Recent results of Micromegas SDHCAL with a new readout chip

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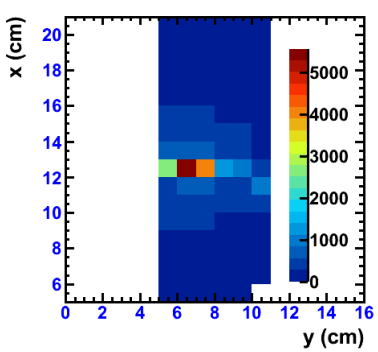
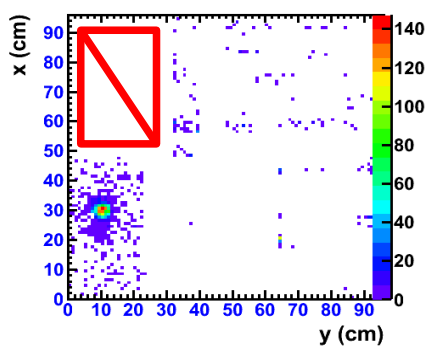
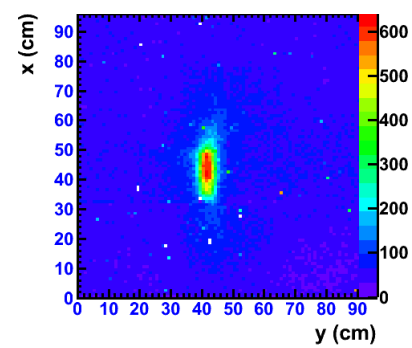
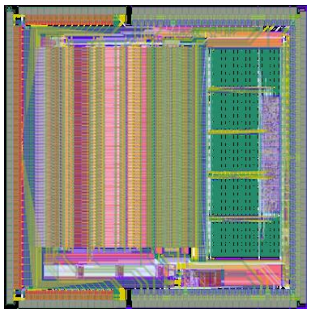
2007-09	2010	2011
GASSIPLEX (HARDROC1) (DIRAC)	HARDROC2	MICROROC
6x16 cm^2 (8x8 cm^2) (8x32 cm^2)	32x48 cm^2 1x1 m^2	32x48 cm^2 1x1 m^2
Shaping 1.2 µs 97 % efficiency < 1.12 multiplicity	Shaping 20 ns 50 % efficiency < 1.06 multiplicity	Shaping 100-200 ns 98 % efficiency < 1.1 multiplicity

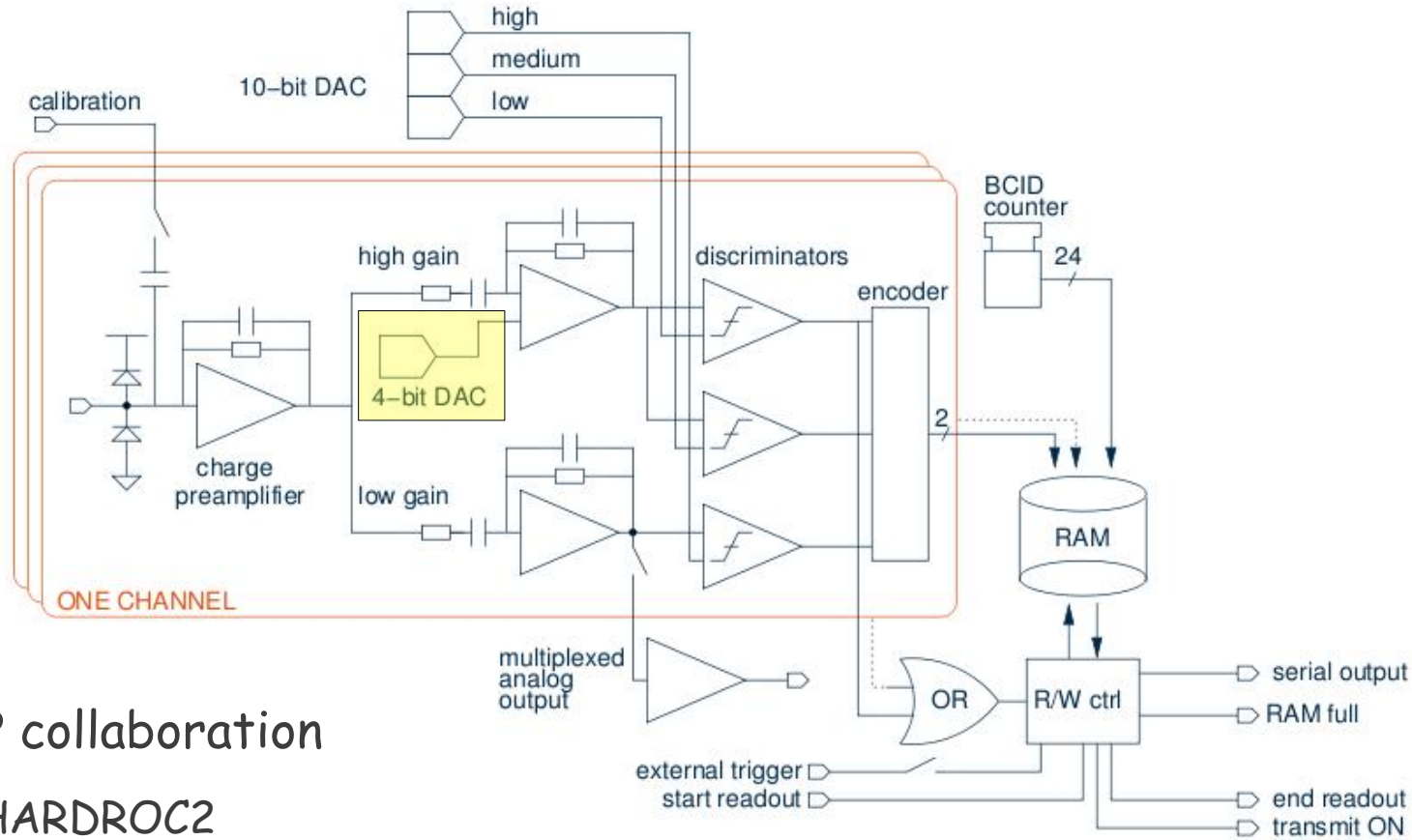






New ASIC, Microroc





- LAL/Omega and LAPP collaboration
  - Same digital part as HARDROC2
- New analogue part
  - Spark protection inside silicon
  - Low noise charge preamplifier
  - 2 shapers of high/low gain
    with variable peaking time (30-200 ns) and dynamic range of 200 and 400 fC
  - Other features: pedestal alignment (offset) DAC, multiplexed analogue readout

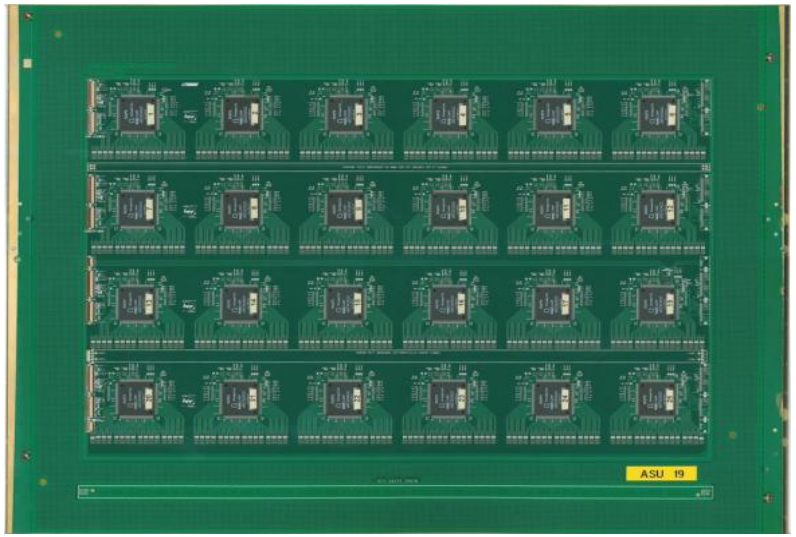
Chip threshold + channel offset
→ virtually 1 threshold / channel

New Active Sensor Unit

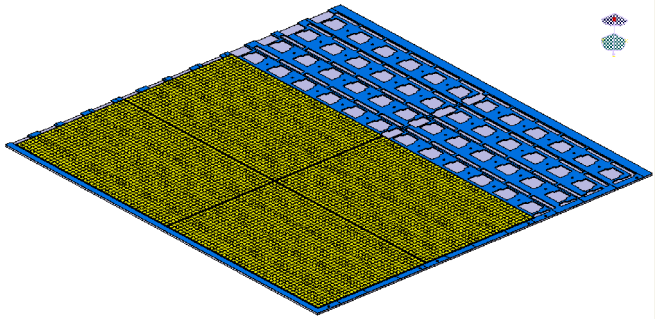
- Microroc status
  - 341 produced, 91.4 % yield
  - 13 ASU equipped, enough for 2 m^2 prototypes

- New PCB routing
  (minor modif. thanks to HR2/MR1 pin-to-pin compatibility)
  - Improved EMC minimizes detector/digital signals X-talk
  - Chip bypass correctly rooted
  - Analog readout
  - Temperature probe

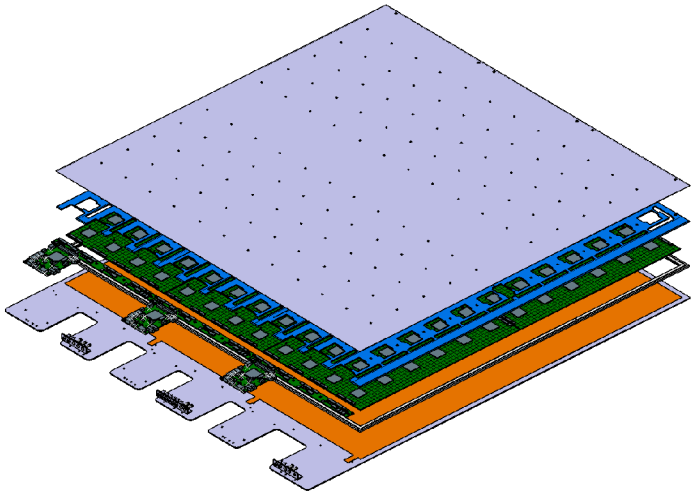
- Improved PCB spark protection network
  - Faster
  - More compact



Improved m2 prototype design

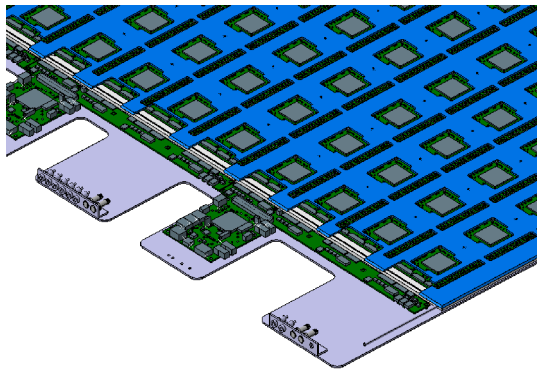


- Gas tightness made by ASU, side frame and drift plate
  → Steel baseplate not necessary anymore
  → Baseplate screwed instead of glued



- Access to ASIC side of ASU
- Eventually: get rid of Fe baseplate
  - CLIC W-HCAL : less steel
  - ILC Fe-HCAL : improve absorber stiffness (+2mm)

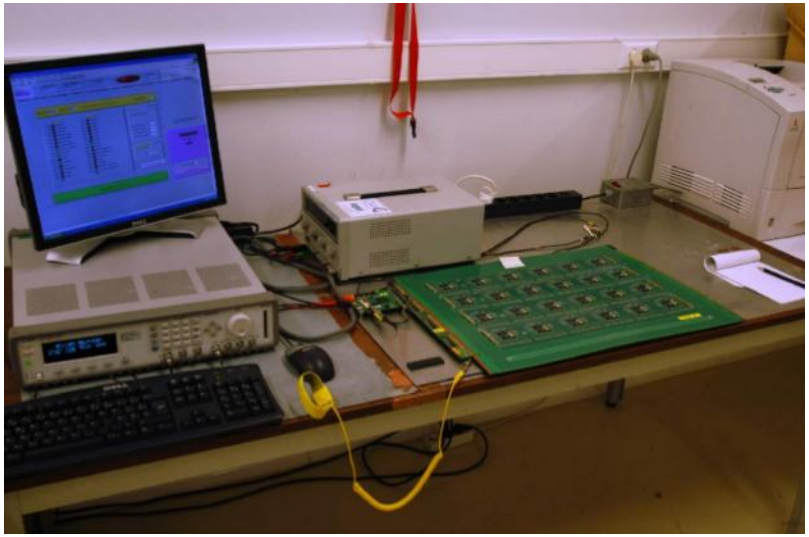
- ASU mask thickness reduced from 3 to 2 mm
  → Thinned chamber (7 instead of 8 mm active thickness)



- Easier access to DIF connectors and LV & HV patch panel when chambers are inserted inside structures

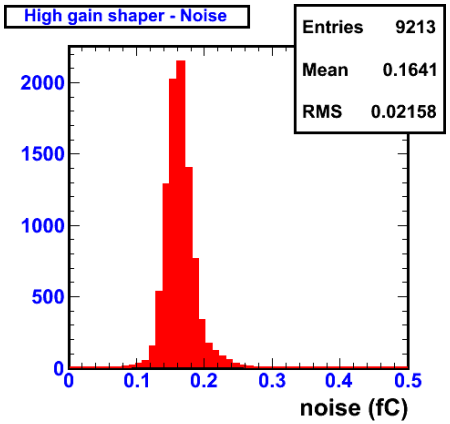
Electronics test (I)

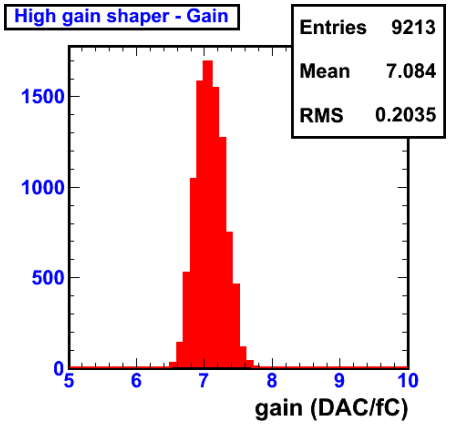
- Verify overall chip functionality
  - High gain shaper noise
    → minimum detection threshold
  - High and low gain shaper gains
    → adjust 3 thresholds

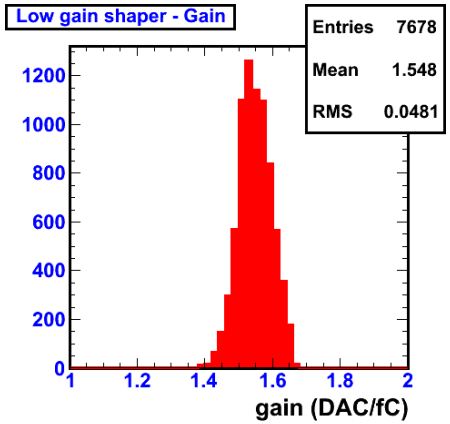


- Over 9216 channels
  - Noise: (0.16 +/- 0.02) fC
  - High gain: (7.1 +/- 0.2) DAC/fC
  - Low gain: (1.55 +/- 0.05) DAC/fC

Low channel threshold
Uniform detector response

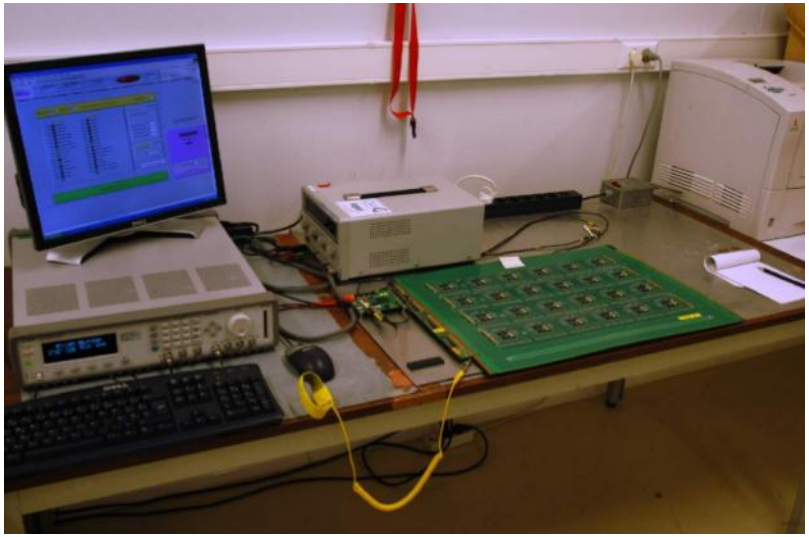




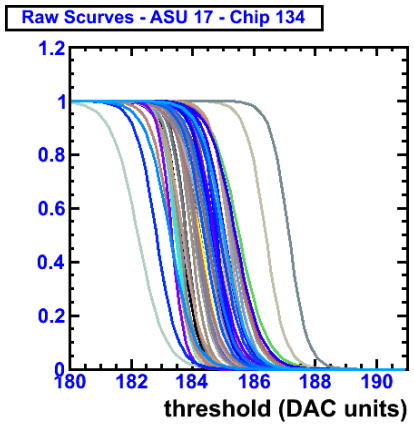


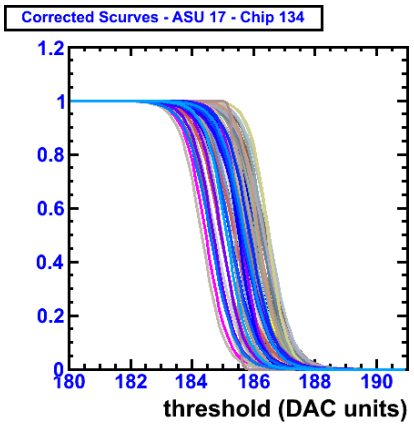
Electronics test (II)

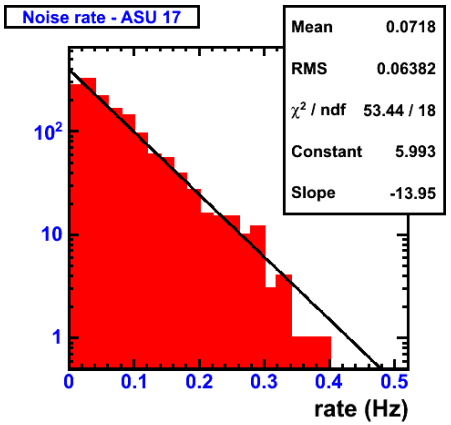
- Determine working settings
  - Determine channel pedestal offset (4 bit DAC)
  - Set value of 3 chip thresholds
- For low threshold
  - Align pedestal for uniform noise rate
    → offset map
    → uniform detection threshold
- For medium and high thresholds
  - Make use of measured shaper gains



Control noise rate and threshold with pedestal offset DAC







Test in gas

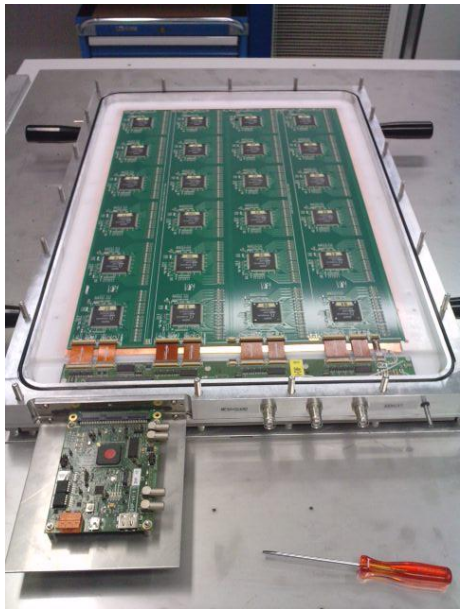
- Clean Bulk from impurities by sparking
  - Increase HV until Paschen's limit is reached (800 V)

- Verify full detection chain and chip settings
  - Place ASU inside test chamber
  - Count ^{55}Fe conversions in 1 cm drift gap
- Photopeak detection (~230 e-) at 260 V in Ar/CF_4/iso 95/3/2!

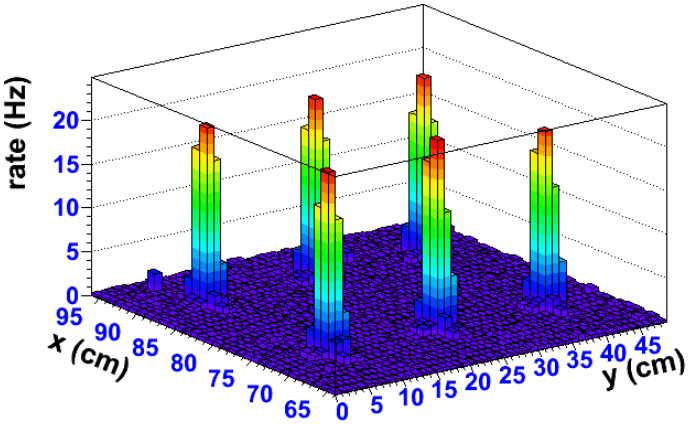
  → Much better than with HR2 (390 V in Ar/iso 95/5)

  → promising for MIP charge detection (MPV of ~14 e-)

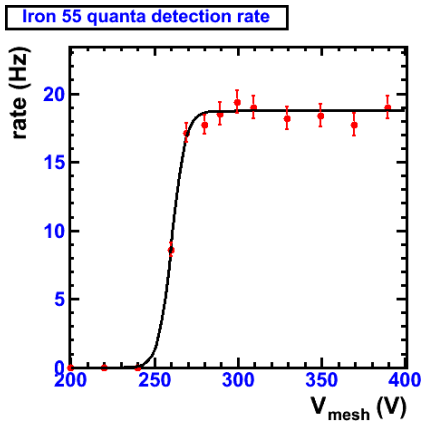
230 e- detected at a gas gain of 100!



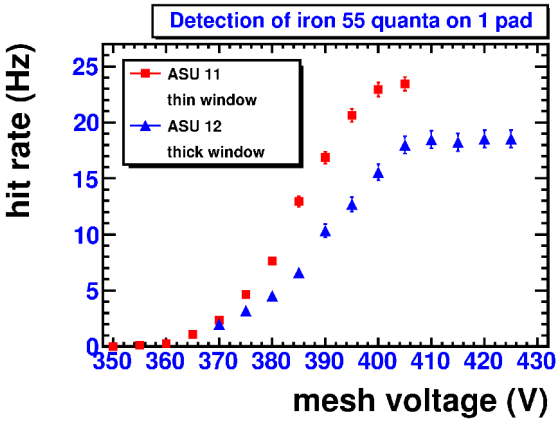
^{55}Fe source profile on 6 positions



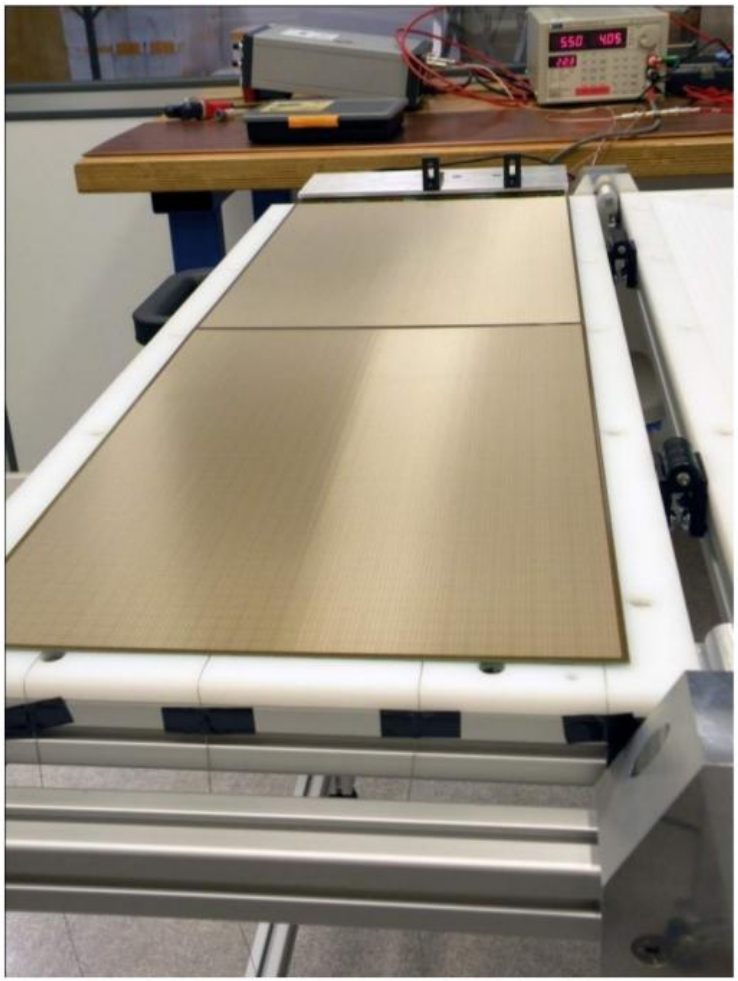
MR1 ASU triple mix.



HR2 ASU double mix.



M2 prototype assembly- June 2010



New tools to manipulate SLAB
→ Easier assembly procedure

July 2010 test beam

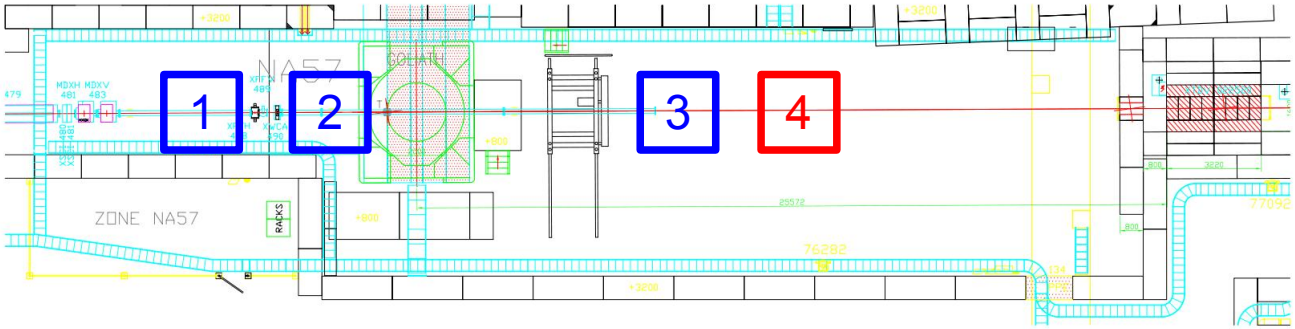
- After test at LAPP,
  good understanding of the detector
  - Noise level under control,
    successful RAMFULL runs
  - ^{55}Fe and cosmic signals seen
  - 3 thresholds under control

  → Ready for beam

- SPS/H4 3-22 August
  - 6 days standalone CALICE
  - 13 days multi-users RD51
    4 set-ups

- Measurements with muons (150 GeV/c)
  - Define working point of detector
    (voltage, shaping & threshold scans)
  - Measure efficiency, multiplicity,
    uniformity (2/3 of area)
  - Demonstrate RAMFULL operation
    in beam conditions
  - Measure multiplicity
    at various beam incidence angle

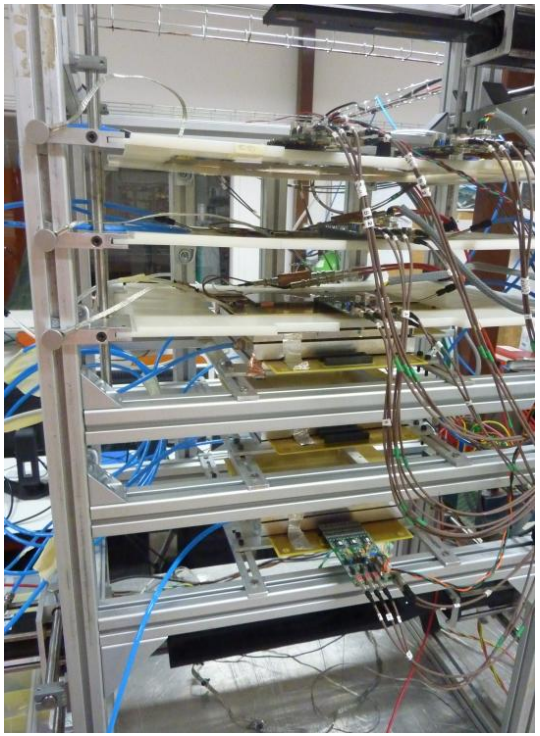
- Measurements with pions (150 GeV/c)
  - Landau distribution with analogue
    readout of low gain shaper
  - Shower signals with 3 thresholds
  - Validate spark protection by operation at
    (too) high gas gain



Long list of goals...

Setup (I)

- Trigger: 3 scintillators, overlap area of 6x16 cm^2
- Tracking
  - Pad telescope of LAPP (Gassiplex)
    3 chambers of 6x16 pads of 1 cm^2
    3 mm drift gap
  - Strip telescope of NCSR Demokritos, NTUA (Gassiplex)
    (RD51 Micromegas telescope)
    6 chambers with 10 cm XY strips of 250 μm pitch
    → active area of 2.4x2.4 cm^2
    7 mm drift gap
  - DAQ: VME ADC + Sequencer and CENTAURE DAQ

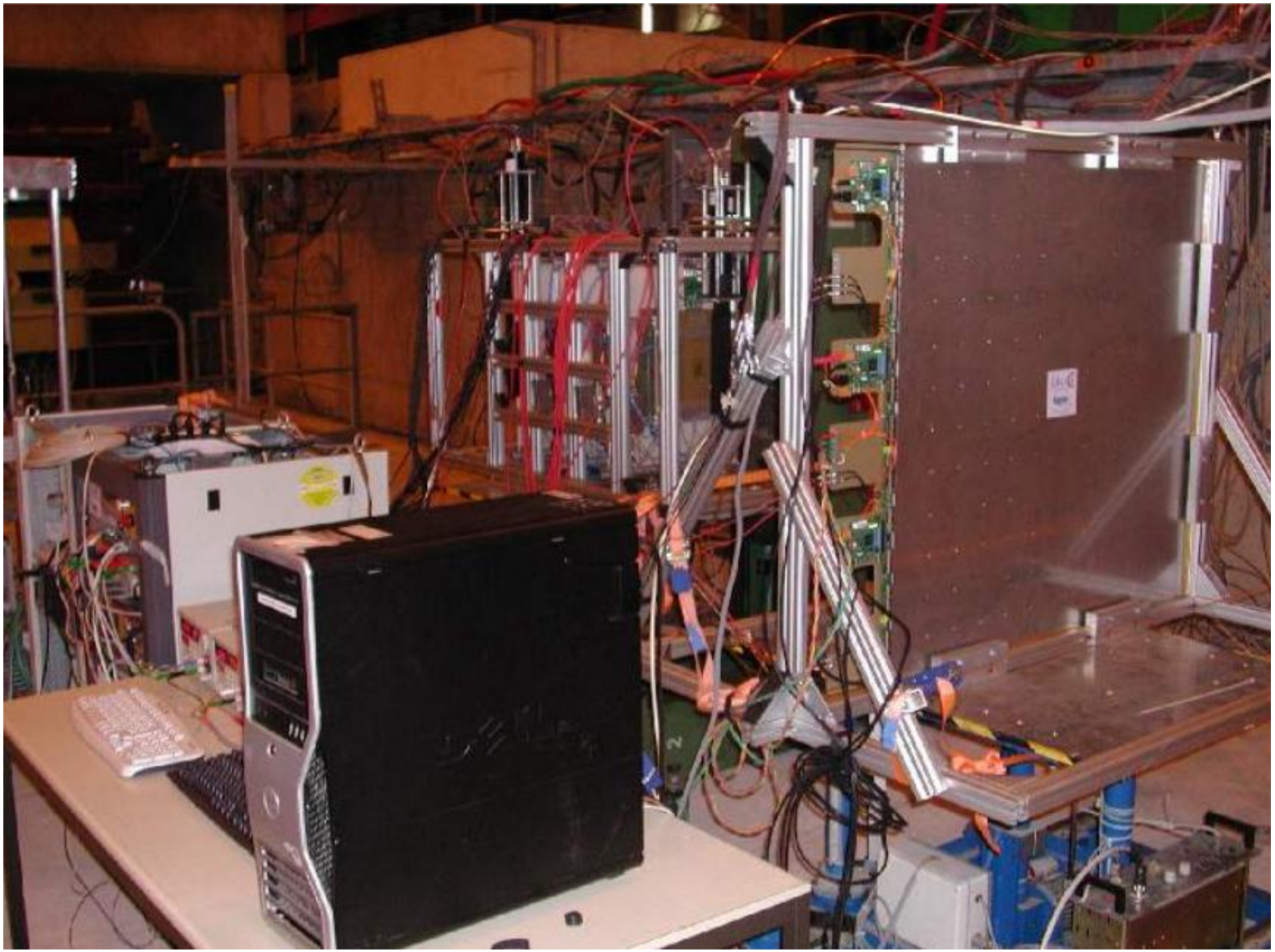


- 1 m2 prototype with 144 Microroc
  - DAQ: (interDIF + DIF + CCC) and LAPP LabView DAQ
  - New gas: Ar/CF_4/iso 95/3/2, so-called "T2K gas"

- Hardware Synchronization telescopes/prototype with busy handshake between VME sequencer and CCC

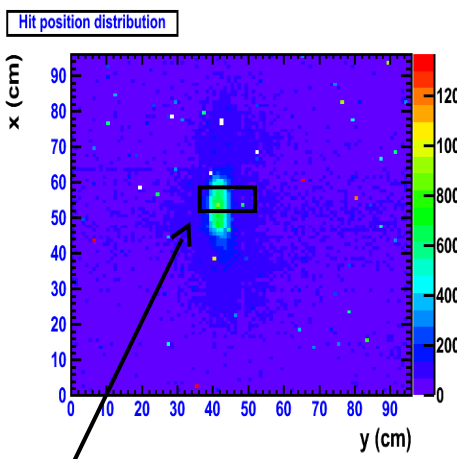
Non-flammable gas!

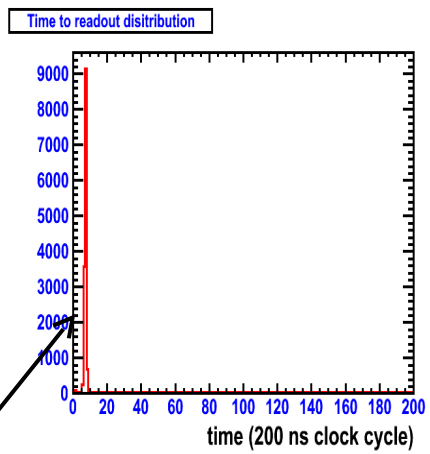
Setup (II)

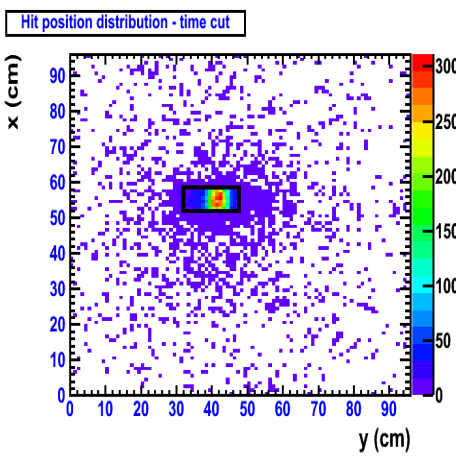


Starting-up

- Installation on 03/08 MD morning
- Noise measurement in the afternoon,
  pedestal and thresholds settings of Microroc chips,
  start flushing gas
- Muon beam 04/08 morning, first beam profile at 8 pm!







Pad chambers

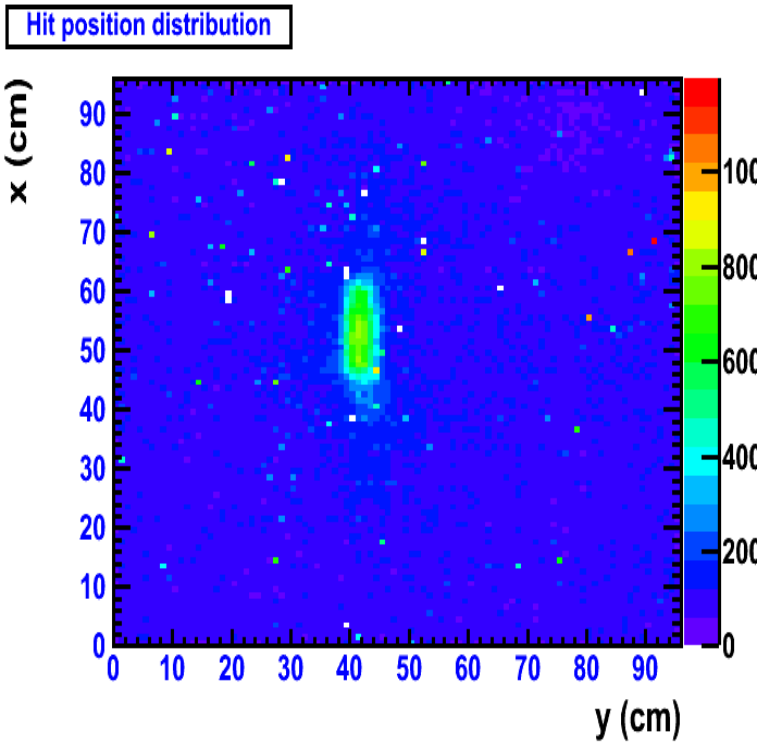
Hits in coincidence
with triggers from scintillators

→Telescopes and scintillators structure rotated by 90° to increase coincidence events

Noise conditions

- Very good noise conditions
  - Pedestal alignment w.r.t. low threshold such that average channel noise rate is 0.1 Hz
  - Less than 10 noisy channels over 9216 during whole test beam
  - Threshold of about 0.7 fC from pedestal width
- RAMFULL time = 127 * 0.1 / 64 ~ 20 s → 0.05 Hz
  low enough to see all beam particles (~200 Hz)!

V_{mesh} = 360 V
RAMFULL mode
All data from detector.
No cut applied.
Very quiet!



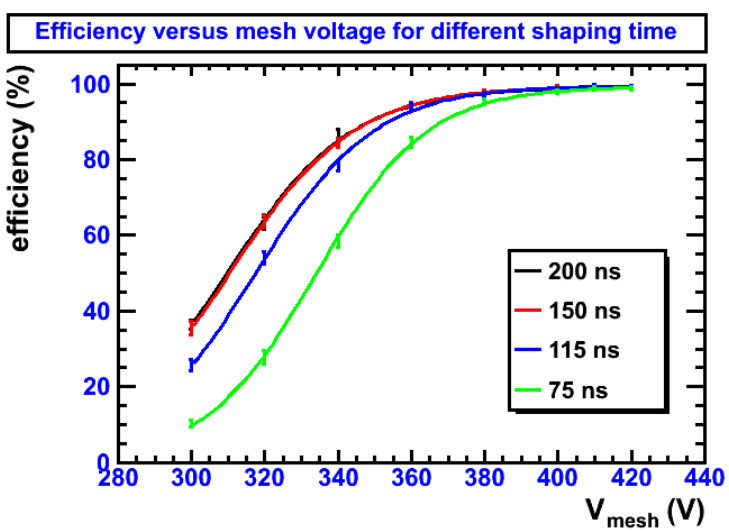
Very preliminary results – Voltage scan

- Efficiency
  - Plateau reached for 4 shaping time
  - Detector signal is 115-150 ns

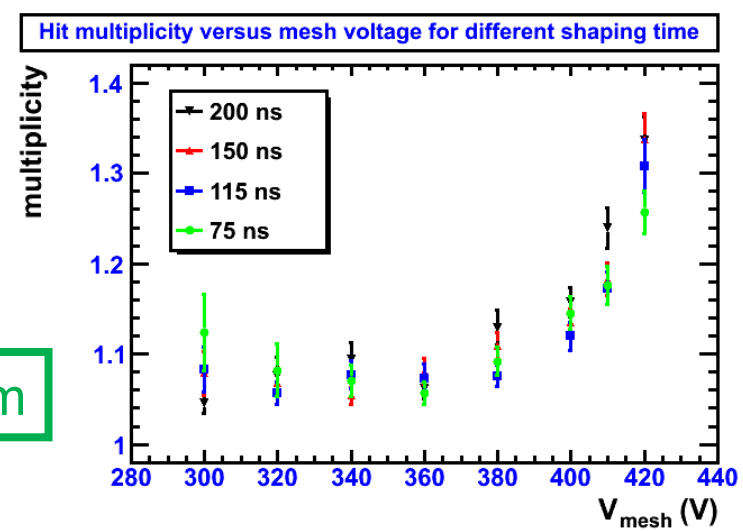
  At 150 ns shaping
  - > 95 % at 365 V
    Gas gain is 1000 only!

- Multiplicity
  - Below 1.1 for efficiency larger than 95 %
  - Compatible with previous measurements

→ Standard settings
200 ns shaping, 0.7 fC threshold, V_{mesh} = 390V, Gain = 3000, V_{drift} = 480V
efficiency = 98 %, multiplicity = 1.1, noise rate = 0.1 Hz/channel



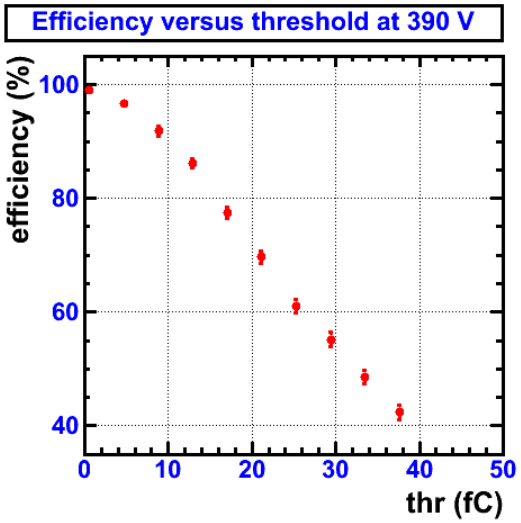
Muon Beam

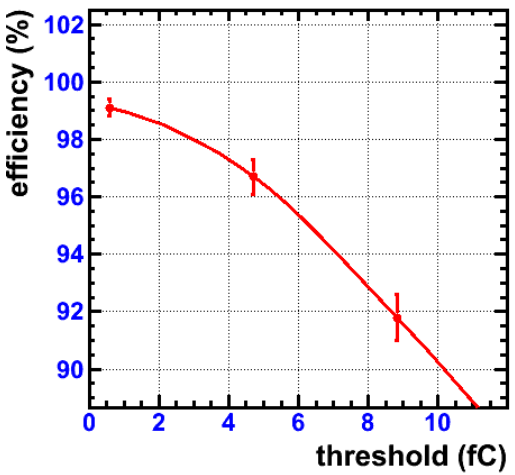


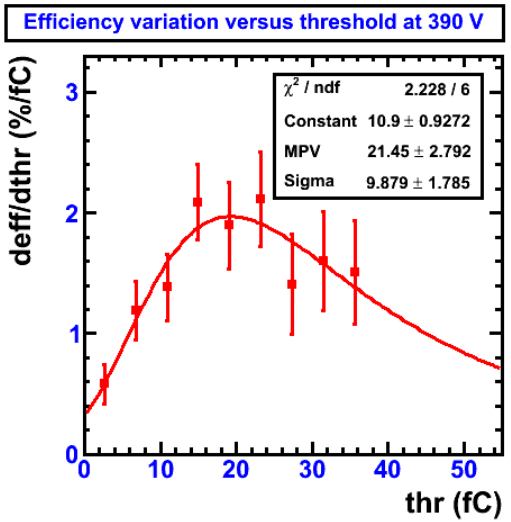
Very preliminary results – threshold scan

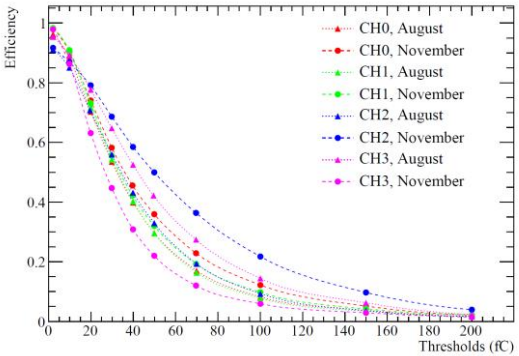
- Minimum threshold ~ 0.7 fC
  efficiency > 98 %
  noise rate = 0.1 Hz/channel
- Increasing threshold to 2 fC,
  noise negligible, efficiency still > 98 %

- Muon Landau MPV
  - With 70 % efficiency,
    threshold = MPV = 20 fC
- Taking differential of eff(thr)
  - Yields ~ 22 fC







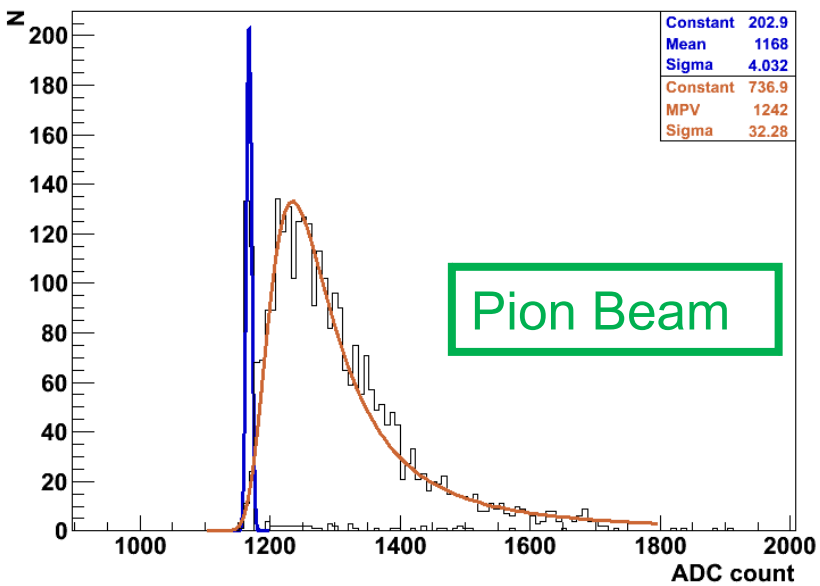


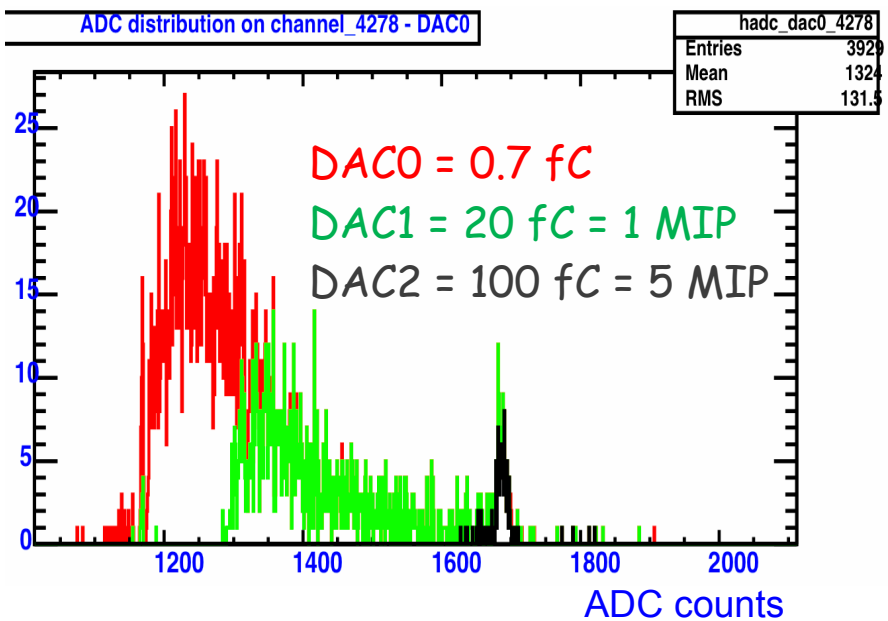
Well compatible with 2008 beam tests
(analog readout, threshold cut offline)

Very preliminary results – Analog RO

- Analog readout
  - Hold of shaper signal (hold time can be varied)
  - Conversion by ADC on DIF board
  - Works with digital readout
- Landau distribution measured on one pad
  - Narrow pion beam (1x3 cm^2) was used
  - 3 thresholds set at ~0, 1 and 5 MIP respectively

3 distribution position agree with threshold settings
→ validate Microroc calibration

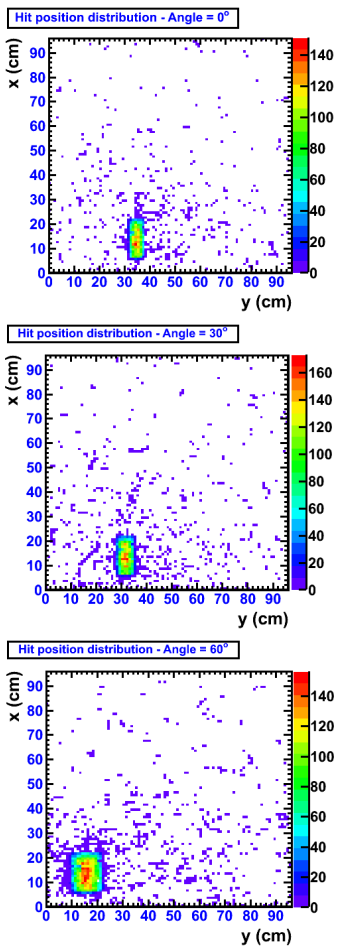




In DHCAL: Analog RO allows to fix and monitor the digital thresholds!

Very preliminary results – angle w.r.t. beam

Different angle of beam incidence (0°, 30°, 60°)
(at 0° the beam direction is perpendicular to the m^2 prototype plane)

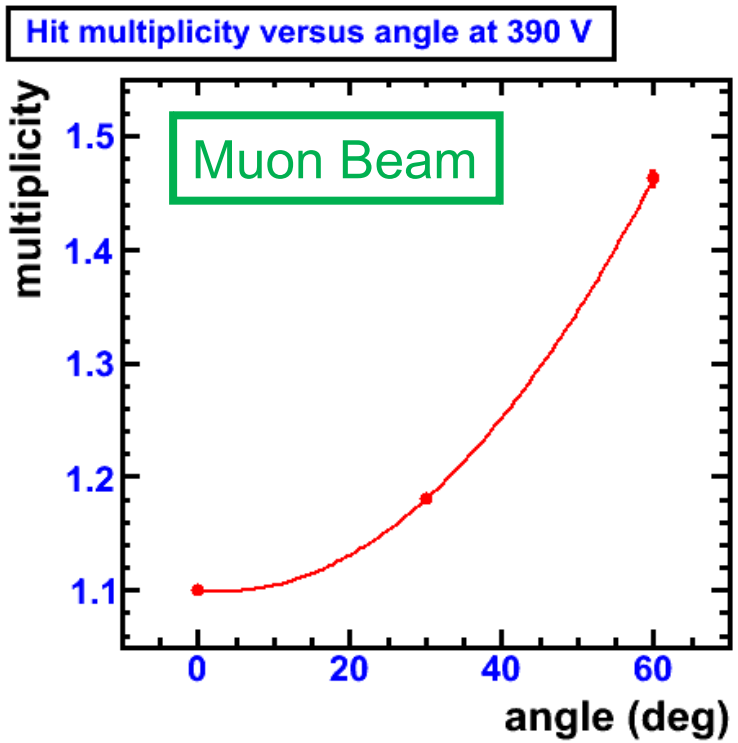


0°

30°

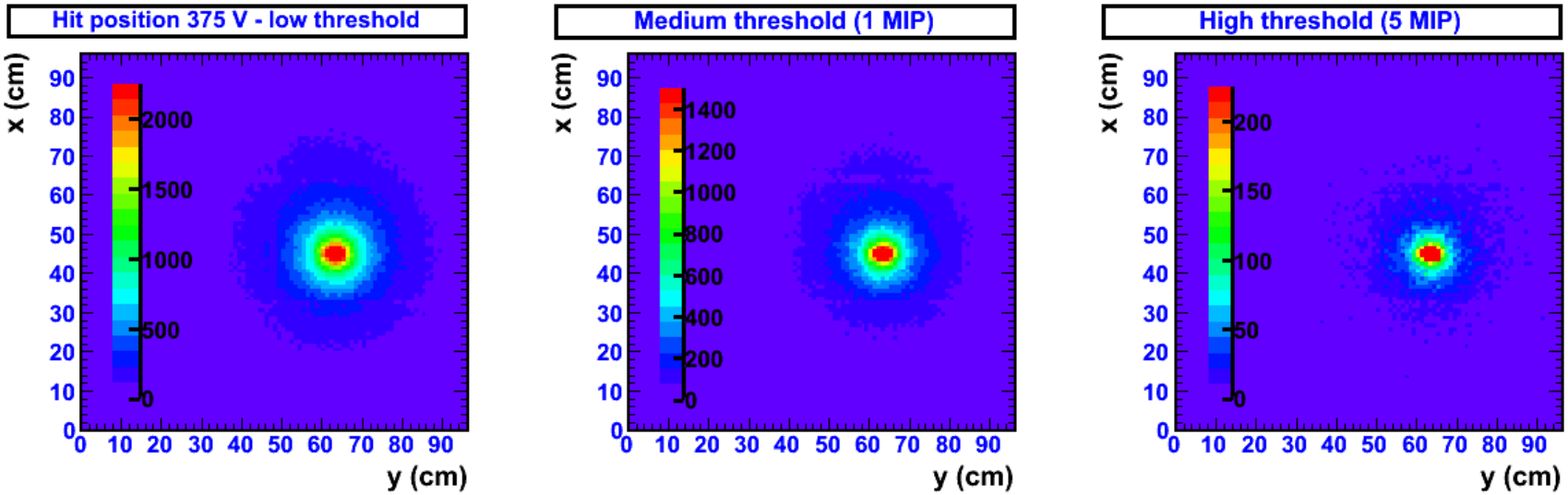
60°

Expected increase of multiplicity with angle
Remains reasonably small: at 60°, below 1.5



Very preliminary results - Showers (I)

- 150 GeV/c pion shower signals with semi-digital RO at 375 V (50000 triggers)
  - 20 cm iron block placed 50 cm upstream the prototype
  - Only air between block and prototype
  - Medium and high thresholds set at 1 and 5 MIP
- Nicely axially symmetric profiles
  → Uniform response of the detector
- Particle density decreases away from the shower axis
  → Narrower profile obtained from medium and high thresholds

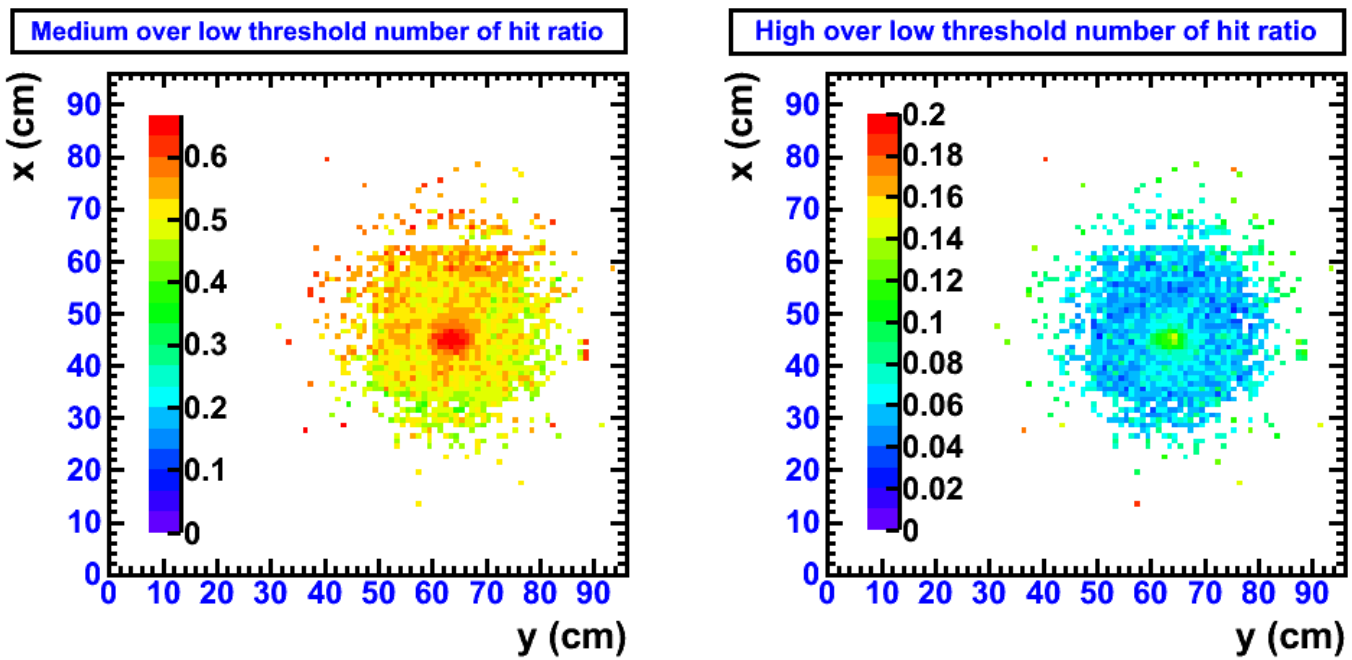


Looks like semi-digital RO of shower signal in Micromegas works!

Very preliminary results – Showers (II)

- Nicely axially symmetric profiles
  → Uniform response of the detector
- Particle density decreases away from the shower axis
  → Narrower profile obtained from medium and high thresholds

Better seen by looking at ratio of number of hits from different thresholds, it increases towards the shower axis

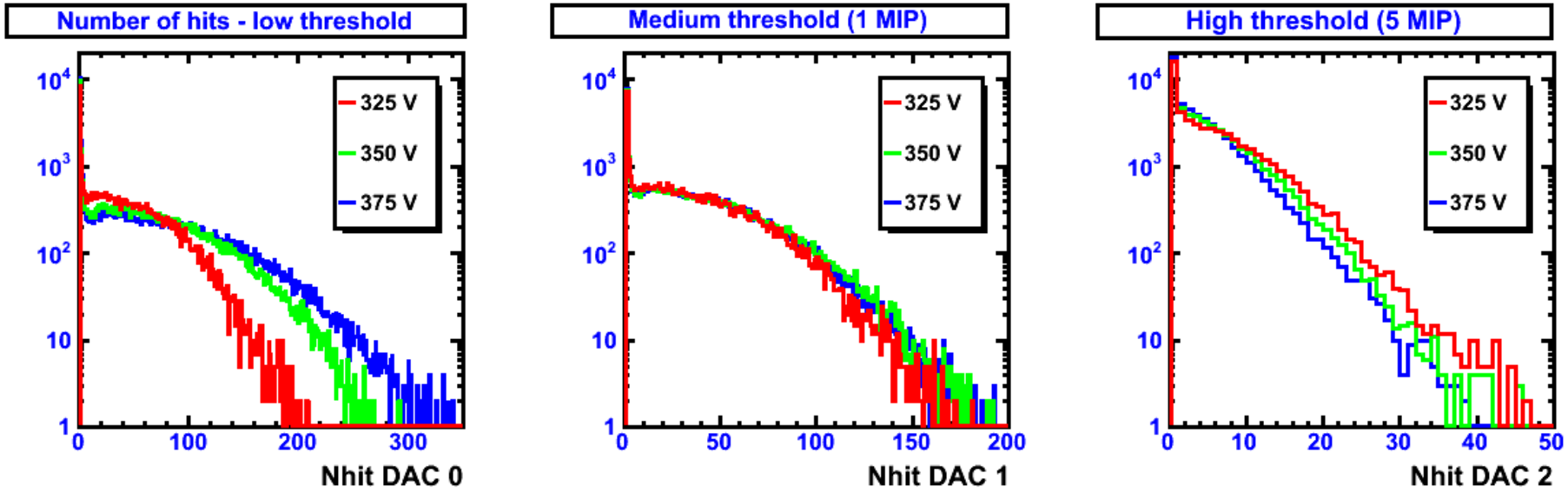


Looks like semi-digital RO of shower signal in Micromegas works!

Very preliminary results – Showers (III)

- 3 runs at mesh voltage of 325, 350 and 375 V
  - MPV charge increases with gas gain
  - Adjust medium and high threshold at 1 and 5 MPV

- Up to 300 hits at 375 V (efficiency > 95 %) !
- Distribution of low threshold changes according to the detector efficiency
- Distributions of medium and high threshold however super-impose!



Thresholds can be set for any given mesh voltage

Conclusion on test beam

- From preliminary results, the Microroc m^2 prototype seems to be an excellent detector
  - Efficiency of 98 %, multiplicity of 1.1 at 0.7 fC threshold
  - Uniform response
  - Almost no noisy channel (8/9216)
  - Noise under control (RAMFULL runs)
  - Semi-digital RO works (thresholds set at will)
  - Shaping 200 ns → signal of 1 μs
    → Max rate of 1 MHz/cm^2

  - Nearly no V_{mesh} trips. Very quiet detector
    At a gas gain of 3000 (390 V), there are very few sparks!
    To be further assessed inside W/Fe structures

Conclusion on project

- MICROMEGAS m^2
  - Bulk process with embedded chips: ok
  - Mechanics : ok
  - Tests beam results
    - Electronic Readout: ok
  - Performances compatible with HCAL requirements

- Future
  - A second chamber is under construction
  - Two chambers should be inserted in the RPC-SDHCAL structure in October
  - Larger production run could be launched in 2012
  - Funding for studies of bulk-MICROMEGAS with resistive layer
  - Continue DAQv2 developments for CALICE

Aknowledegments

- LAPP LC Detector group

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