Edelweiss-II : Dark matter direct detection @ LSM

Gilles Gerbier- CEA / IRFU

http://edelweiss2.in2p3.fr/

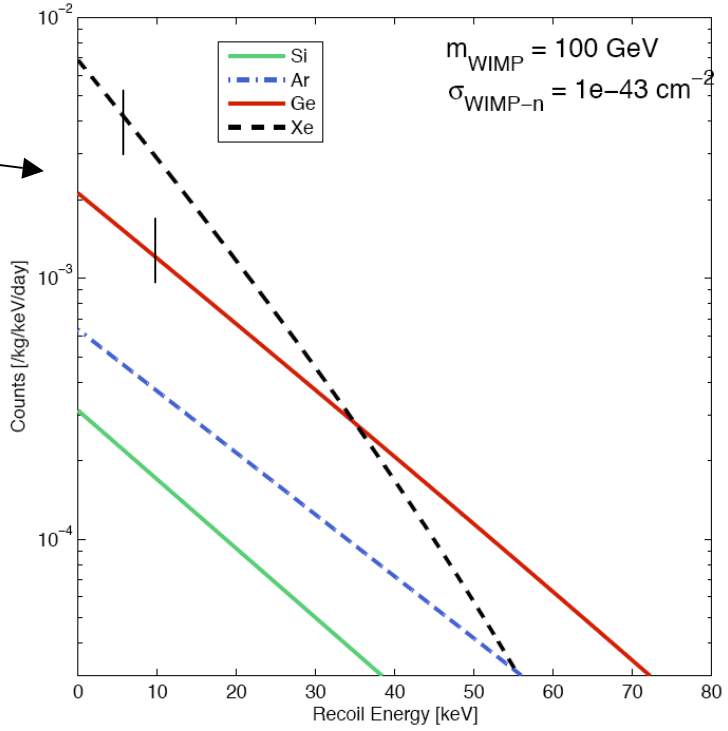
Direct detection of dark matter : principles

- A well-identified science goal:

Detect the nuclear recoil of local WIMPs inside some material

Target the electroweak interaction scale, m ~ GeV-TeV

- At least 3 strategies:
  - Search for a **global recoil spectrum**
  - V(Earth/Sun): Search for a - small - **annual modulation**
  - V(Sun/Wimp gaz): Search for a - large - **directional (forward/backward) asymetry**
- Remove backgrounds!!!
  - Go deep **underground**
  - Use several **passive shields**
  - ***Develop smart detectors*** to identify the remaining radioactivity interactions



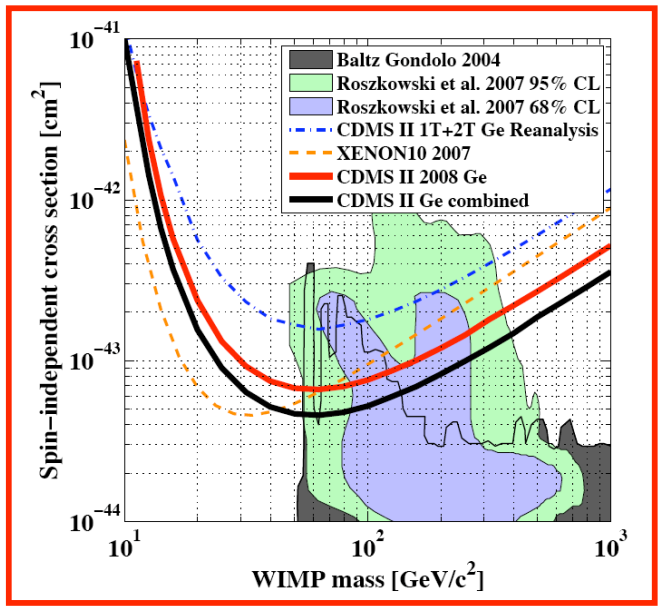
Direct detection of dark matter

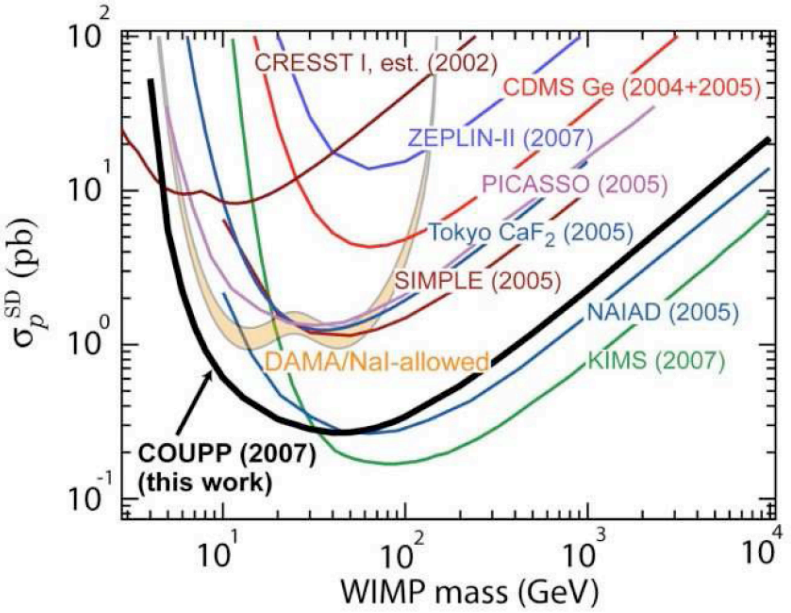
- A well-identified science goal:

Detect the nuclear recoil of local WIMPs inside some material

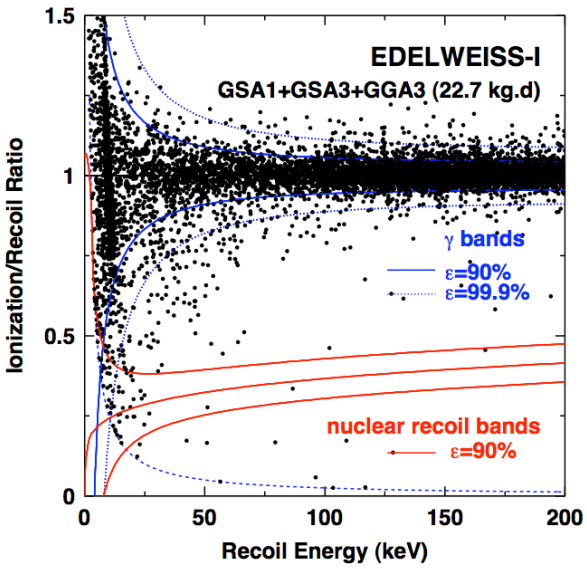
Target the electroweak interaction scale, m ~ GeV-TeV

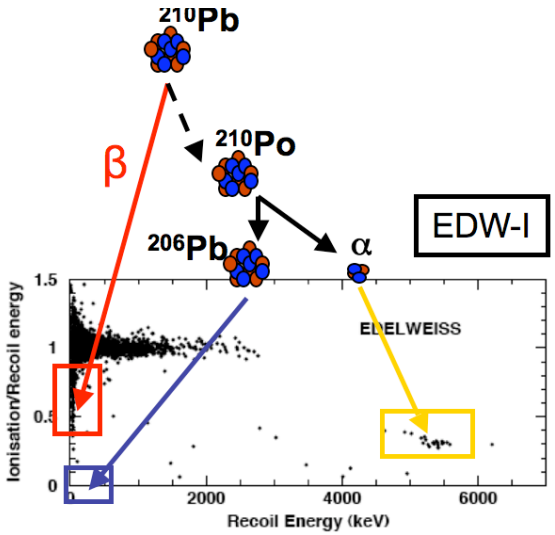
- At least 3 strategies:
  - Search for a global recoil spectrum => limits
  - State of the art





From Edelweiss-I to Edelweiss II:





- Based on the experience from Edelweiss-I 1kg :
  - Conceptually close to CDMS
  - Cryogenic bolometers with heat+ionization channels ⇒ identify bulk gamma-rays
  - Was already limited, in the end, by the presence of surface (β) interactions with incomplete charge collection
  - 62 kg.d with 3 detectors (final results 2005)
- Edelweiss-II :
  - Completely new setup : host up to 100 detectors, of different kinds
  - Development of new detectors

EDW-II:
- CEA Saclay
- CSNSM Orsay
- IPN Lyon
- Institut Néel Grenoble
- FZ / Universität Karlsruhe
- JINR Dubna

Edelweiss collaboration

♦ **CEA Saclay (IRFU & DRECAM)** **Detectors, electronics, acquisition, data handling, analysis**

SPP : E. Armengaud, O. Besida, (G. Chardin), **G. Gerbier**, (L. Shoeffel, A de Lesquen, L Mosca) SEDI : X-F. Navick, H. Deschamps, M. Gros, S. Hervé, M. Karolak, B. Paul, (M. Fesquet), SPEC : (M. Chapellier), P.Pari,

Temporary contributions SEDI/SIS : M. Carty, T. Chaleil, P. Lotrus; F. Nizery, J.L. Ritou, F. Senée

Post-doc/ATER : (R. Lemrani, F. Schwamm) *Thesis : E. Grémion, A. Chantelauze (cotutelle FZK)*

♦ **CSNSM Orsay** **Detectors, cabling, cryogenics, analysis**

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

Post-doc/ATER : Emilano Olivieri *Thesis : O. Crauste, X. Defay, Y. Dolgorouki*

♦ **IPN Lyon** **Electronics, low radioactivity, analysis, detectors**

C Augier, M. De Jésus, P. Di Stefano, J. Gascon, M. Stern, V. Sanglard, + Instrumentation: F. Charlieux,D. Ducimetiere, L. Vagneron

Thesis : S. Scorza, M.A. Verdier

♦ *(IAP Paris* *Low radioactivity, analysis*

(C. Goldbach), G. Nollez)

♦ **Institut Néel Grenoble** **Cryogenics, electronics**

A. Benoit, M. Caussignac, H. Rodenas+ Service électronique et SERAS

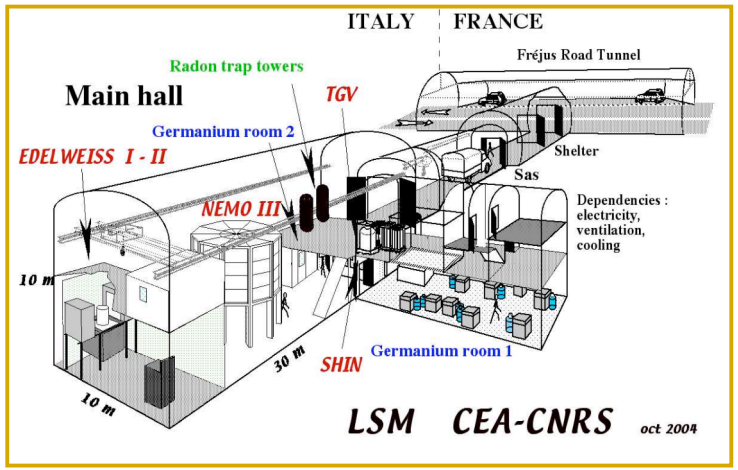
♦ **FZ/ Universität Karlsruhe** **Vetos, neutron detectors, background,**

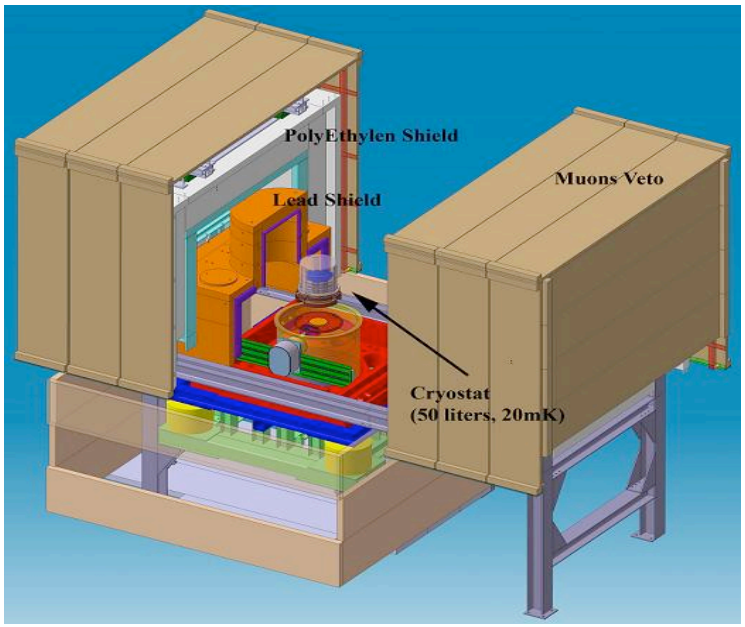
J. Blümer, K. Eitel, H. Kluck, *Thesis : M. Horn, A. Chantelauze (cotutelle FZK)*

♦ **JINR Dubna** **Background, neutron radon monitors**

E. Yakushev. *Thesis : A. Lubashevski, S. Rozov*

The Edelweiss-II setup





- Operated at the Underground Laboratory of Modane (4μ/day/m^2)
- Cryogenic installation (~ 20 mK) :
  - Reversed geometry cryostat
  - Use of pulse tubes
- Shieldings :
  - Clean room + deradonized air
  - Active muon veto (>98% coverage)
  - PE shield
  - Lead shield

  ⇒ γ background reduced by ~2-4 wrt EDW1
- Facilities :
  - Remotely controlled sources for calibrations + regenerations
  - Detector storage & repair within the clean room
- 9 cool-downs already operated

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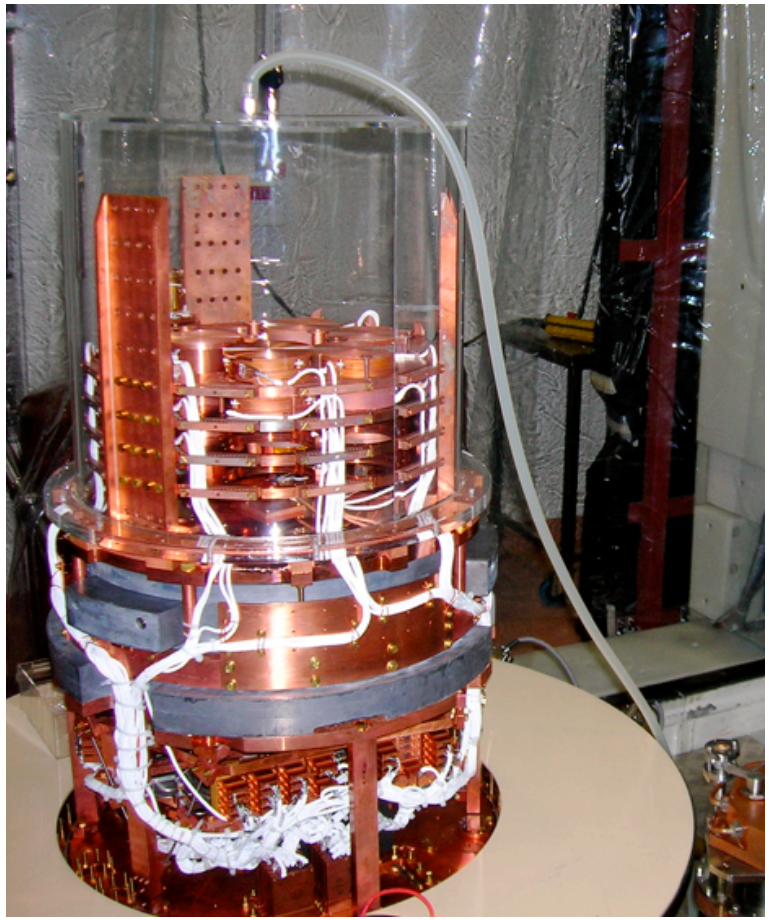

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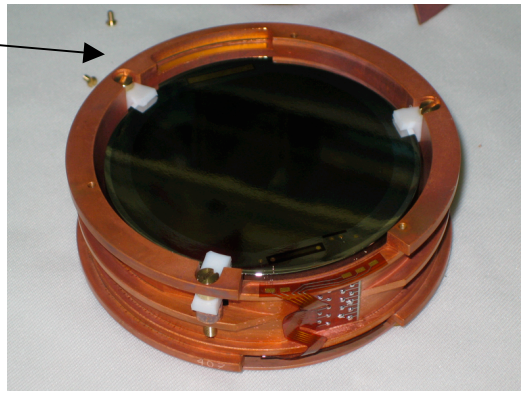
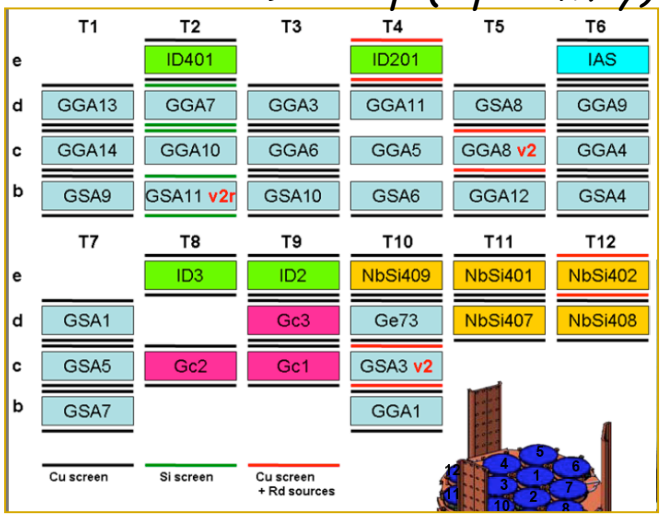
Can operate at the same time:
- R&D on several detectors
- Large exposure acquisitions

Edelweiss-II : the instrumented detectors

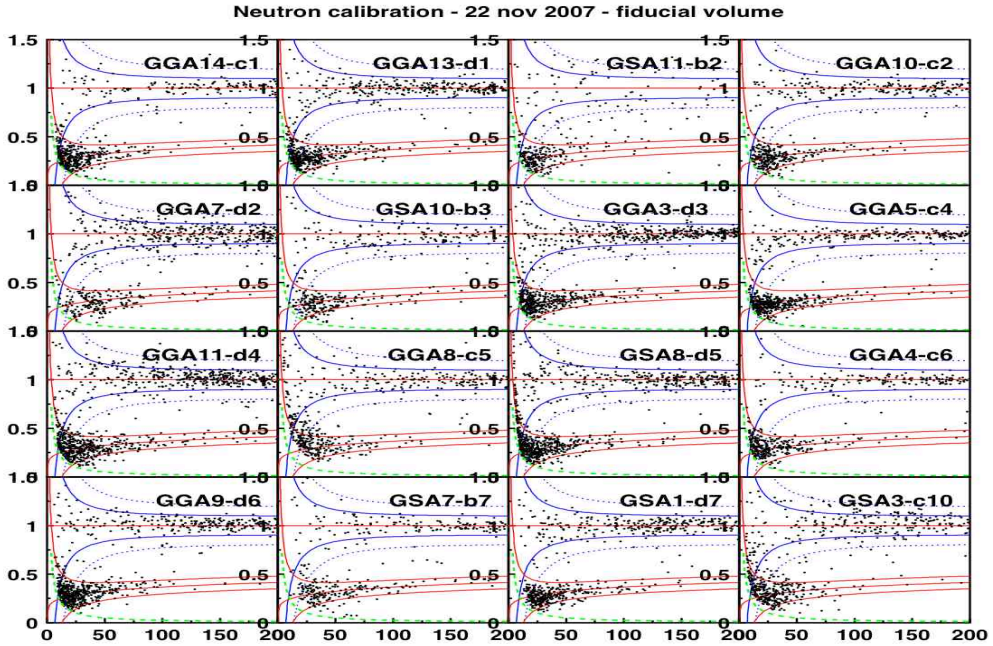
- The « standard » EDW-I NTD bolometers:
  - 2 ionization channels (center+guard)
  - NTD heat channel (edge of detector)
  - New holders, covers, cabling
  - May 2008 : 23 detectors (some with a β source on the cover for « calibration »)
- R&D bolometers for active β rejection
  - « NbSi » detectors (May 2008: 4 detectors)
  - « Interdigit » detectors (May 2008: 4 detectors)
- Some other detectors
  - A Ge73 detector (SD search)
  - A heat/scintillation Al_2O_3 bolometer

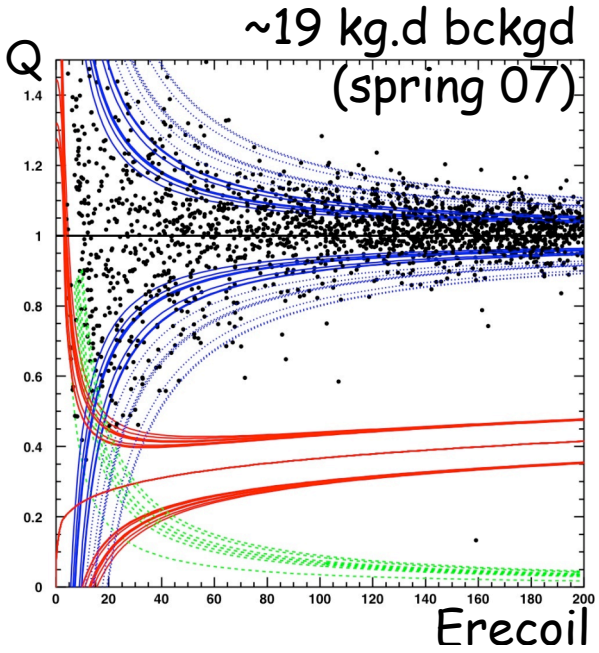


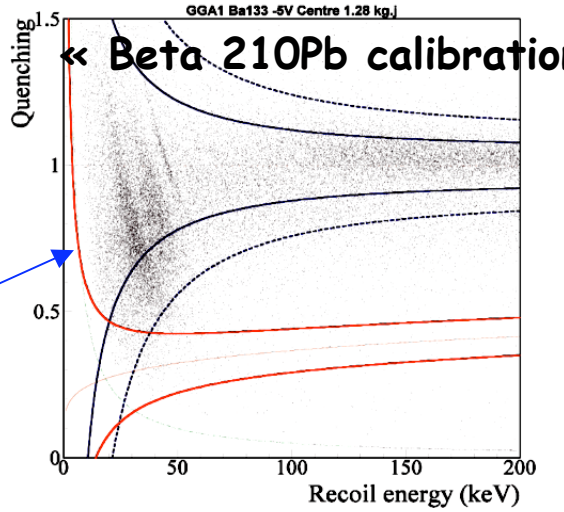
Run 9 setup (April-May)



Standard NTD detector operation





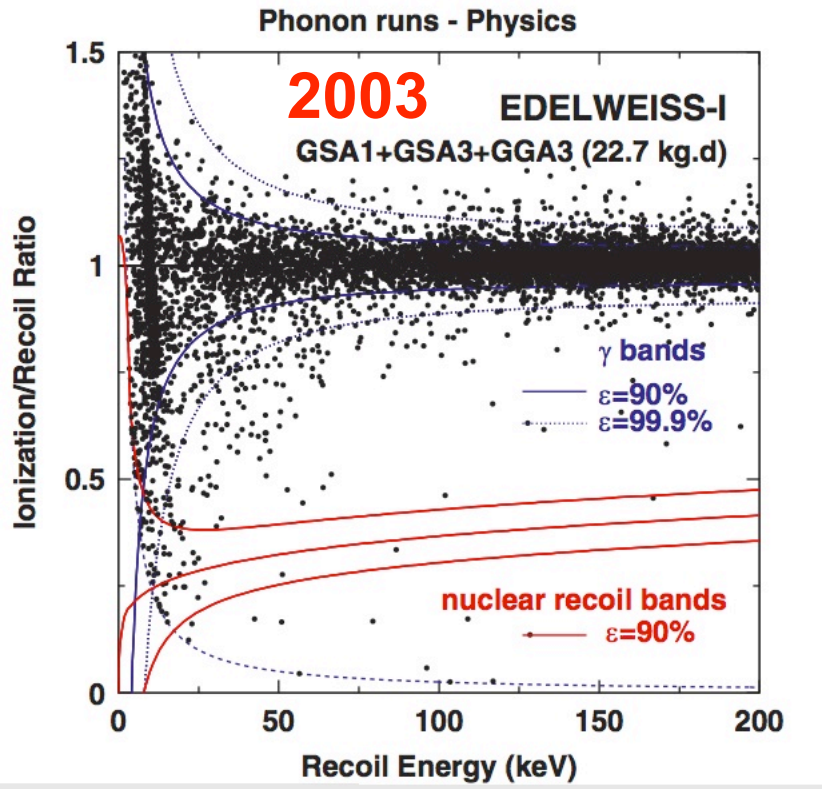


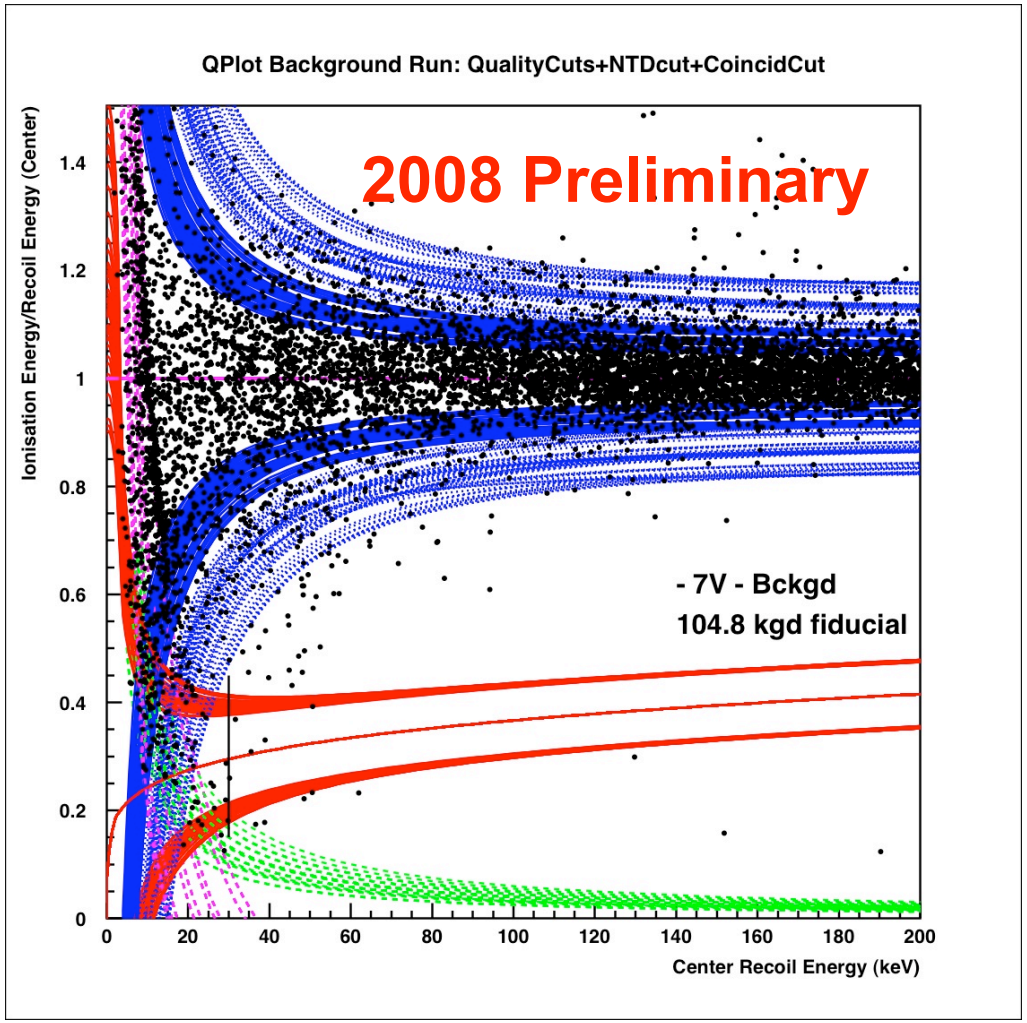
« Beta 210Pb calibration »

- First background runs spring 07, « long » background run last winter
- *Already ~100 kg.d of fiducial exposure accumulated (after quality cuts)*

- Specific studies of detector's response to surface events (« beta calibrations ») to have a quantitative understanding of the background and try to take it into account in the analysis

105 kg.d Ge NTD results -june08

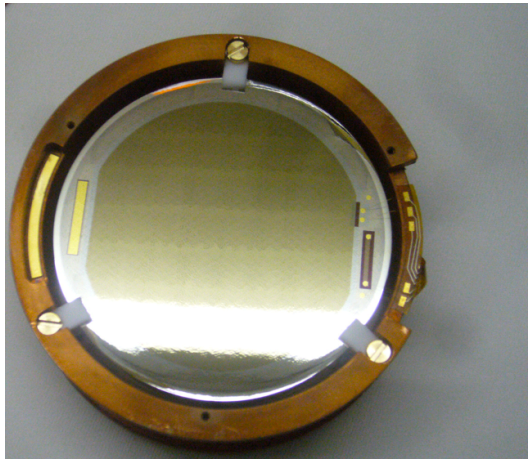


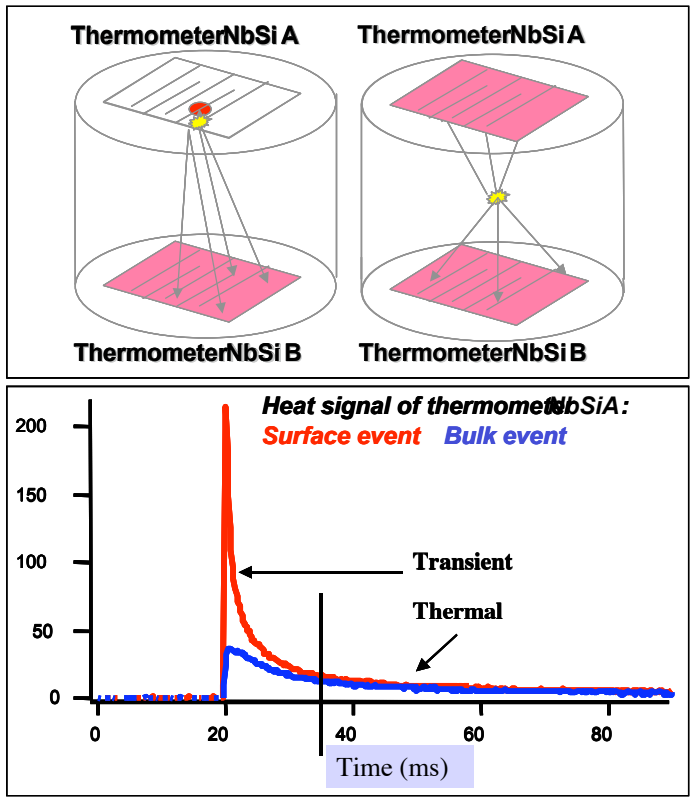


- X4 exposure
- Significant background reduction (~X4)

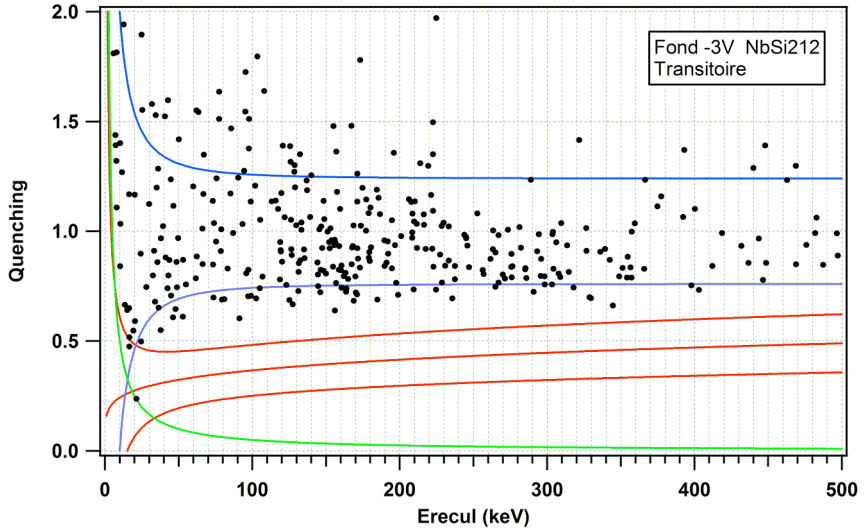
NbSi detectors

- Detectors developed at CSNSM : identify surface events = athermal phonon measurement with Nb-Si films « replacing » the NTDs
- Surface event rejection ok, some problems in 2007 with film contacts / leak currents

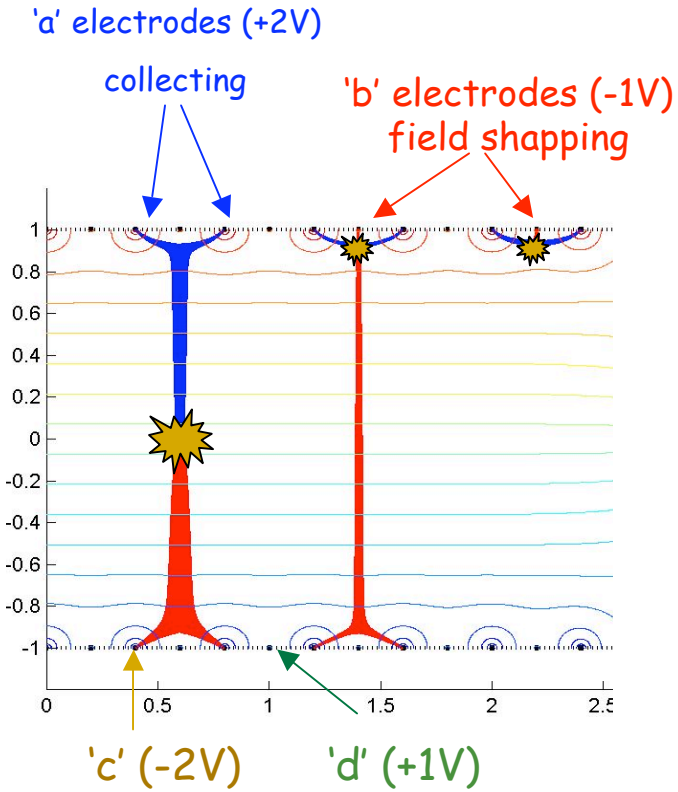


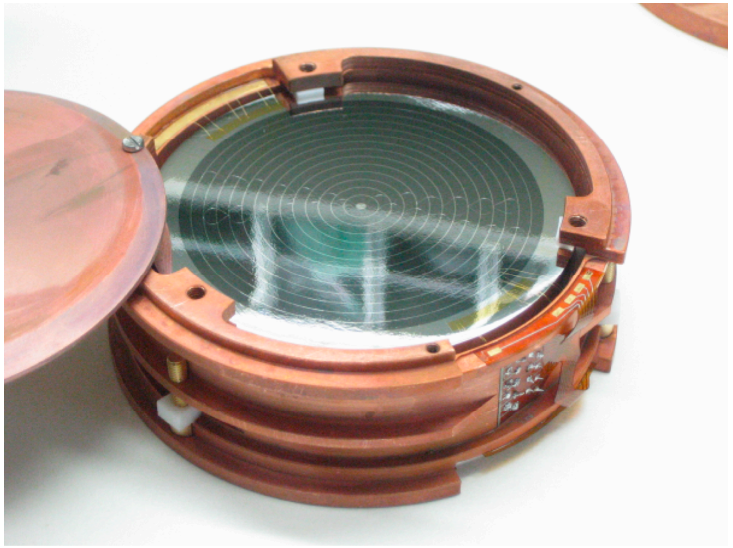


1.5 fiducial kg.d, 2007



Interdigit detectors



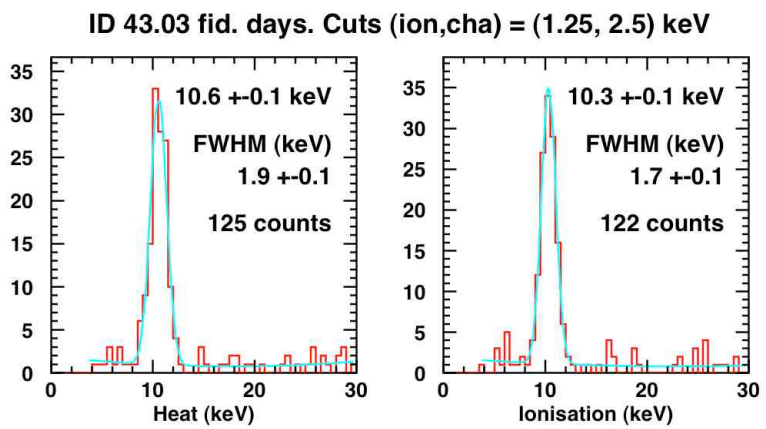


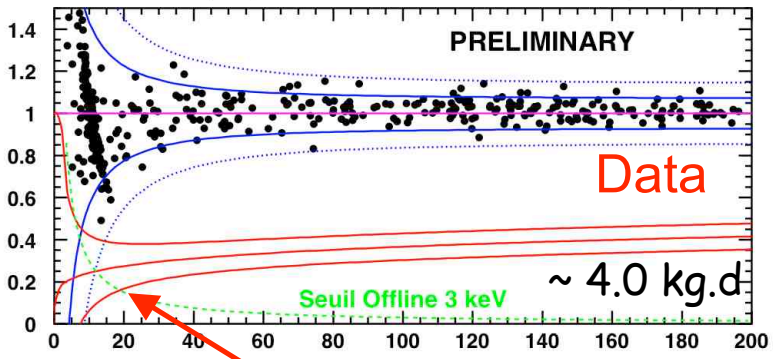
- Keep the standard phonon detector
- Modify the E field near the surfaces with interleaved electrodes (with guards: 6 ionization channels)
- Use 'b' and 'd' signals as vetos agains surface events

From preliminary see-level measurements:

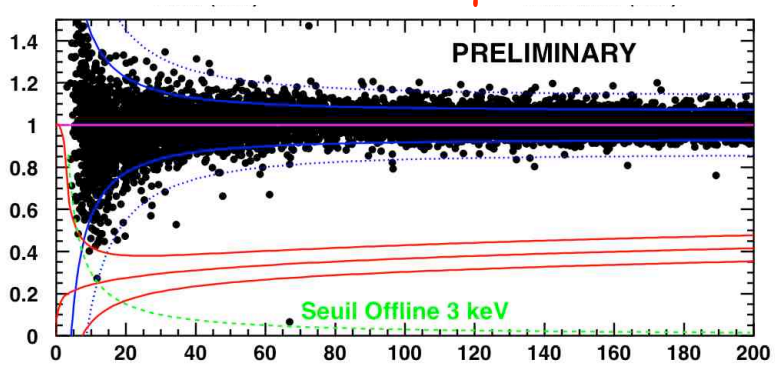
- Surface event rejection > 99.5%
- Fiducial volume (*for a 200g detector*) ~ 50%

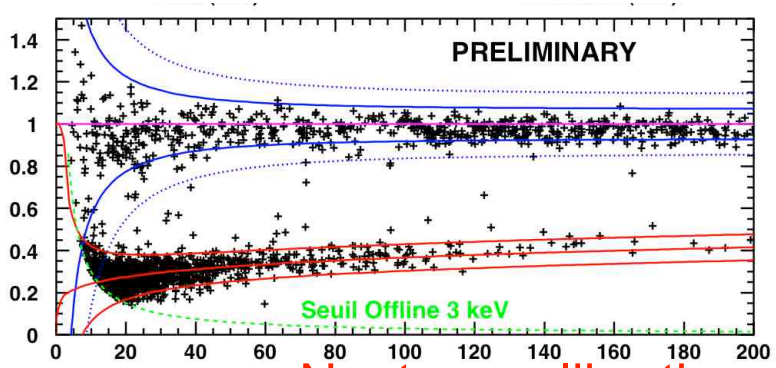
200 g ID results : run 8 @ LSM





γ calibration





Neutron calibration

Threshold < 20 keV

No events below Q=0.5 !

Beta calibration on going and very promising

Low mass WIMP « DAMA solution » (5-10 GeV)

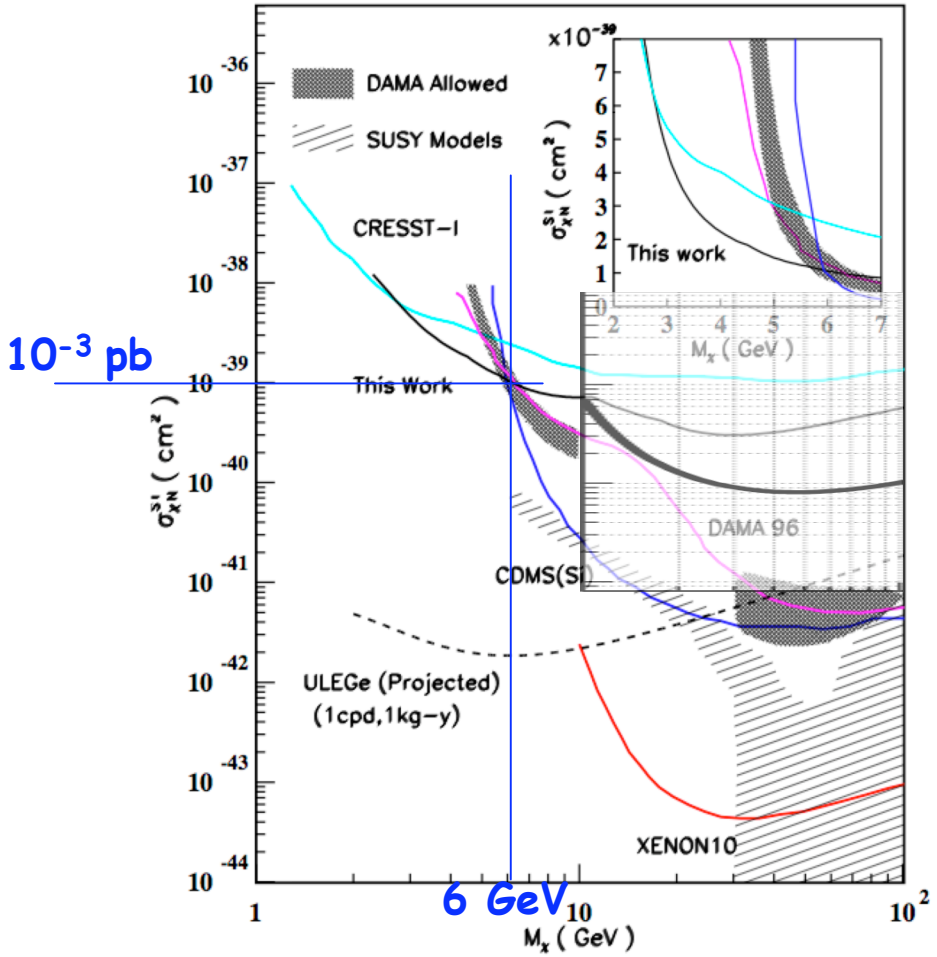
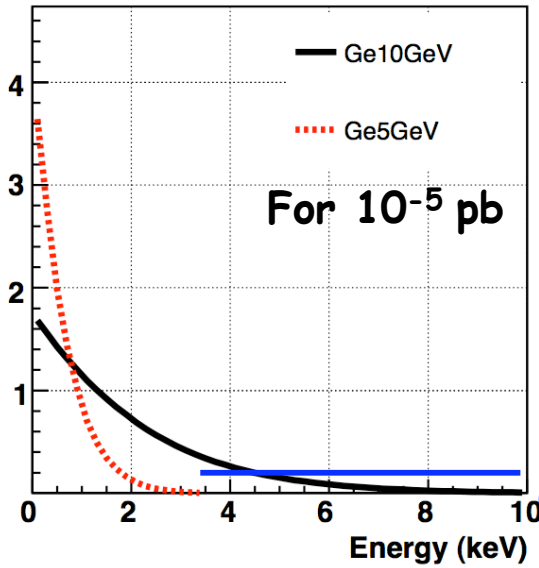


FIG. 5: Exclusion plots of spin-independent χN cross-section



For 10^{-3} pb=>
20 cpd/keV/kg
@ 4 keV

Expect 100 evts/kg.d @ 1 keV Erec for 5 GeV WIMP mass !

=>Study of low mass crystals

Outlook

- EDELWEISS-II is taking data :
  - Quite large exposures in stable conditions already achieved, 5-month cycles with regular improvments and new detectors
  - keV threshold achieved, subkeV under way
  - « New Interdigit » back rejection efficient detector operational, simple and « cheap » detector
  - End of year : 12 detectors mounted
  - 2009 : 20 more => 12 kg total with 50 % fid mass
  - then *2 mass if results and funding ok (~ SuperCDMS), few M€

- Aims
  - ~10^{-8} pb @ 60-100 GeV WIMP mass (~600 kg.d), by 2009
  - then possibly ~ 3 10^{-9} pb, if neutron backg low enough by 2011-2012
  - Adress low mass (5-10 GeV) WIMP
  - Adress 10^{-10} with EURECA