Latest results and future plans for the Edelweiss dark matter search

Benjamin Censier, 
Institut de Physique Nucléaire de Lyon

On the behalf of the EDELWEISS collaboration

Edelweiss collaboration: CEA Saclay (IRFU, IRAMIS), CNRS-CSNSM Orsay, KIT (IK, EKP, IPE) Karlsruhe, CNRS Institut Néel Grenoble, IPN Lyon, Laboratoire Souterrain de Modane, JINR Dubna, University of Oxford, University of Sheffield
EDELWEISS-II Dark matter search

- Search for scattering of WIMP dark matter
  - $\sim 10\text{keV}$ nuclear recoil
  - $<0.01$ events/kg/day

- Needs:
  - Sensitive detectors
    (cryogenic germanium phonon & ionization detectors)
  - Low background
    (passive shielding & ultra-low radioactivity materials)
  - Excellent background discrimination
    (active rejection by vetoing muons & surface events)
  - Long term runs & stability
    (calibrations & cryogenics concerns)

- Laboratoire Souterrain de Modane
  (4800m water equivalent, $4\mu/m^2$/day)
Laboratoire Souterrain de Modane: cosmic muon flux $4 \mu/m^2$/day

Shielding: 4800mwe rock; 20cm lead; 50cm polyethylene
Edelweiss I – Detectors

Target:
Ge crystal

Phonon - signal:
NTD-Ge (~ 20 mK)

Ionisation - signal:
Inner disc / outer guard ring
few V/cm

- Event by event background discrimination
- Limitation: surface events
Edelweiss I – Detectors

Target:
Ge crystal

Phonon - signal:
*NTD-Ge (~ 20 mK)*

Ionisation - signal:
*Inner disc / outer guard ring*
*few V/cm*

- Event by event background discrimination
- Limitation: surface events
Edelweiss I – Detectors

Target:
Ge crystal
Phonon - signal:
NTD-Ge (~ 20 mK)
Ionisation - signal:
Inner disc / outer guard ring
few V/cm

- Event by event background discrimination
- Limitation: surface events
Edelweiss II InterDigit (ID) detectors

Bulk events: charge only on fiducial electrodes (B&D)


Surface events: charge on veto electrodes (A & C + guard rings)

- A: +4 V
- B: −1.5 V
- C: −4 V
- D: +1.5 V

Surface event (β) rejection: $10^5$
Edelweiss II Results


Final result: Submitted to Physics Letters B. arXiv:1103.4070v2

- Run April 2009 - May 2010
  14 months of continuous operation@20mK
  85% duty cycle

- Ten 400g ID Ge detectors, 384kg day

- $4.4 \times 10^{-8}$pb excluded for 85GeV WIMP

- Five nuclear recoil events (above 20keV analysis threshold)

- Background estimate: 3.0 events

[CDMS December 2009 result: $3.8 \times 10^{-8}$pb, 2 nuclear recoil events]
Edelweiss II Background estimate

• Gamma background:
  – Total $1.8 \times 10^4$ events in electron recoil band (20-200keV)
  – Assuming gaussian statistics, no nuclear recoil candidate due to statistical fluctuation expected
  – Non gaussianities ? Systematics ? \(\Rightarrow\) estimation by calibration data
    $^{133}$Ba gamma calibrations \(\rightarrow\) $3 \times 10^{-5}$ leakage into nuclear recoil band
    \(\rightarrow\) \(<0.9\) events
• Surface events – 5000 events, rejection factor $6 \times 10^{-5}$
  \(\rightarrow\) 0.3 events
• Muon induced events missed by veto \(\rightarrow\) <0.4 events
• Neutrons from rock – GEANT4 simulations \(\rightarrow\) 0.11 events
• Neutrons from contaminants in shield/cryostat \(\rightarrow\) 0.21 events
• Neutrons from cabling inside cryostat \(\rightarrow\) 1.1 events

Total background estimate < 3.0 events 90% CL
Edelweiss future plans

• FID800 detectors
  800g crystals, fiducial mass >600g
• 4 FID800, 2 FID400 installed for commissioning run July 2010 – January 2011
• Next goal: Edelweiss-III: Array of 40 FID800 → $5 \times 10^{-9}$ pb

No events in nuclear recoil band
Europe Union Dark Matter Experiment, to search for WIMP interactions to $\sigma \sim 10^{-10} \text{pb}$ (~1 event/tonne/year)

- CRESST and EDELWEISS, and additional groups
- Cryogenic (<100mK) calorimeters
- Multiple target materials: Ge, CaWO$_4$, ZnWO$_4$….
- Mass: above 100 kg towards 1 tonne
Timeline:

2010/2011: Design Study → TDR

2011/12: Digging out of LSM extension begins. In parallel, begin construction of EURECA components away from LSM. Aim for ~100kg stage ($10^{-9}$ pb).

2014: LSM extension ready to receive EURECA.

2015: Begin data taking and in parallel improve and upgrade.

2018: One tonne target installed.

Spokesman: Hans Kraus (2005-2010), since January 2011: Gilles Gerbier
Summary

• Edelweiss-II: Direct WIMP search with cryogenic germanium detectors
• Interleaved electrodes allow surface event rejection
• Ten 400g Ge-ID detectors – 384 kg day
• $4.4 \times 10^{-8}$pb excluded for 85GeV WIMP
• Nuclear recoils: 5.
• Expected background: 3. (gamma, beta leakage, neutrons from cosmic muons, radioactivity)
• …Edelweiss-III ($5 \times 10^{-9}$pb)….EURECA ($10^{-10}$pb)