European Underground Rare Event Calorimeter Array

Hans Kraus

LSM, 16th October 2009

The EURECA Collaboration

United Kingdom

- Oxford (H Kraus, coordinator)
- Sheffield

Germany

- MPI für Physik, Munich
- Technische Universität München
- Universität Tübingen
- Karlsruhe Institute of Technology

International

- JINR Dubna
- CERN

France

- CEA/IRFU Saclay
- CEA/IRAMIS Saclay
- CNRS/Neel Grenoble
- CNRS/CSNSM Orsay
- CNRS/IPNL Lyon
- CNRS/IAS Orsay

Spain

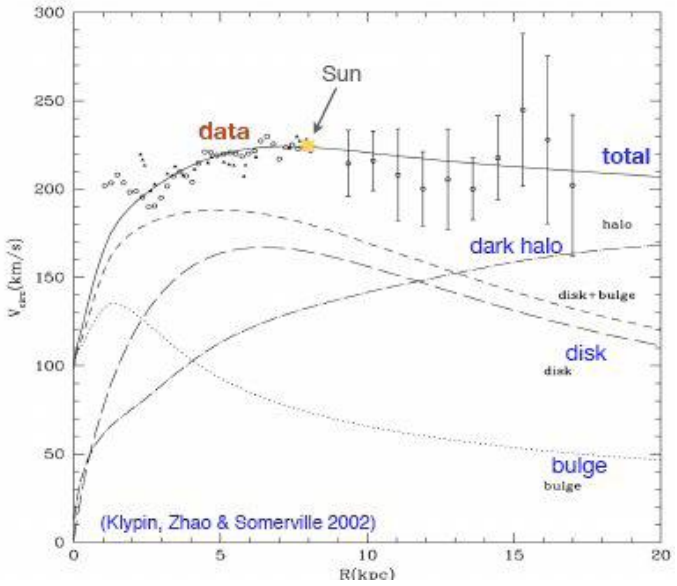
- Zaragoza

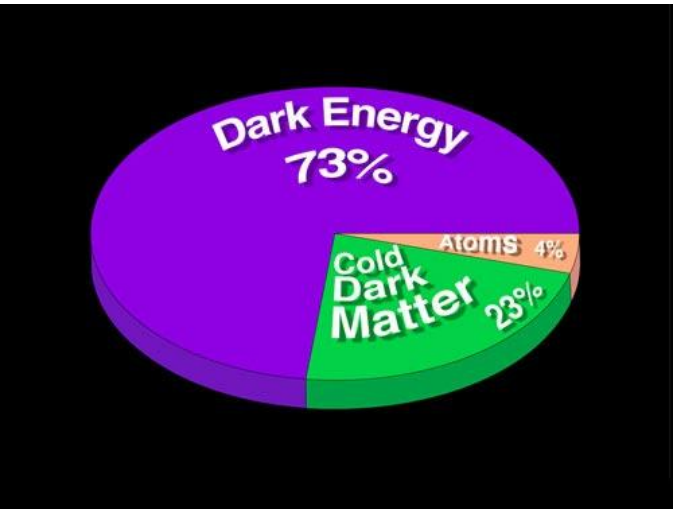
Ukraine

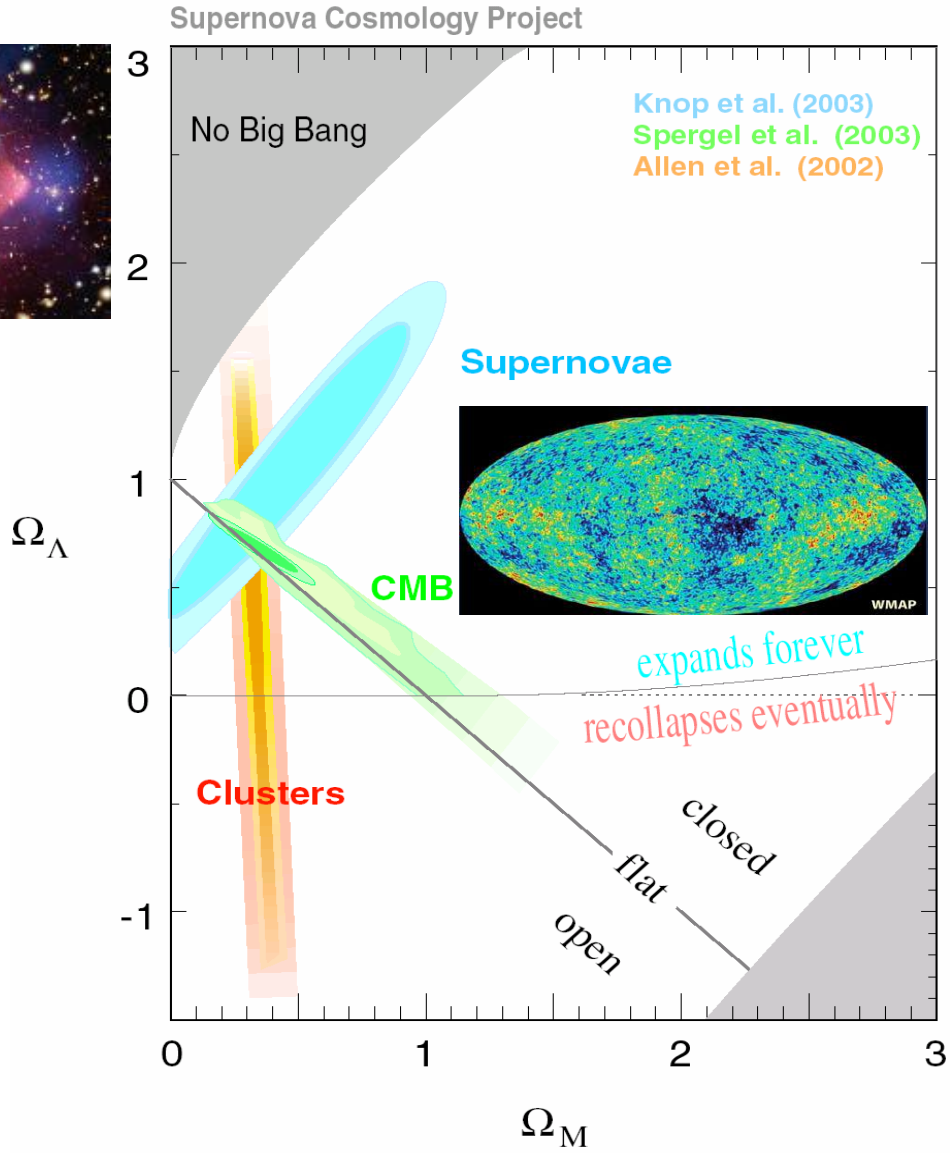
- Kiev

The Key Science Question

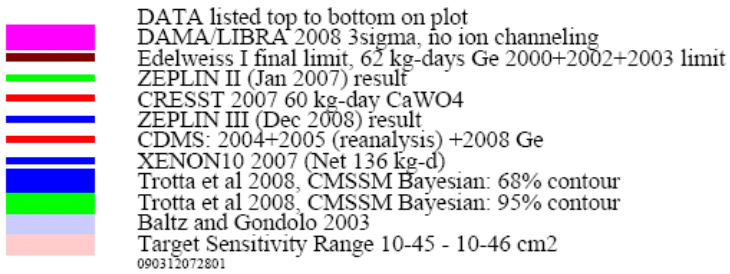
Strong evidence for Dark Matter







Current Results and Aims

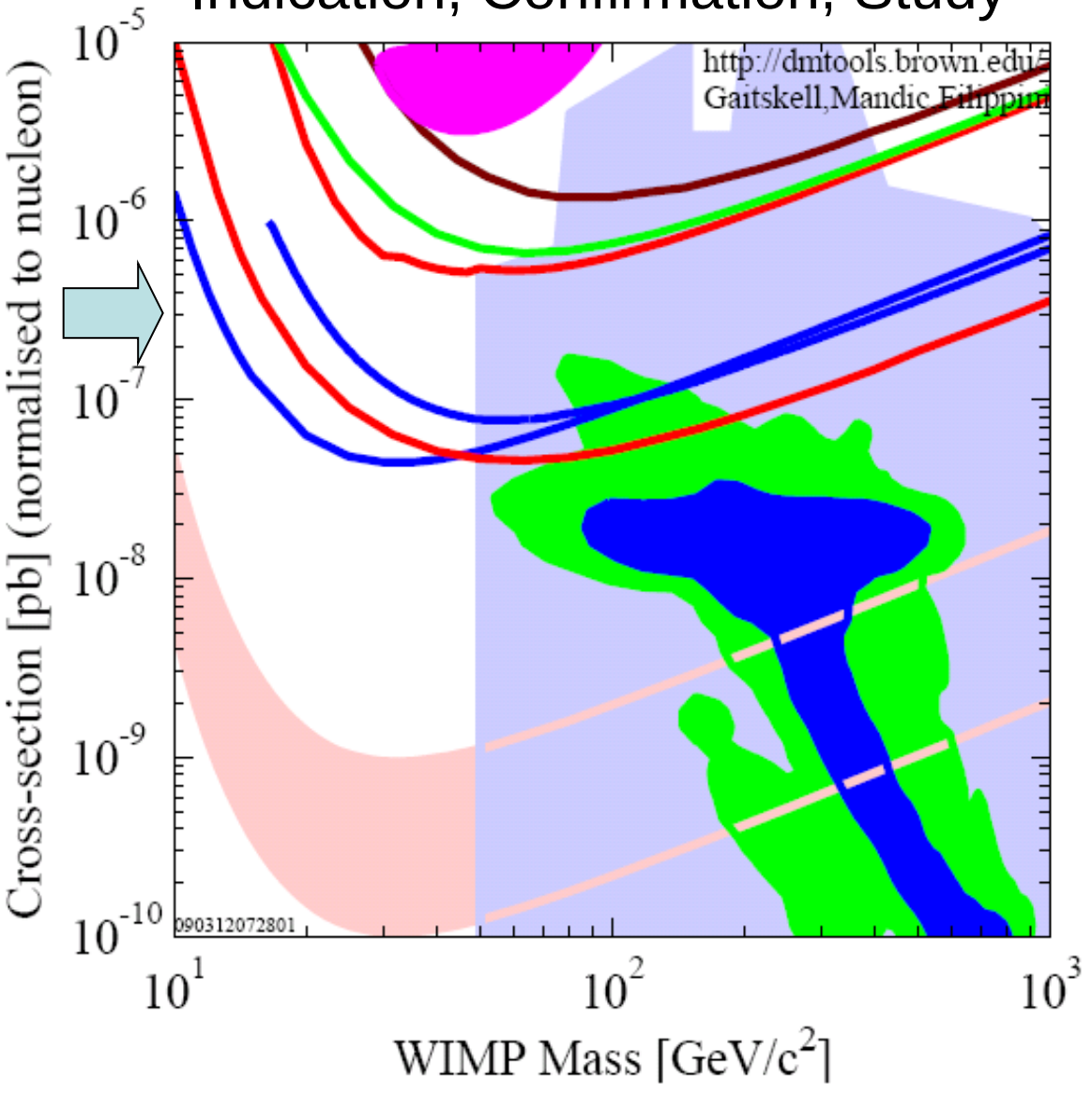


~1 evt/kg/day

~3 evt/kg/year

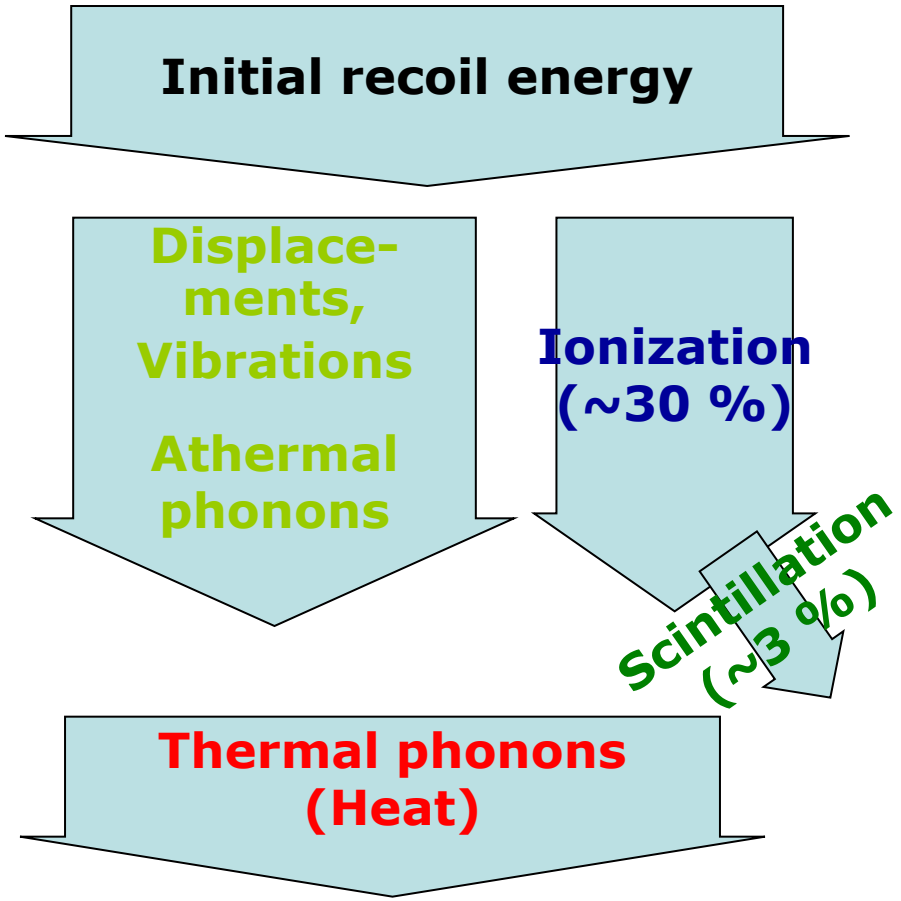
Next aim of "ton-scale" experiments

~30 evt/ton/year



Cryogenic Techniques

Combination of phonon measurement with measurement of ionization or scintillation

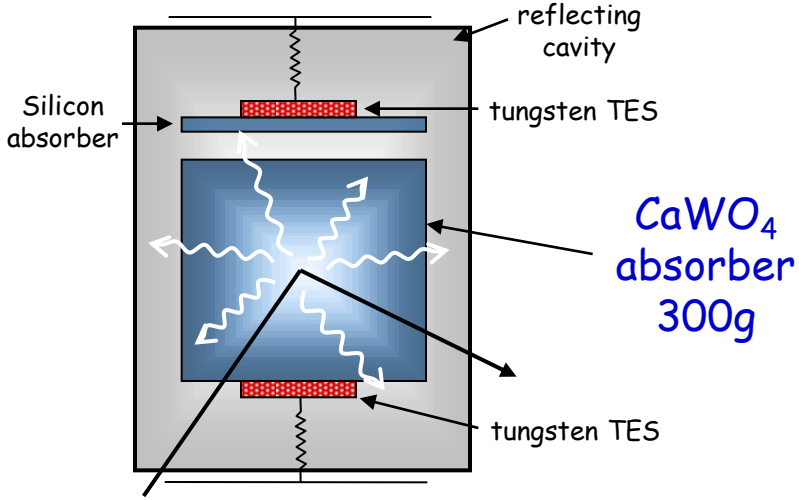


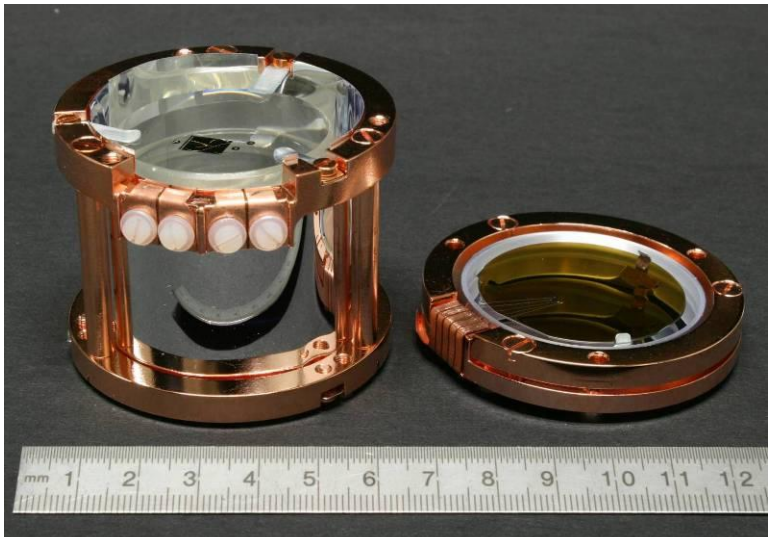
Phonon: most precise total energy measurement

Ionization / Scintillation: yield depends on recoiling particle

Nuclear / electron recoil discrimination.

CRESST Detectors





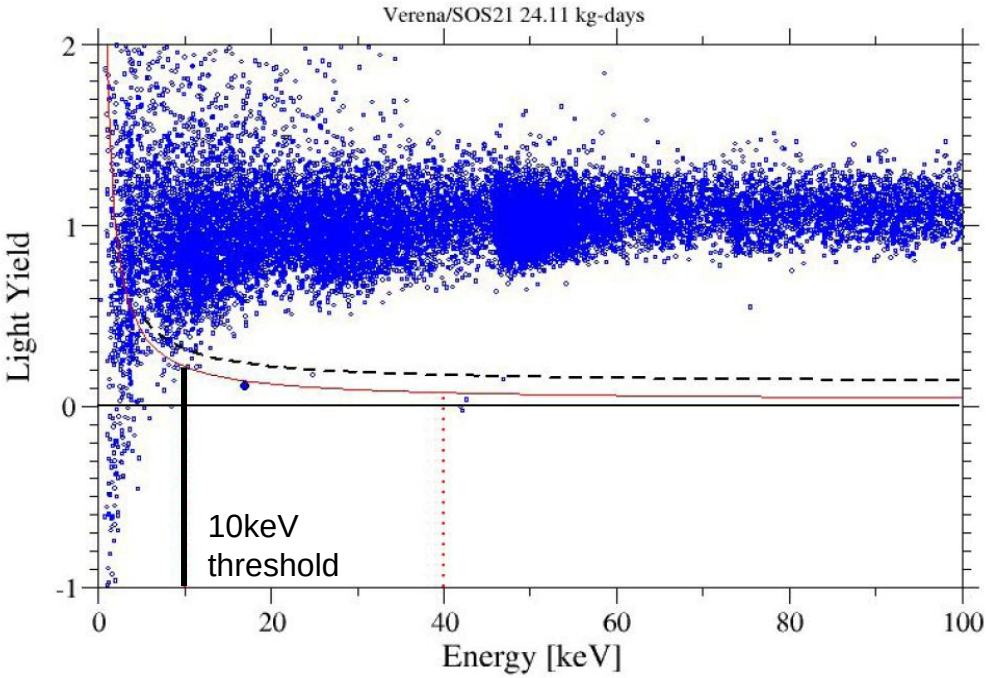
Phonon – Scintillation

Energy scale: Excellent resolution

Particle Identification: Background discrimination

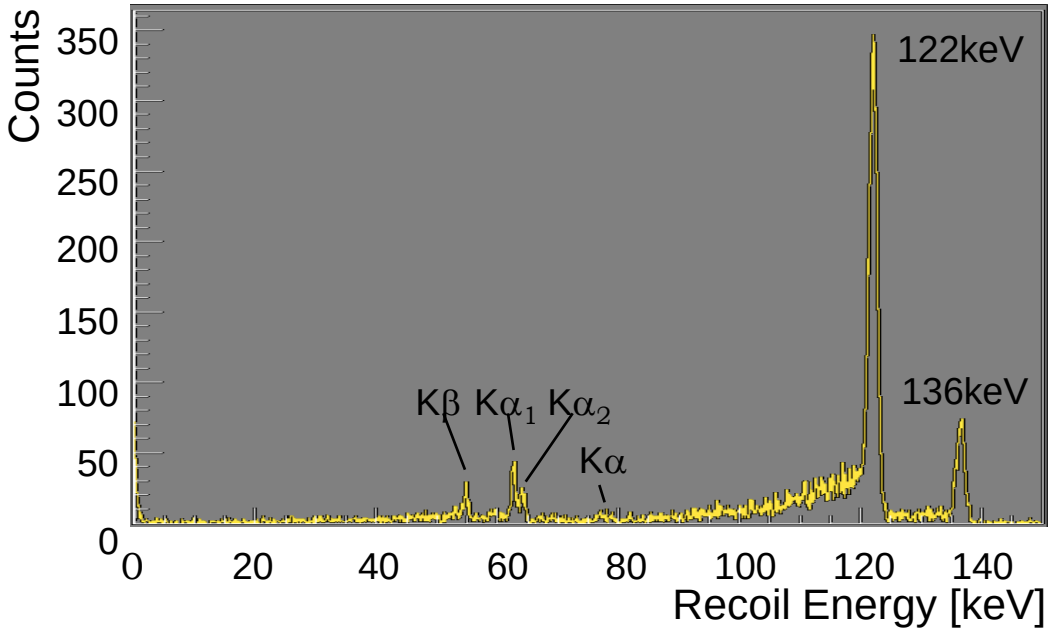
Range of Scintillator Targets

10 Detector Modules running



Detector Capability

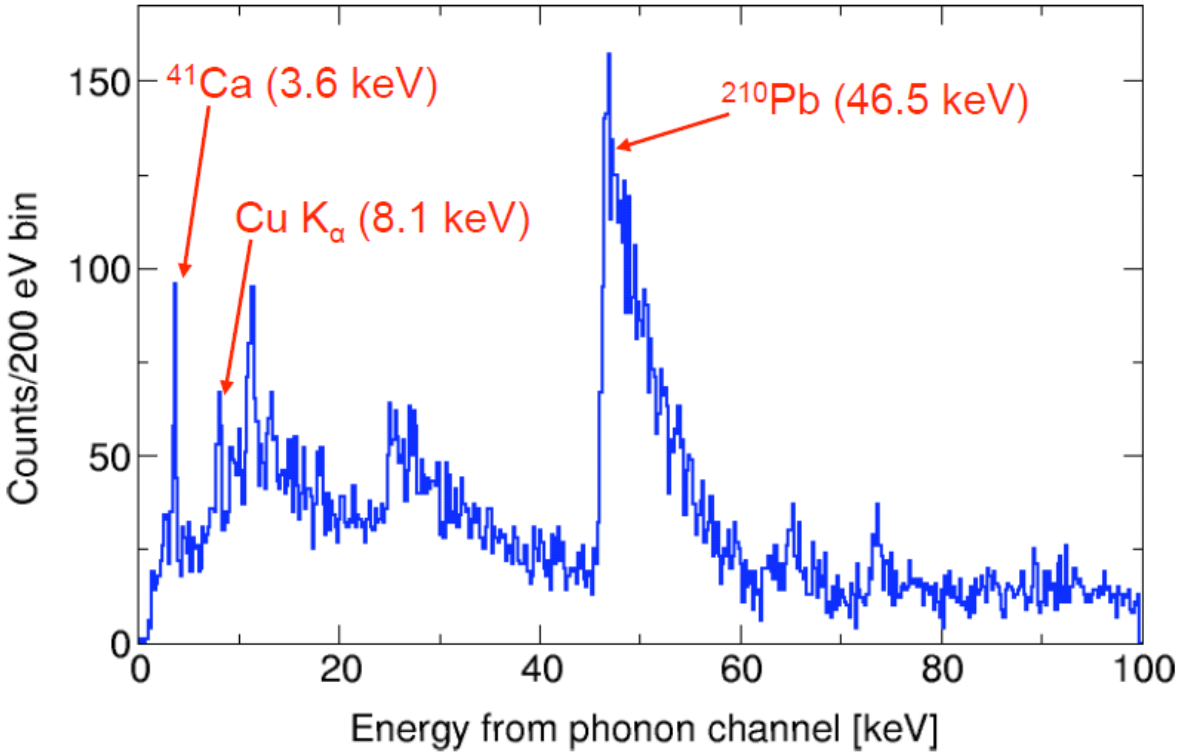
Example of a ^{57}Co calibration:



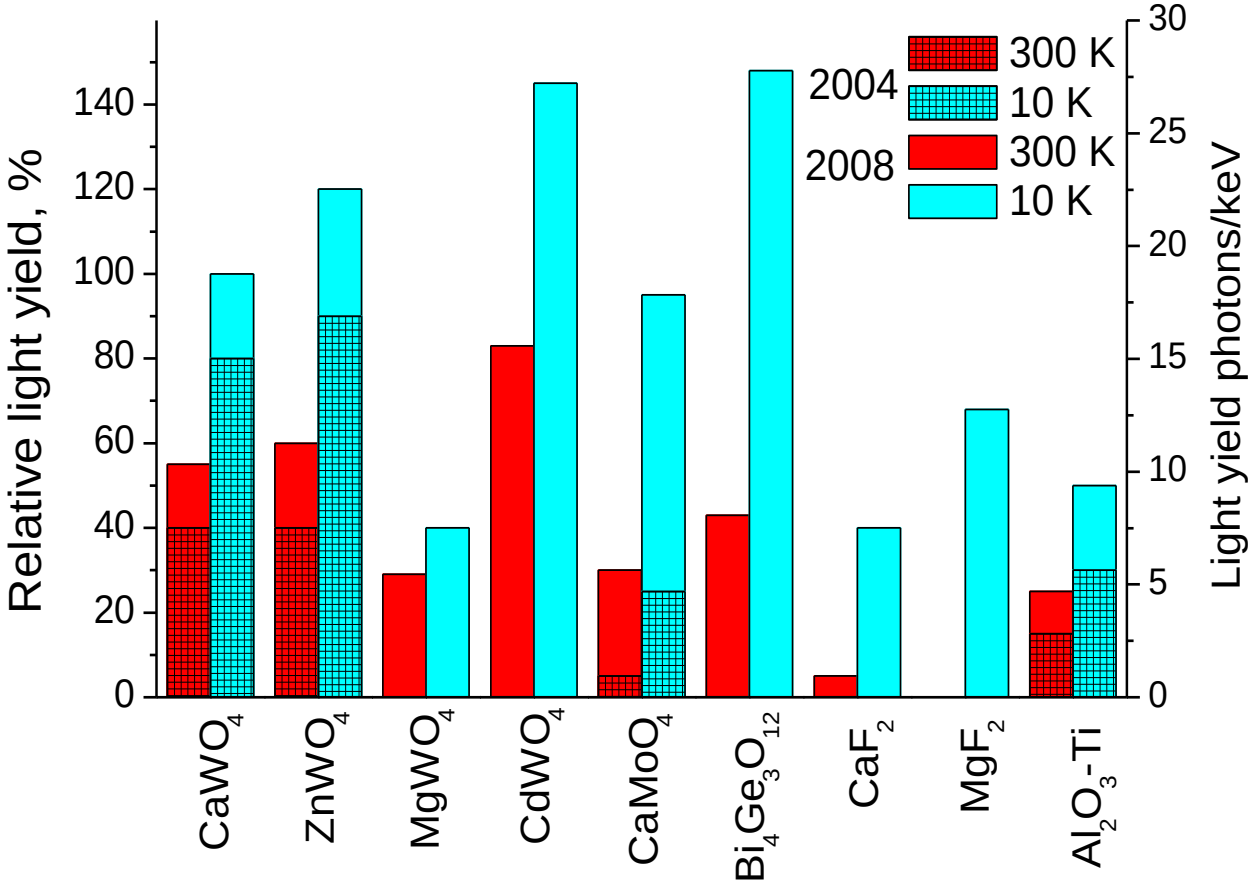
Example of a Background Spectrum:

Resolution at low energy ~ 300 eV (FWHM)

Threshold ~ 1 keV



Cryogen. Scintillators: light yield



Light yield of some targets is already satisfactory;
Further improvement is possible;
Focus and down-selection (RPSCINT workshops).

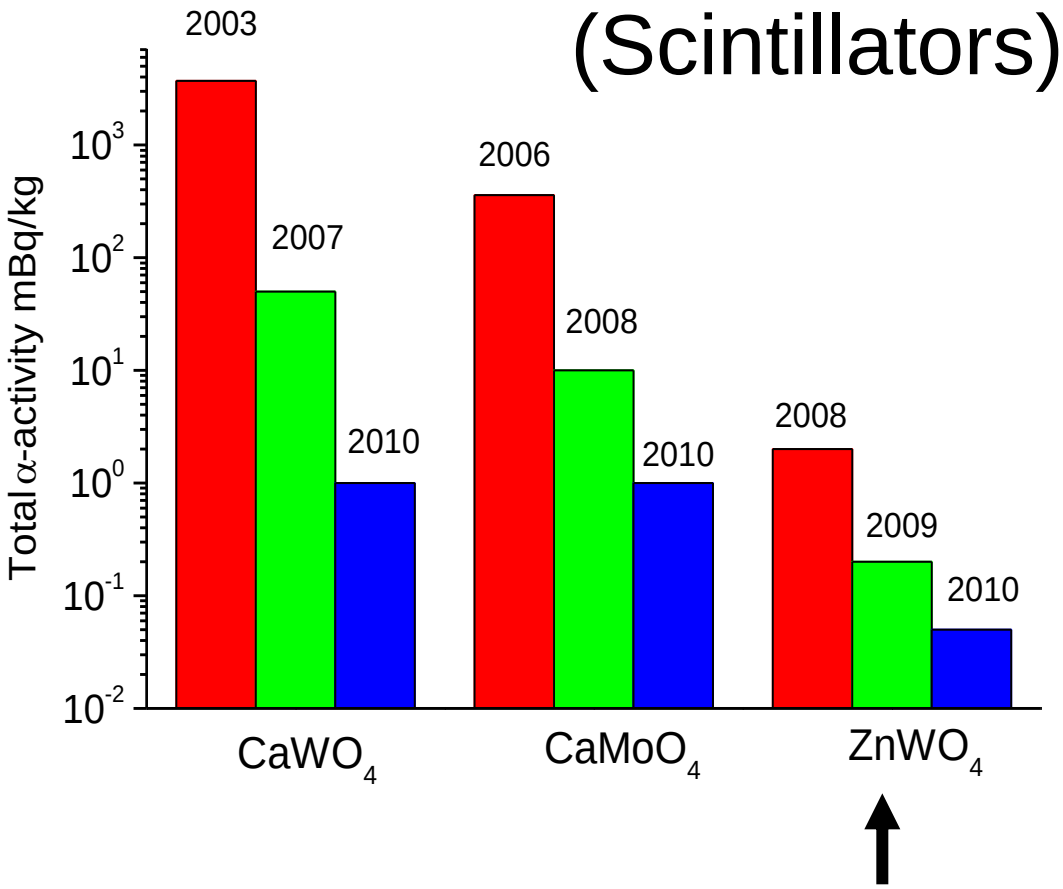
Tackling Intrinsic Radioactivity

(Scintillators)

1) Chemical purification of raw materials

2) Multiple re-crystallisation

3) Need technique for fast reliable assessment of radioactivity at required low levels



α-activity ~ 0.2 mBq/kg obtained for $ZnWO_4$

Achieving <0.01 mBg/kg for $ZnWO_4$ target in EURECA should be possible.

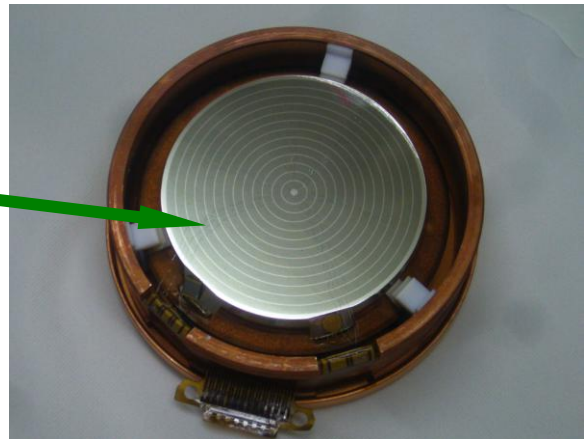
Edelweiss (InterDigitised) Detectors

Phonon – Ionization

Energy scale: Excellent resolution

Particle Identification: Background discrimination

From plain to concentric alternate V electrodes

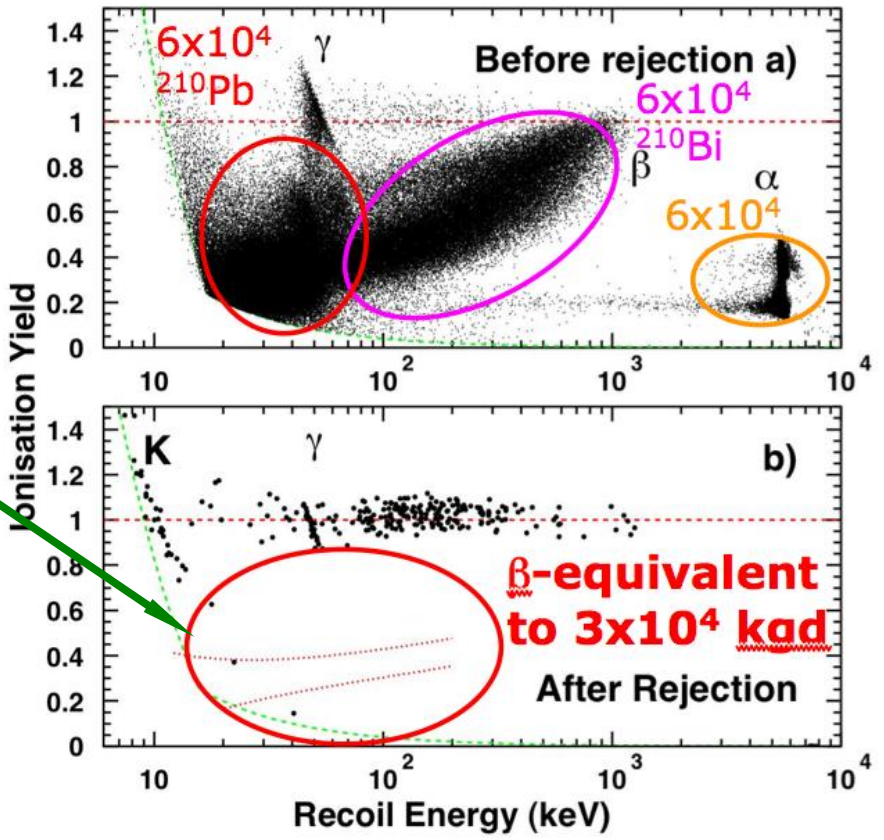


10 new 400g Ge ID detectors running with **InterDigitized electrodes**

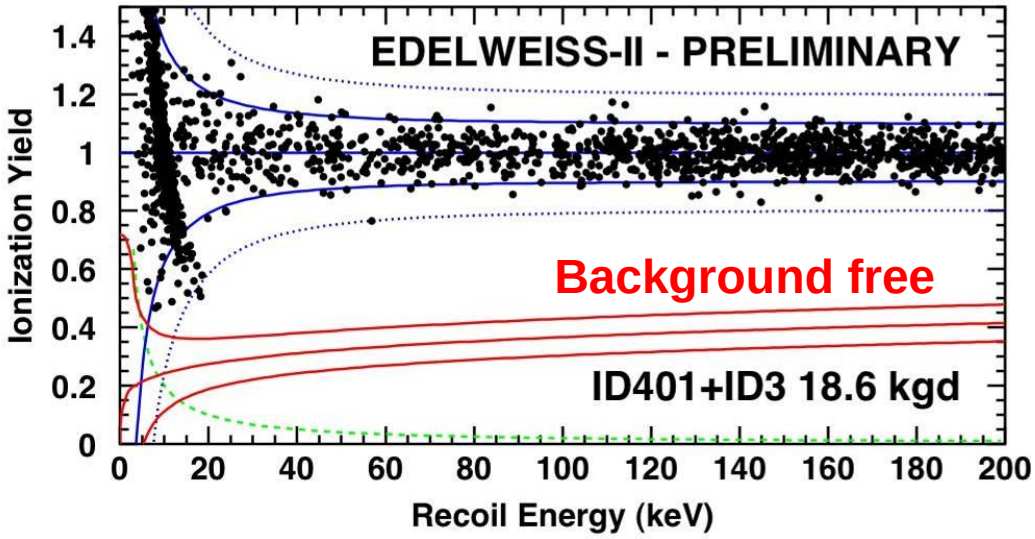
Removes "surface" events (^{210}Pb)
=> clean nuclear recoil band

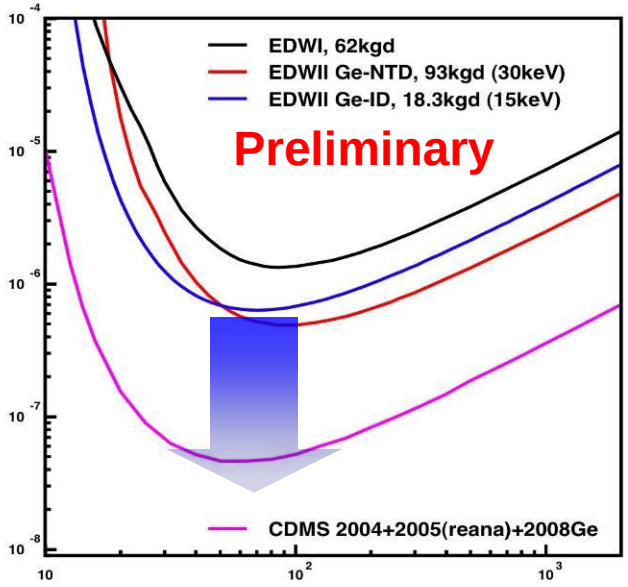
1 β evt expected in 30 000 kg.d
equivalent to 10^{-9} pb sensitivity
+ decrease of ^{210}Pb background
=> EURECA goal

Recent preprint : arXiv:0905.0753v1



Edelweiss Detectors (Status)

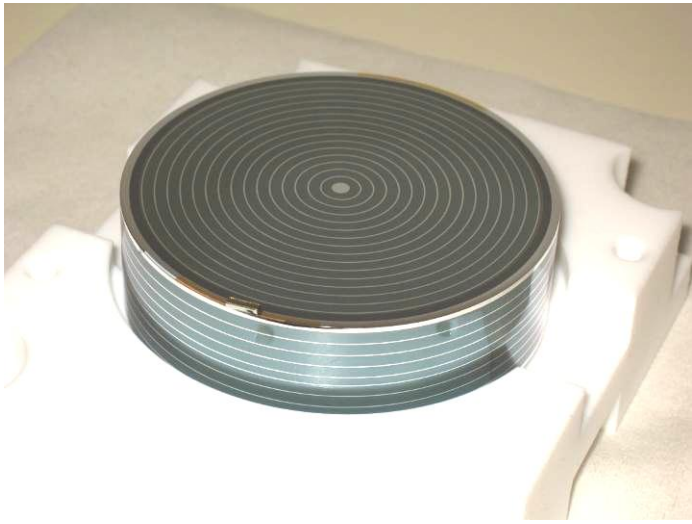




2008:
- 86 live days / 4 months / 2x400g detectors
- 18.3 kg.d with < 15 keV threshold, ~50% eff at 10keV

2009: physics run ongoing
- 10 detectors running (2kg fiducial)
- x 20 improvement by 2010 : 4×10^{-8} pb
- Additional new detectors w increased fiducial volume

(« FIDs » 400g, 800g) => 9 kg fiducial mass end 2010



Work Packages and Global Fit

Memorandum of Understanding signed between EURECA, SuperCDMS, and GEODM

Maintain scientific independence, but collaborate where this is beneficial

Work package	**EURECA**	**Super-CDMS**	**GEODM**
Management	H Kraus	D Bauer	S Golwala
Infrastructure	G Gerbier	D Bauer	S Golwala
Cryogenics	A Benoit	D Bauer	S Golwala
Electronics	J Gascon	J Hall	B Sadoulet
Detectors	A Broniatowski / F v Feilitzsch	P Brink / N Mirabolfathi	P Brink / N Mirabolfathi
Low background	V Kudryavtsev / P Loaiza	P Cushman	P Cushman
Data Analysis	K Eitel	R Schnee	R Schnee

Teams with Proven Expertise

I: Infrastructure

C: Cryogenics

E: Electronics

D: Detectors

L: Low-background

Team	I	C	E	D	L
University of Oxford		X	X	X	
Max-Planck-Institut für Physik Munich		X		X	X
Technische Universität München	X			X	
Eberhard Karls Universität Tübingen	X		X		X
Karlsruhe Institute of Technology	X	X			
CEA/IRFU Saclay	X		X	X	
CEA/IRAMIS Saclay		X	X	X	
CNRS/IN2P3/CSNSM Orsay				X	X
CNRS/IN2P3/IPNL Lyon			X		X
CNRS/INSUE/IAS				X	X
CNRS/Neel Grenoble		X	X		
CNRS/CEA LSM	X				X
JINR/DLNP Dubna				X	X
INR Kiev				X	X
Sheffield University	X				X
CERN	X	X			
CNRS/IAS Orsay				X	X
Universidad de Zaragoza	X				X

Balanced expertise through **~110 people** contributing **~65 FTE**

EURECA in LSM

Timeline:

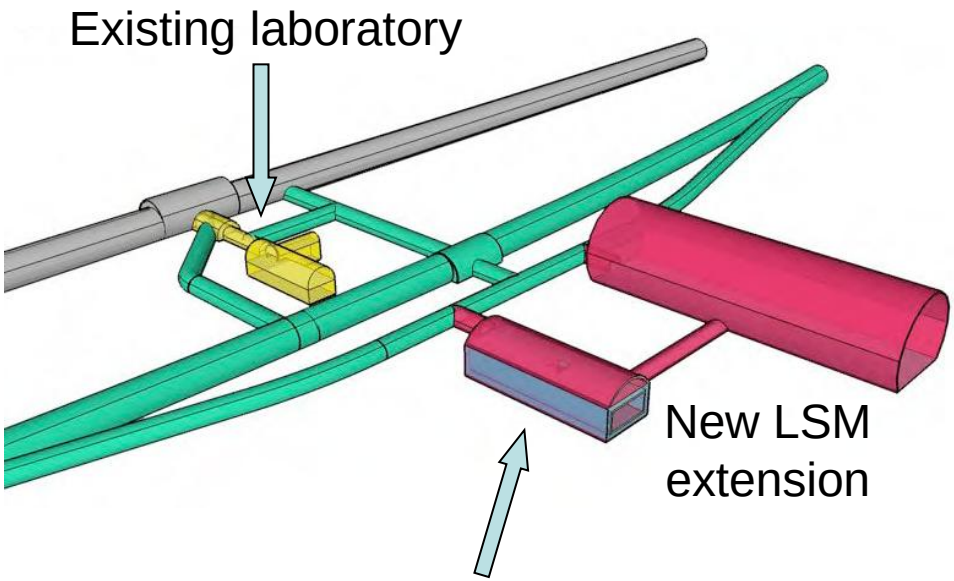
2009/10: Design Study → TDR

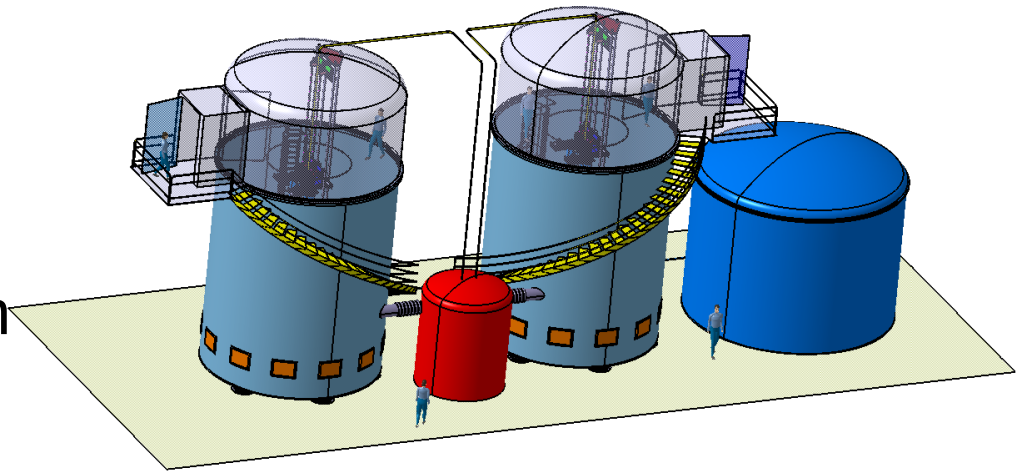
2011/12: In parallel to LSM excavation, begin construction of EURECA components away from LSM. Aim for ~100kg stage (10^{-9} pb).

2014: LSM extension ready to receive EURECA.

2015: Begin data taking and in parallel improve and upgrade.

2018: One tonne target installed.

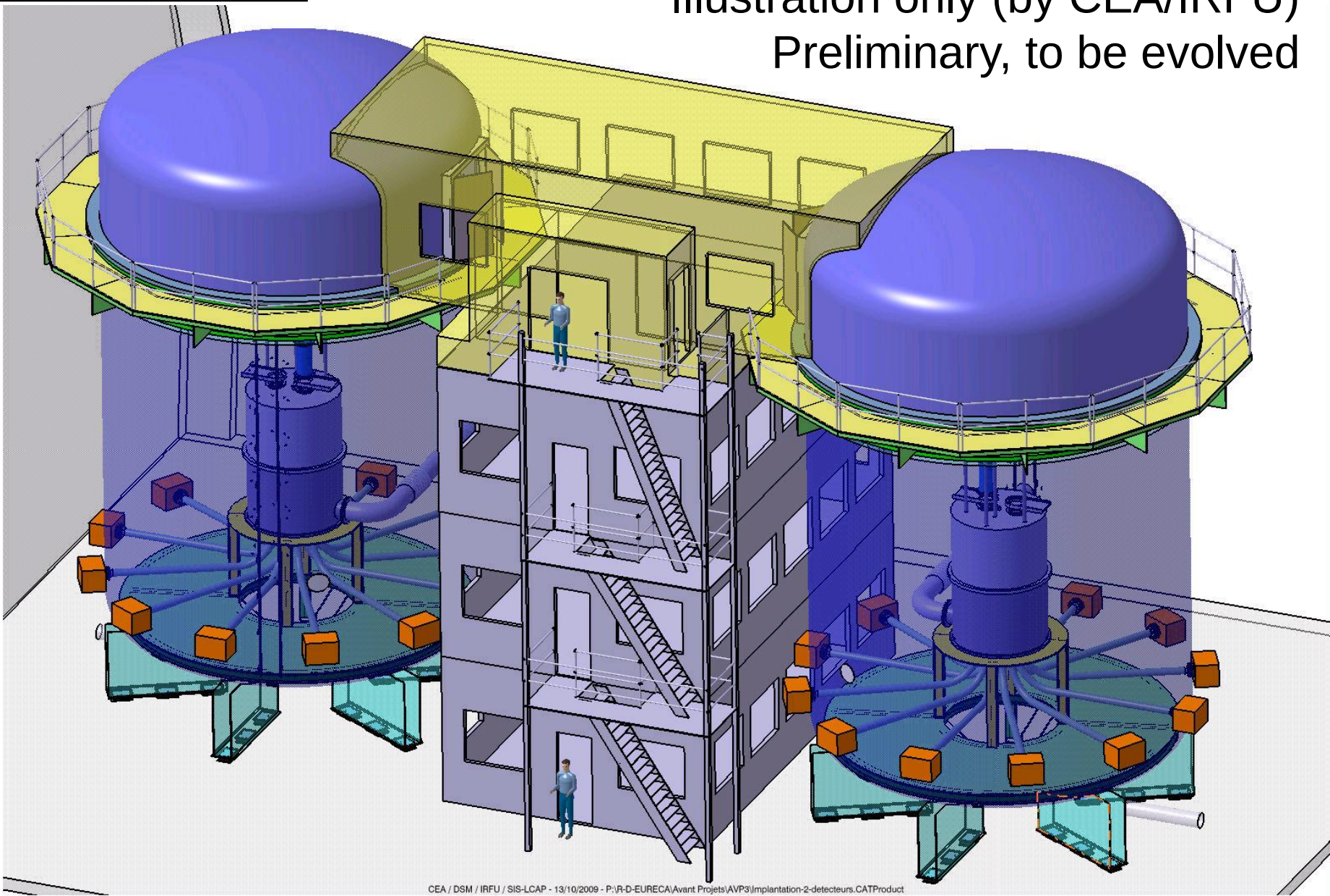




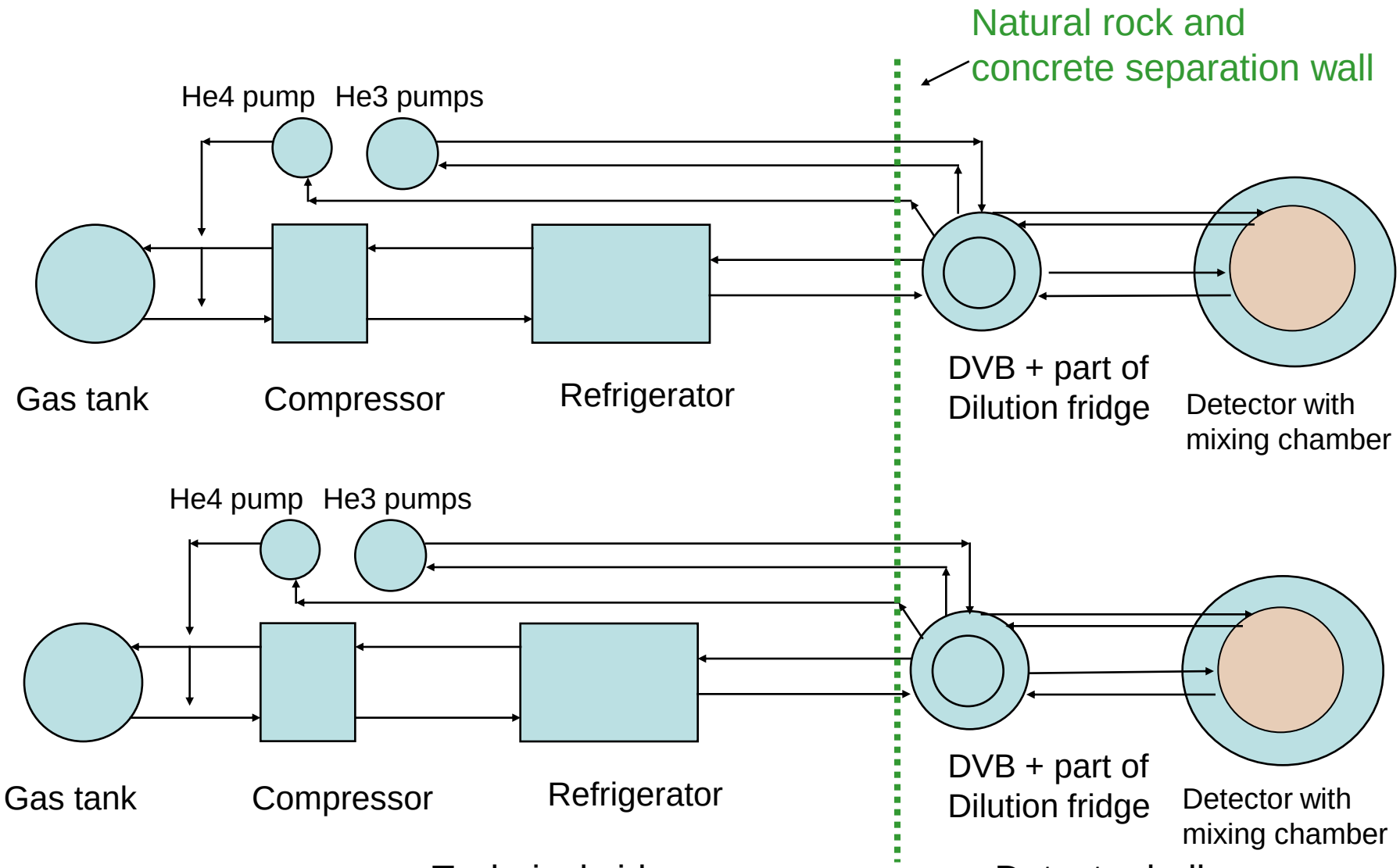
Possible EURECA Facility Layout

More Detailed View of EURECA

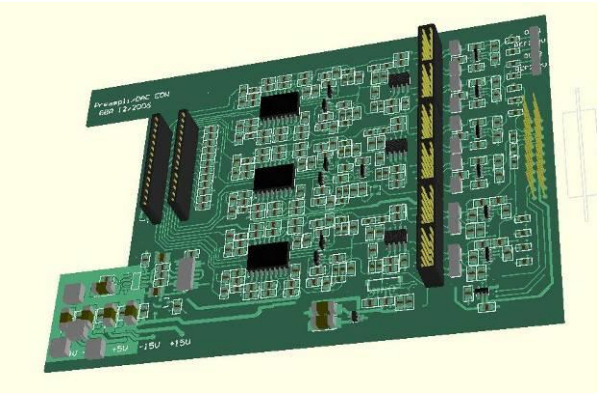
Illustration only (by CEA/IRFU)
Preliminary, to be evolved

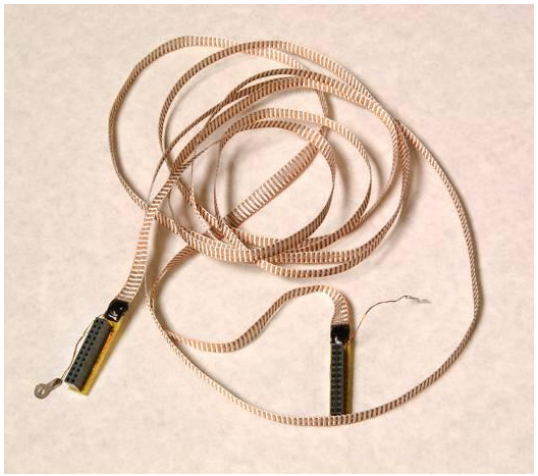


Cryogenics: Equipment Location



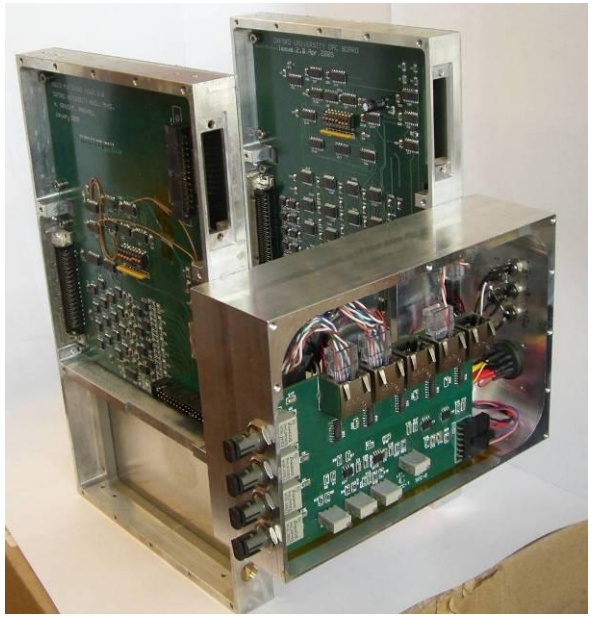
Electronics, cabling, etc





- Reduce cost per channel
- Keep intellectual property in-house
- Already significant savings identified
- Simplify

Design and prototyping on track

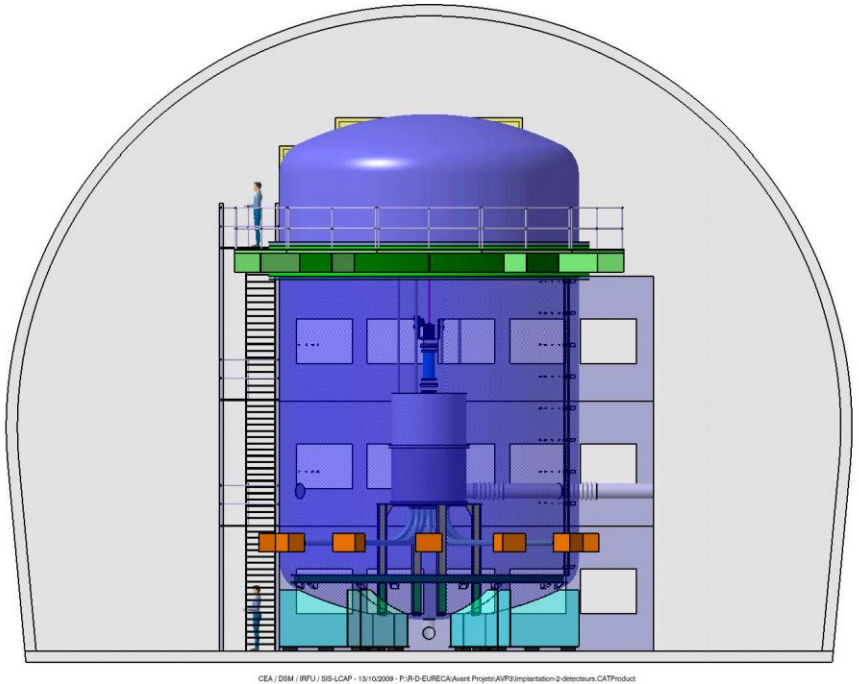


Request Summary

Space: a volume of 30 x 14 x 14 m^3 to accommodate two water shields and the EURECA building in between.

Services: 190 kW electrical power; cooling facilities to remove 190 kW of heat; radon-free air (700 m^3 peak at <0.1 Bq/m^3, safe for people to work in); purification of 1,000 m^3 water; and ~160 m^2 clean room facilities (range of classes).

Away from the EURECA facility: 500 m^3 for water storage and ~150 m^3 for compressors (liquid cryogen system) and gas storage.



Timeline and Summary

Project	09	10	11	12	13	14	15	16	17	18	19
Project R&D											
ASPERA Design Study											
Construction I											
Construction II											
Exploitation I											
Construction III (1 ton)											
Exploitation II											

EURECA is the European Cryogenic Dark Matter Search

Well-aligned with other Tonne-scale Dark Matter Searches

Cryogenic Detectors have excellent discrimination power, low threshold, and good energy resolution.

Near background-free operation allows fast progress.