Edelweiss-II : status and first results

A new generation of background-free bolometers for WIMP search

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From EDWI to EDW II
New ID detectors
Some current results
Outlook

Valfréjus, Ulisse workshop
October 16th 2009

Direct search for WIMPs

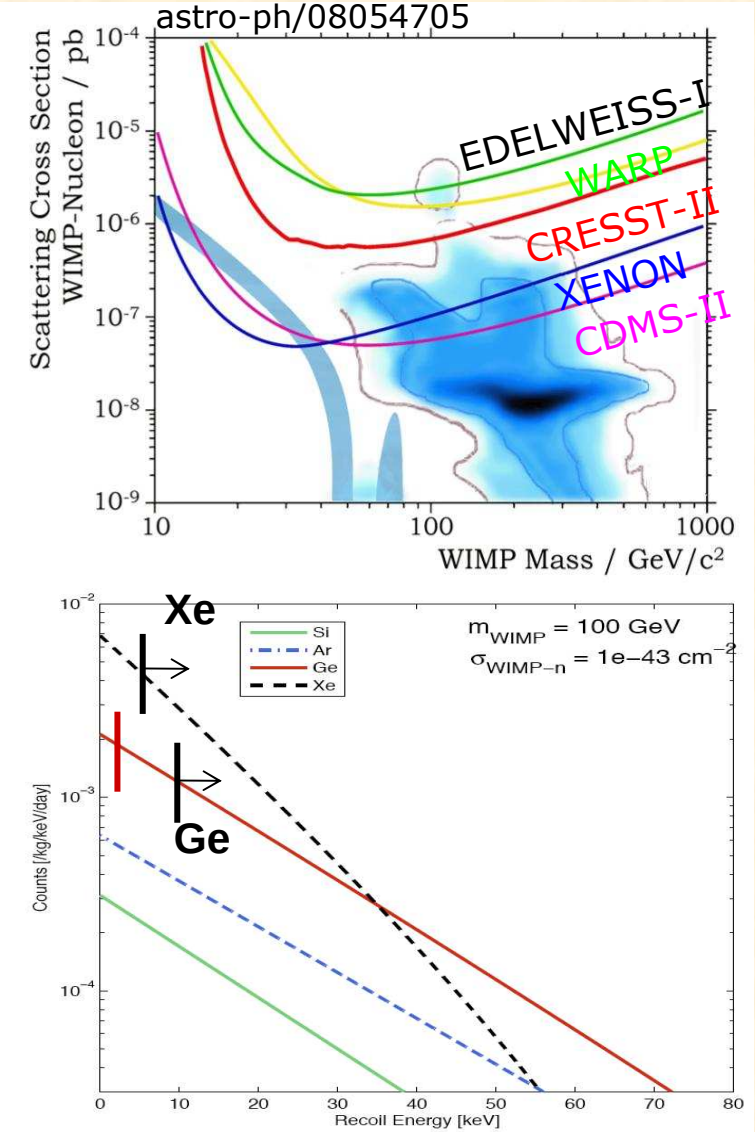
- WIMPs forming our Galactic halo :
  - 10 - 1000 GeV mass
  - v ~ 200 km/s

⇒ 0-50 keV nuclear recoils
(~ exponential spectrum)

- SUSY neutralino (σ prediction)
  <1 collision / kg / month

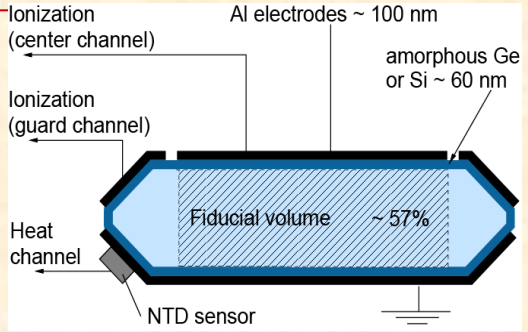
- Cryogenic 10mK **phonon/ionisation** detectors :
  Subkev resolution on both channels
  Low thresholds
  Excellent separation of populations
  => background and signal identification

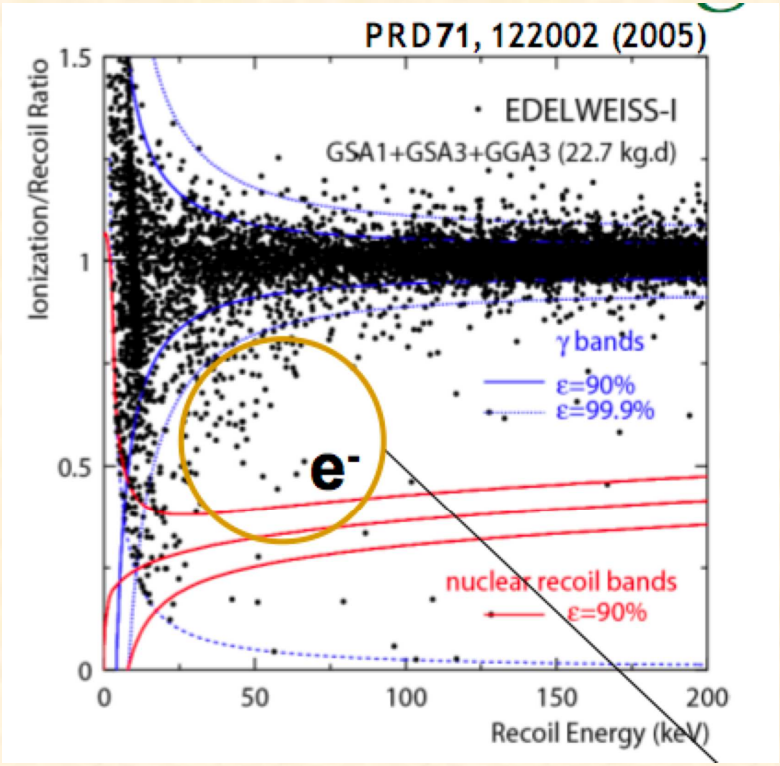
- Also sensitive to electronic recoils,
to inelastic DM, light masses



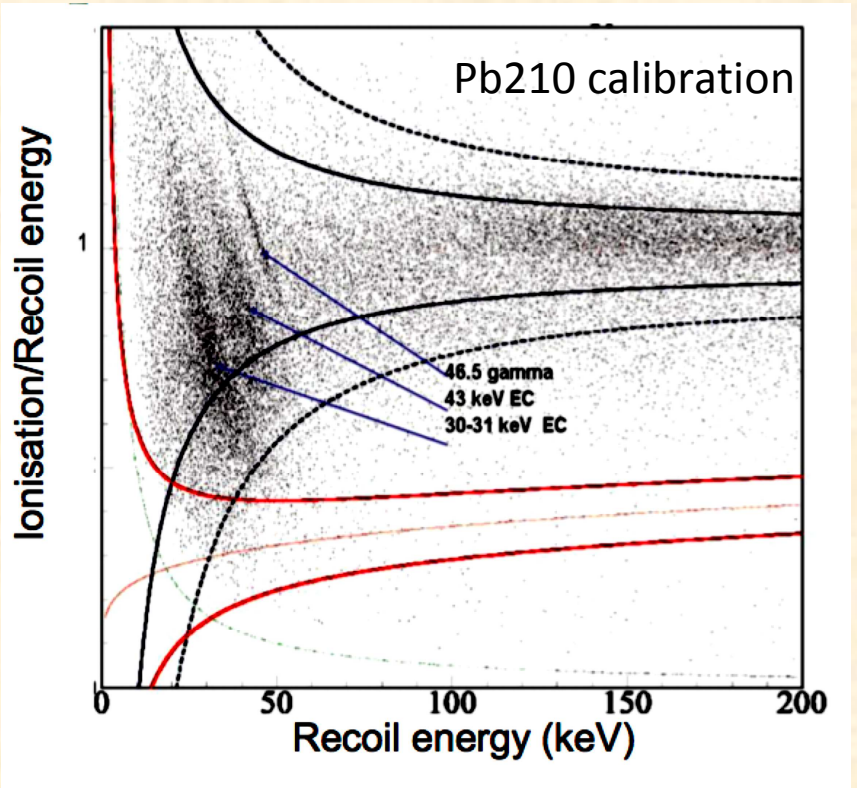
Edelweiss I results /limits (2002-2005) « NTD »

- 3 detectors of 360g, total exposure 60 kg.d
- Charge collection deficit of electron like events : « surface » events => background in ROI
- Demonstrated origin by calibration with ^{210}Pb source





Bad charge collection



- Double nuclear recoils scatter seen => Need to go to next generation EDW II

The Edelweiss II collaboration

Edelweiss
Expérience pour DEtecter Les WIMPs En Site Souterrain

- **CEA Saclay (IRFU and IRAMIS)** — **Detectors, electronics, acquisition, background, analysis**

E. Armengaud, **G. Gerbier**, M. Gros, X-F. Navick, B. Paul, S. Hervé, Y Pénichot, (M. Chapellier), P.Pari

Post-doc: A S Torrento — *Thesis : A. Chantelauze (cotutelle FZK), J Domange BDI*

- **CNRS, CSNSM Orsay** — **Detectors, cabling, cryogenics, analysis**

L. Berge, A. Broniatowski, D. Carré, S. Collin, L. Dumoulin,, F. Lalu, S. Marnieros

Post-doc/ATER : E. Olivieri — *Thesis : O. Crauste, J Domange*

- **CNRS IPN Lyon** — **Electronics, background, analysis, detectors**

C Augier, F. Charlieux, M. De Jésus, P. Di Stefano, J. Gascon, A. Juillard, V. Sanglard, L. Vagneron,

Thesis : MA Verdier, S. Scorza

- **CNRS Néel Grenoble** — **Cryogenics, electronics**

A. Benoit, M. Caussignac, H. Rodenas

- **KIT, Karlsruhe** — **Muon Veto and neutron counter, background**

J. Blümer, K. Eitel, — *Thesis :* H. Kluck, *A. Chantelauze (cotutelle CEA)*

Post doc : V Koslov

- **JINR Dubna** — **Monitoring of neutron and radon backgrounds**

E. Yakushev, S. Semikh — *Thesis : A. Lubashevski, I. Perevozchikov*

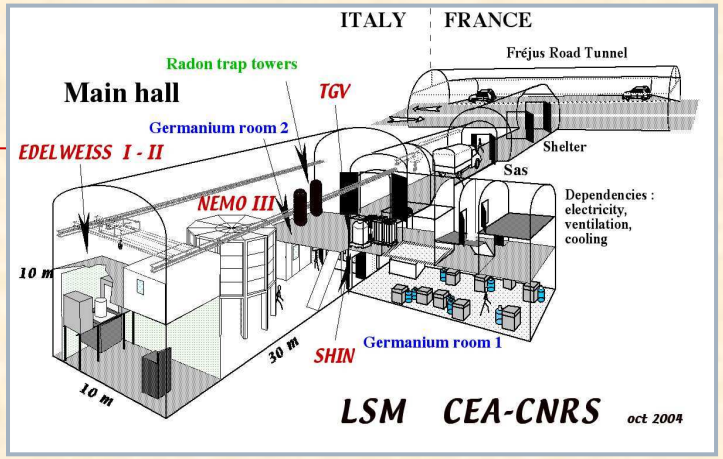
- **Oxford University** — **High impedance sensors, wiring**

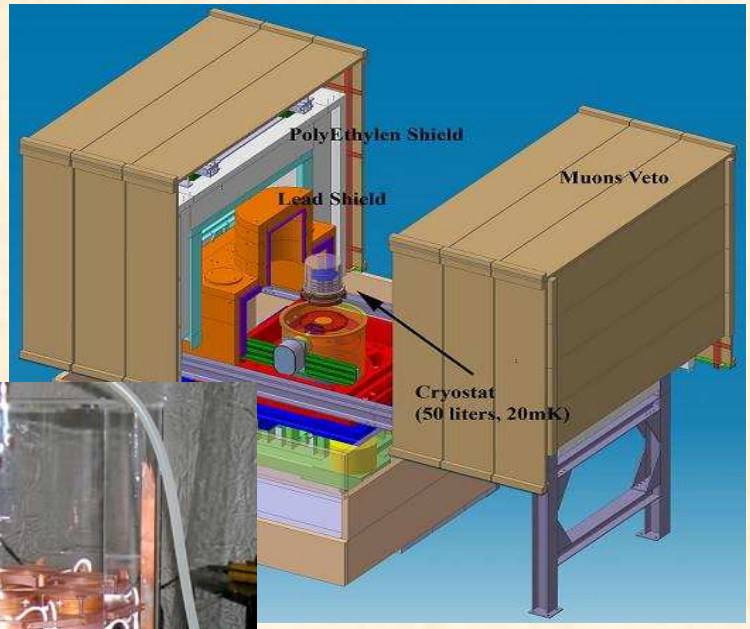
H Kraus, S Henry, V Mikaillik — *Thesis : S Kierkby*

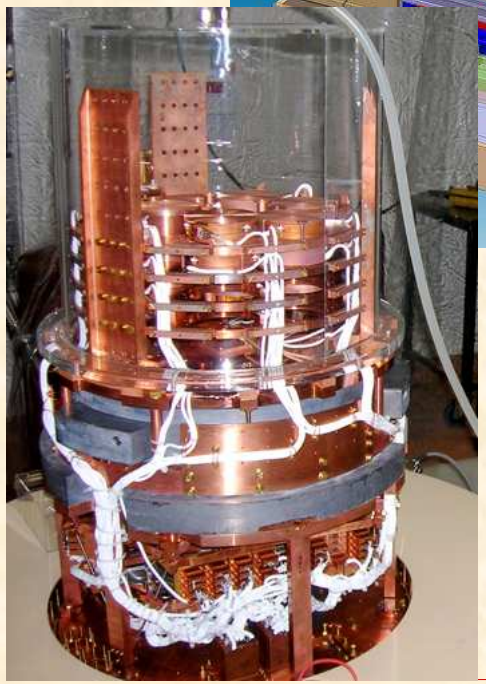
New Official member

The Edelweiss-II experiment

operated /improved since 2006







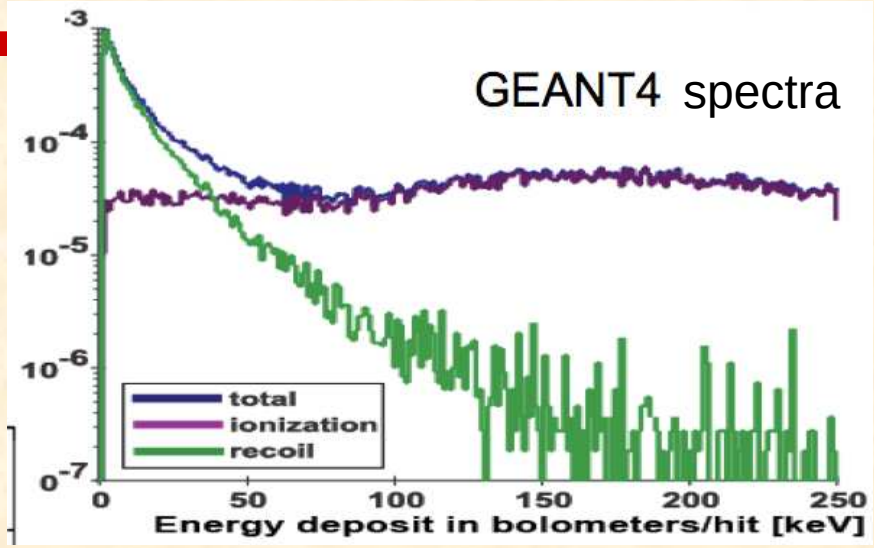
- **Operated at the Underground Laboratory of Modane, 4800 mwe** (4μ/day/m^2)
- Cryogenic installation (~ 20 mK) :
  - Reversed geometry cryostat
  - Use of pulse tubes, Gm reliqufier
- **Can house up to 50 kg of detectors**
- Shieldings :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - 50 cm PE shield, 20 cm Lead shield

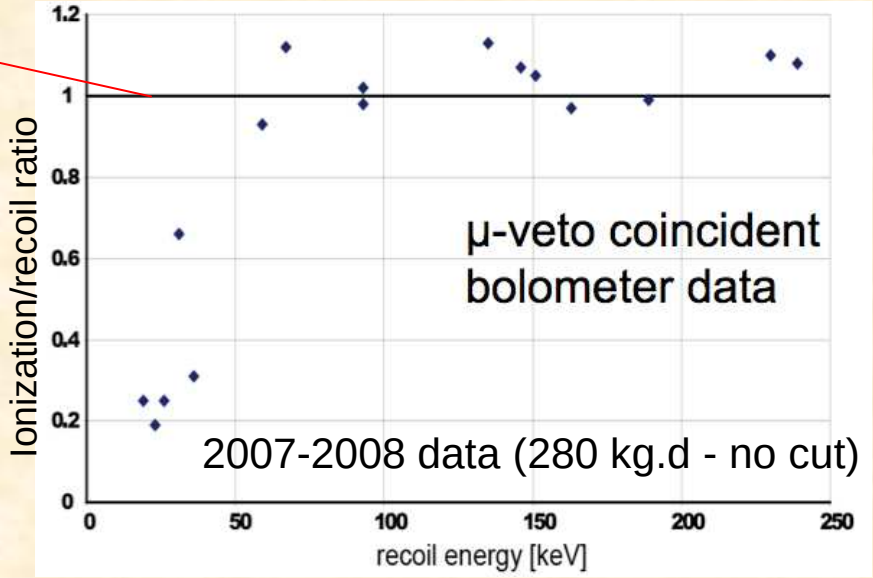
  ⇒ **γ background reduced by ~2 wrt EDW1**
- Facilities :
  - Remotely controlled sources for calibrations + regenerations
  - Detector storage & repair within clean room
- 12 cool-downs already operated

The muon veto in action

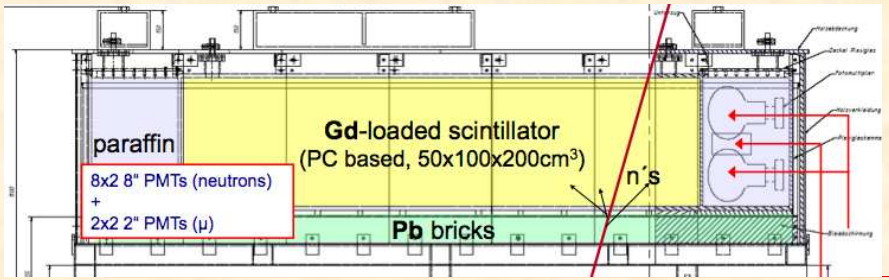
- Interactions in detectors due to muon-induced neutrons inside the shields

- Geant4 - **expected : ~0.03 evts / kg.d**
=> 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

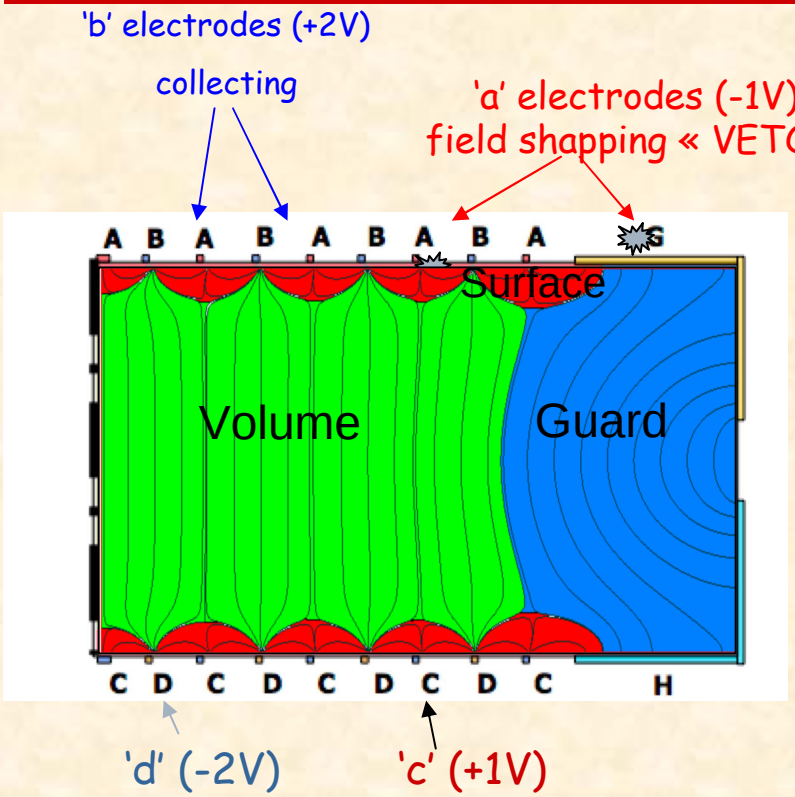




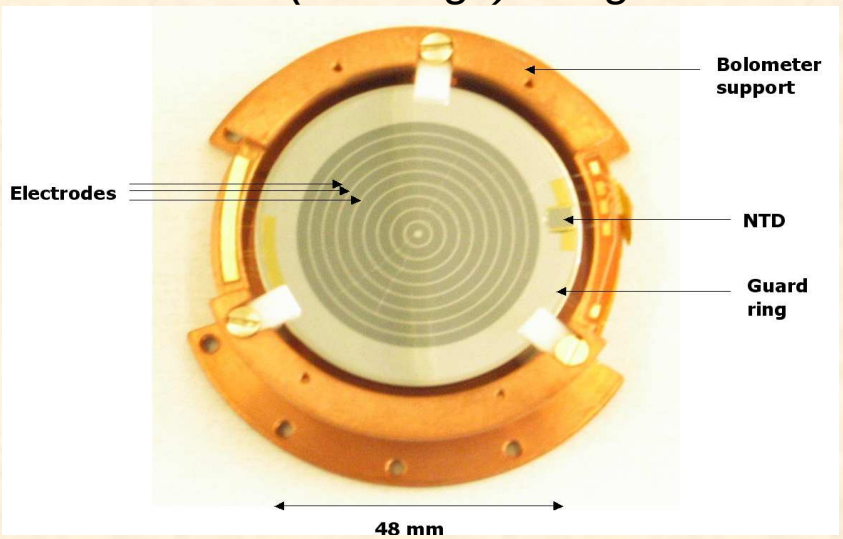
- In addition: neutron detector installed to study μ induced n with higher stats



Surface event rejection: interleaved electrodes



The first« ID » (InterDigit) 200g detector

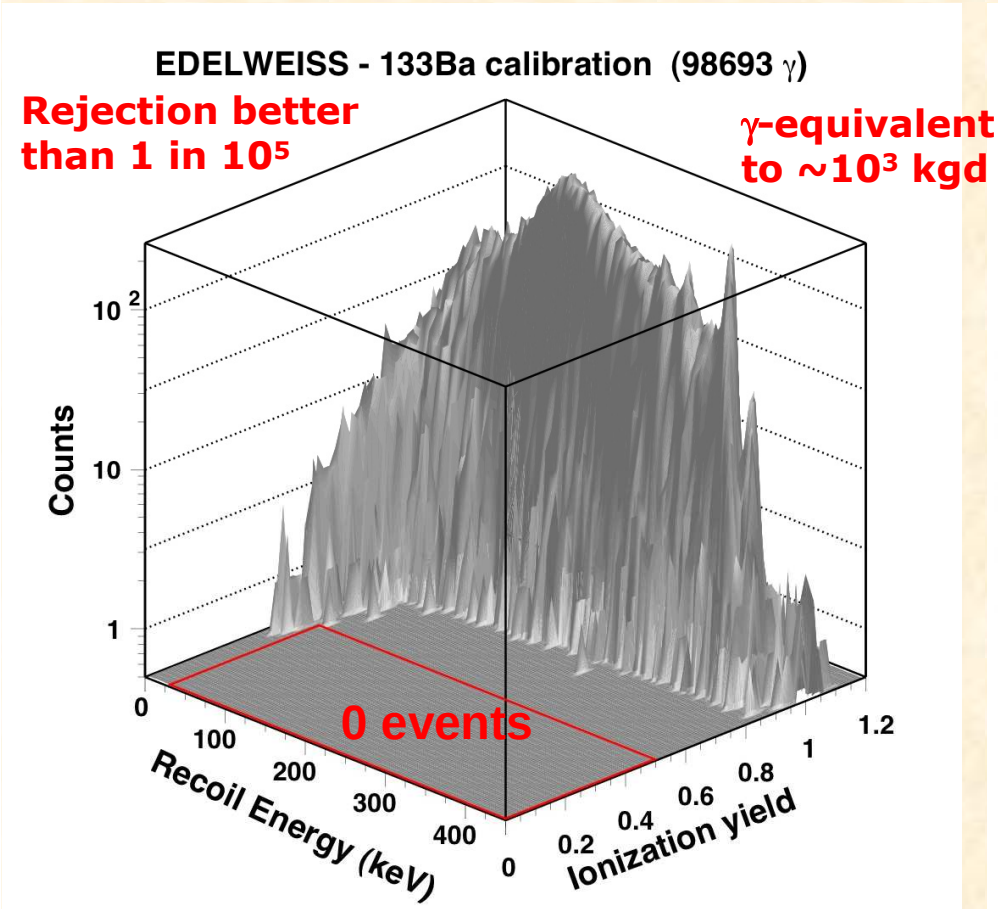


- Keep the EDW-I phonon sensor
- 6 ionisation channels
  => redondancy

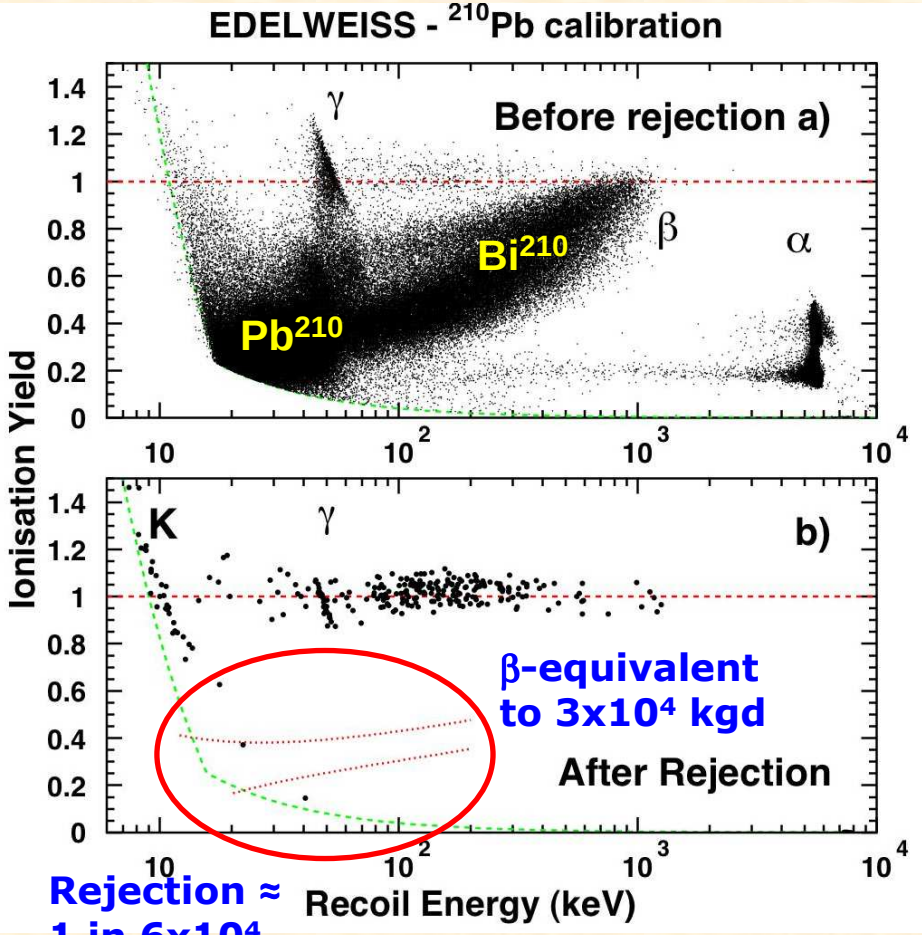
- First detector built 2007
- 1x200g => extended beta calibration
- 3x400g tested in 2008 =>First set of data

IDs : background rejection performances

arXiv:0905.0753
accepted by PLB

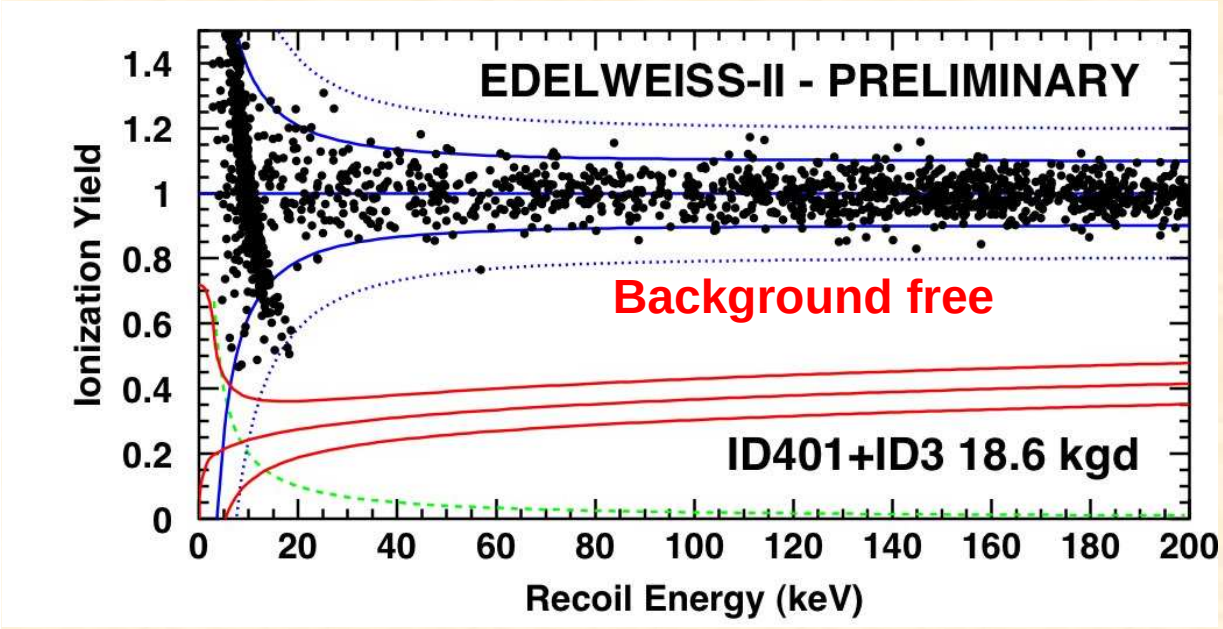


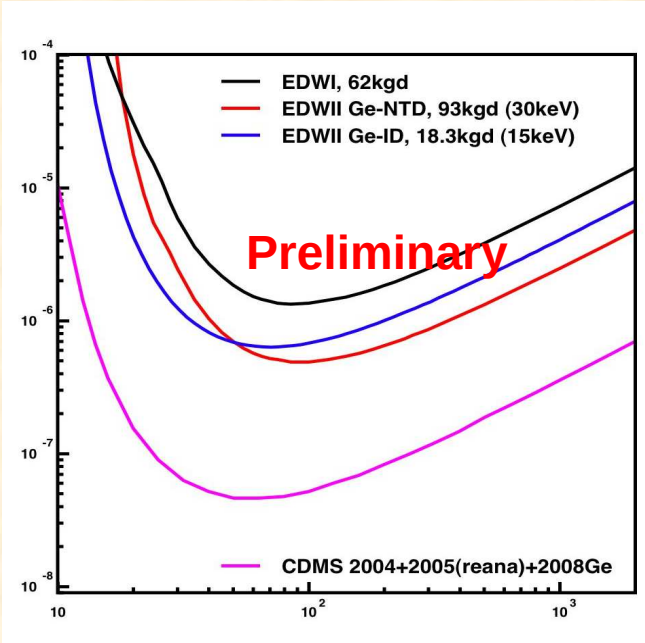
Gamma



Beta

2008 physics run with 2 400g IDs





- 86 live days / 4 months / 2x400g detectors
- 18.3 kg.d with < 15 keV threshold, ~50% eff at 10keV

2009 : detectors in operation

- 5 x ID400: 411 g

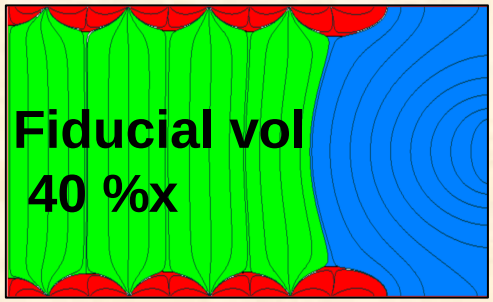
Built @ Orsay-CSNSM

- 5 x ID0: 360 g

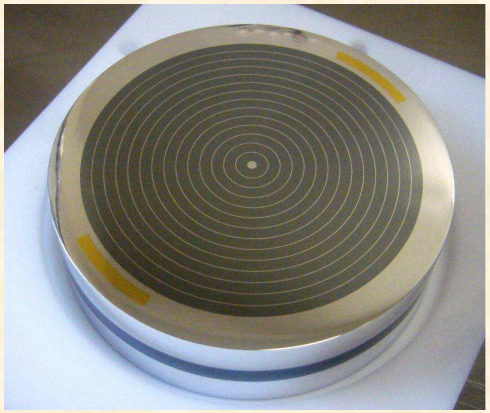
Built by Canberra

- 2 x Full ID: 411 g

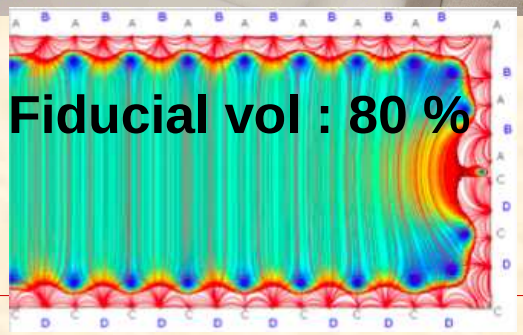
Built @ Orsay-CSNSM

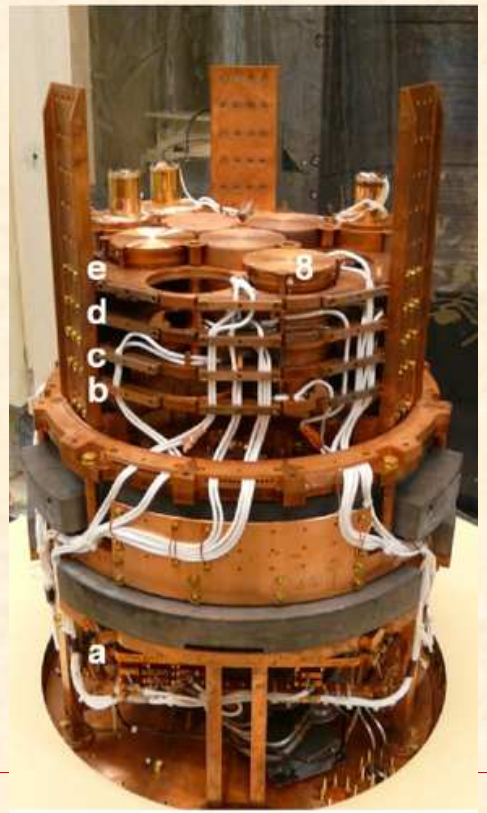


ID401



FID401

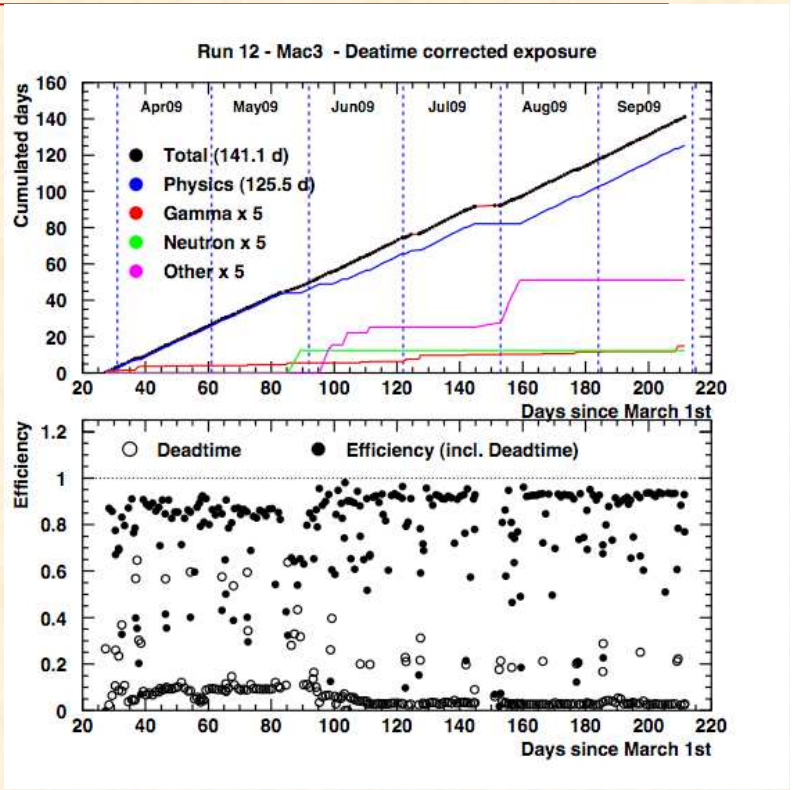




ID3

Exposure run 12

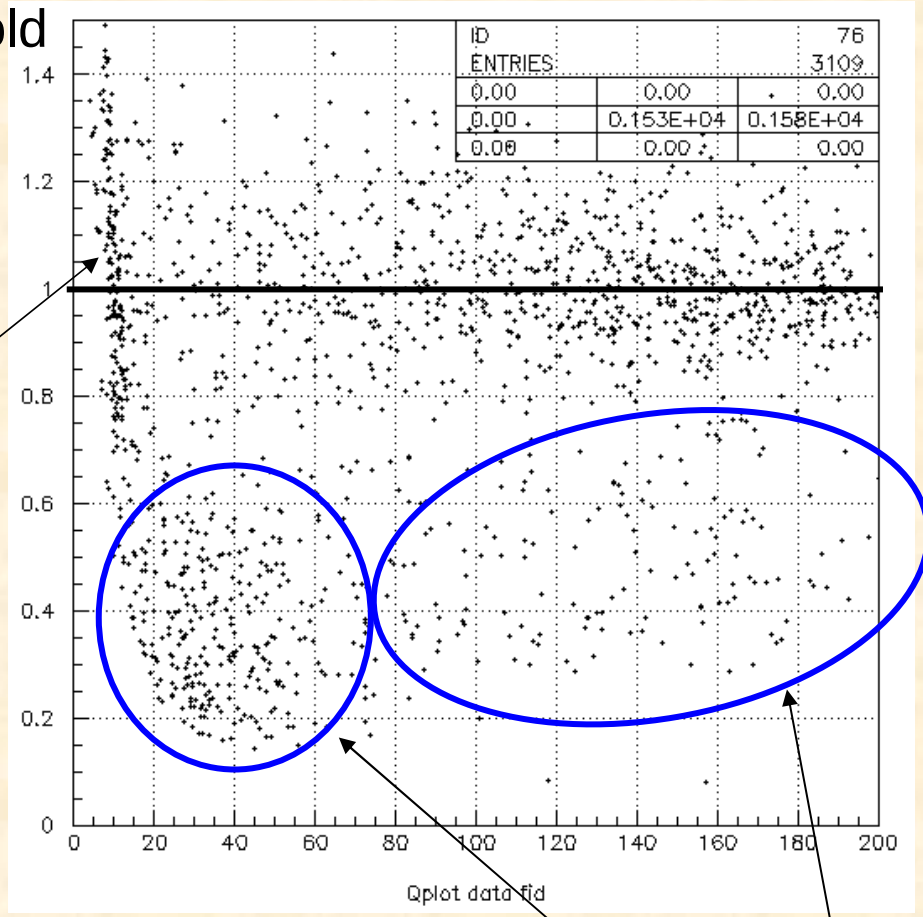
- Physics run started on march 28th
  - Total mass : 3.8 kg (+0.8 FID)
  - Fiducial mass : 1.55 kg (10 ID)
- Total time : 180 d
- Total live time : 140 d
- Physics time : 126 d
- All detectors work
- 4 channels dead /80
- Heat FHWM 0.75-2 keV
- Ionisation FHWM 1-2.5 keV mostly
- Main issue : stability



- Currently analysed data set : april-september = 6 months
  - Raw exposure : 470 kg.d
  - Fid exposure before quality cuts : 190 kg.d

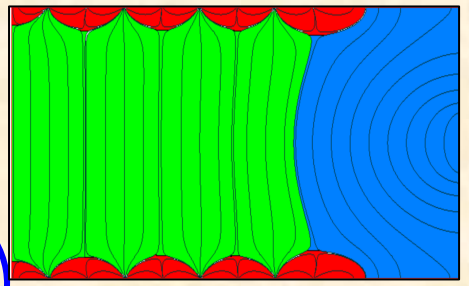
Qplot for « **surface** » events of ID3

4 keV Eion threshold
124 days of data



Expected 10 keV lines from ^{68}Ge cosmogenics

Red region data



Expected beta from ^{210}Pb, from ^{210}Bi

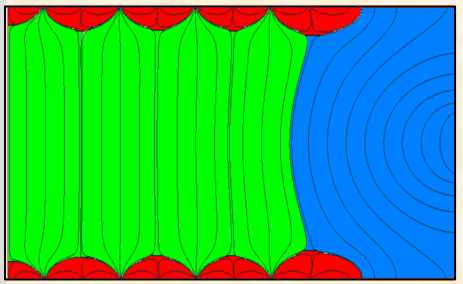
Qplot for volume events

Under analysis

Quality cuts tuned
: noisy (heat, ionisation) periods removal,
: no detector with excess events wrt mean
in control region (Q<0.5, E>Ethresh, not in ROI)

Paper by end of 2009

Green region data



Outlook for next 4 years

- 1) Increase sensitivity to WIMP search
  - fiducial mass x3 in spring, x6 end 2010
  - $<10^{-8}$ pb by 2011 (1200 kg.d)
  - fiducial mass x20 end 2011 =>10 000 kg.d exposure
- 2) Optimisation of detectors
  - Go to 800 g detectors : higher fid mass, **less channels /kg**
  - Redondancy : double heat read out, fast ionisation channel, **anticipate new backgrounds**
  - Lower purity grade study : **cost**
  - Push beta region at higher Q (amorphous Ge layer) **b rejection**
- EURECA : 10^{-10} pb goal = no background in 150 000 kg.d
  - Factor 5 away in beta : **ok**
  - Factor 50 in gamma :
    - better environment : copper from Norddeutsche Affinerie **ok**
    - better rejection measurement : **in progress**
- Detectors well fitted for EURECA and for mass production
  - Efficient, simple to build, robust
  - Industrial production (Ge producers, manufacturers) investigated