Looking for SUSY…

with Edelweiss

- Status
- Prospects
  Edelweiss I
  Edelweiss II

G. Gerbier
CEA/Saclay, DAPNIA
Fréjus Laboratory, CEA/CNRS
-EDELWEISS Collaboration -

CEA-Saclay DAPNIA and DRECAM
CRTBT Grenoble
CSNSM Orsay
IAP Paris
IPN Lyon
FZ-Karlsruhe and Univ. Karlsruhe

Exp intalled in Modane Underground Laboratory (Fréjus Lab)

4800 mwe, 1700 m of rock
- □ flux = 4/m²/d
- neutron flux = 1.6 $10^{-6}$/s/cm²
1kg stage of EDELWEISS I : 3 * 320 g Ge.

• **GGA1**: heat and ionisation Ge 320 gram detector, 20 mm thick
• Aluminium electrodes (center + guard ring) + Ge amorphous layer (built by Canberra/Eurysis)
• NTD sensor glued on guard ring electrode + wiring in Saclay
• «All numerical » acquisition
• Low radioactivity cryostat
• Shield: 30 cm paraffin, 20 cm Pb, 10 cm Cu

**Resolutions @ 10 keV (resp 122) keV**:
• ionisation : 1.3 keV (2.2 keV)
• heat : 1.0 keV (3.0 keV)
Close shield in Roman Pb
1\textsuperscript{st} data taking: Fall 2000, 1 detector mounted and used
2\textsuperscript{nd} data taking: First semester 2002, 1 detector used out of 3
3\textsuperscript{rd} data taking: October 2002 - March 2003, 3 detectors used

1kg stage of EDELWEISS I: 3 * 320 g Ge.
Am-Be neutron source in situ

$^{73}\text{Ge}(n,n')$

Recoil threshold 20 keV

Ionization threshold 3.7 keV

Neutron calibration

Ionization threshold 3.7 keV

Recoil threshold 20 keV

Q = Ionization/Recoil Ratio

EDELWEISS

GGA1 ($^{252}\text{Cf}$ source)

$\gamma$ band

nuclear recoil band $\varepsilon = 90\%$

$\varepsilon = 99.9\%$

$\varepsilon = 90\%$
GSA1 gamma calibration

Calib run equivalent to 60 days running time w/out source \(\Rightarrow\) 9 kg.d exposure

\[
\gamma \text{ ray rejection } \approx 99.99\% \Rightarrow
\]

\(Q = \) run started after extended gamma-ray detector exposure
EDELWEISS-I latest results
oct 2002 – may 2003

• Additional 20 kg/\text{day} fiducial exposure with 3 detectors

• Two events compatible with nuclear recoils
  – recorded during short noisy period

• Present total exposure: 13.8 kg/\text{day} @ \text{E}_{\text{rec}} > 20 \text{ keV},
  30.5 kg/\text{day} @ \text{E}_{\text{rec}} > 30 \text{ keV}
Bolometer-1: $Q = f(E_r)$ diagram

- Exposure: 7.51 kg day (fiducial)
- Best charge channel 100% e at 20 keV

Noisy period?

The 4 events in red (1 inside and 3 outside the neutron zone) all arrived within an interval of a few days out of 90 days total acq time
Bolometer-3: $Q = f(E_r)$ diagram

- Exposure: 10.85 kg day fiducial

- Excellent phonon channel: 300 eV FWHM resolution during most of the runs, noisy charge channel
How well do we measure recoil energy? « Heat Quenching factor »

- We assume above that energy measured from heat signal is total deposited energy i.e. $E_h$ electron = $E_h$ nucl rec
  i.e. $Q_h = 1$. Is that true?

- Take $Q_h = 0.95$ and check what becomes quenching factor $Q_i$ curve

- Compare with data from literature
  - $Q_h$ is 1 ± 0.05
  - $E_{tot}$ known within 5%
Quenching factor summary on Ge

Quenching factor =

Recoil energy (keV)

Qh (Lindhard)
Qh (Chas)
Qh (Shu)
Qh (Messous)
Qh (fit)

Measur. of Qh can be some of order 1 \pm 0.05 from present analysis: in progress
WIMP $\square$ vs M exclusion diagram

- Keep 2 evts as potential signal and set upper limits on WIMP signal
- Correct for:
  - Fiducial volume (known 5%)
  - Efficiencies: nucl. rec, fraction of Wimp signal kept
- Trigger eff. $= 100\% >$ threshold
- No background subtraction
- Same conventional halo, nucl. phys. parameters as DAMA
- Excludes DAMA candidate at 99.8% C.L.
- Compatibility with DAMA?
  - DAMA data internal consistency?
DAMA: Questions of rate budget, PSD analysis

The detected signal is the modulated part \( S_m = 0.02 \) evts/kg/d

\( \Rightarrow \) total WIMP signal \( S_0 \) (2-6 keV) is

- no constraint from NaI0 = 0.86 evts/kg/d
- with constraint from NaI0 = 0.54 evts/kg/d

Annual Modulation is < 7 % of unmodulated part

- Unmodulated « bulk » > 0.02/7 % = 0.3-0.5 cpd/kg/kev

Dependent only on relative velocities of earth/sun: known

Shape is given by WIMP velocity: known (even if directional)

\( \Rightarrow \) 2 implications

- em background has rising shape (even 0 in 2-3 keV in cryst. 8)
- PSD, but much more efficient in 4-6 keV, expect a 8 \( \Rightarrow \) effect in 100 000 kg.d if pure stat( too small discr. in 2-4 keV)
EDELWEISS : what’s next ?

• New run started with improved energy threshold with \( \approx 100\% \) detection efficiency at 15 keV recoil energy (phonon trigger)

• In hand further additional 20 kg.d analysis in progress
• But close to exp level of neutron background (1 evt/60 kg.d)

• December 2003 : end EDELWEISS-I run

• Jan-Dec 2004 : install EDELWEISS-II with
  – 21 \( \square \) 320 g Ge-NTD detectors and
  – 7 « thin film » 200 g Ge detectors : 9 kg
EDELWEISS-II detector setup
(Phase 28 detectors - 8 kg- in preparation)

- 100 liter cryostat for up to 120 detectors: \( \approx 36 \text{ kg Ge} \)
- Development of Nb Si thin film sensors to eliminate surface events

- Clean crystal manufacturing
- Clean room + radon reduced atmosphere \( \sim 0.1 \text{ Bq/m}^3 \)
- Improve sensitivity by \( \approx 100 \)
New 100-liter dilution cryostat:
8-10 mK obtained during several runs
Wiring and cold electronic test: summer 2003
Experimental aims and theoretical predictions

L. Rozkowski et al., hep-ph/0208069

EDELWEISS-I present
EDELWEISS-II sensitivity goal
1 Ton sensitivity goal (optimistic)
Conclusions

• Exclusion diagram of 2002 confirmed by 2003 data
• EDELWEISS sensitive to -optimistic- SUSY models ($\approx 10^{-6}$ pbarn)
• EDELWEISS-II should be ready by 2005 to get factor $\approx 100$ improvement in sensitivity (down to few $10^{-8}$ pbarn) and begin to test more favored models (like CDMS-II, CRESST-II, ZEPLIN-II and -III)
• Testing the bulk of SUSY parameter space (down to $10^{-10}$ pbarn) will require experiments in the one-ton range and extreme background rejection
• European supported programs will start soon