Micromegas progress report

(V. Polychronakos on behalf of the Mamma Collaboration)

- Spark studies
- Preliminary latest test beam results
- Next steps

From a recent talk of Th. Alexopoulos
NTU Athens, with his student K. Dekas
Full talk at:
http://indico.cern.ch/conferenceDisplay.py?confId=105234

1. Sparks

- Sparks are a major concern: they can create dead time and/or damage in the detector
- Sparks develop when local electron charge concentrations exceed a few 10^7 e^- (Raether limit)

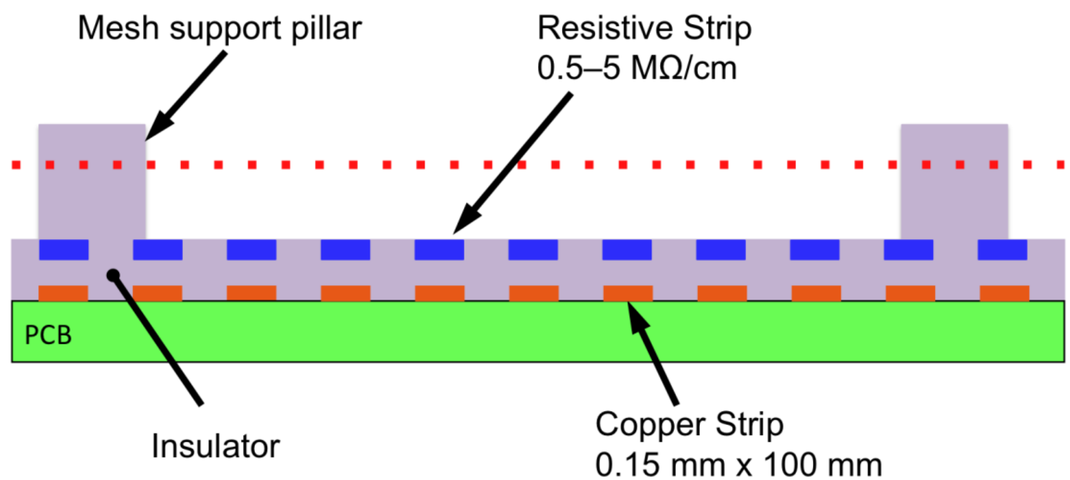
  For a gas gain of 10^4 any ionization process creating ≥1000 electrons in a small volume risks the development of a spark, e.g. heavily ionizing particles induced by neutrons
- Two ways to approach the problem
  1. Avoid high concentrations of charge, e.g. by spreading the charge (multi-stage GEMs or MMs)
  2. Live with it and make the detector insensitive to sparks
- We opted for the latter and evaluated different resistive coating options … and it seems we found one doing the job

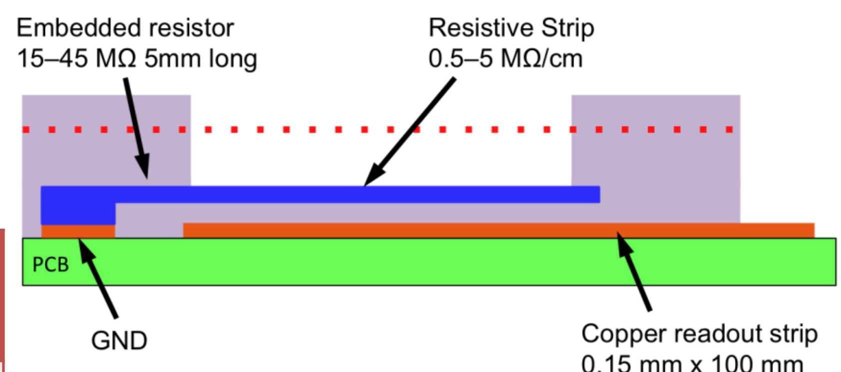
R11, R12 and R13

- Small 100 x 100 mm^2 chamber with 100 mm long strips and 250 µm strip pitch (similar to the previous prototypes – S3, R9, R10), 360 strips in total

Characteristics:

- Resistive strips connected to the ground
- Thin insulating layer between of the resistive and readout strips
- AC coupling of signals
- Sparks are neutralized through the resistive strips to the ground

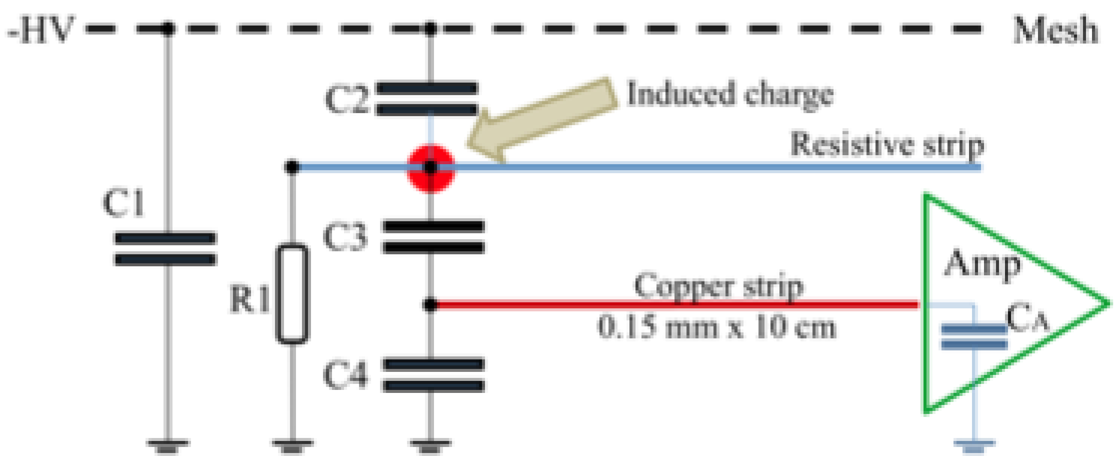




CHAMBER	R11	R12	R13
Resistance to Ground (MΩ)	15	45	20
Resistance along strip (MΩ/cm)	2	5	0.5

Equivalent Circuit

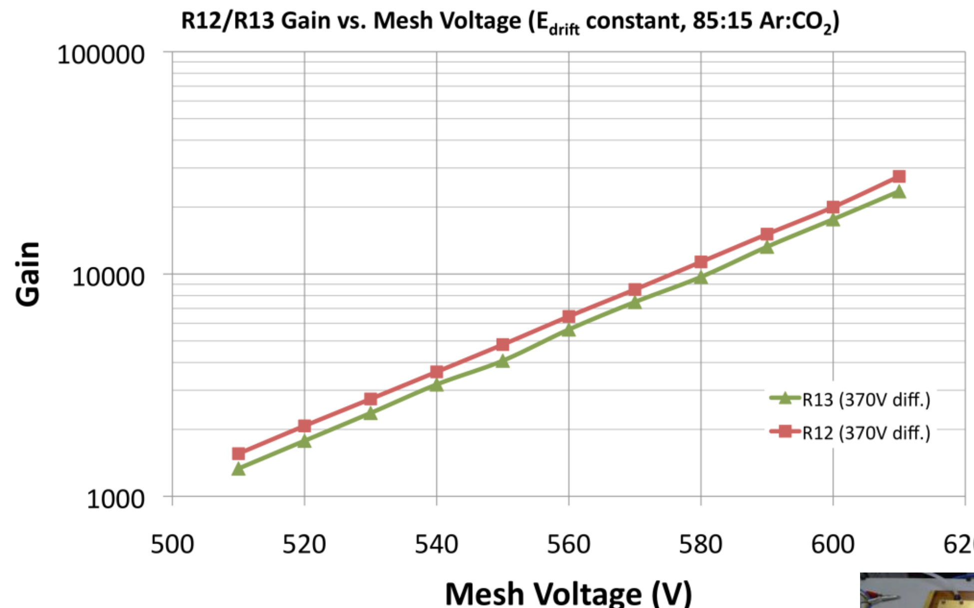
(Rui de Oliveira)

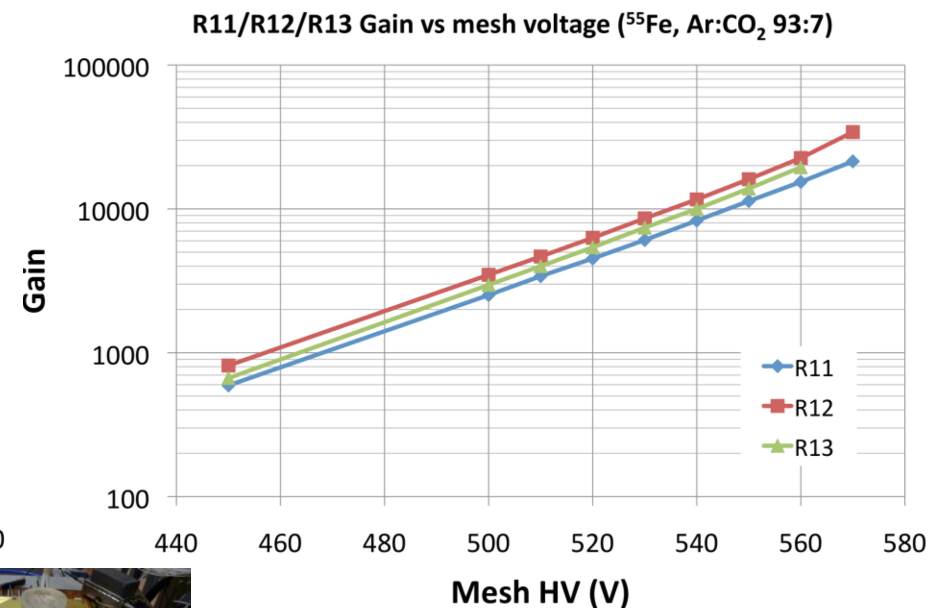


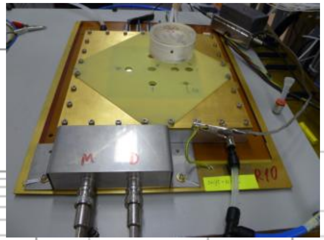
C1 – capacitance Mesh to ground
C2 – capacitance R-strip to ground
C3 – capacitance R-strip to readout strip
C4 – capacitance readout strip to ground
C_A – input capacitance of preamplifier

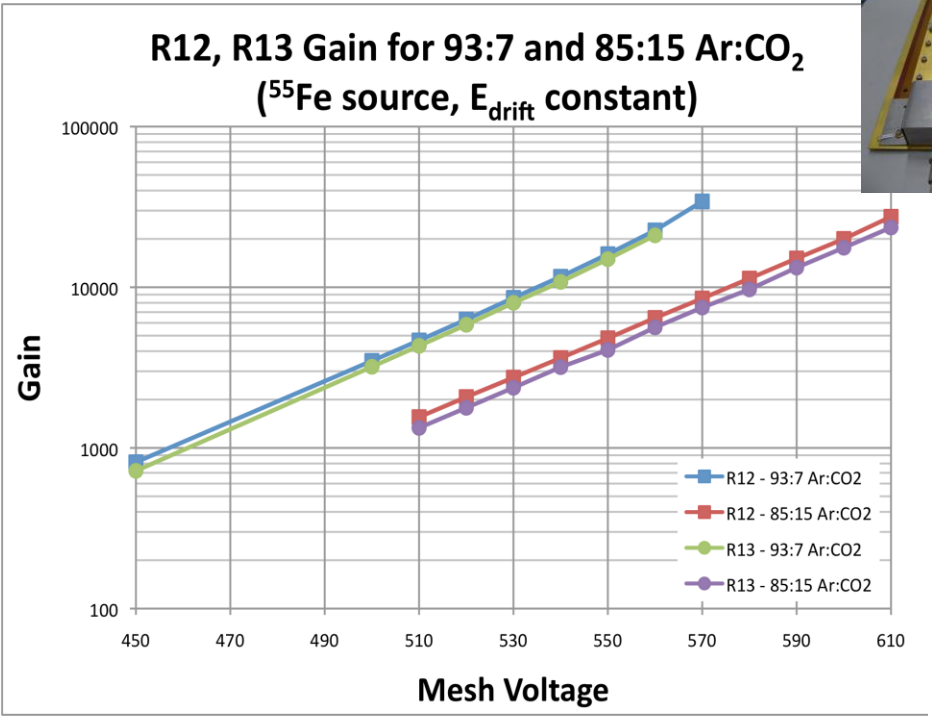
C2, C3 depend on Resistivity of Resistive Layer but the ratio remains constant

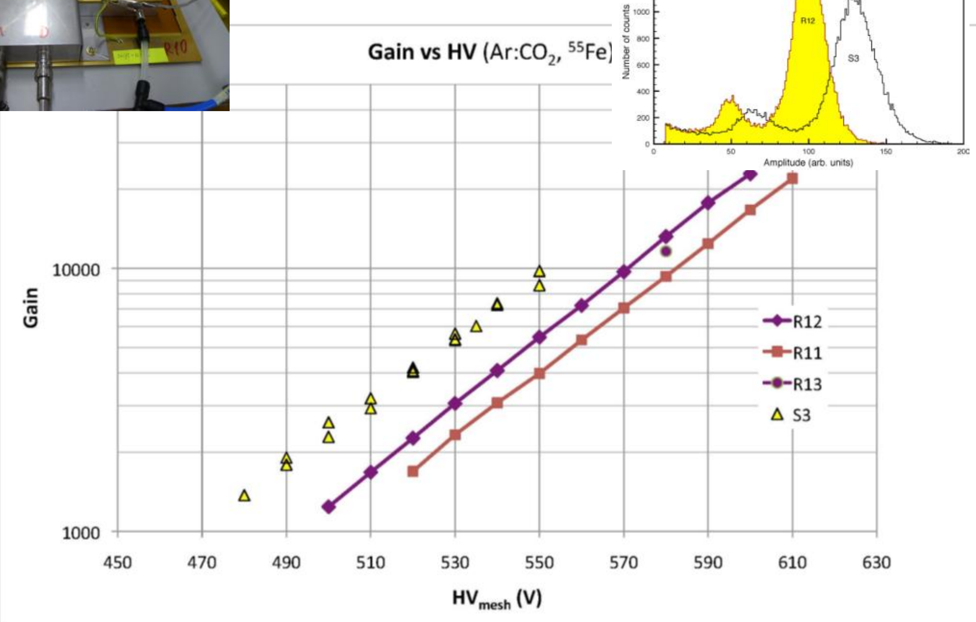
Laboratory tests (1)



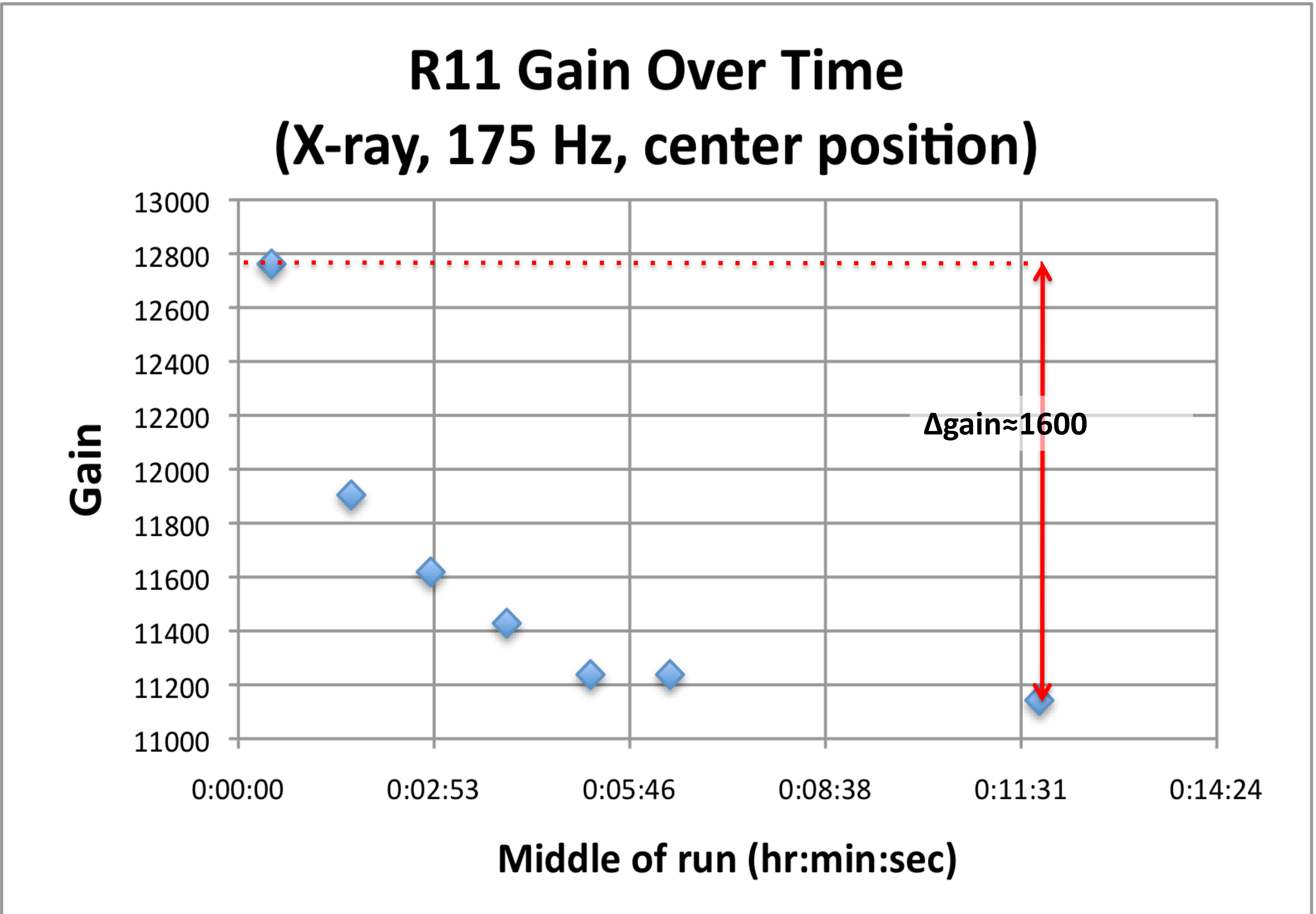




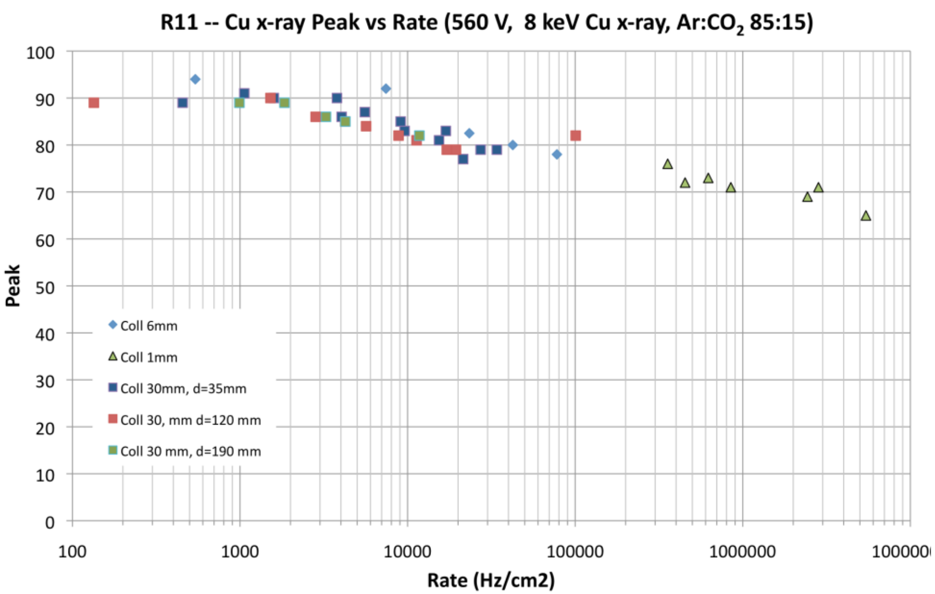


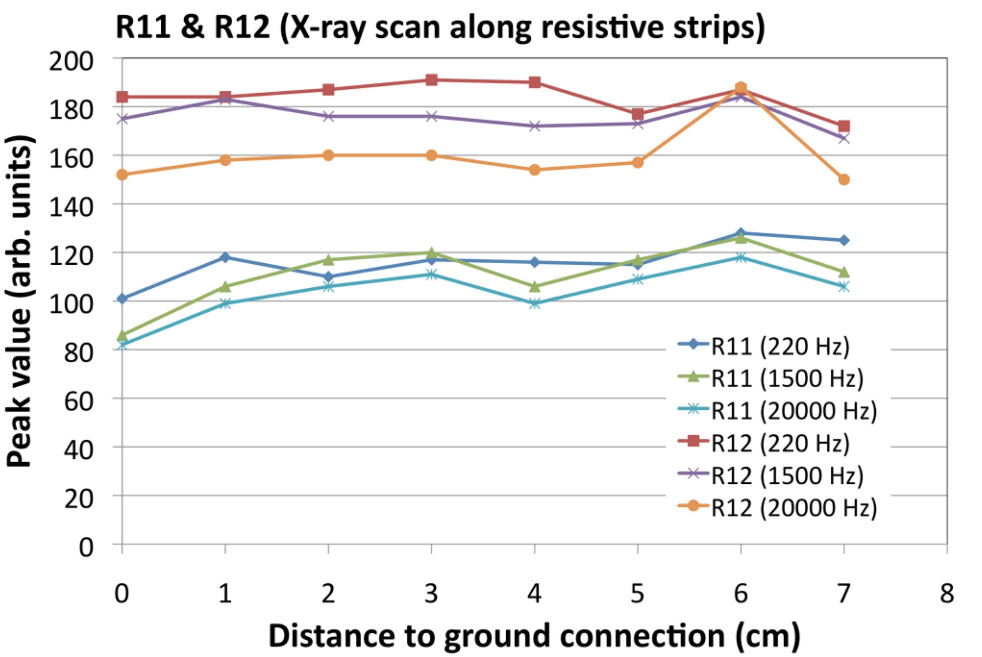


Laboratory tests (3)

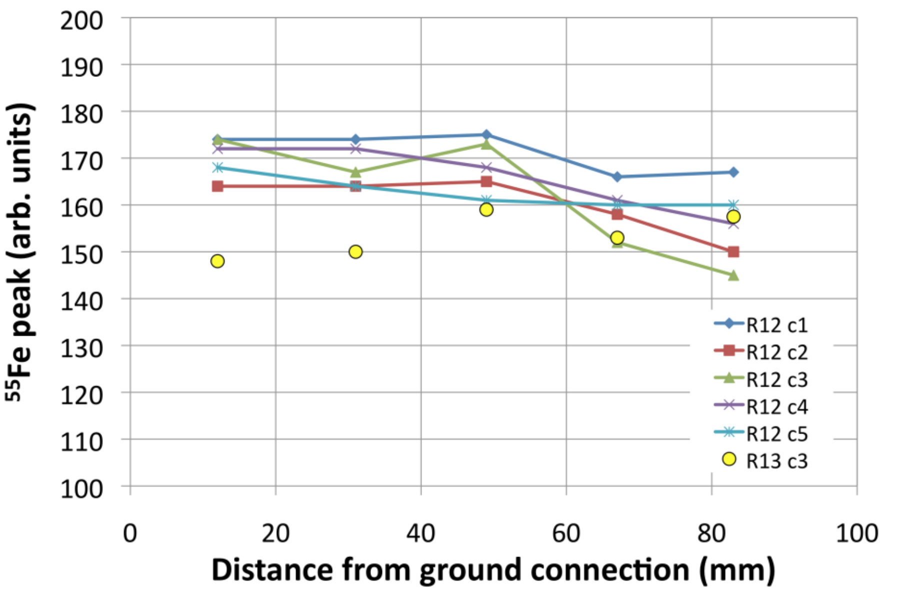


Laboratory tests (5)



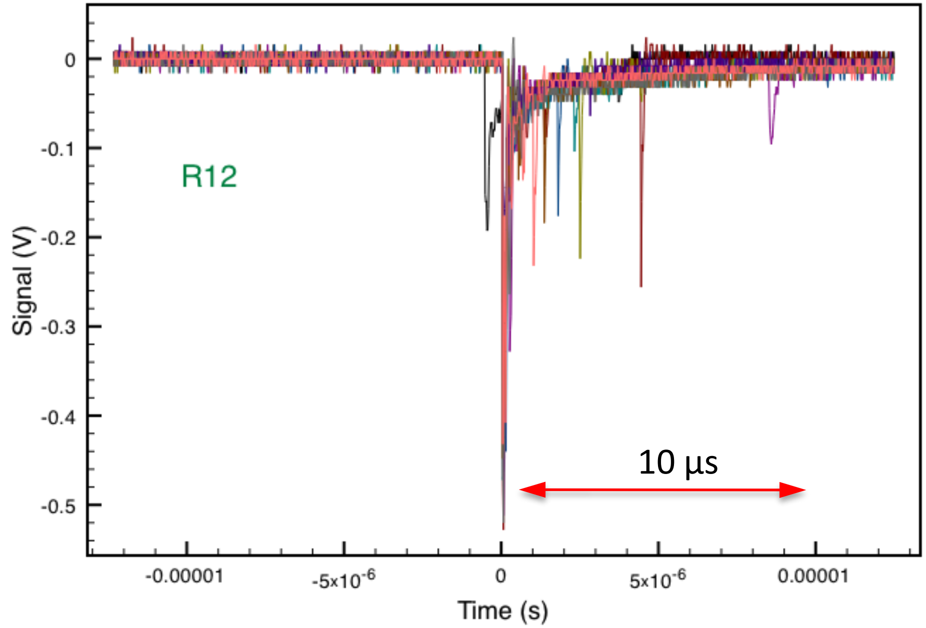


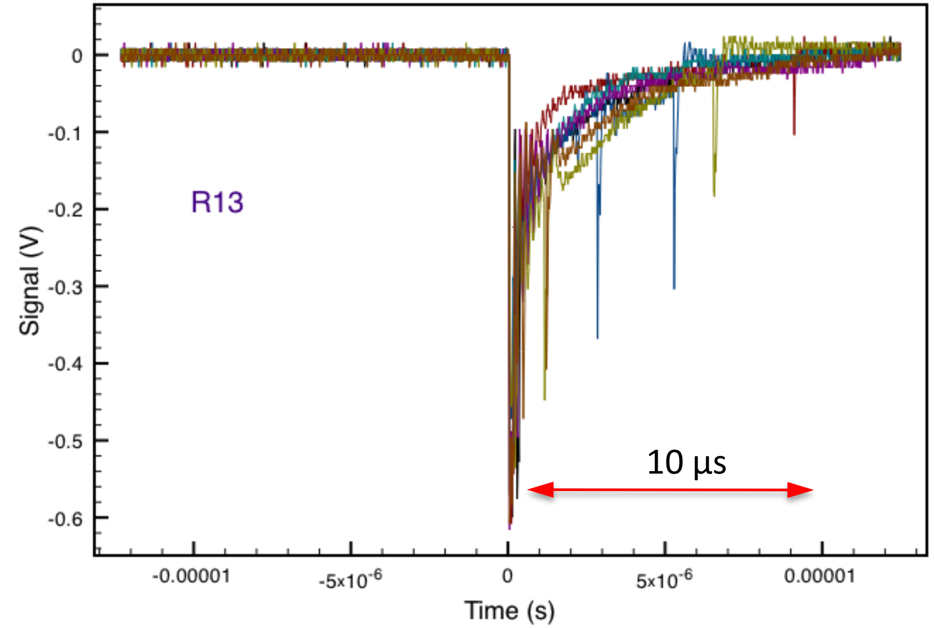
- R11, R12, and R13 are working fine with the ^{55}Fe source and with X-ray gun.
- Very good homogeneity along the strips



Laboratory tests (6)

Spark shape & characteristics – R12 & R13





- Low spark rate
- Spark current is the order of 10-20 nA, almost 1000 times less than for S3 chamber (non-resistive)
- No HV breakdown, no dead time

CHAMBER	R11	R12	R13
Resistance to Ground (MΩ)	15	45	20
Resistance along strip (MΩ/cm)	2	5	0.5

- Short signal ≤ 100 ns
- Maximum 0.5–1 V (direct measurement (50 Ω), w/o amplifier)
- Frequently several short pulses up to 10 µs total duration
- Max current for spark is 10–20 nA (1000 times smaller than for non-resistive chambers)
- No breakdown of HV

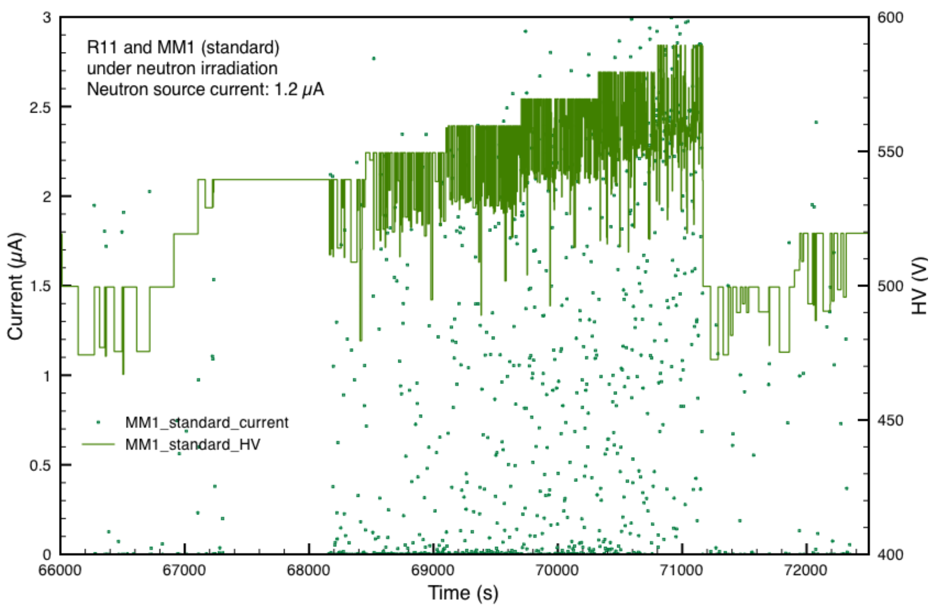
Neutron beam test (3)

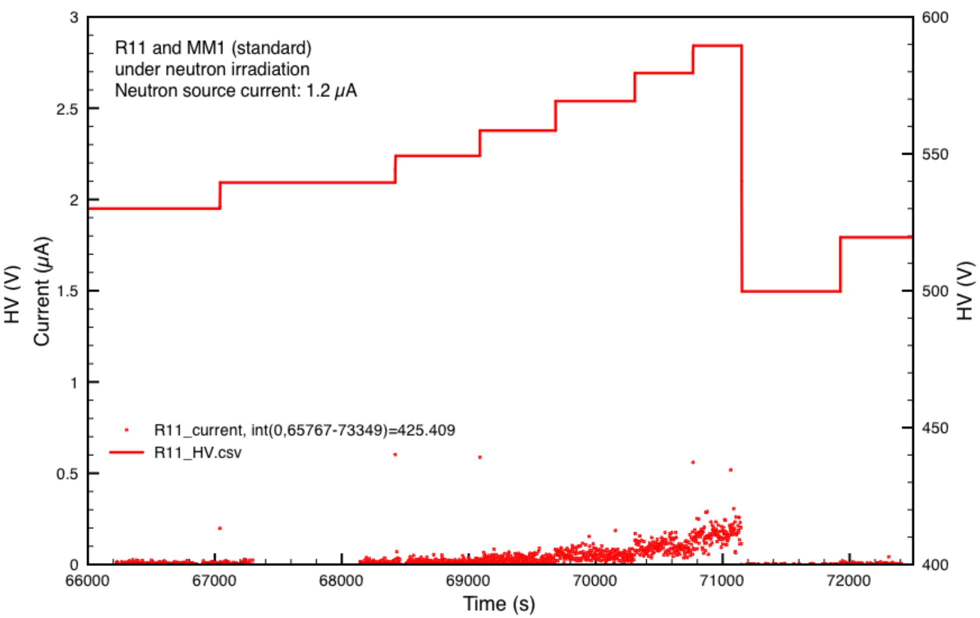
MM mesh currents in neutron beam

Gas: Ar:CO_2 (85:15) Neutron flux: ≈ 1.5×10^6 n/cm^2 s

Standard MM:
Large currents
Large HV drops, recovery time O(1s)
Chamber could not be operated stably

R11:
Low currents
Despite discharges, but no HV drop
Chamber operated stably up to max HV

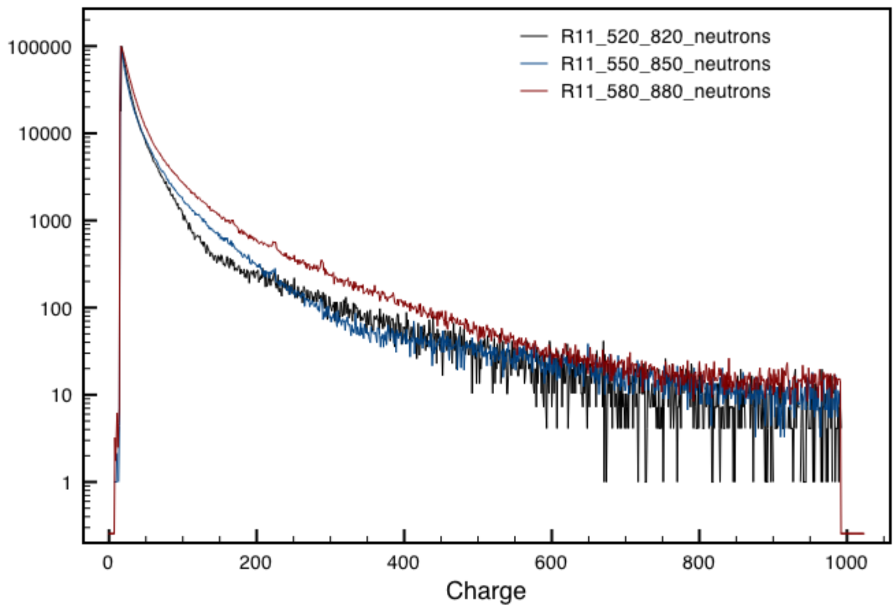




Neutron beam test (2)

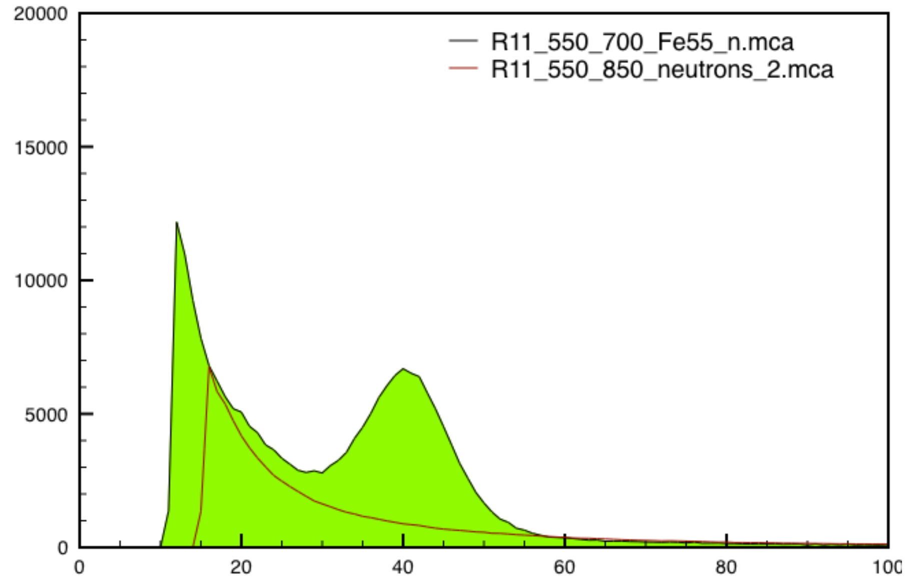
Neutron spectra in R11

Typical charge spectra recorded in neutron beam

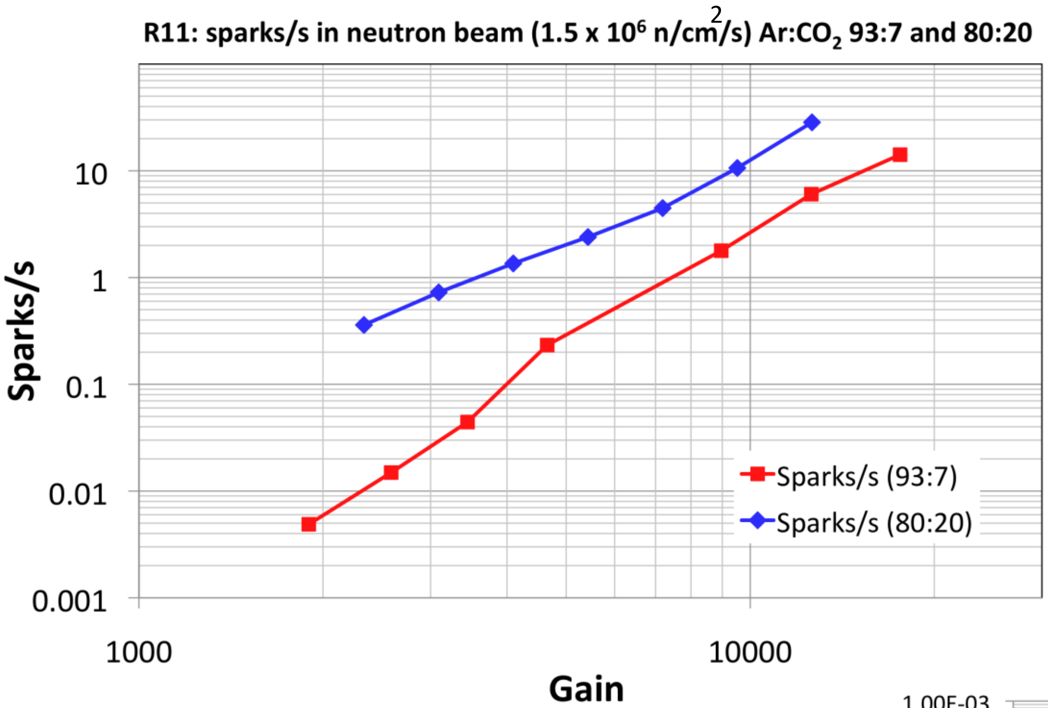


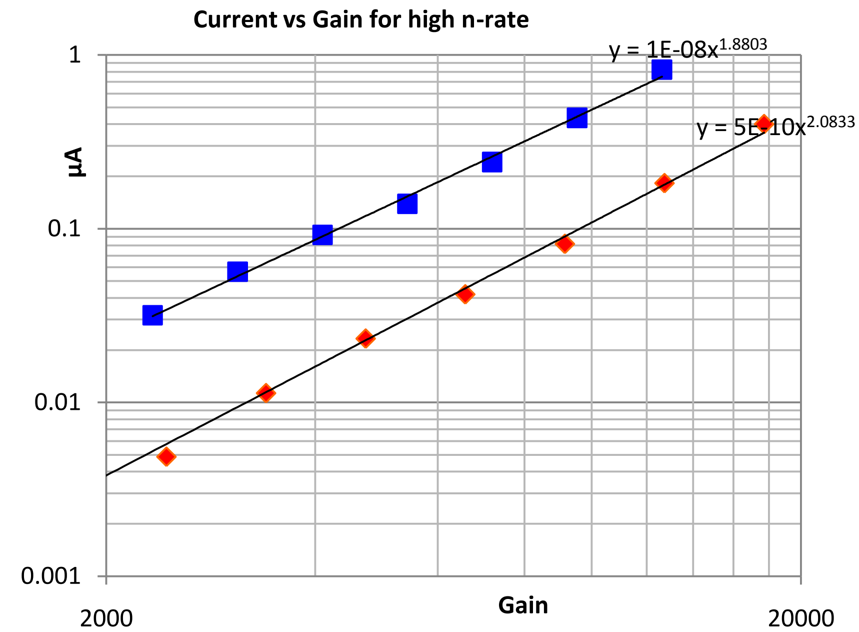
Gas: Ar:CO_2 (85:15)

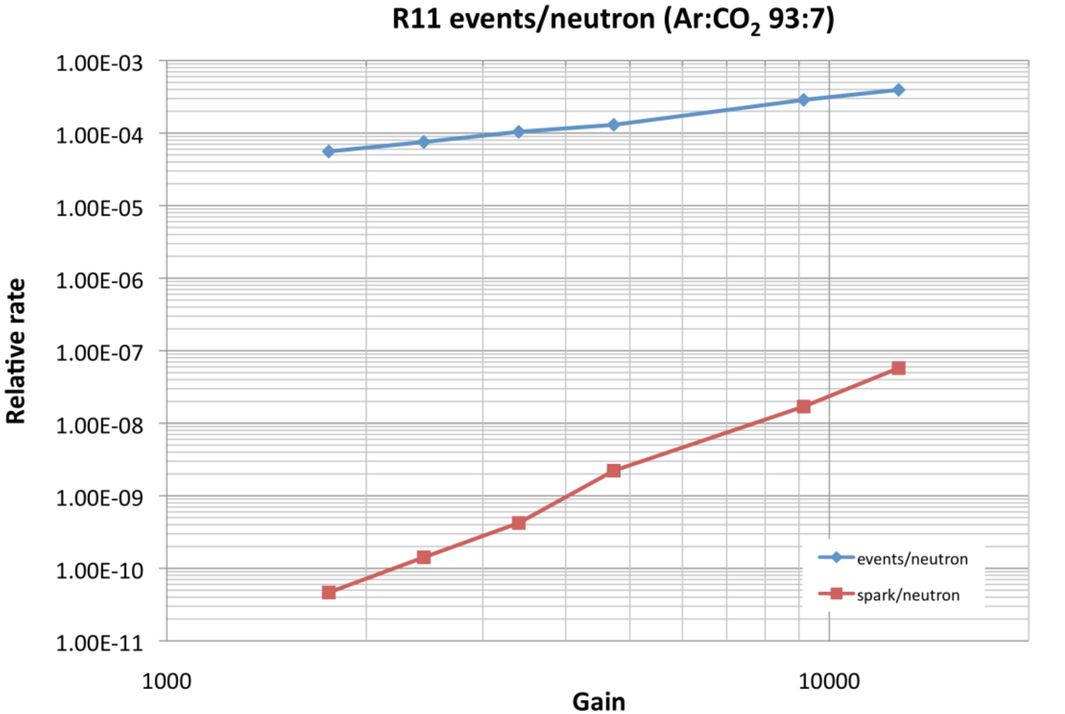
^{55}Fe spectrum taken under neutron irradiation



Neutron beam test (4)







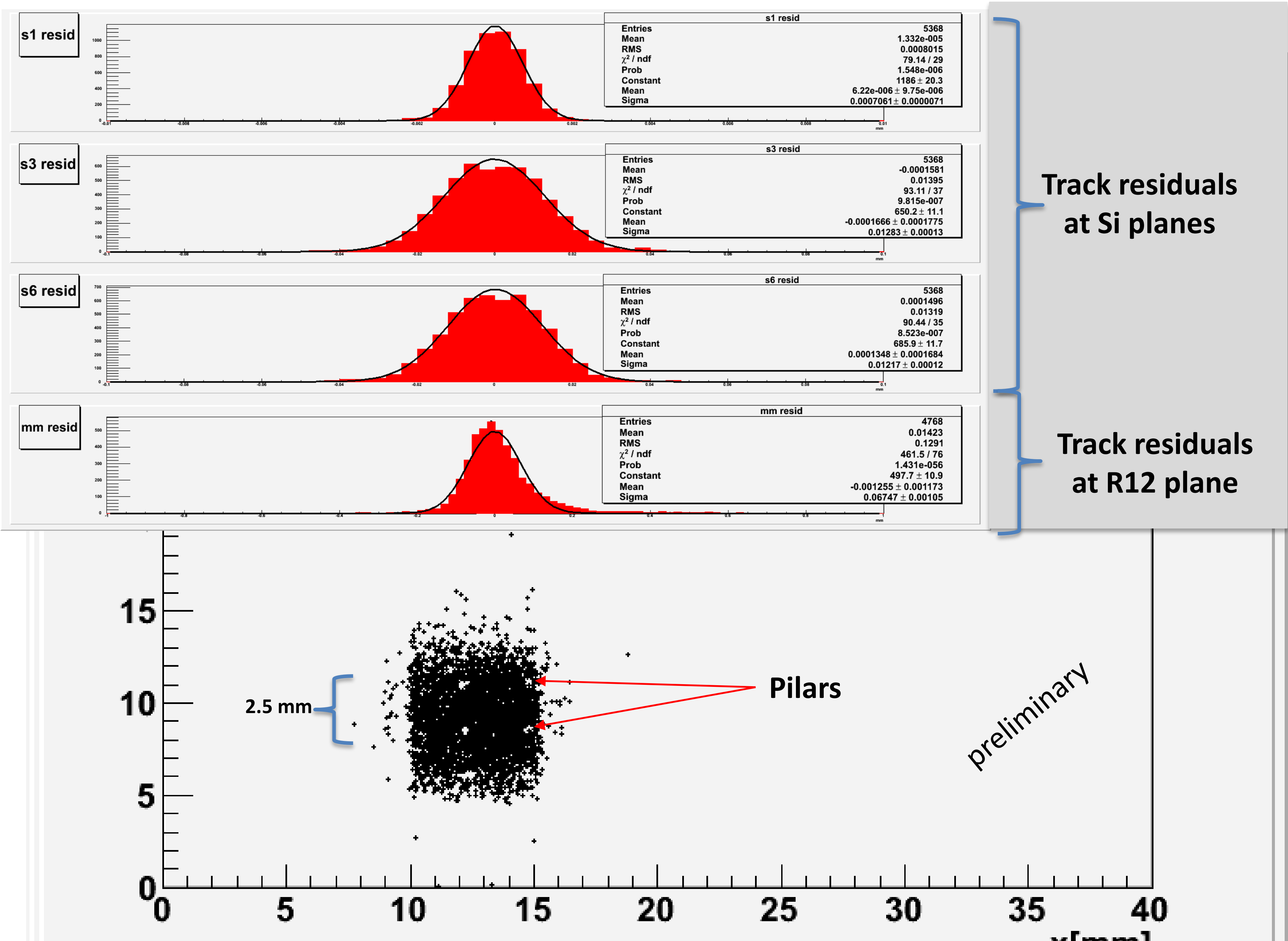
Conclusions from neutron test (R11)

- R11 worked fine in a neutron flux of up to 1.5 x 10^6 n/cm^2 s
- Despite sparks, no HV breakdown, no dead time
- Clear signal from a ^{55}Fe source under neutron irradiation
- Measured three Ar:CO_2 gas mixtures, 93:7 looks very interesting, with a spark rate almost a factor 5 lower than for 80:20

Beam test in H6
July-August 2010

- R11, R12, R13, and P3 chambers were tested in +120 GeV pion beam (intensities 40 kHz & 5 kHz) for two Ar:CO_2 mixtures, 85:15 and 93:7
- Main goals:
  - Study HV and current behavior of resistive and non-resistive chambers in a hadron beam
  - Measure performance (spatial resolution and efficiency) of resistive chambers
  - Study performance of long strips (0.4 m & 1m, non-resistive)
- A few million of events are being analyzed

Beam test in H6



Test beam data.

Si telescope

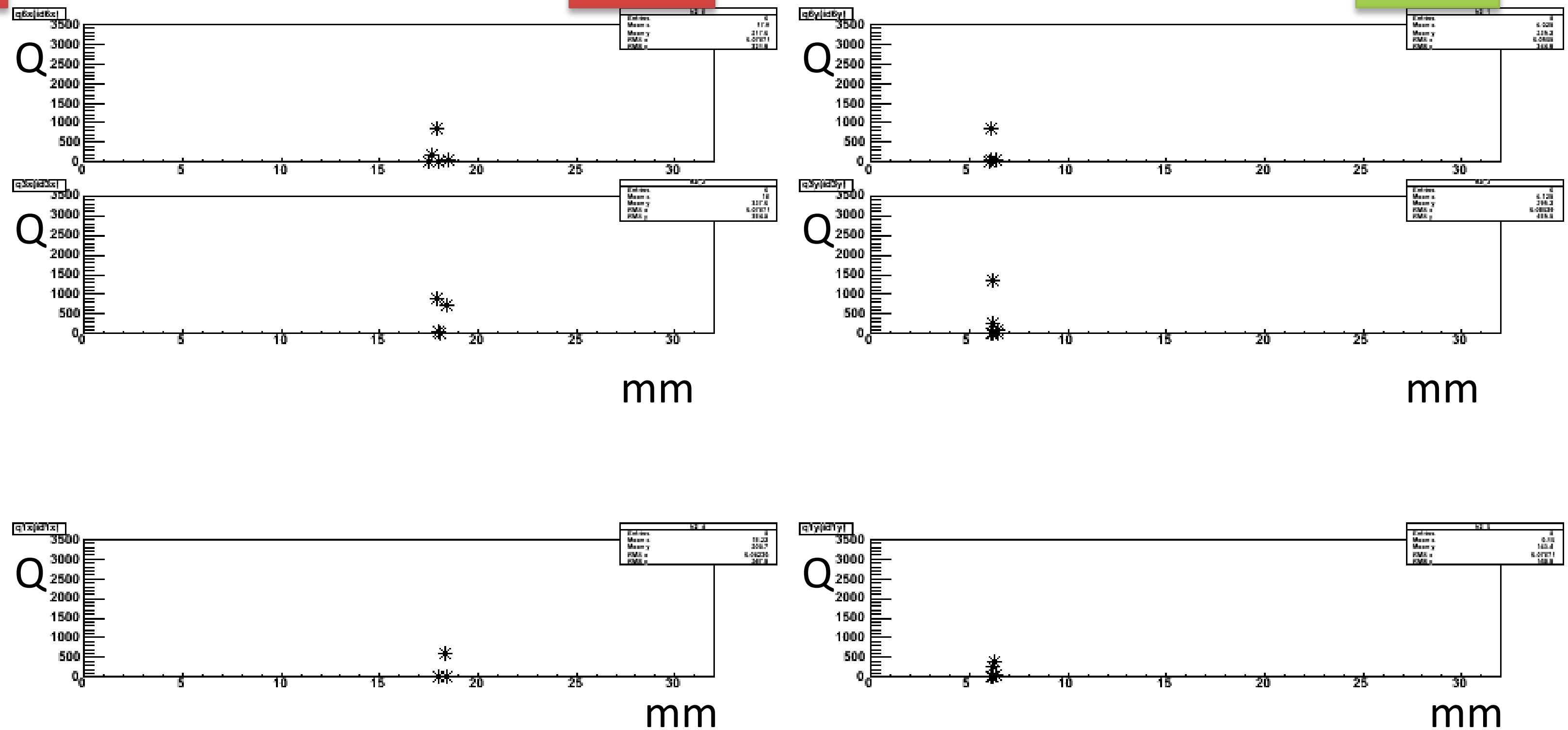
X axis

Y axis

Module 1

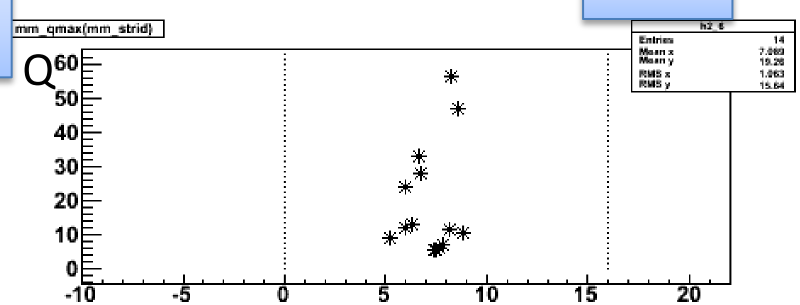
Module 2

Module 3

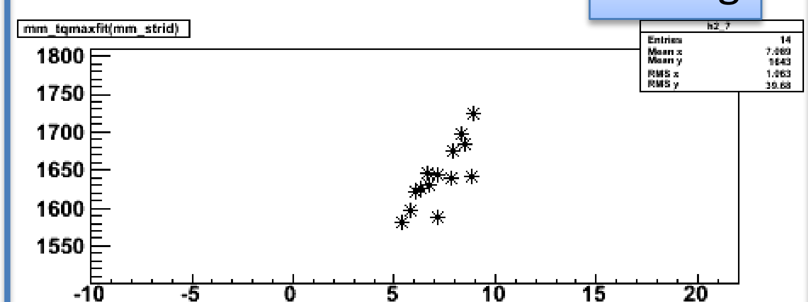


Micromegas at 40°

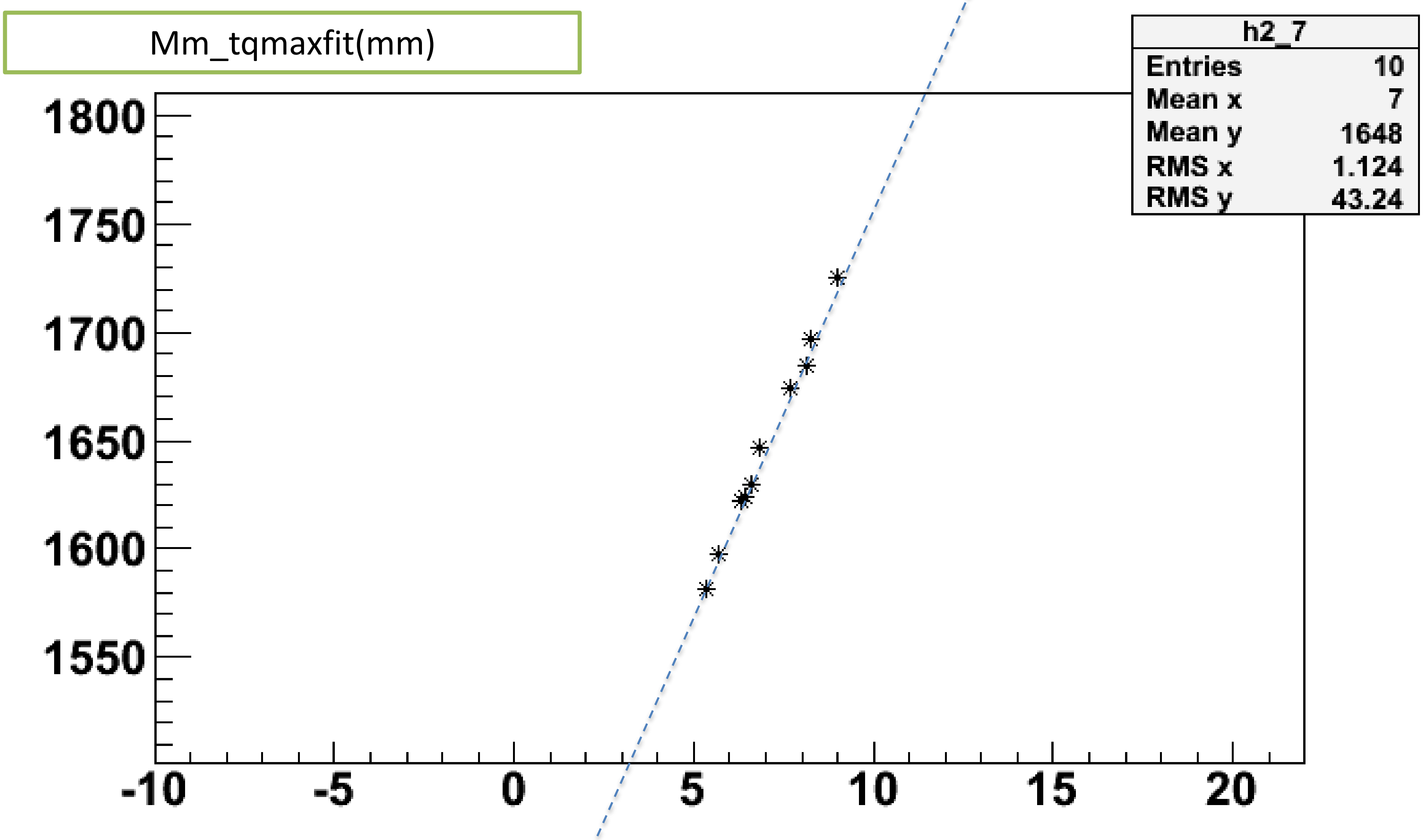
X axis



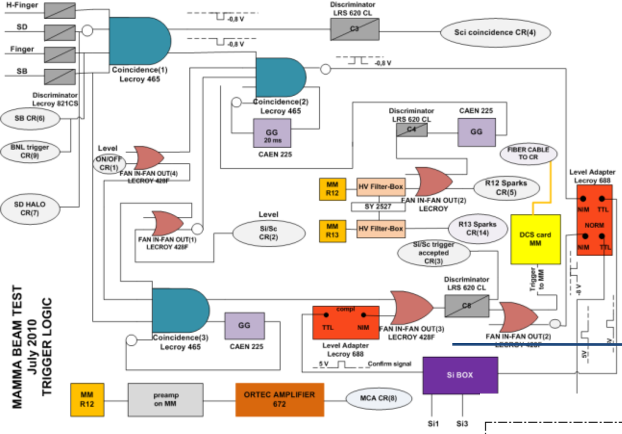
Timing



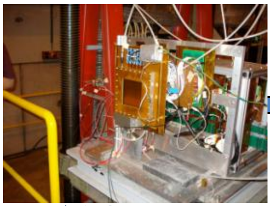
TPC(2): Timing at angle 40° filtered by strip charge



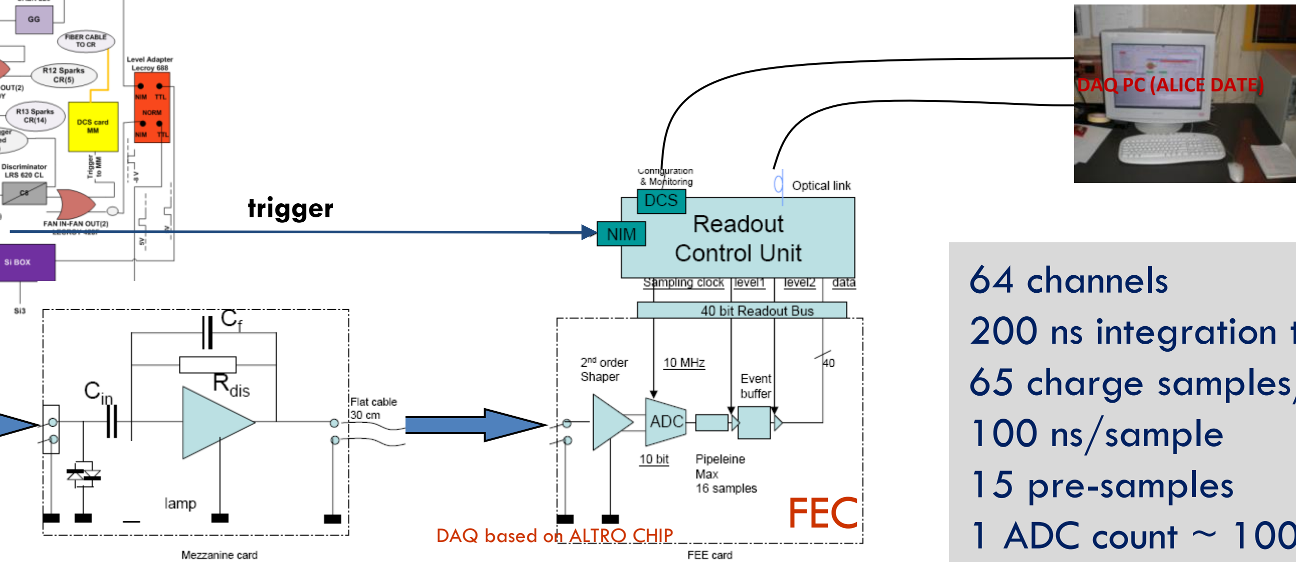
Micromegas Readout



trigger

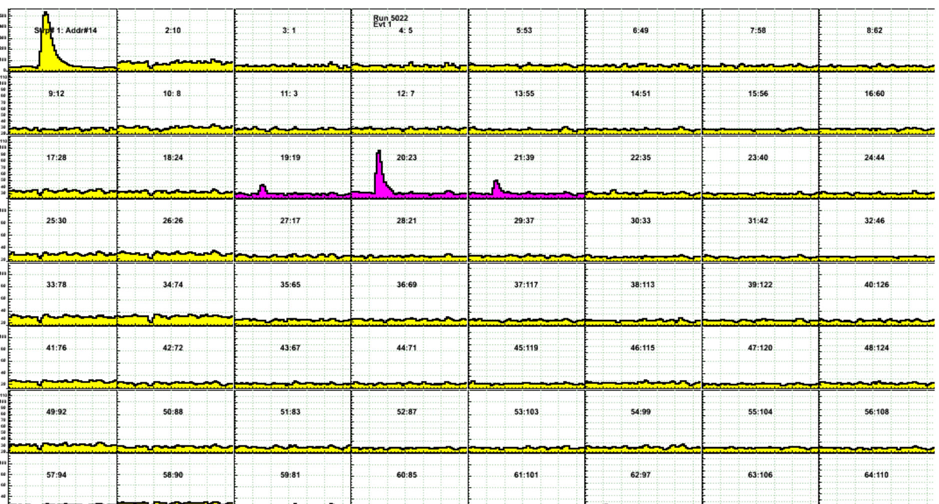


64 channels

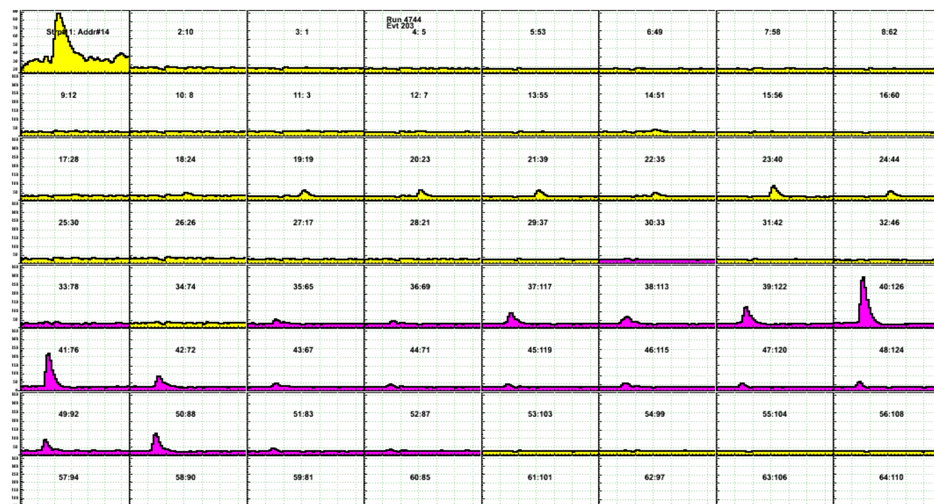


DAQ based on ALTRO CHIP

- 64 channels
- 200 ns integration time
- 65 charge samples/ch
- 100 ns/sample
- 15 pre-samples
- 1 ADC count ~ 1000 e$^-$



normal track



40° incline track

Typical ADC spectra

- Noise subtraction (from 12 pre-samples)
- Custer position from center of gravity

MM readout chip design

- BNL design with the following features
  - Data Driven System with Peak Amplitude and Time Detection
    - On-detector zero suppression, dramatic reduction of data bandwidth
  - Neighbour-channel enabling circuitry (allows for high thresholds without losing small amplitudes)
  - On-chip ADC (10-12 bits?)
  - Simultaneous read/write with built-in Derandomizing Buffers
  - 64 or 128 channels/chip to match detector element size
  - Able to provide Trigger Primitives for on-detector track finding logic
- Based on existing chip developed a few years ago for a TPC application
- Appropriate for a variety of detectors (mMegas, TGC, TPC, GEM, etc.) requiring amplitude and time measurement

Example of/test with BNL TPC ASIC

- Many key features as final chip, but much longer integration time and lower bandwidth
- e.g. on-chip zero suppression: only channels that exceed a predefined trigger threshold (plus the two neighbouring ones are analyzed and read out)
- Output per channel
  - Amplitude
  - Time

Trigger ID → 3263

Strip addresses { 13, 14, 15

Empty event → 3264

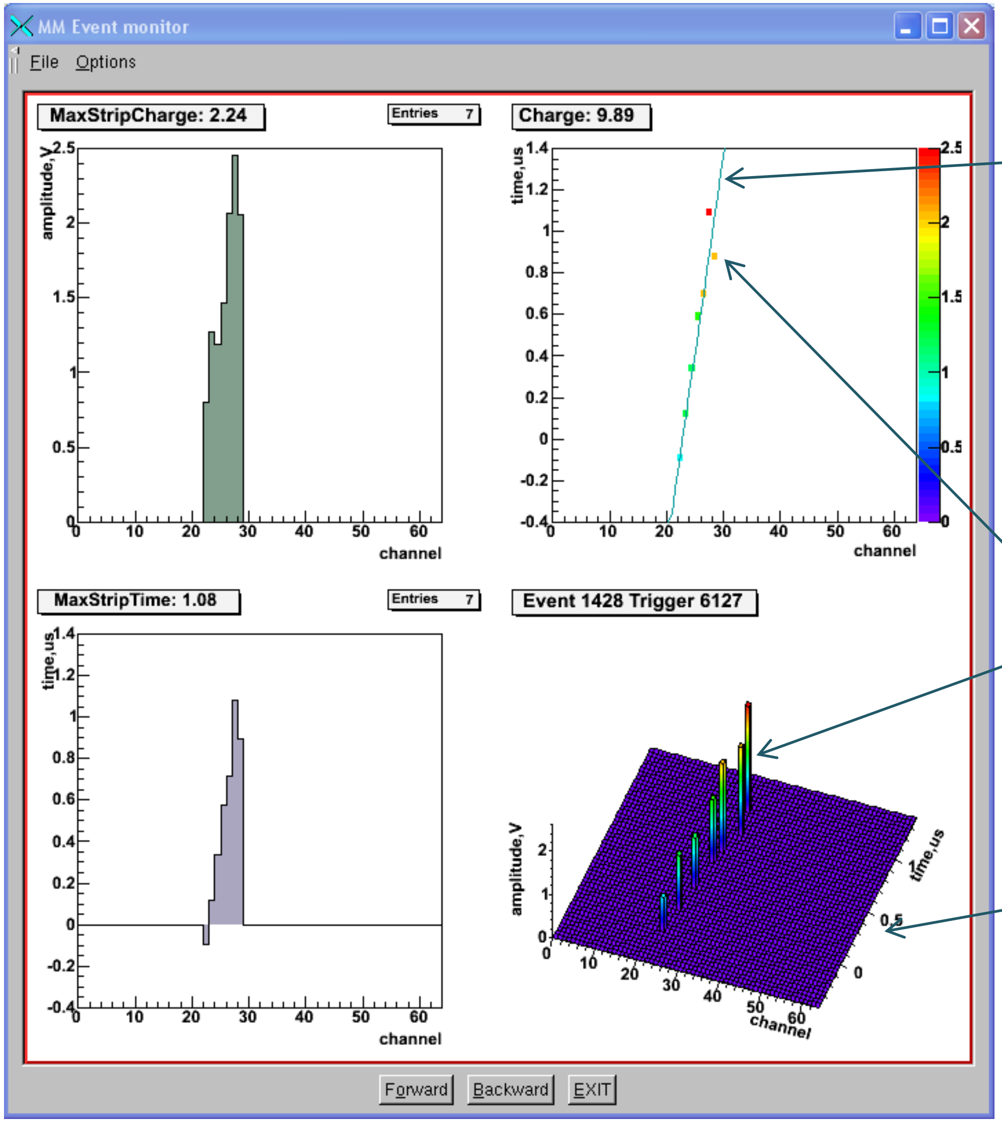
```
        Amplitude Time
3263
13 0.210266 0.424957
14 0.370636 0.437927
15 0.225220 0.412750
3264
3265
0  0.284119 0.457306
1  0.435333 0.418854
2  0.313873 0.450287
3266
3267
…
3281
18 0.206909 0.261841
19 0.902252 0.404968
20 1.113892 0.397491
21 0.597534 0.394440
22 0.304718 0.355682
3282
13 0.225525 0.369110
14 0.406952 0.401764
15 0.382996 0.368195
16 0.225372 0.379486
…
```

Automatic recording of neighbour strips when a channel exceeds hardware threshold (here 0.35)

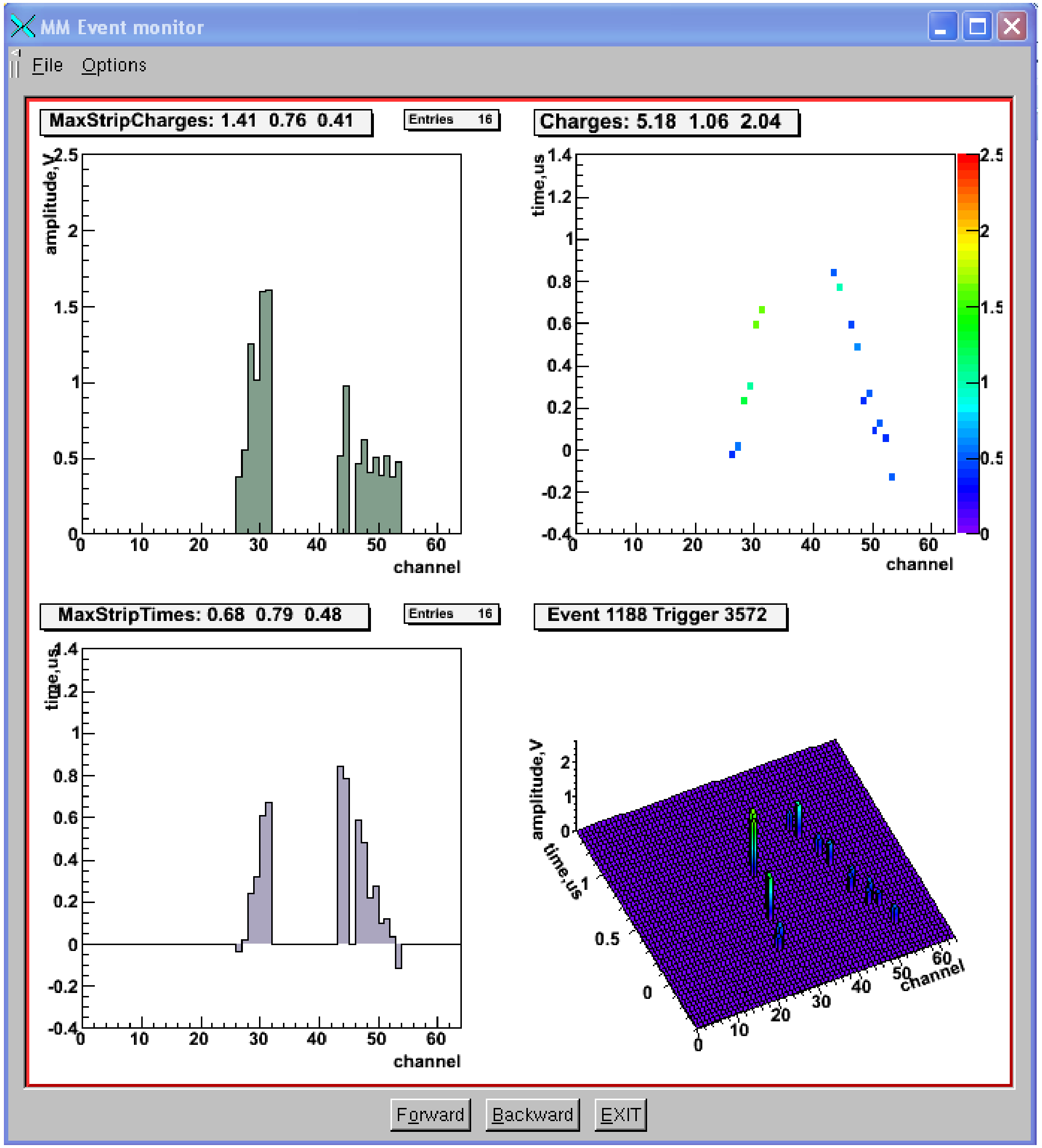
Testbeam data file run26

- **136K triggered events**
- **7.5 Mb ascii**
- **would be much smaller in binary**

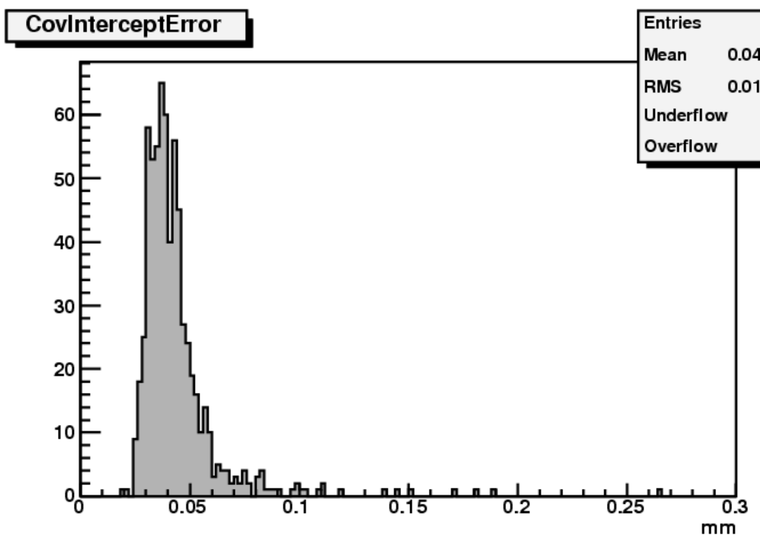
Event Display

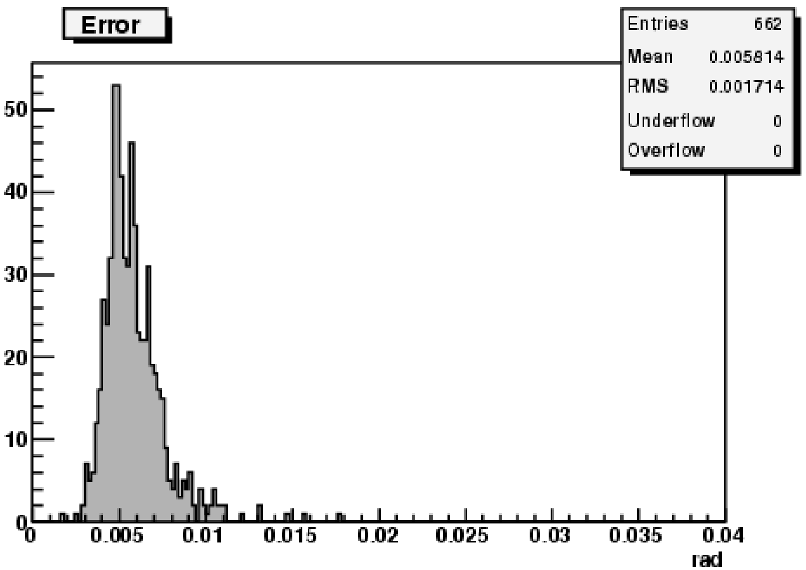


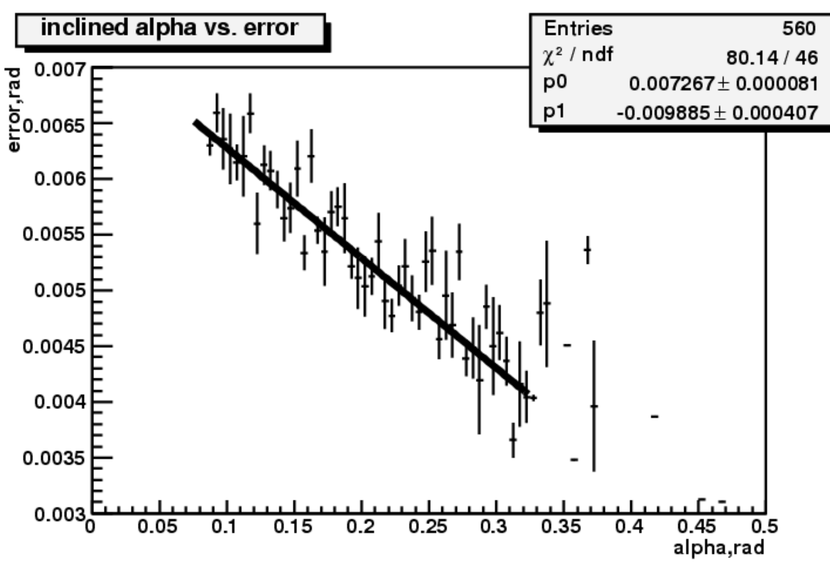
Double Track Events



Precision in determining angle and position



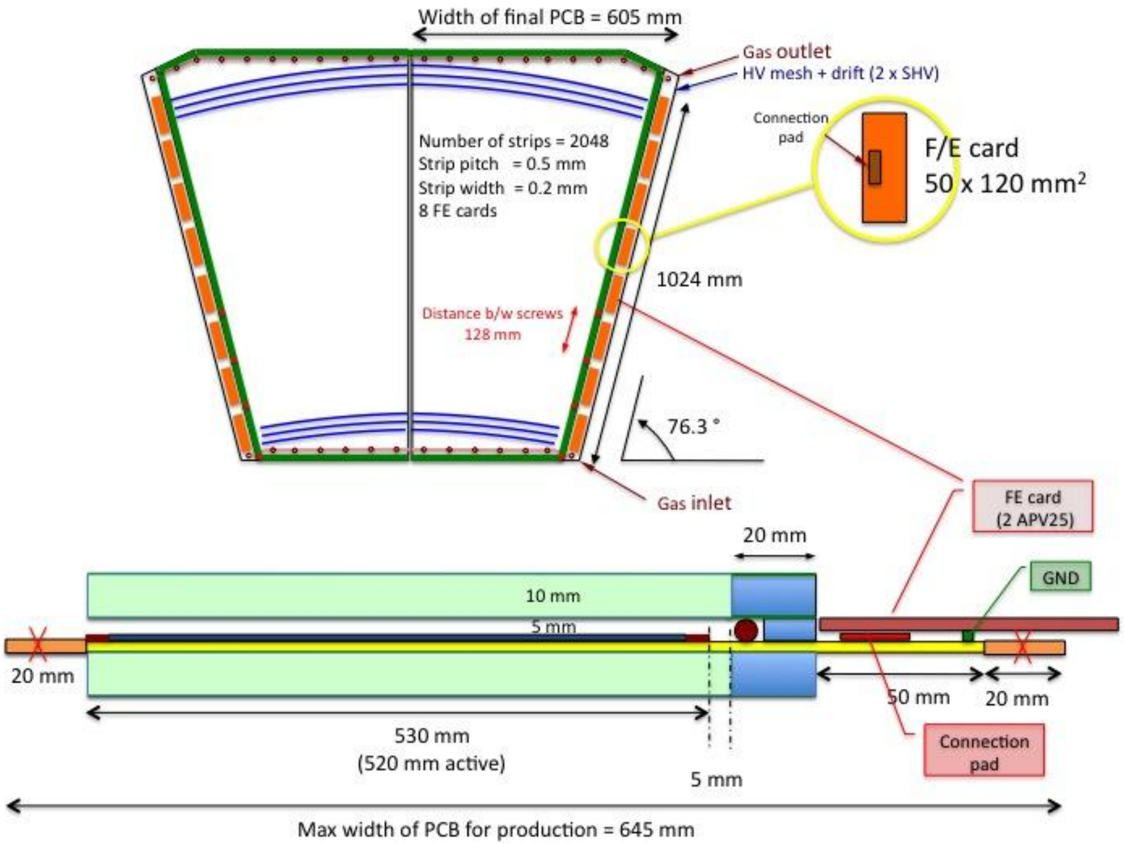




Next steps

- Proceed with full-size prototype (CSC size)
  - First version with a single active plane made of two halves is under design. Limited by size of machines at CERN, it is split in the middle; probably one half with resistive strips and the other half bare
  - Readout with APV25 chip and RD51 readout system; on-chamber electronics integrated; adapter board under design in Naples
  - Test in H6 foreseen in October

Half-size Chamber



Next steps II

- Multi-plane full-size prototype design will start this fall
  - Module-00 with trigger capability and 2D readout could be available by summer 2011…
  - BNL peak finding electronics expected to be available on same time scale
- Could install a test chamber in ATLAS during 2012 shut down