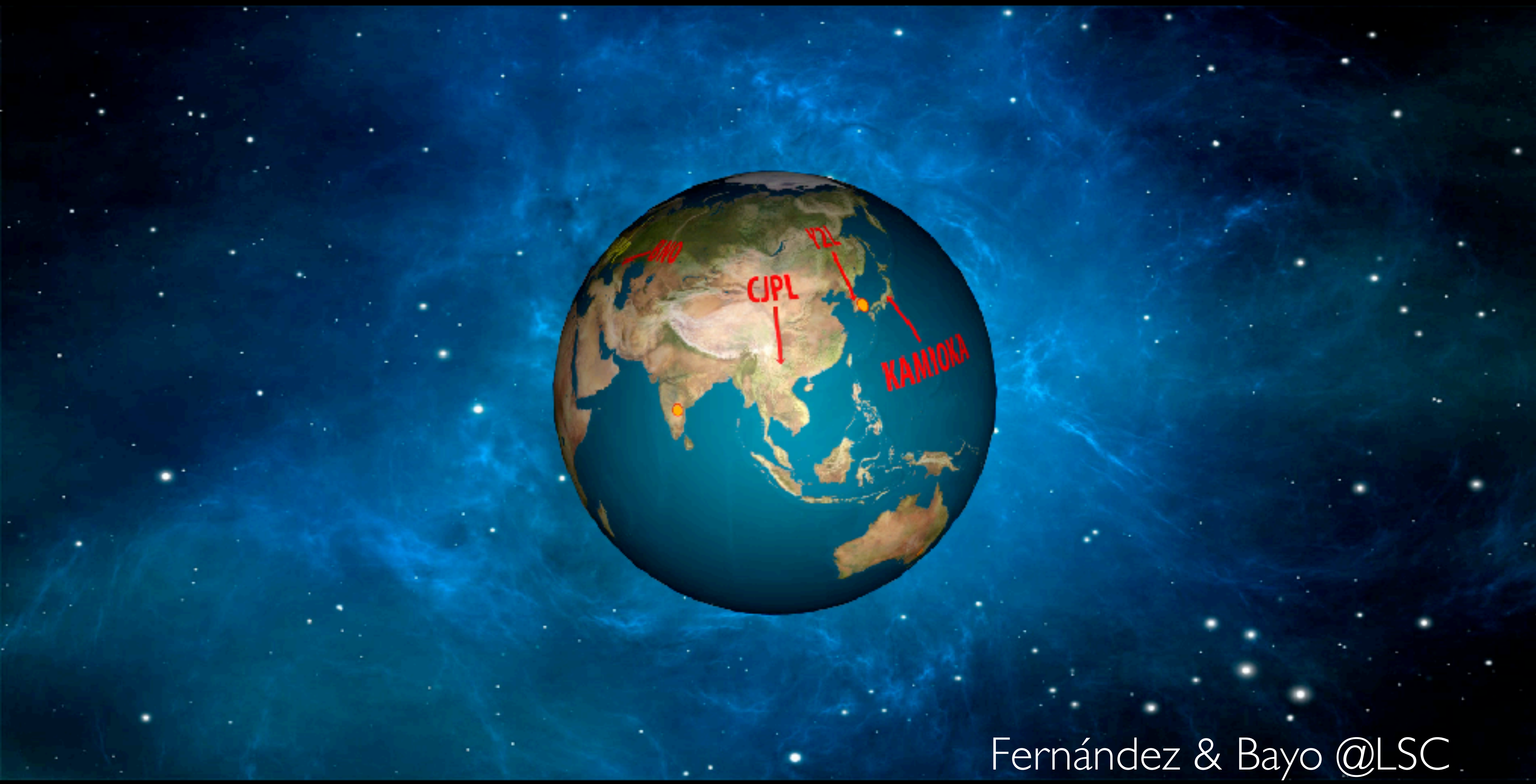
APPEC MEETING 2019 : DEEP UNDERGROUND LABS

INFN LNGS · LSC Laboratorio Subterráneo de Canfranc · LPSC Grenoble LSM Modane · LSM · BOULBY UNDERGROUND LABORATORY



October 31, 2019 Carlos Peña Garay (LSC)

Double Beta Decay APPEC Committee Report

Version 2

October 11, 2019

Committee members: Andrea Giuliani, J.J. Gomez Cadenas, Silvia Pascoli (Chair), Ezio Previtali, Ruben Saakyan, Karoline Schäffner and Stefan Schönert

In order to establish a multi-technology and multi-isotope DBD0ν physics program extensive underground space to host the DBD0ν-experiments is necessary. Facilities, not only in Europe, are encouraged to support this rich physics strategy by providing the necessary underground space (including upgrading existing facilities) as well as onsite expertise in low-background techniques to guarantee an effective and timely implementation of the experiments. Close coordination between the European underground laboratories for hosting prototype detectors and low-background screening is mandatory.

Recommendation 5. The European underground laboratories should provide the required space and infrastructures for next generation double beta decay experiments and coordinate efforts in screening and prototyping.

FIRST ASTROPARTICLE PHYSICS UNDERGROUND LAB (circa 1901)

Neidpath tunnel: First underground physics experiments conducted by CTR Wilson, early 20th century

N.J.T. Smith, DUL review

EXISTING DULs: SOME NUMBERS

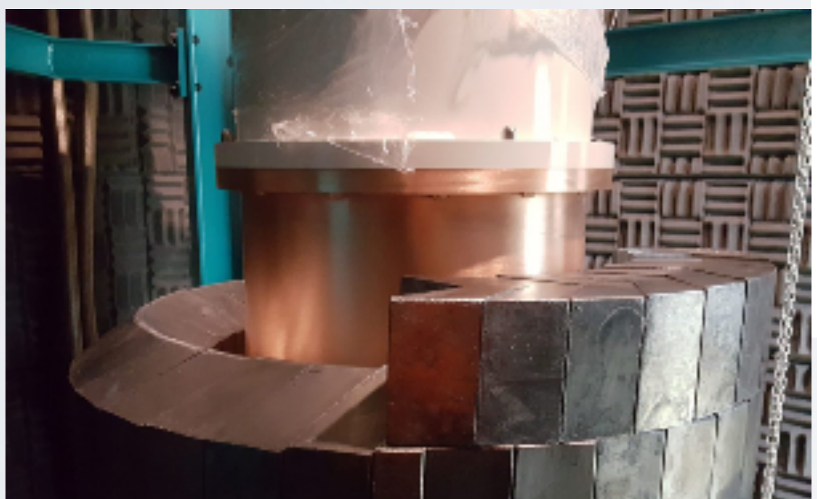
	SNOLab	LNGS	LSC	Boulby	LSM	Callio Lab	Baksan	SURF	CJPL-I/II	Kamioka	Y2L
Date of creation	2003 (1991)	1987	2010	1989	1982	1995	1967	2007 (1967)	2009/ 2014	1983	2003 A6 2014 A5
Personnel	100	106	12	6	12	13	227	125	20	94	4
Surface U/S [m^2]	5350/ 3100	17000/ 95000	1600/ 2550	1700/ 400	400	220	1600/ 10000	1900/ 190	8000	15000/ 3000	300/ 60
Volume [m^3]	30000	**180000**	10000	7200	3500	1000*	23000	7160	4000/ **300000**	150000	5000
Depth [m]	2070	1400	850	1100	1700	1440	1700	1500	2400	1000	700
Access [V or H]	V	H	H	V	H	V / drive in	H	H	H	H	Drive in
Makeup Air [m^3/h]	12000	35000-60000	20000	300	5500	3600	1440	510000	_	6000	3300
Air change/day	10	5-8	48	24	38	7	_	144 (LUX)	_	6	15
Muon flux [m/m^2/s]	$3.1\ 10^{-6}$	$3\ 10^{-4}$	$3\ 10^{-3}$	$4\ 10^{-4}$	$4.6\ 10^{-5}$	$1\ 10^{-4}$	$3\ 10^{-5}$	$5.3\ 10^{-5}$	$2\ 10^{-6}$	10^{-3}	$4\ 10^{-3}$
Radon [Bq/m^3]	130	80	100	<3	15	70	40	300	40	80	40
Cleanliness	2000 or better	Only in sector	Only in sector	10000	ISO9	Only in sector	Only in sectors	3000	Only in sectors	Only in sectors	Only in sectors

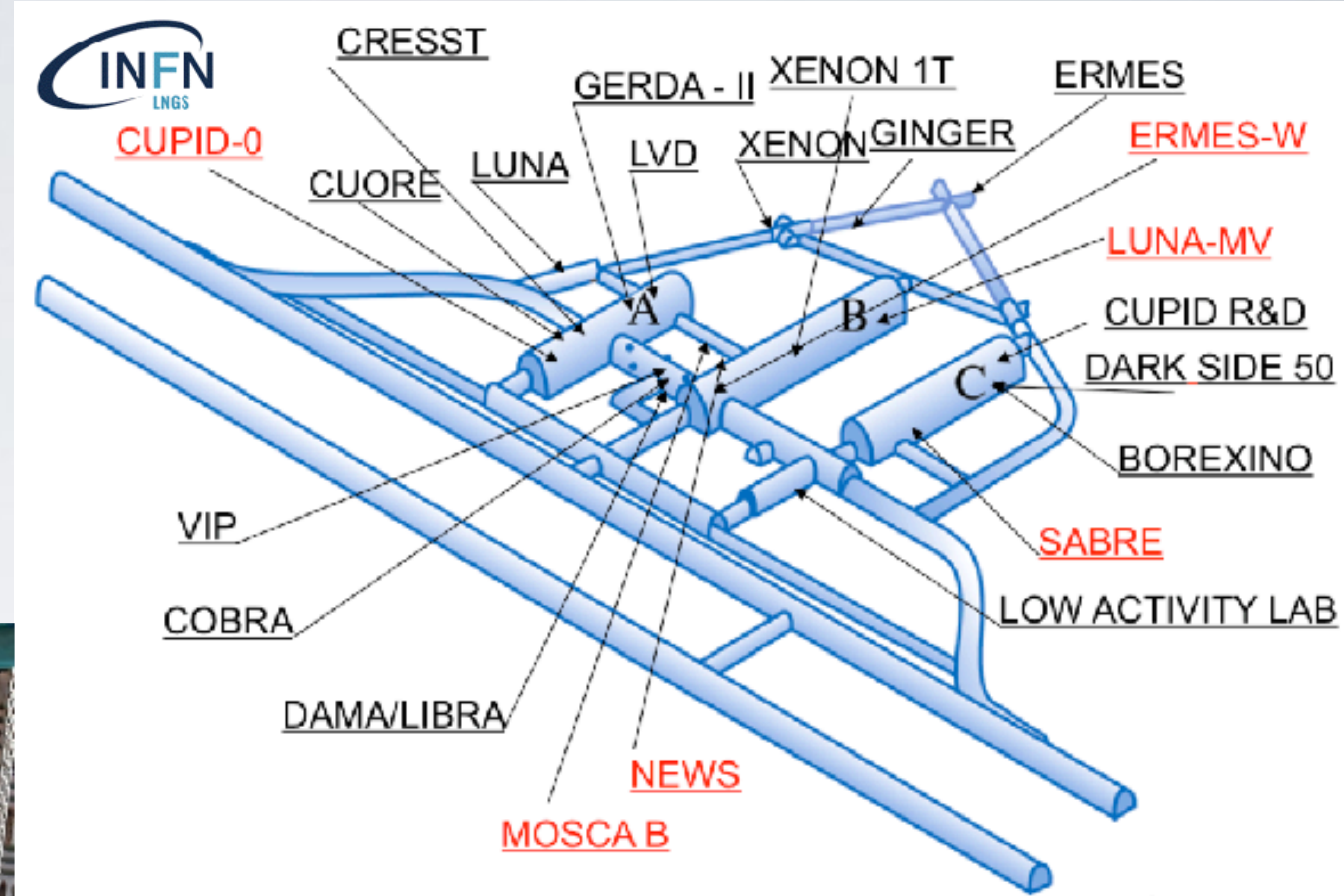
From A. Ianni

CURRENT EXPERIMENTS ON DOUBLE BETA IN EUROPE

Several experiments running in LNGS, LSC & LSM

Doble beta back in Canfranc

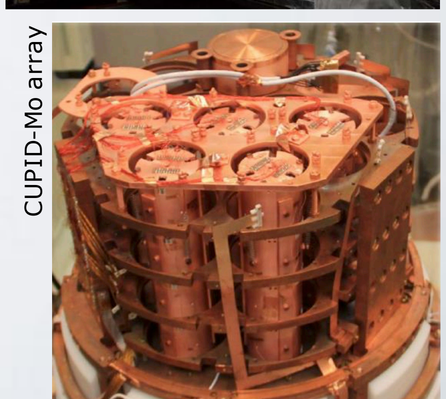




Demonstrators of new detectors for the 0ν double-beta decay

- SuperNEMO
  - 7 kg ^{82}Se target
  - Commissioning started in 2019
  - Tracko-calo: reconstruction of both e- tracks
- CUPID-Mo
  - 20x0.2 kg Li_2MoO_4 crystal (97% ^{100}Mo)
  - EDELWEIS cryostat (21 mK)
  - Heat (FWHM 5.3 keV @ 2.6 MeV) + scintillation (>99.9% rej. of α bkg)
  - Ongoing physics run (started in Jan. 2019)
- TGV & OBELIX
  - Ge arrays for 0ν double e- capture of ^{106}Cd

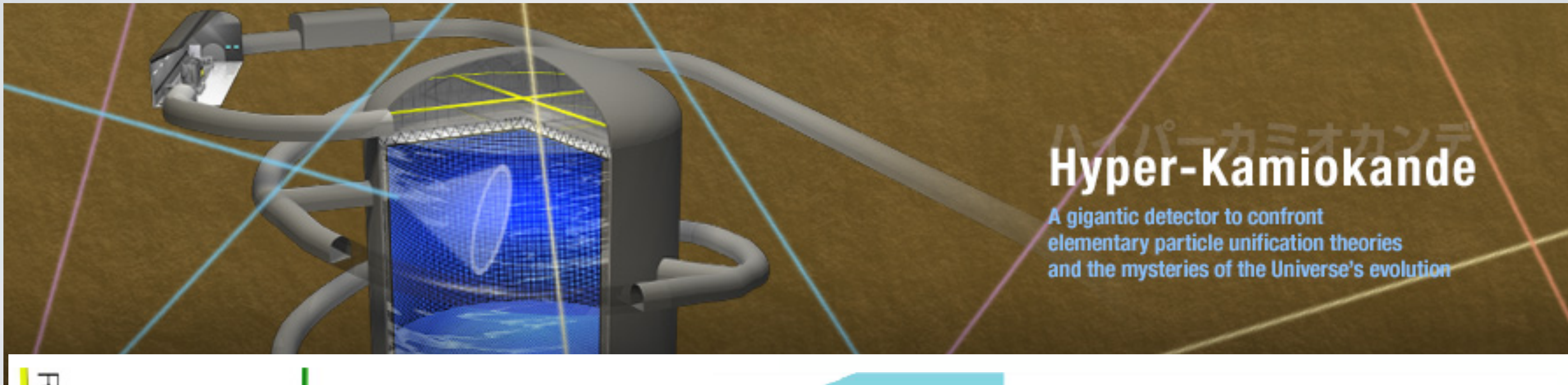
SuperNEMO calorimeter

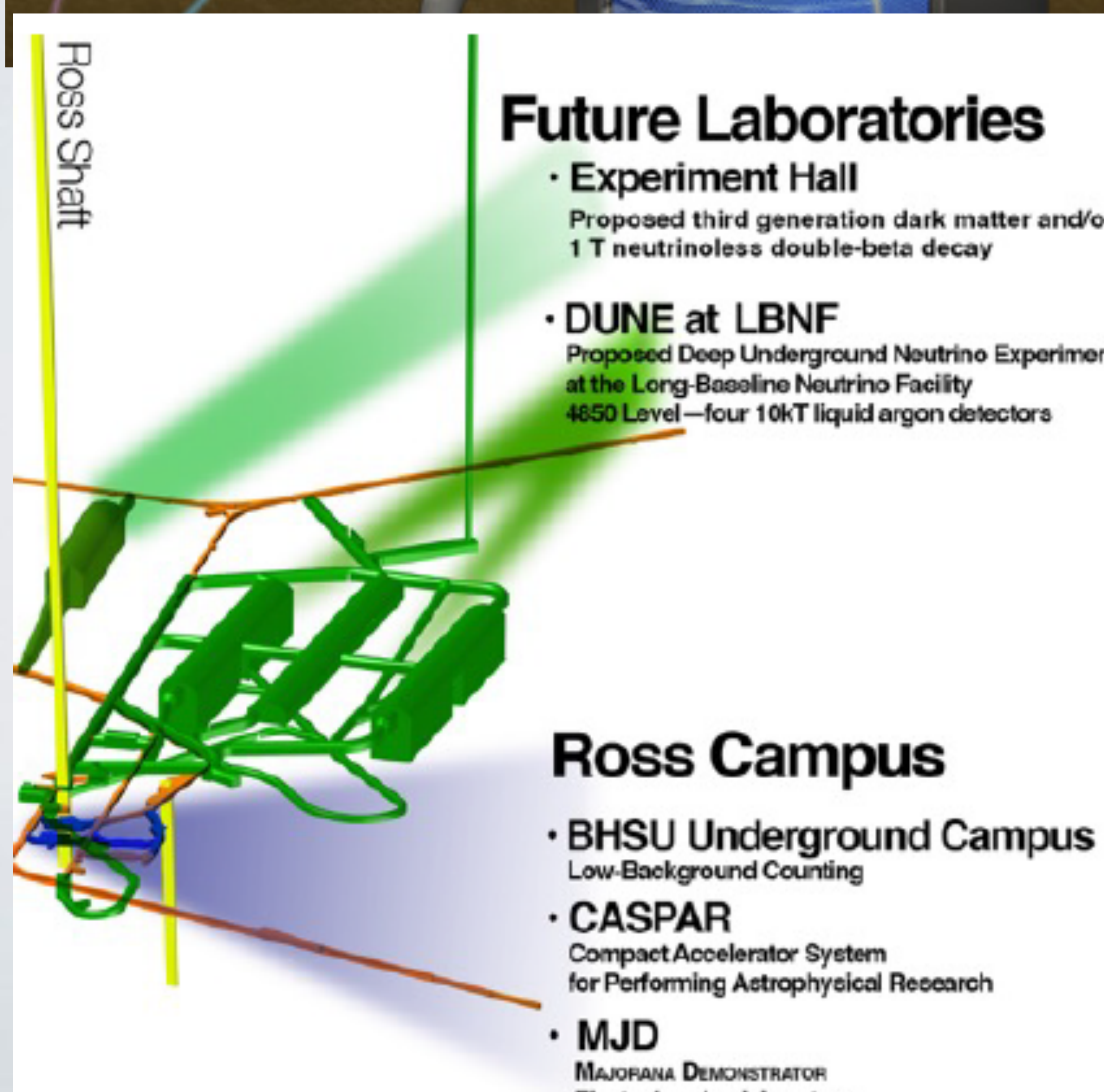


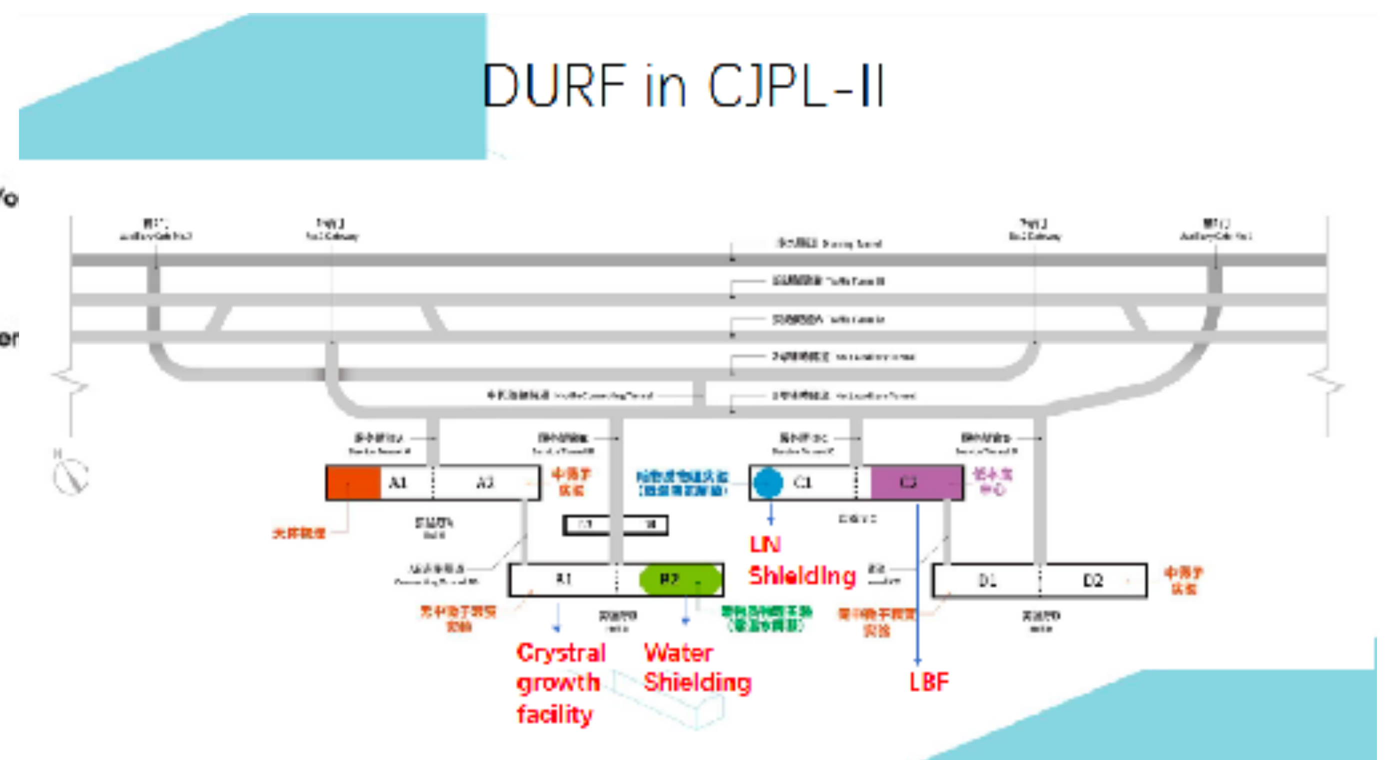
CUPID-Mo array

SPACE & INFRASTRUCTURES: MORE & MORE

Largest DULs outside Europe: Do we need a large deeper lab in Europe?

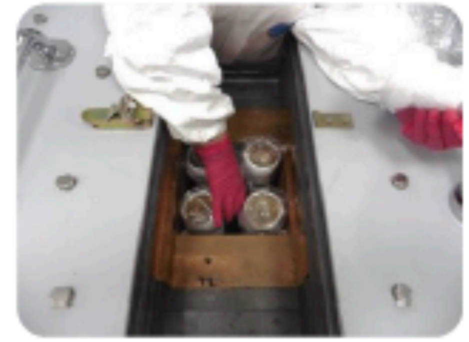






SCREENING: IMPROVED GAMMA SPECTROMETRY

XIA alpha particle counter



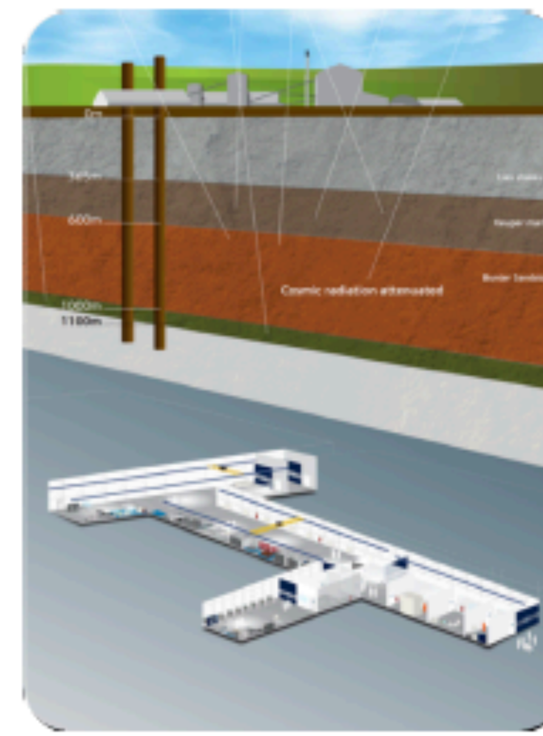
BOULBY UNDERGROUND LABORATORY

Ultra-Low-Background germanium detectors for rare-event detector material screening…

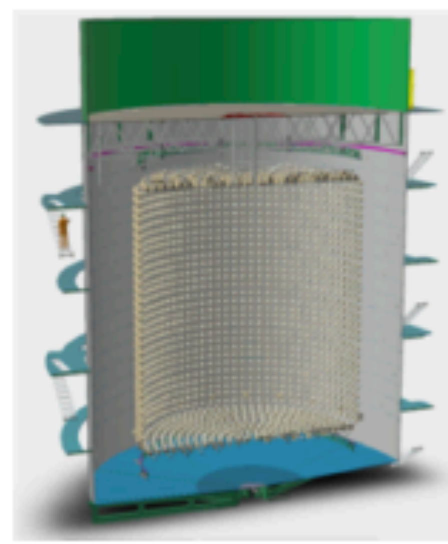
BUGS: Boulby Underground Germanium Suite

Current BUGS Detectors;
- Ortec 1.8 kg p-type (ULB)
- Canberra 2.0 & 3.2 kg p-types (S-ULB)
- 2x Canberra BEGe (5030 ULB, 6530 S-ULB)
- Canberra SAGe Well (S-ULB)
- **XIA System:** <0.0001 alphas/cm^2/hr

STFC Boulby Underground Laboratory, UK

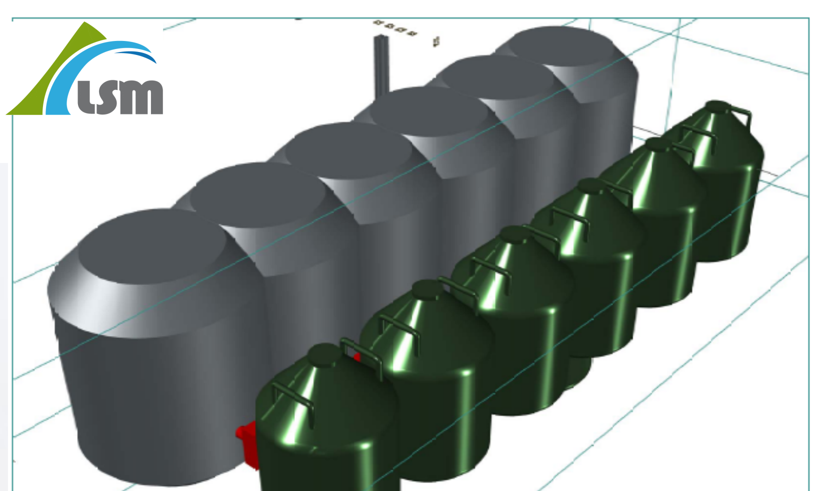


AIT- Advanced Instrumentation Testbed



WATCHMAN:
A 6kT Gd-loaded water detector looking at reactor anti-neutrinos for nuclear security, non-proliferation and technology R&D

UKRI Science and Technology Facilities Council



SCREENING: IMPROVED MATERIALS

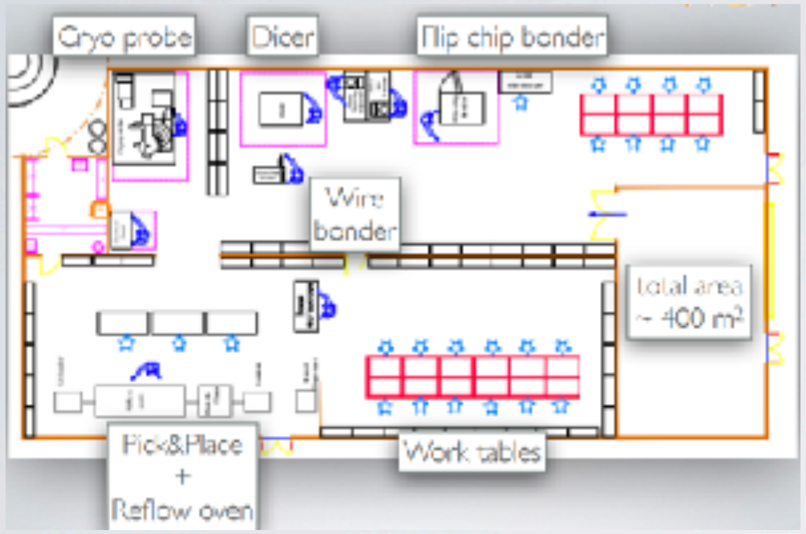
Additive Mechanics will focus on ultra pure metals: Copper and Titanium.
Produce lighter structures than conventional mechanics.
wider interest for astropaticle detectors.
Tests ongoing on Cu powders bulk EF copper.

Goal 2020: e-formed Cu mass production (100 kg) to feed 3D

INFN LNGS

MASS PRODUCTION

PROTOTYPING



Since 2021

NOA is a project funded through the RESTART program which aims to re-launch the economy and advanced training in the 2009 earthquake region.

NOA is using top quality equipment for the packaging of silicon devices

NOA proposal starts in the framework of DarkSide-20k.

SiPMs will be produced by LFoundry and delivered to NOA CR.

NOA will include the following processes all available for wafers up to 8":

- cryogenic and room temperature wafer probing
- dicing
- fully automated flip-chip bonding

Moreover, NOA will include radio-pure processes for SMD PCB productions and an advanced electronic testing facility.

Izabella Kochanek, SiPM@Bari

PROTOTYPING: RITA BASED ON SMFI

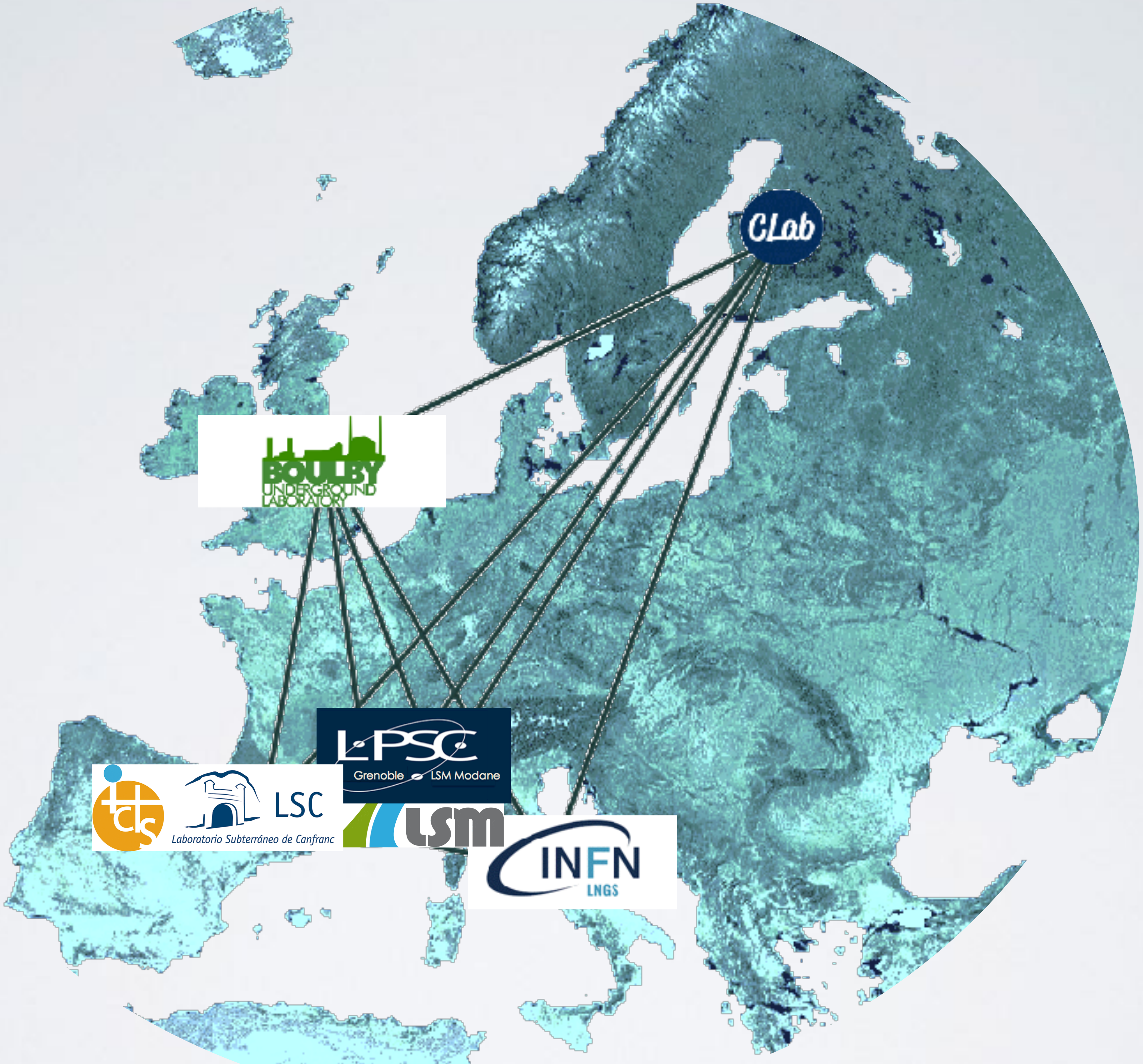
New detection method of Ra with 10^3 atoms sensitivity
Goal: Screening of UltraLow background materials for DM&bb
Makes use of single molecule fluorescence imaging techniques
Molecule with unchelated/chelated fluorescence bicolor
Scheme (budget approved at LSC):

Ra^{++} beam preparation from sample droplets **Mass Spectrometry** → Deceleration **ion trapping** → Capture by molecular filed on gold plate and SMFI induce by strong laser **Ion capture and counting**

Sinergies with NUPECC
(advice/collaboration welcomed)

Built Molecular bisensor with optimal separation: 1909.02782
Good technique to measure ^{226}Ra with best sensitivity
Industrial: New detector for multichannel mass spectrometry
Science: Prototype for single atom Ba detection

FUTURE OF DUL: GLOBAL COORDINATION



Requires formal agreement on sharing methods, calibration, users, applications, clients. Manage Global vs Regional hubs

SUMMARY

Golden era of astroparticle physics

DULs are a necessary condition (success story: neutrinos)

Search for neutrino properties, dark matter & other science

Requirements:

More and Bigger Experiments: More Labs & Space

Bigger challenges to LRT

More Science is coming

Demands more space underground & improved techniques

Labs Strength: stability and regional hub

Labs Strength: Invest on existing techniques & new ones

Some Labs redefining their future role

Go Global requires adapting regional rules

Better materials, screening, new techniques,…