Development of 2.45 GHz ECR ion source test bench

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Outline of Presentation

- Introduction
- Status of facility
- Development of ECR ion source test bench
- Results
- Summary & Future plan

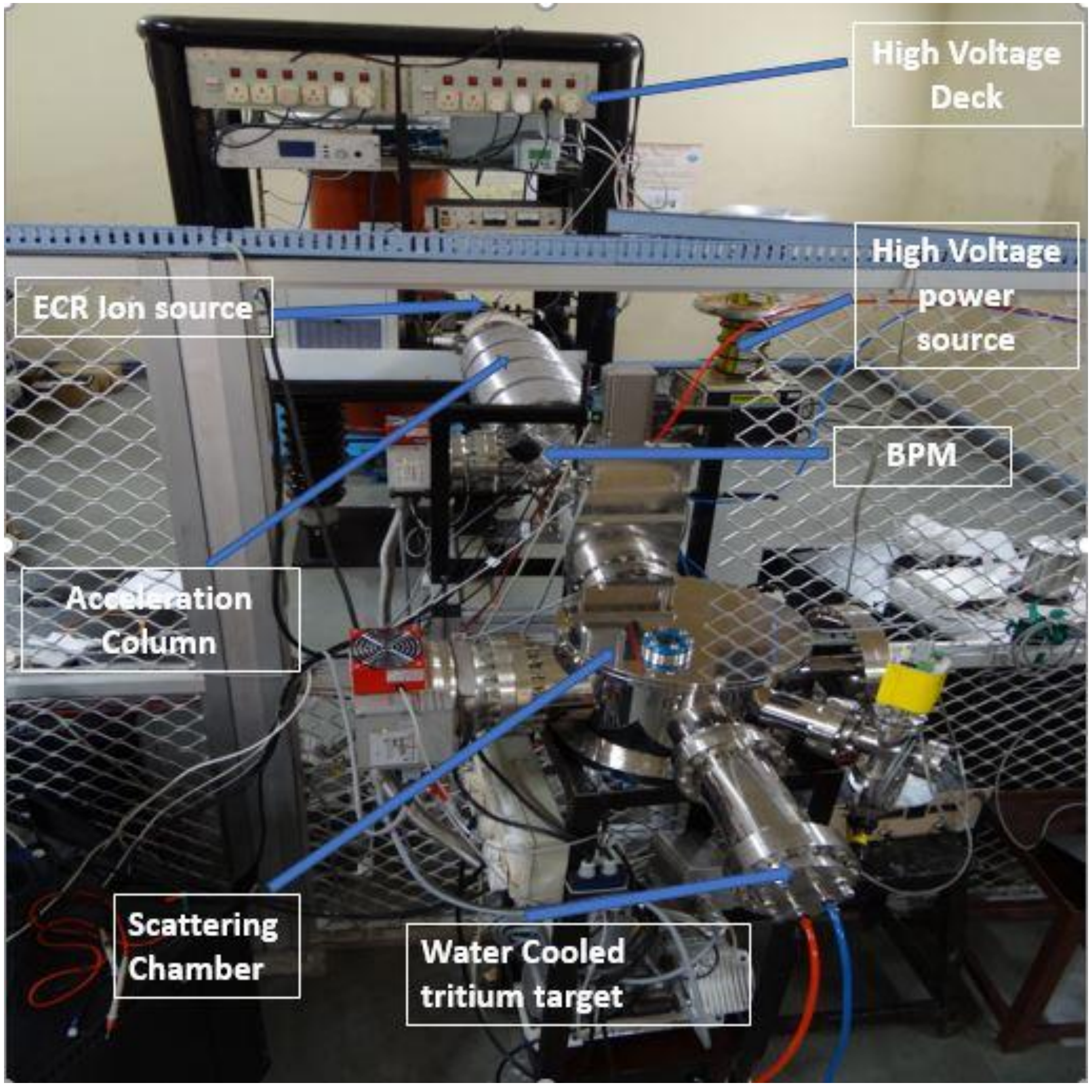
Ongoing project at IPR

1. Accelerator based 14-MeV Neutron generator (~10^{12} n/s)

$$D + T \rightarrow {}^{4}_{2}He + n + 17.6\,MeV$$

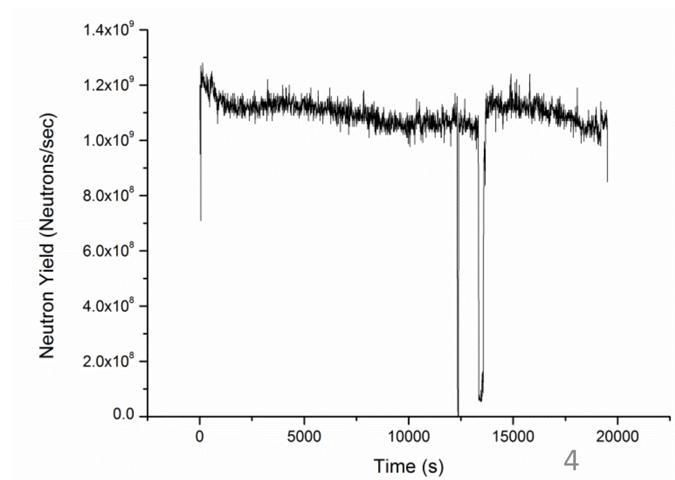
1. 5-MeV, 5 mA RFQ Accelerator for ion beam irradiation.

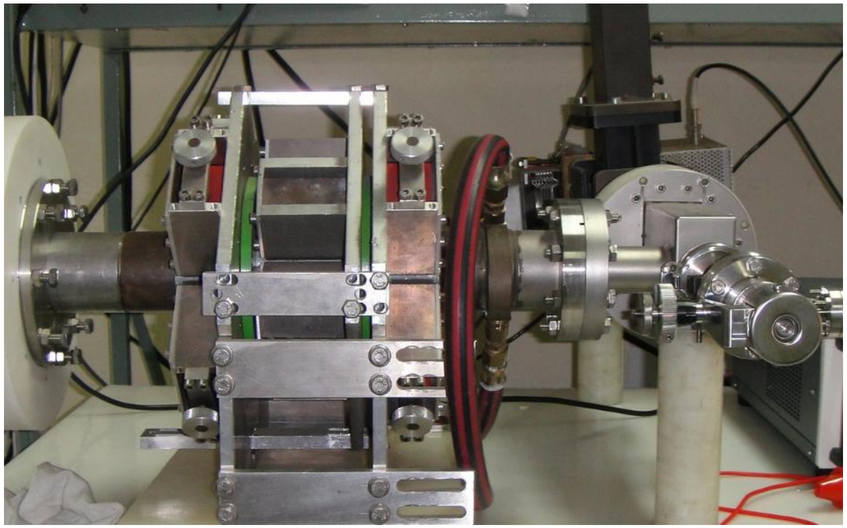
D-T Neutron generator

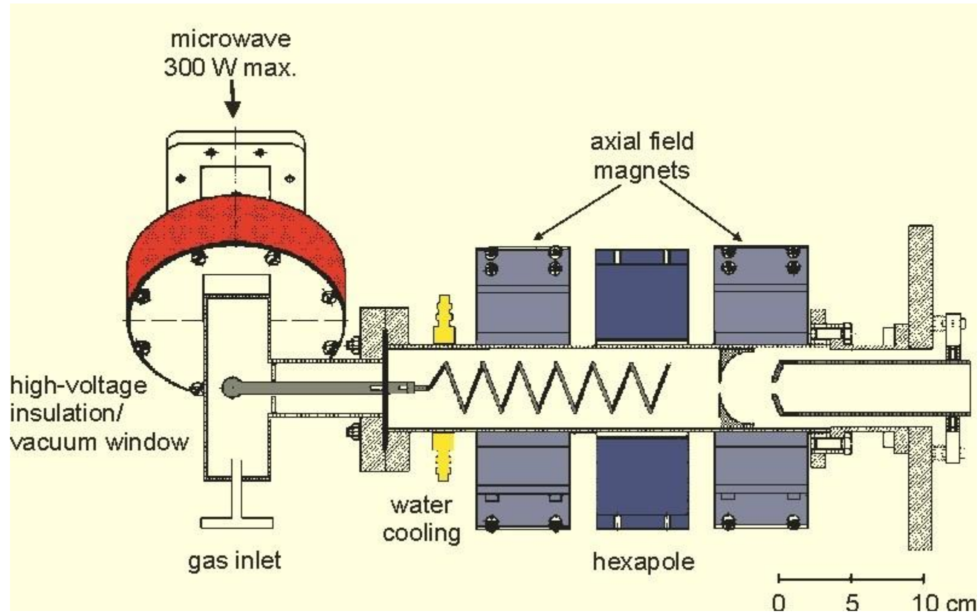


Main Parameters

- Beam Energy – 300 keV
- Beam Current – 0.3 mA
- Target: 10 Ci Ti-T
- Yield: ~ 10^{10} n/s







A LOW POWER LOW COST 2.45 GHZ ECRIS FOR THE PRODUCTION OF MULTIPLY CHARGED IONS

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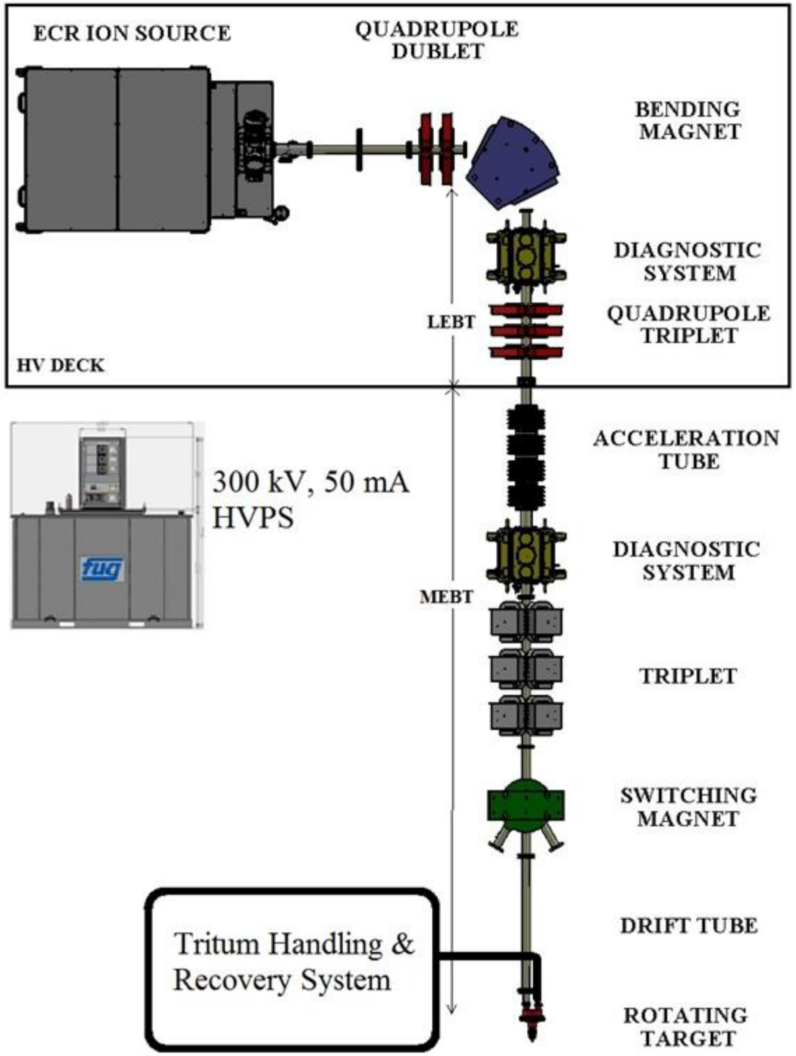
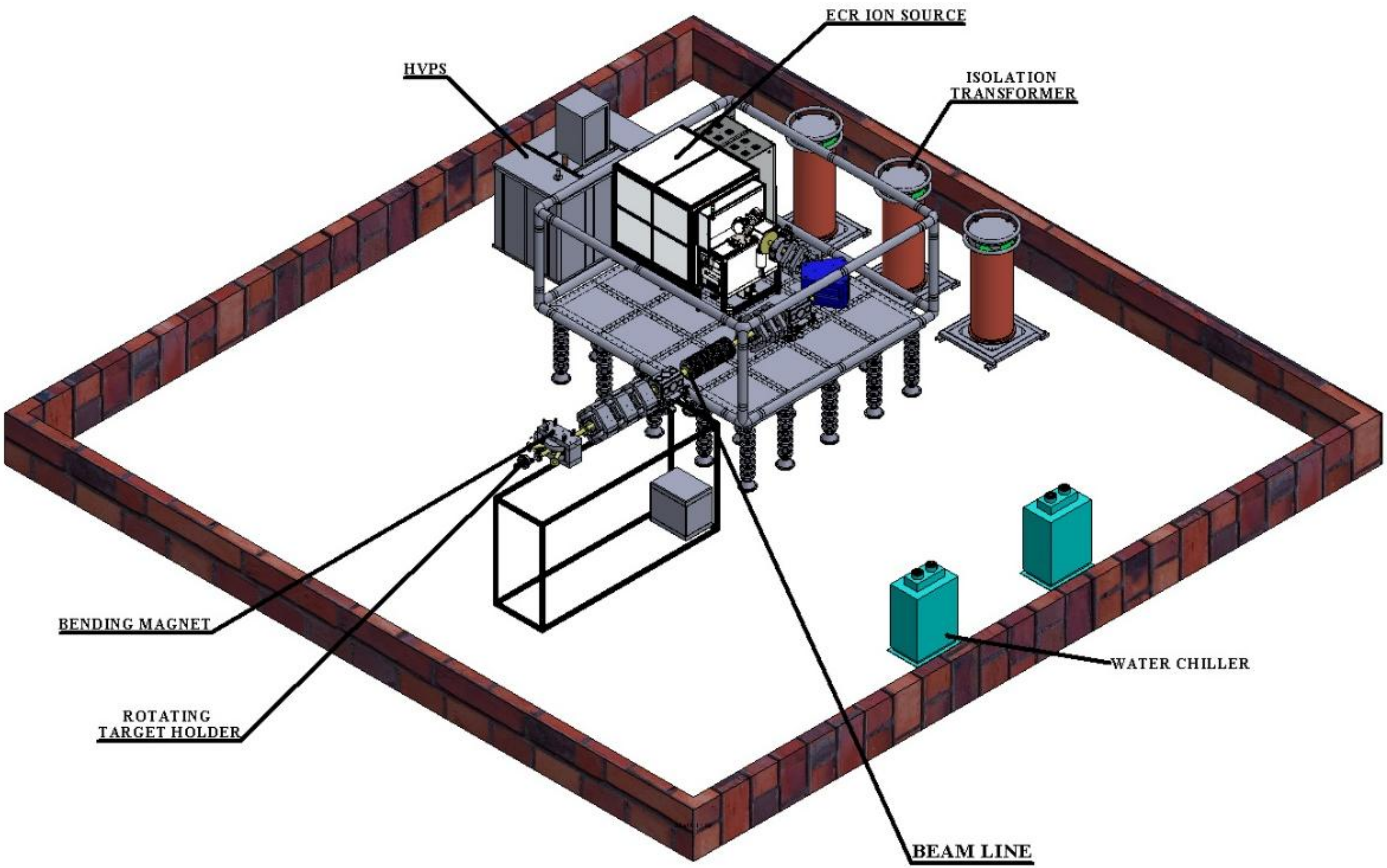
Accelerator based 14-MeV neutron generator



Design Parameter for Accelerator based Neutron Generator	
Type of Machine	DC Electrostatic Accelerator
Max Acceleration Voltage	300 kV (max)
Type of Ion Source	ECR ion source
D^+ Ion Current	20 mA
Tritium Target	140 Ci
Target Type	Rotating & Water Cooled
Estimated Neutron Yield	1-5 x 10^{12} n/s

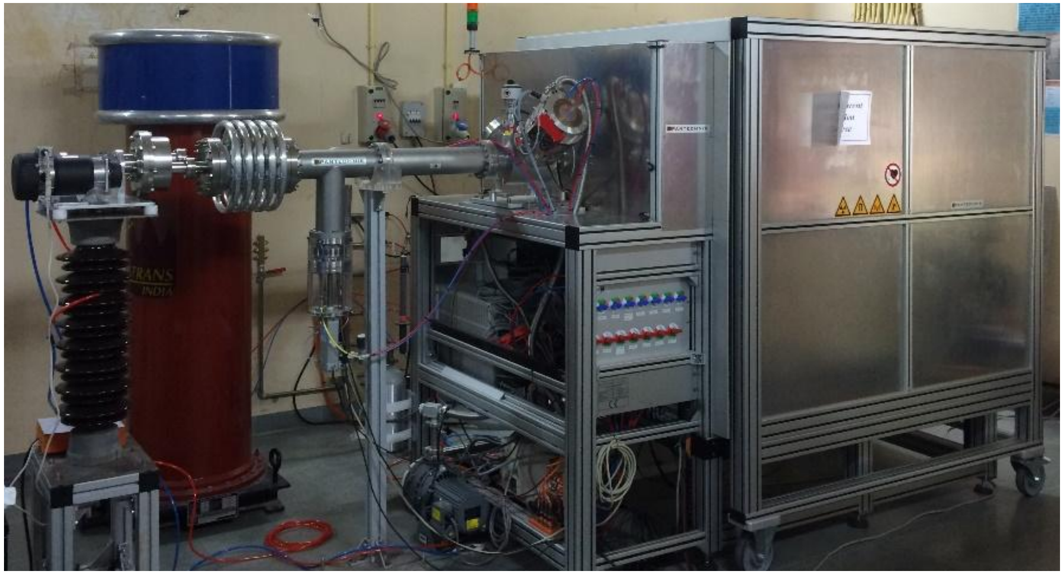
End use of the facility

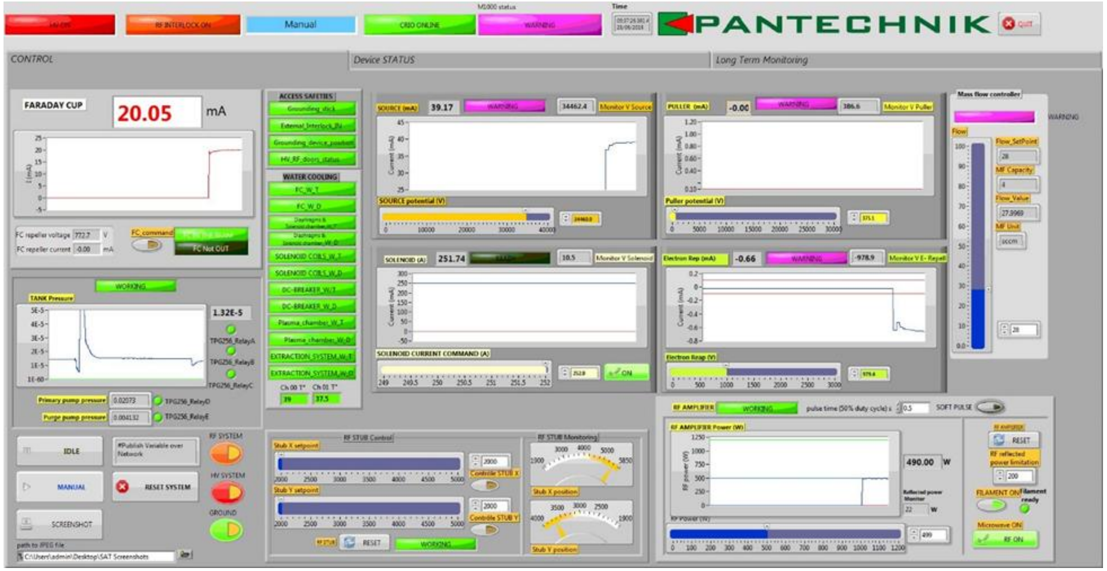
- Benchmark experiments in the field of fusion neutronics
- Validation of neutron transport and activation codes.
- Tritium production measurement
- For diagnostics testing and calibration
- Activation studies
- Cross-section measurement
- Deuterium ion beam irradiation
- Neutron radiography



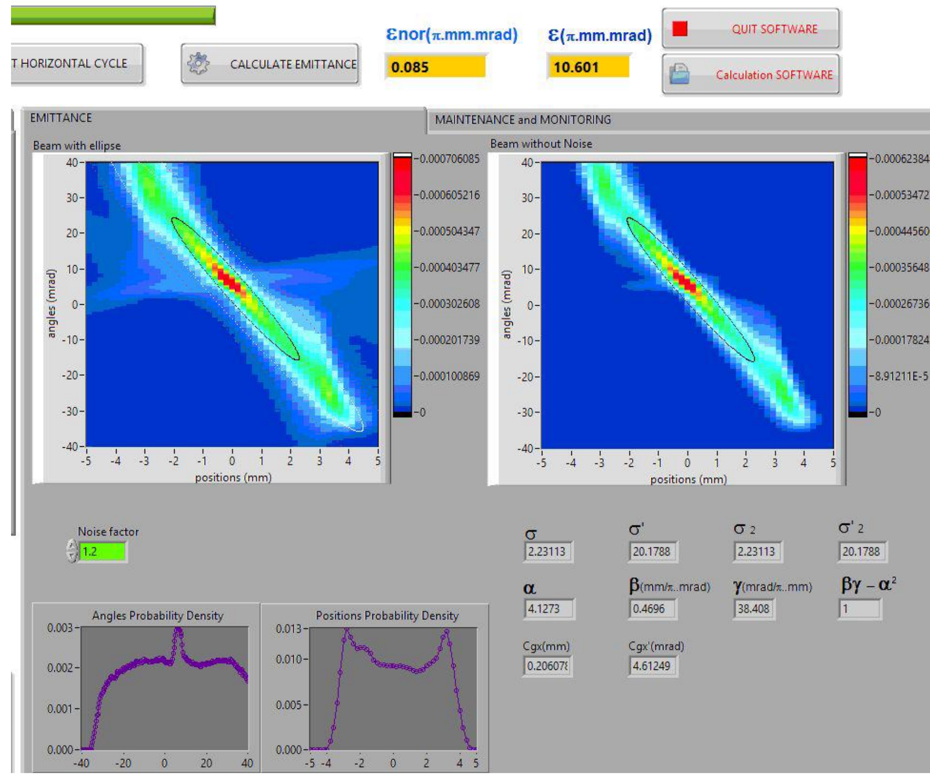
3-D View of Neutron Generator

2.45 GHz ECR ion source bench

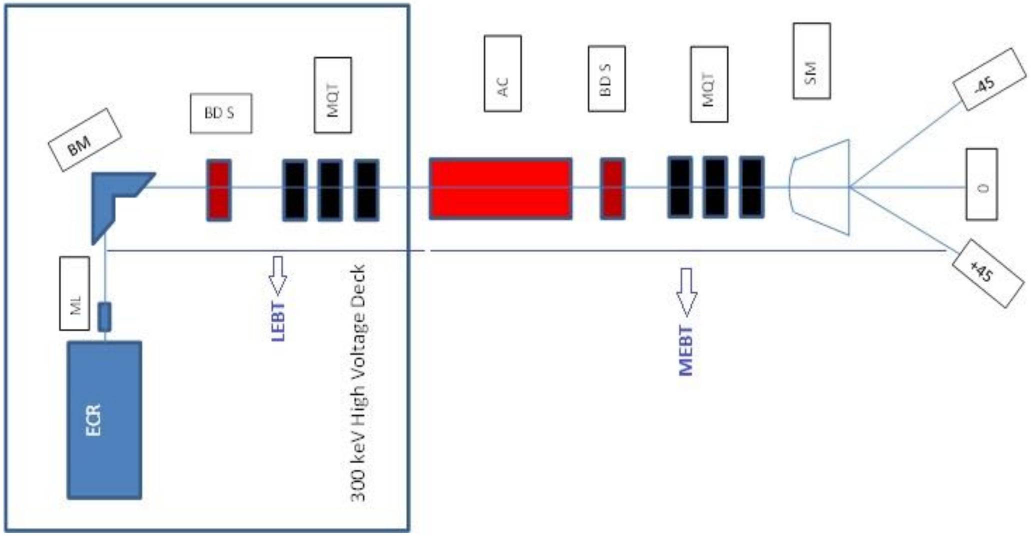




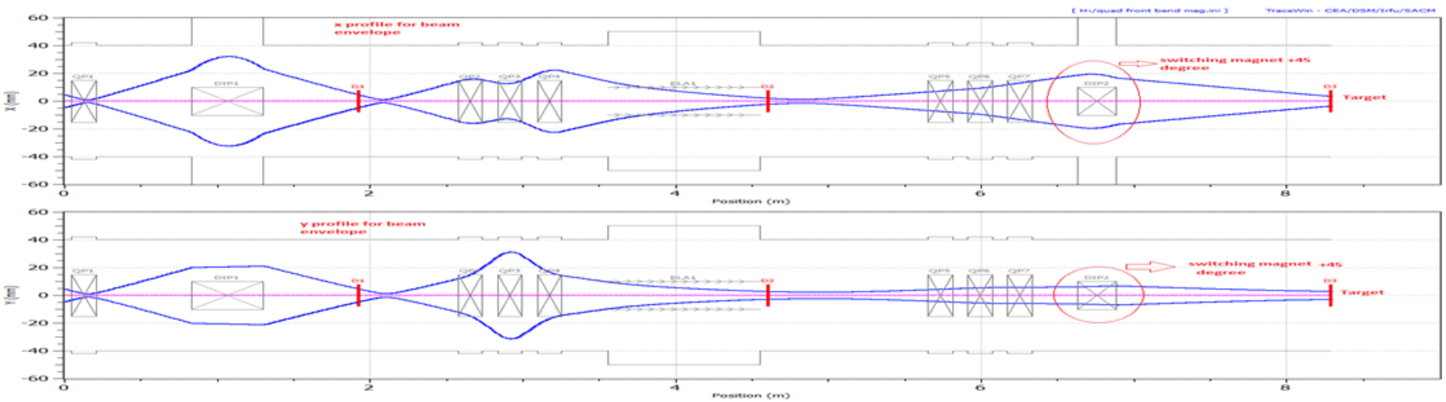
Allison Emittance Scanner



Beam Transport system for 14-MeV NG

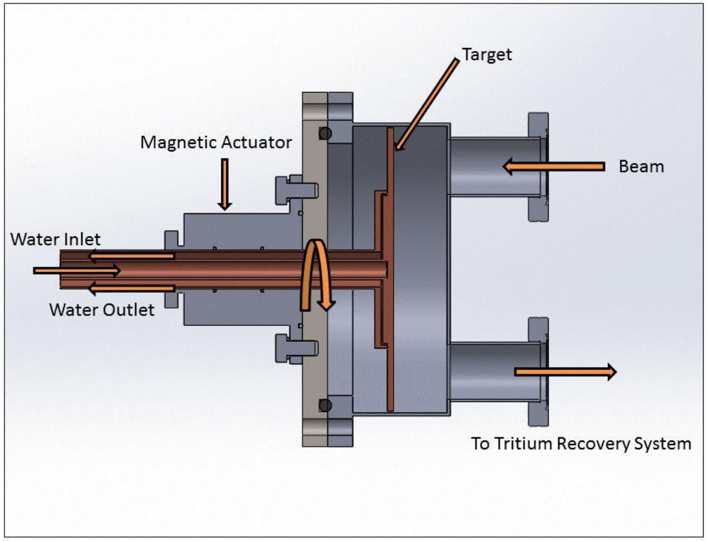


Proposed beam line system



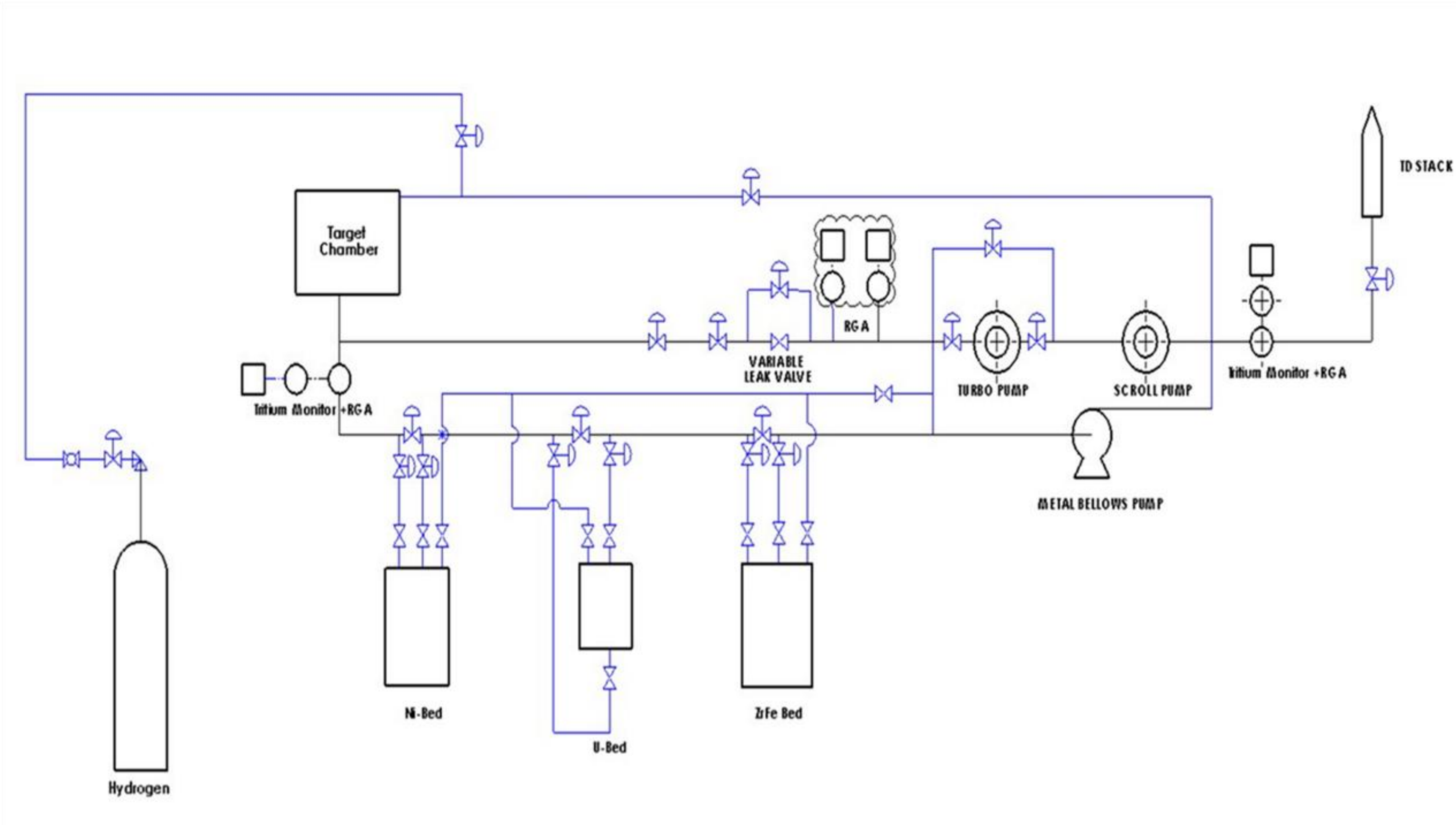
Beam envelope for 20 mA current throughout BTS using Trace Win

Rotating tritium target holder



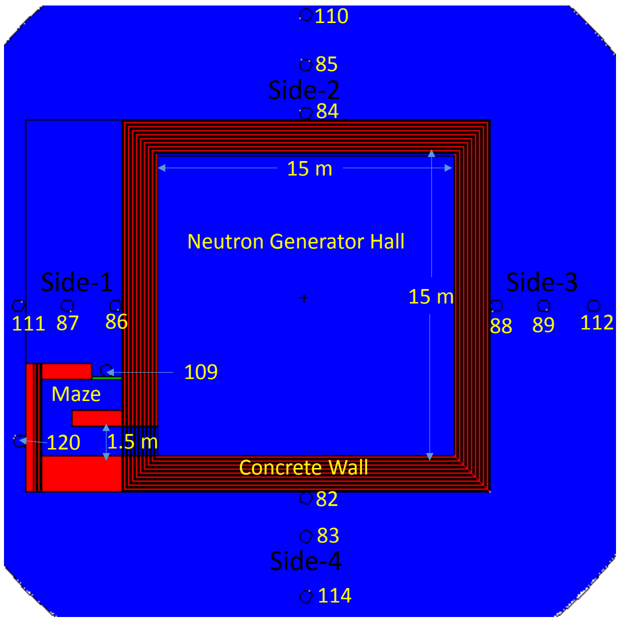
Rotating Tritium Target	
Rotation Speed	100 to 1000 rpm
Flow Rate	20 lpm
Inlet Temp	15-18 ^{o}C
Heat Load	9 kW

Tritium handling & Recovery System

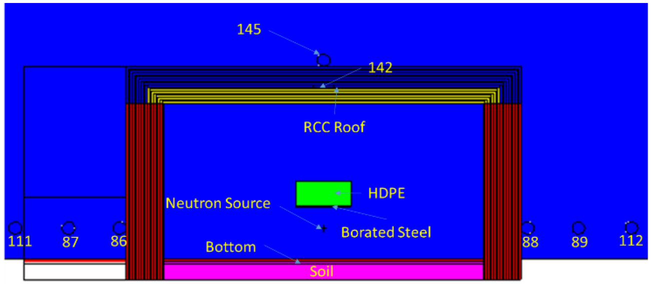


Shielding design of Neutronics Laboratory

MCNP model



Top View



Side View

Zone-1: Normally Accessible Area (Supervised Area)

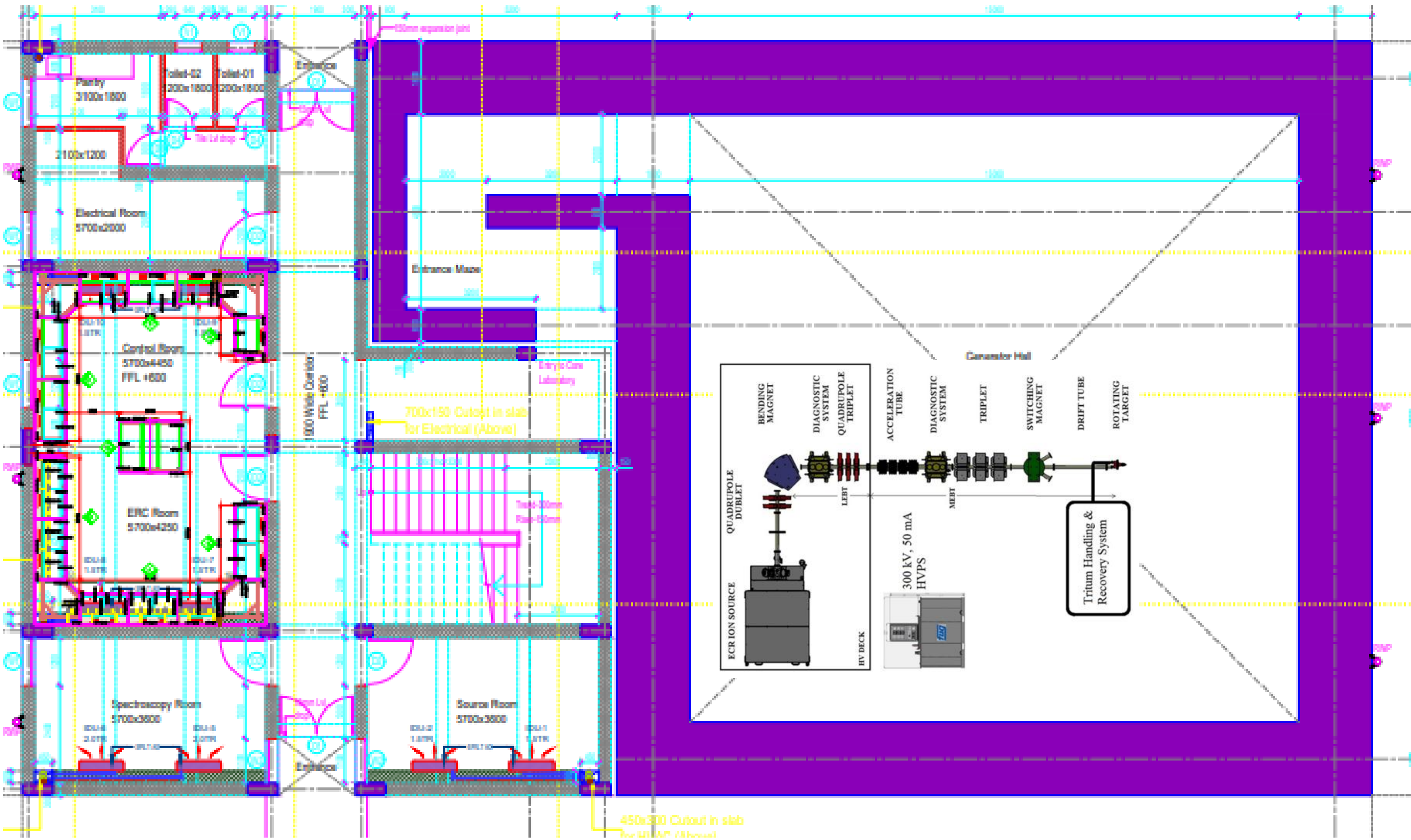
Dose < 1 µS/hr :

Zone-2: Restricted Area (Controlled Area)

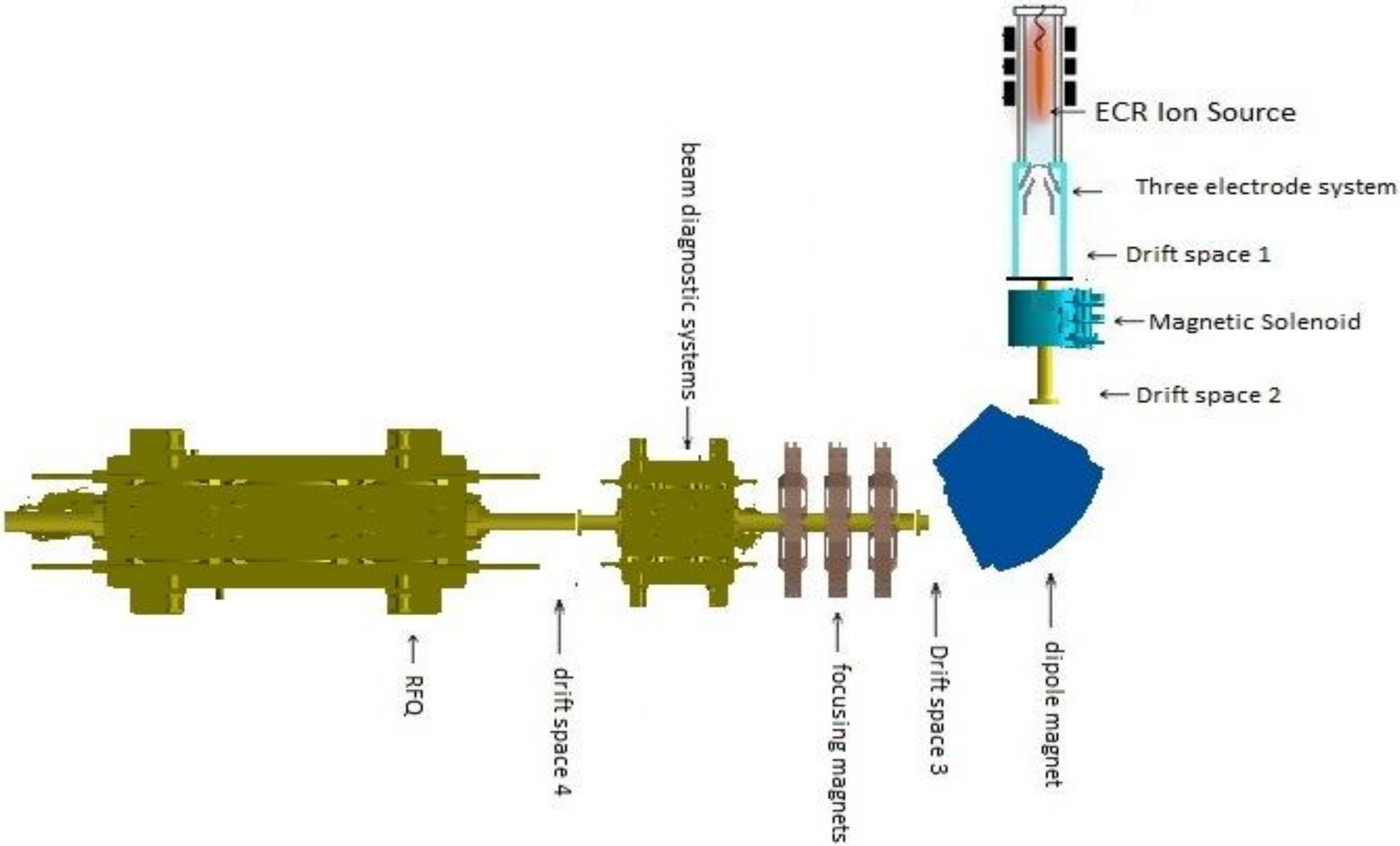
Dose < 10 µS/hr :.

Zone-3 Prohibited Area

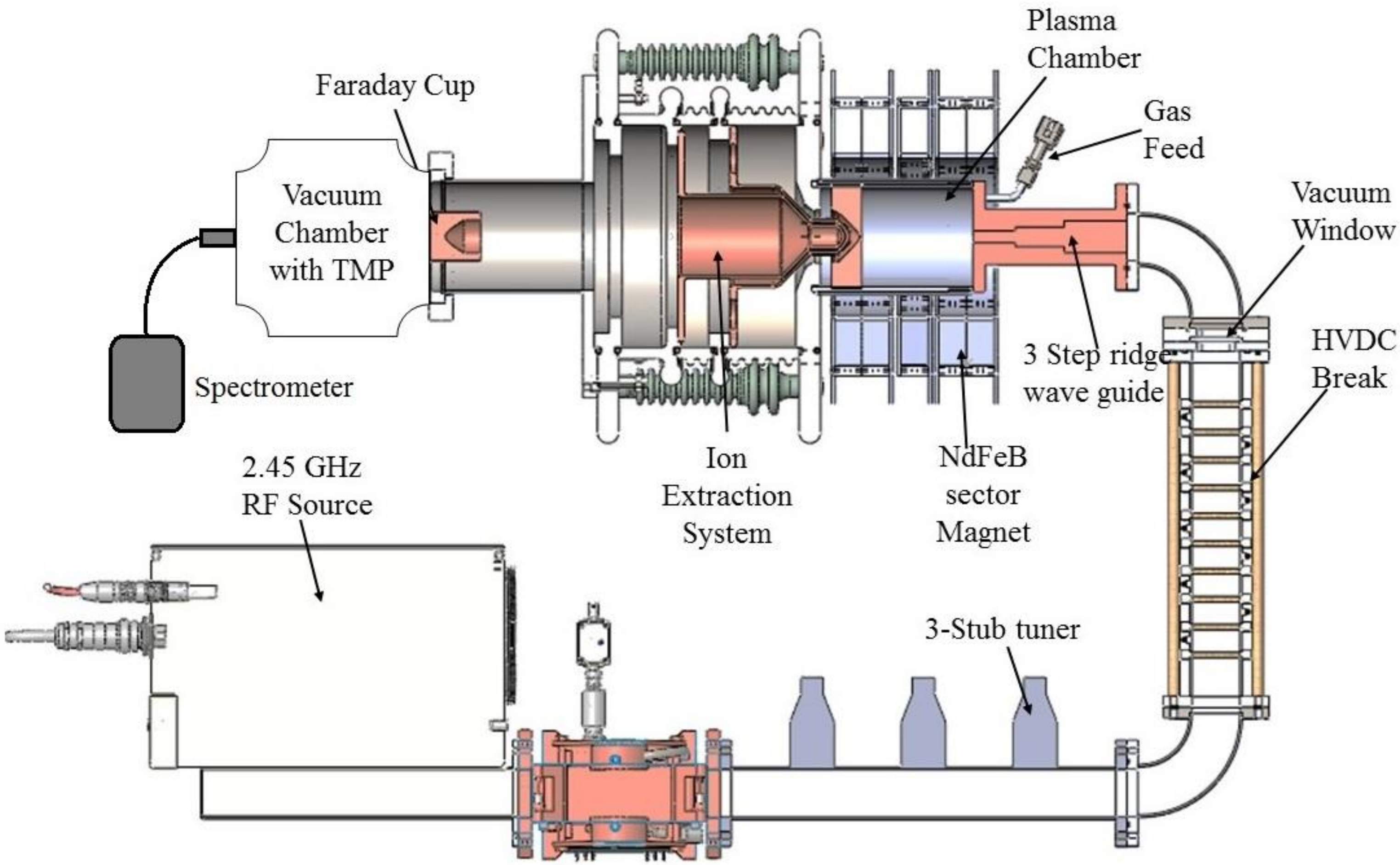
Dose Rate: > 10 µS/hr:


Pantry
3100x1800
Toilet-02
1200x1800
Toilet-01
1200x1800
Entrance
2100x1200
Electrical Room
5700x2000
Entrance Maze
Control Room
5700x4450
FFL +600
ERC Room
5700x4250
1800 Wide Corridor
FFL +600
700x150 Cutout in slab
for Electrical (Above)
Generator Hall
BENDING MAGNET
DIAGNOSTIC SYSTEM
QUADRUPOLE TRIPLET
ACCELERATION TUBE
DIAGNOSTIC SYSTEM
TRIPLET
SWITCHING MAGNET
DRIFT TUBE
ROTATING TARGET
QUADRUPOLE DUBLET
LEBT
MEBT
300 kV, 50 mA
HVPS
ECR ION SOURCE
HV DECK
Tritium Handling &
Recovery System
Spectroscopy Room
5700x3600
Source Room
5700x3600
Entrance
450x300 Cutout in slab

5-MeV, 5 mA RFQ accelerator for Ion beam irradiations

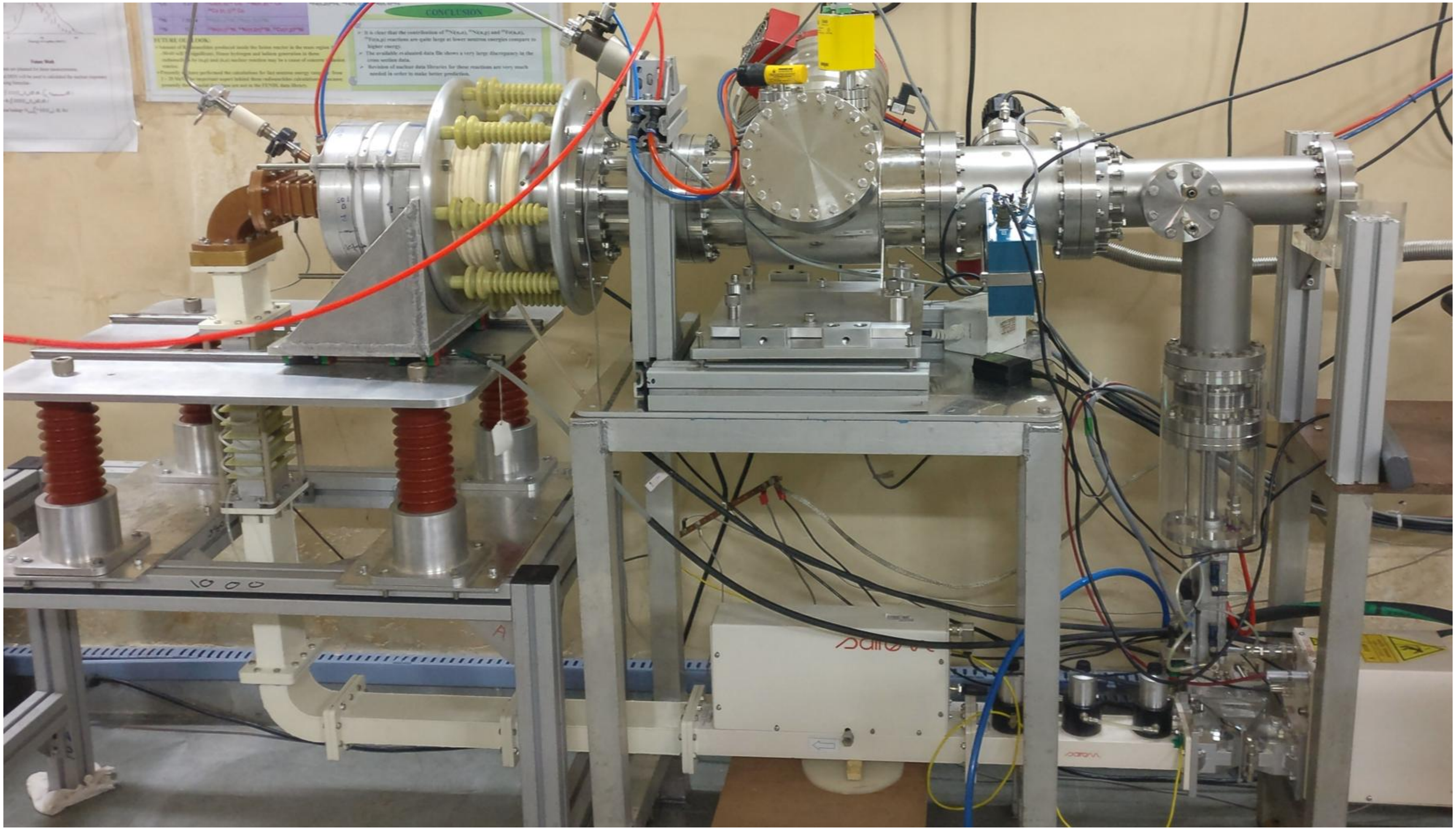


Schematic diagram of 2.45 GHz ECR ion Source



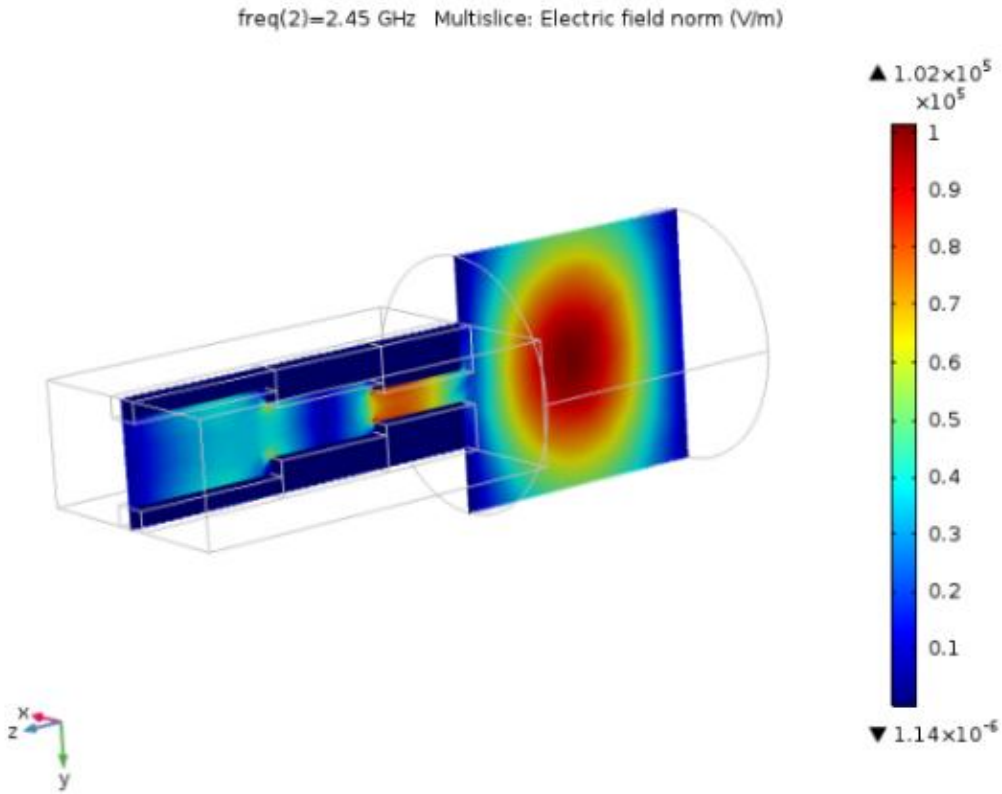
Typical layout of 2.45 GHz ECR ion source

IPR ECR ion source Test bench



IPR ECR Ion source test bench

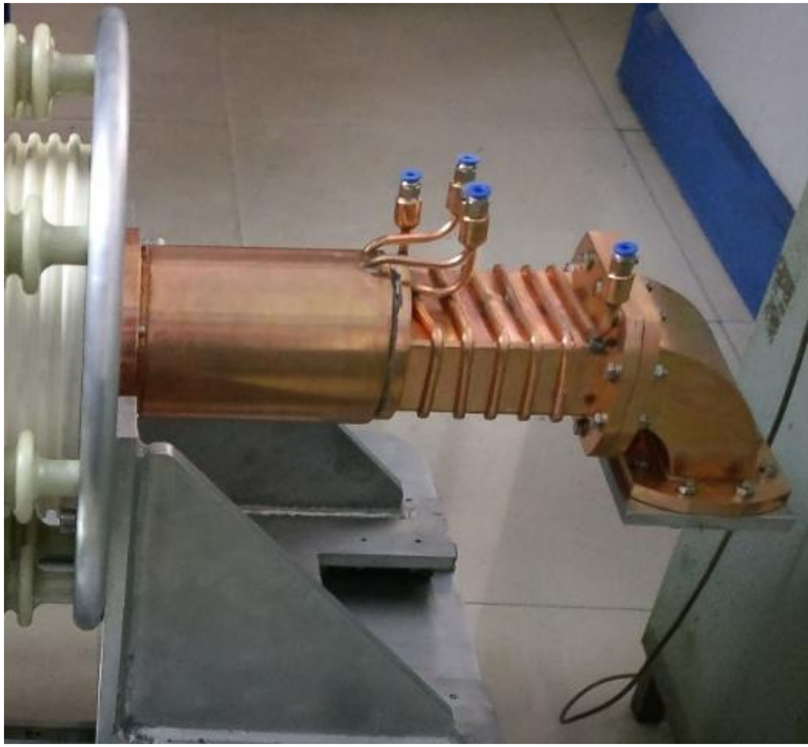
3-Step ridged wave guide



Optimized E-field

3-step ridge wave guide

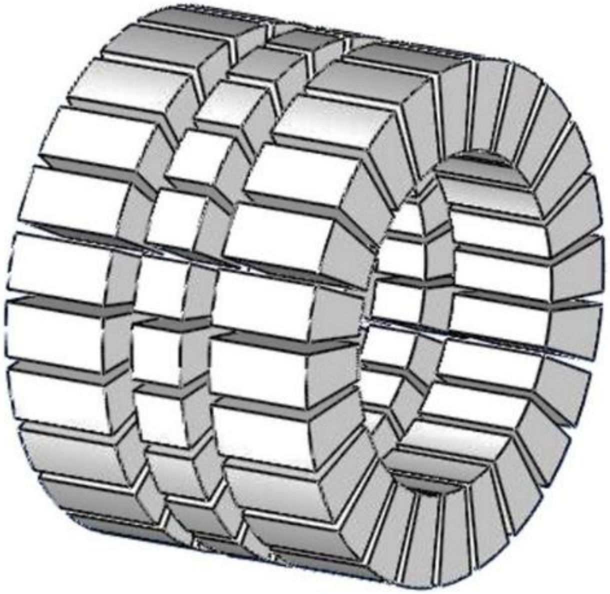
Plasma Chamber



Water cooled plasma chamber

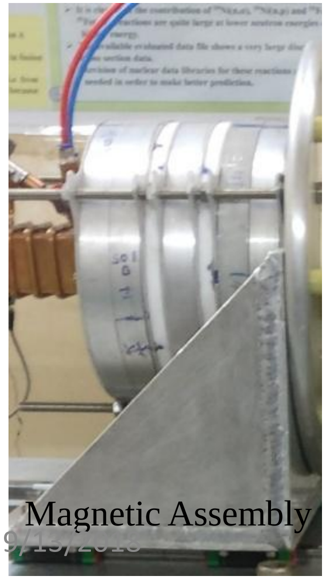
Magnet System

Aluminium Frame

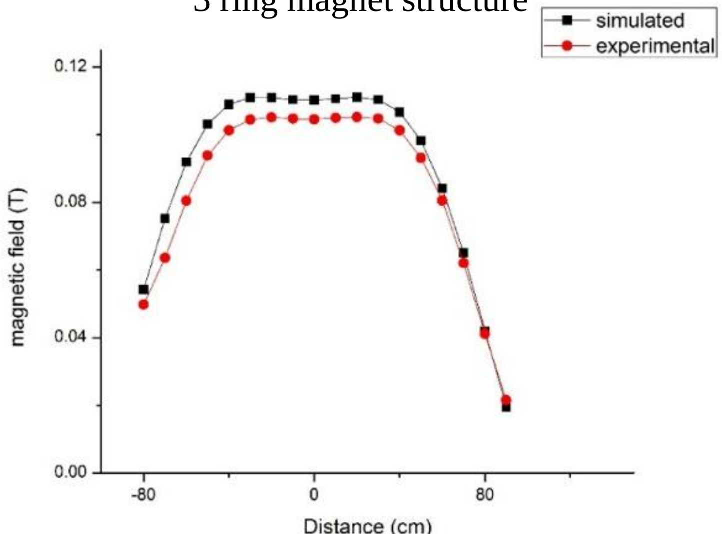


3 ring magnet structure

Photo of NdFeB magnet

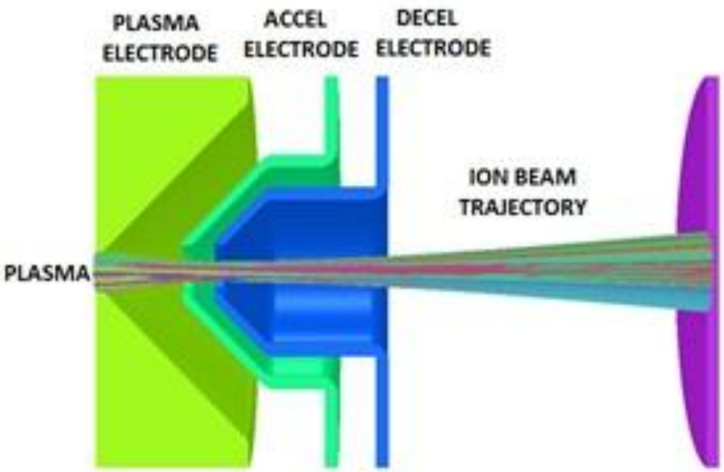


Magnetic Assembly

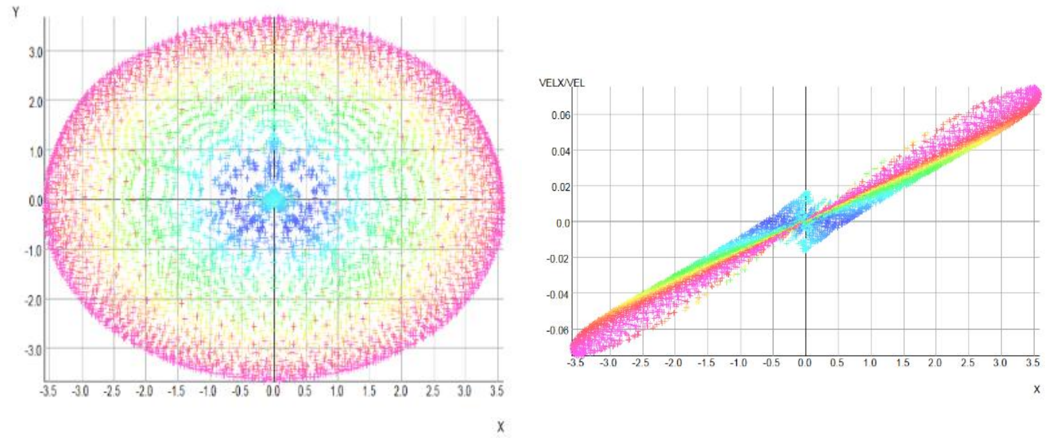


Magnetic field

Ion Extraction System



Tri-electrode extraction system



Ion beam trajectory

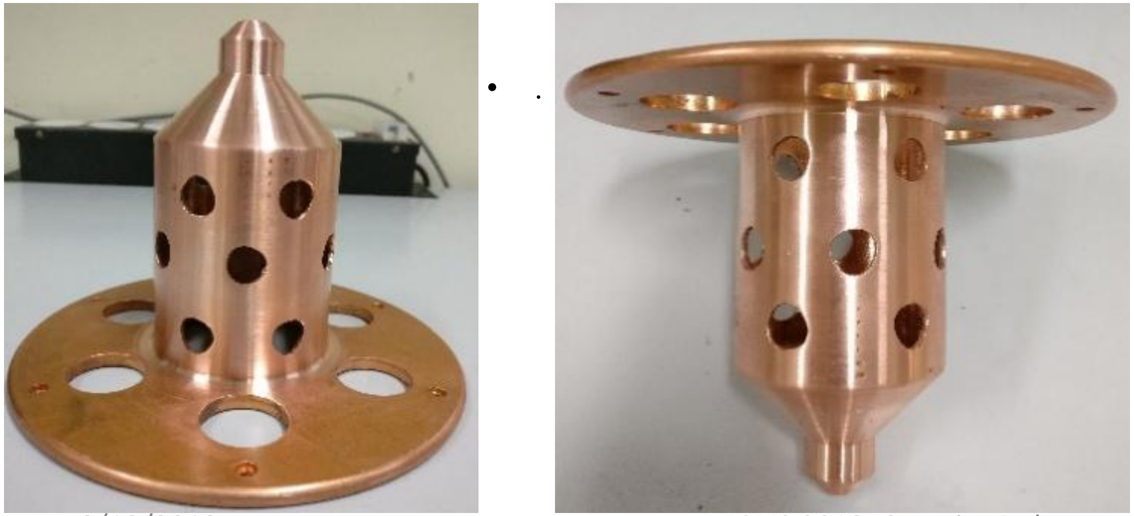
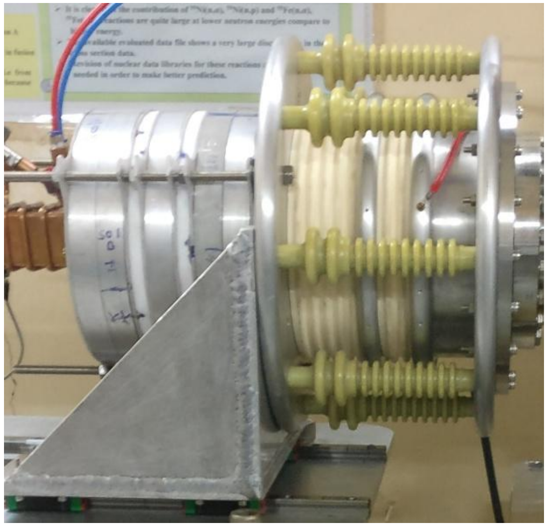
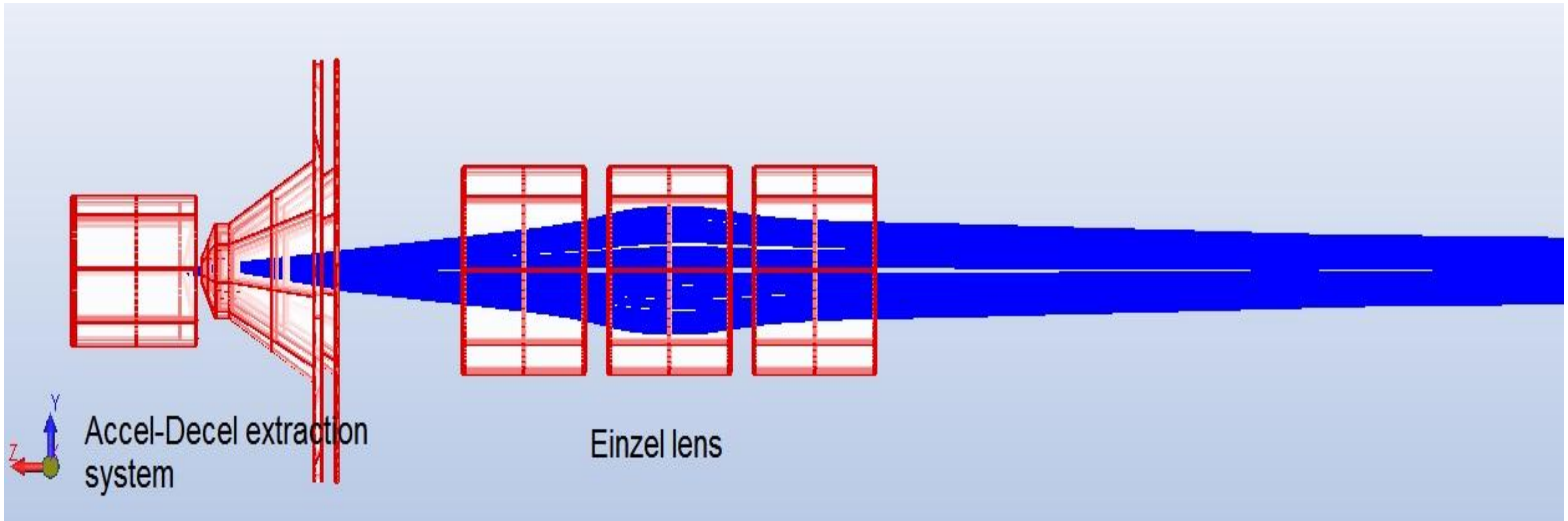


Photo of Electrodes

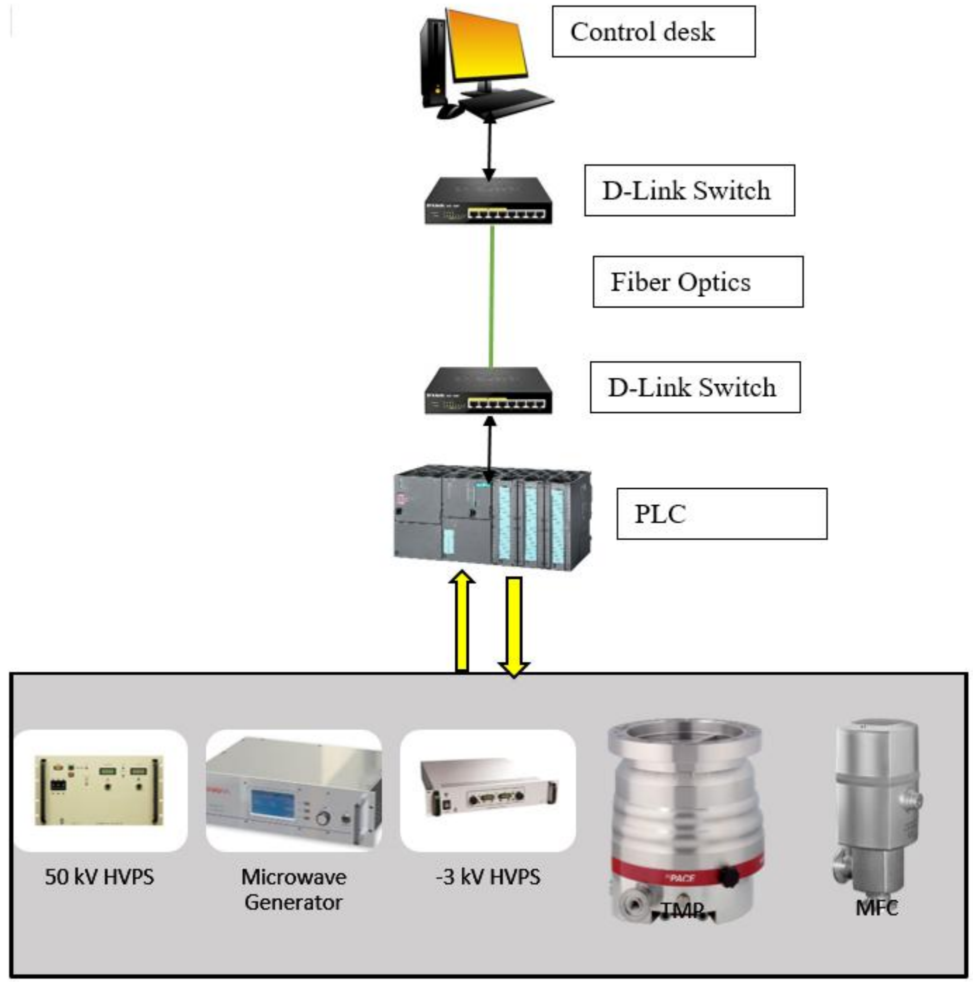


Ion Extraction Assembly

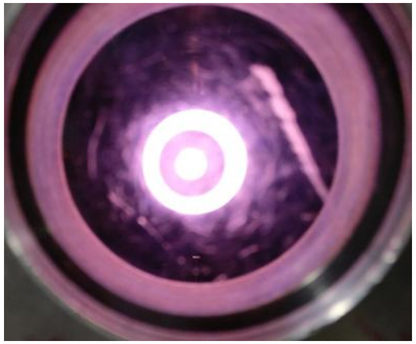
Einzel lens



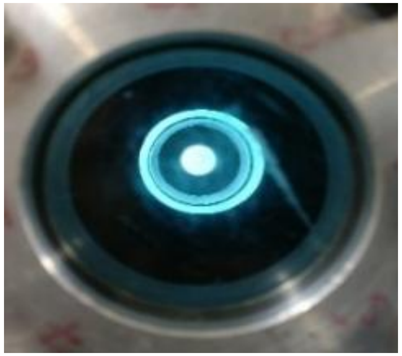
Control system of remote operation of ECR ion source



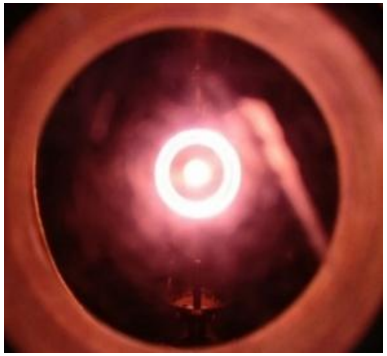
Plasma Characterization



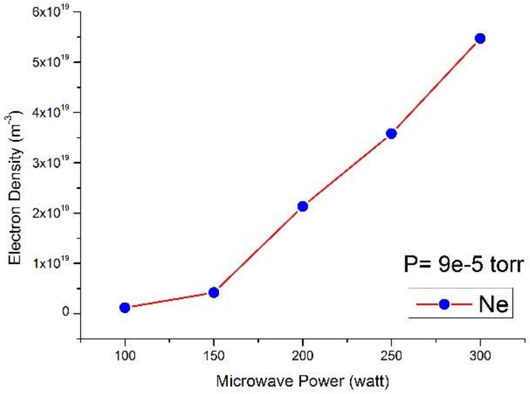
deuterium plasma

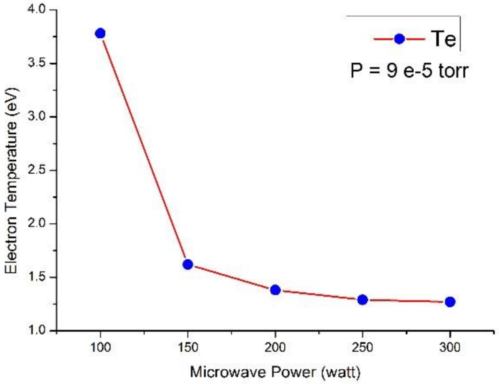


Helium plasma.

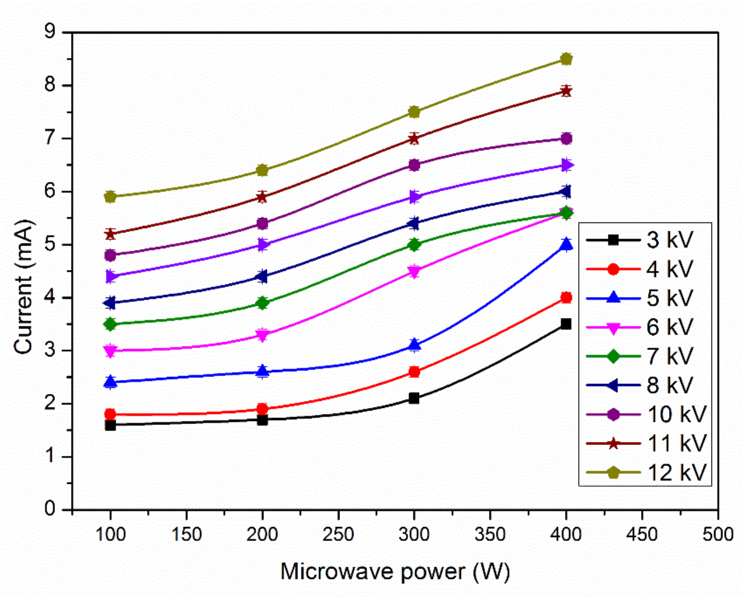


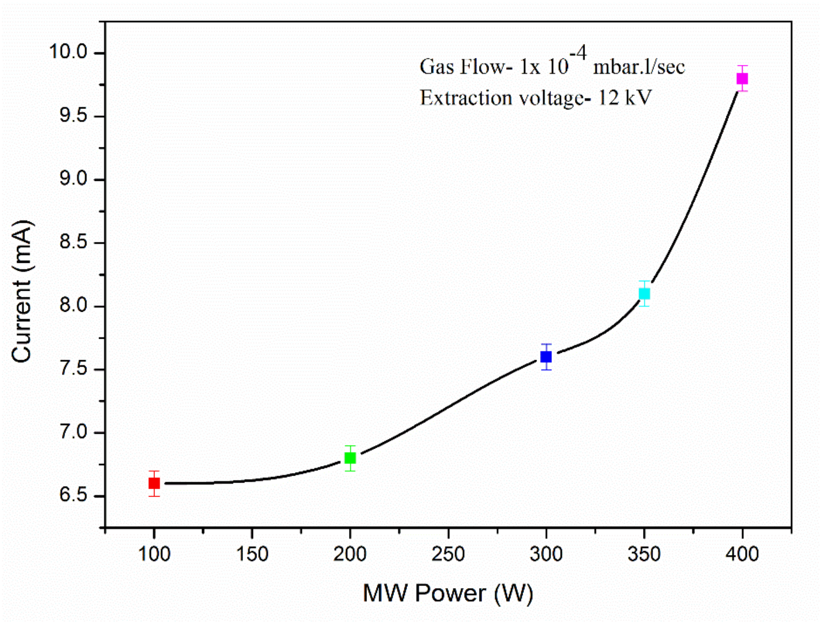
Nitrogen plasma.

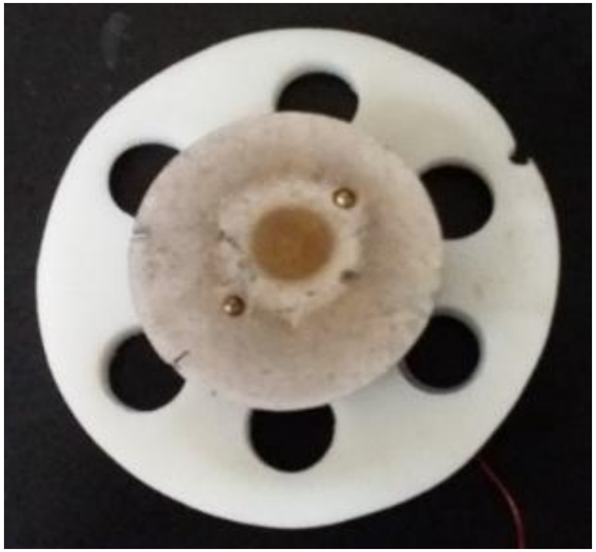




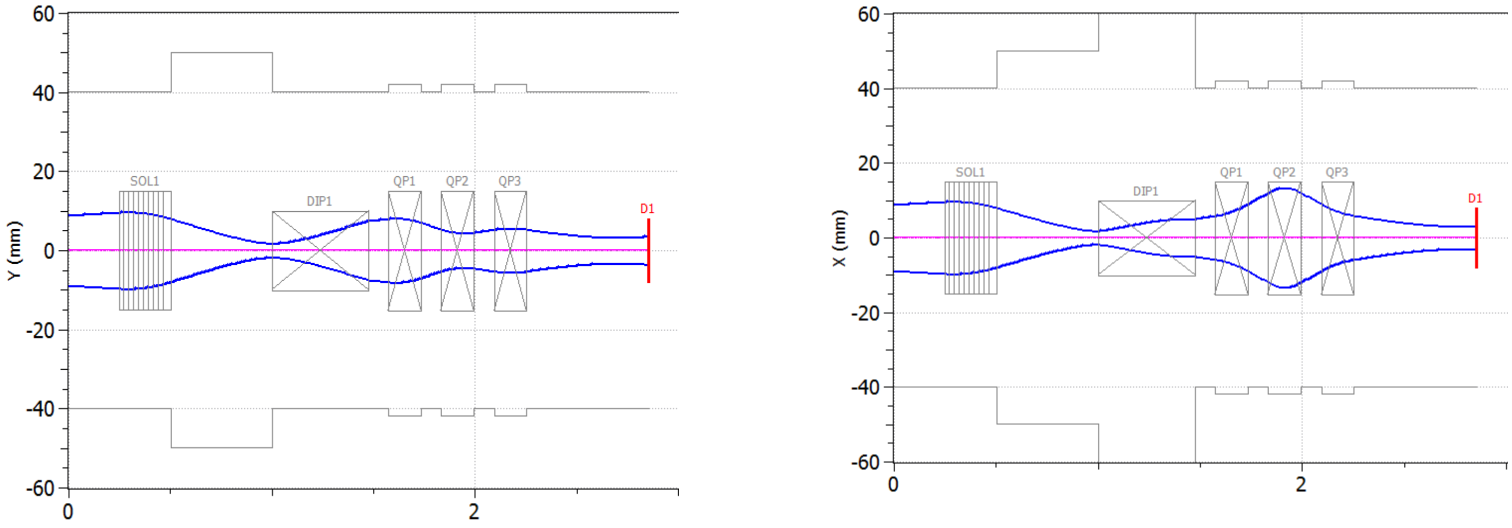
Result of ion beam extraction







Design of LEBT



Beam envelop of x-axis and y-axis for 7 mA ion beam current through LEBT

Summary

- The ECR ion source test bench has been set up and the ECR plasma has been generated using microwave power 100–400 W.
- The plasma parameters are measured in the ion source using optical spectroscopy method
- The extraction system and focusing system have been mounted on ECR ion source test bench and it has been tuned for the beam extraction as function of extraction voltage, microwave power and gas flow rate.

Future Plan

- For the better focusing of the ion beam in to the LEBT, Einzel lens will be replaced with the magnetic lens (Solenoid).
- Typical length of the solenoid is 255 mm with 0.35 T uniform magnetic field.
- It is under fabrication and it will be installed soon.
- To measure the beam emittance at RFQ entrance, Pantechnik make dual Allison emittance scanner will be integrated in to the test bench.

Dhanyavad