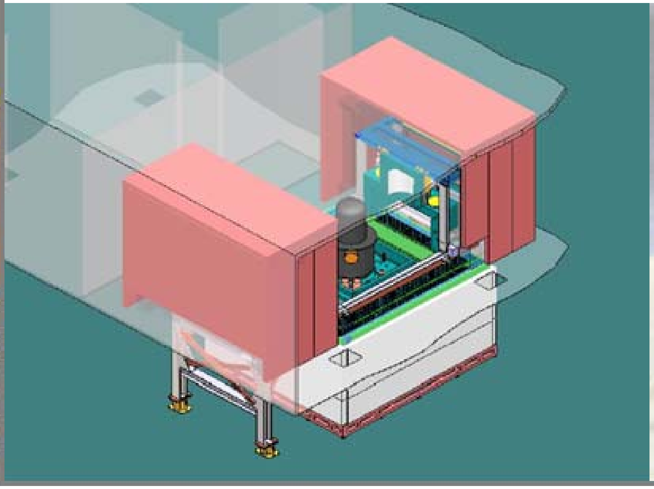
Surface event identification in the EDELWEISS Ge bolometers

Xavier-François Navick (CEA Dapnia)

LRT2006 - Aussois October 06



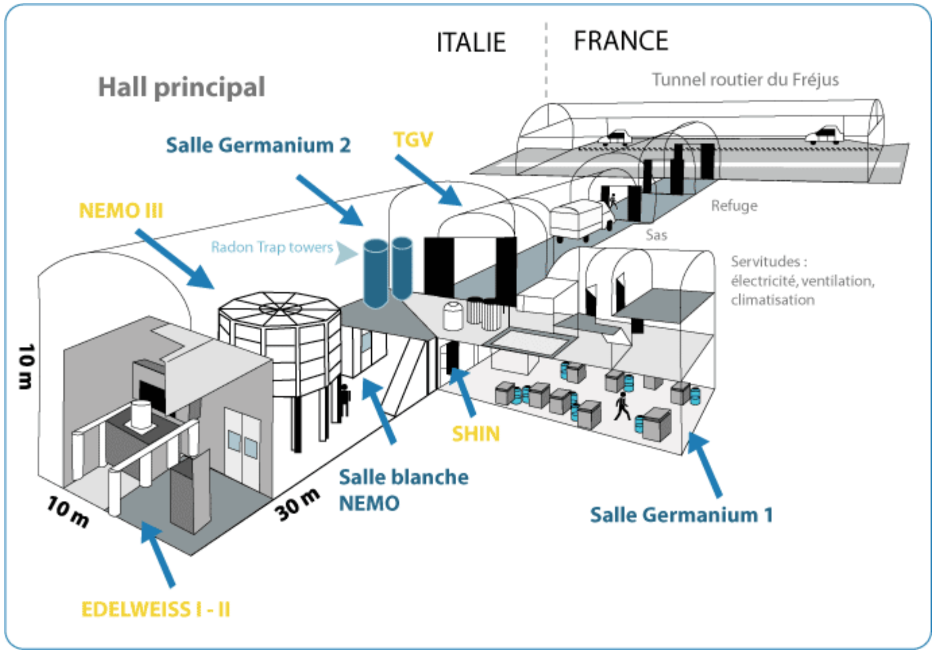
Outlines

- Introduction
- EDELWEISS's ionization-heat detectors
- Surface events in EDELWEISS-I
- Developments to suppress the surface events

Edelweiss collaboration

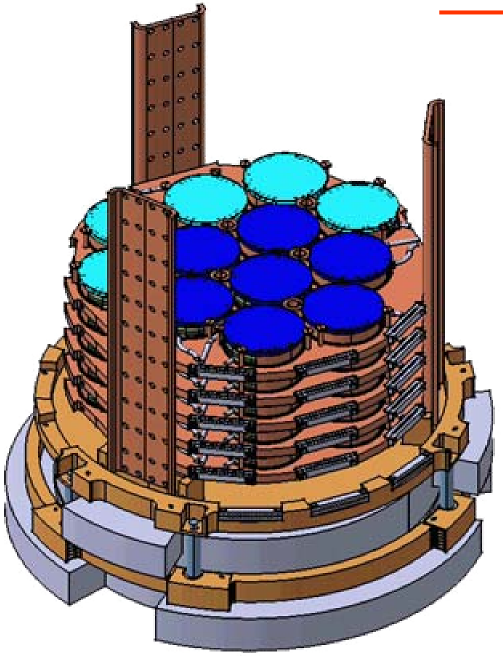
Expérience pour DEtecter Les WIMPs
En SIte Souterrain

- CEA-Saclay DAPNIA/DRECAM
- CRTBT Grenoble
- CSNSM Orsay
- FZK/Univ. Karlsruhe
- JINR Dubna
- IAP Paris
- IPN Lyon



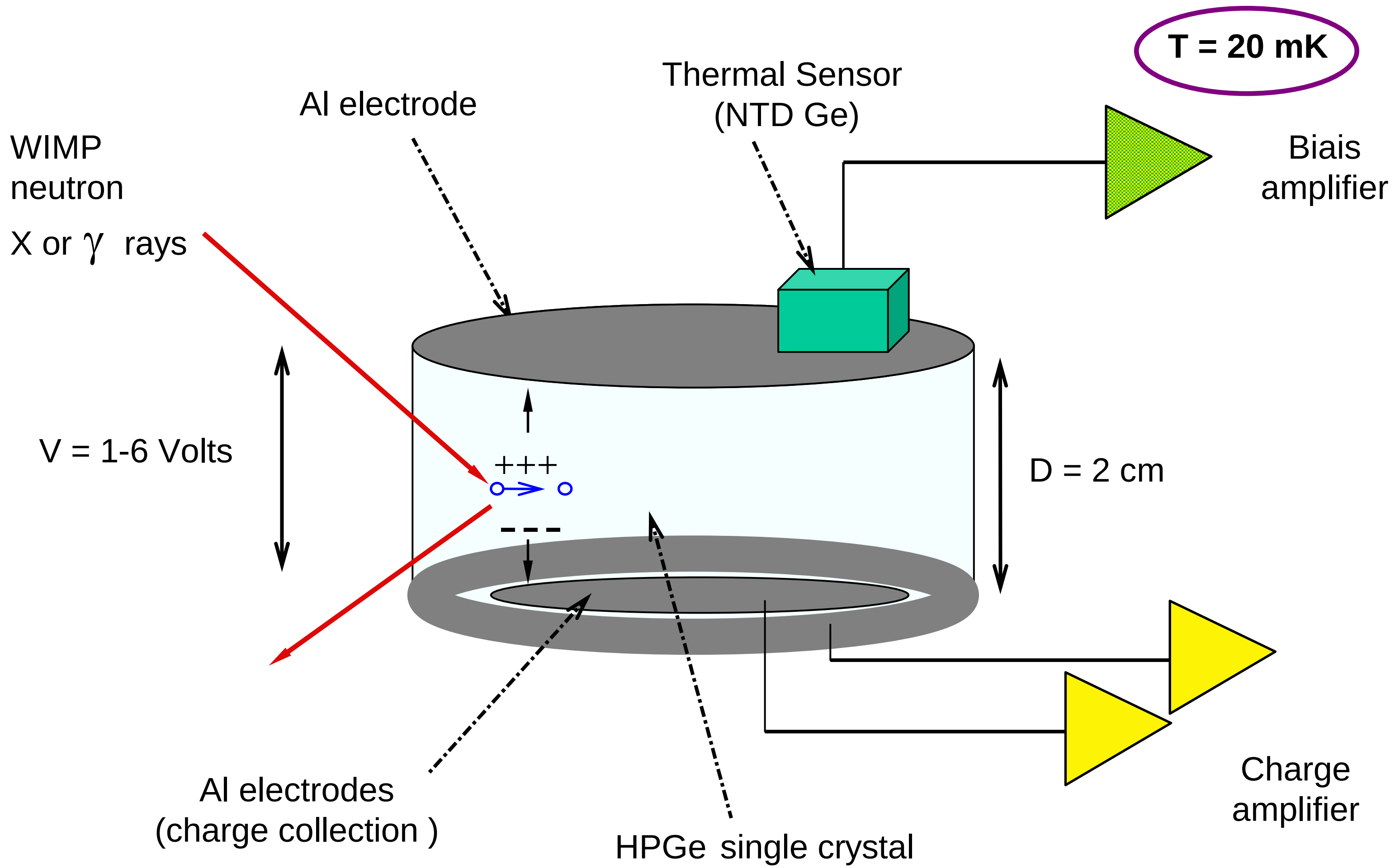
- **Laboratoire Souterrain de Modane**
  - 1700 m depth under the Fréjus tunnel (4800 we)
  - 4 μ /m²/d (10^6 less than at the surface)

Edelweiss-II detectors

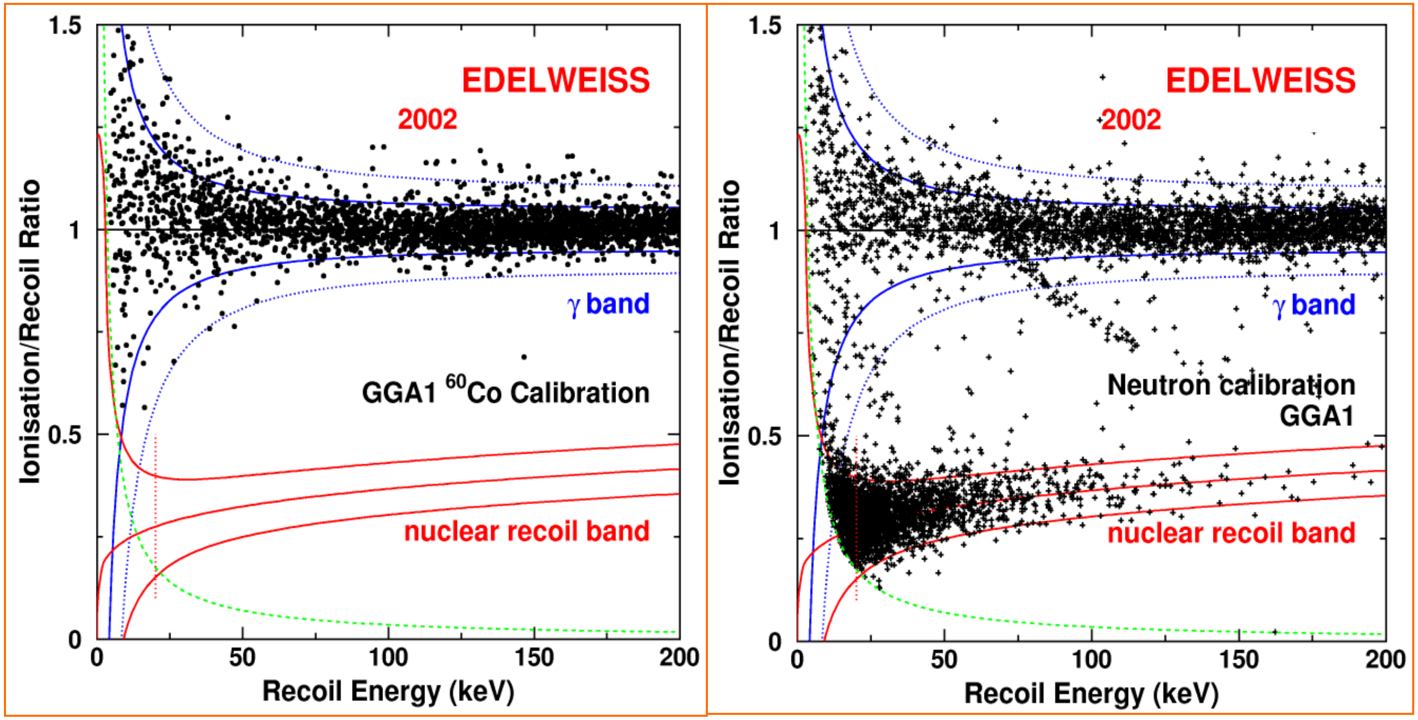


- 2 x 320g Ge/NTD with Cu–springs EDW-I holder
- 19 x 320g Ge/NTD with EDW-II holder and teflon clamp
- 2 x 320g Ge/NTD with Cu–springs EDW-II holder
- 1 x 50g heat and light IAS detector (Al_2O_3)
- 7 x 400g Ge/NbSi

Ionization-heat detectors



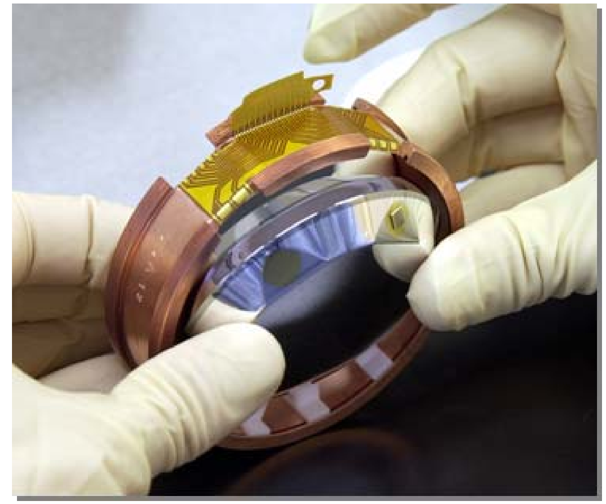
Rejection power



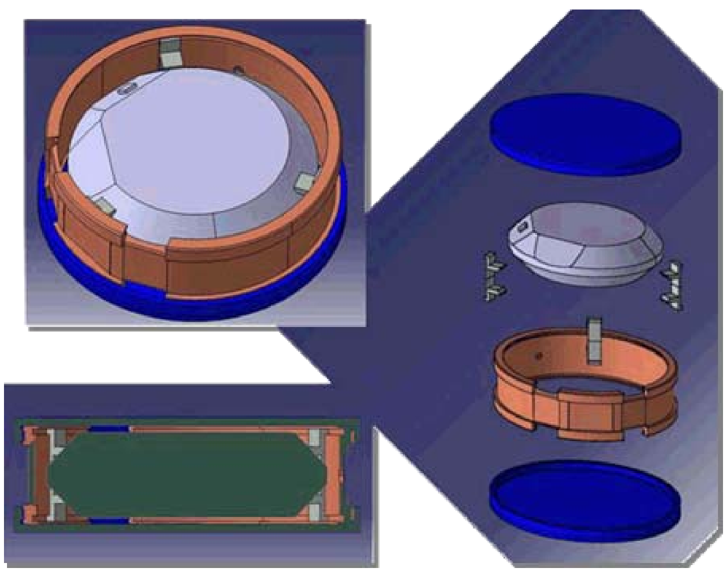
- Simultaneous measurement of ionization and heat => Evt per evt identification
- **Q = Eionisation / Erecul**
  - **Q = 1 for electronic recoil (ambiant radioactivity)**
  - **Q ≈ 0.3 for nuclear recoil (WIMP and neutron)**

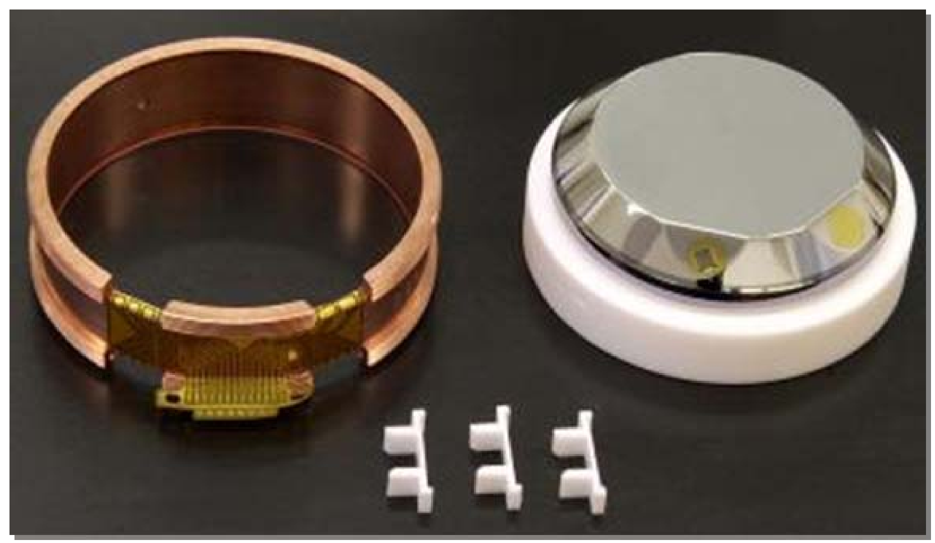
⇒ discrimination γ/n > 99.9% pour Er> 15keV

Edelweiss-II Ge/NTD detectors

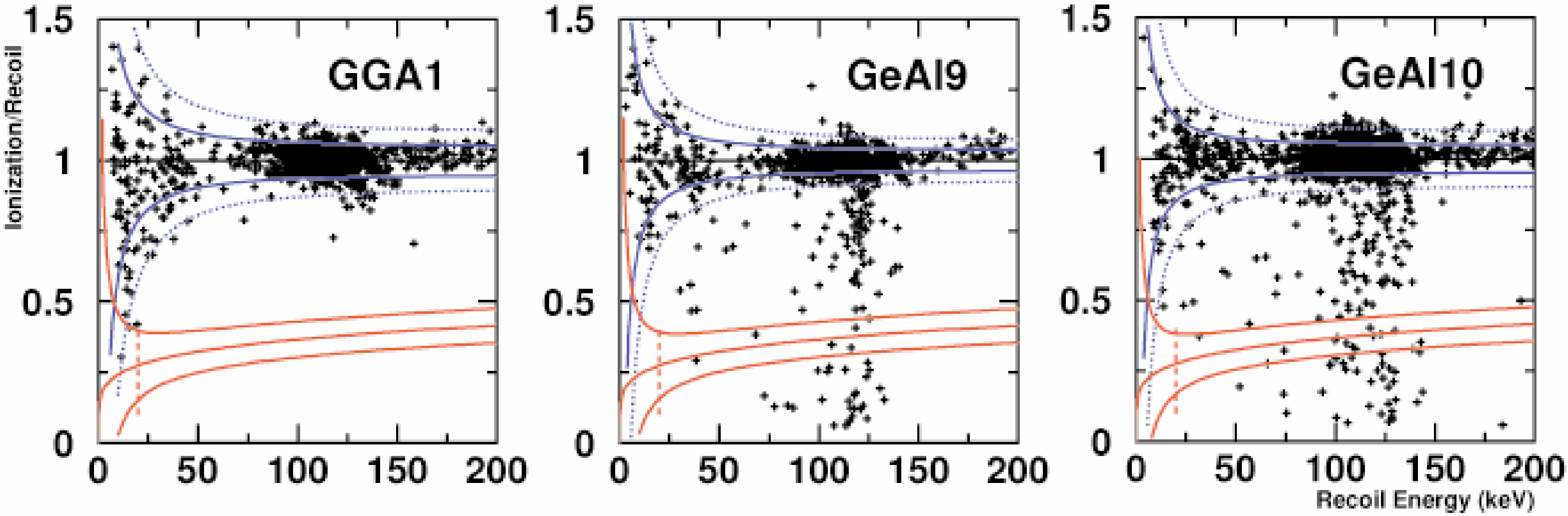


- Developed by CEA Saclay and Canberra
- Optimized NTD size in collaboration with LBNL for sub keV resolution
- New holder and connectors (Teflon and copper only)



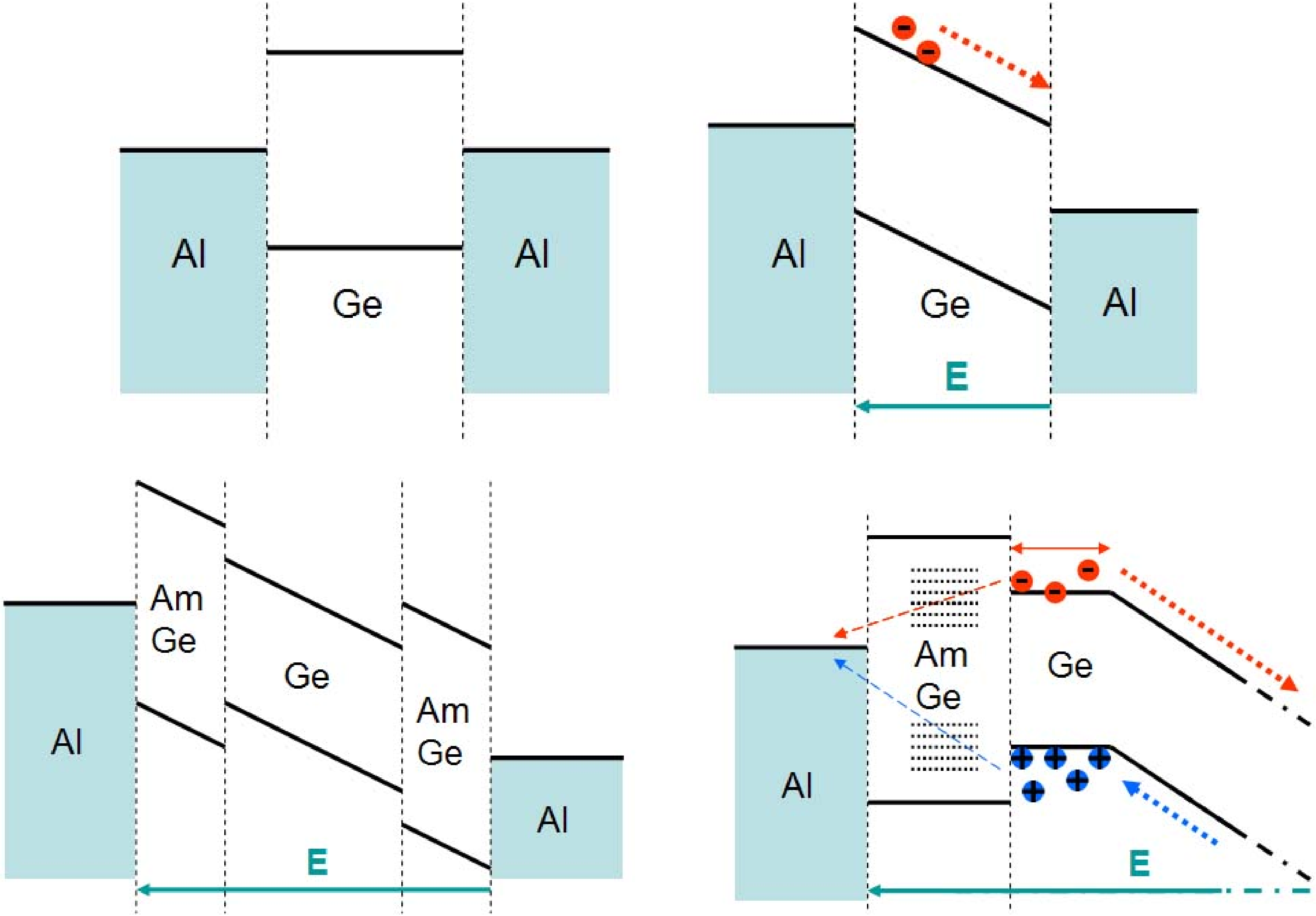


Incomplete charge collection

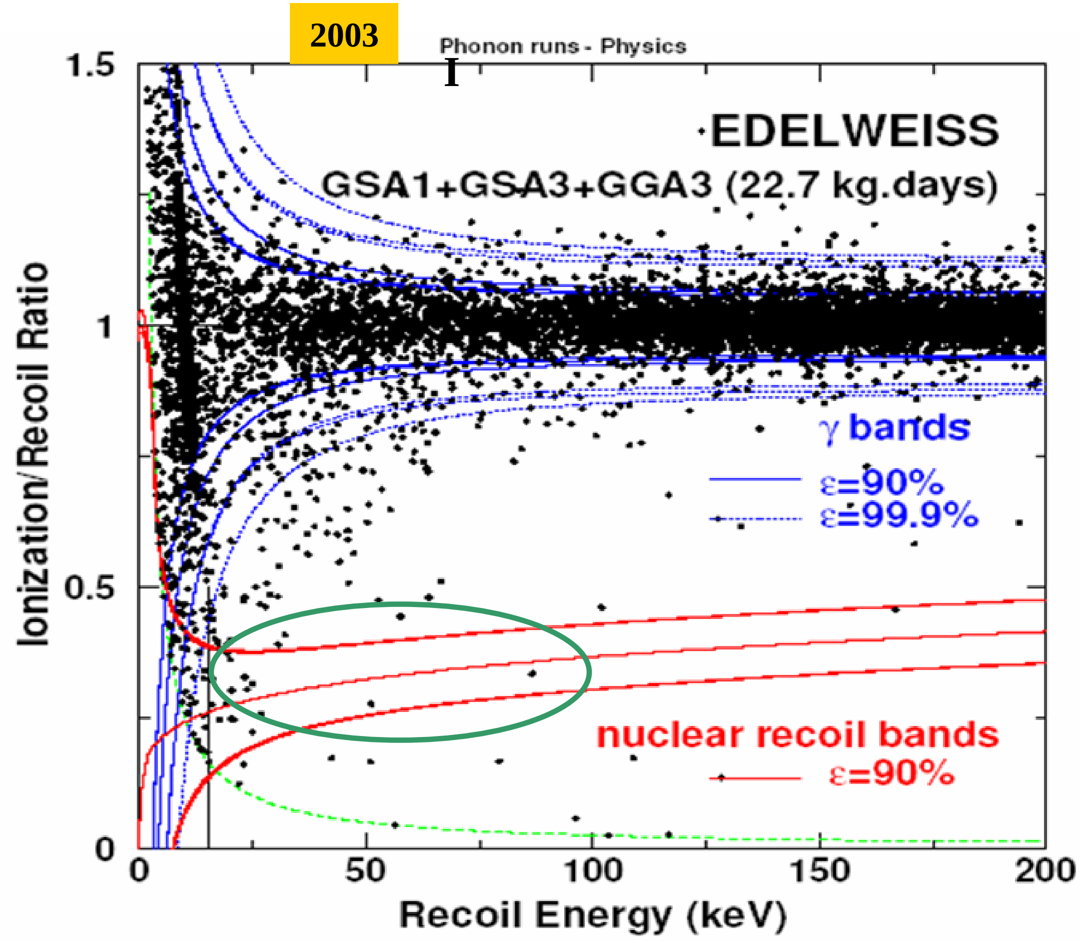


- Amorphous layers (Ge or Si) improve the charge collection
- At very low T and V : electric field is screened => diffusion phase
- Some carriers are trapped in the “wrong” electrode => incomplete collection

Effect of the amorphous layers

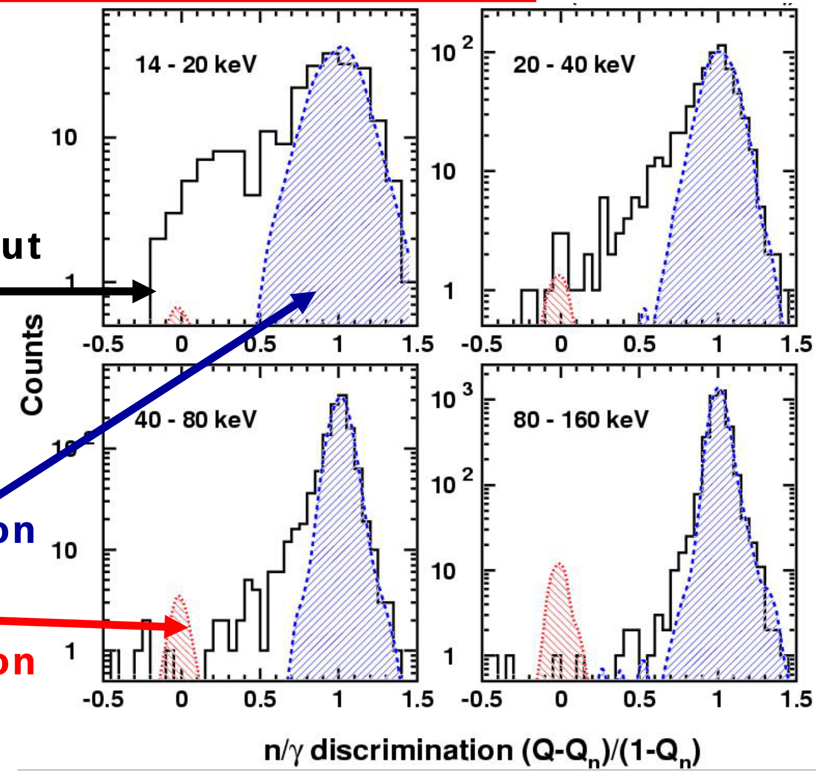


Edelweiss-I data with phonon trigger



Surface events in Edw-I data

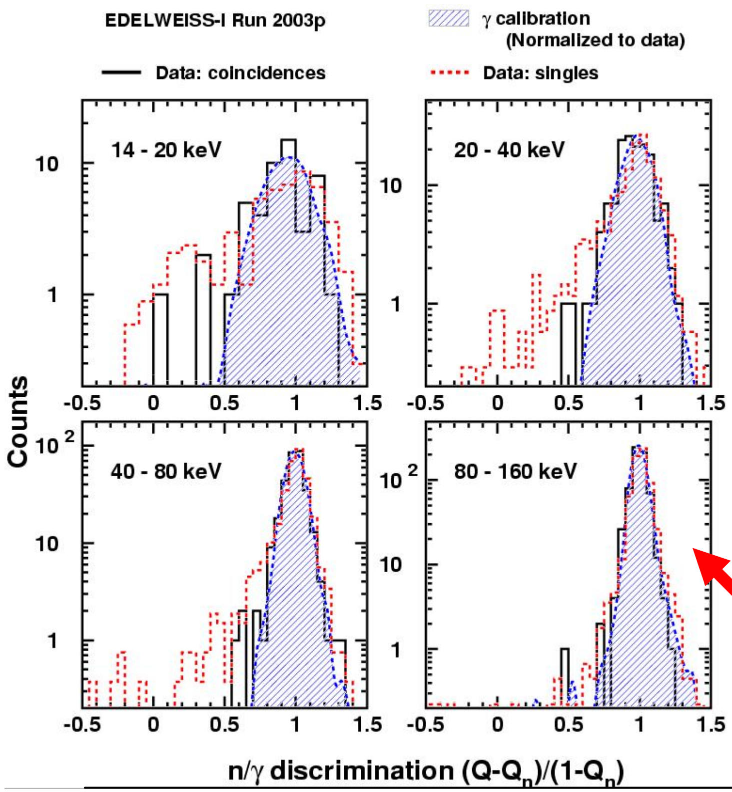
- Tale at low energy in the charge carrier collection profile



Data without source

Gamma Calibration

Neutron Calibration

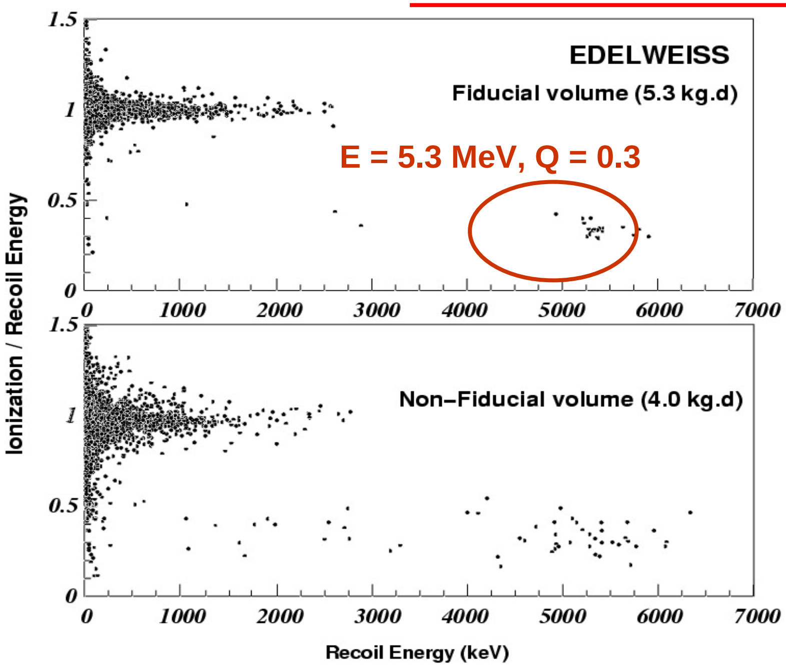


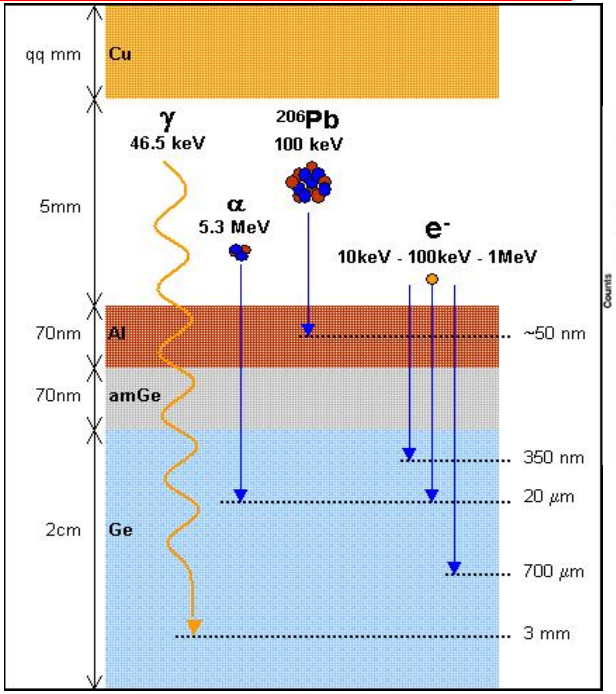
Coïncidences between detectors:

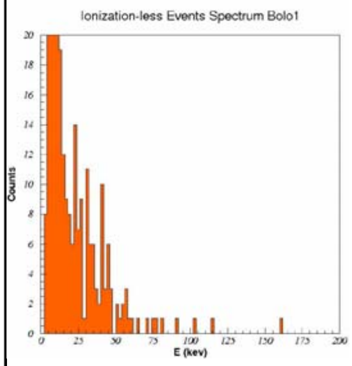
less tale. Radiation does not penetrate the cupper covers (~mm thick)

=> β on surface?

Surface contamination







- α's from ^{210}Po (Eα=5.3 MeV)
  - Q=0.3 → α decays near surfaces
  - Rate ~ 400 /m²/d
  - As expected, non-fiducial part more exposed
- **^{210}Pb on Cu covers or Ge surfaces**
  - Should see Pb recoils and β's

- No ^{206}Pb recoil peak at 100 keV observed as heat-only events: ^{210}Pb implanted in Cu, not Ge.
- Rate of 0.3 < Q < 1.0 events at low energy consistent with expected surface β's
- does not exclude contribution from ^{14}C
- By removing Cu between detectors, these events should disappear, or ID by coincidences

Surface events suppression

- **Initial effort : improve the cupper treatment (Rn contamination study) and reduce the surface exposure to radon**

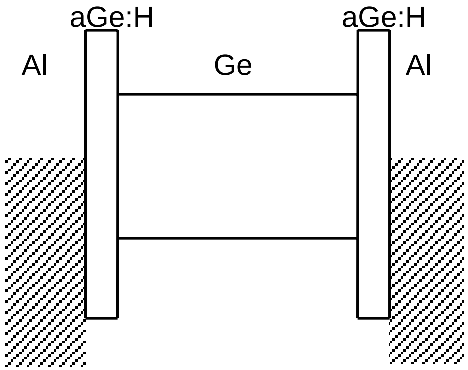
- **Passive rejection : improve the charge collection for surface event**
  - **Physics of the Ge and Si amorphous sublayer**
  - **Detectors with thick electrodes**

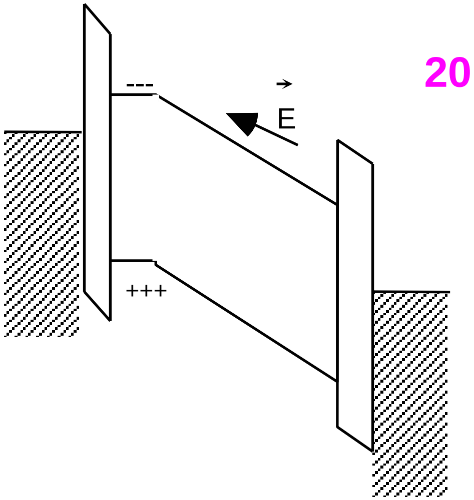
- **Active rejection : <u>identification of the surface events</u>**
  - **Interleaved electrodes**

  <u>localization of the event</u>
  - **Pulse shape analysis of the charge signals**
  - **Detectors sensitive to athermal phonons $\Rightarrow$ Ge/NbSi detectors**

Passive protection

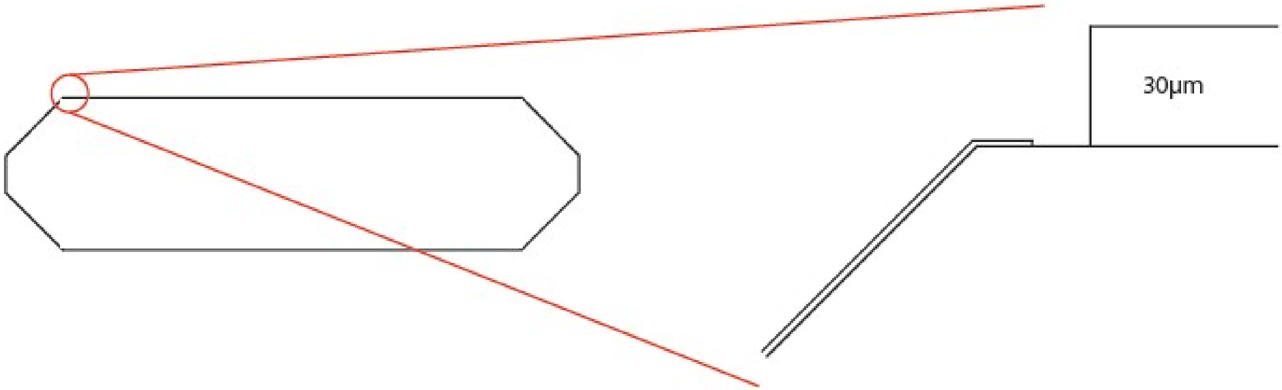
• Amorphous layers: Al / aGe:H / cGe / aGe:H / Al => GGA





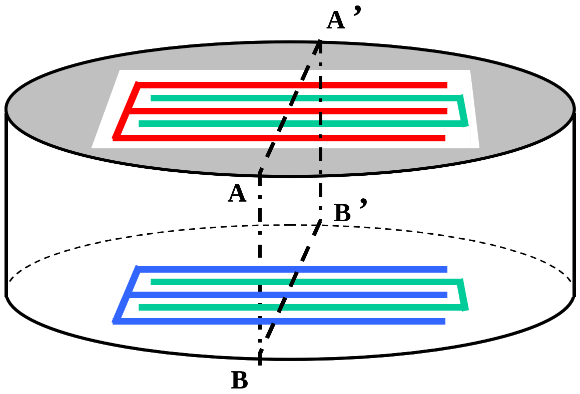
20mK

• Thick electrodes (high entrance window)

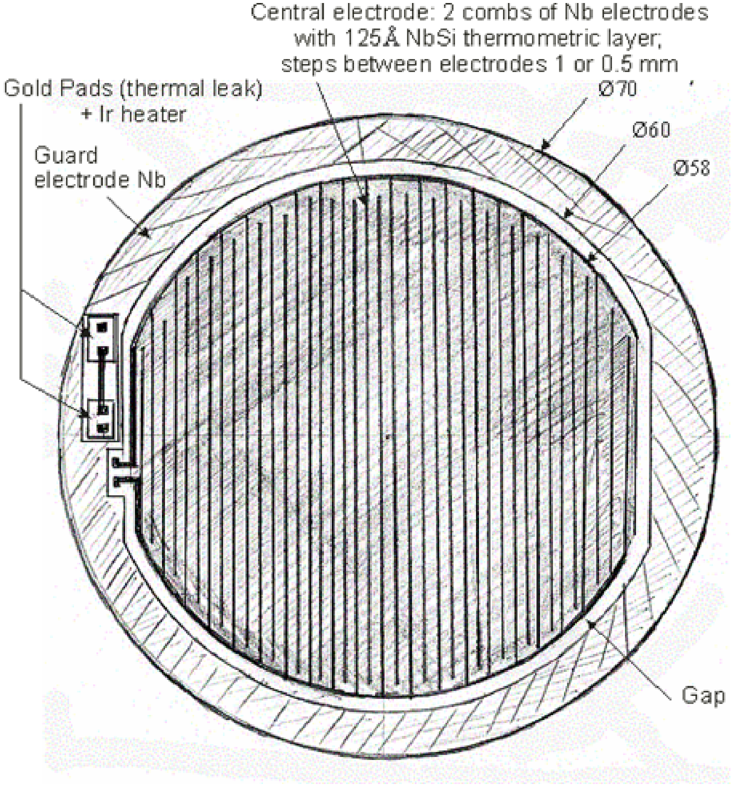


Interleaved electrodes design

Preliminary studies and current developments



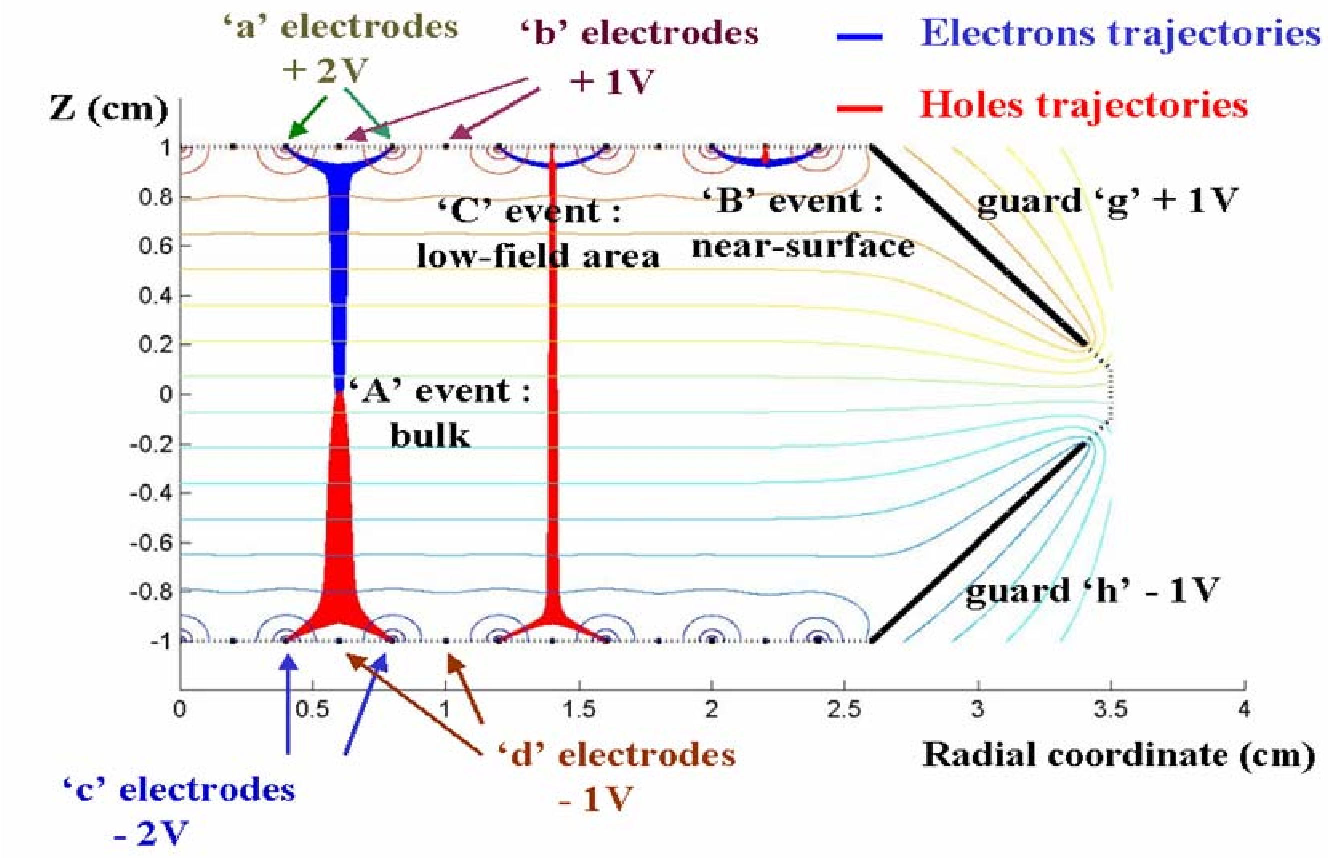
Schematics of detector fitted with interleaved collection electrodes: colors correspond to different voltage biases



Actual design

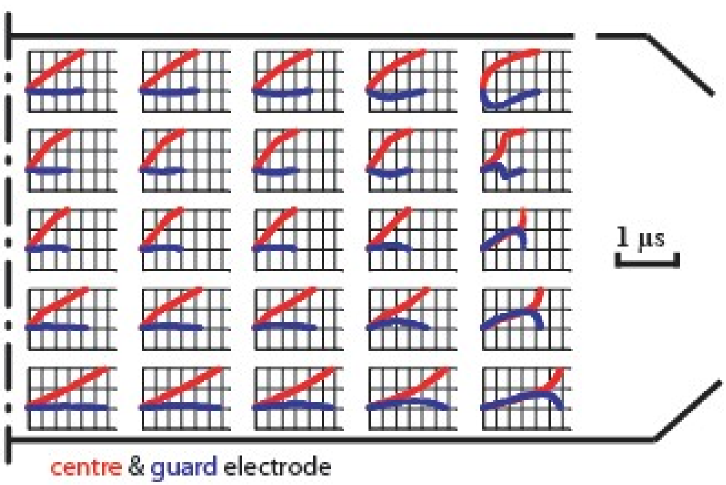
Simulation studies

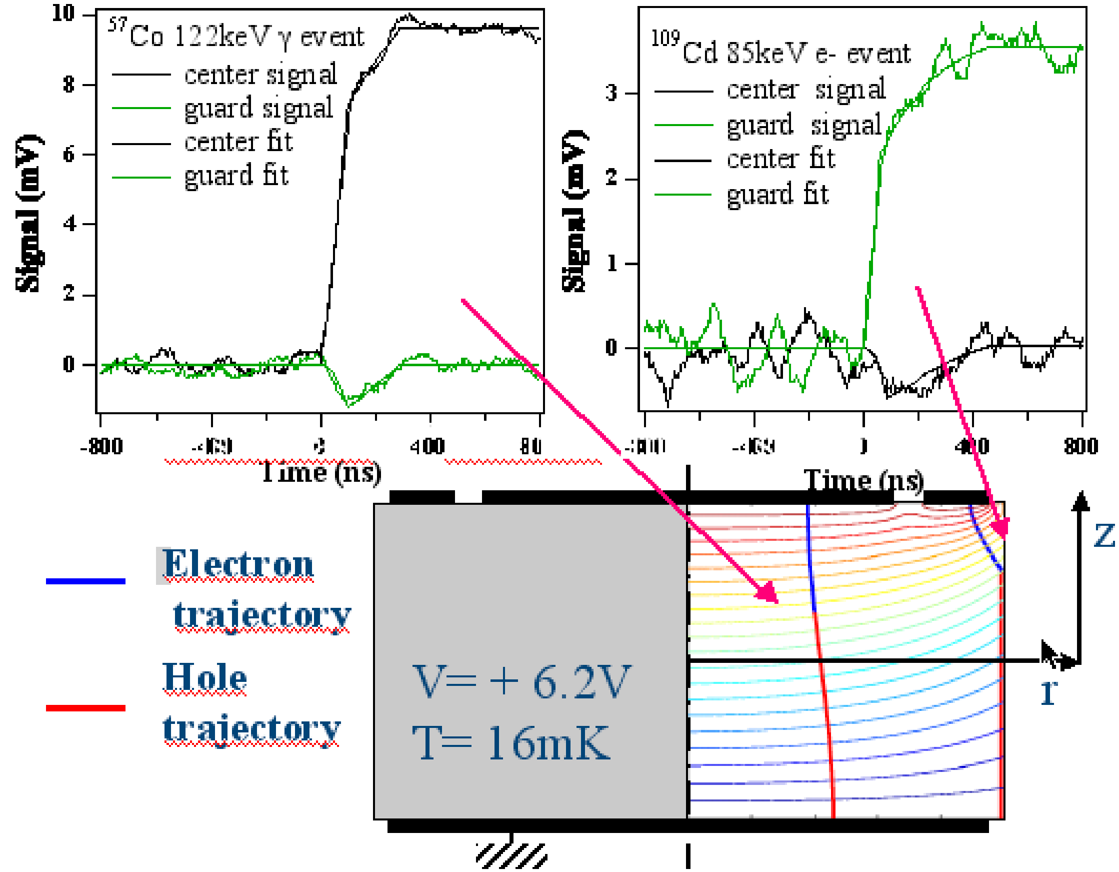
Carrier trajectories and event populations in detector fitted with interleaved collection electrodes



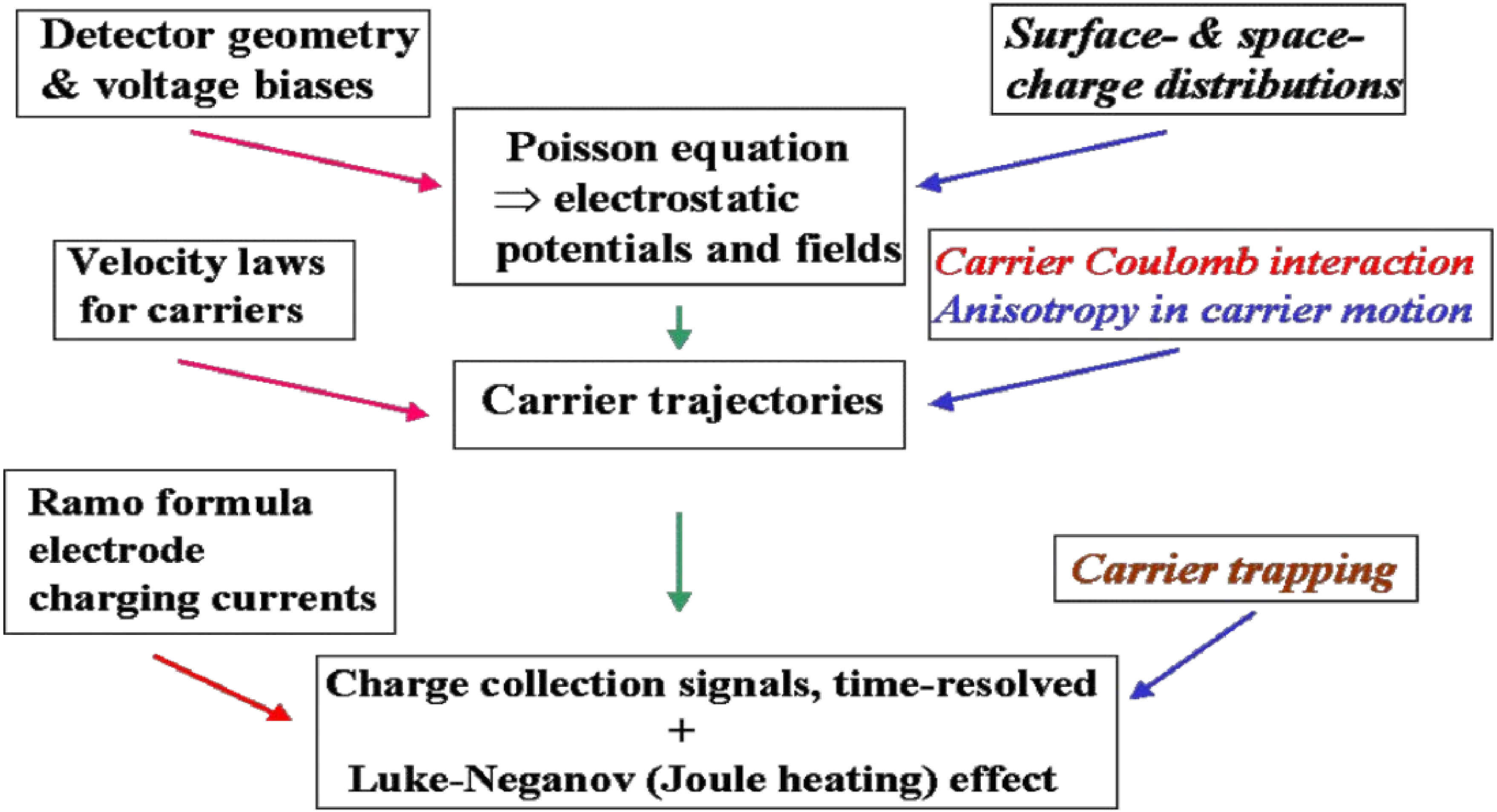
Localization by ionization shape analysis

- Time-resolved charge measurement (with HEMT?)
- Comparaison with a set of simulated pulses

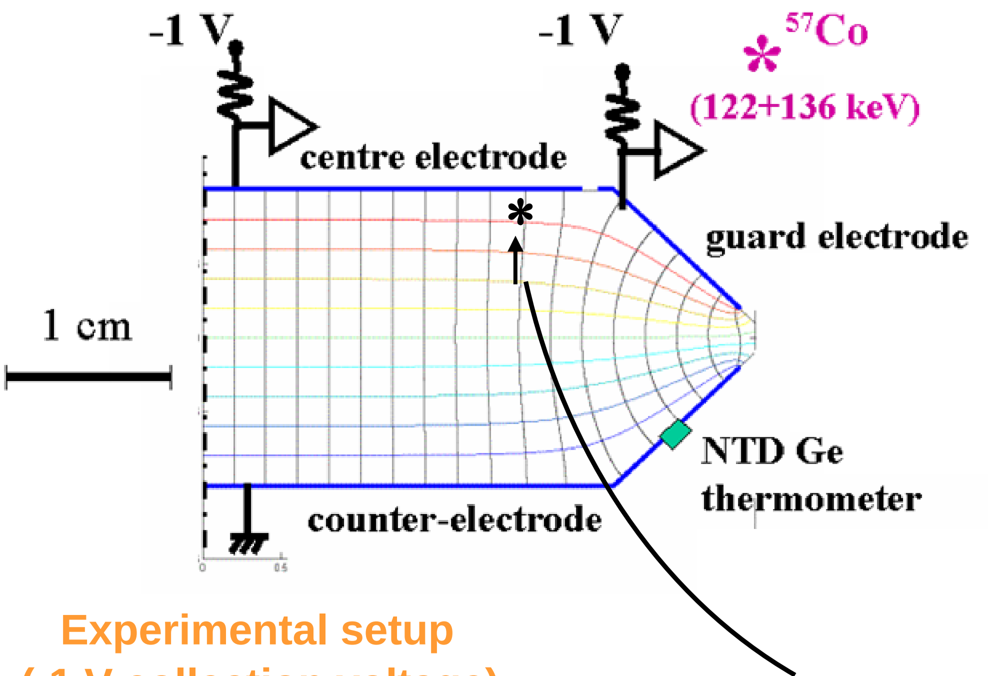




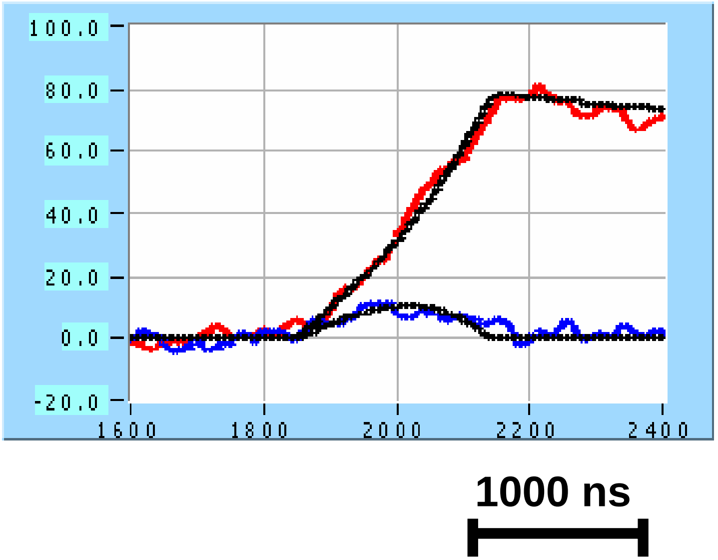
Code for ionization signal simulation



Test at LSM on a 320g Edw-I detector



Experimental setup
(-1 V collection voltage)



Near-surface, 122 keV γ event:

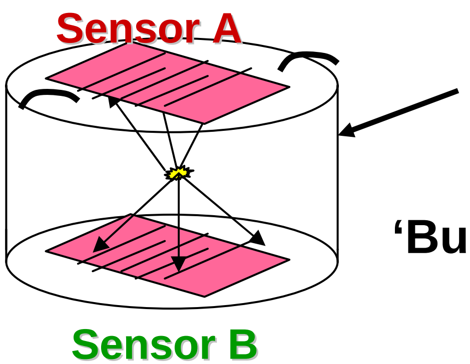
Event location

- **centre electrode signal in red**
- **guard electrode signal in blue**
- **best fit simulation in black**

Due to electronic noise, surface event rejection by pulse-shape analysis is limited in practice to high-energy events only (>≈ 50 keV e.e.)

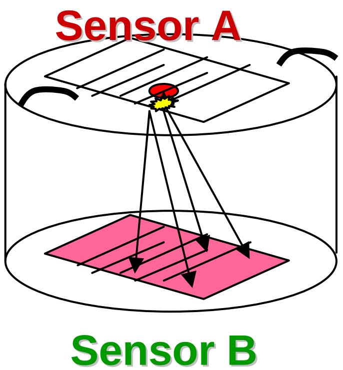
Ge detectors with NbSi sensors

Surface event discrimination: Nb-Si thin films as athermal phonon sensors



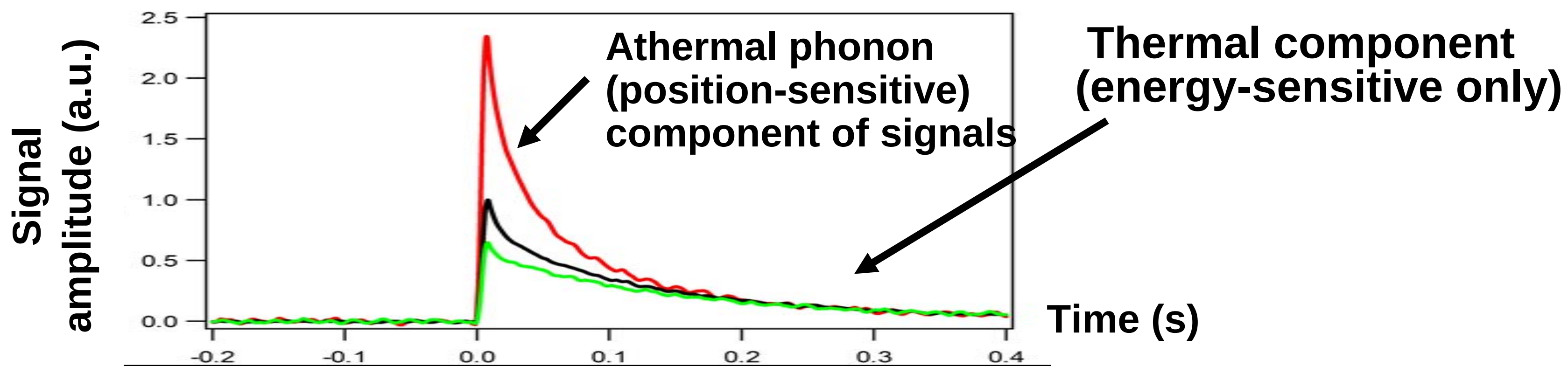
'Bulk event'

'Near-surface event'

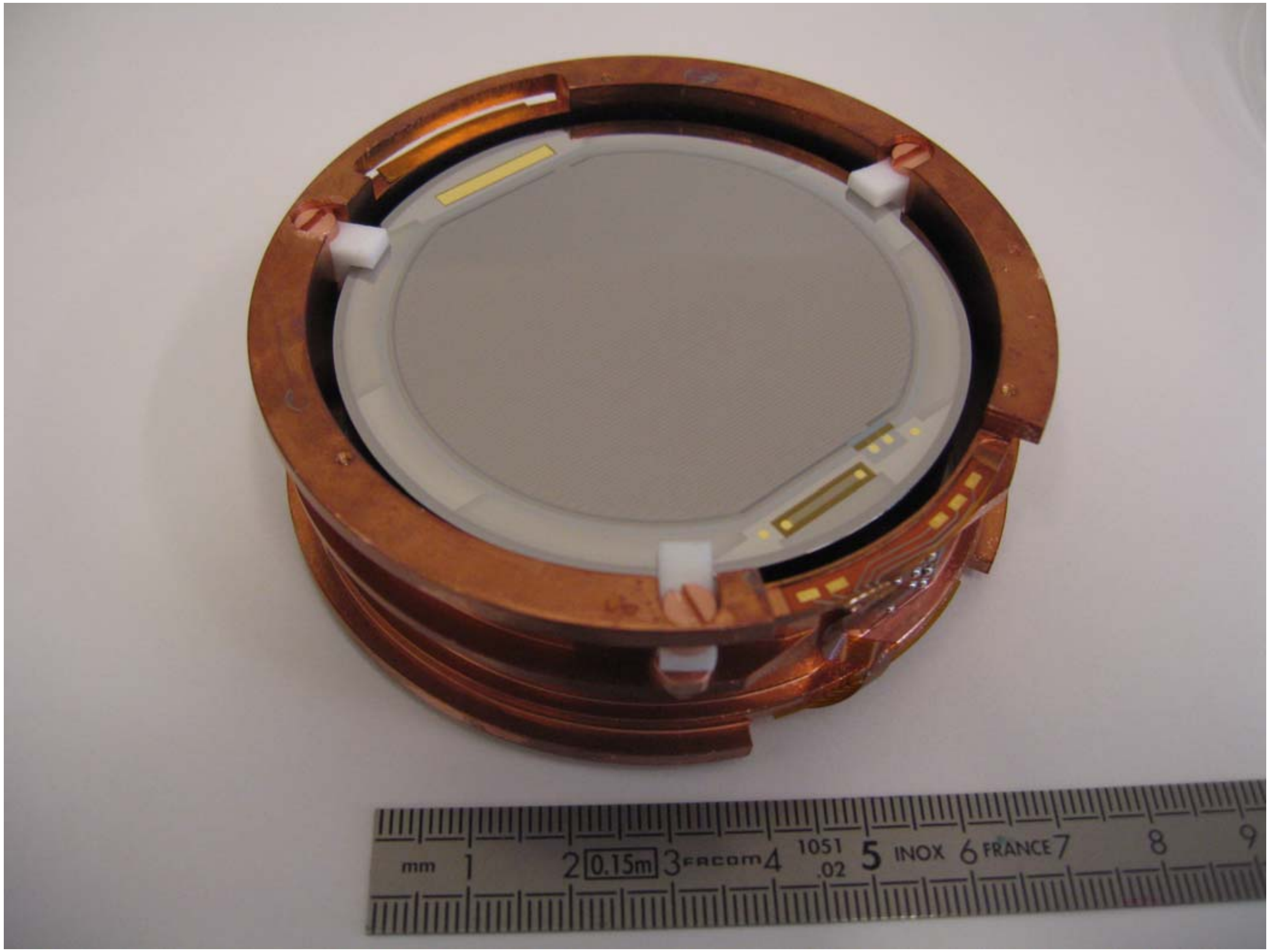


'A' and 'B' sensor responses

'A' sensor response
'B' sensor response



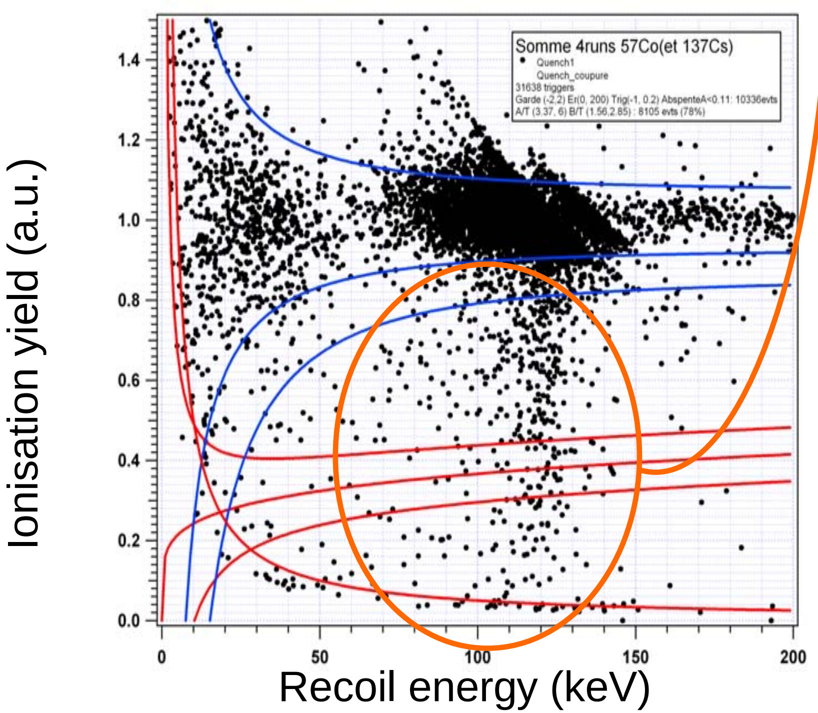
400g Ge detector with NbSi sensors



200g Ge detector with NbSi sensors in the Edw-I set-up at LSM

^{57}Co γ source

(a) Ionization yield vs. recoil energy (thermal component of heat signals only): note the large population of surface events of poor charge collection



(b) With the proper cuts in the athermal component of phonon signals to remove surface events