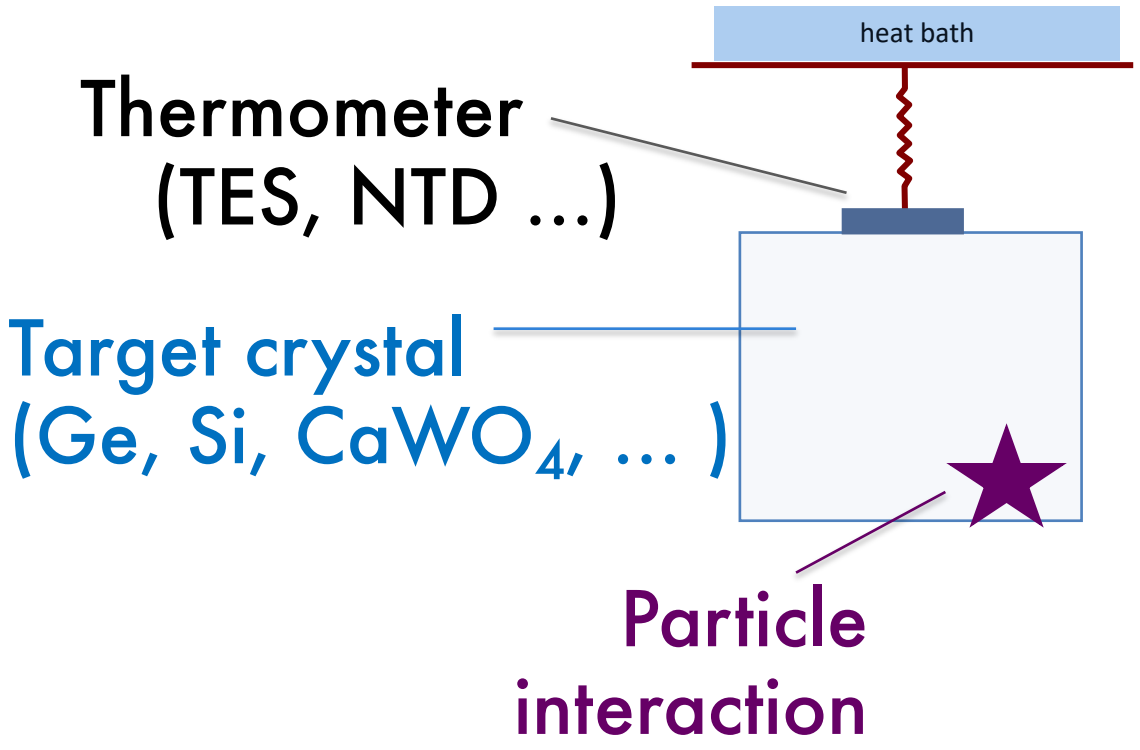
Some notes for the journal club

March 20, 2020

CRYOGENIC DETECTOR
CRESST, CDMS, EDELWEISS …



Primary signal:
Phonons (≳90 %)

(almost) independent of particle type

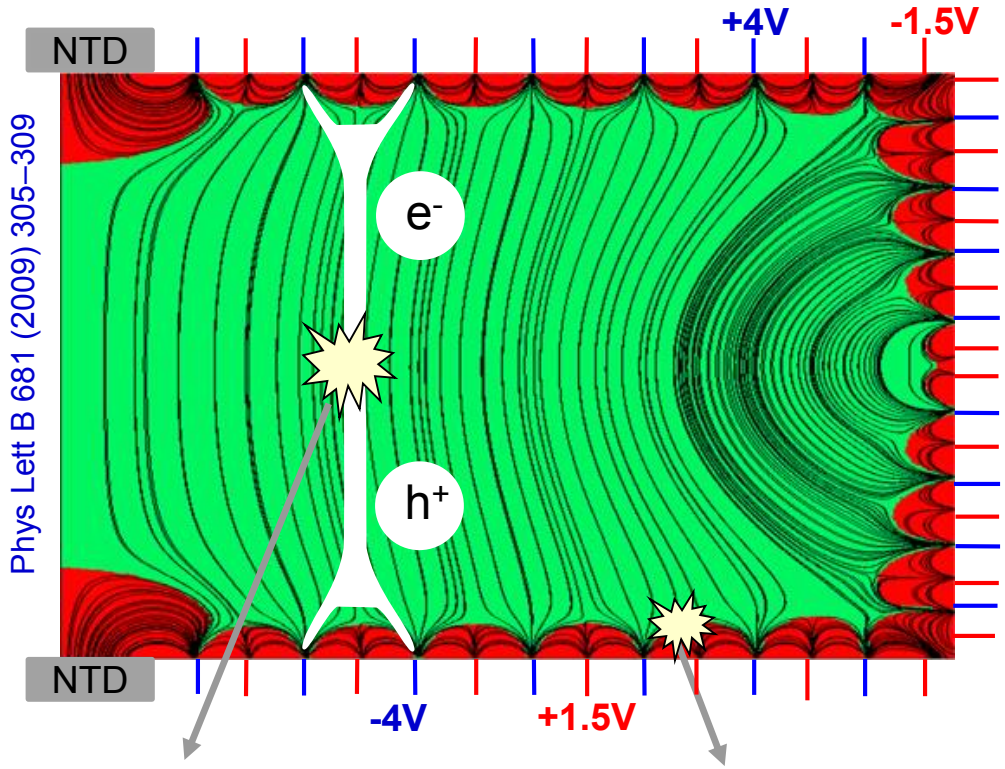
Precise measurement of the deposited energy

Secondary signal for particle identification

EDELWEISS/CDMS: Ionization
CRESST: Scintillation

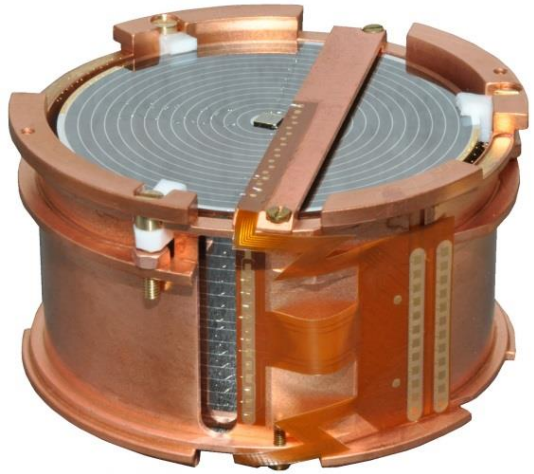
EDELWEISS-III FID800 detectors

Fully **I**nter**D**igitized ~870g HPGe detectors
T_{op}=18mK → heat & ionisation



Bulk/Fiducial event
Charge collected on electrodes C_{top}&C_{bott}

Surface event
Charge collected on electrodes C_{bott}&V_{bott}



Ø=70mm, h=40 mm
2 GeNTDs heat sensors

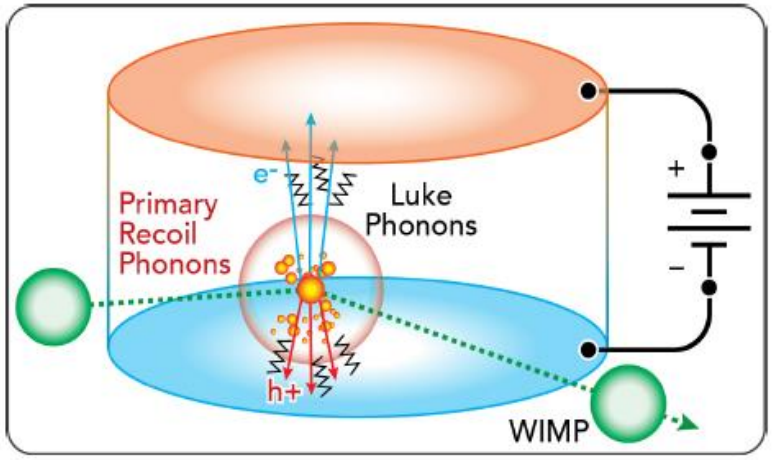
Electrodes:
concentric Al rings (2mm spacing)
covering all faces
XeF_2 surface treatment
to ensure low leakage current (<1 fA)
between adjacent electrodes

J Low Temp Phys (2014) 176: 182-187

"Performance of the EDW-III experiment for direct dark matter searches"
arXiv:1706.01070 (subm. to JINST)

CDMS iZIP:
Same principle, but different phonon sensor (TES)

CDMS lite @ Soudan



making use of Neganov-Luke effect:

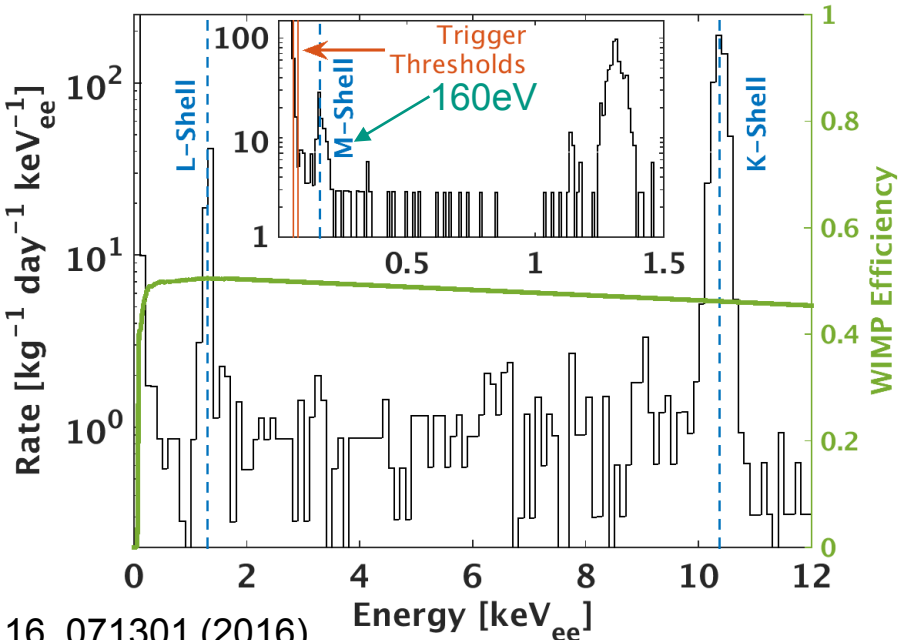
$$E_t = E_r + \frac{1}{3\,eV} E_Q \Delta V$$

with V=70V amplification of heat signal ~24
→ effective lowering the threshold

NL amplification:

- allows $E_{thr} \approx 50 eV_{ee}$
- opens window into ~GeV range

- loss of PID
- needs careful energy calib.



PRL 116, 071301 (2016)

CDMSlite = EDELWEISS High Voltage (HV)

Read ionization via phonon signal on the cost of particle identification

Not a new experiment, just a different readout mode

EQUATION 1

Average energy to create one electron-hole-pair

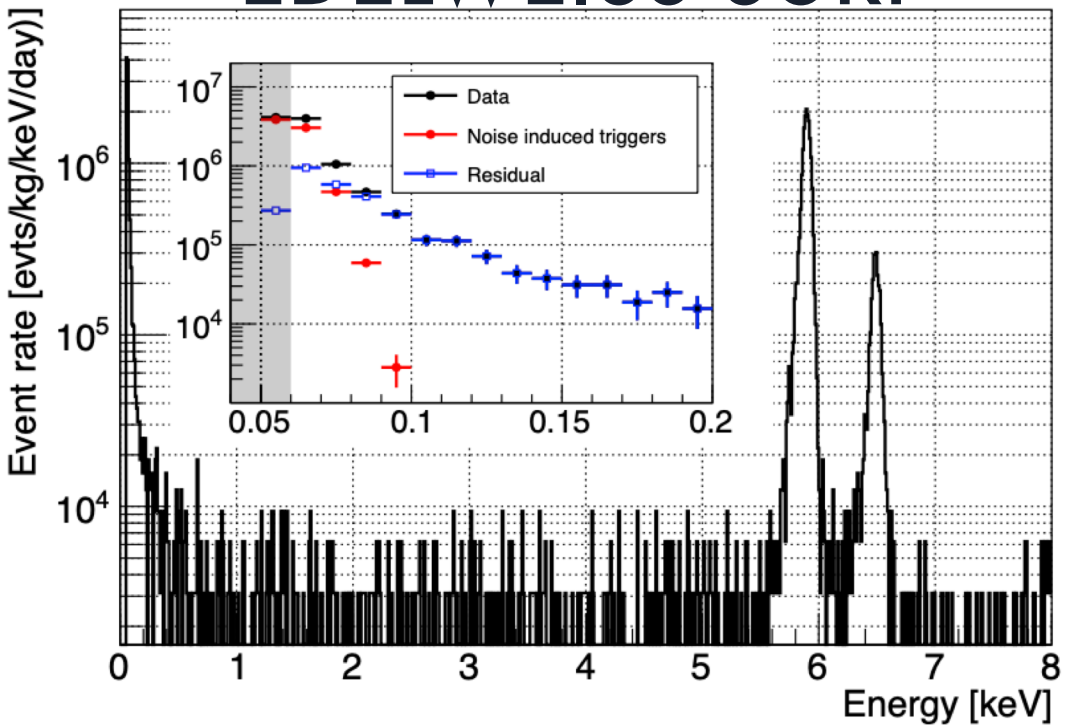
$$E_e = E_{det}\left[y(E_{det}) + \frac{\epsilon_{eh}}{e \cdot V_{det}}\right]$$

Applied Voltage

Y = 1 for an electron recoil
Y < 1 for a nuclear recoil (Lindhard)

THEY COMPARE TWO MEASUREMENTS

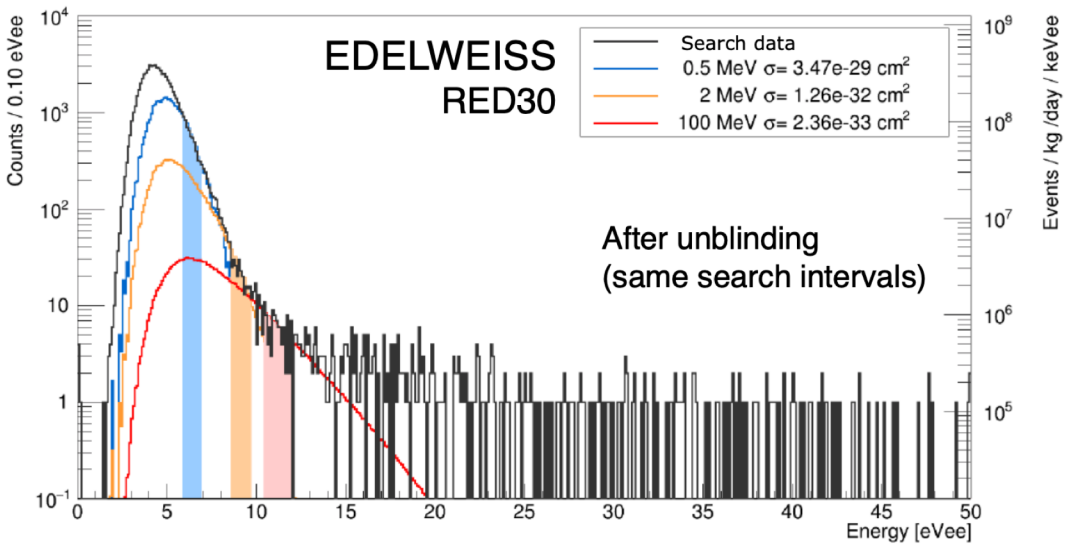
EDELWEISS SURF



33g crystal operated **above ground**
No Neganov-Luke-Amplification (= no HV)
arXiv:1901.03588v2

In the paper called $\mathbf{E_{det}}$ measurement

EDELWEISS RED30

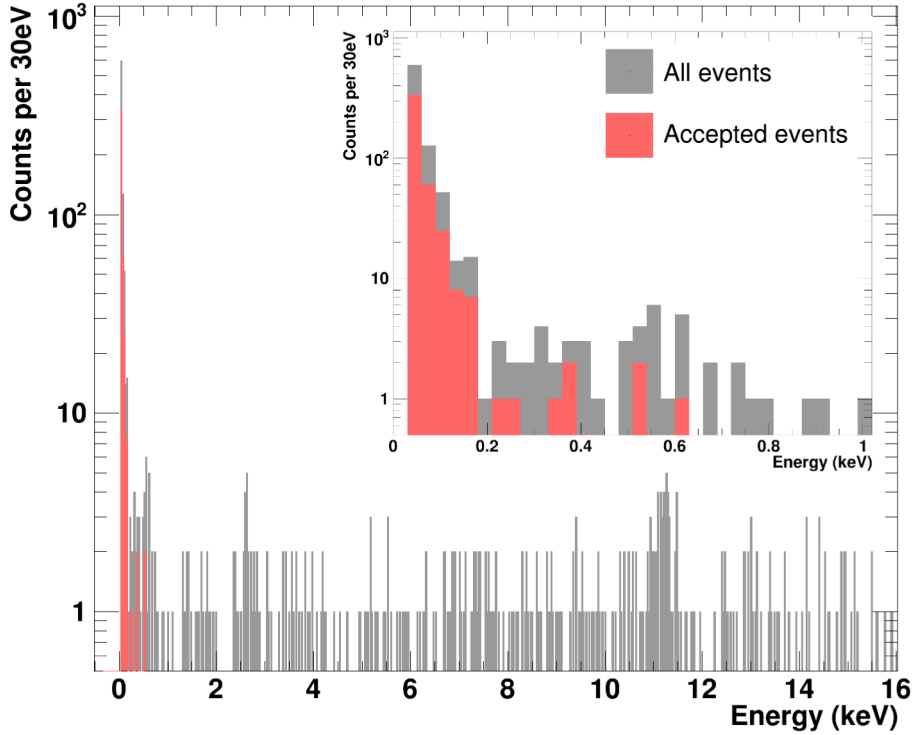


33g crystal operated **underground**
With Neganov-Luke-Amplification (78V)
Gascon TMEX 2020

In the paper called $\mathbf{E_e}$ measurement

LOCAL BIAS: COMMENT ON CRESST

10.1103/PhysRevD.100.102002



Event-type-independent energy

24g $CaWO_4$ crystal, 30.1eV threshold

Ref. [20] points to a 2006 paper of CRESST where cracks were identified by their time correlation as a source of no-light events, but:
big crystals, different holding, different energy scale (factor 100) → a similar analysis was performed for the data on the left, no such time correlation

Summary: crystal cracks are not totally excluded, but this hypothesis is not supported by the time behavior

NUCLEUS PROTOTYPE

- NUCLEUS is an experiment targeting at precision measurements of CEvNS at the Chooz nuclear power plant
- NUCLEUS is based on CRESST technology
- Prototype: 0.5g of Al_2O_3 with 19.7eV threshold (DM interpretation published by CRESST)

Eur. Phys. J. C (2017) 77:637

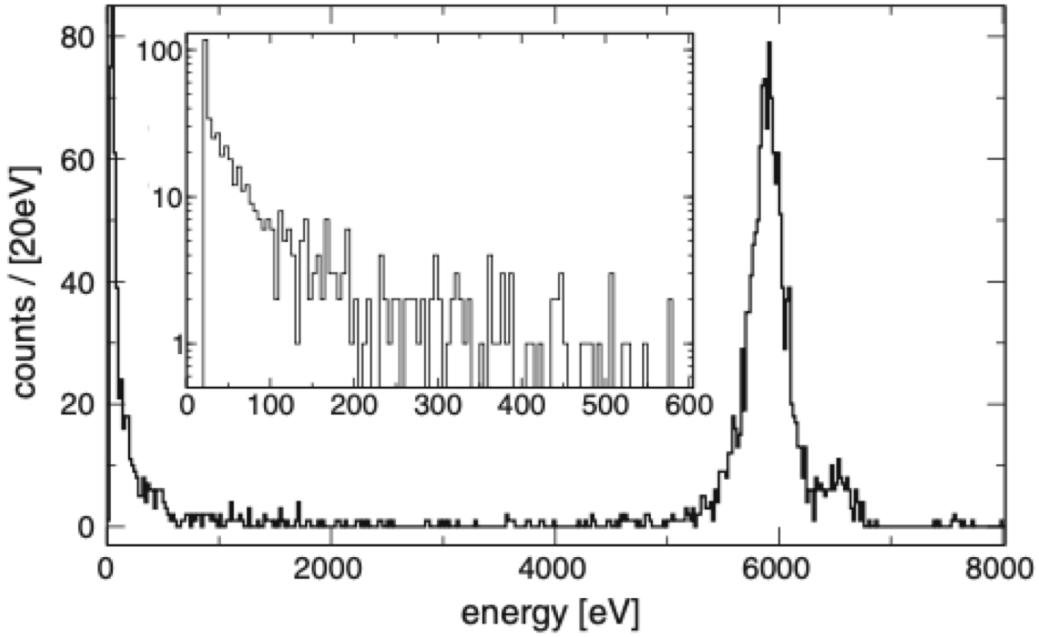


Fig. 2 Total energy spectrum of the 5.3 h measurement in presence of the ^{55}Fe X-ray source with peaks at 5.90 and 6.49 keV. The inset shows the events in the region-of-interest for DM search from the energy threshold of 19.7–600 eV (binning 5 eV). No data quality cuts are applied