Annexure - 1

Doc. No.	**LPSC/HEP/20181224**
Date	**24-12-2018**

Expression of Interest (EOI) for design, development, realisation and supply of Probe Positioning Mechanism for plasma diagnostics of Hall thrusters in vacuum chamber

Due on: 11.02.2019 – 16.00 hrs

Opening on: 12.02.2019 – 10.30 hrs

INDIAN SPACE RESEARCH ORGANISATION

LIQUID PROPULSION SYSTEMS CENTRE

THIRUVANANTHAPURAM – 695 547

DEC 2018

1. Introduction

Liquid Propulsion System Centre (LPSC) is a premier institute in India developing and supplying state of the art liquid propulsion systems for India's space programme. Recently, LPSC has embarked upon the development of Stationary Plasma Thrusters (SPTs) that uses Xenon as propellant. It is proposed to realize a large vacuum chamber to test the thrusters.In order to position the probes used for measurement of plasma parameters of the plume from the thruster, two probe positioning systems are required

I. Near field probe positioning system
II. Far field probe positioning system

The probe has to be located at a parking position and then taken to the specified location within a short timefor taking the measurements and finally taken back to its parking position. Refer Figure 1 for schematic representation of near and far field region where measurements are to be made.

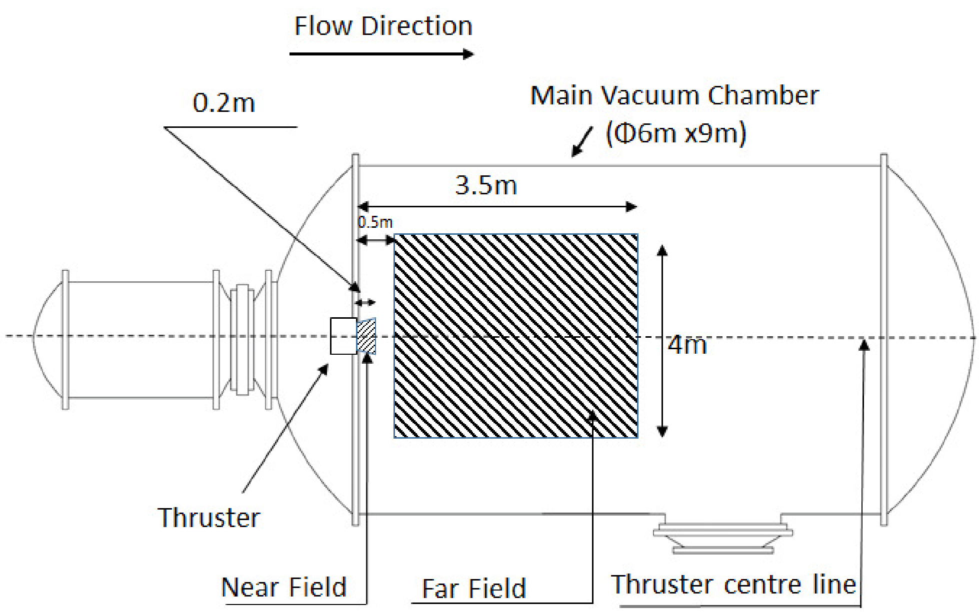

Figure 1 MainVacuum chamber with near field and far field marked

Far field probe positioning system is used for positioning the probes which are used for mapping the plume from 0.5m downstream of the thruster exit to 3.5m axially away from the exit plane of the thruster. In Near-field positioning system, the probes are mounted on a high speed reciprocating system which moves the probe axially inside discharge channel of the thruster and retracts it rapidly. Both the systems are independent and should not be interlinked mechanically. The near field and far field positioning system together comprises the probe positioning mechanism.

This document provides the overall specifications/requirements of the far field positioning system and near field positioning system envisaged inside the vacuum chamber for measurement of plasma parameters.It has drawings of feasible systems which are intended to translate the requirements correctly to the suppliers. Suppliers are free to propose more adept designs.

1.1. Facility description

The Probe Positioning Mechanism shall be installed inside the main vacuum chamber of Large Vacuum Test Facility (LVTF) being established at LPSC Valiamala, Thiruvananthapuram. The LVTF mainly consists of vacuum chambers, vacuum systems and associated accessories. The LVTF comprises of two chambers. The main vacuum chamber is 9 m long with 6 m internal diameter and the small chamber, is 2.5 m long with 2 m internal diameter. The two chambers are connected through a 1.5 m diameter gate valve. Schematic of LVTF with the two chambers and the location of the thruster is given inFigure 2. The small chamber will be used to accommodate the thruster on the thrust stand, with its electrical and gas feeding subsystems while the main vacuum chamber allows free expansion of the thruster plume. The ultimate vacuum level attained during testing without Xenon flow is 1 x 10^{-6} mbar. During the operation of thruster when there is Xenon flow to the vacuum chamber, Xenon Cryogenic pumping systems are used to maintain a vacuum level of 2.0 x 10^{-5} mbar to 5.0 x 10^{-5} mbar.

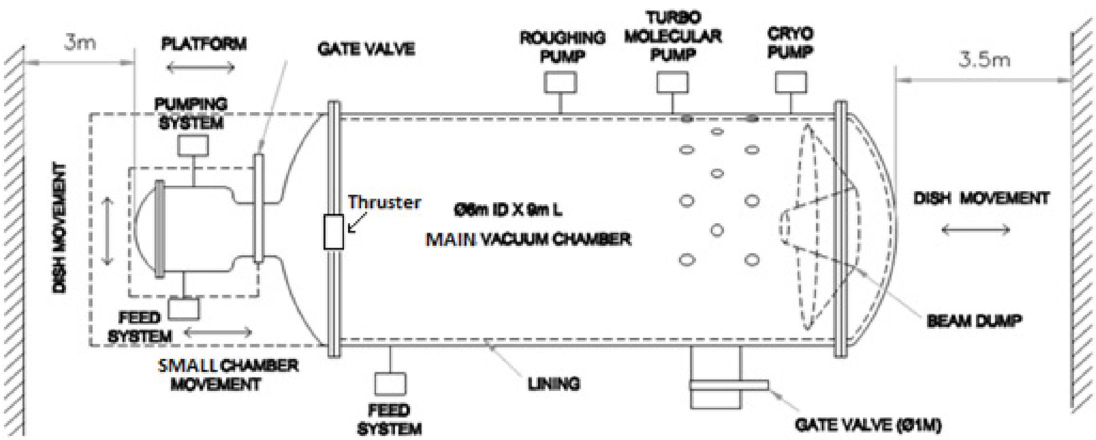

Figure 2LVTF with thruster position

1.2. Scope of the work

The scope of the work envisaged through this expression of interest includes design, development, realization, supply, installation and commissioning of the probe positioning system comprising of

I. Far field probe positioning system
II. Near field probe positioning system

The scope of supply includes

i. Design of the probe positioning system with required freedom of movement and accuracy and automated control system and displays
ii. Realization of the system
iii. Installation, commissioning and demonstration of the system inside LVTF with Hall thruster in operation mode.

The supplier shall envisage the system fulfilling the following requirements

a. All equipments must be vacuum compatible and suitable protection has to be provided against possible plasma induced erosion/sputter.
b. Fixture to mount the probes for near field and far field probe positioning systems.
c. Necessary interface for electrical connections to probes.
d. Position sensing devices and associated measurement and control electronics.
e. A motorized system to move the probes in the specified area inside the vacuum chamber.
f. The position of the probes has to be integrated to a format readable byLabVIEW software version, 2015 or higherduring the data acquisition period
g. Power interface cables and data interface cables along with the required vacuum feed throughs.
h. Power supply system required for powering the movement mechanism.

1.3. Technicaldetails of the proposal

Hall-Effect Thruster (HET) is an electromagnetically controlled plasma device. The fundamental operating principle of HET is to create localized and confined plasma followed by a careful and controlled conversion of the large ionic population of the plasma into an ion beam, by means of directional acceleration which eventually provides the thrust.

The plume from a Hall – Effect thrusters is composed of accelerating ions and diffusing plasma. Inorder to characterize the thrusters developed, it is required to measure the plasma and ion parameters in the near field as well as the far field of the thruster exit at different instants of time. This is accomplished only by developing a mechanical system which places the probes at required positions, holds and retracts it back without disturbing the thruster plume characteristics and before the plasma starts eroding the probe.

The current requirement is to have a separate positioning mechanism in near field and far field of the thrusters. Near field refers to the region close to the thruster exit(200mm downstream of thruster exit plane) and inside of the discharge channel (40mm upstream of the thruster exit plane) where particle impingement effects and thermal energy transfer is large. Far – field comprises of the plume at a distance of 0.5m to 3.5m downstream of the thruster exit. The proposed mechanism is for different thruster configurations.

1.4. Commercial details of the proposal

Vendor shall have previous experience in design and development of positioning mechanisms. Documentary evidence of the same shall be submitted along with the EOI. The company shall be financially strong to execute the work under this expression of interest and must have experience of atleast three years in this field.

The following commercial details of the company and proposal shall be submitted along with the Expression of Interest.

- 1.4.1. Annual turnover for the last three years
- 1.4.2. Proof of experience in the field for atleast3 years
- 1.4.3. List of customers in Aerospace or Scientific area
- 1.4.4. Details of similar systems realised elsewhere
- 1.4.5. Company website

The call for EOI does not carry with it any guarantee for allotment of work.

1.5. Delivery period and milestones

Party has to install the final system at LPSC, Valiamala, Trivandrum-695547, Kerala, India within 12 months from the date of signing of contract.

1.6. Mode of operation of tender

- **1.6.1.** In the first stage, companies have to respond to this Expression of Interest (EOI) explaining their capabilities and expertise to execute the proposed work. **No price is to be quoted.**
- 1.6.2. A tentative scheme of the probe positioning system shall be submitted to demonstrate the vendors capability in realizing the same.

1.6.3. Companies who fulfil the commercial and technical terms may be called for a technical presentation within 3 weeks after submission of Expression of Interest.

1.6.4. Detailed specifications will be given in Request For Proposal (RFP) which will be issued subsequently.

1.6.5. In the second stage,based on RFP, a techno-commercial and price bid will be invited from short listed vendors on two part bid basis.

1.6.6. Final selection will be based on techno- commercial and price bidevaluation.

1.7. Date of submission of EOI

Interested vendors may submit their Expression of Interest in a sealed envelope superscribing as **" Expression of Interest (EOI) for design, development, realisation and supply of Probe Positioning Mechanism for plasma diagnostics of Hall thrusters in vacuum chamber with Reference number of this advertisement and EOI No. TL56 2018032097 due on 11.02.2019 @ 16.00 hrs "** **without any price details** so as to reach LPSC on or before **11.02.2019 @ 16.00 hrs** to the following address:

The Sr. Head, Purchase & Stores
Liquid Propulsion Systems Centre
Valiamala, Thiruvananthapuram – 695 547
Kerala, India

The cover should indicate **" SENDER'S "** address. For any clarification you may contact us at following phone/Fax No.

Telephone : 0471 2567813

Fax : 0472 2800712

EOI received after due date and time will not be considered.

2.Probe Positioning System

2.1. Near Field Positioning System

2.1 Near field probe positioning system

a. Requirements

The near field probe positioning system envisaged is a high-speed probe positioning system which enables probe measurements without destroying the probe itself while limiting perturbation to the plasma as well. It should move the probe from the parking position to the measurement zone and then move the probe in a fast reciprocating axial direction into the discharge channel of the thruster and retract it rapidly.

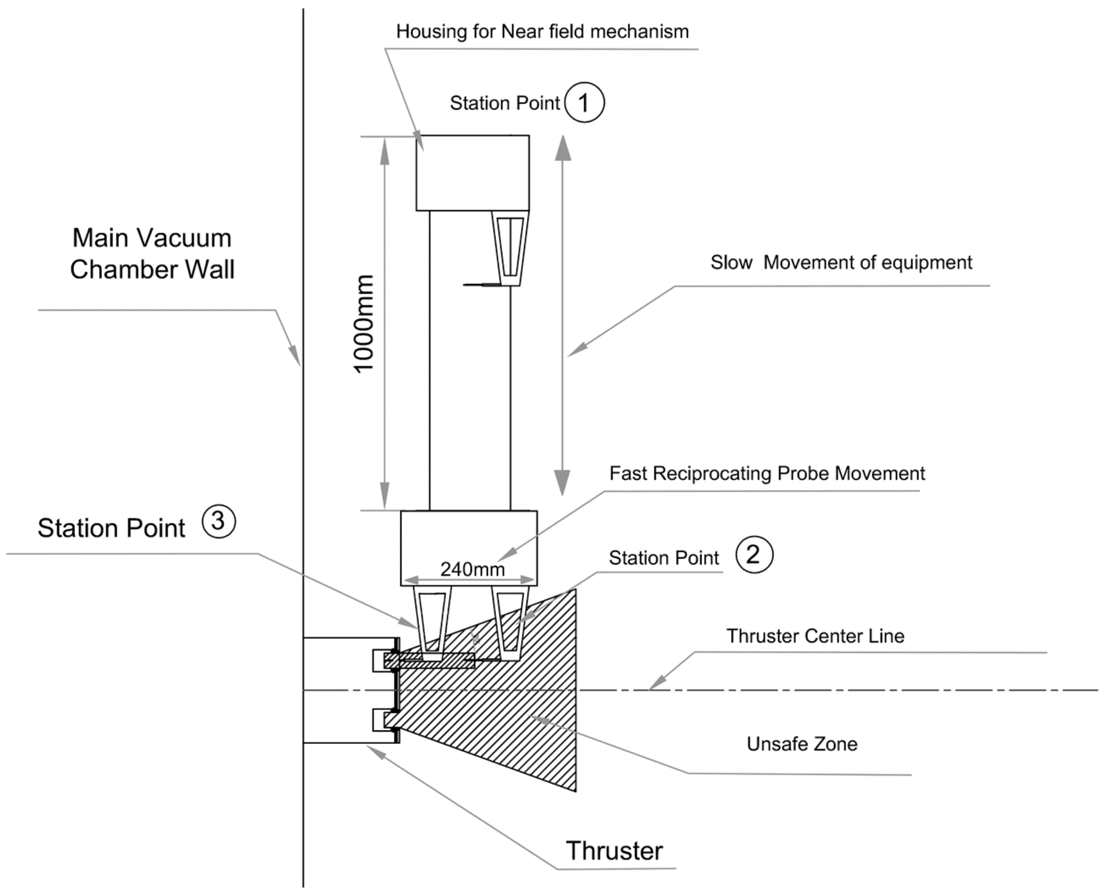

Figure 3 The top view of required radial and axial movements (with approximate dimensions) with a feasible near field mechanism

Figure 3 shows the top view of the required movements of a feasible near field probe positioning mechanism. There are three station points namely 1,2 and 3. The housing for the mechanism should be parked approximately 1000mm radially away as shown in Figure 3at station point 1. It should move to station point 2 with a speed not less than 1m/min. The probe should be moved from station point 2 to 3by a fast forward stroke of 240mm (max) in a time not greater than 160ms. The probe should start its reverse motion in a time not greater than 100ms and then should complete its movement to station point 2 in a time not greater than 160ms. After the measurement is finished the housing should be moved back to station point 1. The details of the near fieldprobe positioning system are given below.

In order to prevent secondary electron emission due to ion/plasma impingements it is preferred to park the equipments in a safe zone within the chamber as shown in Figure. The particle impingement effects will be maximum in the unsafe zone shown in Figure 5.

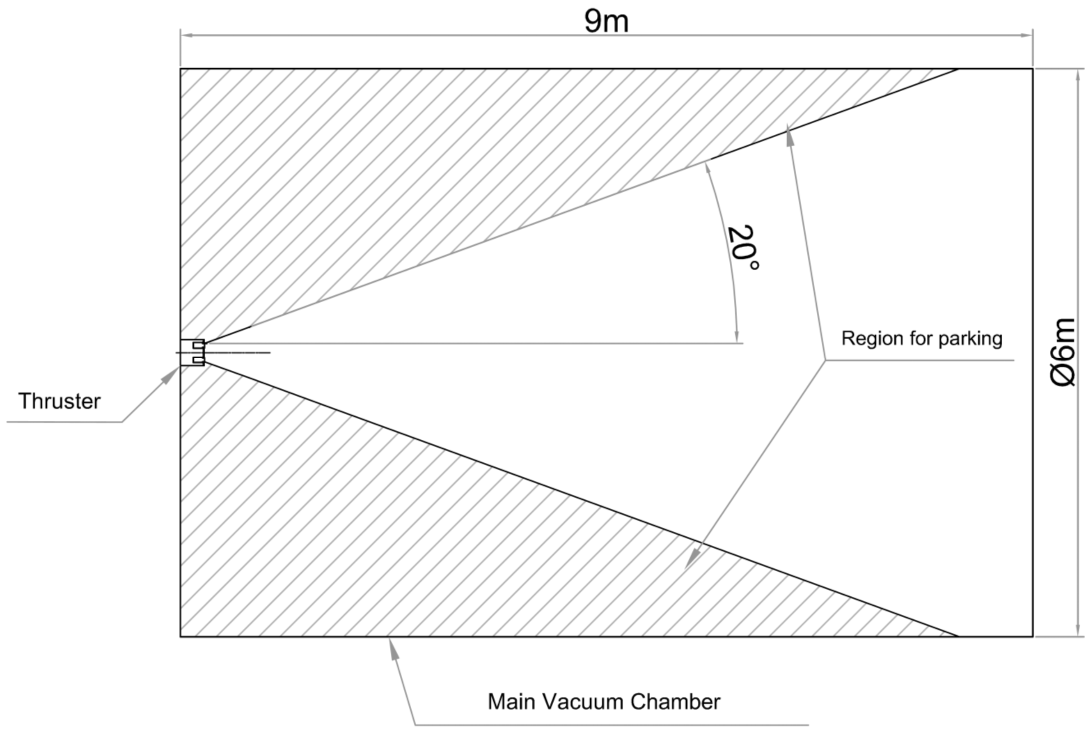

Figure 4 Schematic of region for parking equipments

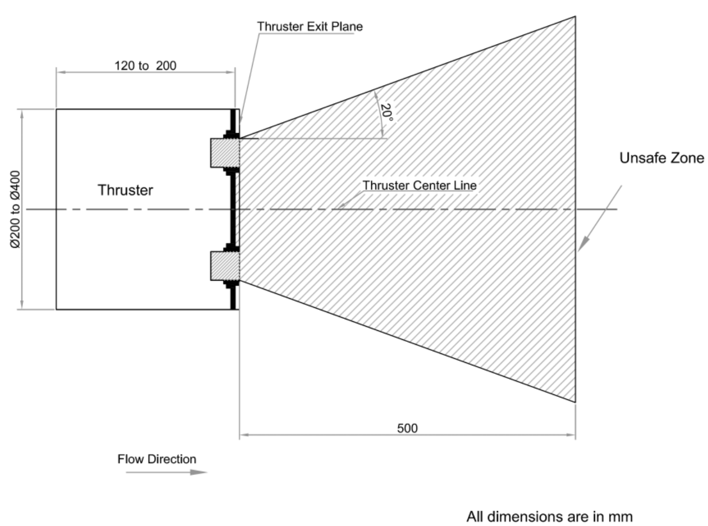

Figure 5 Unsafe zone for parking the equipments

b. **Range of Movement**

The system should be capable of mapping a region beginning from 200mm downstreamof the thruster exitto 40mm(max) upstream of it(inside the annular channel). The mechanism should position the probeat a radial distance (from the thruster center line) ranging from 30 mm(min) to 130mm(max) and then start fast reciprocating motion of probe from 200mm downstream.The zone of measurement is given in Figure 6.

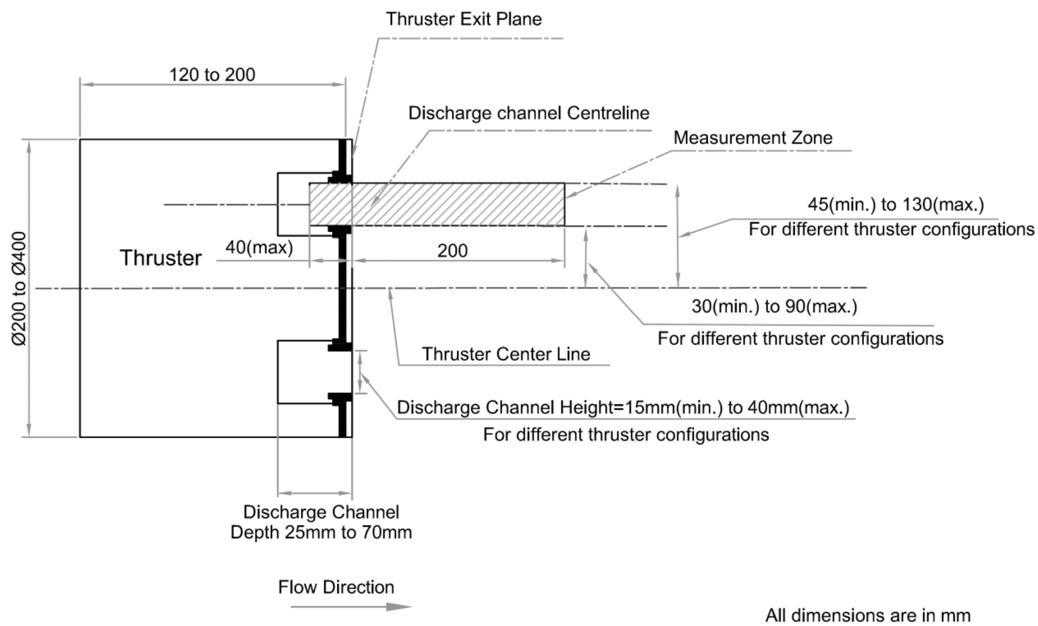

Figure 6 Measurement Zone

The radial movement from the parking position to station point 2 is a slow movement over a distance of approximately 1000mm.

A feasible mechanism with the approximate dimensions isshown in Figure 7. Housing frame for the mechanism and its movement along rails are shown inFigure 8, Figure 9 and Figure 10.The fast reciprocating movement with initial and final positions at a particular radial distance is shown in Figure 11. There should be provision for unmounting the mechanism from the shown position and mounting it to another location at 90˚ in counter clockwise direction as shown inFigure 12

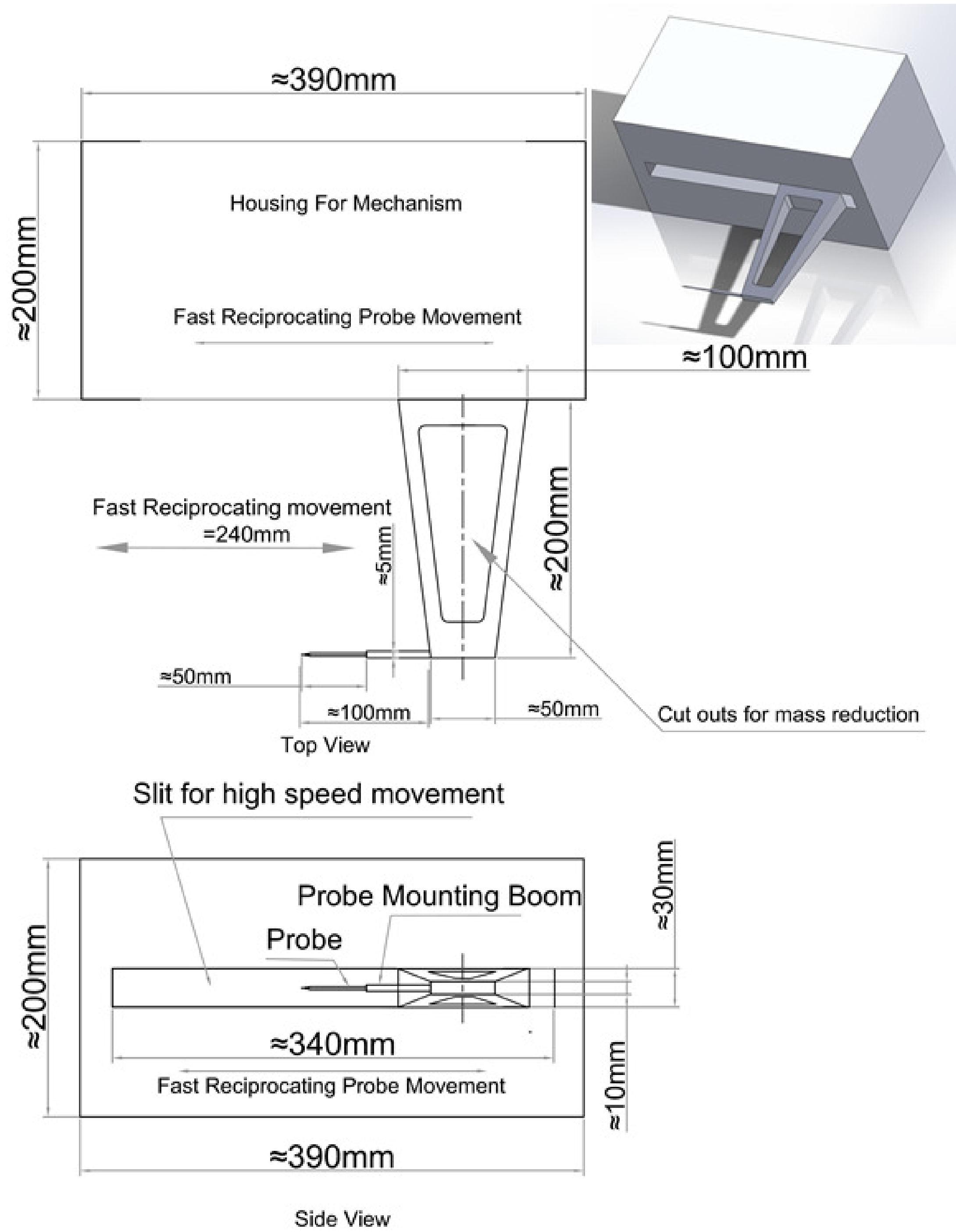

Figure 7 Feasible Near-Field Probe positioning Mechanism with approximate dimensions also shown is the 3D view

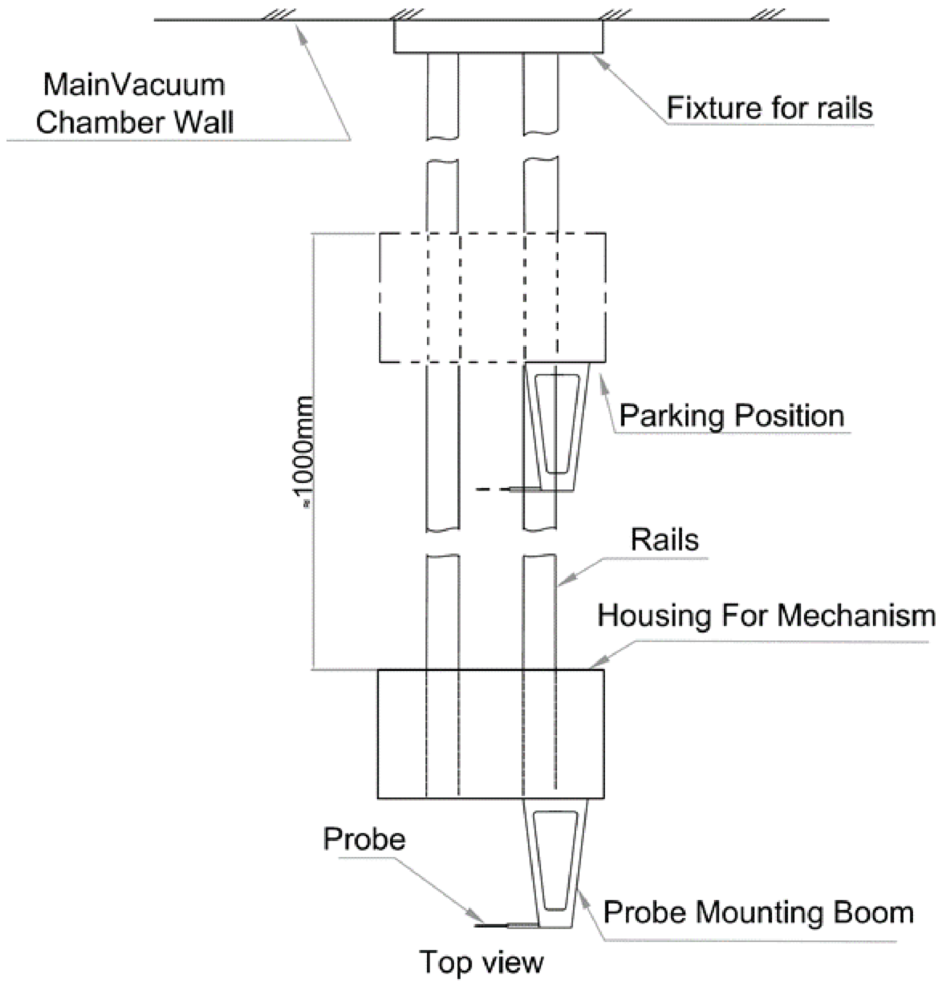

Figure 8 Top View of the mechanism mounted on rails

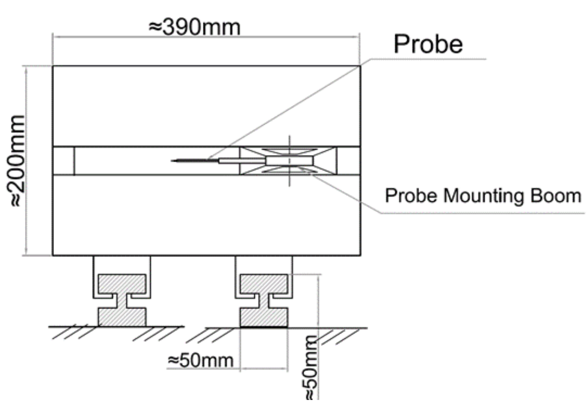

Figure 9 Side View of the mechanism mounted on rails with approximate dimensions

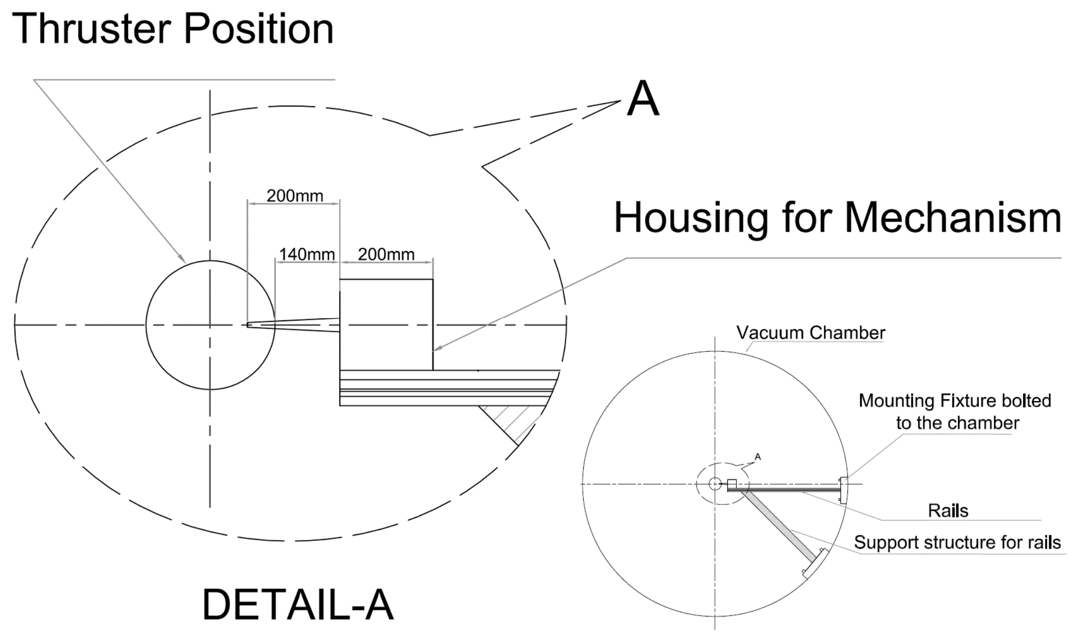

Figure 10 End View (from the beam dump side of the main chamber) of the mechanism mounted on rails with approximate dimensions

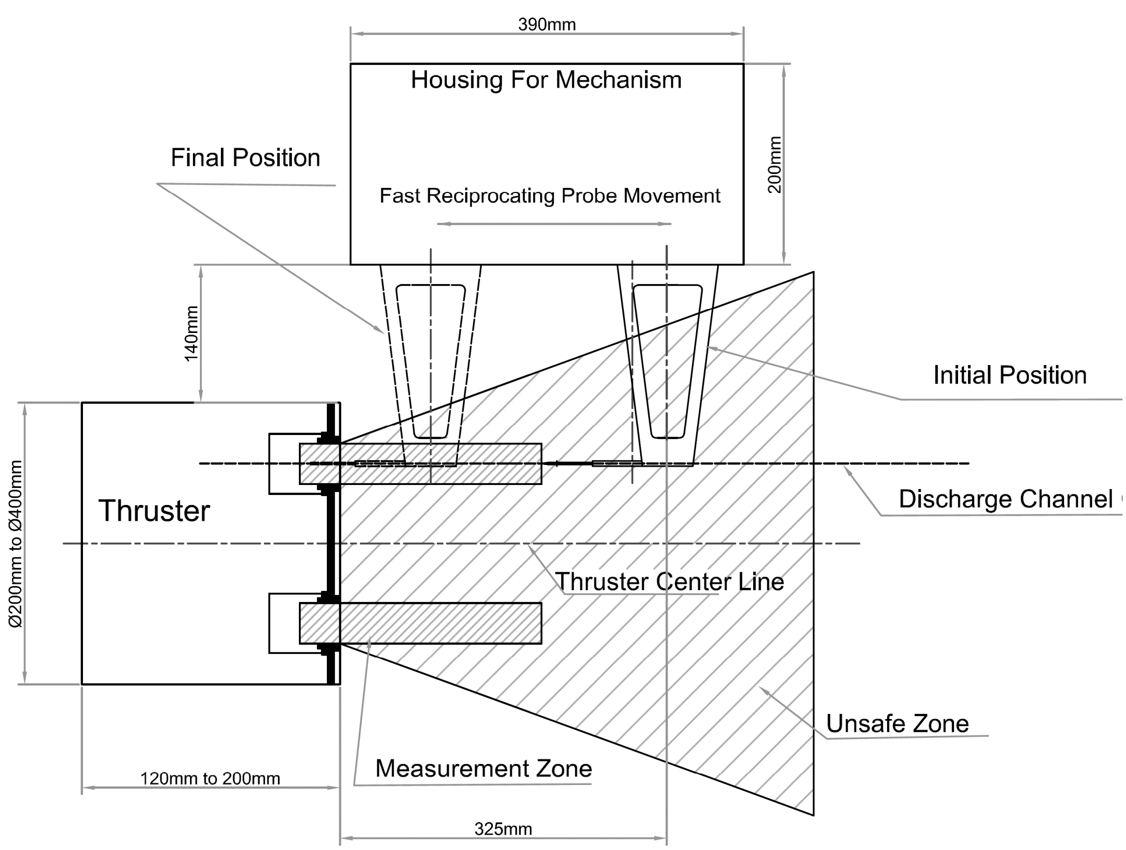

Figure 11 Final and initial position of the boom at a particular radial distance

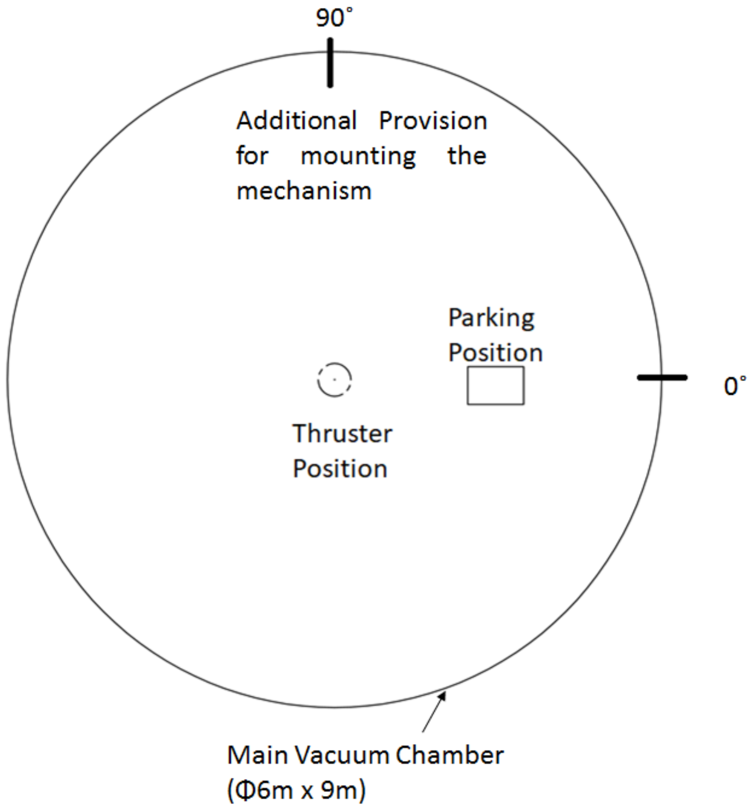

Figure 12 End view (from the beam dump side of the main vacuum chamber)of the parking position and the position for providing additional interface for mounting the mechanism

c. Resolution

The system should be capable of placing the probes at any point within the range of movement along axialdirection (flow direction) and radial direction with a minimum resolution of 100µm.

d. Accuracy

Positioning of the system should be accurate to 500µm or better for both radial and axial movements.

e. Velocity, acceleration and resident Time

For fast reciprocating movement

The system should be capable of going upto avelocity of 3m/s and an acceleration of 4g respectively with a resident time not higher than 100ms. An approximate motion profile of the probe tip is given inFigure 13.

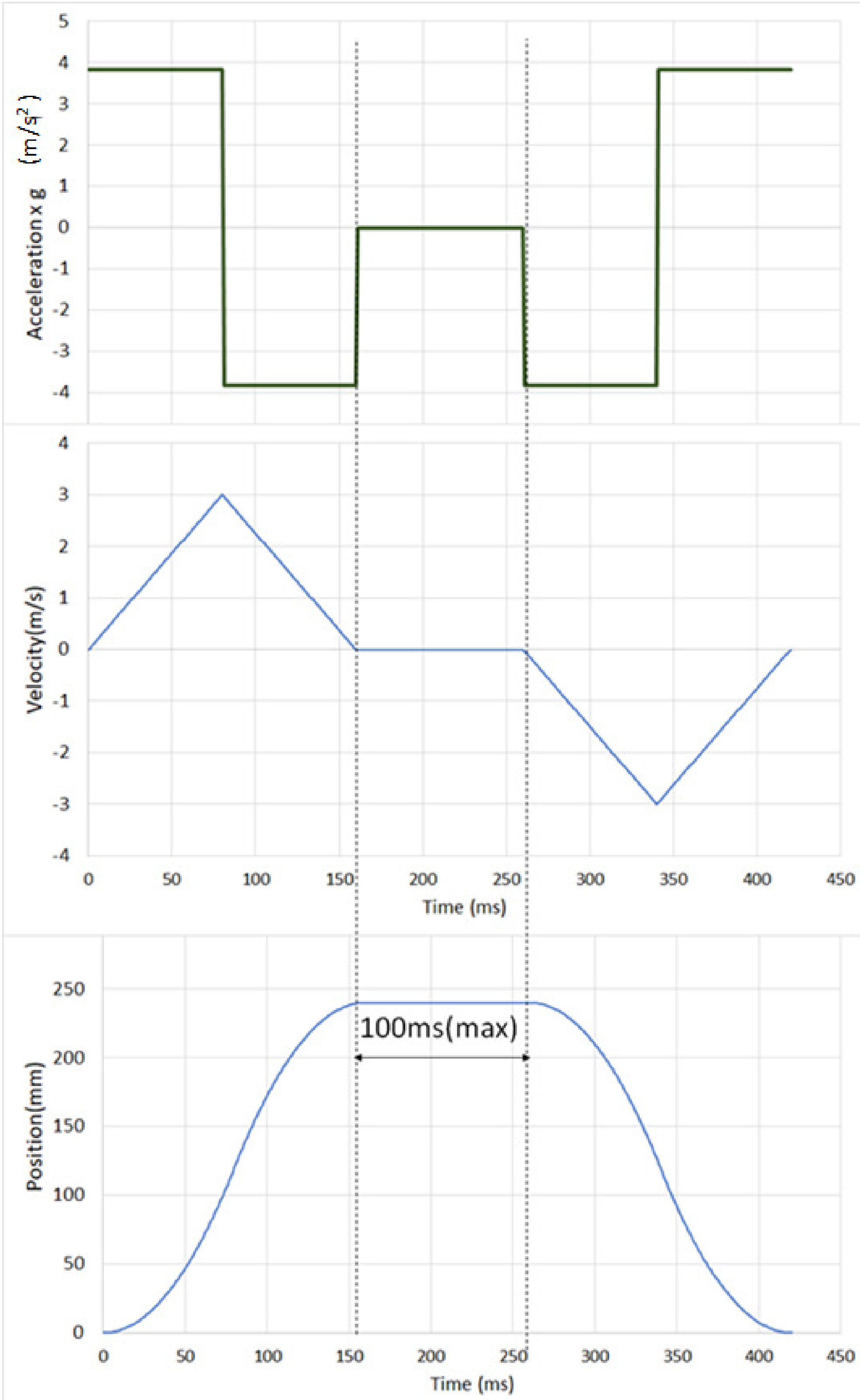

Figure 13 The typical motion profile for the fast reciprocating motion of probe. Position '0' represents the point 200mm downstream of the thruster exit plane and 240mm is the point 40mm upstream of the thruster exit plane

f. Operating Conditions

The near-field probe positioning system should be able to operate in vacuum conditions of 1 x10^{-6} mbar inside the chamber and should withstand direct impact of high energy ions with the estimated heat flux in the range of 0.5kW/m^2 to 2 kW/m^2.

g. Structural Requirements

I. The probes to be mounted on the reciprocating arm weighs not more than 100gm.

II. The structural frequency of the system should be greater than or equal to 50Hz.

III. Preferred raw material is Aluminium Alloy 2000 series with graphite coating for thermal protectionof all external surfaces

IV. The system should have minimum cross-section so that the interaction with plasma can be minimized and plume is least disturbed.

V. The system should not have any interference issues with magnetic field of the thruster and vice versa. The maximum magnetic field intensity is 100G.

VI. The material used should be suitable for vacuum environment with low degassing rates. Lubricants if any used should be vacuum compatible.

VII. The system should have smooth and vibration free movement.

The system should be positioned inside the vacuum chamber. The thruster along with feasible probe positioning equipment,its housing andnear field movement is shown in Figure 11.

h. Probe Configuration

The probe to be mounted has a maximum mass of 100gand its configuration is shown in Figure 14.

i. Fast acting drive mechanism

Regarding the choice of the system for the fast reciprocating movement, the supplier has to explore all conventional systems like brushless DC motor/Ball screw drives as well as new systems like Linear Electric Motors to meet the requirements.

The detailed technical specifications of the system to be realized are given in Table 1.

Table 1 Technical Specifications- Near field probe positioning system

Overall Specification		
Sl. No.	Technical Features	Requirements/Specifications
1.	Movement directions	• Axially, Fast reciprocating probe movement • Radially, Slow movement from parking position

Overall Specification		
Sl. No.	Technical Features	Requirements/Specifications
2.	Measurement range	• Along axial direction: 200mm downstream from the thruster exit plane to 40mm (max) upstream • Radial : 30mm(min) to 130mm(max) from thruster center line
3.	Position accuracy	500 µm or better (axial and radial movements)
4.	Position Resolution	100 µm or better (axial and radial movements)
5.	Probe mass	100g (maximum)
6.	Velocity of travel of probe	0 – 3m/s (seeFigure 13)
7.	Residence Time inside the thruster channel	Maximum of 100ms (see Figure 13)
8.	Acceleration	0 –4g (see Figure 13)
9.	Structural frequency	50Hz or better
General Specifications		
10.	Pressure in vacuum chamber	1×10^{-6} mbar
11.	Heat Flux	0.5 kW/m^2 to 2 kW/m^2
12.	Data acquisition and control system	Online data acquisition system and control system for movement, and logging of command and position feedback. Control and acquisition should happen over Ethernet as well. The position of the probes has to be integrated to a format readable by LabVIEW software version, 2015 or higher during the data acquisition period

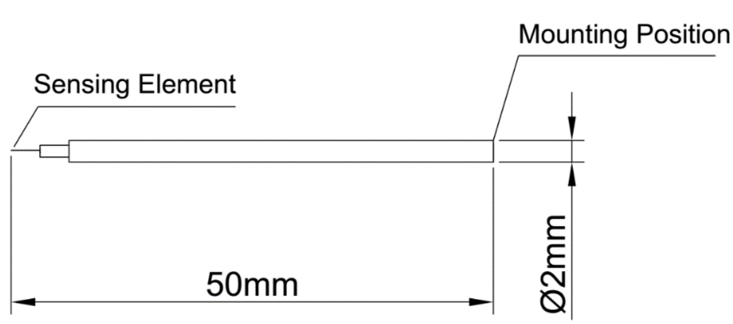

Figure 14Schematic of Probe for near field measurement

2.2. Far Field Positioning System

2.2 Far field probe positioning system

The Far field probe positioning system is used to place the probe for measuring the plasma parameters in the far field region of the thruster plume marked as volume to be probed in Figure 15.

This system has to traverse the zone of the far field in all three axes, to scan the entire volume shown inFigure 15. The probe used is unidirectional so it should always be pointing towards the exit point of the thruster, in all positions within the probe volume. The details are given below.

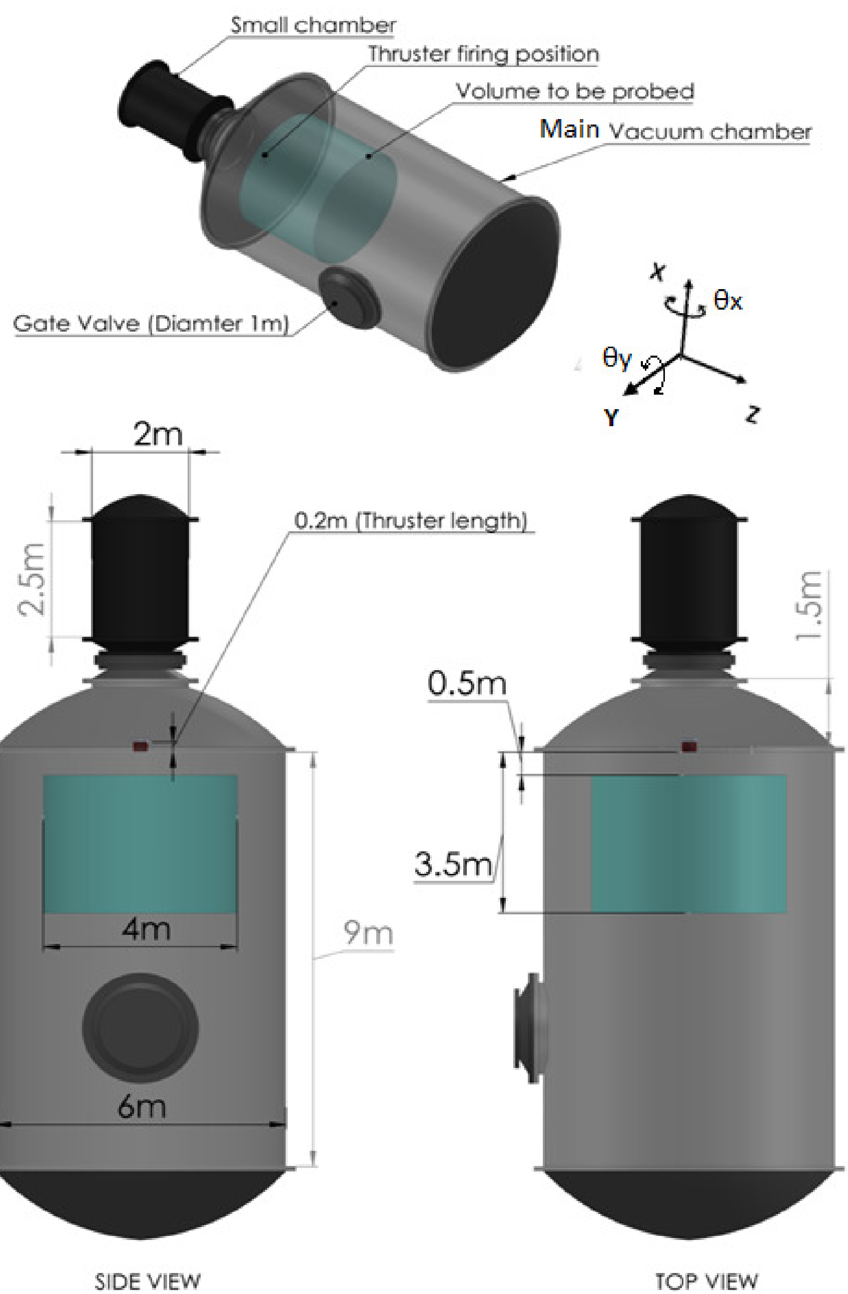

Figure 15 Far field measurement zone

a. Configuration

The far field positioning system should have three axis translation in X, Y, Z, direction and a mechanism which provides angular movement in θ_x and θ_y direction (Refer Figure 15 for angular directions)to ensure that the probes are pointed towards the thruster exit point at all positions. This type of measurement provides a 3D profile of the expanding plume.

b. Range of Movement

The system should be capable of mapping the plume along the thruster axis between 0.5m to 3.5m from the exit plane of the thruster as shown inFigure 15. So the total probing distance in z axis is 3m. Along the y and x direction it should allow for mapping of the plume up to 2m on all sides of the z-axis. For angular motion in θ_x and θ_y direction the movement should range from -80° to +80°.

The unsafe zone for parking the system is shown in red in Figure 16.

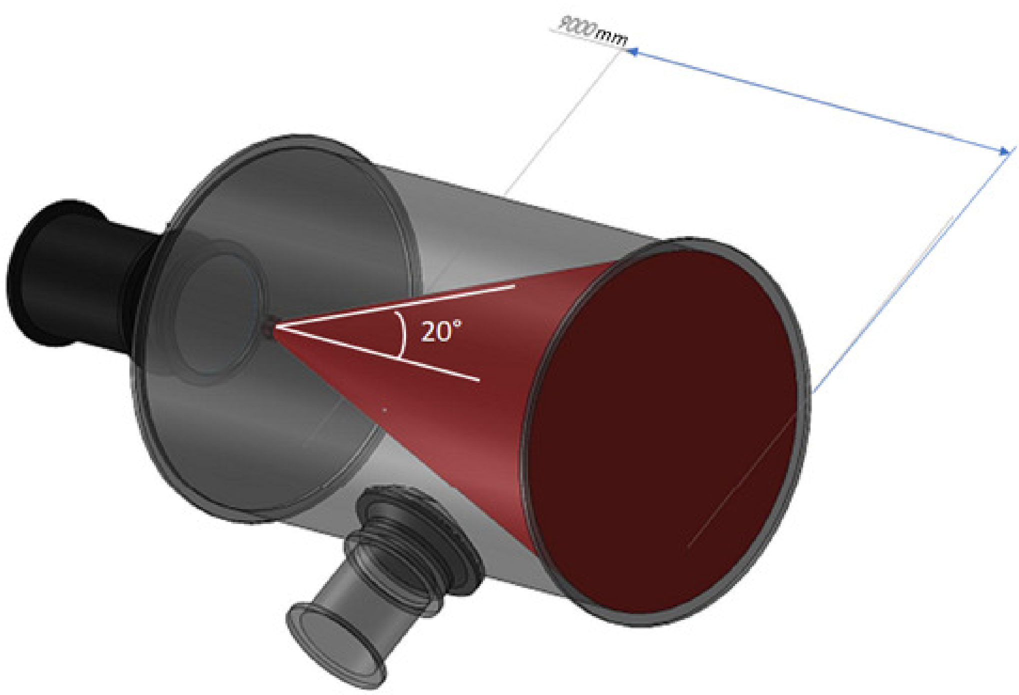

Figure 16 Unsafe zone for parking the system

c. Velocity

The system should be capable of moving with a velocity of 2m/min or better in x,y and z directions.

d. Resolution

The system should be capable of placing the probes at point within the range of movement in x, y and z directionswith a minimum resolution of 0.5mmand a minimum angular resolution of 0.1 degree in θ_x and θ_y direction

e. Accuracy

Positioning of the system should be accurate to 1mm or better in all three directions andangular accuracy of 0.5 degree or better in θ_x and$\theta_y$direction is required.

f. Operating Conditions

The far-field measurement system should be able to operate in vacuum conditions of 1 $x10^{-6}$ mbar inside the chamber and temperature upto70°C. Graphite coating has to be given to all external surfaces to prevent erosion from ion impingement.

g. Structural Requirements

I. The system should be capable of handling probe mass of 5 kg (max).
II. The mounted structural frequency of the probe positioning system should be greater than or equal to 25Hz
III. Preferred raw material is Aluminium Alloy 2000 series with graphite coating for thermal protection on all external surfaces
IV. The system should have minimum cross-section (cross sectional thickness≤125mm as shown in Figure **17**) so that the interaction with plasma can be minimized and plume is least disturbed.
V. The material used should be suitable for high vacuum environment with less degassing rates.
VI. The surface of the system should be protected from impact of high-energy ions by graphite coating.
VII. The system should have smooth and vibration free movement.

A feasible x,y,z translator system for positioning of the probes in far field is shown in Figure 17, Figure 18 and Figure 19.For this mechanism two identical systems are required, one at the bottom and another at the top, to scan the entire zone of 3m length and diameter 4m.

h. Interface Details

The system should be positioned inside the main vacuum chamber. The dimensions of the chamber and volume to be probed are shown in Figure 15.

i. Probe Configurations

The probe configuration is shown in Figure 20.

The detailed technical specifications are given inTable 2

Table 2 Technical specifications far - field positioning mechanism

Overall Specification – Summary		
Sl. No.	Technical Features	Requirements/Specifications

Overall Specification – Summary		
Sl. No.	Technical Features	Requirements/Specifications
Far field Measurements		
1.	Movements	X, Y, Z, θ_x and θ_y At any measurement location in the main vacuum chamber, the probe has to be aligned to the center of the thruster by suitable angular rotations
2.	Minimum distance from thruster	500 mm
3.	Measurement range	In z direction: 0.5m to 3.5m from thruster exit X axis : ±2m from the thruster center line Y axis : ±2m from the thruster center line
4.	Velocity	2m/min or better in x,y and z directions
5.	Position accuracy	1mm or better along x,y and z direction 0.5 degree in θ_x and θ_y direction
6.	Resolution	0.5mm or better along x,y and z direction 0.1degree in θ_x and θ_y direction
7.	Probe mass	5 kg (maximum)
8.	Probe Dimension	See Figure 20
9.	Structural frequency	25Hz or better
10.	Cross-section of the structure	125mm or lower
General Specifications		
11.	Pressure in vacuum chamber	1 x 10^{-6} mbar
12.	Temperature	70˚C
13.	Data acquisition and control system	Online data acquisition system and control system for movement, and logging of command and position feedback. Control and acquisition should happen over Ethernet as well. The position/orientation of the probes has to be integrated to a format readable by LabVIEW software version, 2015 or higher during the data acquisition period

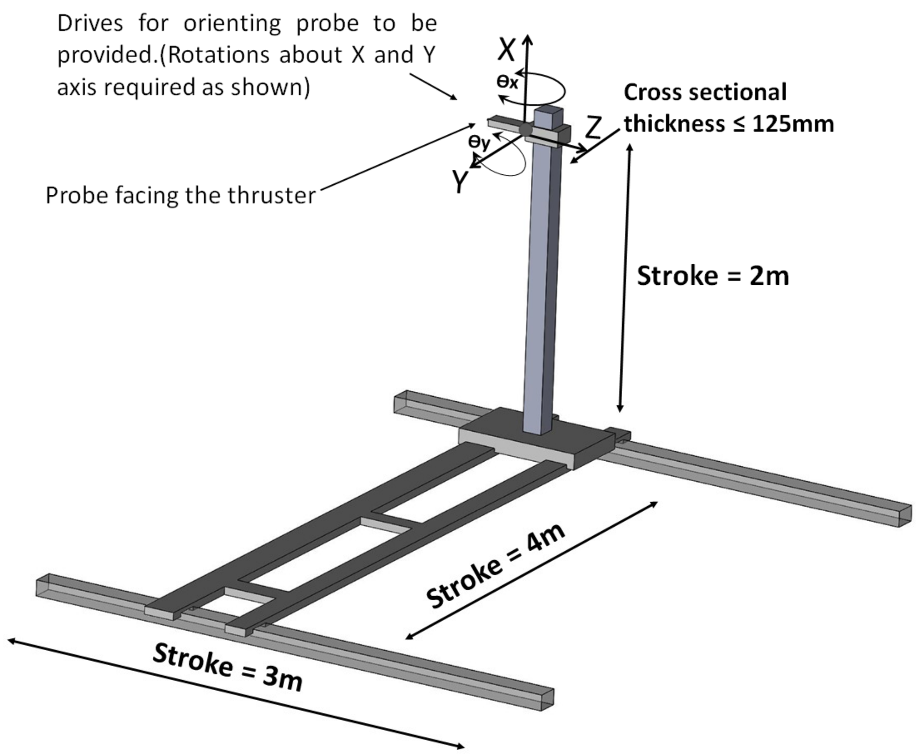

Figure 17 Feasible mechanism for Far field probe positioning - X,Y,Z translator with rotatable mounting point

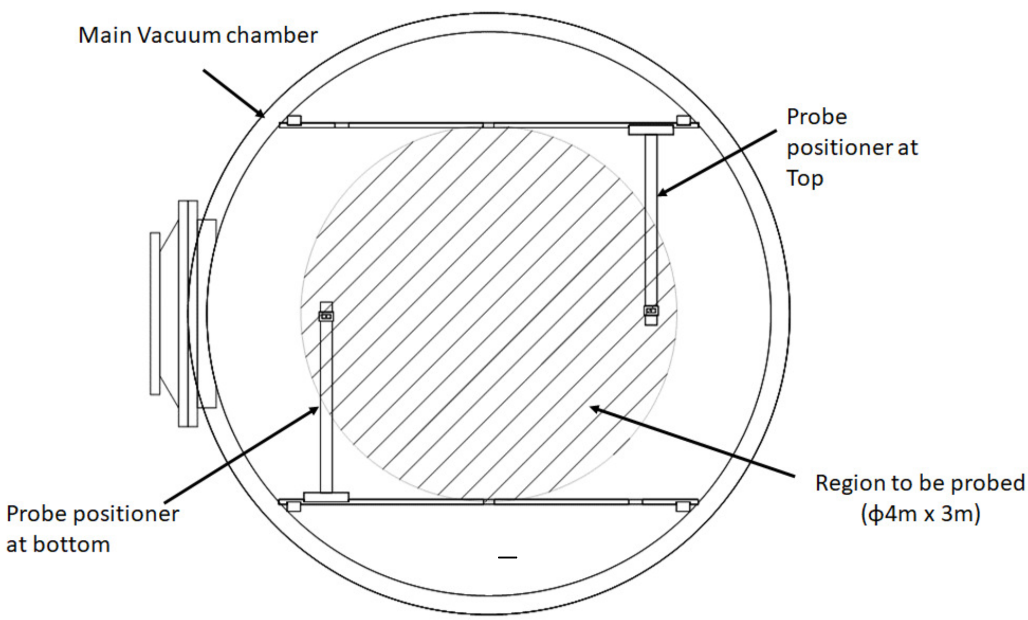

Figure 18 End View of the x,y,z translators position

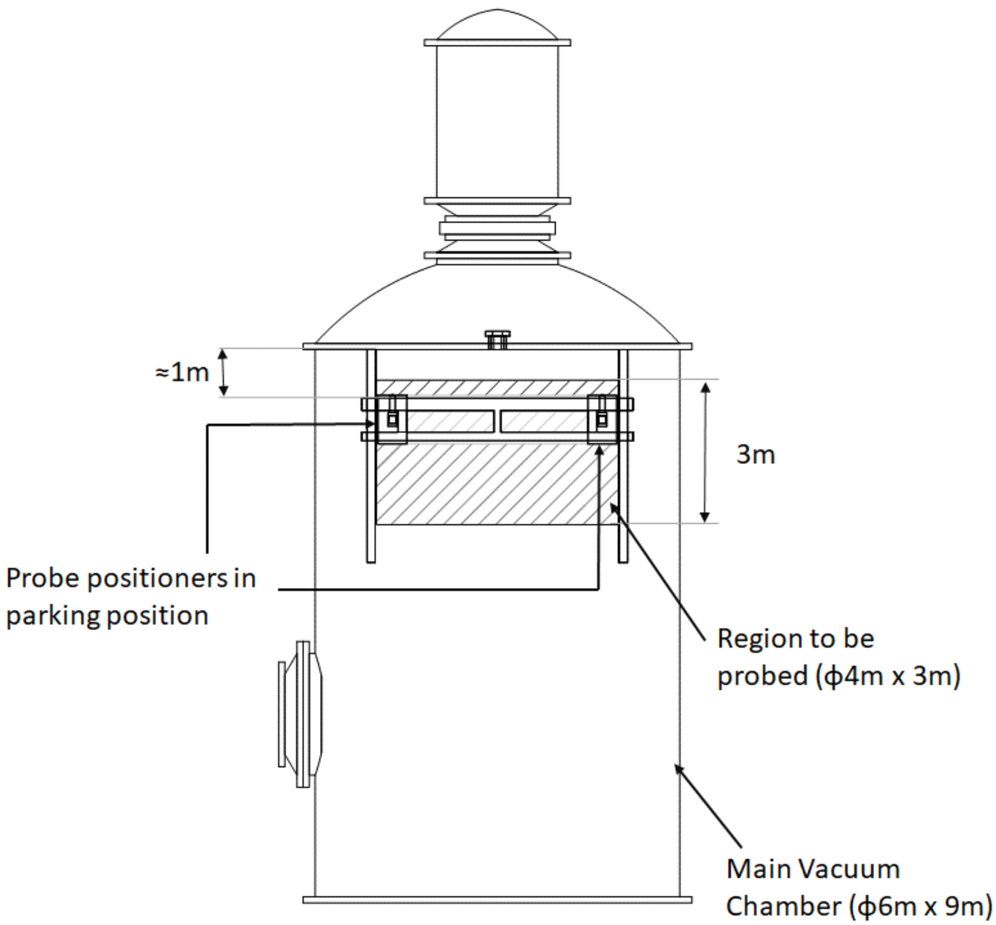

Figure 19 Top View of the translators inside the main chamber

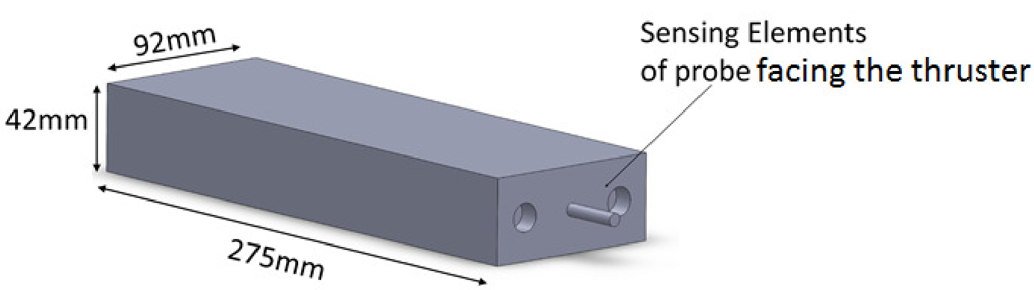

Figure 20 Probe for far field measurements