New results of micromegas (microbulk) detectors

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on behalf of the collaboration
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Signal stabilization time for different micromegas readouts

Micromegas stabilization time

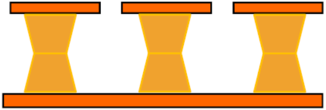
Experiment description

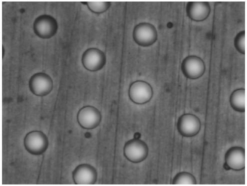
- We have checked the time needed for microbulk readouts to stabilize after voltages have been switched on. Observations in GEMs: some hours.
- Four different micromegas readouts studied:
  - Standard (classical) microbulk (M2).
  - Standard microbulk after being etched (M11).
  - Microbulk with pillars.
  - CAST detector, made with standard microbulk technology and with a 2D anode plane.
    See A. Giganon's talk for more details!!
- Different stabilization times and amplitude variations observed, which can be related to the quantity of kapton.

Micromegas stabilization time

Readouts description

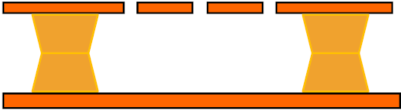
Standard micromegas

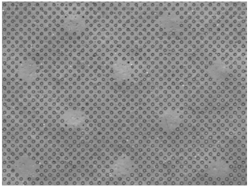




Gap: 50 μm; holes: 40 μm; pitch: 100 μm.

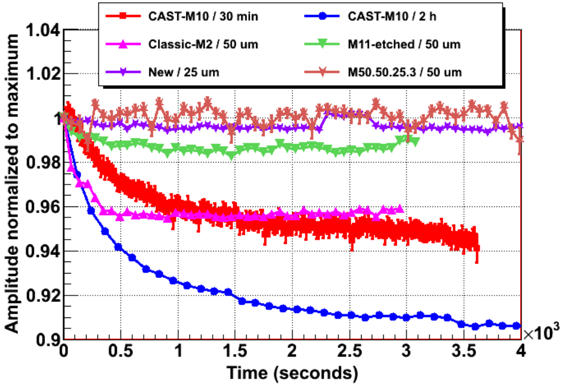
Micromegas with pillars





Areas without holes & full etching underneath normal holes.

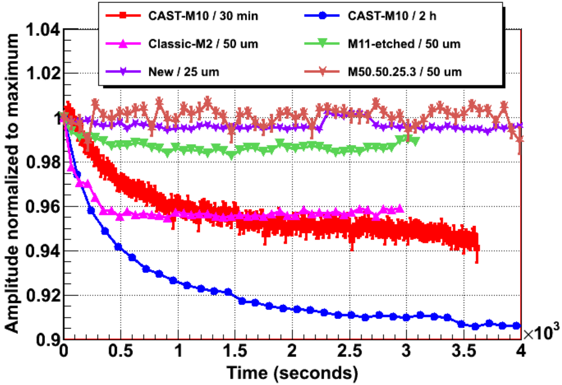
Signal stabilization time
Results



- CAST detector needs 30-40 minutes to stabilize. Kapton?
- A decrease in the amplitude of 5 and 9 % observed.

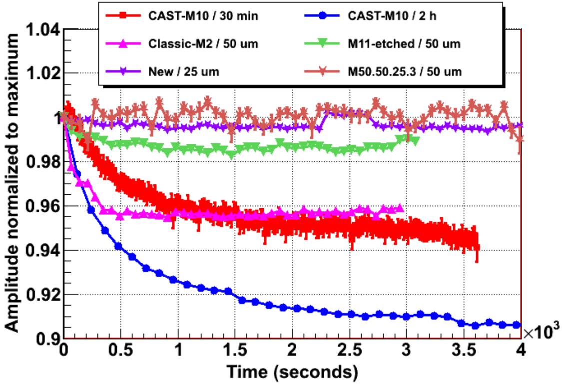
Signal stabilization time

Results



- Standard (and etched) microbulk need 10 mintues to stabilize.
- Signal amplitude decreases a 4 % (standard) and 1.5 % (etched).

Signal stabilization time
Results



- Microbulk with pillars show no amplitude decrease.
- They have the less quantity of kapton of readout studied.

Micromegas readouts at high energy and pressure

Tests with micromegas readouts

Collaboration work: IRFU/CEA-Saclay & University of Zaragoza.

Characterization of microbulks (25 & 50 um gap) with an ^{241}Am source (which emits α 5.5 MeV) at high pressure gases.

- Gain vs amplification field and maximum gain.
- Electron transmission vs ratio of drift and amplification fields.
- Energy resolution vs drift field.

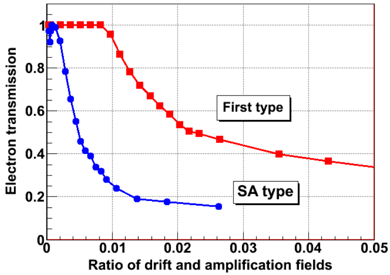
Gases and pressures studied:

- IRFU/CEA-Saclay: Ar-iC_4H_{10} mixtures, Ar and Xe up to 5 bar.
  Results published in the article:
  T. Dafni *et al.*, *Nucl. Inst. Meth. A* **608** (2009) 259-266.
- Zaragoza: same gases up to 10 bar. Results to be published soon!!!

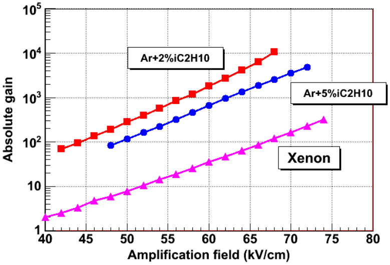
Focus on properties in pure argon.

Micromegas

Readouts characterization: Gain and electron transmission



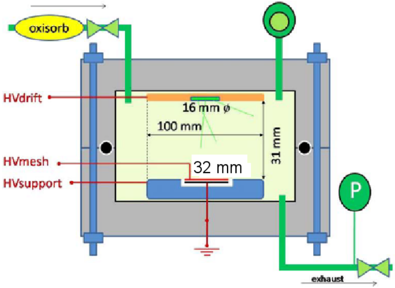
Electron transmission curve



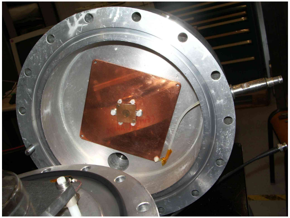
Gain vs amplification field

- Presence of a plateau at low drift fields: all electrons cross the mesh.
- Exponential dependence of the gain with the amplification field.
- Energy resolution in Ar + 5% iC_4H_{10} at 1 bar: 11 % FWHM.

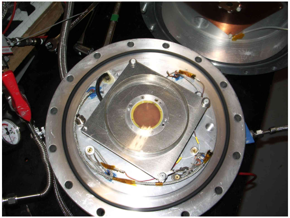
The HELLAZ high pressure TPC
Setup description



Sketch of the setup



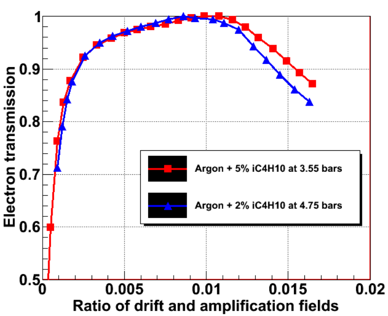
Upper cap



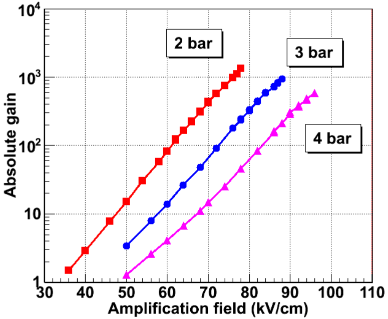
Lower cap

- Aluminium vessel.
- Electric and gas feedthoughs.
- Complete gas system.

Argon-isobutane measurements
Gain and electron transmission



Electron transmission curve

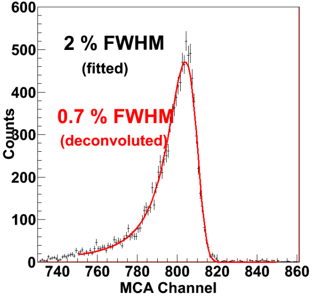


Gain vs amplification field

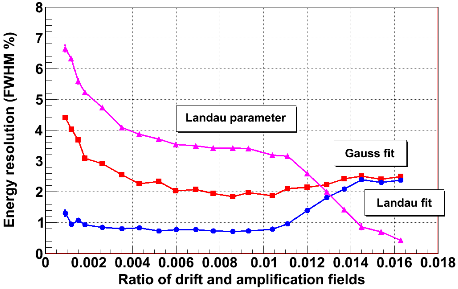
- Electron transmission curve compatible with the standard one.
- Maximum gain reached: $> 7 \times 10^2$ in all pressures.

Argon-isobutane measurements

Energy resolution at 5.5 MeV and 4 bar



Energy spectrum

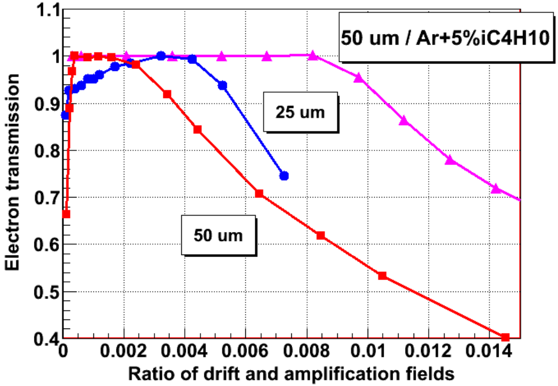


Energy resolution at 5.5 MeV vs drift field

- Energy resolution: 2 and 2.3 % FWHM at 2 % and 5 % iC_4H_{10}.
- Asymmetric shape of the peak due to incomplete charge collection.
- Estimation 0.7 and 0.9 % FWHM at 2 % and 5 % iC_4H_{10}.

Pure argon measurements

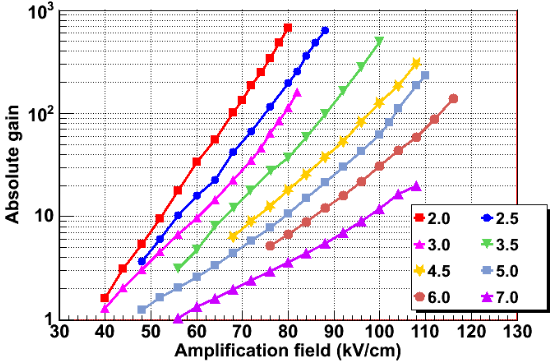
Electron transmission curve



- 50 μm gap: 5 times shorter plateau than in Ar-Iso mixtures.
- 25 μm gap: a strange plateau 2.5 times shorter.

Pure argon measurements

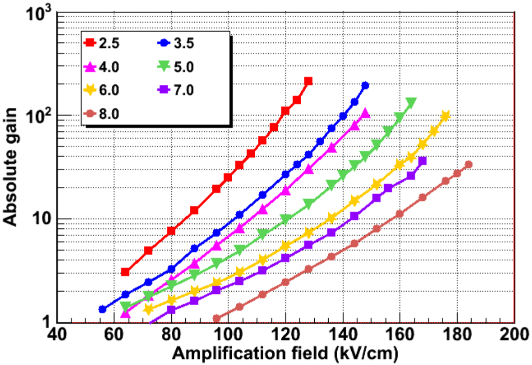
Gain vs amplification field (50 μm-gap)



- At < 3 bar, maximum gain not reached ($> 7 \times 10^2$).
- Maximum gain lowers with pressure (1.5×10^2 at 6 bar).

Pure argon measurements

Gain vs amplification field (25 μm-gap)



- 3 times lower maximum gain than for 50 μm readouts.
- Maximum gain also lowers with pressure but more slowly.

Gain in pure argon

Rose & Korff model

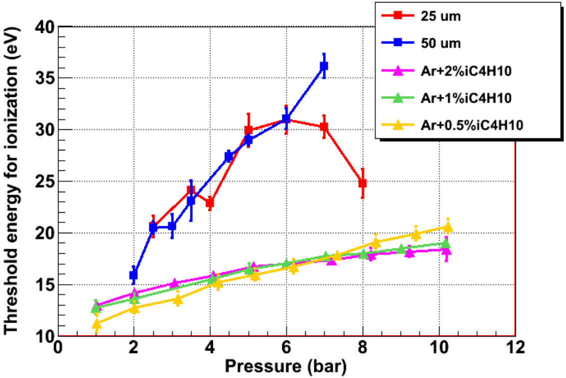
- The gain of a Micromegas detector can be explained by the Rose & Korff model of the avalanche multiplication:

$$ln(G) = \frac{d}{\lambda_e} \; \exp\left(\frac{I_e}{\lambda_e \; E_{amp}}\right)$$

  where d is the gap distance, λ_e is the electron mean free path in the gas, I_e is the threshold energy for ionization and E_{amp} is the amplificaction field.
- We have observed a dependence of I_e and λ_e with pressure. Real gas properties or model divergences?
- Results compared with Ar-Iso measurements in Zaragoza's HPTPC with a readout of 50 μm-gap.

Gain in pure argon

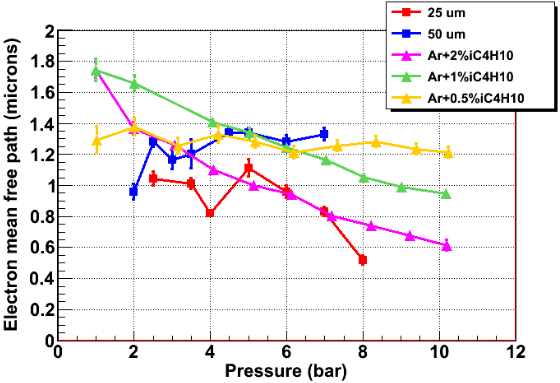
I_e versus pressure in pure argon



- Linear increase of I_e with pressure: $14.45 \pm 3.55(P-1)$.
- Similar dependence for Ar-Iso mixtures but with lower slope. Note that I_e is 10.8 eV for Iso and 15.8 eV for Ar at 1 bar.

Gain in pure argon

λ_e versus pressure in pure argon



- Constant values: 1.3 μm (50 μm) and 1 μm (25 μm).
- Value for the 50 μm-gap readout similar to Ar+0.5%iC_4H_{10}.
- At higher quantities of isobutane, λ_e decrease with pressure.

Pure argon measurements

Energy resolution

The energy resolution values obtained for pure gases in this setup are not so good as in argon-isobutane mixtures because

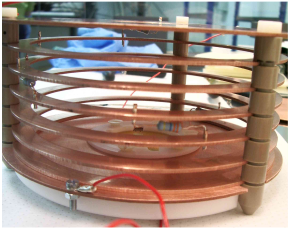
- it has no field cage to make drift field really uniform.
- gas quality is not so good (vacuum $\approx 5 \times 10^{-4}$ mbar and outgassing $\approx 10^{-4}$ mbar l/sec) due to inner components and aluminium TPC.

The experience acquired in this setup motivated the building of a completely new setup in Zaragoza.

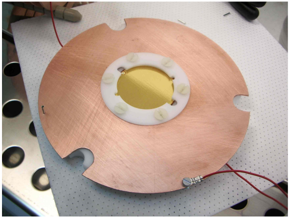
A new high pressure TPC in Zaragoza

Setup description

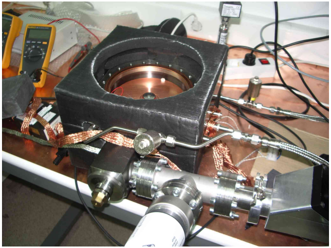
- TPC of stainless steel instead of aluminium.
- Drift structure to make drift field uniform.
- Low-outgassing plastics used: PEEK and DELRIN.



Drift structure



Readout support

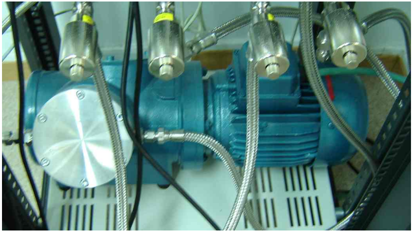


The TPC vessel

A new high pressure TPC in Zaragoza
Setup description

Vacuum and gas system

- Turbomolecular pump.
- Bake-out system (110°C).
- Gas recirculation through purification filters.

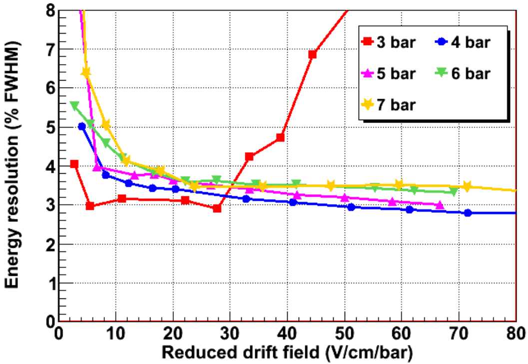


Recirculation pump

Purification filters

Pure argon measurements

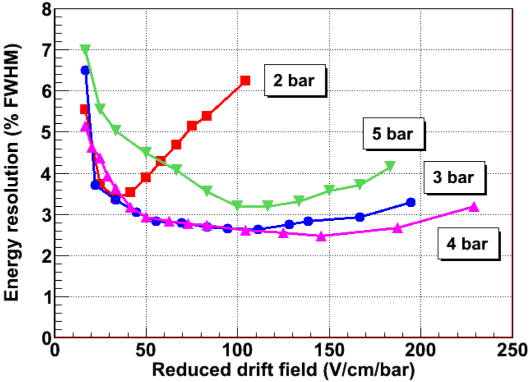
Energy resolution vs drift field at 5.5 MeV



- Values around 3 % and 4 % FWHM between 3 and 7 bar.
- At low pressures: geometrical effects. At high: attachment effects.
- At low drift fields: attachment.

Pure xenon measurements

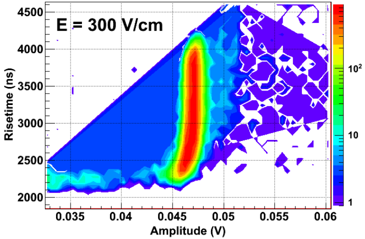
Energy resolution vs drift field at 5.5 MeV

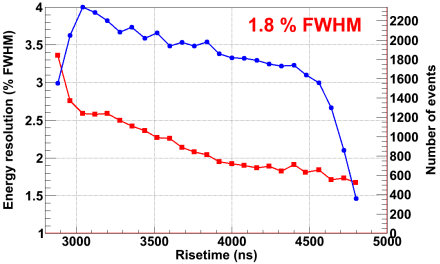


Improvement of values published:
3.4 (2 bar), 2.7 (3 bar), 2.5 (4 bar) and 3.2 % FWHM (5 bar).

Pure xenon measurements

Energy resolution vs drift field at 5.5 MeV

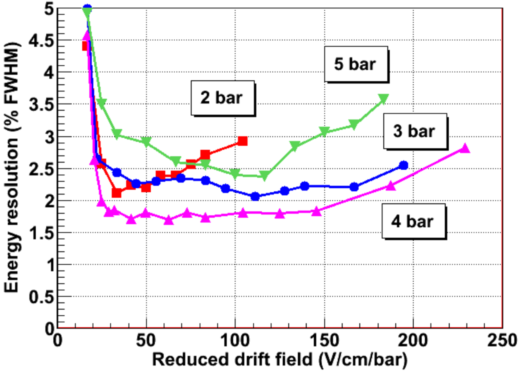




- Estimated energy resolution in absence of remaining effects (a bit of attachment, diffusion, recombination) selecting risetimes.
- Energy resolution is better for events with longer risetime.

Pure xenon measurements

Energy resolution vs drift field at 5.5 MeV



- A value of 1.8 % FWHM obtained at 4 bar.
- Micromegas technology can be applied in a Xenon TPC for a double beta decay experiment!!!!!

Conclusions

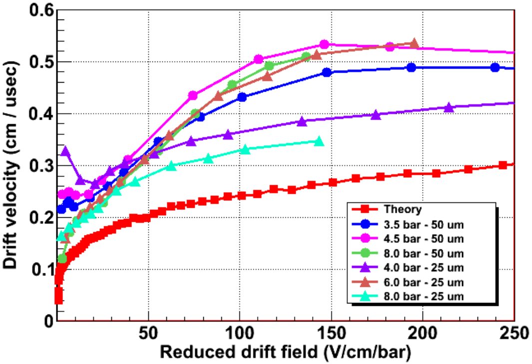
Conclusions

- Observed the time needed to stabilize and the amplitude variation for different microbulk detectors.
- Characterized microbulk readouts in pure argon: gain vs amplification field, electron transmission and energy resolution.
- A shorter plateau observed in electron transmission curves than for argon-isobutane mixtures.
- Gain curves have been fitted to Rose & Korff model: constant value of λ_e and linear dependence of I_e with pressure.
- Energy resolution values between 3 and 4 % FWHM.
- Pure xenon at 4 bar: measured energy resolution of 2.8 % FWHM. Estimated a value of 1.8 % FWHM. Micromegas can be used in a double beta experiment.

Back-up slides.

Pure argon measurements

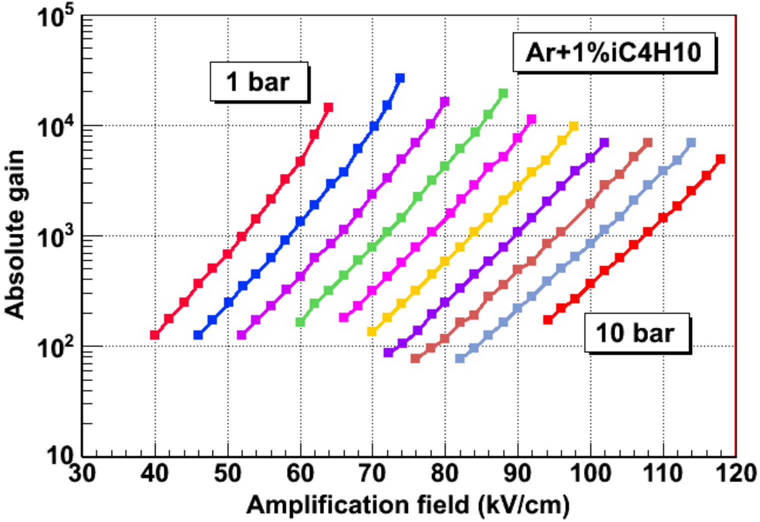
Drift velocity vs the reduced drift field



- Good match between data and theory.
- Differences can be explained by drift field uniformities.

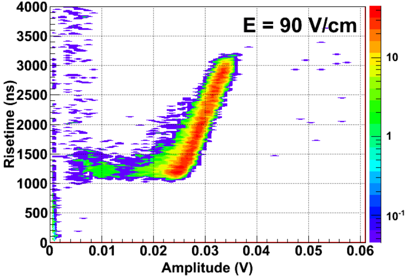
Argon-isobutane measurements

Gain vs amplification field for 1 %

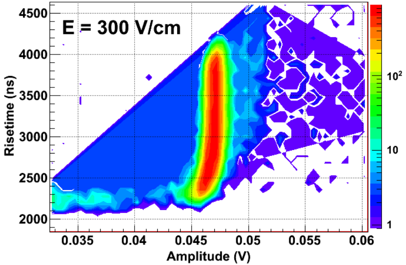


A new high pressure TPC in Zaragoza

Dependence of the amplitude with the risetime



Xenon at 4 bar in Saclay



Xenon at 4 bar in Zaragoza

- Vacuum: 10^{-5} mbar. Outgassing: 10^{-5} mbar l /s.
- No correlation in xenon for pressures up to 4 bar.
- Attachment effects cannot be avoided at 5 bar.