Micromegas progress report

Talk given by J. Wotschack last month
At the ATLAS upgrade week
+ some recent results

- Spark studies
- Readout electronics
- Next steps

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

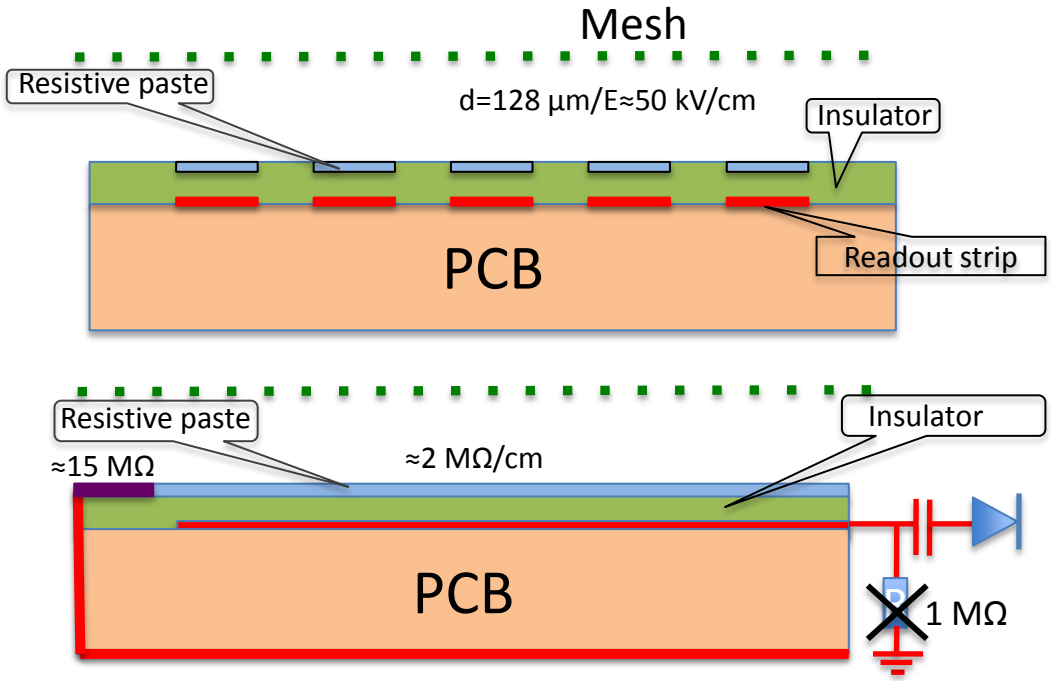
R11

- Small 100 x 100 mm^2 chamber with 100 mm long strips and 250 µm strip pitch (similar to R9 and R10)
- New feature: Resistive strips (≈2 MΩ/cm) are connected through ≈15 MΩ to Ground
- R11 characteristics:

  Resistive strips, separated by a thin insulating layer from readout strips

  Readout strips are floating; capacitive coupling of signals

  Very large currents (sparks) are neutralized through resistive strips to ground

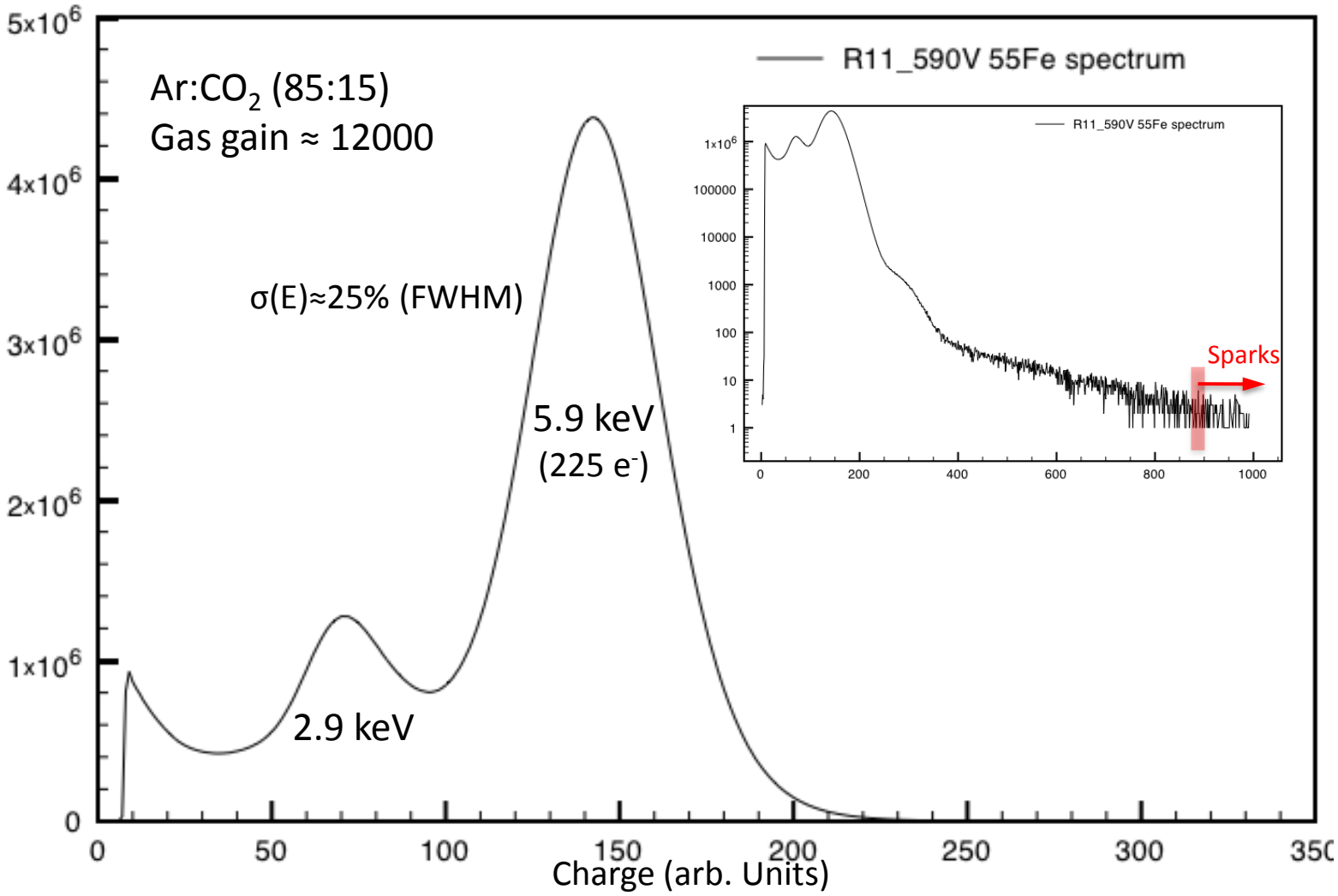


More details on the technology in Rui's 2 talks in WG1 and WG6

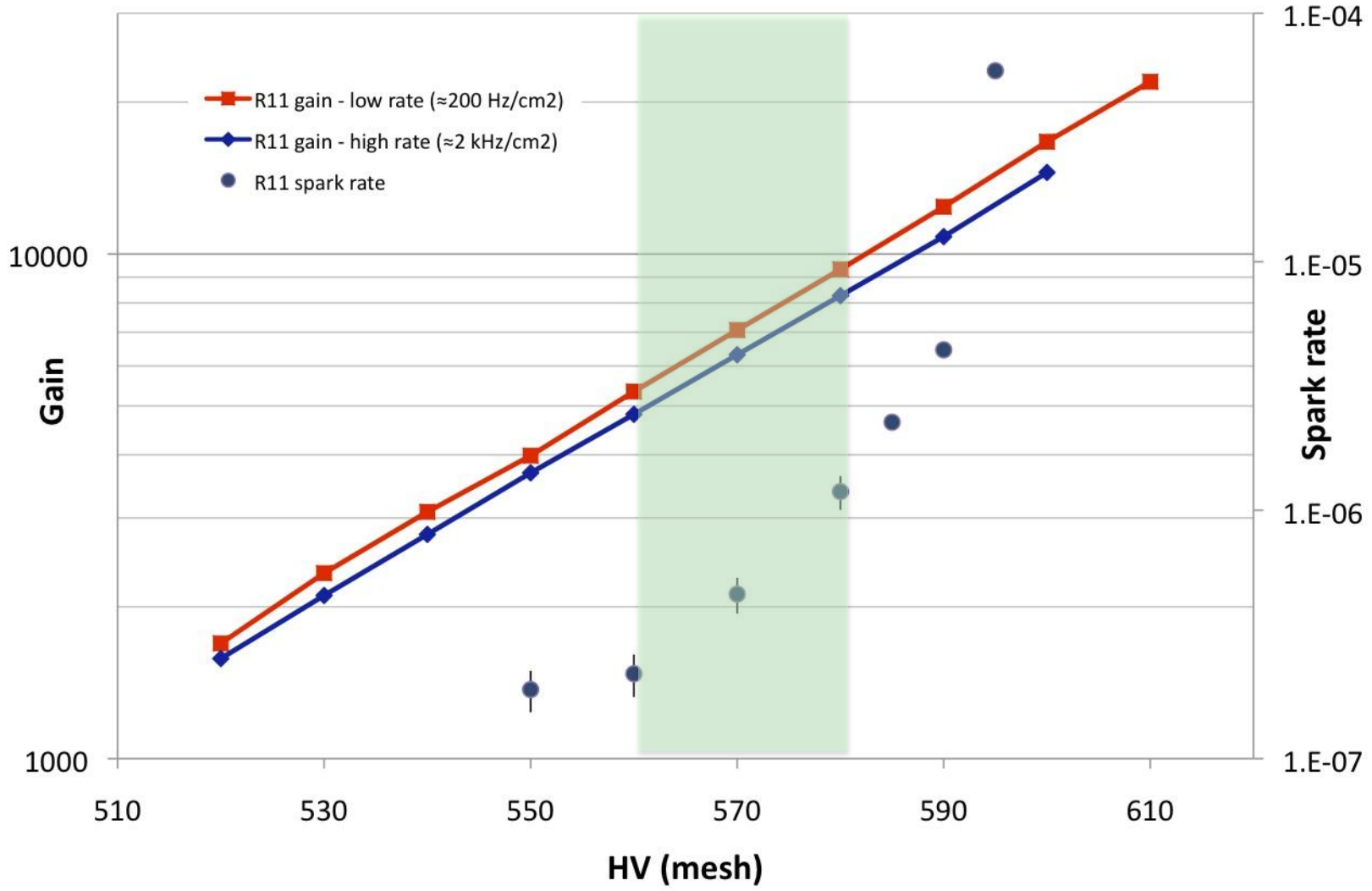
R11 performance

- Clean signals
- ^{55}Fe spectrum, energy resolution ≈25% FWHM
- Gas gain up to 2 x 10^4
- Low spark rate
- Low spark currents (≤20 nA), no HV drop
- Fast spark recovery times, few µs
- Robust: forced many sparks, no damage
- Good high-rate performance

R11 - ^{55}Fe spectrum

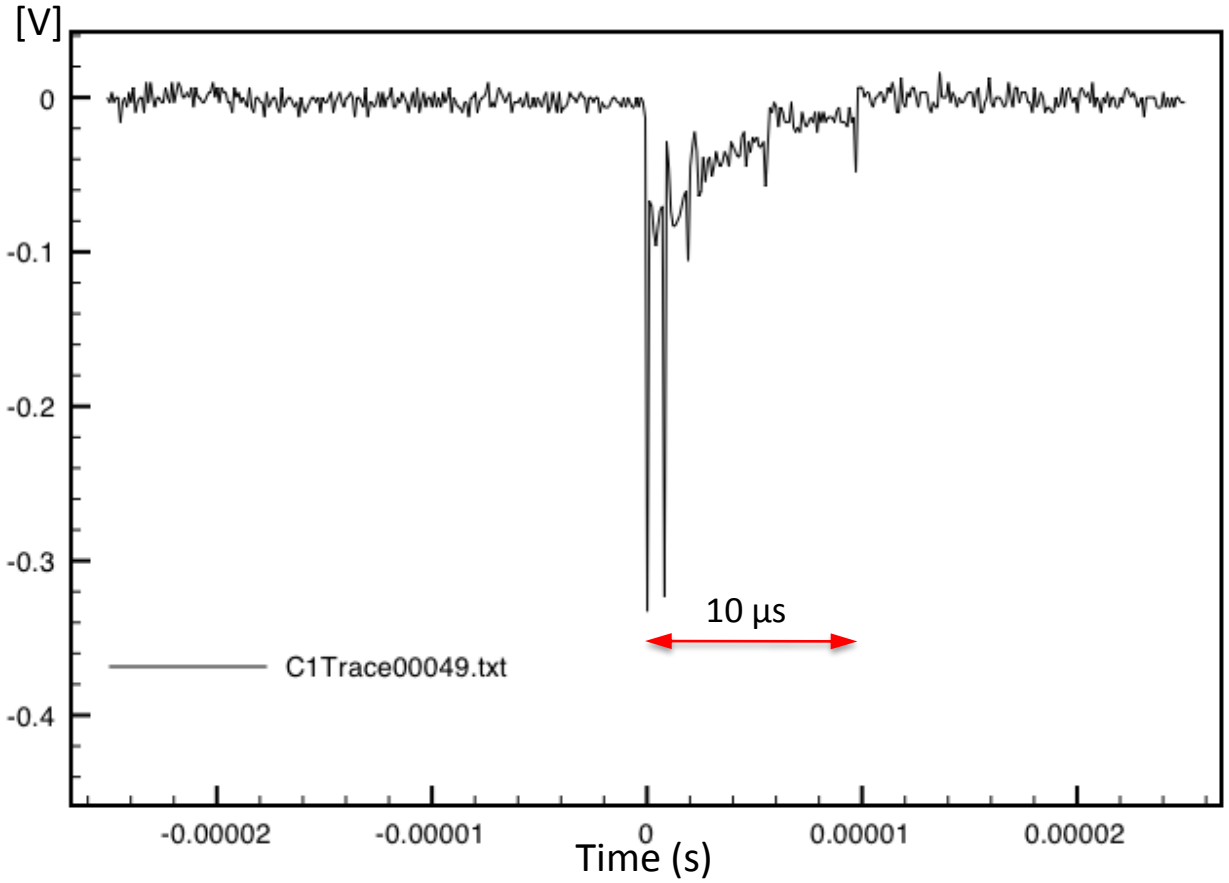


R11 Gas gain & sparks (^{55}Fe)

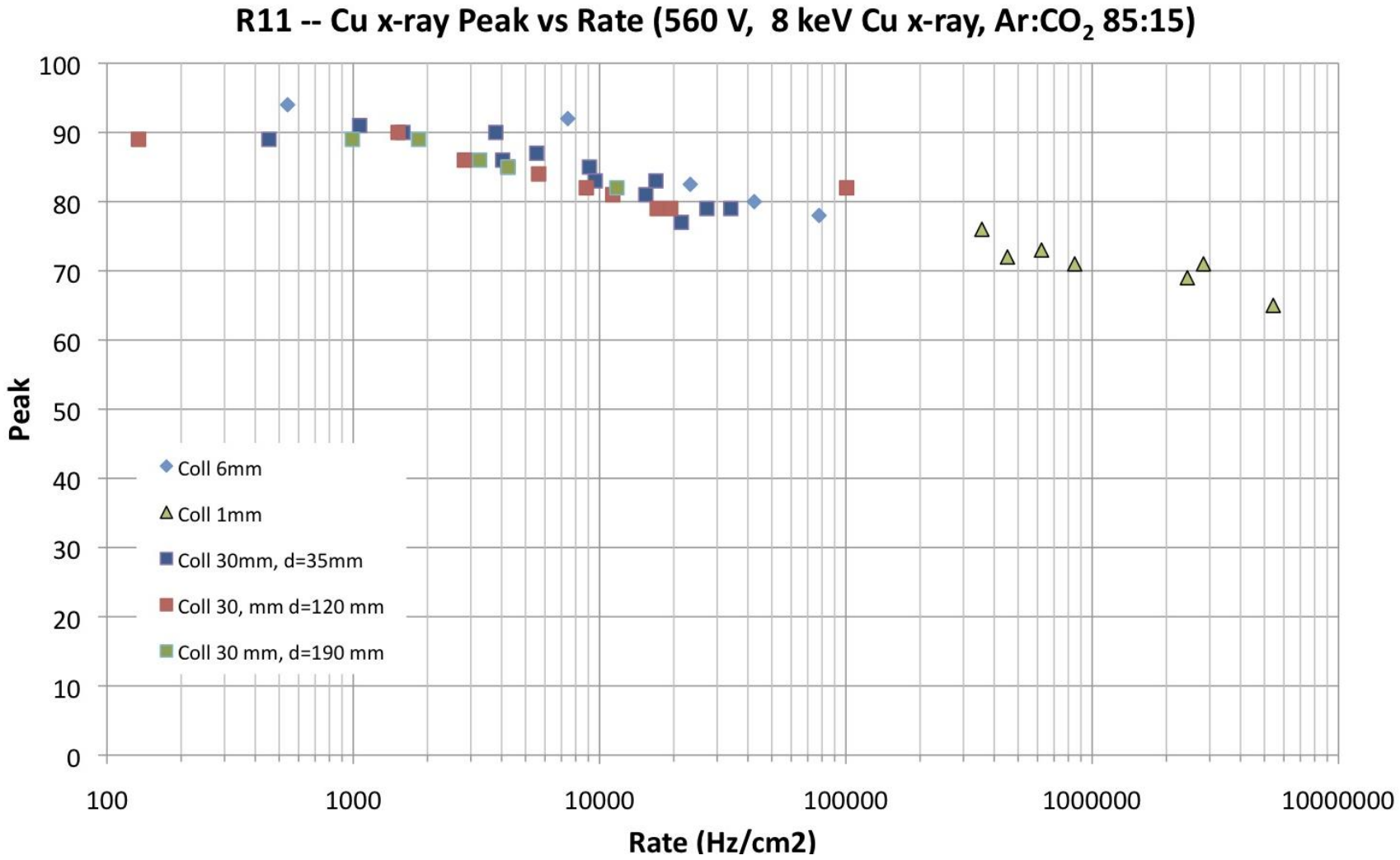


Spark ‘signal’

- 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

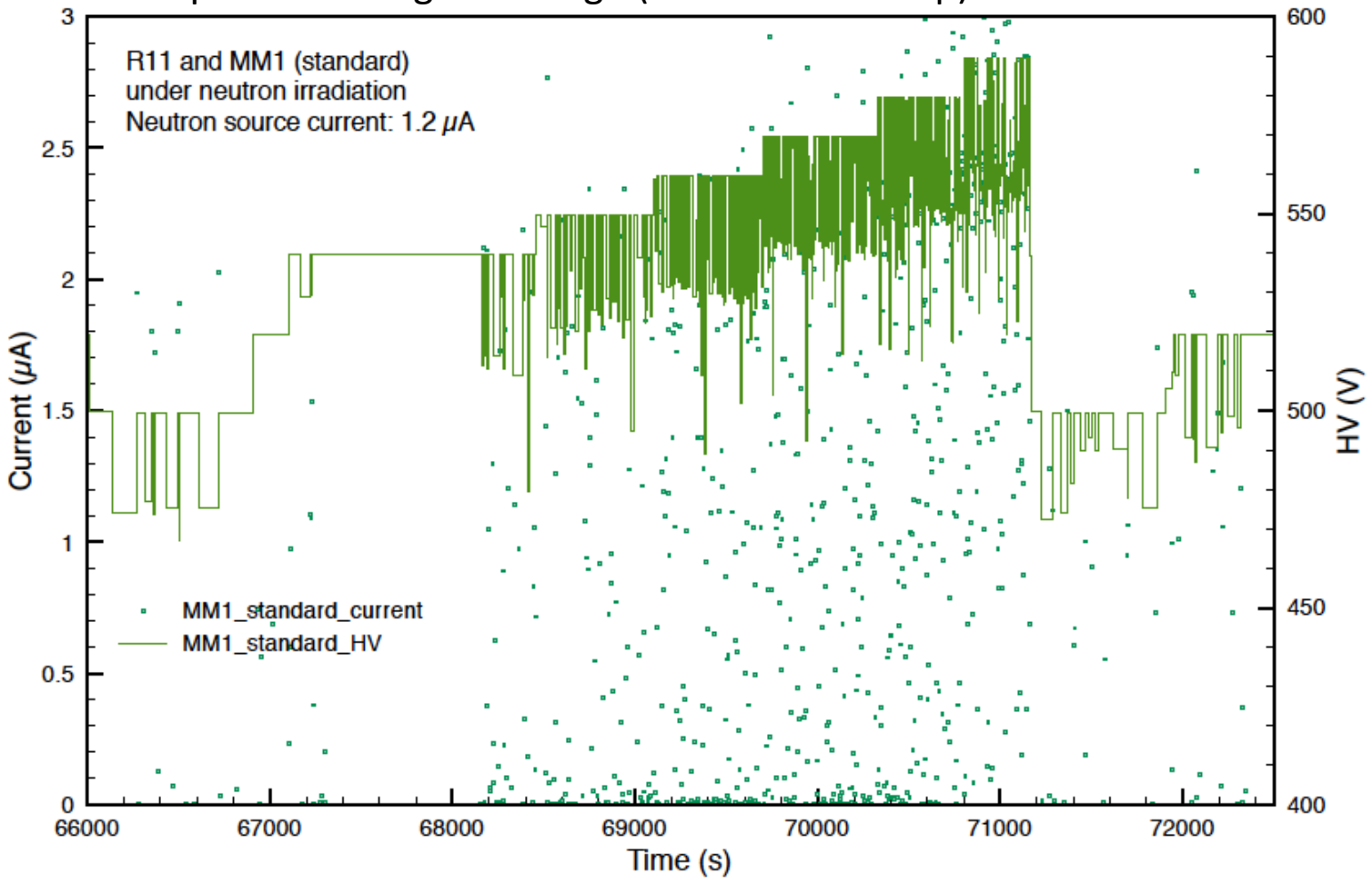


R11 - High-rate performance

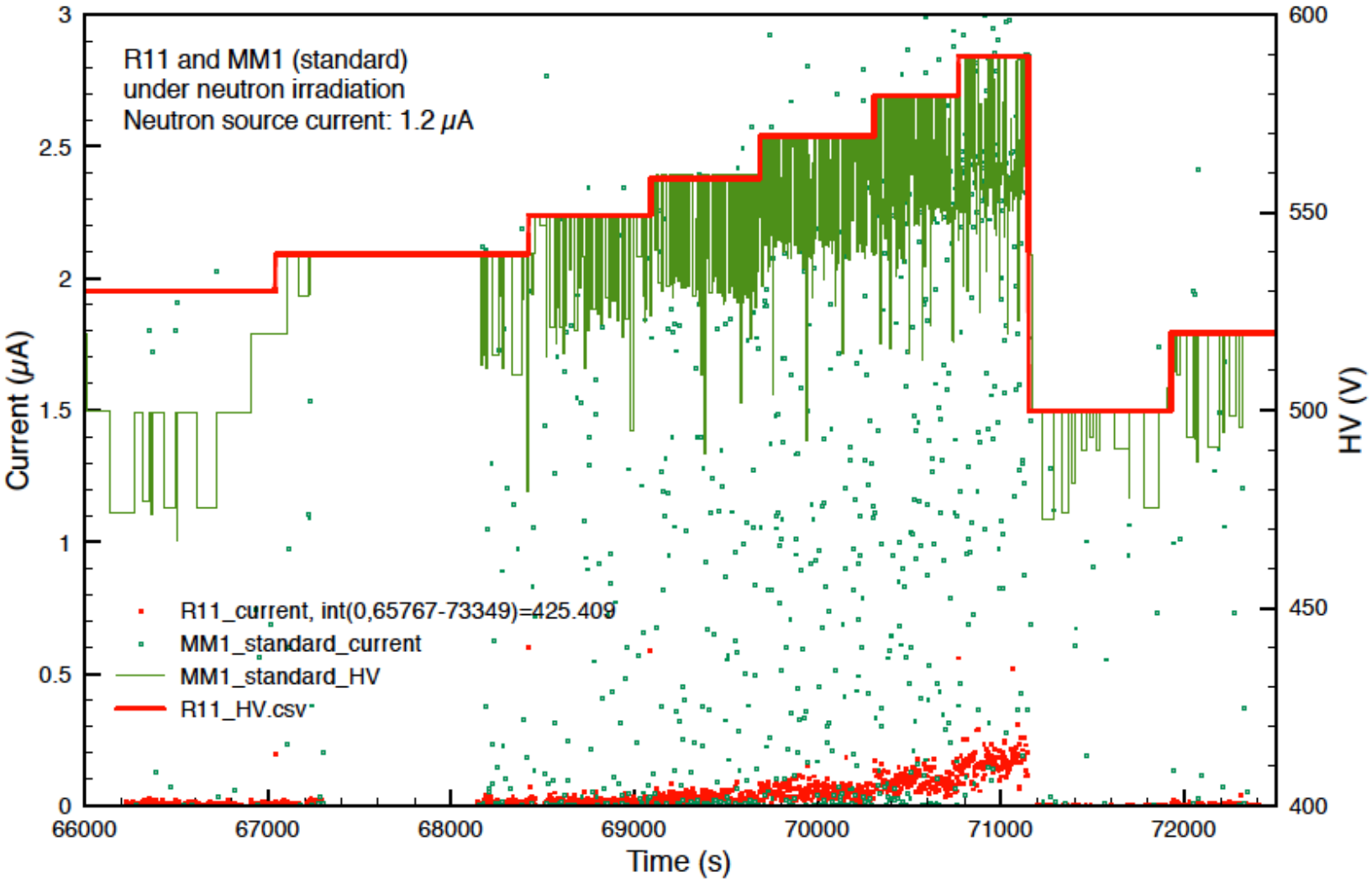


Standard MM under neutron irradiation

Frequent discharge with high (several microamp) currents



R11 performance superimposed



Conclusions on R11

- Detector is robust & stable
- Signals are clean, good gas gain and energy resolution
- Spark rates of $O(10^{-6})$ for gas gains of 5000–10000
- R11 is spark resistant, no HV breakdown and very small spark currents (few nA)
- Excellent high-rate behaviour up to and above 100 kHz/cm^2

So far R11 seems to fulfil all our requirements

Still, a few more things need to be verified, see below …

2. Readout electronics

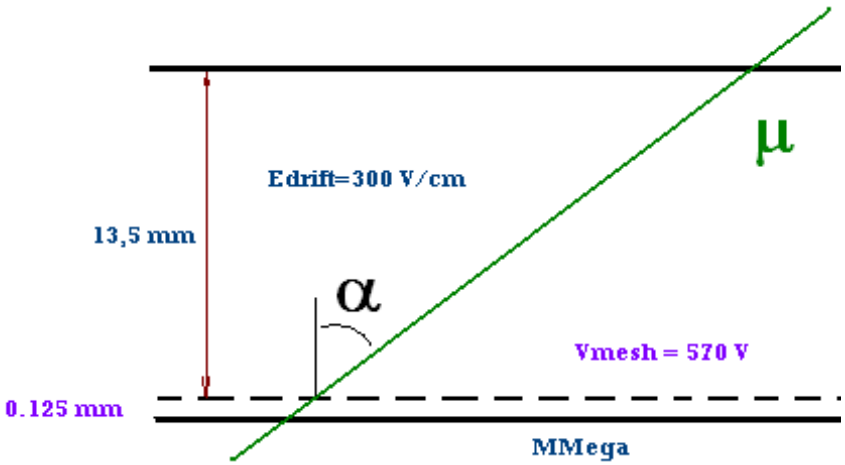
- Several chip designs for micro-pattern gas detectors are under development at BNL, CEA Saclay, LAPP Annecy, …
- Good collaboration between different efforts
- Scalable Readout System is becoming available in summer 2010 (developed in the context of RD51 at CERN); first implementation with APV25 chip to be tested with GEMs and our micromegas (maybe already in July test beam)

MM readout chip design

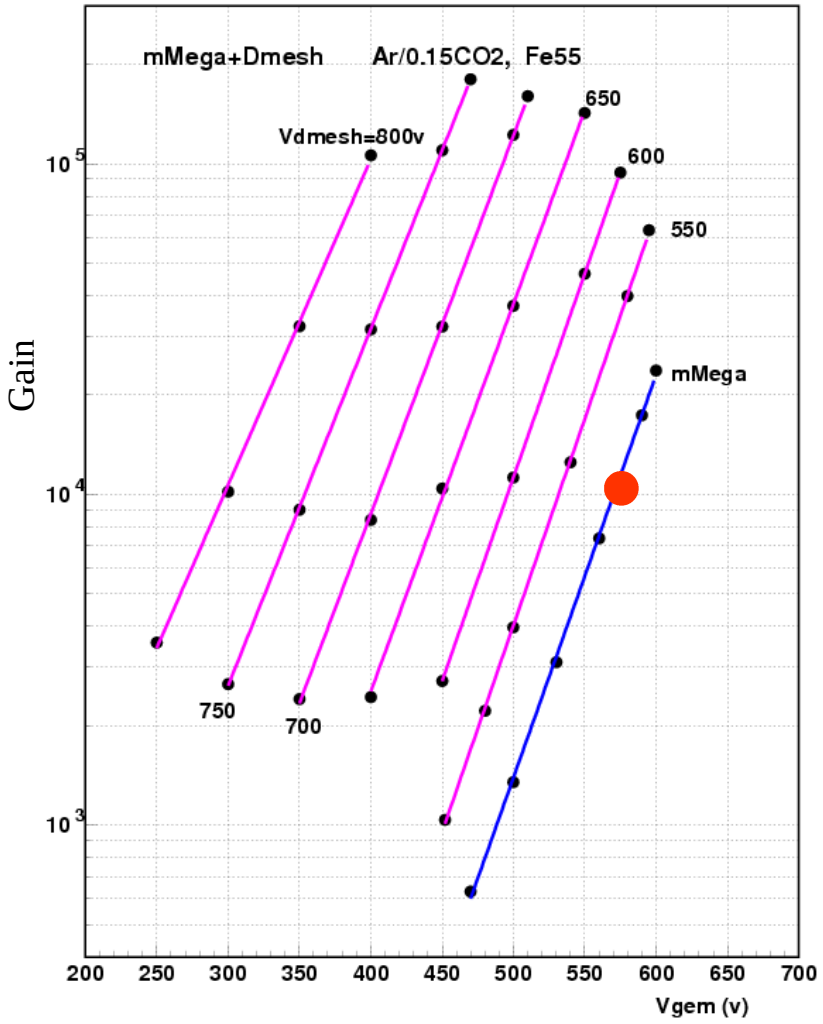
- BNL design with the following features
  - Data Driven System with Peak Amplitude and Time Detection
    - On-detector zero suppression, dramatic reduction of data bandwidth
  - Neighbour-channel enabling circuitry (allows for high thresholds without losing small amplitudes)
  - On-chip ADC (10-12 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

“MicroTPC” Operation of mMegas Detector

E_{drift} 300V/cm V_{drift} ~2cm/μs
V_{mesh} 570 V

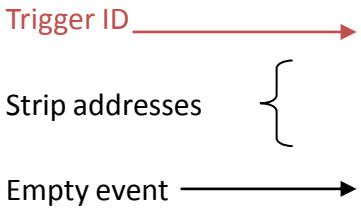


Gain $4 \cdot 10^3$



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



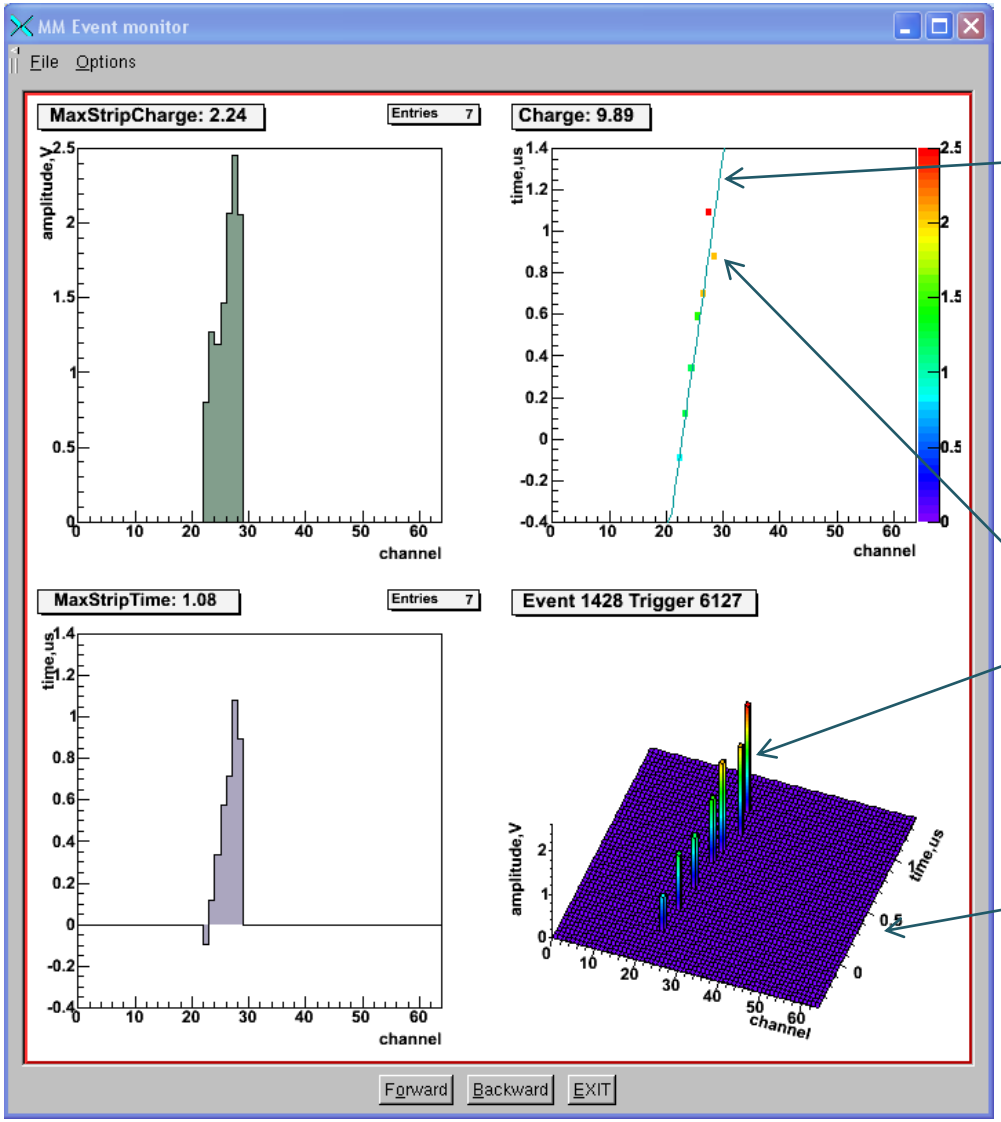
Amplitude Time

```
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
...
```

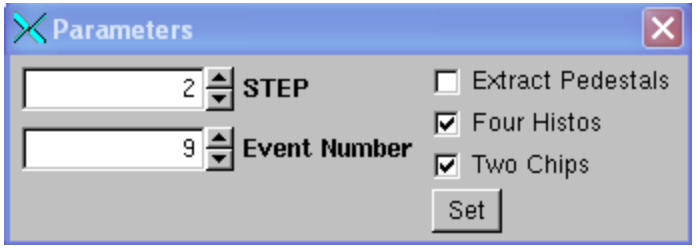
Automatic recording of neighbour strips when a channel exceeds hardware threshold (here 0.35)

Testbeam data file run26
- **136K triggered events**
- **7.5 Mb ascii**
- **would be much smaller in binary**

Event Display



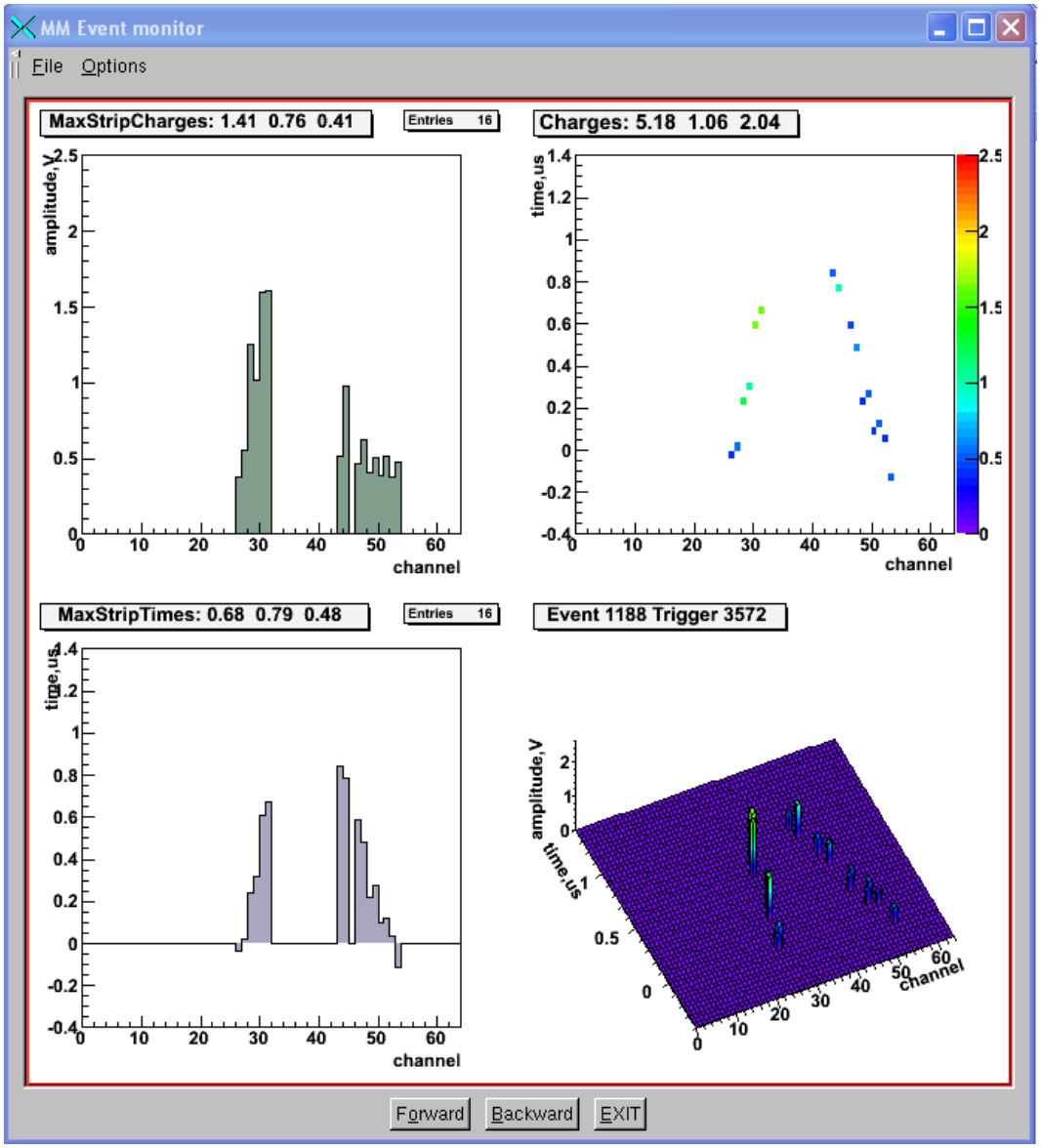
Tracking done on-line



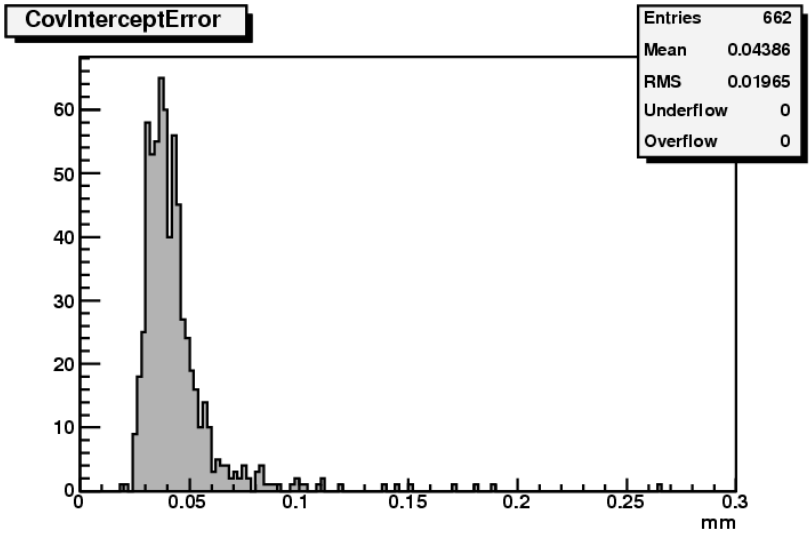
Te same color palette used

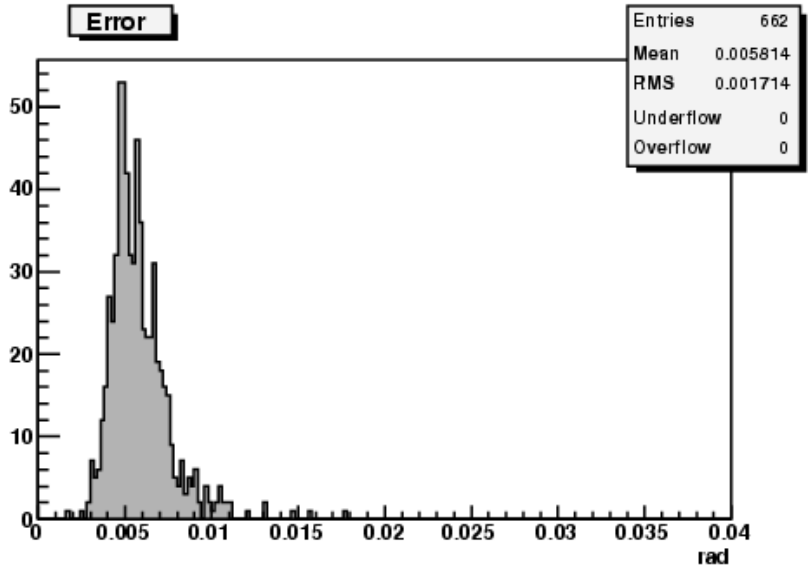
3D Object

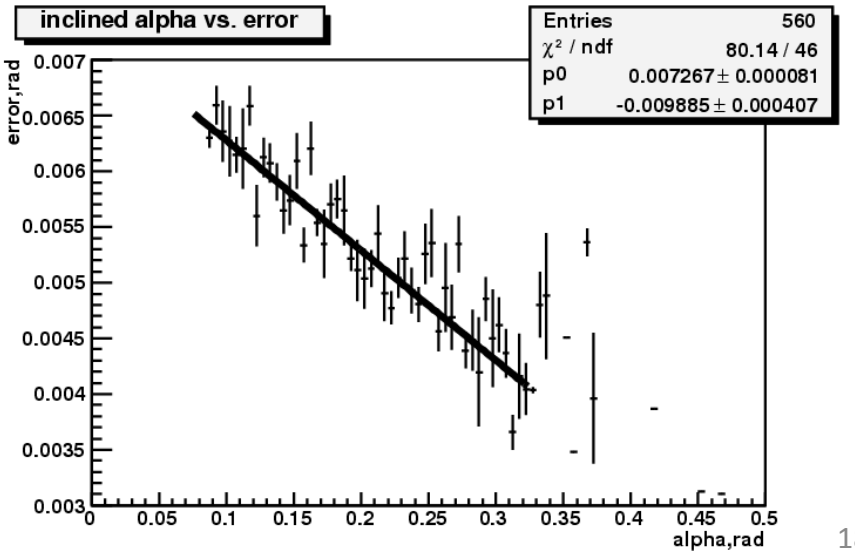
Double Track Events



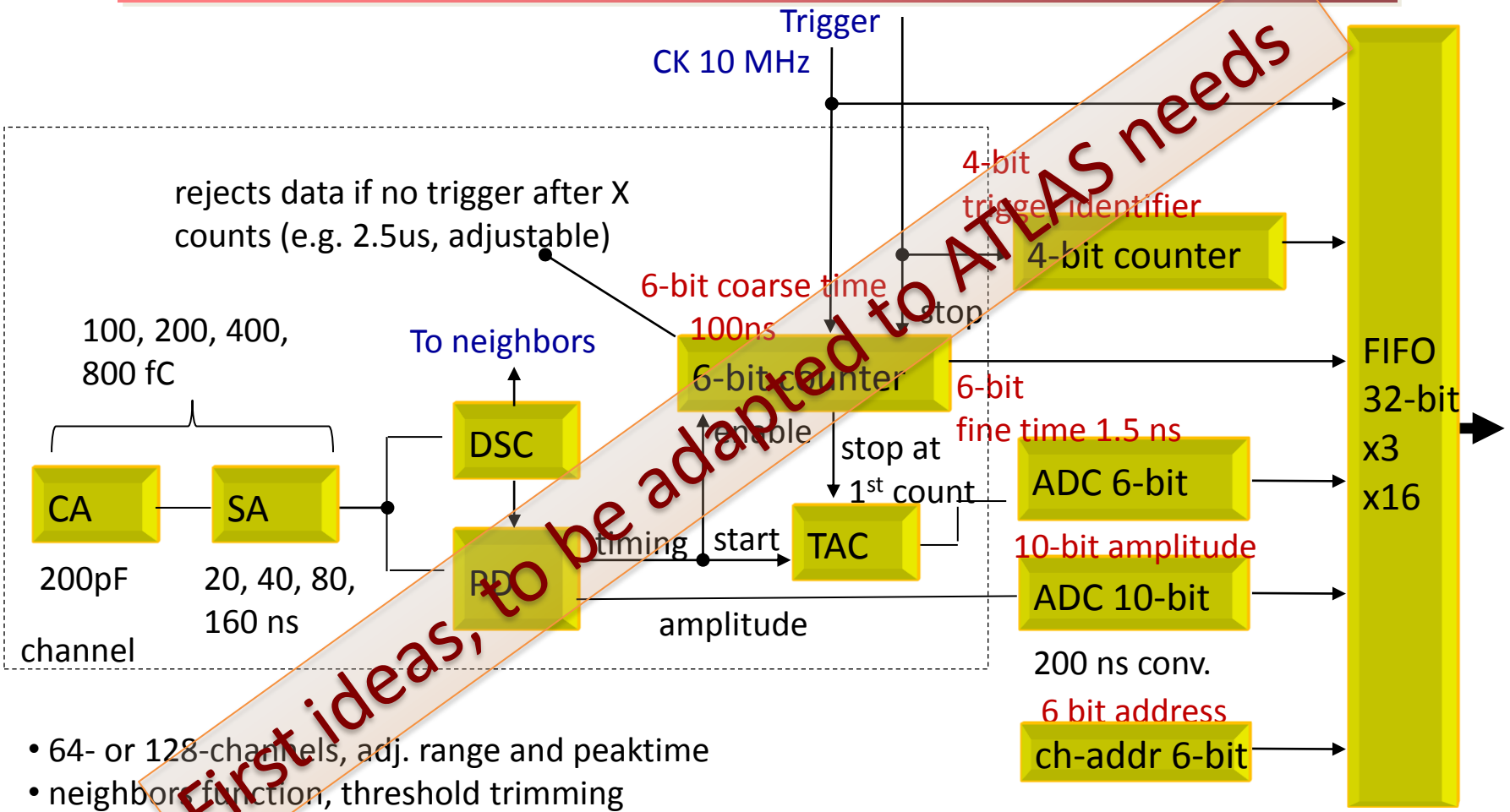
Precision in determining angle and position







An Architecture for Micromegas



- 64- or 128-channels, adj. range and peaktime
- neighbors function, threshold trimming
- analog monitors, masking and calibration functions, temperature sensor
- continuous measurement and readout, derandomizing FIFO
- few mW per channel, chip-to-chip communication (neighbor), fully digital, LVDS interface

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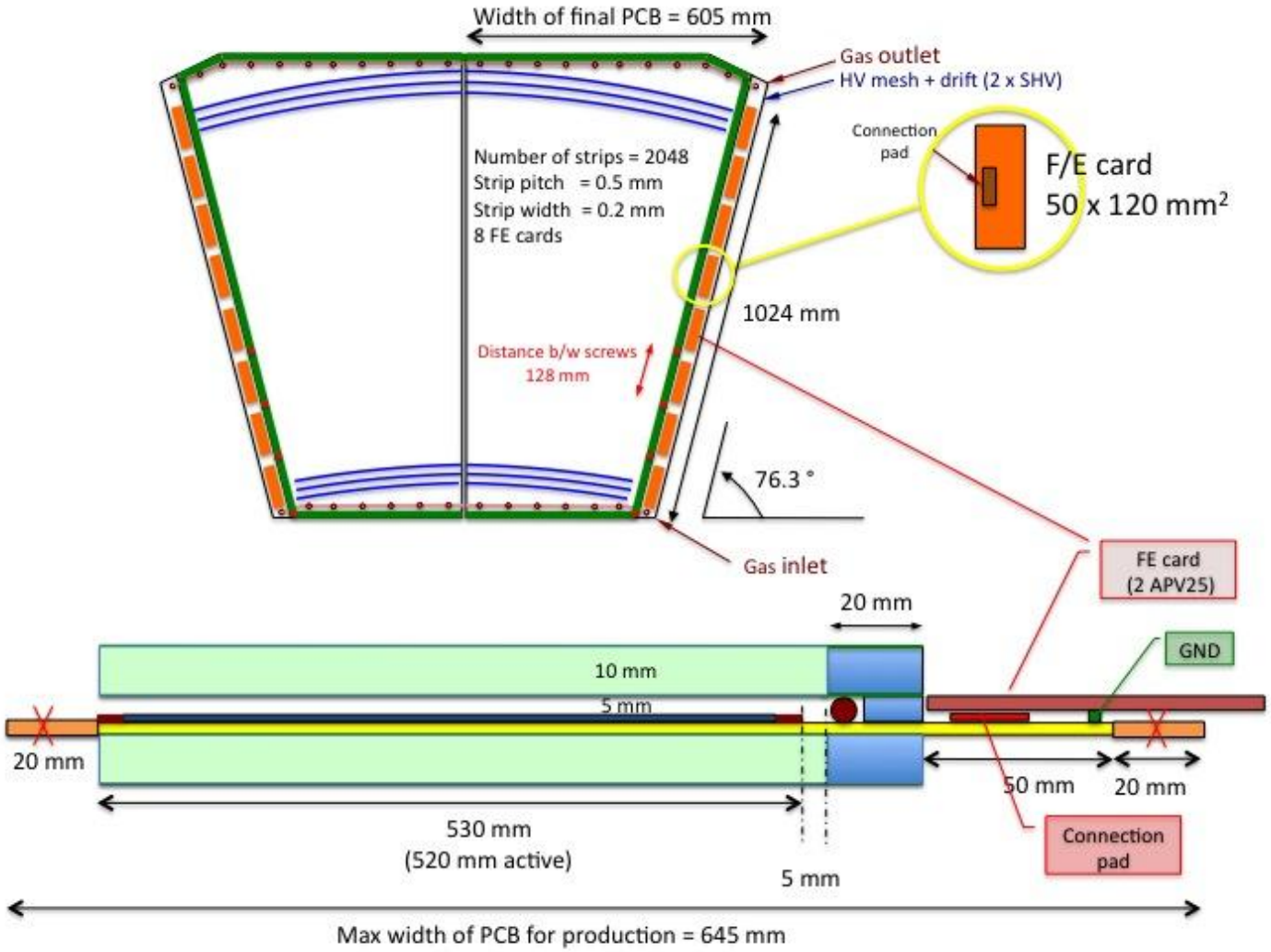
Next steps I

- Optimization of R11 parameters (R, C, …)
- Test of R11 in neutron beam at Demokritos/Athens, May 3-7 (done, more detailed studies later this year)
- Test beam (π's) at CERN (H6) in July and October
- Finalize specifications for readout electronics
  - A first version of the peak finding BNL chip could be available by end of 2010
  - In parallel, work on adaptation of front-end electronics to RD51 readout system will proceed

Next steps II

- 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

Full-size prototype



Next steps III

- 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