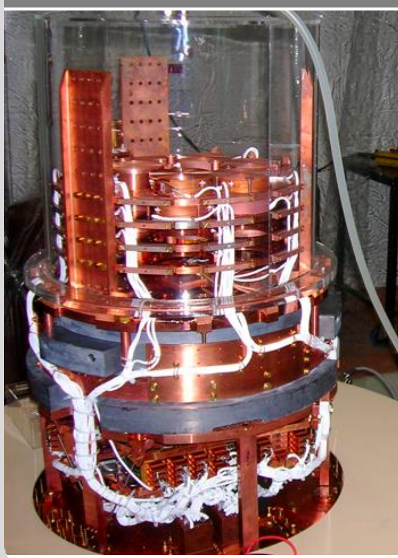
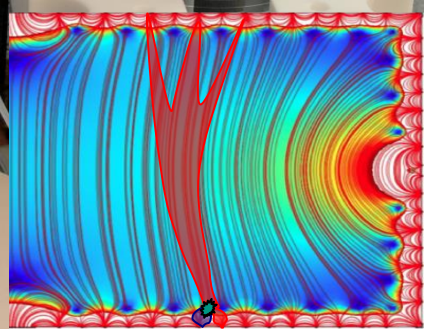
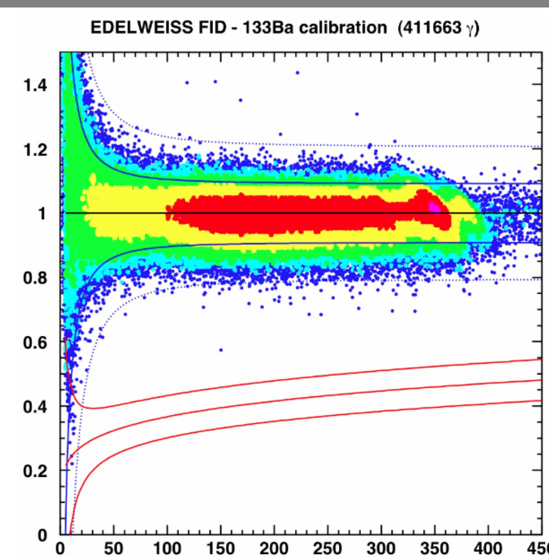
The EDELWEISS dark matter search: Results and prospects

Benjamin Schmidt, KIT, EDELWEISS experiment,
SUSY 2013 @ ICTP Trieste





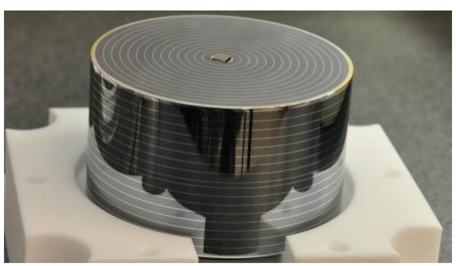


Direct Dark Matter search

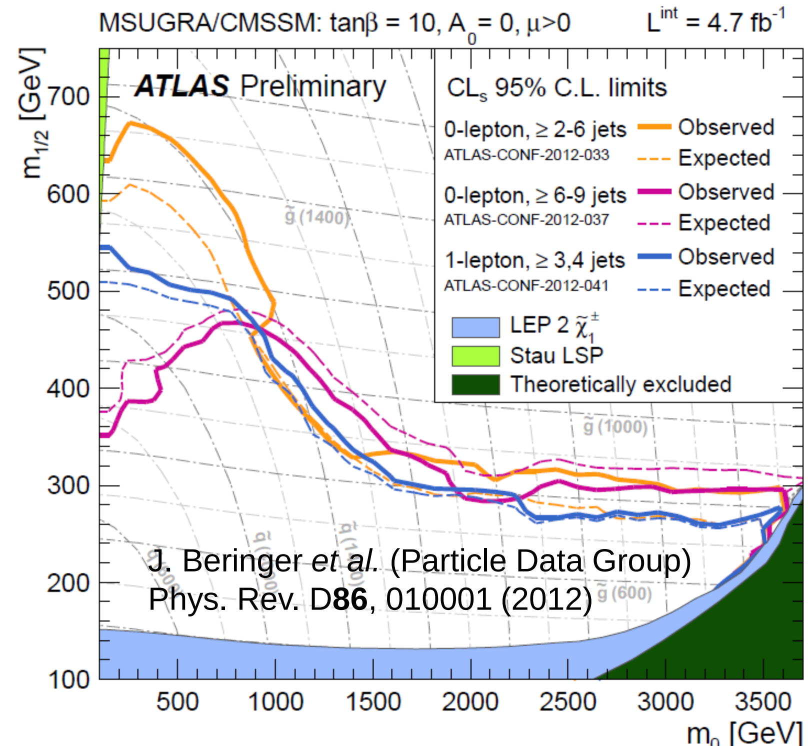
- Evidence for dark matter: galaxy rotation curves, clusters, CMB, nucleosynthesis, bullet cluster

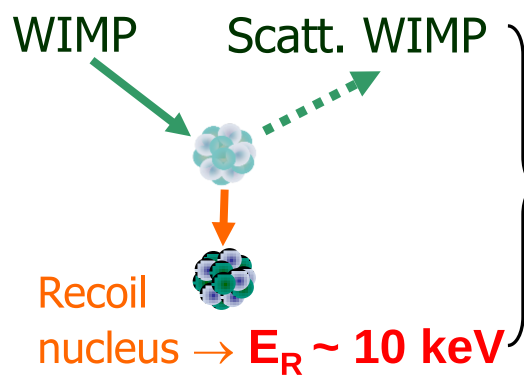
- Candidates: WIMPs – supersymmetric neutralinos, KK particles, technibaryons…

- Search for elastic scattering
  - **~ 10 keV nuclear recoil**
  - **< 1 event/kg/year**
  - **Need excellent background suppression**



- Cryogenic germanium phonon-ionization detectors



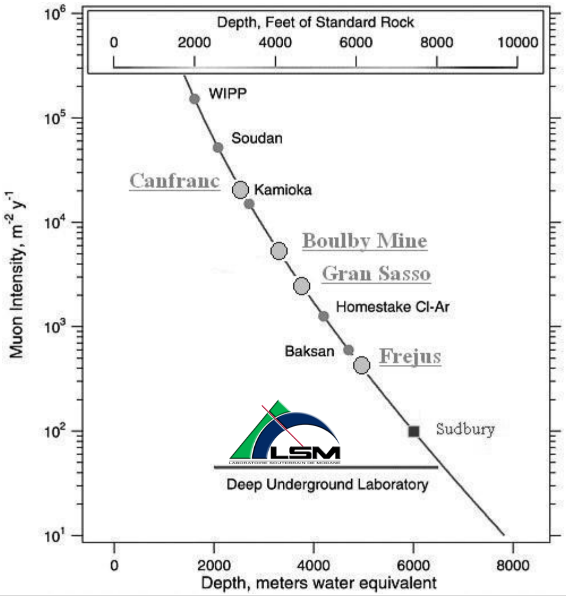


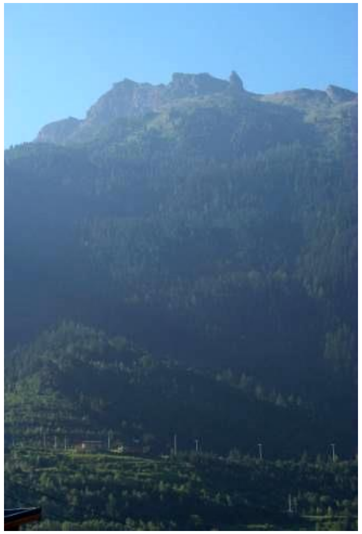
Count rate:

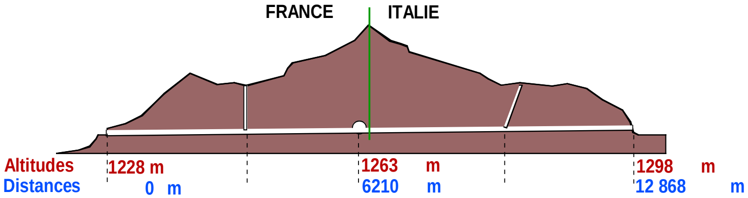
< 1evt/kg/year!

The EDELWEISS Collaboration

- CEA Saclay (IRFU and IRAMIS)
- CSNSM Orsay (CNRS/IN2P3 + Paris Sud)
- IPNLyon (CNRS/IN2P3 + Univ. Lyon 1)
- Néel Grenoble (CNRS/INP)
- Karlsruhe Inst. of Technology (IKP, EKP, IPE)
- JINR Dubna
- Oxford University
- University of Sheffield

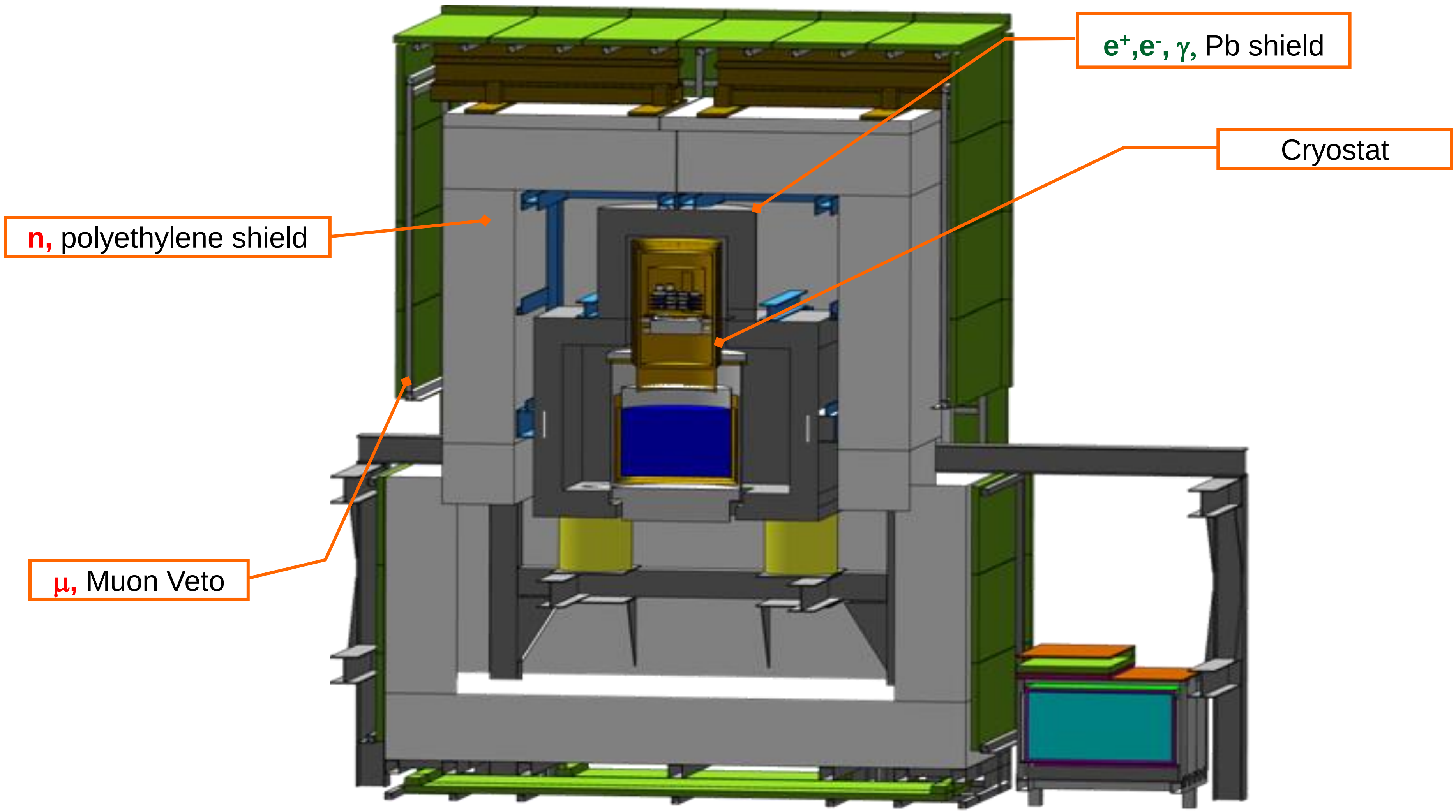






- Experimental site: *Laboratoire Souterrain de Modane (LSM)* in Fréjus Tunnel
- 4800 mwe depth: ~ 5 muon/day/m^2
- 10^{-6} neutrons/cm^2/s (> 1 MeV)
- Deradonized air supply
  (~ 10 Bq -> ~ 30 mBq)

EDELWEISS setup

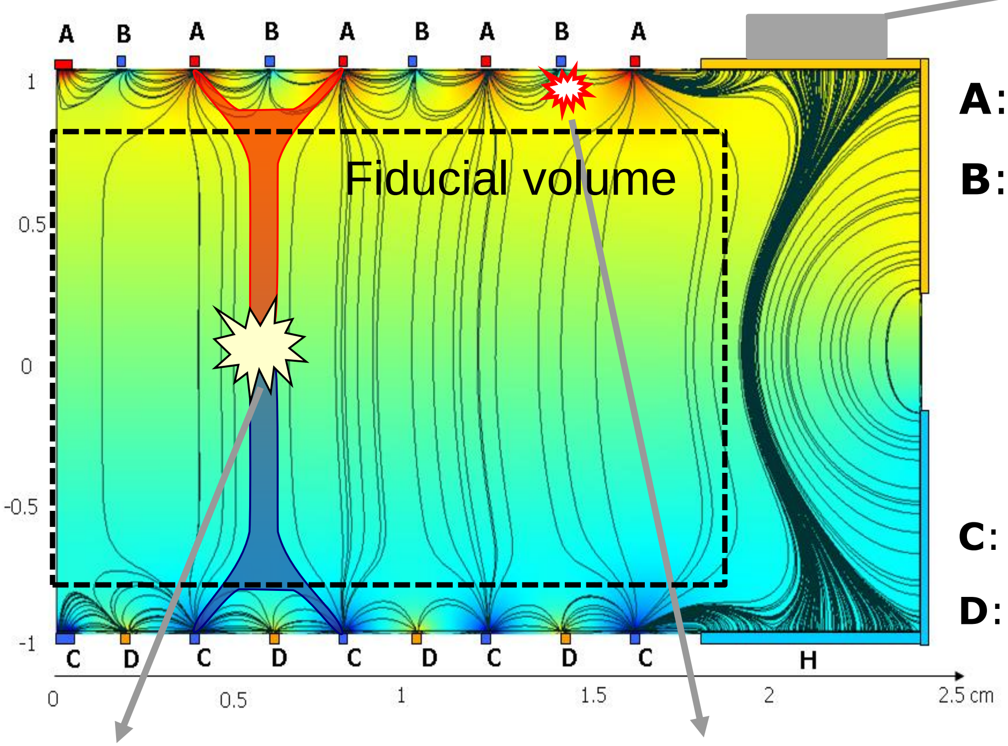


Nuclear recoil event discrimination & Surface event rejection- principle

Karlsruher Institut für Technologie

Event discrimination via simultaneous charge and phonon measurement

Al electrodes ~ 100 nm



A: +4 V

B: −1.5V

C: −4 V

D: +1.5V

Bulk/Fiducial event
Charge collected on electrodes A&C

Surface event
Charge collected on electrodes A&B

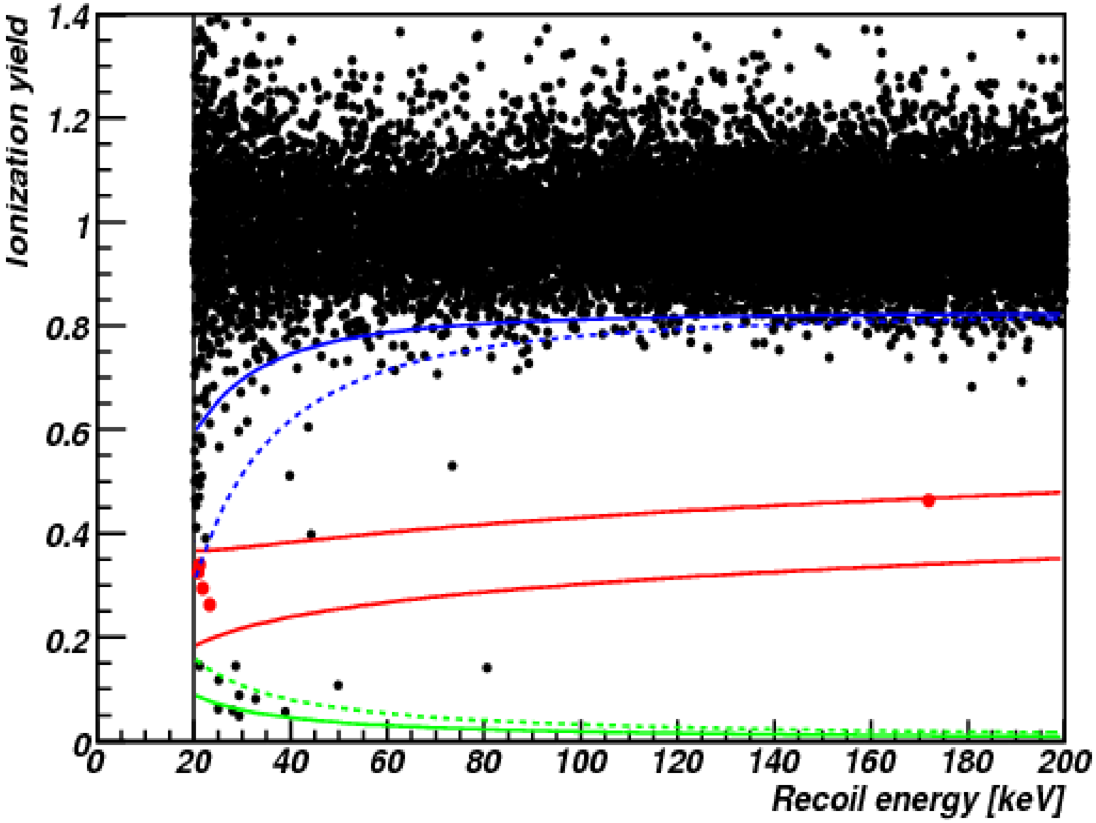
NTD Phonon/Heat sensor
= calorimetric measurement of total energy (T = 18 mK, $\Delta T \sim 0.1\ \mu K/keV$)

Al electrodes
Ionization measurement (sub-keV resolution)

Ionization yield
$Q = E_I/E_{Rec}$ nuclear recoils have ~ 1/3 Q of e-recoils

Results from EDELWEISS-II 2011 (384 kgd)

- Edw-II: semi-blind CDM analysis for O(100 GeV/c^2) WIMP mass
- 1 year/384 kgd of exposure
- 5 events observed
  3 background events expected



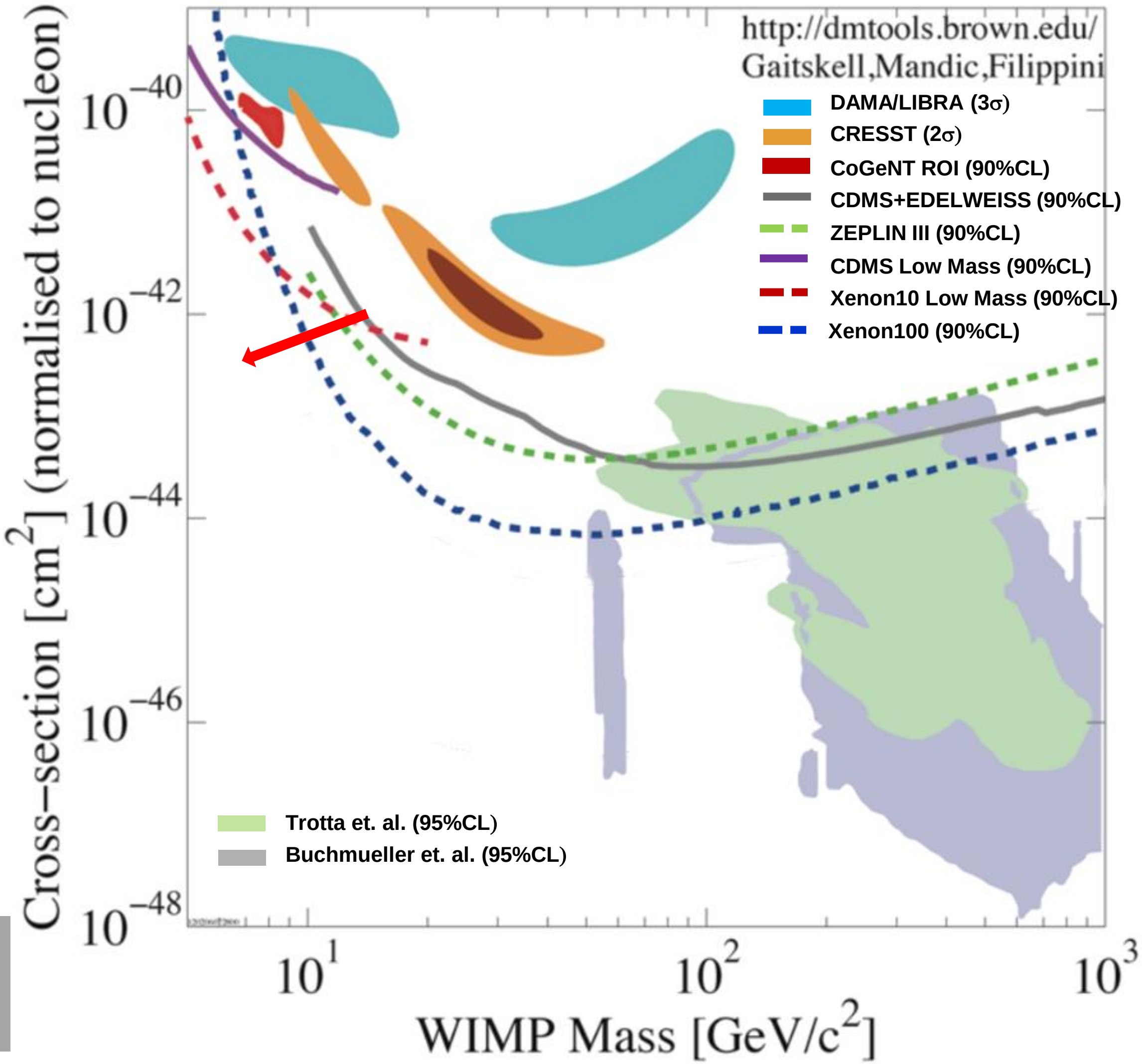
Results EDELWEISS-II

EDELWEISS-II: important progress with cryogenic Ge detectors

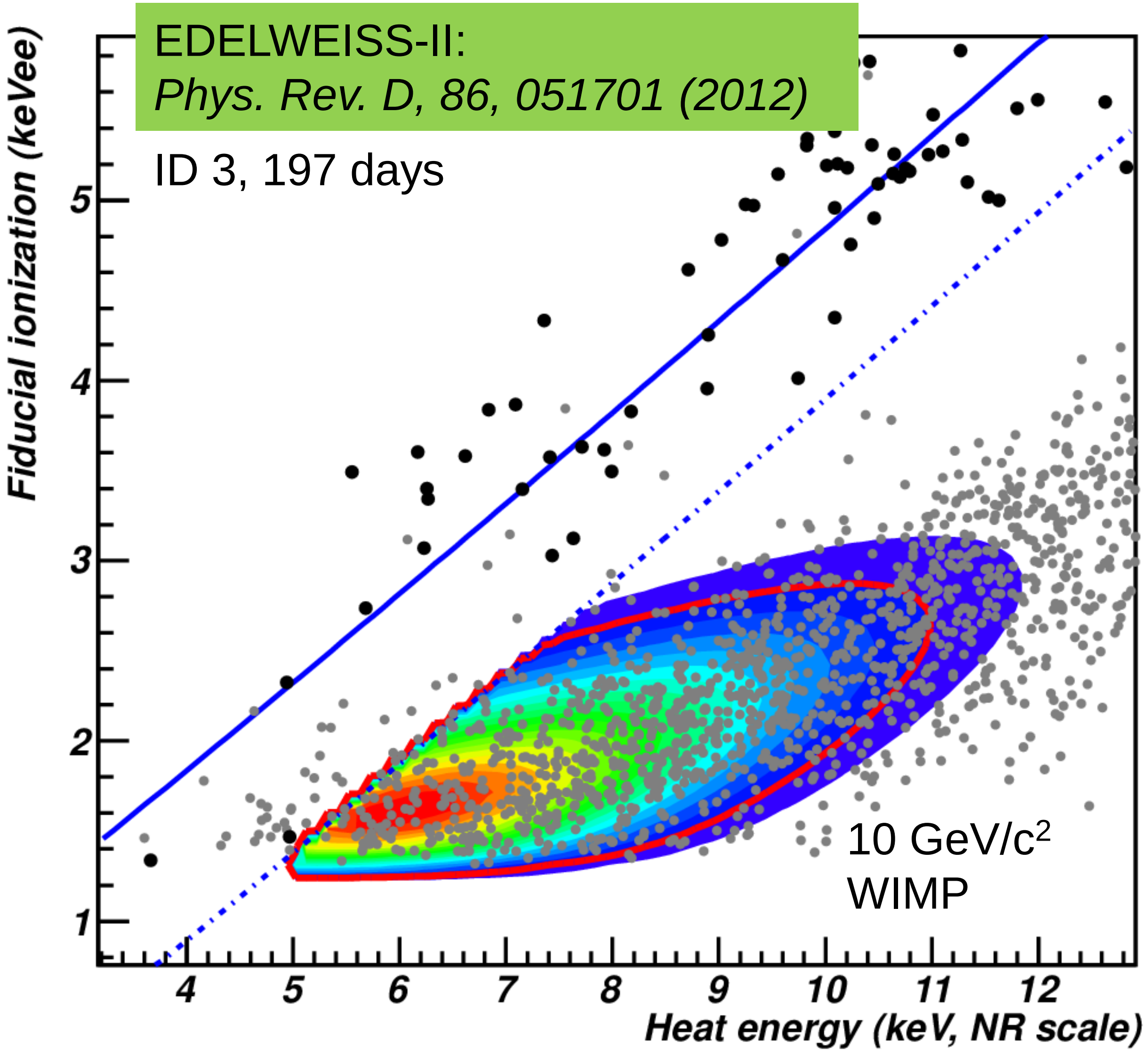
- 4.4×10^{-8} pb (90%CL) sensitivity achieved at 85 GeV/c^2
- Data combined with CDMS
- Backgrounds start to appear

EDELWEISS 2011:
PLB, 702(5), 329-335

CDMS & EDELWEISS 2011:
PRD, 84(1), 1-5



EDELWEISS-II
Low WIMPmass analysis results

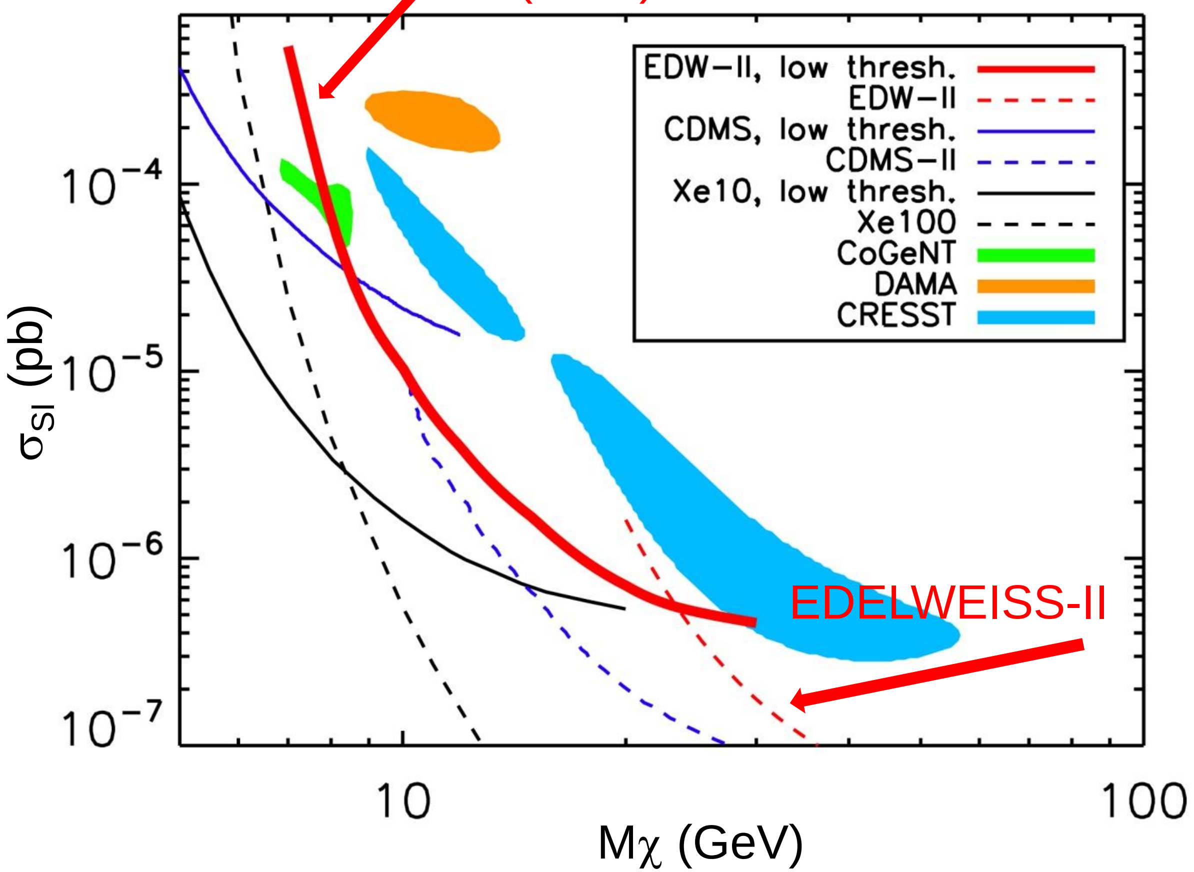


EDELWEISS-II
Low WIMPmass analysis results

- Low energy analysis of 2009-2010 data (4 ID detectors)

- 4/10 ID detectors (~113 kgd)
- 1.4 – 1.9 keV Ionization threshold
- 95% C.L. gamma cut
- Background expect.: γ + ion. threshold + n: 2.9 evts / 1 observed

EDELWEISS-II: *Phys. Rev. D, 86, 051701, (2012)*



Potential for significant progress in EDELWEISS-3

EDELWEISS-II
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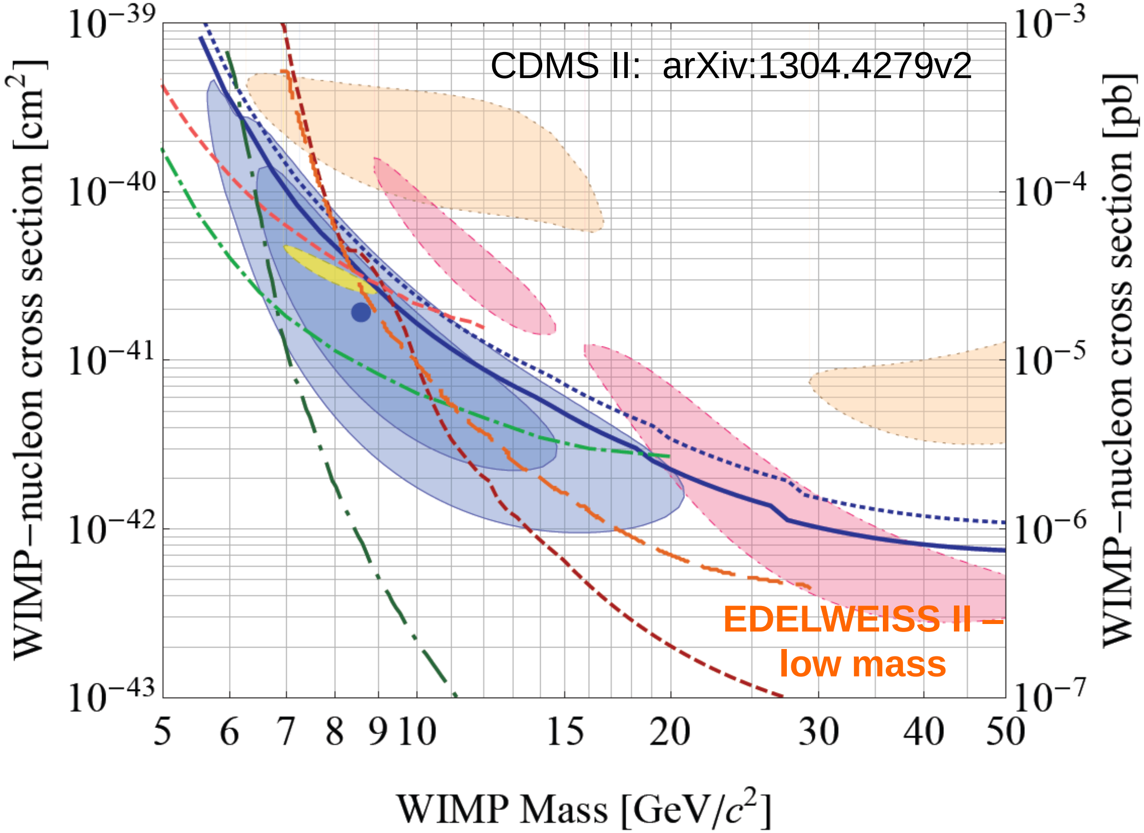
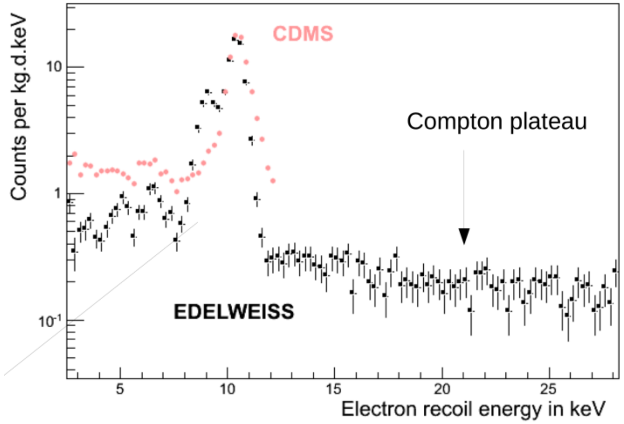


Potential for significant progress in EDELWEISS-3

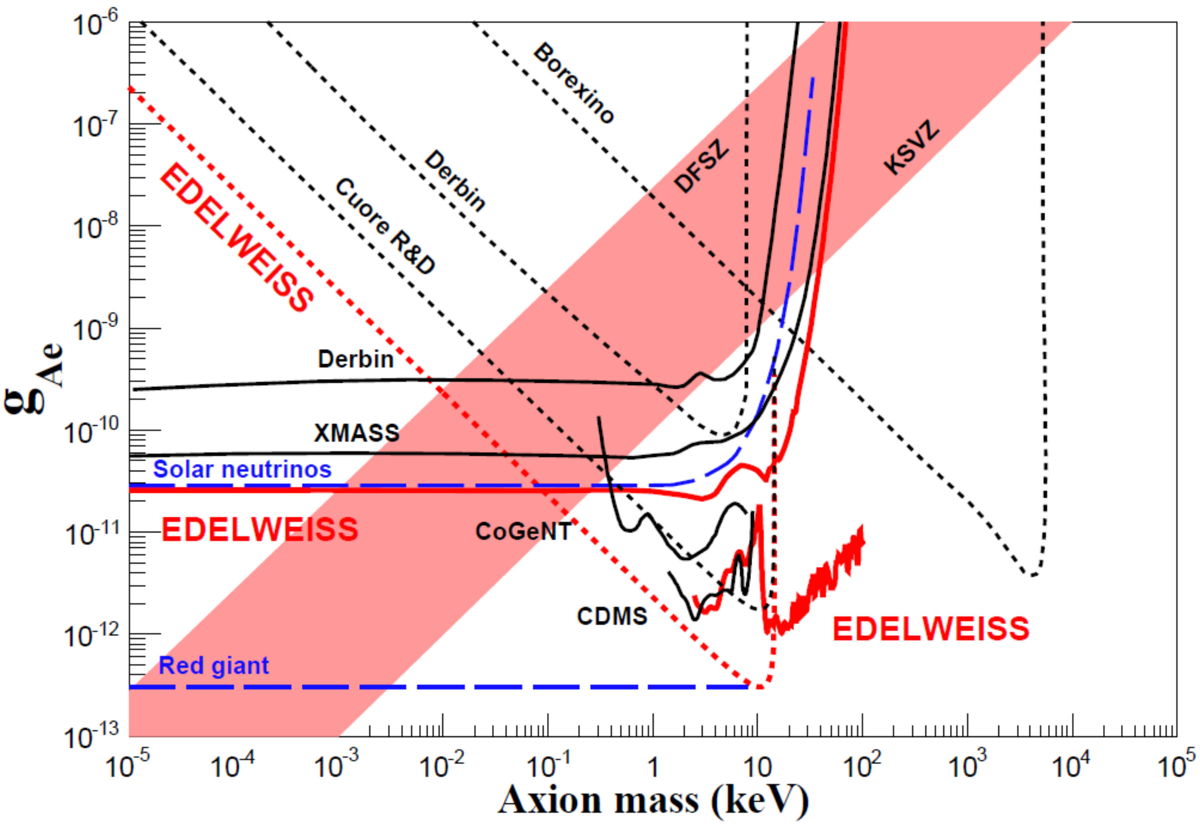
Axion results with EDELWEISS-II data



Low-threshold and high resolution electron recoil spectrum used for axion search

Very low background due to fiducial selection

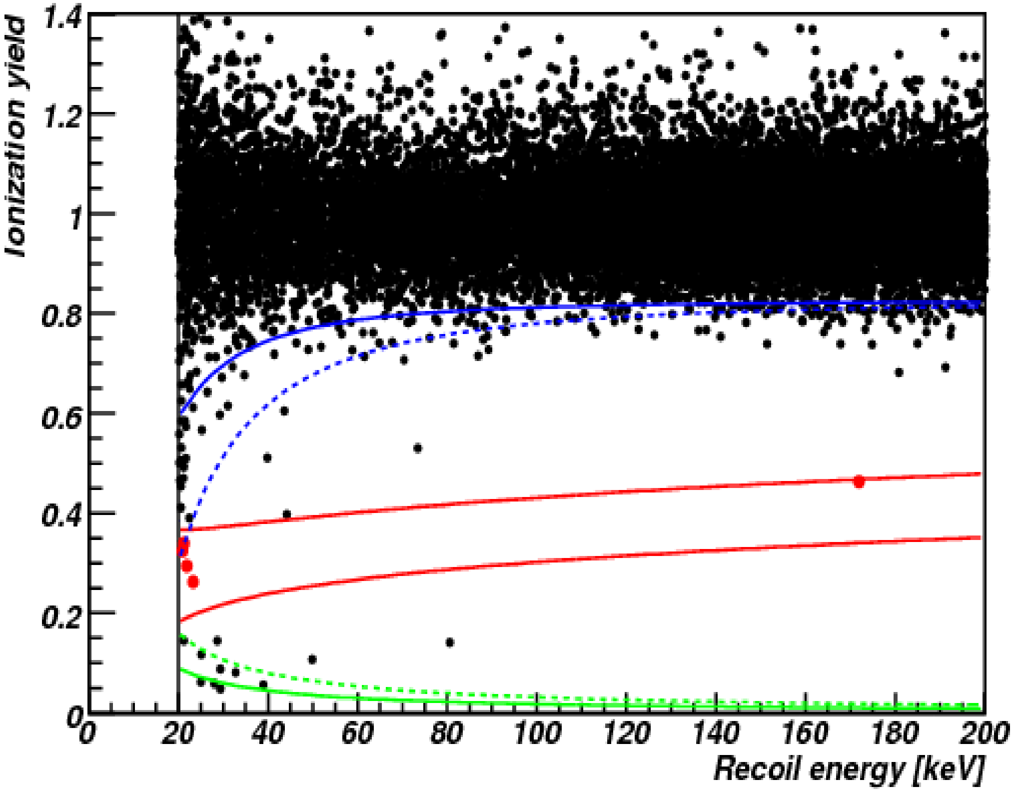
Best/Competitive axion limits (Primakoff, axio-electric, solar or dark matter scenarios with axion like particles)



arXiv:1307.1488

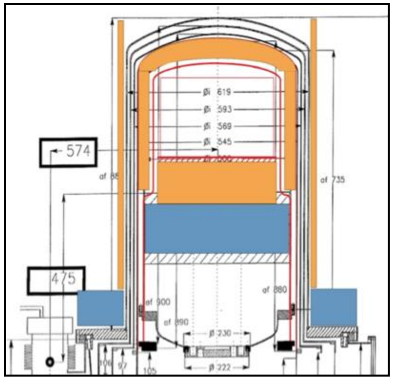
Lessons learned from EDELWEISS-II (384 kgd)

- Further remove background (3 expected events in Edw-II)
  - ≤ 1.2 γ rejection
  - ≤ 1.8 neutrons
- Increase total- and fiducial mass

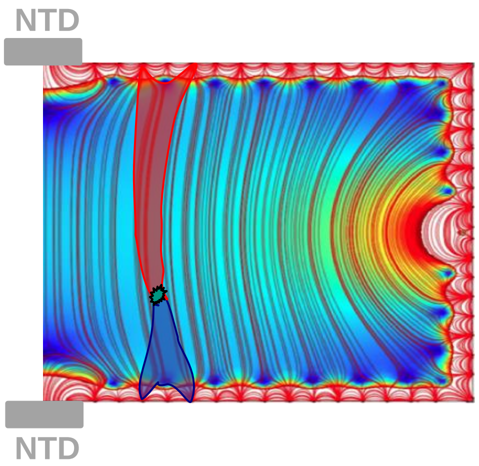


Upgrades in EDELWEISS-3

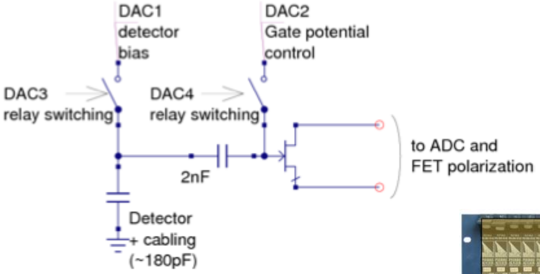
1. Suppression of n-background



2. Improvement of γ discrimination



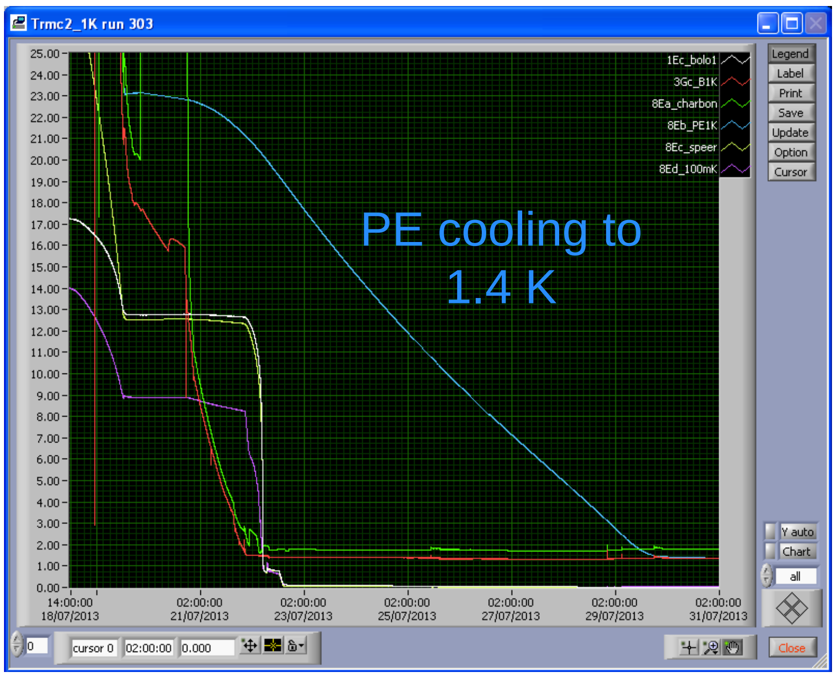
3. Confirmation of β-rejection with new detectors and improved resolutions

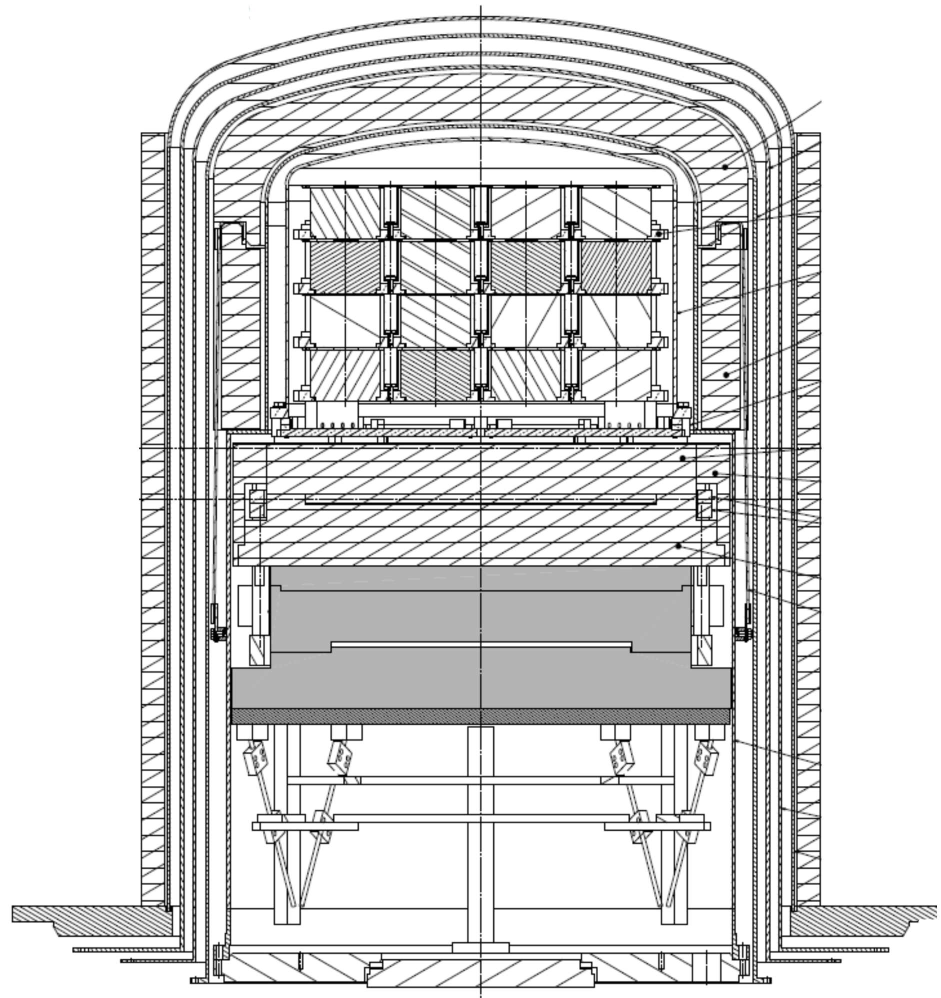


4. Enable upscaling towards 1ton-scale exp.

Upgrades towards EDELWEISS-3
1. Suppression of n background

- Additional cold PE shield
- New Kapton cabling
- Better radiopure connectors
- Redesign of copper shields

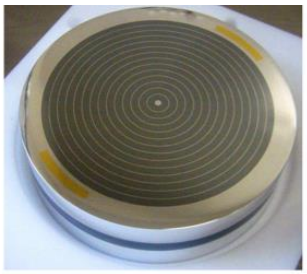


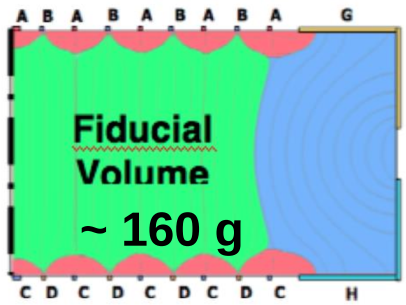


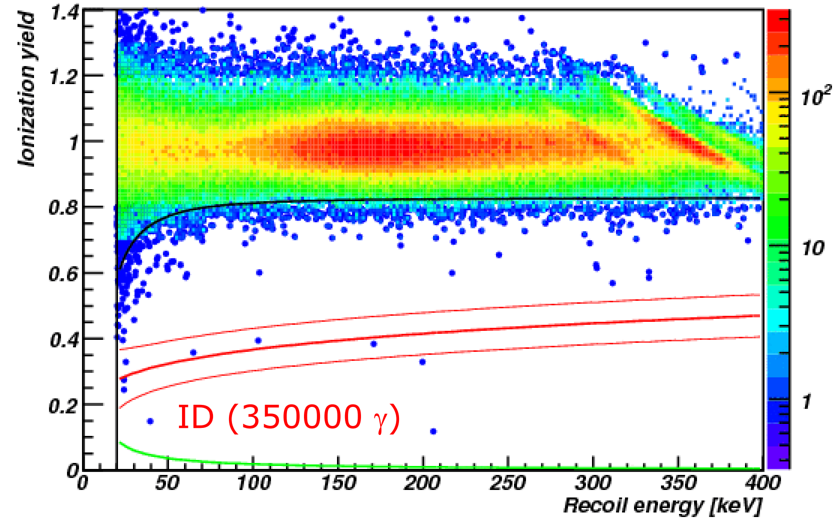
> 10 times better neutron suppression

2. Improvement of γ discrimination

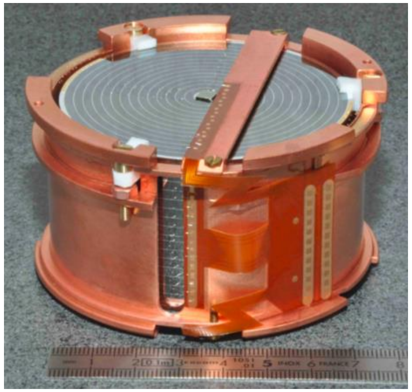
EDELWEISS-II
ID 400 g with ~ **160 g** fiducial mass

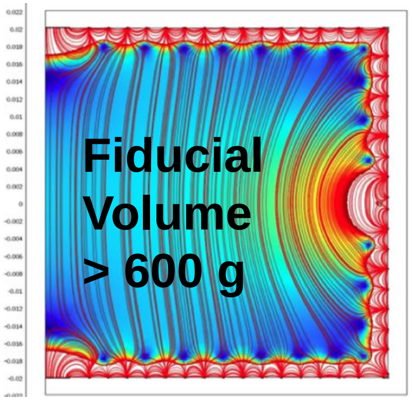


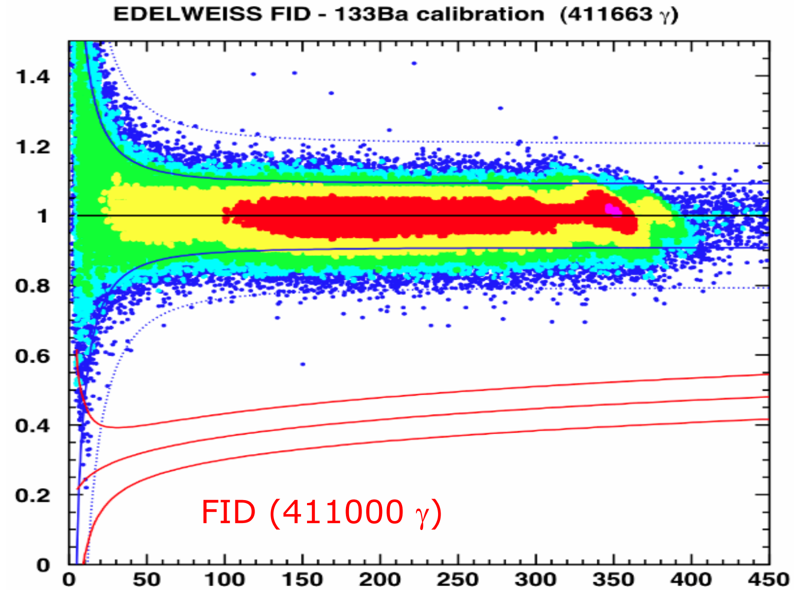




EDELWEISS-III
FID 800 g with ~ **600 g** fiducial mass







 Benjamin Schmidt, SUSY 2013-08-29

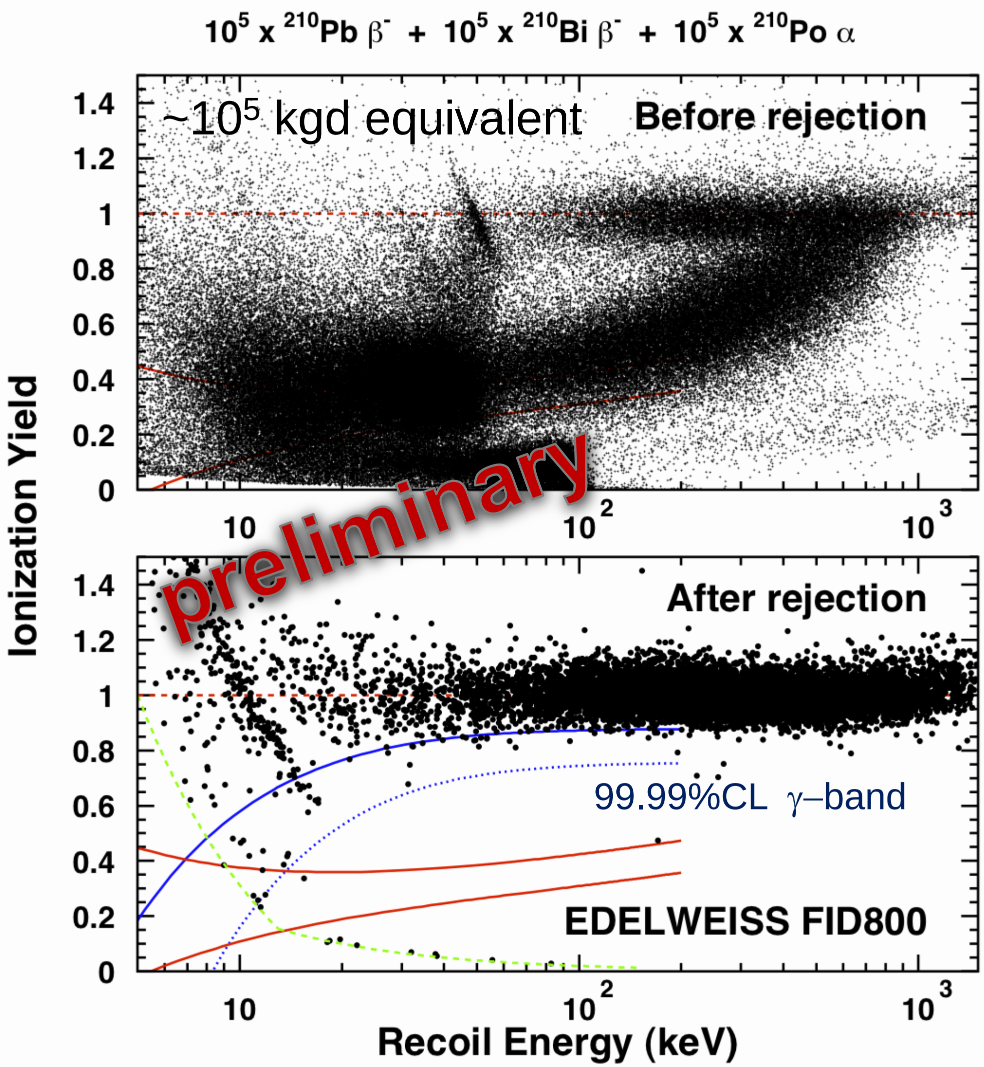
3. Surface rejection measurements – improved resolutions

- Measurement with ^{210}Pb β-source

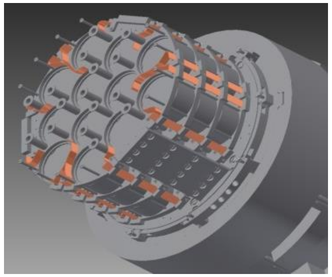
- Surface rejection:
  < 4 x 10^{-5} misidentified events per kgd (above 15 keV)

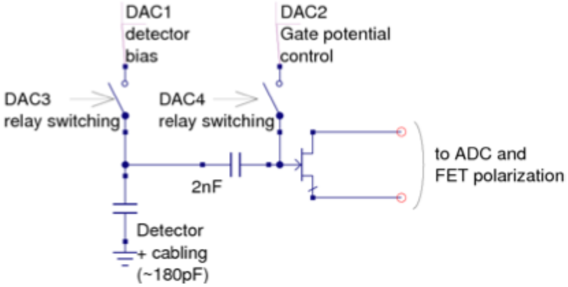
Better than previous EDELWEISS detectors

(< 6 x 10^{-5} misidentified events per kgd, above 20 keV)

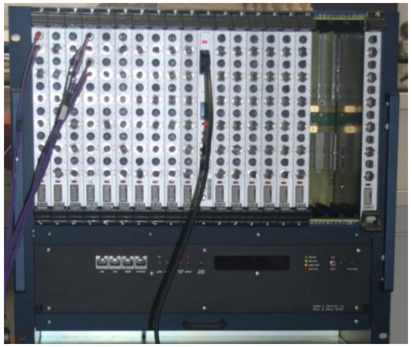


3./4. Improvement of resolutions and thresholds



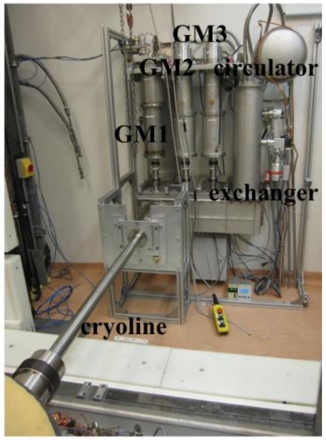


- Resolution improvement aimed at > 30%
  yields sensitivity < 5 keV,
  full sensitivity at ~ 10 keV



- New cables, electronics and integrated DAQ system

- Improved cryogenics system:
  New cryoline
  → better control over thermal shields and less microphonics



Timeline/Projection EDELWEISS-III

- August 2013 (now)
  - **EDELWEISS-III commissioning runs**
  - Upgraded cryogenics
  - ~15 FID 800 g detectors largest cryogenic mass of heat + ion Ge detectors
  - Upgraded readout electronics + Kapton cables
  - Inner PE shield + new Cu screens
- End of 2013
  - Fully equipped cryostat ~40 FID 800 g detectors