

Magnetic Flux-Surface mapping using an Electron Beam Diagnostic at the HSX Stellarator

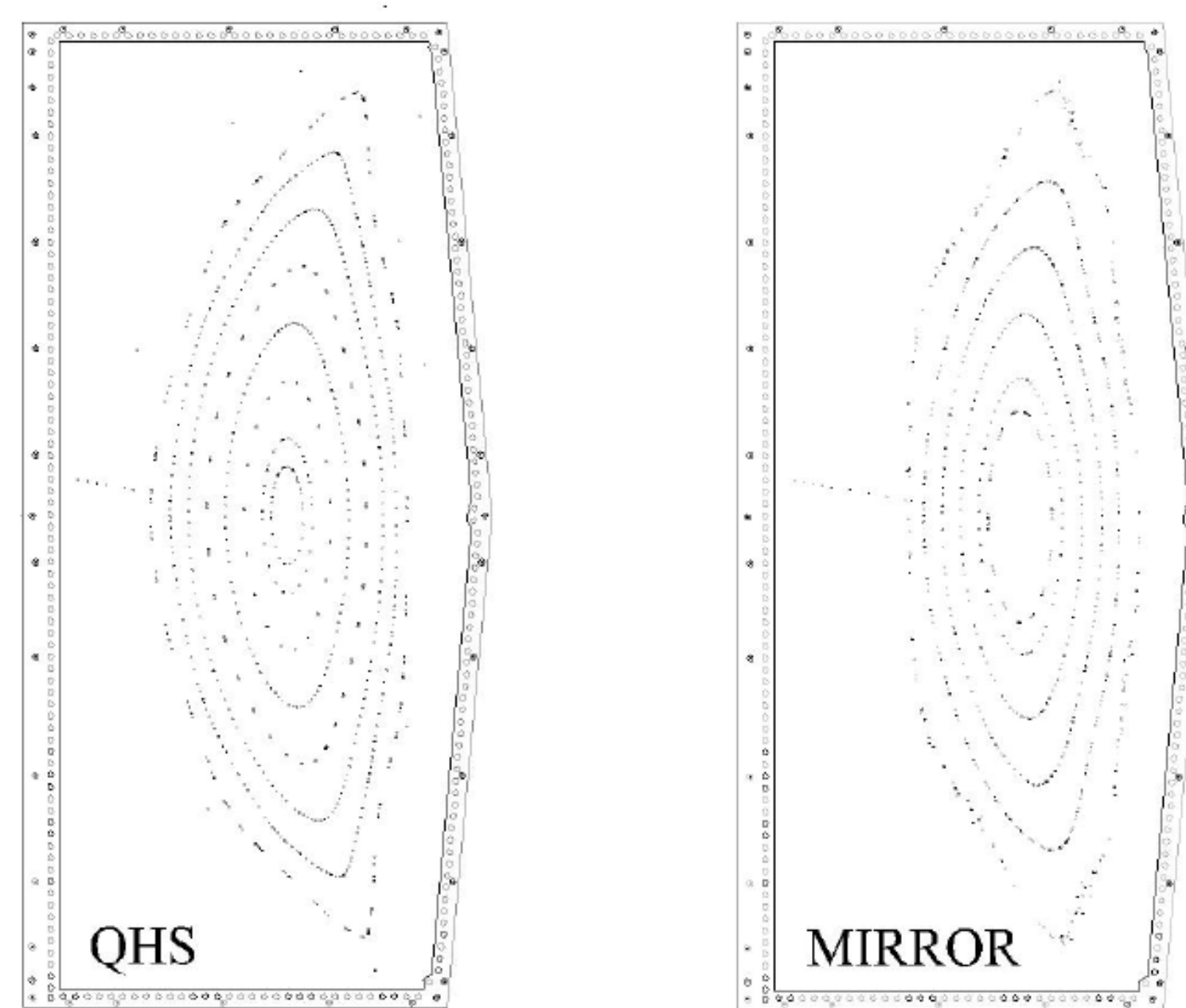
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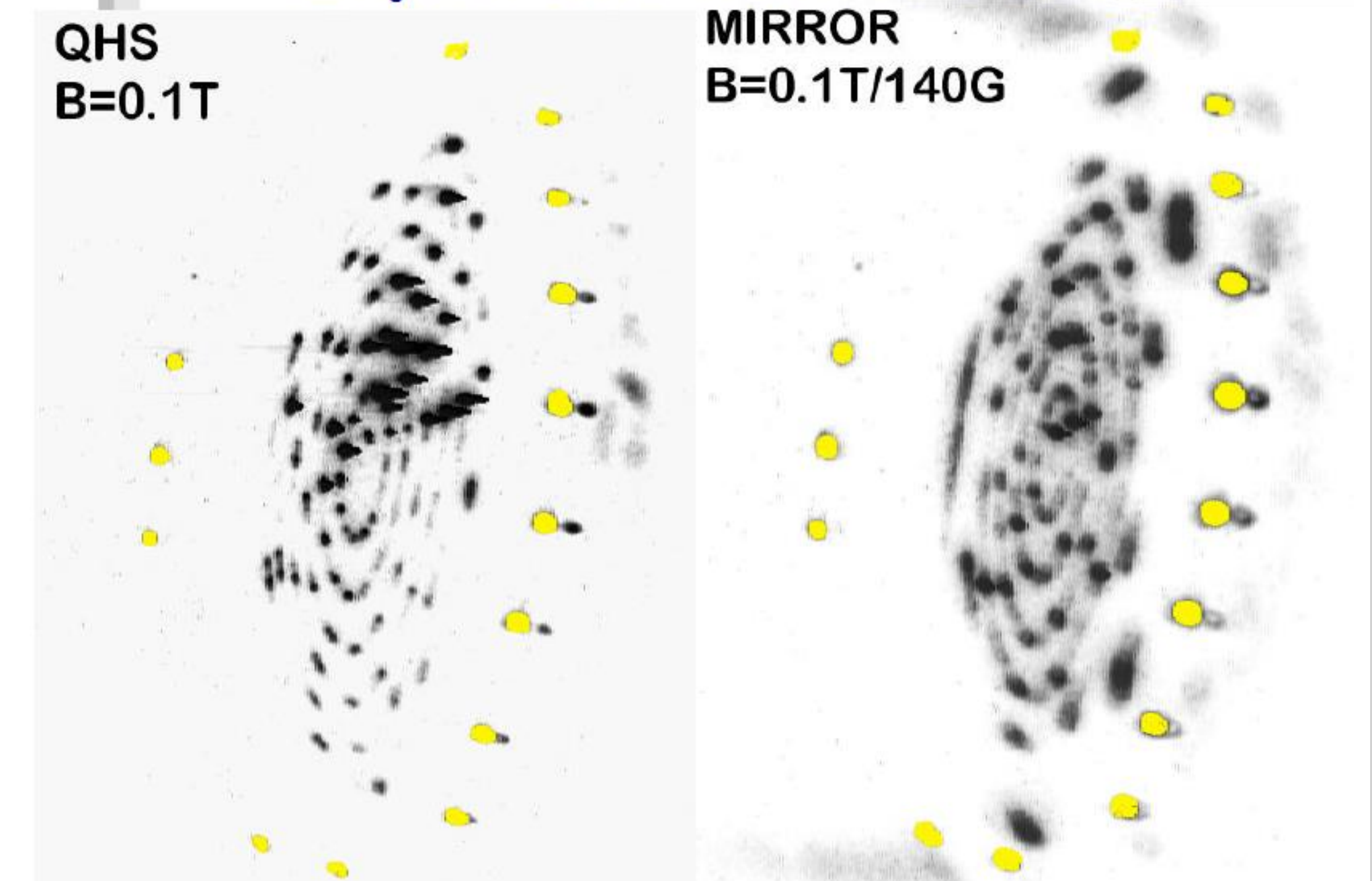
Motivation

- In stellarators, small uncertainties of the alignment of the magnetic field coils can cause a significant degradation of confinement properties
- Field-line mapping is therefore used to check for possible deviations from the expected magnetic field structure
- An electron gun has been developed and commissioned
- Together with a field mapping probe, it is to be installed at HSX
- These two assemblies will be used to reverify and map flux surfaces

Numerical Calculation

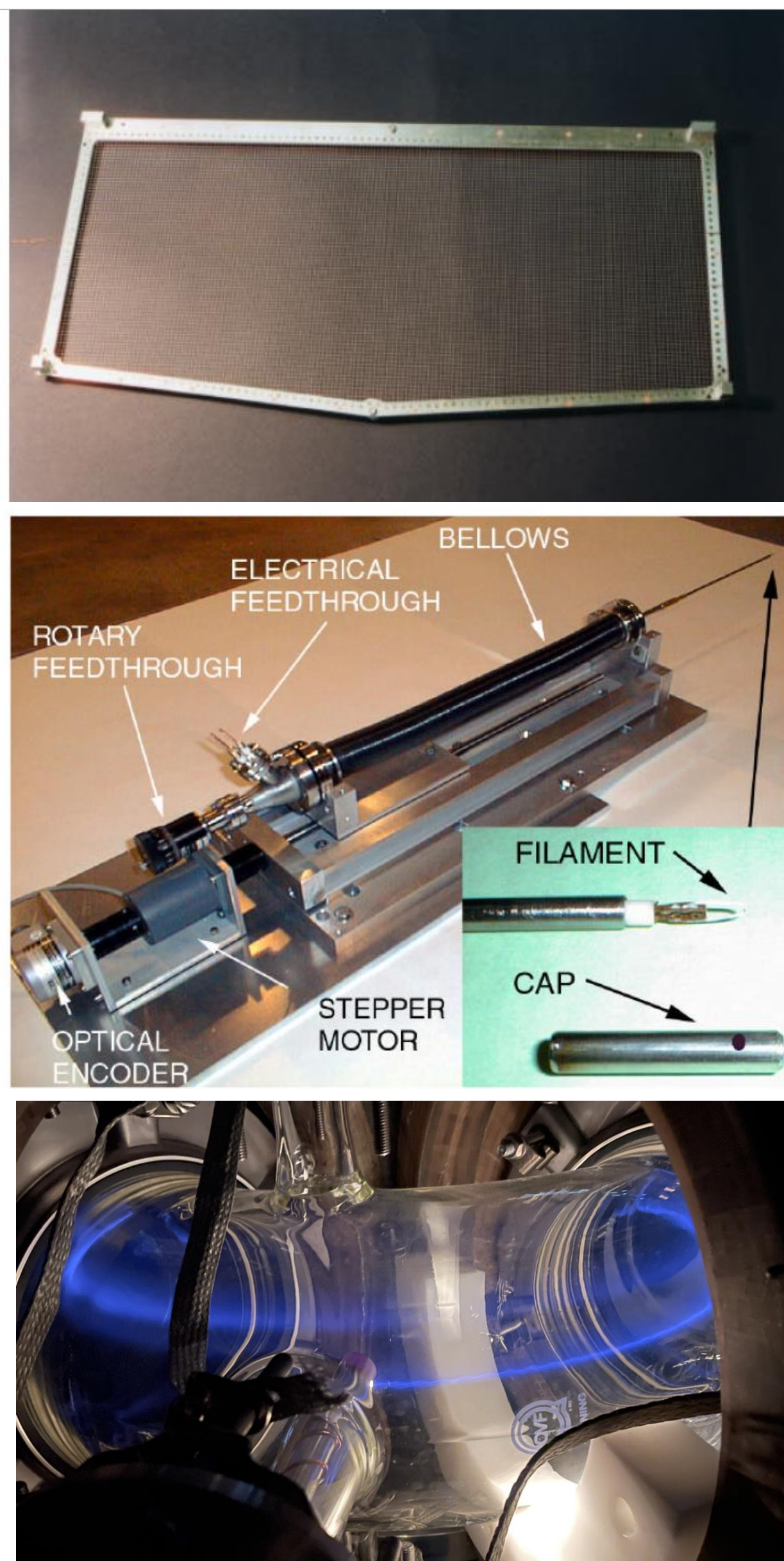


Experimental Results



Previous Work

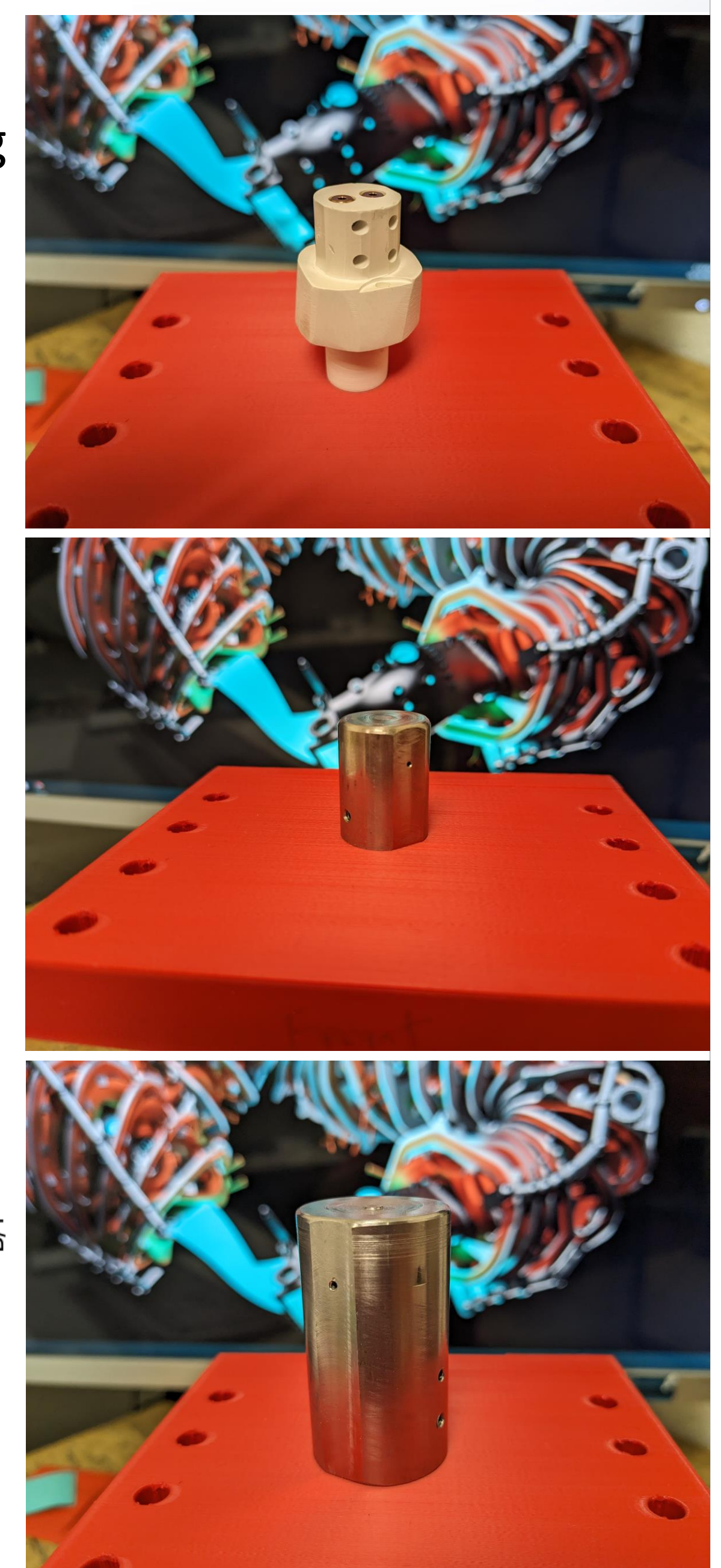
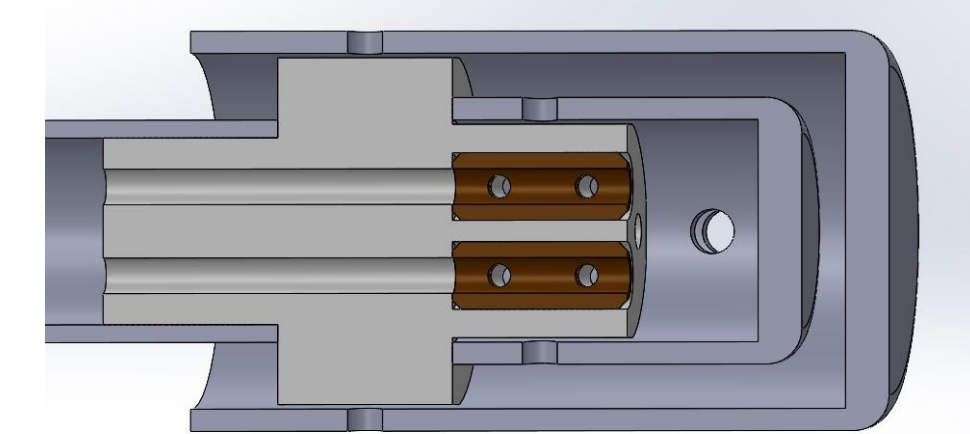
- Initial field mapping at HSX was over 20 years ago
 - Also used an electron gun
 - Aluminum frame and copper mesh with phosphor coating used to map flux surfaces
- Aluminum frame and copper mesh
 - Mesh prevented other operations of HSX
 - Installation and removal delayed further operations
- A different electron gun was tested at the Helicor experiment
 - Similar design to initial mapping gun used
 - Design and development of a newer electron gun was decided upon after results
 - Improved collimated beam and better flexibility were the main drivers



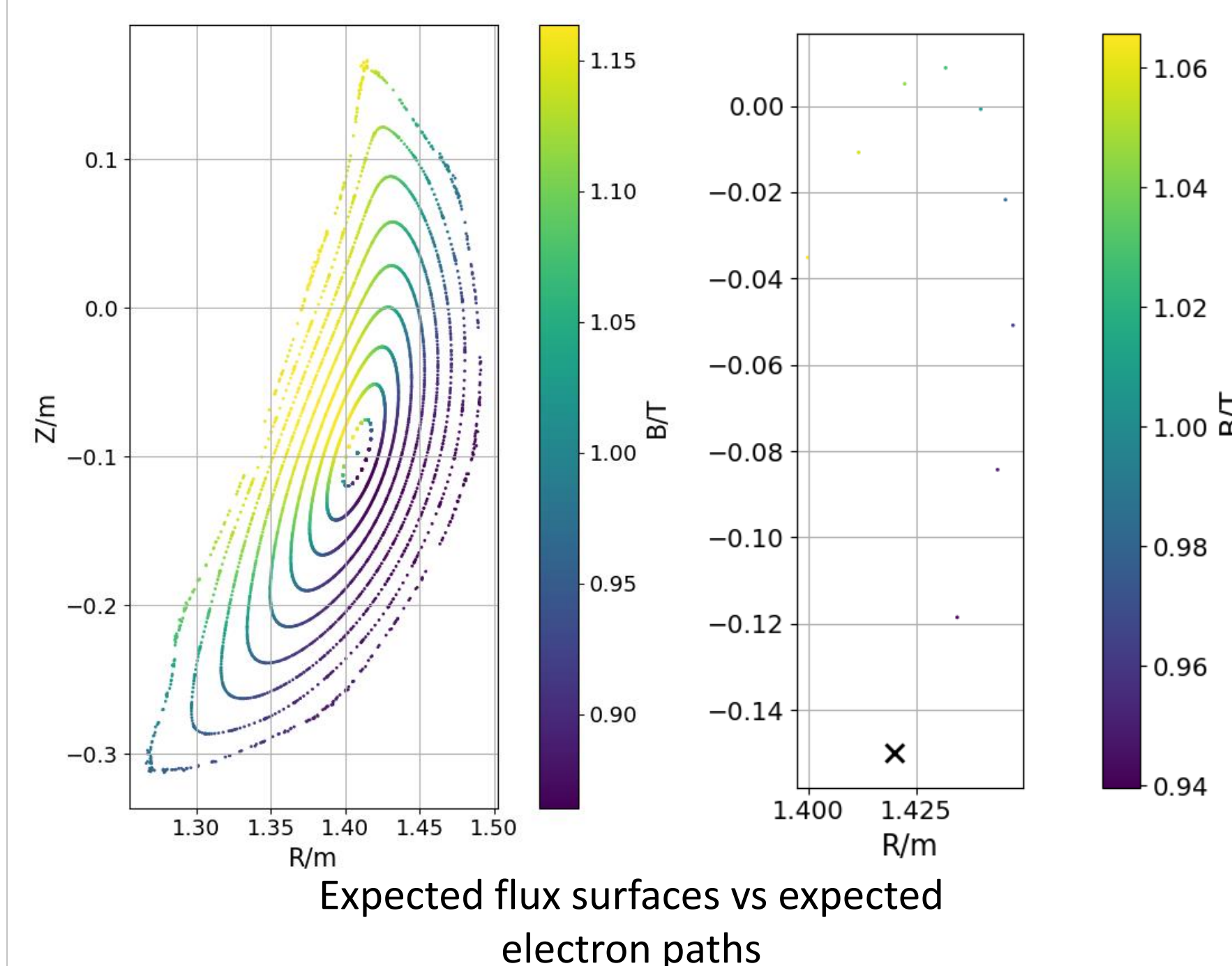
Aluminum Mapping Frame, Initial Electron Gun Setup, and Electron Gun test results at the Helicor experiment

New Electron Gun

- Design implements a Wehnelt Cylinder to help collimate the electron beam
- Dimensions were minimized to reduce shadowing effects
 - Field Line Following code used to determine resolution and shadowing
- Specifications
 - 1.125" \varnothing Outer Cap
 - 0.750" \varnothing Wehnelt Cylinder
 - 0.063" Walls
 - 0.032" Flats
- Inline connectors used to transition from magnet wire to a more flexible wire
 - 18 Gauge Wires
 - Vacuum conditions and high temperatures dictated choices

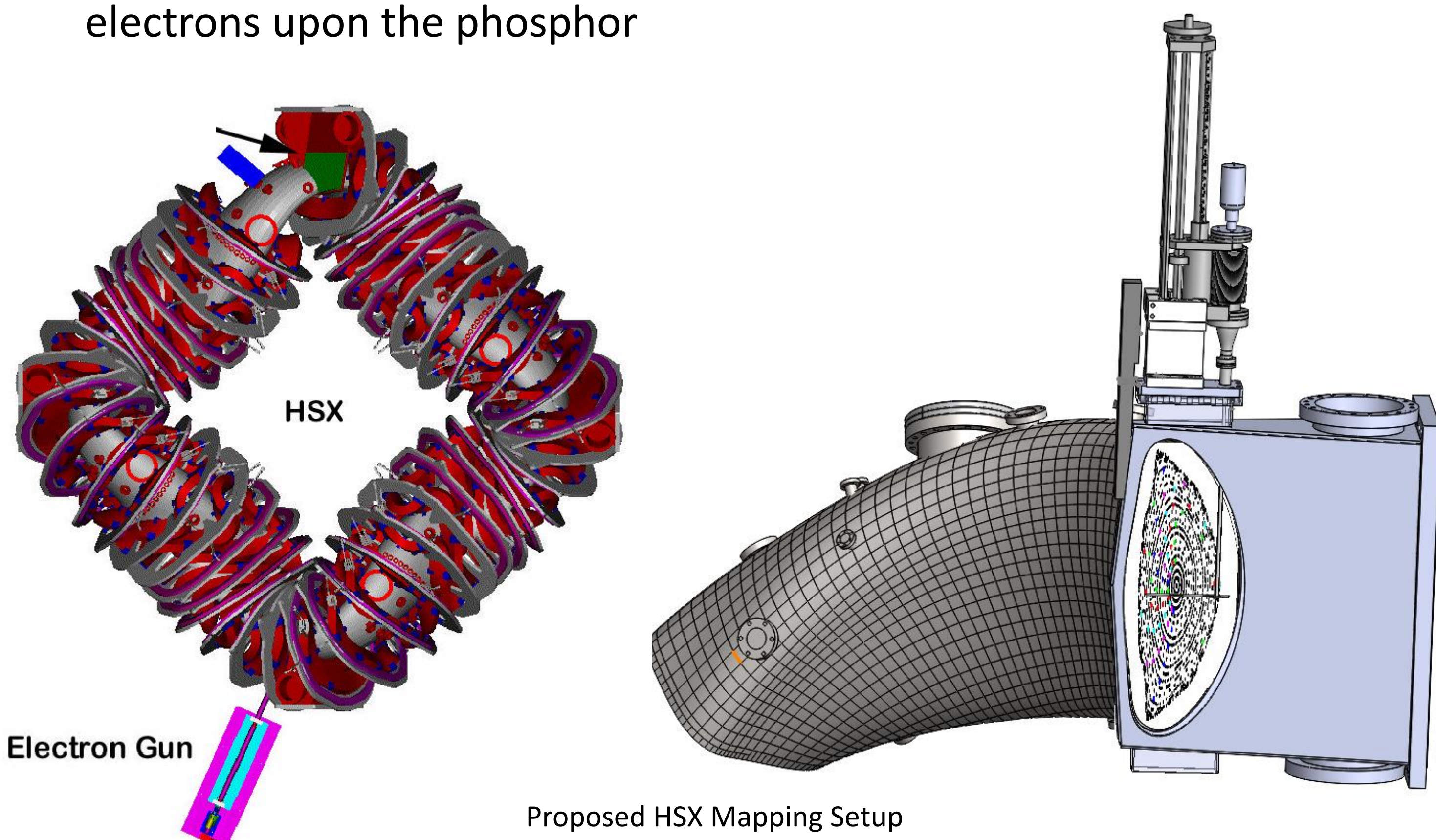


CAD Design of tip, Boron Nitride Insulator, Wehnelt Cylinder, and Outer Cap



Mapping & Verification

- New design of a sweeping phosphor probe designed and partially manufactured
 - Able to stow away during plasma operation
 - Sweeps over half the flux surfaces, which will give the full flux map due to the symmetry of HSX
- Mapping probe to be mounted on one of HSX's four box ports
 - Manually operated with a linear shift mechanism
- Electron gun will be mounted on a further port
 - It will be swept independently of the probe to get a full picture of the flux surface
- Mapping will be visually done by recording glowing impact points of electrons upon the phosphor



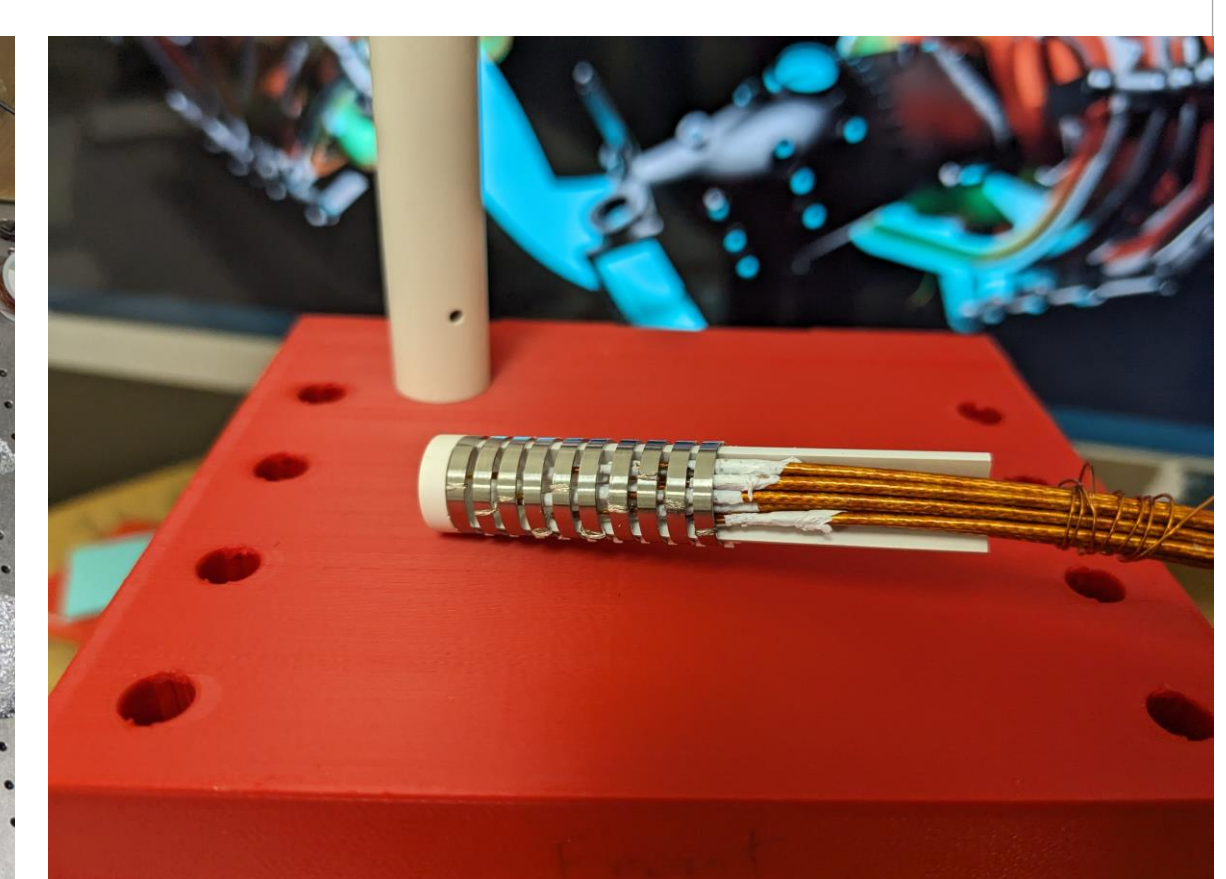
Proposed HSX Mapping Setup

Future Work

- Determine feasibility of alternative field mapping probes
 - Set of capacitive rings can remove need of phosphor rod
 - Phosphor can "poison" vacuum conditions during plasma operation
- Finish manufacturing and testing of current field mapping probe
 - Test against calculated results with electron gun
- Fine tune anything necessary to the gun and probe
 - Revisit designs if needed
 - New electron gun was designed to have multiple configurations by rotating caps by 90°



Newly assembled electron gun



Experimental set of 10 capacitive rings and protective cap

V. Sakaguchi, F.S.B. Anderson, "Initial results of magnetic surface mapping in HSX", 1999