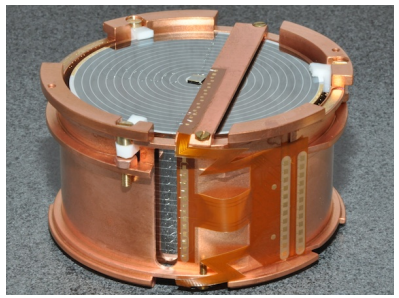
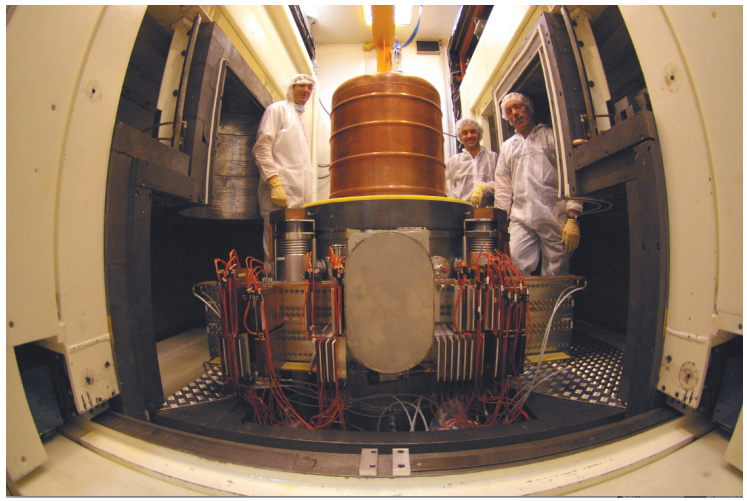
EDELWEISS status and detector performance





ID and FID cryogenic Ge detectors

FID800 surface event rejection

Low-mass and Axion Searches

EDELWEISS-III status

Jules Gascon, IPNLyon
Université Lyon 1 / CNRS

EDELWEISS collaboration

CNRS/IN2P3

CNRS/IN2P3

CNRS/INP

CNRS

CEA/IRFU

CEA/IRAMIS

IKP
EKP
IPE
Karlsruher Institut für Technologie

JINR DUBNA

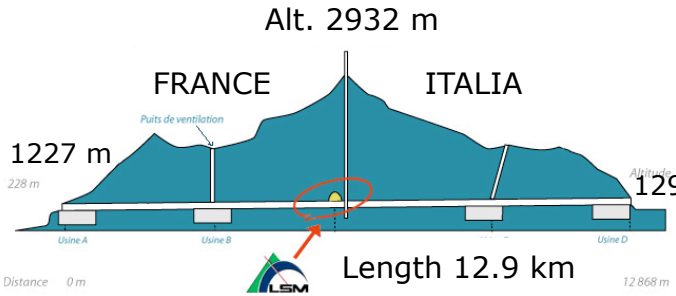
Univ. OXFORD

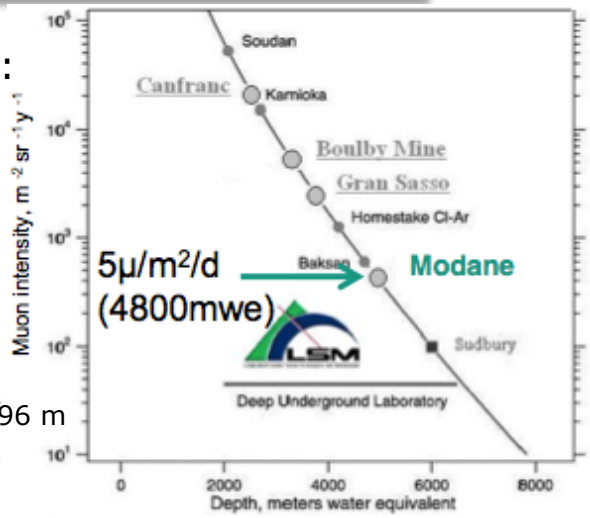
Univ. SHEFFIELD

- Direct Dark Matter search with (simple+robust) cryogenic heat-and-ionization detectors

Karlsruhe, March 2013

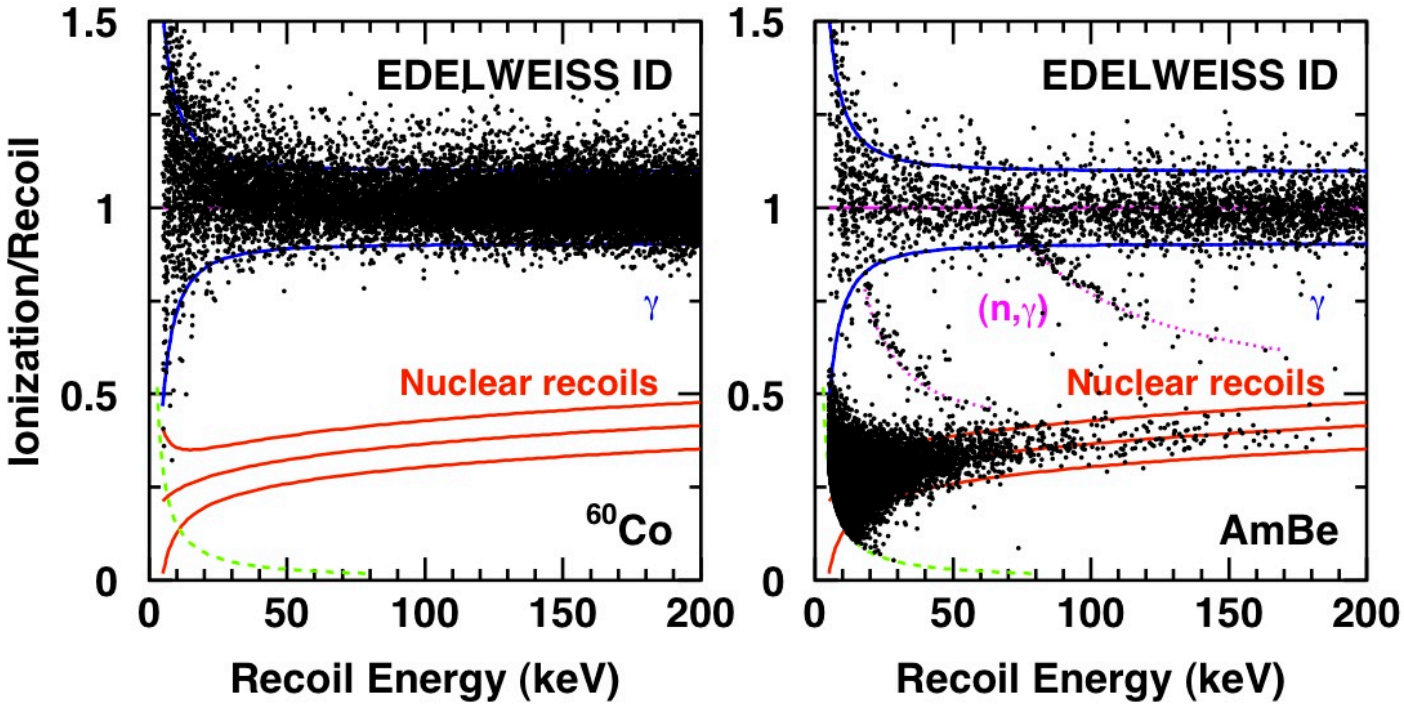
- Low-radioactivity environment: LSM underground laboratory, Modane (Fréjus tunnel)





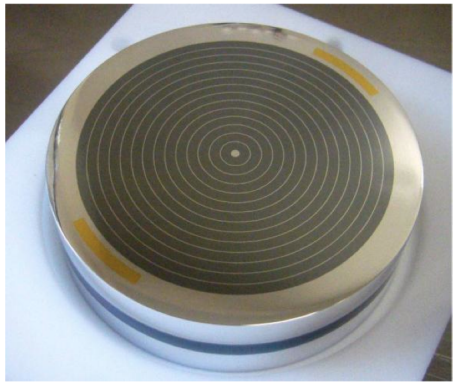
Nuclear recoil discrimination

- Heat: GeNTD thermistor (~15mm^3): R ~MΩ at T= 18 mK, ΔT ~1 μK/keV. Fully thermalized: position-independent signal.
- Ionization: evaporated Al electrodes, polarized at a few V/cm
- Ionization yield for nuclear recoils is ~1/3 of value for e^- recoils
- Limitation: poor charge collection for events <<1mm from surface



Interleaved electrode detector (ID)

- Concentric ring electrodes with alternating potentials
- Surface events (red regions) identified by charge collected on rings at low potential ("veto" electrodes)
- Additional advantage: "veto" electrode act as field shaper for grid effect on "fiducial" electrodes (high field close to surface), helping charge collection
  [Broniatowski, PLB681 (2009) 305]
- Measured surf. rejection: $<6\times10^{-5}$ per incident particle (>20 keV)
- 384 kgd exposure in 2009-2010, $\sigma<5\times10^{-8}$ pb ($M_{WIMP}=100GeV$)

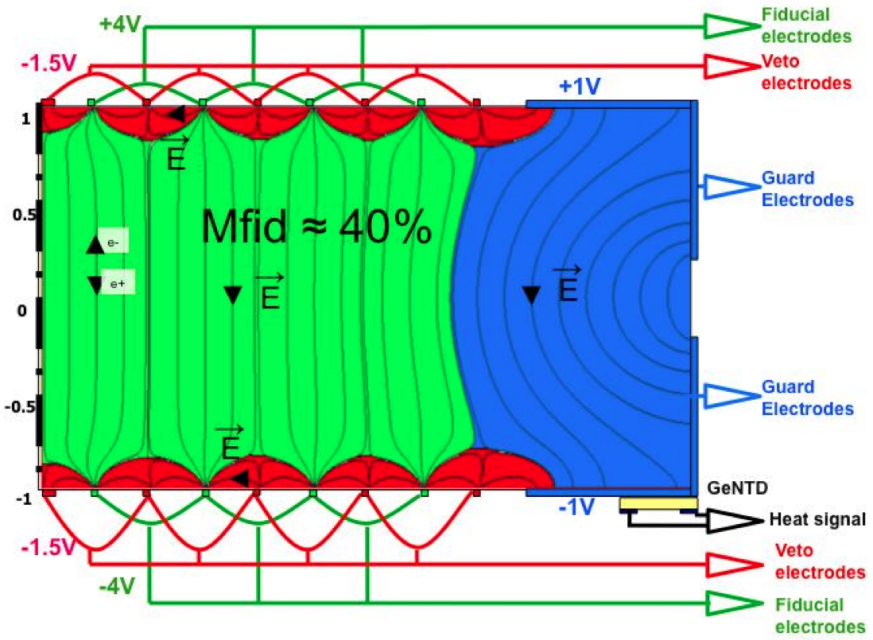


400g cylindrical ID detector

EDELWEISS-II:

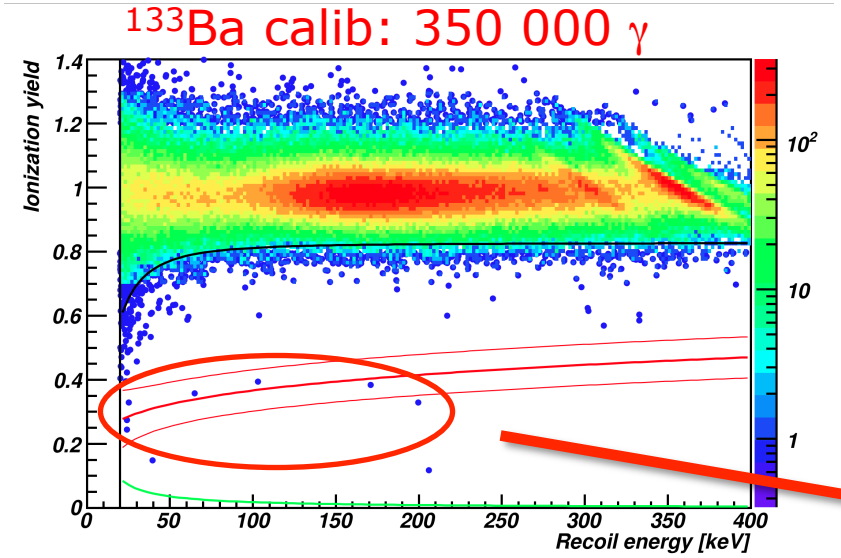
10x400g ID,
1.6 kg tot. fiducial

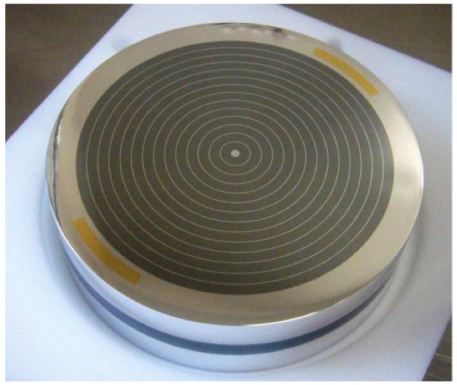
384 kgd collected
(2009-2010)



Interleaved electrode detector (ID)

- Problem: large non-fiducial volume (blue) with low field under flat guard electrodes





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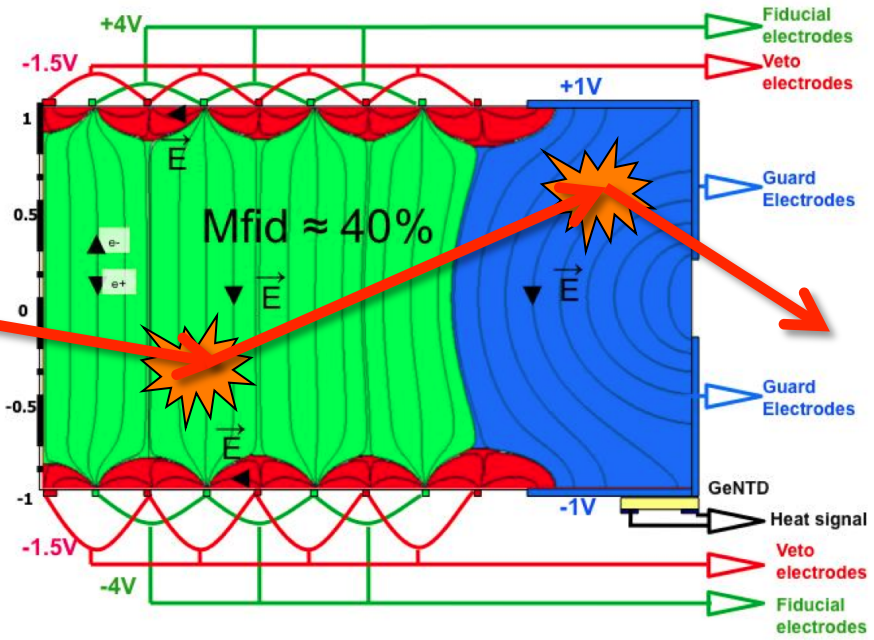
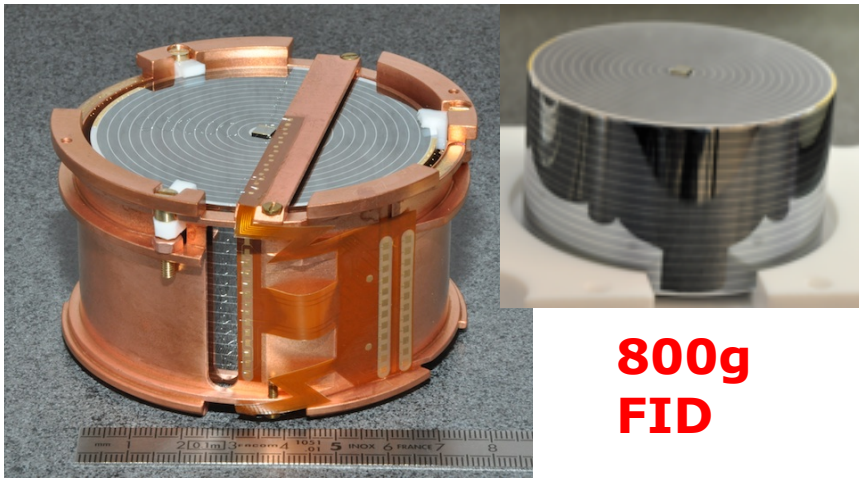
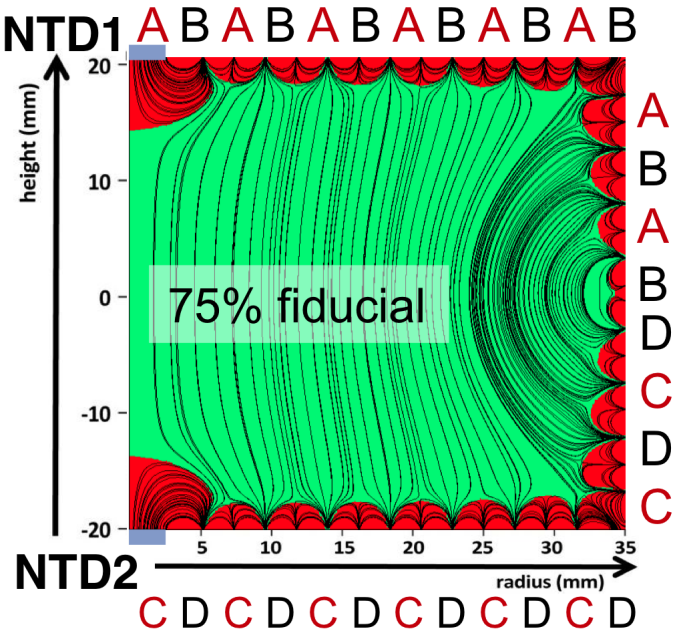


Full ID detector (FID)

- ID electrode scheme over entire surface: fid. volume fraction x2
- Makes possible an increase in total volume (400g->800 g)
- *600g fiducial volume/detector*
- Read out of 4 electrodes (fiducial A+C and veto B+D
- Fiducial selection: B=0, D=0 and redundancy: A=C
- Redundancy in heat read out: two GeNTD per detector (~√2 improved baseline reso.)
- Full exploitation of veto signals: see Q. Arnaud poster Friday 111



800g FID



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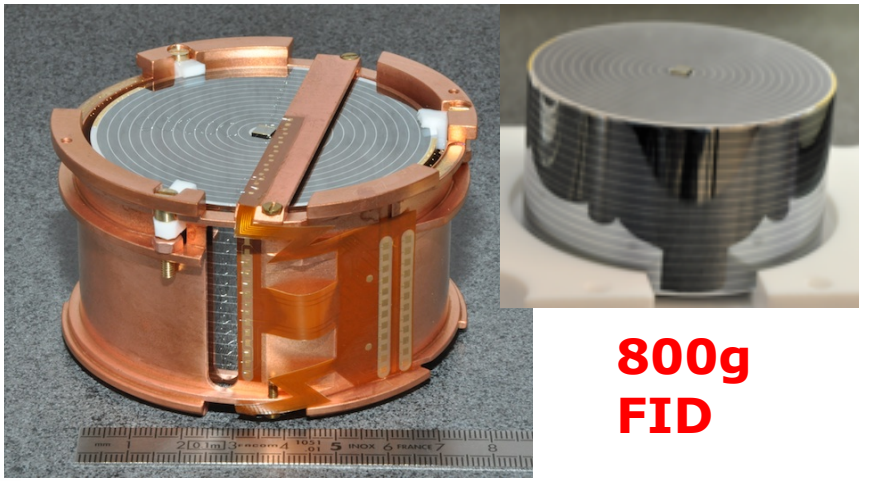
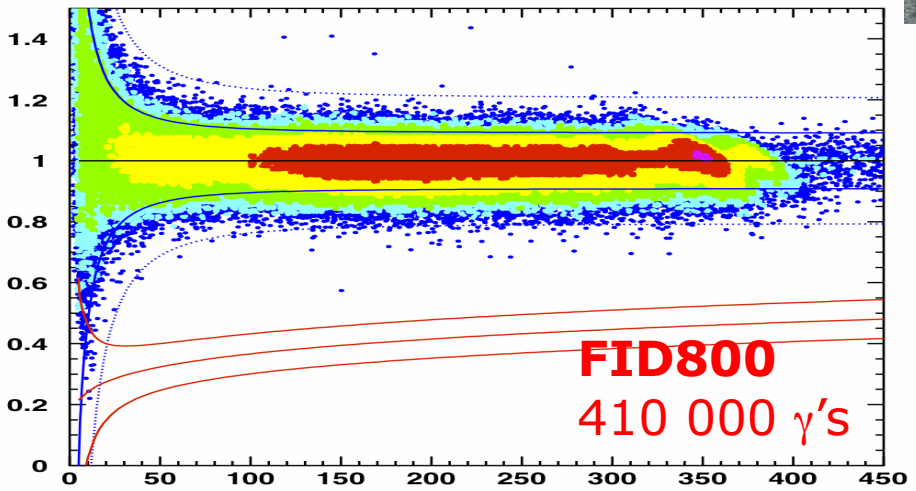
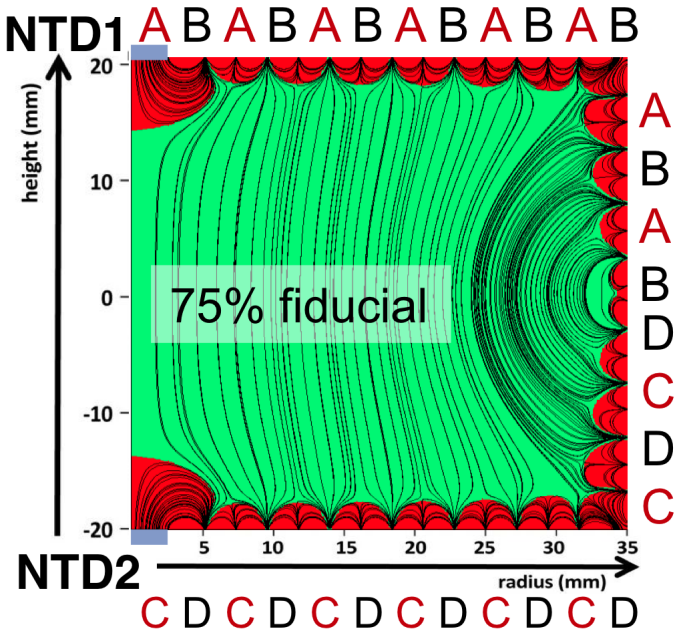


800g FID

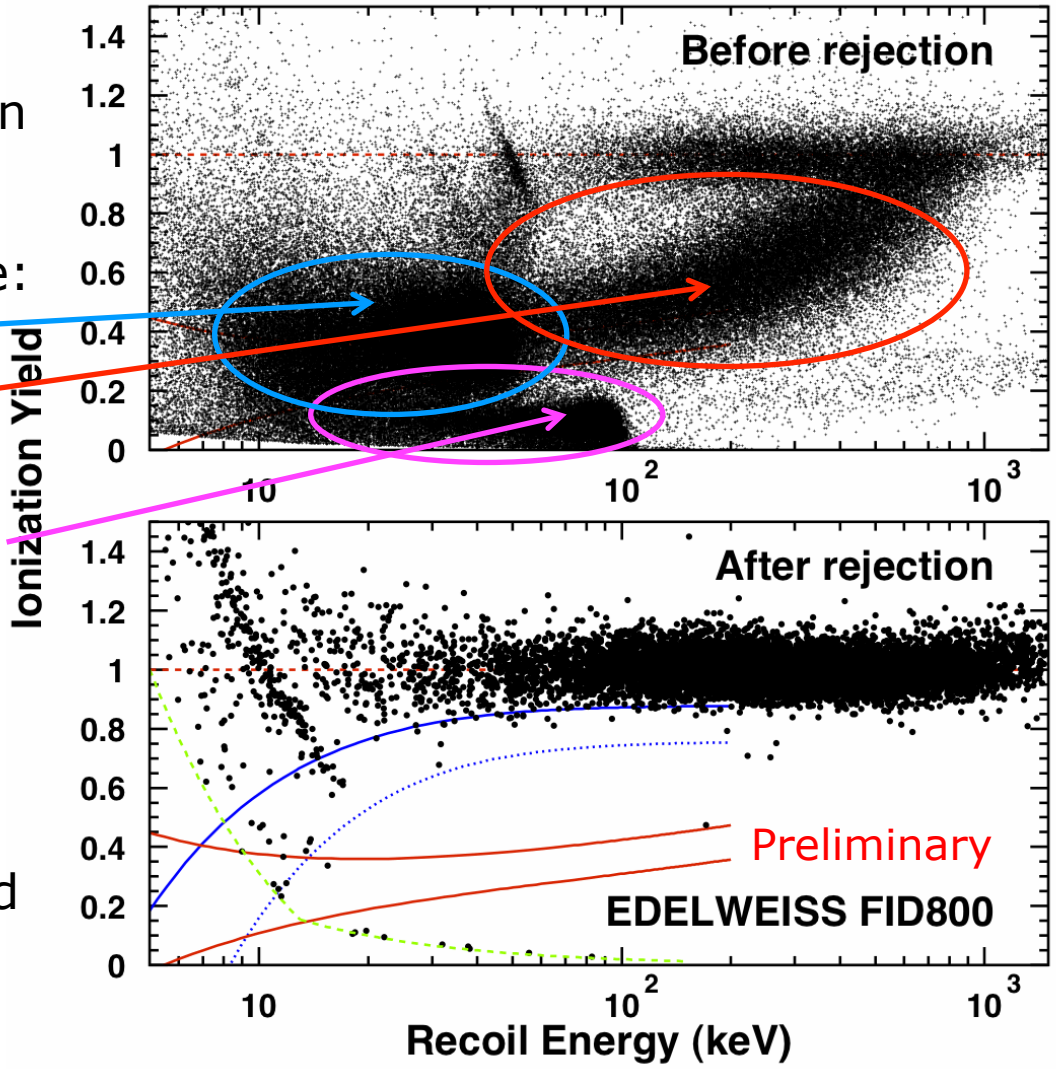




- *Improved gamma rejection* (including Compton scatter)

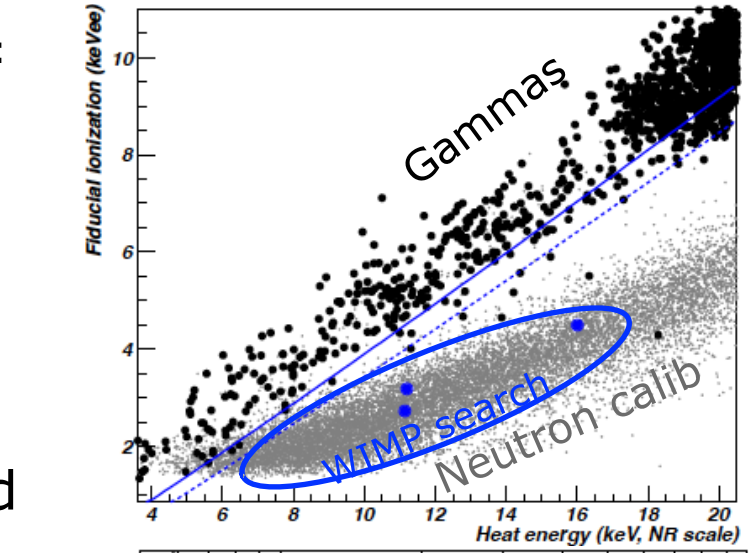
FID detector surface rejection

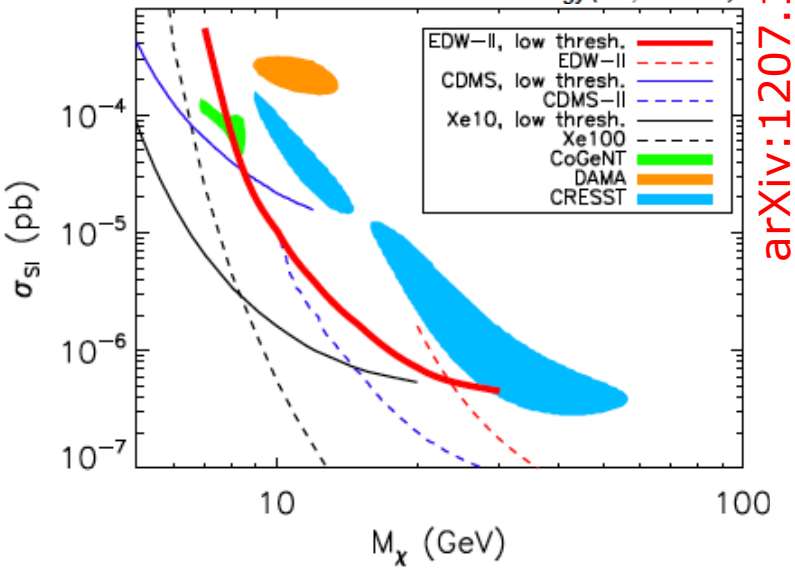
- New: first measurement of surface event rejection with 2xFID800 detector
- Exposure to ^{210}Pb source:
  10^5 x ^{210}Pb β^- +
  10^5 x ^{210}Bi β^- +
  10^5 x ^{210}Po α decay
  (+ 10^5 x ^{206}Pb 100 keV recoils)
- ~10^5 kgd equivalent
- Rejection above 15 keV in NR band <4x10^{-5}
- Better than 200g ID, and over entire surface



Going to lower mass / lower energy

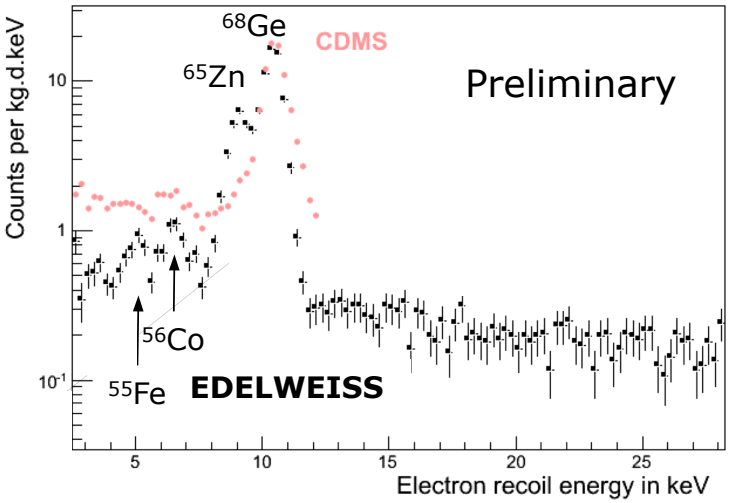
- Avg ID FWHM baselines in 384 kgd sample: 0.9 keV ionization, 1.25 keV heat (acceptable for >50 GeV WIMP search: ~100% eff. for 20 keV recoil threshold)
- Need improvement for ~10 GeV WIMPs
- Low-mass search with 113 kgd with best resolutions [PRD 86 (2012) 051701(R)]
- Fiducial selection applicable down to ~6 keV recoils: Surface event rejections
- Best Ge sensitivity at ~9 GeV





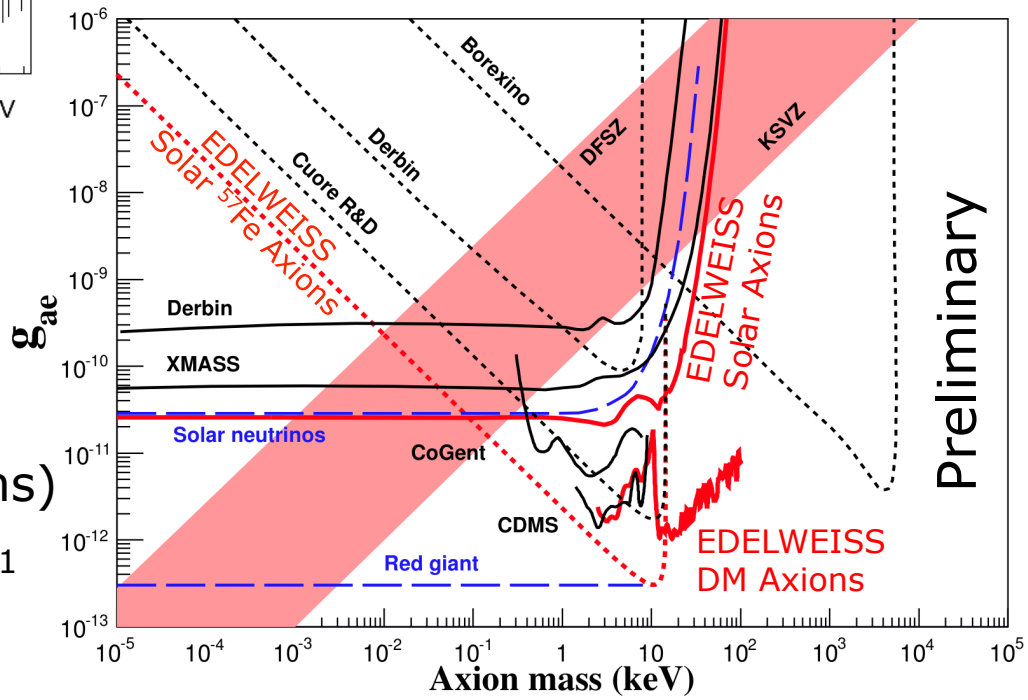
arXiv:1207.1815v1

Axion search



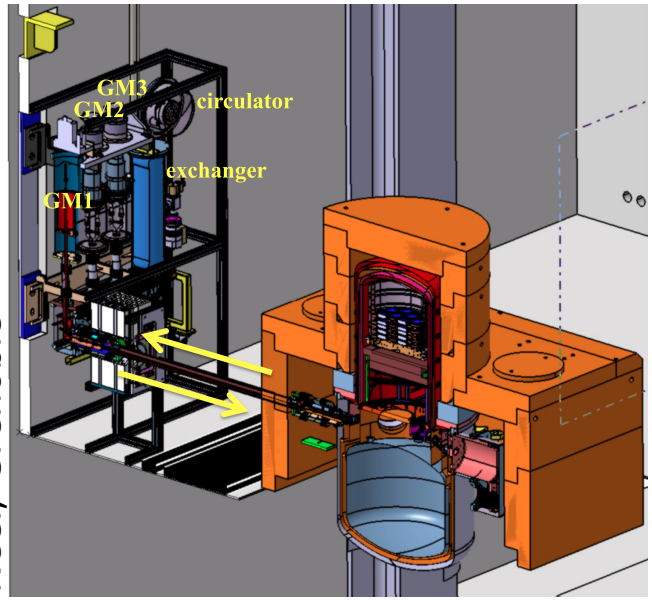
- Low-threshold sample also used for axion search
- Fiducial selection helps reduce background at low energy

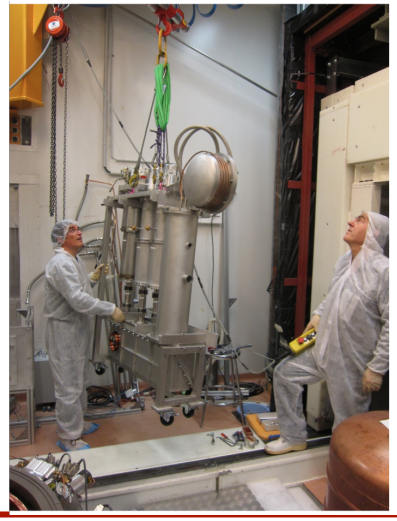
- Competitive axion limits (via Primakoff or axio-electric detection, solar & dark matter axions)
  also: $g_{A\gamma} < 2.1 \times 10^{-9}$ GeV^{-1}

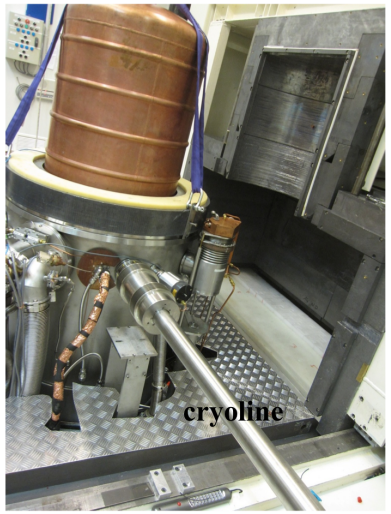


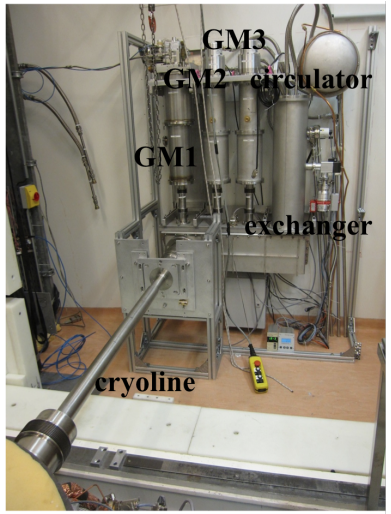
Cryogenics for EDELWEISS-III

- Remove pulse tubes close to cryostat to reduce noise due to microphonics
- Replaced by thermal machines outside the lead and polyethylene shieldings
- Cold distributed to thermal shields using cryogenic fluids (cryoline)



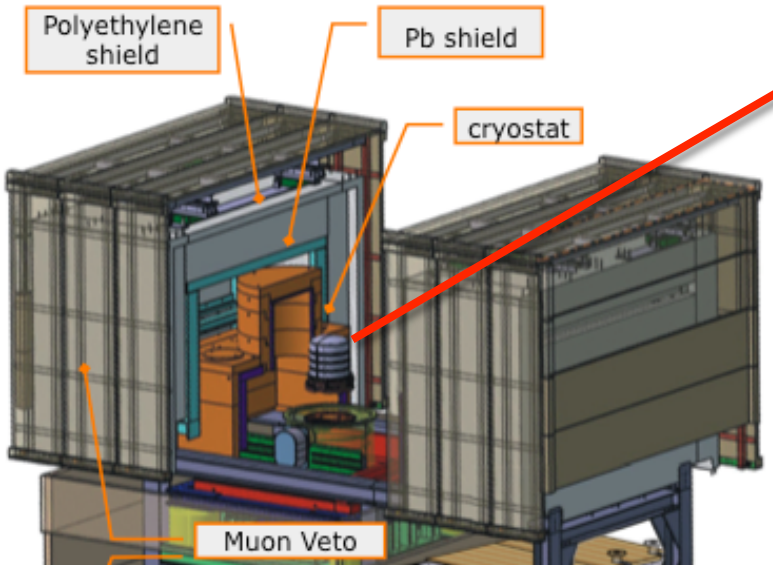


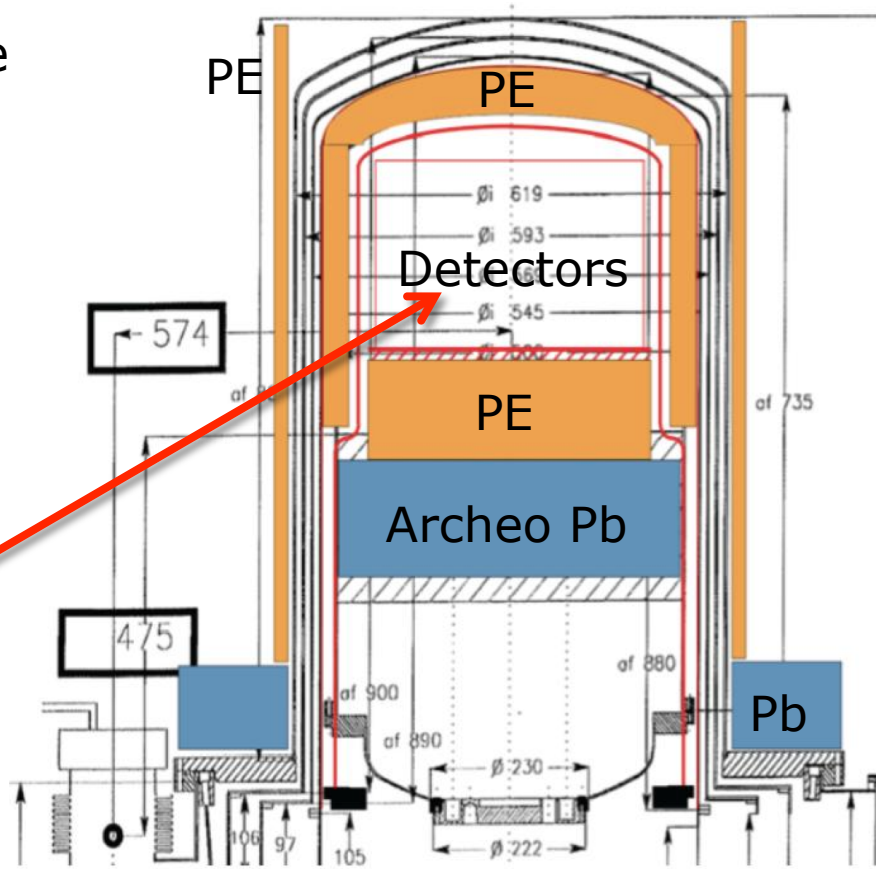




Shielding for EDELWEISS-III

- EDELWEISS-II background limited by neutrons from inside the PolyEthylene shield
  [AstroPart 47 (2013) 1]
- Adding internal PE shield + improved material selection
- Poster Friday 202 (XF Navick)





EDELWEISS-III Status

32 kg Ge array (24 kg fid.) with 40 x FID800

Largest mass of heat-and-ionization Ge detectors

Facility able to acquire 3000 kgd per semester

Improved background (shielding): <1 bkg event for exposure between 4500 kgd (sensitivity 2.5x10^{-9} pb) and 12000 kgd (10^{-9} pb)

Upgrade of **cabling**, **electronics** and **cryogenics**

Achieved in 2012

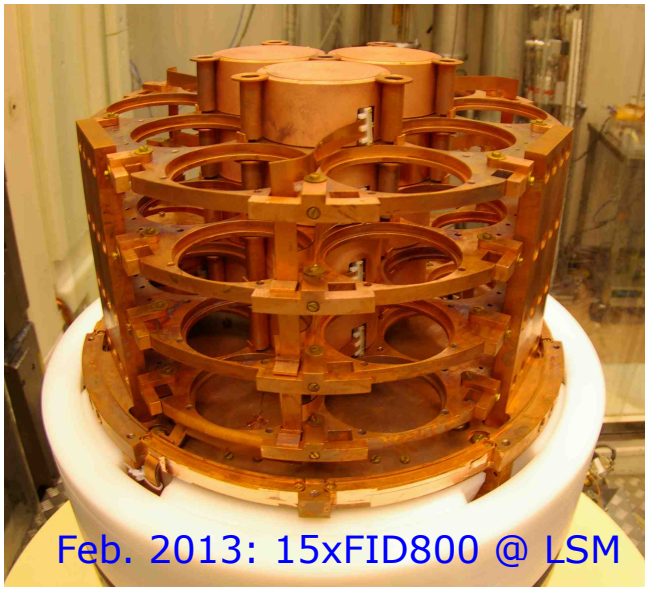
- Ionization and heat resolution improved by >30%
  - ~650 eV FWHM on ionization, <1 keV on heat
  - Full effic. ~10 keV, significant sensitivity below 5 keV
- Found simple & robust solution to control & correct surface current leaks (measured online to <1 fA)

Spring 2013

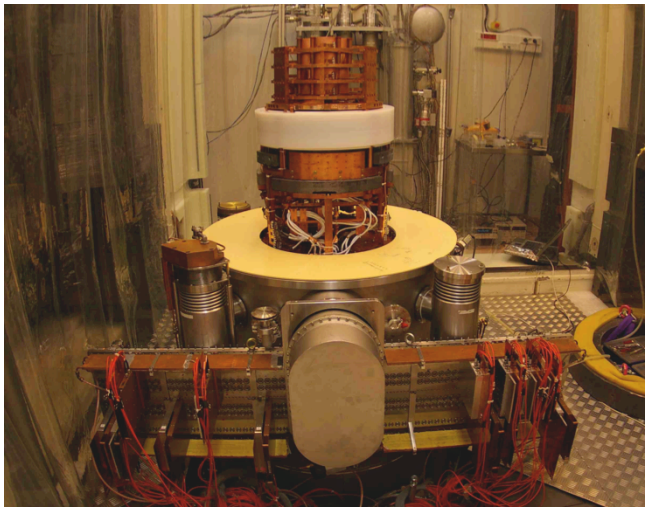
- First commissioning runs with 15 FID800 (12 kg)

End of 2013

- Installation of 40 FID800 (32 kg Ge)



Feb. 2013: 15xFID800 @ LSM



Conclusion

- FID detectors have the γ and surface rejection needed for $\sim 10^{-9}$ pb sensitivity to WIMPs

- Detector production is progressing well (15/40 up to now) and should be completed for deployment end of 2013 of 32 kg (24 kg fid.)
- Physics data taking in 2014-2015