PROCEEDINGS OF SCIENCE

PoS(EPS-HEP2021)856

Beam Diagnostics at KAHVE Lab Proton Source and LEBT Line

Sevim Açıksöz,[a,b,*] **Aytül Adıgüzel,**[c,d] **Hakan Çetinkaya,**[e] **Şeyma Esen,**[c] **Duygu Halis,**[f] **Alis Hamparsunoğlu,**[c] **Taha Batuhan İlhan,**[g] **Atacan Kılıçgedik,**[h] **Oğuz Koçer,**[c] **Salim Oğur,**[a] **Sinan Öz,**[i] **Aydın Özbey,**[g] **Veysi Erkcan Özcan**[a,d] **and Nafiz Gökhan Ünel**[j]

[a] *Department of Physics, Boğaziçi University, Istanbul, Turkey.*
[b] *Turkey R&D Intelligent Application DC Department, Huawei Technologies, Istanbul, Turkey*
[c] *Department of Physics, Istanbul University, Istanbul, Turkey*
[d] *Feza Gürsey Center for Physics & Mathematics, Boğaziçi University, Uskudar, Istanbul, Turkey*
[e] *Department of Physics, Dumlupınar University, Kütahya, Turkey*
[f] *Department of Physics, Yıldız Technical University, Istanbul, Turkey*
[g] *Department of Mechanical Engineering, Istanbul University-Cerrahpasa, Istanbul, Turkey*
[h] *Department of Physics, Marmara University, Istanbul, Turkey*
[i] *Department of Mechanical Engineering, Boğaziçi University, Istanbul, Turkey*
[j] *Department of Physics, University of California at Irvine, California ,USA*

E-mail: kahvelab@gmail.com

*Speaker

KAHVE Laboratory, a particle detector, accelerator, and instrumentation research laboratory located at Boğaziçi University Kandilli Campus area at Istanbul, is currently working on the design of a RFQ operating at 800 MHz that will accelerate proton beam up to 2 MeV. As a first part of this linear accelerator, a Microwave Discharge Ion Source operating at 2.45 GHz frequency including 20 keV electrode extraction system has been designed, produced, and tested to generate hydrogen plasma and extract proton beams from this plasma medium. To transfer beams to the RFQ cavity, Low Energy Beam Transport (LEBT) line, a beam pipe including 2 solenoid magnets, 2 steerer magnets and a beam diagnostic box between these electromagnets, has been designed and produced, tested separately for now. The beam diagnostic box, including a Faraday cup, a pepper pot plate and there will be a home-built scintillator screen, is designed to measure the current, emittance and profile of the incoming beam. Currently, there has been an upgrade on the ion source. Instead using solenoid electromagnets in order to extract ions from the thermal hydrogen plasma, a new Microwave Discharge Ion Source system has been designed and constructed with permanent magnets. After this permanent magnet configuration upgrade, since the system is operated on the high voltage platform, a higher system stability would be achieved. Permanent magnet profile tests were completed to check the simulation results, then the production of new ion source system was completed, currently it is in the test phase before integrating to the system. In the session, it will be discussed that the simulation & experimental measurement results, and any other details of the whole system, which is constructed at KAHVELab all with local resources. These projects are supported by Istanbul University Scientific Research Commission Project ID 33250 and TUBITAK Project no: 119M774

**** The European Physical Society Conference on High Energy Physics (EPS-HEP2021), ****
**** 26-30 July 2021 ****
**** Online conference, jointly organized by Universität Hamburg and the research center DESY ****

1. Introduction

At the Boğaziçi University Kandilli Detector, Accelerator and Instrumentation Laboratory, we are working to build and operate an 800 MHz RFQ that will accelerate beams with a current of approximately 1 mA up to 2 MeV. The proton beamline of this accelerator starts with a Microwave Discharge Ion Source (MDIS) operating at 2.45 GHz frequency to create hydrogen plasma and extract protons with 20 keV electrode system by satisfying ECR condition. These beams are transferred to the RFQ cavity through Low Energy Beam Transport (LEBT) line including 2 solenoid magnets, 2 steerer magnets and a beam diagnostic box (MBOX) between these electromagnets, which is designed to measure emittance, profile and current of the incoming beam to ensure required beam property matching between MDIS and RFQ input. The current operating setup for MDIS, LEBT and MBOX can be seen in the Figure 1.

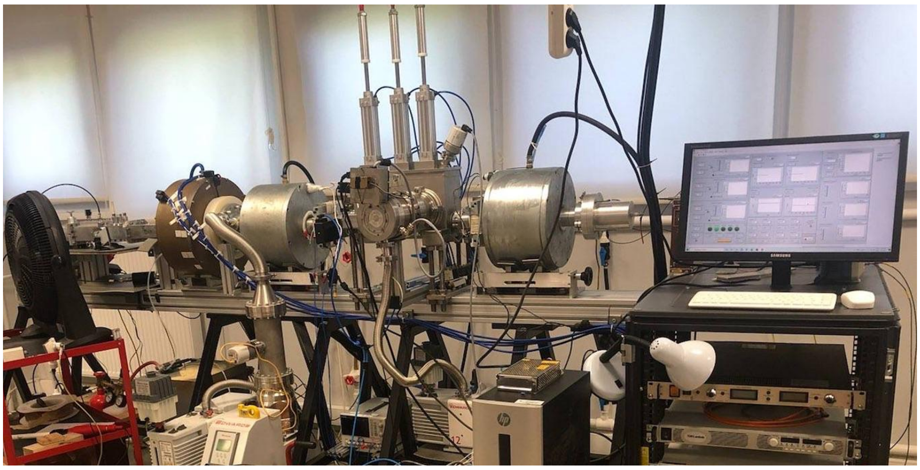
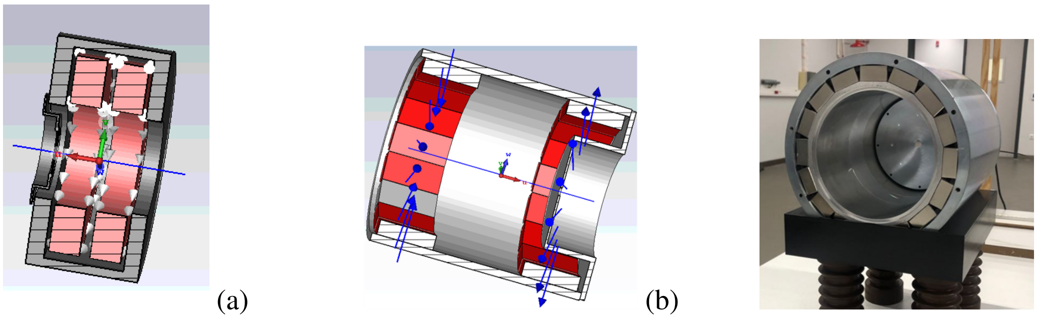


Figure 1: Overall setup for ion source unit, LEBT line and MBOX.

2. 20 keV Microwave Discharge Ion Source

MDIS is the first part of this linear accelerator, proton beams that will be transferred to RFQ through LEBT line, initially extracted from a thermal hydrogen plasma generated using a 2.45 GHz microwave source. Electron Cyclotron Resonance (ECR) condition should be satisfied above the plasma chamber which requires minimum 875 *Gauss* magnetic field for a 2.45 GHz source frequency to achieve optimal condition for plasma density, therefore ideal plasma medium for extraction is met.

To achieve the required magnetic field profile, we have designed and produced two separate magnet & electrode pair systems: an electromagnetic system and a recently produced one with permanent magnets. The current ion source setup with electromagnets consists of 2 solenoids, 525 turns each, it is placed around the plasma chamber and solenoids are cooled by water. In this system, electromagnets require extra current supply and a cooling system that means extra cost, also they are placed around the plasma chamber which may occasionally cause sparks. Our main motivation behind constructing a new Permanent Magnet Microwave Discharge Ion Source (PM-MDIS) is achieving more stable and cost efficient setup. When the electromagnets are replaced with the permanent magnets, higher system stability will be achieved. The new PM-MDIS setup consists 32 neodymium magnets of N40 type placed around plasma chamber.



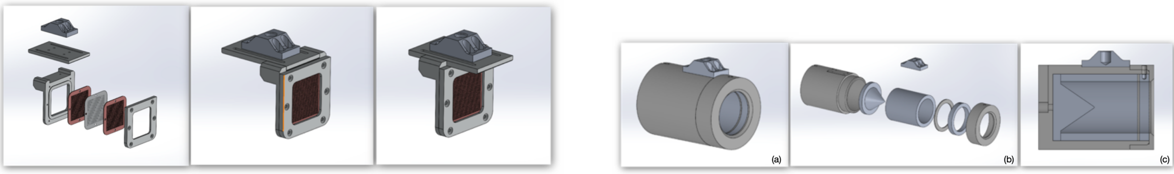
(a) (b) (c)

Figure 2: (a) Electromagnet design of the current setup, (b) and (c) Permanent ring magnet design

3. Low Energy Beam Transport (LEBT) Line and the Beam Diagnostics Box

A Low Energy Beam Transfer (LEBT) line was designed to transfer the proton beams from the extraction point of the ion source to the Radio Frequency Quadrupole (RFQ) in a most efficient way. It has 1.53m length and has been designed with Travel and DemirciPRO [5] softwares. LEBT line includes a beam diagnostics box between the solenoids and steerer electromagnets. The electromagnets are used for focusing, defocusing and steering the beam. Also, the changes in beams' phase space due to the effect of the space charges are calculated by using our own python script "pyDEDA".

The designs for diagnostics apparatuses can be seen in the Figure 3, these mechanisms inside the box are controlled from outside with three pneumatic cylinders. Currently, the incoming beam, including its profile, is monitored using the scintillator screen and the beam current is measured from produced faraday cup. After the production of pepper pot is completed, the beam emittance will be measured through this apparatus.



(a) (b)

Figure 3: (a) Pepper Pot detector design and (b) Faraday cup design inside the MBOX.

4. Future Directions

The circulator for the Ion Source PSU's transmission line is under construction, and it will be integrated to the system after its tests are completed. Also, the magnetic field and HV tests of the Permanent Magnet Ion Source & Beam Extraction unit are completed. It will replace the current electromagnet system in the near future.

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