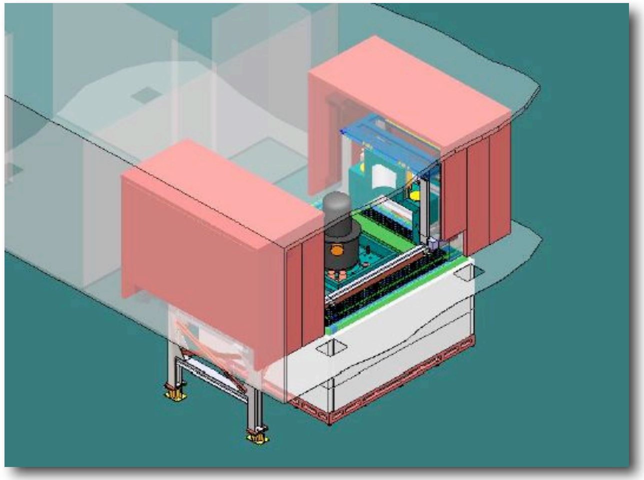
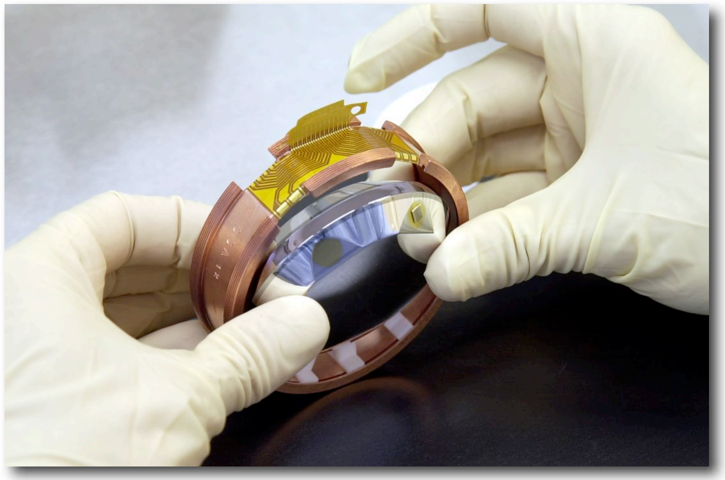
Status of the EDELWEISS-II experiment

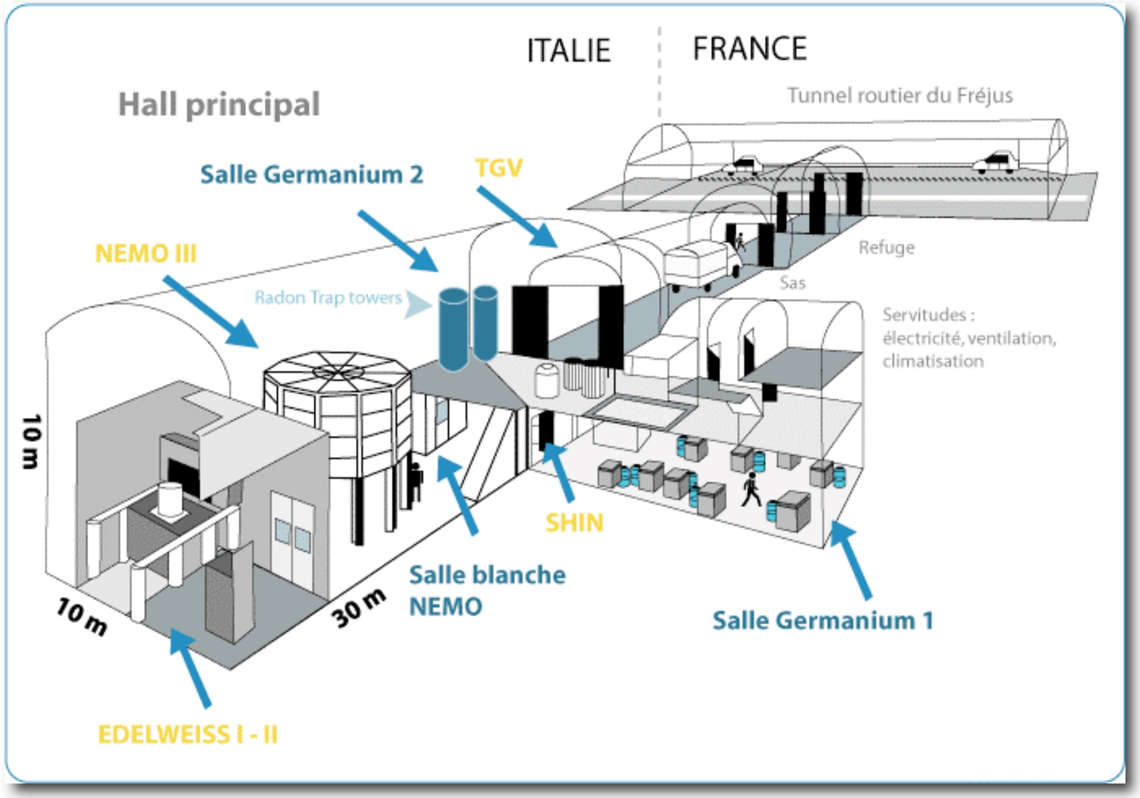
Gabriel CHARDIN

http://edelweiss.in2p3.fr





EDELWEISS, Modane Underground Lab

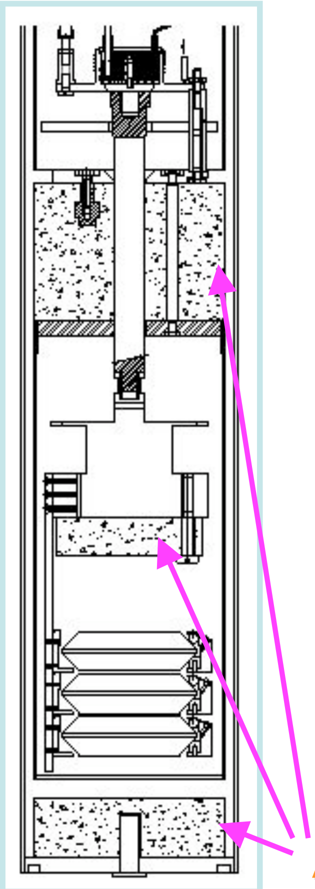


- 1700 m depth in the Fréjus Tunnel (4800 we)
- 4 μ/m^2/day ($\approx 2 \times 10^6$ less than at the surface)
- 1500 neutrons (>1 MeV)/m^2/day (rock radioactivity)

Lessons from EDELWEISS-I, 1kg stage

3 x 320g detectors, 1 liter experimental volume, cryostat made with low radioactivity materials in the Frejus Underground Laboratory

External shield: 30cm paraffin, 20cm lead and 10cm copper



1st data taking: 4.5 kg.d
Fall 2000 GeAl5,GeAl6,Ge8

2nd data taking : 8.6 kg.d
Spring 2002 GGA1,GeAl9,GeAl10

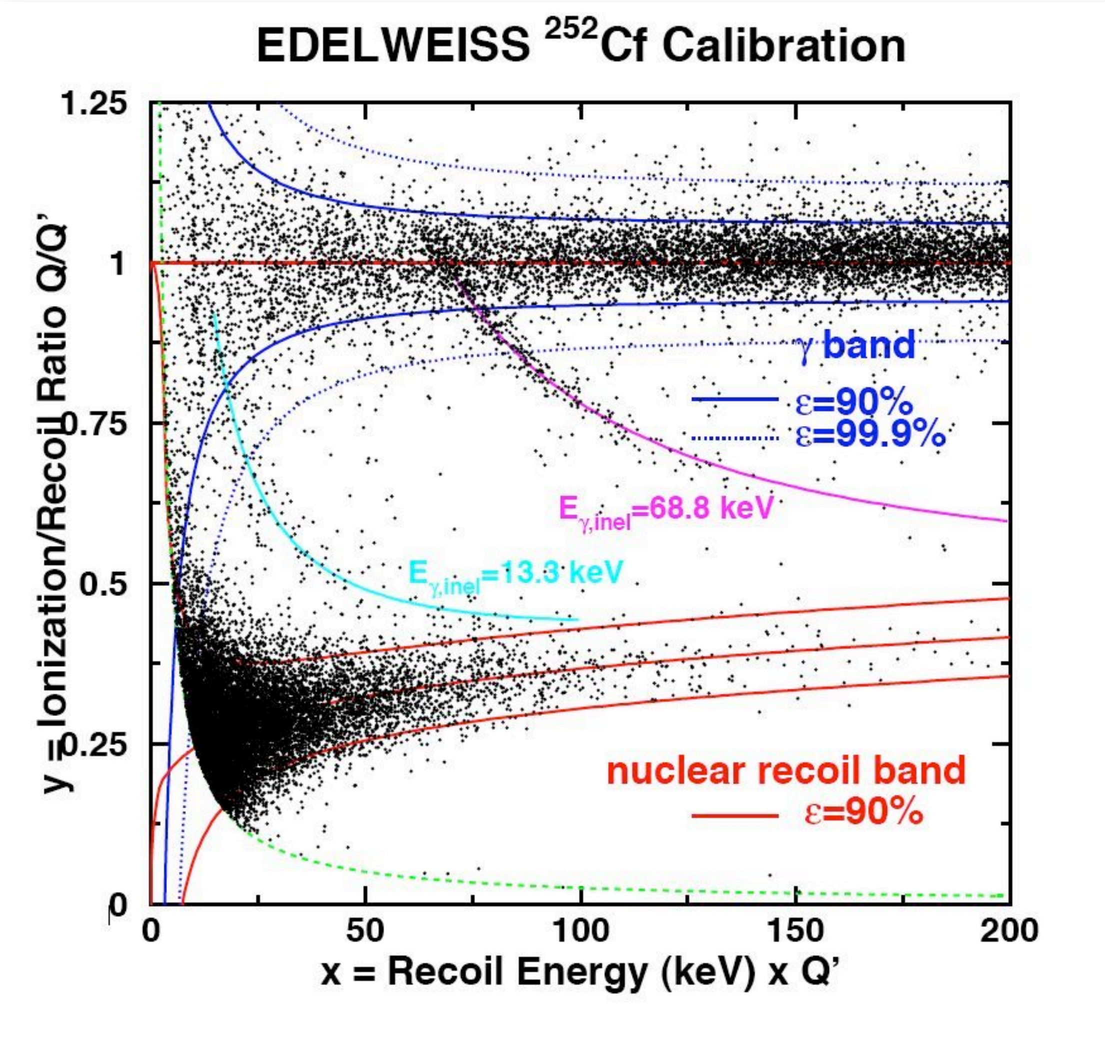
3rd data taking : 19 kg.d
Oct.-Mar 2002 GGA3, GSA1, GSA3

4th data taking : 30 kg.d
April-Nov 2003 GGA3, GSA1, GSA3

Total exposure : 62 kg.d fiducial

Edelweiss: event-by-event discrimination

O. Martineau et al., astro-ph/0310657/



Neutron + gamma calibration

Nuclear recoil discrimination down to 20 keV threshold :

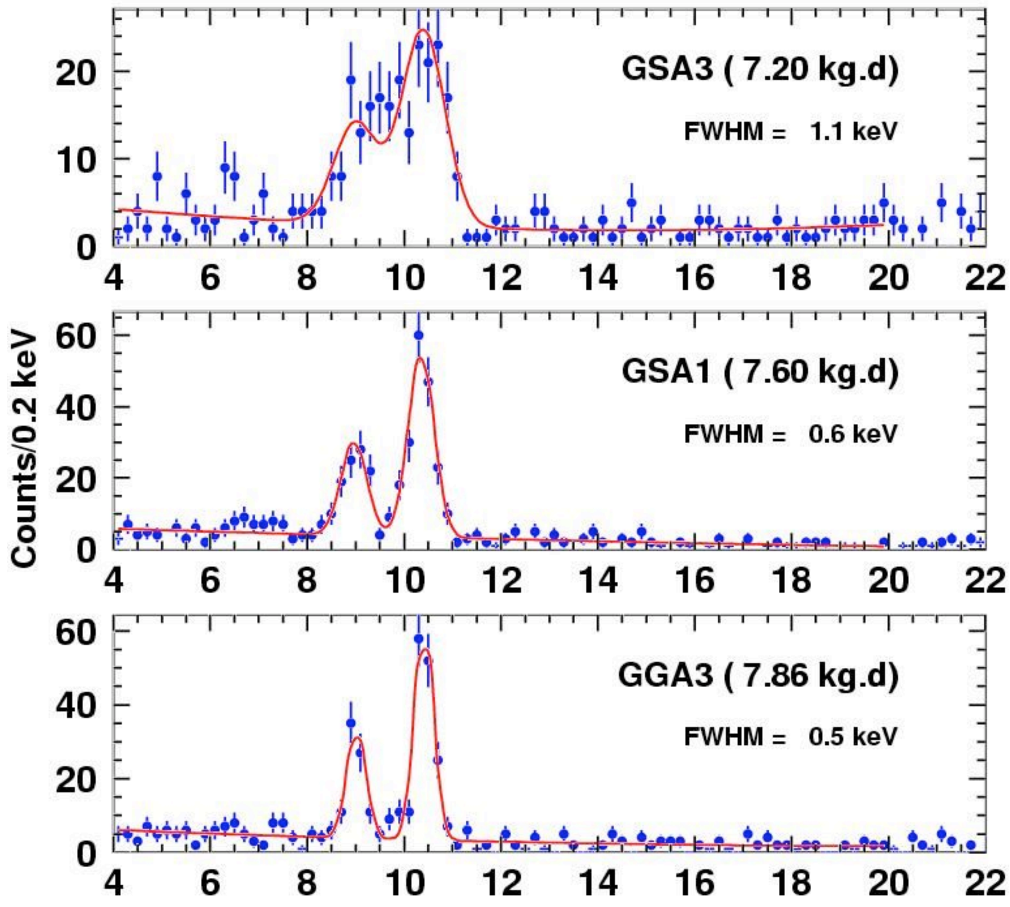
γ-ray rejection > 99.99 %

EDELWEISS thermal detectors: excellent energy resolution

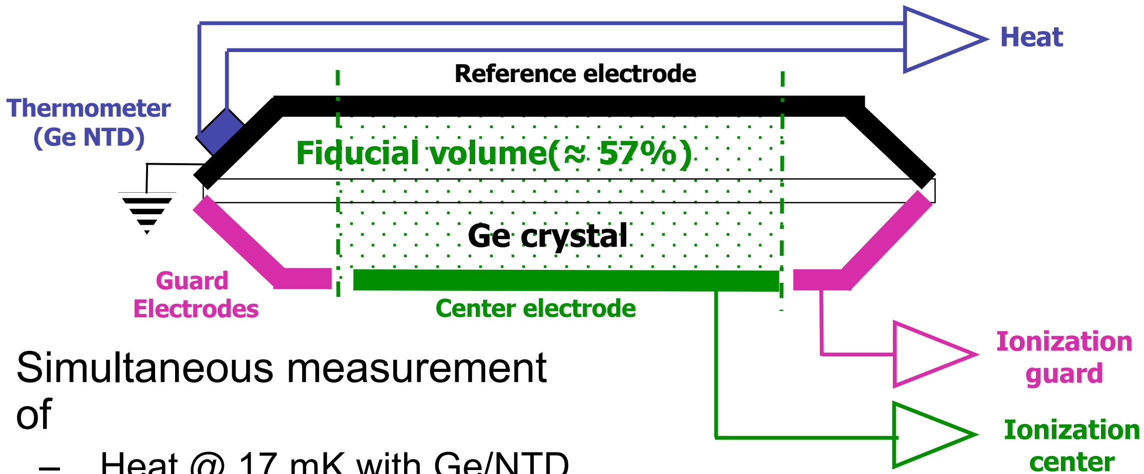
- Sub-keV energy resolution on phonon channels (300eV FWHM on two detectors)
- ≈1 keV FWHM on charge channels

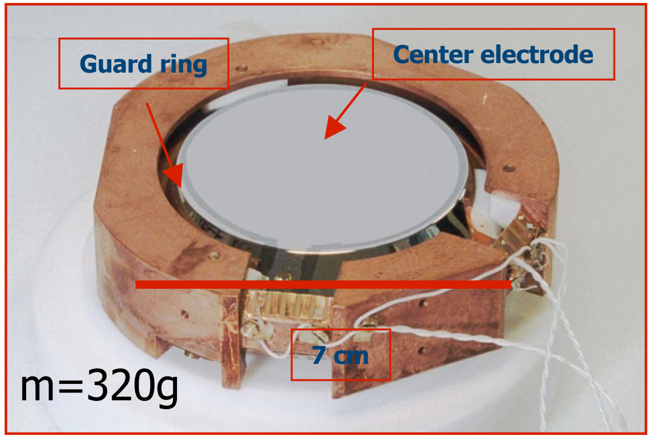
- Background comprehension down to a few keV e.e.

stable over periods of months

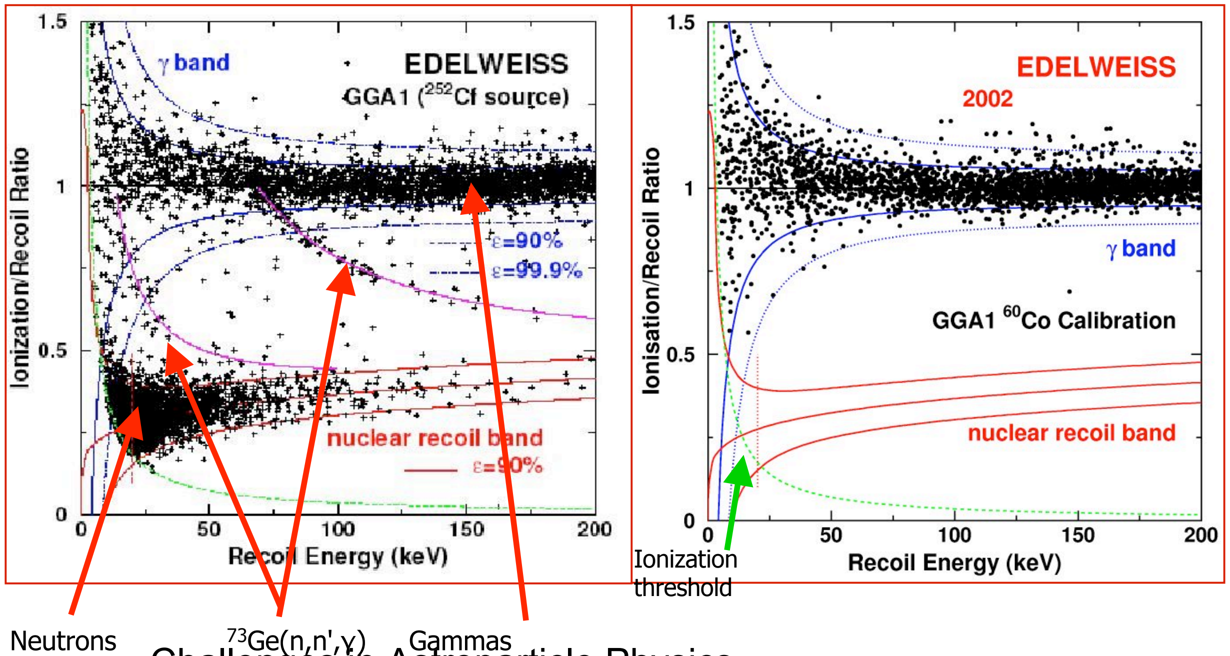


Heat and Ionization Ge detectors



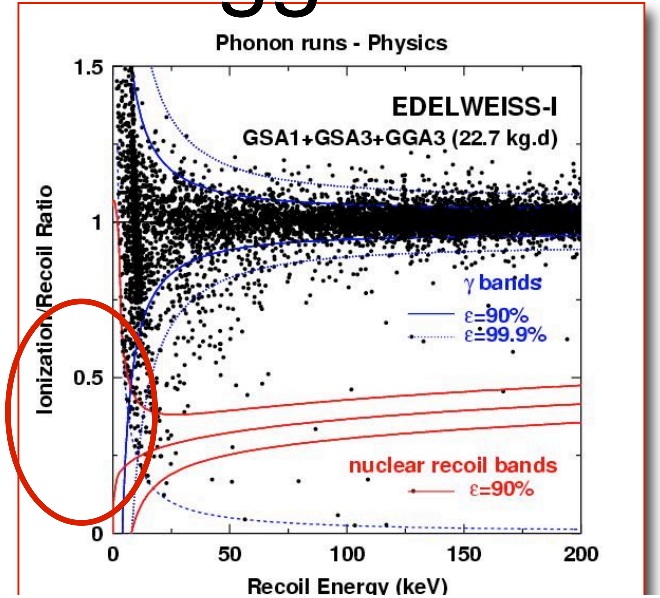


- Simultaneous measurement of
  - Heat @ 17 mK with Ge/NTD sensor
  - Ionization @ few V/cm with Al electrodes
- Different charge/heat ratio for nuclear and electron recoils (WIMP and neutron have lower charge than γs, βs)
- Discrimination event-by-event of electron recoils (main background)
  - E_I/E_R = 0.3 for nuclear recoils
  - E_I/E_R = 1 for electronic recoils

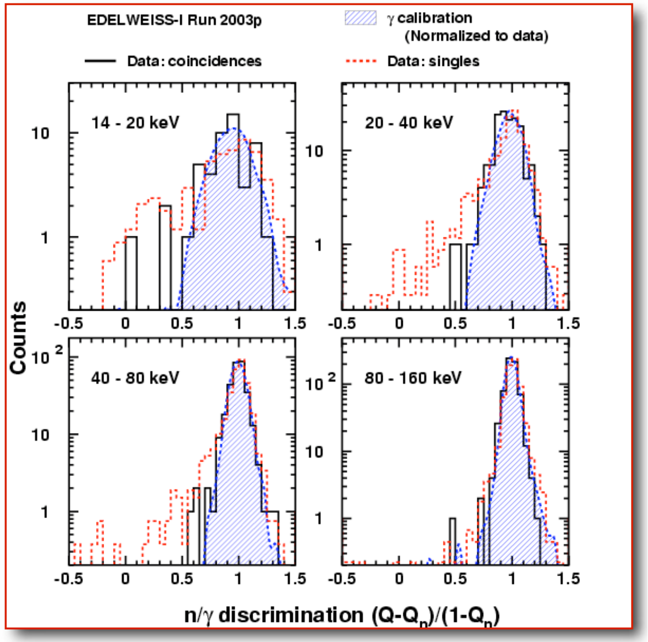


2003 data taking with heat trigger

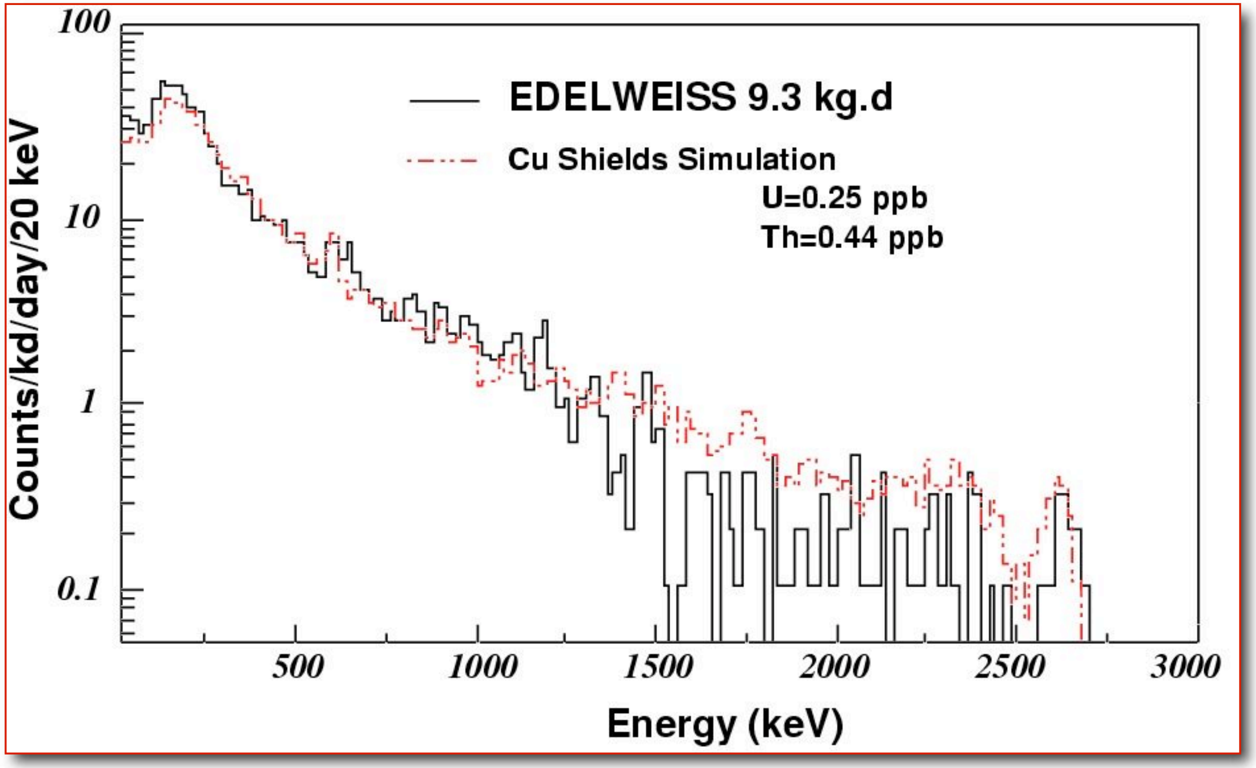
- Several runs between 2000 and 2003
- Last run = data taking with trigger on heat signal
- Improved efficiency at low energy (50 % at 11 keV)
- Stable behavior over 4 months of the detectors
- Fiducial exposure: 22 kg.d
- 18 nuclear recoil candidates > 15 keV



- Possible backgrounds
  - Residual neutron flux
    - 1 n-n coincidence observed
    - 2 single expected by MC
  - Surface electron recoils
    - Miscollected charge events at low energy
    - Leak of events down to the nuclear recoil band not visible in coincidence events
- Further, studies concerning the possible origins for these backgrounds



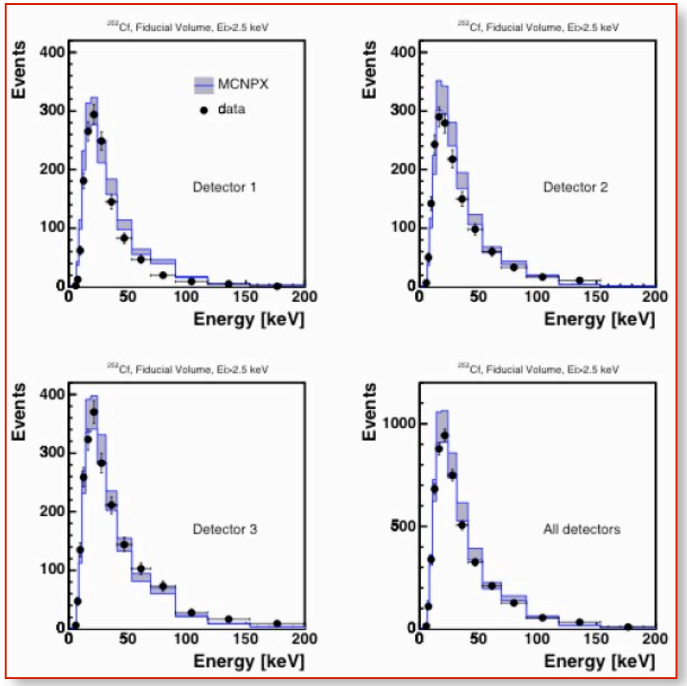
γ-ray background in EDELWEISS-I

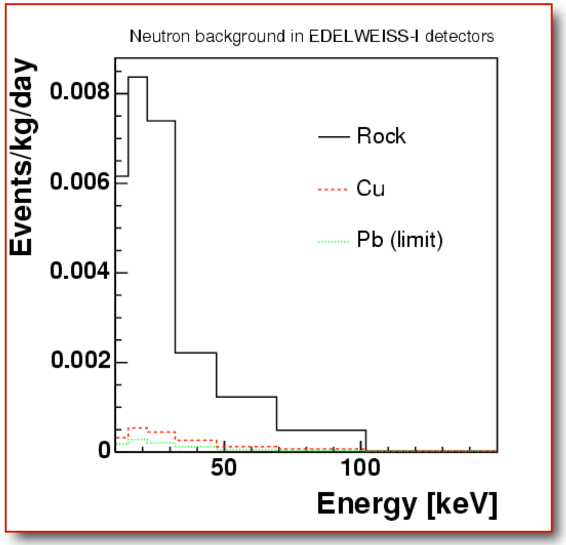


- Before nuclear recoil selection, rate in detectors is ~1.5 event/kg/day/keV at low energy
- At high energy, spectrum shape and rate consistent with simulations of the measured U/Th contamination in the bulk of the Cu shielding
- Room for improvement in EDELWEISS-II, where this Cu is not used

Neutron background in EDELWEISS-I

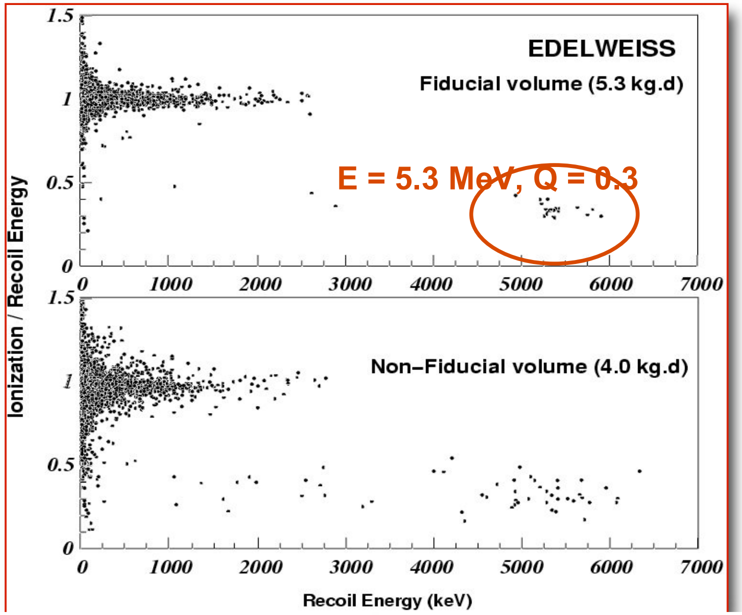
- Recent estimate of the neutron flux in the lab with E >1 MeV : 1.1 ± 0.1(stat) 10^{-6} n/cm²/s
- Good understanding of neutron propagation in the setup (agreement between simulated and experimental spectrum for a neutron calibration)
- Determination of single rate : ~2 nuclear recoil expected in 62 kg.d (ambient radioactivity + U contamination of copper and lead)
- 1 n-n coincidence observed in 62 kg.d
- Not a strong constraint on the single neutron rate in the data
  - Expected ratio double/single ~1/10
  - 1 n-n ⇔ 1 – 40 singles with E_R>15 keV @ 90% C.L.
  - Indistinguishable from the miscollected events in the nuclear recoil band

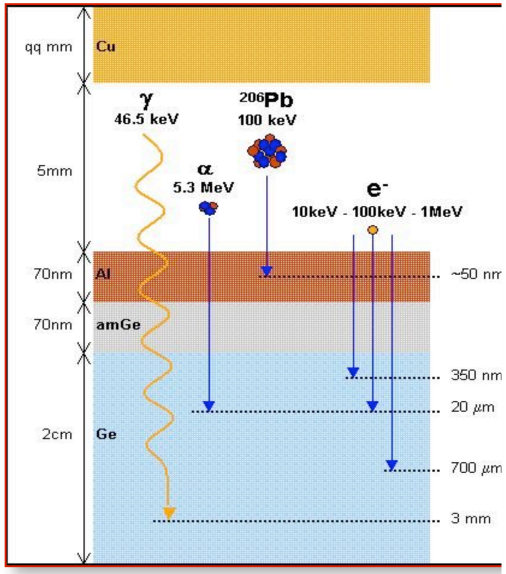


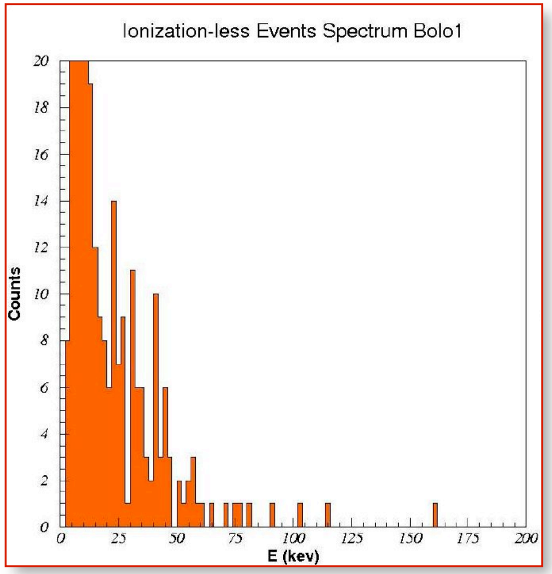


Surface backgrounds in EDELWEISS-I

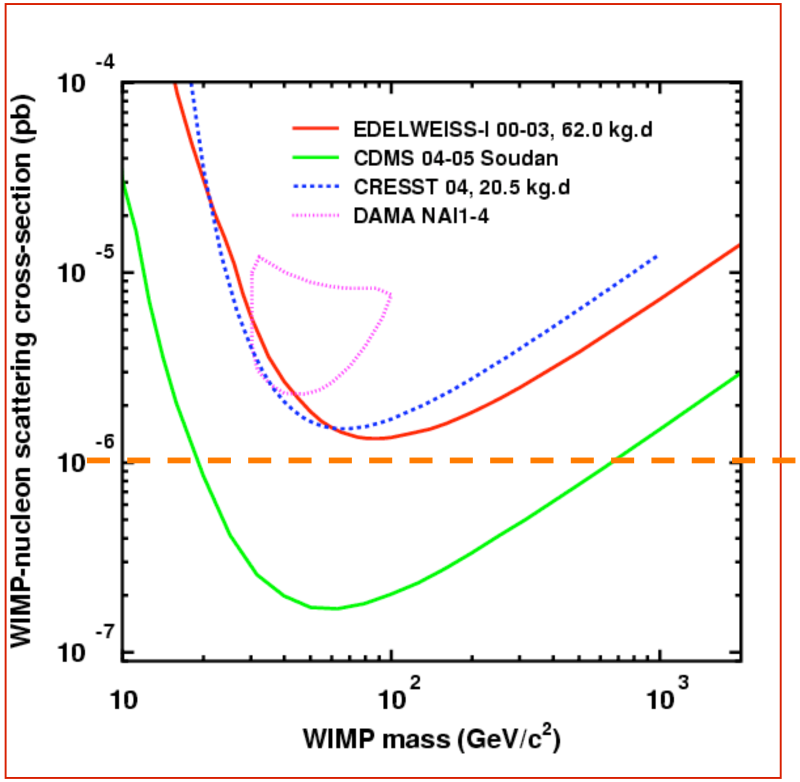
- Peak at E=5.3 MeV
  - α's from ^{210}Po?
  - Q=0.3 → α decays near surfaces
  - Rate ~ 400 /m²/d
  - As expected, non-fiducial part more exposed to α flux
- Very likely due to ^{210}Pb on Cu or Ge surfaces
- No ^{206}Pb recoil peak at 100 keV observed as heat-only events : ^{210}Pb implanted in Cu, not Ge.
- Rate of 0.3<Q<1.0 events at low energy consistent with surface β's expected in ^{210}Pb hypothesis
  - (but does not exclude possible contribution from ^{14}C)
- By removing Cu covers between detectors
  - Events should disappear
  - Better identification by coincidences



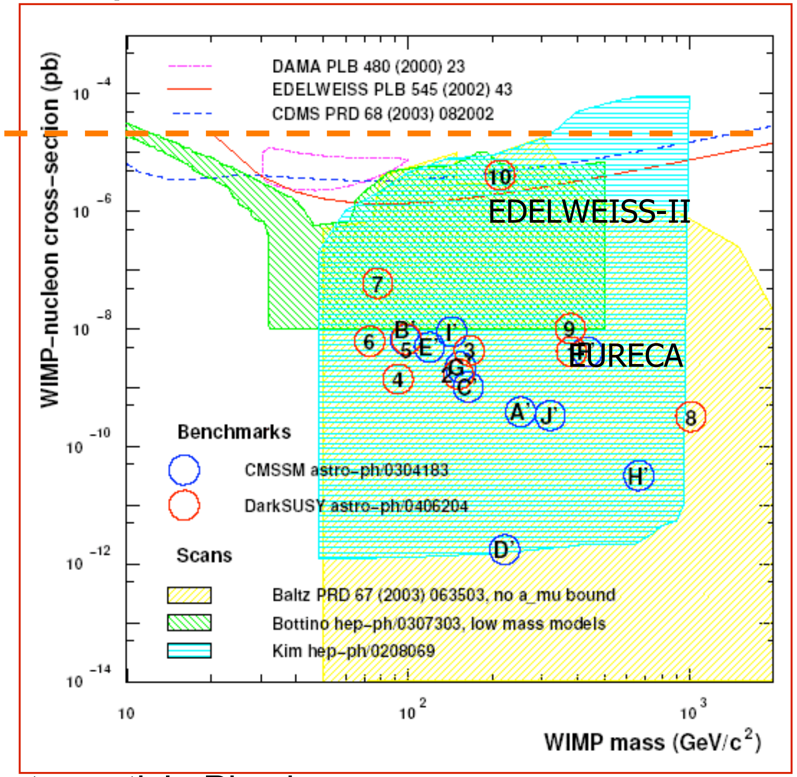




Exclusion limit – Spin Independent



- New exclusion consistent with our previous limits
- Best sensitivity : 1.5x10^{-6} pb @ 80 GeV/c²
- EDELWEISS started to explore some optimistic SUSY models



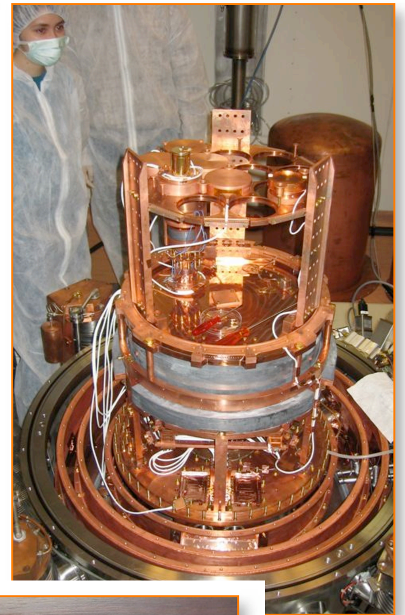
- Need a gain in sensitivity of a factor 100 – 10000 (EDW-II, EURECA*) to explore more interesting SUSY models
- This gain depends on improvements
  - On background discrimination
  - On mass

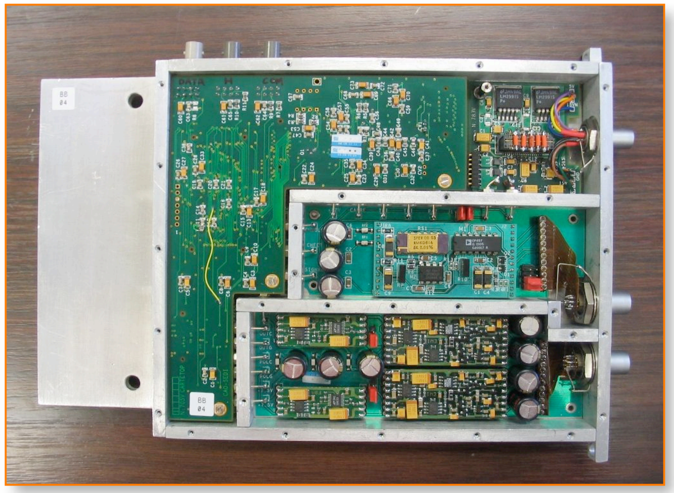
EDELWEISS-II

- Installation in the LSM started summer 2004
- 1^{rst} funded stage : 28 detectors
  - 21*320g optimized Ge/NTD detectors and holders
  - 7*400g Ge/NbSi detectors with active surface events rejections

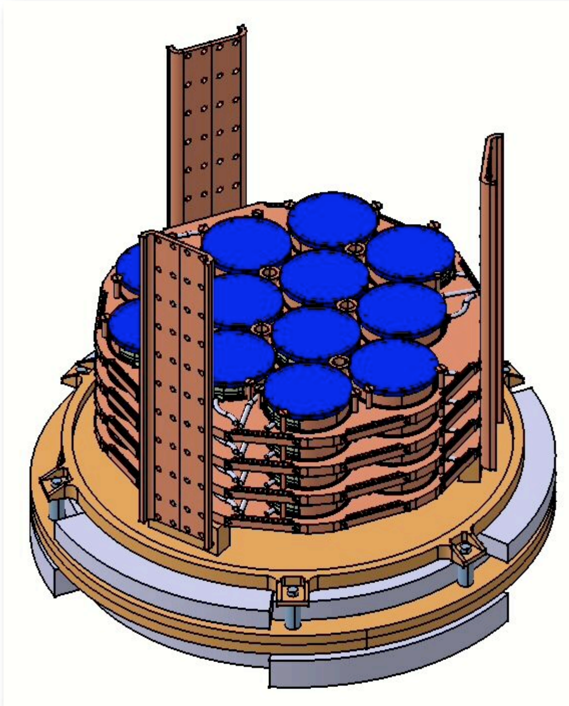
- First cryogenic test with bolometers in january 2006
- **Commissioning run with 8 bolometers**
- New electronic and acquisition systems: square modulation, continuous digitization close to the readout, optical fibers and numerical trigger

- **Goal *100 in sensitivity :**
  - $\sigma_{w\text{-}n} \approx 10^{-8}$ **pb**
  - 0.002 evt/kg/day (E_R>10keV)





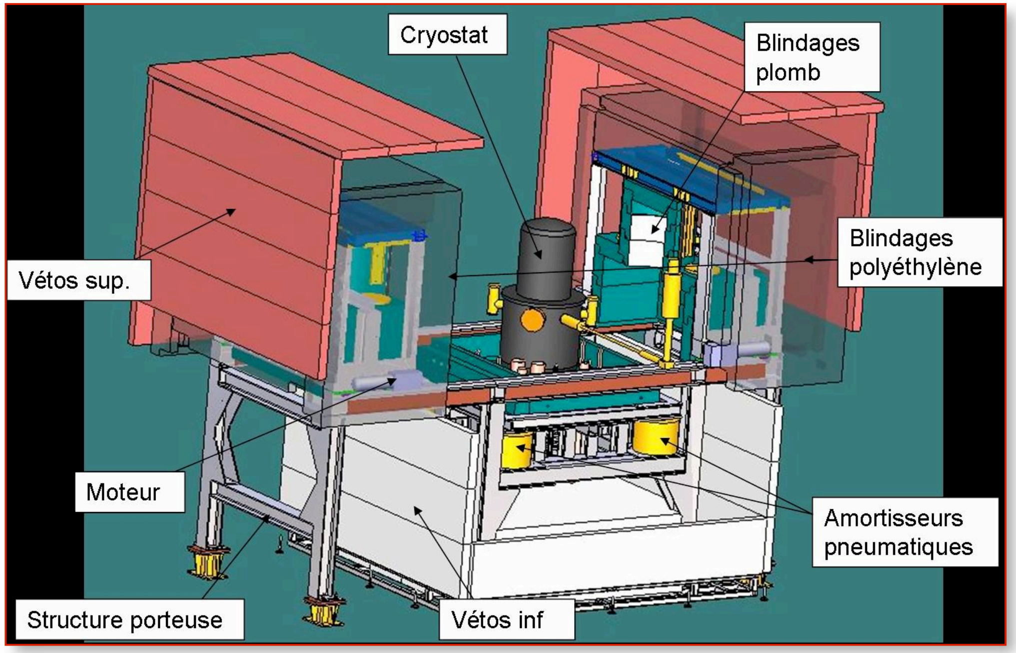
EDELWEISS-II improvements – Cryostat



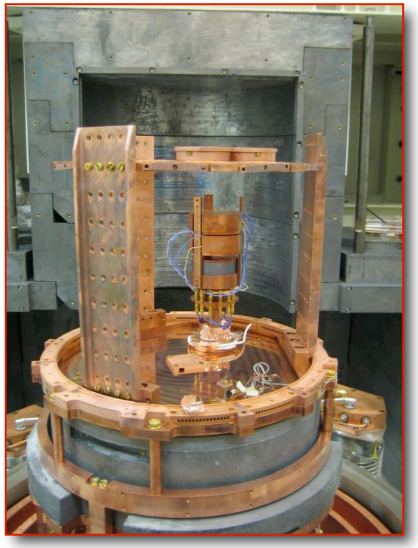
- Reversed geometry
- Nitrogen free : 3 Pulse tubes (50K and 80K screens) and 1 He cold vapor reliquefier (consumption ≈ 0)
- Large volume 50l ⇒ Self shielding
- Up to ≈ 120 detectors ⇒ More statistics
- Compact and hexagonal arrangement ⇒ More coincidence (n bkg)

EDELWEISS-II improvements – Backgrounds

- Radiopurity
- Dedicated HPGe detectors for Systematic checks of all materials
- Clean Room (class 100 around the cryostat, class 10000 for the full shielding
- Deradonized air (from NEMO3) (0.1 Bq/m^3)



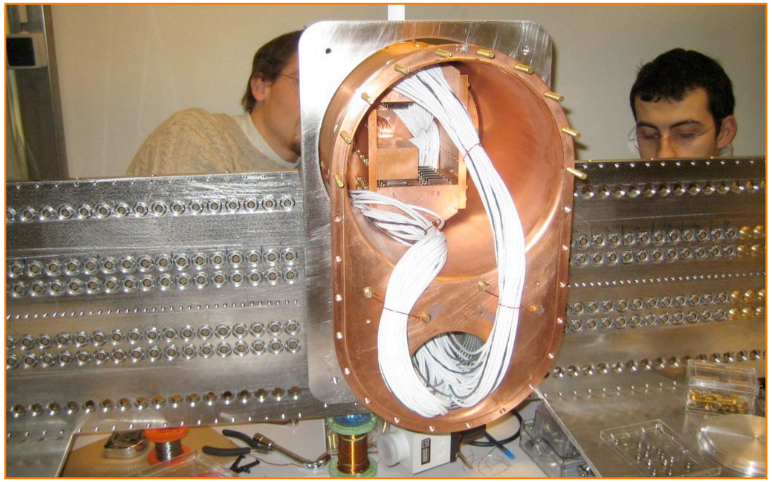
- 20 cm Pb shielding
- Neutron Shielding
  - EDW-I : 30cm paraffin
  - EDW-II : 50 cm PE and better coverage
  - μ veto (99% coverage)

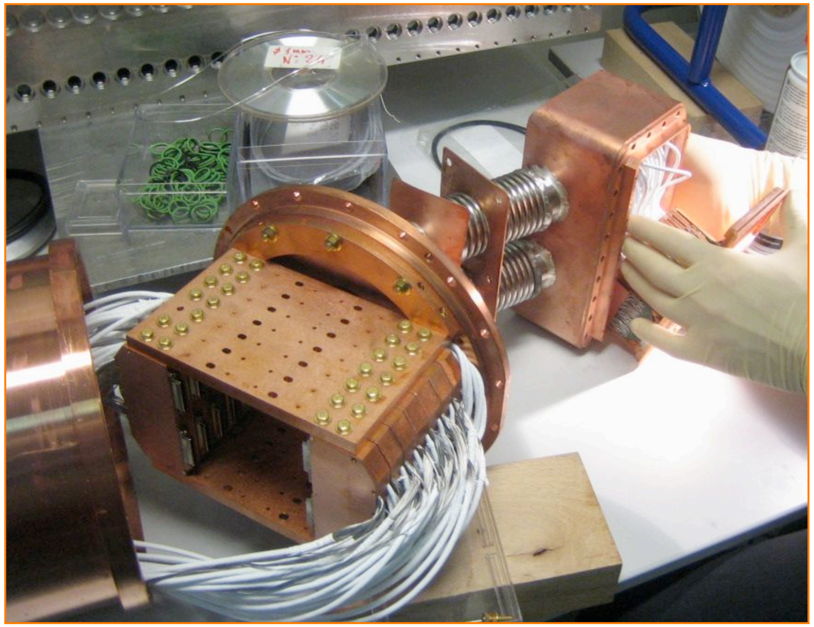


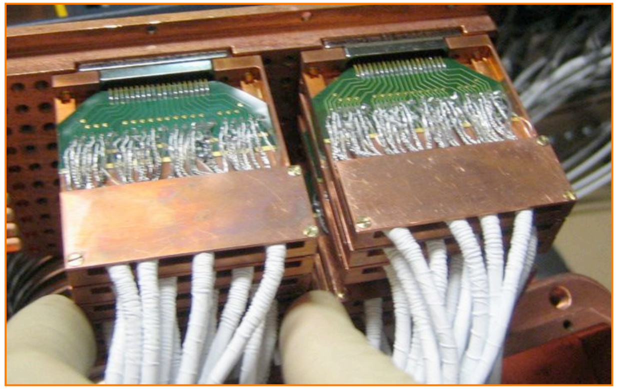
PE shielding
March 2005

Vetos
June 2005

Cryostat, copper screens and shielding waiting in boxes in the clean room. Oct 2005

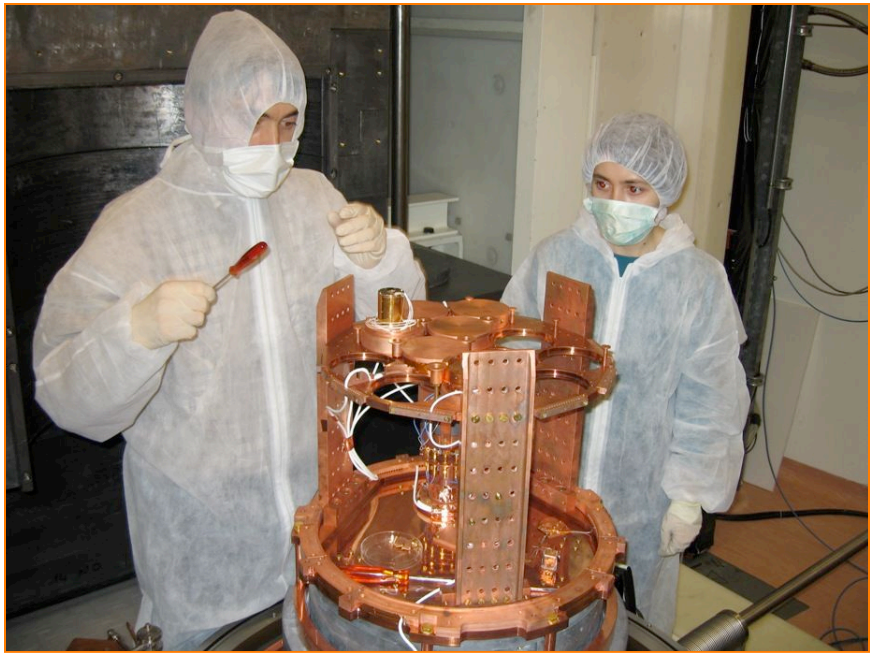






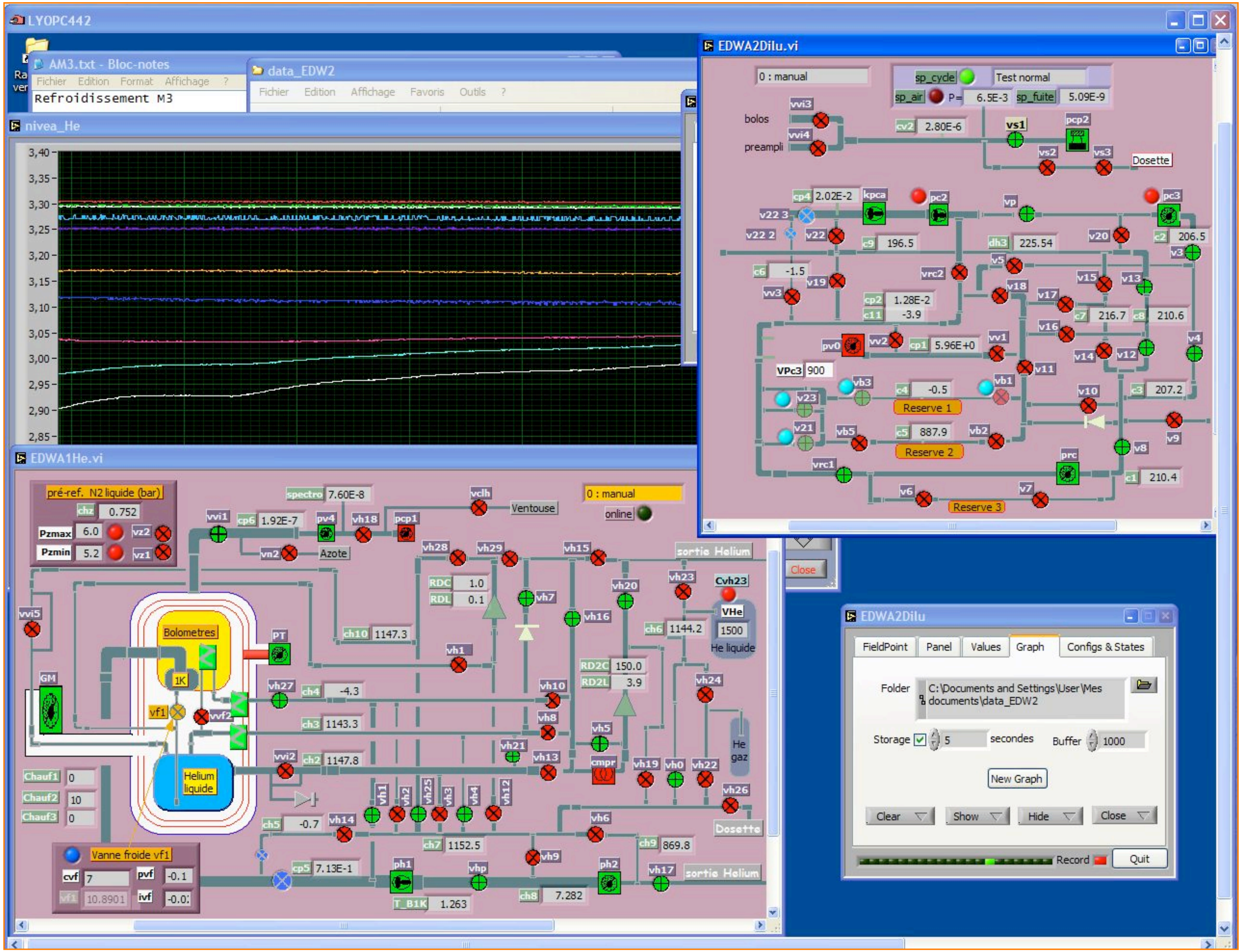
Cabling Dec 2005

- for 60 bolometers in first stage
- ≈1200 coaxes @ 300K !
- ≈ 500 coaxes @ 1 K, 100mK & 10 mK
- ≈ 300 FET and 600 R or C at low T



Installation des 8 premiers détecteurs
Janvier 2006

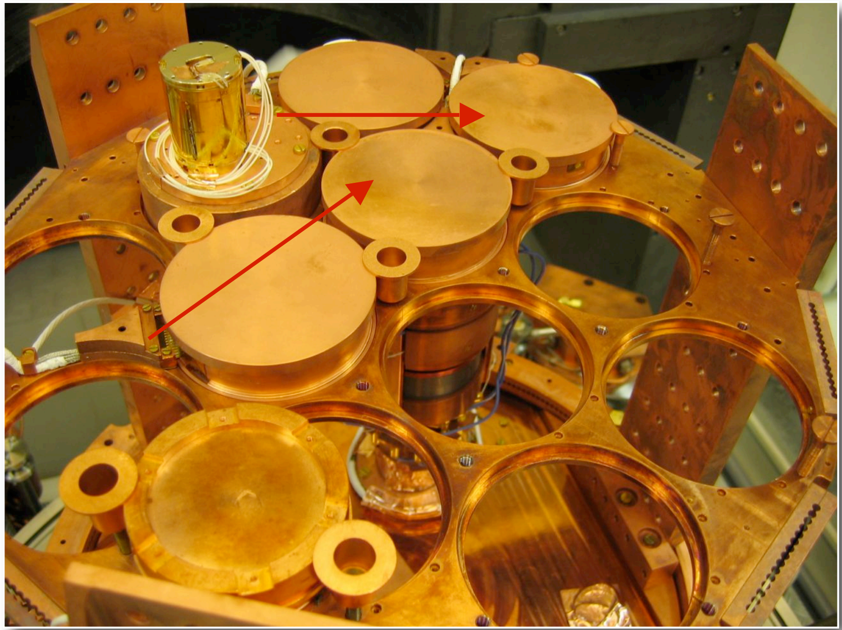
EDELWEISS-II : - Cryostat computer control



EDELWEISS-II present status

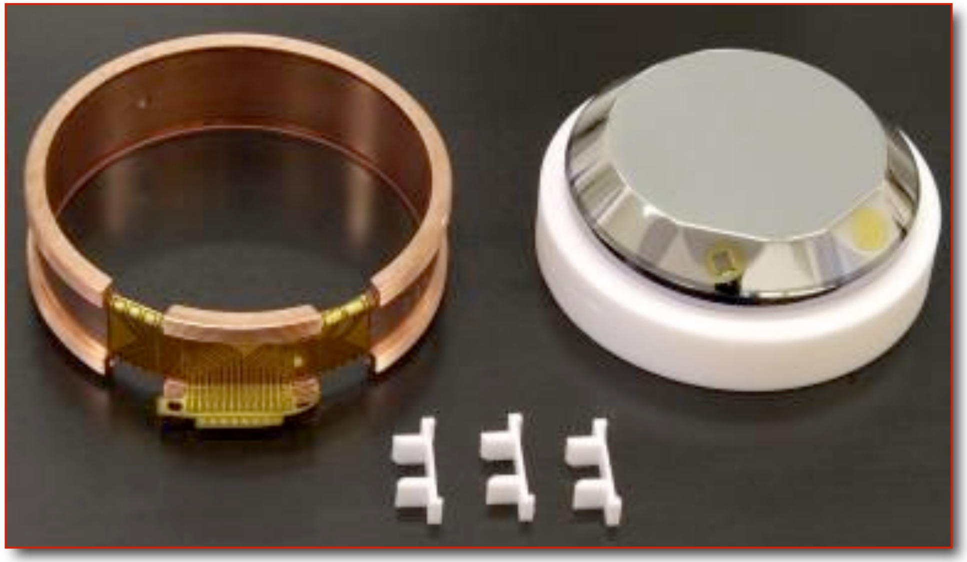
- Commissioning run with 9 bolometers :
  - 2*320g Ge/NTD with EDW-I holder
  - 2*320g Ge/NTD with EDW-II holder and teflon clamp
  - 2*320g Ge/NTD with EDW-II holder and Cu springs
  - 1*IAS 50g heat and light detector (Al_2O_3)
  - 1*200g + 1*400g Ge/NbSi

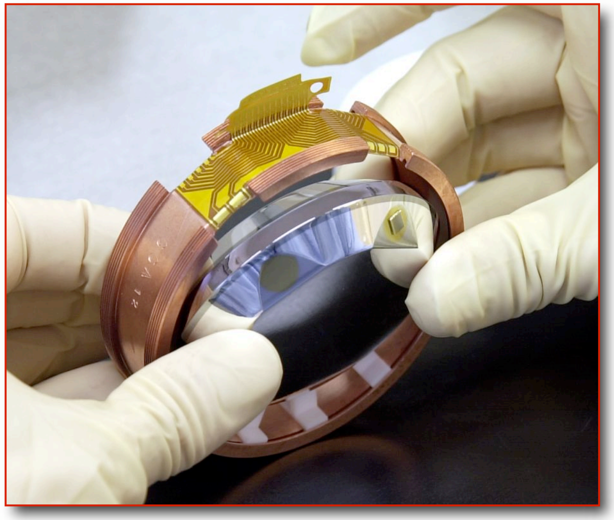
- Goals : Validation of the microphonics (pulse tube decoupling system), new holders and new comb connectors for Ge/ntd, new electronics scheme, new acquisition system…
- Cold and running…
- 28 detectors September 2006 (produced and tested)

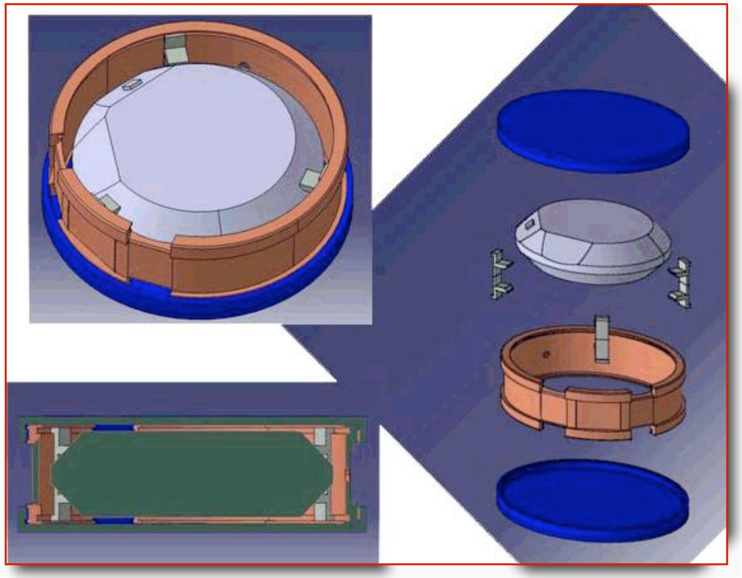


EDELWEISS-II Ge/NTD detectors

- Developed by CEA Saclay and Camberra-Eurisys
- Amorphous Ge and Si sublayer (better charge collection for surface events)
- Optimized NTD size and homogeneous working T (16-18 mK) : sub keV resolution
- New holder and connectors (Teflon and copper only)

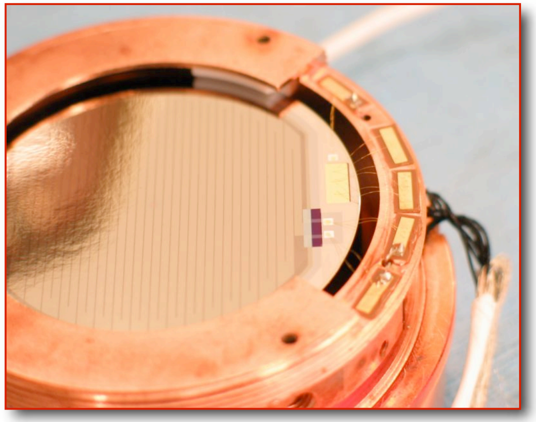






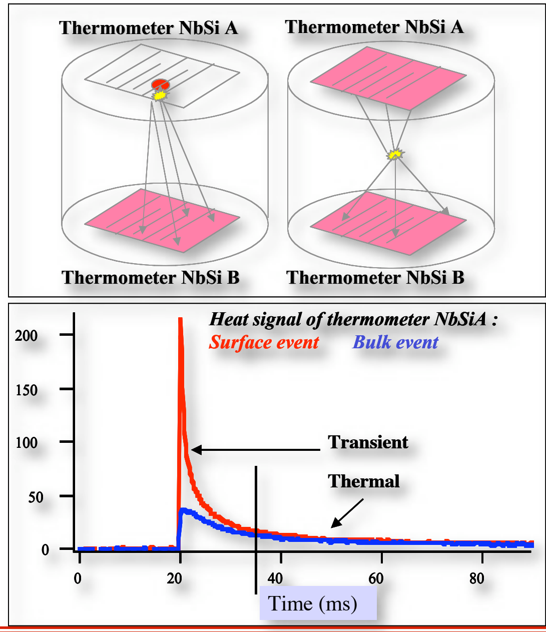
Identification of surface events with Ge/NbSi sensors

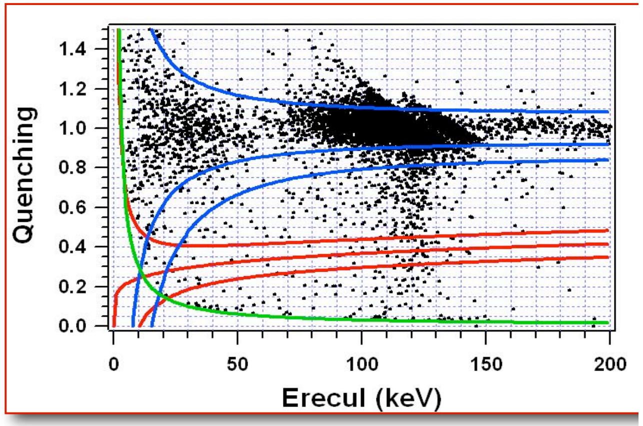
Athermal phonon measurement with NbSi thin film thermometers



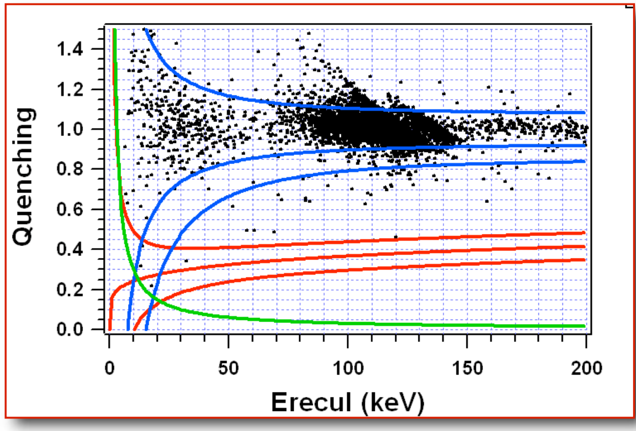
Heat and ionization Ge detectors

- Each signal = thermal + athermal component
- For surface events, athermal higher in NbSia
- Thermal signals proportionnal to the deposited energy





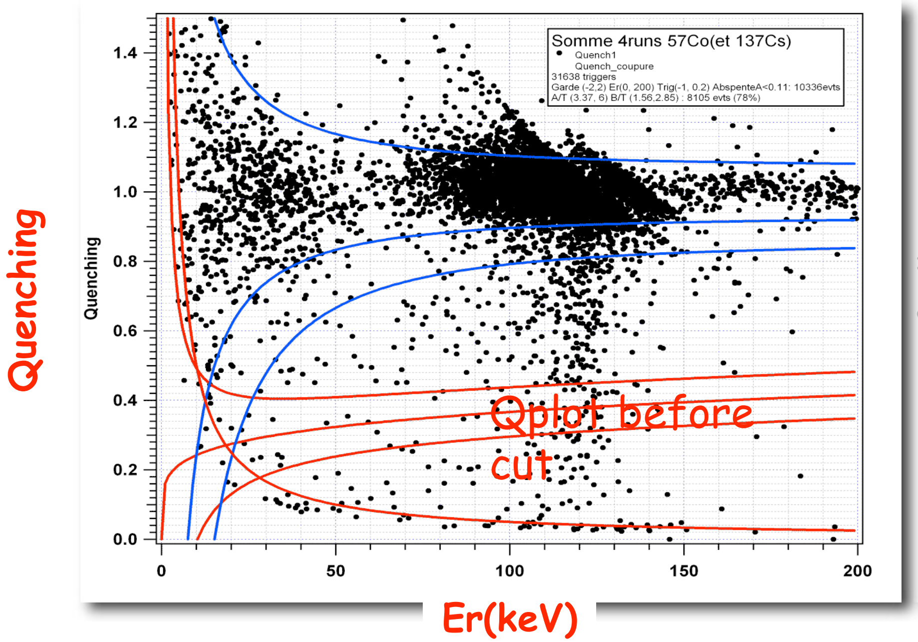
Before rejection

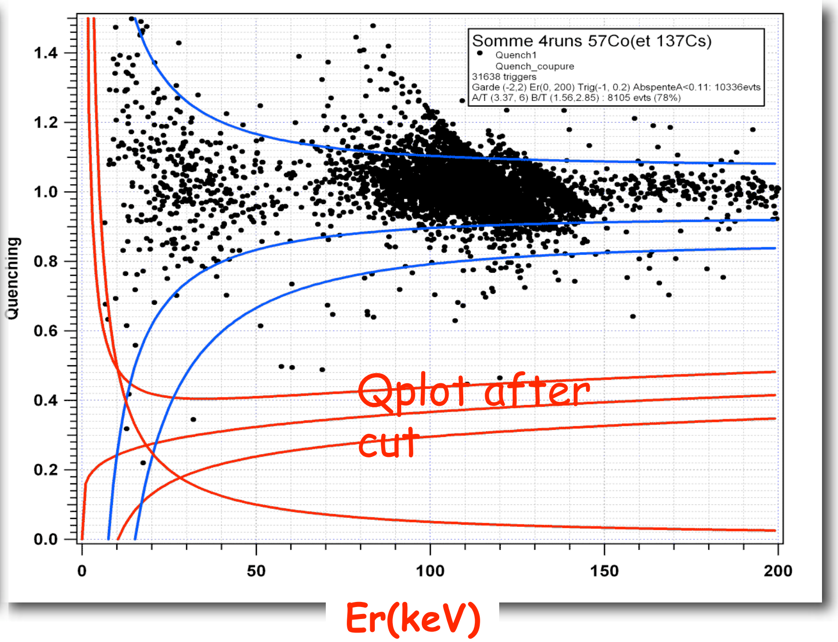


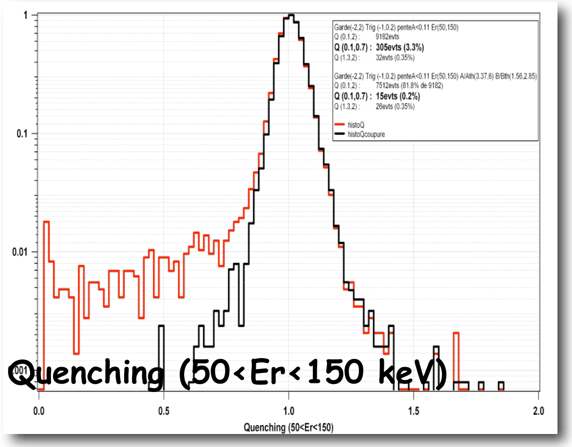
After rejection (1mm cut)

- Tests with 200g prototype in EDELWEISS-I
- Improvement of a factor 20 of the rejection
- Fiducial volume reduction of 10 %

Identification of surface events with Ge/NbSi detector (3)







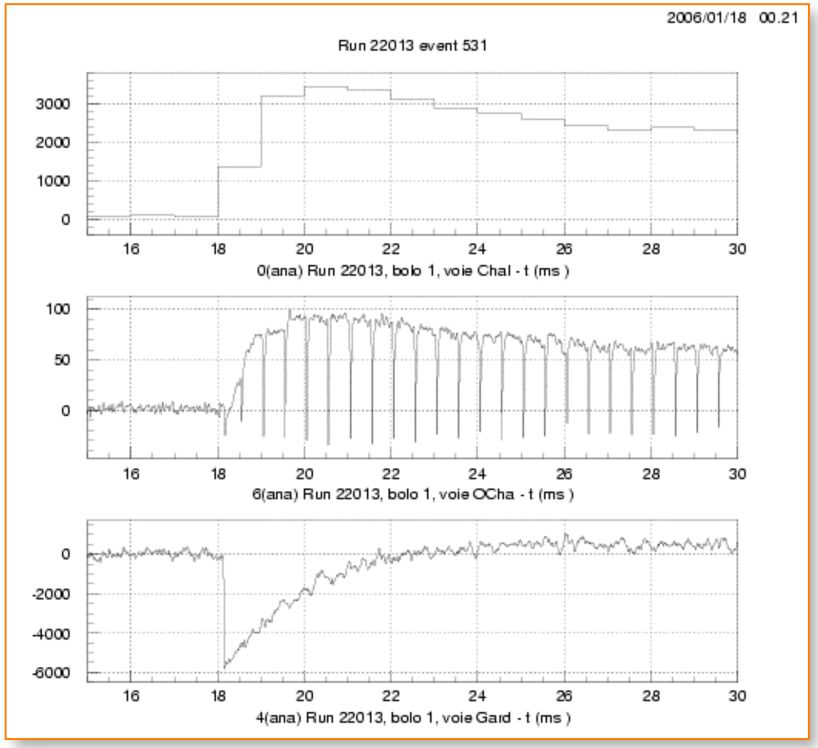
- **95% of the uncomplete collection events are rejected**
(20% of the total events) for a fiducial volume of 90%
- Similar results on physics data taking

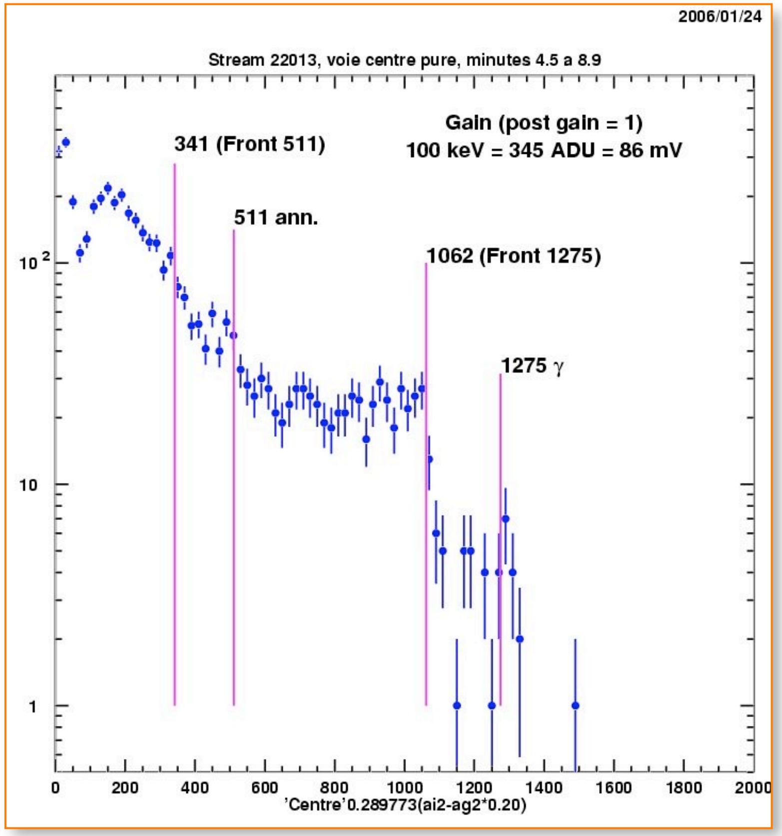
- **7 optimized (size and resolution) 400 g Ge/NbSi detectors in EDELWEISS-II**

EDELWEISS-II present status

- **Tcryostat 10 mK**
- **9 bolometers running:**
  - 2 EDW-I Ge/NTD detectors with EDWI holder
  - 2 EDW-I Ge/NTD detectors with EDWII holder
  - 2 new EDW-II Ge/NTD detectors
  - 1 IAS 50g heat and light detector (Al_2O_3) already tested
  - 1 x 200g already tested in LSM+ 1 x 400g Ge/NbSi

FIRST EDW-II event !





Conclusions

• The validation stage of EDELWEISS-II
(three data takings at 10 mK, 9 detectors) is in progress

• Installation of the first series of 28 detectors (21 NTD-based Ge, 7 NbSi Ge) is expected in October (detectors ready, some electronics missing)

• Several new techniques implemented in EDELWEISS-II
- new digital electronics
- new reversed dilution cryostat
- much larger experimental volume (≈ 50 liter useful volume)
- pulsetubes and helium reliquifier
- active muon veto

• If 28 detector-phase validated, 100-detector stage is expected to be approved and funded in 2007

• Aim : 2 x 10^{-8} picobarn sensitivity
(top of the realistic models according to John)
• Validation of the strategy towards the EURECA ton-scale experiment