LAPP/Demokritos H4 setup

Sampling Calorimetry with Resistive Anode Micromegas

(SCREAM)

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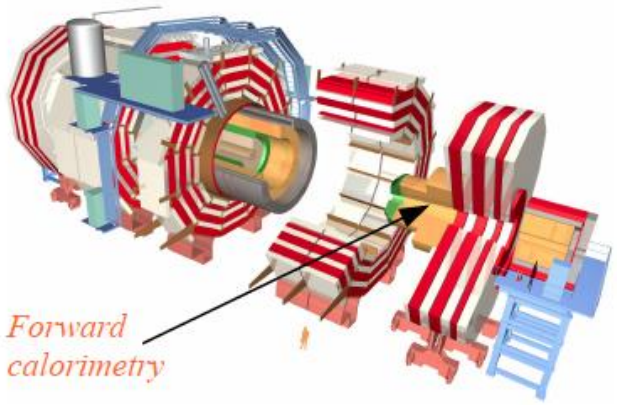
Resistive Micromegas for Particle Flow Calorimetry

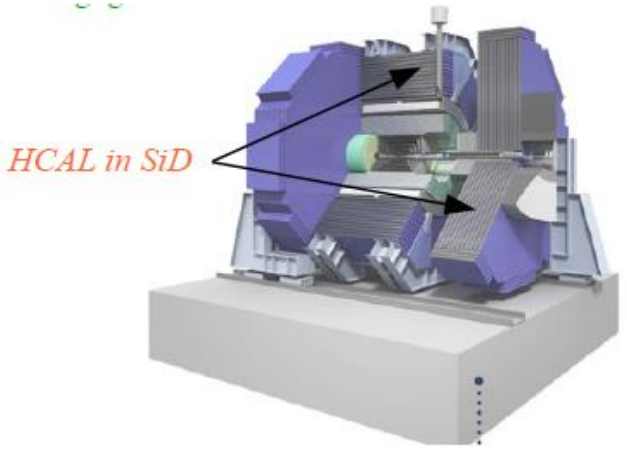
1) At future linear colliders

HCAL with 1x1 cm2 pads, high granularity for PF both in transverse and longitudinal direction, small sensitive area thickness (< 1cm)
➔Removes spark protection diodes from pcb, more cost effective

2) At HL-LHC (CMS)

Backing Hadron Calorimeter to complete the Si-ECAL + HCAL. Rate Capability, ageing, radiation tolerance, discharge attenuation.





Current activities

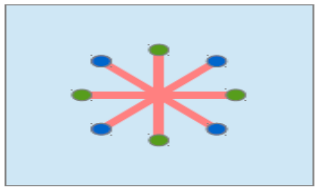
1) Design and explore a large range of resistivities
2) Optimization of the design in terms of response linearity and discharge protection
3) Micromegas studies with X-ray guns and at the RD51 test beam with muons (mips) and pions (also with absorber)

Near Future plans

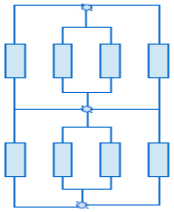
1) Further optimize the design
2) Build a mini hcal prototype (50 x 50 cm2) with several layers of Micromegas + absorber

Shapes and values R1 Detectors for LAPP

Star

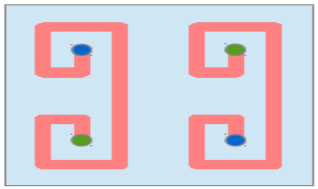


L_{eff} ~ 0.13 cm
R(100 k/sq) ~ 400 kOhm
R(1 k/sq) ~ 4 kOhm



Real values:
40 to 60 KOhms with 10KΩ/Sq
400 to 750 KOhms With 100KΩ/Sq

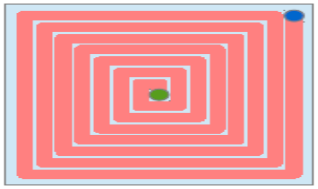
Mirror



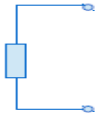
L_{eff} ~ 1.3 cm
R(100 k/sq) ~ 4 Mohm
R(1 k/sq) ~ 40 kOhm

Real values:
400 KOhms with 10KΩ/Sq
4 MOhms With 100Ω/Sq

Snake

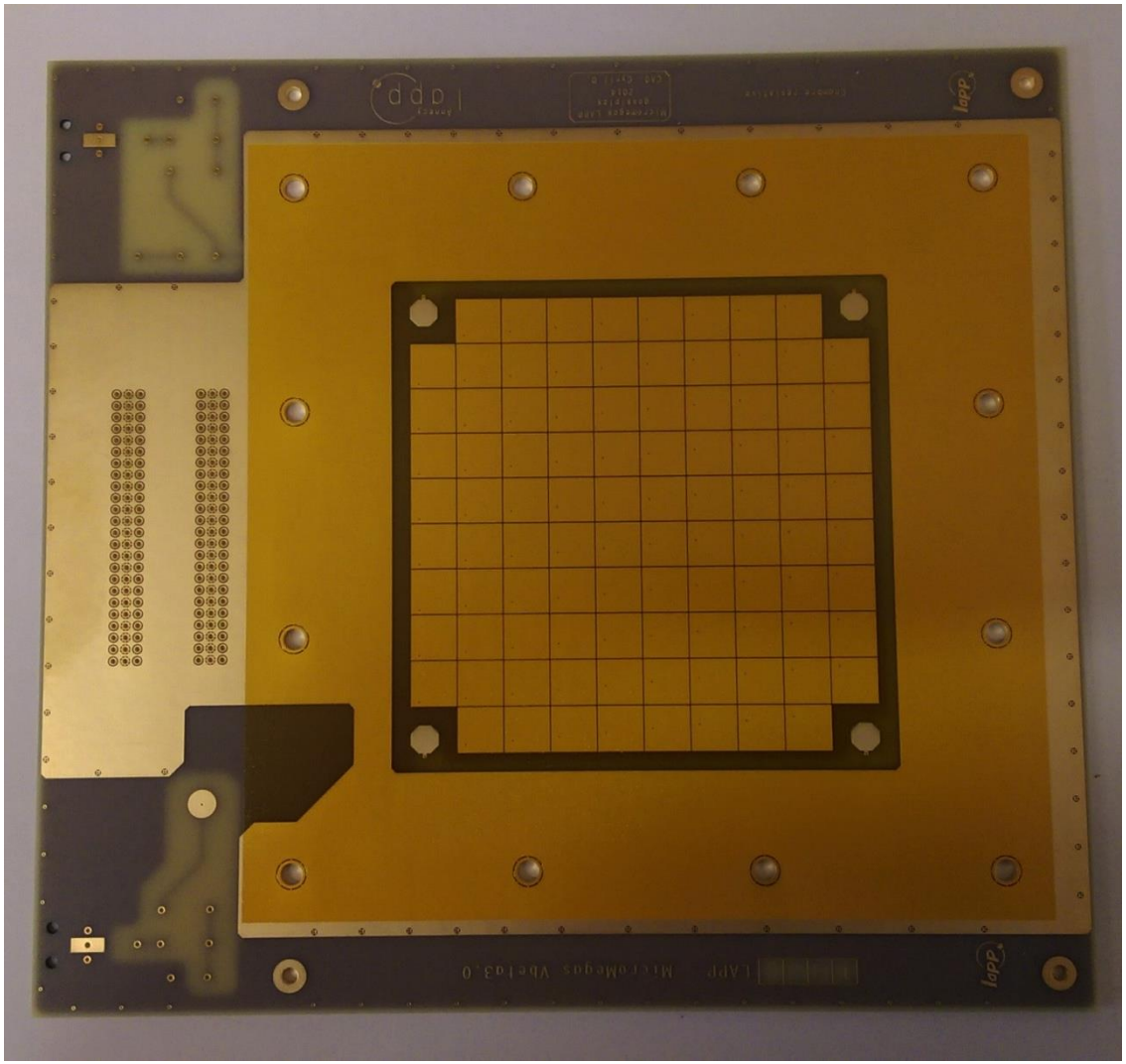


L ~ 13 cm
R (100 k/sq) ~ 40 MOhm
R (1 k/sq) ~ 400 kOhm

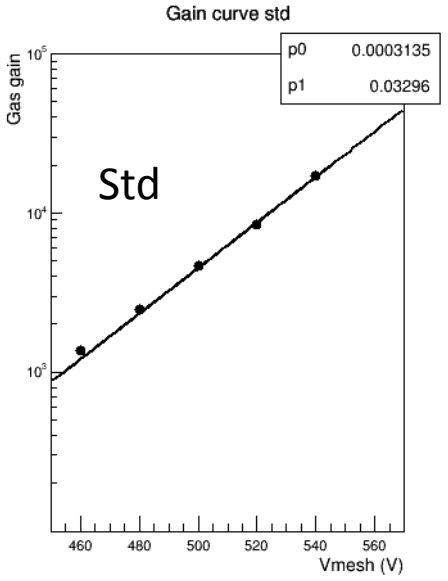


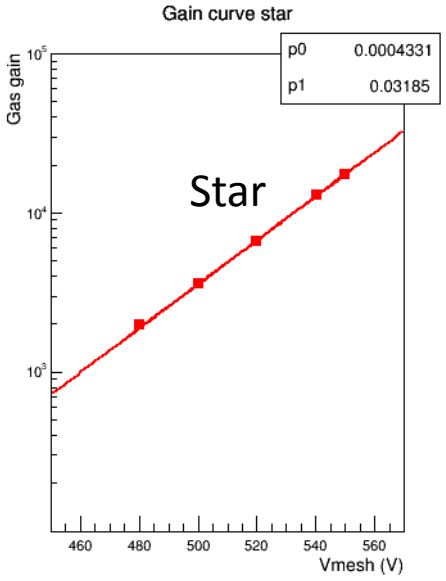
Real values:
4 MOhms with 10KΩ/Sq
40 MOhms With 100Ω/Sq

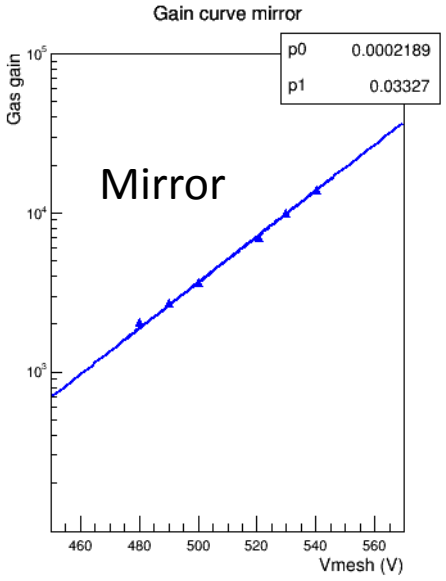
Picture R/O with the first Coverlay pressed on

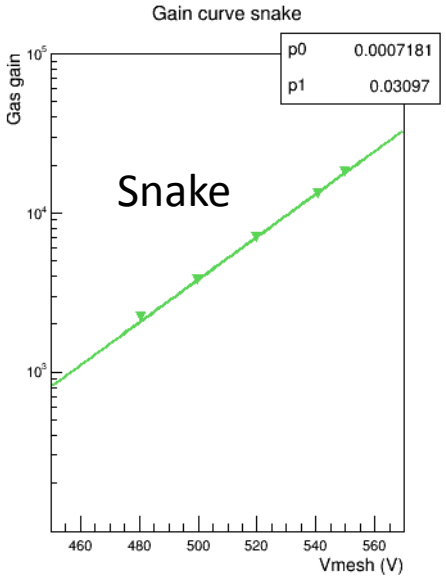


Gain for a Std bulk and the resistive Star, Mirror, Snake

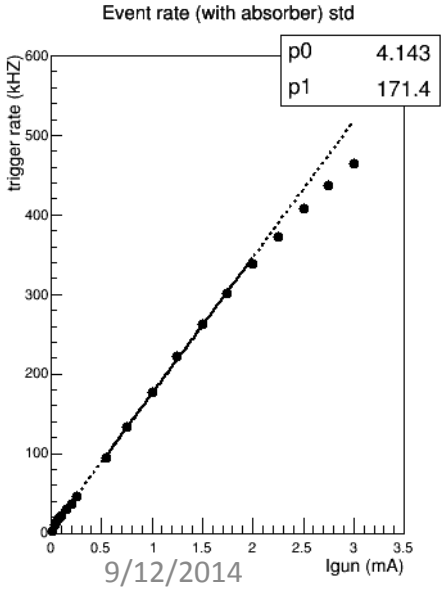


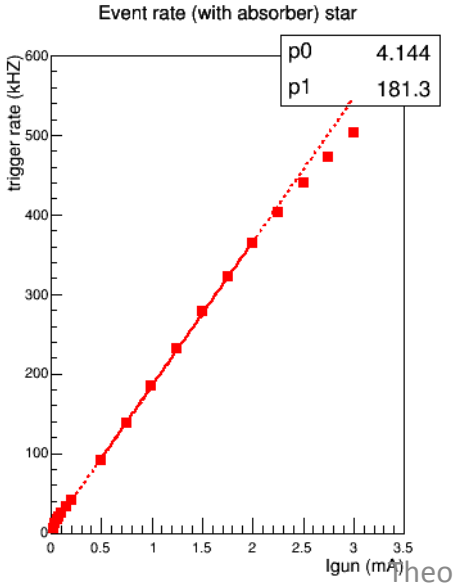


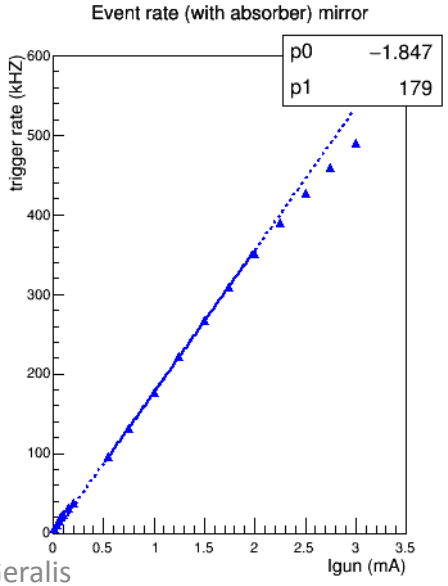


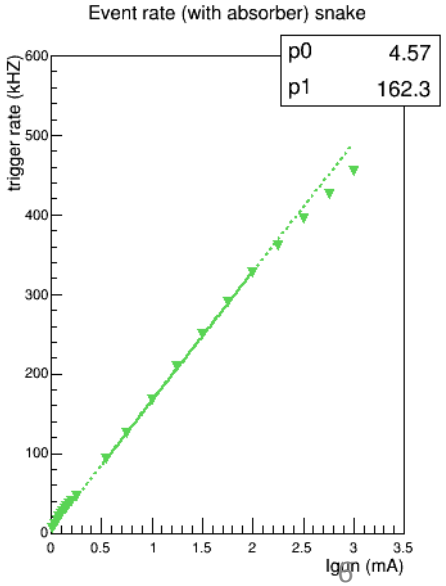


Measured rates with absorbers➔ Scale factor for rates without abs



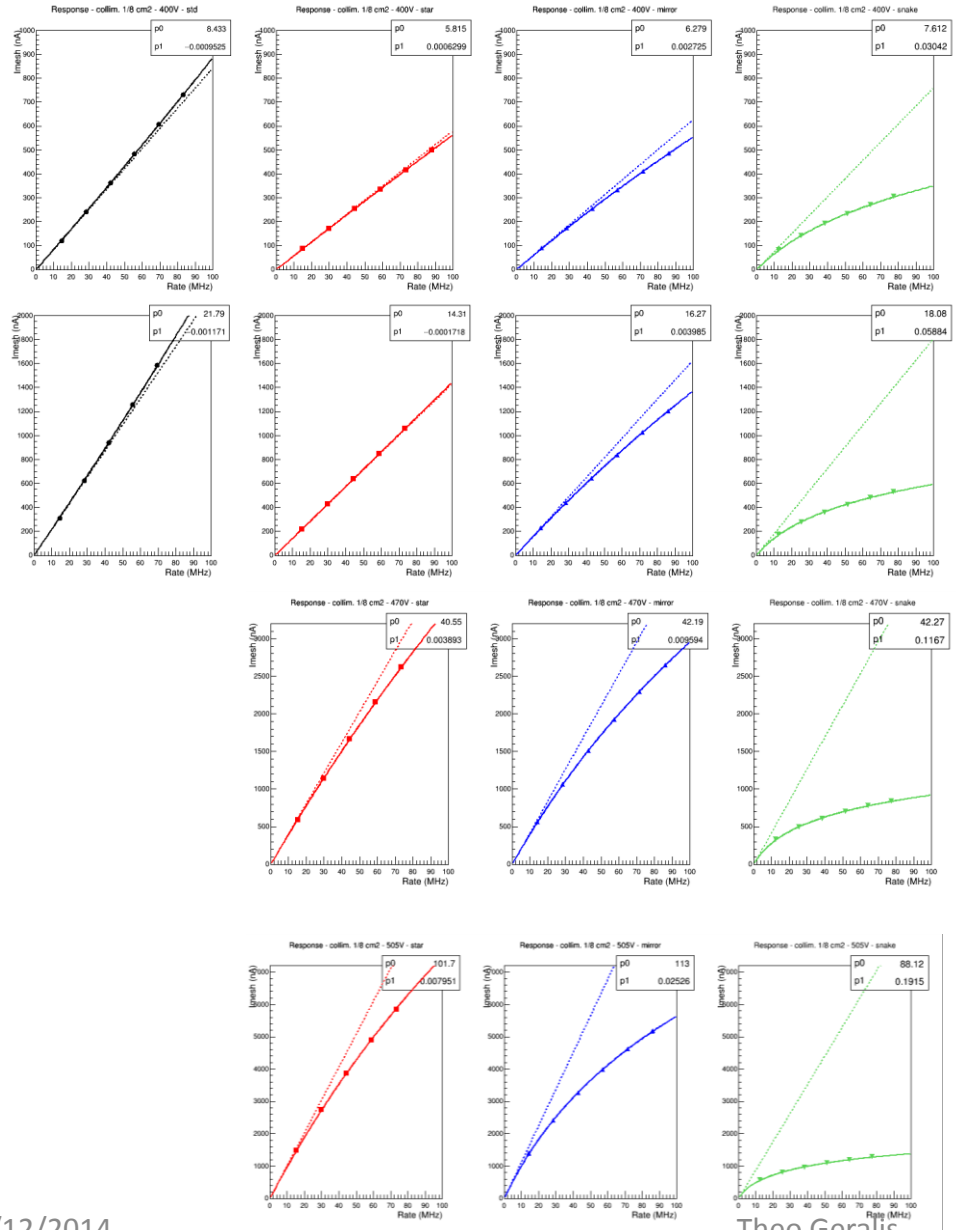






Imesh (nA) vs Rate (of X-rays)

Std Star Mirror Snake



I_{mesh} (Maximum=1000nA)

Linearity at gain = 100

Linearity at gain = 300

Linearity at gain = 1000

Linearity at gain = 3000

Rate (Maximum = 100MHz/cm^2)

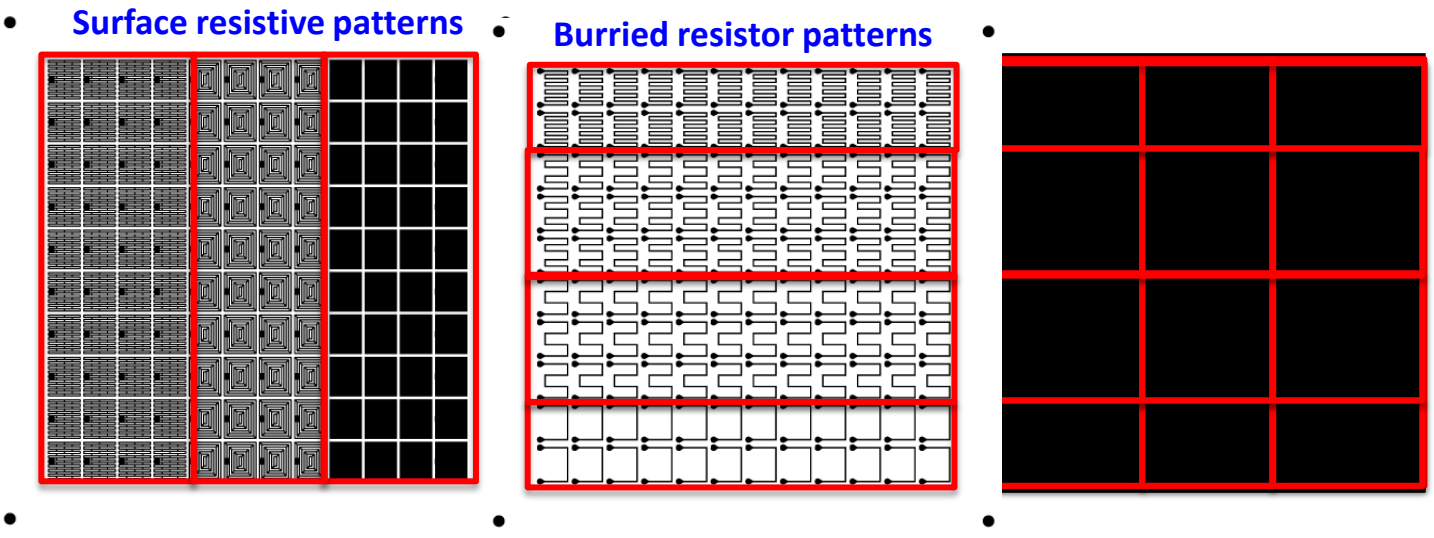
Micromegas production and tests at Demokritos

- **Variable resistivity Micromegas detectors with pads (VRM)**
  - Produced two detectors VRM5, VRM6 (delivered end of Sept.2014)
  - VRM5 resistive paste: 10kOhm/sq (burried)., 100kOhm/sq. (surface)
  - VRM6 resistive paste: 100kOhm/sq(burried), 100kOhm/sq. (surface)

    3 vertical slices of the same burried resistors values

    4 horizontal slices of the same surface resistivity

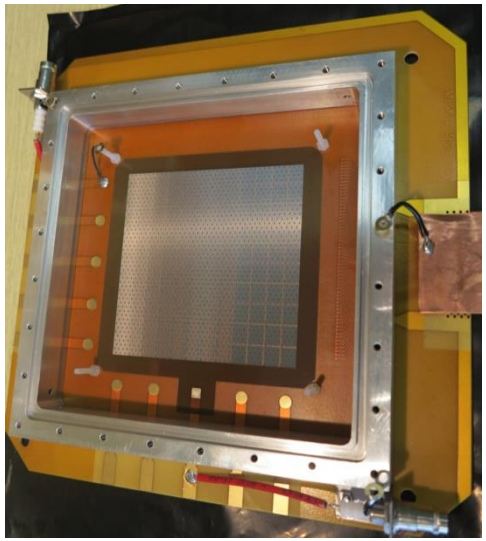
    ➔12 different resistivity areas

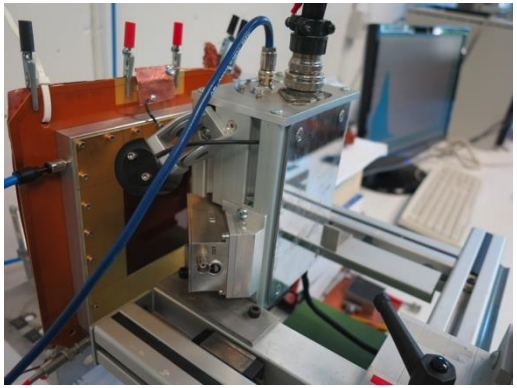


Resistive Micromegas production and tests

VRM5 Resistivities layout

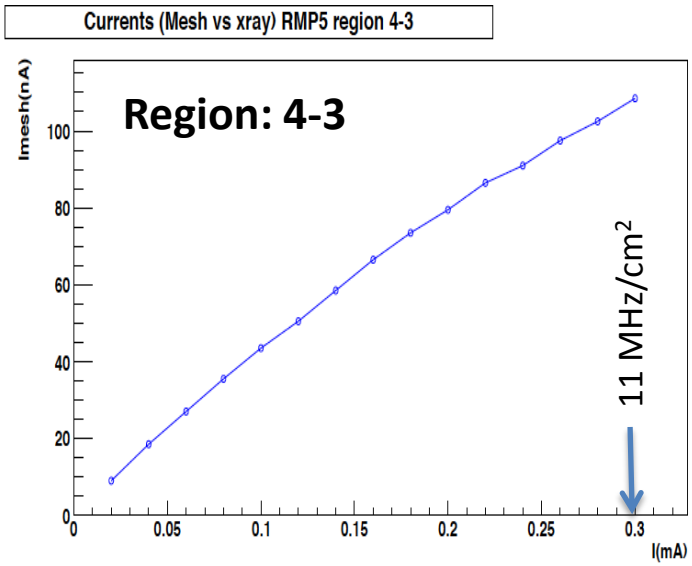
Surface resistivities	Buried resistivities			
0.9	1-3	2-3	3-3	4-3
5.5	1-2	2-2	3-2	4-2
6.0	1-1	2-1	3-1	4-1
MOhm	3.3	2.2	1.7	1.0

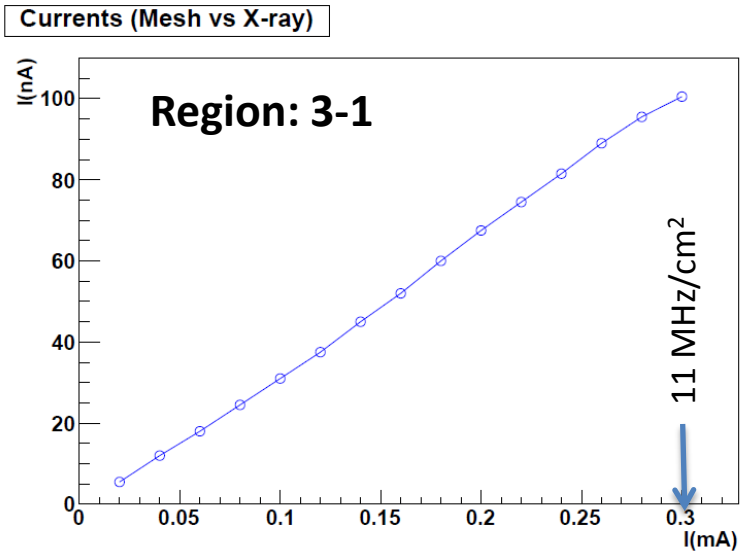




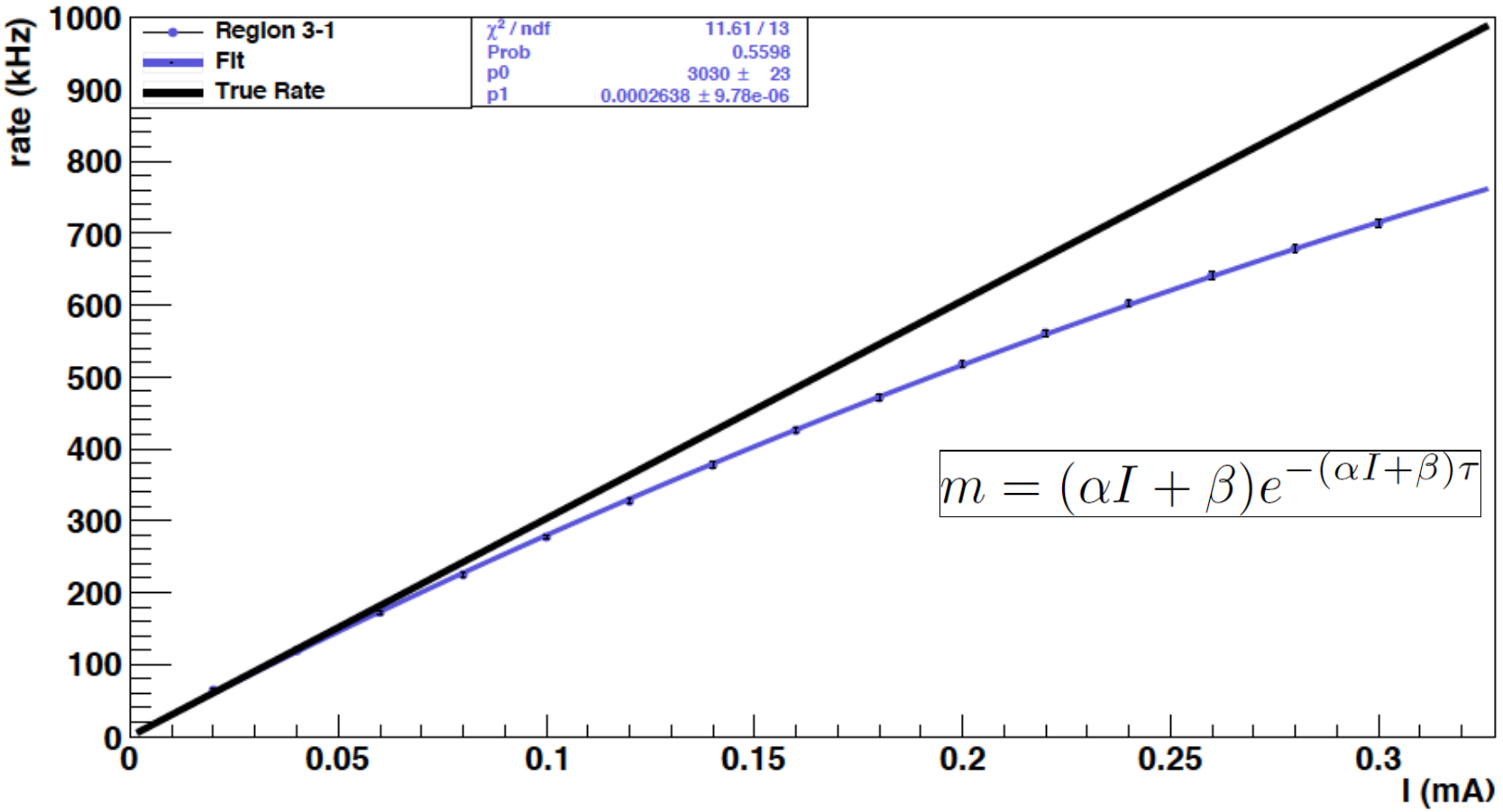
Tests at Demokritos
X-ray tube:
Rh – L line at 3 keV
Rate up to 11 MHz/cm^2

Optimize for linearity in response





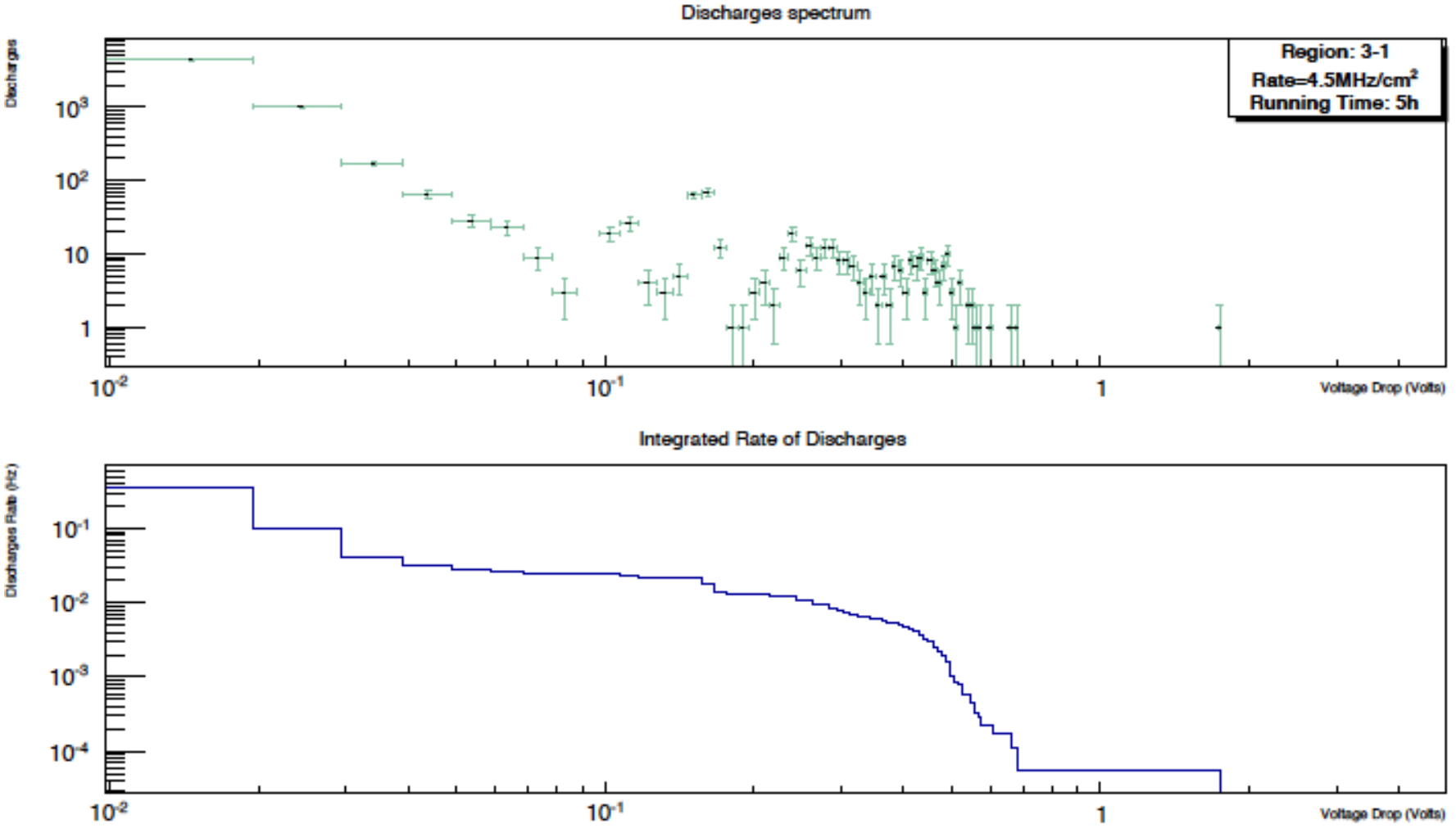
Rate Corrections for the Dead Time



- **m**: measured rate
- **α,β**: Linearity coefficients
- **τ**: Readout Dead Time
- **R=(α*I*+β)**: True Rate

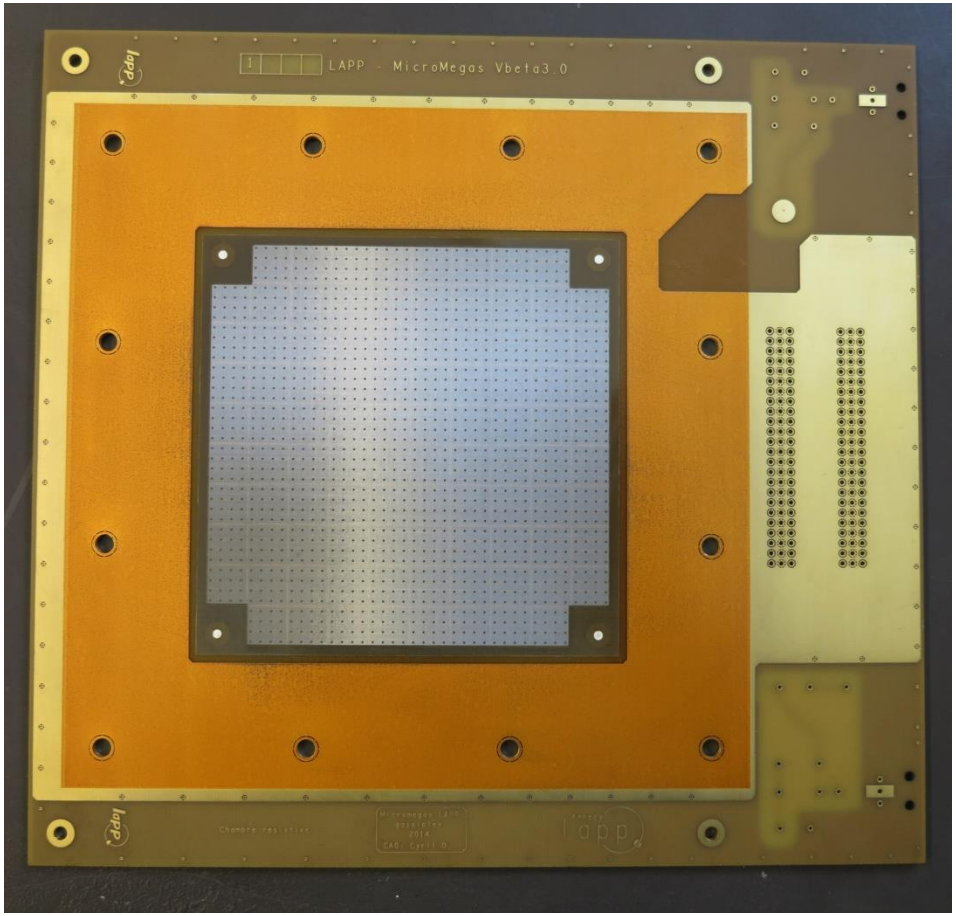
- **α = 3030 MHz/mA**
- **τ = 264 ns**
- **β=0**

Discharges: measure Voltage drop at high rate (11 MHz/cm^2) during 5 h. Record spectrum form V>8mV (Raether limit)



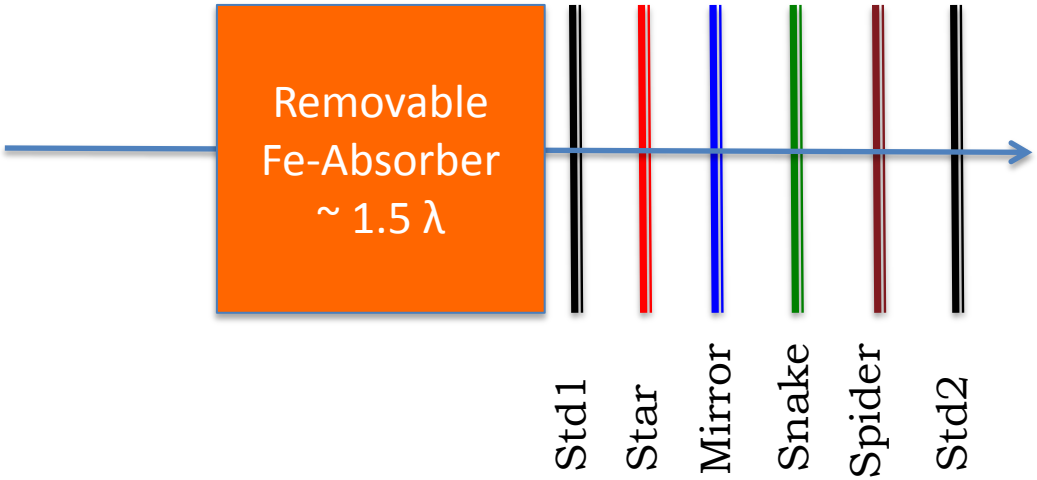
Best response in linearity ➔ Region 3-1 ($R_{burried}$ = 1.6 MΩ, $R_{surface}$ = 6 MΩ)

➔ Build one more Micromegas with uniform resistivity → **Spider**
➔ Installed in the Test Beam setup during the second week

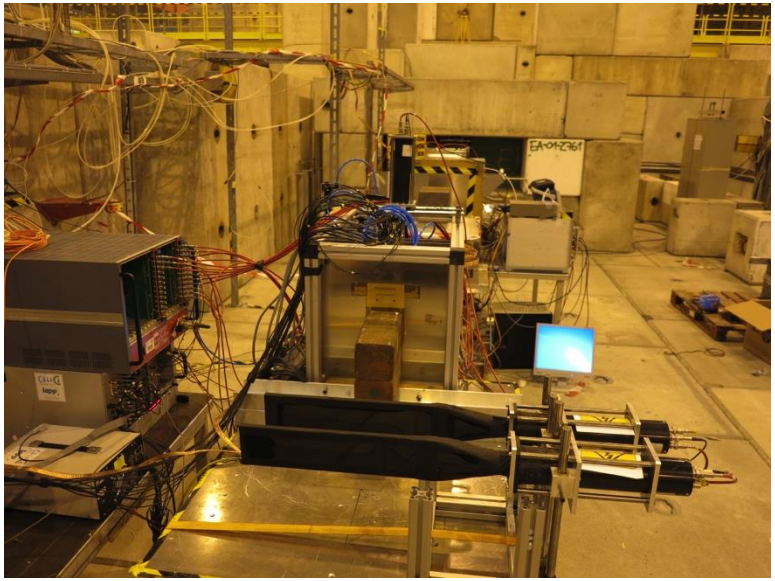


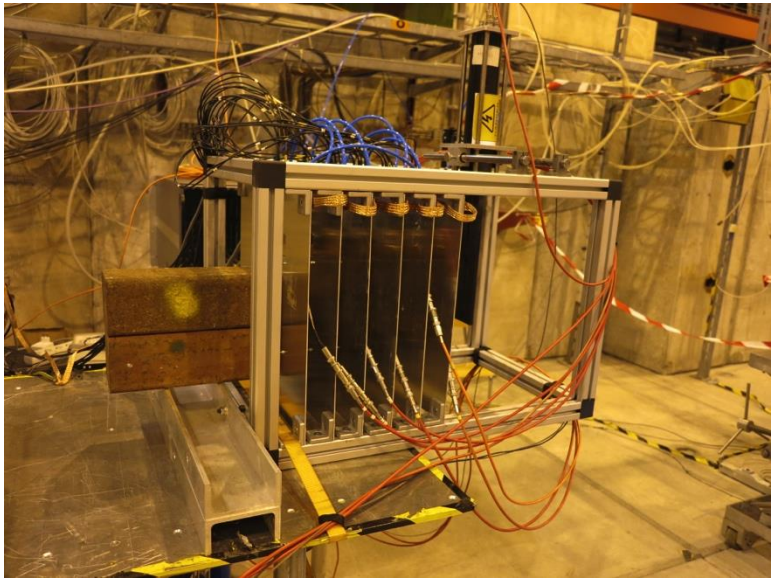
LAPP/Demokritos H4 Test Beam setup

6 Micromegas



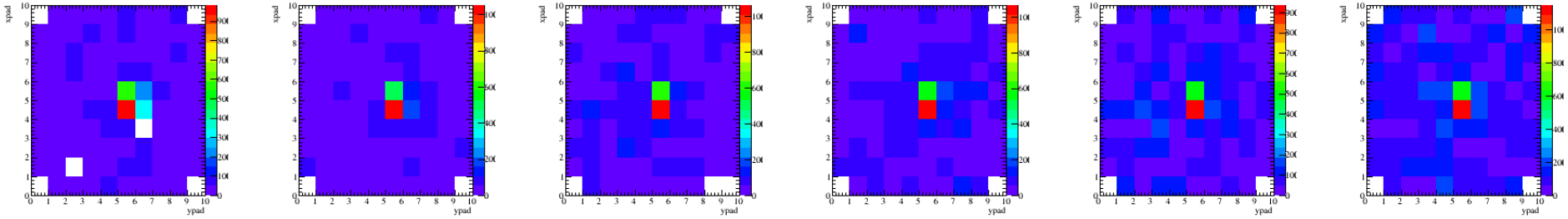
VME Readout (Gassiplex), Monitor HV with RD51 system





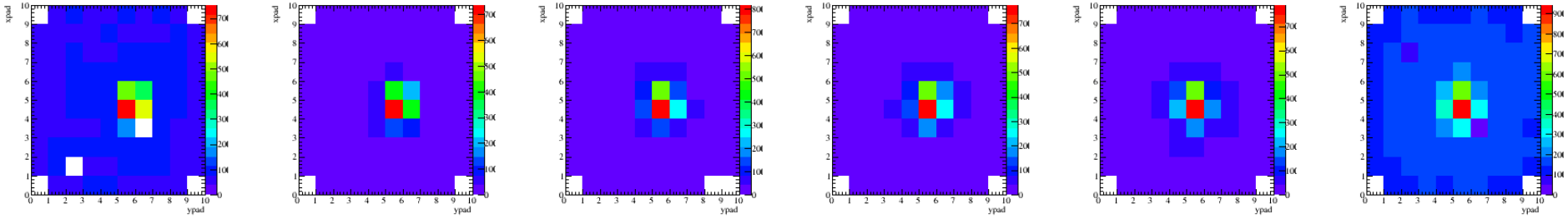
Beam profile with pions at low rate (2kHz)

Std1 Star Mirror Snake Spider Std2

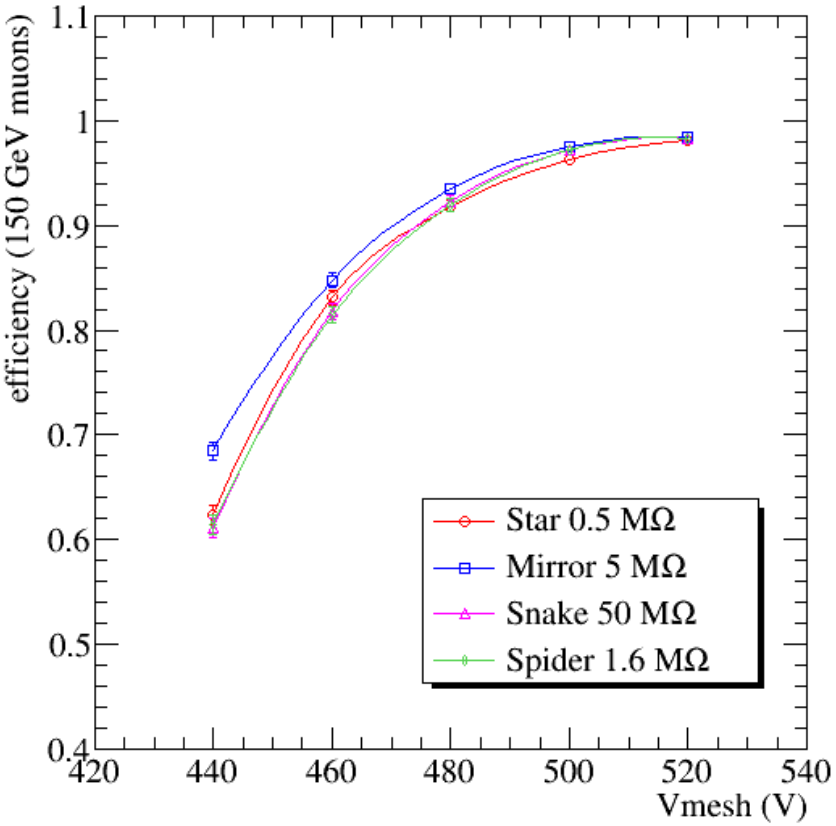


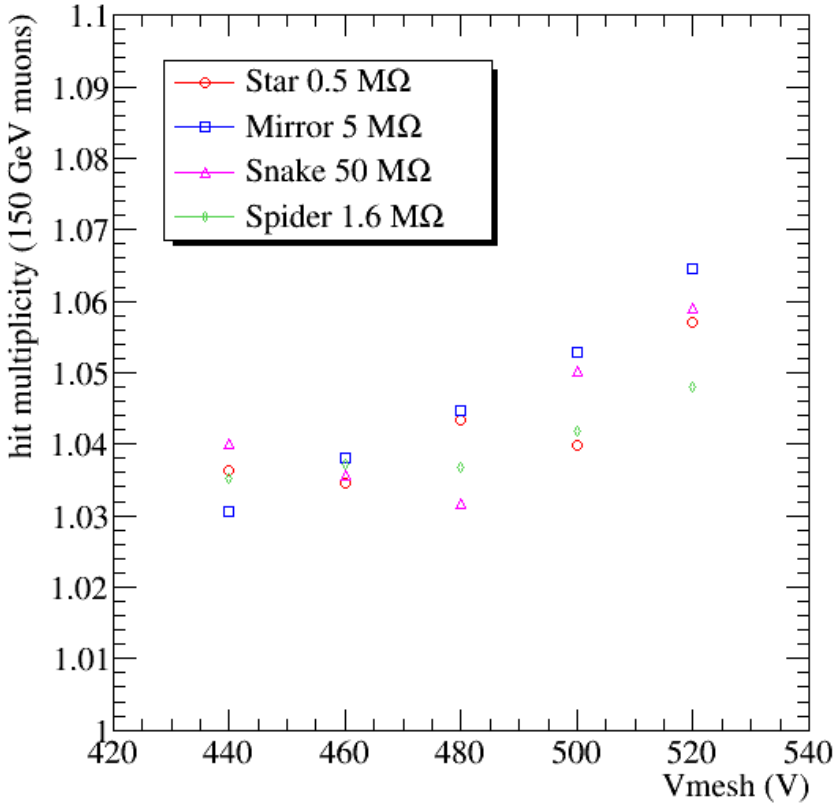
Beam profile with pions at high rate (400kHz)

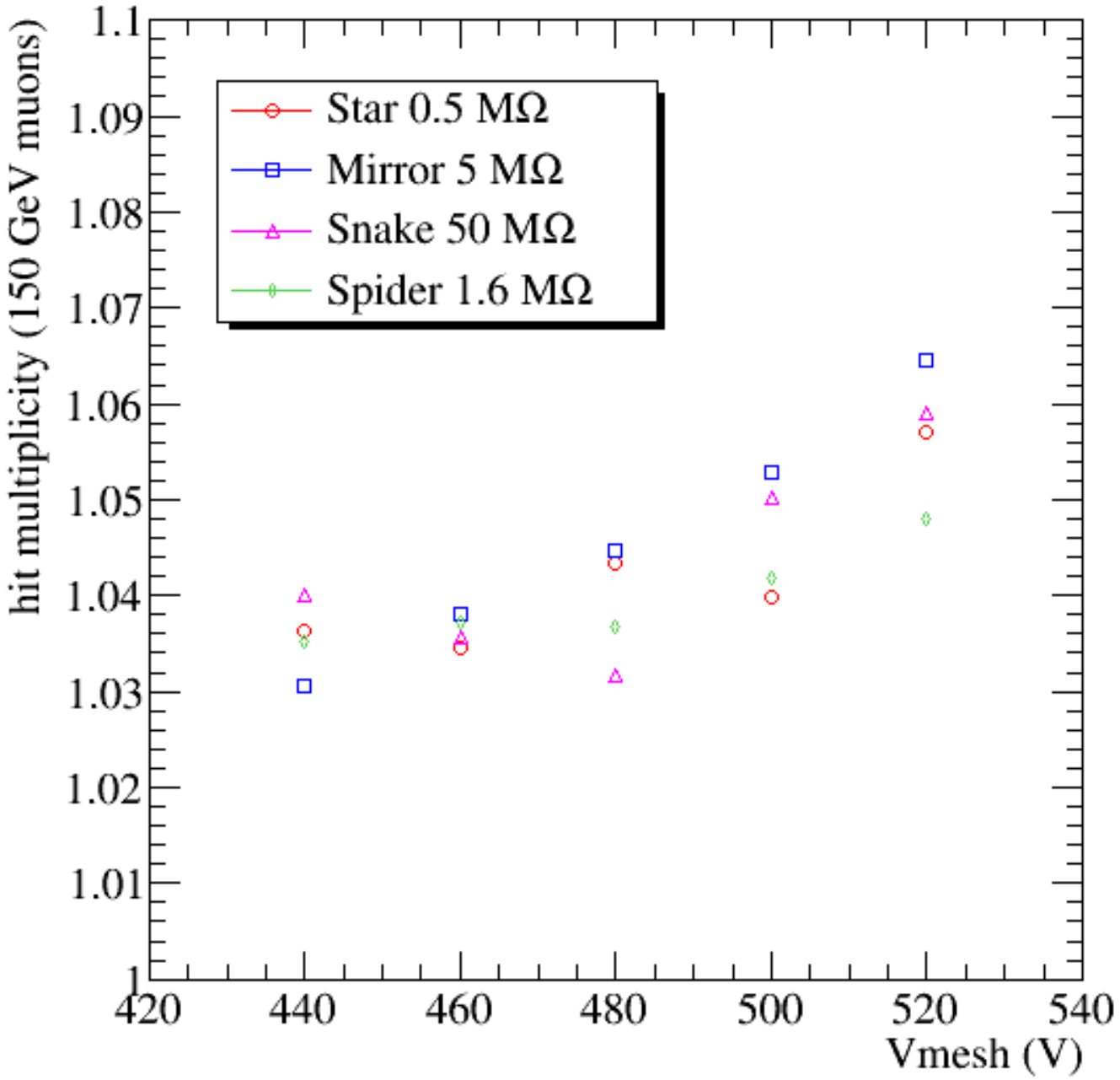
Std1 Star Mirror Snake Spider Std2



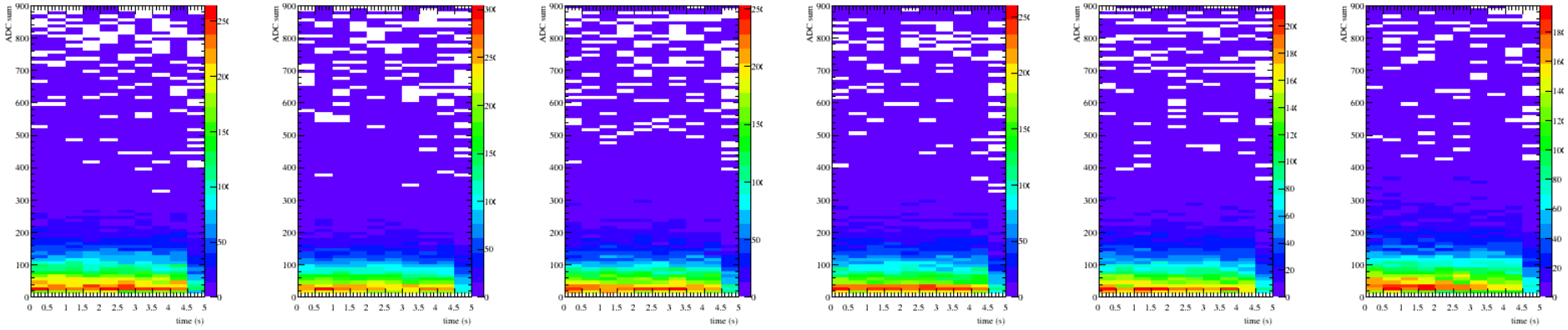
Efficiency and Hit Multiplicity vs Gain

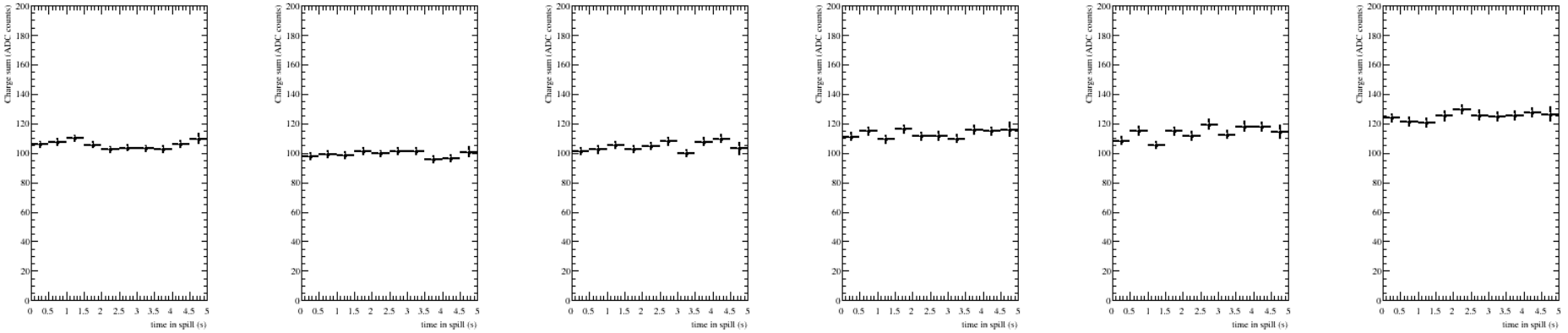




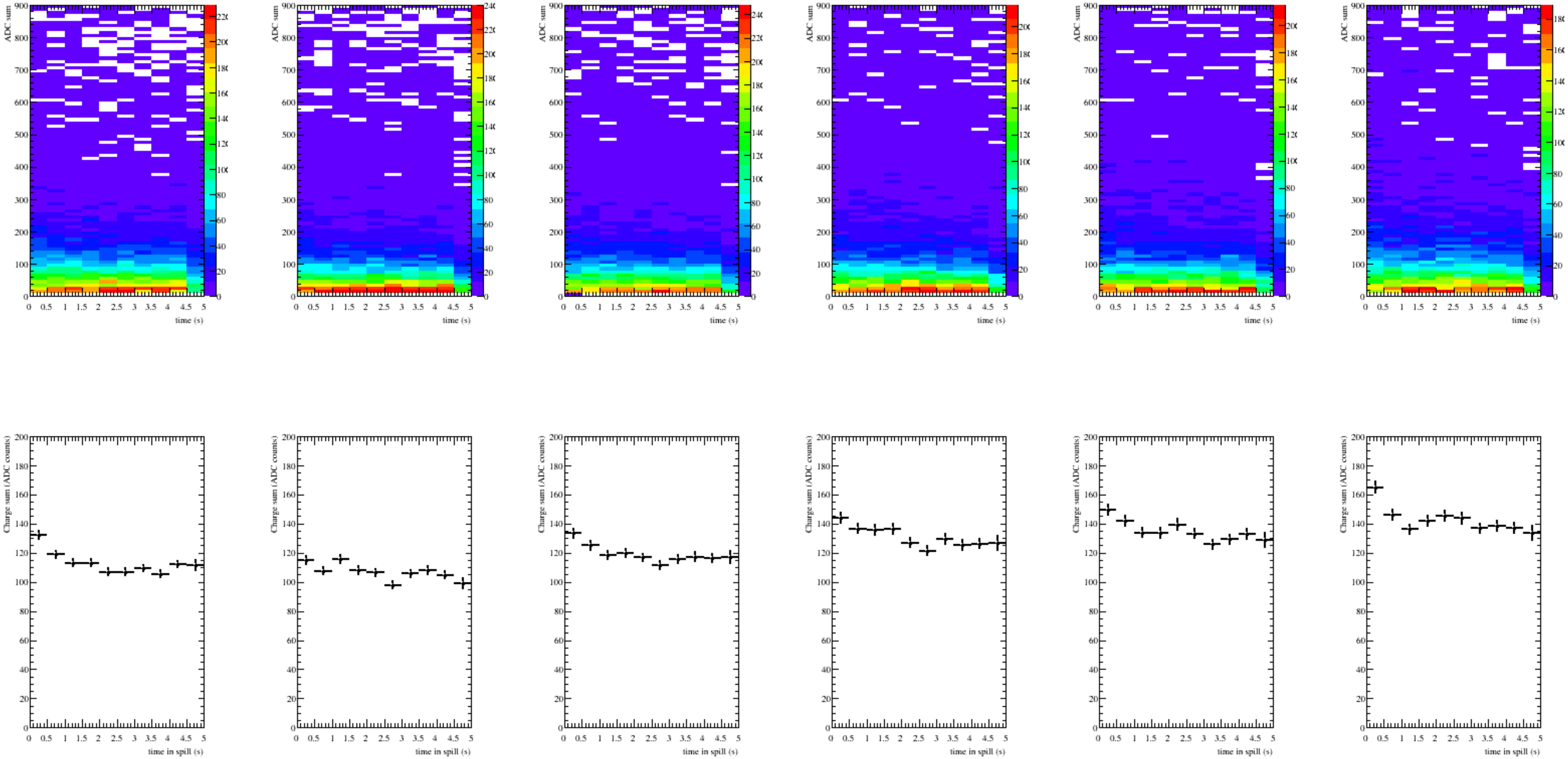

Star 0.5 MΩ
Mirror 5 MΩ
Snake 50 MΩ
Spider 1.6 MΩ
hit multiplicity (150 GeV muons)
Vmesh (V)
1.1
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1
420
440
460
480
500
520
540

ADC vs time in spill with pions at low rate (2kHz)



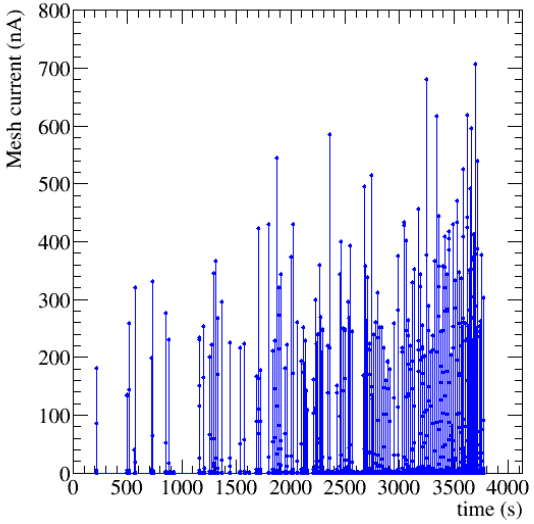


ADC vs time in spill with pions at high rate (400kHz)

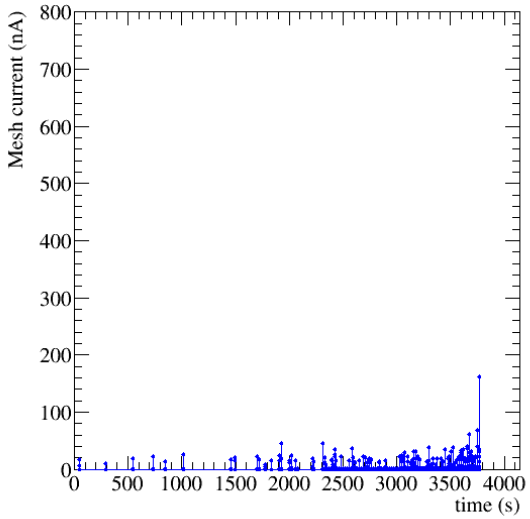


Mesh current with pions at high rates (2kHz – 400 kHz)

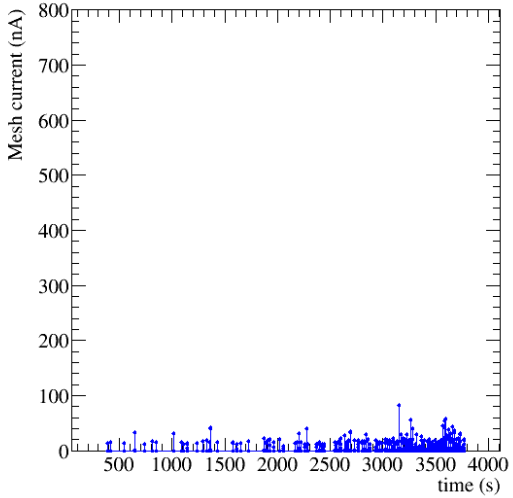
Std1



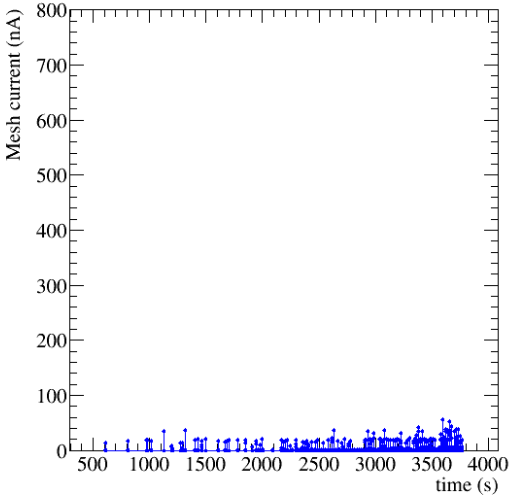
Star



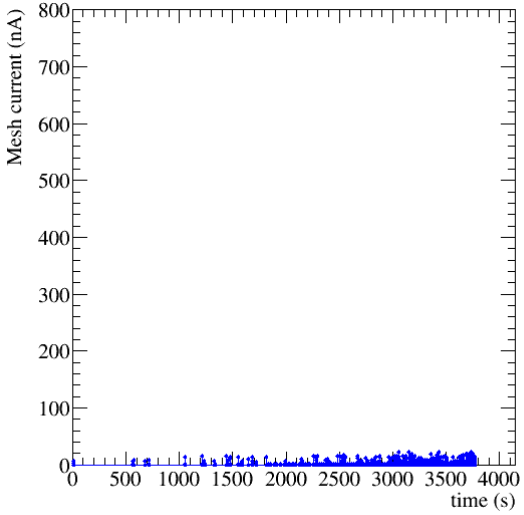
Mirror



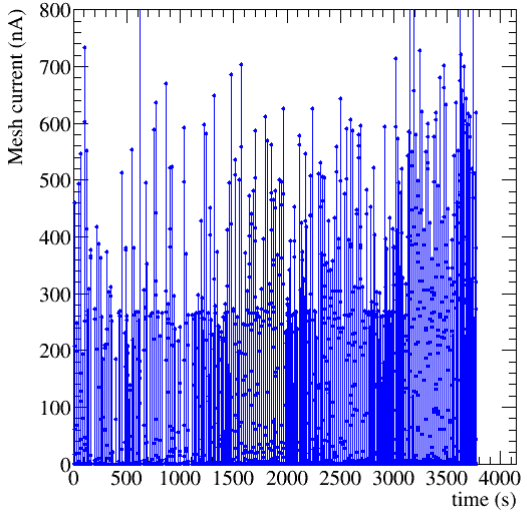
Snake



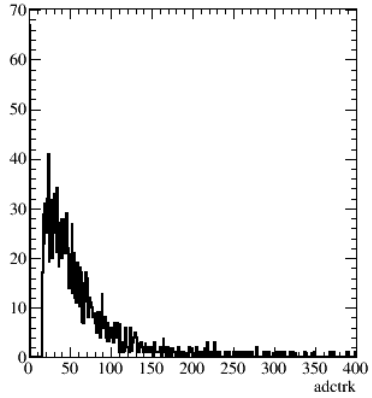
Spider

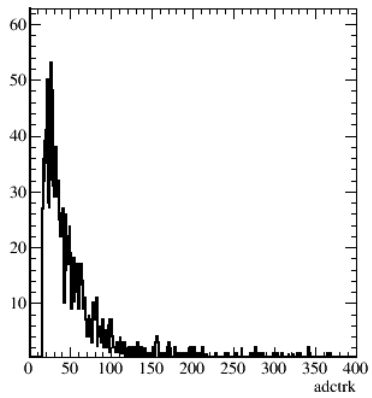


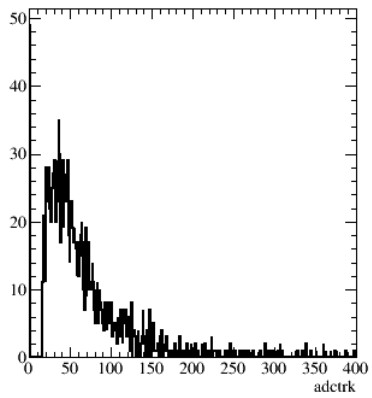
Std2

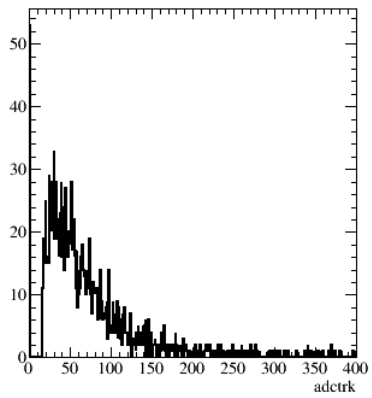


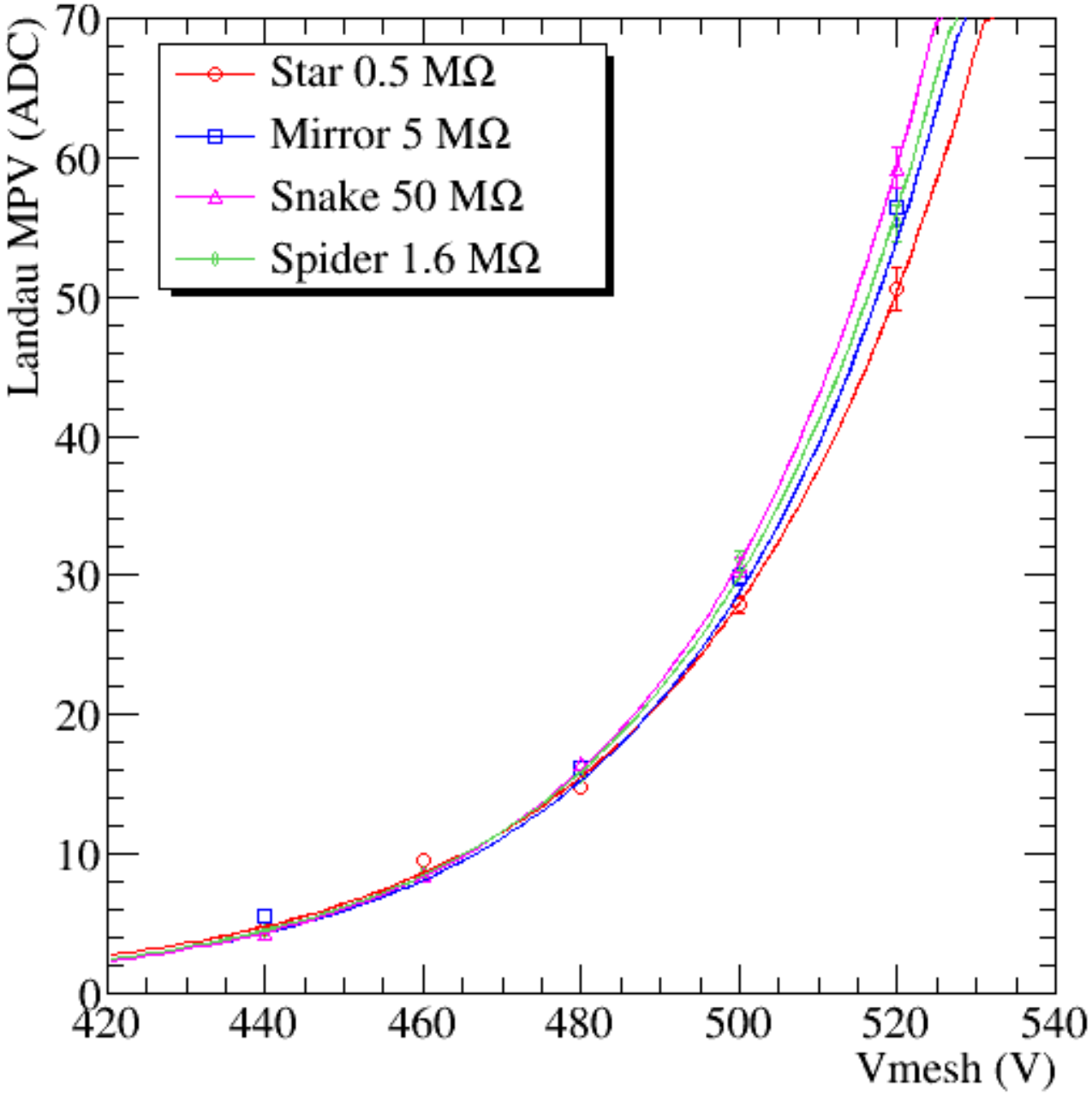
Landau distribution for mips





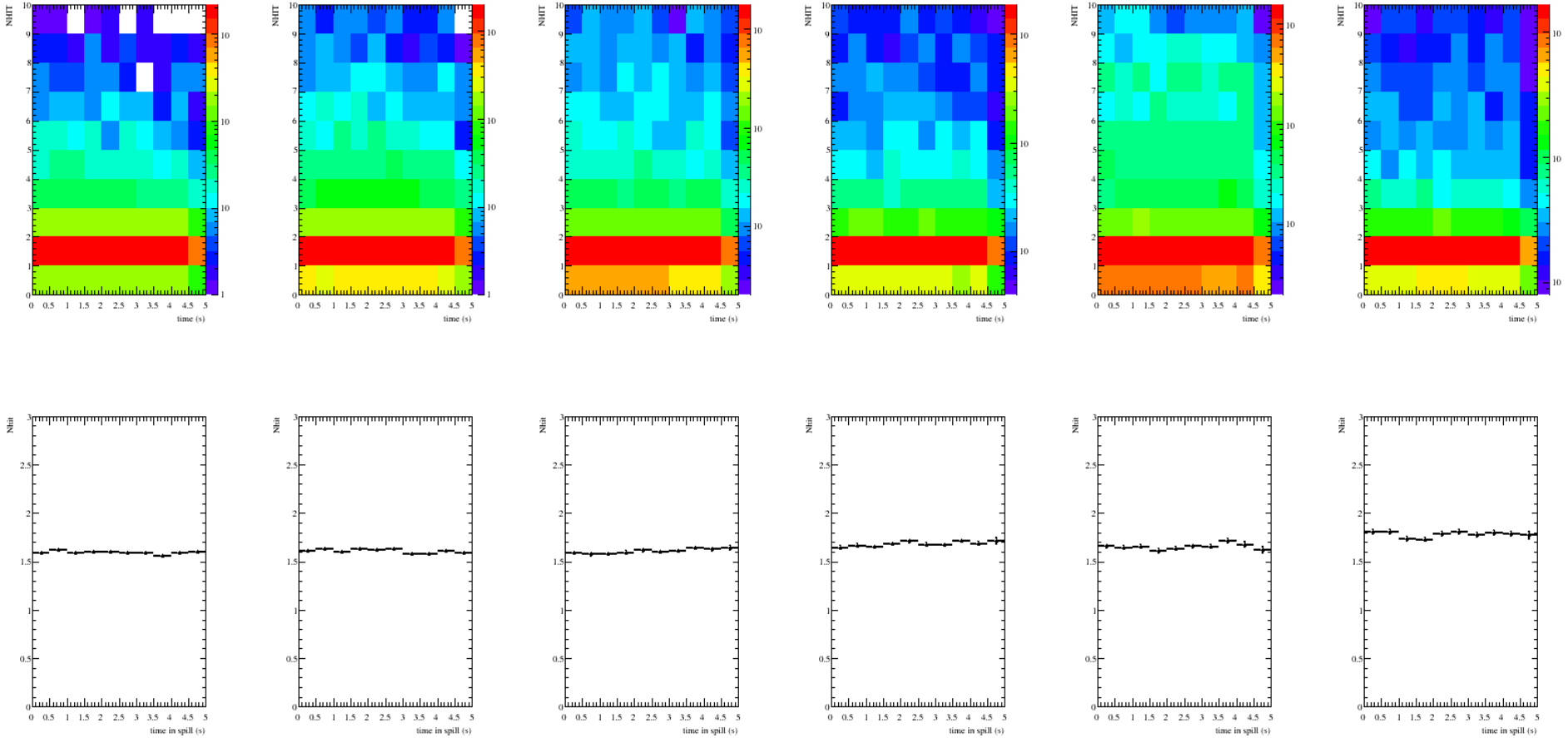





Star 0.5 MΩ
Mirror 5 MΩ
Snake 50 MΩ
Spider 1.6 MΩ
Landau MPV (ADC)
Vmesh (V)
0
10
20
30
40
50
60
70
420
440
460
480
500
520
540

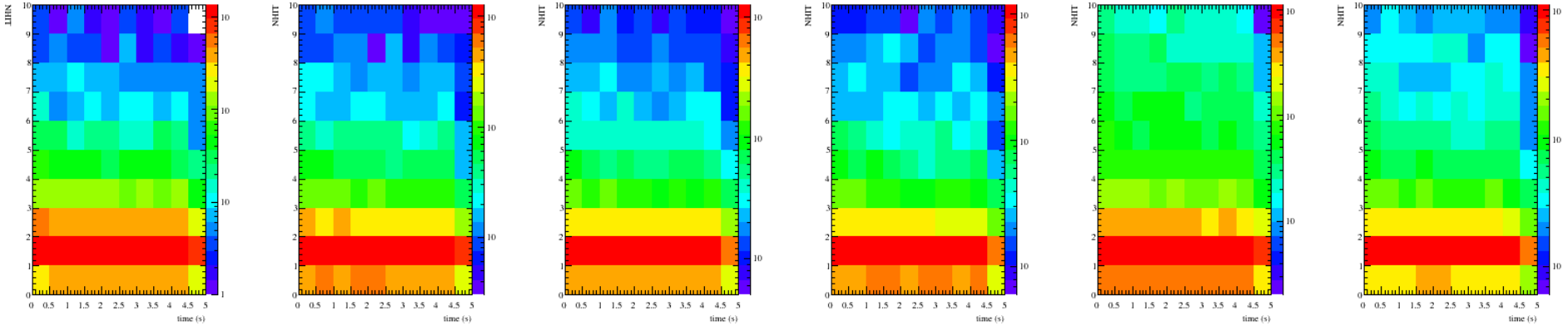
N_{hits} vs time in spill with pions at low rate (2kHz)

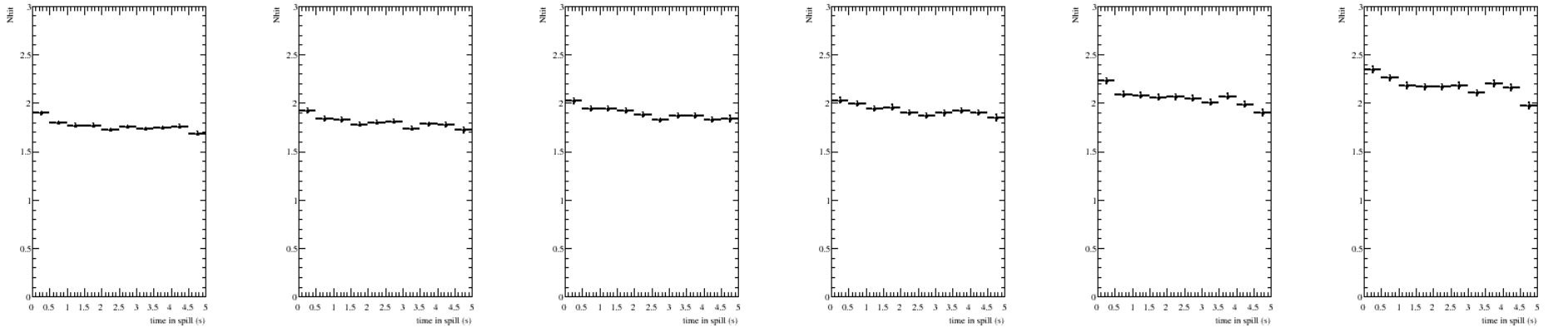
Std1 Star Mirror Snake Spider Std2



N_{hits} vs time in spill with pions at high rate (400kHz)

Std1 Star Mirror Snake Spider Std2





Conclusions and Plans

During the test beam period we have completed:

1) **Study of our detector with mips (Landau)**
2) **Efficiency measurements**
3) **High rate scans at medium gain**
4) **Spark rate**
5) **High rate scans with Fe absorber**
6) **Spark rate with Fe absorber (not presented)**

Remaining

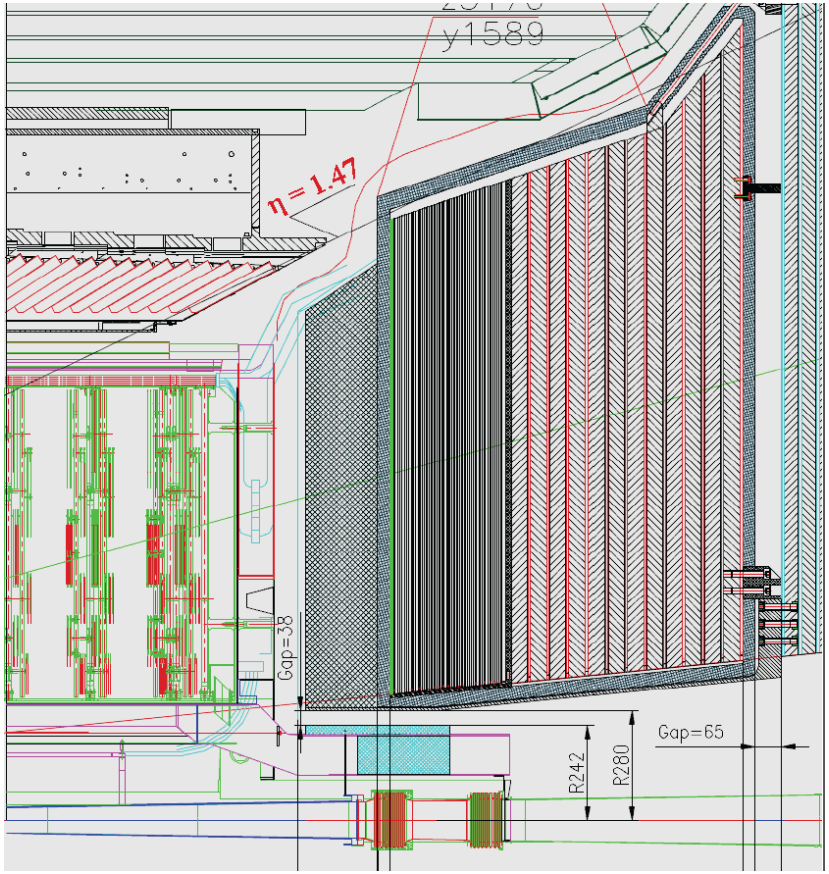
1) **Pion energies scan at different gains**
2) **Rate scan at different gains**

Many THANKS to Rui and Antonio
For their great job

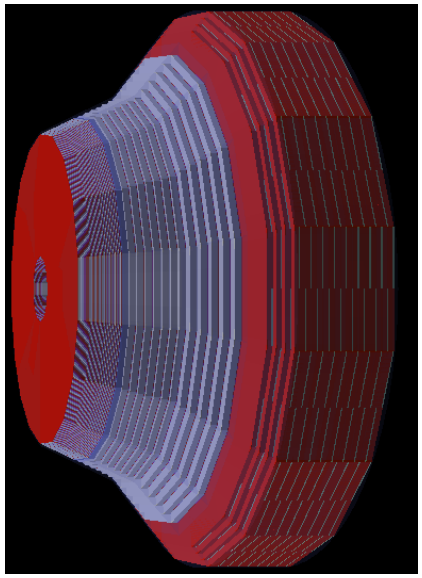
Many THANKS to Eraldo and Yorgos
For their help and support in the RD51 X-ray gun tests and the RD51/H4 Test Beam

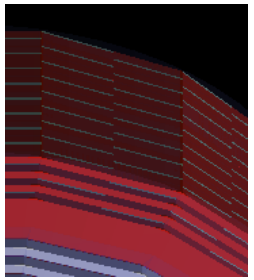
BACKUP

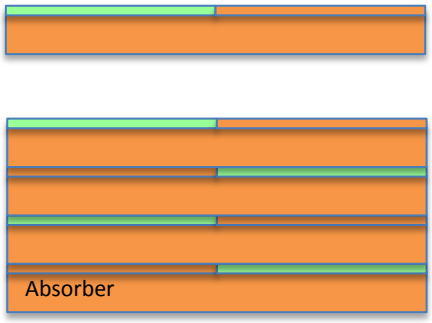
Backing-HE Geometry(V4)



Backing HGCAL
20 Layers
10 Sampling Layers







18 x 10° Identical ϕ – Sectors / Layer

20 Layers x 18 Sectors

- ➔ 150 m^2 / end cap
- ➔ Total Detector Surface : ≈300 m^2

- ➔ 36 Identical ϕ - Sectors x 10 Layers
- ➔ 720 detectors of about 0.4 m^2
  Gap in V4 geometry ~9mm

- ➔ 0.35 – 0.75 Million channels
  (depending on the pad size:2x2 cm^2
  - 3x3 cm^2)