# MIMAC

## MIcro-tpc MAtrix of Chambers

## ( $^3He$ + $C_4H_{10}$ + $CF_4$ )

**A Large TPC for non baryonic Dark Matter search**

Daniel Santos

Laboratoire de Physique Subatomique et de Cosmologie
(LPSC-Grenoble)

(CNRS/IN2P3-UJF-ENSPG)

# MIMAC:
# (MIcro-tpc MAtrix of Chambers )

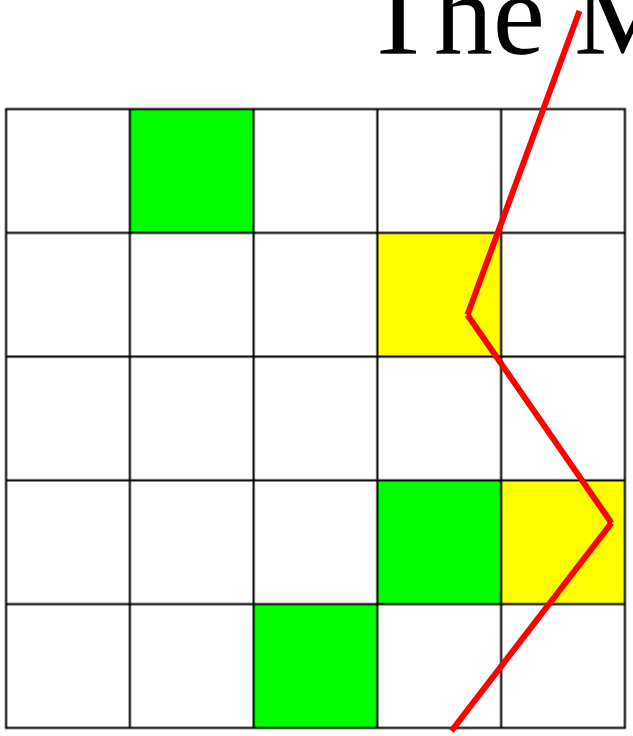
**LPSC (Grenoble) :** **F. Mayet , D. Santos , C. Grignon (post-doc), Ch. Koumeir (post-doc), J. Billard (Ph.D )**

**Technical Coordination : O. Guillaudin**
**- Electronics : G. Bosson, J-P. Richer**
**- Gas detector : A. Pellisier, O. Zimmermann**
**- Data Acquisition: O. Bourrion**
**- Mechanical Structure : Ch. Fourel**
**- Ion source : T. Lamy, P. Sole**

**CEA-Saclay (Dapnia):** **I. Giomataris, P. Colas, A. Giganon, E. Ferrer, J. Pancin, J-P. Mols**

**IRSN (Cadarache):** **L. Lebreton, A. Allaoua**

# The MIMAC project



A multi-chamber detector for Dark Matter

- Track-Energy measurements
- Matrix of chambers (correlation)
- µTPC : Micromegas technology
- $^3$He and $CF_4$ gaz : $\sigma(A)$ dependancy
- Axial interaction
- High or low pressure regime
- Directionnal detector

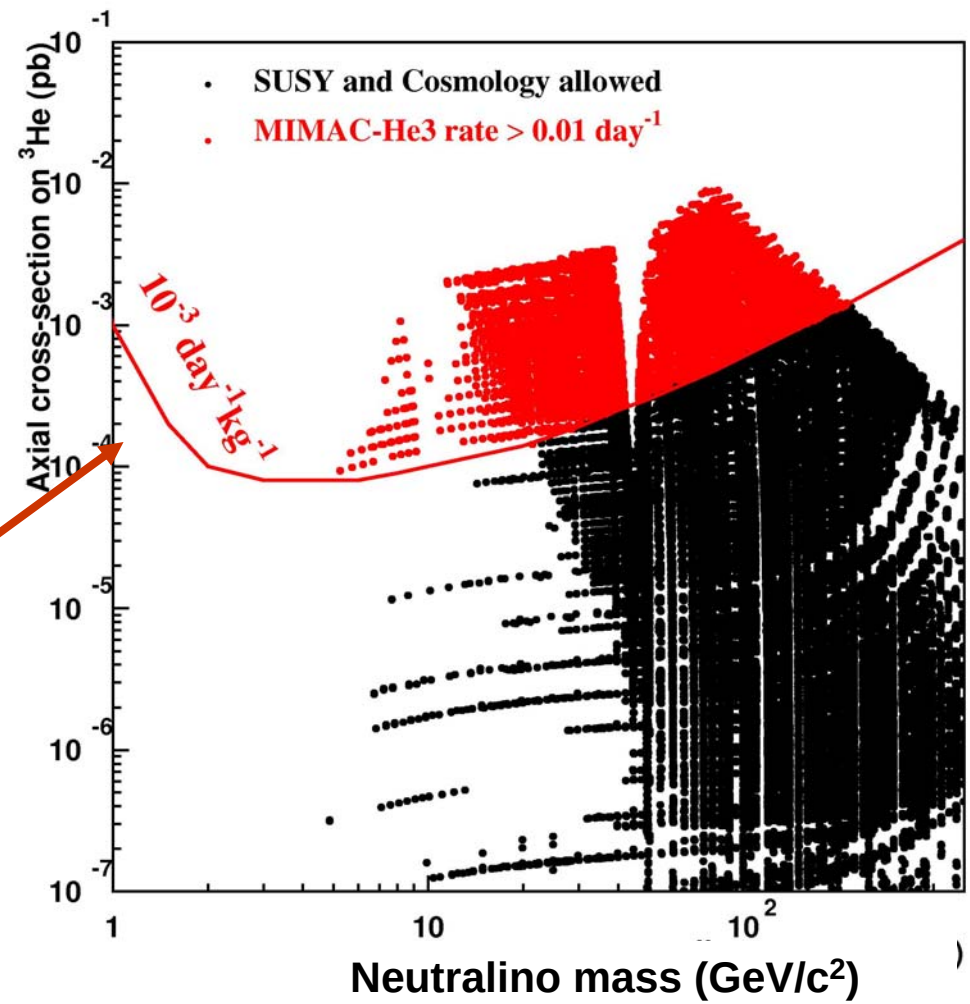
**Rejection of background events :**

- ✓ **Energy (ionization)**
- ➢ **Track**
- ➢ **Direction (Cygnus)**

# Cross section $^3$He-$\chi$ and event rate in MIMAC-He3 (10kg)

- $0.02 < \Omega_\chi h^2 < 0.15$
- Accelerator constrains

Exclusion curve for background $10^{-3}$ kg$^{-1}$jour$^{-1}$



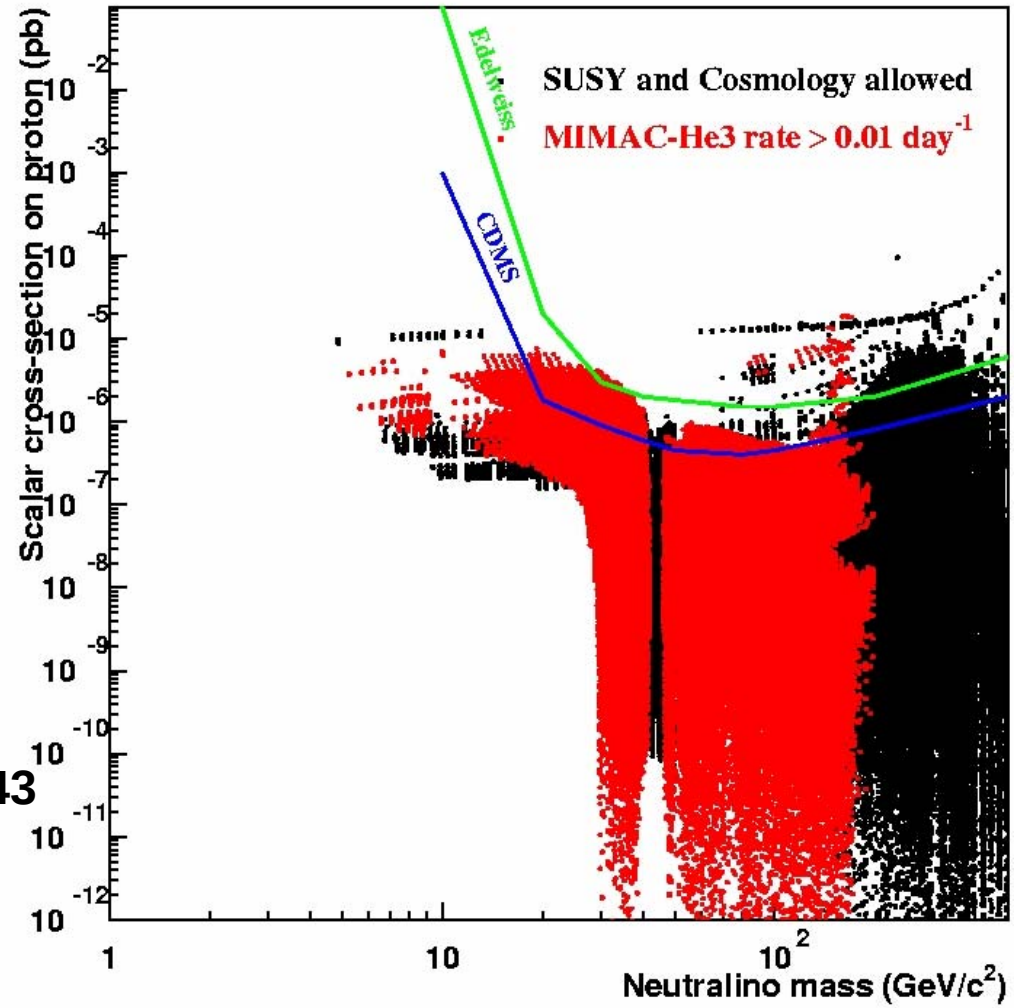



D. Santos (LPSC Grenoble)

# Complementarity with scalar detection

$\sigma_{SD}$ and $\sigma_{SI}$ not correlated

E. Moulin et al, PLB 614 (2005)143



# Why do we think we need a large TPC?

- Directionality

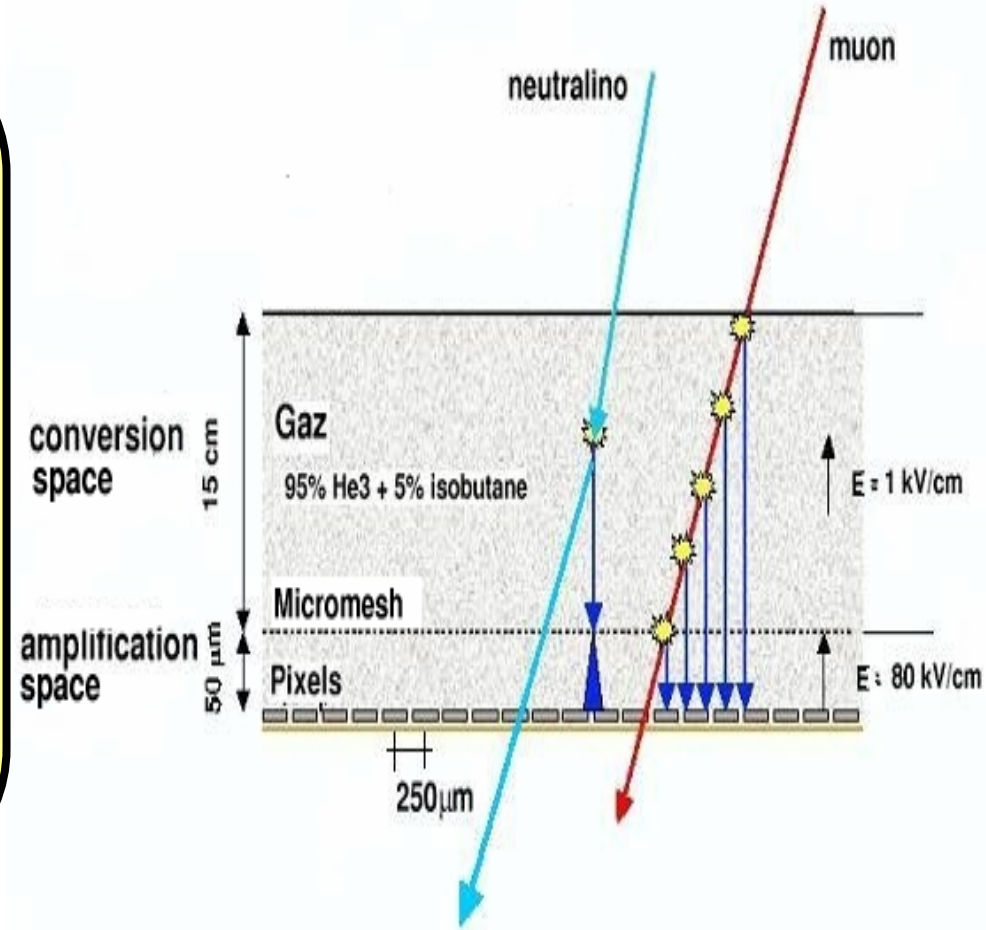
  (correlation with galactic halo)
- Axial interaction ($^{1}H$ ,$^{3}He$, $^{19}F$)

  (complement of scalar (coherent) search )
- Mass dependence cross section (modularity)
- Two different operating modes (pressure)
- Low energy threshold detection (< 300 eV)

# MIMAC:
# (Micro-tpc MAtrix of Chambers )

{ spatial
temporal
energetic } resolution

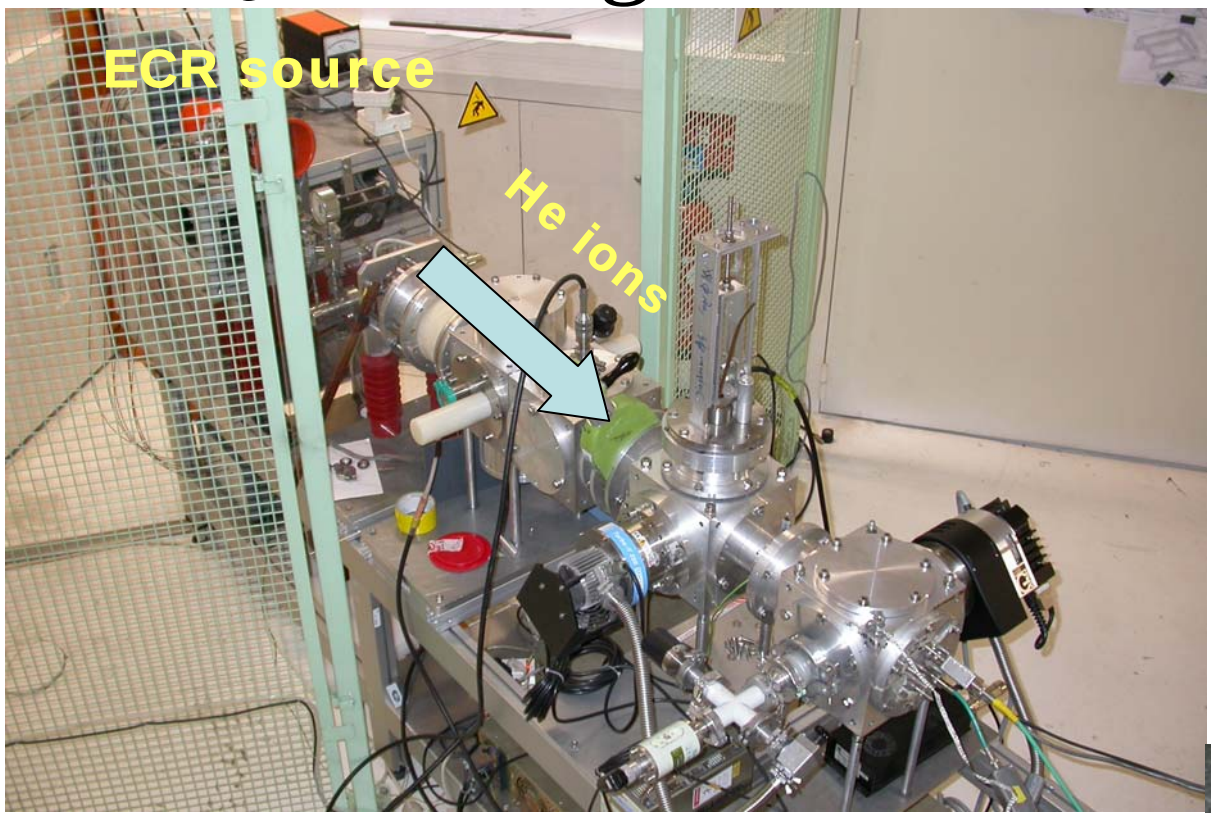
⇒ recoil track
⇒ energy threshold ~ 200eV
⇒ electron/recoil discrimination






D. Santos (LPSC Grenoble)

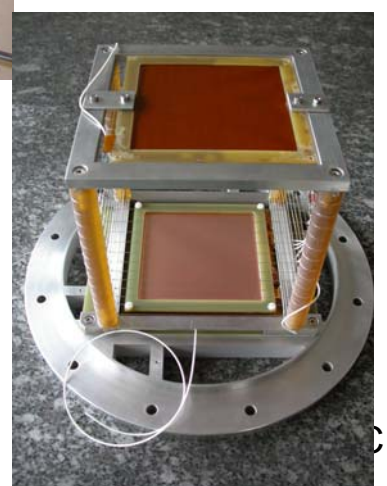
# Quenching factor measurement




- **Low energy ion source**

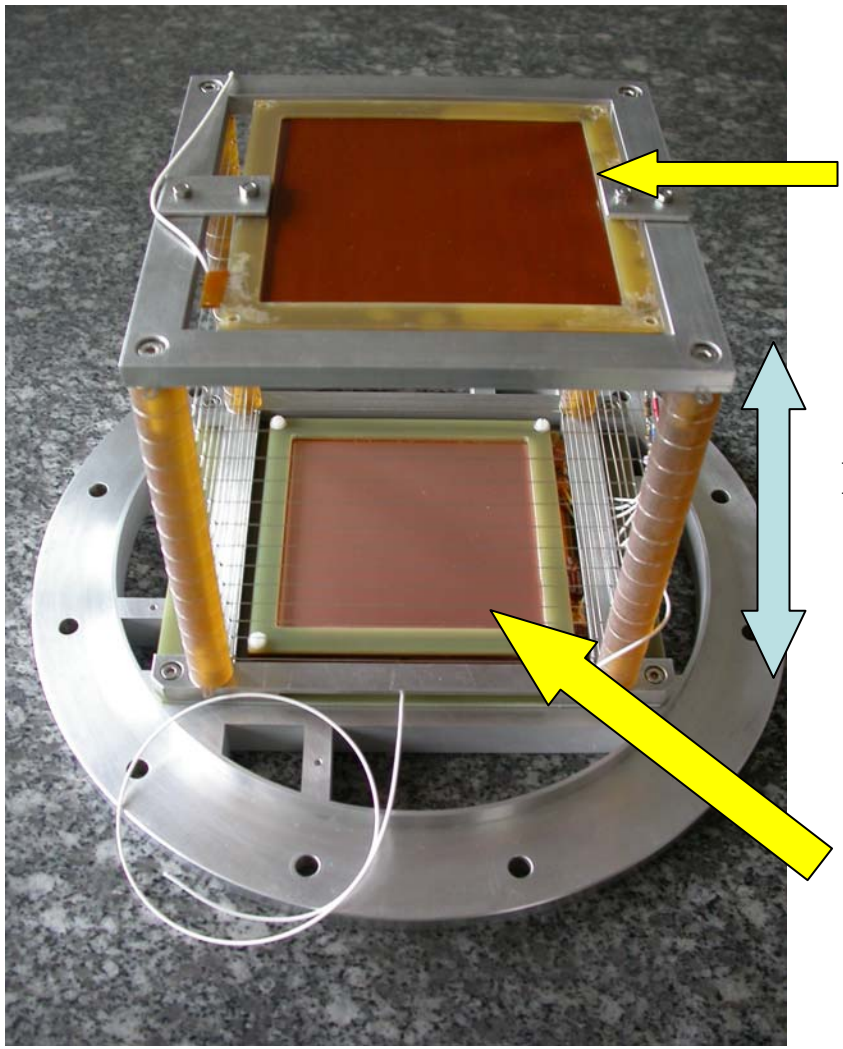
  **1 to 50 keV**

- **Developped @LPSC**



**Micromegas µTPC**

# MIMAC : µTPC chamber



Real size prototype

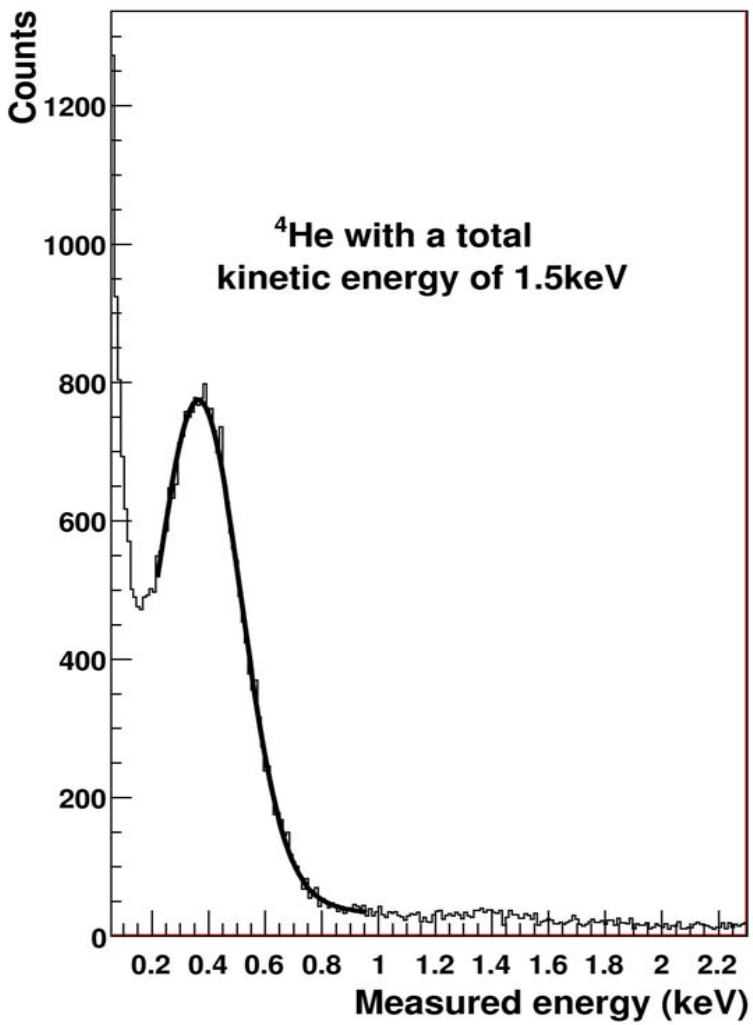
cathod

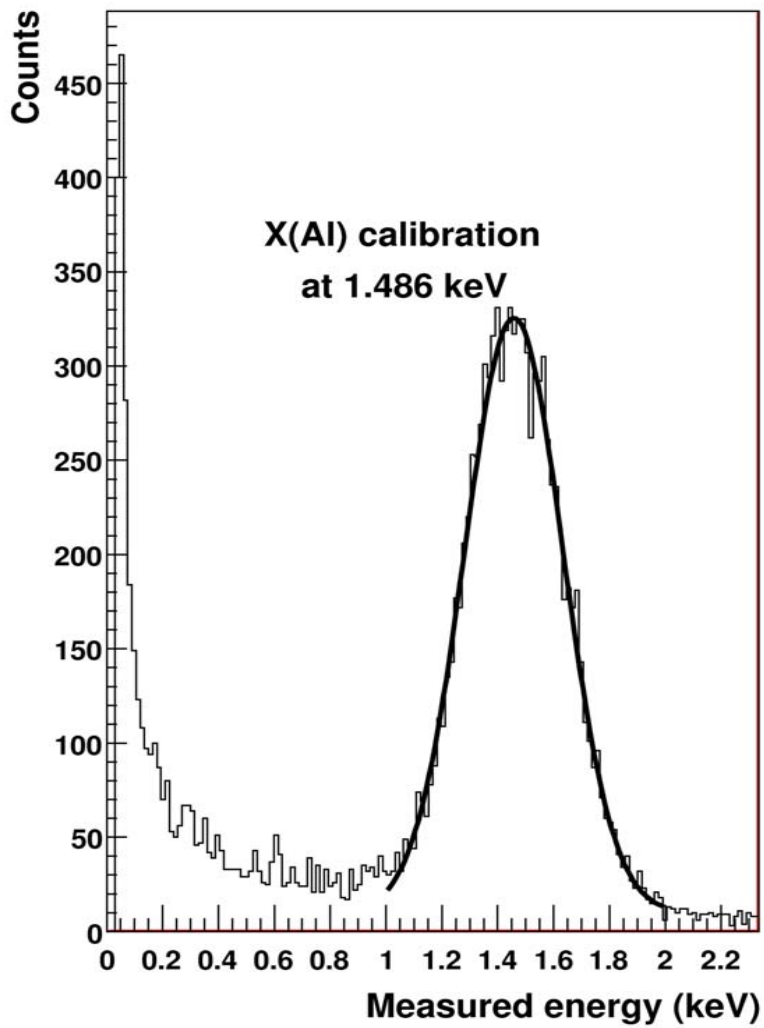
Drift space : 15 cm

Micromegas

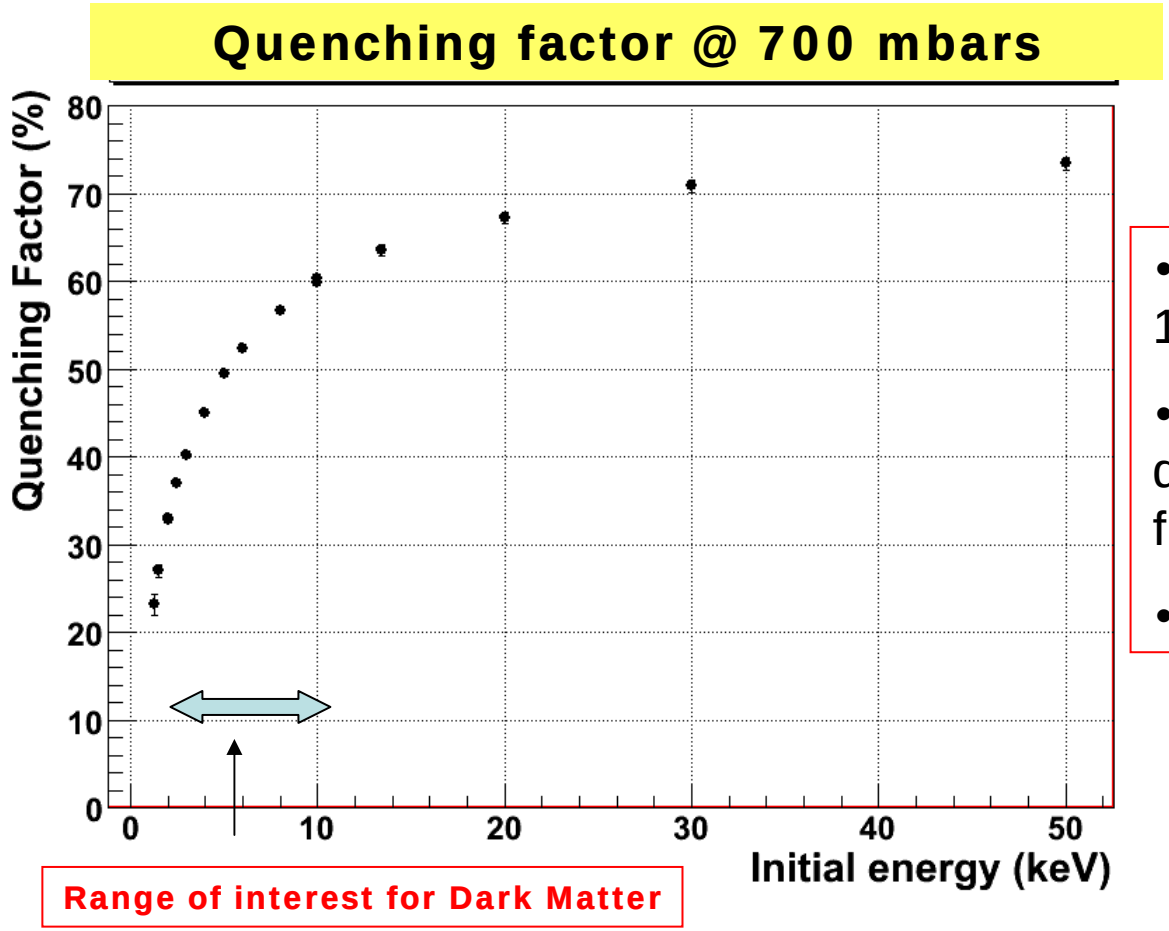
+pixellized anod (x,y)

# Detection of $^4$He (recoils) of 1.5 keV !!
# ( 95% $^4$He + 5% iso) at 700mbars



# QF measurement !!




Measurement of $^4He$

in 95% $^4He$ + 5% $C_4H_{10}$

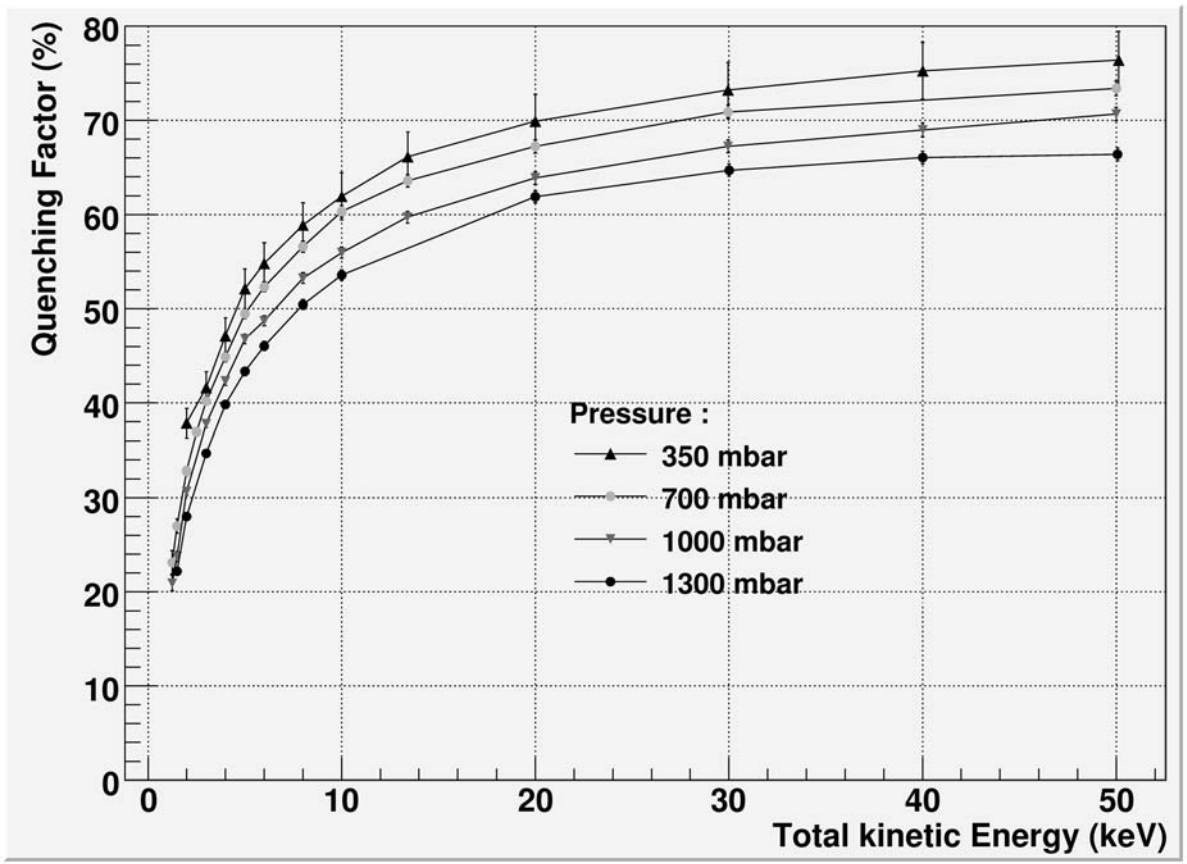
- Threshold :300 eV (ioni.) or 1 keV (recoil)
- The response of this $^4He$ detector is fully understood from 1 to 50 keV
- Dark Matter range : covered



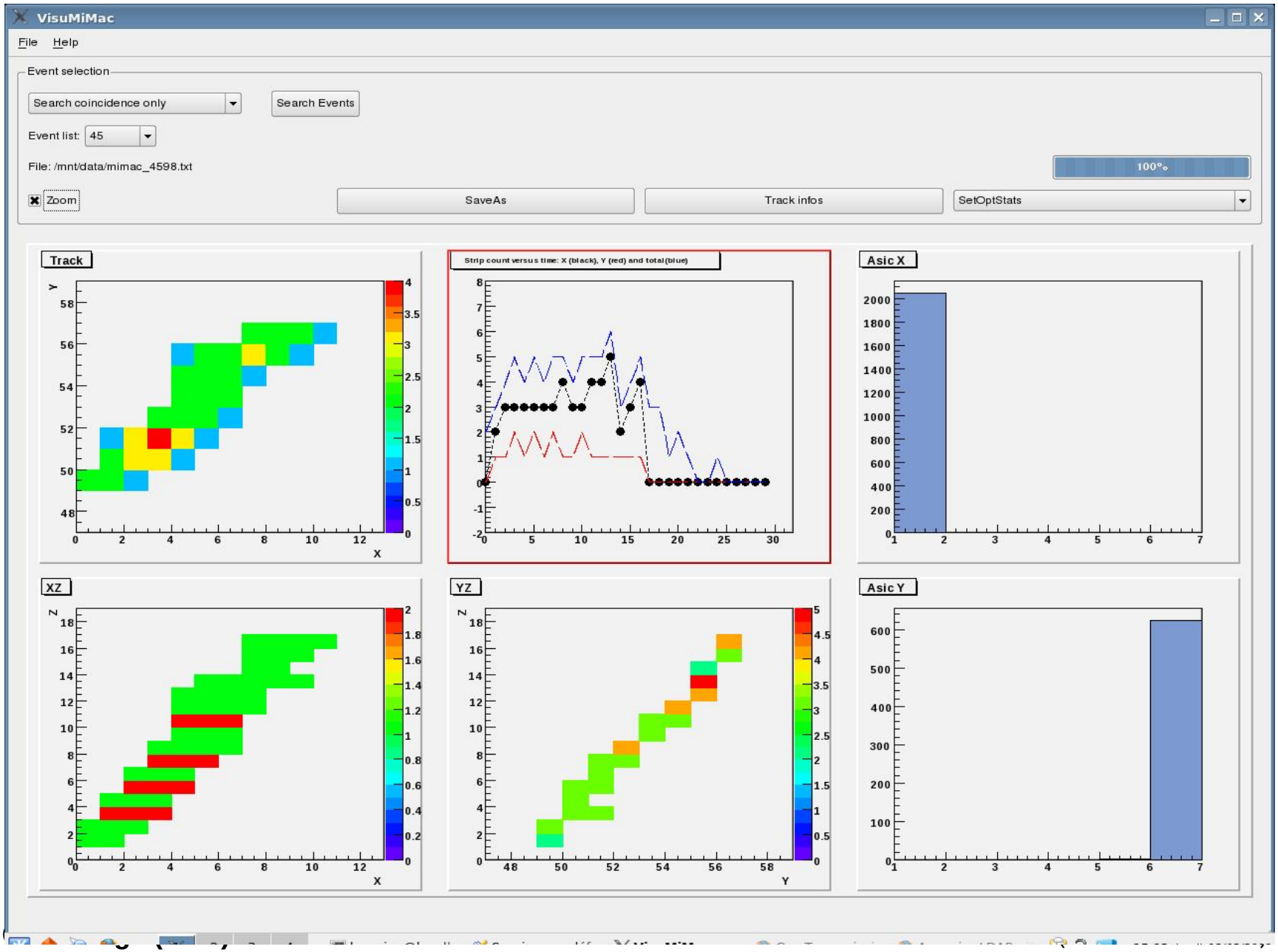
D. Santos (LPSC Grenoble)

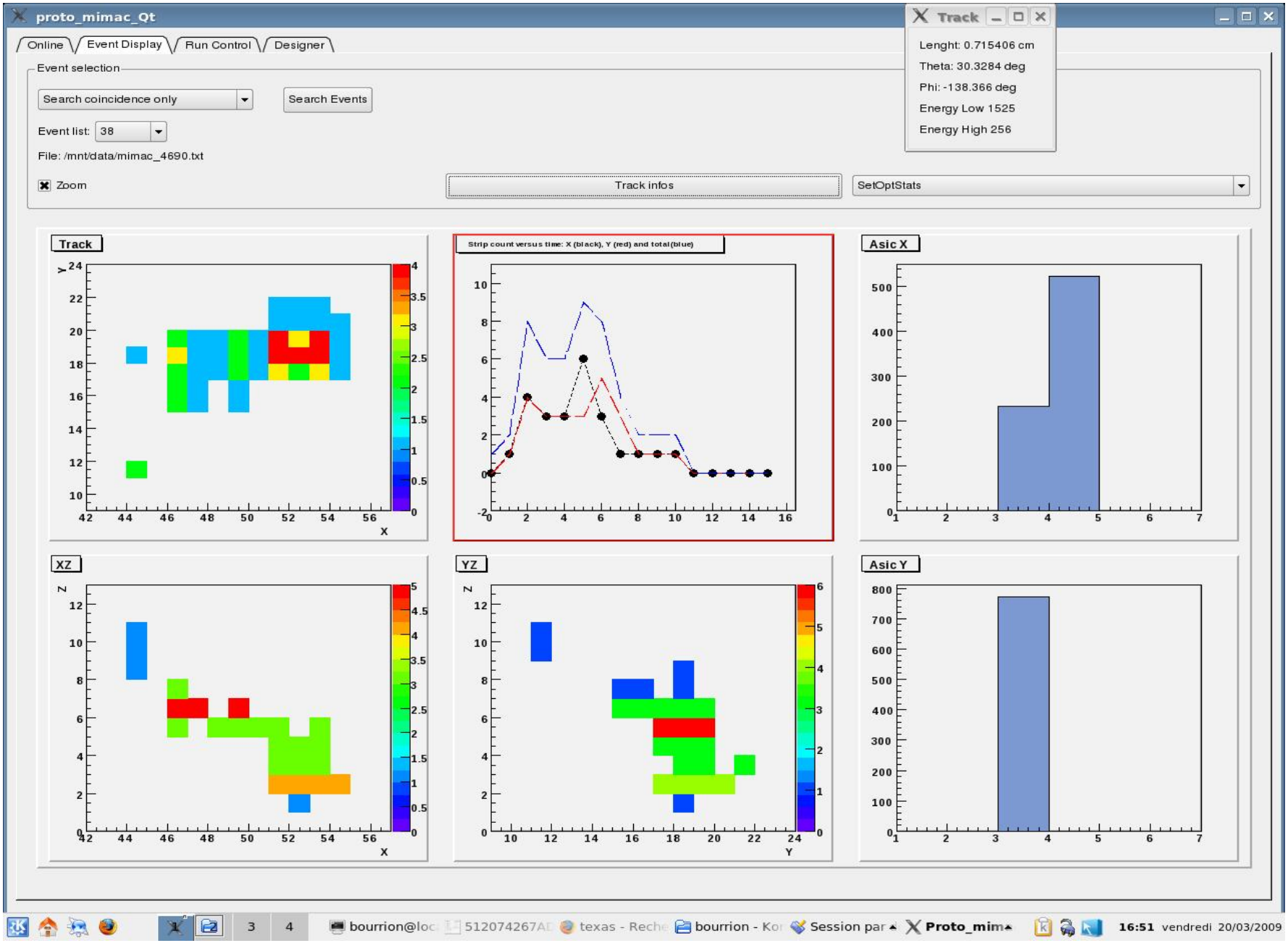
# IQF Measurement of $^4He$ in 95% $^4He$ + 5% $C_4H_{10}$ as a function of the pressure

D. Santos et al. arXiv:astro-ph0810.1137

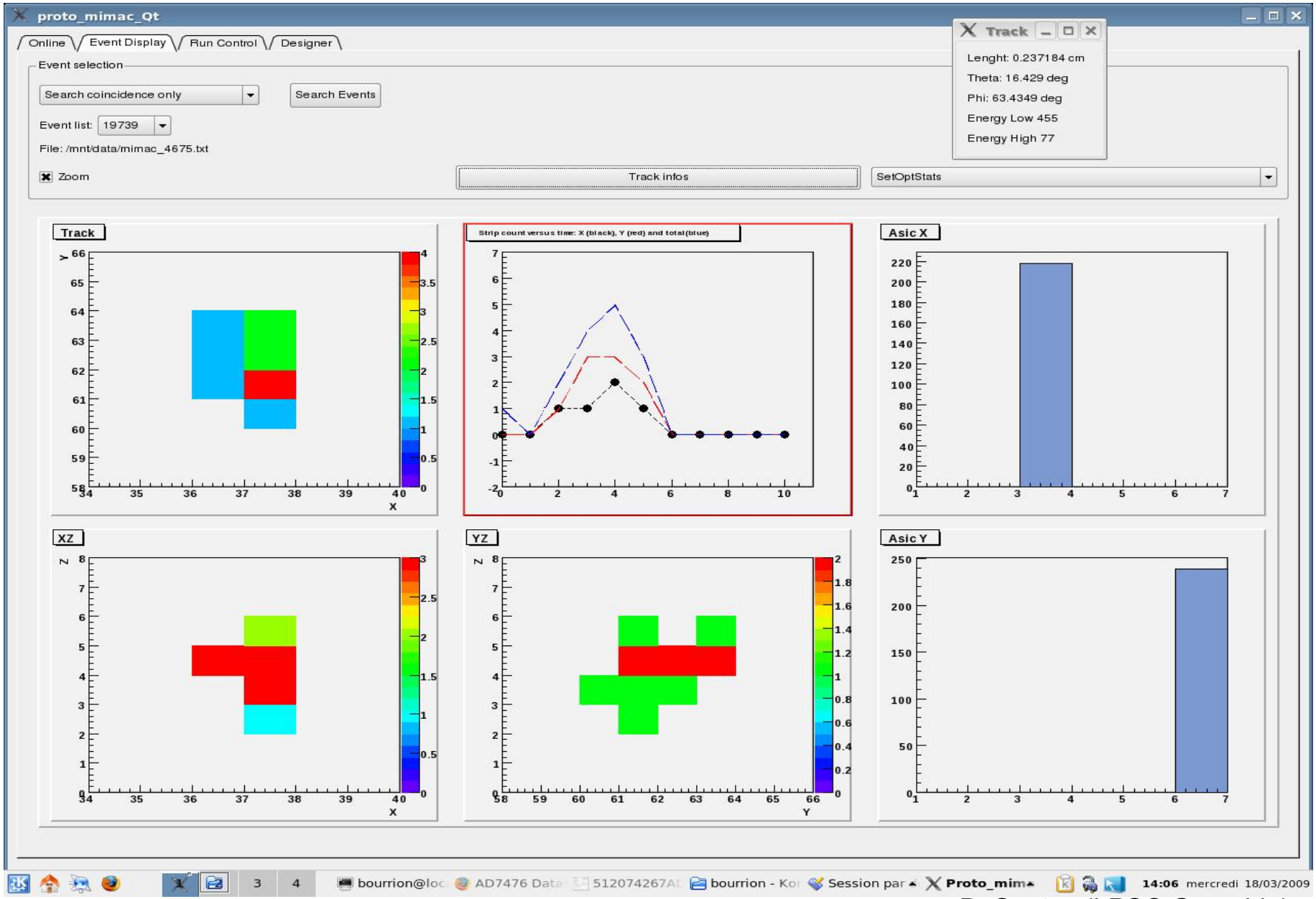


# 3D track measurement of an electron (5.9 keV, 350mbar)

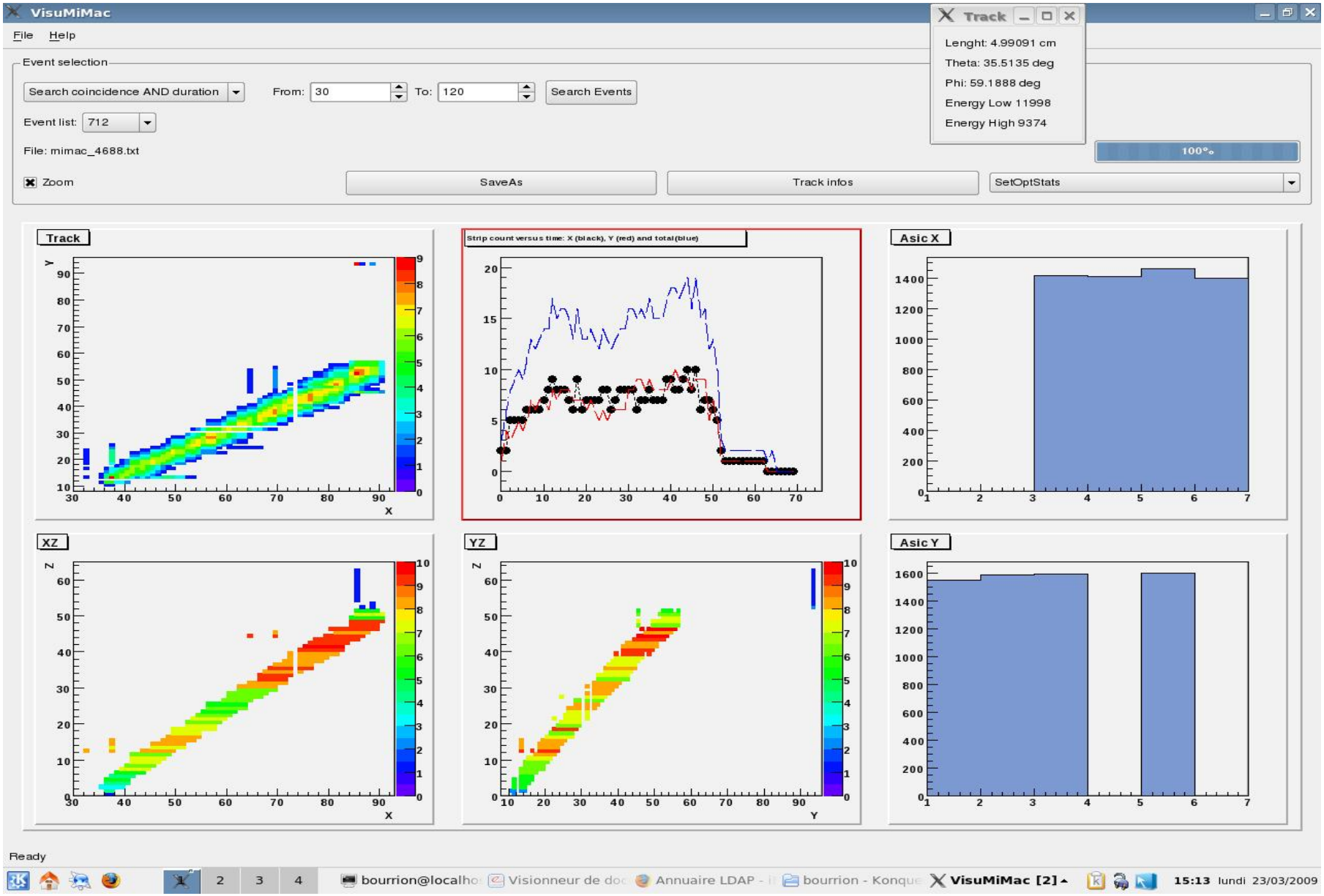



proto_mimac_Qt
Online
Event Display
Run Control
Designer
Event selection
Search coincidence only
Search Events
Event list: 38
File: /mnt/data/mimac_4690.txt
Zoom
Track infos
SetOptStats
Track
Lenght: 0.715406 cm
Theta: 30.3284 deg
Phi: -138.366 deg
Energy Low 1525
Energy High 256
Track
Strip count versus time: X (black), Y (red) and total (blue)
Asic X
XZ
YZ
Asic Y

# 3D track measurement of an electron of 1.5 keV (X(Al))



# **3D track alpha** (radioactivity)



# MIMAC : recoil track measurements

April 2009

@ IRSN Cadarache

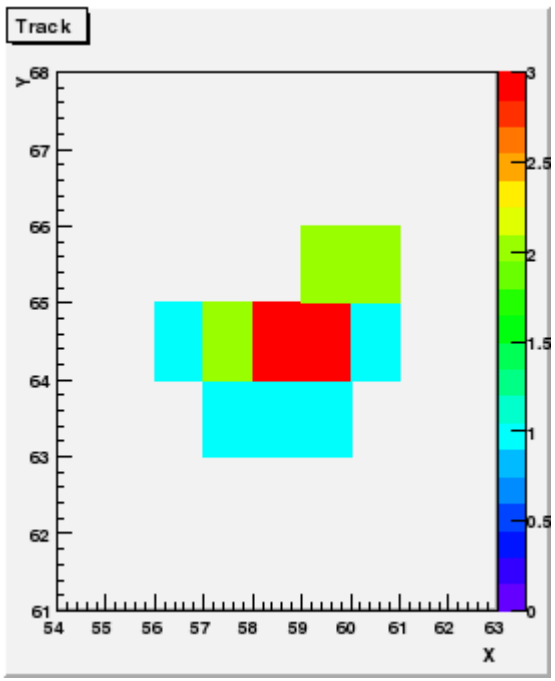
<u>Amande facility</u> :

- Neutron field with energies down to a few keV

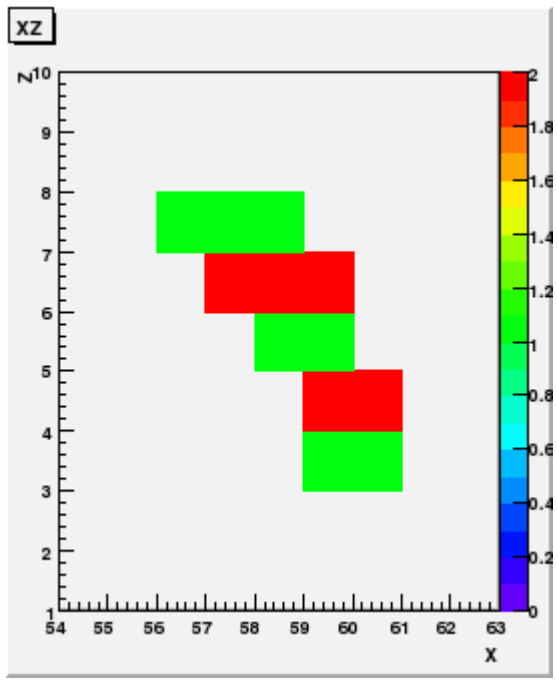
# 6 keV recoil track ($^4$He) projections

300 mbar (95% of 4He, 5% of $C_4H_{10}$ )

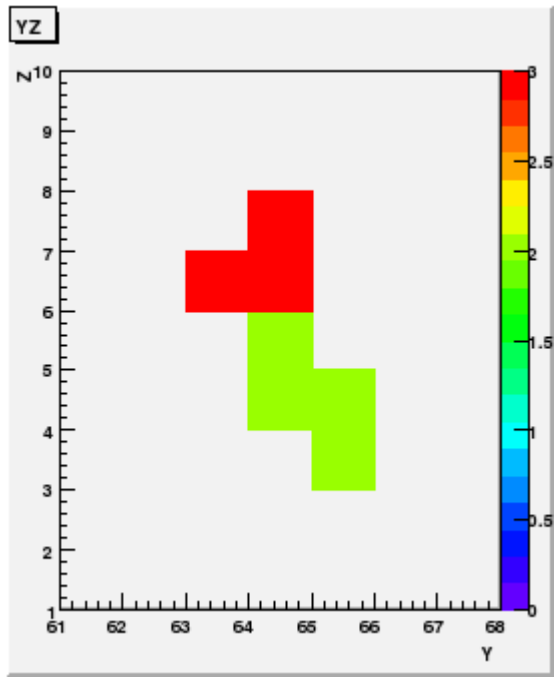
**X-Y**



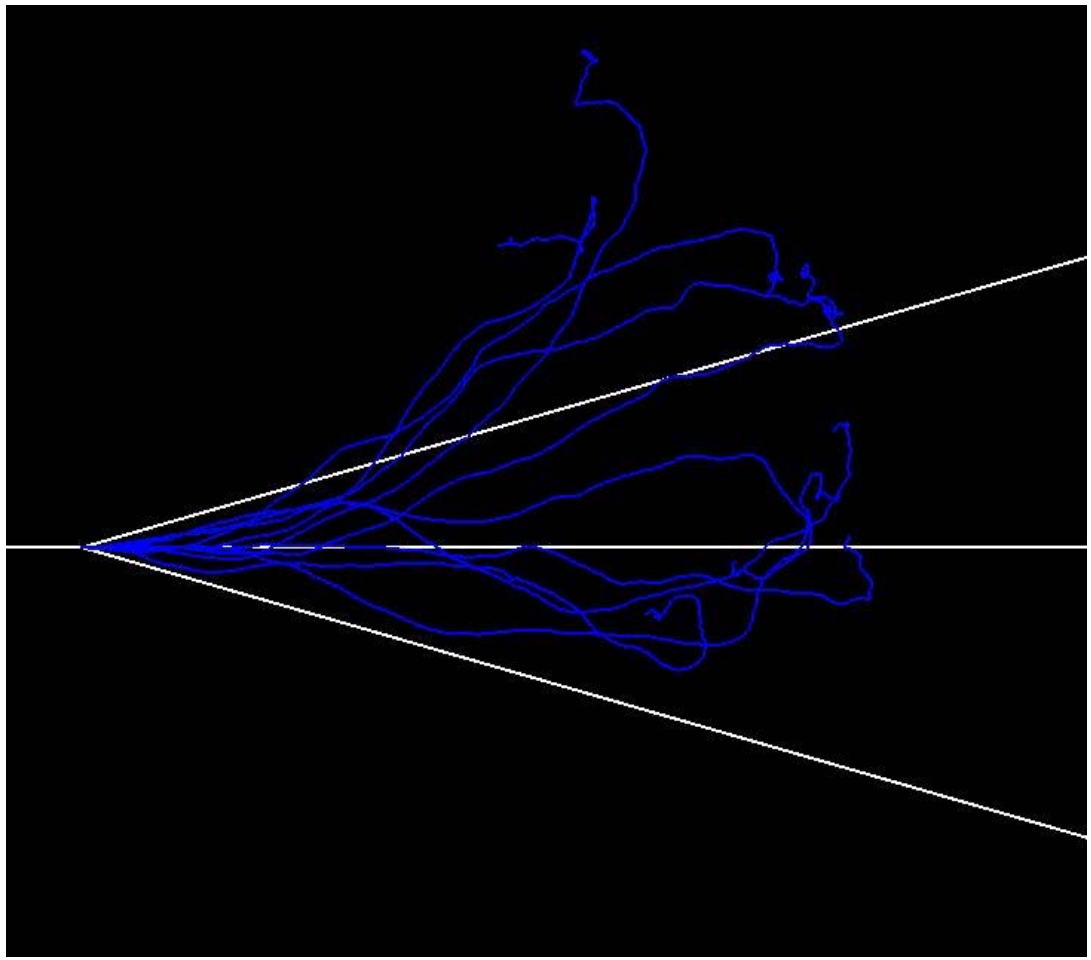

**X-Z**



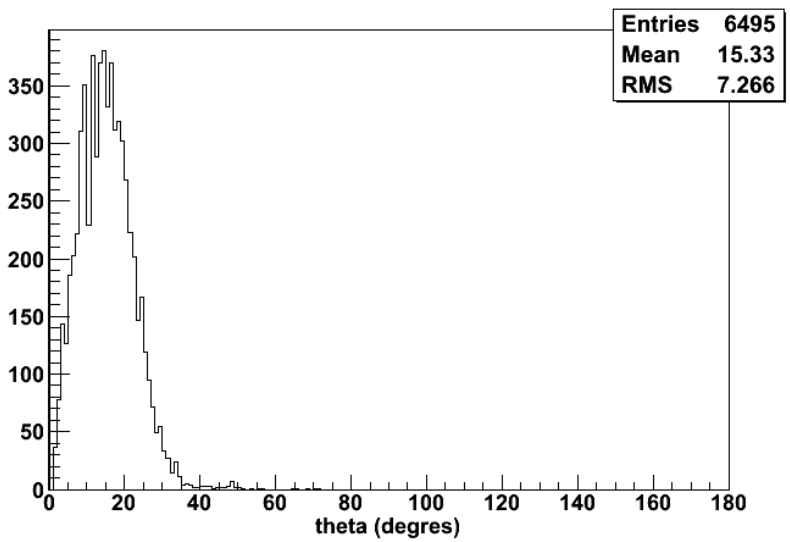

**Y-Z**

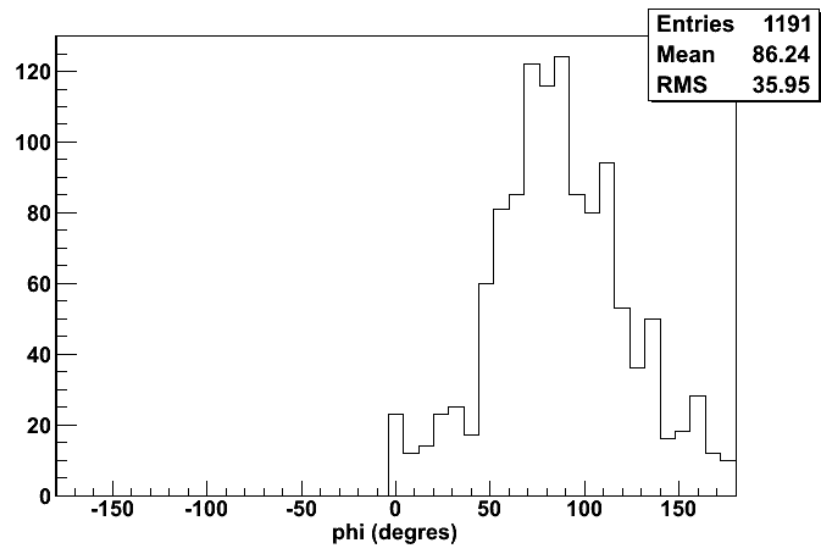


# $^4$He (6 keV) in $^4$He (100mbar)
# range ~ 4mm



# Directionality of recoils measured in 3D (E ~ 120 keV)

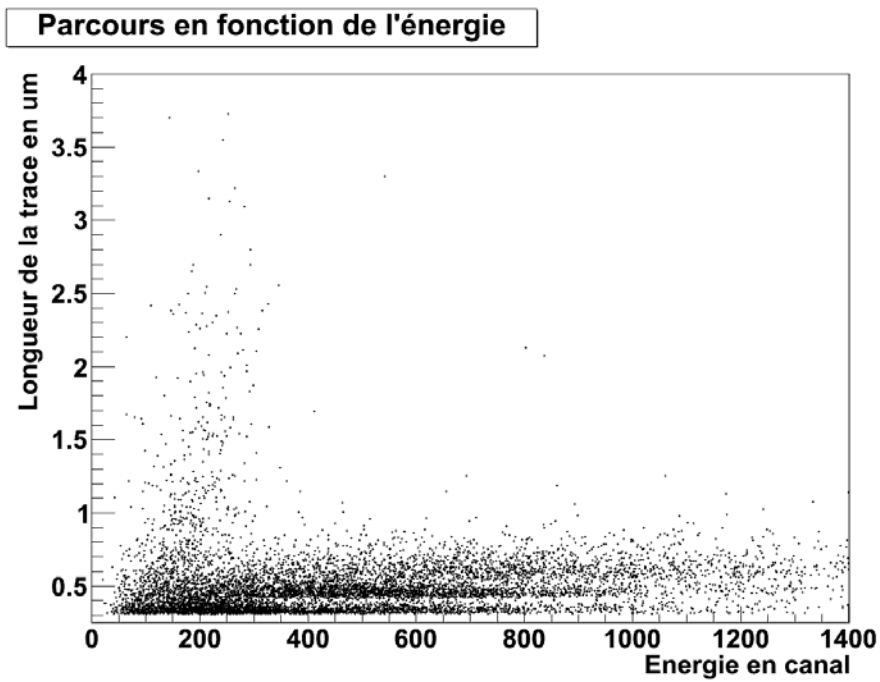


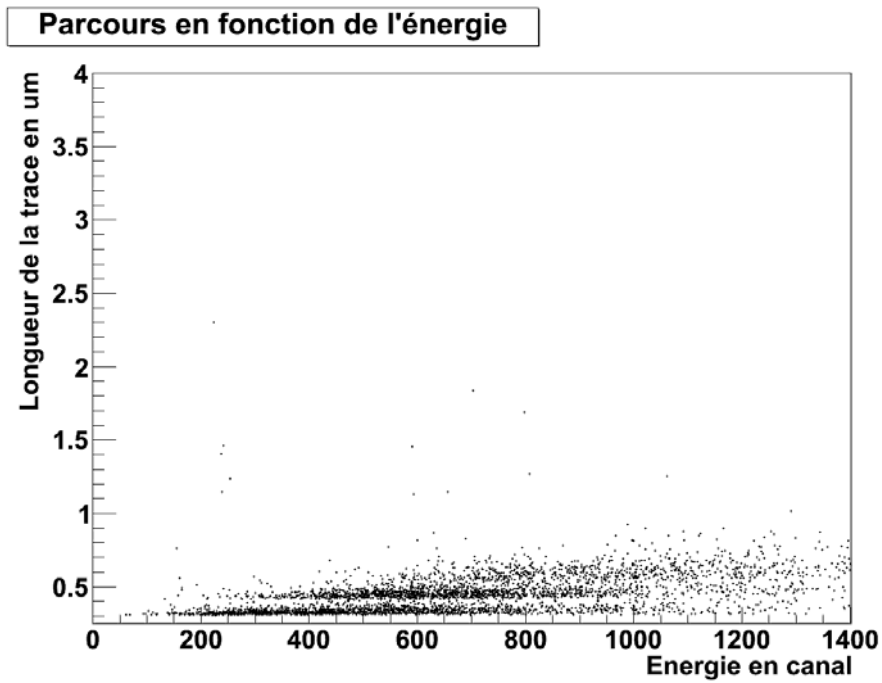



# New degree of freedom to discriminate recoils from electrons from 3D tracks

## Normalized Integrated Straggling (NIS)

**(J. Billard et al. (2009) in preparation)**

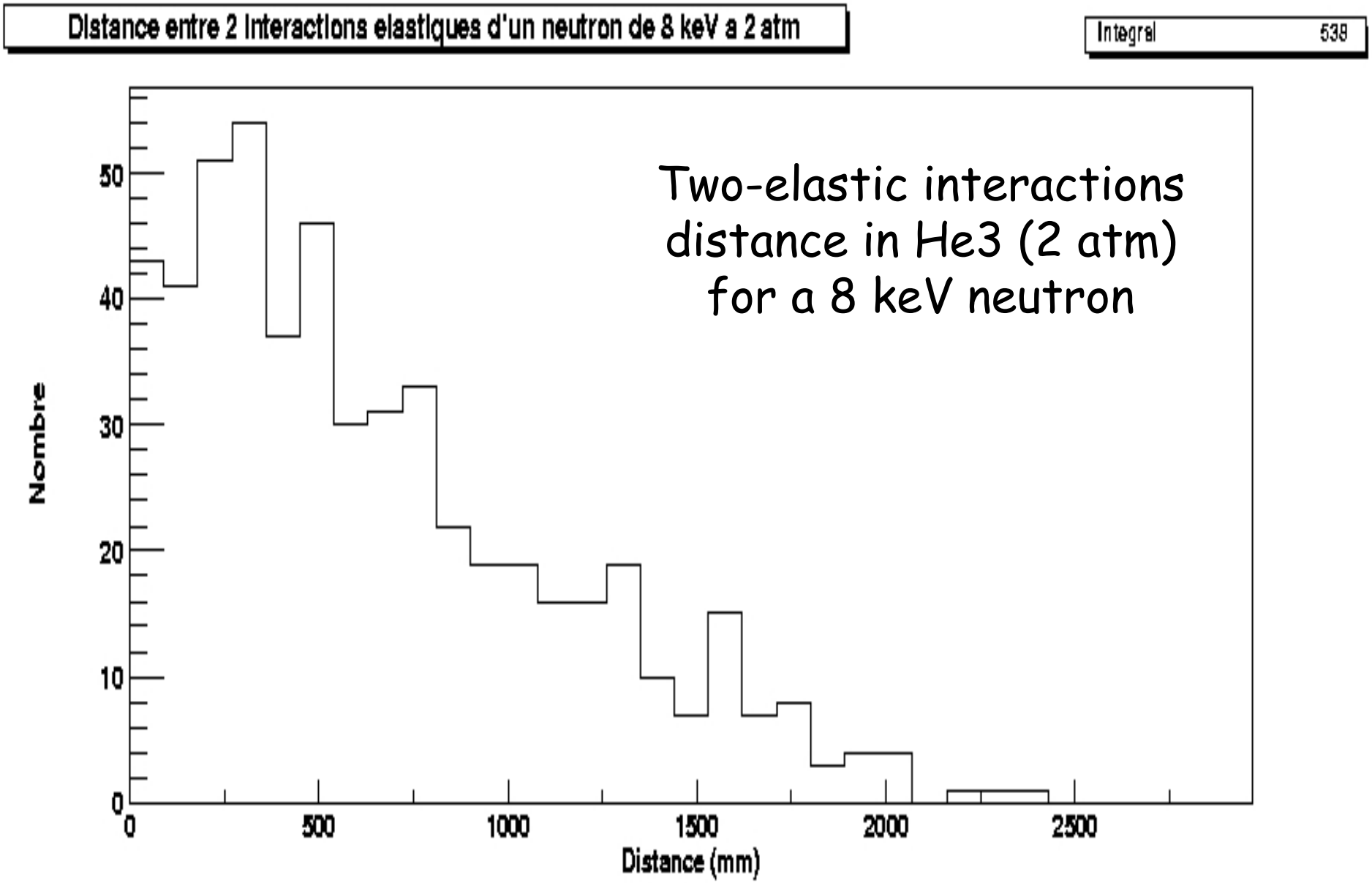


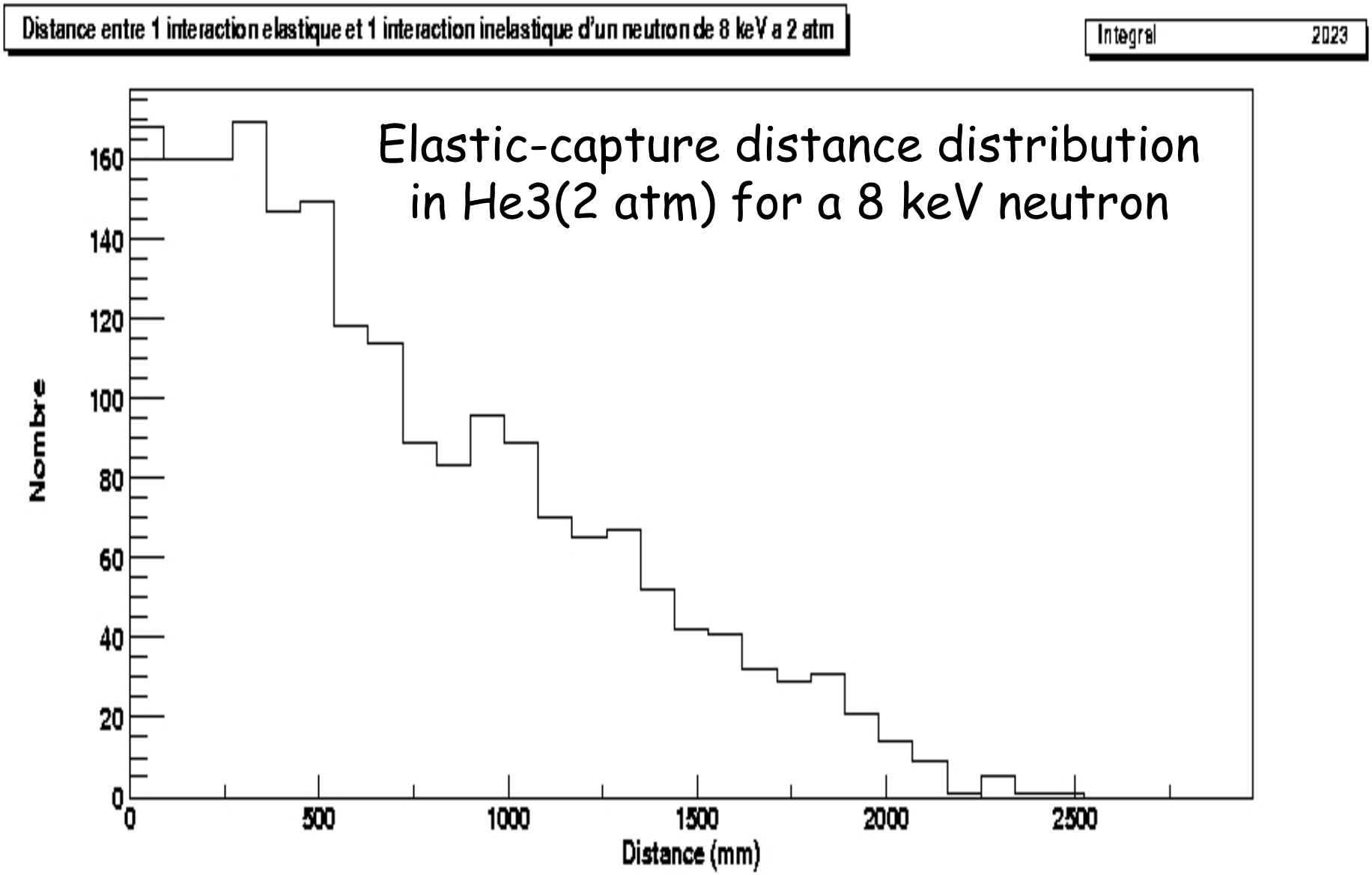



# Conclusion

- MIMAC has measured the IQF of $^{4}He$ and can measured the IQF of $^{1}H$ and $^{19}F$ up to 100 keV.
- MIMAC has designed and built a 3D read-out with a resolution of 300 µm.
- MIMAC has shown tracks in 3D of recoils in a few keV range.
- Future : a $1m^3$ unit design…

  CYGNUS (CosmoloGY with NUclear recoilS) (international collaboration)


Distance entre 2 interactions elastiques d'un neutron de 8 keV a 2 atm
Integral 538
Two-elastic interactions
distance in He3 (2 atm)
for a 8 keV neutron
Nombre
0
10
20
30
40
50
0
500
1000
1500
2000
2500
Distance (mm)


Distance entre 1 interaction elastique et 1 interaction inelastique d'un neutron de 8 keV a 2 atm
Integral 2023
Elastic-capture distance distribution
in He3(2 atm) for a 8 keV neutron
Nombre
0
20
40
60
80
100
120
140
160
0
500
1000
1500
2000
2500
Distance (mm)