Assembly of the first 1 m^2 Micromegas with digital readout for a sDHCAL

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LAPP

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Outline

Micromegas DHCAL project

- Calorimetry based on PFA at future linear colliders: granularity more important than resolution
  $\longrightarrow$ digital readout of 1 cm^2 cells

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  $\longrightarrow$ digital readout of 1 cm^2 cells
- Loss of linearity at high energy ($\geq$ 100 GeV/c)
  $\longrightarrow$ semi-digital readout
- Large area with gaseous detectors
  $\longrightarrow$ RPC, GEM, Micromegas

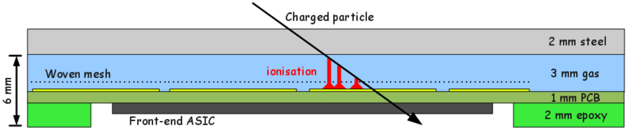
Micromegas DHCAL project

Pros

Proportionality
Low working voltage (≤500 V)
Standard mix (Ar, iC_4H_{10}, CO_2)
Industrial production (Bulk)

Cons

Sparks (rate, gain dependent)
Small charges (≈ 25 fC for MIPs)



R&D efforts for the construction of a
physics and technological sDHCAL prototype of 1 m^3
→ 40 planes of 1 m^2 each (20 mm SS + 8 mm detector)

Performance with small prototypes

- Tests with MIPs carried out at SPS/H2 in 2008
  - 97 % efficiency at 1.5 fC threshold
  - multiplicity below 1.12 (1.5 fC)
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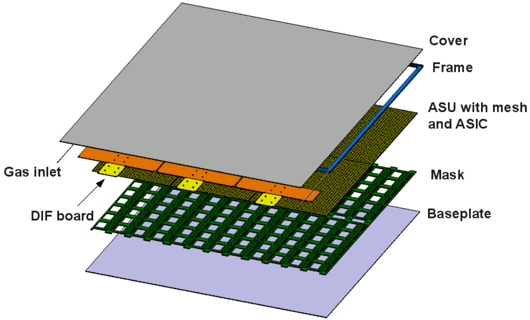
  - 2.36 % K/mbar
- Most results available in 2009 **JINST** 4 P11023

Design of the 1 m^2 prototype

- 6 Active Sensor Units (ASU) of 32×48 cm^2
- 24 ASIC with 64 channels (per ASU)
- 12 mm thick including 4 mm stainless steel (covers)
- Active area of $9216/10^4 \approx 93$ %
- Assembly procedure validated with mechanical prototype



ASU with HARDROC2

- HARDROC2 (64 channels) circuitry:
  - current preamplifier with adjustable gain (0–2)
  - slow/fast shaper for analog/digital readout
  - 3 discriminators with adjustable threshold (individual gains but 3 common threshold)
  - 200 ns timestamping of hits
  - 128 event depth memory
  - power pulsing capability (not used so far)

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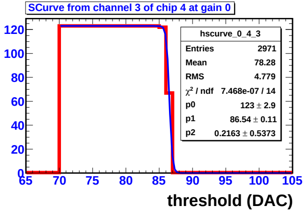
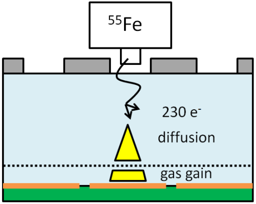
- Fast shaper time constant (20 ns) too short w.r.t. Micromegas signals (150 ns)
  $\longrightarrow$ poor efficiency
  $\longrightarrow$ work on new chip with LAL/Omega on-going (MICROROC)

ASU characterisation

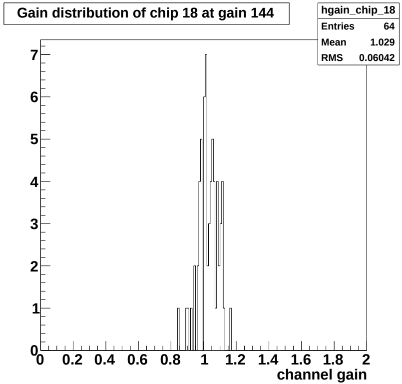
- Electronic test
  - measure noise level
  - identify noisy channels
  - measure preamp gain
  - achieve lowest threshold
- Test in a gas chamber
  - ^{55}Fe quanta
  - study chip parameters
  - effect of drift and amplification field





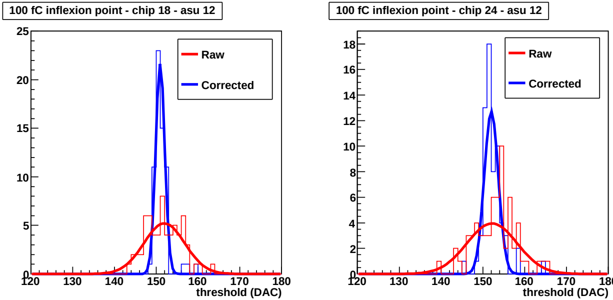
Preamplifier gain measurements

- Measure Scurves for different input charges (0,20,100,200 fC) Agilent pulse generator and attenuator
- Calculate slope of inflexion point VS input charge variations



Gain equalization

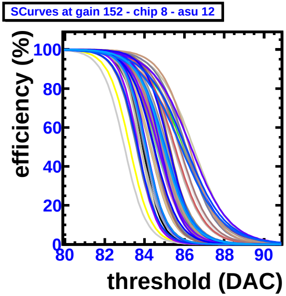
- Apply correction factor to preamplifier gain g
  - simply calculated as $\overline{g}/g_{\mathrm{i}}$
  - check equalization with charge injection:
    Chip 18: 3.2 % → 0.8 % Chip 24: 4.0 % → 1.2 %

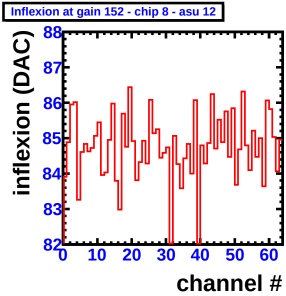


- Uniform response of HCAL will be important
  however, most important with HR2 is to achive low threshold

Pedestal alignment

- How to reach the minimum charge threshold?
  - Ideal case: all pedestal Scurves super-imposed
    $\rightarrow$ threshold 5σ above the inflexion point μ
  - Unfortunately: at same preamp gain, dispersion of μ_i and σ_i
  - But: μ_i and σ_i depends linearly on preamp gain
    $\rightarrow$ adjust gains g_i to minimize spread of μ_i or $(\mu_\mathrm{i}+5\sigma_\mathrm{i})$





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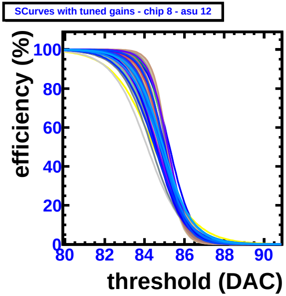

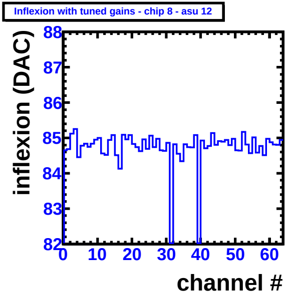

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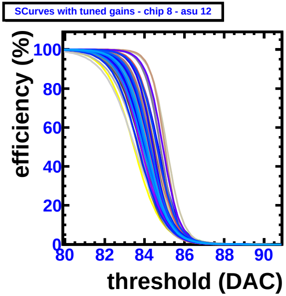

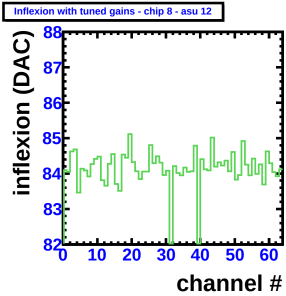

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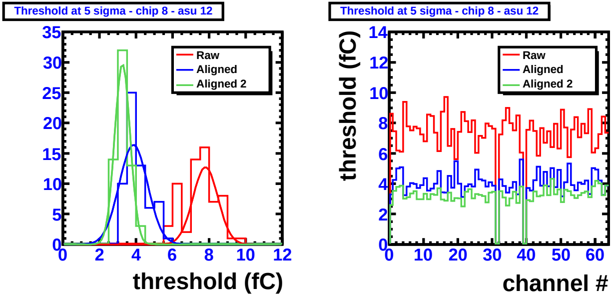

^{55}Fe tests in gas box

- Gas test box
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  - Longitudinal diffusion gives $\sigma_t = D_L\sqrt{z}/v_d = 13\sqrt{z}$ ns
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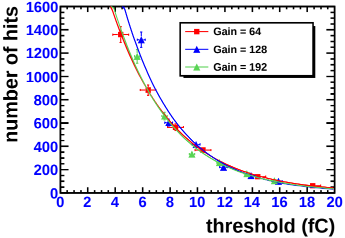
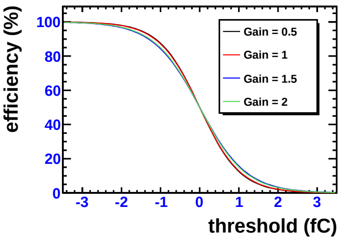
- Method:
  - External signal triggers the readout of the detector (30 Hz)
  - Count the number of hits recorded on the tested pad

Preamplifier gain

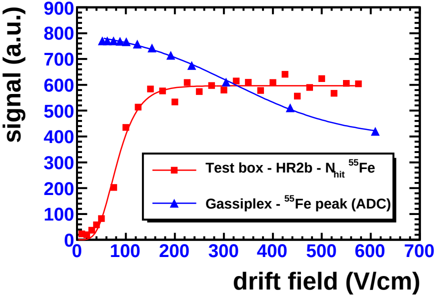
- For a different preamp gains (0.5,1,1.5)
  - Decrease threshold from high value to noise level
  - Signal to noise ratio similar
    $\longrightarrow$ same number of hits





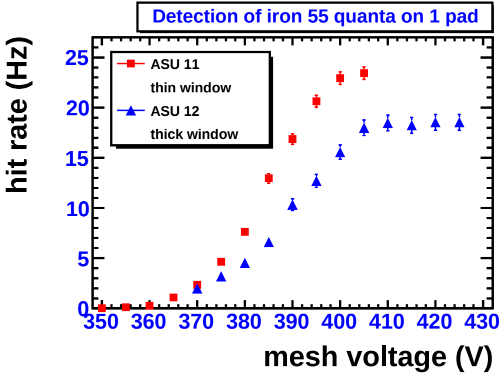
Drift field

- Combination of three effects:
  - Collection efficiency drops above certain field
  - Drift velocity has a local maximum, 4.2 cm/μs at 250 V/cm
  - Long. diffusion coefficient drops: 450–200 μm/$\sqrt{\mathrm{cm}}$ at 100–1000 V/cm
- Last two effects govern time spread of the e^- at the mesh



Amplification field

- At higher amplification field:
  - Total charge induced on pad increases ($\sim \exp(\alpha d)$)
  - But fraction $Q_{\text{electrons}}/Q_{\text{ions}}$ drops ($\sim 1/\alpha d$)
- Net effect is an increase of the number of detected photons
- Plateau reached at 410 V at which the gas gain is about 10^4



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- Assembly started Monday last week, ready for test on Saturday

ASU glueing

- HV and electronics tests
- Glueing of ASU slab on a vetronite mask


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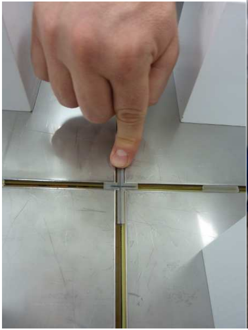
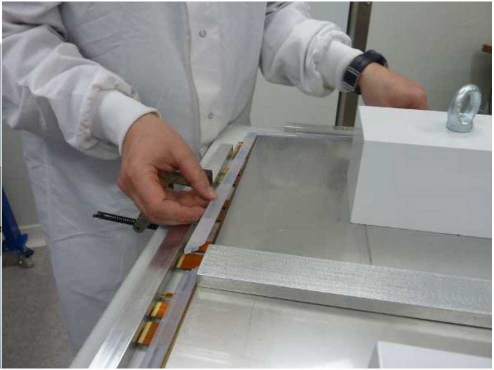
Spacers and frame glueing

- Spacers will define the 3 mm gas gap
- Frame insure gas distribution and tighness



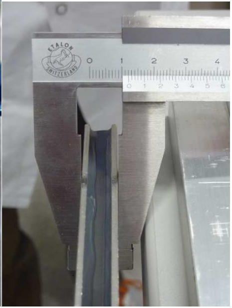


Cathode and cover glueing

- Cathode is a copper foil glued on stainless steel plate
- Cover area larger than 1 m^2 to support the readout electronics

After assembly

- Connection failure of one flexible cable
  $\rightarrow$ 1 row of chip over 12 is not responding, rest is fine
- Total thickness is 12 mm which includes 4 mm of steel
  $\rightarrow$ effective thickess of 8 mm complies with ILC goal
  could be reduced to 6 mm



Conclusion and future plans

- About to complete an important milestone of the projet: fabrication and characterisation of the first 1 m^2 Micromegas prototype with embedded digital electronics
- Focus in the 2 coming weeks on beam test at SPS/H4 starting on June 10^{th}
  Comics test at LAPP till then
- Due to short shaping of HR2, poor efficiency expected
  $\rightarrow$ work on a new chip is on-going in collaboration with LAL/Omega
- New chips available before the end of the year
  $\rightarrow$ more 1 m^2 prototype not before next year