First results of EDELWEISS-II

using Ge cryogenic detectors with interleaved electrodes

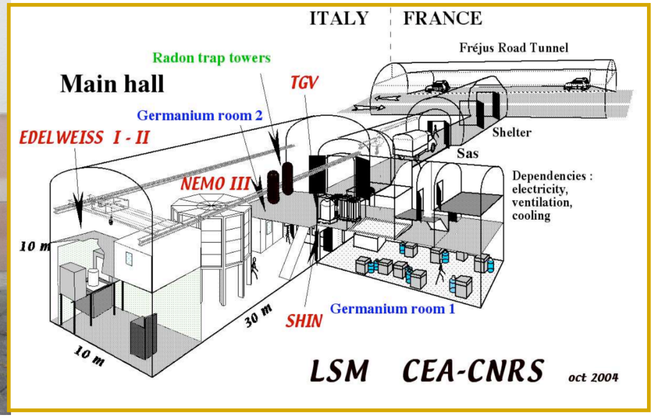
Colloquium APC - Jeudi 11 février 2010

Eric Armengaud - CEA / IRFU

Expérience pour DEtecter Les WIMPs En Site Souterrain

The EDELWEISS collaboration

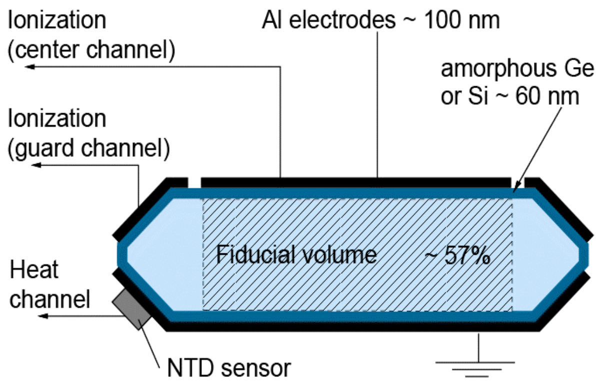
Karlsruhe - oct 09

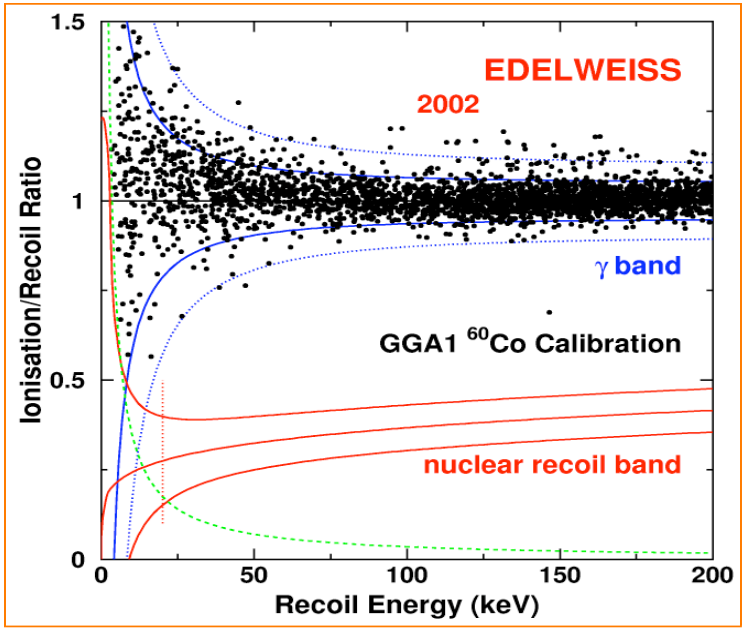


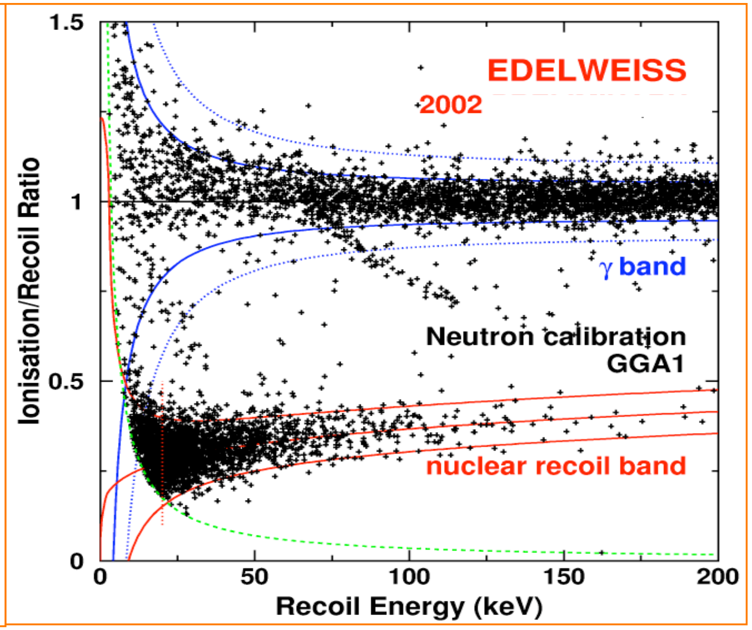
♦ **CEA Saclay (DAPNIA & DRECAM)**	**Detectors, electronics, acquisition, data handling, analysis**
♦ **CSNSM Orsay**	**Detectors, cabling, cryogenics**
♦ **IPN Lyon**	**Electronics, cabling, low radioactivity, analysis, detectors, cryo.**
♦ **Institût Néel Grenoble**	**Cryogenics, electronics**
♦ **FZ/ Universität Karlsruhe**	**Vetos, neutron detectors, background,**
♦ **JINR Dubna**	**Background, neutron radon monitors**
♦ **Oxford Univ.**	**New comer : Detectors, cabling, cryogenics, analysis**

Edelweiss-I detectors

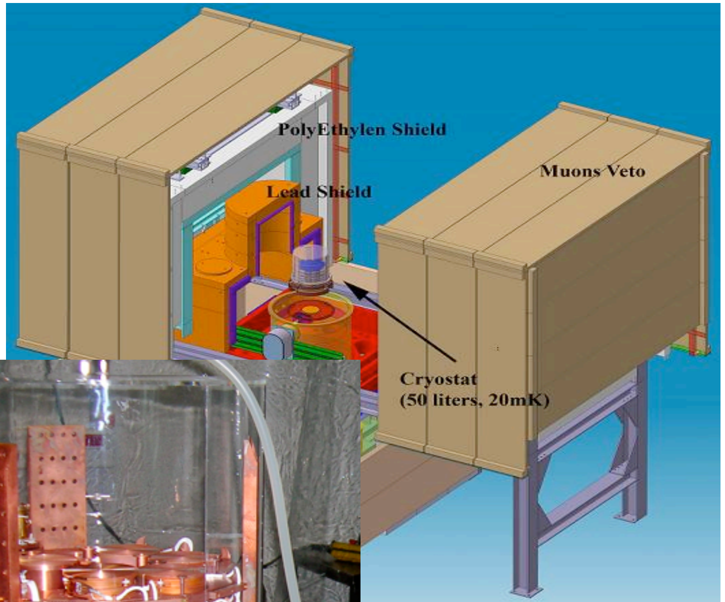
- Germanium bolometers
- Ionization measurement @ few V/cm
- Heat measurement (**NTD sensor**) @ 20 mK
- *Discriminating variable between electronic and nuclear recoils* : « Q » ~ ionization/heat
- **Limitation : surface interactions**

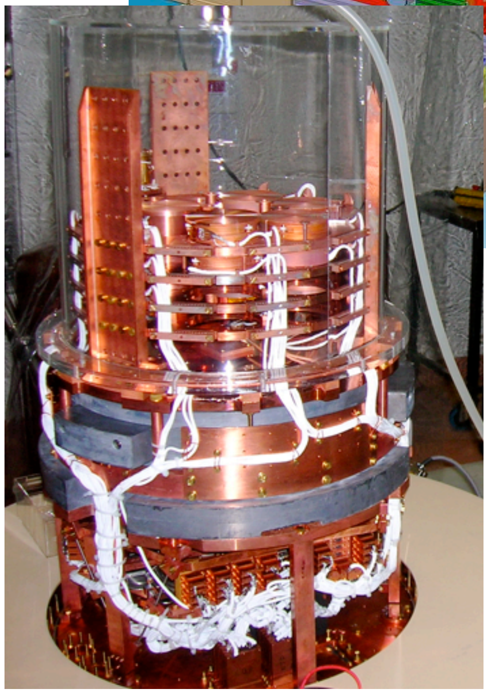






The Edelweiss-II setup

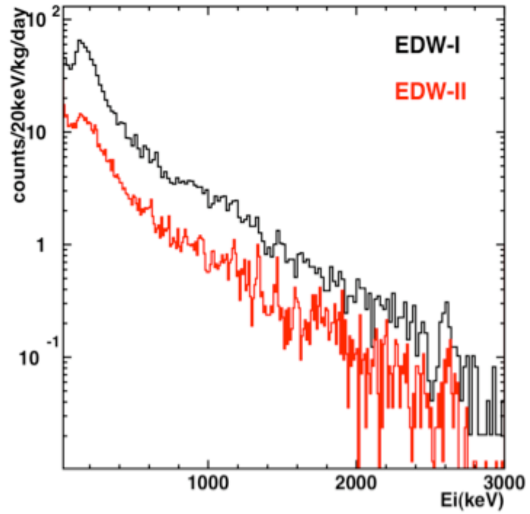




- Operated at the Underground Laboratory of Modane (4μ/day/m²) - deeper than Soudan
- Cryogenic installation (18 mK) :
  - Reversed geometry cryostat, pulse tubes
  - Remotely controlled
- Shieldings :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - PE shield
  - Lead shield

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

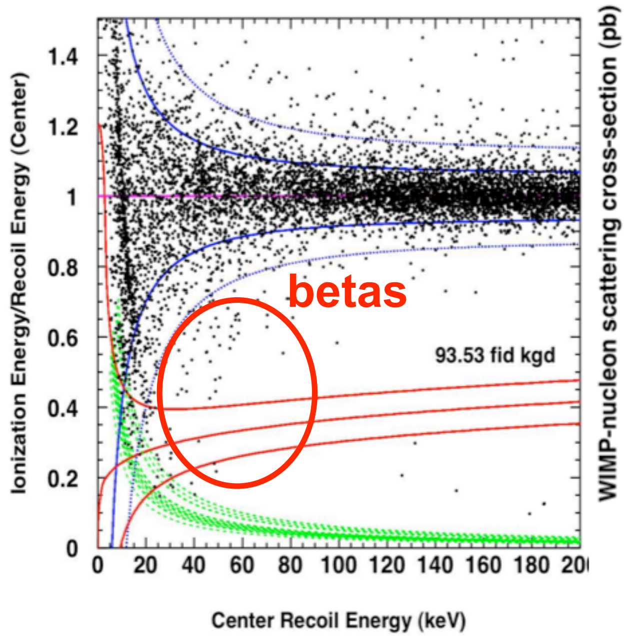
EDW-II setup performances

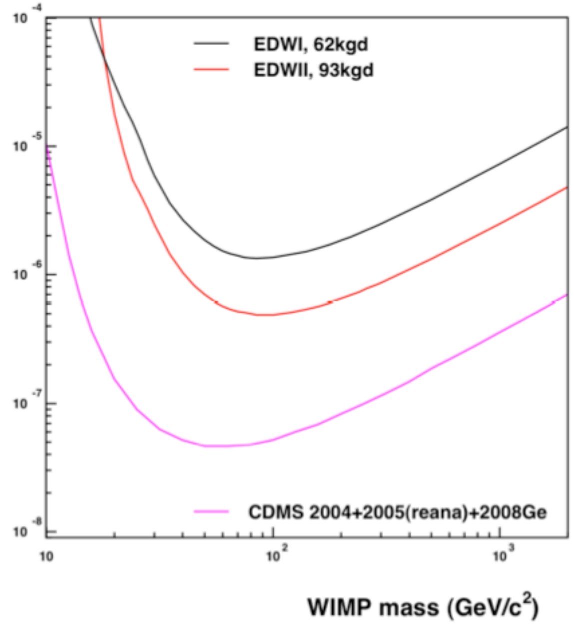


- Reduced gamma background (simulations underway)
- Alpha rate / 2
- Study of 210Pb pollution using a dedicated detector : predicted rate for low-energy betas consistant with the observed rate

WIMP search with Ge-NTD:
- no bckgd subtraction
- improvt wrt EDW-I

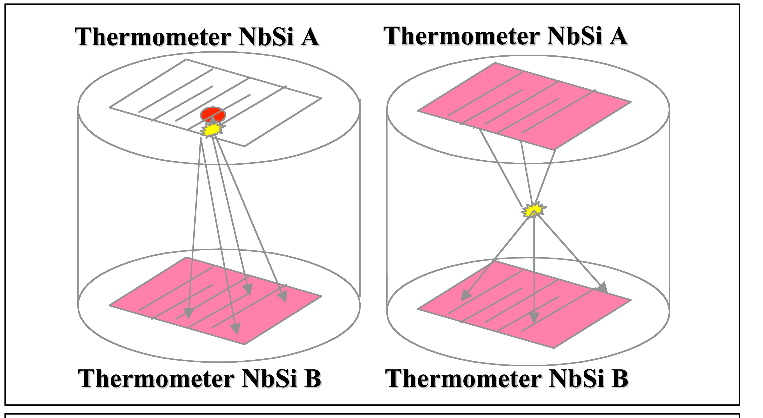
- active rejection of surface evts needed

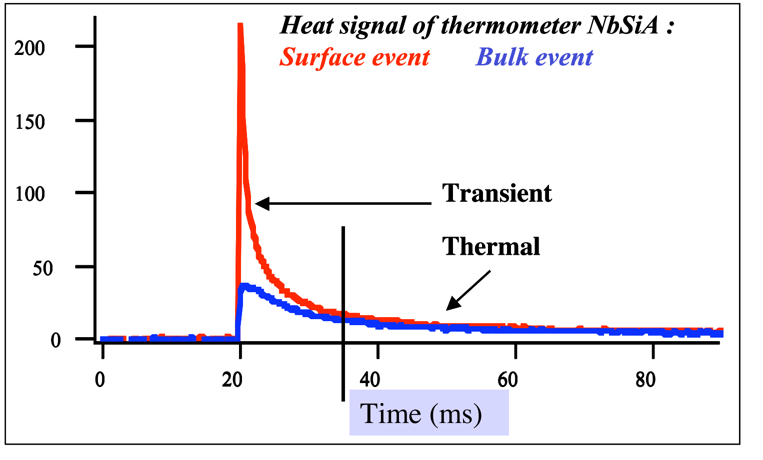




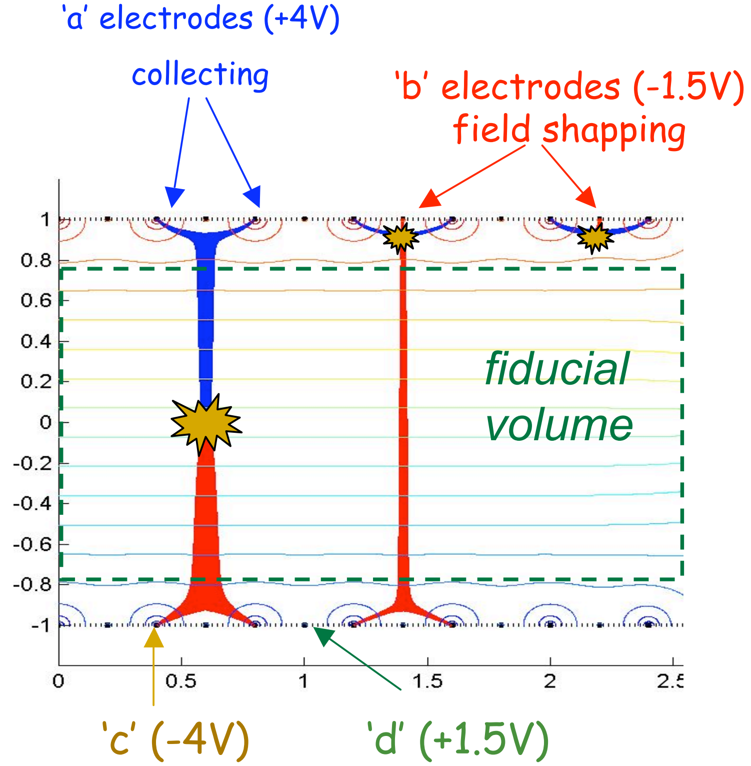
Surface event rejection with phonons : NbSi detectors

- 2 NbSi films measuring athermal phonons + ionization signals
- Surface event rejection correct
- Pbs of threshold / reproducibility

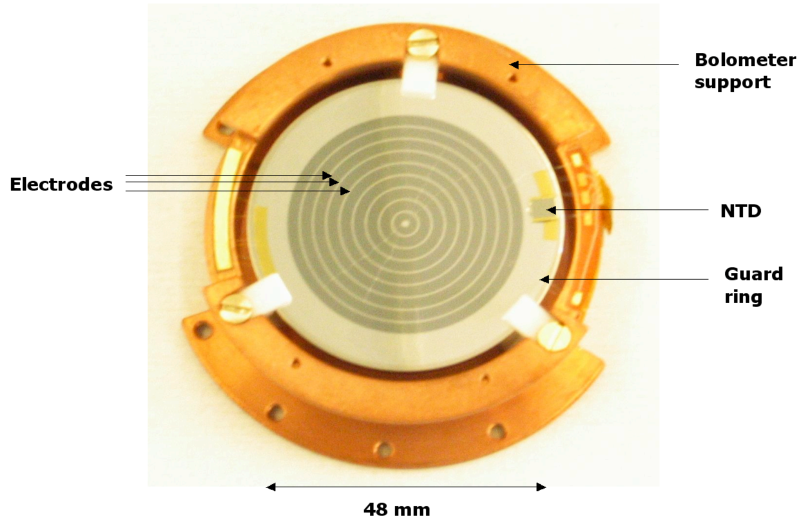




Rejecting surface events with interleaved electrodes



the « ID » (interdigit) detector



First detector built 2007
1x200g + 3x400g tested in 2008
10x400g running since beginning 2009

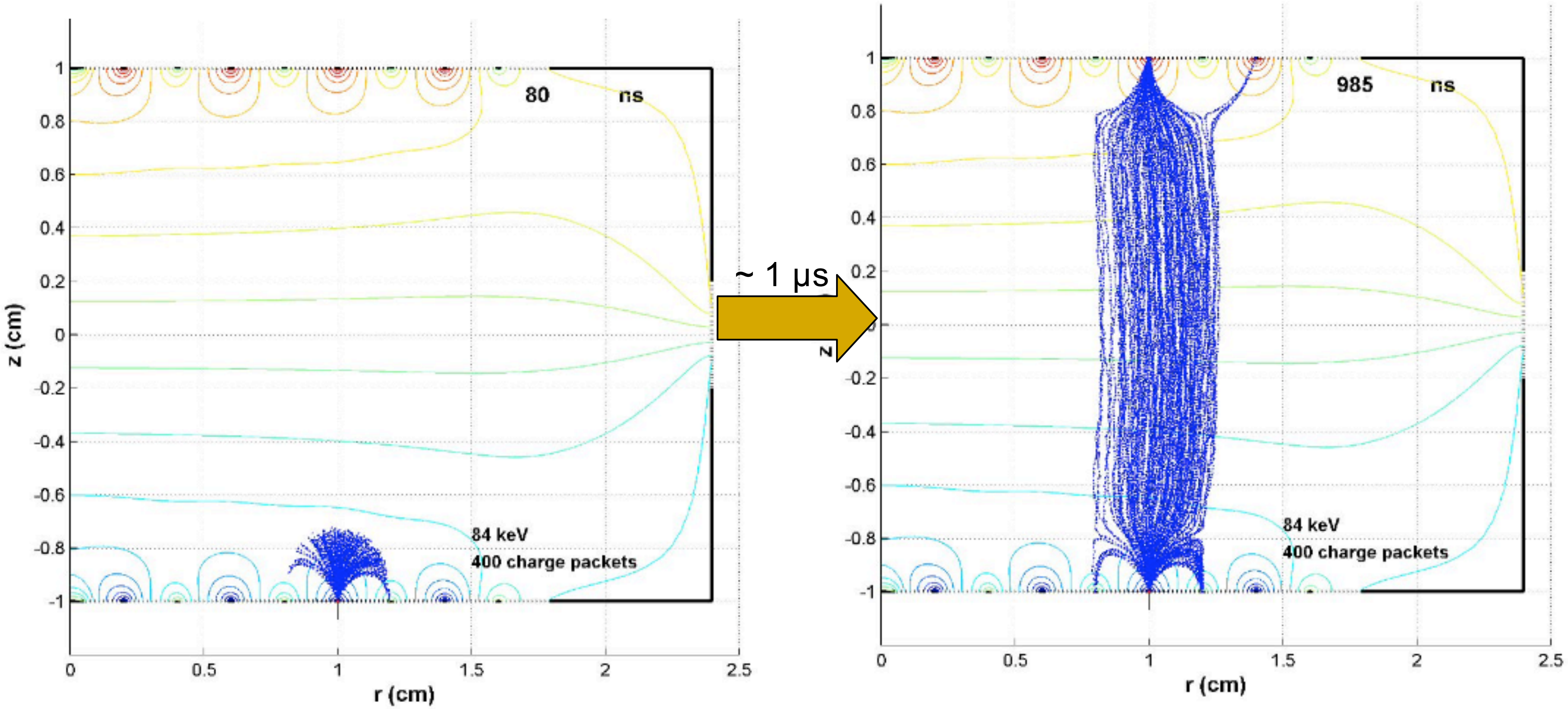
- Keep the EDW-I NTD phonon detector
- Modify the E field near the surfaces with interleaved electrodes
- Use 'b' and 'd' signals as vetos against surface events

Charge propagation in an InterDigit detector

• 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

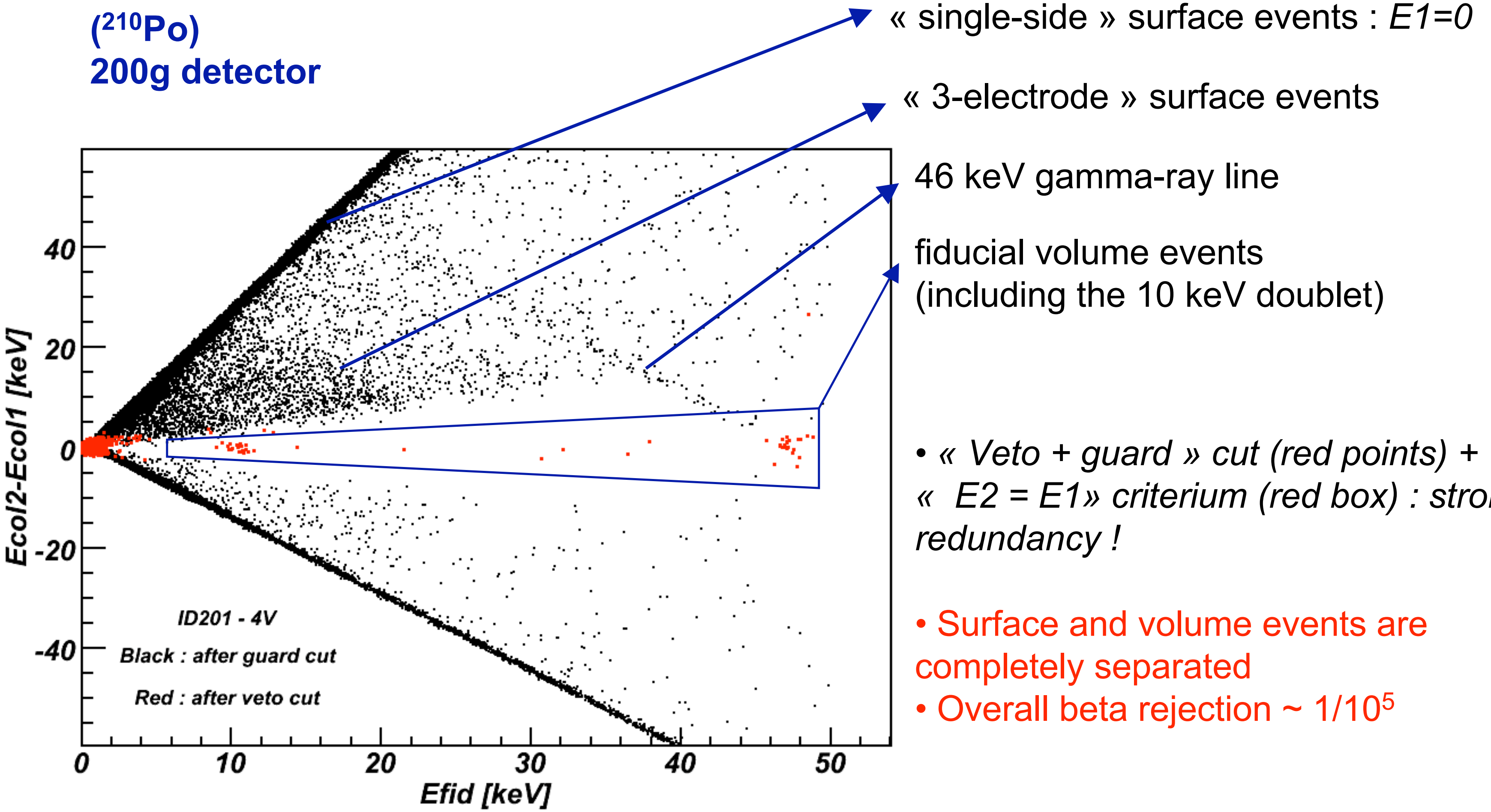
[PLB 681 2009 305]



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

An outstanding surface event discrimination with IDs

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

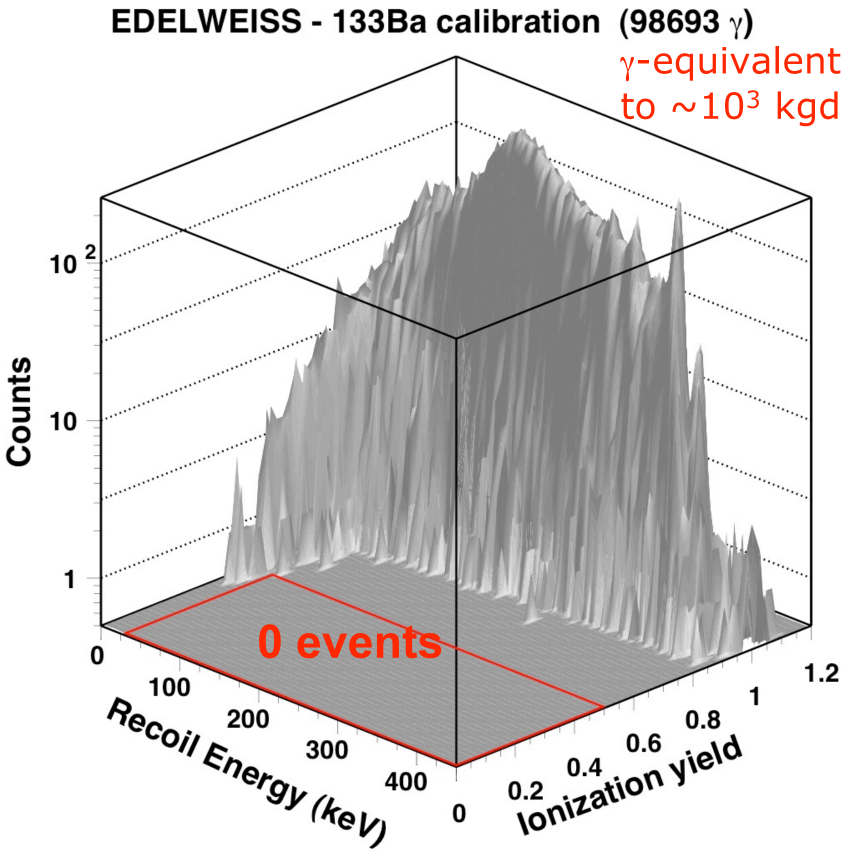


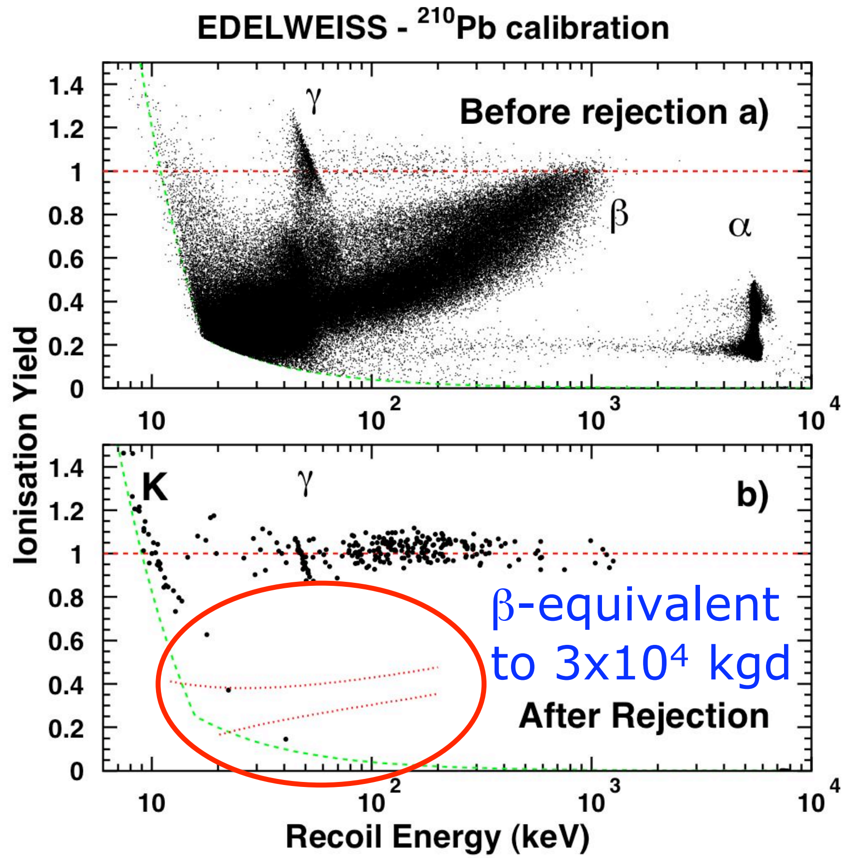
E1 = energy of top collecting electrode
E2 = bottom collecting electrode

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

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

IDs : overall background rejection performances

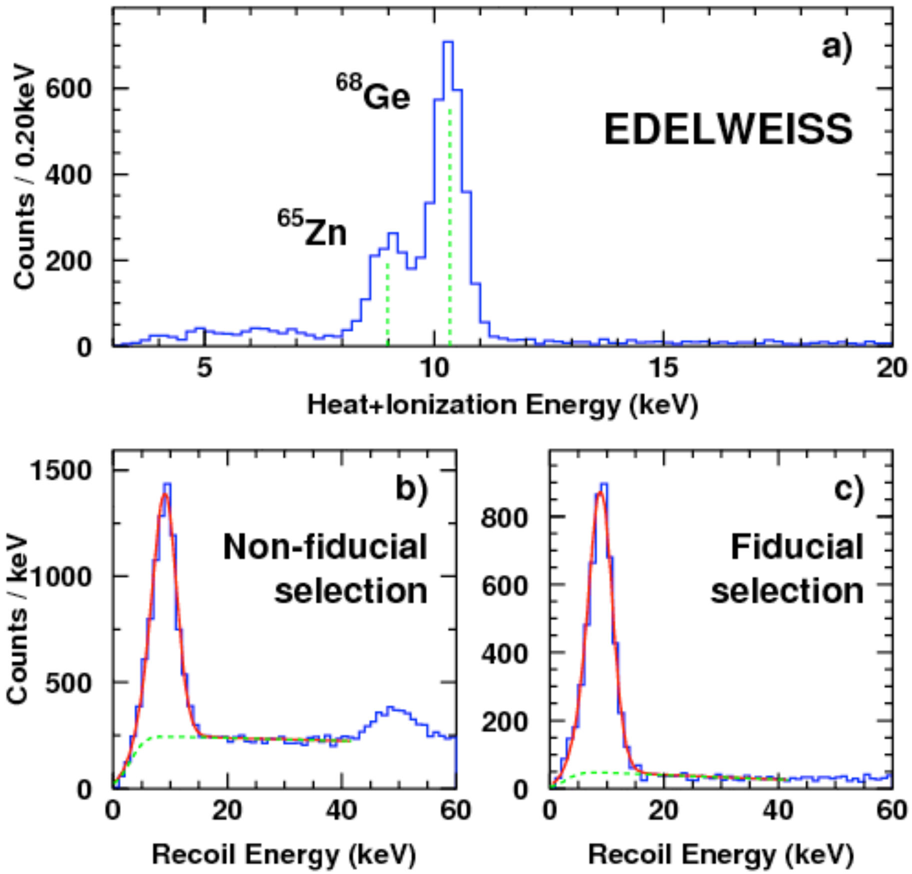


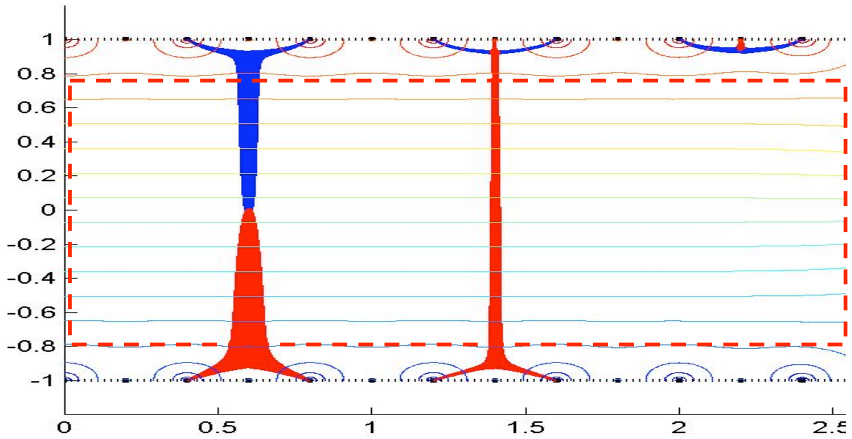


Phys Lett B 681 (2009) 305-309 [*arXiv:0905.0753]*

ID fiducial volume

Data : all WIMP search (9 detectors)



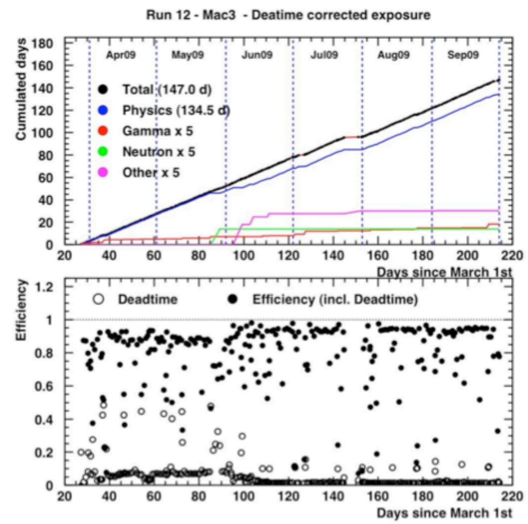


- Estimation with electrostatic models

- 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…)*

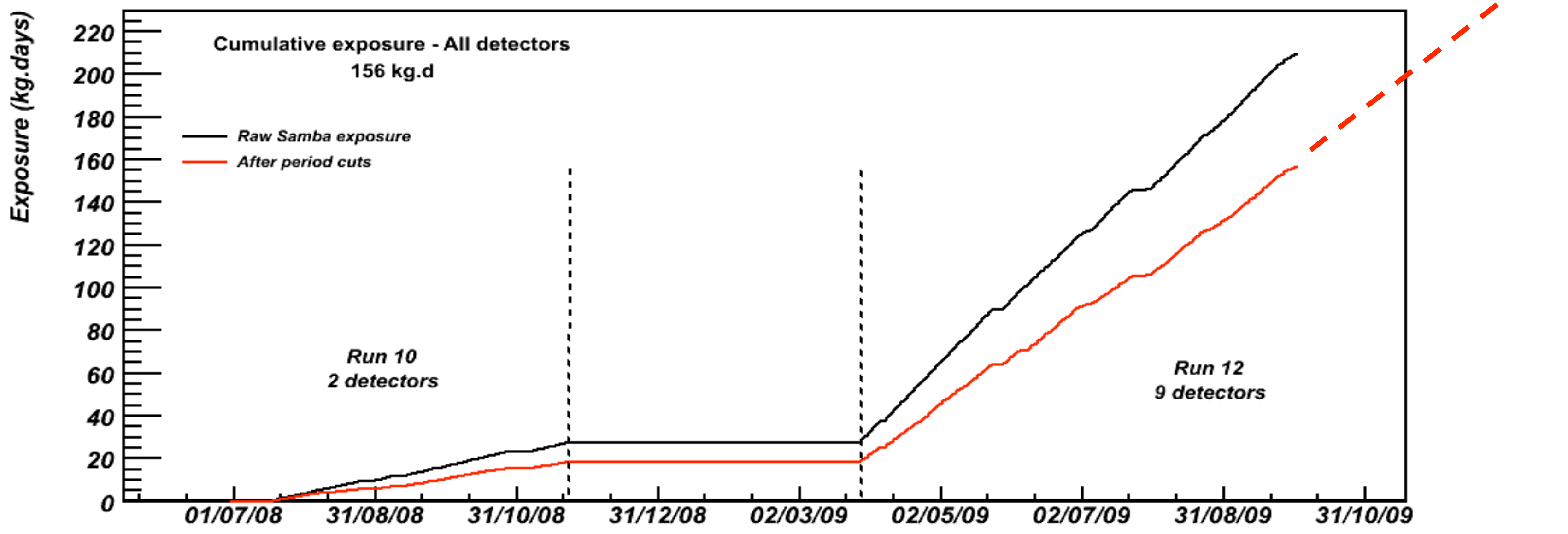
- Other measurement : using neutron calibration
- **Fiducial volume measurement**
166g ± 6 => 160g, *primarily limited by the guard regions*

WIMP search with ID detectors

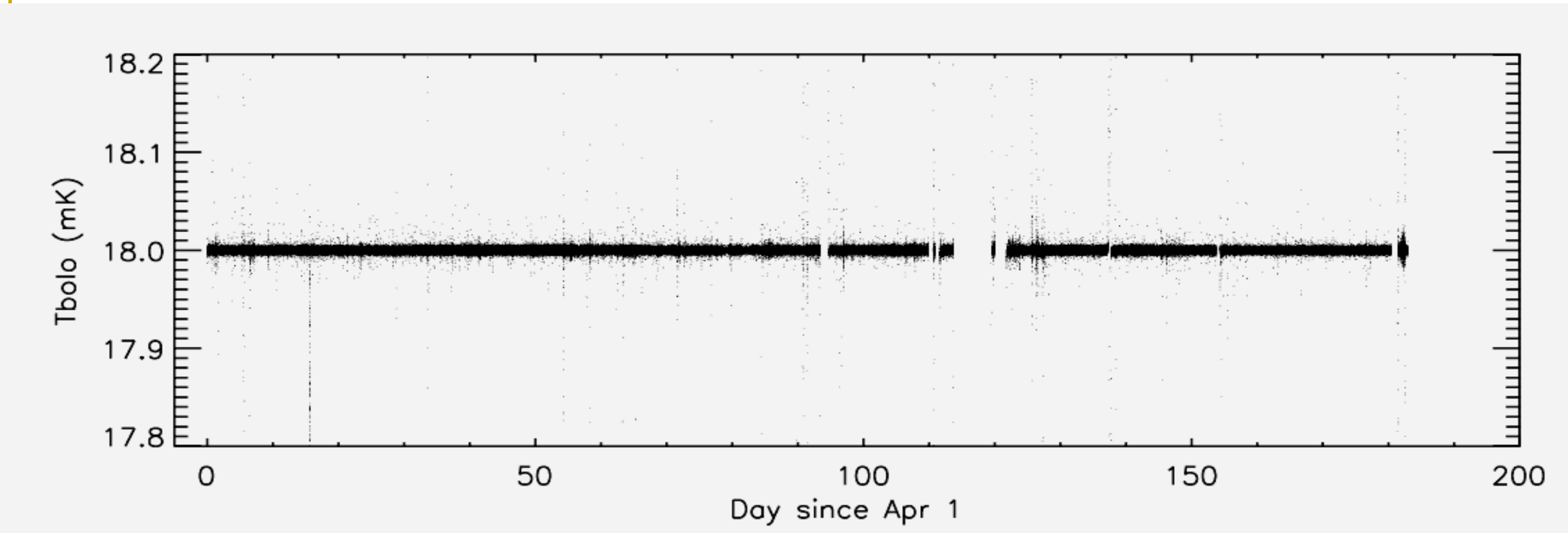


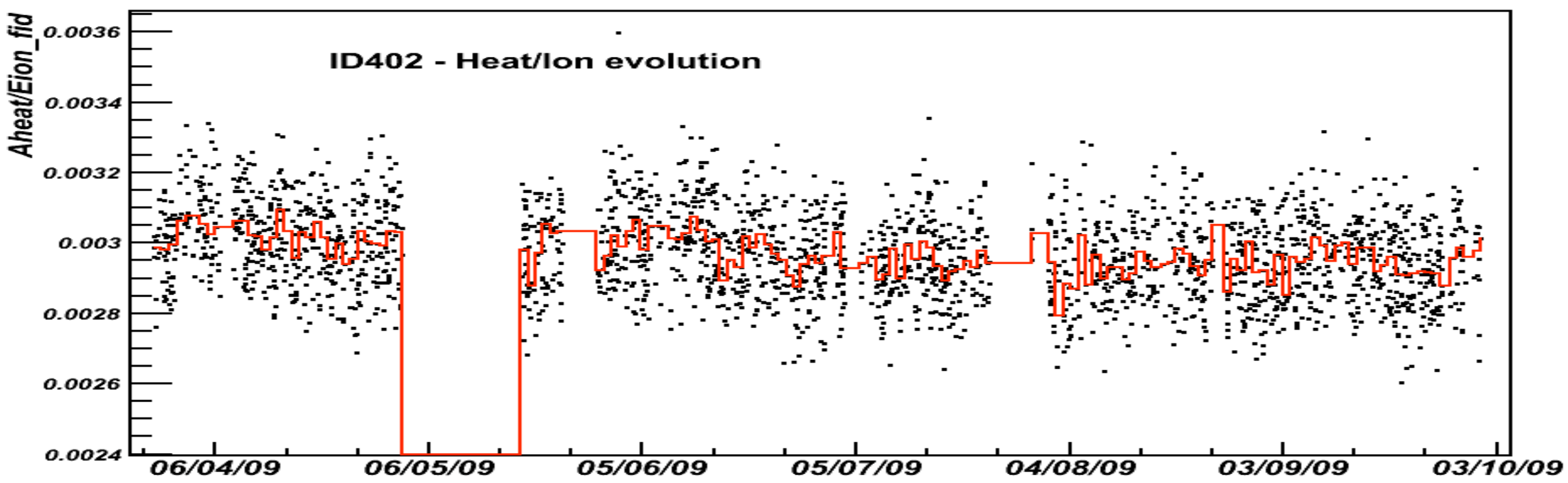
- 20 kg.d in 2008 during validation runs of ID detectors
- Physics run Apr - Sept 2009 : **6 months data** presented
- Oct 2009 - Spring 2010 : run continuing

160 kg.d « post-cut » WIMP search

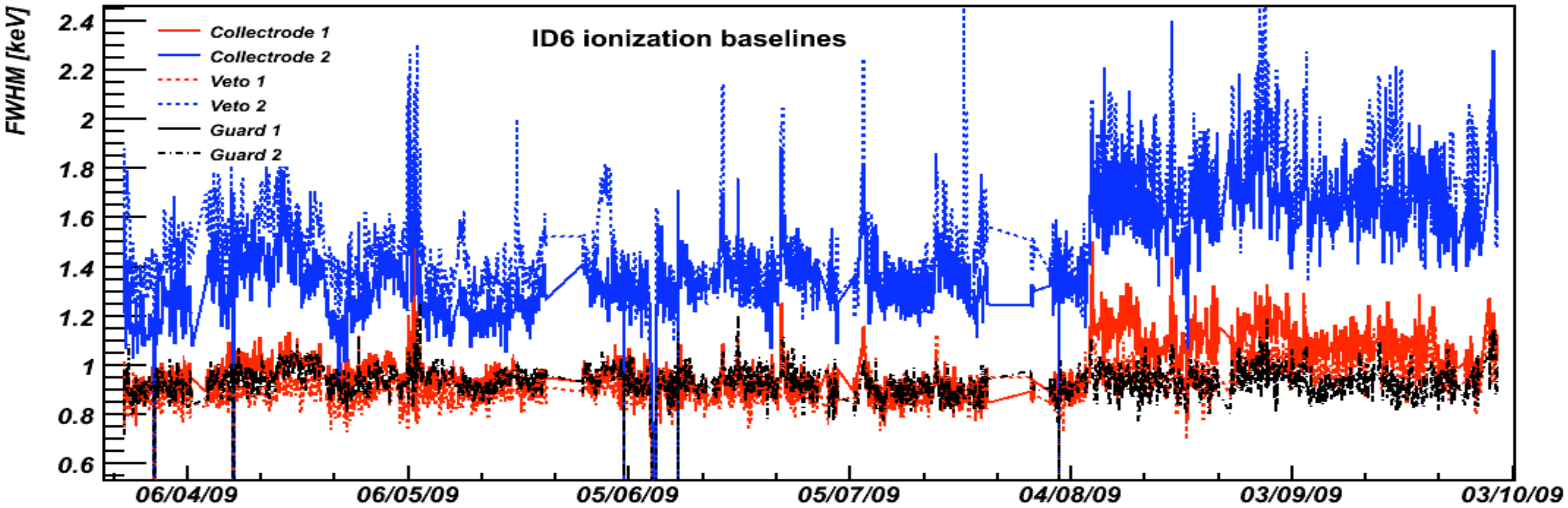


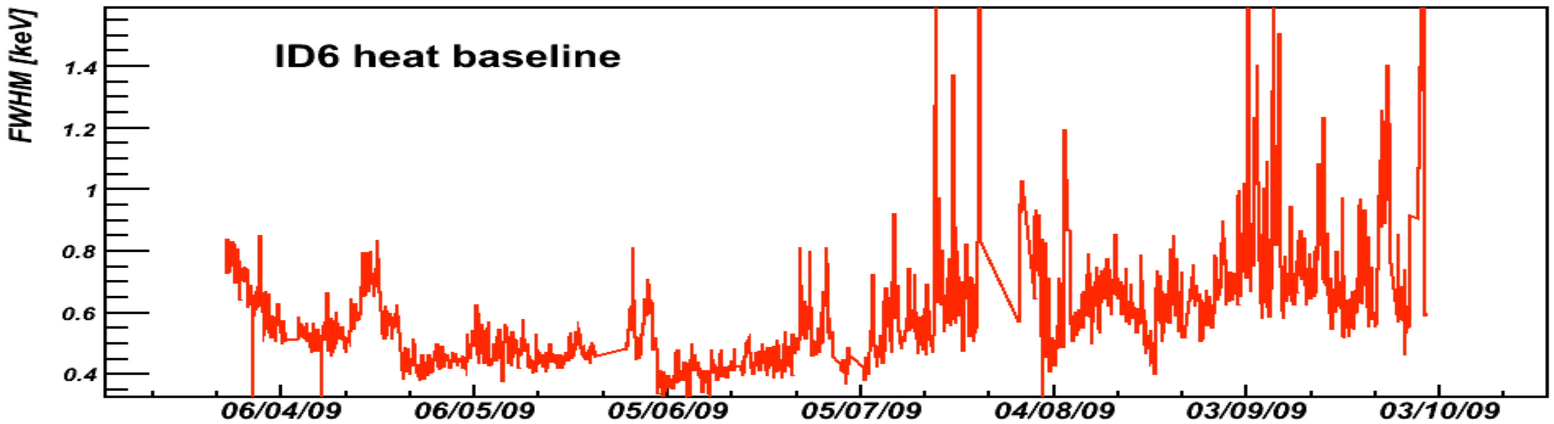
Cryogenics performances & heat sensitivity





Detector noise evolutions





Event reconstruction / Cuts / Data selection

- 2 independent processing pipelines
- Pulse fits with optimal filtering using instantaneous noise spectra

- Working detectors : heat + both « collectrodes » + 3 vetos and guards / 4
  - **9 detectors/10**
  - 10th detector (1 veto + 1 guard not working) ok a posteriori but not included in present analysis

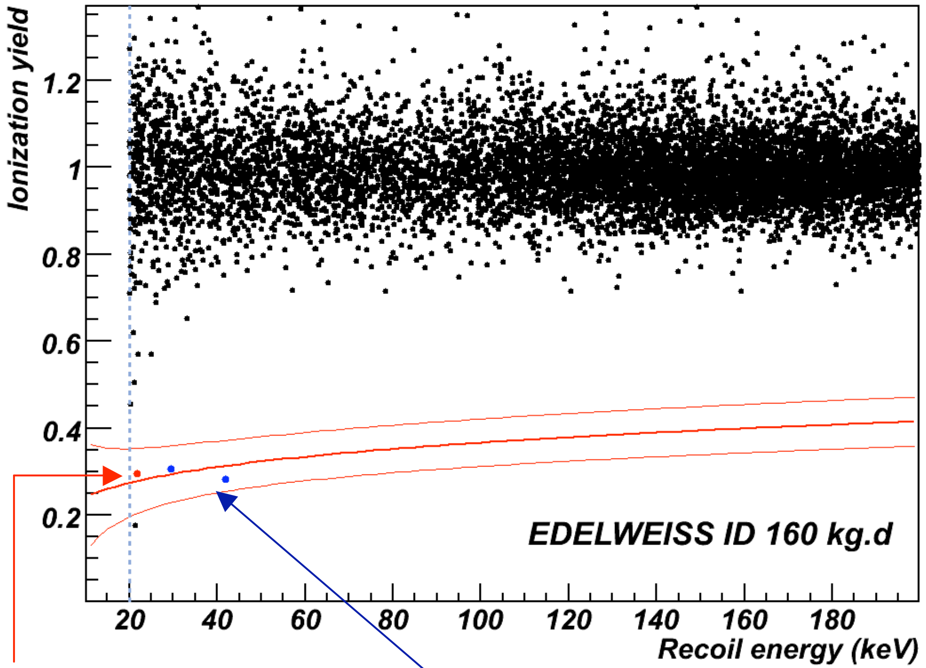
  ⇒ reliability of IDs proved in real conditions

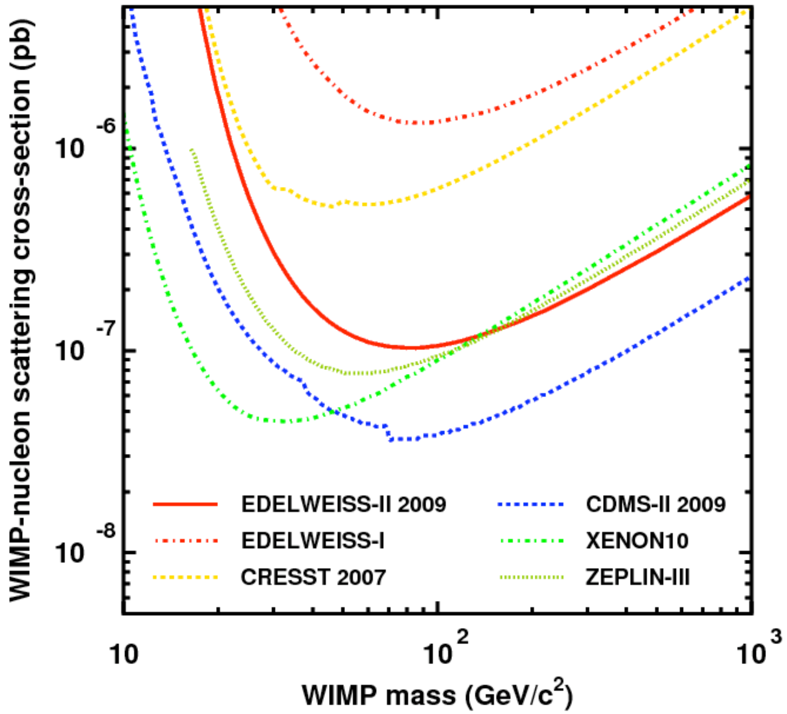
- Period selection based on baseline noises
  - **80% efficiency**
- Pulse reconstruction quality (chi2)
  - 97%
- Fiducial cuts based on ionization signals (160g)
- 90% nuclear recoil, gamma rejection 99.99%
- Bolo-bolo & bolo-veto coincidence rejection (<1%)
- WIMP search threshold fixed a priori *Er > 20 keV*

WIMP search : first result

arXiv:0912.0805

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





« WIMP candidate »
Er = 21 keV

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

Background estimation : work in progress

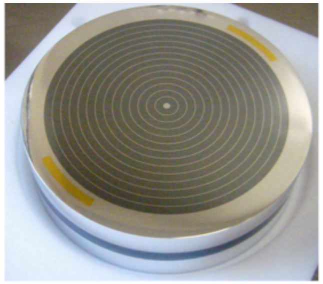
First estimation *from previous calibrations/simulations*:

- 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

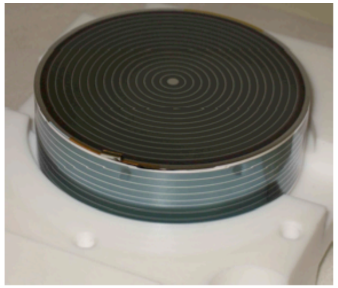
Currently ~ x1.75 exposure

From IDs to FIDs

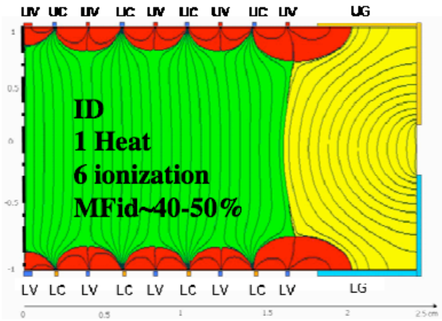


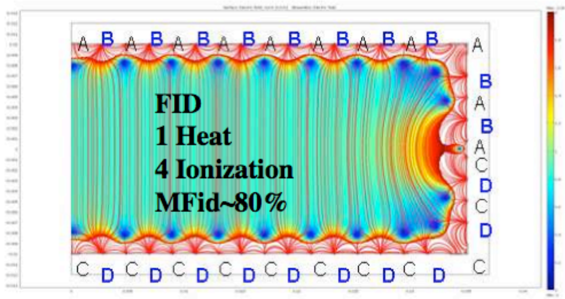
ID401 to 405:
Φ 70mm, H 20mm, 410g
14 concentric electrodes (width 100µm, spacing 2mm)
without bevelled edge.

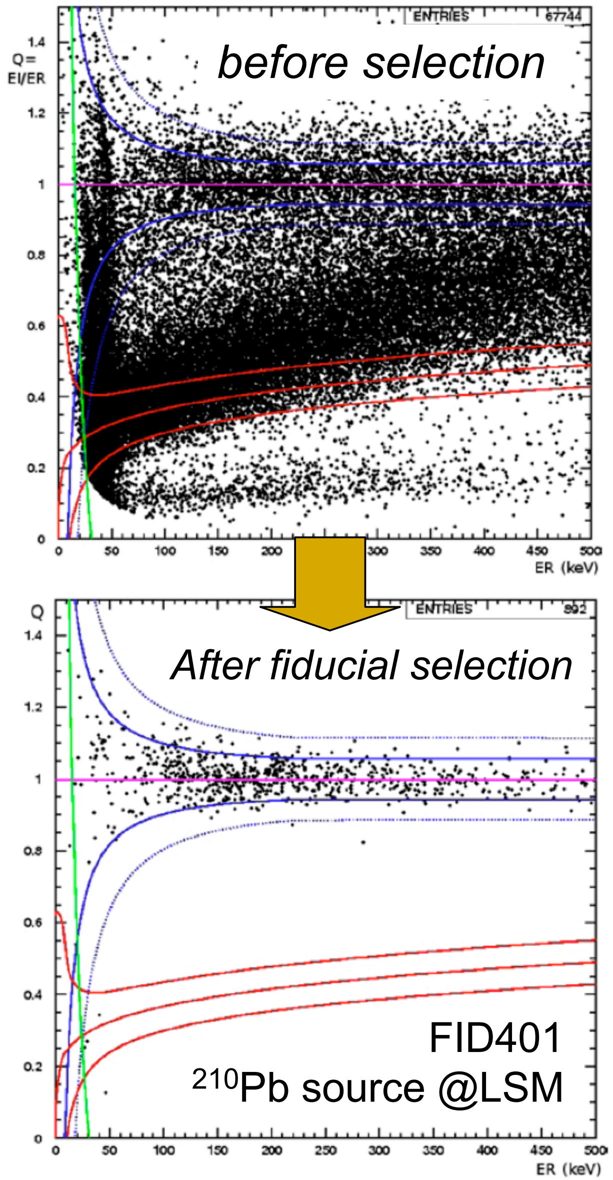
ID2 to ID5:
Φ 70mm, H 20mm, 410g
13 concentric electrodes (width 200µm for ID2, 50 µm for ID3, spacing 2mm)
with bevelled edge 8 mm.



FID401 and FID402:
Φ 70mm, H 20mm, 410g
n concentric electrodes (width 100µm ?, spacing 2mm)
without bevelled edge.



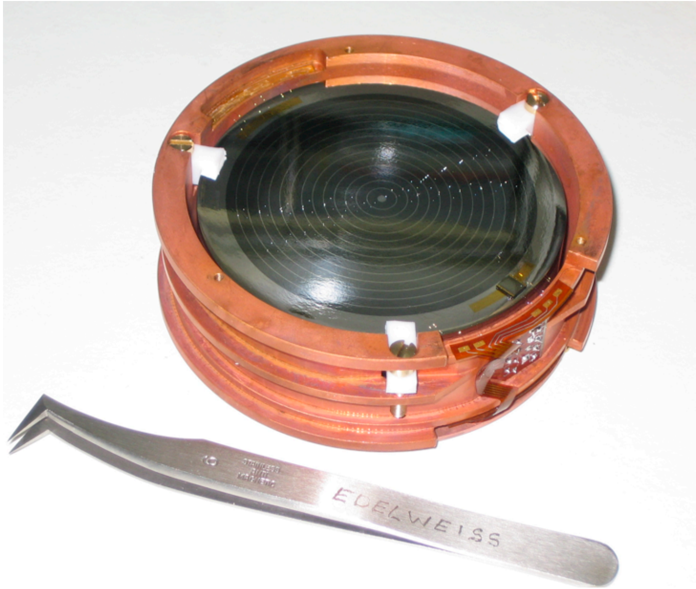




Improving the fiducial mass:
ID200 => ID400 => FID400 => FID800

FID beta rejection @ LSM :
4/68000 for E>25keV

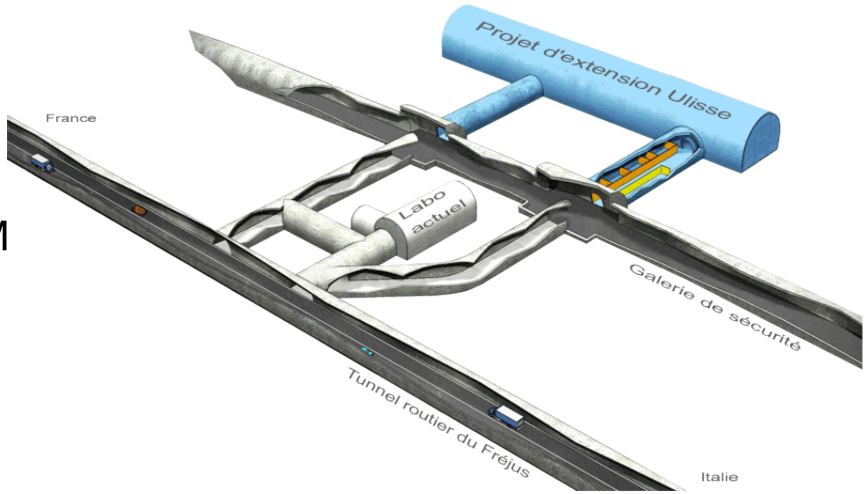
Edelweiss: summary / prospects



- EDW currently in WIMP search with new-generation ID detectors
  - Robust detectors with redundancy and very high beta rejection
  - First 160kg.d => WIMP limit @ 10^{-7}pb, 1 evt observed
  - X2 exposure in Spring (+lower threshold & bg estimations)

- Goals (including FIDs 400+800g)
  - 2011 = 1000 kg.d
  - 2012 = 3000 kg.d

  - Longer term Eureca@Ulisse, new LSM cavity



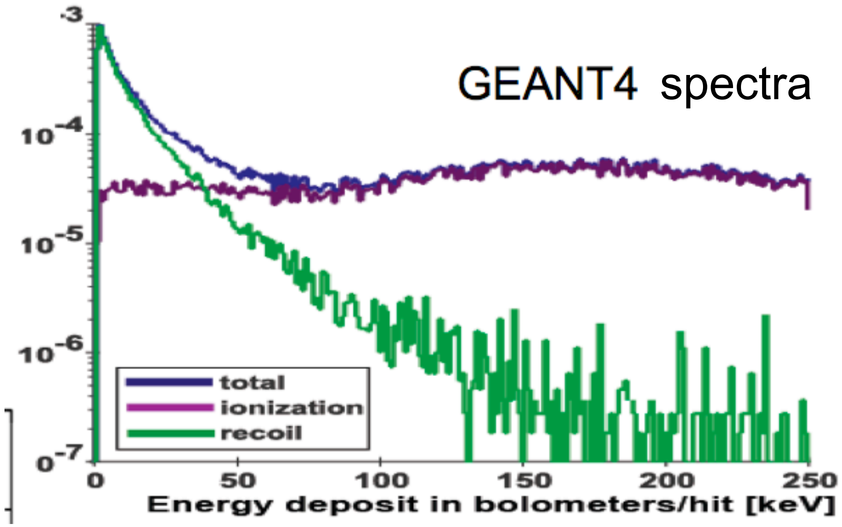
Neutron rejection : the muon veto

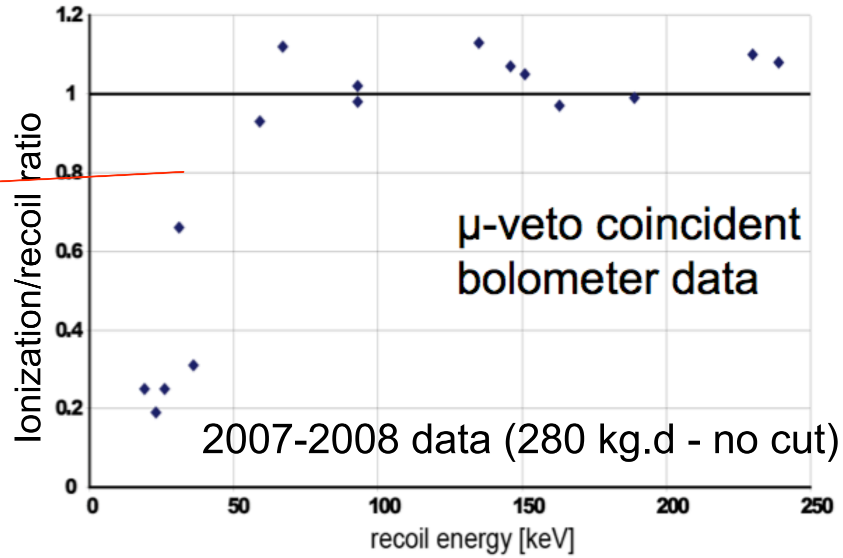
- <u>Interactions in detectors due to muon-induced neutrons inside the shields</u> :
  - Geant4 - expected : ~0.03 evts / kg.d
  - Mostly nuclear recoils below 50 keV

- Measured bolometer - muon veto coincidence rate : ~ 0.04 evts/kg.d

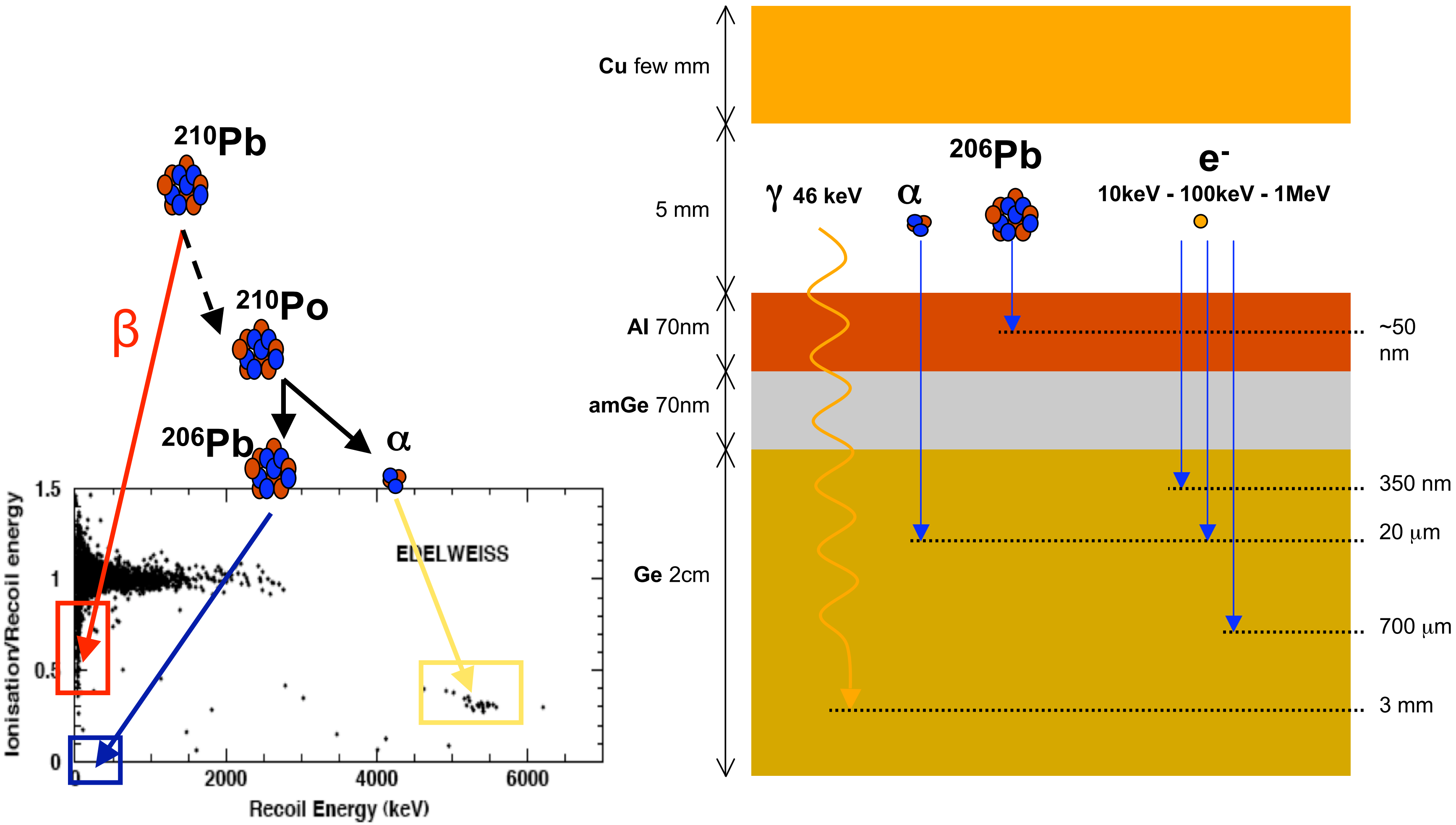
- The ionization yield distribution of coincidences is consistent with muon-induced events

  - In addition: several neutron flux measurements carried out near the experiment

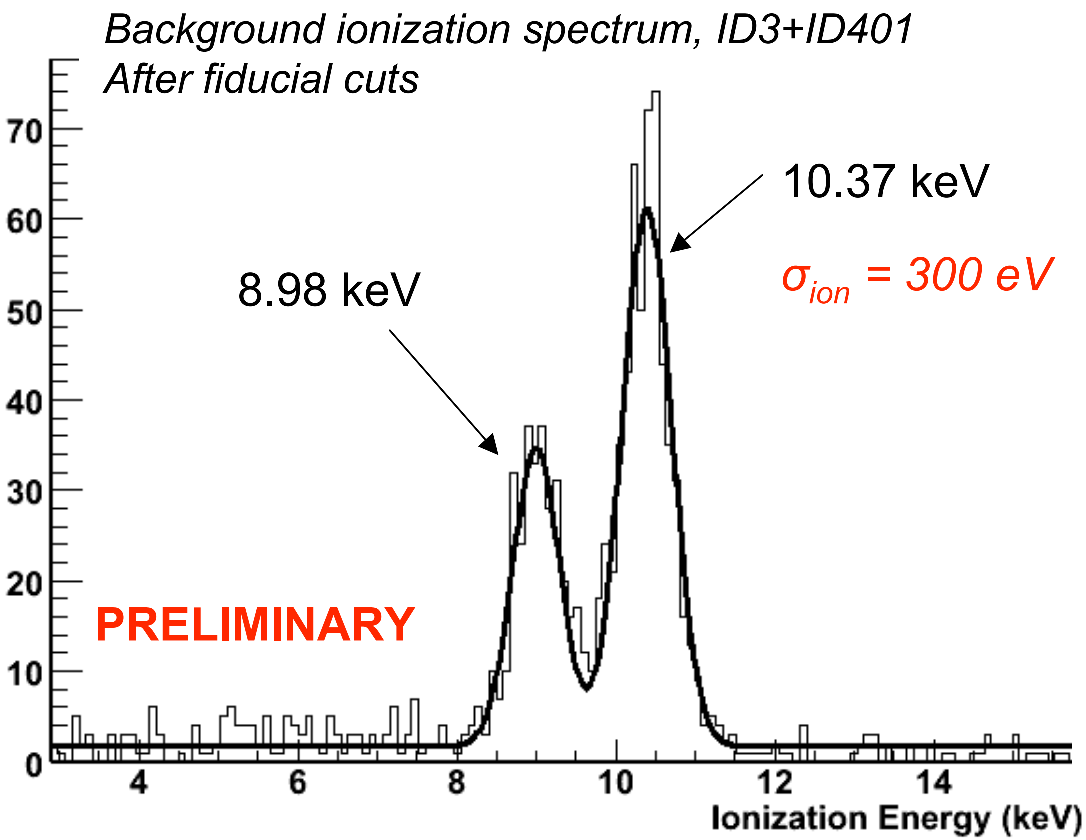




Surface interactions



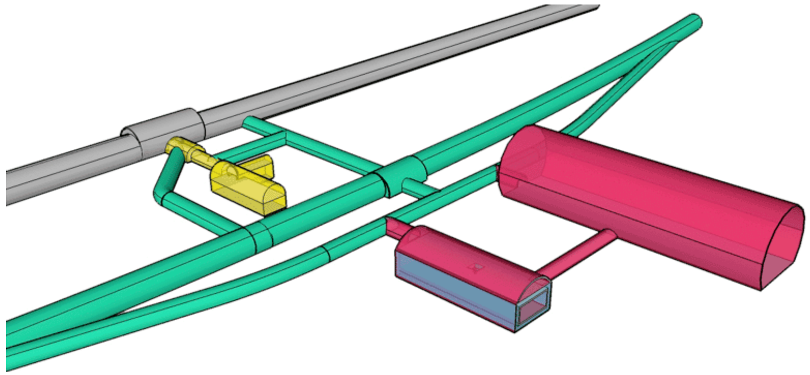
Ionization resolution of IDs

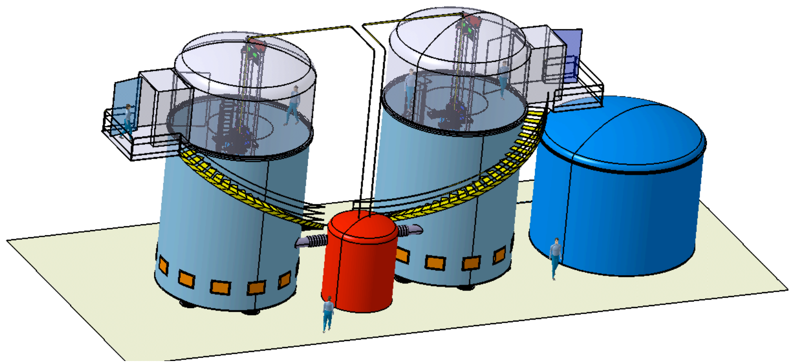


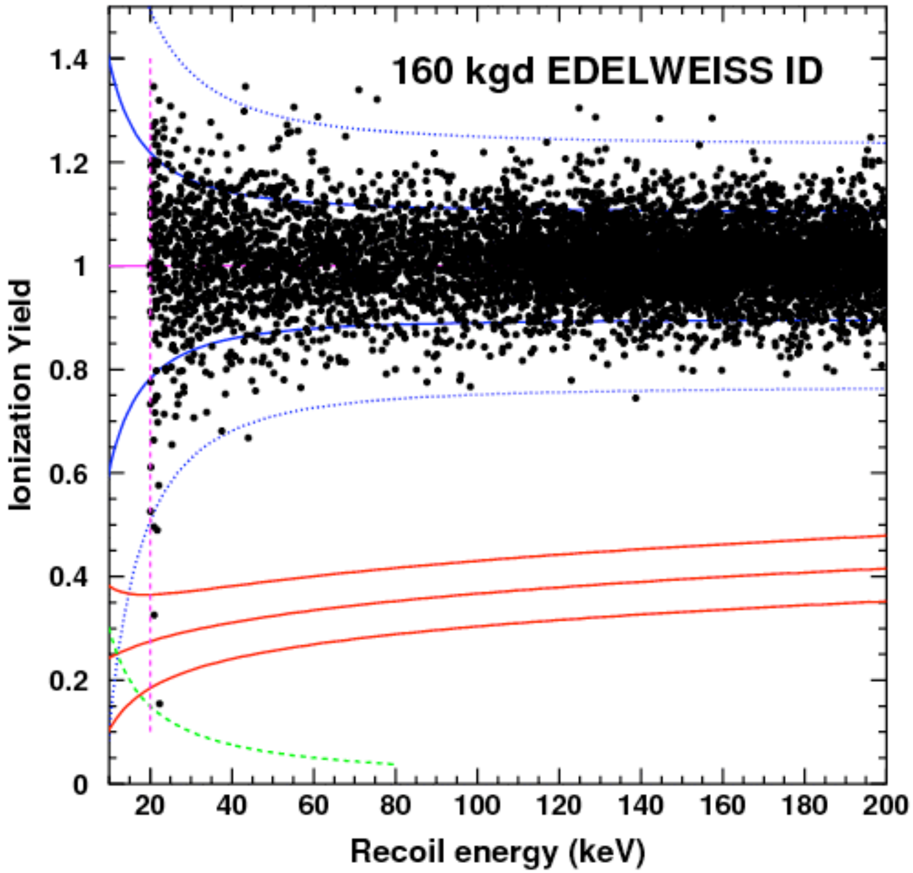
- Ionization resolution important to get a good recoil threshold
- Approx. ~ 20 kg.d of background data with two 400g detectors (2008 data)
- Background dominated by the cosmogenic lines at ~10keV
- Good and stable energy resolution

The future : EURECA

- EURECA: beyond 10^{-9} pb, major efforts in background control and detector development
- Joint effort from teams from EDELWEISS, CRESST, ROSEBUD, CERN, +others…
- >>100 kg cryogenic experiment, multi-target
- Part of ILIAS/ASPERA European Roadmap
- Prefered site: 60 000 m^2 extension of present LSM (4 $\mu/m^2/d$), to be dig in 2011-2012






160 kgd EDELWEISS ID
Ionization Yield
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120
140
160
180
200
Recoil energy (keV)