# ULBS, CES and Environmental Measurements at Laboratorio Subterráneo de Canfranc (LSC)

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ICRM – Low-Level Radioactivity Measurement Techniques - Seattle, 26-30 September 2016

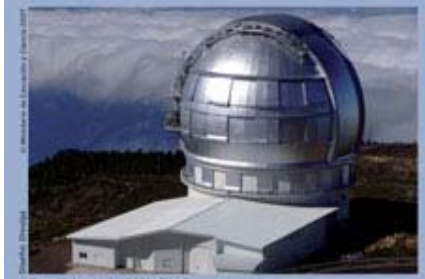
# Outline

- LSC general presentation.
- ULBS.
- Environmental Measurements.
- CES.
- Conclusions.

# Mapa de Instalaciones Científicas y Técnicas Singulares

Buque de Investigación Oceanográfica Hespérides

Reserva Científica de Doñana


Gran Telescopio CANARIAS

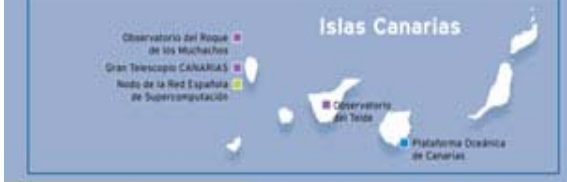
Canal de Experiencias Hidrodinámicas de El Pardo

Sala Blanca del Centro Nacional de Microelectrónica

Plataforma Solar de Almería

Instalación de Ingeniería Civil del CEDEX

Centro Nacional de Supercomputación




## Antártida

- Base Antártica Gabriel de Castilla
- Base Antártica Juan Carlos I

## Áreas de Investigación

Astronomía e Investigación Espacial · Ciencias del Mar, de la Vida y de la Tierra · Ciencias Socioeconómicas y Humanidades · Tecnologías de la Información y las Comunicaciones · Ciencias de la Salud y Biotecnología · Física de Partículas y Microscopía · Energía · Ingeniería

GOBIERNO DE ESPAÑA · MINISTERIO DE EDUCACIÓN Y CIENCIA
Ingenio 2010 · Año de la Ciencia

# LSC General Presentation
## External Buildings

**EDIFICIO SEDE**

- Headquarters & Administration
- Safety and Quality Assurance
- 23 offices
- 4 specialized laboratories
- Mechanical workshop
- Storage room
- Meeting room
- Library
- Conference & exhibition rooms
- 2 apartments

Surface: 1,821 $m^2$
(2,115 $m^2$ built)

**CASA DE LOS ABETOS**

- 2 Classroom
- 1 Conference room
- Exhibitions room

Surface:~400 $m^2$
(460 $m^2$ built)

# LSC General Presentation

## External Buildings

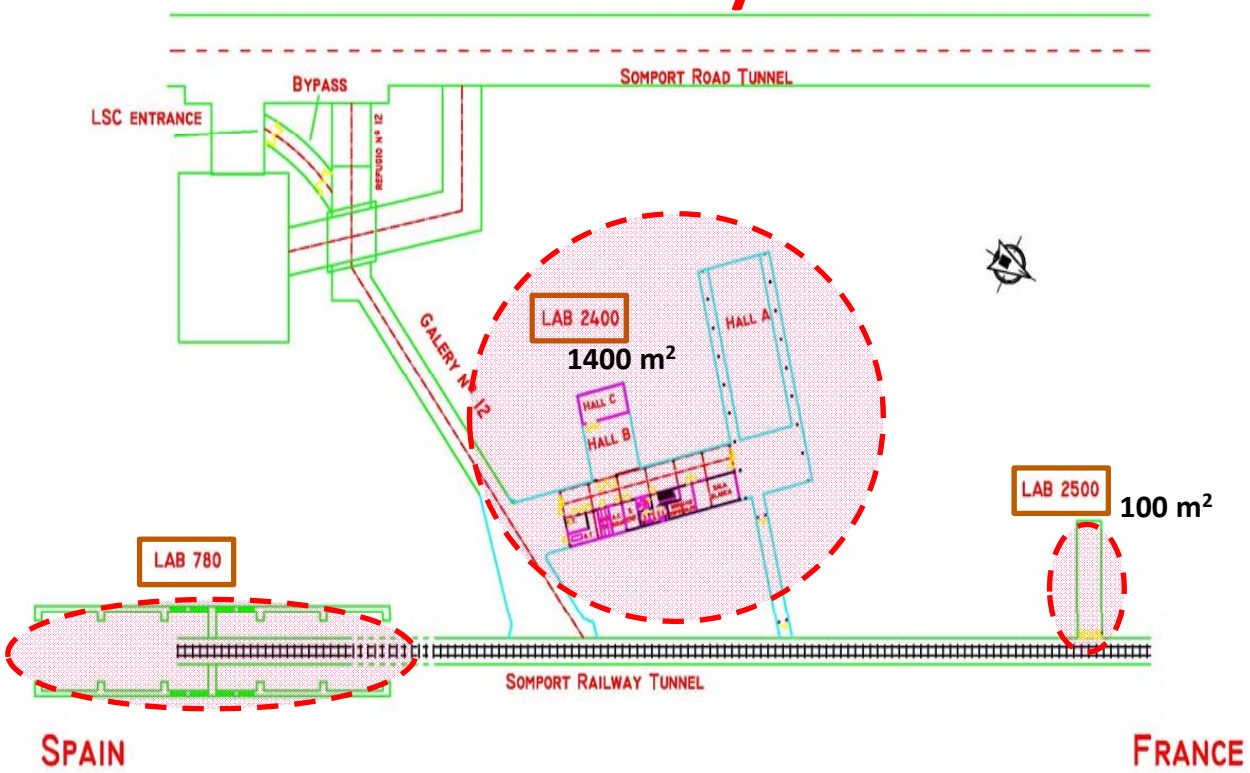
# LSC General Presentation

## 1986: First Lab (12 m²) LAB780

# LSC General Presentation

## Underground facilities

**Nowadays**




**LAB2400**

850 m rock overburden

2,450 meters of water equivalent (m.w.e.) depth

muon flux ~$4\times10^{-3}$ $m^{-2}$ $s^{-1}$

# LSC General Presentation

## LAB2400

Hall A
Mechanical Workshop inside lab
Clean Room

# LSC General Presentation

## Experiments at LSC

- Approved experiments

| | |
|---|---|
| ✓ EXP-01-2008; LoI-2009 (ANAIS) | Dark Matter (NaI, Annual modulation) |
| ✓ EXP-03-2008; LoI-2009 (BiPo) | $0\nu2\beta$ decay (Ancillary to Super-NEMO) |
| ✓ EXP-05-2008; LoI-2009 (NEXT) | $0\nu2\beta$ decay (Enriched $^{136}Xe$ gas TPC) |
| ✓ EXP-06-2009 (SuperK-Gd) | Material screening for SuperK Gd |
| ✓EXP-08-2010 (ArDM) | Dark Matter (two-phase Liquid Argon TPC) |
| ✓EXP-09-2014 (GOLLUM) | Life organisation deep underground |

- Approved observatory

| | |
|---|---|
| ✓ EXP-07-2009 (GEODYN) | Geodynamics (Underground & surface) |

-Expressions of Interest

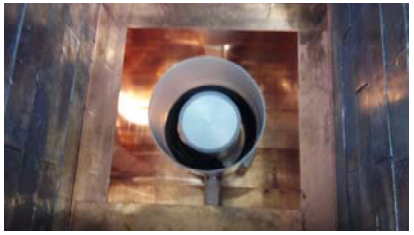
| | |
|---|---|
| ✓EoI-12-2009 (CUNA) | Nuclear astrophysics (New facility) |
| ✓EoI-15-2015 (CLYC4DM) | Dark Matter (Array of CLYC detectors) |
| ✓EoI-16-2015 (A-KWISP) | Force sensor for short-range interactions |
| ✓EoI-17-2016 (T-REX) | Dark Matter (HP Gas TPC) |

# ULBS
## Hall C - LAB2400

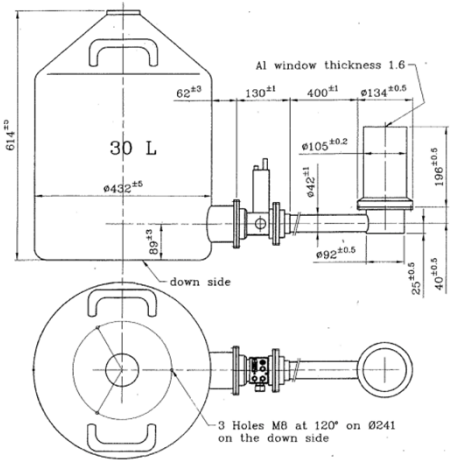
7 HPGe p-type coaxial (2 kg), mounted and taking data

From 2011 performed measurements for: NEXT (>140), SuperKGd, ArDM, BiPo, ANAIS, CUNA, LABAC and KSTAR.

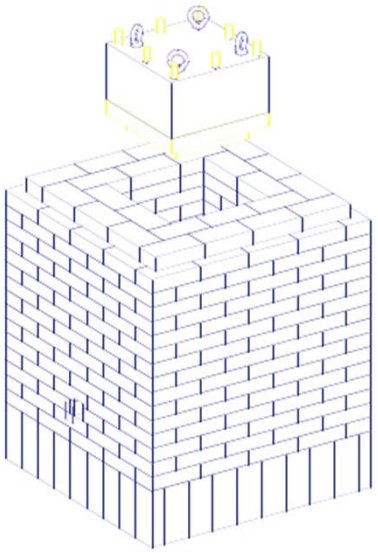
Some measurements from NEXT experiment published in Cebrián *et al*. (2015)

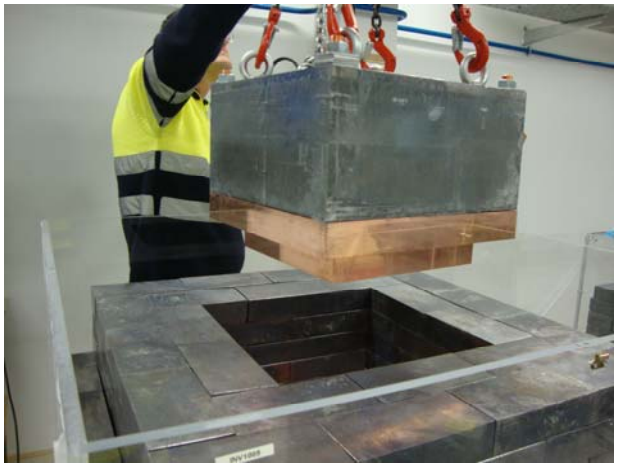


# ULBS
## HPGE shielding Characteristics



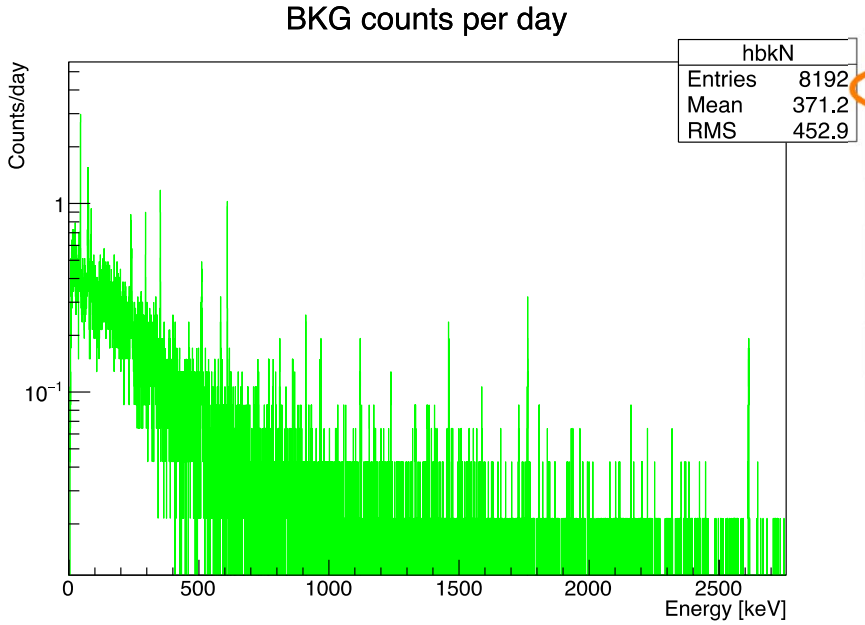

5-10 cm Cu-OFHC
20 cm very low $^{210}$Pb activity lead
Methacrylate Rn box.
Door
$N_2$ from boil-off evaporation





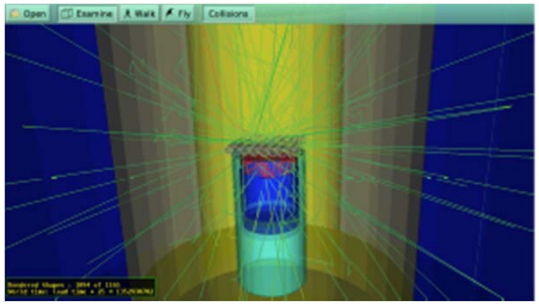
# ULBS

## P-type HPGE Characteristics




| Detector Name | Diameter [mm] | Height [mm] | Weight [g] | Rel. Eff. [%] | FWHM @ 1332 keV [keV] | Cryostat Mat. | Preampl. | Electronics |
|---|---|---|---|---|---|---|---|---|
| GeOroel | 81.4 | 81.7 | 2230 | 109.0 | 1.85 | Al | PSC761 | NIM |
| GeTobazo | 81.2 | 81.2 | 2185 | 110.0 | 2.07 | Al | PSC761 | DSA1000 |
| GeAnayet | 81.0 | 81.1 | 2183 | 109.0 | 1.96 | Al | PSC761 | DSA1000 |
| GeAspe | 81.0 | 81.2 | 2187 | 108.0 | 1.94 | Al | PSC761 | DSA1000 |
| GeLatuca | 81.0 | 81.2 | 2187 | 108.0 | 1.86 | Al | PSC761 | DSA1000 |
| Asterix | 79.0 | 79.0 | 2031 | 95.1 | 2.08 | Cu | Ge2002 | DSA1000 |
| Obelix | 79.0 | 79.0 | 2031 | 92.8 | 2.00 | Cu | Ge2002 | DSA1000 |

Integral 40 keV -> 2700 keV/day/kg = 184 cts.



A MC simulation program, GEBIC, was developed using Geant4. Code adapted to include specific characteristics of each detector.

**<u>Next improvements</u>**: a new SAGe Well type detector, extra $N_2$ gas flushing system inside each sample cavity

# Environmental Measurements

## Radon concentration in air

The measurement of the radon concentration in air has been performed by using a Genitron AlphaGuard P30 instrument. The measurements are carried out continuously and the data is sampled every 10 minutes.

Data expressed as $c_i \pm u_i$ **(i = 1, 2 … n)**

$c_i$ concentration of $^{222}Rn$ in air,

$u_i$ uncertainty,

n number of measurements.

- 4 stations underground
- 1 station on surface (Chemistry Lab.)

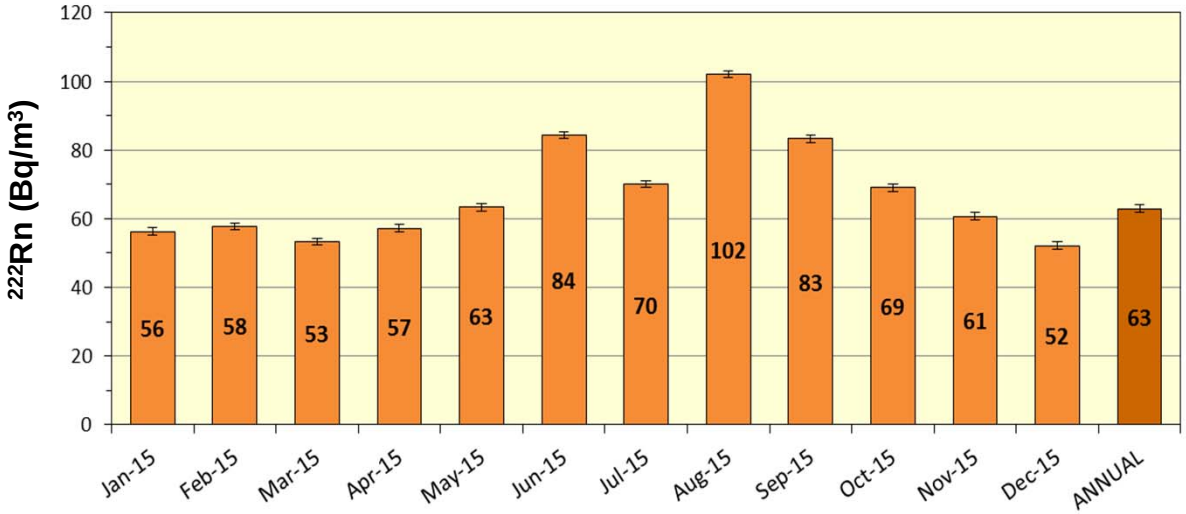
To calculate the monthly or annual weighted average concentration of radon in air and its associated uncertainty, we applied the following expressions:

$$\bar{c}_p = \frac{\sum_{i=1}^{n} w_i c_i}{\sum_{i=1}^{n} w_i} \qquad w_i = 1/u_i^2 \qquad \sigma(\bar{c}_p) = \sqrt{\frac{\sum_{i=1}^{n} \left\{ (c_i - \bar{c}_p)^2 w_i \right\}}{(n-1)\sum_{i=1}^{n} w_i}}$$

# Environmental Measurements

## Radon concentration in air - Hall A

Monthly average of Radon concentration in air




**Hall A, 2015**

the average Rn concentration in air was 63 Bq/m$^3$
max in August (~102 Bq/m$^3$)
min in Dec. (~52 Bq/m$^3$)

| | Jan-15 | Feb-15 | Mar-15 | Apr-15 | May-15 | Jun-15 | Jul-15 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Dec-15 | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hall A | 56 | 58 | 53 | 57 | 63 | 84 | 70 | 102 | 83 | 69 | 61 | 52 | 63 |
| Hall B | 58 | 59 | 56 | 60 | 66 | 86 | 71 | 103 | 85 | 70 | 62 | 54 | 65 |
| Hall C | 61 | 62 | 56 | 60 | 66 | 87 | 74 | 106 | 86 | 71 | 64 | 55 | 66 |

# Environmental Measurements

## Environmental radioactivity

The environmental radioactivity is measured with several UD-802A Panasonic thermoluminescent dosimeters (TLD). After each two months of exposure the ambient dose equivalent $H^*(10)$ is evaluated

| Element | Crystal | Shield | Range |
|---|---|---|---|
| E1 | $Li_2B_4O_7$ | Plastic Layer 14 mg/cm$^2$ | β Rays<br>γ Rays<br>X Rays |
| E2 | $Li_2B_4O_7$ | Plastic Layer 160 mg/cm$^2$ | high energy β<br>γ 10 keV-10 MeV<br>X Rays |
| E3 | $CaSO_4$ | Plastic Layer 160 mg/cm$^2$ | γ 25 keV -70 MeV(*) |
| E4 | $CaSO_4$ | Lead 0,7 mm | γ 25 keV -10 MeV(*) |

(*)High sensitivity for low intensities

The elements E3 and E4 are very sensitive to gamma radiation and used for evaluation of low doses such as environmental radiation.

- 7 stations underground
- 7 station on surface

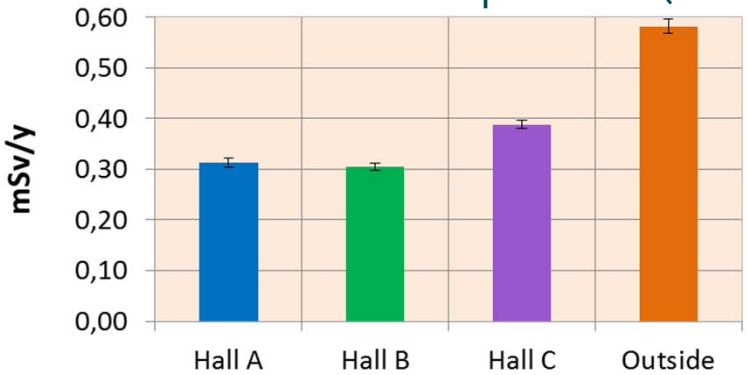
# Environmental Measurements

## Environmental radioactivity

Ambient dose equivalent (µSv/month) in LAB2400 and outside

| Date | Feb-15/Mar-15 | Apr-15/May-15 | Jun-15/Jul-15 | Aug-15/Sep-15 | Oct-15/Nov-15 | Dec-15/Jan-16 |
|---|---|---|---|---|---|---|
| Hall A | 25.68 ± 0.54 | 25.00 ± 0.25 | 28.81 ± 0.49 | 30.56 ± 0.75 | 25.94 ± 0.47 | 26.18 ± 0.49 |
| Hall B | 24.58 ± 0.48 | 24.70 ± 0.68 | 26.68 ± 0.38 | 28.30 ± 0.60 | 24.26 ± 0.50 | 24.39 ± 0.38 |
| Hall C | 32.65 ± 0.34 | 30.18 ± 0.43 | 33.30 ± 0.31 | 35.57 ± 0.66 | 31.08 ± 0.52 | 31.08 ± 0.57 |
| Outside | 44.71 ± 1.00 | 47.11 ± 0.86 | 50.51 ± 1.17 | 53.66 ± 1.11 | 46.90 ± 0.86 | 49.54 ± 0.70 |

Ambient dose equivalent (mSv/y) in LAB2400 and outside




| H*(10) (mSv/y) | |
|---|---|
| Date | 2015 |
| Hall A | 0.31 ± 0.01 |
| Hall B | 0.31 ± 0.01 |
| Hall C | 0.39 ± 0.01 |
| Outside | 0.58 ± 0,01 |

Both the Radon concentration in air and the ambient dose equivalent H*(10) are much lower than the allowed ones according to the Spanish regulations (600 Bq/m³/y, 1 mSv/y).

# CES
## Chemistry Lab – External Building

Electro-forming is a method of producing pieces by the deposition of a metal onto a mold, which is subsequently removed.

- Fixed current density direct electroplating
- High-purity commercial chemicals & ultra-pure water
- OFHC copper anodes

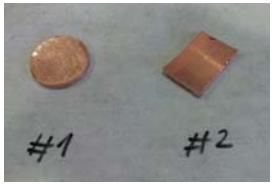
From 2014 performed electro-formed copper pieces: ANAIS, LNGS Collaboration.

*Picture courtesy of ANAIS Collaboration*

- 1st set-up operative
- 2nd set-up under construction

# CES
# Chemistry Lab – External Building

Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) at LNGS (Italy) was used to analyze the Th and U contamination at the surface and bulk in copper samples, Nisi (2015), Chemistry Service Report.




| Sample | Description | Surface assay | | Bulk assay | |
|---|---|---|---|---|---|
| | | **Th** [ppt] | **U** [ppt] | **Th** [ppt] | **U** [ppt] |
| #1 | OFHC copper , raw material, 15g | 280 | 48 | 4.6 | ~1 |
| #2 | Electroformed copper obtained at CES, 12.3g | 49 | 22 | <1 | <1 |

The error is estimated to be about 10%.

New ICP-MS results from a Semi-Quantitative analysis and Th & U sensitive analysis performed at LNGS of electroformed copper recently presented at M. L. Di Vacri talk (Monday 26th)

**Next improvements**: a new set-up at the underground clean room and improving the technique. Besides, more ICP-MS assays are foreseen to be developed in collaboration with PNNL and LNGS.

# Conclusions

- LSC is an international multi-disciplinary research infrastructure dealing with neutrino physics, dark matter, geophysics and biology.
- The ULBS and CES facilities allow to carry out R&D activities and give support to experiments working at LSC.
- ULSB will play an important role during the design and installation of new experimental set-ups at LSC.
- CES is being used to carry out several R&D activities in collaboration with other Laboratories and research.
- Permanent monitoring of environmental parameters is carried out to detect any anomaly of the low-level radioactivity.

Thank you!