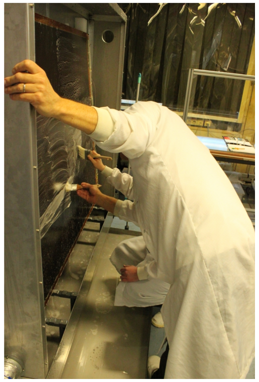
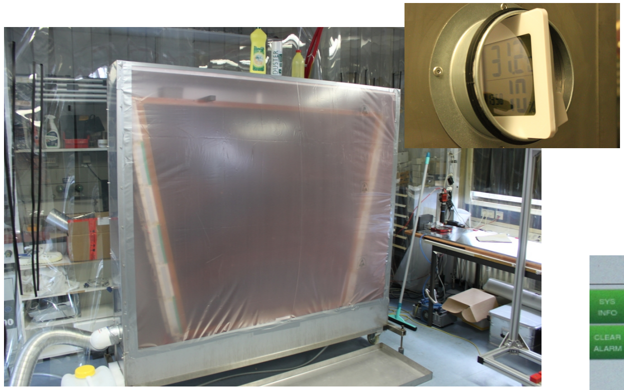
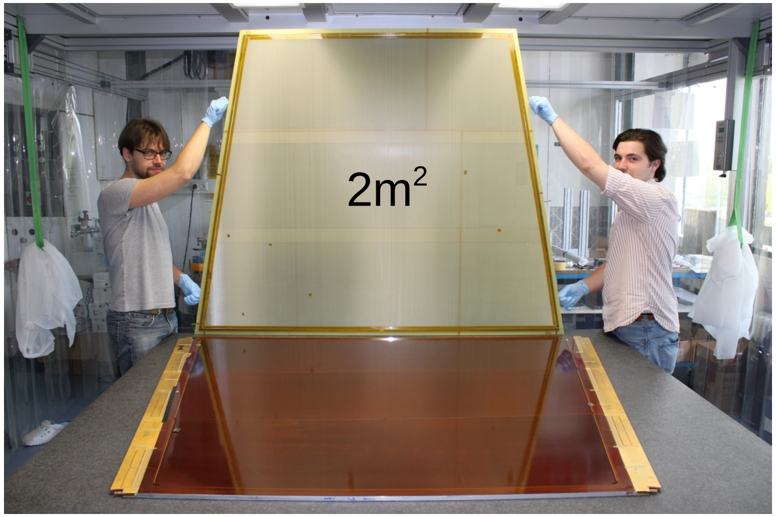
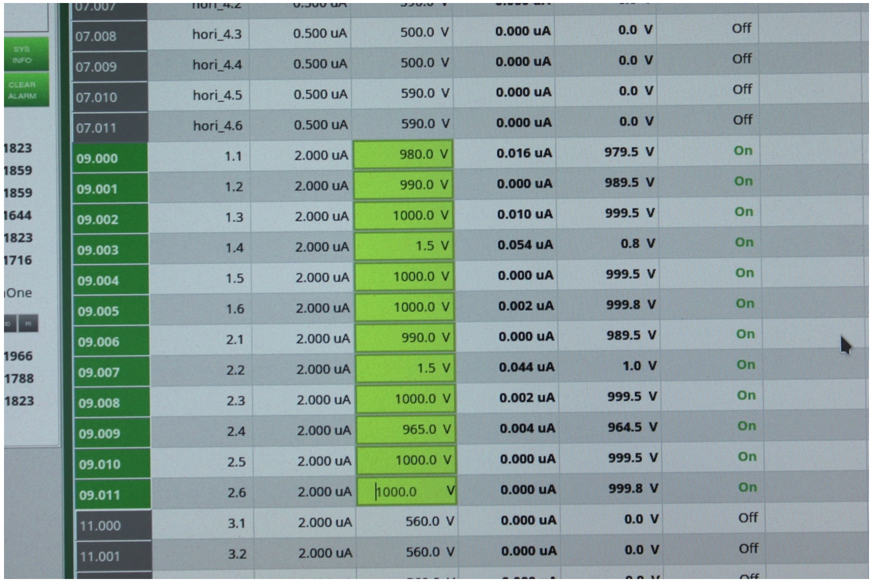
HV Stability of Large Size Resistive Strip Micromegas Chambers









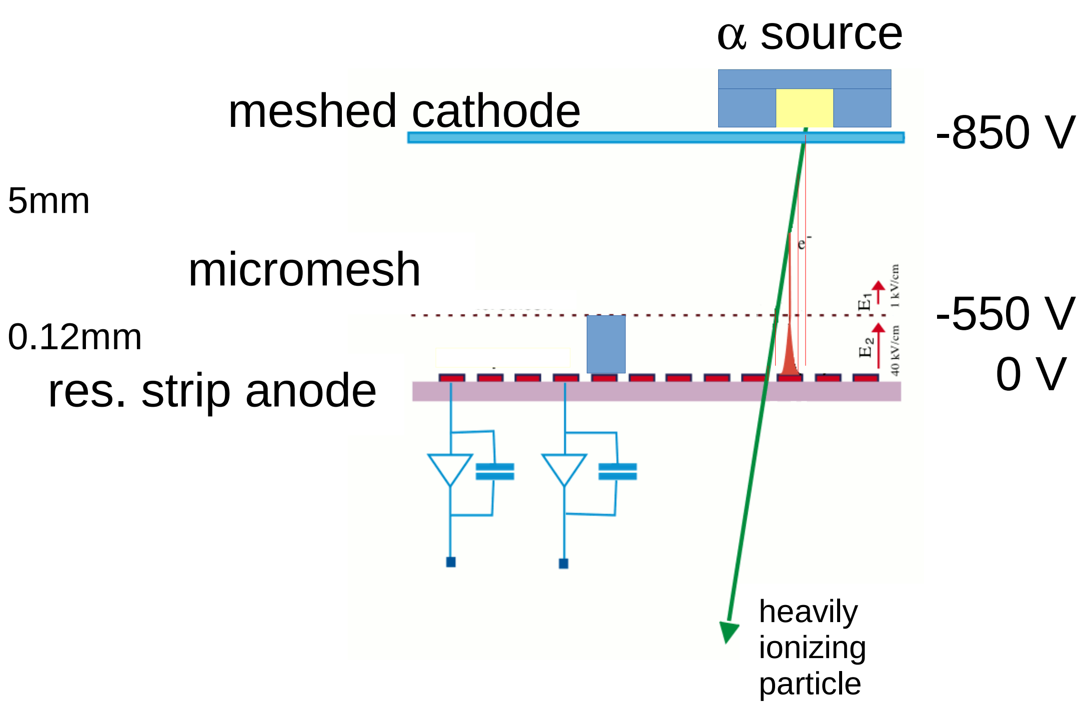
07.008	hori_4.3	0.500 uA	500.0 V	0.000 uA	0.0 V	Off
07.009	hori_4.4	0.500 uA	500.0 V	0.000 uA	0.0 V	Off
07.010	hori_4.5	0.500 uA	590.0 V	0.000 uA	0.0 V	Off
07.011	hori_4.6	0.500 uA	590.0 V	0.000 uA	0.0 V	Off
09.000	1.1	2.000 uA	980.0 V	0.016 uA	979.5 V	On
09.001	1.2	2.000 uA	990.0 V	0.000 uA	989.5 V	On
09.002	1.3	2.000 uA	1000.0 V	0.010 uA	999.5 V	On
09.003	1.4	2.000 uA	1.5 V	0.054 uA	0.8 V	On
09.004	1.5	2.000 uA	1000.0 V	0.000 uA	999.5 V	On
09.005	1.6	2.000 uA	1000.0 V	0.002 uA	999.8 V	On
09.006	2.1	2.000 uA	990.0 V	0.000 uA	989.5 V	On
09.007	2.2	2.000 uA	1.5 V	0.044 uA	1.0 V	On
09.008	2.3	2.000 uA	1000.0 V	0.002 uA	999.5 V	On
09.009	2.4	2.000 uA	965.0 V	0.004 uA	964.5 V	On
09.010	2.5	2.000 uA	1000.0 V	0.000 uA	999.5 V	On
09.011	2.6	2.000 uA	1000.0 V	0.000 uA	999.8 V	On
11.000	3.1	2.000 uA	560.0 V	0.000 uA	0.0 V	Off
11.001	3.2	2.000 uA	560.0 V	0.000 uA	0.0 V	Off

a fully personal review

Ralf Hertenberger, LS Schaile, LMU München

RD51 HV workshop Garching 21. June 2018

Standard Micromegas
Discharges Between Mesh and Anode @ High Charge Density
(non destructive but deadtime inducing)



5.8 MeV α induce discharges
@ 3 * 10^8 e^-/mm^2
Raether limit

acceleratorphysics:
heavily primary ionizing particles
accompany
minimum ionizing muons

working point muon detection:
550 V

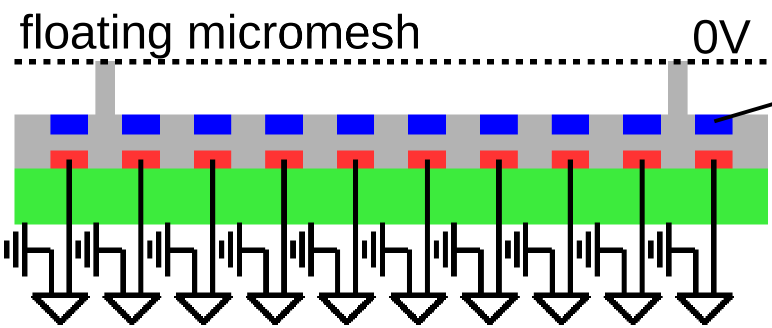
working point α detection:
450 V

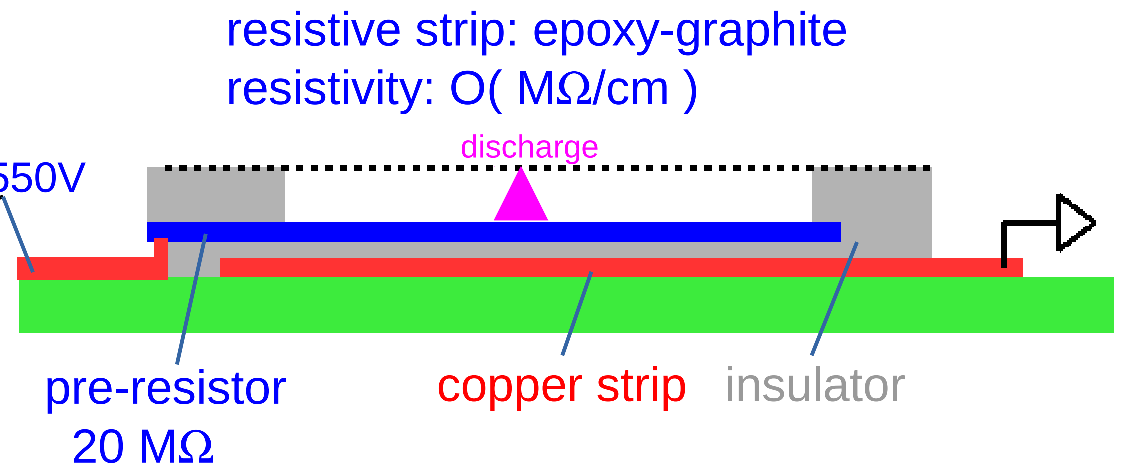
↓

discharge protection is necessary

Resistive Strip Micromegas (1D Readout)

resistive strip technology

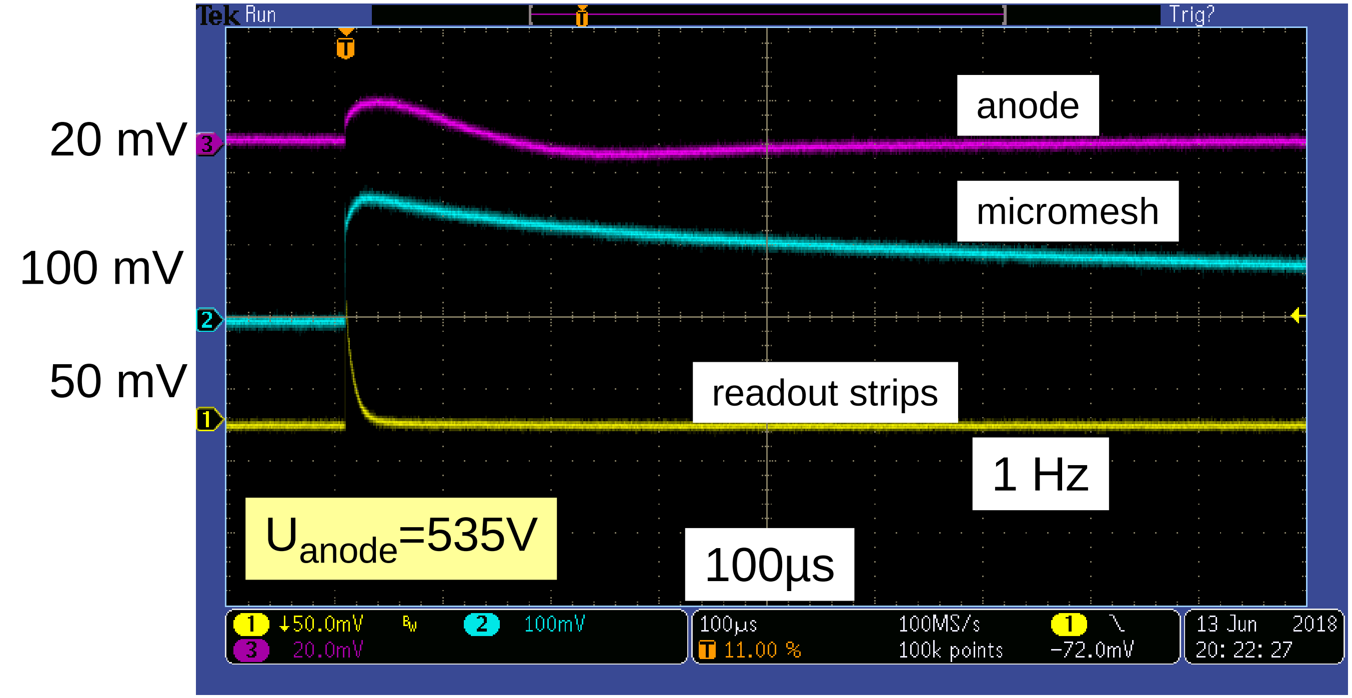


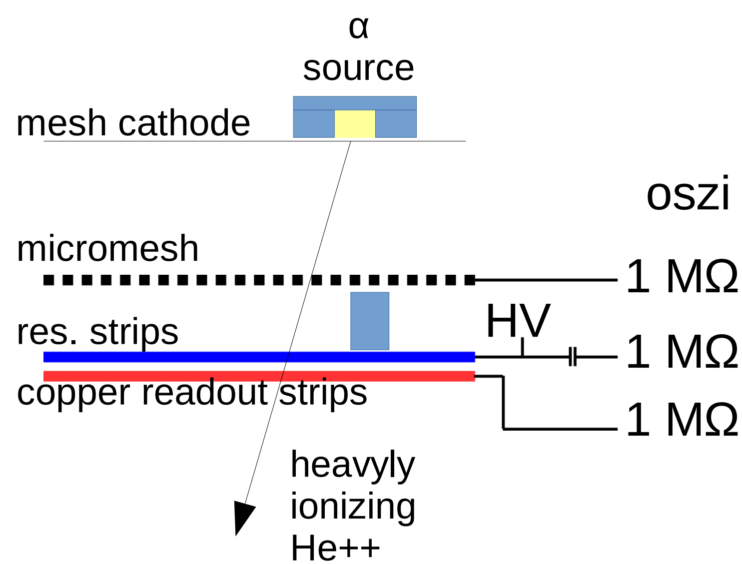


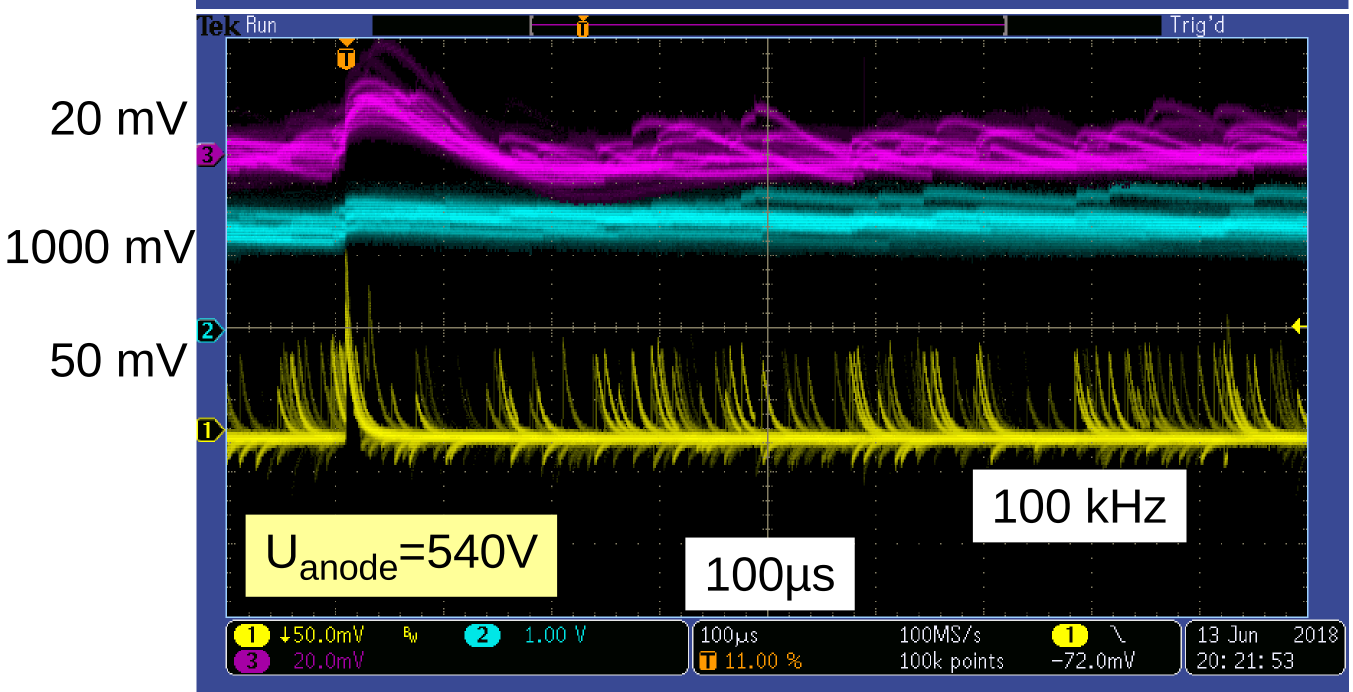
potential equilibrium locally around discharge

discharge / streamer is not able to develop fully
restricted to small part of a strip

Discharge Protection Seems to Work (T-Chamber)





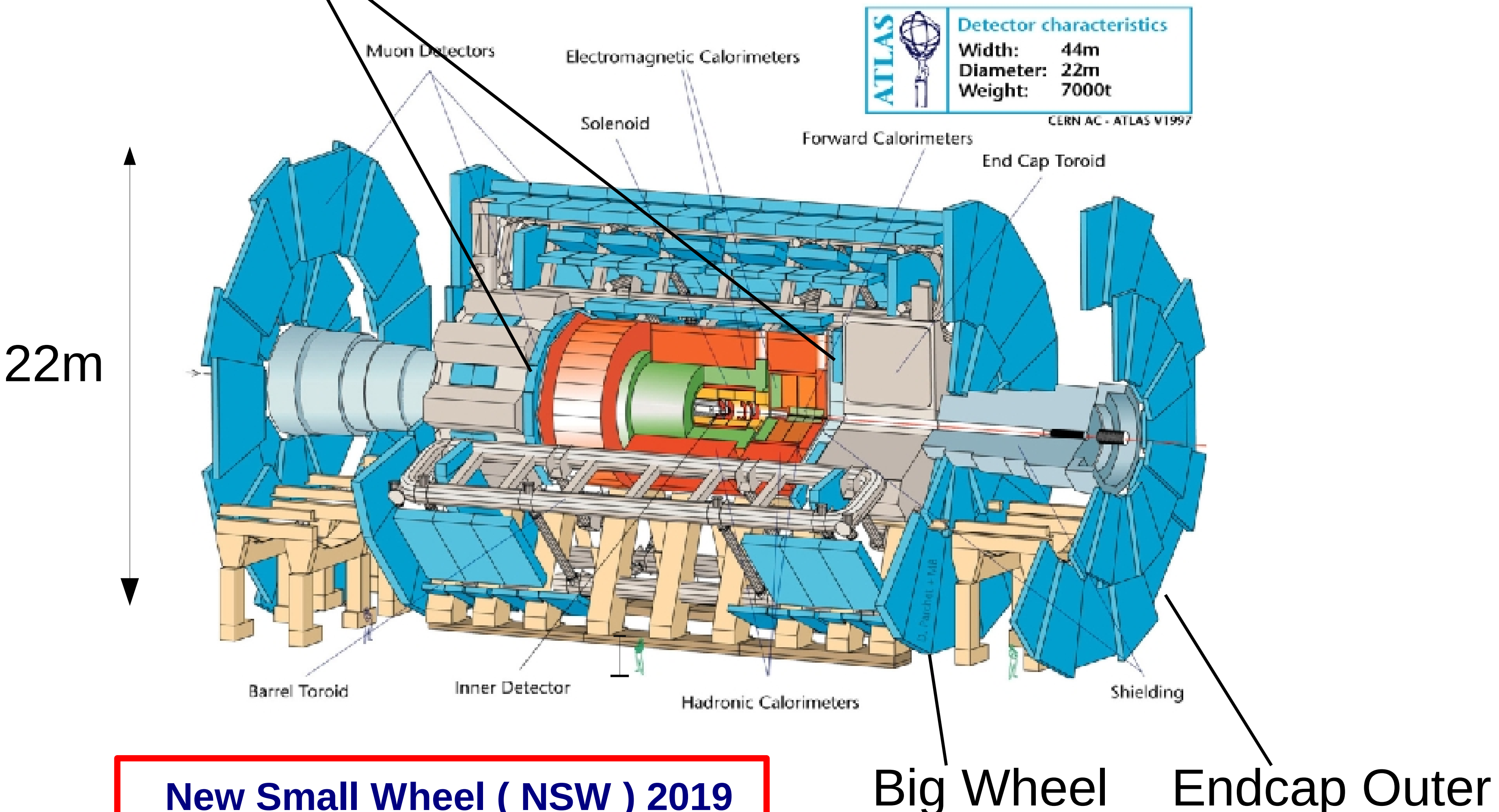


5.8 MeV α induce discharges
@ 3 * 10^8 e^-/mm^2
Raether limit

still no substantial change in U_{amp}

ATLAS: Muons Are Accompanied by Strongly Ionizing Background

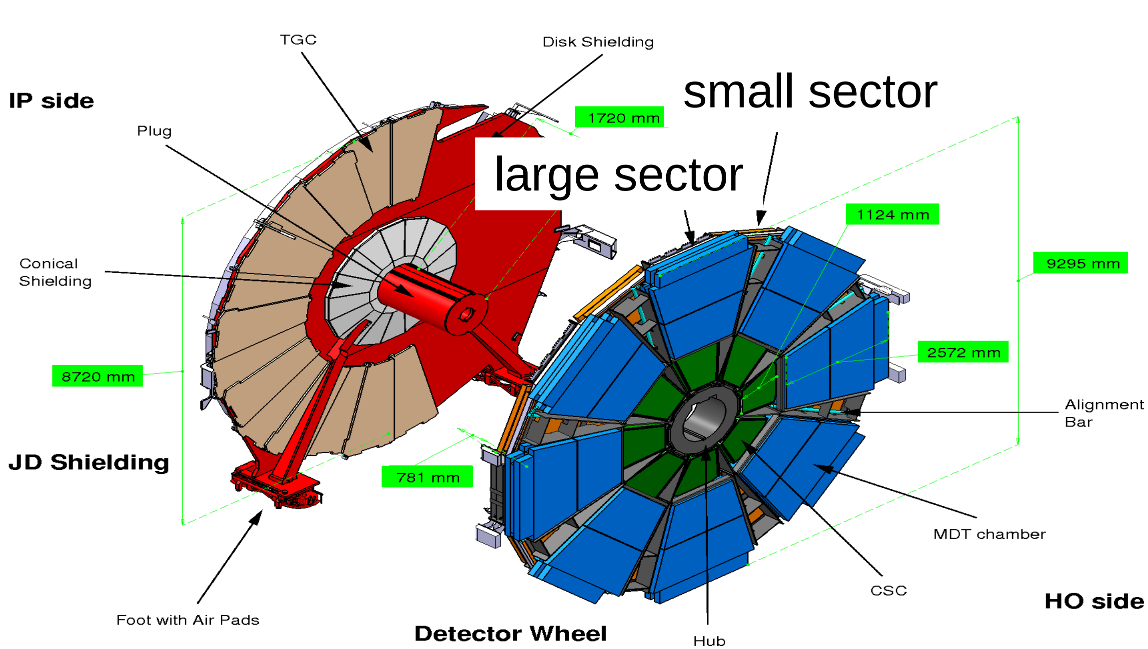
Small Wheel: highest background rates



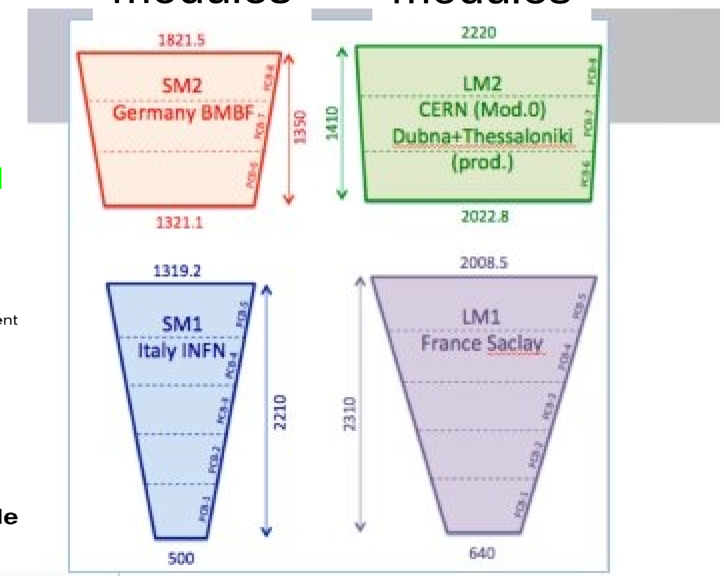
New Small Wheel (NSW) 2019

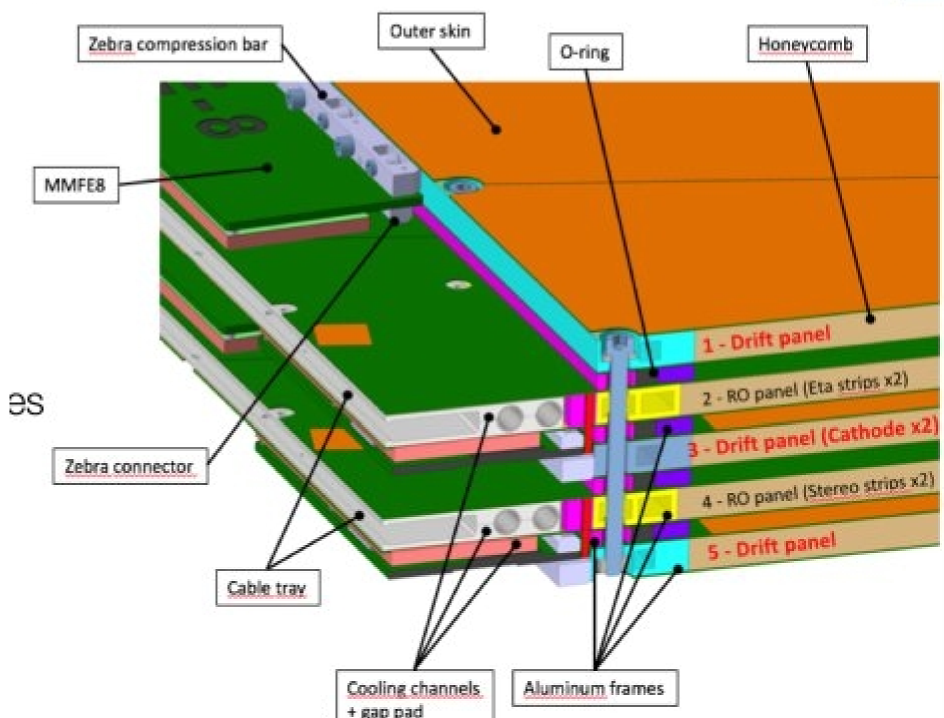
MM: precision chambers

Resistive Strip Micromegas for the ATLAS Muon NSW

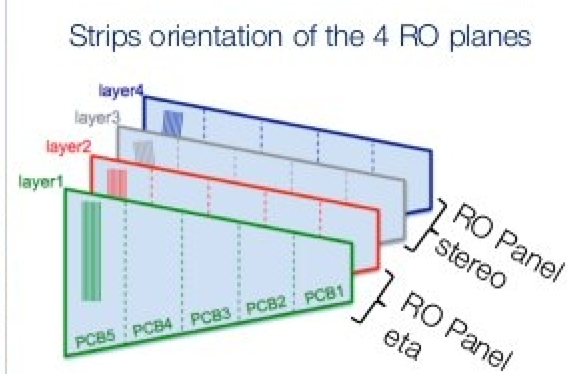


small modules   large modules

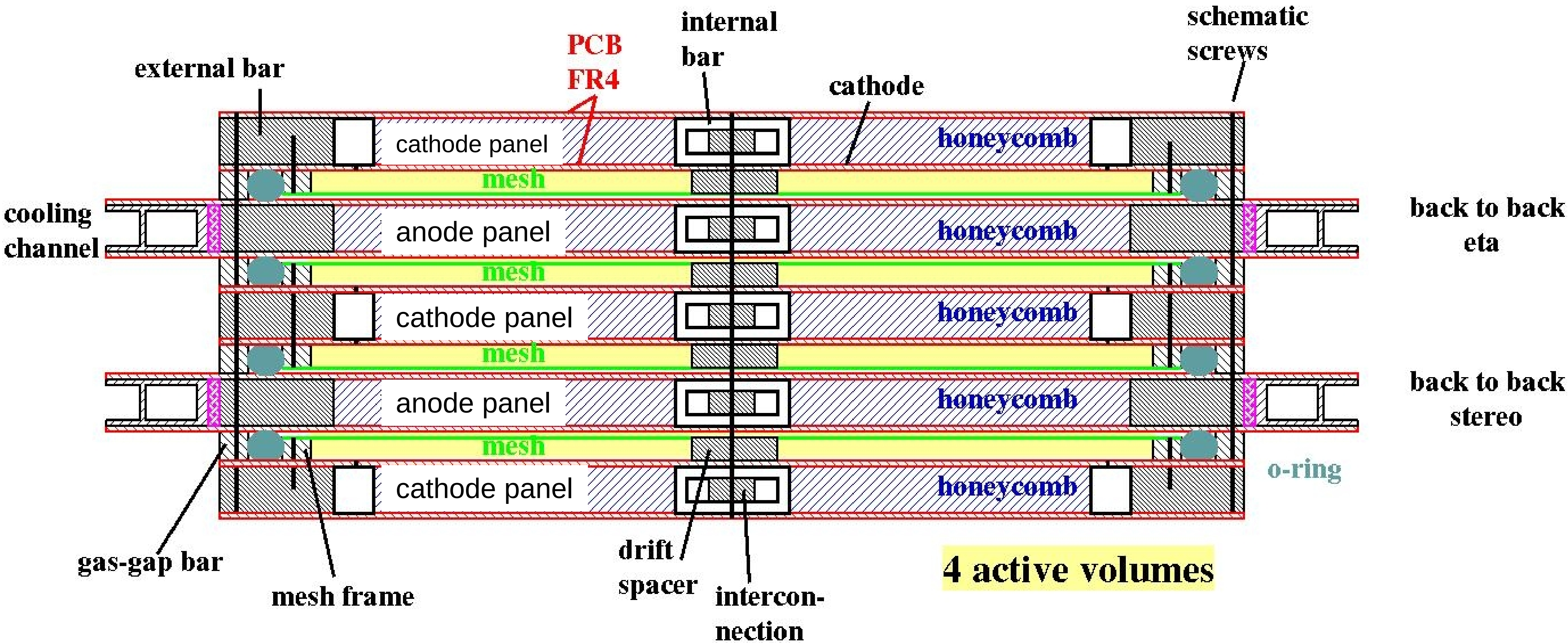




4 active layers



Schematic of a 2m² Quadruplet
4 active layers



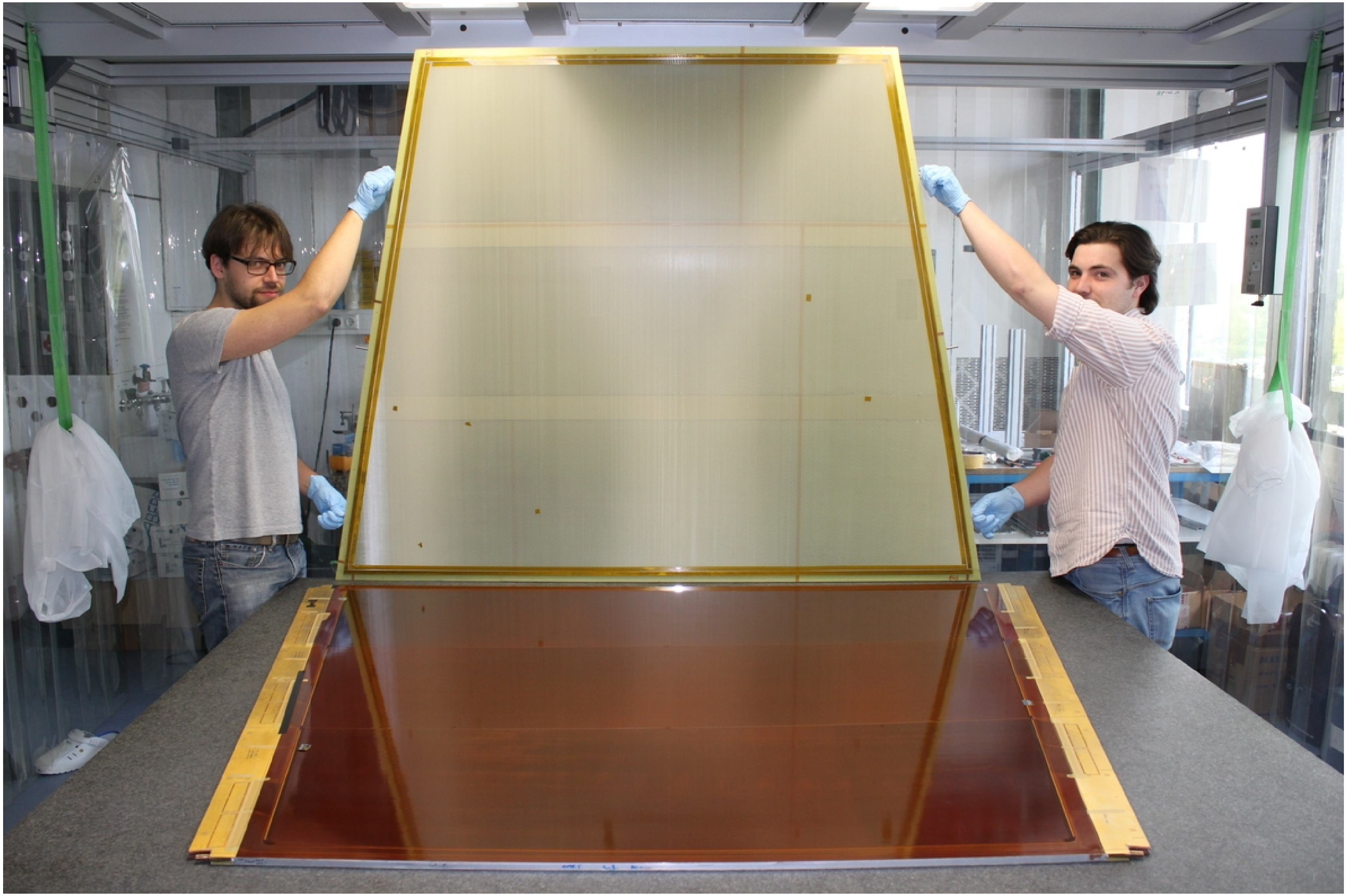
5 honeycomb reinforced sandwich panels

floating grounded mesh (no bulk technology)
mounted on cathode panels

the active area is in between drift and readout panels

cathode panel:
with micromesh attached to it
grounded floating mesh

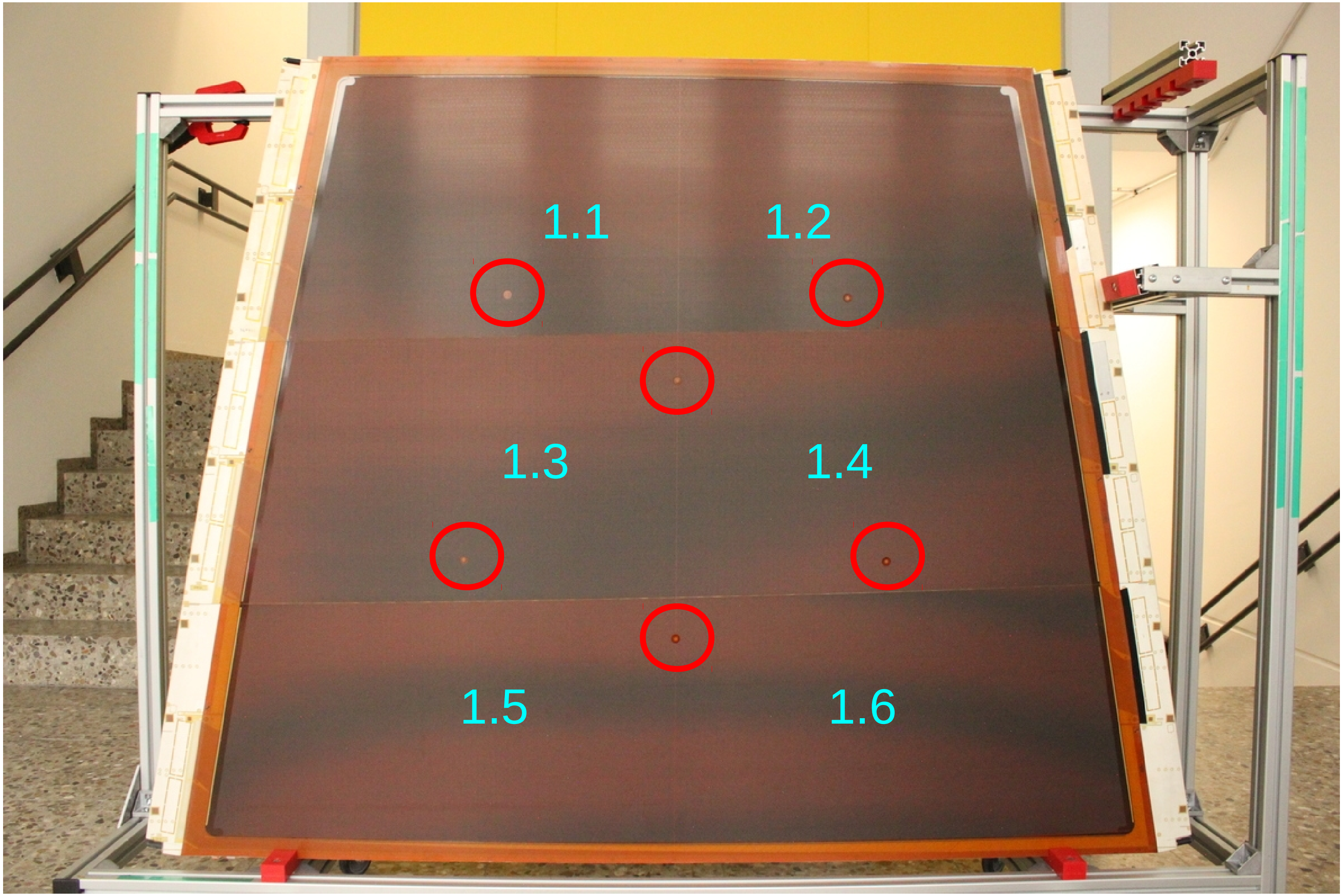
P
R
E
S
R
I
E
S



P
R
E
S
R
I
E
S

microstructured anode panel:
resistive strips with pillars

A SM2 Stereo Readout-Panel



3 PCBs
6 HV sectors

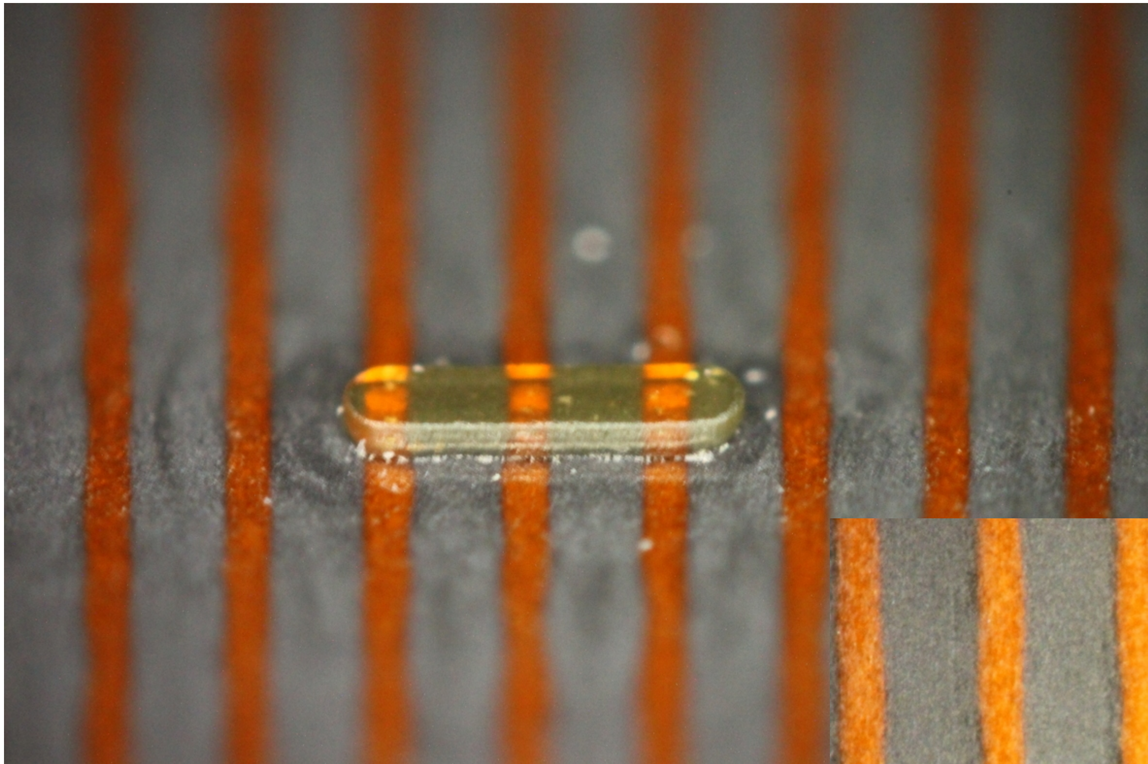
3068 strips, 425 µm pitch, 1.5 deg tilted against horizontal direction
120 µm high insulating pillars every 7 mm
6 interconnection regions no blow-up, but also to define floating mesh

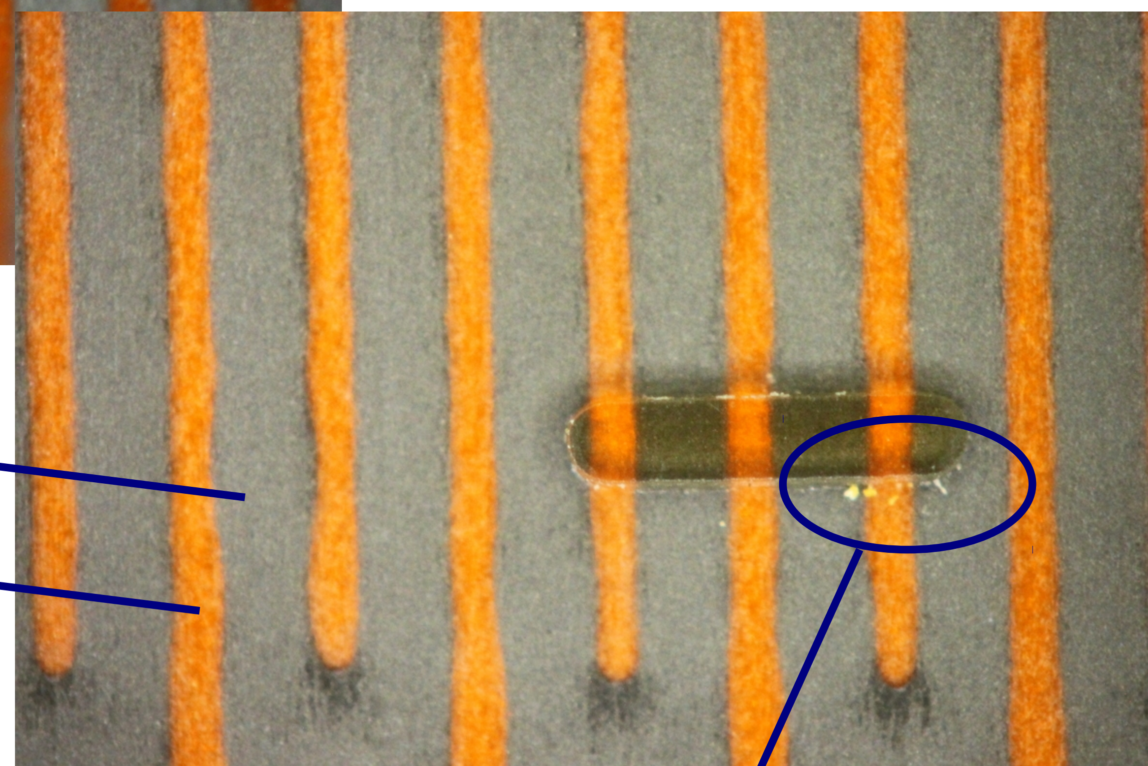
120 µm Pyralux Pillars Define the Distance Micromesh - Anode

pillar material: Pyralux
O(50000) pillars per plane

dust and dirt concentrates around the base of the pillars

=> dedicated washing procedure





inspection

micro crystal cleaner
readout panels

NGL drift panels

micro crystal cleaner
2^{nd} side ro panel

cleaning with deionized water

rinsing with warm tap water + use of brush

SM2 Cleaning @ Cern
total time 1-2h

Wet Cleaning:

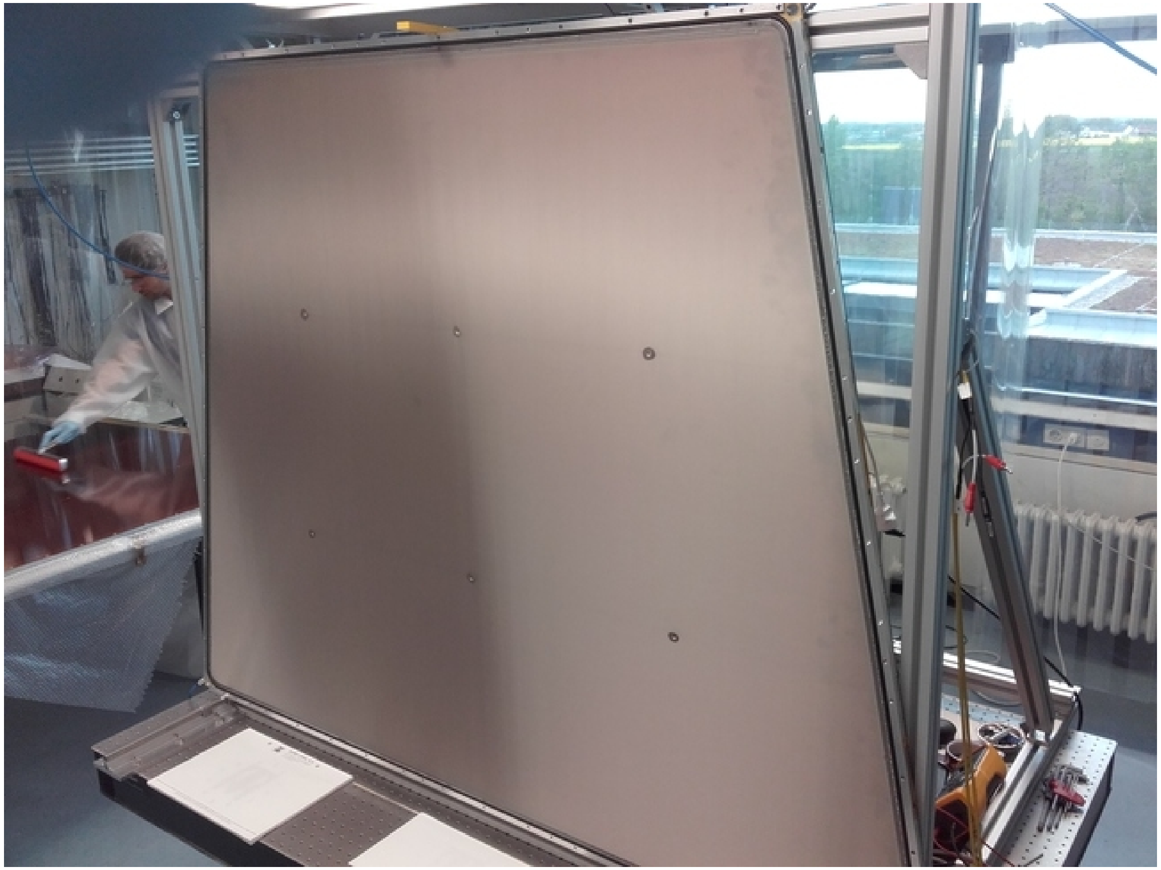
1. remove remnants from lithographic production processes

2. remove dust and dirt

The Wet Cleaning is implemented at all 4 production sites

It works, all remnants of the lithographic production processes can be efficiently removed

Assembly Station in a Laminar Flow Tent (Iso5)



dry cleaning of an external drift panel using vacuum + brush and the sticky roller

in the background: dry cleaning of a readout panel

Assembly Station

the cleaned readout panel
is placed
against the drift panel

A Completed Quadruplet on the Assembly Station

HV test under dry air starts immediately after assembly
dry air is used to avoid long waiting time for Ar:CO_2 flushing

SM2: Status of Cleaned Multiplets

multiplet	cleaned in	# of wet clean. cycles	dry air	Ar:CO2	# of sectors @ U_{max}	panels in multiplet
M2 doublet:	Cern	1x	990 V	590 V	12/12	eta2
M1 quplet:	MUC	2x	990 V	560 V	24/24	eta1 / stereo1
M3 doublet:	MUC	1x	975 V	not yet	10/12	stereo 4 + 2x polished ext. drift
eta3:	MUC	1x	not yet	not yet	?	eta3 / stereo 4 + polish. in. drift
M4 quplet:	MUC	0x	under prep.			eta4 / stereo 5 (both glued)

(stereo1, 2, 3 subject to bad SS6 pcbs)

SM2: Status of Cleaned Multiplets

	multiplet	cleaned in	# of wet clean. cycles	dry air	Ar:CO2	# of sectors @ U_{max}	panels in multiplet
1.	M2 doublet:	Cern	1x	990 V	590 V	12/12	eta2
2.	M1 quplet:	MUC	2x	990 V	560 V	24/24	eta1 / stereo1
3.	M3 doublet:	MUC	1x	975 V	not yet	10/12	stereo 4 + 2x polished ext. drift
	eta3:	MUC	1x	not yet	not yet	?	eta3 / stereo 4 + polish. in. drift
	M4 quplet:	MUC	0x	under prep.			eta4 / stereo 5 (both glued)

(stereo1, 2, 3 subject to bad SS6 pcbs)

SM2 M2 Doublet: HV Test under Dry Air in Munich

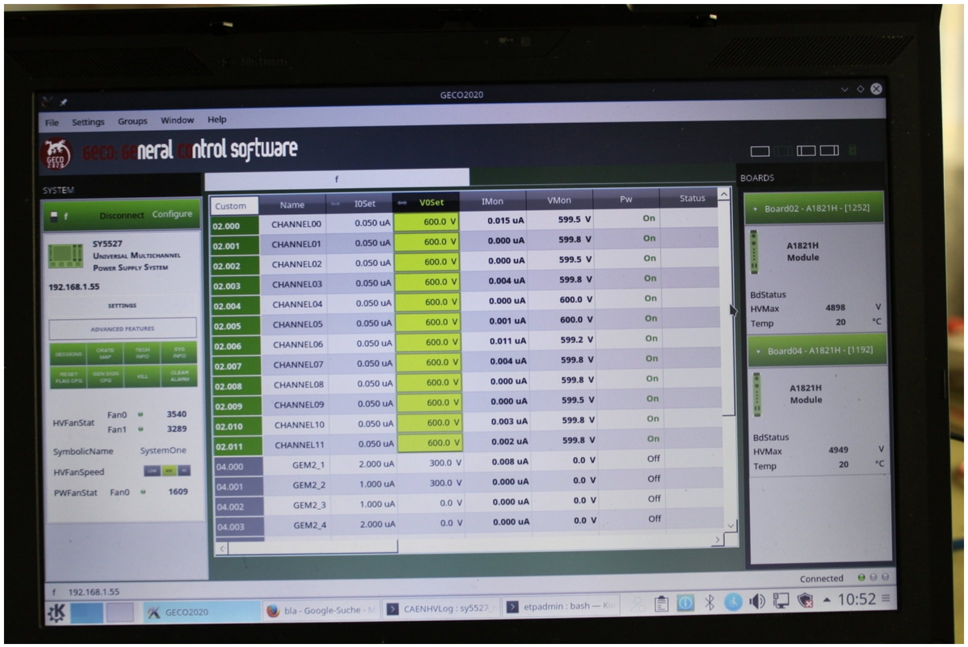
(cleaned @ Cern, after transport from Cern, no reopeneing)

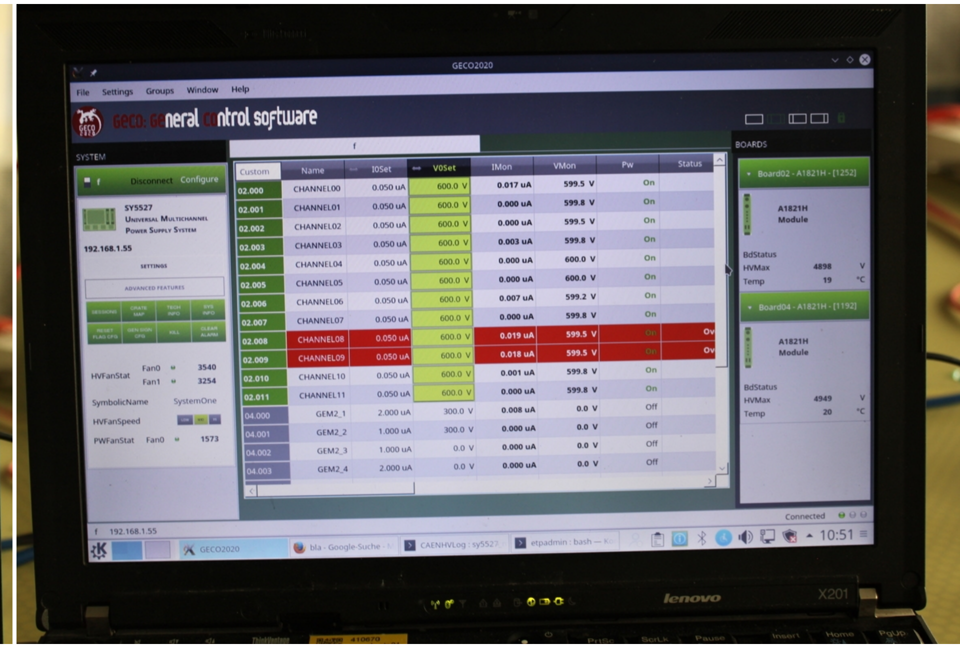
channel 0 and channel 6 have 10 nA offset

all 12 HV sectors are well below 10 nA
identical result as at Cern after cleaning
but there are short trips every few seconds

990 V seems to be the max. sust. voltage (< breakdown voltage)

SM2 M2 Doublet: HV Test under Ar / CO_2 in Munich
600 V





channel 0 and channel 6 have 10 nA offset

at 600 V some sectors become instable

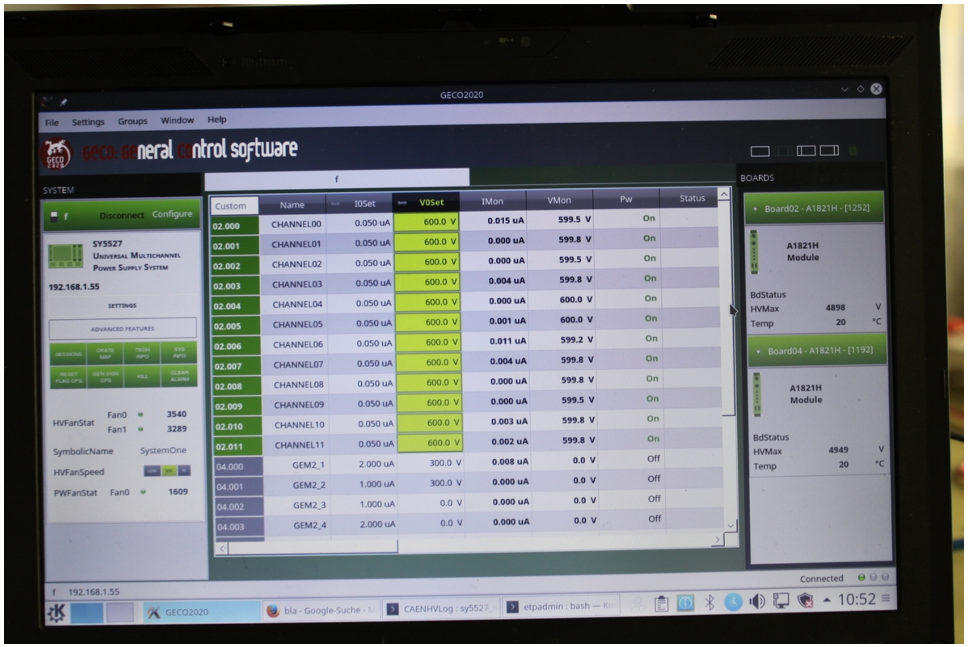
=>

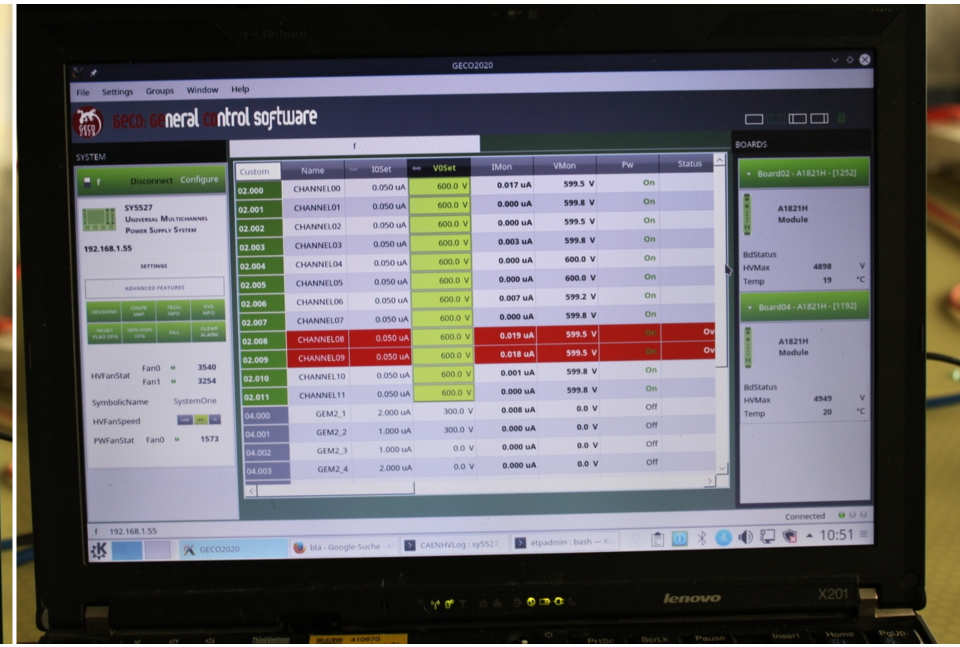
590 V in Ar/CO2   <=>   990 V in dry Air (pressure depedent)

590 V seems to be the max. sust. voltage for this SM2 doublet

several reopenings and dry cleaning were necessary for this

SM2 M2 Doublet: HV Test under Ar / CO2 in Munich
600 V





channel 0 and channel 6 have 10 nA offset

at 600 V some sectors become instable

=>

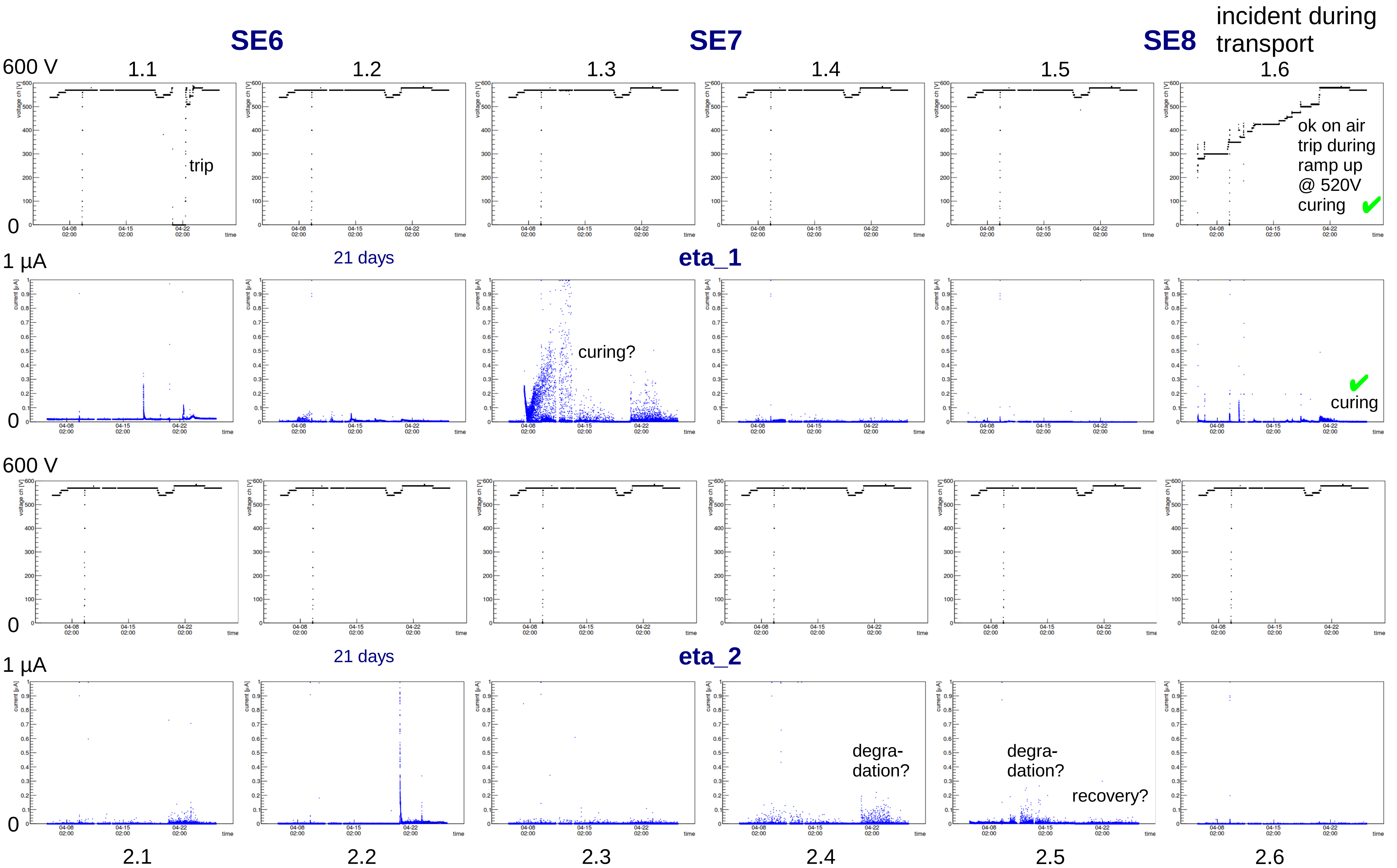
590 V in Ar/CO2   <=>   990 V in dry Air (pressure depedent)

590 V seems to be the max. sust. voltage for this SM2 doublet

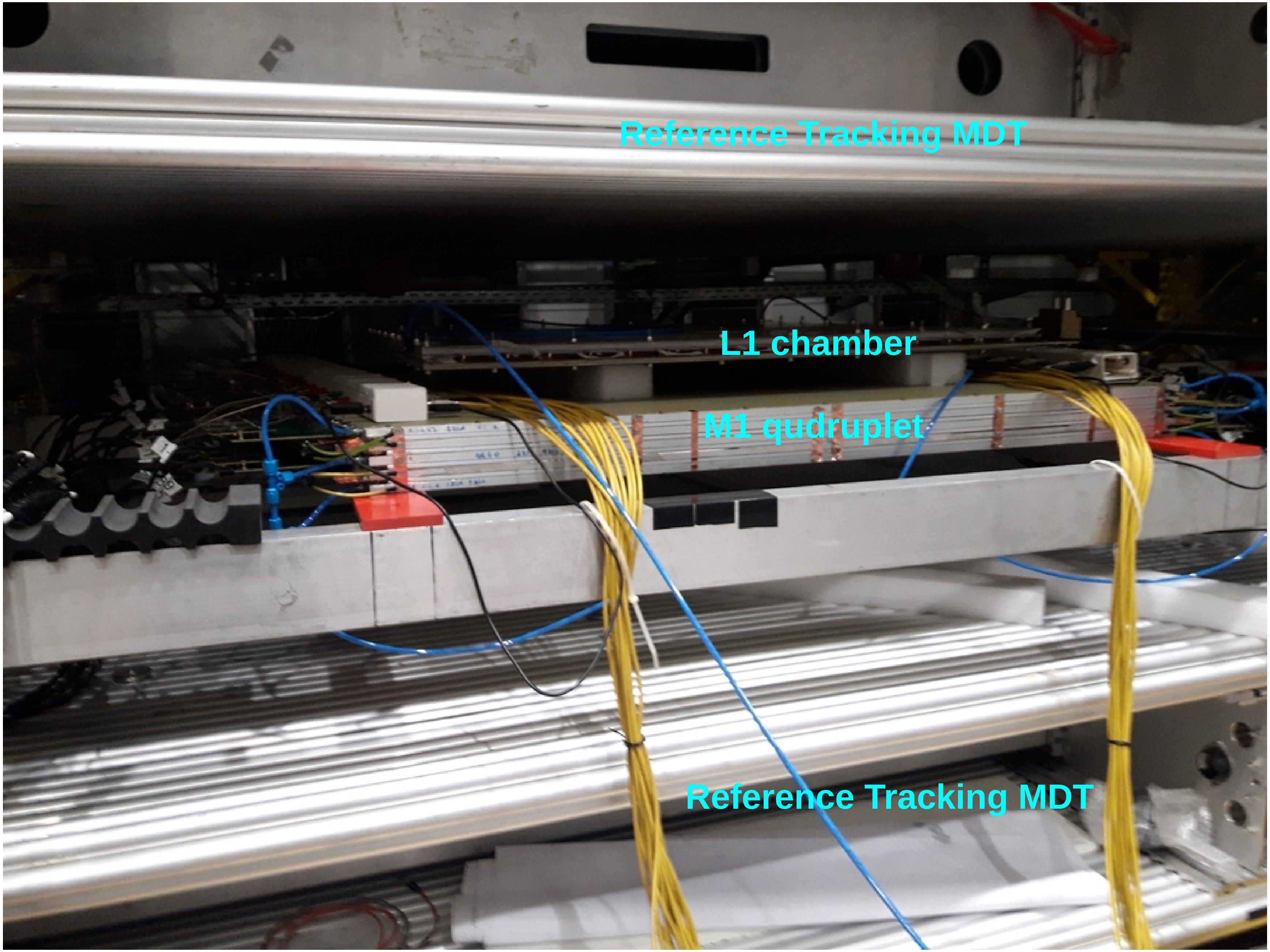
several reopenings and dry cleaning were necessary for this

SM2 M2 Doublet in the Cosmic Ray Facility Ar:CO2 93:7

5. 4. 2018 - 26. 4. 2018 **540 V - 580 V (590 V)**



The M1 Quadruplet in the Munich Cosmic Ray Facility

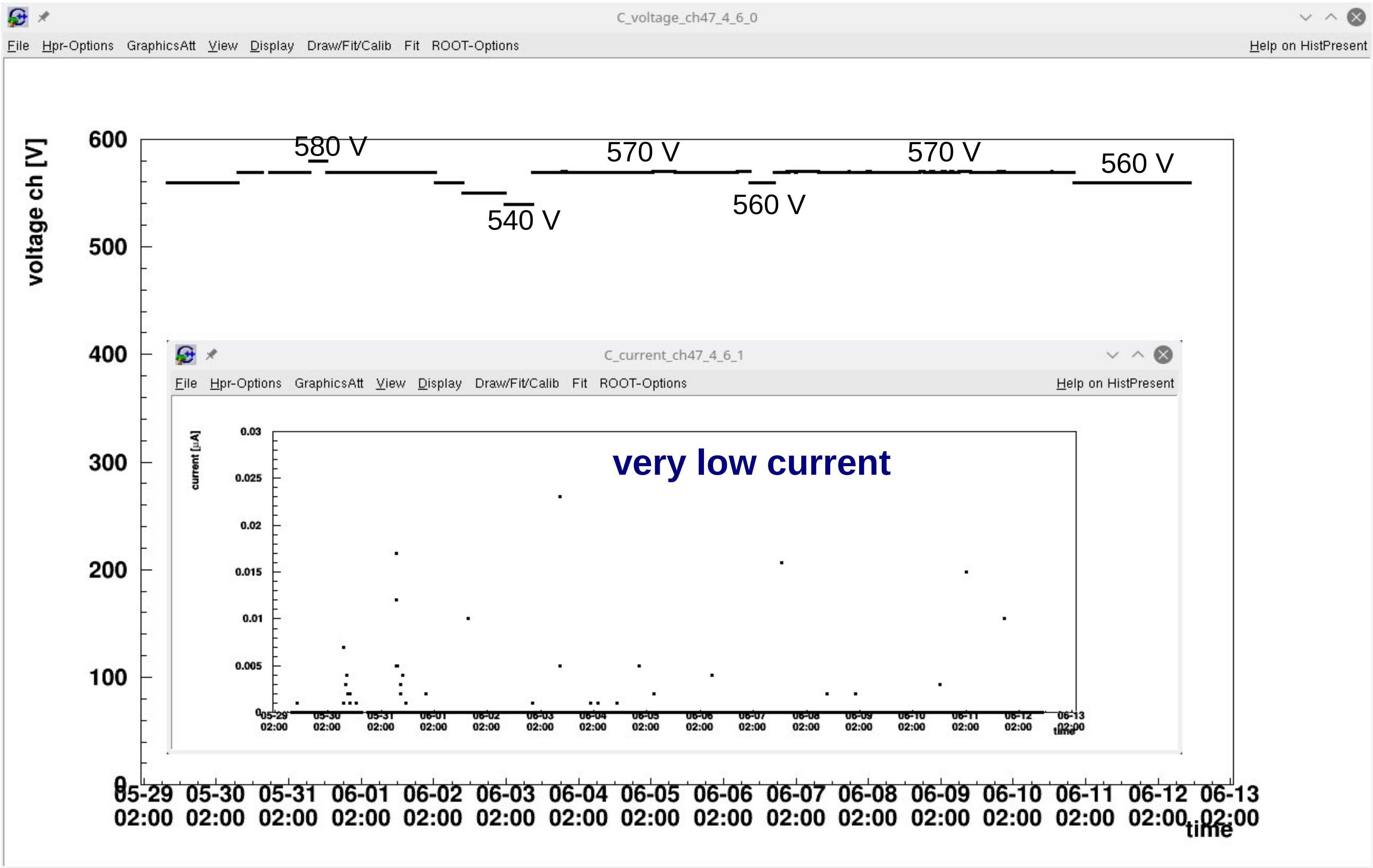


Full APV electronic readout

SM2 M1 Quadruplet in the Cosmic Ray Facility Ar:CO2 93:7

29. 5. 2018 - 12. 6. 2018 **540 V - 580 V**

timescale of the HV scan in the CRF: e.g.: SE8 Eta_out

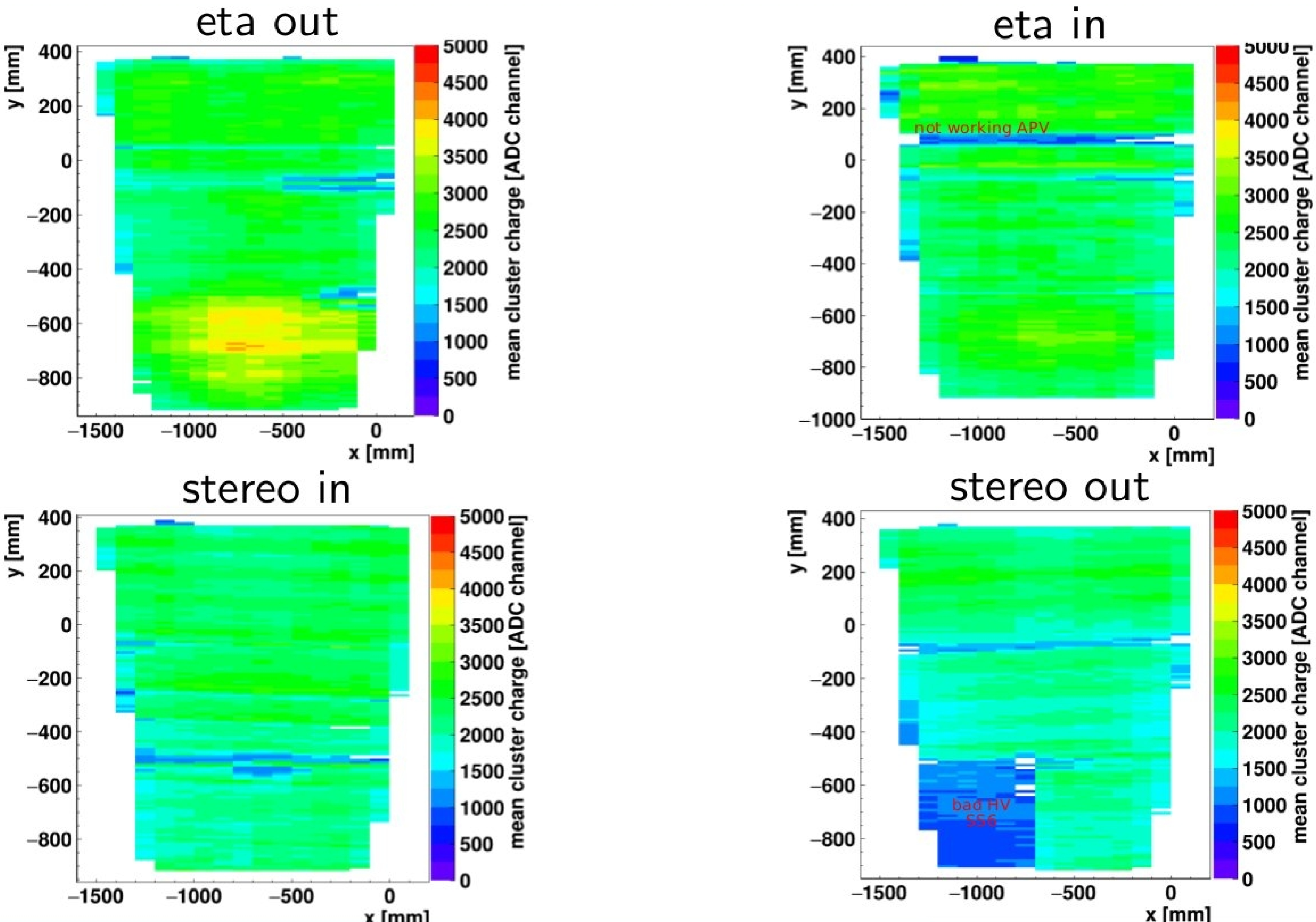


580V was not long term stable ↔ environmental influence?

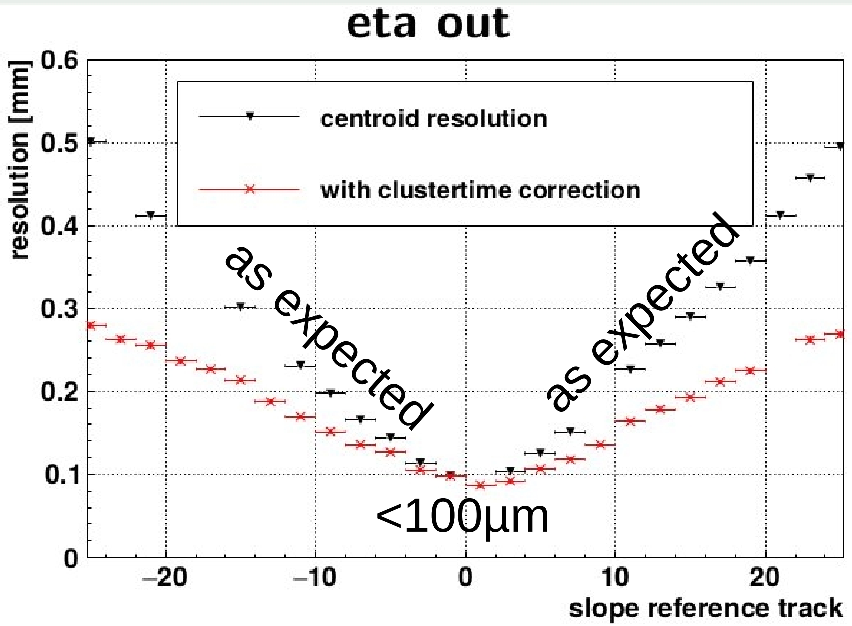
1 SS6 HV sector became bad after short time defective pcb many missing pillars problem solved

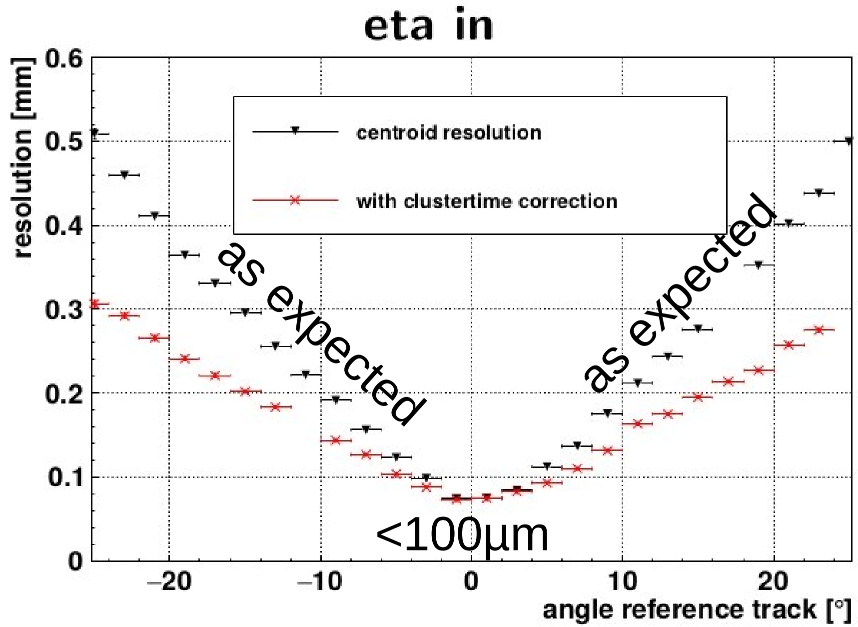
SM2 M1: Cosmic Ray Facility Data

Anode : 570 V, Cathode : 300 V, Ar:CO_2 93:7 vol%
Mean Cluster Charge



Position Resolution as Function of the Incident Angle





- residual distribution for each angle separately
- fit with double Gaussian

  analysis sigma narrow Gaussian only

  (reject multiple scattering)
- consider track uncertainty of reference chambers:

  $\sigma_{\text{micromegas}} = \sqrt{\sigma^2_{\text{res}} - \sigma^2_{\text{track}}}$
- resolution is for perpendicular incident close to expectation
- charge weighted clustertime correction improves residual distribution considerably

  analysis ongoing:

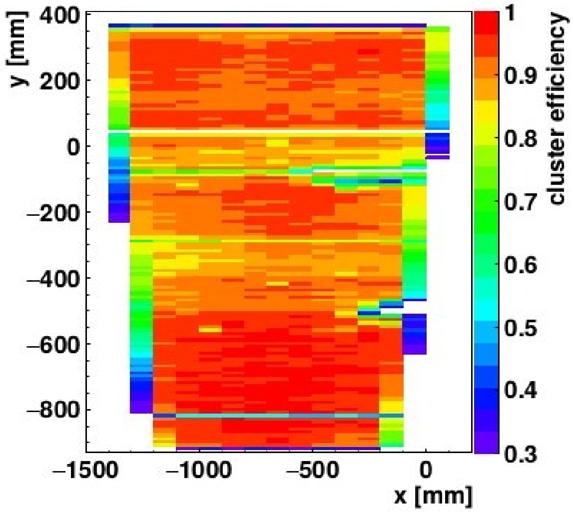
  0.2 mm @ 20° expected

  (see B.Flierl PhD thesis - Particle Tracking with Micro-Pattern Gaseous Detectors)

Efficiency (Preliminary)

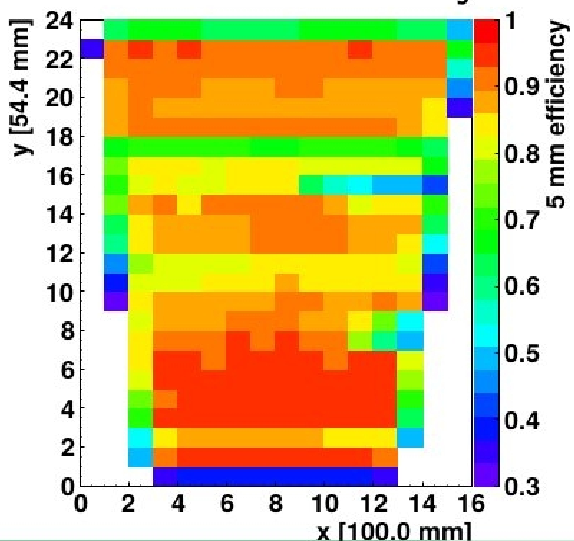
amplification 570 V, drift 150 V

cluster efficiency

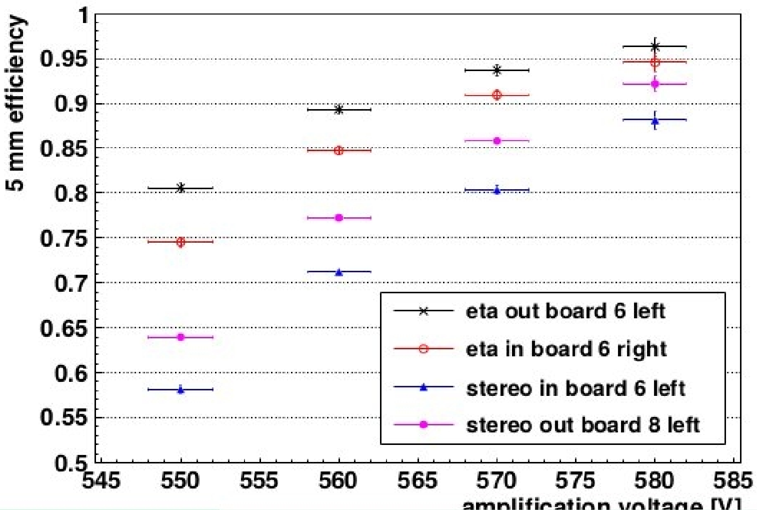


eta_in

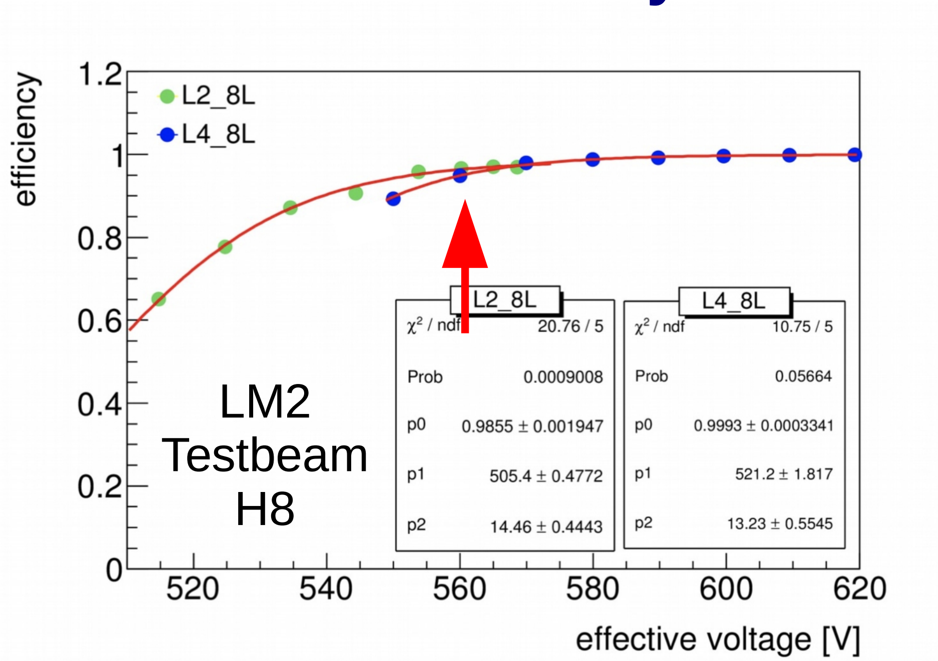
5 mm efficiency



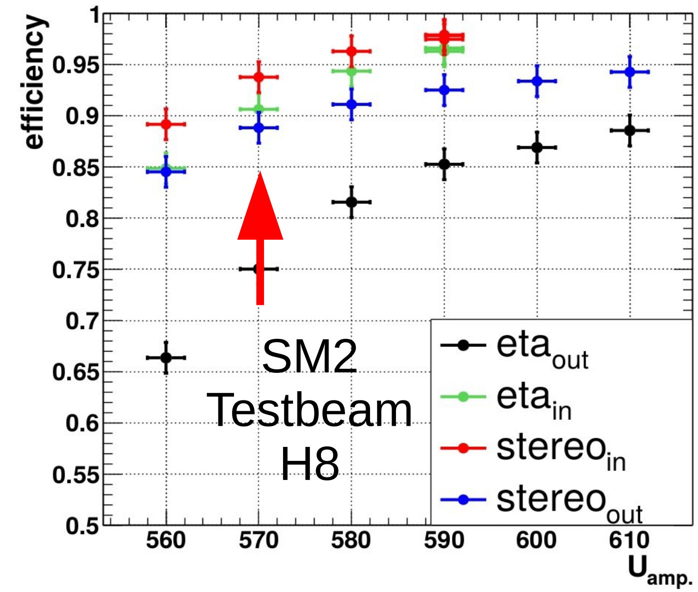
- preliminary results
  $\Rightarrow$ cuts have to be checked
- cluster efficiency:
  number of cluster with at least 2 strips divided by number all of tracks going trough partition
- 5 mm efficiency:
  number of cluster within 5 mm to track prediction
  divided by number of all tracks going trough partition
- efficiency decreased by missing strips / zebra?



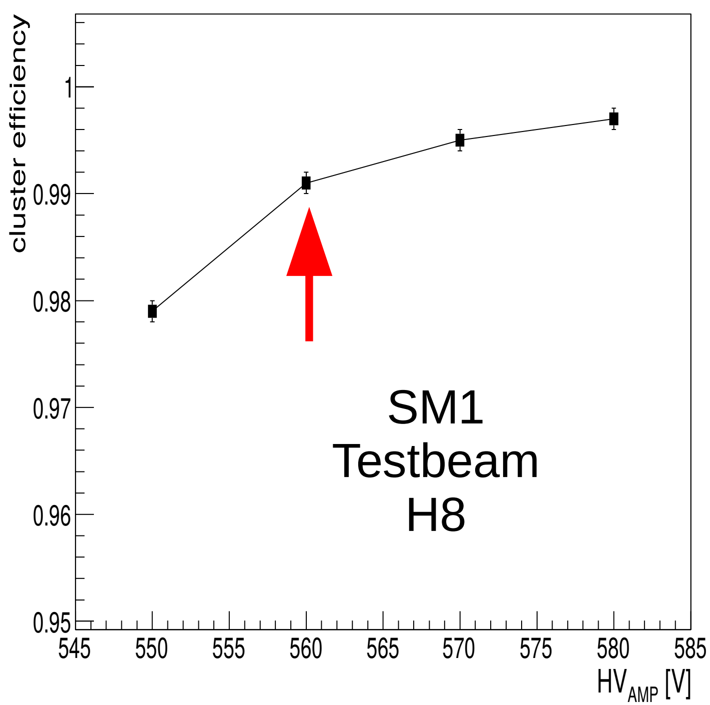
Efficiency Turn On Curves for Module 0



screen printed res. strips



sputtered resistive strips



efficiencies were in the plateau above 560-570 V

stable situation

higher primary ionisation than MIPs

20. April 2018   Summary of the Facts:

working point: 560 - 580 V

max voltage: 590 - 600 V

the small dynamic range between 580 and 590 V
is driving the question:

can we increase the margin between work.point and max.voltage by

1. increasing the break down voltage
2. lowering the working point

=>
compare with

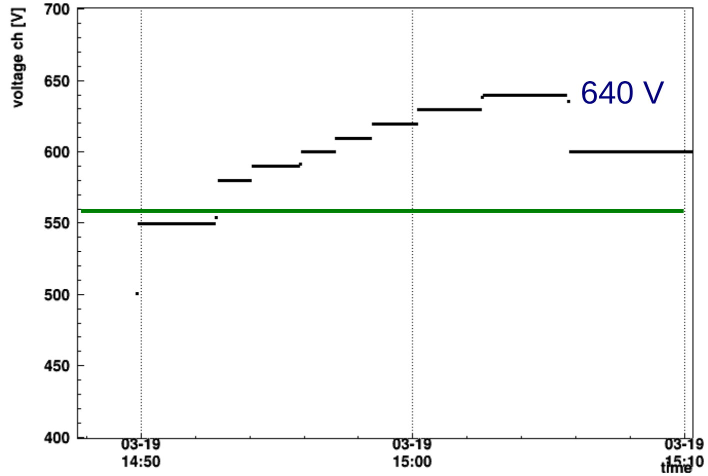
1. data from T-chamber (18/45 calendered mesh)

2. data from ExMe chamber (F.Kuger 2016)   similar to SM2
   (ExMe: exchangeable mesh)

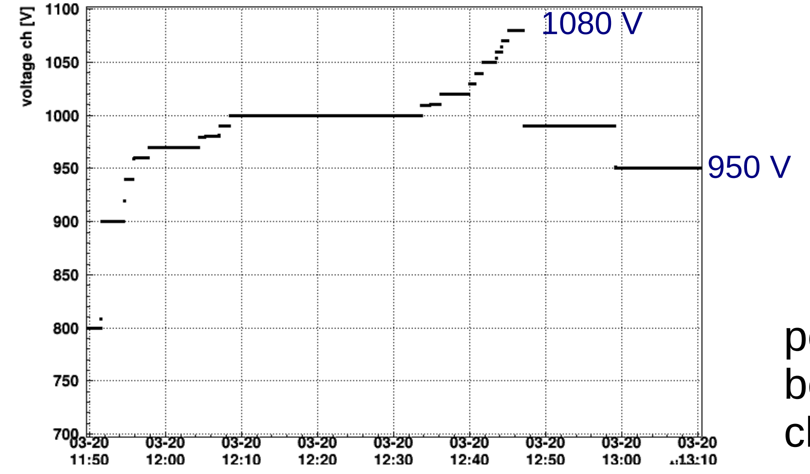
HV Max. Voltages and Currents T-Chamber 19. 3. 2018 (RH + PL)

(the T-chamber was connected to the output of the SM2 Multiplet)

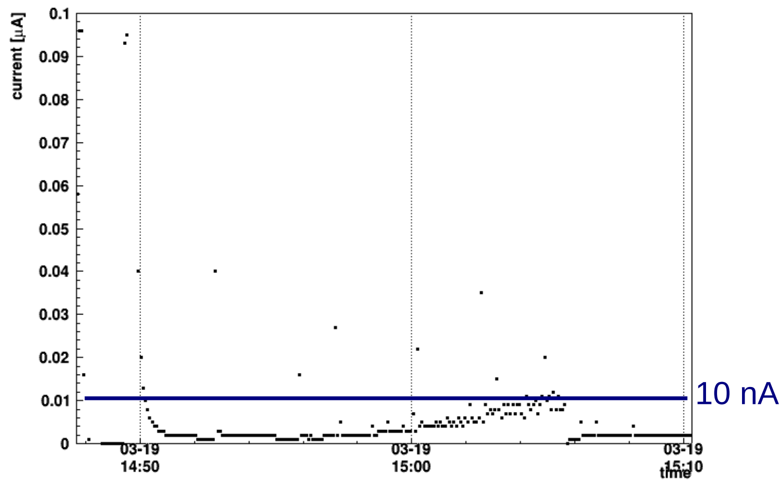
Ar / CO_2

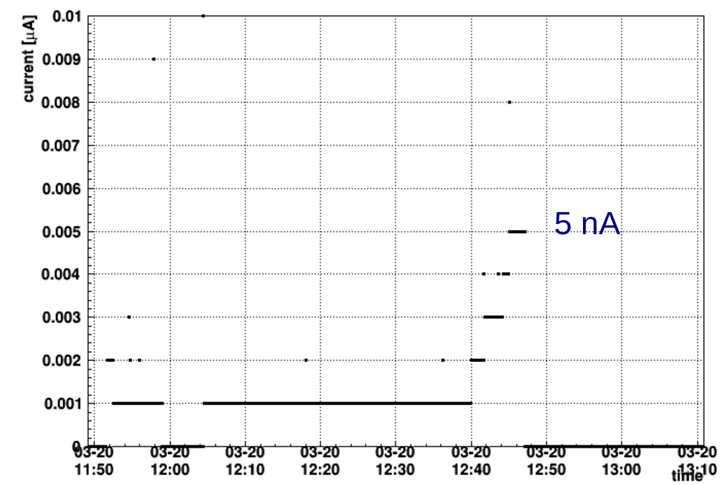


Air dry



perfectly behaving chamber

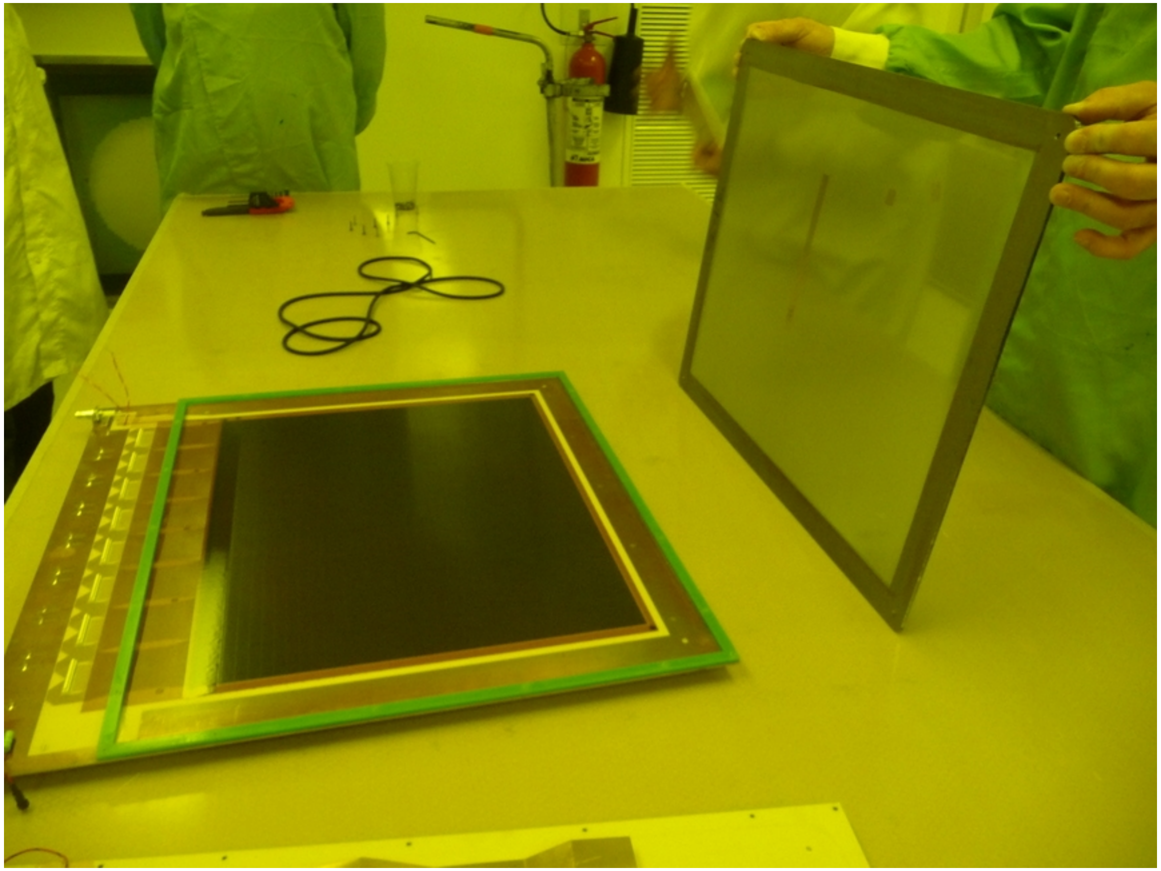




current rises smoothly above threshold voltage

	work. point V	max. voltage	pillar height	mesh dimensions	mesh type
T-chamber	520	620	105 µm	18/45 calendared	bulk
NSW MM	570	590	120 µm	30/71 non-calendared	floating mesh

The ExMe Chamber

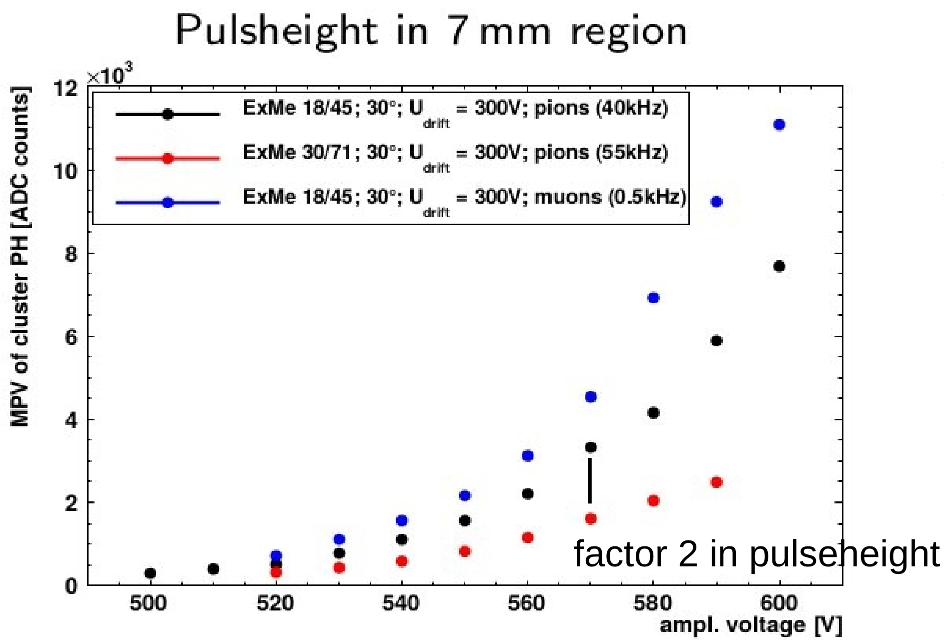


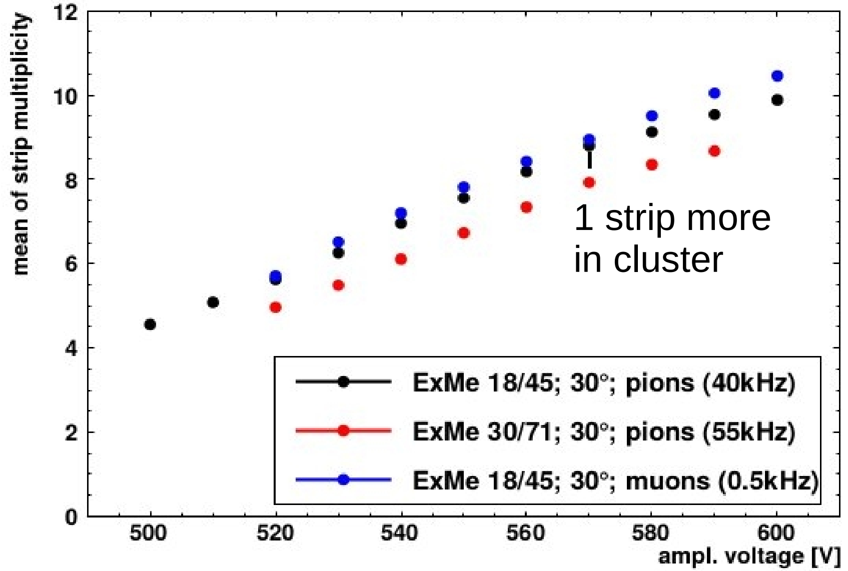
anode similar to NSW MM 120 µm high pillars, 7mm distance
easy to exchange meshes
under otherwise unchanged conditions

the 30/71 mesh has been polished, see later

H8 Testbeam May 2018: ExMe2 Chamber with 30/71 and 18/45 Mesh

Pulseheight (mesh comparison)





18/45 calendared mesh
30/71 polished mesh

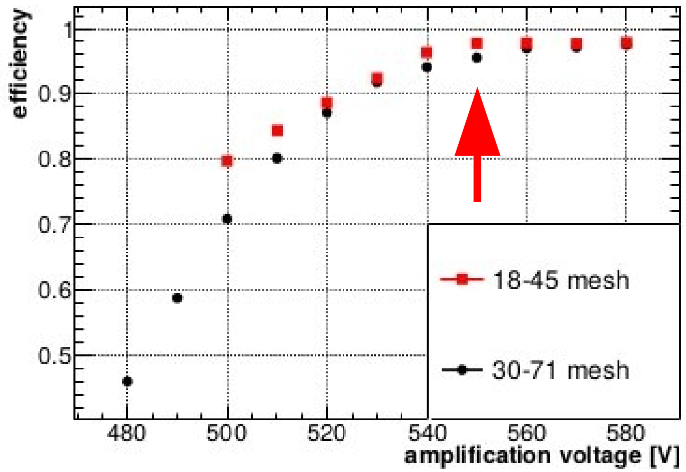
Mesh comparison:

- Pulseheight measured in 7 mm pillar region, here shown @ 30°
- (18-45) µm mesh shows significantly higher amplification than (30-71) µm mesh
- Factor 2 @ 570 V
- Higher working point of (18-45) µm mesh (due to Kapton passivation ?)
- On average higher strip multiplicity at (18-45) µm mesh

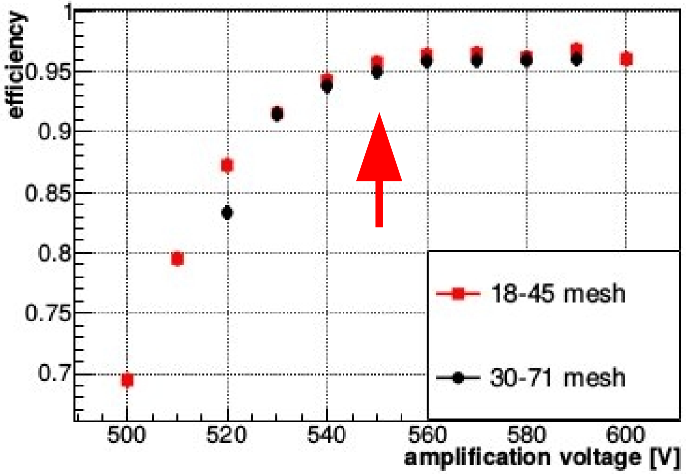
in agreement with Cern Fe55 ExMe results

5 mm Efficiency

0° inclination



30° inclination



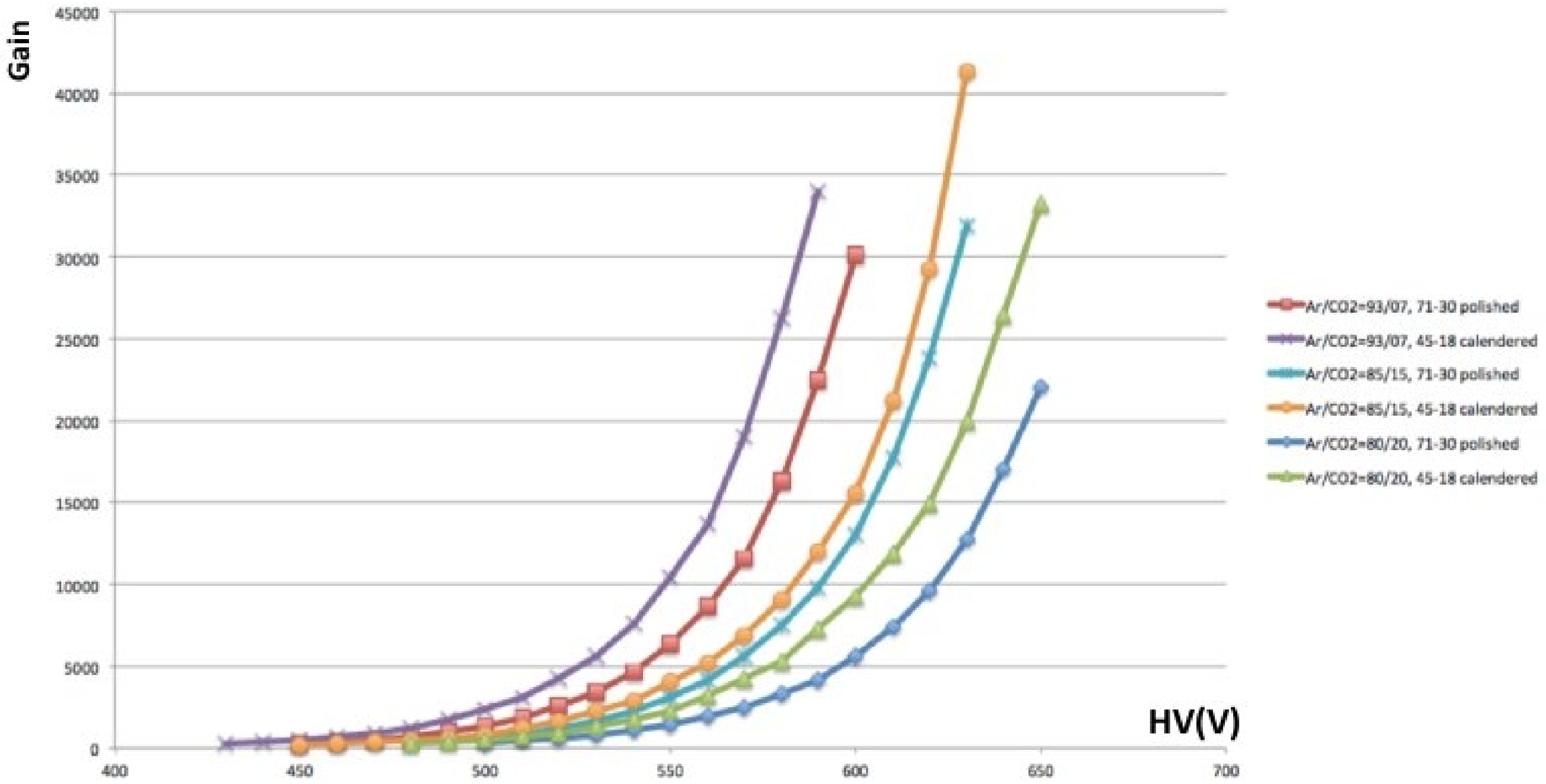
turn on curves not fully compatible with factor of 2 higher pulse height @ 18/45

- Efficiency: Cluster (min. 3 strips) within $\pm 5\,\mathrm{mm}$ from prediction
- $E_{drift} = 600\,\mathrm{V\,cm}^{-1}$
- (30-71) μm seems to have steeper turn-on curve
- At plateau: insignificant difference between both meshes
- $\epsilon \geq 95\,\%$ $U_A \geq 550\,\mathrm{V}$

U_{work} = 550 V ? for ExMe Chamber

Gas mixture comparison

- Mesh: 45/18 and 30/71 polished
  - Higher gain of 45/18 for all mixtures, difference seems not to be constant with CO2 fraction



E-Field at Micromeshes

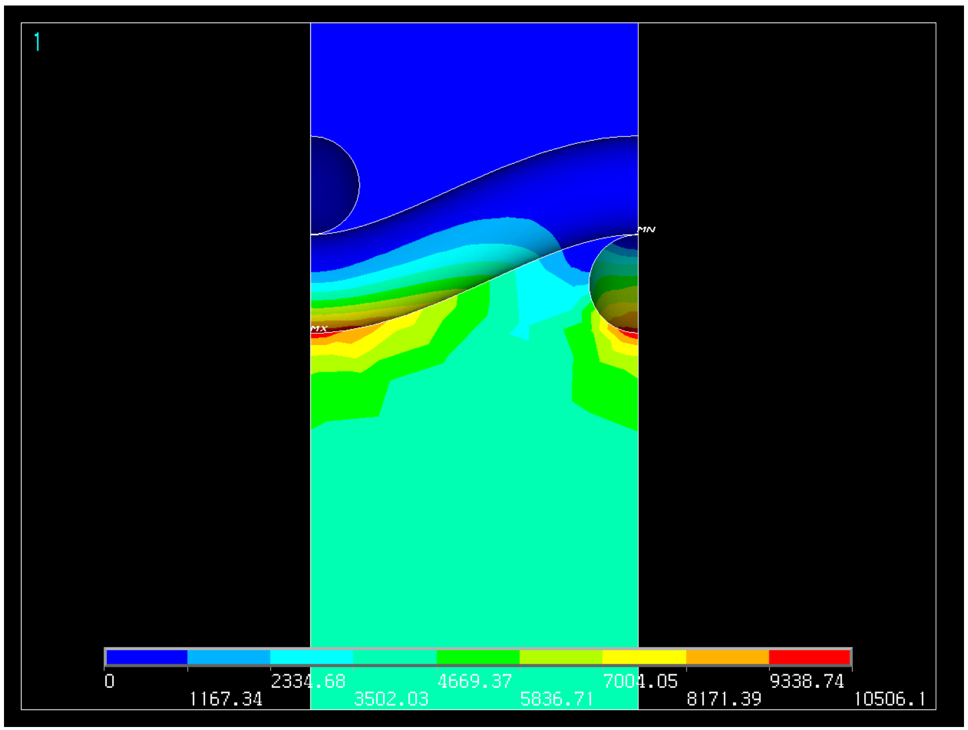
Ansys Simulation (M. Herrmann)

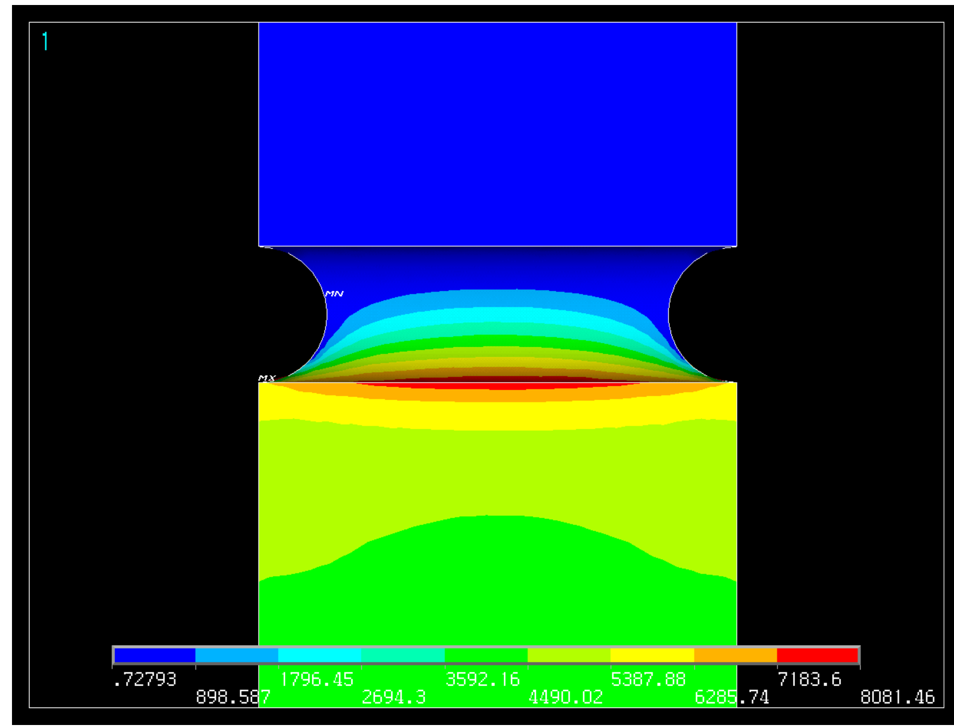
U_{anode}=540 V U_{drift}=-300V

simulation of a calendared mesh

SM2

T-chamber





plain weave mesh 30-71
120 µm

E_{max} = 105 kV / cm
E = 44 kV / cm

flat mesh 18-45
120 µm

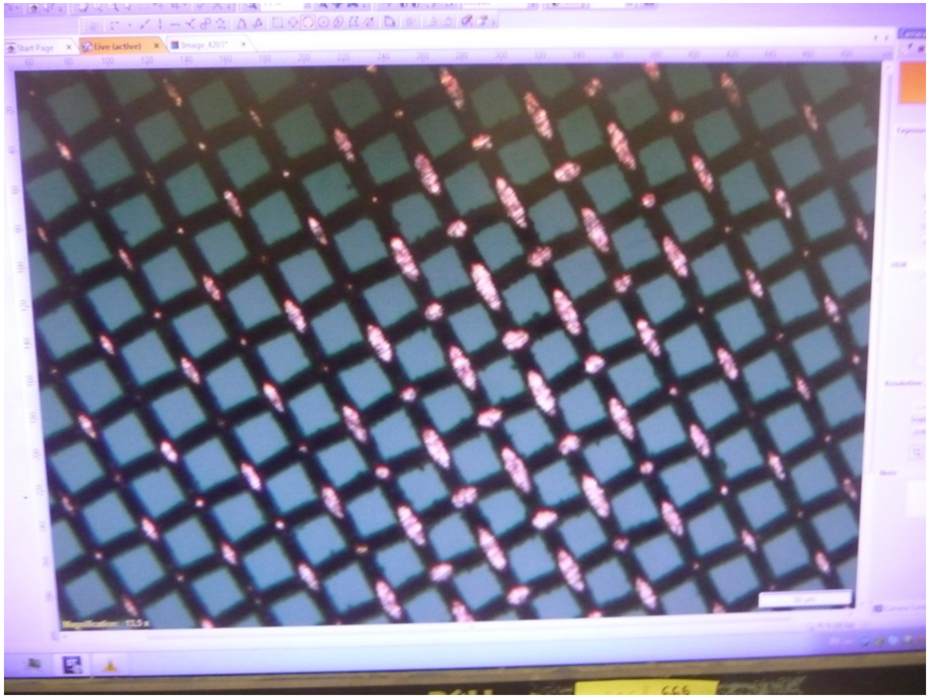
E_{max} = 81 kV / cm
E = 36 kV / cm

NB: the weakest point defines the break through voltage !
polishing of the mesh might be beneficious

SM2 M3 Doublet:

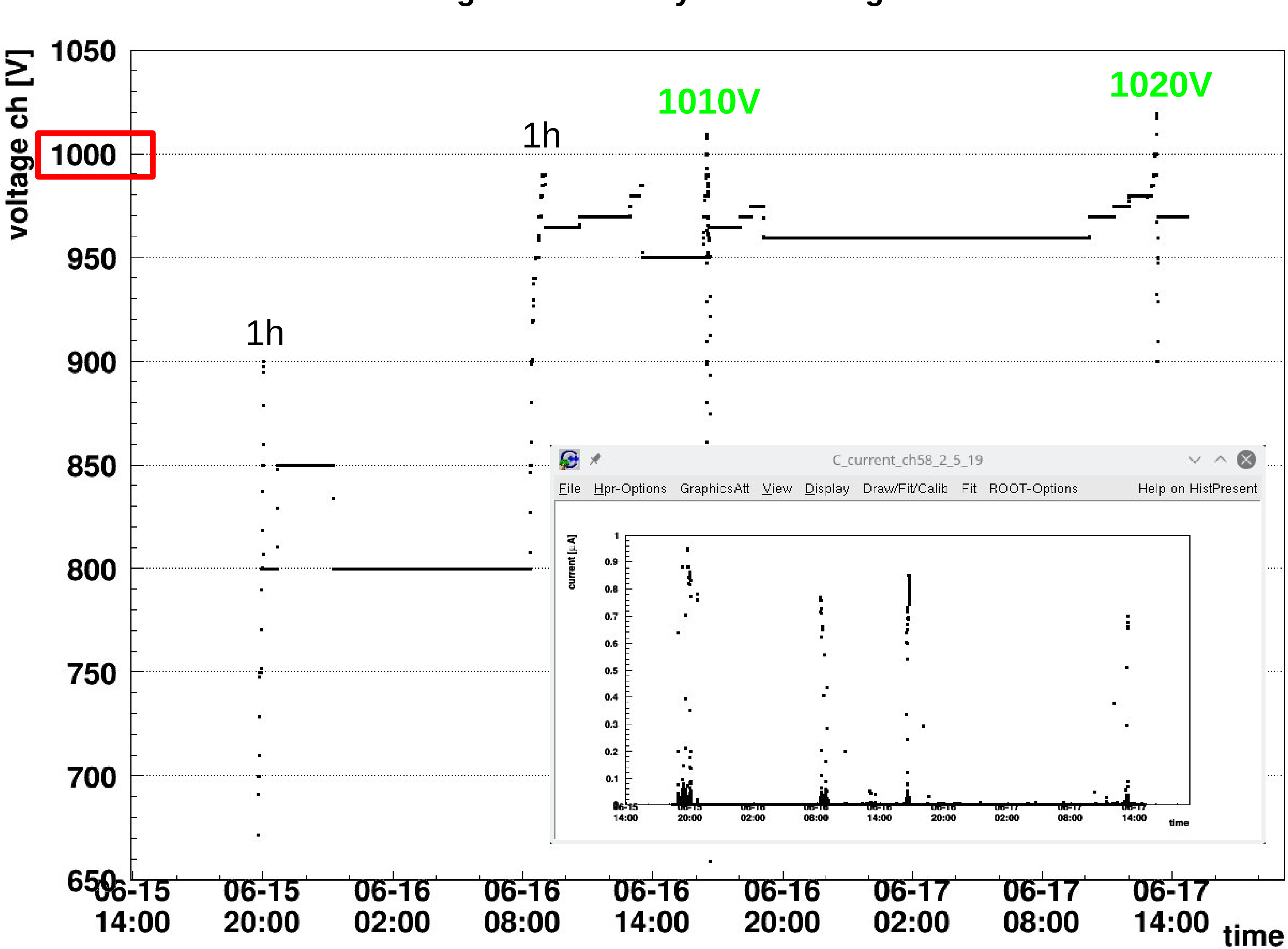
stereo4
+
2x polished drift panel

assumption: polishing of the mesh
=>
less E_{field} exaltation



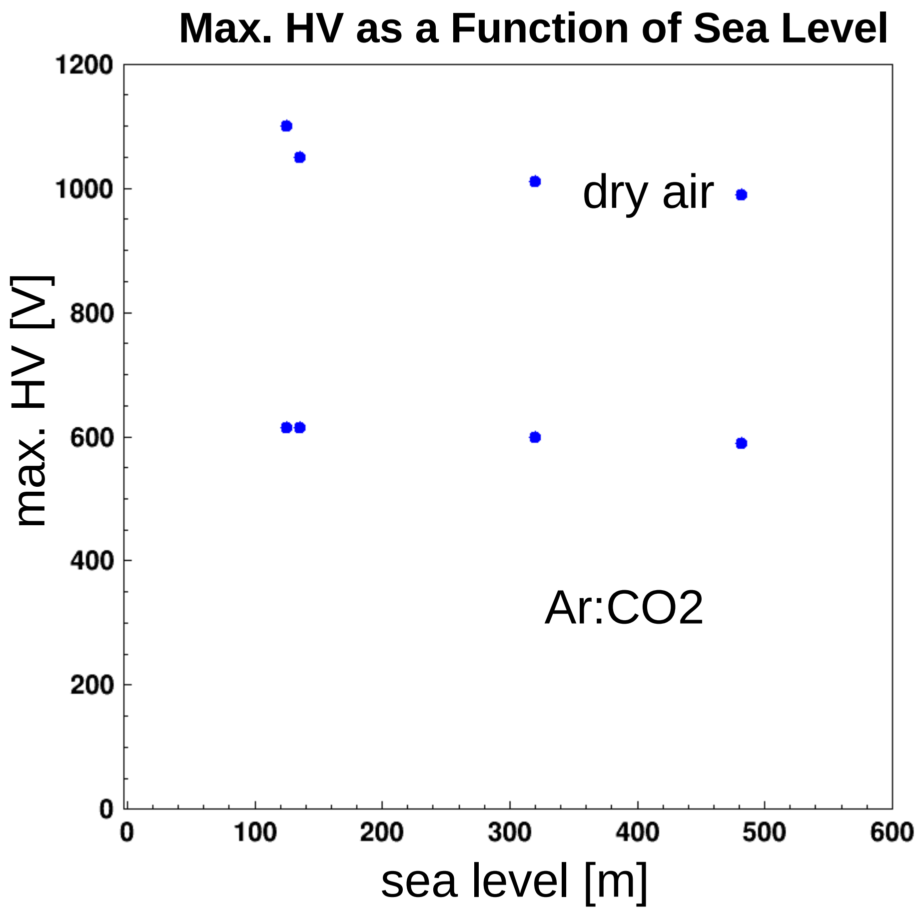
SM2 M3 Doublet: HV Scan Example HV Sector 2.5

HV Ramp-Up Started Immediately After Assembly Together With Dry Air Flushing



quiet currents, higher values only during change of HV U_{max}=1000V 10/12 sectors

All 4 Production Sites Experience Similar Results



Dubna: 125 m

Saclay: 130 m

Frascati: 320 m

Garching: 482 m

U_{work} = 570 V → 550 V is under investigation

- polished meshes, calendared meshes I, D, Cern
- gas studies Cern, F, D, I
- VMM electronic + drifttime including analysis

Summary :

3 multiplets have been cleaned
cleaning works, 1x wet cleaning
but several reopeneings still necessary for successful dry cleaning

excellent spatial resolution under cosmics
efficiency high, but not too high yet (missing strips, zebra ?)
similar HV behaviour for all 3 multiplets => systematic effect ? mesh ?
similar HV behaviour for the other multiplets from the other 3 sites

potential degradation of HV behaviour by time at a few HV sectors
narrow dynamic range between U_{max} and U_{work}

the polishing of the mesh seems to have positive effects
but the results are not yet fully conclusive
a test in Italy shows no improvement using polishing
a comparison of calendared and uncalendared 30/71 mesh shows no effect using ExMe

test of M1 at SPS 120 GeV pion beams next week
VMM electronic
gas studies: Ar:CO2 93:7, Ar:CO2 85:15, Ar:CO2:C4H10 91:7:2, H_2O content

ExMe Chamber tests are ongoing: meshes, gas-mixtures

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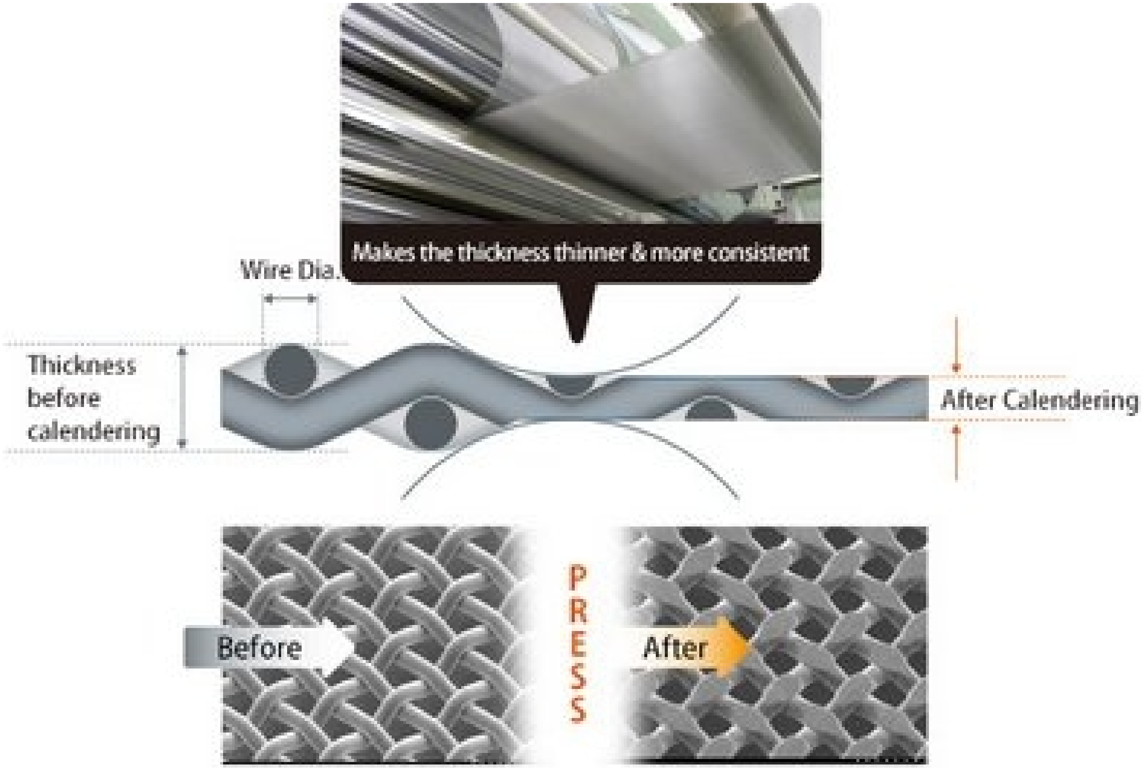
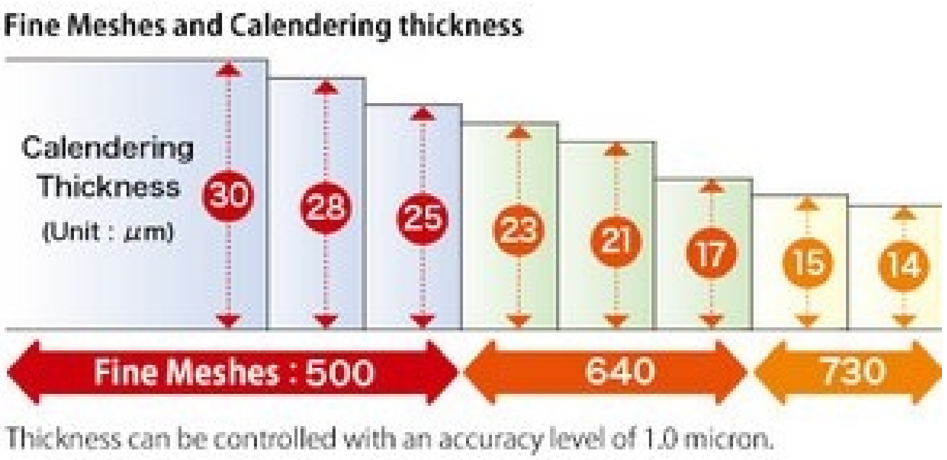
Theo Alexopoulos
Paolo Iengo
Mariagrazia Alveggi
Mauro Iodice

Backup

Calendering of a Mesh





Gas mixture

- Results from old Micromegas prototype (bulk, non resistive)