Latest results of EDELWEISS-II

using Ge cryogenic detectors with interleaved electrodes

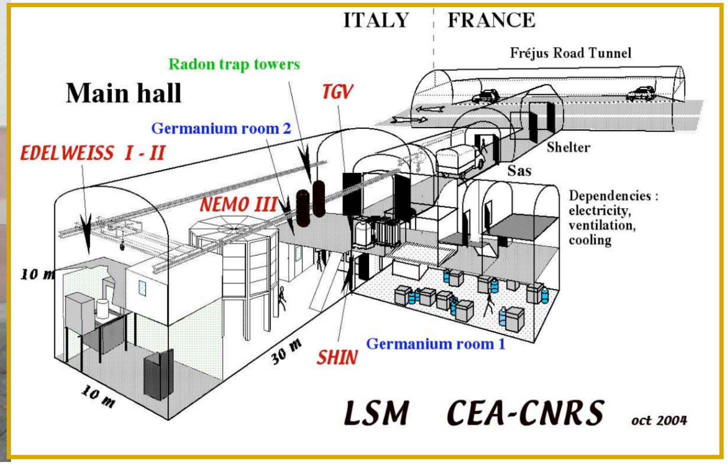
Identification of Dark Matter

Montpellier, 26 July 2010

Eric Armengaud - CEA / IRFU

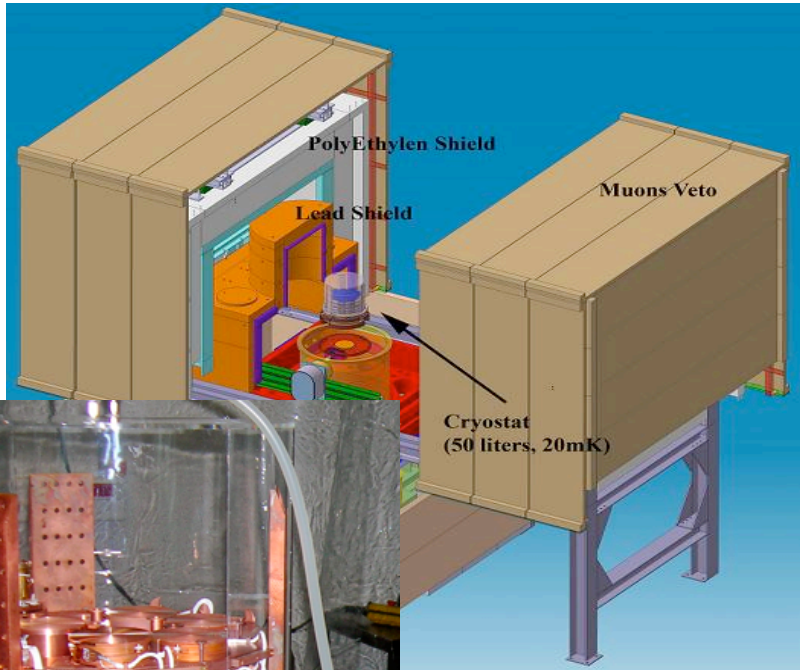
The EDELWEISS collaboration

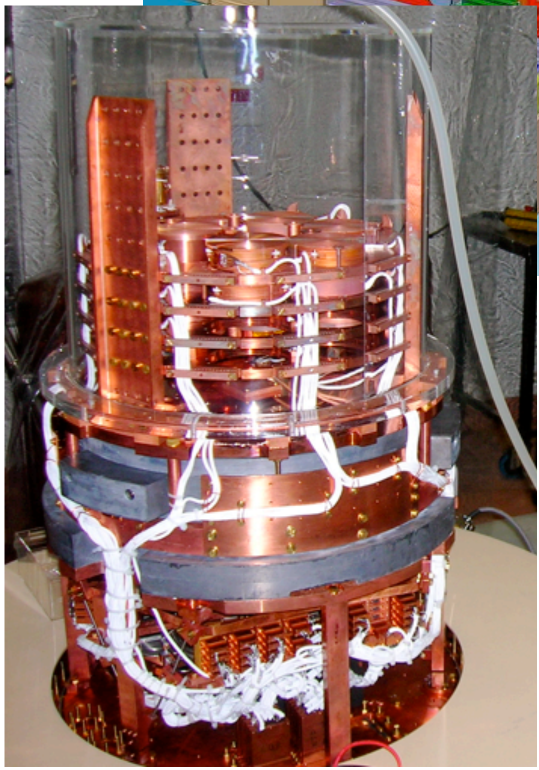
Karlsruhe - oct 09



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. (2009)	**Detectors, cabling, cryogenics, analysis**
Sheffield Univ. (2010)	**MC simulation**

The Edelweiss-II setup



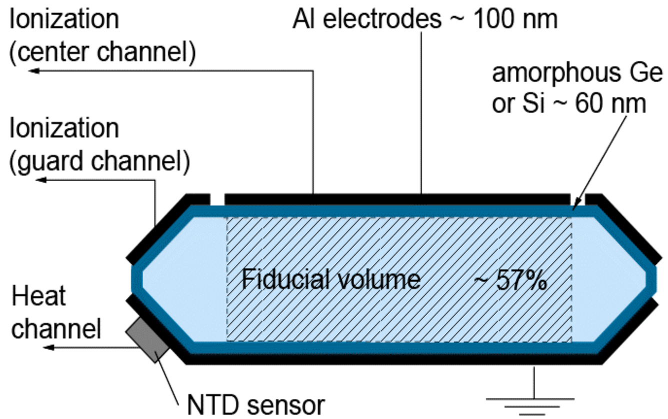


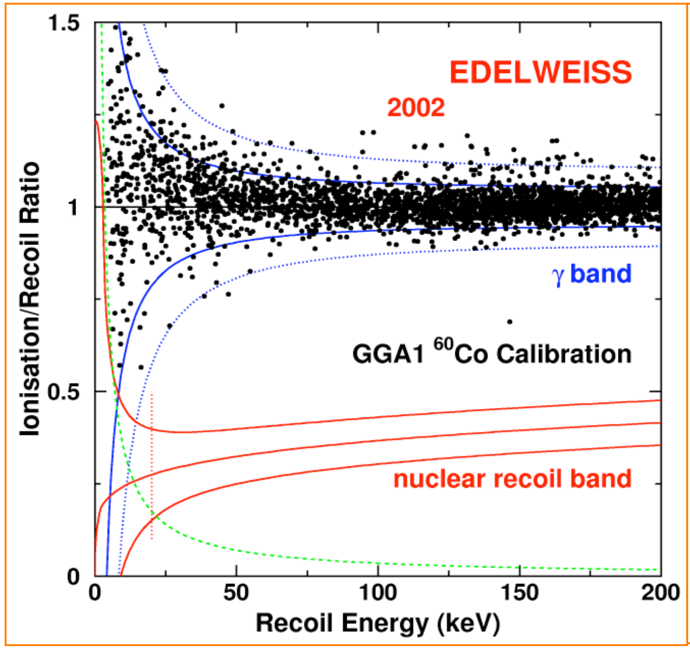
- Operated at the Underground Laboratory of Modane (4µ/day/m^2) - deeper than Soudan
- **Goal 5x10^{-9} pb**
- Cryogenic installation (18 mK) :
  - Reversed geometry cryostat, pulse tubes
  - Remotely controlled
  - **Can host up to 40kg of detectors**
- Shieldings :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - PE shield
  - Lead shield

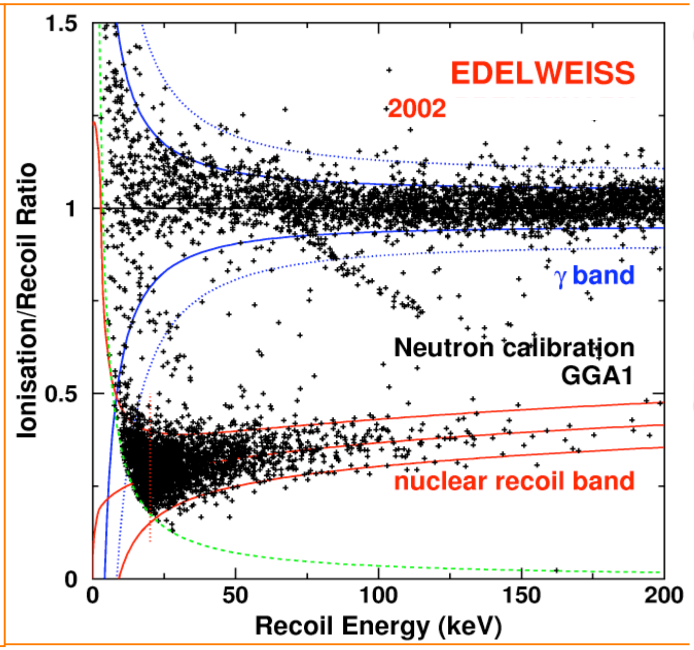
  ⇒ γ background reduced by ~3 wrt EDW1
- (Many) others :
  - Remotely controlled sources for calibrations + regenerations
  - Detector storage & repair within the clean room
  - **Radon detector down to few mBq/m^3**
  - **He3 neutron detector (thermal neutron monitoring)**
  - **liquid scintillator neutron counter (study of muon induced neutrons)**
- 12 cool-downs already operated

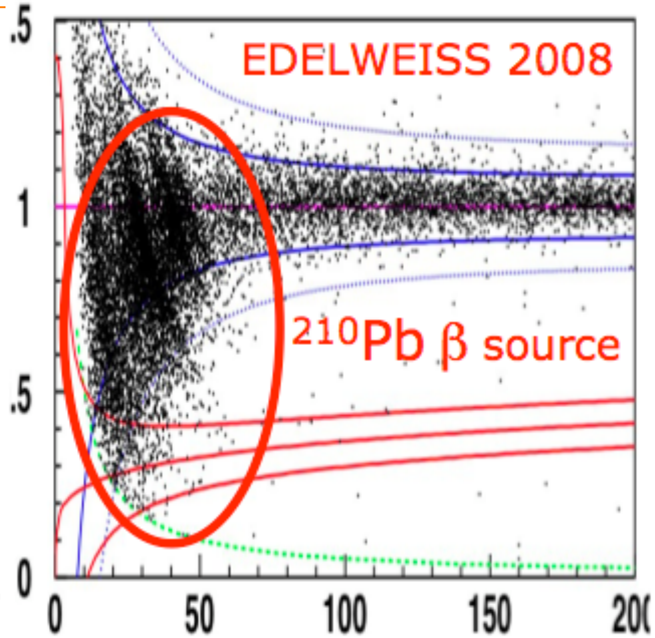
Edelweiss-I detectors

- Germanium bolometers
- Ionization measurement @ few V/cm
- Heat measurement (**NTD sensor**) @ 20 mK
- *Discriminating variable between electronic and nuclear recoils :* « Q » ~ ionization/heat
- **Limitation : surface interactions**

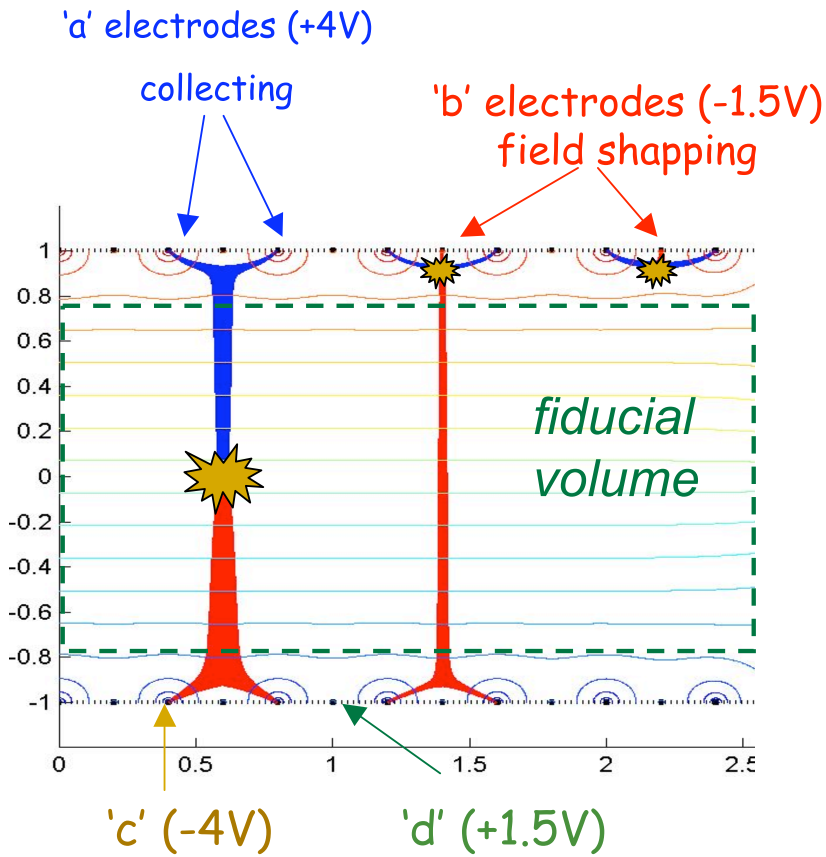




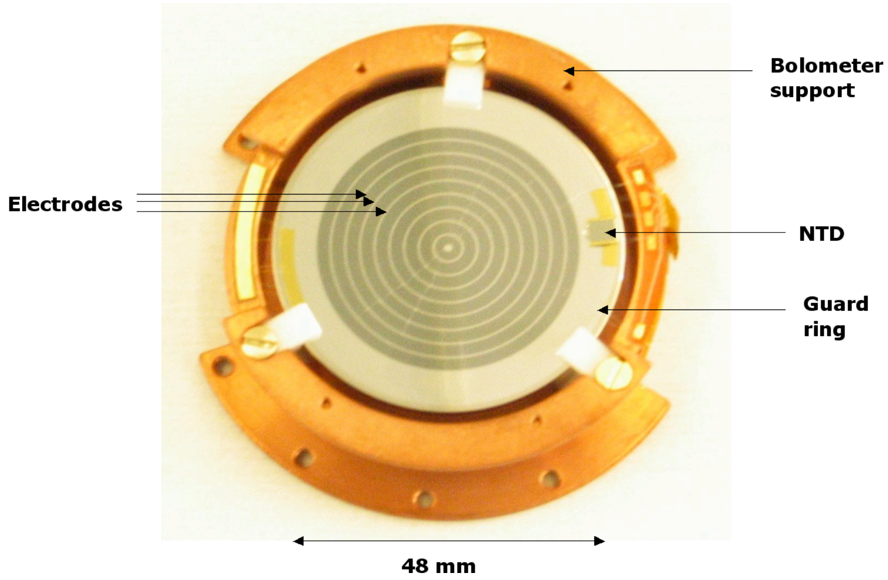




Rejecting surface events with interleaved electrodes



the « ID » (interdigit) detector



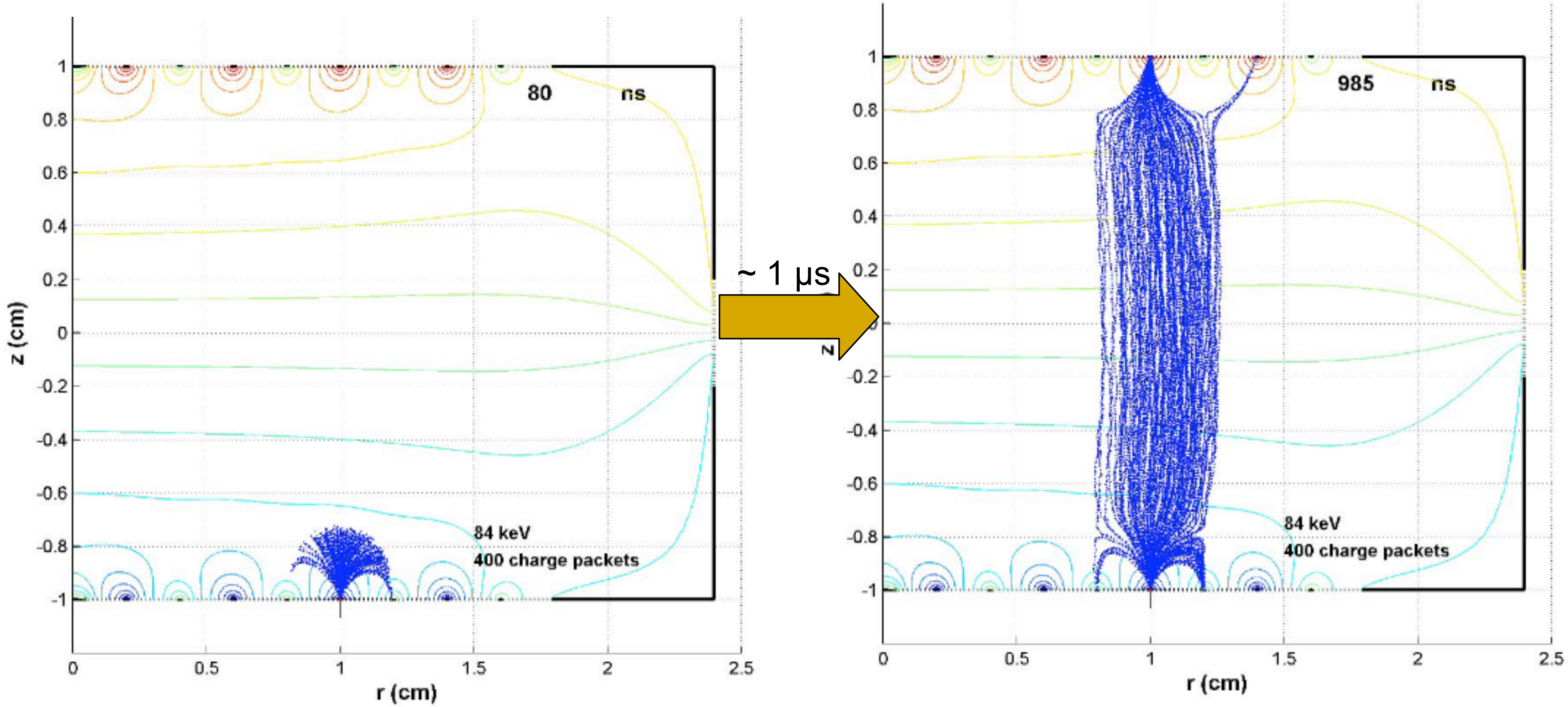
- Keep the EDW-I NTD phonon detector
- Modify the E field near the surfaces with interleaved electrodes
- Use 'b' and 'd' signals as vetos against surface events

First detector built 2007
1x200g + 3x400g tested in 2008
10x400g running 1 year 2009-2010

Charge propagation in an InterDigit detector

• Initial expansion of the charge cloud due to Coulomb interactions is sufficient to generate charges in the vetos even in
  - regions of low electric field
  - regions just under the collecting electrodes

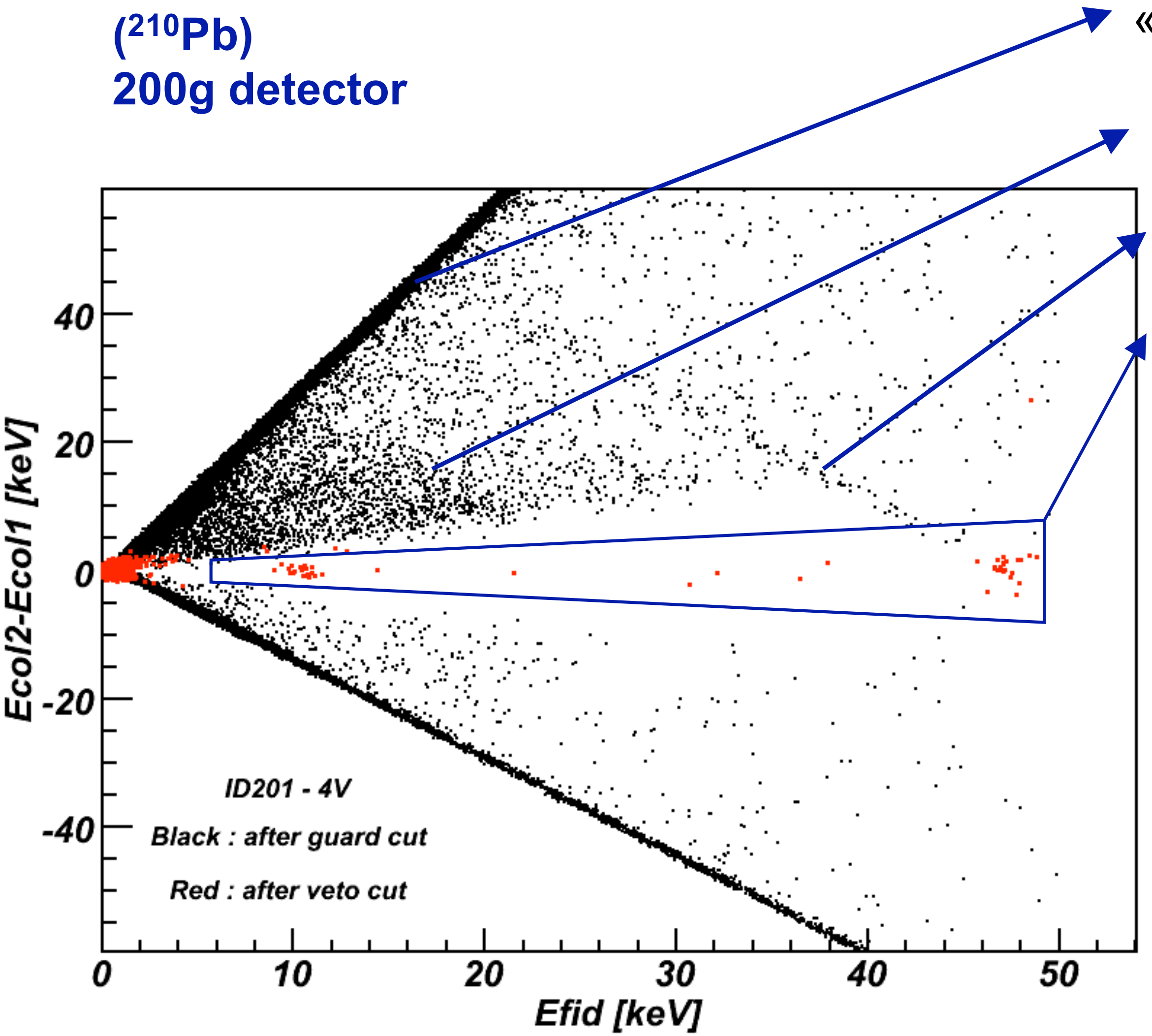
[PLB 681 2009 305]



Simulation : interaction under a collecting electrode
(no anisotropy effect taken into account)

An outstanding surface event discrimination with IDs

Beta calibration
(^{210}Pb)
200g detector



- *« Veto + guard » cut (red points) + « E2 = E1» criterium (red box) : strong redundancy !*

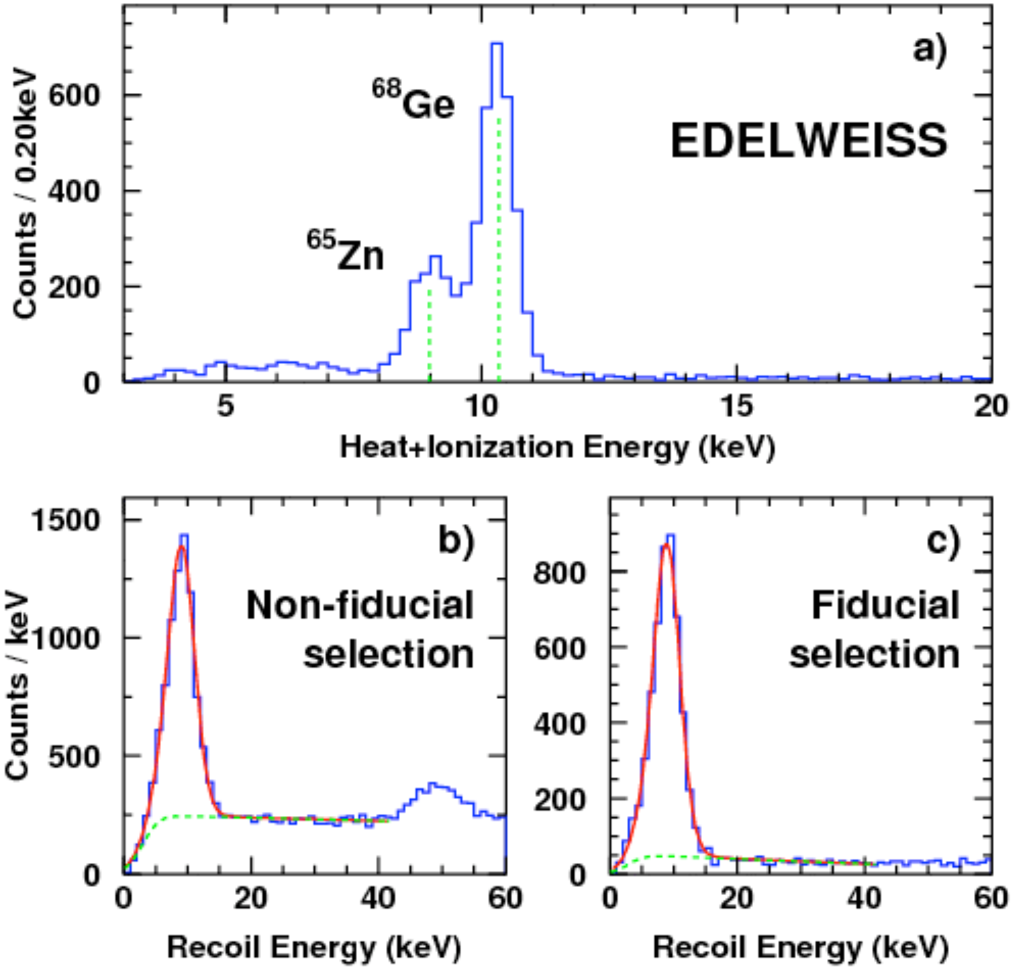
- Surface and volume events are completely separated
- Overall beta rejection ~ 1/10^5

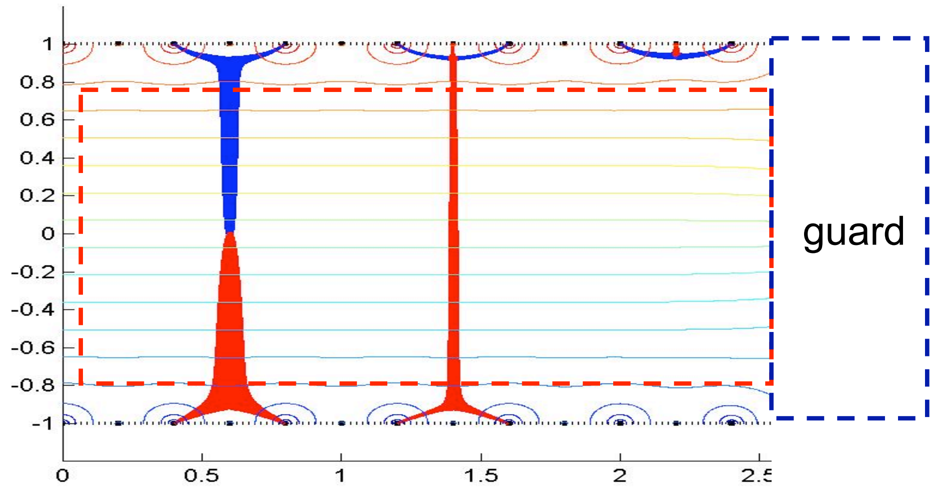
E1 = energy of top collecting electrode
E2 = bottom collecting electrode

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

ID-400g fiducial volume

Data : 9 detectors - background runs





- Estimation with electrostatic models
- Measurement with cosmogenic lines:
  - ^{68}Ge and ^{65}Zn isotope lines at ~10keV, background electron recoil events
  - *Homogeneously distributed in the volume of the cristal*
  - *Real-condition measurement of fiducial cuts efficiencies at low energy in WIMP search conditions (baselines, voltages…)*

Other measurement : using neutron calibration

- **Fiducial volume measurement**

166g ± 6 => 160g, *primarily limited by the guard regions*

WIMP search with ID detectors

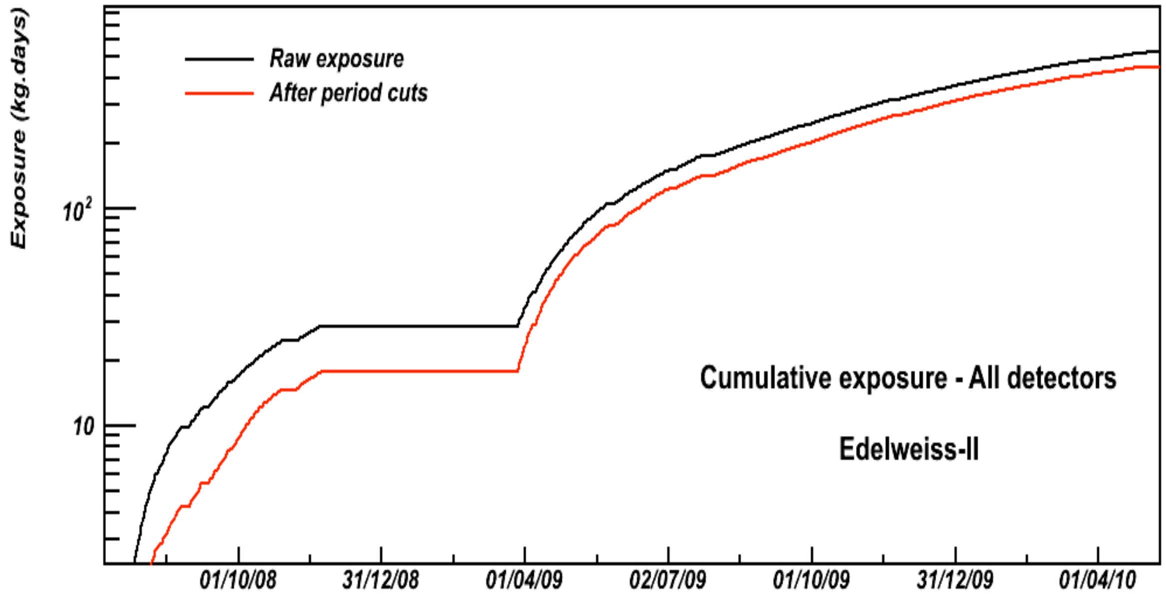
~ 20 kg.d in 2008 during validation runs of ID detectors (2 detectors)

Physics run Apr 2009 - May 2010 (10 detectors) : ~ 300 kg.d

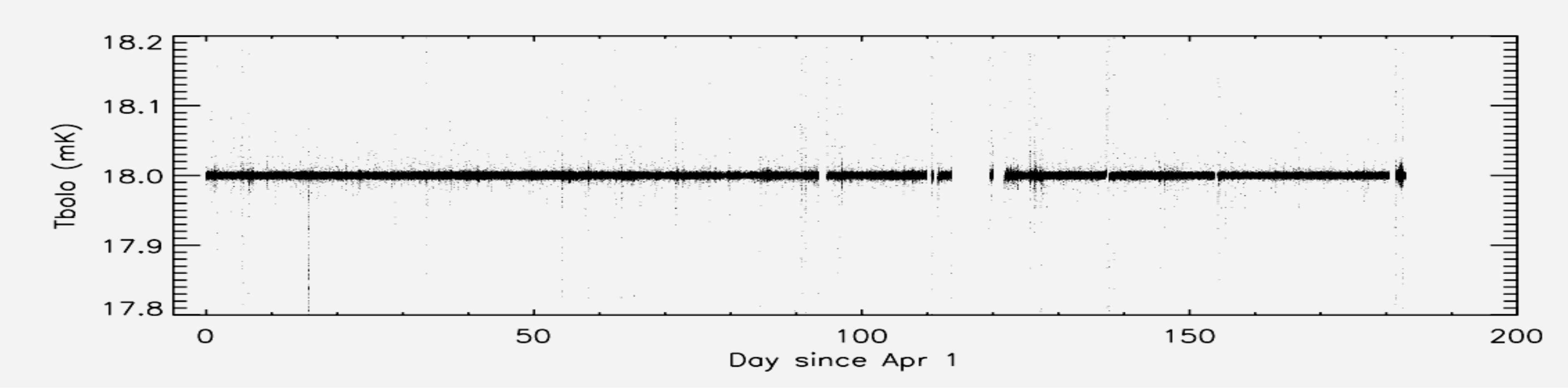
- Published : 2008 + 6 months 2009 = 160 kg.d - ***PLB 687 (2010) 294–298*** **[arXiv:0912.0805]**
- *Preliminary* results of the complete run presented here

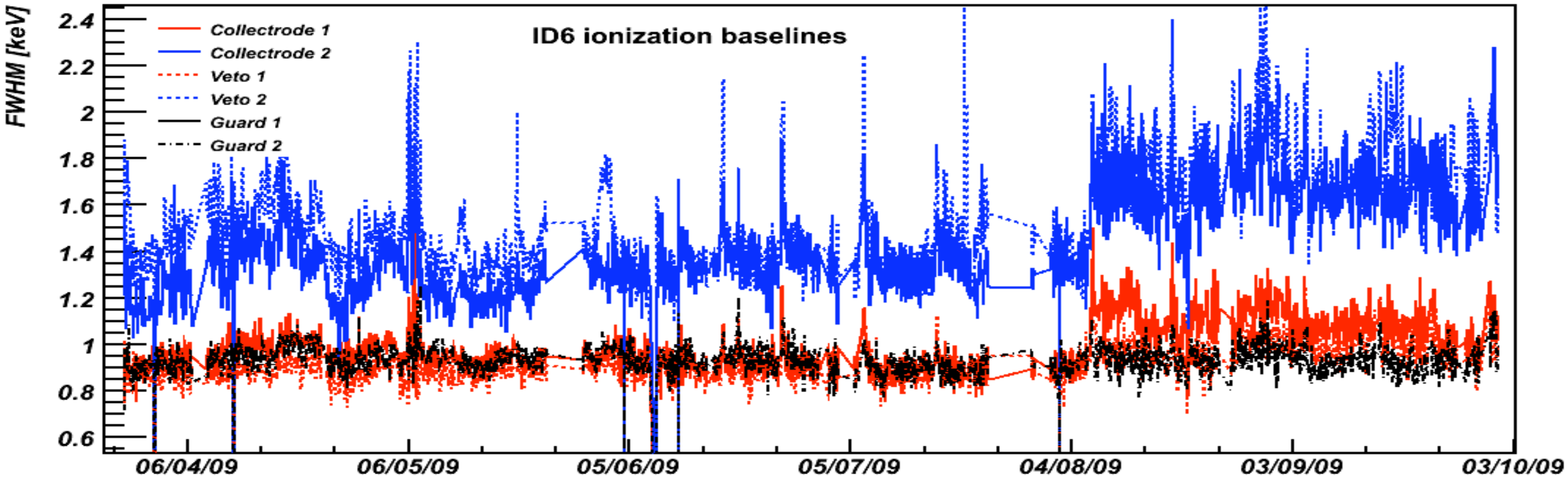
- All detectors working
- 90% electronics channels, 9/10 bolos used in the analysis presented here

- Few days gamma / neutron calibrations



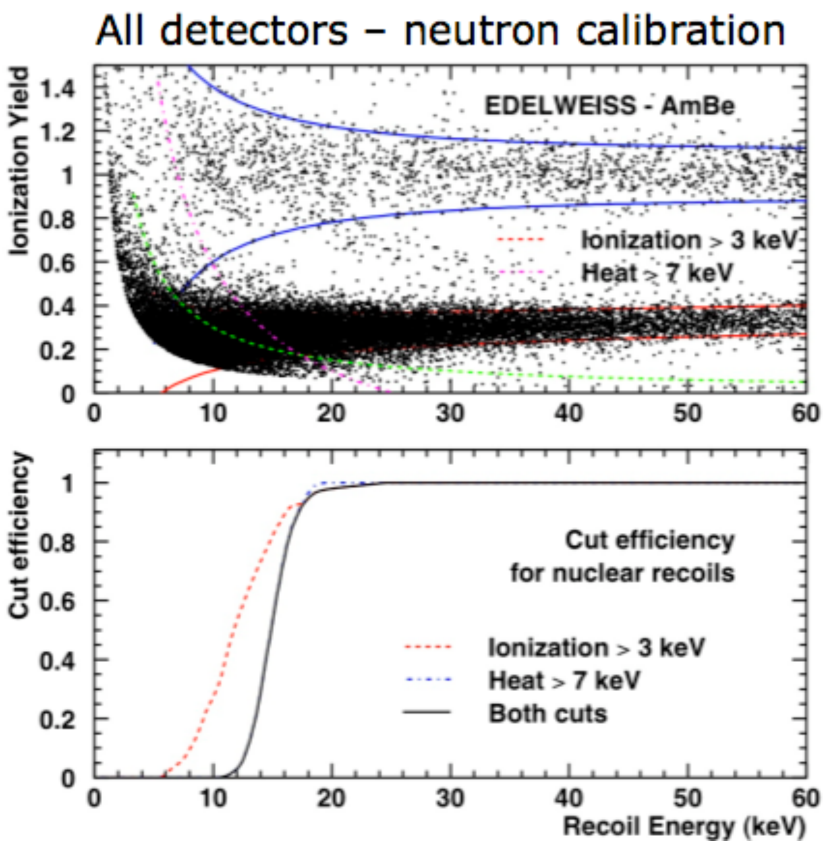
« One of the coldest place in the Universe » …
Continuously at 18 mK during more than 1 year !





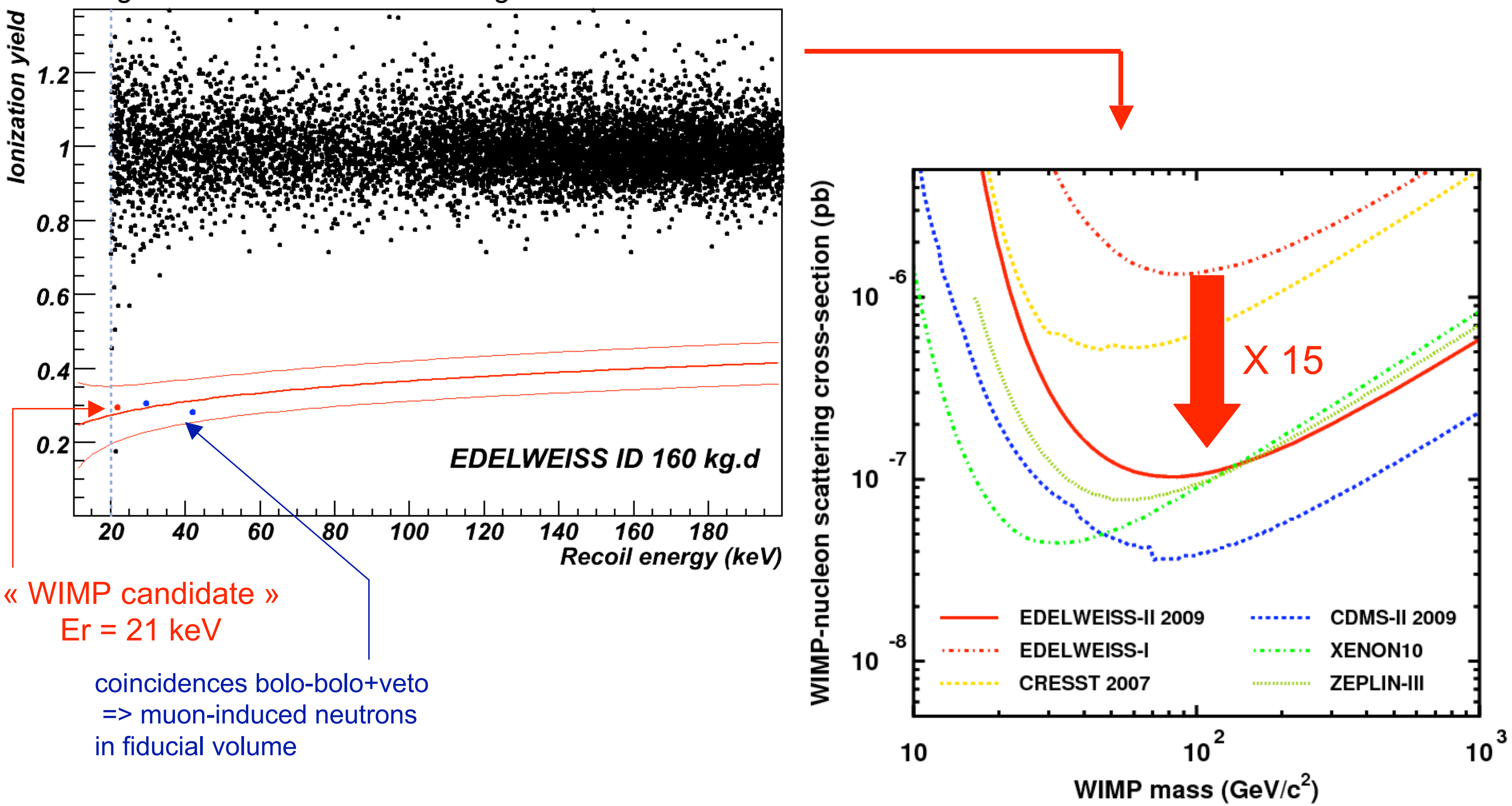
Data analysis of the first 6 months

- 2 independent processing pipelines
- Pulse fits with optimal filtering using instantaneous noise spectra
  - Average baseline resolution heat 1.2 keV, ion 0.9 keV
- Period selection based on baseline noises
  - **80% efficiency**
- Pulse reconstruction quality (chi2)
  - 97%
- Fiducial cuts based on ionization signals (160g)
- 90% nuclear recoil, gamma rejection 99.99%
- Bolo-bolo & bolo-veto coincidence rejection (<1%)
- WIMP search threshold fixed a priori *Er > 20 keV* *(~100% acceptance)*



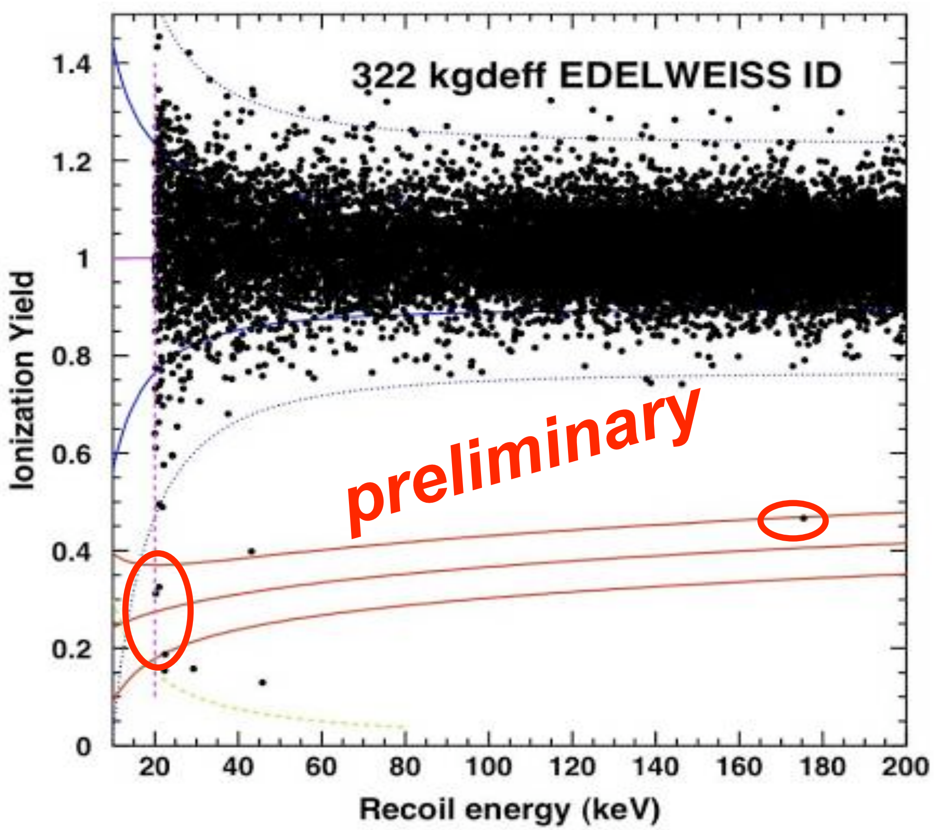
WIMP search : first six month result

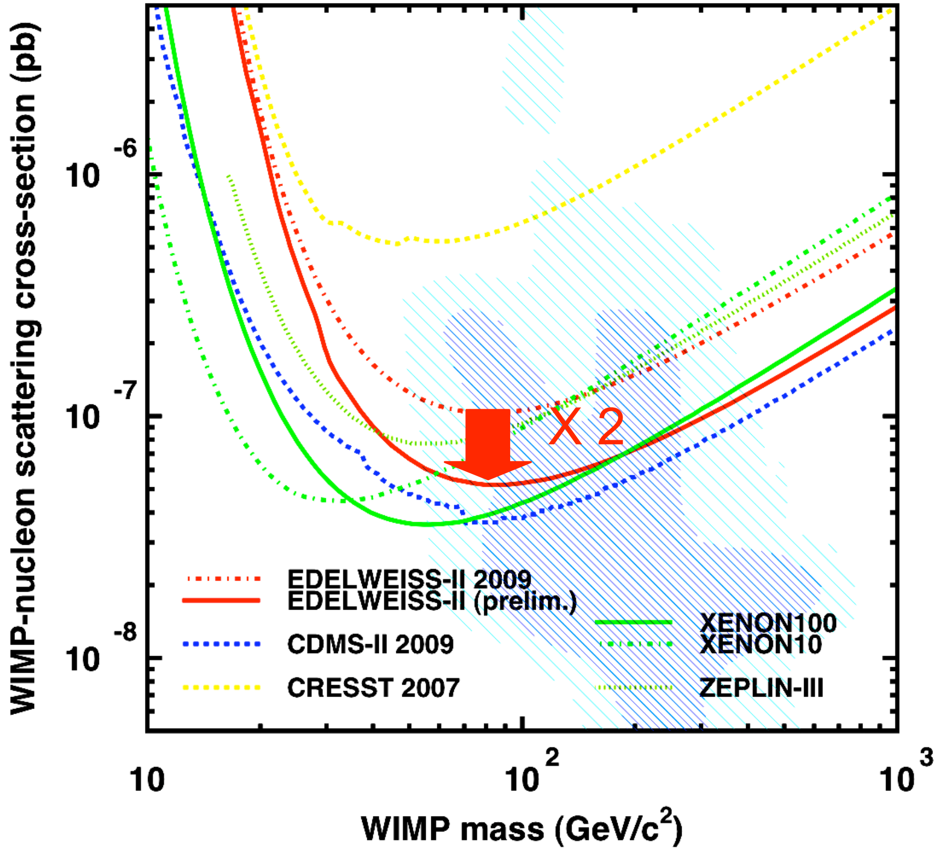
160 kg.d x 90% NR band = 144 kg.d



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

Preliminary results from the complete data set (end of run May 20th 2010)





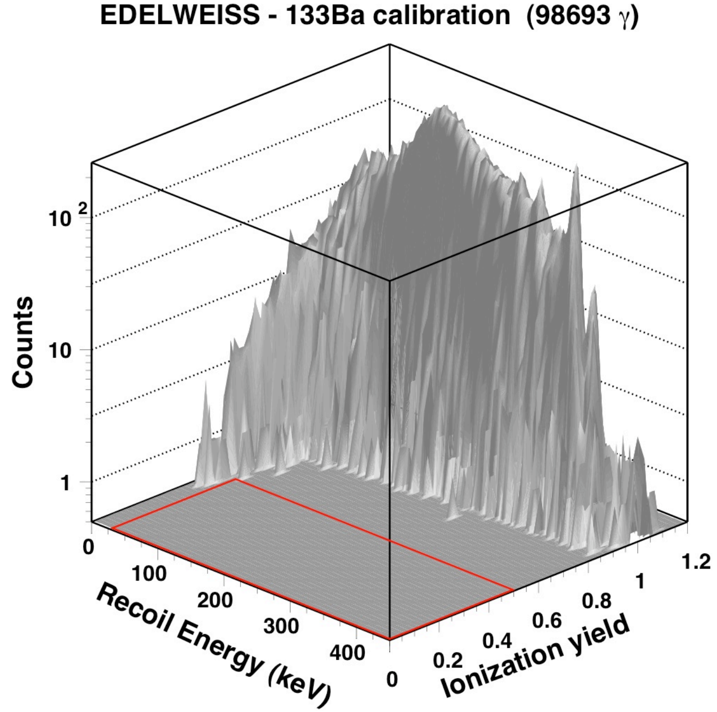
- Results obtained by blindly applying the published analysis to new data.
  - Second analysis ongoing (increase the kgdeff, lower threshold)
- Sensitivity increased by a factor 2 (scale with stat)
  Best limit 5×10^{-8} pb
- **3 evts near threshold in NR band, 2 outliers at higher energies**
  Background starts to appear ?

Background studies : ongoing

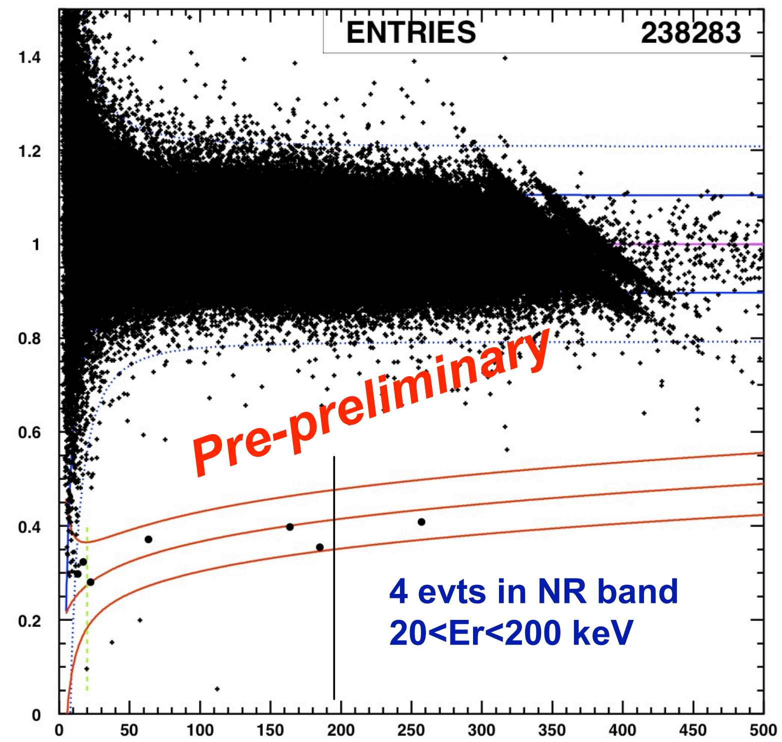
- *Gamma*: ^{133}Ba calib rejection x observed bulk γ <1.0
- *Beta*: β source rejection x observed surface evts <0.2
- *Neutrons from* μ's: μ veto efficiency x observed muons <0.25
- *Neutrons from Pb*: measured U limits x Monte Carlo simu <0.1
- *Neutrons from rock*: measured neutron flux x Monte Carlo simu <0.1
  MC cross-check with outside strong AmBe source

SUM < 1.6 for the whole wimp run (90% CL)

Status of gamma calibrations



With 2 detectors : gaussian behaviour, no candidate event in a first analysis

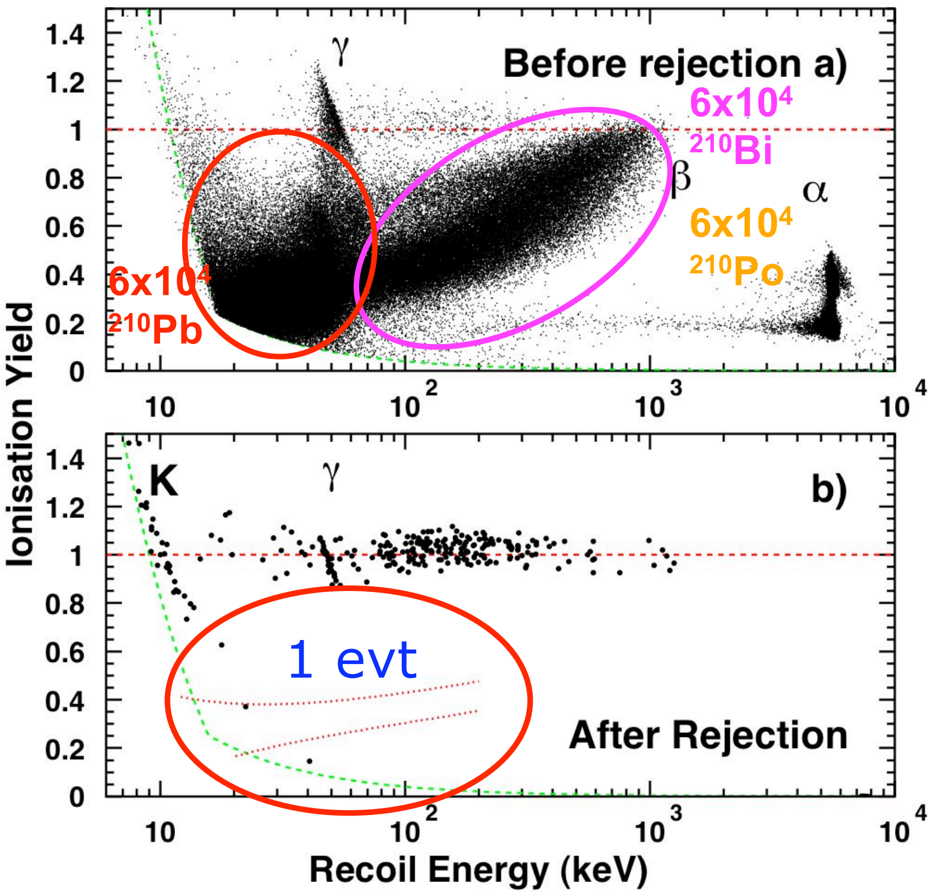


Statistics x 2.5, all 10 detectors : 4 events

- ^{133}Ba calib: 134 000 evts in 20-200 keV ⇒ 0.5 event expected in 16 600 evts in WIMP run
- Knobs to improve
  - Recombination e-h ? optimise operation of polarisation voltages, regeneration procedures
  - Pile up, multisite events ? fast readouts on ionisation, 2 NTD heat measurements, segmentation

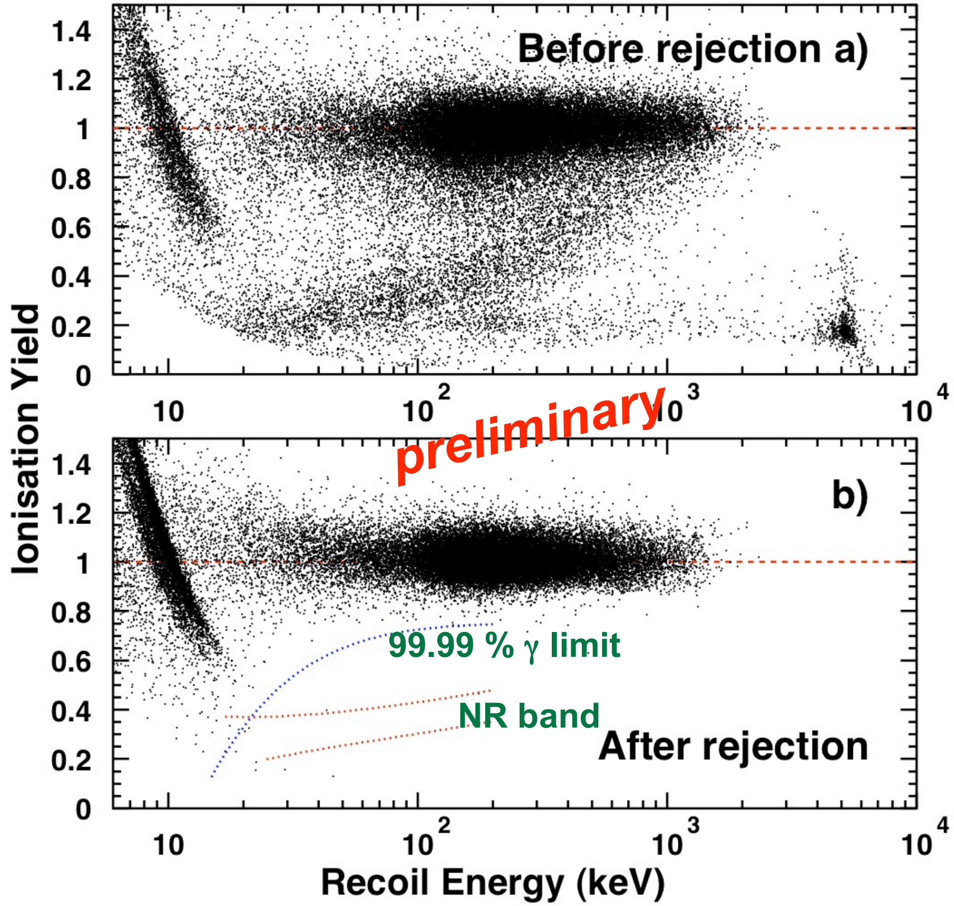
Beta calibrations & backgrounds

^{210}Pb calibration



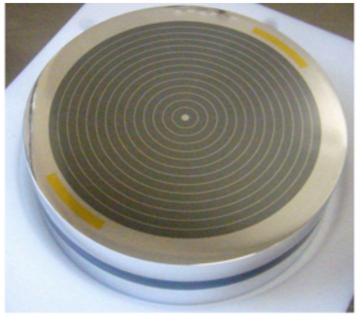
PLB 681 (2009) 305-309 [*arXiv:0905.0753]*

Data for WIMP search



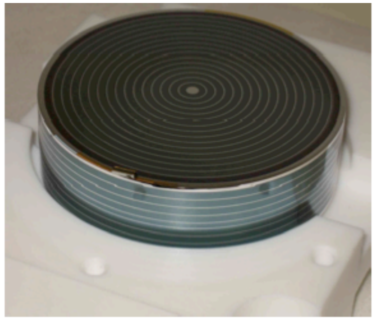
- Identified surface events in data
  - < 0.2 evt (90%CL) expected after rejection
- Knobs to improve
  - change surface treatment (increase Q_{beta})
  - Improve ionization energy resolutions (low-energy discrimination)

From IDs to FIDs



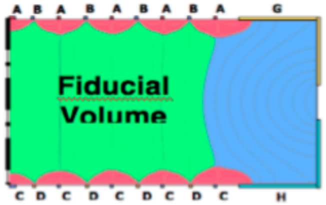
ID401 to 405:
Φ 70mm, H 20mm, 410g

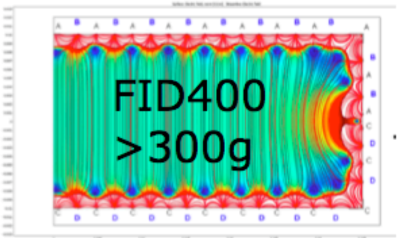
ID2 to ID5:
Φ 70mm, H 20mm, 410g

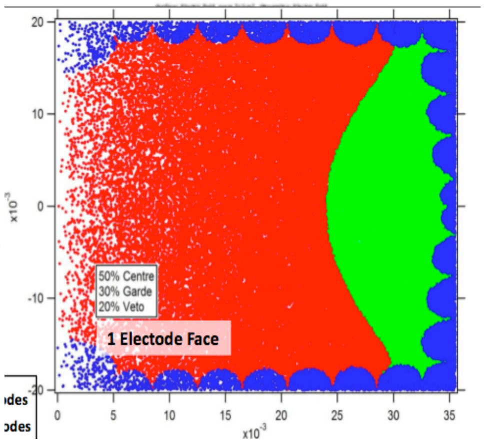


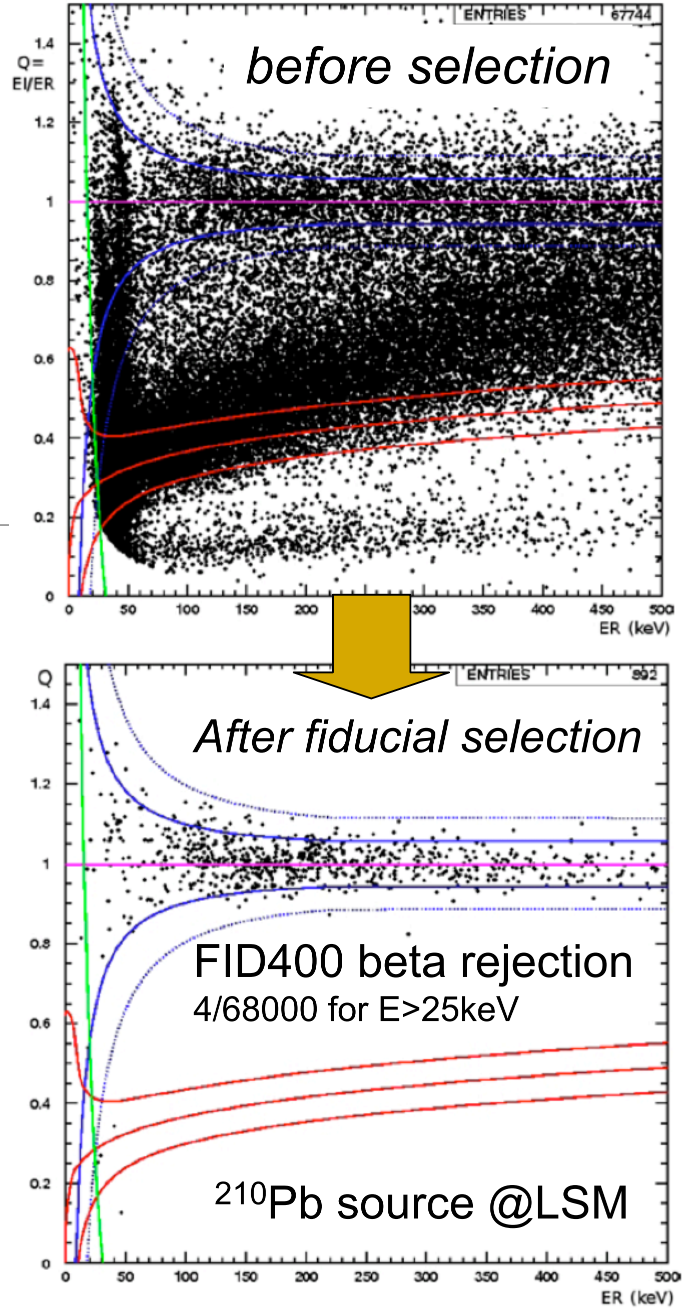
FID401 and FID402:
Φ 70mm, H 20mm, 410g

ID400
160g





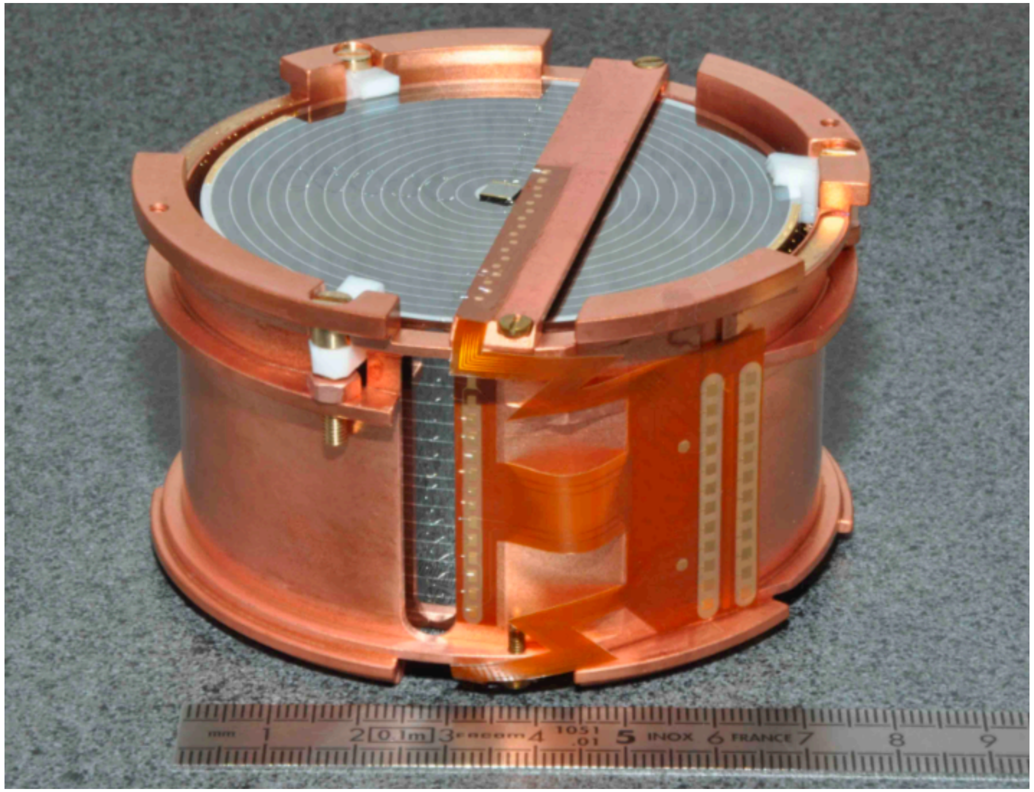




Improving the fiducial mass:
ID200 => ID400 => FID400 => FID800

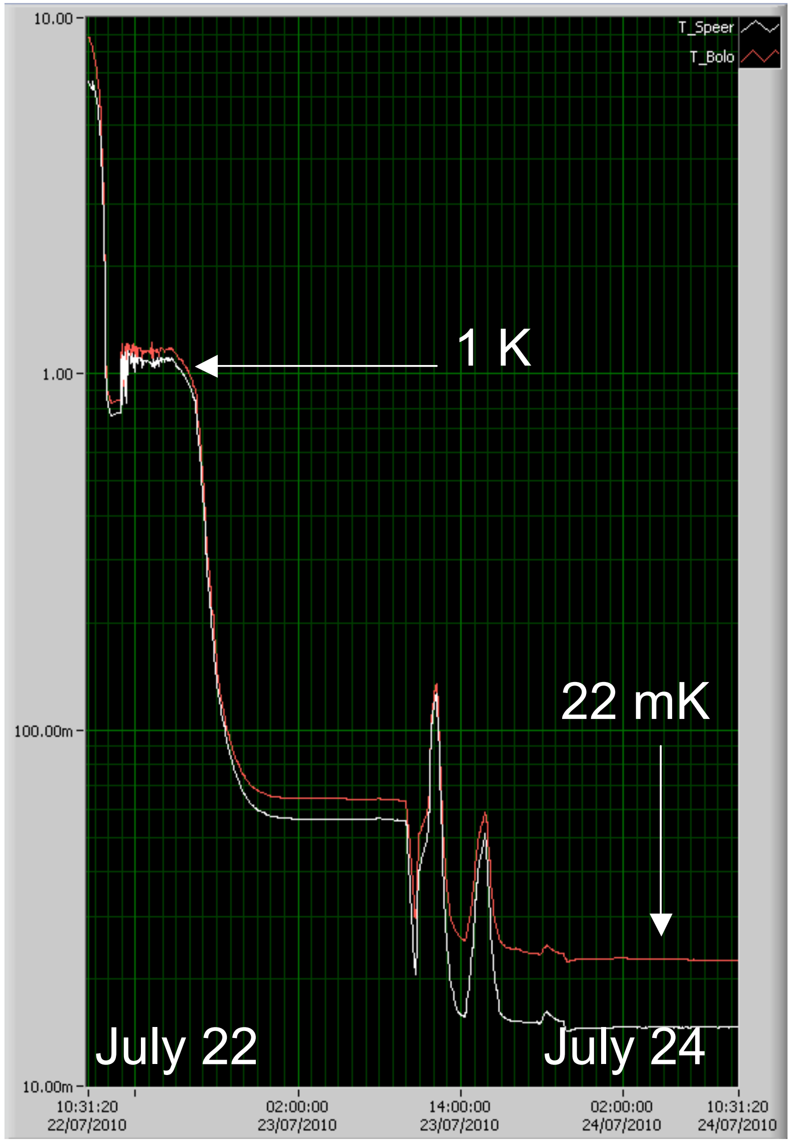
- Production of FID detectors performed at CSNSM Orsay with dedicated evaporation system

July 3rd : 4 FID800+2 FID400 installed at LSM



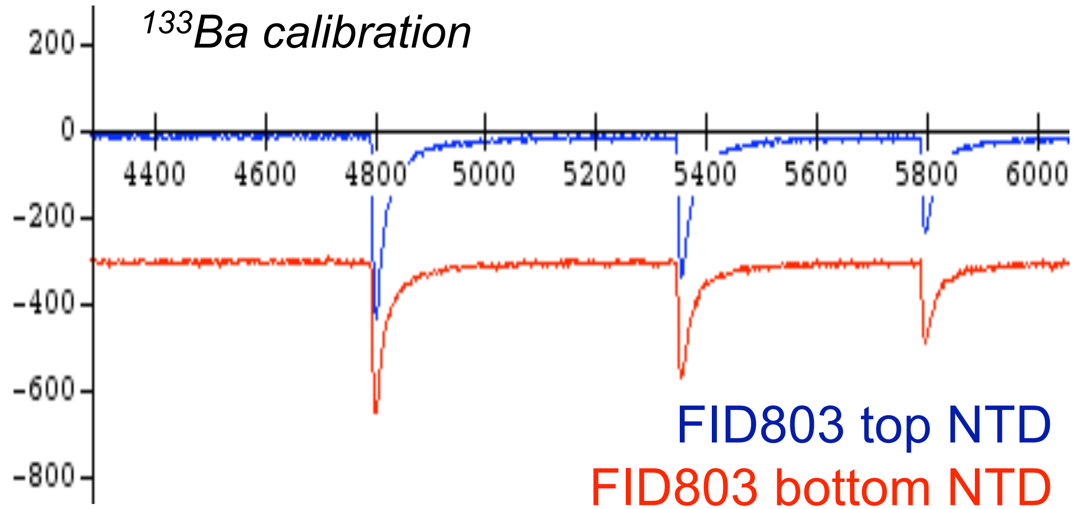
800 g detector, 2 NTD, 6 electrodes
2 « fiducial » volumes
218 ultrasonics bondings / detector

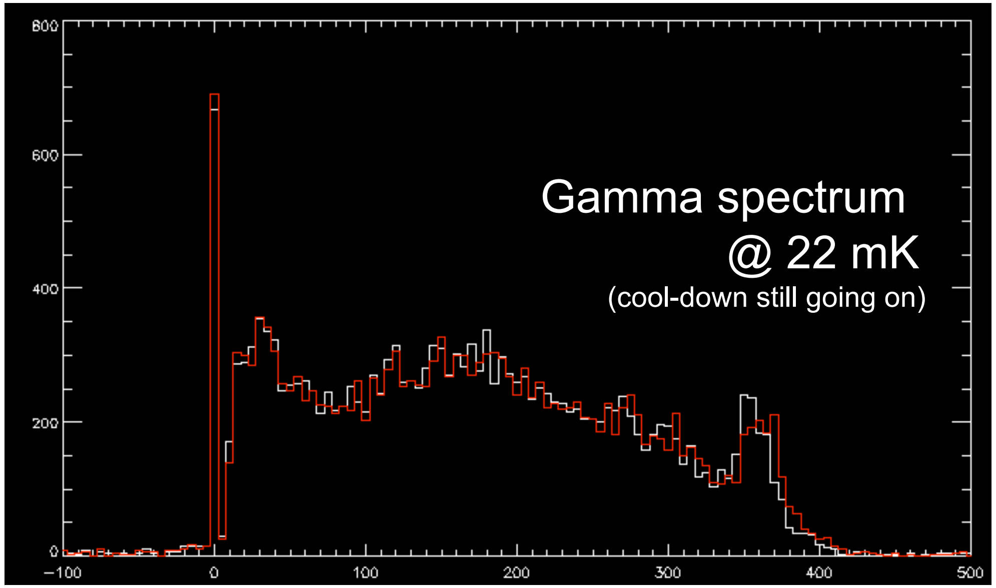
Cool-down started July 15th



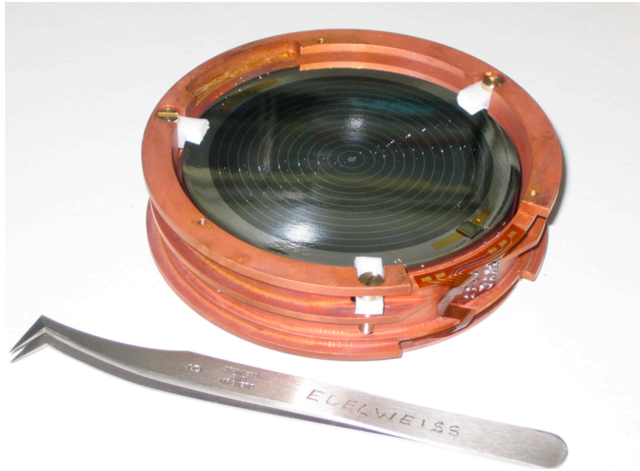
First heat pulses on 800g bolometers with interleaved electrodes

^{133}Ba calibration





Edelweiss: summary / prospects



- Edelweiss new-generation ID detectors :
  - Robust detectors with redundancy and very high beta rejection
  - Preminary analysis of 1 year data =>
    - No hint of WIMPs
    - 5×10^{-8} pb sensitivity achieved
- New Goal 5×10^{-9} pb
  - Improvements wrt future backgs
    - Increased redondancy for ionisation and heat measurements
    - Fast readout (multisite, pile up)
    - Lower μ phonics, internal PE shield
  - New prototypes FIDs 800g now working at LSM
    - 2011 = 1000 kg.d
  - Build 40 detectors, upgrade set-up
    - 2012 = 3000 kg.d