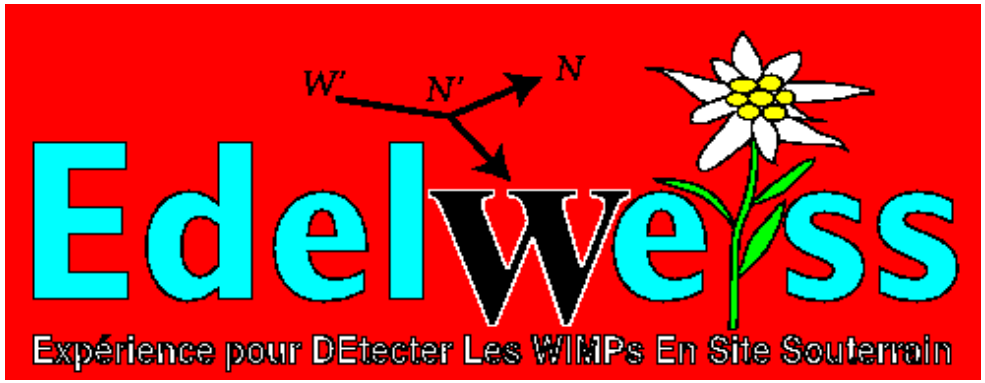
# Recent Results from the




# Dark Matter Search

P. Di Stefano

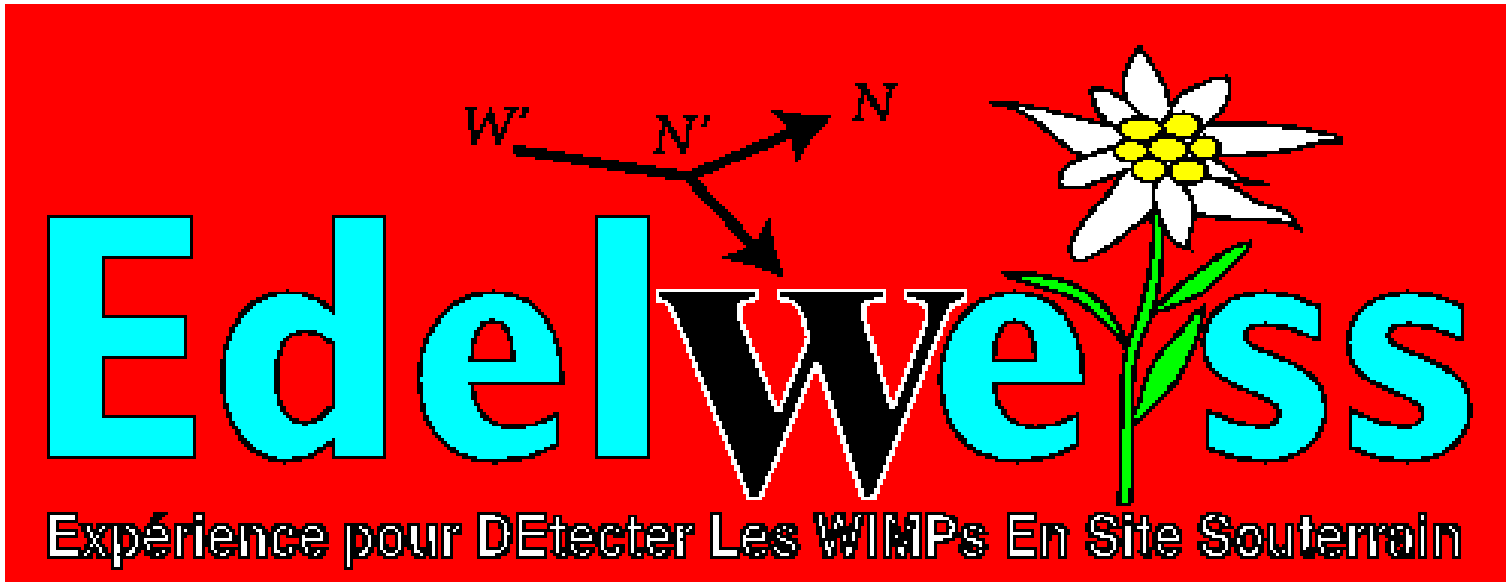
Université Claude Bernard / Institut de Physique Nucléaire de Lyon

distefano@ipnl.in2p3.fr

for the EDELWEISS collaboration

Outline:

- EDELWEISS I **astro−ph/0206271** **accepted Phys. Let. B**
- EDELWEISS II




# A WIMP direct detection experiment in a deep site

**IAP Paris:** C. Goldbach, M. Martin, G. Nollez

**IPN Lyon:** A. Bonnevaux, L. Chabert, B. Chambon, M. De Jésus, P. Di Stefano, D. Drain, J. Gascon, E. Gerlic, M. Goyot, J–P. Hadjout, O. Martineau, V. Sanglard, M. Stern, L. Vagneron

**CRTBT Grenoble:** A. Benoit, M. Caussignac, H. Rodenas

**CSNSM Orsay:** L. Bergé, A. Broniatowski, L. Dumoulin, A. Juillard, S. Marnieros, N. Mirabolfathi, S. Collin

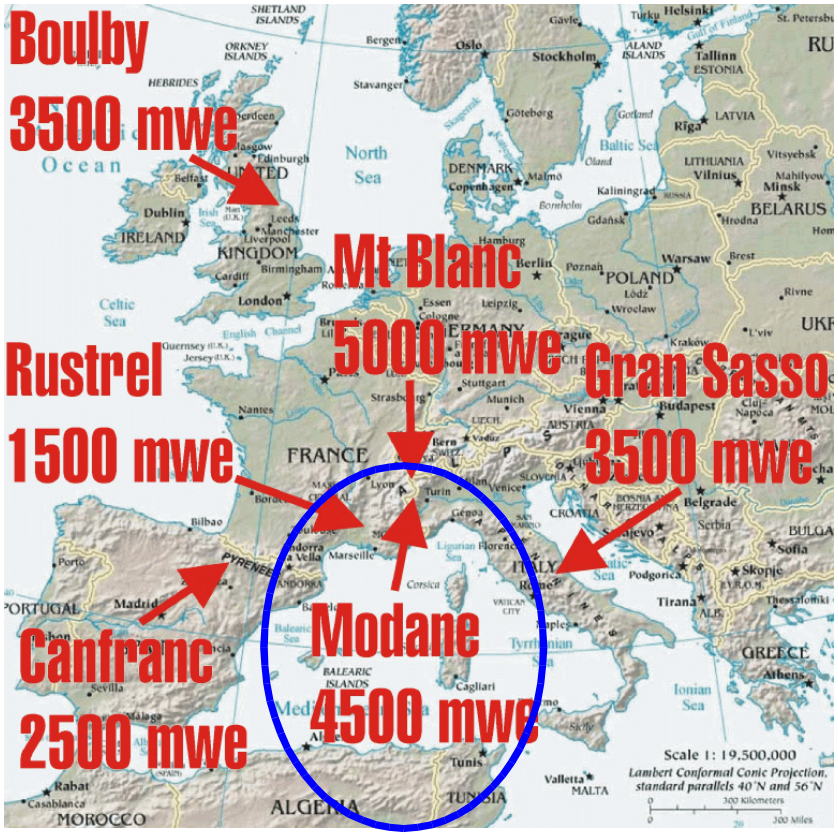
**DAPNIA Saclay:** G. Chardin, H. Deschamps, G. Gerbier, M. Gros, S. Hervé, A. de Lesquen, M. Loidl, J. Mallet, L. Mosca, X–F. Navick, F. Nizery, L. Shoeffel

**DRECAM Saclay:** M. Chapellier, P. Pari

**Laboratoire Souterrain de Modane:** Ph. Charvin, C. Riccio

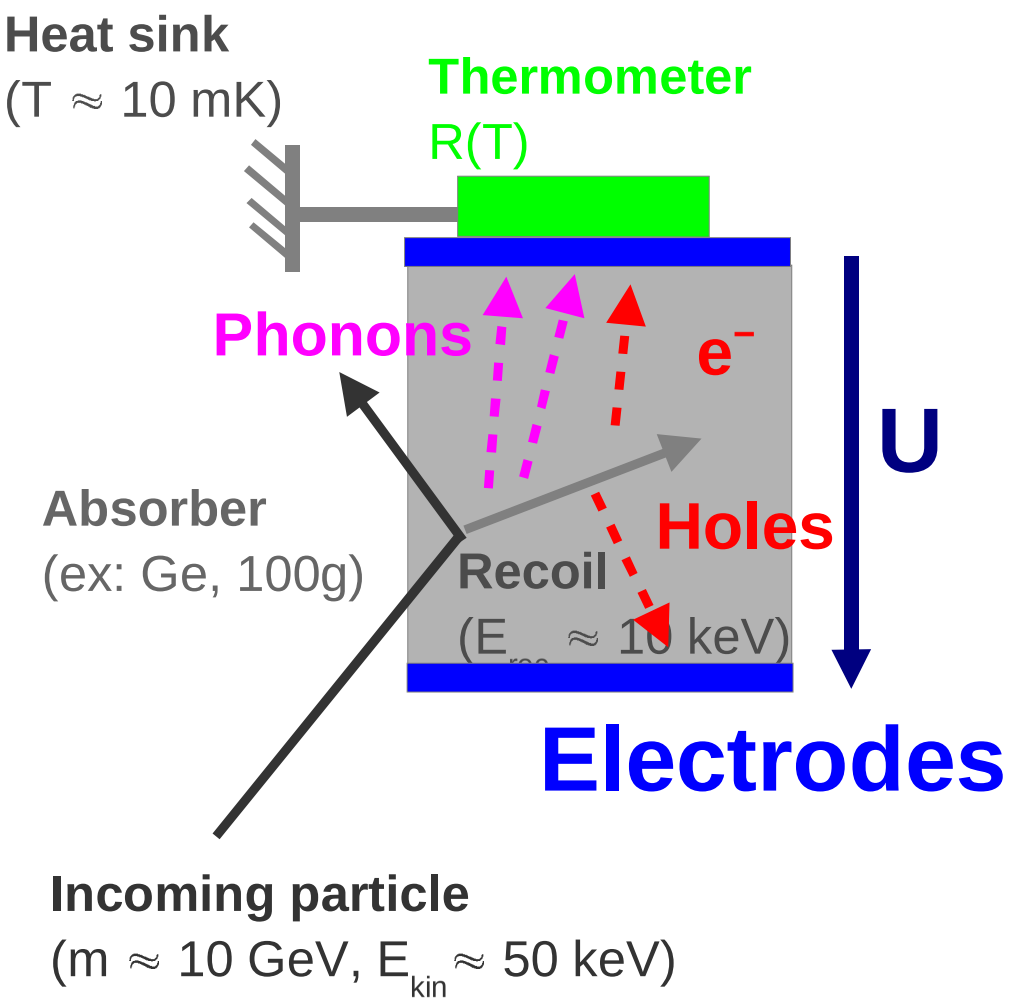
# EDELWEISS at the LSM*

- *Modane Underground Laboratory




- Depth: 4500 meters water equivalent
- Muons: 4 /m$^2$/day
- Fast neutrons: $\approx$ 1.6 $10^{-6}$ /cm$^2$/s

# Ionization−Phonon Detectors




- Phonon signal: $\Delta T/T \approx$ 0.1% over ms
- Charge signal: $\approx$ 1000 pairs over μs
- γs, βs ionize more than WIMPs, neutrons

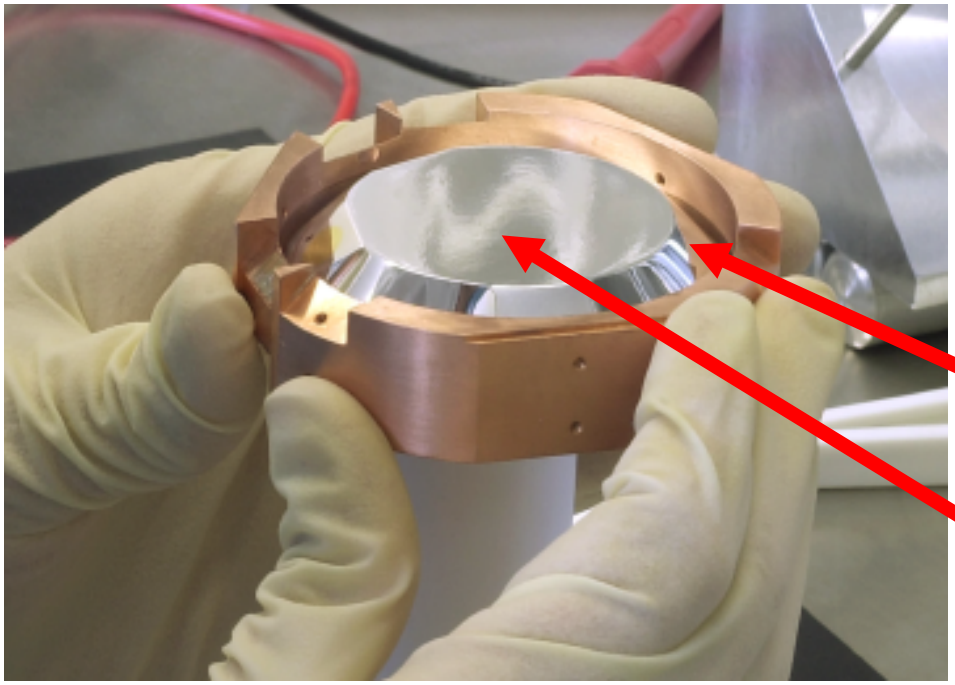
➔ Event by event background rejection

✗ Miscollected charge for surface events ?

astro−ph/0004308,0002462

# EDELWEISS 2002

- 320 g Ge phonon−ionization detector



- NTD thermometer
- Al electrodes

- 3 different devices installed at LSM
- Measures against surface events:
  - Double electrodes
    - Outer: more exposed to possible contaminants
    - Inner: homogenous electric field, fiducial vol.
  - Amorphous Ge surface treatment (one detector)

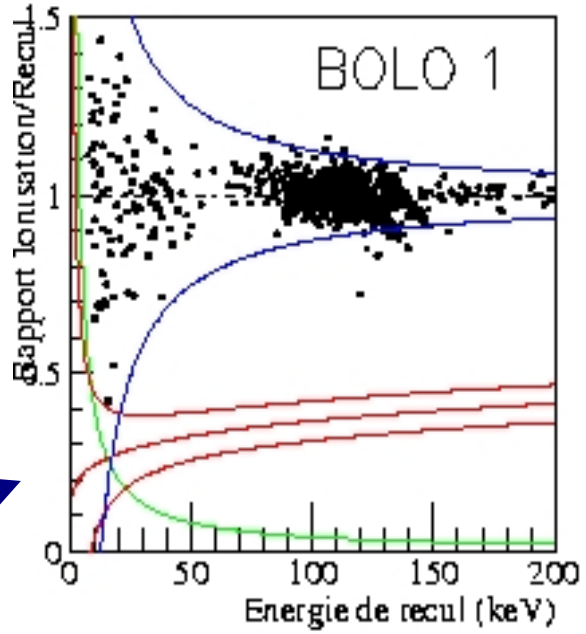
# Photon Calibrations

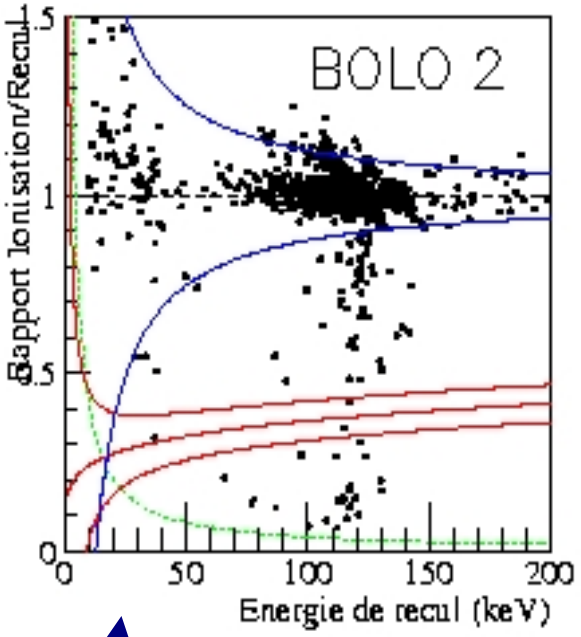
$^{57}$Co (122 keV)

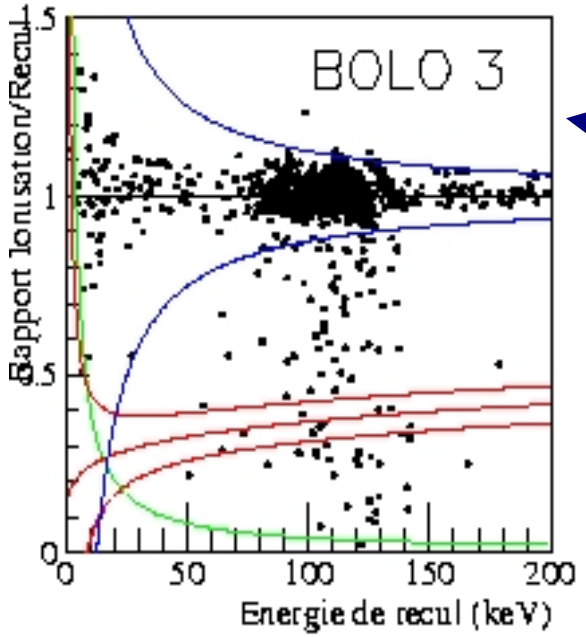
**Detector with amorphous Ge surface treatment**

**Few miscollected events**

**99.99 % bckgd rejection ($^{60}$Co)**



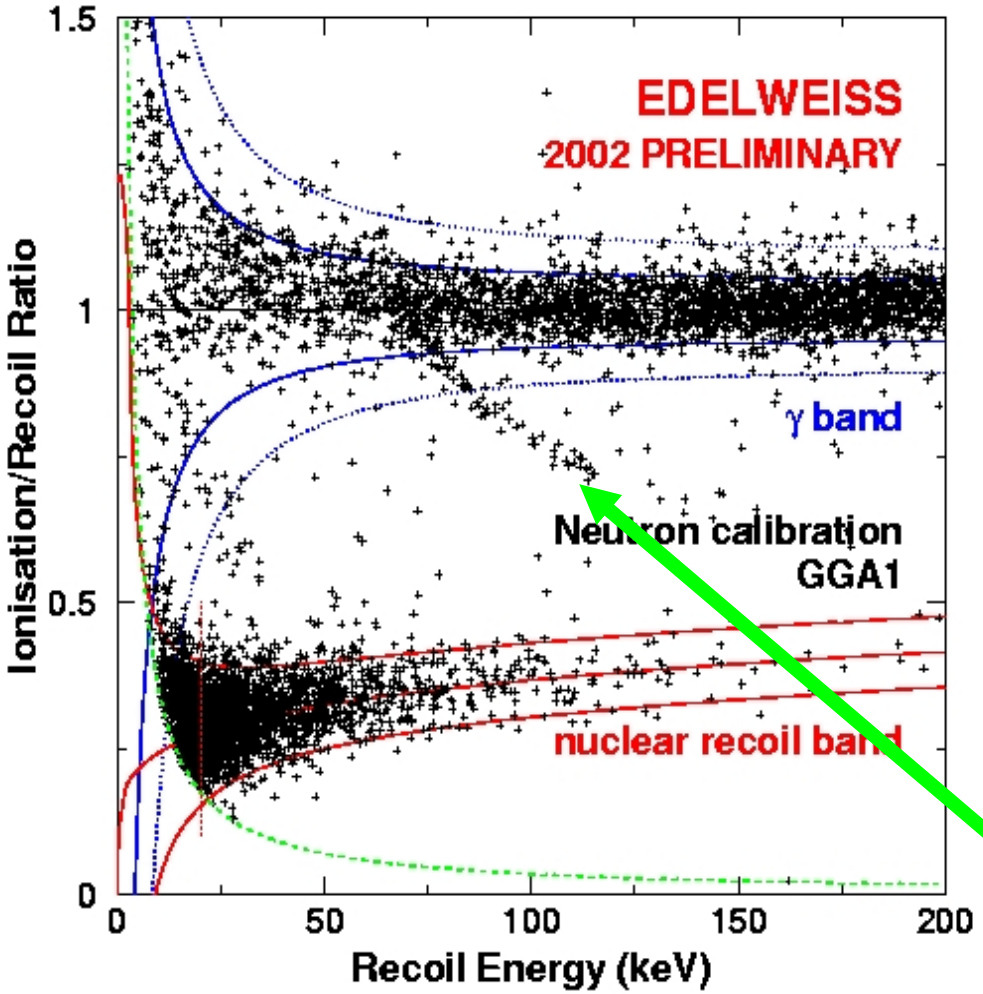




**Other detectors**

**"Many" miscollected events**

**97.8–98.7 % bckgd rejection ($^{60}$Co)**

# $^{252}$Cf Neutron Calibration




- Excellent separation down to 15 keV
- Uniform interactions in crystal quantify fiducial volume: 57 ± 3% (also from bulk contaminations)
  (O. Martineau, PhD thesis)
- Inelastic scattering on $^{73}$Ge (V. Sanglard, DEA report)

# Fiducial Volume

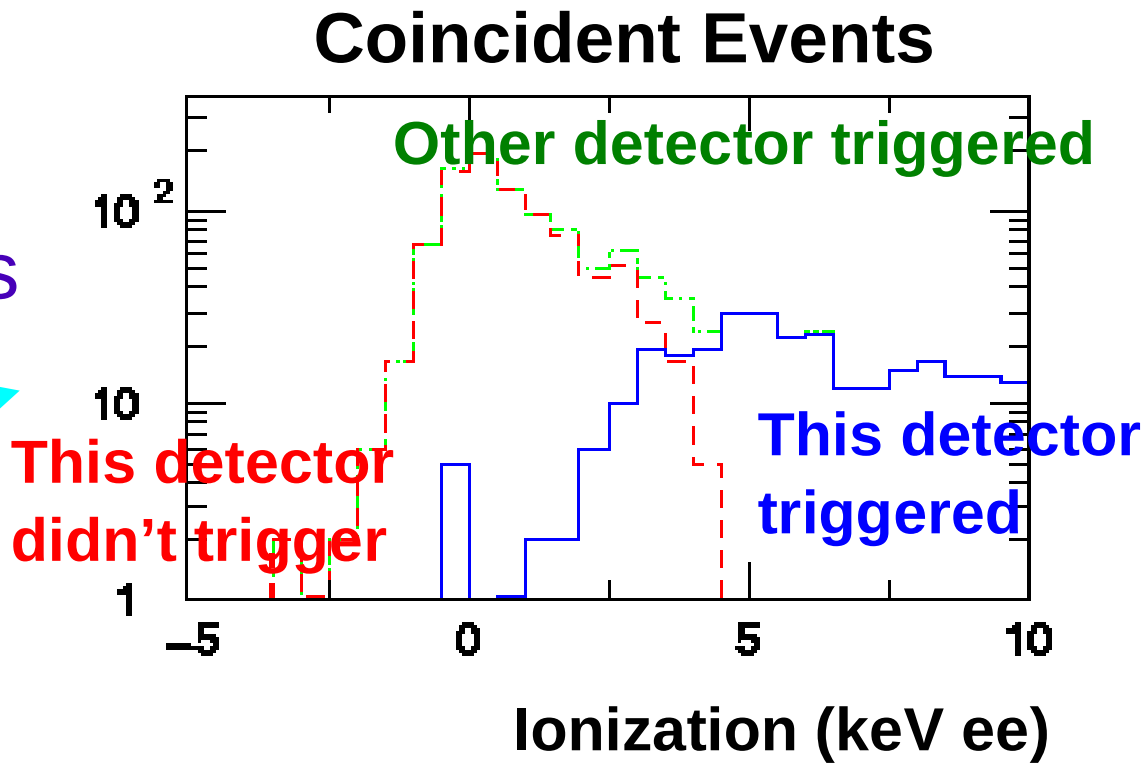
(O. Martineau, PhD thesis)

- Detector with two electrodes
- Define fiducial volume by events with > 75% of their charge on inner electrode

- Determined by uniform interactions in detector:
  - Neutron calibrations (corrected for multiple scatters)
  - Bulk contaminations in bckgd runs
- Volume is 57±3 % of total

# Threshold Efficiency

- Hardware threshold set by ionization
- Independent studies of efficiency:
  - Neutron calibration
  - $^{60}$Co calibration vs Monte Carlo
- Both: 50% efficiency at 3.7 keVee

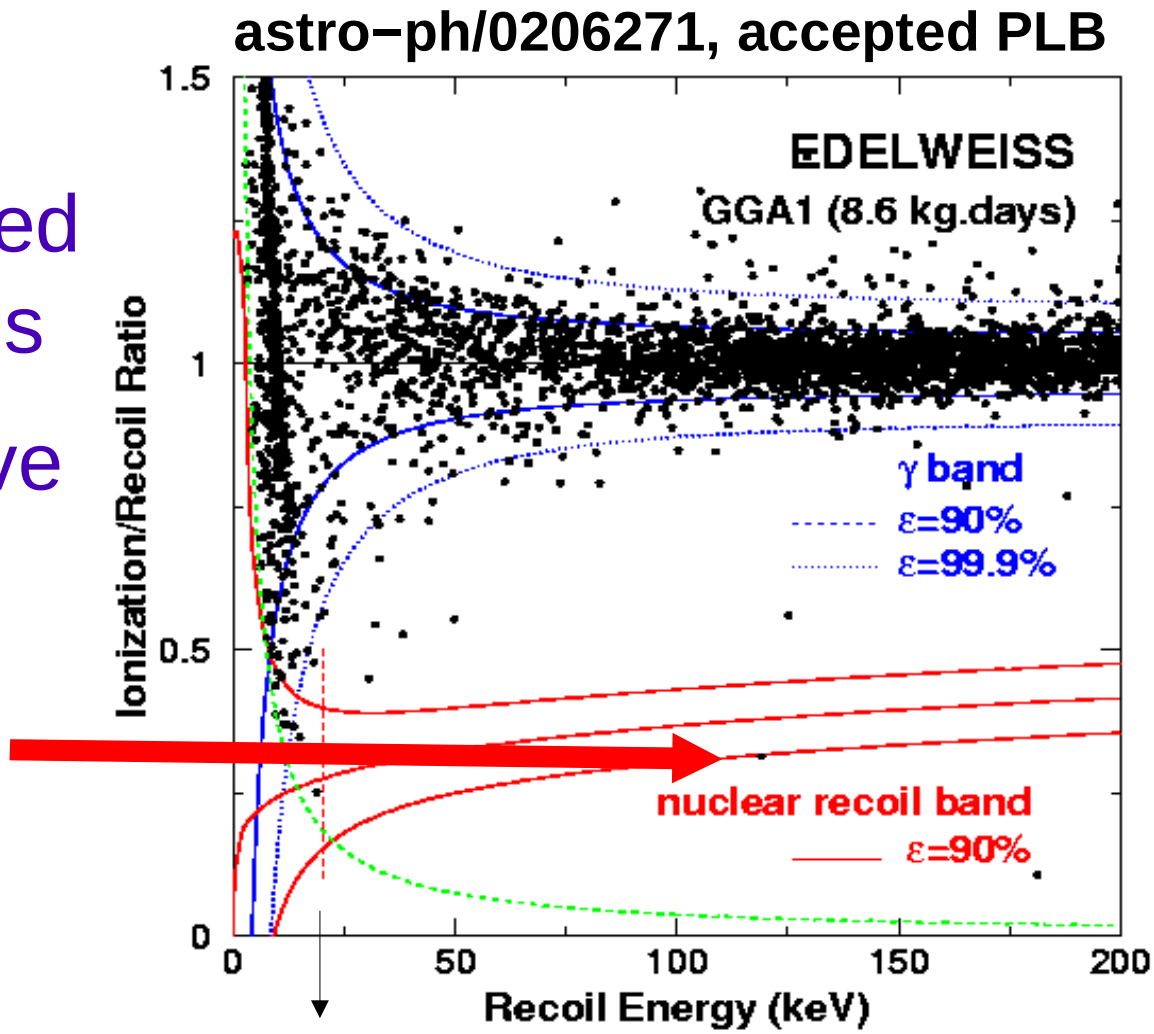



➔99% efficiency > 20 keV

# EDELWEISS 2002 Background

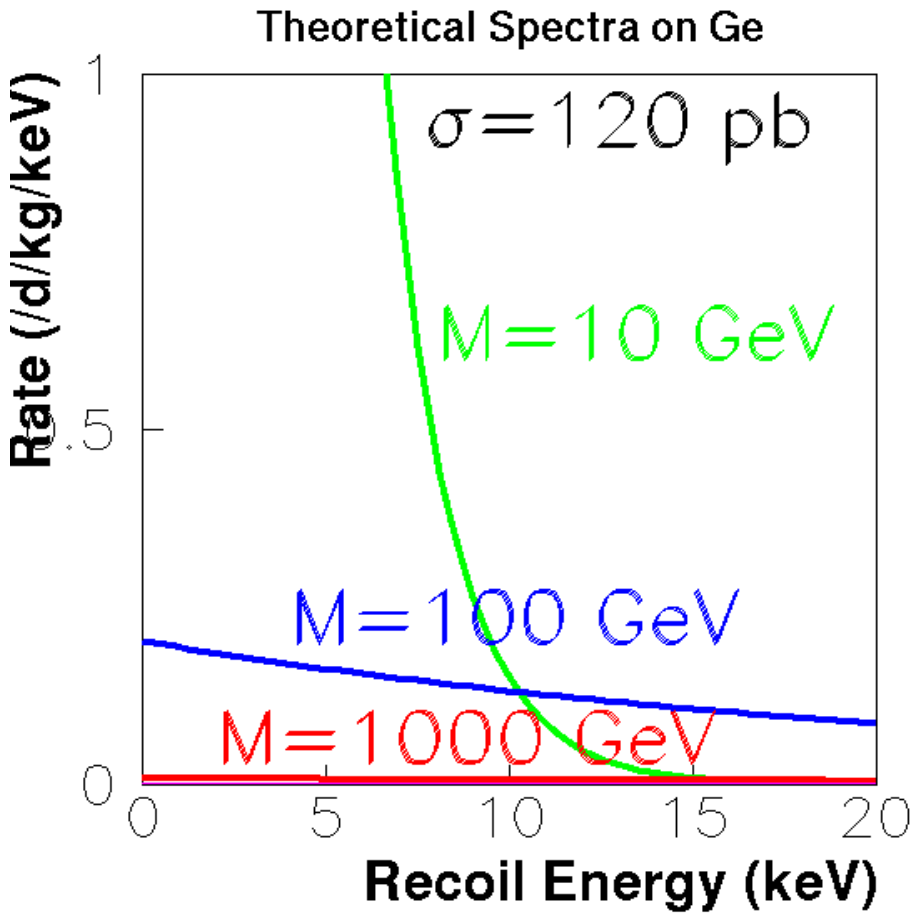
- Feb−May 2002
- Detector selected from calibrations
- 7.4 kg.d effective exposure

**At most 1 nuclear recoil event above threshold**




20 keV threshold

# EDELWEISS 2002 Limits

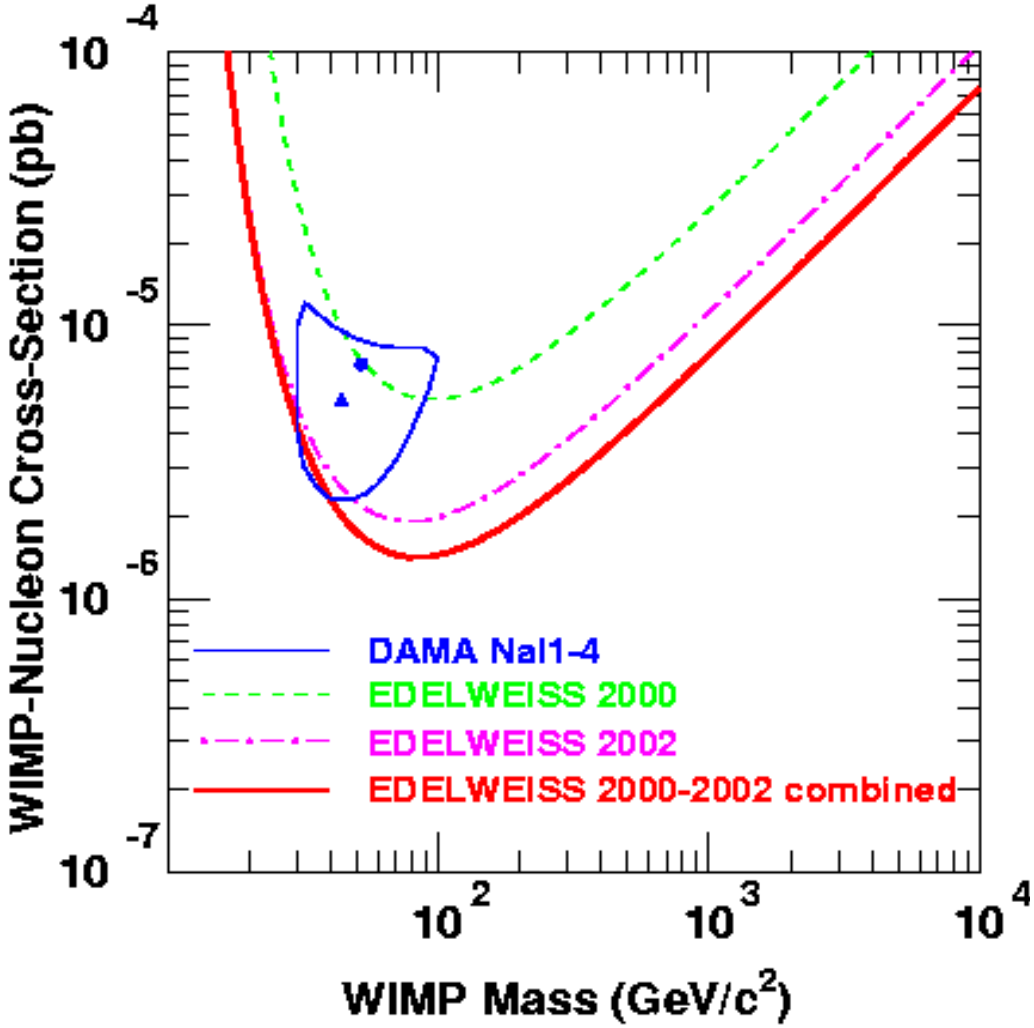



- The lighter the WIMP, the lower the expected recoil energies are

➔Observed 119 keV recoil is irrelevant for $m_{WIMP}$ < 10 TeV (> 95% signal below 119 keV)

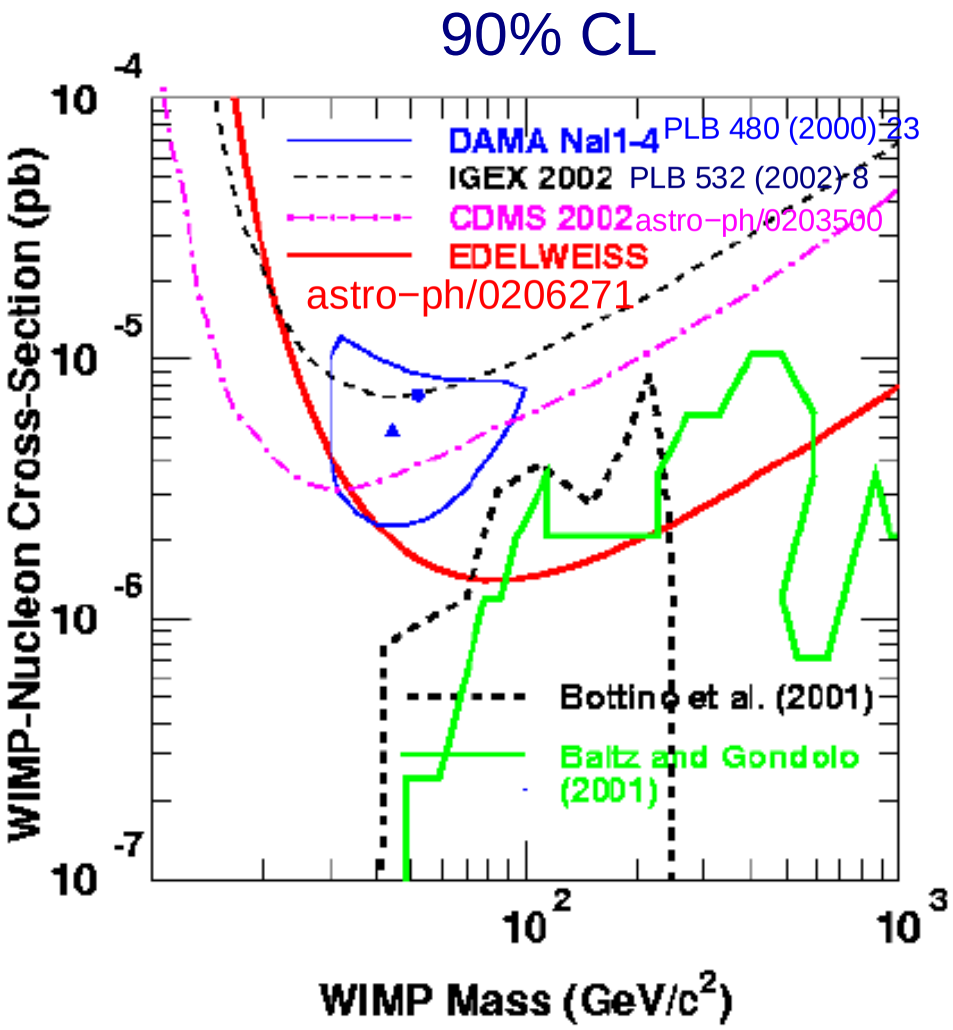
# EDELWEISS 2001 vs 2002

- 2001 astro−ph/0106094, PLB 513 (2001) 8:
  - 30 keV threshold
  - 4.3 kg.d
  - 0 events
- 2002 astro−ph/0206271, accepted PLB:
  - 20 keV threshold (ionization improved)
  - 7.4 kg.d
  - 1 event at 119 keV



# EDELWEISS 2001+2002 Limits

- Usual assumptions
  - Spin−indpt $A^2$ coupling, form factor
  - Std halo ($\rho$=0.3 GeV/cm$^3$,$v_{rms}$=270 km/s, $v_{Earth-Halo}$=230 km/s)
- New sensitivity reached
- Incompatible with DAMA interpretation of NaI modulation



# EDELWEISS and DAMA

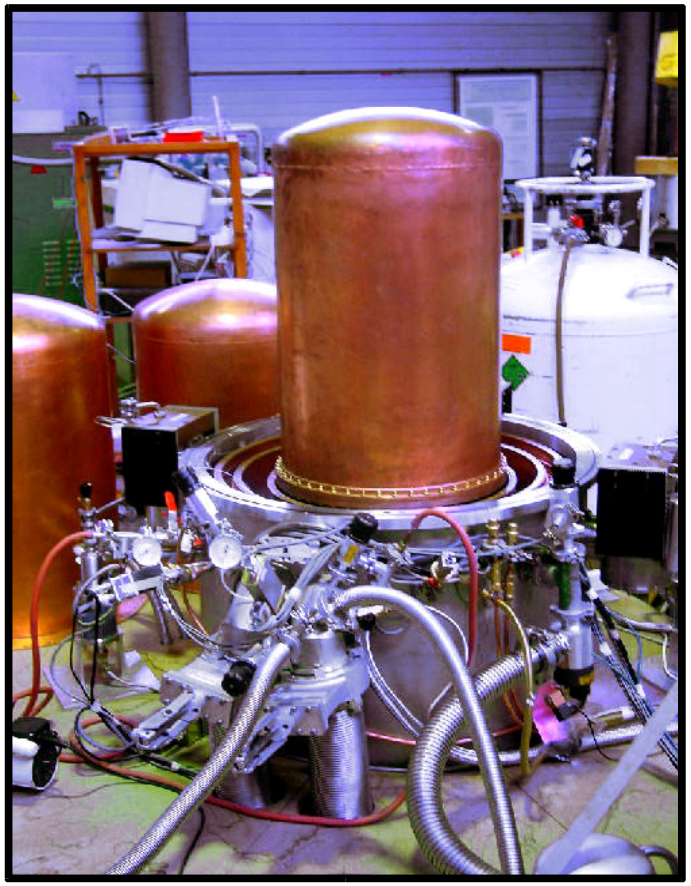
## Usual assumptions

- Astrophysics: halo ($\rho$=0.3 GeV/cm$^3$, $v_{rms}$=270 km/s, $v_{Earth-Halo}$=230 km/s)
- Particle Physics: $\sigma_{SI} \propto A^2$, Helm form factor

- DAMA Na1−4
  - m=52 GeV
  - $\sigma$=7.2 $10^{-6}$ pb
- 9.8 events expected between 20−64 keV
- ✗ 0 observed
- ✗ $P_{Poisson}$=0.006%

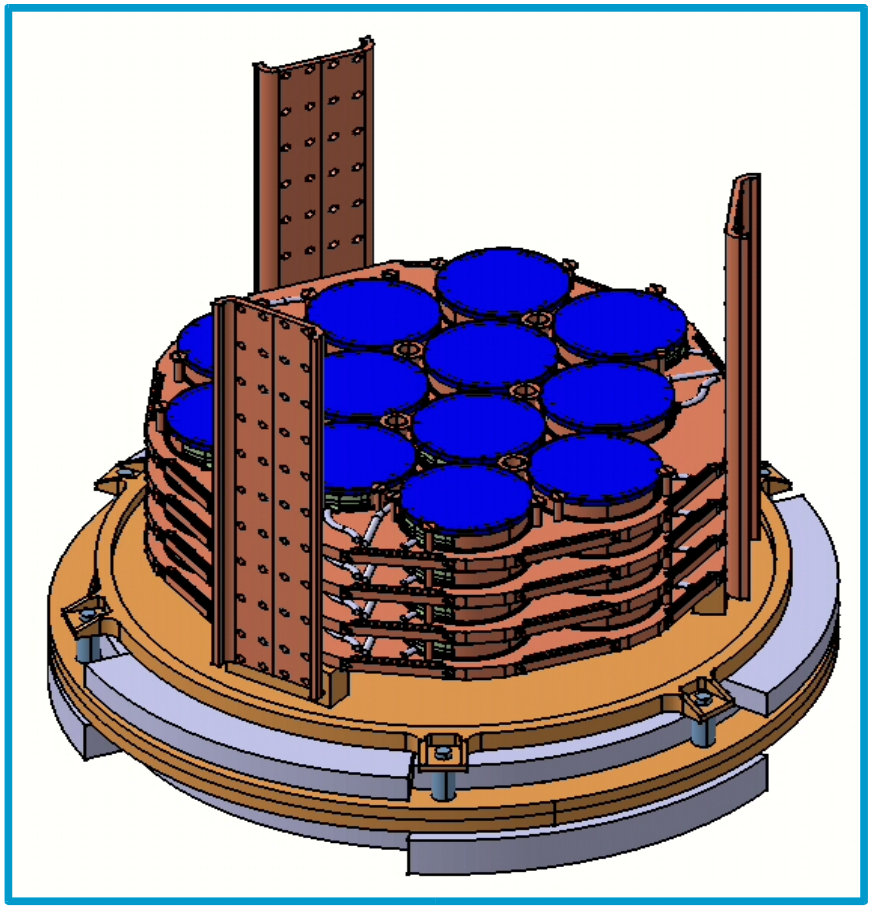
- DAMA Na1−4+0
  - m=44 GeV
  - $\sigma$=5.4 $10^{-6}$ pb
- 6.2 events expected between 20−64 keV
- ✗ 0 observed
- ✗ $P_{Poisson}$=0.2%

# EDELWEISS II Cryostat



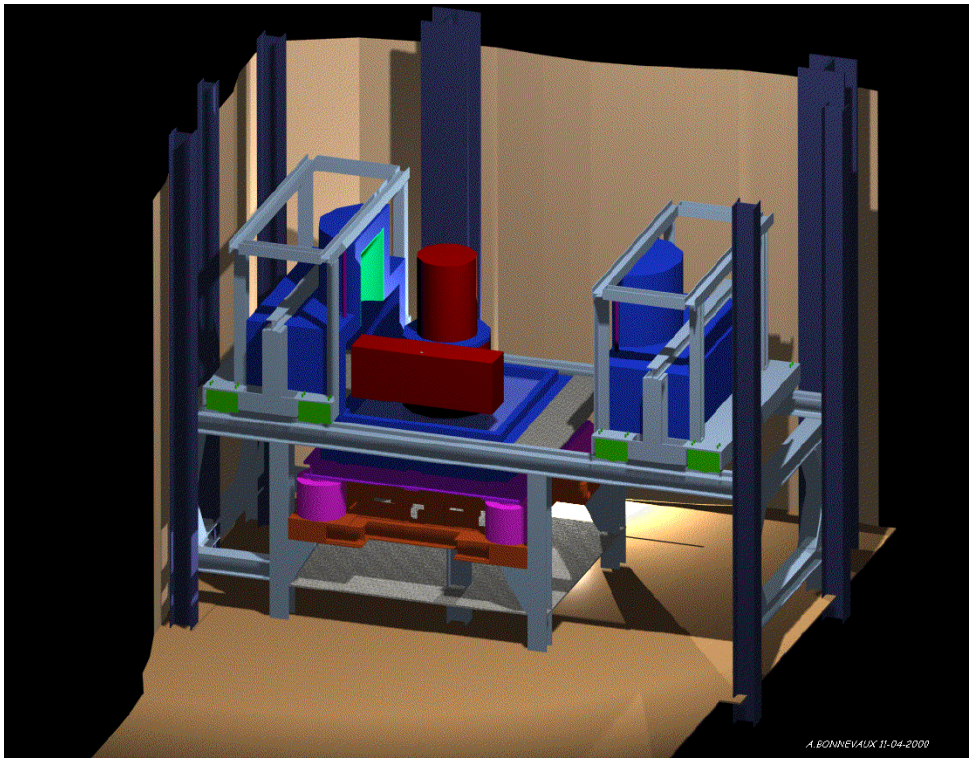
- Novel design (reversed, pulse tubes)
- 30 mK reached at Grenoble
- To LSM March 2003

- 21 detectors funded 2004 (7.6 kg)
- Room, power for 36 kg

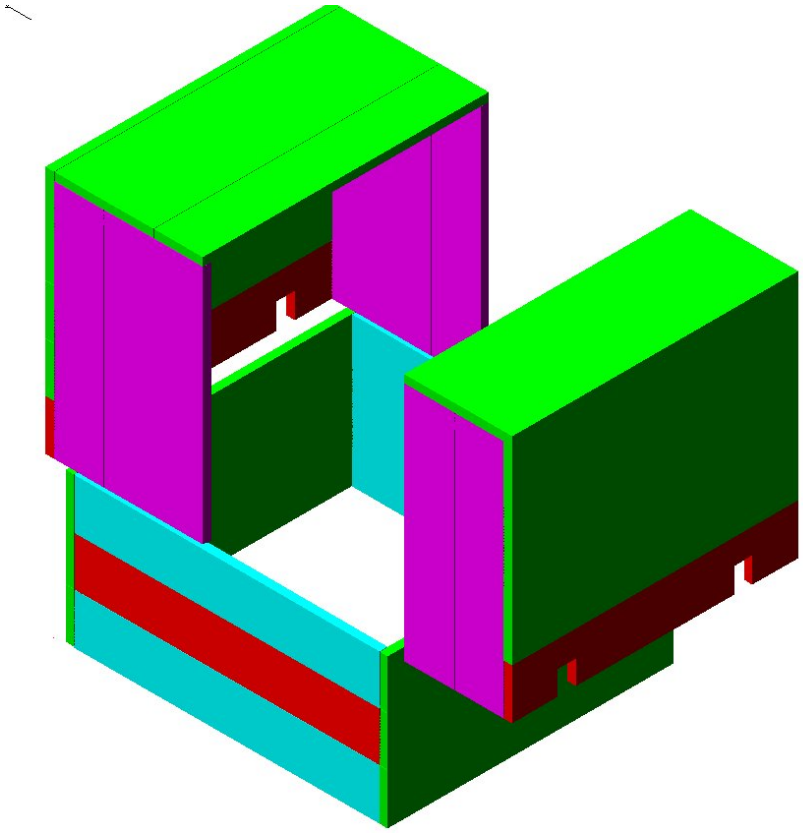


# EDELWEISS II Setup

- Cryostat, Pb shields ...



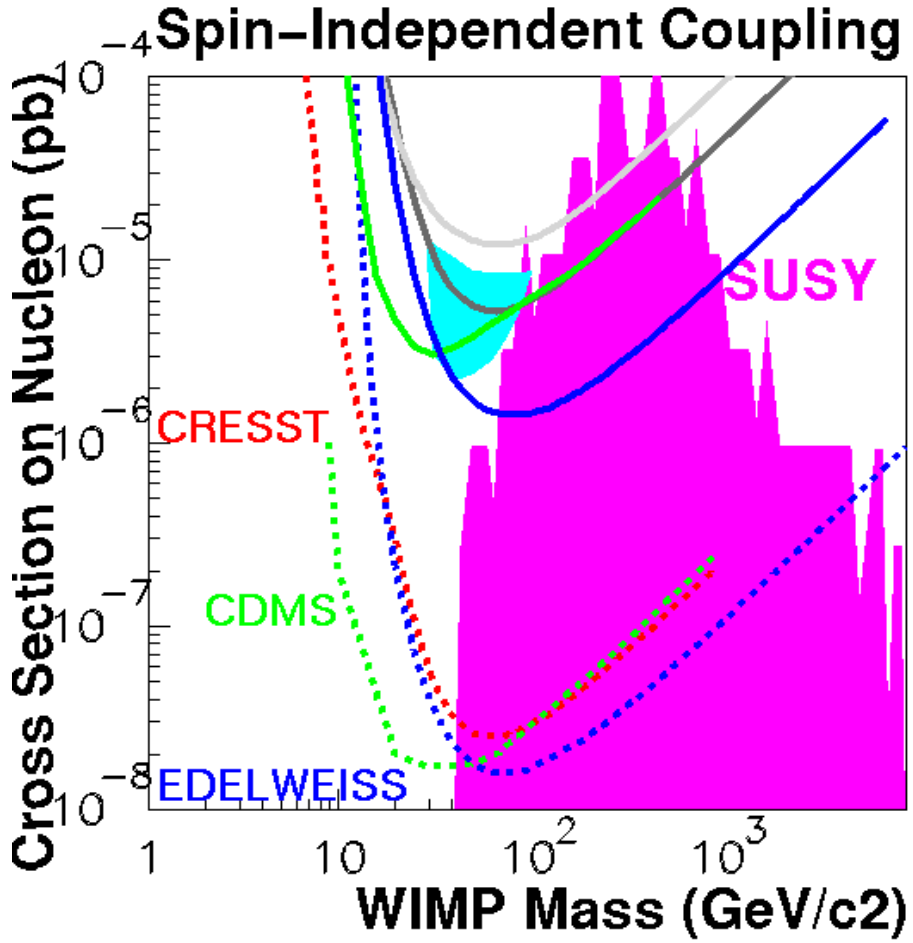

- ... in vetos



# EDELWEISS II Sensitivity

- Next generation cryo experiments
  - ≈10 kg
  - γ,β bckgd discrim.
- 2−3 years exposure
- Neutron bckgd ?

astro−ph/0202099



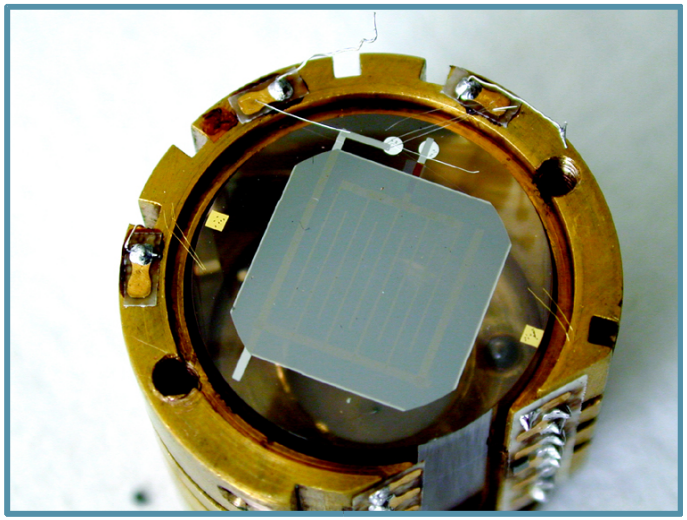
# EDELWEISS II vs Neutrons

- Neutrons from rare LSM μ interacting in rock, Pb shielding may limit sensitivity
- Study of μ, μ veto underway (L. Chabert, PhD thesis)
- Collaboration with FZ Karlsruhe

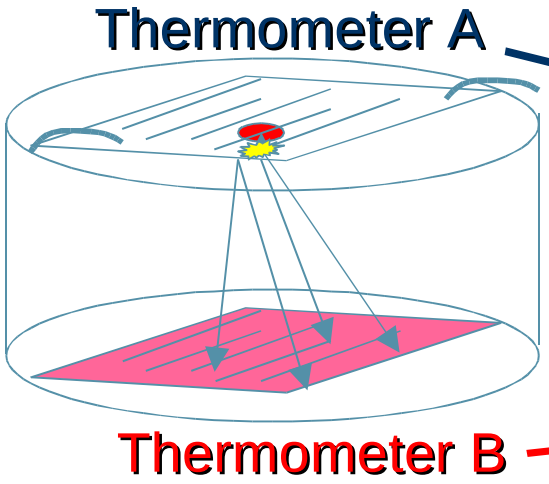
- Recycled KARMEN veto modules ?

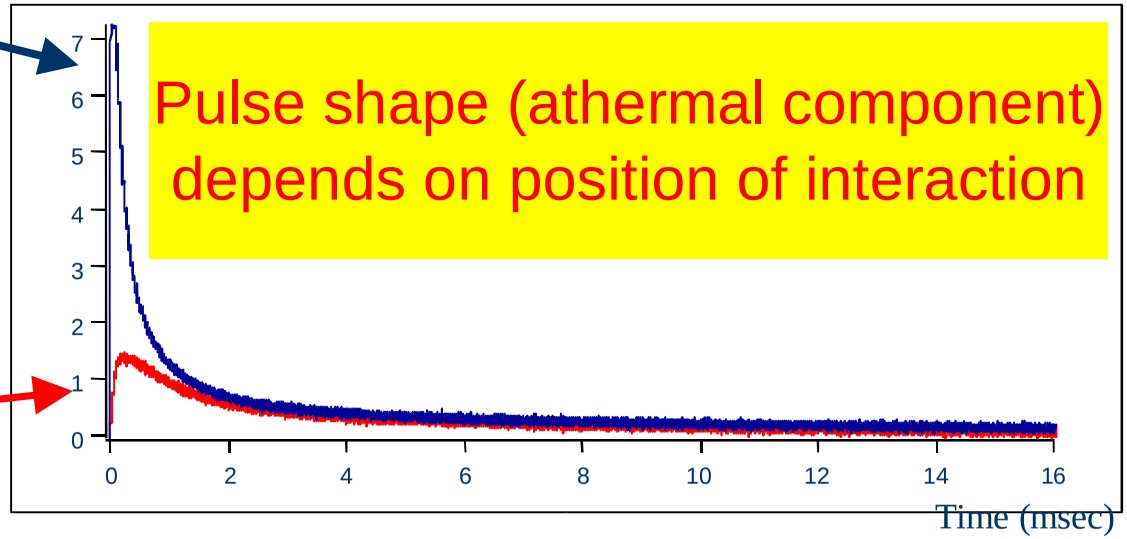
# Identification of near surface events (phonon channel)

N. Mirabolfathi et al. (CSNSM Orsay)



- **NbSi thin film sensors sensitive to athermal phonons**
- **Comb geometry : non linear effect for near thermometer events.**



# Status of EDELWEISS

- EDELWEISS now has best spin independent limits on WIMPs
- Limited by statistics ➡ 3 improved detectors planned for late summer 2002
- EDELWEISS II installation begins 1$^{st}$ quarter 2003, aims to be online early 2004
- Goals:
  - Two orders of magnitude gain in sensitivity
  - R&D for an international 1 ton experiment