Low mass WIMP searches with EDELWEISS III: first results

Thibault de Boissière
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Part I

The EDELWEISS-III experiment
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Setup and status

24 detectors running
Physics data since summer 2014
Expect 3000 kg.d for Summer 2015
The EDELWEISS-III experiment:
Detector scheme

4 ionisation channels: A,B,C,D (interleaved electrodes)

2 heat channels:
Thermal photon measurement with NTD

800 g detector
600 g fiducial mass

**Bulk (fiducial) event:** charge is collected in B and D
The EDELWEISS-III experiment:
Detector scheme

800 g detector
600 g fiducial mass

Bulk (fiducial) event: charge is collected in B and D
Surface event: charge is collected in A and B or C and D

4 ionisation channels: A,B,C,D (interleaved electrodes)
2 heat channels: Thermal photon measurement with NTD

Electric field lines

Zoom Surface C/D
The EDELWEISS-III experiment: Background rejection
The EDELWEISS-III experiment: Background rejection

Fiducial gamma
The EDELWEISS-III experiment: Background rejection

Fiducial gamma

Surface Gamma
The EDELWEISS-III experiment: Background rejection

- Fiducial gamma
- Surface Gamma
- Surface Beta
The EDELWEISS-III experiment: Background rejection

- Fiducial gamma
- Surface Gamma
- Surface Beta
- Surface Lead
The EDELWEISS-III experiment: Background rejection

Fiducial gamma
Surface Gamma
Surface Beta
Surface Lead
Heat only
The EDELWEISS-III experiment: Background rejection

- We remove surface events using the ionisation channels
- We combine ionisation and heat to discriminate fiducial gamma and heat only versus WIMPs

Fiducial gamma
Surface Gamma
Surface Beta
Surface Lead
Heat only

25 GeV WIMP
Part II
First EDWELWEISS-III search for low mass WIMPs
First EDWELWEISS-III search for low mass WIMPs:
Foreword

We picked one standard detector:
- Unblinded a small fraction of the data set, Aug – Dec 2014.
- Allows us to prepare the analysis
- Exposure 35 kg.d after cuts.

We define a simple region of interest (ROI):
- In particular Heat >1.5 keVee (3.6 keVNR)

We use Boosted Decision Trees within this ROI:
- Combine the 6 variables (4 ionisation and 2 heat) for Signal/Background discrimination

Background models are data driven:
- Use regions without signal (sideband) to build the model
- Use calibrations as crosscheck.
WIMP search data:
Boosted Decision Trees
WIMP search data: Boosted Decision Trees
WIMP search data: Boosted Decision Trees

Cut value

![Histogram and scatter plot showing WIMP search data with boosted decision trees.](image)

- **Data**
- **Lead**
- **Beta**
- **Gamma**
- **Heat-only**
- **WIMP 6 GeV**

**Axes:**
- BDT output
- Heat (keV)
- Fiducial Ionisation (keV)

**Color Legend:**
- Data (black)
- Lead (brown)
- Beta (green)
- Gamma (blue)
- Heat-only (red)
- WIMP 6 GeV (gray)
First EDELWEISS-III result: low mass exclusion limit

Limit obtained with a single detector

- Poisson limit after BDT cut
- Analysis threshold: 1.5 keVee (3.6 keVNR)
- 35 kgd exposure after cuts
First EDELWEISS-III result: low mass exclusion limit

Expect fast improvements in sensitivity:

- We already have x10 more data of similar quality
- Run ongoing
- Will decrease the analysis threshold
Backup
For 10 GeV WIMP
Online trigger efficiency
AmBe calibration: $n + 60\% \gamma$'s

$^{133}\text{Ba}$ calibration: $\gamma$'s

Nuclear Recoils
$Q \approx 1/3$
(“quenching”)

Ionization yield
$Q = E_{\text{ion}} / E_{\text{recoil}}$

Electron Recoils
$Q = 1$
(by normalization)
WIMP direct detection
Brief review

- We have **evidence** for Dark Matter: CMB, Lensing, Galaxy Rotation curves...

- Well motivated **candidate**: WIMP (massive, stable, charge neutral, weakly interacting)
  → It provides the missing matter density in a natural way

- **Detection** scheme:

  ![Diagram: WIMP from galactic halo, Elastic collision, Energy recoil](image)

**Challenges:**
- Many backgrounds
- Low energy scale for the recoil (~ keV)
- Low event rate (< evt/kg/year)