NEXT prototype based on Micromegas readouts

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NEXT EXPERIMENT

- A high-pressure, 100 kg gaseous Xe TPC to look for the **$0\nu\beta\beta$ decay of ^{136}Xe**
  - **$Q_{\beta\beta}$ at 2.46 MeV**
- **Baseline**: an **EL TPC**, energy measured by PMTs and tracking with SiPM.

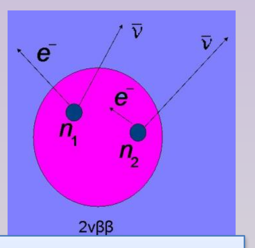
Parallel Study:

Microbulk Micromegas with pixelized anode to measure both energy in the mesh, tracks on the pixelized anode.

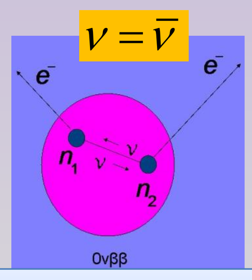
DOUBLE BETA DECAY

$\beta\beta0\nu$ would provide crucial information on

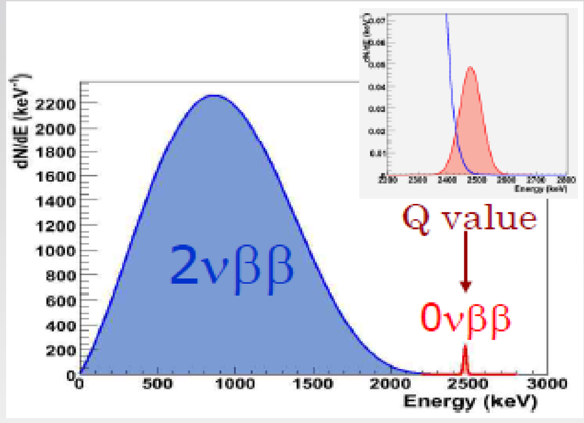
- ➢ Neutrino nature (Dirac or Majorana)
- ➢ Neutrino mass hierarchy (inverse or direct)



ββ2ν standard process, already observed (recently results in Xe from EXO & KamLand-Zen



ββ0ν process BSM, only possible if ν is Majorana.



Requierements

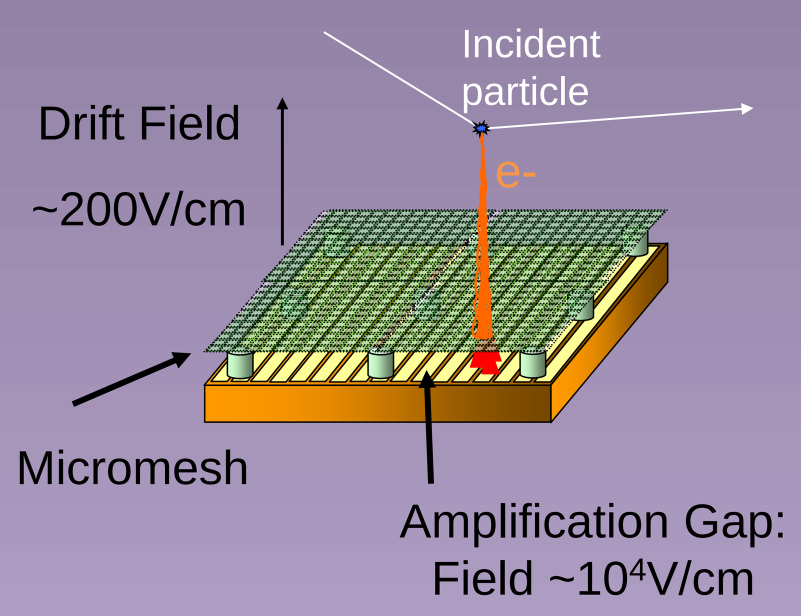
- ❑ Good energy resolution to separate **ββ0ν from ββ2ν** signal
- ❑ Ultra low background (~10^{-4} counts/keV/kg/yr for m_ν ~ 50 meV)
- ❑ High masses of isotope
- ❑ Pattern recognition

→ advantage using **pixelized detectors + gas TPC**

MicroMegas Detector [Y. Giomataris, Ph. Rebourgeard, J.P. Robert and G. Charpak, Nucl. Instr. Meth. A376(1996) 29-35]

MicroMesh Gaseous Structures (MicroMegas) are an improved amplification structure used to measure the ionized signal in a gaseous detector.

Detector Basics



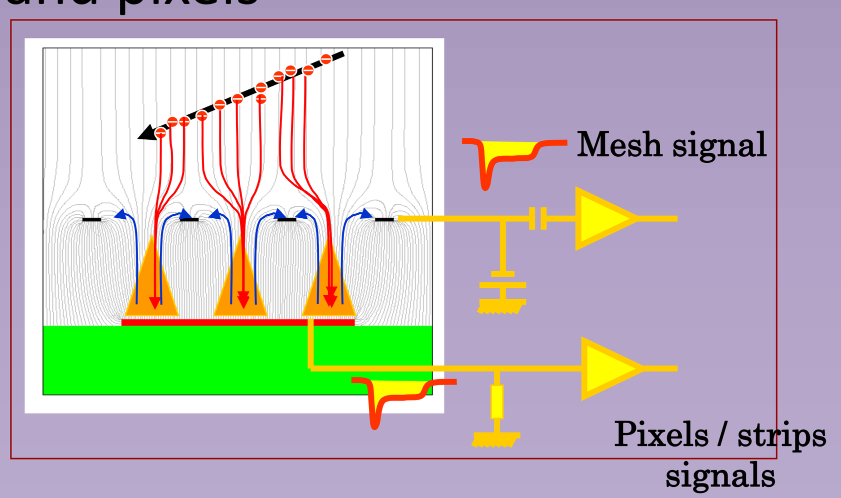
Metallic micromesh suspended over an anode plane by insulator pillars

→ amplification gap 50-100 μm

→ e- drifted go through the mesh

→ avalanche in the gap

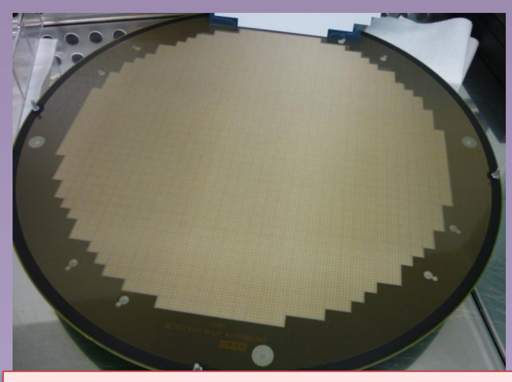
→ detectable signals in mesh and pixels



- ❑ Robust and with gains > 10^3
- ❑ Very good spatial resolution
- ❑ Tested up to 10 bar in Xe
- ❑ Under continuous development

Bulk Technology

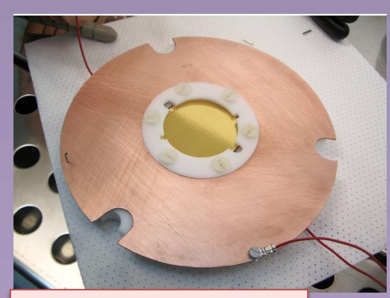
- ❑ Mesh glued to anode
- ❑ Pixelized anode



Active region Ø=30cm
1252 pixels independently read
0.8 cm pixel
50 μm gap

MicroBulk Technology

- ❑ Made from a single Cu-Kapton foil
- ❑ High homogeneity
- ❑ Radiopure low mass-constructed [S. Cebrian et al, Radiopurity of Micromegas readout planes, Astropart.Phys. **34** (2011) 354-359]



Ø = 35 mm
50 μm gap

Largest area with μbulk technology
Each sector radius = 14 cm
1252 pixels independently read
0.8 cm pixel
50 μm gap

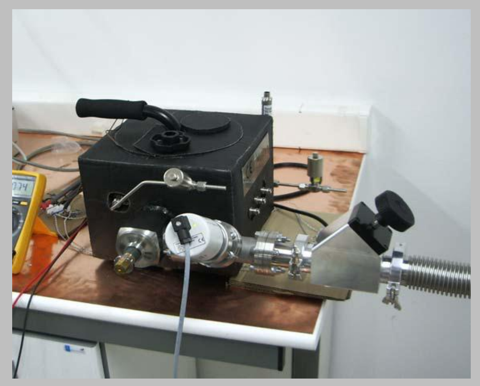
NEXT-MM Prototype

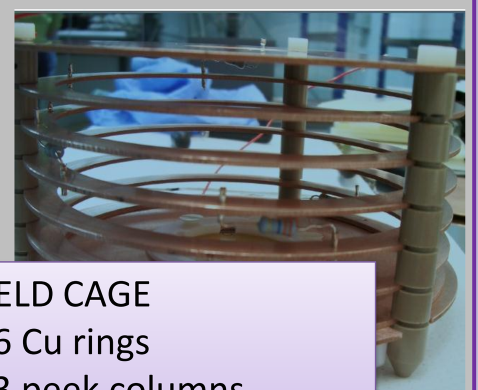
NEXT-0-MM

Test μbulk readouts in HP Xe and Xe mixtures

SETUP

- Stainless steel vessel 2.4 l
- 6 cm drift
- Backing out cycles
- Low outgassing materials (~10^{-6} mbar x l/s)
- P up to 12 bar

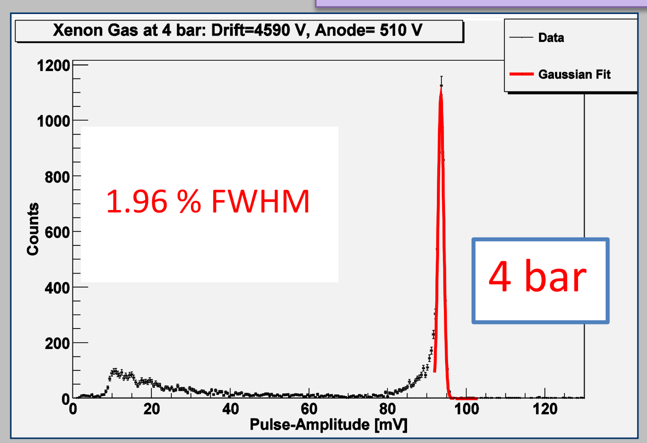




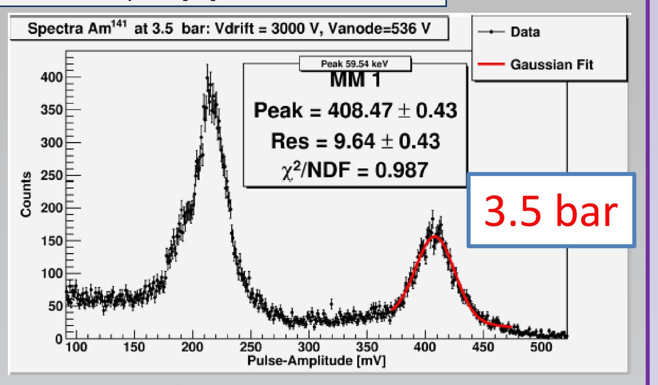
FIELD CAGE
6 Cu rings
3 peek columns
6 resistors 10 MOhm

PURE XENON

- Alphas 5.5 MeV from Am-241 source
  - ✓ΔE = 1.96 % FWHM @ 4bar
  - ✓Attachment observed at higher pressures. Best value obtained ΔE = 4.81 % FWHM @ 8 bar



- Low energy gammas 59.54 keV
  - ✓ΔE = 9.53 % FWHM @ 3.5 bar

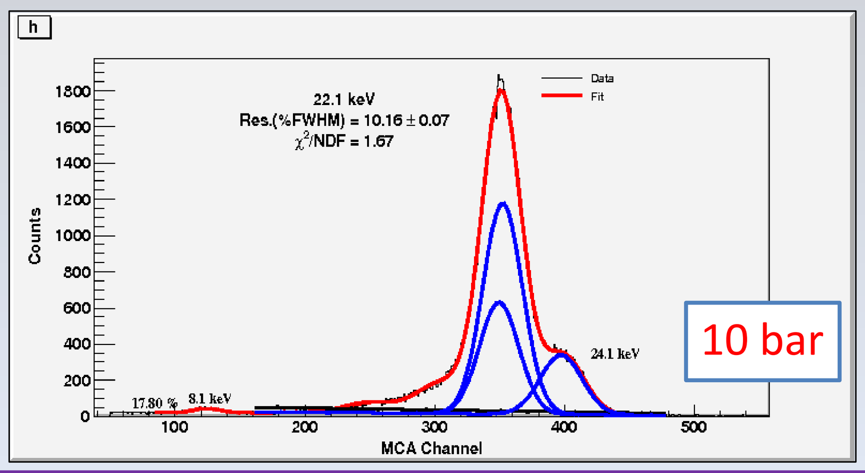


XENON MIXTURES

- ➢ Higher gains, 500 in Xe-TMA, 100 in Pure Xe @ 10 bar
- **Xe-TMA** (Penning Mixture) → study for each pressures which is the optimal fraction of TMA (higher gain and better E Resolution)

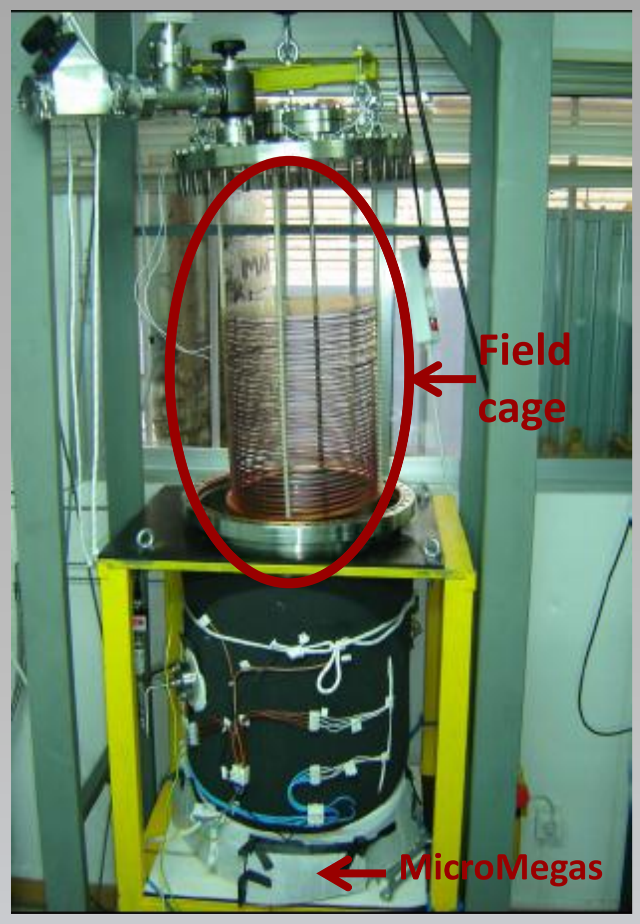
Cd-109 source 22.1 keV,
1cm drift, 1.8 % of TMA

ΔE = 10.16% FWHM **@ 10bar**
→ ΔE = 1.02 % FWHM @ $Q_{\beta\beta}$



NEXT-MM

Test μbulk readouts in realistic conditions (e- tracks fully contained)

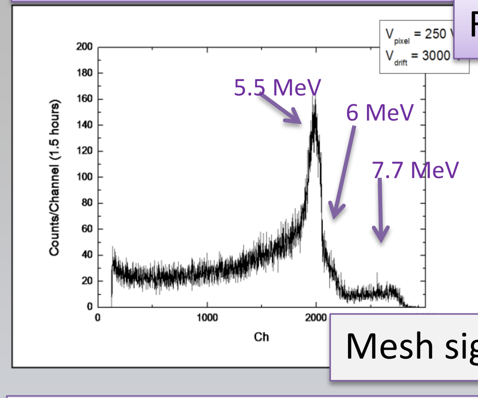


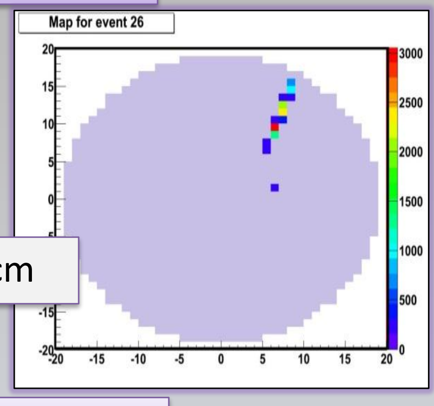
SETUP

- Prototype of medium size (1 kg Xe @ 10 bar)
- 35 cm drift, Height 60 cm, Ø 39.6 cm, 74 l
- Backing out cycles
- Low outgassing materials (< 10^{-6} mbar x l/s)
- Tested up to 15 bar

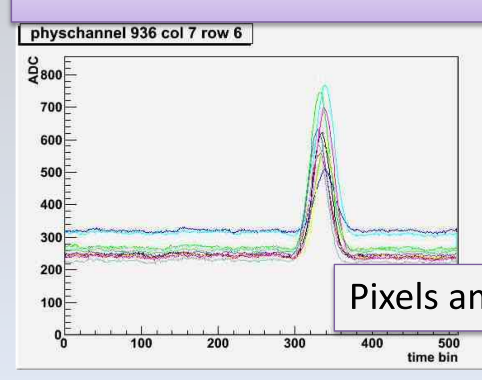
T2K electronics - based on the AFTER chip

FIRST RESULTS- Bulk in Ar-Iso 2 %

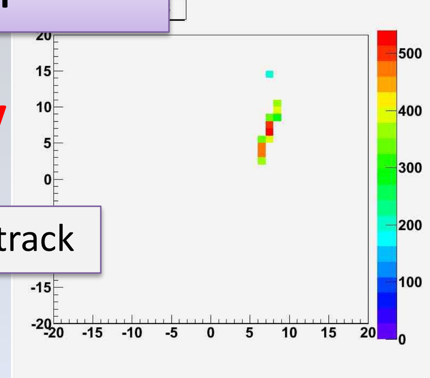




FIRST RESULTS- Bulk in Xenon



Preliminary



CONCLUSIONS - OUTLOOK

- ❑ Micromegas have shown excellent performance for rare events searches.
- ❑ Testing Penning Mixtures with Xe in order to find the optimal scenario regarding gain and energy resolution for Micromegas (NEXT-0-MM).
- ❑ Firsts tests with a bigger μBulk in Xe and Xe-TMA with NEXT-MM prototype.
- ❑ Studies of discrimination techniques based on tracking in NEXT-MM .

12th Pisa Meeting on Advanced Detectors. Elba. May 2012