COMPASS RICH Grounding Scheme

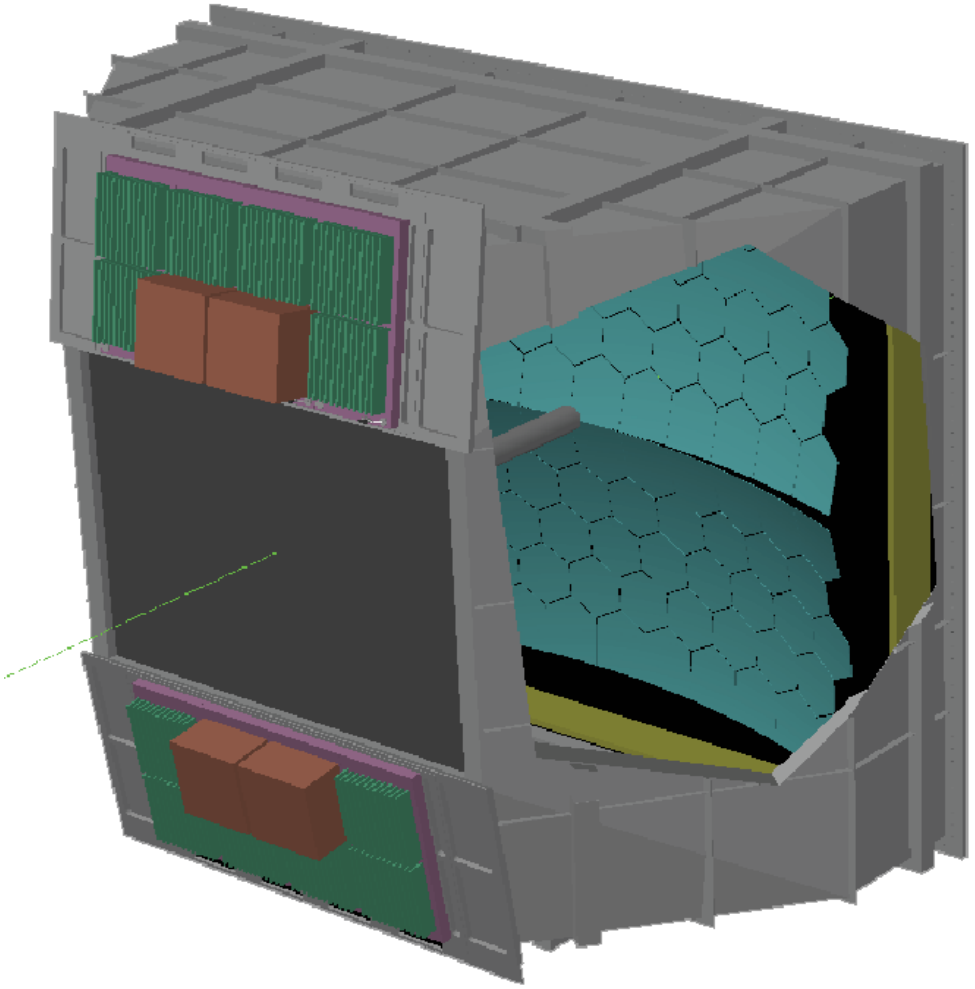
ePIC Collaboration Meeting

January 23, 2025

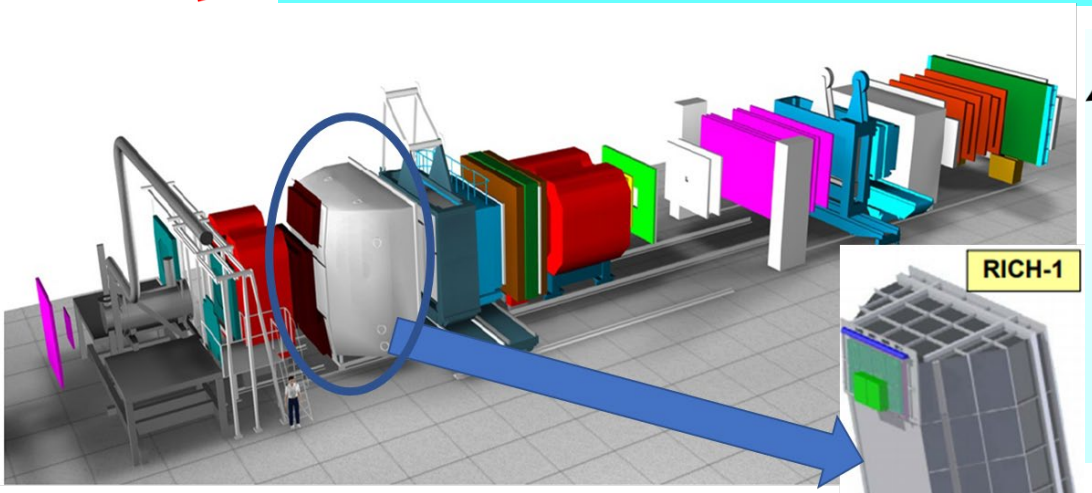
Fulvio Tessarotto
(INFN – Trieste)

Outline

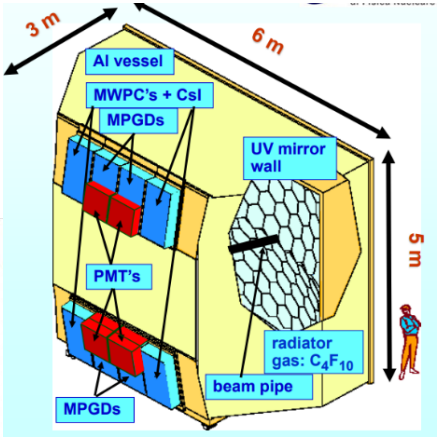
- COMPASS RICH-1 and its environment
- The need of good grounding
- The strategy and implementation effort
- The effects of good grounding
- Maintaining good grounding over the years



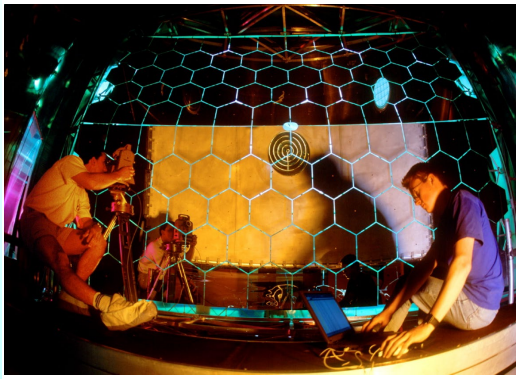
COMPASS/AMBER RICH-1



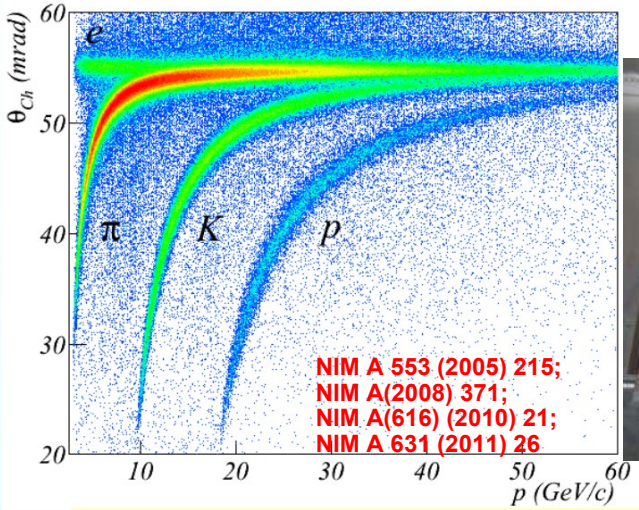
NIM A 577 (2007) 455
NIM A 779 (2015) 69



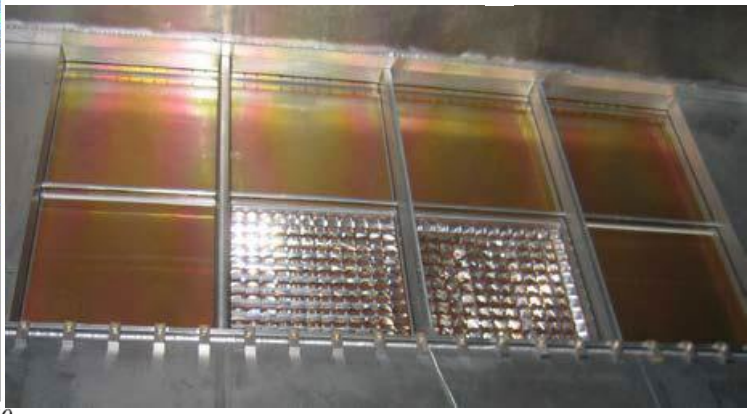
3 m long C_4F_{10} radiator



21 m² UV mirrors



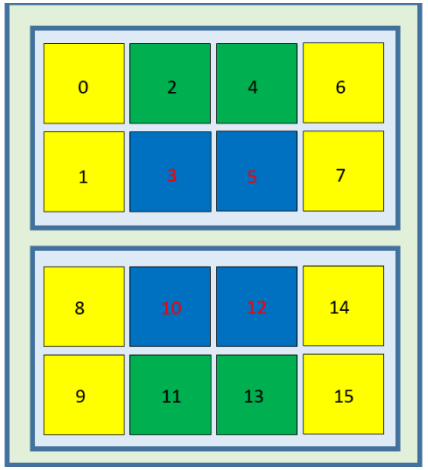
NIM A 553 (2005) 215;
NIM A(2008) 371;
NIM A(616) (2010) 21;
NIM A 631 (2011) 26



5.6 m² photon detection surface

three photon detection technologies:

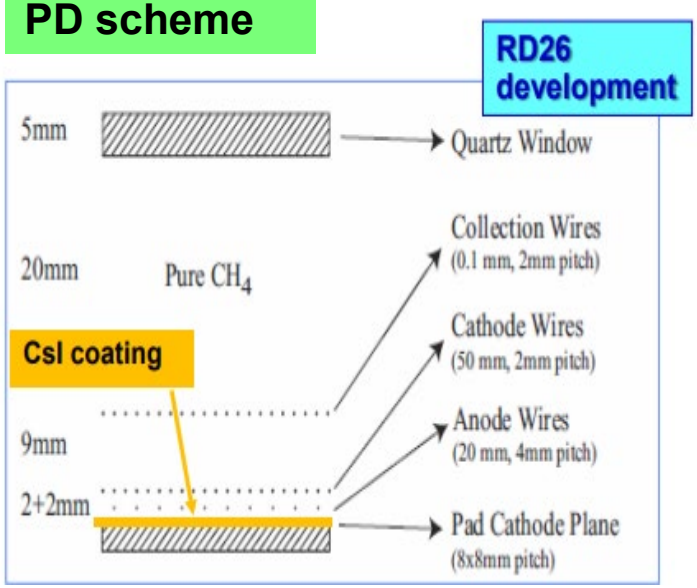
- MAPMTS
- Hybrid PD
- MWPC

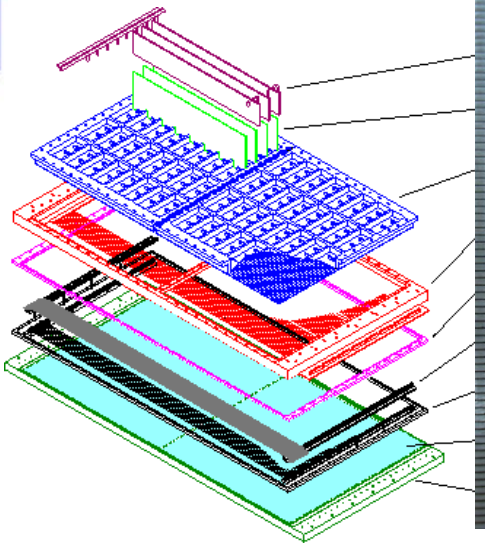


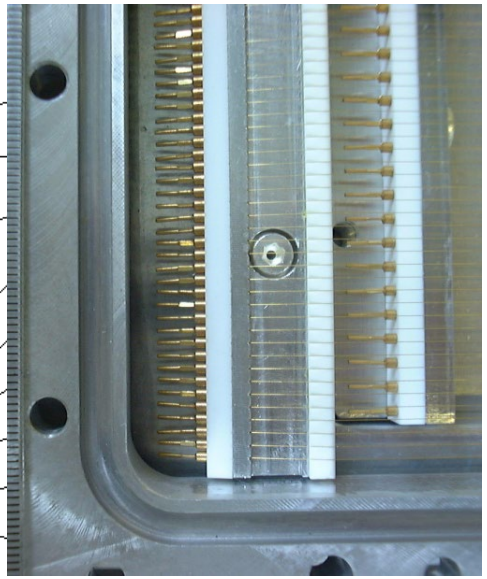
Designed in 1996, in operation from 2002, upgraded in 2006 and 2016

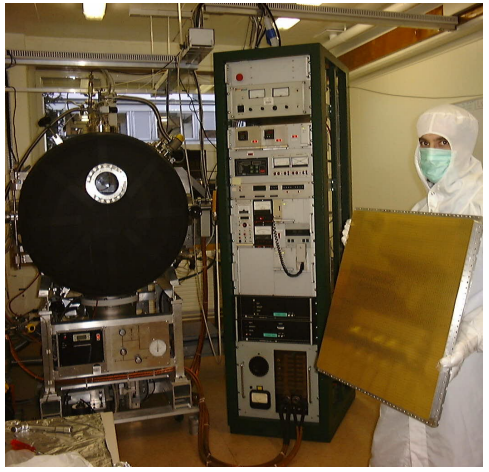
MWPCs with CsI

PD scheme



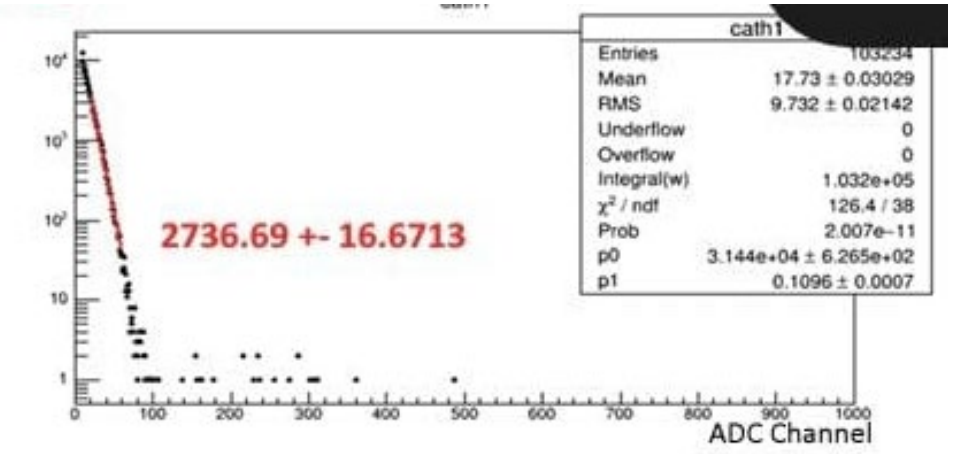






5.6 m^2 MWPC's +CsI: in operation since 2002 with FEE upgraded for 2.9 m^2 in 2006

The challenge



very small signal amplitude

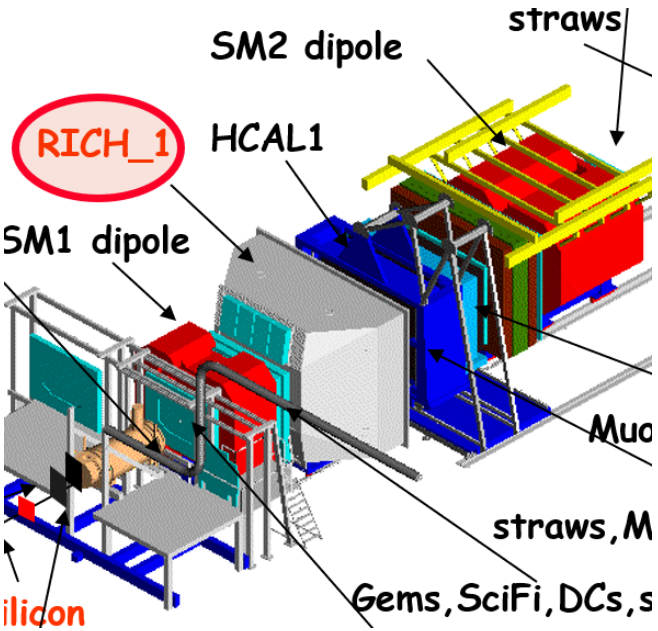
Highly noisy environment

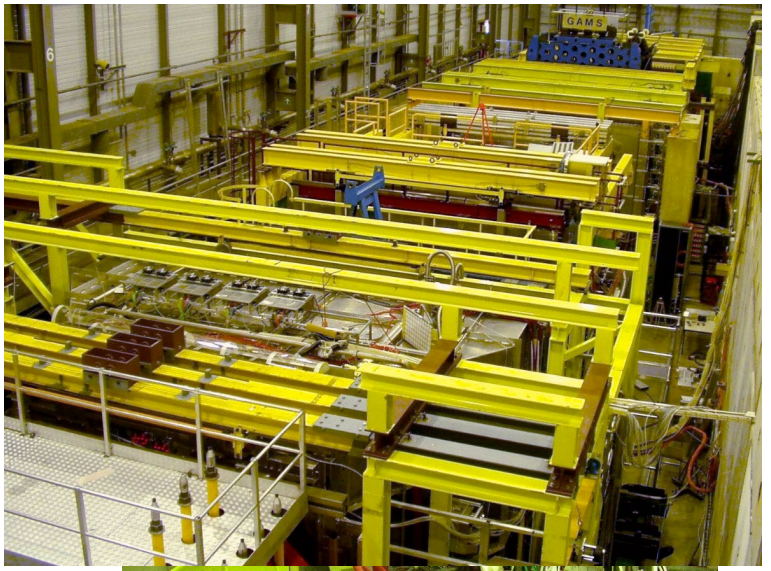
nearby magnets:
- SM1 with large aperture
- SM2 (5000 A, 200 V)
- COMPASS PT solenoid with cryogenic system

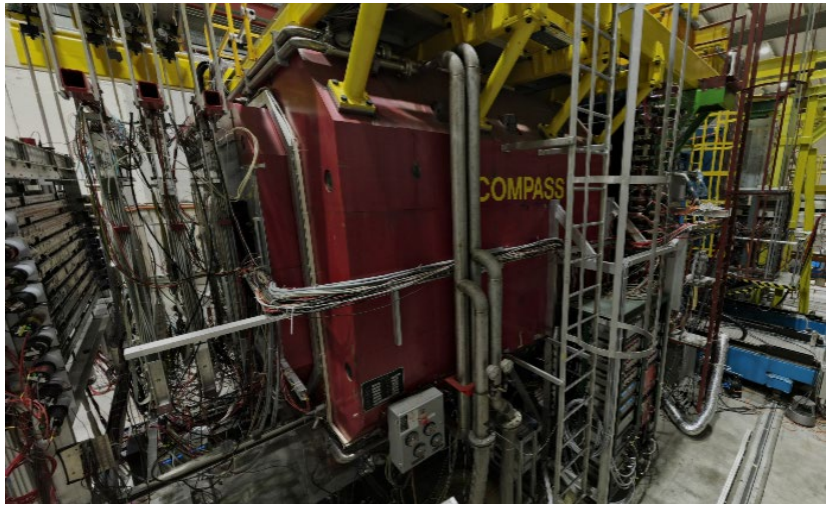
Many large pumps systems
Detectors with gas and cooling circulation systems
Electronics for nearby detectors,
Various infrastructure systems, …

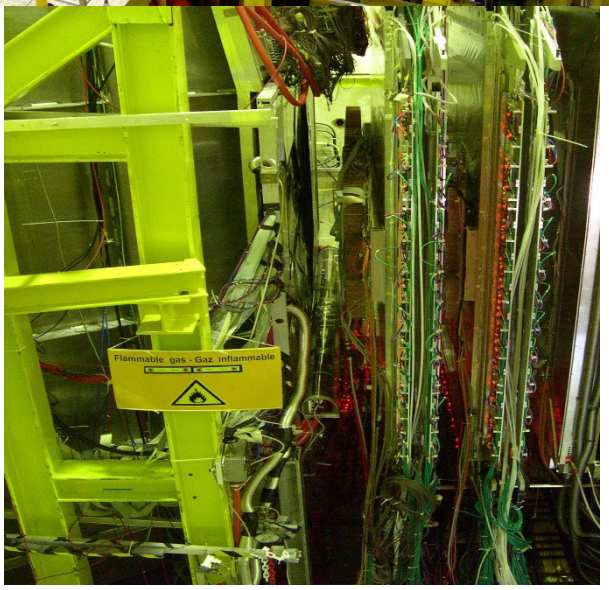
- Electromagnetic Interference
- Ground Instability

COMPASS RICH-1

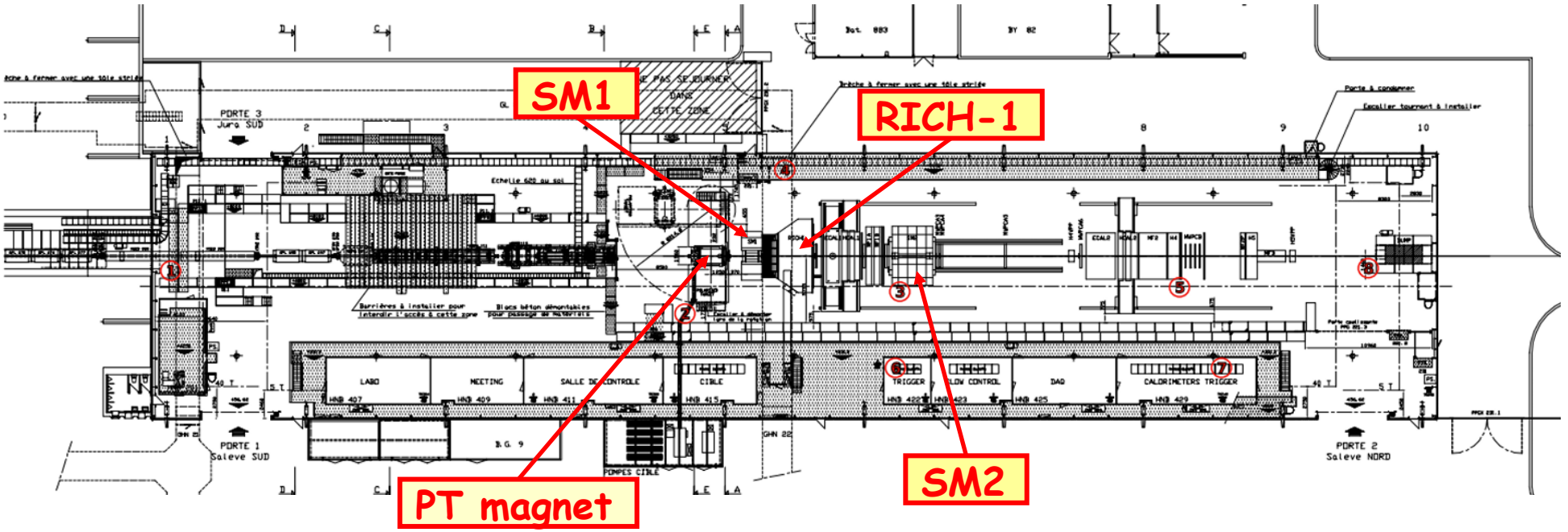








The Experimental Hall EHN2



Two main grounding networks in the Hall:

1) power grounding 2) detectors grounding

Large dissipation also on detector grounding distribution lines in EHN2

We were forced to implement a dedicated grounding line for RICH-1 only

Dedicated rails, electrically decouple everything from all other infrastructures

Decoupling and electrical isolation is non-trivial to implement and to maintain

The strategy

Dedicated RICH-1 grounding line, for RICH-1 exclusive use
Isolation from all components with external electrical connections to power lines or other detectors

All readout and services control via optical links,
All services electrically decoupled at the RICH-1

FULLY FLOATING HV AND LV POWER SUPPLY LINES

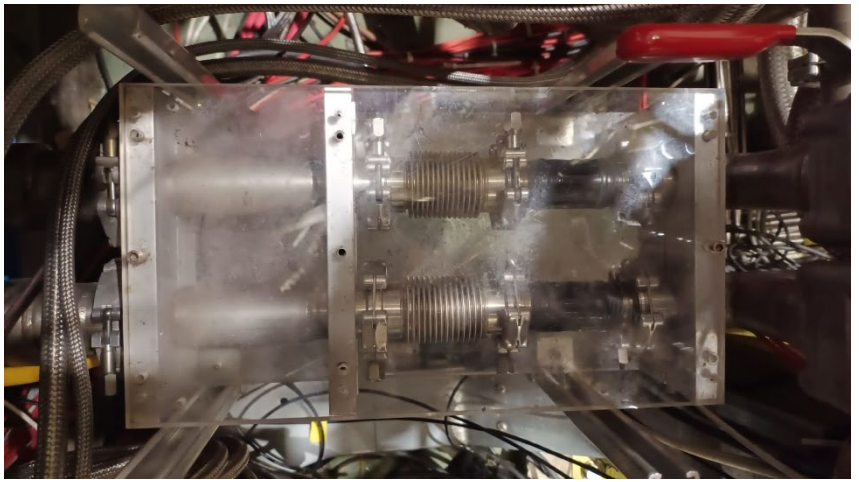
Direct and strong electrical anchoring of the vessel and the main RICH detector electrodes to ground

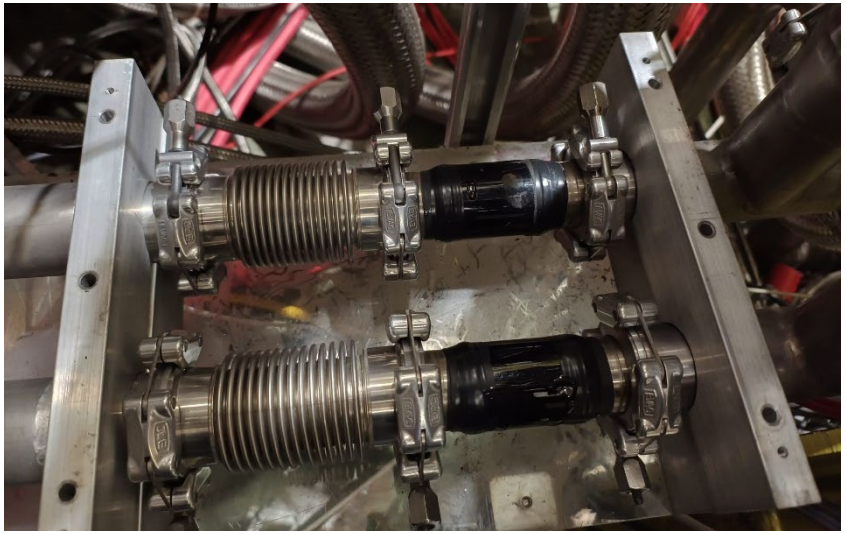
Careful, complete electromagnetic shielding of FEE

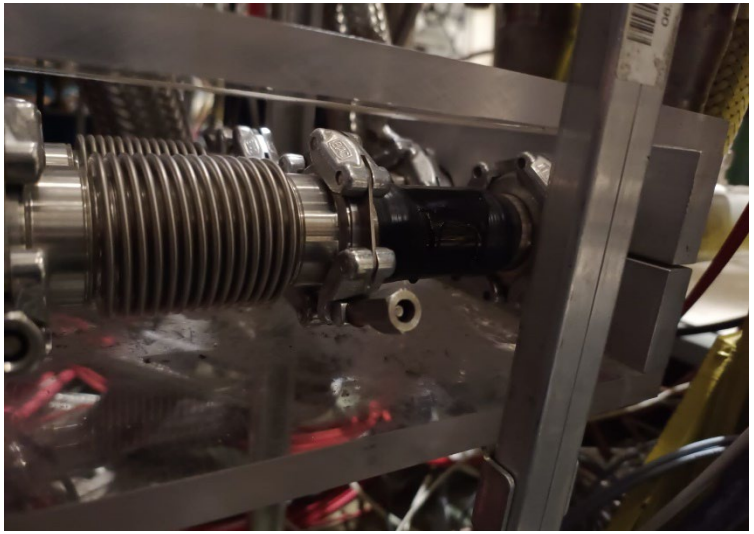
Cu plates for FEE water cooling used as grounding distribution elements

C_4F_{10} gas lines decouplers

- Ceramic pipe elements with stainless steel NW40 connections
- Light tightness implemented externally
- Mechanical supports bridging two grounding lines ➔ mechanical strength + electrical isolation





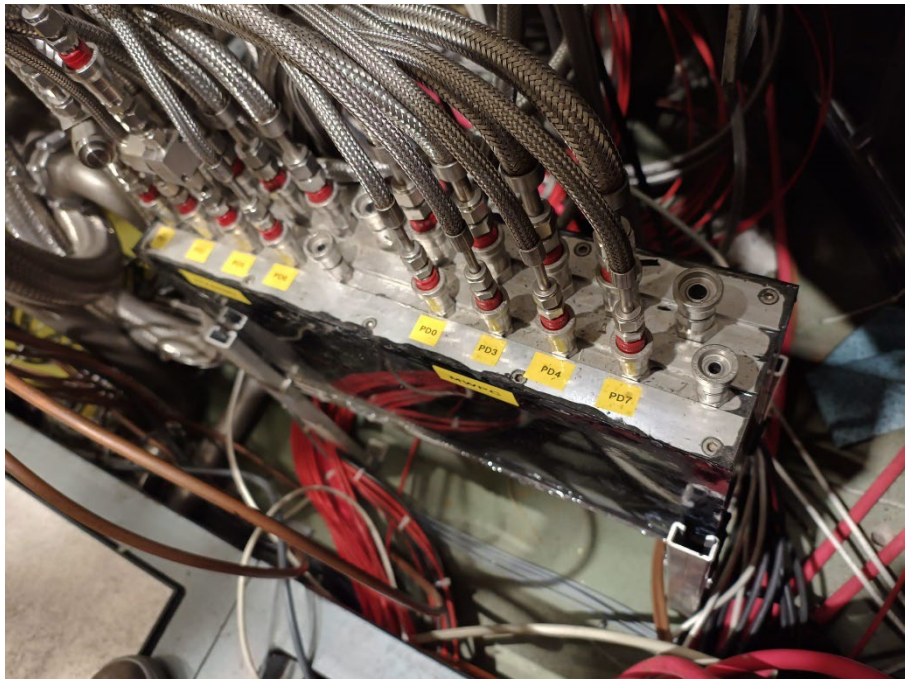


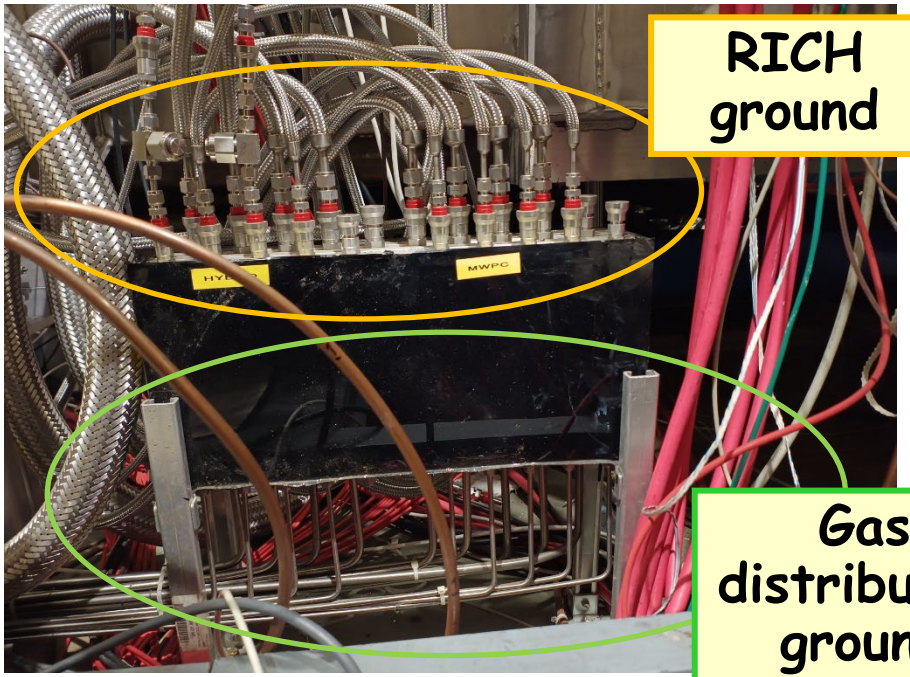
CH_4 gas lines decouplers

20 custom glass pipe elements glued on 10 mm diameter stainless steel pipes with Swagelok QC connectors

Flammable gas connections ➔ CH_4 leak detectors (on yet another grounding)

Light tightness implemented on the box. The lower half of the box is on the gas distribution grounding, the upper half on RICH-1 grounding.





Other decouplers for:

He line for minimal material in the beam pipe inside RICH-1

N_2 lines for
- preventing condensation on the fused silica lenses,
- preventing surface current leaks in the HV distribution boxes,
- guarantee proper operation of the 20000 external 0.5 GΩ resistors of anode pads

Water lines for the frontend electronic cooling

Pressure sensors for the RICH radiator gas system operation

Temperature control sensors distributed inside RICH-1

P,T sensors inside the Gaseous Photon Detectors for gain stabilization

LED for MAPMTs testing/monitoring

D_2 lamp for CsI response testing/monitoring

Nikon Cameras for CLAM (RICH internal control of mirror alignment)

Interlock temperature sensors for protection of digital electronics

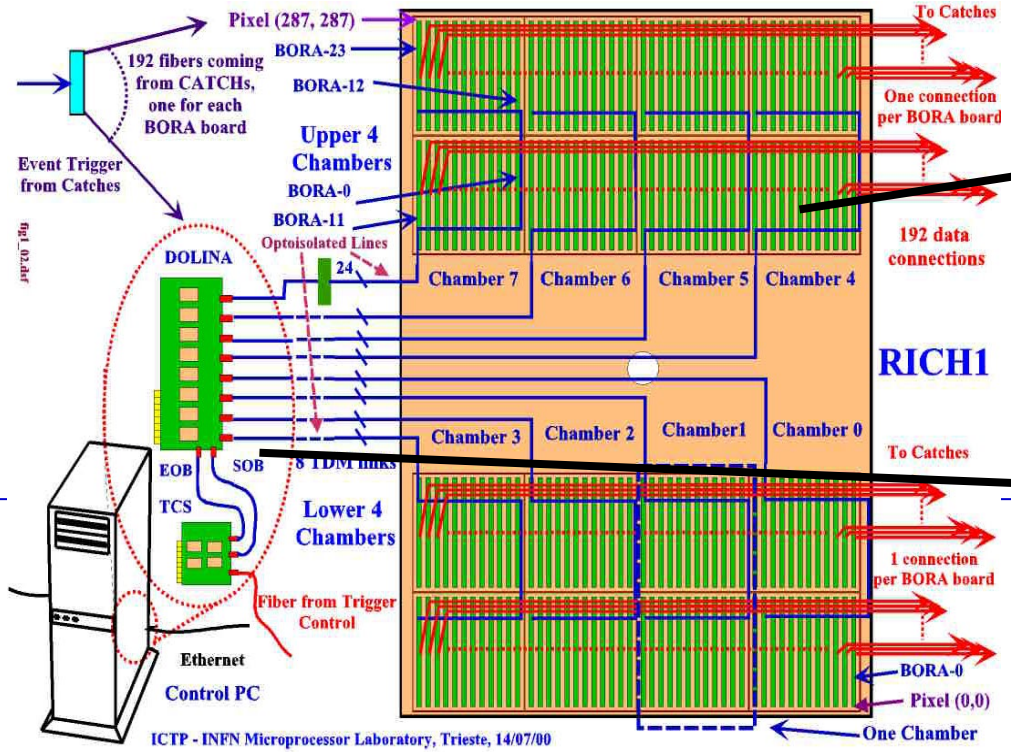
...

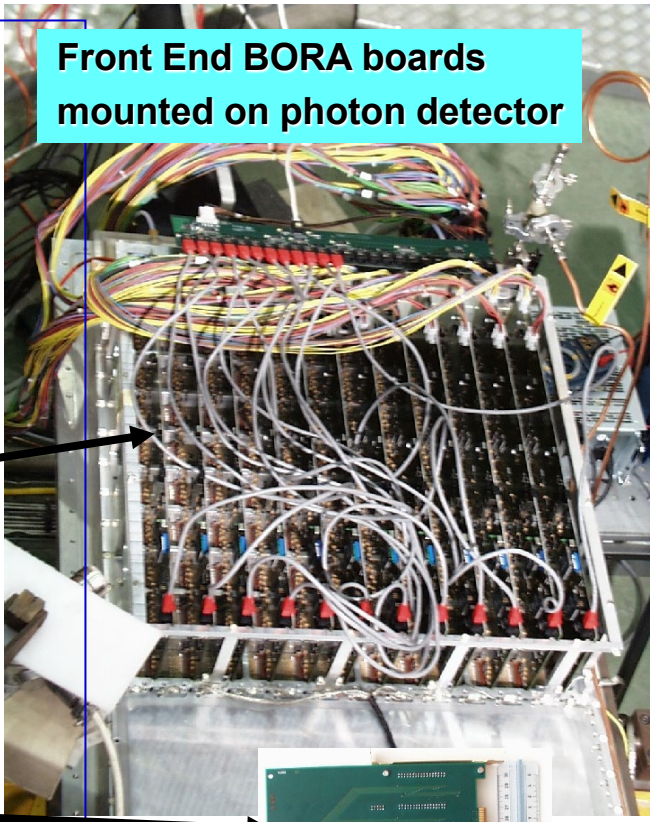
RICH-1 FIRST READ-OUT

analogic read-out system, 84,000 channels with local intelligence (DSP, FPGA in FE BORA board)

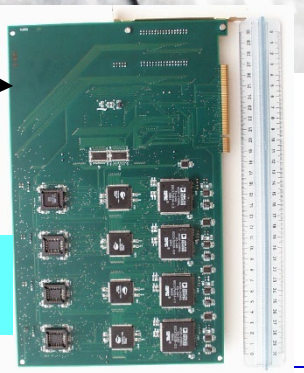
average noise level: ~ 2000 e^-, non-homogeneous, in 2001

reinforced ground lines in 2002 ➔ noise level: ~ 1100 e^-





Front End BORA boards mounted on photon detector

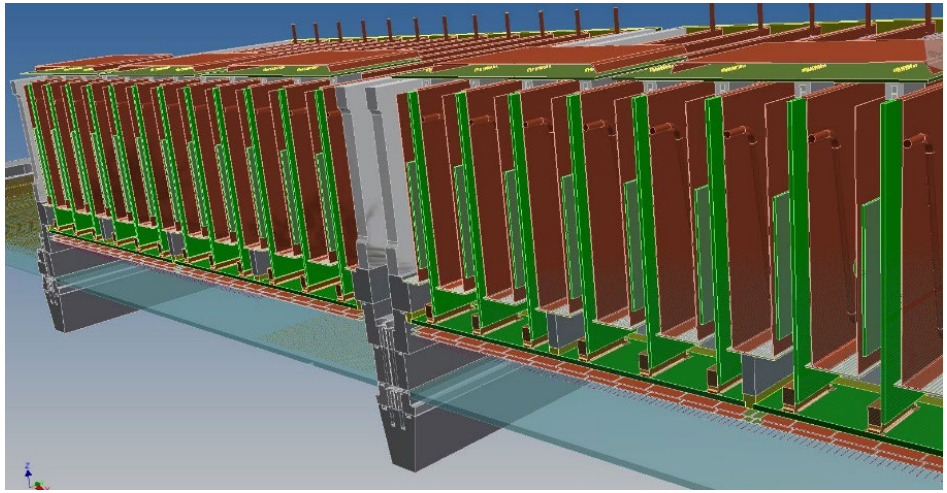


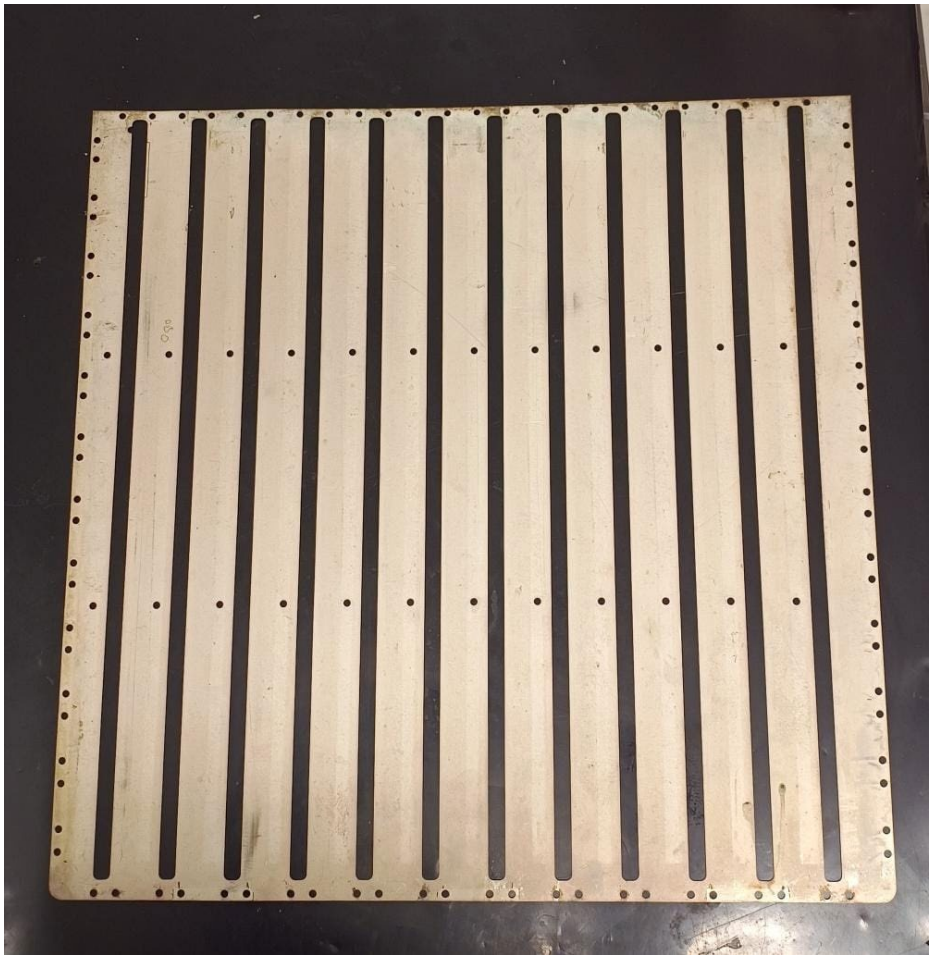
PC resident control board DOLINA

Radiated noise shielding

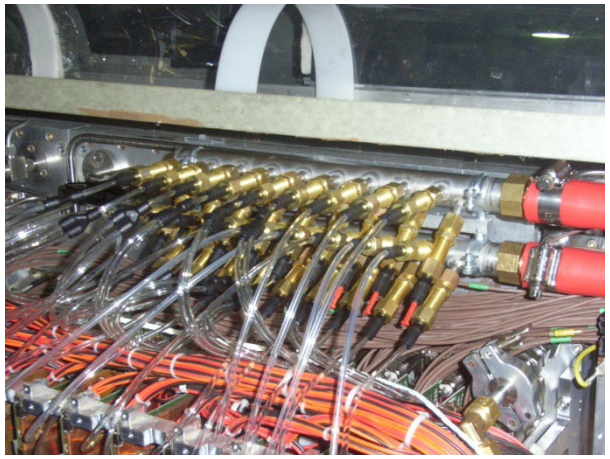
Electromagnetic Shielding provided by 1 mm thick Cu plates (600 cm x 600 cm) with electro-erosion cuts (for frontend boards insertion), Ag coated

Water cooling plates used for e.m. shielding and as grounding distribution elements

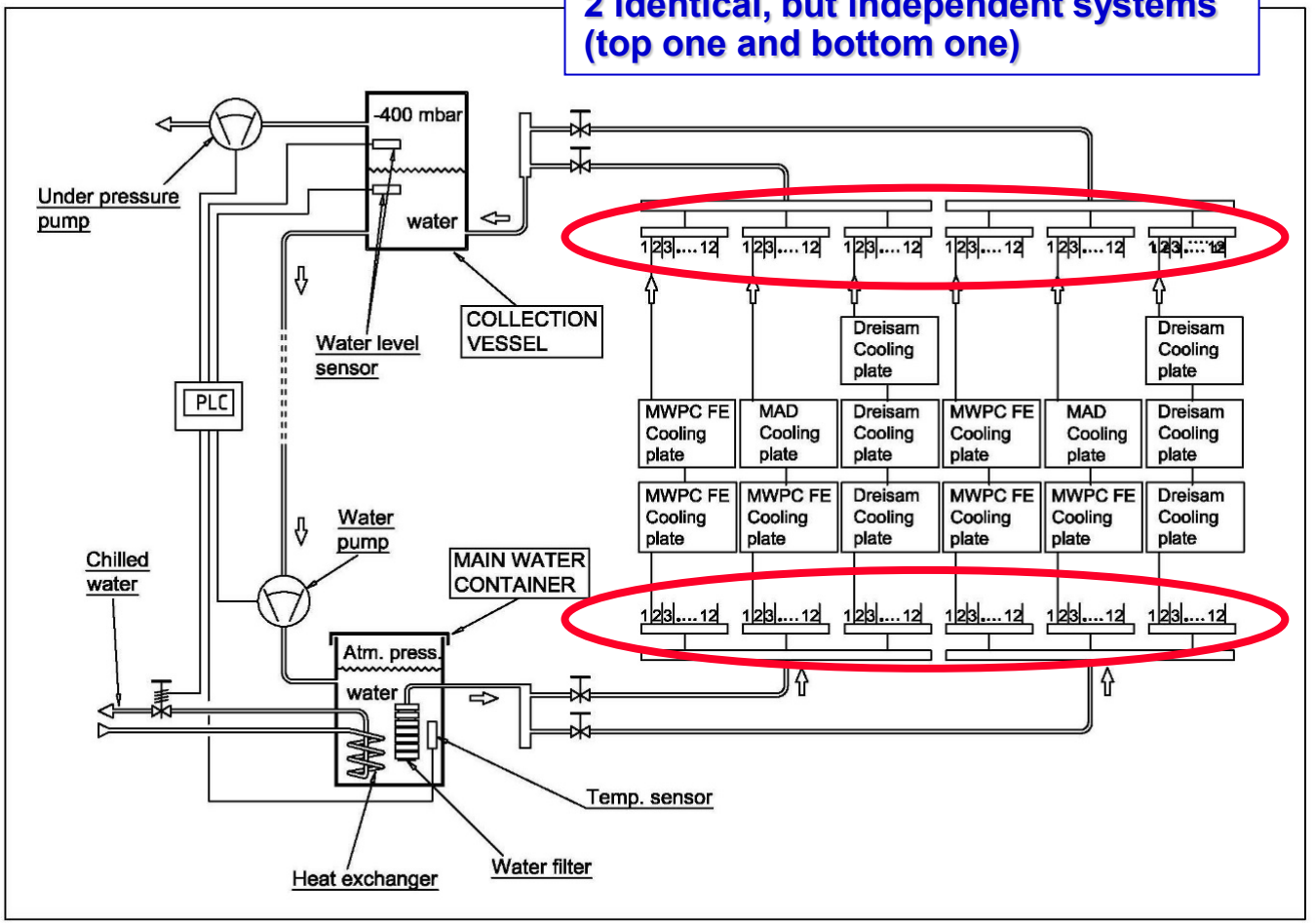




Underpressure H_2O cooling system

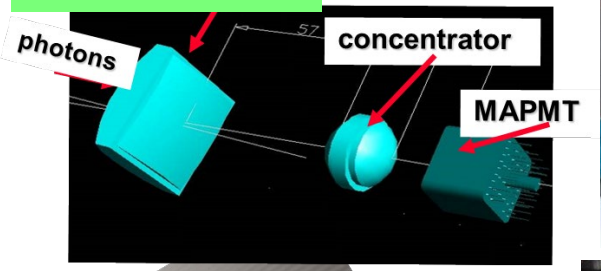


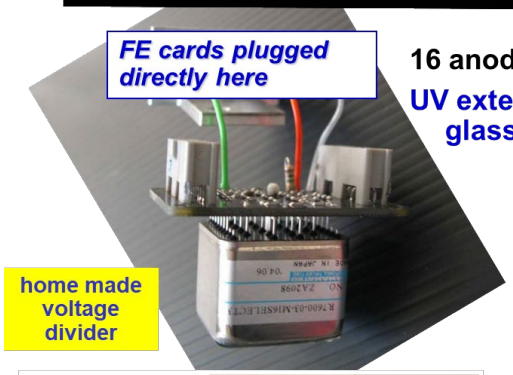
2 identical, but independent systems (top one and bottom one)



COMPASS MAPMTs with lenses

PD scheme

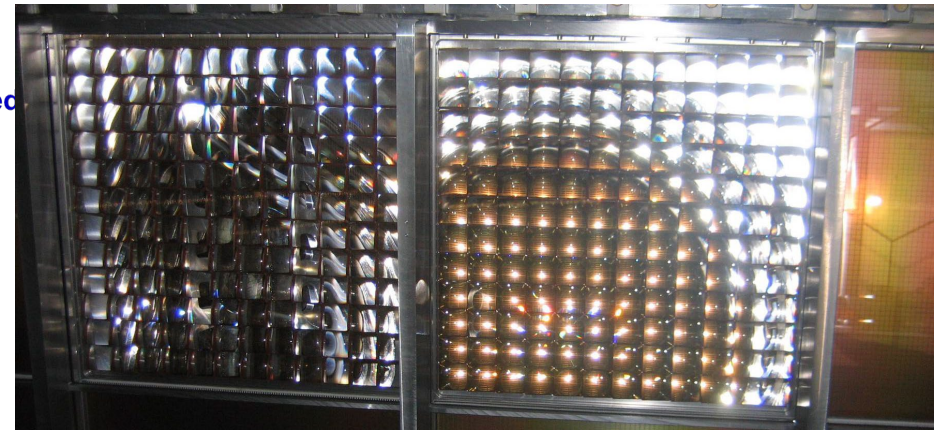


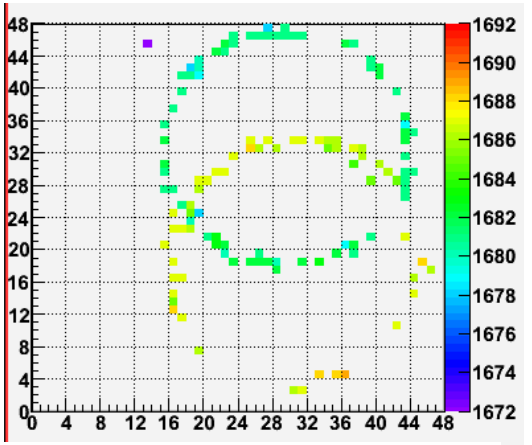


16 anodes

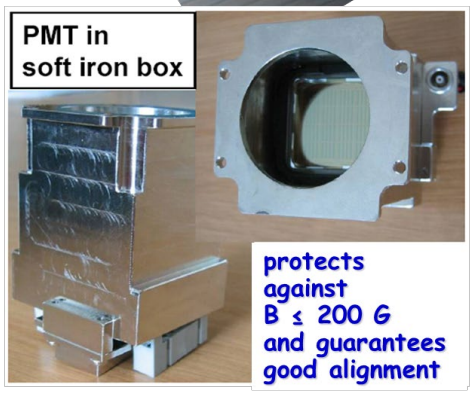
UV extended glass

home made voltage divider

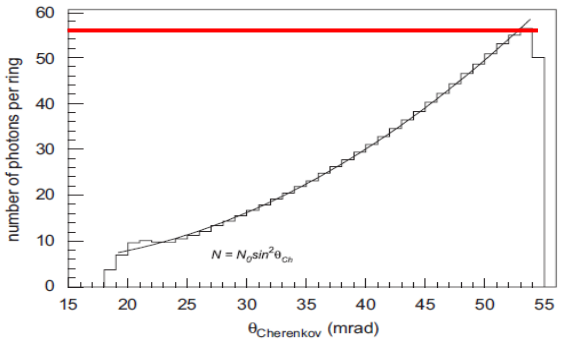


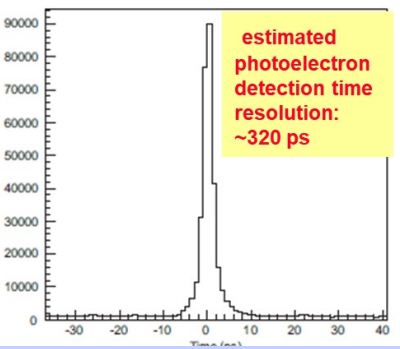


PMT in soft iron box

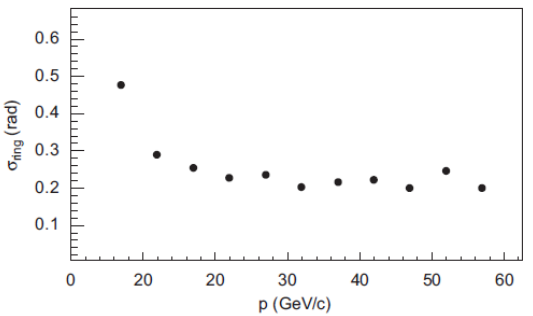


protects against B ≤ 200 G and guarantees good alignment



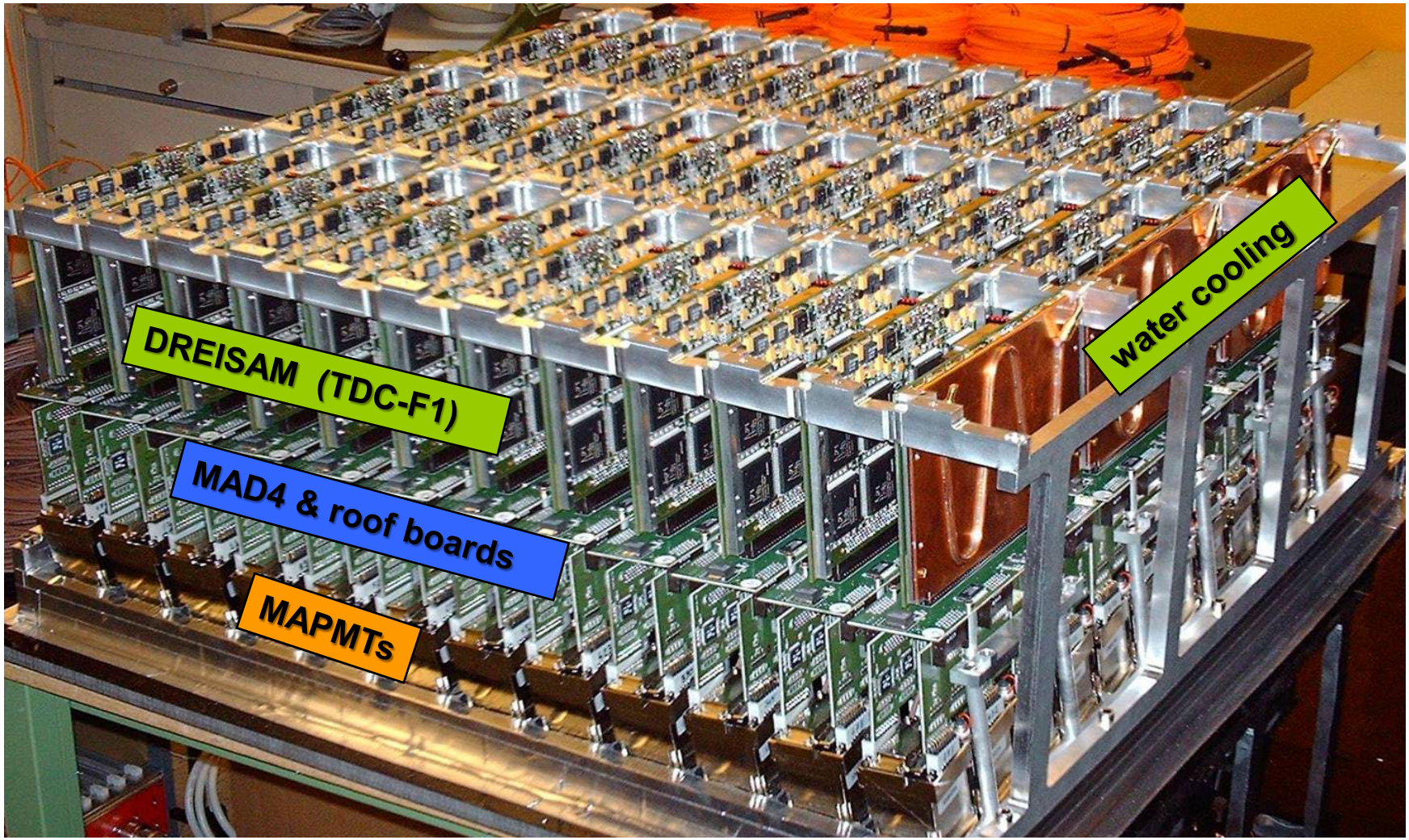


estimated photoelectron detection time resolution: ~320 ps



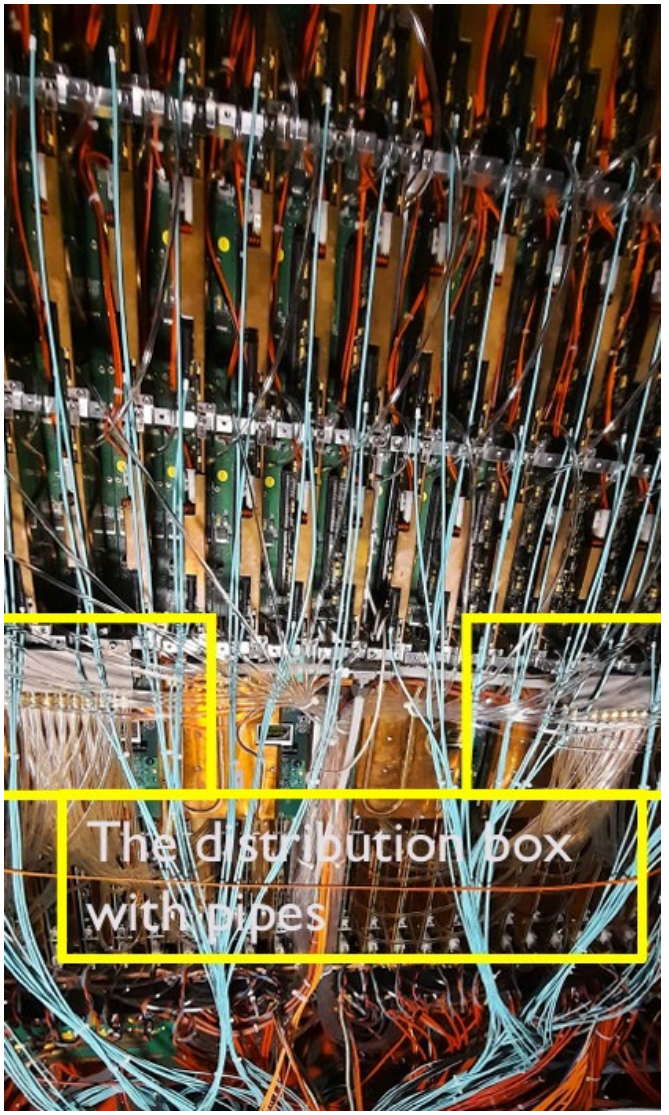
Implemented in 2006. Excellent performance, no failures, no instabilities, no need of HV adjustment

MAPMT readout



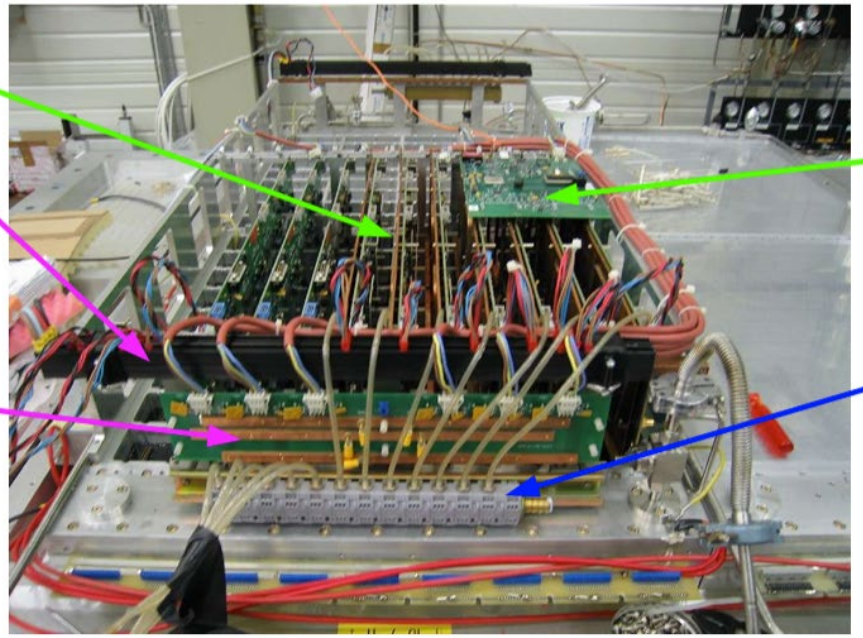
Mechanical support elements: Cr-coated Cu to avoid effects of contact potential with Al frames

Underpressure water cooling



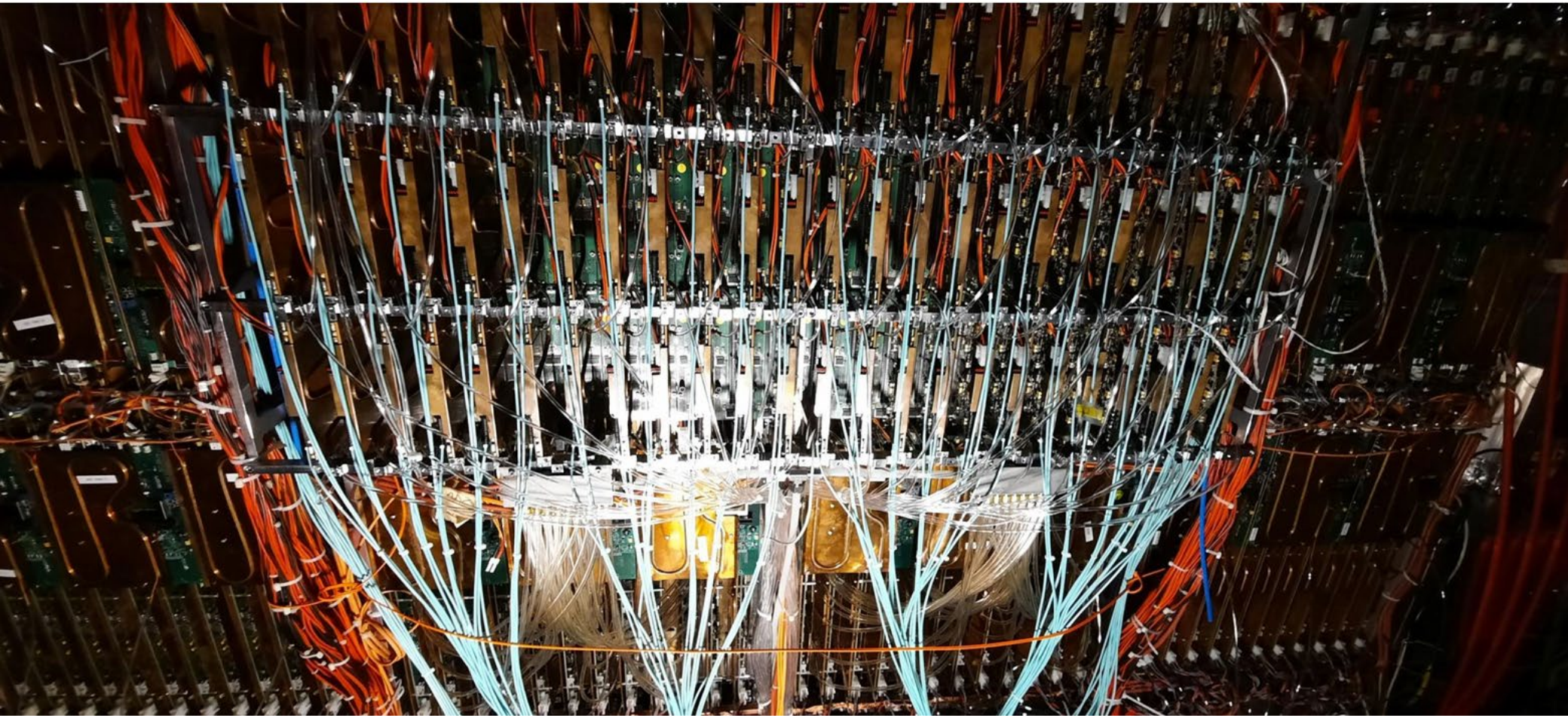
Upgrade of MWPC readout

Setup on RICH chambers

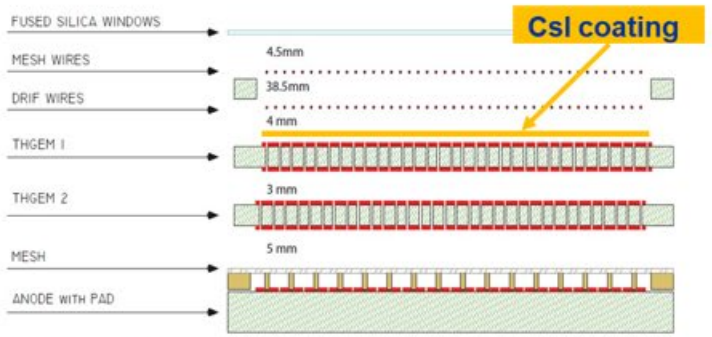


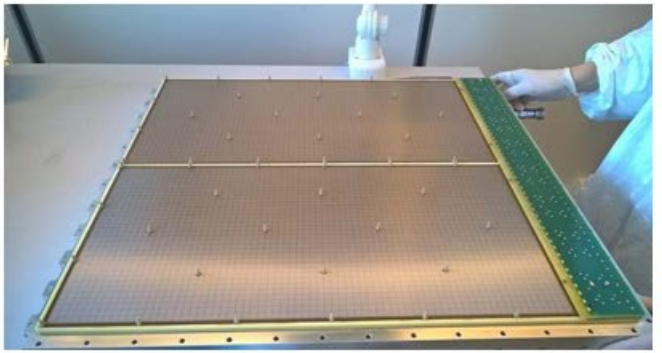
Careful design of the APV25-based FEE boards, grounding distribution and shielding elements

Upgrade of readout in 2006



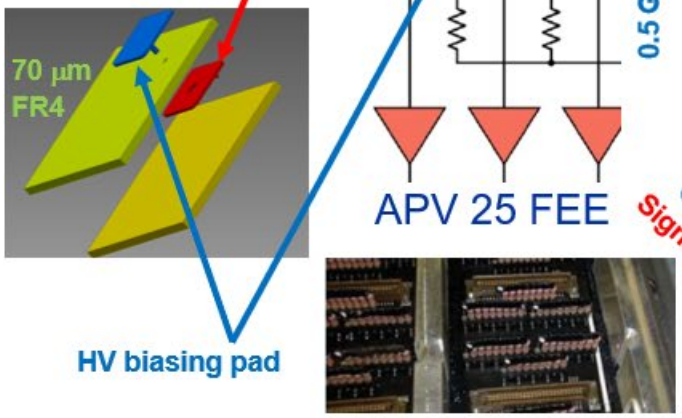
Hybrid THGEM + Micromegas detectors

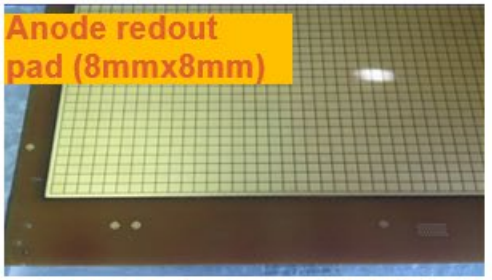




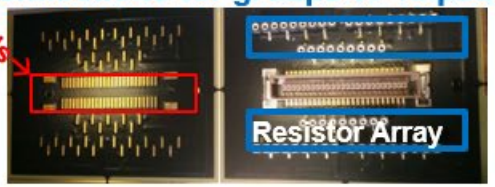
2016: in total 4 60 x 60 cm² detectors formed by 30 x 60 cm² active elements

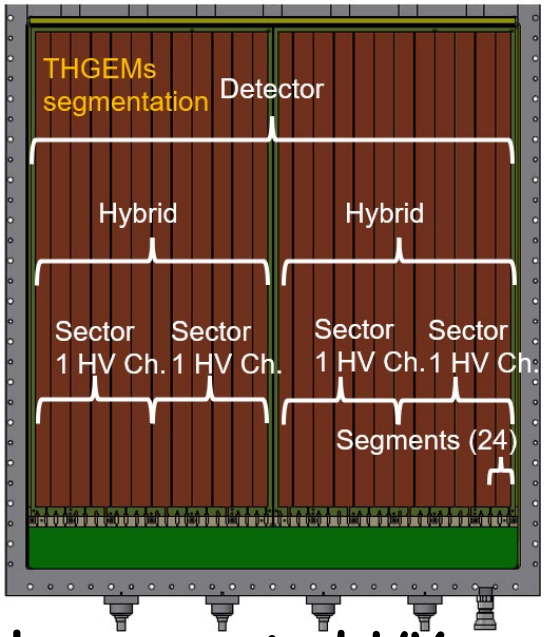
Signal read- out from the buried pad (original approach)





Connections for groups of 48 pads

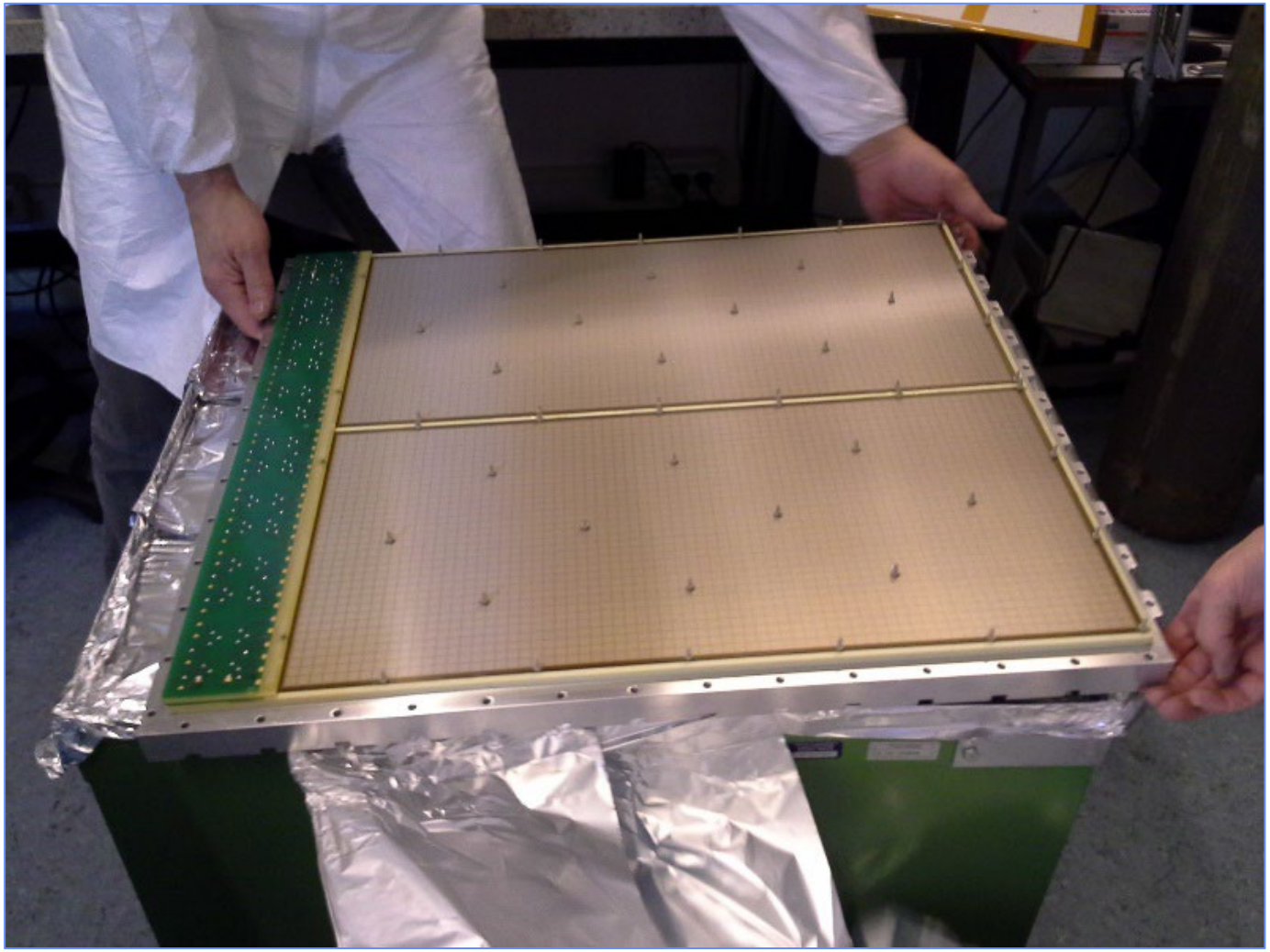




0.5 GΩ individual anode pad resistors

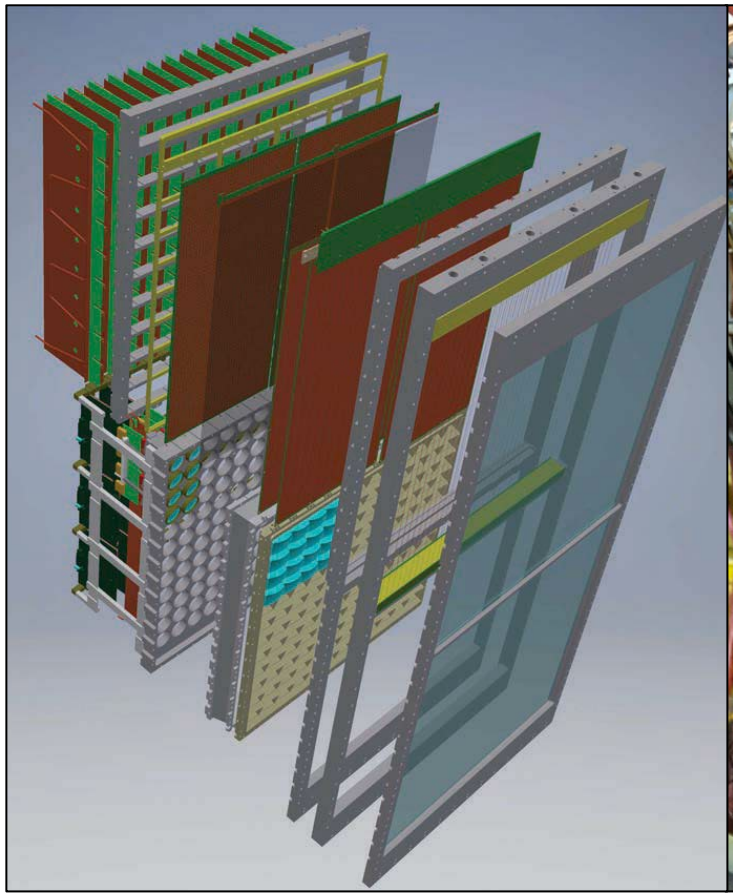
Highly segmented HV system

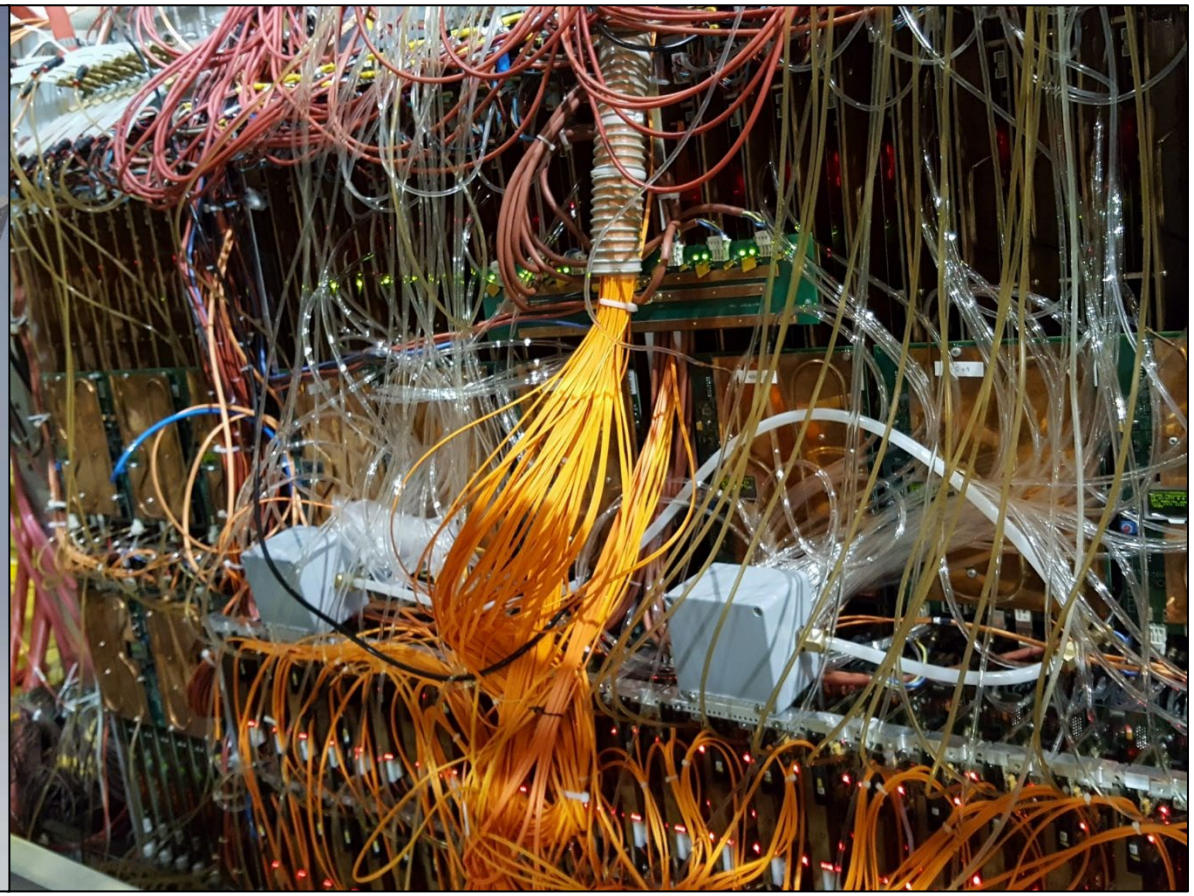
Grounding of the Micromegas



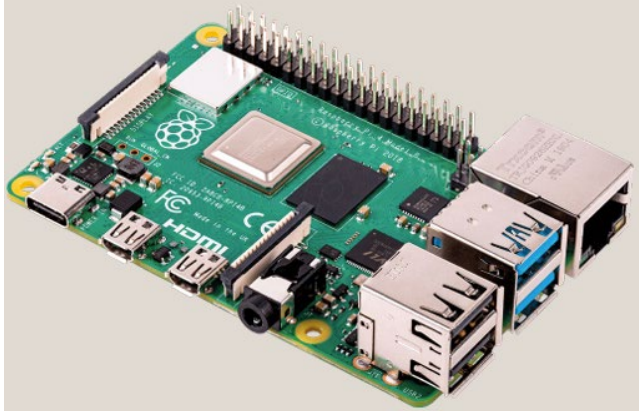
Strong grounding of the Micromegas mesh by embedding a strip of the mesh (~5 mm x 300 mm) in silver paste with copper bride on the service side of the detector.
The connection allows easy disconnecting for debugging studies.

More services after upgrade

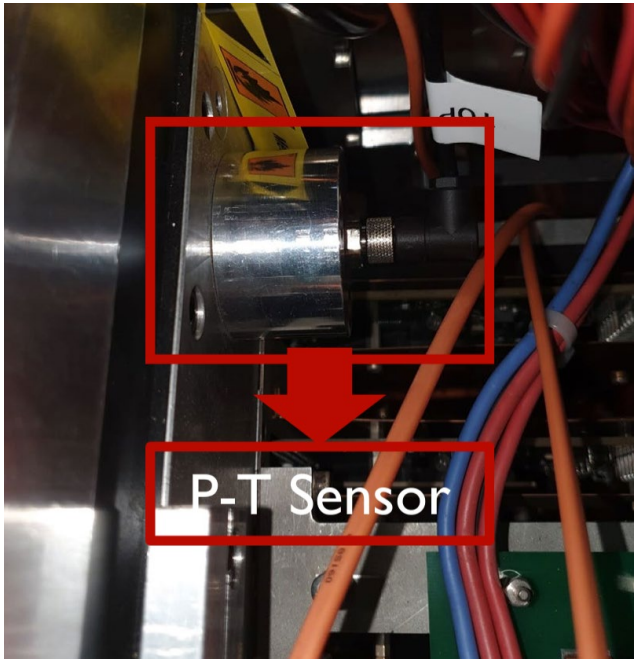


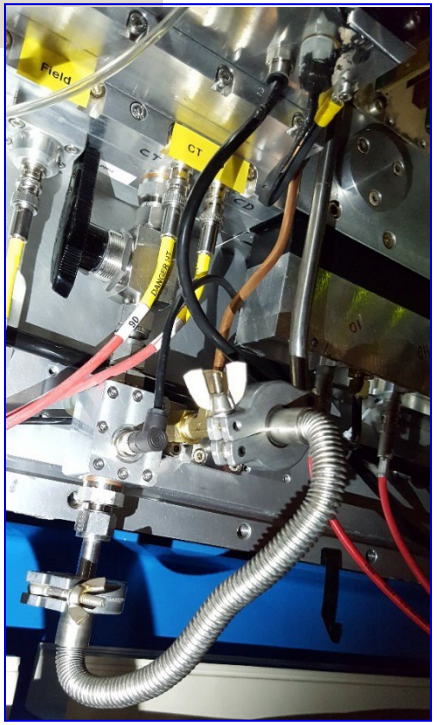


P,T sensors for HV adjustment



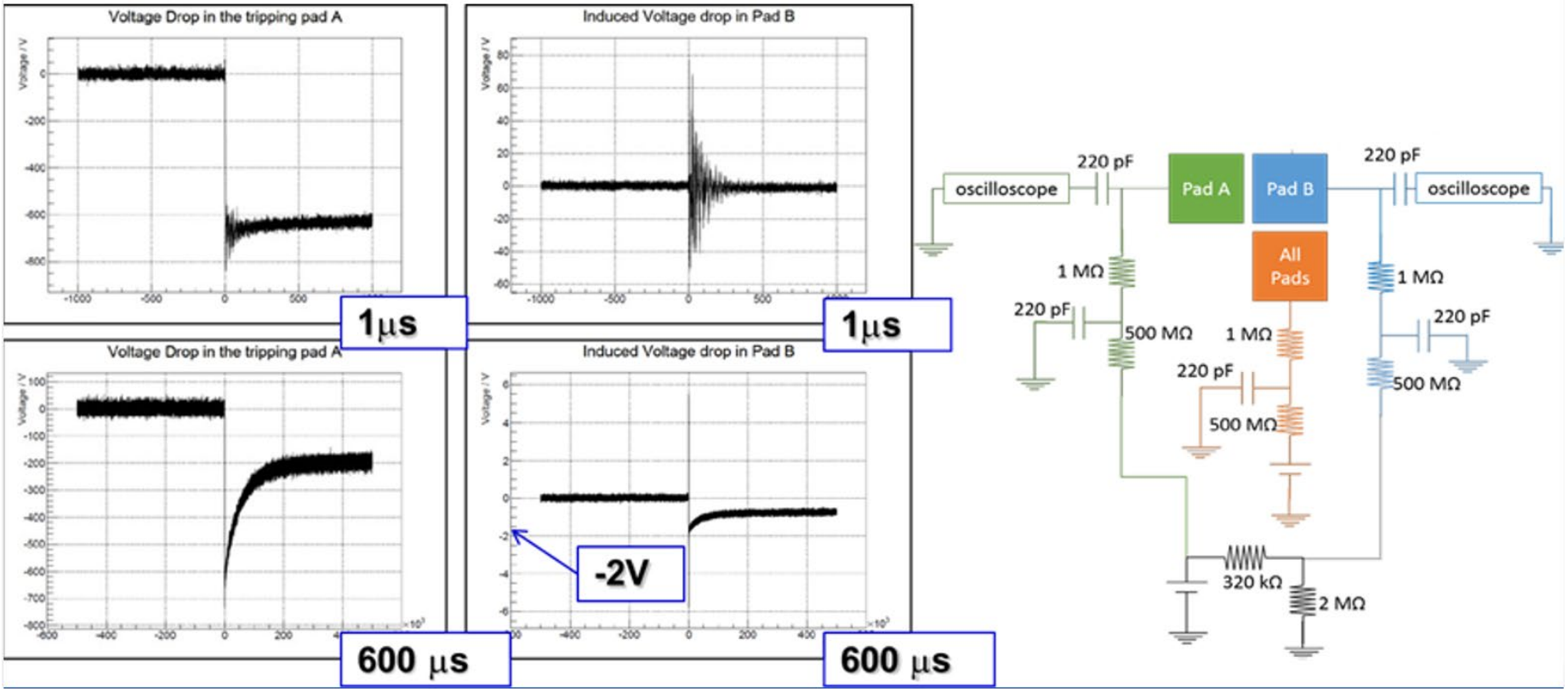
- Rasberry – PIs (R – Pis) are standard micro computers.
- We use R – PIs to control our pT sensors installed in the gas input and output lines for our gaseous detectors [both MWPCs and Hybrids]





3D printed box to hold the R – PI and the connectors connected to it and to the pT sensors.

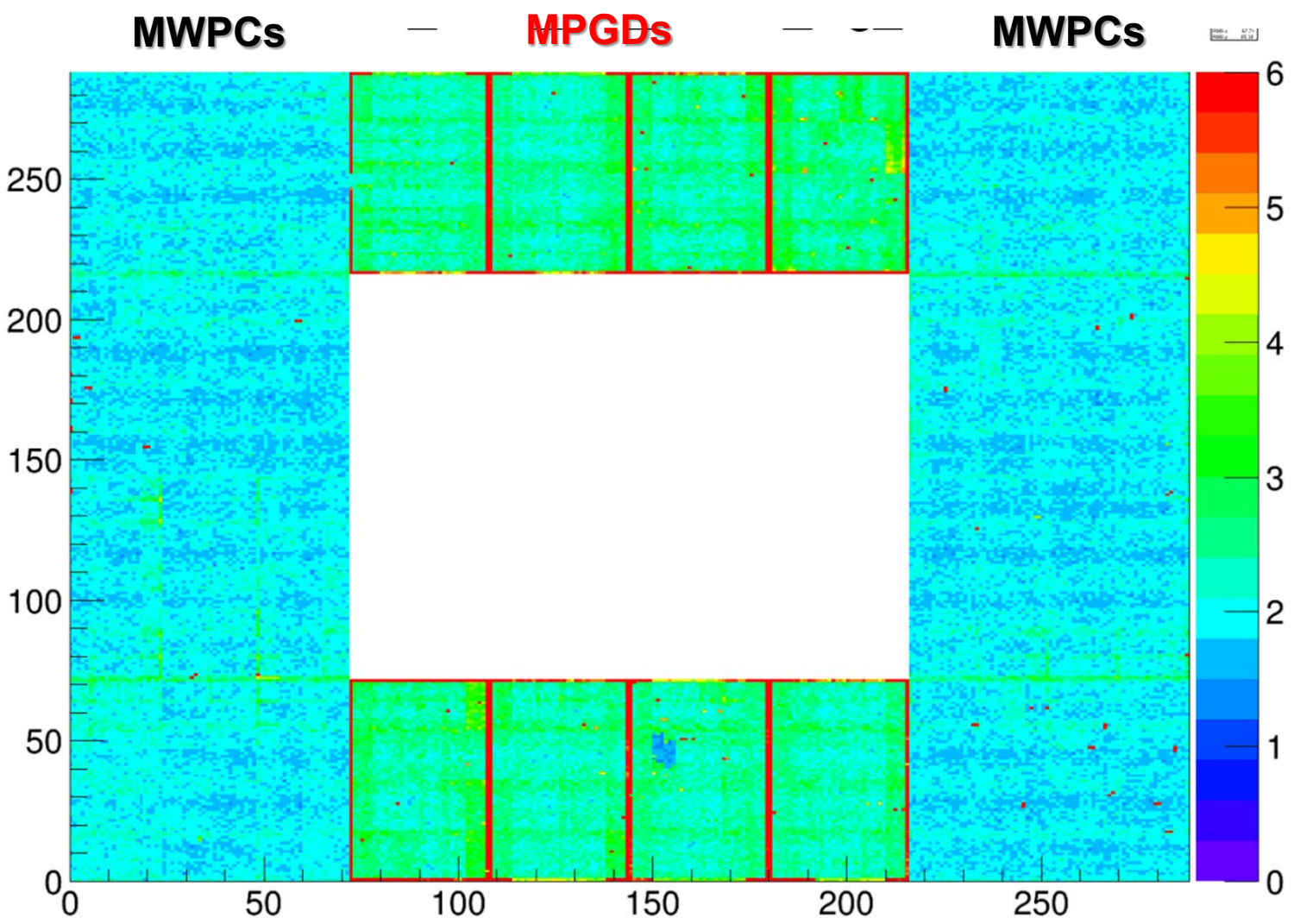
Protection resistors effect



A discharge on pad A has minimal effect on neighboring pad B

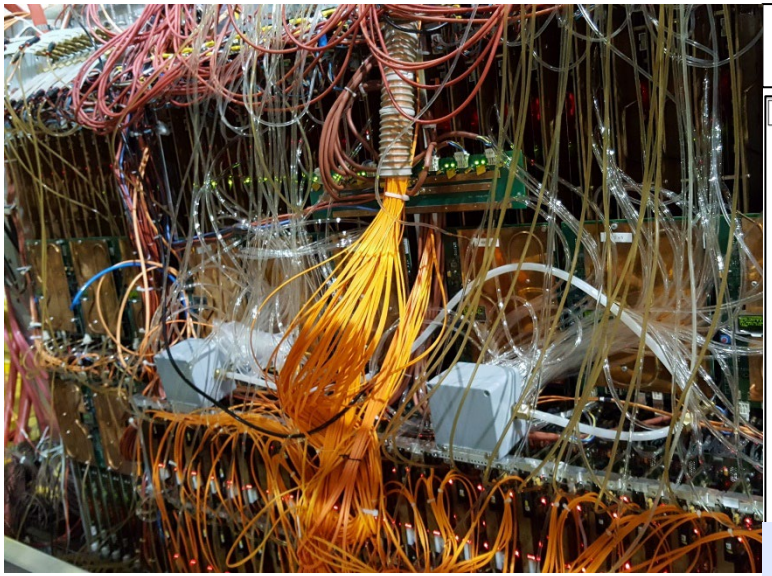
Good grounding ➔ A resilient system operating well also with some (~0.1%) anodic pads shorted to ground

Noise level for ~62k APV channels

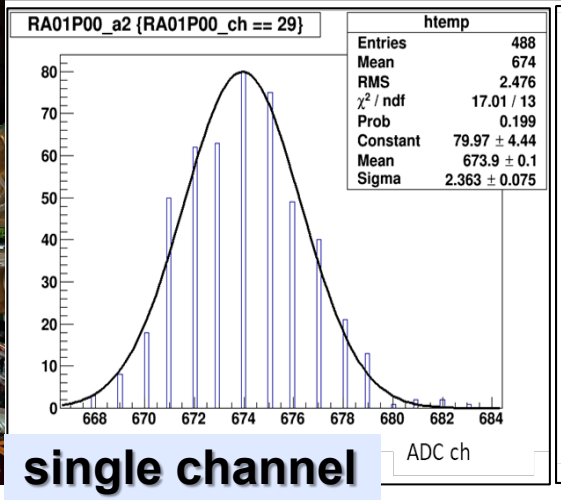


Color scale in ADC channels (~300 e^-/ch)

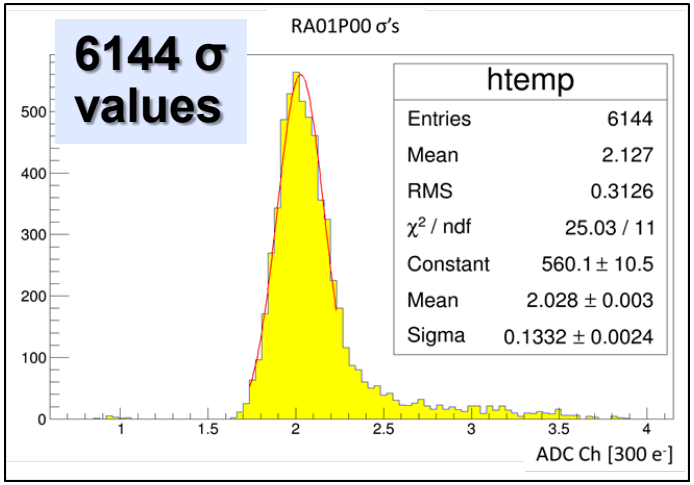
Noise level and pedestal stability



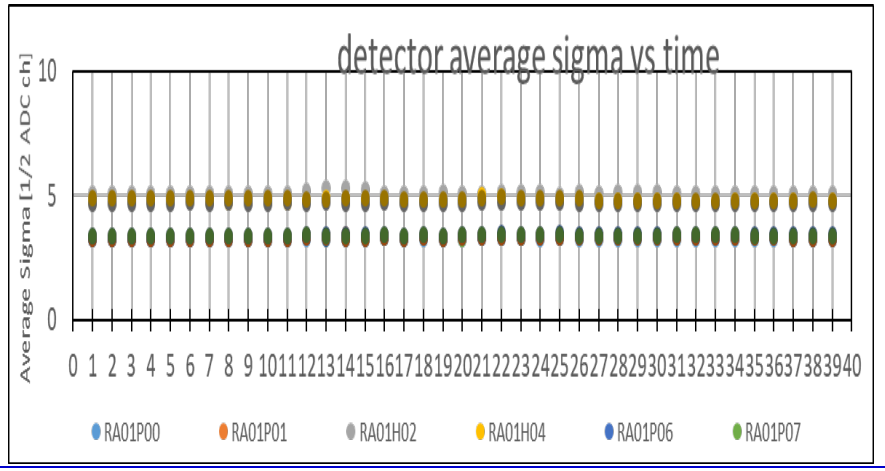
- 12 Detectors, 6144 Ch each.

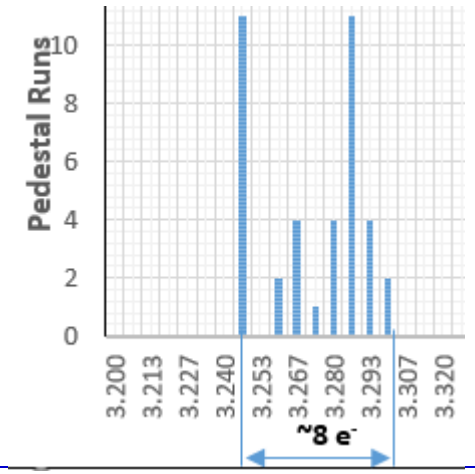


single channel



- 39 APV Pedestal Runs during COMPASS 2017 run.





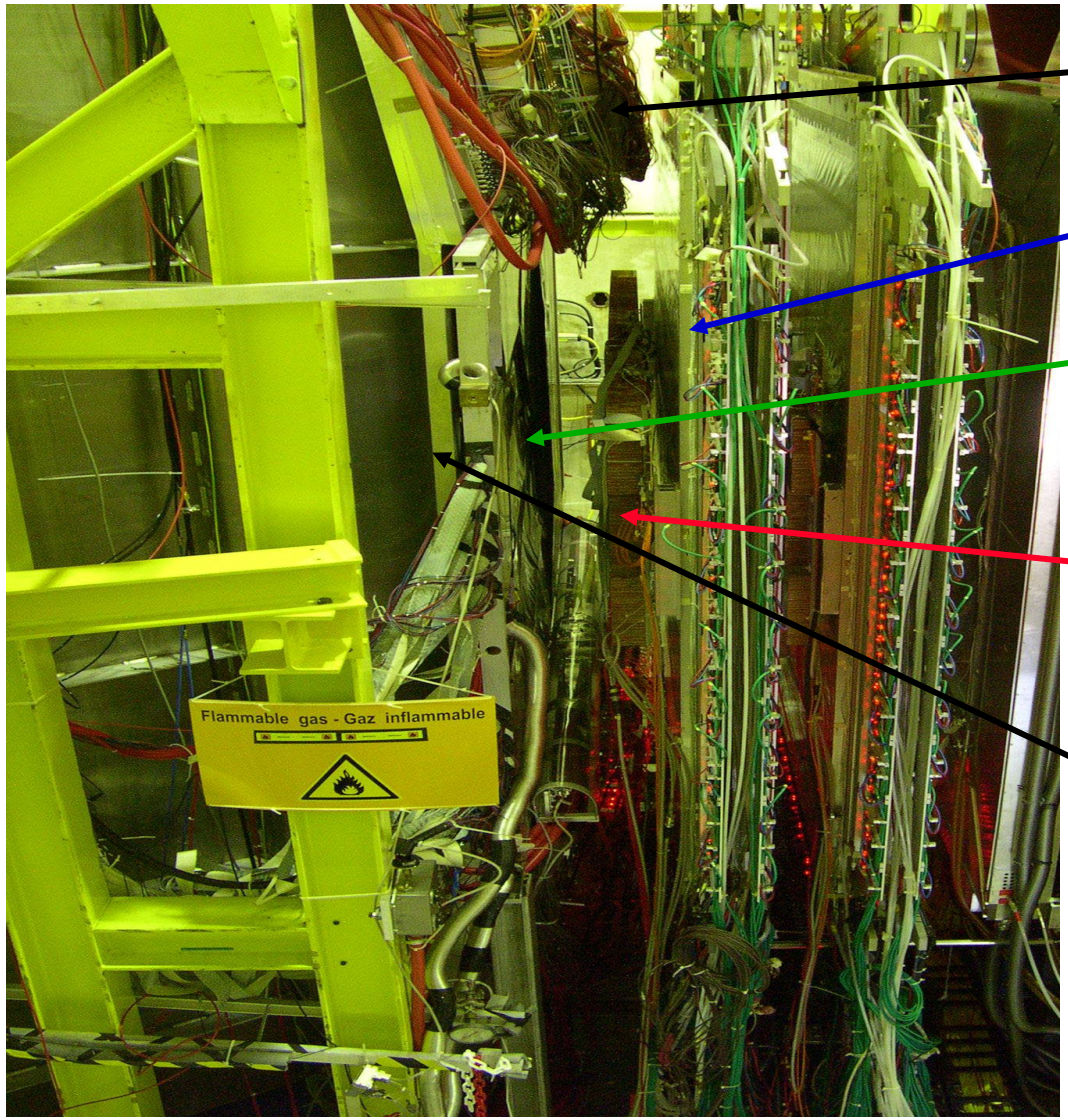
The APV-based F/E is the same for MWPCs +CsI and Hybrid PD's

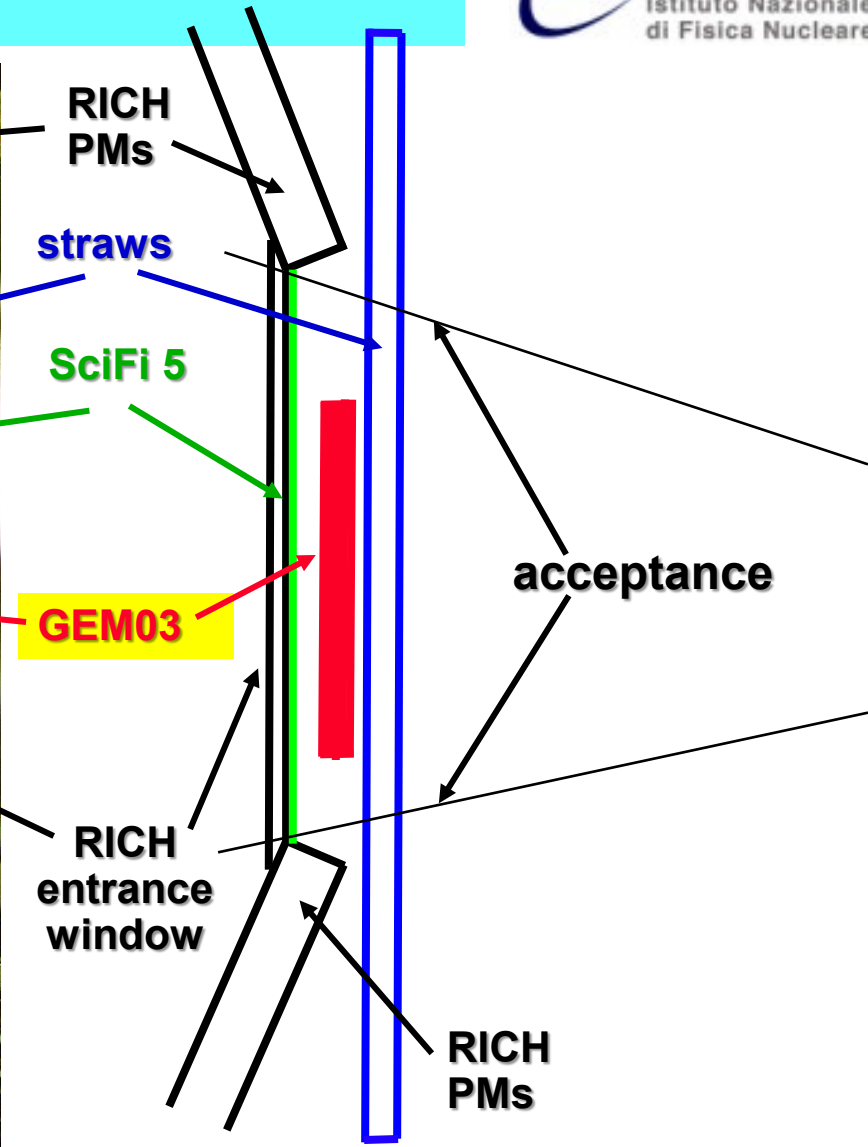
The niose levels are:

- MWPC: ~ 600 e^-
- **Hybrid: ~ 800 e^-**

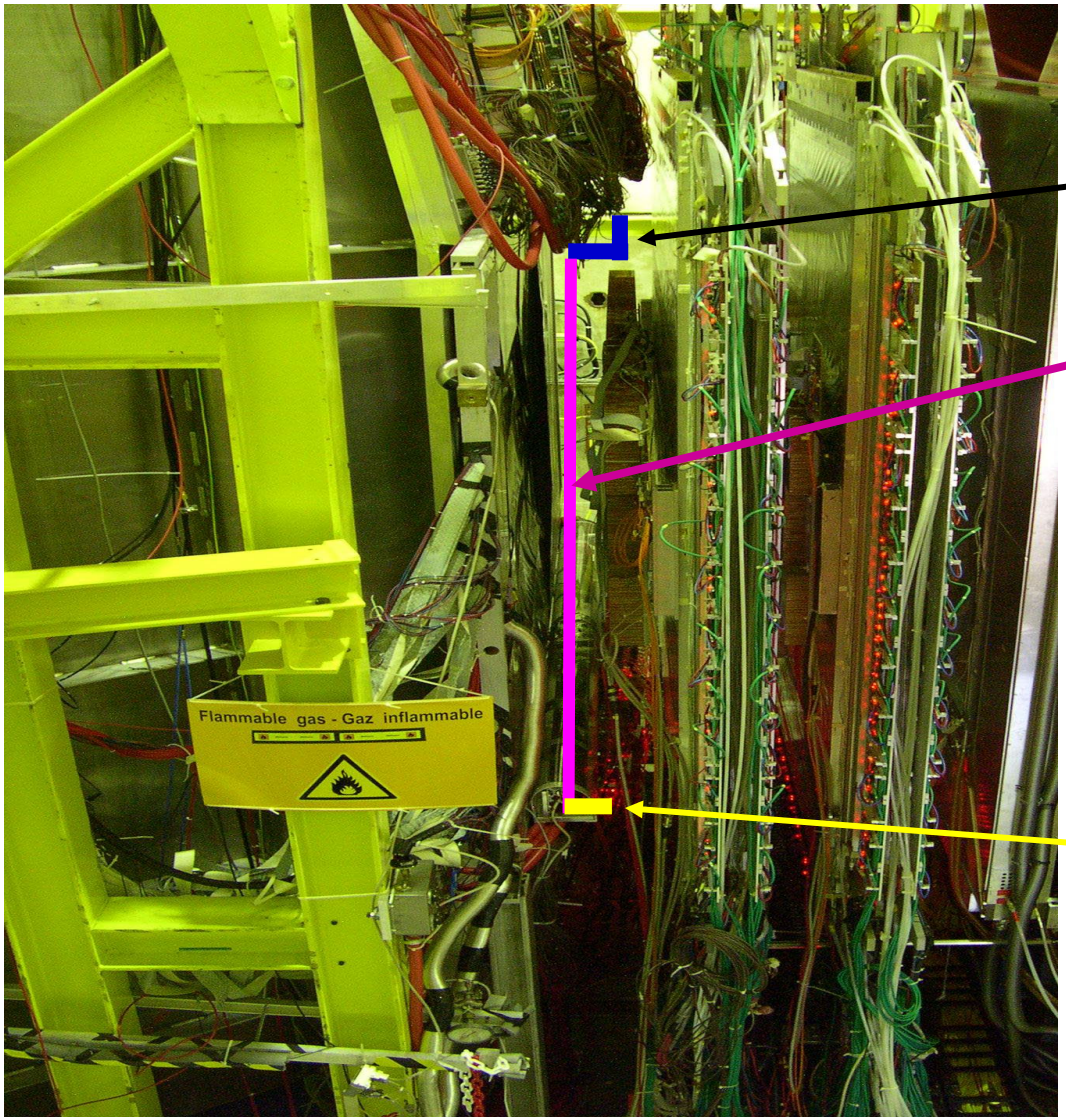
The noise levels are very stable in time

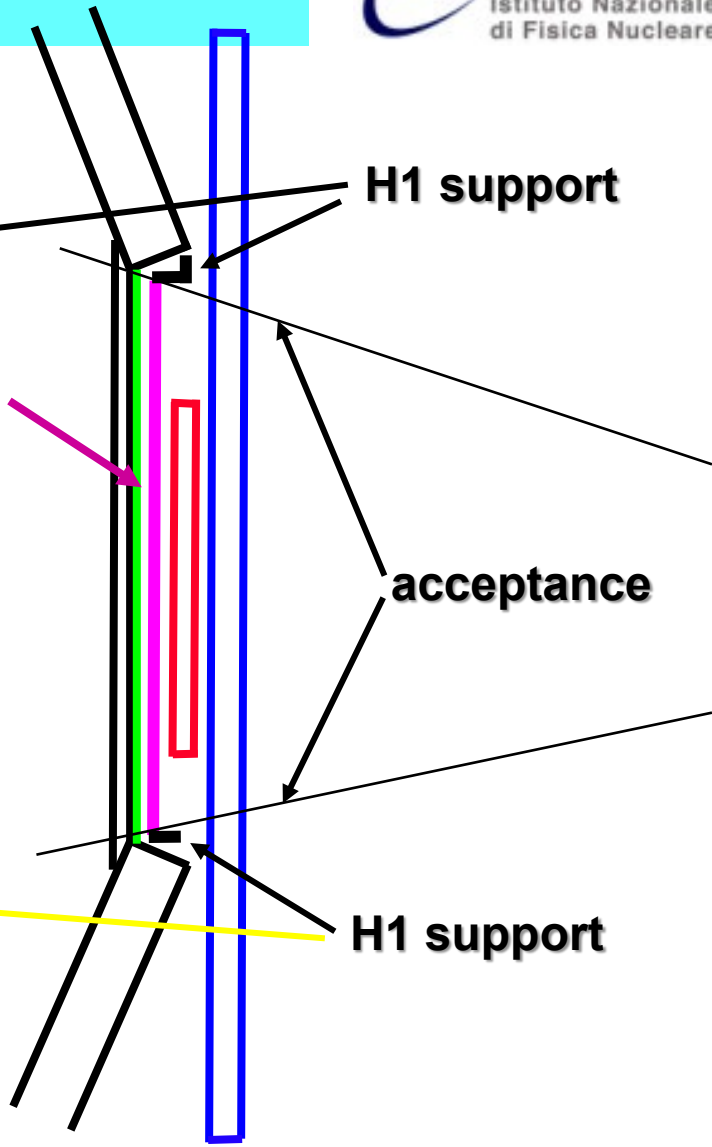
Maintaining good grounding



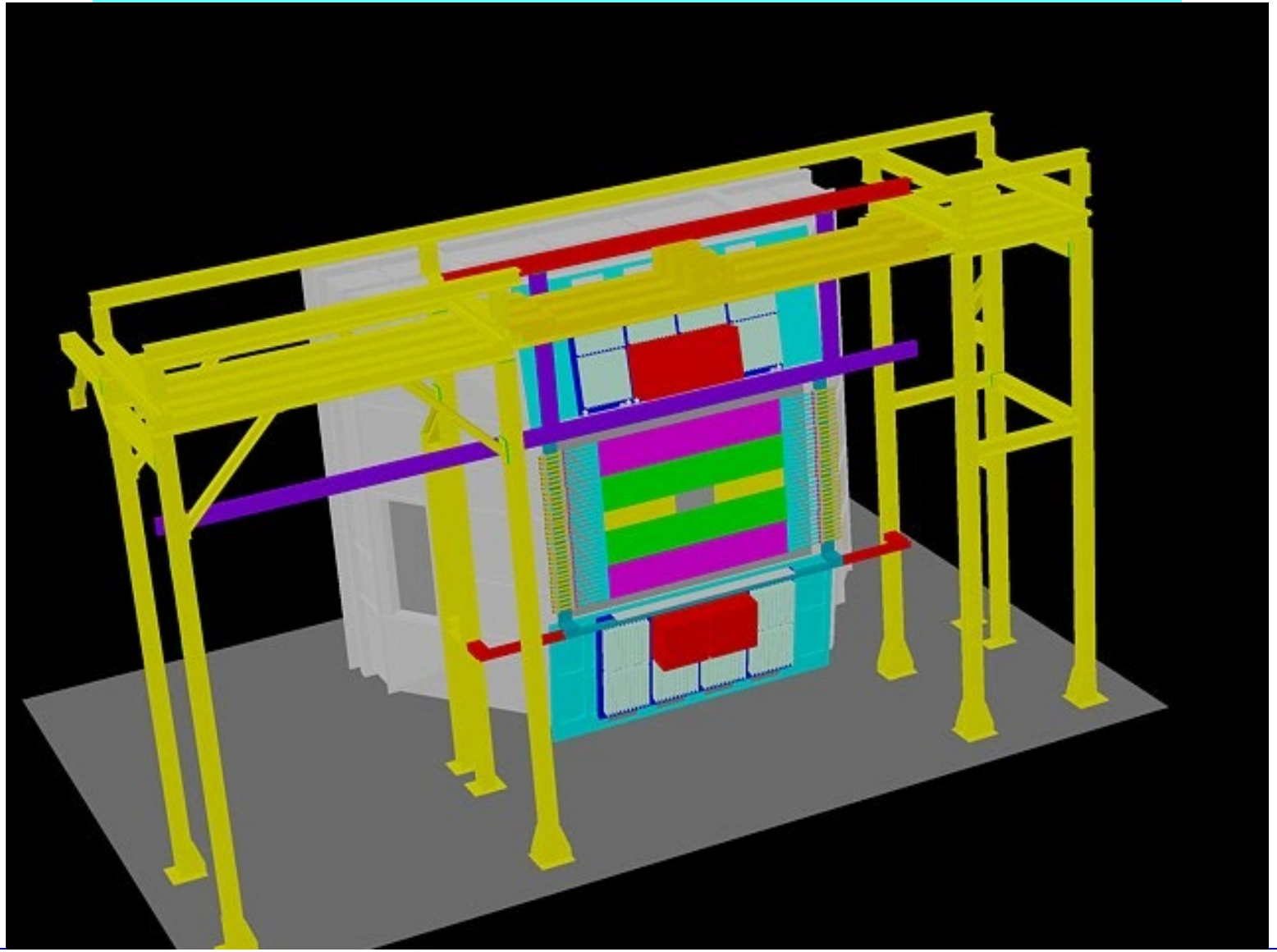


Challenging insertion of H1

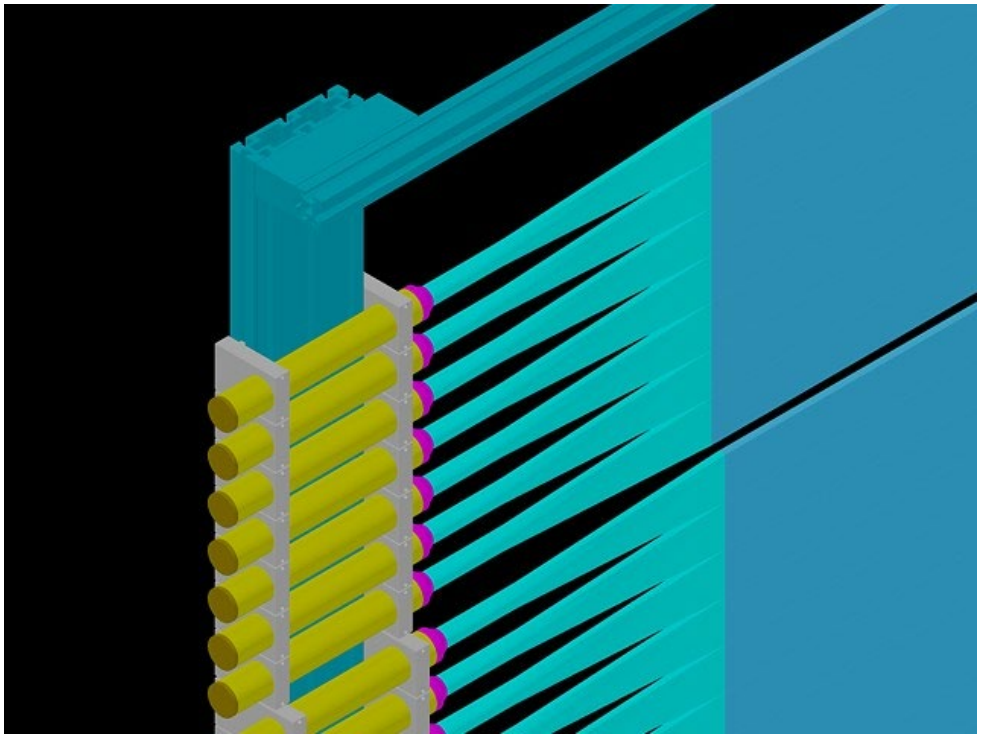


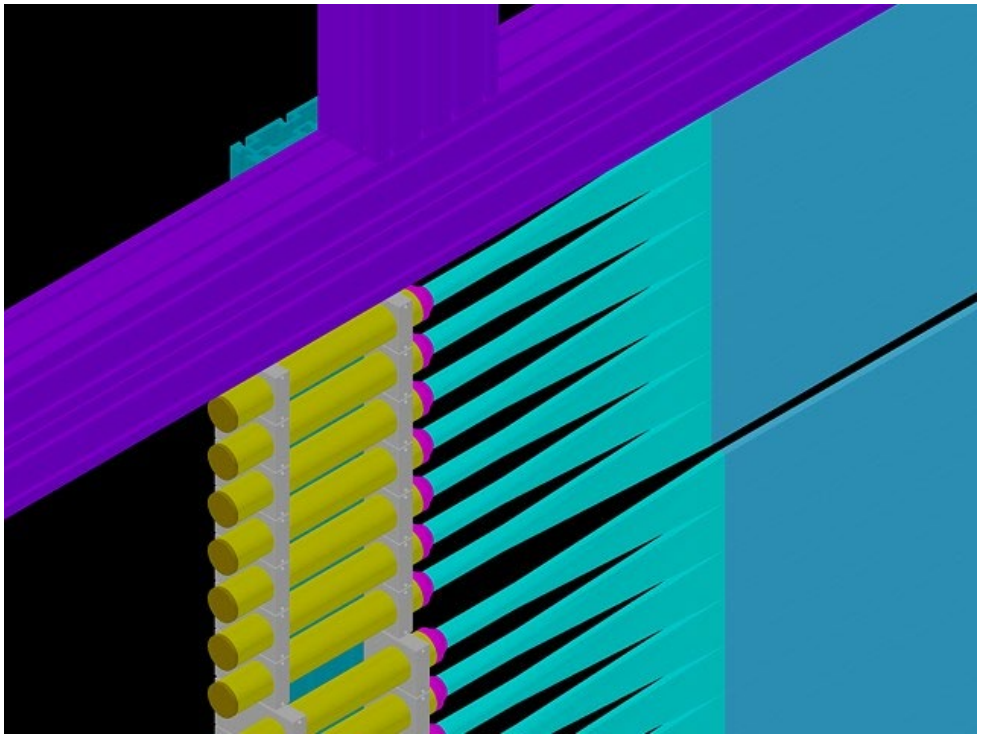


Solution

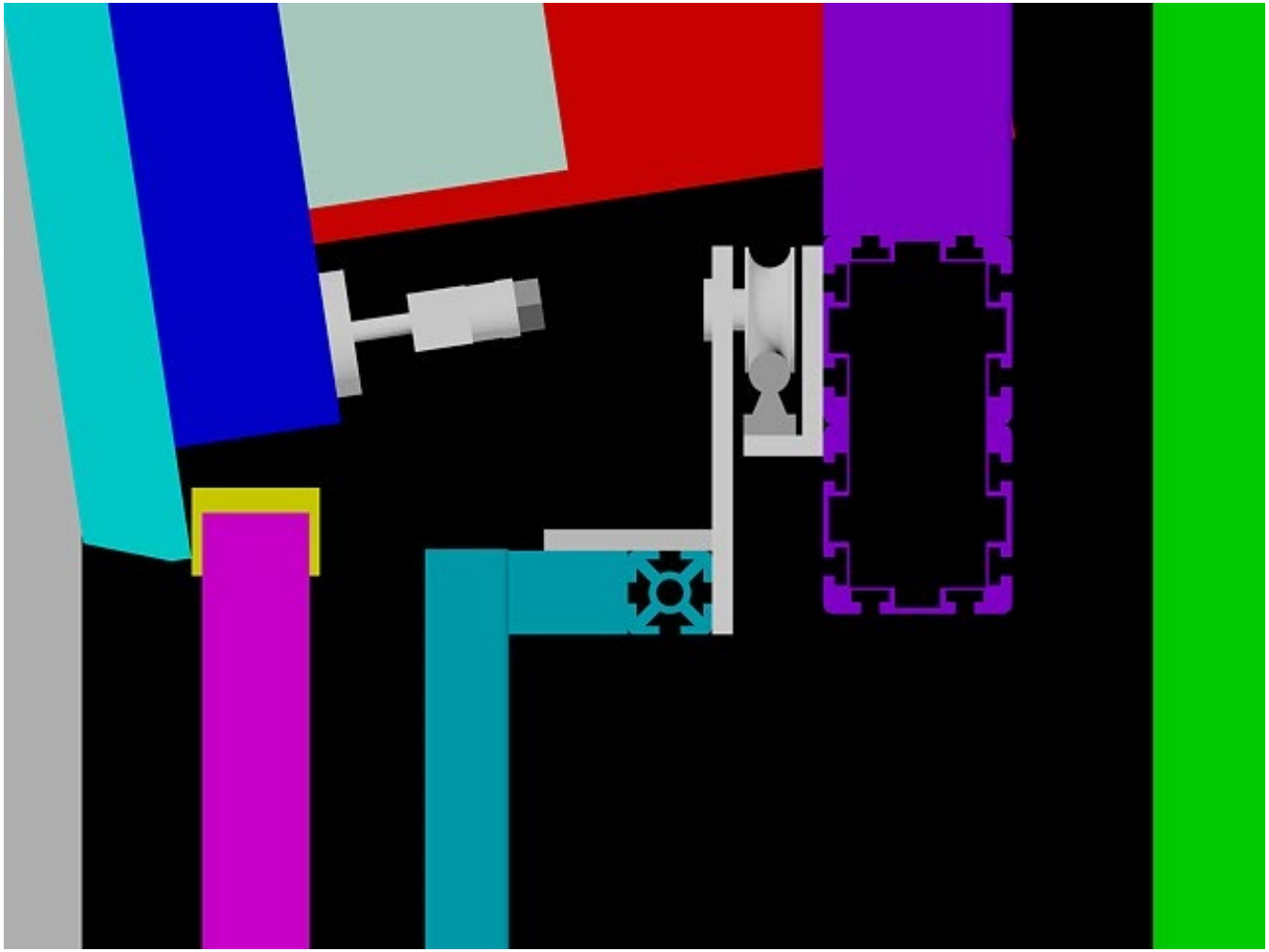


Solution





Solution



COMPASS H1 detector hanging on beams decoupled from RICH grounding