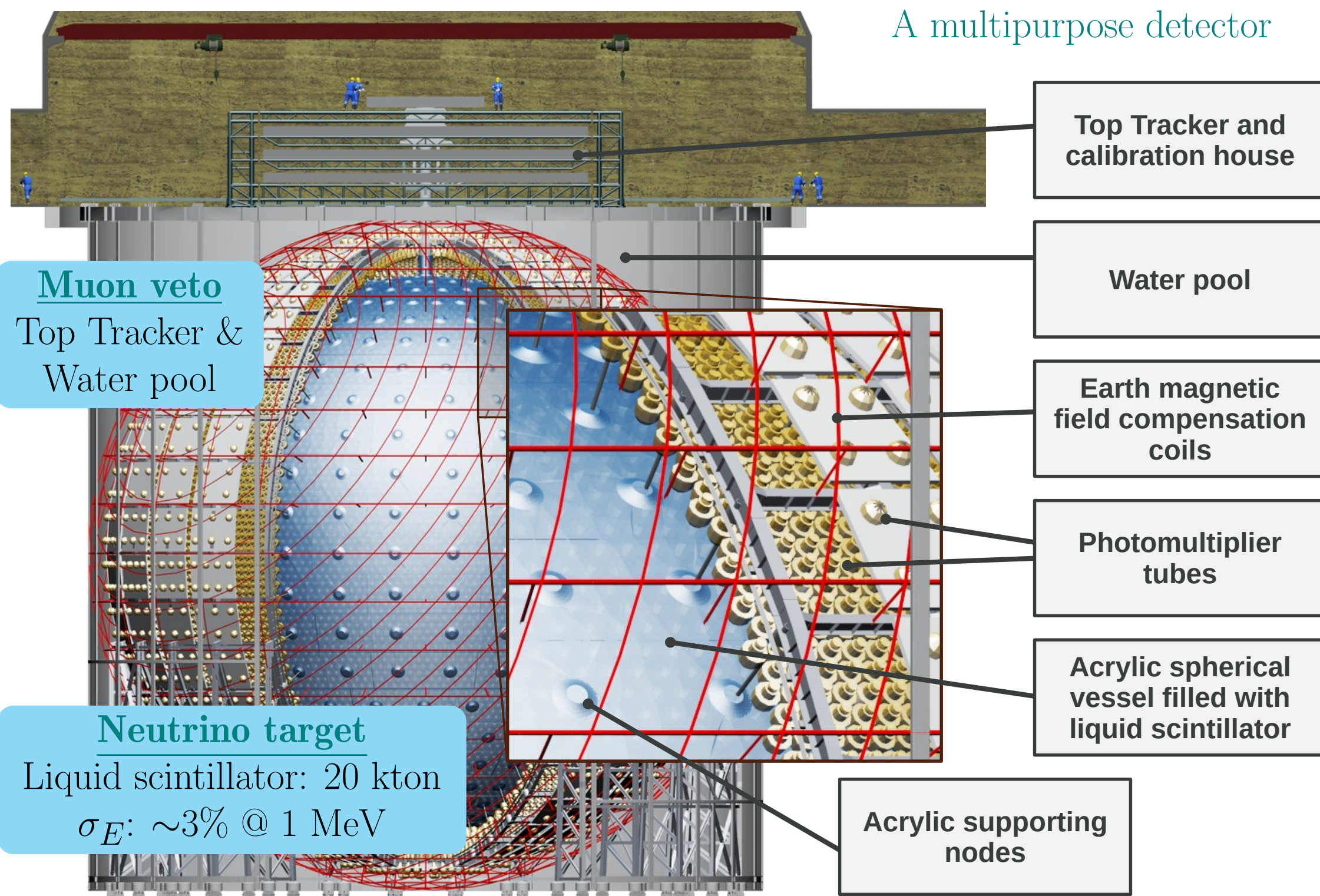


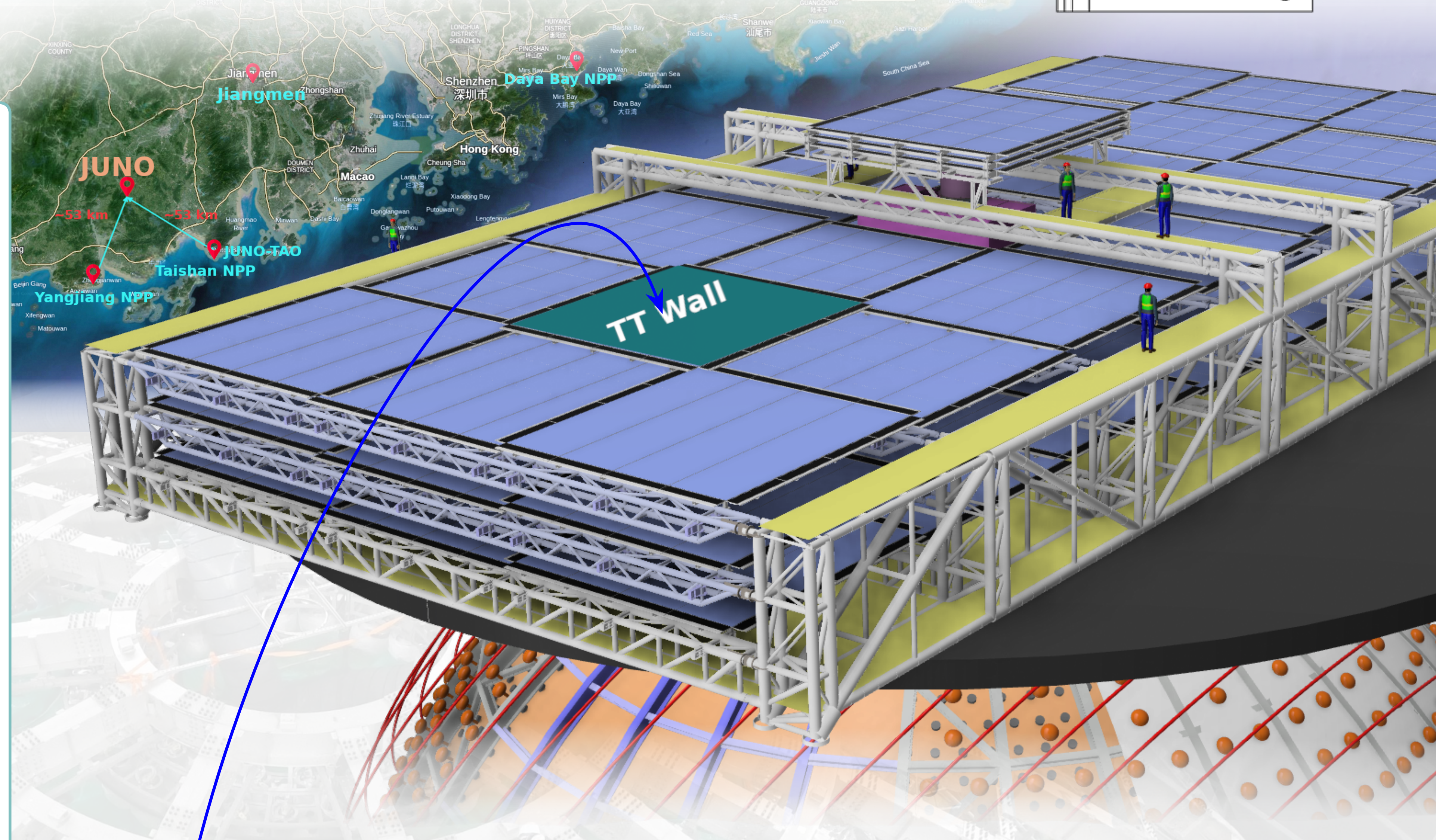
## JUNO Experiment

### The Jiangmen Underground Neutrino Observatory (JUNO)

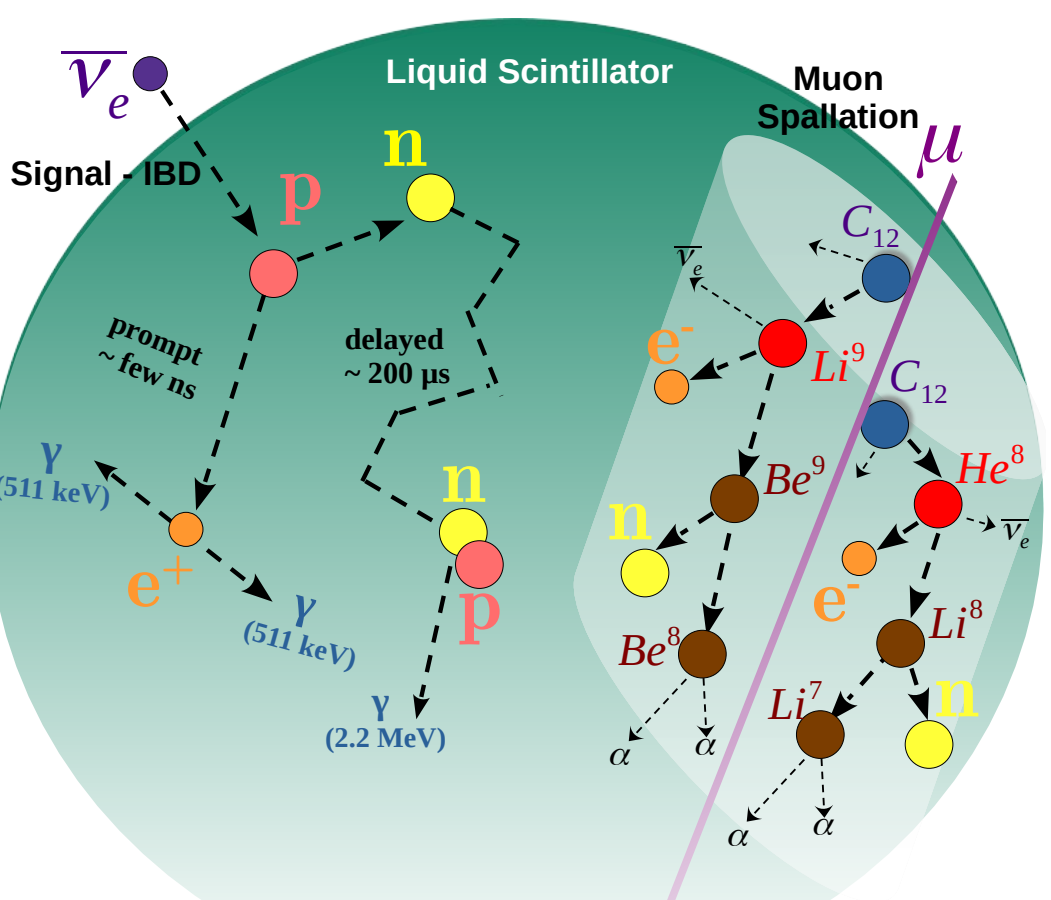
A multipurpose detector



**Main goal:** Neutrino mass ordering:  $3\sigma$  in six years of data taking [1]



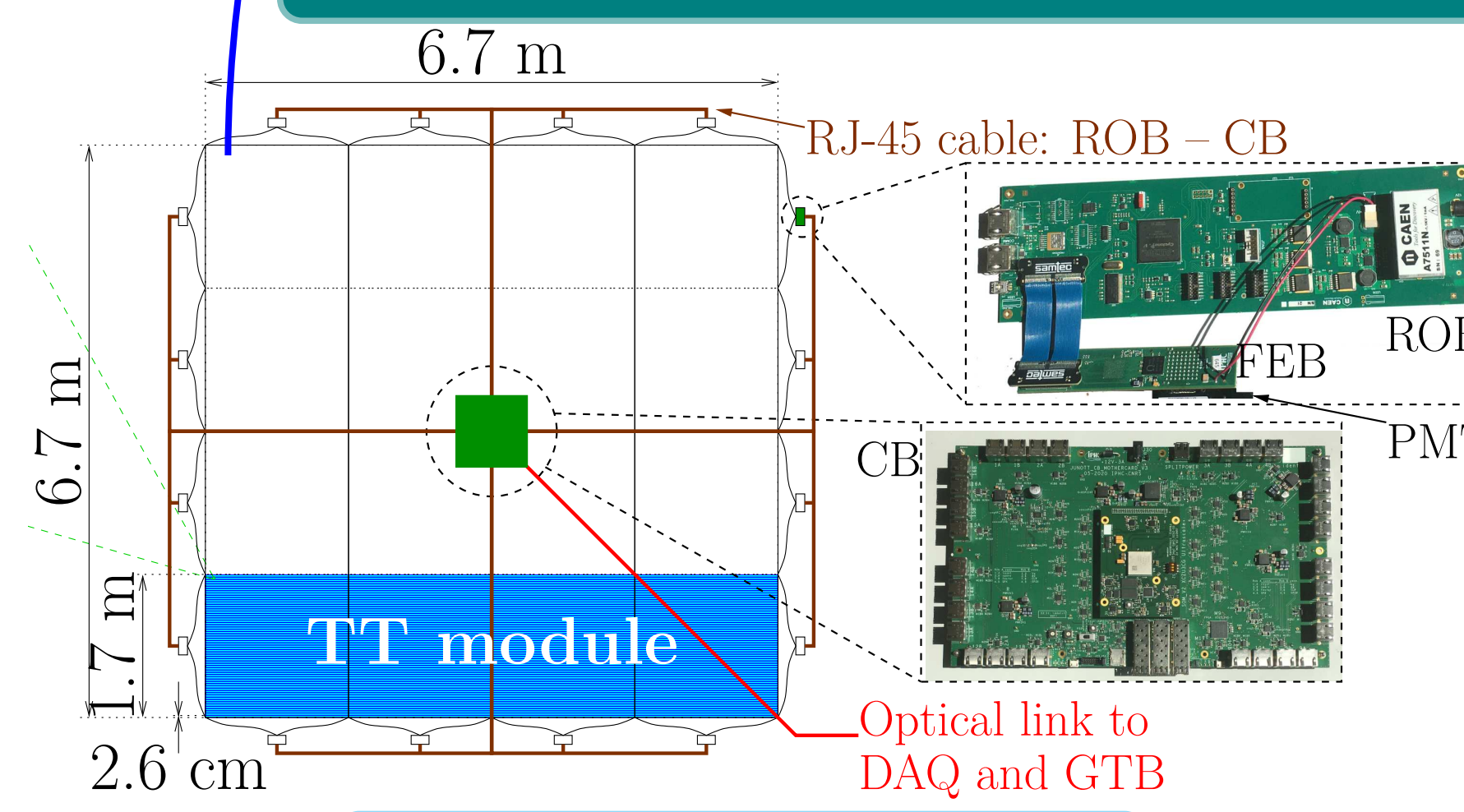
## Reactor signal & Background



- **Source:** Taishan & Yangjiang NPP
- $\sim 53$  km,  $26.6$  GW<sub>th</sub>
- **Detection:** Inverse Beta Decay (IBD)
- $\bar{\nu}_e + p \rightarrow n + e^+$  (coincidence signal)
- **Main Backgrounds:** Accidental, Cosmogenic, Geoneutrinos, Other reactors
- **Cosmogenic background**
- $^9\text{Li}/^8\text{He}$  decay:  $\mu$ -induced isotopes
- $^9\text{Li}/^8\text{He} \rightarrow ^8\text{Be}/^7\text{Li} + n + e^-$  mimics IBD

Veto events in a cylindrical volume around well reconstructed muon tracks

## Top Tracker electronics

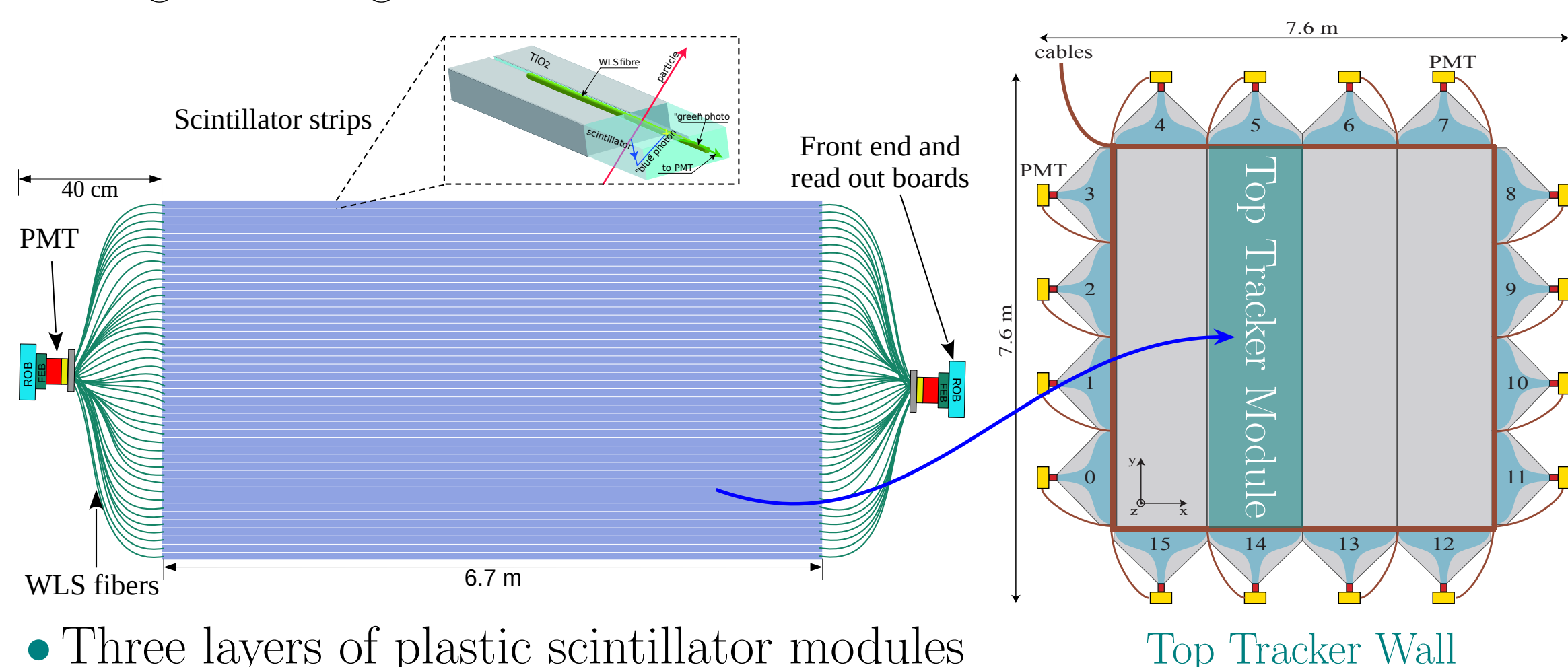


Hardware ready!  
already on site or arriving soon

- New electronics developed for high background rates
  - **Front-end board (FEB):** MA-PMT interface
    - MAROC3<sup>1</sup> chip for digitization
  - **Readout board (ROB):** slow control, power supply & MAROC3 management
  - 16 ROB/FEBs per TT wall, 992 each needed
  - **Concentrator board (CB):** L1 trigger & timestamping
    - 1 per TT wall, 63 needed in total
  - **Global Trigger board (GTB):** L2 trigger, 1 required
- <sup>1</sup>Multi-Anode Read-Out-Circuit [S. Blin et. al., JINST 5 (2010)]

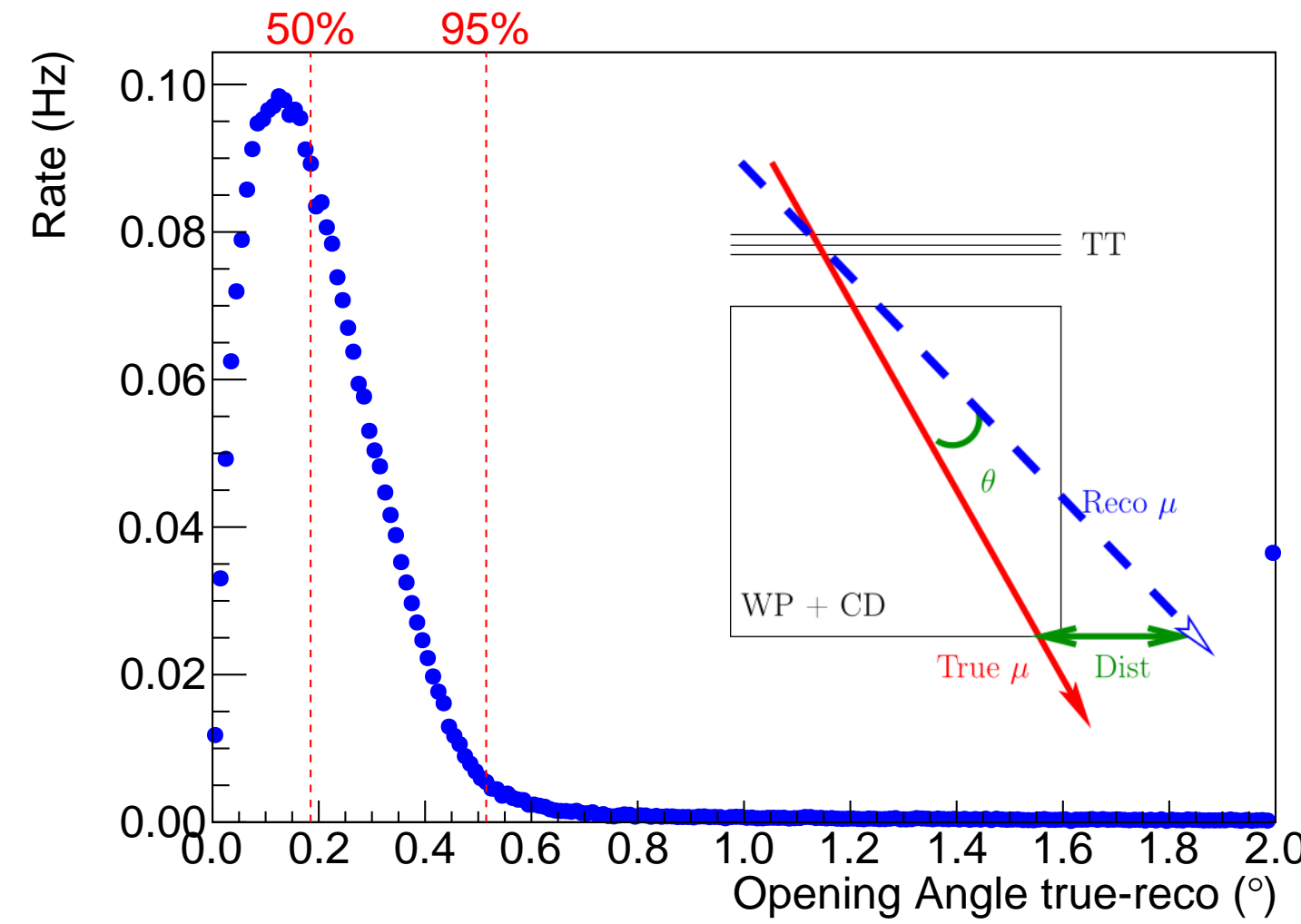
## The Top Tracker detector

**Main task:** Track muons crossing the liquid scintillator and evaluate the cosmogenic background contribution.



- Three layers of plastic scintillator modules
- Re-purposed from the OPERA Target Tracker [2]
- **Top Tracker Module:** 64 scintillator strips with MA-PMT at either end.
- **Top Tracker Wall:** Two planes of 4 modules each placed in  $\perp$  directions
- Total of 63 walls in three layers:  $\sim 60\%$  coverage over water pool & track 30% of muon flux at JUNO.

## Muon Reconstruction



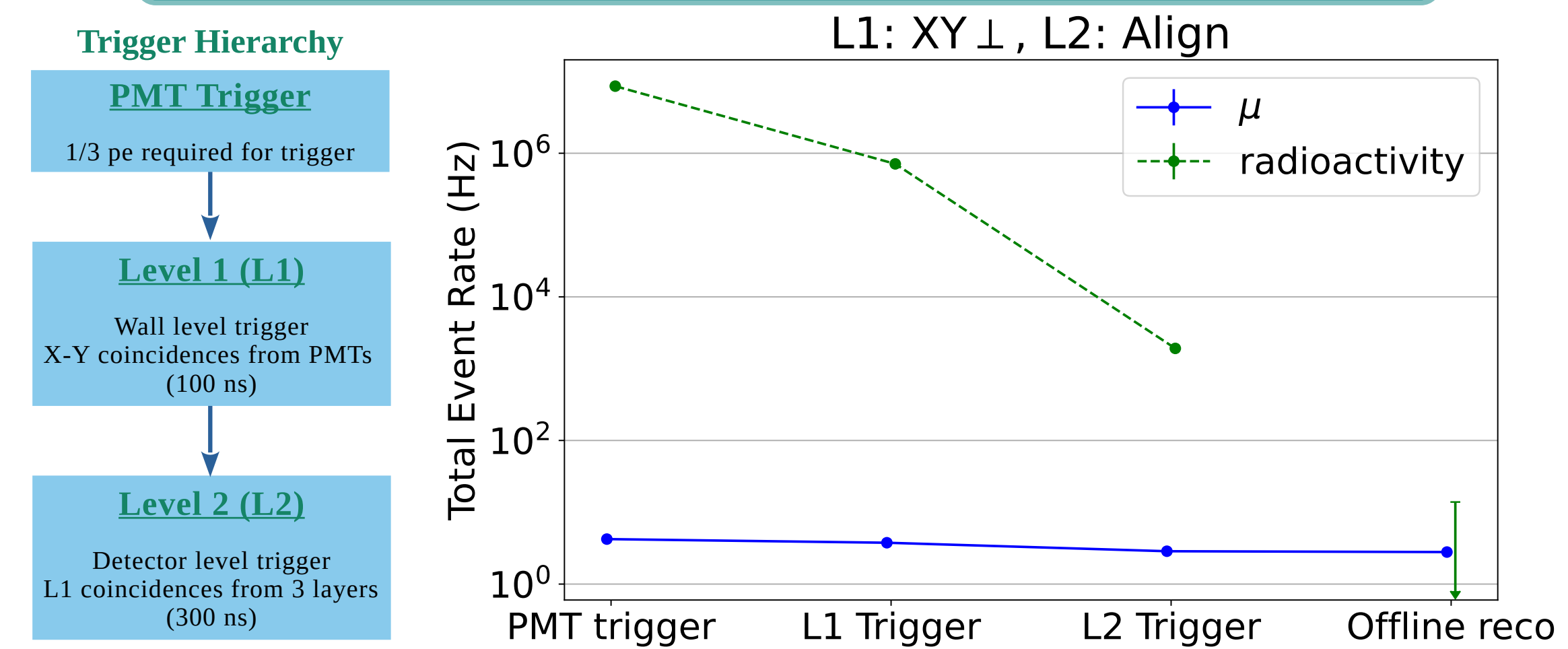
- Median angular resolution  $\sim 0.2^\circ$
- Reconstruct  $\sim 97\%$  of muons passing TT.

## Top Tracker Prototype



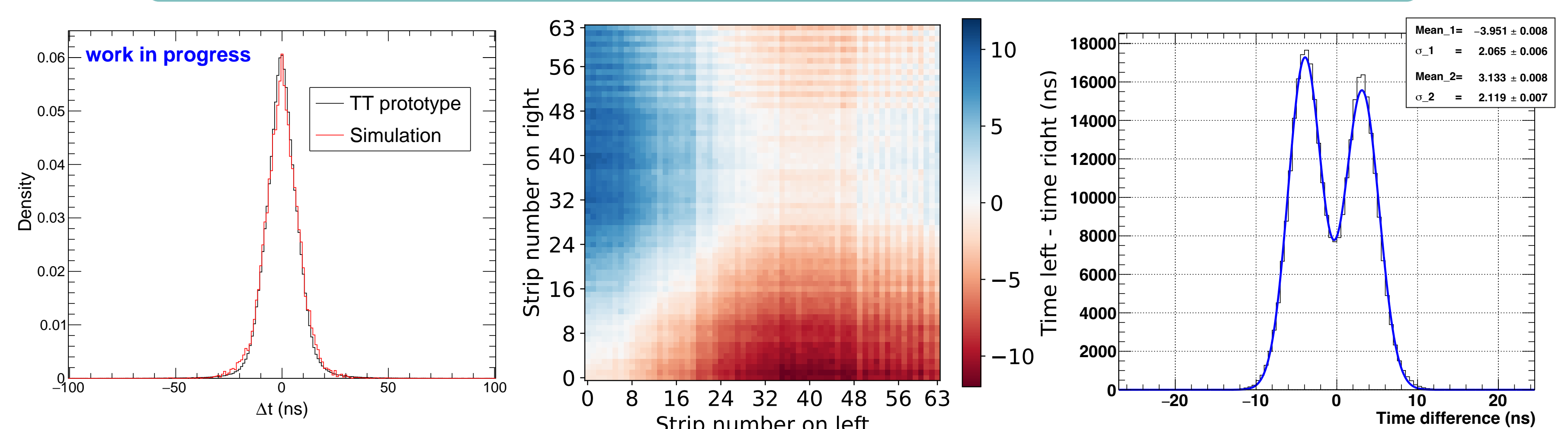
- Built with same materials as the Top Tracker
- Used to test and calibrate the Top Tracker electronics.
- Prototype is rotatable to study the cosmic rays direction

## Expected trigger rates



- High rates of radioactive decays from surrounding rocks
- Radioactivity background rate:  $\sim 8$  MHz PMT trigger [3]
- Muon rate  $\sim 4$  Hz (650 m overburden)
- $\mathcal{O}(10^4)$  reduction from PMT level to L2 trigger; the remaining orders of magnitude are removed during offline reconstruction

## TT Prototype tests & Simulation



- Collected cosmic muon data
- 2D plot: X-Y  $\Delta t$  dependency on position on module (geometrical effect)
- X-Y  $\Delta t$  @ L1: good agreement between data & MC
- Right plot:  $\Delta t$  between rightmost & leftmost L1 trigger with prototype in  $90^\circ$  after correcting for fiber length/timewalk  $\Rightarrow$  time dispersion of  $\sim 2$  ns

## References

[1] JUNO Collaboration. Prog. Part. Nucl. Phys. 123 (2022) [arXiv:2104.02565]

[2] OPERA Collaboration, Nucl. Instrum. Meth. A 577 (2007) [arXiv:physics/0701153]

[3] JUNO Collaboration, Nucl. Instrum. Meth. A 1057 (2023) [arXiv:2303.05172]