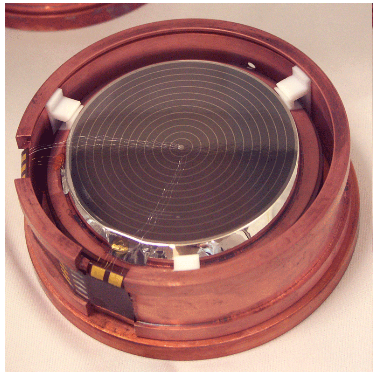
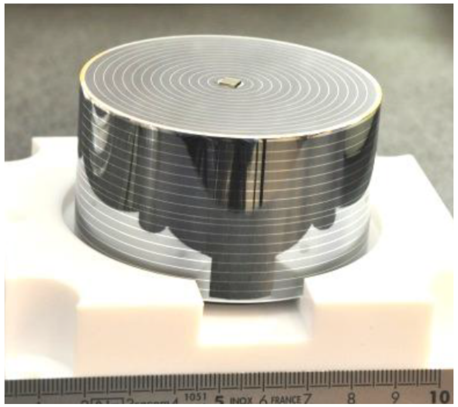
Status and prospects of the EDELWEISS direct WIMP search



EDELWEISS-II: WIMP search results with cryogenic germanium detectors with interleaved electrodes (ID)



EDELWEISS-III: large detectors fully covered with interleaved electrodes (FID)

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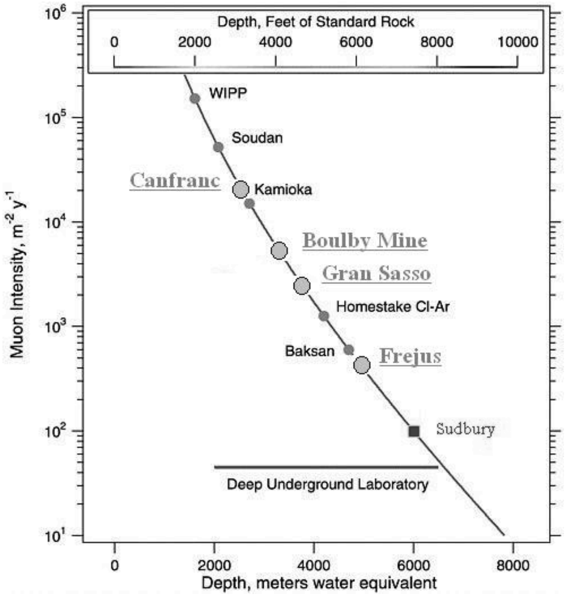
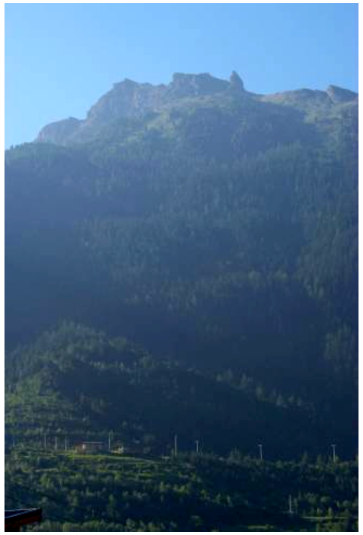
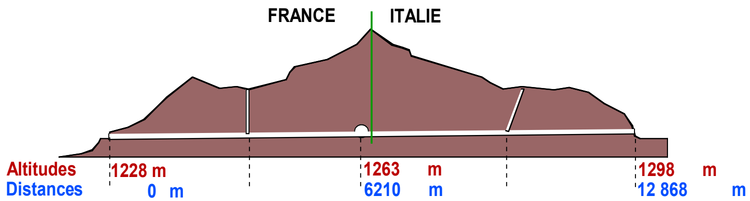
The EDELWEISS Collaboration

- CEA Saclay (IRFU and IRAMIS)
- CSNSM Orsay (CNRS/IN2P3 + Paris Sud)
- IPNLyon (CNRS/IN2P3 + Univ. Lyon 1)
- Néel Grenoble (CNRS/INP)
- Karlsruhe Inst. of Technology (IK, EKP, IPE)
- JINR Dubna
- Oxford University
- University of Sheffield

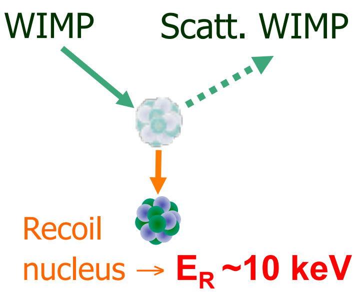




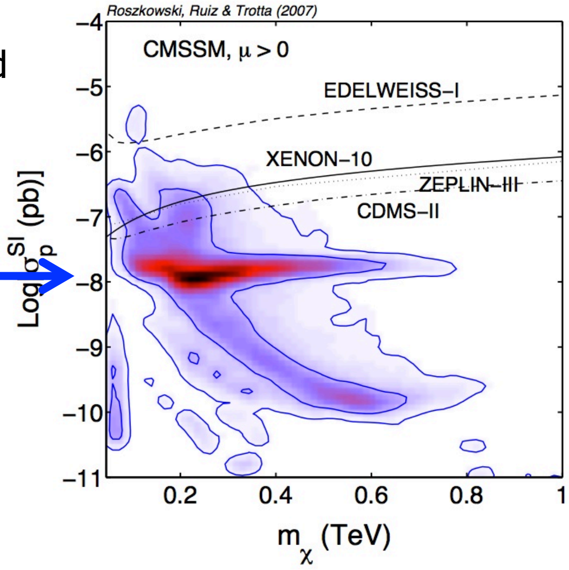


- Unique experimental site: *Laboratoire Souterrain de Modane (LSM)* in Fréjus Tunnel
- 4800 mwe depth: 4 muon/day/m^2
- 10^{-6} neutrons(>1 MeV)/cm^2/s
- Deradonized air supply

Direct WIMP searches



- "Simple" event counting: scattered nuclei in a detector/target (E_{RECOIL} ~10-100 keV)
- 10^{-8} pb ~ 1 evt/kg/year

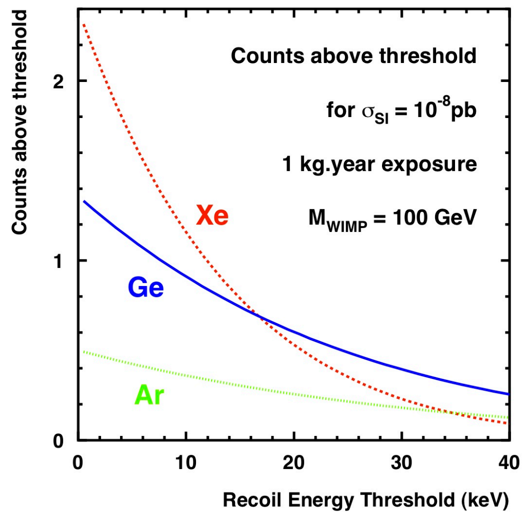


Main challenge: ***extreme suppression of low-energy backgrounds from natural radioactivity***

(for comparison: people = 10^{10} decay/kg/year)

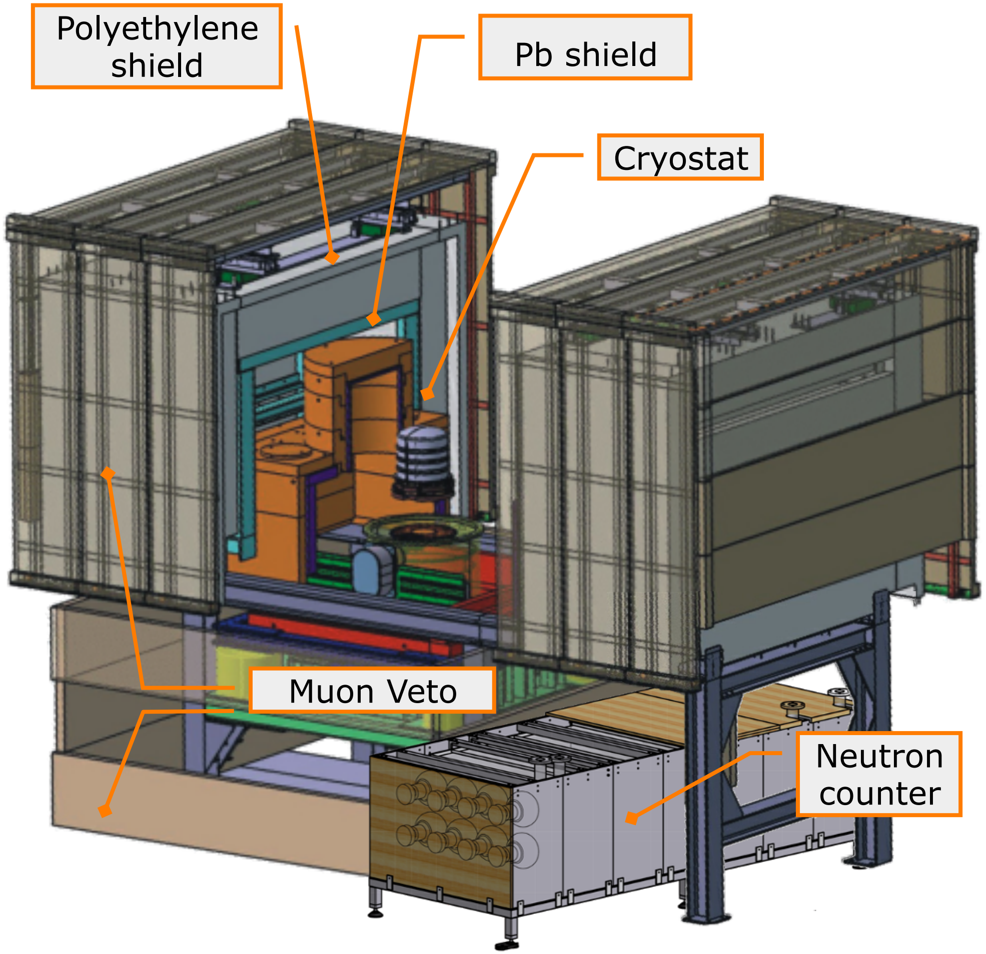
- *Material selection*
- *Shielding (surroundings + cosmics)*
- *Rejection*
- *Detailed understanding of background tails and detector imperfections.*

Cryogenic germanium detectors: purity + energy resolution + identification of nuclear recoils by combining heat+ionization measurements



Calculation based on Lewin & Smith convention [Astrop 6 (1996) 87]

EDELWEISS-II Setup



Up to 40 kg Ge detectors at ~18 mK

Simple and robust detector design

Radiopurity

dedicated HPGe detectors for systematic checks of all materials

Clean room

(class 100 around the cryostat, class 10000 for the full shielding)

Deradonized air (down to few mBq/m^3)

Gamma and neutron shielding

20 cm Lead + archeological lead
50 cm Polyethylene

Active μ veto (>98% coverage)

+ μ-n coincidence measurement

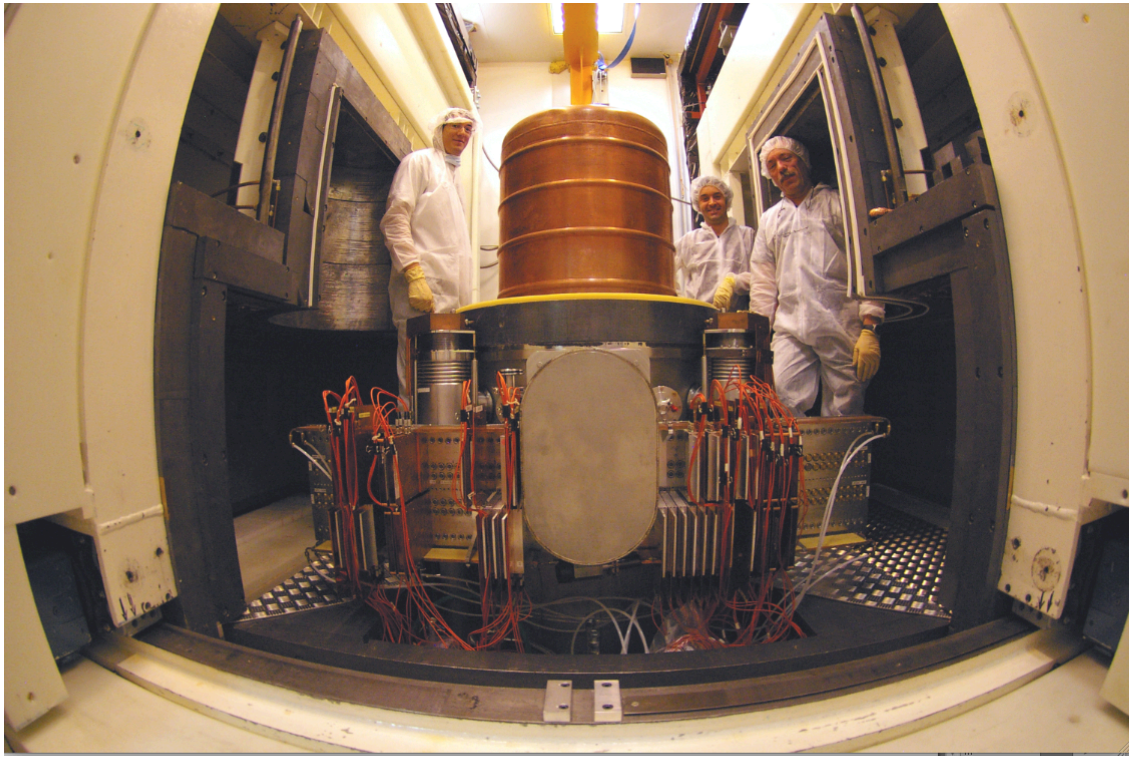
Background studies

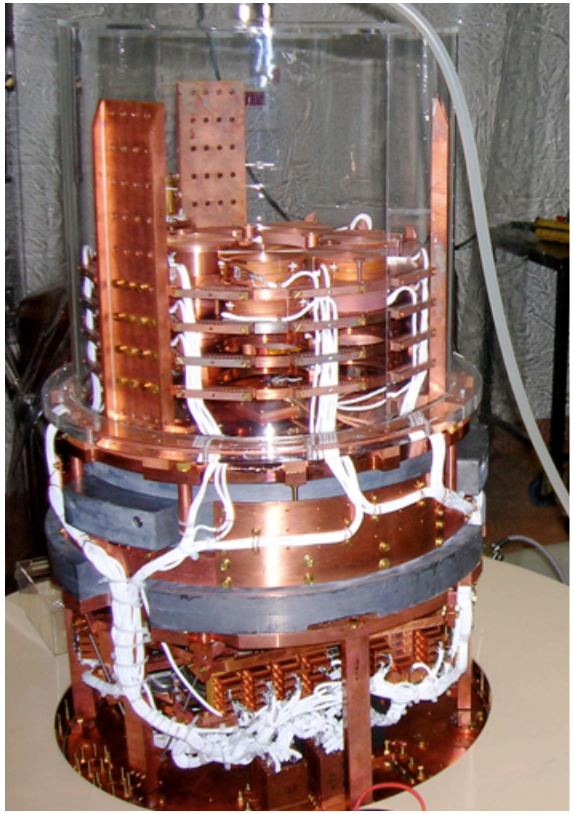
- He3 thermal neutron (inside/outside shields)
- Large liquid scintillator neutron counter

PhaseII sensitivity goal:

$\sigma_{\chi\text{-n}}$ = few 10^{-8} pb (~0.002 evts/kg/d)

EDELWEISS-II in pictures

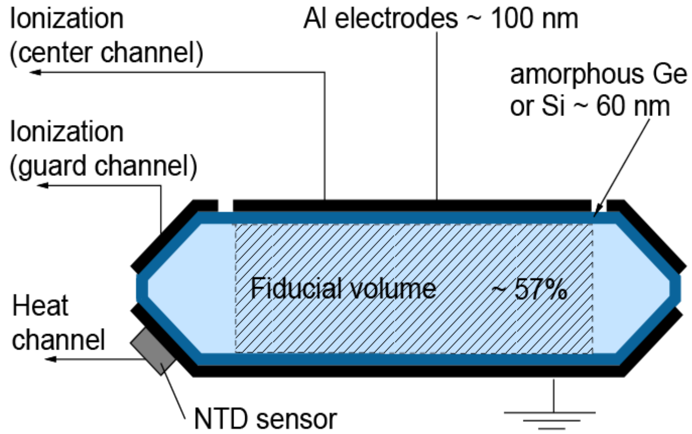


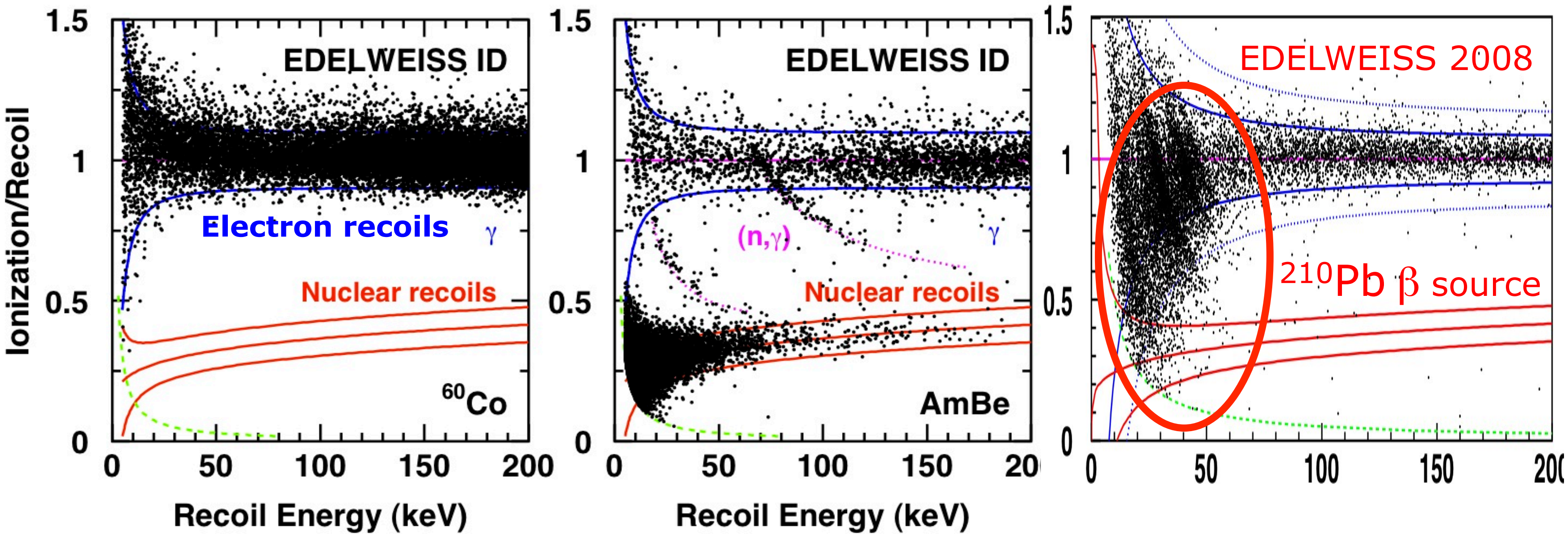


- Opened shields (with electronics)
- Detectors inside the cryostat

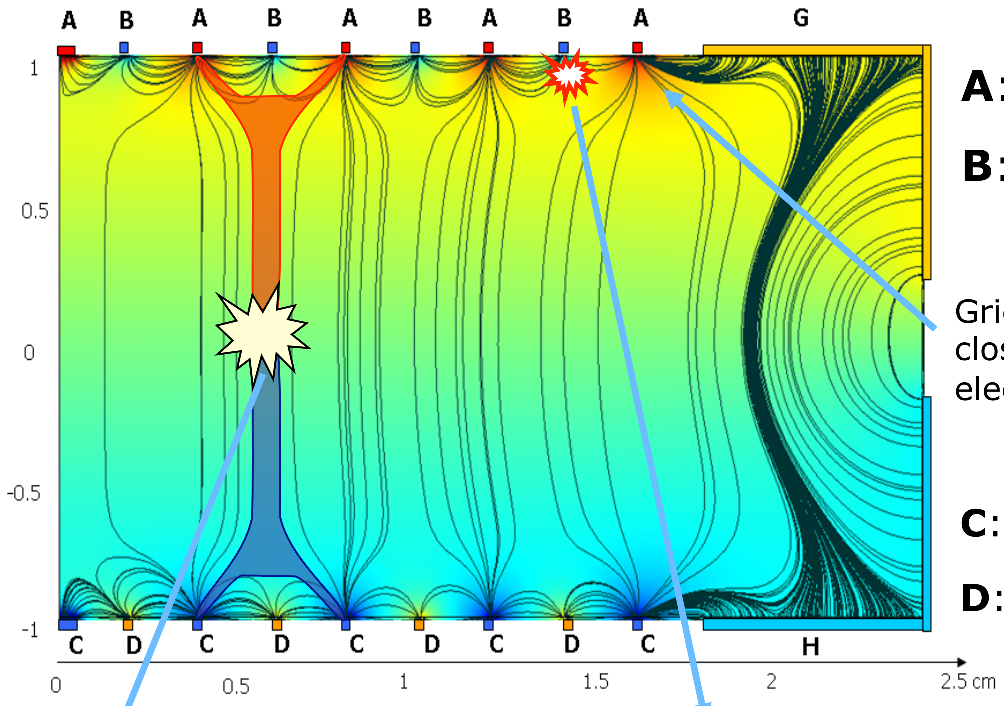
EDELWEISS Heat+Ionization detectors

- Phonon/Heat signal = true calorimetric measurement of total energy (NTD-Ge thermistor: T= 18 mK, $\Delta T \sim 1\ \mu K/keV$)
- Ionization yield (Al electrodes, sub-keV resolution): for nuclear recoils, it's ~1/3 of yield for e^- recoils
- Limitation: deficient charge collection near surface (low field, low temperature)





Interleaved electrodes for surface rejection



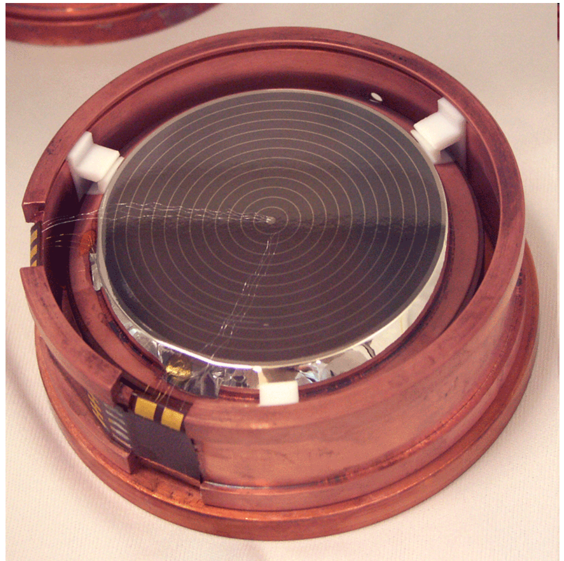
A: +4 V

B: −1.5V

Grid effect close to fiducial electrodes

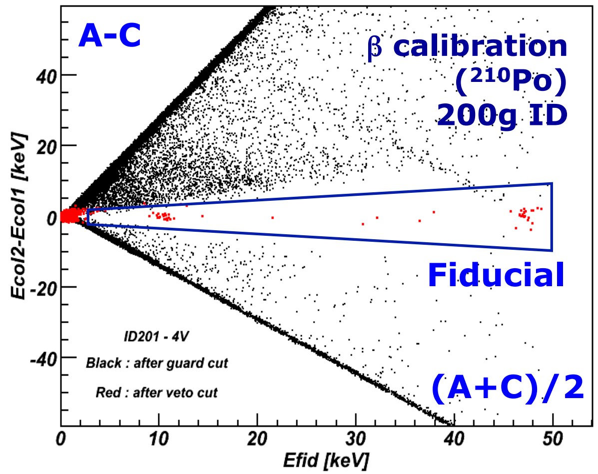
C: −4 V

D: +1.5V



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

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



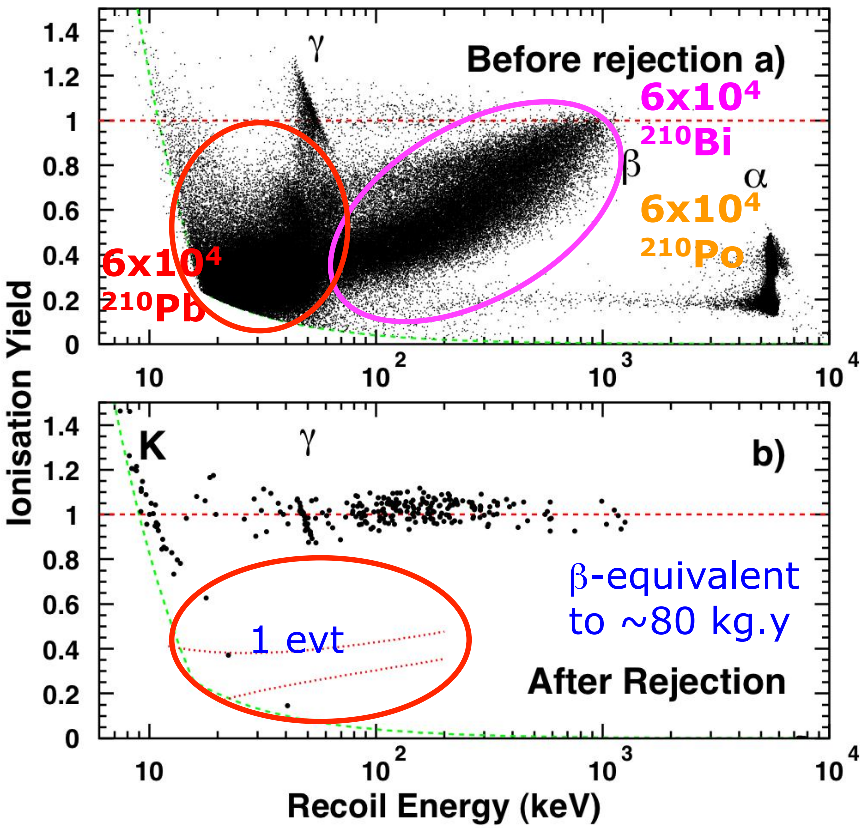
Redundancy: Can cut on B, D surface electrodes or on the balance between the two fiducial electrodes A-C

PLB 681 (2009) 305 *[arXiv:0905.0753]*

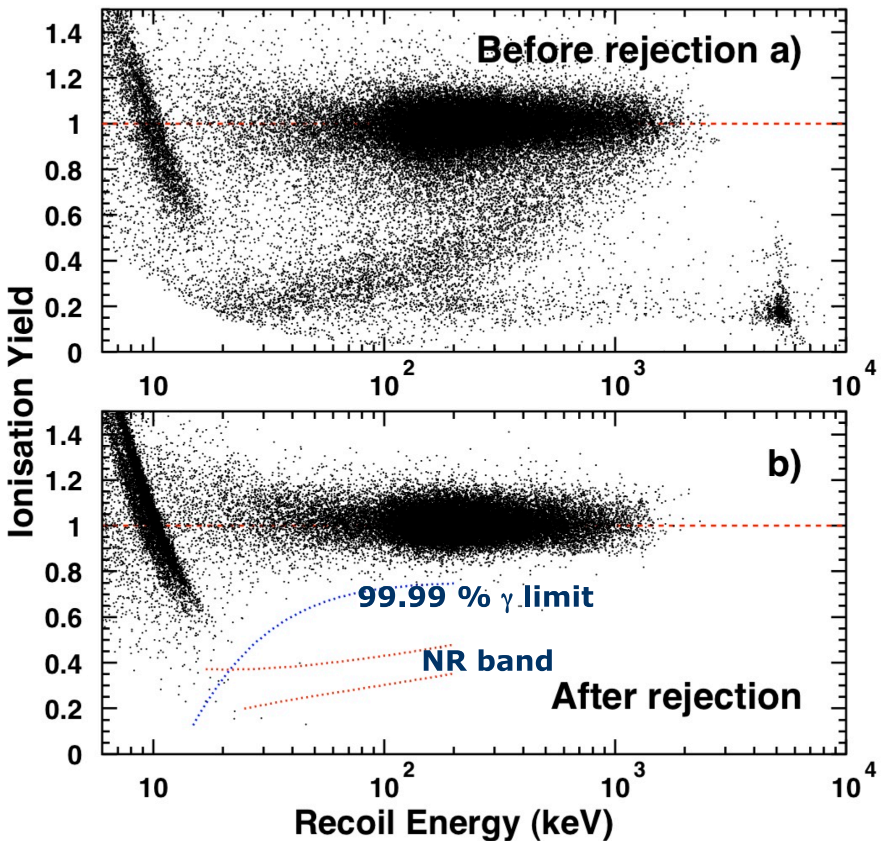
Surface rejection of ID detectors

- High-statistics test of surface rejection in interleaved region:
  - <0.3 evts expected in ~400 kgd exposure
  - Detailed test of actual backgrounds

^{210}Pb calibration



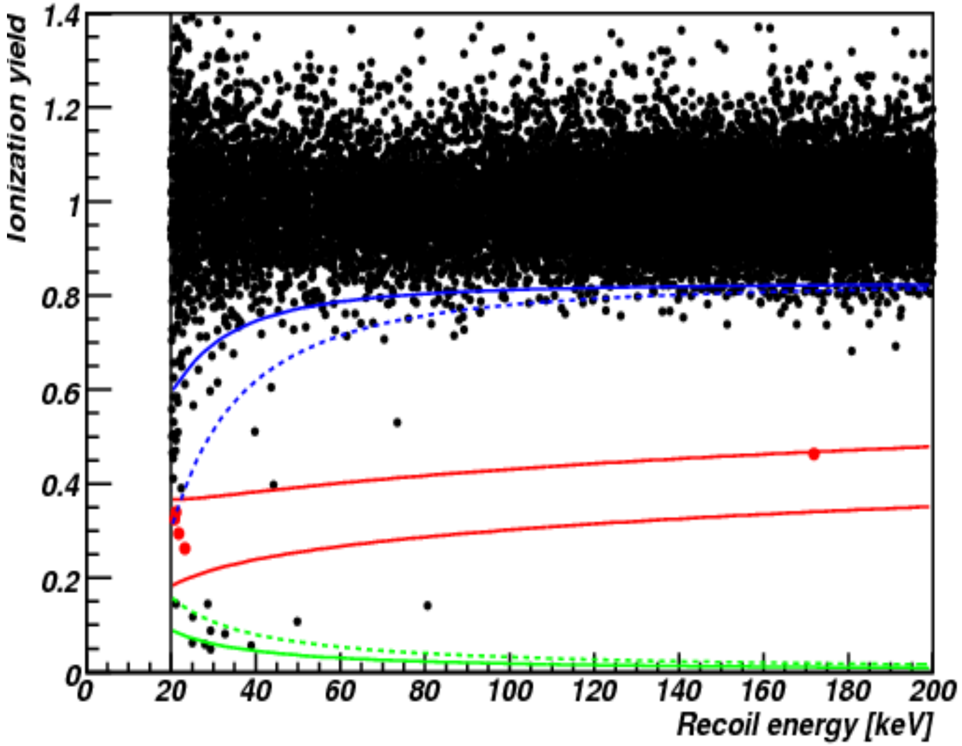
Data for WIMP search



WIMP search with ID detectors

- First significant search (384 kgd exposure) with ten x 400g IDs
- Search focused on medium and high mass WIMPs (analysis threshold 20 keV)
- 14 months, 85% duty cycle + extensive calibrations
- Five nuclear recoil candidates observed
- Background estimate: 3 events
  - ~1/3 γ rejection
  - ~1/3 uncertainties in (n,α) reactions inside the cryostat
  - ~1/3 other measured imperfections

+ problems associated with presence of large non-fiducial volume?



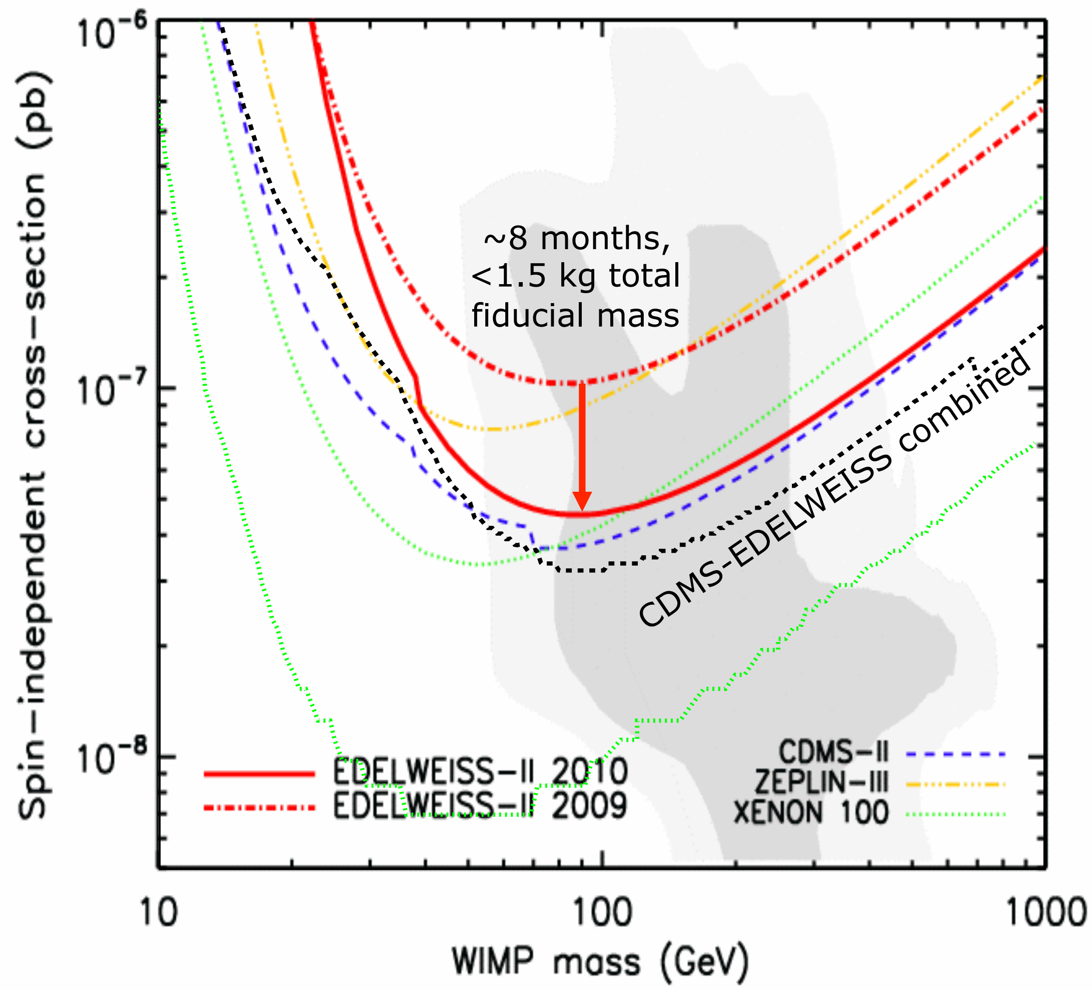
Preliminary results:
PLB 687 (2010) 294-298
Final results:
Accepted PLB [arXiv:1103.4070]

Spin-independent limits

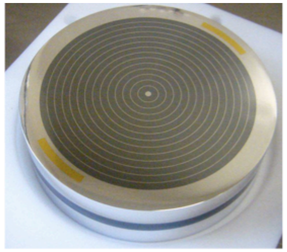
- Despite limitations due to backgrounds, fairly competitive WIMP limit + fast improvement in ~8 months

- Combined CDMS+ EDELWEISS limit: see P. DiStefano's talk

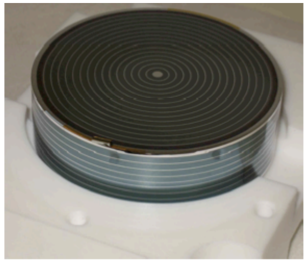
- Also: limits in inelastic scenario (clean recoil spectra at high energy) [arXiv:1103.4070]



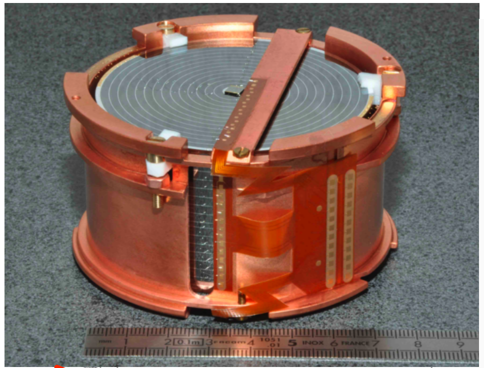
« Full » ID detectors (FID)

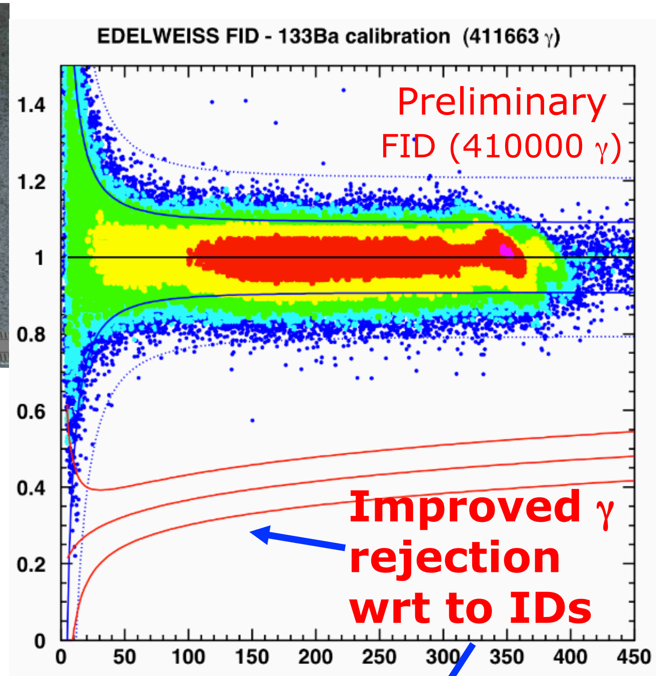


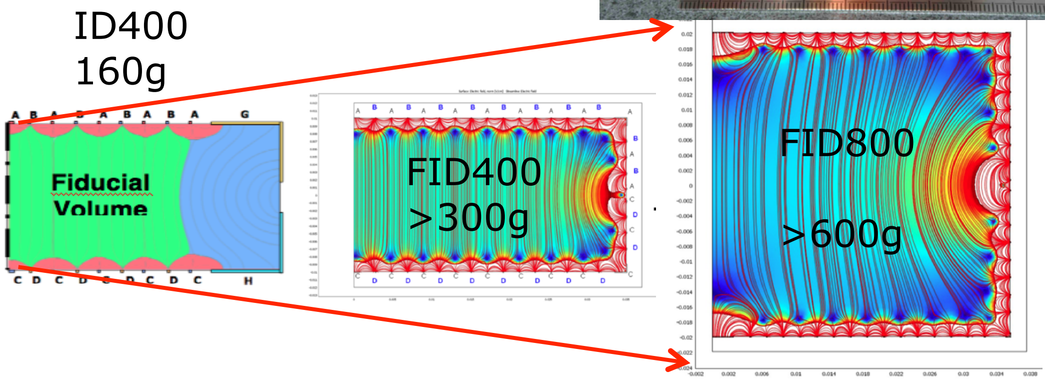
ID401 to 405:
Φ 70mm, H 20mm, 410g



FID401 and FID402:
Φ 70mm, H 20mm, 410g

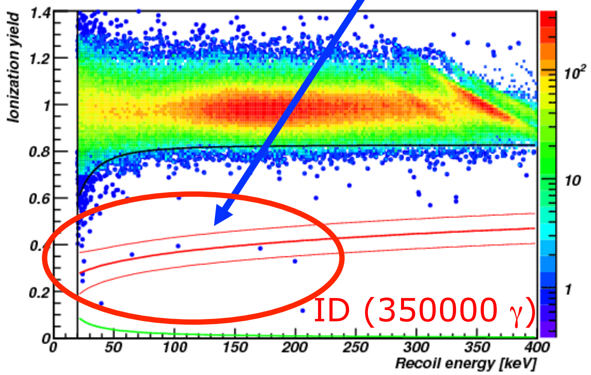






⇒ *Reduce non-fiducial volume*
⇒ Optimization of field map, improved surface treatment and added redundancy

⇒ Doubling/Quadrupling the fiducial mass:
ID400 => FID400 => FID800 (4 at LSM now)
10kg in 2011, 30kg in 2013 -> goal 3000 kgd



Conclusions

- EDELWEISS-II has reached a sensitivity of ~4.4×10^{-8}pb with ten 400 g ID detectors
- It lead to the development of improved FID detectors (with a larger fiducial volume and better rejection) and a better understanding of present background sources.
- EDELWEISS-III (funded)
  - 40 x 800 g FIDs, >25 kg fiducial mass: deployment by end 2012
  - Goal: 3000 kgd (<6 months) for 5×10^{-9}pb
  - EDELWEISS-II environment (cryogenics, cabling, shielding) upgraded for further reductions of backgrounds
  - Electronics, cabling & cryogenics tuned for lower thresholds
- Longer-term future: FID technology scalable for a larger cryogenic experiment such as EURECA at LSM extension