EURECA – A Cryogenic Dark Matter Detector

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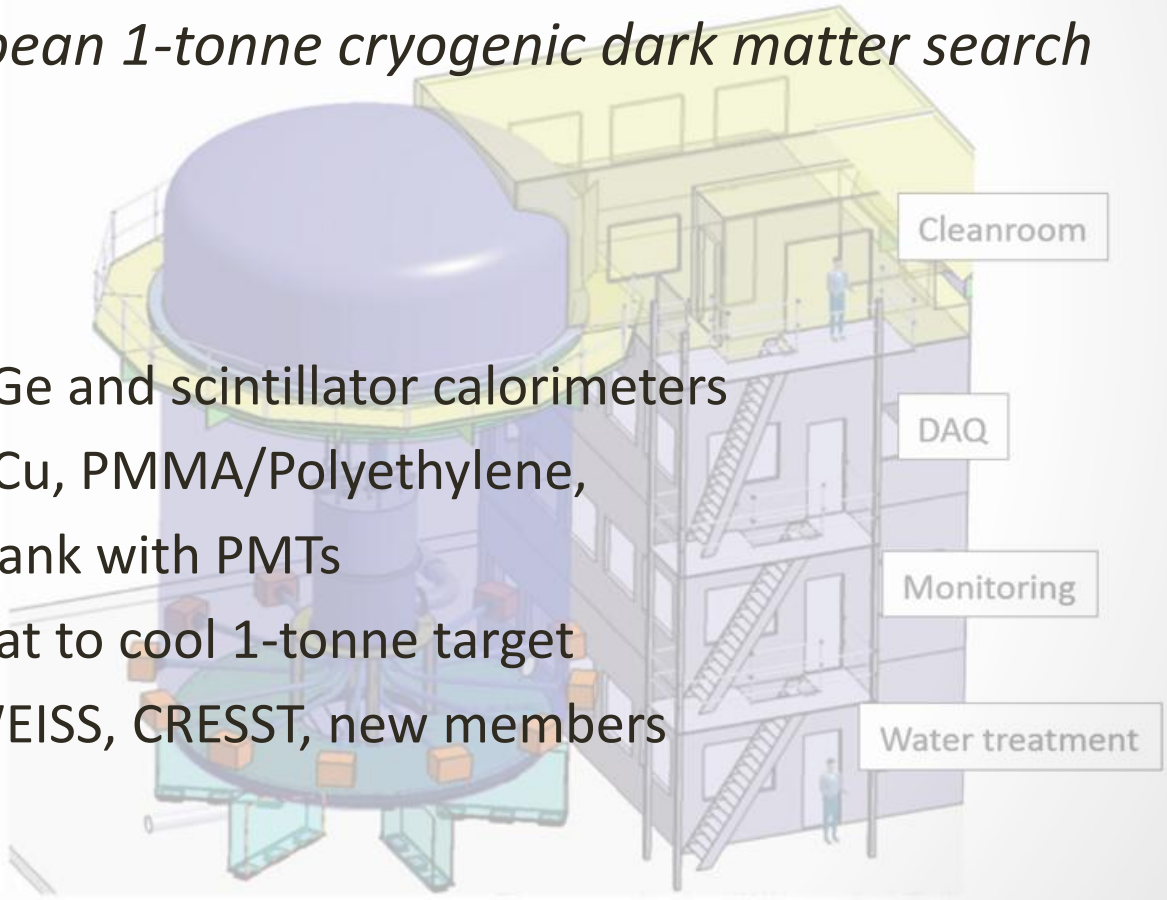
EURECA

European **U**nderground **R**are **E**vent **C**alorimeter **A**rray

- The future European 1-tonne cryogenic dark matter search

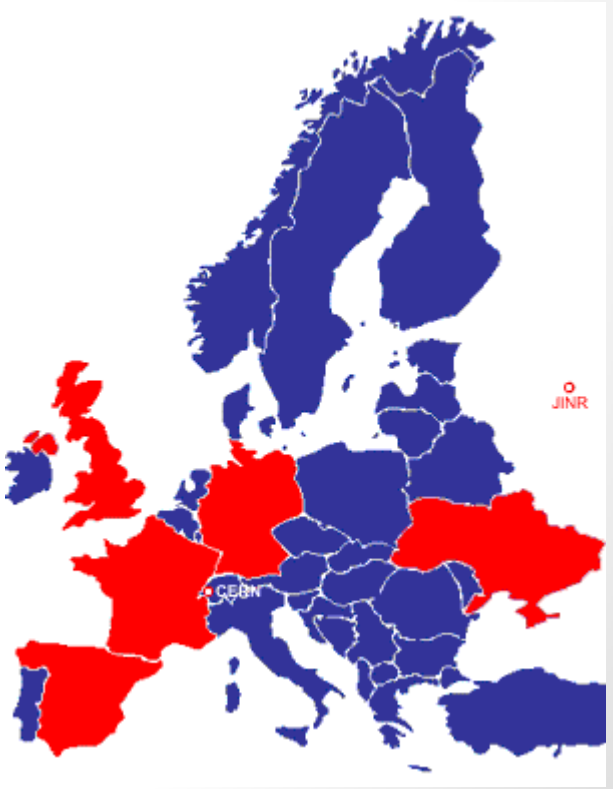


- ***Aim:*** $<10^{-10}$pb
- ***Detectors:*** Cryogenic Ge and scintillator calorimeters
- ***Shielding:*** Radiopure Cu, PMMA/Polyethylene,
  3m water tank with PMTs
- ***Infrastructure:*** Cryostat to cool 1-tonne target
- ***Collaboration:*** EDELWEISS, CRESST, new members

The Collaboration

EDELWEISS + CRESST + ROSEBUD + new members

- **France**
  - CEA: IRFU, IRAMIS
  - CNRS: CSNSM, IPNL, Institut NÉEL, IAS, ICMCB
- **Germany**
  - MPI Munich
  - TUM
  - Universität Tübingen
  - Karlsruhe Institute of Technology (IKP, IK, IPE)
- **United Kingdom**
  - University of Oxford
  - University of Sheffield
- **Spain**
  - Universidad de Zaragoza
- **Ukraine**
  - INR Kiev
- **Russia**
  - JINR Dubna
  - Kurchatov
- **Slovakia**
  - Bratislava



Two Stages of EURECA

EURECA will consist of a single cryostat large enough for phase 2

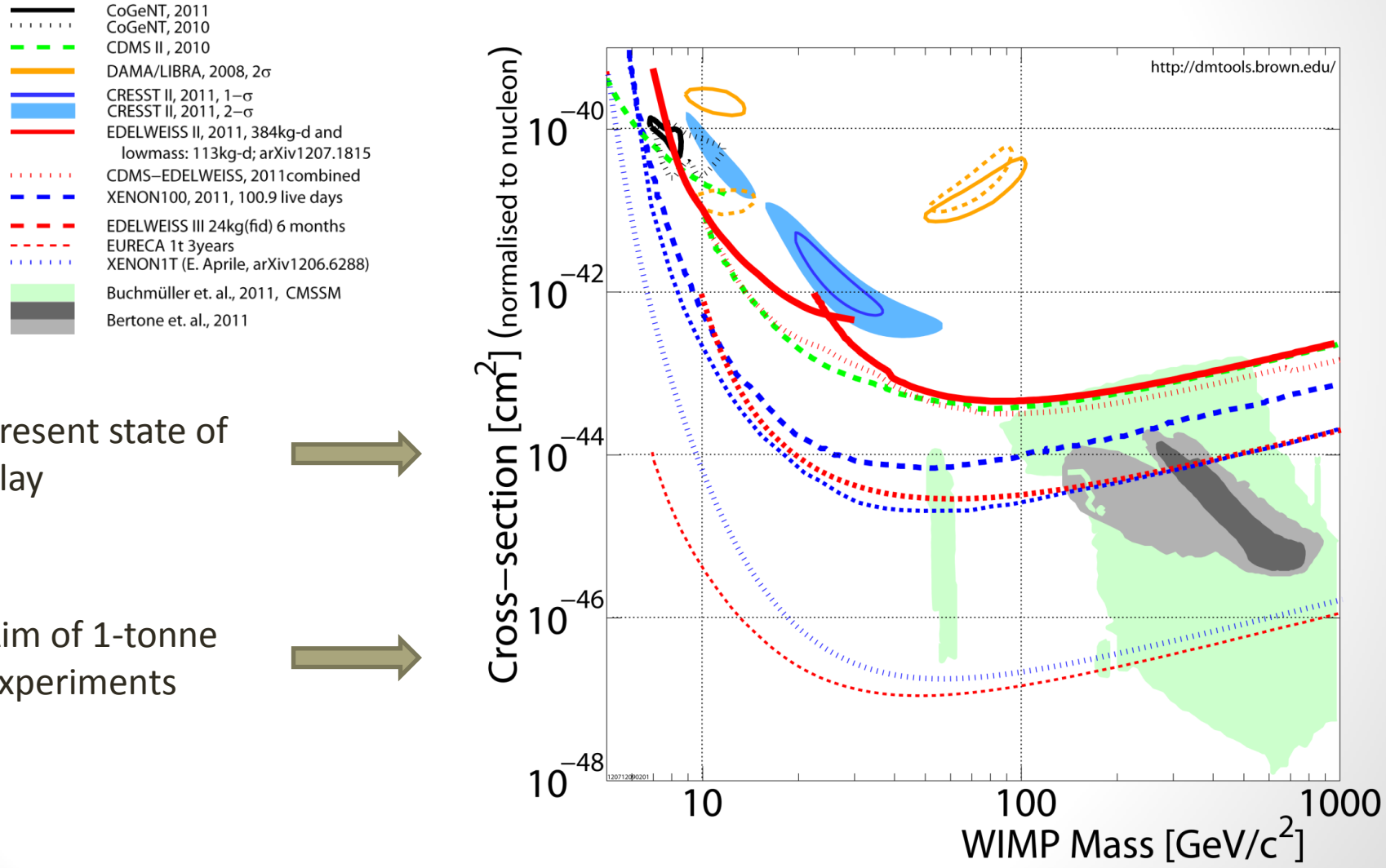
- 1st phase
  - building the infrastructure, cryostat and shielding
  - a subset of the detectors
- 2nd phase
  - 850kg of additional detectors

EURECA	Goals
Phase 1	
Cross section (SI)	$3 \cdot 10^{-10}$ pb
Mass to be operated	150 kg
Residual background (all sources)	10^{-2} evts/kg/y in RoI
Duty cycle	70 %
Time of operation	1 year
Phase 2	
Cross section (SI)	$2 \cdot 10^{-11}$ pb
Mass to be operated	1000 kg
Residual background (all sources)	$< 10^{-3}$ evts/kg/y in RoI
Duty cycle	70 %
Time of operation	3 years

Objectives of EURECA

EURECA Conceptual Design Report

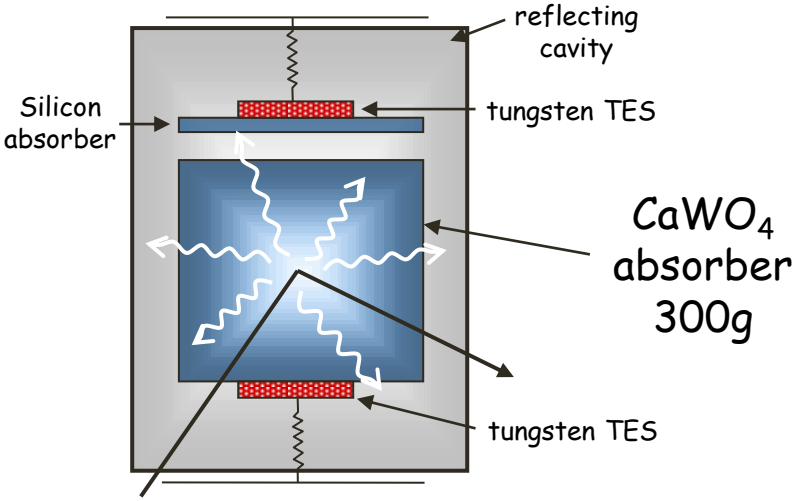
Sensitivity Reach

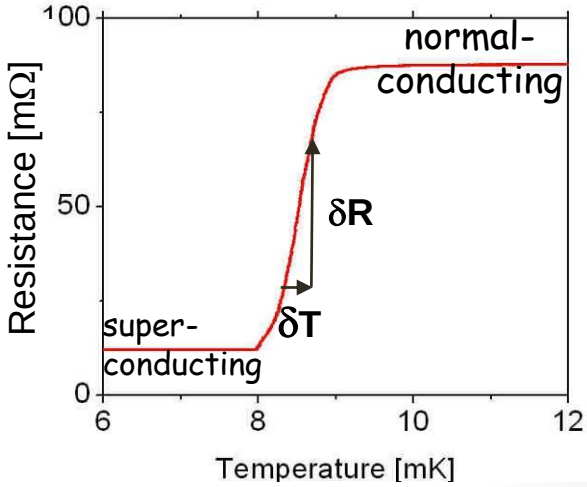


Present state of play

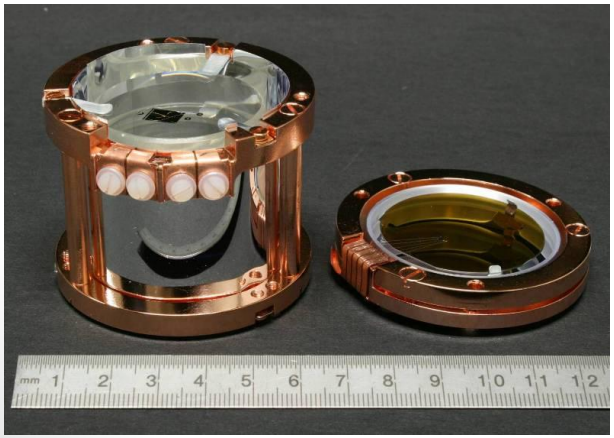
Aim of 1-tonne experiments

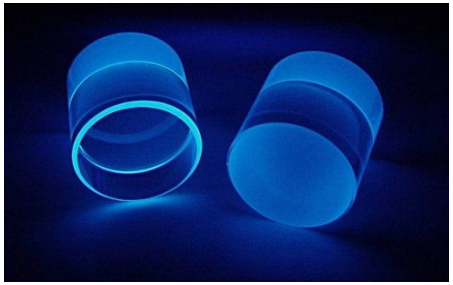
Phonon-Scintillation (CRESST)

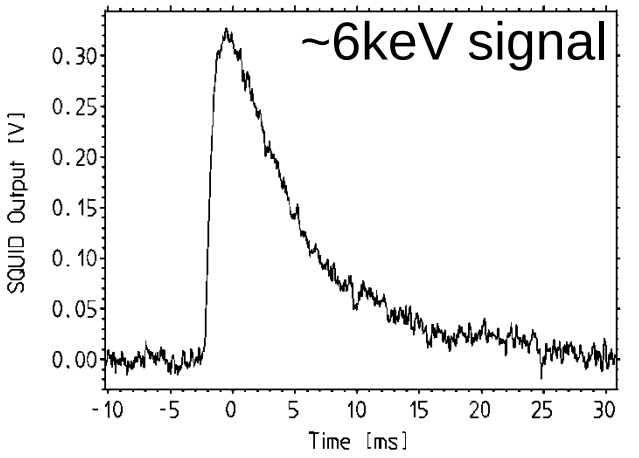




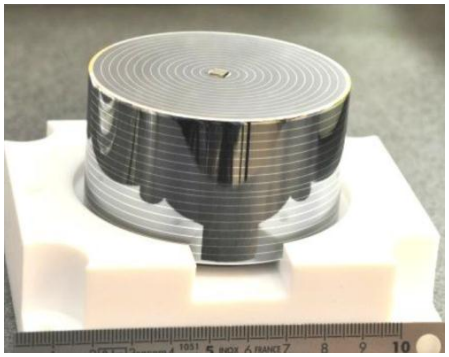
Width of transition: ~1mK
Signals: few μK
Stablity: ~ μK

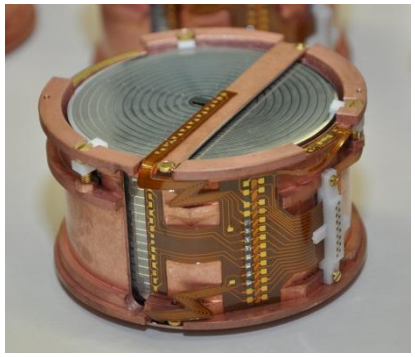


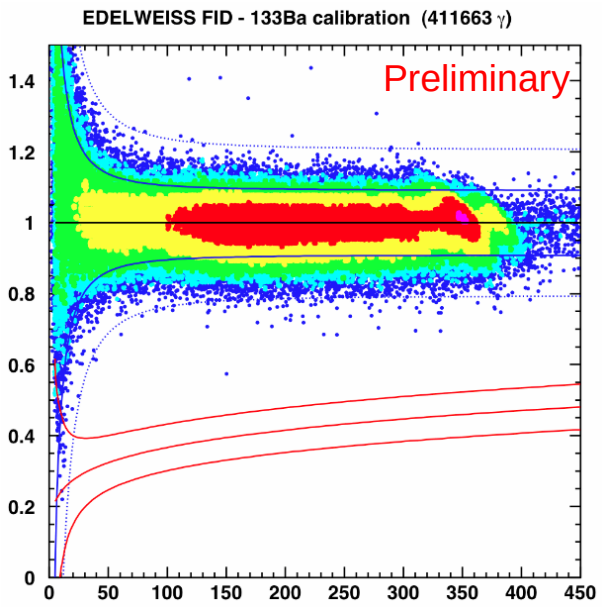




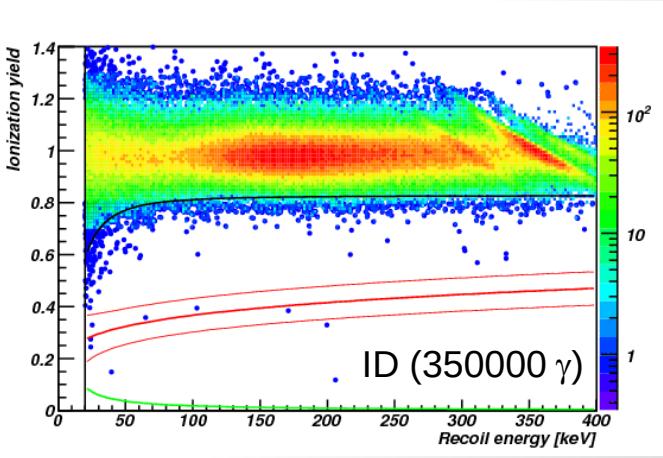
Phonon-Ionization (EDELWEISS)





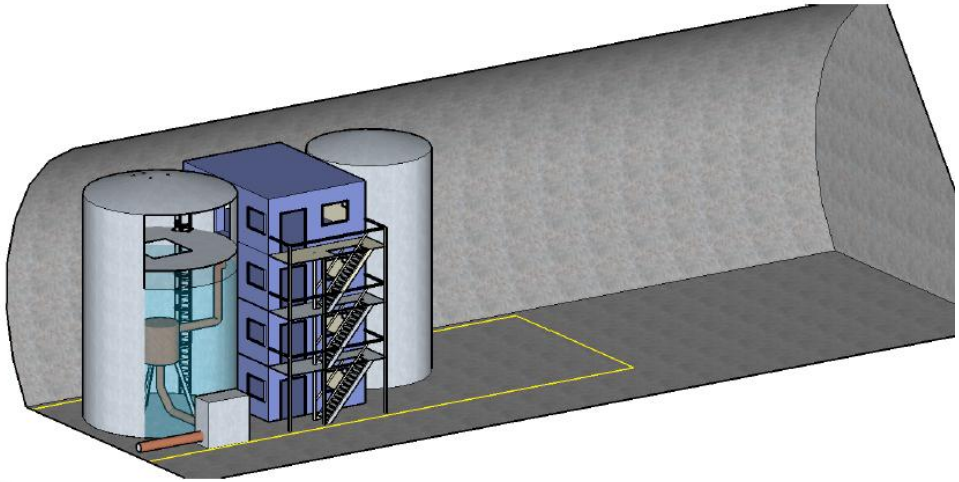


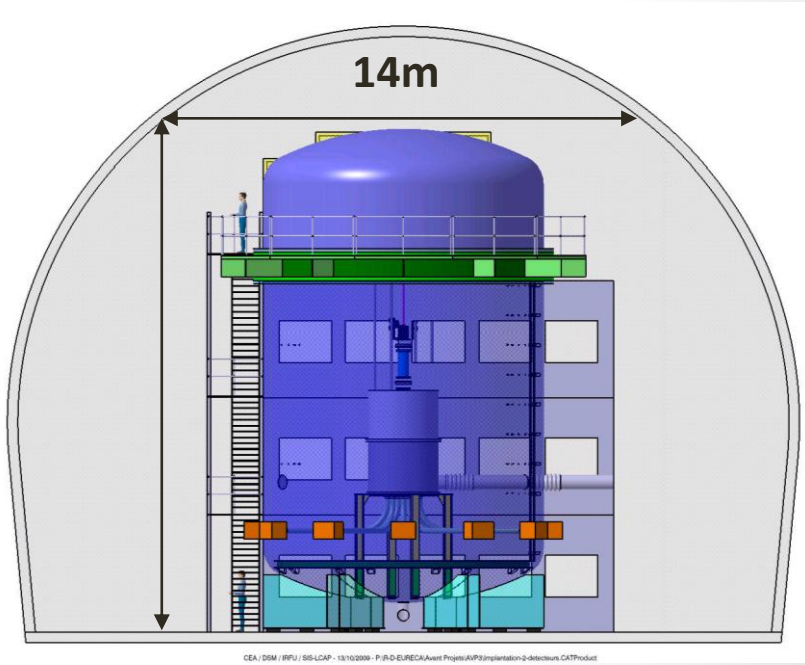
- All fiducial volume: more statistics than stacked ID-400 statistics
- No event in NR
- Expected to be and is indeed better than IDs!



Facility Layout

- One cryostat – on the left
  - base temperature: 7mK
  - large water instrumented (PMT) shield
  - container on the right – water buffer
- Two cryostat version also studied





Initial commissioning and validation of prototypes and detectors

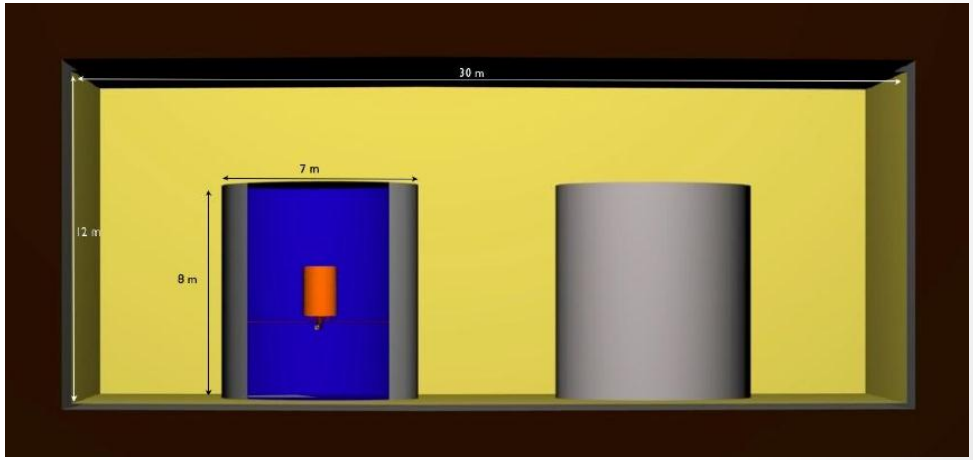
– in existing EDELWEISS and CRESST facilities

Shielding Arrangements

- Target sensitivity: 1 event/tonne/year
- Gamma rejection: 10^{-5} in ROI
- Shielding: 3m water, 15cm copper, 20cm CH_2/acrylic
- Radiopurity:
  - <0.02mBq/kg U/Th in Cu of cryostat
  - <10mBq/kg U/Th in material inside inner shielding

Geant4 simulations

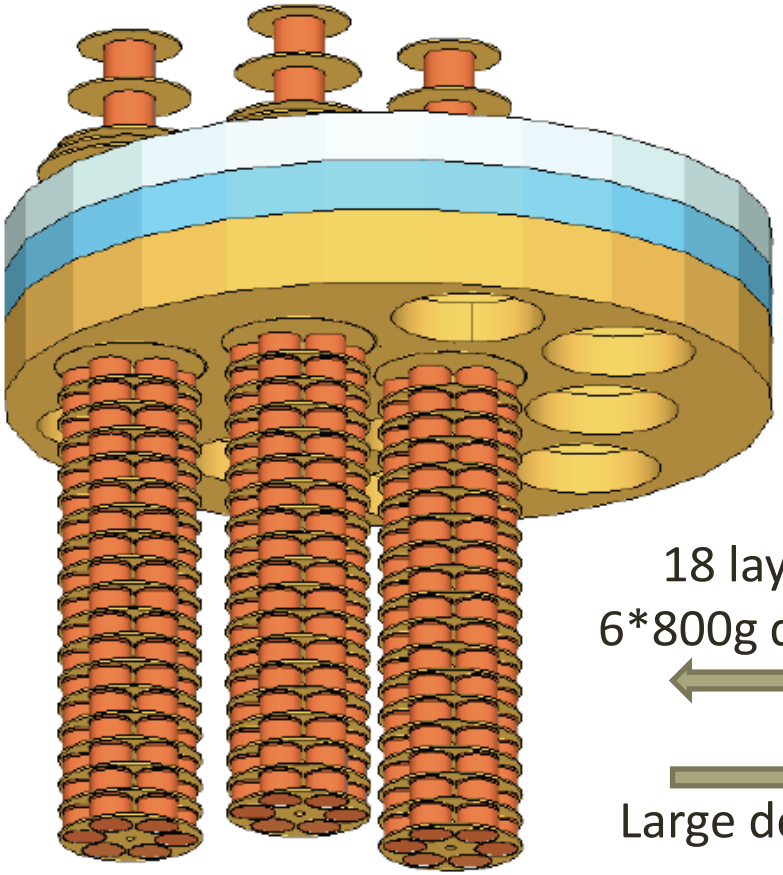
Astroparticle Physics
34 (2010) 70-79



- Expected gamma rate: 0.02 events/kg/day/keV (20-200keV)
- Expected neutron rate: <1.1 events/tonne/year

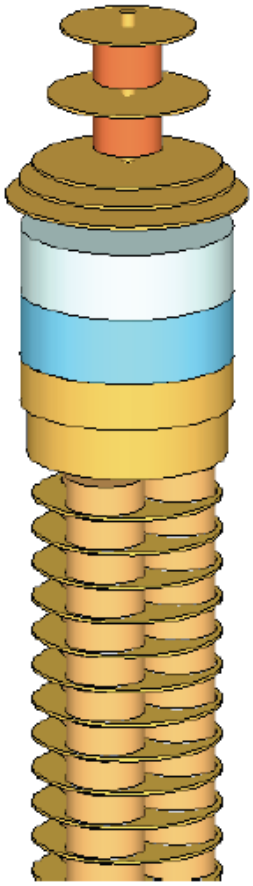
Detector Tower

- 12 towers, each equipped with electronics, cabling and shielding
- Space at 300K, 60K and 1.8K to accommodate individual electronics



18 layers of
6*800g detectors

Large detectors



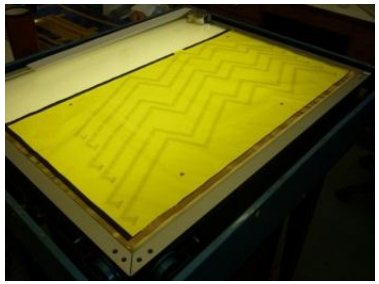
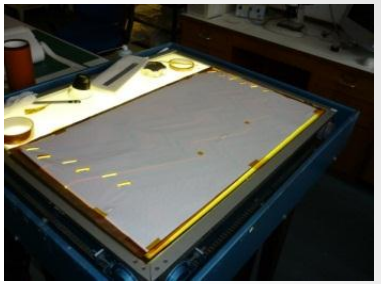
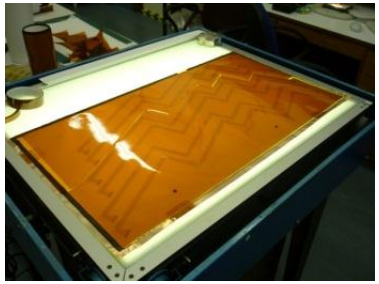
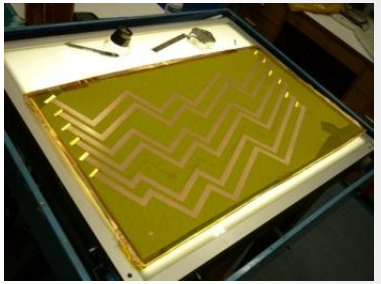
Various temperature levels (from room temperature down to 10mK)

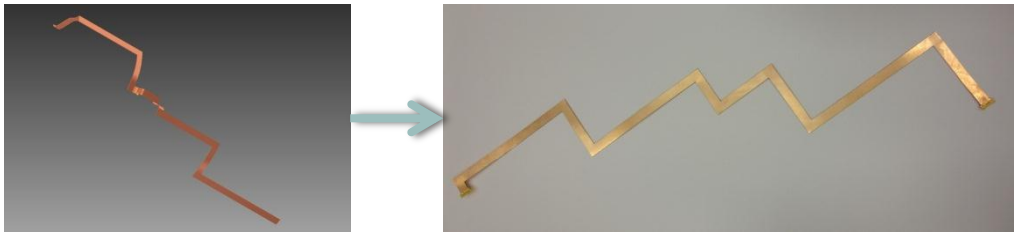
Shielding

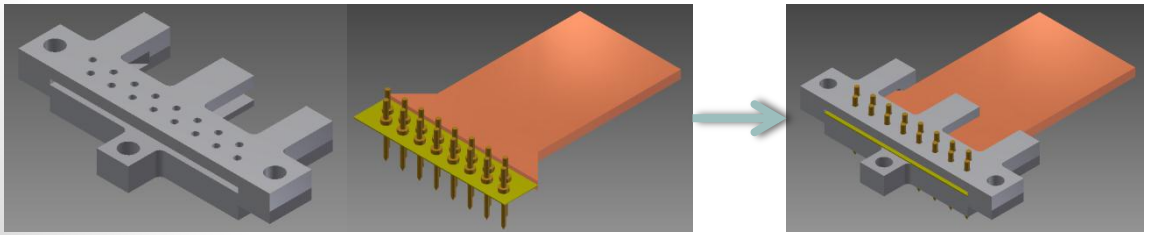
Detectors

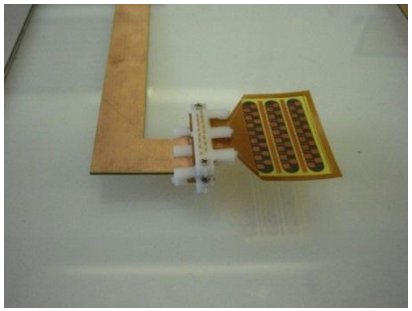
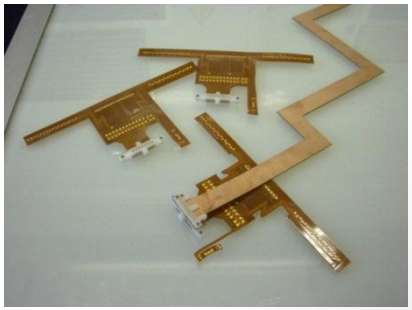
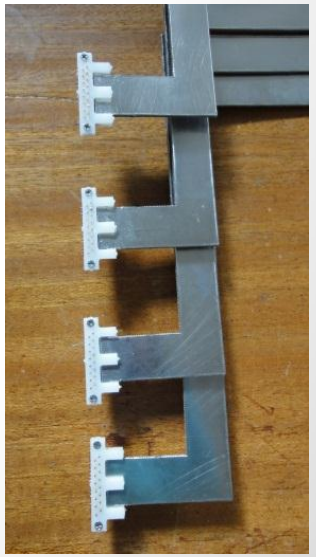
Cryogenic Cabling

- Can be used at <10mK
- Complete in-house solution
  - Full control over the process
- Selected and assessed materials only
- Semi-rigid for low noise performance
- With internally designed connectors
- Individual design for each position
  - Low material and space budget





CryoDetectors – Global Convergence

Germanium
phonon – ionization

$CaWO_4$
phonon – scintillation

CDMS
Soudan

EDELWEISS
Modane

CRESST
Gran Sasso

SuperCDMS
SNOLAB

Since 2009
Increasing collaboration towards common experiment

EURECA

Phase I (150kg)
Phase II (1000kg)

Summary

- European joint force
- Two-step approach (150kg and 1t)
- Cross section reach 10^{-10}pb -> 10^{-11}pb
- Multi-target approach
- Background ≈ 10^{-3}/(kg·year)
- Coordinated cooperation with Super-CDMS
- Conceptual Design Report 2012