MICROMEGAS for Imaging Hadronic Calorimetry at Linear Colliders

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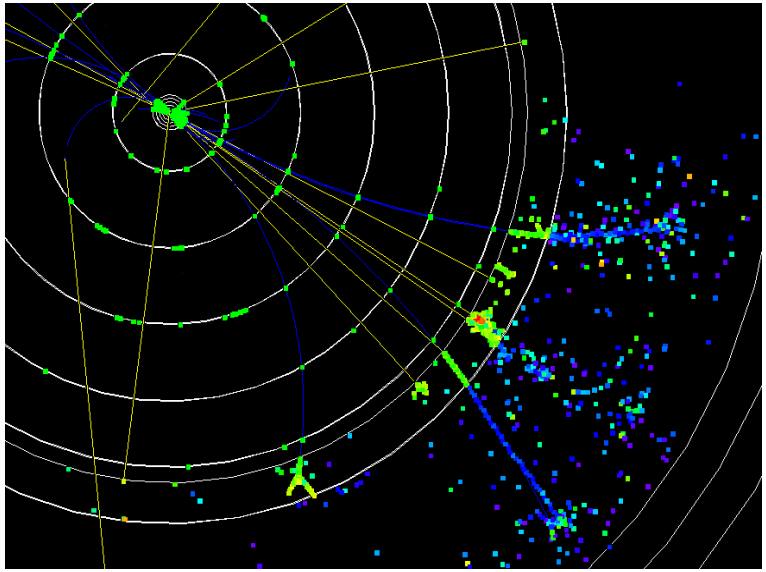
on behalf of the CALICE collaboration

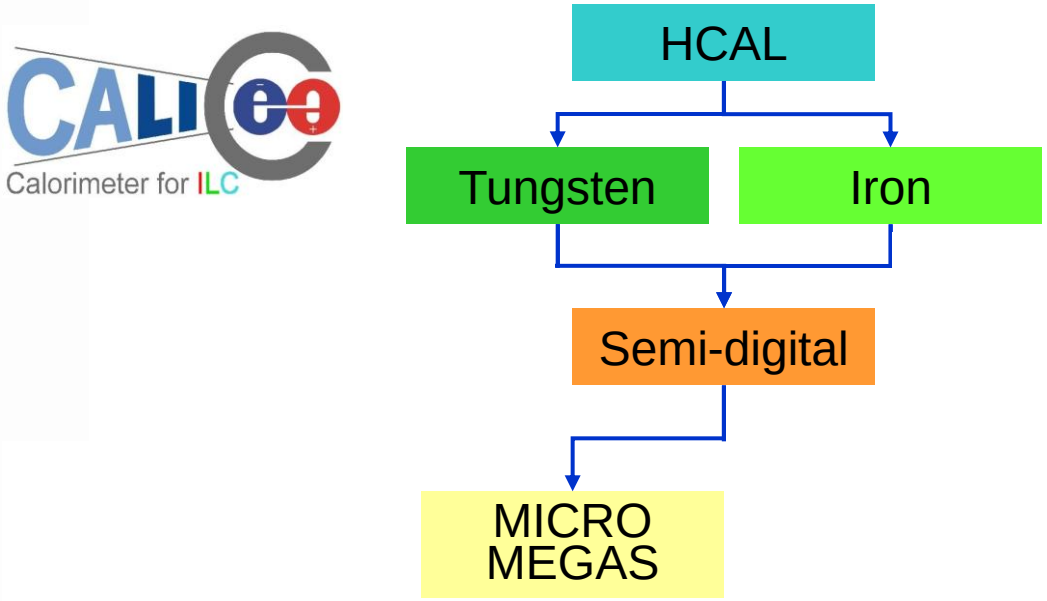
Calorimetry at Linear Colliders

- Calorimetry based on Particle Flow
  ⇒ Imaging calorimeters:
  Compact showers
  High granularity



- For hadronic calorimeters
  - Granularity more important than energy resolution (up to 30 million channels)
    → *digital* option :
    1 bit readout – 1cm^2 cells
  - DHCAL : loss of linearity at high energy (100 GeV/c)
    → *semi-digital* option:
    2 bit readout – 1cm^2 cells

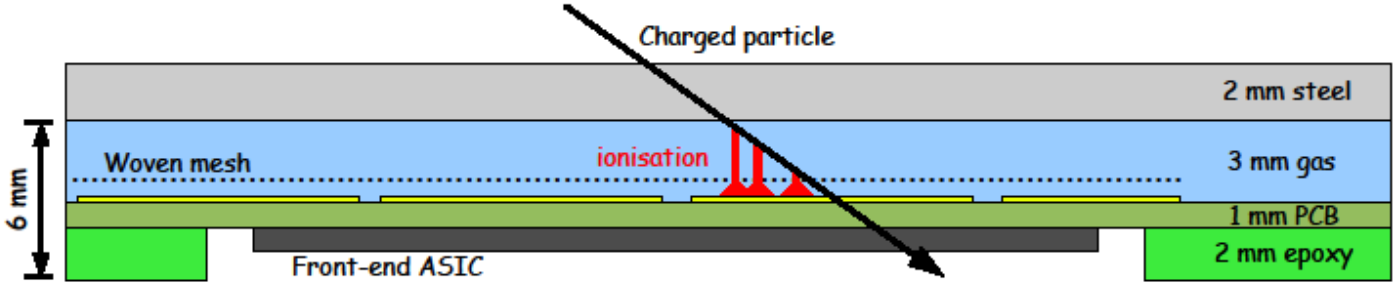
HCAL R&D



- SiD HCAL Mechanical Engineering Studies (N. Geffroy)
- Simulations (J. Blaha)
  - HCAL extensive studies (analog or digital/semi-digital readout, W or SS…)
  - SiD and CLIC Detector effort
- Developments for a 1m^3 SDHCAL with MICROMEGAS within the CALICE and RD51 collaborations

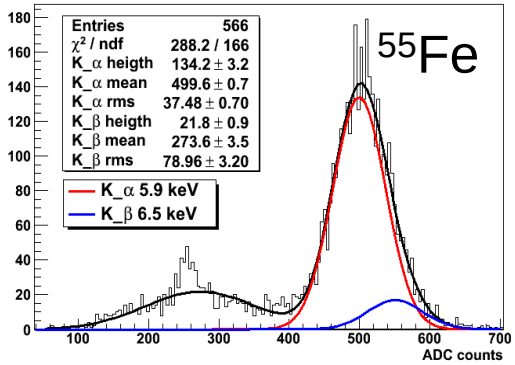
MICROMEGAS for a SDHCAL

- Characteristics:
  - Proportional mode
    3 mm ionisation gap
  - Bulk-MICROMEGAS
    128 μm amplification gap
  - 1 cm^2 pad
  - Electronics:
    embedded 2 bit readout
    (3 thresholds)
  - Operating at low voltage
    < 500 V
  - High detection rate
  - Robust, cheap (industrial process)
  - Thickness:
    down to 6 mm
  - Gas : Ar95% Isobutane5%



MICROMEGAS for a SDHCAL

- Prototype basic performances (analogue readout)
  - Energy resolution @ 5.9 keV ~ 7.5 % (FWHM = 17.6 %)
  - MIP most probable value : ~ 20 fC
  - At 1.5 fC threshold :
    - Efficiency > 97% with 1% relative variation (384 channels)
    - Multiplicity < 1.1



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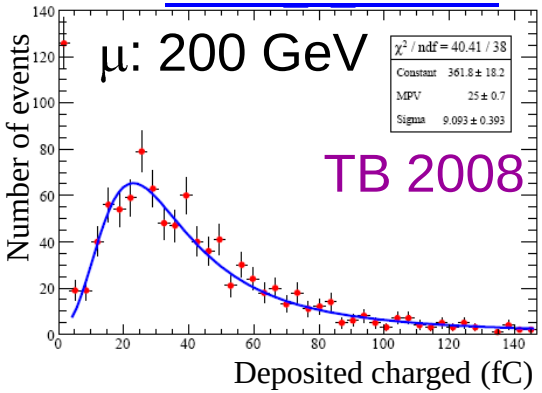
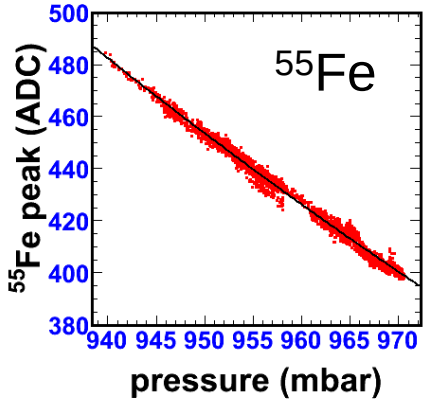
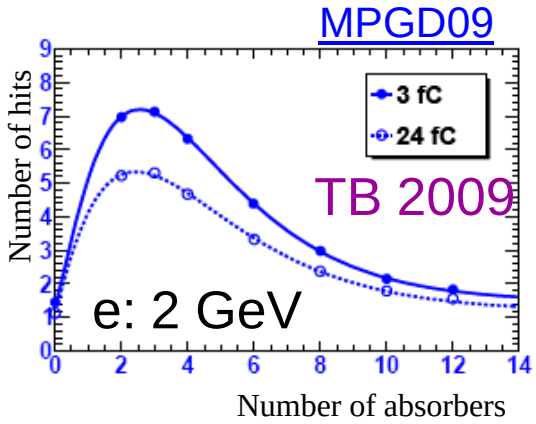


MICROMEGAS for a SDHCAL

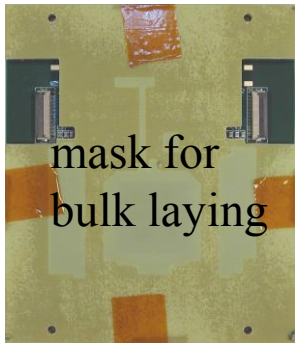
- Prototype basic performances (analogue readout)
  - Gain sensitivity to ambient parameters
    - pressure : –0.6 %/mbar
    - temperature : 1.4 %/K
  - Excellent behaviour in electromagnetic and hadronic showers

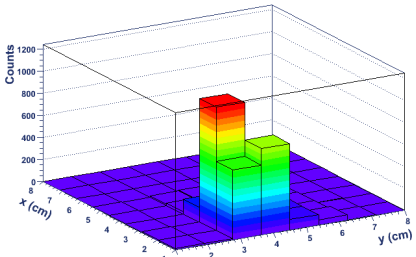




1 m² MICROMEGAS Prototype

- 2008 : First operational Bulk MICROMEGAS with 1 embedded readout electronics !
- 2009 : 48x32 cm² bulk MICROMEGAS with 24 embedded ASICs





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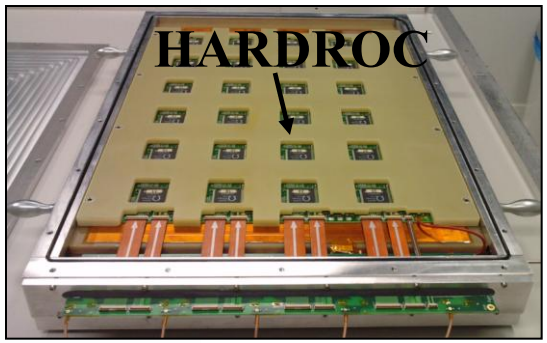
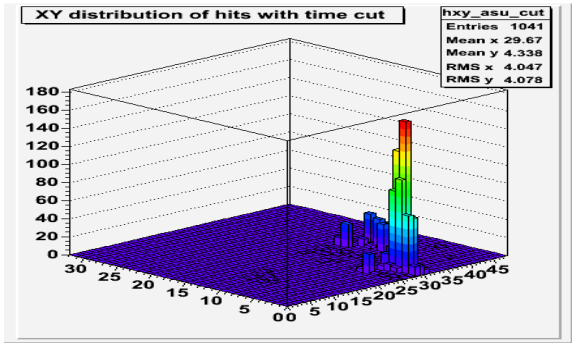
Beam Profile
Aug. 2008

1/6 of m²



Test box



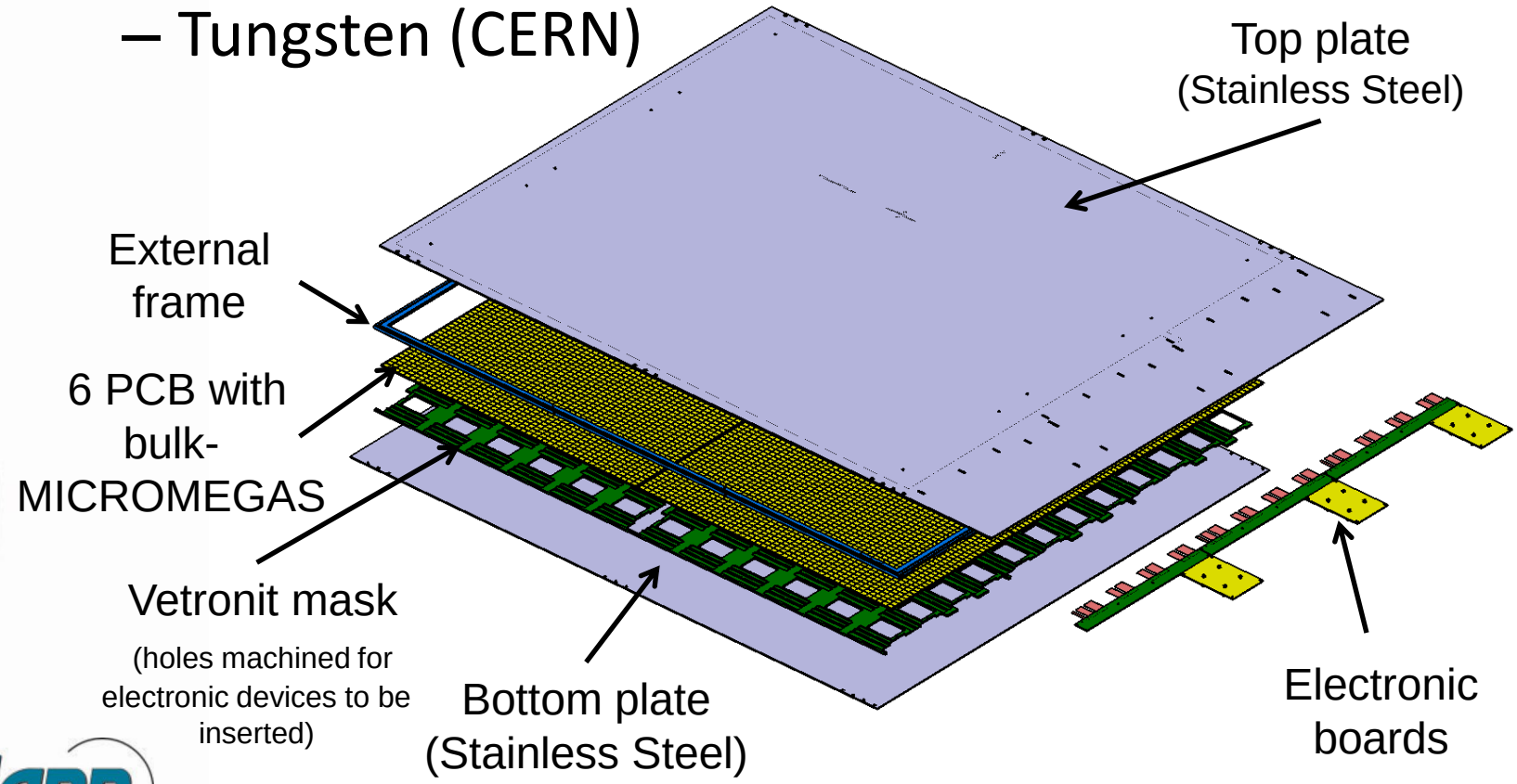
Beam Profile Nov. 2009

1 m^2 MICROMEGAS Prototype

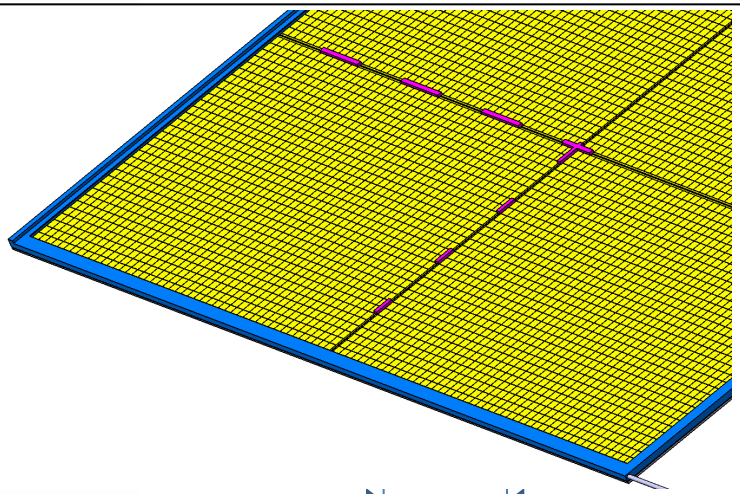
- Prototype technological choices
  - 6 independent bulks
    (controlled individually inside the test box)
  - 24 ASICs per bulk (64 channels per ASIC)
  - 5 mm gap between pads from 2 bulks
    → 2 % dead area inside gas volume
  - 12 mm total thickness
    (incl. 2+2mm steel covers)
  - 1 Detector interface board (DIF) per slab (2 bulks)
  - Fits for the 1m^3 steel or tungsten structures

1 m^2 MICROMEGAS Prototype

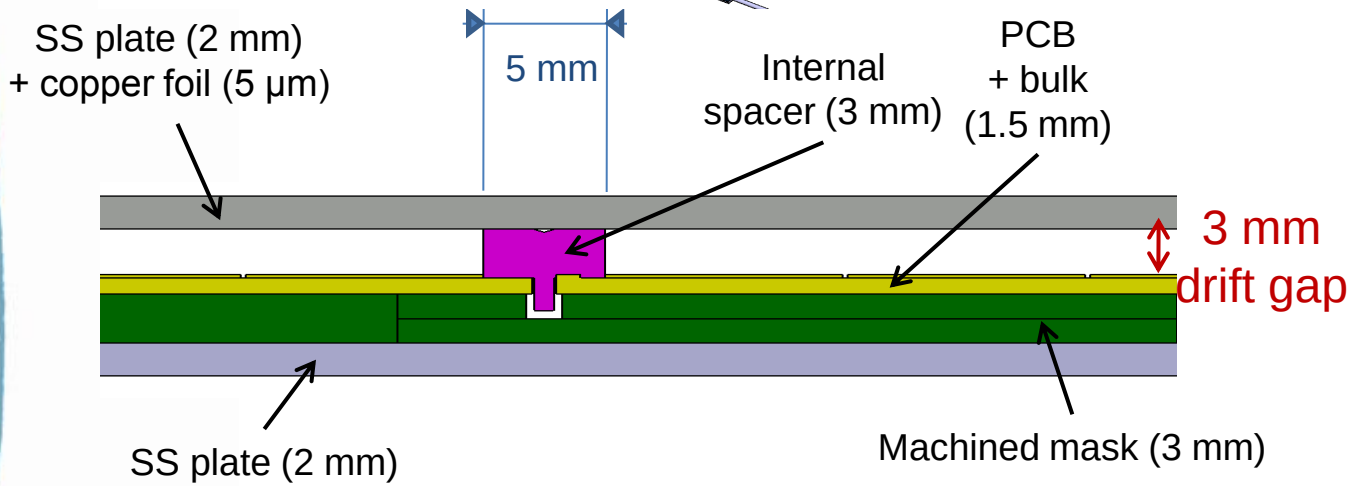
- MICROMEGAS layers fit in 2 large structures:
  - Iron (CIEMAT)
  - Tungsten (CERN)



1 m² MICROMEGAS Prototype



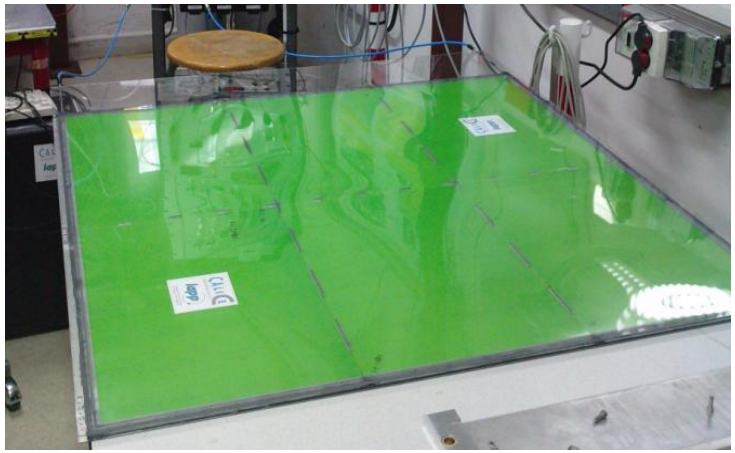
frame + internal spacers
fix the 3 mm drift gap



11.5 mm thickness + glue + tolerance = 12 mm total thickness

1 m^2 MICROMEGAS Prototype

- 2009 :
  Assembly procedure validated on mechanical prototype
- 2010 :
  first prototype
  - 4 bulks with HR2
  - 1 bulk with HR2b
  - 1 dummy PCB

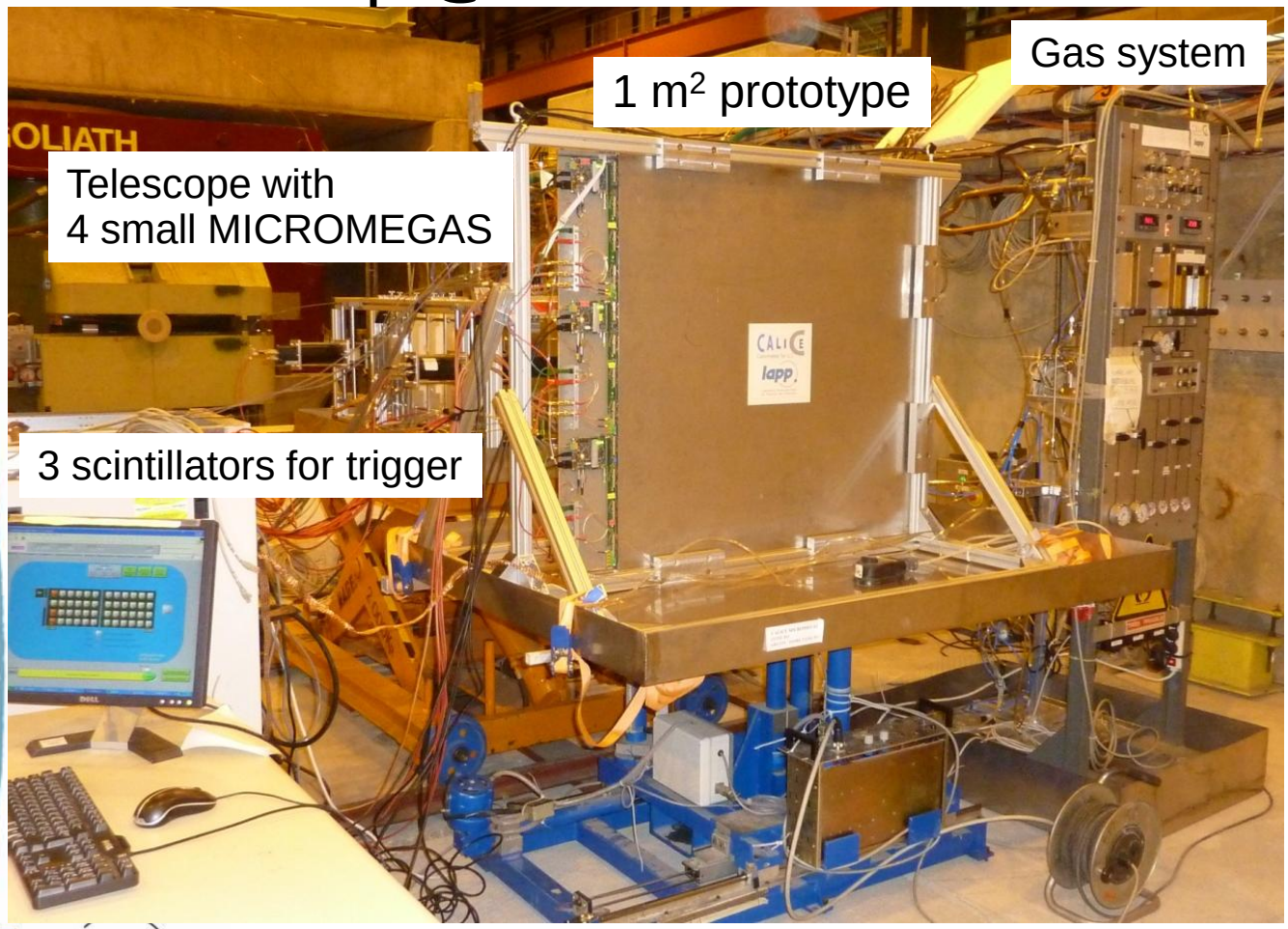


After 1 week

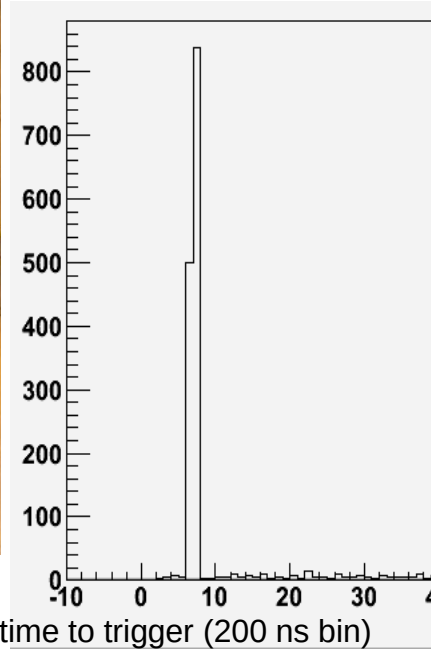
the 1 m^2 is fully assembled!

1 m^2 June/Jully 2010 Test beam CALICE & RD51 beam time

- TB setup @ CERN-SPS



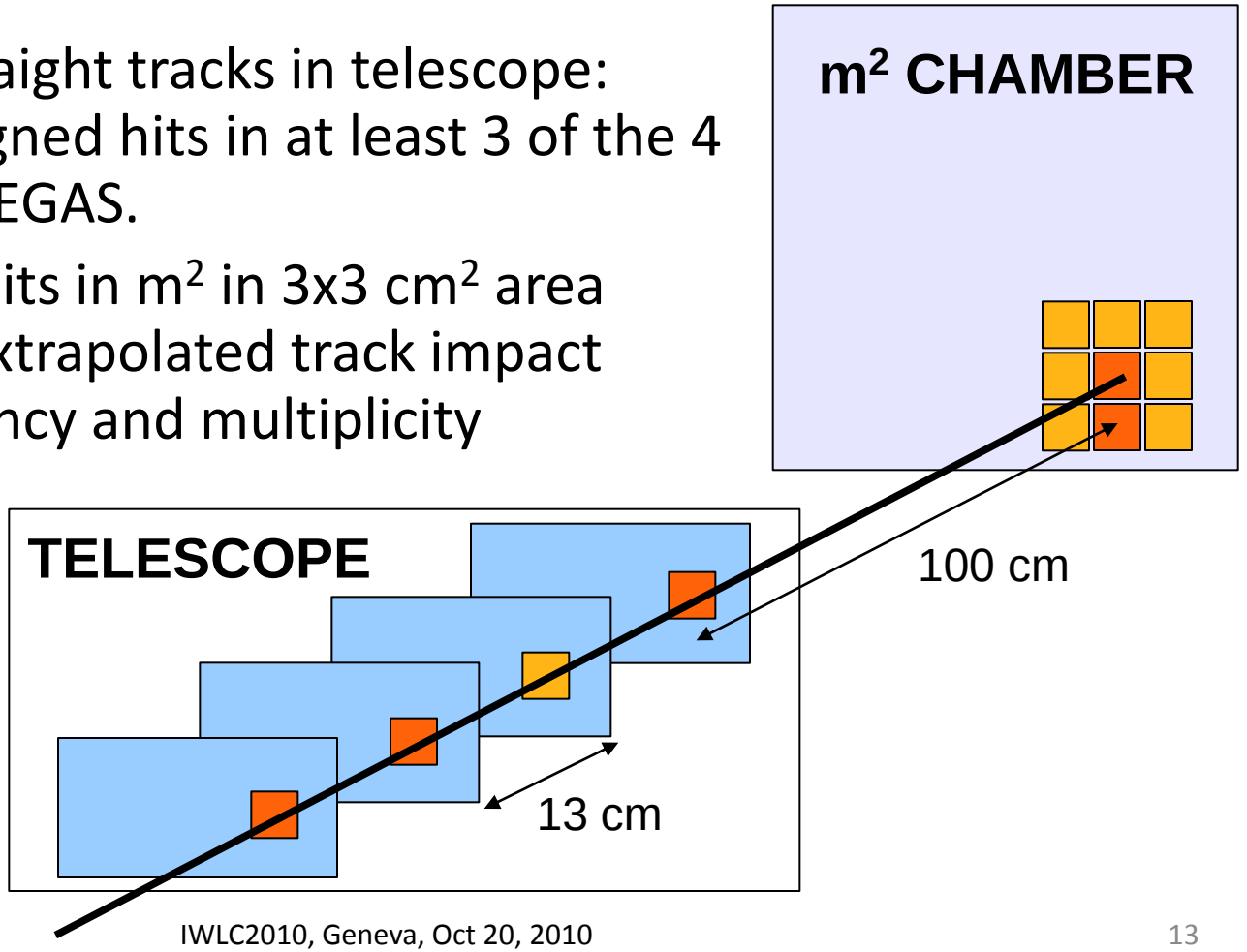
- synchronization telescope+1m^2 (busy $\Rightarrow$ veto)
- Delay of ~1 μs between trigger and HR2 readout: time to trigger info used to find beam particle hits



time to trigger (200 ns bin)

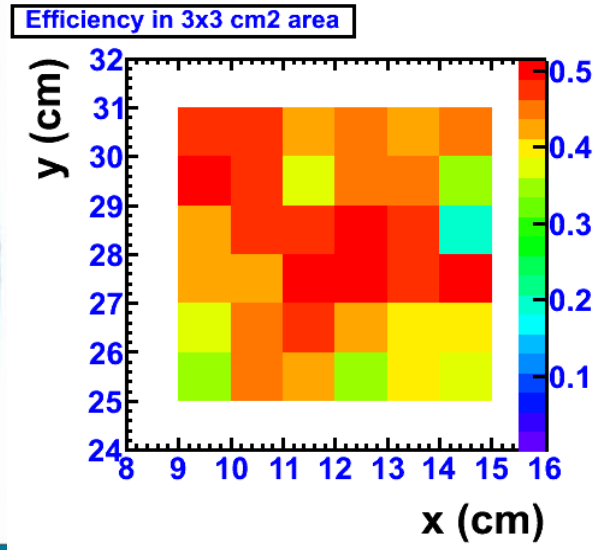
Preliminary Analysis (M. Chefdeville)

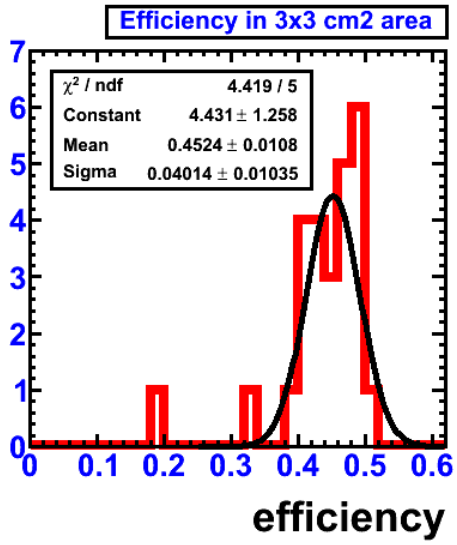
- Use telescope to extrapolate tracks to the m^2
  - select straight tracks in telescope: single aligned hits in at least 3 of the 4 MICROMEGAS.
  - look for hits in m^2 in 3x3 cm^2 area around extrapolated track impact $\Rightarrow$ efficiency and multiplicity

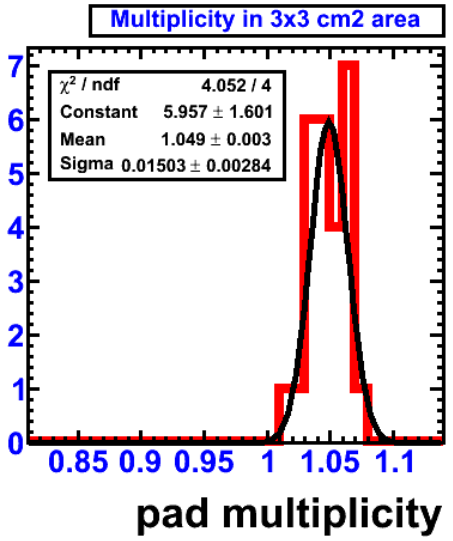


Preliminary Results (M. Chefdeville)

- V_{mesh}= 420V ⟹ maximum efficiency
  - Gas gain ~ 15000 → expected Landau MPV ~ 20 fC
  - due to a too short shaping time of HR2, only 10 % of the signal is seen → effective signal MPV is 2 fC !
- Noise hit probability after time cut ~ 0.01 % per channel
- 1 chip (HR2b with gain equalized)
  - Average efficiency of 45.2 ± 4.1 %
  - Average multiplicity of 1.05 ± 0.02

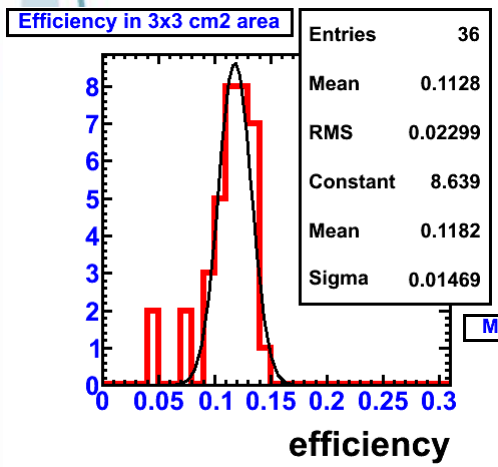




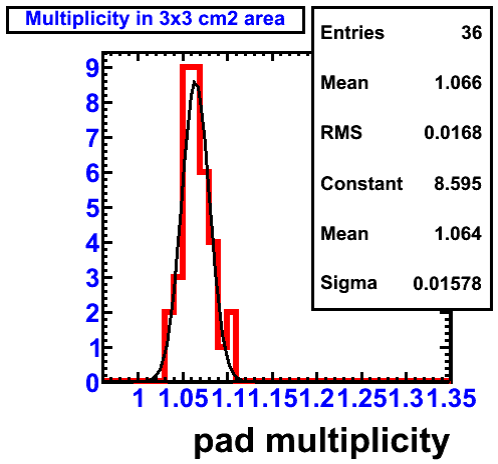


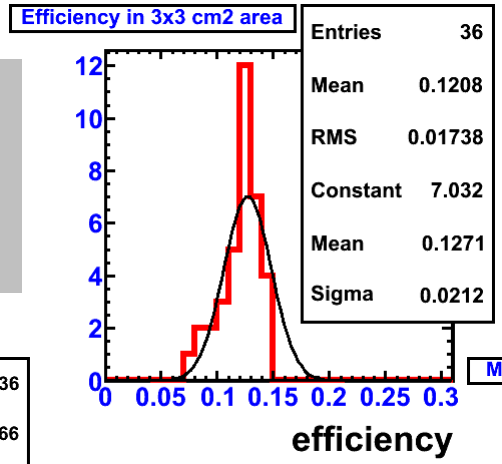
Preliminary Results (M. Chefdeville)

- V_{mesh}= 410V $\Rightarrow$ uniformity for efficiency/multiplicity
  - All chips of the HR2b bulk
  - 400000 triggers per chip
- First results on 2 chips : mean values and RMS remain the same

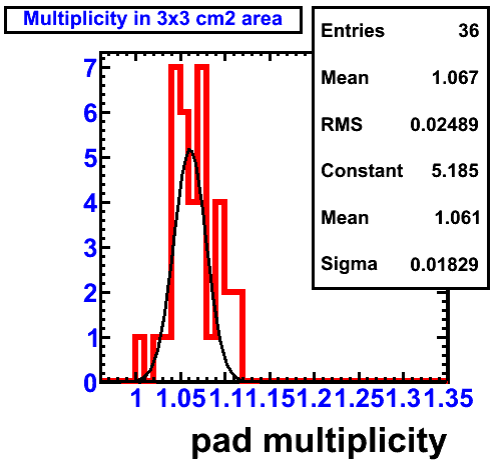


CHIP 124
Close to center
11.2 % +/- 1.5 %
1.07 +/- 0.02



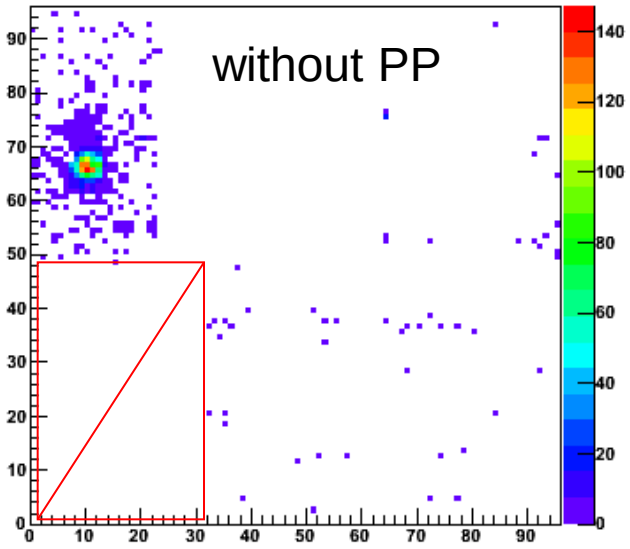


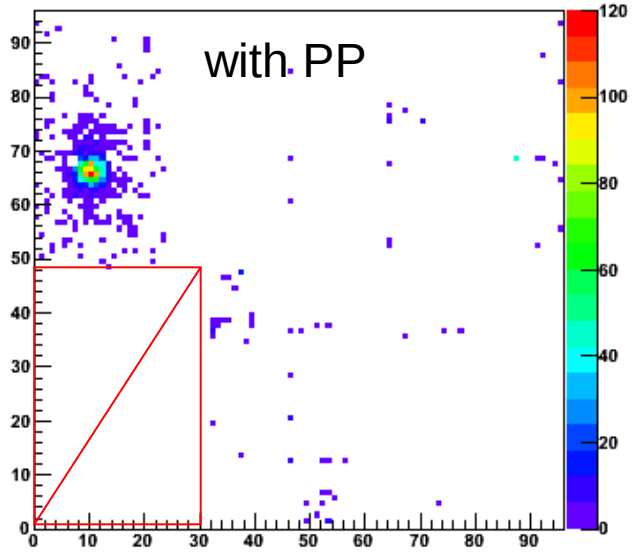
CHIP 114
Close to spacers
12.7 % +/- 1.6 %
1.07 +/- 0.02



Power Pulsing (R. Gaglione, G. Vouters)

- Preliminary study
  - DIF+InterDIF ~ 1.2-1.3 A
  - HR2 of 1 ASU (analog) ~ 0.4-0.5 A , except for first ASU ~ 1.4A (12 faulty chips)
  - 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: quantitative analysis is on going





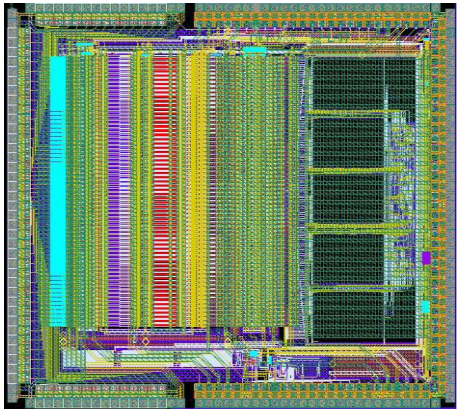
1 m^2 Test Beam Summary

- Mechanics : the Square Meter is gas tight and robust.
- Electronics :
  - Careful grounding : good noise condition
  - Electronic gain equalized (only for HR2b)
  - Successful synchronization between Gassiplex (telescope) and HR DAQs
  - The HR DAQ is stable and reliable
  - Power Pulsing was performed for the complete square meter
- Detector :
  - MESH are stable (very few HV supply trips)
  - High gain possible (MESH tested up to 420V = Gas gain up to 15000)
- Software :
  - Reconstruction of simultaneous events from both DAQs
  - File book keeping
- Lot of data taken with the whole MICROMEGAS Square Meter (5 ASUs) plus multiplicity and efficiency scan of each HR2b
  $\Rightarrow$ Very promising preliminary results

Progress on DAQ and FE

- Detector Interface (DIF)
  - 170 DIF board have been produced and tested
  - 165 out of 170 DIFs are fully operational
  - Intermediate DAQ with CCC fully operational
  - CALICE DAQ v2 collaboration work : DHCAL-DIF code

- MICROROC (for SDCHAL- MICROMEGAS or GEM)
  - Development with LAL/OMEGA
    - Same digital part as HARDROC (LAL/OMEGA)
      ⇒ easy integration to actual PCB and DAQ
    - New analogue part + sparks protection network (LAPP)
    - Shaping time matching the detector signal duration
    - Blocks integration (LAL/OMEGA)
  - First prototypes have been produced
  - Preliminary tests :
    - functionality ok
    - peaking time matching specification
    - gain values at 10 % from simulation
    - trigger on 1fC (Cdet ~75pF)



Conclusion

- Success of the first 1m^2 MICROMEGAS prototype:
  - Mechanical design and assembly procedure of the 1 m^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
- Design and production of MICROROC, a MICROMEGAS optimized readout ASIC
- DIFs for 1m^3-RPC have been produced and successfully tested. An intermediate DAQ is available for large number of DIFs readout for MICROMEGAS or RPC

Future

- Finalise test beam data analysis of the 1 m^2 prototype
- Test beam of 1 m^2 prototype inside the W-structure NOW!
  - common counter with AHCAL-DAQ -> shower profile
- Extensive test of the new FE readout electronics MICROROC
- Production of several 1 m^2 chambers with MICROROC
- Participation in the CALICE DAQ v2 effort

19th November 2010 : 1m² MICROMEGAS inside the W-structure (T7 @ CERN-PS)

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Irfu cea saclay

LAL Omega

IPNL lyon

Imperial College London

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