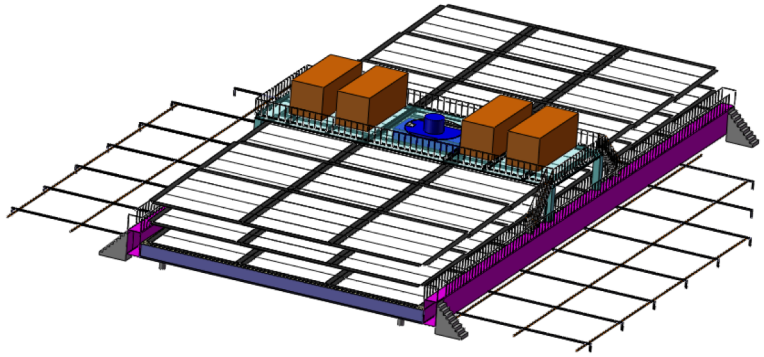
Project

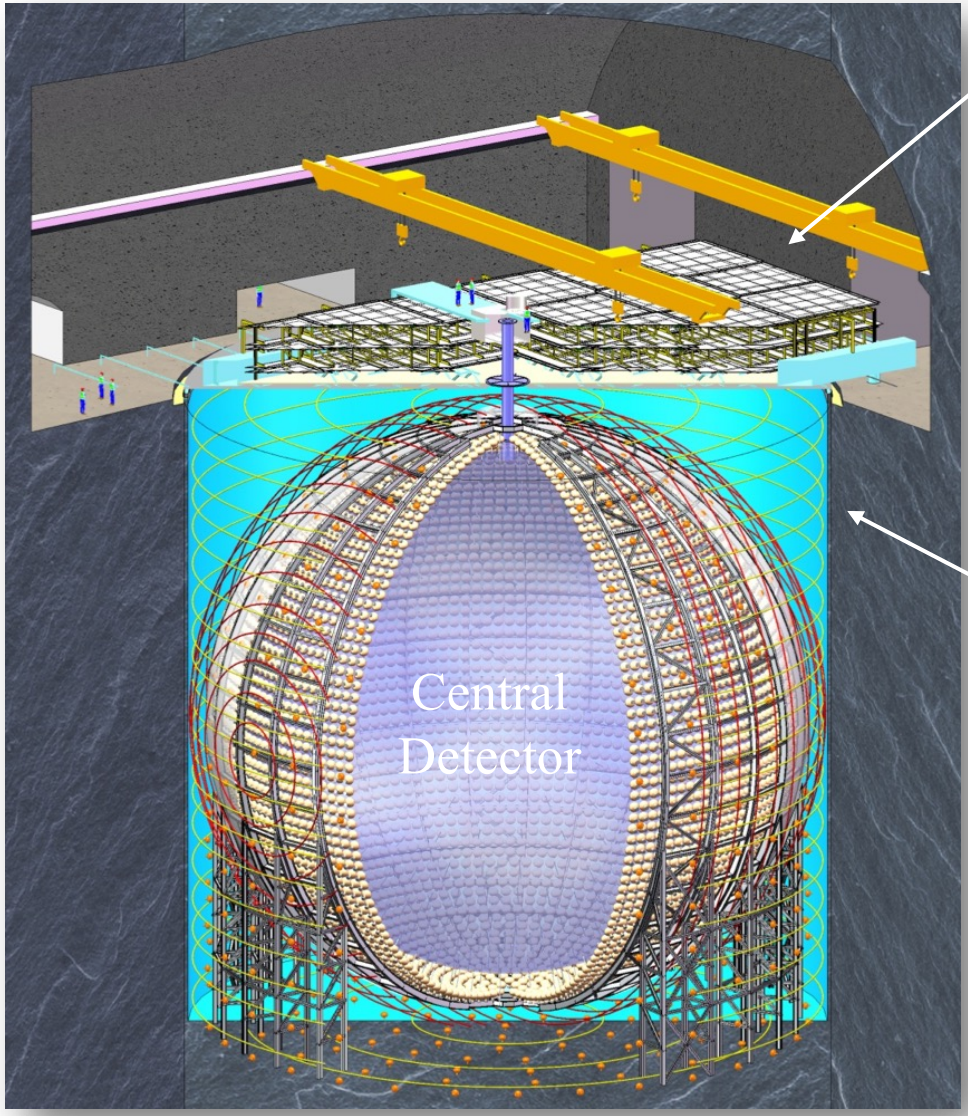
Top Tracker-JUNO



Eric Baussan
On behalf of TT Group

11th FCPPL Workshop
May. 22-25, 2018.

The JUNO Veto System



Top Tracker

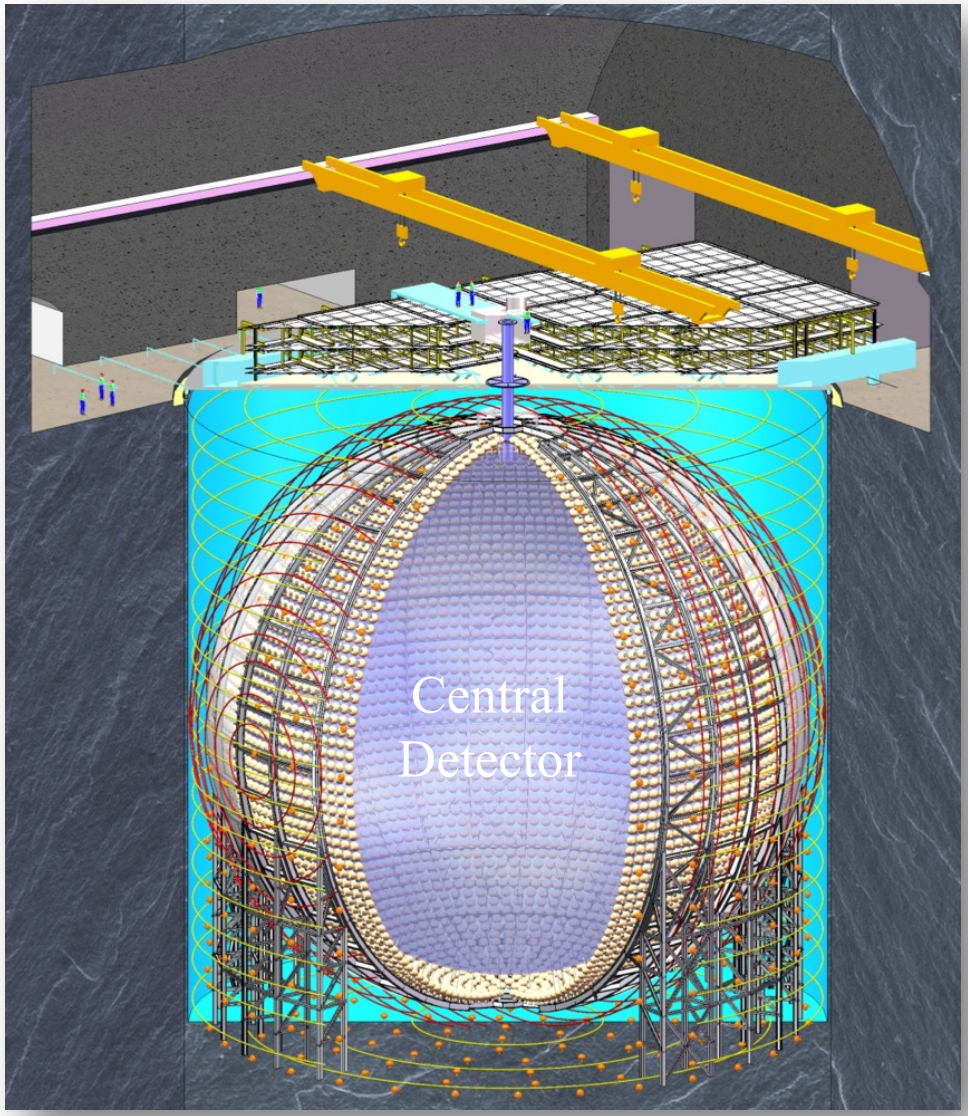
⇒ The Top Tracker will reuse the Target Tracker of OPERA experiment with good performance in term stability, and take benefit from previous study for muon track reconstruction.

Outer Veto

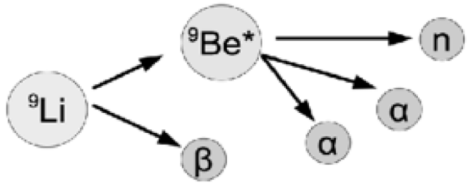
⇒ The Outer veto is filled with 20-30 kton of ultrapure water in the pool, read by 2000 PMT's (20") and provide a good detection efficiency (> 95%)

⇒ Water system: Employ a circulation/polishing water system and keep a good water quality - including radon control.

JUNO - Top Tracker



- Veto for the covered surface (impossible to cover all surface around the central detector).
- Study the production of ^{9}Li/^{8}He produced by muons crossing the detector and mimicking IBDs (~80 against ~60 IBD/day).
- Study the production of fast neutrons produced by muons crossing the surrounding rock.
- Precise measurement of the energy spectrum of cosmogenic isotopes.
- Define the cuts to be applied in the CD to reduce these backgrounds.
- Introduce all measured parameters in the simulation.
- Better estimation of systematic uncertainties induced by this noise.

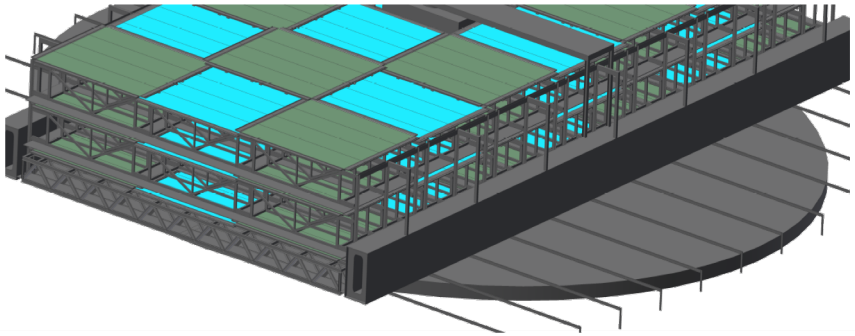


JUNO - Top Tracker

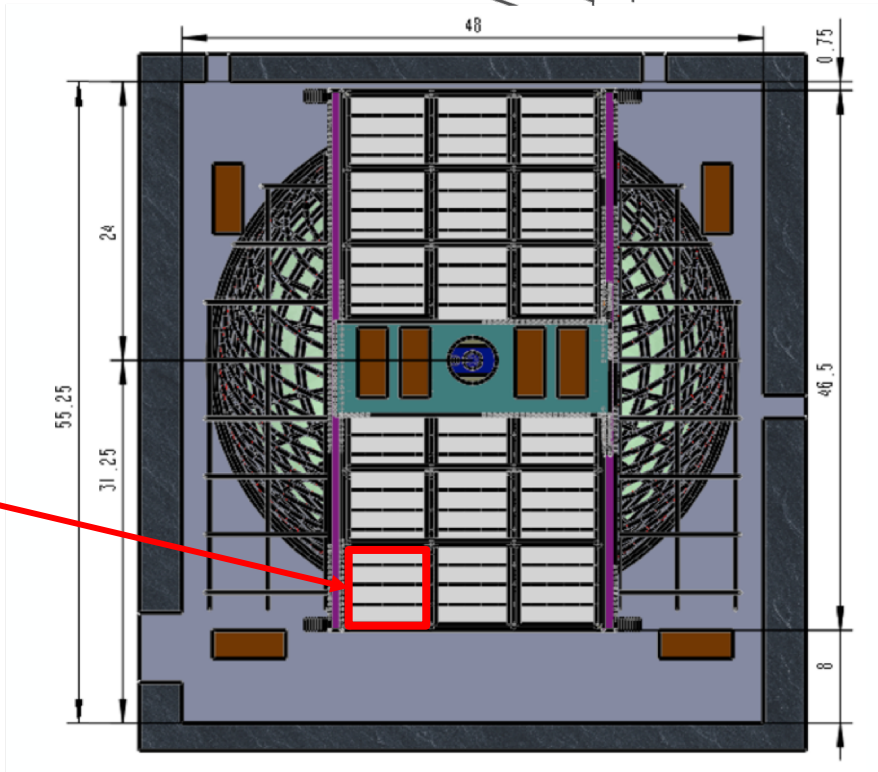
Main Features:

- OPERA Target Tracker:
  - 2783 m² (XY cell : 26.4mm x 26.4mm)
  - 56 walls (6.7m × 6.7m)

=> Covered area : 630 m²

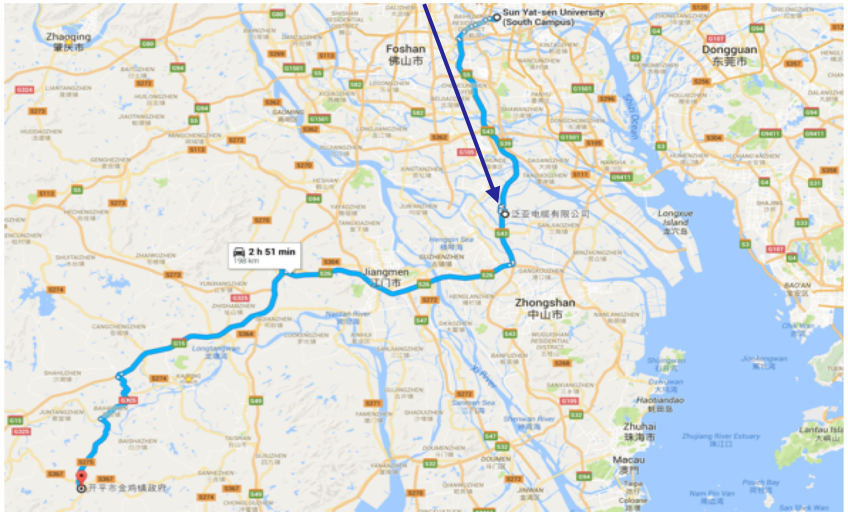


TT Wall

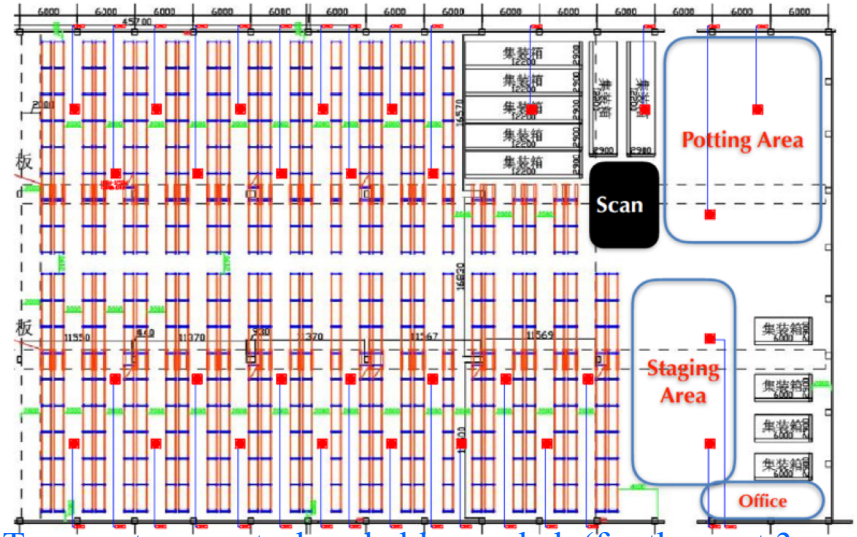


TT Storage

TT storage (and PMT testing)



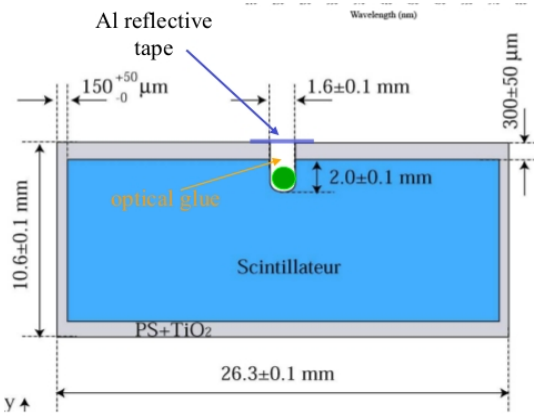
Pan-Asia Warehouse



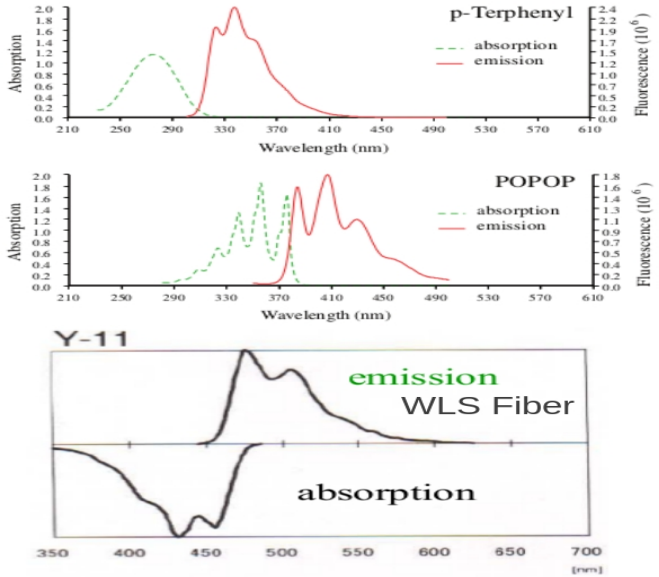
Temperature control probably needed (for the next 3 years)

Top Tracker - Module

Scintillator strip dimensions:



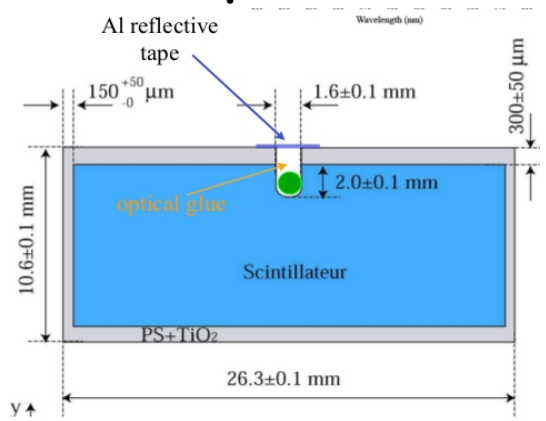
Components:



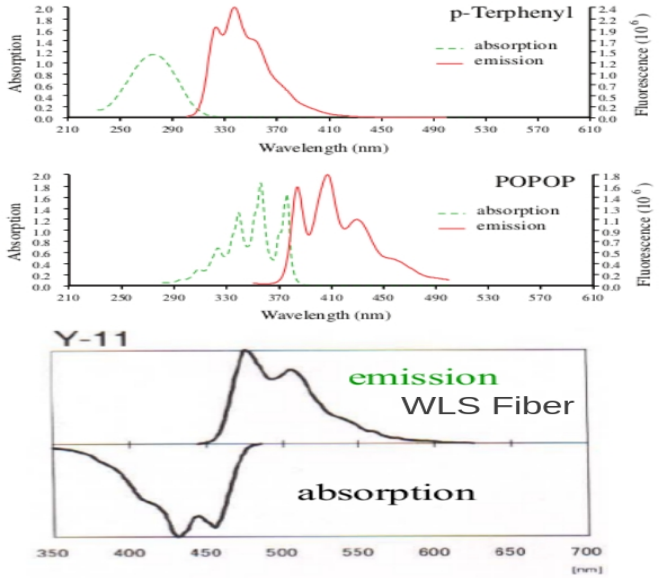
TT Modules

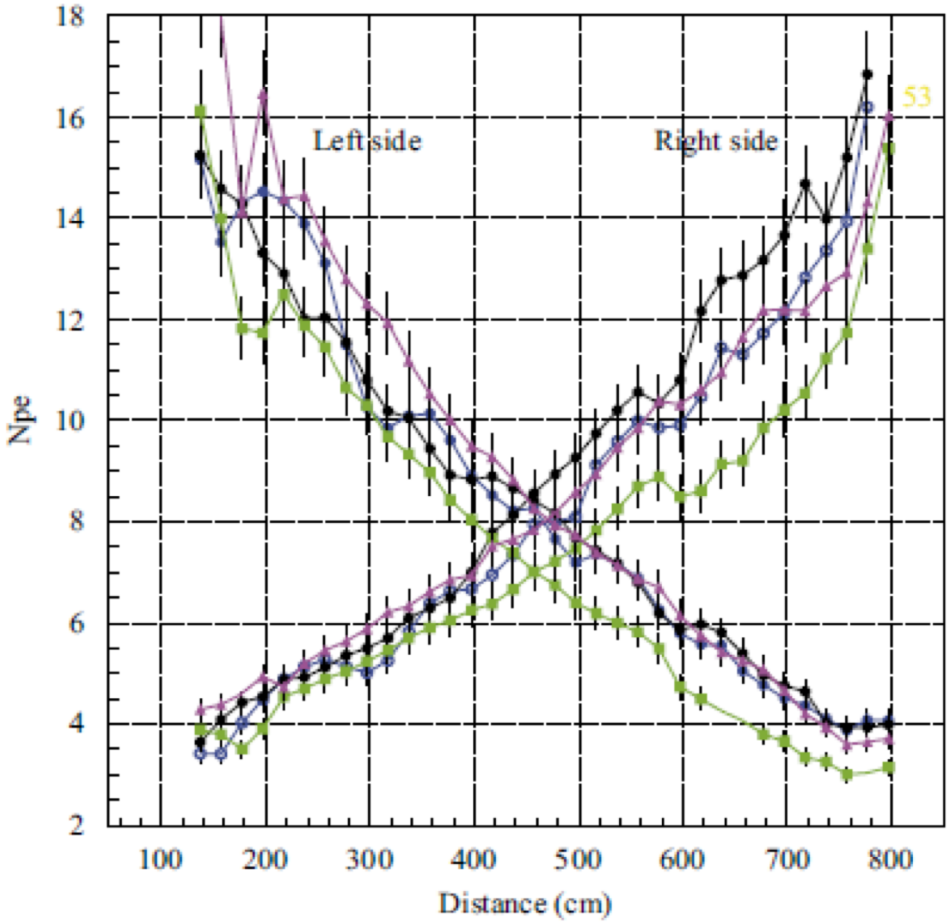
Top Tracker - Module

Scintillator strip dimensions:



Components:

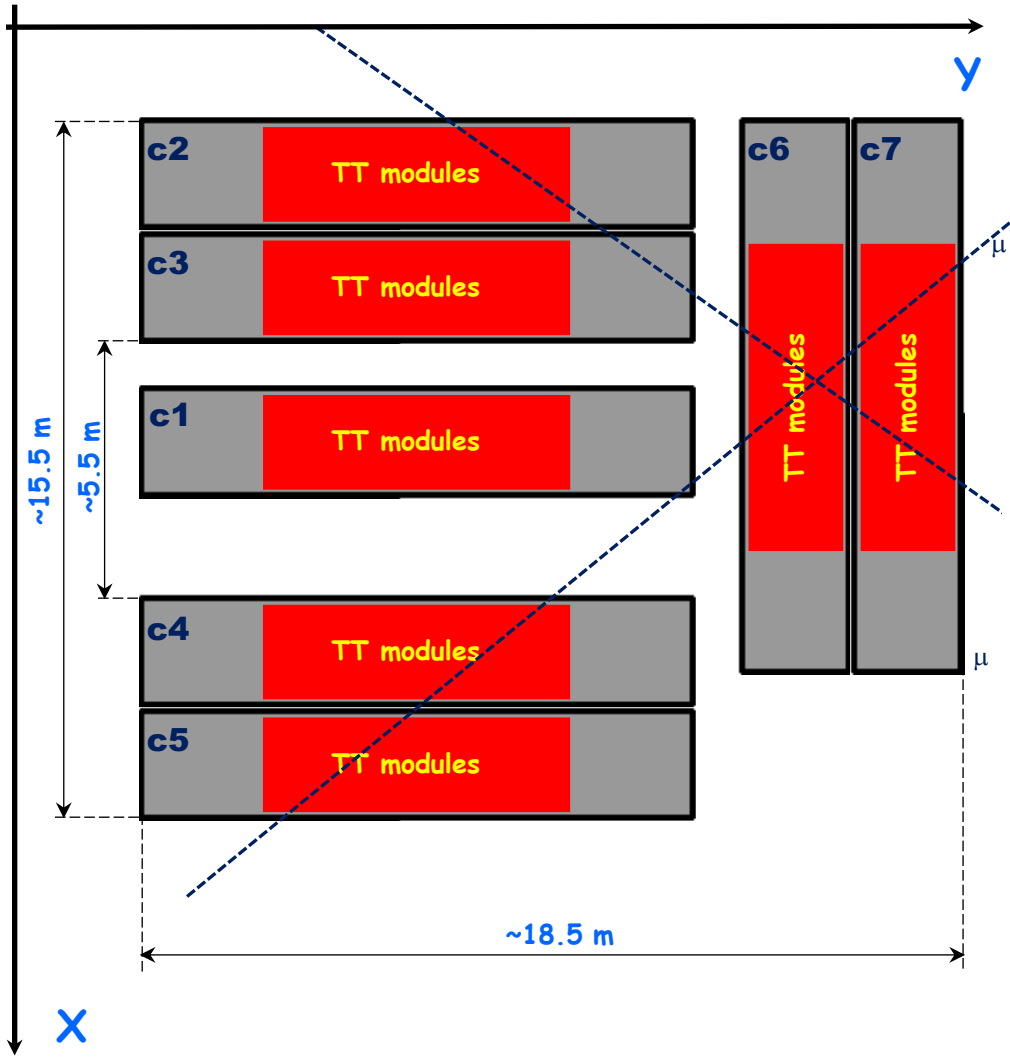




Light yield vs hit position

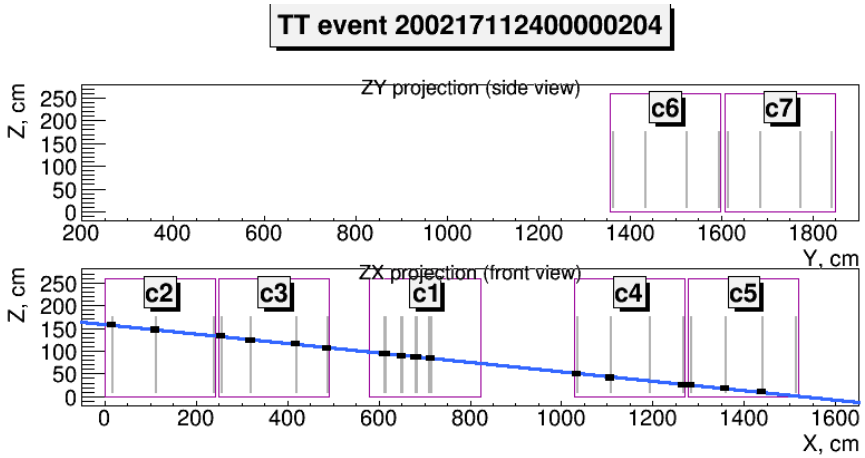
Top Tracker - Module

Layout of the TT Modules in warehouse



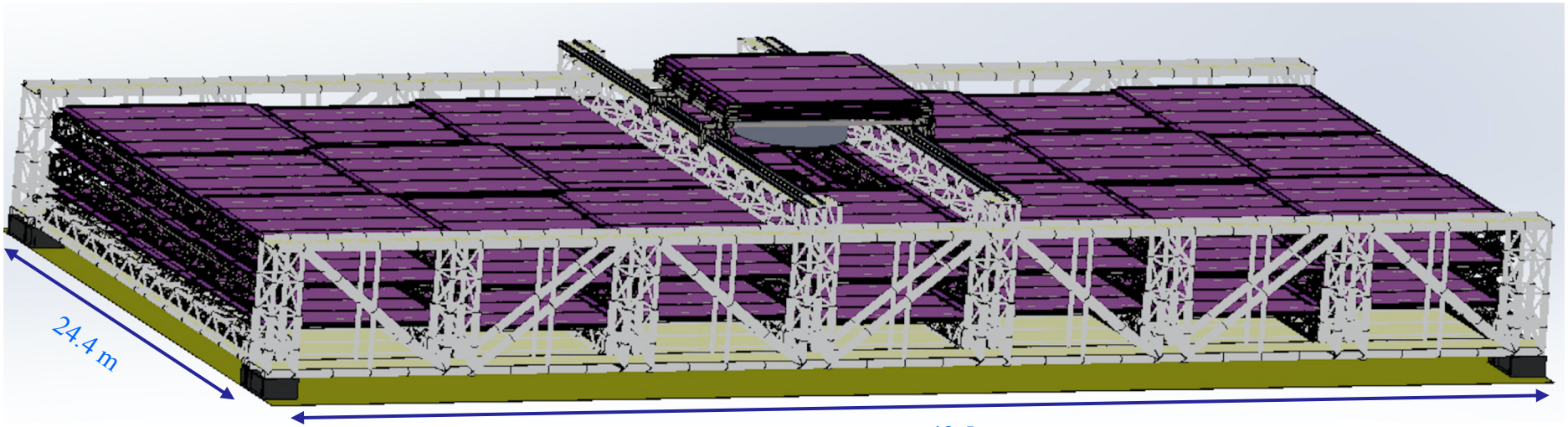
Monitoring on site:

- Use existing electronic to several TT modules
- About 200h of data taking
  => 270 million of event recorded
- Long muon track selected + strong shower : > 15 hits TT Planes



No noticeable ageing observed

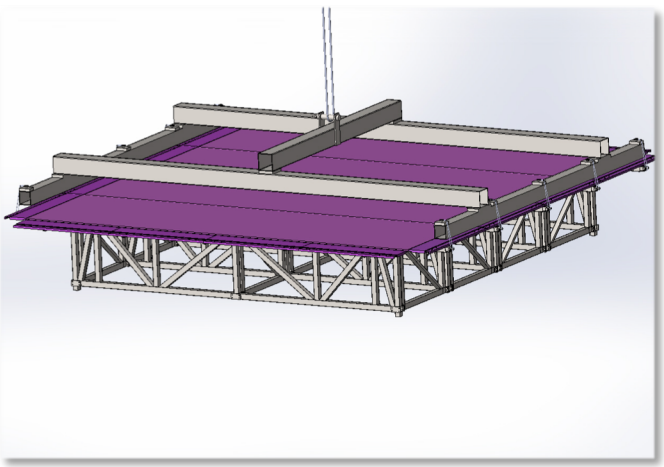
TT Mechanical Structure



Top Tracker

Wall Support structure

Lifting tool

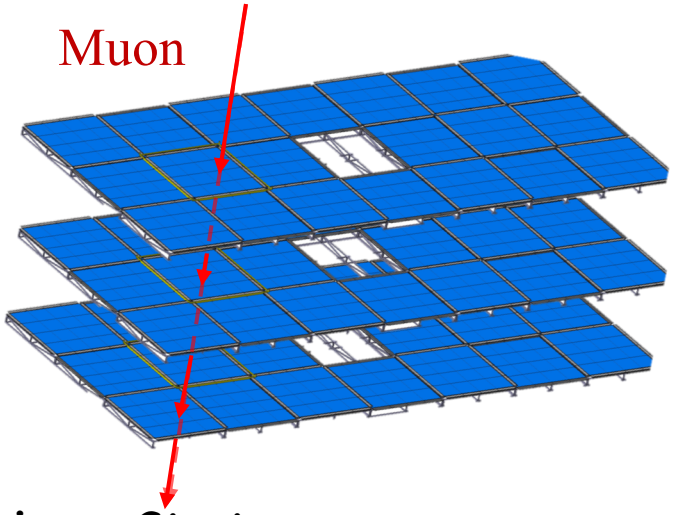


Crane transportation

Top Tracker Strategy

Main TT features:

- 62 walls in 3 layers
- 992 PMT's => 63488 electronic channels



Trigger Strategy:

Level 1:

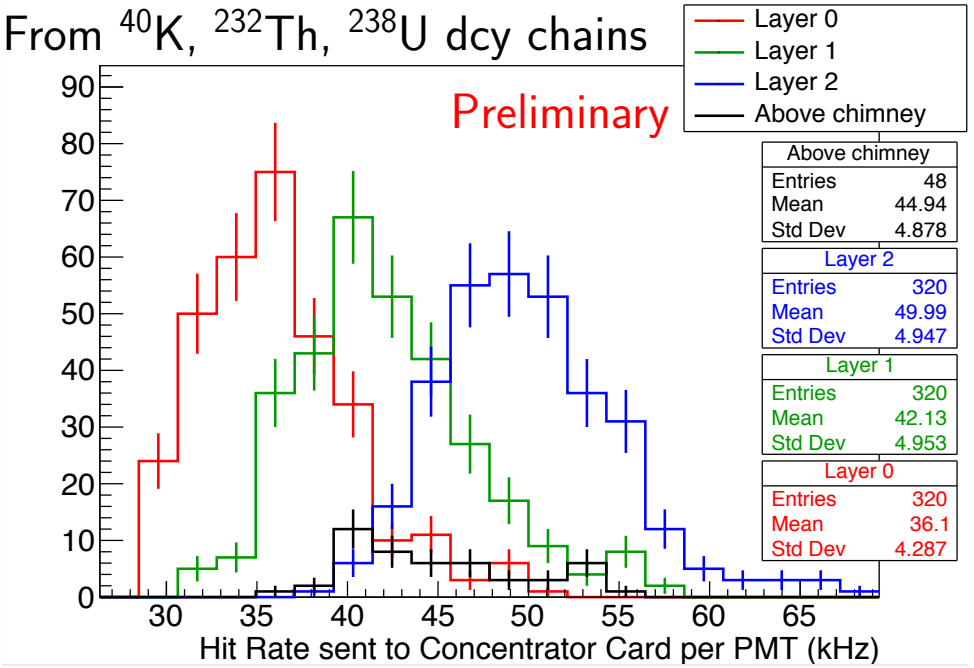
- Wall level (Square of 6.7x6.7m^{2})
- 64*16 Channels
- Counting rate: 50 kHz/PMT
- L1 trigger selection needed (~10 kHz/wall)

Level 2:

- Global level for track alignment

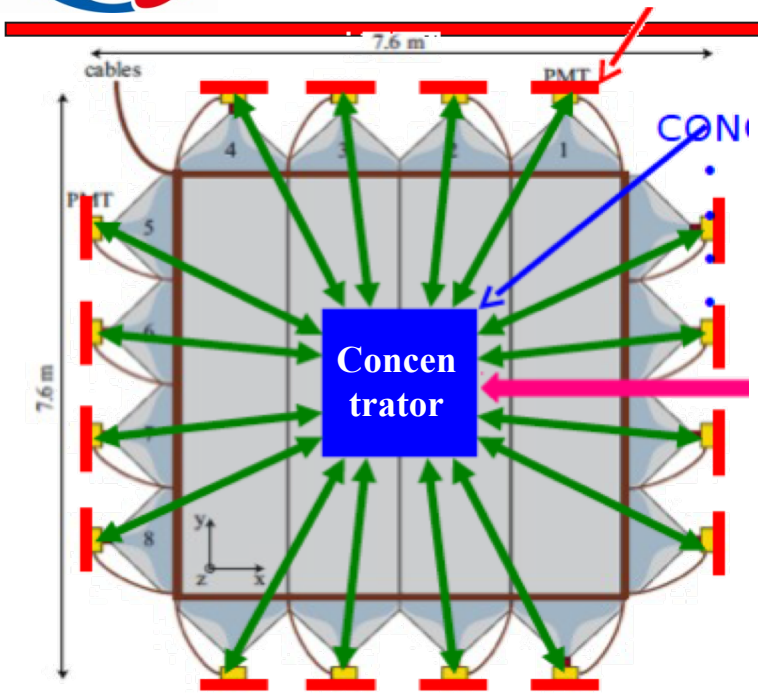
Expected rate:

- The event rate per channel is 32x higher in JUNO site compared to Gran Sasso Laboratory due to rock radioactivity.



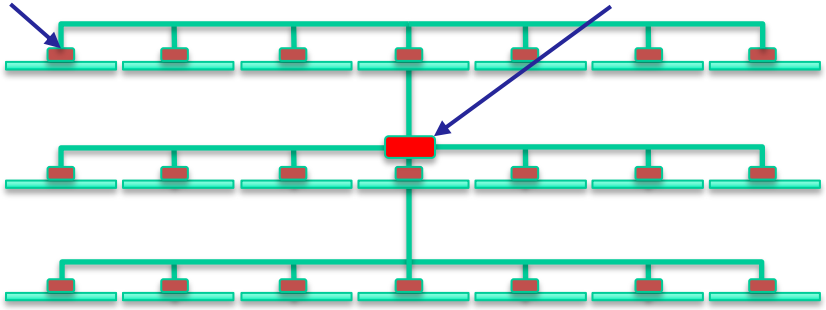
- Coincidences based on 3 aligned points can drastically reduced the rate and can be done offline

Top Tracker Architecture



Local XY trigger (LV1)

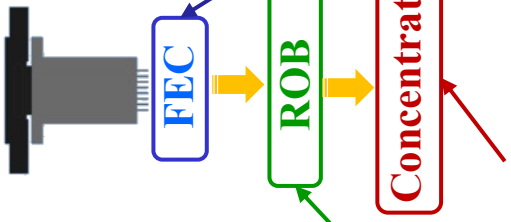
Global trigger (LV2)



Feedback to the sensors in less than 1 µs

Front End Card (FEC, 16 cards per wall):

- MAROC3 Chip + logic



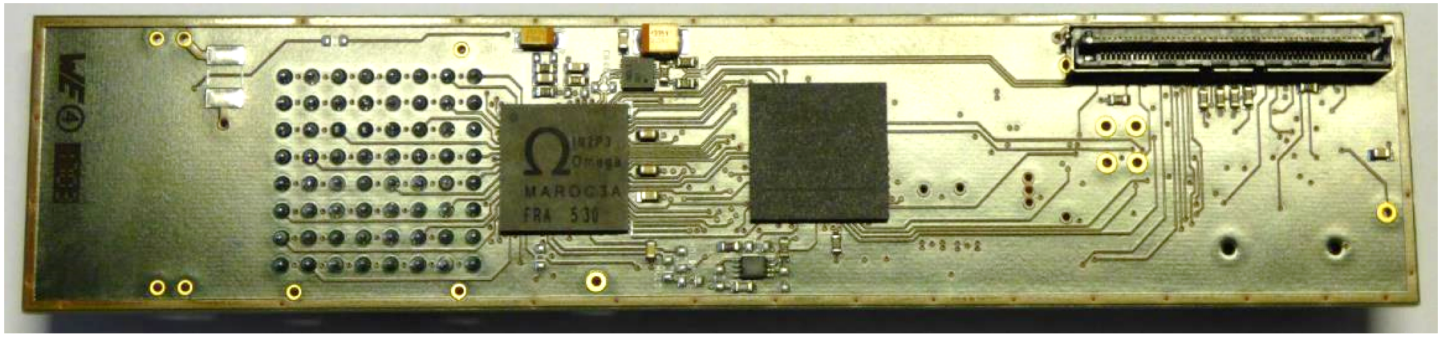
Concentrator board (1 card per wall):

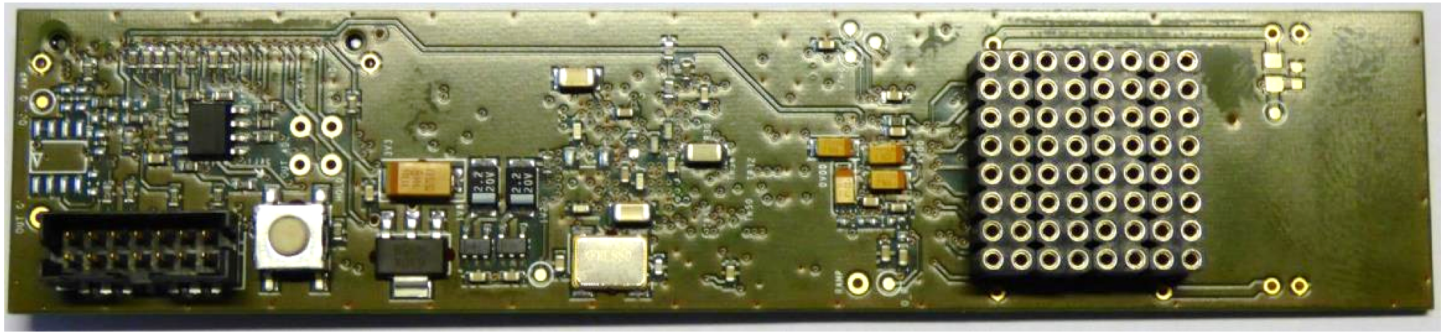
- Generate wall trigger
- Trigger Timestamp wrt GPS signal
- Measure time difference PMT OR and trigger
- Collect read out data and send them to DAQ.
- Deliver DCS command to ROB boards

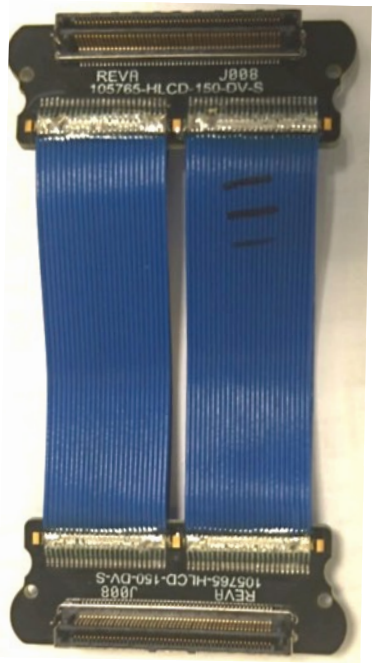
Read Out Board (ROB, 16 cards per wall):

- Manages MAROC3 settings
- Hosts PMT Power Supply
- FADC for charge read out
- Send PMT OR to concentrator

TT Electronics : Front End Card







FEB-ROB connector (already tested)

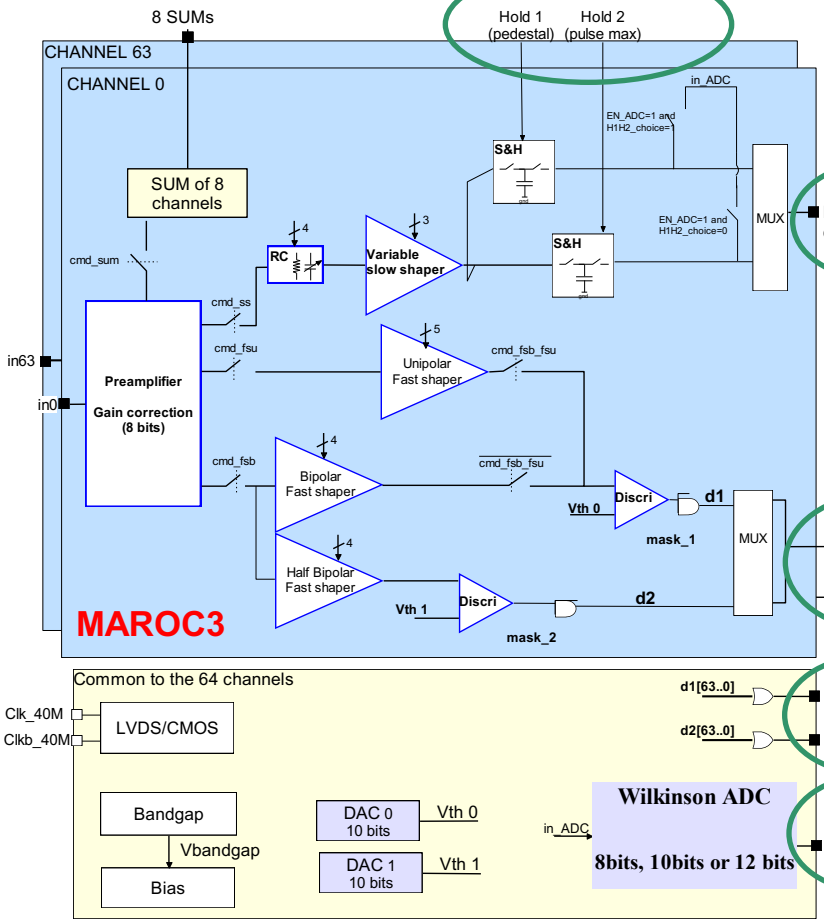
	AVDD = DVDD = 3.5V	FPGA = 5V	Power
Consumption	150 mA	170 mA	2W

Status:

- Fully tested no problems observed
- Ready for production

Production schedule begin in September 2019

TT Electronics : MAROC3



Hold : Track and hold signal

Out_Q : Mux charge output of the 64 channels in case of externals ADC

64 Triggers

OR triggers

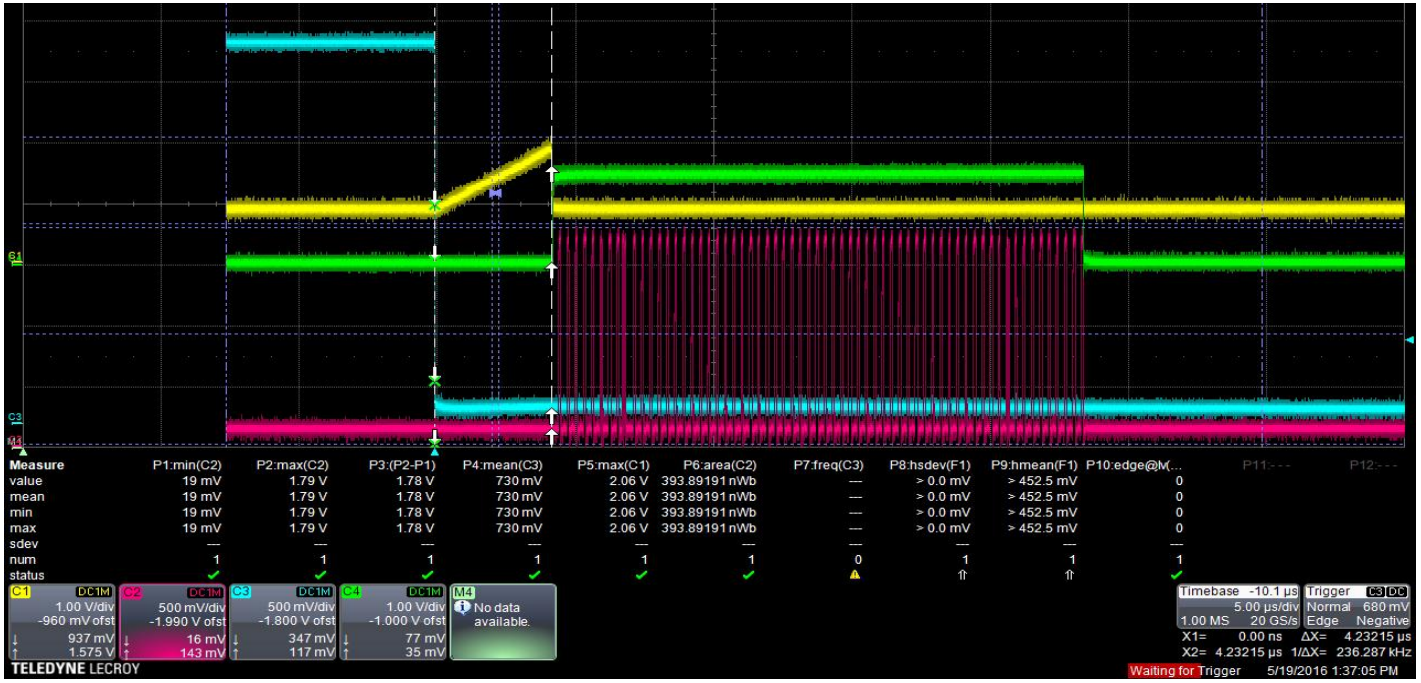
Out_ADC : Internal ADC output

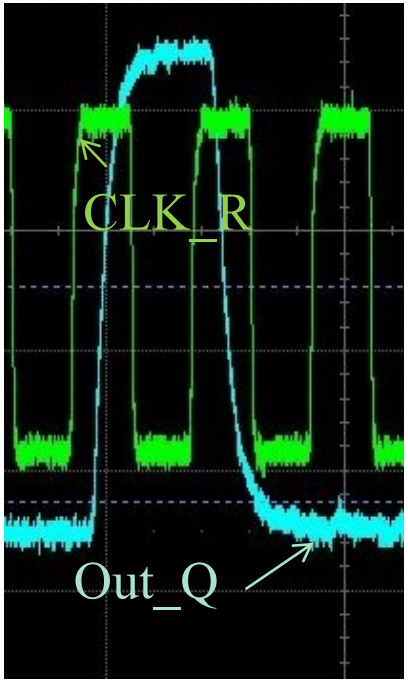
Chip features:

- Preamplifier gain dynamic 0-4 => fixed by calibration runs
- Slow shaper parameter charge readout and digital section shaper chosen according to OPERA experiment.

TT Electronics : MAROC3

Two options are available: Wilkinson data reading (14µs) or external ADC (10µs)





- Fast OR used for trigger validation in the Concentrator
- If trigger rejected => RESET interrupts the ADC conversion => no data sent to the Concentrator
- If trigger validated => no RESET => conversion completes => data sent to the Concentrator

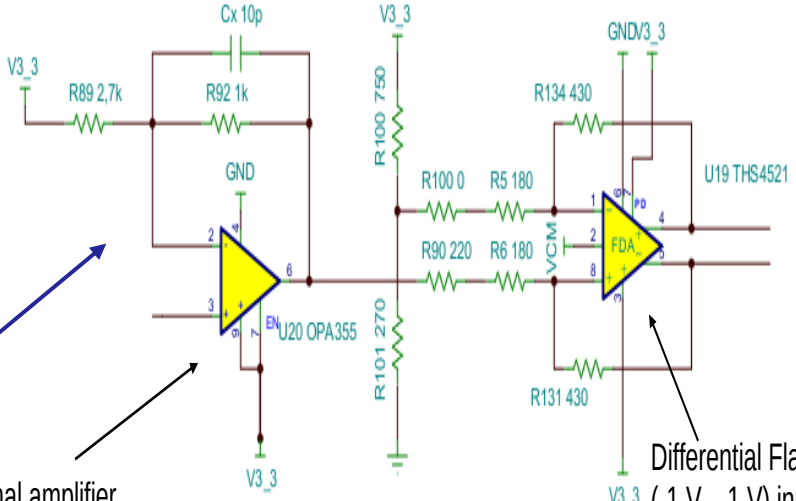
TT Read Out Board

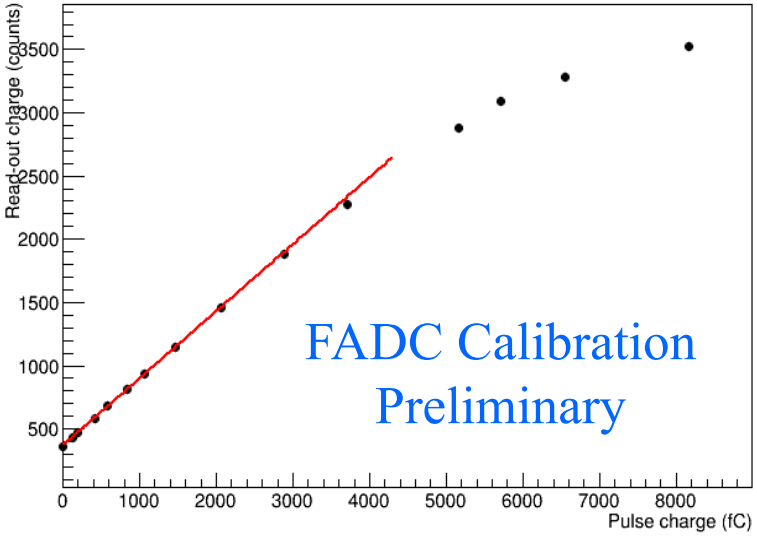
Task list:

- MAROC3 settings
- OR from MAROC3 transmission to concentrator (also through 10 m cable)
- Digital pattern acquisition from FPGA on FEC
- Hold signal to MAROC3 for analog chain (timing frozen, 2.5 ns jitter)
- Wilkinson data from MAROC3 acquisition
- Charge read-out with external Flash ADC (FADC)
- Test pulse for calibration
- PMT HV management

Status:

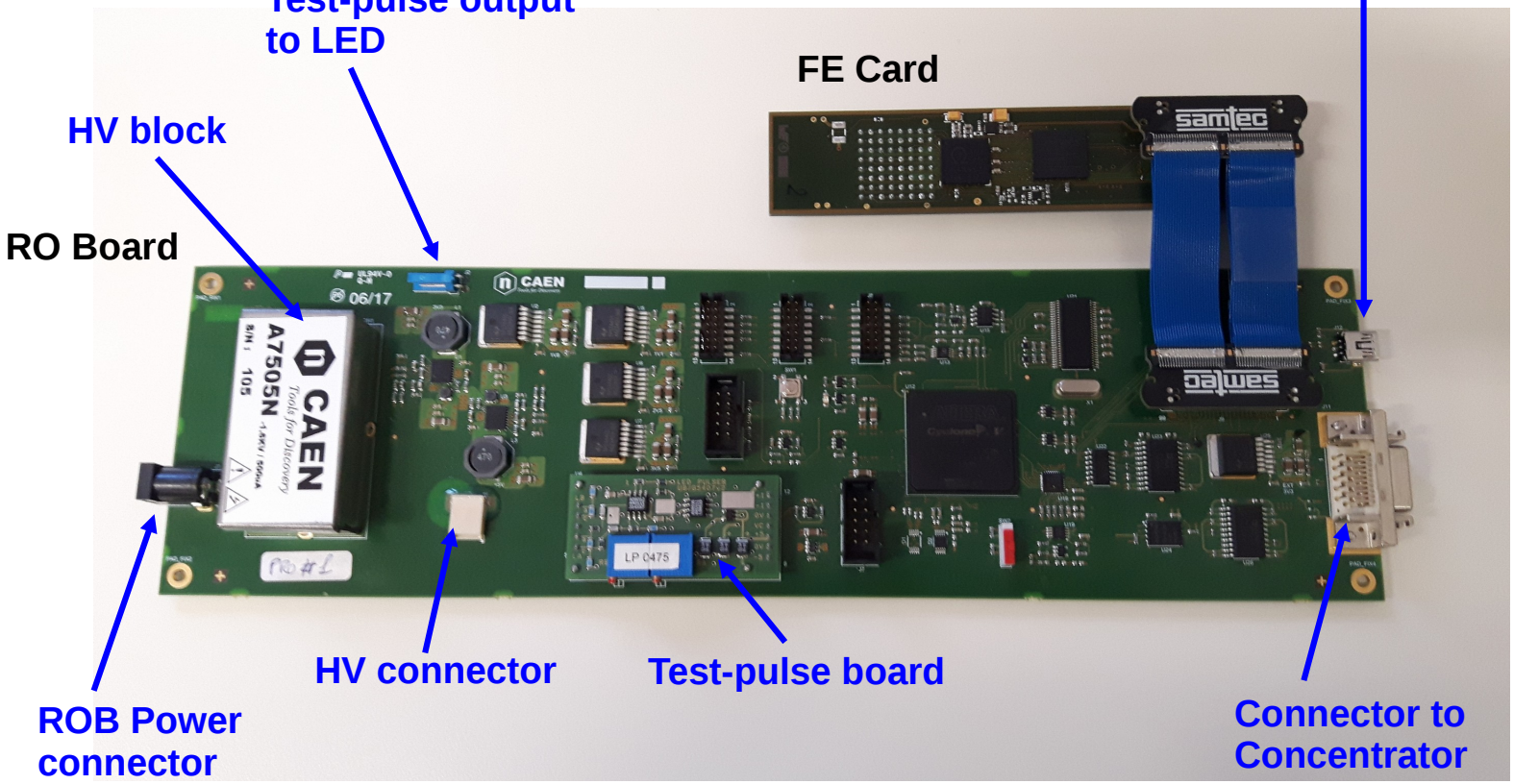
- Functionnality items checked at IPHC and LNF
- Mechanical compatibility check with module
- 5 ROB's delivered and tested





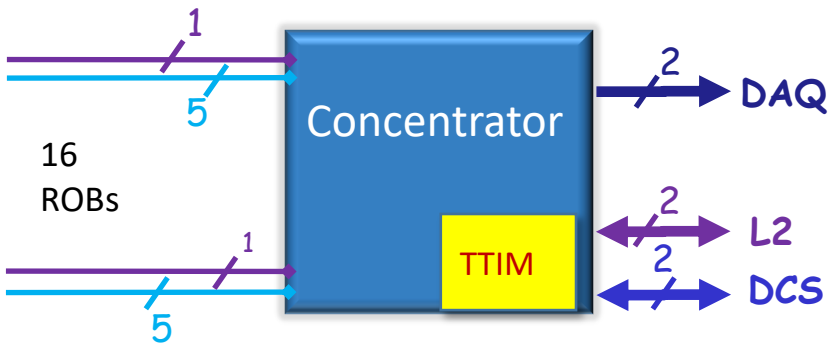
TT Electronics

Tests of integration between the Front-End Card and the Read-Out Board (Strasbourg, June and November 2017).



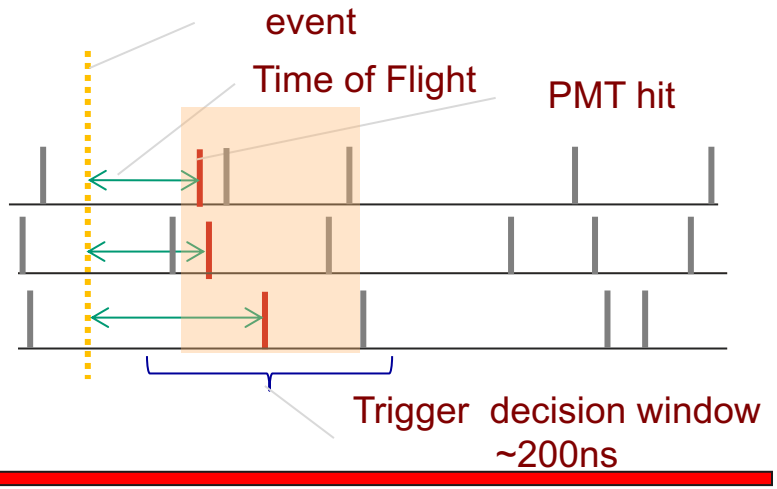
TT - Concentrator

- Acquiring information from ROB
  - Hits in coincidence
  - Charge
- Reset and programming of the FE ASIC
- Acceptance of interesting events
  - Timestamp with approximately 1ns time resolution for each event coming from the ROB
- Veto of background noise
  - We aim to reduce the background radioactivity noise to approximately 10 kHz / wall
- Misc. requirements (optional)
  - Periodic/random triggers for detector study
  - Data throttling in case of extreme noise rates
  - Commissioning study



→ Fast OR
→ Serial OUT
← Serial IN
← Clock
← Reset
←?→ Spare

3x single fiber mono-mode

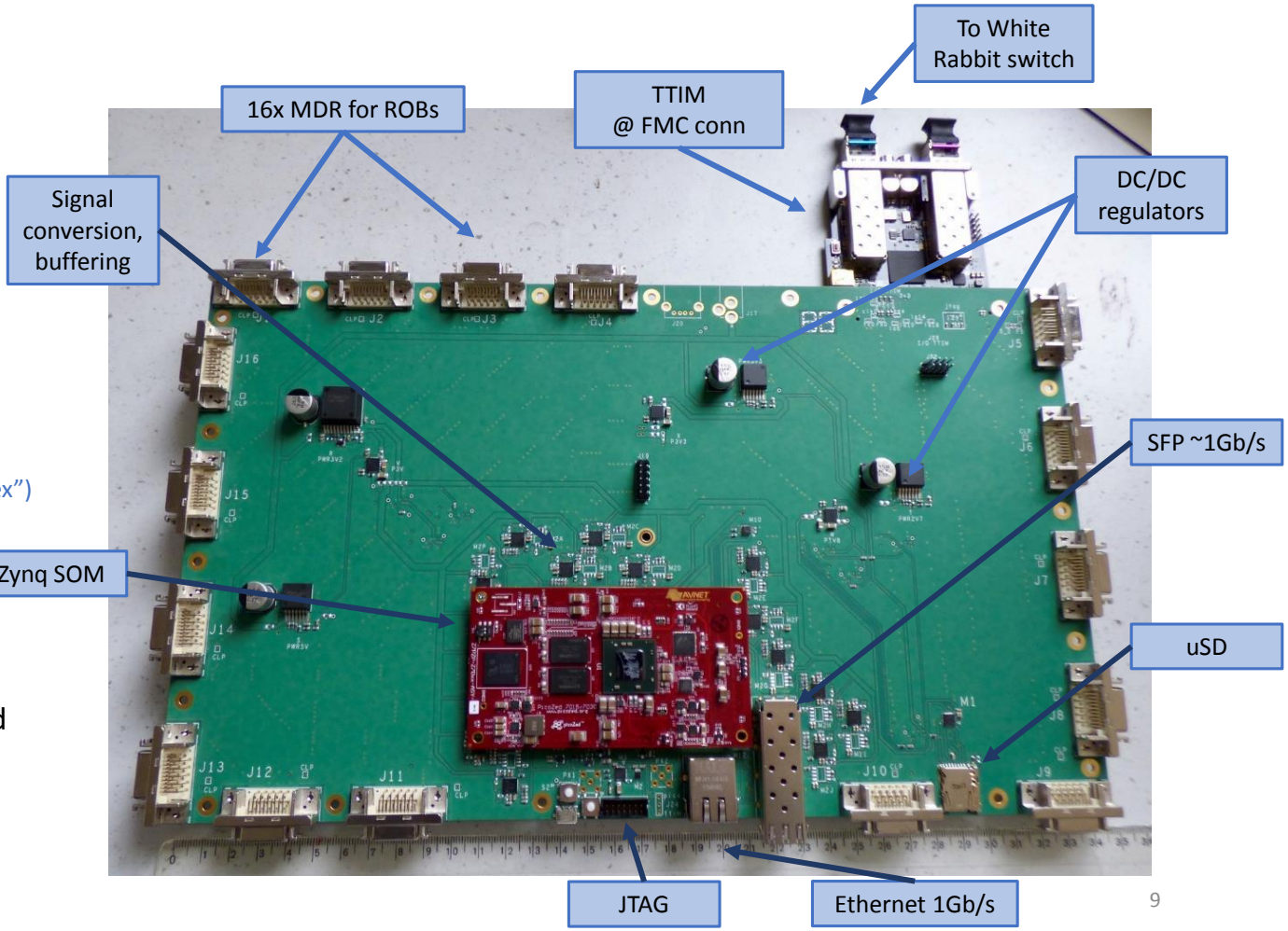


TT - Concentrator

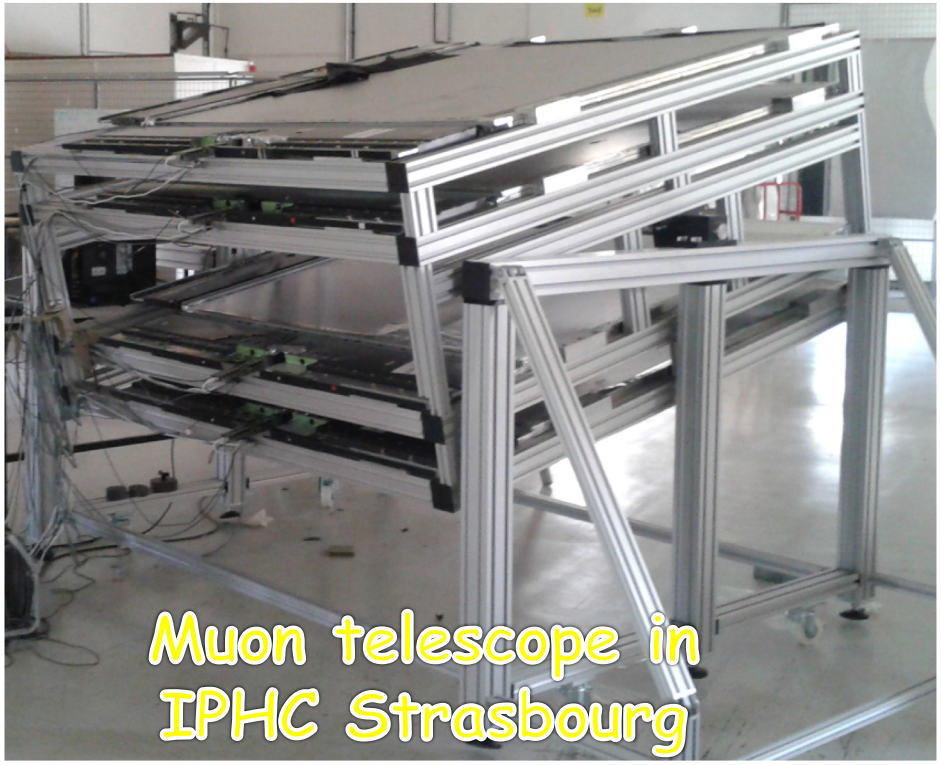
Prototype

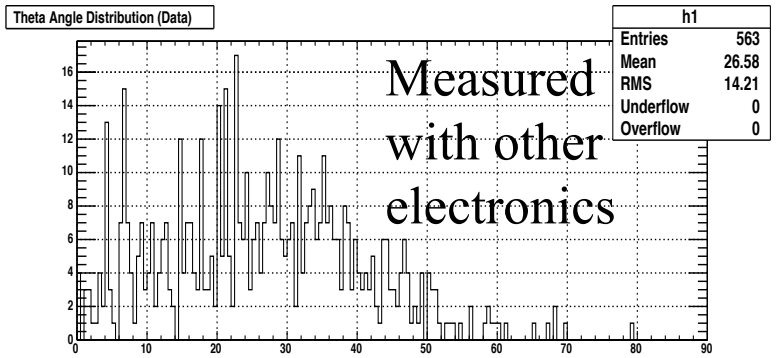
- ~ 200 x 340 mm^2
- 8 layers
- Min space/trace 125 um
- ~ 1000 components
- +12V DC
- SOM 3x100 pins
  - ZYNQ 7030 (XC7Z7030, “Kintex”)
  - Using 99% of available IOs

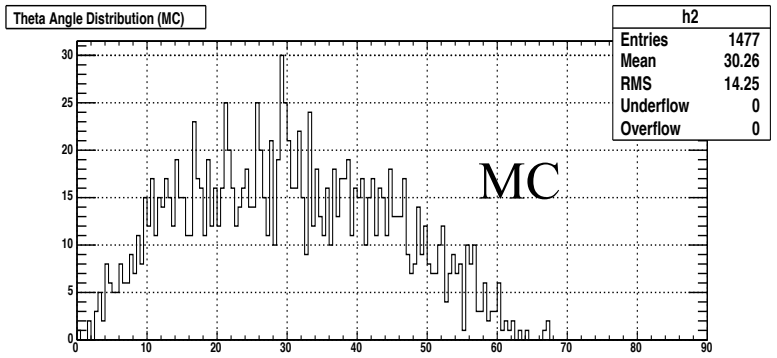
2 boards have been assembled



TT Prototype



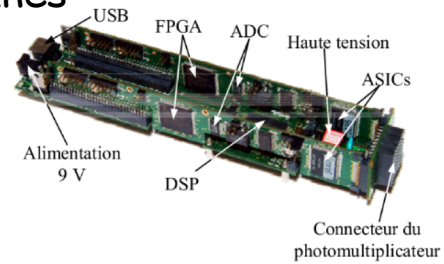




Muon angular distribution

Main features:

- 8 reduced modules from TT-OPERA allowing 4XY detection planes 1.7x1.7m^2, 8x64 = 512 PMT channels
- Specific electronic developed for medical application to be replaced by TT electronics
- Test the whole DAQ chain +XY coincidence on four layers with JUNO electronics



Outline

- TT modules are in stored in warehouse in China and equipped for ageing monitoring.
- TT mechanical support completed and finalized with prototypes in Dubna
- The TT Front-End and Read Out cards is almost frozen
- First concentrator prototype will be tested
- TT Prototype will be equipped with JUNO Electronics for validation
- Installation 2021

Thank you