ARIADNE+ Highlights

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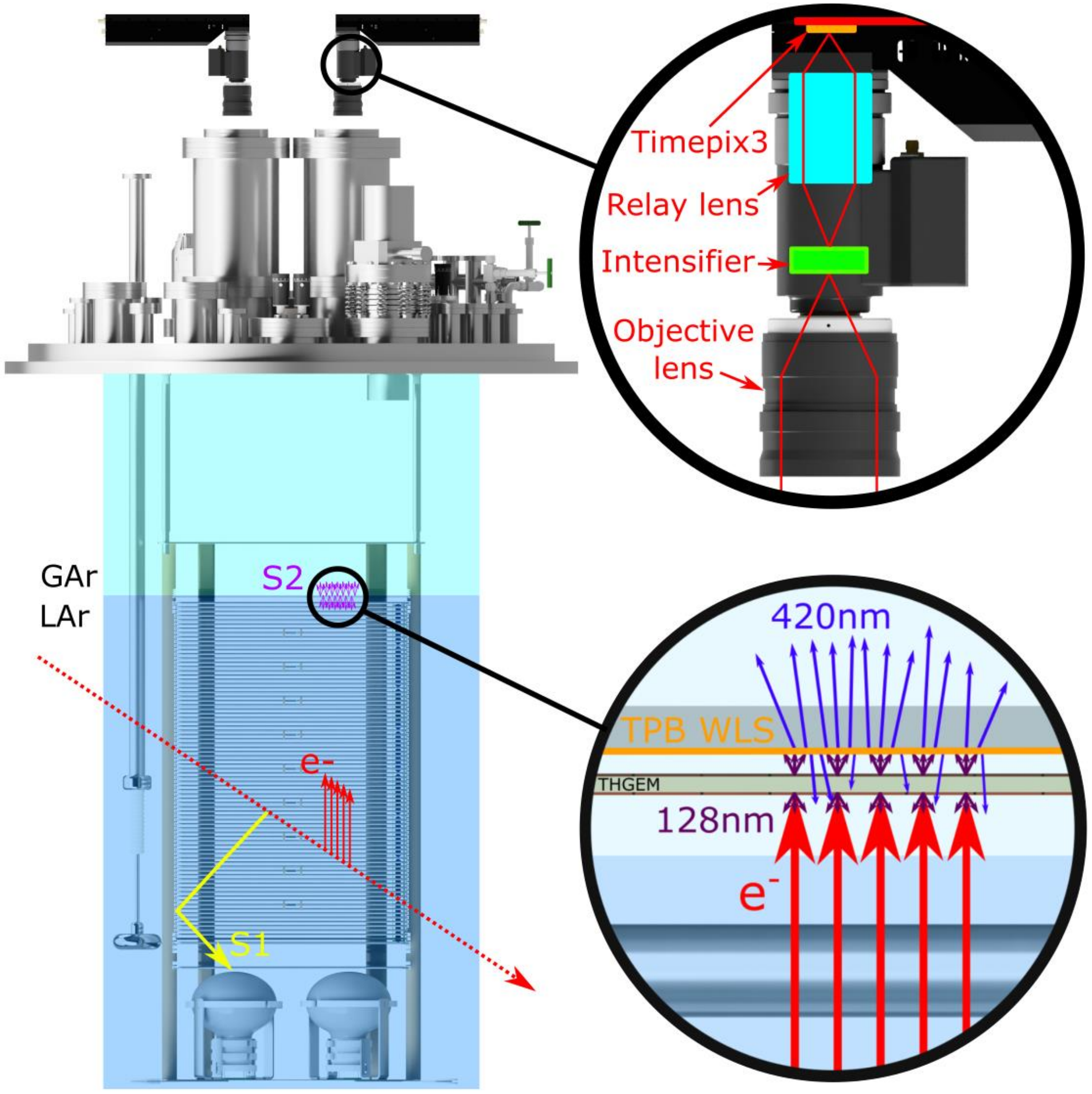
Readout of ARIADNE using TPX3, Dec 2019

Throughgoing particles ionise Liquid Argon and produce prompt scintillation light (S1)

Ionisation electrons drifted to liquid surface and extracted into gaseous phase.

Electrons accelerated within THGEM holes, producing secondary scintillation light (S2) by gas Argon excitations.

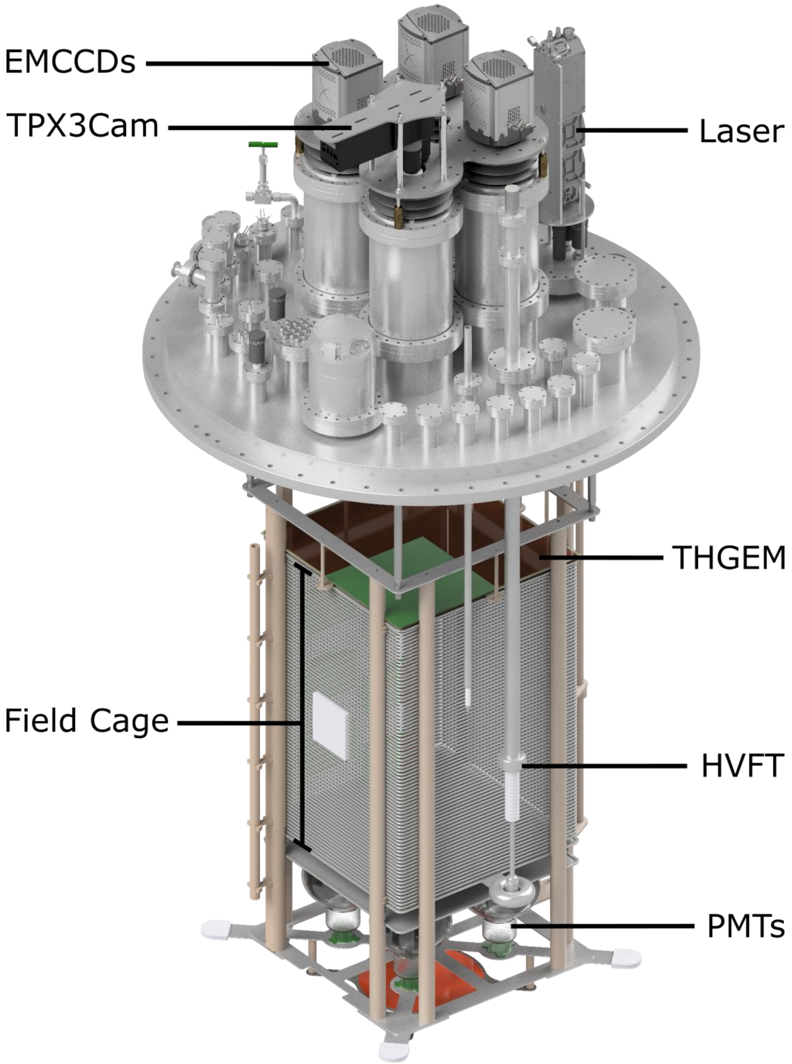
Event reconstruction performed by detecting S2 light with externally mounted cameras.

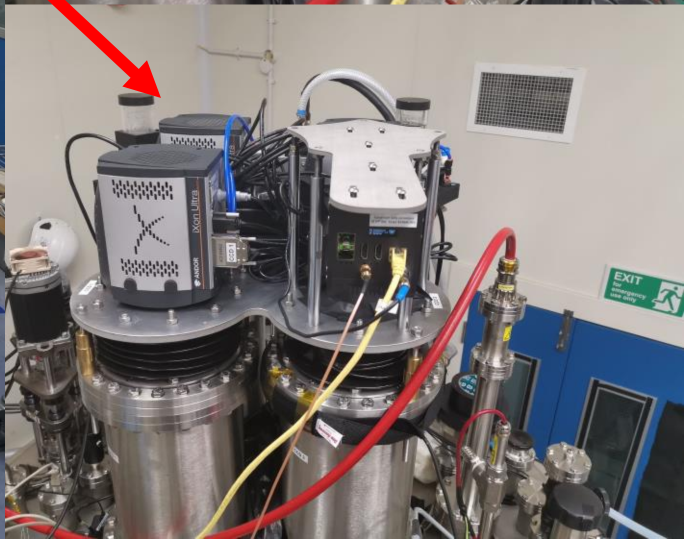


A R I A D N E

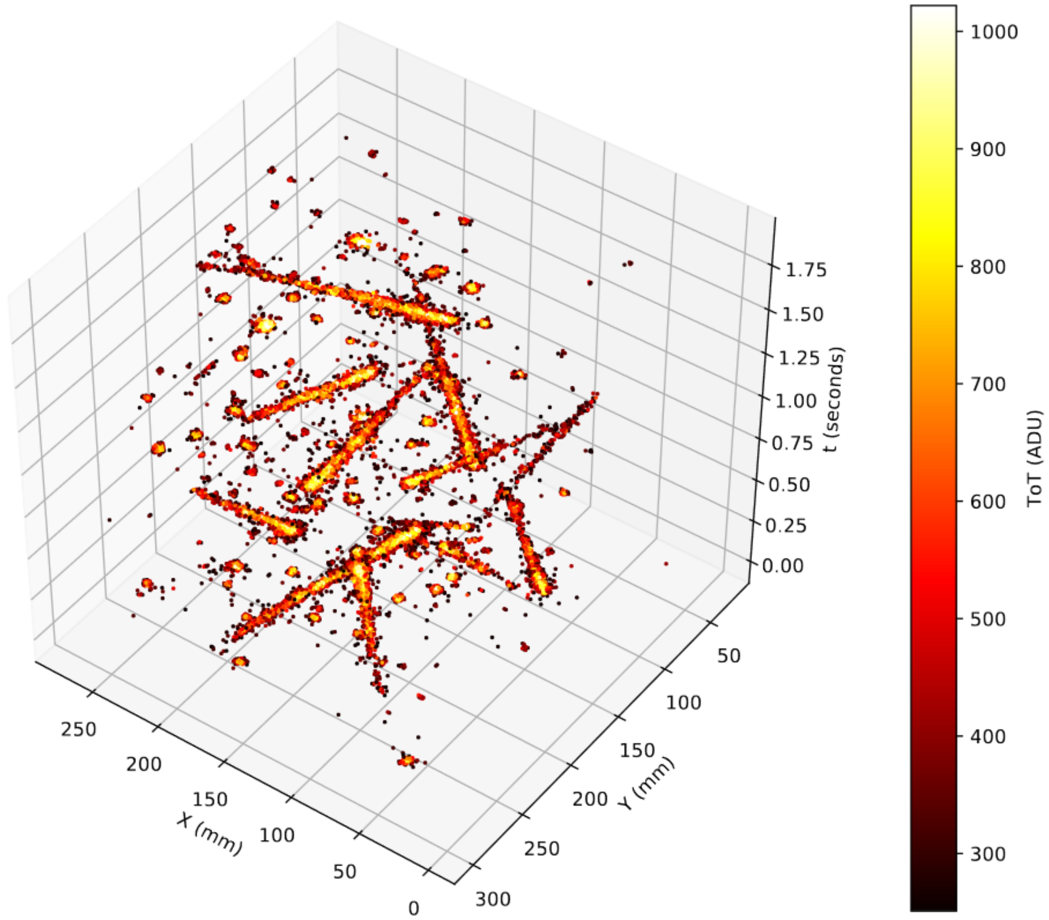
Timepix3 camera installed in place of a single EMMCD camera.
~ 26cm x 26cm field of view

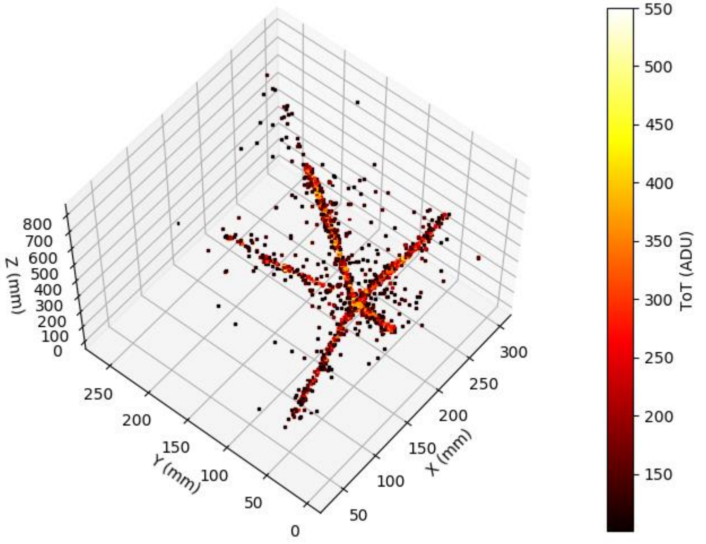
Photonis Cricket image intensifier with Hi-QE green photocathode.
30% quantum efficiency at 430nm (TPB peak emission)

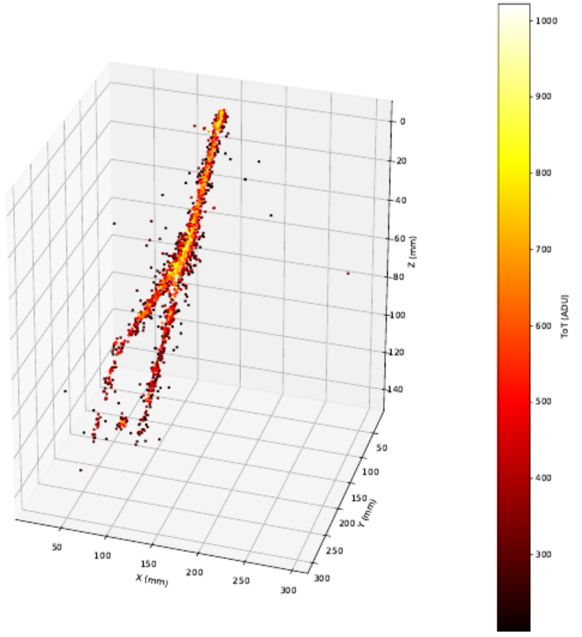


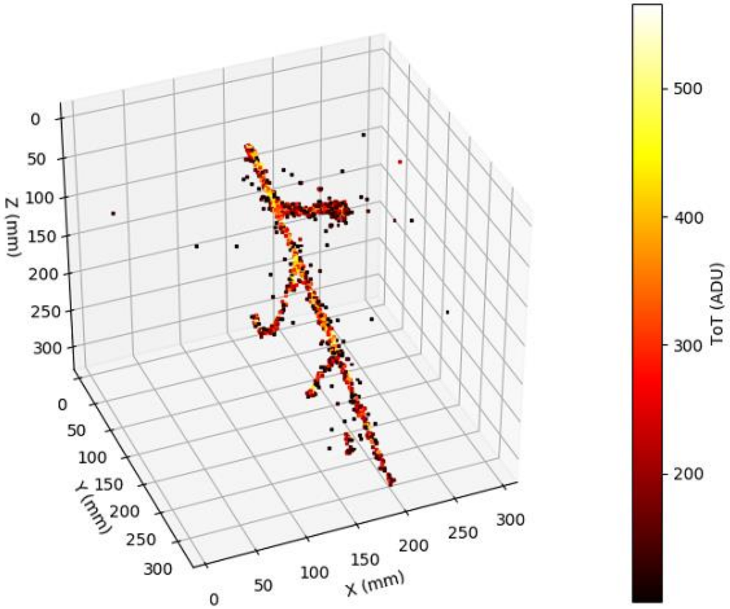


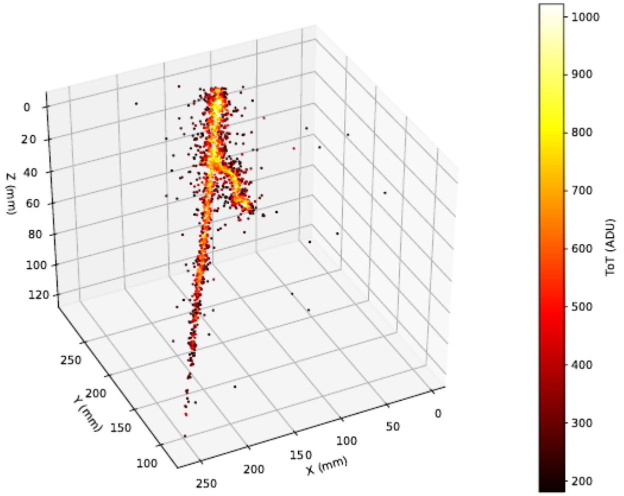
Streaming data view (1 second window):



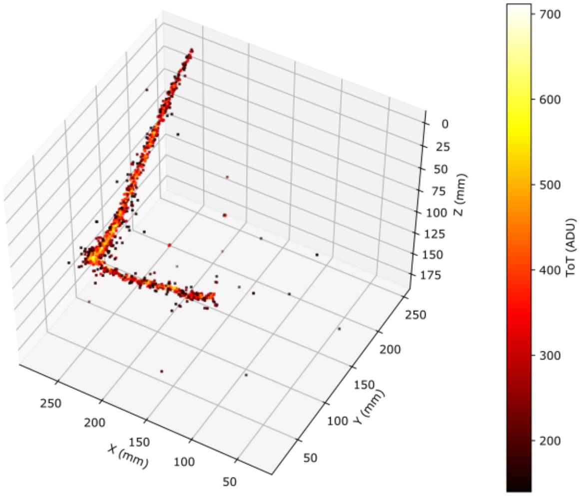


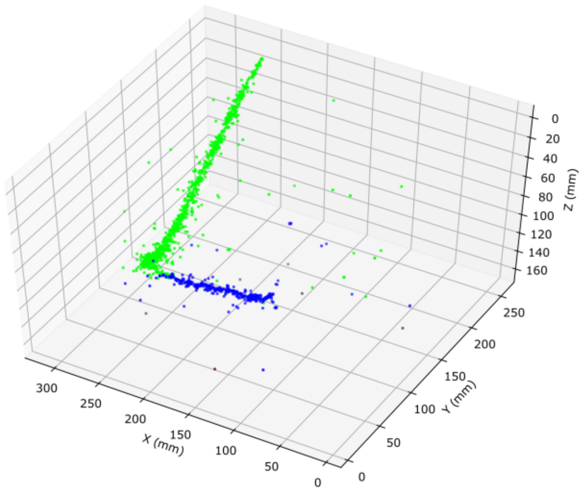


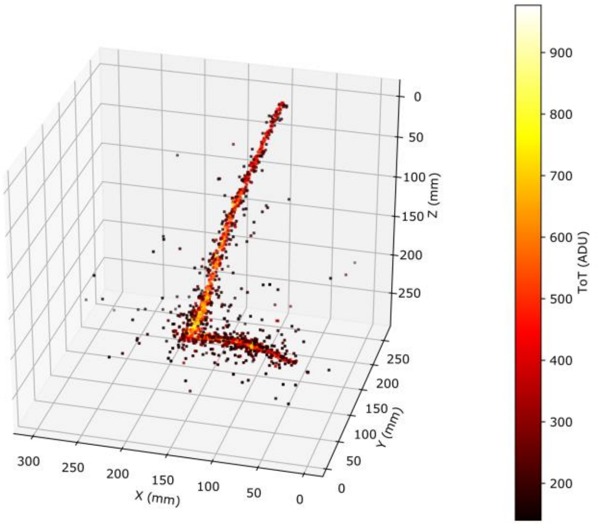


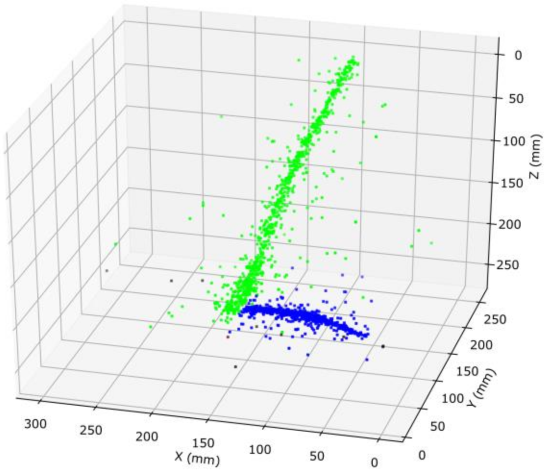


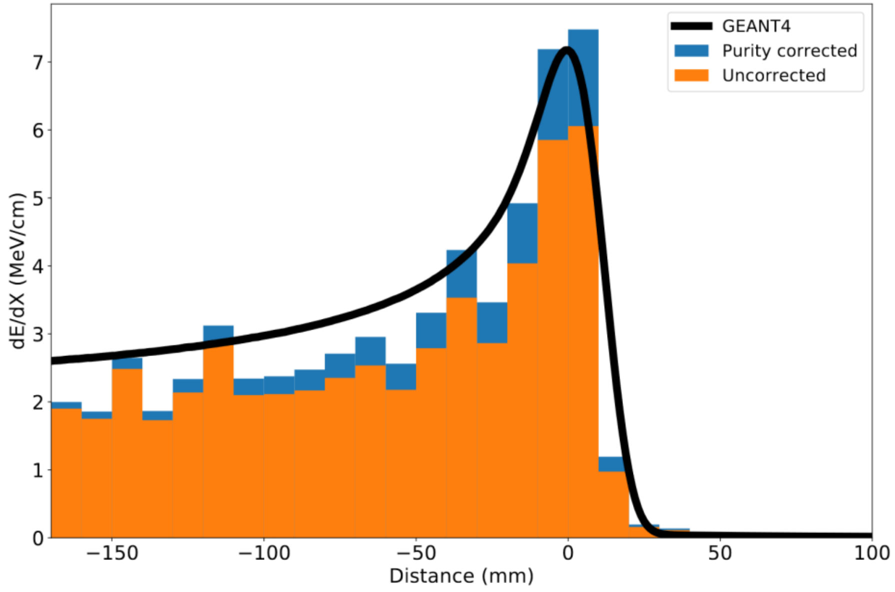
Stopping muons

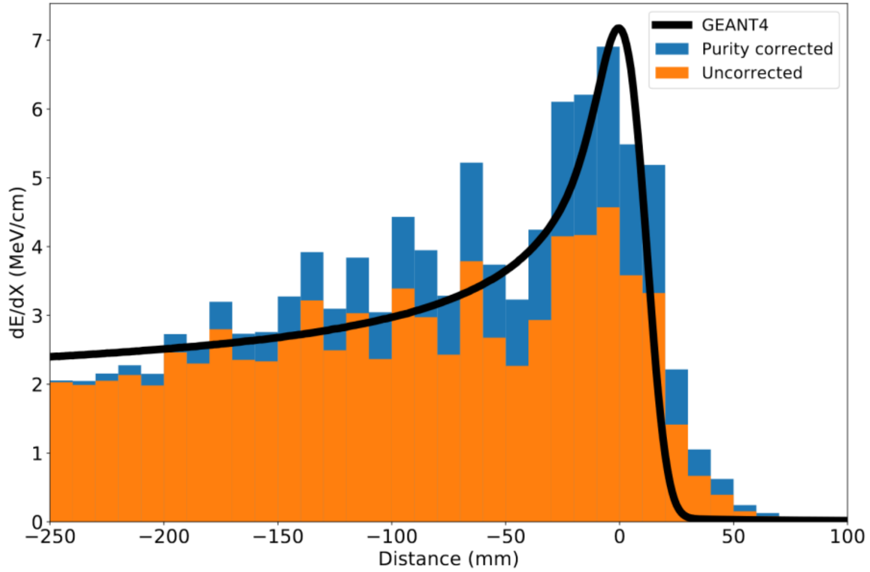










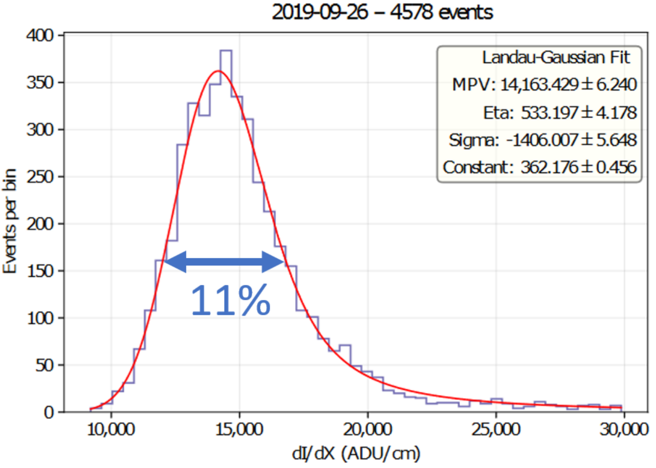


Publication: https://arxiv.org/abs/2011.02292

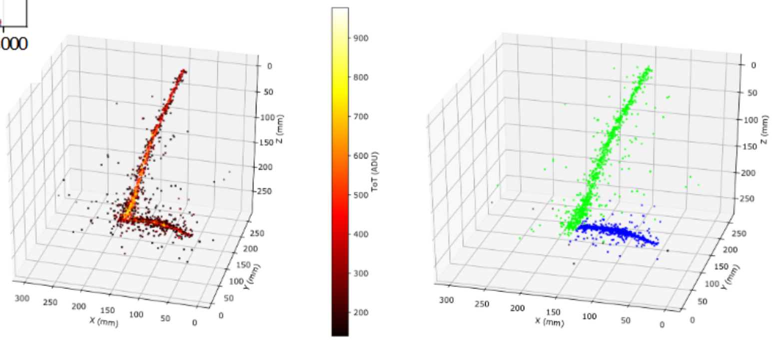
Timepix LAr results

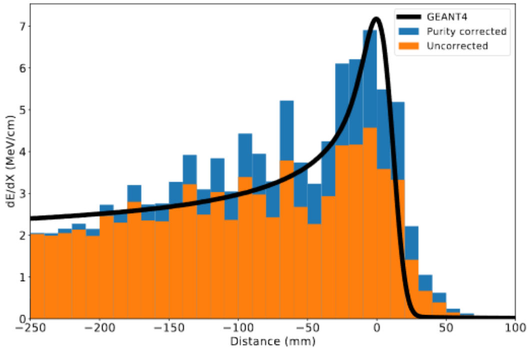
Timepix LAr paper submitted to ArXiv November 2020

Throughgoing muon energy resolution



Stopping muons





- Measurement of electron lifetime
- Electron drift velocity measurement
- Energy resolution using cosmic muons
- Stopping muon measurements

Article

Optical Readout of the ARIADNE LArTPC using a Timepix3-based Camera

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Received: 4 November 2020; Accepted: 24 November 2020; Published: date

Abstract: The ARIADNE Experiment, utilising a 1-ton dual-phase Liquid Argon Time Projection Chamber (LArTPC), aims to develop and mature optical readout technology for large scale LAr detectors. This paper describes the characterisation, using cosmic muons, of a Timepix3-based camera mounted on the ARIADNE detector. The raw data from the camera are natively 3D and zero suppressed, allowing for straightforward event reconstruction, and a gallery of reconstructed LAr interaction events is presented. Taking advantage of the 1.6 ns time resolution of the readout, the drift velocity of the ionised electrons in LAr was determined to be 1.608 ± 0.005 mm/μs at 0.54 kV/cm. Energy calibration and resolution were determined using through-going muons. The energy resolution was found to be approximately 11 % for the presented dataset. A preliminary study of the energy deposition ($\frac{dE}{dX}$) as a function of distance has also been performed for two stopping muon events, and comparison to GEANT4 simulation shows good agreement. The results presented demonstrate the capabilities of this technology, and its application is discussed in the context of the future kiloton-scale dual-phase LAr detectors that will be used in the DUNE programme.

Keywords: Time projection Chambers (TPC); Noble liquid detectors; Micropattern gaseous detectors; Photon detectors for UV, visible and IR photons (solid-state)

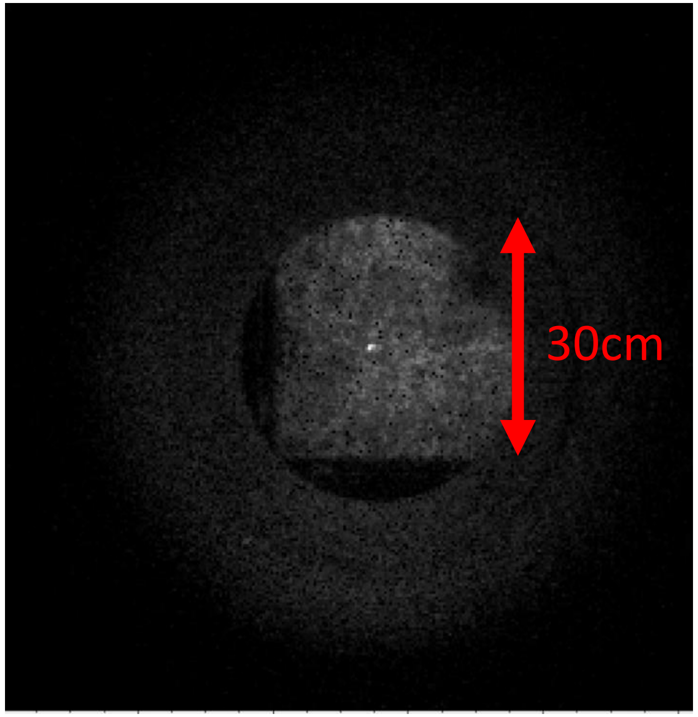
1. Introduction

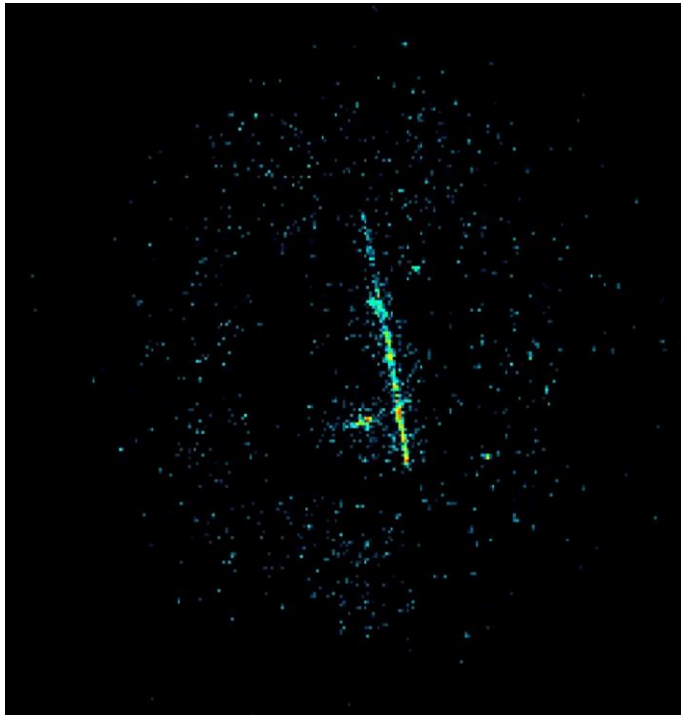
Liquid Argon Time Projection Chambers (LArTPCs) have been an indispensable type of particle detector for over 40 years, and have only continued to grow in size and sophistication. The current generation of neutrino detectors - such as SBND (112 tons), MicroBooNE (89 tons) and ICARUS-T600 (470 tons), which together make up the Short Baseline Neutrino Program [1], and the single- (411 tons) and dual-phase (300 tons) ProtoDUNE experiments [2,3] - are already approaching the kiloton-scale. It is evident then that future LArTPCs in the neutrino sector will be able to reach the kiloton-scale - for example, four 17,000 ton LArTPCs have been proposed for use on the DUNE project [4–10].

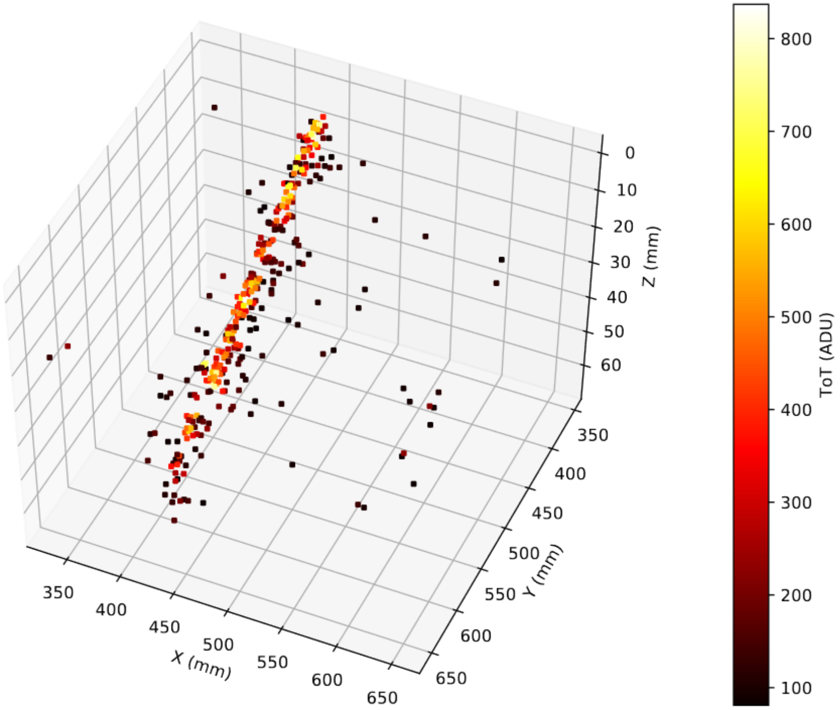
Given the high construction and operating costs, as well as the sheer complexity, of such large detectors, early and innovative R&D therefore has the potential for a large return on investment over an experiment's lifetime.

Publication: https://arxiv.org/abs/2011.02292

Towards larger areas



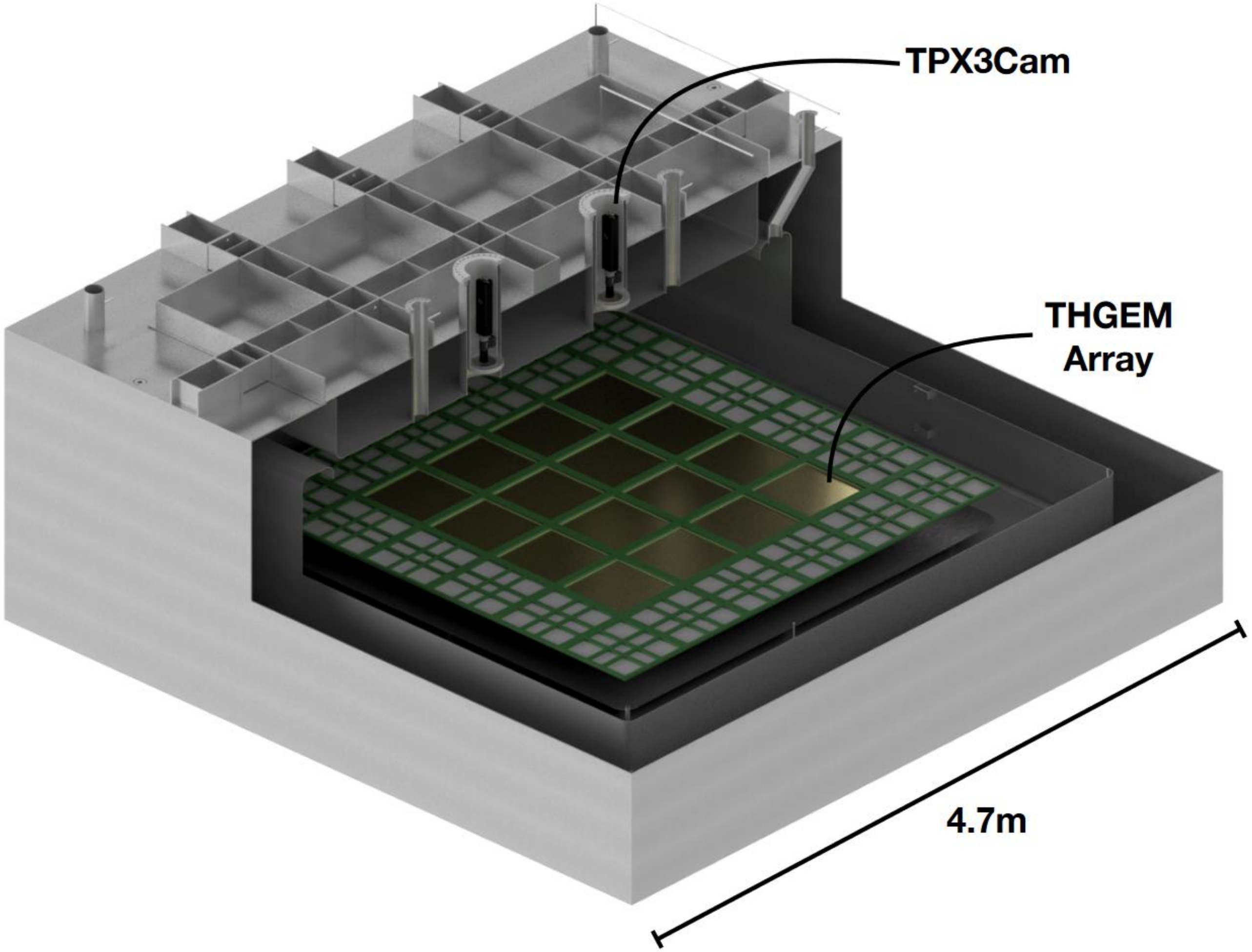




On ARIADNE we tested the TPX3 camera using a 15mm focal length lens.
Simulated field of view is 1m x 1m per camera, 4mm/pixel resolution

Scaling this readout approach to a large detector seemed promising.

Submitted LOI for optical readout testing at the CERN Neutrino platform, Oct 2020



Letter of Intent: Large-scale demonstration of the ARIADNE LArTPC optical readout system at the CERN Neutrino Platform

P. Amedo[3], D. González-Díaz[3], A. Lowe[1], K. Majumdar[1], K. Mavrokoridis*[1], M. Nessi†[2], B. Philippou[1], F. Pietropaolo[2], F. Resnati[2], A. Roberts[1], Á. Saá Hernández[3], C. Touramanis[1] and J. Vann[1]

[1] *University of Liverpool, Department of Physics, Oliver Lodge Bld, Liverpool, L69 7ZE, UK*
[2] *European Organization for Particle Physics (CERN), Geneva, Switzerland*
[3] *Instituto Galego de Física de Altas Enerxías (IGFAE) Rúa de Xoaquín Díaz de Rábago, s/n, Campus Vida, 15782 Santiago de Compostela, Spain*

Abstract

Optical readout of dual phase liquid argon TPCs has been successfully demonstrated by the ARIADNE 1-ton experiment to be a very viable and attractive alternative to charge readout. TPX3 cameras have been shown to be capable of providing a full 3D event reconstruction. In this letter of intent we describe optimisation and testing of the TPX3 camera based technology at a large scale for the potential use in a DUNE kton-scale module. To this end we propose instrumenting the existing 5m×5m CERN cryogenic vessel at the Neutrino Platform with TPX3 cameras. Four TPX3 cameras with a total field of view of 2m×2m will collect the secondary scintillation light produced in the THGEM holes. Cosmic ray data will be collected and a stopping muon analysis will be performed.

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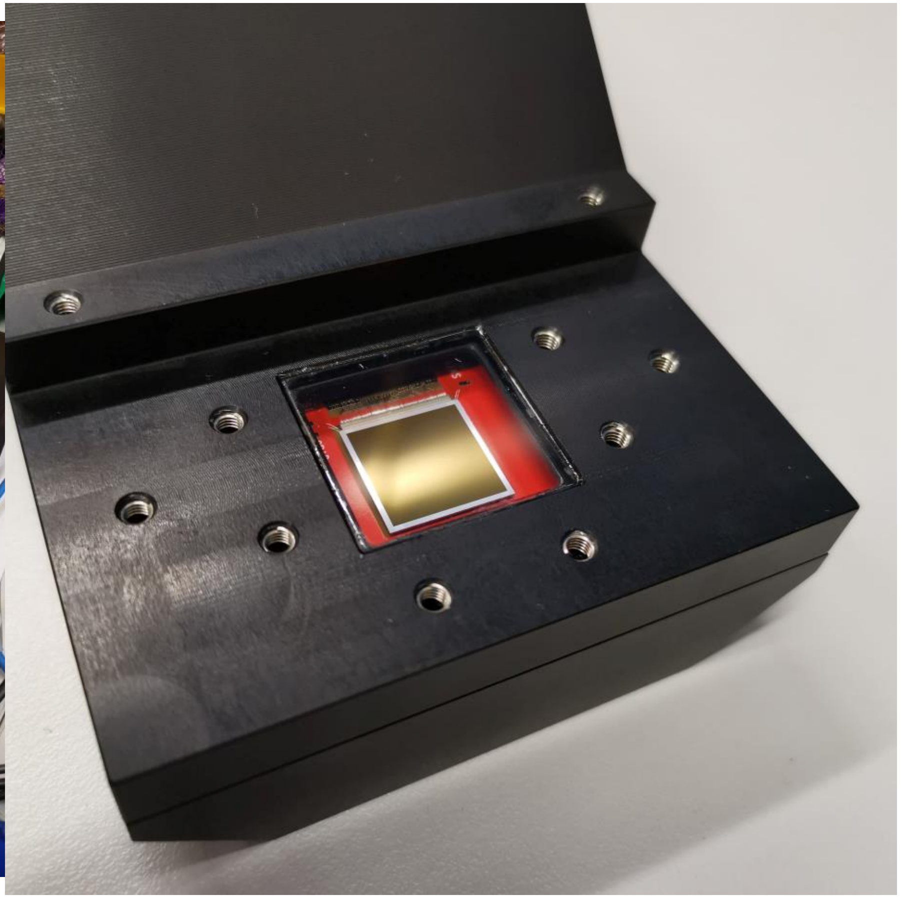
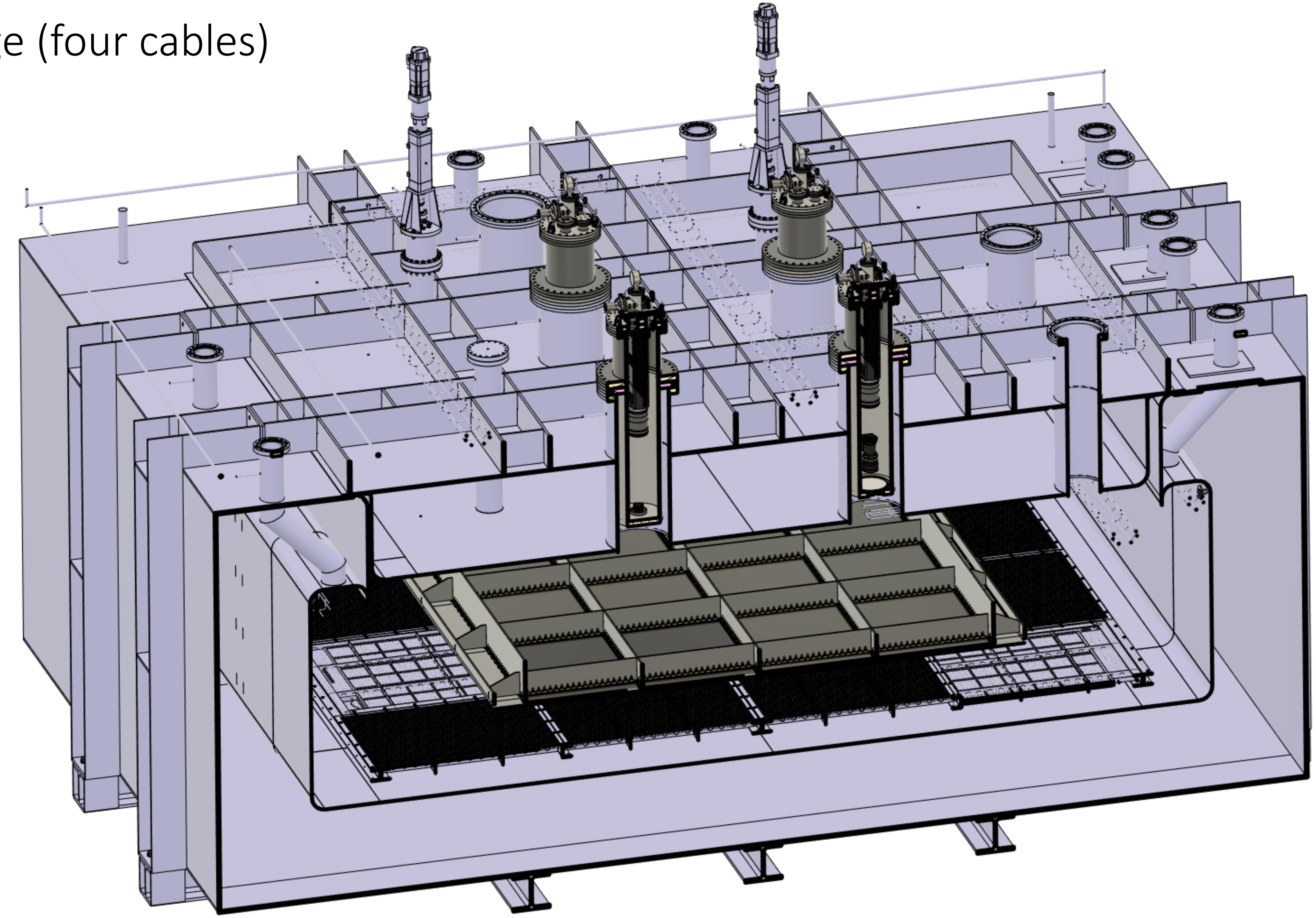
†CERN contact: Marzio.Nessi@cern.ch

Development of custom TPX3 Camera housing

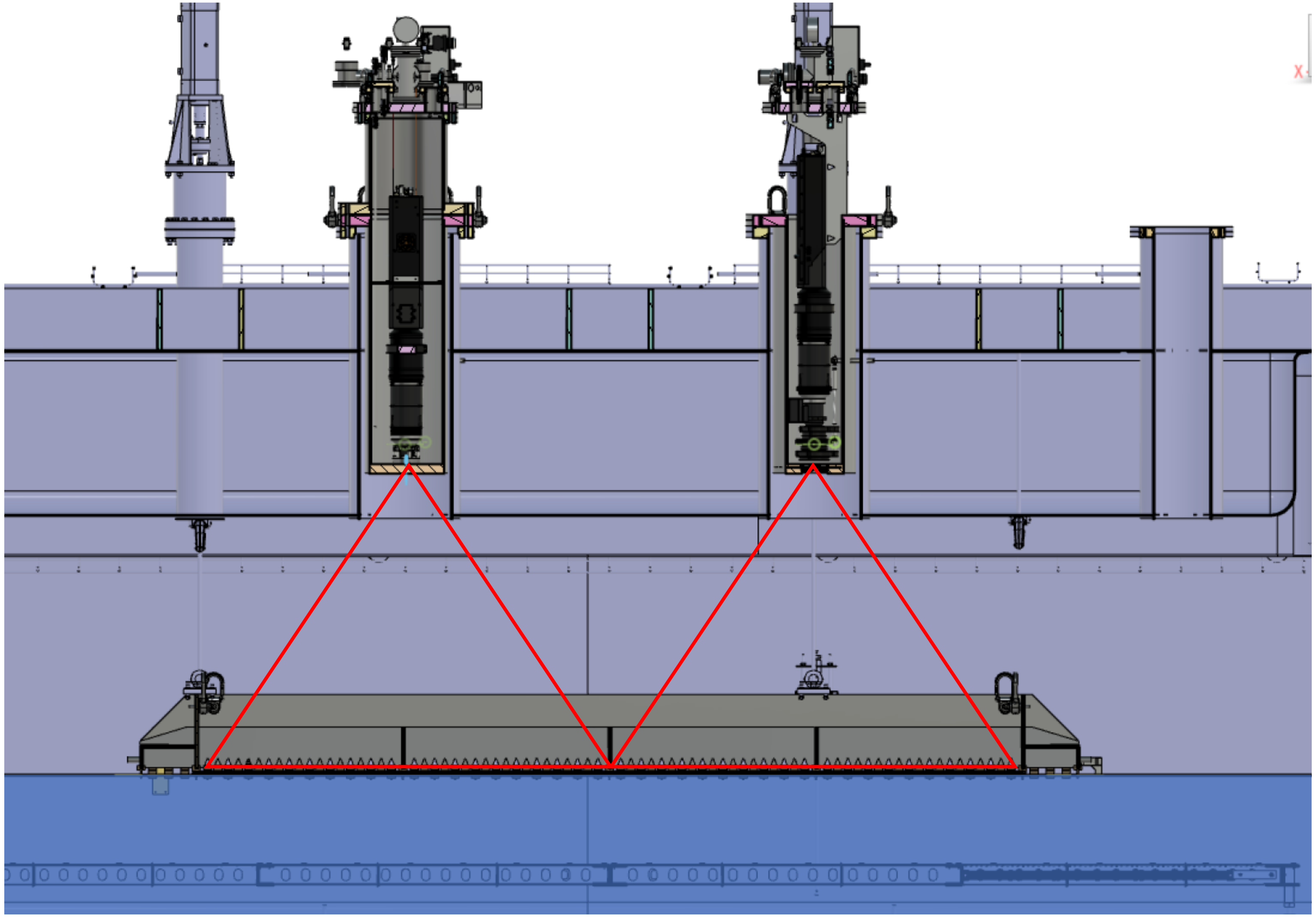


Coldbox overview / Integration

- LRP Suspended from top flange (four cables)
- 2.3m x 2.3m LRP Structure
- 2m x 2m active area
- 3x Visible intensifiers
  1x VUV intensifier



Coldbox readout principle

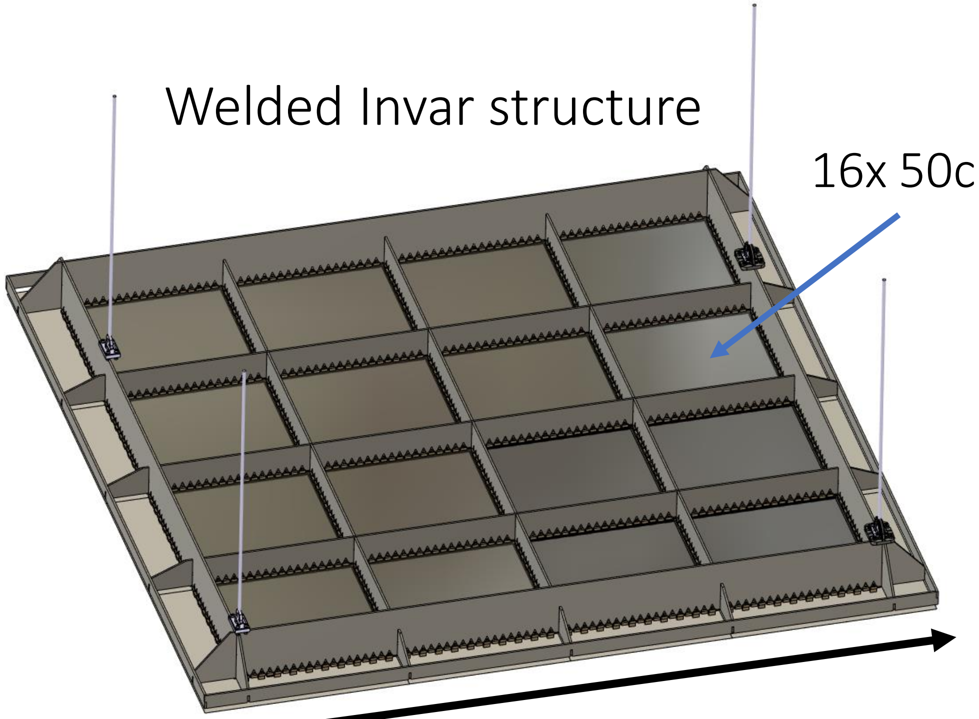


Each camera has a readout area of 1.1m x 1.1m

LRP Design

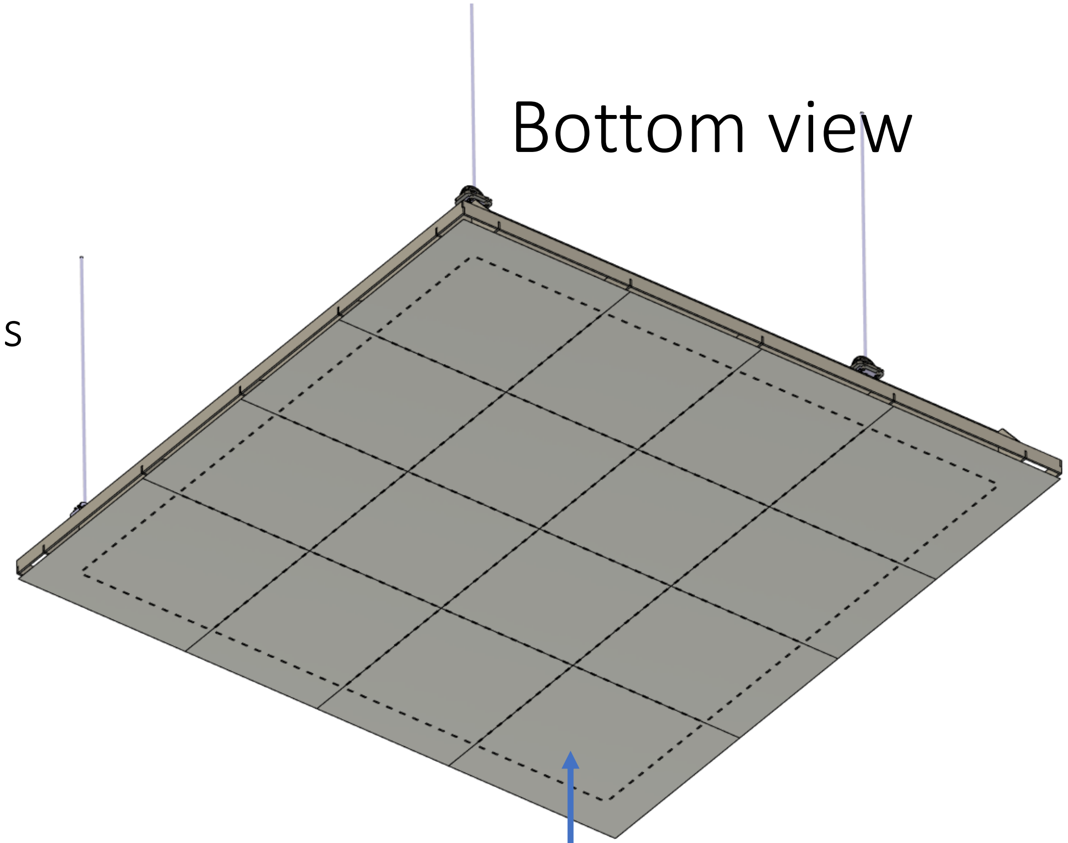
Welded Invar structure

16x 50cm square G-THGEMs

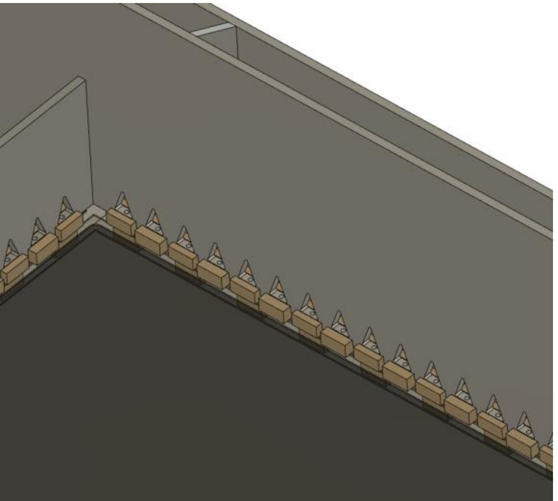


2.3m

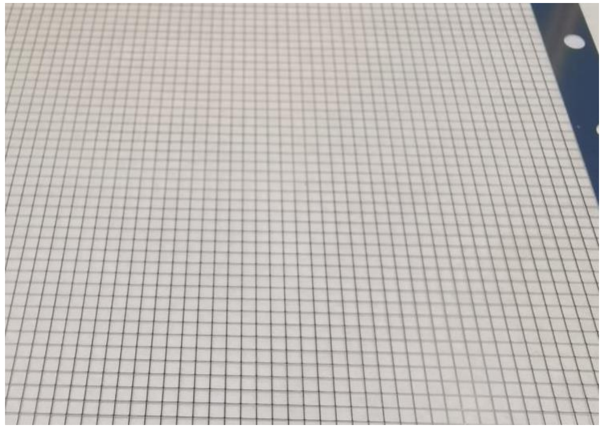
Bottom view

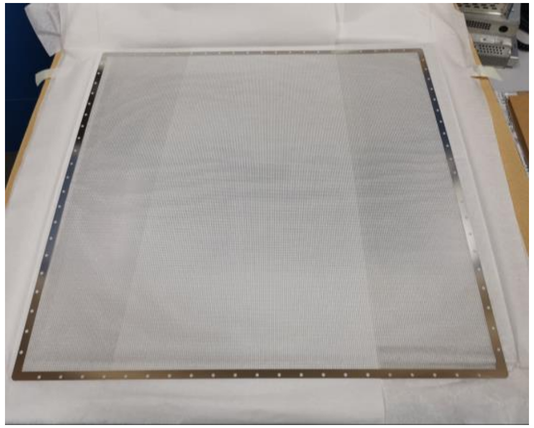


Photochemically etched extraction grids

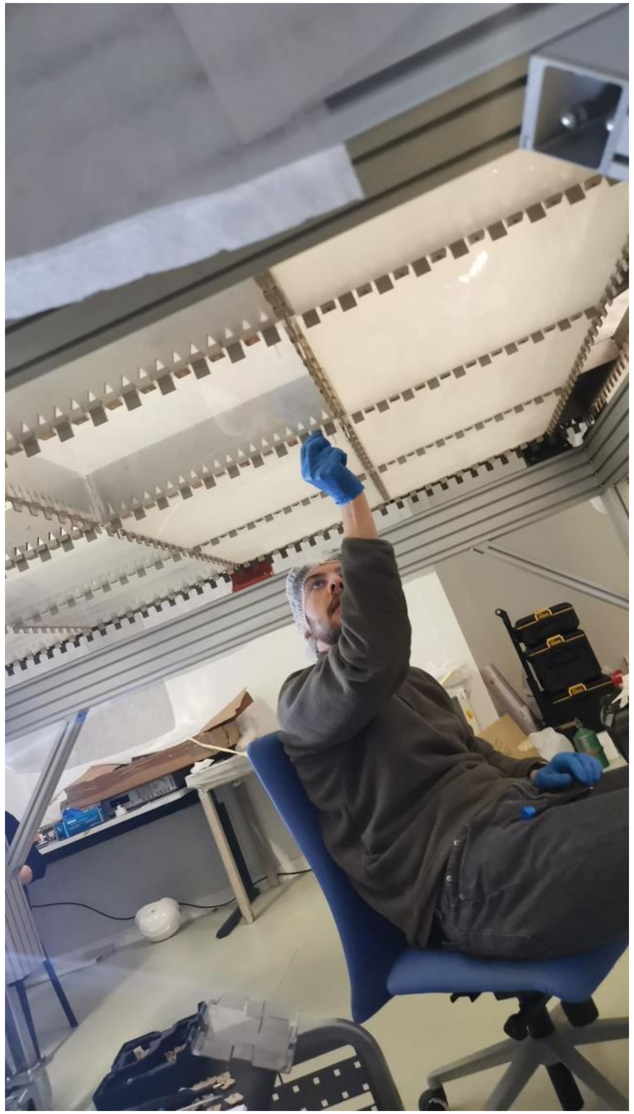


THGEMs/Extraction grids supported by PEEK Spacers





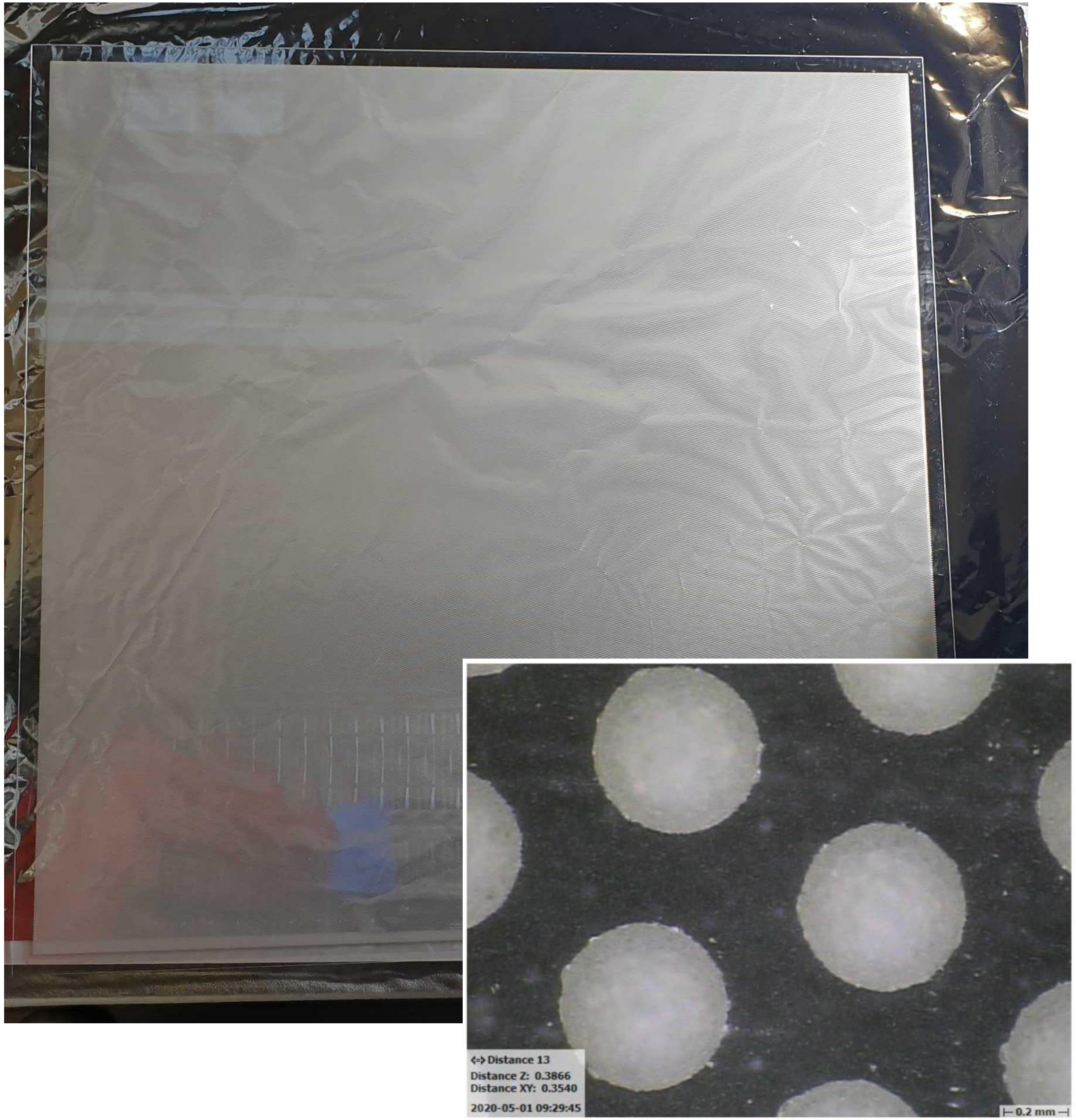
LRP Assembly at CERN



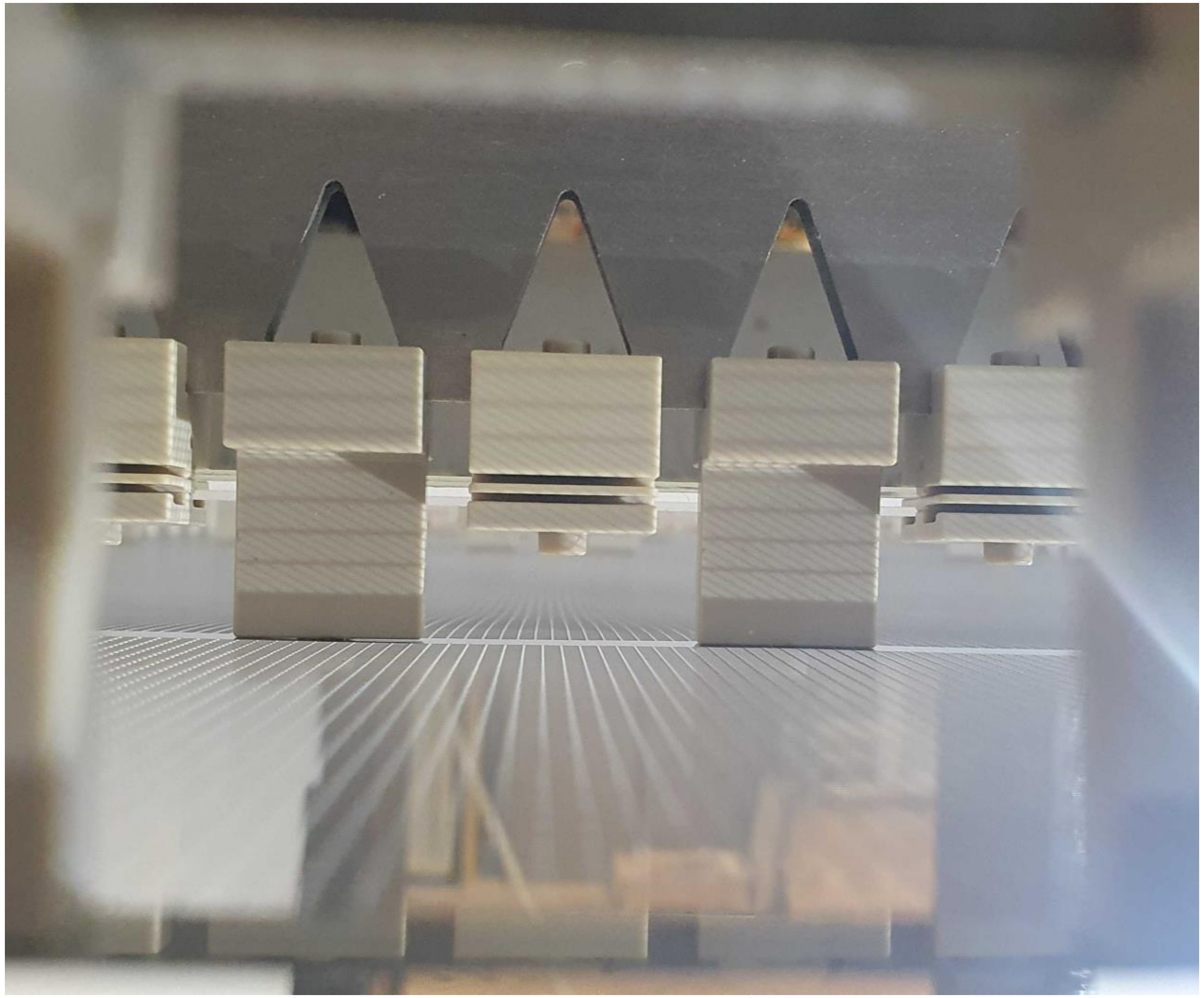
50cm Glass THGEMs

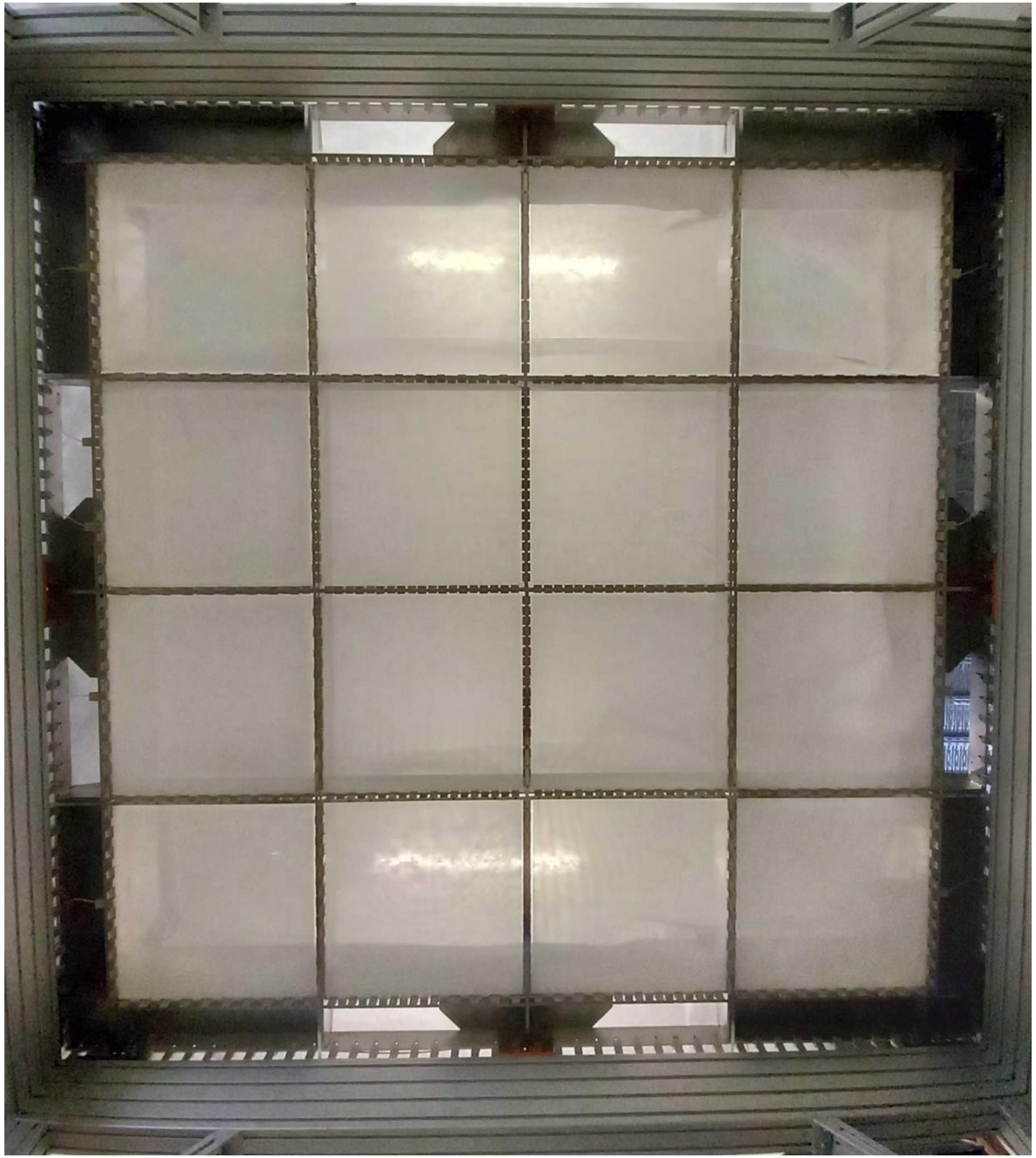
Sixteen 50cm x 50cm glass THGEMs

1.1mm thick,
500µm ID holes,
800µm pitch hexagonal array

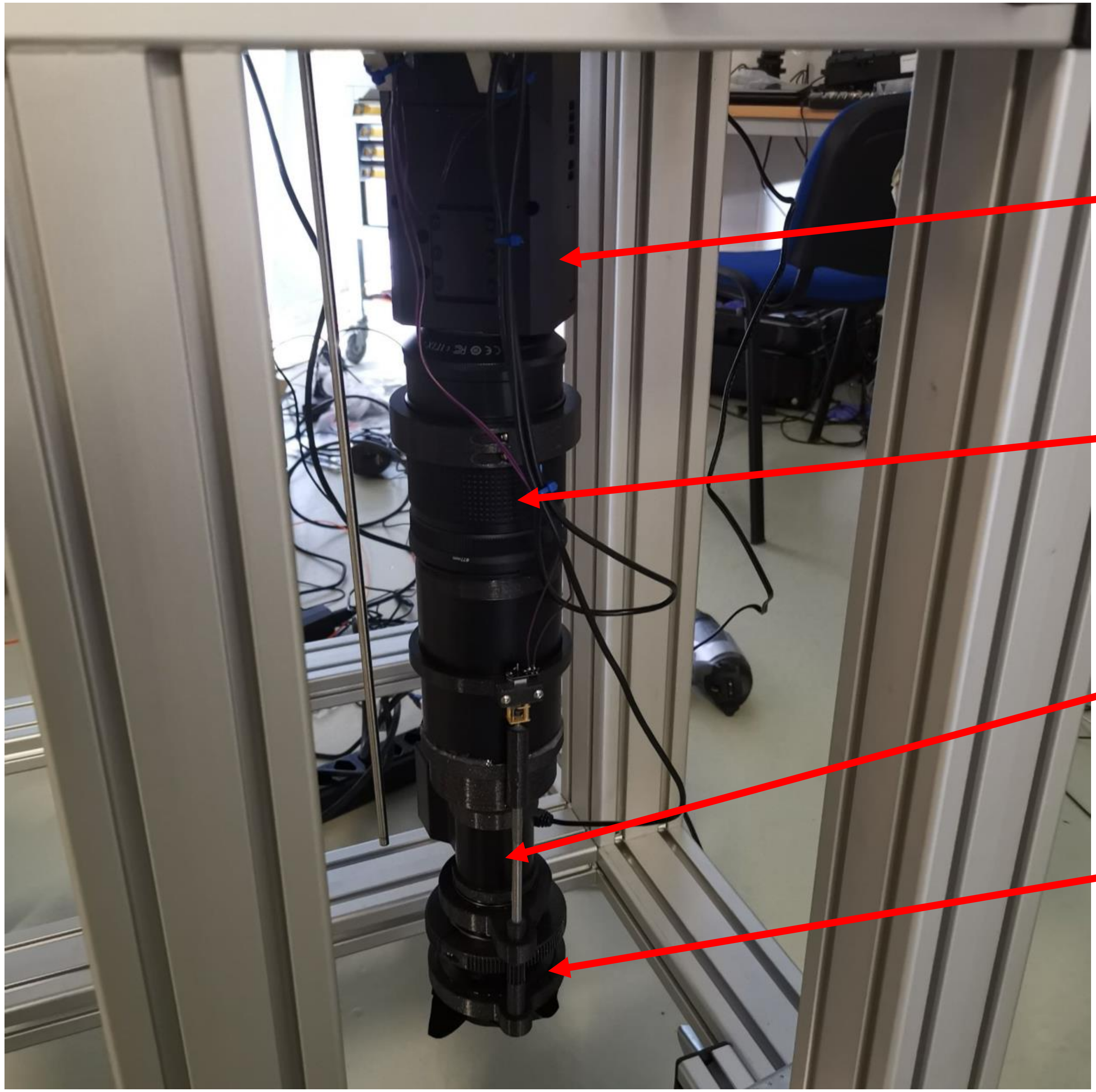


LRP Assembly





Optical readout system



Timepix 3 Camera

Relay optics

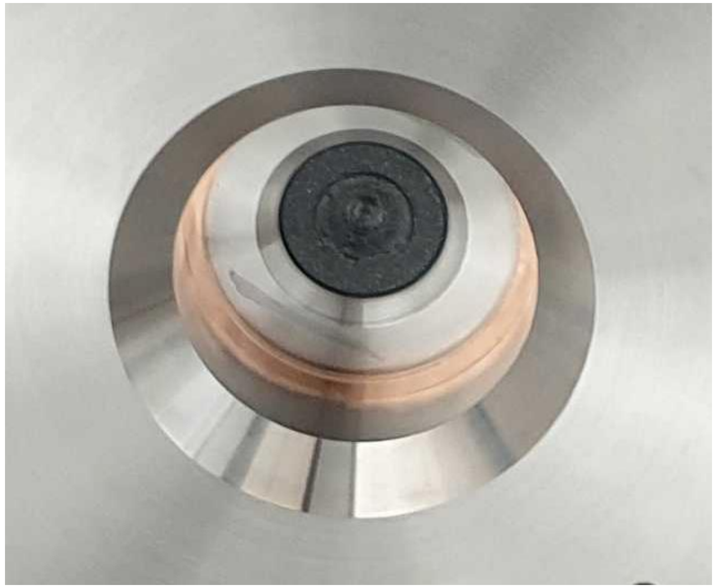
Image intensifier

Objective lens

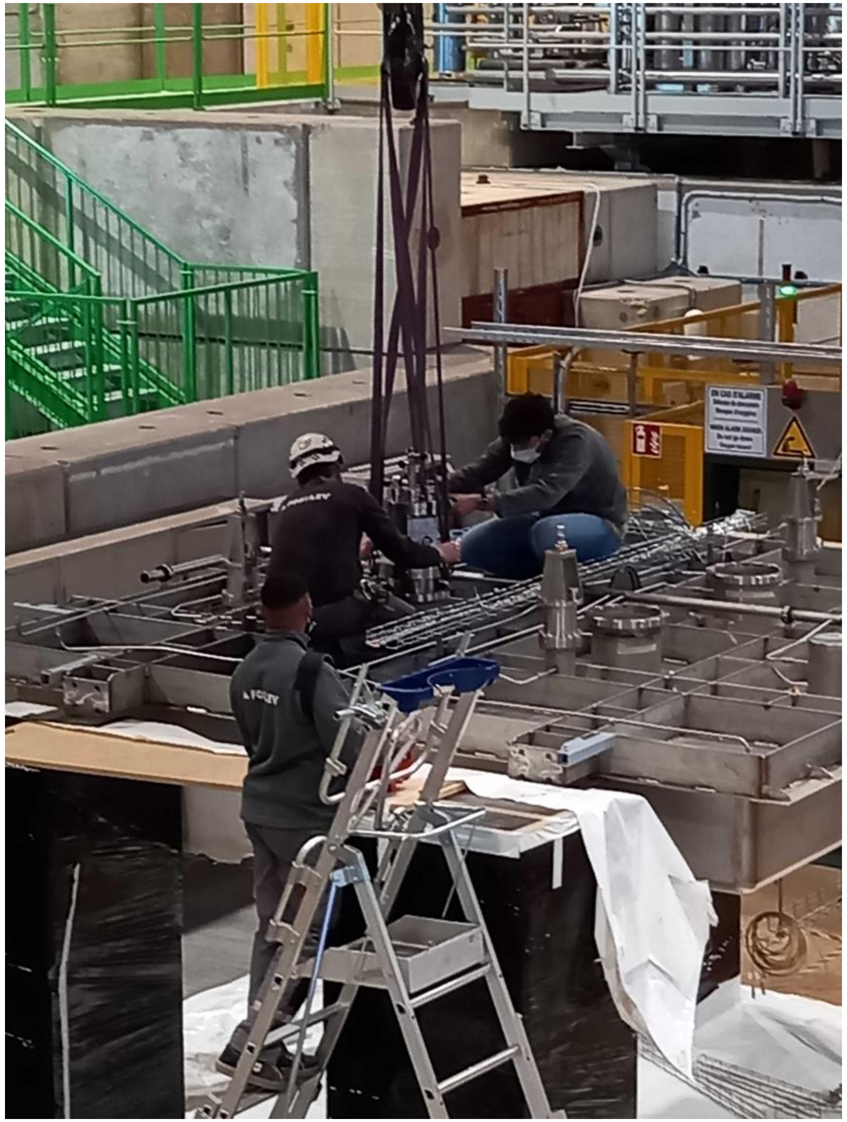
Optical readout system

Visible lenses

VUV Lens



Coldbox integration



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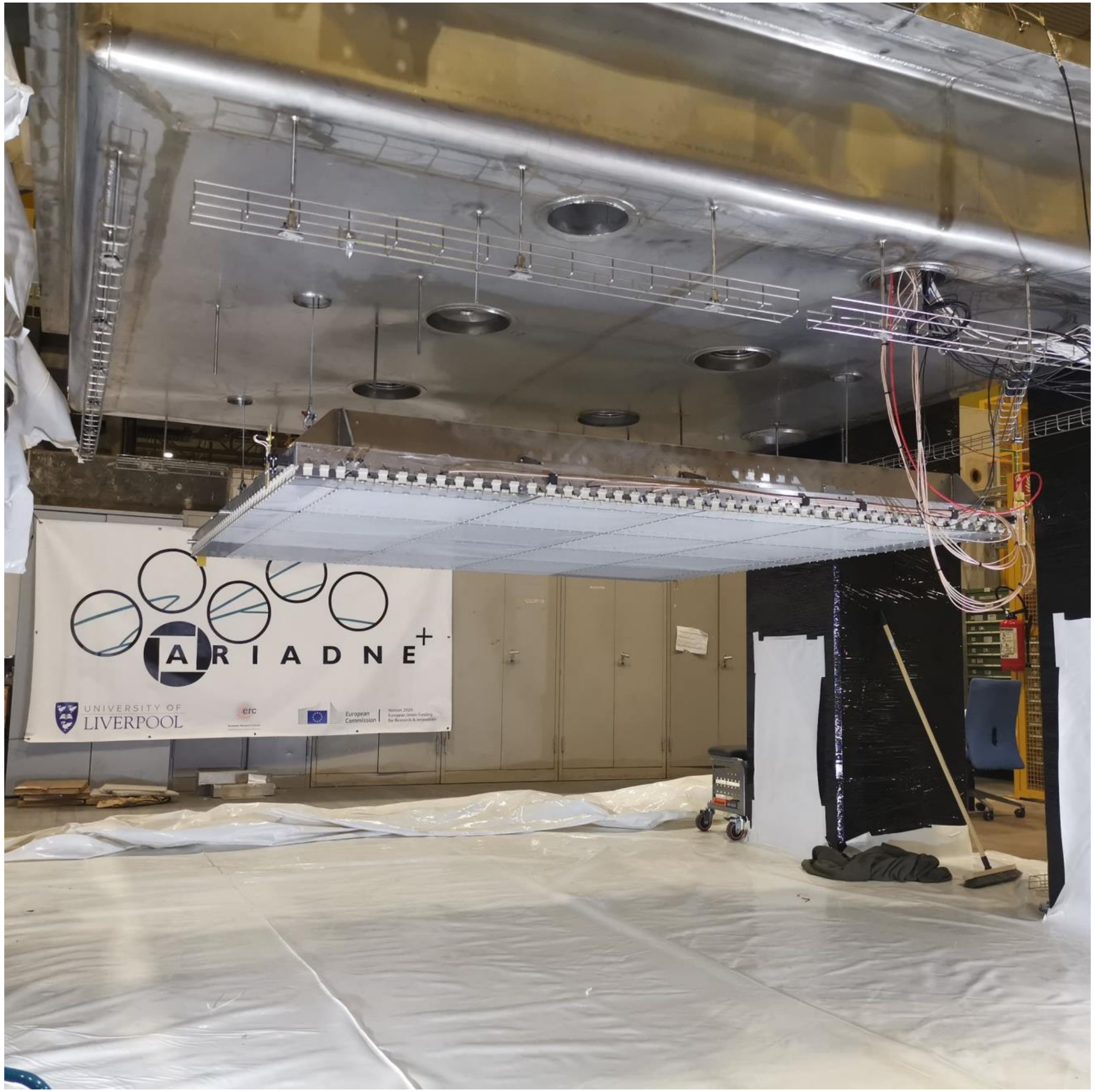
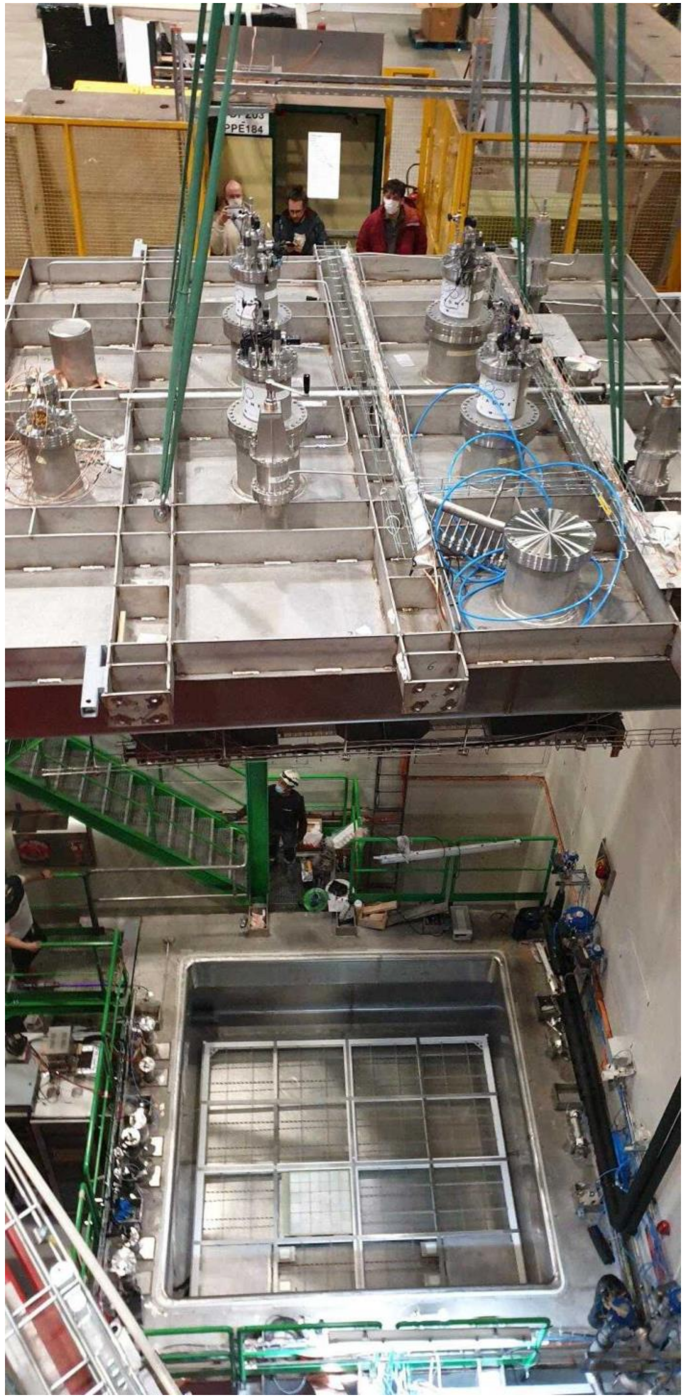
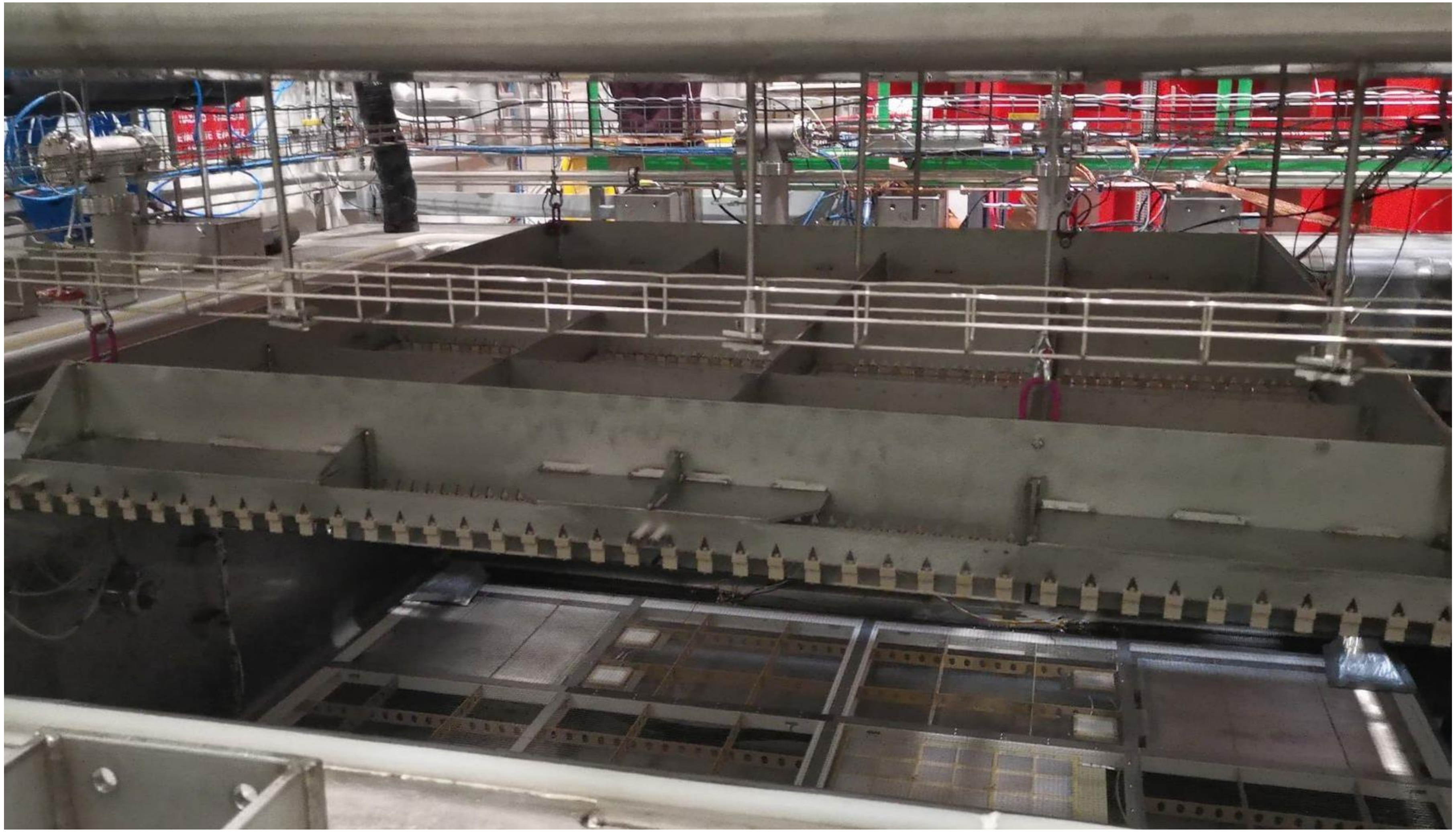


Coldbox integration

Coldbox integration

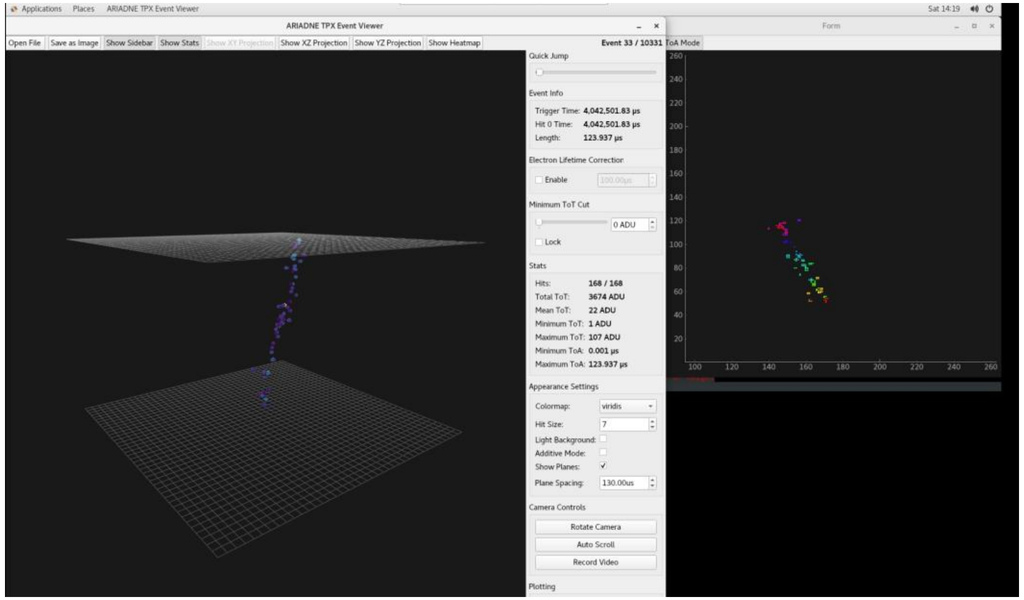


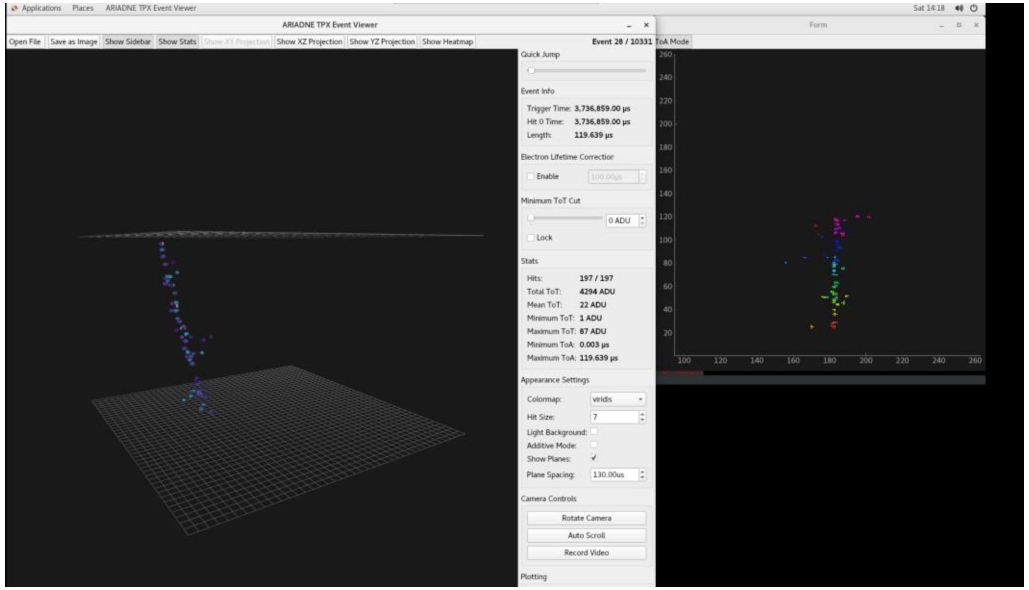


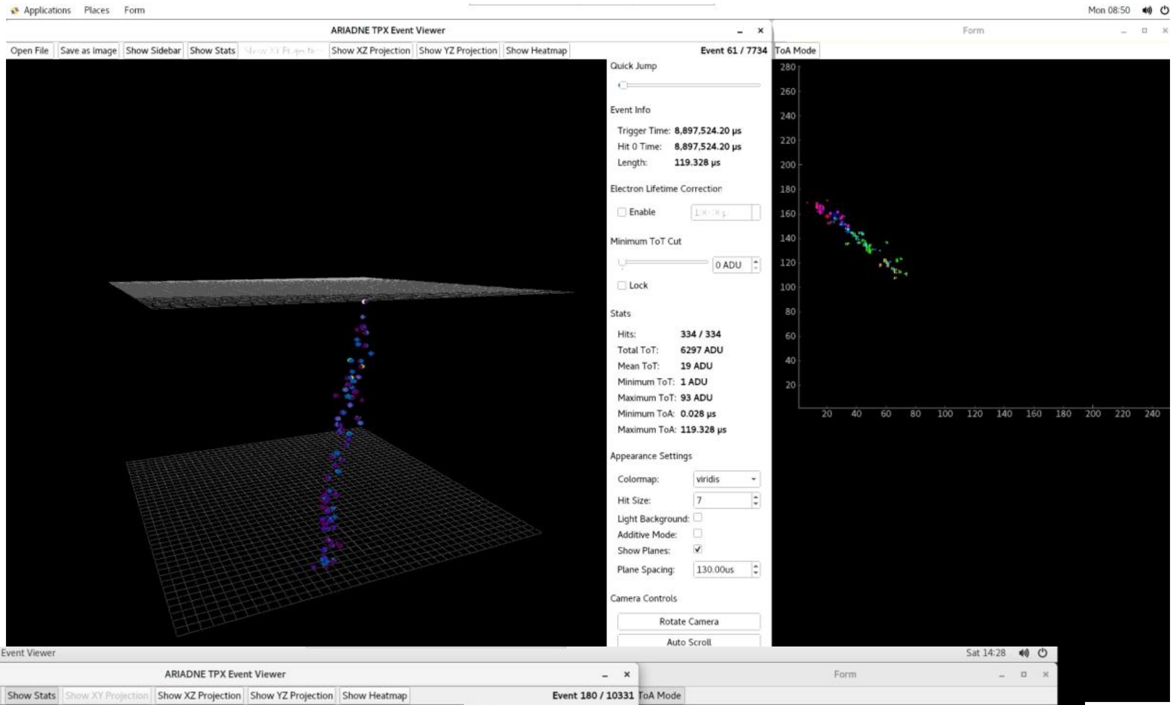
Coldbox integration

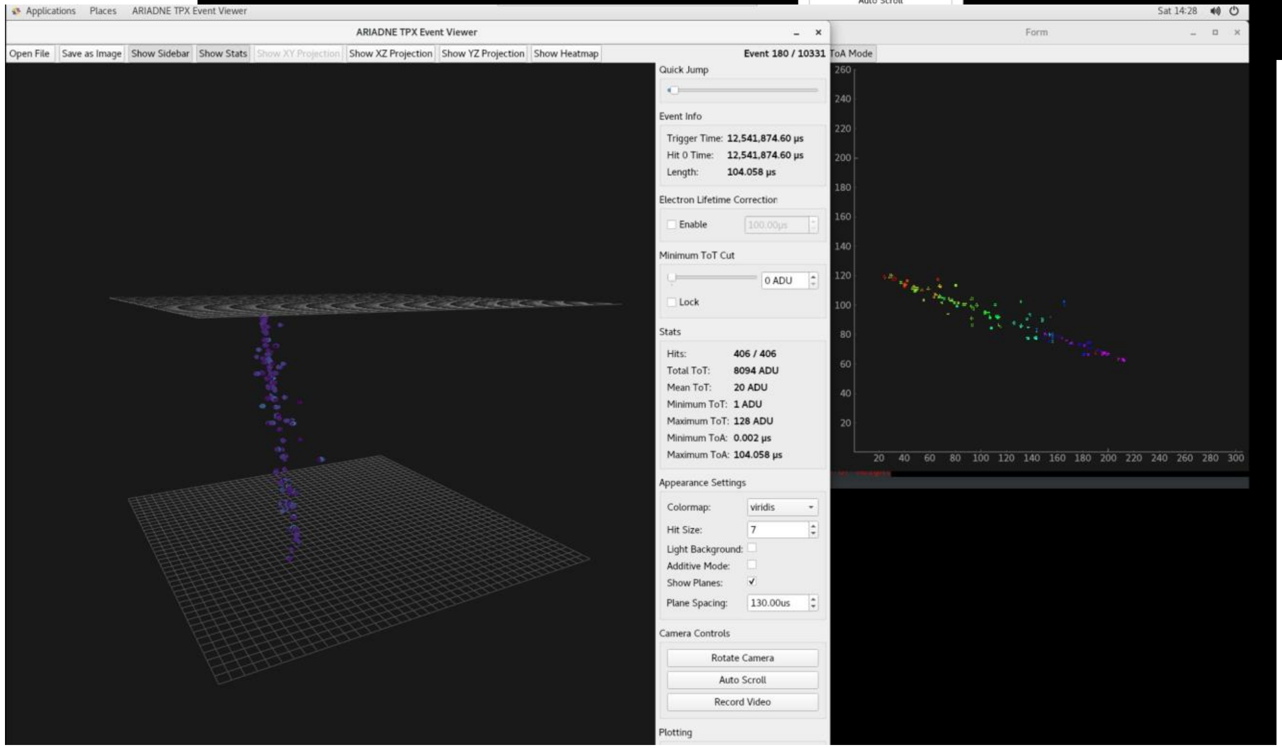
LAr filling

Three weeks data taking



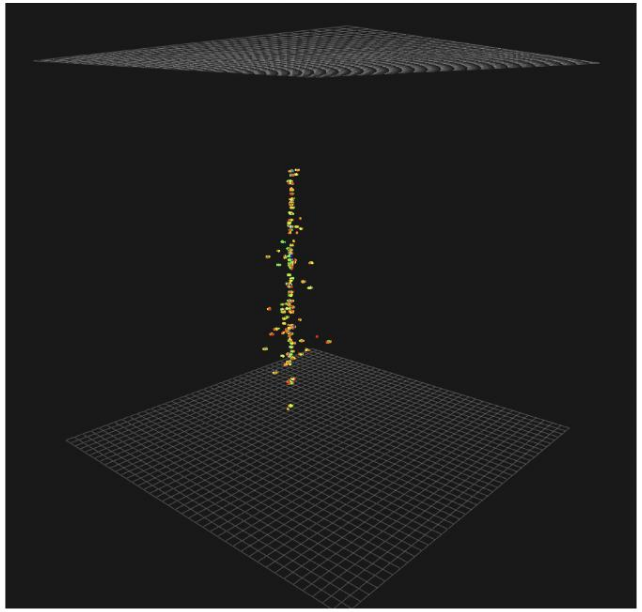


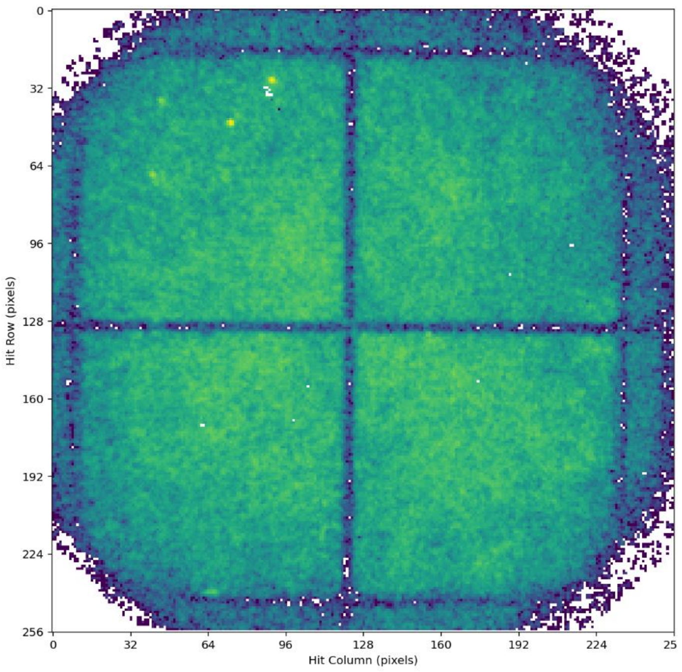




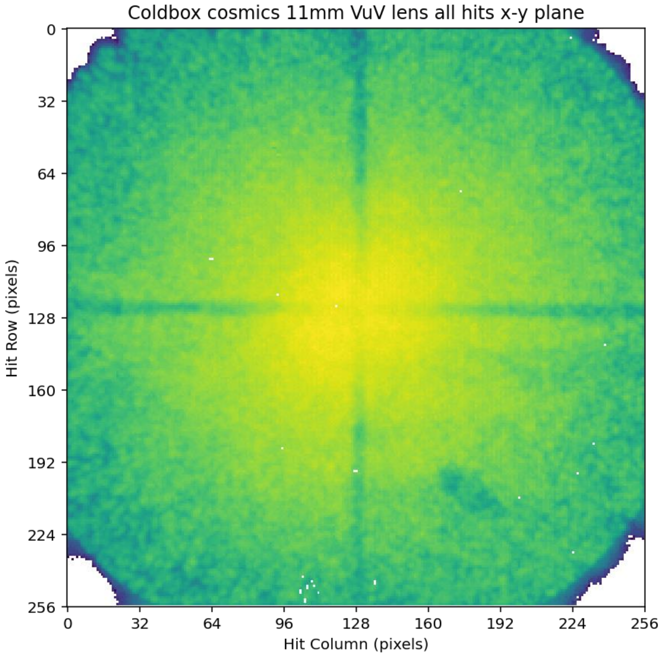
Dismounting (Monday 4^{th} April)

Ongoing analysis

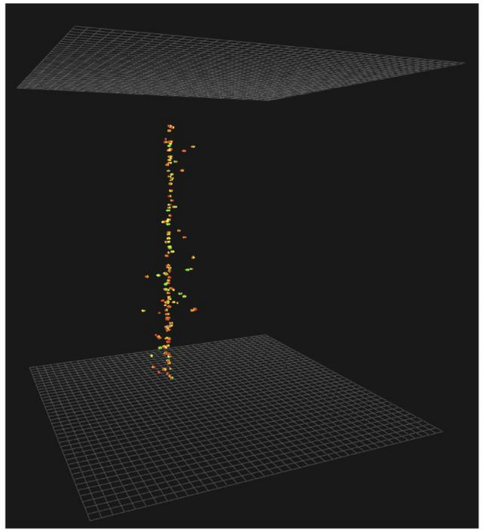


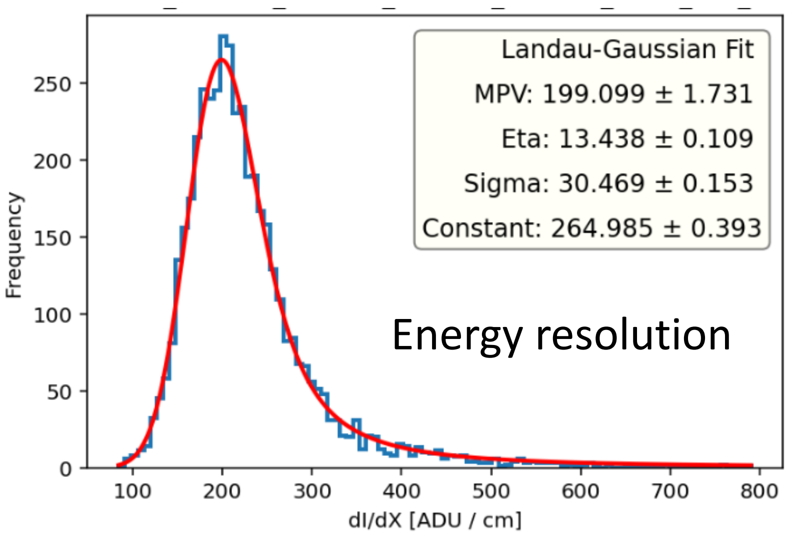


Visible integral

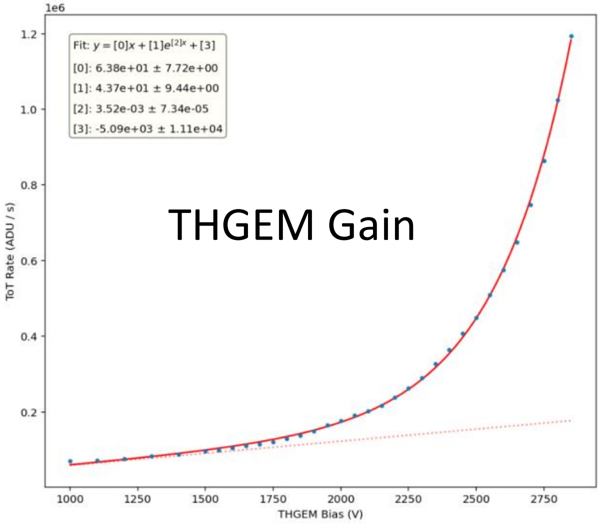


VUV Integral





Energy resolution



THGEM Gain

Outlook

Presenting results at DUNE collaboration meeting

- Presentation slot for module of opportunity
- Presentation at near detector technologies

Continued R&D will be ongoing

- Further development of VUV optics -> Improved resolution/light collection

Big thanks to the workshop and the HEP group for supporting us throughout