Joint Research Activity JRA1

Low Background Techniques for Deep Underground Science (LBT-DUS)

DRAFT
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I. DESCRIPTION OF THE JOINT RESEARCH ACTIVITY

1. SCIENTIFIC AND TECHNOLOGICAL EXCELLENCE

1.1 Objectives and originality of the joint research activity JRA1

The ultimate sensitivity of the experiments searching for rare event physics is dictated by the background level achieved. Consequently, it is imperative first to discover and understand sources of background, determining its nature and location and then develop strategies to diminish and to reject it. That goes in parallel with the development of state-of-the-art ultralow background techniques for producing and measuring radiopure materials That is a common issue in all searches in Neutrino Physics and Astroparticle Physics.
The underground laboratories have, as their main objective, to provide the conditions needed for such low background experiments, i.e., a deep underground site to avoid cosmic radiation and put at the user disposal methods, techniques and equipment to deal with all sources of background, intrinsic to the detectors, to their components, materials, shieldings, … (i.e., their level of radiopurity) as well as those characteristic of the environment (radon, neutron and gamma fluxes, …) which should be driven to their lowest level.

1.1.1 Objectives of the JRA
The main objective is to identify and measure the different backgrounds contributing to a given experiment, and to design methods and apply techniques to reduce it. This Joint Research Action will largely benefit from the collaboration established with the teams of the particular experiments being performed in the various Underground Laboratories. However, the experience accumulated in the handling of the background problems and the similarity of techniques used in the various underground sites to monitoring and reduce the background, justify to join efforts to investigate and develop state-of-the-art methods and techniques to commonly address the background issue.
The JRA is carried on jointly by the four EU underground labs: Laboratori Nazionali del Gran Sasso (Italy), Laboratorio Subteraneo de Canfranc (Spain), Laboratoire Souterrain de Modane (France) and Boulby Underground Lab (UK). A detailed description of the 4 infrastructures can be found in the A1 sector of the IA proposal. Beside the underground labs staff, several external teams, expert in the field of ultra-low background techniques which are operating experiments in the underground labs, will contribute to the JRA.
The impact of the JRA is directed in improving the quality of the services offered by Underground Labs to the scientific community in the sectors of astroparticle physics and rare-event physics, as well as improving the efficiency of the research carried on in the Labs.

1.1.2 Originality and innovation of the JRA
Rare Event experiments in Astroparticle Physics need underground sites using ultra-low background techniques. Improvement of these techniques through dedicated programs of Research, Development and Innovation to the highest degree of excellence must be encouraged. To push forward the current sensitivity limits new techniques must be developed. That is a common undertaking of all experiments. However, **in most of the cases, there is no coordination between the teams performing such experiments, so a big amount of effort is spent looking essentially for the same items. It is clear that a cooperative effort in R&D to upgrade Ultra-low Background facilities (ULBF), up to a level of excellence, and to offer an European coordinate ULBF for multidisciplinary applications will be most welcome by the European scientific community in low-background fundamental physics experiments, as several of the proposed techniques in this JRA-1 are original and innovative.**

1.2 Implementation plan of the joint research activity

We intend to organize the JRA in four Tasks as follows:

- **Task 1. Implementation of a Database of the background components inside the EU deep underground sites.**
  To characterize the environmental background components (in particular neutrons, gammas, muons, and Rn contamination in the air and in the water) in the four underground sites LNGS, LSM, LSC, and Boulby. To collect, coordinate and analyse existing information, and subsequently, organise a campaign of new relevant measurements in the different labs, with the aim of covering missing data, and solving possible inconsistencies. This is particularly important for the neutron and gamma background components. Different techniques and detectors will be employed and results compared. The final deliverable of Task 1 will be a consistent database of the relevant background components in the 4 underground labs.
- **Task 2. Development of a standard library of background simulation codes.**
  To develop reliable and well tested MC simulation codes to identify and quantify the components of the background in a variety of experiments and of the typical backgrounds in underground sites, needed to design the underground experiments. To establish a coherent library of codes available for the users of the Labs. The joint effort should contribute to exchange and optimise the know-how among the different participants. The comparison of data from Task 1 with the simulations will validate and test the codes. On the other hand the simulation codes will help in the interpretation of data collected in Task 1.
- **Task 3. Creation of a coordinated set of European Ultra-Low-Background Facilities (ULBF).**
  To carry on R&D for the upgrading of ultra-low background techniques and facilities of the underground labs. In particular, development of background rejection techniques, active and passive shieldings, veto systems, atmosphere control systems to reduce radon levels, pulse shape discrimination techniques, fragmentation of calorimeter detectors etc. The deliverable of this R&D activity will be a world-wide value and coordinated system of European facilities for ultra-low background measurement applications in rare event physics and in other fields (environmental phyiscs, archeometry and radiodatations, geophysics, …). A more detailed description of the proposed facilities can be found in section 3.2.1
- **Task 4. Implementation of a European Database of radiopurity of the materials and purification techniques.**
  To establish a EU database containing: (a) information on radioactive contamination of materials tipically used for the construction of detectors employed in rare-event physics and ultra-low background instrumentation; (b) information on purification techniques used to improve the radiopurity of materials; (c) information on cosmogenic activation of different materials. On the other hand; new measurements of radiopurity of materials and its optimization will be carried on, using the new capabilities offered by the R&D and facilities of Task 3. The deliverable of Task 4 will be an up-to-date database accessible to all researchers interested in the use of highly radio-pure materials.

A graphical representation of the tasks discussed above and their interdependency is shown in Figure JRA1-1. The expected multi-annual execution plan is illustrated in the chart JRA1-2. Milestones and final deliverables can be identified in the tables.

A more detailed execution plan of the project in the first 18 months divided by task is as follows:

Time (months)	Task 1	Task 2	Task 3	Task 4
0	EC meeting in parallel with working group meetings Organisation of the activities			
	* Collect existing information * Planning new measurements	*Organising existing codes *Planning new software developments needed *planning platforms and program languages	* Planning the coordination between labs * Installation of ULBF facilities in the different labs (see section 3.2.1 for a detailed description)	*Collect existing information *Planning new measurements *Planning DB platform
6	EC meeting LBT-DUS general meeting Summary and organisation of the proposed activities			
	* Set-up instrumentation for gamma and neutron measurements in the different labs * Implementation of Rn monitoring systems in the labs * Start of the background measurements	* Implementation of MC codes for the relevant bck and instrumentation	* Installation of ULBF facilities in the different labs	*Implement DB platform *Collect existing information, introduce in the DB *Start coordinated measurements on new materials
12	EC meeting			
	* First full survey information of neutron, gamma and radon flux *Collecting data on radiopurity of the rock and concrete in underground labs	* Interpretation of results from Task 1 * Tests of the MC codes	* Start-up of ULBF facilities in the different labs	* continue measurements on new materials *collect data on purification techniques
18	EC meeting LBT-DUS general meeting Planning of the activities for JRA1 – Step 2			

Chart JRA1-1. Graphical representation of the interdependencies of the Tasks of the JRA

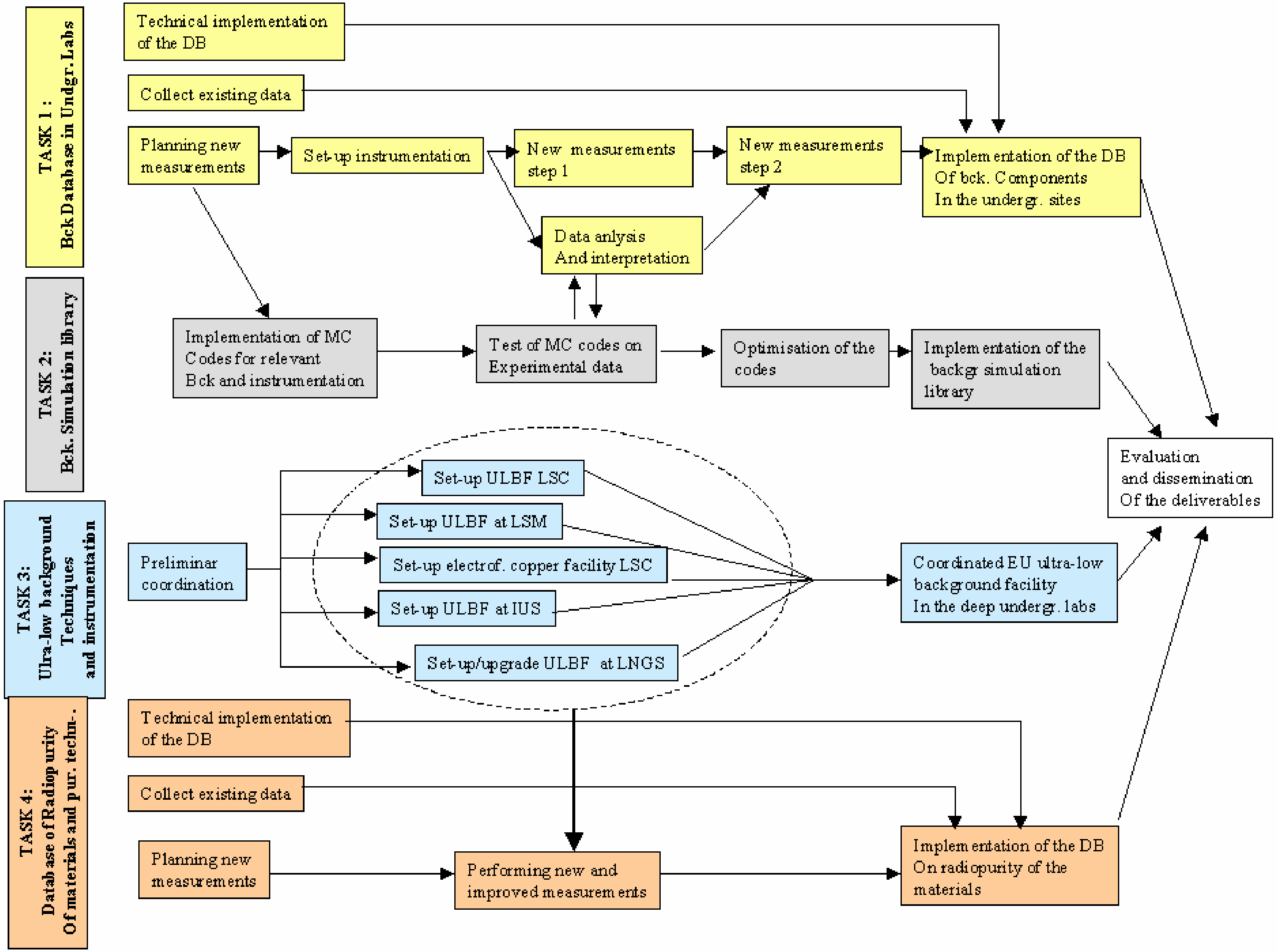

Chart JRA1-2. Multi-annual implementation plan of the Joint Research Activity

	Year 1												Year 2												Year 3											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
TASK 1 Database of the background components of the EU deep underground sites																																				
Collecting existing data				■	■	■																														
Planning new measurements				■	■	■													■	■	■	■	■	■	■	■	■									
Gamma rays: set-up instrumentation							■	■	■	■	■	■																								
Neutrons: set-up instrumentation							■	■	■	■	■	■																								
Gamma rays: survey in undgr labs										■	■	■	■	■	■	■	■	■							■	■	■	■	■	■						
Neutrons: survey in undgr labs										■	■	■	■	■	■	■	■	■							■	■	■	■	■	■						
Set-up of upgraded Radon monitoring systems							■	■	■	■	■	■	■	■	■	■	■	■																		
Data analysis and interpretation										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Final implementation of the database																									■	■	■	■	■	■	■	■	■	■	■	■
TASK 2: Development of a standard library of background simulation codes																																				
Implementation of MC codes for the relevant backgrounds/instrumentation				■	■	■	■	■	■	■	■	■																								
Analysis of data collected in the background monitoring campaign with the MC codes										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Optimisation of the codes													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Design and implementation of the library													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Final tests/Optimisation of the library																															■	■	■	■	■	■
TASK 3: European Ultra-Low-Background Facility																																				
Set-up/Upgrade ULBF facilities at LNGS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																	
Set-up of ULBF at LSC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																	
Implementation of electroforming fac. LSC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																	
Set up/upgrade ULBF facilities at Boulby	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																	
Upgrading of ULBF fcilities LSM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																	
Common planning of further developments of the ULBF facilities																				■	■	■	■	■	■	■	■	■	■	■						
Coordination and information exchange (indicative)							■	■	■										■	■	■										■	■	■			
TASK 4: European Database of radiopurity of the materials and purification techniques																																				
Design and. implementation of the DB platform				■	■	■	■	■	■	■	■	■																								
Defining new measurements							■	■	■	■	■	■							■	■	■	■	■	■												
Collecting existing data into the DB				■	■	■	■	■	■	■	■	■																								
Measurements on new materials							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Final optimisation of the database																															■	■	■	■	■	■
Activities common to all tasks																																				
Preparation of the JRA activities	■	■	■																																	
Evaluation and dissemination of the deliverables																															■	■	■	■	■	■

2. QUALITY OF THE MANAGEMENT

2.1 Management and competence of the partecipants

2.1.1 Management structure

The general management of the JRA will be done by an executive committee (EC) formed by:

- **The JRA1 coordinator (LNGS director)**
- **The Directors of LSC, LSM and IUS**
- **The Four Task Coordinators (see below)**

The EC meets twice per year (or more often if necessary) to manage the overall JRA activities and monitor the status of the JRA.

As discussed in section 1.2, the activities of JRA1 are organised in 4 tasks; correspondingly paricipants are divided into 4 working groups; each working group is leaded by a Task Coordinator. Each working group works under the coordination of the task coordinator. The participants in JRA1 take part in one or more of the four working groups (see section 2.1.2). We anticipate that the composition of the working groups can to some extent change according to specific needs during the execution of the JRA activity.

The coordination of the four tasks will be as follows:

Task 1 : LNGS : N. Ferrari

Task 2 : LSC : J. Morales

Task 3 : LSM:

Task 4 : LNGS : M. Laubenstein or A. Ianni

Planning of the JRA activity will be done with the organization of periodical working meetings of the different working groups to be scheduled by the task coordinator. Representatives of the different participant institutions will take part at the meetings. As a general rule the meetings will be held every 6 months just before the EC meeting: proposals and discussions at the working group level will be reported by the coordinators at the EC meetings. Joint working meetings of two or more working groups needing exchange of informations can be also organized.

Each task coordinator can organise exchange of personnel among the institutions in order to allow joint working periods of the participants and exchange of data/information. For instance this possibility is going to allow travels of participants in the underground labs for measurements, or the possible travel of staff of a given underground lab to a different lab for joint working days.

The funds for working meetings and personnel exchange are under the administration of the Task coordinator.

Periodic reports of the status of the project will be given at the general IA meetings and scientific committee as requested by the IA management.

We plan to have three general meetings of the JRA1, respectively at month 6, 18, and 30 after the beginning of the activity. The meetings will be held in connection with those of the general IA meetings.

The grant for the JRA1 will be divided for among the four Institutions operating the Underground labs as discussed in section 2.2. The directors of the labs will be responsible of the administration of the assigned funds in collaboration with the task coordinators.

2.1.2 Tasks of the participant institutions and researchers.

The institutions participant in the JRA are listed in Table JRA1-3, together with the total number of researchers and the expected size of research effort in person-months divided by task.

Table JRA1-4 reports the complete list of names of the researchers involved in the JRA, their home institution, affiliation within JRA1, and the experience and knowledge of the different groups which will be employed in the JRA.
In the Annex I we give a selection of relevant publications divided by task and participant groups.

[list of publication: MISSING – it will be sent asap]

2.2 Justification of the financing requested

2.2.1 Expected budget of the project and community contribution.
The duration of JRA1 will be 3 years. The total budget of the project will be around 3.2 M€, and the grant requested to EU 1.4 M€.
Table JRA1-5 lists the single items divided by task and participant institutions. Here is a justification of the single items:

Task 1 : Tot. budget 530 k€, EU grant 255 k€

- Travel and subsistence for joint working days (60 k€), corresponding to 400 person-days, 150€/person-day (travel+subsistence). Includes travels of external participants in the underground labs; the possible travel of staff of a given underground lab to a different lab for measurements conducted jointly; and working meetings organized by Task 1 coordinator. We require a grant covering all the costs.
- Consummables: materials needed for the operation of the detectors employed in the measurements (liquid nitrogen, cables, etc.). A rough evaluation is about 20 K€; all costs will be covered by Underground labs.
- Personnel costs from Task 1 participants (preparation and test of the instrumentation, bck measurement campaigns, data analysis, DB implementation). From Table JRA1-3 we evaluate 84 person-months, corresponding to about 168 k€.
- Additional technical support from Underground technical staff during the measurement campaigns: 2 person-months per lab. Tot 8 person-months. The costs will be covered by Underground labs.
- Grant for a post-doc position for scientific and technical support of Task 1 coordinator (3 years, 140 k€)
- New equipments for background measurement and monitoring. Here is a list of new equipments we plan to employ for the measurement campaign in the different labs.
  - LNGS : Neutron measurement facility; gas detector, DAQ, 10 k€
Radon measurement facility (upgrade with modern detector+DAQ), 10 k€
Tot. requested grant 10 k€
  - LSM: Radon Precision Measuring Facility (RPMF): two very sensitive Silicon detectors of the Radon present in the air; total cost 30 k€.
Tot. requested grant 15 k€.
  - IUS: Radon measurement facility: detector, daq, filters, air conducts, software 20k€
Neutron measurement facility: gas detector and daq – 10k€
Tot. requested grant 15 k€.
  - LSC : Neutron measurement facility; gas detector and DAQ, 10 k€
Radon measurement facility (Detector+DAQ), 20 k€
Tot. requested grant 15 k€

Task 2 : Tot budget 380 k€, EU grant 202 k€

- Upgrade of computing infrastructures to host the libraries and support calcolus + additional technical support from computing staffs for implementation of a common access and mirroring system of the libraries, 40 k€. Requested grant: 32 k€.
- Personnel costs from Task 2 participants (test and development of the MC codes, implementation and documentation of the libraries). From Table JRA1-3 we evaluate 85 person-months, correspondong to about 170 k€.
- Grant for travel and subsistence for joint working days of members of Task 2 working group (30 k€), to cover about 200 person-days, 150 €/person-day (travel+subsistence).
- Grant for a post-doc position for scientific and technical support of Task 2 coordinator (3 years long, 140 k€)

Task 3 : Tot budget 1719 k€, req. EU grant 570 k€

Details of costs are given below:

- Installing/upgrading facilities at LNGS include the following items (all in K€)

ITEM		Budget	Grant
Installation of the new ULBF	building	40	-
	services (electricity, nitrogen distribution, etc),	40	-
	2 HPGe detectors with shielding,	140	40
	1 liquid scintillator counter (low-level)	70	70
	Electronics and DAQ	20	-
	Technical support from lab staff for installation and start-up of ULBF facility	12 person-months	-
Implementation of chemical lab for sample preparation for radiodating	laboratory equipment	60	-
	electrolytic enrichment of 3H	35	-
	benzene synthesis line	60	-
	pre-treatment system of samples	35	-
	AMPTEC XRF system+software	20	20
	PCs for DAQ and software	7	-
	Technical support from lab staff for installation and start-up of chemical lab facility	12 person-months	-
Upgrade of the LLBF (LENS Low Background Facility) for external users	Equipments	20	10
	Technical support from lab staff for installation and start-up of chemical lab facility: 3 person-months	3 person-months	-
Upgrade of the GNO ULBF facilities for external users	Equipments	20	10
	Technical support from lab staff for installation and start-up of chemical lab facility	3 3 person-months	-
	TOT BUDGET	570 +30 person-months	150

- Installing/upgrading facilities at LSC includes the following items:

ITEM	Budget	Grant
Completion of HPGe (and NaIs) benches for radiopurity (and total activity) measurements of materials (2 low background Ge detectors + 1 NaI crystal, electronic and shielding)	160	70
Installation and operation of a cooper electroforming facility for ultra-low background applications	100	40

Study of the feasibility of melting and machining pure lead for ultra-clean shielding	10	
Study of the feasibility for growing of crystals (Ge, TeO2, …) at underground sites	10	
TOT BUDGET	280 +12 person-months	110

- Installing/upgrading facilities at LSM includes the following items

ITEM		Budget	Grant
Upgrade of ULBF facility at LSM	Cryo-generators for Ge detectors, at LN_2 temperature	300	50
	Very low background Ge detector (R&D)	60	30
	Ge detector for low-energy gammas (R&D)	60	30
	TOT BUDGET	420 +12 person-months	110

- Installing/upgrading facilities at IUS includes the following items

ITEM	Budget	Grant
Upgrade of 2 Kg Ge facility (automation, LB copper vessel, test vessels, daq)	15	15
Construction of scintillator test neutron/muon background veto:	50	15
Development of underground radio-purification system for gases	20	10
Technical/Scientific support	27 person-months	-
TOT BUDGET	85 +27 person-months	40

- Personnel costs from Task 3 participants (R&D for the development of the facilities; coordination and exchange of information). From Table JRA1-3 we evaluate 110 person-months, correspondong to about 220 k€.
- Grant for personnel costs (1 post-doc fellowship, 3 years, 140 k€). The fellowship is in support of the Task 3 coordinator.

Task 4 : Tot. budget 380 k€, req. EU grant 163 k€

- Equipment for the implementation of the database (10 K€), including personal computer (server), software, hardware (scanner+digital camera), consumables (tapes, CD-rom etc.). We require a grant of 5 K€.
- Consummables for measurements of radiopurity of materials: include liquid nitrogen, and maintenance for about 1000 detector-operating days corresponding to a cost of about 40 k€. All the costs are charged to the underground labs.
- Grant for travel and subsistence for joint working days of members of Task 4 working group (18 k€), corresponding to 120 person-days, 150 €/person-day (travel+subsistence).

- Personnel costs from Task 4 participants (implementation of the DB, planning of new measurements, R&D in the purification techniques sector). From Table JRA1-3 we evaluate 86 person-months, corresponding to about 172 k€.
- Grant for personnel costs (1 post-doc fellowship, 3 years, 140 k€). The fellowship is in support of the Task 4 coordinator.

Items common to all Tasks: Total costs: 220 k€; req. EU grant 220 k€

- Executive Commetee metings, 7 meetings, 8 participants (6 travelling) 25 K€
- General LBT-DUS meetings, 3 events, 70 participants (60 travelling) 100 K€
- Overheads, include support for management and administration of the JRA1 activities 100 K€

We propose to divide the grant among the 4 labs (LNGS, LSC, LSM and Boulby) according to the scheme reported in Table JRA1-7. This assumes that LNGS coordinates Task 1, Task 2 and general management of JRA1; LSC coordinates Task 2; and LSM coordinates Task 3.

2.2.1 Durable equipments

The durable equipment covered by costs under this project are reported in Table JRA1-7
All the durable equipments will be user later as facilities of the underground labs.

Table JRA1-3: Participants, sharing of tasks, research effort of JRA1

	Participant Institution	Research effort for each task (person-months)					Contact	Participant Researchers	tot # researchers	Average Time on JRA (over the 3 years)
		1	2	3	4	Tot				
1	INFN Laboratori Nazionali del Gran Sasso	17	7	27	17	68	A. Bettini	A. Bettini, N. Ferrari, A. Ianni, M. Laubenstein, E. Bellotti, C. Cattadori, L. Pandola, F. Arneodo, F. Vissani, A. Razeto, C. Bucci, S. Nisi	12	15%
2	Laboratorio Subterraneo de Canfranc, Spain	10	20	15	5	50	A. Morales	A. Morales, J. Morales, J.A. Villar, I.G. Irastorza, S. Cebrian, J.M. Carmona, G. Luzon, M. Martinez, C. Pobes	9	15%
3	Laboratoire Souterrain de Modane, France	12	11	17	10	50	L. Mosca	M. De Jesus, Ph. Hubert, D. Lalanne, C. Marquet, G. Nollez, J. L. Reyss, C. Riccio, C. Goldbach, G. Gerbier	9	15%
4	Institute for Underground Science, UK	10	13	15	8	46	N. Spooner	N. Spooner, D. Tovey, S. Cartwright, V. Kudryavstsev, L. Thompson, S. Paling, J.McMillan, P. Lightfoot, G. Nicklin, M. Robinson, M. Carson, T. Lawson, B. Morgan, T. Gamble	13	10%
5	Max Planck Institut fuer Kernphysik Heidelberg, Germany	-	-	16	11	27	S. Schoenert	S. Schoenert, D. Motta, G. Heusser, H. Simgen, B. Freudiger	5	15%
6	INFN sez. di Milano,Italy	-	4	-	18	22	A. Giuliani	A. Giuliani, O. Cremonesi, M. Pavan E. Previtali	4	15%
7	CNRS/IN2P3/IPN,Lyon, France	3	5	3	-	11	E. Gerlich	E. Gerlic, P. Di Stefano	2	15%
8	CEA/DSM/DAPNIA, Saclay, France	-	3	3	-	6	X.F. Navick	X.F. Navick	1	10%
9	Technical University Munich, Germany	-	5	3	3	11	W.Rau	H. Wulandari, W.Rau	2	10%
10	Forschungszentrum Karlsruhe, Germany	-	5	-	-	5	K.Eitel	K.Eitel	1	10%
11	Institute of Physics, University of Silesia, Poland	8	8	-	-	16	J. Kisiel	J. Kisiel, B. Tucka, B. Kozlowska	3	15%
12	Rutherford Appleton Laboratory, UK	4	4	4	6	18	N. Smith	N. Smith, J. Mulholland, R. Luscher, D. Lewin, P. Smith, R. Priest, L. Yeoman	7	7%
13	Università di Roma 3, dip. Di Fisica Italy	2	-	5	-	7	W. Plastino	W. Plastino	1	20%
14	INFN sez. di Padova,Italy	4	-	-	-	4	C. Broggini	C. Broggini	1	10%
15	INFN Sez. Napoli, Italy	6	-	-	3	9	R. Santorelli	F.Carbonara, R.Santorelli	2	15%
16	INFN Sez. Pavia, Italy	4	-	2	5	11	C. Vignoli	G.L. Raselli, C. Vignoli, G. Introzzi	3	10%
17	Politecnico di Milano, Italy	8	-	-	-	12	A. Cesana	A. Cesana, L. Garlati	2	10%
	TOTAL	**84**	**85**	**110**	**86**	**365**			**77**	

Table JRA1-4: List of Researchers participant to the JRA1, roles, and competences

Home Institution	Affiliation for JRA1	Name	Qualif. (*)	Ts 1	Ts 2	Ts 3	Ts 4	Specific Roles in the JRP organization	Specific competences employed in the JRA (divided by participant groups)
INFN, LNGS	INFN Laboratori Nazionali del Gran Sasso	A. Bettini	EXP	x	x	x	x	JRA1 leader, LNGS director	Low-background instrumentation and techniques (HP Ge detectors, scintillator detectors), purification techniques, MC simulations for low energy gamma and for neutrons; experiments in rare event physics and neutrino physics; construction of ULBF facilities at LNGS
INFN, LNGS		N. Ferrari	EXP	x		x	x		
INFN, LNGS		A. Ianni	EXP			x	x		
INFN, LNGS		M. Laubenstein	EXP	x		x	x		
INFN, LNGS		L. Pandola	PhD	x	x				
INFN, LNGS		F. Vissani	EXP		x				
INFN, Sez. Genova		A. Razeto	EXP	x	x				
INFN, LNGS		C. Bucci	EXP				x		
INFN, LNGS		S. Nisi	TEC				x		
INFN, LNGS		F. Arneodo	EXP	x					
Univ. Milano Bicocca		E. Bellotti	EXP			x	x		
Univ. Milano Bicocca		C. Cattadori	EXP			x	x		
University of Zaragoza	Laboratorio Subteraneo de Canfranc	A. Morales	EXP	x		x	x	LSC director	Low backgr. Techniques (instrumentation HpGe, shieldings, Rn monitoring, electroforming copper, MC simulation for gamma and neutrons); experiments in rare event physics (Axion search, DM, bb decay)
University of Zaragoza		J. Morales	EXP	x	x	x			
University of Zaragoza		J.A. Villar	EXP		x	x	x		
University of Zaragoza		I.G. Irastorza	EXP	x	x	x			
University of Zaragoza		S. Cebrian	EXP	x	x	x			
University of Zaragoza		J.M. Carmona	EXP		x	x			
University of Zaragoza		G. Luzon	EXP		x	x			
University of Zaragoza		M. Martinez	PhD		x				
University of Zaragoza		C. Pobes	PhD		x				
CEA-Saclay	Laboratoire Souterrain de Modane	L. Mosca	Exp.			x		LSM director	γ spectroscopy, neutron background, radon detection, pulse-shape discrimination, veto systems, very low background Ge detectors,earth sciences, radiodatations, evironmental studies, MC calculations, material selection and purification.
CNRS/IN2P3/IPN, Lyon		M. DeJesus	Exp.	x	x	x			
CEA/DSM/DAPNIA, Saclay		G.Gerbier	EXP	x	x	x			
IAP-Paris		C.Goldbach	Exp	x			x		
CENBG-Bordeaux		Ph. Hubert	Exp.	x		x	x		
LAL/IN2P3-Orsay		D. Lalanne	Exp.	x		x	x		
CENBG-Bordeaux		C. Marquet	Exp.		x		x		
IAP-Paris		G. Nollez	Exp.		x		x		
LSCE-Gif/Yette		J.L. Reyss	Exp			x	x		
LSM (Fréjus)		C. Riccio	Tec.			x	x		

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Table JRA1-4 (continued): List of Researchers participant to the JRA1, roles, and competences

Home Institution	Affiliation for JRA1	Name	Qualif. (*)	Ts 1	Ts 2	Ts 3	Ts 4	Specific Roles in the JRP organization	Specific competences employed in the JRA (divided by participant groups)
IUS Boulby	Institute of Underground Science, Boulby, UK	N. Spooner	Exp			x		IUS Director	Dark matter searches, scintillators and gas detectors, low bacground studies, HP Ge detectors, radon and gamma assay, neutrino physics, low bacground fabrication,, low background data bases, neutron activation and mass spectrometry, veto design
IUS Boulby		D.Tovey	Exp	x	x				
IUS Boulby		S. Cartwright	Exp		x				
IUS Boulby		V.Kudryavtsev	PD	x	x				
IUS Boulby		L. Thompson	Exp		x				
IUS Boulby		S.Paling	PD			x			
IUS Boulby		J.McMillan	PD		x	x	x		
IUS Boulby		P.Lightfoot	PD			x			
IUS Boulby		G.Nicklin	TEC			x			
IUS Boulby		M.Robinson	PhD		x				
IUS Boulby		M.Carson,	PD		x				
IUS Boulby		T.Lawson	PD	x		x			
IUS Boulby		B.Morgan	PhD		x				
IUS Boulby		T.Gamble	TEC			x			
Univ. Milano Bicocca	Univ. Milano Bicocca, Italy	M. Pavan	EXP		x		x		Low energy nuclear physics, bolometry, MC simulation of background for rare event physics, conduction of experiments in rare-event phyisics (neutrinos, double beta)
Univ. Milano Bicocca		O. Cremonesi	EXP		x		x		
Univ. Milano Bicocca		E. Previtali	EXP		x		x		
Univ. Dell'Insubria	Univ. Dell'Insubria	A. Giuliani	EXP		x		x		
MPI Heidelberg	MPI Heidelberg, Germany	S. Schoenert	EXP			x	x		Low energy nuclear physics, low radioactivity, ultra-low background Ge diodes, ultra-low background gas proportional counters
MPI Heidelberg		G. Heusser	EXP			x	x		
MPI Heidelberg		D. Motta	Phd			x			
MPI Heidelberg		H. Simgen	Phd			x	x		
MPI Heidelberg		B. Freudiger	Phd			x	x		
Technical University Munich	Technical University Munich, Germany	H.Wulandari	PhD		x				Monte Carlo Simulation, low background measurements, rare event search, neutron meas.
Technical University Munich		W.Rau	EXP		x	x	x		
CEA/DSM/DAPNIA, Saclay	CEA/DSM/DAPNIA, Saclay, France	X.F.Navick	EXP	x		x			
Forschungszentrum Karlsruhe	Forschungszentrum Karlsruhe, Germany	K.Eitel	EXP		x	x			
CNRS/IN2P3/IPN, Lyon	CNRS/IN2P3/IPN, Lyon, France	P.Di Stefano	EXP	x		x			
CNRS/IN2P3/IPN, Lyon		E. Gerlic	EXP	x	x	x			

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Table JRA1-4 (continued): List of Researchers participant to the JRA1, roles, and competences

Home Institution	Affiliation for JRA1	Name	Qualif. (*)	Ts 1	Ts 2	Ts 3	Ts 4	Specific Roles in the JRP organization	Specific competences employed in the JRA (divided by participant groups)
Rutherford Appl. Laboratory	Rutherford Appleton Laboratory, UK	N.Smith	Exp		x				Enginering studies for low background and dark matter studies, construction of the Boulby facility, low bakground fabrication techniques and analysis, shielding design and construction, veto design
Rutherford Appl. Laboratory		J.Mulholland	TEC			x			
Rutherford Appl. Laboratory		R.Luscher	Exp			x			
Rutherford Appl. Laboratory		D. Lewin	Exp	x			x		
Rutherford Appl. Laboratory		P. Smith	Exp		x				
Rutherford Appl. Laboratory		R. Priest	TEC			x			
Rutherford Appl. Laboratory		L. Yeoman	TEC			x			
IOP Silesia	Institute of Physics, University of Silesia, Poland	J. Kisiel	EXP	x	x				Gamma and neutron spectrometry
IOP Silesia		B. Tucka	EXP	x	x				
IOP Silesia		B. Kozlowska	EXP	x	x				
INFN Sez. Padova	INFN Sez. Padova, Italy	C. Broggini	EXP	x					Gamma and neutron spectrometry
Polit. Milano – Dip. Ing. Nucl.	Politecnico di Milano – Dip. Ing. Nucl., Italy	A.Cesana	EXP	x					Gamma and neutron spectrometry Rn measurents; instrumentation and methods for bck measurements.
Polit. Milano – Dip. Ing. Nucl.		L.Garlati	PhD	x					
INFN Sez. Pavia	INFN Sez. Pavia, Italy	G. Introzzi	EXP				x		
INFN Sez. Pavia		G.L. Raselli	EXP	x		x			
INFN Sez. Pavia		C. Vignoli	EXP	x		x	x		
INFN Sez. Napoli	INFN Sez. Napoli, Italy	F. Carbonara	EXP	x			x		Archeometry, instrumentation and methods for bck measurements
INFN Sez. Napoli		R. Santorelli	EXP	x			x		
Università Roma 3	Università Roma 3, Italy	W. Plastino	EXP	x		x			Rn monitoring; ultra-low bck applications to geophyisics; radiodatations
TOT PARTICIPANTS DIVIDED BY TASK				33	37	44	32		

Phd=Phd Student; PD=Post-doc ; TEC=Technician; EXP=Experienced researcher staff

Table JRA1-5: Budget and financial requests for JRA1 divided by Task and participant.

Item	Participants	Total Budget (k€)	EU Grant (k€)
TASK 1 Database of the background components of the EU deep underground sites			
Travels and subsistence for bck monitoring campaigns and joint work days and wokshops Task 1 working group	Shared among all participants in Task 1 on the base of the research effort (table JRA1-3); administration of funds Task1 coordinator	60	60
Consummables for bck monitoring campaigns	Shared among undergrund labs	20	-
Support from the Underground lab technical staff	Shared among undergrund labs	32	-
New equipments for bck measurements	LNGS, LSM, LSC (see talso able JRA1-5)	80	40
Personnel costs (preparation and test of the instrumentation, new bck measurement campaigns, data analysis, DB implementation) from task 1 participants	Tot budget shared among participants in Task 1 on the base of the research effort (table JRA1-3)	168 k€ 84 pers/month	-
post-doc fellowship, 3 years in support of Task 1 coordinator	LNGS	140	140
	TOTAL COSTS TASK1	**530**	**255**
Task 2: Development of a standard library of background simulation codes			
Upgrade of computing infrastructures to host the libraries and support calcolus + additional technical support from computing staff	Shared LNGS, LSC, LSM, Boulby	40	32
Travels and subsistence for joint work days Task 2	Shared among all participants in Task 2 on the base of the research effort (table JRA1-3) administration of funds: Task 2 coordinator	30	30
Personnel costs (test and development of the MC codes, implementation and documentation of the libraries) from task 1 participants	Tot budget shared among participants in Task 2 on the base of the research effort (table JRA1-3)	170 k€ 85 pers/month	-
post-doc fellowship, 3 years in support of Task 2 coordinator	LSC	140	140
	TOTAL COSTS TASK2	**380**	**202**
Task 3 : European Ultra-Low-Background Facility			
Installing/Upgrading ULBF facilities at LNGS	LNGS	570	150
Scientific/technical support for ULBF facilities at LNGS from Task 3 participants	LNGS, MPI-HD, Univ. Roma 3, INFN Pavia	100 k€ 50 pers/month	-
Upgrading of the facilities at LSC (installation of electroforming copper facility, and of the ULBF facility)	LSC	280	120
Scientific/technical support for ULBF facilities at LSC from Task 3 participants	LSC	30 k€ 15 pers/month	-
Installing/Upgrading facilities at LSM	LSM	420	110
Scientific/technical support for ULBF facilities at LSM from Task 3 participants	LSM, CNRS Lyon, CEA Saclay	46 k€ 23 pers/month	-
Installing/Upgrading facilities at IUS	IUS	85	40
Scientific/technical support for ULBF facilities at Boulby from Task 3 participants	IUS	38 k€ 19 pers/month	-
Travels and subsistence for joint work days Task 3	Shared among all participants in Task 3 on the base of the research effort (table JRA1-3) administration of funds: LSM	10	10
post-doc fellowship, 3 years in support of LSM	LSM	140	140
post-doc fellowship, 3 years in support of IUS	IUS	140	140
	TOTAL COSTS TASK3	**1859**	**700**

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Table JRA1-5 (continued): Budget and financial requests for JRA1 divided by Task and participant

Item	Participants	Total Budget (k€)	EU Grant (k€)
Task 4 : European Database of radiopurity of the materials and purification techniques			
Equipment for implementation of DB	LNGS	10	5
Consummables and services (measurements of radiopurity samples)	Shared LNGS, LSC, LSM, Boulby on the base of the research effort	40	-
Travels and subsistence for joint work days Task 4	Shared among all participants in Task 4 on the base of the research effort (table JRA1-3) administration of funds: LNGS	18	18
Personnel costs (implentation of the DB, planning of new measurements; R&D in the purification techniques sector) from Task 4 participants	Tot budget shared among participants in Task 2 on the base of the research effort (table JRA1-3)	172 k€ 86 pers/month	-
post-doc fellowship, 3 years in support of Task 3 coordinator	LNGS	140	140
	TOTAL COSTS TASK4	**380**	**163**
Items common to all tasks and all participants			
EC Meetings (6 events, 8 persons)		25	**25**
General LBT-DUS meetings		100	**100**
Overheads (Administration and management of LBT-DUS)		100	**100**
	GRAND TOTAL COSTS	**3374**	**1545**

Table JRA1-6: Administration of the Grants for JRA1 [changes in the ripartition of funds still possible]

Laboratori Nazionali del Gran Sasso		
Task	**Item**	**Grant (k€)**
Task 1	Administration of travels and subsistence costs for bck monitoring campaigns and joint work days and wokshops Task 1 working group	60
Task 1	New equipments for bck measurements	10
Task 1	Post-doc Fellowship	140
Task 2	Upgrade of computing infrastructures LNGS	8
Task 3	Grant for Installing/Upgrading ULBF facilities at LNGS	150
Task 4	Equipments for implementation of DB	5
Task 4	Administration of Travels and subsistence costs for joint work days Task 4 working group	18
Task 4	Post-doc Fellowship	140
All tasks	General meetings LBT-DUS	100
All tasks	General Administration and management of LBT-DUS (to discuss)	100
All tasks	Executive Commitee meetings	25
	TOT Grant LNGS	**756**

Laboratorio Subteraneo de Canfranc		
Task	**Item**	**Grant (k€)**
Task 1	New equipments for background measurements (radon and neutron background)	10
Task 2	Administration of travels and subsistence costs for bck monitoring campaigns and joint work days and wokshops Task 2 working group	30
Task 2	Upgrade of computing infrastructures LSC	8
Task 2	Post-doc Fellowship Task 2	140
Task 3	Grant for Installing/Upgrading ULBF facilities at LSC	110
	TOT Grant LSM	**298**

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Table JRA1-6 (continued): Administration of the Grants for JRA1

Laboratoire Souterrain de Modane		
Task	**Item**	**Grant (k€)**
Task 1	New equipments for bck measurements	15
Task 2	Upgrade of computing infrastructures LSM	8
Task 3	Administration of travels and subsistence costs for bck monitoring campaigns and joint work days and wokshops Task 4 working group	10
Task 3	Grant for Installing/Upgrading ULBF facilities at LSM	110
Task 3	Post-doc Fellowship Task 3	140
	TOT Grant LSM	**283**

IUS Boulby		
Task	**Item**	**Grant (k€)**
Task 1	New equipments for bck measurements	15
Task 2	Upgrade of computing infrastructures at IUS	8
Task 3	Grant for Installing/Upgrading ULBF facilities at Boulby	40
Task 3	Post-doc Fellowship Task 3	140
	TOT Grant IUS	**203**

Table JRA1-7: Durable equipment covered by costs under JRA1

Equipment	Comments	Installation	Approx. Value	EU grant
Hybrid system HP-Ge + liquid scintillator	Task 3 See text	LNGS	140	110
XRF system	Task 3 See text	LNGS	20	20
Neutron measurement facility	Task 1 See text	LNGS	10	10
Equipments for upgrade of LLBF and GNO-ULBF facilities	Task 3; electronic modules, DAQ systems	LNGS	20	20
Radon Precision Measuring Facility (RPMF)	Task 1 Two,very sensitive Silicon detectors of the Radon present in the air	LSM	30	15
Cryo-generators for Ge detectors, at LN_2 temperature (up to 14)	Task 3 Replace LN_2 as cooling system for Ge detectors	LSM	300	50
Very low background Ge detector (R&D)	Task 3 Decrease by a factor 10 the background of the present Ge detectors.	LSM	60	30
Ge detector for low-energy gammas (R&D)	Task 3 Reach a good sensitivity for γ's below 30 keV	LSM	30	15
Neutron and Radon measurement facility	Task 1	LSC	30	10
2 low background Ge and NaI, electronic and shielding	Task 3	LSC	160	70
Eq. for electroforming Cu facility	Task 3	LSC	100	40
Neutron measurement facility	Task 1	IUS	10	10
Rn measurement facility	Task 1	IUS	20	5

3. European ADDED VALUE

3.1 Interest for European Research Infrastructures and their users

The results obtained with the present JRA will provide a more efficient use of the underground infrastructures, as well as its efficient use:

- All four EU deep underground sites will have a complete and coordinated database of the different background components, which will be extremely useful for planning future experiments and for the interpretation of data of the ongoing experiments.
- Simulation codes able to reproduce the conditions inside the underground sites will be implemented and tested with the data from Task 1. The library of codes will be supported by the computing infrastructures af all the labs and accessible to the scientific community.
- A set of facilities for ultra-low background applications coordinated at a European level will be available for the scientific community in the EU underground labs. This will reinforce the EU R&D possibilities offered to the astroparticle community; at the same time the enlargement and coordination of the facilities is supposed to open and strengthen the applications of ultra-low background techniques to multidisciplinary research.
- The database with the radiopurity characteristics, including also the information for the most important purification techniques relevant for underground physics should become a reference for researchers planning or designing equipements for underground experiments.

As a consequence the JRA will provide also improved access capabilities to the underground infrastructures in terms of scientific and technical support.

EU deep underground labs are of world-wide relevance both for the extension of the facilities, and the scientific activity (see section 1.2.2 of the TA1 proposal): a cooperation and integration of the EU deep underground sites is of paramount importance in order to compete with the research efforts and developments especially Japan and in USA.
In fact Underground science is an active field of research outside EU, with laboratories of various sizes and various depths in operation or planned for operation. For a summary of the situation outside Europe see section 1.2.1 of the TA1 proposal.

3.2 Exploitation of results

3.2.1 Improved Instruments and new technology

The databases and library codes with the planned characteristics of coordination and compatibility should become a new tool for underground science research in EU.

The new or upgraded ULBF facilities in the underground labs have also an European added value in terms both of improved instruments and technology; this is explained more in detail in the following for each installation:

LNGS

- **The upgrade of the existing low background counting facility** has the aim to increase the potential of the already existing Germanium detector laboratory by adding well-type detectors and new Ge-detectors built according to the most up-to-date technology. Moreover, in the past years the need for a multidisciplinary research has become evident and will be implemented with this upgrade. In fact in the new facility is included the plan of doing radio dating in ultra-low-background conditions, developing in the same time well-known standard techniques towards new innovative ways of measurement. Above all, ^{14}C-and ^{3}H-dating will be addressed with this new facility, including later also XRF techniques, which will be of big interest to geologists, archaeologists and environmental scientists. Moreover, collaborations with space science is possible, giving the possibility to measure very small samples with dedicated detectors. The new low background counting facility will be located underground in a prefabricated building along one of the service tunnels. The preparation of dating samples will be done outside in the chemical labs of the LNGS.

- The ULBF facilities presently used by the GNO experiment will be enlarged and upgraded: the facilities are unique for measuring ultra-low radioactivity samples with gas proportional counters (f.i. it is possible to measure concentrations of the order of the microBq/m3 of Rn) or with scintillator detectors. Facility GNO-S1 is presently used by the experiment and will be upgraded and reconverted at the end of the experiement as a ULBF facility of the Lab. A second facility (GNO-S2) is in a commissioning phase.
- The ULBF facility presently (LLBF) used by the LENS experiment for its pilot phase (or a copy of it) will be upgraded in the next years to become a facility of the lab. LLBF consists presently of a massive high purity shielding of Poliethylene/Pb/Steel/Cooper including a shielded volume of several m3 in conttrolled atmosphere.

LSC

- The ULBF presently used in LSC will be upgraded and enlarged with new ultralow Ge detectors and NaI for radiopurity measurements. Equipment for neutron and radon measurements and control will be installed.
- The **underground facility for electroforming copper** and production of pure lead bricks will be available at LSC in 2005.

The objective is to produce underground the purest copper free from cosmogenic activated radioimpurities (copper is an essential material ingredient in most component detectors – cryo and non-cryogenic-), needed for ultra low radiopurity background experiments.

In the new Canfranc (enlarged) facility, a set of clean rooms of class 100 to 1000 (totalizing ~80-100 m^2) will be installed. In these and in an adjacent zone, an electroplating facility to fabricate high-purity copper parts of the detector systems will be used. A mechanical workshop to machine the electroformed pieces will be settled nearby. The copper components of low background detectors will be electroformed from an ultrapure $CuSO_4$ solution onto polished stainless-steel mandrels. Whenever possible, mandrels will be designed to minimize sharp edges and the anode will be electroformed from the purest available copper. The solution will be contained in high-density polyethylene recipients and only Teflon, copper and stainless-steel parts will be allowed to come in contact with the solution to avoid contaminations. Technical personnel with experience in the actual electroplating facility (in the Zaragoza University laboratory) will be charged to operate this new installation.

A small room in the mechanical workshop sector of the new Canfranc will be dedicated to the making of lead shielding. Archaeological lead (and other old lead) will be melted (two-three times for cleaning up of impurities) in a pure inert gas atmosphere in a special tungstate crucible. The resulting pure lead will be melted again into bricks (or other forms) pieces and machined according, following the technique followed successfully by the Zaragoza group along more than ten years.