DESIR Status report
SAC meeting, September 2011

The present report presents the progress achieved of the DESIR facility in the last 12 months. Progress is presented for the DESIR building, the beam lines, the SHIRAC beam cooler, the HRS high-resolution separator, the two Penning-trap systems, the MLLtrap for high-precision mass measurements and the PIPERADE beam-preparation Penning trap, and the LUMIERE facility. For the BESTIOL facility, we give a short update report on the total-absorption gamma spectrometer to be installed at DESIR. All these elements constitute major equipments which will be installed at DESIR permanently or on a long-term basis.

1. Status of the DESIR buildings

J.-C. Thomas, GANIL

1 - Status after the consolidation of the building program (April 2011)

The organization of the different rooms in the transport tunnels and in the DESIR building has been optimized in April 2011, together with the distribution of the supply crates and the choices of technical solutions regarding the equipment handling. Figures 1 and 2 show 2D drawings of the different parts of the DESIR facility, the composition of which is summarized in table 1.

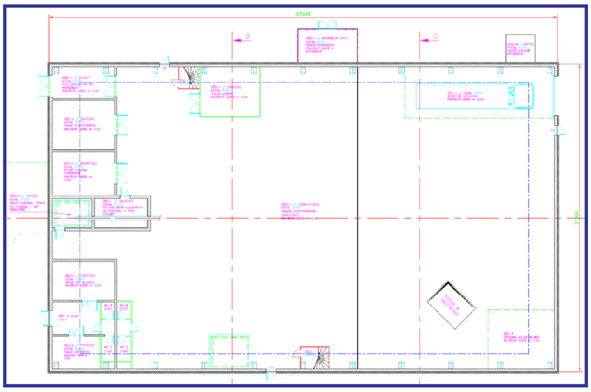

Figure 1: 2D drawing of the DESIR experimental area (April 2011).The main transport beam line will occupy the centre of the building. Different rooms are located on the left side of the hall: an acquisition and control room, and several accommodation rooms.

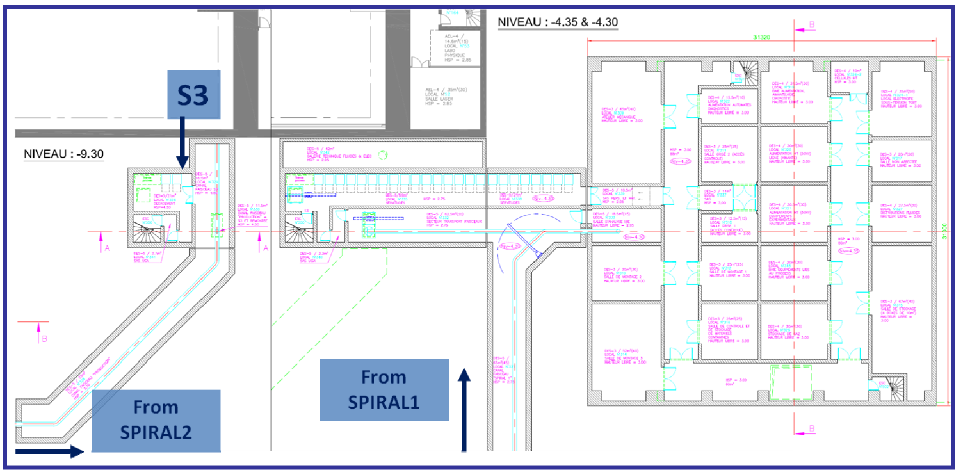

Figure 2: 2D drawing of the DESIR transport tunnels and of the main building underground (April 2011), the latter being divided in a number of supply rooms.

Code secteur	Nom secteur	Nom local	Programme	Projet	Programme	Projet			
			N° salle		Surface	Largeur	Longueur	Hauteur sous plafond	Surface
DES-1	Salle expériences	Salles d'expériences (50 m x 30 m)	301	301	1500 m²	30,00 m	50,00 m	6,00 m	1330 m²
		Salle laser	302	302	30 m²	5,00 m	5,95 m	3,00 m	30 m²
		Source test alimentant le faisceau + RFQ Cooler	303	303	0 m²	3,40 m	5,35 m	6,00 m	16 m²
		Zone de livraison	304	304	-	5,20 m	15,10 m	6,00 m	
		Sas personnel et matériels	-	340	-	3,20 m	6,40 m	3,00 m	21 m²
TOTAL SURFACES DES-1					1500 m²				1397 m²
DES-2	Annexes salle expériences	Poste central commande	305	305	20 m²	4,20 m	6,40 m	3,00 m	29 m²
		Salle acquisition	306	306	30 m²	5,00 m	6,40 m	3,00 m	32 m²
		salle de réunion	307	307	25 m²	3,90 m	6,40 m	3,00 m	25 m²
		Salle de repose	308	308	15 m²	3,50 m	4,90 m	3,00 m	17 m²
TOTAL SURFACES DES-2					90 m²				103 m²
DES-3	Locaux liés au process	Atelier mécanique	309	309	40 m²	6,20 m	10,80 m	3,00 m	65 m²
		Salle grise 1 (accès contrôlé)	310	310	15 m²	2,50 m	5,00 m	3,00 m	13 m²
		Salle grise 2 (accès contrôlé)	311	311	25 m²	5,00 m	5,00 m	3,00 m	25 m²
		Salle montage 1	312	312	25 m²	5,00 m	5,00 m	3,00 m	25 m²
		Salle de montage 2	313	313	30 m²	4,70 m	6,20 m	3,00 m	30 m²
		Salle de montage 3	314	314	40 m²	6,20 m	8,70 m	3,00 m	52 m²
		Salle de stockage (4 boxes de 10m²)	315	315	40 m²	5,40 m	11,50 m	3,00 m	67 m²
		Salle de contrôle et de stockage de matériels contaminés	316	316	25 m²	5,00 m	5,00 m	3,00 m	25 m²
		Salle non affectée	317	317	20 m²	3,80 m	5,40 m	3,00 m	20 m²
		Sas personnel et matériels	-	341	-	2,20 m	5,00 m	3,00 m	11 m²
TOTAL SURFACES DES-3					260 m²				333 m²
Code secteur	Nom secteur	Nom local	Programme	Projet	Programme	Projet			
			N° salle		Surface	Largeur	Longueur	Hauteur sous plafond	Surface
DES-4	locaux de servitudes	Baies équipements liés au process	318	318	30 m²	5,00 m	6,00 m	3,00 m	30 m²
		Baies alimentation, aimants, vide, diagnostic	319	319	30 m²	5,50 m	6,00 m	3,00 m	32 m²
		Alim HT (50kV) ligne (aimants)	320	320	30 m²	5,00 m	6,00 m	3,00 m	30 m²
		Alim HT (50kV) équipement expérimentaux	321	321	30 m²	5,00 m	6,00 m	3,00 m	31 m²
		Alimentations automates - diagnostics	322	322	10 m²	3,00 m	5,00 m	3,00 m	16 m²
		Transformateur(s)	323	323	Extérieur	3,50 m	6,10 m	extérieur	21 m²
		Local électricité - sous-station - TGBT	324	324-1	50 m²	5,40 m	6,80 m	3,00 m	35 m²
		Local électricité - cellule HT		324-2	50 m²	2,80 m	3,30 m	3,00 m	10 m²
		Azote liquide	325	325	9 m²	3,00 m	3,00 m	extérieur	9 m²
		Stockage de gaz	326	326	30 m²	5,00 m	6,00 m	3,00 m	30 m²
		Distributions fluides	327	327	30 m²	5,00 m	5,40 m	3,00 m	28 m²
TOTAL SURFACES DES-4					240 m²				271 m²
DES-5	Secteur transport faisceaux	Canal faisceau 'PROD'	328	328	30 m²	3,00 m	30,00 m	3,70 m	87 m²
		Canal faisceau S3	329	329	30 m²	3,00 m	5,80 m	4,50 m	18 m²
		Canal faisceau 'PROD + S3' et remontée	330	330	10 m²	3,00 m	5,70 m	4,50 m	18 m²
		Canal faisceau 'SPIRAL 1'	331	331	45 m²	3,00 m	23,00 m	2,75 m	52 m²
		Secteur transport faisceaux	332	332	20 m²	3,00 m	8,80 m	2,75 m	47 m²
		Salle d'analyse IBE	333	333	15 m²	3,00 m	6,00 m	2,95 m	19 m²
		Salle faisceau 'PROD-S3 + SPIRAL 1' et remontée	334	334	30 m²	3,40 m	4,00 m	6,00 m	12 m²
		Servitudes local 328	335	335	-	2,70 m	30,00 m	3,70 m	74 m²
		Sas UGA	336	336	-	2,10 m	3,00 m	4,50 m	7 m²
		Servitudes local 331 et 332	338	338	-	1,80 m	35,40 m	2,75 m	90 m²
		Sas personnel et matériels	339	339	-	1,60 m	6,90 m	2,95 m	11 m²
TOTAL SURFACES DES-5					180 m²				434 m²

Table 1: Description of the different DESIR rooms in the main building (DES-1 to DES-4) and in the beam transport tunnels (DES-5).

During the building consolidation phase, technical specifications of the DESIR building in terms of power consumption and dissipation have been refined and turned out to be in rather good agreement (see table 2) with the initial expectations from which the SPIRAL2 Phase 2 prime contractor estimated the price of the facility construction.

Re-evaluation of the power consumption		Initial figures (building program)
High currents (400V+220V)	869 kW	1140 kW
Maintained power	81 kW	68 kW
Power dissipated in air	236 kW	314 kW
Power dissipated in water (5 bars)	145 kW	124,5 kW
Water flow	36m³/h (9,2 m³/h for the experimental area)	24,9 m³/h

Table 2: Comparison of the initial (building program, May 2009) and re-evaluated power consumption of the DESIR facility (April 2011).

2 - Status by the end of the preliminary design study phase (September 2011)

The DESIR infrastructure is being studied within the Phase 2 of the SPIRAL2 project by the primary contractor, together with the SPIRAL2 infrastructure group. The buildings include the beam transport tunnels from the existing GANIL facility, from the SPIRAL2 production building and from the S3 experimental area, as well as the DESIR building consisting in an experimental hall (level 0) and its associated supply rooms (level -1). Figures 3 and 4 show the state of the art of the 3D model produced in the preliminary design study phase. In particular, one can distinguish the different networks associated with the operation of the facility:

- In orange: Ventilation
- In pink and red: Electricity
- In blue and in light blue : Fluids

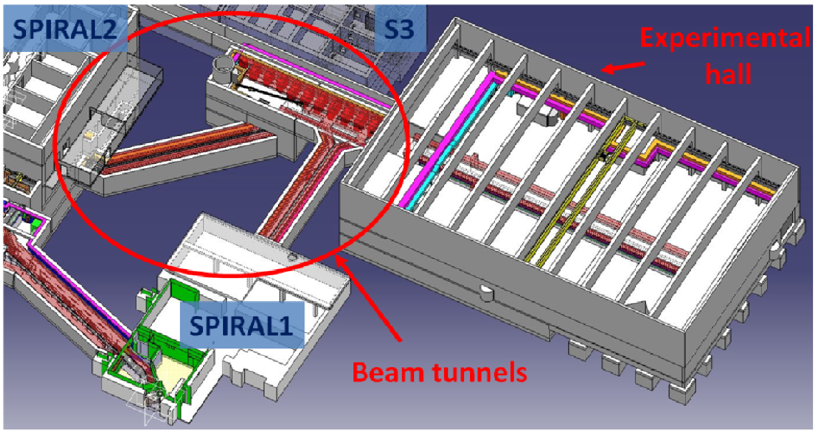

Figure 3: General view of the DESIR beam transport tunnels and experimental hall provided by the SPIRAL2 infrastructure group in the preliminary design study phase.

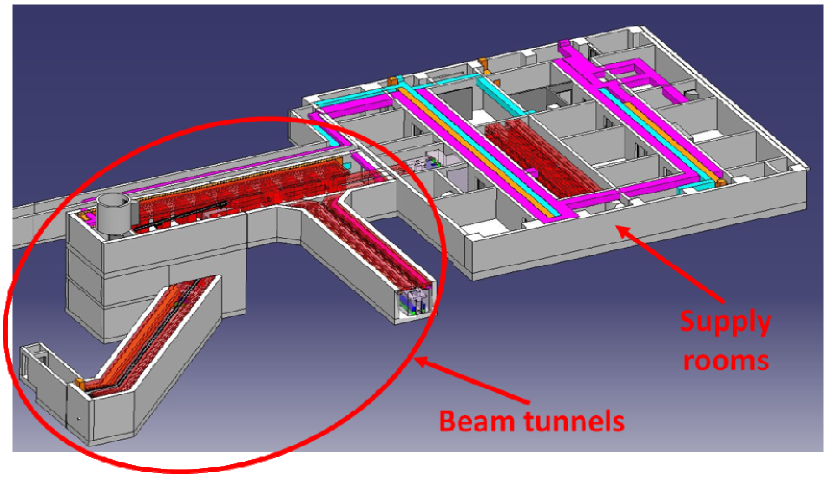

Figure 4: General view of the DESIR beam transport tunnels and supply rooms provided by the SPIRAL2 infrastructure group in the preliminary design study phase.

3 - Beam intensity limitations (March 2011)

A safety study has been performed by the primary contractor in order to determine the constraints on the building infrastructure and on the intensity of the delivered radioactive beams imposed by the requirement that the DESIR experimental hall is run as a green area (dose rate < 25 µSv/h at 1 m from the collection point of the activity). The study was based on the two main constraining beams, namely ^{90}Kr and ^{132}Sn. The conclusion is threefold:

- With respect to the DESIR environment (outside the wall) and the protection of the users (around the experimental setup), the ^{90}Kr beam activity is limited to 6.6E+7 Bq and the one of ^{132}Sn to 3.25E+7 Bq provided that the walls of the DESIR experimental hall are 30 cm thick and 2 m high, and that the users are not allowed to approach the collection point at a distance less than 1m during the operation of the facility (see figure 5),
- The collection points of the experimental setups must be set at a minimum distance of 3 m with respect to the DESIR building walls (see figure 5),
- Due to the small size of the IBE station and of the gas storage room, the ^{132}Sn beam activity needs to be limited to 1.05E+7 Bq, unless a nuclear ventilation of the two rooms is implemented.

Because of the costs of a nuclear ventilation, it was decided to restrict the ^{132}Sn beam activity to a level compatible with a standard ventilation class (C1), which translates into beam intensity limitations for ^{90}Sr and ^{132}Sn of 6.6E+7 and 3E+6 Bq, respectively.

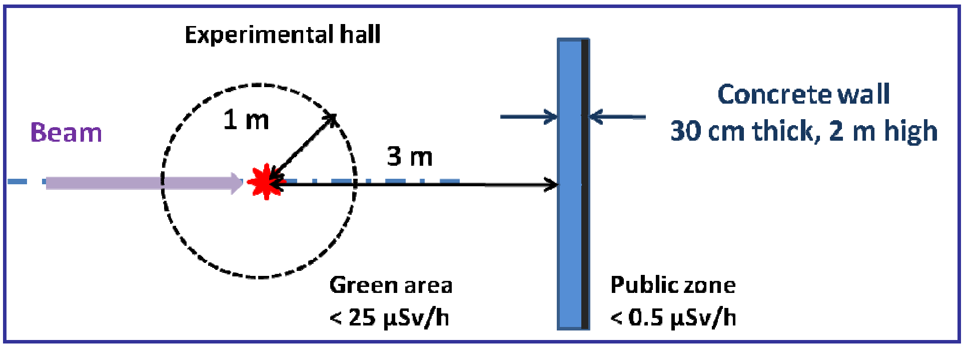

Figure 5: Constraints imposed by safety considerations for the use of radioactive beams in the DESIR experimental hall.

4 - EQUIPEX funding (September 2011)

The DESIR collaboration proposes to finance the construction of the facility via the 2011 EQUIPEX call (answer by 2012). The funding request amounts to ~14.1 M€ for:

- The construction of the buildings (beam transport tunnels and main building): GANIL,The construction of the beam lines towards and inside the DESIR hall: IPNO, in collaboration with GANIL and CENBG,
- The construction of general purpose equipments (an identification station and an ion buncher): IPHC and CSNSM in collaboration with LPC Caen, GANIL and CENBG,
- The implementation of user facilities (stable-ion sources, a mechanical workshopand a radioprotection laboratory): CENBG in collaboration with LPC Caen and GANIL.

~1.1 M€ are further requested for the facility operation, from July 2015 to January 2010 (54 months).

Three DESIR representatives will be specifically in charge with prospective related to nuclear energy studies, industrial and medical applications and material science.

The project will require 517.4 man.months of manpower, and 42 man.months of CDD over the 90 months of the project. The timeline of the project is given in table 3.

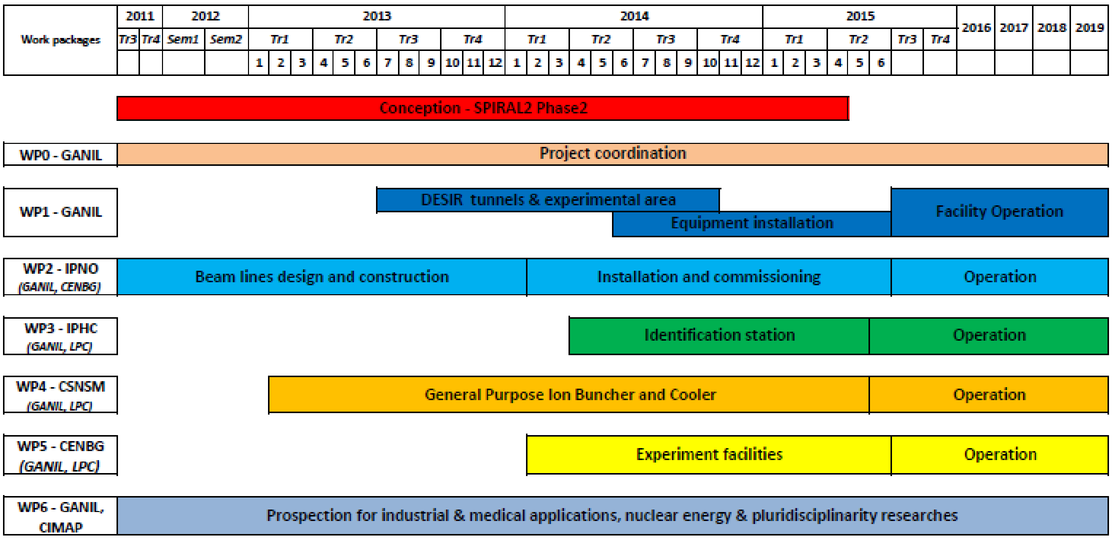

Table 3: Timetable of the DESIR construction and operation within the framework of the 2011 EQUIPEX funding request.

2. The SHIRAC cooler

Gilles Ban, LPC Caen

The high intensity SPIRAL II cooler is designed to cool beams up to 1 µA and down to an emittance of 1 pi mm mrad. To achieve these performances, the main difference to existing coolers is the RF voltage and frequencies, which are in the range of a few MHz and a few kV. The cooler has been completed at the end of 2010 and it is right now under intensive tests and characterization with an ionization surface offline source. The tests are performed with alkaline ions at an energy of 5 keV. Preliminary measurements have been made with low current (nA) and the transmission vs the Mathieu parameter is shown on figure 6. Preliminary transmission measurements with 1µA beams result above 60%. The emittance measurement of cooled beams has just started and preliminary results will be available soon. We are also investigating operation points (voltage, frequency, gas pressure) to obtain the best possible performance. The triplet to couple the cooler and the HRS is set up downstream of the cooler and will also be characterized.

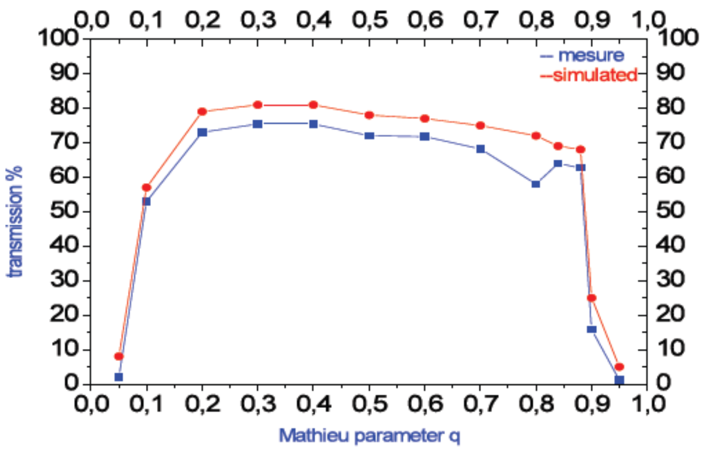

Figure 6: Cooler transmission as a function of the Mathieu parameter.

3. The HRS high-resolution separator

Teresa Kurtukian Nieto, CEN Bordeaux-Gradignan

1 – Technical description

The main goal of the HRS is to provide mono-isotopic beams of exotic nuclei coming from the 1+ line of the SPIRAL2 production building. The HRS has been designed with a maximal geometrical acceptance of 5π.mm.mrad (~90% transmission), and E=60 keV beams within the limits of a magnetic rigidity of 0.6Tm. The mass dispersion of the HRS is 31 cm/%, which allows a maximal resolving power m/Δm of 31000 for a 1π mm.mrad beam emittance. The first module consists of two 90° magnetic dipoles (D) with 36º entrance and exit angles, four matching quadrupoles (MQ), two focusing quadrupoles (FQ), two focusing sextupoles (FS) and one multipole (M) with the configuration QQSQDMDQSQQ. Mirror symmetry is kept with respect to the mid-plane to minimize aberrations. Focusing and corrective elements are all electrostatic and thus settings are independent of mass. The second module is fully electrostatic (two quadrupole doublets and two 45° benders) and allows to re-inject the purified beam into the 1+ beam line of SPIRAL2, homothetic at 80 π mm mrad.

2 – Status report

- **Optics:** The ion-optics of the HRS is well defined. This design is expected to be validated by worldwide experts attending the 2nd DESIR/SPIRAL2 HRS Workshop that will be held in Bordeaux on November 17-18, 2011.
- **Modularization:** The HRS has been already technically conceived as a modular structure (7 modules in total) in coherence with the principles adopted for the whole SPIRAL2 radioactive beam transport installation.
- **Infrastructure:** The interface with the general infrastructure is managed via SMARTEAM. 3D model of the HRS and its connection with the RFQ-Cooler is available. The HRS skeleton can be found in figure 7.
- **Alignment:** The alignment principles of the different sections of the HRS are stated in the Note I-019462. The definition and the location of the necessary specific tools to do it (mirrors, etc) are made in agreement with the land surveyor of the Project, and can be found under the reference EDMS I-025649.
- **Fabrication:** Dipole magnets will be ordered in 2012 (400 k€ are available via a CPER agreement between the French government and the Région Basse-Normandie). All electrostatic elements will be built at CENBG.
- **Assembly:** The HRS assembly and the first tests of alignment and characterization will be performed at CENBG. An assembly hall has been constructed for this purpose and other projects. After theses tests, the whole system will be transferred to the SPIRAL2 site.

4. Status of the DESIR low energy transfer beam-line

Luc Perrot, IPN Orsay

1 - Beam dynamics studies

Careful and detailed studies to the beam dynamics have been performed during the last six months. The studies concerned the lines from S1 (SPIRAL1/LIRAT), S2 (SPIRAL2 Production building), S3 (the exit of the low energy branch of the Super Separator Spectrometer) and the ground level of the DESIR hall. Special attention was paid in order to have a perfect match with the previously defined skeleton and the geometrical points of the buildings. Due to the numerous line interconnections coming from three locations and the two changes in vertical level, systematic verification must be done.

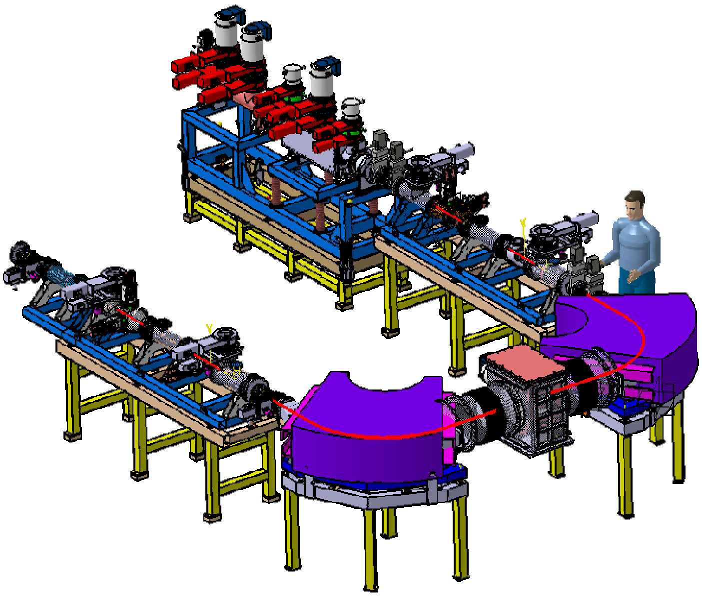

Figure 7: 3D view of the DESIR HRS presently under study at CENBG.

Basics structures have been chosen especially for the 90° deviations (2 benders associated with 3 quadrupoles) and the straight sections designed with 3 quadrupoles. In this way, we can match the beam in a more stable configuration which will be independent from the input beam energy. Therefore at the entrance of each beam line coming from S1, S2 or S3, the beam has to be matched properly.

First basic calculations were initiated by F. Varenne from GANIL using GALOPR. Full calculations using the TRANSPORT and TraceWin codes are now available.

Very recently, a collaboration has been initiated with D. Toprek from the VINCA Institute in Belgrade in order to help us in the full design of the DESIR transfer beam lines. We are working on a benchmark with TRANSPORT and GICOSY. Search for the optimum location along the lines of the orbit correctors and the beam diagnostics is also under way.

As an example, Figure 8 shows the transverse beam optics for a 60keV beam with a RMS transverse emittance of 20π.mm.mrad from the waist matching point in the SPIRAL2 production building up to the waist point in the DESIR hall.

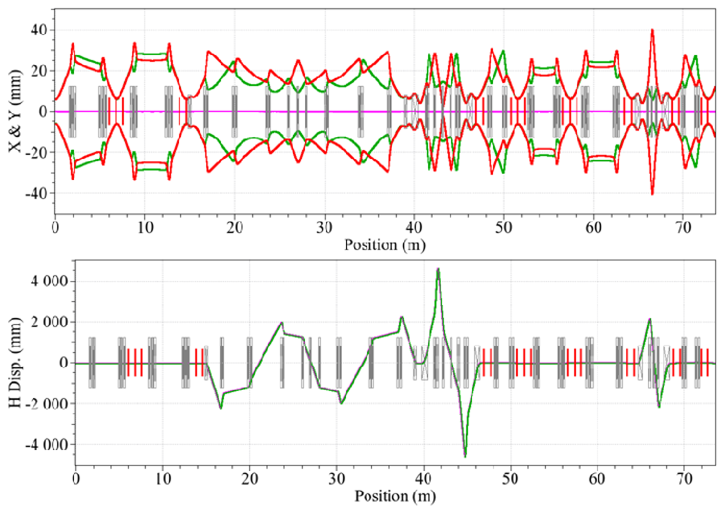

Figure 8: 2 RMS transverse beam emittance for a $^{132}Sn^{1+}$ beam at 60keV along the transfer line from the SPIRAL2 production building up to the DESIR building. The bottom picture represent the dispersion term of the transfert beam line.

2 - Mechanics integration
The mechanical design is under way, too. Up to now the detailed study with respect to the beam dynamics and the building constraints is performed. The work is now focused on the transfer line from the production building up to DESIR.

3 - Organisation
IPNO is responsible for the beam transfer line design. The full design includes the beam optics, benders, quadrupoles, steerers, mechanical structure, implementation, vacuum studies, diagnostics studies, supervision... This work is performed within a collaboration between IPNO, GANIL, CENBG and CSNSM. After the construction of a prototype section at IPNO, the main construction of the mechanical parts (support structures, beam pipes, feedthroughs etc.) will be performed by BARC, Mumbai.

5. Status of the LUMIERE facility

Gerda Neyens, Leuven

The CRIS (Collinear Resonance Ionisation Spectroscopy) beam line has been installed and tested by members of the LUMIERE collaboration at ISOLDE-CERN. The LUMIERE beam line will be based on this design. With the CRIS method of collinear spectroscopy, based on a two-step resonant re-ionization process in an ultra-high vacuum (UHV) environment, experiments with beam intensities down to few ions/sec should become possible. During the past year, several aspects of the method were successfully tested. A 75% neutralization efficiency was achieved in the charge exchange cell, combined with a vacuum of better than 5.10^{-9} mbar in the atom-laser interaction region obtained by differential pumping. The beam transport efficiency was modelled and optimized from 20% to 80% transmission up to the interaction region by adding a quadrupole doublet before the charge exchange cell. Another quadrupole doublet was placed just before the final bending point, to achieve a transmission of better than 50% to the end of the beam line, where the resonance ionization signal is detected in a background-free environment. The fraction of non-resonant ions produced in the UHV rest gas and reaching the detection region was less than 1/50.000 and can still be further optimized.
The progress with the CRIS development has now directly influenced the LUMIERE technical design which commenced in June 2011. To achieve the multi-user and multi-experiment goals of LUMIERE, the layout of the lines are now based on an extended and sectioned adaptation of the CRIS design. The former, the extension of the line, has been shown in ion-optical simulation to permit the formation of multiple beam waists (essential for fluorescence based spectroscopy) and the latter, the downstream section, to provide a line optimized for re-ionization and polarization. All key design elements fit within the DESIR hall layout and provide the greatest scope for future extensions.
Figure 9 shows the CRIS beam line.

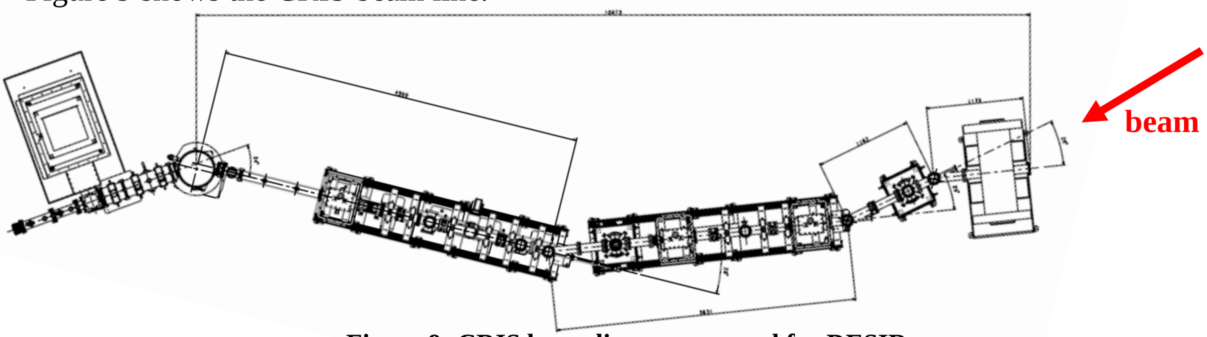

Figure 9: CRIS beam line as proposed for DESIR.

6. Status of the MLLtrap facility

Peter Thirolf, Munich

Recent work performed at MLLTRAP targeted two issues: (i) R&D was performed towards the development of an in-trap (alpha-) spectroscopy setup via the design of a cubic arrangement of position-sensitive Si strip detectors replacing the central ring electrode of the measurement Penning trap. Customized Si strip diodes have been developed with a Russian manufacturer and UHV- as well as cryo-compatible ceramic (AlN) carrier boards and customized, compact high-density PEEK connectors have been developed and manufactured. Work is ongoing to commission the detectors in the laboratory as well as under magnetic field conditions. An independent and optimized trap electrode system, allowing for a fast exchange between the mass measurement and in-trap setups is under construction. (ii) Using highly-charged ions in the Penning trap allows for a significant improvement of the mass accuracy, or, alternatively, the use of shorter measurement times for short-lived exotic species. Since any charge-breeding technique requires a subsequent q/A separator to select the charge state of interest, a 'Multi-Passage-Spectrometer' based on a dipole magnet with round pole tips is under construction at MLLTRAP. In order to allow for a fast ramping of the magnet, thus enabling a rapid variation of its bending power between injection of singly-charged and extraction of highly-charged ions, a laminated magnet yoke has been chosen. Together with a customized power supply, periodic ramping of the magnet can be performed within 50 ms, suitable also for short-lived ion species. A scanning robot was constructed for an automated map of the magnetic field on a 1 mm grid in 3D. Based on the resulting field map with more than 4 million data points, ion-optical trajectory simulations for the design of deflectors and correction lenses inside the magnetic field are in progress.

Figure 10 shows the MLLtrap presently installed at the Maier-Leibniz laboratory in Garching.

Figure 10: MLLtrap at its development stand in Garching.

7. The PIPERADE facility for beam preparation

Stéphane Grévy, CEN Bordeaux-Gradignan

The CENBG, in collaboration with CSNSM and GANIL, is going to develop the PIPERADE (PIege de PEnning pour ions RAdioactifs a DEsir) project. Its aim is to accumulate, clean and trapp large ensembles of radioactive ions in order to perform high precision spectroscopy experiments at DESIR. Such experiments are needed, for example, for the determination of fundamental constants of the electroweak Standard Model of the fundamental interactions. The system will be composed of an RFQ cooler and buncher and a double Penning trap. It will be used for studies with nuclei produced either by SPIRAL1, SPIRAL2 or S3.
In September 2010, we requested funds from the French ANR (Agence National de la Recherche), the CRA (Conseil Régional Aquitaine), and the University of Bordeaux 1. All these institutions agreed to finance the project. In addition, IN2P3 and the Max Planck Institute of Heidelberg support the project by financing a PhD student. The project will to start in October 2011.

The total investment cost allocated is about 850 k€. The allocated manpower costs for permanent people amount to a total of 314 k€ and travel costs of 42 k€ have been foreseen in the budget.

8. Beta-decay total absorption spectrometer for DESIR

José Luis Tain, CSIC Valencia

At DESIR we plan to carry out measurements of the β-decay intensity distribution over the full accessible decay energy window using total absorption γ-ray spectroscopy. A new spectrometer has been built by the Surrey-Valencia collaboration and will be used at DESIR. It is a compact design, based on BaF2 scintillation material. The spectrometer is segmented to allow the registration of the γ-ray cascade energy and multiplicity distribution in addition to the total cascade energy. It is expected that this feature will bring a major improvement in the accuracy of the data deconvolution. A first experiment has been performed at the IGISOL separator of JYFL (Finland) at the end of 2009 and during the last year we have been working on the detector characterization and analysis procedure. This included development of an off-line recalibration procedure for the accurate reconstruction of events, the development of pileup correction algorithms based on event information and extensive Geant4 Monte Carlo simulations of the spectrometer response. Work has started in order to replace the present analog electronics with digital electronics.
An alternative spectrometer design is also under development. It is a modular design based on NaI(Tl) in this case, with a large central hole to allow the implantation of broad secondary beams. This spectrometer could also be employed at DESIR and it has specific advantages since allows the placement of large ancillary detectors inside. A first prototype has been developed and tested and more modules are under construction.

Summary

The present progress report concerns only the major equipment to be installed at DESIR. Other smaller size devices are presently also under study or construction and will enrich the experimental program at DESIR. These setups include charged-particle setup, neutron and gamma-ray detectors and much more.
The DESIR project is well on time and will be ready when first beams will be available for use in DESIR by July 2015.