# Results of the EDELWEISS-II WIMP dark matter direct search experiment

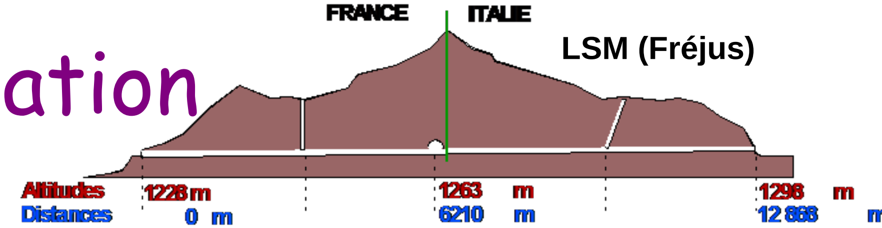
**XXIInd RENCONTRES DE BLOIS**

**Château de Blois, July 15th-20th 2010**

**Corinne AUGIER, IPNL**

**UCBL Lyon 1 – IN2P3/CNRS**

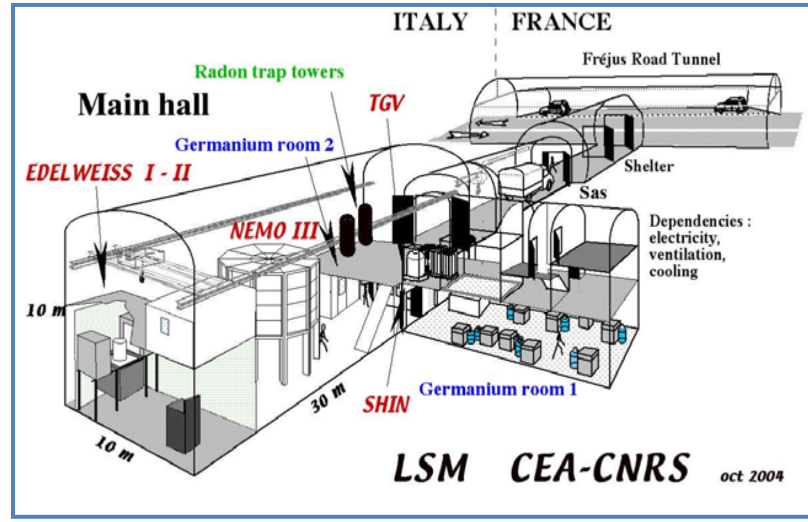
# The EDELWEISS collaboration





Karlsruhe - oct 09

4800 mwe

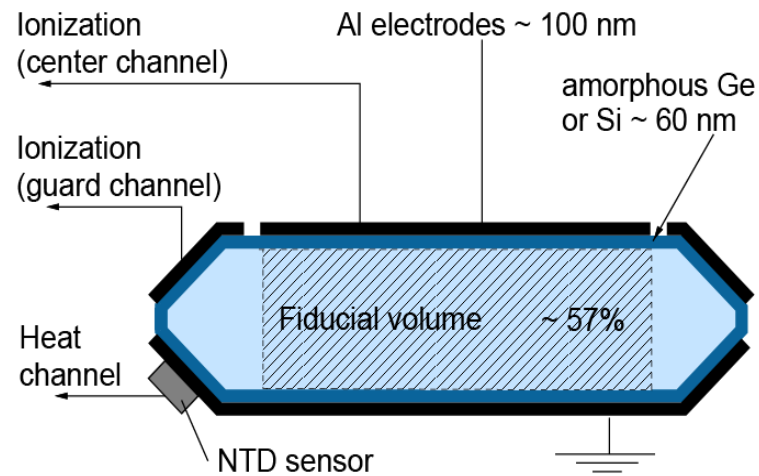


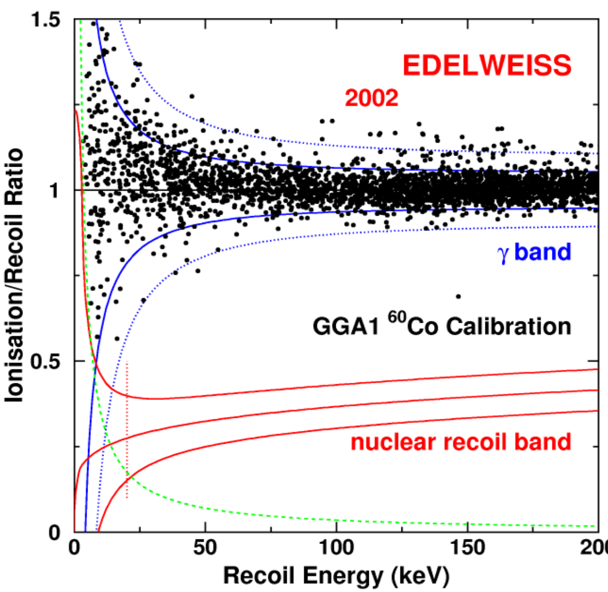

- CEA Saclay (IRFU & IRAMIS) — Detectors, electronics, acquisition, data handling, analysis
- CSNSM Orsay — Detectors, cabling, cryogenics
- IPN Lyon — Electronics, cabling, low radioactivity, analysis, detectors
- Institut Néel Grenoble — Cryogenics, electronics
- Karlsruhe IK,IEKP (+ IPE 2011) — Vetos, neutron detectors, background, electronics
- JINR Dubna — Background, neutron and radon detectors
- Oxford Univ. — New comer 2009: Detectors, cabling, cryogenics, analysis
- Sheffield Univ. — New comer 2010: MC simulation

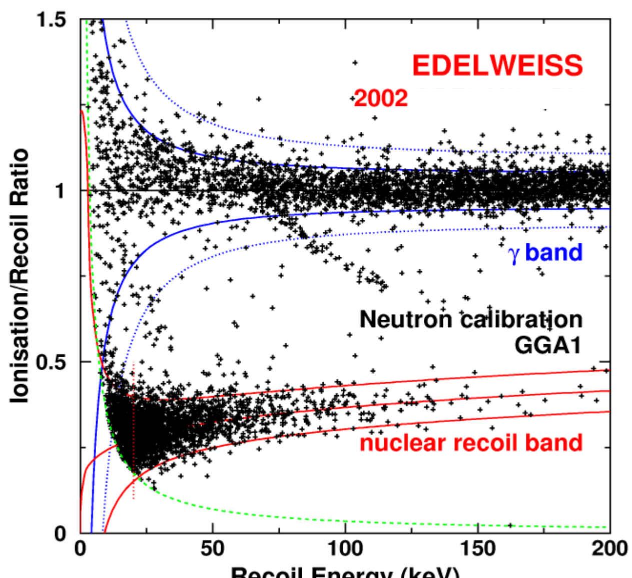
# EDELWEISS-I detectors

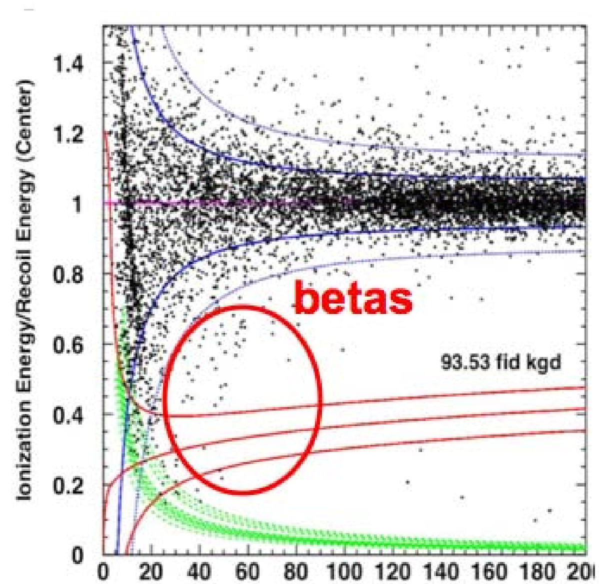
Direct search of WIMP dark matter by energy measurement of detector nuclei recoils induced by the interaction of WIMPs from Milky Way galaxy

- Germanium crystals bolometers with both ionization and heat measurements $\rightarrow$ plain aluminum electrodes + NTD sensor at 20 mK
- WIMP and n bkg $\rightarrow$ nuclear recoils
- e-, $\gamma$, $\alpha$ bkgs $\rightarrow$ electron recoils
- Discrimination using electron and nuclear recoils: $E_R = f(E_I, E_H)$ and $Q = E_I / E_R$
- Limitation: surface interactions



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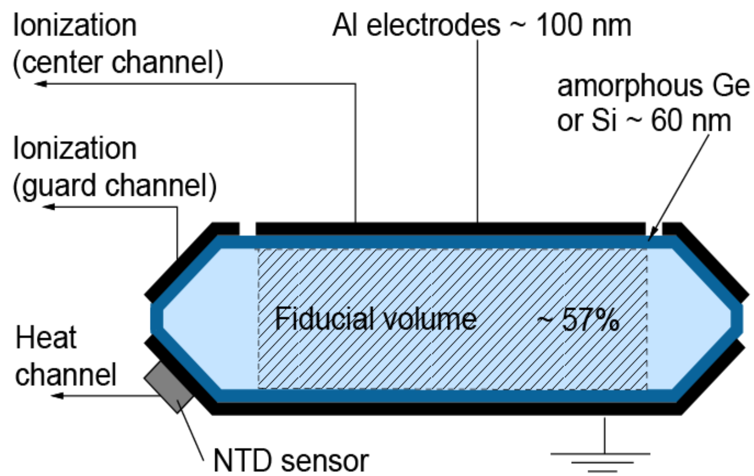
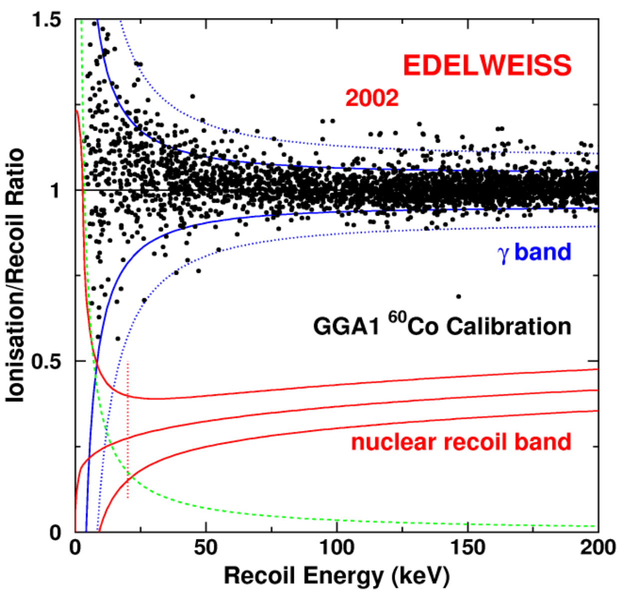
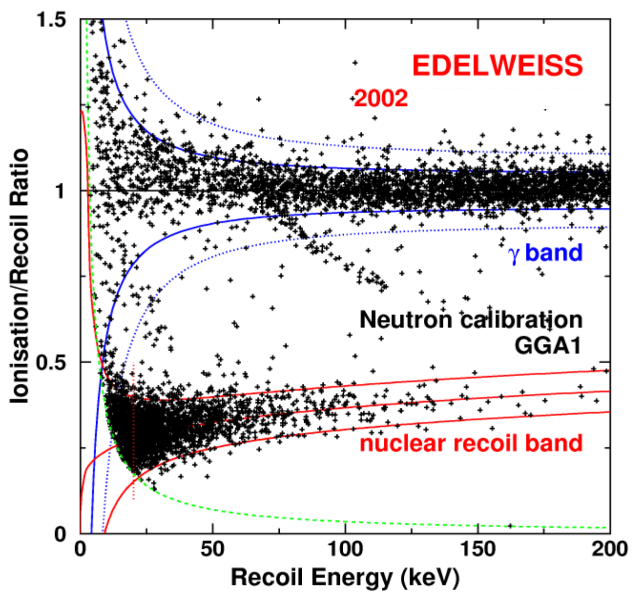
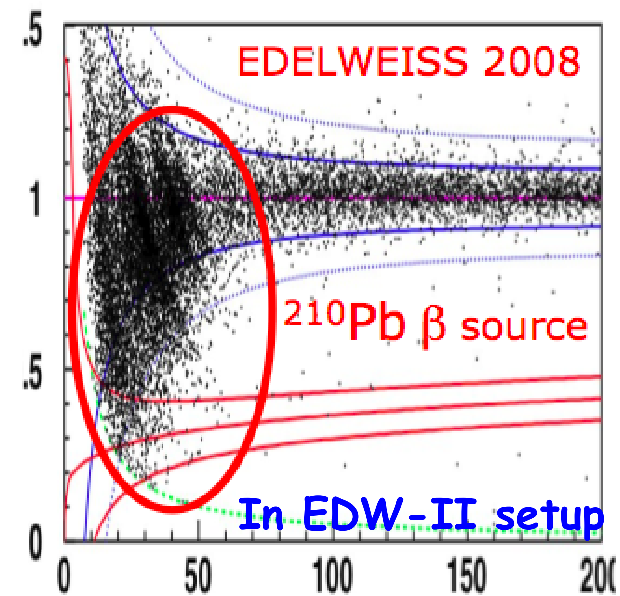
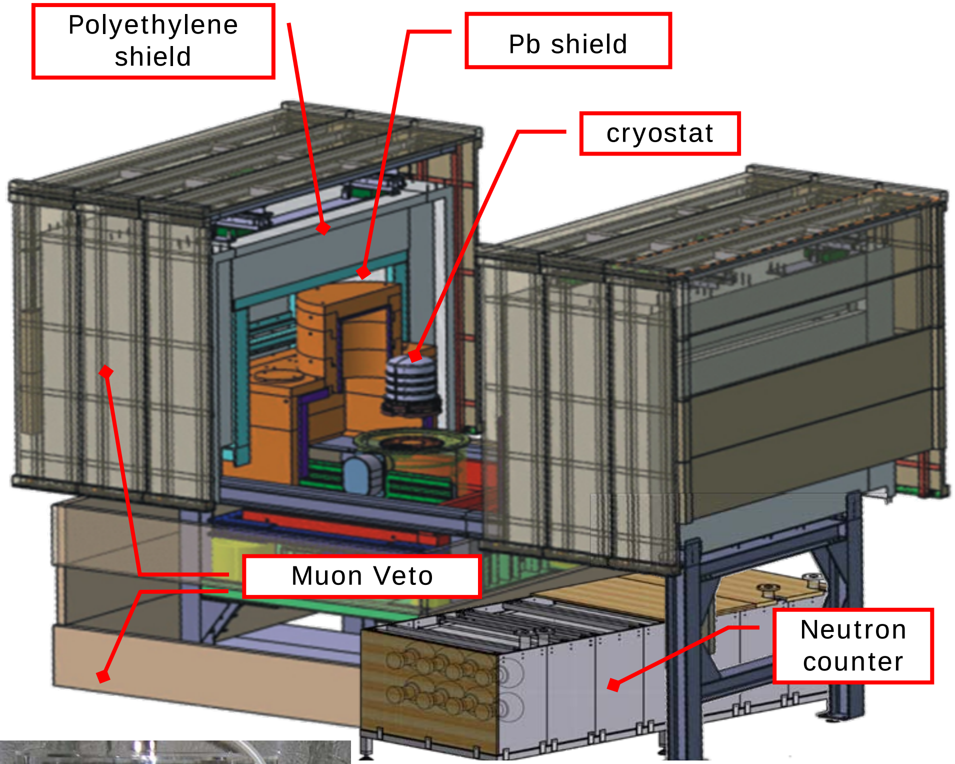


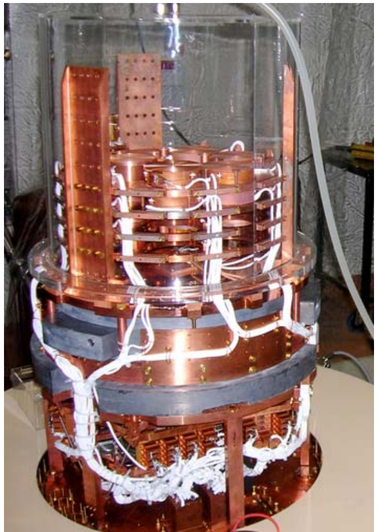



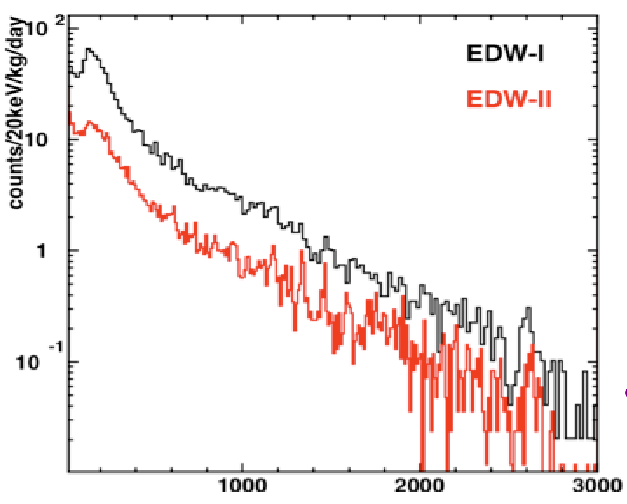



# The Edelweiss-II setup

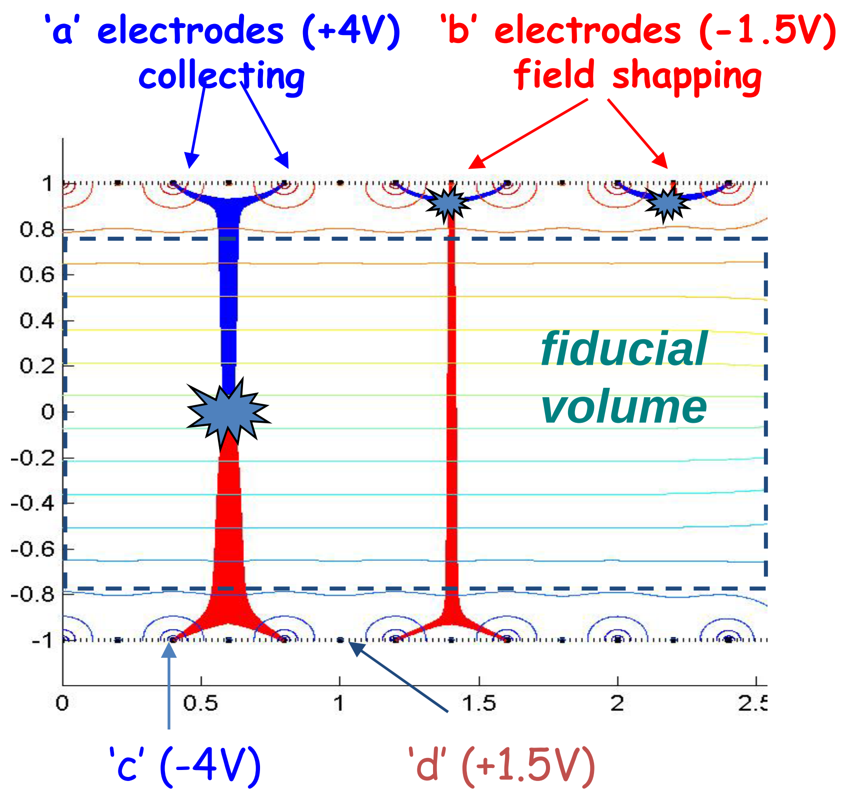


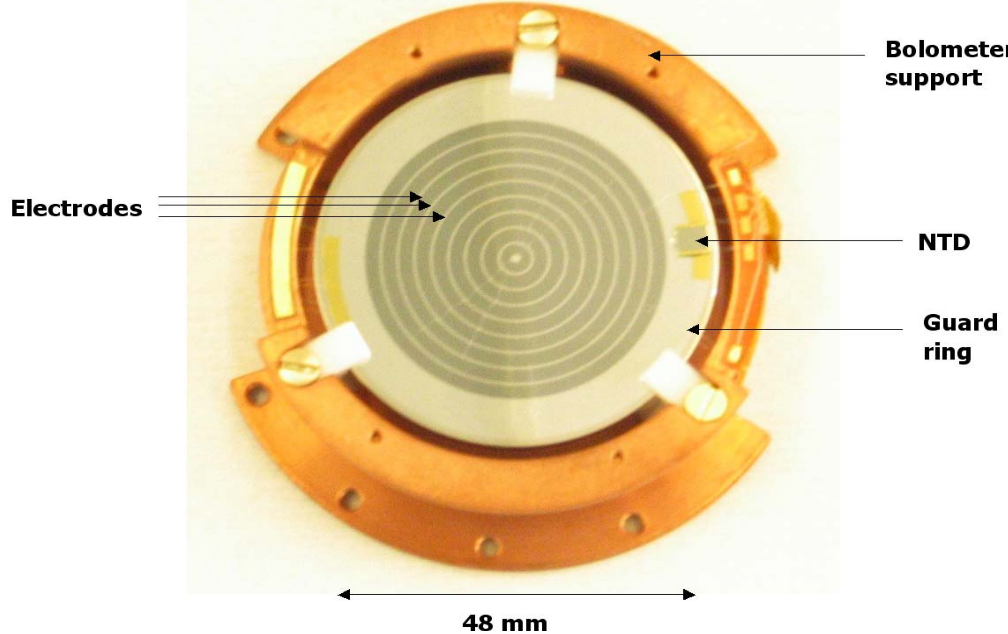



- Operated at the Fréjus Underground Laboratory in Modane (LSM, 4μ/day/m²)
- **New goal 5x10$^{-9}$ pb**
- Cryogenic installation (at 18 mK) :
  - Reversed geometry cryostat, pulse tubes
  - Remotely controlled
  - **Can host up to 40 kg of detectors**
- Shieldings:
  - Clean room + deradonized air
  - Active muon veto (> 98% coverage)
  - PE shield 50 cm
  - Lead shield 20 cm
  - → **γ background reduced by ~3 wrt EDW-I**
- Others:
  - Remotely controlled sources for calibrations + regenerations
  - Radiopurity selection of materials (HPGe)
  - Detector storage & repair within the clean room
  - **Radon detector down to few mBq/m³**
  - **He3 neutron detector (thermal neutron monitoring)**
  - **Liquid scintillator 1 T neutron counter (study of muon induced neutrons)**
- 12 cool-downs already operated since 2006

# Rejecting surface events with interleaved electrodes




« ID » (InterDigit) detector




First prototype 200g built in 2007
1x200g + 3x400g tested in 2008
**10x400g in run 12 since beginning 2009**

- Modify the E field near the surfaces with interleaved electrodes
- Use 'b' and 'd' signals as vetos against surface events
- Rejection factor > $10^4$ for low-energy surface events induced by $e^-$ from $^{210}Pb$
- Heat: keep the EDW-I NTD sensor

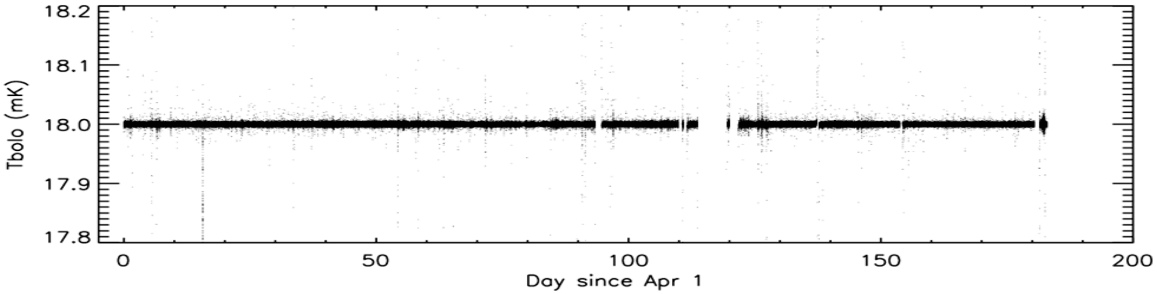
*PLB 681 (2009) 305-309 [arXiv:0905.0753]*

# WIMP search with ID detectors: Run 12

**Run 12 from April 1st 2009 to May 20th 2010**

- 418 d total
- 322 d data (77% of 418)
- 305 d WIMP physics (73% of 418)
- All the 10 detectors working
- 90% electronics channels ok
- 9/10 bolos for Physics
- 8 d gamma calib
- 5 d neutron calib
- 4,5 d « other »

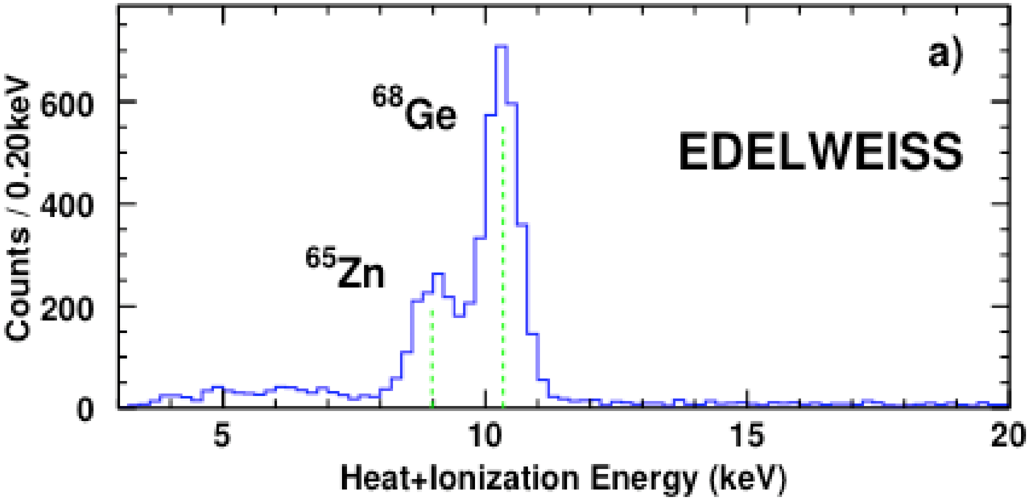
*« One of the coldest place in the Universe » … Continuously at 18 mK during more than 1 year !*




**Baseline resolutions:** **Heat: 0.6 to 2 keV, average = 1.2 keV**
**Ionization: 0.8 to 1.2 keV, average = 0.9 keV**

- $\gamma$-ray energy of fiducial events
- all detectors used in WIMP search
- online heat threshold 3.5 keV
- 8.98 and 10.34 keV peaks associated with e.c. decay of cosmogenically activated $^{65}Zn$ and $^{68}Ge$.

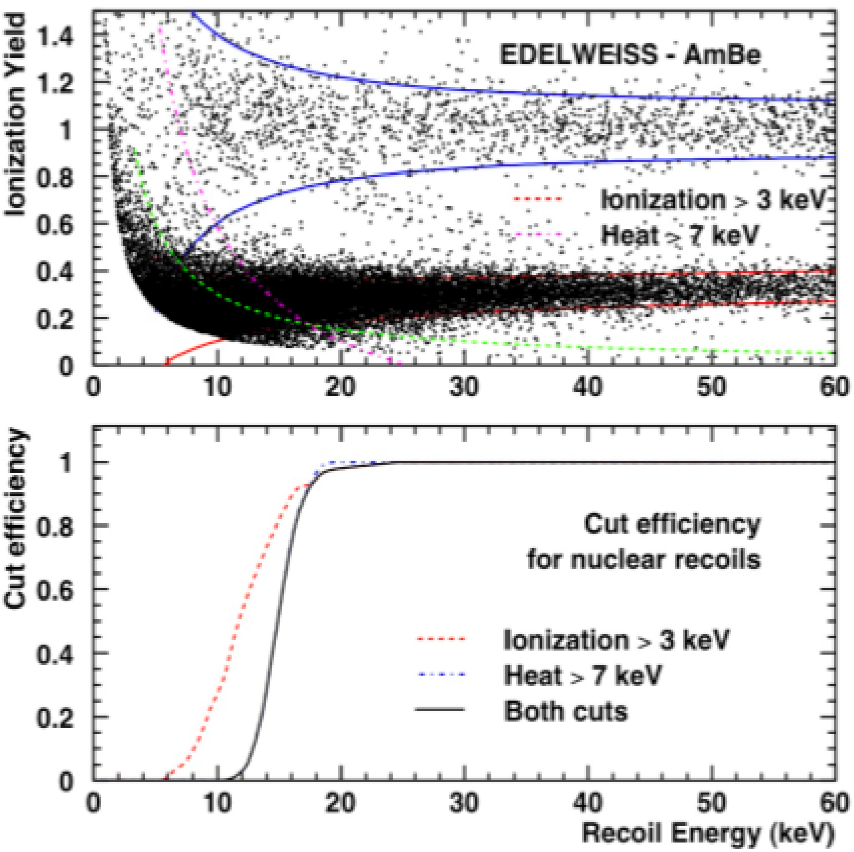
**→ 160 g fiducial mass for the 10 ID400 detectors.**



# Data analysis of first 6 months

- 2 independent processing pipelines
- Pulse fits with optimal filtering using instantaneous noise spectra
- Period selection based on baseline noises
  80% efficiency
- Pulse reconstruction quality (chi2)
  97% efficiency
- Fiducial cuts based on ionization signals (160g ≡ 40%)
- 90% nuclear recoil acceptance
- 99.99% gamma rejection
- Bolo-bolo & bolo-veto coincidence rejection
- WIMP search threshold fixed a priori
  Er > 20 keV (100 % acceptance)
- Agreement between the results of the two analyses

All detectors – neutron calibration

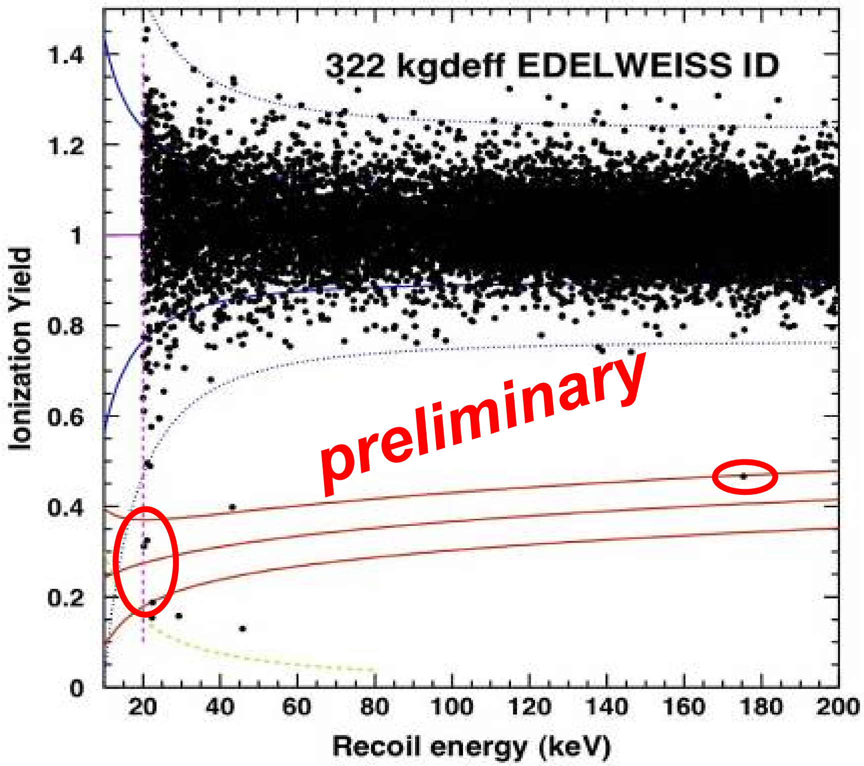


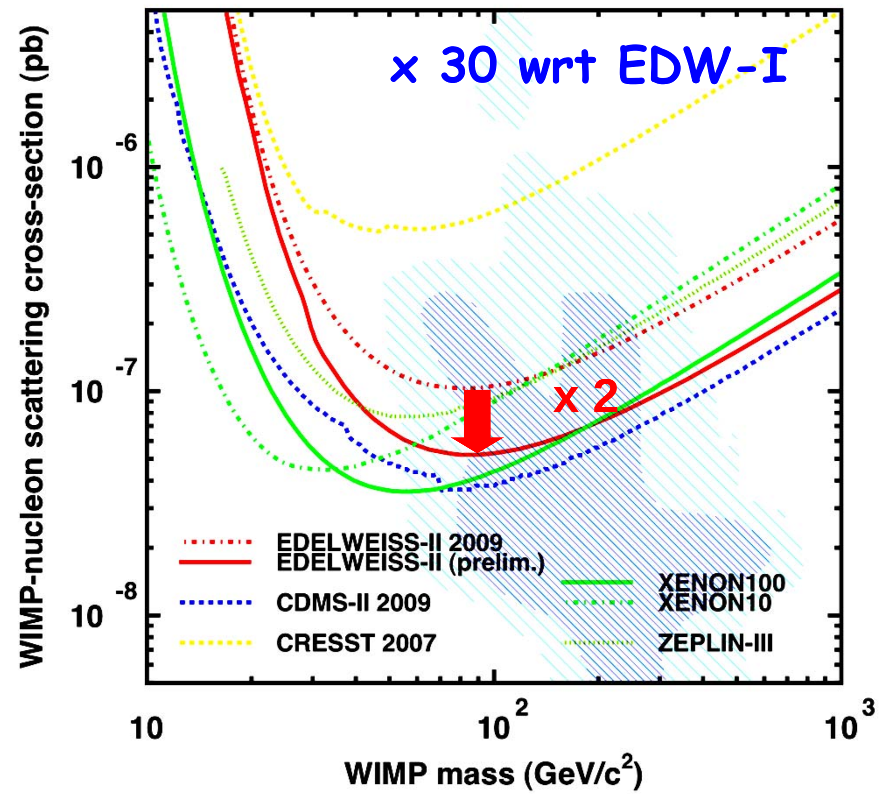

Effective exposure 144 kg.d - One nuclear recoil candidate above 20 keV

Best limit: $\sigma_{SI}$(W-N) = $1.0 \times 10^{-7}$ pb at $M_W$ = 80 GeV (90%CL) x15 wrt EDW-I

*EDELWEISS Coll. / E. Armengaud et al. PL B 687 (2010) 294–298* [arXiv:0912.0805]

# WIMP search: last result (end of run May 20$^{th}$ 2010)




**Preliminary result** : 1$^{st}$ analysis with same cuts as first 6 months,
2$^{nd}$ analysis ongoing ⇒ Increase in the sensitivity of factor 2 (scale with stat)

**3 evts near threshold + 1 evt at 175 keV in the NRB** **x 30 wrt EDW-I**

Best limit: **$\sigma_{SI}$(W-N) = 5.0x10$^{-8}$ pb at $M_W$ = 80 GeV** (90%CL)

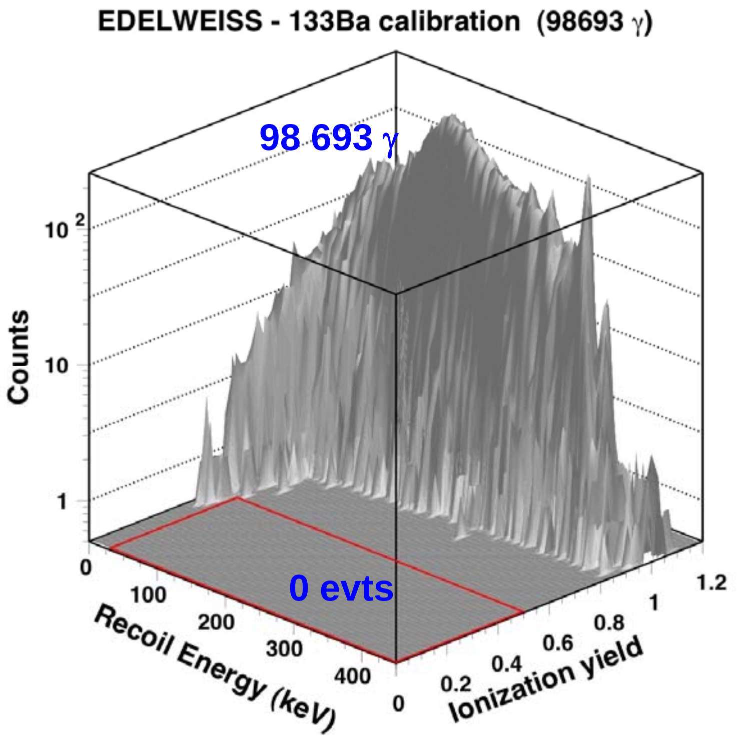
→ background starts to appear?

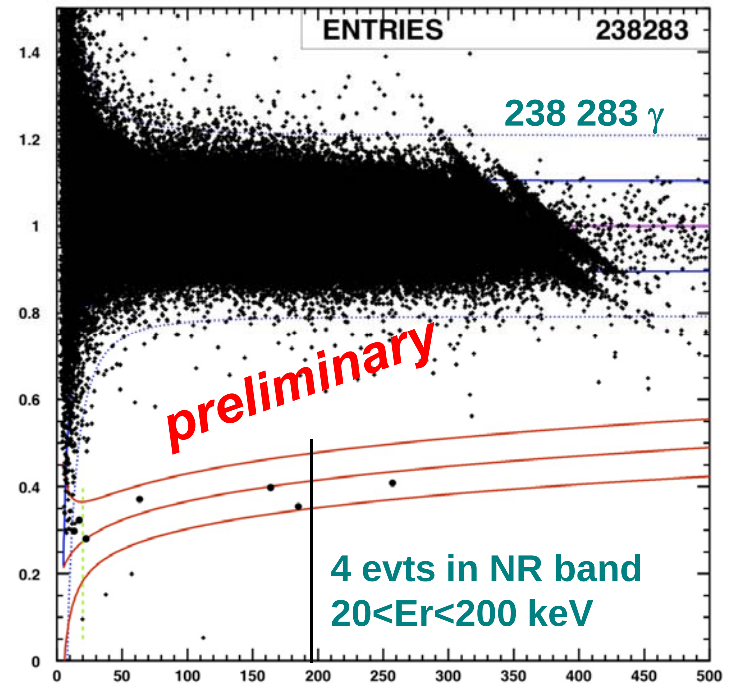
# Background studies

| | | |
|---|---|---|
| **Gammas:** | $^{133}$Ba calib rejection × observed bulk $\gamma$ | $< 1.0$ |
| **Betas:** | $\beta$ source rejection × observed surface evts | $< 0.2$ |
| **Neutrons from $\mu$'s:** | $\mu$ veto efficiency × observed muons | $< 0.25$ |
| **Neutrons from Pb:** | measured U limits × Monte Carlo simu | $< 0.1$ |
| **Neutrons from rock:** | measured neutron flux × Monte Carlo simu<br>MC tuned with outside strong AmBe source | $< 0.1$ |

**SUM < 1.6 for the whole WIMP run (90% CL upper limit)**

# Status of gamma $^{133}$Ba calibrations



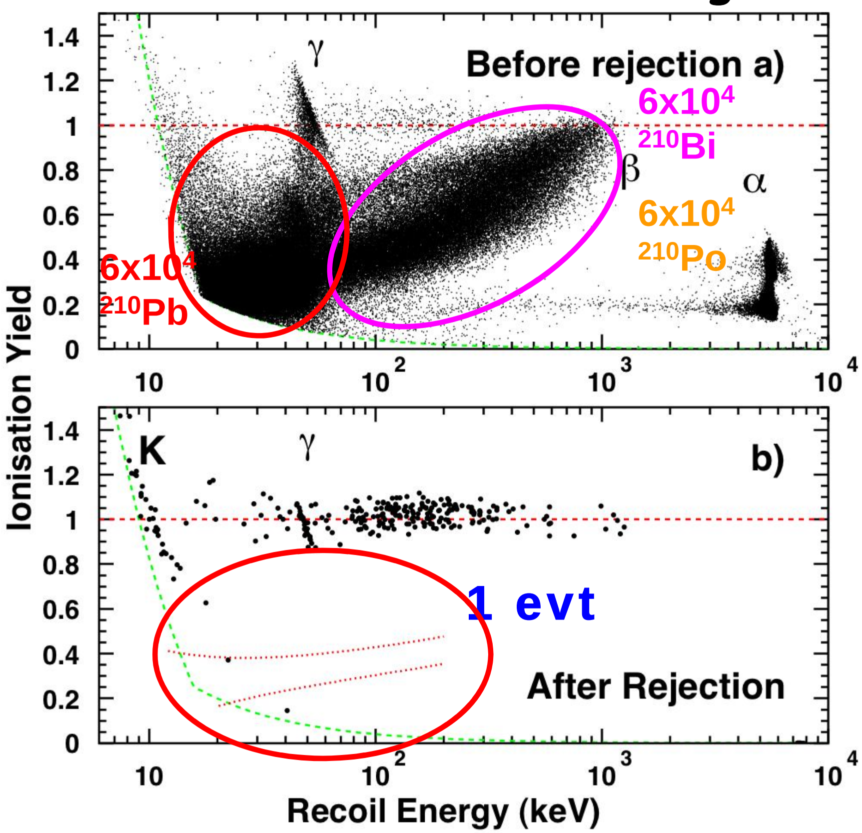

With 2 detectors: gaussian behaviour
No candidate event for Q < 0.5

Statistics x 2.5, all 10 detectors
$\Rightarrow$ 4 evts in the NRB

- $^{133}$Ba calib: 134 000 evts in 20-200 keV $\Rightarrow$ < 1 evt (90%CL) expected in 16 600 evts WIMP run
- Knobs to understand/improve:
  - Recombination e-h : optimize operation of polarization voltages, regeneration procedures
  - Pile up, multisite events : new fast readouts on heat and ionization
  - 2 NTD heat measurements for information redundancy

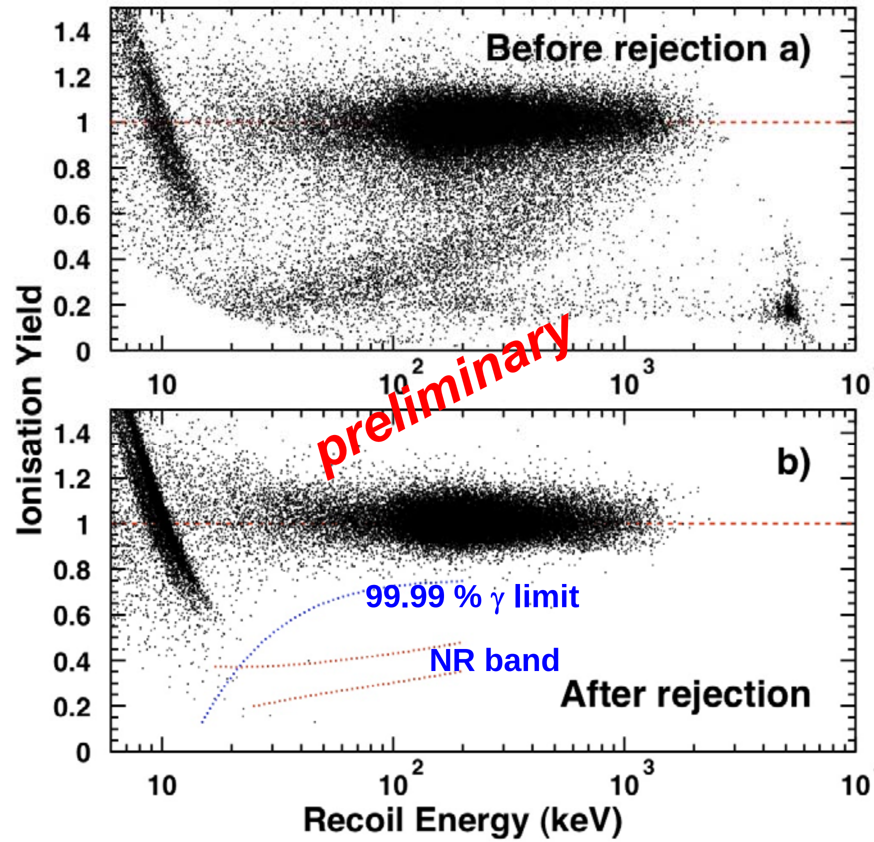
# Beta calibrations & backgrounds

## $^{210}$Pb calibration – 1$^{st}$ 200g ID



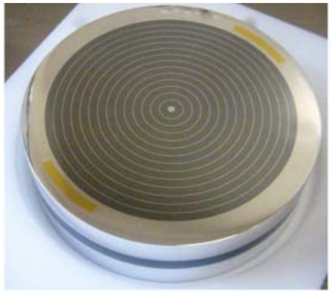

*PLB 681 (2009) 305-309 [arXiv:0905.0753]*

## Data for WIMP search – Run 12



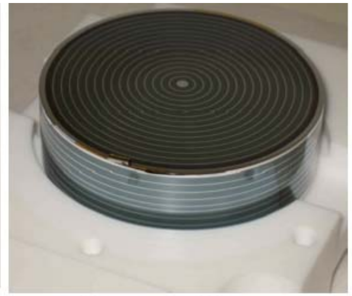

- Rejection factor + identified surface events in data
  - < 0.2 evt (90%CL) expected after rejection
- Knobs to improve:
  - change surface treatment
  - better E resolutions

# New run: from IDs to FIDs



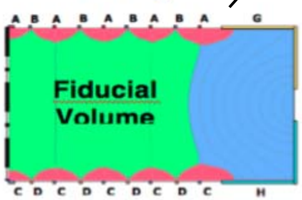
ID401 to 405:
Φ 70mm, H 20mm, 410g

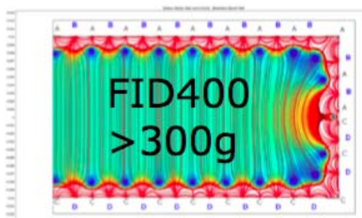
ID2 to ID5:
Φ 70mm, H 20mm, 410g

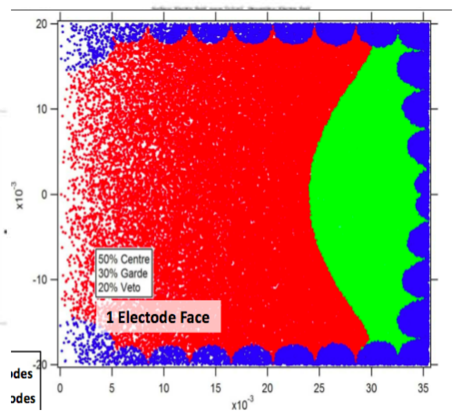


FID401 and FID402:
Φ 70mm, H 20mm, 410g

ID400
160g



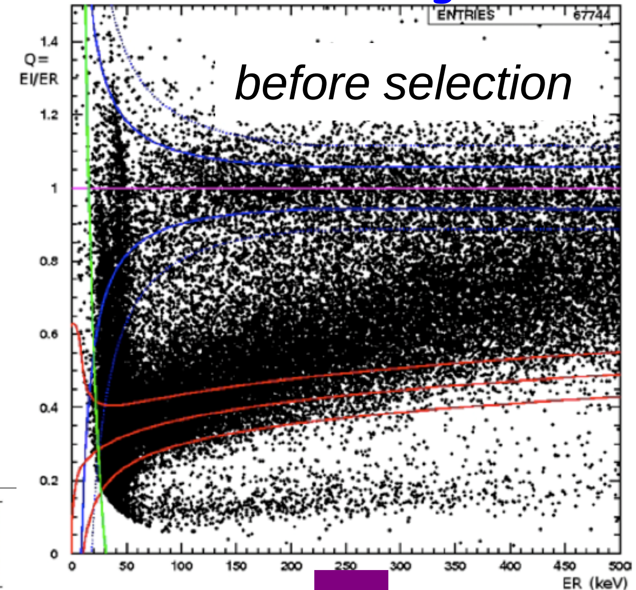



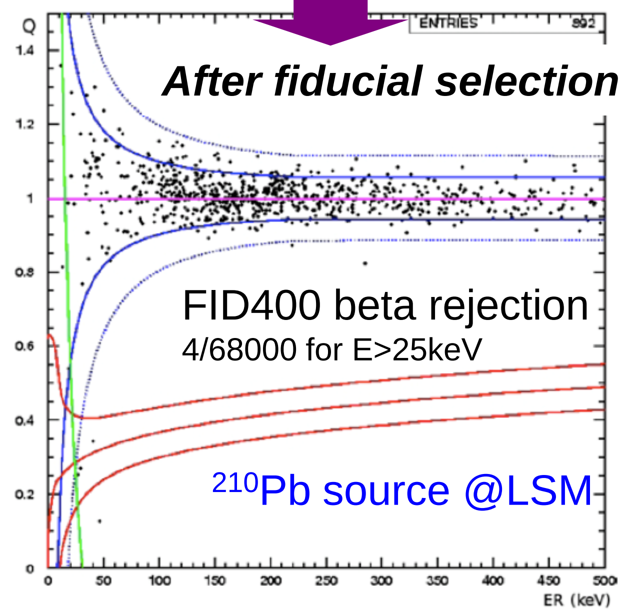

**Fiducial mass x2 x4**

**ID200-ID400 ⇒ FID400 ⇒ FID800**

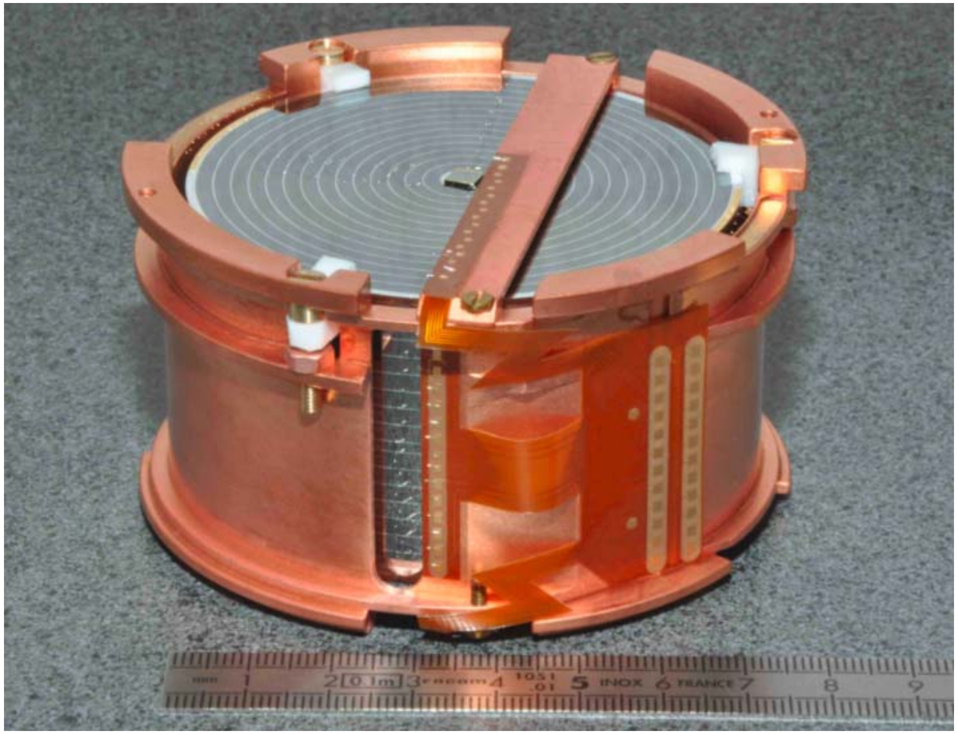
- Production of FID detectors performed at CSNSM Orsay using dedicated evaporation system

Run 12 - 400 g FID



# July 3rd: 4 FID800 installed in LSM cryostat
# Cool down of run 13 before end of July



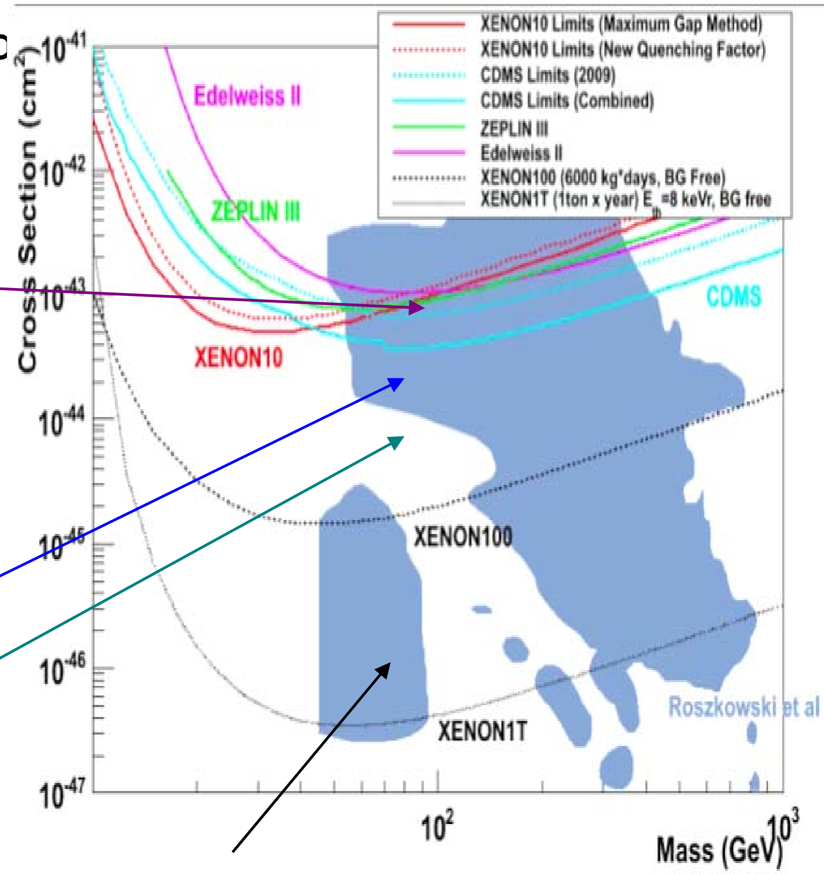
FID800: 800 g « ID » detector, 2 NTD
6 ionization electrodes ⇒ detector segmentation
218 ultrasonics bondings / detector

# EDELWEISS: summary/prospects

- EDW new-generation ID detectors:
  - Robust detectors with redundancy and very high beta rejection
  - Preliminary analysis of 1 year data ⇒
    - **No hint of WIMPs**
    - **$5 \times 10^{-8}$ pb sensitivity achieved**
- New Goal: $5 \times 10^{-9}$ pb
  - Improvements wrt future bkgs
    - Increased redundancy for ionization and heat measurements
    - Fast readout (multi-site evts, pile up)
    - Lower μ phonics, internal PE shield
  - New prototypes: FID800

    2011: 1000 kg.d
  - Build 40 detectors, upgrade setup

    2012: 3000 kg.d

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