DELIVERY STATUS OF THE ELI-NP GAMMA BEAM SYSTEM

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Abstract

The ELI-NP GBS is a high intensity and monochromatic gamma source under construction at IFIN-HH in Magurele (Romania). The design and construction of the Gamma Beam System complex as well as the integration of the technical plants and the commissioning of the overall facility, was awarded to the Eurogammas Consortium in March 2014. The delivery of the facility has been planned in for 4 stages and the first one was achieved in October 31st 2015. The engineering aspects related to the delivery of stage 1 are presented.

INTRODUCTION

In the ELI-NP Gamma-ray source under construction in Magurele (Bucharest, Romania) [1], the photons will be generated by Compton back-scattering at the interaction between a high quality electron beam and a high power recirculated laser. The machine is expected to achieve an energy of the gamma photons tunable between 1 and 20 MeV with a narrow bandwidth (0.3%) and a high spectral density (10^4 photons/sec/eV). The LINAC will deliver a high phase space density electron beam in the 300-740 MeV energy range. The repetition rate of the machine is 100 Hz and, within the RF pulse, up to 32 electron bunches will be accelerated, each one carrying 250 pC of charge, separated by 16 ns. The photo-injector is based on an S-band 1.6 cell RF gun fabricated with a new technique recently developed at LNF [2], followed by two 3m long travelling wave (TW) S-band structures. The LINAC booster is composed of twelve 1.8 m long TW C-Band structures that have been designed with a damping of the HOM dipoles modes in order to avoid beam break-up (BBU) due to the multi-bunch operation. In the paper we will describe the LINAC modules related to the contractual phase I delivery with their main features.

MODULES DESCRIPTION

The overall accelerator, laser recirculators, gamma beam characterization systems and beam dumps are divided in 36 modules that are pre-assembled and tested in order to reduce the time needed to assemble the machine in Magurele. The layout of the first four LINAC modules related to the phase I delivery are given in Figure 1.

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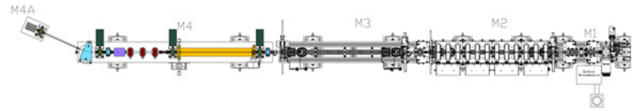

Figure 1: The layout of the first four modules.

Table 1: Main Parameters of the RF Gun

Structure type	1.6 cell
Working frequency	2.856 [GHz]
Cathode peak field	120 MV/m
Repetition rate	100 Hz
RF input power	14 MW
Coupling coefficient	2.6
Cathode type	Copper
Unloaded quality factor	14500
RF pulse length	1.5 us

Table 2: Main Parameters of the Gun Solenoid

Solenoid type	A
Current	176 A
Max B field	0.4 T
Length	180 mm
N. of coils	2
Bore	60 mm

Module M1

The first module includes the S-band gun, the gun solenoid (type A) for beam emittance control, two vacuum valves (one all metal and one fast valve to prevent RF gun contamination in case of incident), the laser injection chamber for the photocathode, a dual plane steerer magnet, a diagnostic chamber with a YAG screen, a beam current monitor and two 75 l/s star cell ion pumps. The main RF gun and gun solenoid parameters are given in Table 1 and 2, respectively. All components have been delivered by the subcontractors and successfully assembled in the module. The RF gun has been tested at high power and the final performance in term of cathode peak field, RF pulse length and repetition rate have been met. A picture of the whole assembled module without the gun is shown in Figure 2 and a detail drawing of the laser injection scheme is given in Figure 3. The last mirror, that reflects the power laser to hit the photocathode, is in air and the angle of laser incidence on the copper cathode is 2.5 deg. The picture of the RF gun under high power test is given in Figure 4.

ISBN 978-3-95450-147-2

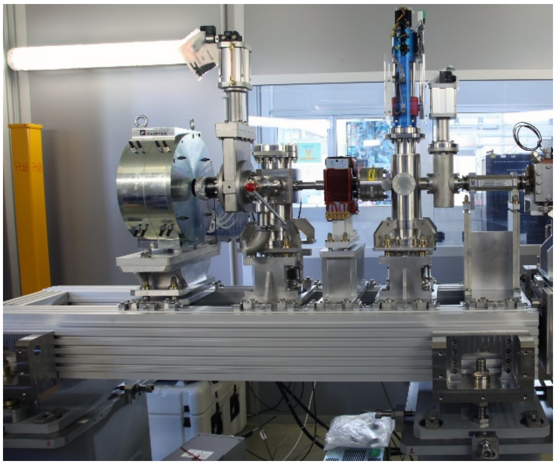

Figure 2: Module M1 without the gun installed.

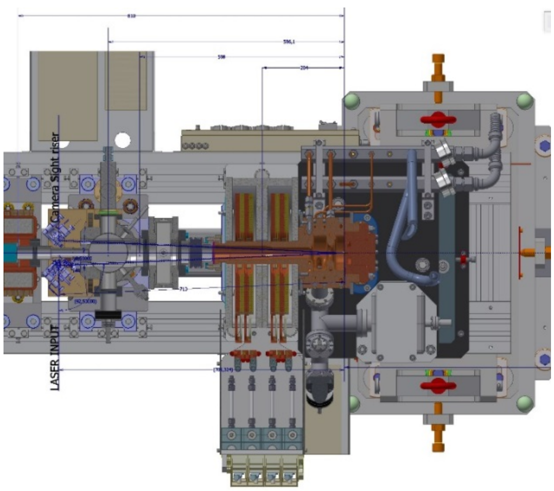

Figure 3: The laser injection scheme.

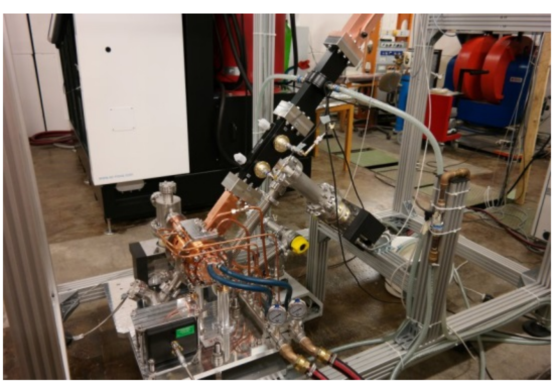

Figure 4: Picture of the S-band gun under high power test.

Module M2-M3

The picture of the assembled second and third modules is shown in Figure 5. The modules house the two S-band accelerating structures. They have a symmetric feeding system and are constant gradient. A multi-coil solenoid is located around the first accelerating structure and allows compensating the beam emittance distortion due to the longitudinal bunch compression by velocity bunching. The main RF accelerating structure and multi-coil solenoid parameters are given in Table 3 and 4 respectively. One of the two structures has been tested at high power and the design parameters in term of average accelerating field, RF pulse length and repetition rate have been met. Each module is equipped with four single plane steerers mounted at the entrance and exit of the accelerating structures. The steerers are assembled with a tilt of 90 degrees to allow horizontal and vertical beam correction. The multi-coil solenoid was designed at LNF and built by the Eurogammas subcontractor Danfysik. The solenoid is divided in four sections and each section contains an electric series of three coils. Each single coil can be individually aligned with respect to the magnet yoke because of its xyz mount and can be surveyed through reference fiducials exiting the iron yoke itself. The coil alignment and magnetic axis centering can be performed with the magnet powered on. The final tuning of the magnetic axis was performed at the Danfysik facilities within a precision of 80 microns RMS. The module 3 has a diagnostic chamber in between the two accelerating structure and two 75 l/s star cell ion pumps.

Figure 5: Modules M2 and M3.

Table 3: Main Parameters of the S-band Structures

Structure type	3 m Constant gradient
Working frequency	2.856 [GHz]
Average accelerating field	23 MV/m
Repetition rate	100 Hz
RF input power	45 MW
Phase advance per cell	$2\pi/3$
RF pulse length	1.3 μs
Filling time	0.8 μs

Table 4: Main Parameters of the Multi-coil Solenoid

Solenoid type	B
Current	177 A
Max B field	0.10 T
Length	2770 mm
N. of coils	12
Bore	306 mm
N. of sections	4

Module M4-M4a

The module M4 includes the first C-Band damped accelerating structure [3]. This structure has been designed at LNF and produced at the Eurogammas partner COMEB. The high power RF Conditioning has been performed and the nominal parameters have been reached. A picture of the module, assembled at STFC, is shown in Figure 6.

Figure 6: Photo of the module M4 and M4A.

Table 5: Main Parameters of the C Band Structure

Structure type	Quasi CG
Length	1.8 m
Number of cells	102 + in/output couplers
Working frequency	5.712 GHz
Working mode	2π/3 TW
Average acc. field	33 MV/m
Repetition rate	100 Hz
RF input power	40 MW
RF pulse length	0.8 μs
Filling time	0.3 μs

Downstream the C-Band section a S-Band transverse deflecting cavity (Figure 7) is installed to perform time-resolved beam measurements, a triplet of quadrupoles and diagnostic devices (beam screen and strip line monitor). In Table 6 the main parameters of the RF Deflecting structure are shown, this structure is fed by the klystron gun using a power divider and a variable phase shifter while a double RF Switch allows to switch off the cavity when not used. At the end of the module a dipole drives the beam to a spectrometer dump line to measure beam energy and energy spread. The assembly and the procurement of the magnet as well as the vacuum system are under STFC responsibility. Both modules (M4 and M4a) are fully assembled and currently under vacuum at STFC premises.

Table 6: S-Band Transverse Deflecting Cavity Parameters

RF frequency	2.856 GHz
Repetition frequency	100 Hz
Number of cells	5
Working mode	π (SW)
Max RF input power	5 MW
Maximum deflecting voltage	5 MV
Unloaded Q factor	16000
Coupling coefficient	3

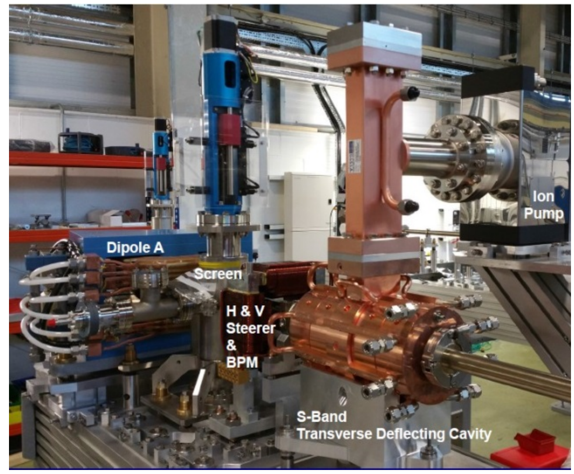

Figure 7: S-Band transverse deflecting cavity.

CONCLUSION

The phase I of the ELI-NP project was successfully accomplished in October 2015. The design and production of the accelerator equipments have followed the project schedule and the first four modules of the low energy LINAC were successfully assembled, tested and accepted by the customer at the vendor location. The modules 1-3 were designed and assembled at the Frascati National Laboratories while the modules 4 and 4a at the STFC laboratories in England.

ACKNOWLEDGEMENT

The author would like acknowledge all the technicians who took part in the project and not expressly indicated in this paper. In particular, we would like to thank, P. Chimenti and R. Di Raddo for the vacuum assembly of the modules, M. Paris and F. Putino for the alignment of the components.

REFERENCES

[1] TDR EuroGammaS proposal for the ELI-NP Gamma Beam System, http://arxiv.org/abs/1407.3669.
[2] D. Alesini, et al, PRST-AB 18, 02001, 2015.
[3] D. Alesini et al, *in Proc. of IPAC'16*, Busan, Korea, MOPMW004, this conference.