Dark Matter Search

- CEA-Saclay DAPNIA and DRECAM
- CRTBT Grenoble
- CSNSM Orsay
- IAP Paris
- IPN Lyon
- Modane Underground Laboratory (Fréjus)
- FZ-Karlsruhe and Univ. Karlsruhe

Fréjus Underground Laboratory

- 4800 m water eq.
- Muon flux ≈ 4 muons/m²/day
- Neutron flux ≈ 1.5 \times 10^{-6} \text{ s}^{-1} \text{ cm}^{-2}
  (mainly from rock radioactivity)
The 1 kg stage

Shield:
- 30 cm paraffin
- 15 cm lead
- 10 cm copper

Low radioactivity dilution cryostat base temperature
\( \sim 15 \text{ mK} \)

Roman lead shielding

3x320 g detectors

Ge or Si amorphous layer

Guard ring

Fiducial vol. \( \sim 57 \% \)
Edelweiss: event-by-event discrimination

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

Neutron + gamma calibration

Nuclear recoil discrimination down to 20 keV threshold:
\( \gamma \)-ray rejection > 99.99 %
EDELWEISS thermal detectors: excellent energy resolution

• Sub-keV energy resolution on phonon channels (down to 250 eV baseline, 350 eV FWHM at 10 keV)
• ≈1 keV FWHM on charge channels

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

O. Martineau et al., astro-ph/0310657/
Previous EDELWEISS-I result:
2002 data from a 320 g detector

- 3 months data
  acq: 0 event
  (1?)
- Sensitivity:
  $1.4 \times 10^{-6}$
  picobarn
- Nuclear recoil calibrations at start and end of data taking

2003 ionization data

- Exposure: 7.51 kg x day
- Energy threshold: 20 keV

- Exposure: 3.72 kg x day
- Energy threshold: 30 keV

- Exposure: 10.85 kg x day
- Energy threshold: 30 keV

- 3 events compatible with nuclear recoils
  - 1 event @ $E_{\text{rec}} = 200$ keV
  - 2 events to calculate the upper limit on the WIMP-nucleon cross section
Phonon trigger data

• Trigger efficiency very precisely determined by coincidence spectrum in neutron data

• Threshold at 50% efficiency (in recoil energy)
Edelweiss-I 2004 preliminary

- $\approx 62 \text{ kg x day total data sample}$
- lower energy threshold ($\approx 15 \text{ keV}$)
- 6 events above 30 keV ($\approx 9 \text{ keV e.e.}$)
- incompatible with DAMA without assuming unconventional interactions
- 1 double interaction (10% proba.): neutron background?
\(^{137}\)Cs calibration with improved trigger

- High statistics \(\gamma\)-ray \(^{137}\)Cs calibration
  \((\approx 10^5\) events\)
  - Charge collection quality checking
  - Exposure (in gamma rays) corresponding to \(\approx 2\) years of data taking
- \(\approx 10\) nuclear recoil events observed after one week
- \(\approx 26\) after two weeks
- Coincidences observed between detectors
- Small neutron pollution (identified)
$^{137}\text{Cs}$ calibration with new trigger (2)

- **Top detector**
  - 5 events in nuclear recoil band with 1 coincidence
  - Further away from background pollution

- **Middle detector**
  - 9 events in nuclear recoil band with 2 coincidence
  - Closer to background pollution

- **Bottom detector**
  - 12 events in nuclear recoil band with 1 coincidence
  - Closest to background pollution
$^{137}$Cs calibration with new trigger (3)

- Summary of all three detectors
- $\approx 26$ events in nuclear recoil band
- $> 50,000$ events below 200 keV recoil energy
Edelweiss-I 2004 (almost final)

- \( \approx 62 \text{ kg x day} \) total data sample
- lower energy threshold (\( \approx 15 \text{ keV} \))
- 6 events above 30 keV (\( \approx 9 \text{ keV e.e.} \))
- no background subtraction
- conservative limit: 2002 confirmed with much larger statistics
- stability of Edelweiss limit when energy threshold or analysis method are changed
Edelweiss-I 2004 (almost final)

- ≈ 62 kg x day total data sample
- lower energy threshold ($\approx 15$ keV recoil energy)
- 6 events above 30 keV recoil ($\approx 9$ keV e.e.)
- incompatible with DAMA without fine-tuning and unconventional interactions
- no background subtraction
- conservative limit: 2002 confirmed with much larger statistics
- **Next step: EDELWEISS-II**
Edelweiss II: new setup

- Shield
  - 20 cm lead
  - 50 cm PE
  - Muon veto
- Efficient protection against neutron and gamma ray background
- Sensitivity
  - Edelweiss I: < 0.2 evt/kg/day
  - Edelweiss II goal: 0.002 evt/kg/day
Edelweiss-II “10 kg stage”

- March 2004: EDELWEISS-I stopped
- Spring 2005: EDELWEISS-II with 21 x 320-g + 7 x 400-g Ge detectors (≈ 10 kg germanium)

- Dilution fridge: 8-10 mK obtained on several runs
- Much larger available volume > 50 liter
- 120 detector capacity: ≈ 35 kg Ge
Experimental status and theoretical predictions

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

EDELWEISS, CRESST

CDMS 2004

EDELWEISS-II, CDMS-II
CRESST-II... sensitivity goals

1 Ton sensitivity goal (optimistic)

L. Rozkowski et al., hep-ph/0208069
200g. NbSi bolometer design and readout

Two Nb$_{x}$Si$_{1-x}$ high impedance sensors. (100kΩ – 20MΩ)
Sensor thickness = 60nm

Heat and center charge electrodes are common. (crosstalk corrections are crucial)
Incomplete collection

Guard vs. Center electrodes
Ge/NbSi bolometer @ 35 mK

Incomplete collection events on unmetallized lateral surface (maximized)
Center charge electrode

$E_{\text{ionisation}} \in [-4 : 4] \text{ keV}$

Baseline

160 steps 0.05 keV

Pure Center events
320 steps 0.5 keV

$E_{\text{Heat}} \in [-10 : 150] \text{ keV}$

1,0 keV

122 keV line

1,4 keV
Thermometer A

300 steps 0.5 keV
$E_{\text{Heat}} \in [-15 : 15]$ keV

Baseline

FWHM 7 keV

Pure Center events
160 steps 1 keV
$E_{\text{Heat}} \in [-10 : 150]$ keV

FWHM 9 keV
@ 122 keV
Thermometer B

300 steps 0.5 keV
$E_{\text{Heat}} \in [-15 : 15] \text{ keV}$

Pure Center events
160 steps 1 keV
$E_{\text{Heat}} \in [-10 : 150] \text{ keV}$
Sum of all calibration runs
1 run 57Co B-side : 5588 triggers
1 run 57Co A-side : 6872 triggers
2 run 57Co A-side +137Cs: 19178 triggers

Before athermal cut

After athermal cut
Projections of previous 2D histograms
Low-background data
Q-plot before cuts
Low-background data

Q-plot after cuts
Conclusions

• 2002 exclusion limit confirmed by 2003 data (no background subtraction)
• Events at low energies: small n contamination?
• Edelweiss-I sensitive to optimistic SUSY models (10^{-6} pb)
• With a much larger setup, Edelweiss II intends to test more favored models (≈ few 10^{-8} pb)
• Elimination of surface events (passively and actively) is essential for the success of this program