

Directional detection with MIMAC

Micro-tpc MAtrix of Chambers

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Introduction

- Direct Detection
- Directionnal detection

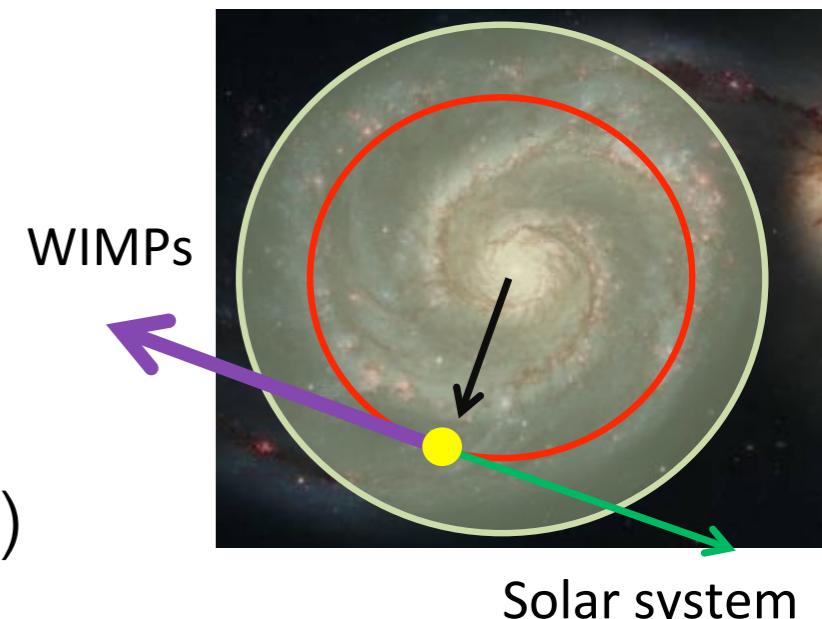
Direct detection

Candidate: Weakly Interacting Massive Particle (WIMP):

- Massive
- No electric charge & No color
- Gravitational & weak interaction

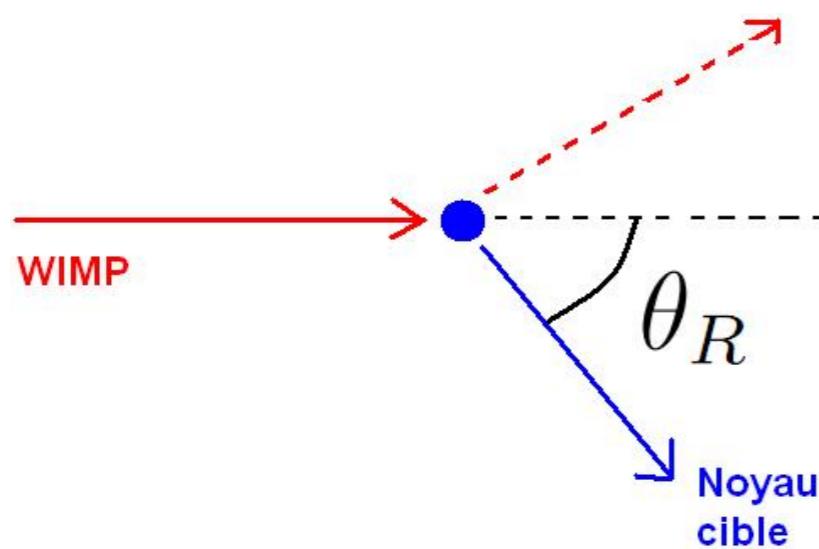
Dark matter halo:

- Surrounding the Milky Way
- Maxwellian velocity distribution (Hydro simulation)



Direct detection principle:

Measuring the energy transferred to the nuclei

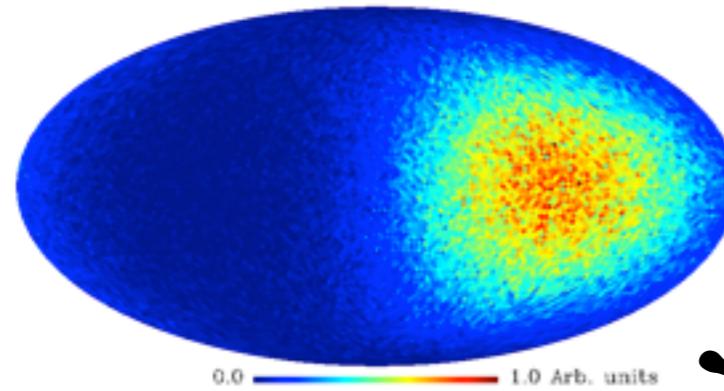


Ultimate background: neutrons

Directional detection

Recoils angular distribution:

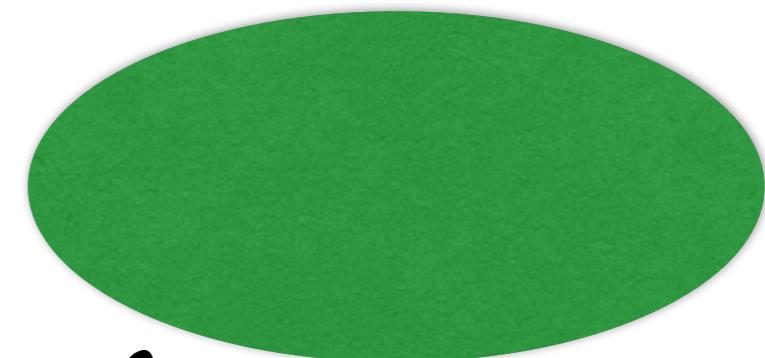
→ Anisotropy



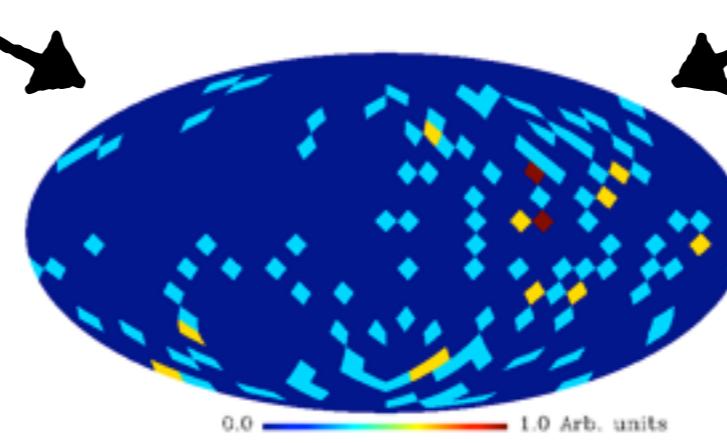
Typical measured recoil angular distribution

Neutrons angular distribution:

→ Isotropic



Simulation with 100 WIMPs & 100 bkgds



$\mathcal{L}(\ell, b, m_\chi, \lambda)$ Profile likelihood analysis
J. Billard *et al.*, Phys. Rev. D **85** (2012) 035006

Constraints on WIMP and Halo properties

Target: ^{19}F ← Strong coupling to the axial interaction

Directional detection principle:

Measurement of the **energy** and the **track** of the recoils

Detection strategy

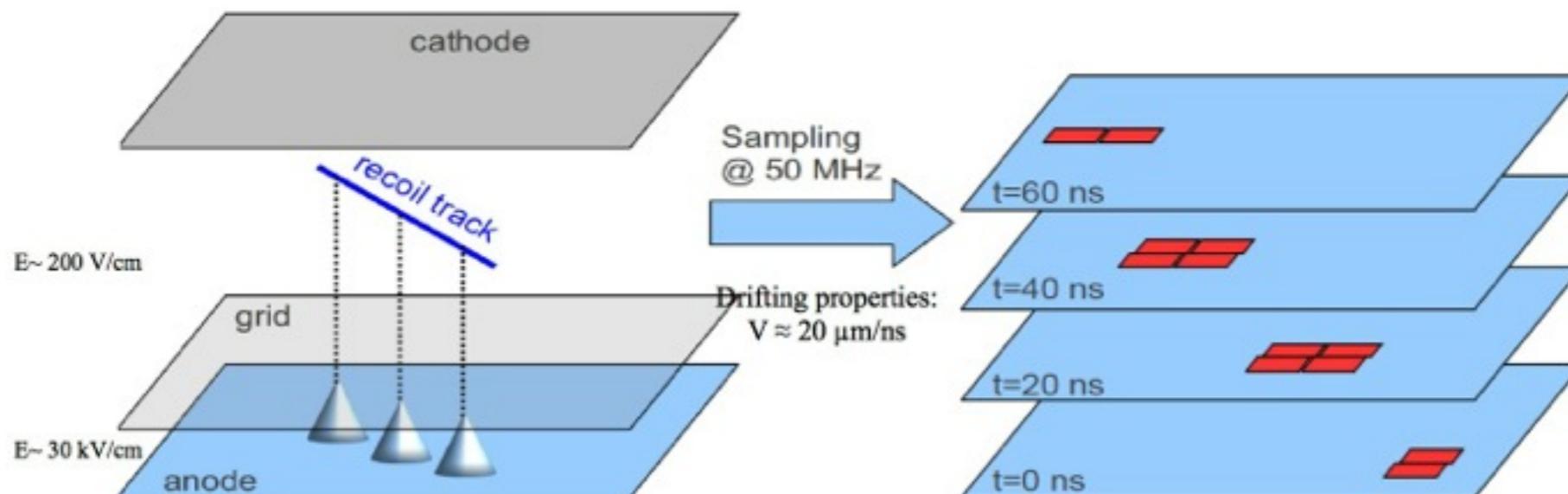
- The bi-chamber module
- MIMAC detection strategy
- Observable

MIMAC detection strategy

MIMAC detector: $\mu\text{TPC} = \text{TPC} +$

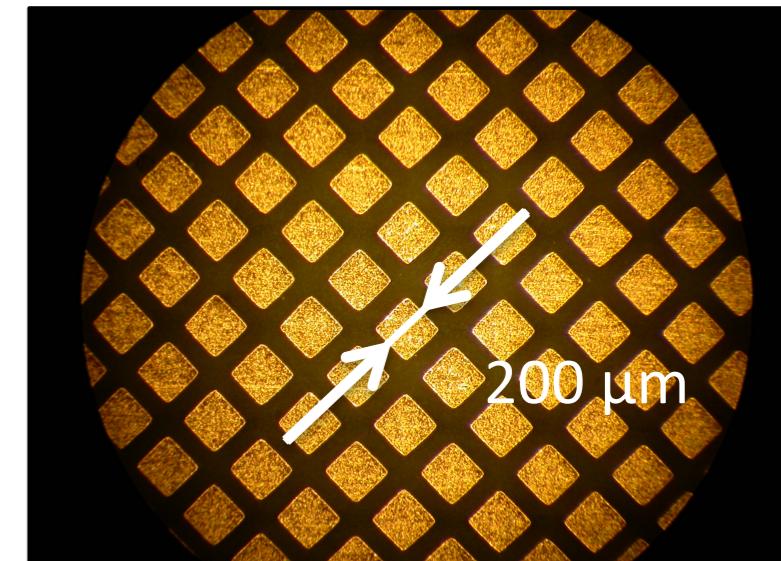
Pixelized Micromegas
Fast & self-trigger
electronic

Sampling:
512 strips @ 50 MHz
 $T_{Sampling} = 20\text{ ns}$



Scheme of a MIMAC μTPC

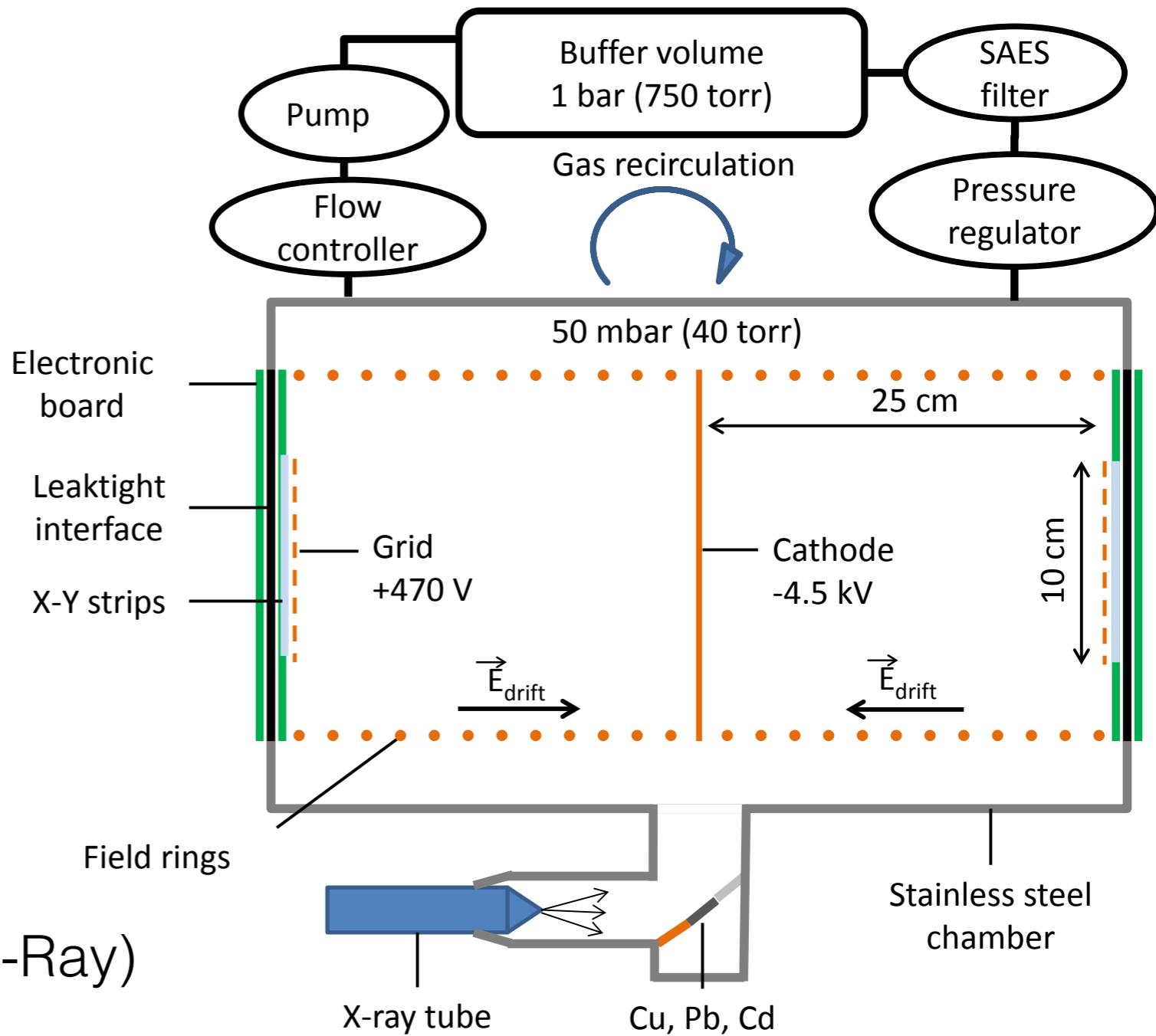
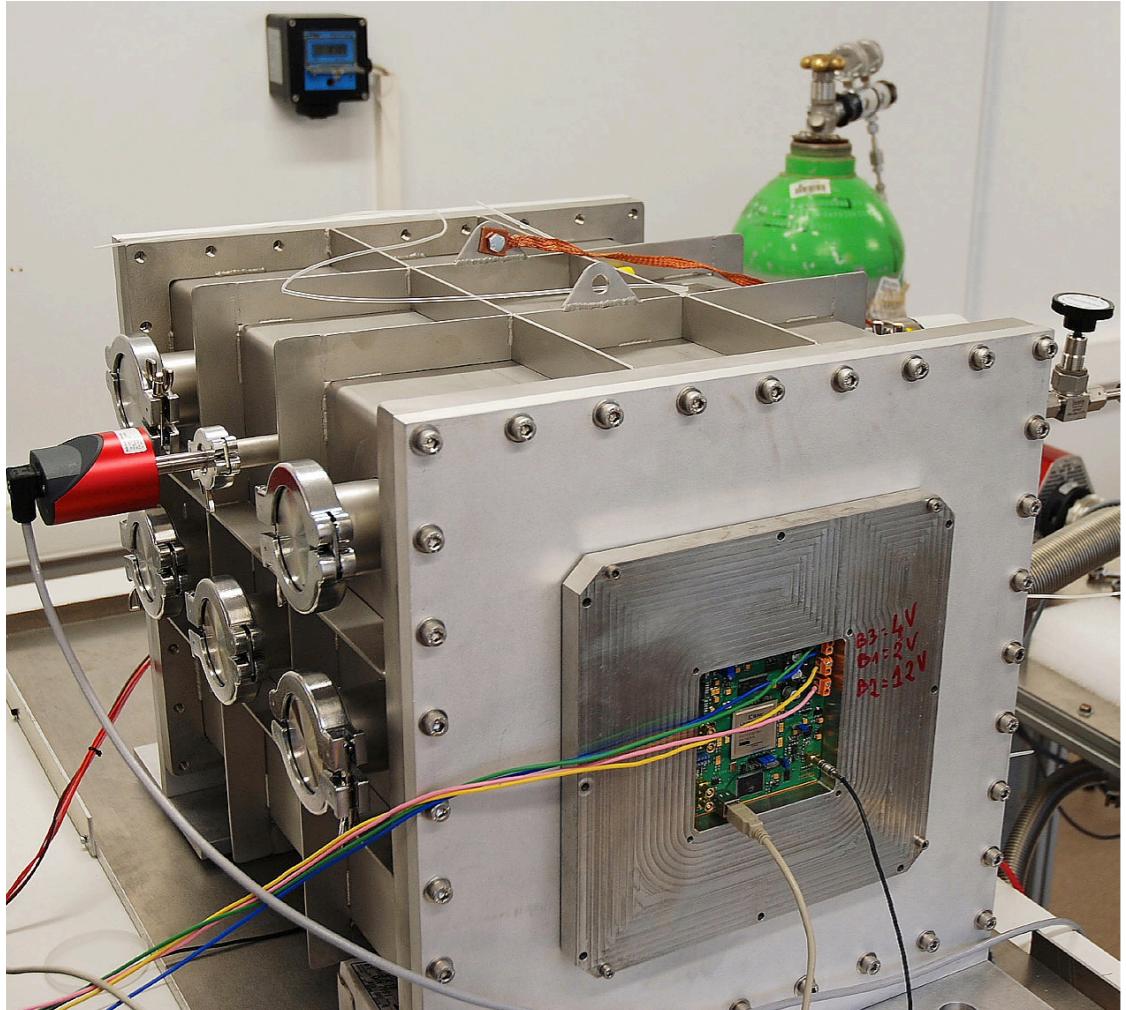
Evolution of the collected charges on the anode



Gas mixture: 70% CF₄ + 28% CHF₃ + 2% C₄H₁₀ @ 50 mbar

Goal: Nuclear recoil track measurement

The bi-chamber module



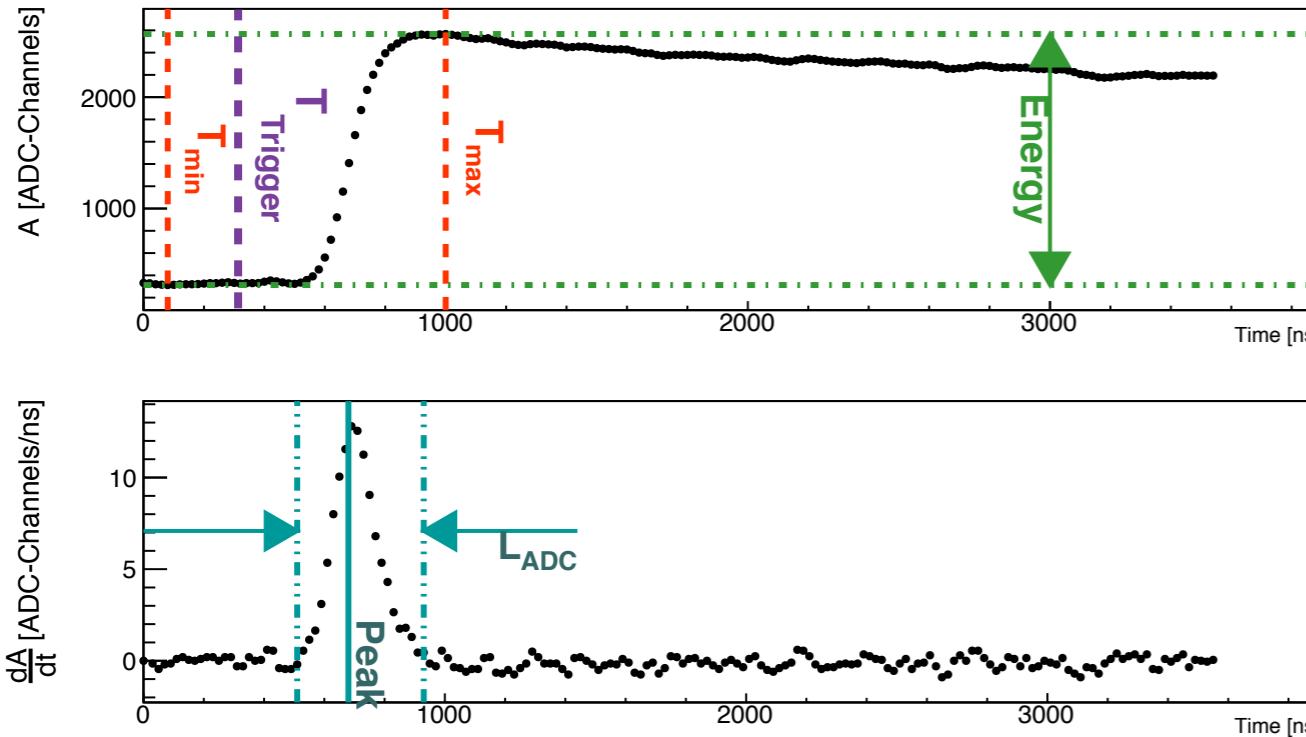
Active volume: ~ 5 L

Online calibration: twice week (X-Ray)

Installed at Modane Underground Laboratory (**LSM**) in june 2012

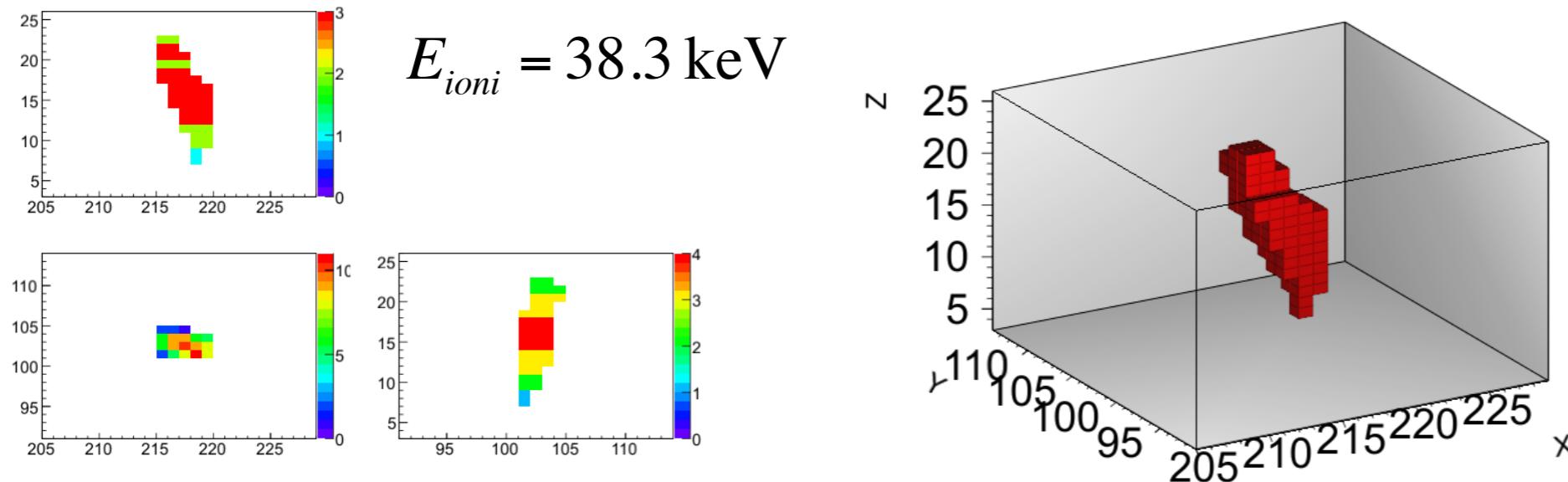
Observables

Flash-ADC (charge integrator)



- Energy
- ADC Length
- Number of peak & position
- $A \equiv T_{peak} - T_{trigger}$
- $B \equiv T_{max} - T_{peak}$
- ...

Pixelized anode (Micromegas)



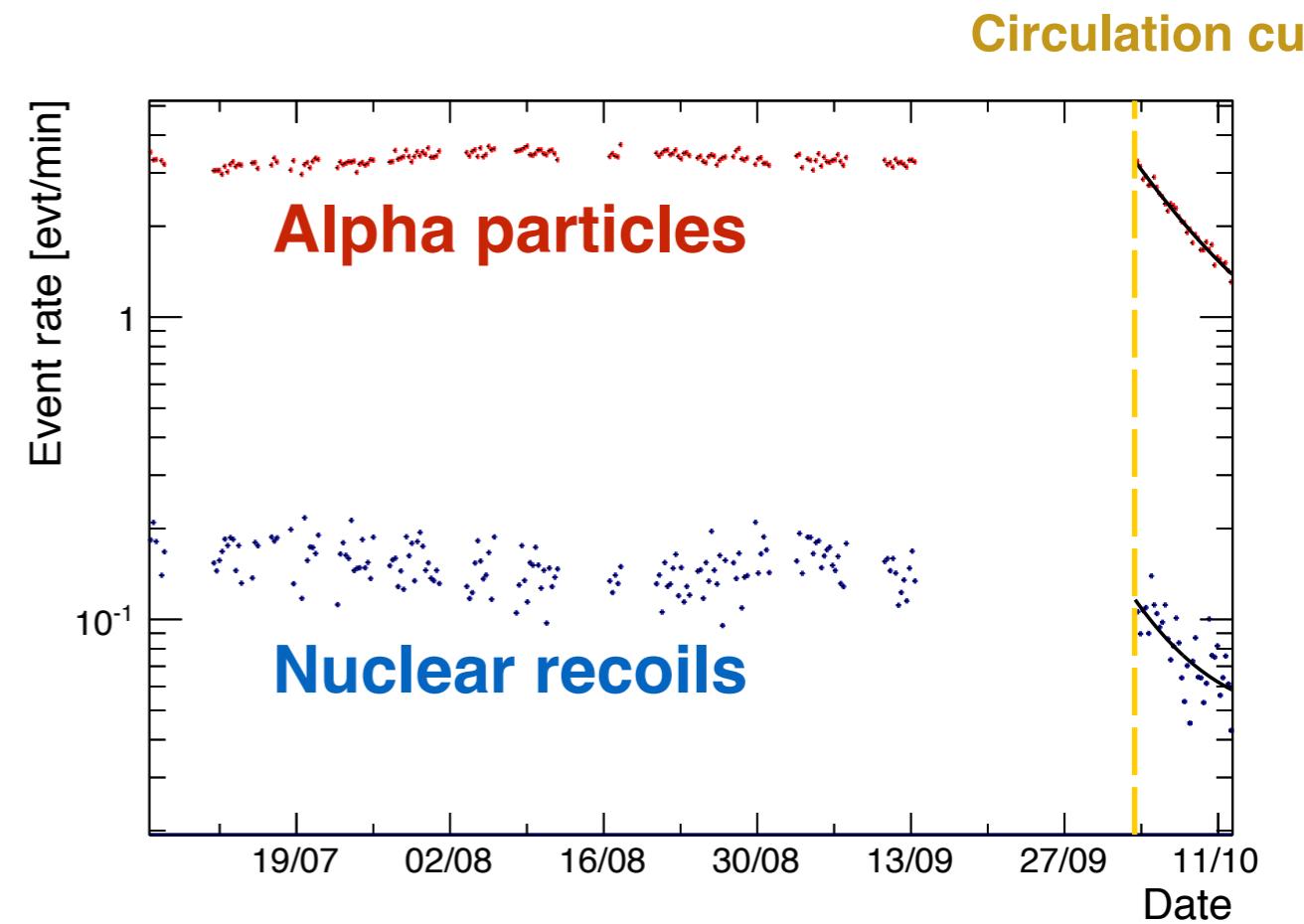
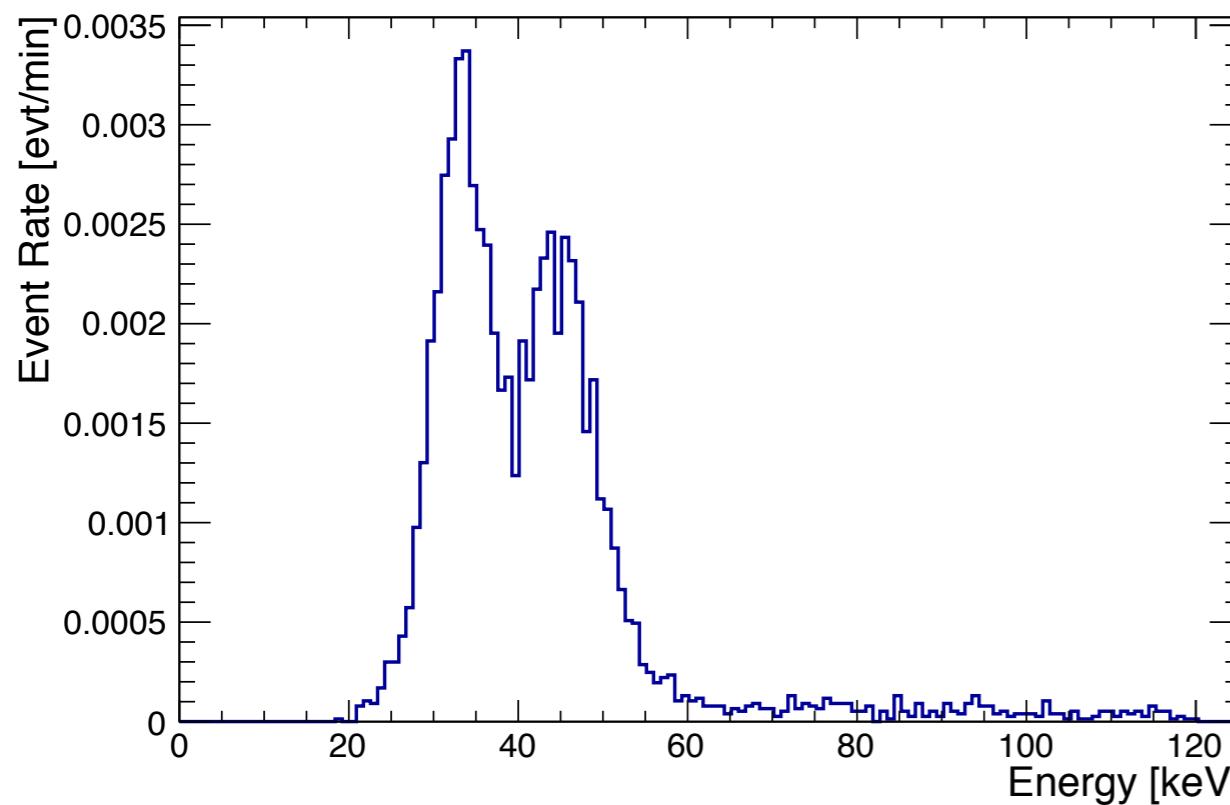
- (X,Y) fiducialisation
- Curved Length
- Track homogeneity

Results

- Results
- Interpretation: Radon progeny
- Discrimination

Results

Data 2012



Exponential decreasing compatible with the decay of the ^{222}Rn (3.8 days)

No contribution from ^{220}Rn

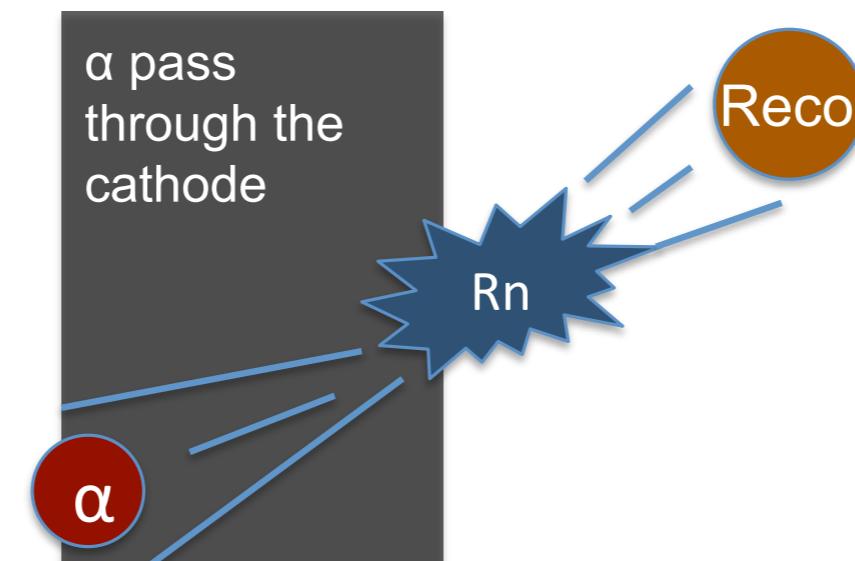
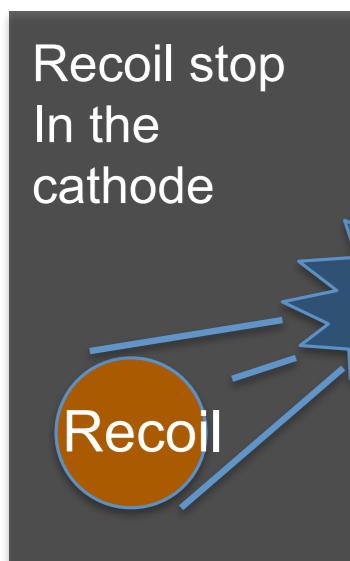


Observation of the ^{222}Rn progeny

Interpretation: Radon progeny

Intrinsic material pollution from ^{238}U

→ 3 alpha decays in the ^{222}Rn chain (cut form ^{210}Pb life time)



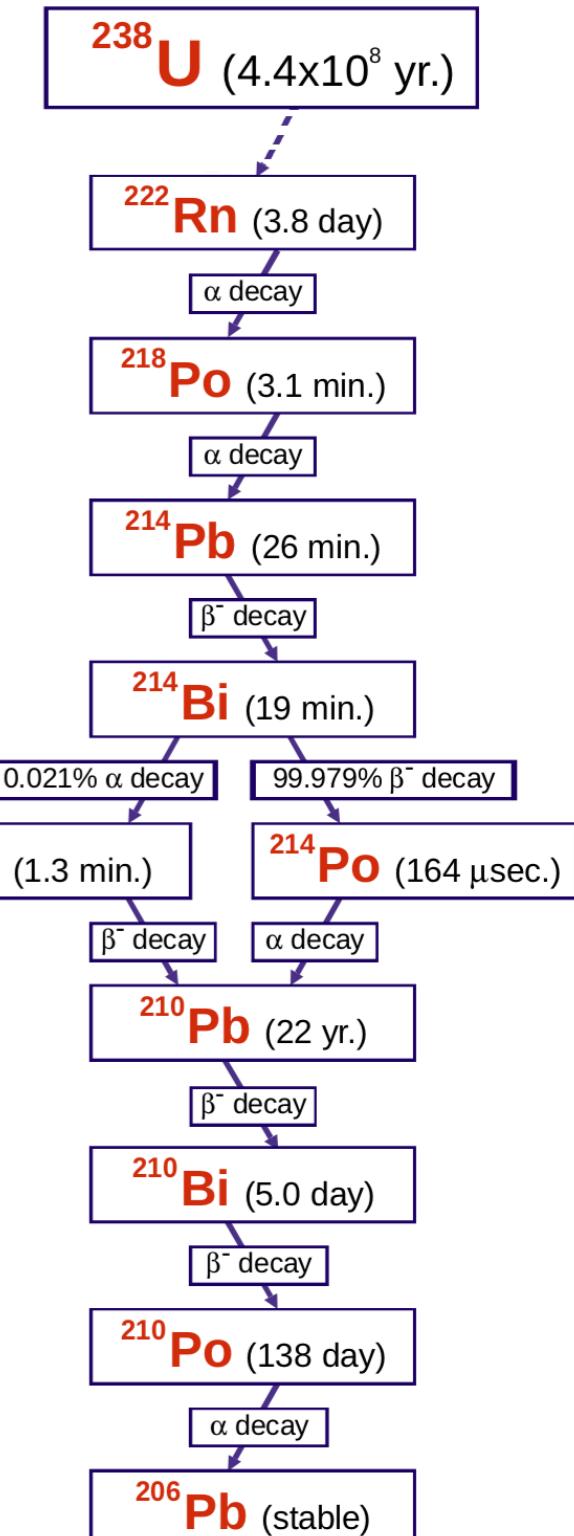
$$E_{kin}^{\alpha} \approx 5 \text{ MeV}$$

$$E_{kin}^{recoil} \approx 100 \text{ keV}$$

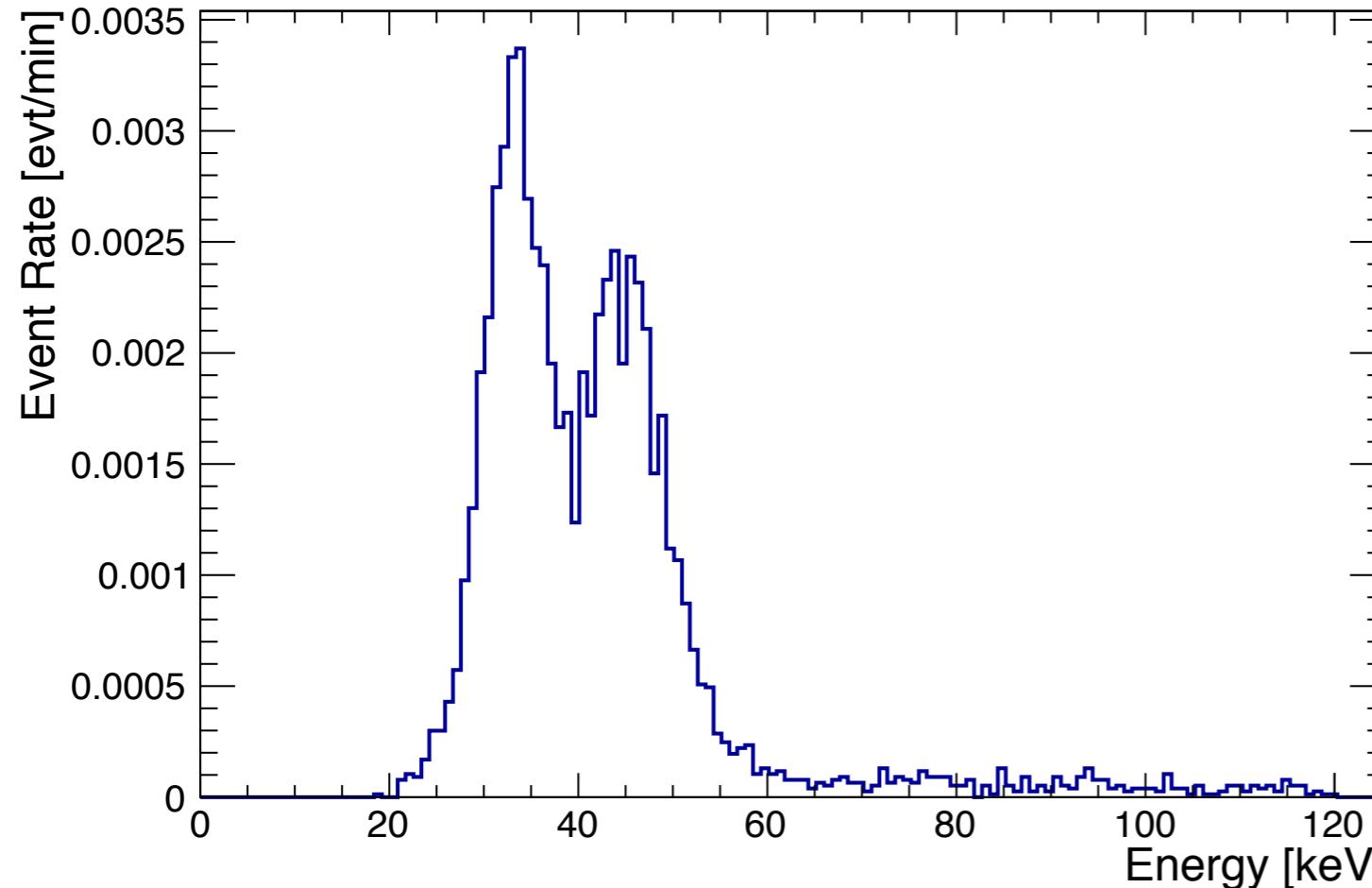
Ionization Quenching

Flash-ADC saturation

$$E_{ion}^{recoil} \approx 30 \text{ keV}$$



Results



It is the 1st radon progeny measurement

But:

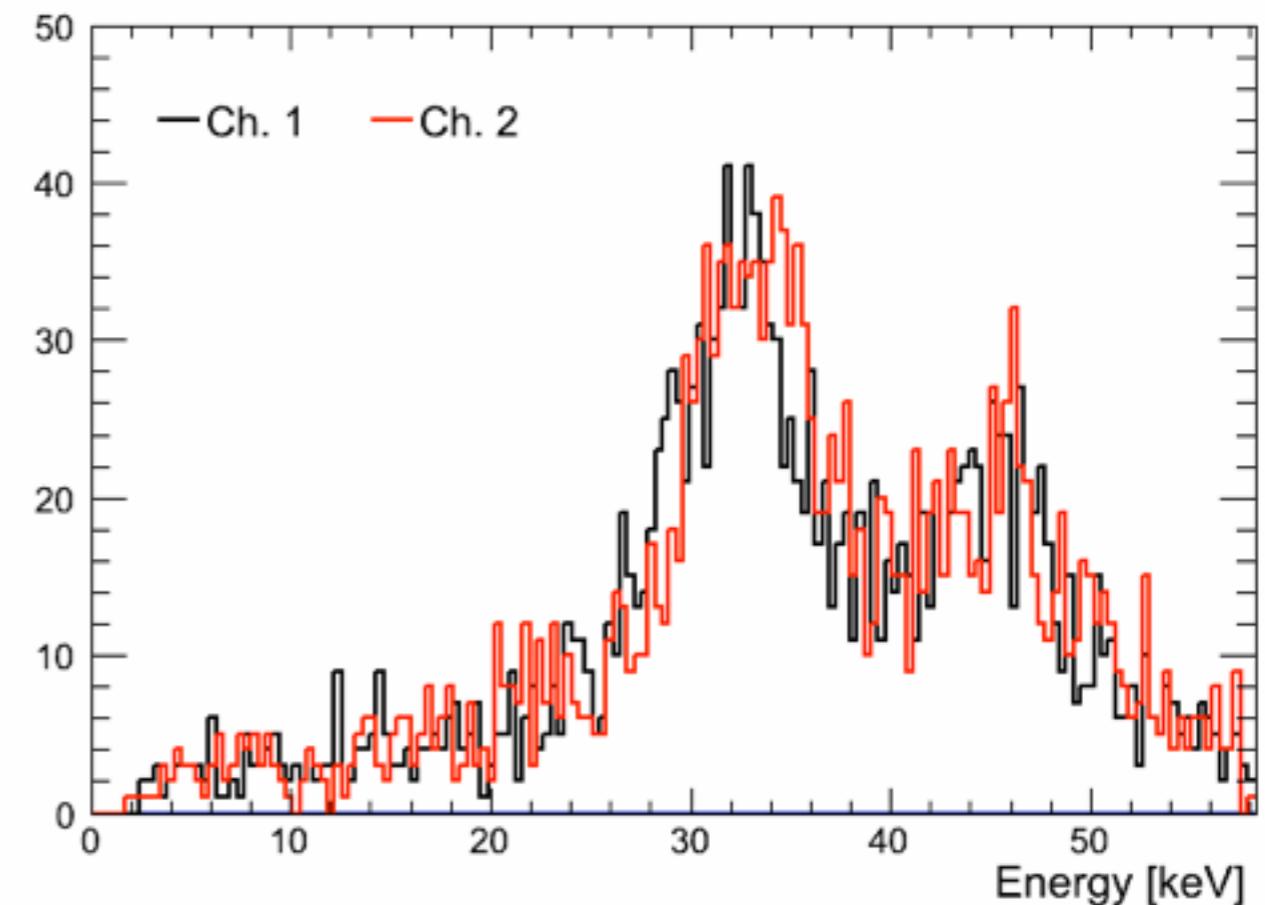
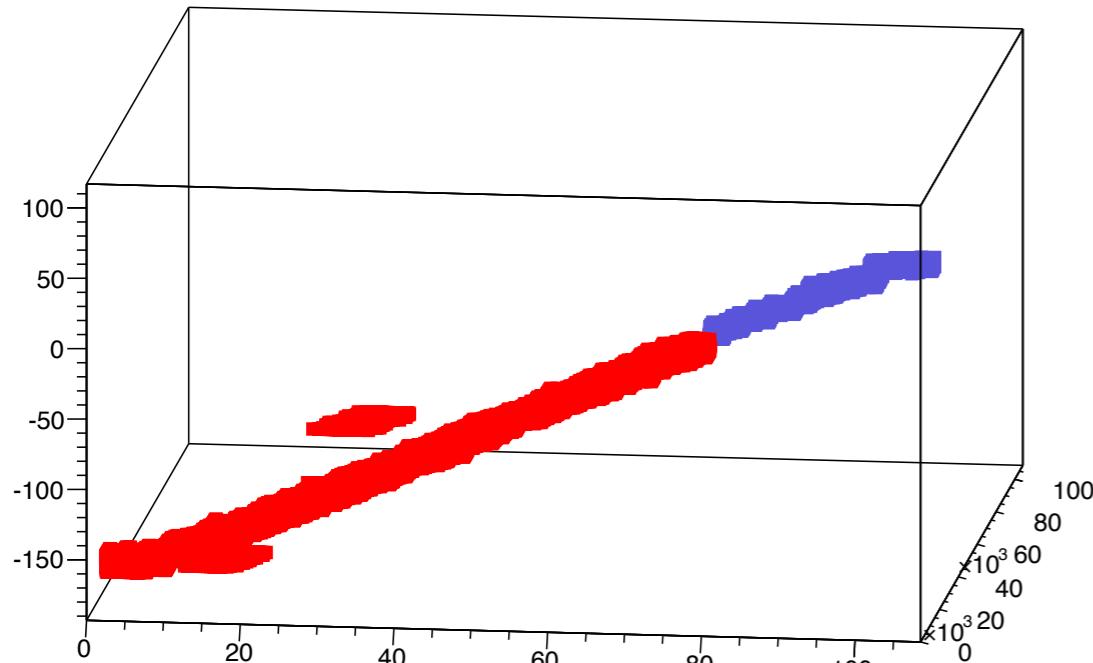
It isn't Dark Matter!!!!

Problem: Discrimination

Radon discrimination

Run 2013:

- Data taking in progress
- Chambers synchronisation available



Discrimination using coincidence: Possible

Conclusion

Conclusion

No evidence of Dark Matter yet

Directional detection: Promising direct Dark Matter search strategy

Radon observation: Demonstration of the detection strategy interest

Study of the discrimination is in progress

Next step: 1 m³ detector (multiplication of bi-chamber modules)

Final project: 50 m³ → International context

MIMAC collaboration

LPSC (Grenoble): F. Mayet , D. Santos
Q. Riffard (Ph.D) (started in October 2012)

Technical Coordination : O. Guillaudin

- Electronics : G. Bosson, O.Bourrion, J-P. Richer
- Gas detector : O. Guillaudin, A. Pellisier
- Data Acquisition: O.Bourrion
- Mechanical Structure : Ch. Fourel, S. Roudier, M. Marton
- Ion source (quenching) : P. Sortais, J-F. Muraz

Saclay (IRFU): I. Giomataris, E. Ferrer, F.J. Iguaz, J-P. Mols (uM detectors)

CCPM (Marseille): J. Busto, Ch. Tao, D. Fouchez, J. Brunner (Radon filtering)

Neutron facility (AMANDE) :

IRSN (Cadarache): L. Lebreton, D. Maire (Ph. D.)