

The MATHUSLA Test Stand

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on behalf of the MATHUSLA Collaboration

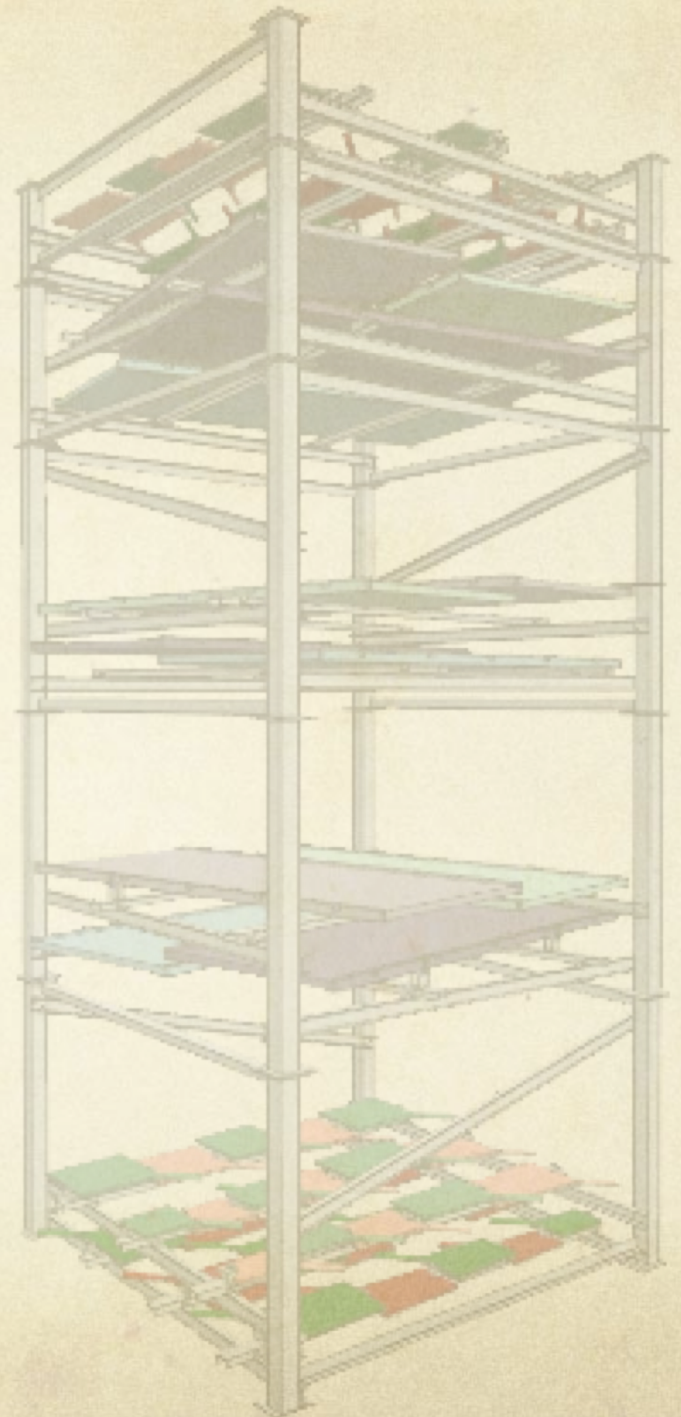


27th August 2018

MATHUSLA Workshop - Simons Center



UNIVERSITY of
WASHINGTON



Why a MATHUSLA Test Stand?

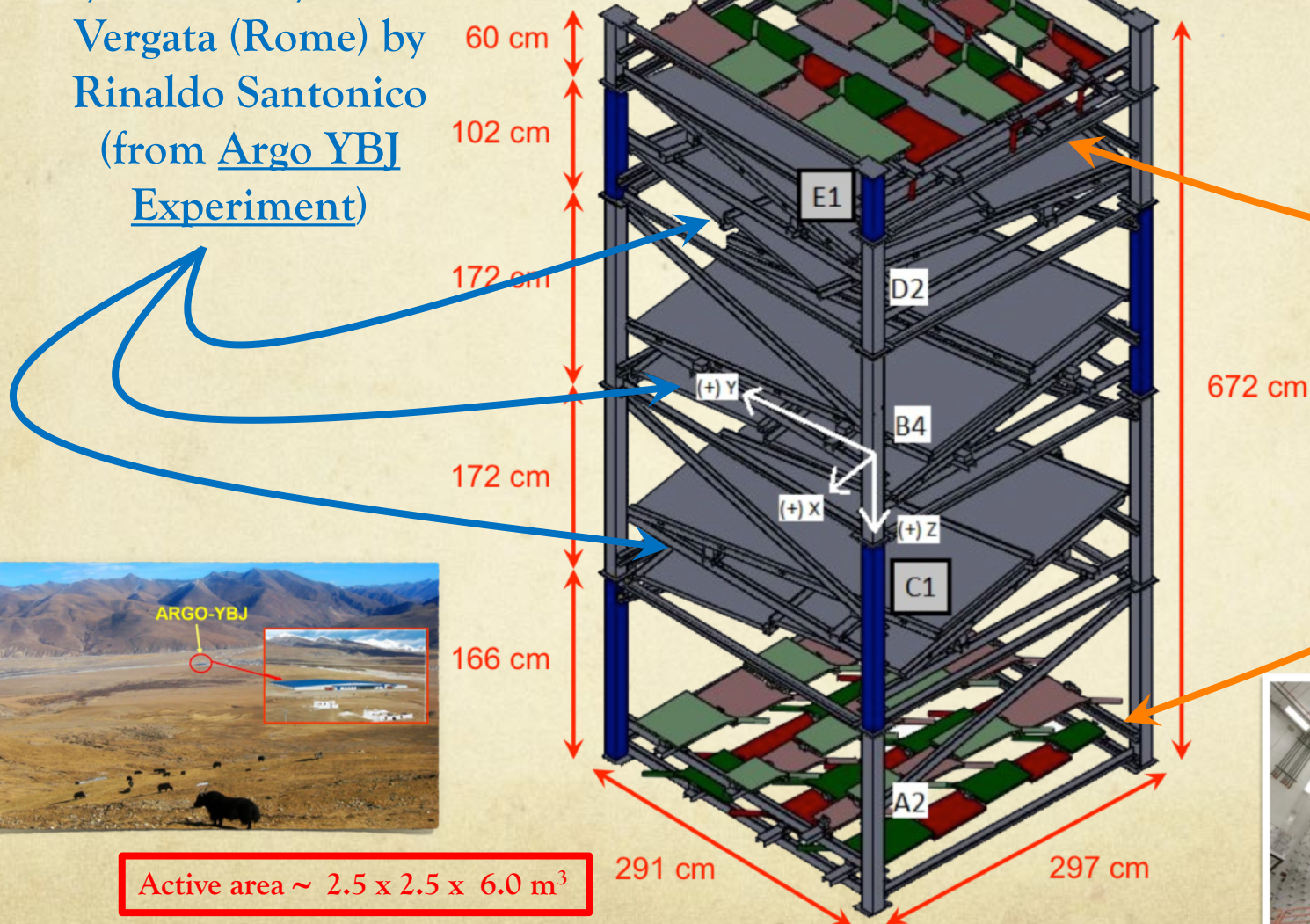
- A test stand with a detector layout similar to the one envisioned for the MATHUSLA detector was assembled at CERN in November 2017 (thanks to the help of CMS and ATLAS)
- The main goal of the test stand is to provide empirical information on potential backgrounds coming from LHC (as well as from cosmic rays)
 - ✓ The test stand is taking data with the **LHC beam on**
 - To provide an estimate of the **background expected from LHC collisions**
 - ✓ ...and **LHC beam off**
 - To provide good measurements of the **background from cosmic rays** and information about their trigger and identification
- All the tests performed until the end of LHC Run 2 will be crucial to understand the LHC-related background rate
- All this information can be used to optimize the final design of the main detector and tune the background simulations

The MATHUSLA Test Stand

3 layers of RPCs provided
by University of Tor
Vergata (Rome) by
Rinaldo Santonico
(from Argo YBJ
Experiment)



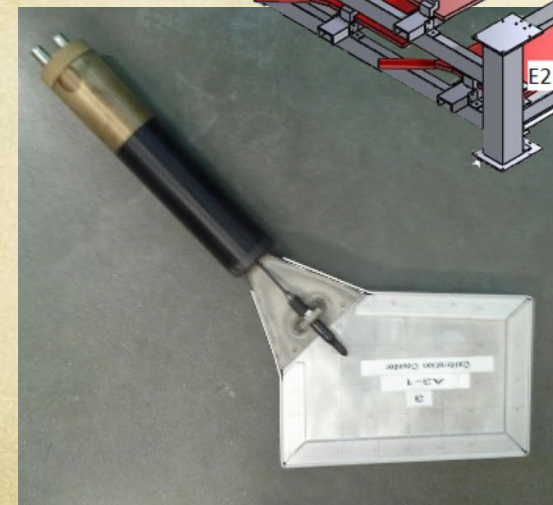
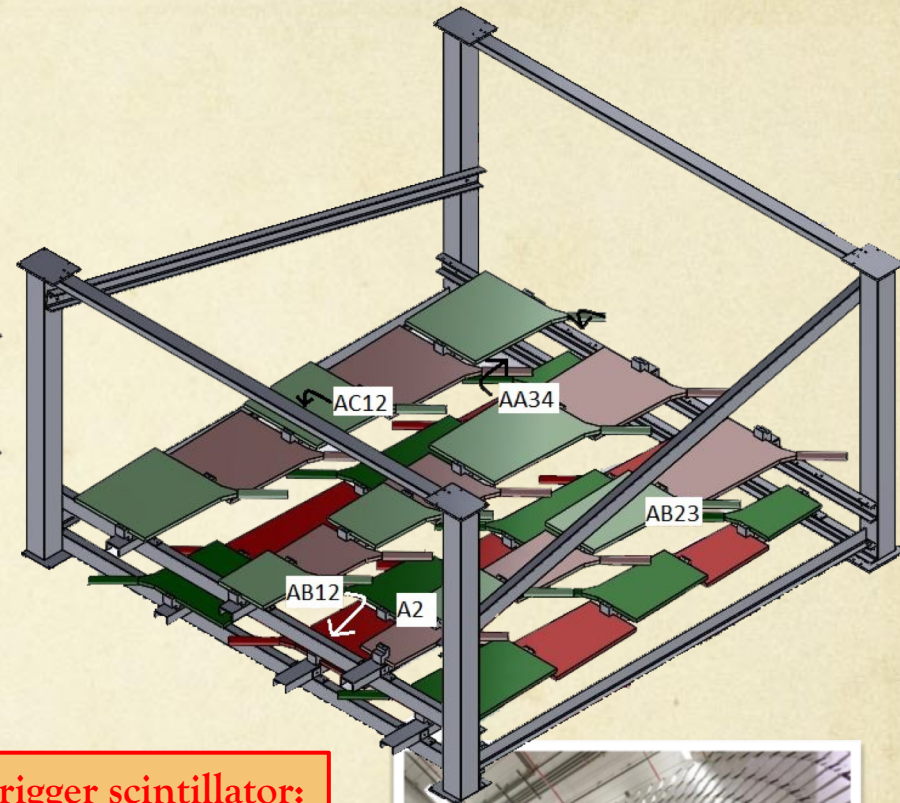
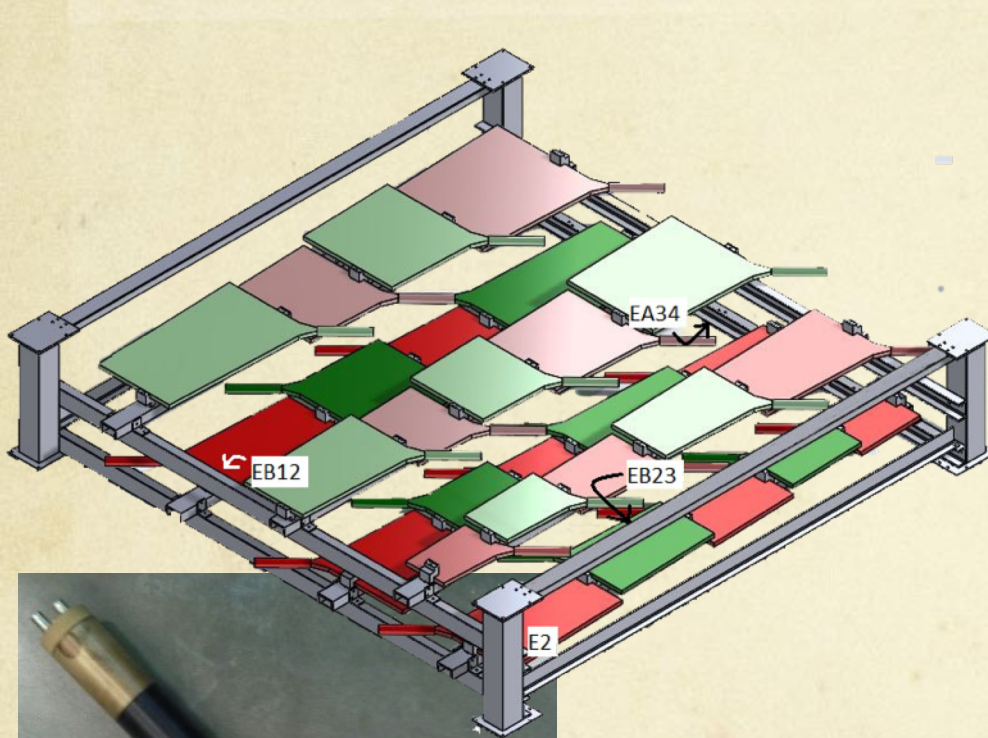
Top and bottom
scintillator layers
from Tevatron DØ
provided by
Dmitri Denisov



Test Stand Scintillator Details

Top - 31 scintillators

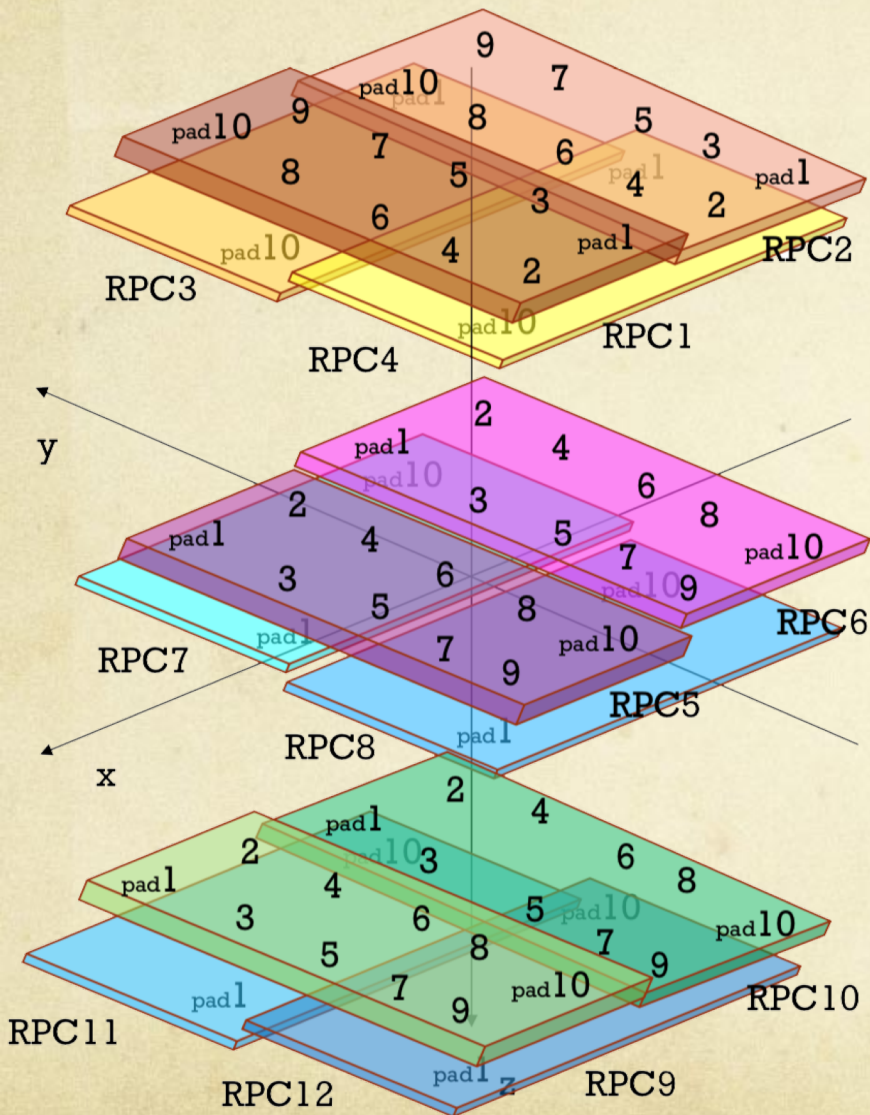
Bottom - 28 scintillators



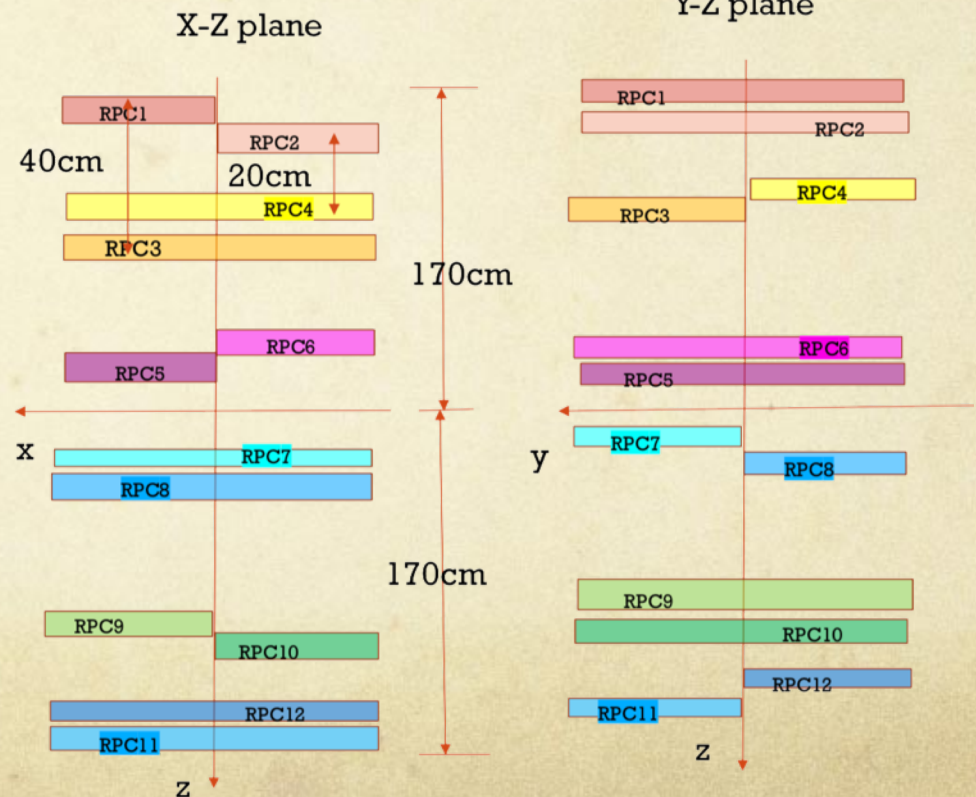
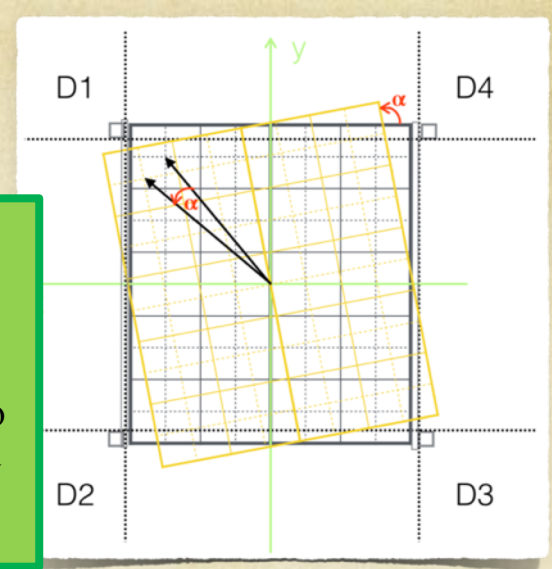
D0 forward MUON trigger scintillator:
12.8-mm-thick BICRON 404A of
trapezoidal shape + WLS bars for light
collection



Test Stand RPC Details

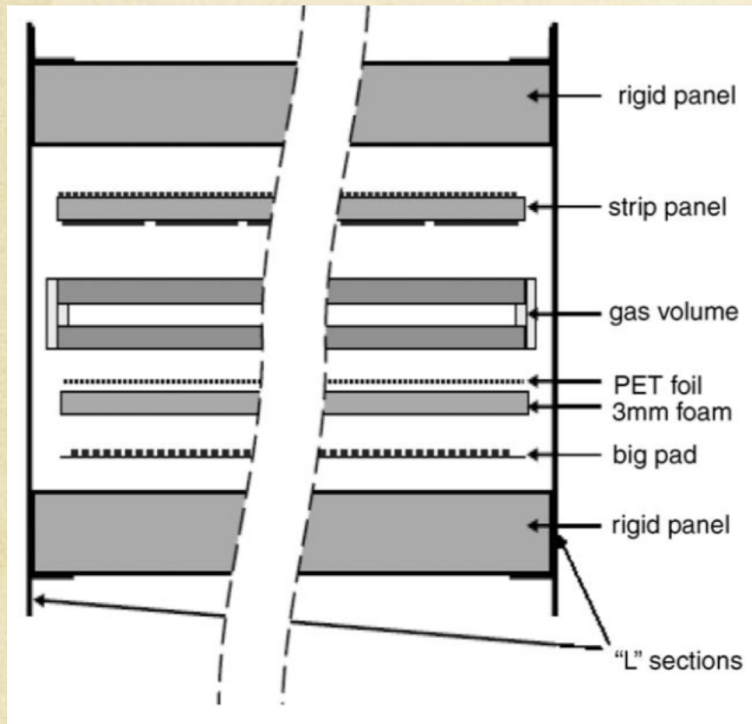


Small stereo rotation angle between the 3 tracking planes to reduce ambiguity and ghost hits



Test Stand RPC Details

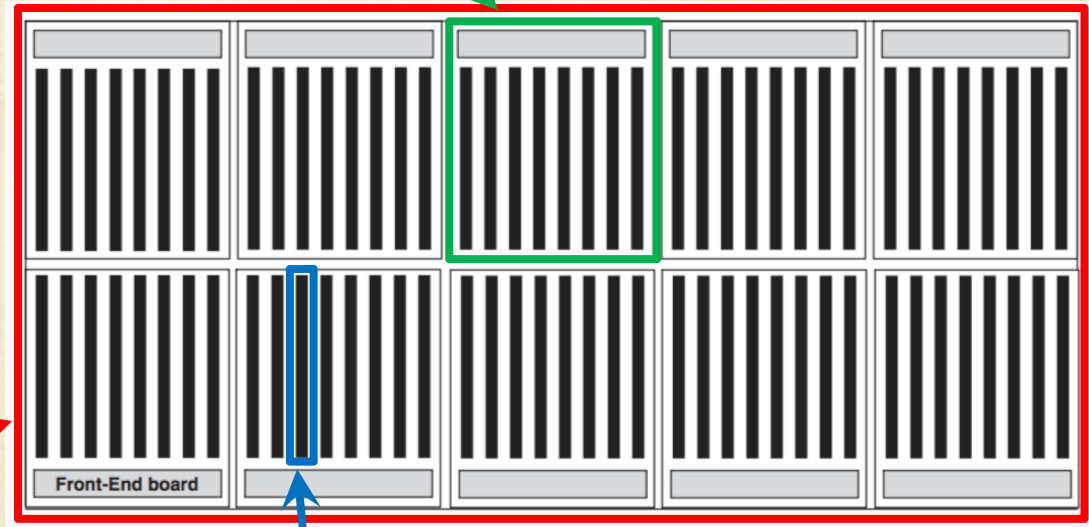
- 12 RPCs from the prototype of ARGO YBJ cosmic ray shower experiment in Tibet



- ✓ Operating in streamer mode
- ✓ Ar + ATLAS RPC gas ($\text{C}_2\text{H}_2\text{F}_4/\text{Iso-C}_4\text{H}_{10}/\text{SF}_6$ (94.7/5/0.3))

10 Pads ($55.6 \times 61.8 \text{ cm}^2$) for each RPC

Chamber size: $1.25 \times 2.80 \text{ m}^2$



8 Strips ($6.75 \times 61.8 \text{ cm}^2$) for each Pad

Test Stand DAQ and Trigger

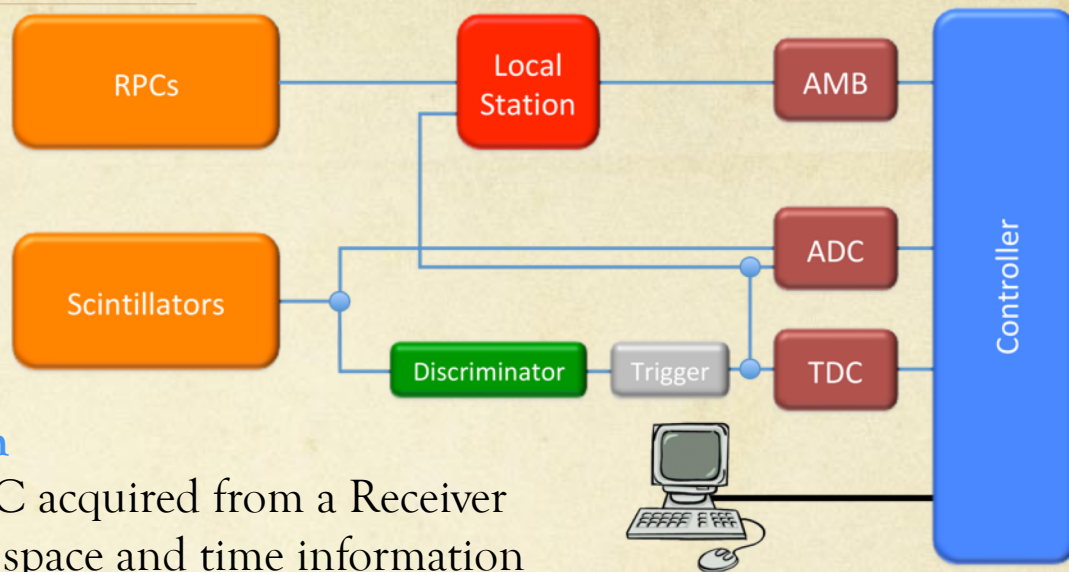
Test module DAQ

➤ Scintillators

PMTs interfaced with a VME CAEN module

➤ RPCs: Argo Experiment Local Station

(from Lecce, Italy). Data from each RPC acquired from a Receiver Card which reads out and digitises the space and time information from 10 pick-up pads and gives out the pad multiplicity for trigger purposes. On trigger occurrence the Local Station sends the collected data to the PC



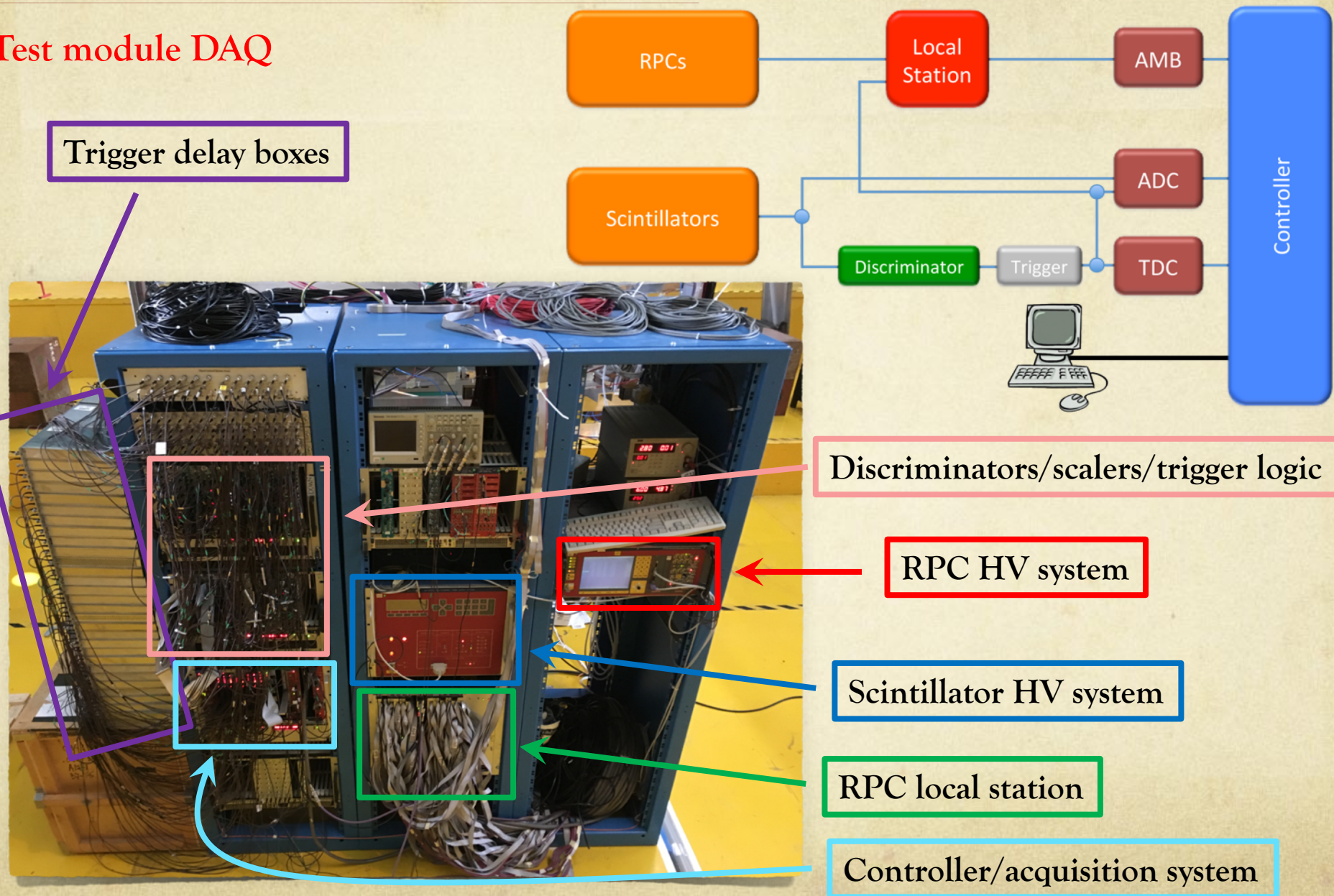
Test module trigger

Two possible triggers: top and bottom scintillators in coincidence, with:

1. Timing appropriate for downward going particle (cosmic ray events can be used for space and time alignment)
2. Timing appropriate for upward going particle

Test Stand DAQ and Trigger

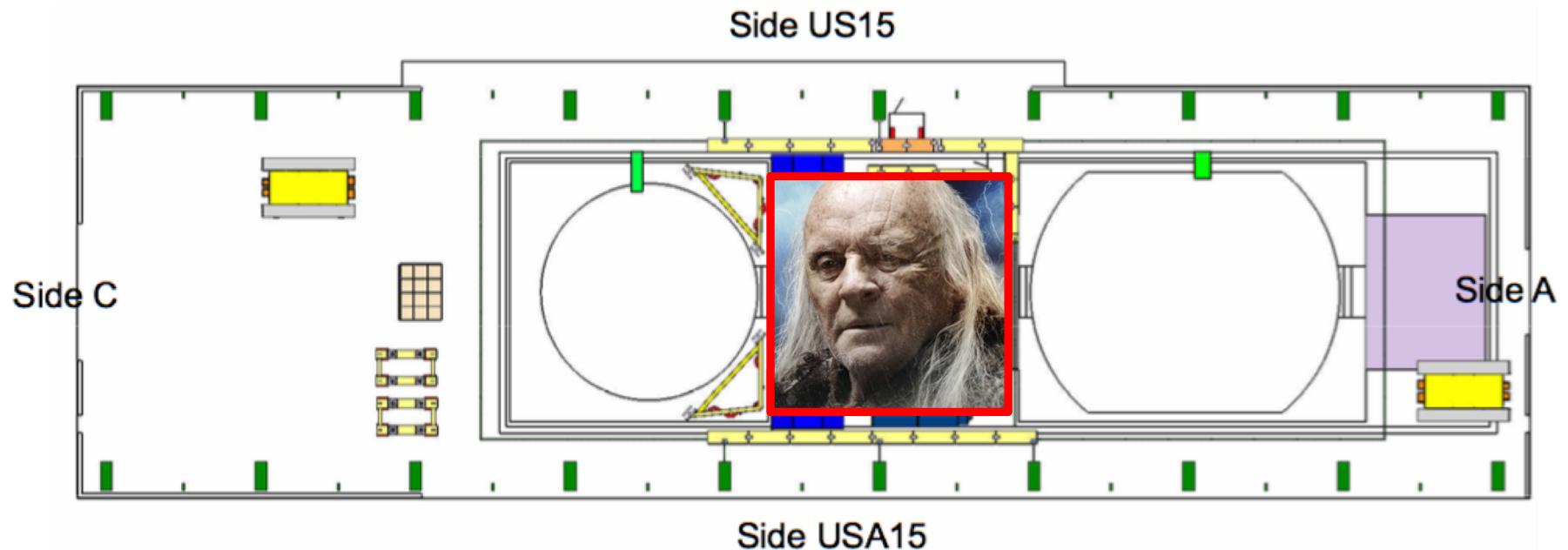
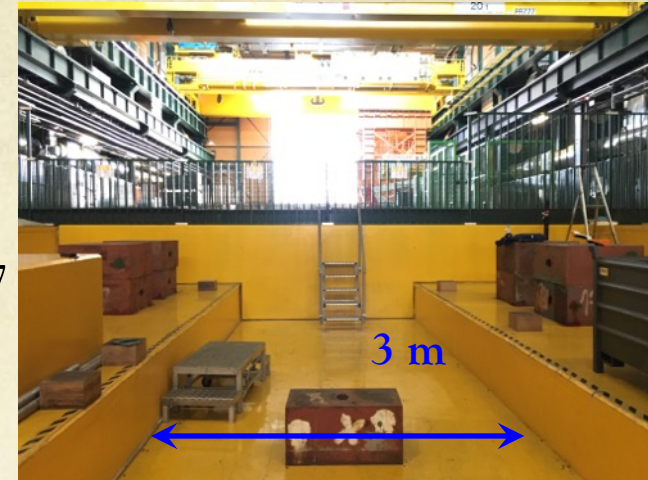
Test module DAQ



Test Stand Installation in ATLAS P1

- Cosmic background (\sim) well understood
- Need to quantify the **background from ATLAS**
- Test stand installed in the (Buffer Zone) on the surface area above ATLAS (exactly above IP) in November 2017 (during ATLAS operations this space is empty)

✓ **Detector commissioning**



Test Stand Installation in ATLAS P1

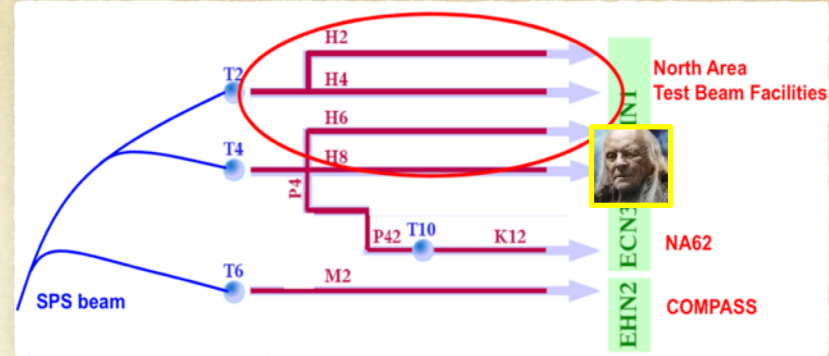
Henry L. putting the last bolt



November 2017 P1 data-taking lasted < 2 weeks

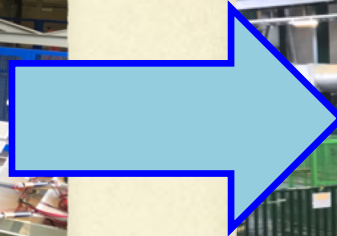
Test Stand @ H8

- With the opening of the ATLAS cavern in December 2017, the buffer zone was filled with ATLAS radioactive material (beam pipe shielding, etc...)
- At the **end of November MATHUSLA test stand moved to a temporary space in CERN Preveessin** (H8 SPS extraction line)
 - Performed test with cosmic rays
 - Improved data-taking
 - Improved performance of the RPCs



Test Stand Back to P1 @ End May 2018

- MATHUSLA test stand move back to ATLAS P1



- Data taking will continue until the end of LHC p-p collisions (November)
- Several on-going studies and optimisation

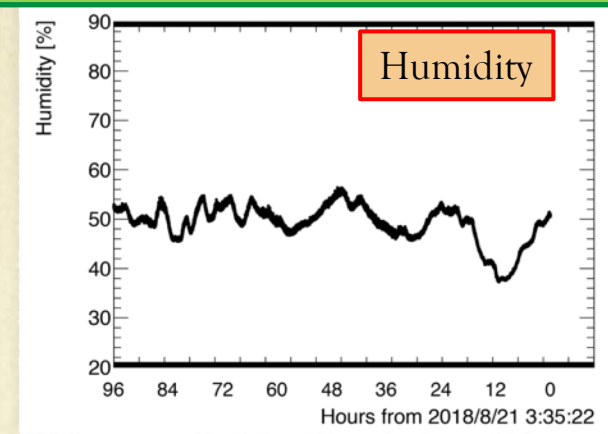
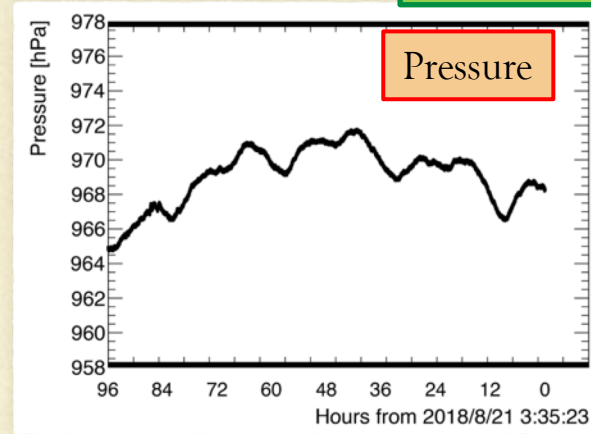
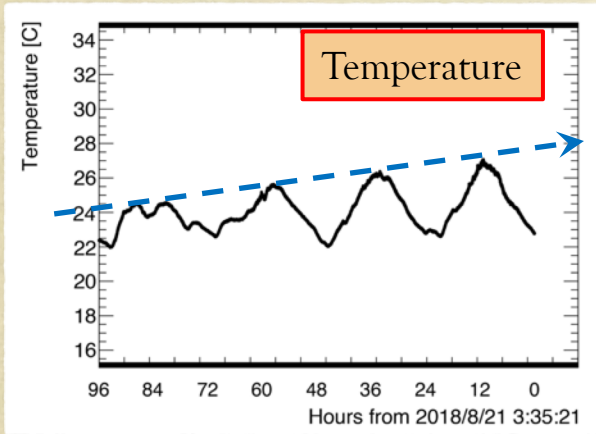


MATHUSLA Test Stand Performance

RPC Performance vs Environmental Conditions

➤ Environmental conditions

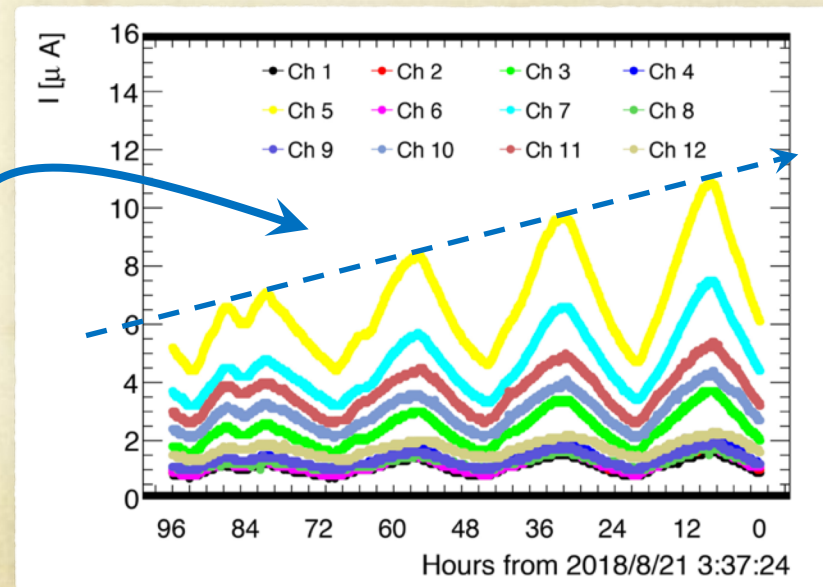
Monitoring system (realised with an **Arduino** and a **Bosch BME280**) installed in ATLAS SX1 building



...modify the RPC behavior/performance

[Operational features, monitoring and control for the RPCs in the Argo-YBJ experiment - P. Camarri, JINST 8 T03002]

Clear dependence of the currents absorbed by the chambers on the **temperature** (and also **pressure**)



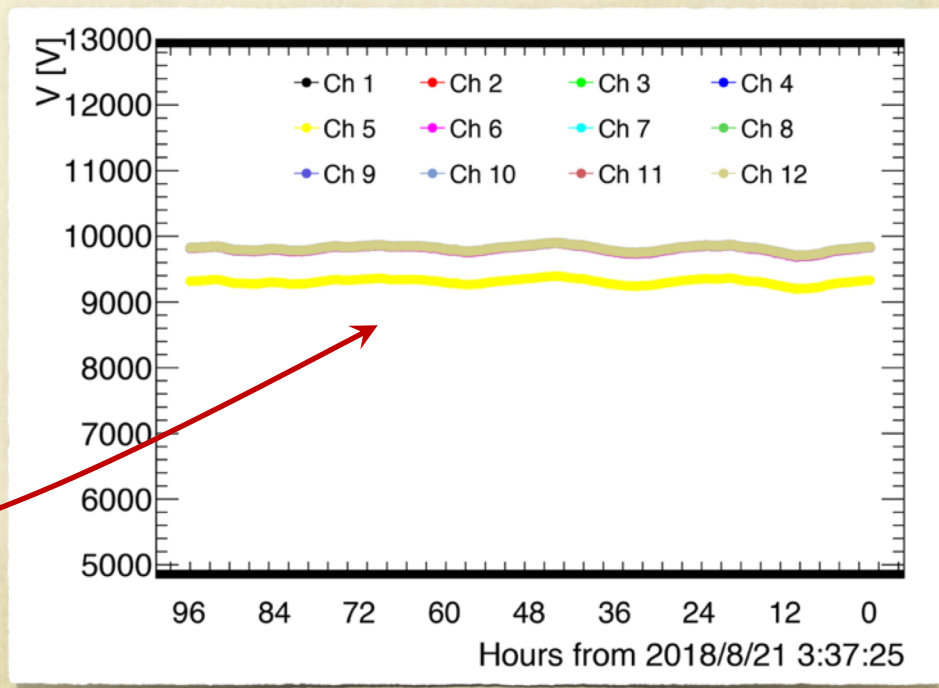
RPC HV Tuning

- The HV of each RPC depends on the **instantaneous pressure** and on the **1 hour delayed temperature**

$$V_{\text{eff}} = V_{\text{app}} \frac{T}{T_0} \frac{p_0}{p} \quad \Rightarrow \quad \text{We want to obtain a constant effective voltage} \quad \Rightarrow \quad V_{\text{app}}(t) = V_0 \frac{T_0}{p_0} \frac{p(t)}{T(t-1\text{h})}$$

[temperature] = K , [pressure] = Pa , [voltage] = V

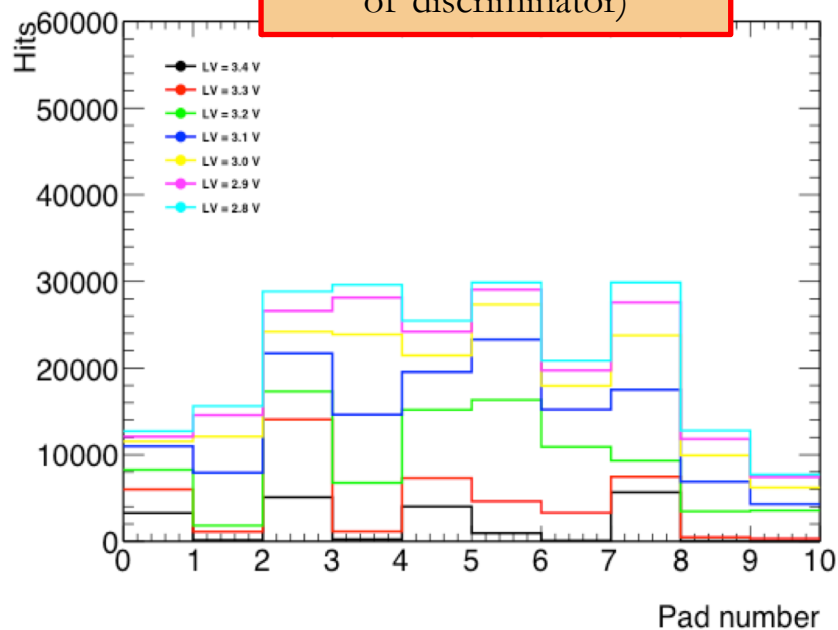
- Implemented an **automatic control system** that monitors temperature and pressure in SX1 and **changes the HV of each chamber accordingly**



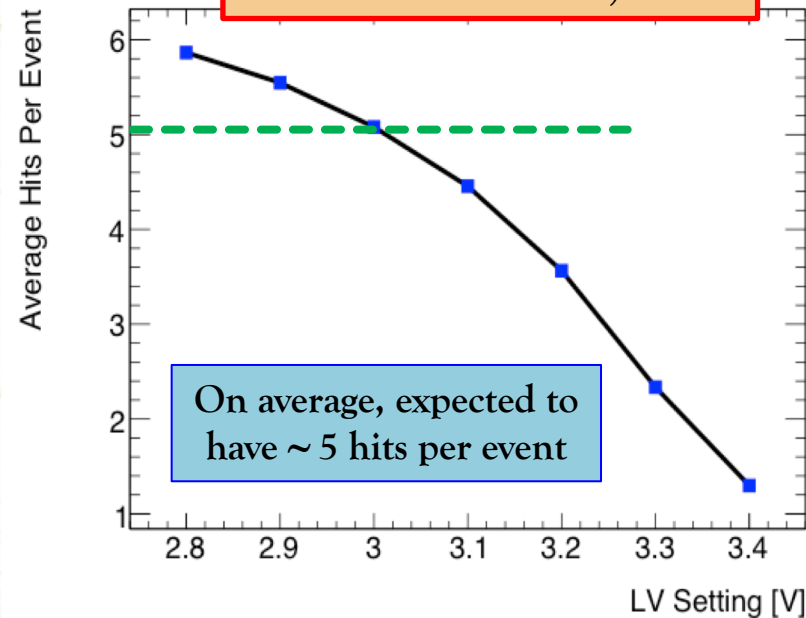
RPC Front-End Readout Tuning

- Front end electronics based on GaAs custom chip consisting of eight discriminator channels each with an output of single-ended ECL level
- Front end discriminator threshold need to be tuned
 - ✓ A too low threshold will increase the number of noisy (fake) hits

RPC pad occupancy
(tuning voltage threshold
of discriminator)



RPC average hits per event
(tuning voltage threshold
of discriminator)

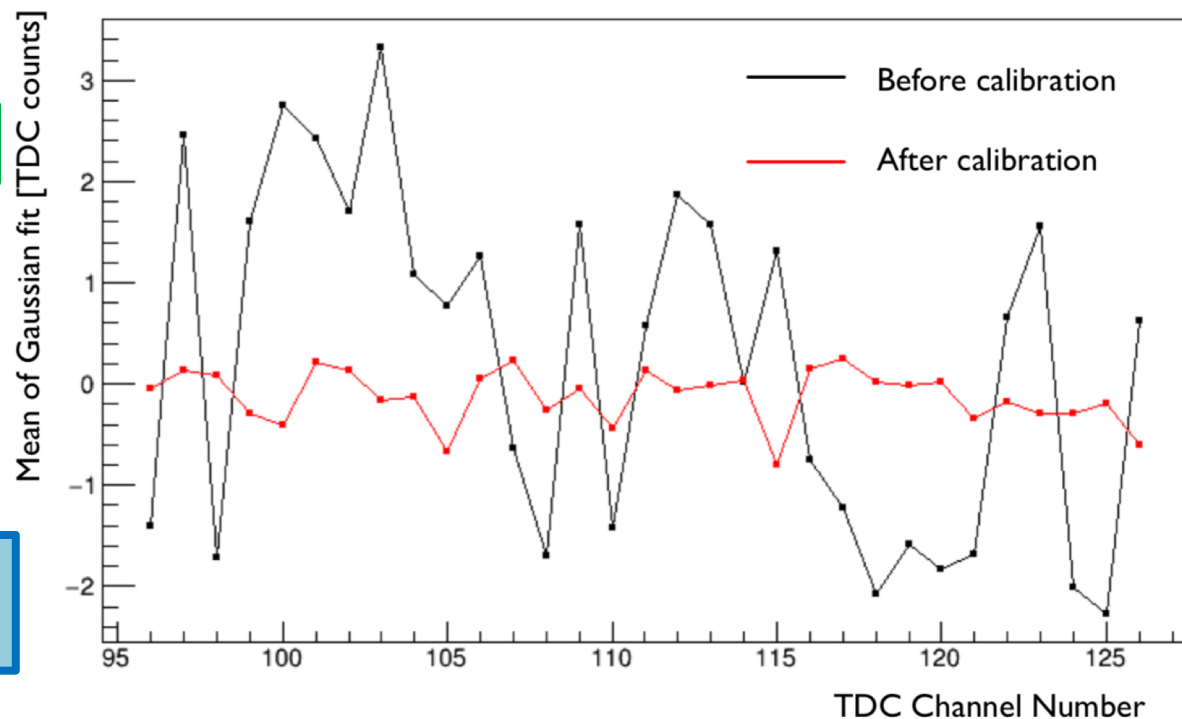


Scintillators Timing Corrections

- Signal propagation time from the scintillators to the TDC input channel is not zero
- Time is different from counter to counter and it depends on HV setting, counter size, etc...
- Delay is calculated for each scintillator (Gaussian fit of the distribution)
 - Time is corrected at hardware level w.r.t. a reference counter

Very good calibration!

...but still margin
for improvements

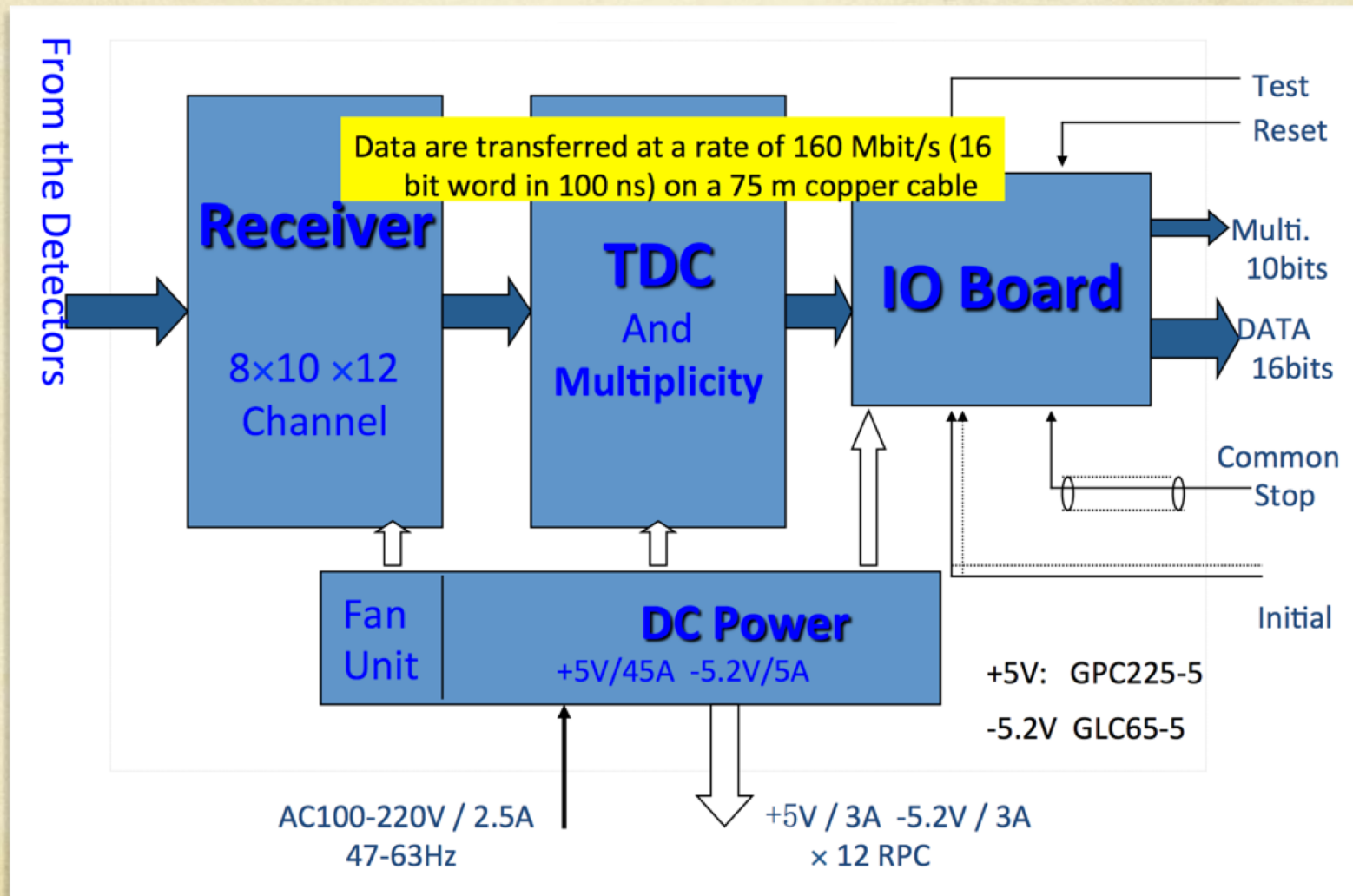


Conclusions

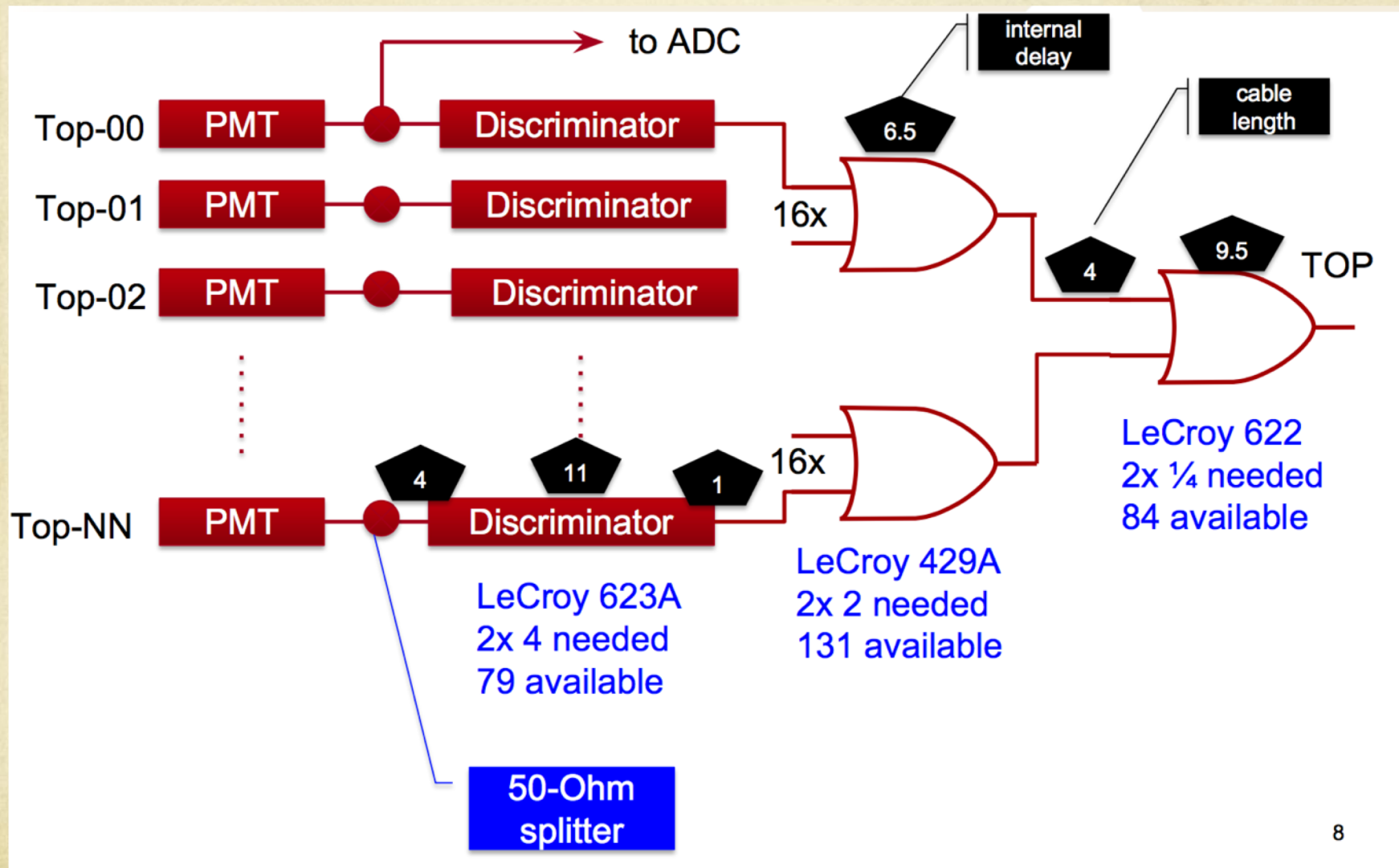
- A test stand with a detector layout similar to the one envisioned for the MATHUSLA detector was assembled in November 2017
 - ✓ Main purpose is to measure the background coming from LHC
 - ✓ Performance have been optimised over the past months
 - ✓ Data taking is currently running smoothly and it will continue until the end of p-p LHC Run 2 (November 2018)
- A lot of data have already been collected and data analyses are ongoing
- All these information will be extremely useful for the tuning of the background simulation and the optimization of the design of the main detector

BACKUP

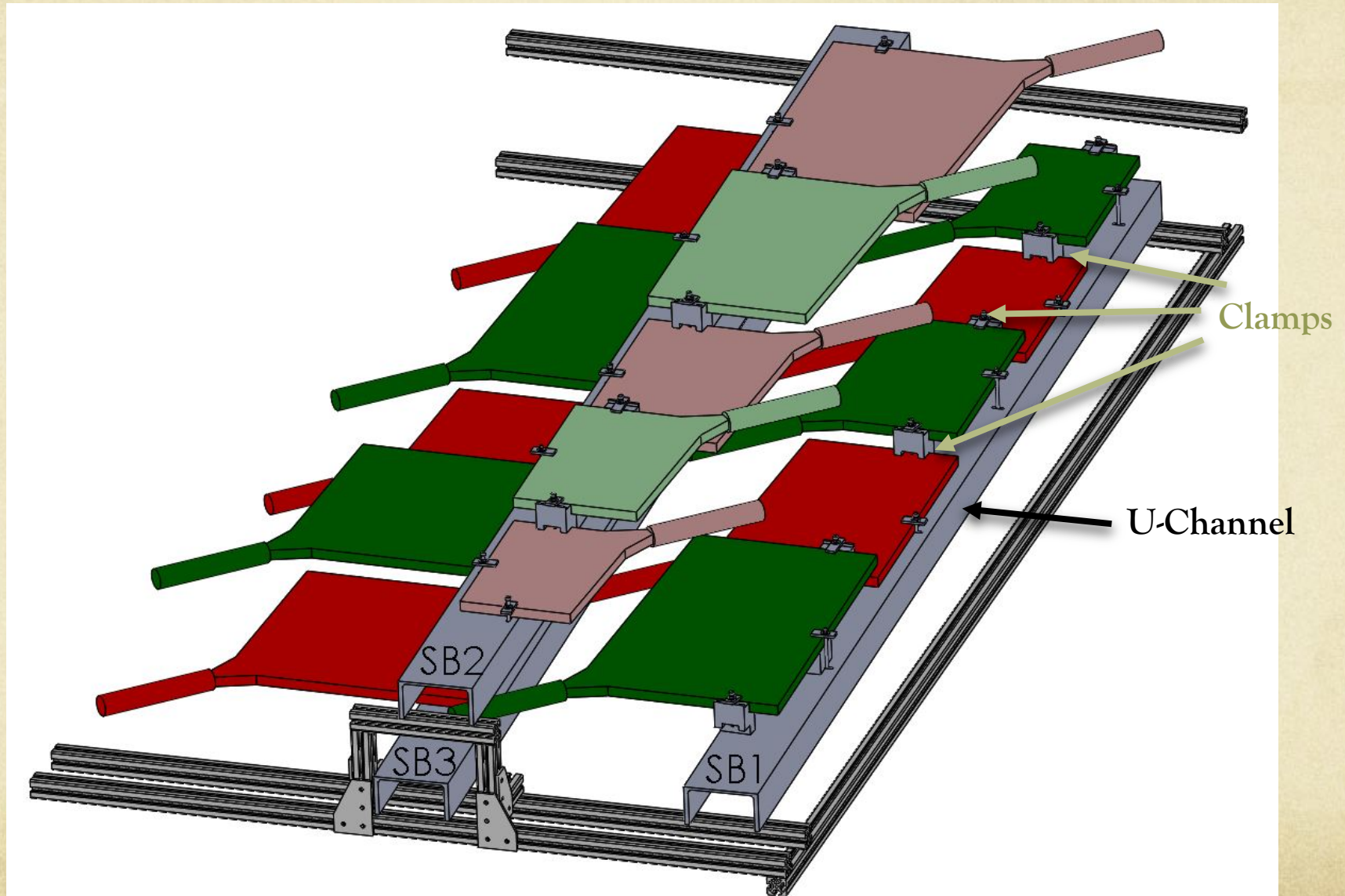
Local Station Details



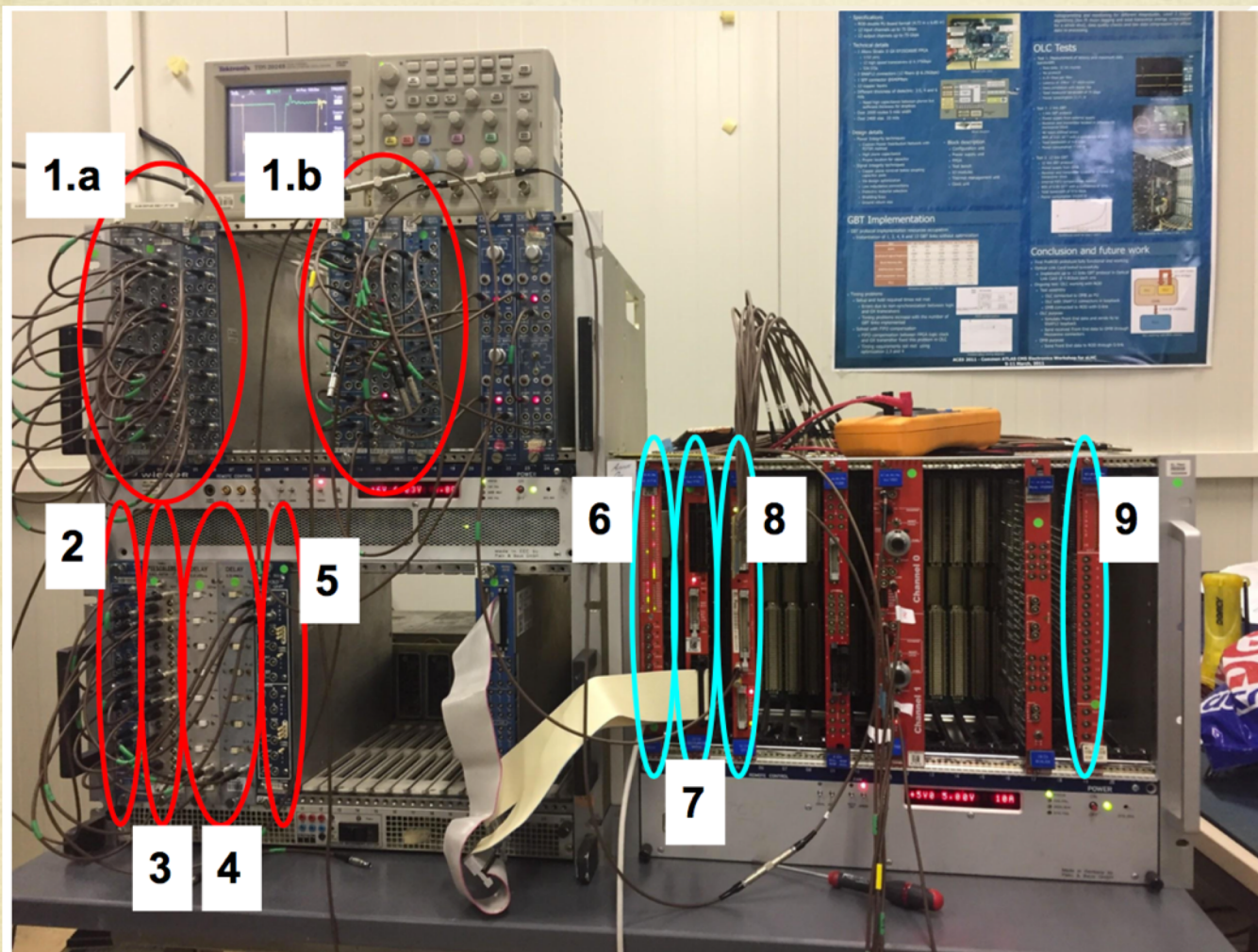
Trigger Implementation Details



MATHUSLA – Scintillators Support Details (1)

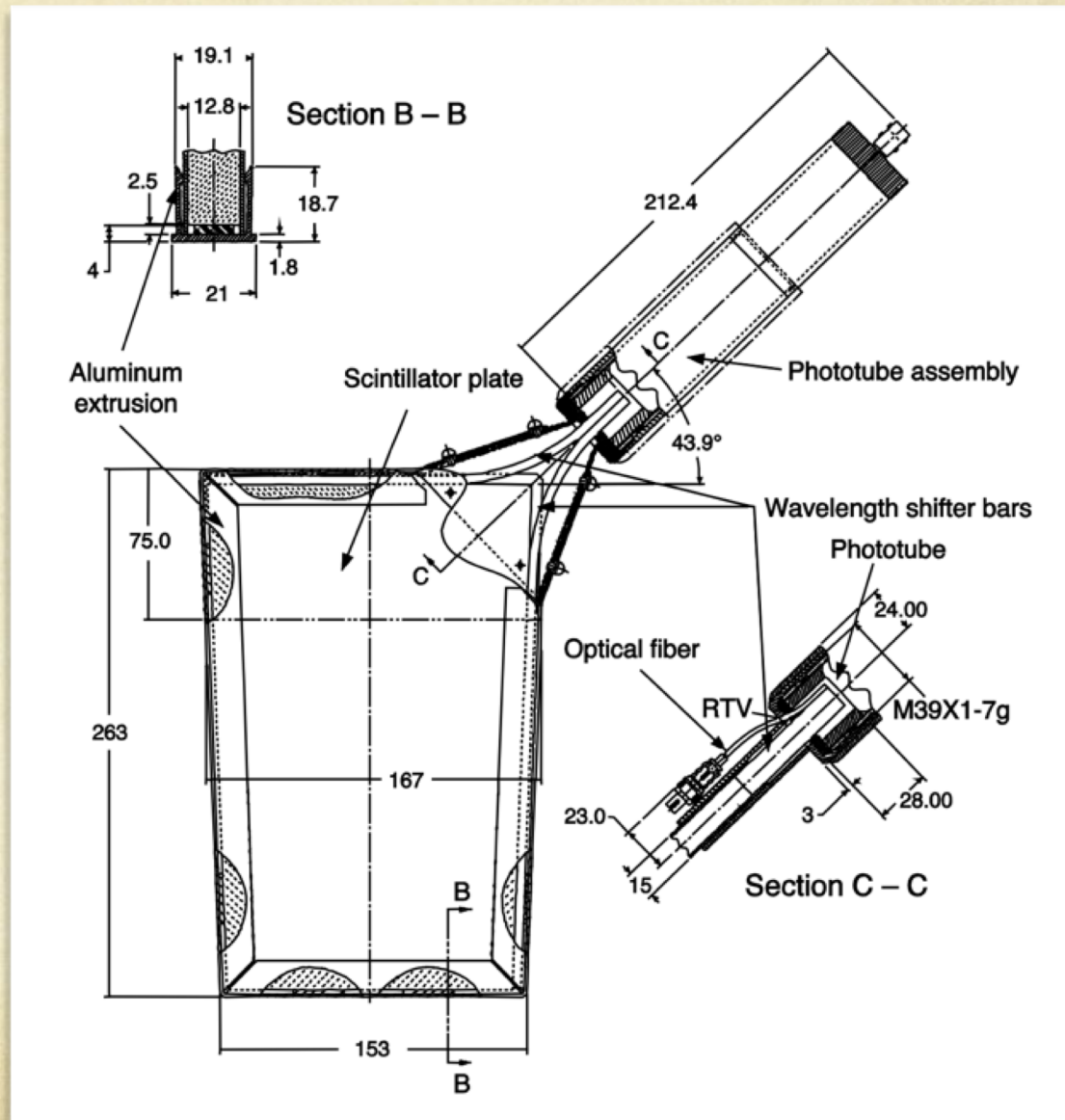


MATHUSLA - Trigger Development (1)



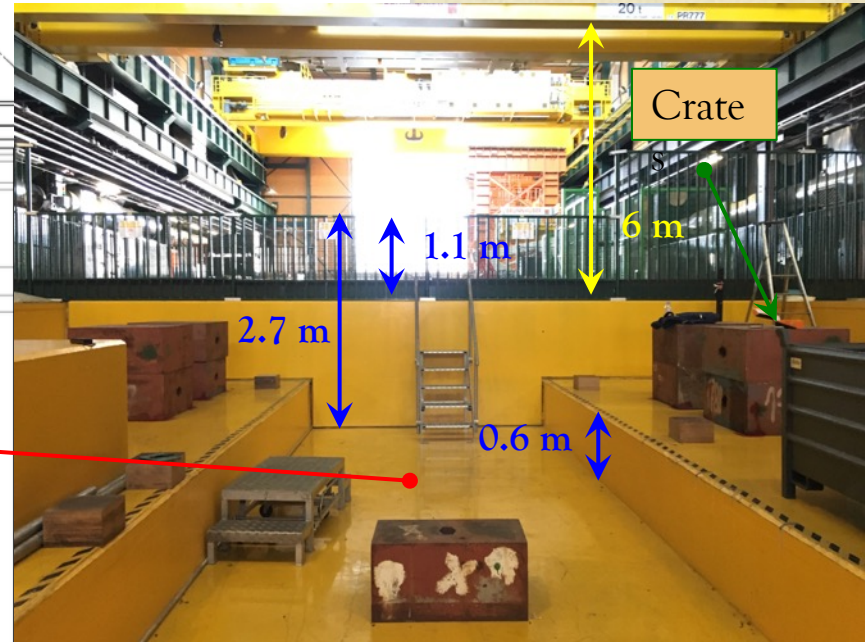
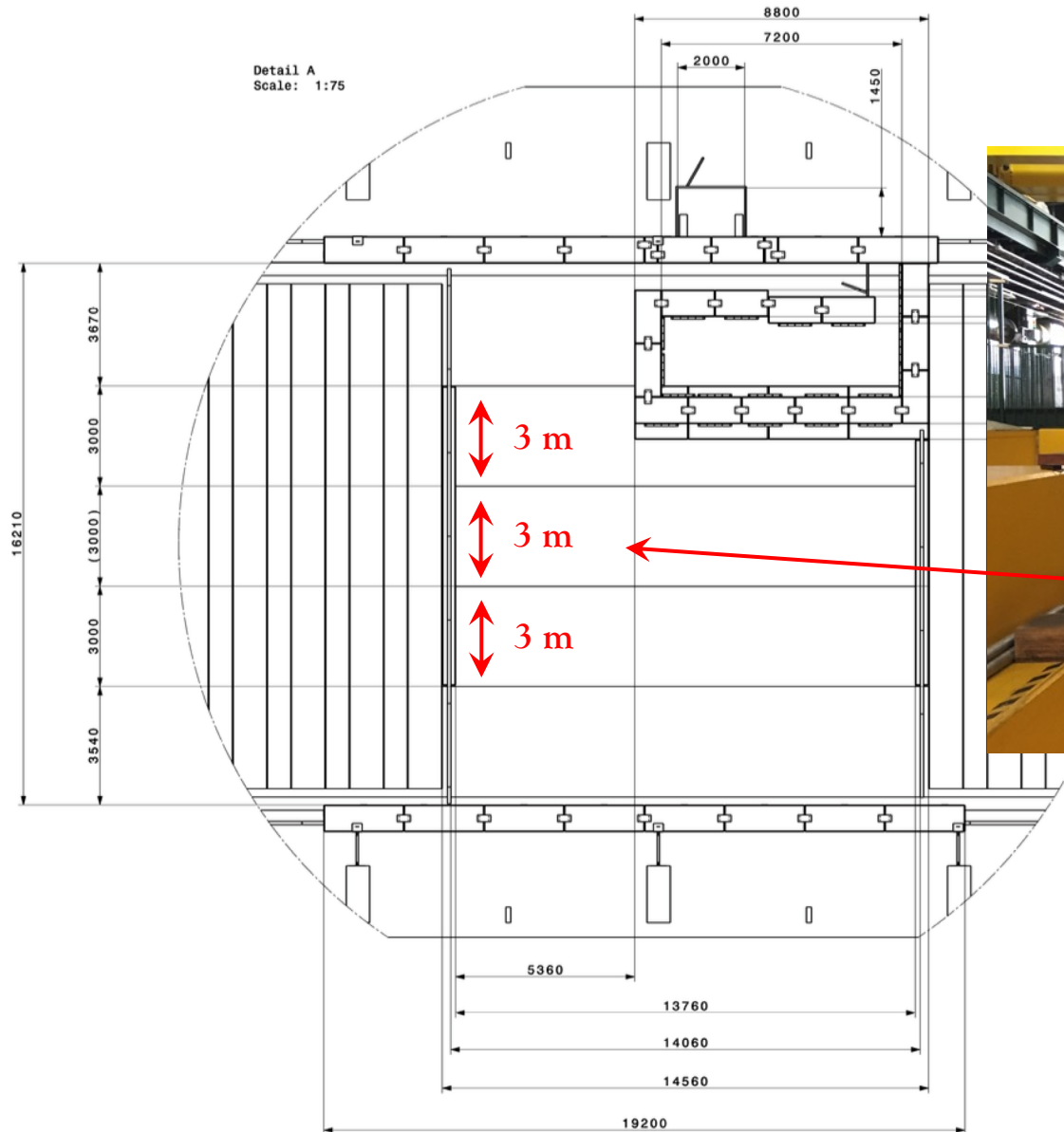
1. Disc + first level OR logic
 - a. TOP
 - b. BOTTOM
2. Second level OR + AND between TOP & BOTTOM
3. Prescaler
4. Delay boxes
5. OR for 4 triggers
6. Controller
7. TDC
8. ADC
9. Input Register

MATHUSLA - Scintillators Details



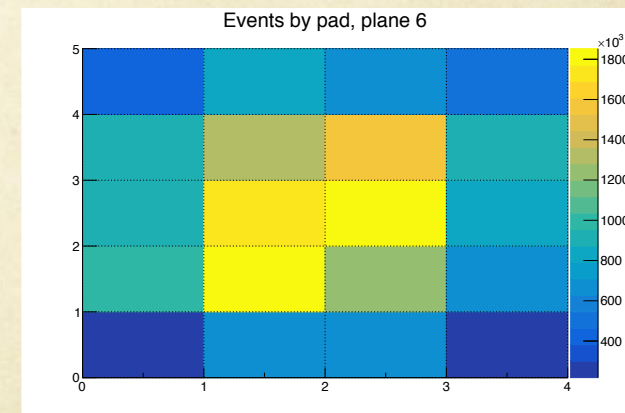
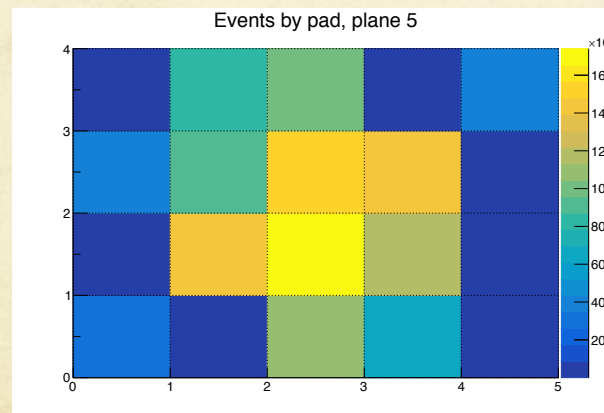
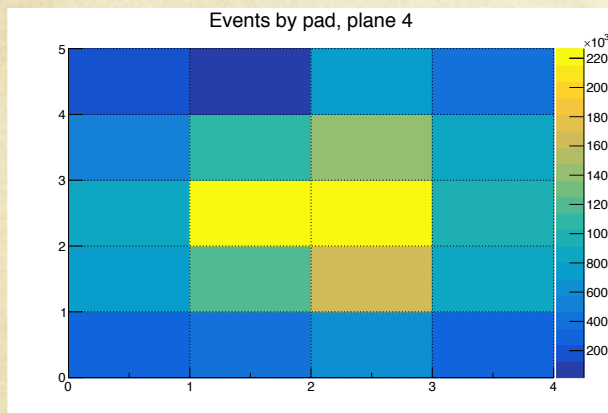
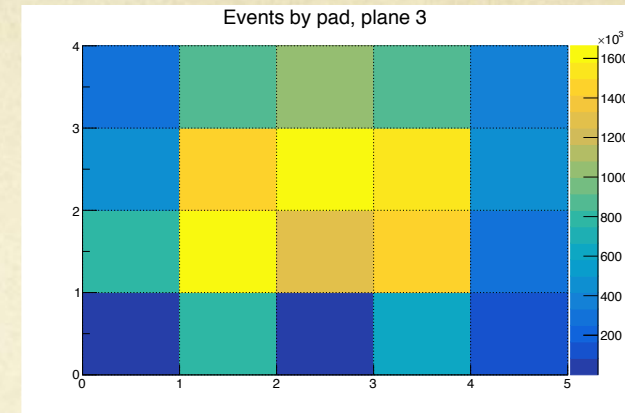
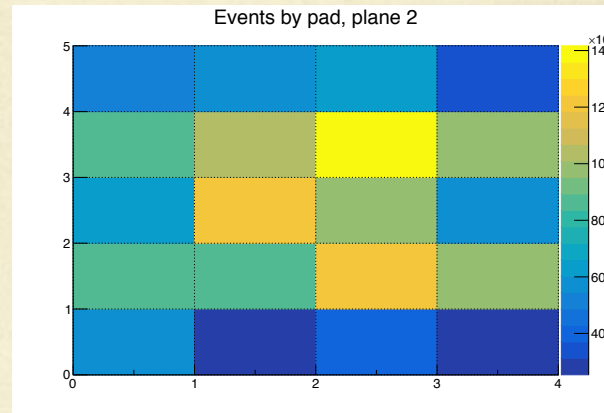
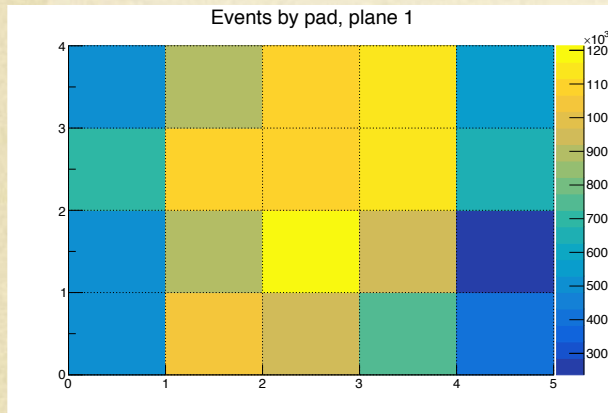
Installation in ATLAS P1

Detail A
Scale: 1:75



MATHUSLA Performance - RPC

➤ Number of event per pad



MATHUSLA Performance - RPC

➤ Number of event per strip

