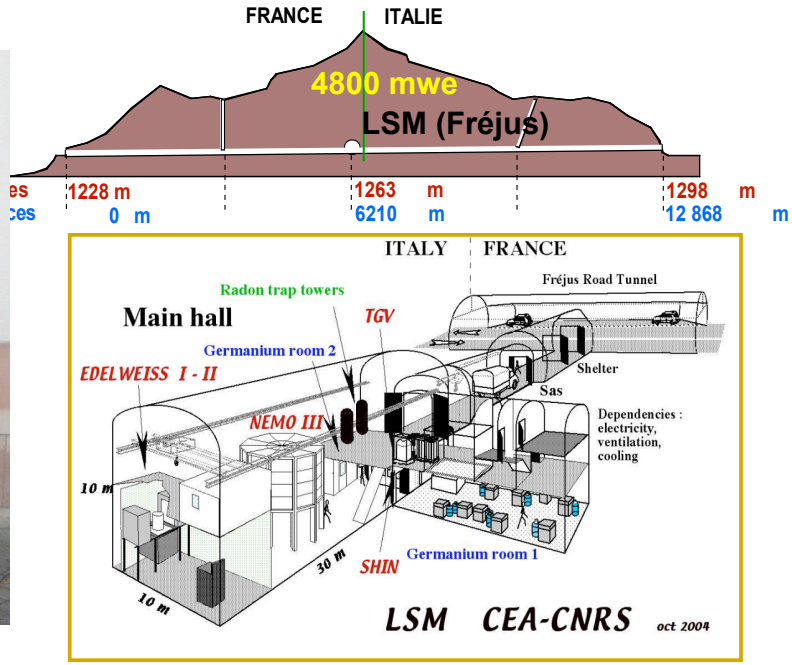
EDELWEISS-II : Searching for WIMPs

Last results using Ge cryogenic detectors with interleaved electrodes

6th Patras Workshop on Axions, WIMPs, WISPs
Zurich, July 5th-9th 2010
Gilles Gerbier - CEA / IRFU

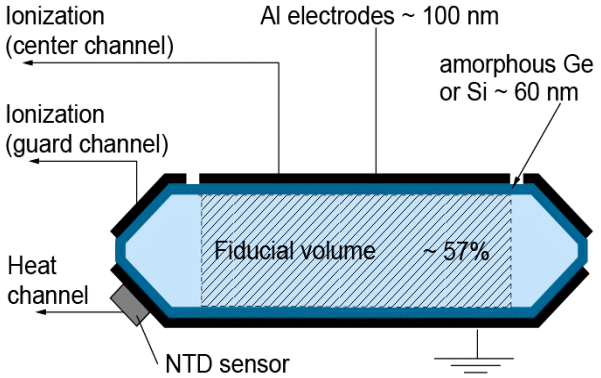
The EDELWEISS collaboration

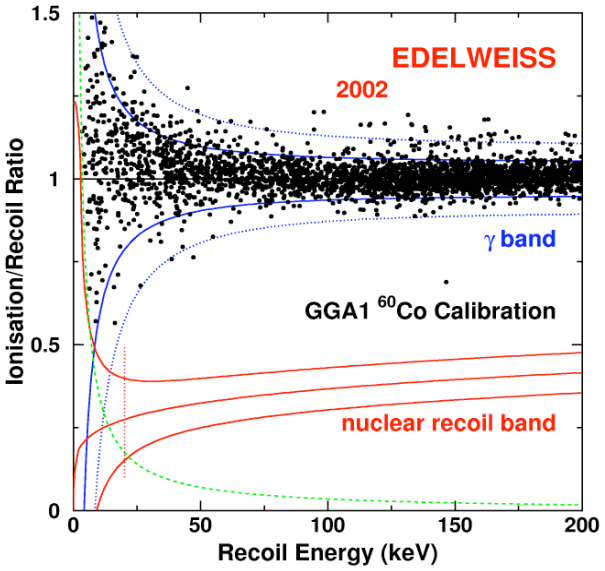


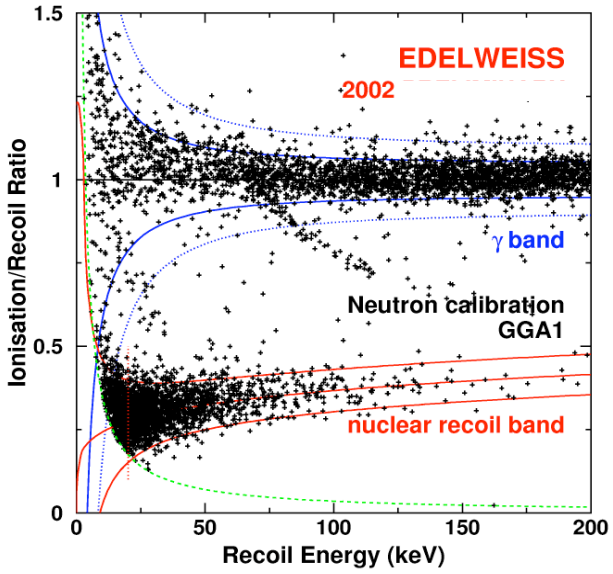
- **CEA Saclay (IRFU & IRAMIS)** Detectors, electronics, acquisition, data handling, analysis
- **CSNSM Orsay** Detectors, cabling, cryogenics
- **IPN Lyon** Electronics, cabling, low radioactivity, analysis, detectors
- **Institut Néel Grenoble** Cryogenics, electronics
- **Karlsruhe IK,IEKP (+ IPE 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

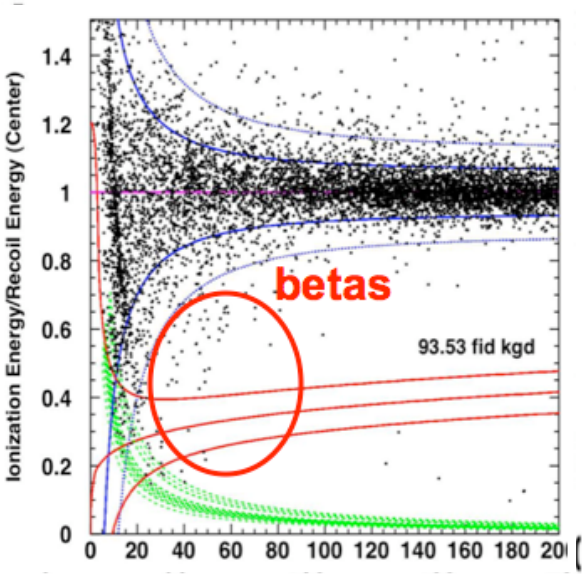
Edelweiss-I detectors

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









Edelweiss-I detectors (=>2008)

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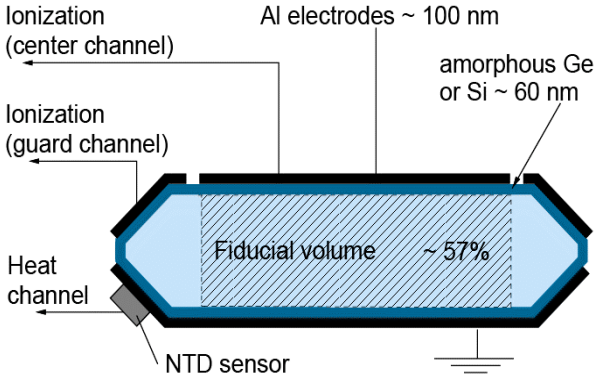
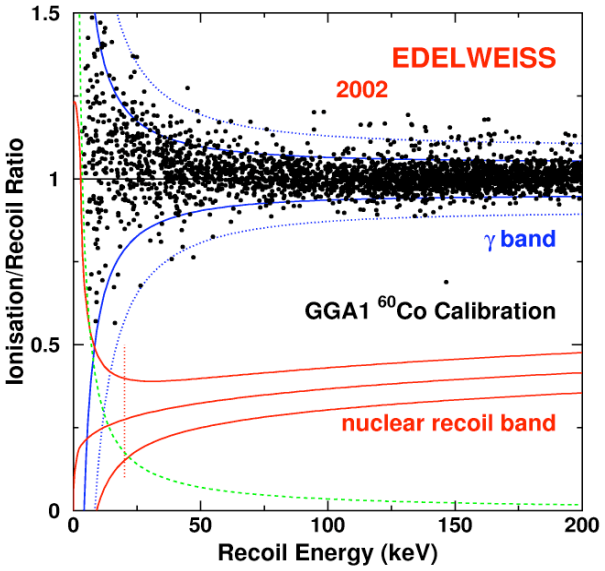
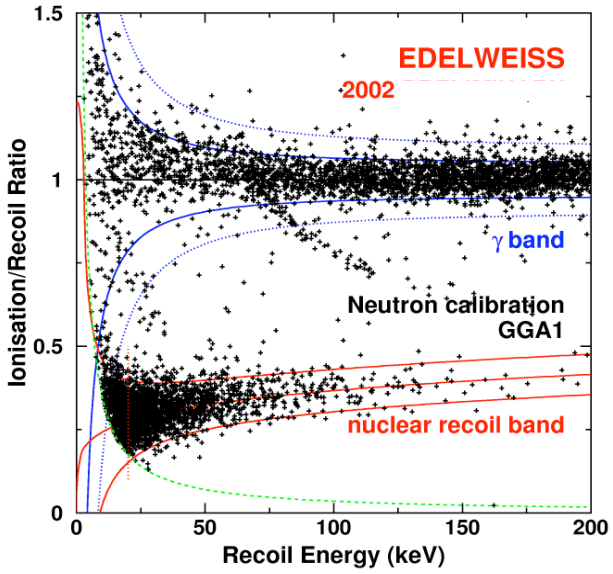
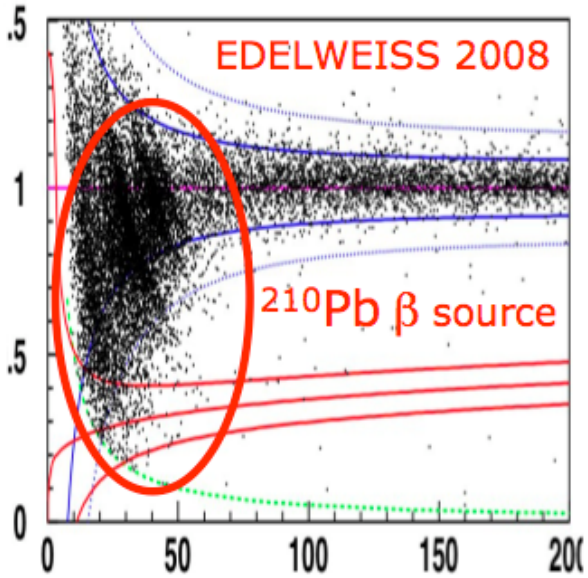
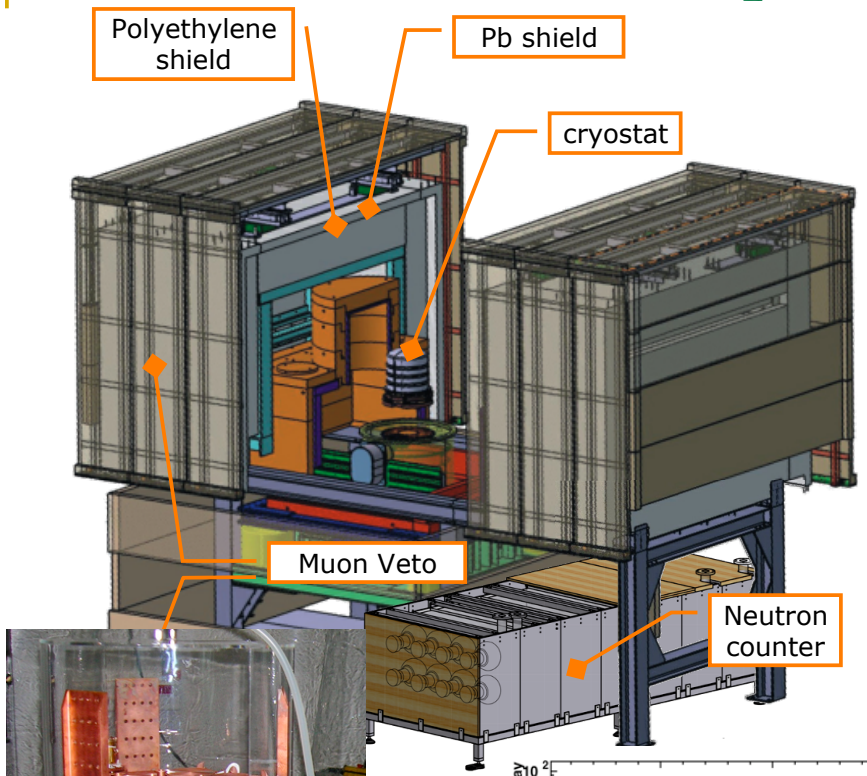


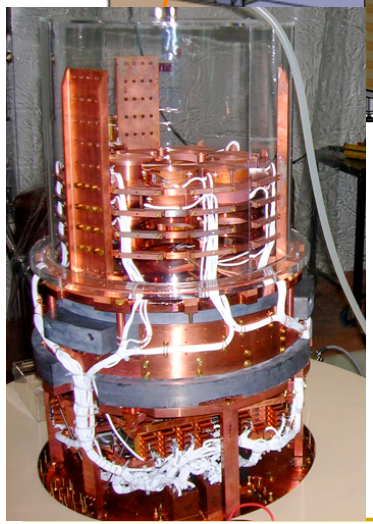


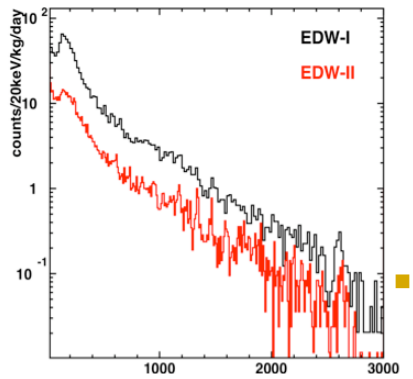




The Edelweiss-II setup



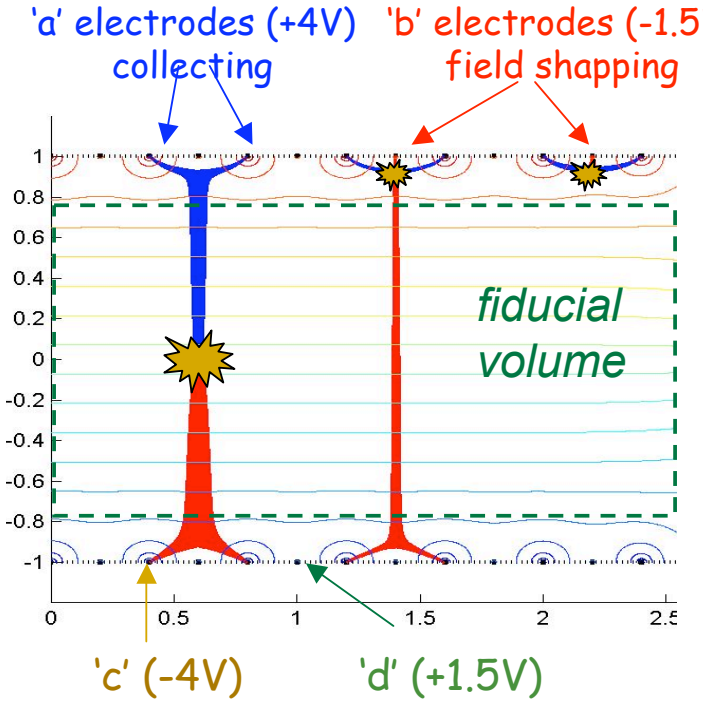




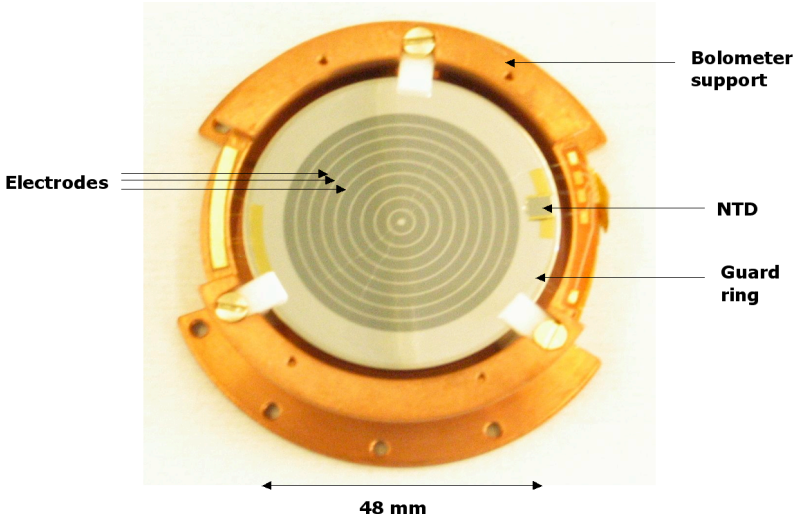
- Operated at the Underground Laboratory of Modane ($4\mu/day/m^2$) - deeper than Soudan
- **Goal $5\text{-}10^{-9}$ pb**
- Cryogenic installation (18 mK) :
  - Reversed geometry cryostat, pulse tubes
  - Remotely controlled
  - **Can host up to 40 kg of detectors**
- Shieldings :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - PE shield 50 cm
  - Lead shield 20 cm

  ⇒ **γ background reduced by ~3 wrt 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 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 detector built 2007
1x200g + 3x400g tested in 2008
10x400g running since beginning 2009

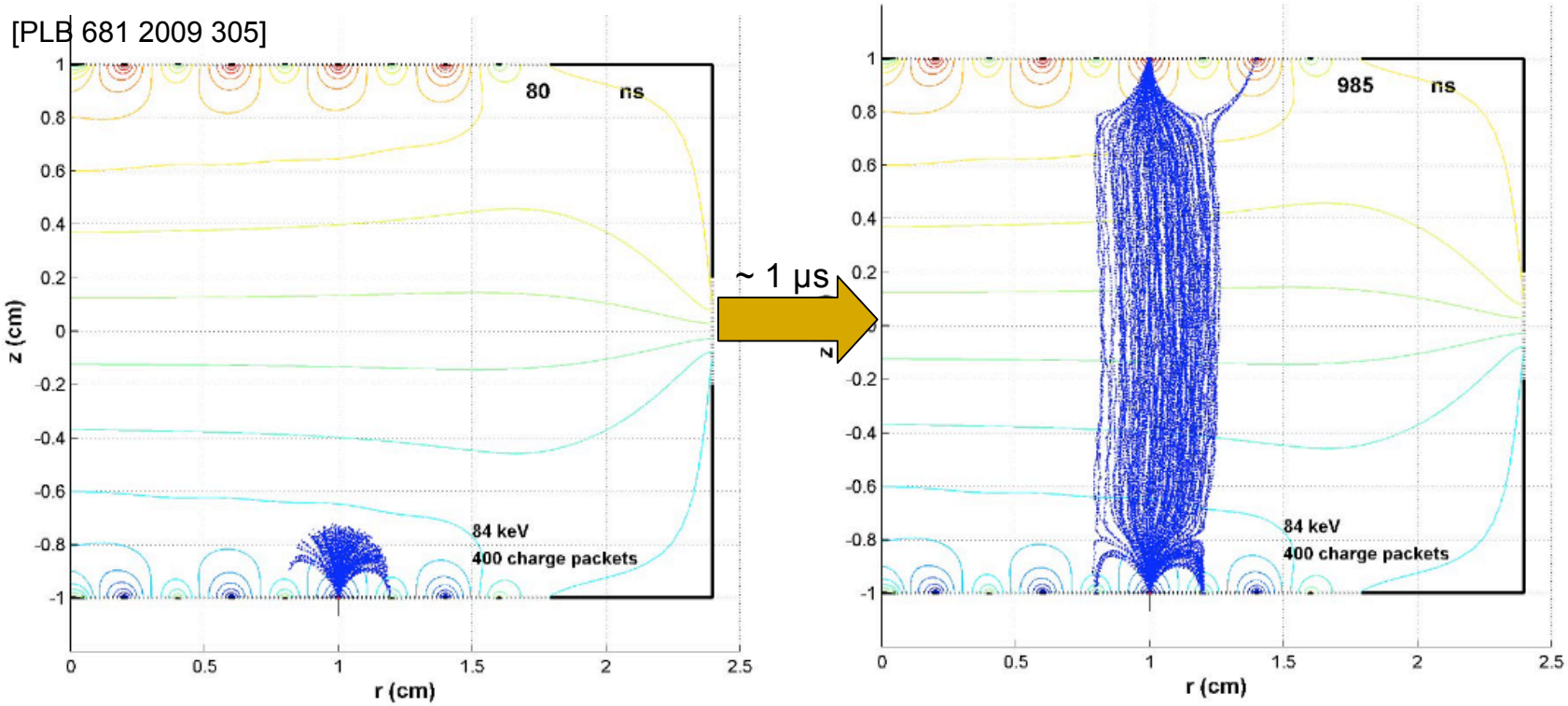
PLB 681 (2009) 305-309 [*arXiv:0905.0753*]

- 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

Charge propagation in an InterDigit detector

- Some initial worries about
  - regions of low electric field
  - regions just under the collecting electrodes
- But simulation showed that initial expansion of the charge cloud due to Coulomb interactions is sufficient to generate charges in the vetos

[PLB 681 2009 305]

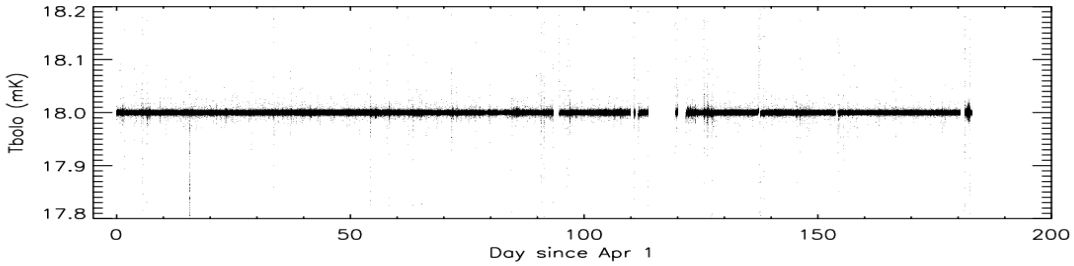


Simulation : interaction under a collecting electrode
(no anisotropy effect taken into account)

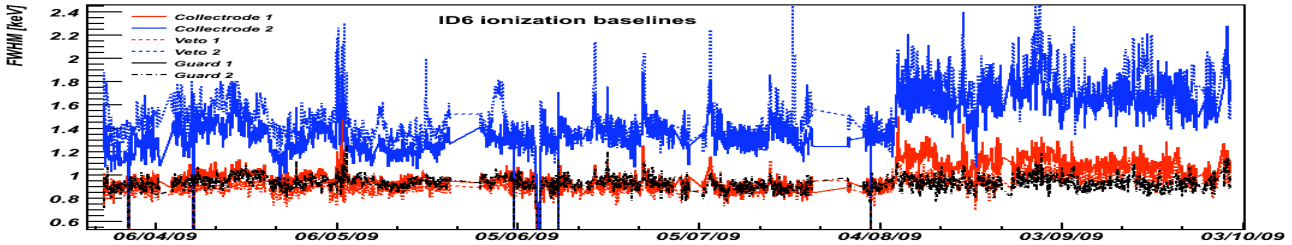
WIMP search with ID detectors : « run 12 »

- **Run 12 from april 1st 2009 to may 20th 2010**
  - 418 d total
  - 322 d data (77% of 418)
  - 305 d physics (73% of 418)
  - All detectors working
  - 90% electronics channels ok
  - 9/10 bolo for Physics
  - 8 d gamma
  - 5 d neutron
  - 4,5 d «other»

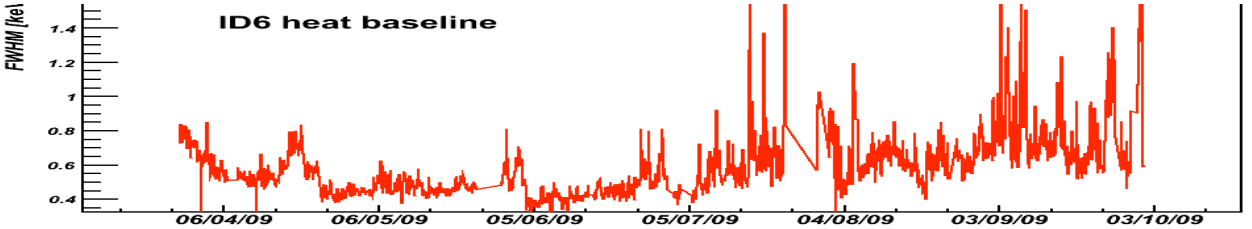
« One of the coldest place in the Universe » … Continuously at 18 mK during more than 1 year !



Ionisations baseline



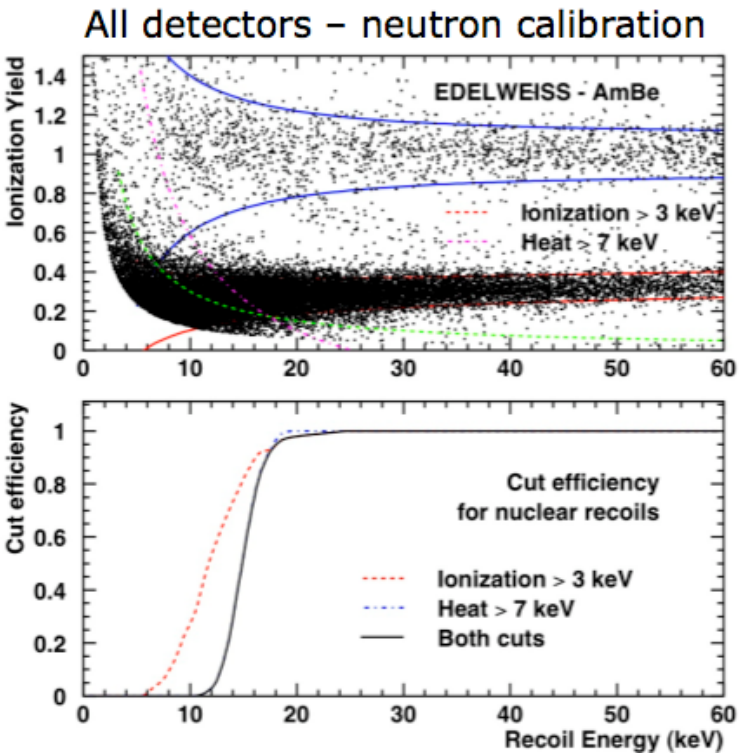
Heat baseline



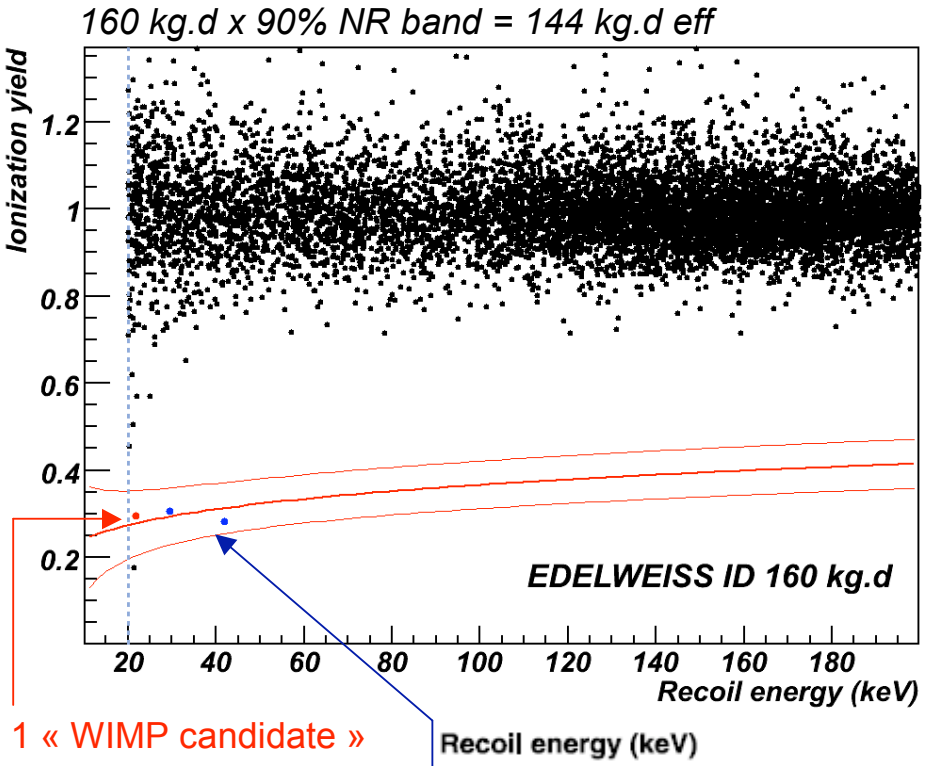
Data analysis of first 6 months

- 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)
- 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)

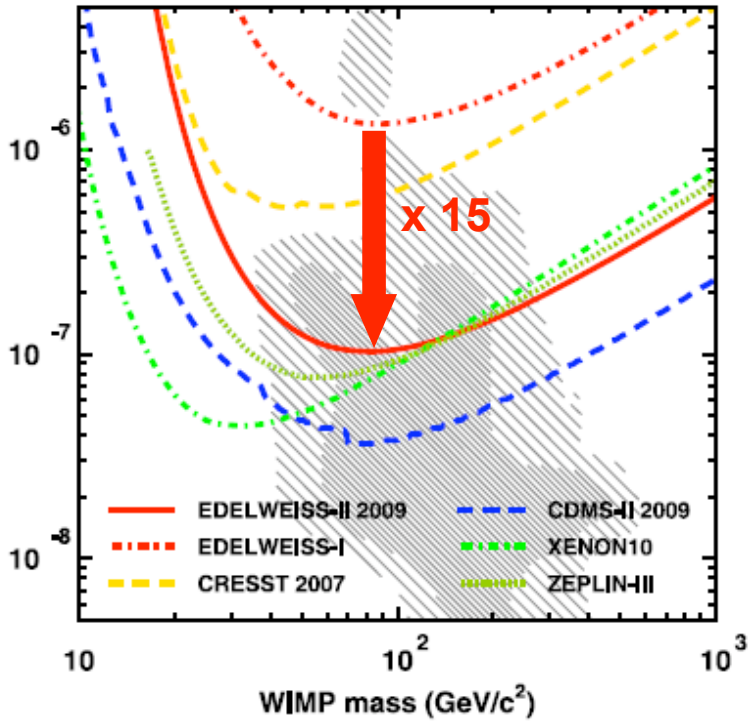
- Agreement between the results of the two analyses



WIMP search : first 6 month result (start Apr 1st 2009)



2 coincidences bolo-bolo+veto
=> muon-induced neutrons in fiducial volume



Background estimation : work in progress

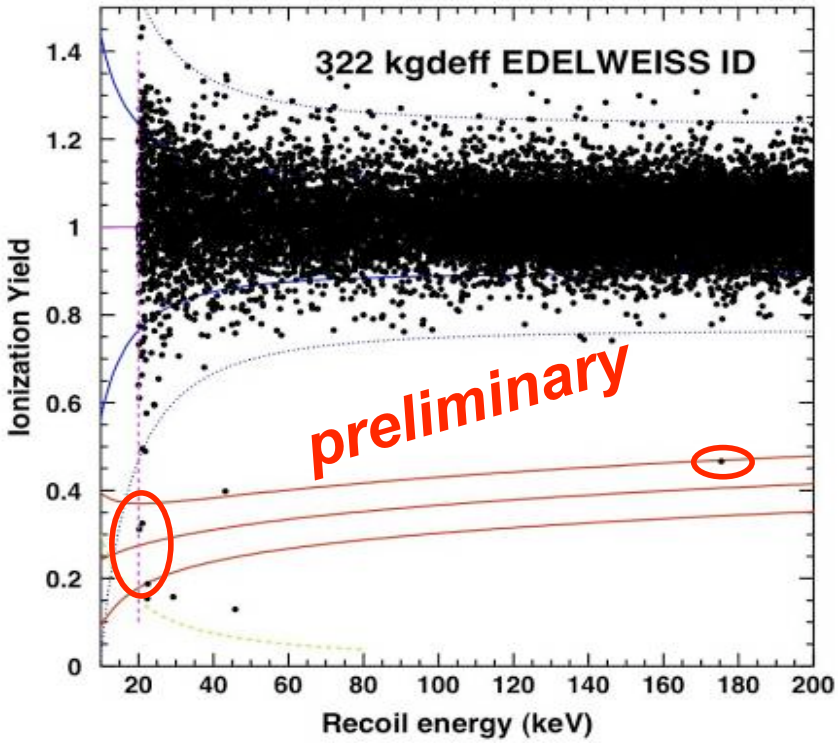
First estimation *from previous calibrations/simulations*:

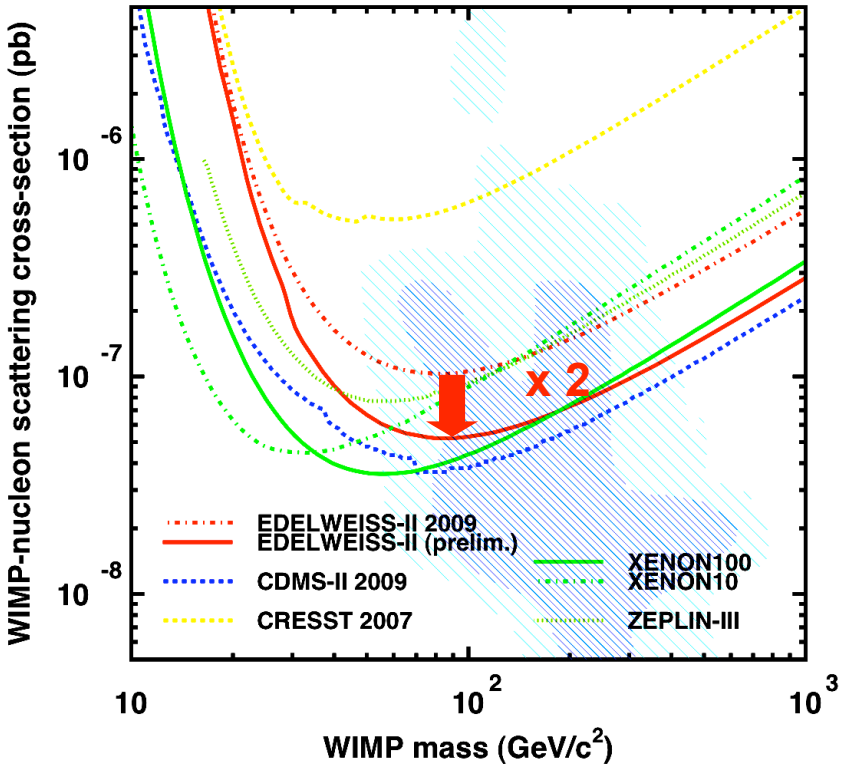
- gamma < 0.01 evt (99.99% rejection)
- beta ~ 0.06 evt (from ID201 calibration+obs. surf. evts)
- neutrons from ^{238}U in lead < 0.1 evt
- neutrons from ^{238}U+(α,n) in rock ~ 0.03 evt
- neutrons from muons < 0.04 evt

} < 0.23 evt

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

WIMP search : last result (end of run May 20th 2010)





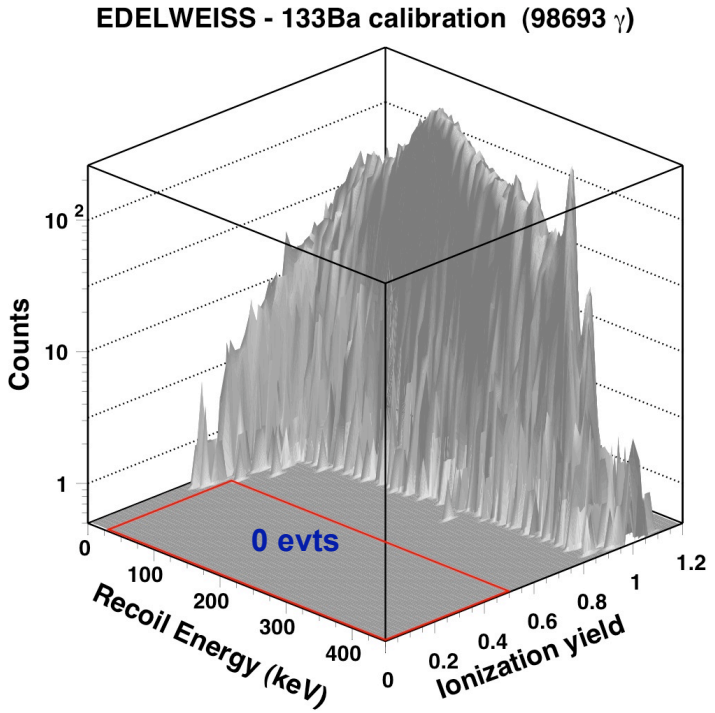
Preliminary result : 1st analysis w same cuts as first 6 months, **2nd analysis ongoing**
=> Increase in the sensitivity of factor 2 (scale with stat)
3 evts near threshold in NR band, 2 outliers (1 @ 175 keV in NR band)
Best limit 5.10^{-8} pb at Mw~80 GeV, background starts to appear ?

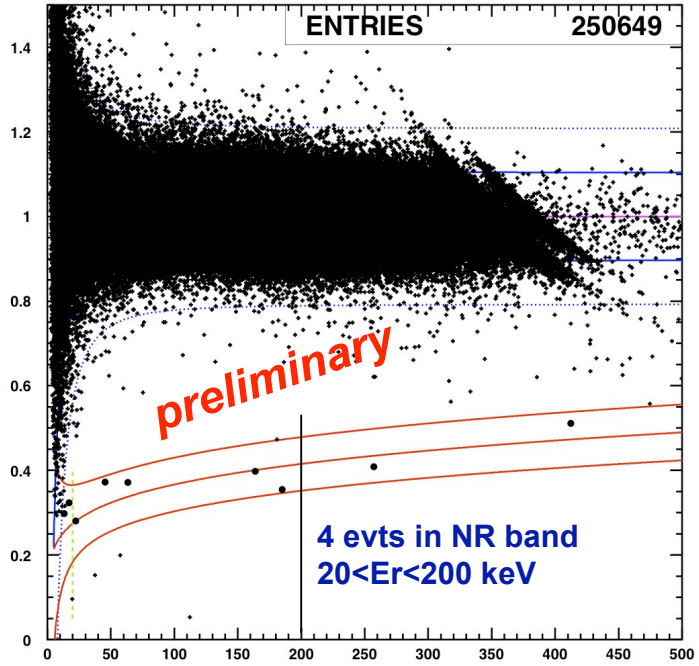
Backgrounds

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 MC tuned with outside strong AmBe source	<0.1

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

Gamma calibrations : status





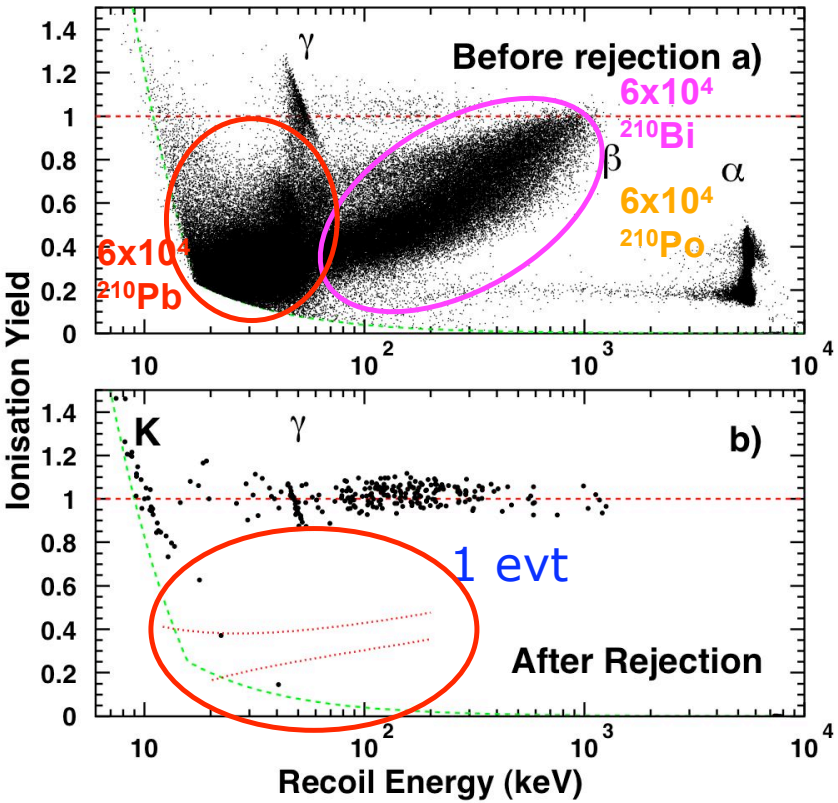
2 det, gaussian behaviour, no cand event

Stat * 2.5, all 10 detectors, 4 evts

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

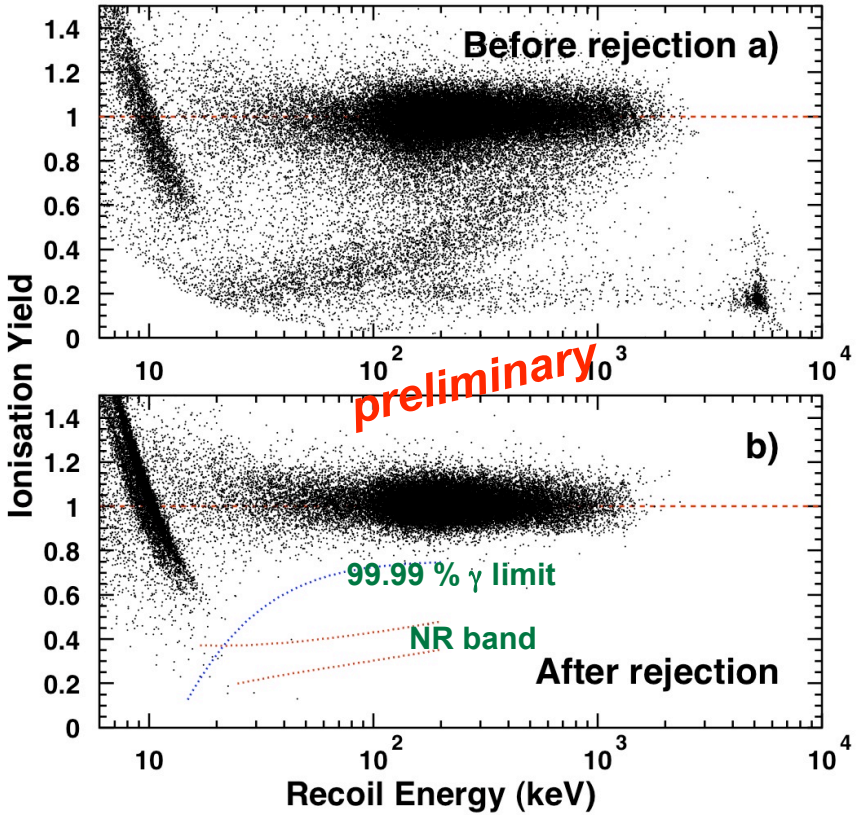
Beta calibrations & backgrounds

^{210}Pb calibration



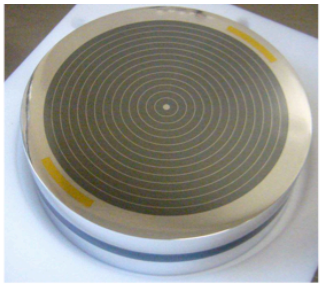
PLB 681 (2009) 305-309 [*arXiv:0905.0753*]

Data for WIMP search

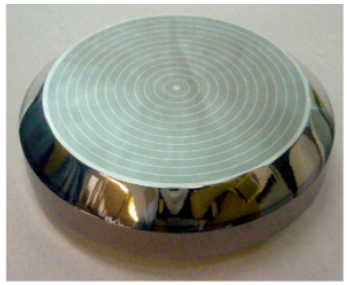


- Identified surface events in data
  - < 0.2 evt expected after rejection
- Knobs to improve
  - change surface treatment
  - better E resolutions

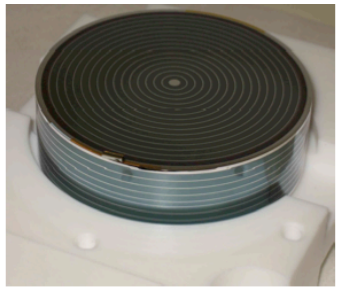
Future : from IDs to FIDs



ID401 to 405:
Φ 70mm, H 20mm, 410g

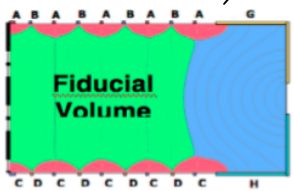


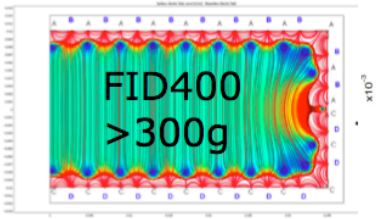
ID2 to ID5:
Φ 70mm, H 20mm, 410g

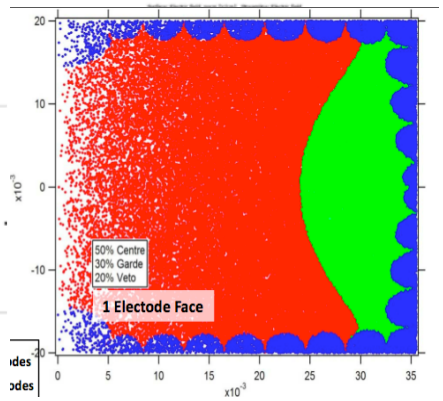


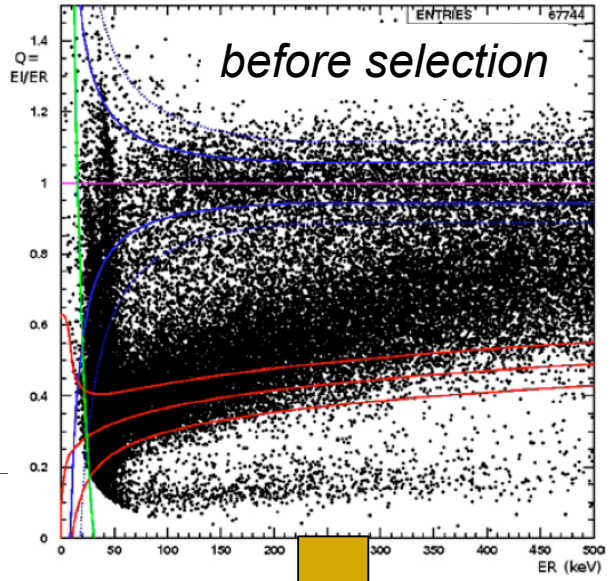
FID401 and FID402:
Φ 70mm, H 20mm, 410g

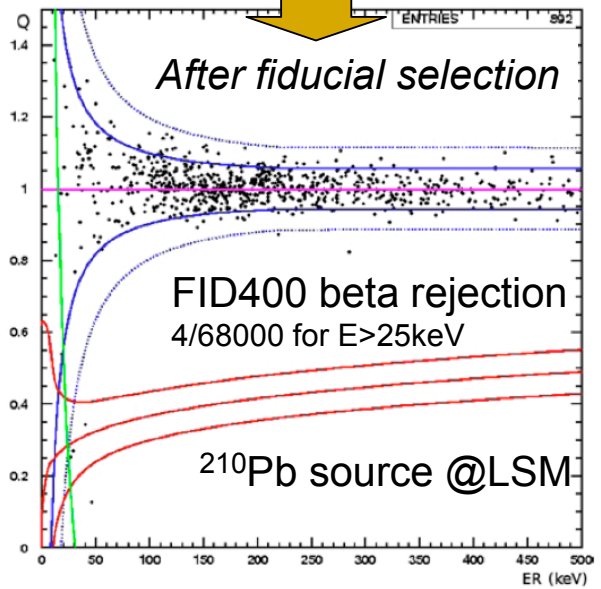
ID400
160g







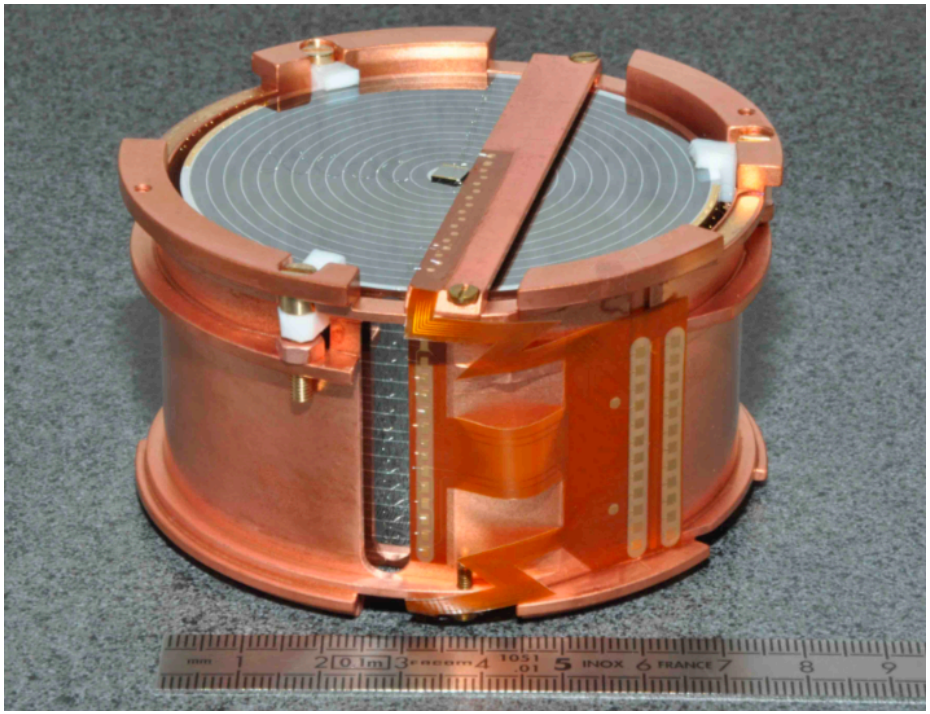




Fiducial mass	x2	x4
ID200 => ID400 =>	FID400 =>	FID800

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

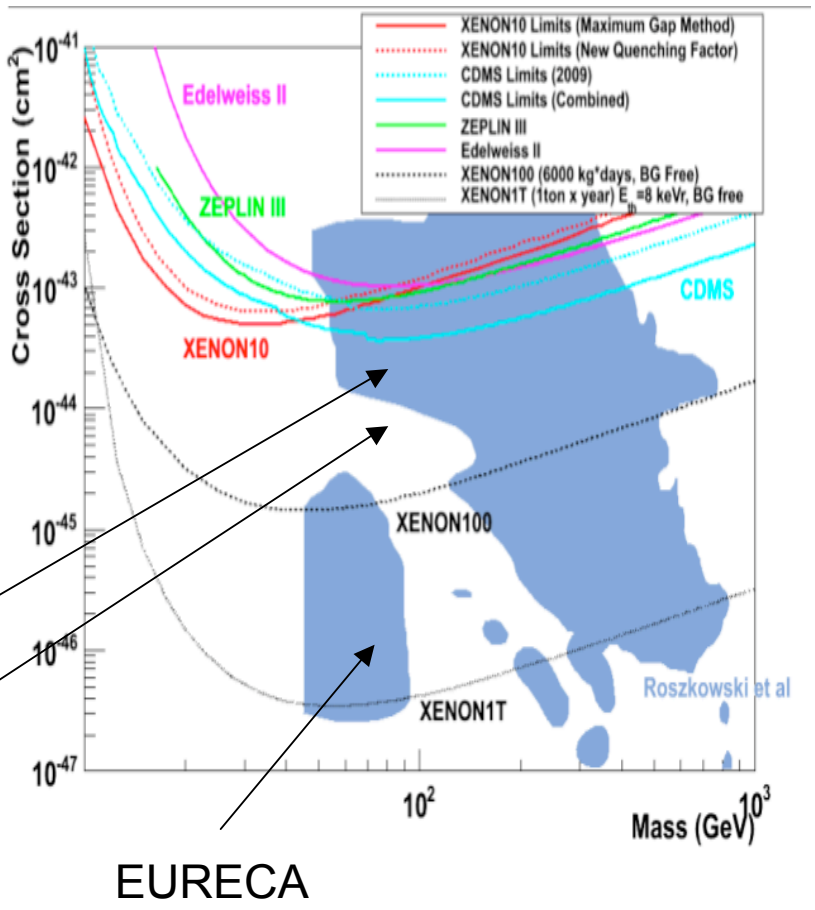
July 3rd : 4 FID800 installed in LSM cryostat
Cool down on july 15th



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

Edelweiss: summary/prospects

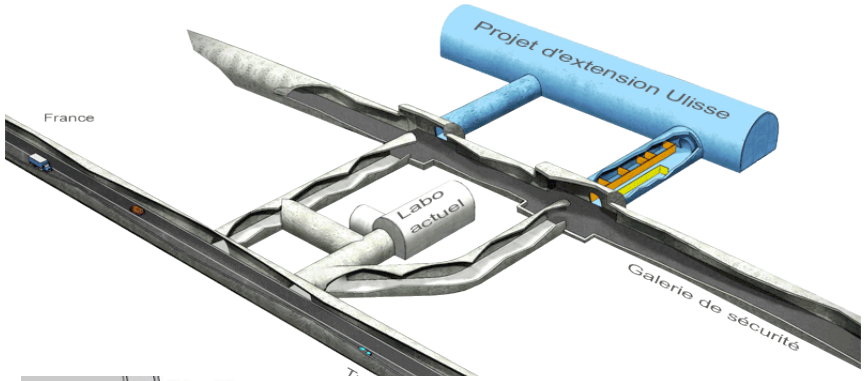
- Edelweiss new-generation ID detectors :
  - Robust detectors with redundancy and very high beta rejection
  - Preminary analysis of 1 year data =>
    - No evidence of WIMPs
    - 5 10^{-8} pb sensitivity achieved
- New Goal 5 10^{-9} pb
  - Improvements wrt future backgs
    - Increased redondancy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

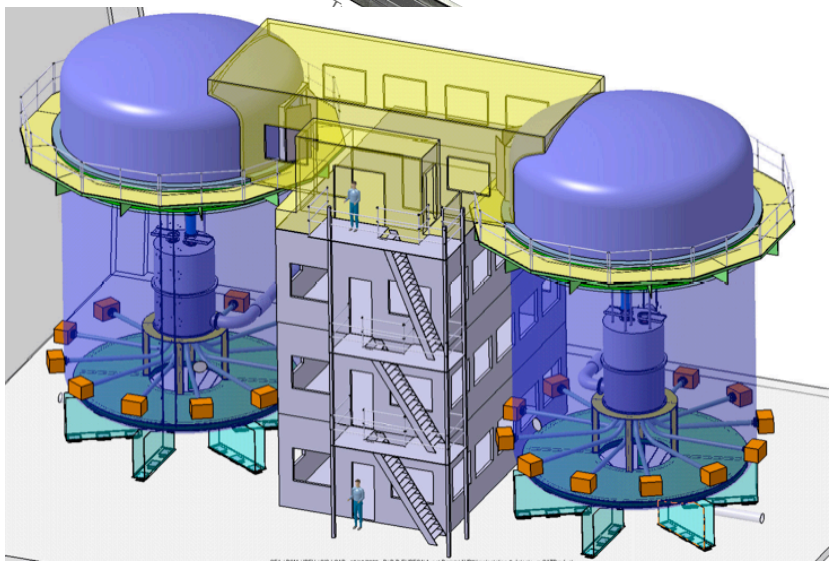


EURECA

Further future : EURECA

- EURECA goal : 10^{-10} pb, 500 kg to 1 T cryogenic experiment, multi-target
- "Generation 2" project with major efforts in background control, detector development, infrastructure
- Joint European collaboration of teams from EDELWEISS, CRESST, ROSEBUD, CERN, +others…
- Part of ASPERA European Roadmap
- Prefered site: 60 000 m^2 ULISSE extension of present LSM (4 $\mu/m^2/d$), to be dig in 2011-2012





- Collaboration agreement with SuperCDMS & GeoDM for common studies

Memorandum of Understanding between the EURECA, SuperCDMS, and GEODM collaborations

On behalf of the EURECA collaboration	On behalf of the SuperCDMS collaboration	On behalf of the GEODM collaboration
Hans Kraus	Blas Cabrera	Sunil Golwala
Hans Kraus EURECA Spokesperson	Blas Cabrera SuperCDMS Spokesperson	Sunil Golwala GEODM Spokesperson

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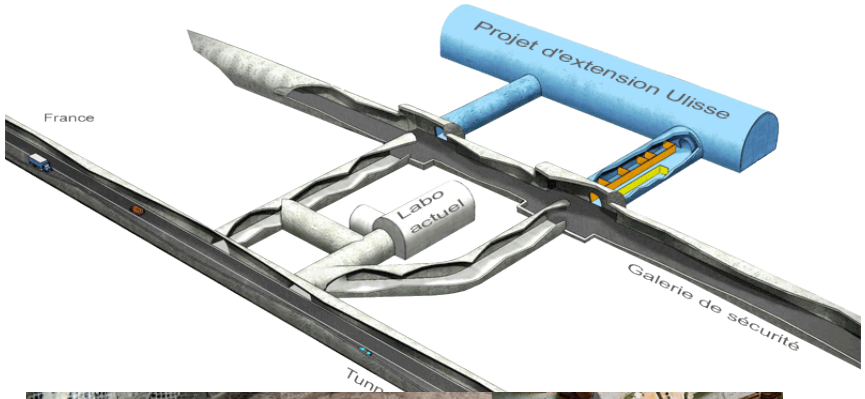

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