Update on RPC activity for pathfinder

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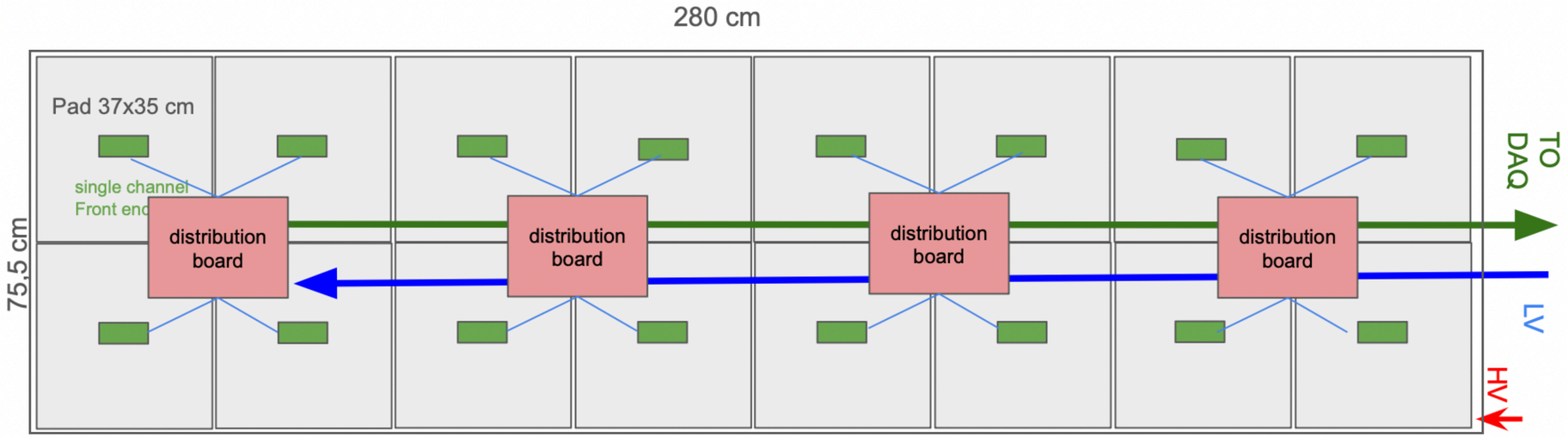
B) **INFN LNF**
C) **Università Tor Vergata**
D) **INAF**

Full size chamber layout

RPC layout - ver. 2.1



1 LV cable

4 ethernet cables (signal) + 1 (DCS)

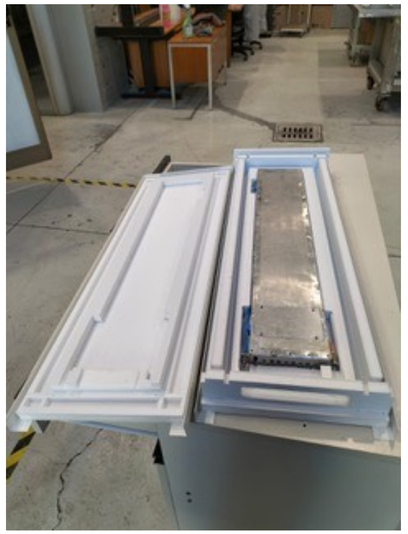
1 HV cable

Dimensions: 288 x 80 cm x cm
Weight = 30 kg

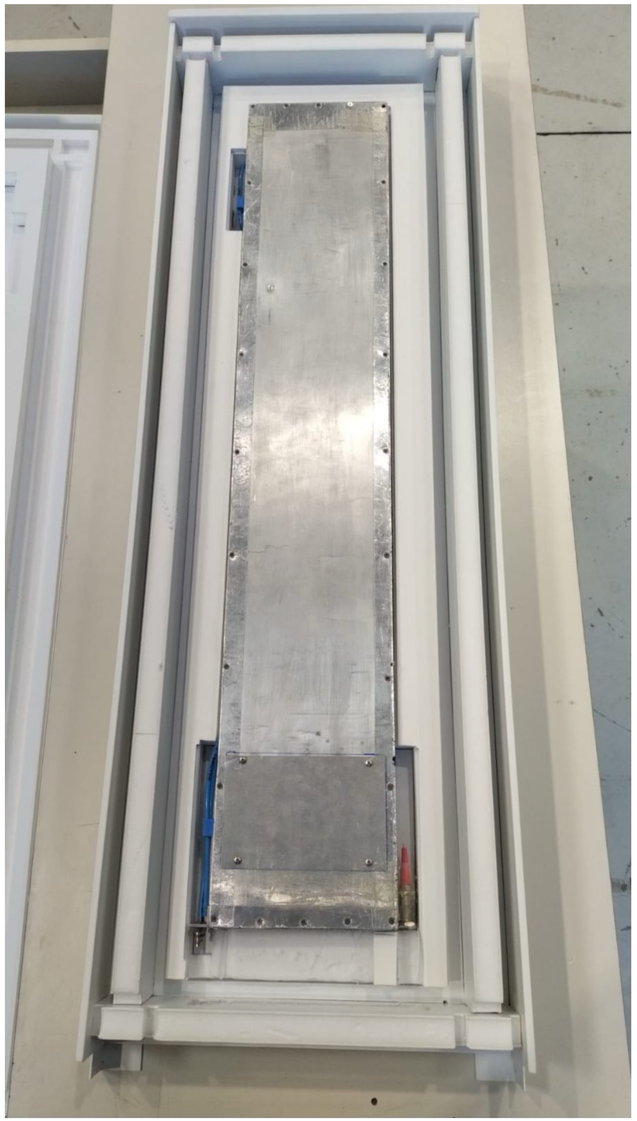
Thermal coverage

- Thermal coverage for outdoor operations



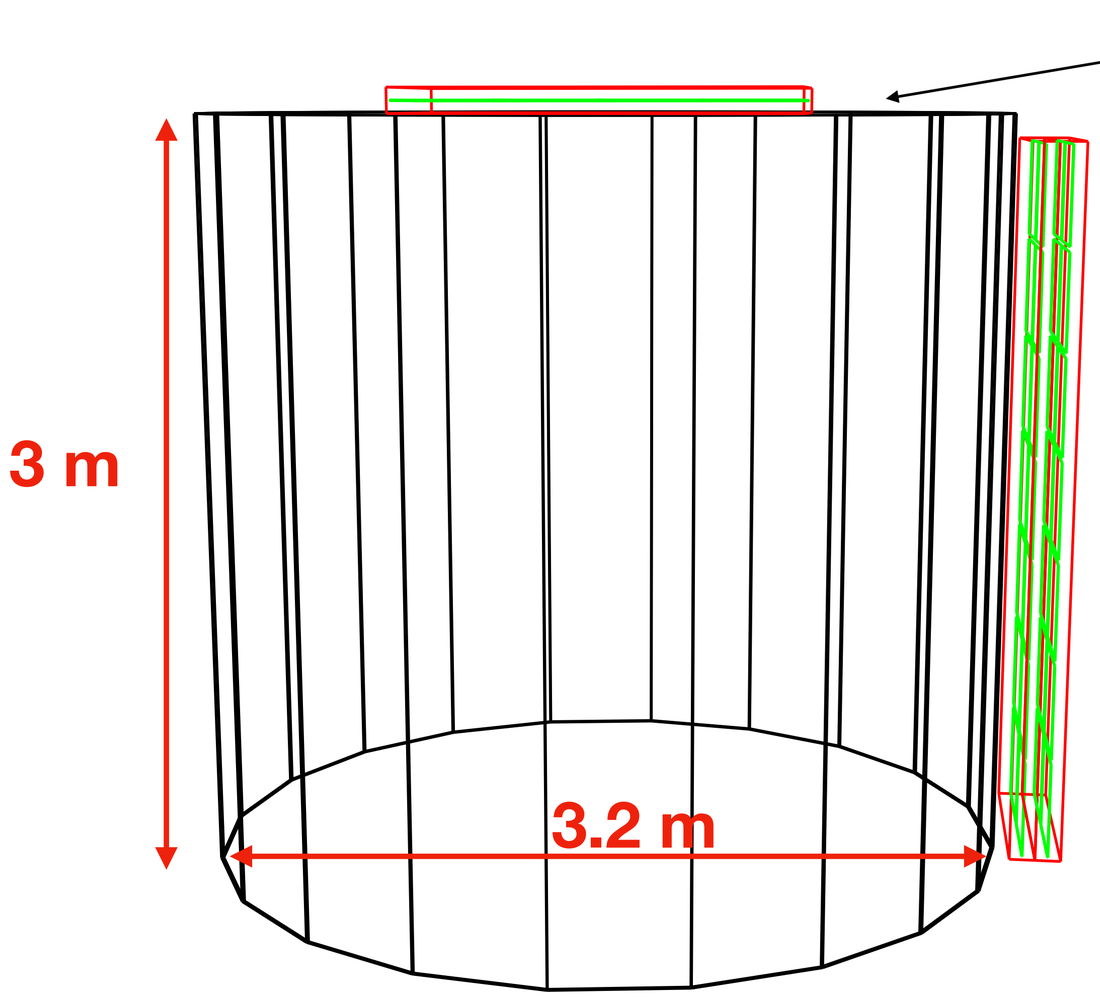
- Prototype for small chamber designed and produced
- Test of temperature cycles ready to start

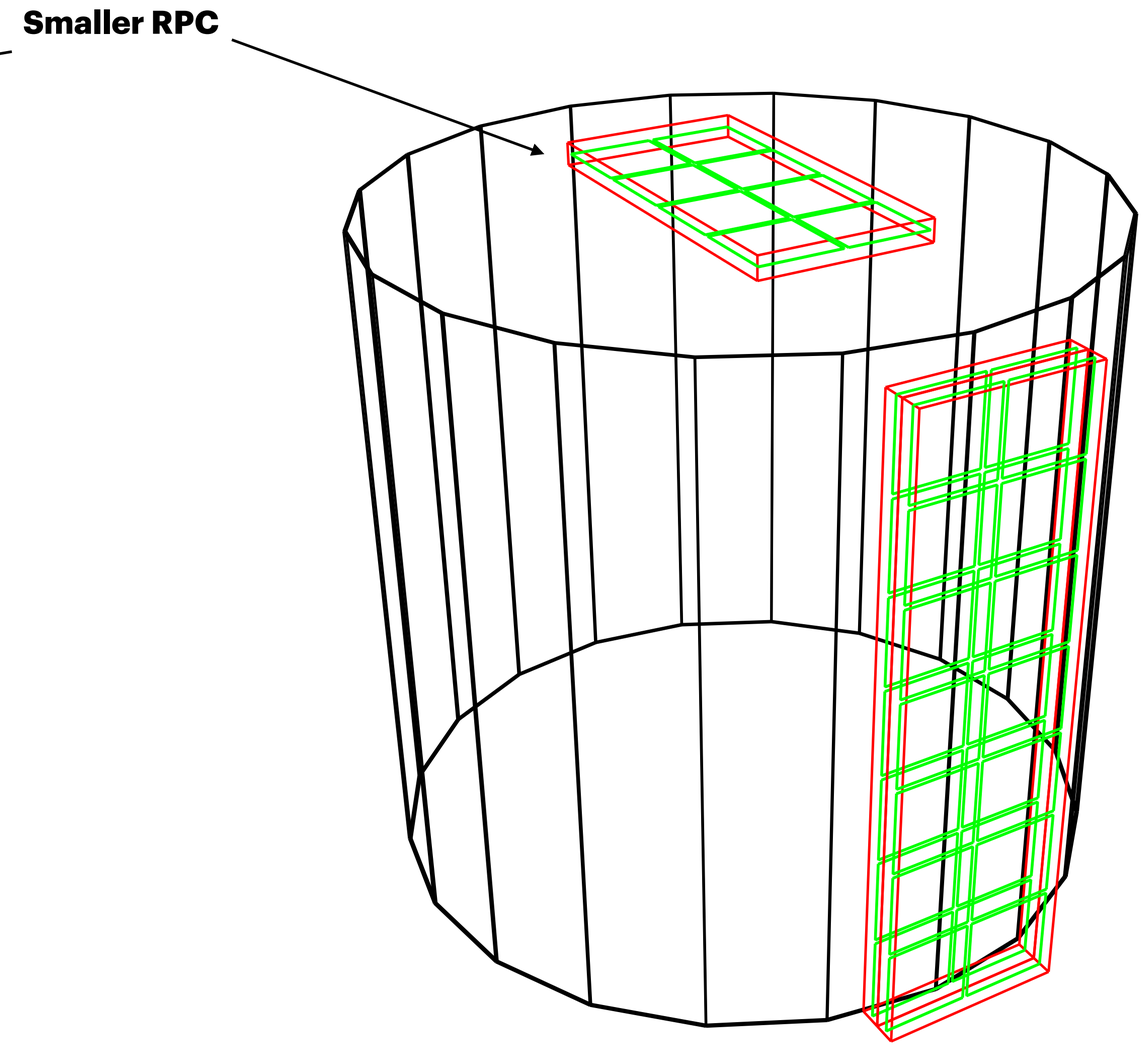


Layout for Milano test

Tank dimeter 3.2 m
Tank height = 3 m

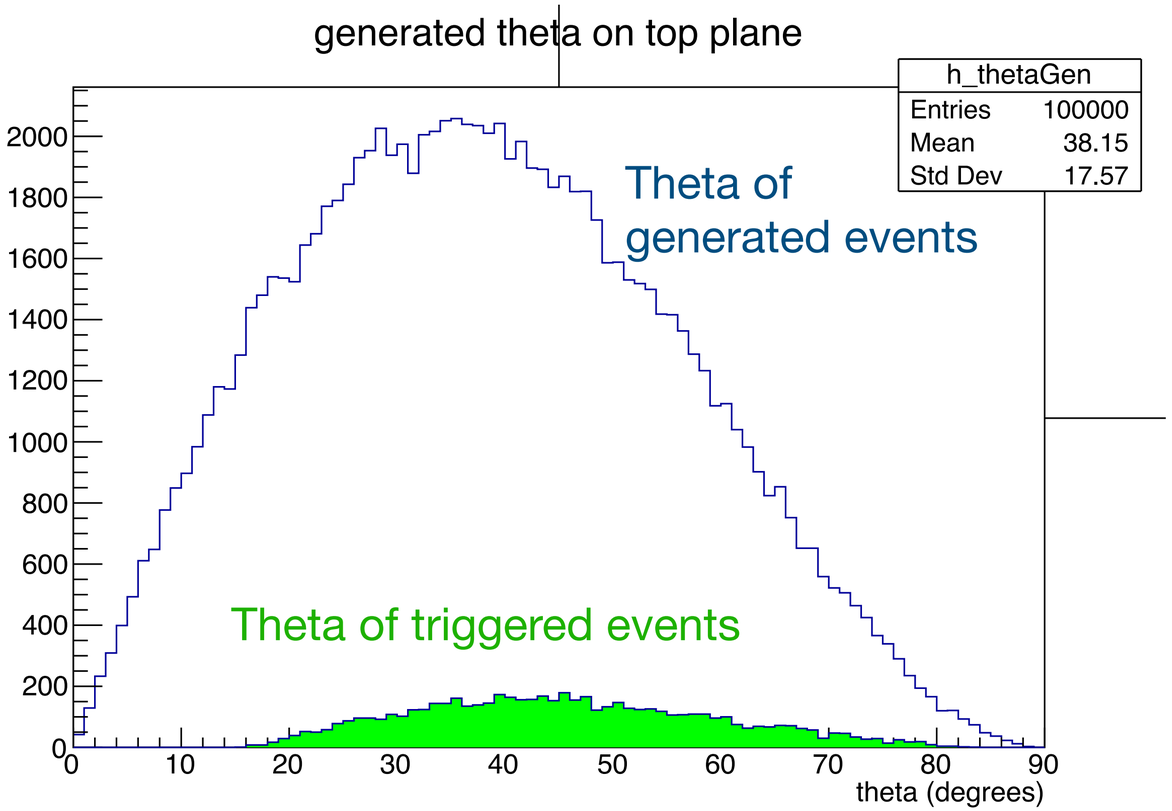
TOP: 1 RPC layer and 1 Chamber **1.6 m x 0.8 m**
LATERAL: 2 RPC layers with 1 Chamber each **2.8 m x 0.8 m**

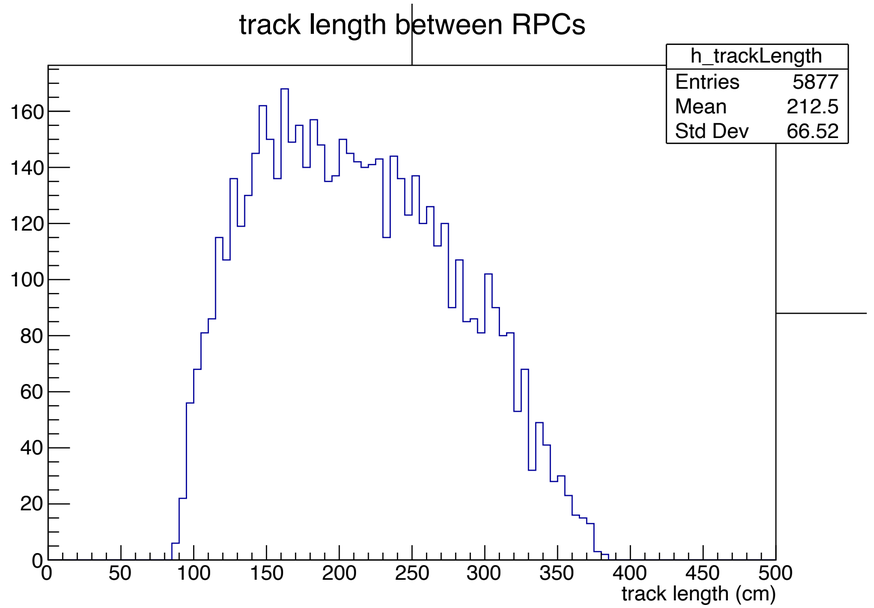


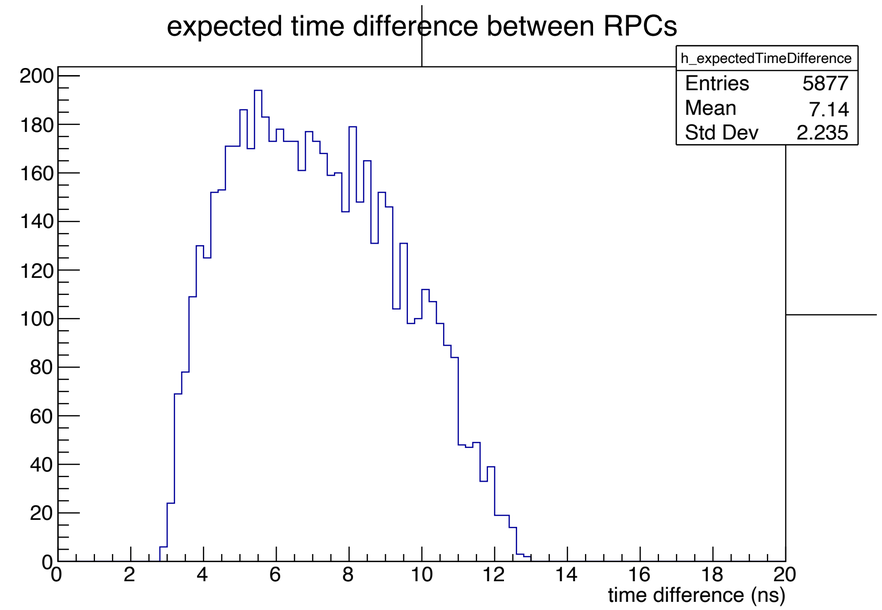


Simulated Cosmic Muons for Milano test

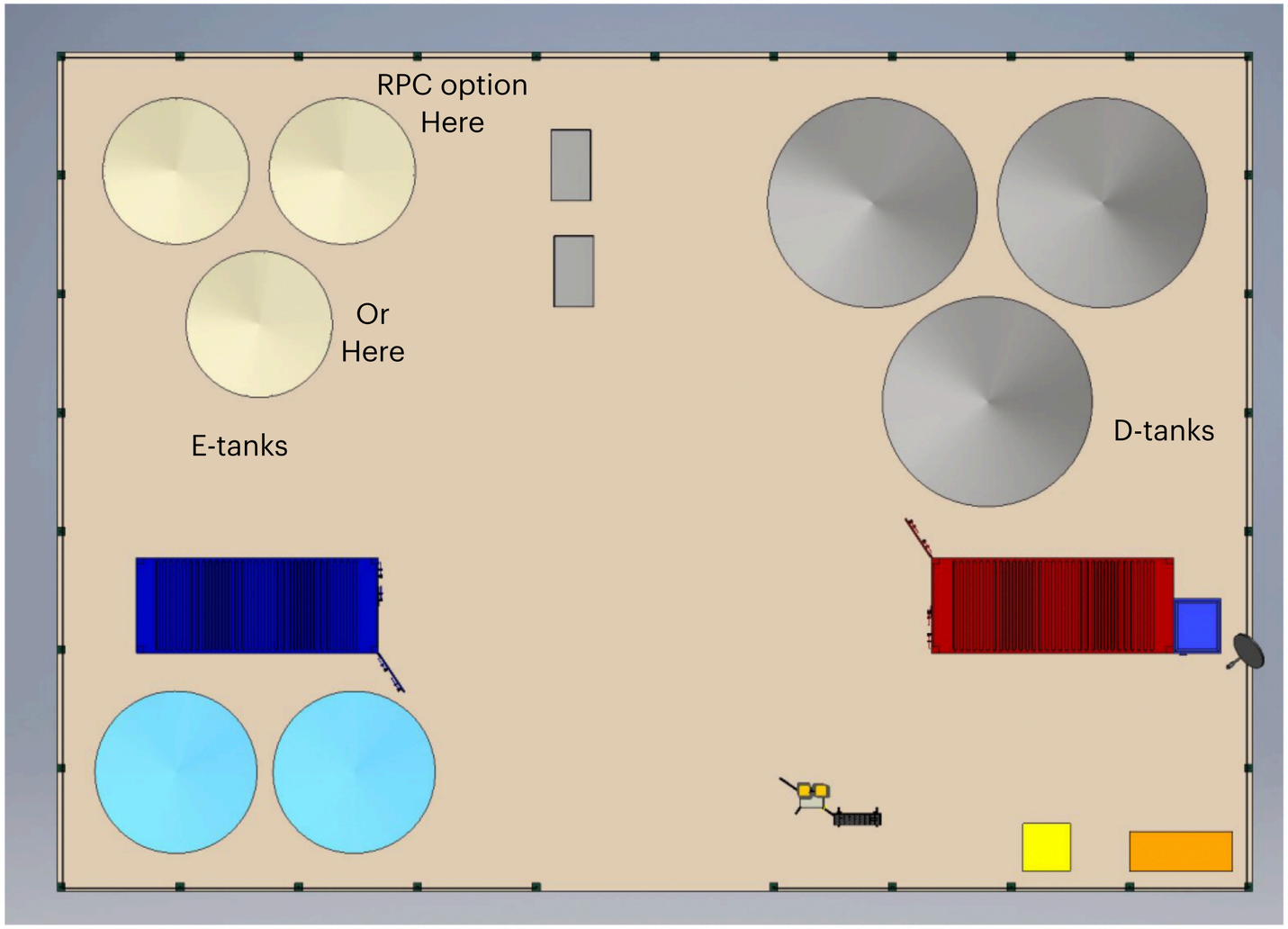
100000 Muons simulated on **TOP RPC** (**Area=1.28 m²**)
5877 Muons triggered
Geometrical Acceptance = **5.9%**
Expected Coincidence rate = 100 hz/m² * 1.28 m² * 0.059 = **7.5 hz**







Pathfinder

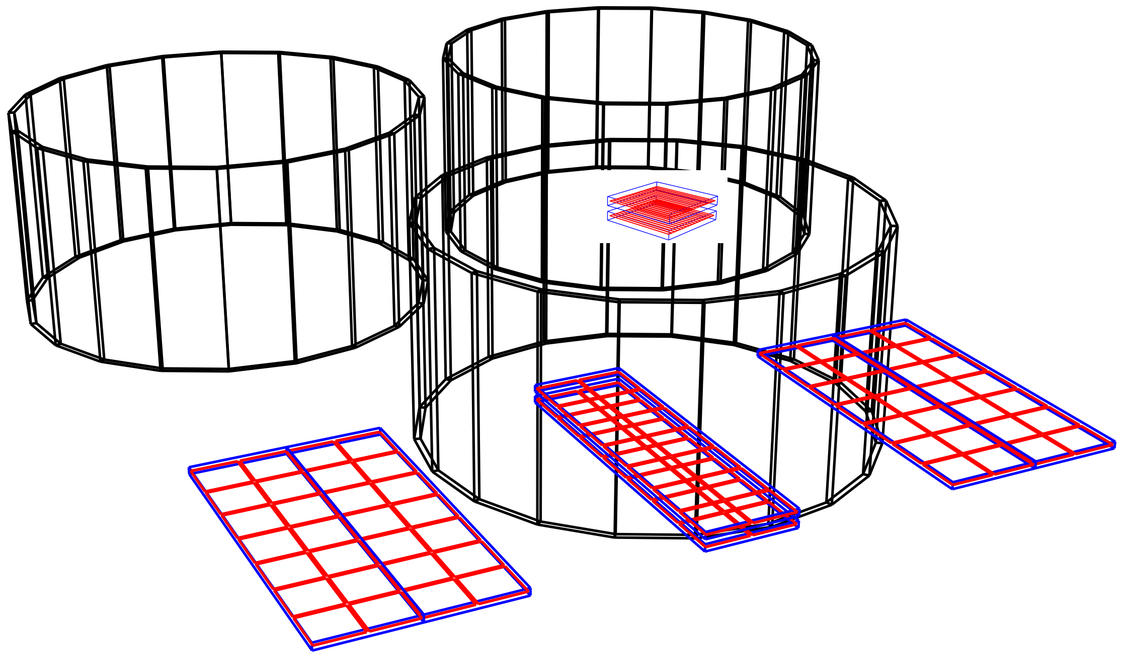


Pathfinder layout: possible options

Assumptions:

- tanks placed on a concrete basement and 6 RPCs placed in a slot of the basement (2 under the tank) 2-4 on the sides
- Something on the top (to be studied the possibility to place RPCs on top): simple baseline solution assume 2 small RPCs (50x50 cm^2)

Baseline proposal



Possibility to trigger on several typologies of cosmic muons:

- **from top to bottom**
- **From top to lateral**

Possibility to trigger on showers according to pad multiplicity

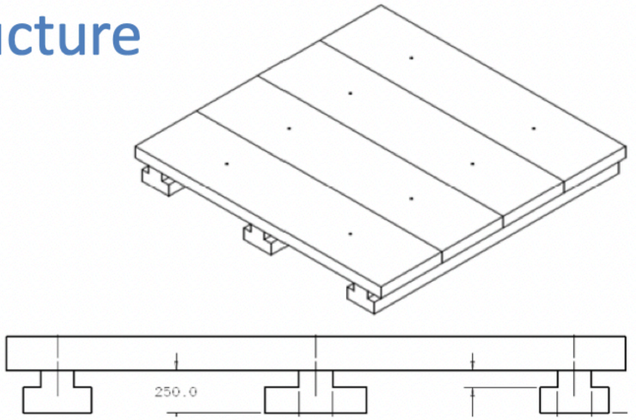
Open issues

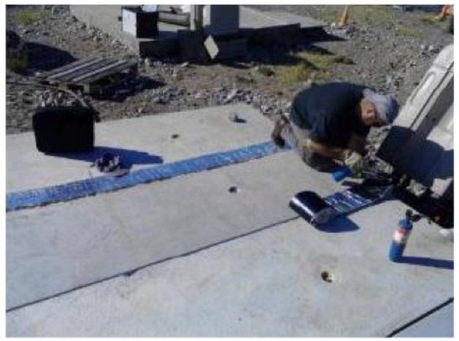
- **To be defined which tank to be instrumented**
  - **According to logistic of installation**
  - **Which kind ? White - black - coated**
- **To be defined how to fix small RPCs on the tank:**
  - **Discussion with Ulisses**

RPC on the bottom: concrete basement from Auger test

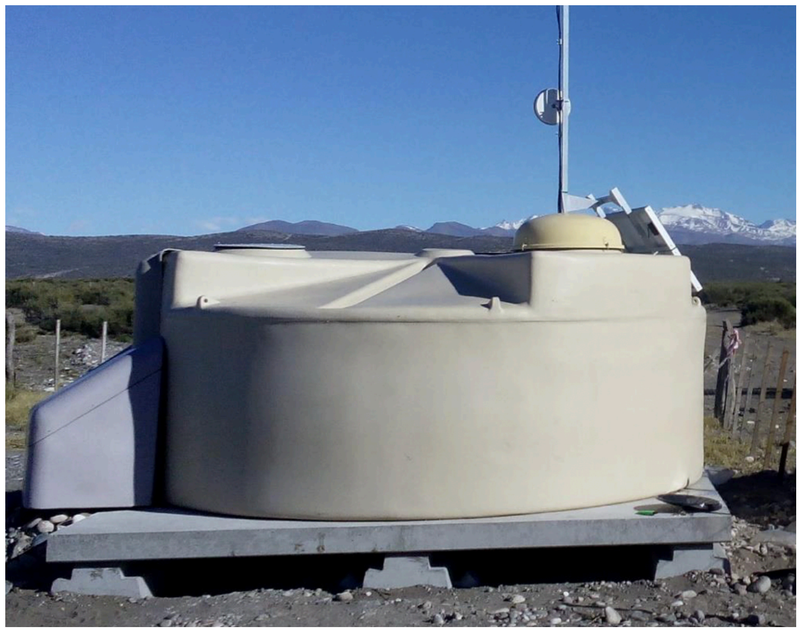
The support structure

Precast structure built at the observatory
Transported to the field
Installed in a couple of hours
(Emptying/Filling the tank
is more time consuming)





From a presentation of Lisboa Group



Gas system

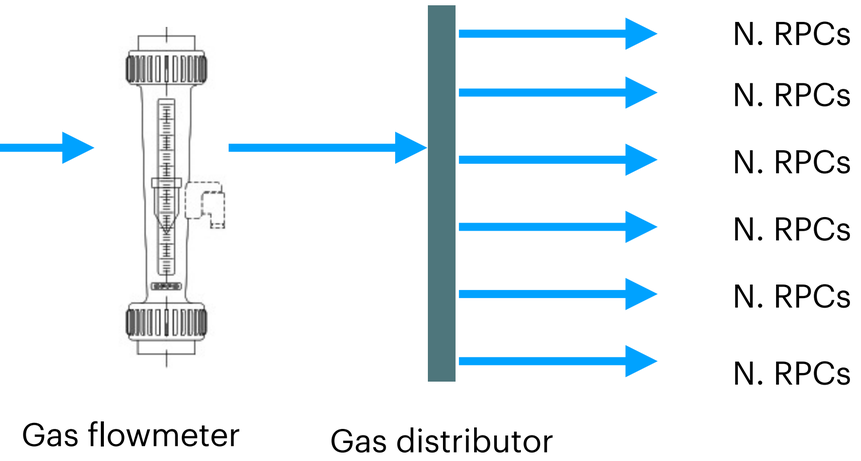
- Simplified gas system assuming operations in **pure HFO1234ze ($H_3C_2F_4$) or TFE ($H_2C_2F_4$).**
  - **Non flammable, works at vapor pressure of few bars**
  - No need for a gas mixer
  - **Pure TFE tested by Lisbon colleagues for MARTA RPCs in Auger**
  - **Pure HFO to be tested in laboratory in Tor Vergata and LNF**

- From the gas bottle to a a simple flowmeter to control the flow, and via pipes to RPCs
  - Specific layout of gas distribution will depend on final design (mix flow in parallel/series)

- Low flow rate: **3 Volumes/day**

- Typical HFO bottle (40 kg - price order of 1500 Euro)
- Typical TFE bottle (40 kg - price order of 800 Euro)
- enough for 4 months (assuming 6-8 operating RPCs)

- **Gas bottle to be placed in a hole done on ground and a small cabinet** on top (Liquefaction temperature around -20 °c)



PRELIMINARY LAYOUT

HV-LV power systems

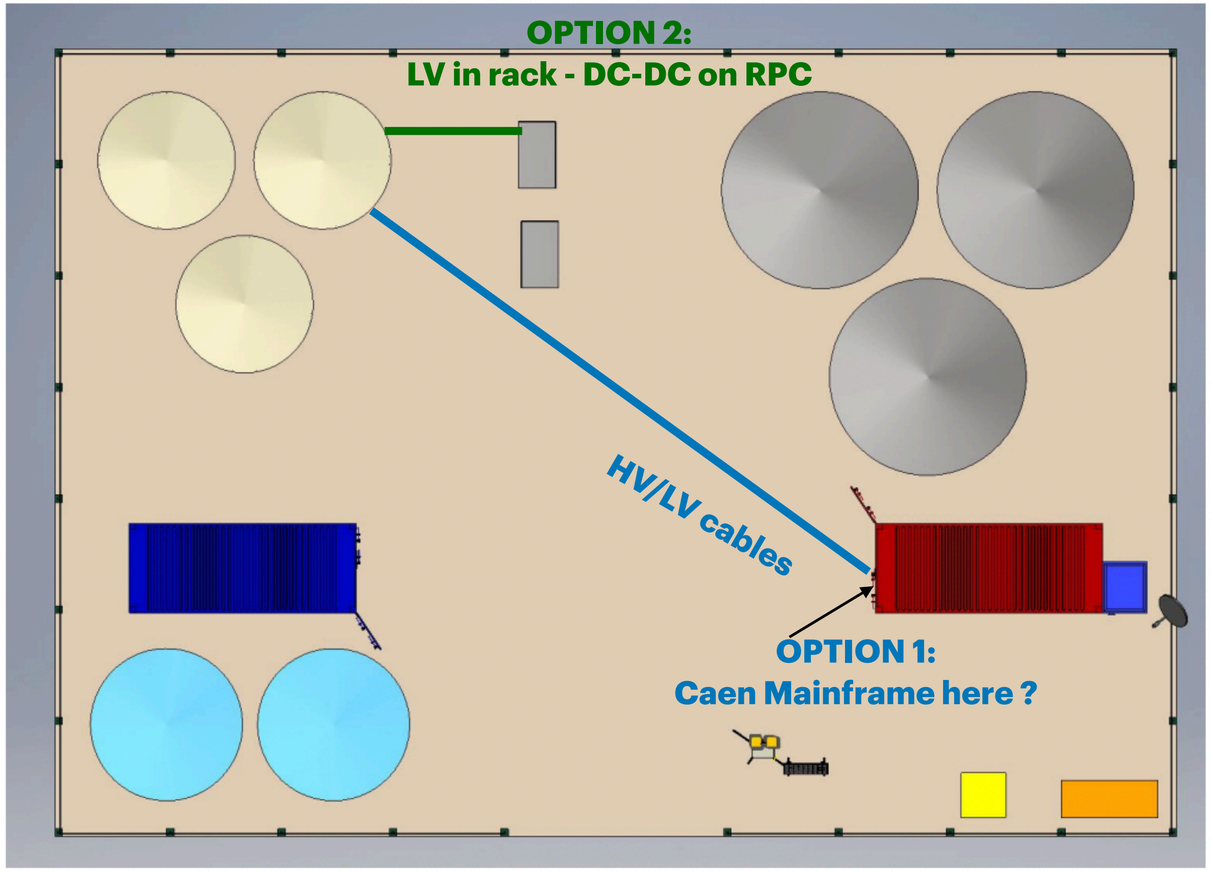
OPTION 1: will be tested on Milano tank

- CAEN mainframe (6U unit - **depth 80 cm**):
  - **One HV board (mod.):** 6 channels,15 kV, 1 mA per channel
    - Max current per chamber 100 uA -> 1.1 Watt/chamber
    - Total power for 8 chambers about 9 Watt (15 Watt considering 60% efficiency)
  - **One LV board (mod. A1517A): 6** channels (7 V, 4 A)
    - Front end board power 0.07 Watt/card -> 1.12 Watt/chamber
    - Total power for LV (8 chambers): <9 W (15 Watt considering 60% efficiency)

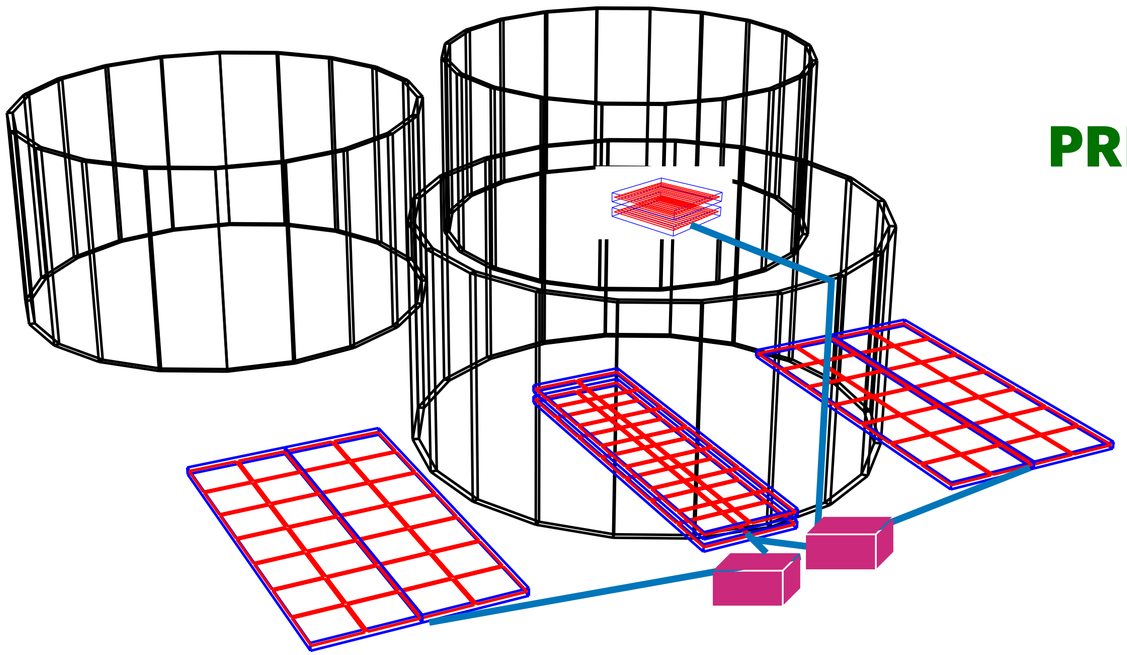
CAEN power supply mainframe

OPTION 2: under development and test in Tor Vergata

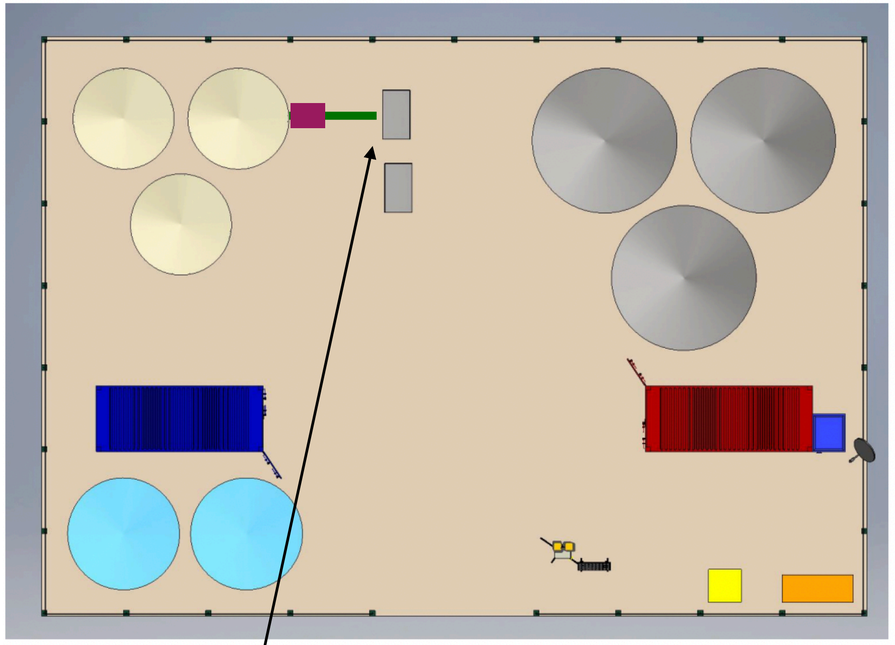
- LV power supply
  - Can we take the LV from the field node rack ?
  - How can we control it ? Power on/off -rump up/down
- DC-DC converter for HV mounted on RPC:
  - Under test



DAQ (baseline option)

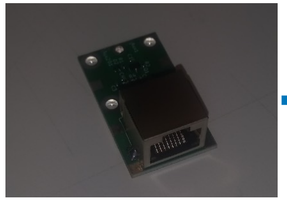


PRELIMINARY



VME crate in rack

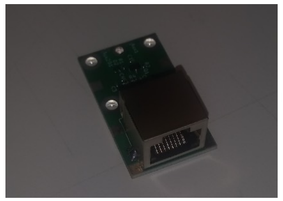
Front End board on RPC



5 Ethernet cables/chamber

Splitter box

20 Ethernet cables/splitter box (4 chambers)



5 Ethernet cables/chamber

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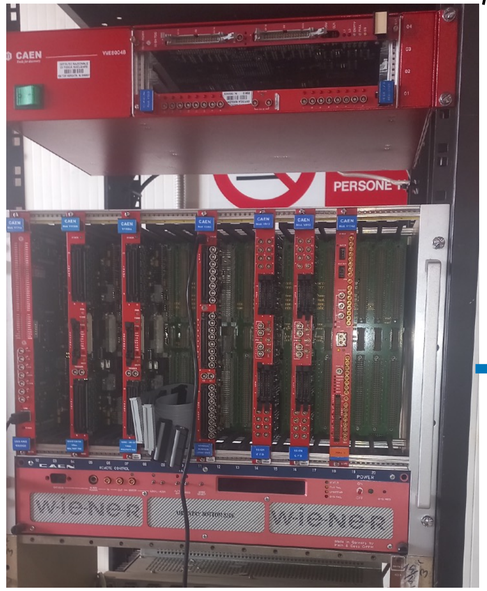


How to synchronize with PMT DAQ ?

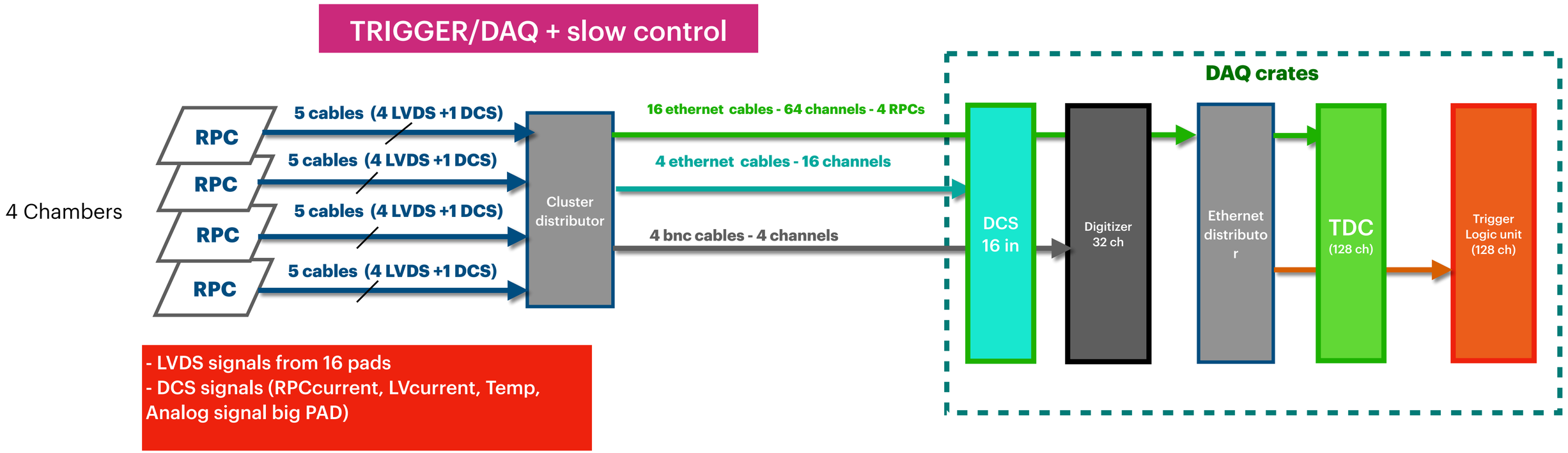
Cluster distributor (for 4 chambers)

As the distance between RPCs and final electronics Rack could be more than 15 mt and in order to reduce the number of long cables, a cluster distributor will be used close to RPCs:

- no problems for cable length
- Reduce numbver of long cables
- Easier cabling

Cluster DAQ system

POSSIBLE LAYOUT FOR MILANO (up to 4 chambers easily extendible to 8 chambers)



Power budget table

To be done

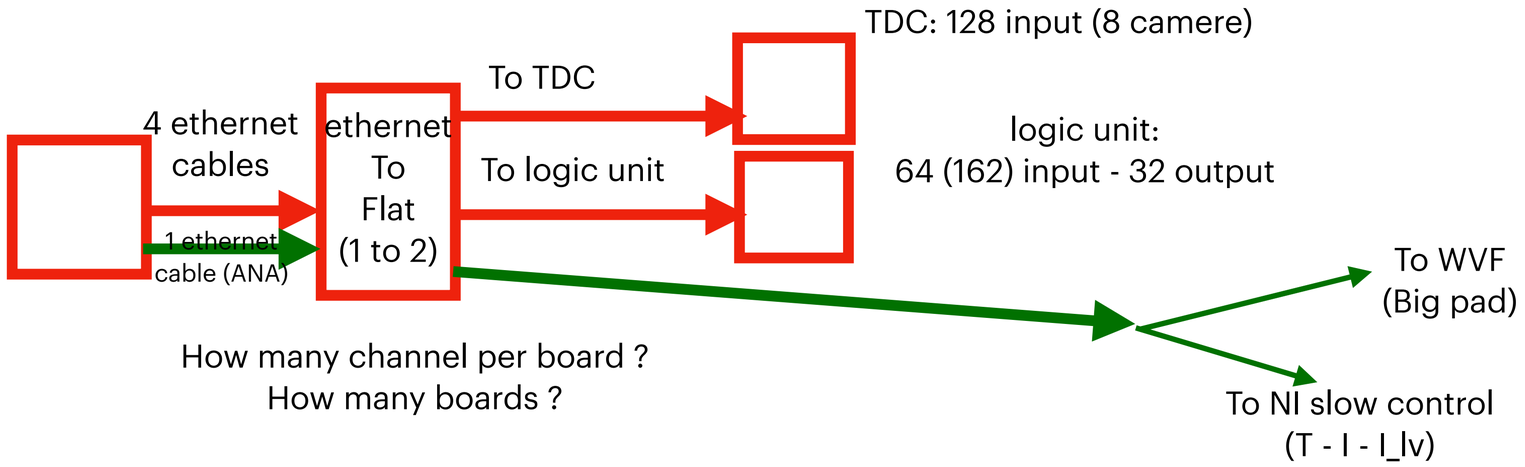
Work in progress and action items

- One full size chamber almost ready to be tested in Tor Vergata
  - Plan to certify the design and prepare 2 more chambers for Milano test
- Pathfinder layout proposal ready for 1 E-tank
  - Plan to contact Brazilian group to verify the possibility to fix 2 small RPCs on top of the tank
  - Contact with Lisbon colleagues to evaluate how to procure the concrete basement
  - Two proposals for Power supply
    - HV mainframe in server container
    - DC/DC converter option under evaluation
  - DAQ via VME crate
    - To verify space in the field nodes
    - Fix power budget
  - Help needed for DAQ
    - From VME to final server
    - To evaluate digitizer on chamber (can we discuss the possibility to adapt Napoli board for our needs?)
  - Costs
    - 90 % of the project covered
    - Missing DAQ boards will be recovered in Tor Vergata/LNF
    - Gas to operate pathfinder - thermal jacket - consumption still missing: O(10 KEuro) Commissione 2
    - Concrete prefab + footboard on side RPCs missing: Can we have it as infrastructure from SWGO ?

Backup

DAQ system
(Present layout based on what we are planning for Milano test)

- VME crate (8U)
- Ethernet converter crate (8U)



- 1 TDC (128 ch -> 8 camere) -> 5 TDC x 40 RPC (1 disponibile + 1 spare)
- 1 Logic unit (64 , exp to 162?) -> 4 (12 RPCs?) -> 10 (4) Logic init x 40 RPC (1 disponibile senza exp)
- 1 WVF. (32 canali) -> leggo 32 RPC
- 1 scheda NI per DCS (16 ch) -> leggo 5 camere -> 8 schede x 40 RPC

Se assumiamo che la ethernet converter board fa anche

R&D for a joint RPC-WCD project

RPC have been already presented in the past as a possible option for gamma ray physics in south hemisphere

More recently .... In the framework of PNRR CTAplus, Working Package 1520, INAF

INFN will support the construction and test of an hybrid RPC + Water-Cerenkov of about 100 m²

Rome TorVergata group lead the RPC construction project starting from the Argo experience

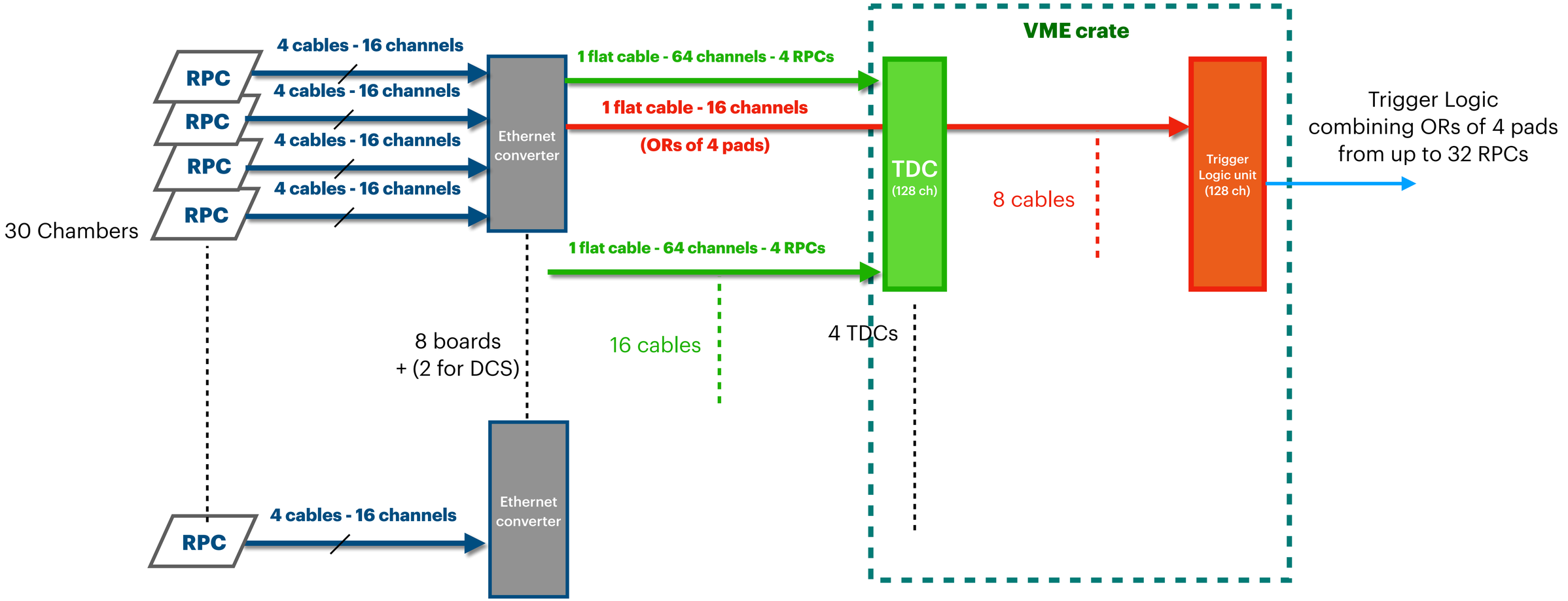
Timeline for the project:

- Tenders closed by the end of 2023:
  1) Front-End Read-Out per RPC production
  2) HPL electrodes production for RPC
  3) HV, LV e Read Out systems
  4) **Full assembled RPCs production-> Nº 32 RPC total area 73 m² + extra 25 m²**

     Note: 1 Cluster of Argo 50 m² produced physics results (Astroparticle Physics 17 (2002) 151–165)
- Test station preparation before April 2024
- RPC Production and test: main fraction before end of 2024
- Site definition for final test end of 2024
- Installation and operations in 2025
- **Could it be of inserest as R&D for SWGO ?**

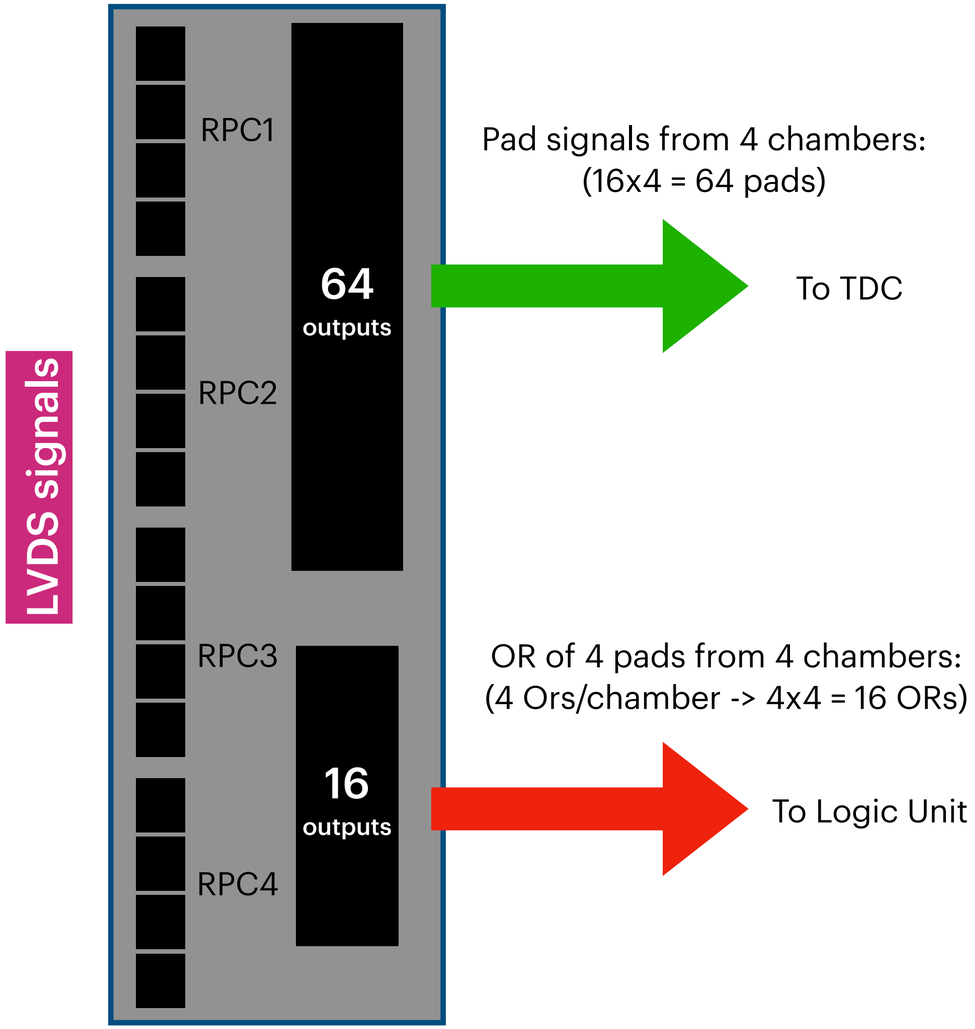
DAQ system

POSSIBLE EXTENSION FOR PATHFINDER (30 chambers) or alternative improved DAQ

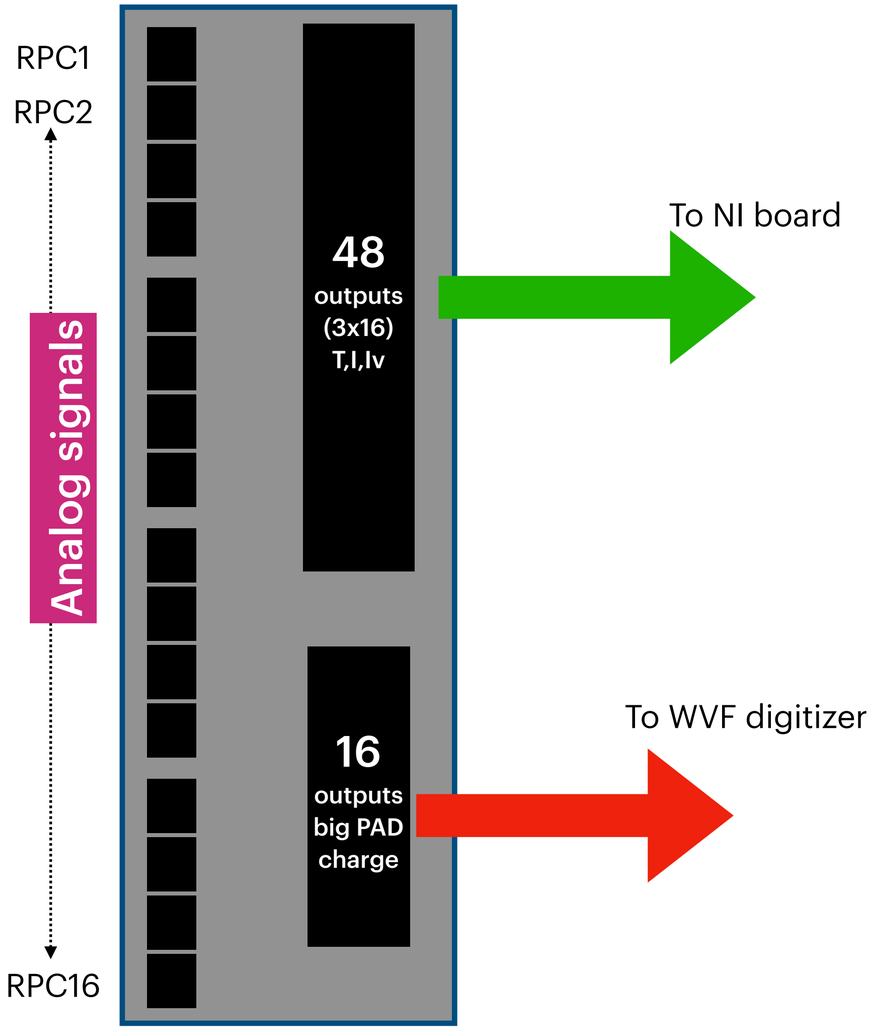


Ethernet converter

Ethernet DAQ converter (require power for OR)



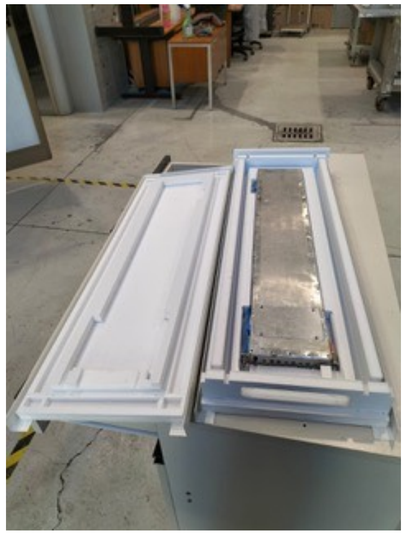
Ethernet DCS converter (Passive)



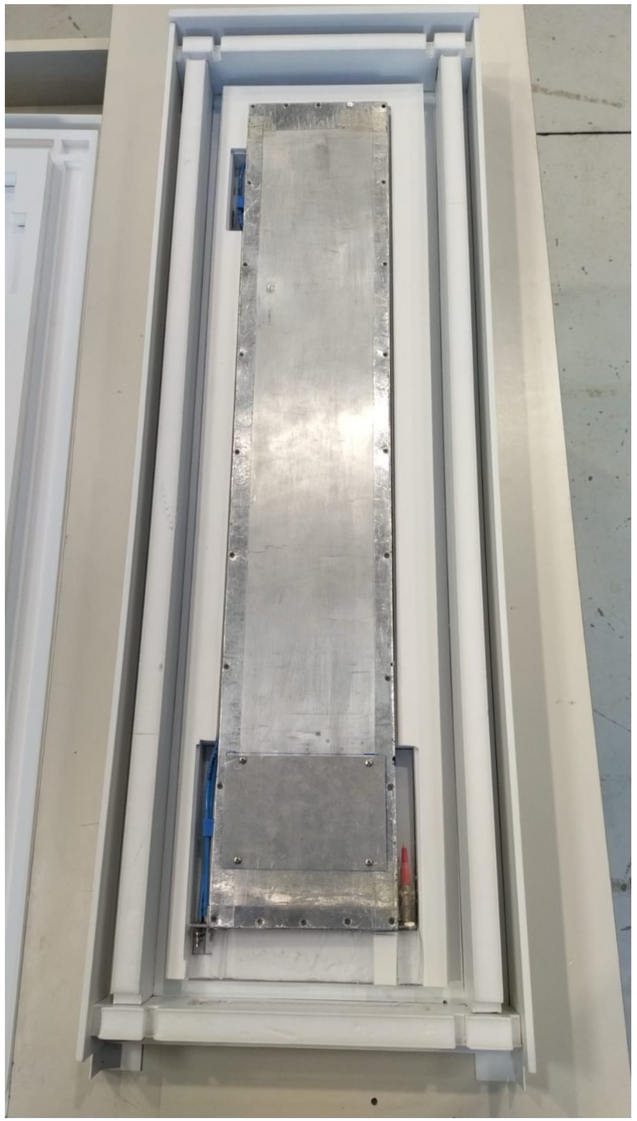
Thermal coverage

- Thermal coverage for outdoor operations



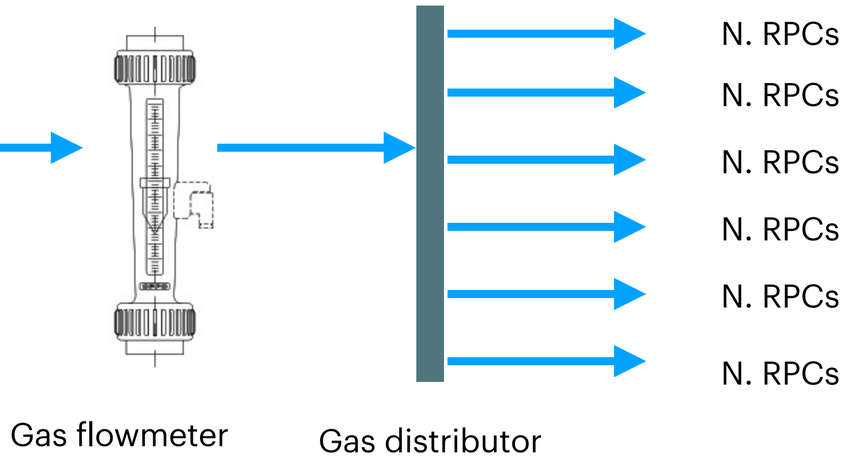



- Prototype for small chamber designed and produced
- Test of temperature cycles ready to start



Gas system

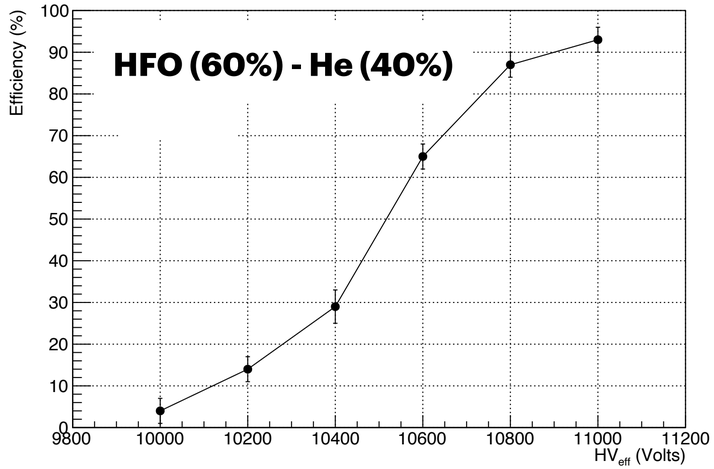
- Simplified gas system assuming operations in **pure HFO1234ze.**
  - **Non flammable, works at vapor pressure of few bars**
  - No need for a gas mixer
  - Long term test started in laboratory
- From the HFO bottle to a a simple flowmeter to control the flow, and via pipes to RPCs
  - Specific layout of gas distribution will depend on final design (mix flow in parallel/series)
- Low flow rate: **3 Volumes/day**
- Typical HFO bottle (40 kg - price order of 1500 Euro) enough for 1,5 months
- **HFO bottle to be placed in a small cabinet** (Liquefaction temperature around -20 °c)

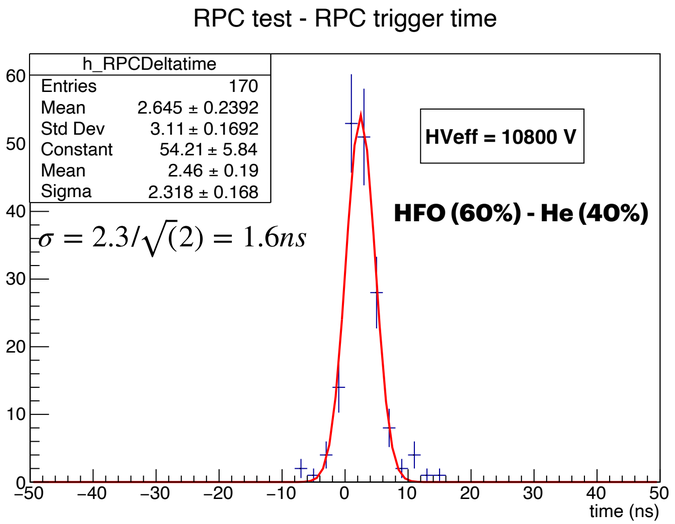


Gas flowmeter

Gas distributor

PRELIMINARY LAYOUT



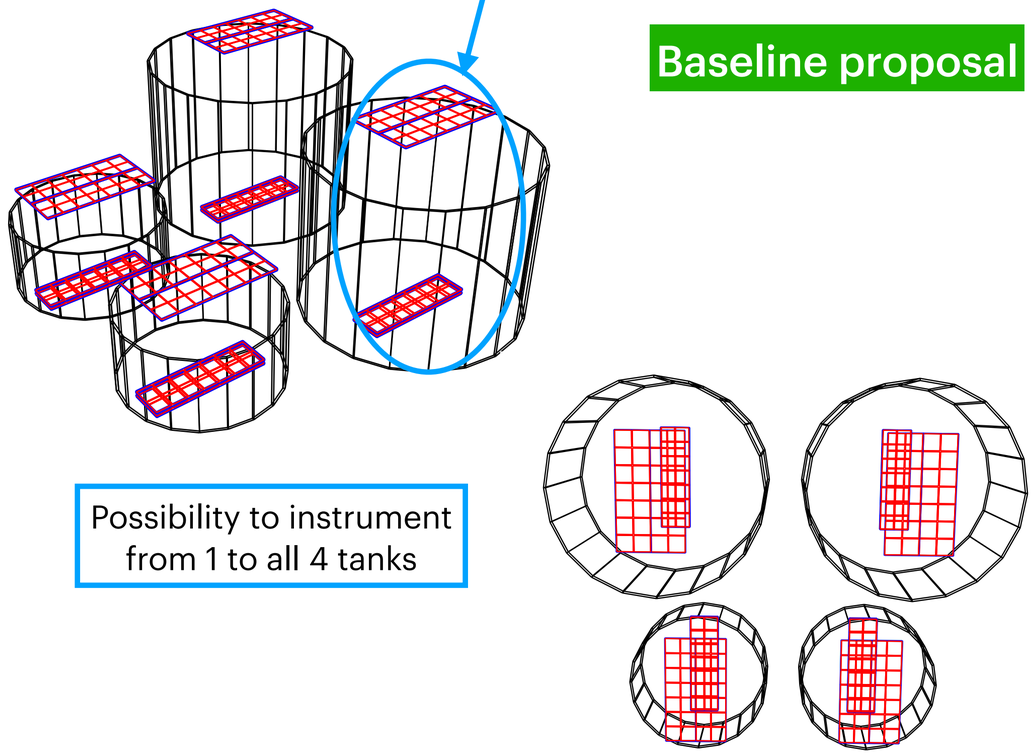


Pathfinder layout (open to discussion)

Assumptions:

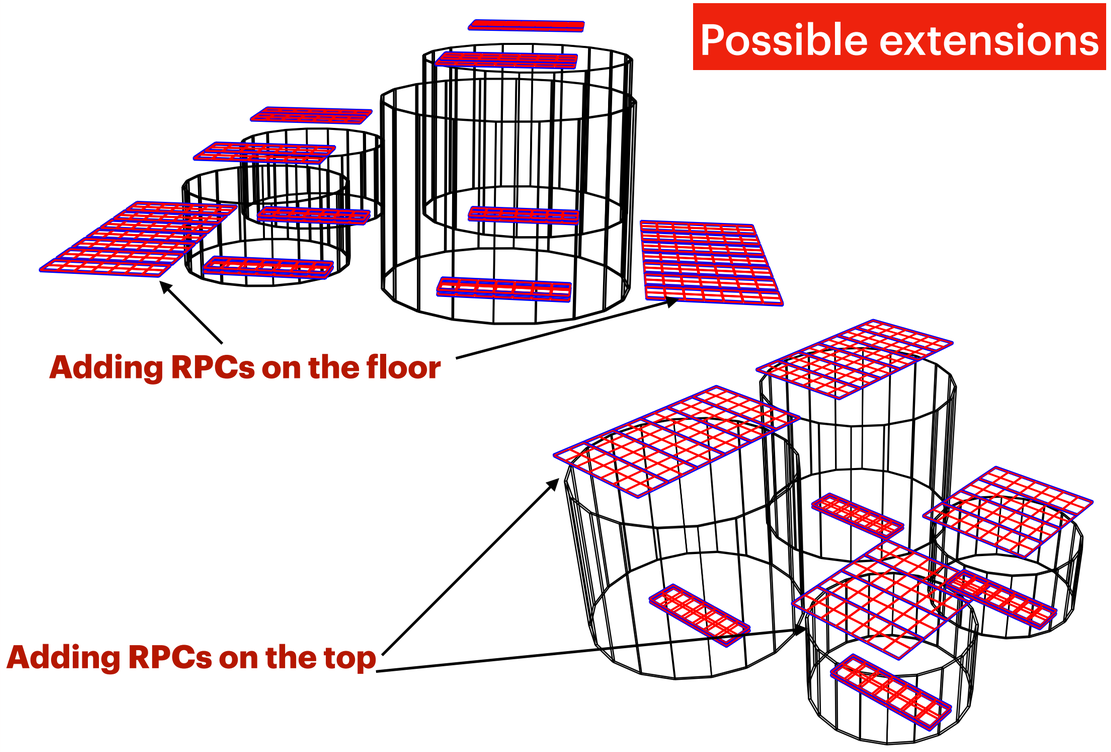
- tanks placed on a concrete basement and 2 bottom RPCs for each tank are placed in a slot of the basement under the tanks
- One layer of 2 RPCs placed on top of each tank (mechanics to be defined)
- Possibility to place few more RPCs on the floor to select tracks crossing the tank from the side
- Exercise assume from 4 (1 tank instrumented) to 30 RPCs
- **RPC Cluster: 4 RPCs**

Baseline proposal



Possibility to instrument from 1 to all 4 tanks

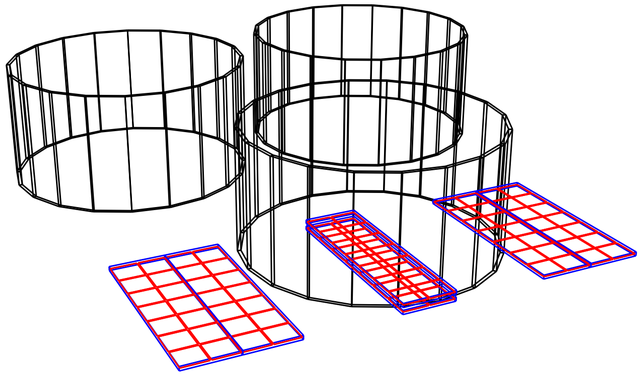
Possible extensions

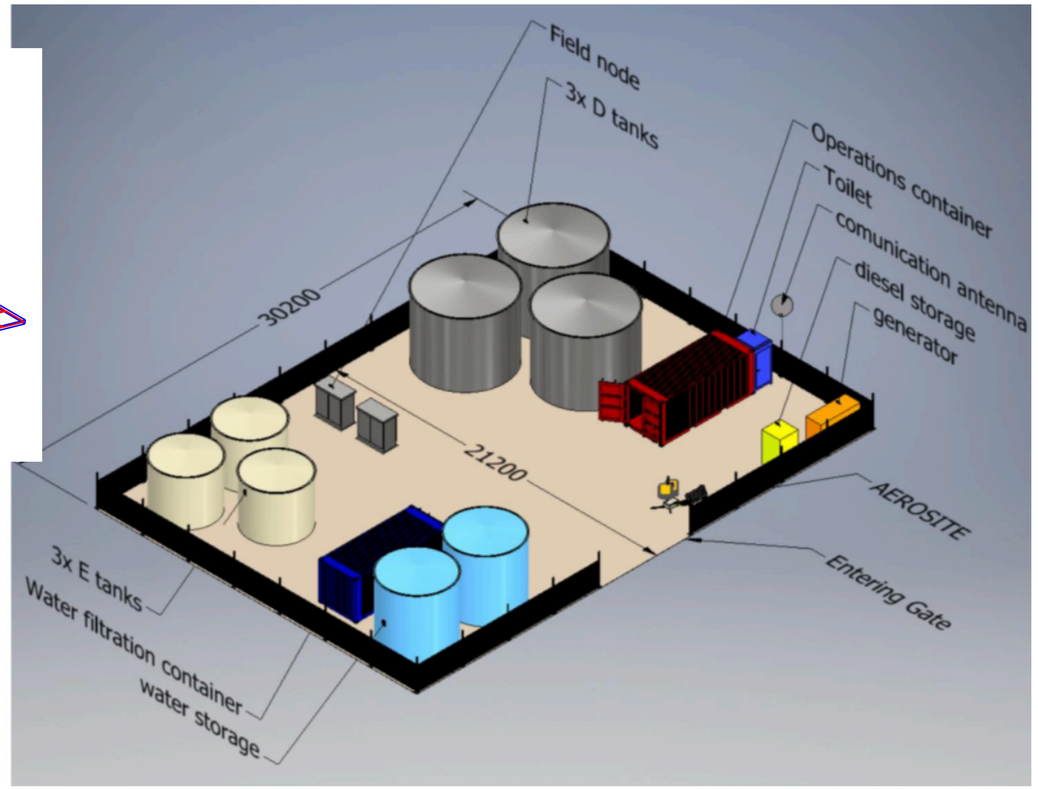


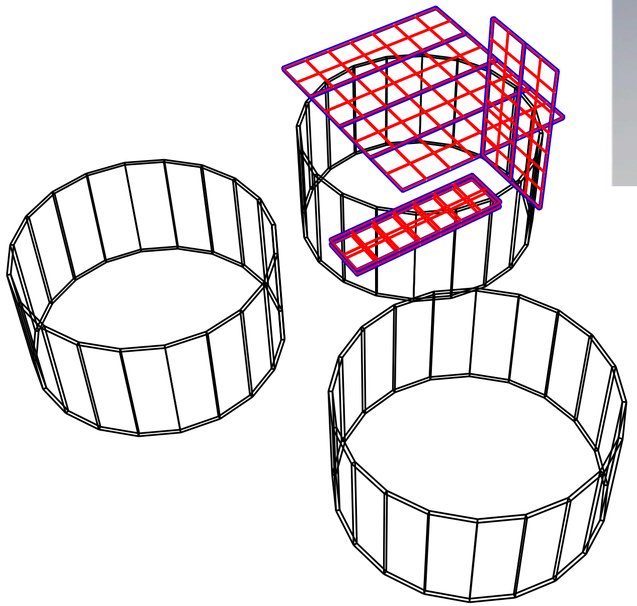
Possibility to trigger on showers according to pad multiplicity

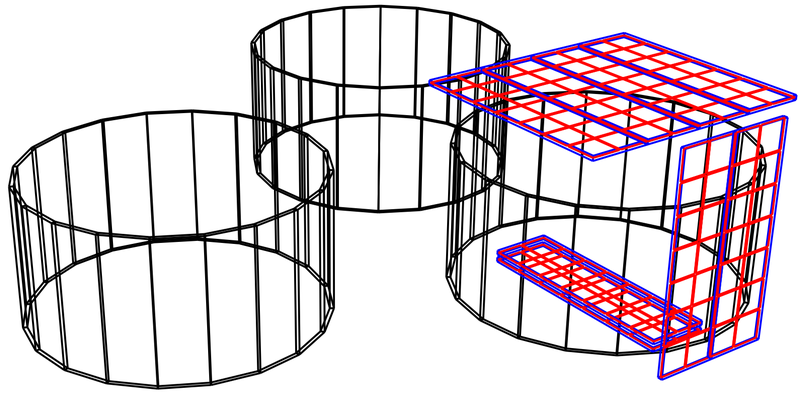
Layout del 10 Febbraio 2025

PATH FINDER




Field node
3x D tanks
Operations container
Toilet
comunication antenna
diesel storage
generator
30200
21200
AEROSITE
Entering Gate
3x E tanks
Water filtration container
water storage

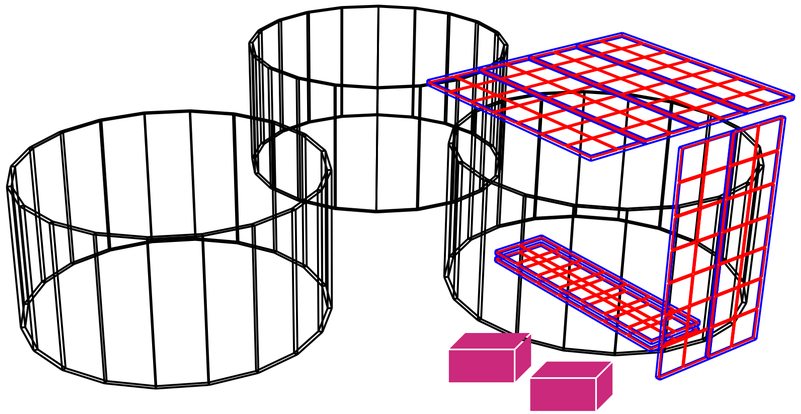




Cluster distributor

As the distance between RPCs and final electronics Rack could be more than 15 mt and in order to reduce the number of long cables, a cluster distributor will be used close to RPCs:

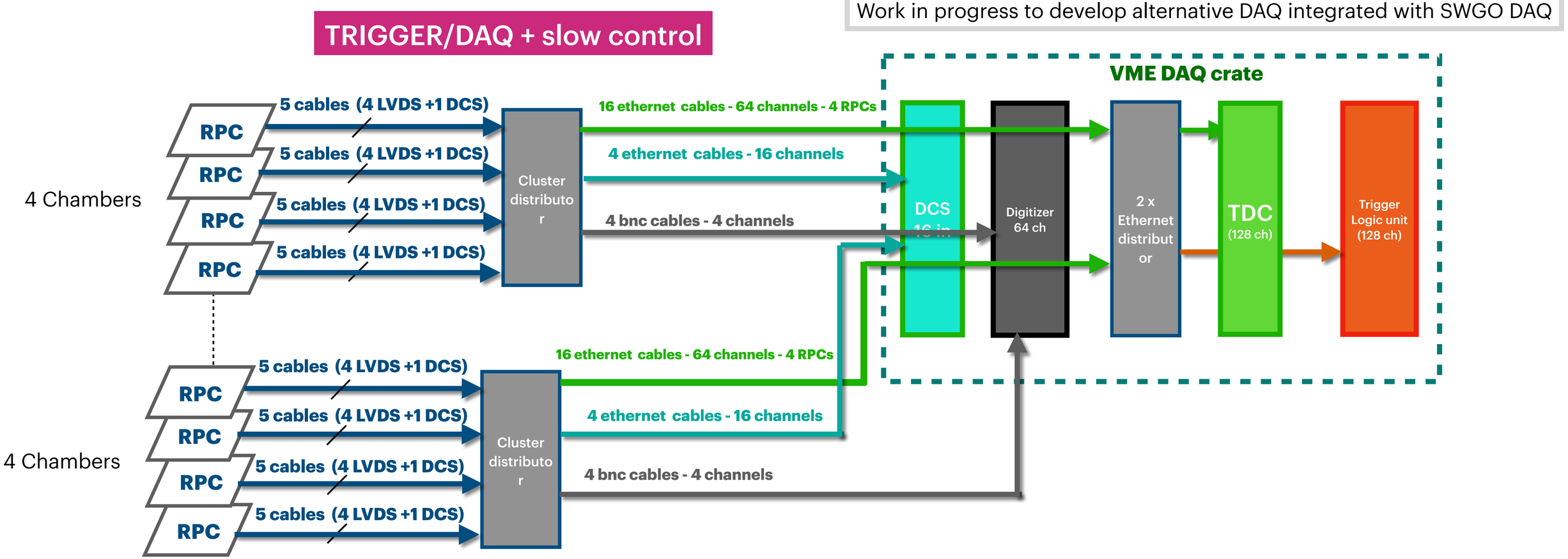
- no problems for cable length
- Reduce numbver of long cables
- Easier cabling



DAQ system (preliminary layout)

V1 FOR PATHFINDER (8 chambers) DAQ baseline

Baseline layout available by second half of 2025.
Work in progress to develop alternative DAQ integrated with SWGO DAQ



Conclusions

- Production of RPCs and electronics is ongoing smoothly
- Baseline Gas system layout ready and simple
  - Long term test started in laboratory
  - Alternative mixture available
- Power system layout available (< 50 Watt)
- Cluster distributor layout designed
- DAQ layout (O(200 Watt) to be verified)
  - Preliminary baseline layout designed
- Preliminary thermal coverage prototype ready for small chamber
  - Temperature cycling test starting now
- In order to finalize and freeze design of the layout we need reference people to discuss possibl constraints/possibilities in Pampa La Bola

Logistic Summary (PRELIMINARY)

	Values for 30 chambers	Number of boards/ channels	Comment
HV+LV power (Watt)	70 watt		3 W (HV) 20 W (LV) 20 W (system) 20 W (fan at min.)
VME crate power	150-200 watt	Max 6 boards	According to n. Boards
N. Cables signal + DCS (ethernet)	150		Max length of signal cable should be
N. Of crates	3	10 (converters) + 10 (VME) + 2 (power)	Power supply + VME crate + converter crate
N. Bottles for 1 year (HFO 40 kg)	8		Assuming 24 h/day 365 days/year
Gas distribution box	1 box 6 units		
HV-LV distribution box	1 box 6 Units		
Cluster distributor box	8		Each box instrument 4 RPCs

A single rack would house all the needed material (yellow rows in the table)