ESS-BILBAO Accelerator : Progress Report

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Abstract. The ESS-Bilbao (ESSB) light ion linear accelerator has been conceived as a multi-purpose machine, useful as the core of a new standalone accelerator facility in southern Europe, as well as fulfilling specifications to take part within the the European Spallation Source design and prototyping. The machine is designed to serve as a driver of a low-energy neutron target aiming to carry out development work focussed onto optimization of the neutronic performance of moderator systems as well as on instrumentation for thermalized and fast neutrons.

1. Introduction

The decision to build a MW-range, accelerator-based spallation neutron source as the next generation large-scale neutron facility for Europe is at present under consideration on the basis of experience gained during the construction and commissioning of the SNS in the US and the JPARC facility in Japan. The underlying technology has however advanced since the time when both facilities reached final design stages and therefore time is now ripe to learn from past lessons and define the development areas which would allow ESS to benefit from recent advances in technology while maintaining a reliable, low risk, design.

Within the current European context, ESS-Bilbao (ESSB) has entered a new endeavor within which while being a partner of the ESS project aims to develop significant in-house capabilities needed to support the country participation in a good number of accelerator projects worldwide (IFMIF/EVEDA, LINAC4/SPL, FAIR, XFEL, ESRF upgrades, ISIS-FETS etc.). On such grounds ESSB has started the construction of a modular, multipurpose compact accelerator-driven low-energy neutron source which should serve as a benchmark for components and subsystems relevant for the ESS project as well as to provide the spanish science and technology network with hands-on experience on power accelerators and neutron beam systems. Moreover, the project will also stimulate the spanish science industry with some advanced manufacturing capabilities. Finally, ESSB will configure a local neutron source which will serve as training center for neutron users and technologists as well as a platform to prepare and design of experiments to be further carried out at a large facility. The main parameters of ESS-BILBAO accelerator are sumarized in the Table 1.

The present document reports on the status of manufacturing process of the room temperature accelerating structures, the general layout of the building as well as an ovweview of the target station design.

Maximum kinetic energy	50-60	MeV
Peak current	75	mA
Repetition Rate	20-30	Hz
Frequency (bunches)	352.2	MHz
Maximum pulse length	1.8	ms
Source Speaces	H^+ and H^-	
Total Length of accelerator elements	29.5	m
Extraction Emittance (T)	0.7 π mm mrad	(norm.)
Normalized Extraction Emittance (L)	0.20 π ° MeV	
	1.0 π mm mrad	(norm.)
Number of klystrons	4	2.8 MW at peak
Efficiency of RF	0.85	

Table 1. Parameters of ESS-BILBAO Accelerator

2. The general layout

The ESSB facility will be located in the UPV/EHU- University of te Basque Country at the Leioa-Erandio Campus. The Figure 1 shows the ground preparation works at no more than 400 m form the university main buildings. This situation close to the campus brings in some constraints in the available space for the facility that has been addressed by means of the design of a building having some of its infrastructure underground. The accelerator is placed in the underground level (Figure 6) of the building form the ion source to the main beam-dump. At the end of the DTL the beam is extracted to the ground level to the neutron production and proton irradiation targets. A substantial portion of the available surface at the ground level is thus reserved for such an avail. The conditioning of the terrain has been completed and the construction of the building is expected to start next year.

Figure 1. Situation in UPV/EHU Leioa-Erandio University Campus

3. The Accelerator

The main accelerator components are summarized in the following table 3. It mainly consists on components which will operate at room temperature, followed by a test cryomodule comprising

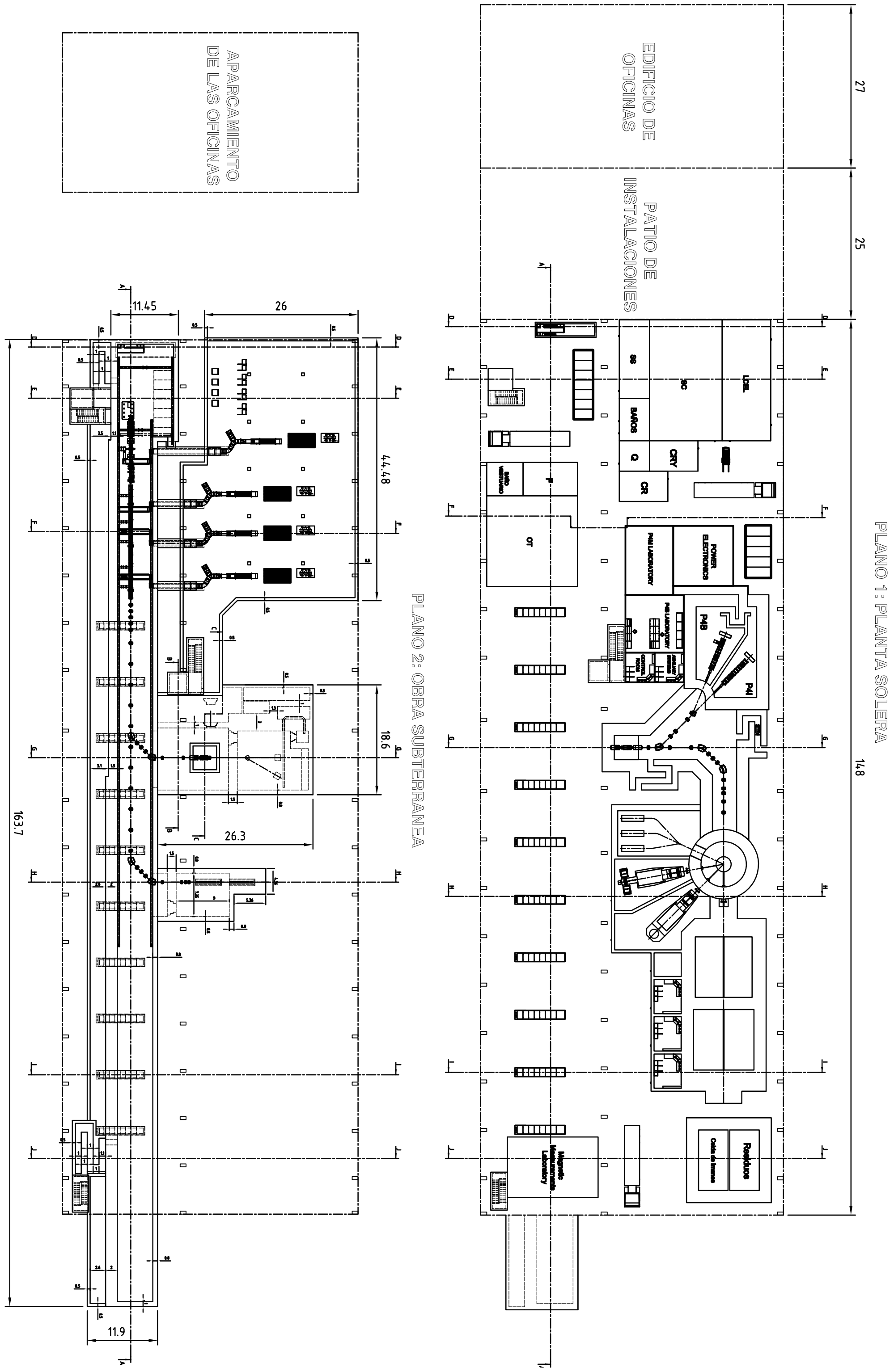

Figure 2. Ground and underground levels for ESSB building

Element	Length (m)	Energy (MeV)	Cavs.	Gaps	RF (MW)	Klystrons
Source	1.5	0.075	-	-	-	-
LEBT	4					
RFQ	3.9	0.075 - 3.0	1	560	1.2	1
MEBT	3	3	2	-		
DTL	14.6	3 - 50	3	85	3.8	3
Spokes	3.5	50 - 60	2	4	0.8	1

Table 2. Accelerator Components

two model spoke superconducting resonators and will be placed in the underground level of the building.

3.1. The Ion Source

The Ion Sources of ESSB comprises a H- and a H +. The H- source is Penning-trap source based upon the ISIS-FETS design [1], it is already in operating at ESSB Zamudio installations. A comprehensive set of diagnostics which includes current mearuring devices such as AD and DC current transformers and a Faraday cup, a retarding potential analyzer for determination of particle energy and a beam profile monitor of pepperpot type have already been installed within a diagnostics vessel. The H+ is in assemblage phase in the UPV/EHU campus, and it is expected to start the operation along this year.

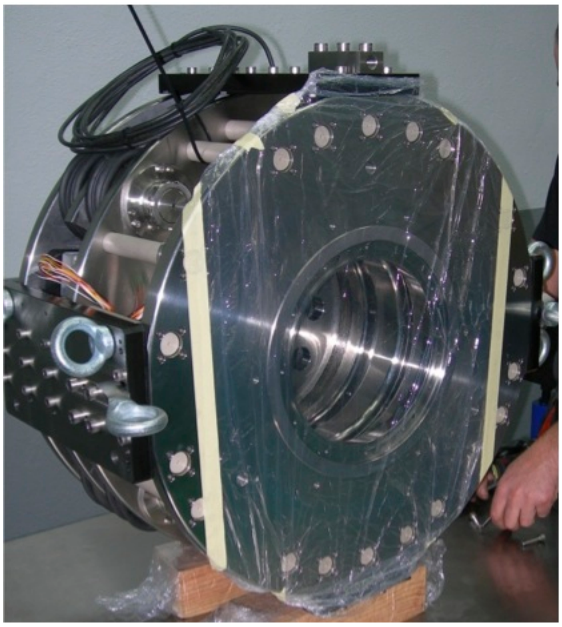

Figure 3. The accelerator column for the ECR proton source being installed at the ESSB facility

3.2. The low energy beam transport

The goal of the LEBT is to transport the beam from the ion source into the entrance of the Radio Frequency Quadrupole (RFQ), where the converging beam needs to fit into the acceptance of the RFQ. Our LEBT will be based on a four-solenoid design using for the purpose a set of magnets and which are essentially an extension of those previously built and operated at ISIS-FETS. The rationale behind the use of such a long LEBT derives from the need to focus the non-axially symmetric beam produced by the Penning source as well as from the need to fully control the four degrees of freedom of beam transport dictated by the requirement to transform beams of H+/H-. The structure is thus built using four magnets which incorporate built-in Lambertson dipoles for beam steering as well as the relevant diagnostics. The LEBT magnets as already be manufactured by local companies and the vacuum system will be delivered along next months. The Figure shows the LEBT assembly in Zamudio installations.

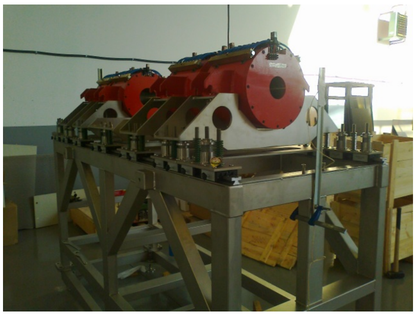

Figure 4. The LEBT solenoids

3.3. The RFQ

As current experience from MW range spallation sources show, this accelerating structure can rightly be considered as one of the Achilles heels of the whole acceleration chain [2]. This structure has been develop in the framework of the collaboration between ESS-BILBAO Accelerator Team, the Rutherford Appleton Laboratory, the Imperial College of London, ASTeC and the University of Warwick. The design will be completed along 2012 and some manufacturing test has been perform. The Figure shows an example of the actual status of design.

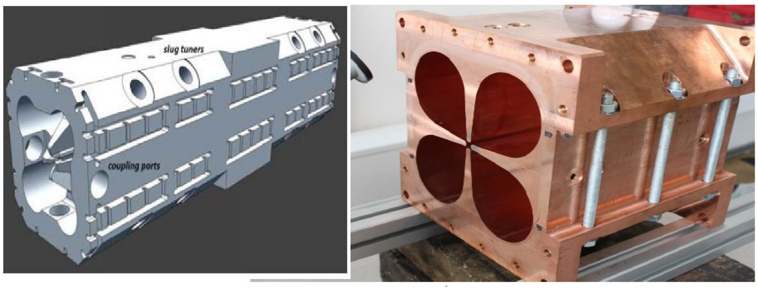

Figure 5. The RFQ design

3.4. The DTL

The reference design for a structure to accelerate protons up to energies above 3 MeV consists in three Alvarez DTL tanks which should be able to raise the beam up to a final energy of 50 MeV. The design upon we rely on is an adaptation of that developed for the LINAC4 project which employs a FOFODODO lattice made upon permanent magnets of some 45 mm in length and able to provide a gradient of 55.5 T m-1. The first tank with a length of 4.6 m and a bore radius of

10 mm provides a beam with a final energy of 13 MeV and second and third with lengths of 5.12 m and 4.87 m yield energies at their output of 27.3 MeV and 40.5 MeV respectively. The tanks comprise sets of drift tubes suspended from a girder by a single cylindrical structure in numbers of 45, 30 and 22 for the three tanks respectively. The Figure shows the DTL manufacturing process carried out by the local company "Mancisidor".

Figure 6. The DTL manufacturing

4. The Target Station

The extraction at 50 MeV allow us to configure a LENS-Type [3] source based on $^{9}Be(p,n)$ reaction. The total beam power rise up to 112 kW in full power operation, 12 times more than LENS, and due to that it is not possible to configure an stationary target. In other to solve this problem a rotating target as been proposed with 20 single beryllium sheets which supports 5,6 kW. In order to produce low energy neutrons a methane reflector is proposed surrounded by a beryllium reflector. The full description of this target station can be found in 323-SORDO. The station is under design and it is expected to manufacture a prototype at the end of 2012.

5. Conclusions

The final design of the ESSB accelerator is close to be finish and the manufacturing of all the components has started. The first modules of the accelerator (ion sources and LEBT) are in assembling/commissioning phase and it is expected to start the operation of it along this year. The conditioning of the terrain has conclude and the construction of the building will start in the beginning of 2013. Concerning the target station, the conceptual design has conclude and it is expected to close the engineering design along this year.

The operation of ESSB facility will start along 2016 with the small neutron source for testing ESS components.

Acknowledgments

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