Micromegas DHCAL status report

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On behalf of the LAPP LCD group

CALICE Collaboration Meeting, 22 – 24 September 2010, Casablanca, Morocco

In2p

Outline

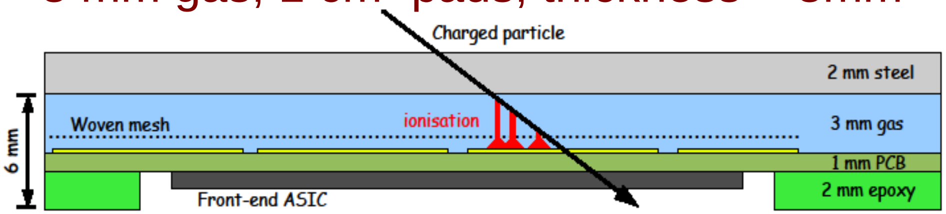
1. Micromegas basic performance
2. $1m^2$ prototype – design and test
3. Test beam of the $1m^2$ prototype
4. Readout electronics and DAQ
5. Simulation studies
6. Test beam plans (2010/2011)
7. Conclusions

MICROMEGAS for DHCAL

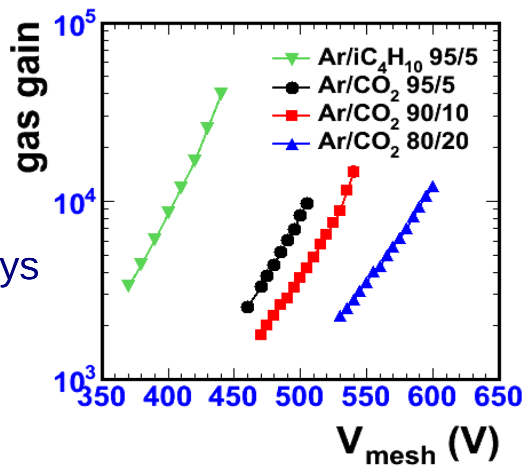
- Proportional mode
- Low working voltage
- Standard gas mixtures
- Robust (Bulk technology)
- High rate capability

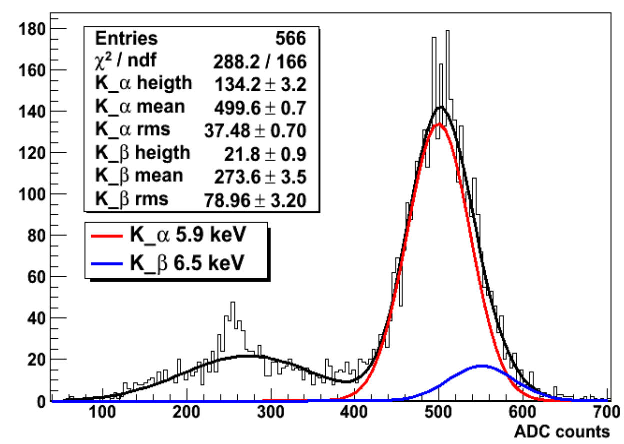
- Sparking
  - Depends on gain & rate
  - Protection exists (RD51)
- Large area
  - Relatively new
  - RD51: MAMMA, SDHCAL

3 mm gas, 1 cm^2 pads, thickness < 8mm



Maximum gain:
- 40.000 for ^{55}Fe X-rays
- 15.000 for MIPs



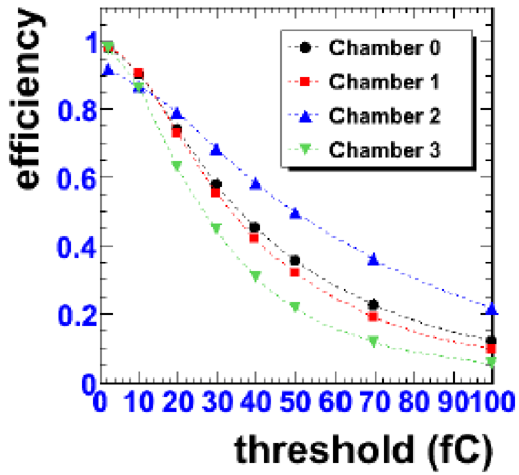


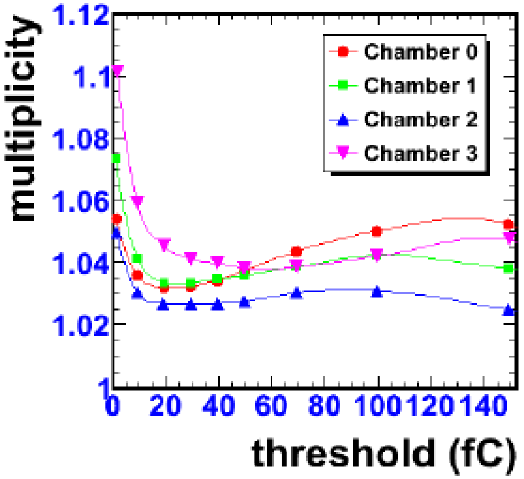
Energy resolution @ 5.9 keV
~ 7.5 % (FWHM = 17.6 %)

Basic performance (reminder)

- Efficiency (th = 1.5 fC) about 97% with a variations less than 1%
- Hit multiplicity (th = 1.5 fC) below 1.12

2009 JINST 4 P11023





Ambient parameters

- Pressure: -0.6%/mbar
- Temperature: 1.4%/K

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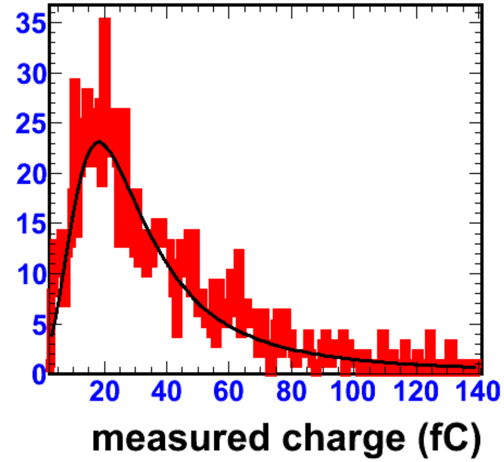


MIP MPV ~20fC with a variations of 11% (th = 1.5 fC) Over 96cm^2

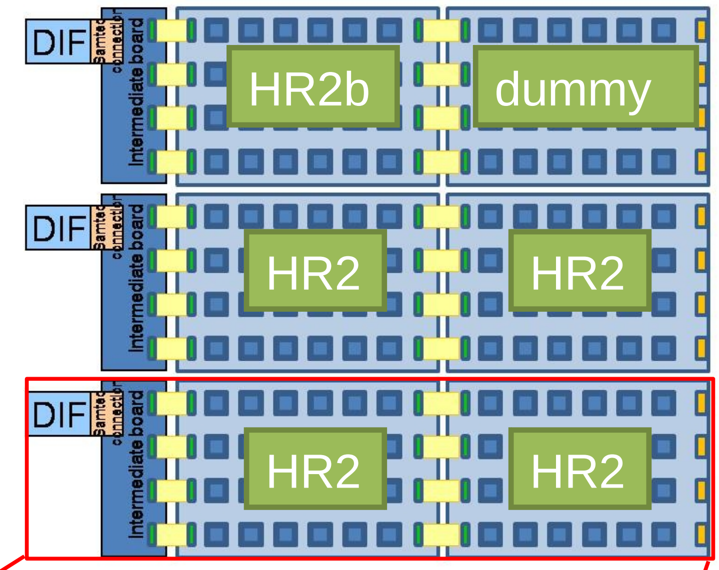
1 m^2 MICROMEGAS prototype

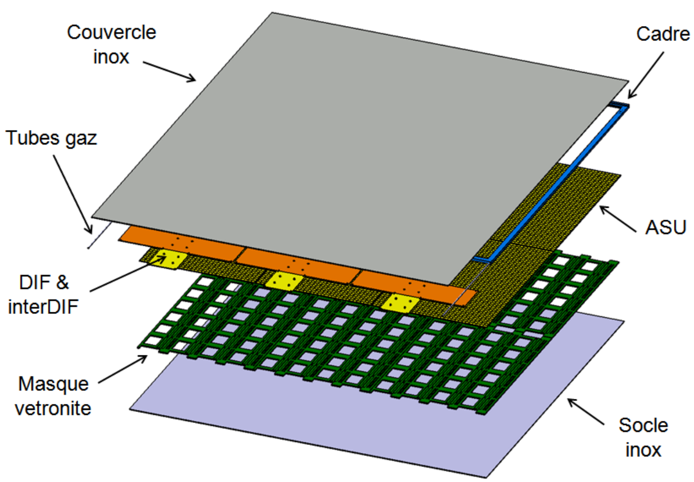
Features

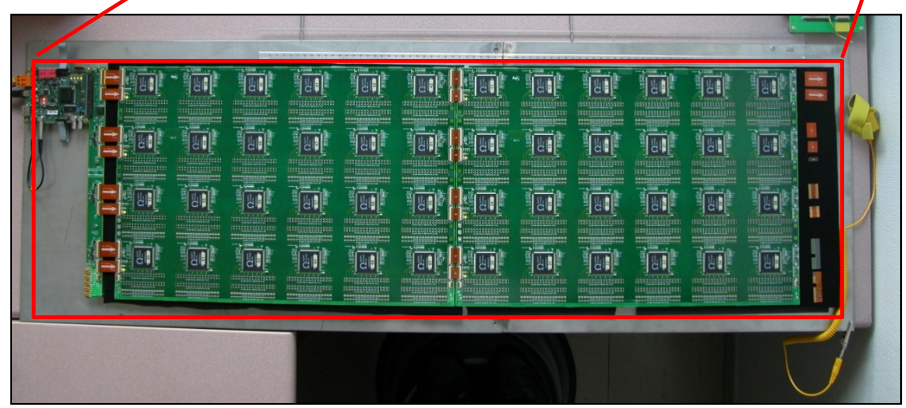
- 6 ASU of 48x32 cm^2 (24 ASIC / ASU)
- Dead area < 2 % inside gas volume
- Total thickness of 1.2 cm (incl. 2+2mm steel covers)
- 3 DIF boards

Test of each ASU separately first

Assembly procedure validated on mechanical prototype in 2009



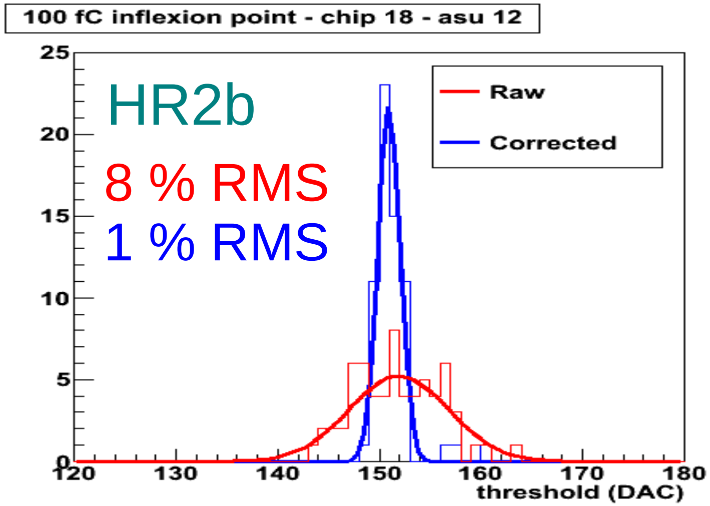




HR2 calibration and test of 48x32 ASU

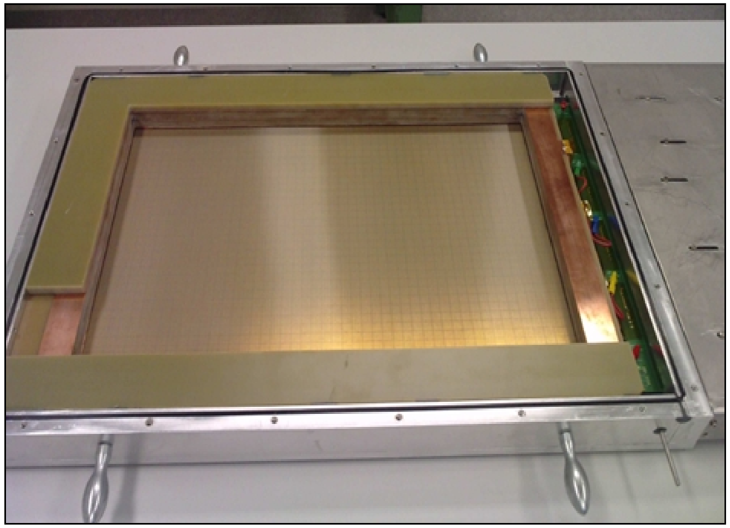
HR2b calibration with test charge

- Some fluctuations of signal over different channels (11% over 100 cm^2) → Correct detector non-uniformity with individual channel gains
- Proof of principle on preamplifier gain distribution obtained → 1 % RMS after equalization



ASU test with X-rays

- Test of complete chain (Bulk/HR/DAQ) inside a test box
- Each readout cell can be measured individually



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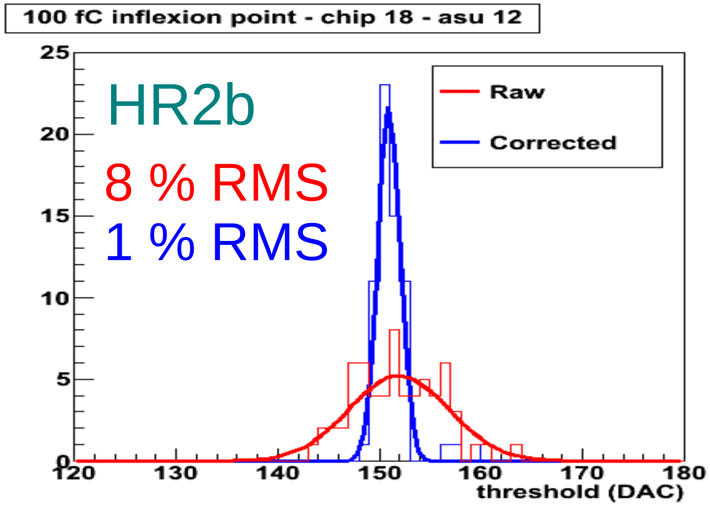

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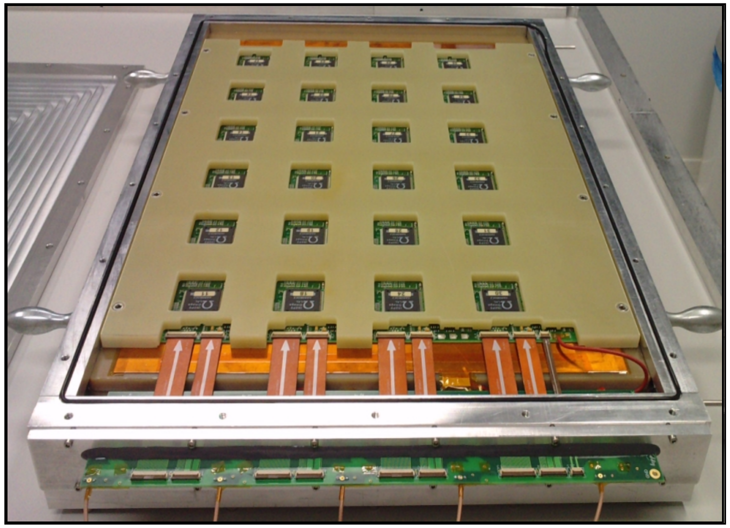

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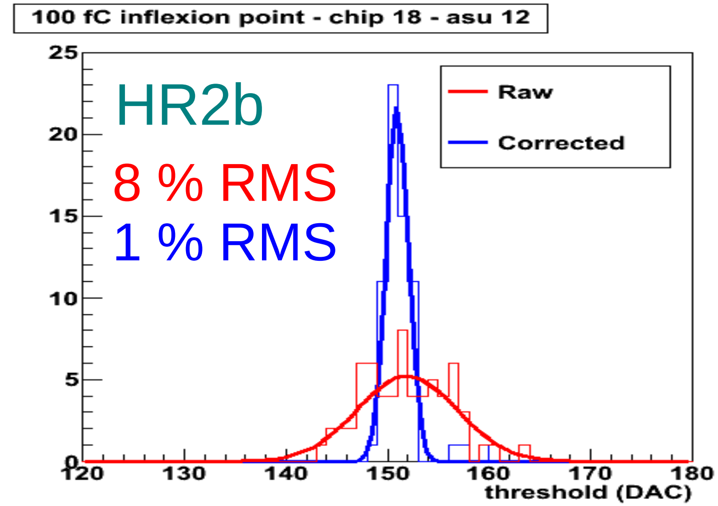

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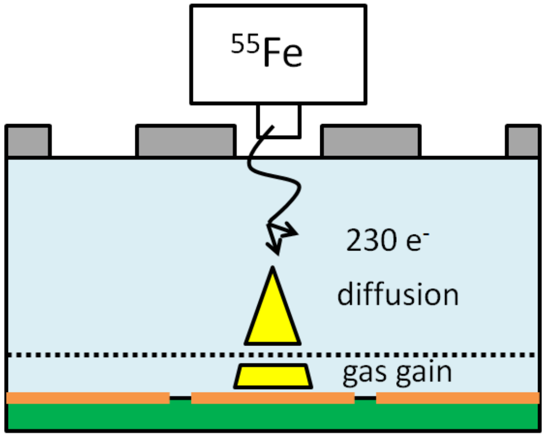

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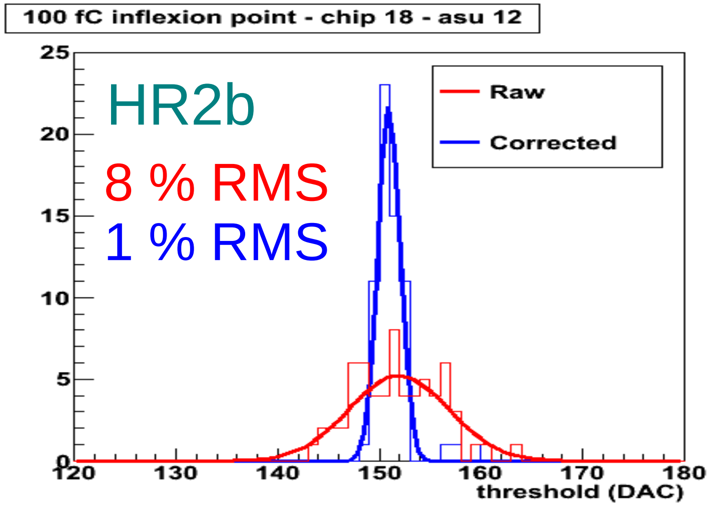

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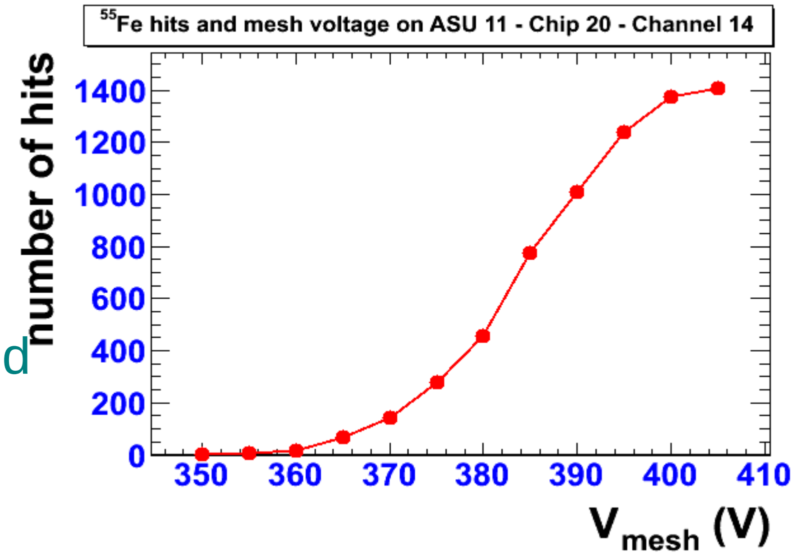
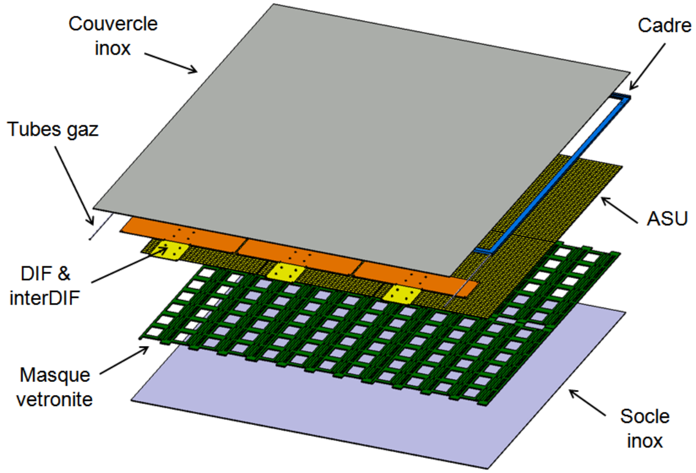
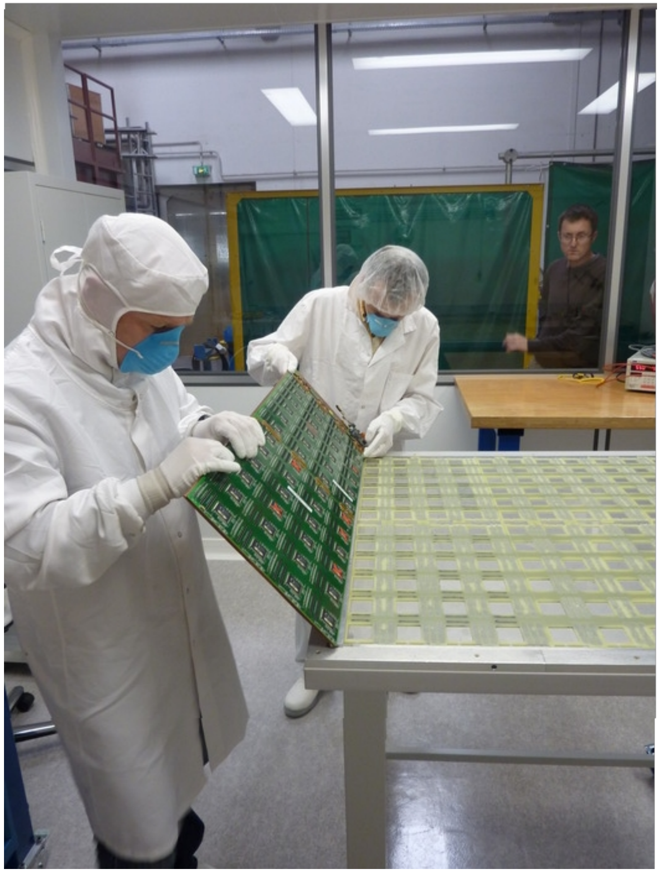


Assembly of the 1 m^2

1. Gluing of ASU slab on a vetronite mask





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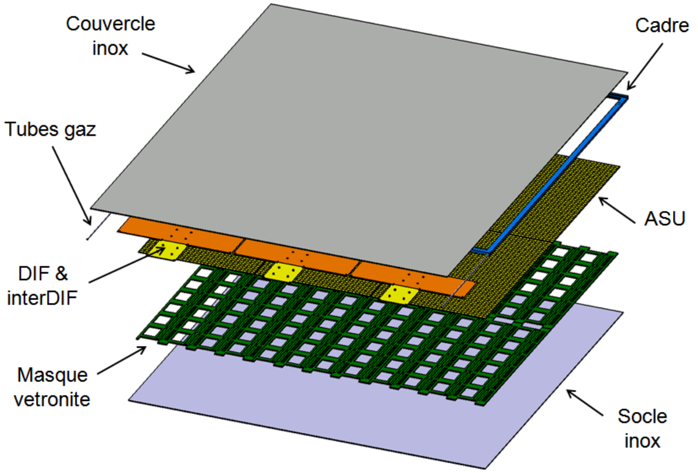

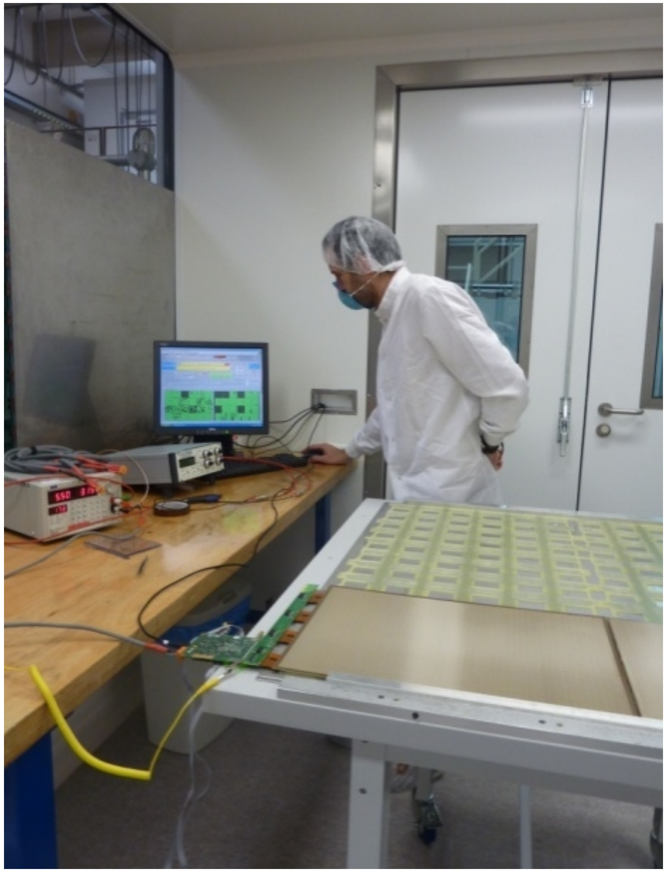

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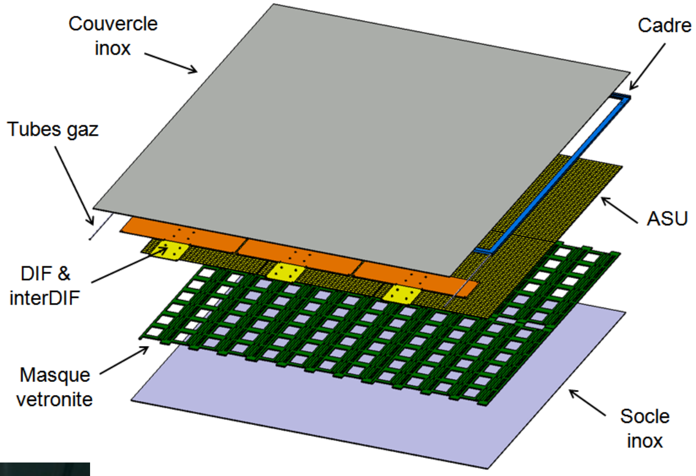

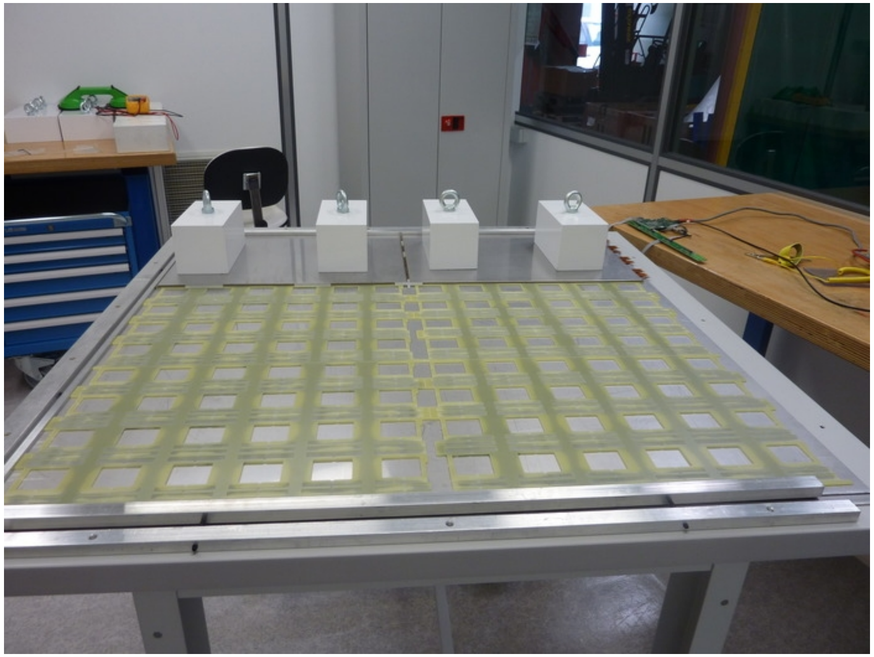

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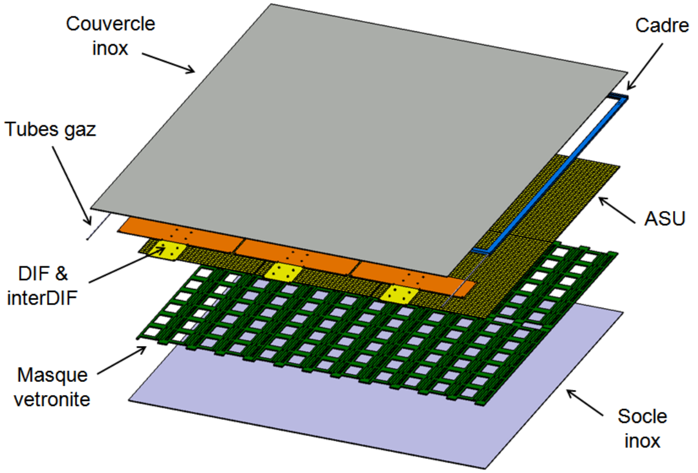

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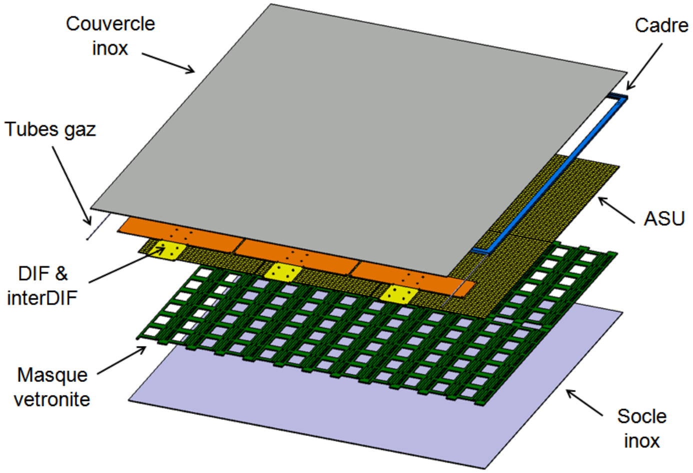
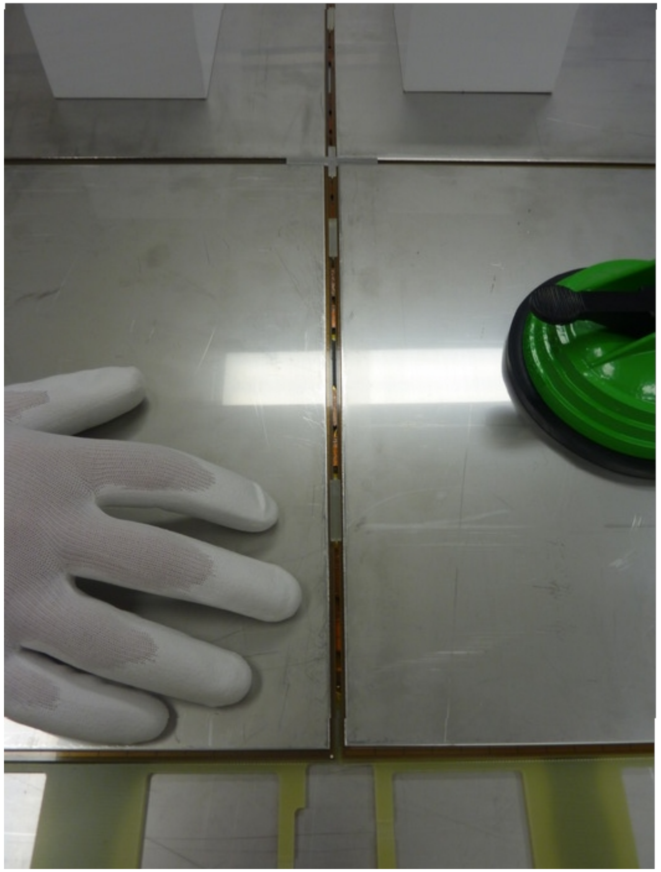
2. Spacers and frame gluing





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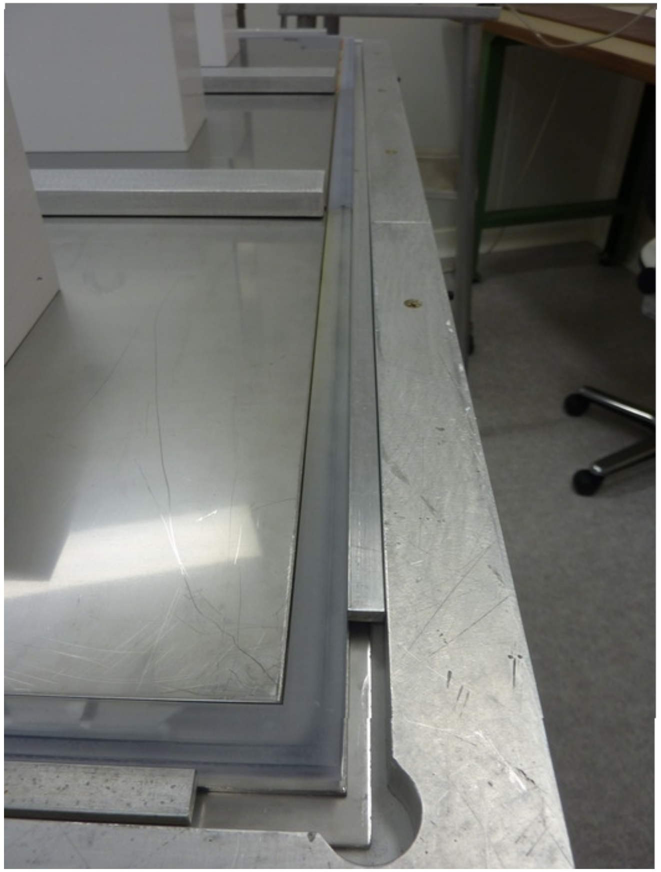
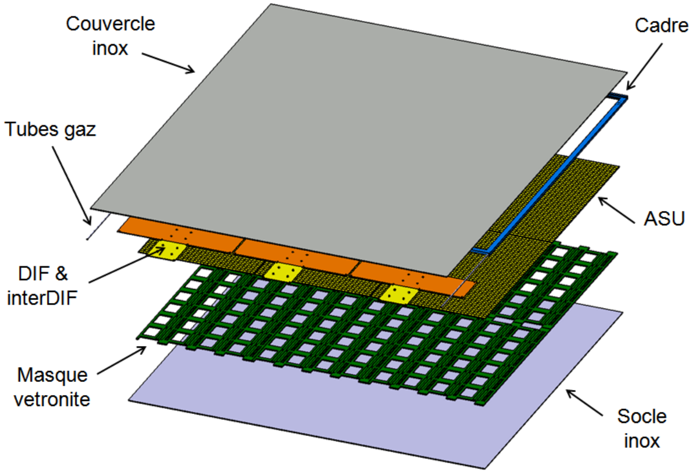
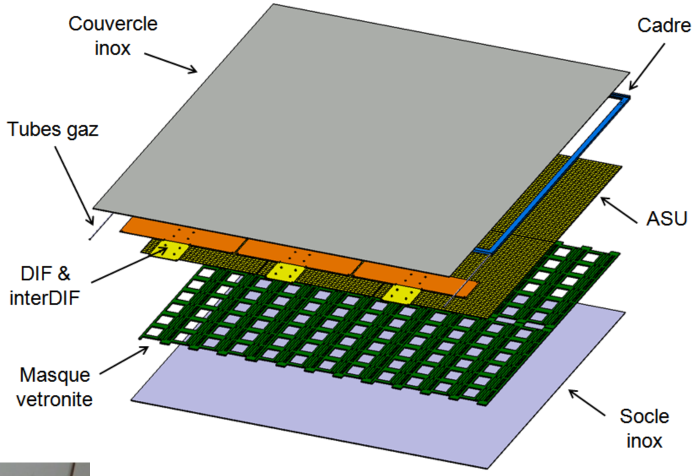
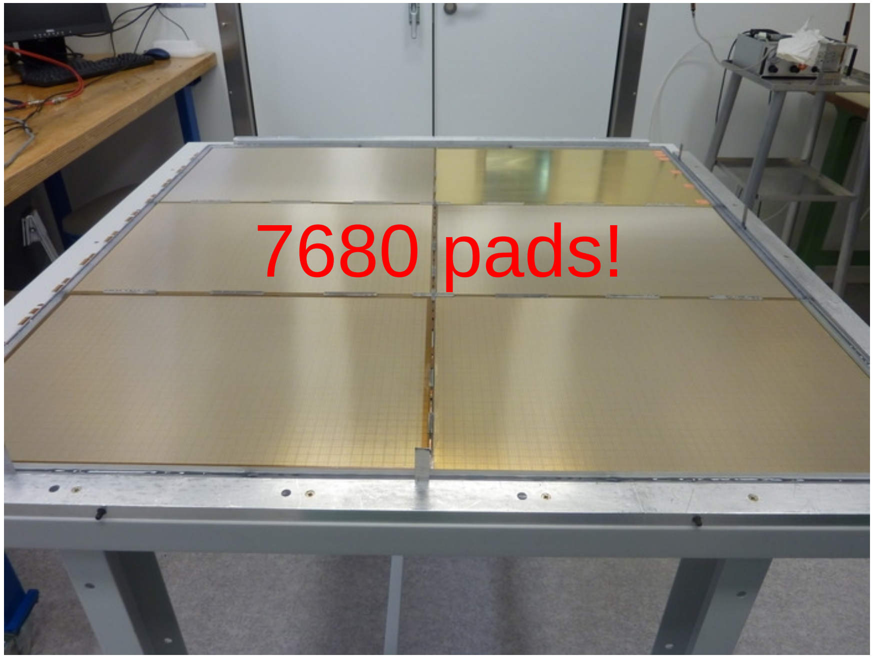




Assembly of the 1 m^2

1. Gluing of ASU slab on a vetronite mask
2. Spacers and frame gluing
3. Cathode and cover gluing





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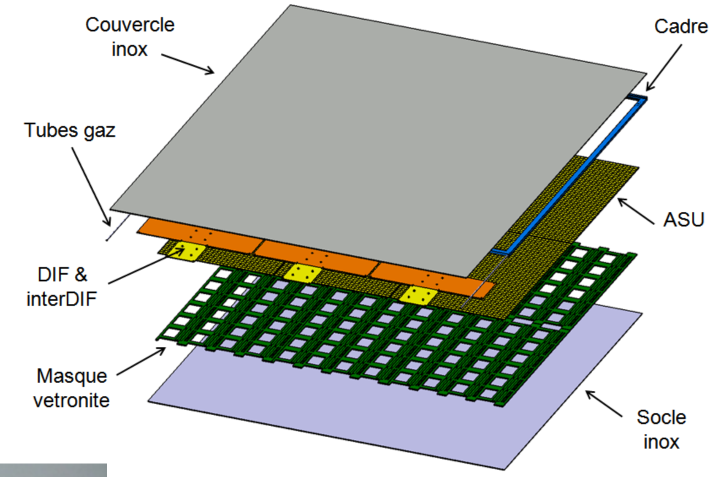

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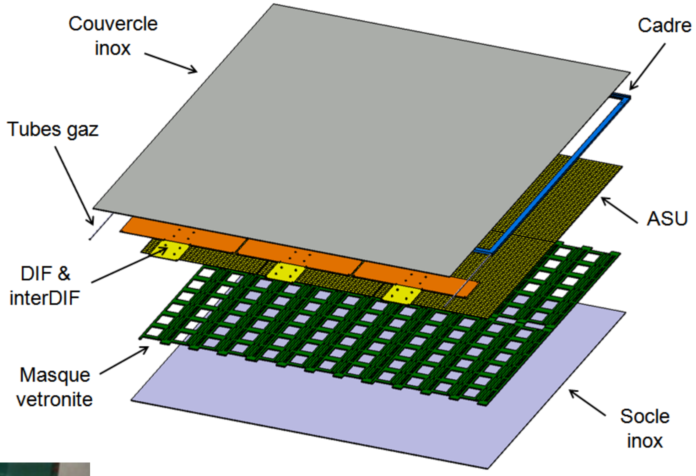

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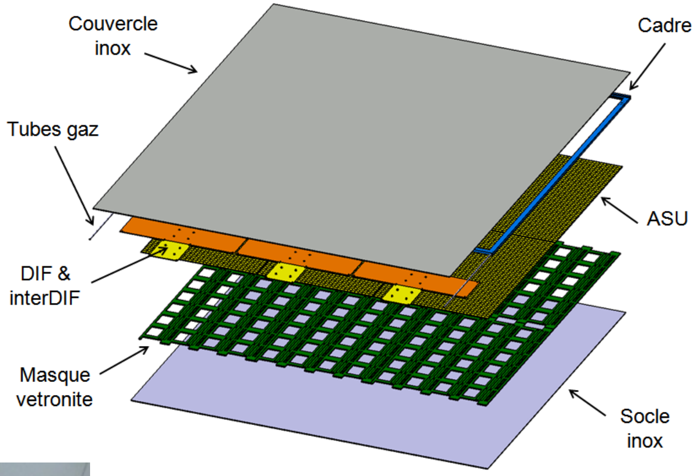
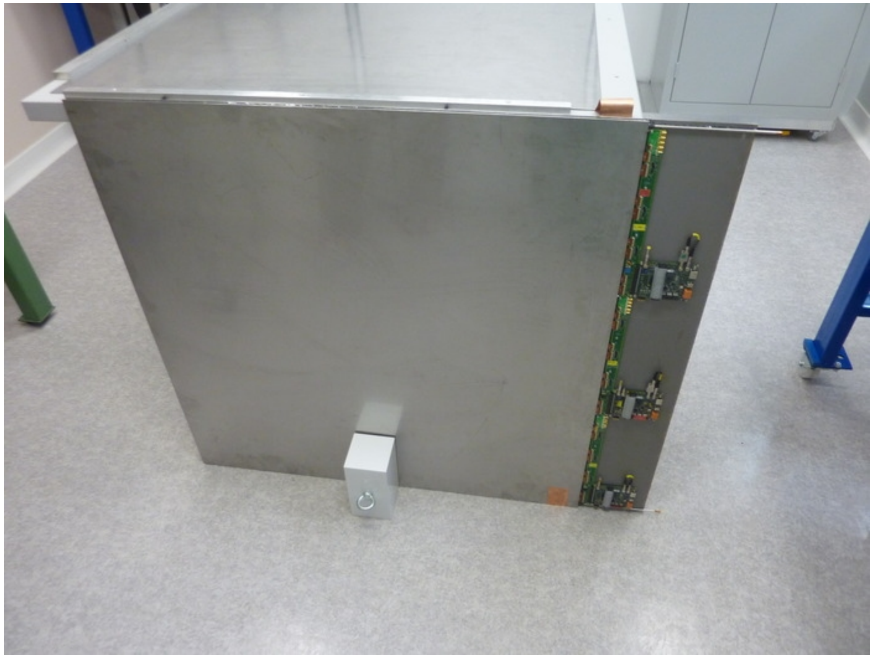
After 1 week the 1 m^2 is fully assembled!





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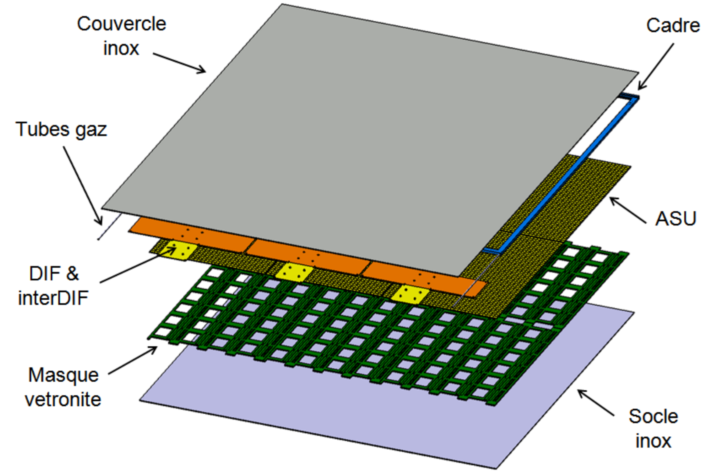
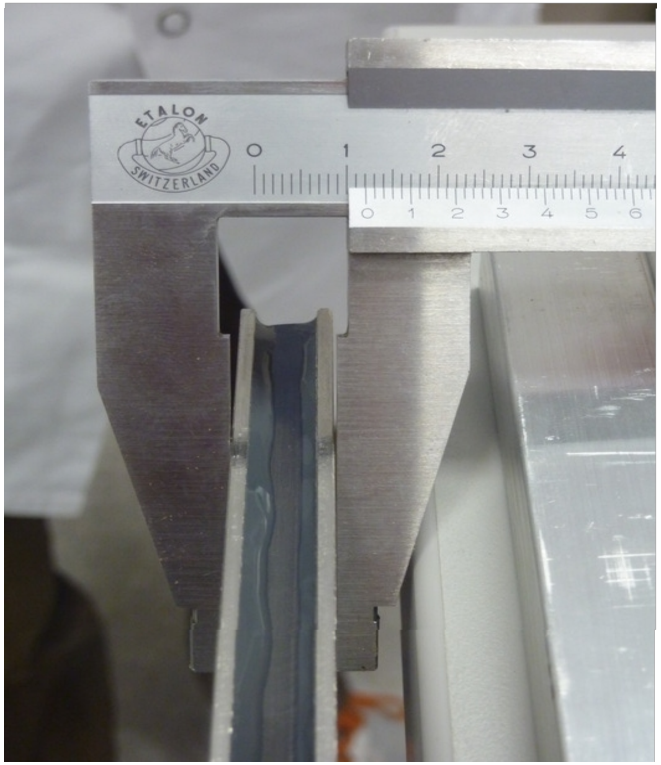
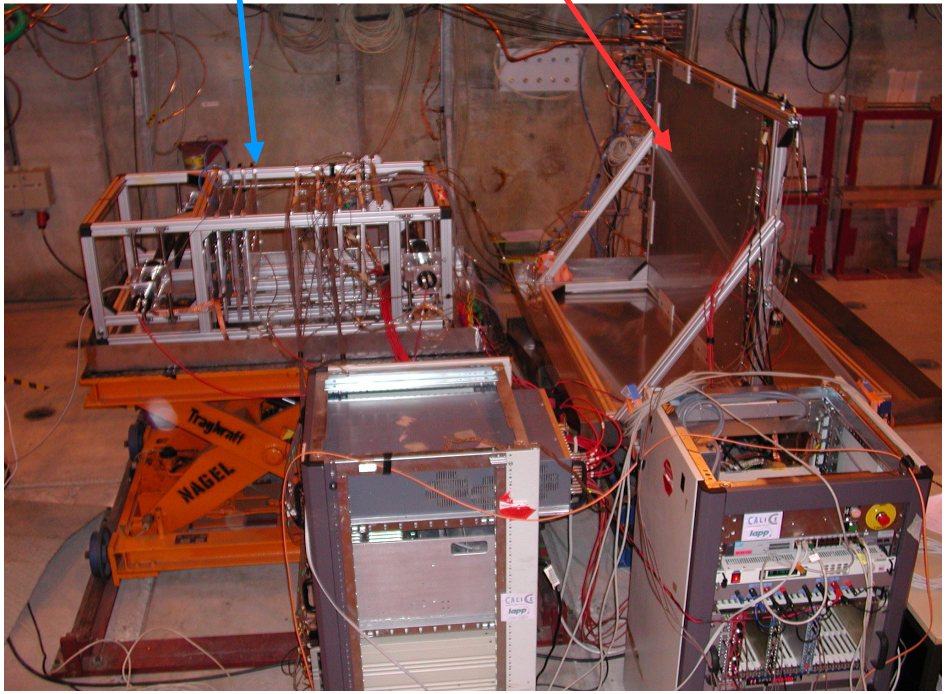




Total thickness is 12 mm which includes 2+2 mm of steel
→ 8 mm effective thickness complies with ILC goal (easily could be reduced to 7 mm)

Test beam of the 1 m^2 - set-up



SPS/H4 beam

- 4 weeks in June/July 2010
- 150 GeV/c muons and pions

Detectors

- 3 scintillators for triggering
- Telescope with 4 Gassiplex chambers
- 1m^2 chamber downstream of the telescope

DAQ

- CAEN ADC/sequencer VME module and LabView Centaure
- DIF (synchronized with CCC) and LabView program
- Trigger obeys BUSY and READY signal logic → common event numbering for off-line reconstruction

Rates

- Beam rate and scintillators trigger rate ~1kHz,
- Acquisition rate ~ 100Hz

Test beam of the 1 m^2 - goals

4 weeks CERN SPS H4: 2 weeks from 10th June (CALICE) and 2 week from 24th (RD51, beam shared with other groups)

TB program with muon beam (150 GeV/c) at low intensity

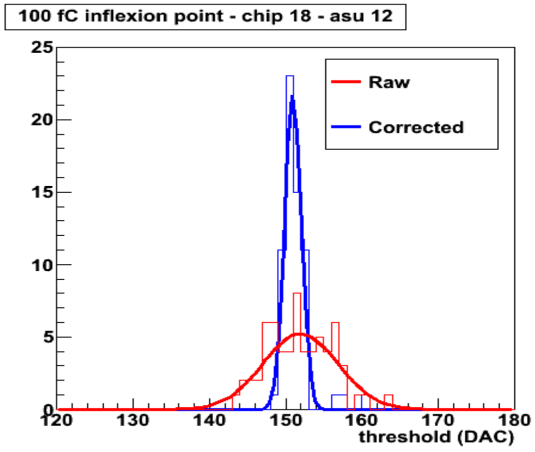
- Test overall functionality of the detector
- Reach high gas gains and the lowest detection threshold on chips
- Validate/rule out assembly and technological choices
- Measure efficiency, multiplicity and uniformity
- Compare performance with and without power-pulsing of chips

N.B. The 1m^2 prototype efficiency will be low (Shaping time short w.r.t. Micromegas signals), nevertheless, several technological choices can be validated and unforeseen problems can be found before the next prototype with an optimised electronics (MICROROC)

Chip settings

Chip parameters:

- Shaping time (per chip) – set to max ~ 20 ns
- Threshold (per chip)
- Preamplifier gain (per channel)

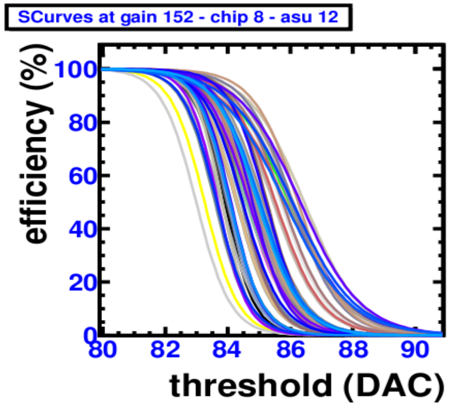


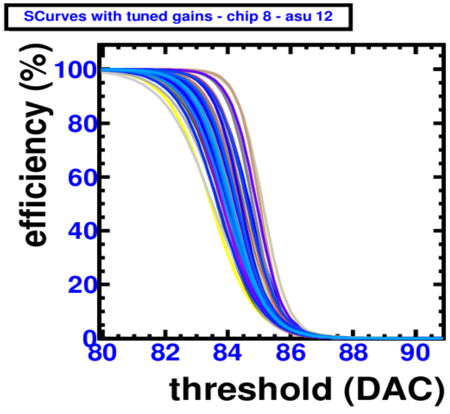
Uniform response settings:

- Gain equalization by injection of test charges
- Proved to work in laboratory
- Charge threshold given by pedestal dispersion (~ 10 fC)

Low threshold settings:

- Align S-curve end-points (μ+5σ) using preamplifier gains
- Increase gain dispersion, but reduce thresholds
- Used in the test beam

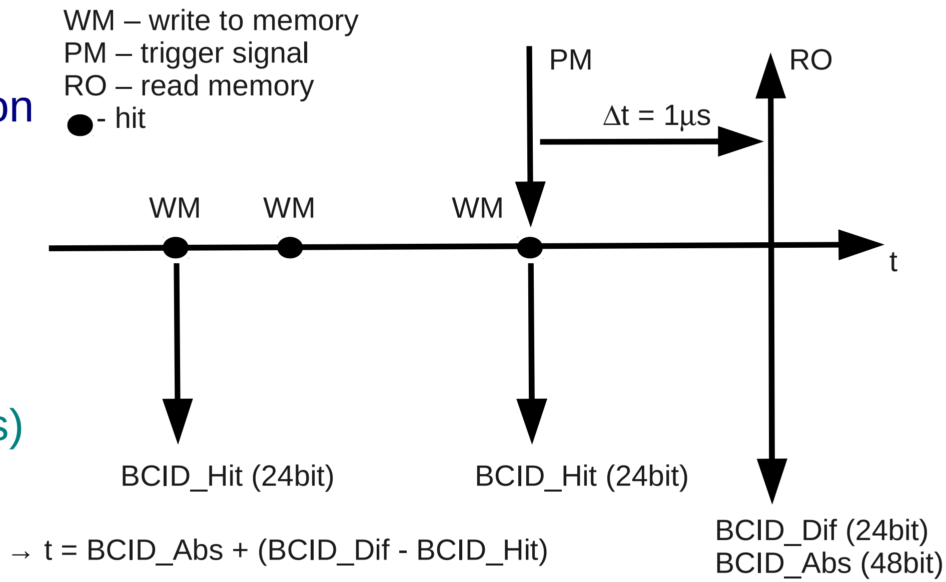




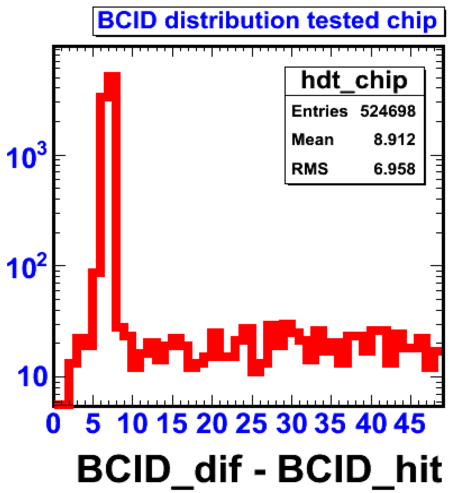
Time stamping

Timing features
- Time-stamping with 200 ns precision
- Clock distributed to DIFs by CCC
- 127 event depth chip memory

Time stamping
- Time of hits, BCID_hit (24 bits)
- Time of readout, BCID_abs (48 bits)
- Time of readout, BCID_dif (24 bits)

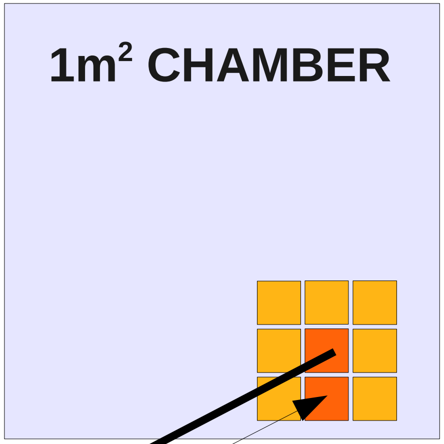


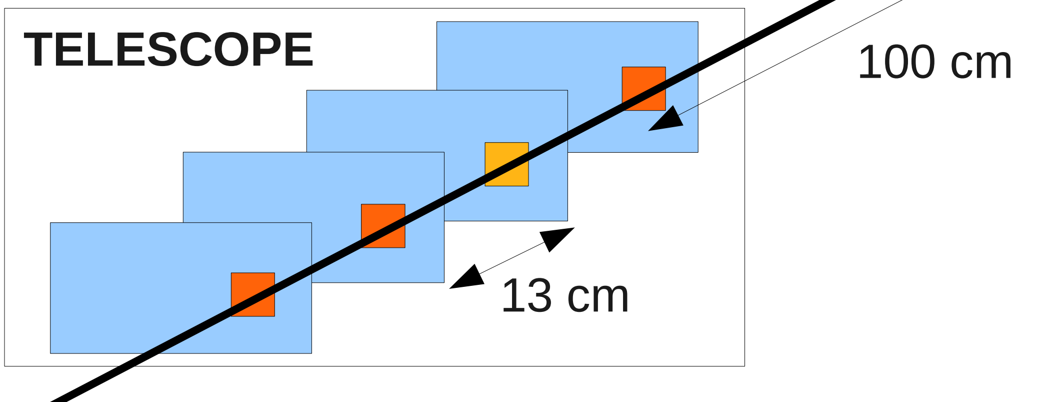
Signal selection
- Delay of 1 us between PM signals and readout
- So hits from triggering particles have:
  - BCID_dif - BCID_hit ~ 5 clock cycles (1 μs)
- Chips S/N ratio > 100
- Noise hit probability/chip < 1 %
  after time cut on BCID



First results on TB data analysis

- Runs @ 420 V to determine the maximum efficiency (given the shaping time issue)
- Runs @ 410 V to determine the efficiency/multiplicity values and uniformity
- Use telescope to extrapolate tracks to 1m^2 prototype Same pad size (1x1 cm^2) in telescope and 1m^2 prototype
  - → select straight tracks in telescope: single aligned hits in at least 3 of the 4 chambers
  - → look for hits in 1m^2 chamber in 3x3 cm2 area around extrapolated track impact

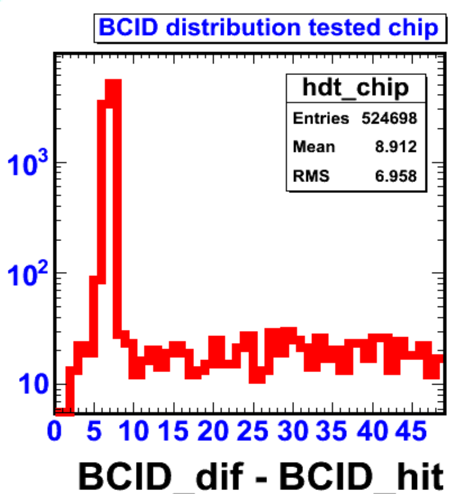


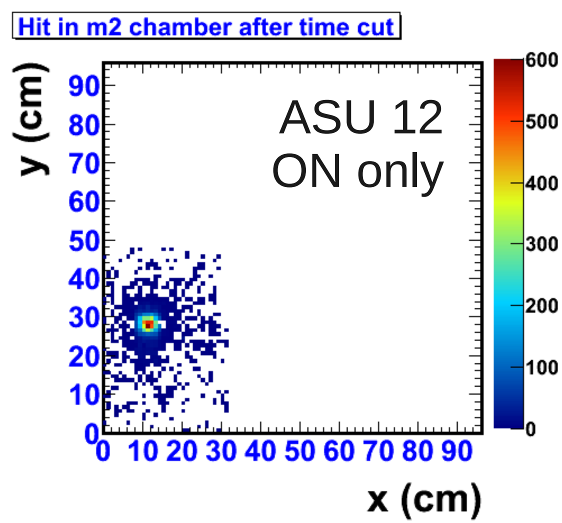


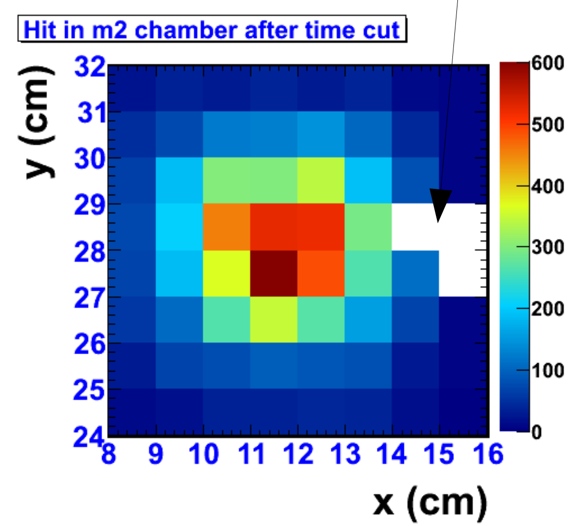
Runs @ 420 V

- Gas gain of 15000 → expected Landau MPV ~ 20 fC
  - Only 10 % of the signal is seen → effective signal MPV is 2 fC !
- Approx. 40000 triggers recorded
  - 200 Hz muon beam centered on 1 chip of ASU 12
- S/N ratio in time peak of 208 (3 noisy channels switched OFF)
  - Peak contamination after time cut < 0.5 % for the chip
  - Noise hit probability after time cut ~ 0.01 % per channel

Noisy channels switched off

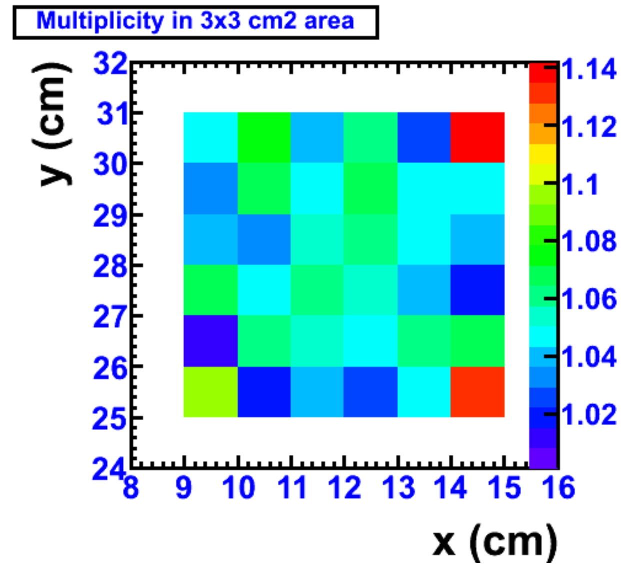


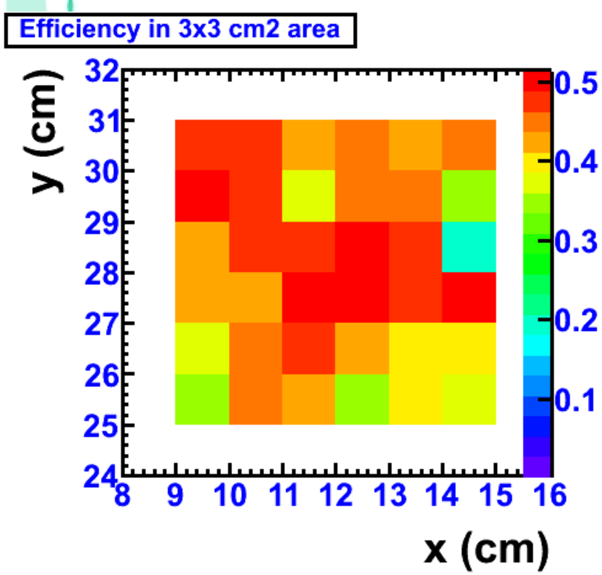


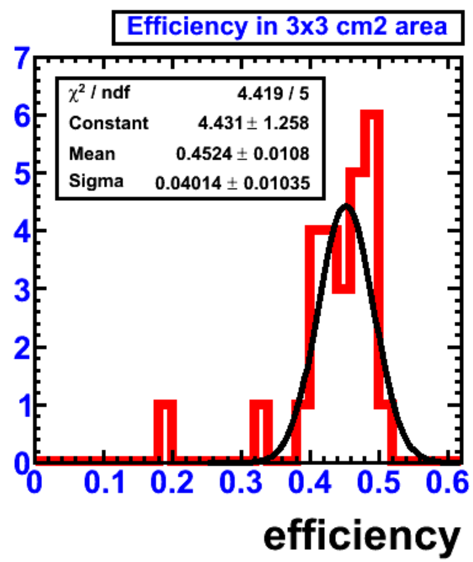


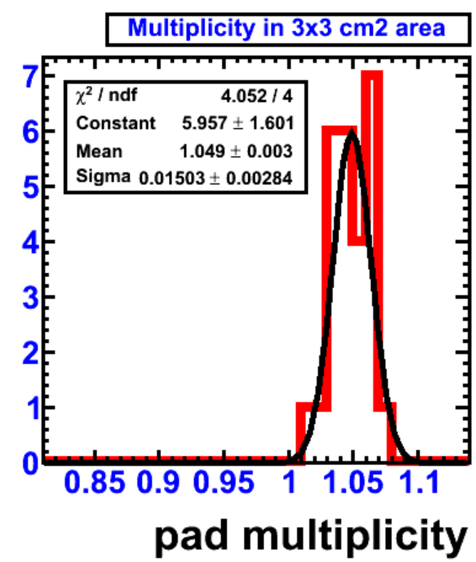
Runs @ 420 V

- Average efficiency of 45.2 +/- 4.1 %
  Remember: only 10 % of the signal is seen!
- Average multiplicity of 1.05 +/- 0.02
  Compatible with previous measurements with Gassiplex







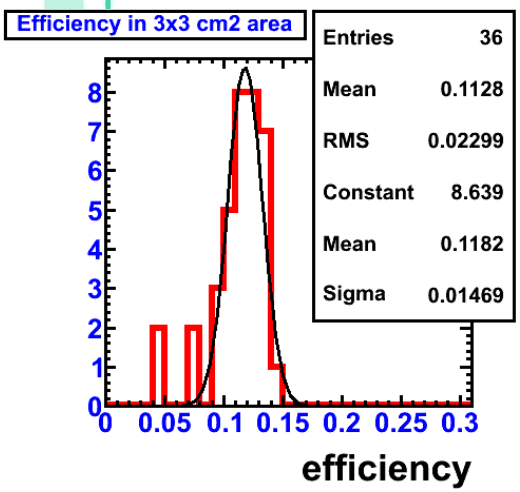


Efficiency error < 5%

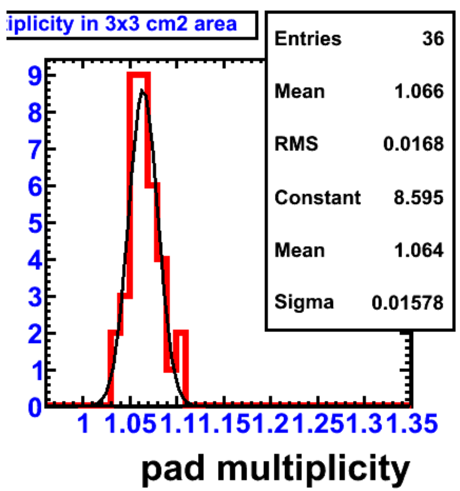
Efficiency error < 2.5%

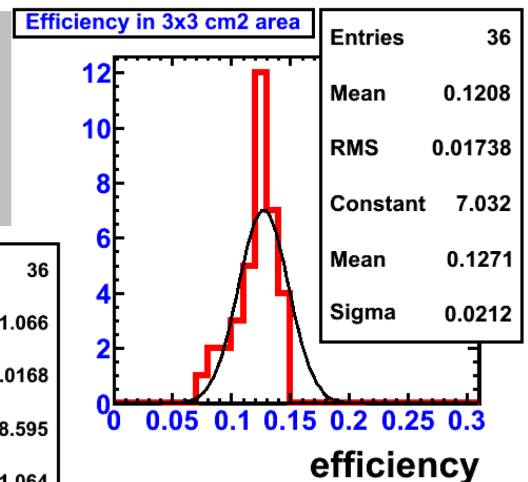
Runs @ 410 V

- Lower gas gain and higher threshold configurations → much lower efficiency
- Determine the uniformity of efficiency and multiplicity over the $1 m^2$ chamber area → beam directed at a few chips with 400000 triggers per chip
- First results on 2 chips indicate that the mean and RMS remain the same
  - To be completed with more results on more chips

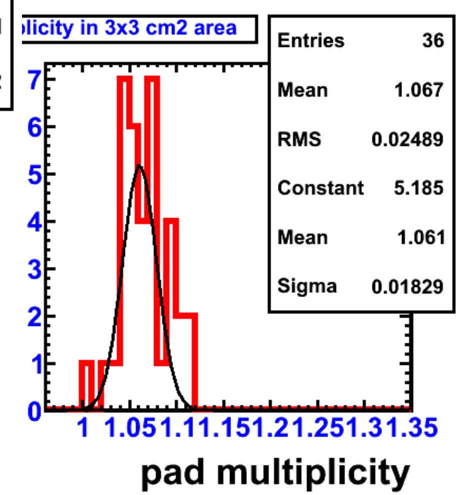


CHIP 124
Close to center
11.2 % +/- 1.5 %
1.07 +/- 0.02





CHIP 114
Close to spacers
12.7 % +/- 1.6 %
1.07 +/- 0.02



Efficiency error < 1%

Power pulsing

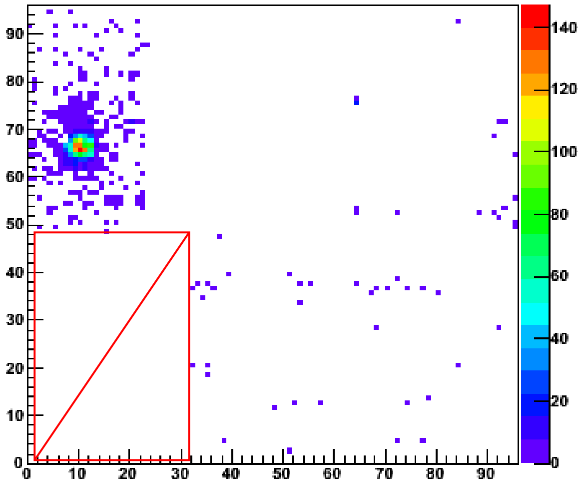
FE power comsumption:

- DIF+InterDIF: ~ 1.2-1.3 A
- HR2 of 1 ASU (analog) ~ 0.4-0.5 A , except for first ASU ~1.4A (12 deffect preamp)
- HR2 of 1 ASU (DAQ or Digital) ~ 0.02A

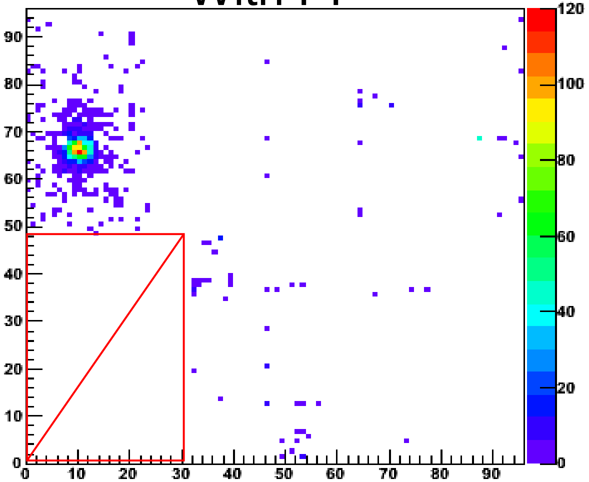
Switch ON/OFF the analog part of all chips during SPS spill.

- this corresponds to a current of ~ 3 A (4*0.4+1.4) during analog_OFF
- t_ON = 2 ms and t_OFF = 10 ms
- S/N ratio are similar

Without PP



With PP



First encouraging results → quantitative analysis is ongoing

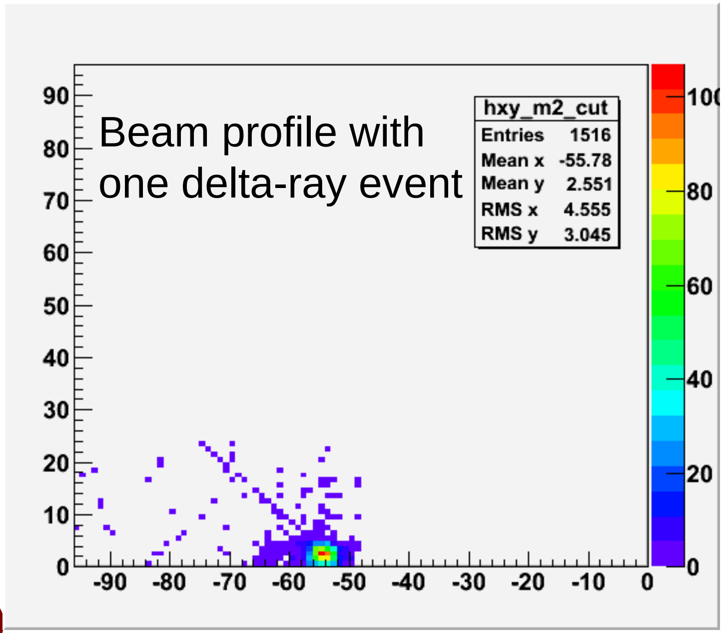
Test beam summary

Mechanics

- $1m^2$ is gas tight and robust

Electronics

- Careful grounding - good noise condition
- Electronic gain equalized (only for HR2b)
- Successful synchronization between Gassiplex and HR DAQs
- The HR DAQ is stable and reliable
- Power Pulsing for the complete $1m^2$



Detector

- Meshes are stable (very few HV supply trips)
- High gain possible (Mesh tested up to 420V = Gas gain up to 15.000)

Software

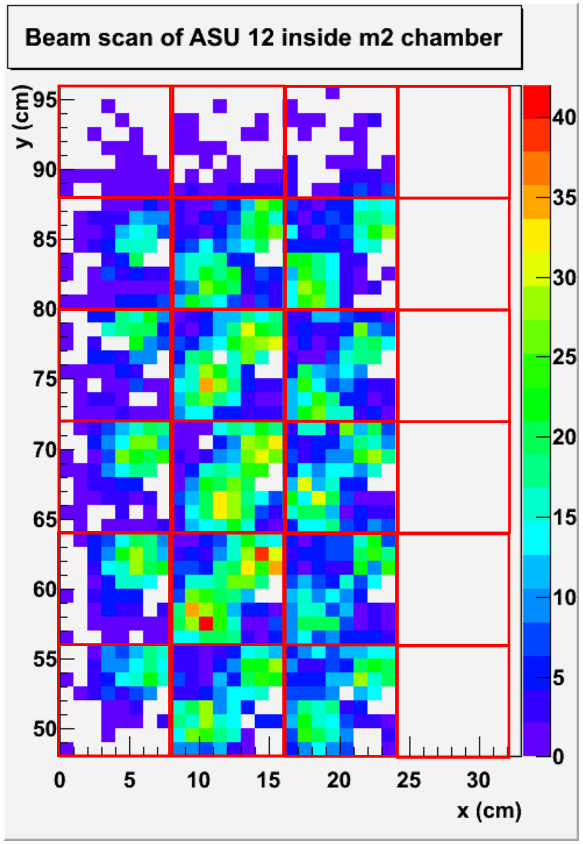
- Reconstruction of simultaneous events from both DAQs (telescope + $1m^2$)
- Data file book keeping under development for next test beam

All 5 ASUs of the $1m^2$ have showed response (beam profiles). Lot of data have been taken with ASU with HR2b, for instance, efficiency scans on a few chips with 400.000 trigger per chips.

Test beam analysis – next steps

- Uniformity studies, run on different chips
- High voltage studies (sparks, performance)
- Pion/muon runs comparison
- Pressure and temperature effects
- HV and noise rate studies

...

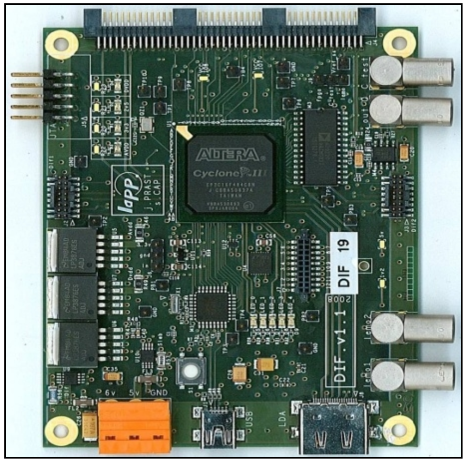


Next test beam

Test of the 1 m^2 chamber in the W-structure with AHCAL:

- ~3 weeks (from 3rd November 2010) CERN PS T9
- Objective:
  - First comparison between 1cm^2 pad Micromegas and 3cm^2 scintillating tile layers
    - need synchronisation AHCAL/DHCAL
    - limited performances due to low efficiency but compulsory for next year test beams
- Road map:
  - Gas pipe for T9 ready - same gas installation for T7 and T9 as at H4 in June 2010
  - finalize DAQs synchronization
  - Integration with W-structure at T7 (Installation foreseen around the 13rd October) and first test with muons

Progress on FE and DAQ electronics

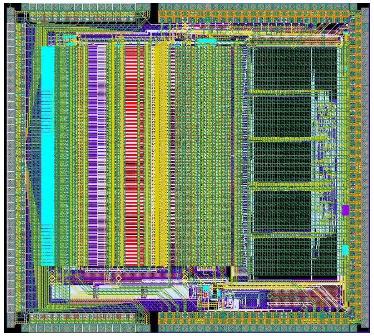


Detector Interface (DIF)

- 170 DIF board have been produced and tested
- 165 out of 170 DIFs are fully operational and ready to be used
- Intermediate DAQ with CCC fully operational

MICROROC

- New readout chip MICROROC
- Development with LAL/OMEGA
- Shaping time matching the detector signal duration
- Same digital part as HARDROC (same DAQ)
- First prototypes have been produced



WHCAL test beam

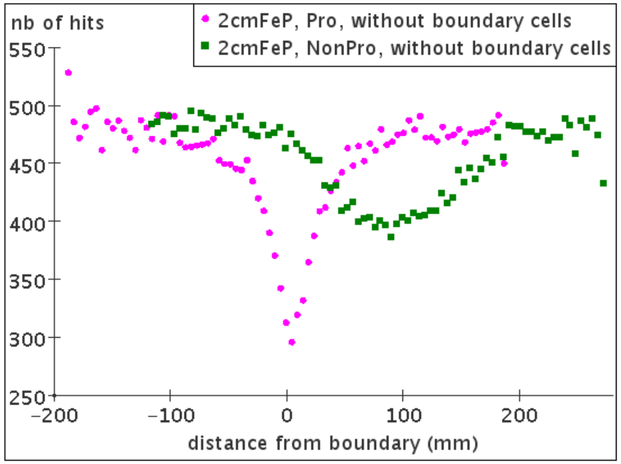
- Work on DAQ synchronization for AHCAL/DHCAL
- Solution uses 2 DIFs to generate common event number

For more details see G. Vouters' talk in electronics section

Simulation studies

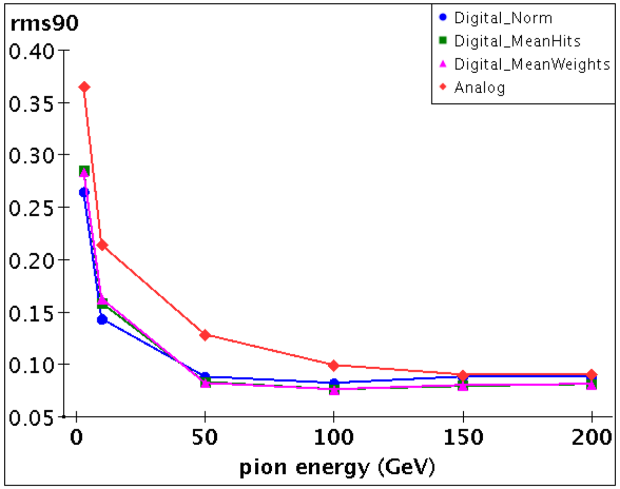
SiD HCAL performance for different mechanical designs

- Comparison projective and tilted geometries
- Boundary effects and impact of dead zones
- Study completed, analysis note coming soon



Optimization of the semi-digital readout

- Focus to improve calorimeter linearity and energy resolution
- Comparison of several numerical techniques to determine optimal weights and thresholds
- Promising results, study in progress,



Test beam study

- Help to establish physics program for future test beams
- Comparison of simulation and test beam data
  → Geant4 validation

Conclusions

1. Success of the first 1m^2 Micromegas prototype:
   - Mechanical design and assembly procedure of the 1m^2 prototype have been validated
   - Smooth functioning during test beam over one month
   - Test beam main goals have been successfully reached. First results are available
2. Design and production of an optimized readout ASIC
3. DIFs for 1m^3 have been produced and successfully tested. An intermediate DAQ is available for large number of DIFs readout
4. Simulation work has allowed a better understanding of the SiD detector and has given valuable informations for test beams

Current work

1. Data analysis of the 1 m^2 prototype test beam in June/July 2010
2. Test beam of actual 1 m^2 prototype with the W-structure in November 2010
3. Work towards the production of several 1 m^2 chambers with new frontend electronics
4. Participation in the new CALICE DAQ effort
5. Test of the new readout electronics for future 1 m^2 chamber. First MICROROC chips have been received