Preliminary design of BLISI, an off resonance microwave proton source

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A new high current off resonance microwave H+ source is currently in the last stages of design at ESS Bilbao, in collaboration with two external companies Elytt and AVS. The design is intended to be a high-stability, high-current ion source capable of delivering a 70 mA proton beam with a 70 keV energy at the end of the extraction. The plasma system designed by Elytt consists of a water-cooled plasma chamber that sits between two independently powered magnetic coils that generate the ECR magnetic field; in addition they can be moved independently to further shape the magnetic field in the chamber. A CPI 2.7 GHz klystron provides the microwave energy and a fully controlled microwave system to minimize reflected power and improve the source overall performance is also under construction. The extraction column designed by AVS will consist of a movable tetrode system designed for a maximum acceleration potential of 70 kV, the shape of the electrodes is at an earlier design stage at ESS-Bilbao. We will present the current layout of the source, simulations and schematics of the source.

Ion Beam Characteristics

Beam energy	70 keV
Total current	80 mA
Proton fraction	>85 %
Emittance	<0.2 π mm mrad
Availability	98 %
Duty Factor	3 % to 10 % (pulsed beam)
Pulse	1.5 to 2 ms
Repetition rate	up to 50 Hz
Microwave klystron	2 kW at 2.7 GHz

The main parts of the BLISI ion source

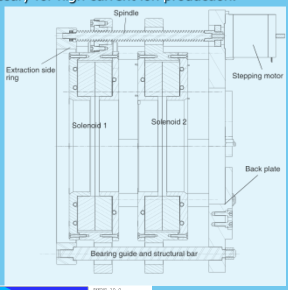
A) Magnetic Structure

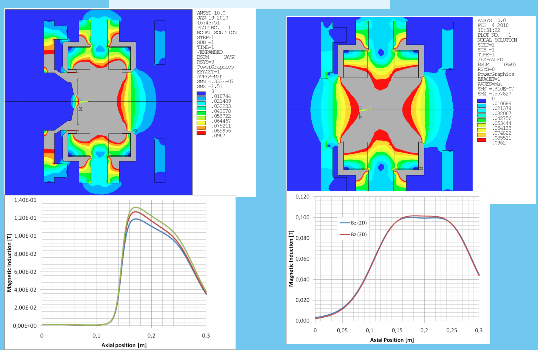
Two independently movable coils shielded by iron yoke and also support plates made of iron for additional shielding of the extraction region.

Each coil will consists of 2 pancakes for lowering necessary current and giving additional degree of freedom in shaping the magnetic field inside the plasma chamber.

On entire region of the chamber we will have a field of 0.115 T and on the both ends of the chamber it will be at the ECR electron cyclotron resonance value for our working microwave frequency i.e. 0.964 T.

Such configurations will allow having an plasma density even 10 times higher then critical plasma density and consequently we will achieve overdense plasma condition necessary for high current ion production.

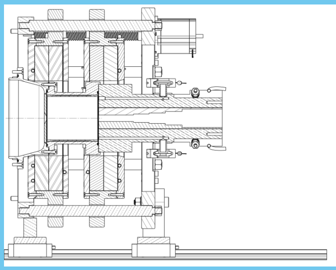




B) Microwave System

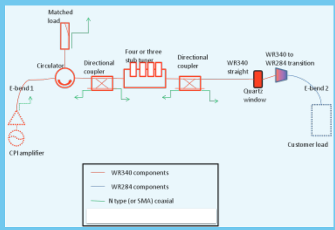
It will consists of the klystron generator at 2.7 GHz with power output of 2.5 kW produced by CPI company. Waveguides WR340 type, four stub ATU – automatic tuning unit, bidirectional coupler and circulator has been ordered at Sairem company.

Waveguide transition for coupling with the plasma chamber, electronics for ATU and electronics for pulsing the klystron amplifier will be made by us.



The main reason for using klystron instead of magnetron is that it is easier for maintenance and better for pulse mode operation.

The 2.7 GHz working frequency has been chosen since it will generate higher plasma density.



C) Gas Inlet System

The gas inlet system will have a close control loop consisting of gas dosing valve UDV 140, full range vacuum gauge, and control unit RGB 050 from Pfeiffer company.

It will allow keeping constant pressure in the plasma chamber and consequently more stable plasma and extracted proton beam. In such a way probability of sparks and plasma instabilities, the two main reasons for beam failure, will be significantly reduced. In addition an insulation valve will serve as safety for the sudden gas overflow in case of any electrical or control problems.

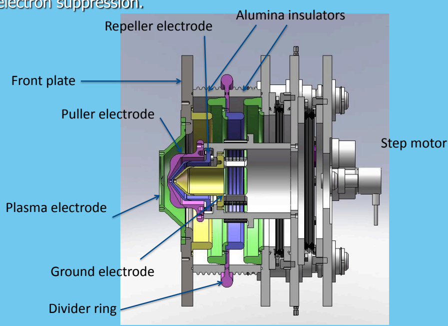
D) Extraction System

The extraction system consist of 4 electrodes. The first one is plasma electrode attached to the plasma chamber and having the voltage of the HV platform, i.e. 70 kV. Another 3 electrodes are packed in the extraction column, separated via alumina insulator from the HV platform.

They will be movable as an entire group, it means keeping the fixed distance between them, and changing only acceleration gap from the plasma electrode.

First and third electrode of this group are grounded and water cooled, serving for shaping the beam.

The second one, so called repeller, shall be on negative voltage of 3kV serving for electron suppression.



Conclusions

The Bilbao Center for Accelerator Science and Technology is a large scale accelerator facility under construction in Spain. The first machine of the future facility will be a high intensity Proton Linear Accelerator. The first part of such a proton LINAC will be BLISI – Basque Light Ion Source Injector. It will be used for proton and deuteron injection into the RFQ (radio frequency quadrupole), which constitutes the first bunching and acceleration segment of the LINAC complex.

It is intended to work in continuous and pulsed mode with reliability of 200 hours.