Design of a Charge-Breeder Ion Source for Texas A&M University

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Outline

- Purpose
- Design Rules
- Design Features
- Summary

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Purpose

The purpose of this project was to design and construct a charge-breeder ECR source for the Texas A&M University Cyclotron.

An additional goal was to provide a test bed for developing technology and techniques specific to charge-breeder ECR ion sources

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Purpose

- Overall efficiency important
- Designed to be charge-breeder from the outset.
- Modular design facilitates swapping of major components for technology development.

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Design Rules

- Highest practical frequency
- "Copper" solenoids
- Maximize solenoid bore
- $B_{ext} \sim 2 \bullet B_{ecr}$
- $B_{min} \sim 0.8 \bullet B_{ecr}$
- $B_{inj} \geq 2 \bullet B_{ecr}$ (difficult)
- Maximize plasma chamber diameter
- Sextupole: $B_{wall} \sim 2 \bullet B_{ecr}$

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Design Features

- No water-to-vacuum joints
- Put cooling channels between plasma chamber and sextupole
- Ample pumping of rf waveguide
- Modular design
- Mount charge-breeder on “rails” to facilitate maintenance.

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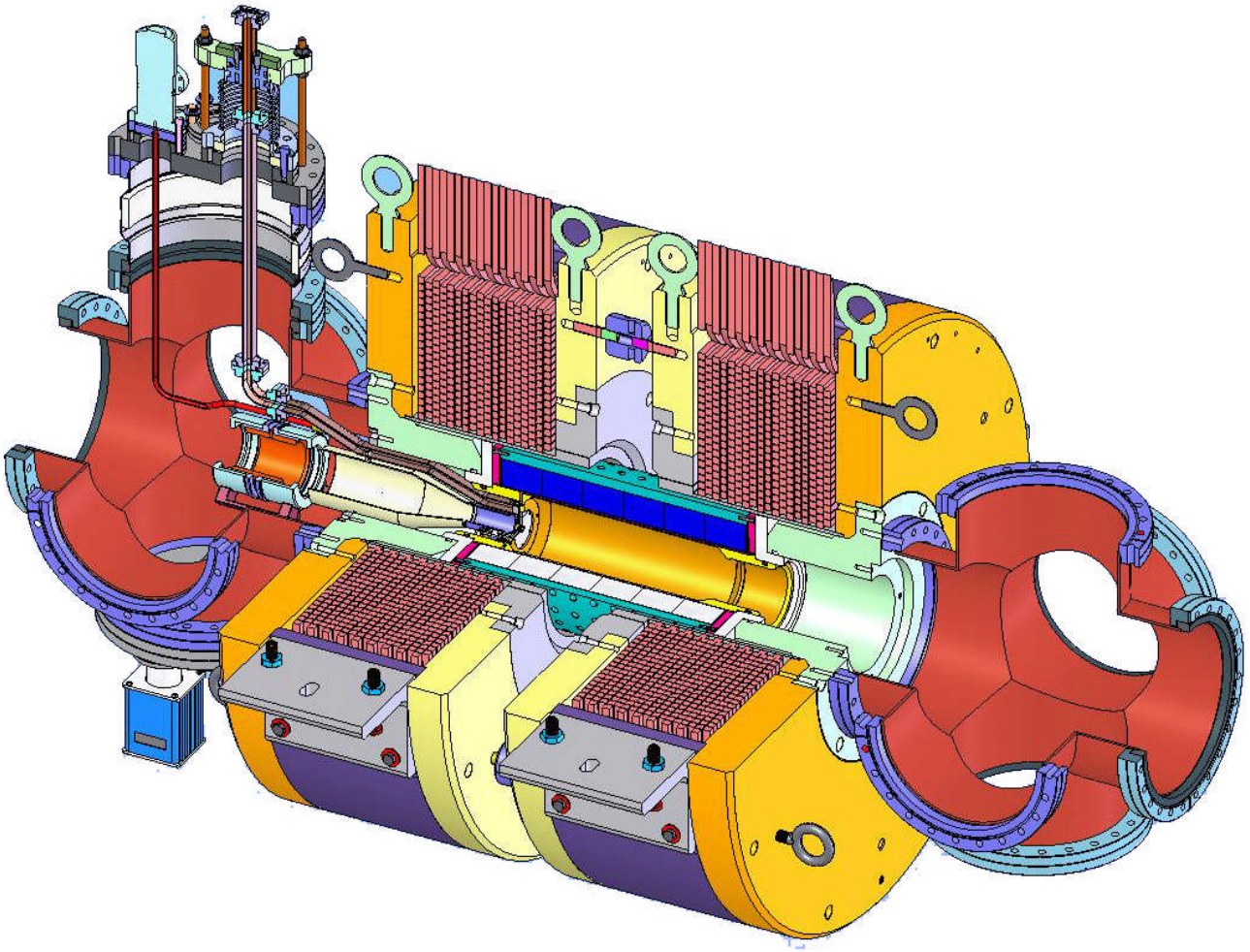
Design Features



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Solenoids

Solenoids based on AECR-U design

- Added more steel in endwalls
- Bore limited to 20 cm
- Added steel “plugs” ($B_{inj} \sim 2.5 \bullet B_{ecr}$)

Solenoids

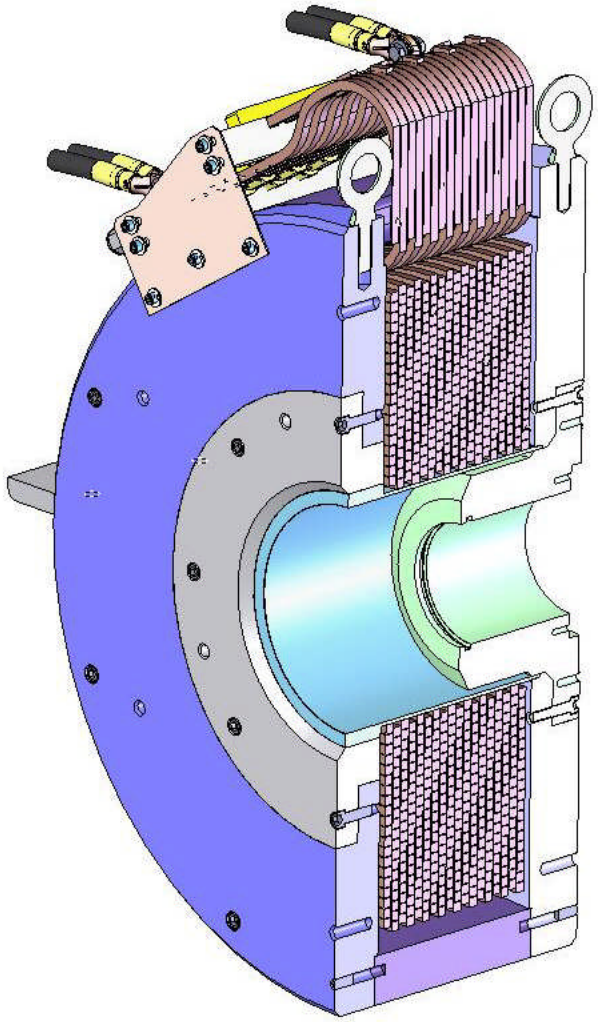
Solenoid Configuration

Replaceable plugs at both ends

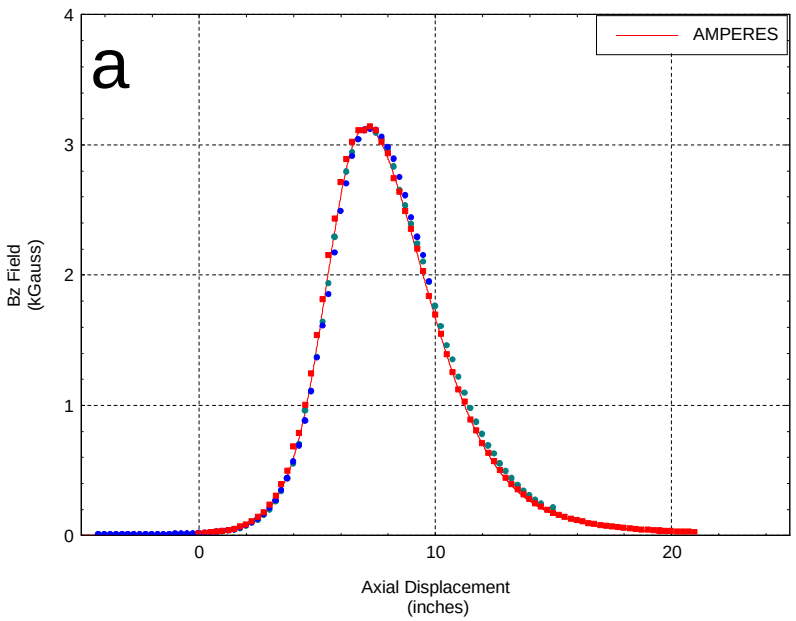
Facilitates changing mirror ratio and injection/extraction field magnitudes.

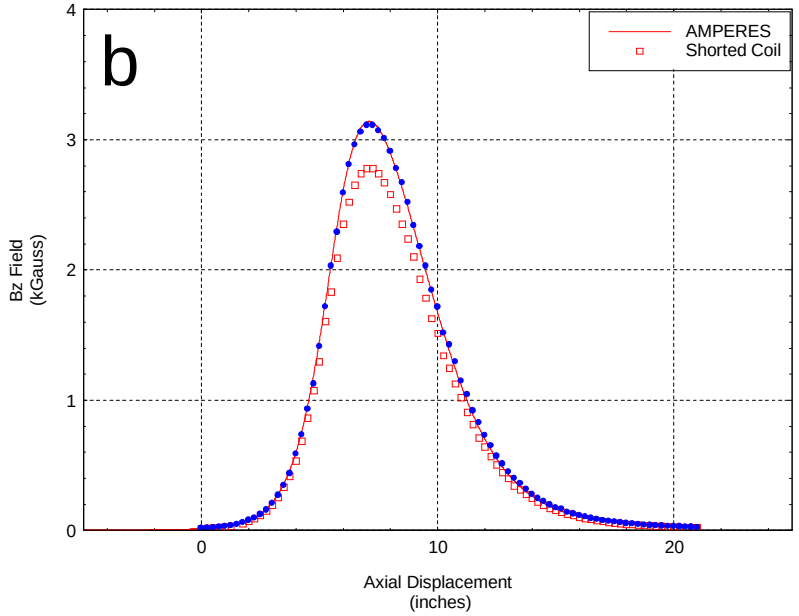
Polycarbonate bore tube

for HV isolation (copper foil for HV transient protection)



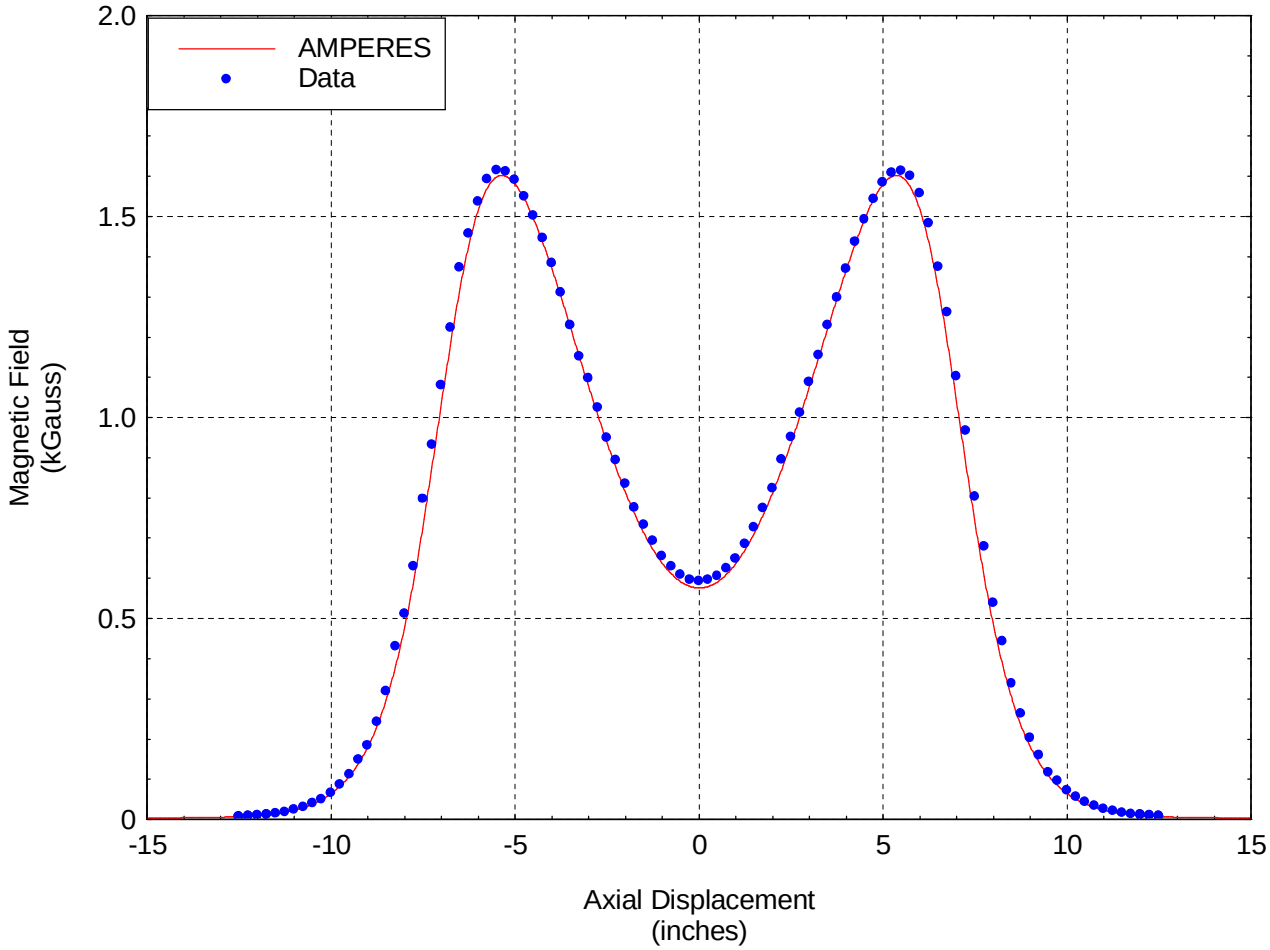
Solenoids





Solenoid Field Plots

Solenoids



ECR Solenoid Field Plot

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Sextupole

24-block Halbach configuration

9.5 cm ID x
19.2 cm OD x
30.0 cm long

Bwall ~ 2.2•Becr
No radial access
Bore and ends
"sealed"

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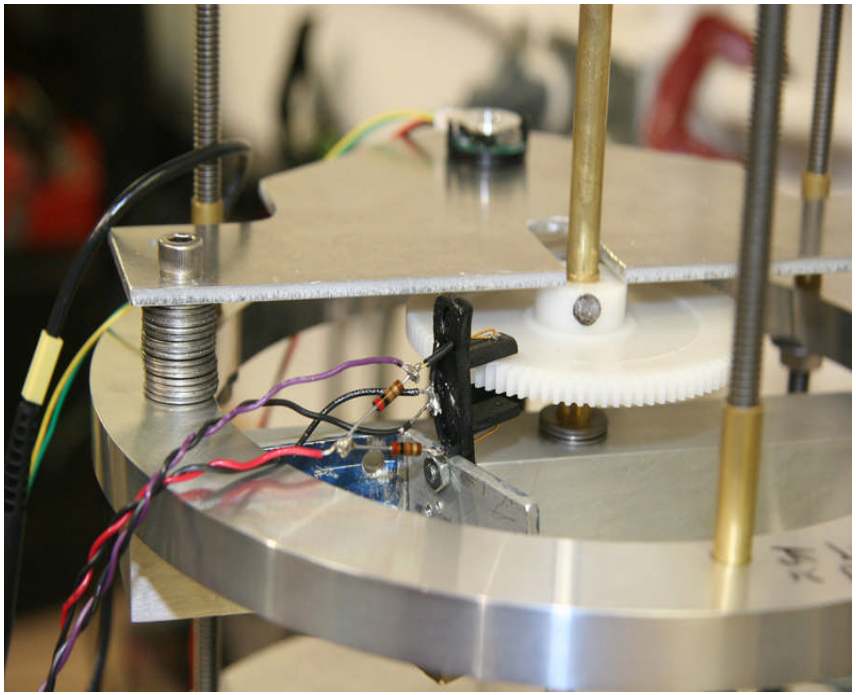
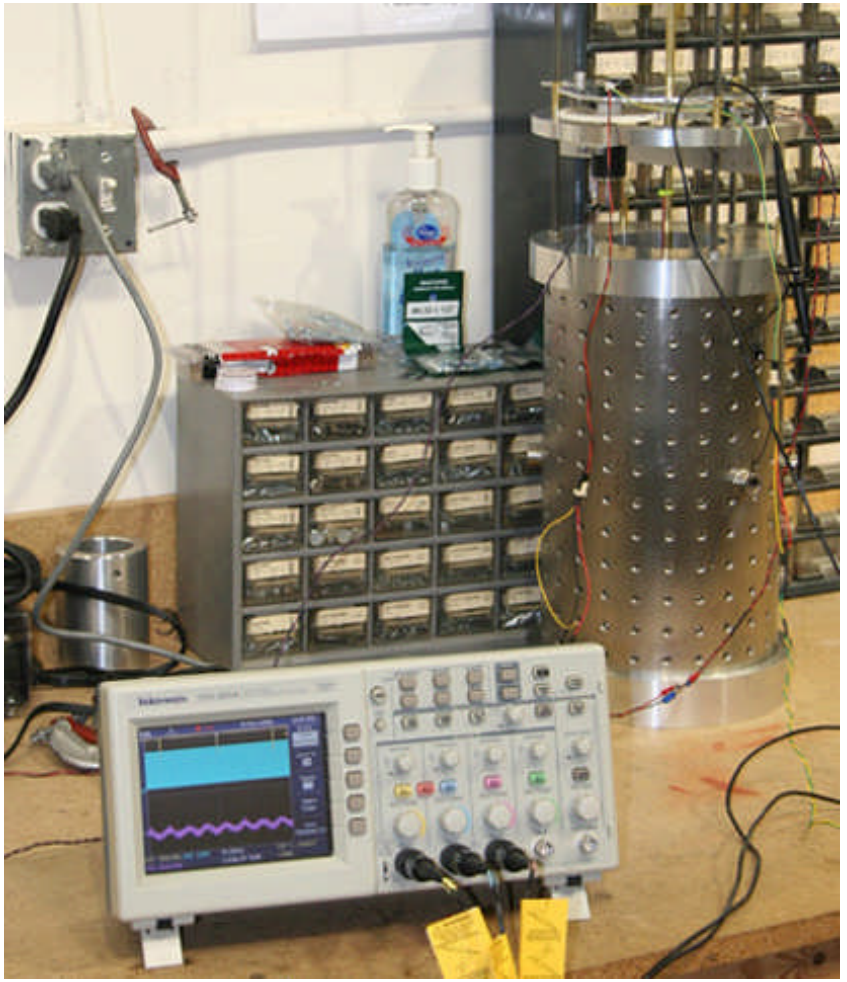
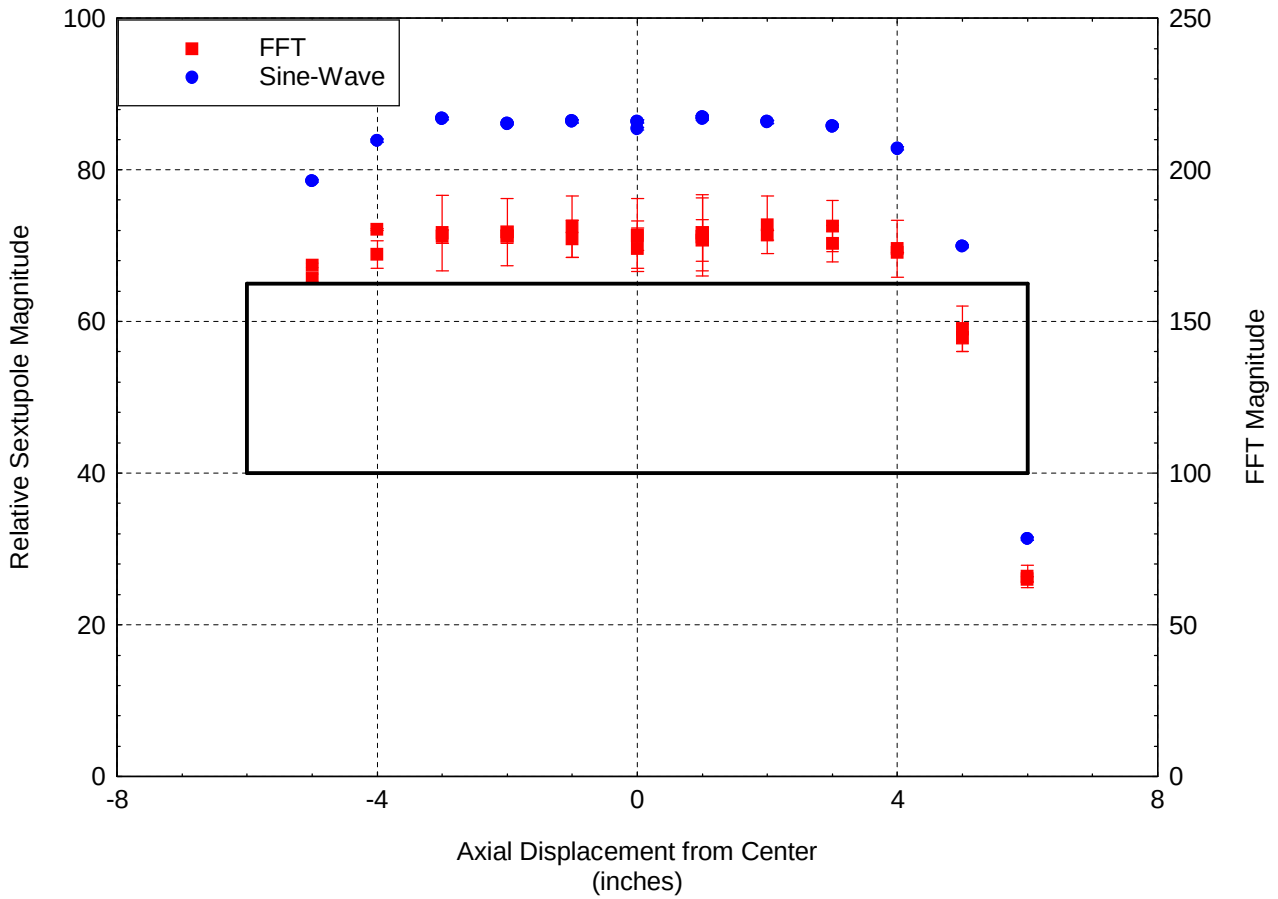
Sextupole

Measured sextupole field with rotating loop





Sextupole

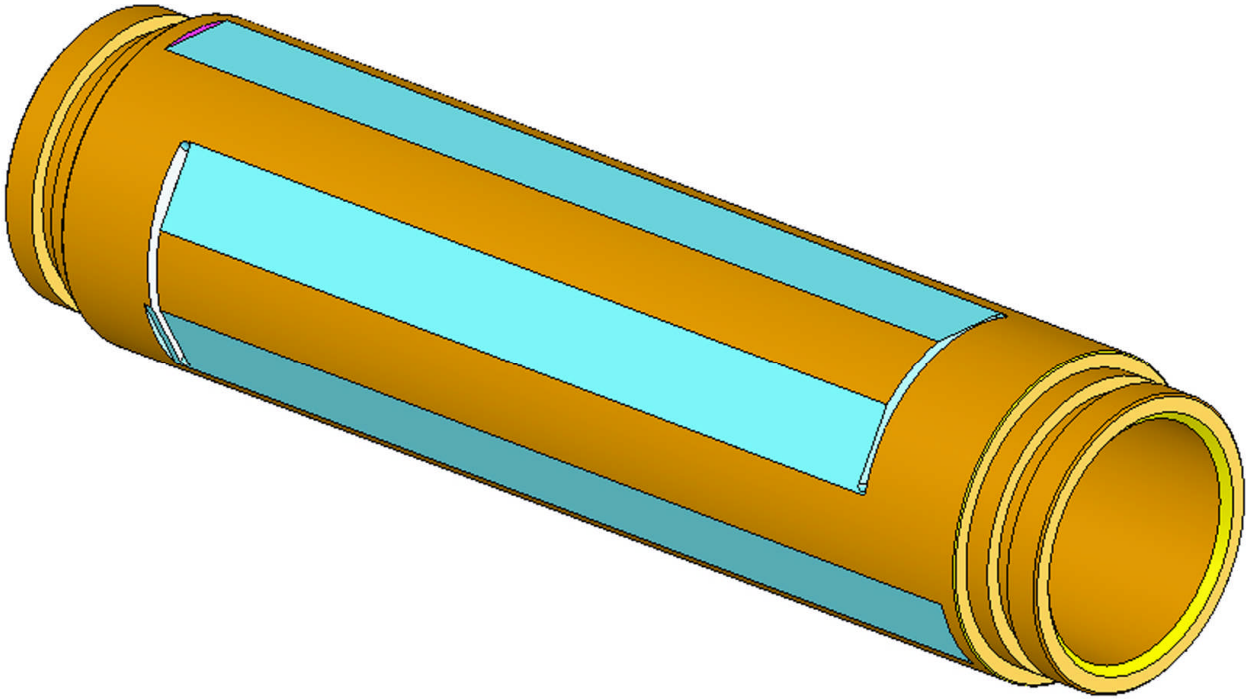


Measured sextupole field with rotating loop

Plasma Chamber

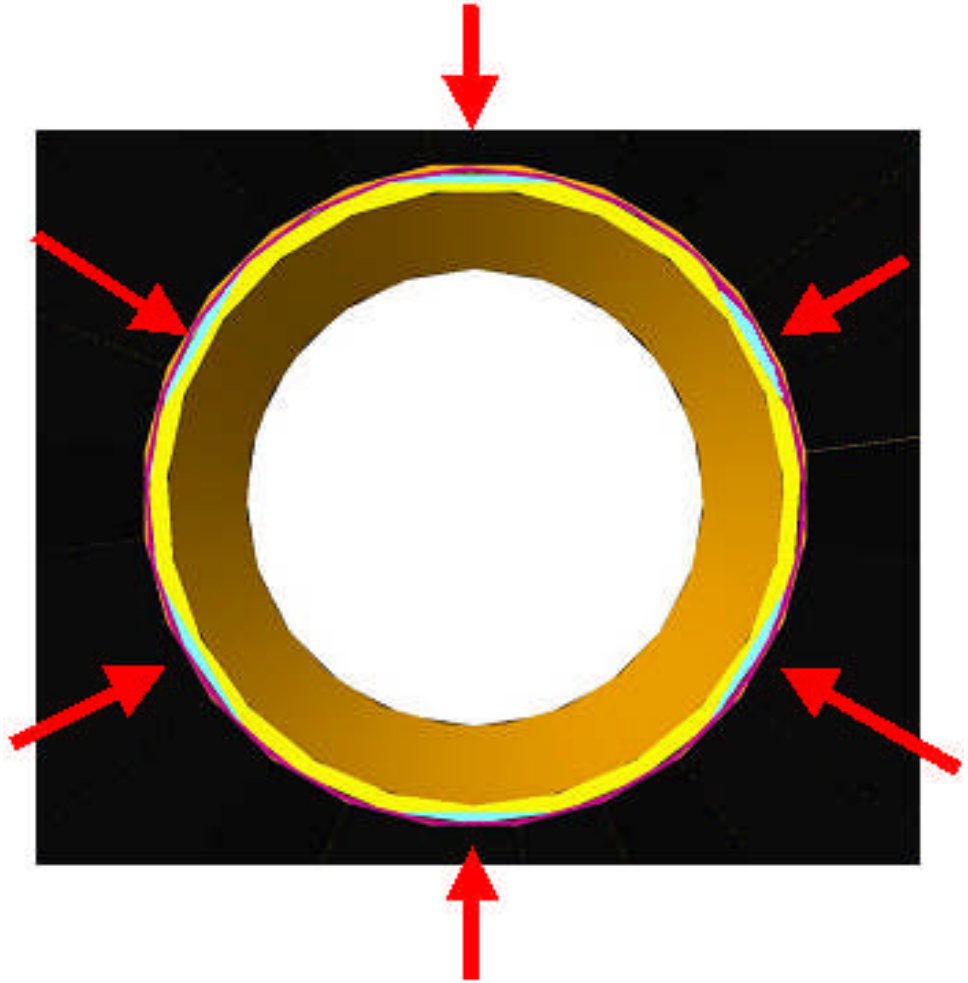
- Easily replaced, low-cost item
- 6061 Aluminum
- 9 cm ID

Plasma Chamber



Cut “flats” on OD of plasma chamber for water cooling channels.
Puts cooling between magnet and source of heat.

Plasma Chamber



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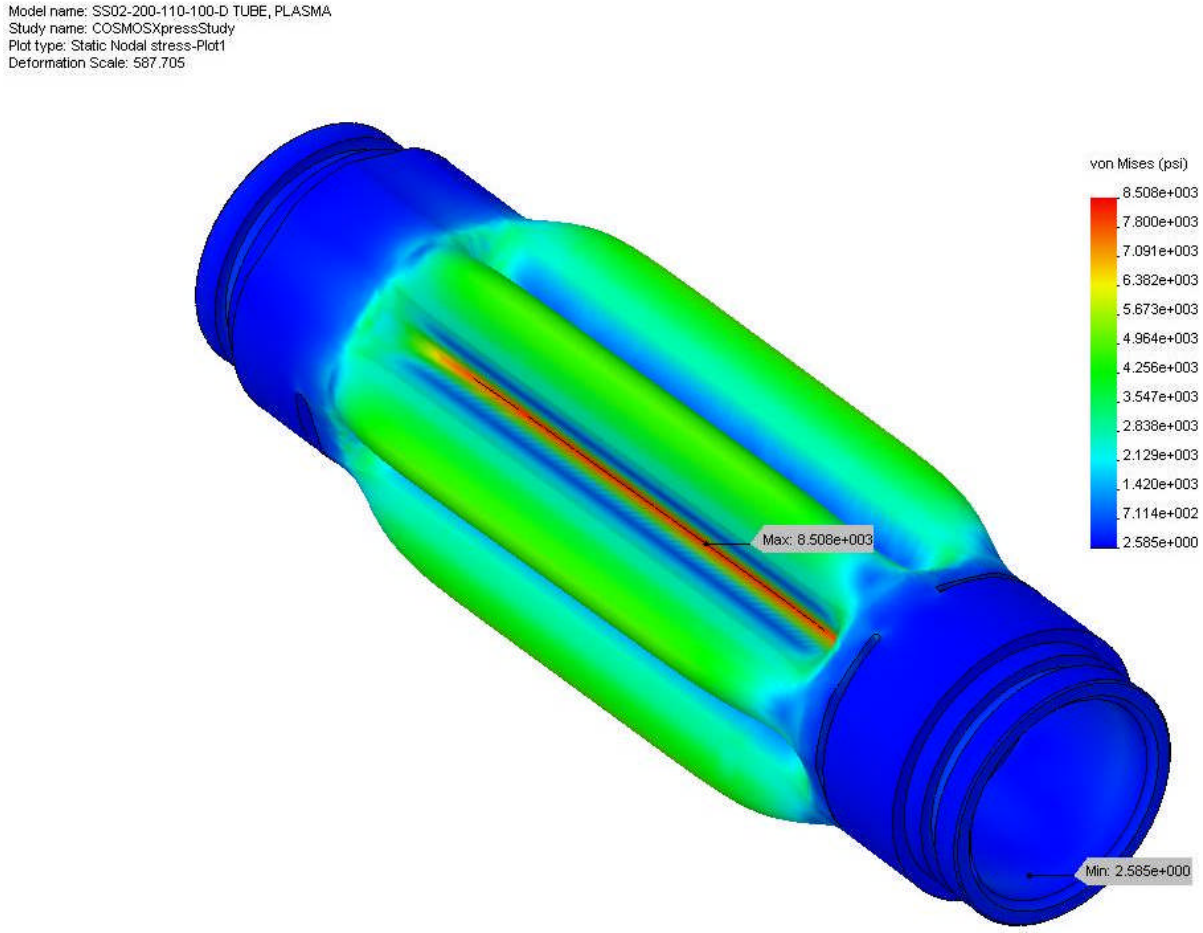
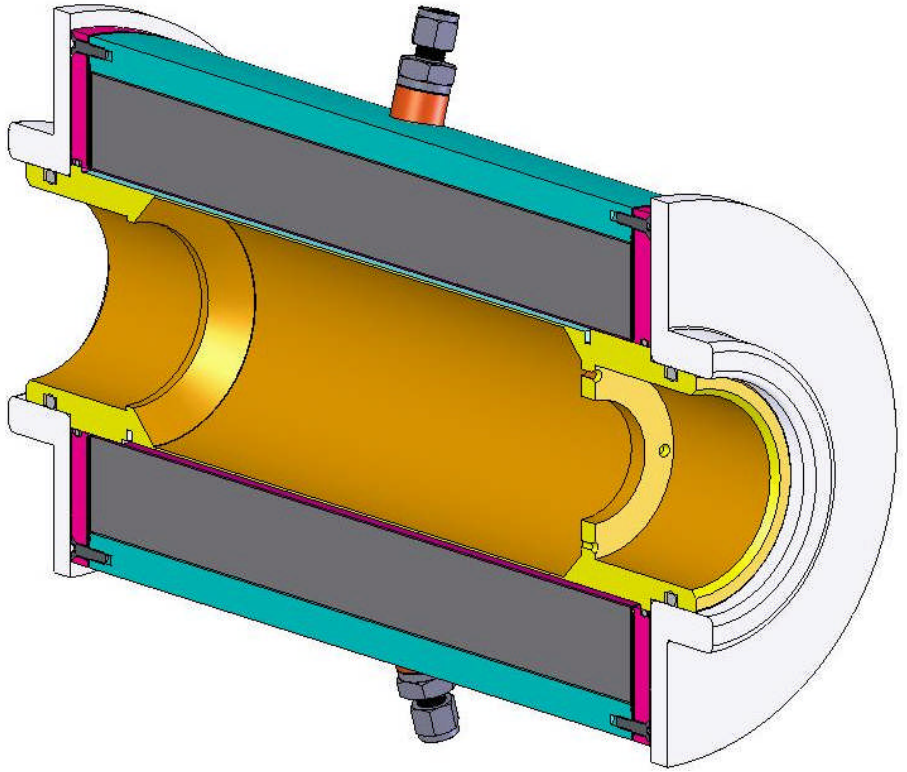


Stress analysis of plasma tube with 75 psi water.
Ratio of max stress to yield ~4.8

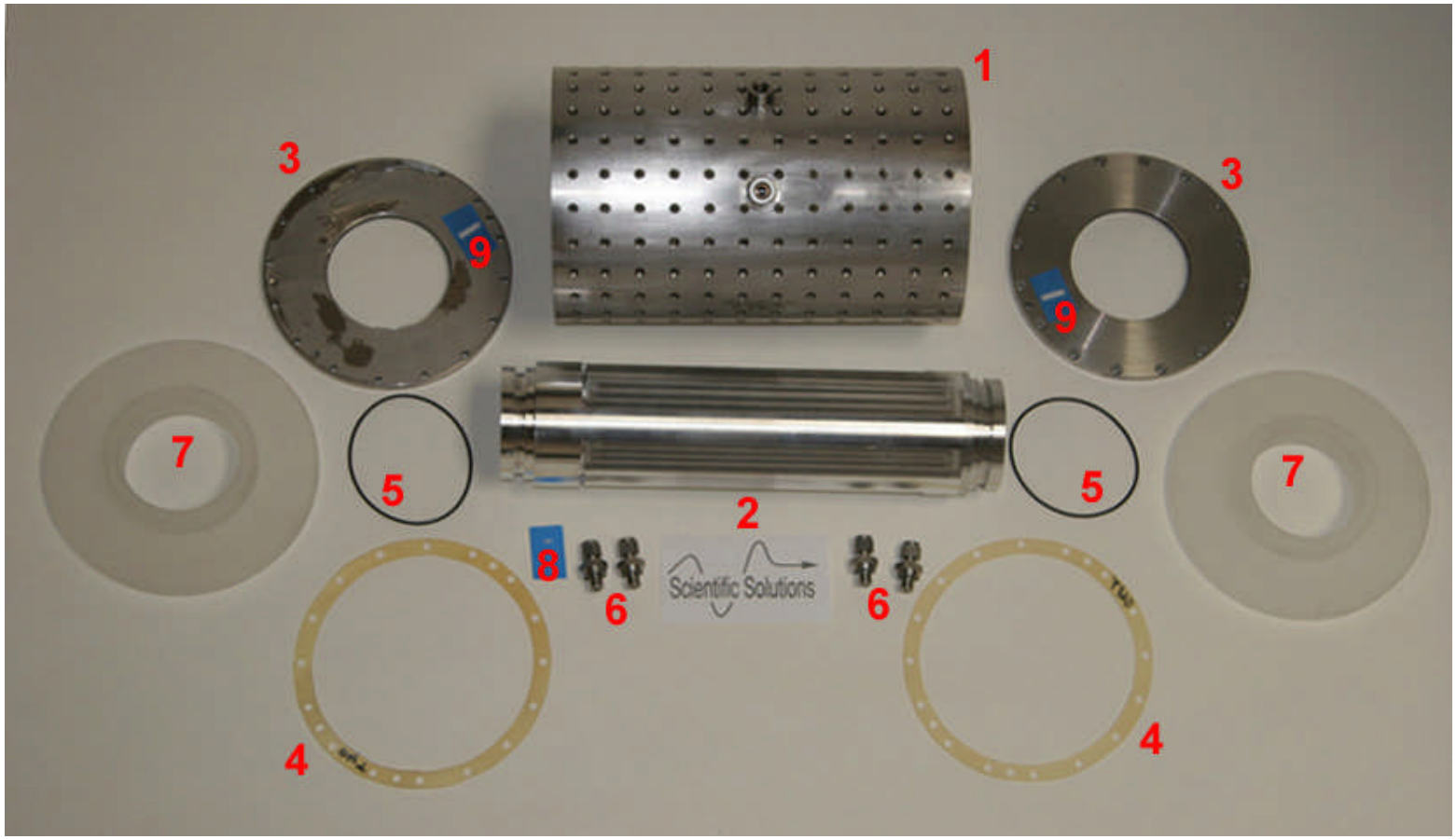
HV Assembly

Plasma Chamber
Sextupole Assembly
Rexolite HV insulators



No water-to-vacuum joints
Vacuum seal on OD of plasma tube and OD of HV insulators (no fasteners required and automatically self-aligns).

HV Assembly



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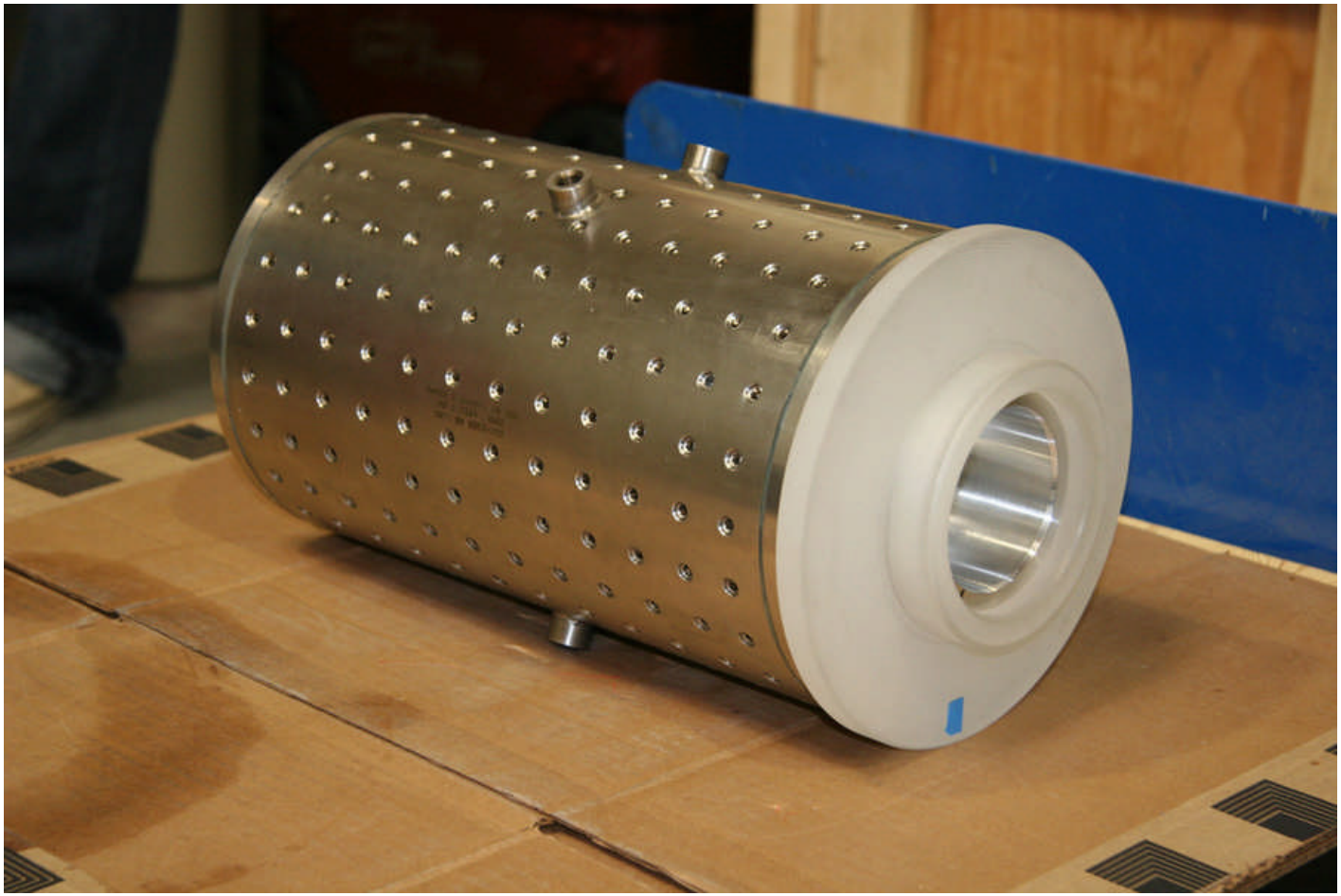
HV Assembly



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HV Assembly

One solenoid mounted on rails to facilitate installation of HV assembly.

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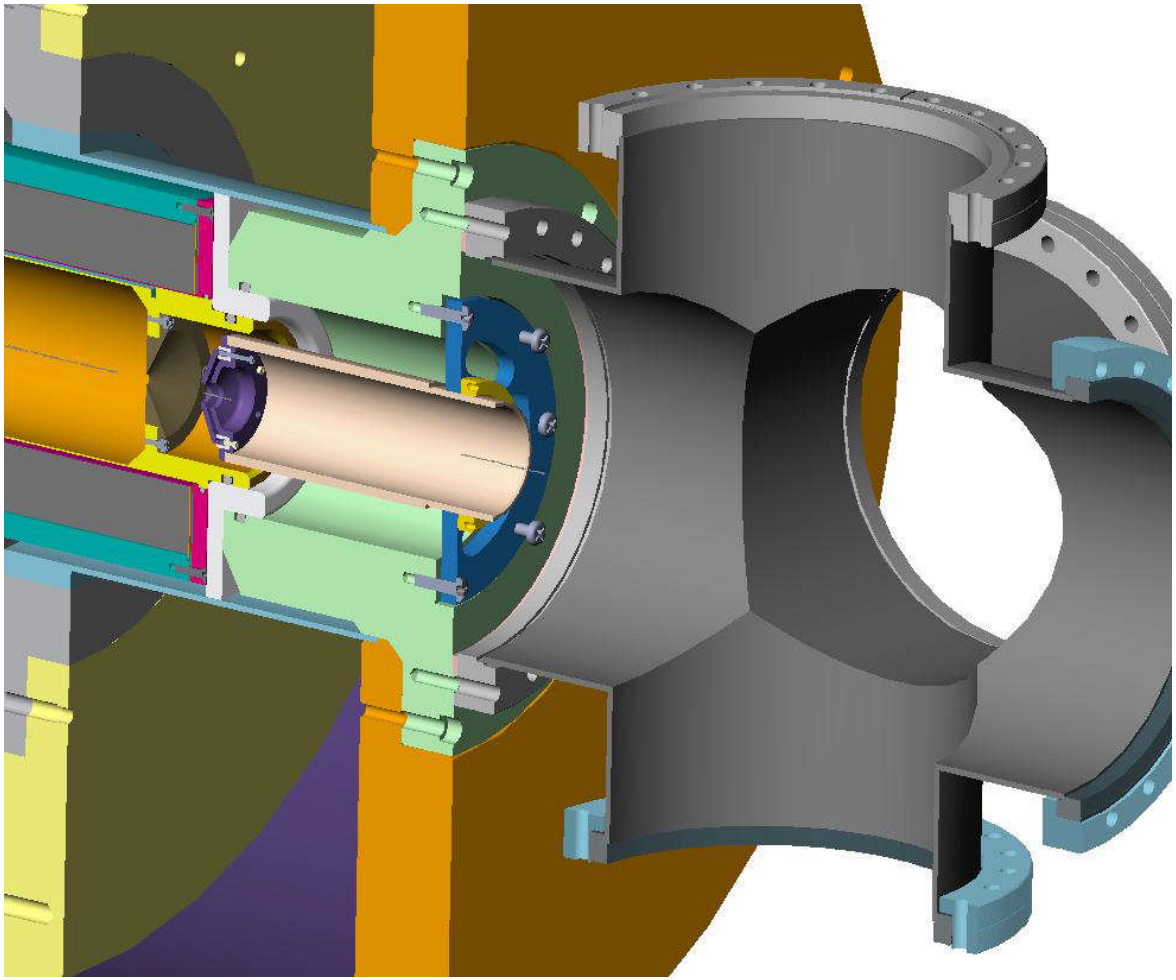
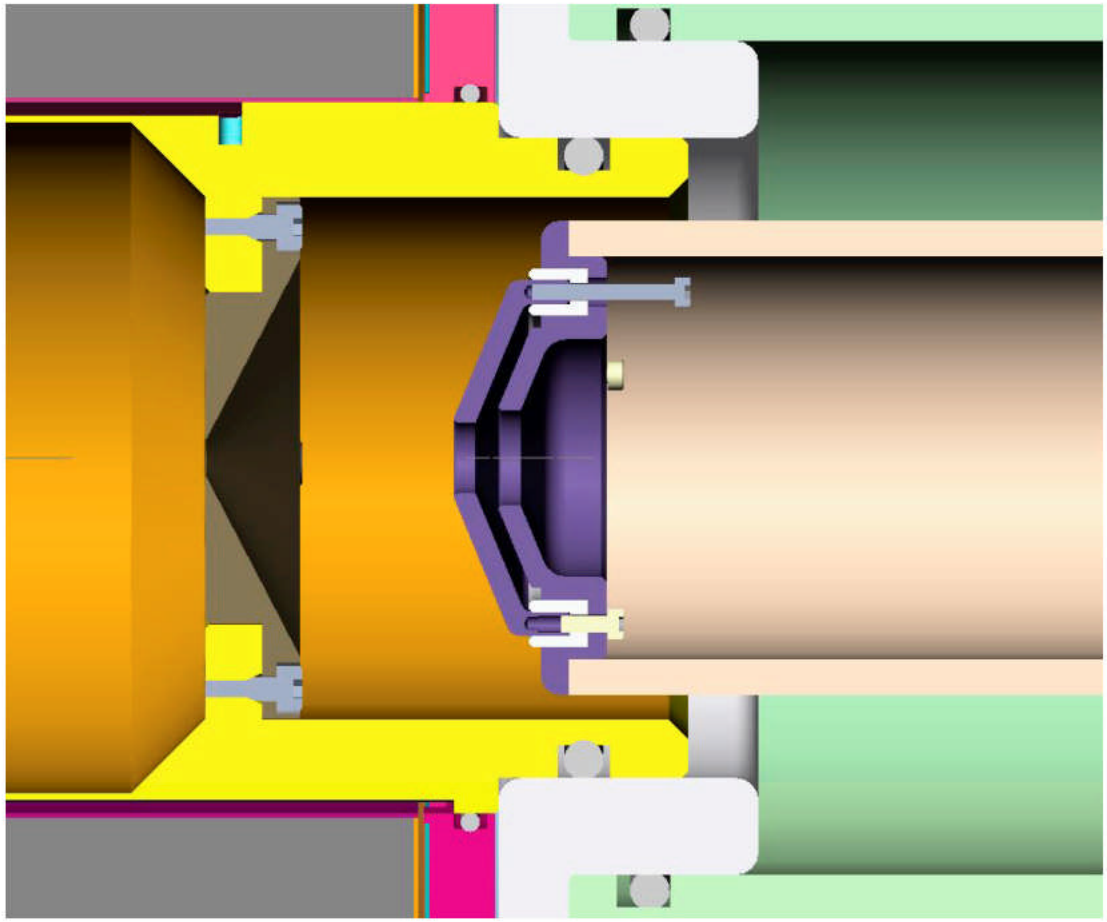
Extractor



Extractor End of Charge-Breeder

Extractor

Extractor design is conventional “puller” assembly with the addition of an electron trap electrode.



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Extractor

Puller Assembly

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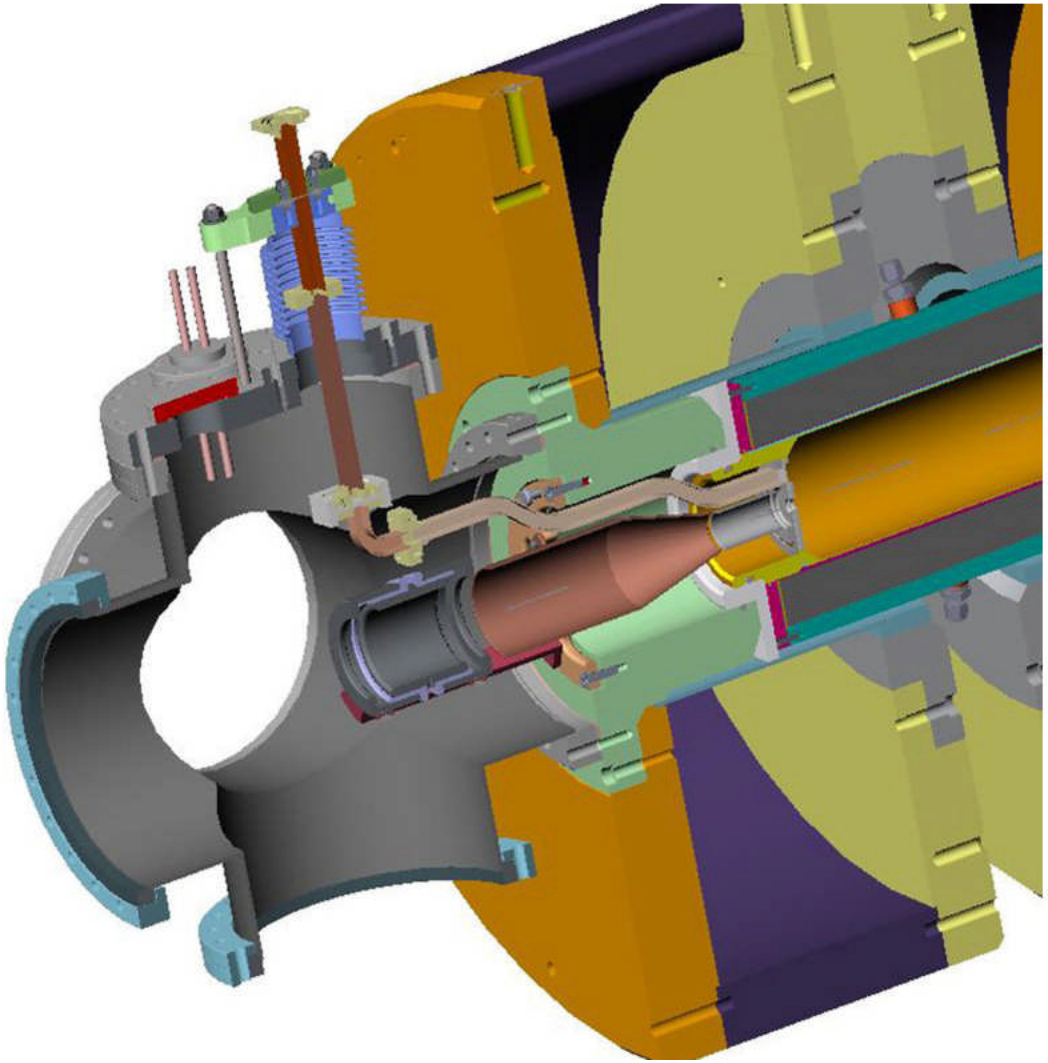
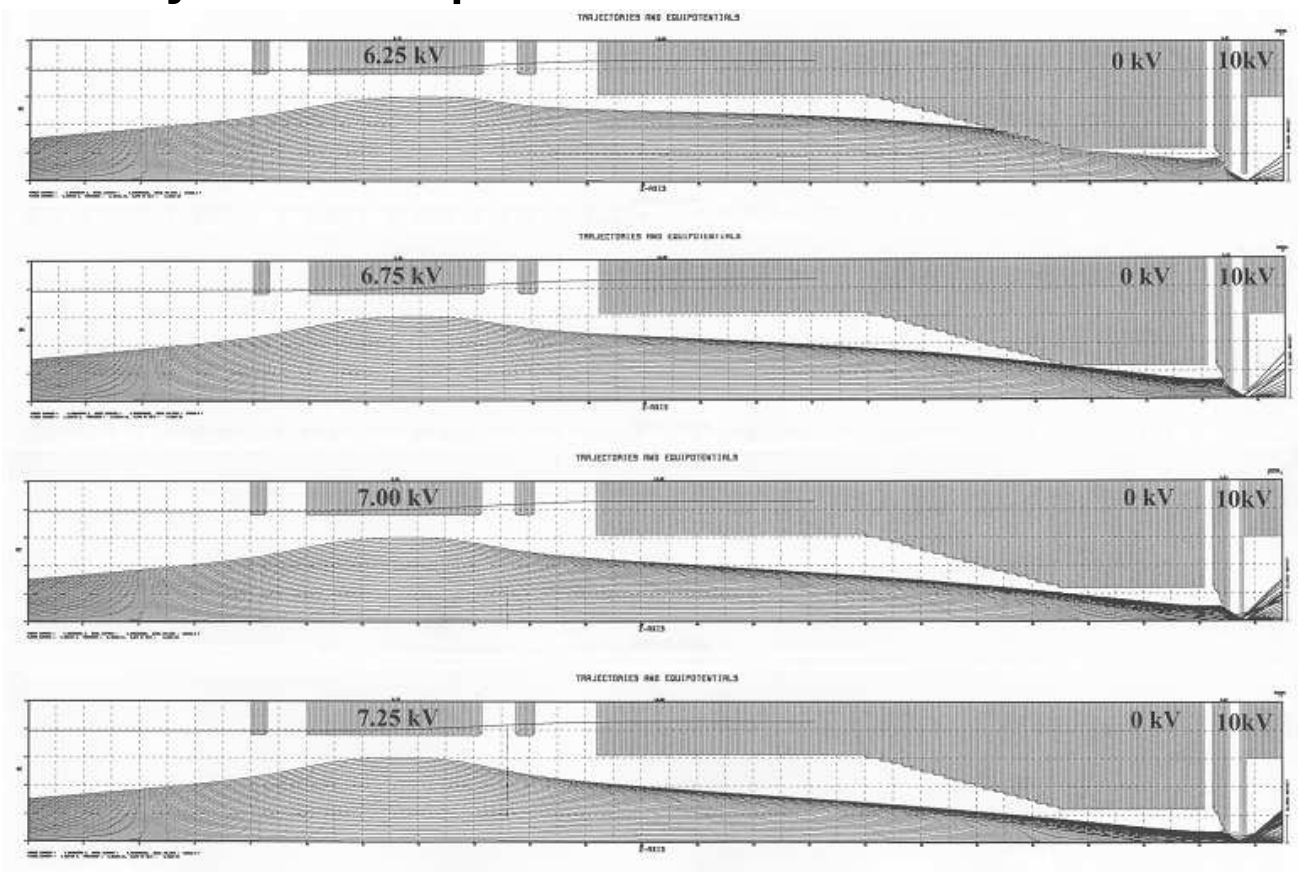
Injector

Injection end of charge-breeder.



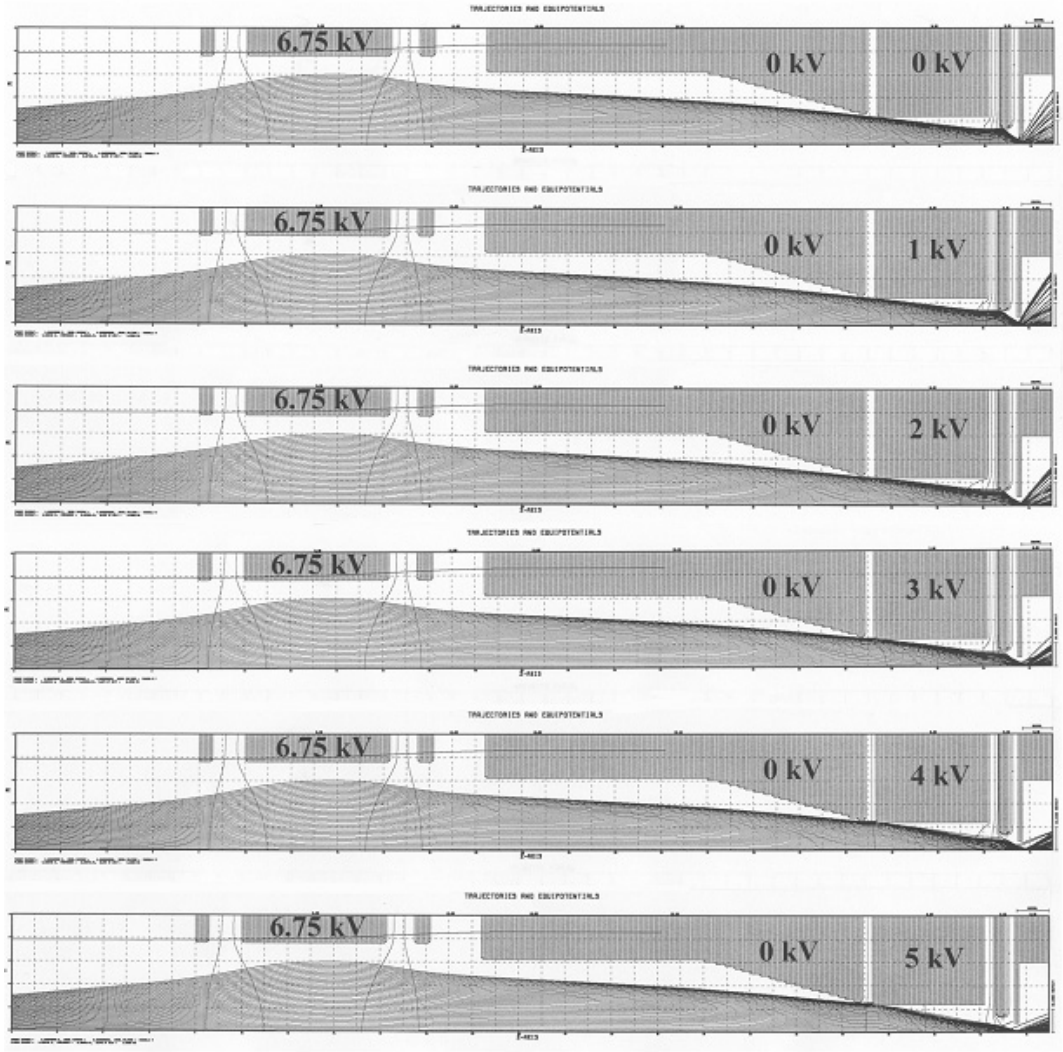
Injector

One Einzel lens is insufficient to match beam into the injection aperture.



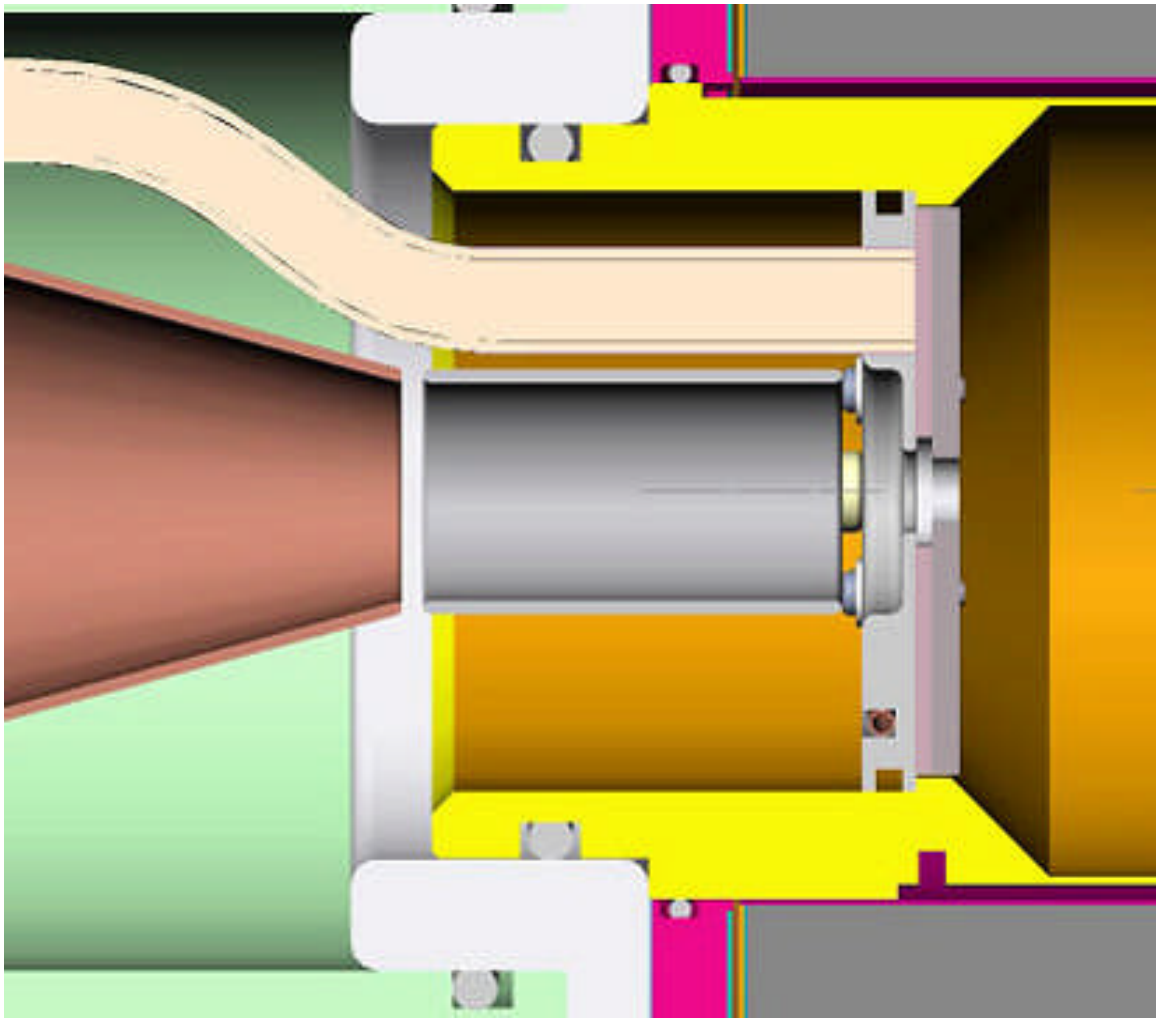
Injector

Two Einzel lenses works well.

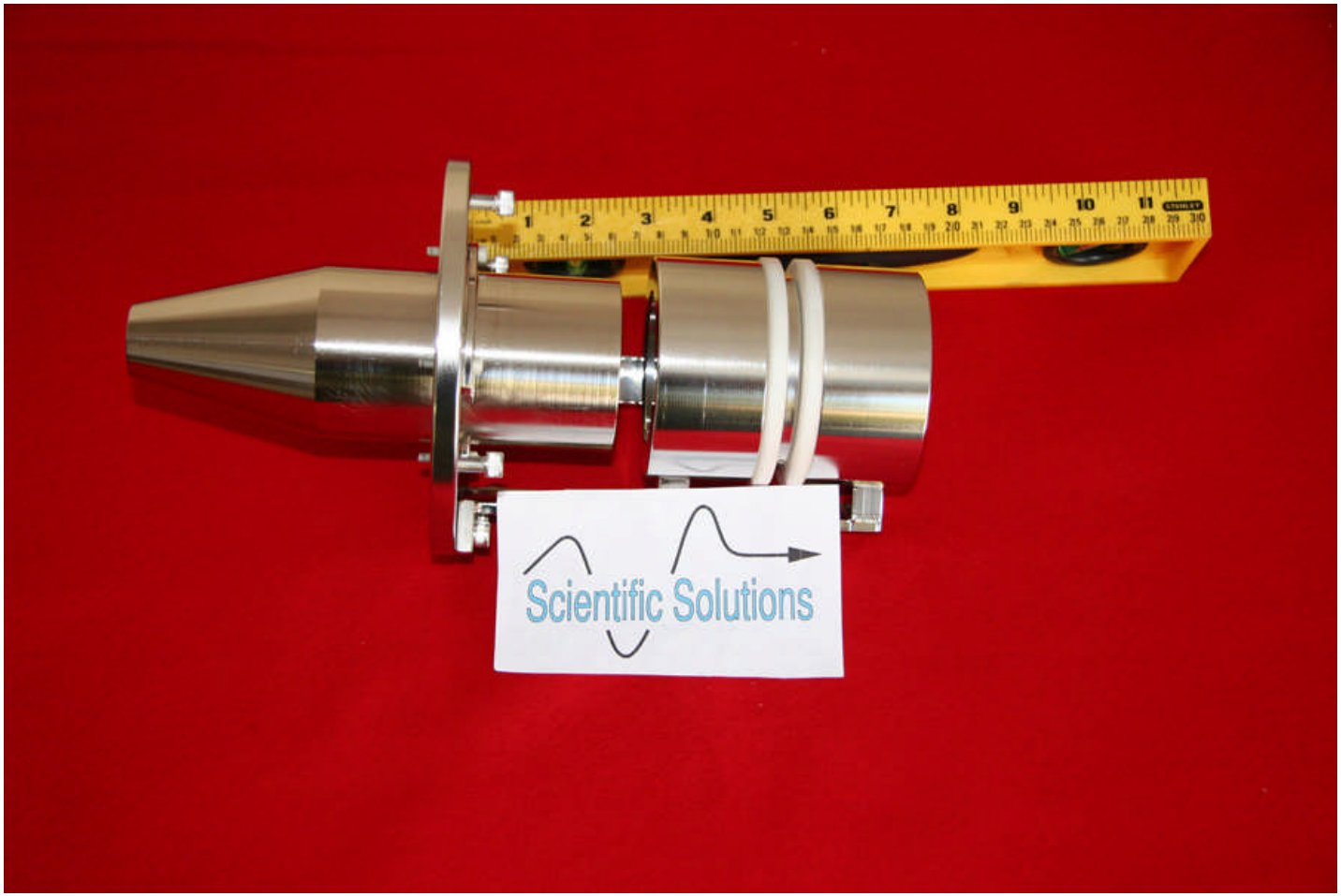


Injector

Injection end of charge-breeder.

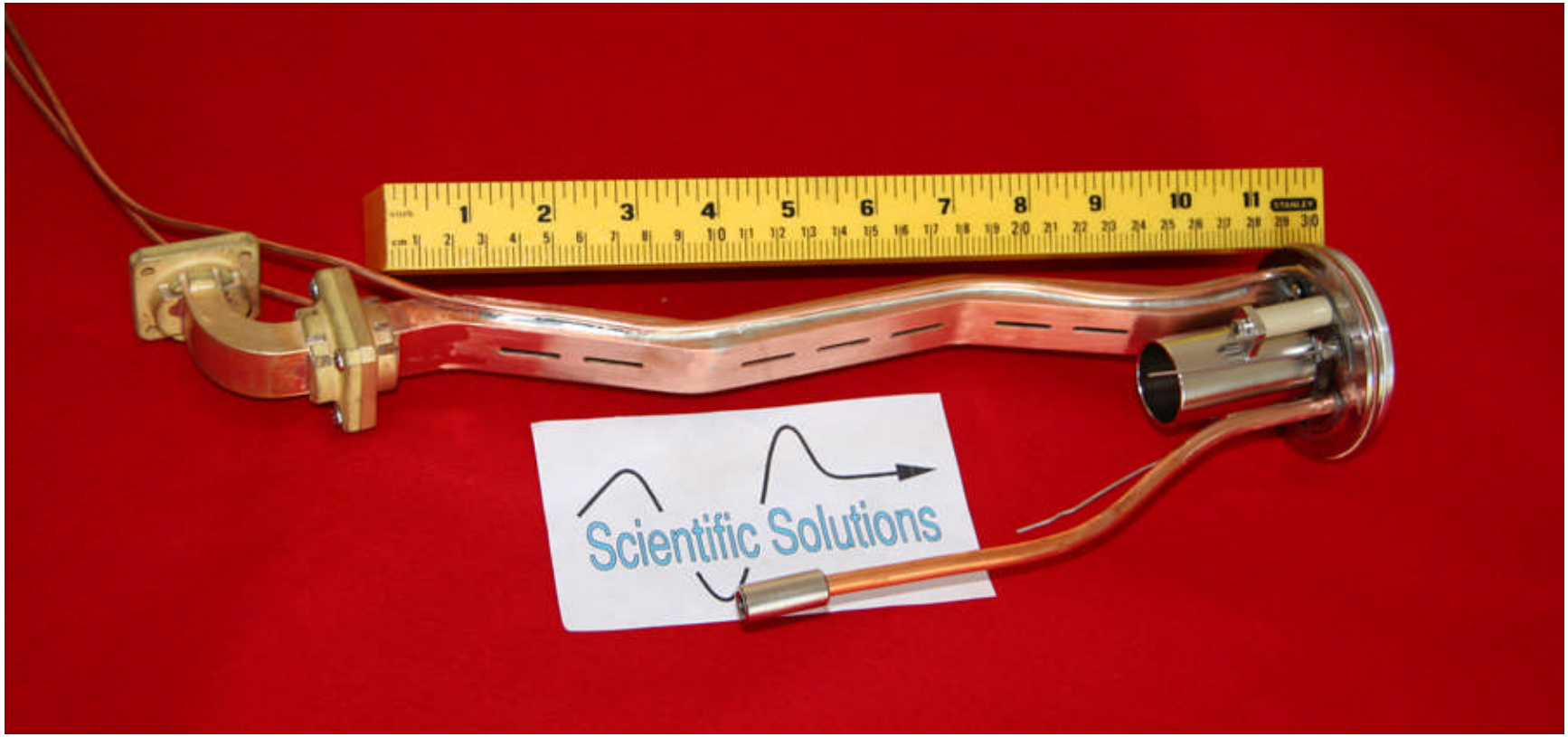


Injector



First Einzel lens and ground shield.

Injector



Plasma endwall assembly

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Injector

Plasma endwall

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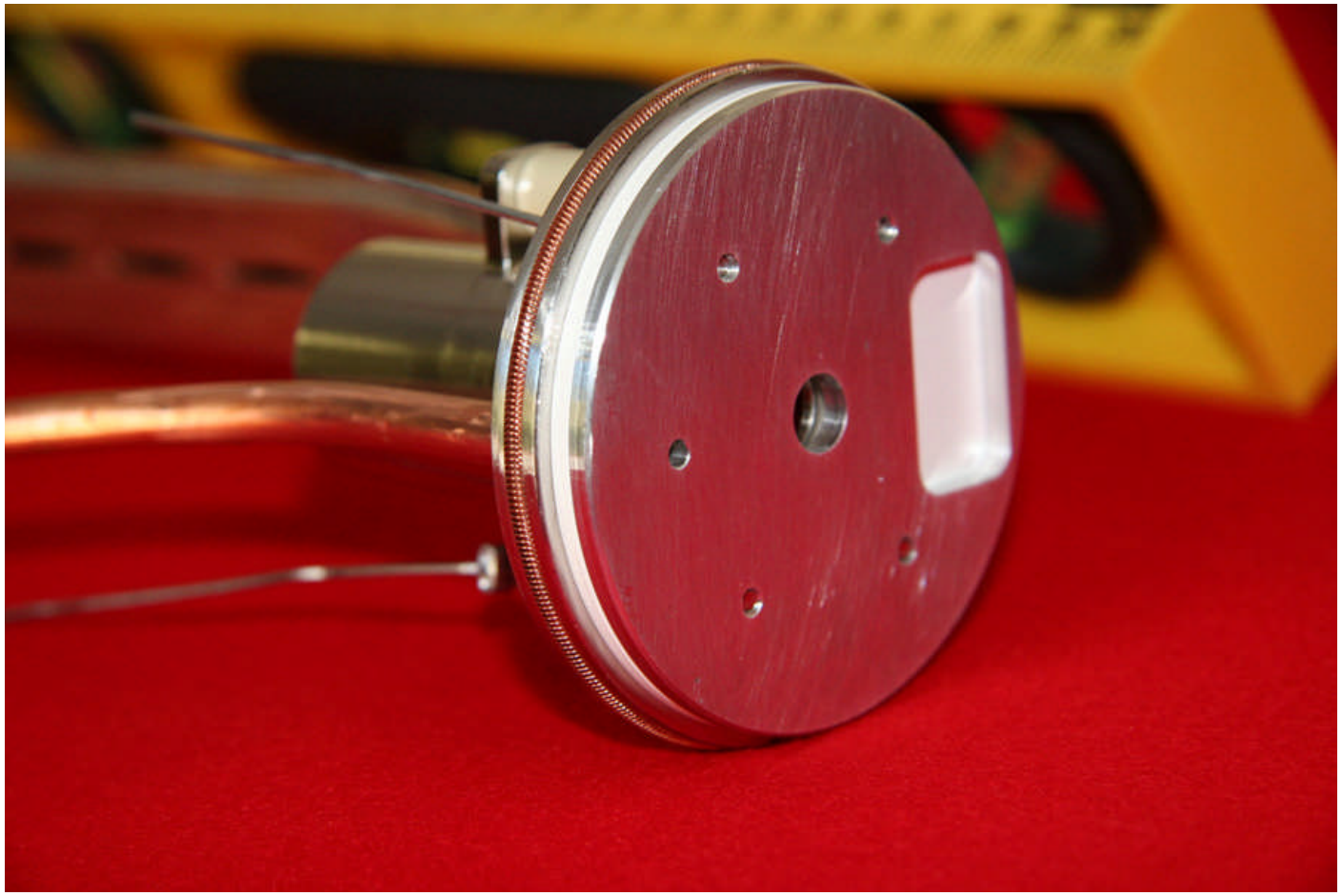
Injector



Plasma endwall

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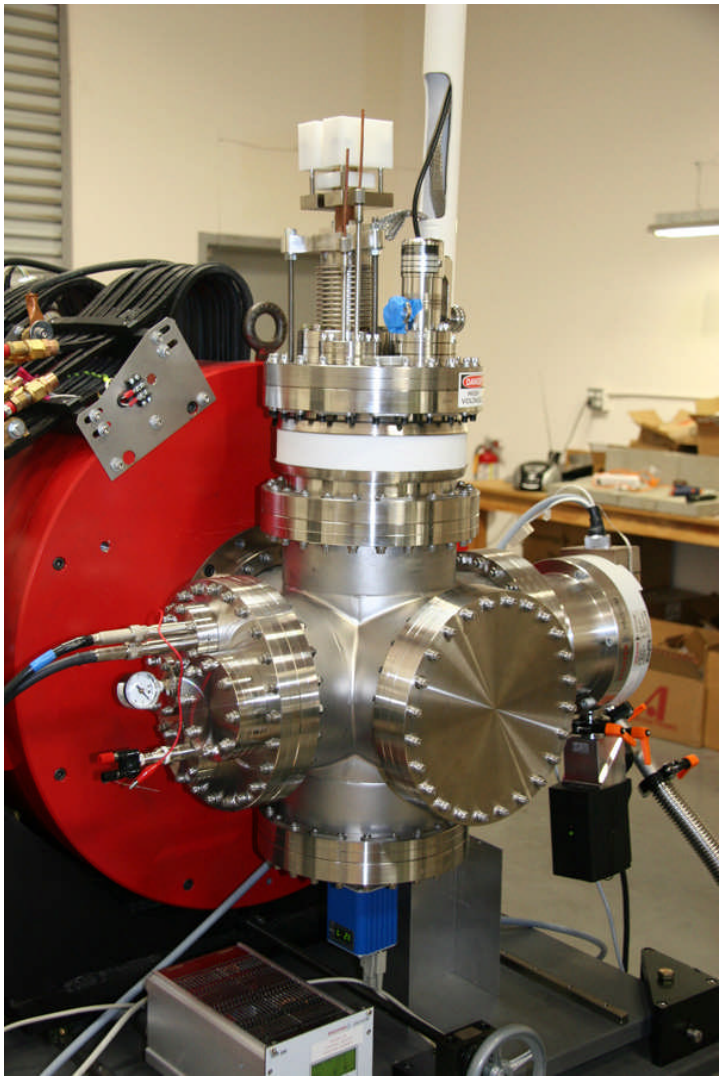
Injector

Injection end of charge-breeder.



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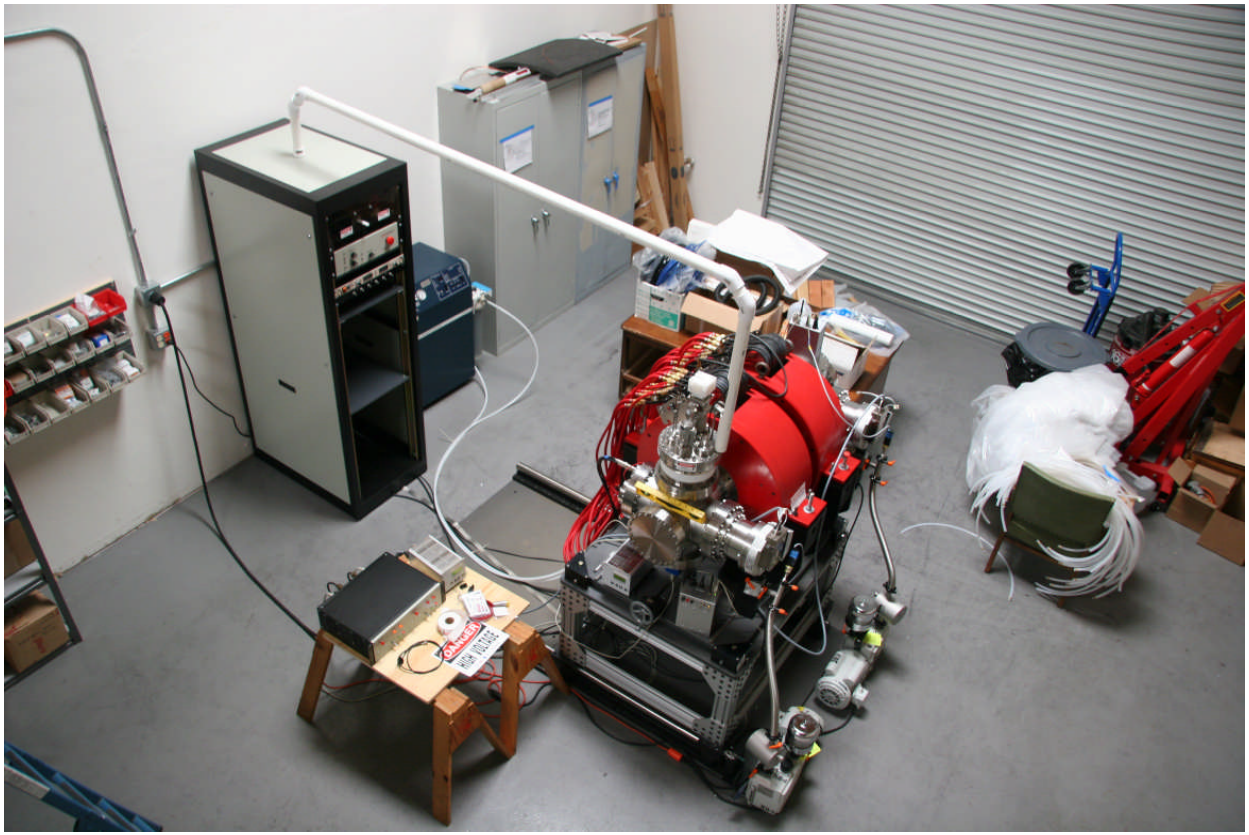
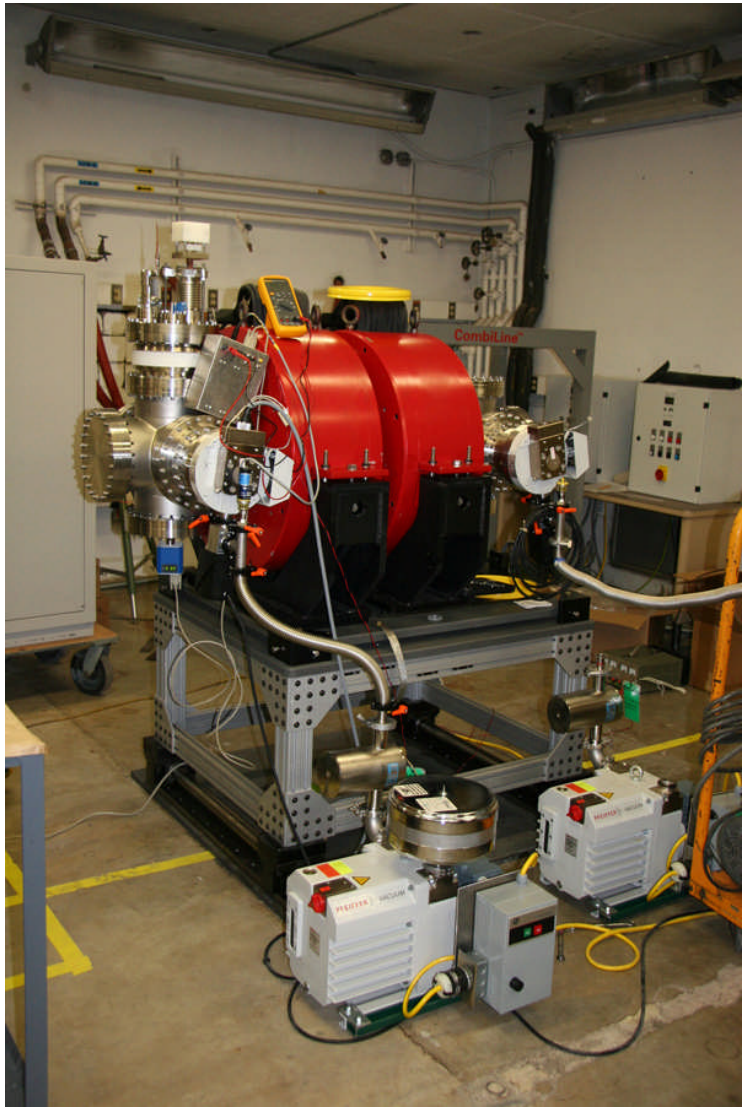
Support Stand



Charge-breeder mounted on rails to facilitate installation and/or removal for repair/maintenance.

Installation

Charge-breeder installed in accelerator vault at TAMU cyclotron.



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Features

1. Installed TAMU October 2007
2. Baseline vacuum 10^{-9} Torr
3. Solenoid magnets run at half-current
4. HV tested to 15 kV
5. Testing injection with SPIG (G. Tabacaru)
6. Demonstrated “Distributed Data Acquisition” concept.

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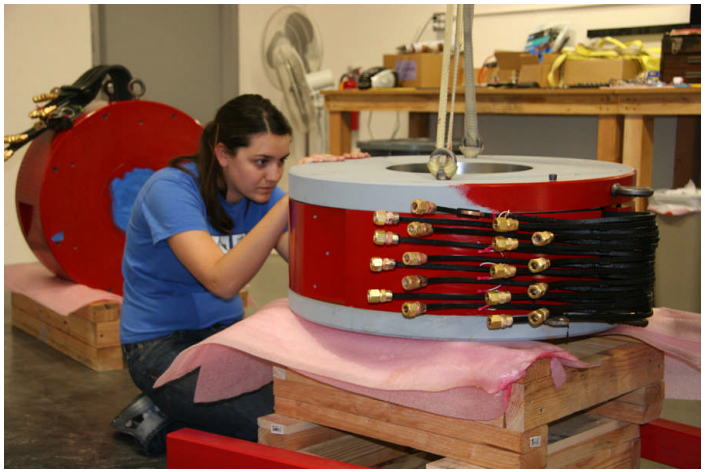

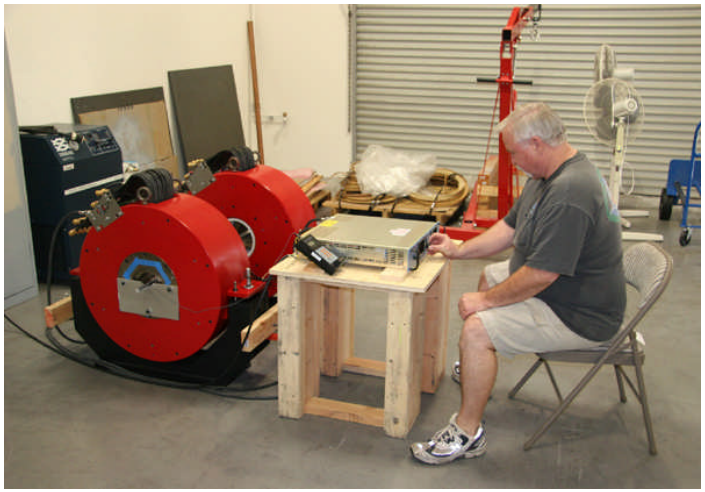

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