A Geant4-based framework for the optical simulation of interactions in ND-GAr

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Primary scintillation in ND-GAr

The IGFAE team have shown that

- there is at least one viable argon-based gas mixture that provides a strong enough scintillation signal;

- and that (according to simulations) such a signal could be detected with a dense array of cooled SiPMs at the cathode with good time resolution for a low energy threshold.

Primary scintillation in ND-GAr

Assuming:

- Photons generated from a 5 MeV proton
- R_{anode} = 0%
- Readout plane covering full cathode area (SiPM@650nm or Arapuca@UV (170/275 nm)

Gas mixture	Ar/CF4 (99/1)	Ar/CF4 (99/1)	Ar/Xe (assume only Xe scintillation)
Photon wavelength (λ)	650 ± 75 nm	275 ± 50 nm	170 ± 6 nm
Energy to produce a photon (W_{SC})	1400 eV	5500 eV	40 eV
Scintillation yield (Y_{SC})	714 ph/MeV	182 ph/MeV	25000 ph/MeV
Reflectivity teflon	95%	85%	60%
GE at mid chamber (z = 2.5 m)	46.9%	41.5%	29.1%
QE	20% (SiPM)	15% (Arapuca w/o TPB)	5% (Arapuca with TPB)
N_{phe}	335	56	1818

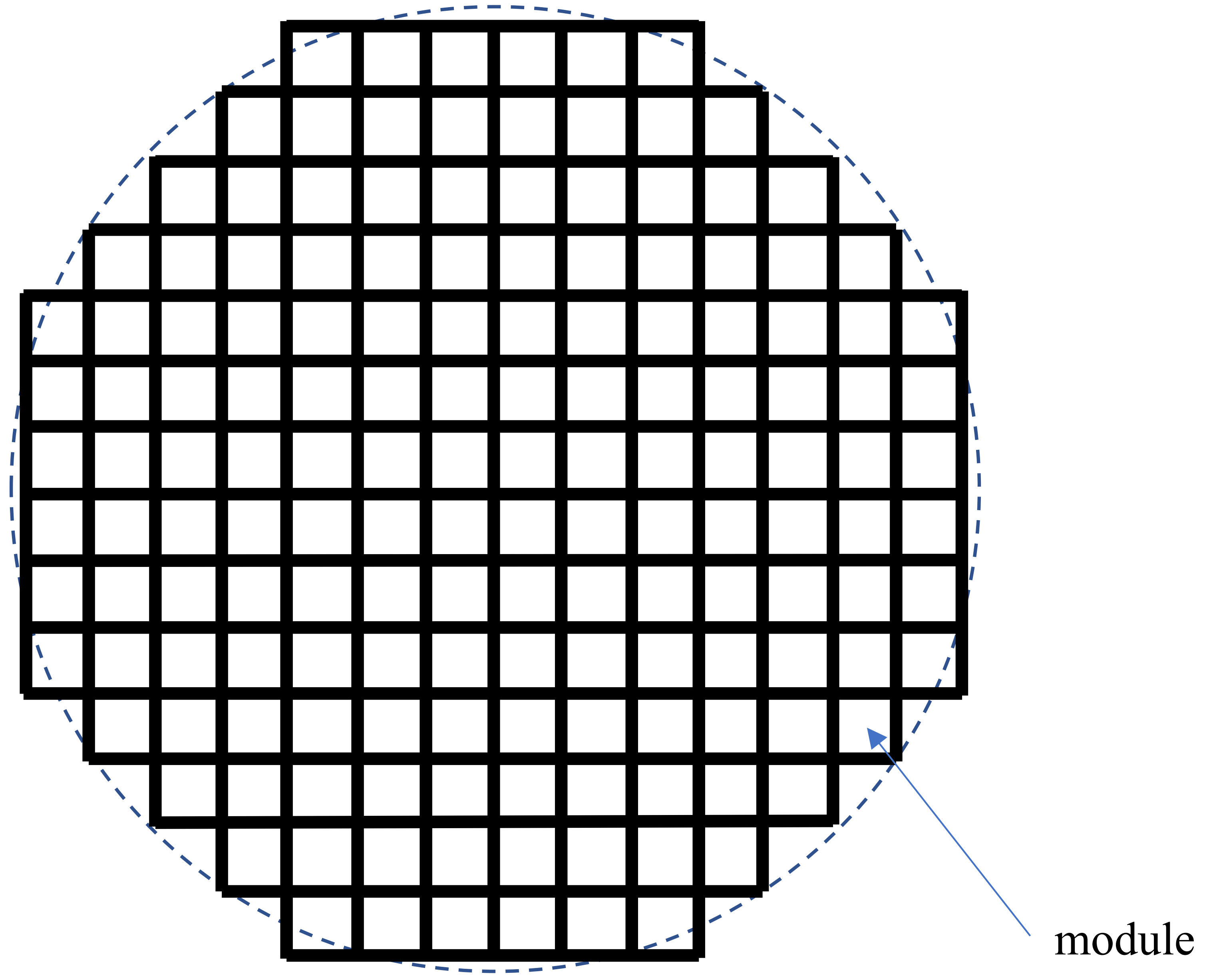
(Summary table by Diego G.)

Chosen concept for photodetector plane

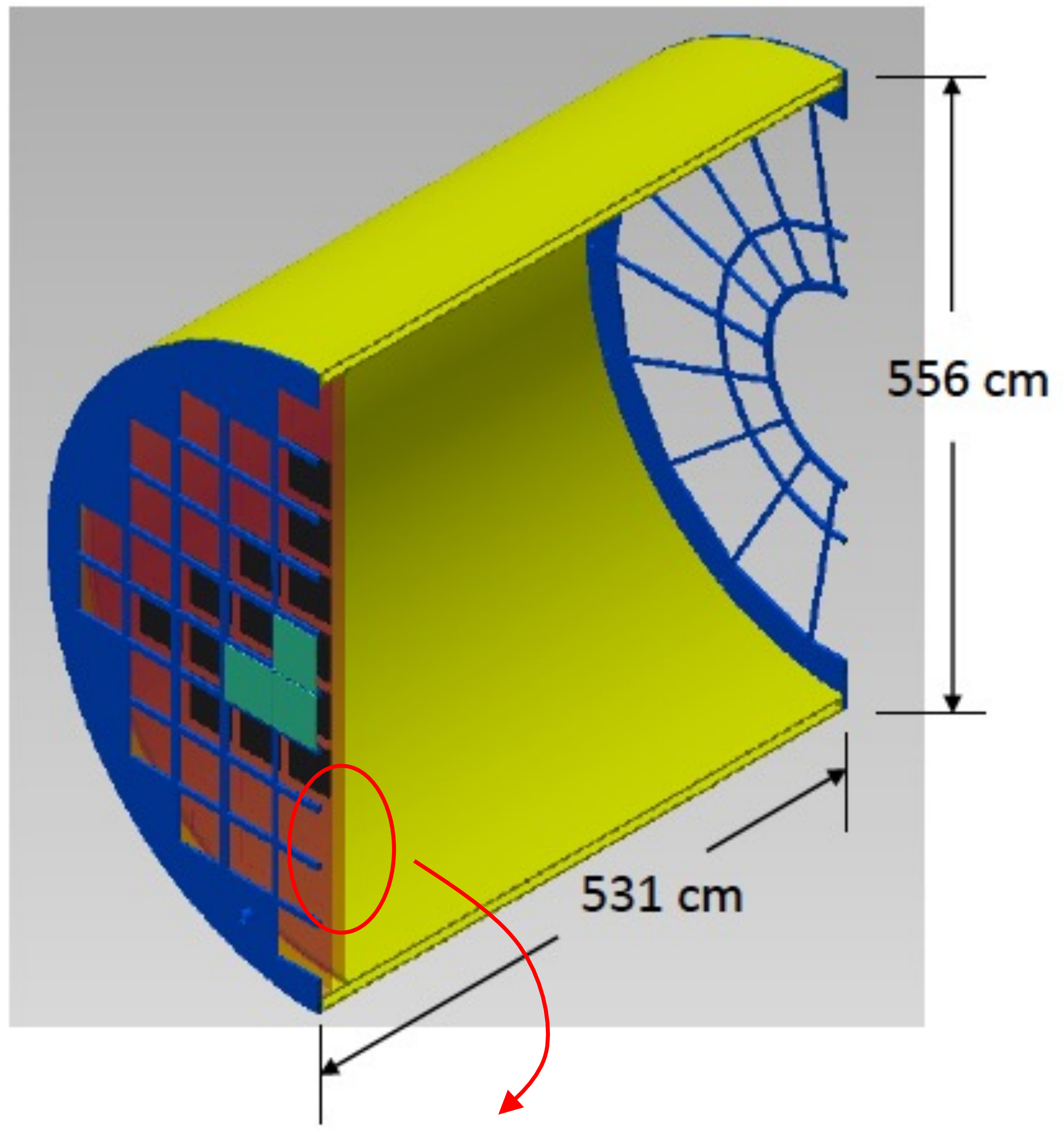
Best scintillating mixture only x5 more N_{phe}

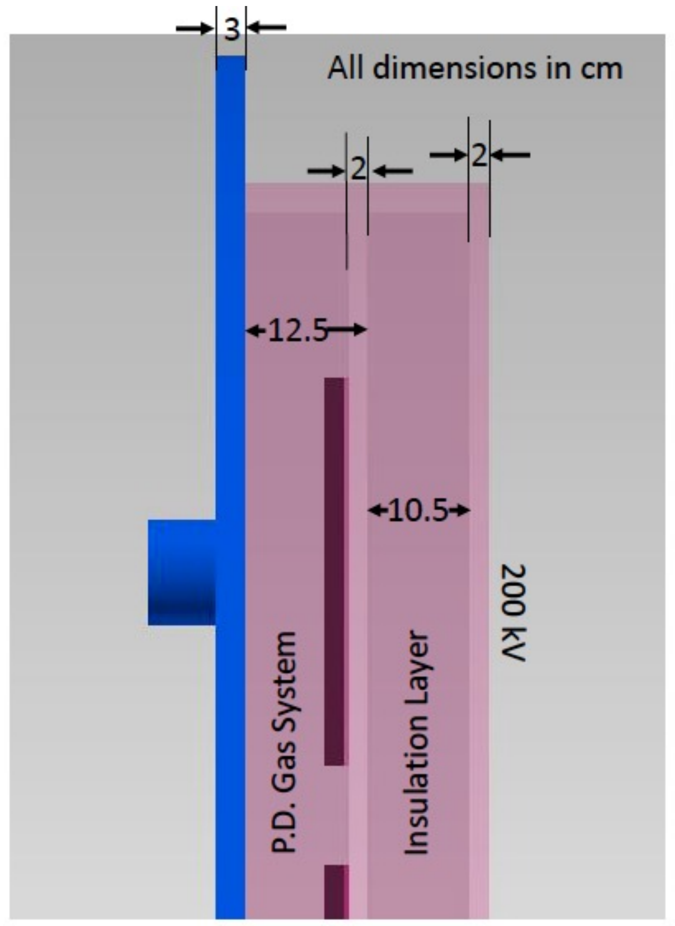
Primary scintillation in ND-GAr

(Approximate layout
ball-park numbers)



125-150 modules in cathode plane
196-256 tiles per module
16 SiPMs (6mm x 6mm) per tile (ganged)
32000 readout channels





Primary scintillation in ND-GAr

To establish firmly and explore further the concept, we want to study with simulation

- the limiting factors (e.g. optical pile-up) that can affect the reconstruction of the scintillation signal under realistic conditions;
- and the physics channels for which the scintillation signal may be particularly useful.

To address quickly the first goal, we have developed a new Geant4 application based on the simulation framework of the NEXT experiment.

Detector simulation

The application can simulate interactions in the TPC from particle guns or arbitrary input files.

It simulates as well the generation and detection of the corresponding primary signals (ionisation and scintillation), including drift effects (attachment and diffusion) and the generation of secondary scintillation.

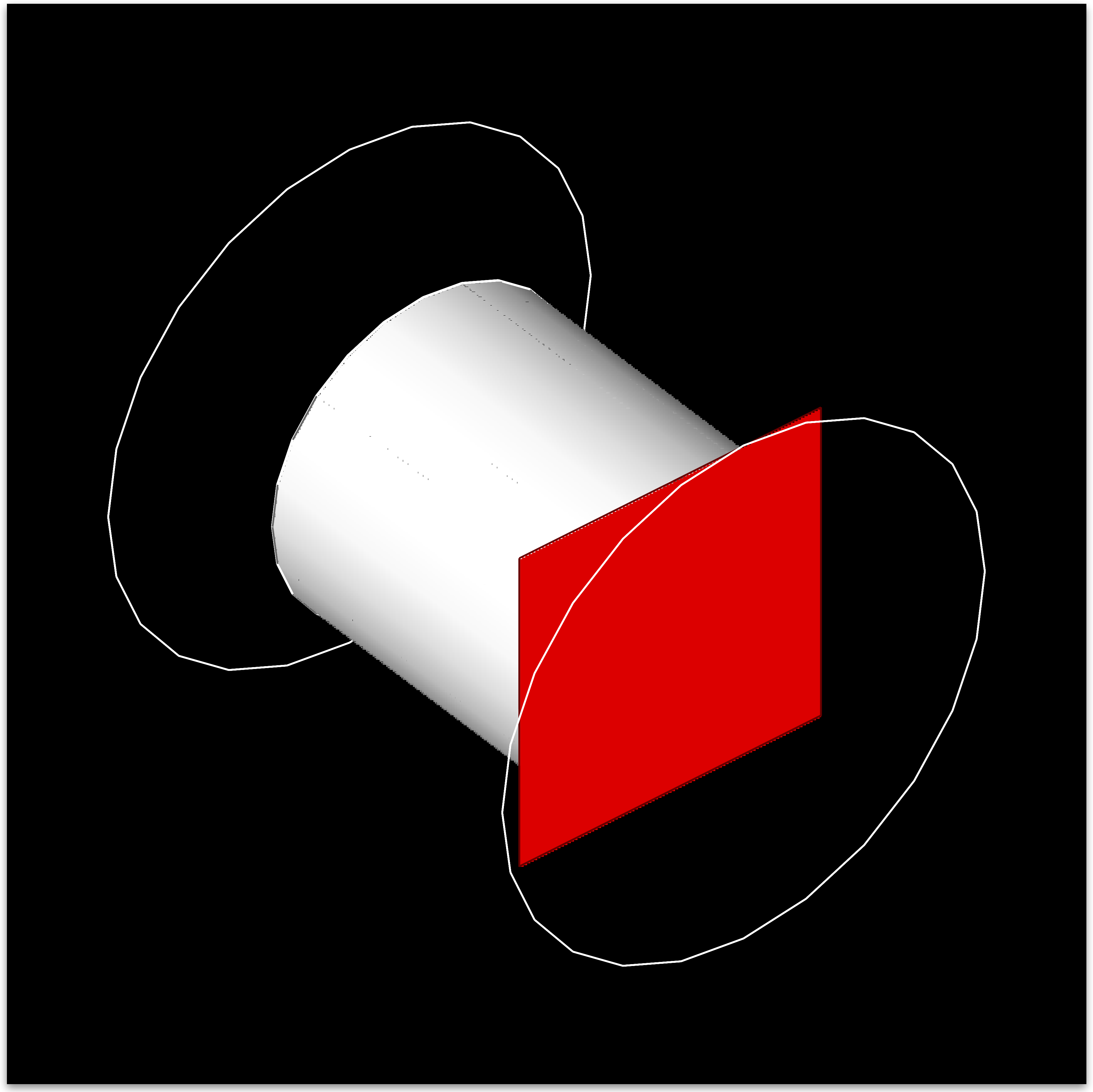
It produces an output HDF5 file that contains a record of the interactions and the waveforms registered by the SiPM tiles.

The code is publicly available in GitHub. Let us know if you're interested!

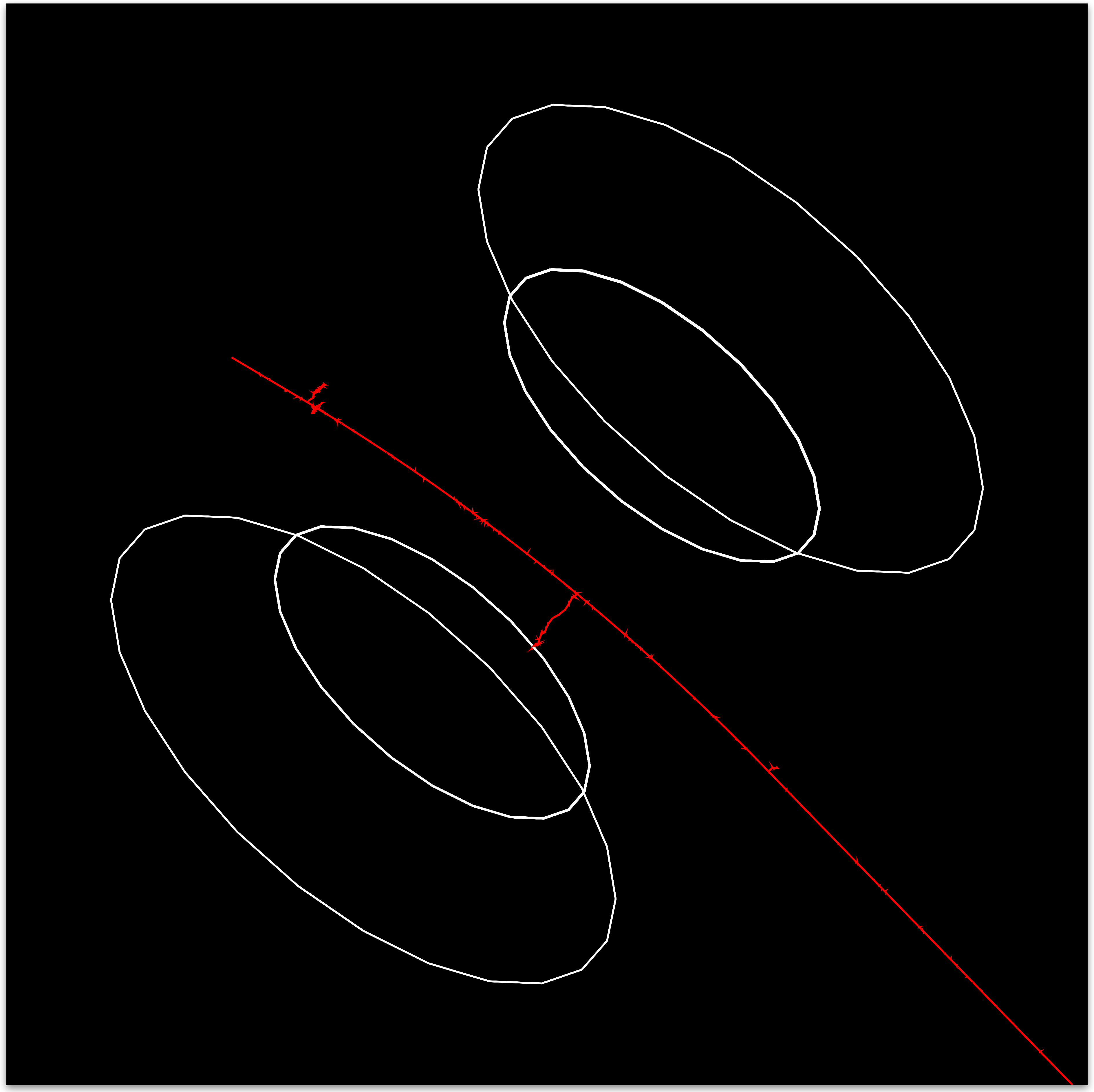
Detector geometry

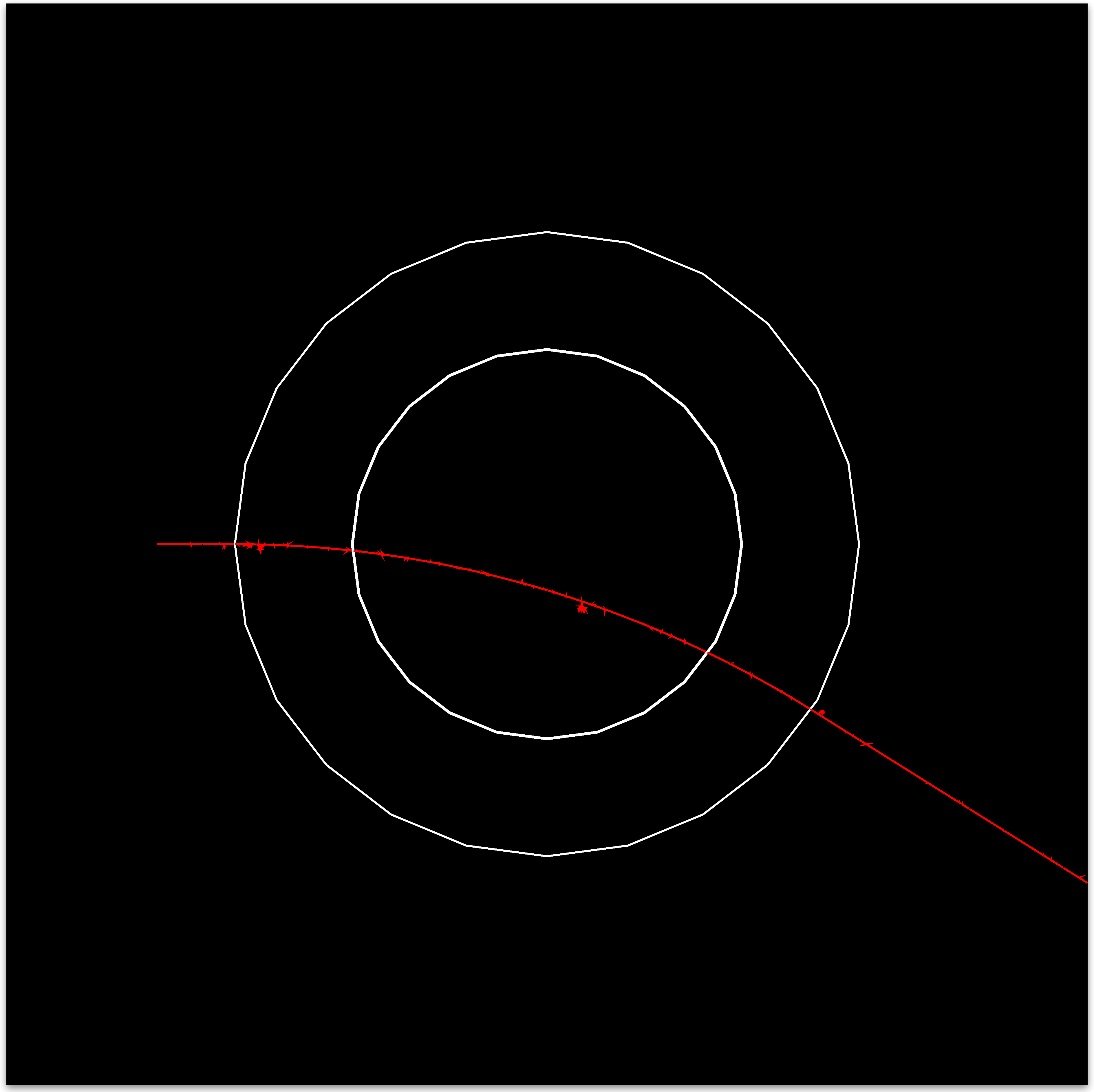
We have implemented a basic optical geometry of the TPC, including the array of photosensors and a PTFE tube as reflector.

At this stage, a more detailed geometry (or a description of the ND-GAr volumes outside the TPC) is not required.

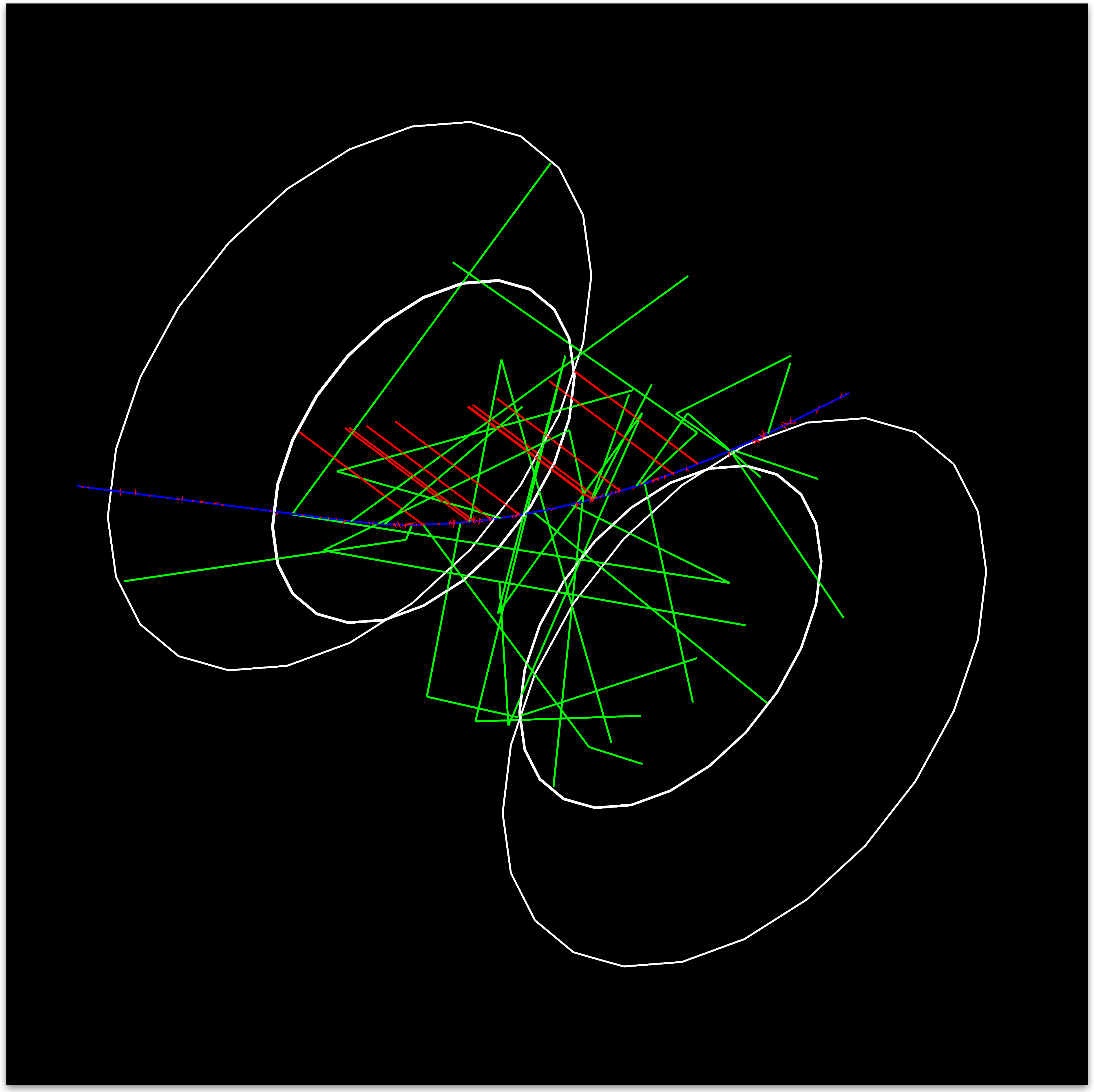


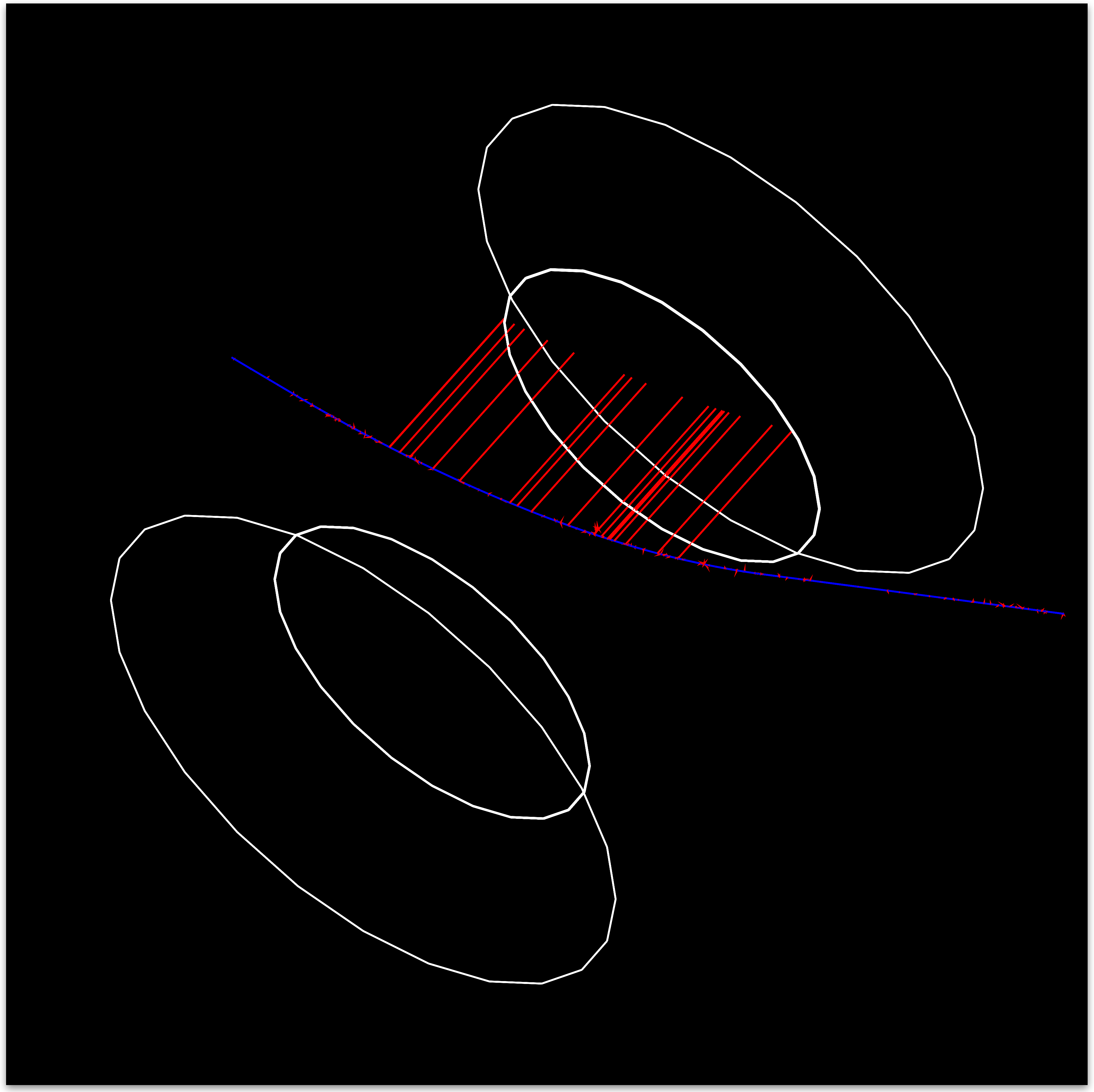
Event generation



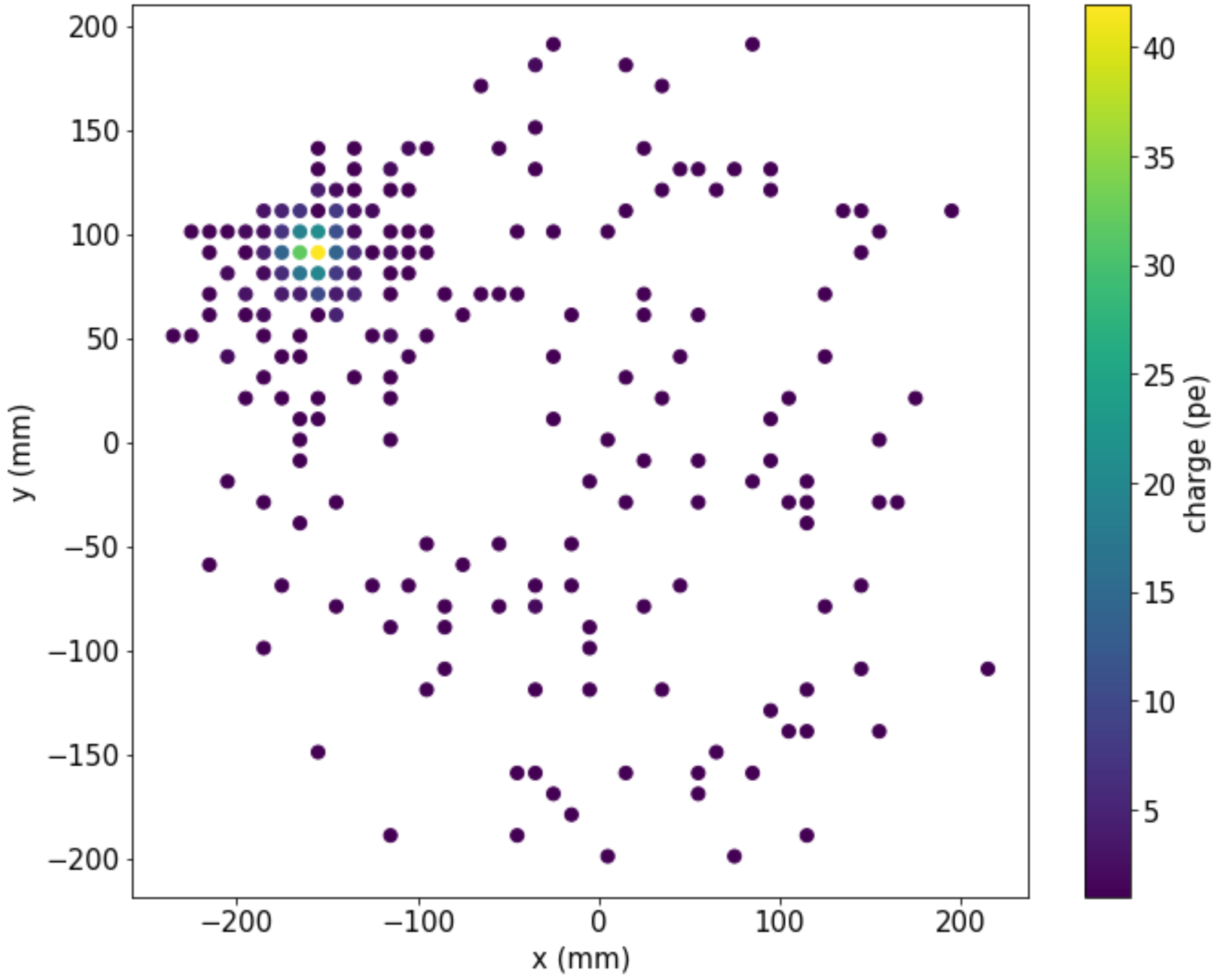


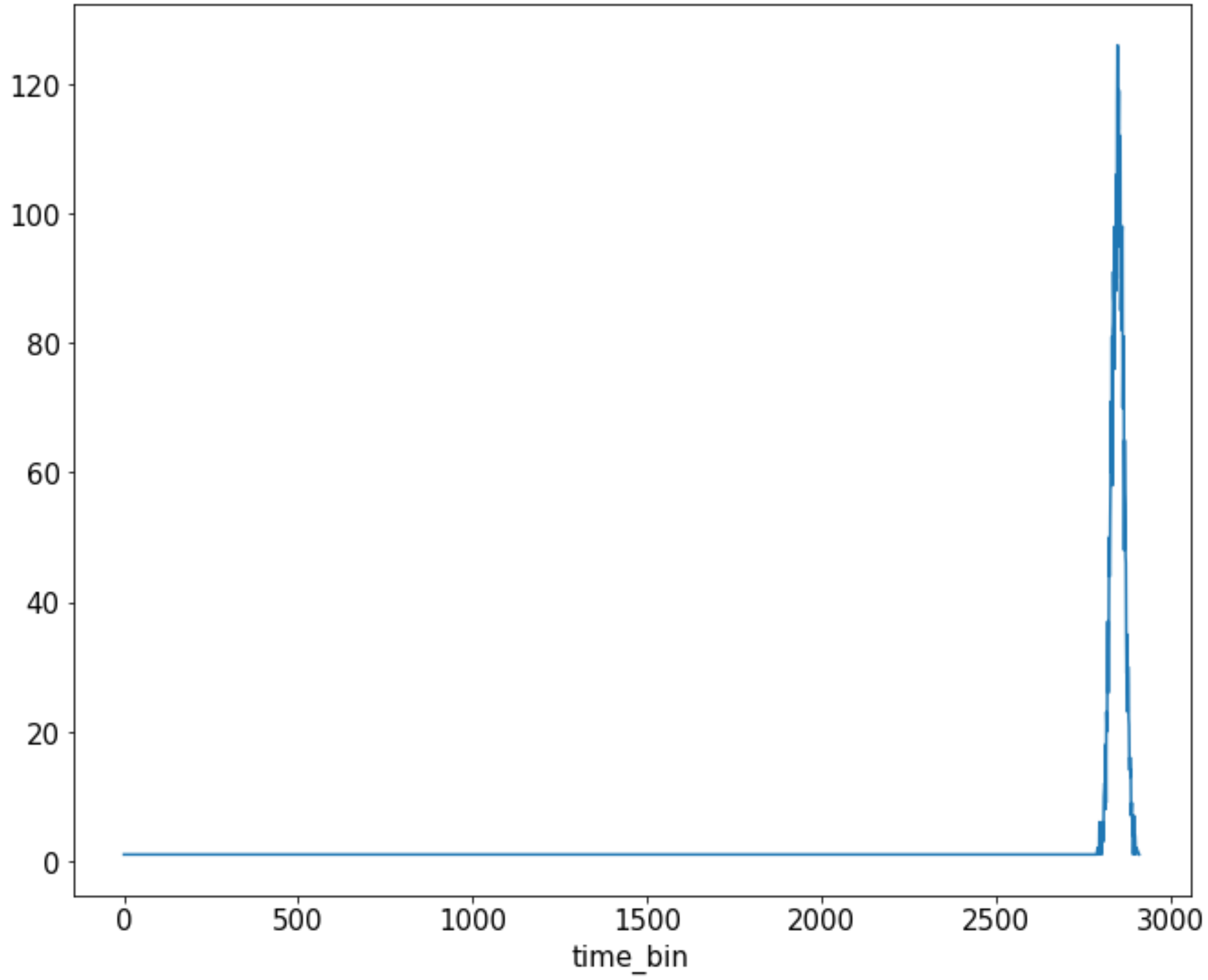
Scintillation and ionization drift





SiPM signals





Next steps

We will evaluate two things:

- Impact of secondary scintillation (S2) in the reconstruction of the primary scintillation signal (S1).
- S1 pile-up as a function of the TPC activity

Results are on the way. Stay tuned!