# A three dimensional probe positioner[a)]

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In order to sort out the physics that is important in many plasma experiments, data in three dimensions (3D) are becoming necessary. Access to the usual cylindrical vacuum vessel is typically restricted to radially or axially insertable probes that can pivot. The space that can be explored usually has significant restrictions either because probe travel must be along a travel path, or a "wobbly" probe positioner requires one to map between a moveable coordinate system and a preferred laboratory coordinate system. This could for example introduce errors in measurements of vector quantities such as magnetic field or flow. We describe the design and implementation of a 3D probe positioner that slides in two dimensions on a double *O*-ring seal and radially inserts along the third dimension. The net result is that a 3D space can be explored in a laboratory Cartesian reference frame. © *2008 American Institute of Physics.* [DOI: 10.1063/1.2956746]

## INTRODUCTION

Many important plasma physics problems are fundamentally three dimensional in nature. However, practical investigations that include experiment, theory and computational simulations frequently are simplified to one or two dimensional approaches. From the experimental standpoint, there is much that can be learned from fully three dimensional (3D) data sets. In particular, insertable probes can yield much useful information about electric and magnetic fields, particle characteristics, flows, and more. Access to the typical vacuum vessel for plasma experiments must respect the requirements for vacuum sanitary practice, ease of adjustment, and wide range of probe field of view. Probe scans can usually be carried out in one dimension, or with rotatable assemblies two dimensions. Sometimes a restricted 3D volume can be explored, with a coordinate system that is attached to some probe and insertion assembly that also rotates. The rotating coordinate system can add confusion with probe detectors that have angular dependent sensitivities, such as directional magnetic or electrostatic probes, energy analyzers, etc. There is a need for a low technology probe positioner that is simple, easy to use and fabricate, and reasonably precise for 3D probe positioning with a 3D Cartesian coordinate system.

## DESCRIPTION OF THE PROBE POSITIONER

We show here a 3D probe positioner that moves in $x$-$y$-$z$ Cartesian coordinates, without rotation, and can scan a 3D volume that can be larger than $10\times10\times10$ cm$^3$. We can maintain an absolute precision better than 1 mm, with relative spatial precision much better than that.

The original design allowed exploration of the 3D structure of magnetohydrodynamics magnetic kink instability and magnetic reconnection problem in the magnetic reconnection scaling experiment (RSX) at LANL. RSX is shown in the Fig. 1. RSX uses two plasma guns to generate two plasma current channels embedded in a background magnetic guide field.[1] The linear geometry of flux ropes with finite length and nonperiodic boundary distinguishes the RSX reconnection from other toroidal experiments. The two flux ropes have parallel currents which mutually attract, so that the collision velocity can be experimentally controlled. Similar to the reconnection occurring in nature, the merging of flux ropes in RSX is 3D. There is a current driven kink instability that propels each flux rope and the collective pair of ropes into helical gyrations. A collision between flux ropes creates a 3D patch of reconnection.

As shown in Fig. 2 cross section and the Fig. 3 exploded assembly view, the probe positioner itself has an aluminum plate that is bored for an access hole with a small KF25 gate

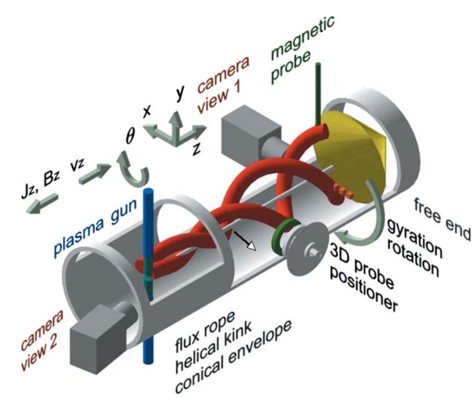


FIG. 1. (Color online) Schematic of the RSX experiment showing plasma guns, kinking flux ropes, external anode, fiducial line at the vessel $z$ axis, and geometry. Probe positioners are located at several 6 in. Conflat vessel ports.

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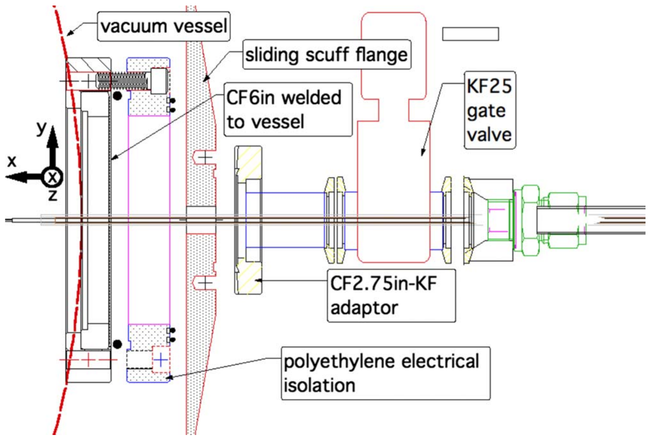


FIG. 2. (Color online) Schematic two dimensional exploded assembly view of the RSX scuff probe positioner, with a sample probe inserted into the vacuum vessel.

valve, which allows probe insertion through a modular probe "garage" as depicted in Fig. 4. The probe is constructed with $\frac{1}{4}$ in. SS 304 tube, with internal pyrex insulation, and copper shielding. The probe assembly slides on a double *O*-ring seal situated at the outboard end of the probe 0.5 in. OD garage in the *y*-*z* plane. The gate valve has a roughing pumpout port with a separate knob valve. The probe insertion into the vacuum vessel volume can be slid in the *x* direction through a double *O*-ring seal. The net movement is thus 3D, with no tilting required. Movements must be slow, between successive shots, since the experiment is pulsed. The whole assembly is held up by LabJacks, and held onto the vacuum vessel so it does not fall off during maintenance and up-to-air procedures.

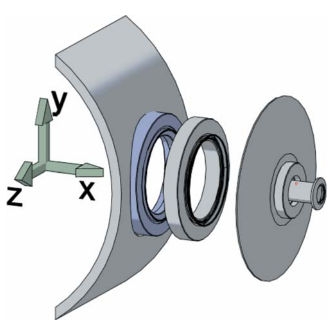


FIG. 3. (Color online) Schematic 3D exploded assembly view of the RSX scuff probe positioner, showing KF-25 fitting on tapered disk. The *y*-*z* plane sliding action occurs on the double *O*-ring seal to the plastic insulator flange, which in turn is *O*-ring sealed to the vessel Conflat fitting.

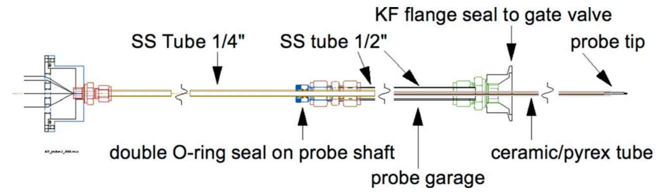


FIG. 4. (Color online) Schematic exploded assembly view of the RSX standard probe design, showing Swagelok seals, $\frac{1}{4}$ in. SS probe shaft, and the $\frac{1}{2}$ in. SS tube probe garage assembly which allows retraction to the air side of the gate valve and enable probe changeout while maintaining vacuum integrity.

## CONCLUSION

This probe positioner has turned out to be a low technology, inexpensive, easy to implement device that enables 3D data sets to be acquired with a minimum of resources. Data taken with this probe positioner can be found in several recent publications.[1–5] At present we are constructing a larger version with a rectangular flange that allows substantially more travel ($>$10–20 cm) in the *y*-*z* directions. It is vacuum sanitary, although the *O*-ring seal approach is not as clean or as bakeout compatible as would be possible using bellows. This same idea could be implemented with bellows at a substantially larger cost. For instance a welded bellows, or even several stacked and joined bellows with a 6 in. bore attached to an 8 in. conflat flange could be used to allow movement in all the *x*-*y*-*z* directions. A radial throw of approximately 30 cm in the *x* direction, and 10–15 cm in the *y*-*z* plane could be achieved. However then a more elaborate alignment and positioning mechanism than the one described here would be required.

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