DIAGNOSTIC STATION OF PROTON BEAM AT KAHVELAB (PTAK)

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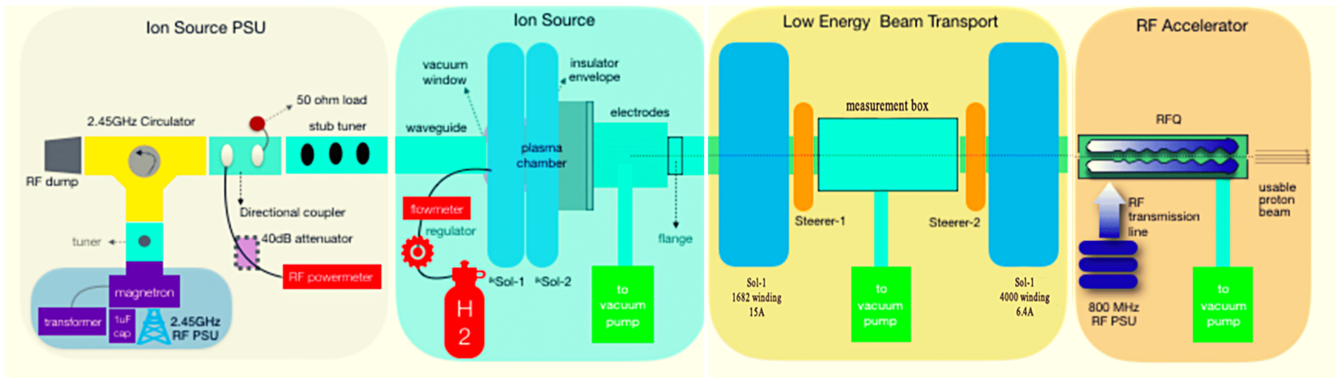

A testbeam using a Radio Frequency Quadrupole (RFQ) operating at 800 MHz, to accelerate a 1.5mA proton beam to 2MeV energy has been designed, manufactured and is currently being commissioned atKAHVELab, Istanbul. The beam from the microwave discharge ion source (IS) must be matched to the RFQ via an optimized Low Energy Beam Transport (LEBT) line which also contains an integratedmeasurement station, called MBOX. The MBOX is designed to measure the beam current and profile, as well as the beam emittance, to ensure an accurate match between IS and RFQ. It includes a number ofdiagnostic tools: a Faraday Cup, a scintillator screen, and a pepper pot plate (PPP). During the commissioning, beam images were taken at different points on the beamline. Other measurements were alsotaken with different screen materials and different plates in the MBOX box. The analysis software was also developed and tested for the PP photo analysis. This contribution will present the proton beamlinecomponents, MBOX diagnostic tools and will focus on the measurements, especially on the PPP emittance analysis.
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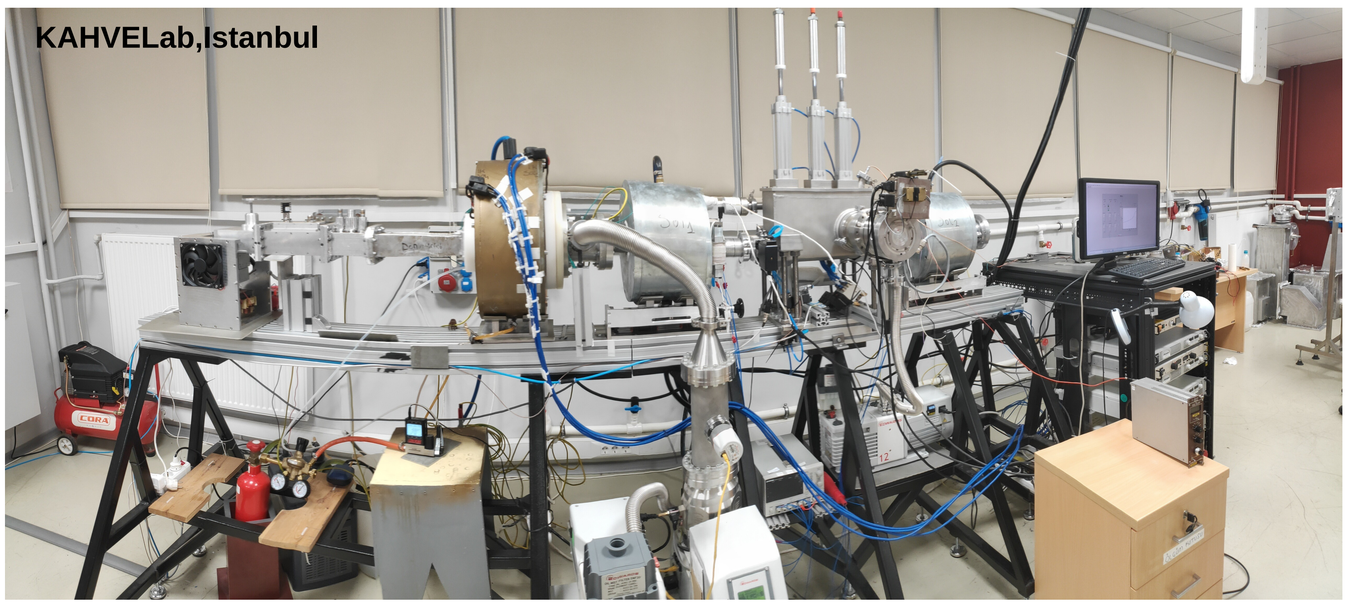


PROTON SOURCE BEAM LINE AT KAHVELAB

ION SOURCE

The ion source consists of 3 parts which are transmission line to transfer 2.45 GHz microwaves from magnetron to plasma chamber, plasma chamber where ions produced and extraction system which transfers ions from plasma chamber to beam line.

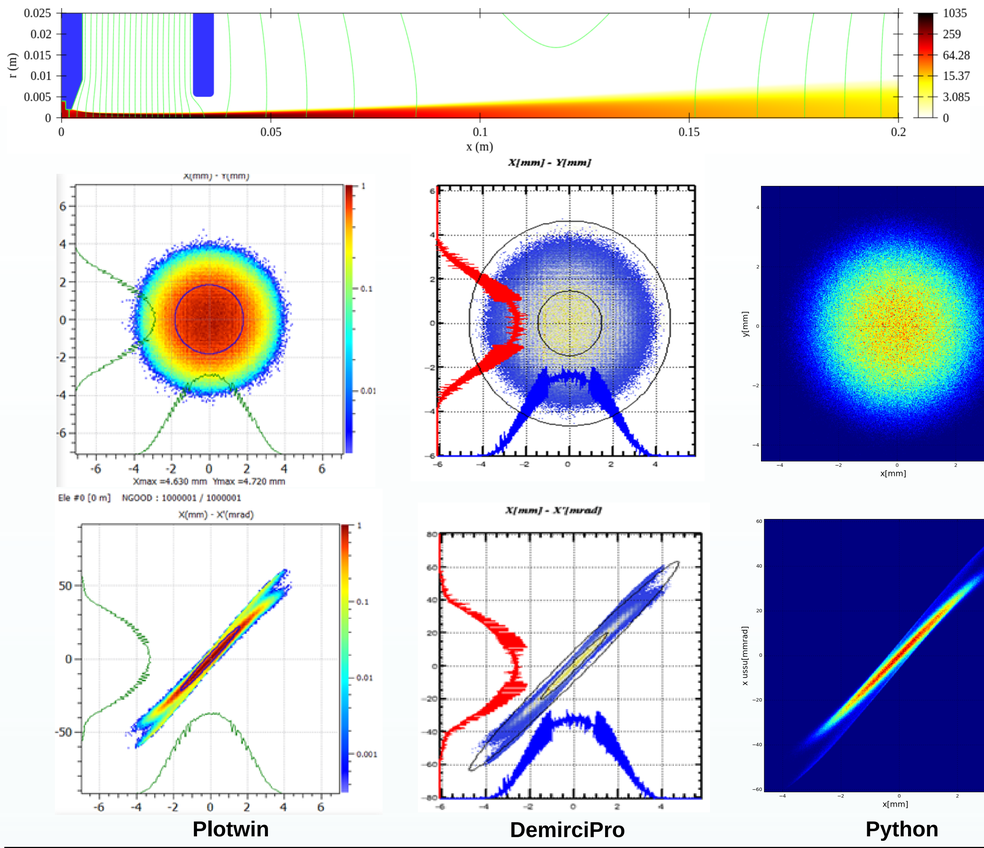
LOW ENERGY BEAM TRANSPORT

In the LEBT line, there are two water-cooled solenoid magnets with the same physical dimensions and designs, different number of turns, two identical steerer magnets and a measurement box. The sensors in the measurement box are designed to be moved by means of pneumatic motors. The whole line is to be located on the vacuum pipe. It is kept under vacuum by one mechanical and one turbo molecular pump system.

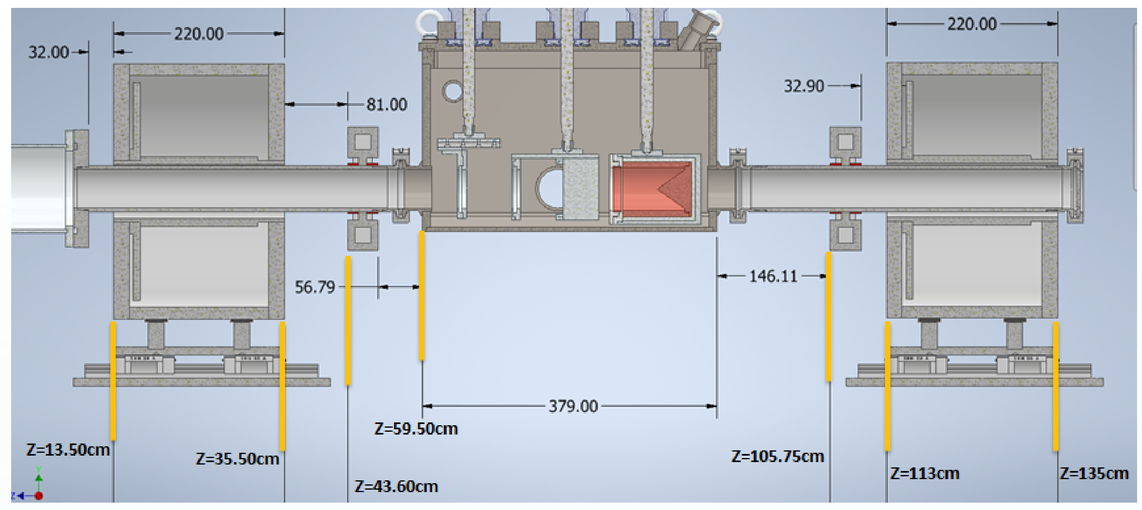
MEASURMENT BOX

It is the structure used for beam dynamics placed between LEBT magnets. Performs three measurements:

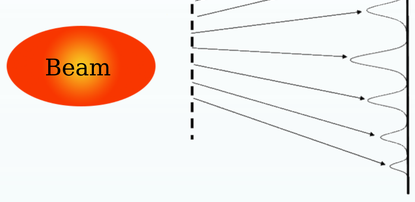
- beam emittance (Pepper Pot Mask)
- beam profile (Scintillator Screen)
- current (Faraday Cup)



Simulation of ions extracted from plasma using a two-electrode system (with IBSIMU)



	Plotwin	DemirciPro	Python	Unit
ε-norm	0.0299	0.0297	0.0298	πmm.mrad
α	-6.416	-6.416	-6.41	---
β	0.472	0.472	0.472	mm/π.mrad



Emittance Measurement by Pepperpot

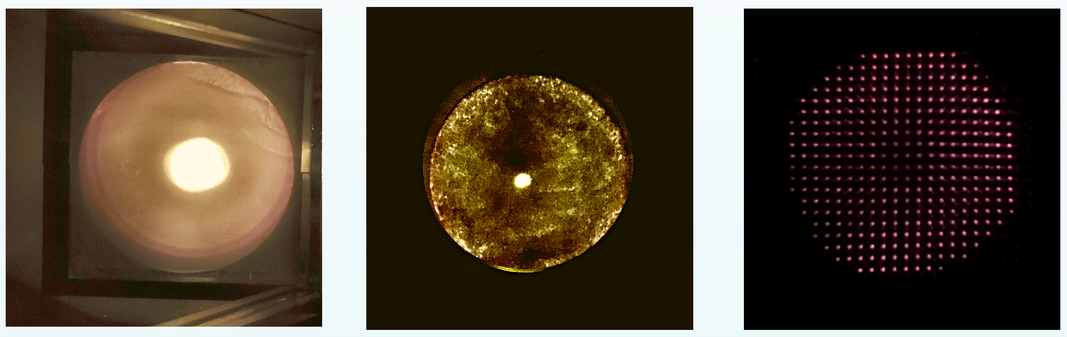
The scanning of the whole beam size in both planes needs quite a lot of time with very stable beam conditions. To overcome the scanning procedure a plate with thin holes in defined distances (pepperpot) produces a lot of beamlets in the x, y plane.

Advantages of pepper pot method

- Single shot measurement
- Less prone to space charge effect
- Can obtain x and y emittance at one measurement

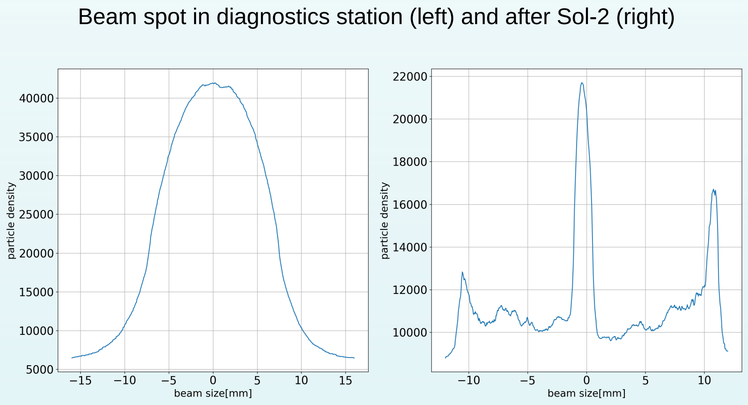
PROFILE & EMITTANCE MEASUREMENT

Captured image of the beam on the phosphor screen



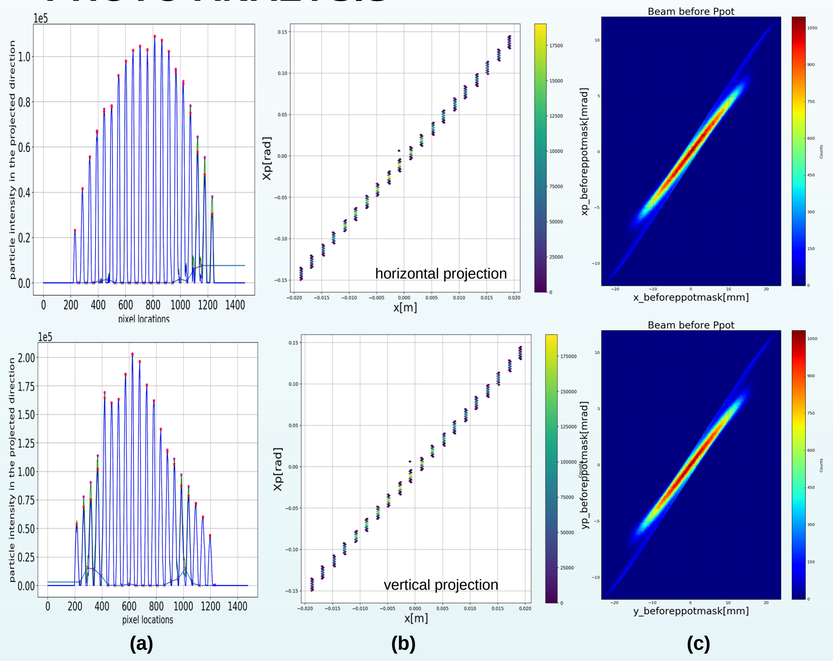
Beam spot in diagnostics station (left) and after Sol-2 (right)

PP plate: 5x5cm, 250 μm stainless steel, pinholes φ=100 μm.



	Sim.	Measured
ε-norm [πmm.mrad]	0.031	0.029
α	-4.5	-18.9
β [mm/π.mrad]	1.33	2.13
beam size(mbox) [mm]	14.8	15
beam size after s2 [mm]	1.9	2

PHOTO ANALYSIS



(a,b)

The photograph taken after mbox was analyzed to find the beam emittance and Twiss parameters representing the beam.

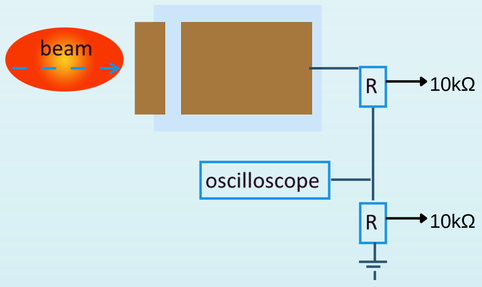
The analysis software was developed locally in Python.

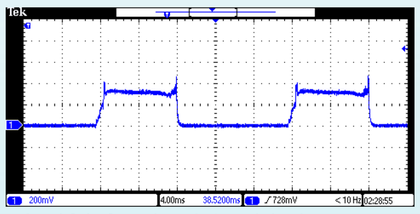
(c)

Graphs were obtained with known simulated x-x' and y-y' values.

	Photo Analysis (x)	Photo Analysis (y)	Simulation (x)	Simulation (y)	Unit
ε-norm	0.029	0.033	0.029	0.030	πmm.mrad
α	-18.9	-13.54	-6.38	-6.37	---
β	2.13	1.83	1.34	1.33	mm/π.mrad

CHARGE MEASUREMENT





FC signals: d.f. is found as 0.4 and the beam current as 0.03 mA

- Bias = 0V
- Current = 0.03mA
- Duty Factor = 0.4
- Average Current = 0.012mA

RESULTS AND OUTLOOK

- Simulation and experimental studies were performed for the 20 keV proton beam.
- Beam profile and charge measurements taken on the LEBT line and their simulations are consistent with each other.
- The Pepper Pot emittance simulation was compared with DemirciPro and the results were found to be consistent.
- It was seen that the measurement could be taken with the hand-made phosphor screen. Measurements can be compared by taking different screens.
- LEBT line measurements showed that the beam could match the RFQ with the specified configurations.
- RFQ is being manufactured for beam tests in 2023.

References;
[1] Yildiz, H., et al., "Compact measurement station for low energy", JINST 12 T02006, 2017., [2] Adiguzel, A., et al., "Ion source and LEBT of KAHVELab proton beamline", arXiv 2208.00529, 2022., [3] Adiguzel, A., et al., "Low-energy Proton Beam Diagnostics: An Integrated Solution", In preparation, 2022.
[4] T. Kalvas, et. al., IBSIMU: A three-dimensional simulation software for charged particle optics, Rev. Sci. Instrum. 81, 02B703, 2010., [5] Cakir, O., Celebi, E., Cetinkaya, H., Kolenoglu, H., Turemen, G., et al., "DemirciPro's tools for completingthe Linac: Ion source and LEBT line", arXiv:2103.11829[physics.acc-ph].
[6] Ilhan, T.B. et al., "Control Systems of DC Accelerators at KAHVELab", IBIC2022., [7] D. Uriot. Plotwin v4.0 User Manual, CEA Saclay, 2017.