

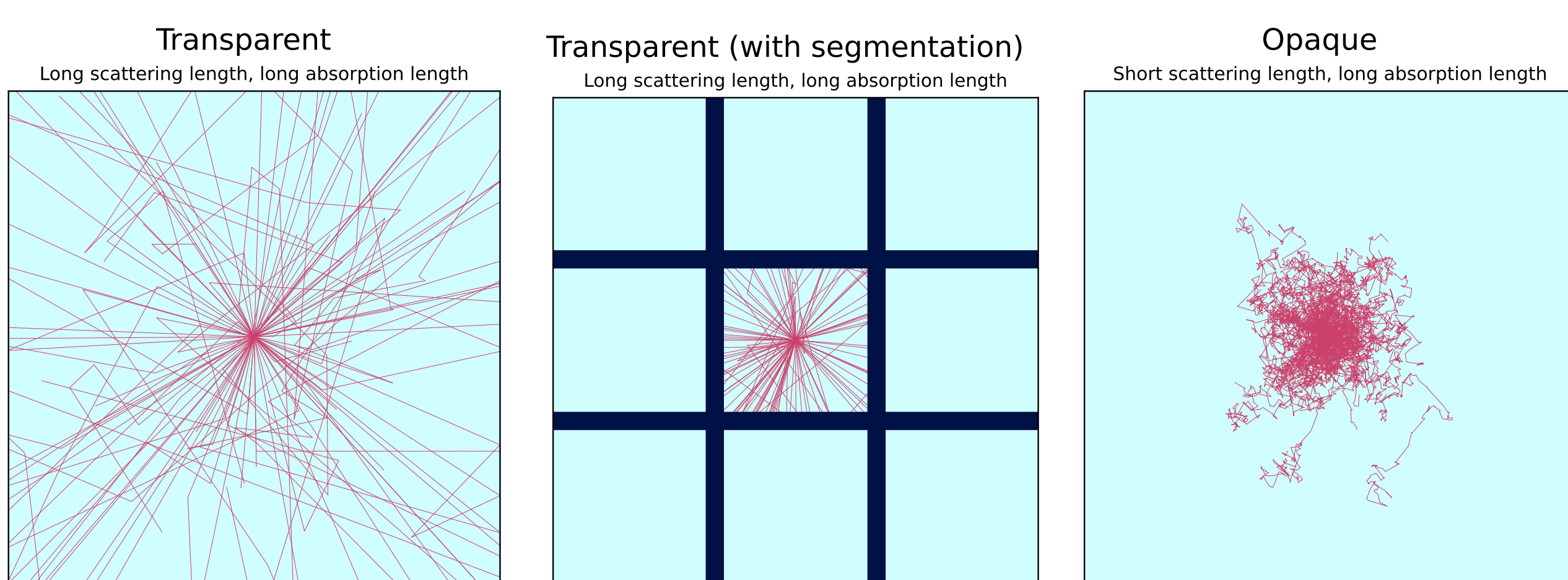
# MUON TRACKING IN A LIQUIDO OPAQUE SCINTILLATOR DETECTOR

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## The LiquidO concept [1]

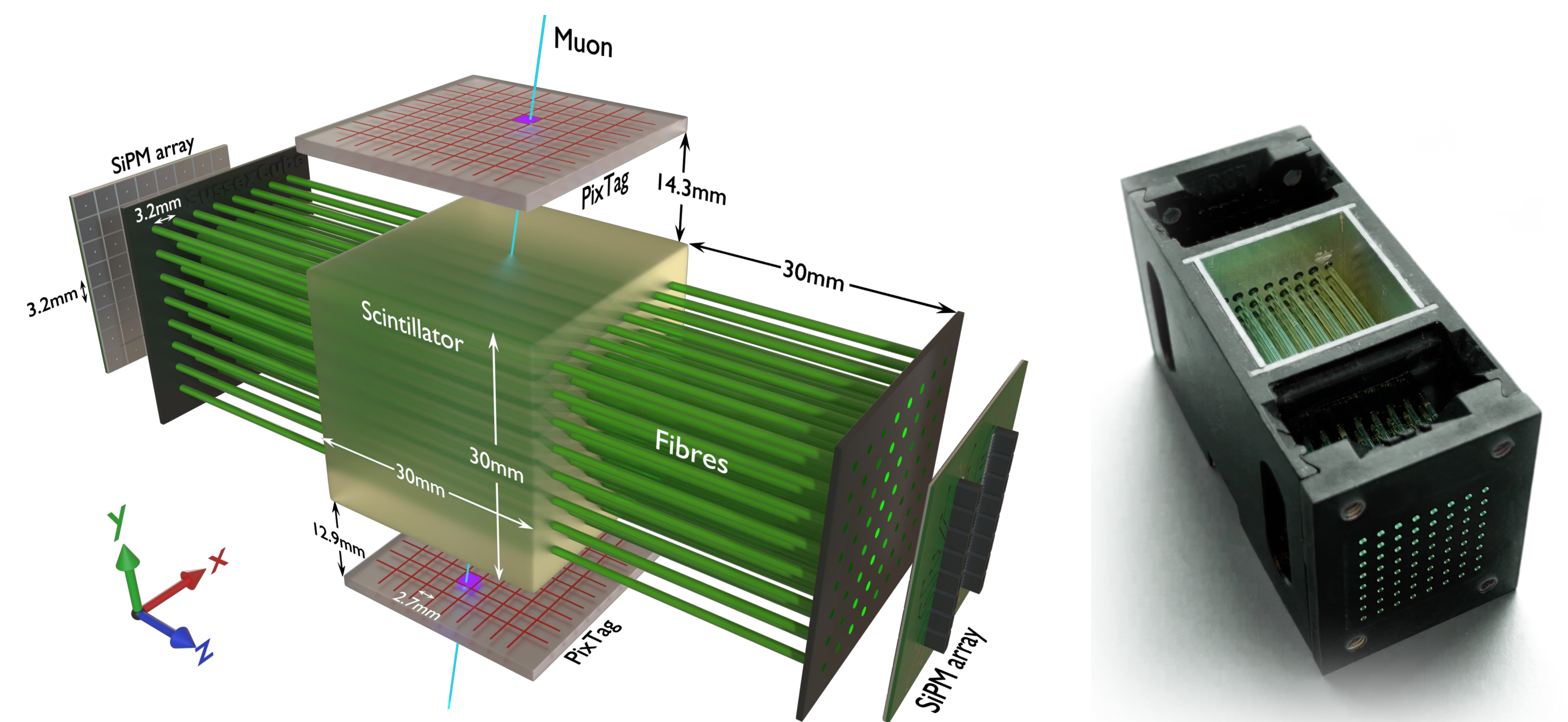
- **Opaque scintillator** forces scintillation photons to undergo a random walk about their origin: stochastic confinement of light.
- Arrays of **wavelength-shifting (WLS) fibres** pick up and transmit the light to silicon photomultipliers (SiPMs).
- **Excellent position resolution** due to light being confined close to source.
- Improvements in **detector simplicity, cost and active material proportion**, as segmentation is obtained stochastically without the need for physical material.



## 64-fibre Cube detector

The 64-fibre Cube comprises:

- 3D printed resin skeleton
- 3cm × 3cm fiducial volume
- Uses PETsys TOFPET2 readout
- 8 × 8 grid of WLS St Gobain fibres
- 3.2mm fibre pitch
- 8 × 8 Hamamatsu SiPM arrays
- Segmented scintillator “Pix-Tags” for muon selection



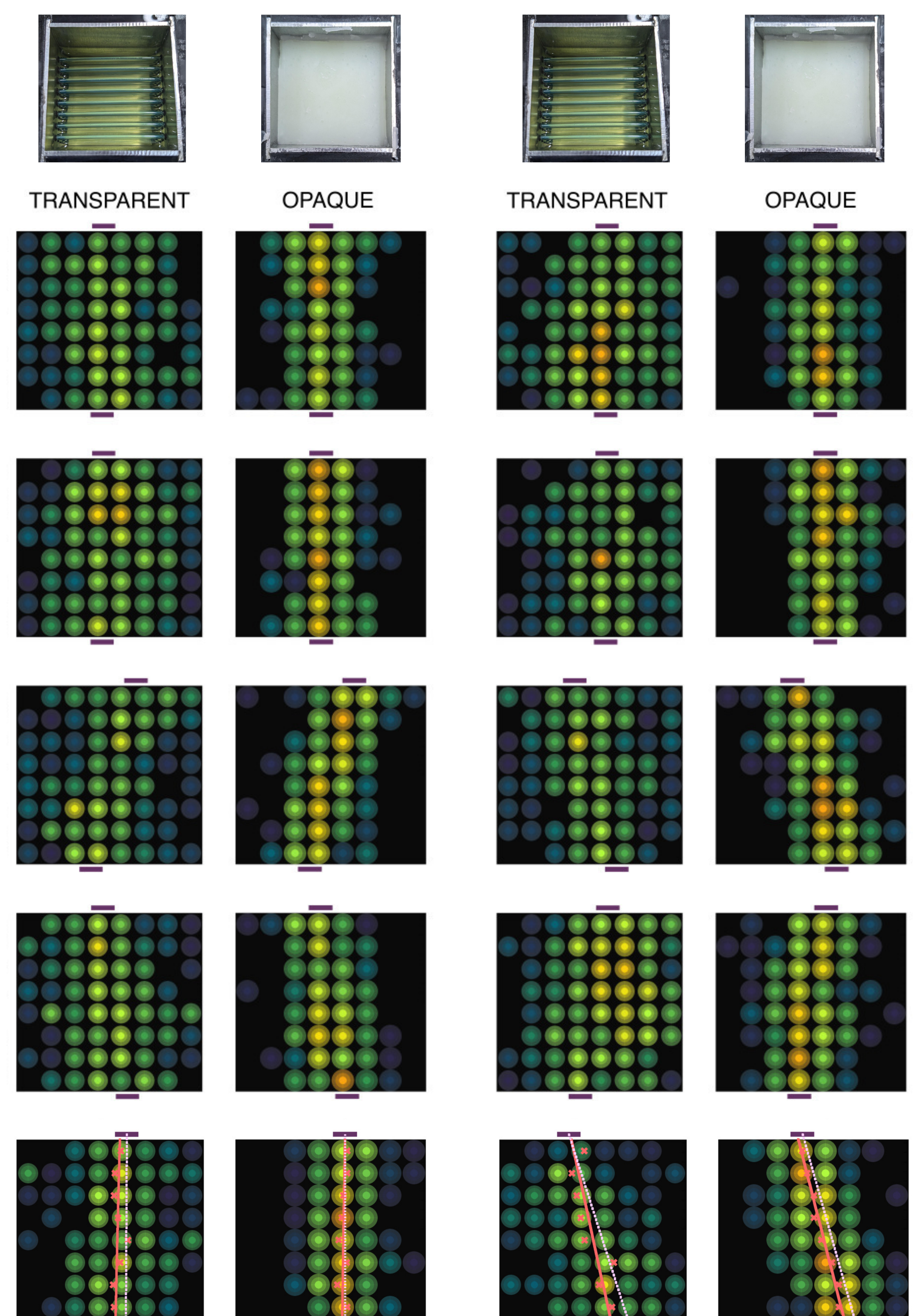
## Muon tracking & resolution

- Position of muon determined **row by row**.
- Coordinate at each row calculated using quantity **analogous to centre of mass**.
- Muon path is obtained from linear fit of muon position in each row.
- Two types of fits are performed:
  - ➔ **1 fit** using reconstructed points from **all 8 rows**
  - ➔ **8 fits** using reconstructed points from **all but 1 row**
- **Unbiased estimate of position resolution** for row  $j$  obtained from the standard deviation of the distribution of the 8-row fit residuals,  $\delta_j^8$ , and the 7-row fit residuals,  $\delta_j^7$ , using the geometric mean<sup>[2]</sup>:

$$R_j = \sqrt{\sigma_{\delta_j^8} \cdot \sigma_{\delta_j^7}}$$

Detector	Fibre/pixel pitch	Resolution
64-fibre Cube opaque	3.2 mm	0.45 mm
64-fibre Cube transparent	3.2 mm	0.73 mm
Theoretical rectangular segmented detector	3.2 mm	0.92 mm
Hypothetical scaled 64-fibre Cube opaque	15 mm	~2.1 mm
Triangular segmented detector <sup>[3]</sup>	15 mm	2.5 mm

Assuming the pitch:resolution ratio is constant.



## References

- [1] LiquidO Consortium. Neutrino physics with an opaque detector. Commun Phys 4, 273 (2021). LiquidO website: <https://liquido.ijclab.in2p3.fr/>
- [2] R. Carnegie, et al., Resolution studies of cosmic-ray tracks in a TPC with GEM readout, Nuclear Instruments and Methods in Physics Research Section A 538 (2005) 372
- [3] X. Luo et al., Development and commissioning of a compact Cosmic Ray Muon imaging prototype, Nuclear Instruments and Methods in Physics Research Section A 1033 (2022) 166720.