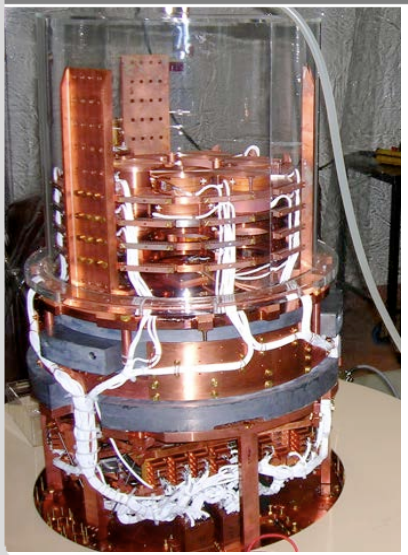
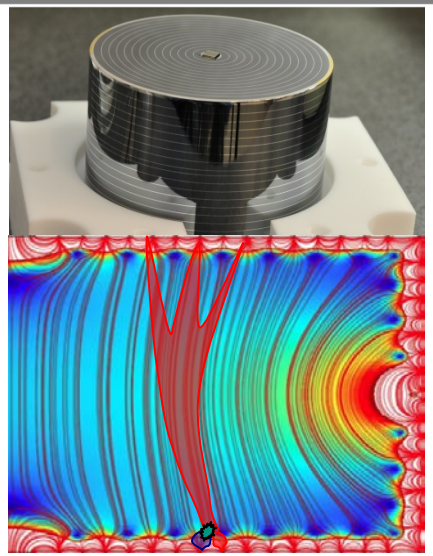
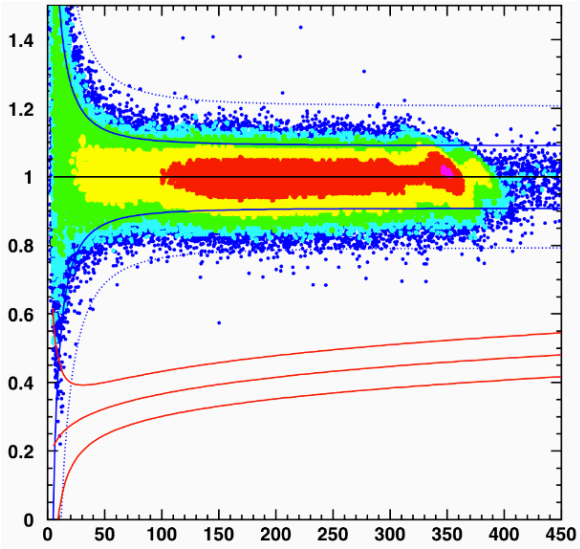
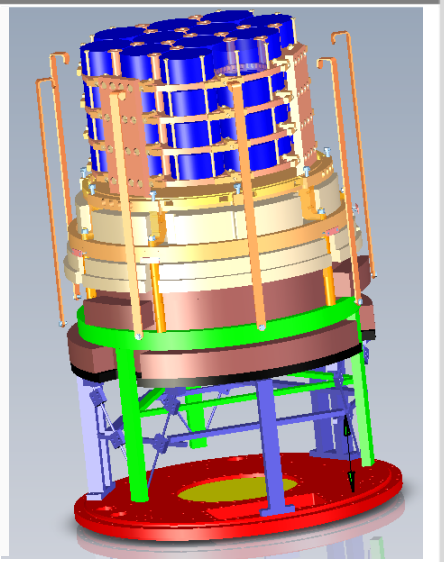
The EDELWEISS DM search

Klaus Eitel, for the EDELWEISS collaboration



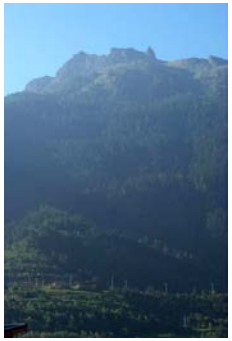


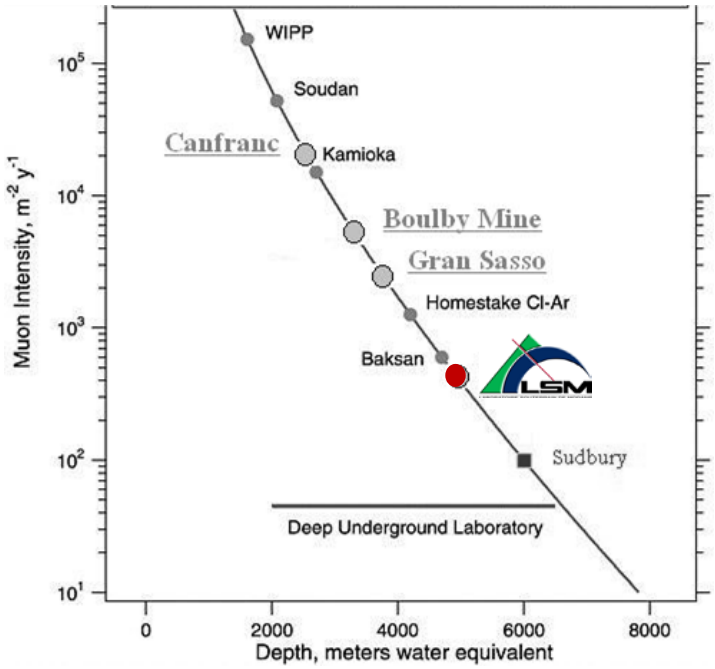


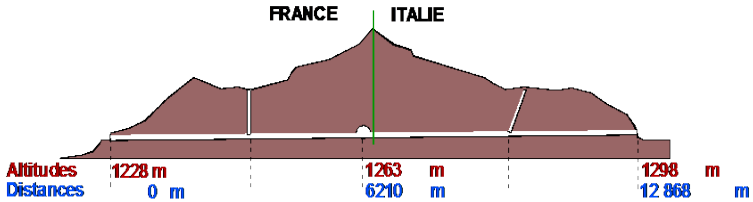


The EDELWEISS Collaboration

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





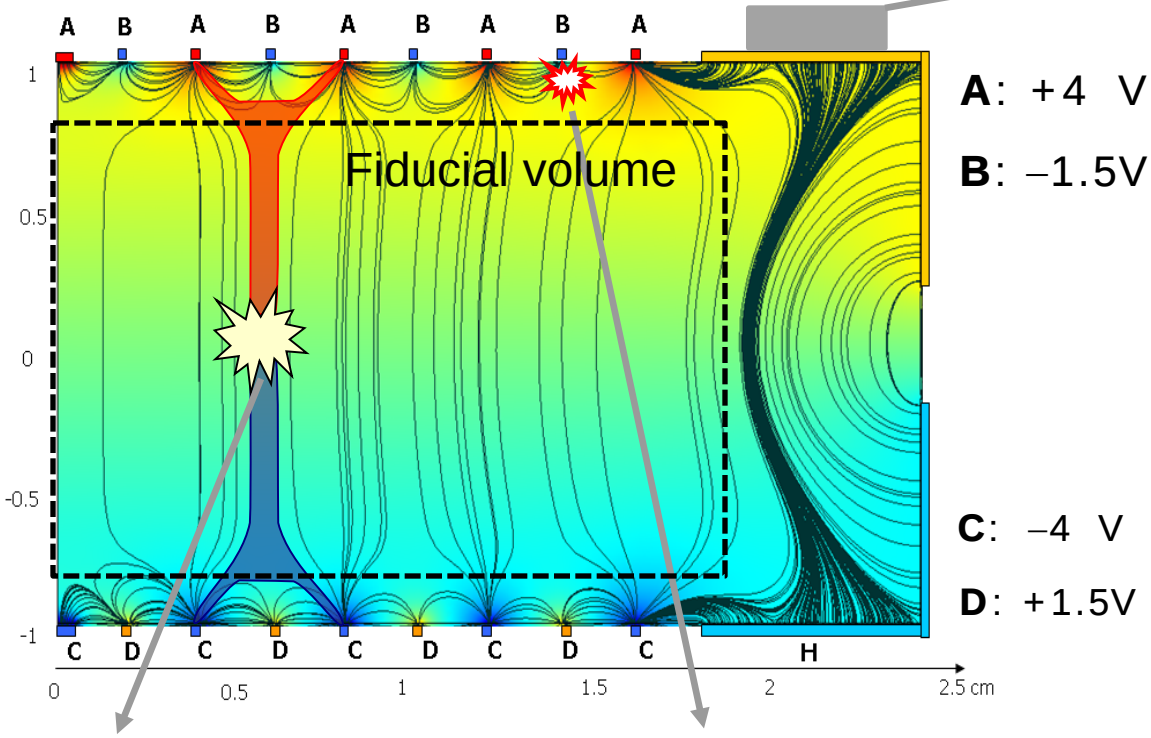


- Experimental site: *Laboratoire Souterrain de Modane (LSM)* in Fréjus Tunnel
- 4800 mwe depth: ~5 muon/day/m^2
- 10^{-6} neutrons/cm^2/s (>1MeV)
- Deradonized air supply (~10 Bq → ~30 mBq)

EDELWEISS Ge heat&ionisation detectors

Event discrimination via simultaneous charge and phonon measurement

Al electrodes ~100 nm



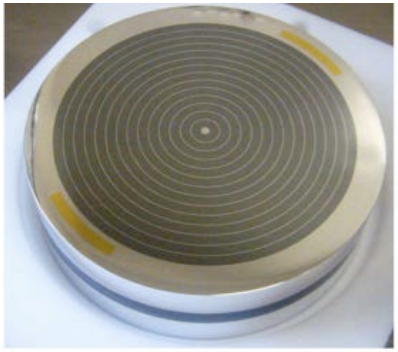
Bulk/Fiducial event
Charge collected on electrodes A&C

Surface event
Charge collected on electrodes A&B

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

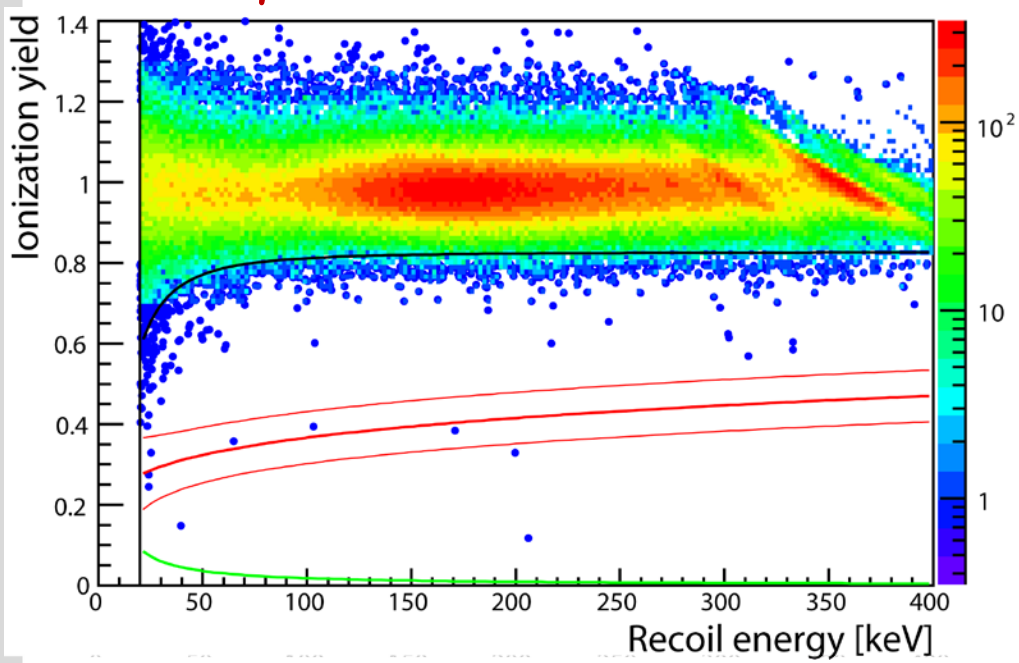
Al electrodes
Ionization measurement (sub-keV resolution)

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

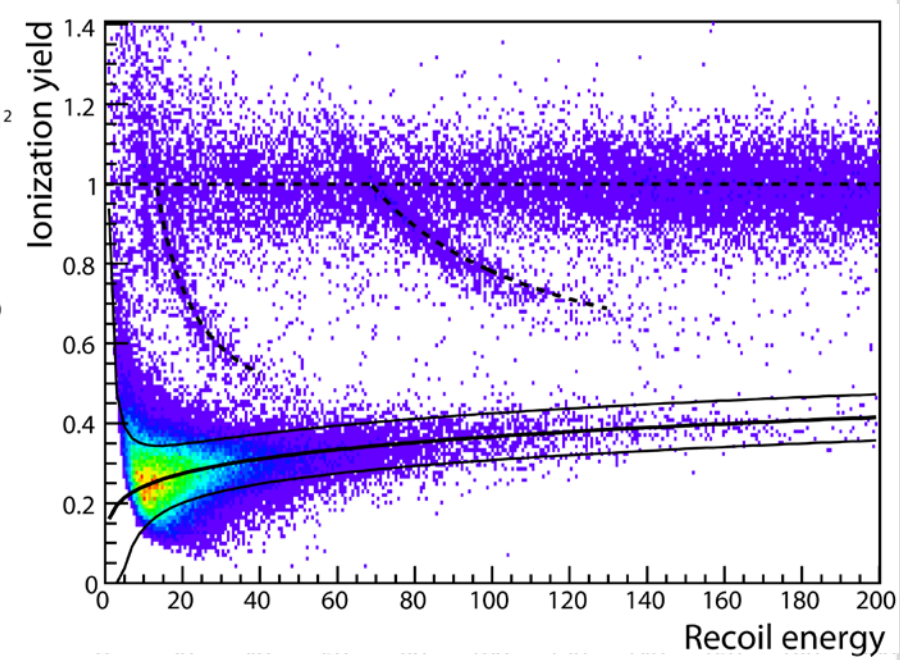


calibration with γ/n-sources

γ calibrations with ^{133}Ba



n calibrations with AmBe

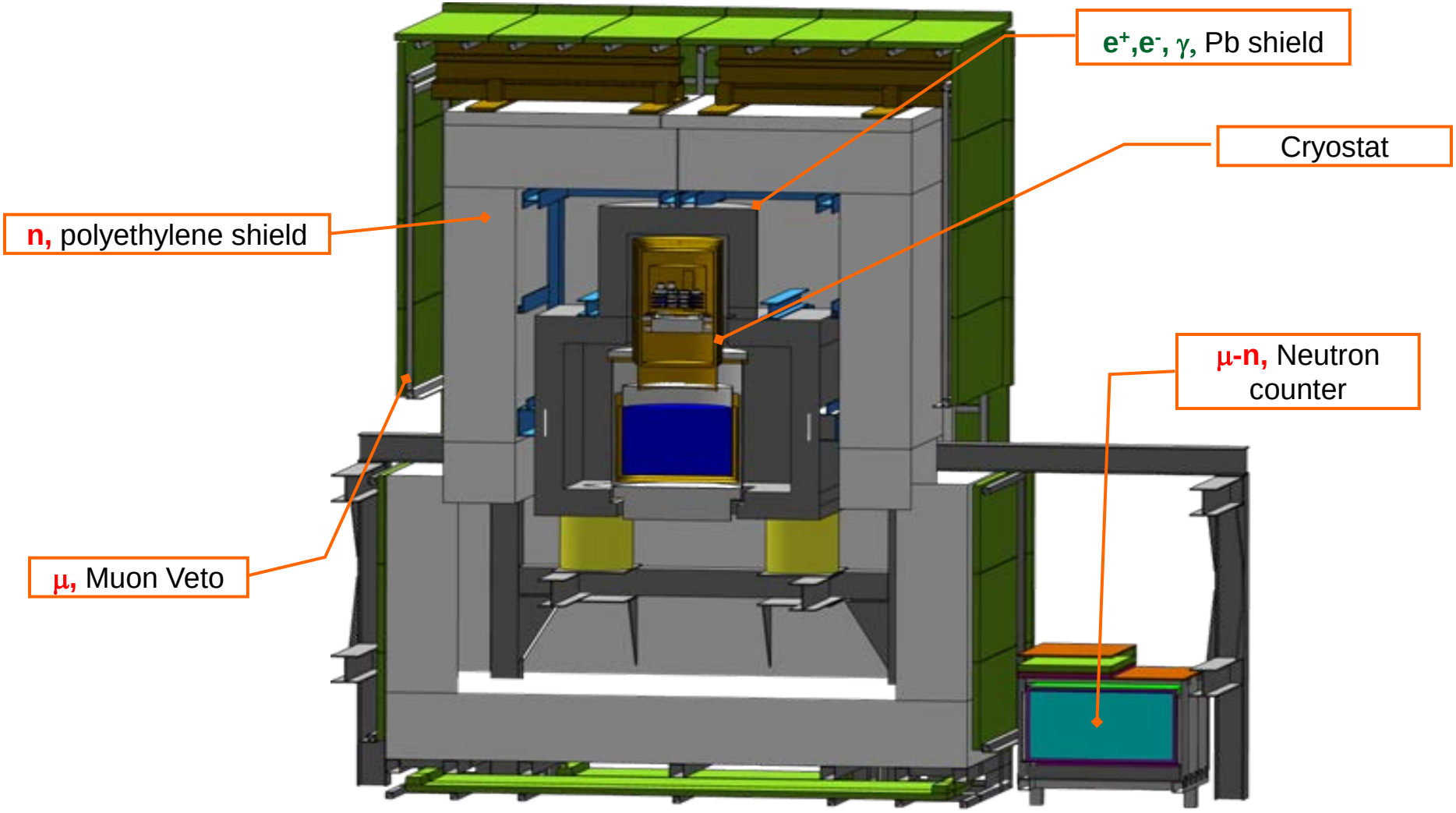


more than 350.000 γ´s
γ suppression factor $3x10^{-5}$
1 ”NR” for every 30k γ´s (20-200keV)

90% CL signal region
$Q = 0.16\ E_r^{0.18}$ from <10 to 200keV
(detection efficiency below 20keV)

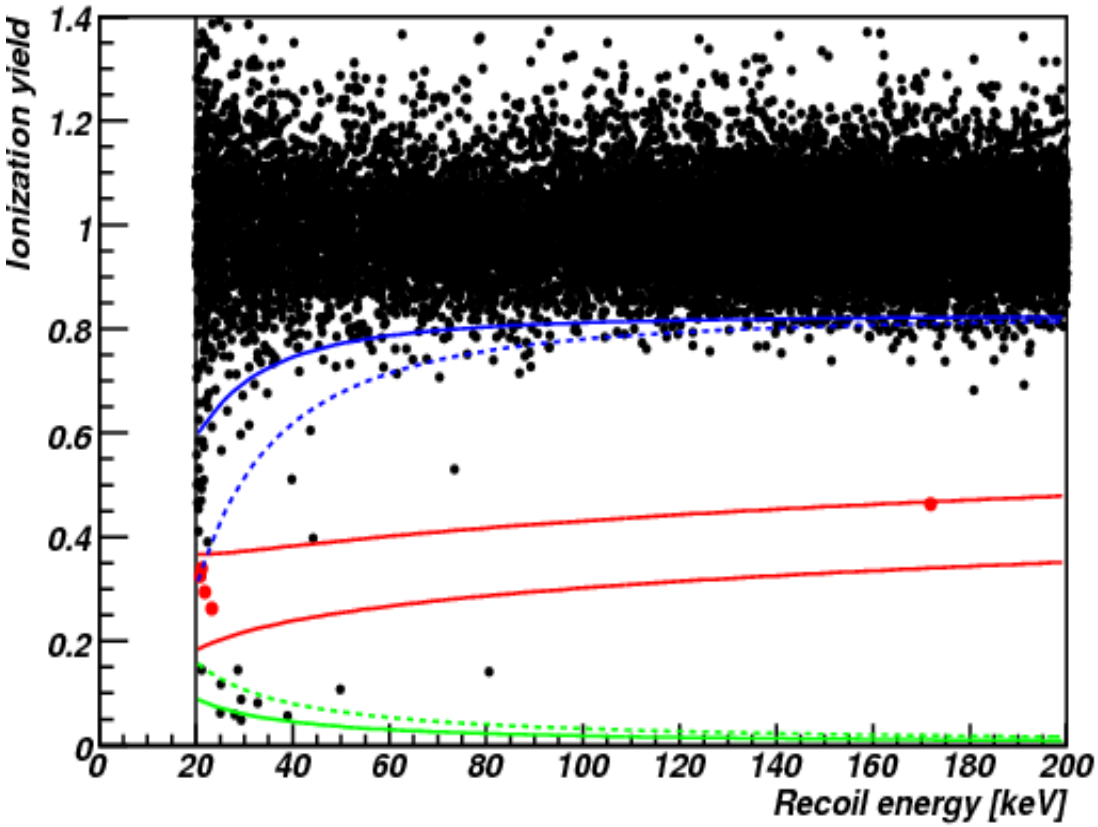
P. Di Stefano et al., ApP14 (2001) 329
O. Martineau et al., NIMA 530 (2004) 426
A. Broniatowski et al., PLB 681 (2009) 305

EDELWEISS setup



Results from EDELWEISS-II 2011 (384 kg.d)

- Edw-II: semi-blind CDM analysis for ~100GeV WIMP mass
- 13 months / 384 kg.d of exposure
- 5 events observed
  3 background events expected



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

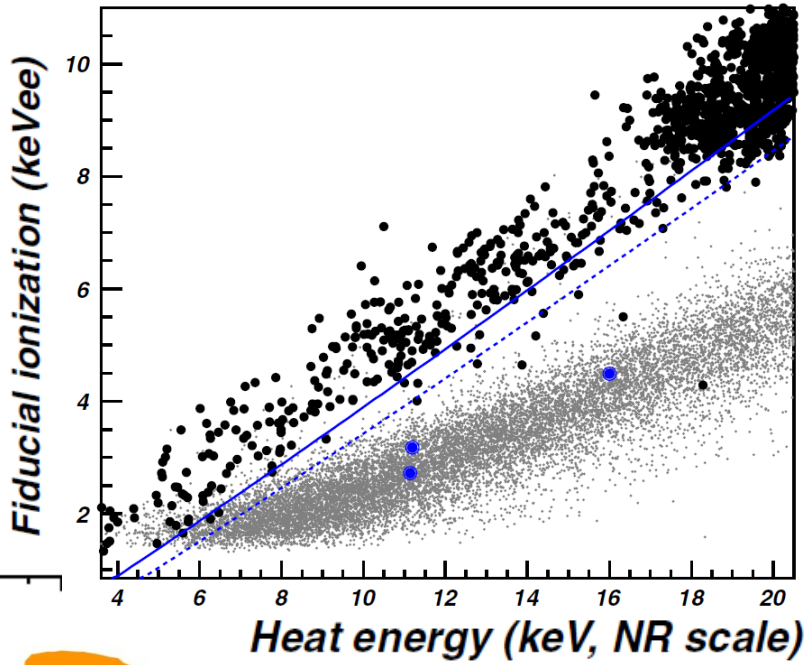
CDMS & EDELWEISS 2011:
PRD, 84(1), 1-5

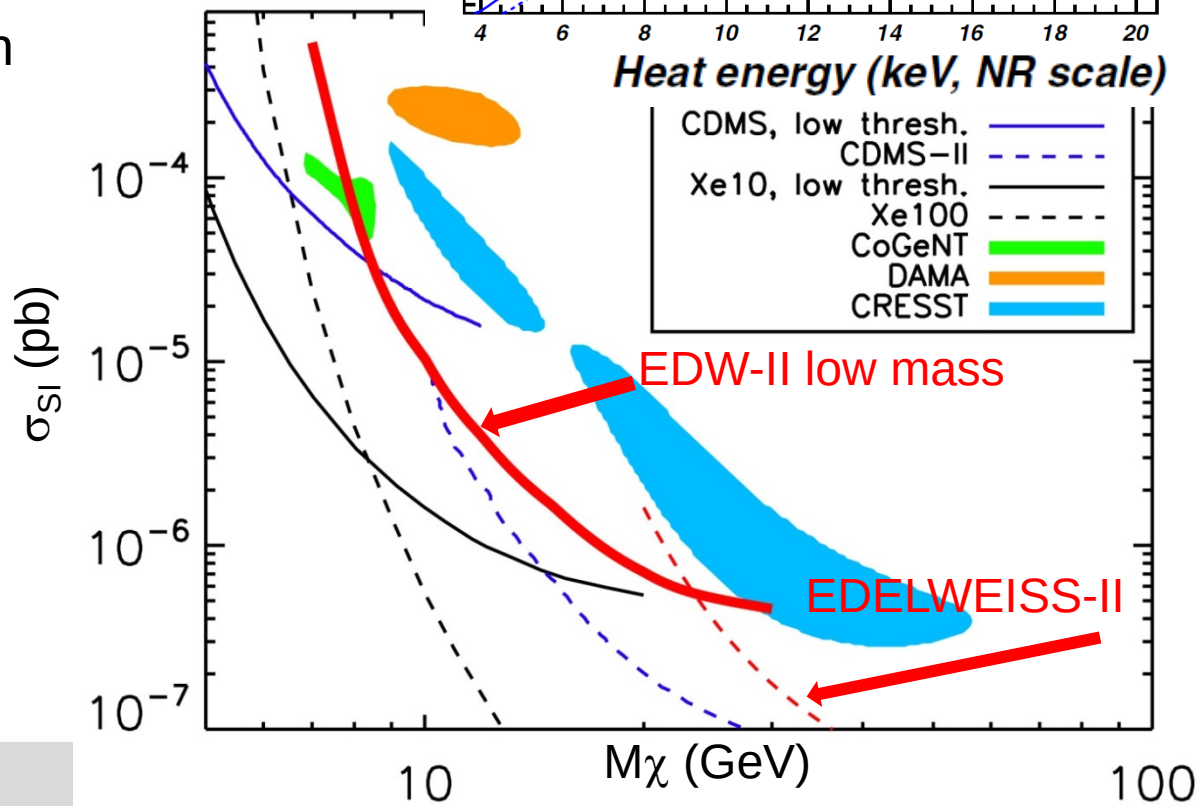
Avg ID FWHM baselines in 384 kgd sample:
0.9 keV ionization, 1.25 keV heat
(acceptable for >50 GeV WIMP search:
~100% eff. for 20 keV recoil threshold)

EDELWEISS-II
Low WIMP mass analysis

- 2009-2010 data (best ID detectors)

- 4/10 ID detectors (~113 kg.d)
- 1.4 – 1.9 keV Ionization threshold
- 95% C.L. gamma cut
- Background expect.: γ + ion. threshold + n: 2.9 evts / 1-3 observed





PRD, 86, 051701(R), (2012)

EDELWEISS-II
Low WIMP mass analysis results

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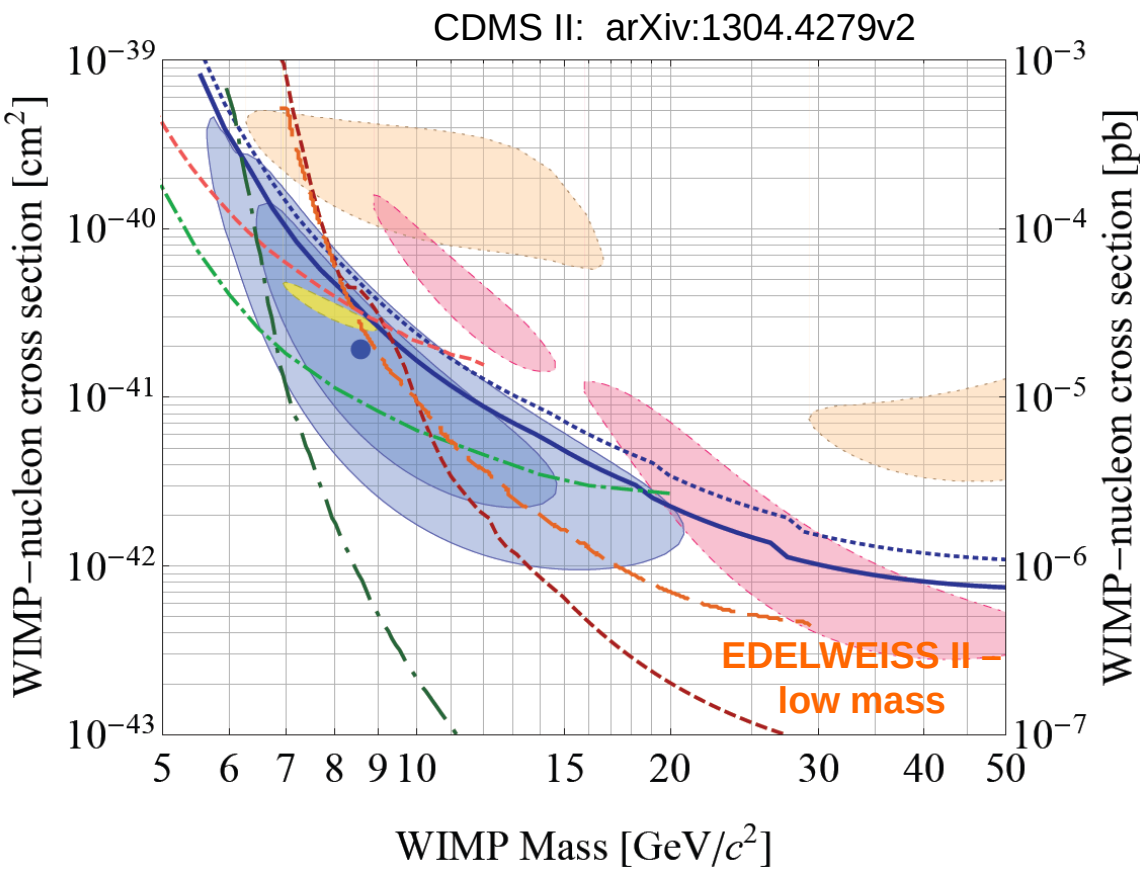
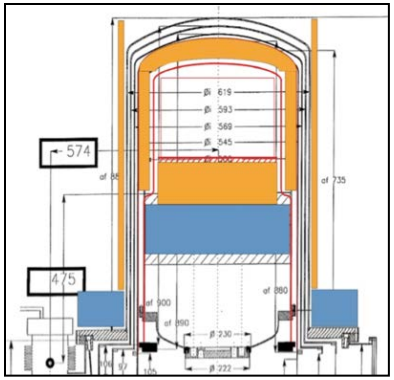
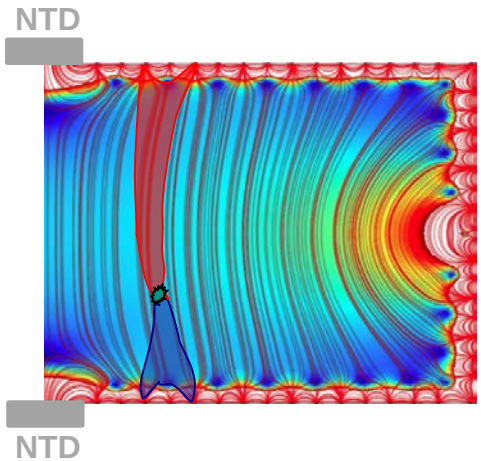


Upgrades → EDELWEISS-III

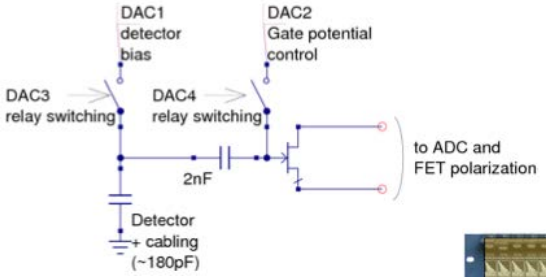
1. Suppression of background



2. Improvement of γ discrimination



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

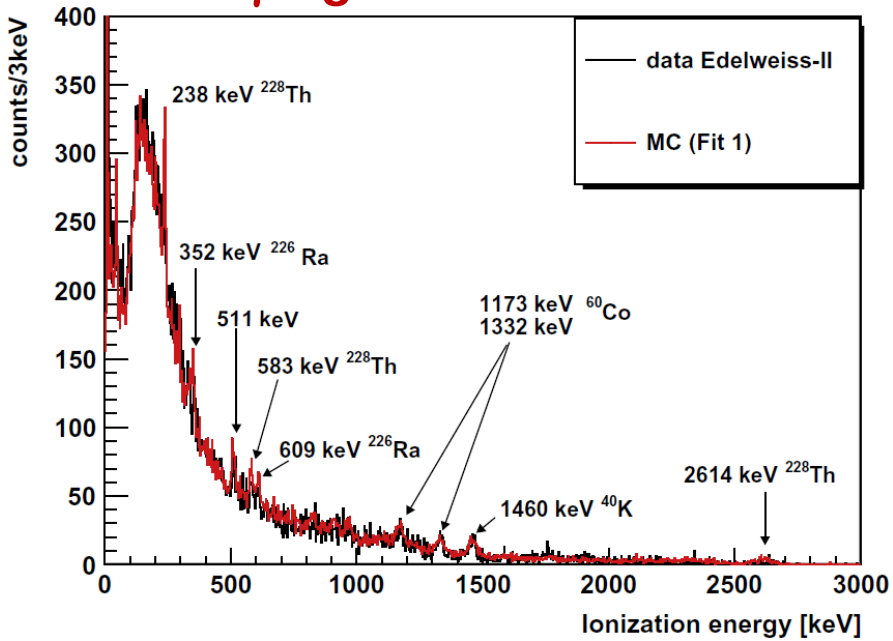


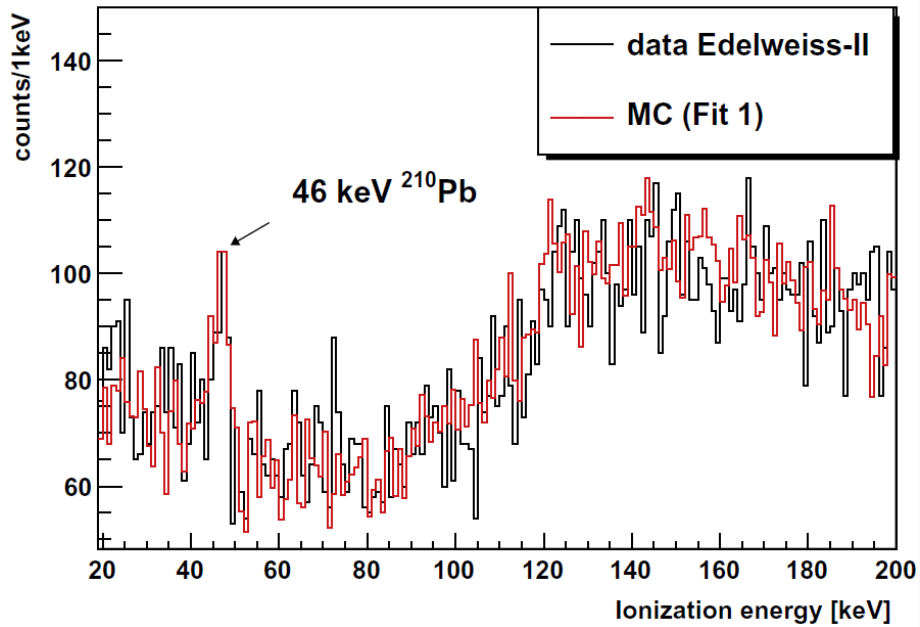
4. Enable upscaling towards 1ton-scale exp.

Upgrades towards EDELWEISS-III
1. Suppression of background

- detailed studies of remaining background

γ-bgd and ambient neutrons → arXiv:1305.3628, Astrop. Phys. **47** (2013) 1



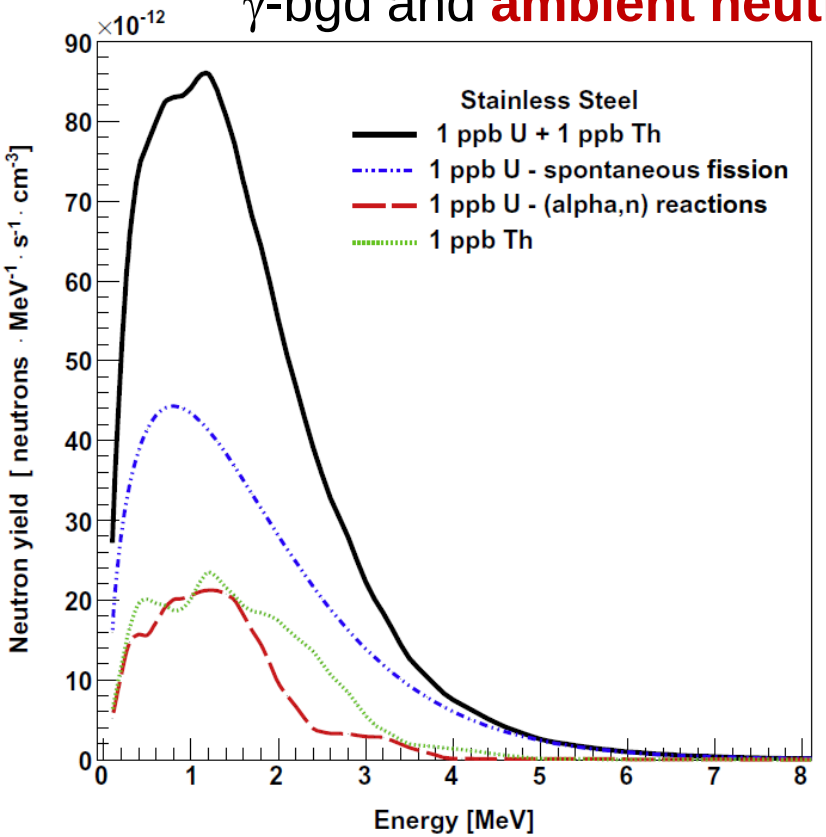


	Material	γ rate (evts/kg/day) 20–200 keV	fraction (%)
major sources only	Detector casings/CuC2 copper	14	17
	Disks, bars, 10 mK chamber/ CuC1 copper	9.5	12
	Screens 7–11/copper	**32.5**	**40**
	Pollution 300 K	22	27
	Total MC	82	
	Total data	82	

Upgrades towards EDELWEISS-III
1. Suppression of background

- detailed studies of remaining background

  γ-bgd and **ambient neutrons** → arXiv:1305.3628, Astrop. Phys. **47** (2013) 1



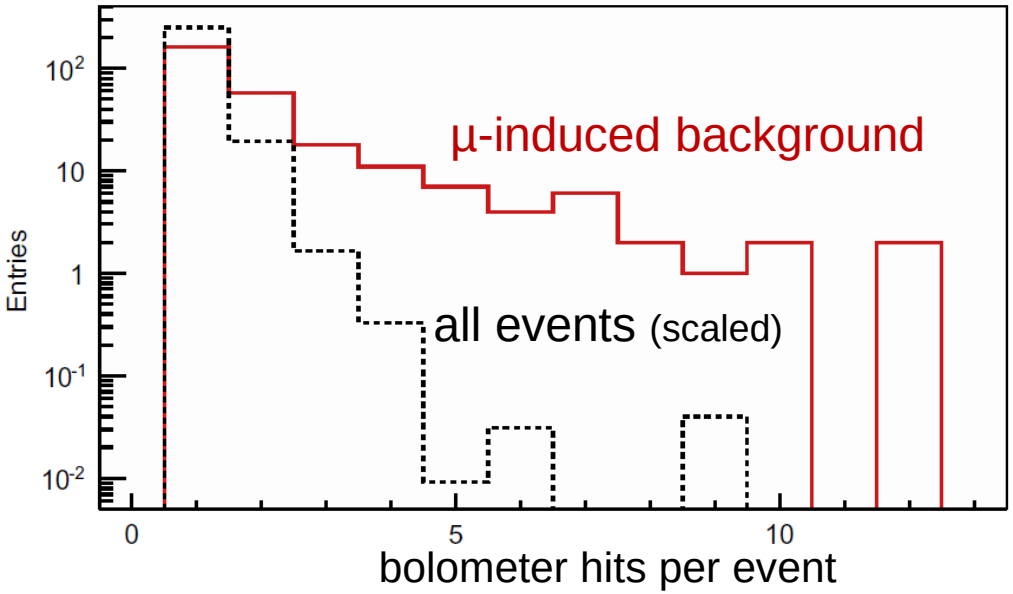
Source	Material	Neutron events
Hall walls	Rock	<0.01
Hall walls	Concrete	<0.1
Shielding	Polyethylene	<0.01
Shielding	Lead	<0.08
Support	Stainless steel	<0.01
Support	Mild steel	<0.04
Warm electronics	PCB	1.0 ± 0.5
1 K connectors	Aluminium	0.5 ± 0.2
Thermal screens, crystal supports	Copper	<0.1
Coaxial cables	PTFE	<0.5
Crystal holders	PTFE	<0.01
Electrodes	Aluminium	<0.01
Total		<3.1

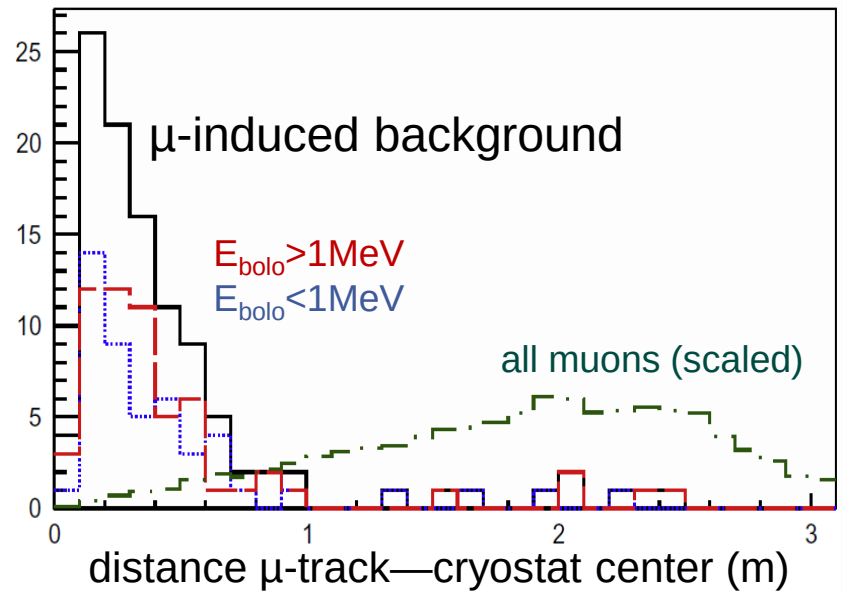
G4 neutron signatures/rates cross-checked via calibrations with AmBe sources inside(20n/s) & outside($2x10^5$n/s) passive shielding

Upgrades towards EDELWEISS-III
1. Suppression of background

- detailed studies of remaining background

μ-induced neutrons → arXiv:1302.7112, Astrop. Phys. **44** (2013) 28





$$\Gamma^{\mu-n} = (0.008^{+0.005}_{-0.004})\ \mathrm{evts}/(\mathrm{kg\ d})$$ before μ-veto cut

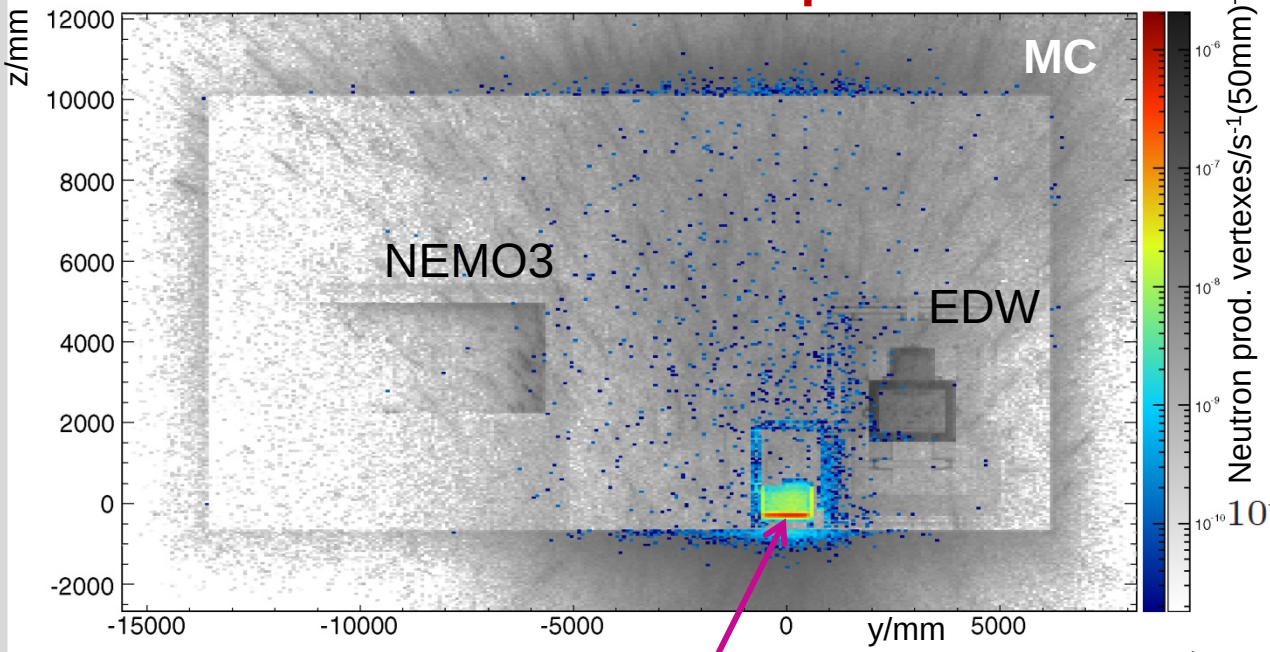
EDW-II: after μ-veto cut: $N^{\mu\text{-}n} < 0.72$ evts (90%CL)

EDW-III: after μ-veto cut: $N^{\mu\text{-}n} = 0.6^{+0.7}_{-0.6}$ evts (90%CL, 3000kg.d)

(not yet included: multiplicity enhancement, addtl. modules)

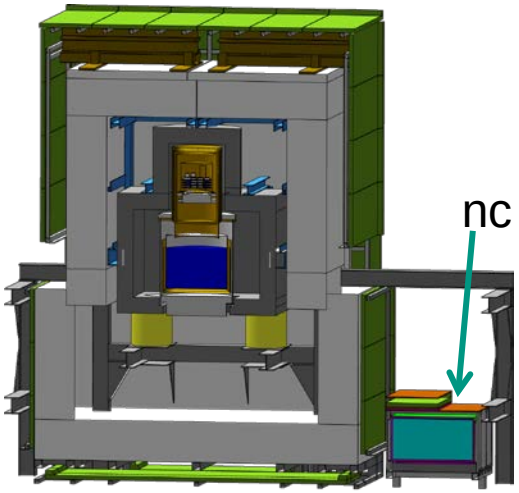
Upgrades towards EDELWEISS-III
1. Suppression of background

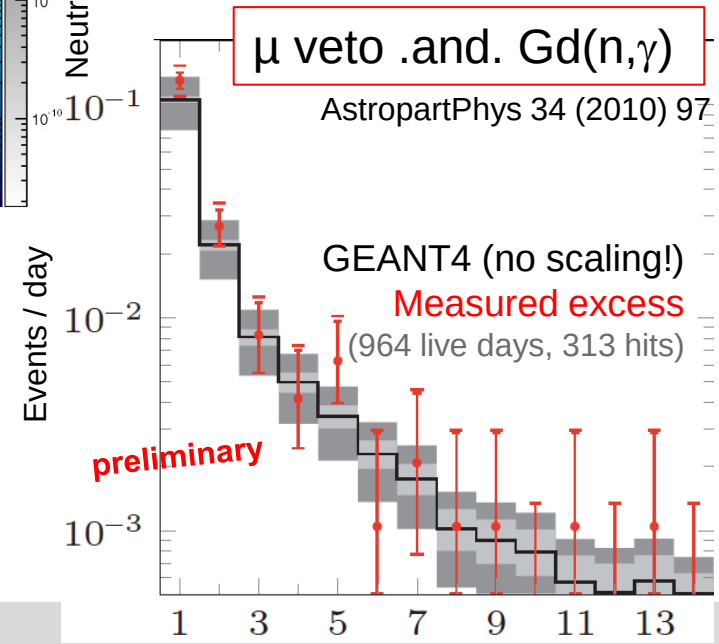
- Dedicated measurement of **μ-induced neutrons**



grey:
production vertices of
>4x10^5 μ-ind.neutrons
color:
prod. vertices of
detected n´s via Gd(n,γ)

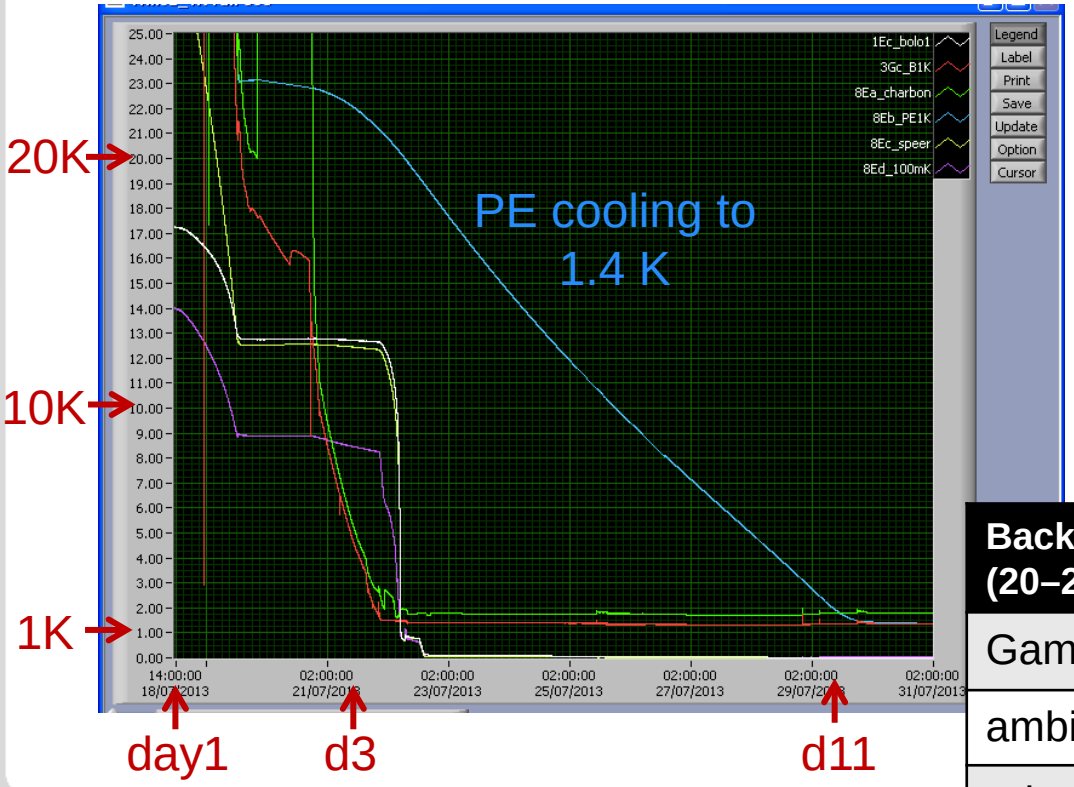
neutron
counter

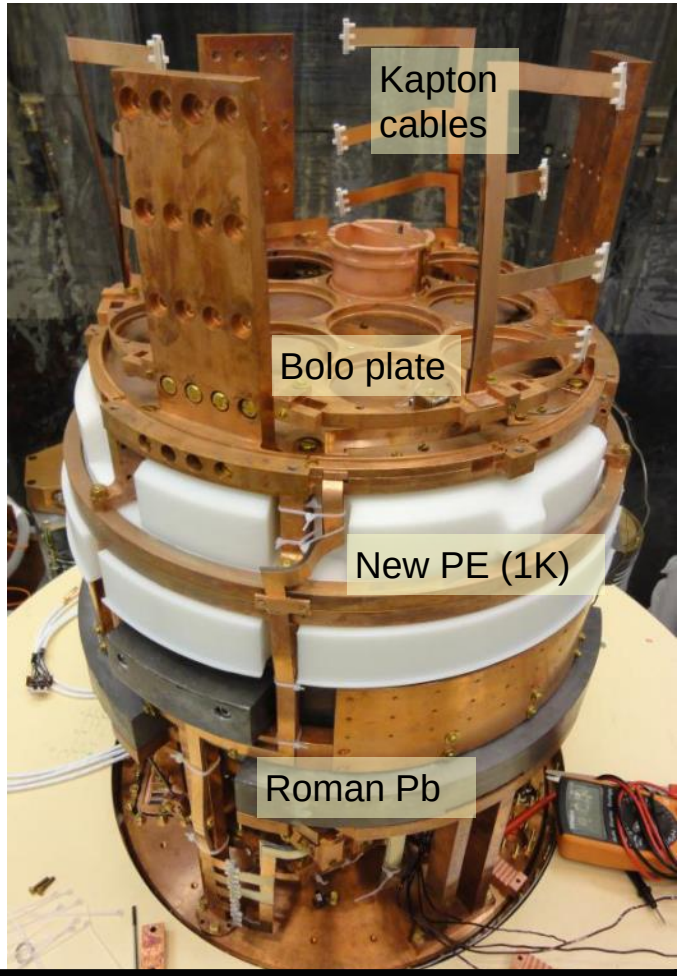




Upgrades towards EDELWEISS-III
1. actions against background

- additional cold PE shield
- new Kapton cabling
- better radiopure connectors
- redesign of NOSV copper shields

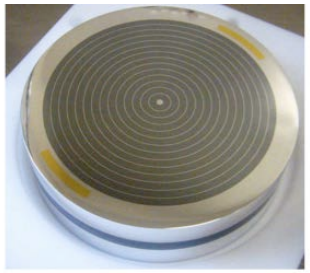


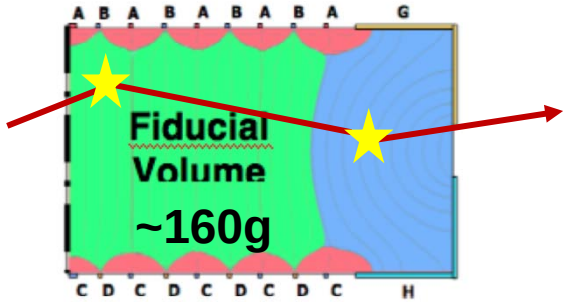


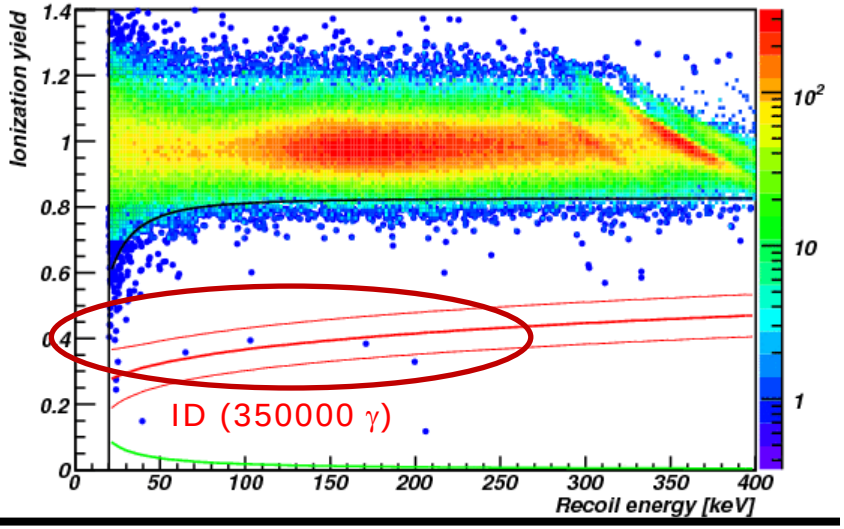
Background (20–200 keV)	EDW-2 (evt / kg.d)	EDW-3 (evt / kg.d)
Gamma rate	82	14 – 44
ambient n´s	$< 8.1 \cdot 10^{-3}$	$(0.8 – 1.9) \cdot 10^{-4}$
μ-induced n´s	$< 2 \cdot 10^{-3}$	$< 2 \cdot 10^{-4}$

2. Improvement of γ discrimination

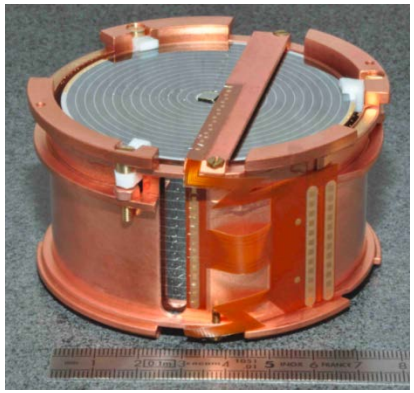
EDELWEISS-II
ID 400g with 10x **160g** fiducial mass

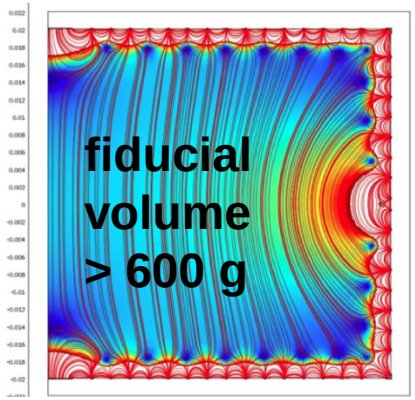


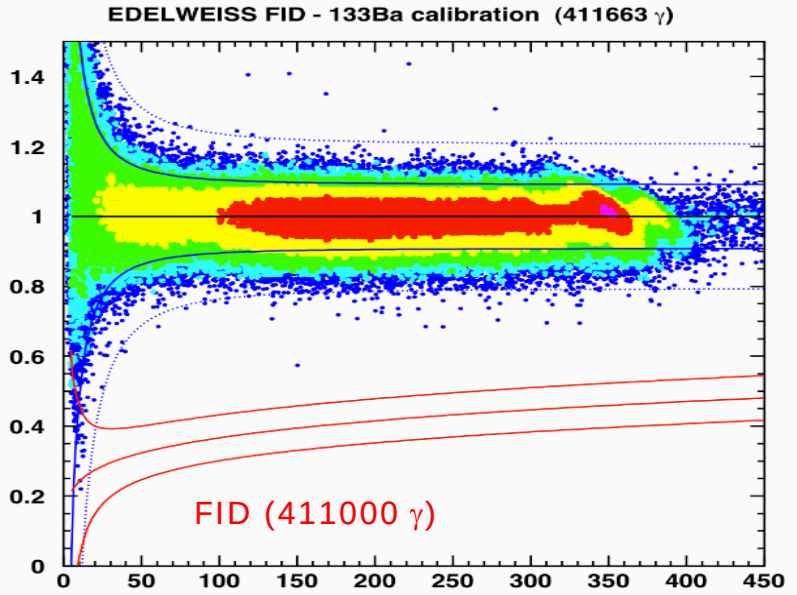




EDELWEISS-III
FID 800g with 40x ~**600g** fiducial mass





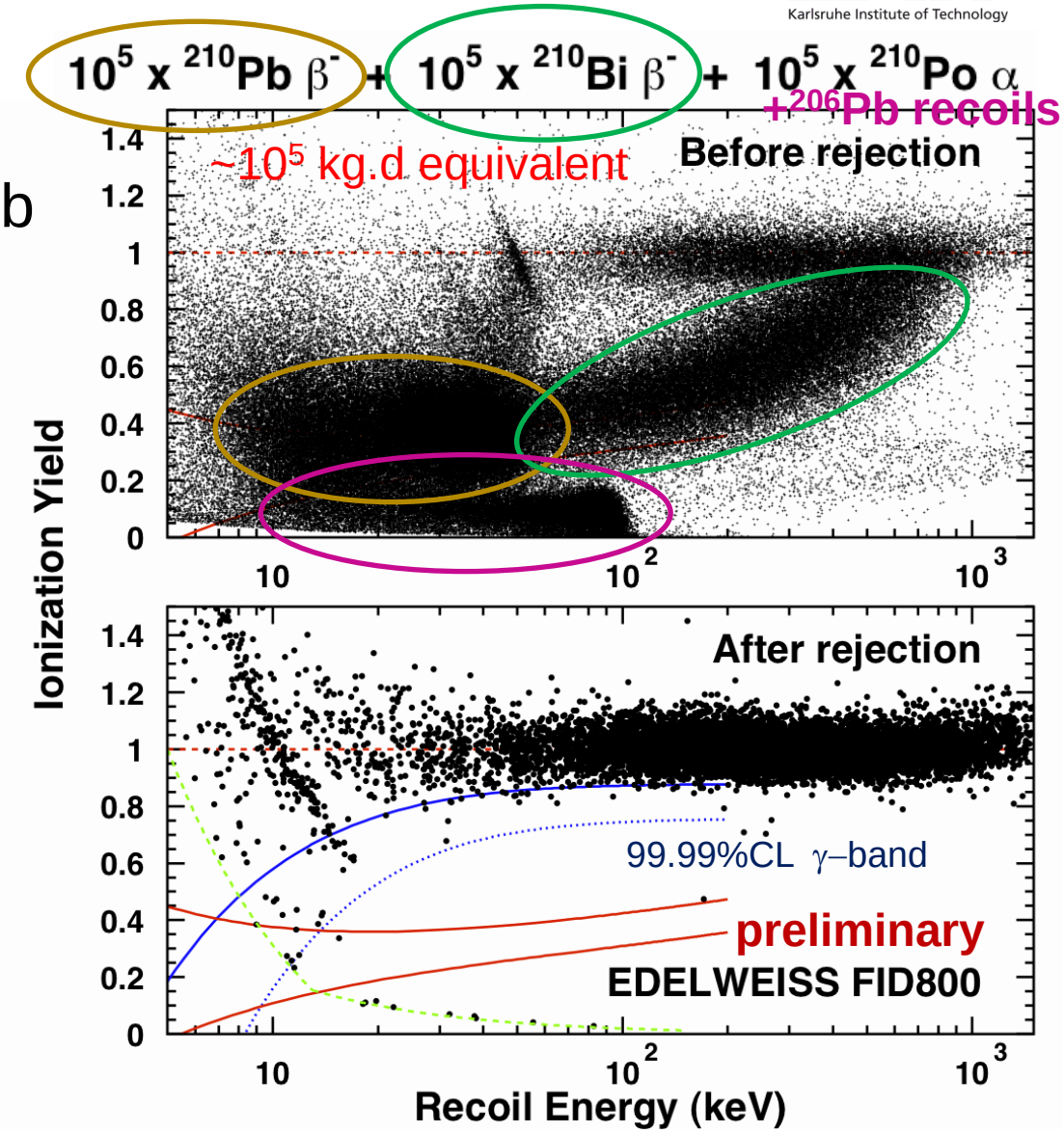


3. Surface rejection measurements – improved discrimination

- measurement with ^{210}Pb β-source

- surface rejection:
  < 4 x 10^{-5} misidentified events per kg.d (E_{rec}>15 keV)

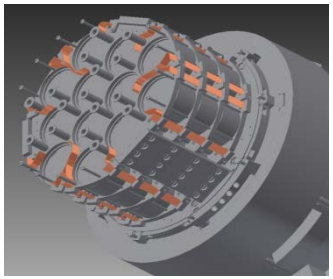
better than previous EDELWEISS detectors
(< 6 x 10^{-5} misidentified events per kg.d, E_{rec}>20 keV)

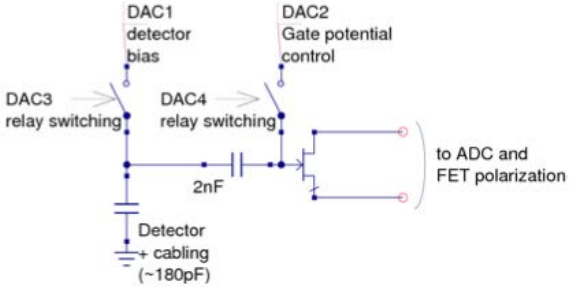


3./4. Improvement on resolutions and thresholds

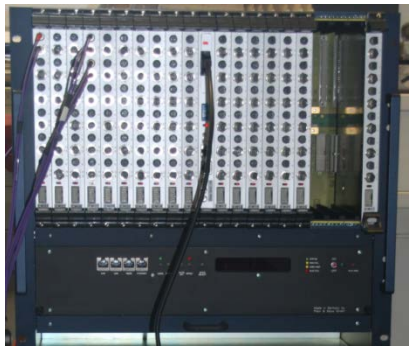
- resolution improvement aimed at > 30%

  yields sensitivity < 5 keV, full sensitivity at ~10 keV

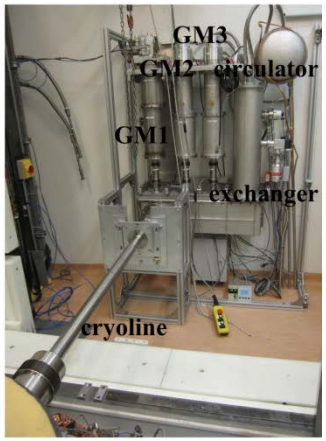




- new cables, electronics and integrated DAQ system

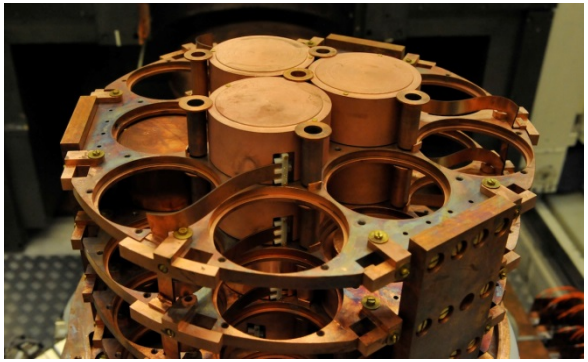


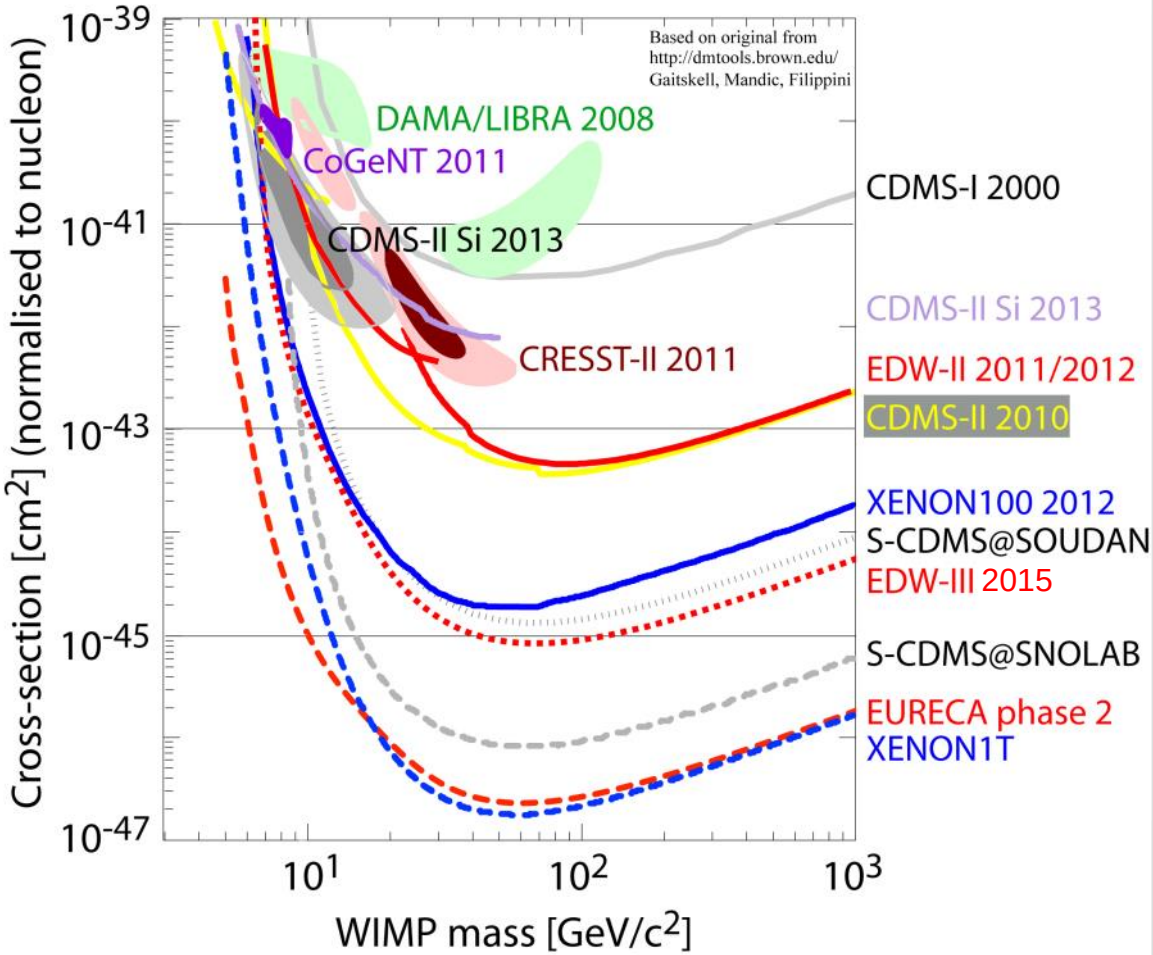
- improved cryogenics system:
  - Remove pulse tubes close to cryostat to reduce noise due to microphonics
  - Replaced by thermal machines outside the Pb & PE shieldings
  - Cold distributed to thermal shields using cryogenic fluids (cryoline)



Timeline/Projection EDELWEISS-III

- Sept. 2013 (now)
  - **EDELWEISS-III commissioning runs**
  - upgraded cryogenics
  - 15 FID 800g detectors
  - upgraded readout electr + Kapton cables
  - inner PE shield + new Cu screens





- end of 2013
  - fully equipped cryostat with 40 FID 800g detectors

Conclusions & outlook

- EDW-I → EDW-II factor 20 improvement
- EDW-II: 10 ID Ge bolometers m_{det} = 400g; m_{fid} = 160g ➔ 1.6kg_{fid}
  - 20-200keV: 5 evts, <5.1 bgd (dominated by ambient n´s)
  - 5- 20keV: 1-3 evts, <3 bgd (1.7 n´s + 1.2 γ´s)
- EDW-III: 40 FID Ge bolometers m_{det} = 800g; m_{fid} = 600g ➔ 24kg_{fid}
  - upgrade of inner cryostat, new internal shield
  - upgrade of cabling and electronics
  - reduction of bgd (gammas: 2-6; neutrons >10)
- EDW-III 3000kgd_{fid} exposure in 6 months (no bgd expected)
- EDW-III detector technology ready for 1-ton cryogenic array