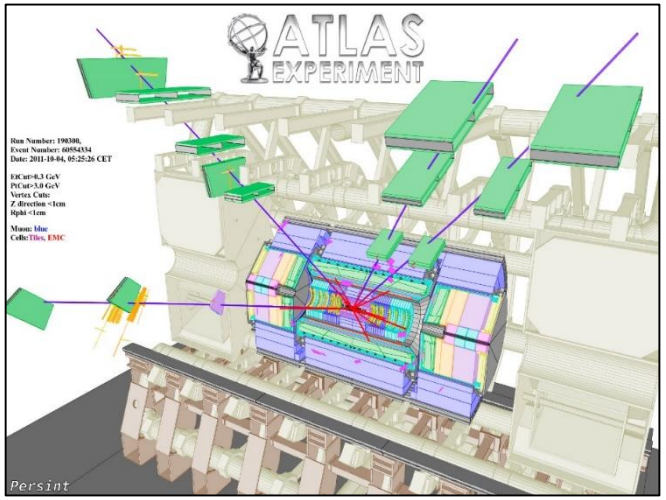
DE LA RECHERCHE À L'INDUSTRIE

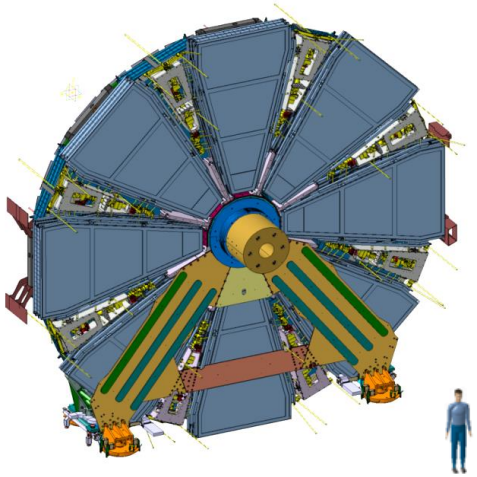
cea

The ATLAS – NSW project

(New Small Wheel)

Updated !





Philippe Schune
for the ATLAS-Saclay NSW group

CEA, Paris – Saclay
Paris – Saclay University

France – Ukraine workshop
IJCLab, univ. Paris – Sud, 20/10/2020

université PARIS-SACLAY

www.cea.fr

Irfu.cea.fr

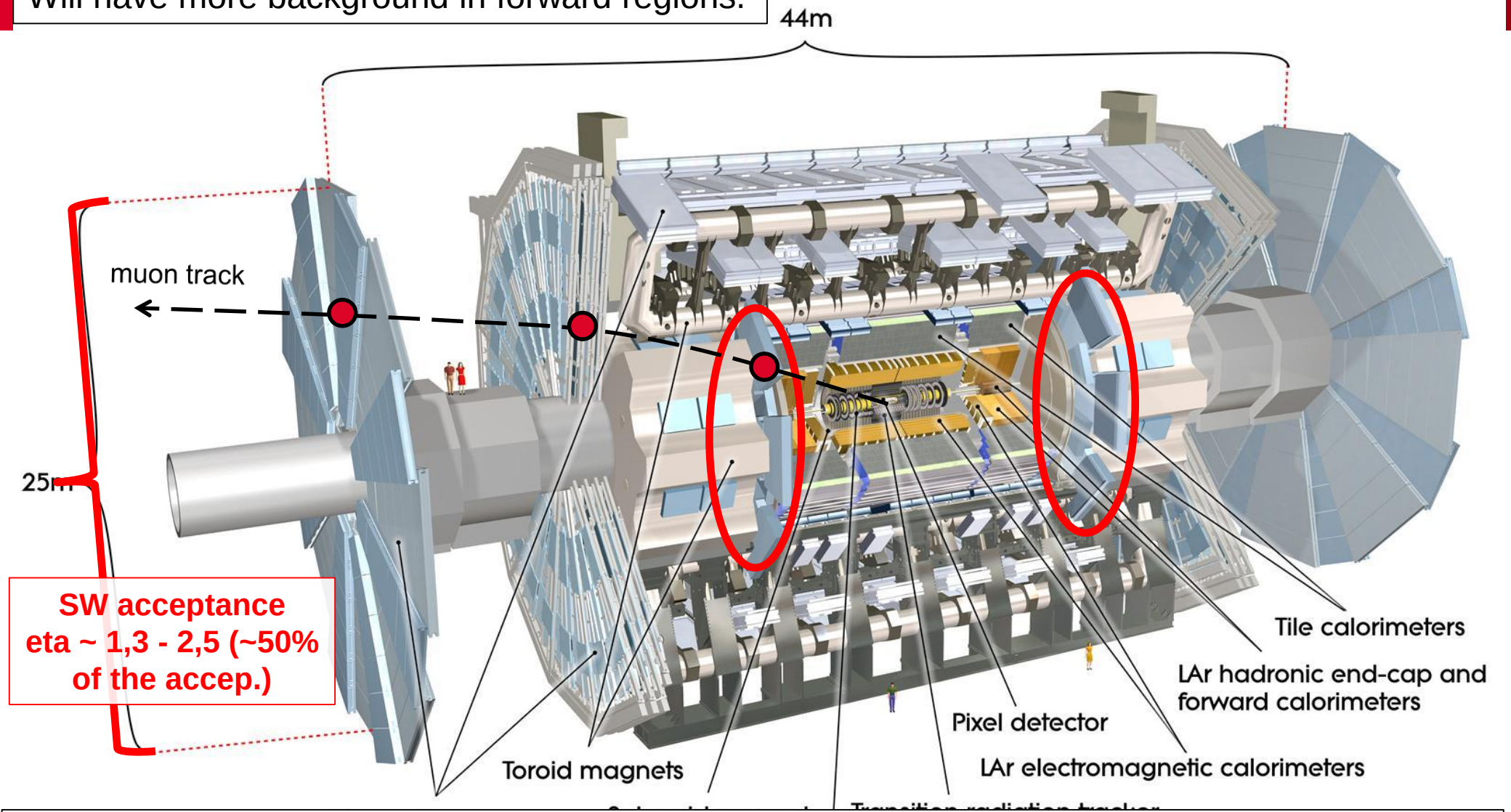
2019 layout :

- ATLAS NSW muon s [illegible] view of HL-LHC
- The NSW project
  - Description *(sTGC MWPC detector type)*
  - MM *MPGD detector type*
    - Design, construction and metrology
    - Functioning
    - Production
- NSW status as conclusion

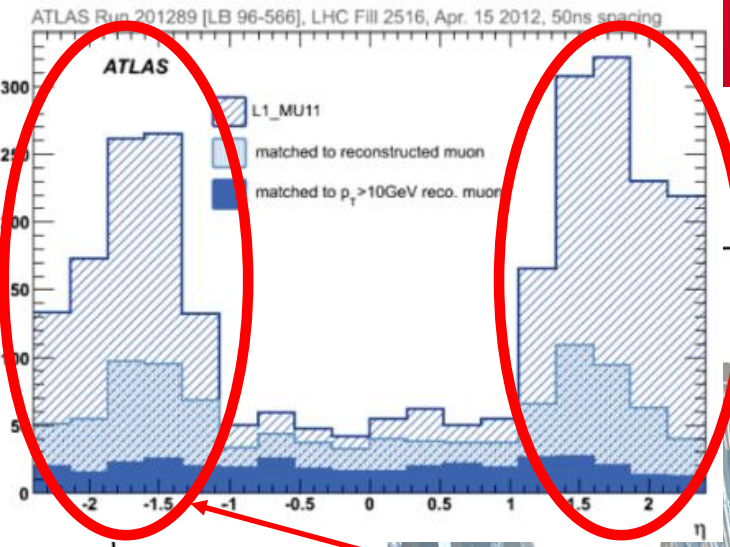
2020 :

In this talk, we will discuss practical details, and some parameters and working conditions of our (built) Micromegas detectors.

HL-LHC => x5 present Luminosity
Will have more background in forward regions.



Muon sagitta is only ~500 micron at momentum of 1 TeV
15% measurement => 75 microns measurement precision
Thus detector resolution should be ~50 - 100 microns **with aligt + B-field knowledge + detector construction negligible** !



At $L = 3x10^{34}$

Single μ L1 rate (kHz)

	Mu20	Mu40
Without NSW	60	29
With NSW	22	10

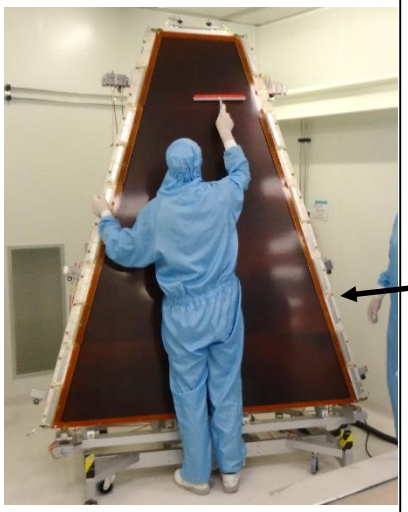
NSW-A installation : ~09/2021
NSW-C installation during LS2 ? **not yet decided…**

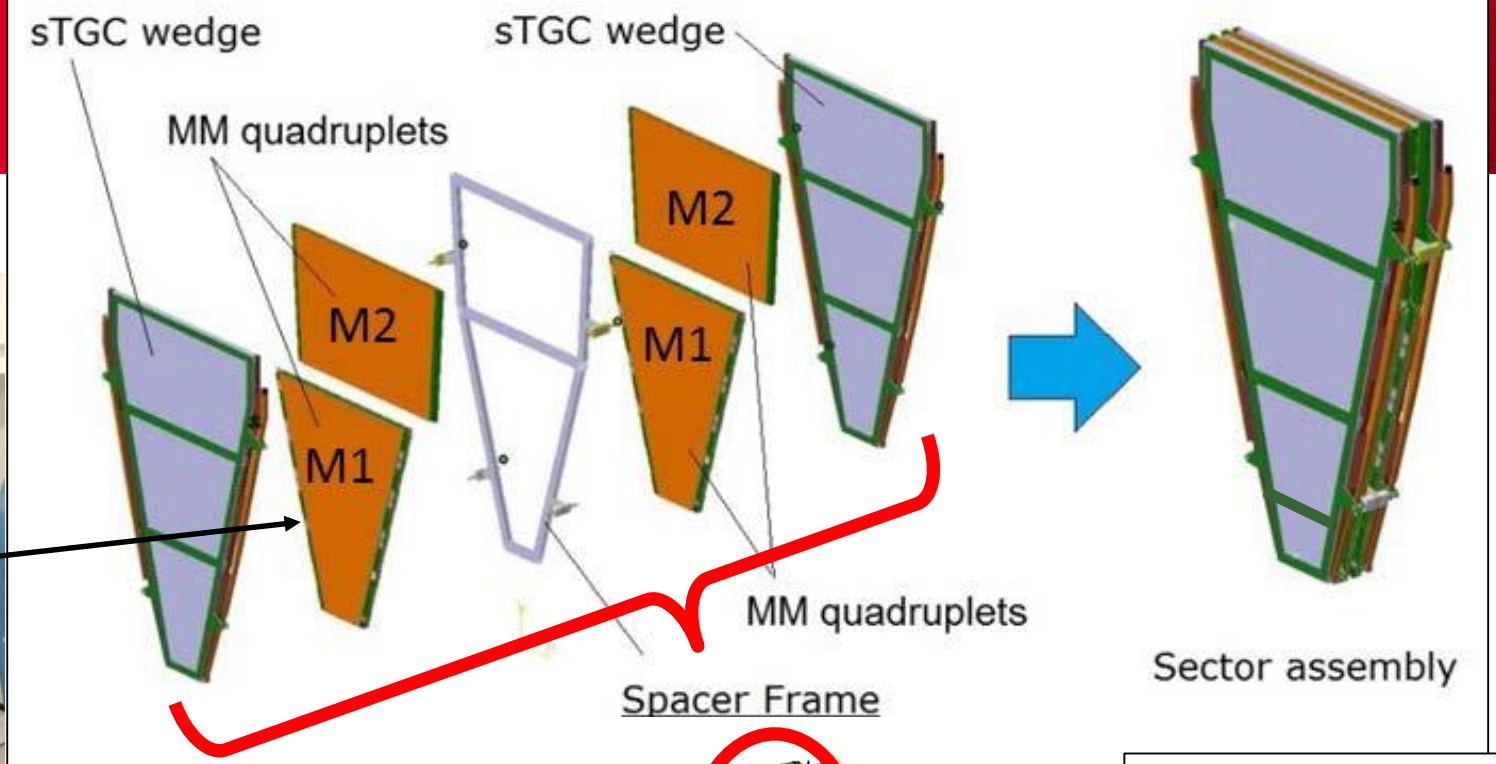
NSW should have :

Total resolution on precision coordinate of a muon track, i.e. sag. measurement : ~50 microns

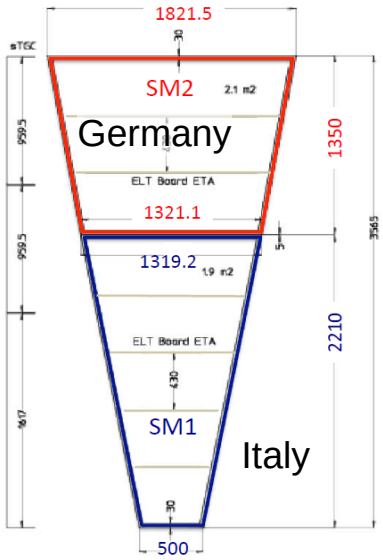
Trigger L1 capability with angular track recons. of ~1mrad

Resist to high background from m.i.p. up to neutron deposit.

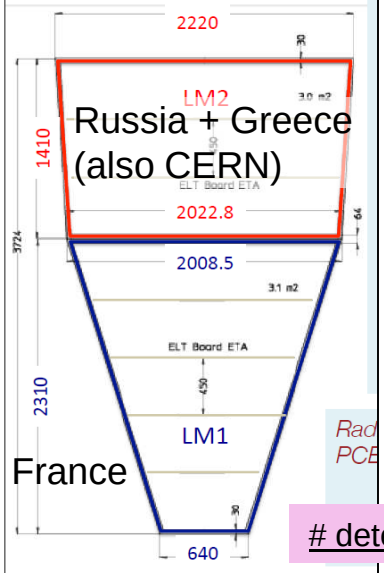


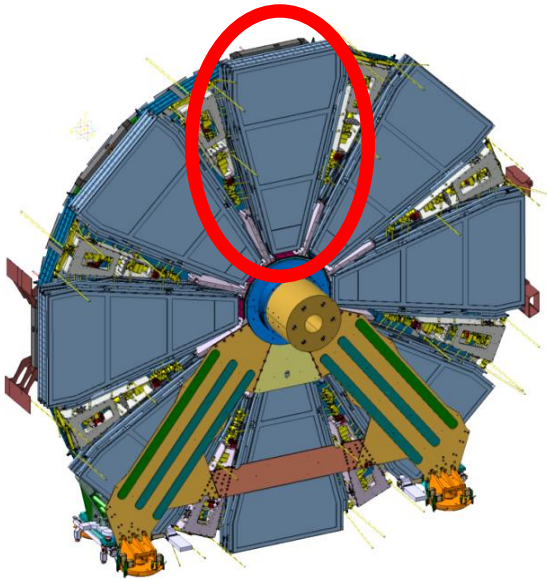


Small sector modules



Large sector modules





Each Micromegas (MPGD) and sTGC (MWPC) modules are 4 planes detector.
Each ~2 to 3 m².

<u>For Micromegas there is :</u>
8 sectors x2 modules
x 2 wheels

=> 32 modules of each type to be build (4 types)

<u># detectors build:</u> Italy 100% - last week, Germany 90%, Saclay 66%, Russia+Greece ~55%

Principle of Micromegas MPGD detector

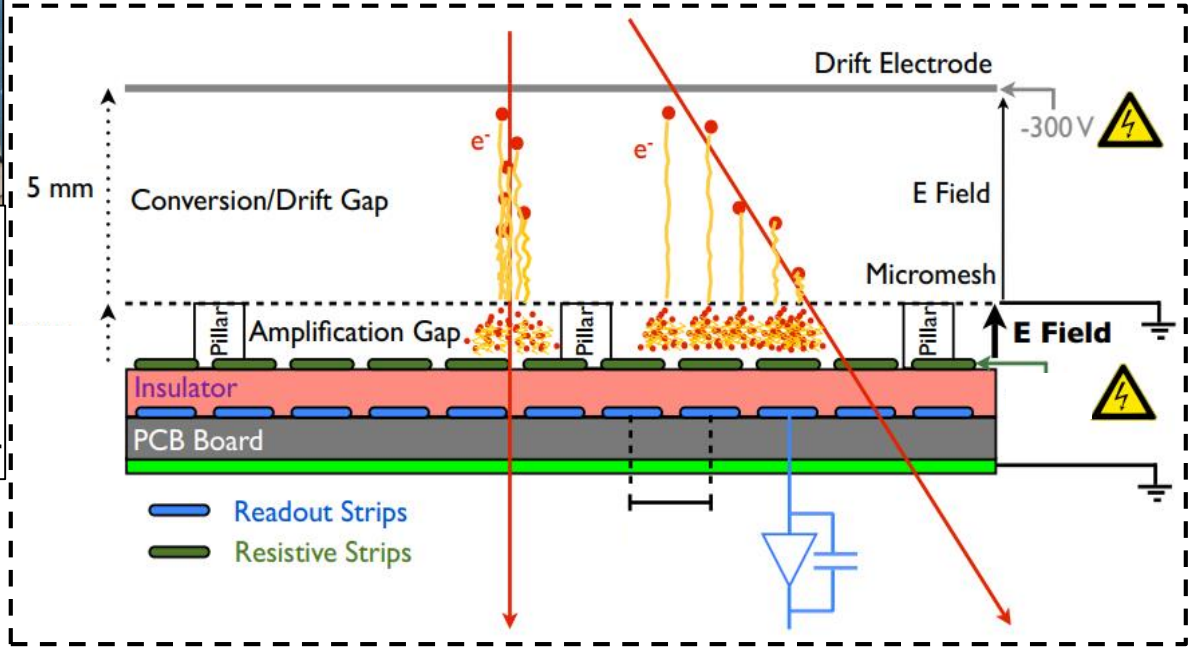
Nominal values :

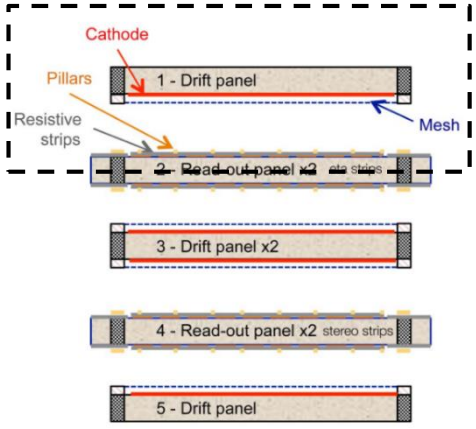
- 15 kHz / cm2 max flux
- Gas: Ar + 7% CO2 *(also considered to have +2% iso-C_4H_{10})*
- Drift HV: 300 V
- Nominal amplification HV: 570 V
- Pilars height ~120 μm *(should have been 128 μm)*
- Gain ~8000

Saclay MM :
5 RO PCB / gap,
width 45 cm, L=0.6 to 2m,
1024 strips each.
Strip pitch is 450 μm.
=> 20 k chanels / detector

MM used in (micro-) TPC mode to recover resolution.

The mesh - stainless steel tissue with wires 30 μm ∅ - is glued on the cathode panel.

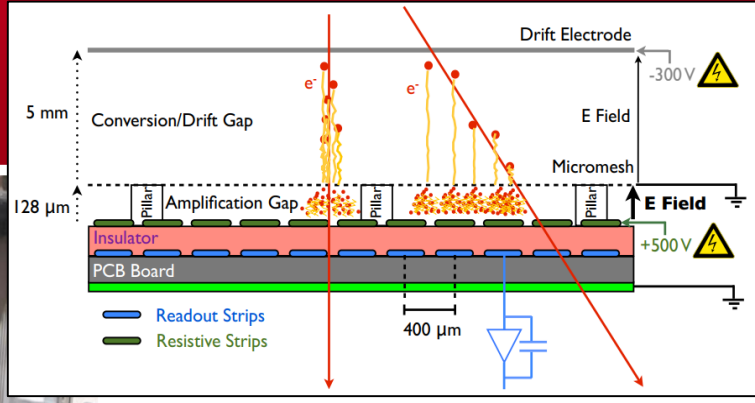




Explained in 2019

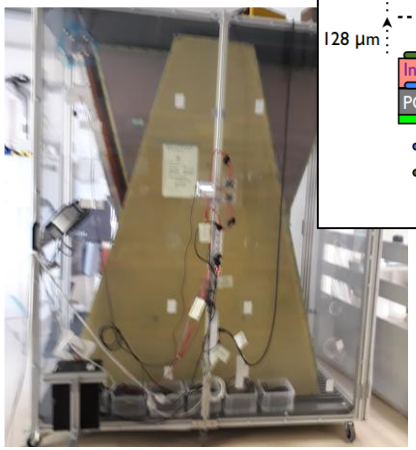
Mechanical construction precision : ~50 microns within the meas. plane
~100 microns perp. to " " "

Fighting pollution, dusts, etc.

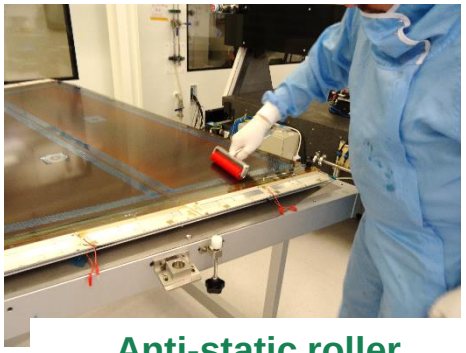


Readout panel washing

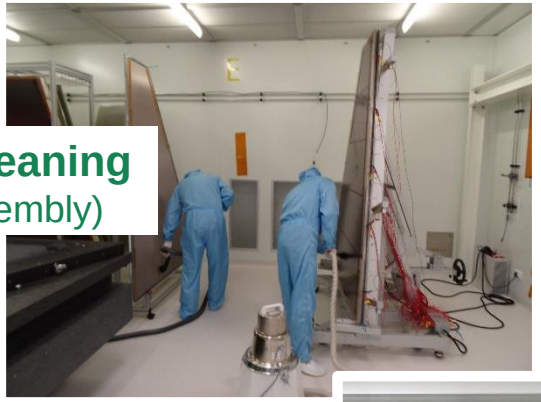
Mesh washing
before gluing to drift panel



Drying box for panels



Anti-static roller cleaning (before passivation)

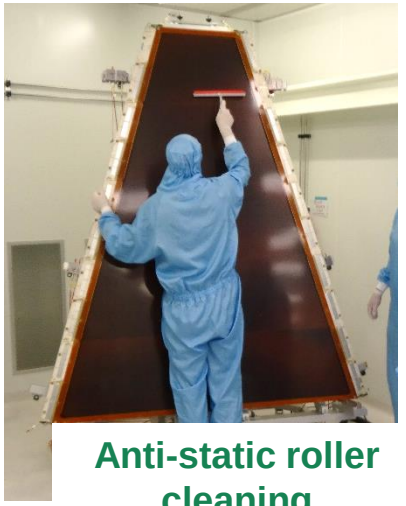


Vacuum cleaning
(before assembly)

Cleaning the Module assembly area

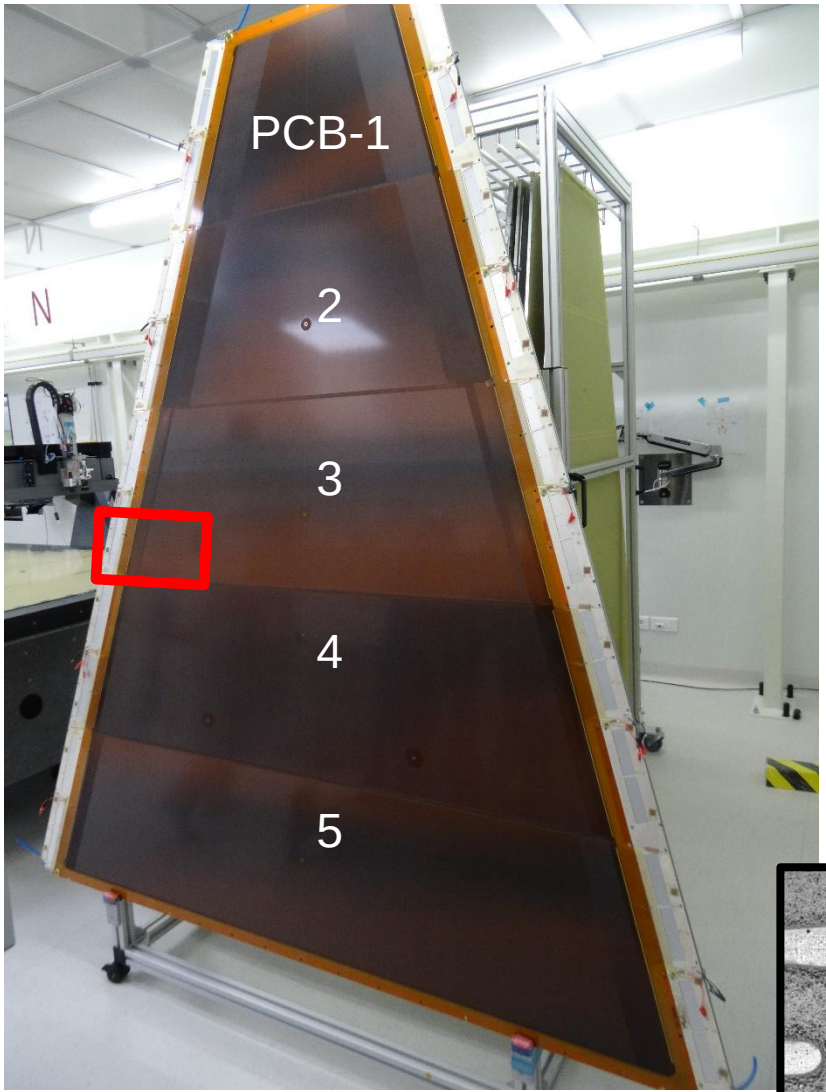
iso-propanol cleaning
(before assembly)

O-ring cleaning



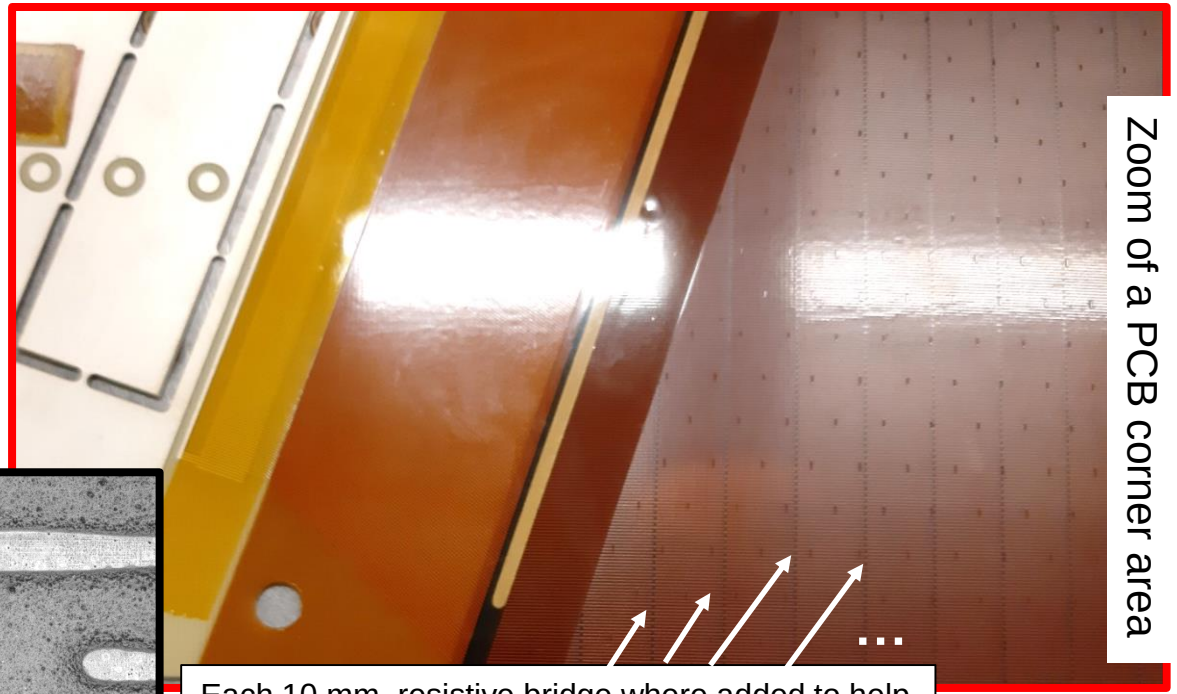
Anti-static roller cleaning

Details of a RO panel

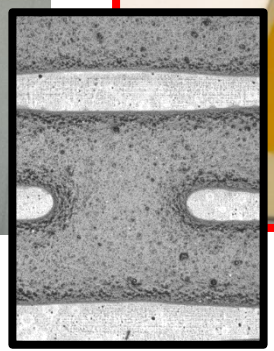


Kapton foil + resist : Japan contribution

RO elx area
RO Cu-strips
Kapton foil
Silver Line HV "wall" (passivated area (in Pyralux
Resistive strips area on top of Cu strips



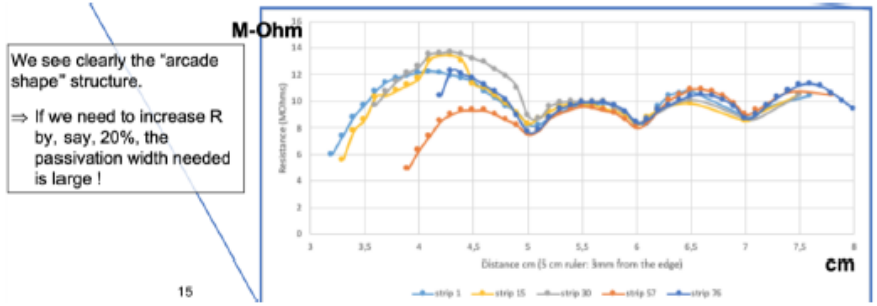
Zoom of a PCB corner area



Each 10 mm, resistive bridge where added to help evacuating avalanche charges between several strips. Problem : it decreases the local resistivity !

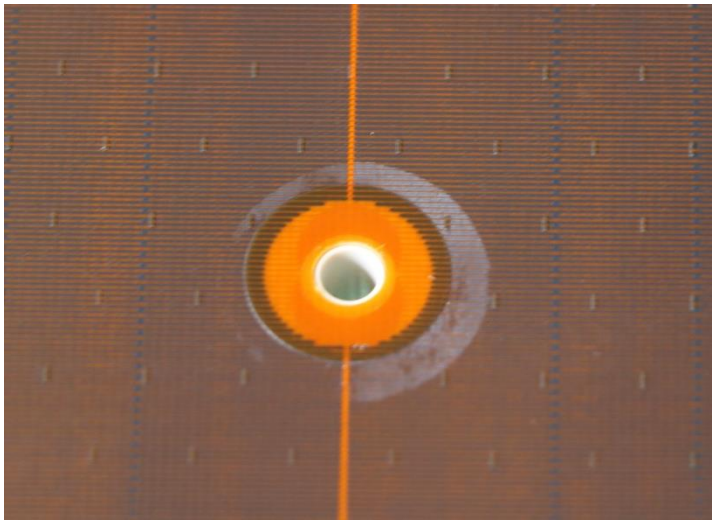
Evolution on HV Issues

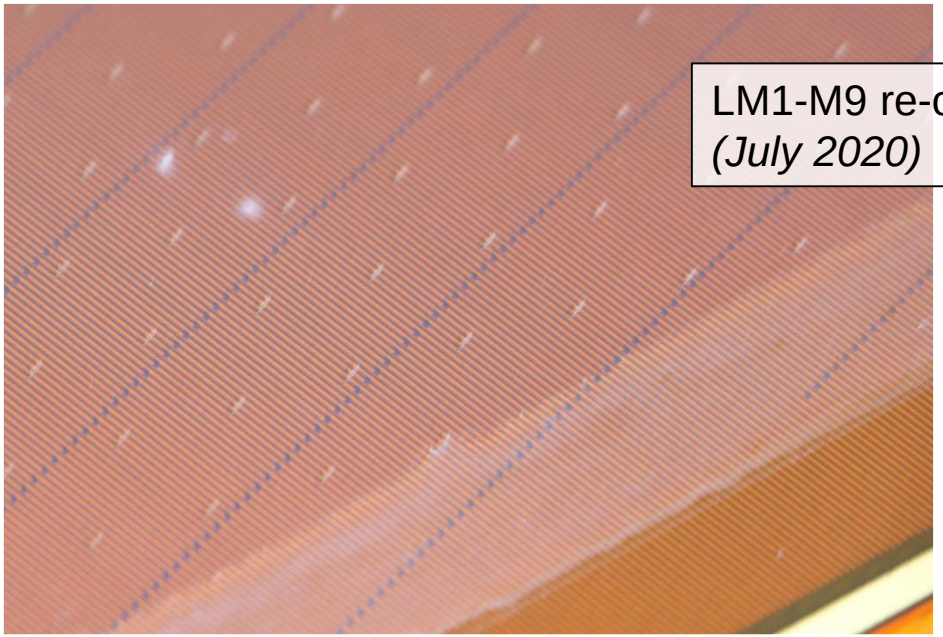
- HV sparks:
  - Triggered by: humidity, defects, ionic contamination, tails in amplification, high ionization
  - Controlled by: Resistive layer, quenching in gas
- Several issue during hot and humid summer in keeping low humidity (need high flux an long flushing): flush modules/DW well in advance the tests
- Deal with very low resistance (mostly in Large modules LM1 in particular)
- No much help from passivation in these cases



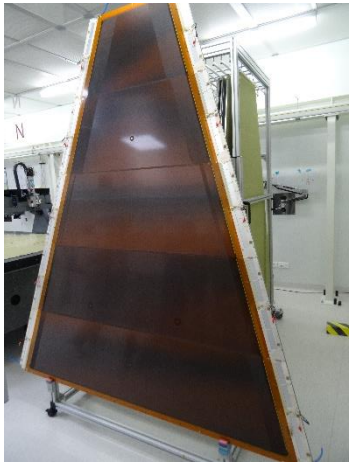
Slow increase in Resistance
Would need to passivate/lose a lot of active area

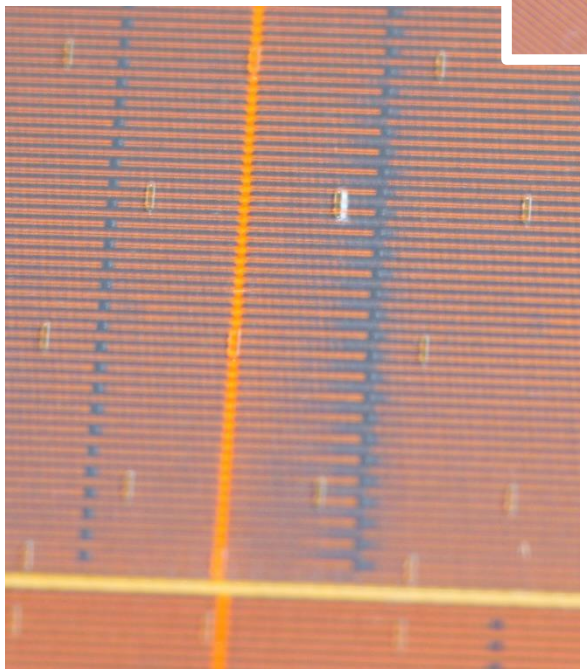
Example of damage area *because of too much - local - sparking*

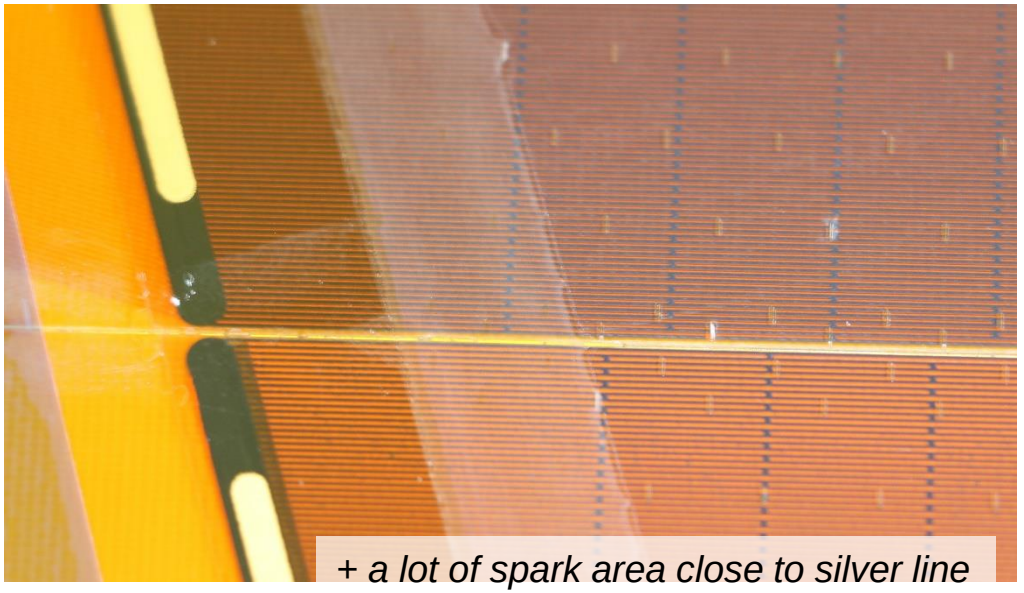




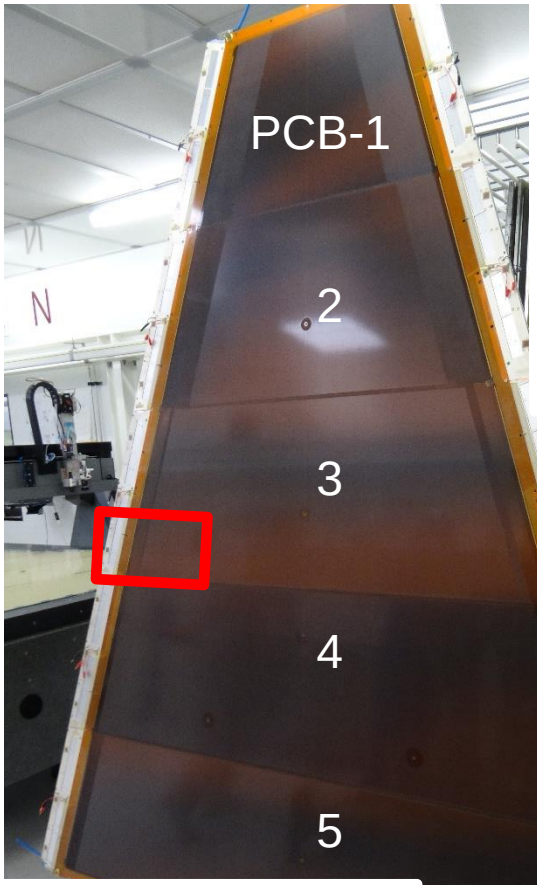
LM1-M9 re-opening
(July 2020)

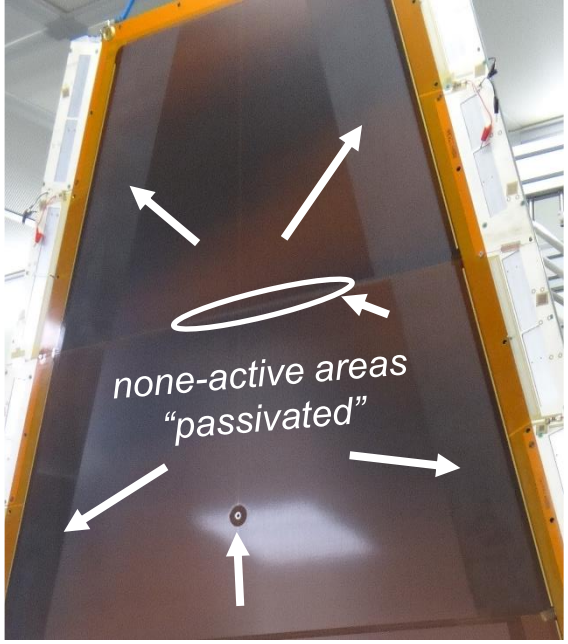


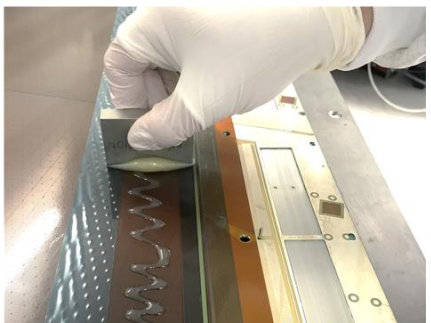




+ a lot of spark area close to silver line







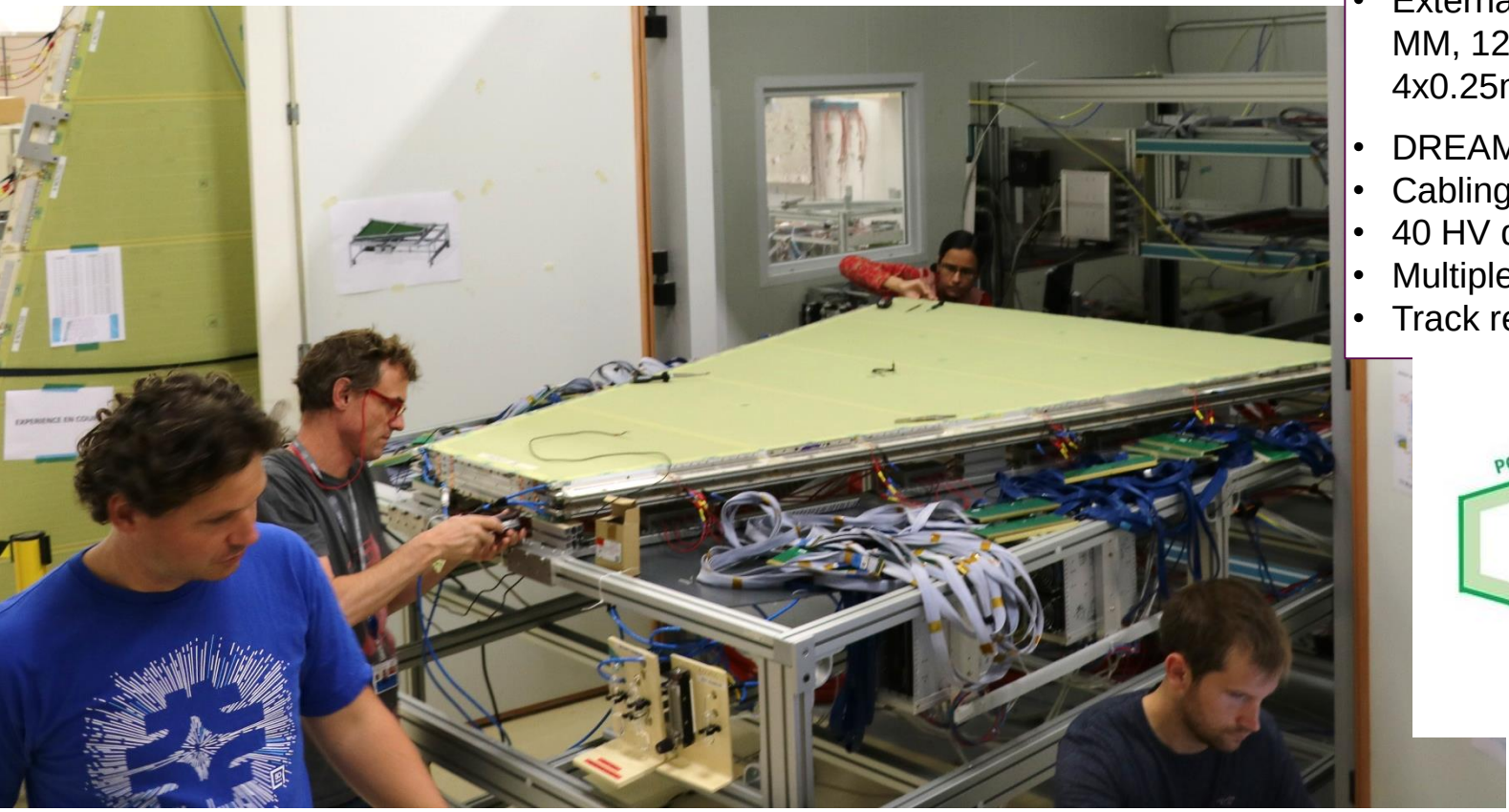
Kapton foil + resist : Japan contribution

RO elx area
RO Cu-strips
Kapton foil
Silver Line HV "wall" (passivated area (in Pyralux
Resistive strips area on top of Cu strips

Zoom of a PCB corner area

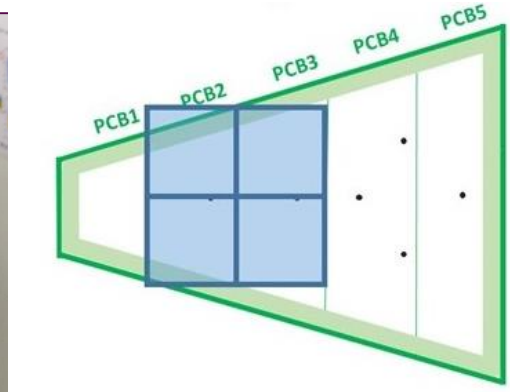
Cosmic bench to qualify a MM Module

- Gain curve values for each gap
- Efficiency values



Cosmic bench composition:

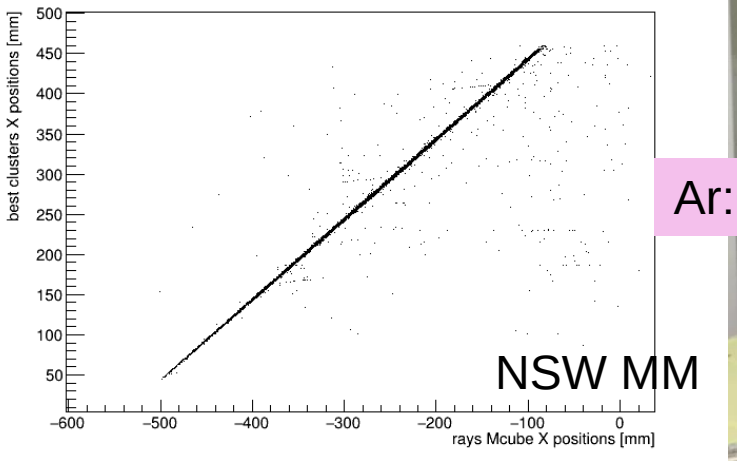
- External tomograph (3 layers of 2D MM, 126 μm pilars, 1cm drift, 4x0.25m^2, 16 multipl.)
- DREAM elx - timing digitization
- Cabling – micro-coaxial
- 40 HV distribution
- Multiplexing x2
- Track reconstructing algorithm



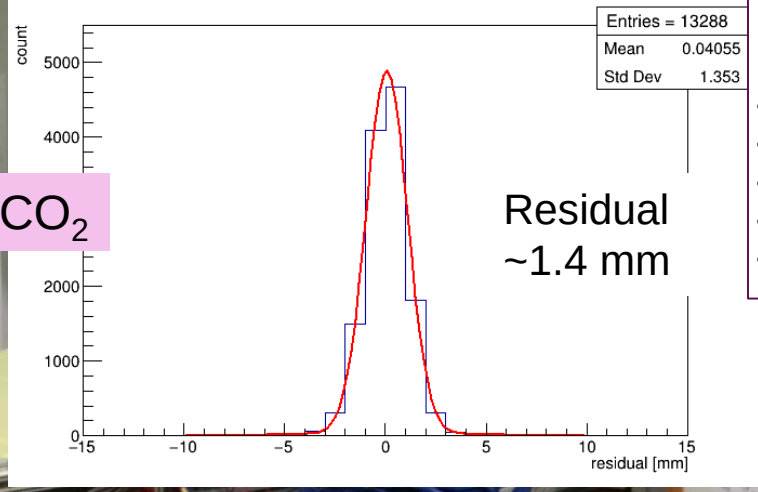
Cosmic bench to qualify a MM Module

- Gain curve values for each gap
- Efficiency values

Reference



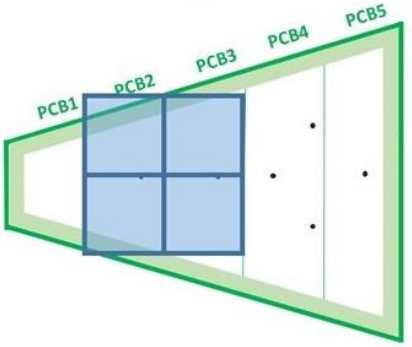
$Ar:CO_2$

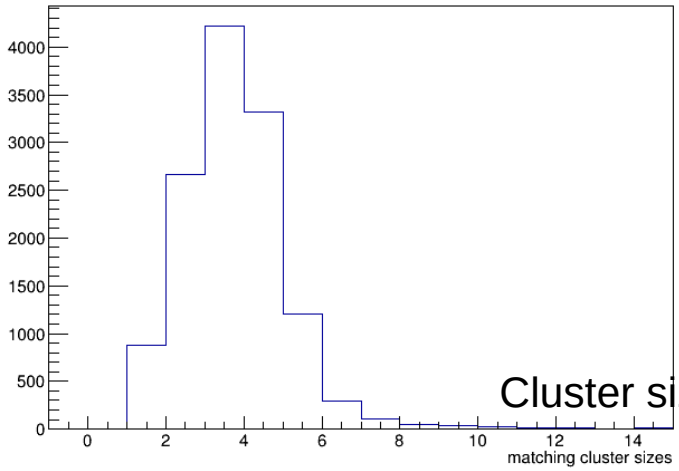


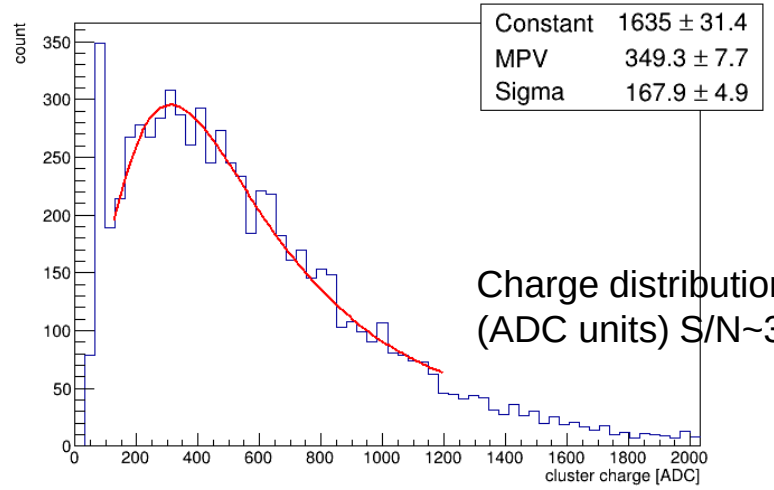
Residual
~1.4 mm

Cosmic bench composition:

- External tomograph (3 layers of 2D MM, 126 μm pilars, 1cm drift, 4x0.25m^2, 16 multipl.)
- DREAM elx - timing digitization
- Cabling – micro-coaxial
- 40 HV distribution
- Multiplexing x2
- Track reconstructing algorithm







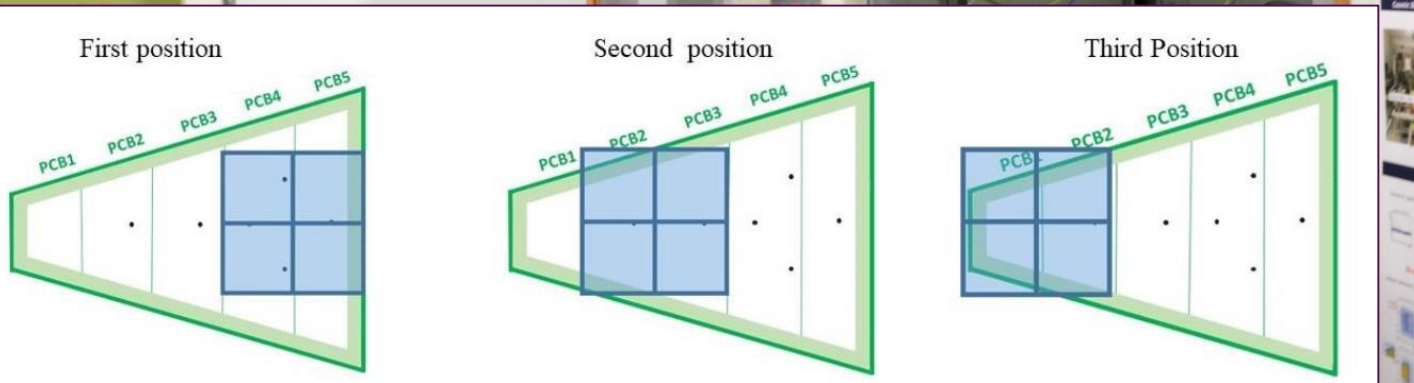
Charge distribution of clusters (ADC units) S/N~3.5

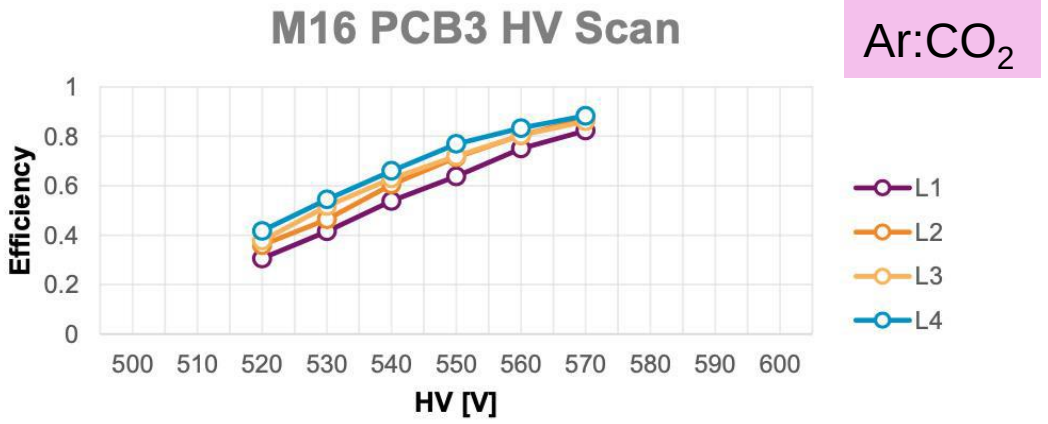
Cosmic bench to qualify a MM Module

- Gain curve values for each gap (per ~3x3cm^2 size)
- Efficiency values

Cosmic bench composition:

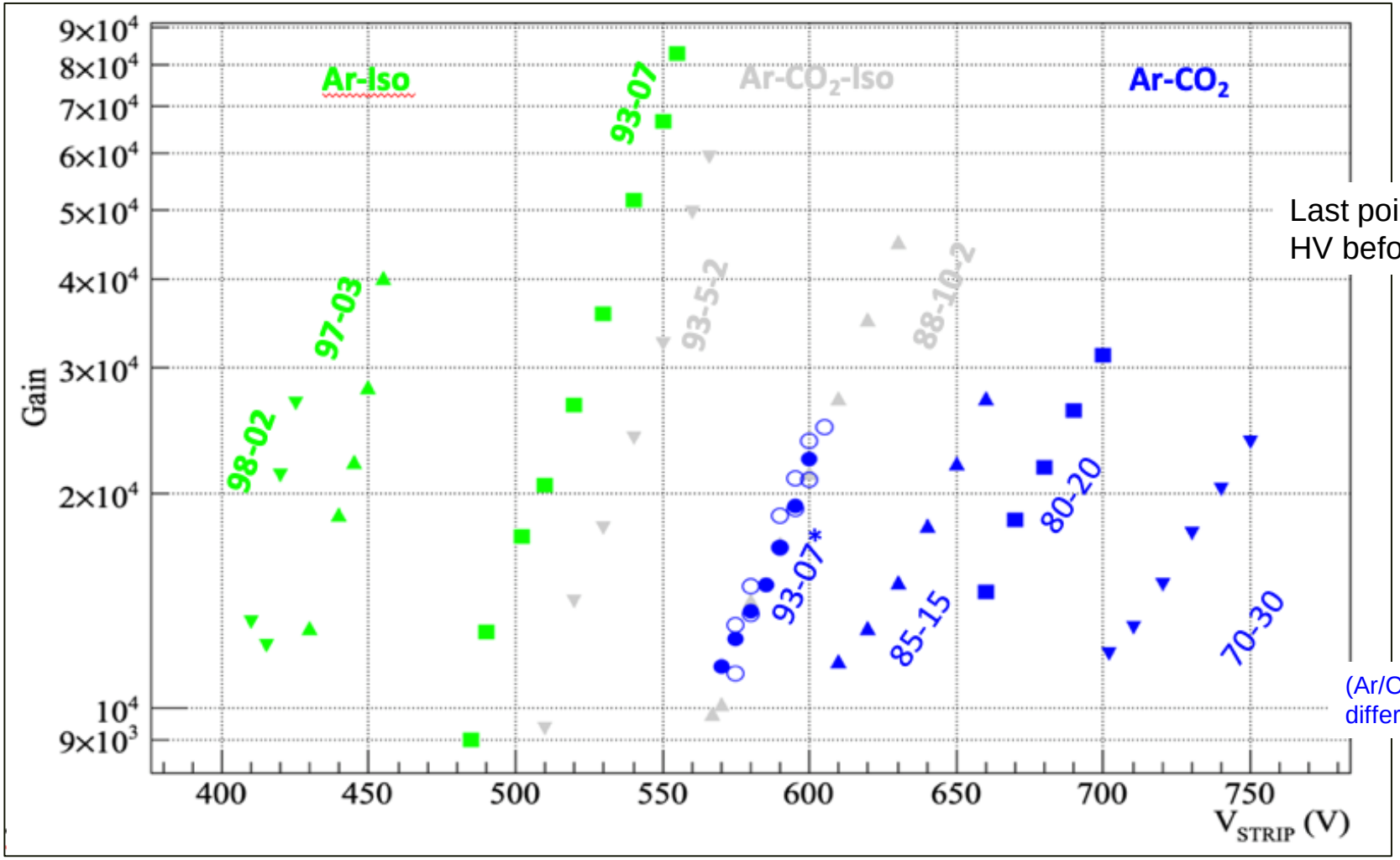
- External tomograph (3 layers of 2D MM, 126 μm pilars, 1cm drift, 4x0.25m^2, 16 multipl.)
- DREAM elx - timing digitization
- Cabling – micro-coaxial
- 40 HV distribution
- Multiplexing x2
- Track reconstructing algorithm





Ar:CO_2

NSW Micromegas Gain distribution w.r.t. some gas mixture



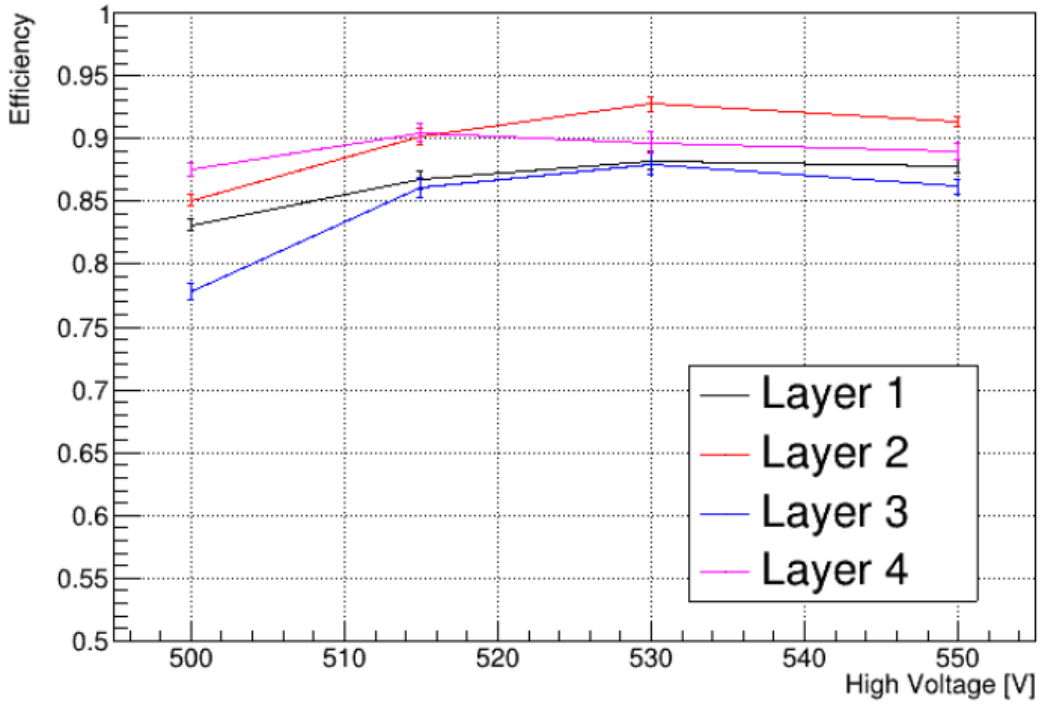
Last point is ~highest HV before instability

(Ar/CO2 93-07 : 3 different measurements)

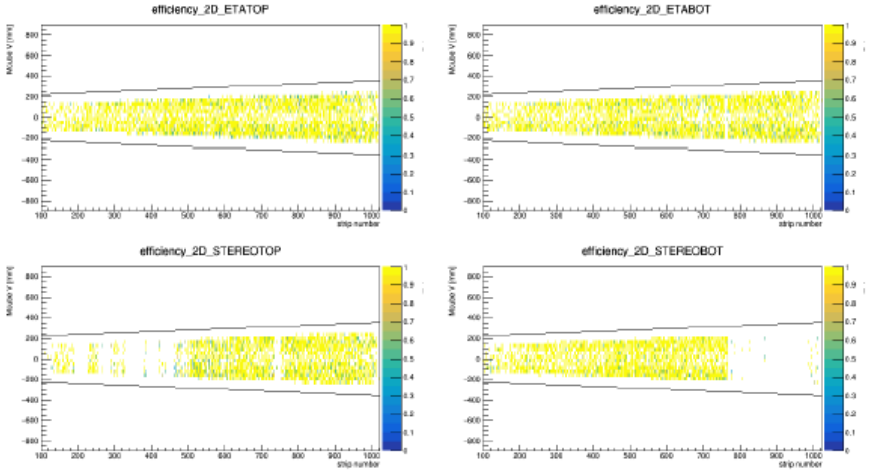
CO_2 and Iso-butane are both quencher gas.
Some penning effect occurs on Ar with Iso-butane, increasing the number of primary e-

Efficiency for Ar:CO2+2% iso-b

- M25 data taking with ar-co2-iso 93/5/2 to crosscheck previous results from 2019 and 2018



Efficiency at 500V

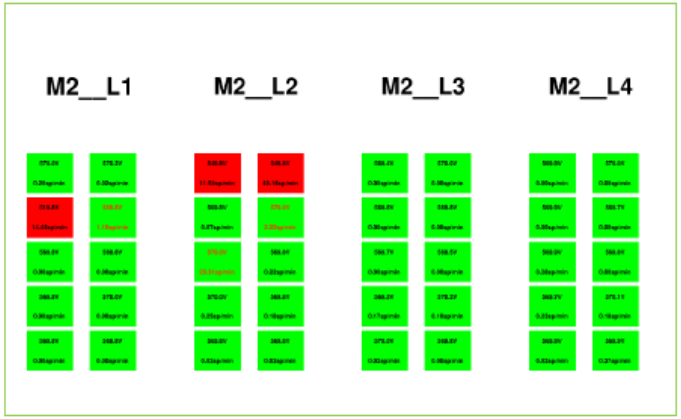


MPV [ADC]	Layer 1	Layer 2	Layer 3	Layer 4
500 V	276.3	224.7	200.7	309.1
515 V	409.1	346.8	292.6	464.8

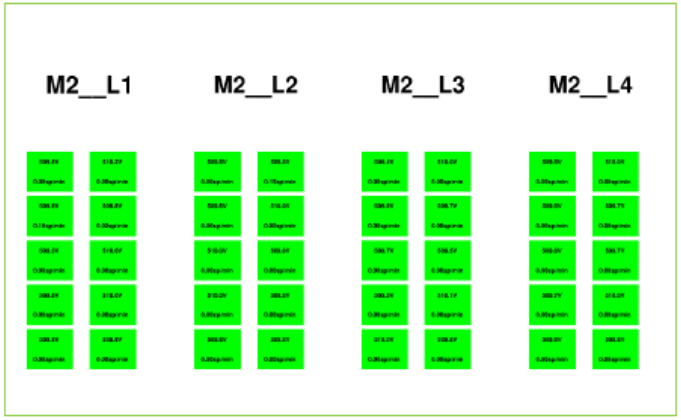
570V gain at 350adc => ~510V

Cosmic bench to qualify a MM Module

- **M2 HV performances :**
  - All sparking and HV recovered in iso
  - No correlation with performances in clean room at 850V in air …

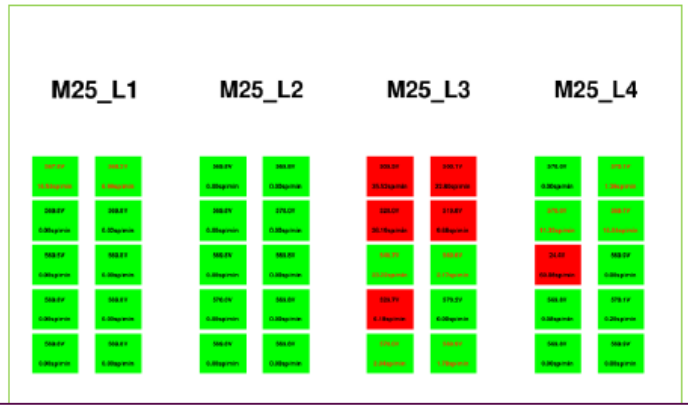


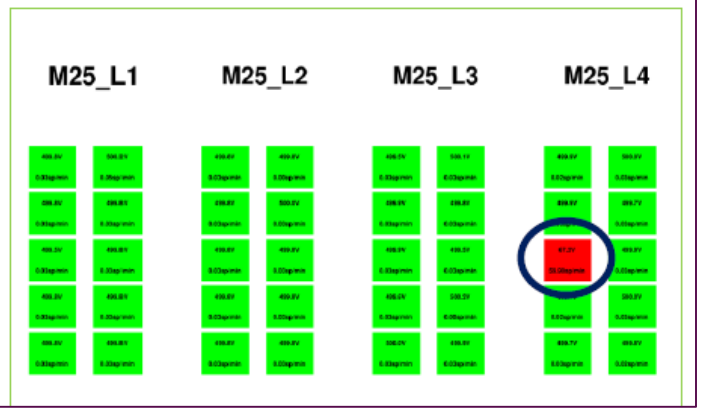
Ar:CO_2



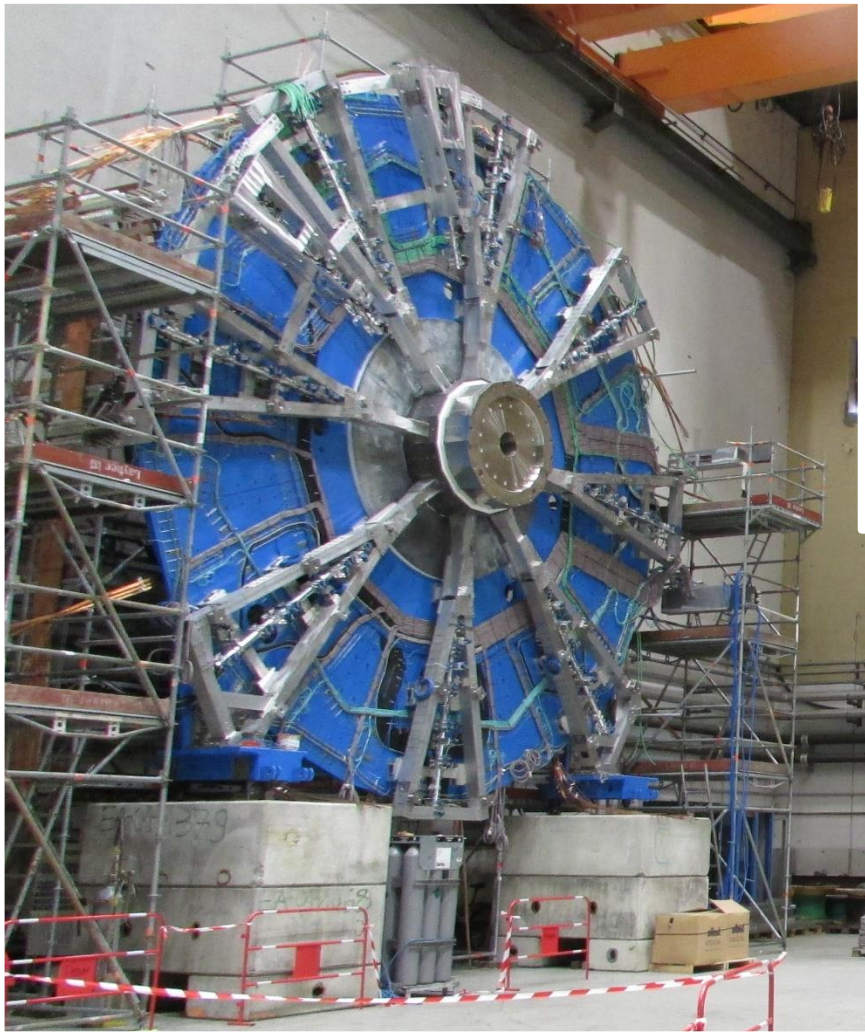
Ar:CO_2: iso-butane

- **M25 HV performances :**
  - All sparking and HV recovered in iso except one
  - The bad sector was good at beginning **then suddenly died in ar/co2**





Where are we at CERN for the assembly in sectors in Sept. 2019



Where are we at CERN for the assembly in sectors in Oct. 2020

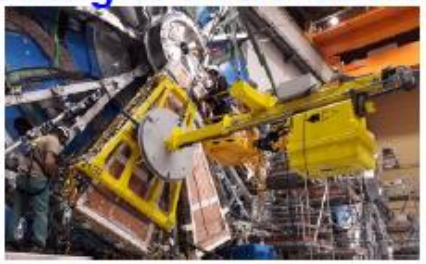
NewA12+A14

11/03/2020

+A16

27/07/2020

Sealing of sTGC on A12



28/07/2020 31/07/2020

+A10

03/08/2020

3 sectors installed and 1 dismounted in 3 weeks

+A08

28/08/2020

+A02

02/09/2019

+A06

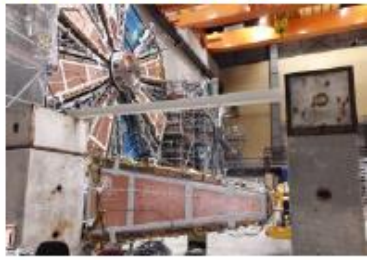
11/09/2020

-A14

16/09/2020

A14 out of wheel for reparation, then for Elx noise study

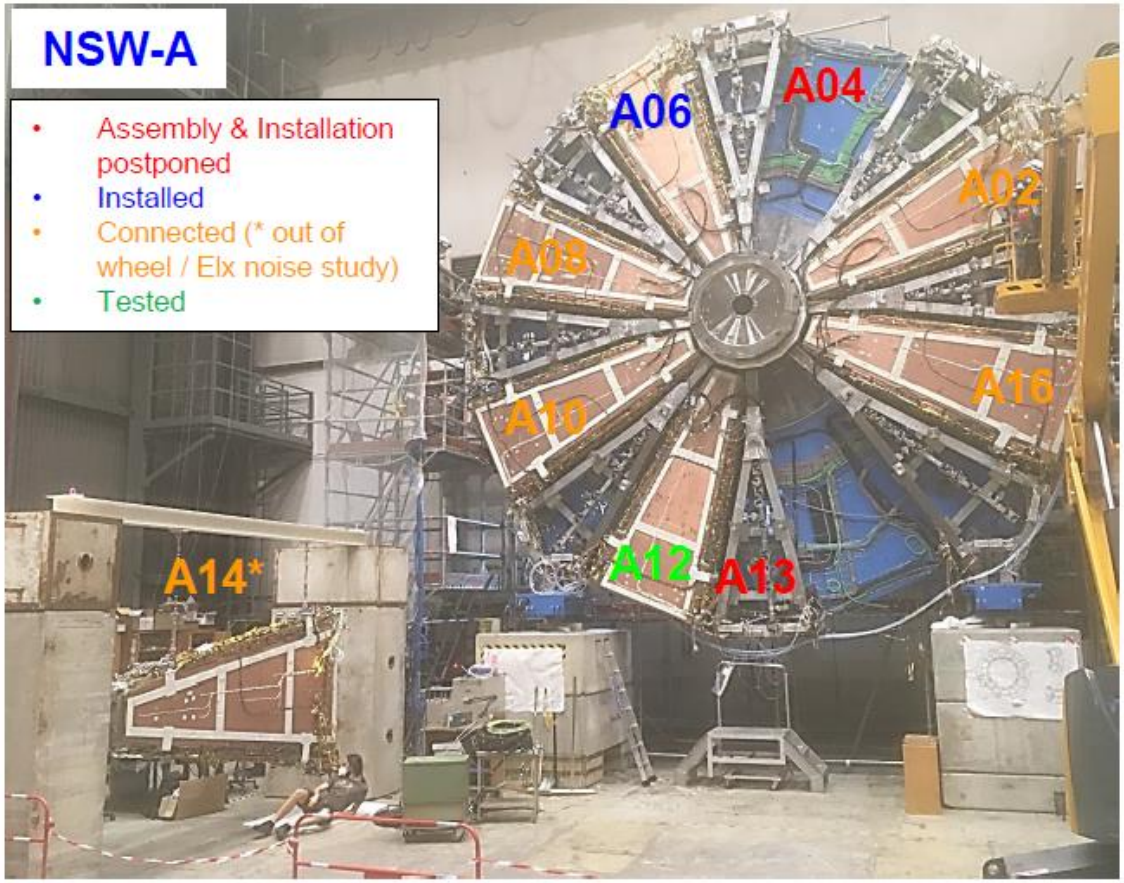
16/09/2020



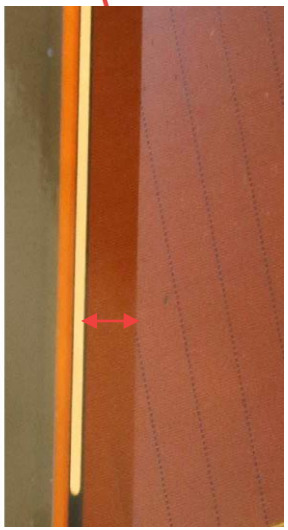
24/09/2020

Where are we at CERN for the assembly in sectors in Oct. 2020

- 6 small sectors on NSW-A, ongoing tests with sector A14 out of the wheel (elx noise study)
  - Small sector installation status: sector 12 - 14* - 16 - 10 - 8 - 2 - 6 - 4
  - Large sector installation sequence: sector 13 - 11 - 15 - 9 - 1 - 7 - 3 – 5
  - Commissioning is ongoing for small sectors A12, A10 and A08
  - Installation of small sector A04 in january 2021 → Waiting for a new sTGC confirm wedge
  - Installation of first large sector A13 → MM-DW did not pass the HV acceptance test, waiting for decision



Conclusions (1)



At least 2 or 3 of the NSW MM construction groups loose a lot of **time, energy and money** to fight with some problems which are almost solved today, after an effort for understanding them :

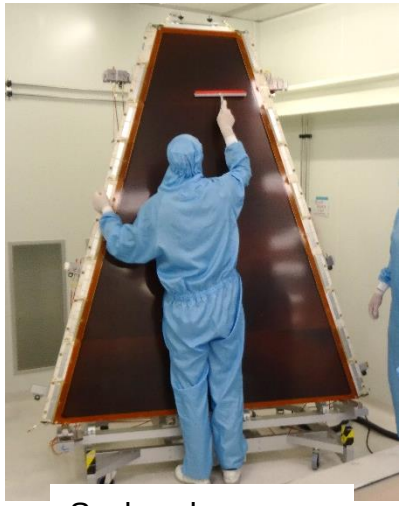
- Too low resistivity of the resistive layer (eq. to or below 5 M-Ohm locally / strip)
- Resistivity bridge layout is problematic for some PCBs
- Humidity problems, more important due to previous weakness (RH <8% needed)
- The Ar+CO2+2% iso-butane gas mixture is considered
  (this gas is under long term irradiation tests at CERN – in gamma's – and in Germany in neutrons ~1 MeV range. A X-ray irradiation is also planned)

Pushed by the previous ATLAS management, organizing the NSW project activities and decisions looking too much to the planning constraints was a mistake, especially at the beginning where more R&D would have been needed.

What about the MPGD technology ?

- Micromegas are robust detectors *(almost ~flat field configuration)*
- Resistive detectors – GEM, MM, etc. – need a more careful detector design and simulations *(E field, R-strip, tests, etc. some were missing for the ATLAS-NSW…)*

Conclusions (2)



Saclay clean room

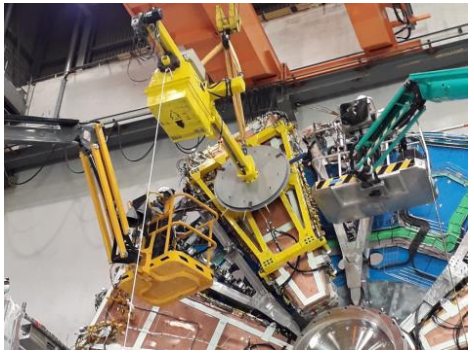
Saclay should have delivered its 32 four gaps Micromegas LM1 Modules in April 2021.

Both NSW types of detectors – sTGC and Micromegas – should be produced by Spring 2021.

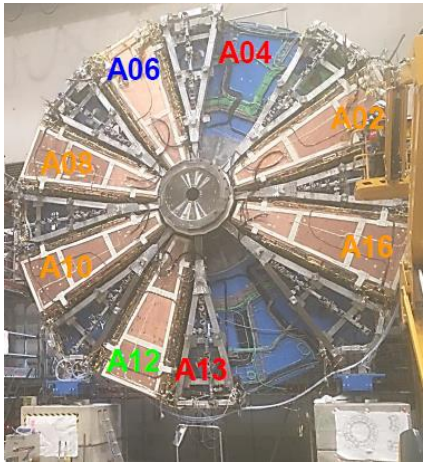
Commissioning and integration teams are working at CERN trying to install, check and debug sectors each ~15 days. Noise problems on first sectors *(new Faraday cage on some elx cards, …)*

- The first wheel NSW-A could be installed in ATLAS in ~Sept. 2021.
- Today's prediction for NSW-C is end of 2021.

Integration area at BB5



Installing detectors on first NSW



Merci pour votre attention

Thank you for your attention

Commissariat à l'énergie atomique et aux énergies alternatives
Centre de Saclay | 91191 Gif-sur-Yvette Cedex

Etablissement public à caractère industriel et commercial | RCS Paris B 775 685 019

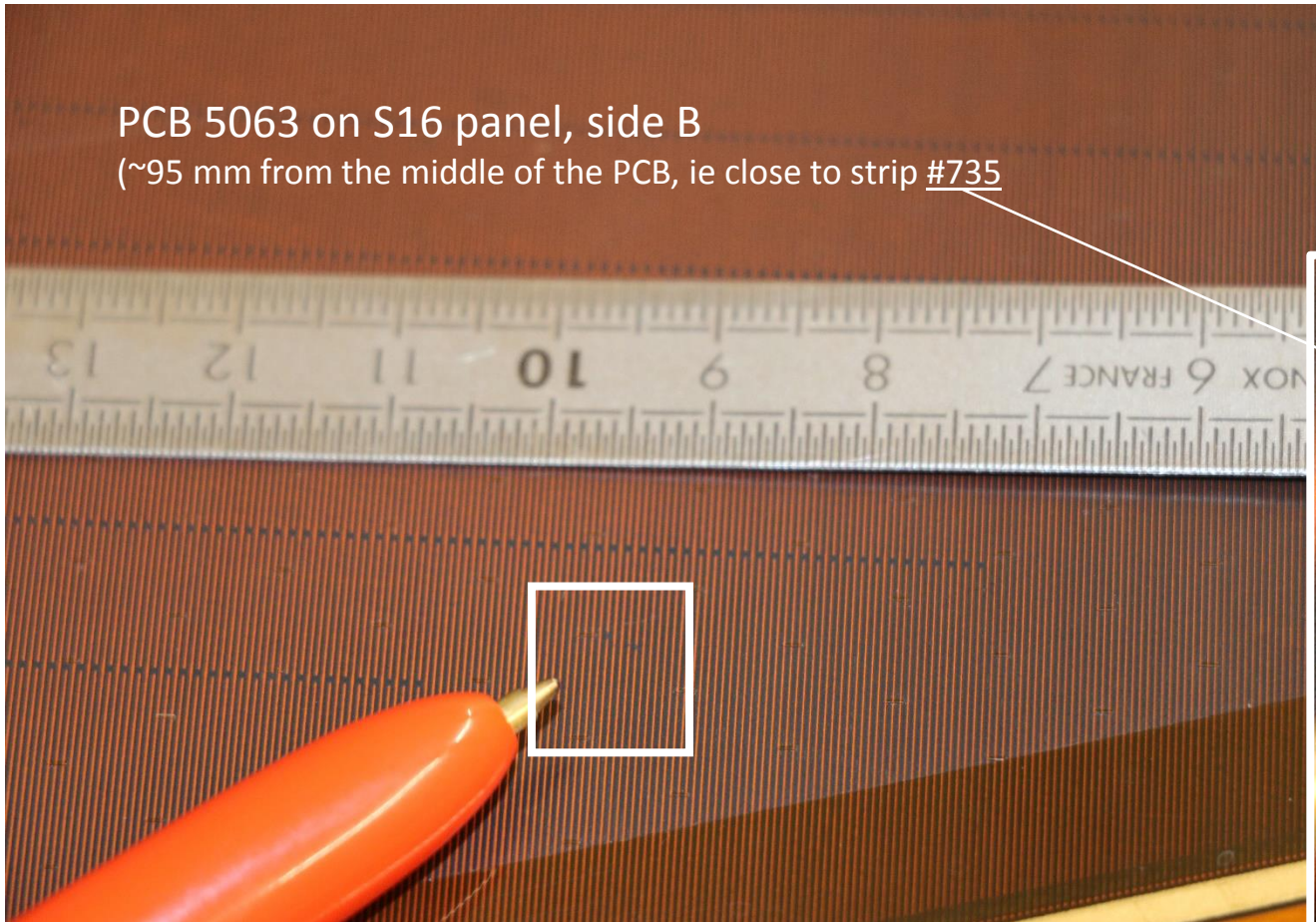
DRF - IRFU
CEA Paris - Saclay
Paris-Saclay University
France

Importance of some resistive defects

Looking carefully to PCB edges close to the silver line for **S16**, **S17** and **E16** LM1-Saclay panels one sees :

- There is some resistive defects close to the silver line (up to ~30 mm)
- **They are located at the same place on all PCBs of the same type** : e.g. LS-5048, LS-5063, LS-5017, LS-1067
- This is also true for LS-1… and for Eta PCBs.
- These defects are certainly coming from the serigraphy mesh + its pattern.

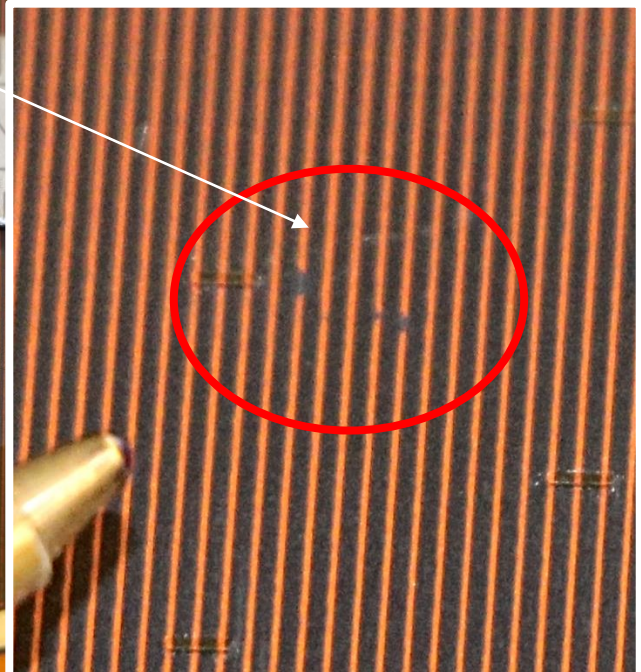
PCB 5063 on S16 panel, side B
(~95 mm from the middle of the PCB, ie close to strip #735



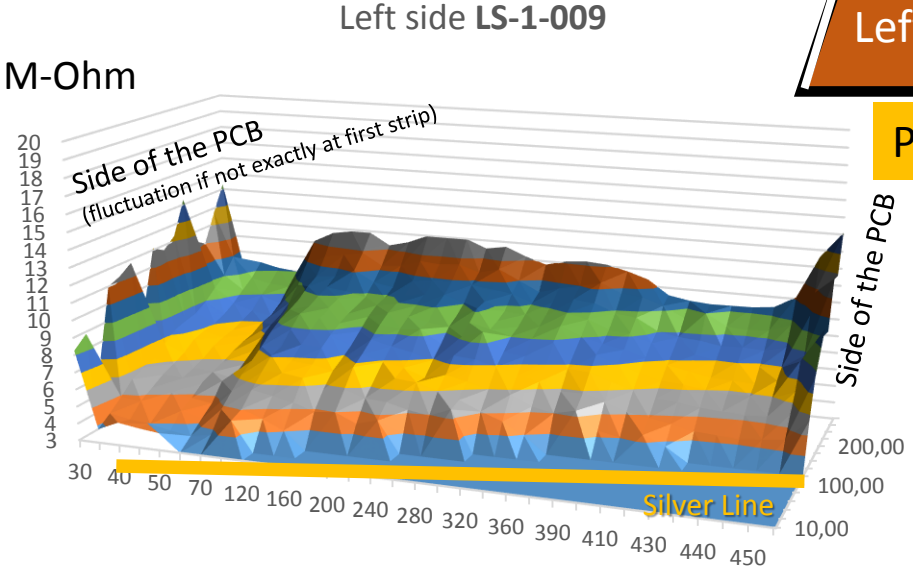
Strip resistance on several strips :

Reduced by ~2.8 M-Ohm, and normally ~7.2, i.e. **R is ~40 % decreased**

(measured with a small probe at a given distance // to the silver line)



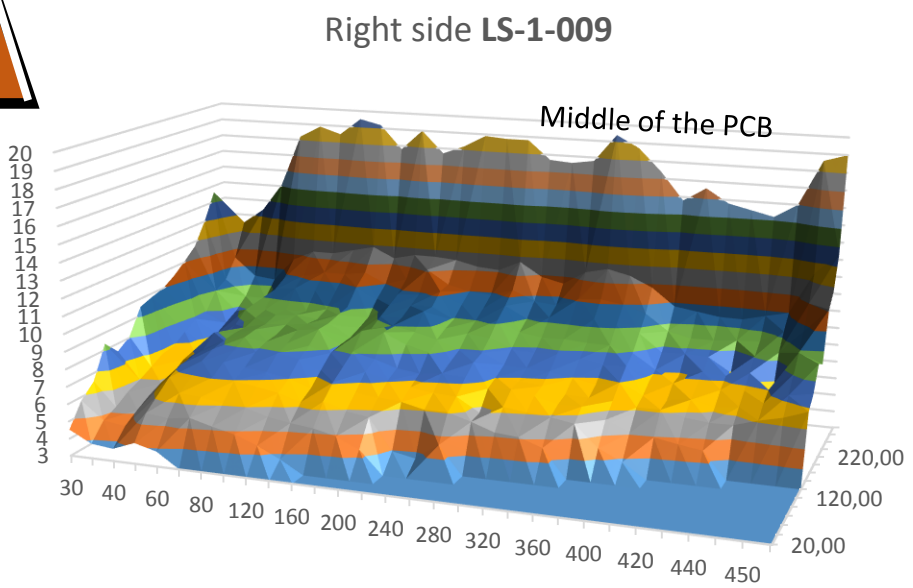
Left side **LS-1-009**



Left | Right

PCB LS-1

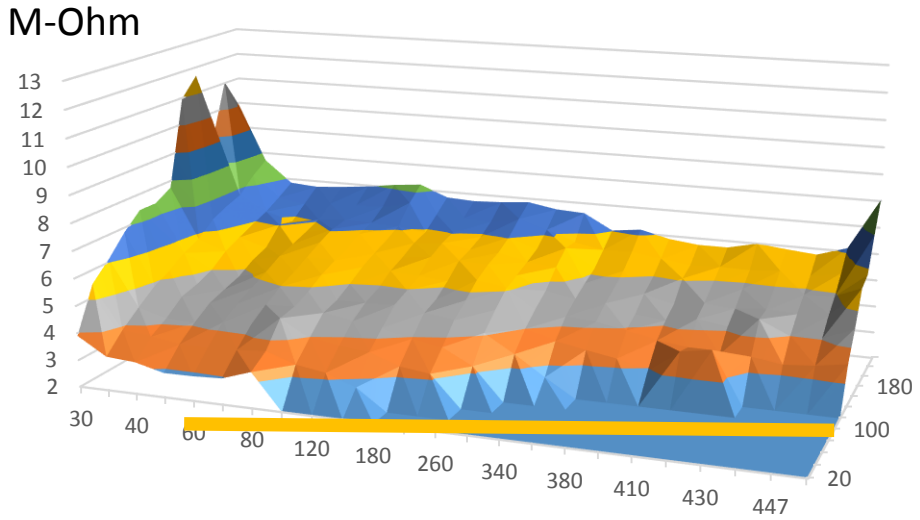
Right side **LS-1-009**



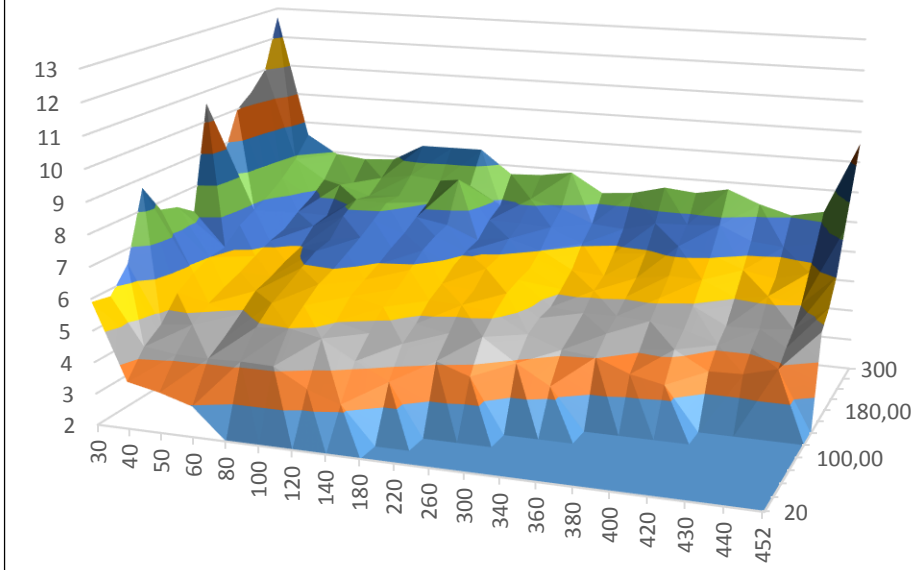
R_{min} ~ 3.6 M-Ohm	~3.7 M-Ohm
~2.9 M-Ohm	~3.0 M-Ohm

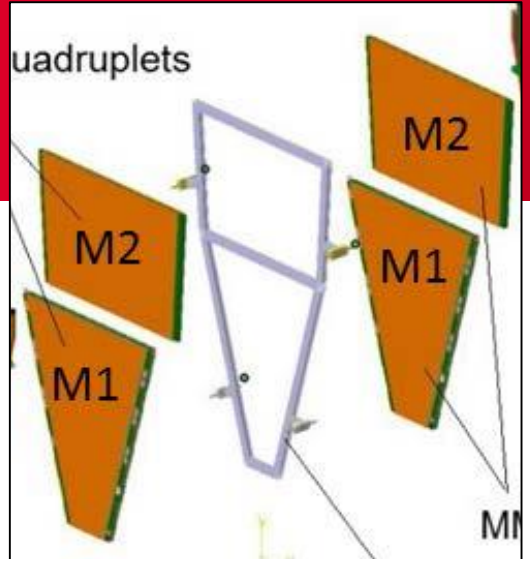
Left side **LS-1-070**

(also right side part. meas.)



Right side **LS-1-048**

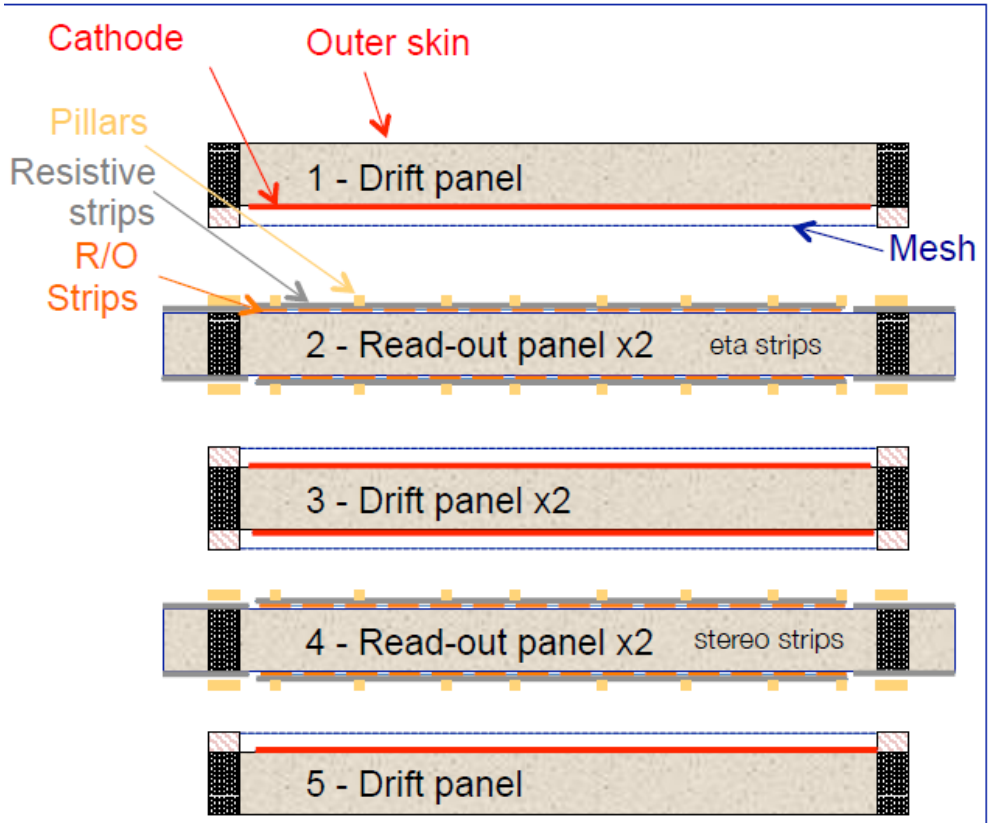


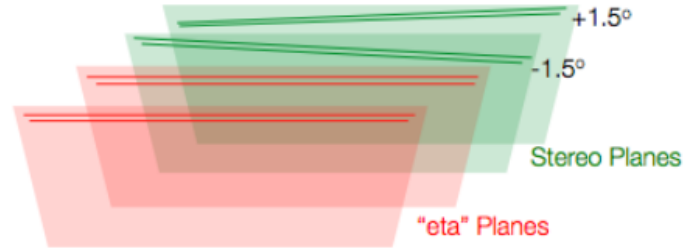


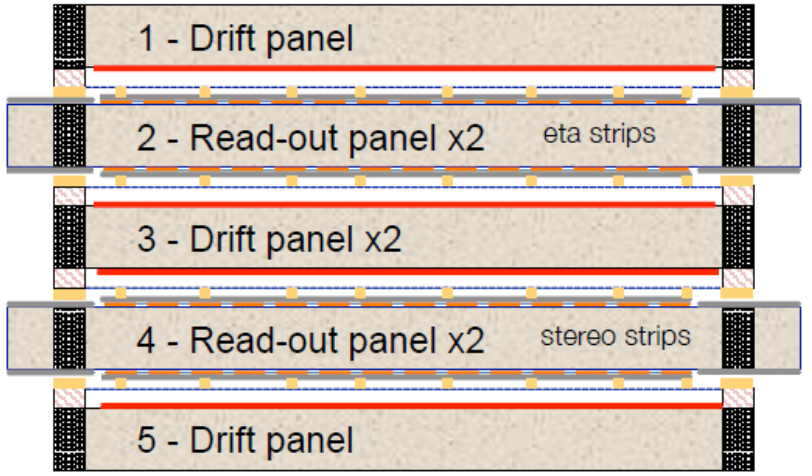
Each MM module is made with 3 drift panels
+ 2 double side RO panels assembled together

⇒ 4 drift gap, each of 5 mm gas thick.
20 k-channels / detector
~2 to 3 m²

Physicist model





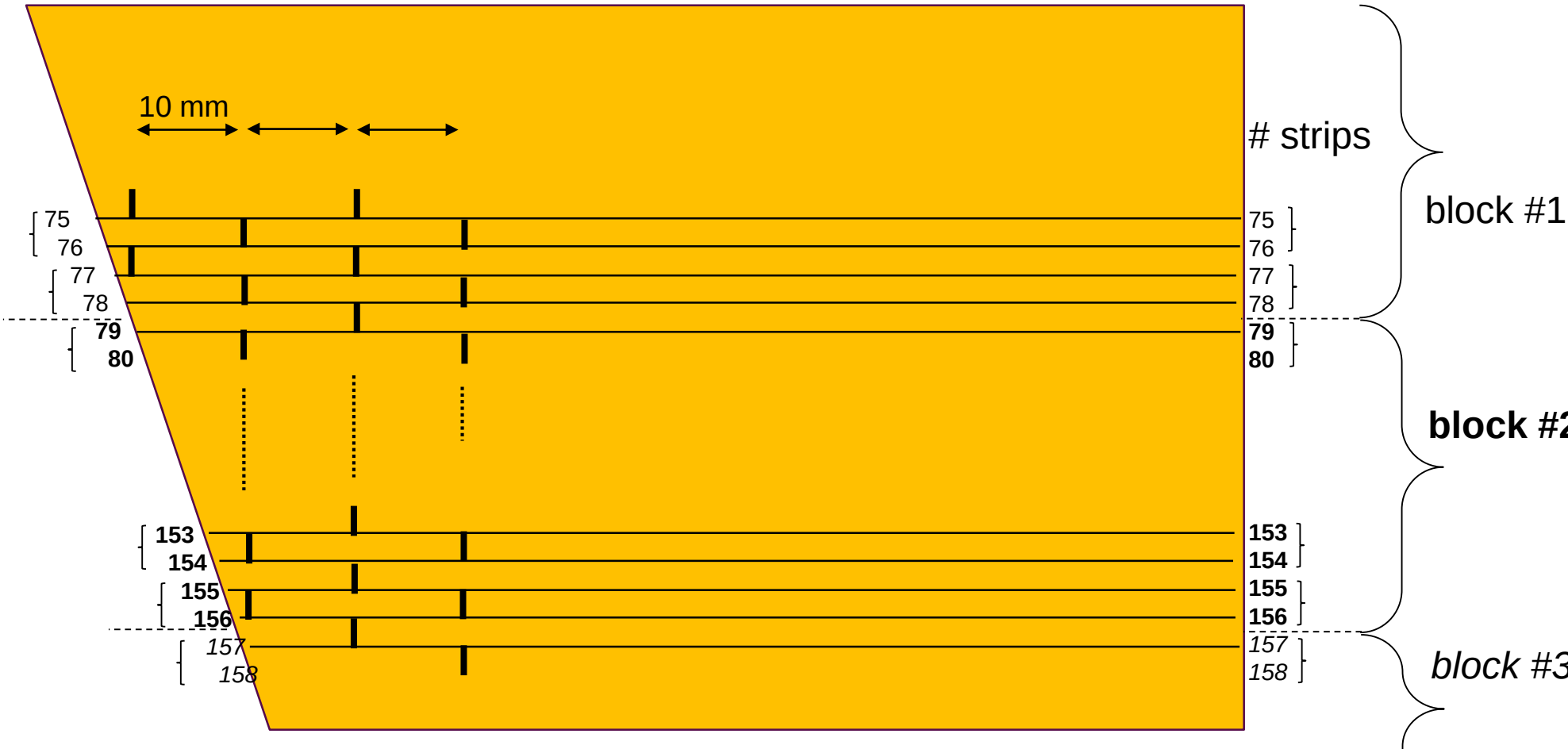


stack ~80 mm

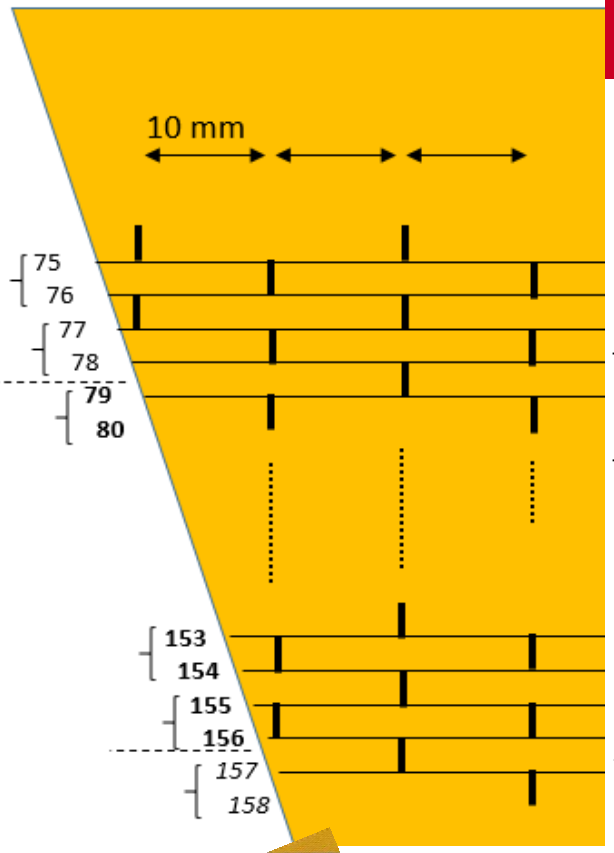
- CADENCE (Virtuoso) program (hypothesis : R <u>linear</u> as 1 M-Ohm / mm)
- Results could be re-scaled for a different resistivity
- Idea of E.Delagne : basic cells based on a 2 strips layout with some connexio (L=20mm) + trick for R=R(1-x)+R.x

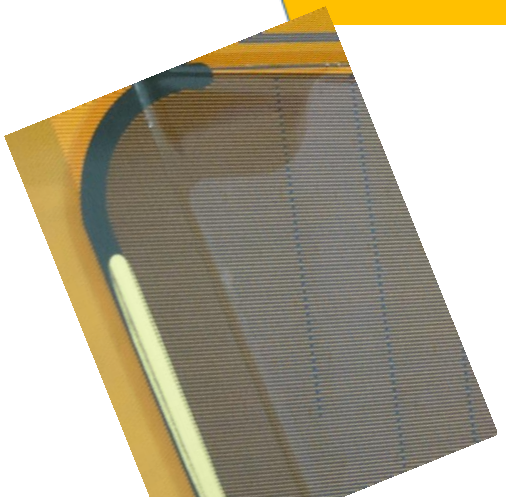
<u>Then introduction of :</u>

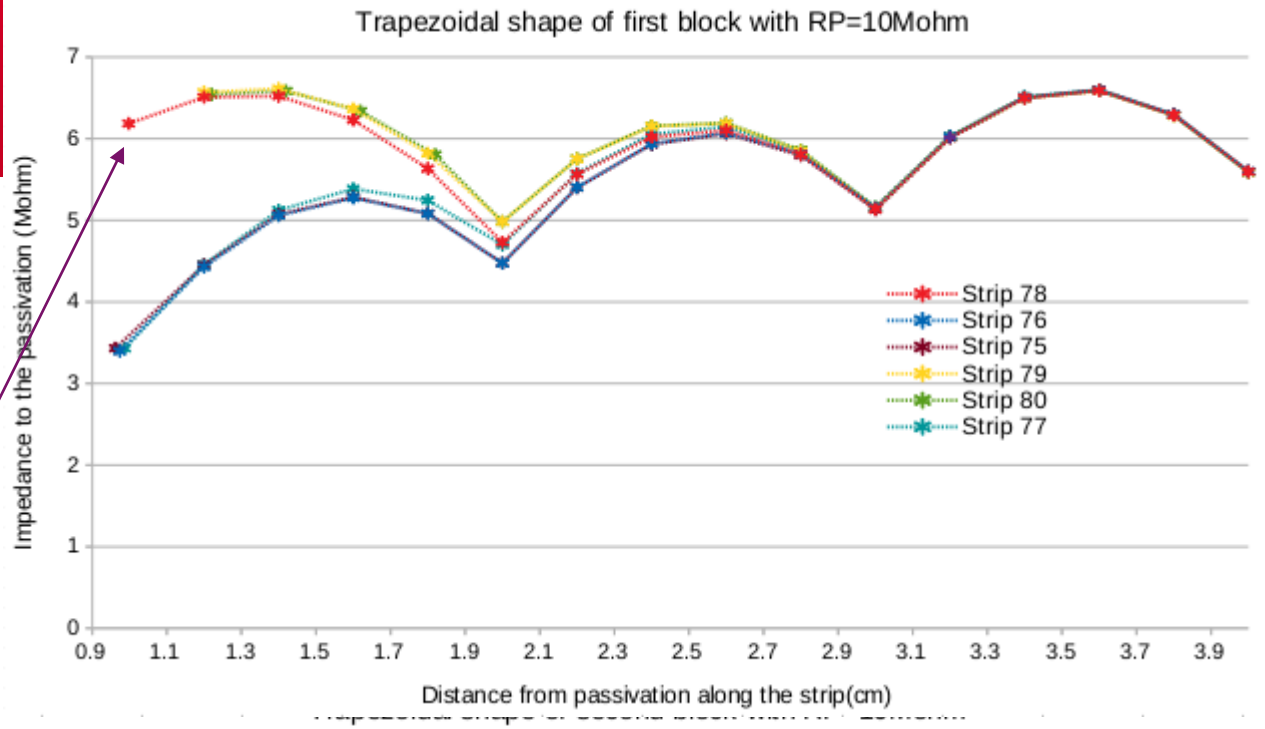
- Several individual cells needed to simulate real geometry (angle)
- Tests of different R connexion between strips ; different strip lengths ; different layout of R-connexion

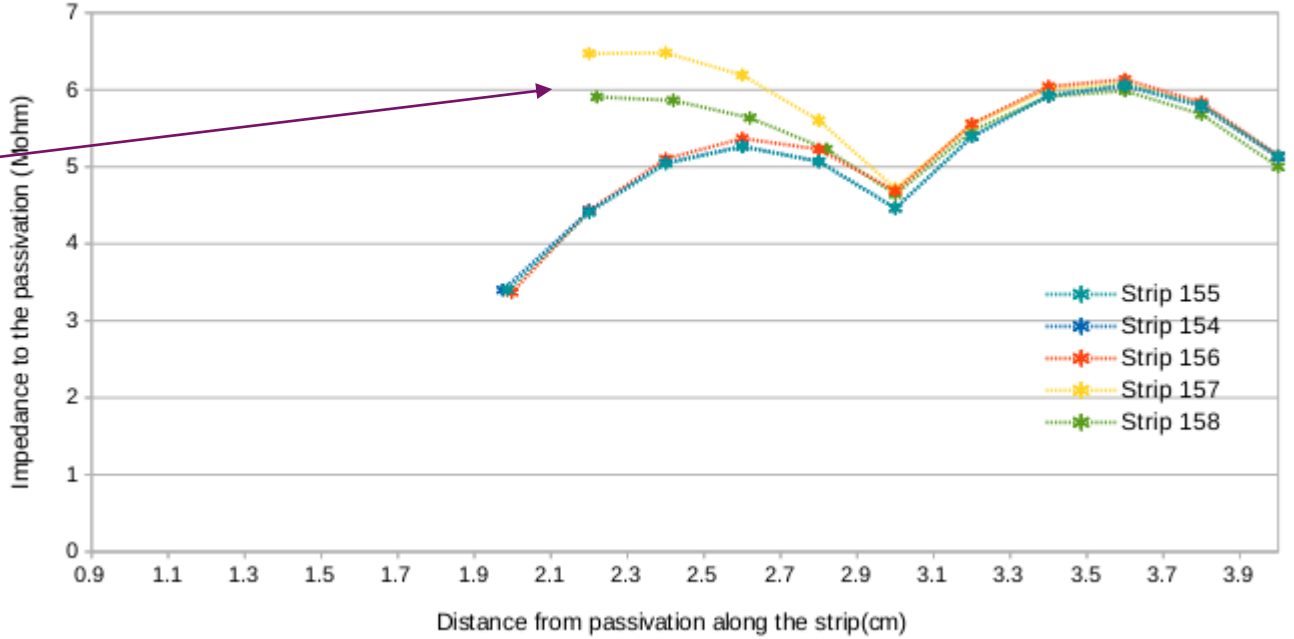


Th.Thavarajah, E.Delagne, Ph.Schune

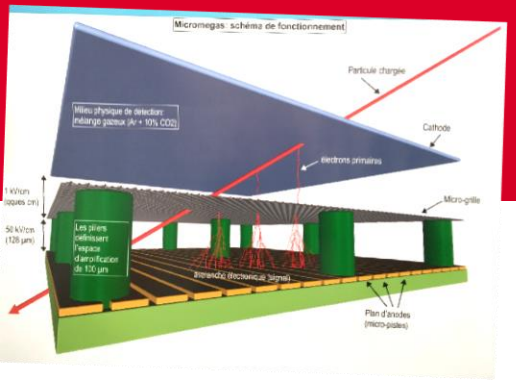

10 mm
75
76
77
78
79
80
153
154
155
156
157
158

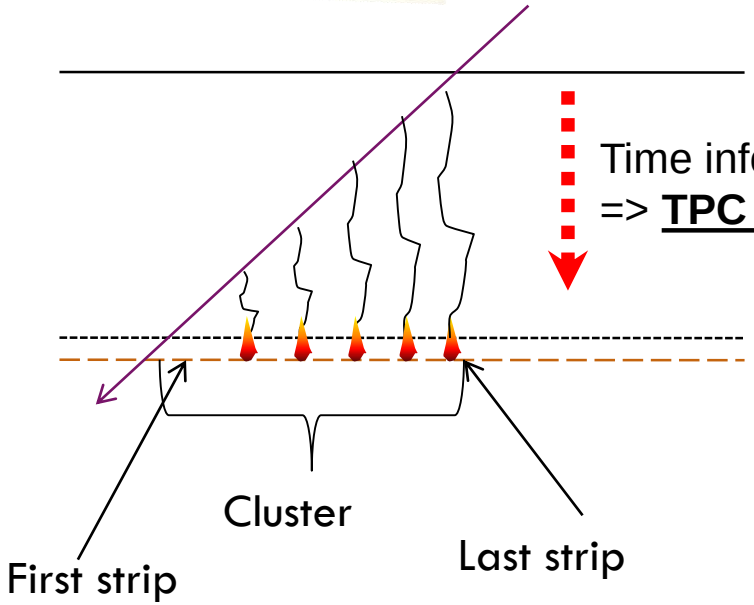


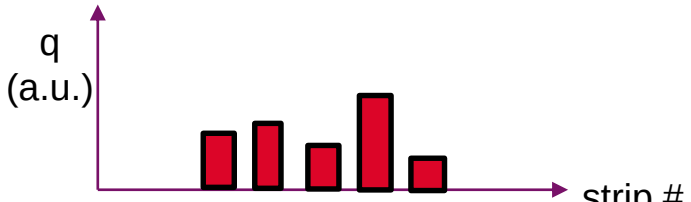

Trapezoidal shape of first block with RP=10Mohm
Impedance to the passivation (Mohm)
Distance from passivation along the strip(cm)
Strip 78
Strip 76
Strip 75
Strip 79
Strip 80
Strip 77

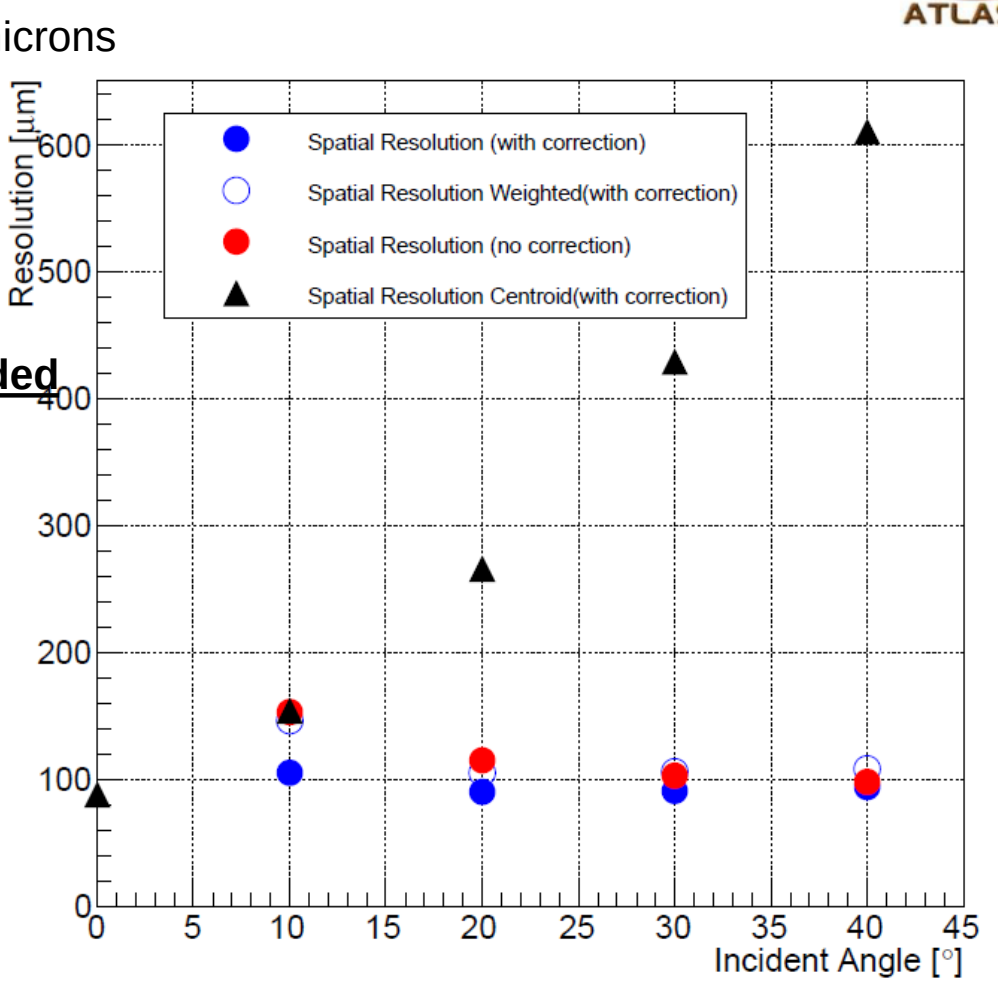

Impedance to the passivation (Mohm)
Distance from passivation along the strip(cm)
Strip 155
Strip 154
Strip 156
Strip 157
Strip 158

MICRO TPC MODE









Track angle (deg.)

angular range of the NSW

in gaz (1 atm.) ~1 ionization cluster each ~200 microns

Saclay production implementation

<=> LM1 area

<=> ~50 m

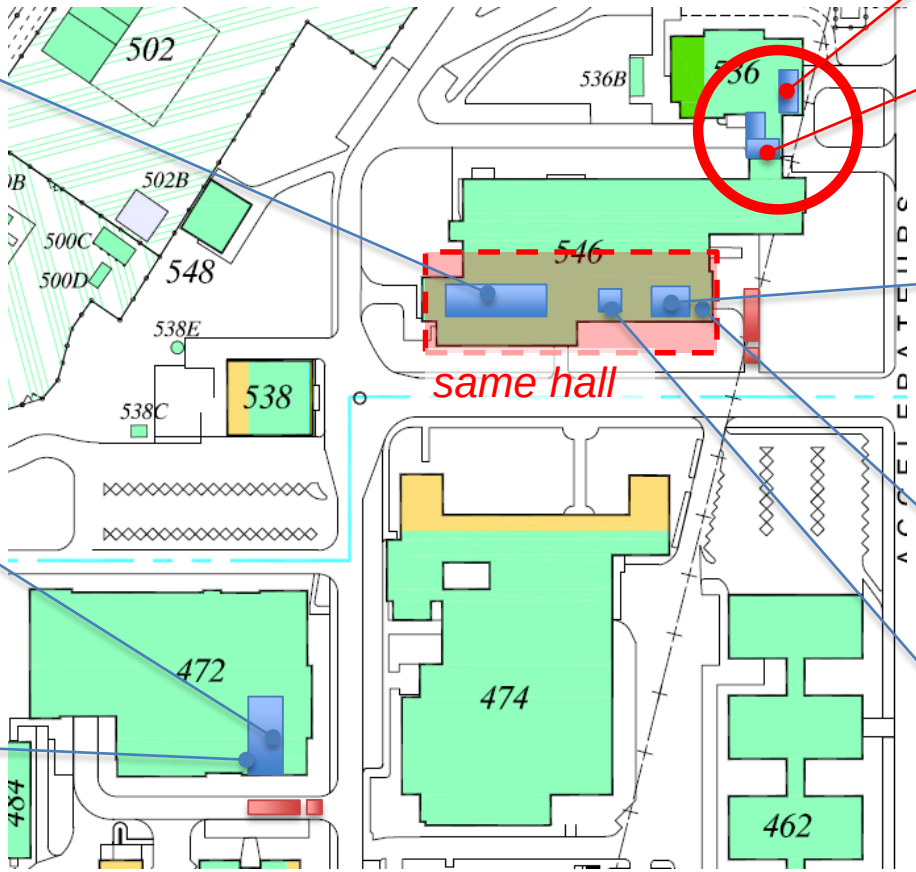
New area since June
Total ~100 m²

Clean room
(with a small area for panel preparation behind). Area ~130 m²

outside

RO and drift PCB preparation
(Datcha hall)
Also some storage

Repair area



Mesh streching machine

Storage and bars control

outside

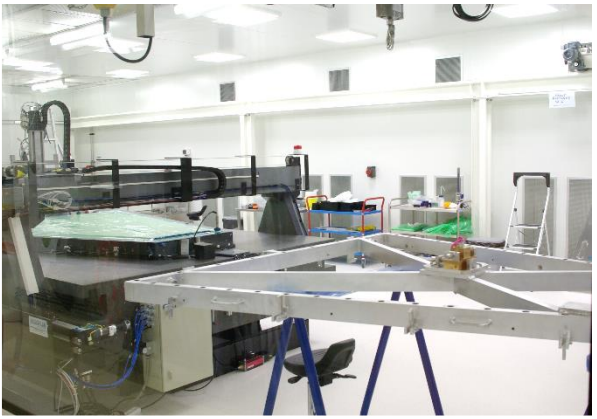
Tente area for panel preparation (soldering, etc.)

Storage area and area for preparing Modules for CERN

Cosmic bench (already with Mcube cosmic bench !)

Saclay productio

<=> LM1 area



outside

RO and drift PCB