Large TPCs for low energy rare event detection

NNN05 Next Generation of Nucleon Decay and Neutrino Detectors 7-9 April 2005 Aussois, Savoie, France

- **Highlights from the Paris TPC workshop**
- **Spherical TPC project and motivation**

I. Giomataris

SECOND WORKSHOP ON LARGE TPC FOR LOW ENERGY RARE EVENT DETECTION

LPNHE - Paris VI and VII Universities

Place JussieuTour 33 Rdc PARIS, France 20 - 21 December 2004

Gaseous TPCs :

1) **Low energy neutrino detection** (neutrino oscillations, solar neutrinos, double beta decay, magnetic moment, supernova), I. Vergados, G. Gounaris, I. Irastorza, Ph. Gorodetzky,G. Bonvicini, Z. Daraktchieva, M. Green, M. Zito

2) **Axion search,** Th. Dafni, B. Beltran

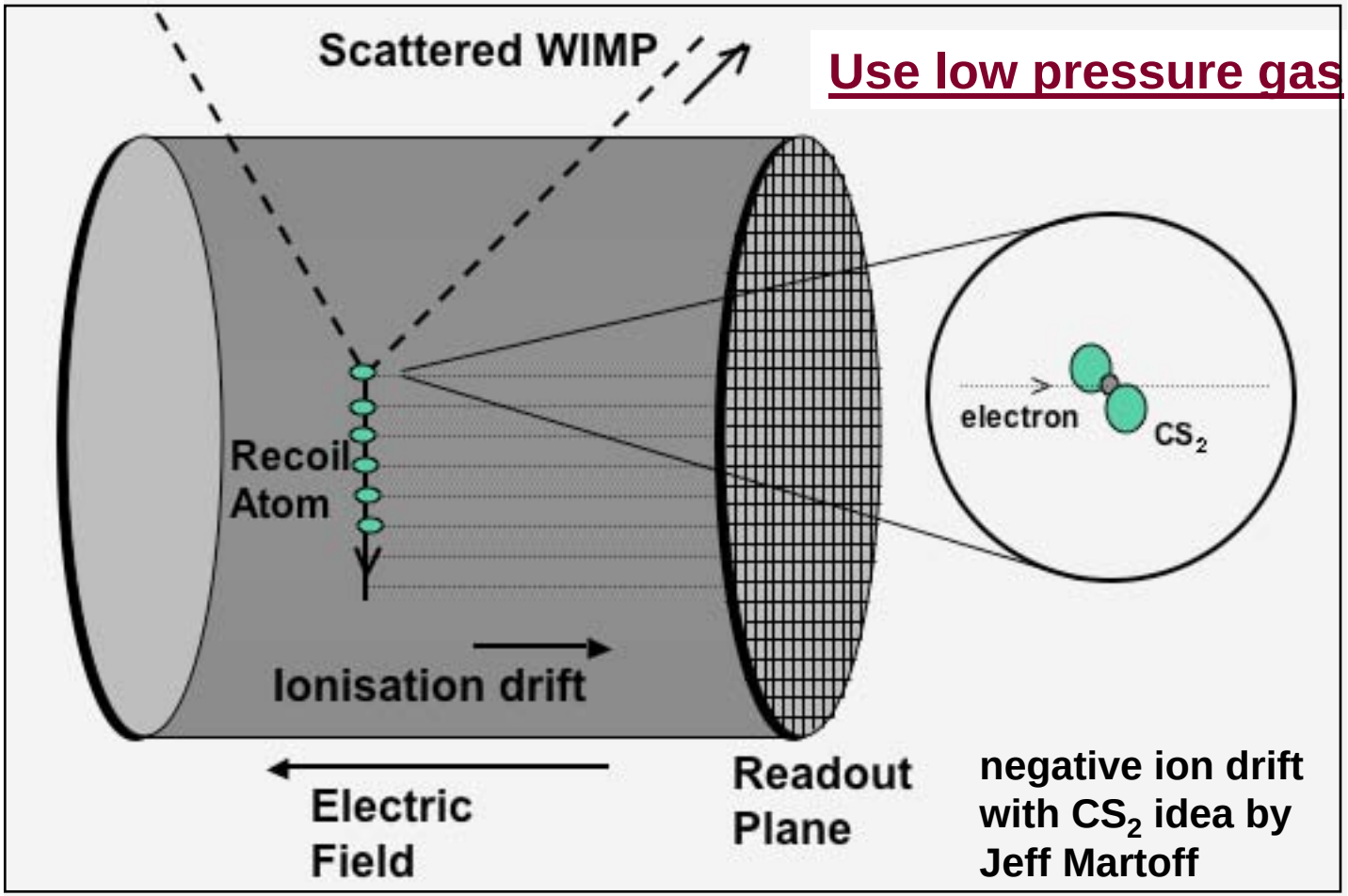
3) **WIMP search with recoil direction**, B. Sadoulet, N. Spooner, D. Santos

Liquid TPCs,

A. Rubbia, E. Aprile, N-J-T. Smith, Ph. Lightfoot, V. Peskov

DRIFT and Prospects for a Large Scale Directional WIMP TPC

N. Spooner



Main motivation : drifting ions instead of electrons reduces the diffusion effect

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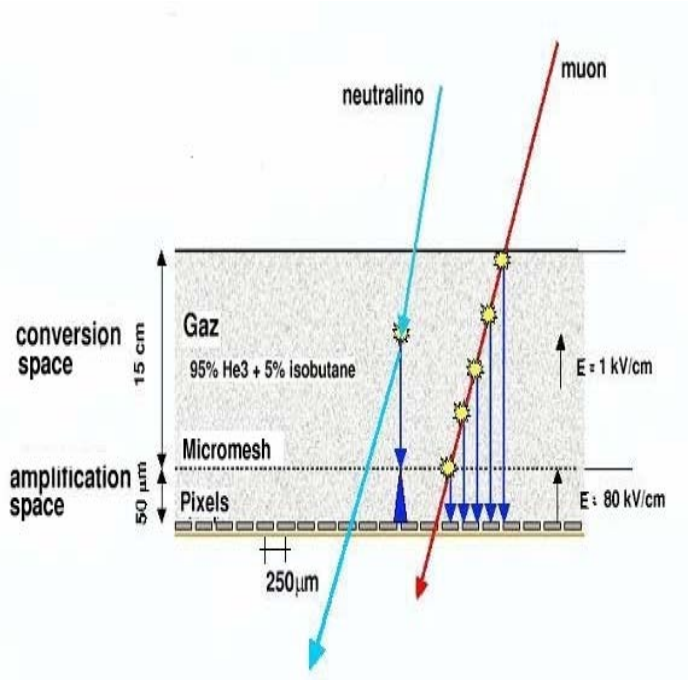
MIMAC-He3 :MIcro-tpc Matrix of Chambers of He3
(D. Santos)

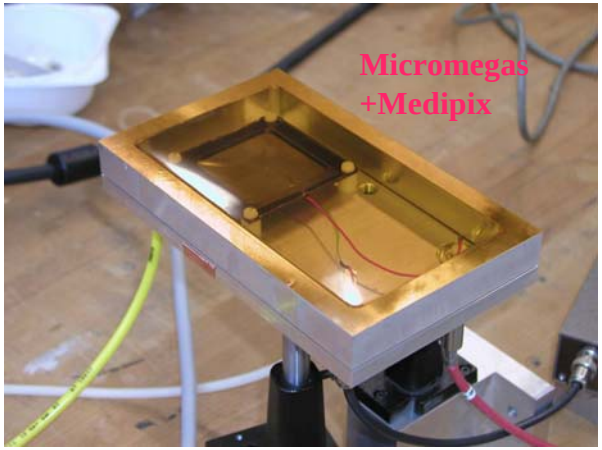
^{3}He for axial detection of non-baryonic dark matter

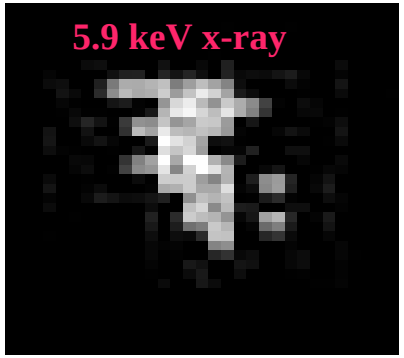
High spatial temporal resolution
recoil track projection
⇒ energy threshold < 1 keV
⇒ electron/recoil discrimination



Last refinement: CMOS integrated pixel anodes (H. Van der Graaf)

Idea : Combine micro-pad CMOS with high accuracy MPGD like Micromegas





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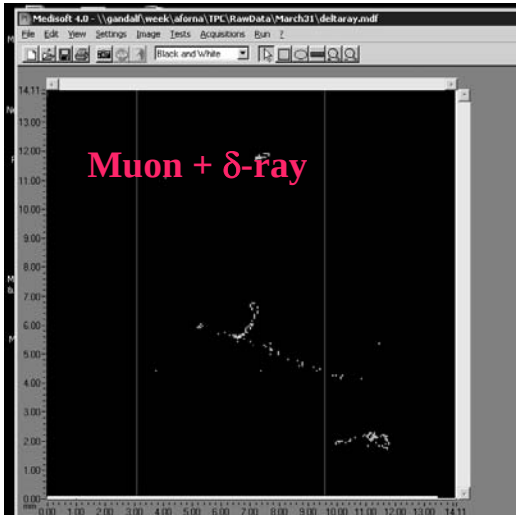
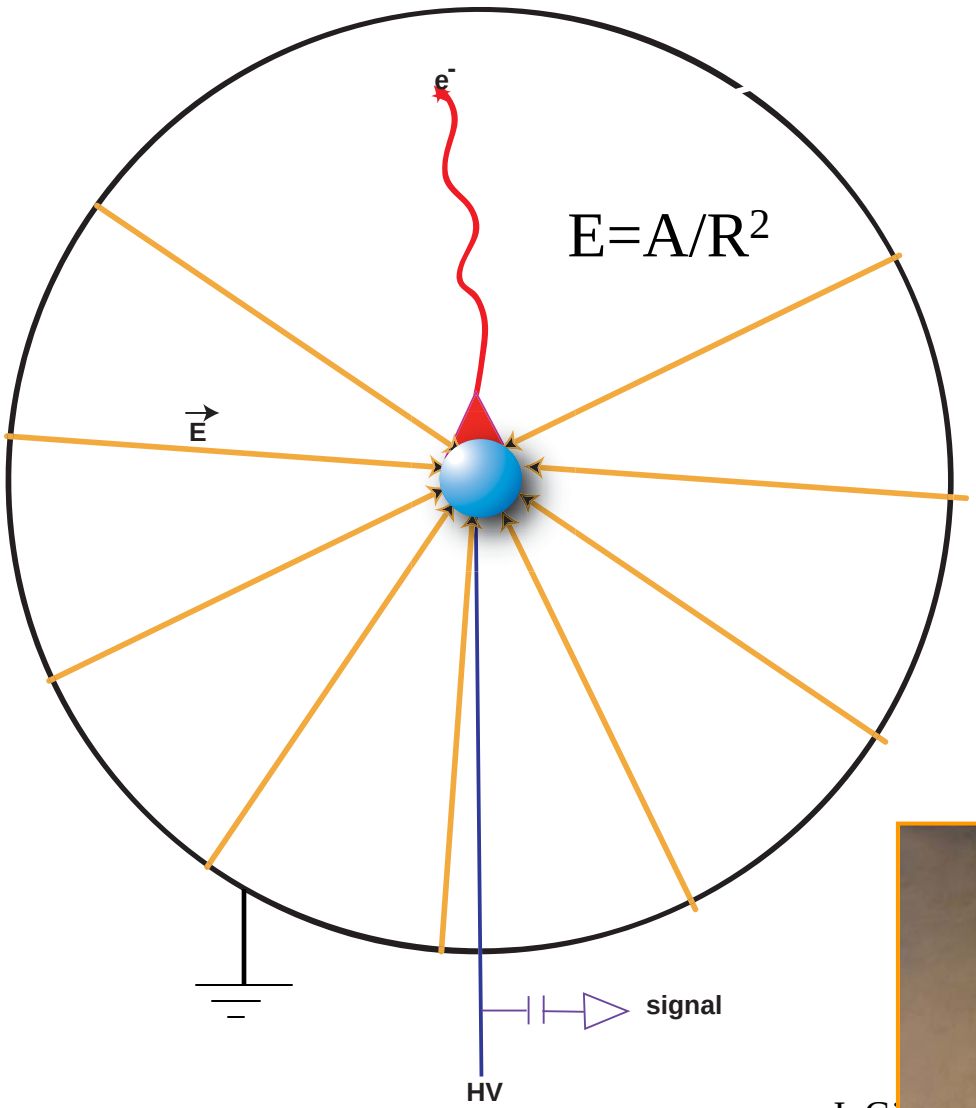
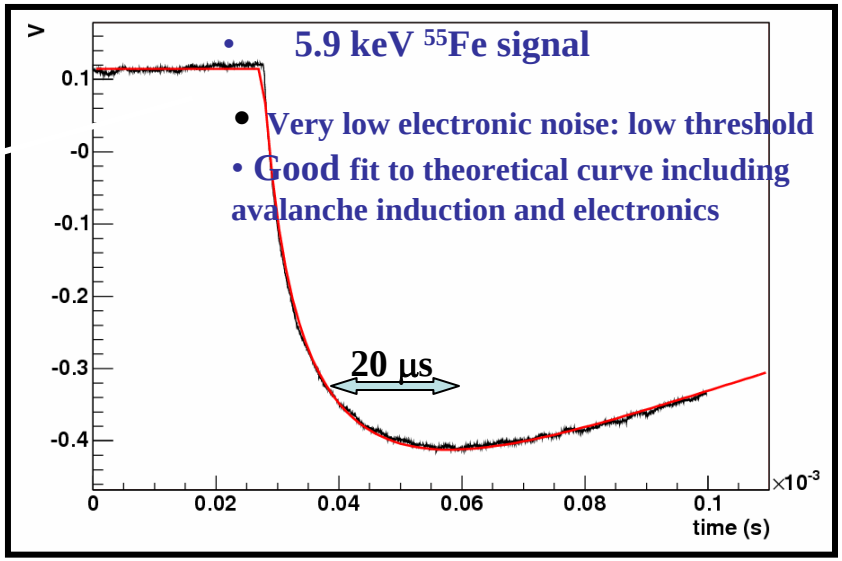
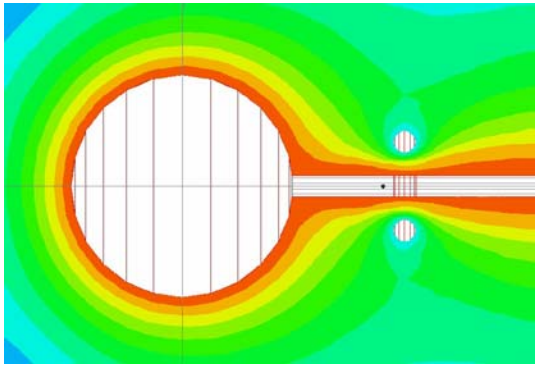


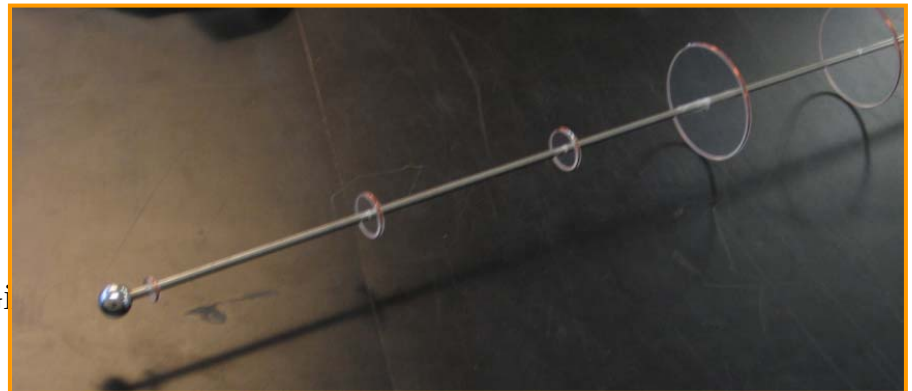
Spherical TPC with spherical proportional counter read-out





- 5.9 keV ^{55}Fe signal
- Very low electronic noise: low threshold
- Good fit to theoretical curve including avalanche induction and electronics





The spherical TPC concept: Advantages

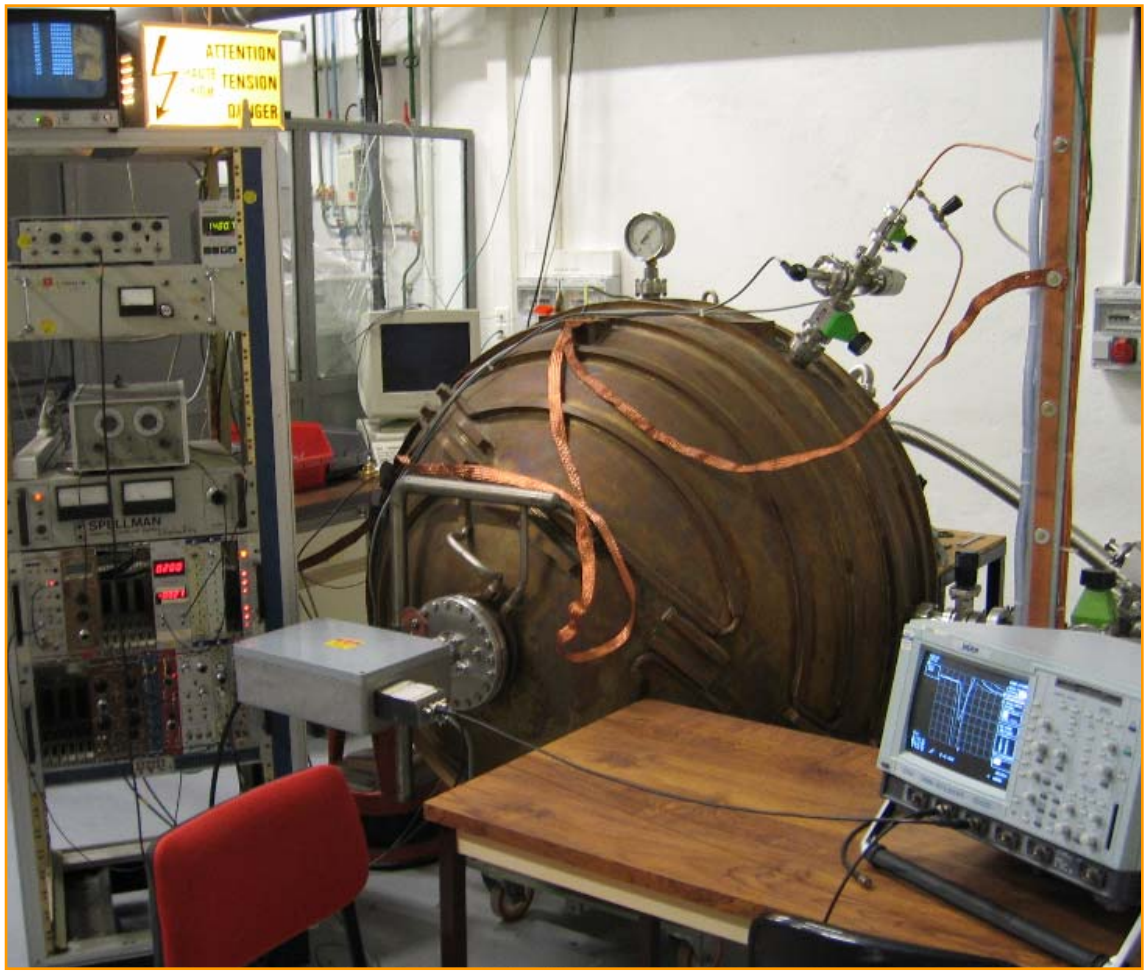
- Natural focusing:
  - large volumes can be instrumented with a small readout surface and few (or even one) readout lines
- 4π coverage: better signal
- Still some spatial information achievable:
  - Signal time dispersion

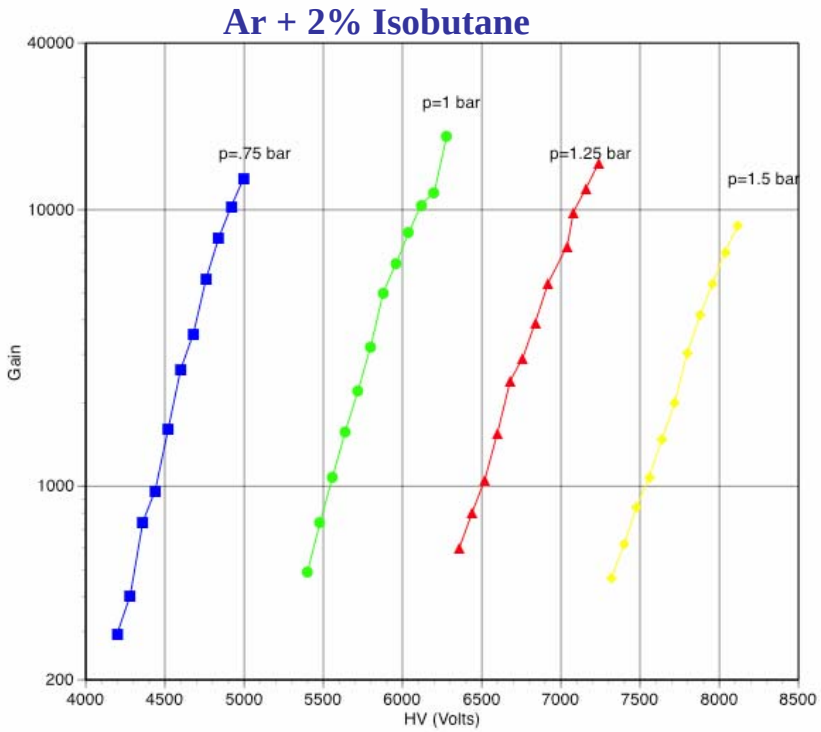
- Other practical advantages:
  - Symmetry: lower noise and threshold
  - Low capacity
  - No field cage
- Simplicity: few materials. They can be optimized for low radioactivity.
- Low cost

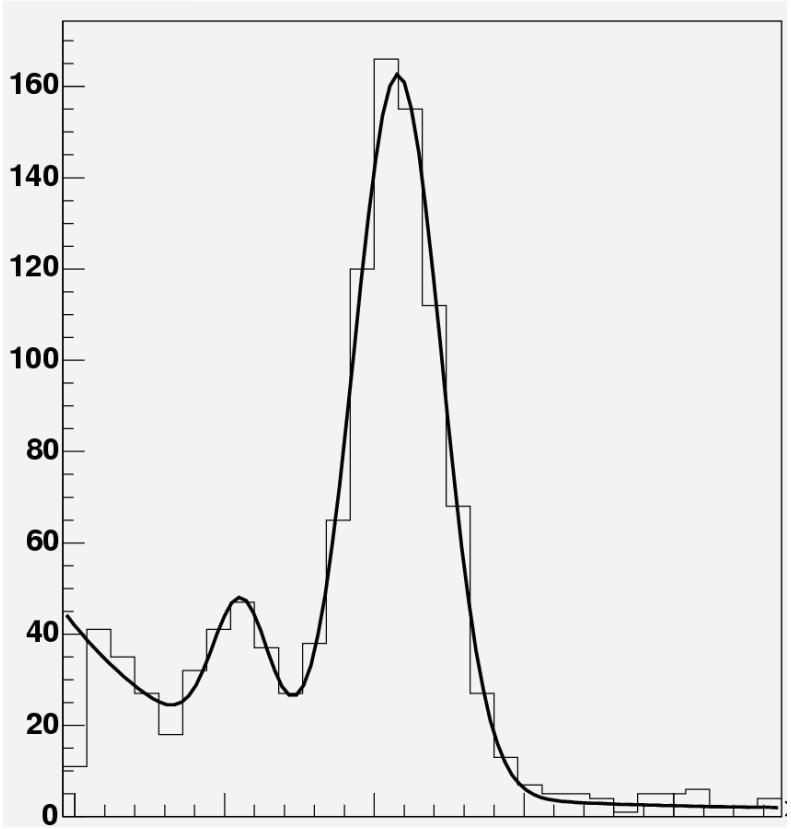
The way to obtain large detector volumes keeping low background and threshold

First prototype: the Saclay sphere

- D=1.3 m
- V=1 m^3
- Spherical vessel made of Cu (6 mm thick)
- P up to 5 bar possible (up to 1.5 tested up to now)
- Vacuum tight: ~10^{-6} mbar (outgassing: ~10^{-9} mbar/s)



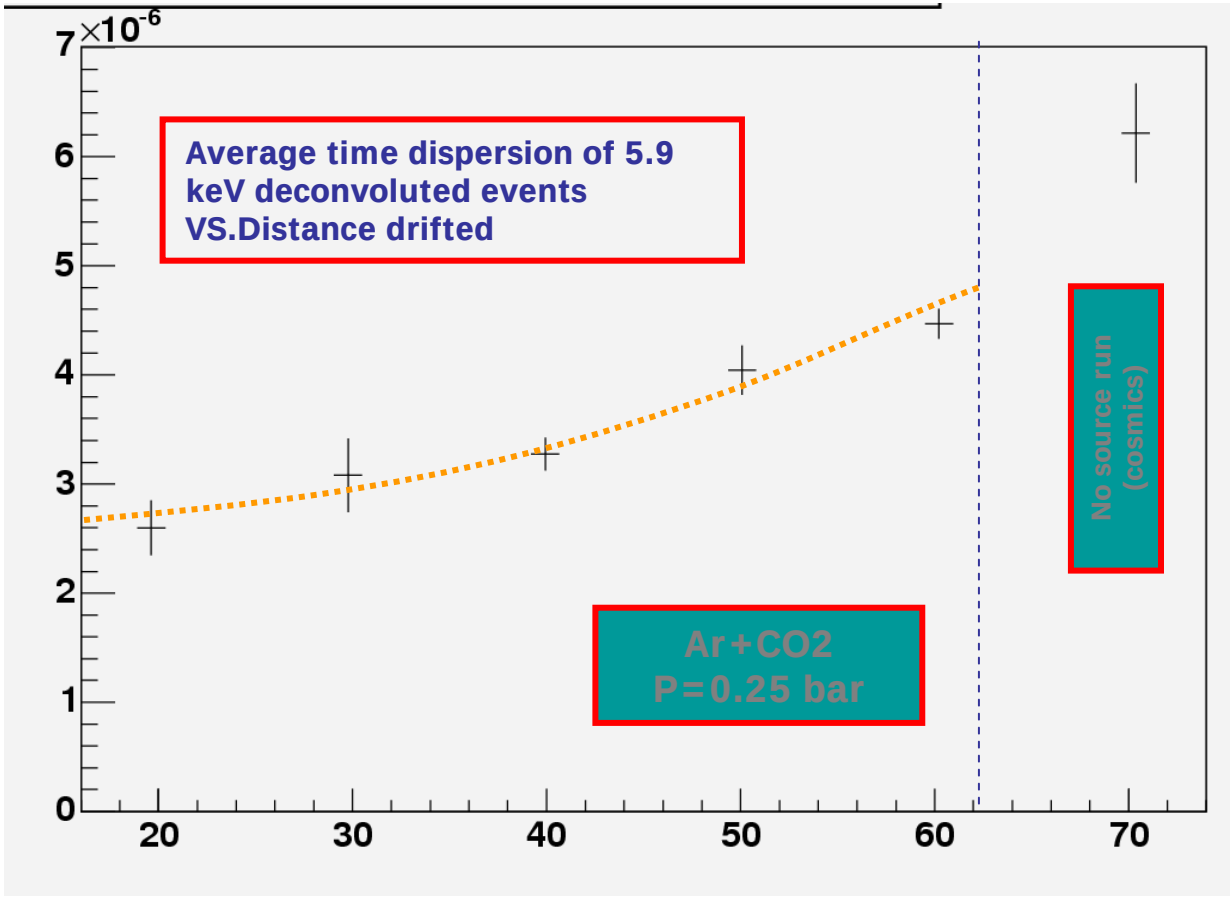




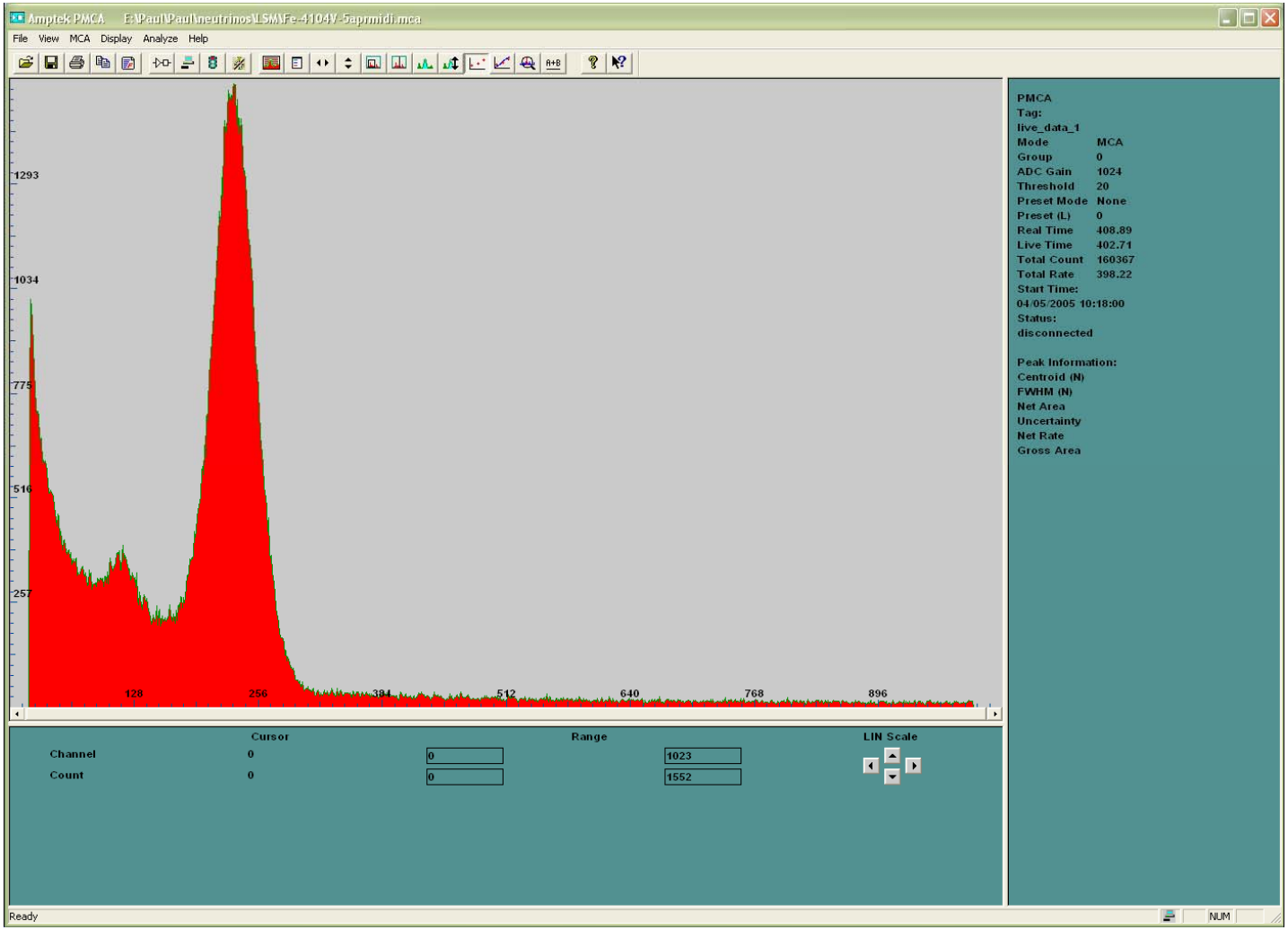
- Stability:
  - tested up to ~3 months.
  - No circulation of gas. Detector working in sealed mode. (1 pass through an oxysorb filter)
- No absorption observed
  - Signal integrity preserved after 60 cm drift.
  - Not high E needed to achieve high gain.

First results

- Even with a very simple (and slow) readout, we have proved the use of dispersion effects to estimate the position of the interaction (at least at ~10 cm level).
- Further test are under preparation to better calibrate (external trigger from Am source)



First underground tests in LSM 5-4-2004



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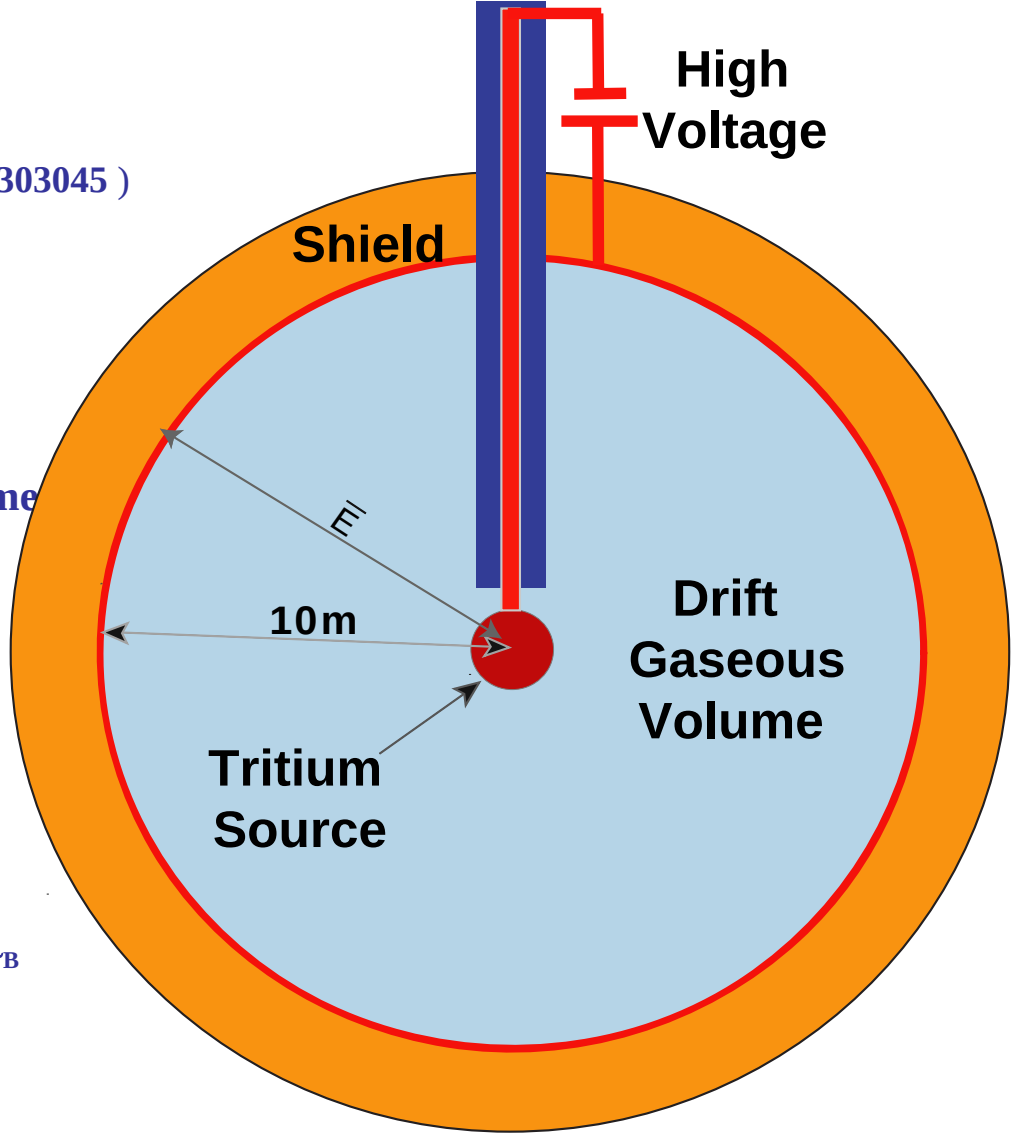
Long term program

NOSTOS I. Giomataris, J. Vergados, hep-ex/0303045)

- Large Spherical TPC 10 m radius
- 200 MCi tritium source in the center
- Neutrinos oscillate inside detector volume L_{23}=13 m

$$P(\nu_e \rightarrow \nu_{\mu,\tau}) = \sin^2 2\theta_{13} \sin^2 \pi \frac{L}{L_{23}}$$



Objectives

- Measure θ_{13} (systematic free)
- Neutrino magnetic moment studies << 10^{-12} μ_B
- Measurement of the Weinberg angle at low energy

Short term (3 year program)
Neutrino-nucleus coherent elastic scattering

$\sigma \approx N^2E^2$, *D. Z. Freedman, Phys. Rev.D,9(1389)1974*

1. Nuclear reactor measurement sensitivity with present prototype

after 1 year run ($2x10^7$s), assuming full detector efficiency:

- Xe ($\sigma \approx$ $2.16x10^{-40}$ cm^2), $2.2x10^6$ neutrinos detected, E_{max}=146 eV
- Ar ($\sigma \approx$ $1.7x10^{-41}$ cm^2), $9x10^4$ neutrinos detected, E_{max}=480 eV
- Ne ($\sigma \approx$ $7.8x10^{-42}$ cm^2), $1.87x10^4$ neutrinos detected, E_{max}=960 eV

Challenge : Very low energy threshold
We need to calculate and measure the quenching factor

2. **Spalation source measurement with present prototype**

3. **Supernova neutrino detection with a 2nd demonstrator (4 m)**

For E_ν = 10 MeV $\sigma \approx N^2E^2 \approx 2.5x10^{-39}$ cm^2, T_{max} = 1.500 keV
For E_ν = 25 MeV $\sigma \approx 1.5x10^{-38}$ cm^2, T_{max} = 9 keV
Expected signal : 100 events (Xenon at p=10 bar) per galactic explosion (including detector threshold and quenching factor)
Idea : A European or world wide network of several (tenths or hundreds) of such simple (one channel), robust and low cost detectors (**$T_{life\ time}$ >> 1 century**)

Conclusions

- **Large volume TPCs are already used for rare event detection**
- **Combined with new MPGD precise detector can provide low energy threshold and recoil directionality**
- **A novel detector based in the spherical geometry with spherical proportional counter read-out has been successfully tested and it is under development.**
- **Many applications in low energy neutrino physics are open**