

Développement de μ TPC Micromegas pour la recherche d'évènements rares : D2S2 (MIMAC)

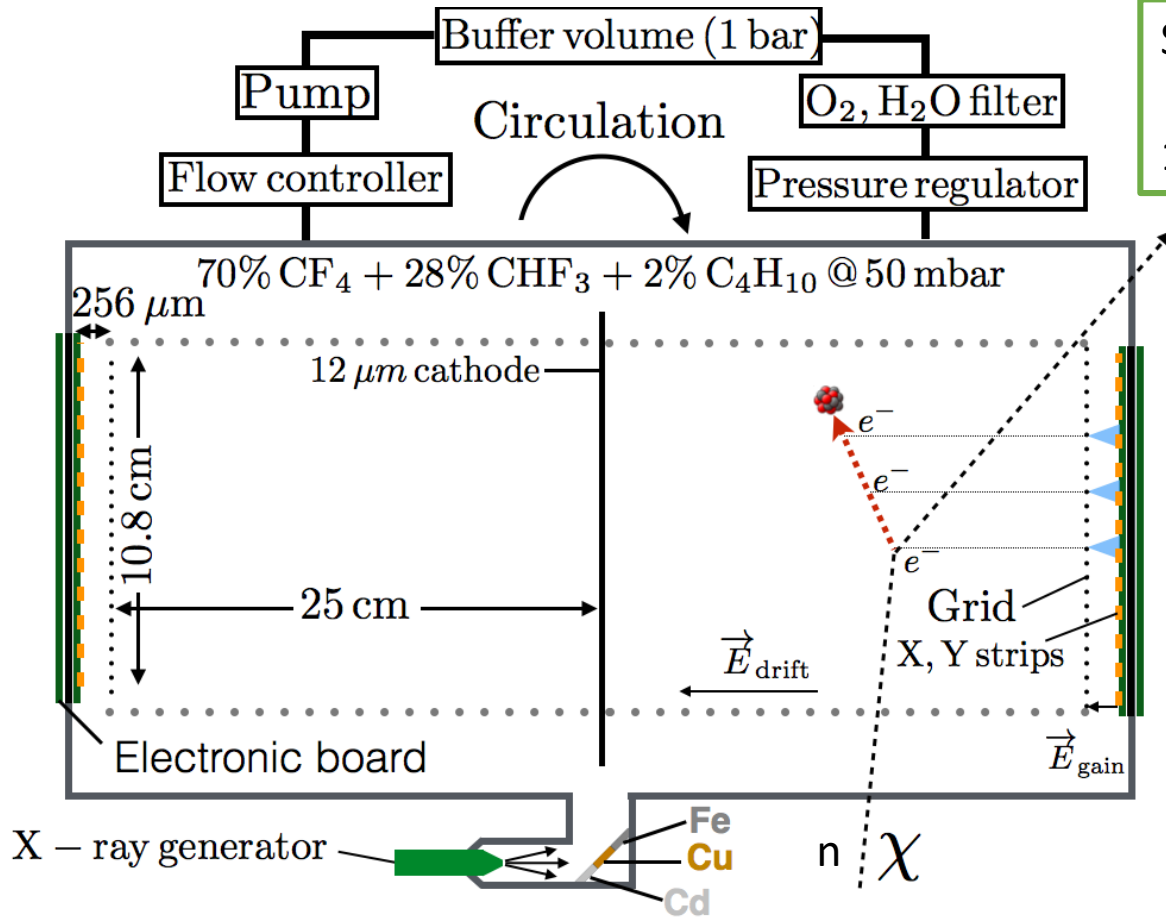
LPSC (Grenoble) : D. Santos, F. Naraghi

- SDI : M. Marton, N. Sauzet, O. Guillaudin
- Electronique : (G. Bosson, J. Bouvier), O. Bourrion,
E. Lagorio
- Ilias Ourahou (PhD LPSC)

D2S2 : **Détection Directionnelle** de matière sombre et des neutrons pour la **Science** et la **Société**

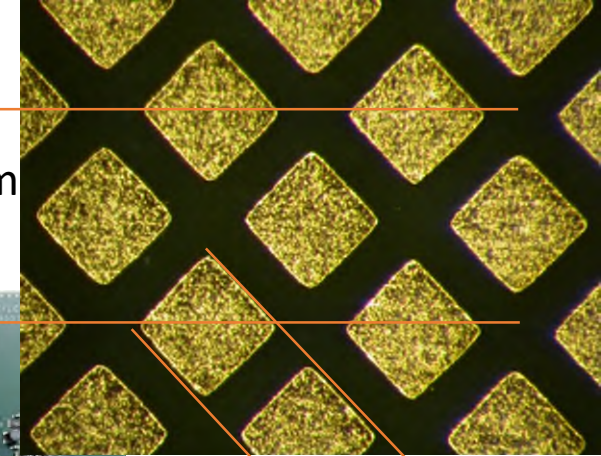


R&D : Prototype μ TPC gazeuse basse pression (30 mbar)



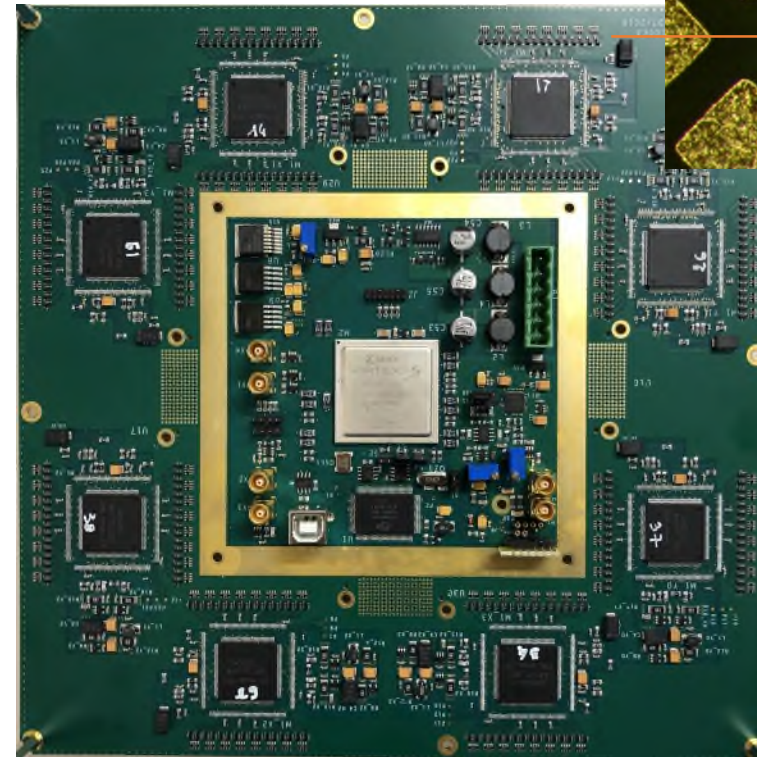
Seuil en énergie : < 1keV
seuil / voie ~ 3000 à
10 000 e^- ($\sim \text{fC}$)

424 μm



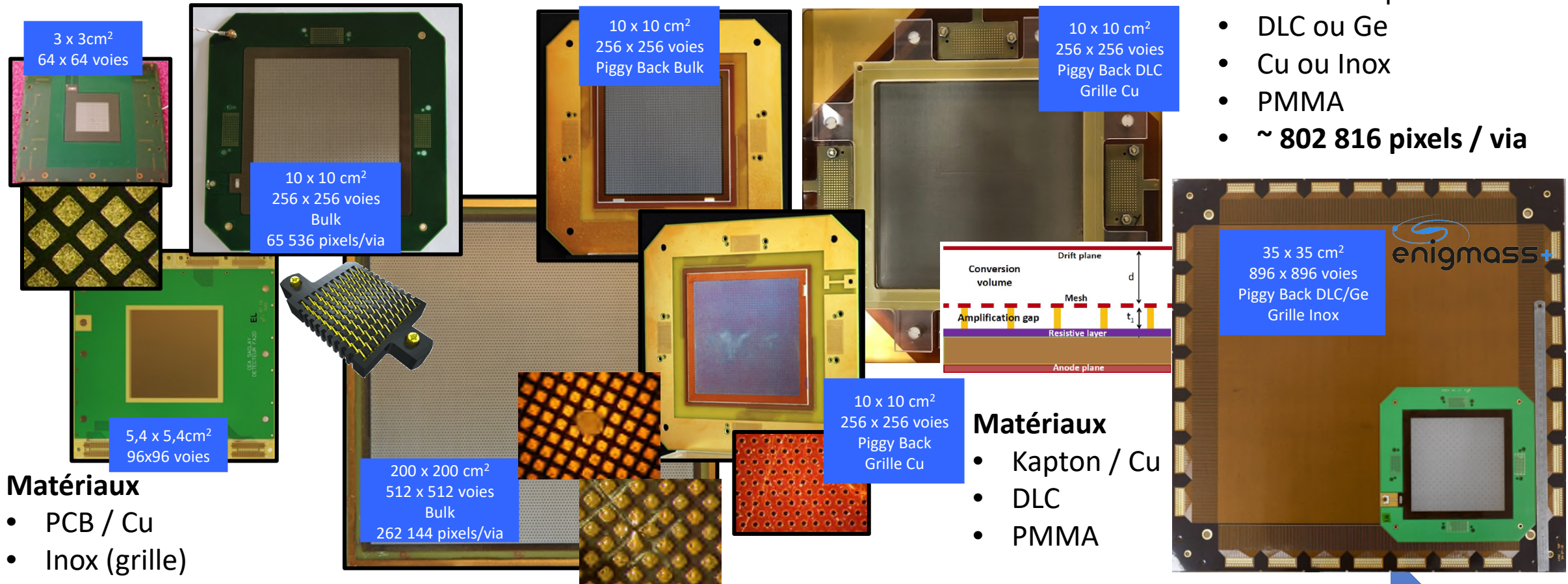
200 μm

- 512 voies $\rightarrow$ 65000 pixels
- Lecture pixels : 20 ns (50 MHz)
- Energie : ADC (50 MHz)
- Horloge externe



Gap 256 à 512 μm

Développement des Micromegas



2007

2009

2011

2012

2016

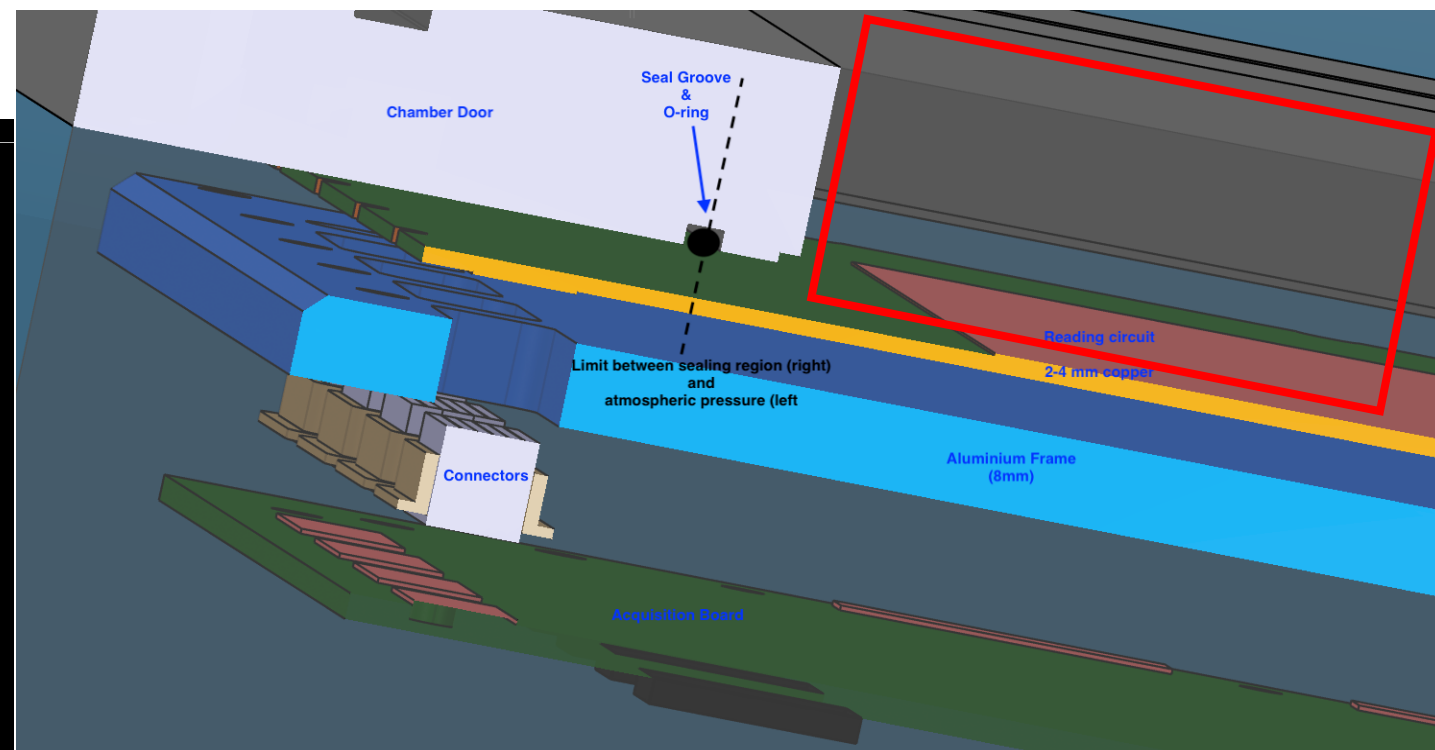
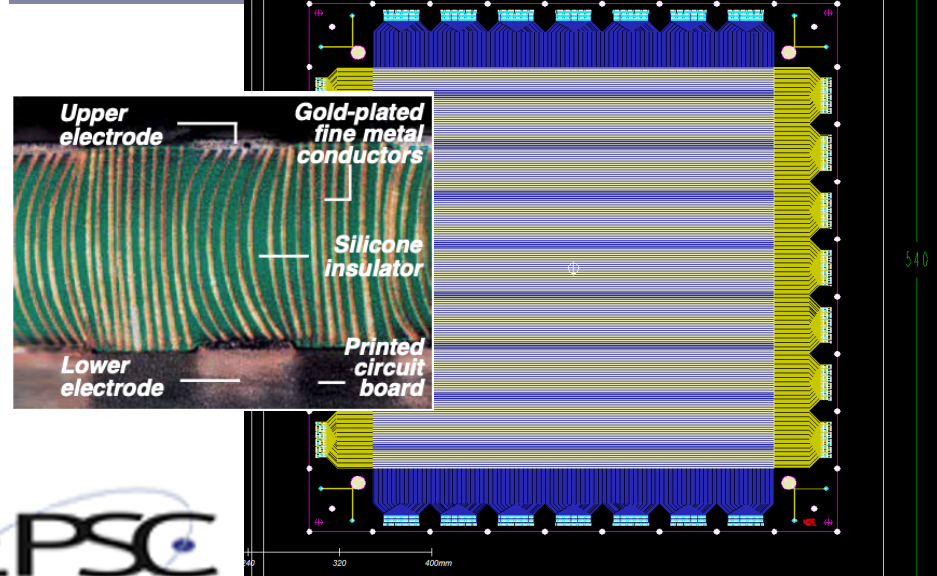
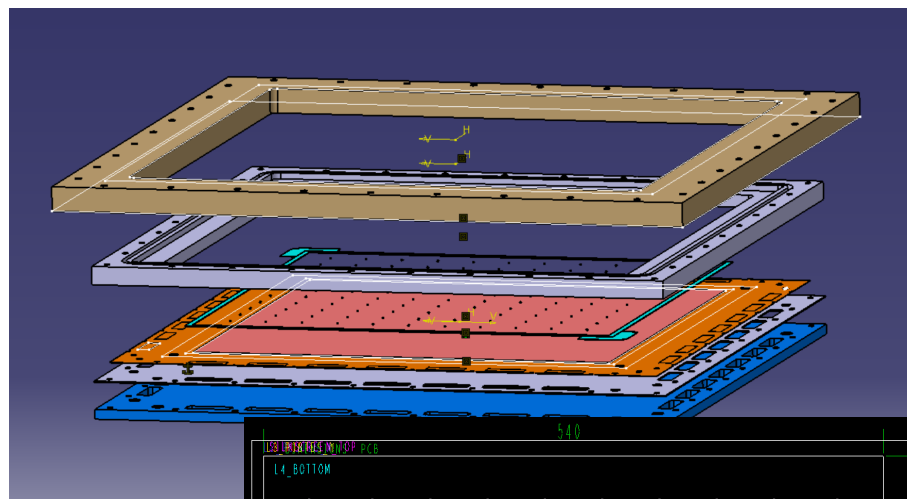
2022

2026

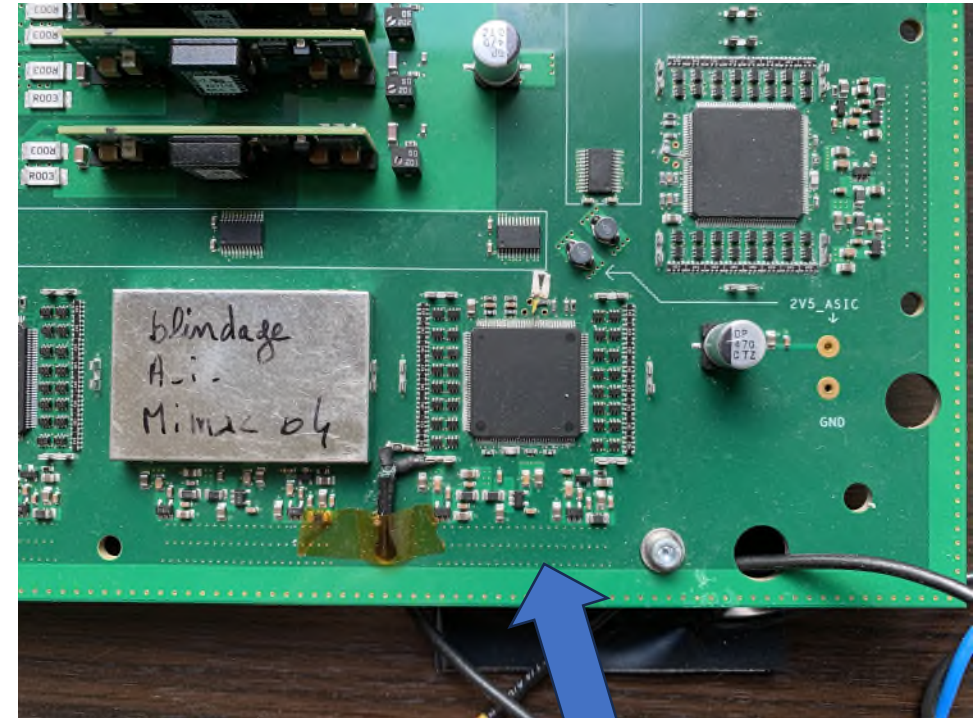
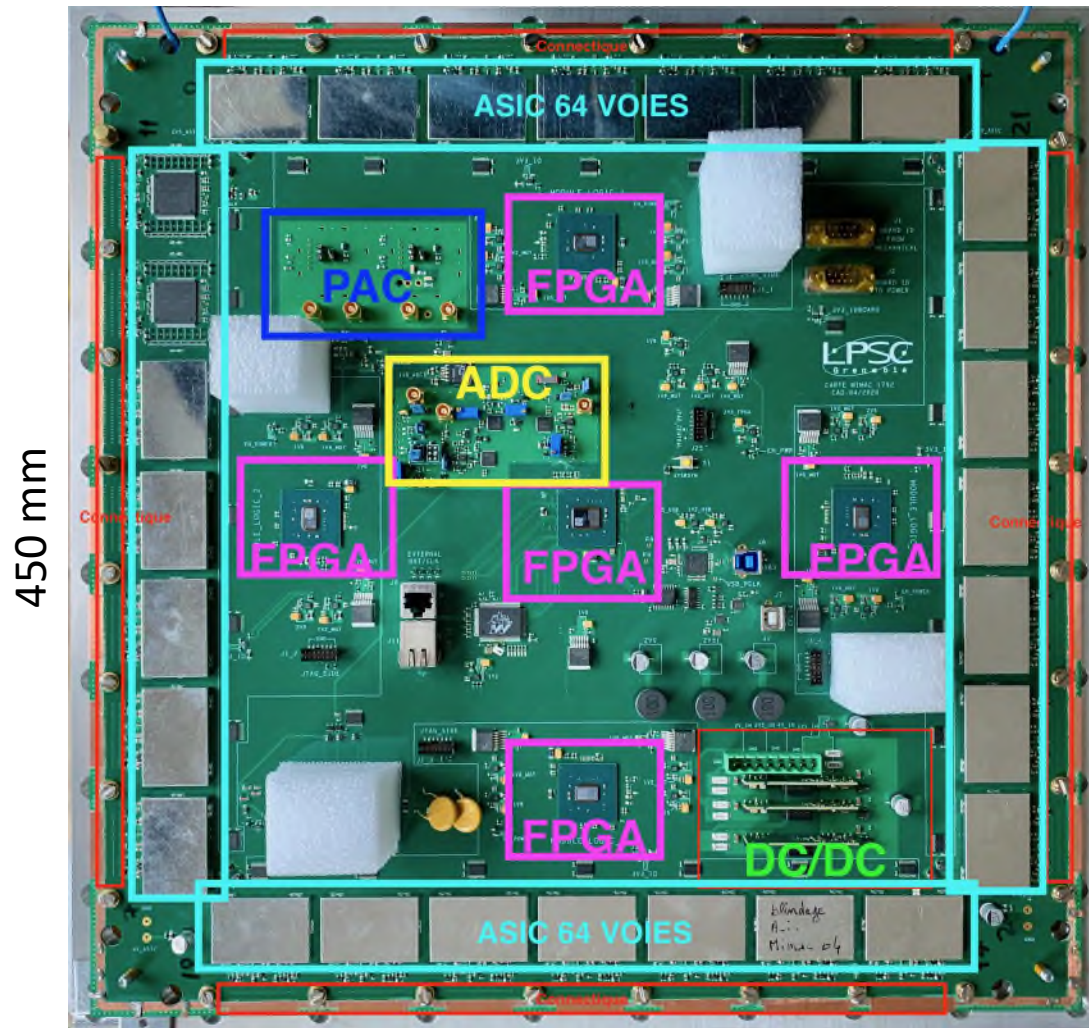
Maquette 3D

Cahier des charges :

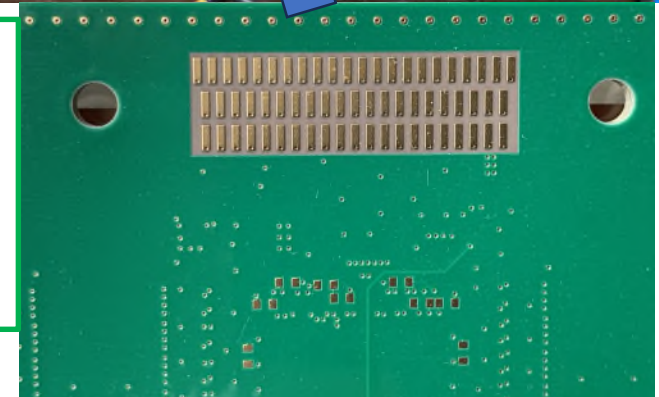
- Aligner 1792 pavés en une fois !!!
- Tenue au vide : 30 - 50 mbar (taux de fuite « faible »)
- Connecteurs sur mesure (Zebra)



Carte 1792 voies (LPSC) + ASIC MIMAC (LPSC)

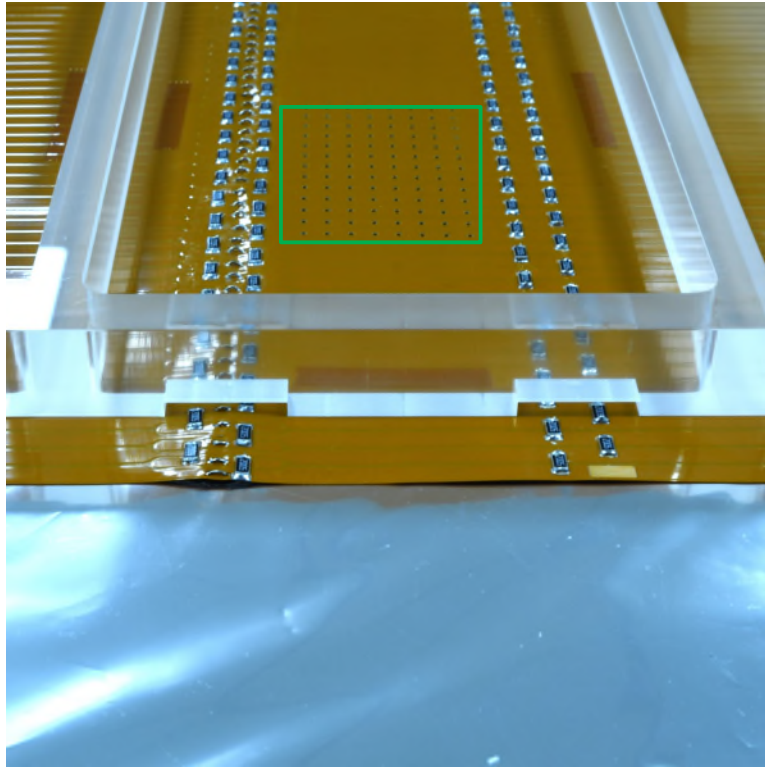
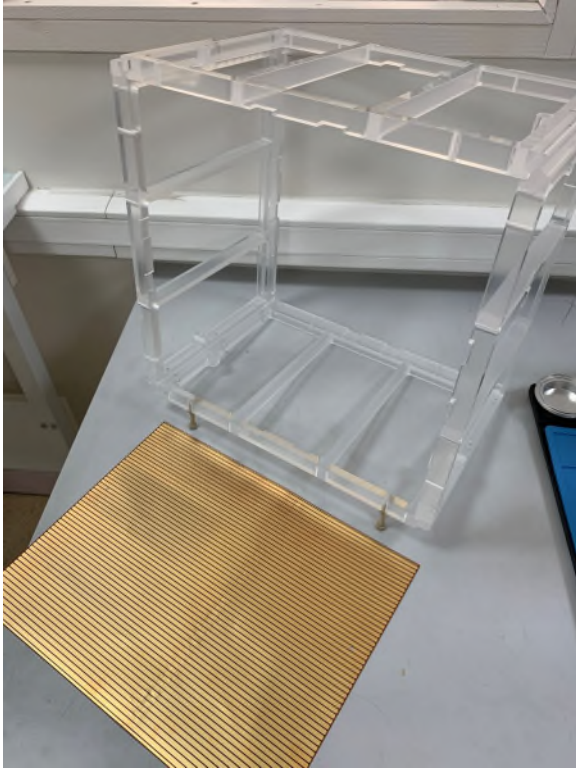


- 28 ASIC s(64 chs)
- 5 FPGAs
- 2 ADCs
- 3 DC/DCs
- 2 PACs

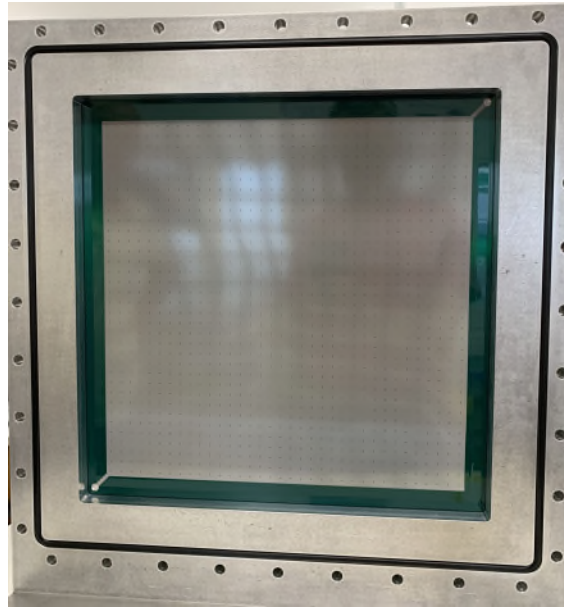


Cage de champ

- Matériaux : PMMA / Kapton / Cu
- 300 résistances ($10\text{ M}\Omega$,)



2 Détecteurs construits



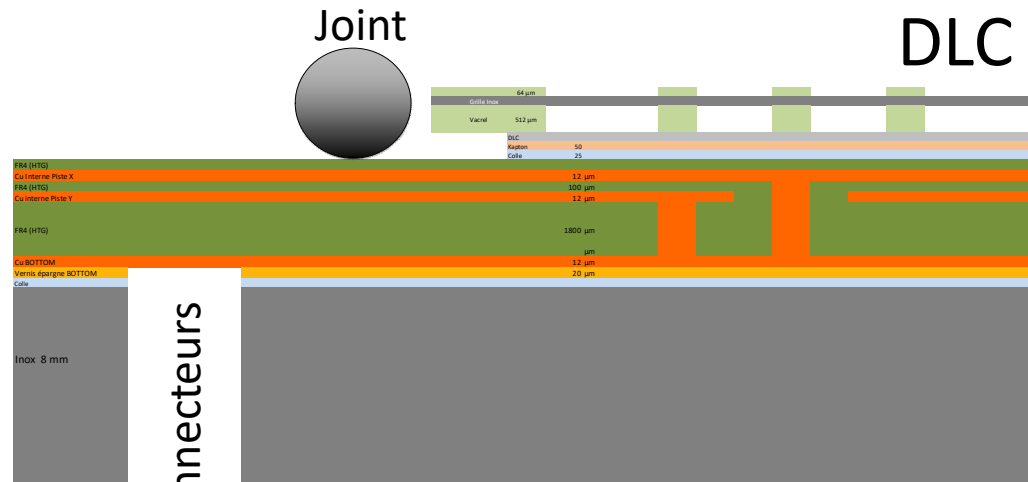
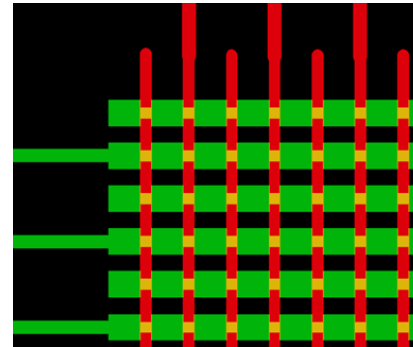
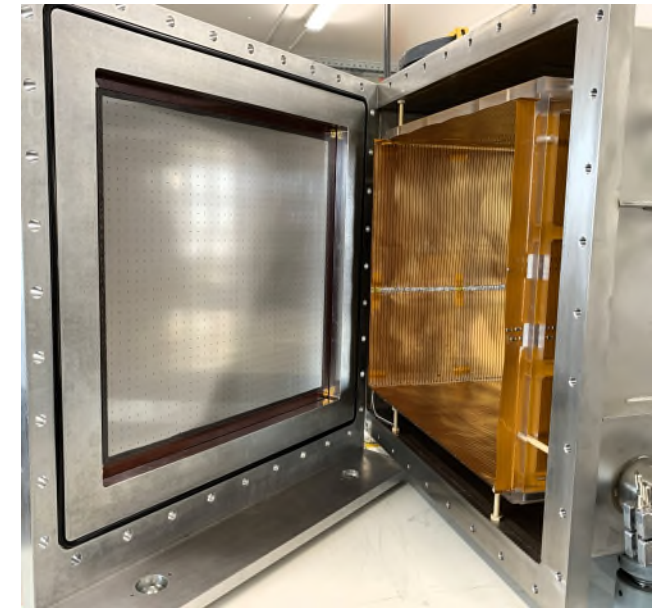
-  PCB
-  Kapton
-  Cuivre
-  Inox
-  Colle

Gap 500 μm

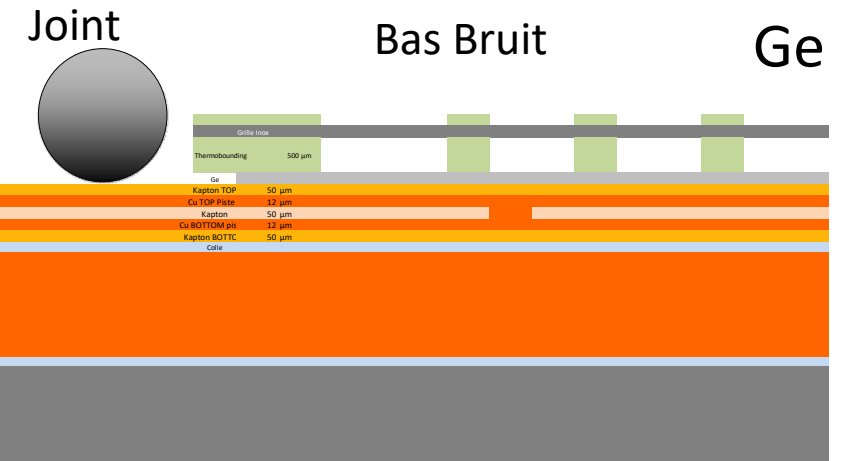
Grille : Inox 18/25

Résistif : DLC / Ge

- Kapton DLC : 30 - 50 $\text{M}\Omega/\square$
- Ge : 100 – 200 $\text{M}\Omega/\square$



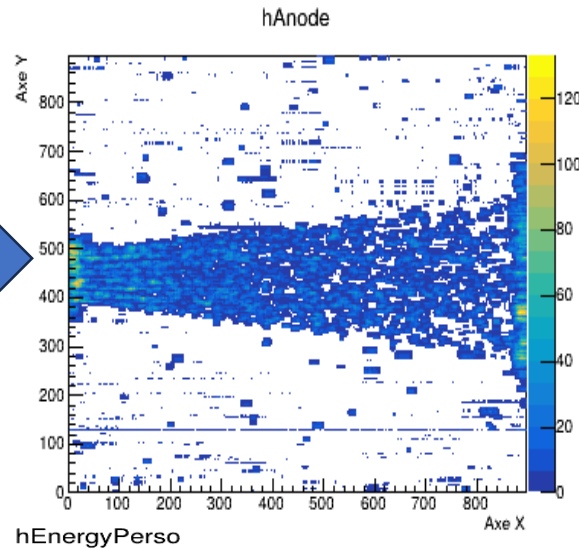
PCB (CERN - GDD)



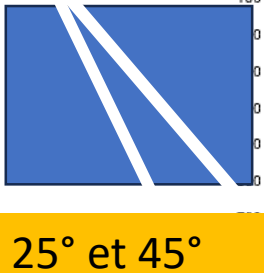
Kapton / Cu
(USTC – Hefei, China)

Caractérisation : générateur X, Alpha,...

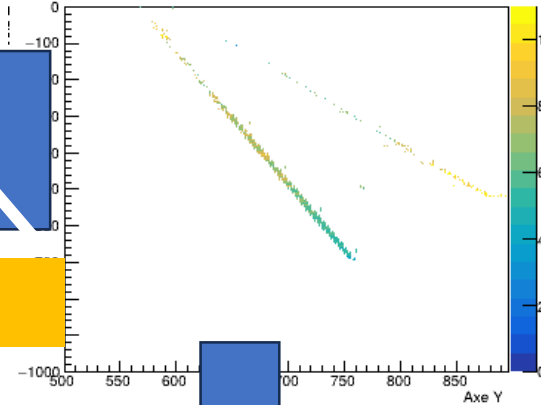
GeneX



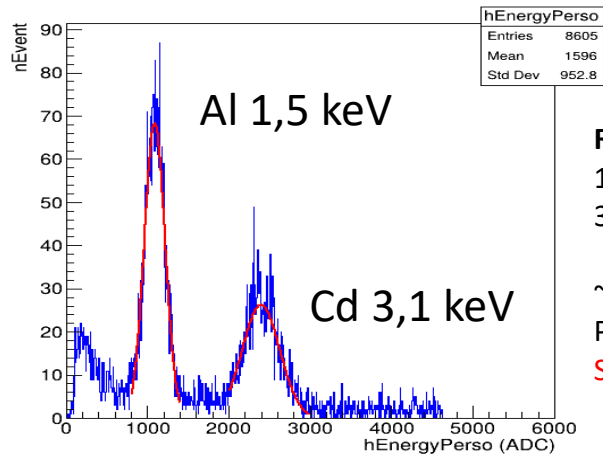
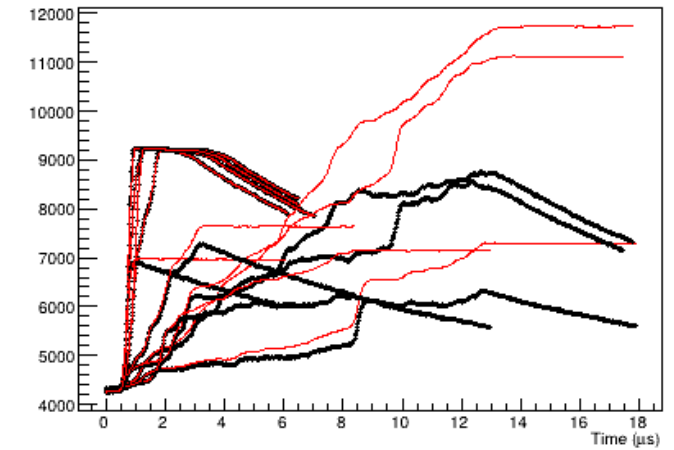
Collimateur
Alpha



hTrackYZ



Raw Flash and Corrected

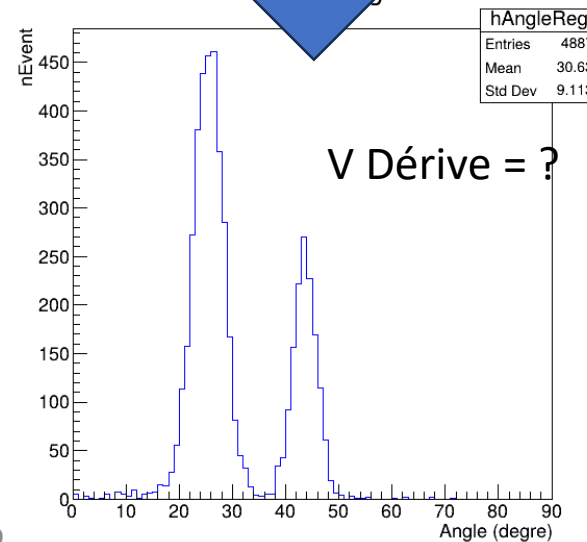


Résolution :

1.5 keV : 27,4 % (FWHM)
3.1 keV : 22,6 % (FWHM)

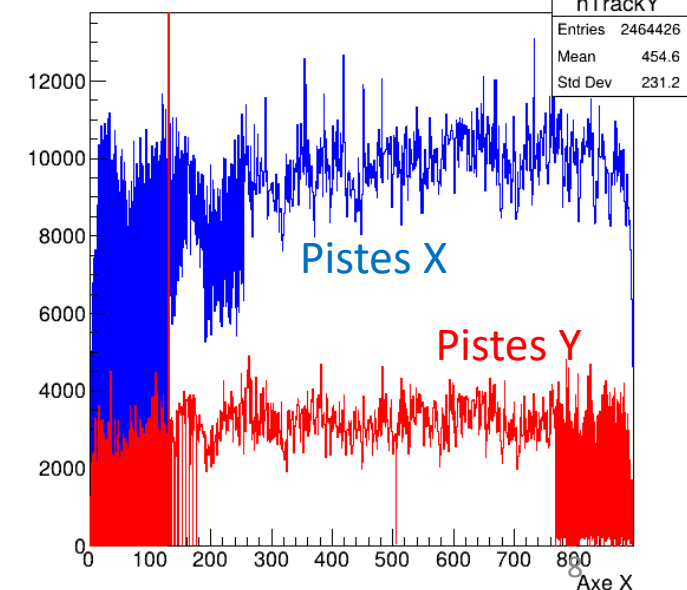
~ 1,3 eV/bin
Plage d'énergie : 5,8 keV
Seuil : 100 eV

V Dérive = ?



GDR D

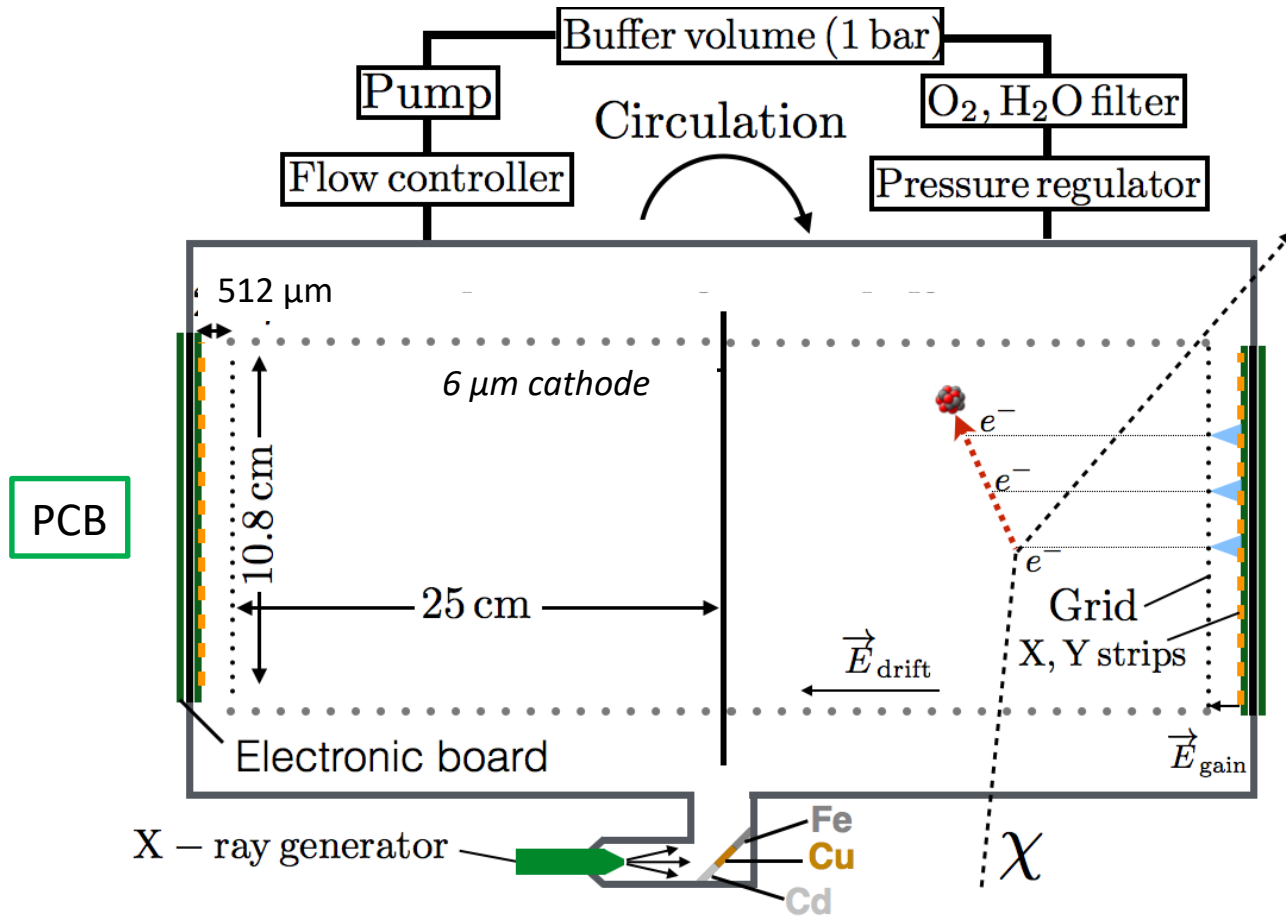
hTrackY



Dark Matter with directional detection

MIMAC-10 cm @ LSM Modane (sans blindage)

Ilias Ourahou (PhD LPSC)



Kapton /Cu/PMMA

Caractéristiques :

- Volume utile : 6 l
- Gaz : C₄H₁₀ / CHF₃ (50/50)
- Pression : 30 mbar
- 1024 voies
- 0,5 g de gaz.
- ~400 jours de Data

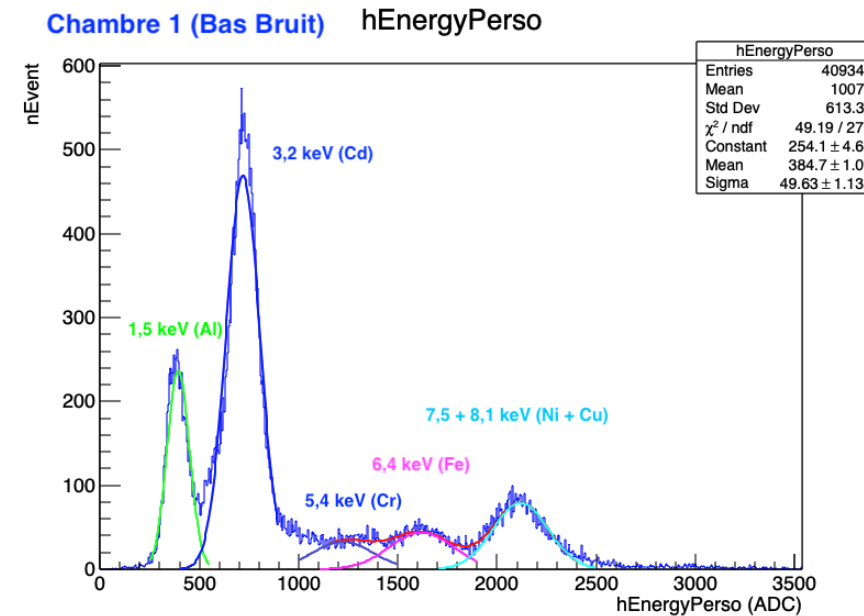
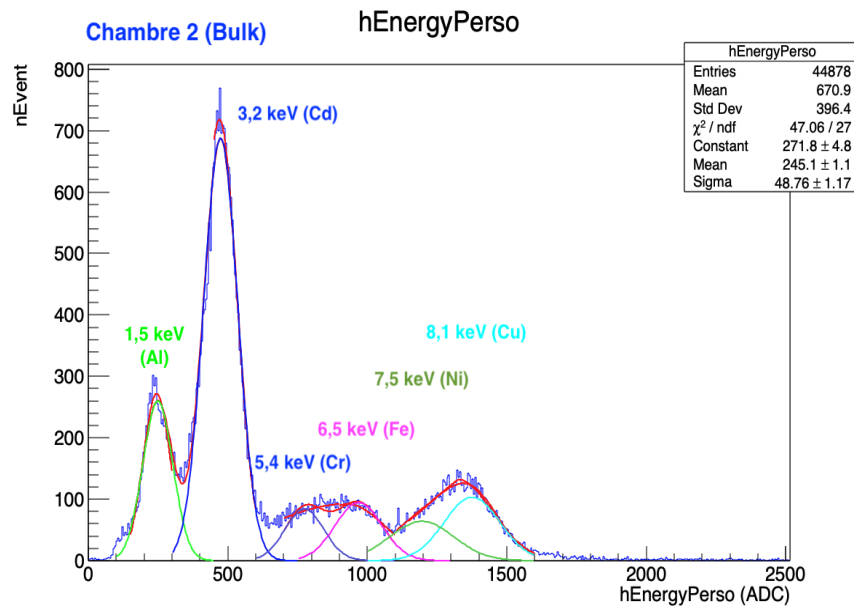
Etalonnage 30 mbar C4H10 / CHF3 (50% / 50%)

Générateur X sur feuilles métalliques

- Aluminum (Al K α and K β) énergie : **1.49 keV ()**
- Cadmium (Cd L α and L β) énergie : **3.16 keV ()**
- Chrome (**Cr , 5.4 keV**), Fer (**Fe 6.5 keV**) Nickel (**Ni 7.4 keV**)
- Cuivre (K α and K β) énergie : **8.17 keV ()**

Seuil : ~ 300 eV

PCB / pixel

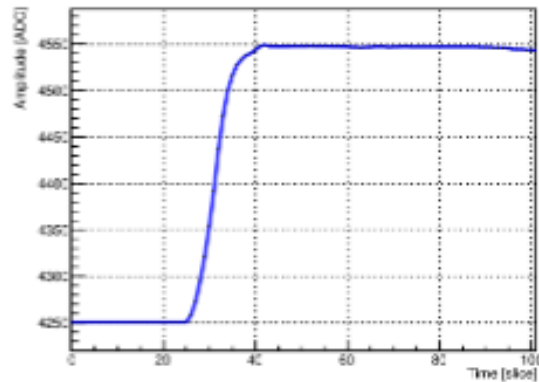


Kapton
Cuivre
DLC
PMMA

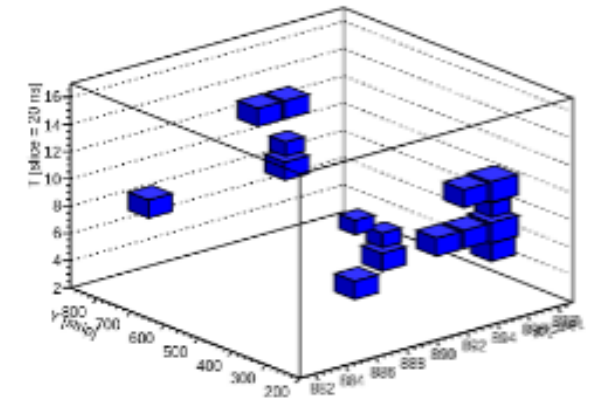
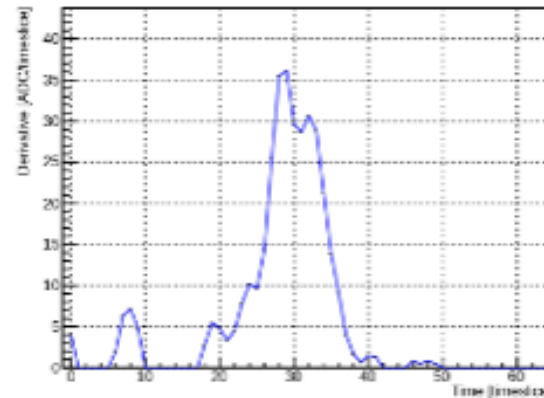
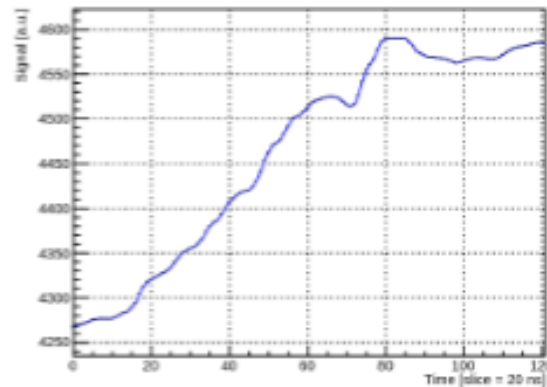
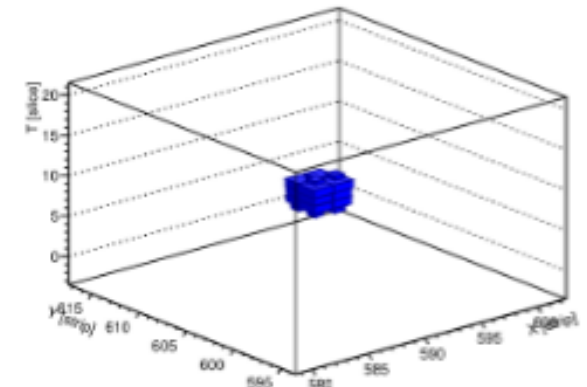
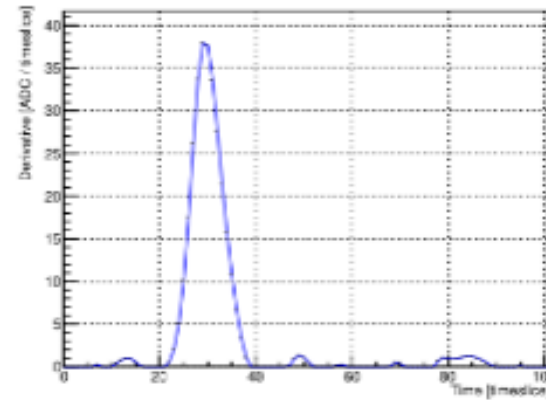
Sélection des données :

Analyse Flash et dérivée

Raw Flash



Dérivée

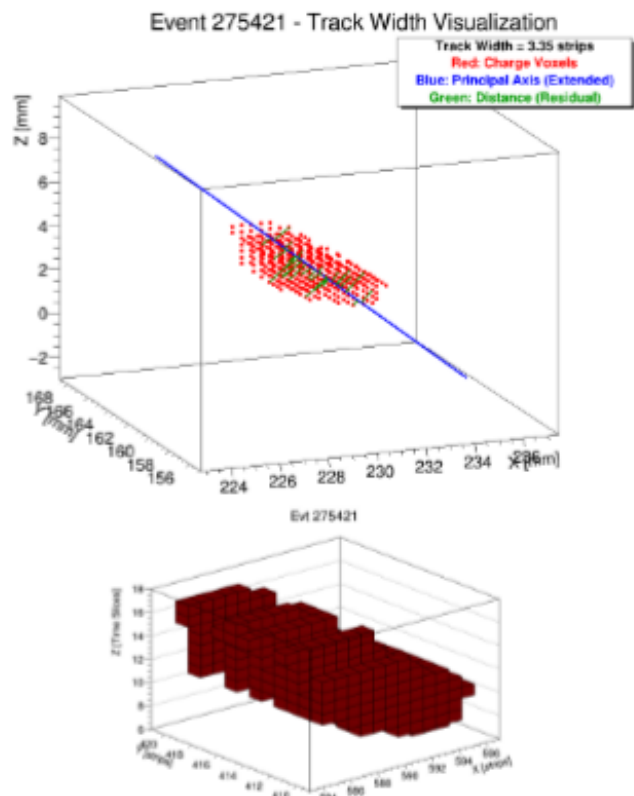


Recul Nucléaire

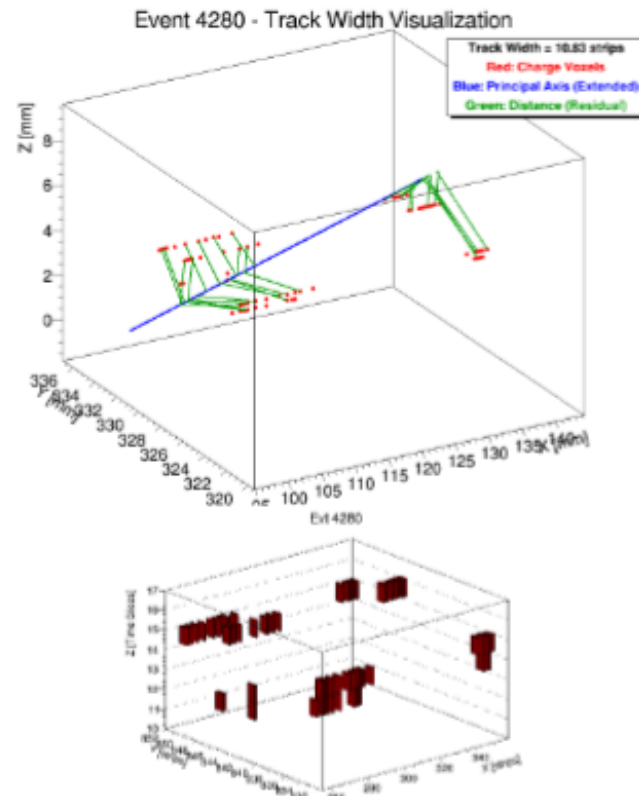
Electron

Sélection des données

Largeur de trace (w)

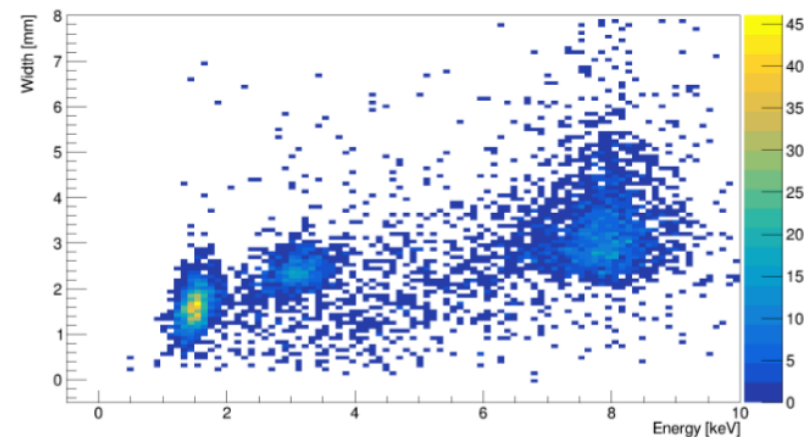


(a) Nuclear Recoil Candidate (4.09 keV)



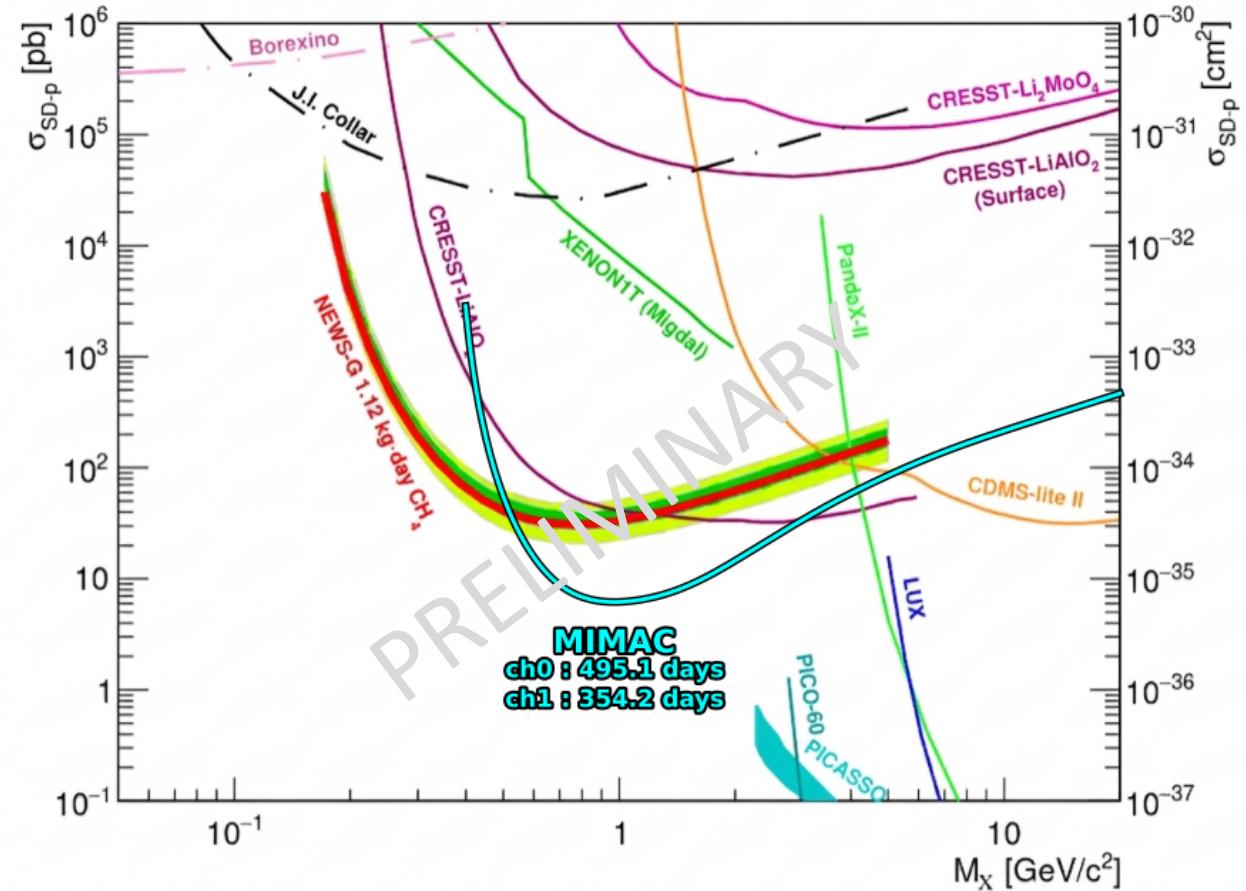
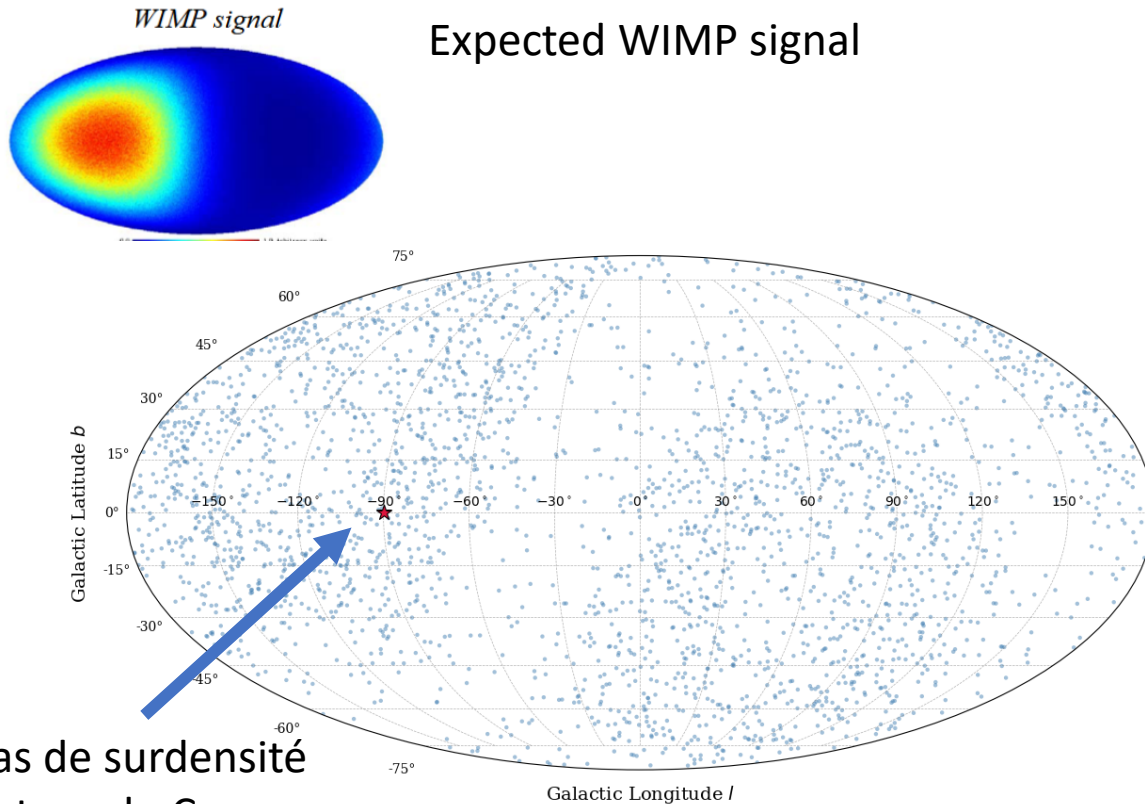
(b) Electron Recoil Background (4.59 keV)

Distribution des largeurs de traces pour des électrons de la calibration



Courbe d'exclusion pour WIMP @ 1 GeV (sans blindage, 6 litres)

Carte des reculs pour le Proton,
Plage d'énergie < 4.4 keV



MIMAC ~ 0.2 kg . j NEWS-G ~ 1,12 kg . j

Perspectives / Conclusion

Nouvelle μ TPC (35 x 35 x 29 cm³ x 2) , 70l, 3600 voies

- Matière noire (C4H₁₀ / CHF₃) (2027 @ LSM, x12)
 - Détection directionnelle cohérente de neutrinos (He/CF₄)
 - Spectrométrie neutrons rapides (He/CO₂ à 1 bar)
- >Caractérisation de déchets nucléaires
- > Fond neutron dans les laboratoires souterrains (C4H₁₀ / CHF₃)

