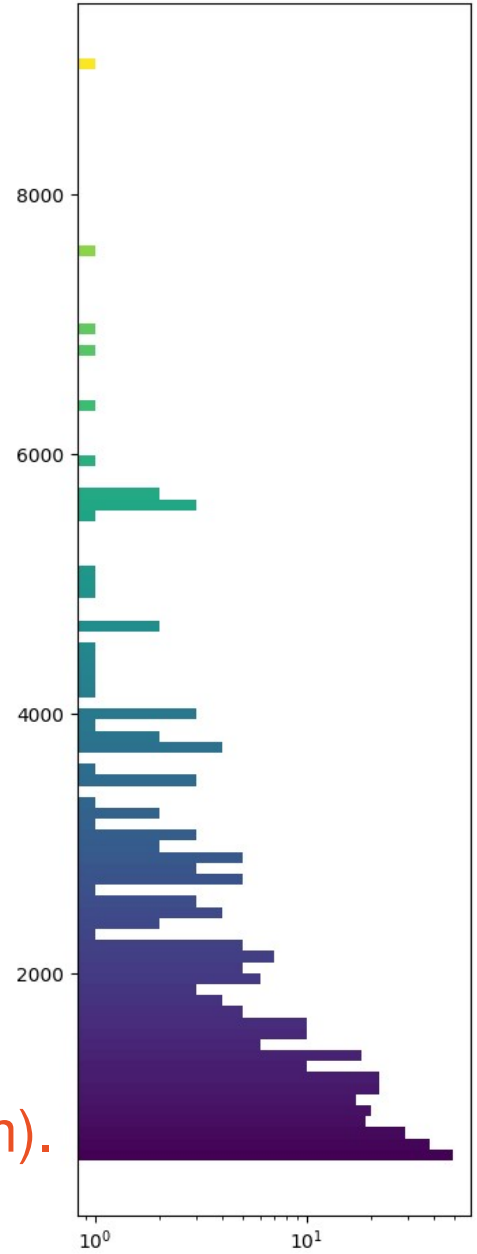


Display of reconstructed voxels in the same GEANT muon event (axis in mm).
This is a 4x4 cam simplified geometry.

After solid angle corrections

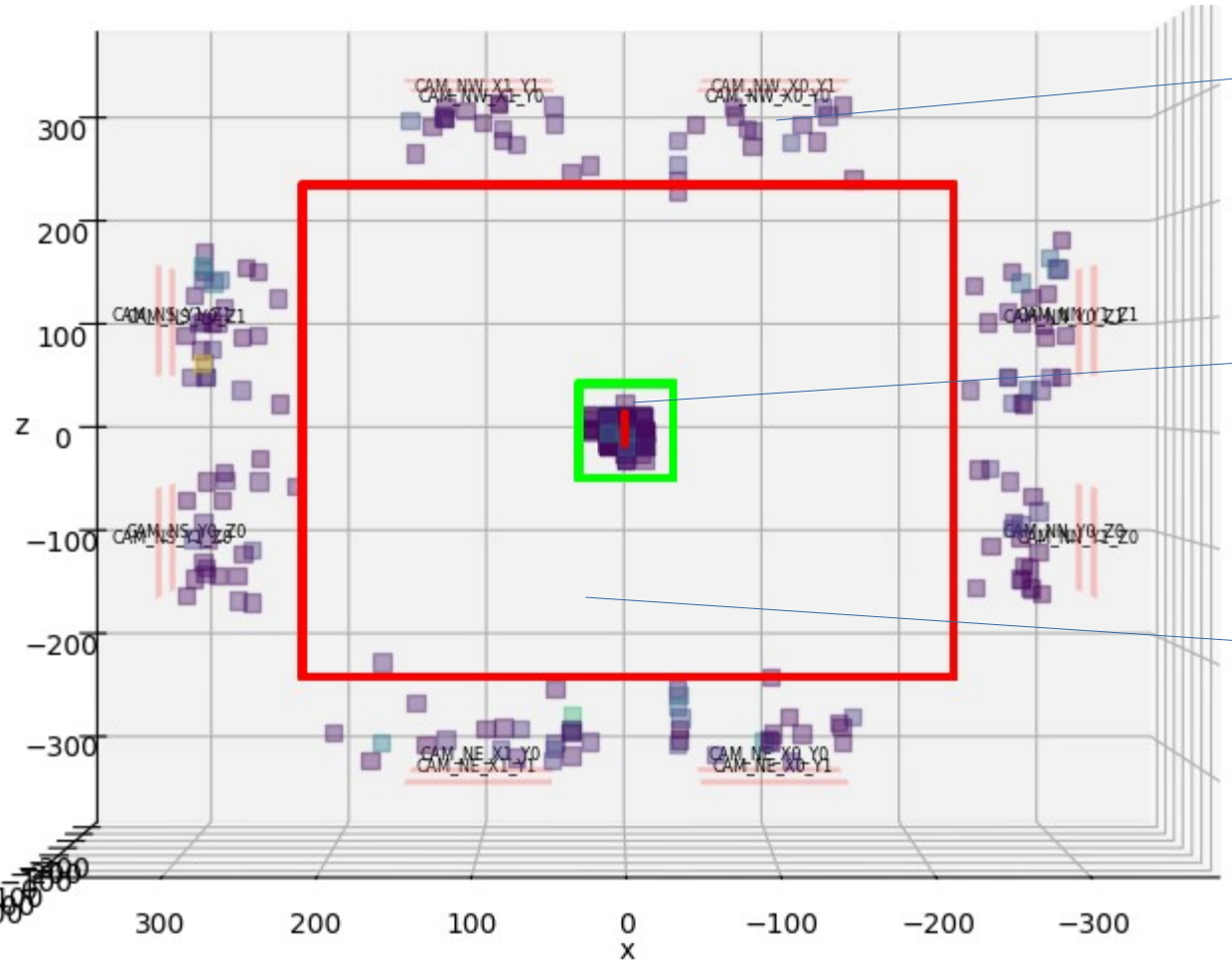
Cut with score > 600 a.u.
for visualization





Display of reconstructed voxels in the same GEANT muon event (axis in mm).
This is a 4x4 cam simplified geometry.

Comparison metrics

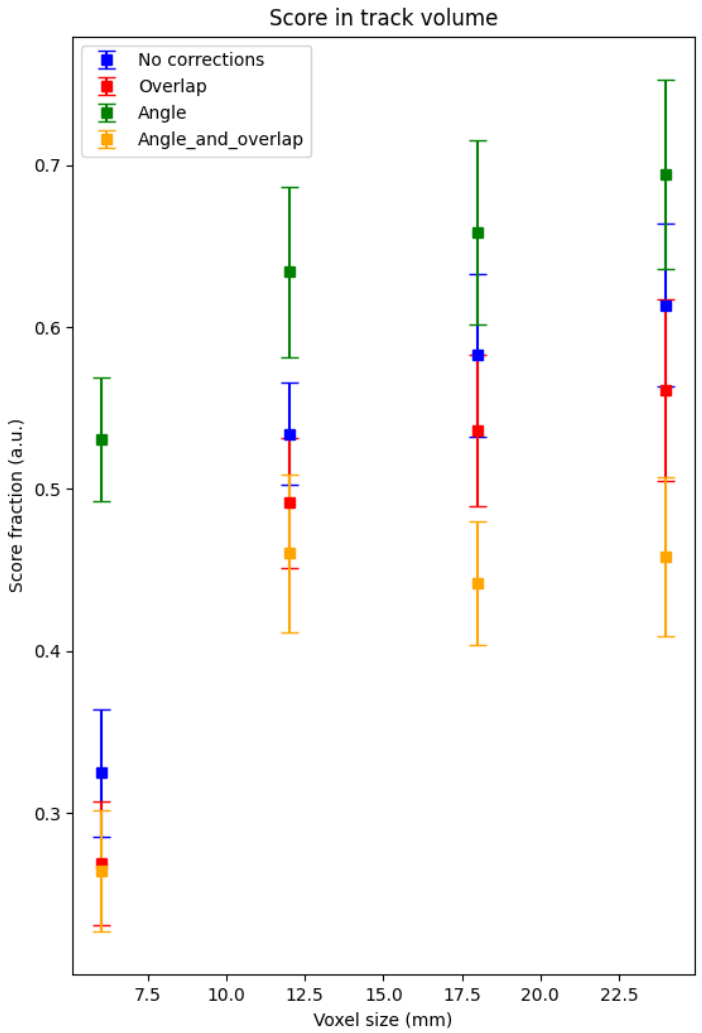


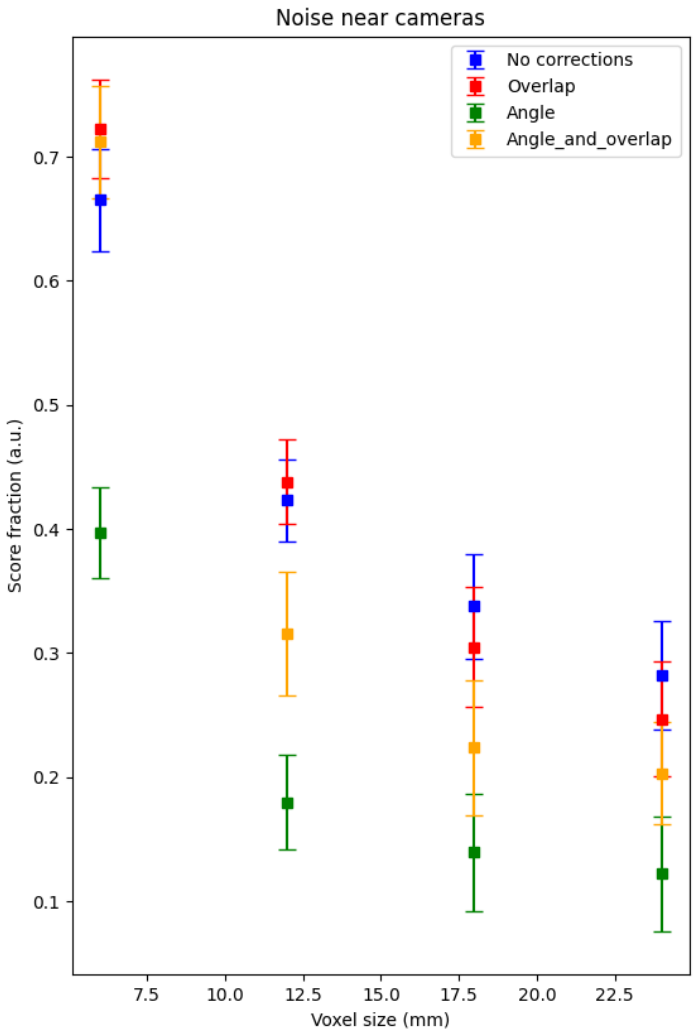
Noise near cameras
(within 8 cm from cameras)

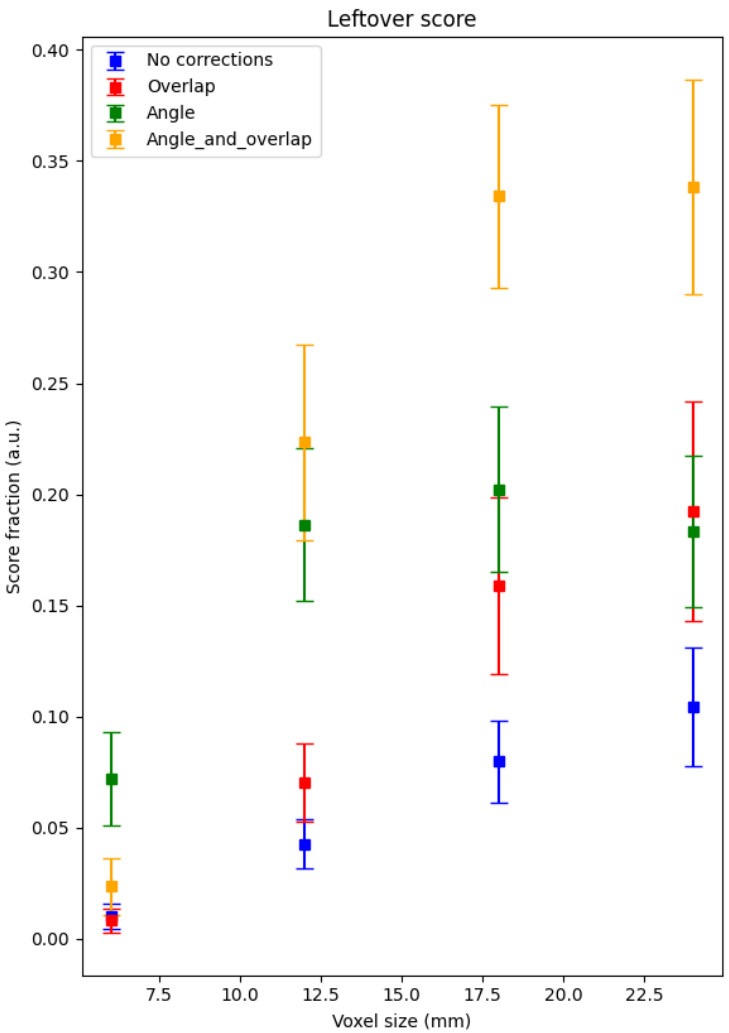
Score in track volume
(within 3 cm from track)

Leftover score

Comparison metrics







Computational cost

The probability matrix depends only on the geometry, thus it needs to be computed only once (not every event). Nevertheless, we are bounded by some computing constrains: **GPU RAM** (4x32 GB on HPC) and **computing time** (33h max on HPC).

Voxel size impacts both GPU RAM and computing time.

Minivoxel number impacts only computing time (since the values are averaged before transferring the data outside of the GPU).

Conclusions

The corrections for the solid angle computation greatly improved the (preliminary) reconstruction, reducing the relative score of noisy voxels near cameras by a factor 2.

On the other hand, the overlap correction does not seem to improve (preliminary) reconstruction.

Reducing the voxel size under 12 mm results in a lower signal/noise ratio.

Next steps:

- Use the full GRAIN geometry
- Compare event reconstruction between with and without solid angle correction.