Latest results from the EDELWEISS Direct Dark Matter search

Klaus Eitel, Karlsruhe Institute of Technology, KCETA, IK

- DM search with Edelweiss-2
- Experimental set-up & new Ge detectors
- Published results & latest update
- Special muon&neutron investigations

Karlsruhe Institute of Technology

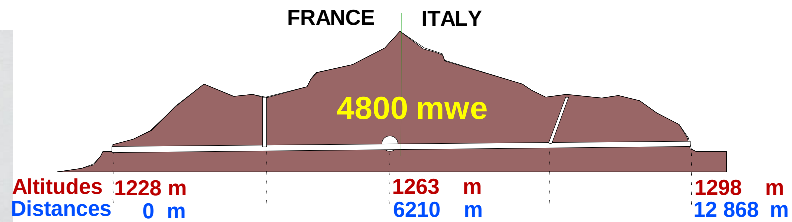
Latest res

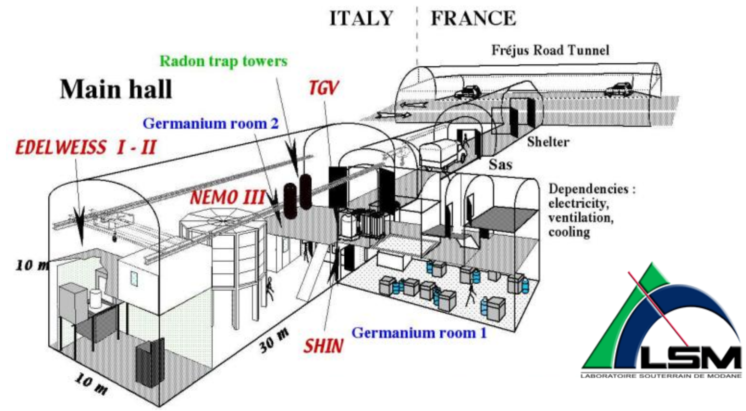
Direct D

Klaus Eitel, Karlsruhe Institute of Technology, K

- DM search with Ede
- Experimental set-u
- Published results &
- Special muon&neut

The EDELWEISS Collaboration



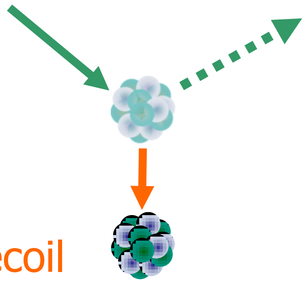


• CEA Saclay (IRFU & IRAMIS)	• Detectors, electronics, aquistion, data handling, analysis
• CSNSM Orsay	• Detectors, cabling, cryogenics
• IPN Lyon	• Electronics, cabling, low radioactivity, analysis, detectors, cryo
• Institut Néel Grenoble	• Cryogenics, electronics
• KIT: IK, IEKP +IPE (2010) Karlsruhe	• Vetos, neutron detector, background, analysis, electronics
• JINR Dubna	• Background, neutron, radon monitors
• Oxford University (since 2009)	• Detectors, cabling, cryogenics, analysis
• Sheffield University (since 2010)	• MC simulations

DM search with Edelweiss Ge bolometers

❖ **Direct detection of WIMPs** (Weakly Interacting Massive Particles):

WIMP Scatt. WIMP



Recoil nucleus → E_R ~10 keV

Count rate:

< 10^{-2} evt/kg/day!

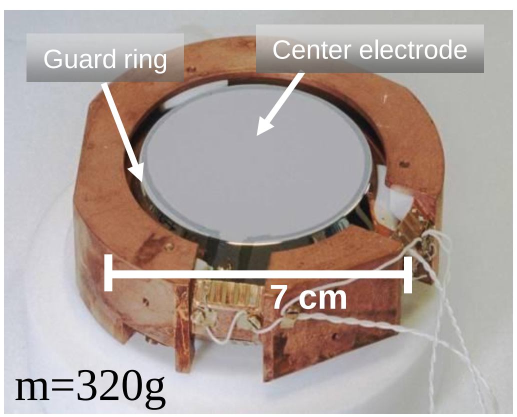
Challenges to overcome:

- **α, β, γ ;**
- **Neutrons;**
- **μ-induced events;**

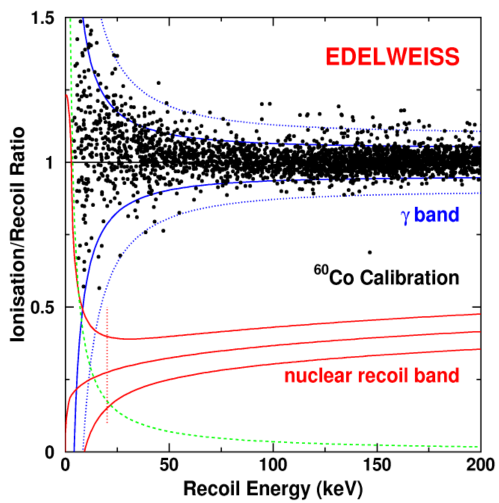
Way to go:

- **low radioactivity;**
- **powerful rejection;**
- **background knowledge;**

❖ **EDW:** bolometers of pure natural **Ge** @LSM (4800 mwe):



Ge/NTD



- **Simultaneous measurement**
  - **Heat** @ 17 mK with Ge/NTD thermometer
  - **Ionization** @ few V/cm with Al electrodes
- **Evt by evt identification** of the recoil by ratio $Q=E_{ionization}/E_{recoil}$
  - **Q=1 for electron recoil**
  - **Q≈0.3 for nuclear recoil**

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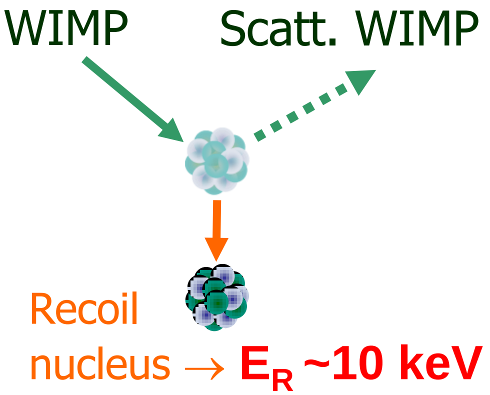

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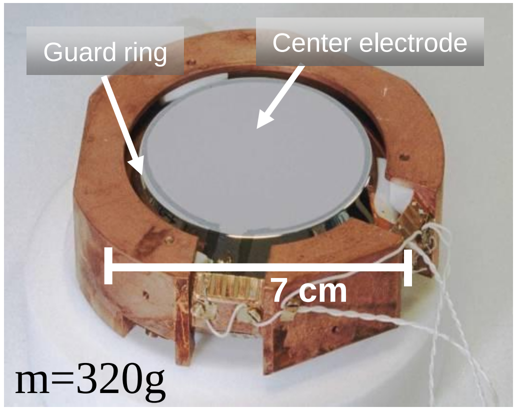

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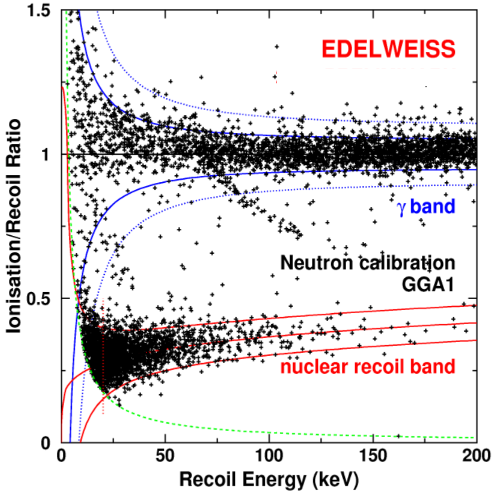

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EDW-2 (3) experimental set-up

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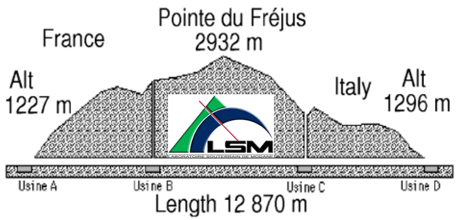
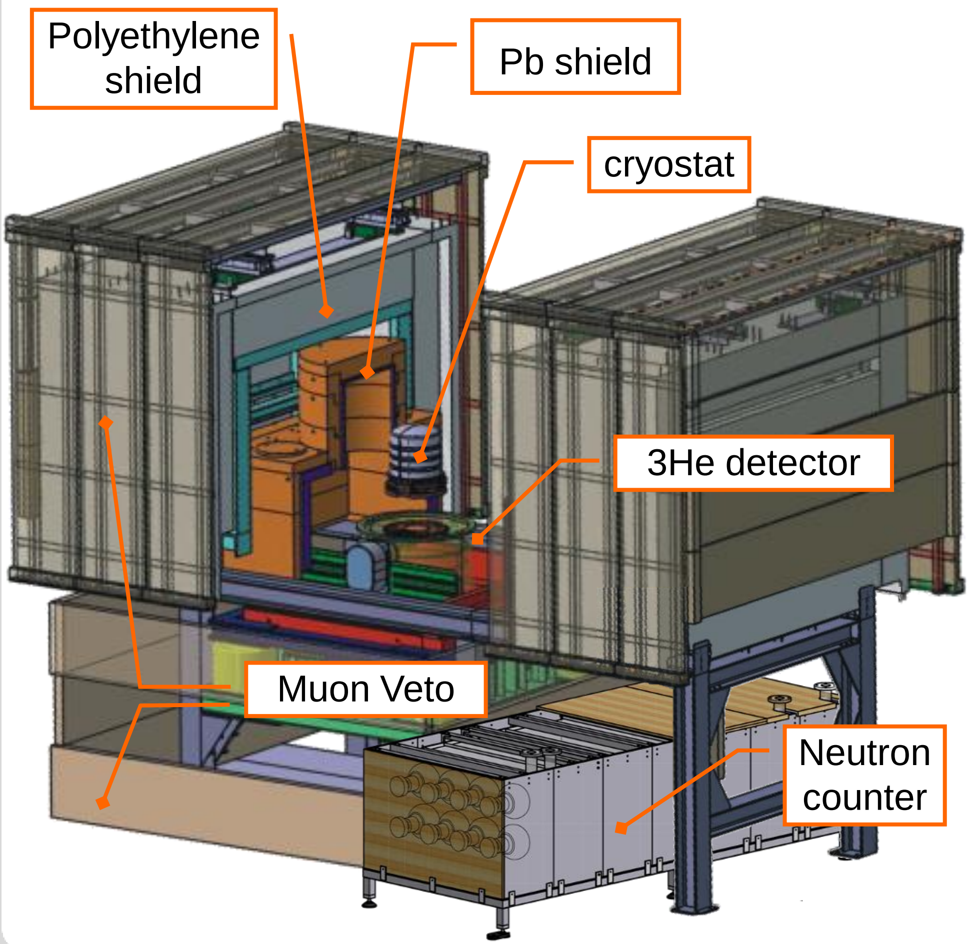


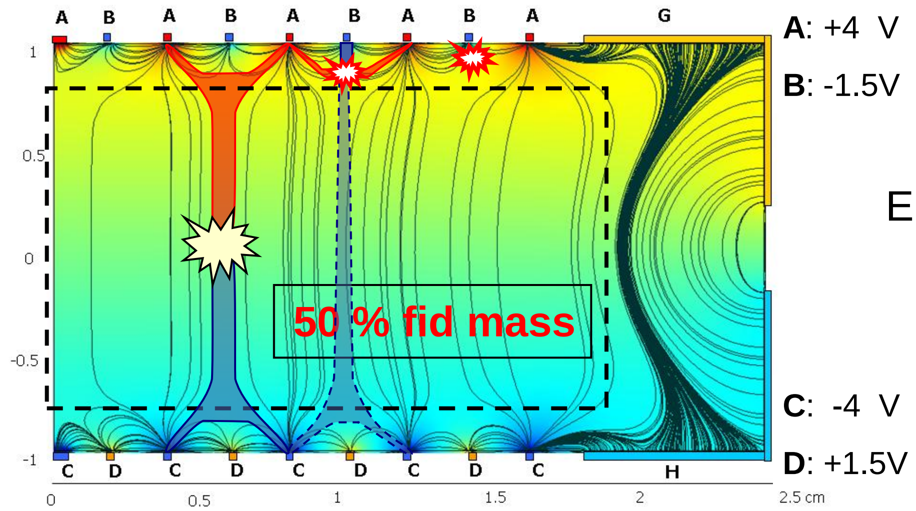
Shielding: ~ 4800 mwe

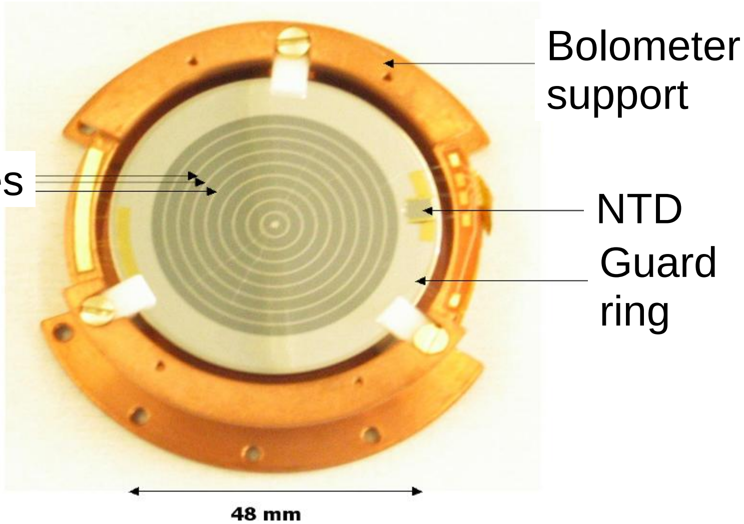
μ-flux: ~ 4-5 / m² / day



- **Goal** $\sigma_{\chi\text{-}n} = 5 \cdot 10^{-9}$ **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 EDW-1**
- (Many) others :
  - Remotely controlled sources for calibrations + regenerations
  - Detector storage & repair within the clean room
  - Radon detector down to few mBq/m^3
  - thermal neutron monitoring (^{3}He det.)
  - study of muon induced neutrons (liquid scintillator 1 m^3 neutron counter)
- 12 cool-downs operated since 2006

ID-detectors with annular ring electrodes





InterDigitized electrodes (**ID**):

- Keep the EDW-I NTD thermal sensor
- Modify the E-field near the surfaces with interleaved electrodes
- Use 'a' and 'c' signals as 'collection' electrodes and 'b' and 'd' signals as vetos against surface events

- 1 x 200g installed Nov. 2007, 1x200g + 3x400g tested in 2008;
- since Jan. 2009: 10 IDs are running (Run 12);

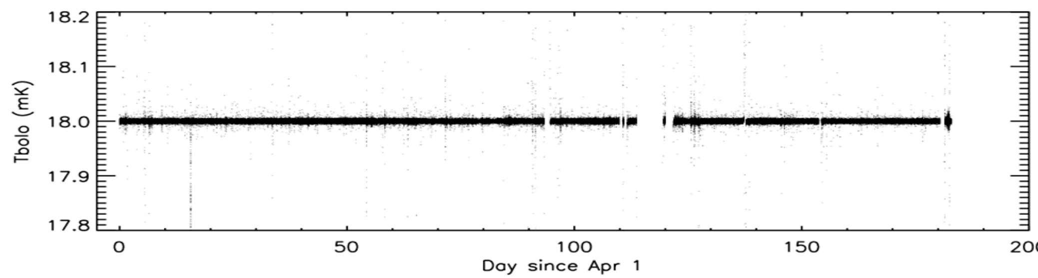
Phys Lett B 681 (2009) 305-309 (arXiv:0905.0753)

WIMP search with ID detectors : «run 12»

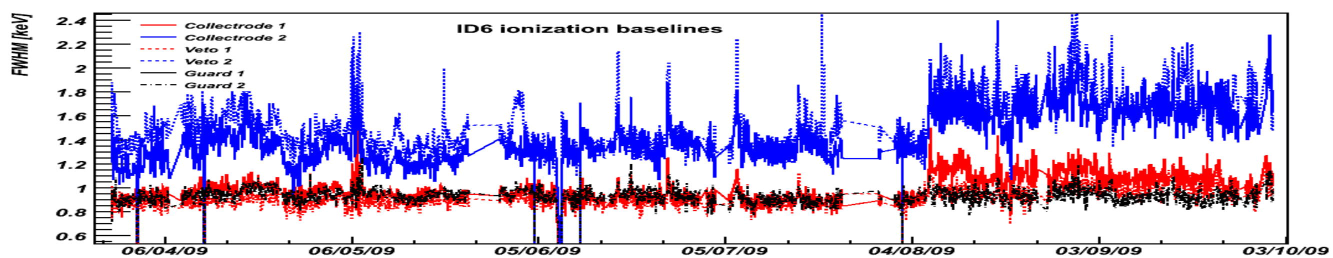
Data collected from April 1st 2009 to May 20th 2010

- 418 d total
- 322 d data (77% of 418)
- 305 d WIMP search (73% of 418)
- All detectors working
- 90% electronics channels ok
- 9/10 bolometers for Physics
- 8 d gamma
- 5 d neutron
- 4,5 d «other»

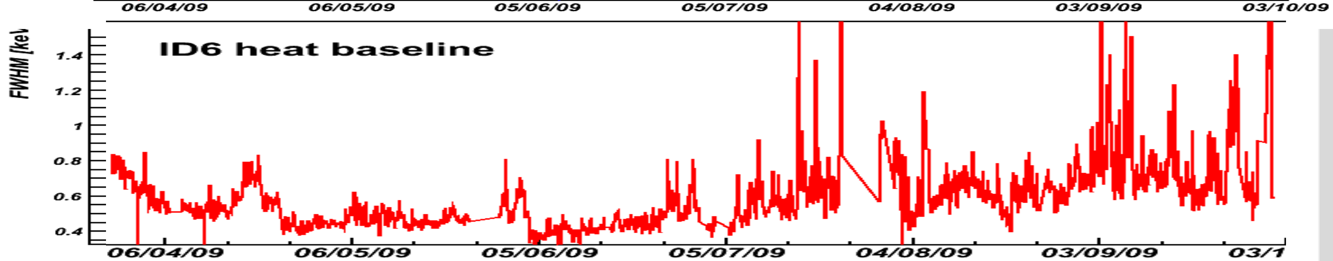
« One of the coldest place in the Universe » … Continuously at 18 mK during more than 1 year !



Ionization baseline



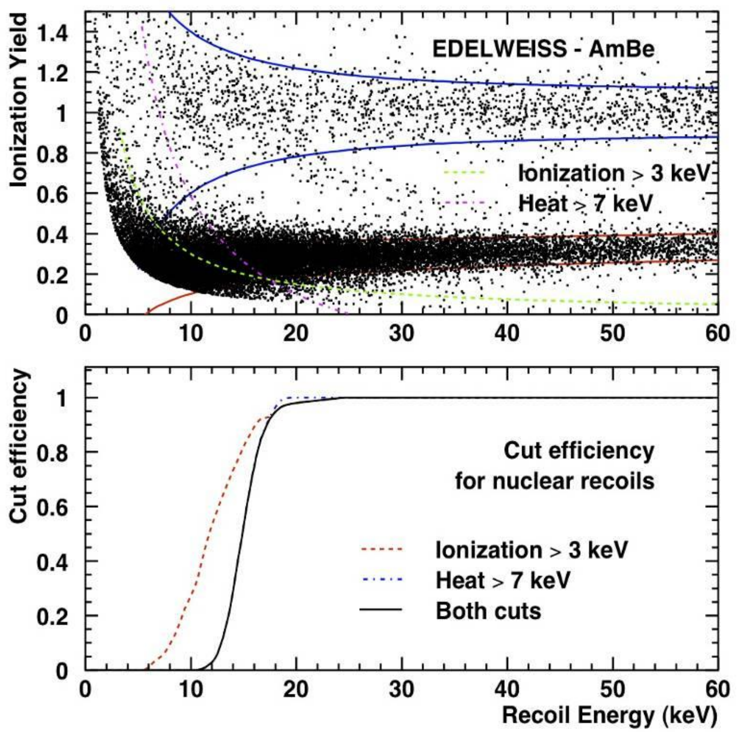
Heat baseline



Data analysis for first 6 months (Apr-Sep'09)

- 2 independent processing pipelines
- 9 out of 10 detectors are accepted
  (heat + coll.elect + 3/4 vetos&guards)
  10th detector -> 1 veto & 1 guard are off
- Pulse fits with optimal filtering using instantaneous noise spectra
- Period selection based on *baseline noises*
  - **80% efficiency**
- Pulse reconstruction quality (χ^2)
  - ε = 97%
- Fiducial cuts based on ionization signals (160g)
- $\varepsilon =$ 90% nuclear recoil, gamma rejection 99.99%
- Bolo-bolo & bolo-veto coincidence rejection (ε>99%)
- WIMP search threshold fixed a priori *Erecoil > 20 keV*
  - 20 keV recoil far from efficiency thresholds
    (full efficiency achieved with ~3 keV ionization and ~7 keV heat thresholds):
    robust results independent of analysis details
- Agreement between the results of the two analyses

All detectors – neutron calibration



Phys Lett B 687 (2010) 294
(arXiv:0912.0805)

WIMP search : first result (1st 6 month)

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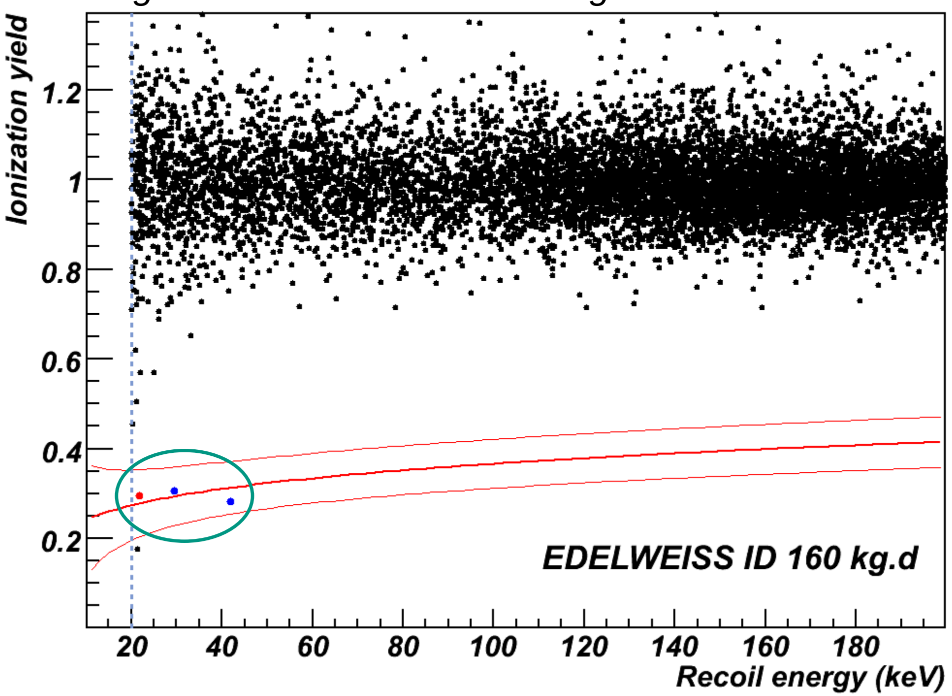
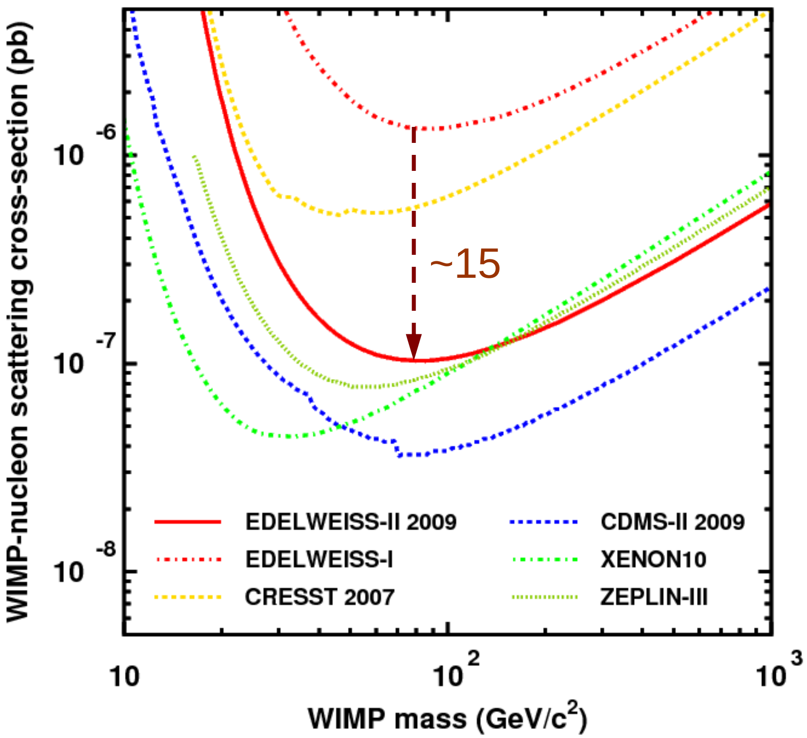
160 kg.d x 90% NR band = 144 kg.d





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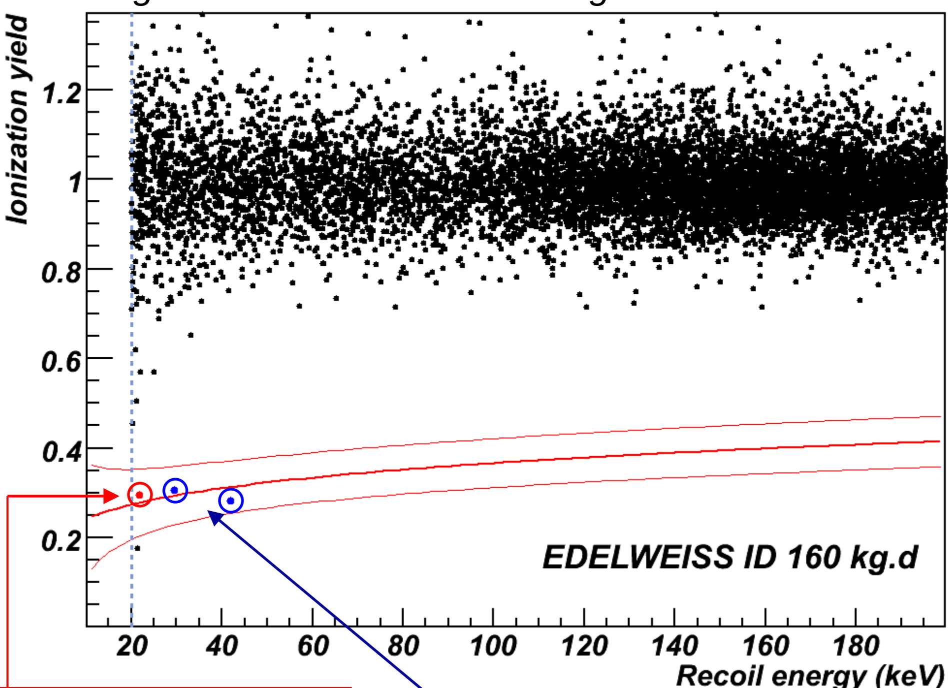

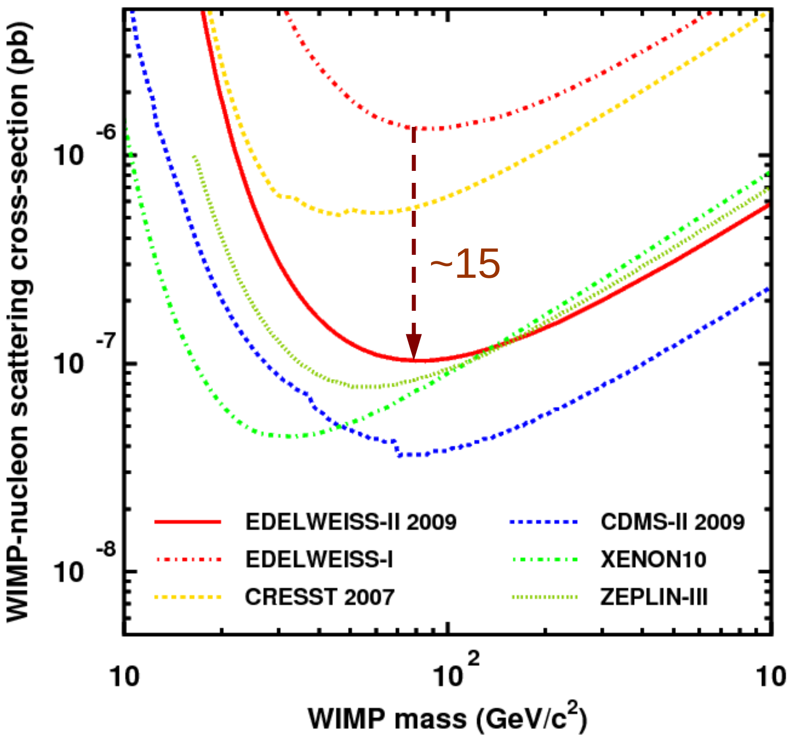

« WIMP candidate »
E_{recoil} = 21 keV

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

Phys Lett B 687 (2010) 294
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Background estimation (work in progress!):

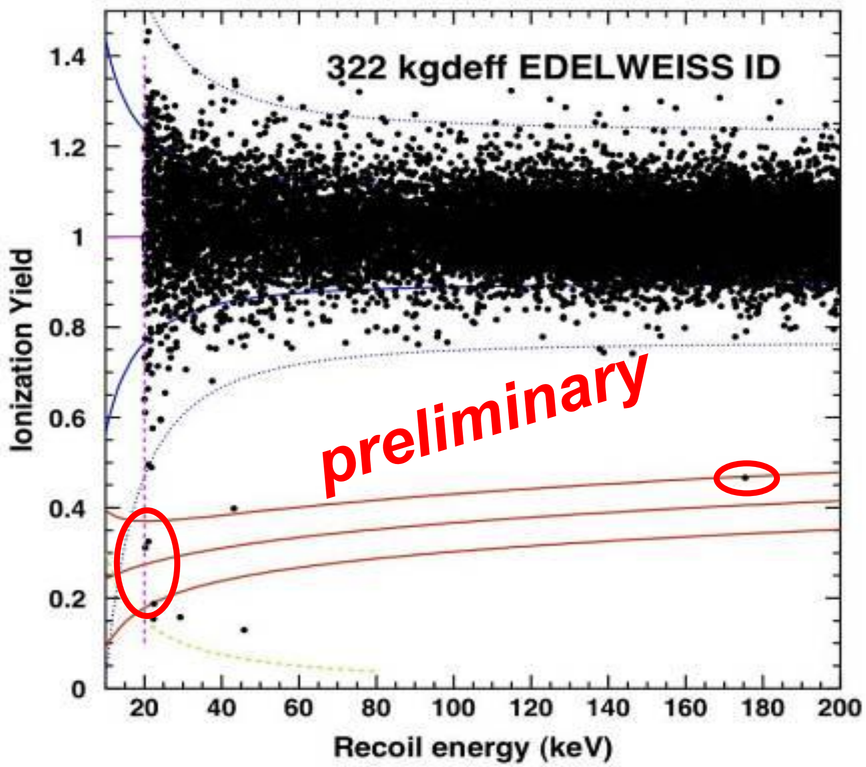
First estimation *from previous calibrations/simulations*

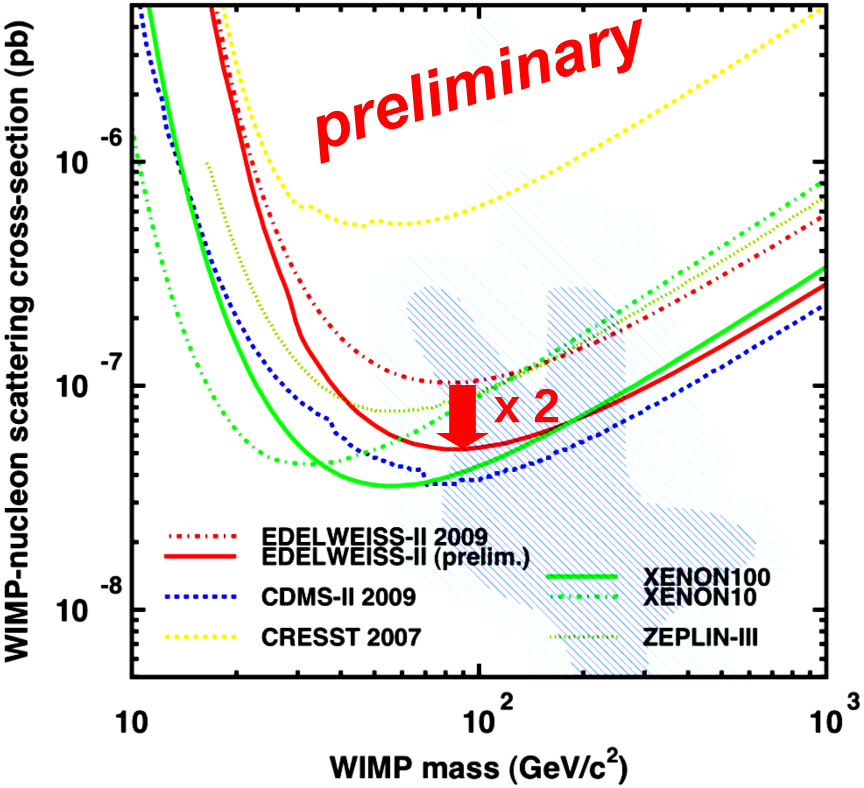
- gamma < 0.01 evt (99.99% rejection)
- beta ~ 0.06 evt (from ID201 calibration+obs. surf. evts)
- neutrons from ^{238}U in lead < 0.1 evt
- neutrons from ^{238}U+(α,n) in rock ~ 0.03 evt
- neutrons from muons < 0.04 evt

< 0.23 evt

P_{bkg}(1) = 21%

WIMP search : latest results (end of Run 20.05.10)





Preliminary result :

1st analysis with same cuts as first 6 months, 2nd analysis is ongoing

=> Increase in the sensitivity by factor of 2 (scales with statistics)

3 events near threshold in NR band (1 outlier) + 1 outlier (1 @ 175 keV in NR band)

Best limit 5.10^{-8} pb at M(WIMP)=80 GeV, BUT *background starts to appear ?*

Backgrounds (full Run)

- *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 simul. <0.1
- *Neutrons from rock*: measured neutron flux x Monte Carlo simul. <0.1

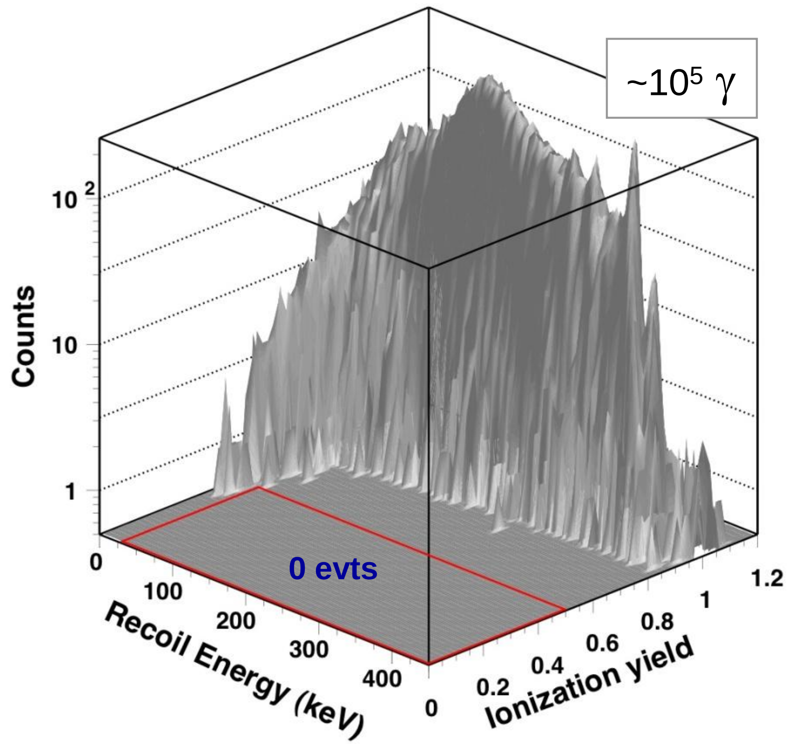
  MC tuned with outside strong AmBe source

SUM (background) < 1.6 for the whole WIMP run (90% CL)
while 4 events are observed in WIMP run

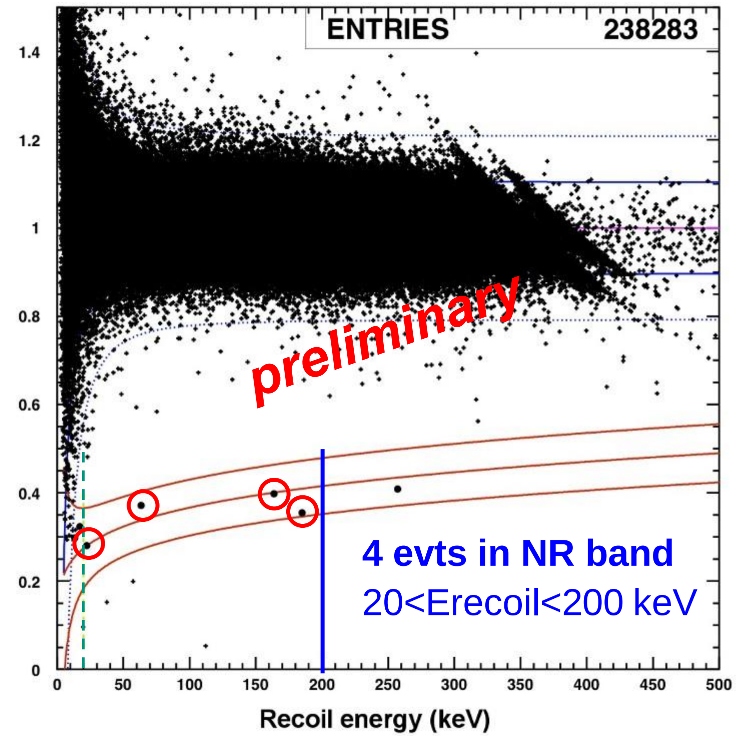
=> Further investigation of the backgrounds and detector performance (calibration)

Gamma calibrations with ^{133}Ba: status

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



2 bolos, Gaussian behaviour, no cand event

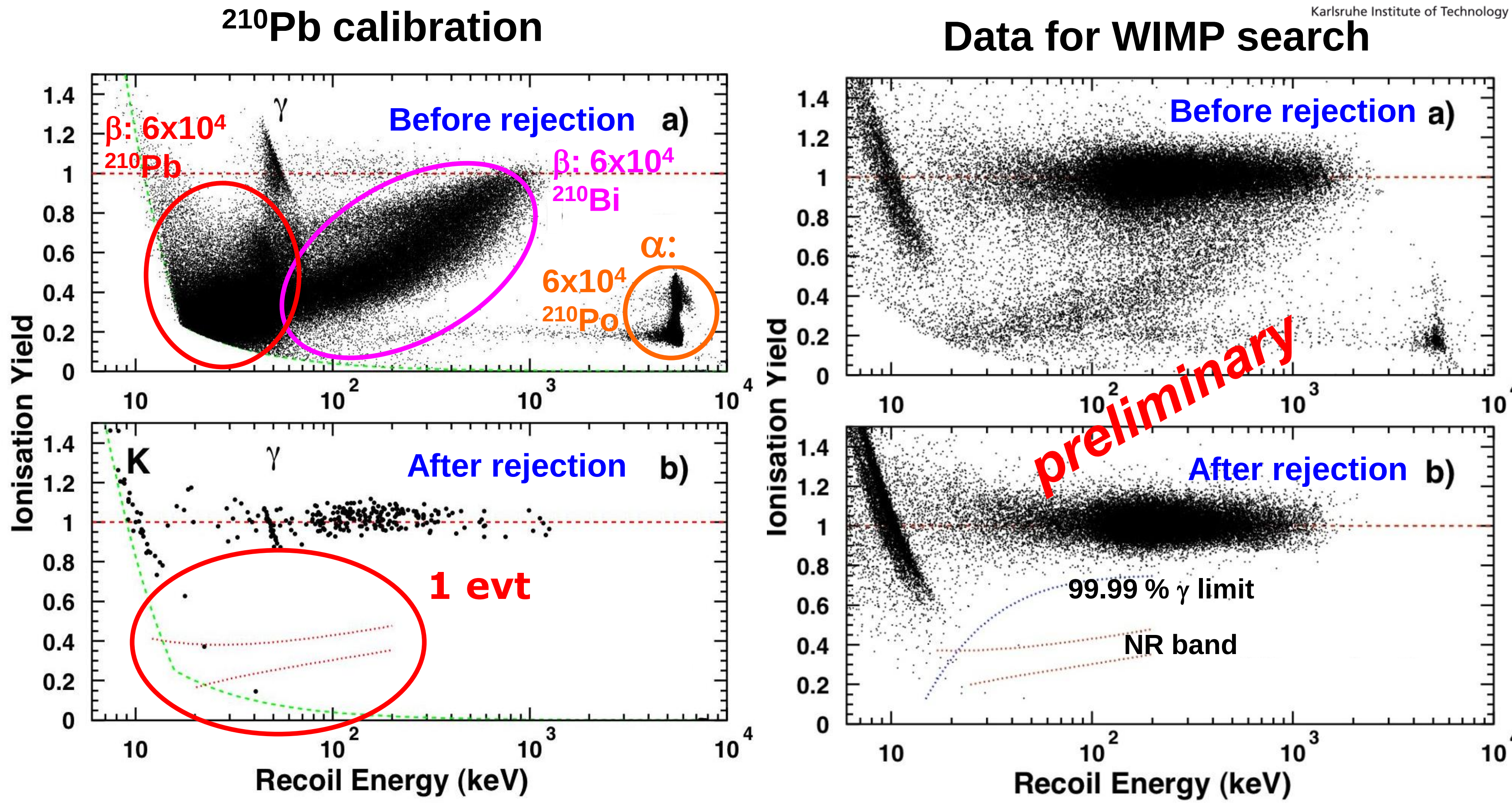


Stat x 2.4, all 10 detectors, 4 evts

- ^{133}Ba calib: 4 evts in 134 000 evts in 20-200 keV =>
  <1 evt expected in 16 600 evts in WIMP run (90% CL)
- Knobs to understand / improve:
  - Recombination e-h : optimise operation of polarization voltages, regeneration procedures
  - Pile up, multisite events : fast readouts on heat and ionization
  - 2 NTD heat measurements, segmentation

Beta calibrations & backgrounds

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

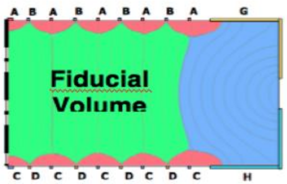


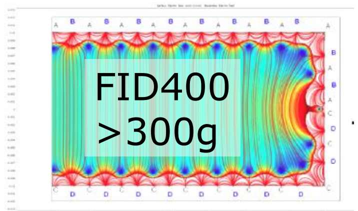
- Identified surface events in WIMP data: < 0.2 evt expected after rejection
- Knobs to improve: - change surface treatment
  - better energy resolutions

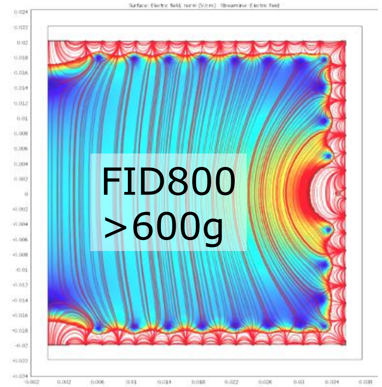
Next steps …

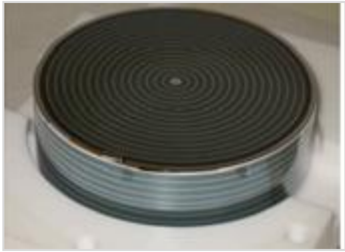
- Doubling/Quadrupling the fiducial mass:
  ID400 => FID400 => FID800

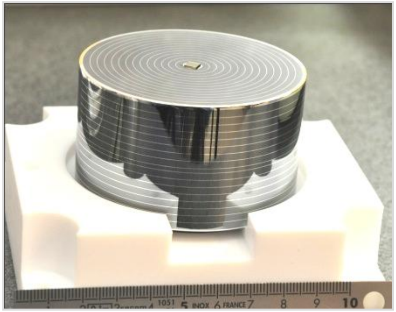
ID400 (160g)

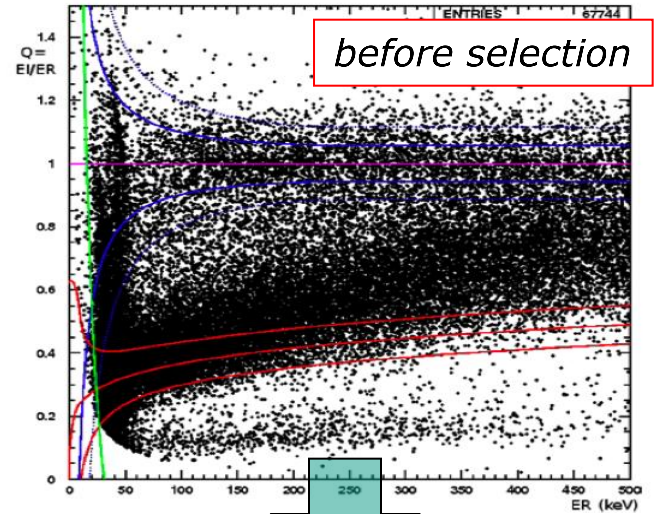


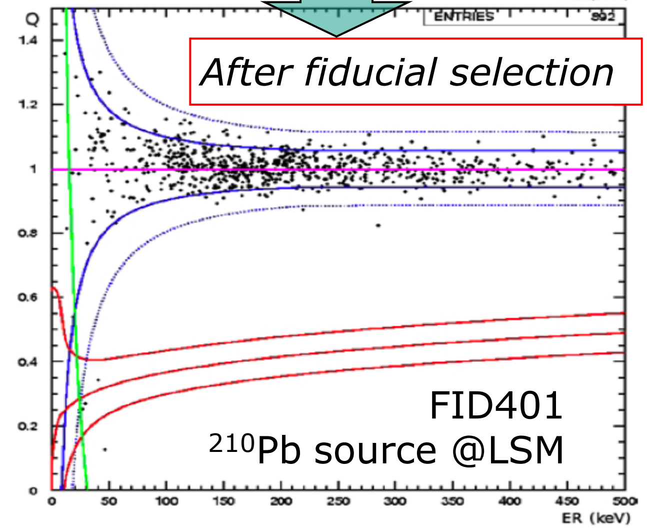












4 / 68000 for E>25keV

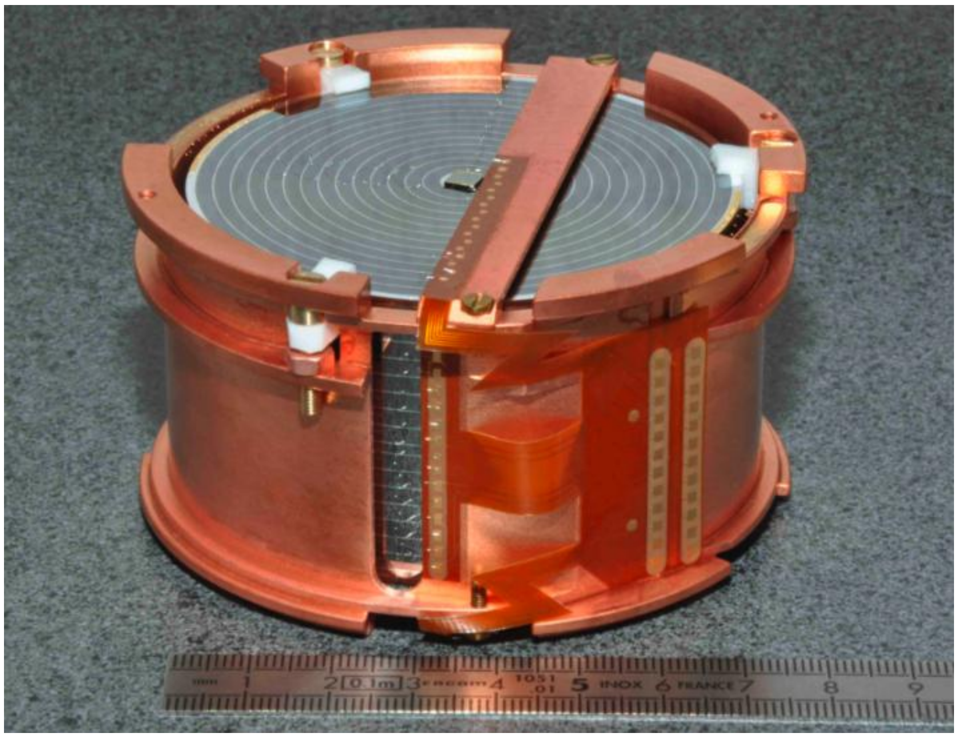
- **Goals:** with FIDs 400+800g program, continue doubling of accumulated exposure every year

  2011 = 1000 kg.d

  2013 = 3000 kg.d

Upcoming physics run

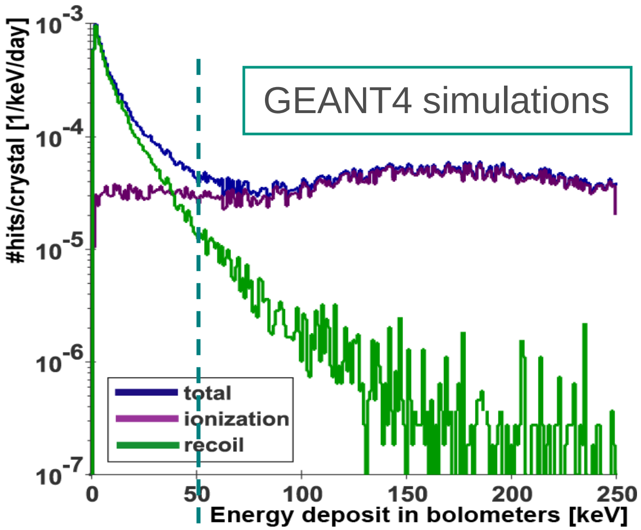
- July 3rd: 4 FID800 installed in LSM
- since July 27th: T<20mK



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

μ-induced background study

1.



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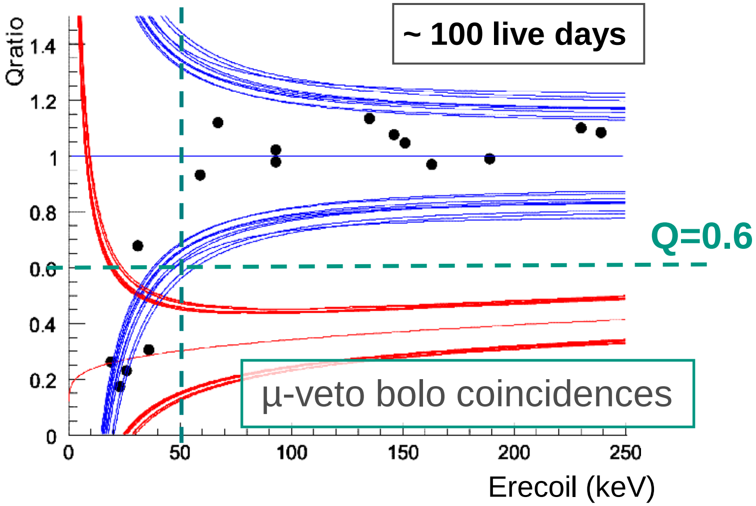
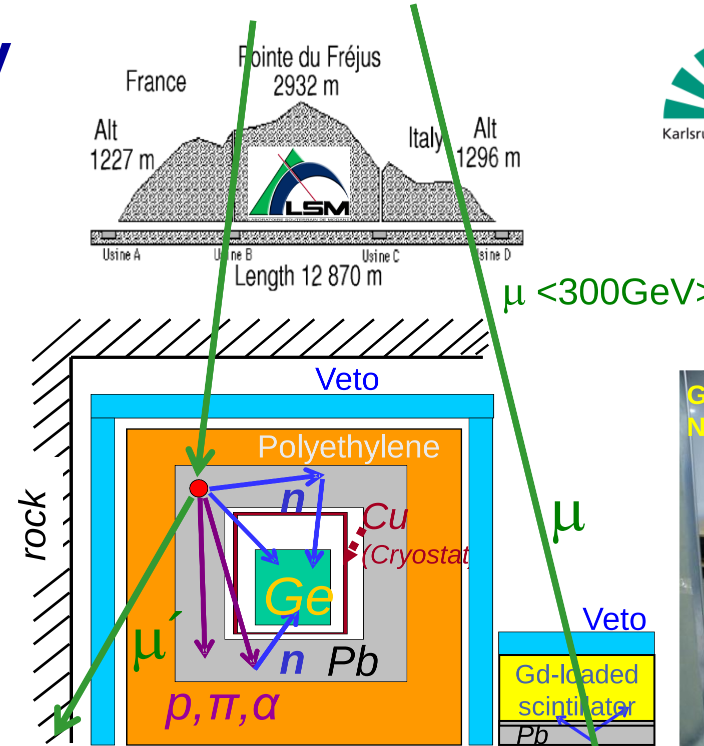
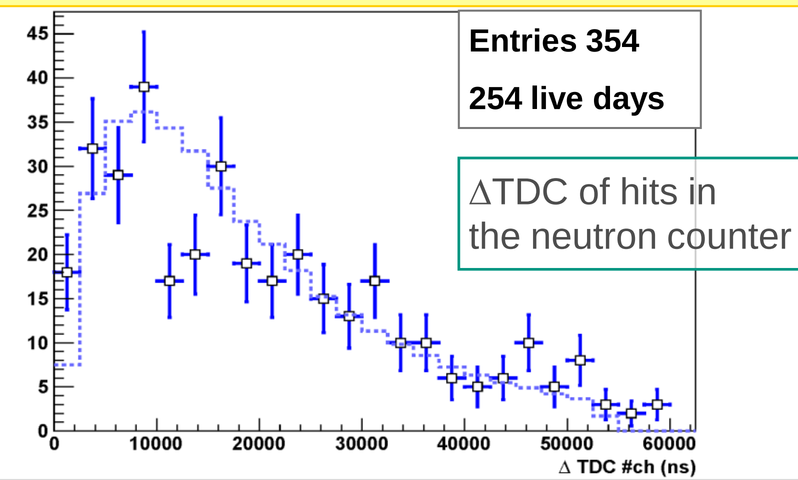




V. Kozlov et al., Astropart. Phys .34(2010)97.; arXiv:1006.3098

3.



Edelweiss summary & prospects

Karlsruhe Institute of Technology

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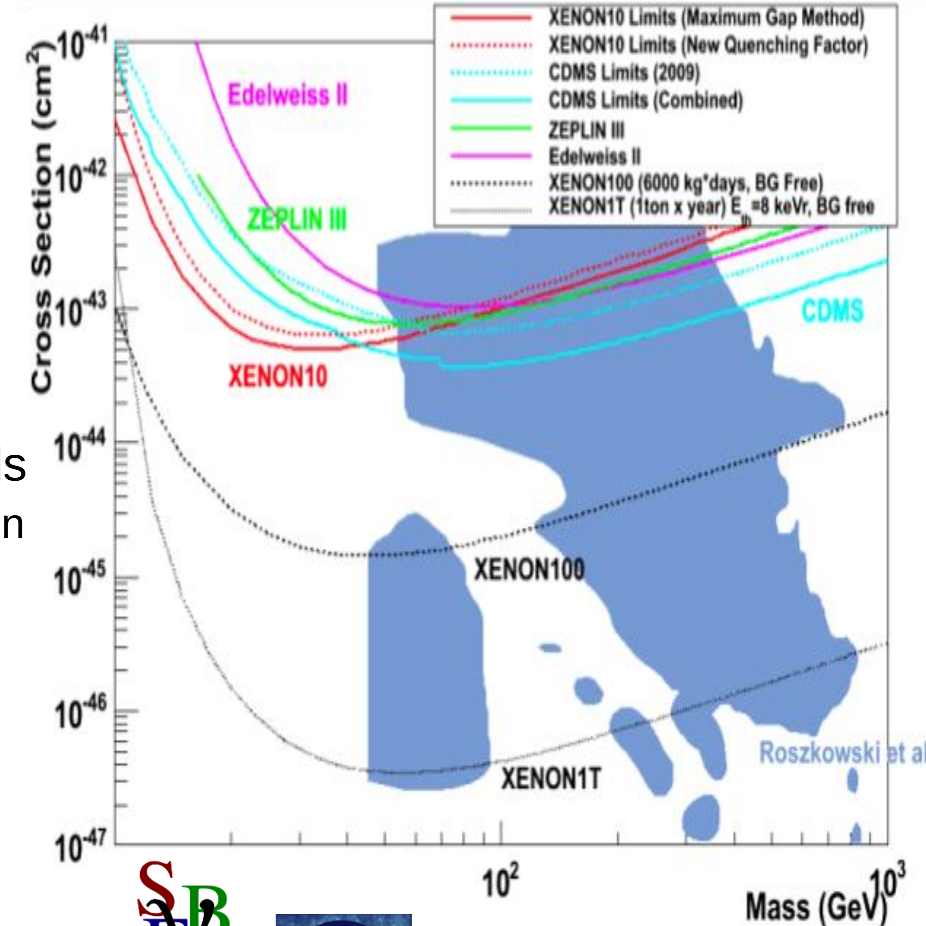
  - robust detectors with redundancy and excellent beta rejection
  - muon&neutron investigations
  - preliminary analysis of 1 year data
    - no evidence for WIMPs so far
    - 5 x10^{-8} pb sensitivity achieved
- **new goal 5 x 10^{-9} pb**
  - improvements wrt to future backgds
    - increased redundancy for ionisation and heat measurements
    - fast readout (multisite, pile up)
    - lower microphonics, internal PE shield
  - new prototypes: FID 800g
    - 2011 ➔ 1000 kg.d
  - build&install 40 detectors upgrade set-up
    - 2012 ➔ 3000 kg.d



ANR DFG ILIAS

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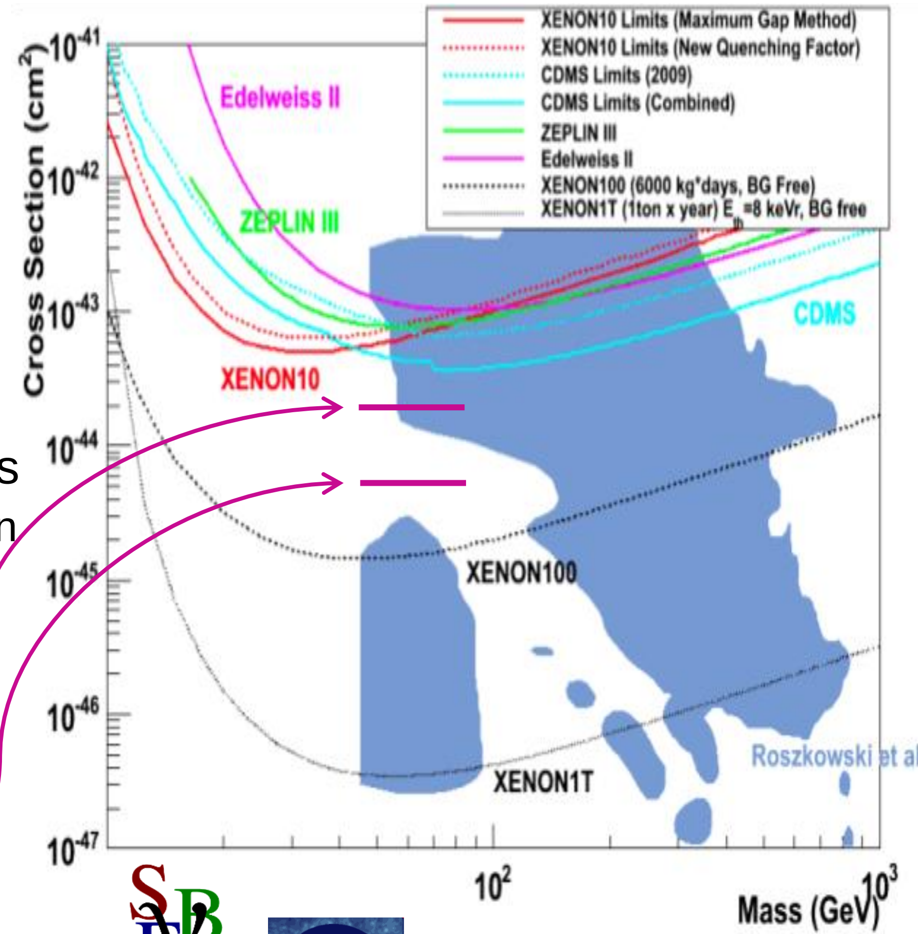
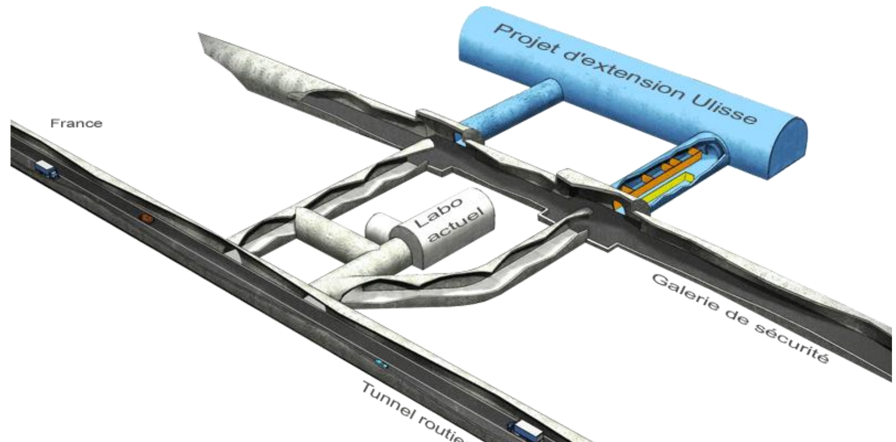


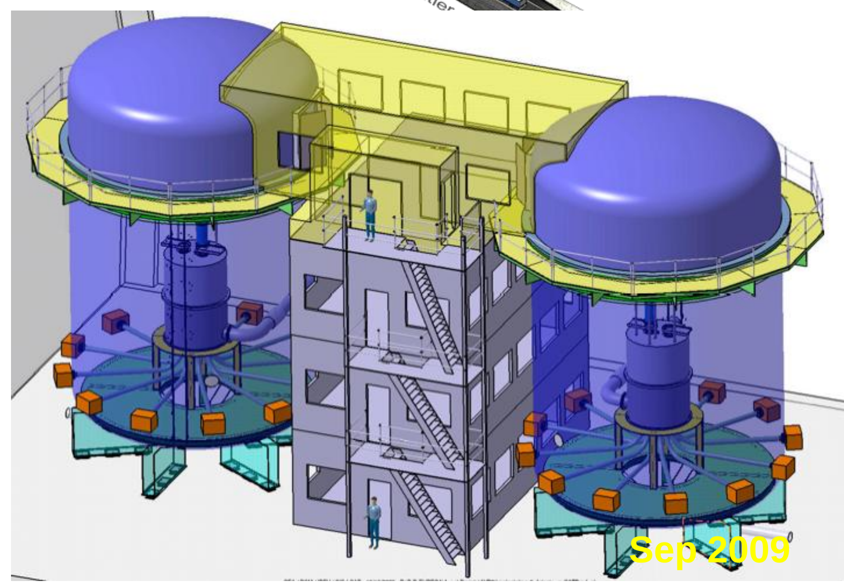
Further future: EURECA

http://www.eureca.ox.ac.uk/

- EURECA goal: 10^{-10} pb, 500 kg to 1 tonne 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
- Preferred site: 60 000 m^2 ULISSE extension of present LSM (4 μ/m^2/d), to be excavated in 2011-2012
- Collaboration agreement with SuperCDMS & GeoDM for common studies
- MoU between 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 EURECA Spokesperson	Blas Cabrera SuperCDMS Spokesperson	Sunil Golwala GEODM Spokesperson





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