EDELWEISS : Dark Matter search from phase 2 to phase 3.

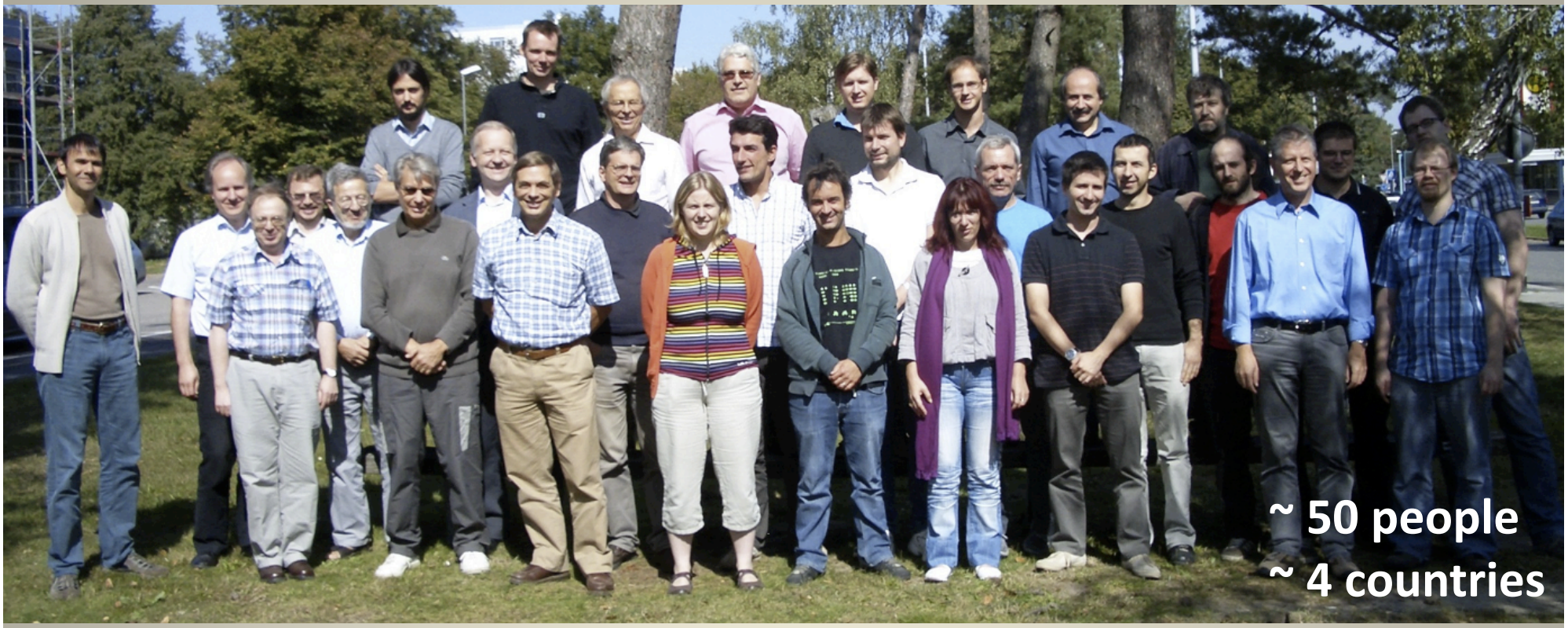
24ème Rencontres de Blois

30th May 2012

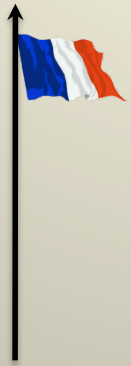
Antoine Cazes

Université Claude Bernard Lyon 1

The EDELWEISS Collaboration

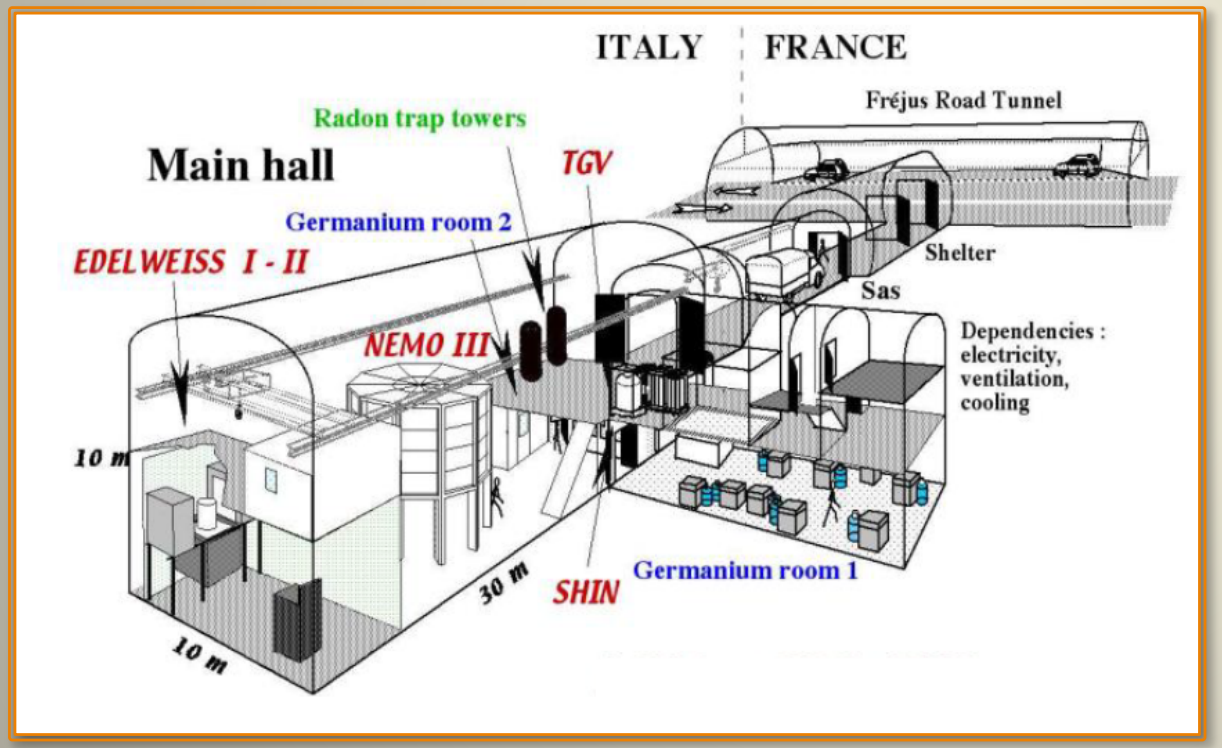


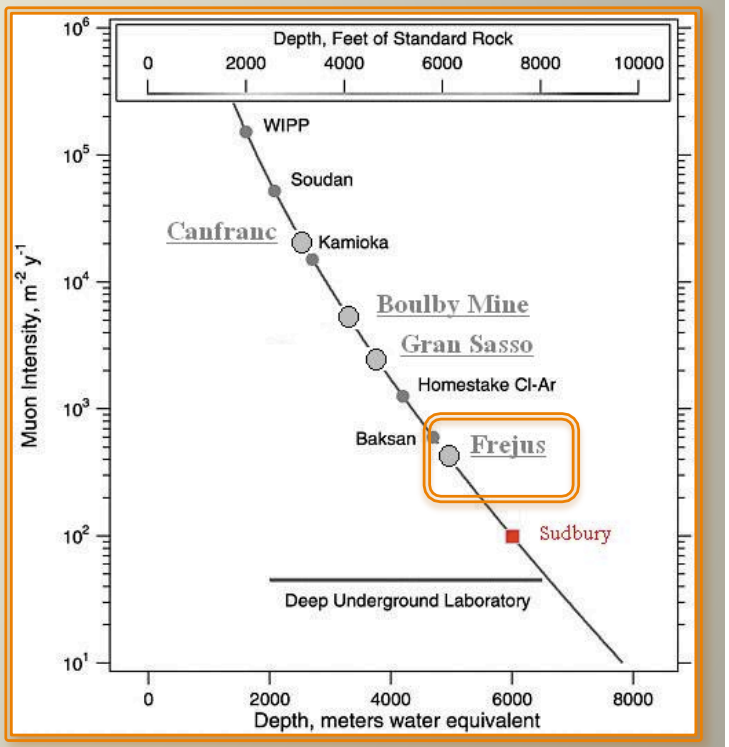
- CEA Saclay
- CSNSM Orsay
- IPN Lyon
- Institut Néel Grenoble



- Karlruhe Istitute of Technology
- Oxford University
- Sheffield University
- JINR Dubna

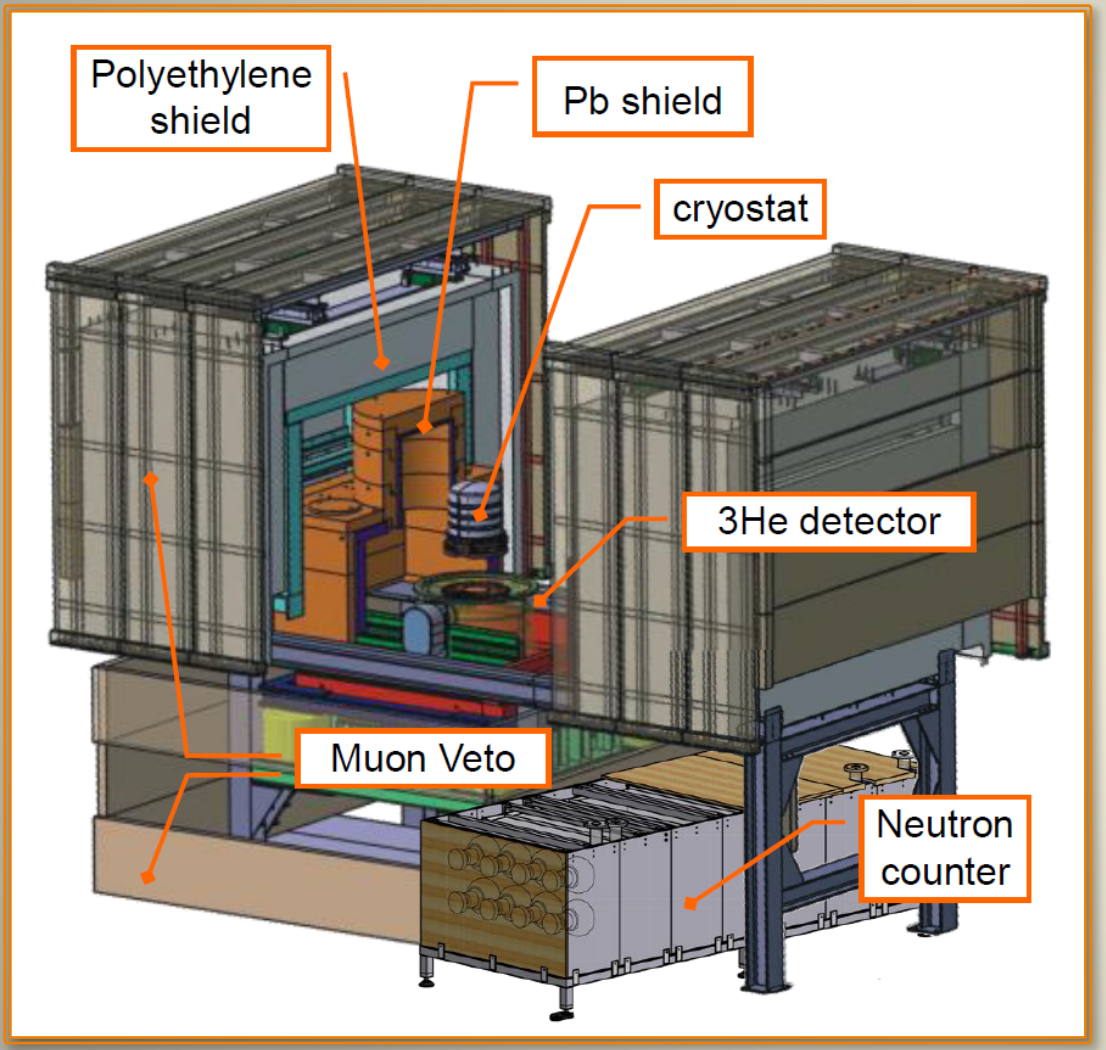
Laboratoire Souterrain de Modane





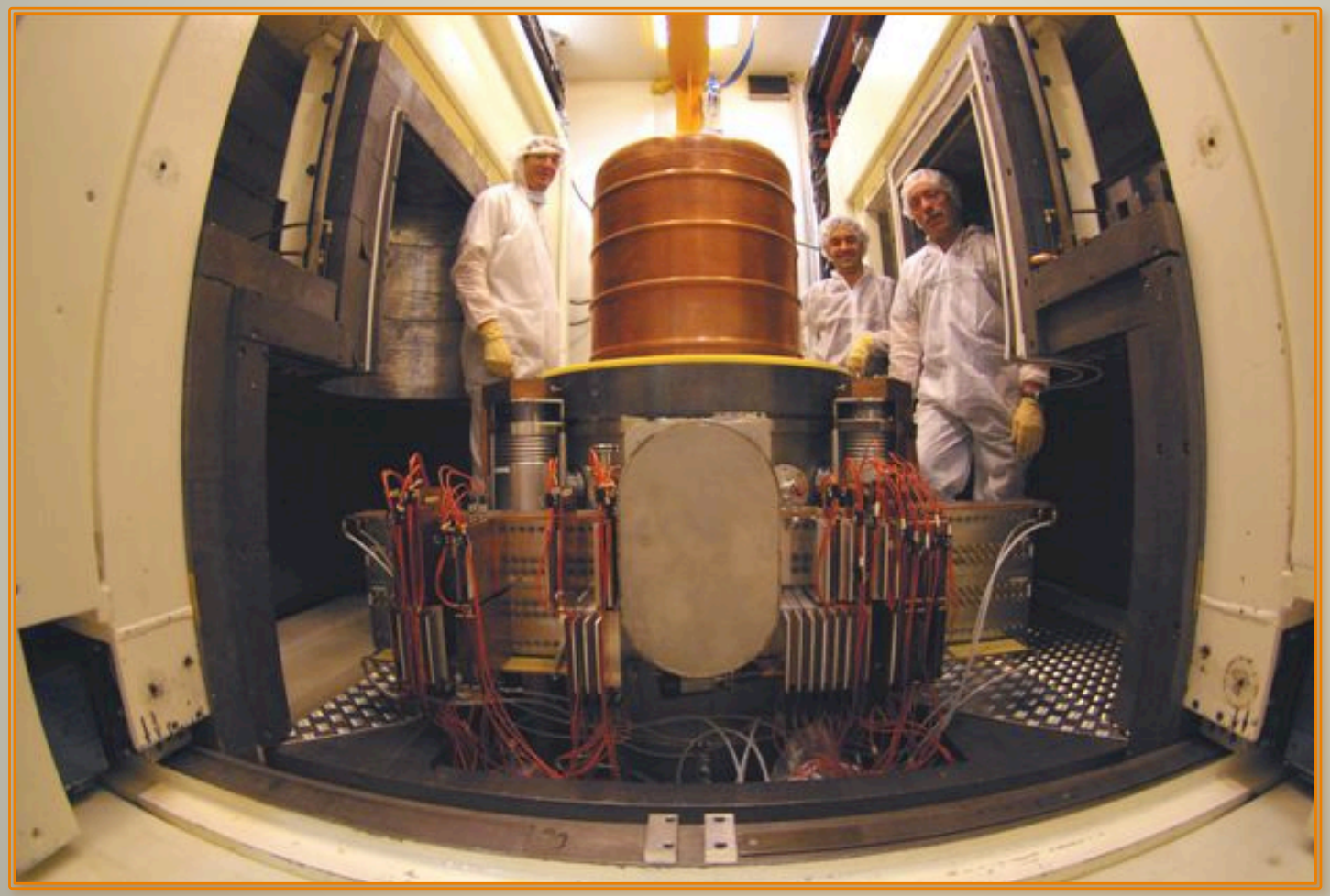
cosmic muon flux 4 $\mu/m^2/day$

EDELWEISS detector



- Cryogenic set-up (18 mK) :
  - **Host Germanium bolometers**
  - **Up to 40kg**
- Shieldings :
  - Clean room + **deradonized air 10 mBq/m^3**
  - Active muon veto (>98% coverage)
  - 50 cm PE shield + 20 cm lead shield
- Monitoring detector
  - Radon detector sensitive down to few mBq/m^3
  - ^{3}He neutron detector (thermal neutron monitoring inside shields) sensitivity ~10^{-9} n/cm^2/s
  - Liquid scintillator neutron counter (study of muon induced neutrons)

Some pictures



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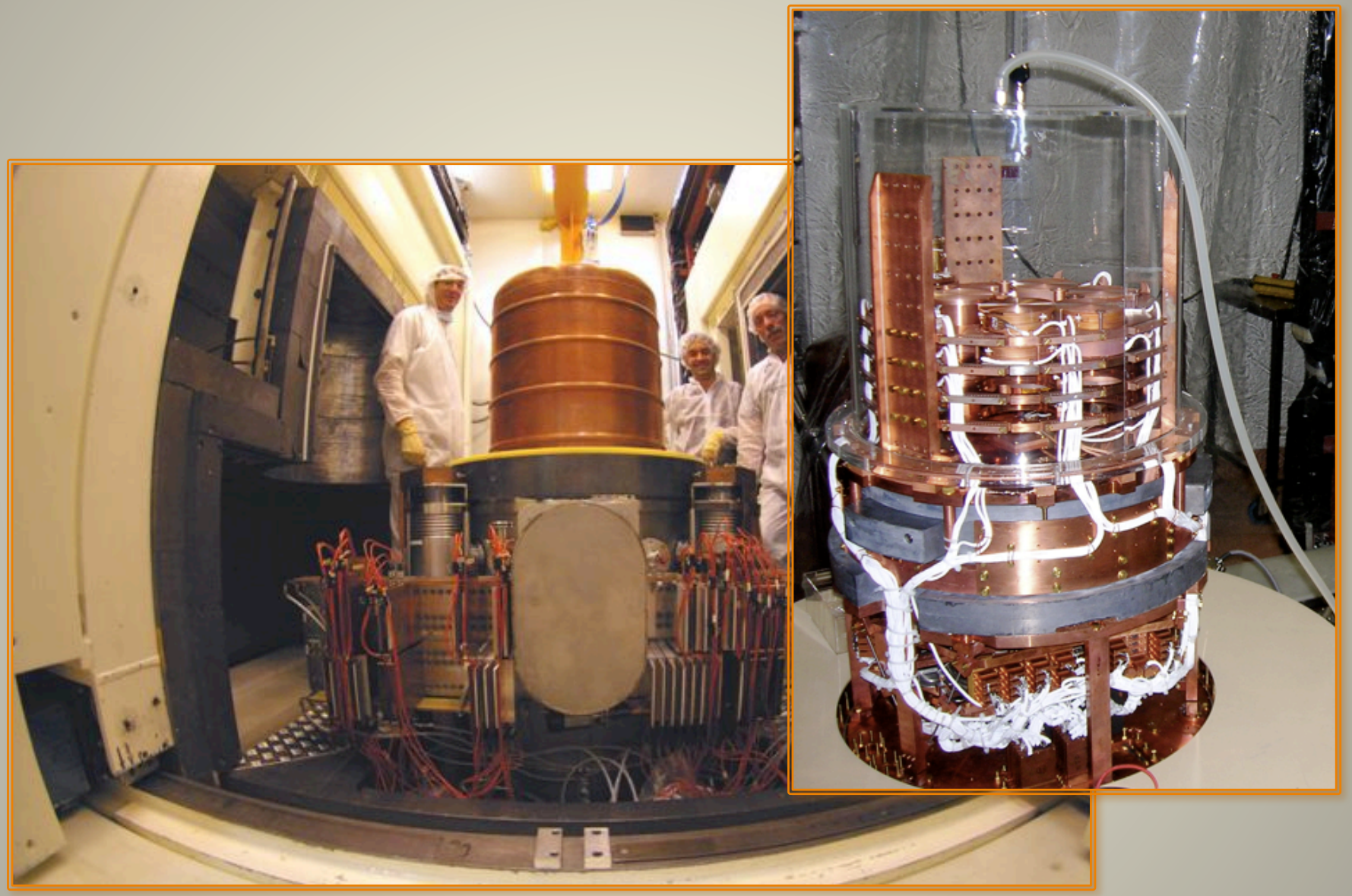
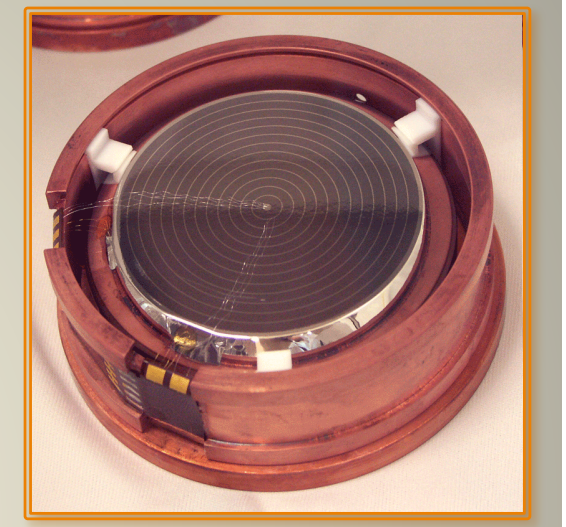


InterDigit (ID) detectors

- ~ 400 g Germanium crystal at 20mK
- Interleaved electrodes at different potentials allows rejection of surface events
- Ionisation detection @ few V/cm
- Phonon detection (NTD sensor)
- Discrimination of nuclear recoils (WIMPs, neutrons) from electron recoils (α, β, γ)



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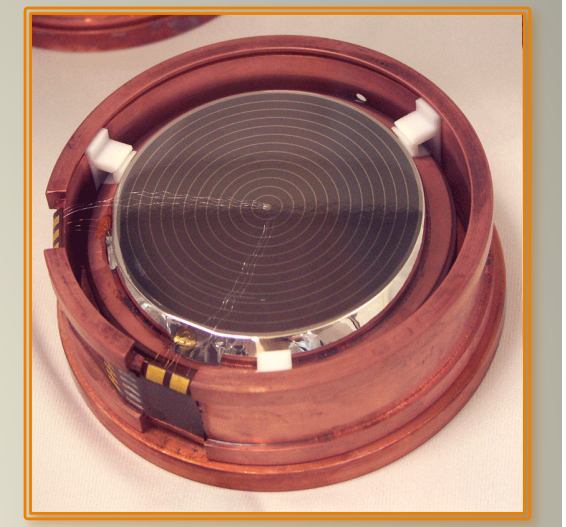

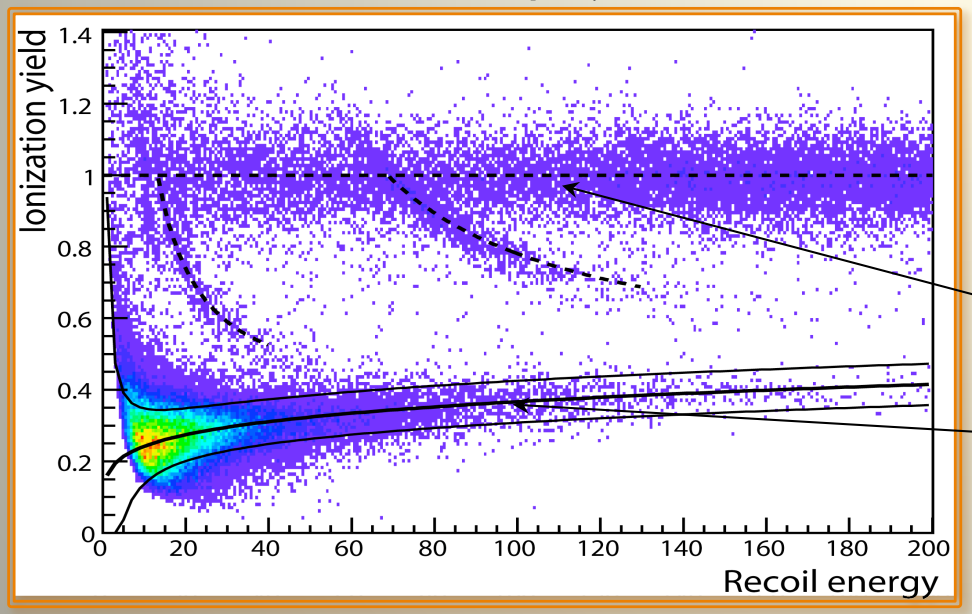

- E_{Ion} / E_{recoil}
- $E_{recoil}=E_{heat}(1+V/3)-E_{ion}*V/3$

(to take into account Luke effect)

Gamma interactions

Nuclear recoil candidates

Neutron Calibration

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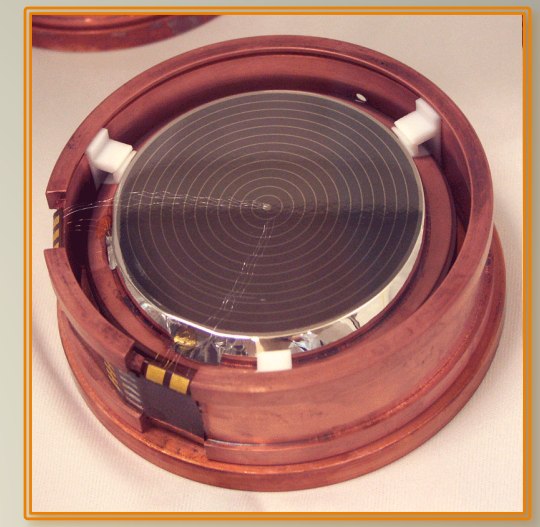

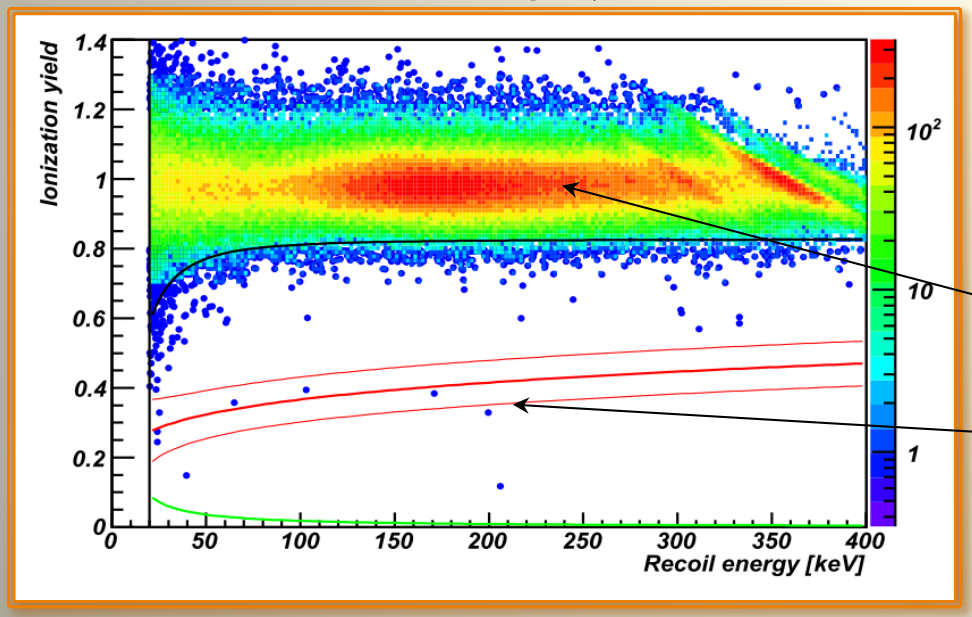

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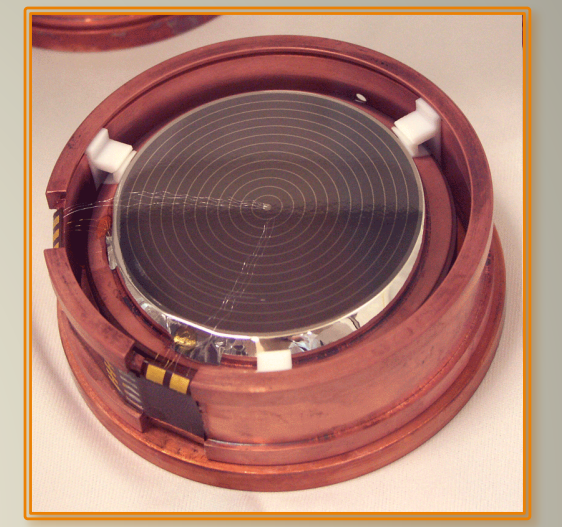

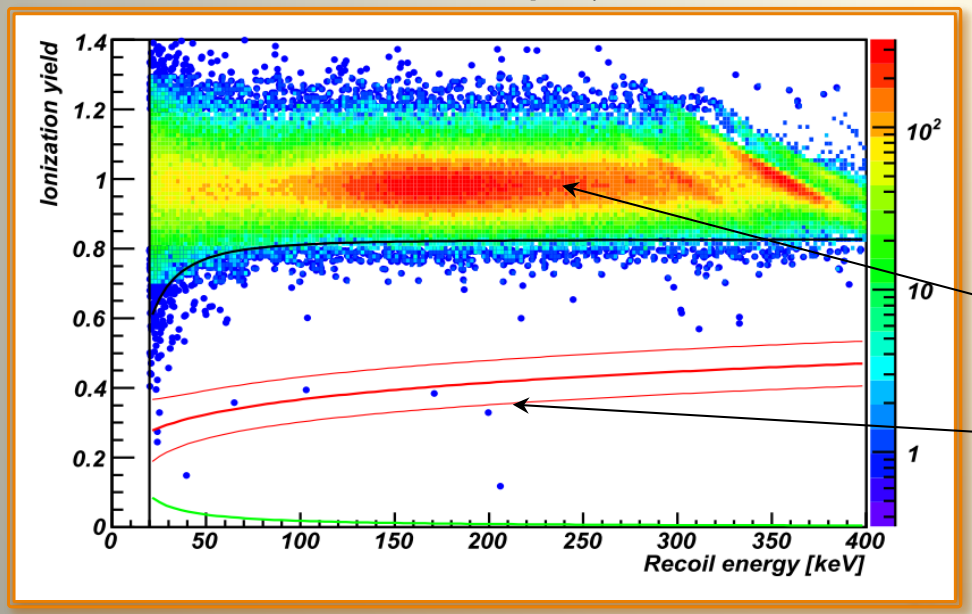

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(to take into account Luke effect)

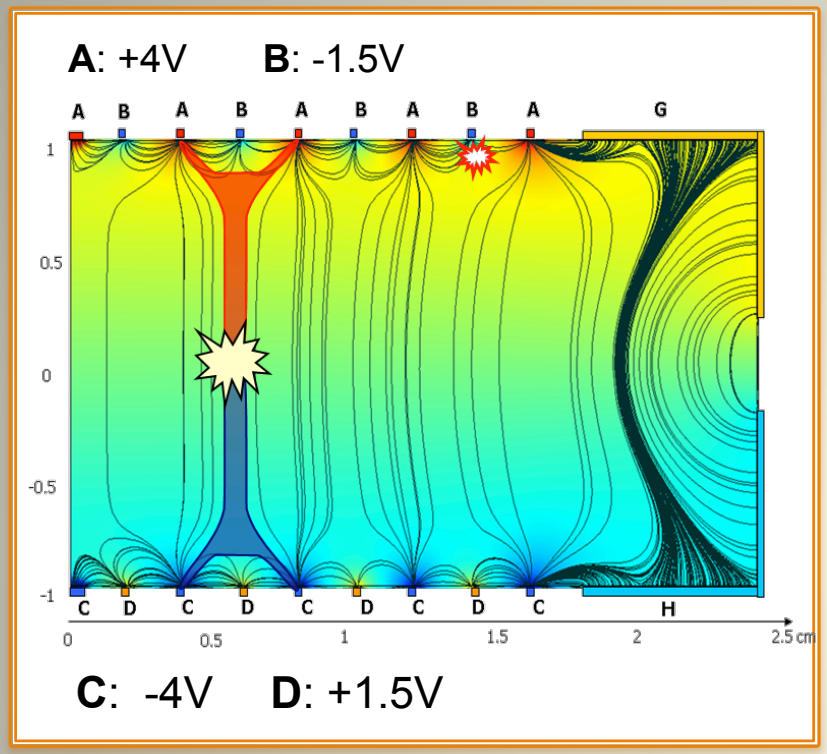
Gamma interactions

Nuclear recoil candidates

Gamma Calibration

gamma rejection: (3±1).10^{-5}

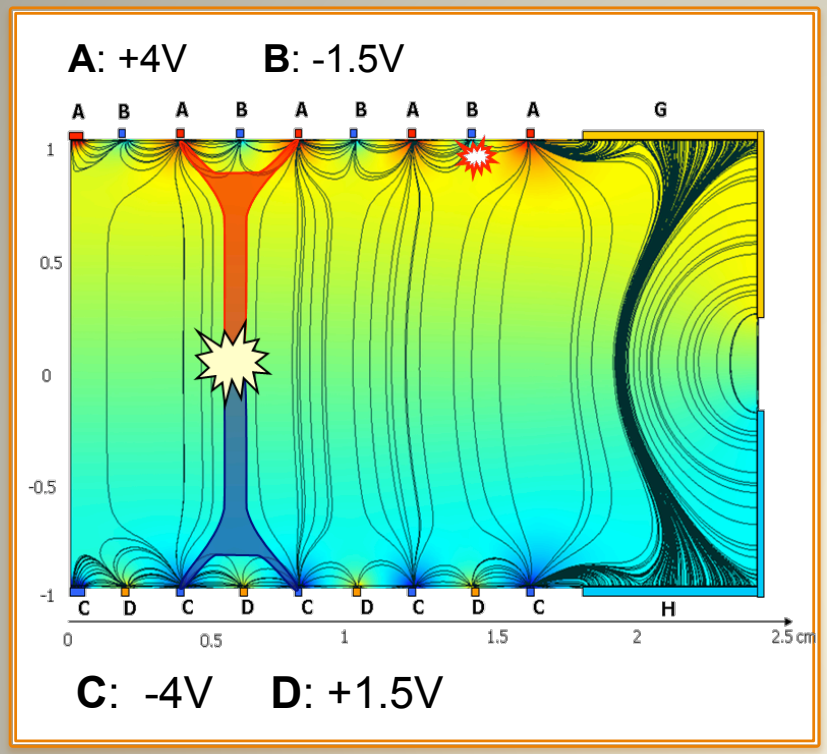
Surface Event Rejection

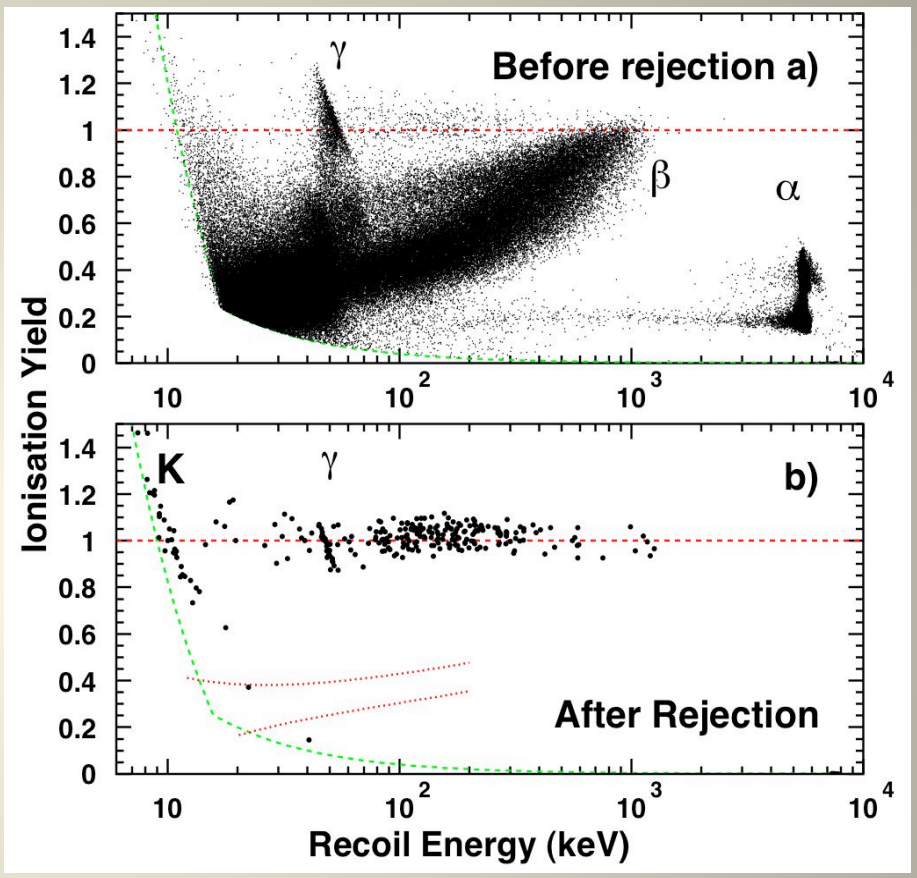


- Bulk events:
  - charge → AC (Fiducial electrodes)
- Surface events:
  - charge → AB or CD

Surface Event Rejection

^{210}Pb Calibration
6×10^4 β events





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A. Broniatowski et al Phys Lett B 681 (2009) 305

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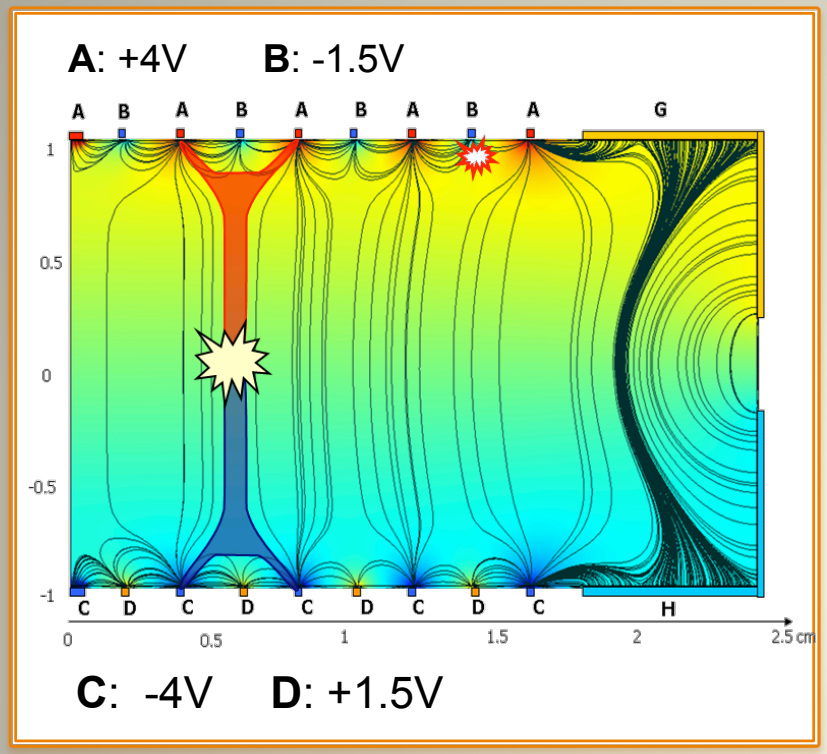
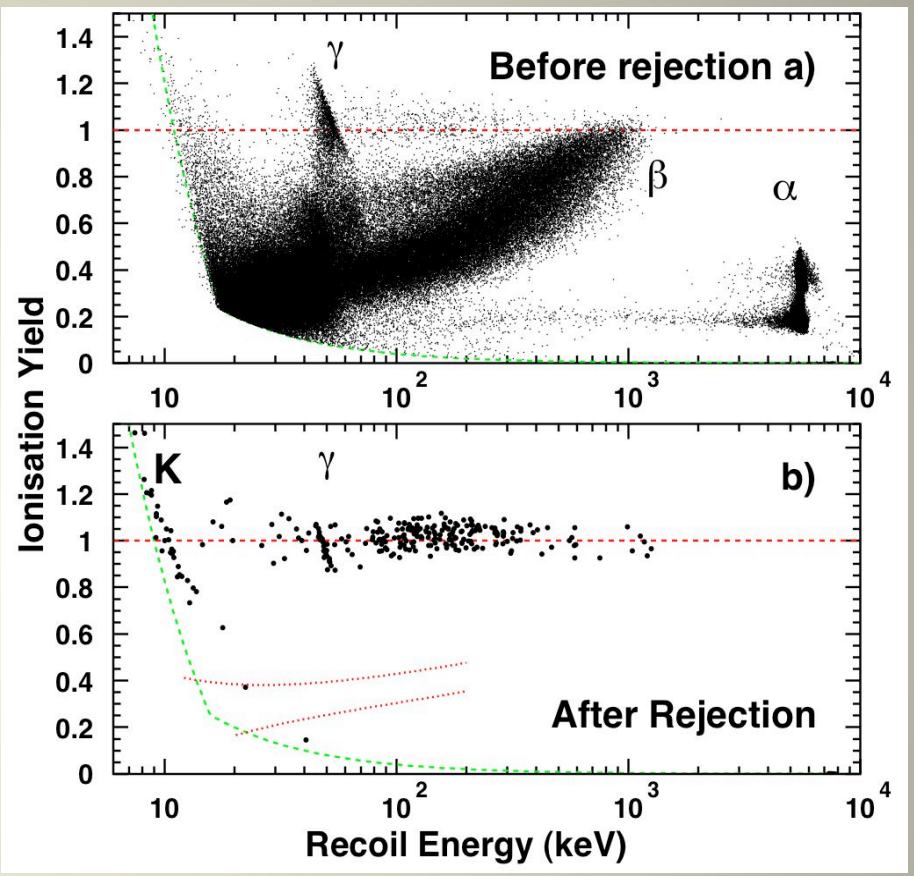




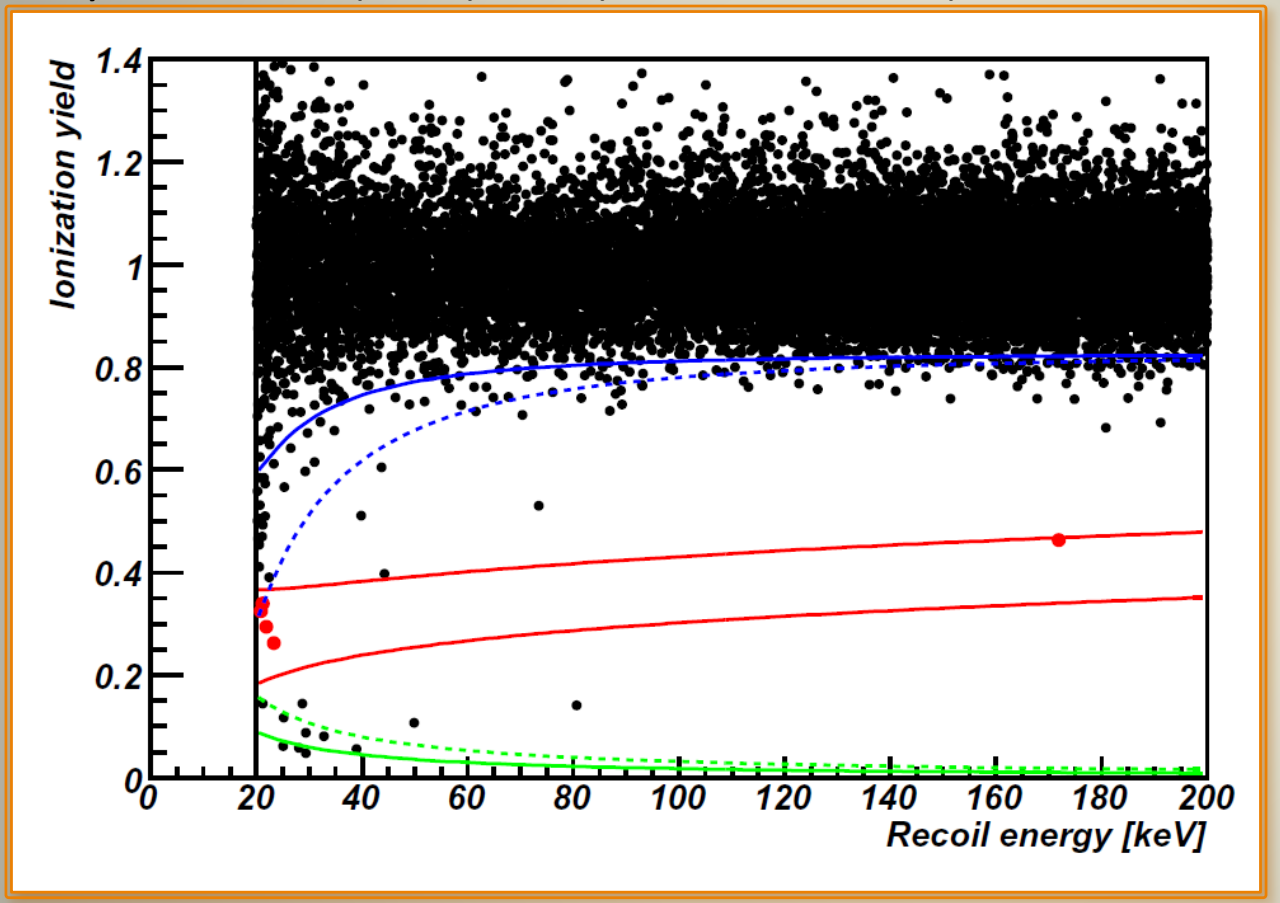
- Bulk events:
  - charge → AC (Fiducial electrodes)
- Surface events:
  - charge → AB or CD

A. Broniatowski et al Phys Lett B 681 (2009) 305

Surface event (β) rejection: 6×10^{-5} (90% CL)

EDELWEISS II – final result

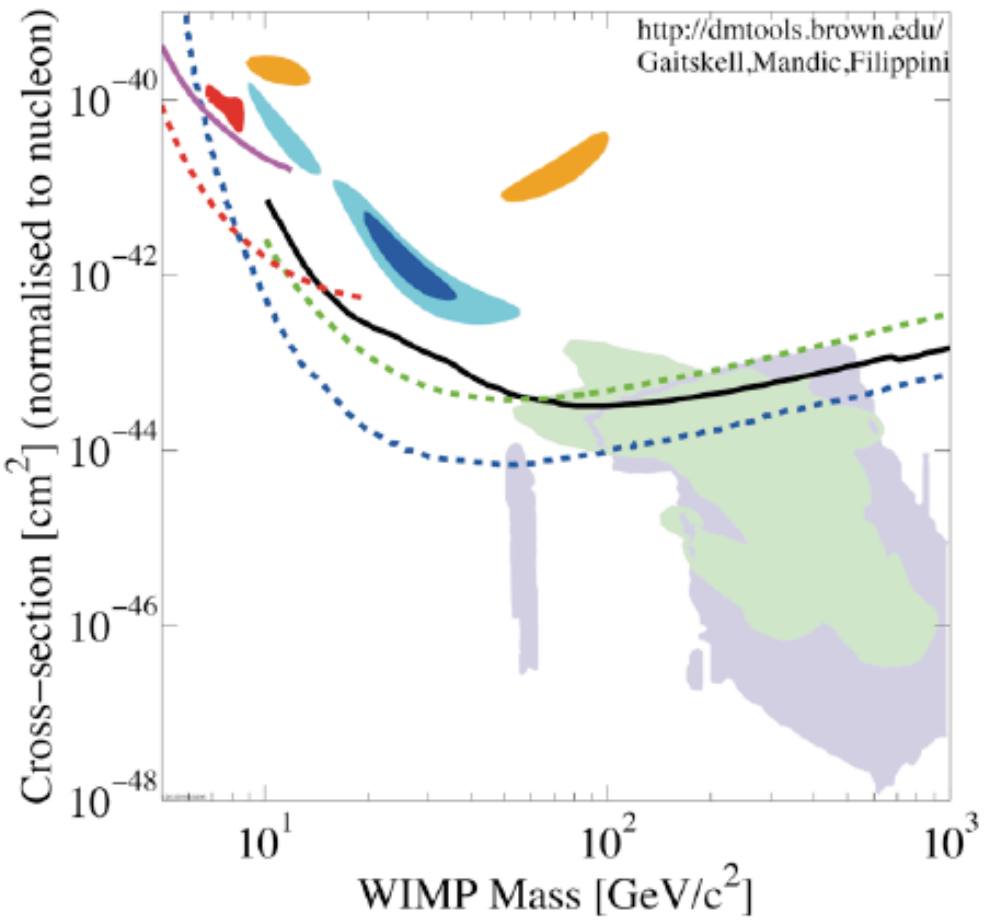
Phys Lett B 702 (2011) 329; (arXiv: 1103.4070)



- 10 ID 400 detectors
- 1 year
- 384 kg.d
- 5 nuclear recoil events (>20keV)
- 3 expected background events
  - 0.9 gamma
  - 0.3 beta
  - 1.8 neutrons

standard halo : $\sigma_{SI} < 4.4 \times 10^{-8}$ pb at 90%C.L. for $M_{WIMP} = 85$ GeV/c^2

Direct Detection Current Status



DAMA/LIBRA EPJ **C56** (2008)

CoGeNT PRL **106** (2011)

CRESST II 2 sigma arXiv: 1109.0702

CRESST II 1 sigma arXiv: 1109.0702

CDMS Low E, PRL **106** (2011)

CDMS + EDW, Phys Rev D **84** (2011)

ZEPLIN III, arXiv: 1110.4769

XENON100 PRL **107** (2011)

XENON10 Low E, PRL **107** (2011)

CMSSM Trotta et al, (2008)

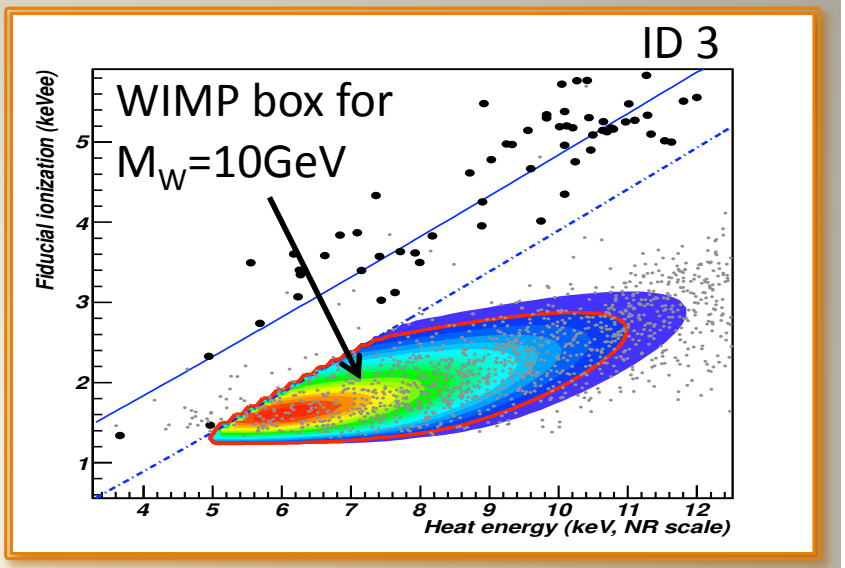
CMSSM with LHC and XENON 100
Buchmueller et al, arXiv: 1110.3568

LOW MASS WIMP

- ID Detectors sensitive to nuclear recoil < 5keV
- New analysis with E_{recoil}<20keV
- Selection of data set compatible with low energy threshold
- Careful measurement of efficiency at low energy
- Analysis :
  - Observables:
    - Best energy estimator for NR at low energies, based on the heat signal only : E_{recoil}

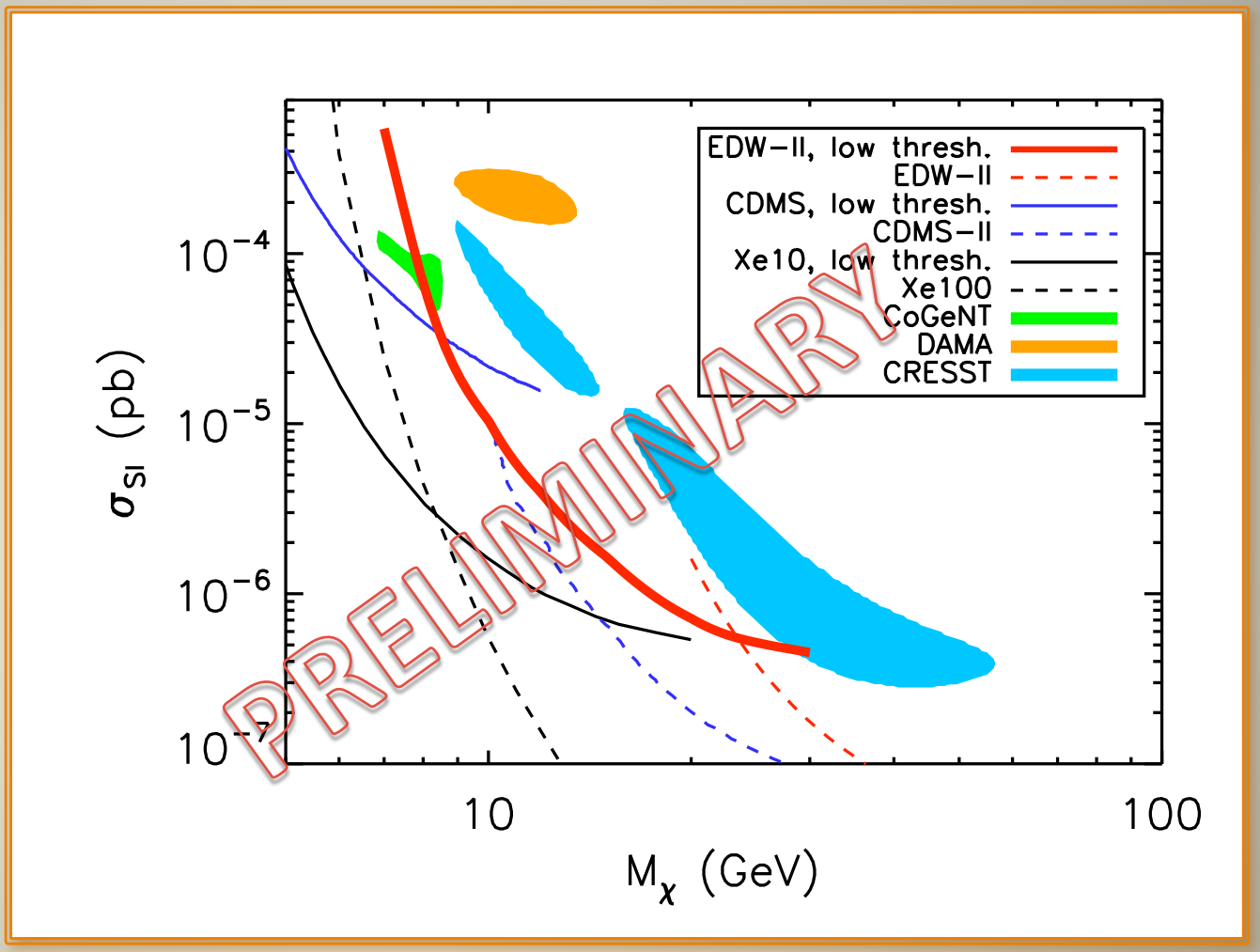
$$E_{heat} = \frac{E_{rec}}{1+V/3}\left(1+\frac{V}{3}0.16\,E_{rec}^{\;0.18}\right)$$

    - Use ionization signals to select fiducial events and reject heat-only events and gamma-rays
  - Select WIMP region in the Erecoil-Eion plane : «WIMP box» definition: isolevel of the WIMP density ρ *such that 90% of the* WIMP signal is inside this isolevel.
  - Take into account measured efficiencies (both as a function of heat and ionization energies)



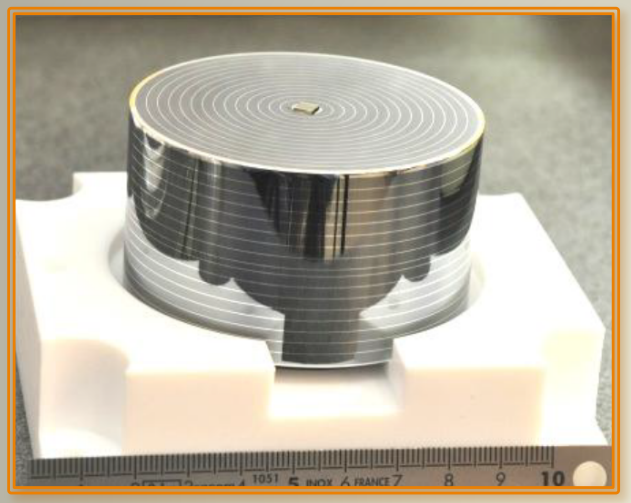
LOW MASS WIMP

- exposure: 113 kg.d
- Estimated background :
  - Neutron < 1.7
  - Gamma : 1.2
  - Heat-only << 1
  - Surface events are negligeable background.
- Limit derived from simple Poisson statistics in the «WIMP box»



$\sigma_{SI} < 1.10^{-5}$ pb at 90%C.L. for $M_{WIMP} = 10$ GeV/c^2

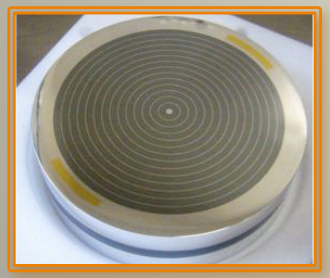
EDELWEISS III
1) Increase detector Mass

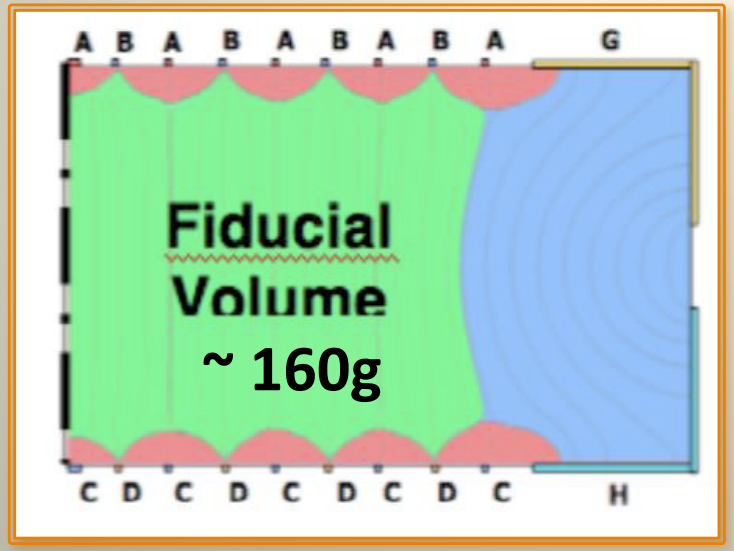


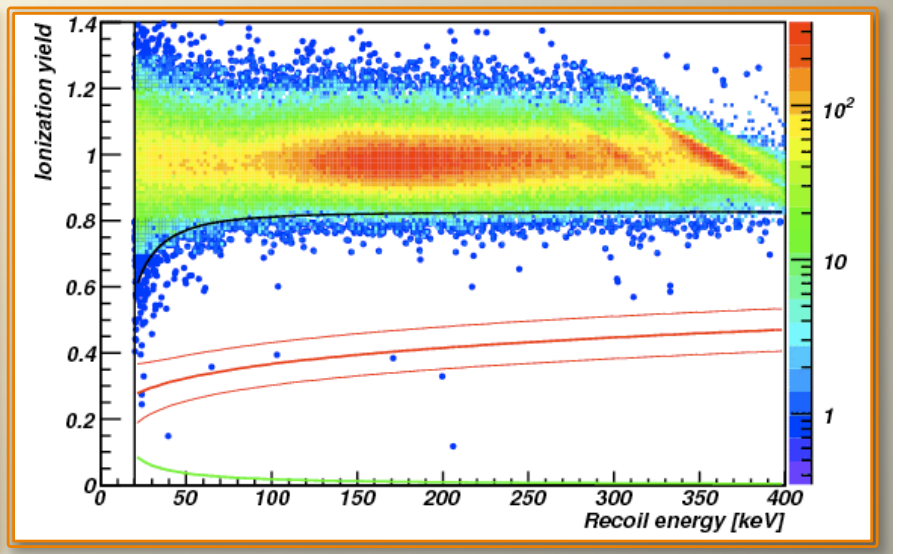
ID 400 -> FID 800 :

- 800g crytal
- inter digit electrodes also on the cylindrical edge

ID 400







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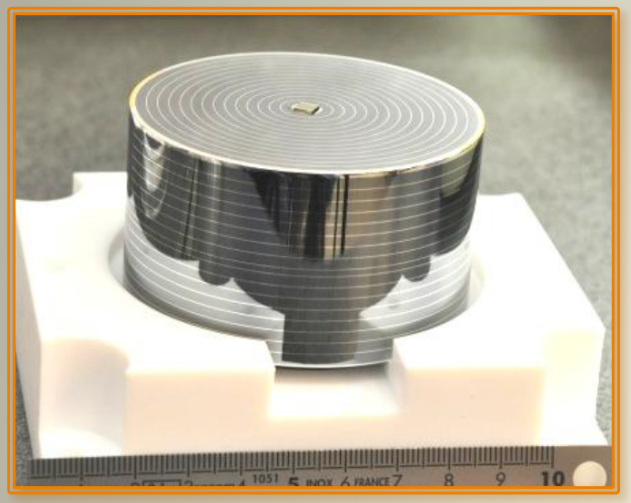

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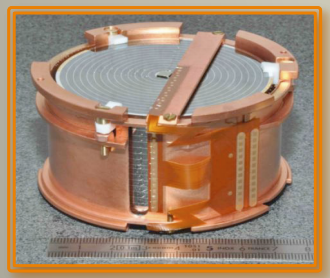
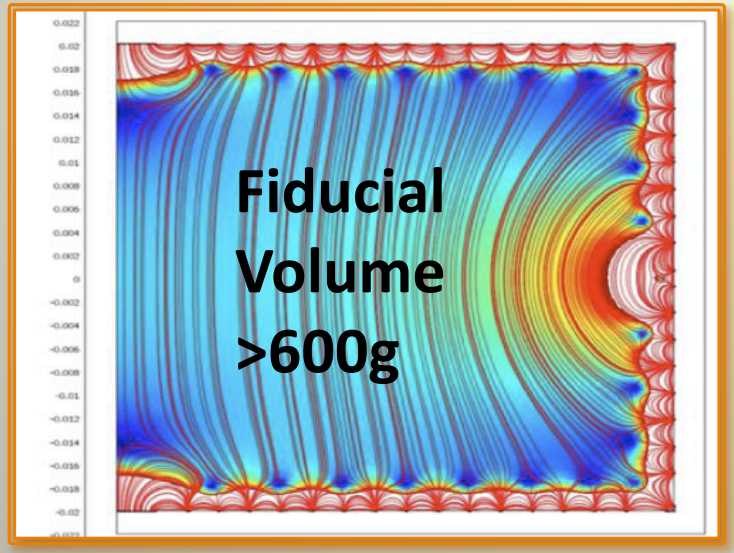
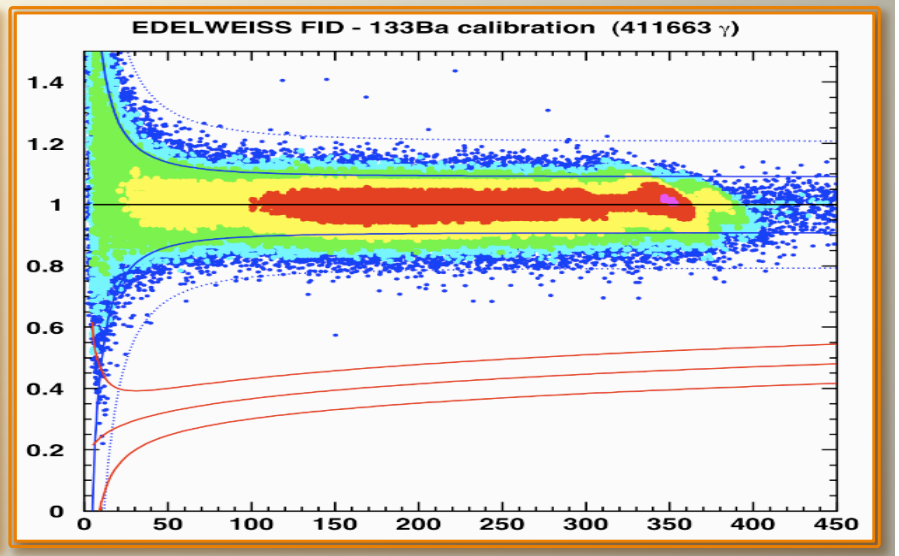
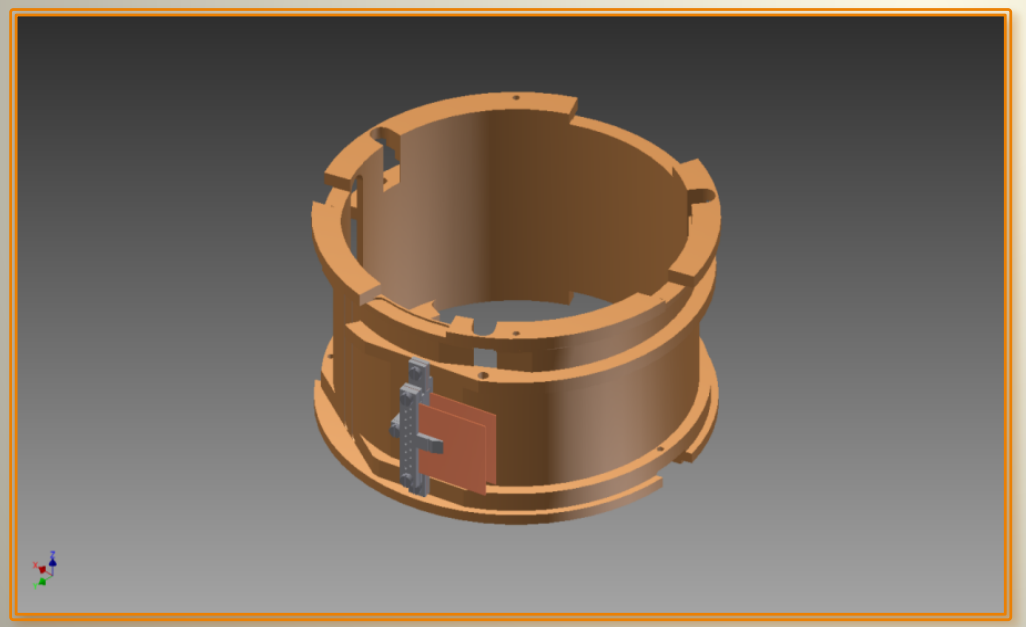


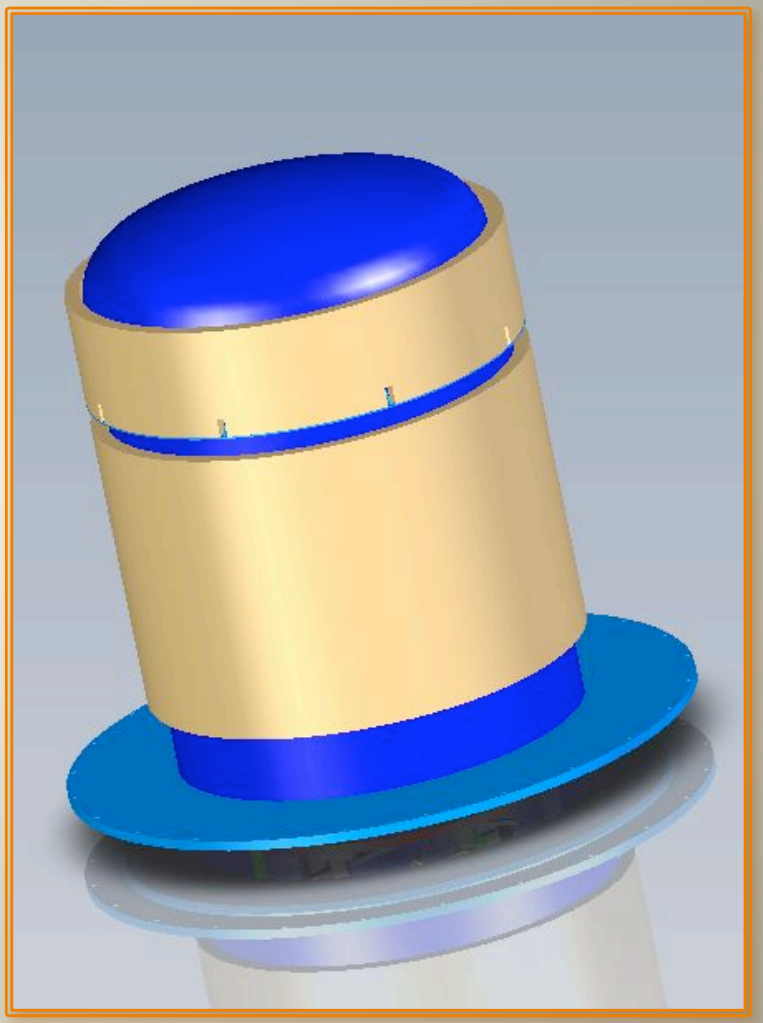




EDELWEISS III
2) Decrease background

- New PE internal Shielding
- New kapton cabling, connectors, electronics
- New copper thermal shielding





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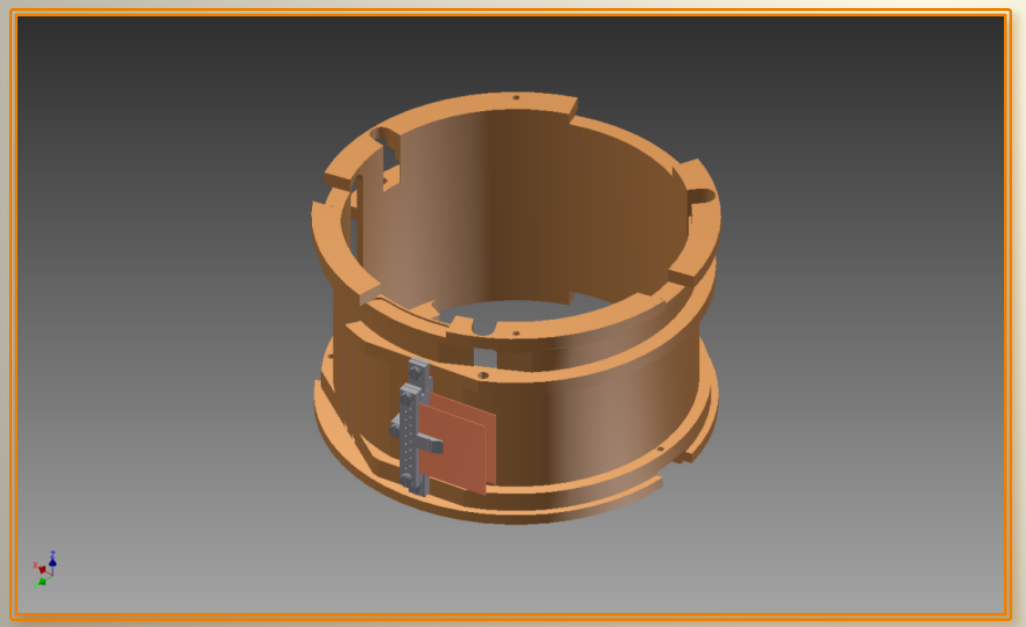
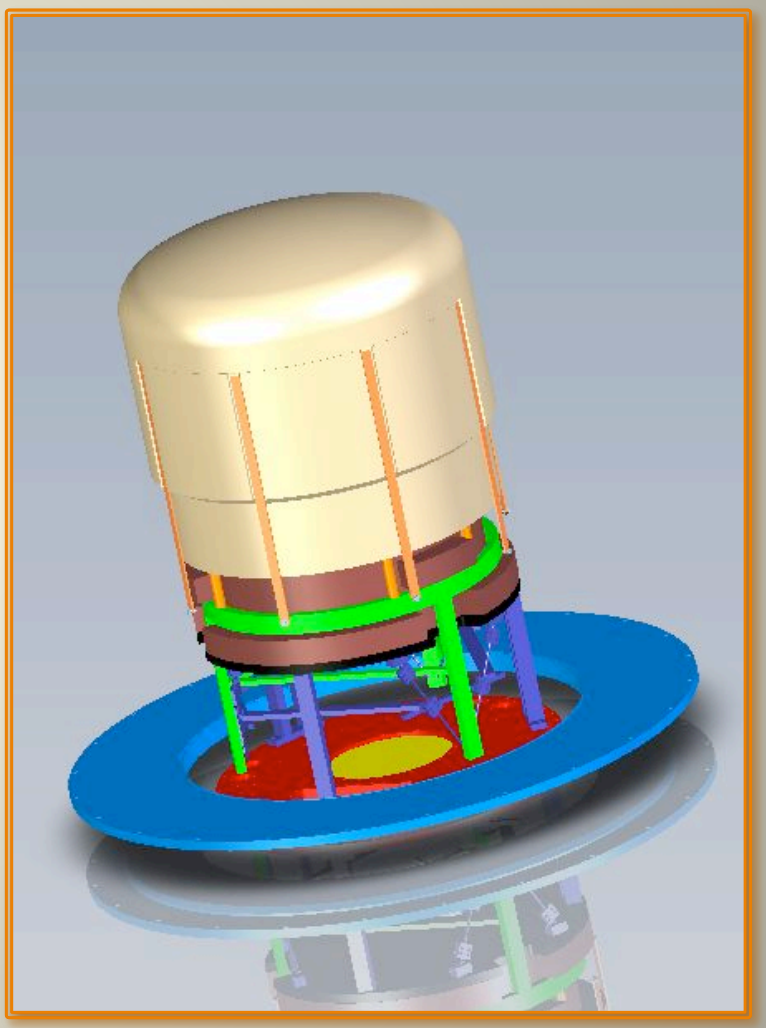
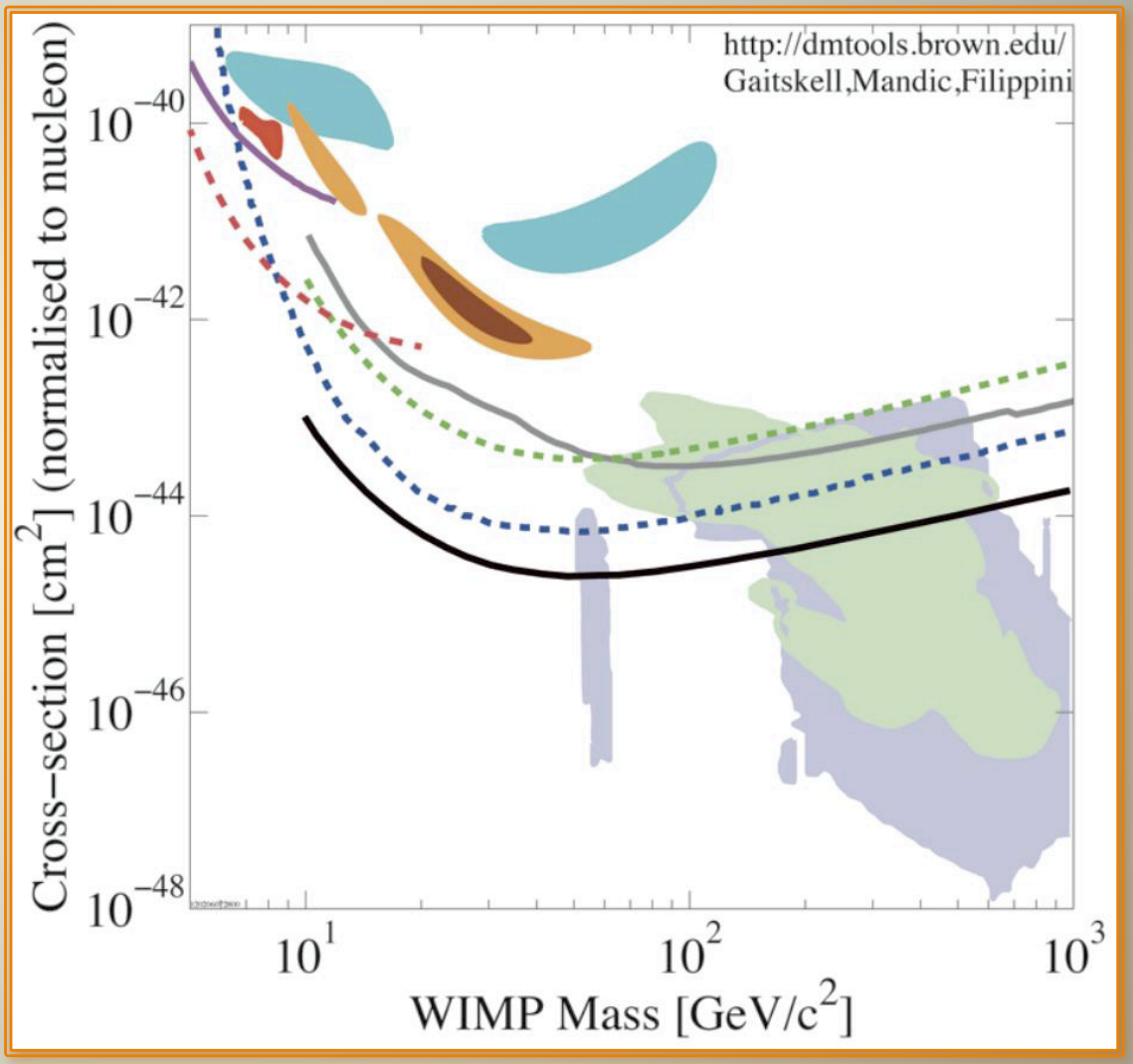




EDELWEISS III
3) perspective

- Now:
  - New cryogenics
  - ~10 FID 800 detectors
  - BBV2 readout electronics
  - New support structure
- September 2012
  - New Cu shielding
  - Inner PE-shield
  - Kapton cabling
- 2013
  - Fully equipped cryostat 48 FID 800g detectors



Conclusion

- New limit for low mass WIMP for EDELWEISS ID data
  - $\sigma_{SI} < 1.10^{-5}$ pb at 90%C.L. for $M_{WIMP} = 10$ GeV/c^2
- New FID detector with increased fiducial volume and better gamma rejection.

- Preparing EDELWEISS III with 40kg Ge array.