NDM '06
Paris, September 3-9, 2006

Search for Dark Matter with EDELWEISS

Status and future

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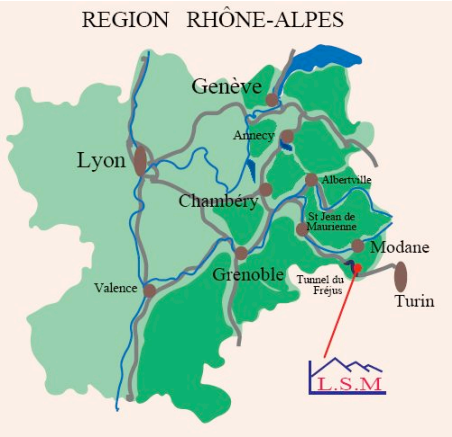
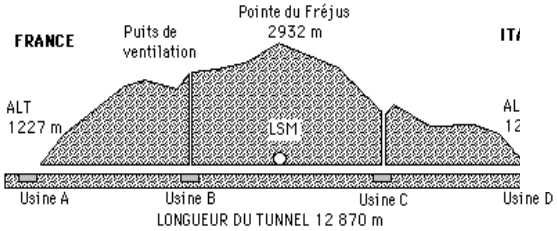
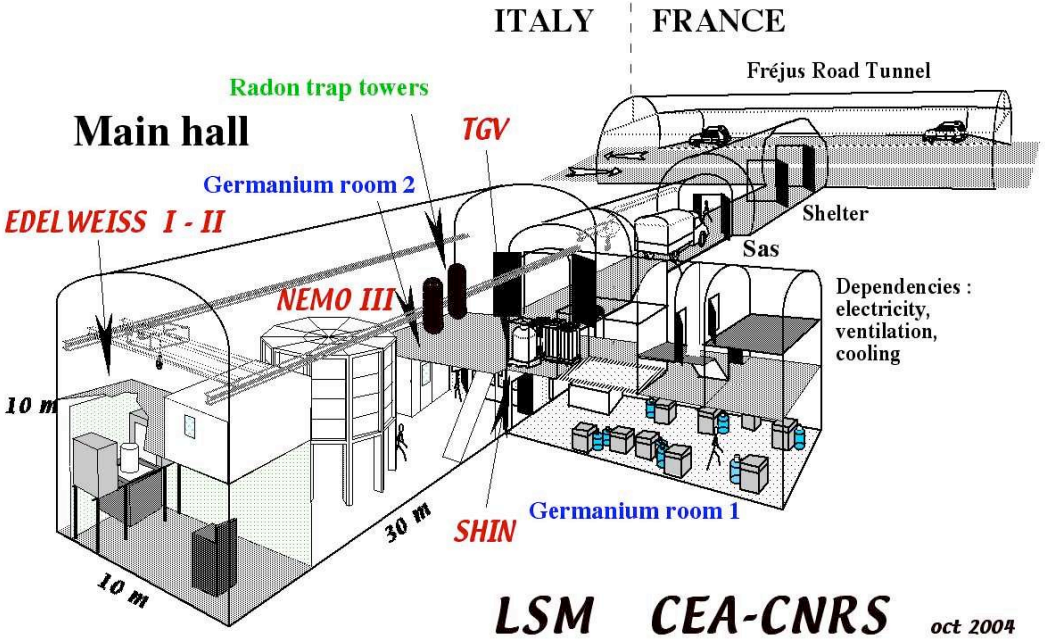
Modane Underground Laboratory

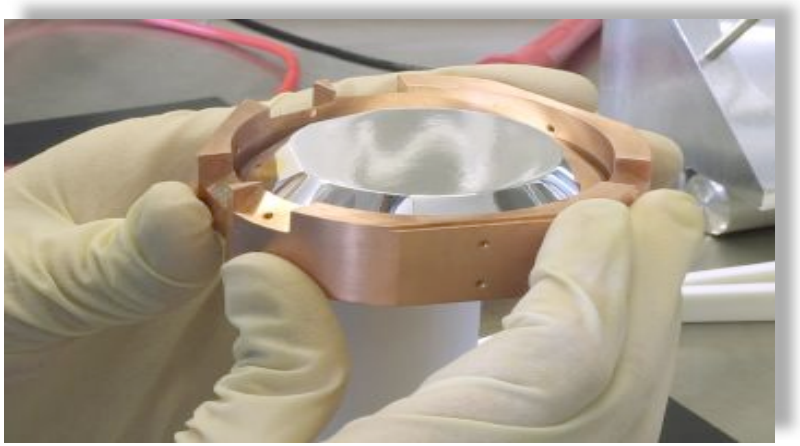




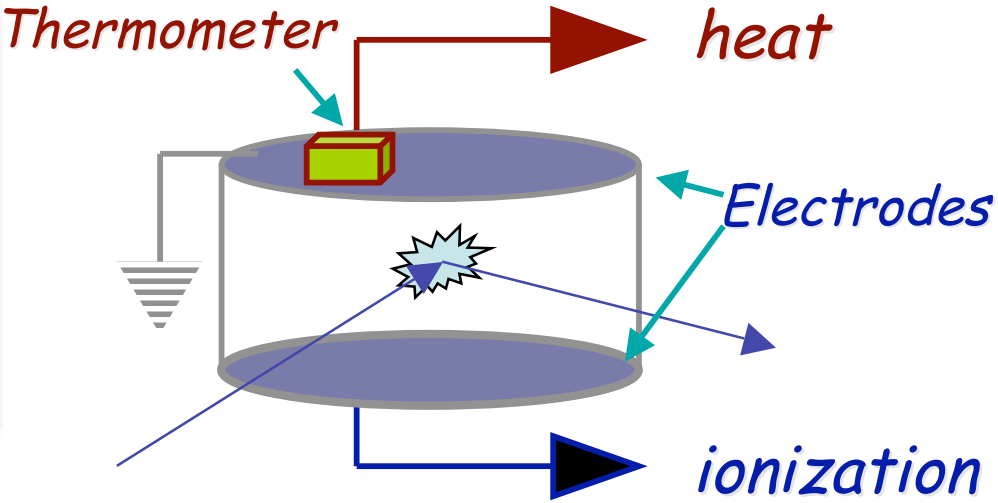


-> 1700 m depth in the Fréjus Tunnel (<-> 4800 m water)
-> 4 μ/m^2/day (≈ 2 × 10^6 less than at the surface)
-> 1500 neutrons (>1 MeV)/m^2/day (rock radioactivity)

Ionization-heat cryogenic detectors



Edelweiss Ge bolometer

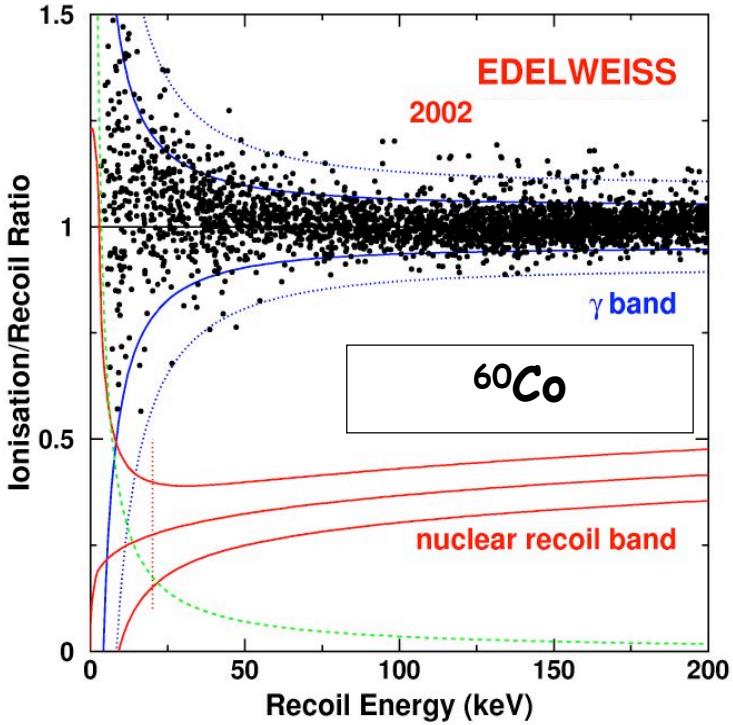


- Different charge/heat ratio for nuclear recoils and electronic recoils

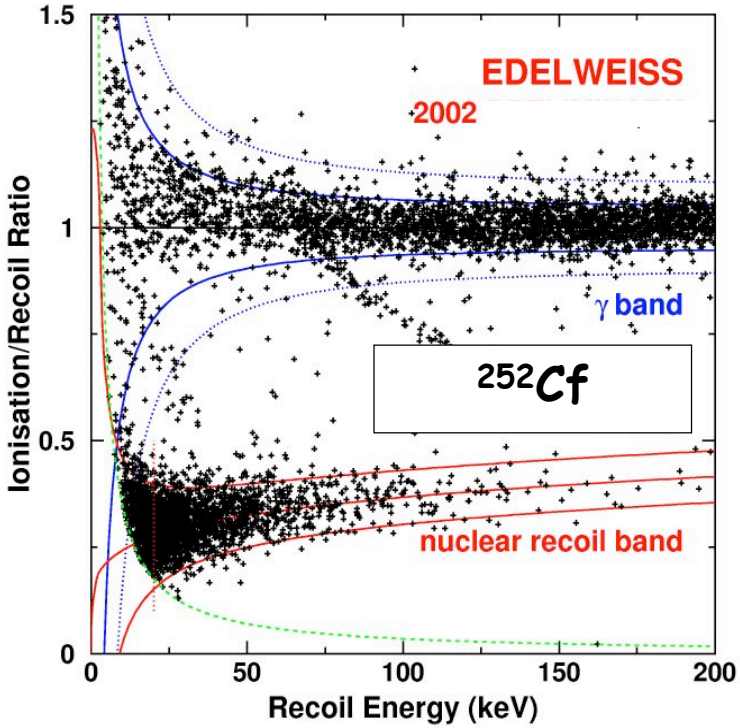
-> event by event discrimination

Discrimination performance

^{60}Co calibration
no γ below Q=0.7



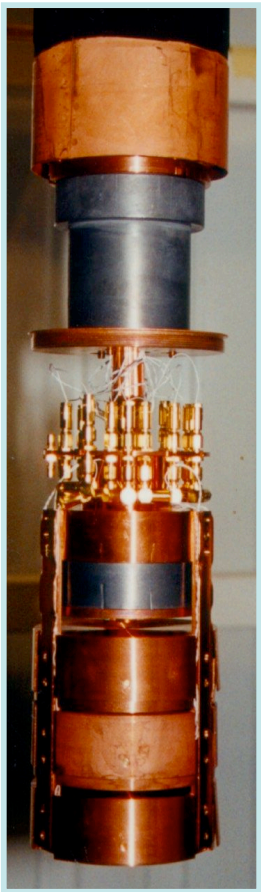
^{252}Cf calibration
Neutrons in nuclear recoil band

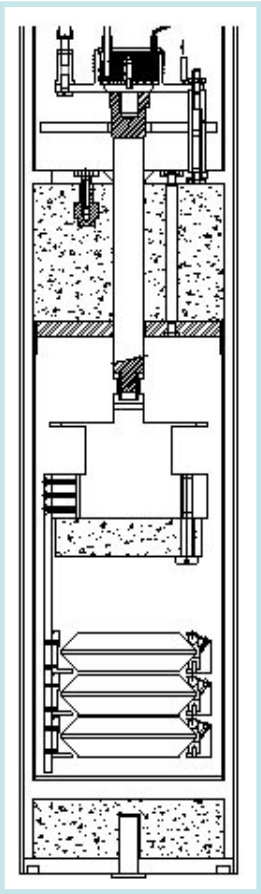


-> γ rejection > 99.9% for E_{recoil} > 15keV

Lessons from EDELWEISS I

3x320 grams bolometers



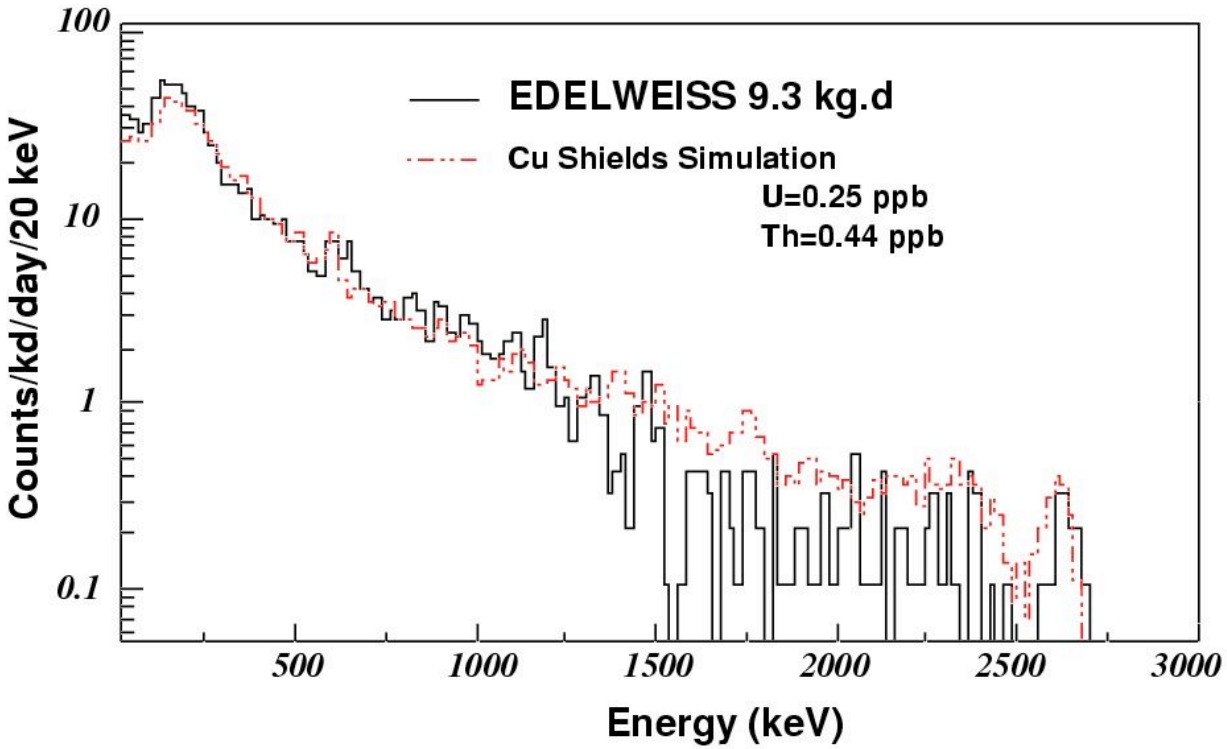


Fall 2000 5 kg.d
Spring 2002 8.6 kg.d
-> astro-ph/0206271
Phys. Lett. B 545 (2002) 43

Oct.-Mar 2003 25.7 kg.d
April-Nov 2003 22.7 kg.d

Total : 62 kg.d
-> astro-ph/0503265
V.Sanglard et al., PRD **71**,122002 (2005)

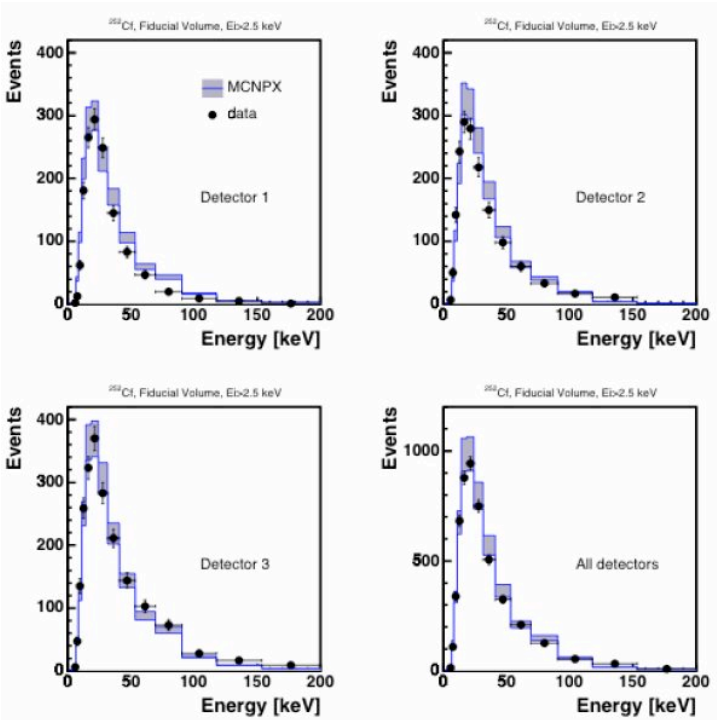
γ-ray background in EDELWEISS-I



- At low energy : ~1.5 event/kg/day/keV
- At high energy, data consistent with simulations of the measured U/Th contamination in the Cu shielding

Neutron background in EDELWEISS-I

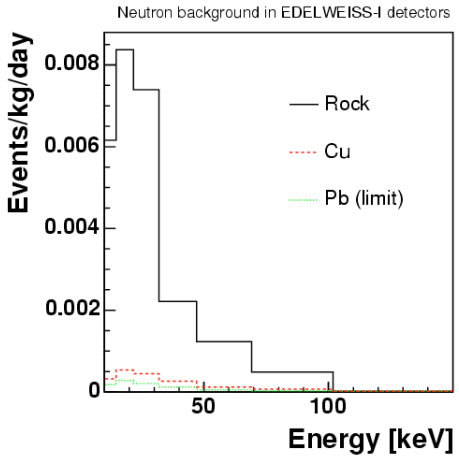
Neutron calibration run ^{252}Cf



-> agreement between data and MCNPX simulation

Neutrons in Low background runs

Simulation with neutrons from U/Th in rock, + U in Lead and Copper shielding



Simulation : ~2 nuclear recoil in 62 kg.d

Data : 1 n-n coincidence (double/single ~1/10)

-> Not a strong constraint on singles

(Indistinguishable from the miscollected events)

1 n-n ⇔ 1 – 40 singles with E_R>15 keV @ 90% C.L.

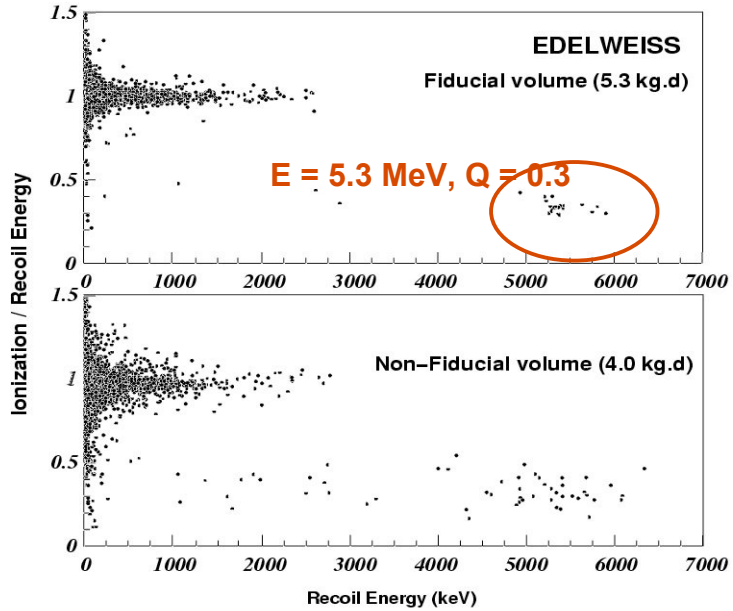
Surface backgrounds in EDELWEISS-I

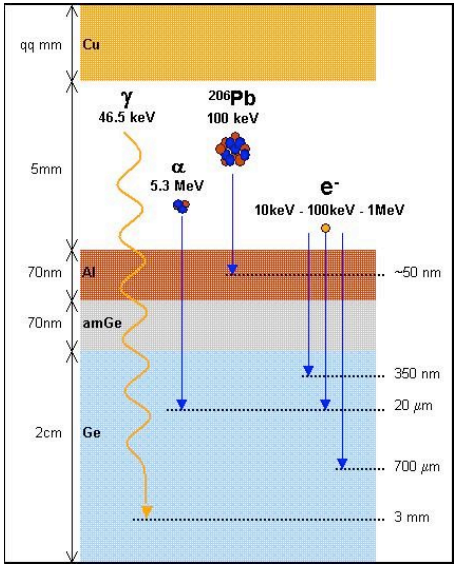
- Peak at E=5.3 MeV and Q=0.3 (400 /m^2/d)
  -> surface α's from ^{210}Po?

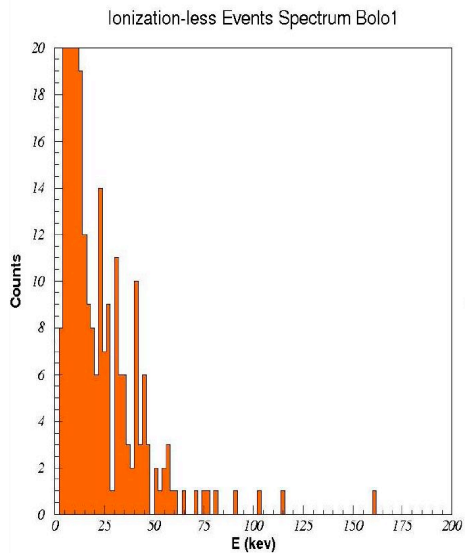
- No ^{206}Pb recoil peak at 100 keV (observed as heat-only events)
  -> ^{210}Pb implanted in Cu, not Ge.

- Rate of surface β's consistent with ^{210}Pb hypothesis
  - but does not exclude possible contribution from ^{14}C

-> Remove Cu covers between detectors
Should remove background and allow identification by coincidences

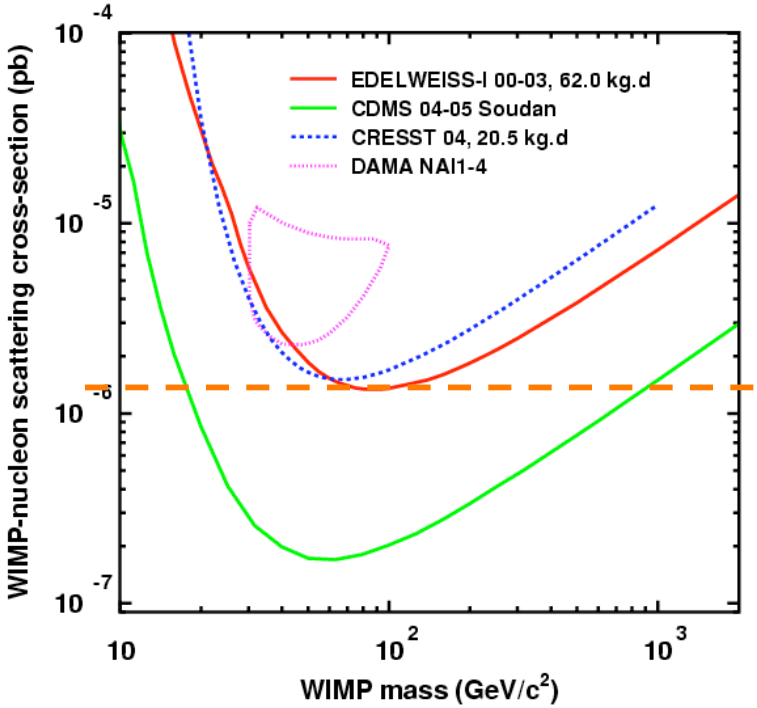


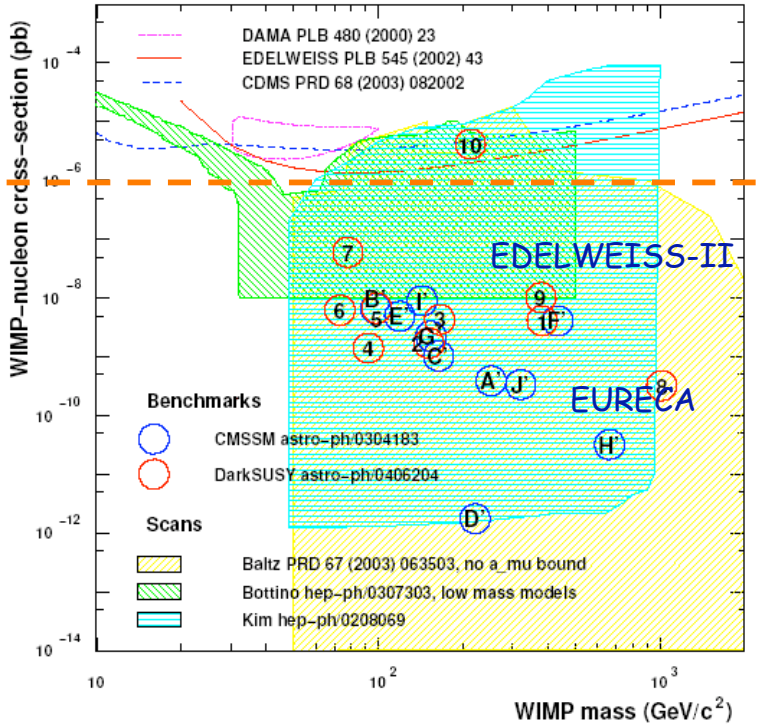




Exclusion limit – Spin Independent

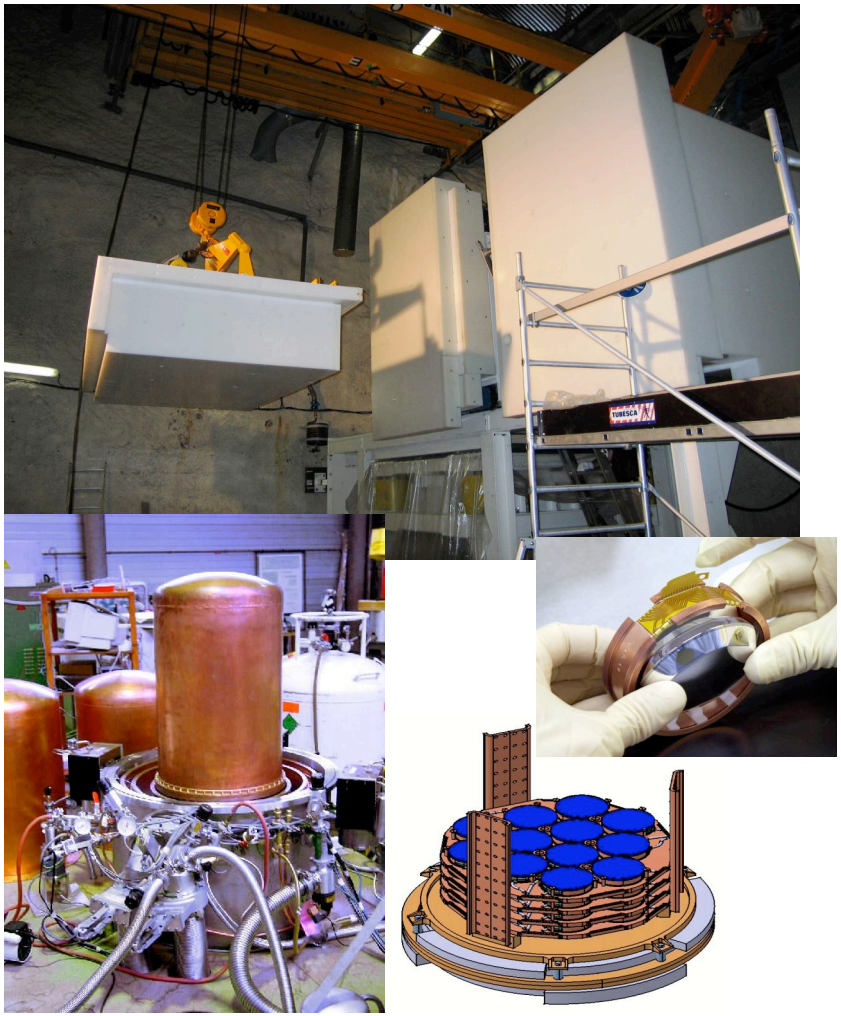
- Best sensitivity : 1.5×10^{-6} pb @ 80 GeV/c^2
- EDELWEISS started to explore some optimistic SUSY models





- Need a gain in sensitivity of a factor 100 – 10000 (EDW-II, EURECA*) to explore more interesting SUSY models

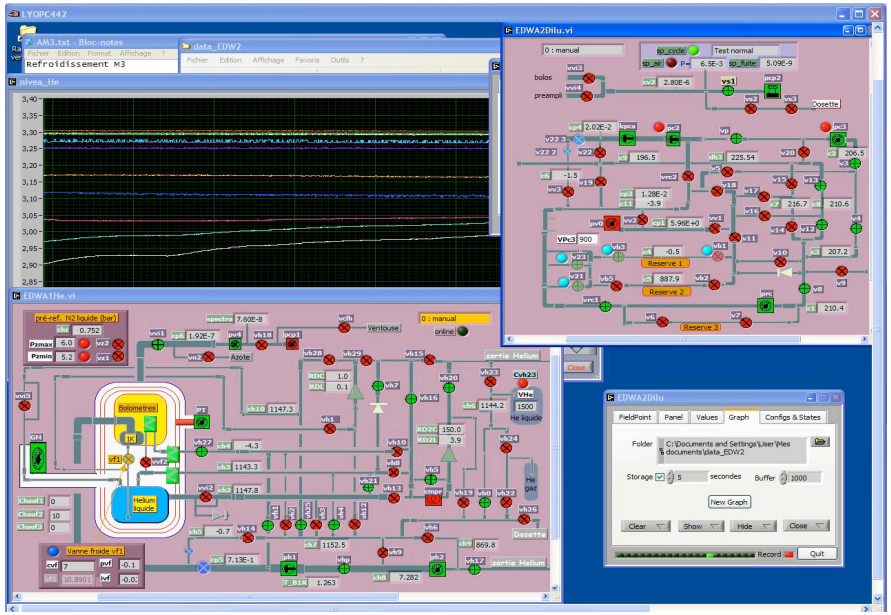
EDELWEISS-II



- Installation in the LSM started January 2005
- 1rst 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 9 bolometers on-going
- Goal : factor 100 increase in sensitivity with up to 120 detectors in cryostat:
  -> $\sigma_{w-n} \approx 10^{-8}$ pb
  -> 0.002 evt/kg/day (E_R>10keV)

EDELWEISS-II - Cryostat

computer control



- 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)

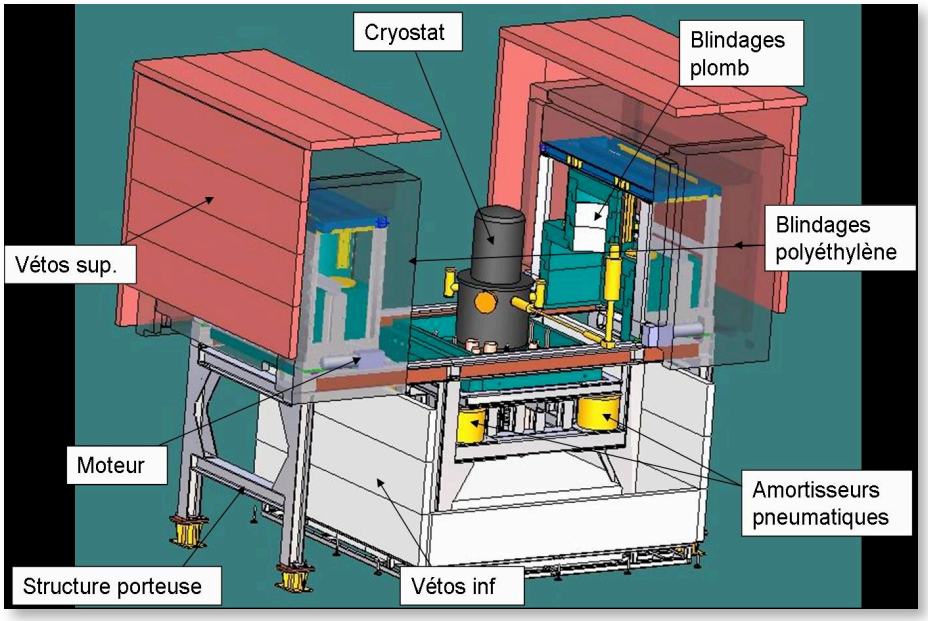
EDELWEISS-II - Backgrounds improvements

-> Better material selection
(dedicated HPGe detectors)

-> Clean Room
(class 100 around the cryostat,
class 10000 for the full shielding)

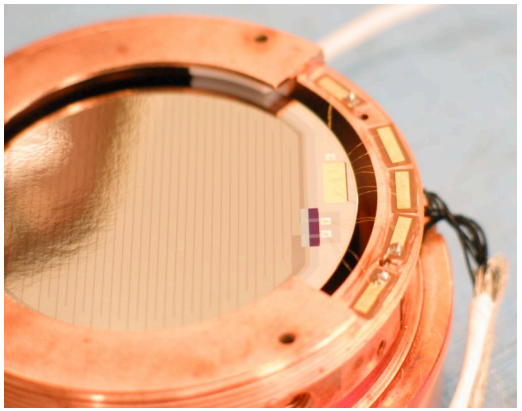
-> Deradonised air factory
100 m^3/h - 0.1 Bq/m^3
(instead of 5 Bq/m^3)

-> Better shielding
- 20 cm Pb shielding
- Neutron Shielding
  - 50 cm PE and better coverage
  - μ veto (99% coverage)



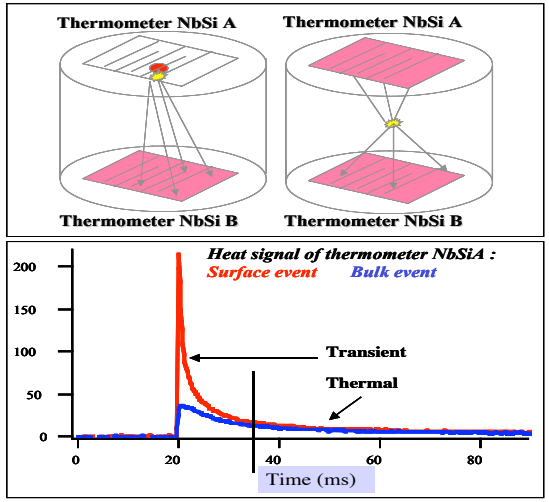
Identification of surface events with Ge/NbSi sensors

Athermal phonon measurement with NbSi thin film thermometers

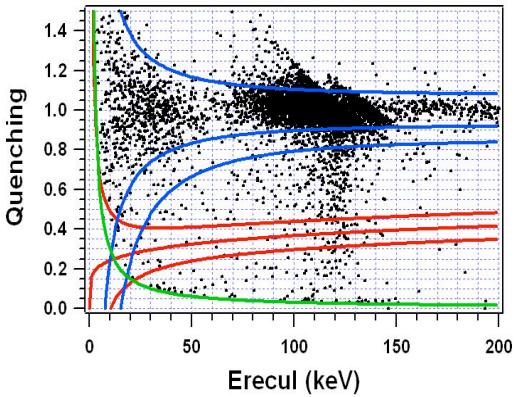


Heat and ionization Ge detectors

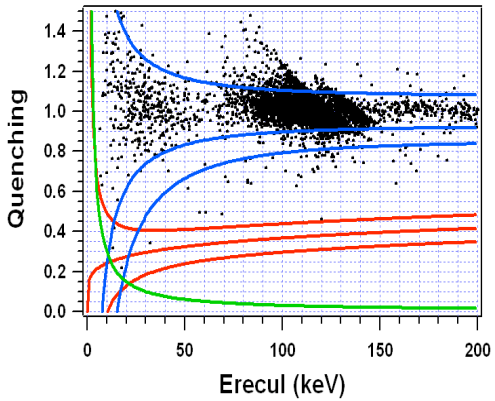
- For surface events, athermal signal higher on one face
- Thermal signals proportional to the deposited energy



γ-ray ^{57}Co calibration



Before rejection

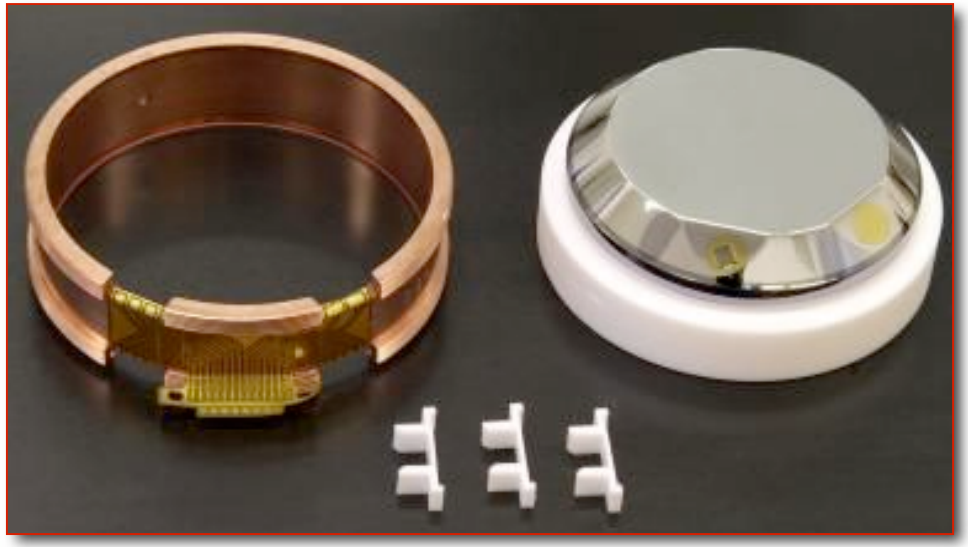


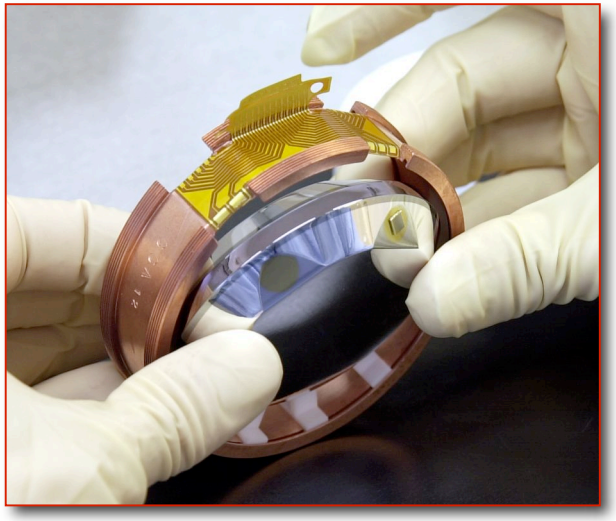
After rejection (1mm cut)

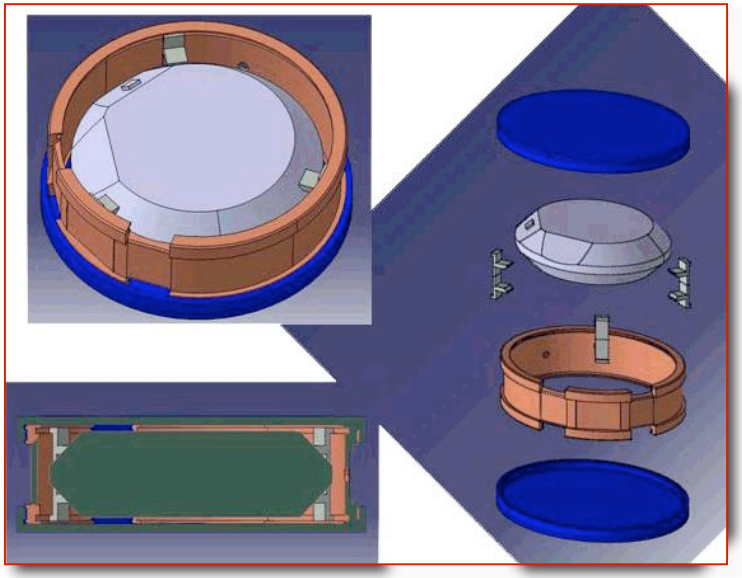
- Improvement by a factor 20 of the rejection
- Fiducial volume reduction of 10 %
- Similar results on low-background runs in LSM

EDELWEISS-II Ge/NTD detectors

- Amorphous Ge and Si sublayer (better charge collection for surface events)
- Optimized NTD size and homogeneous working T (16-18 mK) : sub keV resolution
- Low radioactivity new holders and connectors (Teflon and copper only)

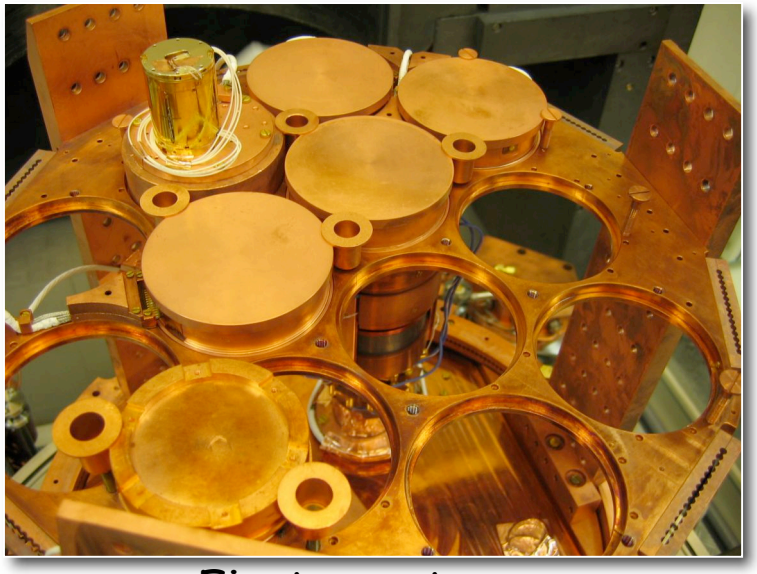




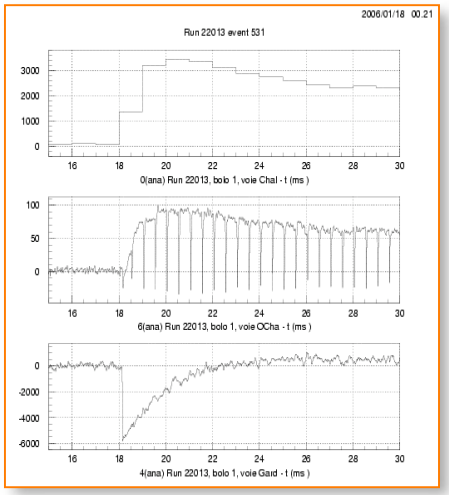


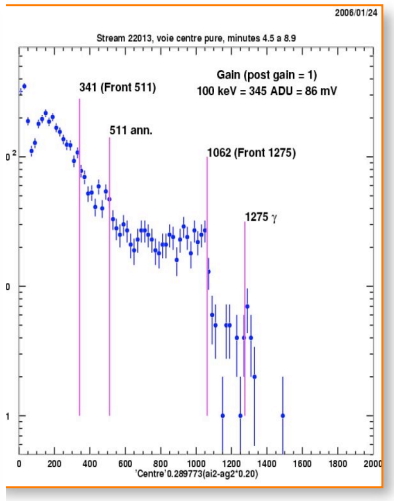
EDELWEISS-II present status

- 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 October 2006 (produced and tested)



First events…

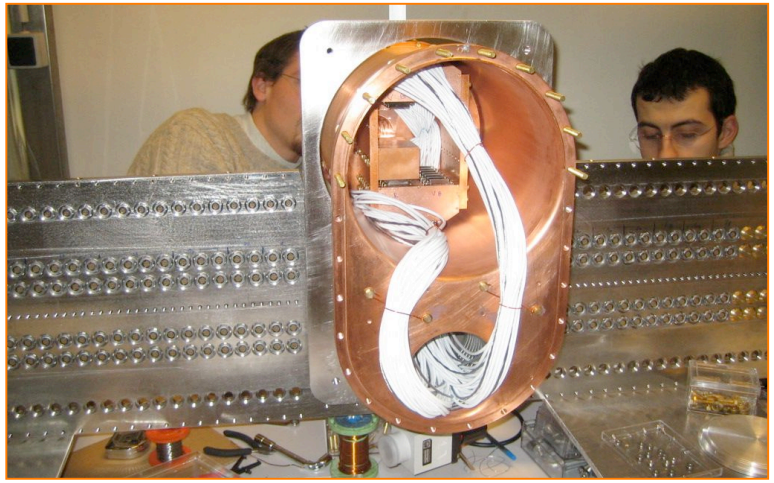


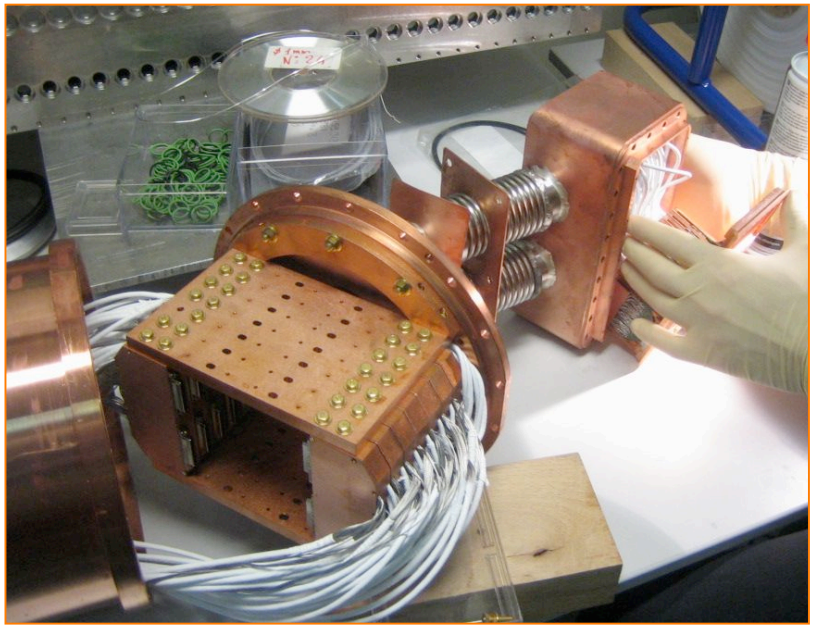


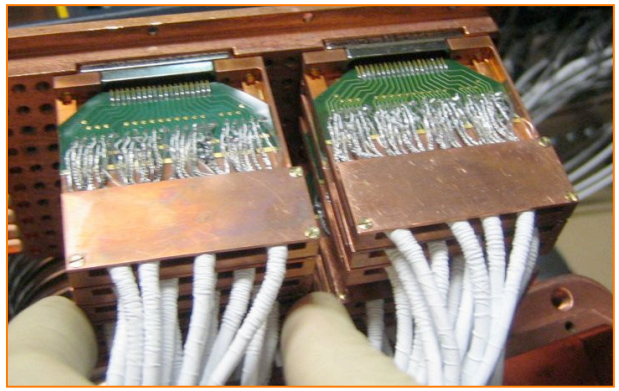
PE shielding
March 2005

Vetos
June 2005

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

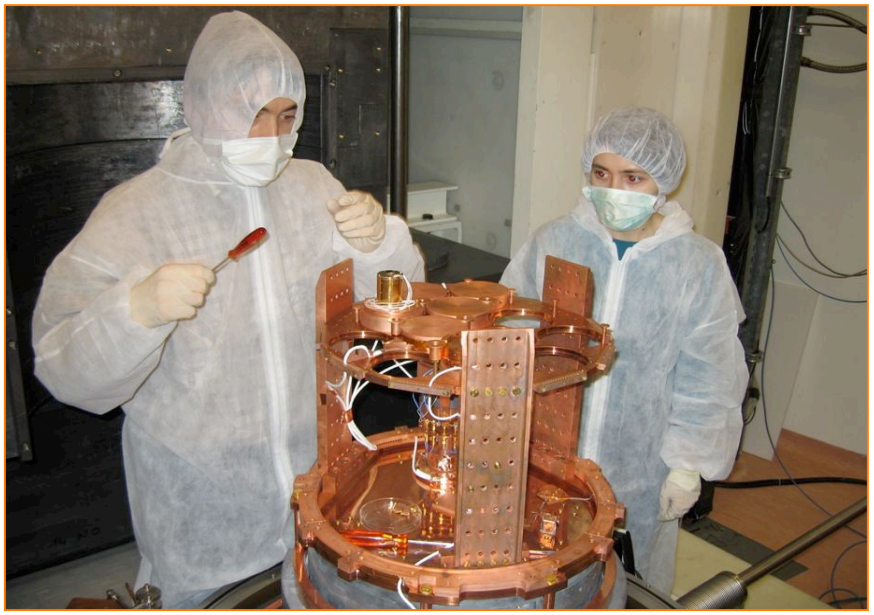


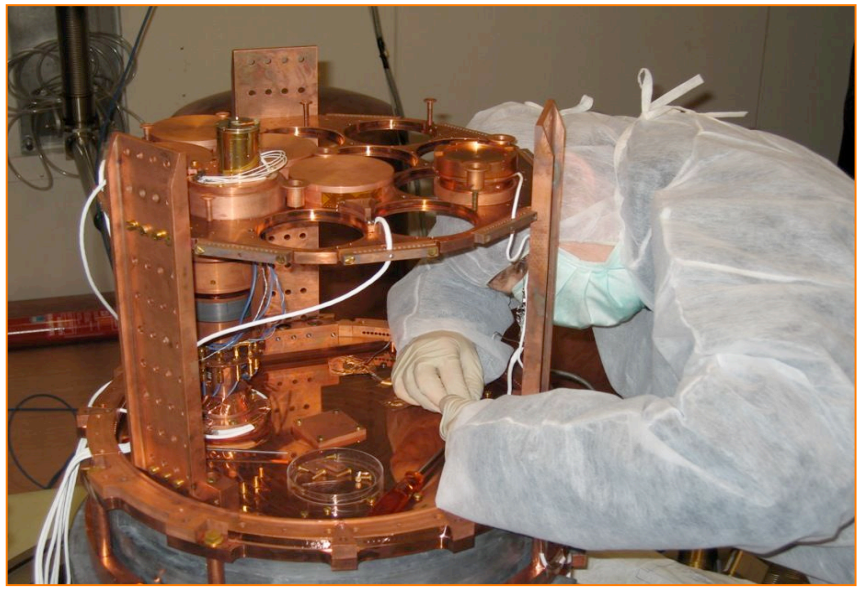




Cabling Dec 2005

- 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 of the first detectors
January 2006

Conclusions

- The validation stage of EDELWEISS-II with 9 detectors is in progress

- Installation of 28 detectors (21 NTD-based Ge, 7 NbSi Ge) is expected in October

- 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

- When 28 detector-phase validated, request for funding of 100-detector stage

- Aim : 2×10^{-8} picobarn sensitivity
- Validation of the strategy towards the EURECA ton-scale experiment