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on behalf of the JUNO Collaboration
IPHC CNRS/Université de Strasbourg, France.
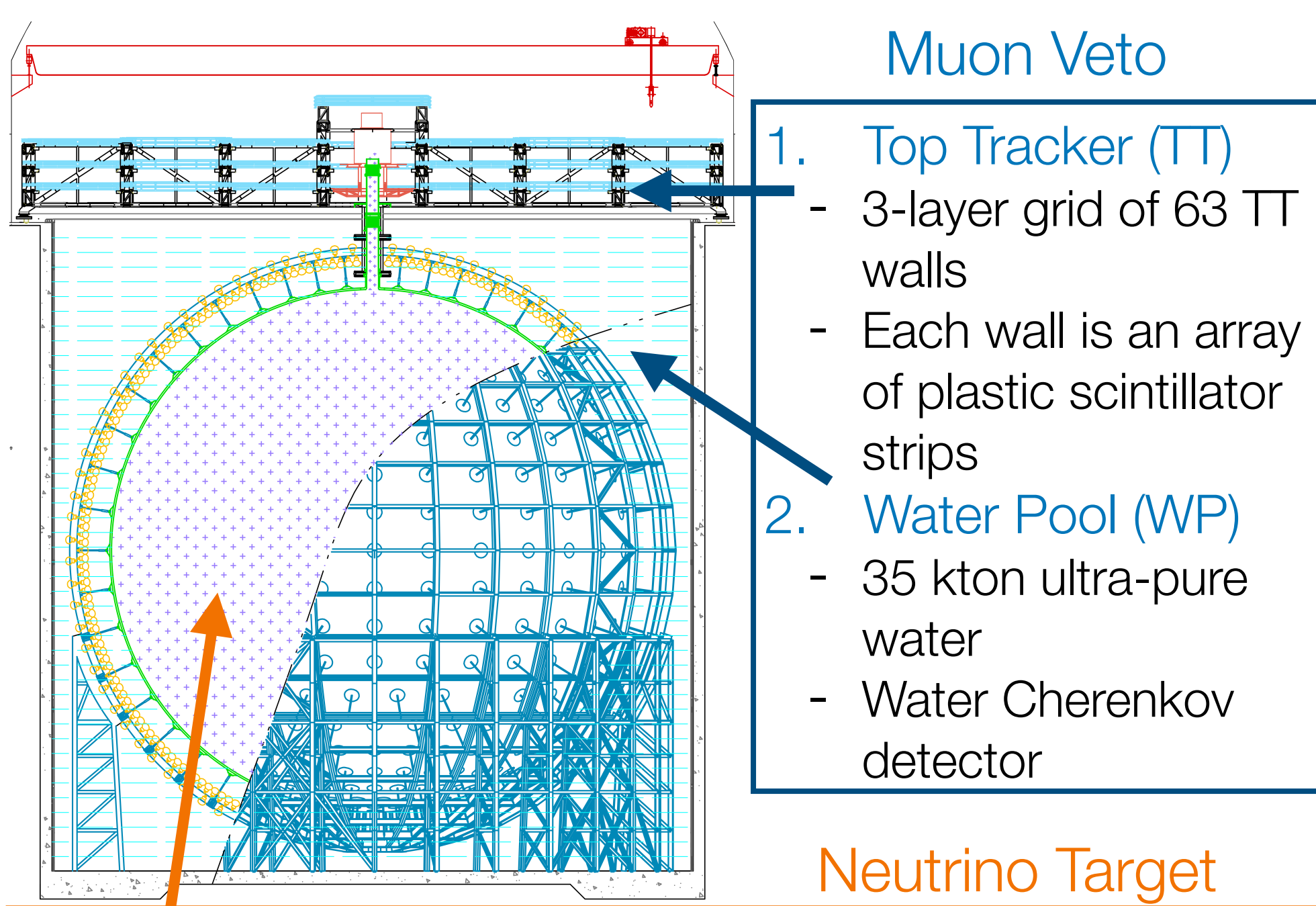deshan.sandanayake@iphc.cnrs.fr | jpandre@iphc.cnrs.fr

The Jiangmen Underground Neutrino Observatory (JUNO)

Muon Veto
1. Top Tracker (TT)
   - 3-layer grid of 63 TT walls
   - Each wall is an array of plastic scintillator strips
2. Water Pool (WP)
   - 35 kton ultra-pure water
   - Water Cherenkov detector

Neutrino Target

Central Detector (CD)
- 20 kton liquid scintillator detector
- 17612 20-inch & 25600 3-inch PMTs (75.2% coverage)

- **Main goal**: Determine neutrino mass ordering.
  (3σ after 6 years of data taking)

The Top Tracker detector

- Re-purposed from the OPERA Target Tracker[1].
- Study contribution to the JUNO signal from
  - Cosmogenics (^{9}Li, ^{8}He, ...)
  - fast neutrons
  originated by cosmic muons.

Related posters at NEUTRINO 2024:
- Haoqi Lu, The Water Cherenkov Detector of JUNO.
- Xiaonan Li, JUNO underground facility.

Signal and background for detecting electron—antineutrinos

- **Signal**: Inverse beta decay (IBD)
  $$\bar{\nu}_e + p \rightarrow e^+ + n$$
  Prompt, ~few ns   Delayed, ~200μs

- **Most problematic background**: μ-induced ^{9}Li/^{8}He isotopes

  $$^9\text{Li}/^8\text{He} \rightarrow {}^8\text{Be}/^7\text{Li} + e^- + n$$
  Mimics IBD signature

- Veto events within a cylindrical volume of radius 3m around a well reconstructed muon track for 1.2 s.

Top Tracker trigger rate

L1: XY ⊥, L2: Align
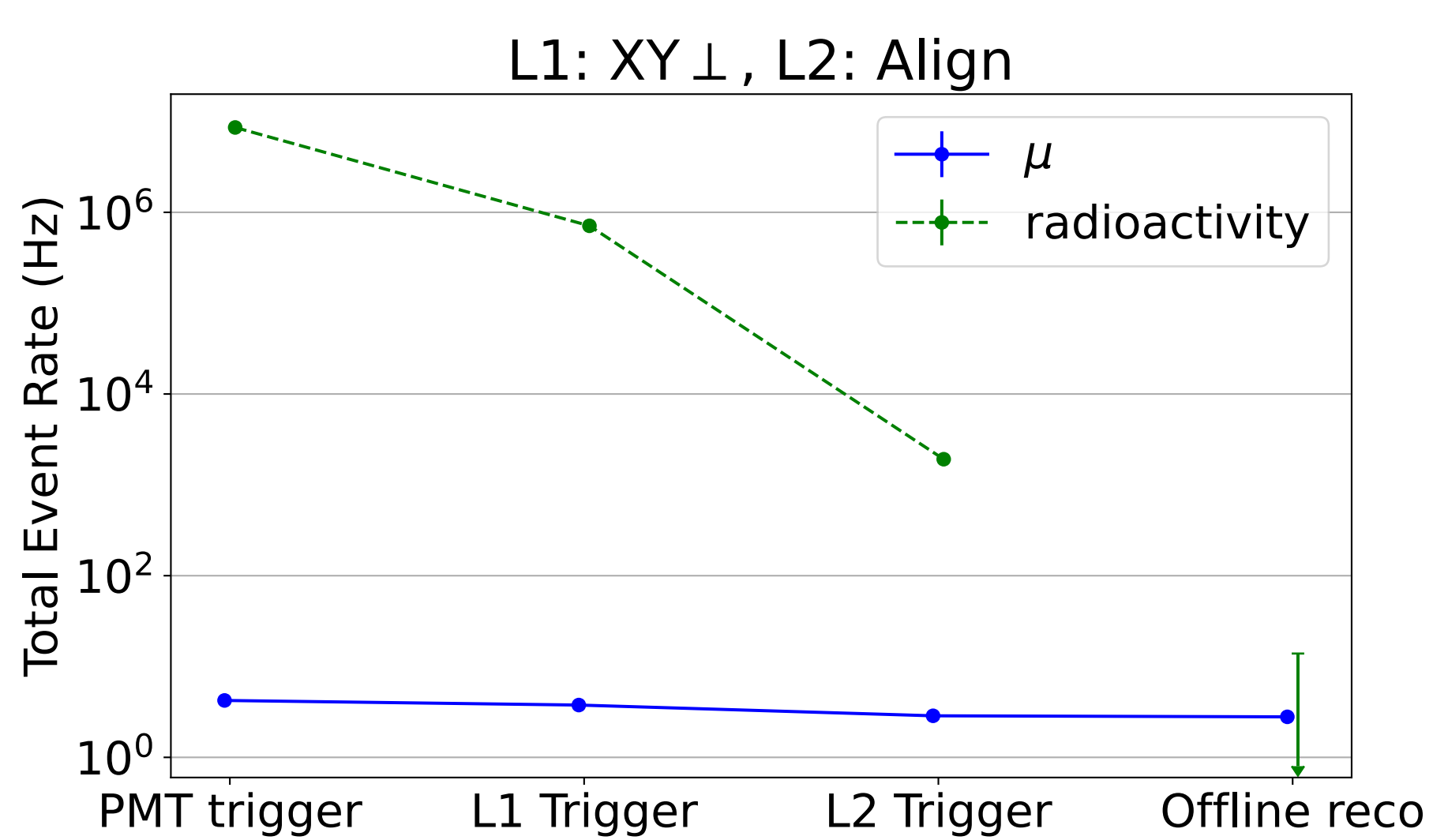
- Radioactivity background rate: ~8 MHz PMT trigger
- Muon rate: ~4 Hz.
- L1 trigger: select coincidence between 3 PMTs within 100 ns in each TT wall.
- L2 trigger: Select aligned L1 triggers on all TT layers within 300 ns.
- Offline reconstruction: Reject residual background using detailed channel information.
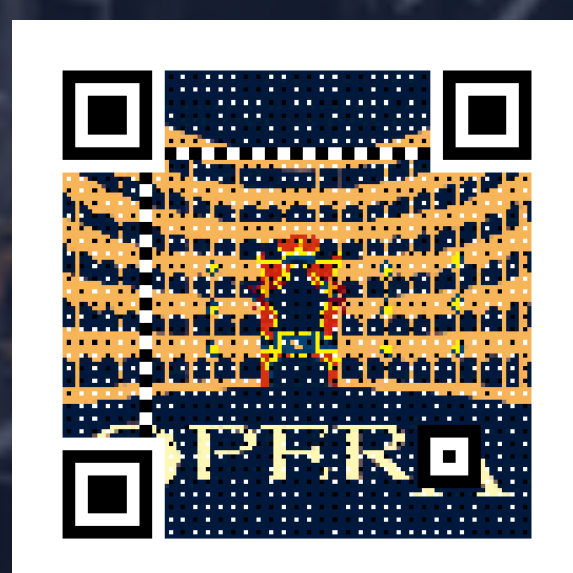
The Top Tracker
of the JUNO Experiment

precisely track cosmic muons crossing JUNO

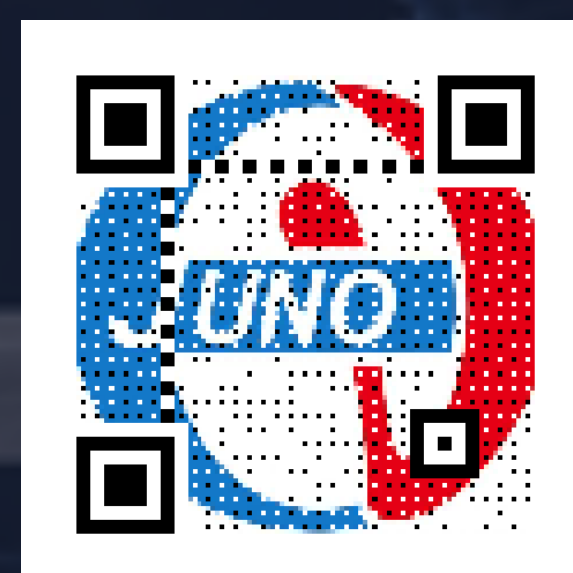study the cosmogenic ^{9}Li/^{8}He isotope background

References

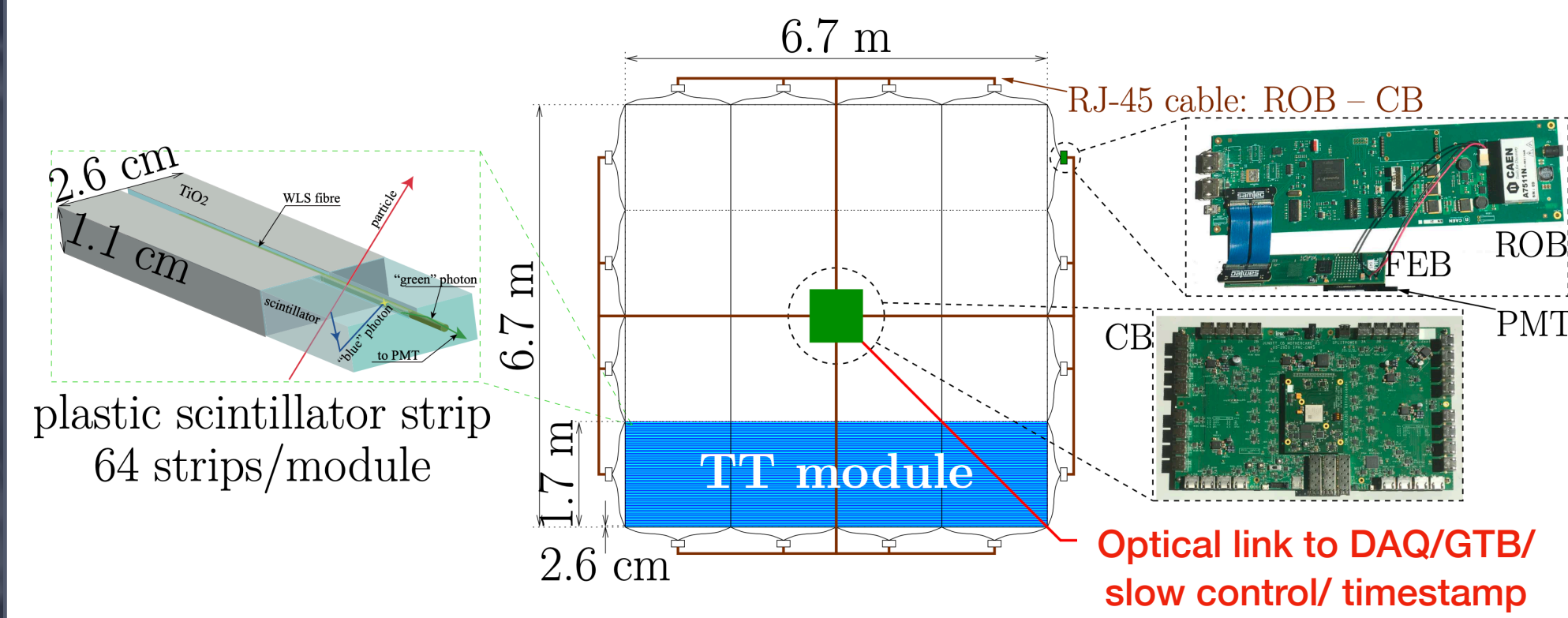[1] OPERA Collaboration, Nucl. Instrum. Meth. A 577 (2007)

[2] JUNO Collaboration, Nucl. Instrum. Meth. A 1057 (2023)

[3] JUNO Collaboration. Prog. Part. Nucl. Phys. 123 (2022)

The Top Tracker electronics

- New dedicated electronics to cope with the high PMT trigger rates & perform efficient event selection.

6.7 m — plastic scintillator strip 64 strips/module — TT module — Optical link to DAQ/GTB/ slow control/ timestamp

- 16 PMTs/ROBs/FEBs per Top Tracker wall, 63 walls, 64512 PMT channels total.
- **Front-end board (FEB)**: PMT interface & MAROC3* chip readout, 992 needed.
- **Readout board (ROB)**: slow control, power supply & MAROC3 management, 992 needed.
- **Concentrator board (CB)**: L1 trigger & timestamping, 63 needed.
- **Global trigger board (GTB)**: L2 trigger, 1 needed.
- Hardware ready; all electronics already on site or arriving soon.

* - Multi-anode read-out circuit [S. Blin et. al., JINST 5 (2010)]

Top Tracker Muon Reconstruction

JUNO Top Tracker simulation
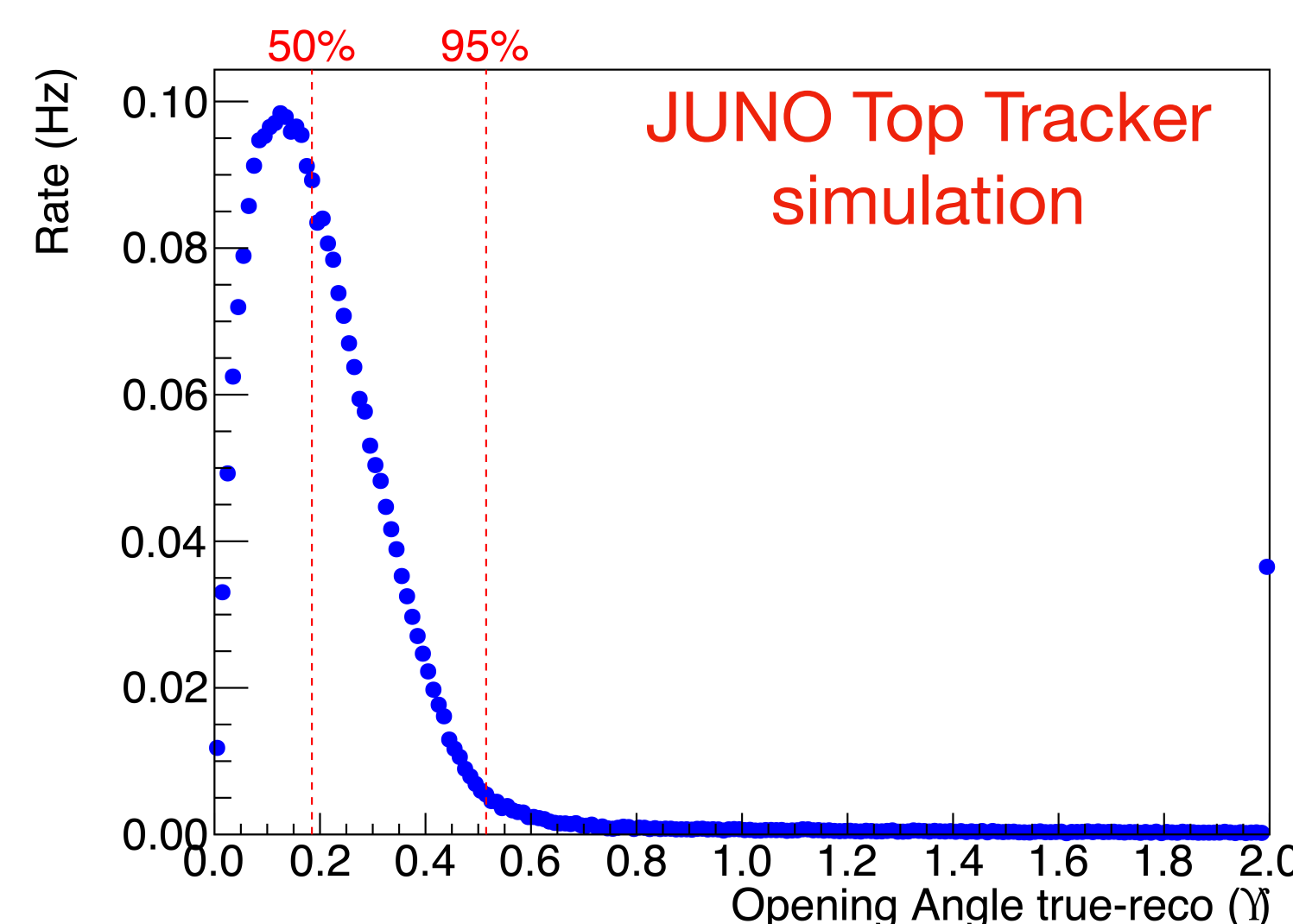
- Reconstruct muon 3D crossing points based on aligned x-y triggers.
- Fit 3D lines to each group of more than three 3D points at different vertical positions via a χ^2 minimisation.
- Able to reconstruct ~97% of all muons passing through the Top Tracker with high precision.

Performance analysis using muons
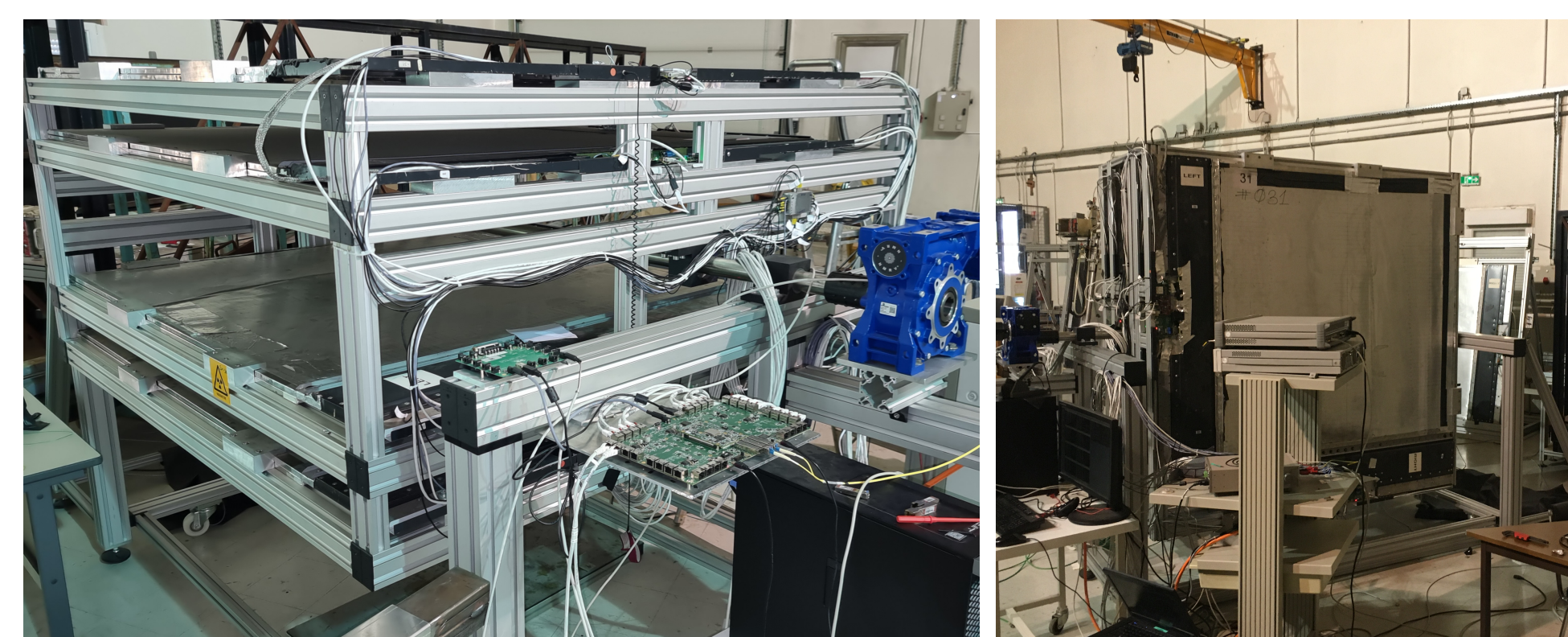
- Top Tracker prototype - used to test & calibrate Top Tracker electronics using muons.
- Built with same materials as the Top Tracker.
- Measured cosmic muon flux by orienting the prototype walls vertically.
- x-y coincidence tagging & timestamping within a few ns-level precision.

TT wall