EDELWEISS: Latest results and future plans

Johann Gironnet,
Institut de Physique Nucléaire de Lyon

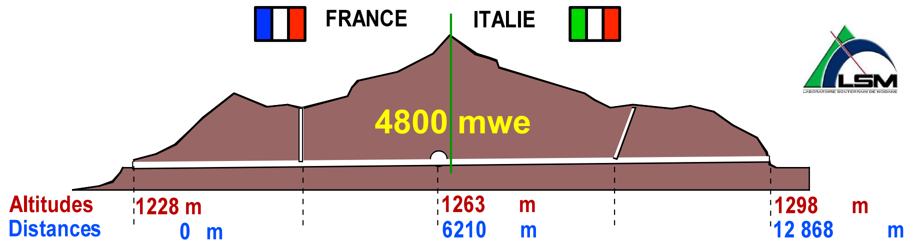
On the behalf of the EDELWEISS collaboration

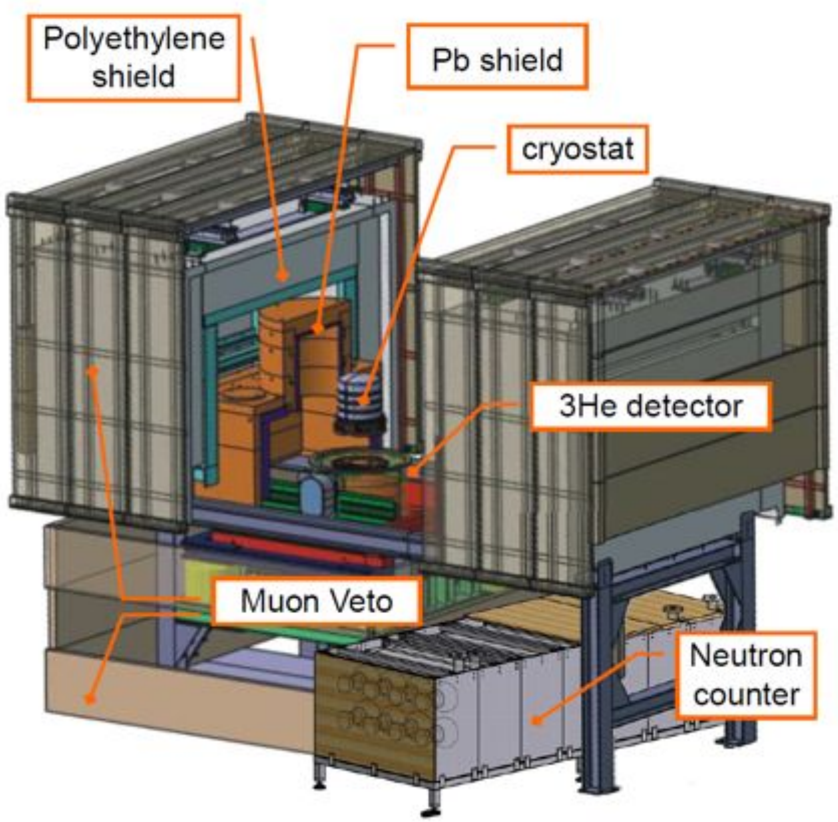
Edelweiss collaboration: **CEA Saclay** (IRFU, IRAMIS), **CSNSM Orsay** (CNRS/IN2P3 + Univ. Paris Sud), **Karlsruhe Institute of Technologye**, **Institut Néel Grenoble** (CNRS/INP), **IPN Lyon** (CNRS/IN2P3 + Univ. Lyon 1), **Laboratoire Souterrain de Modane**, **JINR Dubna**, **University of Oxford**, **University of Sheffield**

Outline

- Edelweiss : “ID technology”, results of 1 year run
- Combination of data with CDMS : results
- Prospects of Edelweiss for 2012-2013
- Further future : EURECA

The EDELWEISS-II infrastructure

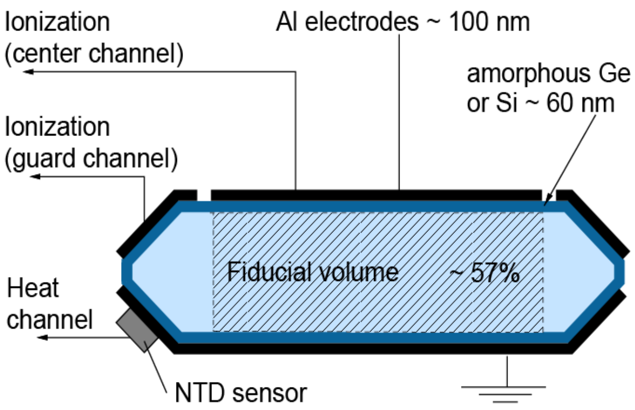


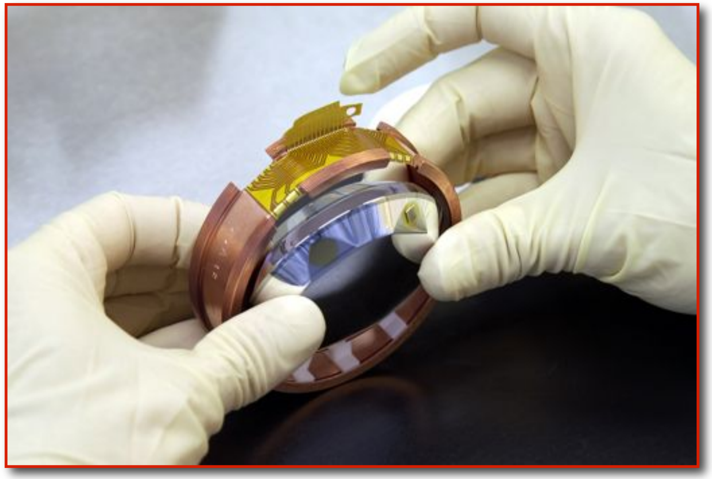


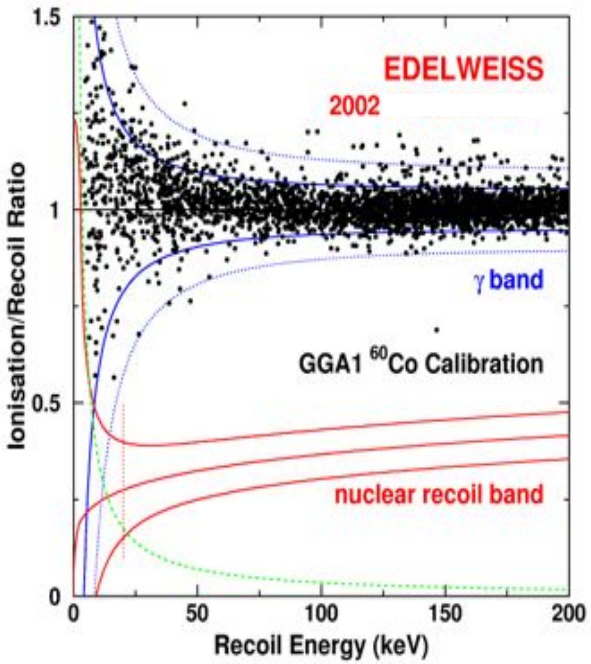
Global setup view

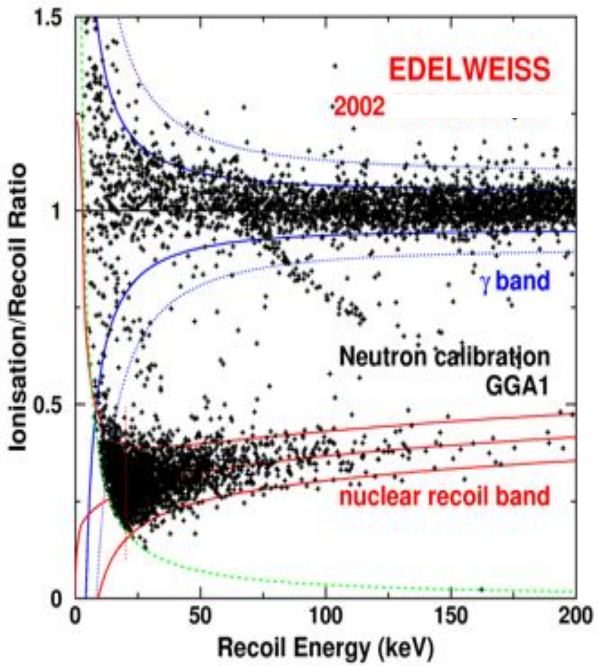
- **Place:** Laboratoire Souterrain de MODANE
  cosmic muon flux: 4 μ/m2/day
- **Cryogenic installation (18 mK)** :
  - Reversed geometry cryostat, pulse tubes
  - Remotely controlled
  - **Can host up to 40kg of detectors**
- **Shieldings** :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - 50-cm PE shield
  - 20-cm lead shield
- **Other items**:
  - Remotely controlled sources for gamma calibrations + regenerations
  - AmBe sources of neutron calibrations
  - **Radon detector down to few mBq/m^3**
  - **He3 neutron detector (thermal neutron monitoring inside shields) sensitivity ~10^{-9} n/cm^2/s**
  - **Liquid scintillator neutron counter (study of muon induced neutrons)**

EDELWEISS-I detectors: GeNTD discrimination principles









→ **Target:** Ge crystal

→ **Simultaneous measurement**

- **Heat** @ 20 mK with Ge/ NTD thermometer
- **Ionization** @ few V/cm with Al electrodes

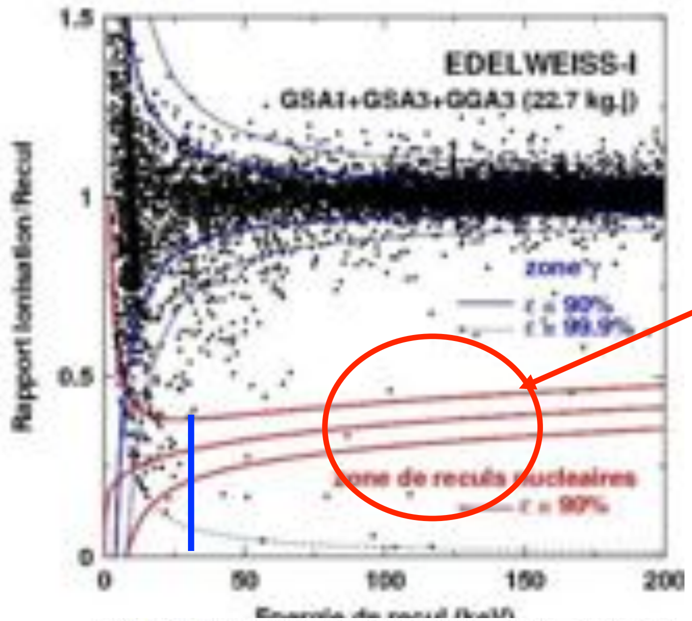
→ **Evt by evt identification** of the recoil

→ Q=E_ionization/E_recoil

- **Q=1 for electronic recoil**
- **Q≈0.3 nuclear recoil**

→ **GeNTD detector : discrimination γ/n > 99.99% for Er> 15keV**

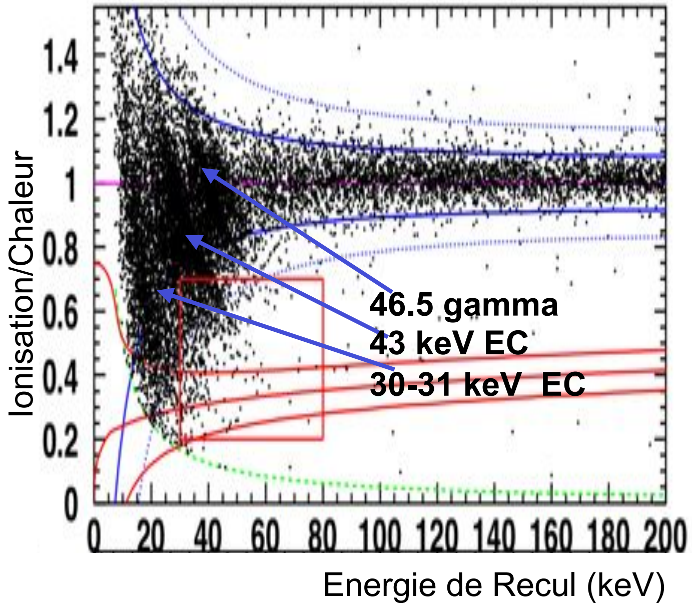
EDELWEISS-I/-II dectectors: surface evts background…



→ **Poorly collected events in Physics runs:**

Population identified as originating from ^{210}Pb at surface of detector or Cu cover

→ **Limitation: surface events**



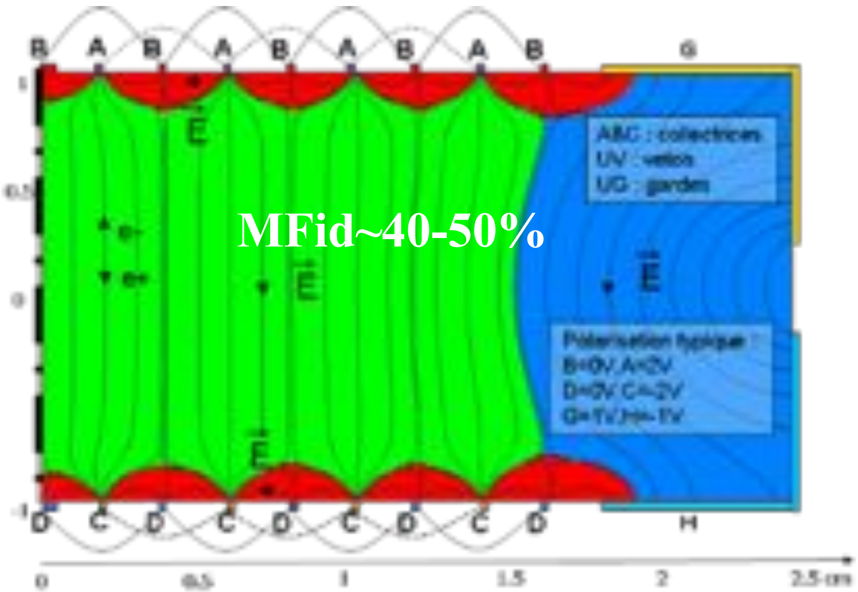
→ **Dedicated β 210 Pb calibration**

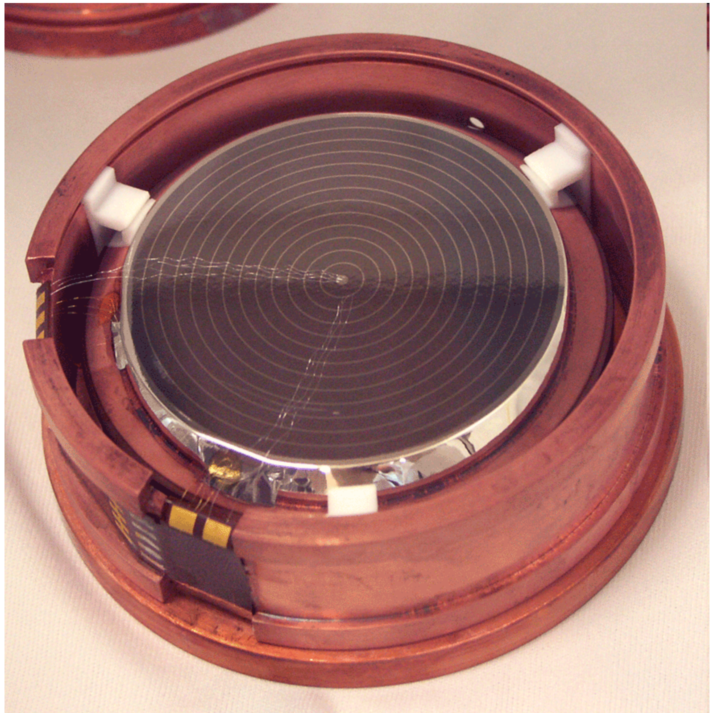
(β source = Rate = 2500 * EDW1)

- ≈ 2% of the betas in the nuclear recoil zone for 30<Er<100keV
- **β rejection ~1/10000 needed to reach < 10^{-8} pb**

→ **Last year's R&Ds have focused on this issue :**
Ge/NbSi and ID/FID technologies

ID detectors : surface events rejection with interleayed electrodes





→ R&D program funded by ANR 2006-09

- First test on a 200 g detector in 2007

→ Interleaved electrodes + guards

→ Biases to have an **electric field :**

~ horizontal near the surface and

~ vertical in the bulk

→ Easy cuts on « veto » + guard electrodes define the fiducial zone : β rejection > 1/15000

A. Broniatowski et al ***Phys Lett B 681 (2009) 305*** *[arXiv:0905.0753]*

Physics run with 10 IDs

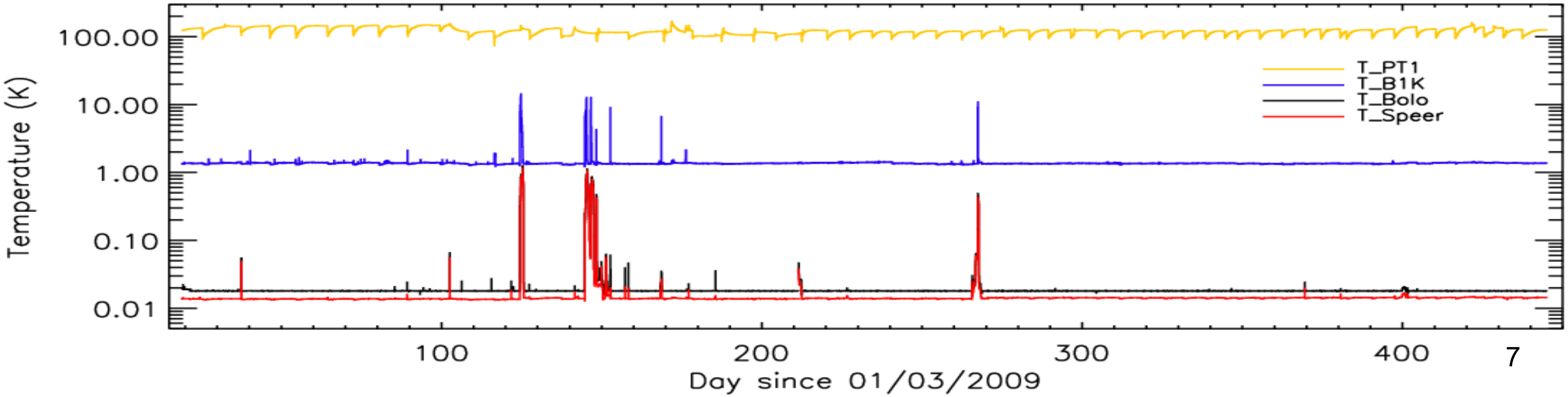
→ April 2009 – May 2010: 10 x 400 g Ge ID-detectors

- 325 days physics
- 10.1 days gamma calibration
- 6.4 days neutron calibration

✚ July-Nov 2008: 2x400 g Ge ID-detectors

→ Total effective exposure: 384 kg.d

- Analysis threshold at 20 keV
- Bolometer temperature stable ~18 mK



Gamma calibration

→ **Regular calibrations**

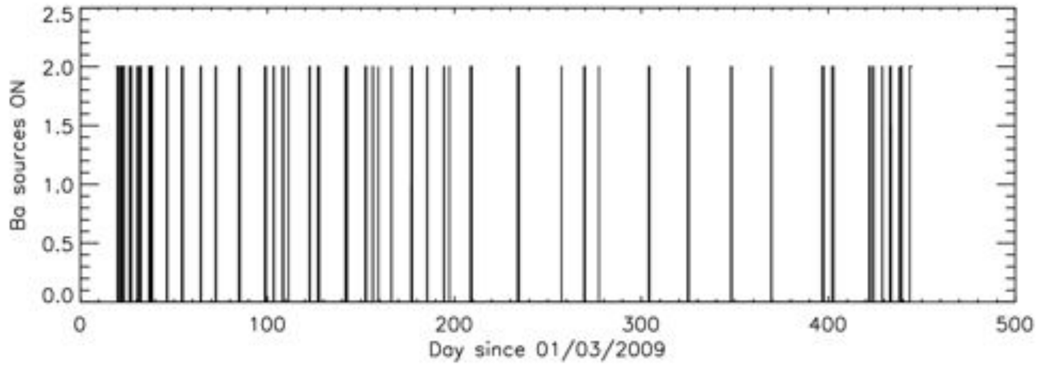
background runs with two motorized ^{133}Ba sources (356 keV)

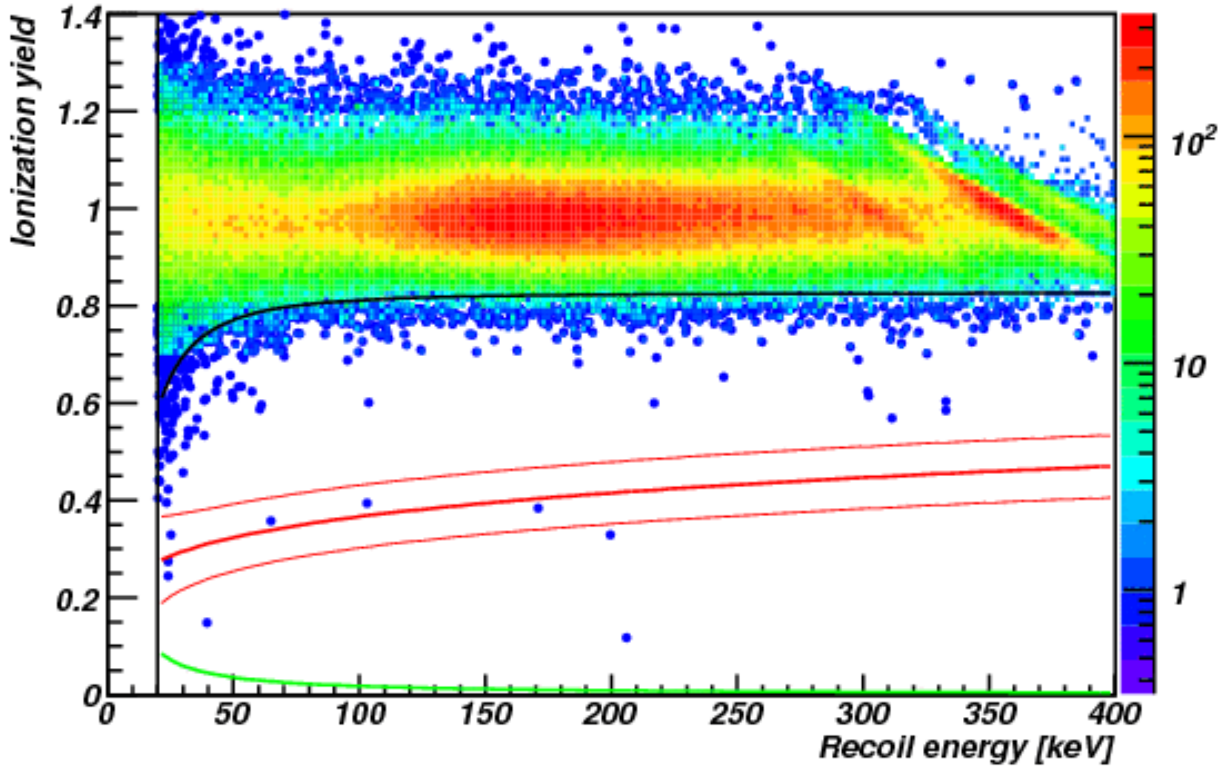
- all IDs stacked
- same analysis/cuts as for bg data
- more than 350000 fiducial evts

→ **Good γ rejection**

~ (3±1)x10^{-5} for 20<E<200keV

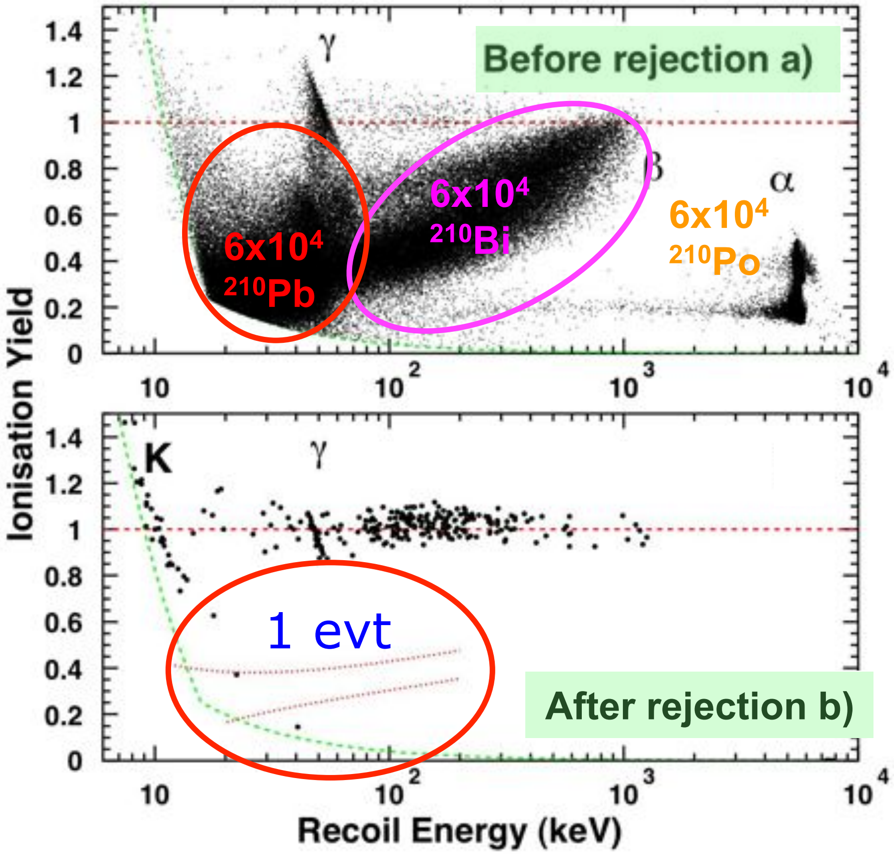
- limited by “anomalous” events
- study of possible mechanisms under way : may be limited by the « dead zone » at the veto-guard interfaces





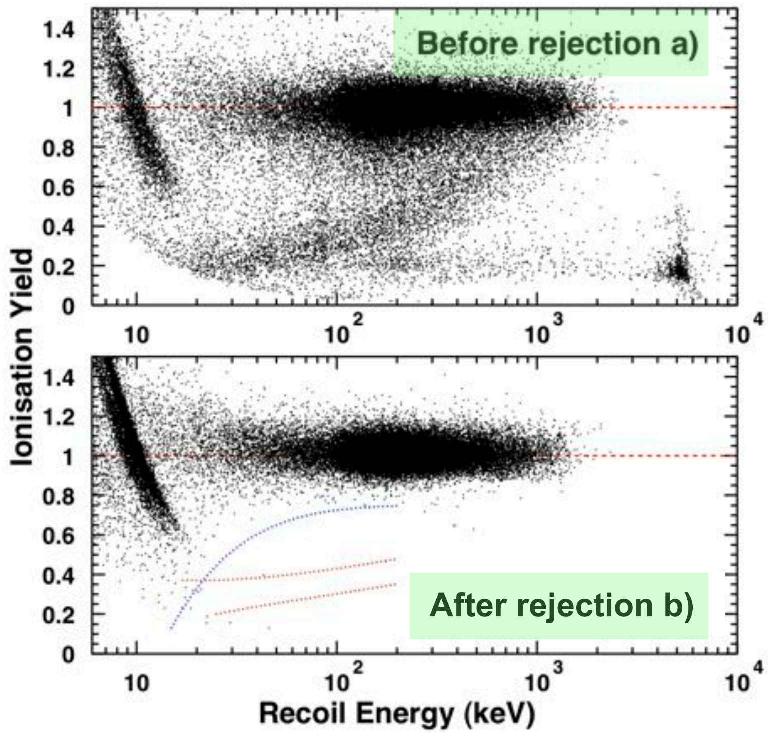
Ionization yield for surface events

^{210}Pb calibration (2008)



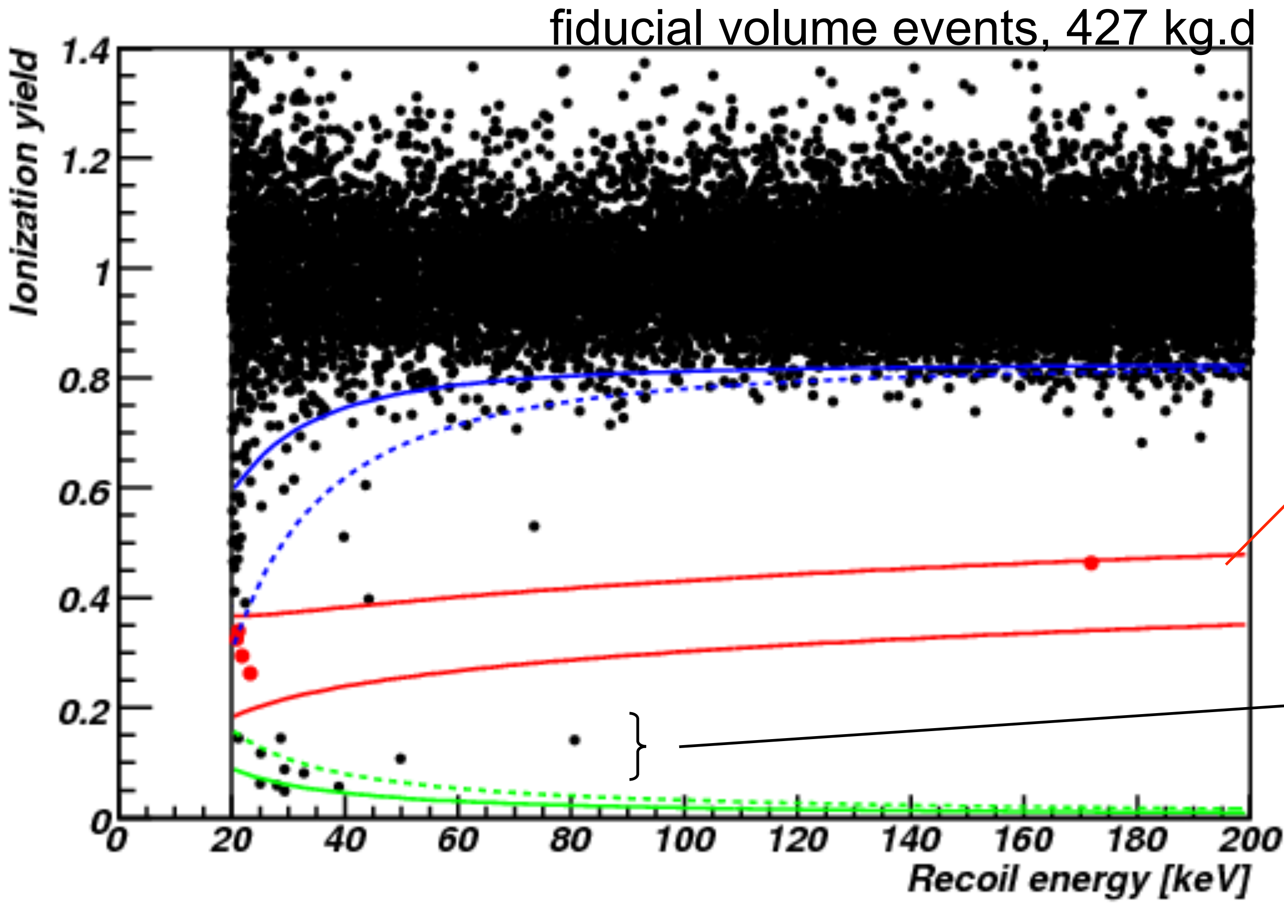
PLB 681 (2009) 305-309 [*arXiv:0905.0753]*

Background data



- Much better than anticipated !

WIMP search : final results



Five WIMP candidates:

- 4 evts: 20.8 < E < 23.2 keV
- 1 evt @ 172 keV

« alpha tail »

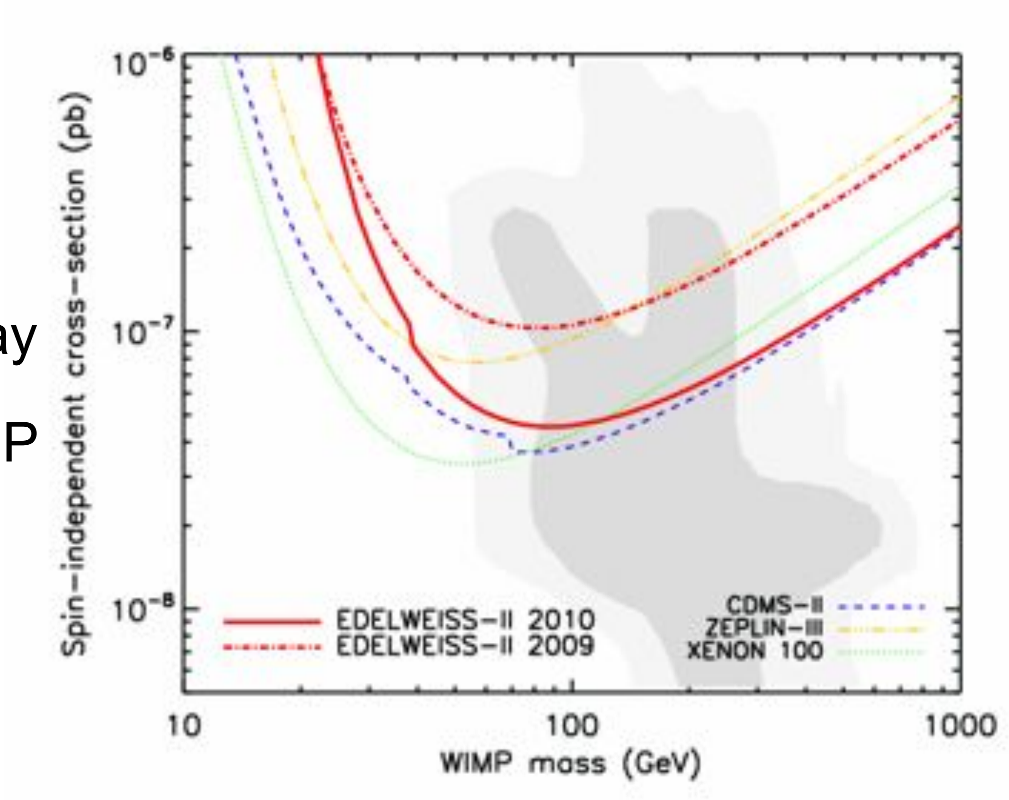
arXiv1103.4070

EDELWEISS II: Results

Preliminary result: *Physics Letters B 687 (2010) 294-298*

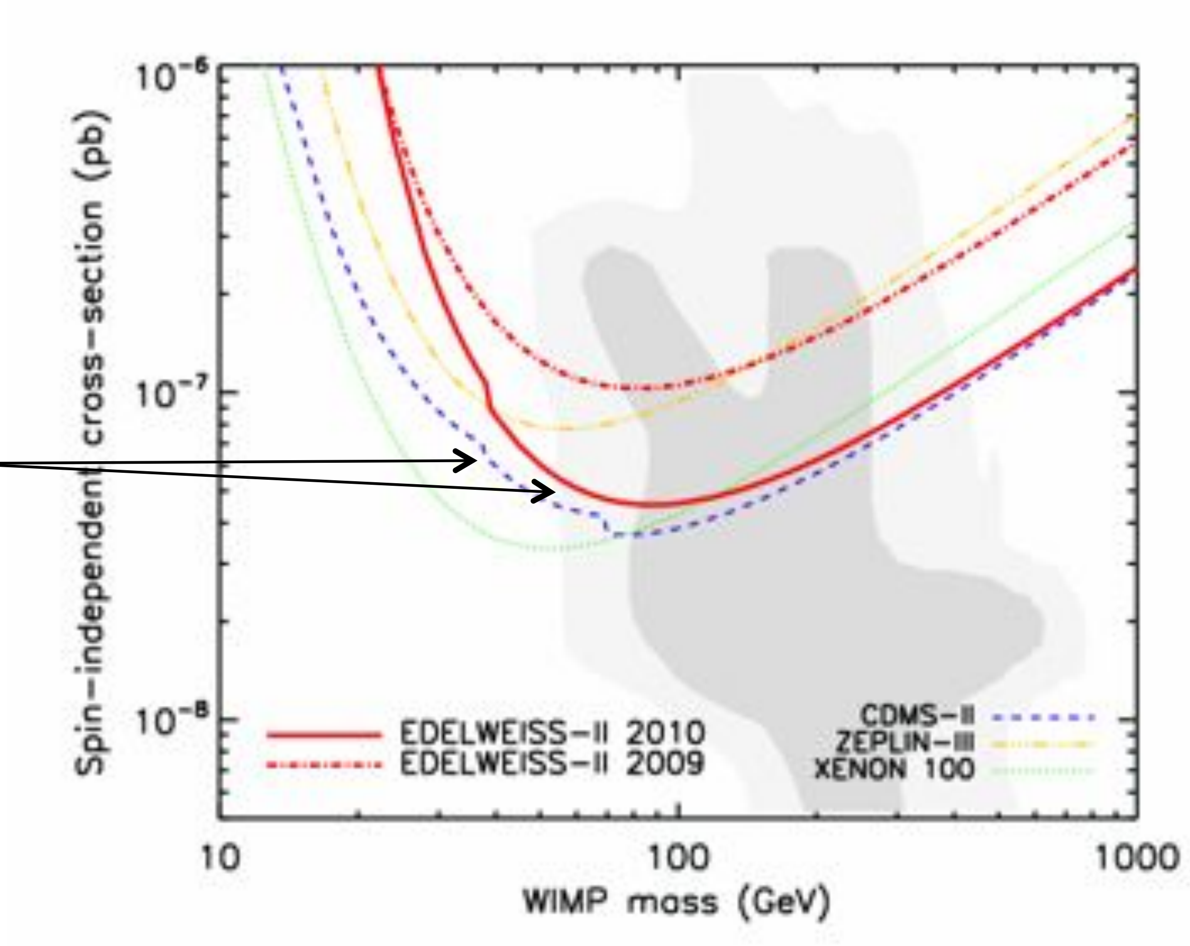
Final result: Submitted to Physics Letters B. *[**arXiv:1103.4070v2**]*

- Run April 2009 - May 2010
  14 months of continuous operation@20mK
  85% duty cycle
- 10 x 400g ID Ge detectors, 384kg day
- 4.4×10^{-8}pb excluded for 85GeV WIMP
- Five nuclear recoil events (above 20keV analysis threshold)
- Background estimate: 3.0 events



Elastic WIMP scattering limits : similar sensitivities from CDMS and EDELWEISS

- Limits very close with identical nucleus : why not combine data ourselves ?



arXiv:1103.4070

Combining Germanium data

arXiv:1105.3377v1 [astro-ph.CO] 17 May 2011

Combined Limits on WIMPs from the CDMS and EDELWEISS Experiments

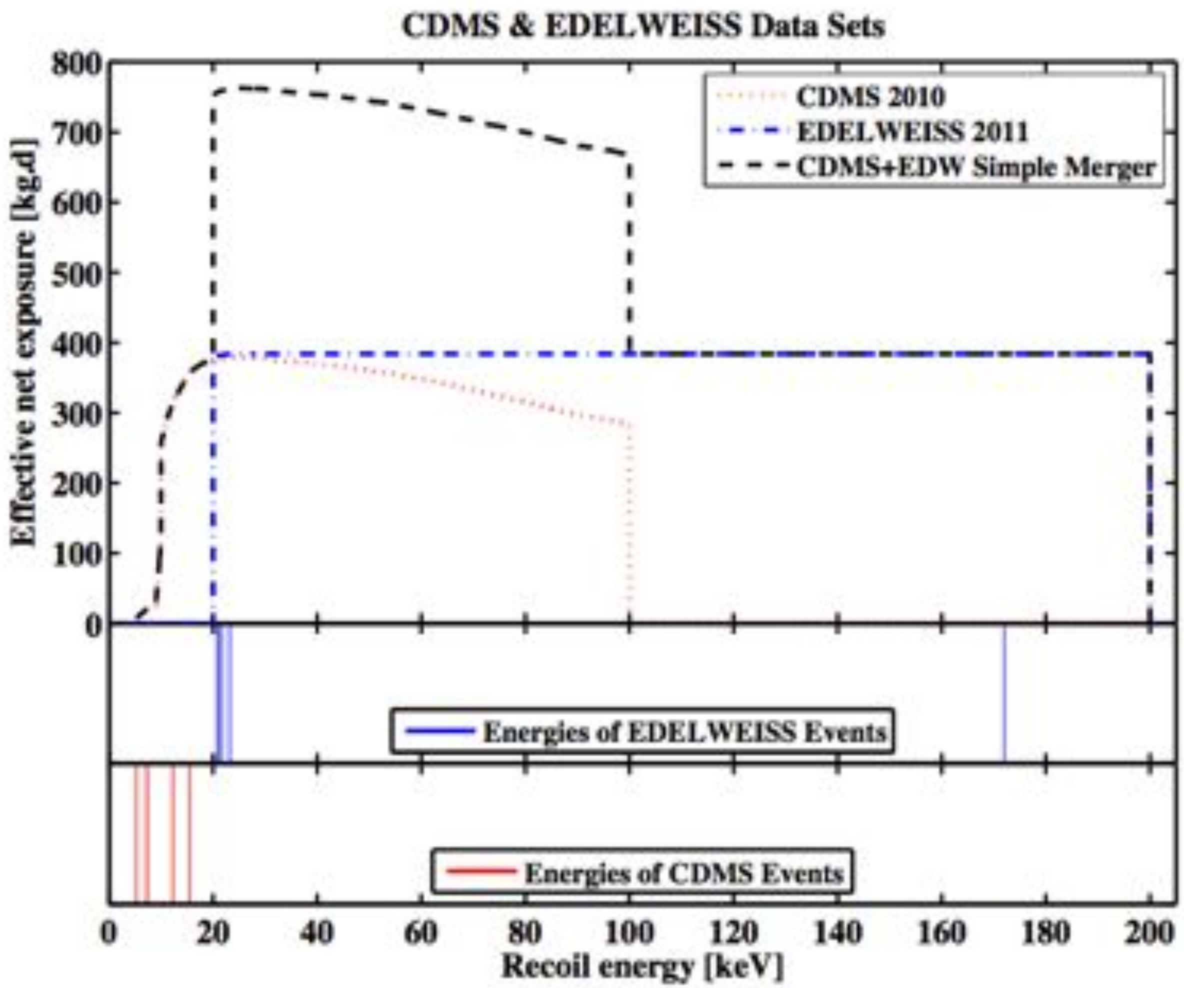
Z. Ahmed,[1] D. S. Akerib,[2] E. Armengaud,[7] S. Arrenberg,[30] C. Augier,[5] C. N. Bailey,[2] D. Balakishiyeva,[28]
L. Baudis,[30] D. A. Bauer,[4] A. Benoît,[14] L. Bergé,[3] J. Blümer,[8,9] P. L. Brink,[18] A. Broniatowski,[3] T. Bruch,[30]
V. Brudanin,[10] R. Bunker,[26] B. Cabrera,[22] D. O. Caldwell,[26] B. Censier,[5] M. Chapellier,[3] G. Chardin,[3]
F. Charlieux,[5] J. Cooley,[21] P. Coulter,[15] G. A. Cox,[8] P. Cushman,[29] M. Daal,[25] X. Defay,[3] M. De Jesus,[5]
F. DeJongh,[4] P. C. F. Di Stefano,[16,5] Y. Dolgorouki,[3] J. Domange,[3,7] L. Dumoulin,[3] M. R. Dragowsky,[2]
K. Eitel,[9] S. Fallows,[29] E. Figueroa-Feliciano,[13] J. Filippini,[1] D. Filosofov,[10] N. Fourches,[7] J. Fox,[16] M. Fritts,[29]
J. Gascon,[5] G. Gerbier,[7] J. Gironnet,[5] S. R. Golwala,[1] M. Gros,[7] J. Hall,[4] R. Hennings-Yeomans,[2] S. Henry,[15]
S. A. Hertel,[13] S. Hervé,[7] D. Holmgren,[4] L. Hsu,[4] M. E. Huber,[27] A. Juillard,[5] O. Kamaev,[16] M. Kiveni,[23]
H. Kluck,[9] M. Kos,[23] V. Kozlov,[9] H. Kraus,[15] V. A. Kudryavtsev,[17] S. W. Leman,[13] S. Liu,[16] P. Loaiza,[11]
R. Mahapatra,[24] V. Mandic,[29] S. Marnieros,[3] C. Martinez,[16] K. A. McCarthy,[13] N. Mirabolfathi,[25] D. Moore,[1]
P. Nadeau,[16] X-F. Navick,[7] H. Nelson,[26] C. Nones,[7] R. W. Ogburn,[22] E. Olivieri,[3] P. Pari,[6] L. Pattavina,[5]
B. Paul,[7] A. Phipps,[25] M. Pyle,[22] X. Qiu,[29] W. Rau,[16] A. Reisetter,[29,19] Y. Ricci,[16] M. Robinson,[17] S. Rozov,[10]
T. Saab,[28] B. Sadoulet,[12,25] J. Sander,[26] V. Sanglard,[5] B. Schmidt,[8] R. W. Schnee,[23] S. Scorza,[21,5]
D. N. Seitz,[25] S. Semikh,[10] B. Serfass,[25] K. M. Sundqvist,[25] M. Tarka,[30] A. S. Torrento-Coello,[7] L. Vagneron,[5]
M.-A. Verdier,[16,5] R. J. Walker,[7] P. Wikus,[13] E. Yakushev,[10] S. Yellin,[22,26] J. Yoo,[4] B. A. Young,[20] and J. Zhang[29]
(The CDMS and EDELWEISS Collaborations)

[1] Division of Physics, Mathematics & Astronomy, California Institute of Technology, Pasadena, CA 91125, USA
[2] Department of Physics, Case Western Reserve University, Cleveland, OH 44106, USA
[3] CSNSM, Université Paris-Sud, IN2P3-CNRS, bat 108, 91405 Orsay, France
[4] Fermi National Accelerator Laboratory, Batavia, IL 60510, USA
[5] IPNL, Université de Lyon, Université Lyon 1, CNRS/IN2P3, 4 rue E. Fermi 69622 Villeurbanne cedex, France
[6] CEA, Centre d'Etudes Saclay, IRAMIS, 91191 Gif-Sur-Yvette Cedex, France
[7] CEA, Centre d'Etudes Saclay, IRFU, 91191 Gif-Sur-Yvette Cedex, France
[8] Karlsruhe Institute of Technology, Institut für Experimentelle Kernphysik, Gaedestr. 1, 76128 Karlsruhe, Germany
[9] Karlsruhe Institute of Technology, Institut für Kernphysik, Postfach 3640, 76021 Karlsruhe, Germany
[10] Laboratory of Nuclear Problems, JINR, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia
[11] Laboratoire Souterrain de Modane, CEA-CNRS, 1125 route de Bardonnèche, 73500 Modane, France
[12] Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
[13] Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
[14] CNRS-Néel, 25 Avenue des Martyrs, 38042 Grenoble cedex 9, France
[15] University of Oxford, Department of Physics, Keble Road, Oxford OX1 3RH, UK
[16] Department of Physics, Queen's University, Kingston, ON, Canada, K7L 3N6
[17] Department of Physics and Astronomy, University of Sheffield, Hounsfield Road, Sheffield S3 7RH, UK
[18] SLAC National Accelerator Laboratory/KIPAC, Menlo Park, CA 94025, USA
[19] Department of Physics, St. Olaf College, Northfield, MN 55057 USA
[20] Department of Physics, Santa Clara University, Santa Clara, CA 95053, USA
[21] Department of Physics, Southern Methodist University, Dallas, TX 75275, USA
[22] Department of Physics, Stanford University, Stanford, CA 94305, USA
[23] Department of Physics, Syracuse University, Syracuse, NY 13244, USA
[24] Department of Physics, Texas A & M University, College Station, TX 77843, USA
[25] Department of Physics, University of California, Berkeley, CA 94720, USA
[26] Department of Physics, University of California, Santa Barbara, CA 93106, USA
[27] Departments of Phys. & Elec. Engr., University of Colorado Denver, Denver, CO 80217, USA
[28] Department of Physics, University of Florida, Gainesville, FL 32611, USA
[29] School of Physics & Astronomy, University of Minnesota, Minneapolis, MN 55455, USA
[30] Physics Institute, University of Zürich, Winterthurerstr. 190, CH-8057, Switzerland

(Dated: May 18, 2011)

CDMS+EDELWEISS : the data

- "Simple merger method"
- More sophisticated ones also used in paper
- Quite good spirit and efficiency to complete analysis in few months

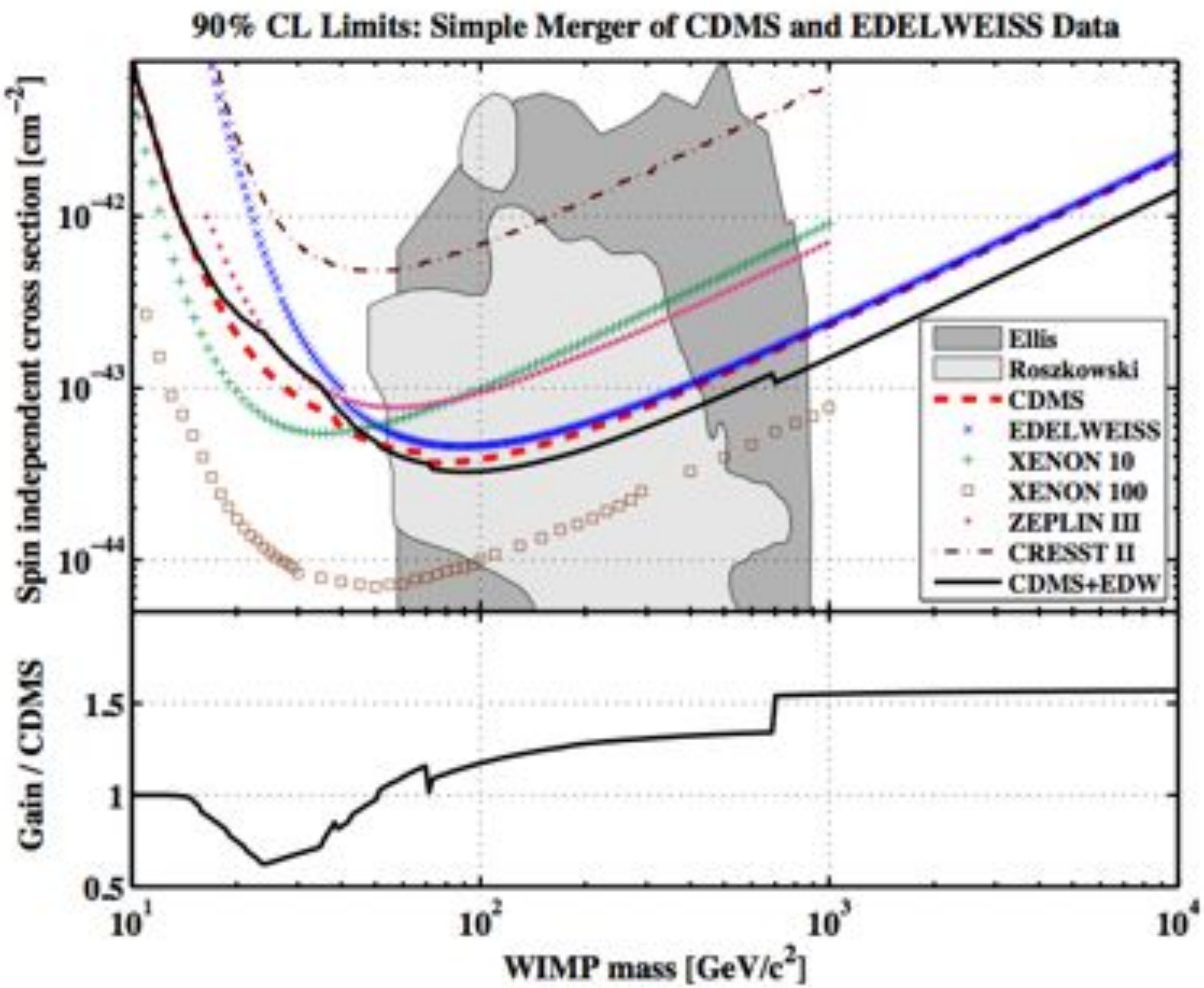


CDMS+EDELWEISS : the limits

1 TeV:
x2 behind **XENON 100**

100 GeV:
x3 behind **XENON 100**

Below 70 GeV:
>x5 behind **XENON 100**



What's next : The EDELWEISS-III project

Goal :

- Reach ~5 x10^{-9} pb region by 2012
- Allow reliable cross-check in case of signal by other experiment
- Preparation for 1-ton EURECA phase

Detectors : operate 32 fid kg by mid 2012 (Run 12 = 1.6 kg)

- New FID800 detectors : bigger Fid Mass, Heat redundancy (higher γ rejection), Fid segmentation, new surface treatment (higher β rejection)

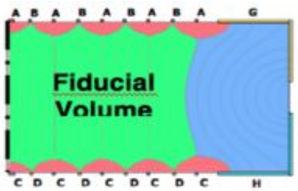
Upgrade

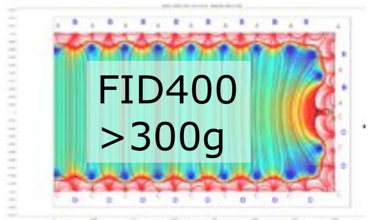
- Cryogenics better threshold
- Electronics with fast channel digitization and acq soft update better discrimination
- Wiring for 112 channels (now 56) with 1 diff. heat and 4 ionization each
- **Shielding (internal PE) + μ veto : decrease the neutron background**

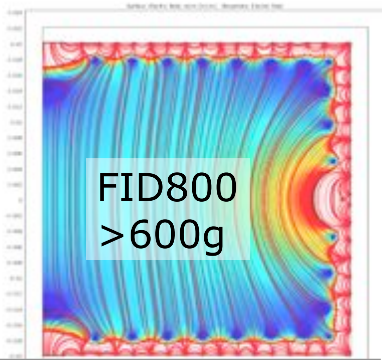
Next step: EDELWEISS III

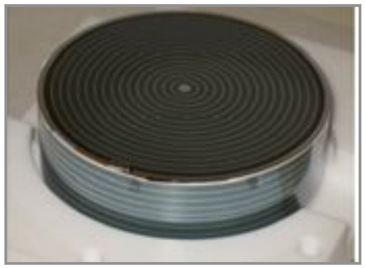
Doubling/Quadrupling the fiducial mass:
ID400 => FID400 => FID800

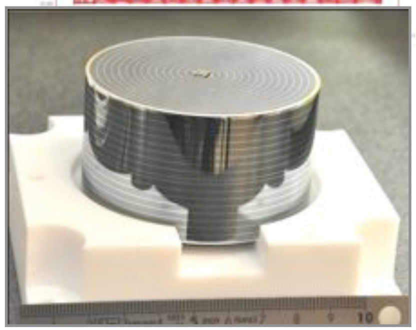
ID400 (160g)











Goals: with FIDs 400+800g program, continue
doubling of accumulated exposure every year

2011/12 => 1000 kg.d

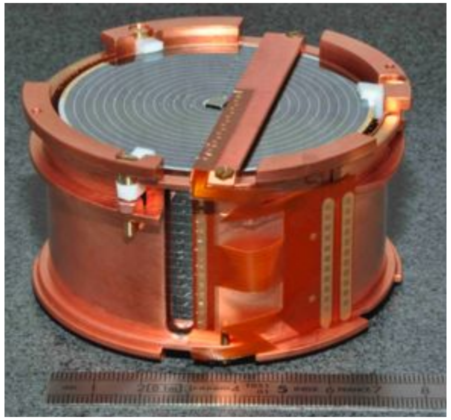
2013 => 3000 kg.d

EDELWEISS-III : The FID800 detector

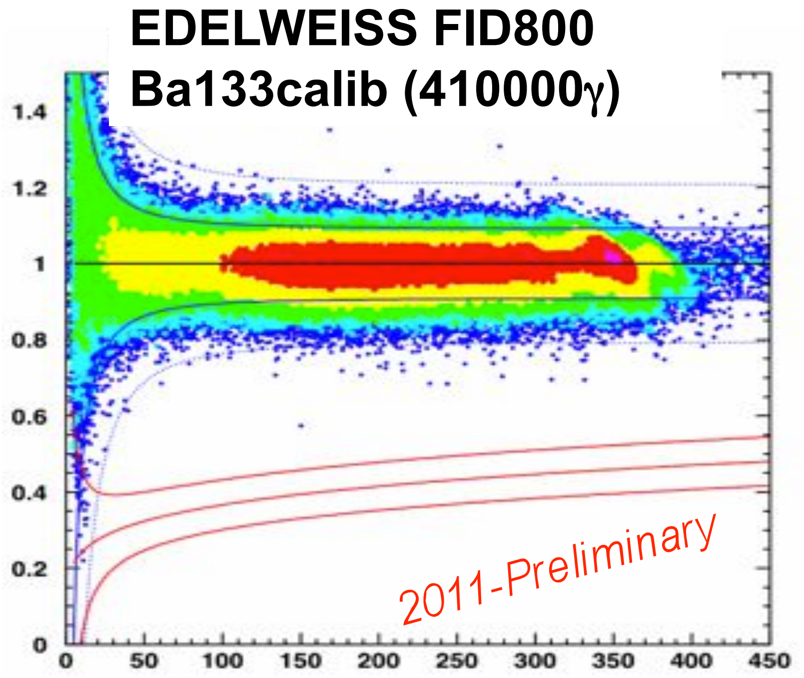
→ Increase mass + sensitivity :

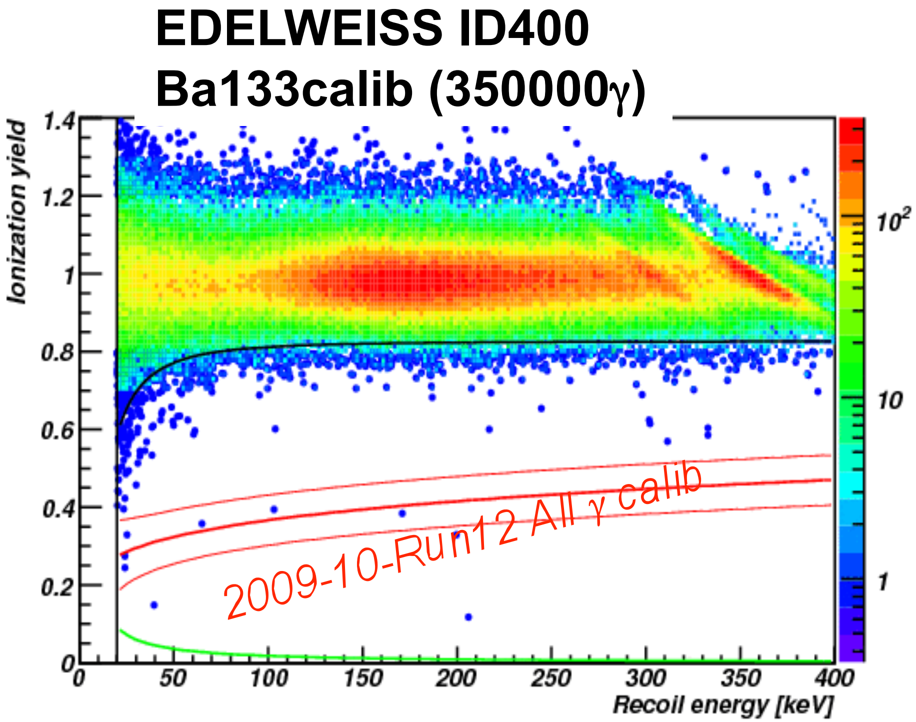
- 800g crystal
- 2 NTDs sensors per detector
- interleaved electrodes on all the surface : no « guard » region anymore,

~ 80% fiducial volume



→ 8 detectors already in commissioning





→ γ rejection looks much better than for ID400

EURECA

Timeline:

2010/2011: Design Study → TDR

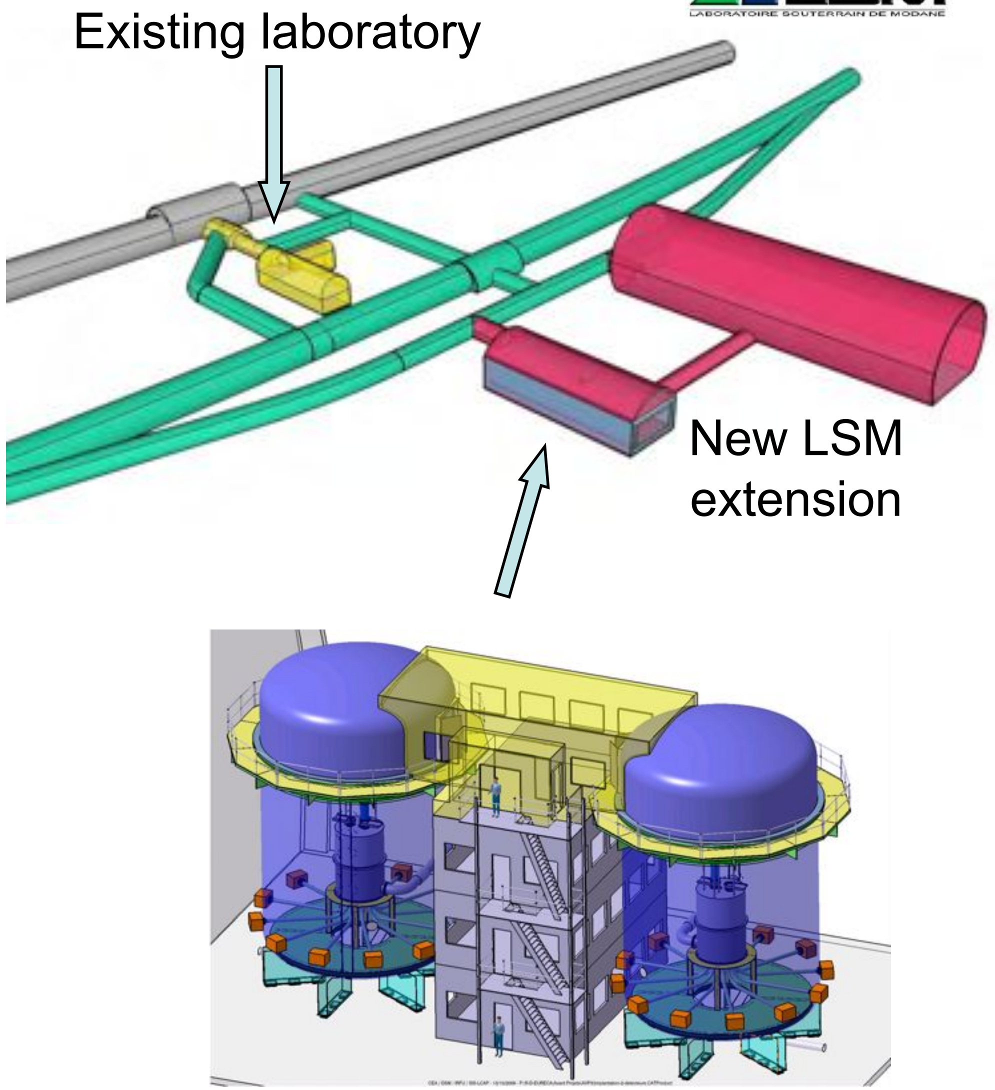
2011/12: Digging out of LSM extension begins. In parallel, begin construction of EURECA components away from LSM. Aim for ~100kg stage (10^{-10} pb).

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



Possible EURECA Facility Layout

Summary & prospects

- **EDW new-generation ID detectors:**
  - interleaved electrodes allow surface event rejection
  - robust detectors with redundancy and excellent beta rejection
  - final analysis of >1 year data
    - Nuclear recoil 5
    - 4.4 x10^{-8} pb excluded for m=85GeV

- **new EDW-3 goal: 5 x 10^{-9} pb**
  - improvements wrt to background
    - increased redundancy for ionisation and heat measurements
    - fast readout (multisite, pileup)
    - lower microphonics,
    - PE shield
  - new FID 800g 2011/12 ➔ 1000 kg.d
  - build&install 40 detectors set-up
    - 2013 ➔ 3000 kg.d
- **EURECA:** (10^{-10}pb)

Backup

EDELWEISS II Background estimate

- Gamma:
  - -Total 1.8×10^4 events in electron recoil band (20-200keV)
  - - Assuming gaussian statistics, no nuclear recoil candidate due to statistical fluctuation expected
  - - Non gaussianities ? Systematics ? => estimation by calibration data ^{133}Ba gamma calibrations
  - $\rightarrow 3\times10^{-5}$ leakage into nuclear recoil band → **0.9 events**
- Beta: Surface events – 5000 events, rejection factor 6×10^{-5} → **0.3 events**
- Muon induced events missed by veto → **0.4 events**
- Neutrons:
  - - from rock – GEANT4 simulations → **0.11 events**
  - - from contaminants in shield/cryostat → **0.21 events**
  - - from cabling inside cryostat → **1.1 events**

Total background estimate : 3.0 events