

# Characterisation of a Planar Opaque LiquidO Detector with Cosmic-Ray Muons

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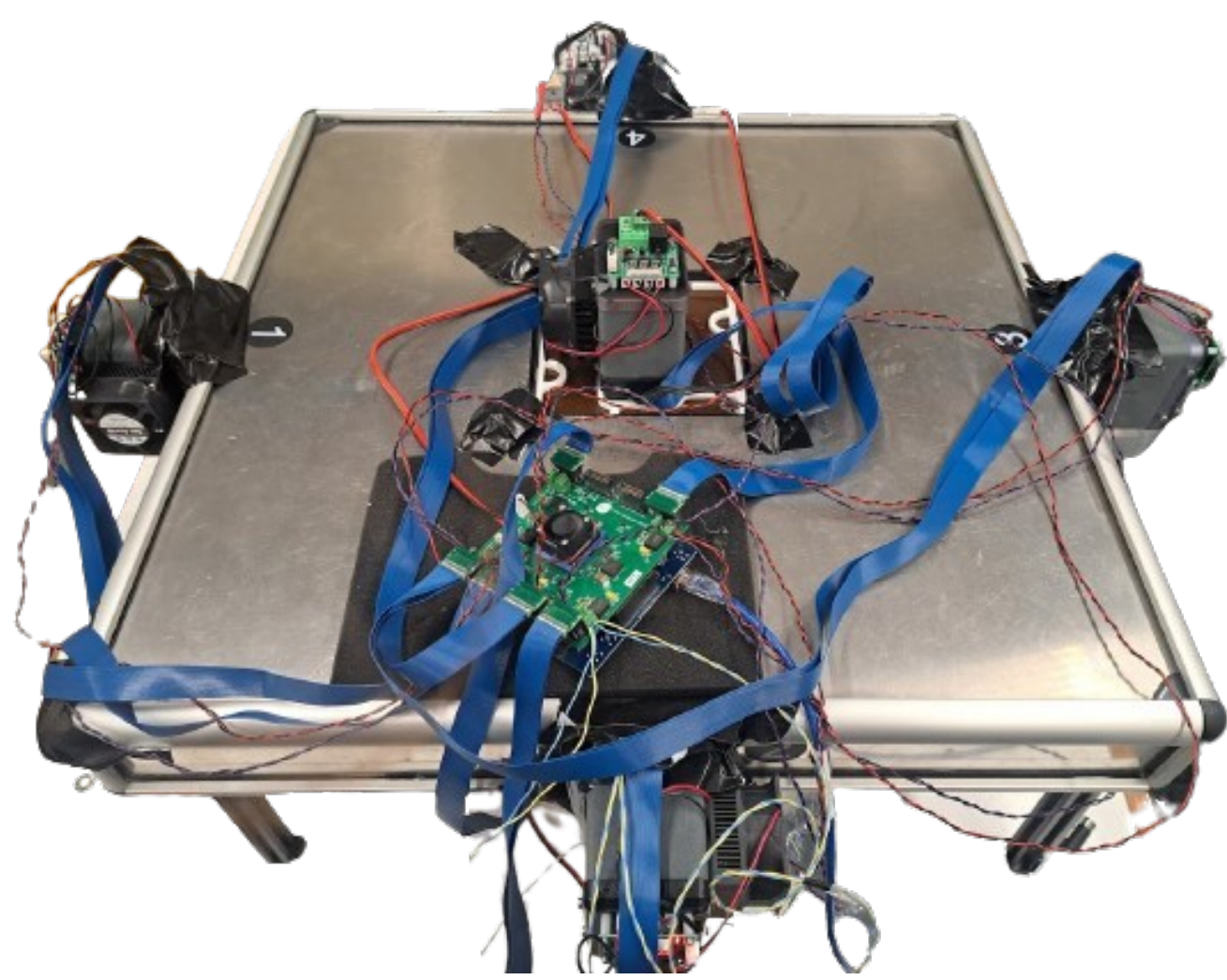
On behalf of the  
LiquidO Collaboration

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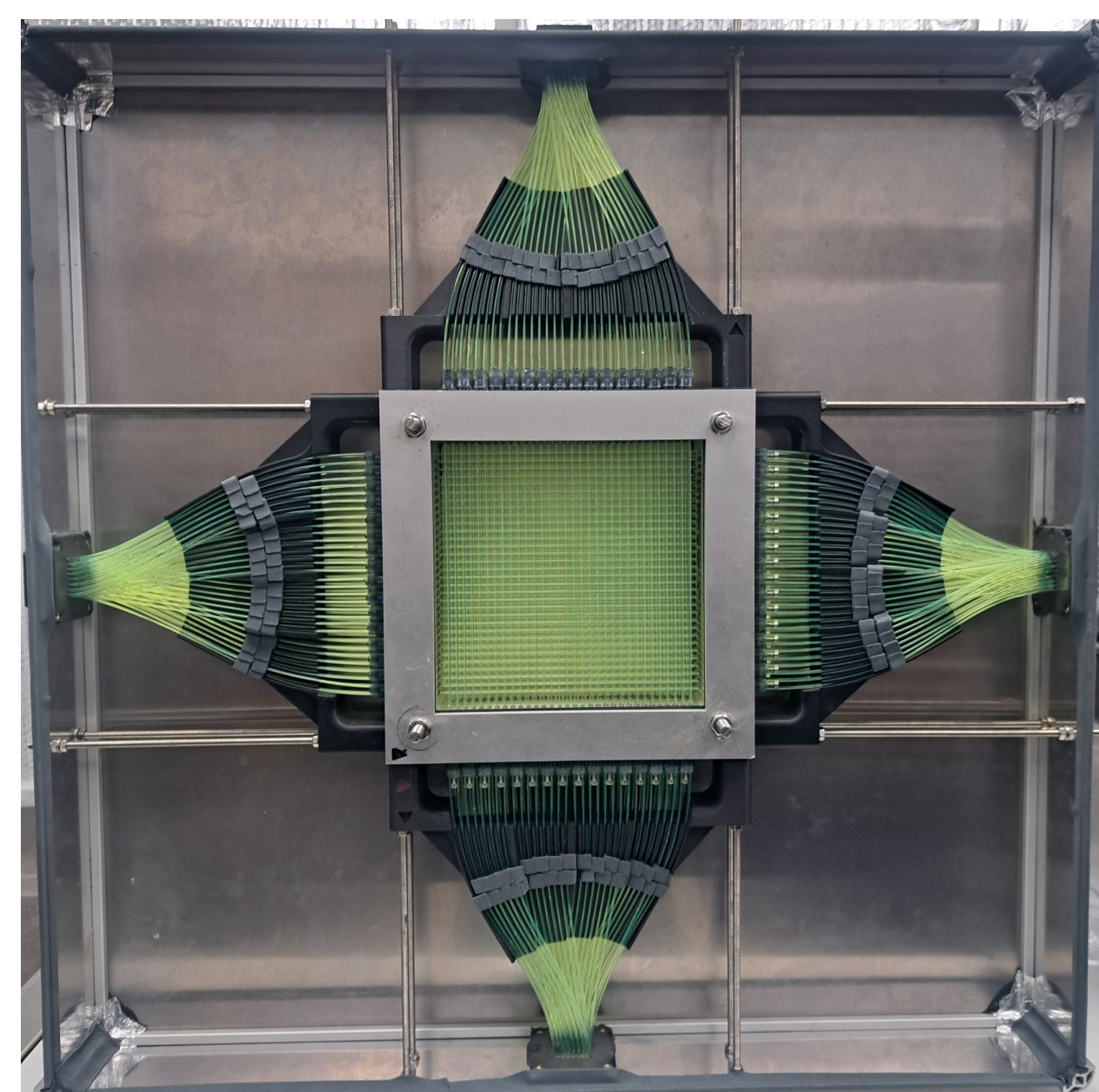


## 1 Muon Imaging

Muon imaging is a non-intrusive and non-destructive imaging method with uses in nuclear security, civil engineering, archaeology, and many other areas<sup>[1]</sup>. This poster shows a prototype that will test the performance of a LiquidO detector in muon tomography.



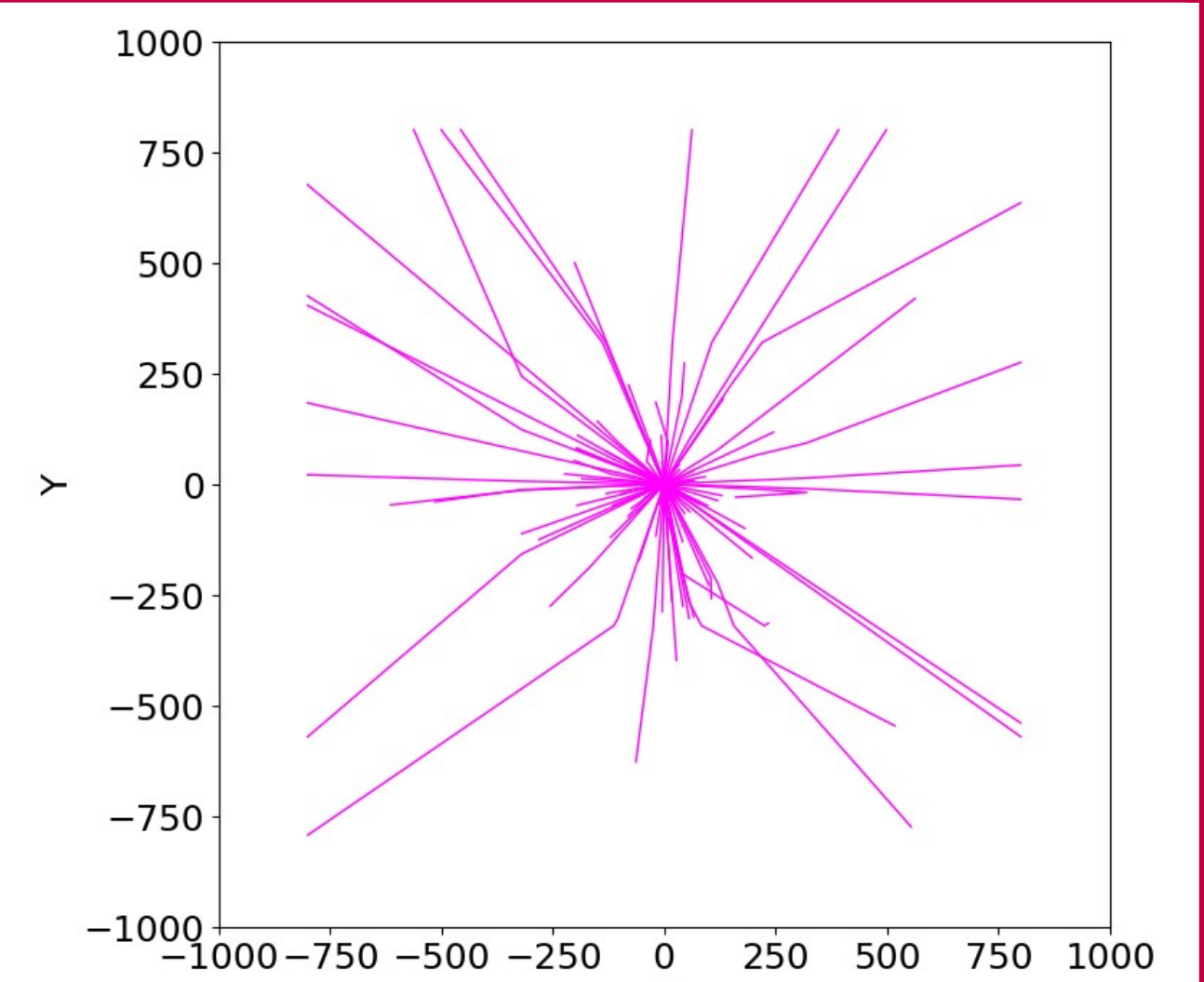
↑ The detector instrumented with lid



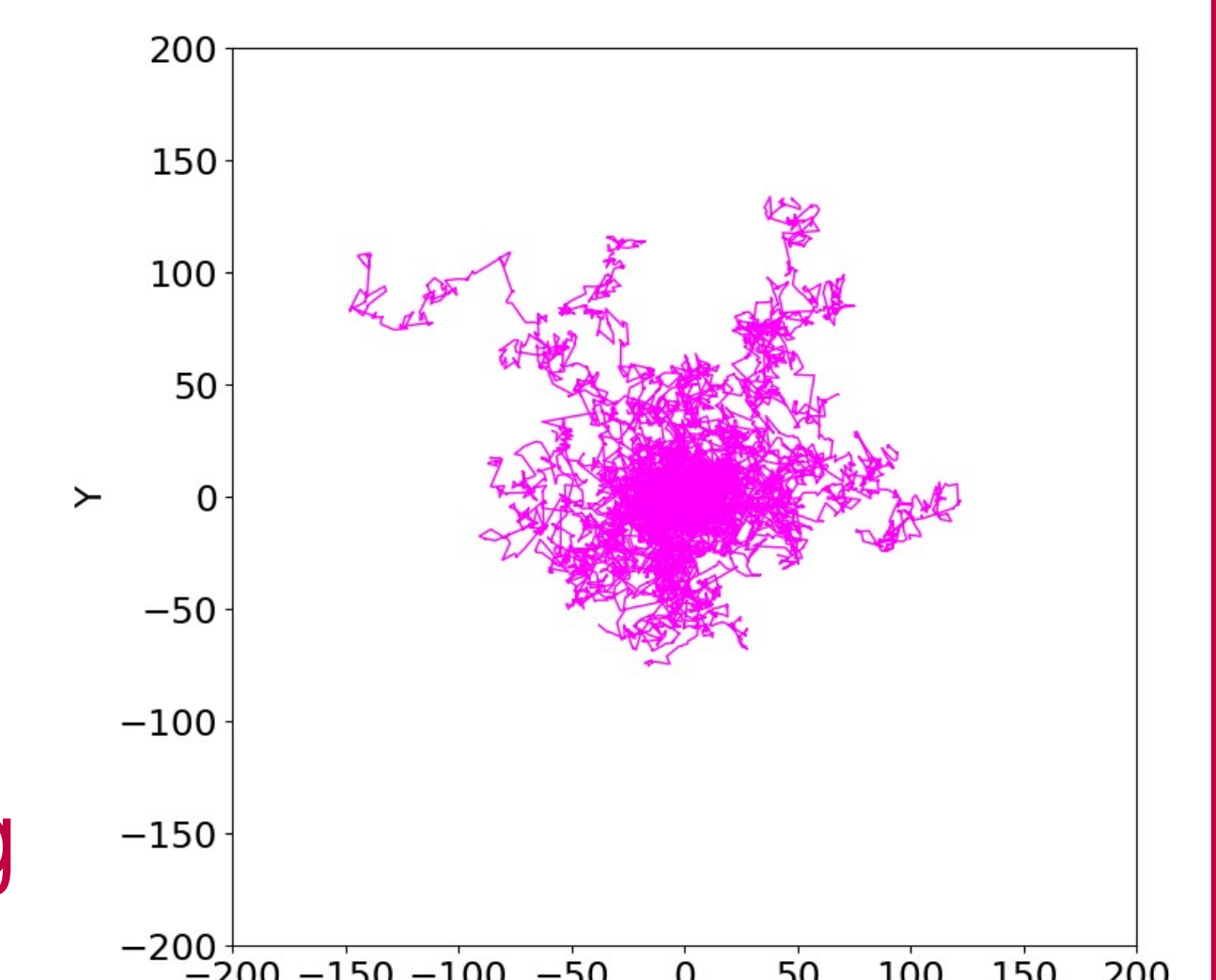
↑ Photo of the detector showing the inner volume

## 2 The LiquidO Concept<sup>[2]</sup>

- ▶ **Opaque** light-producing media (e.g. **scintillator**) makes up the detection volume.
- ▶ Opacity forces photons to undergo a random walk about their origin = **stochastic confinement of light**.
- ▶ Dense arrays of **wavelength-shifting fibres** pick up and transmit the light to silicon photomultipliers (SiPMs).
- ▶ **High-resolution imaging** without physical segmentation.



↑ Light paths in transparent media

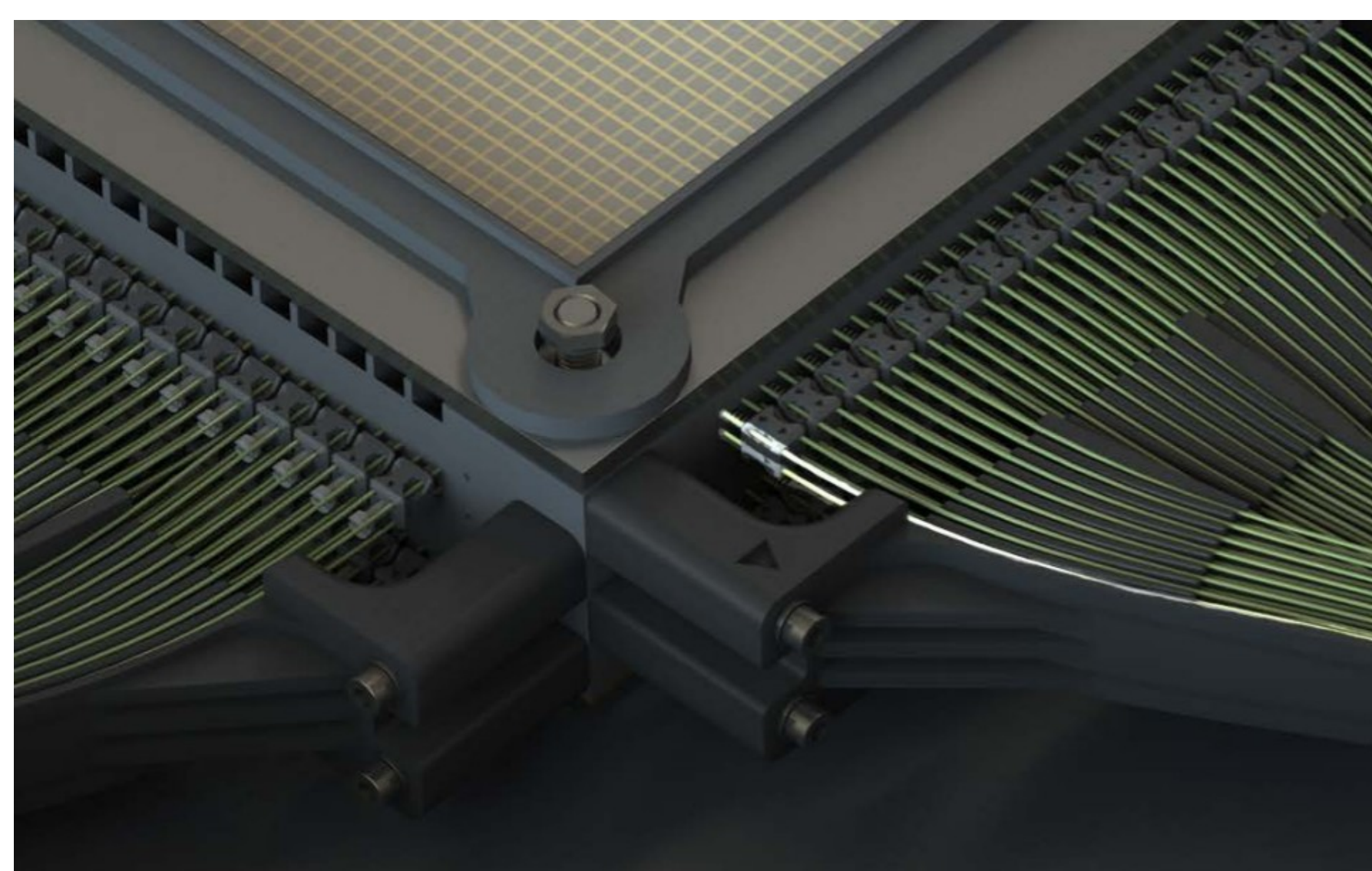


↑ Light paths in opaque media

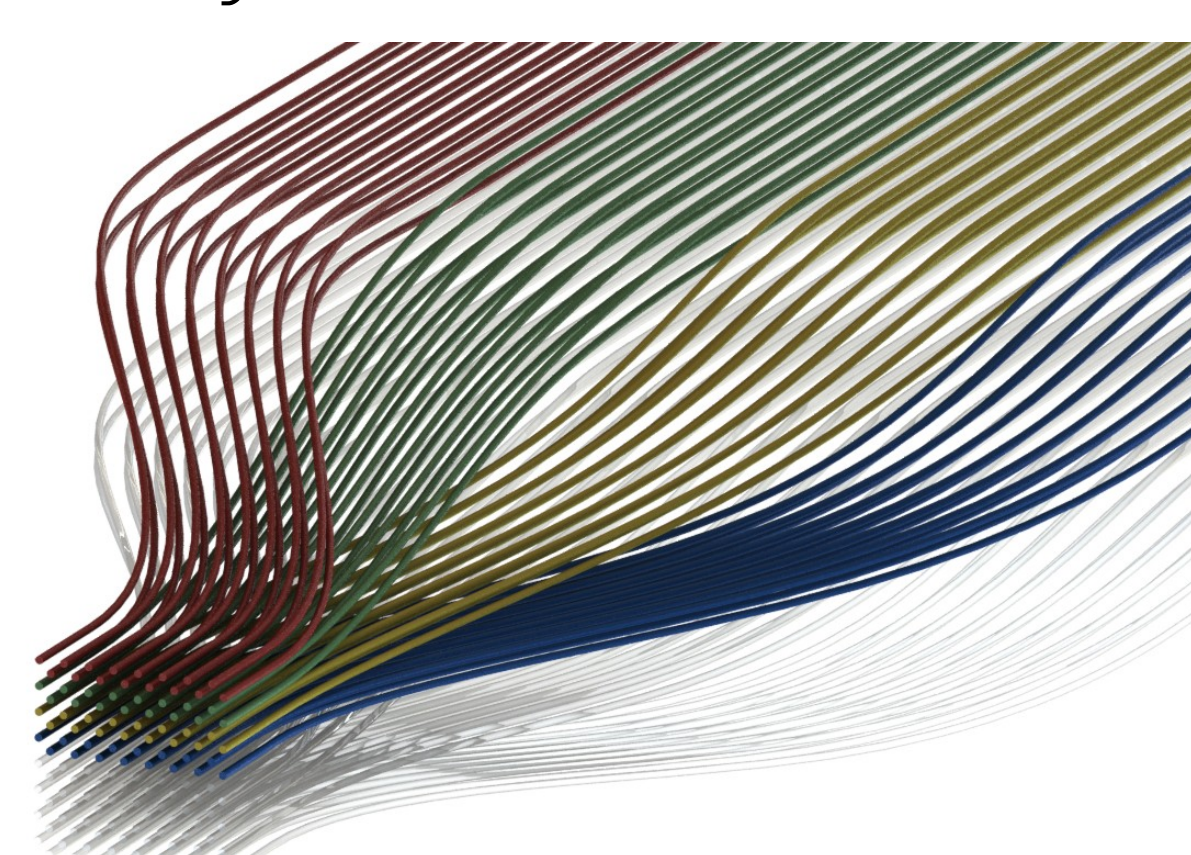
## 3 The Tile: A Planar LiquidO Detector

The Tile has:

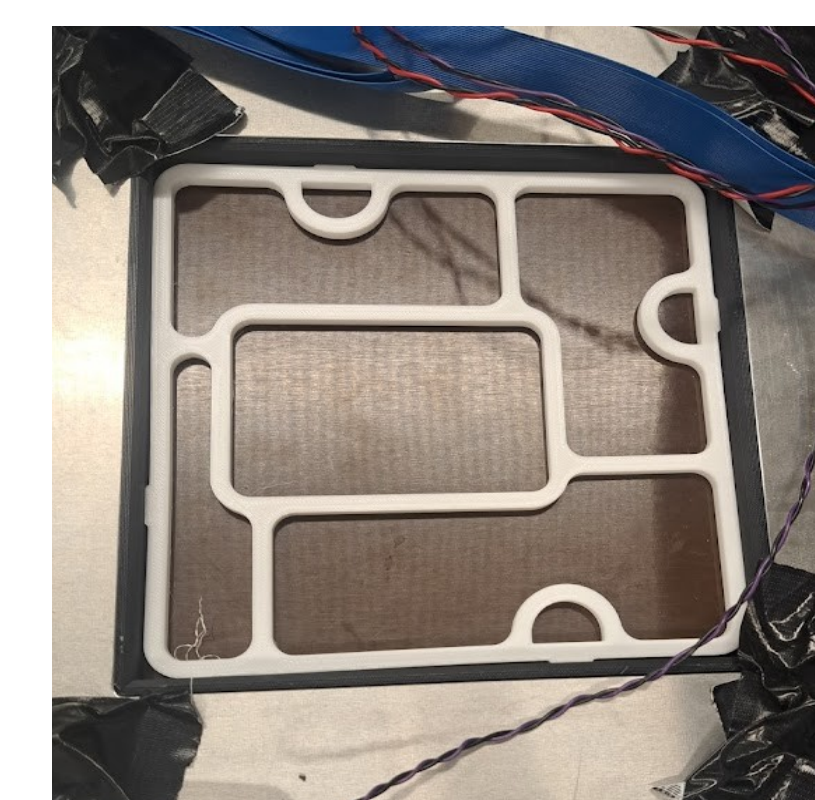
- ▶ 16.8 x 16.8 x 5.5 cm<sup>3</sup> scintillator volume
- ▶ 8 layers of St. Gobain BCF-91A wavelength shifting fibres
- ▶ 5 mm fibre pitch in x, y, and z directions
- ▶ Light collection with Hamamatsu S13361-3050-AE-08 SiPM arrays
- ▶ 2 fibres per SiPM to increase light output
- ▶ Read out using PETsys TOFPET2 ASICs<sup>[3]</sup>
- ▶ 'NoWaSH'<sup>[4]</sup> opaque scintillator using LAB+PPO+POPOP+15w.t.% wax with a ~0.5 mm scattering length
- ▶ Expect ~17,000 muons/hr



The eight layers of fibre act as four layers. Each pair of layers goes to one SiPM on the array. In the graphic above, the two lit up fibres share an SiPM. The diagram below illustrates how the 32 fibre long rows converge into the 8 x 8 grid to match the SiPM array dimensions.



Above and below the Tile sit two pixelated muon taggers, each made of 64 optically separated transparent plastic scintillator cubes covering a 3 x 3 cm<sup>2</sup> area. This enables tagging of 12 muons/hr through specific regions for a high-confidence selection of muons through key positions for characterisation purposes.



Above to the left shows a 3D printed guide for centring a tagger. Above to the right shows a tagger with its cooling module attached. The square on the front plate covers the tagger area.

### References:

- [1] Muon Imaging: Present Status and Emerging Applications. IAEA Tech Doc.
- [2] LiquidO Consortium. Neutrino physics with an opaque detector. Commun Phys 4, 273 (2021). LiquidO website: <https://liquido.ijclab.in2p3.fr/>
- [3] Bugalho, R. et al. Experimental characterization of the TOFPET2 ASIC. Journal of Instrumentation 14 (2019).
- [4] Buck, C. et al. Novel opaque scintillator for neutrino detection. Journal of Instrumentation 14 (2019).