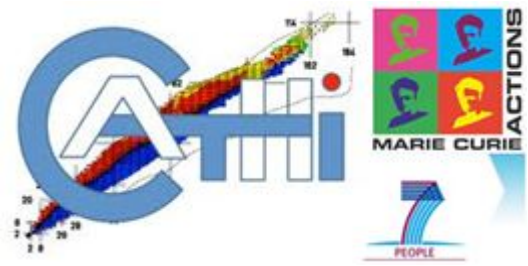

Cryogenics, Accelerators and Targets at HIE-ISOLDE

CATHI 2nd Progress Report

Project activity report for the period: 01/11/2012-31/10/2013

Yacine Kadi (CERN) : WP0 leader, Project Coordinator
W. Venturini, S. Calatroni (CERN) : WP1 leaders
E. Bravin (CERN) : WP2 leader
J. Bauche (CERN) : WP3 leader
J.C. Gayde, Y. Muttoni (CERN) : WP4 leaders
D. Voulot (CERN) : WP5 leader
R. Catherall (CERN) : WP6 leader
G. Vandoni (CERN) : WP7 leader
T. Giles, F.J.C. Wenander (CERN) : WP8 leaders
A.P. Bernardes (CERN) : WP9 leader

The research leading to these results has received funding from the European Commission under the FP7-PEOPLE-2010-ITN project CATHI (Marie Curie Actions - ITN).
Grant agreement no PITN-GA-2010-264330.

This work is part of CATHI Work Package 0: Project management.

Content

1. WP0: Management of the CATHI project

Main achievements

Realization of the CATHI sharepoint website
Completion of the sixteen ESR and three ER recruitments (ER1 recruited on 1/1/2013)
Outreach:

- Realization of the CATHI "take part" video;
- Participation in the CERN Open Days event 28-29 Sep. 2013
- Organization of the EU-DG visit

Dissemination:

- Sponsorship of young researchers for attending EMIS2012 (2-7 Dec. 2012 in Riken, Japan), SRF2013 (23-27 Sep. 2013 in Paris, France) and ThEC2013 (27-31 Oct. 2013 at CERN) International Conferences
- Preparation of the Annual CATHI Technical Workshop held on 28-29 Nov. 2013

Summary of WP0 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D00	OWSF	Overall Web Site Frame ready	1	Achieved month 1
D01	AR1	1st Progress Report	12	Achieved month 21
D02	PR1	1st Periodic Report	24	Achieved month 29
D03	AR2	2nd Progress Report	36	Achieved month 41
D04	PR2	2nd Periodic Report	48	-
D05	FPR	Final Project Report	48	-

Status of milestones

Num	Short name	Description	Planned month	Status
M01	OKM	Organization of the Kickoff meeting	1	Achieved month 1
M02	ESRA	First ESR Appointment	3	Achieved month 5
M03	CRR	Complete recruitment of all ESR and ER	12	Achieved month 15 for ESR Achieved month 26 for ER

Summary of past and planned meetings

The management team meets as needed and interacts regularly with WP coordinators.

	Date	Venue	Attendance	Objective(s)
Kick-off meeting	23/05/11	CERN	≈ 30	Launch CATHI-ITN
General Meetings	14/11/11	CERN	≈30	1st General meeting
	12/12/12	CERN	25	Prepare ISOLDE Meeting on 17-19 Dec
	28-29/11/13	CERN	115	1st CATHI Technical Workshop
CSMB	12/12/11	CERN	15	Review administrative, financial issues and the progress within each WP Prepare the mid-term review on 26 Sep
	07/08/12	CERN	-	

	12/12/12	CERN	12	Preparation of the 1st Periodic Report
	20/03/13	CERN	8	
	26/03/13	CERN	2	
	17/04/13	CERN	5	Review administrative, financial issues and the progress within each WP
CFM	22/11/11	CERN	9	Follow-up the progress of the individual research projects and review the integration of the Researchers.
	13/12/11	CERN	9	
	09/02/12	CERN	10	
	04/05/12	CERN	12	
	14/08/12	CERN	9	Prepare the mid-term review on 26 Sep
	19/09/12	CERN	22	
	10/10/12	CERN	16	Follow-up the progress of the individual research projects and review the integration of the Researchers.
	23/10/12	CERN	7	Preparation of the CERN Engineering School
	31/10/12	CERN	16	Presentation of career opportunities and Marie-Curie Fellow Association
	28/11/12	CERN	12	Report on the Marie-Curie annual conference
	09/01/13	CERN	25	Gathering Galettes des Rois
	30/01/13	CERN	14	Organization of technical courses for 2013 and outreach activities
	06/03/13	CERN	18	Setting up of CATHI Blog
	23/08/13	CERN	19	General discussion on end-of-contract issues and preparation for CERN Open Days
	28/01/14	CERN	16	Organization of training course in Project Management and End-of-Contract issues
MTR	26/09/12	CERN	≈30	CATHI Mid-Term Review

The CATHI Supervisory Board and Management Committee (CSMB) meets on the occasion of the general meetings and specifically at least every 6 months, or more frequently if required.
The CATHI Fellow meetings (CFM) take place every month and is attended by the Project Coordinators.

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Press article in CERN bulletin	-	-	11
CERN Annual Report 2011	-	-	17
Progress report #1	Report	12	21
Mid-Term report	Report	23	23

Further comments

The HIE (**H**igh **I**ntensity and **E**nergy)-ISOLDE project embraces new developments in radioisotope selection, improvements in charge-breeding and target-ion source development. For extending the physics reach of the facility, the most significant component is the Superconducting linear accelerator with a minimum energy of 10 MeV/u (HIE-LINAC) which will replace most of the existing ISOLDE post accelerator.

It must be stressed that the design and construction of a SC accelerator is a highly multidisciplinary task. The R&D activities of the ESRs and ERs are broken down into nine work packages (1-9) summarized below.

Moreover the collaboration with the Associated Partners has been strengthened all along the project through the participation to the R&D activities and the hosting of the CATHI fellows during their secondment periods.

Seven new Associated Partners have joined the CATHI project:

1. University of Liverpool (UK)
2. University of Manchester (UK)
3. Department of Nuclear Physics, DSM-IRFU (CEA-Saclay, France)
4. Brookhaven National Laboratory (USA)
5. Brandeis University (USA)
6. Technical University of Liberec (Czech Republic)
7. Regional Centre for Special Optics and Optoelectronics Systems, TOPTEC, Turnov (Czech Republic)

2. WP1: Superconducting Cavity Developments and Tests

Work package number	**1**	**Start date or starting event:**	Month 7
Work package title	SuperConducting Cavity Development and Tests		
Activity Type	RTD		
Person-months	**96 (ESR1: N. M. Jecklin, 36 months; ESR2: I. Mondino, 36 months and ER1: Pei Zhang, 22 months)**		
Associated Partners	IPN-Orsay, INFN-LNL, SDMS, ZANON, CINEL, CI		
Objectives	Develop techniques to realize and test a SuperConducting resonant cavity of the quarter-wave type (QWR) using the technology of niobium film sputtering over a copper substrate at HIE-ISOLDE.		
Description of work	1. **ESR2**: Specification and conceptual study of the SC cavity and subsequent realization of the prototype low-beta cavity. 2. **ESR2**: Setup of the cryomodule test stand and cold tests of the SC cavity (investigation of Q-drop effect). 3. **ER1**: Development of QWR frequency tuning strategy, QWR multipacting study and design study of the low-beta cavity. 4. **ESR1**: Development and qualification of Niobium thin film sputtering techniques on the prototype and series high-beta copper cavities.		
Deliverables	D06. Report on the SC cavity baseline mounting and sputtering **(ESR1)** D07. Report on the SC cavity performance measurements **(ESR2)** D08. Report/publication on the QWR frequency tuning strategy (**ER1**) D09. Report on the multipacting study of the high-beta cavity (**ER1**) D10. Final report and/or journal publications on the QWR Cavity Dev. and Tests **(ESR2)**		

Main achievements

Continuing effort has been put in the upgrade of the coating facility and the optimization of the coating process. The workflow to produce and characterize a test Nb coated cavity has been consolidated in view of the reception of the series cavities from industry. A crucial milestone was reached in April 2013 when the test cavity Q2_8 reached 6 MV/m at 7 W dissipated power, which is 30% higher then the specifications for HIE ISOLDE and will allow - in the first phase of the project- running at 5.5 MeV/a up to A/q =4.5. This improved RF performance where reproduced on other test cavities and the first series production cavitiy QP2 in October 2013.

The SRF program for the HIE-ISOLDE project, focused on the development of Nb sputtered QWR generating 6 MV/m at 10 W power dissipation was vigorously pursued in 2012 in collaboration with our Associated Partners (IPN-Orsay, INFN-LNL and TRIUMF) with encouraging results. A second RF test cryostat for Quarter Wave Resonators was setup in IPN-Orsay, a third test cryostat is under construction in INFN-Legnaro laboratory. Links with our Associated Partners in Industry is strengthening as we proceed with the industrialisation of the series QWRs (Zollern and Research Instruments in Germany for the forging and machining of the copper substrates respectively.

ER1 main achievement (Pei Zhang):

Tuning strategy: The tuning strategy of the high-beta cavity has been developed. We decided to take a two-step tuning strategy for all the high-beta cavities in order to decouple the cause of the cavity frequency shift. The cavities will be firstly pre-tuned after the production to compensate the manufacturing error by changing the outer cavity length. Then a tuning system has been designed to compensate variability of frequency shift during the cool-down process.

This tuning strategy significantly simplified the tuning system design and consequently reduces the production cost. The cavity inner conductor has also been elongated by 2.5mm to fulfil the sensitivity of the new tuning plate. Two such simplified plates have been produced by CERN MME group, subsequently sputtered with niobium and tested with cavity at cold. Both the sensitivity and the coarse tuning range have reached the design target and reported in the SRF2013 paper [2]. The mechanism of the cavity pre-tuning has been studied and a report is in preparation.

Multipacting study: The study of multipacting in high-beta cavity has been conducted by simulation using CST Particle Studio. The multipacting barrier has been predicted and reported on an internal meeting. The predictions are consistent with the cavity RF test. The multipacting study using another simulation code ACE3P is underway. A report on the multipacting study using CST and ACE3P will be written in year 2014.

Low-beta cavity design study: The main parameter of the low-beta cavity has been worked out together with colleagues doing beam dynamics. The simulations results have been benchmarked with different computer codes. A meeting with sputtering team (ESR1) and RF test team (including ESR2) is planned in the near future in order to launch the production of a prototype low-beta cavity to study sputtering. The multipacting study of low-beta cavity is also planned using both CST Particle Studio and ACE3P.

Others: The frequency sensitivity due to cavity geometry changes has been studied with simulations for high-beta cavities. This is important to evaluate the frequency errors from cavity deformation at different locations. A report is in preparation. The impact of defects on the sputtered niobium surface on the cavity quality factor has been studied with simulations. This serves as a guide to understand the cavity behaviour during the RF cold test and give some hints to set the requirements for niobium thin film sputtering. A report is in preparation.

ESR1 main achievement (Noémie Jecklin):

Coating optimization: The main issues encountered on the coating during year 2012-2013 (for example: too low temperature bakeout, peel-off and matness of coating on inner conductor tip, lack of thickness at the top of the cavity corresponding to the high magnetic field region) have been addressed and allowed to exceed the HIE-ISOLDE specifications. The main steps undertaken during this development phase are emphasized below.

- An important step forward in our development was installing inside the vacuum chamber infrared lamps, by means of which higher temperatures could be reached during bake-out, thus allowing increasing the substrate temperature during the coating.
- Once high temperatures could be reached the attention was turned to the Nb deposition rate, which controls the final level of impurities in the film. The deposition rate could be increased by gradually pushing up the sputtering power (from the initial 2 kW to 8 kW).
- Another variant introduced during the development was the nature of the working gas during sputtering. We started by using krypton. In July 2012 we have changed to argon, according to LNL practices. It is likely that argon is better adapted than krypton to the bias technique because it preferentially re-sputters impurities which have a more similar atomic weight, while the re-sputtering of Nb is enhanced by Kr, reducing the effective coating rate.
- The next parameter that we looked at was the film thickness. It is known that a minimum value, likely at least 1 μm, is required to have good RF performances. It was

then tried to increase the coating time to get a globally thicker Nb film. This gave encouraging results.

- A dummy copper cavity has been designed as a sample holder. Once that became available, the thickness distribution could be investigated on samples. It was realized that the coating rate at the cavity top was much lower than anticipated.
- Realizing the importance of the *local* sputtering rate opened the way to the next breakthrough. What was needed was to change the distribution of deposition rate (thickness), in order to increase it at the cavity top, where the maximum RF current is. This was done by reducing the distance between the cathode and the cavity top.

Specifications reached: Thanks to the changes made to improve the coating characteristics, the HIE-ISOLDE specifications were reached for the first time with the high-beta cavity design early 2013. The specifications were then exceeded for the high-beta cavity design.

Procedures: The full coating step strategy of high-beta cavities has been established. Fully detailed procedures for the coating process have been written and are currently under approval.

ESR2 main achievement (Irene Mondino):

RF tests of Superconducting Cavities: The RF test strategy of the high-beta cavity has been developed and established. Full detailed procedures for the RF tests at warm and cold have been written. After the mounting, some RF measurements are performed on the cavity, including resonance frequency measurements, attenuation measurements and tuning range. Then the cavity is cooled down and the first step is the conditioning of the multipacting both at warm and at cold. Once the cavity is conditioning, the Q_0 vs E measurement is performed, including calibration points study, Lorentz detuning and frequency shift measurements.

Conditioning: Different strategies of multipacting conditioning have been studied and developed. Full detailed procedure for the thermal cycle and He processing have been written and approved.

Tuning system measurement: The LLRF system for HIE ISOLDE has been developed from the LLRF team and Irene Mondino participated in the commissioning. Using the LLRF system, different measurements on the tuning system have been successfully performed (tuning plate coarse range, resolution and hysteresis).

Test stand: The RF test stand has been automatized. A Labview interface to automate the usage of processing and measuring equipment has been developed and commissioned. A complete inventory of the current hardware has been written and new hardware solutions have been purchased.

Report: The written documentation of the RF tests is uploaded on EDMS after each test.

Summary of WP1 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D06	TR-Sput	Report on the SC cavity baseline mounting and sputtering	30	Expected month 36
D07	TR-QWR	Report on the SC cavity performance measurements	36	According to plan
D08	TR-TU	Report on QWR frequency tuning strategy	22	According to plan
D09	TR-MP	Report on cavity multipacting study	22	According to plan
D10	DR-QWR	Final report and/or journal publications on the QWR Cavity Dev. and Tests	6, 12, 36	According to plan

Status of milestones

Num	Short name	Description	Planned month	Status
M04	TS-Sput	Report on specifications of QWR sputtering bench	12	Achieved month 17
M05	DR-CM	RF design report of tuning system	22	According to plan
M06	TS-QWR	Report on Conceptual Design and Specifications of the High-Beta QWR	6	Achieved month 6
M07	TN-QWR	Report on the cold tests of QWR cavity prototypes	12	Achieved month 27
M08	Proc-test	Procedures and recording of test results for series cavities	36	According to plan

ER1, ESR1 and ESR2 are members of the accelerating structure working group within the HIE-ISOLDE project and report on a regular basis (oral presentations of the test results and written technical reports).

Summary of WP1 past and planned meetings/visits

Date	Venue	Attendance	Objective(s)
July 2011	Legnaro, Italy	-	Technical visit
March 2012	Berlin, Germany	25-30	3rd annual review of the EUCARD WP-10-SRF collaboration
April 26-27, 2012	CERN	25-30	HIE-ISOLDE Cryomodule Review

May 20-25, 2012	New-Orleans, USA	-	3rd International Particle Accelerator Conference
June 18-21, 2012	Chicago, USA	-	12th Heavy Ion Accelerator Technology Conference
July 2012	Legnaro, Italy	-	Cold RF tests at INFN LNL of a 1.3 GHz superconducting cavity produced at CERN with the HIPIMS technique
September 9-14, 2012	Tel-Aviv, Israel	-	25th Linear Accelerator Conference
January 21, 2013	CERN	25-30	HIE-ISOLDE Cavity Review
Feb-Apr 2013	Orsay, France	-	Cold RF tests at INPN Orsay of Q3_4 and QP1_2 superconducting cavities produced at CERN
May 12-17, 2013	Shanghai, China	-	4th International Particle Accelerator Conference
September 22-27, 2013	Paris, France	-	16th International Conference on RF-Superconductivity and Accelerator Physics

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Conceptual design and specifications of the QWR sputtering bench – Final Report	Report	M04	(12) 18
Conceptual Design and Specifications of the High-Beta QWR - Final Report	Report	M06	(6) 6
Report on the cold tests of QWR cavity prototypes - Intermediate Report	Report	M07	(12) 18
Procedures and recording of test results - Intermediate report	Report	M08	(36) 18
Publications on the QWR Cavity Dev. and Tests – Intermediate report	Report	D10	(36) 18
Publication on QWR tuning system design	Conf. Proc.	M05	(22) 12

ER1, ESR1 and ESR2 are authors or co-authors of the following publications:

- W. Venturini Delsolaro et al. “Status of the superconducting RF activities for the HIE-ISOLDE project”, Proceedings of LINAC12

- N. Jecklin et al. “Niobium coatings for the HIE-ISOLDE QWR superconducting accelerating cavitie”, Proceedings of SRF 2013
- W. Venturini Delsolaro et al. “Nb Sputttered Quarter Wave Resonators for HIE ISOLDE”, Proceedings of SRF 2013
- A. Sublet et al. “Preliminary results of niobium thin film coating for HIE-ISOLDE SRF cavities obtained by magnetron sputtering”, Proceedings of SRF 2013
- A. Sublet et al. “Thin film coating optimization for the HIE-ISOLDE SRF cavities : coating parameters study and film characterization”, Proceedings of SRF 2013
- P. Zhang et al., “The Tuning System for the HIE-ISOLDE High-Beta Quarter Wave Resonator”, Proceedings of SRF2013, Paris, France, Sep 23-27, 2013

Training Courses attended:

- 11.2011 Electricity security course, at CERN
- 06.2012 Radiological Protection course, at CERN.
- 09.2012 “Self-Rescue Mask (Biocell)” at CERN
- 12.2012 “Working in Clean Room” at CERN
- 01.2013 “Growth of Thin Films and Nanostructures”, EMPA, Dübendorf, Switzerland
- 02.2013 “Sixth International Accelerator School for Linear Colliders” at Asilomar Conference Center, Pacific Grove, California, USA
- 03.2013 “LabVIEW for beginners” at CERN
- 04.2013 CERN Accelerator School on “Superconductivity for Accelerators”, Erice, Italy
- 04.2013 “CST Particle Studio” at CERN
- 06.2013 “US Particle Accelerator School” at Fort Collins, Colorado, USA
- 12.2013 “CV writing and interview skills” at CERN

3. WP2: Beam Instrumentation Development

Work package number	**2**	**Start date or starting event:**	Month 13
Work package title	Beam Instrumentation Development		
Activity Type	RTD		
Person-months	**60 (ER2: E. Daniel Cantero, 24 months and ESR3: A. Garcia Sosa 36 months)**		
Associated Partners	LPC-Caen, NSCL-MSU, CINEL, GANIL, INFN-LNL, CI, IPN-Orsay		
Objectives	Develop radiation-hard beam instrumentation for the 10 A*MeV SuperConducting LINAC and a particle detector suitable for measuring very faint radioactive beams.		
Description of work	1. **ER2, ESR3**: Design, fabricate and lab test prototype of position, profile and intensity monitors 2. **ER2, ESR3**: Design, fabricate and lab test prototype of phase and energy monitors. 3. **ER2, ESR3:** Design, fabricate and lab test prototype of emittance meter 4. **ER2, ESR3:** Carry out irradiation tests. 5. **ER2:** Carry out system-level integration tests and supervision work.		
Deliverables	D11. Conceptual design and sign-off specifications of beam instr. for SC Linac **(ER2)** D12. Define procedures for assembly, installation and commissioning **(ER2)** D13. Conceptual design and specifications of solid state beam instrumentation **(ESR3)** D14. Complete testing/irradiation and system-level integration test. Final conference report and/or journal publication **(ESR3)**		

Main achievements

The beam instrumentation work package has progressed enormously despite the late recruitment of ESR3 (month 13) and ER2 (month 20). Both Researchers benefitted from research previously initiated by the Beam Instrumentation group at CERN. This development involved a closed collaboration with other CERN groups namely, beam optics, accelerator operators, and control system groups.

Several tests were carried with stable and radioactive ion beams delivered at CERN-ISOLDE facility and also at the ISAC accelerator in TRIUMF, Canada. In those tests the performance of the prototype Faraday cup and scanning slit for total beam current and beam profile measurements was analysed. The final design for the short and long Faraday cups has been completed and tested with beam at energies and intensities similar to the ones that will be delivered in the future HIE-ISOLDE REX post-accelerator.

ER2 and ESR3 have done a secondment at TRIUMF facilities during July-September 2013, under the supervision of V. Verzilov and R. Laxdal. During their time there, they benefited from the interaction with various experts in beam instrumentation technologies and also performed measurements of the final designs for the faraday cups using beams delivered from the superconducting accelerating Linac ISACII.

The conceptual design for the solid state detectors has been finalised, it will consist of a series of silicon detectors with capacities of performing energy and time of flight spectrometry. That solution has been tested at REX-ISOLDE during the first months of 2013 and the results have achieved the requirements stated in the specifications. At the moment the specific electronic modules associated with the detectors is being reviewed and soon will be defined.

During a stress test of the guiding mechanism for the slit scanner of the prototype diagnostic box in April 2013, a failure in the proposed lubrication system was detected. After a thorough analysis with various experts from different CERN departments lead to the decision of a re-design of the device using a linear actuator with a guiding system placed outside vacuum. This minimises risks in terms of possible failures or dust production which might directly affect the working availability of the Linac, especially in the case of the short diagnostic boxes that will be located in between the cryomodules. A

new design had been proposed for the mentioned linear actuator together with the collaboration of the company AVS. The acceptance test procedures for this new prototype mechanism are currently being defined and tests of the new device will be carried on at the headquarters of AVS in Spain during the first months of 2014.

Three new potential partners have teamed up in this development namely, the University of Liverpool (giving rise to a PhD thesis for ESR3), TRIUMF research facility in Vancouver, Canada (possibilities for secondment) and AVS in Spain (industrial development).

Summary of WP2 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D11	CDR-DB	Conceptual design and specifications of the beam diagnostic boxes	12	Achieved month 10
D12	Proc-DB	Procedures for assembly, installation and commissioning	24	According to plan
D13	CDR-SS	Conceptual design and specifications of the solid state detector	9	Expected month 30
D14	TR-tests	Report of the prototype tests	36	According to plan

Status of milestones

Num	Short name	Description	Planned month	Status
M09	Proto-SS	Production and test of prototype solid state detector	30	Expected month 34

Both ESR3 and ER2 are members of the HIE-ISOLDE High-Energy Beam Transfer Line and Cryomodule working groups where they both report on a regular basis (oral presentations of the test results and written technical reports).

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Conceptual design and specifications of the beam diagnostic boxes – Final Report	Report	D11	(12) 10
Conceptual design and specifications of the solid state detector – Status Report	Report	D13	(9) 30
Report on the prototype tests – Status Report	Report	D14	(36) 17

ESR3 is main author and co-author of the following publications:

- A. Garcia Sosa et al, "Beam Instrumentation For The HIE-ISOLDE Linac at CERN", Proceedings of IPAC12
- D. Voulot et al, "Status of the HIE-ISOLDE Superconducting Linac Design", Proceedings of IPAC12
- S. Aghion et al, "Prospects for measuring the gravitational free-fall of antihydrogen with emulsion detectors", Journal of Instrumentation, 8 (08), P08013. (2013).
- A. Garcia Sosa et al., "Secondary emission monitor for keV ion and antiproton beams". Proceedings of IBIC 2013, Oxford, UK. (TUPF02).

ER2 and ESR3 are also authors of the following publications

- E. D. Cantero et al, "Experimental results and numerical simulations of the HIE ISOLDE short Faraday Cup", Poster presented at the ISOLDE Workshop and Users meeting 2012, Geneva, December 2012.
- A. Garcia Sosa et al, "Preliminary Study of the HIE-ISOLDE Beam Profile Monitor", Poster presented at the ISOLDE Workshop and Users meeting 2012, Geneva, December 2012.
- D. Lanaia et al, "HIE Beam Commissioning Planning and Preparation Work", Oral contribution presented at the ISOLDE Workshop and Users meeting 2012, Geneva, December 2012.
- A. Sosa et al, "PIN Photodiode test in the REX-ISOLDE post-accelerator", EDMS No. 1238408.
- E. D. Cantero et al, "Performance Tests of a Short Faraday Cup Designed for HIE-ISOLDE", presented at IPAC13, Shanghai, May 2013.
- E. Bravin et al, "Report on the failure on the scanning slit movement of the prototype HIE-ISOLDE Diagnostic Box", HIE-BDB-TN-0001, EDMS No. 1284254, Geneva, 2013.
- E. D. Cantero and A. G. Sosa, "HIE-ISOLDE Faraday cups tested with ion beams at TRIUMF", Vancouver, October 2013.

On December 13, 2012 an internal review meeting was held at CERN, "HIE-ISOLDE internal review on need for long DB version", where all the experimental results obtained with the prototype DB were shown and discussed with experts. https://indico.cern.ch/conferenceDisplay.py?confId=221456

4. WP3: Warm Magnet Design

Work package number	**3**	**Start date or starting event:**	Month 12
Work package title	High-Energy Beam Transfer Lines Magnet Design		
Activity Type	RTD		
Person-months	**36 (ESR4: Panagiotis Farantatos)**		
Associated Partners	Scientific Magnetics and CI		
Objectives	Design, manufacture and commission compact warm magnets for the 10 A*MeV SuperConducting LINAC and new beam transfer line.		
Description of work	1. Specification of the magnet parameters. 2. Design and implementation of the whole magnet system. 3. Sign-off call for tender for the magnets procurement in industry. 4. Participate in preliminary system tests using the 5.5 A*MeV SuperConducting LINAC.		
Deliverables	D15. Conceptual design of beam line magnets and distribution D16. Technical specifications of beam line magnets and distribution. Final conference report and/or journal publication		

Main achievements

ESR4 is involved in all aspects of the magnet work package. His work is focussing on the quadrupole magnet design where he has performed magnetic simulations to assess and optimize the field quality based on various pole profiles.

He has also performed a sensitivity analysis of the design to the iron magnetic properties. Besides this, he has organized meetings at CERN with electrical steel producers as to discuss about the requirements of the HIE-ISOLDE magnets.

In parallel to this, he has written the technical specifications for the dipoles and quadrupoles of the HIE-ISOLDE High Energy Beam Transfer line. In collaboration with his supervisor and other colleagues of the section, he has refined the document which is now the basis for procurement of normal conducting magnets for other projects. ESR4 has also participated to the magnet mechanical design meetings with the design office, which is in charge of drafting the specification drawings for the procurement of the magnets.

ESR4 has also achieved the following:

- Field quality assessment of the quadrupole magnets
- Qualified magnet manufacturers classification and evaluation
- Magnetic interference study of the steerer's stray field to nearby equipement (stepping motor, turbo-molecular pump)
- Magnetic shielding proposal for the turbo-molecular pump operating next to the steerer, assuring undisturbed operation under the steerer's stray field

ESR4 has been very active with the organization of Normal Conducting Magnets Section bench for CERN Open Days event (*28/09/2013 – 29/09/2013*) at SM18: Experimental demonstrations of the Lorentz force of a steering magnet and of the focusing/defocusing property of a quadrupole magnet acting on a particle beam.

Summary of WP3 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D15	CDR	Conceptual design of the quadrupole magnets (SC Linac and HEBT)	12	Achieved month 15
D16	TSR	Technical specifications of the warm magnets (SC Linac and HEBT)	18	Achieved month 21

Status of milestones

Num	Short name	Description	Planned month	Status
M10	IDR	Identification of requirements	3	Achieved month 6
M11	COR	A magnetic shielding proposal for turbo-pump operating inside HIE-ISOLDE steerer's stray field	36	According to plan

ESR4 is a member of the HIE-ISOLDE High-Energy Beam Transfer Line and Cryomodule working groups where they both report on a regular basis (oral presentations of the test results and written technical reports).

Summary of WP3 past and planned meetings

Date	Venue	Attendance	Objective(s)
From ESR month 3	CERN	Weekly	HEBT working group meetings
April 2012	CERN	1	Conceptual design review
July 2012	CERN	1	Technical design review
From ESR month 6	CERN	Weekly	Magnets mechanical design meetings
From ESR month 1	CERN	Bi-weekly	TE/MSC/MNC section meetings
September 2013	CERN	6	dipole and quadrupole magnets' Specification Committee meeting
Oct 22-23, 2013	Aalborg University, DK	-	seminar on Materials and Applications: Magnetism in Sustainable Energy – Rare Earth Materials for Magnetic Components, organized by UK Mangetics Society
Nov 28-29, 2013	CERN	115	"New electromagnets for the HIE-ISOLDE facility: Current work status" presented at the HIE – ISOLDE Workshop: The Technical Aspects

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Conceptual design of the quadrupole magnets – Final Report	Report	D15	(12) 15
Identification of requirements – Final Report	Report	M10	(3) 6
Technical specifications of the warm magnets (SC Linac and HEBT)	Report	D16	(18) 21

ESR4 is main author and co-author of the following publications:

- Beam Transfer Line Quadrupole Magnets (PXMQNLINWP) for the HIE-ISOLDE Facility, CERN EDMS 1252655
- Technical Specification of the MBHEM Dipole Magnets for the HIE-ISOLDE Beam Transfer Lines, CERN EDMS 1253017
- Design and Performance of the Beam Transfer Lines for the HIE-ISOLDE Project, IPAC12
- Quadrupoles for the beam transfer lines of HIE-ISOLDE, IPAC13

Attended Training Courses

- National Instruments LABVIEW (*12/6/2013 – 14/06/2013*)
- Risk Management (*24/09/2013 – 25/09/2013*)
- CST Particle Studio (*08/10/2013 – 09/10/2013*)
- ANSYS Emag (*15/10/2013 – 16/10/2013*)

Outreach Activities

- Member of the CERN guides: Guiding schools in an almost weekly basis at SM18.
- Activity Animator at SM18 during CERN Open Days event (*28/09/2013 – 29/09/2013*) at the Normal Conducting Magnets section bench.
- Presenter of the CATHI project bench during CERN Open Days event at building 40.

5. WP4: Linac Integration and Innovative Alignment Method

Work package number	**4**	**Start date or starting event:**	Month 3
Work package title	Linac Integration and Innovative Alignment Method		
Activity Type	RTD		
Person-months	**2x36 (ESR5: Eleftherios Zografos and ESR6: Guillaume Kautzmann)**		
Associated Partners	GANIL, INFN-LNL, CI, IPN-Orsay		
Objectives	Carry out full integration studies for the different accelerator and experimental beam lines of HIE-ISOLDE and subsequent alignment of all the SC accelerating cavities, the beam monitors and the magnets.		
Description of work	1. **ESR5:** Carry out design and space arrangement of the HIE-ISOLDE area. 2. **ESR6:** Implement permanent internal monitoring lines to follow the relative movements of the cryo-cavities and solenoid inside each vacuum vessel. 3. **ESR6:** Design of specific electro-optics cameras and control applications. 4. **ESR6:** Electro-optical & environmental characterization of optical packages.		
Deliverables	D17. Final report on integration studies (**ESR5**) D18. Report on implementation and commissioning (including procedures) of the complete alignment system (**ESR6**)		

Main achievements

Integration work was vigorously pursued the last 12 months thanks to Eletherios Zografos (ESR5). We have noticed major advances in terms of integration of 3D layout models for the Superconducting Linac, the High-energy Beam Transfer Lines and the experimental devices:

- Three experimental stations are foreseen behind the SC linac to accommodate the existing Miniball gamma array, a new HELIOS type experiment and a multipurpose beamline. The layout of these lines has to be compatible with the available space in the ISOLDE hall and allow for future experiments and extensions like a possible recoil separator behind Miniball or the connection of a storage ring which is foreseen to be installed in a separate building next to ISOLDE.
- In addition the transfer line has to be modular to allow for the staged installation of the SC linac. A periodic focussing channel was chosen with a period of 2.62 m, identical to the length of the high beta cryomodule, based on a doublet channel with alternating long and short drift allowing for the insertion of bending magnets in the long drift and beam diagnostics and corrector magnets in the short drift between the quadrupoles. The layout and optics was optimised to minimise the number of magnet families so that only one type of quadrupole and dipole are employed.
- A hardware baseline structure for the entire HIE-ISOLDE project has been created and is now managed via SmarTeam (the Product Data Management system) and EDMS (the Engineering and Equipment Data Management System).

The technological options are now almost all fixed for the HIE-ISOLDE Alignment System, so called MATHILDE (Monitoring and Alignment Tracking for Hie-IsoLDE). The concept is mainly based on well-proven elements such as the camera-style sensor called HBCAMs. The various key elements such as the viewports and the possible target types have been studied and tested successfully in different situations, taking in account the constraints due to vacuum or cryogenic conditions.

On the target side, the chosen solution is based on the properties of high-index (n≈2) glass balls that are giving a retro-reflective effect when measured and illuminated by HBCAM lasers. The effect has been studied and validated, even with measurements in cryogenic and vacuum conditions.

A HBCAM camera, based on the existing BCAM, has been developed and validated within the expected precision. The new features of this device include a CCD upgrade, a shorter focal length, the addition of an illumination ring and a calibration to a nominal value of output power of the device lasers.

Concerning the needed software, a prototype of the mathematical model is ready and has proved successfully the alignment concept on a partial but almost full size model equipped with metrological table prototypes and existing BCAMs. The final software version is under development and has been designed in order to fit in the standardized CERN environment. Once the software will be more advanced, its validation is planned with an extended test bench equipped with HBCAMs, viewports and targets.

The goal is to use a first version of the system once the first cryo-module will be assembled and ready for vacuum and cryogenic tests.

Four new potential partners have teamed up in this development namely, Brandeis University (USA), Technical University of Liberec (Czech Republic), Toptec (Czech Republic) and Hydro-Quebec in Canada (industrial partner).

Summary of WP4 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D17	FR	Final Report on integration studies	36	According to plan
D18	IAP	Installation and alignment procedures	24	Expected month 36

Status of milestones

Num	Short name	Description	Planned month	Status
M12	ID-Bas	Identification of equipment and infrastructure	12	Achieved month 12
M13	CAD	CAD of integration studies	30	Expected month 36
M14	ID-SU	Identification of requirements for BCAM test	3	Achieved month 6
M15	DAQ	Mechanical design and DAQ	12	Achieved month 16
M16	TN-SU	Validation report of the alignment system	36	According to plan

Both ESRs are members of the HIE-ISOLDE High-Energy Beam Transfer Line, Cryomodule and Infrastructure & Integration working groups where they report on a regular basis (oral presentations and technical documents).

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Identification of equipment and infrastructure	Report	M12	(12) 12

Identification of the Requirements for the BCAM tests	Report	M14	(3) 6
Conceptual Design and DAQ of the new Monitoring System	Report	M15	(12) 16

Guillaume Kautzmann (ESR6) is main author and co-author of the following publications:

- G. Kautzmann et al. "The HIE-ISOLDE Alignment and monitoring system Software and test mock up", Proceedings of IWAA12
- J.C. Gayde et al., "HIE-ISOLDE Alignment and Monitoring System Technical Design and Project Status", Proceedings of IWAA12
- G. Kautzmann et al. "HIE-ISOLDE Alignment and monitoring system of the LINAC", Poster of ISOLDE Workshop and Users meeting 2012
- G. Kautzmann et al. "HIE-ISOLDE – Latest developments of the HIE-ISOLDE Alignment and Monitoring System", Proceedings of the HIE-ISOLDE Workshop-The Technical Aspects 2013

Guillaume Kautzmann (ESR6) has achieved a secondment at Brandeis University in three parts (USA, for a total length of 7 weeks) dealing with mounting, testing, debugging and calibrating HBCAMs.

6. WP5: Superconducting Linac Commissioning

Work package number	**5**	**Start date or starting event:**	Month 13
Work package title	SuperConducting Linac Commissioning		
Activity Type	RTD		
Person-months	**36 (ESR7: Davide Lanaia)**		
Associated Partners	GANIL, INFN-LNL, CI, IPN-Orsay		
Objectives	The ESR training will be focused on the development of machine tune-up procedures that will later be implemented in the control software for the linac operation and active participation in the startup of the machine.		
Description of work	1. Draft the specification of the controls and of the beam monitoring tools specific to the HIE-REX Linac 2. Definition of tuning procedures and management of machine protection and alarm system 3. Draft console applications to be used by the operators for the Linac tuning and monitoring 4. Follow progress of the different aspects of the Linac design, construction and installation 5. Assist in the commissioning of the new machine		
Deliverables	D19. Report on specifications for controls and beam diagnostics D20. Commissioning Plan.		

Main achievements

Due to the short nature of REX runs (typically three to ten days) and the need for frequent energy and beam changes dictated by the physics programme, REX operation requires fast and reliable set-ups and the possibility to switch between beams or change the energy within a few hours. The second challenge is the use of weak radioactive beams that cannot be monitored on conventional Faraday cups and profile monitors, which require the linac to be set-up with a stable pilot beam before being scaled to the appropriate A/q. For this reason stringent tolerances were specified for the alignment of the linac and HEBT elements and a comprehensive error study of the linac and transfer lines was undertaken. The stability and linearity of the optics and RF is also essential.

The size and complexity of the machine will increase with the energy upgrade, for example the number of RF cavities will increase from 7 in the present NC linac to 35 in the final version of the HIE linac. The cavity phases will also become A/q dependent as the velocity profile changes with A/q in the SC part of the linac. For this reason an automatic phasing procedure is foreseen using a Si-detector either by tracking the relative energy change or, when the 100 ns bunch spacing becomes available, using a time of flight method. The possibility of using calculated settings and automated optimisation software is also investigated and some initial tests have already been done on the existing linac.

Main activities performed in this phase:

- Support in the Beam Transfer Lines Layout specifications.
- Support in the Linac Working Group. Proposal for new application for the SC linac.
- Specification for control and beam diagnostic. Cooperate in the writing of the functional specification of the diagnostic boxes for HIE-ISOLDE;
- Development and test of the HIE-Converter application. This tool allows operators to convert machine settings in optics file and vice-versa. This routine was developed using Java code and future possible options are under study.
- Development and test of the HIE-Phase Up application. This tool will help the operators to phase up the cavities, providing an intuitive GUI. A calibration curve between the cavity acquired voltage in the cavity tank and the effective voltage experienced by the beam is also provided and can be used for future study. This routine was developed using Java code.
- Upgrade of the existing beam diagnostic application. The beam diagnostic application will maintain the skin of the REX one. The GUI of the Faraday cups will remain the same. A new GUI panel for the beam profiler will be developed.

- Secondment at INFN – LNL. Participation in the operation of the SC linac in the PIAVE-ALPI complex, alignment campaign, emittance data analysis, re-commissioning of the ALPI linac after realignment.
- Secondment at TRIUMF. Participation in the operation of the ISAC II SC linac. Full development and test, using Matlab code, of a routine for cavity phase up using a time of flight system. The same algorithm used to develop the TRIUMF tool will be used at CERN to write a phase up routine by means of a time of flight system.
- Emittance study. Measured emittance of the existing REX-Linac at different energies and different beam shape. Wrote a software routine for data cleaning and data analysis;
- Stripping foil study. Measure the effect of stripping foil of different thickness on the beam energy. Software simulation with SRIM 2012 performed in order to have a comparison with measured data.
- Commissioning Planning: Work on test and time schedule that will be followed during the beam commissioning phase

Summary of WP5 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D19	TSR	Specifications for controls and beam diagnostics	12	Achieved month 24
D20	CR	Commissioning Plan	36	Achieved month 25

Status of milestones

Num	Short name	Description	Planned month	Status
M17	BTR	First tests with beam	24	Achieved month 16
M18	FCR	Control Applications	36	Achieved month 25

Summary of past and planned meetings

Date	Venue	Attendance	Objective(s)
December 2011	INFN-LNL	2	Visit of ALPI-PIAVE and discuss operation of SC-linac
May 2012	TRIUMF	3	Visit of ISAC2, discuss operation of SC-linac and buncher-chopper
22 March 2012	CERN	7	Planning and definition of operation software
18 April 2012	CERN	7	Console applications and controls interlocks definition
23 August 2012	CERN	6	SC solenoid interlocks meeting
3 September 2012	CERN	9	HIE-linac machine protection and safety system

18-19 December 2012	CERN	>20	HIE-ISOLDE Commissioning Plan and Operation Software
13 January 2013	CERN	4	Power Converter Control Meeting
06 February 2013	INFN-LNL	5	Define secondment objective and plan activities
21 February 2013	INFN-LNL	10	Report of activities and PIAVE-ALPI re-commissioning after alignment
March 2013	CERN	15	Report on the secondment activities at INFN-LNL
17 June 2013	TRIUMF	4	Define Secondment objective and plan activities
21 August 2013	TRIUMF	>10	Report on application and test performed at TRIUMF
September 2013	CERN	>10	Report on TRIUMF secondment activities
28-29 November 2013	CERN	>20	HIE-ISOLDE Commissioning Plan and Software Development

Davide Lanaia is a member of the HIE-ISOLDE High-Energy Beam Transfer Line working group where he reports on a regular basis and acts as a scientific secretary (oral presentations and technical documents). He is also a member of the HIE-ISOLDE Linac working group where reports on a regular basis the progress of his work.

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
HIE-ISOLDE beam transfer lines layouts	Report	-	-
Carbon Stripping Foil Analysis	Report	M17	9
Transverse Emittance Measurements at REX-ISOLDE	Report	M17	12
Functional Specification of Beam Diagnostic Boxes for HIE-ISOLDE	Report	D19	9
Planning and Resources Requirements for the Commissioning and First Two Years of Operation of HIE-ISOLDE	Report	D20	17
Development of new software application for HIE-ISOLDE	Report	D19	17
ISAC-II phasing high level application in MATLAB	Report	M18	20
HIE-ISOLDE Converter Application. Algorithm and user manual	Report	M18	25

HIE-ISOLDE Phase Up Application. Algorithm and user manual	Report	M18	25
HIE-ISOLDE Commissioning Plan	Report	D20	25

Davide Lanaia is co-author of the following publications:

- D. Voulot et al. “Status of the HIE-ISOLDE Superconducting Linac Design”, Proceedings of IPAC12
- A. Parfenova et al. ” Design and performance of the beam transfer lines for the HIE-ISOLDE Project”, Proceedings of IPAC12
- D. Lanaia et all. “Operation Software for the HIE-ISOLDE Super Conducting Accelerator”, Abstract of Linac14

7. WP6: ISOL Target & Front-End Upgrade Studies

Work package number	**6**	**Start date or starting event:**	Month 3
Work package title	Studies for ISOL Target and Front-End Upgrades		
Activity Type	RTD		
Person-months	**180 (ESR8; ESR9; ESR10, ESR11 and ESR12: 36 months each)**		
Associated Partners	GANIL, INFN-LNL, IPN-Orsay, JYFI, SIDeA		
Objectives	The ESR training will be focused on R&D work on ion sources, target material and beam purification. Key issues include the study of target materials and maintaining the production rates of radioisotopes, thermal and shock studies, radiation protection and beam optics.		
Description of work	1. **ESR8:** Carry out simulations of proton beam interactions with existing and potential target materials using FEM structural codes 2. **ESR8:** Establish experimental programme to validate the simulations and verify the production rates and diffusion constants for different material prototypes 3. **ESR9:** Thermal studies on target unit: off line tests, electro-thermal simulation via ANSYS code and prototyping of new concepts aiming at better thermal control uniformity. 4. **ESR9:** Alternative cooling solution study: simulations and off line tests on heat pipes, cooling wings and redesign. 5. **ESR10:** Optimization of the target(s) design for the study and optimization of different layout scenarii in terms of radiation protection issues, including benchmarking of code 6. **ESR11:** Carry out beam optics simulations as a function of target and ion source parameters and beam profile requirements for mass separation 7. **ESR11:** Draft functional and conceptual design of a new Front End including its integration into the existing facility 8. **ESR12:** Perform design study for the low-level control of the new front end and the High Resolution Separator (HSR) magnet 9. **ESR12:** Carry out dedicated study on state-of-the-art high accuracy positioning and sensor systems for the extraction electrodes as well as the control of devices for the safe manipulation of the target		
Deliverables	D21. Publication of test results and post analysis for the ISOL target material studies **(ESR8)** D22. Report on alternative cooling solution for the standard target unit **(ESR9)** D23. Final Report on the conceptual design of the ISOL target **(ESR9)** D24. Publication of the Safety File and risk analysis of the ISOL target **(ESR10)** D25. Final conference report and/or journal publication for the target layout optimization **(ESR10)** D26. Functional specifications of the extraction optics and front-end **(ESR11)** D27. Conceptual design, risk analysis and Safety File for the extraction optics and new front-end **(ESR11)** D28. Report on the front-end and HSR magnet control **(ESR12)** D29. Prototype of front-end control system including actuators and sensors **(ESR12)** D30. Simulator of the HSR dipole integrated magnetic field **(ESR12)** D31. Prototype of the HSR magnet control system **(ESR12)**		

Main achievements

The targets and the target station (also known as Front End) are at the heart of all operations at ISOLDE. Although continuous R&D work on ion sources, target materials and beam purification contributes to the quality of the RIBs provided at ISOLDE, the proposed increase in proton beam intensity implies a completely new challenge in terms of operation and equipment lifetime. Key issues include the study of target materials and maintaining the production rates of radio-isotopes, thermal and shock studies, radiation protection and beam optics. Main achievements realized so far are described in detail below.

Target material studies: The lifetime of the present Target and Ion Source Units is of 1e19 integrated protons delivered as pulsed beam obtained typically after two weeks of operation. The increased proton beam intensity poses a number of challenges in particular heat dissipation and fatigue issues. In this context, **Michal Czapski (ESR8)** has successfully performed an irradiation campaign of the prototype target materials prepared at Saint Gobain using proton beams at ISOLDE and HiRadMat facilities located at CERN. After one year of cool-down the targets are being now open for further analysis of ageing under irradiative conditions. As complimentary target investigation Michal carried out a safety study of hydrogen production in ISOLDE target under a controlled water leak in the target system.

Target conceptual design (Engineering): In line with the target material studies, further developments will be required for the conceptual design of future target units with emphasis on overall target and ion source design in terms of thermal dynamics, shock effects and fatigue. A rather extensive bibliographic study was performed by **Serena Cimmino (ESR9)** in order to complete the measurement instrumentation database namely for pyrometers and thermocouples. This literature search included thermal tests on target containers and resulted in the development of a thermal standard calibration procedure. Serena was heavily involved in the electro-thermo-mechanical analysis of a novel molten salt target developed at CERN to test the production of Ne^{18} for the Beta Beam project. Furthermore, Serena is in charge of the preliminary design of a 50 kW neutron spallation source which will be tested online at TRIUMF in the fall 2014. Currently Serena is dealing with a redesign of the standard target ISOLDE unit cooling aiming at an increase of the safety during online runs. The alternative designs are going to be prototyped and tested off-line for validation.

Target conceptual design (Physics): **Leonel Morejon Hernandez (ESR10)** continued and finalized the previous started work. First, the studies for the beam dumps on GPS and HRS was completed with the preparation of two reports: one of them studying the current performance in terms of energy deposition of both dumps, from Fluka simulations; and the second studying in the same way the performance of a future modification to HRS beam dump In order to avoid problems that were made evidenced from the simulations sumarized in the first report. On the work related to the dose assessments for ISOLDE's tunnel and new targets' storage area, new work was started to cover for different new questions raised, meaning finding the dose related to the new shielding and robot rails due to their activation, and the benchmarking of the Fluka simulations on ISOLDE through comparing the simulated values with measurements previously performed on-site. The work on assessing the dose from the stored targets' and from the neutrons resulting from the targets irradiation has kept going and some reports are being prepared but not yet finalized.. **Leonel Morejon Hernandez (ESR10)** completed the "Python: Advanced hands-on" course offered from CERN, and also a "CV writing and Interviewing techniques" course organized within the CATHI project. He attended several conferences and schools: the International Nuclear Physics Conference 2013 in Florence, the Euroschool on Exotic Beams in Dubna, attended the Thorium Energy Conference at CERN and participated in the ISOLDE Workshop and Users meeting held at CERN. During the last quarter, the secondment work with AIMA company in Nice, was discussed and a work content was sketched during a visit. A secondment there is to be planned.

Extraction optics and front-end design: The extraction optics plays an important role in the initial beam transport and the quality of the beam supplied to the mass separators. Important factors include the emittance of the beam and the beam profile to avoid any beam losses. Furthermore, due to the increased radiation levels proportional to a higher proton beam current, the new FE design must be more radiation resistant and will require a minimum of hands-on maintenance. **Jacobo Montano (ESR11)** has been rather active in familiarizing himself with the different evolutions of the ISOLDE front-ends. He has finalized the design and construction of a new prototype of the ISOLDE target unit which has been mounted on the new offline separator test bench for conditioning and complete characterization of the new ion extraction system. The new offline lab has been commissioned in collaboration with Mathieu Augustin (ESR15). The front-end#8 is totally operative with fully installed instrumentation and different sources are under test. An extended analysis has been performed at simulation level in order to characterize the prototyped model thermally, electrically and its particle

extraction behaviour as well. This analysis will be validated with the experimental tests of the last year. In 2013, some thermal test were performed already with the new extraction system prototype considering its proximity to the ion source. An alternative heating system has been prototyped and will be tested during the last year of activities. This prototype is based on the application of electron bombardment heating of the target container. With this mechanism it is expected to reduce considerably the amount of current used for target heating and in consequence several risk factors would be removed or diminished. During 2013 one week of collaboration was spent at Cyclotron manufacturer company AIMA in Nice, France. The plan is to establish a collaboration with them as contemplated in the Marie-Curie ITN program. This final collaboration has to be scheduled according with the intense experimental agenda planned for the following months. After the publication of the « Design Study Report » (end of July) one month of secondment can be envisaged.

Low-level controls: The front-end control includes high accuracy positioning of the extraction electrodes as well as the control of devices for the target manipulation safety (i.e. clamps, pistons, shutters). Although seemingly a typical example of industrial control, many challenges have to be addressed as result of the new target increased energy and consequent increasing of the radiation integrated dose on the front end (i.e. several hundreds of Gray). Similarly, The HRS dipole integrated magnetic field has to be controlled to an accuracy of a few ppm. In order to achieve this requirement an accurate model of the magnet has to be determined. This should be able to predict the integrated magnetic field value by the knowledge of the supply current and the current value of the magnetic field. This latter is given by a punctual measurement performed with an NMR (Nuclear Magnetic Resonance) probe. The model should take into account the multi-poles errors so to elaborate in the future correction laws using the high order magnets to be installed on-line. After a 3 month secondment at SIDeA (industrial partner) to gain valuable experience on NI LabView RT control systems, **Martino Colciago (ESR12)** has performed a detailed review of the current control systems of the ISOLDE HRS. He has updated it to the BE-CO standards using the new Front End Software Architecture (FESA) and now the control system is going to be tested in an ad hoc test bench. In the meantime he is developing a possible innovative solution for the future control system, based on LabVIEW Real Time. The chosen architecture is a feedback control loop using a proportional–integral–derivative controller (PID). Moreover, a nonlinear compensator is foreseen in the feed forward line and an observer of the system, which is developed using an accurate model of the magnet, completes the controller. The proposed control system is currently under development. It will be validated on a test bench before an experimental tuning campaign is setup on the real magnet..

Summary of WP6 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D21	DR	Report on the target material studies	36	According to plan
D22	AC	Report on alternative cooling solution for the standard target unit	12	Expected month 36
D23	CDR	Conceptual design report of the new target	36	According to plan
D24	Risk-TAL	Risk analysis of the target beam dumps	24	Expected month 30
D25	CDR-TAL	Final report on target analysis	36	According to plan
D26	FS	Functional specifications of the extraction optics	12	Achieved month 17
D27	CDR	Conceptual design report and risk analysis of the extraction optics and front-end upgrade	36	According to plan
D28	TSR	Specification for front-end and HRS magnet	12	Achieved month 16

D29	ProFE	Prototype of the front-end control system	24	Expected month 36
D30	CR	Report on the simulation of the HRS magnetic field	29	Expected month 24
D31	ProHRS	Prototype of the HRS magnet control system	36	Expected month 29

Status of milestones

Num	Short name	Description	Planned month	Status
M19	IDM	Identification of target materials and future proposals	5	Achieved month 5
M20	Lit-Stud	literature studies of potential target materials	18	Achieved month 12
M21	On-Stud	Irradiation campaign of selected target materials	24	Achieved month 18
M22	PIA	Post-irradiation analysis	12	Achieved month 15
M23	Therm-Mech	Thermo-mechanical studies	24	Achieved month 11
M24	Off-Cool	Conceptual Design of a new cooling system	30	Expected month 36
M25	SIM-TAL	FLUKA simulations of the target area layout	6	Achieved month 9
M26	DES-TAL	Design of the new target storage area	12	Expected month 30
M27	Shield-TAL	Design of target area shielding	18	Expected month 30
M28	Comp-TAL	Validation with measurements	30	Achieved month 3
M29	IDO	Identification of the extraction optic requirements	3	Achieved month 3
M30	LL-Spec	Control system functional specification	9	Achieved month 9
M31	FE-LL	Front-end control system design	21	Expected month 32
M32	HRS-LL	HRS magnet control system design	33	Expected month 36

Summary of WP6 past and planned meetings/visits

Date	Venue	Attendance	Objective(s)
16 January 2013	CERN	2	Separator Magnet meeting
7 February 2013	CERN	10	HIE-Isolde project review
June 2013	Firenze, Italy	-	International Nuclear Physics Conference
August 2013	Brugge, Belgium	-	Eleventh International Topical Meeting on Nuclear Applications of Accelerators. AccApp2013
August 2013		-	Euroschool on Exotic Beams
September 2013	SCK-CEN Mol, Belgium	-	Workshop on Radioactive Ion Beam Production and High-Power Target Stations

24 October 2013	CERN	5	HIE-Isolde HRS Test bench
27-31 October 2013	CERN	250	Thorium Energy Conference, ThEC13
13 November 2013	CERN	10	Isolde LS1 control renovation
28-29 November 2013	CERN	-	HIE-ISOLDE Workshop - The Technical Aspects
14 February 2014	CERN	2	Meeting on HRS FESA3 class
22 January 2014	CERN	6	Meeting on HRS NMR test
5 December 2013	CERN	2	Meeting on HRS renovation

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Advanced silicon carbide and aluminum oxide with unidirectional open porosity as new prototype target materials for radioisotope beam production	Report	M19, M20	(18) 12
HRMT01-TISD Experiment Safety file	Report	M21	(18) 18
Post-Irradiation analyses of a Molten Salt target – Final report	Report	M22	(12) 15
Electro-Thermal Analyses of a Bare Ta Container	Report	M23	(24) 8
Thermal analyses of a Molten Salt target	Report	M23	(24) 11
FLUKA simulations of the target area layout	Report	M25	(6) 9
Comparison of FLUKA simulations and dose measurements – Final Report	Report	M28	(30) 3
Functional specifications of the extraction optics – Final Report	Report	D26	(12) 17
Front End Extraction Optics Design Upgrade - Requirements	Report	M29	(3) 3
Control system functional specification – Final Report	Report	M30	(9) 9
Specifications for front-end and HRS magnet – Final Report	Report	D28	(12) 16
HRS magnet control system design – Intermediate Report	Report	M32	(33) 16

Michal Czapski, Serena Cimmino and Jacobo Montano are co-authors of the following publications:

- M. Czapski et al. "Advanced SiC and Al_2O_3 as model targets for radioisotope beam production at HIE-ISOLDE", Proceedings of EMIS 2012 to be published in NIMB

- S. Cimmino et al., "Online Operation of a Molten Salt Target at ISOLDE for the Beta Beams: Validation of Electro-Thermal Simulation with Experimental Data", Proceedings of EMIS 2012 to be published in NIMB
- J. Montano et al., "Design Upgrade of the ISOLDE Target Unit for HIE-ISOLDE", Proceedings of EMIS 2012 to be published in NIMB

Attended Training Courses:

- ANSYS: Introduction to ANSYS Workbench Mechanical
- Cours de mesures thermiques
- FLUKA course
- ANSYS Workbench advanced
- AXEL: Introduction to Particle Accelerators
- Ergonomics - Applying ergonomic principles in the workplace
- CV writing and interview skills
- Python: Advanced hands-on
- LPI 101 - Introduction à Linux
- FESA : Introduction

8. WP7: ISOLDE Target Area and Class-A Laboratory Upgrade

Work package number	**7**	**Start date or starting event:**	Month 6
Work package title	ISOLDE Target Area and Class-A Laboratory Upgrade		
Activity Type	RTD		
Person-months	**2x36 (ESR13: Andrea Polato and ESR14: Mario Armin Hermann)**		
Associated Partners	GANIL and INFN-LNL		
Objectives	The ESRs will acquire the necessary knowledge and collaborate to the different phases of the design of HVAC and cooling systems for the future HIE-ISOLDE facility and participate actively in the startup of the machine.		
Description of work	1. **ESR13:** Dimension the components of the Cooling and Ventilation installations 2. **ESR13:** Define and integrate the Cooling and Ventilation plant in the general layout of the building 3. **ESR13:** Elaborate the technical specifications and participate in the call for tender for the procurement in industry 4. **ESR14:** Present a planning, perform the engineering study, organize tests and carry out the preliminary design and integration of the new vacuum system 5. **ESR14:** Optimize the choice of control and diagnostic equipment 6. **ESR14:** Design a new gas recuperation system taking into account radiation safety and contamination hazards		
Deliverables	D32. Report on existing facilities (**ESR13**) D33. Design report on the Cooling and Ventilation upgrade for HIE-ISOLDE (**ESR13**) D34. Vacuum engineering for the ultrahigh vacuum of the SC linac (**ESR14**) D35. Vacuum studies for the radio frequency quadrupole cooler and buncher RFQCB (**ESR14**)		

Main achievements

Given the exposure to highly radioactive environment the cooling and ventilation system of the CERN-ISOLDE Facility has to guarantee the highest standards in terms of efficiency, safety and ease of maintenance. **Andrea Polato (ESR13)** joined the Cooling and Ventilation group in October 2011 (month 12) and immediately interfaced with the other groups and CERN staff (engineers and physicists) for the different phases of the design of HVAC and cooling systems for the future HIE-ISOLDE. The main achievements concern the dimensioning of the components of the installations, the definition of the layout of the stations, the integration of the plant in the general layout of the building and the preparation of the tendering documents (equipment selection, and Bill of Quantities redaction). In this frame, the work regarding the design of the cooling and HVAC systems for the extension of the Class-A Laboratory to host MEDICIS involves all the skills listed above from the sizing exercise, to the equipment selection and the redaction of the Bill of Quantities. The design of an airlock chamber of separation between Class-A laboratory and Target contributes to the improvement of the confinement among the two areas. The works for the installation of the new ISOLDE Hot Cell and for the new targets handling robots constitute an opportunity to participate to the on-field activities. Technical visits to Associated Partners were organized to assess the different regulations and procedures used at the GANIL/SPIRAL-2 facility in Caen, France, at the PSI facility in Villigen, Switzerland and INFN/SPES facility in Legnaro, Italy. During his internship period (I15) at the European Spallation Source (based in Lund, Sweden) he started the design activities of the Nuclear HVAC for the facility Target system. The training course focused on the ventilation and on the fire risk management inside nuclear facilities (TC14) contributed to develop the technical skills required for the tasks assigned.

WP7 work package covers as well the integrated vacuum system of the linac, the vacuum improvements related to beam quality, the target units, the primary pumping systems, and the collection, storage, and exhaust of radioactive gases. All these issues have to be addressed with the increase of proton beam intensity. The HIE-ISOLDE linac vacuum system has to respond to the three criteria of reliability, robustness and minimal downtime in case of failure during operation.

Mario Armin Hermann (ESR14) joined the Vacuum and Surface Coating group in April 2011. He was the first ESR to be recruited within CATHI. During the first months of his training at CERN, Mario Hermann contributed to the drafting of the technical specifications of the vacuum system, the 3D layout and its integration into the ISOLDE Facility.

Mario Hermann performed an engineering study of the pumping down of the superconducting cryomodule and calculated outgassing rate estimates. These were compared with measurements on different materials that he organized and carried out. In the framework of the development of a new RFQCB for beam quality improvement, he measured pressure profiles along the existing RFQCB, ISCOOL, and benchmarked the results of the code MOLFLOW+. Further, he set up Monte Carlo and Electrical Network Analogy simulations to study the vacuum profiles in the RFQCB. Additionally, he established the vacuum layout for the off-line RFQCB and conceived possible control logics.

To analyze safety improvement of the gas recuperation system, Mario prepared and operated a dry pump set-up, based on multi-roots pumping technology and absorber filters, by-passing the present layout to pump while operating highly contaminating targets. Collaborating to establish the vacuum layout of the linac cryomodules, Mario prepared a test-bench representing a prototype of the pumping system. This test bench is utilized to study cryomodule vacuum process options and to measure material outgassing properties for the SC linac. Measurement of material outgassing properties and the determination of helium trapping behaviour of a proposed RF cable were then performed on this test-bench to accompany the design of the cryomodule elements.

The goal of former D35 was modified to better fulfill the needs of the project schedule. This activity is now taken over by a Technical Student. Results will be included in the HIE-ISOLDE design study report.

The major focus in 2013 was on the study of the propagation of pressure waves within a beam tube following vacuum rupture. This activity was developed in collaboration with the vacuum team of SPIRAL2 at GANIL. Theoretical modeling of the flow process was realized by viscous finite-element fluid dynamics and molecular regime Monte-Carlo simulations. Subsequently, a real-scale 28m long test bench was built up and commissioned. Equipped with fast reaction vacuum gauges, it permits to study the dynamics of leak propagation in a model system. In addition, the test bench permits to test and qualify a commercial fast valve system.

Summary of WP7 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D32	TR-CV	Report on similar systems at other facilities	12	Achieved month 24
D33	CDR-CV	Conceptual design of the cooling and ventilation upgrade	24	Achieved month 28
D34	ES-Vac	Vacuum engineering for the ultrahigh vacuum of the SC linac	18	Expected month 36
D35	CDR-Vac	Vacuum studies for the radio frequency quadrupole cooler and buncher RFQCB	36	According to plan

Status of milestones

Num	Short name	Description	Planned month	Status
M33	ES-HVAC	Engineering specifications of the cooling and ventilation upgrade	36	According to plan
M34	ID-Vac	Identification of the vacuum system requirements	6	Achieved month 12
M35	Proto-Vac	Prototypes and Tests	24	Achieved month 24

Andrea Polato (ESR13) is a member of the HIE-ISOLDE Infrastructure, Integration and Installation working group, of the HIE-ISOLDE Design Study working group and the CERN Ventilation working group where he reports on a regular basis (oral presentations and technical documents).

Mario Armin Hermann (ESR14) is a member of the HIE-ISOLDE Infrastructure, Integration and Installation working group, of the HIE-ISOLDE Cryomodule and HEBT working groups and of the HIE-ISOLDE Design Study working group where he reports on a regular basis (oral presentations and technical documents).

Summary of past meetings

Date	Venue	Attendance	Objective(s)
22rd January 2012	GANIL, France	50	ESR13: Participation to Spiral 2 week
21-22nd November 2012	PSI (CH)	15	ESR13: Visit to PSI ventilation and cooling installations
15th – 16th April 2013	CEA Cadarache France	5	ESR13: ESS and ITER ventilation issues
12th – 14th July 2011	INFN-LNL, Italy	15	ESR14: Visit to compare ALPI and SPES with HIE-Isolde vacuum (Linac vacuum aspects and operation, Front End vacuum, RFQCB vacuum simulation)
25-27th September 2011	Warsaw	~100	ESR 14: Marie Curie Researchers Symposium, Warsaw. Representing CATHI. Poster, “ITN CATHI at CERN”
10th – 12th January 2012	GANIL, France	6	ESR14: Visit on Spiral1 vacuum design and operation, as well as Spiral2 vacuum issues related to safety (vacuum layout, equipment choices, gas recuperation, fast valves)
19th - 21st March 2012	INFN-LNL, Italy	3	ESR14: Visit to share knowledge in vacuum simulations for the RFQCB using Molflow+
5-7 December 2012	CERN	10	ESR14: Visit of R. Levallois and P.Dolégiéviez (GANIL) with presentation of Spiral2 vacuum and dedicated discussions on remote

			manipulation, fast valves, vacuum simulation
4th – 6th February 2013	GANIL, France	6	ESR14: Participation of ESR14 as reviewer, to review of SPIRAL2 vacuum system safety by fast valves
14th – 19th July 2013	GANIL, France	4	ESR14: Visit to GANIL in view of a collaboration on fast valve systems and pressure wave propagation

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
ESR13: Final Report for the works concerning the back-up tank refilling and drain circuits for the GPS and HRS targets of the ISOLDE Facility	Report	-	4
ESR13: GANIL/SPIRAL2 visit report	Report	D32	(12) 5
ESR13: INFN/SPES design review report	Report	D32	(12) 11
ESR13: PSI visit report	Report	D32	(12) 13
ESR13: ESS/Lund: design review report on the nuclear ventilation project at ESS	Report	D32	(12) 18
ESR13: Preliminary Design Report on the HIE-ISOLDE HVAC system	Status Report	D33	(24) 14
ESR13: Preliminary Design Report on the HIE-ISOLDE Cooling system	Status Report	D33	(24) 14
ESR13: Preliminary Design Report on the MEDICIS Cooling system	Status Report	D33	(24) 24
ESR13: Preliminary Design Report on the MEDICIS Pressure specification	Status Report	D33	(24) 24
ESR13: Preliminary Design Report on the MEDICIS HVAC system	Status Report	D33	(24) 24
ESR14 Report on outgassing measurements of various survey components	Report	M35	(24) 6
ESR14 Report on outgassing measurements ESA thermal radiation shielding foils	Report	M35	(24) 8
ESR14 Report on outgassing measurements on Andrews radio frequency power cable	Report	M35	(24) 13
ESR14 Report on outgassing measurements on survey ball lenses	Report	M35	(24) 24
ESR14 INFN-LNL visit report, 12-14 July 2011	Report	D34	(18) 4
ESR14 GANIL visit report, 10-12 January 2012	Report	D34	(18) 9
GV TRIUMF visit report, 6-12 February 2012	Report	D34	(18) 10
ESR14 INFN-LNL visit report, 19-21 March 2012	Report	D34	(18) 12
ESR14 Pumping speed measurements of EBARA PDV250 dry pump	Report	M35	(18) 18
ESR14 GANIL visit report, 4-6 February 2013	Report	D34	(18) 22
ESR 14 The HIE-ISOLDE Vacuum System	Poster, EURO	D34	(18) 13

	RIB		
ESR14 Simulations of the HIE-ISOLDE radio frequency quadrupole cooler and buncher vacuum using the Monte Carlo test particle code Molflow+	Article NIMB	D35	(18) 23

Mario Hermann is co-author of the following publications:

- M. Hermann et al., "ITN CATHI at CERN", Proceedings of Marie Curie Researchers Symposium 2011
- M.A. Hermann et al. "The HIE-ISOLDE Vacuum System", Proceedings of EURORIB2012
- M. Hermann et al., "Simulations of the HIE-ISOLDE radio frequency quadrupole cooler and buncher vacuum using the Monte Carlo test particle code Molflow+", Proceedings of EMIS 2012 to be published in NIMB

9. WP8: Radioactive Ion Beam Quality Improvement

Work package number	**8**	**Start date or starting event:**	Month 12
Work package title	Radioactive Ion Beams Quality Improvements		
Activity Type	RTD		
Person-months	**96 (ESR15: Mathieu Augustin 36 months; ESR16: Carla Babcock 36 months and ER3: Andrey Shornikov 24 months)**		
Associated Partners	JYFI, MPIK, NSCL-MSU, Scientific Magnetics,		
Objectives	The ESRs will acquire the necessary knowledge and collaborate to the different studies for the improvements of the radioactive ion beam quality in both resolution and purity.		
Description of work	1. **ESR15:** Define the functional and technical specifications for the production of an off-line separator 2. **ESR15:** Assembly and commissioning of the off-line separator 3. **ESR15:** Carry out design study of a high resolution magnet including the integration of multi-pole corrections 4. **ESR15:** Elaborate the technical specifications and participate in the call for tender for the procurement in industry 5. **ESR16:** Elaborate a functional and conceptual design of a Radio Frequency Quadrupole Cooler and Buncher (RFQCB) 6. **ESR16:** Provide a design for a pre-mass separator and setup a test stand 7. **ER3:** Carry out high-current electron beam simulations in order to establish a viable electron beam design 8. **ER3:** Carry out beam-optics simulation of the A/q-separator connecting the EBIS breeder to the existing linac		
Deliverables	D36. Specifications for Off-line separator (**ESR15**) D37. Full design Report of high resolution magnet (**ESR15**) D38. Specifications for call for tender (**ESR15**) D39. Design report of a Radio Frequency Quadrupole Cooler and Buncher (**ESR16**) D40. Functional specifications and Conceptual Design Report of a Pre-mass separator (**ESR16**) D41. Final conference report and/or journal publication on test results (**ESR16**) D42. Preliminary report on magnetic field configuration and electron beam design (**ER3**) D43. First order mechanical design of electron gun, drift tube structures and collector (**ER3**) D44. Final report on magnetic field, electron beam and ion optics, electron collector design and charge breeding performance (**ER3**)		

Main achievements

Beam quality is an important factor for the success of many experiments at HIE-ISOLDE and covers many different aspects. For example, transverse emittance will greatly enhance the selectivity of collinear spectroscopy, bunched beams will simplify and improve injection into other devices such as the REX electron beam ion source, cooled beams will improve ion transport through the complex beam line system at ISOLDE and the improved resolution of mass separation will contribute to better ion beam selectivity.

Off-line separator and high-resolution separator magnet: ISOLDE has now a second operational off-line separator ; it will be used for both the testing of prototype targets and eventually provide ion beams for the off-line physics program. The off-line produced its first test beam in October 2013 and is on a good path to completion with the impending comissioning of a bending dipole magnet for mass separation, and later the installation of a Radio Frequency Quadrupole Cooler Buncher (RFQCB) following the relocation of the off-line in its new premises in early summer 2014.
A new HRS separator magnet design is an important element for the separation of isobaric beams with a mass resolution of up to 20000. **Mathieu Augustin (ESR15)**, embarked on the study of the High Resolution Separator (HRS). Following the technical requirements, a new design has been proposed in

terms of magnet characteristics and beam optics. Advanced numerical simulations regarding the magnet design are currently being carried out for precise definition of magnet specifications.
Training:

- CST Particle Studio , April 2013;
- COMSOL Multiphysics Workshop, July 2013;
- CERN EDUSAFE ITN Scientific Writing, October 2013.

RFQ cooler and pre-separator magnet: In parallel to the high-resolution magnet design, the beam quality before mass separation plays a major role towards the high resolution of the separator magnet. The beam should have an emittance of < 3 pi.mm.mrad to be able to achieve a mass resolution of ~ 20000. This can be done using a Radio Frequency Quadrupole Cooler and Buncher (RFQBC) prior to injecting the beam into the magnet. However, to minimize space charge effects of the total beam, a pre-separator should be installed prior to beam injection into the RFQBC. **Carla Babcock (ESR16)**, has been leading the design and procurement of the new version of the RFQBC for use on the off-line test stand. New 3D models were updated, quotes were obtained and a delivery schedule was established. Several modifications were proposed by **Carla** in order to improve the performance of the pumping system. Beam optic simulations were also carried out to understand and improve the injection and extraction electrodes designs. The pre-separator design study was launched in parallel. **The RFQCB for HIE-ISOLDE** has now been constructed based on the pieces procured during the first year, and is in the process of being wired and having the vacuum systems installed. The improvements previously envisioned during the piece procurement process have been included in the new design, including several developments to the vacuum system and modifications that will allow lasers to enter the RFQCB, opening the door to new physics experiments. Some of these changes have been tested on the existing RFQCB, which has been removed from the beam line in order to adjust it's alignment, change faulty connectors and improve the design of the helium injection system. Work with the existing RFQCB has shed light on problems that may be faced during operation of the new RFQCB. Beam optics simulations have been extended to include all phases of the beam passage through RFQCB, from injection to extraction.
Secondment (I18):

- TRIUMF, June and July 2013.

Training (TC17):

- Beam Optics Simulation codes – CST Microwave Studio course at CERN, April 10-11 2013;
- UK Nuclear Physics Summer School in Bristol, Aug. 27–Sept. 7;
- CV writing and Interview Techniques Course at CERN, Dec. 2-3

Upgrade of the REXEBIS charge breeder: The present accelerator scheme makes use of a charge-breeder source, but the higher beam intensities anticipated with HIE-ISOLDE and the desire to charge breed heavy elements within a shorter time ask for an upgrade of the present breeding system (REXTRAP and REXEBIS). **Andrey Shornikov (ER3)** is carrying out a performance and suitability evaluation of the different existing options. **Andrey**, started at CERN July 1st 2012 with knowledge transfer and establishing collaborations. In this phase leading EBIS laboratories were visited, and broad panel of experts visited CERN to give us the latest status. A collaboration was established with Brookhaven National Laboratory to take advantage of their preliminary development of a high-performance electron gun (HEC^2 gun) and infrastructure suitable to test it. The collaboration resulted in the new electron-gun project. The HEC^2 gun was built at CERN, installed at BNL and brought to test operation by Nov 2013 with active participation of CERN personnel on the BNL site (two visits of total 5 man-months). The tests are ongoing, and the earliest results of 1.5 A at 30 keV make the HEC^2 gun the most powerful electron gun built with high compression design for an EBIS. Due to extra construction and commissioning duties, the initial scope of the work package was shifted towards testing, rather than pure design. The deliverables now include contributions from R. Mertzig, a PhD student involved in some activities related to the charge breeder project.

Summary of WP8 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D36	FS	Off-line separator specifications	11	Achieved month 15
D37	CDR-HRS	Design report of HRS magnet	18	Expected month 33
D38	TS-HRS	HRS magnet specifications	26	Expected month 33
D39	CDR-RFQBC	Design report of the RFQ cooler	18	Achieved month 8
D40	CDR-PMS	Design report of the pre-mass separator	18	Expected month 30
D41	FDR-Beam	Final Design report of the beam purification system	36	According to plan
D42	PDR-EBIS	Magnetic field and electron beam preliminary design report	13	Expected month 21
D43	MDR-EBIS	First order mechanical design report	21	Achieved month 15
D44	FDR-EBIS	Final design report of the magnetic field, electron beam and ion optics, electron collector design and charge breeding performance.	24	According to plan

Status of milestones

Num	Short name	Description	Planned month	Status
M36	INS-OLS	Assembly and commissioning of the off-line separator	36	Expected month 33
M37	INS-PMS	Set up pre-mass separator test stand	24	Expected month 31
M38	Proto-test	Prototypes and Tests	30	Expected month 32
M39	BO-EBIS	Evaluation of breeder options	6	Achieved month 8
M40	ST-EBIS	Evaluation report on electron beam simulation tools	10	Achieved month 10
M41	WS-EBIS	HIE-EBIS workshop	19	Achieved month 4

Summary of past and planned meetings

Date	Venue	Attendance	Objective(s)
25.05.2012	MPIK	3	Design aspects of Heidelberg -type EBIT
17.07.2012	CERN	4	Vacuum challenges of HIE-EBIS
27.08-3.09.2012	BNL	4	RHIC EBIS and Test EBIS at BNL as prototypes for HIE-EBIS
3-11.09.2012	NSCL/MSU	4	ReA3 EBIT as a prototype for HIE EBIS
End of September 2012	CERN	4	Cryogenic aspects of superconducting magnet for HIE-EBIS
16-17.10.2012	CERN	35	Wide expert board meeting on HIE-EBIS
Dec. 2-7 2012	Matsue, Japan	~200	Electro-magnetic isotope separation conference EMIS 2012
Feb. 20-22 2013	CERN	-	LA3NET workshop on laser applications
28-29.05.2013	Jyväskylä, Fi	~20	The charge breeder project presented to EURISOL design study community in preparation of ENSAR-2 program grant application to fund the future development beyond CATHI scope
Nov. 4-6 2013	Aachen	-	LA3NET Laser Application Workshop

25-27.11.2013	CERN	~100	ISOLDE user meeting, the results of the first operation of the HEC^2 gun at BNL are presented to ISOLDE community
Nov. 28-29 2013	CERN	~100	HIE-ISOLDE workshop
18-21.05.2014	MSU, USA	~50	Presenting the HEC2 project to the broad EBIS community on its most important bi-annual meeting. Establishing new collaborations.

Documents produced

Title	Type	Deliverable / Milestone	(Foreseen) achieved month
Specifications of the Off-Line Separator	Report	D36	(11) 15
Design report of the RFQ cooler	Report	D39	(18) 8
Design study of an upgraded charge breeder for ISOLDE: Report on breeder options	Report	M39	(6) 8
Evaluation report on electron beam simulation software	Report	M40	(10) 10
Report on the HIE-EBIS Workshop	Report	M41	(19) 4
First order mechanical design of electron gun, drift tube structures and collector	Report	D43	(21) 15

Andrey Shornikov, Mathieu Augustin and Carla Babcock are co-authors of the following publications:

- A. Shornikov et al. "Design Study of an upgraded charge breeder for ISOLDE", Nuclear Instruments and Methods in Physics Research Section B, Volume 317, pp 395-398, DOI: 10.1016/j.nimb.2013.06.030
- M. Augustin et al., "Design upgrade of the Mass Separator Magnets for HIE-ISOLDE", Proceedings of EMIS 2012 to be published in NIMB
- C. Babcock et al., "Upgrade of the Radio Frequency Quadrupole Cooler and Buncher for the HIE-ISOLDE Project", Proceedings of EMIS 2012 to be published in NIMB

10. WP9: General Safety and Radiation Protection

Work package number	**9**	**Start date or starting event:**	Month 17
Work package title	General Safety and Radiation Protection Implication Studies		
Activity Type	RTD		
Person-months	**24 (ER4: Sandra Giron)**		
Associated Partners	GANIL and IPN-Orsay		
Objectives	The ER will acquire the necessary knowledge in the radiation protection aspects of the extension of the REX post-accelerator for radioactive ions He will collaborate with the teams in charge of the rebuilding of the target area for allowing a primary beam power between 10 kW and 30 kW – a factor of 3 to 10 above the present beam power at ISOLDE. The ER will also participate actively in the startup of the machine.		
Description of work	1. Draft parts of the HIE-ISOLDE safety file dealing with radiation protection 2. Provide professional assistance to solving questions of radiation safety 3. Estimate the activation and radiation levels from beam loss of heavy ions 4. Estimate the radiation levels from x-ray emission of RF cavities 5. Apply and monitor the foreseen protection systems 6. Assist in the commissioning of the new machine		
Deliverables	D45. Design report on the shielding of the future post-accelerator D46. Final report on the Estimation of the activation of the machine for the radioactive waste inventory		

Main achievements

Radiation Protection, as one of the aspects of overall Safety of the planned HIE-ISOLDE facility, is the responsibility of the project management in charge of planning, building and operating the future installation. The mandate of the radiation protection group is to support the decision-making of the HIE-ISOLDE project management in matters of Radiation Protection. For this purpose, the radiation protection group accompanies all design stages of the new project with guidance on applicable rules, and with numerical estimates of radiological impact. It collaborates with the project management in the optimization process. The goal of this process is to converge to technical solutions and administrative procedures ensuring the lowest reasonable radiological impact of the project on workers and the environment (ALARA–principle). The radiation protection group approves the chapters on radiation protection in the Safety File of the facility.

Since March 2012, Sandra Giron (under the supervision of CERN Radiation Protection group) has accompanied the radiation protection aspects of the extension of the REX post-accelerator for radioactive ions, and collaborated with the teams in charge of the re-design of the target area for allowing a primary beam power between 10 and 15 kW – a factor of 3 to 5 above the present beam power at ISOLDE.

Important milestones have been achieved regarding the shielding of the new post-accelerator, the protection of the new service buildings housing the cryogenics system, cooling and ventilation, and the electrical systems which are in the line of sight of the present HRS beam dump. X-ray emitted by superconducting prototype cavities have been measured both at SM18 at CERN and IPN-Orsay in France, to evaluate the source term of radiations. The shielding design of the future post-accelerator has been designed in close collaboration with the team in charge of the services integration. The geometry has been validated by FLUKA simulations.

The evaluation of secondary radiation fields from heavy ions with E/A = 10 MeV/u (and the shielding against them) is on the critical path of the REX-extension. There is very little experience with this subject at CERN and a collaboration with CEA/IRFU (Saclay, France) has been setup to overcome this. By comparison with ALPI at INFN/Legnaro and ISAC2 at TRIUMF, that are both similar facilities to HIE-ISOLDE, neutron emission has been identified as a secondary risk for future the post-accelerator (after X-rays). The typical ion beams and their associated intensities has been listed to

evaluate ion beam losses and the dose rates expected at Faraday cups and magnetic dipoles outside the shielded enclosure.

Two new potential partners have teamed up in this development namely, TRIUMF research facility in Vancouver, Canada (possibilities for secondment), and CEA/IRFU/LENAC lab in Saclay, France (technical training on particle transport codes). A visit to TRIUMF was organised to retrieve feed-back on the ISAC2 facility. During her secondment at CEA, Sandra Giron compared the performances of two Monte Carlo transport codes (FLUKA and PHITS) to predict neutron fluxes and radio-isotope production after irradiation of a sample by radioactive beams at low energy.

Training:

- Certification of radiation protection expert in Switzerland was obtained (2 weeks IRA-Lausanne with examination
- FLUKA course in JLAB (USA);
- NUCLEONICA course;
- PHITS course.

Secondment:

- CEA-Saclay in the context of SPIRAL2.

Summary of WP9 Deliverables and Milestones

Status of deliverables

Num	Short name	Description	Planned month	Status
D45	CDR-shield	Design of the shielding of the Post-accelerator	15	Achieved month 21
D46	CDR-waste	Estimation of activation of the machine for the radioactive waste inventory	24	According to plan

Status of milestones

Num	Short name	Description	Planned month	Status
M42	TN-Codes	Comparison of different radiation transport codes	3	Expected month 24
M43	TN-RIBloss	Estimations of beam loss of heavy ions	7	Achieved month 12
M44	TN-XRay	Estimation of radiation levels from x-ray emission of RF cavities and comparison with measurements	11	Achieved month 12
M45	TN-Dose	Estimation of prompt dose during operation, conditioning and maintenance	20	According to plan

Sandra Giron is a member of the HIE-ISOLDE Infrastructure, Integration and Installation working group where she reports on a regular basis (oral presentations and technical documents).

Documents produced

Title	Type	Deliverable /	(Foreseen) achieved

		Milestone	month
Specification of the sources of radiation and maximum beam intensities and energies of the HIE-ISOLDE Linac	Report	M43	(7) 12
Status report on the measurements of X-rays emitted by cavities during RF tests at SM18	Report	M44	(11) 7
Preliminary estimation of the shielding requirements of the SC linac	Report	D45	(15) 10

Summary of past and planned meetings

Date	Venue	Attendance	Objective(s)
From month 2	CERN	every 2 weeks	HIE-ISOLDE integration meetings
April 2012	JLab	7	FLUKA training course
2012	-	-	People 2012 Marie Curie Conference
December 2012	GANIL	3	Visit of the SPIRAL2 future facility
February 2013	INFN Legnaro	7	Participation to ALPI conditioning in Legnaro and discuss RP issues
April 2013	IPN Orsay	7	X-ray measurements at HIE-ISOLDE prototypes cavity
June 2013	Aix en Provence	7	Neutron and Ion Dosimetry symposium (NEUDOS)
June 2013	NEA	7	PHITS training course
January 2014	CEA	36	Secondment : comparison on different transport codes for target activation by a ion beam at low energy + benchmarking
November 2014	CERN	1	HIE-ISOLDE safety review
November 2014	CERN	2	Presentation of the technical aspects of the HIE-ISOLDE project

Publication

- S. Giron et al., Radiation Protection Study related to the future post-accelerator of the HIE-ISOLDE project, Radiation Protection Dosimetry 2013, doi:10.1093/rpd/nct297