Micromegas R&D status report

Arizona, Athens (U, NTU, Demokritos), Brookhaven, CERN, Harvard, Istanbul (Bogaziçi, Doğuş), Naples, CEA Saclay, Seattle, USTC Hefei, South Carolina, St. Petersburg, Shandong, Stony Brook, Thessaloniki

https://twiki.cern.ch/twiki/bin/view/Atlas/MuonMicromegas

Joerg Wotschack/CERN-PH

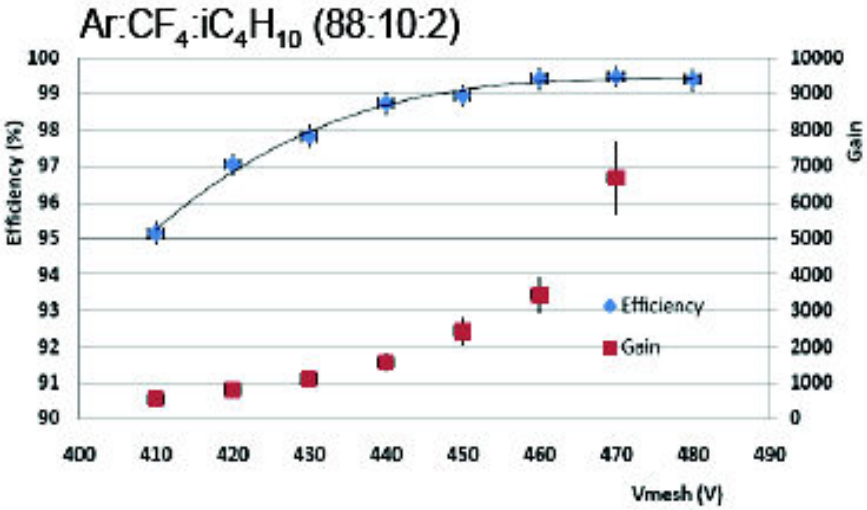
Why micromegas technology

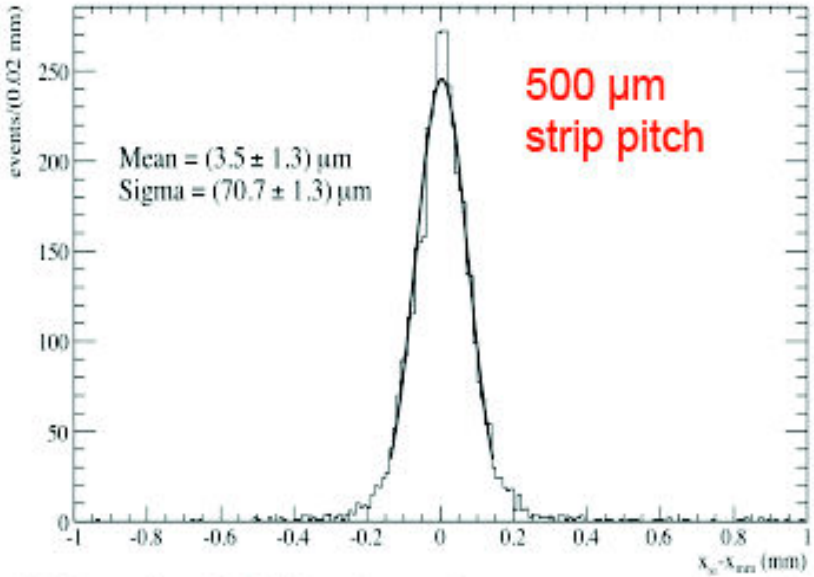
- Robust detector that can be industrially produced
- Excellent performance (see MPGD2009, K. Nikolopoulos)
  - Very good spatial resolution
  - Timing performance sufficient for triggering
  - Potential to deliver track vectors in a single plane for track reconstruction and LV1 trigger
- Flexibility in the readout segmentation
- Excellent rate capability & ageing properties

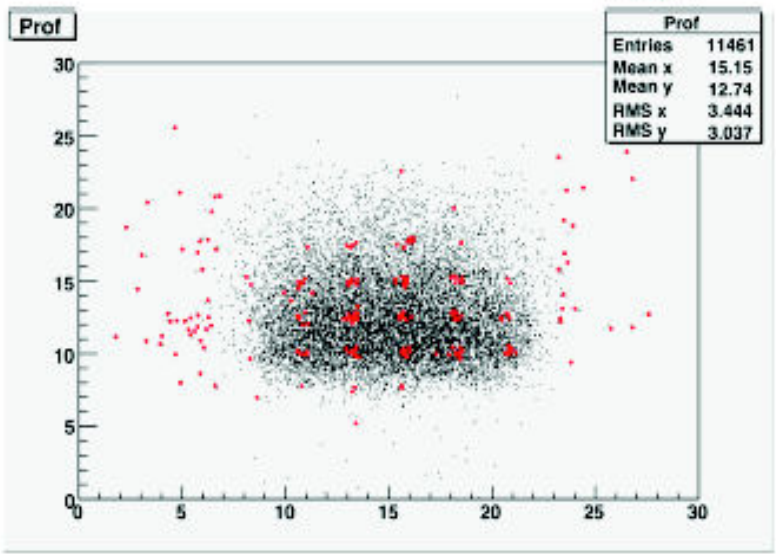
2008: Demonstrated performance

- Safe operating point with excellent efficiency (gas gain: 3–5 x 10^3)
- Superb spatial resolution has been demonstrated in test beam

$\sigma = 35.7 \pm 2.0(\text{stat}) \pm 5.0(\text{syst})\ \mu\text{m}$

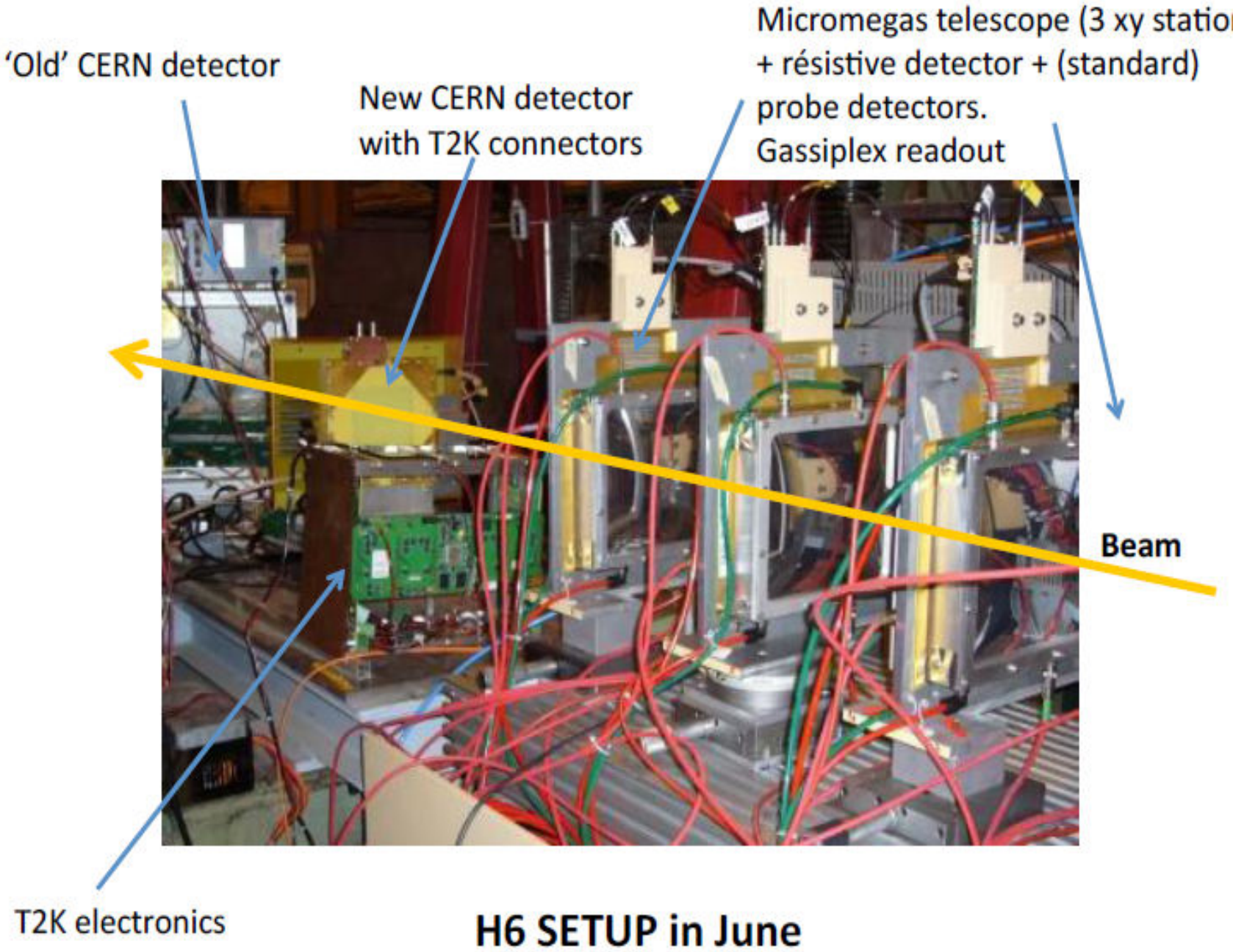






Activities in 2009

- Test beam runs in H6 at CERN in Jun, Jul, Nov; combined effort with Saclay & Greek groups
  - MM performance with/out isobutane in Ar:CO_2
  - Study performance of MM with resistive coating
  - Timing performance
- Neutron beam at Demokritos
- Towards specification of front-end electronics
- Towards larger chamber size



H6 SETUP in June

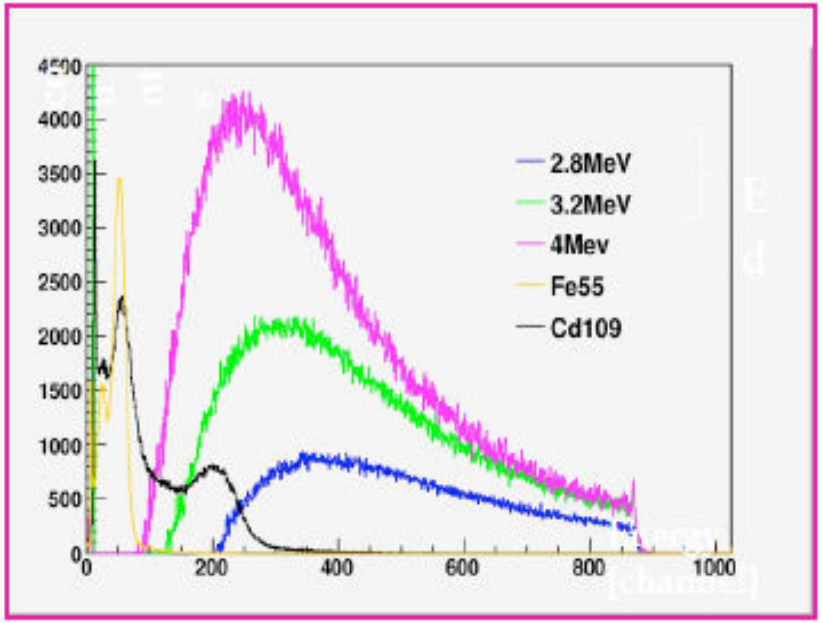
A concern: discharges/sparking

- Micromegas are different from wire chambers
  - No wires to break
  - Spark rate in test beam (10–20 kHz/cm^2): < 1 Hz
  - Many sparks over test beam exposure, no damage
- Sparking leads to a partial discharge of the amplification mesh => dead time during charge-up
- Different spark reduction options under study
  - Resistive coating (Saclay + CERN)
  - Mesh segmentation
  - Double step amplification (GEM + MM, MM + MM)

Tests in neutron beam 2009

- Low energy neutrons account for a good fraction of the expected counting rate in the muon chambers (to be upgraded) in ATLAS
- Two periods of data taking in the neutron beam at Demokritos Nat. Lab (Athens)
- Several chambers exposed (also TGCs)

- Response to neutrons is 20–30 x min. ionizing (prelim.)
- Large signals, close to spark limit (~10^7 e^-)



Tests with alpha particles in lab

- Alpha particles from radon decay inside the gas
- Typical energy deposit is 10–20 x deposit by neutrons (large discharge probability)
- Can gain about one order of magnitude in discharge probability by pre-amplification stage (GEM)
- Performance of MM with resistive coating when exposed to alpha particles still to be tested

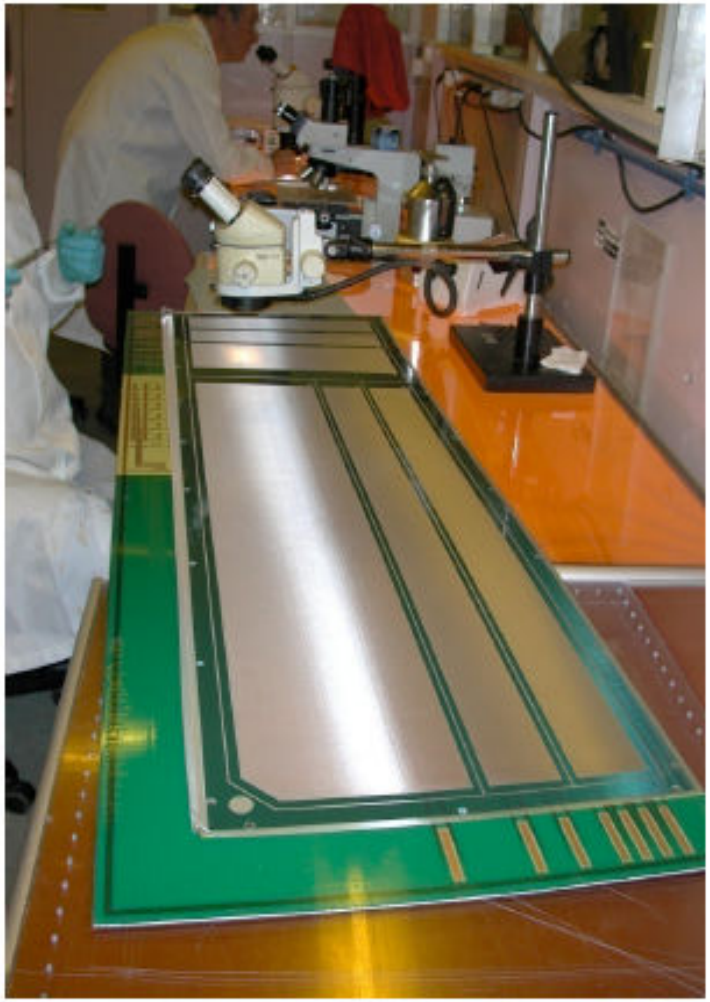
Resistive coating studies

- Layer of resistive material above readout strips to reduce current during discharge
  - Resistive film (continuous) on an insulator
    - Charge spreading => good and bad, works
  - Resistive paste on strips, separated insulators
    - Difficult to control, complicated in production, failed
  - Strips on insulator through resistor to ground + capacitive coupling to readout strip
    - Simple, promising; prototype under construction, will be tested next week

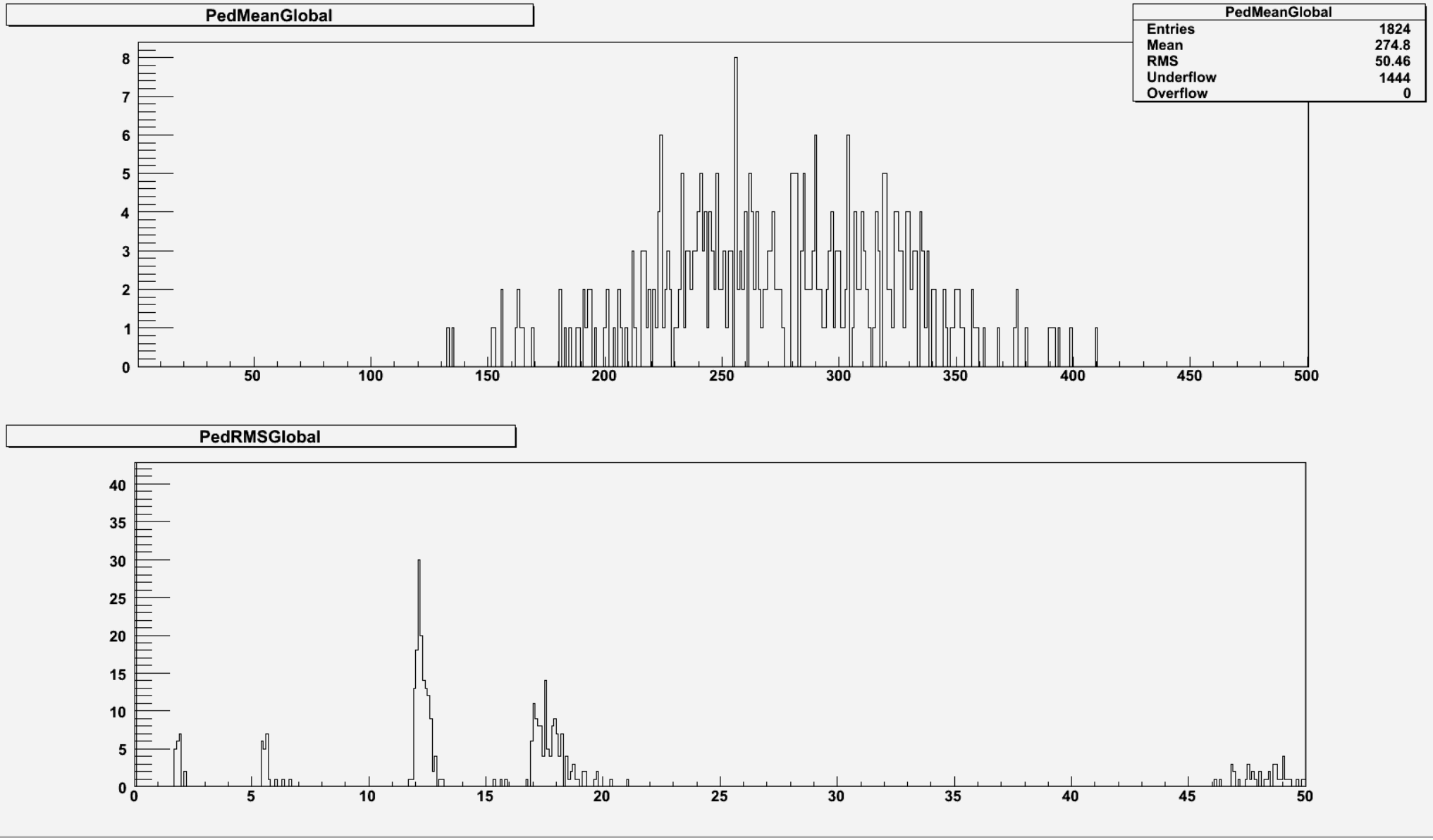
To be done in 2009/10

- Try different front-end electronics and readout (T2K, TRT, BNL, …)
  - Aim for specifications for readout electronics by spring 2010
- Continue study of spark reduction/protection
- Evaluate 1.5 x 0.5 m^2 prototype (test beam starts this week)
- Design of CSC-size prototype in fall 2009; to be constructed in 2010 (at CERN and possibly in industry (BNL))
  a) Single plane (1.2 x 1.2 m^2)
  b) Chamber with several bulk micromegas for precision/trigger/2nd co-ordinate planes
- Start work on integration in ATLAS …
  - Aim for a realistic layout for the ATLAS upgrade LoI in 2010

On the road to large-area detectors



- 1.5 x 0.5 m^2 prototype assembled yesterday
- Under gas since this morning
- Final tests in lab before test beam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PedMeanGlobal
Entries 1824
Mean 274.8
RMS 50.46
Underflow 1444
Overflow 0
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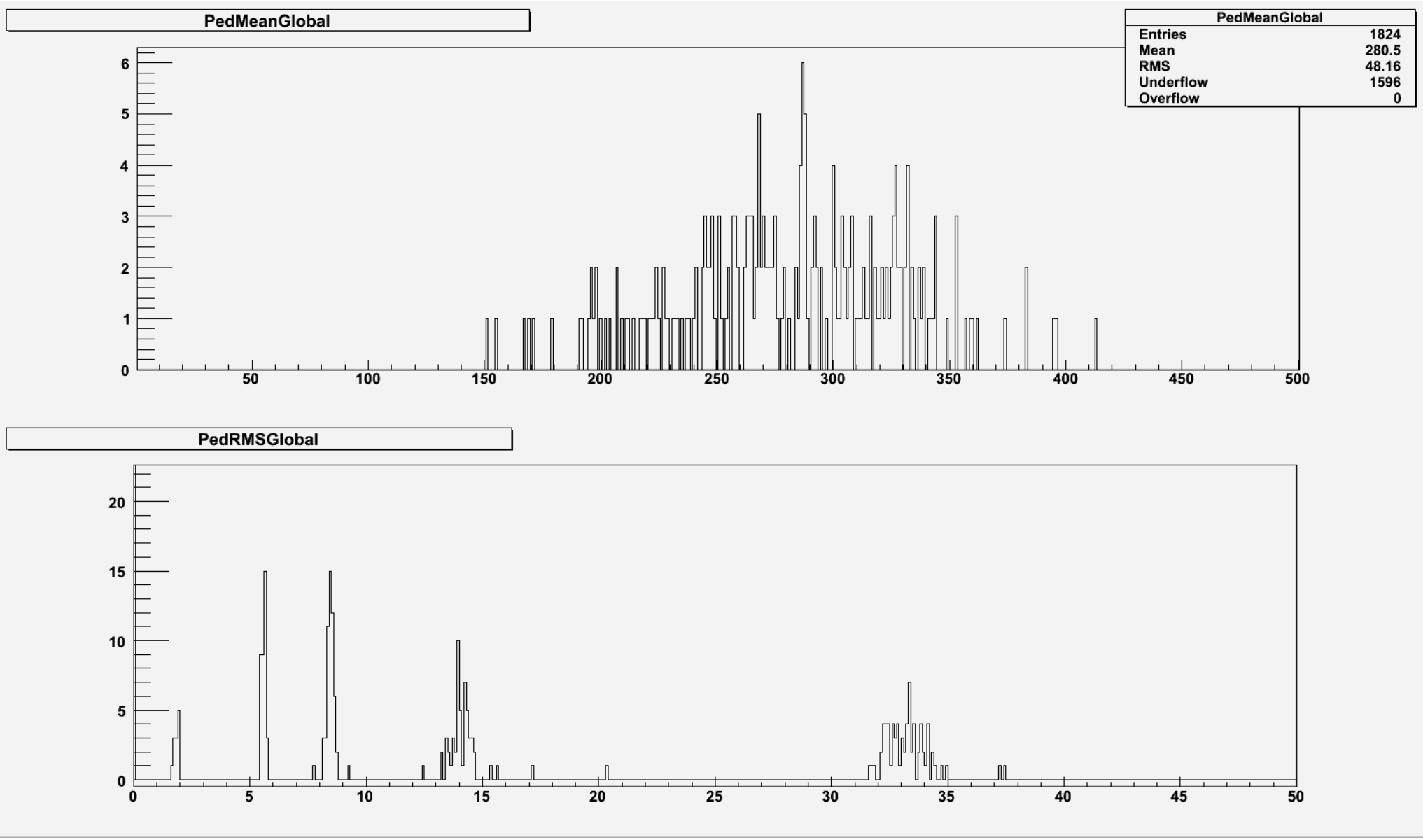
PedRMSGlobal
0 5 10 15 20 25 30 35 40
0 5 10 15 20 25 30 35 40 45 50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PedMeanGlobal
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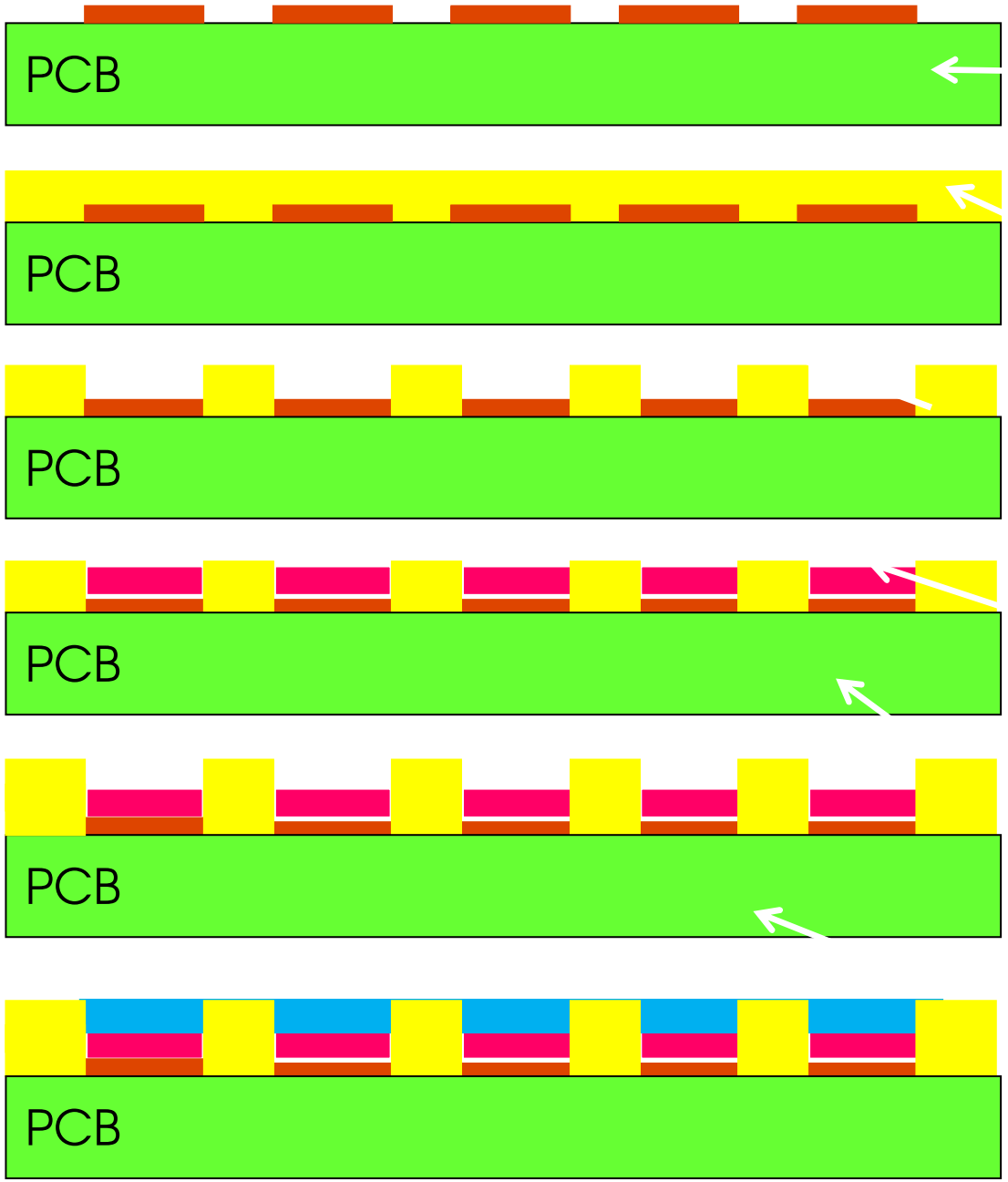
Mean 280.5
RMS 48.16
Underflow 1596
Overflow 0
0 1 2 3 4 5 6
50 100 150 200 250 300 350 400 450 500
PedRMSGlobal
0 5 10 15 20
0 5 10 15 20 25 30 35 40 45 50

Recent (last week) Activities

Spark Protection: Version 3



Pcb

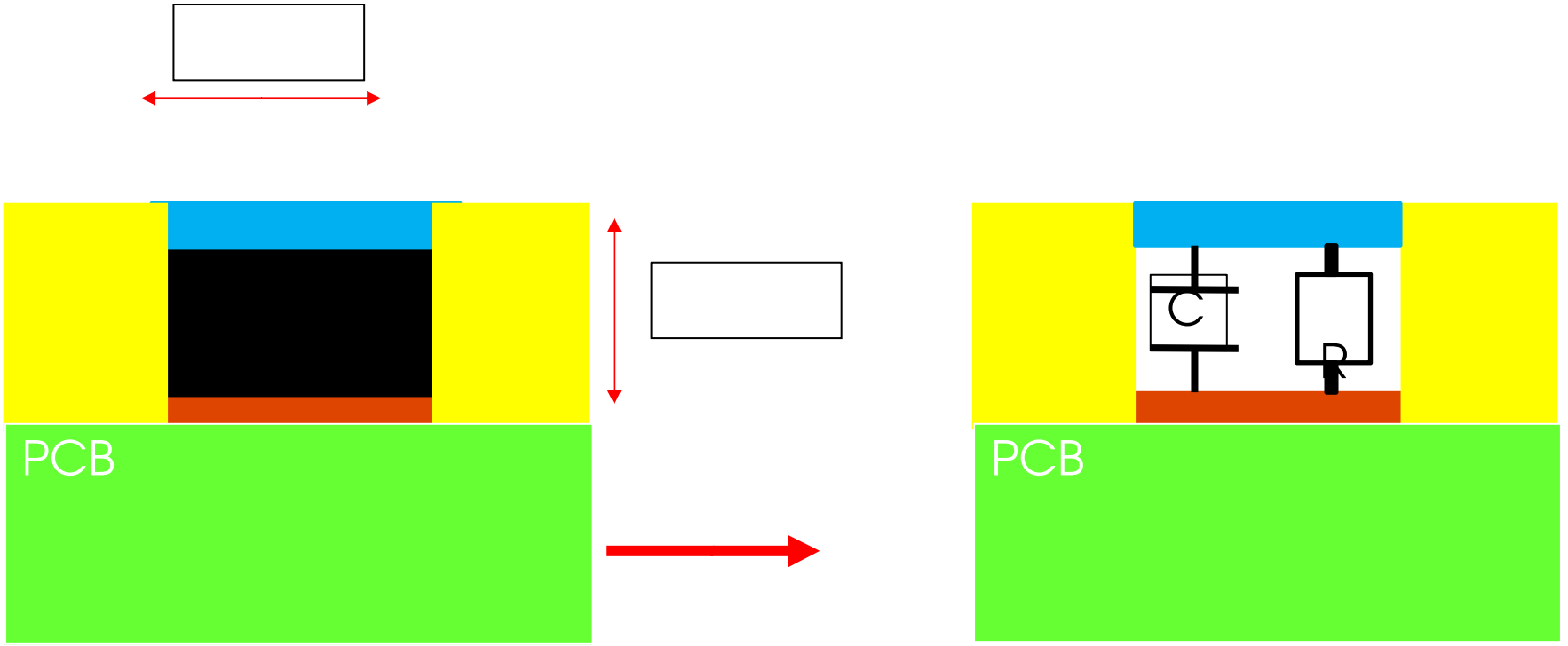
Coverlay deposit

Coverlay devellopment

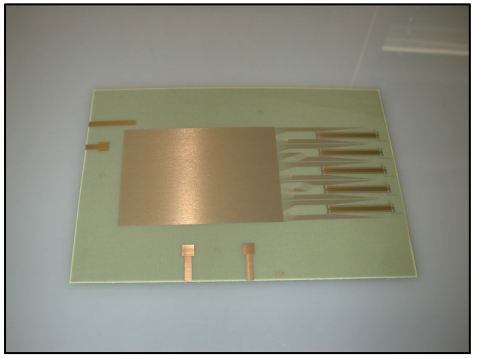
Resistive paste filling

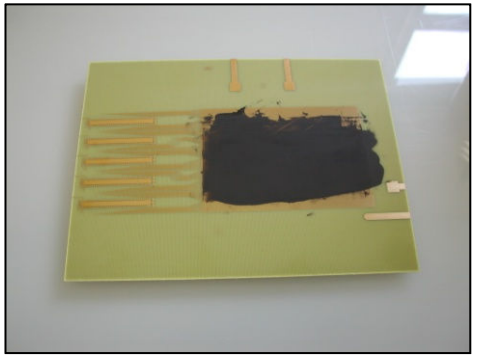
2nd Coverlay deposit

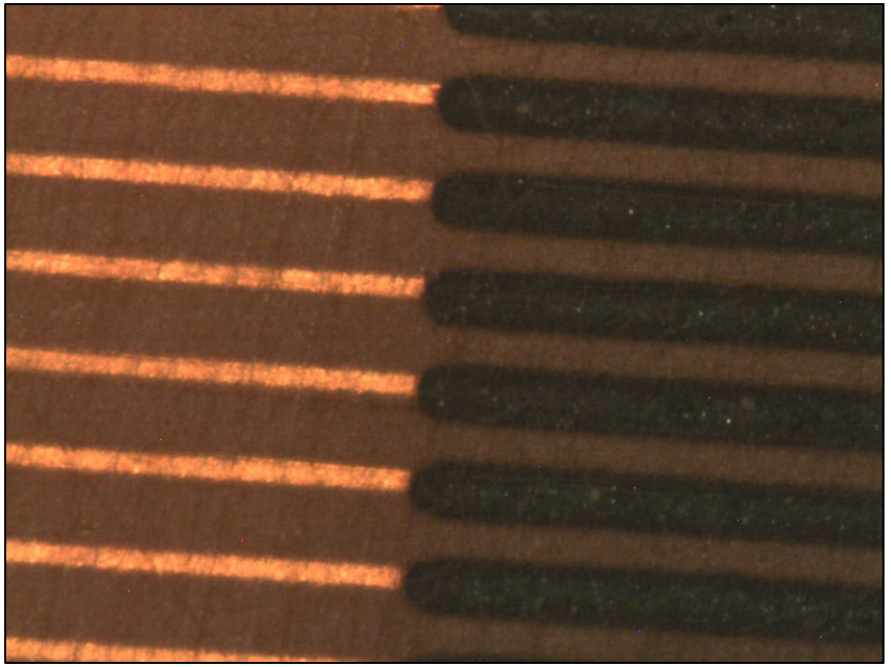
Silver paste filling

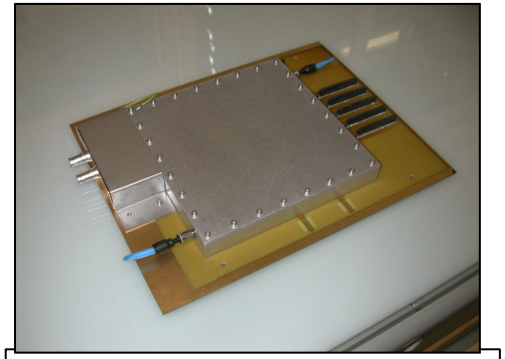


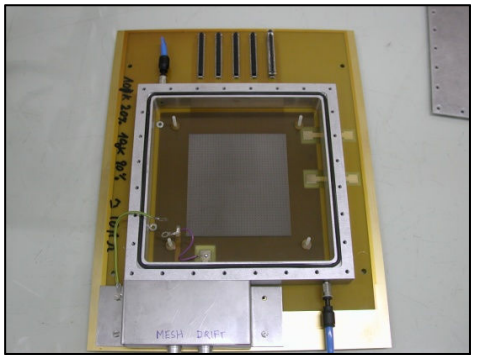
For 1 cell:
-C= 0.026 pF
-R= 10 M-ohms
-RC=260 ns



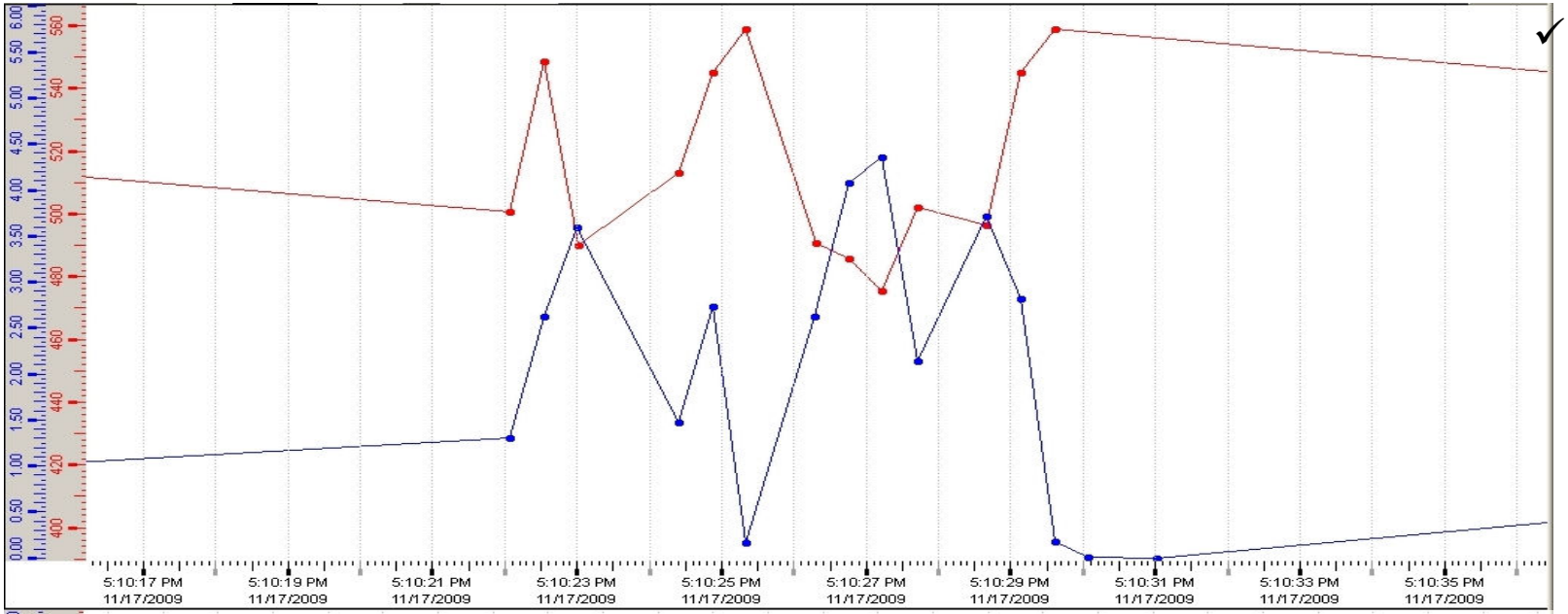




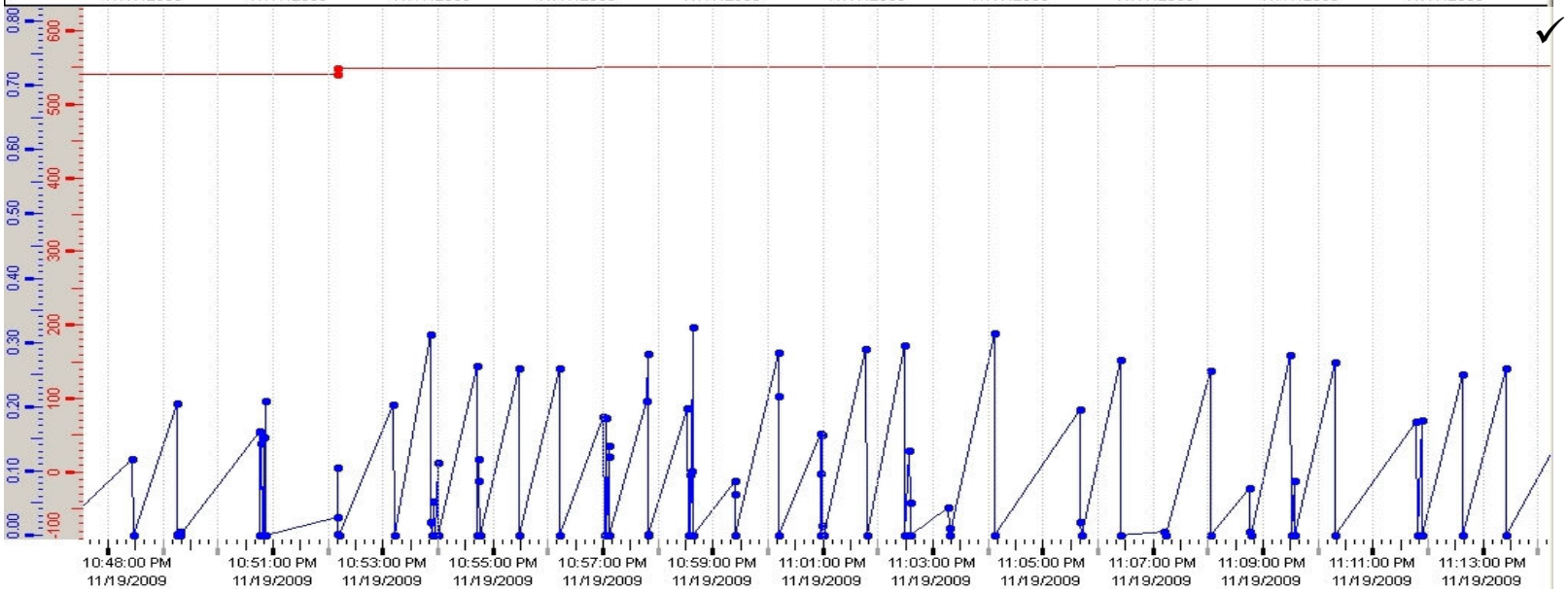



MESH DRIFT

SLOw Control SYstem

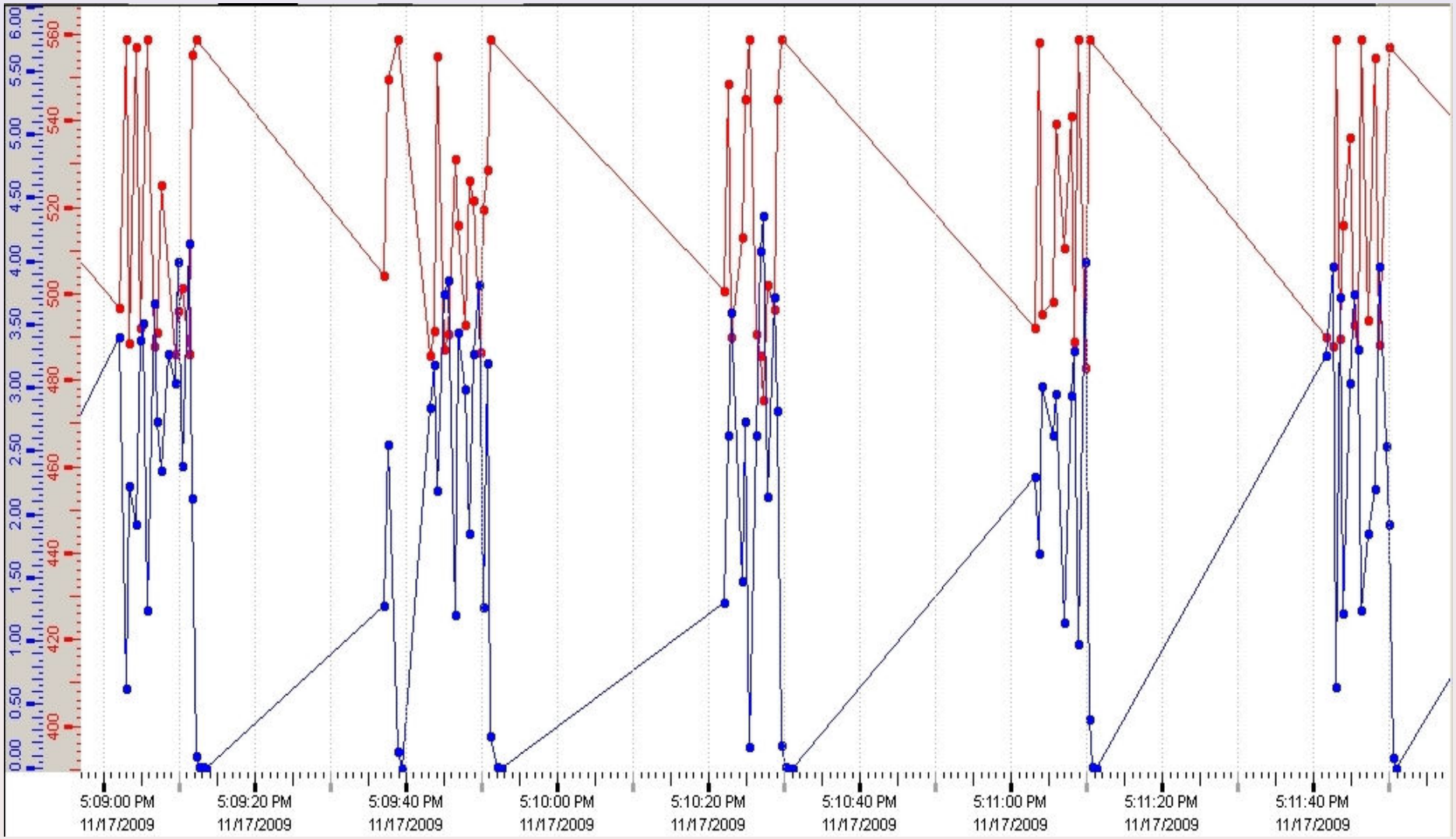


✓ P1 with 560/860V @ 100kParticles.
- 5 disch/spill
- 70V drop
- I ~ 3-4uA.



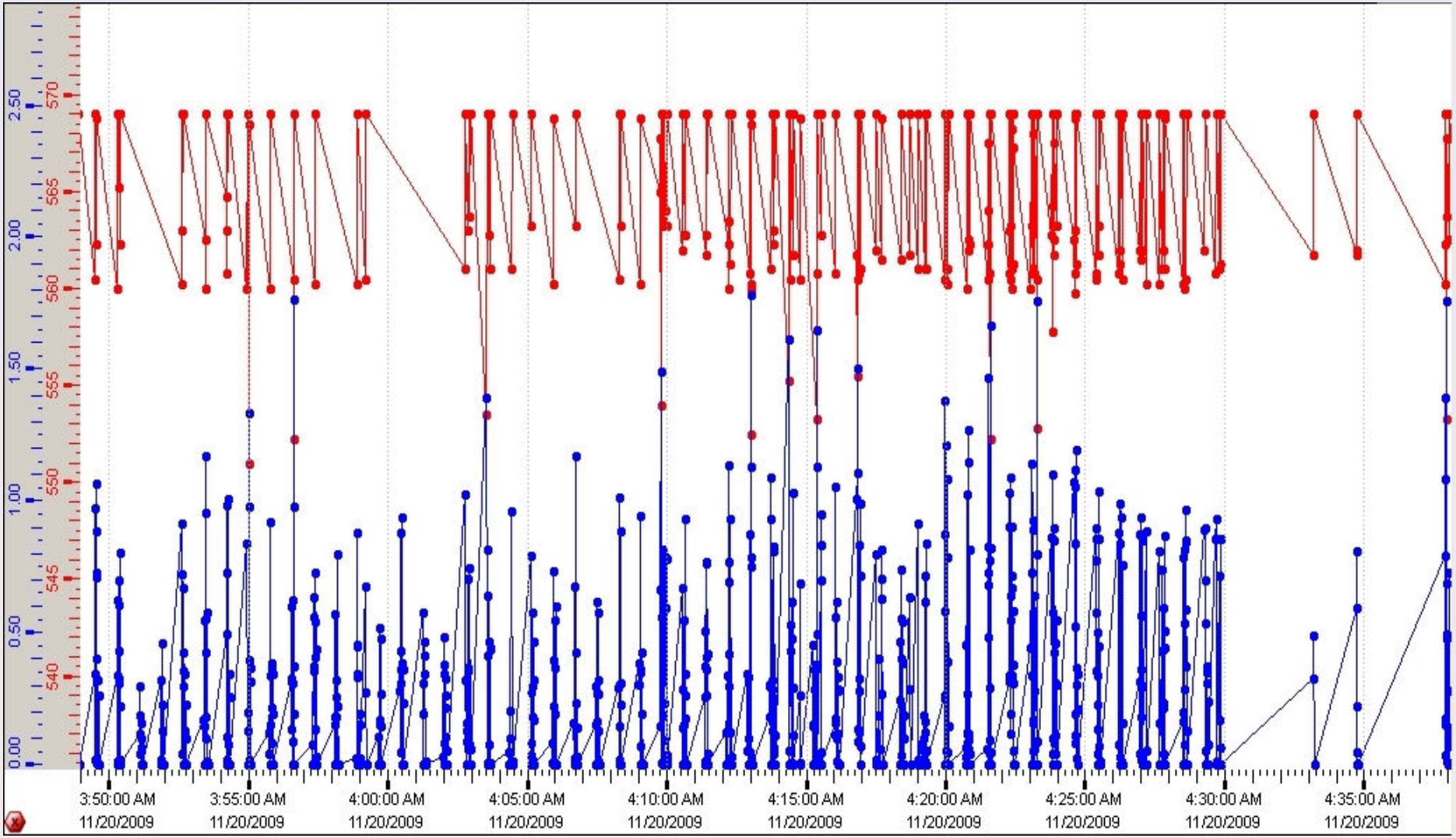
✓ R3 with 550/850V @ 100kParticles.
- 2-3 disch/spill
- 0V drop
- I ~ 20 nA.

- ✓ P1 with 560/860V @ 100kParticles. Constant number of discharges per spill.

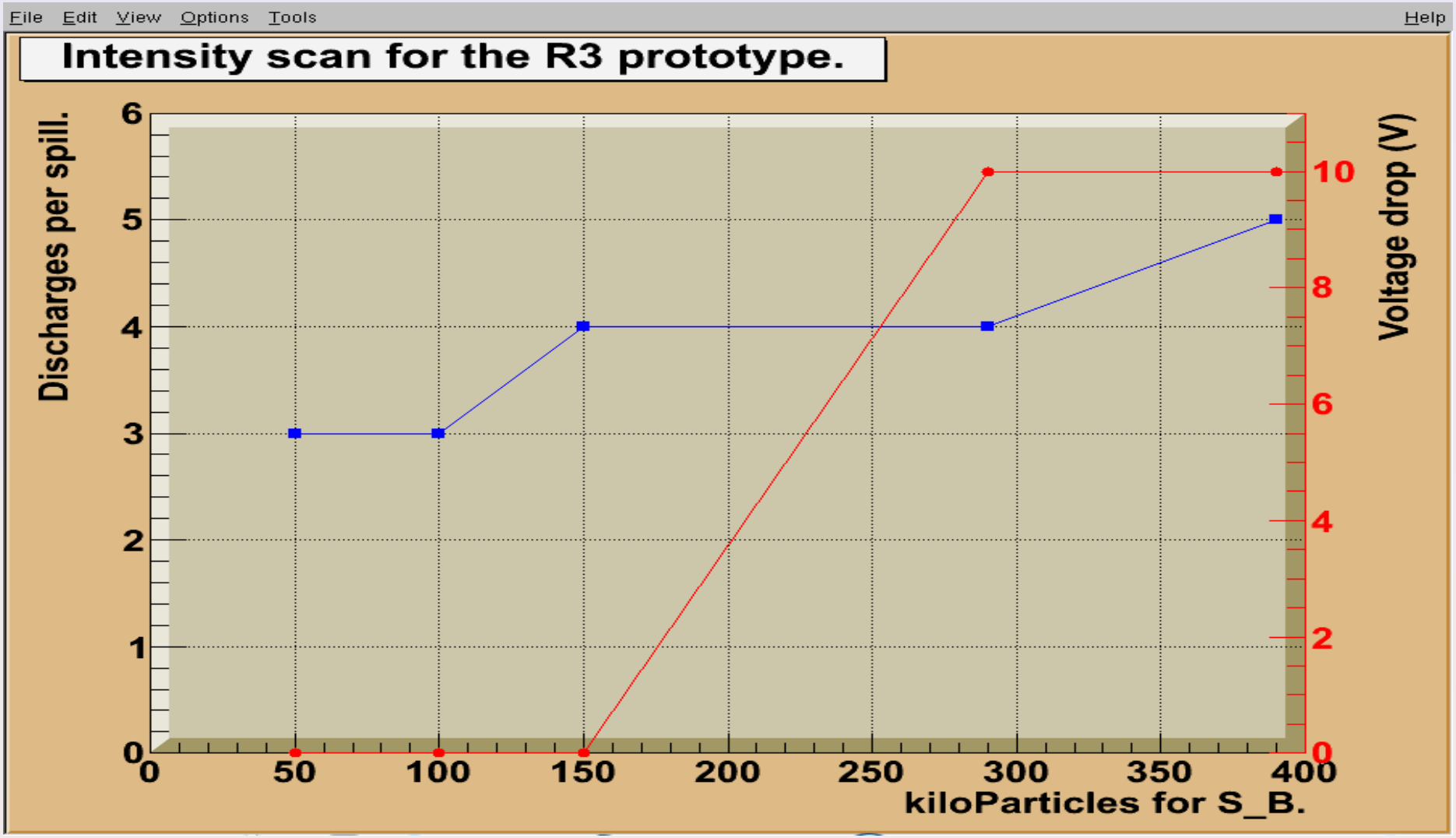


SLOw Control SYstem

- ✓ R3 with 570/870V @ 390kParticles. Constant number of discharges per spill and voltage drop ~ 10V.



- ✓ Intensity scan of R3 with discharges per spill (blue) and voltage drop (red).

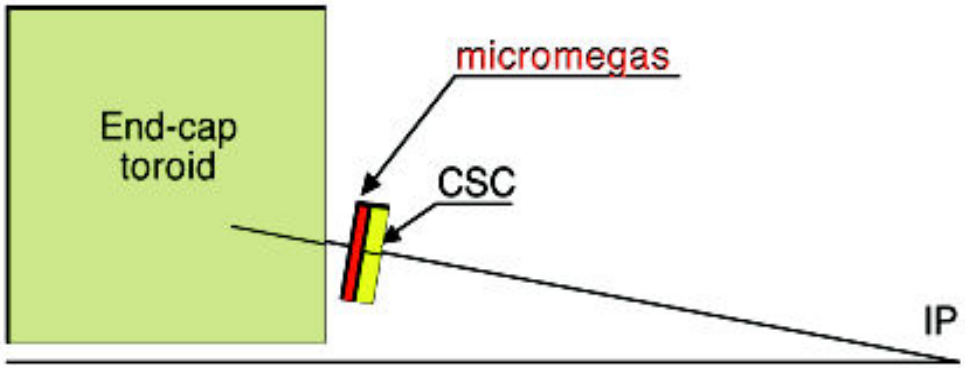


Summary

- R&D so far has demonstrated:
  - excellent efficiency and spatial resolution of MMs
- Still to be shown:
  - timing performance;
  - High-rate performance + insensitivity to sparking.
- Growing interest in the community; good synergy within RD-51 Collaboration
- Next (big) step, until spring 2010:
  - Construction of full-size prototype, including demonstrator for front-end electronics + readout

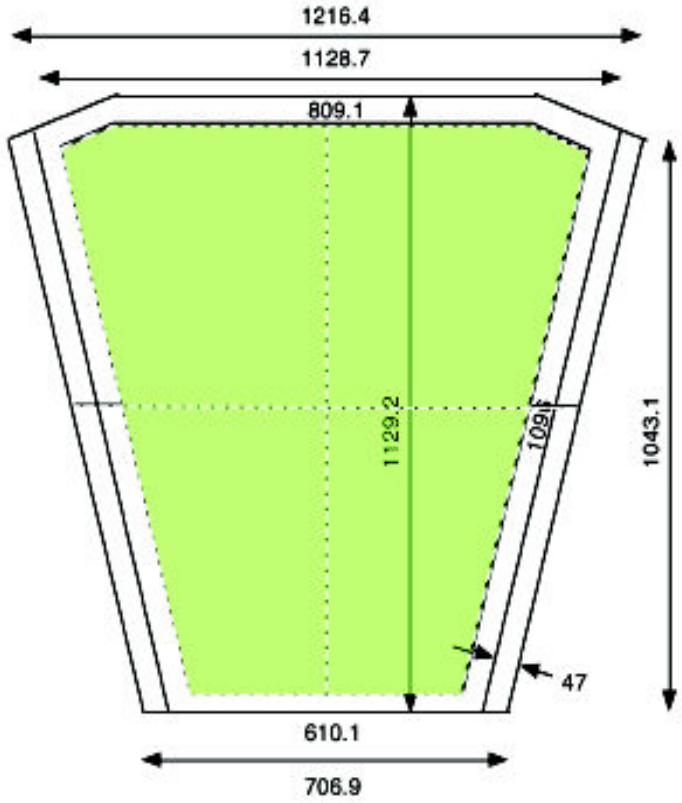
Additional slides, Plans for ATLAS upgrade prototype

Towards upgrade Phase I

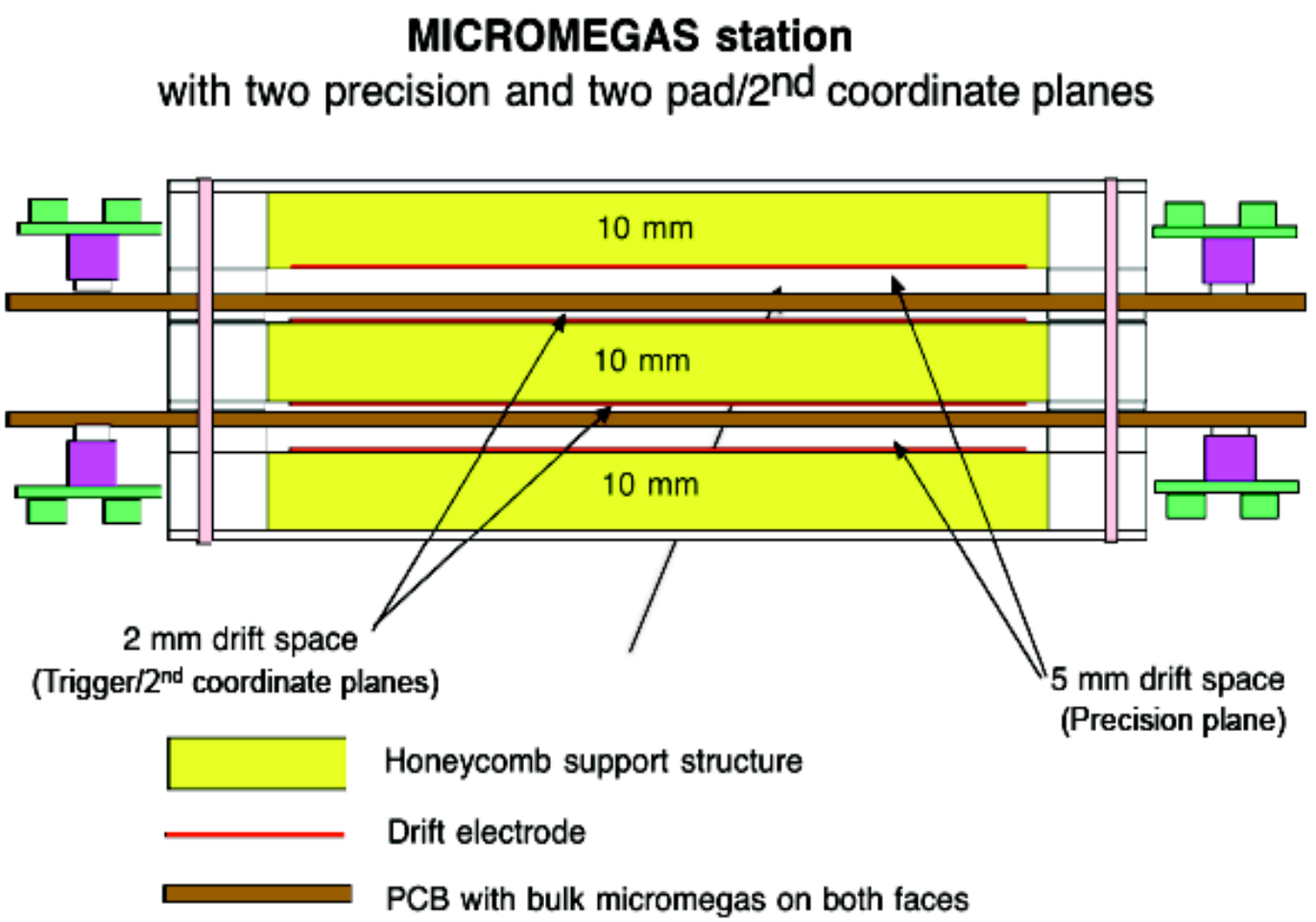


- Thin chambers to be added to CSCs
- Number of channels/module for 500 µm pitch:
  - 2400 x 2 = 4.8 k (precision strips)
  - O(200) strips for 2nd coordinate
  - O(1000) pads for space points
  - Total/module: 6 k channels
- 32 chambers of 1 m^2 with 4 active layers each (total MM area 100 m^2)
- Total # of channels : 200 k

Large CSC size/shape



Module (schematic)



Electronics

- Many chips are on the market that have some of the desired functionality, but none has all
- Phase I schedule allows for the development of new electronics
- BNL are ready to undertake a preliminary design effort (Funding request to DOE is about to be submitted as part of the US ATLAS Upgrade Effort)
- Strong interest of Saclay for common front-end electronics development (CLAS12 at Jefferson Lab); also LAPP Annecy
- CERN: demonstrator for integrated electronics using the APV25 chip as test bed for scalable r/o system (RD51 Collab.)