

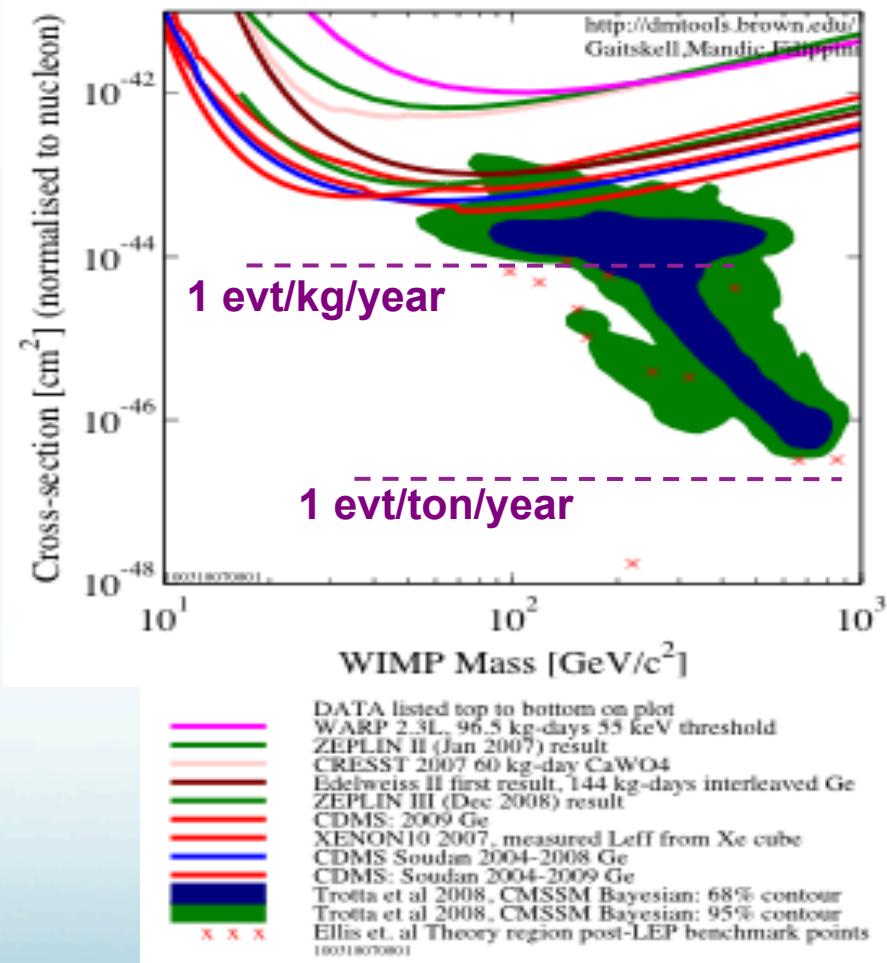
# Latest results of EDELWEISS II

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CEA/IRFU/SPP – Saclay

Rencontres de Moriond 2011  
« EW and Unified Theories »

# WIMP search

- Motivated by the « WIMP miracle »
- Very small rate of WIMP-nucleus scattering is expected
- Detector sensitivity must improve to scan the parameter space:
  - Increase exposure (time and detector mass)
  - Lower energy threshold ( $E_R \sim$  few keV)
  - Control of backgrounds ( $\gamma$ ,  $\beta$  radioactivity, cosmic muons, neutrons)



# EDELWEISS

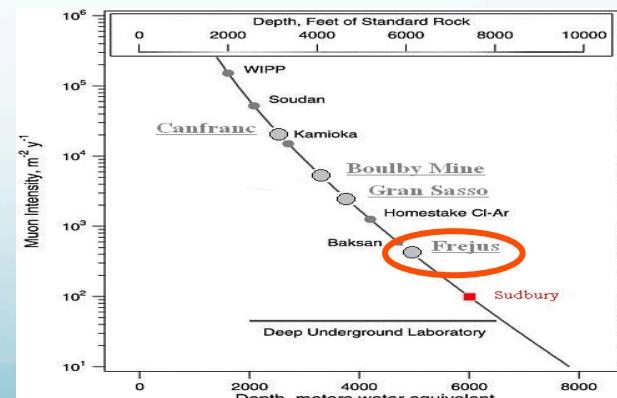
## Direct detection of dark matter with Ge bolometers



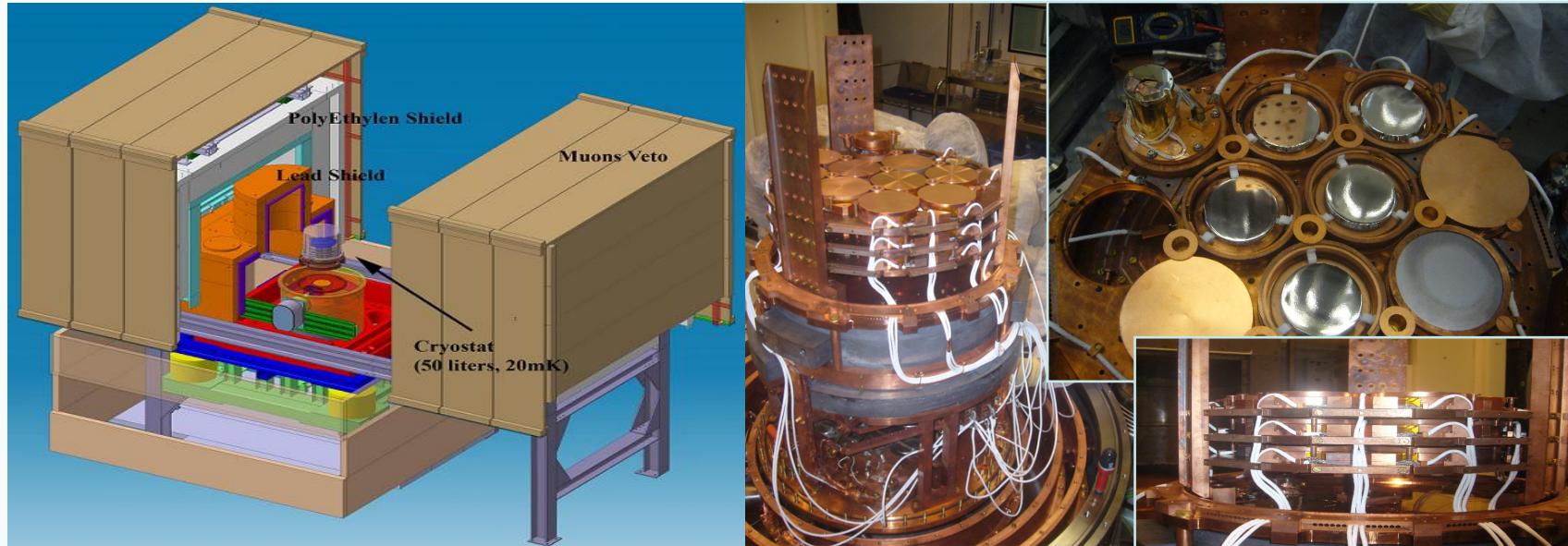
- CEA Saclay (IRFU and IRAMIS)
- CSNSM Orsay (CNRS/IN2P3 + Univ. Paris Sud)
- IPNLyon (CNRS/IN2P3 + Univ. Lyon 1)
- Néel Grenoble (CNRS/INP)
- Karlsruhe Institute of Technology
- JINR Dubna
- Oxford University (joined in 2009)
- Sheffield University (joined in 2010)

Detector installed in Laboratoire Souterrain de Modane (Fréjus tunnel):

- Deepest site in Europe:  $4 \mu\text{m}^2/\text{day}$
- $10^{-6} \text{n/cm}^2/\text{s}$  ( $E > 1 \text{ MeV}$ ) from rock

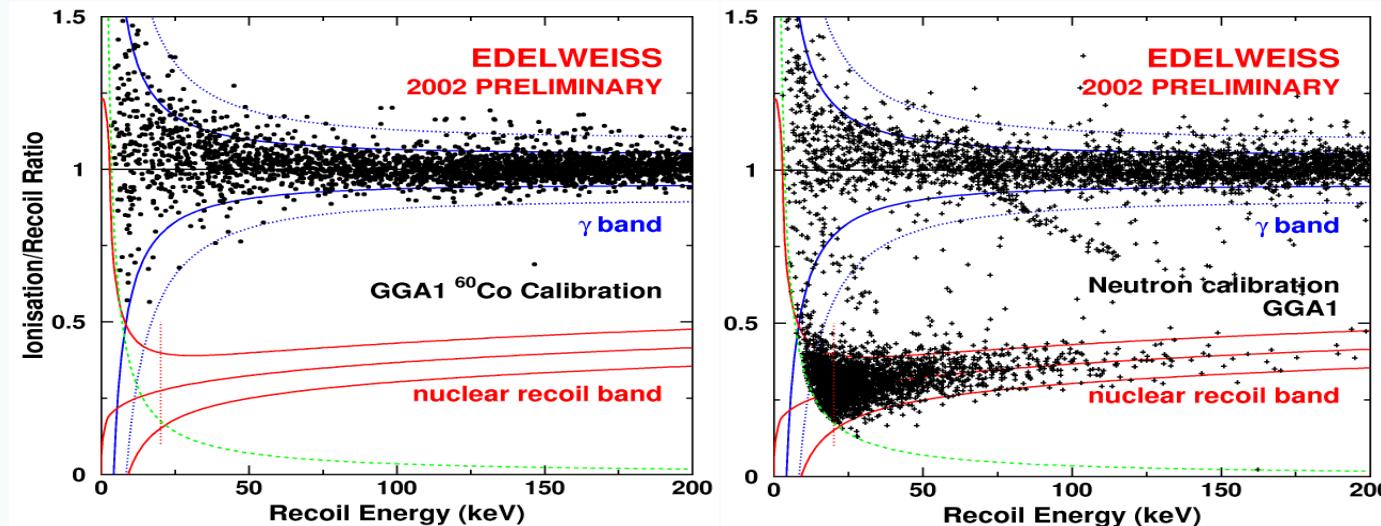


# EDELWEISS II

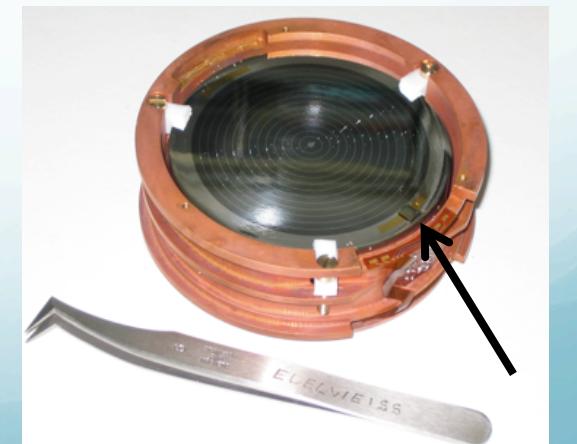


- **Ge bolometers at 20 mK (dilution refrigerator)**
- **20-cm archaeological lead shield ( $\gamma$ )**
- **50-cm polyethylene shield (fast n)**
- **Active muon veto > 98% coverage**
- **Clean room & deradonised air ( $\beta$ )**
- Rn, neutron detectors
- Remotely controlled  $^{60}\text{Co}$ ,  $^{133}\text{Ba}$  sources for detector regeneration &  $\gamma$  calibrations
- AmBe source for neutron calibrations

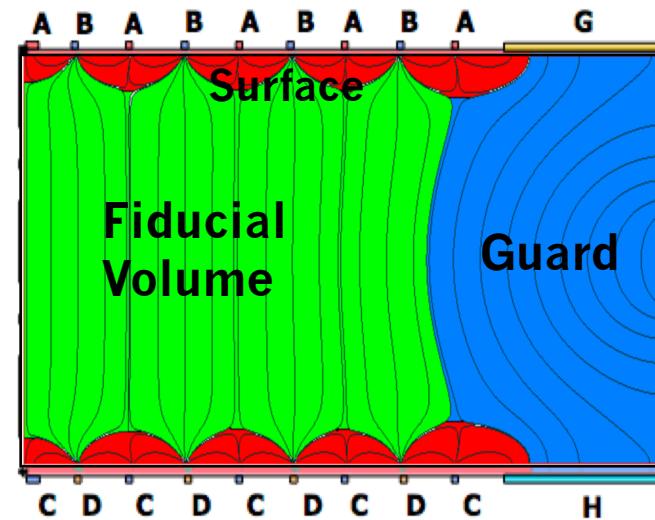
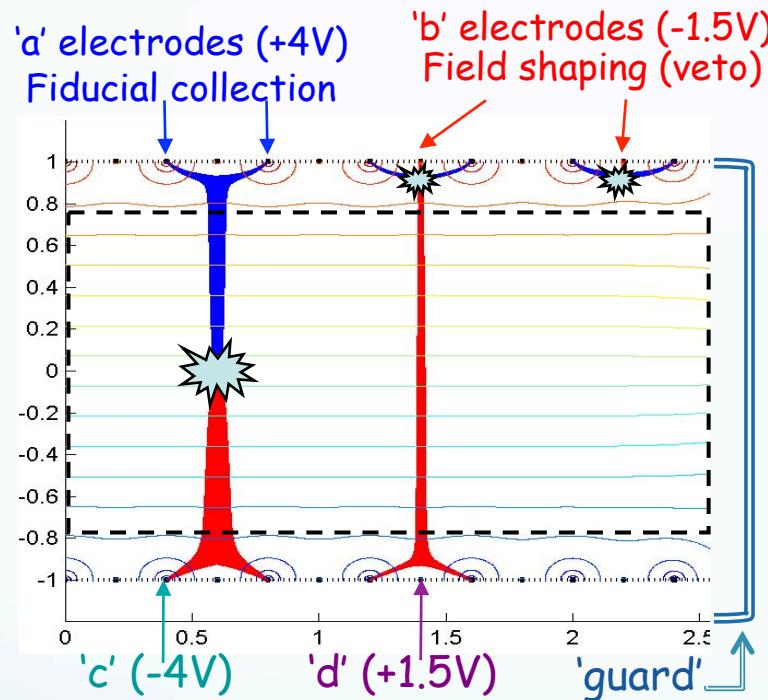
# Detection principle



- Ge bolometers: heat + ionisation signals
  - Heat: NTD sensor at 20 mK
  - Ionisation: Al electrodes on surfaces (few V/cm)
- Discrimination:  $Q = \text{Ionisation}/\text{Heat}$ 
  - $Q \sim 1$  electron recoil
  - $Q \sim 0.3$  nuclear recoil (in Ge)



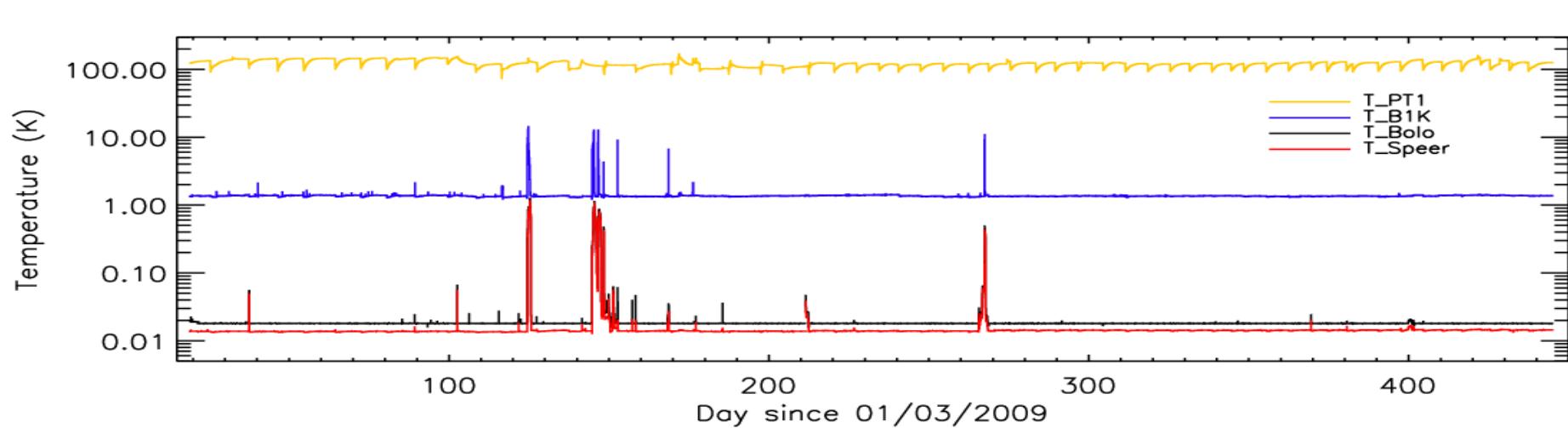
# ID detectors



- Surface events rejection problem: bad charge collection turns into low Q → WIMP-like signal !!
- New INTER-DIGIT electrode design:  $\sim 10^{-5}$  gamma and beta rejection ([Phys Lett B 681 \(2009\) 305-309](#))

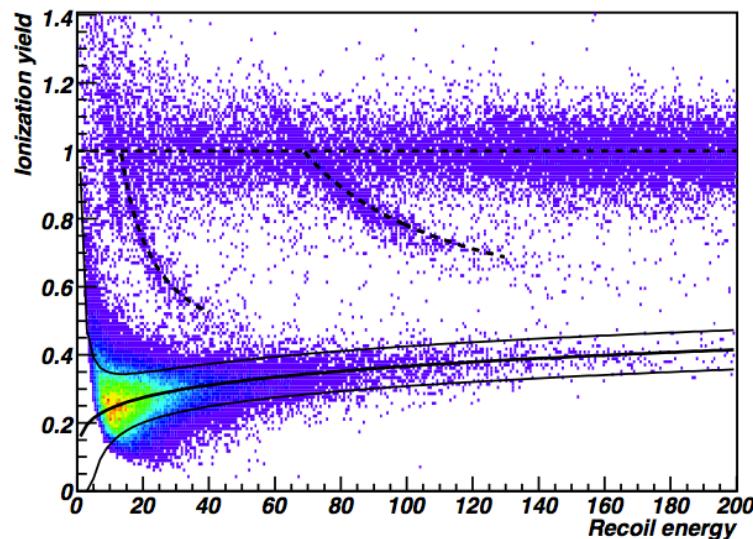
# Data set

- April 2009 – May 2010: 10x400 g Ge ID-detectors  
325 d physics + 10.1 d gamma cal + 6.4 d neutron cal
  - + July-Nov 2008: 2x200 g Ge ID-detectors
- Total effective exposure: **384 kg.d**
- Analysis threshold at 20 keV
- Bolometer temperature stable ~18 mK

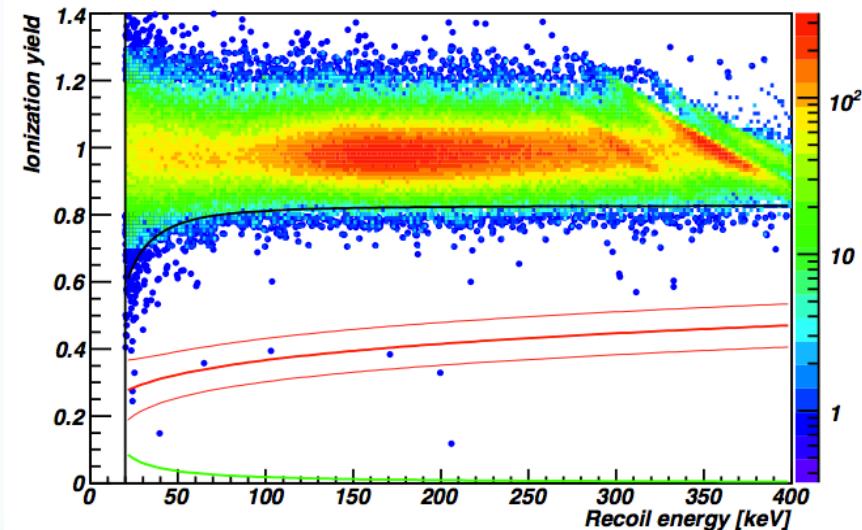


# Calibrations

Neutron (AmBe)

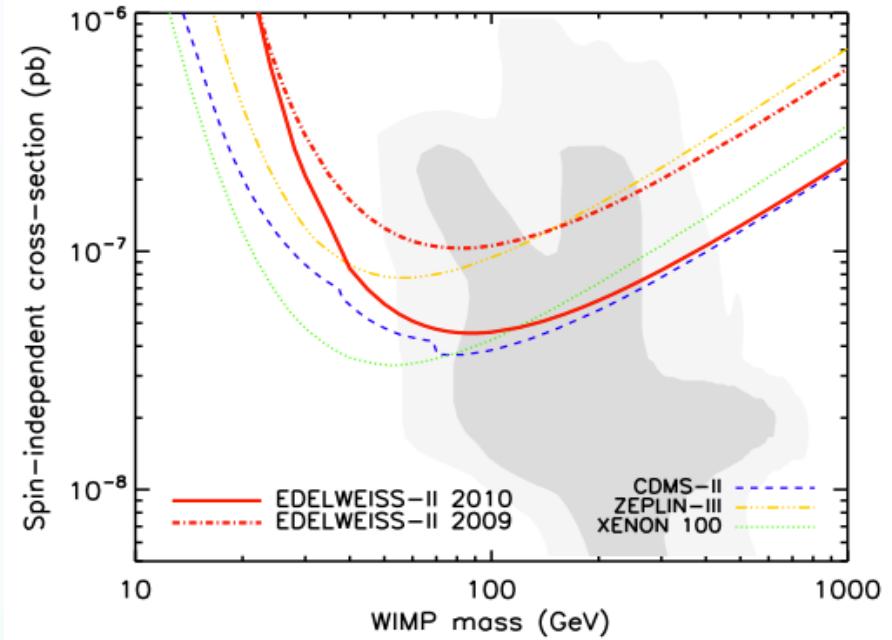
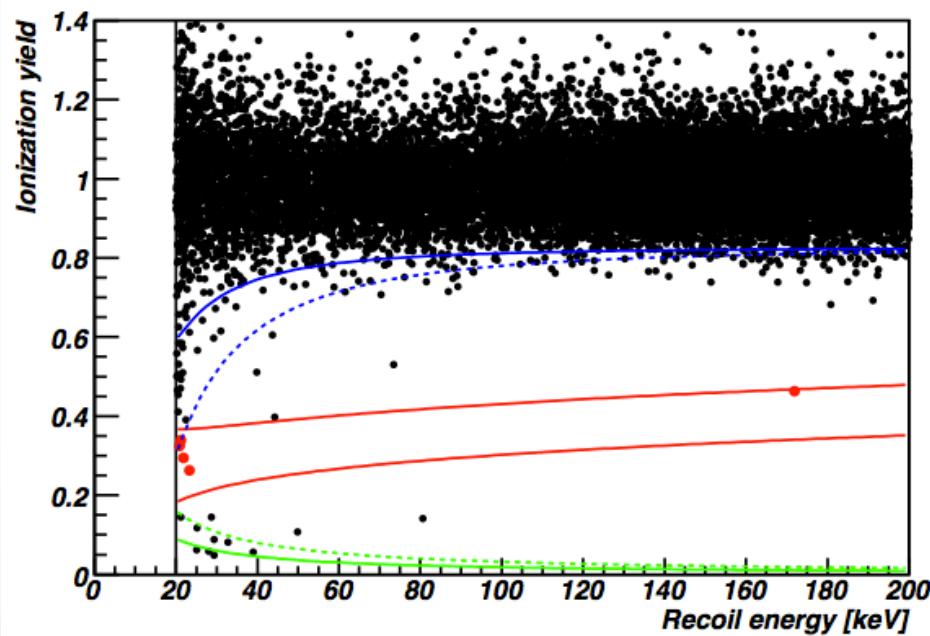


Gamma ( $^{133}\text{Ba}$ )



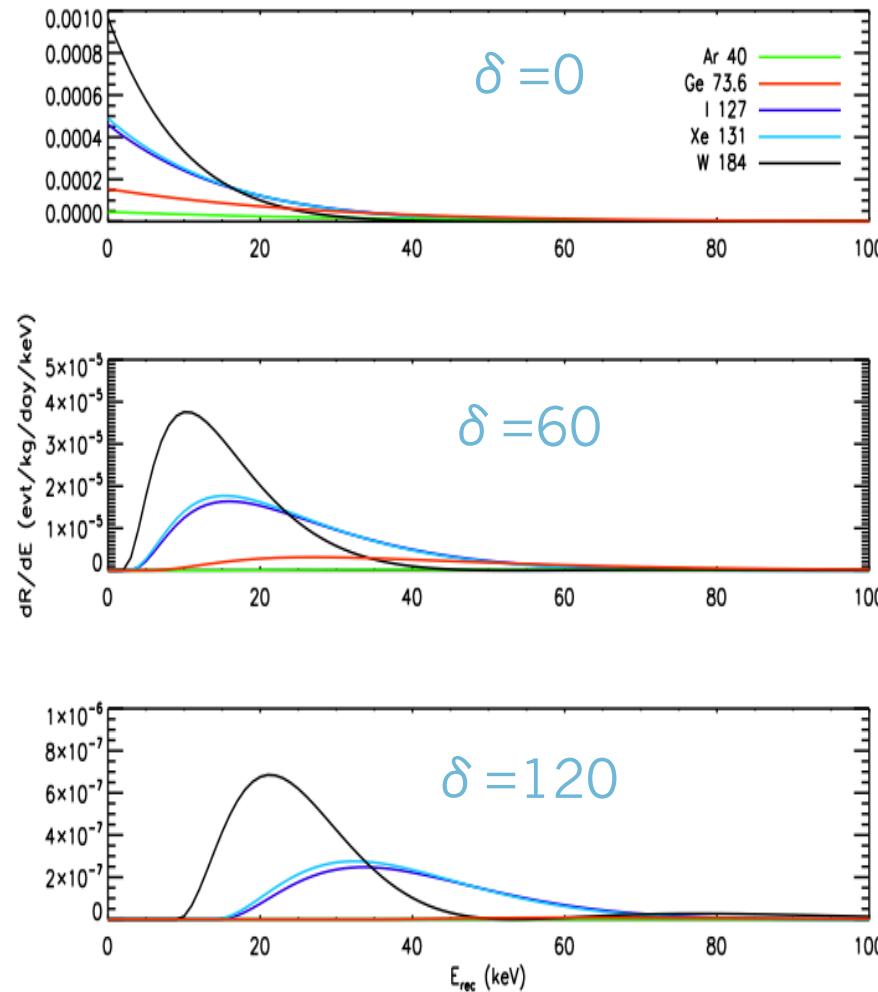
- Gamma rejection  $3 \times 10^{-5}$
- 6 events in NRB in gamma calibration: being investigated
  - Not due to bad resolution or missing electrodes

# WIMP search



- 5 events in WIMP band:  
20.8, 21.1, 21.8, 23.2, 172 keV
- Expected background: < 2.9 evt
- Elastic scattering scenario (90%CL)  
 **$4.4 \times 10^{-8} \text{ pb}$  at  $M\chi=85 \text{ GeV}$**   
( x2.7 better than 2009 result )

# Inelastic scattering



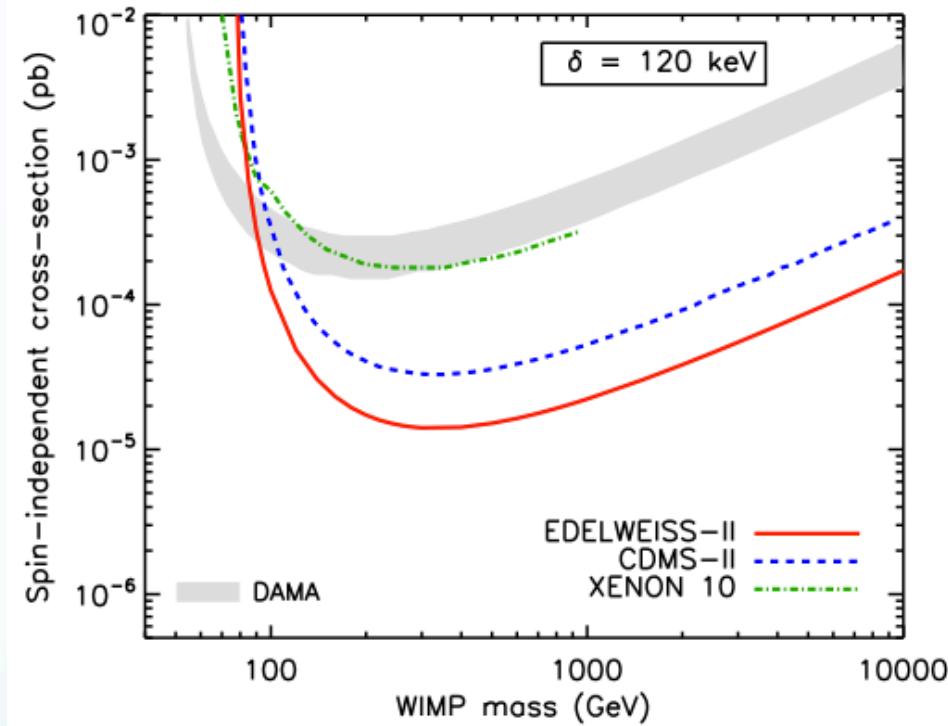
- Dark matter modulated signal claimed by DAMA/LIBRA vs. null detection in all the other direct detection experiments

- $X + m \rightarrow X^* + m$  ( $\delta \sim 100 \text{ keV}$ )

$$v_{\min} = \underbrace{\frac{1}{c^2} \sqrt{\frac{1}{2mE_R}}}_{v_{\min}^{el}} \left( \frac{mE_R}{\mu} + \delta \right)$$

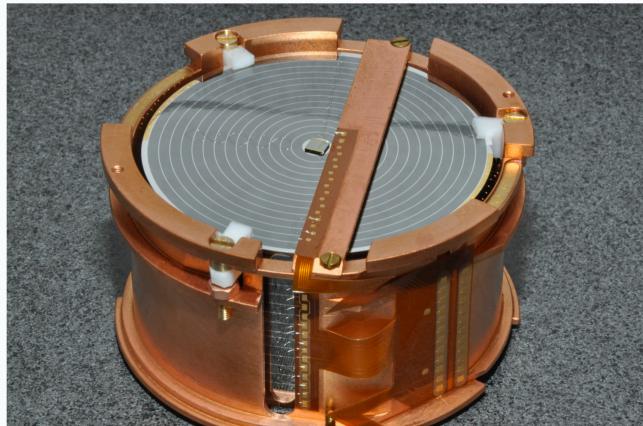
- Signal globally reduced and suppressed at low recoil energies
- Heavier targets preferred
- Modulation is enhanced

# Inelastic WIMP search

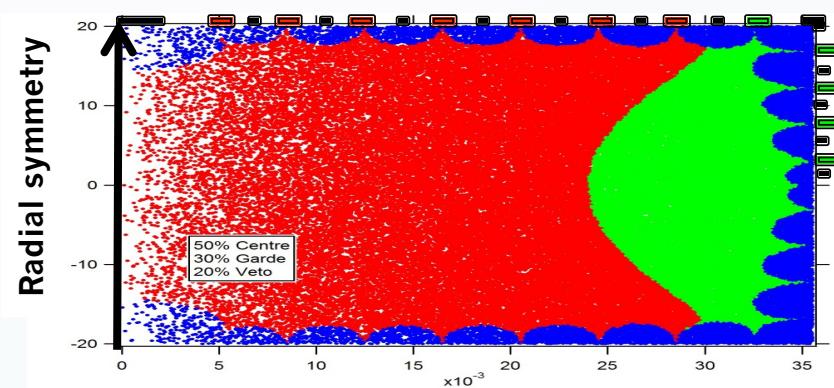
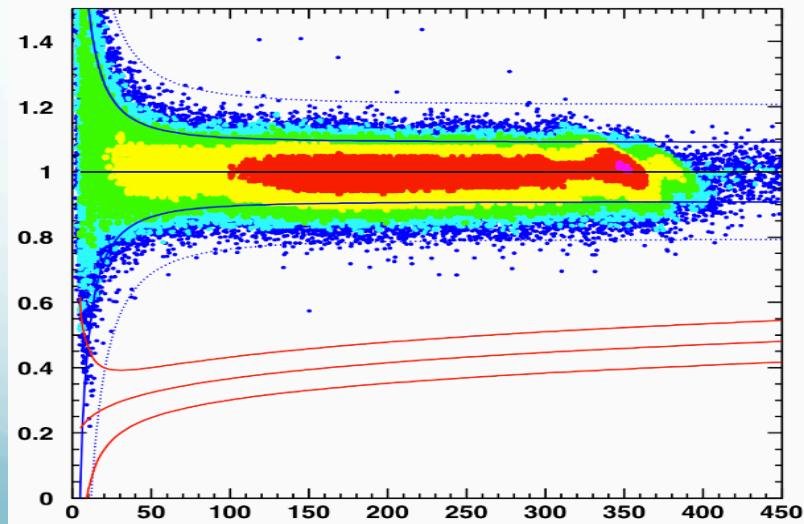


- 5 WIMP candidates: 20.8, 21.1, 21.8, 23.2, 172 keV
- $v_{\text{esc}} = 544$  km/s (RAVE survey, arXiv:0611671, 2007)
- **DAMA allowed region excluded for  $M\chi > 90$  GeV (90%CL)**

# New detectors FID 800



EDELWEISS FID -  $^{133}\text{Ba}$  calibration (411663  $\gamma$ )

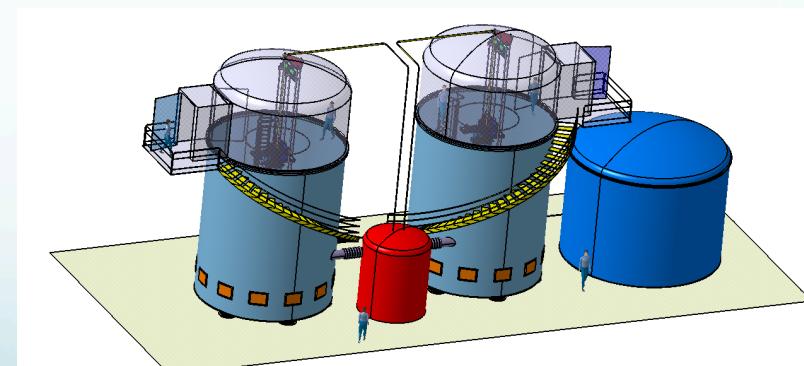
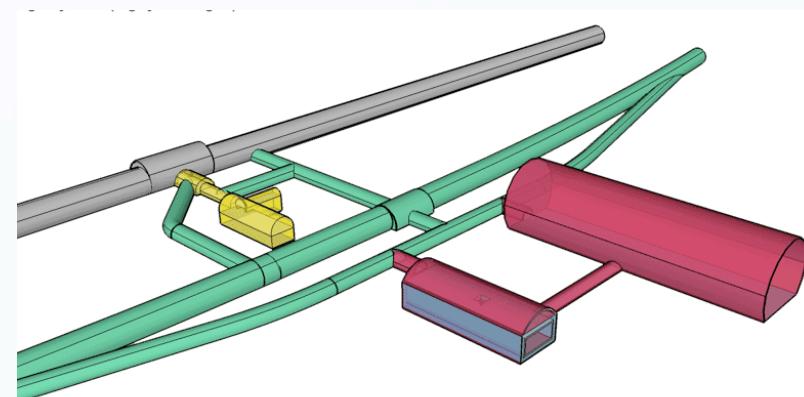


- Increase mass + sensitivity
  - Full ID coverage
  - Surface event rejection in fiducial & guard volumes
  - 2 NTD sensors per bolometer
- Gamma calibration: no events in NRB → better than IDs
- Next phase EDW-III: install 40 bolometers FID800 →  $5 \times 10^{-9} \text{ pb}$



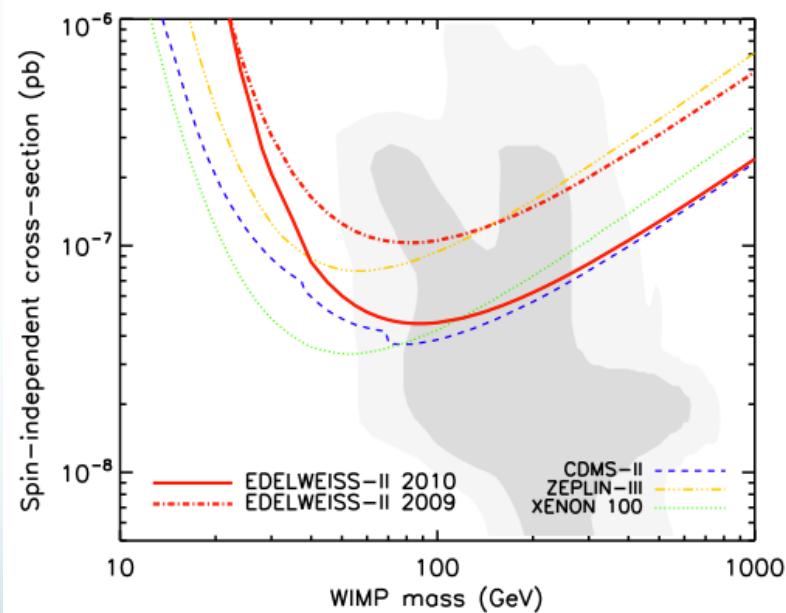
## European Underground Rare Event Calorimeter Array

- EURECA: beyond  $10^{-9}$  pb, major efforts in background control and detector development
- Joint effort from teams from EDELWEISS, CRESST, ROSEBUD + others...
- >>100 kg cryogenic experiment, multi-target
- Part of ILIAS/ASPERA European Roadmap
- Preferred site: 60 000 m<sup>3</sup> extension of present Laboratoire Souterrain de Modane, to be dug in 2011-2012



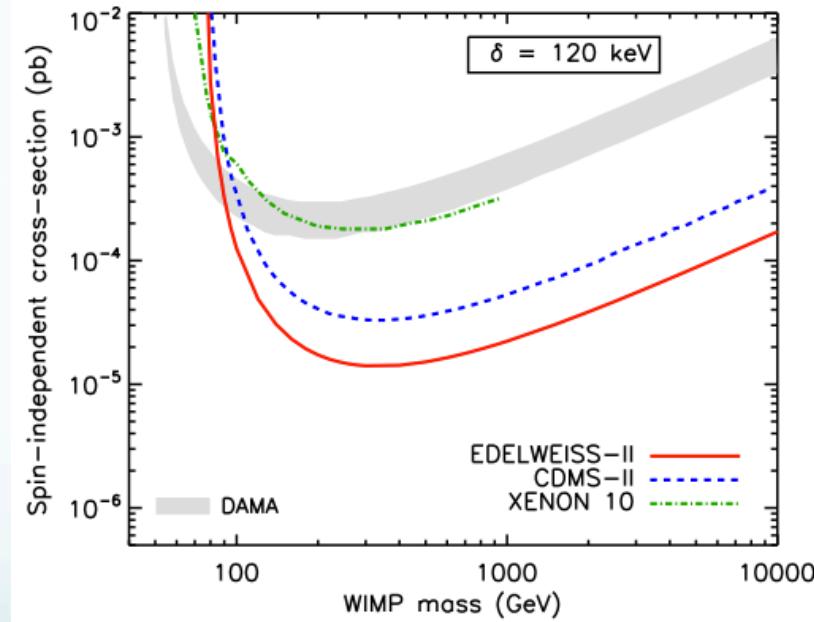
# ID summary

## Elastic scattering



$4.4 \times 10^{-8}$  pb at  $M\chi=85$  GeV

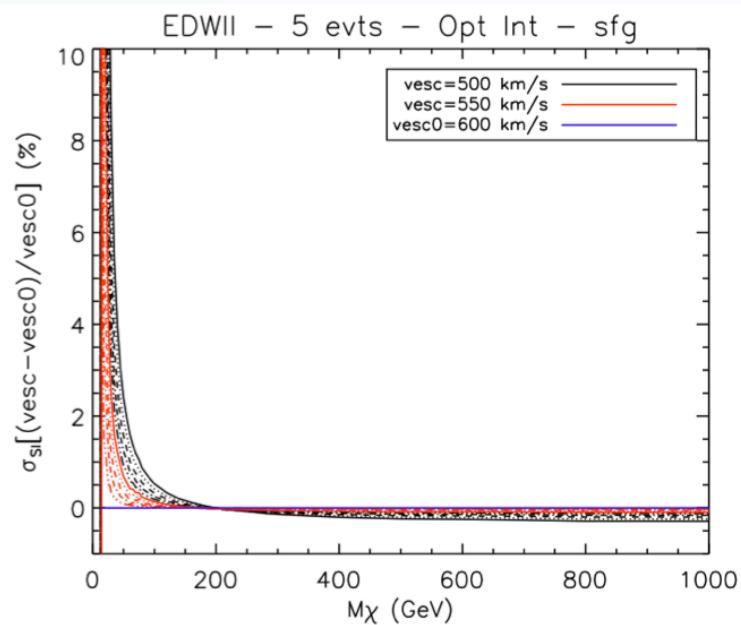
## Inelastic scattering



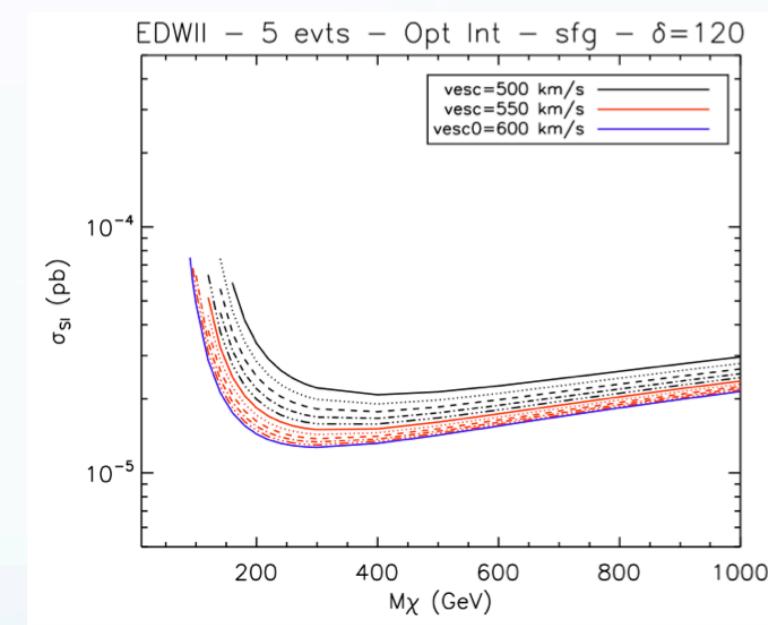
DAMA excluded for  $M\chi > 90$  GeV

# Effect of $v_{\text{esc}}$ on sensitivity

$\delta = 0$  ( $\sigma$  rel diff)



$\delta = 120$  ( $\sigma$  abs value)



- $500 < v_{\text{esc}} < 600 \text{ km/s} ; M_\chi > 200 \text{ GeV}$
- Relative change in sensitivity  $< 0.5\%$  elastic scattering ( $\delta=0$ )  
 $< 60\%$  inelastic scattering ( $\delta=120$ )