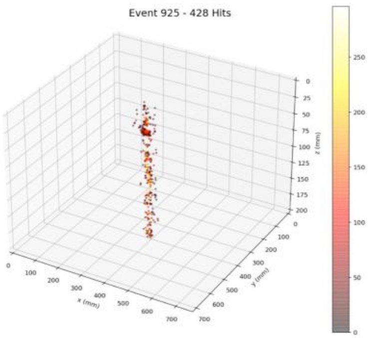
First Year Work

Liquid Argon Detectors:

Optical Readout & Glass-THGEM Development

Heriques Frandini Gatti

Supervisor: Dr. Kostas Mavrokoridis.



June 2026

Introduction & Outline

Research objective:

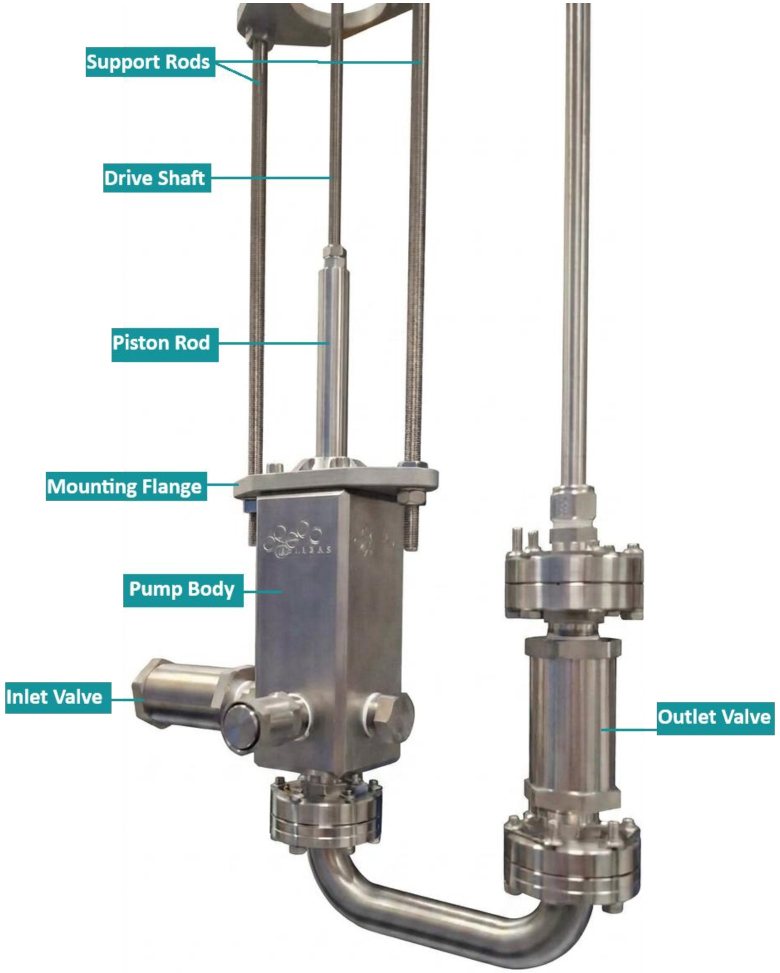
Develop, validate, and apply novel technologies for noble liquid TPC detectors through technical innovation, with a specialized focus on advancing optical readout systems and the advancement of THGEM-based detector components.

Outline:

- ❑ ARIADNE Upgrades:
  - Novel cryogenic piston pump.
  - THGEM new connectors.
  - Capacitive level meters.
- ❑ Glass-THGEM Facility:
  - Photolithography workspace.
  - Micro-sandblasting protocols.
- ❑ Timepix4 Sensor Evaluation:
  - Integrated Timepix4 into the demonstrator to leverage its timing and space resolution.
- ❑ Future Work.

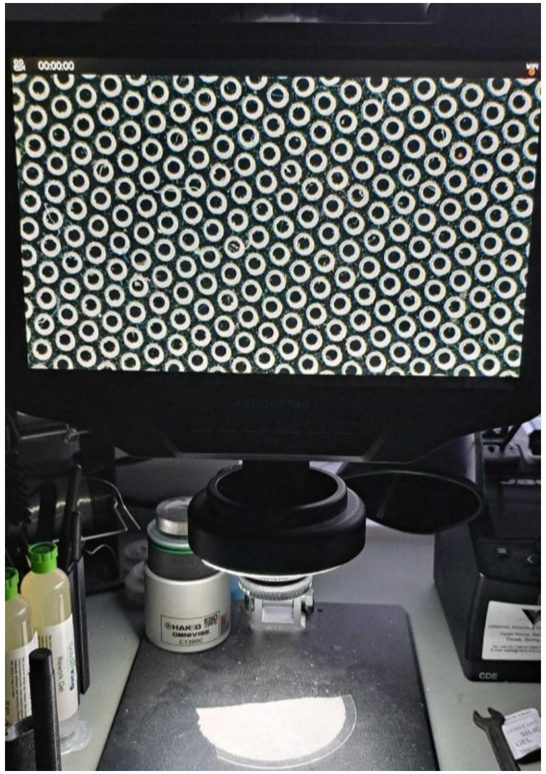
ARIADNE Upgrades

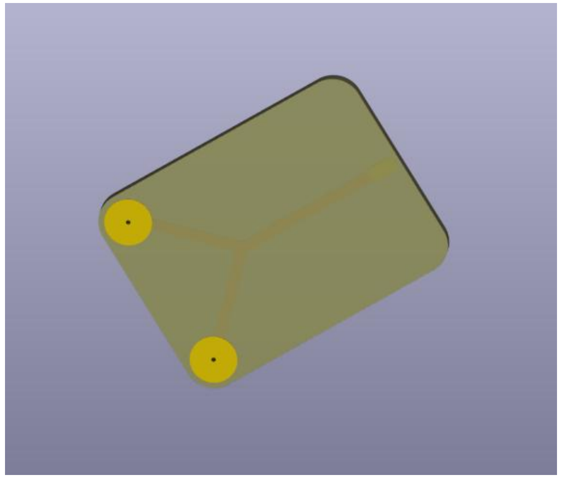
- Novel cryogenic displacement piston pump:

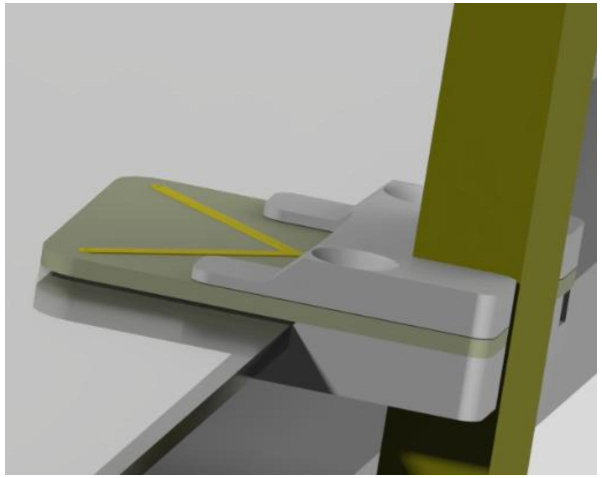


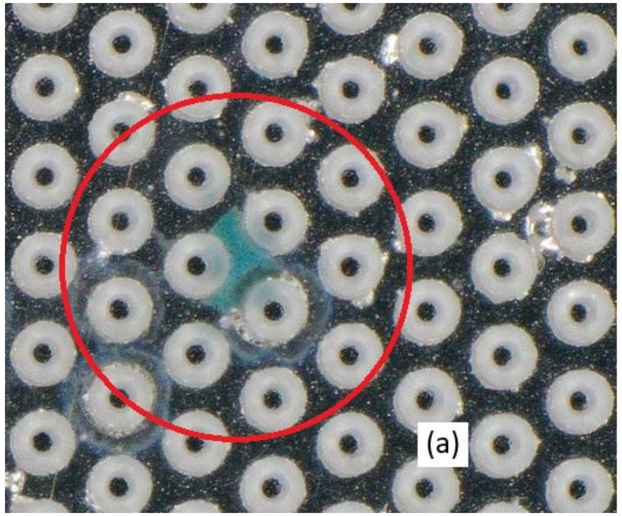
ARIADNE Upgrades

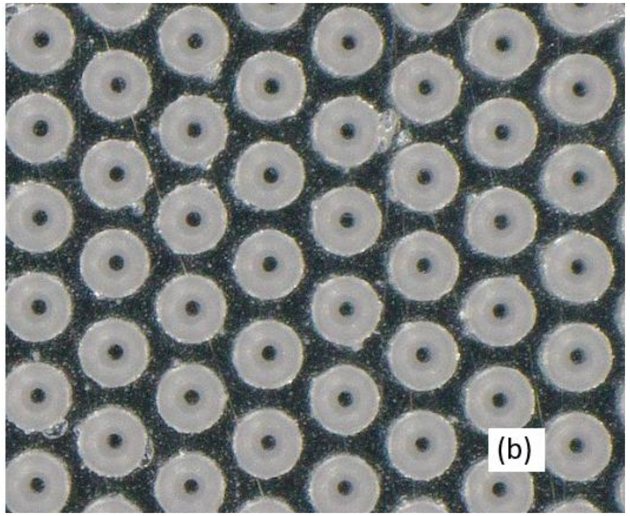
- THGEM cleaning replacement and new connectors:

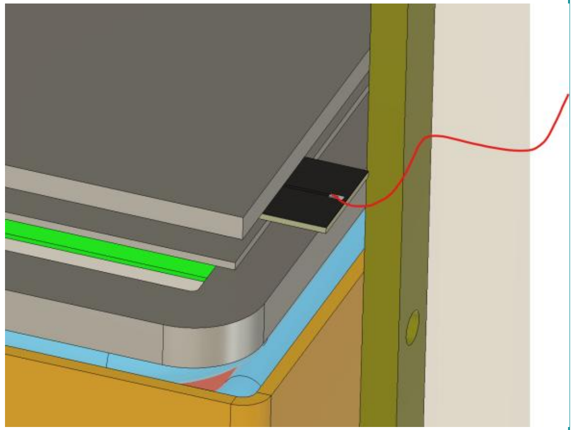










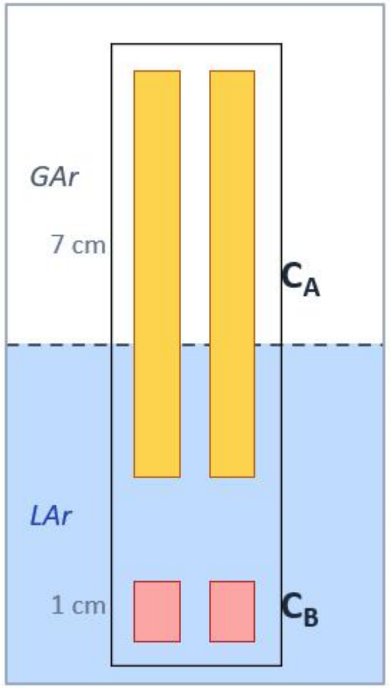


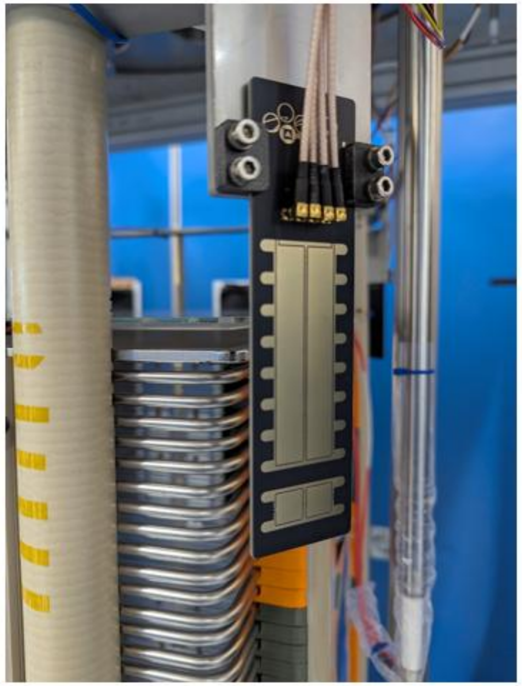
ARIADNE Upgrades

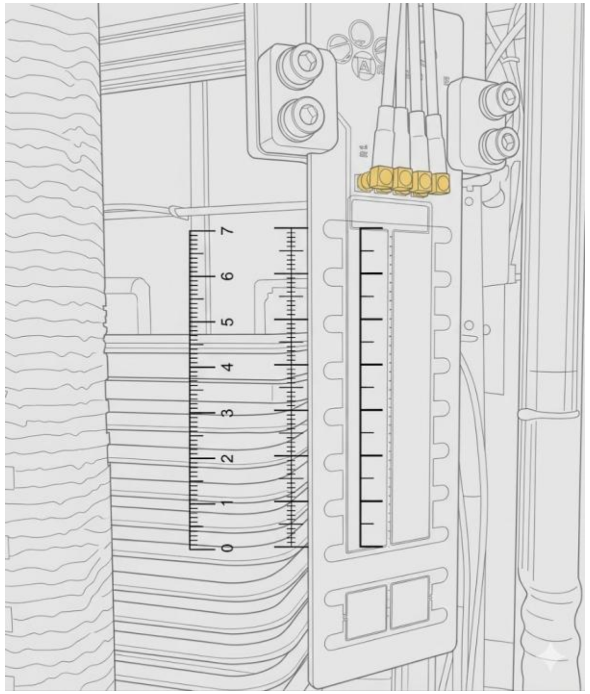
❑ Capacitive level meters:

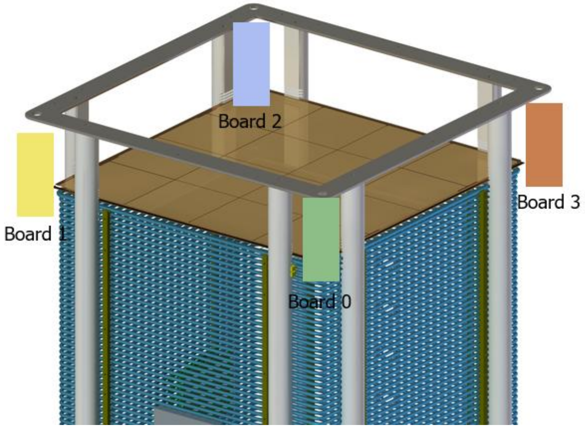
$$Level\ cm = \frac{Val - offset}{Calibration}$$

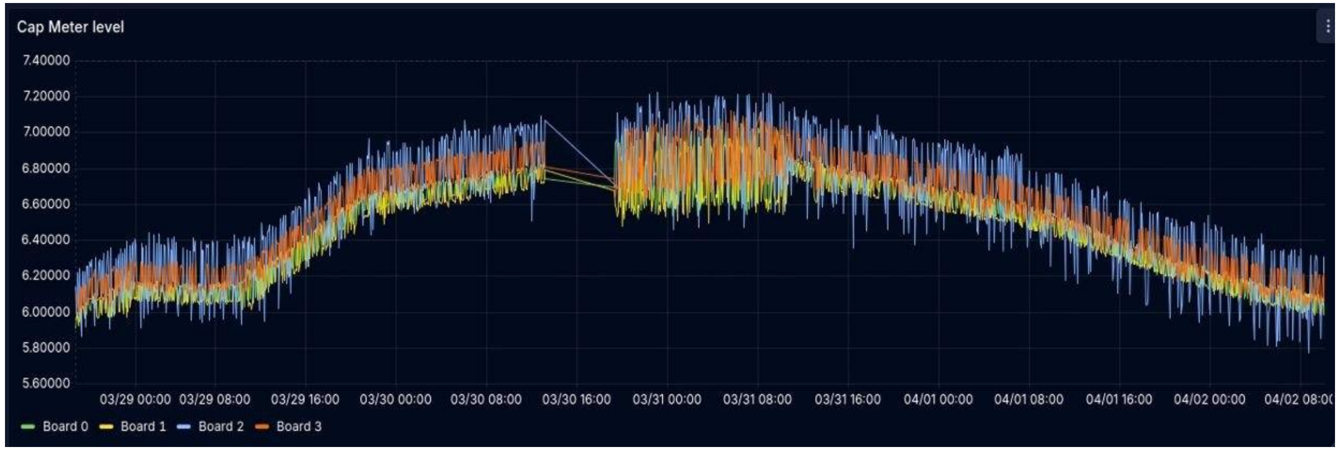
Val	live capacitance reading on the long strips, C_A
Offset	C_A baseline value in pure gaseous argon
Calibration	ΔC_B per cm — from gas → liquid step





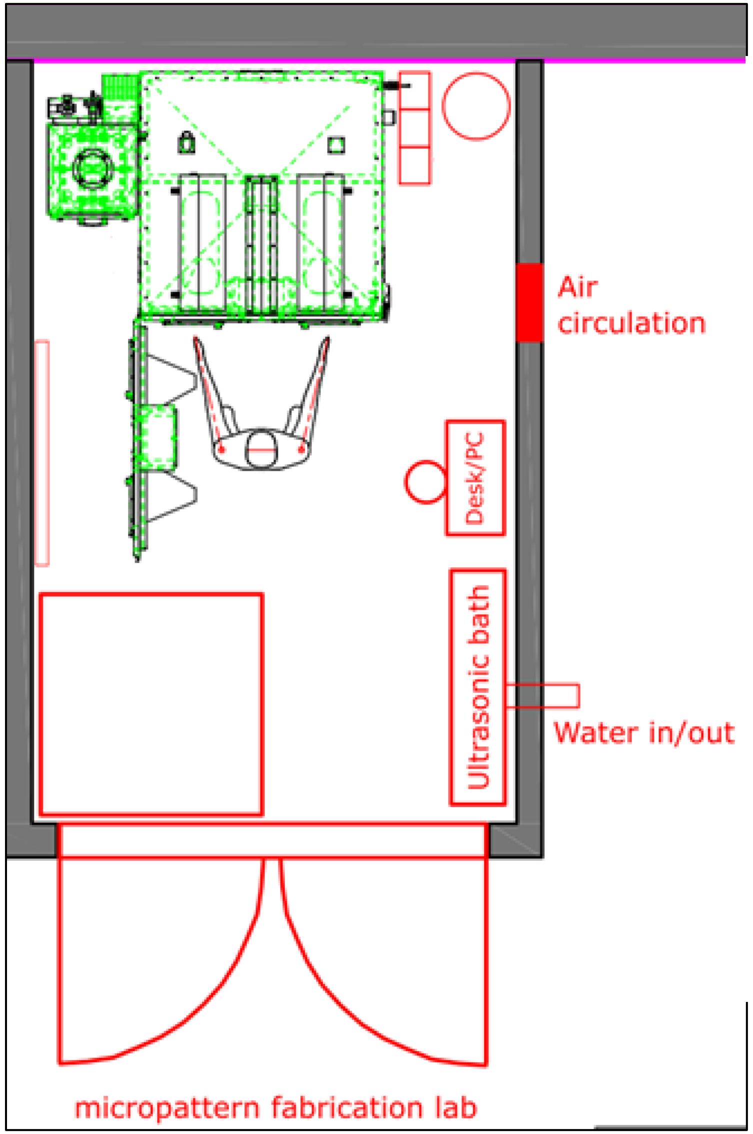


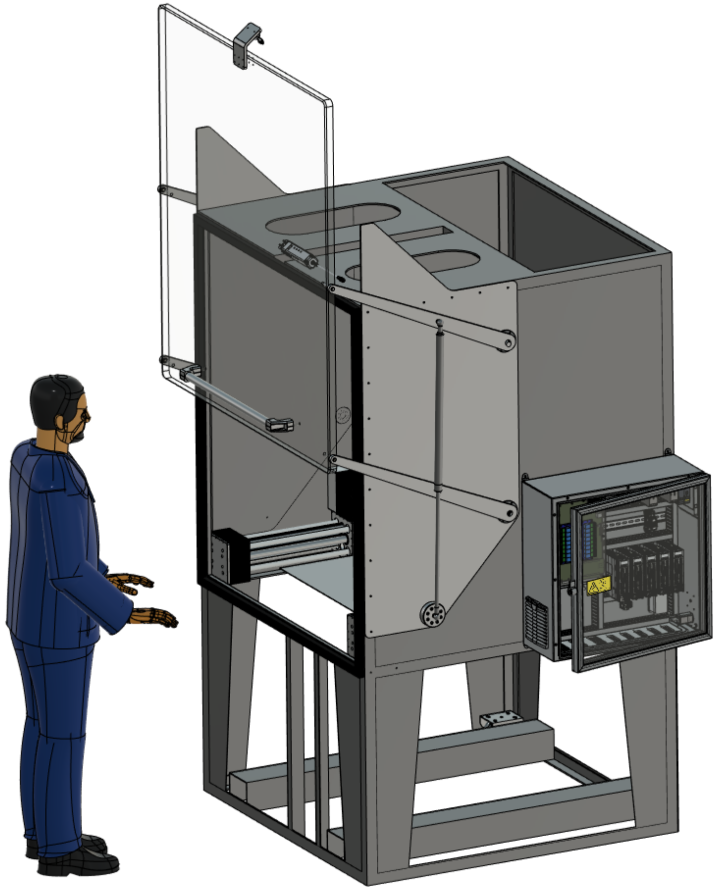




Glass-THGEM Facility

- Photolithography workspace:





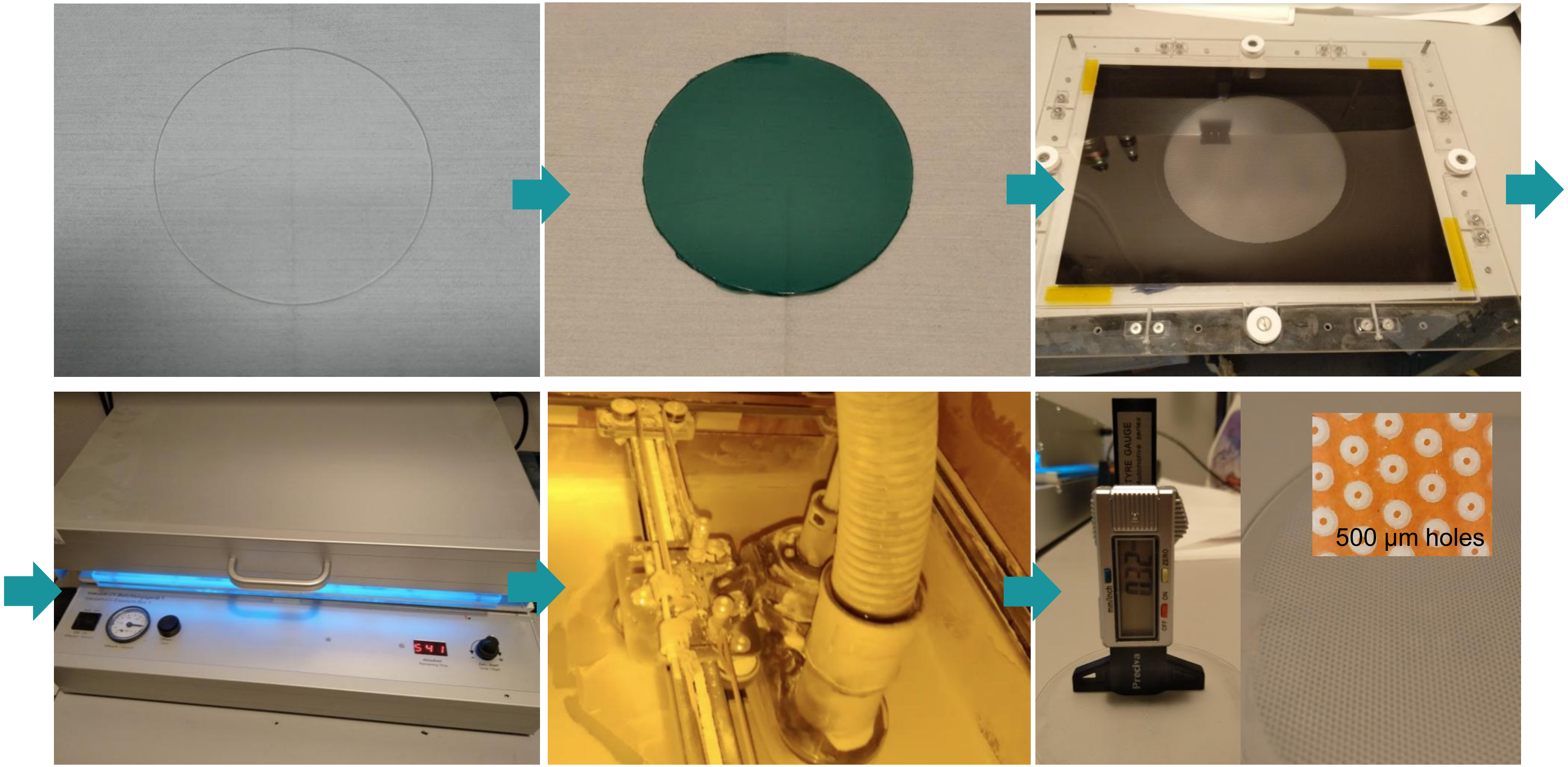
Glass-THGEM Facility

ARIADNE

MicroPattern Detector Facility

UNIVERSITY OF LIVERPOOL

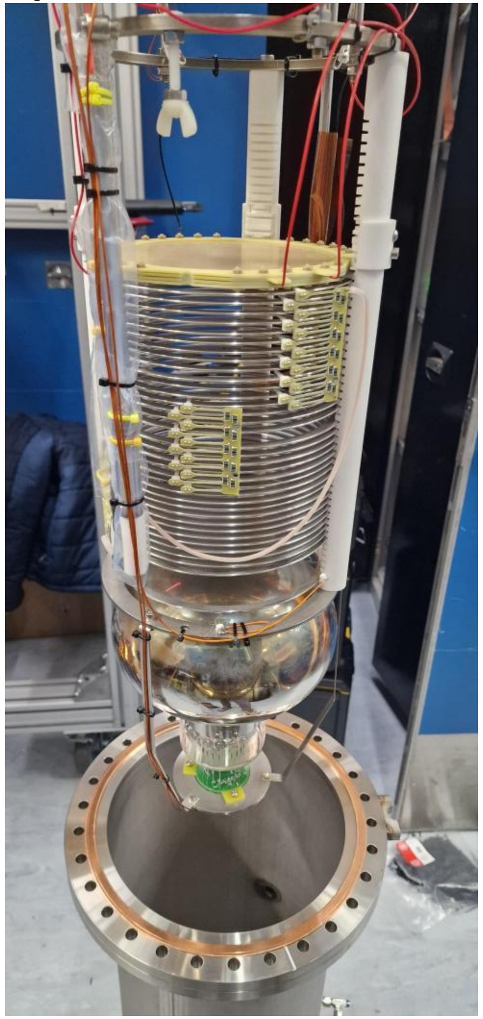
❑ Micro-sandblasting protocols:

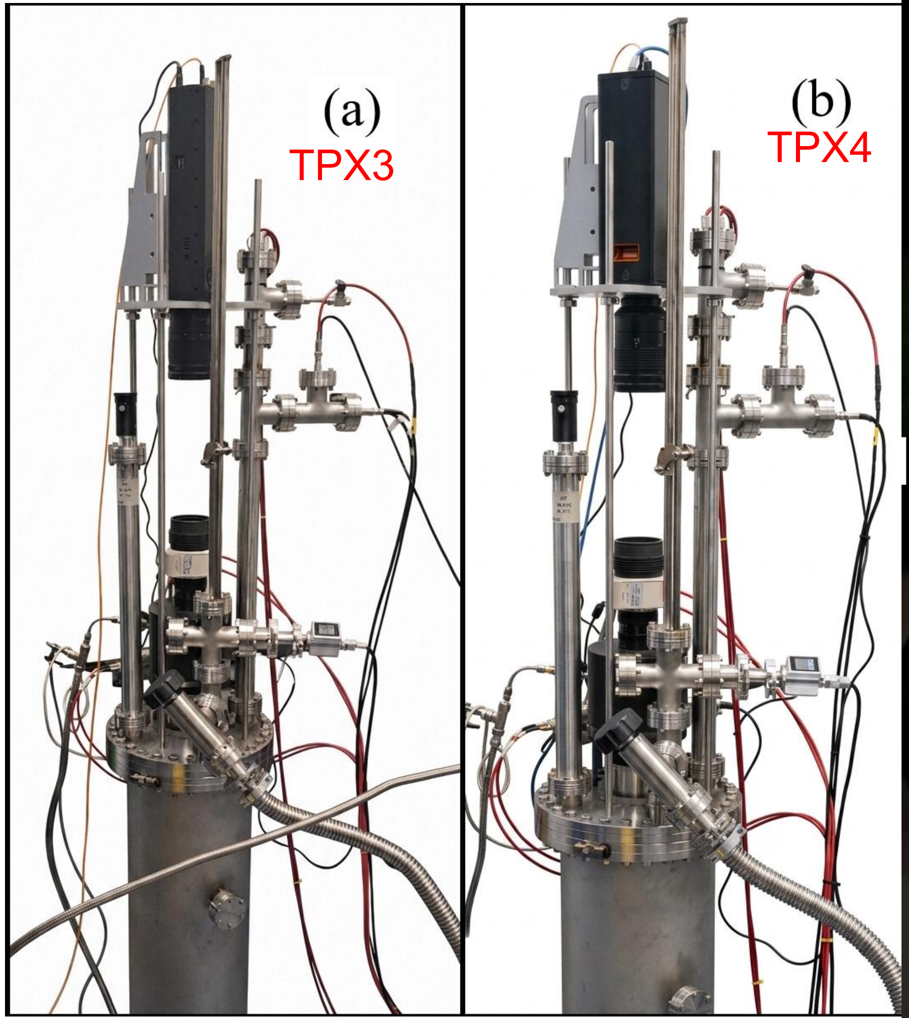


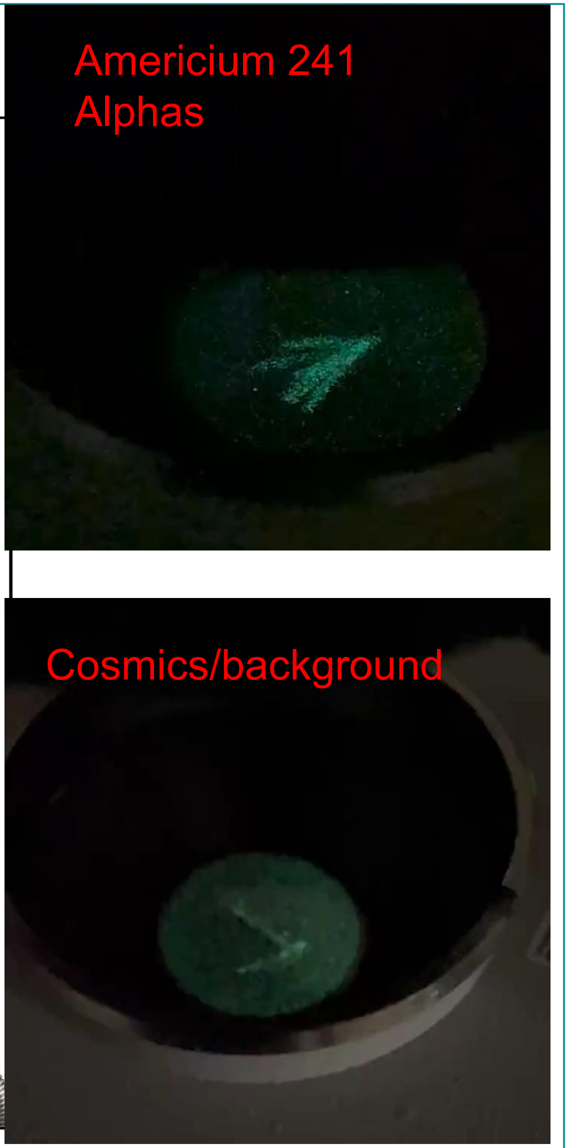
Timepix4 Sensor Evaluation

- Integrated Timepix4 into the demonstrator :

- both chips share a 55×55 μm2 pixel pitch.
- Timepix4 increases the sensor matrix to 448×512 pixels (approximately 230k channels) compared to the 256 × 256 matrix (65k channels) of Timepix3.
- Timing precision is also improved narrowing from 1.5625 ns down to 195 ps

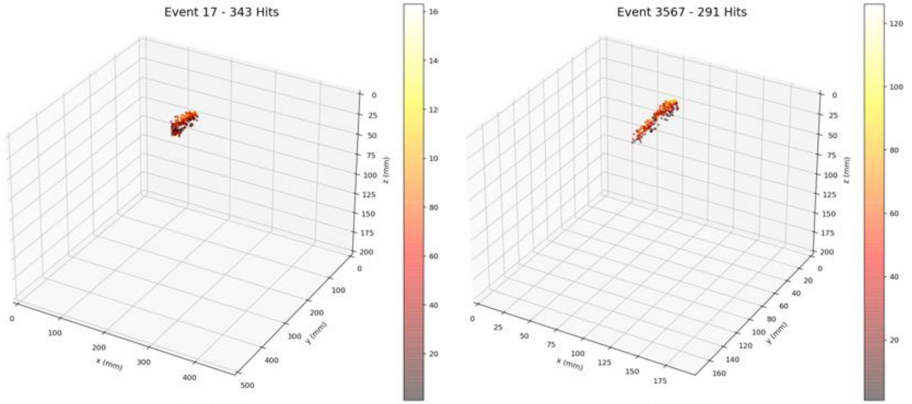




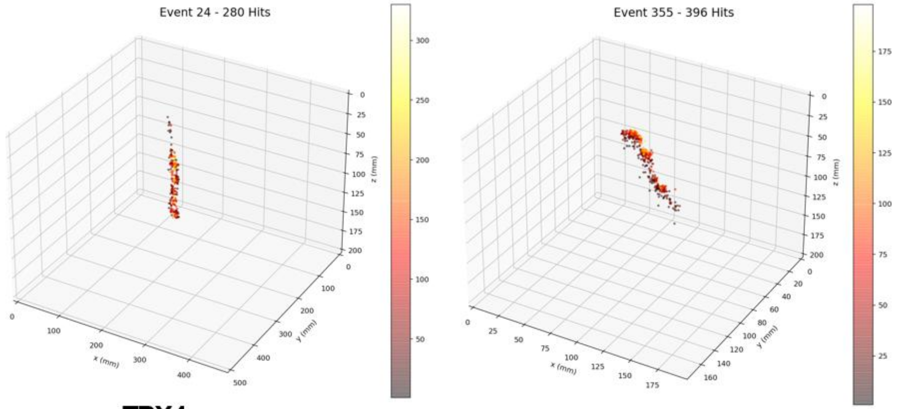


Timepix4 Sensor Evaluation

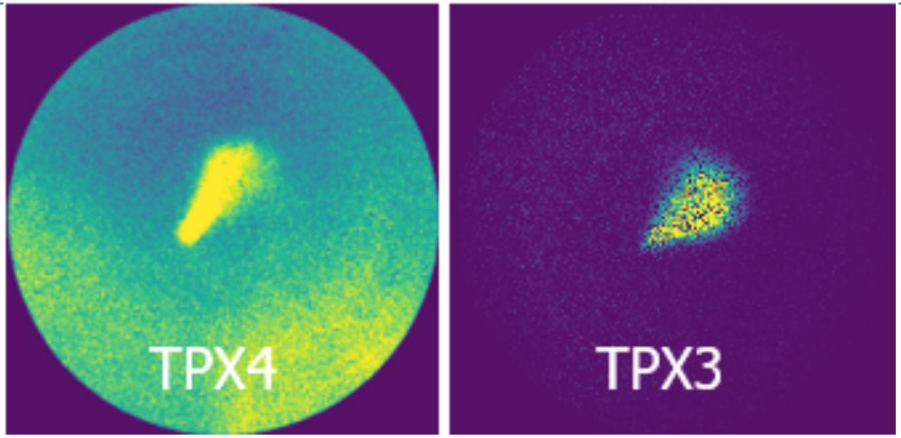
- Preliminary Comparison Analysis Results :



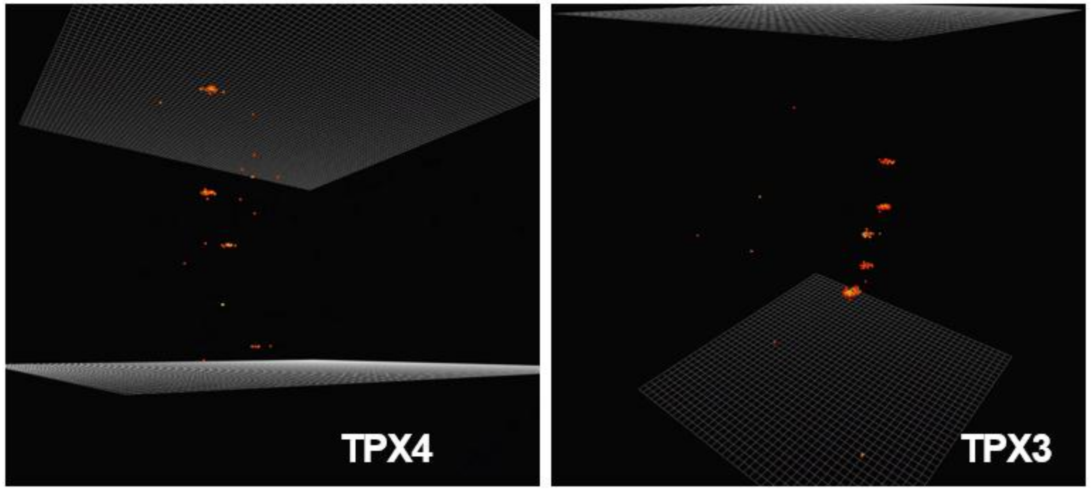
TPX4 ^{241}Am alphas TPX3



TPX4 Cosmics TPX3



Field of view ^{241}Am alphas



^{55}Fe gammas

Future Work

ARIADNE:

- Upgrade the slow control and remote operation systems.
- Implementing in-line liquid argon monitoring.
- Redesigning the camera mounting platform.
- Enhancing light-tightness and thermal insulation on the top flange.

Glass-THGEM Facility:

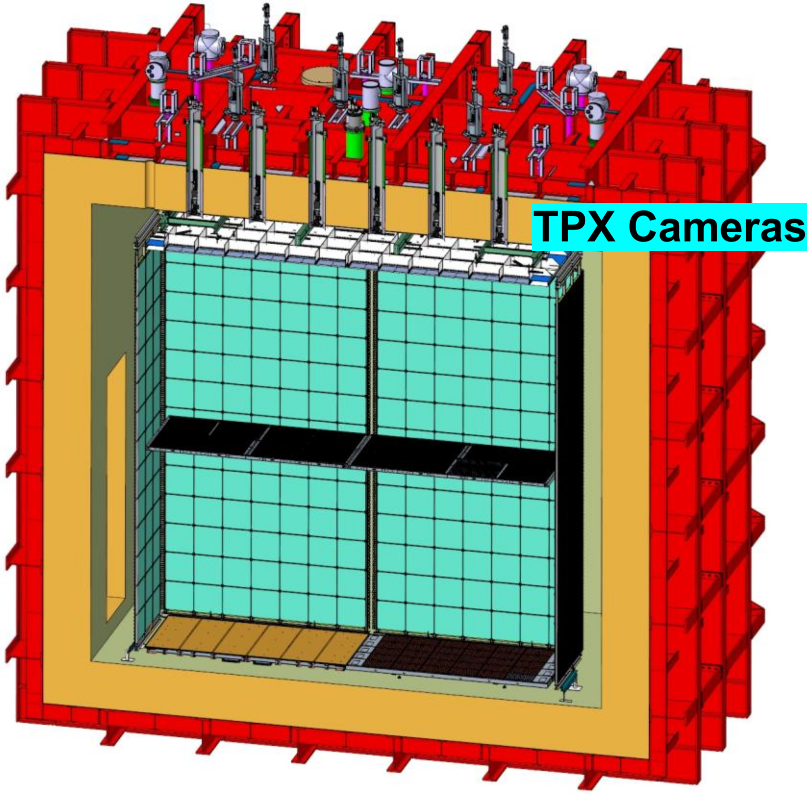
- Completing the commissioning of the final sandblasting machine.
- Testing various blasting parameters.
- Evaluating alternative masking procedures.
- Test the performance of new glass GEMs in prototype gas TPC

Timepix4 Sensor Evaluation:

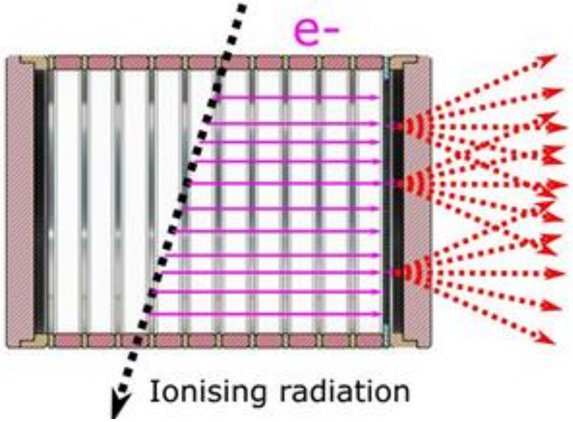
- Finish the undergoing analysis of the collected data.
- Future calorimetric analysis of this data.
- Assist further hardware and software development.
- Extend the test in ARIADNE detector using a liquid medium.

Next Large scale Steps

- ProtoDUNE III Run proposal submitted by DUNE to SPSC to test DUNE Phase II technologies in NP02:



- Development of a permanently sealed gaseous detector, which incorporates THGEMs:



Extra Slides

Liquid Argon Detectors:
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Background

Academic Background:

- Bachelor's Degree in Science and Technology - UFABC
- Bachelor's Degree in Physics - UFABC
- Master's Degree in Physics - UNIFAL

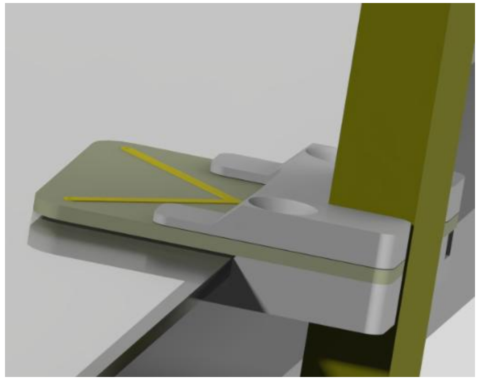
Experience:

- Cryogenics and Vacuum designs and applications
- Scientific Applied Instrumentation
- Photon Detection System in TPCs

Current Work

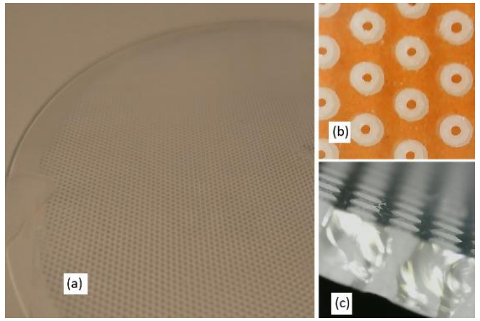
ARIADNE Upgrades:

- Novel cryogenic piston pump.
- THGEM new connectors.
- Capacitive level meters.



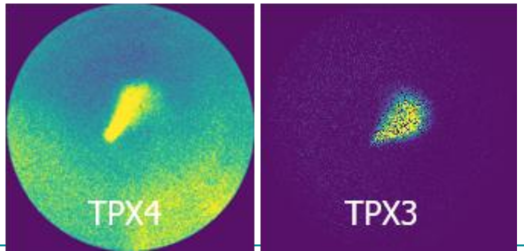
Glass-THGEM Facility:

- Photolithography work space.
- Micro-sandblasting protocols.



Timepix4 Sensor Evaluation:

- Integrated Timepix4 into the demonstrator to leverage its timing and space resolution.



Future Work

Data Analysis:

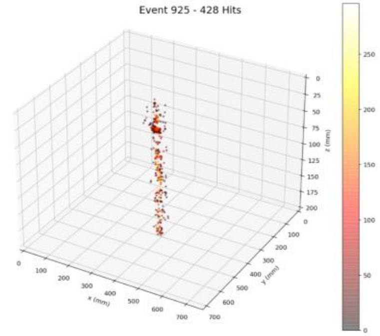
- Finalize comparative performance data analysis between Timepix4 and Timepix3 camera runs.

Prototype Characterization:

- Initiate comprehensive gain testing, stability tracking, and discharge mapping on home fabricated Glass-THGEMs.

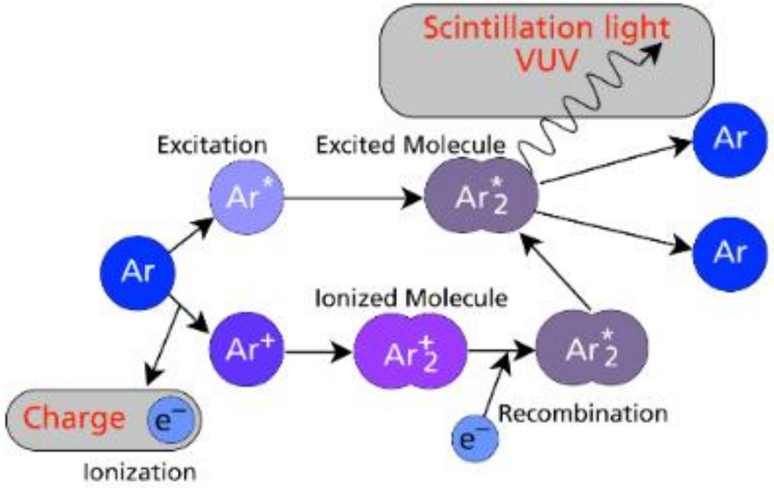
Continue Upgrades :

- Keep the hardware upgrades on ARIADNE detector.

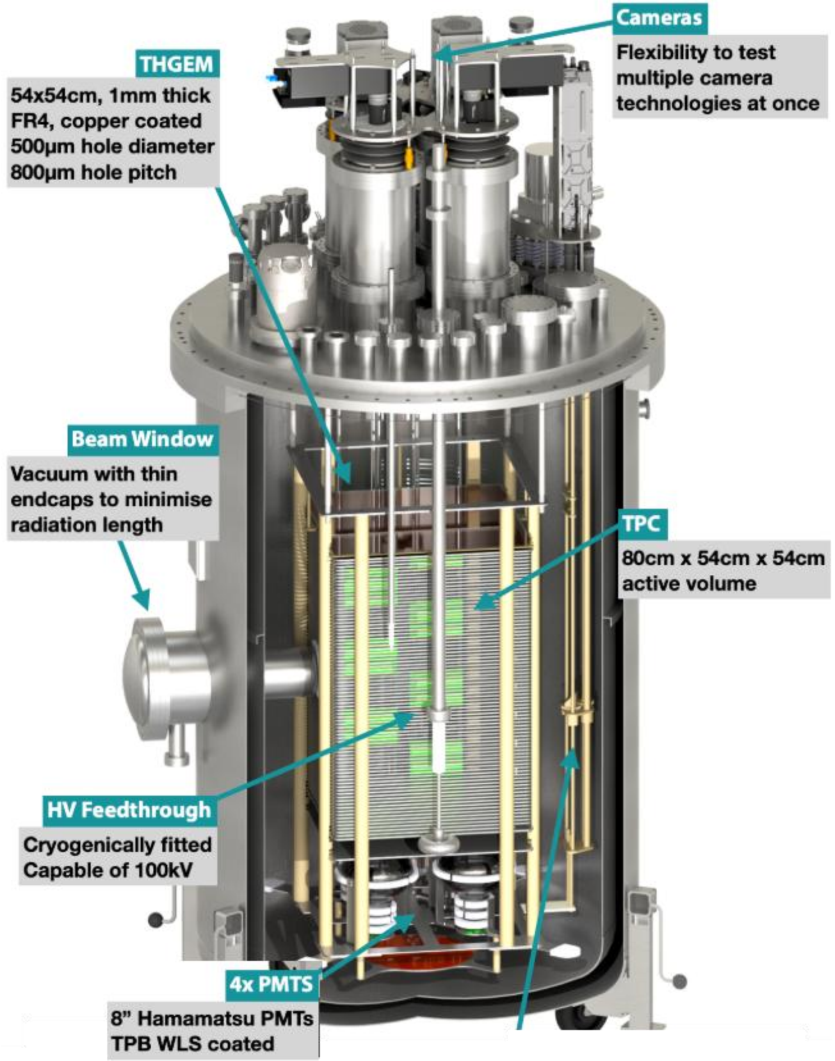


Liquid Argon as medium

- High density 1,4 g/cm3;
- There is no electron affinity allowing long drift-time;
- High electron mobility;
- Is easy to purify and reach high levels of purity;
- It is inert;
- Excellent optical properties

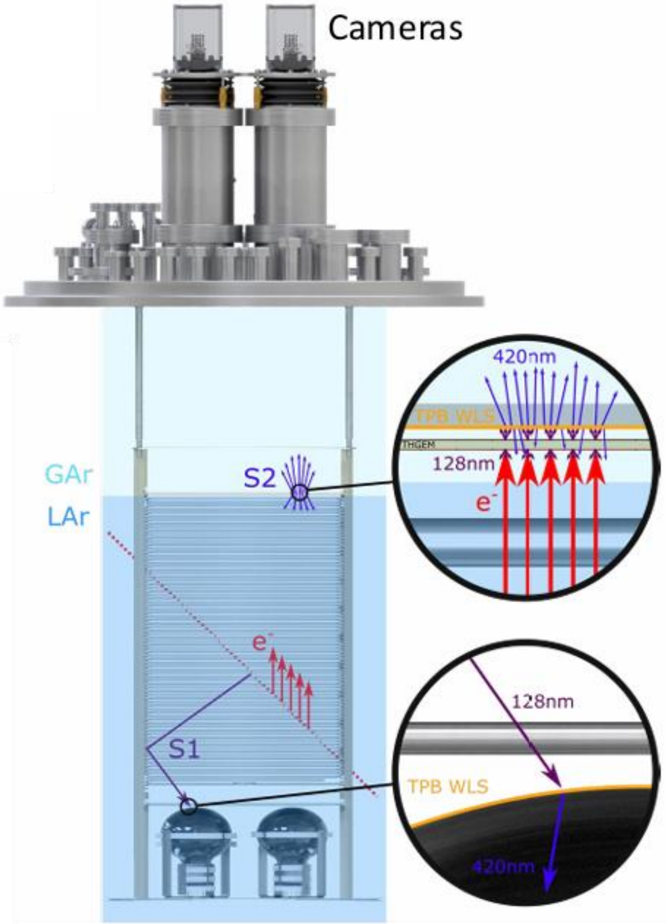


The ARIADNE Liquid Argon detector



3D Optical TPC Detection Principle

- Incoming particles ionise LAr and create prompt scintillation light (S1)
- Electrons drift towards the extraction grid situated below the liquid level
- A THGEM(THick-Gaseous Electron Multiplier) amplifies drift charge (capable of >30 kV/cm in LAr) generating secondary scintillation light (S2)
- WLS(Wavelength Shifting) before imaging with ultrafast camera



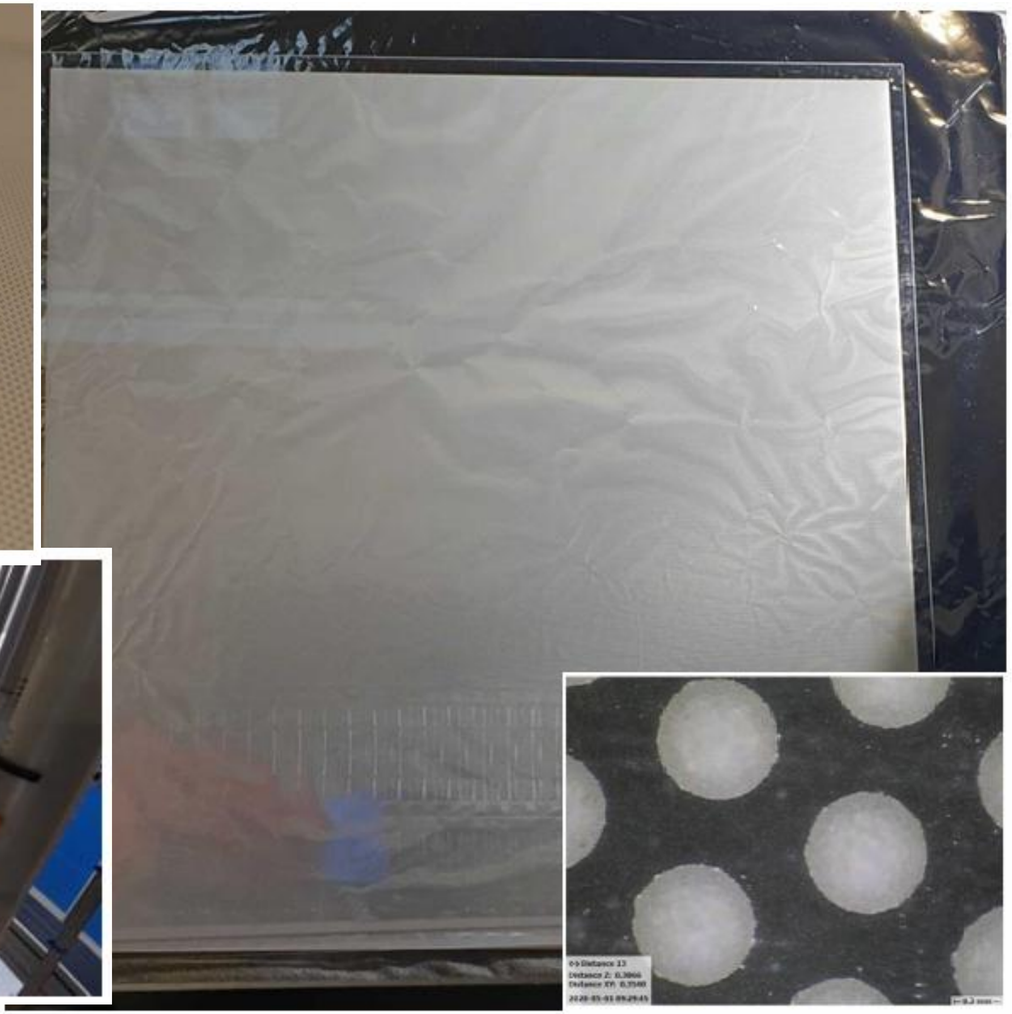
<u>Benefits over previous charge readout techniques:</u>

- **High resolution**
- **Sensitivity to low energies**
- **Very low noise, decoupled from TPC**
- **Ease of access**
- **Cost efficient**

ARIADNE Key component: G-THGEM

Sixteen 50cm x 50cm glass THGEMs 1.1mm thick, 500µm ID holes, 800µm pitch hexagonal array

Novel Glass THGEMs developed at Liverpool (Patent GB2019563.2)

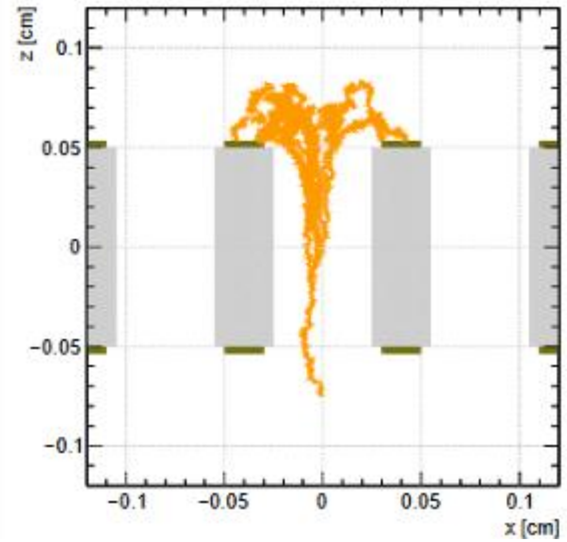


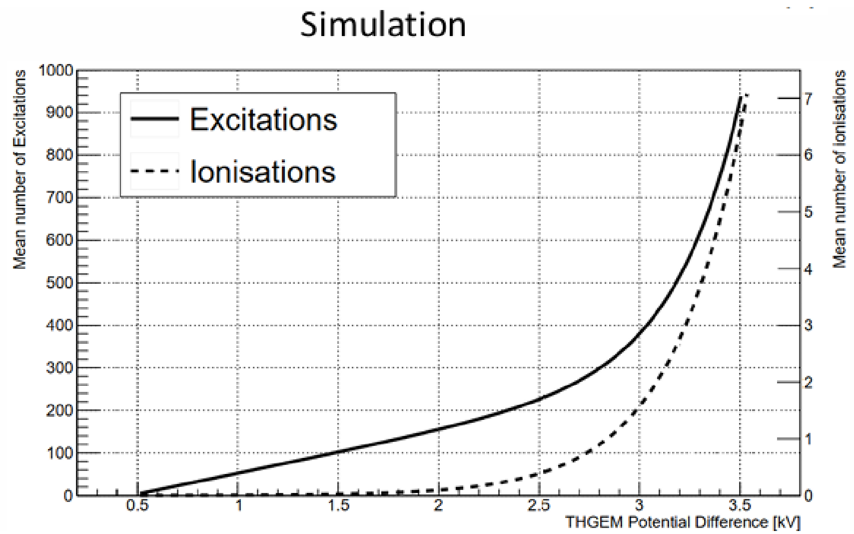
THGEM S2 light production

VUV (126nm) light produced through de-excitation of Argon gas. TPB Wavelength shifter above THGEM converts to 430nm.

At low field (<2KV/cm), S2 light production is linearly proportional to THGEM field. No charge gain. Very stable operation without discharges. No ion production.

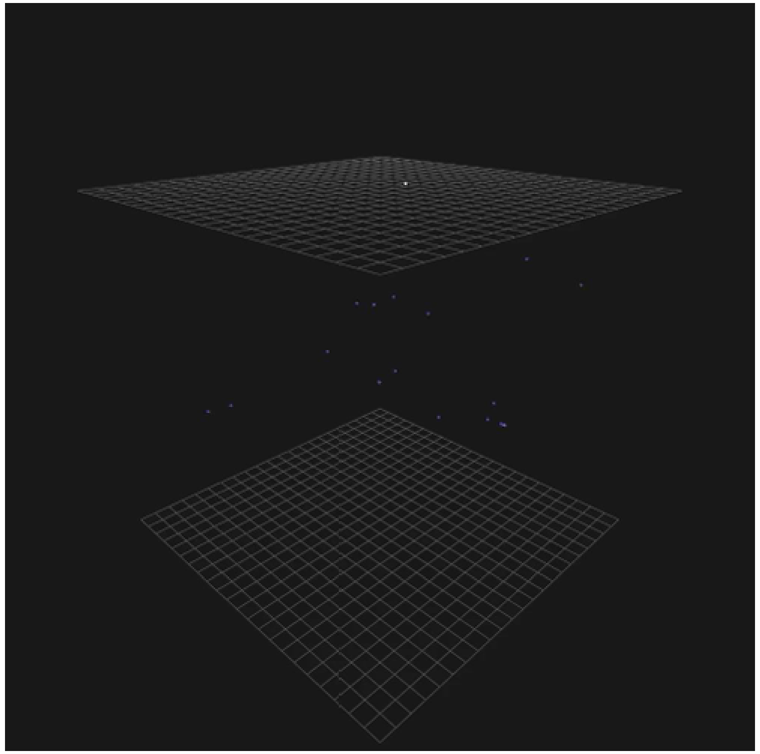
At higher fields, electron multiplication occurs (Townsend avalanche). Exponentially increasing S2 light production -> Improved sensitivity/threshold





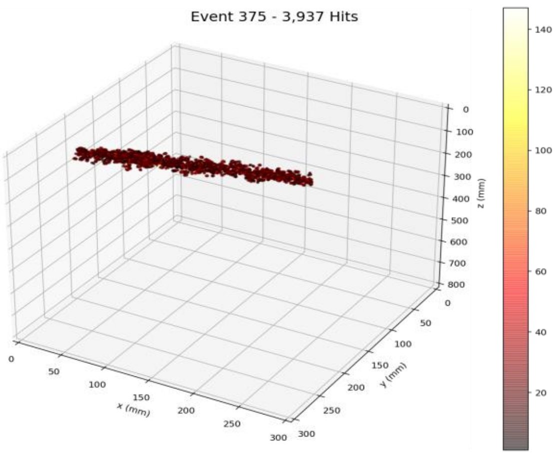
3D image forming

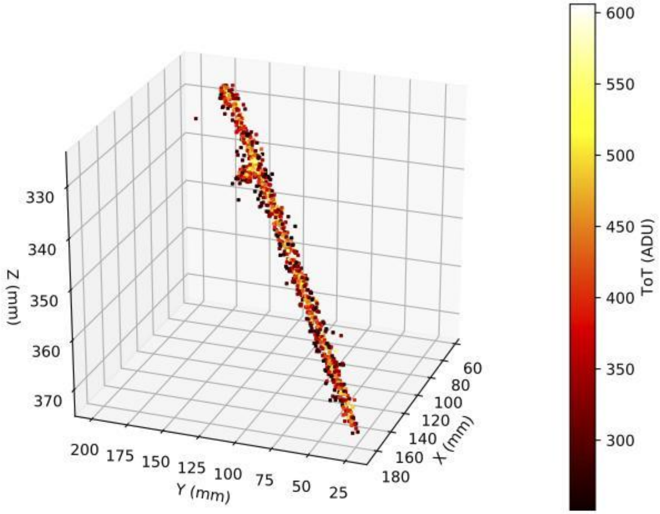
Side View

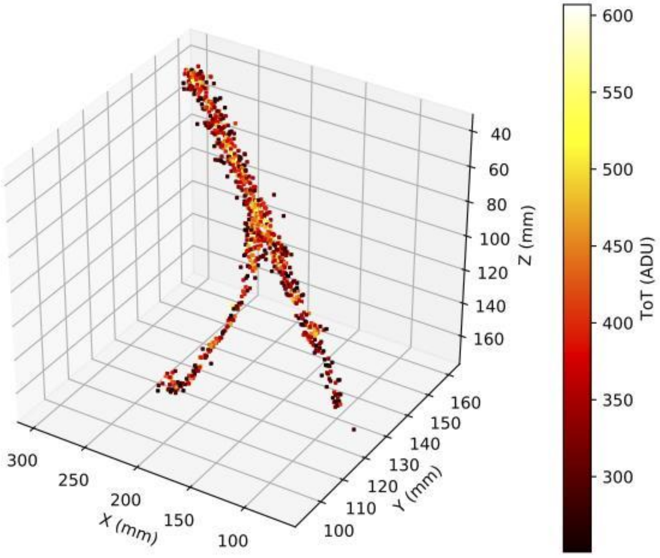


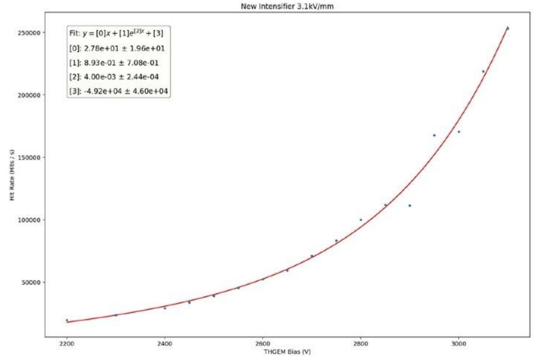
Top View

Some results









MicroPattern Detector Facility (MPDF)

Dedicated abrasive machining facility in the University of Liverpool physics building

Fully automated with machining area of 850mmx850mm

The primary goals of the facility are;

- Production of bespoke THGEM structures for Liverpool and external customers
- Perform R&D towards optimisation of structures (resistive coatings, novel patterns, etc)
- Provide a general-purpose facility for abrasive machining: **Not limited to glass. Any brittle material i.e. ceramic, carbon fibre etc can all be machined**

This facility will be used to produce all glass THGEMs required for the protoDUNE operation.