

Dual-Phase Photon Detector System (DP-PDS)

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DUNE-IFIC Meeting, 2019-03-07

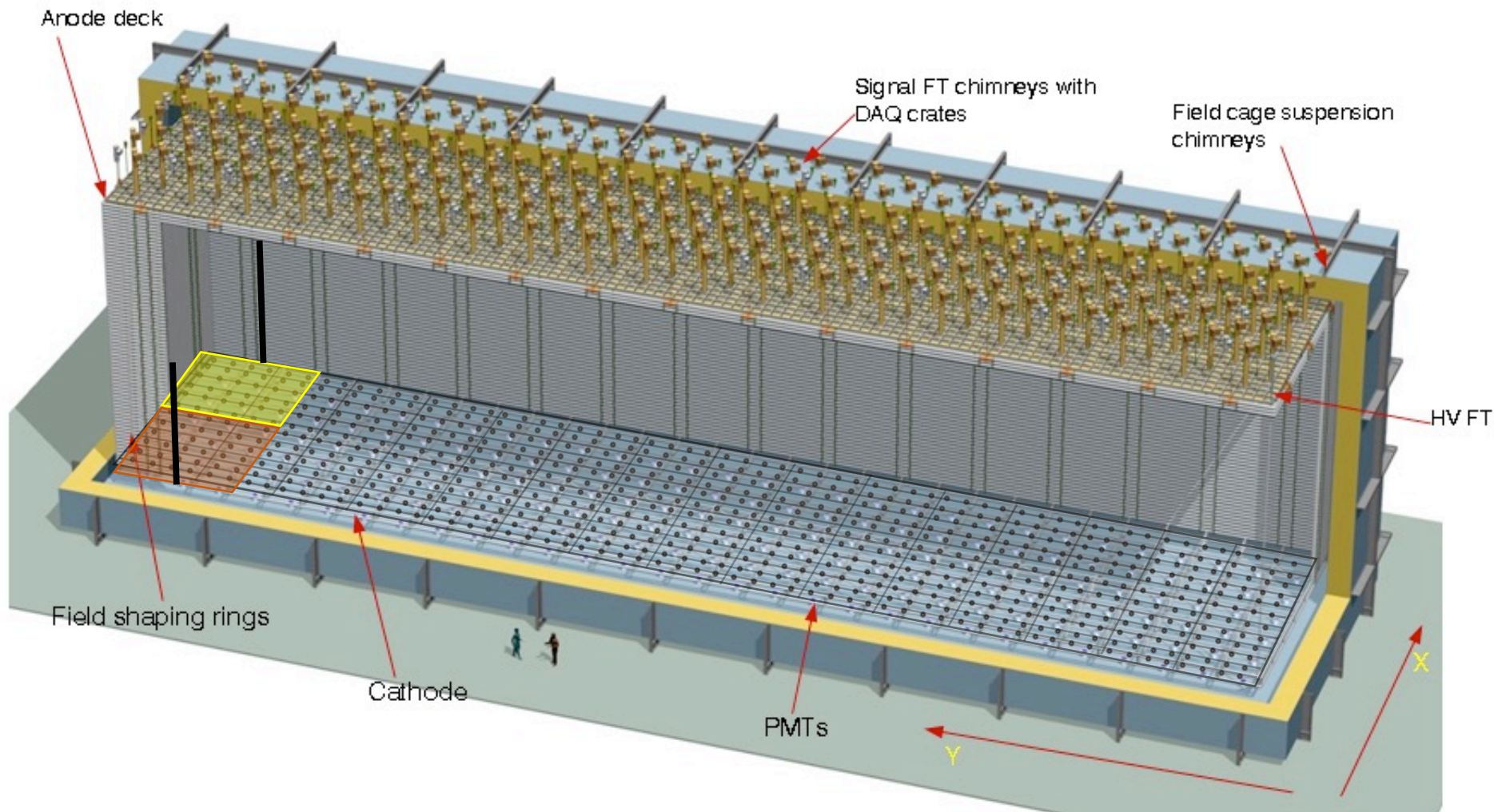
TDR schedule for DP-PDS chapter

- First draft to TDR general editors delivered on **March 1st**, 2019
- Second draft to TDR editors due **April 5th**, 2019
- Version to be reviewed by LBNC due **April 26th**, 2019
- TDR process to be completed by **July**, 2019
- 1st draft can be found here: <https://cernbox.cern.ch/index.php/s/6zNvySk5BKQ1WSj>
- In the following, I will review some of its highlights

Physics requirements and goals

- Scientific **requirements**:
 - Event fiducialization for non-beam events, particularly for proton decay
 - Supernova burst triggering with PDS, at least up to Milky Way boundaries (20 kpc)
 - Scintillation-Based calorimetry, particularly beam events
- Additional scientific **opportunities**:
 - Electron attachment correction for the charge-based energy measurement in non-beam events
 - Event timing in high multiplicity supernova burst events
 - Improved event identification via scintillation-scintillation-based Michel electron tagging

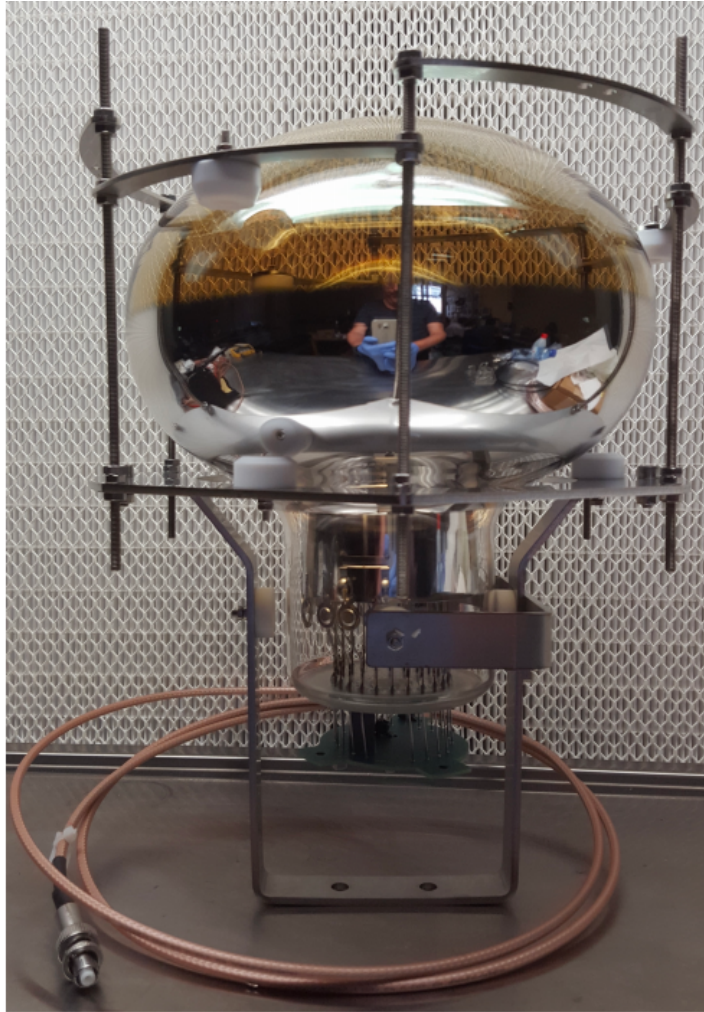
Design overview



Detector design specifications

Description	Specification	Rationale
Minimum light yield	$> 1 \text{ PE/MeV}$	Enable fiducialization of NDK candidates
Average light yield	$> 3 \text{ PE/MeV}$	Enable PDS-based triggering on galactic SN bursts
Relative timing accuracy among hit	$< 100 \text{ ns (RMS)}$	Enable effective clustering of PMT signals based on relative hit timing information
Hit signal-to-noise ratio	> 5	Efficiently reconstruct single-PE hits while rate of electronics noise hits remains manageable
PMT dark count rate	$< 100 \text{ kHz}$	Dark counts should have negligible effect on clustering algorithm and PDS-based calorimetry
Analog range per channel	$> 100 \text{ PE / (channel} \times 6 \text{ ns)}$	Minimize hit saturation for scintillation-based calorimetry in beam neutrino interactions over characteristic 6 ns time of prompt scintillation light production
Time resolution	$< 1 \text{ } \mu\text{s}$	Enables 1 mm position resolution for 10 MeV SNB candidate events for instantaneous rate $< 1 \text{ m}^{-3} \text{ ms}^{-1}$

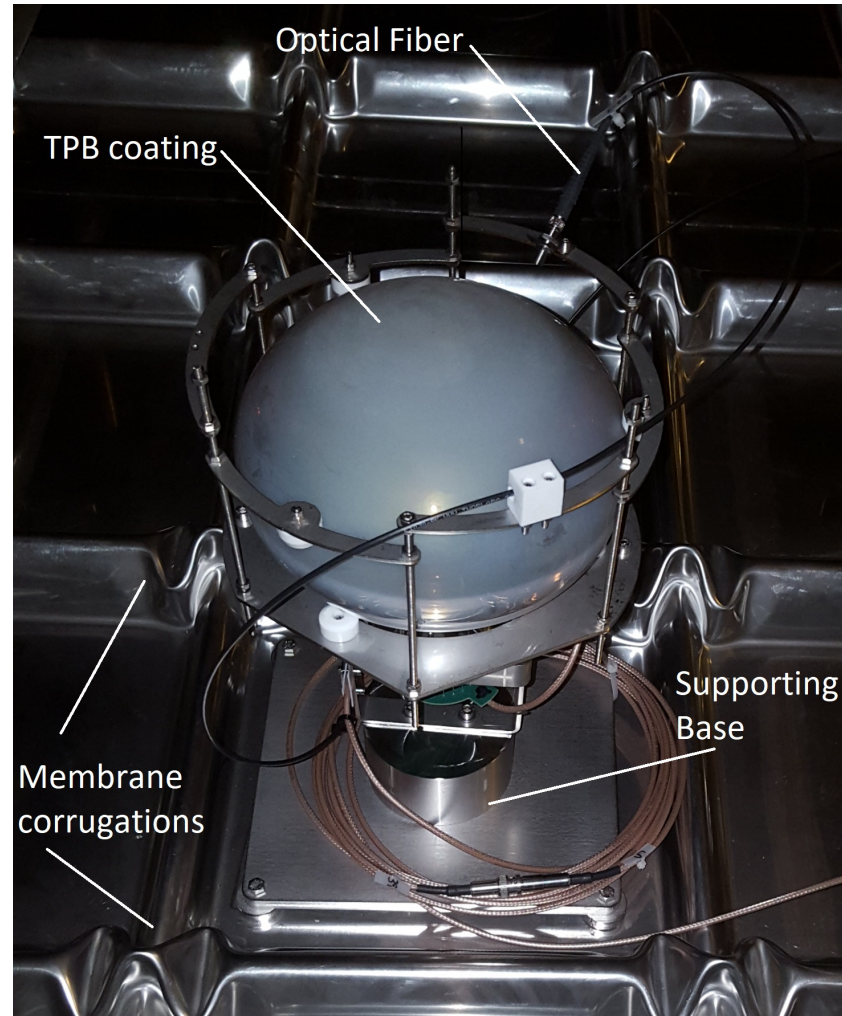
Photosensor system



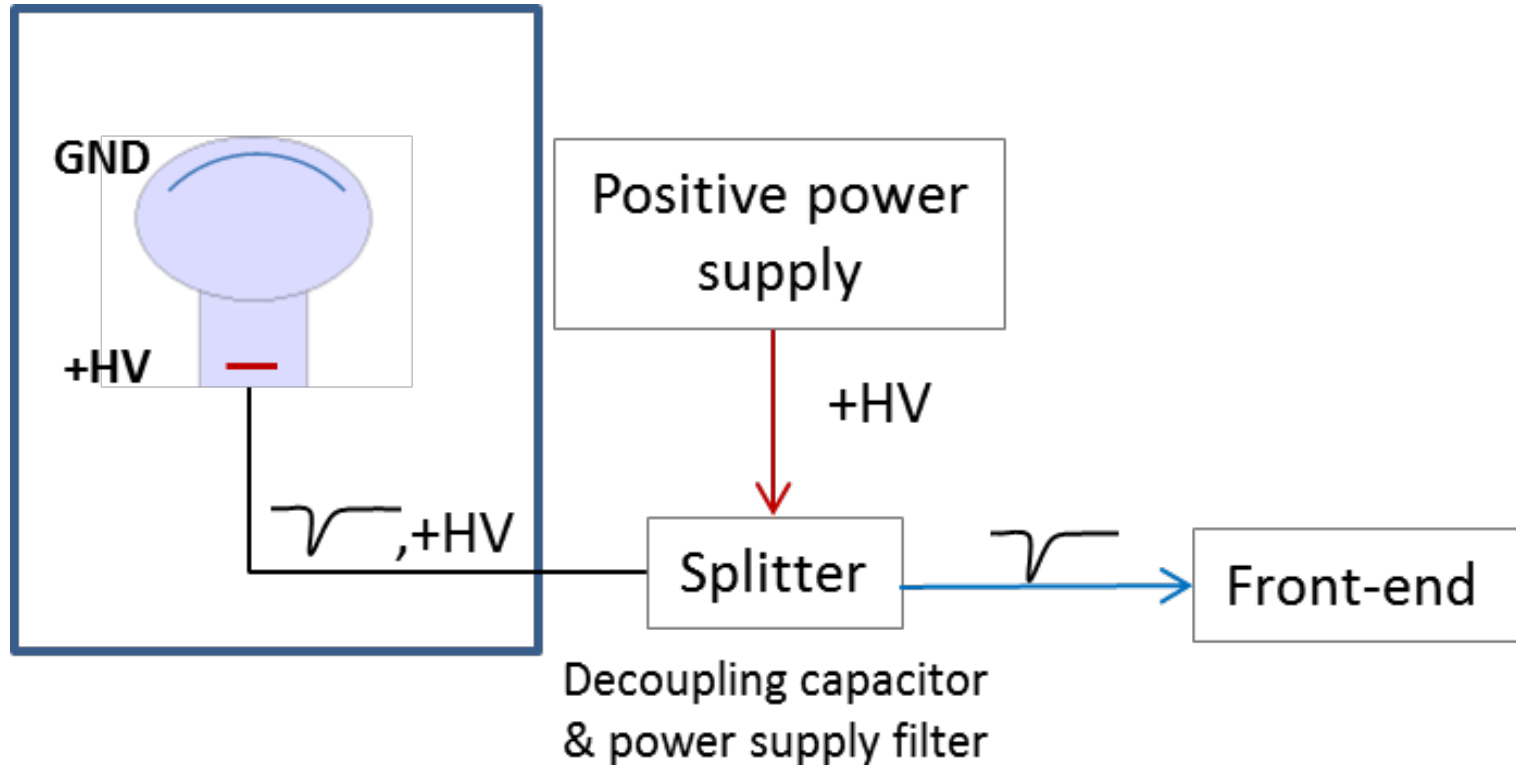
PMTs and support structures in WA105



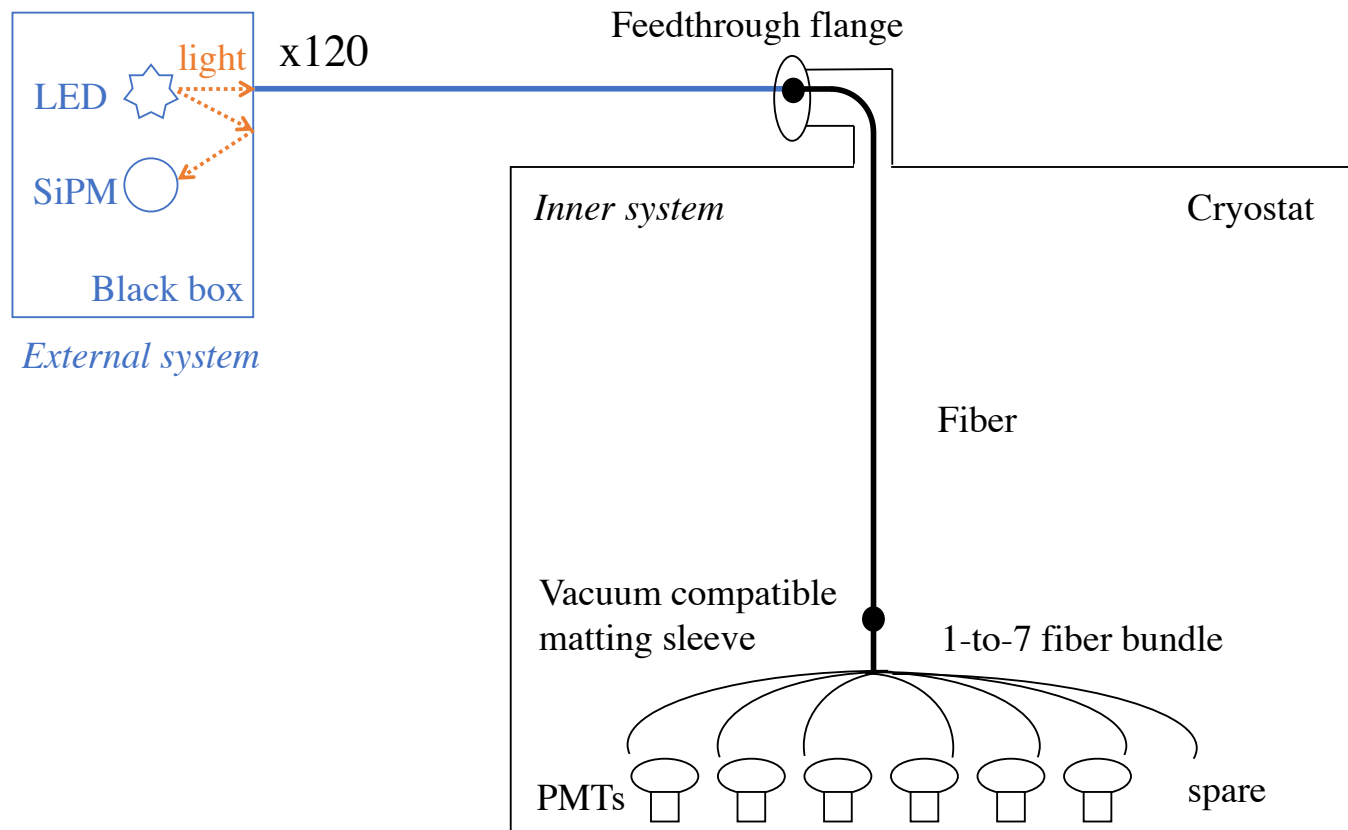
PMT and support structure in ProtoDUNE-DP



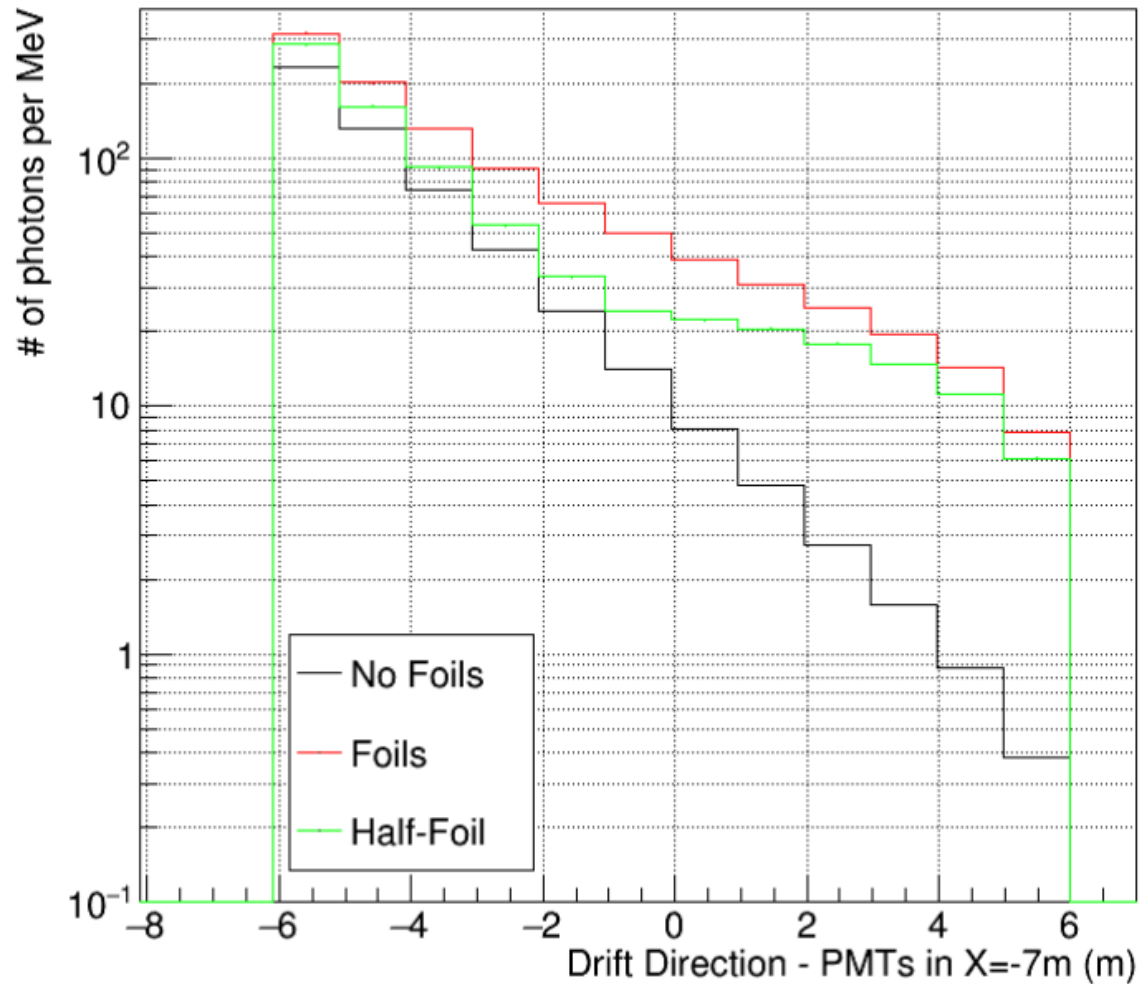
PMT base and HV/signal splitter



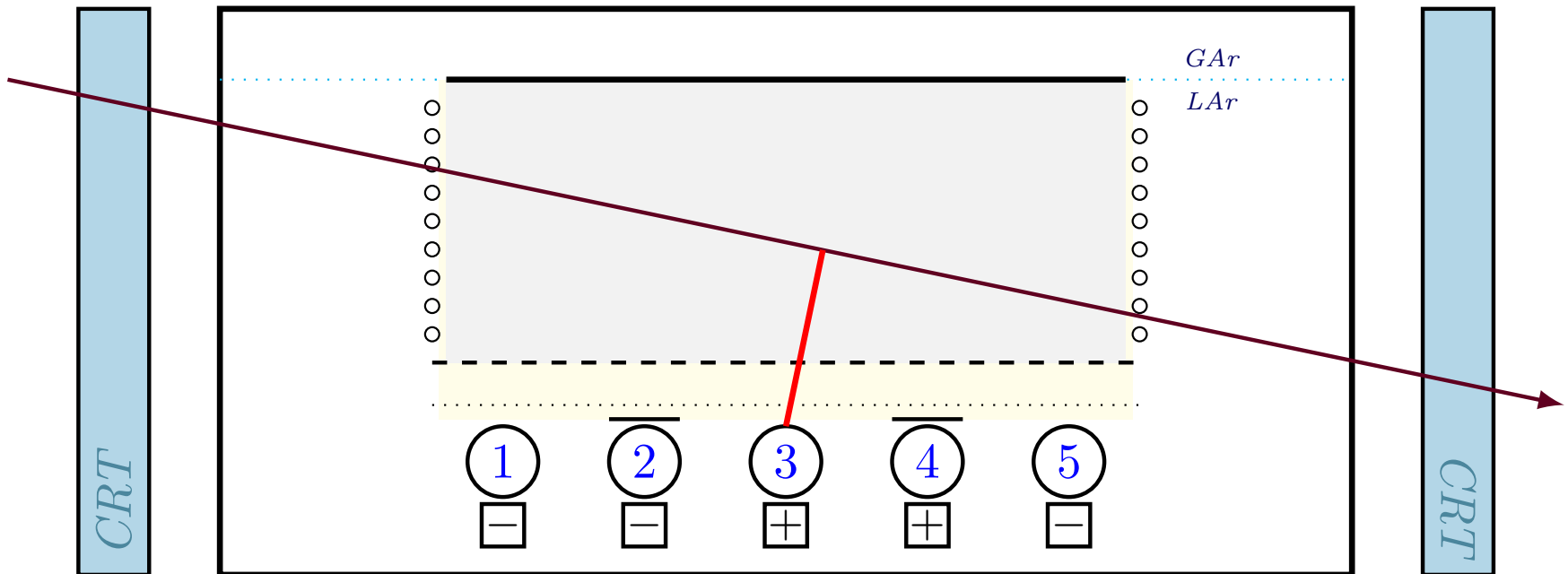
Calibration system



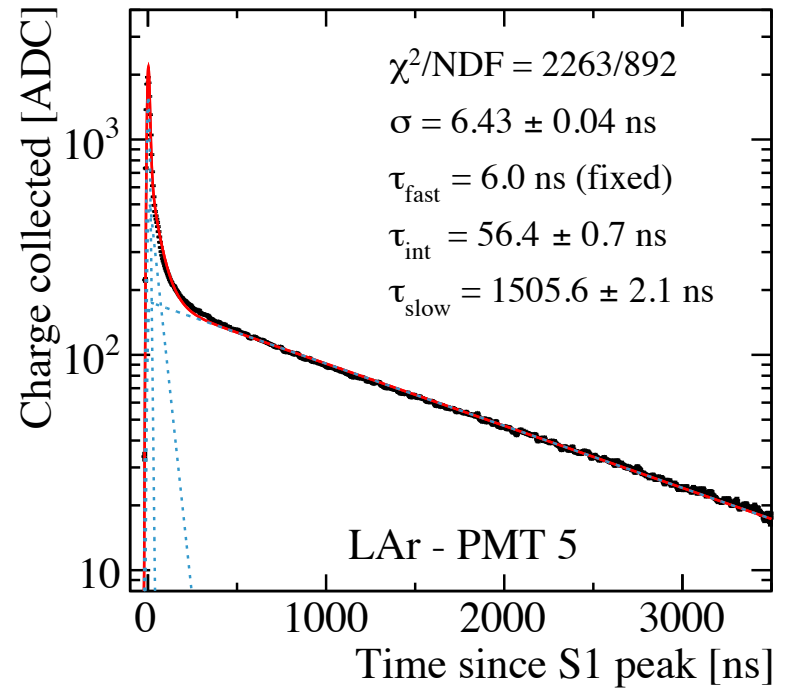
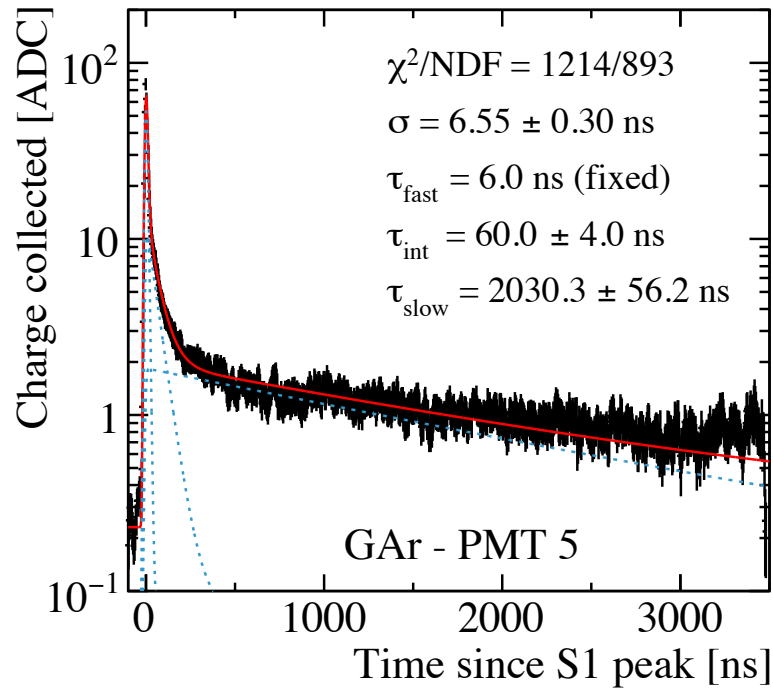
Photon detector simulation in FD module



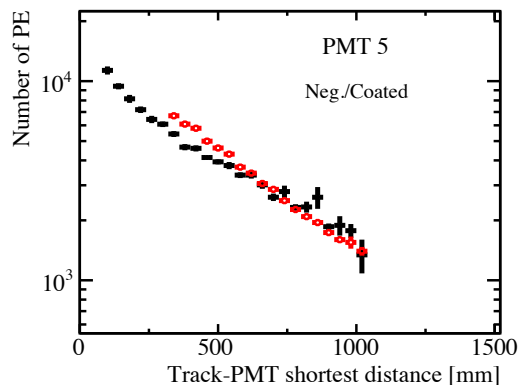
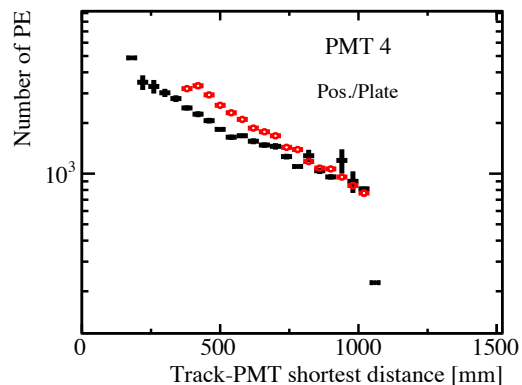
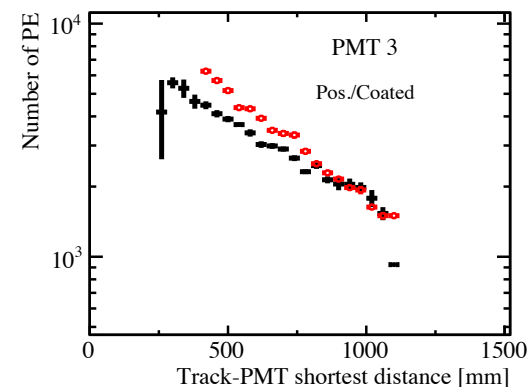
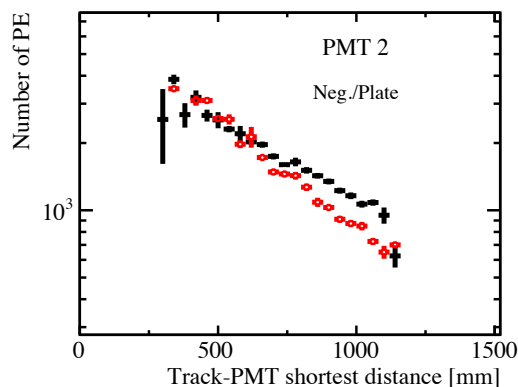
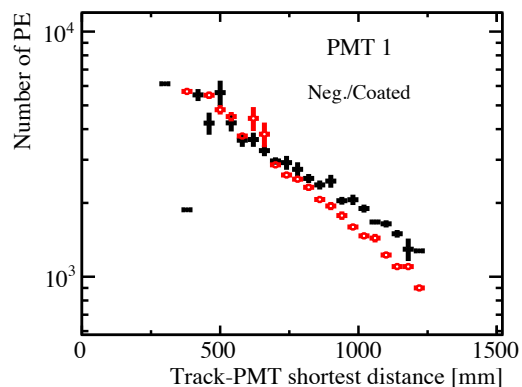
Schematic view of WA105



Scintillation time profile in WA105

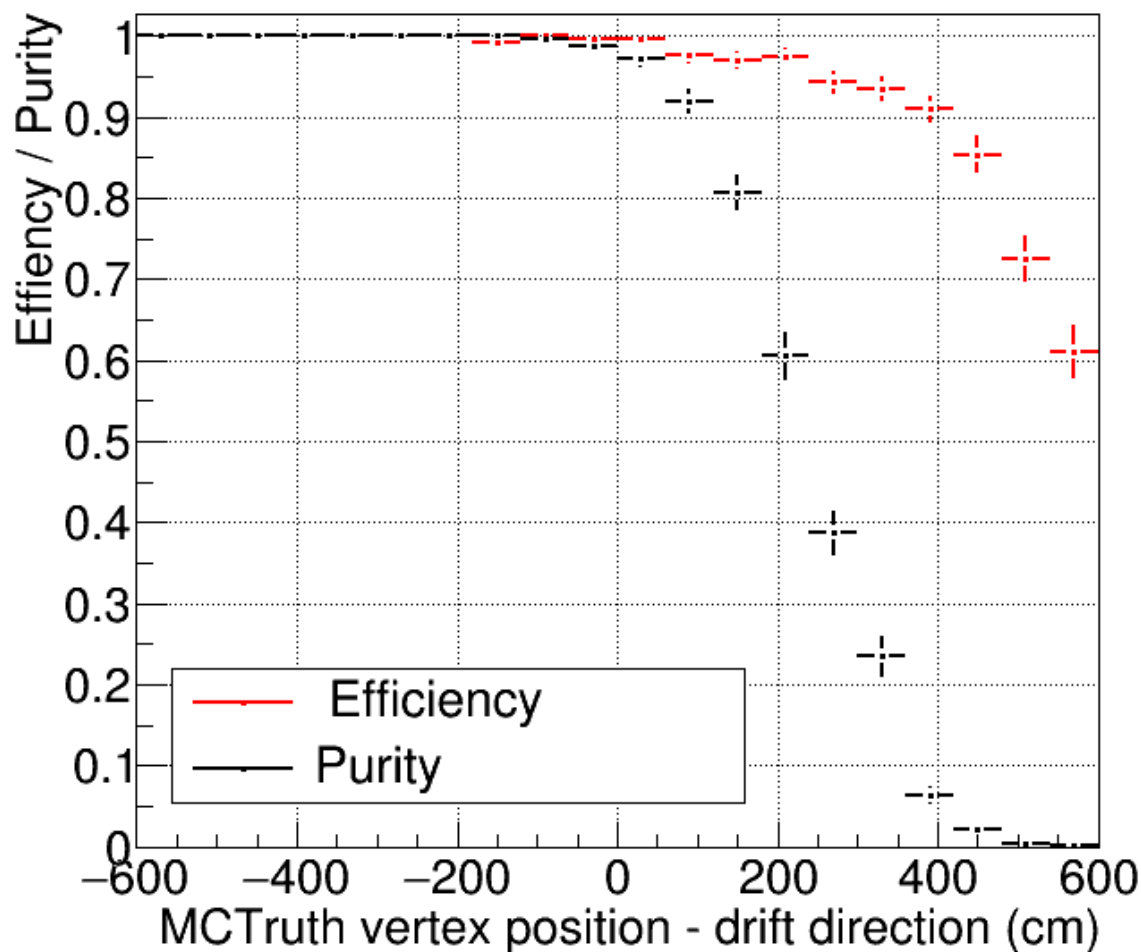


Data/MC comparisons in WA105

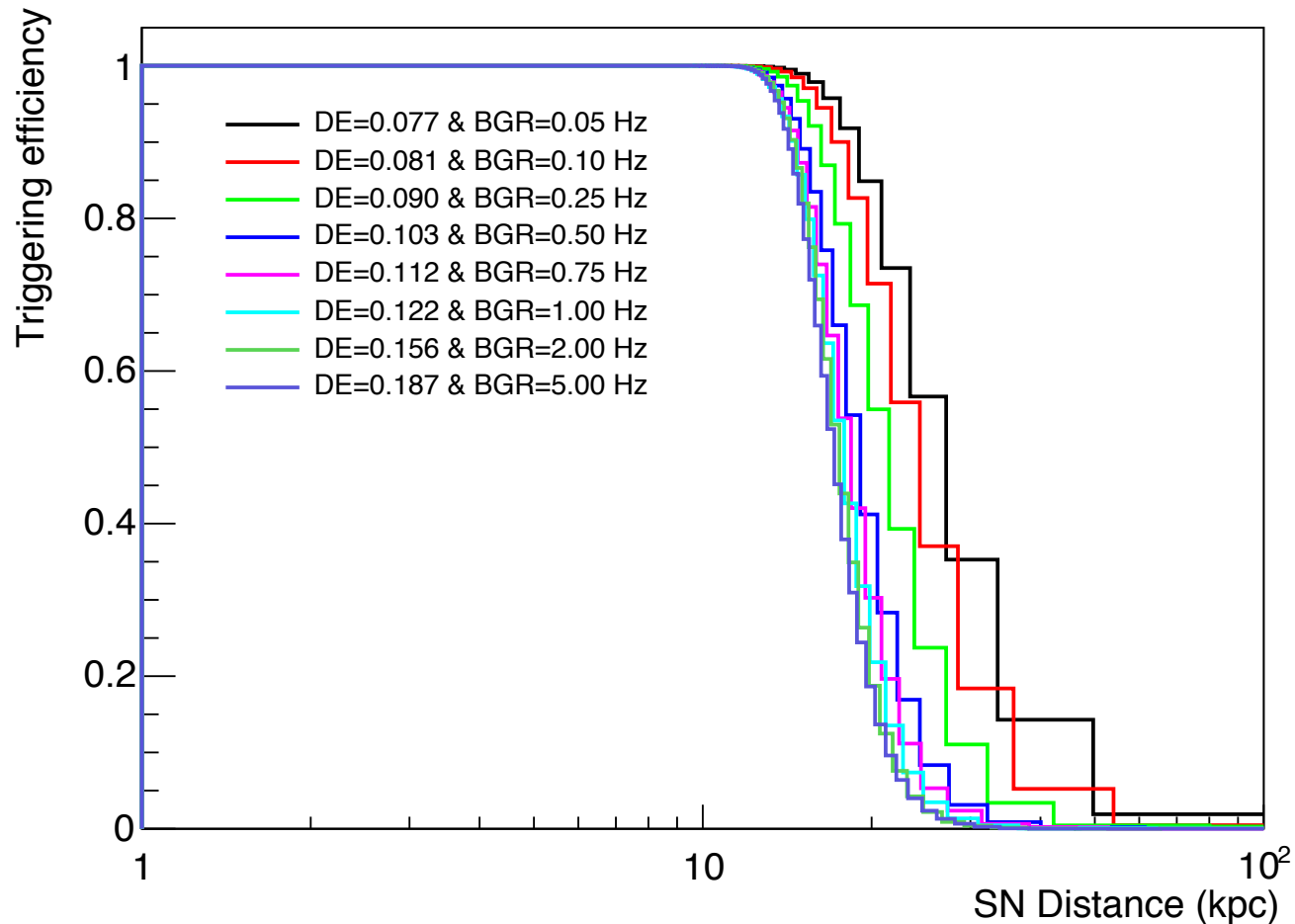


✚ Data
✚ MC

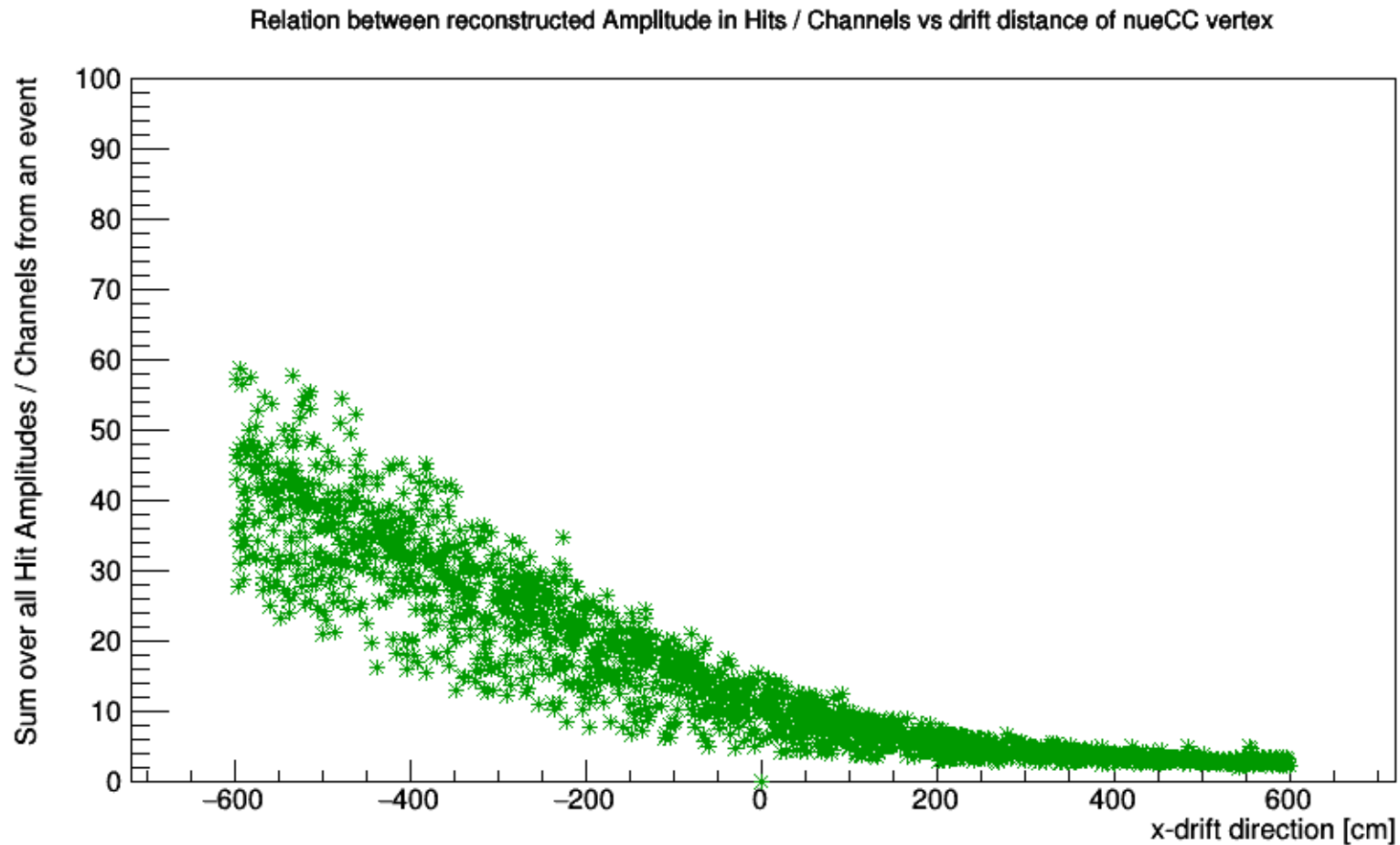
Event t0 reconstruction in NDK



Suopernova burst triggering



PMT saturation studies in beam events



Pre-installation period milestones

Milestone	Start date	End date
PMT preparation and installation (can be done in batches)		
PMT procurement procedure and production	01/2021	12/2022
PMT base design and manufacturing	01/2022	12/2022
PMT support structure production and assembly	08/2022	01/2023
PMT characterization - 10 PMTs/week (two facilities)	02/2023	12/2023
TPB coating (two facilities similar to that for CERN ICARUS)	01/2024	12/2024
Splitter production and tests	05/2024	12/2024
Light calibration system		
Fibers, light source tests and procurement	06/2023	05/2024

Installation period milestones

Milestone	Start month	End month
PMT cable and fiber routing in cryostat from flange to bottom (depends on FC and flange installation)	1	2
PMT testing, installation in cryostat and cabling (120 PMTs/month)	2	8
PMT support installation on the membrane (in parallel by sector with PMT installation)	2	8
Splitter installation (in parallel with PMT installation to test cabling and connections)	2	8
Fiber calibration system installation (in parallel with PMT installation with validation test)	2	8