2.45 GHz microwave ion source operation for 170 kW SRF linac long term commissioning

Liu Yuguo[1,2], **Liu Jianli[1]**, Wu Qi[1,2], Sun Liangting[1,2,✉]

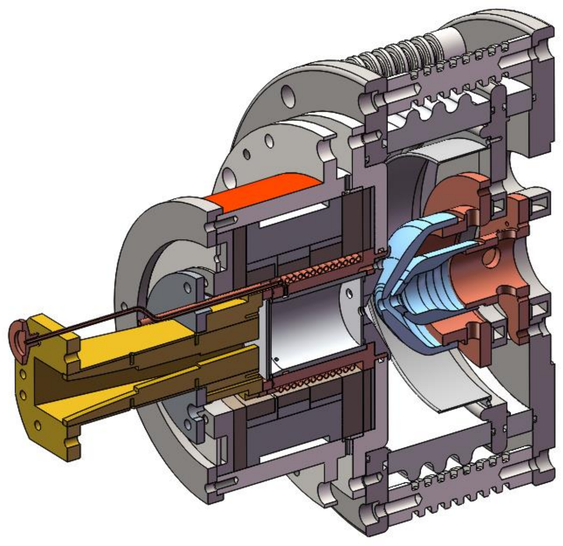
1.Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China
2. School of Nuclear Science and Technology, University of Chinese Academy of Sciences, Beijing 100049, China
✉ sunlt@impcas.ac.cn

Continuous wave (CW) ion beam power of 170 kW has been recently demonstrated with the Superconducting Radio Frequency (SRF) linac CAFe at IMP. A 2.45 GHz microwave ion source was used as the beam injector at the warm front end. For the stable operation at such a beam power, total extraction beam current of more than 25 mA was delivered at the beam energy of 20 keV. For the reliable long duration operation with low extraction energy and relatively strong space charge effect, the distance and position of each electrode were carefully optimized and collimated to avoid any beam trip due to the beam losses and high voltage discharge on the electrodes.

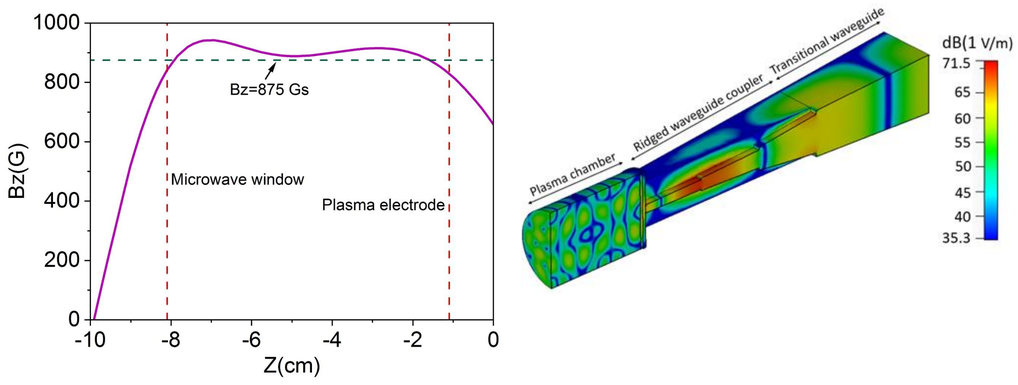
Parameters and design of ion source

Extraction voltage	20 kV
Extraction aperture	5.0 mm
Extraction beam current	20 mA H^+
Plasma chamber diameter	50 mm
Plasma chamber length	70 mm

Parameters of the ion source



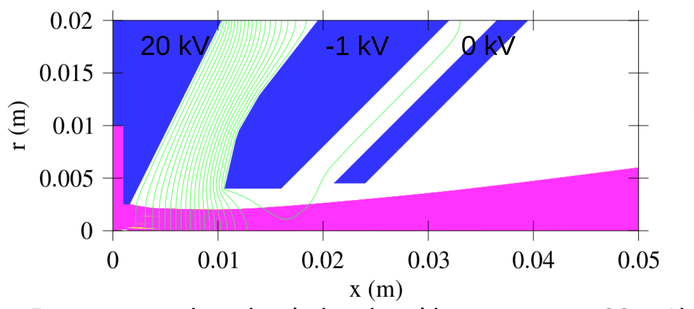
Structure drawings of the ion source



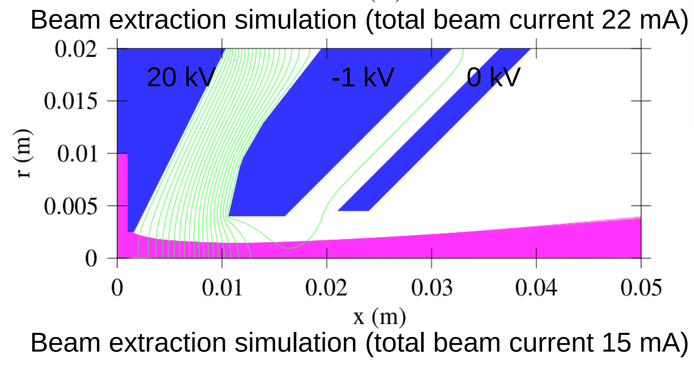
Simulated magnetic field and electric field distribution in plasma chamber

The needed magnetic field of ion source is generated by several NdFeB magnet rings, and a ridged waveguide is used as a RF power coupler between the WR284 waveguide and plasma chamber.

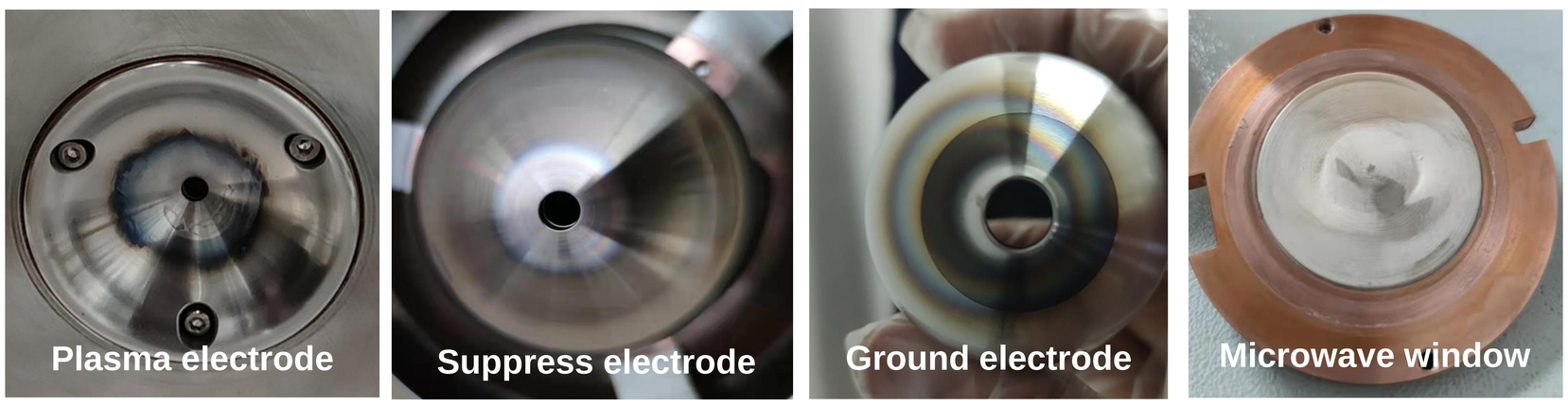
Beam extraction electrodes



Beam extraction simulation (total beam current 22 mA)



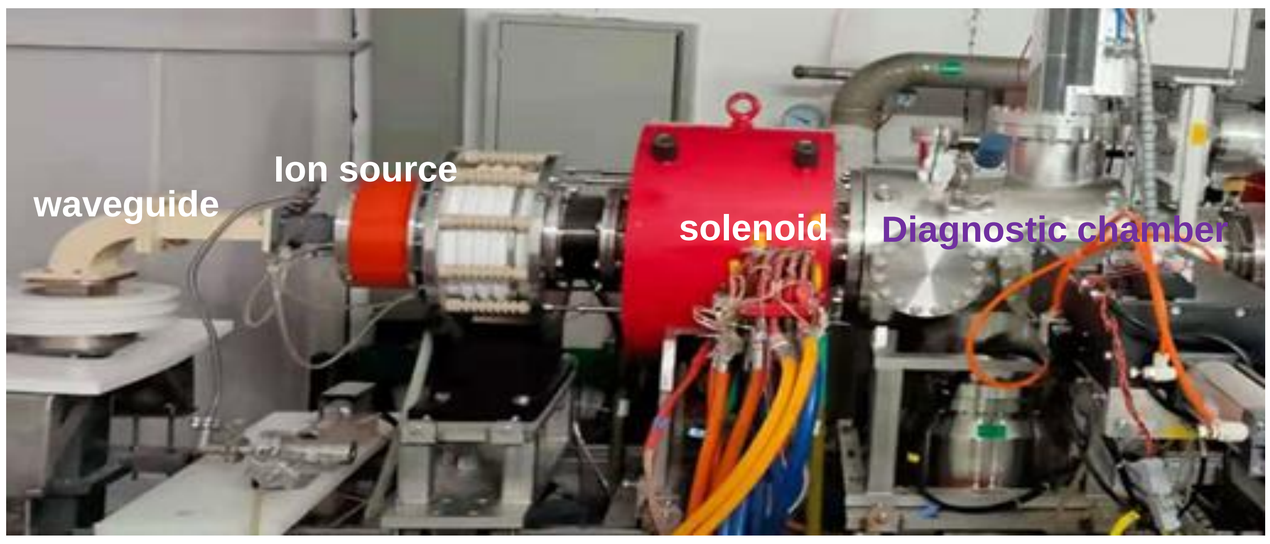
Beam extraction simulation (total beam current 15 mA)



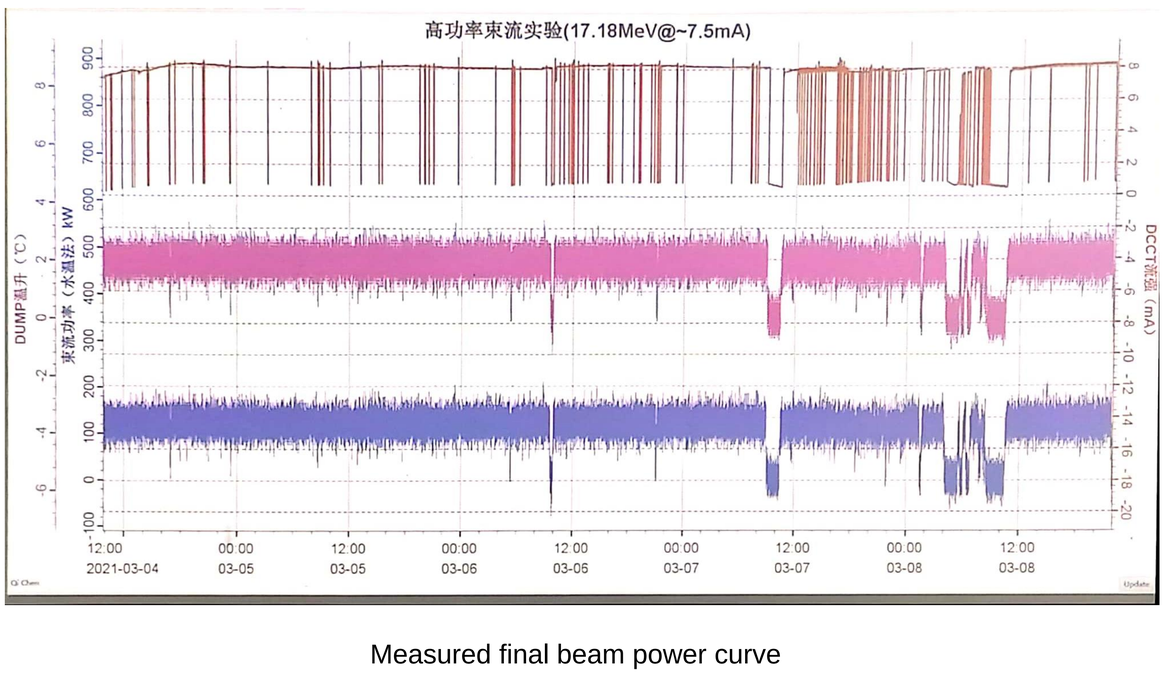
Picture of electrodes and microwave window after long term operation

The extraction beam divergence increasing rapidly due to the space charge effect, after a 72 hours continuous CW beam operation, the surfaces of all the three electrodes were seriously bombard by the ion beam and secondary electrons.

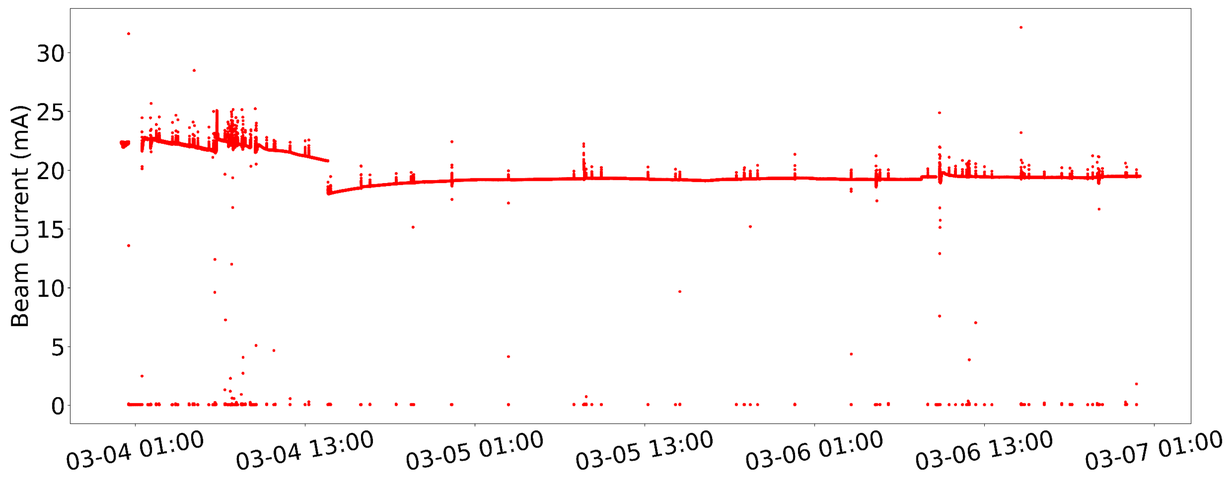
Long term operation of ion source



Picture of ion source and LEBT system



Measured final beam power curve



Extraction beam current during 72 hours operation

The extraction beam current of ion source was 20 mA and extraction voltage was limited to be 20 kV, the extraction beam divergence is pretty large and the risk of high voltage break down is increased, therefore the microwave power and gas pressure during the ion source operation were optimized to reduce the gas consumption, and the extraction electrodes also were carefully collimated, with those measures the ion source operated reliably during a 100 hours long term test and the maximum extraction beam current could reach 25 mA.

Institute of Modern Physics
Chinese Academy of Sciences