Electrostatic Septum For AGS

C. Pai
Brookhaven National Laboratory
Collider-Accelerator Department
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AGS H20 Electrostatic Septum

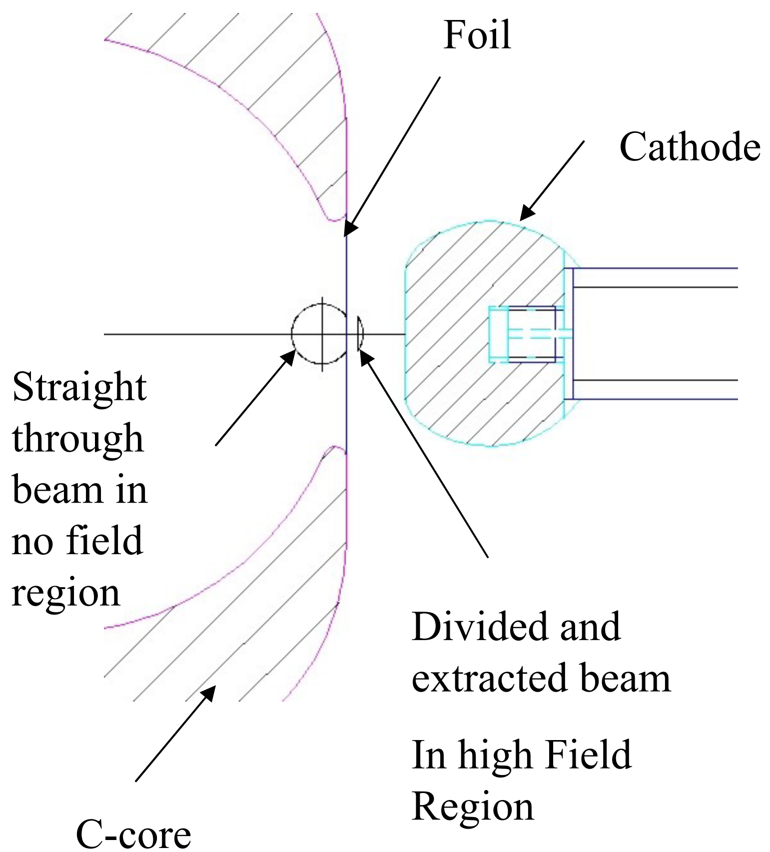
The current septum was redesigned and built in 1998 by J. Hock. The previous septum was built In 1981.

The major changes are:

1. Wire was changed to foil after extensive test.
2. Hollow welded cathode was changed to solid rod.
3. Stainless steel vacuum chamber and high vacuum hardwares were used to improve vacuum quality and shorten pump down time (6 hours to 1 hour).
4. Spring preload was added in the drive system to eliminate backlash.
5. Installation procedure was improved for quick access and removal to reduce radiation exposure.

Function of Electrostatic Septum

The Electrostatic Septum is used as the first device in the AGS slow beam extraction. The septum consists of a serious of thin foils. These foils are supported by a C-core and form a ground plane along the beam path. With a near by cathode two zones are created, a strong electric field In the cathode side and a no field zone in the C-core side. When beam hit foils, the beam will be divided by two. The part in the electric field will be deflected and extracted. The other Part in the no field zone will just go straight through. A small percentage of beam will be lost in the foils.



H20 Electrostatic Septum Specifications

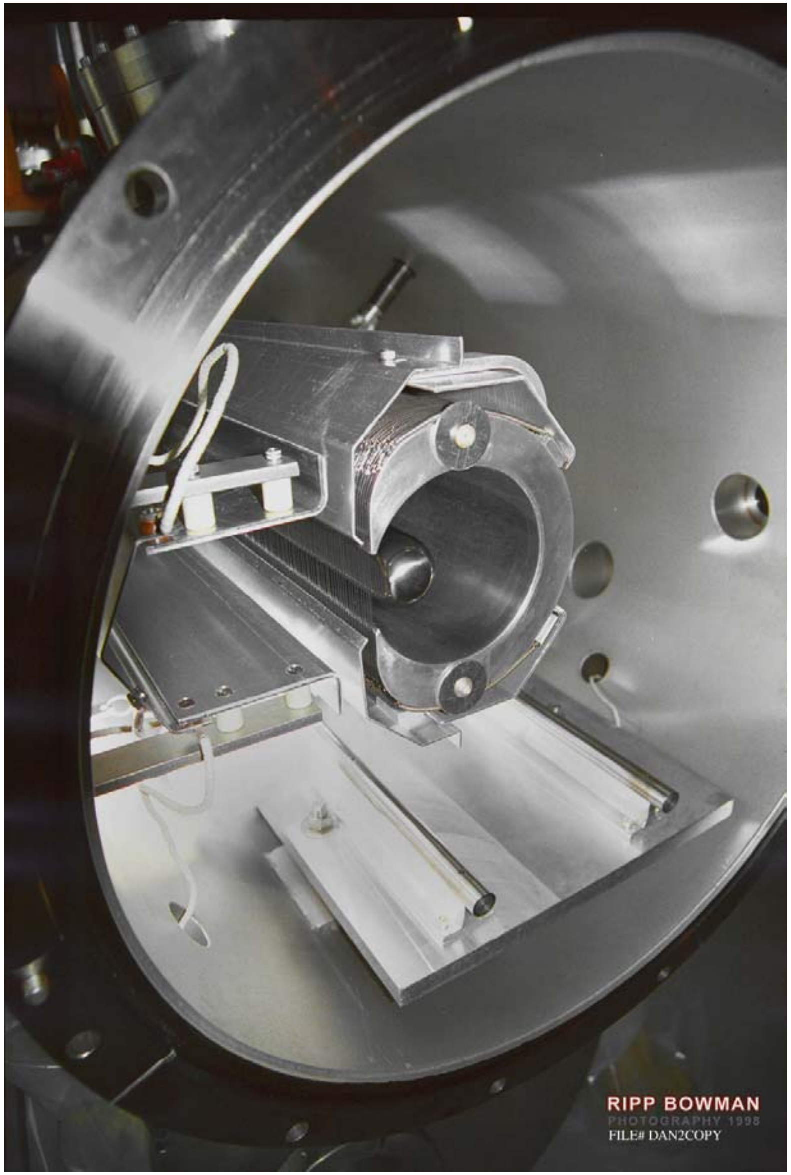
	Current	Upgraded (RSVP)
Horz. gap (mm)	10	10 - 30 (variable)
Vert. gap (mm)	20	30.4
Length (m)	2.3	2.3
Field (KV/cm)	80	80
Voltage (KV)	80	80
Motion (cm)	3.81 (Together)	3.0 (Cathode) & 1.0 (foil)

Major Components of Electrostatic Septum

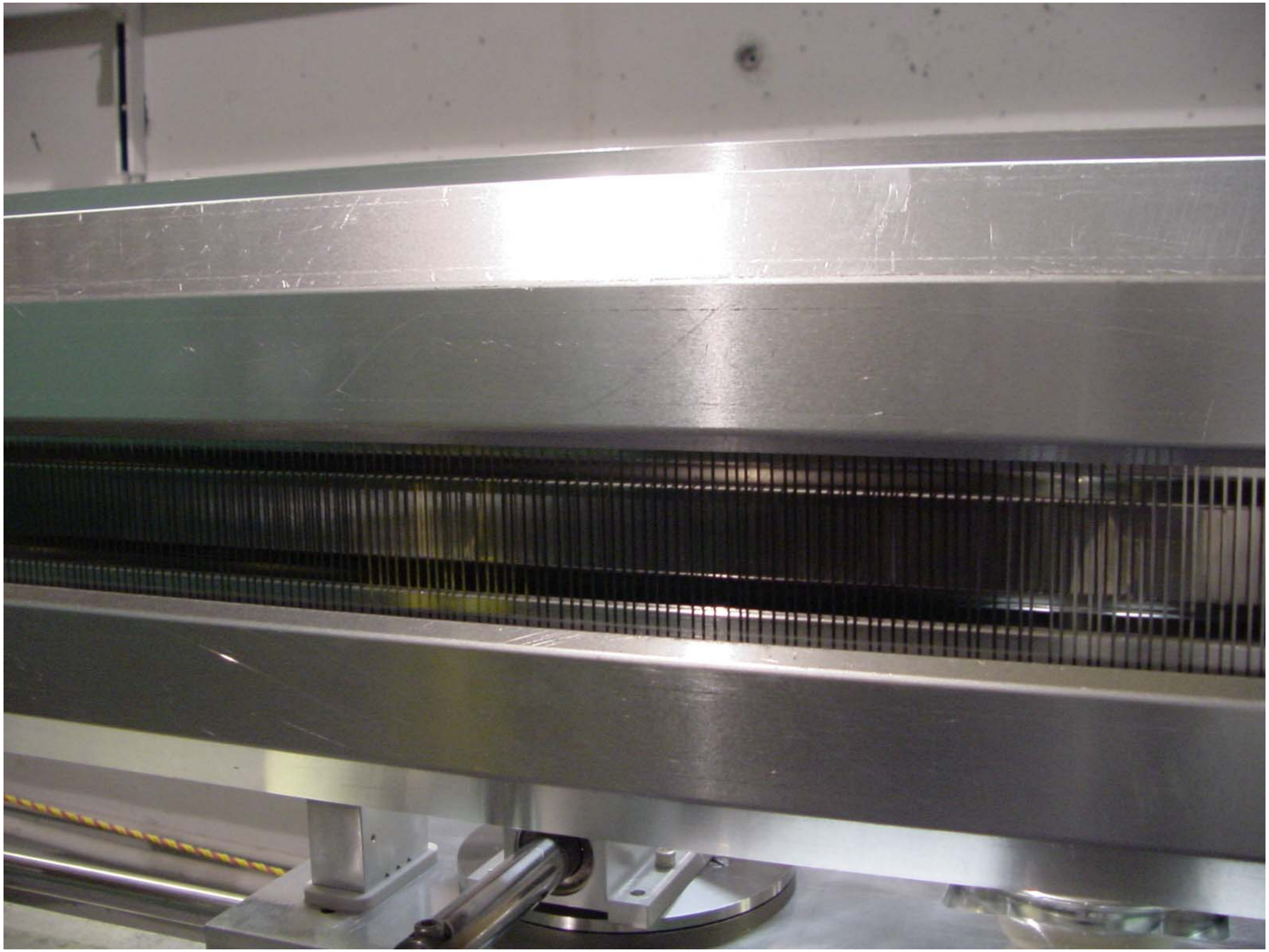
1. Large Vacuum chamber (24” OD) and many flanges.
2. High Voltage cathode and C shape core (90” L)
3. Ground plane: Septum Foil (720 pcs, .125” spacing).
4. High voltage Feedthrough and standoff (90KV)
5. Motion Feedthroughs with Bellows
6. Motors, Gear drives and Linear slides
7. Motion controls and switches

Current H20 Electrostatic Septum in AGS

Inside view of Current H20 Electrostatic Septum

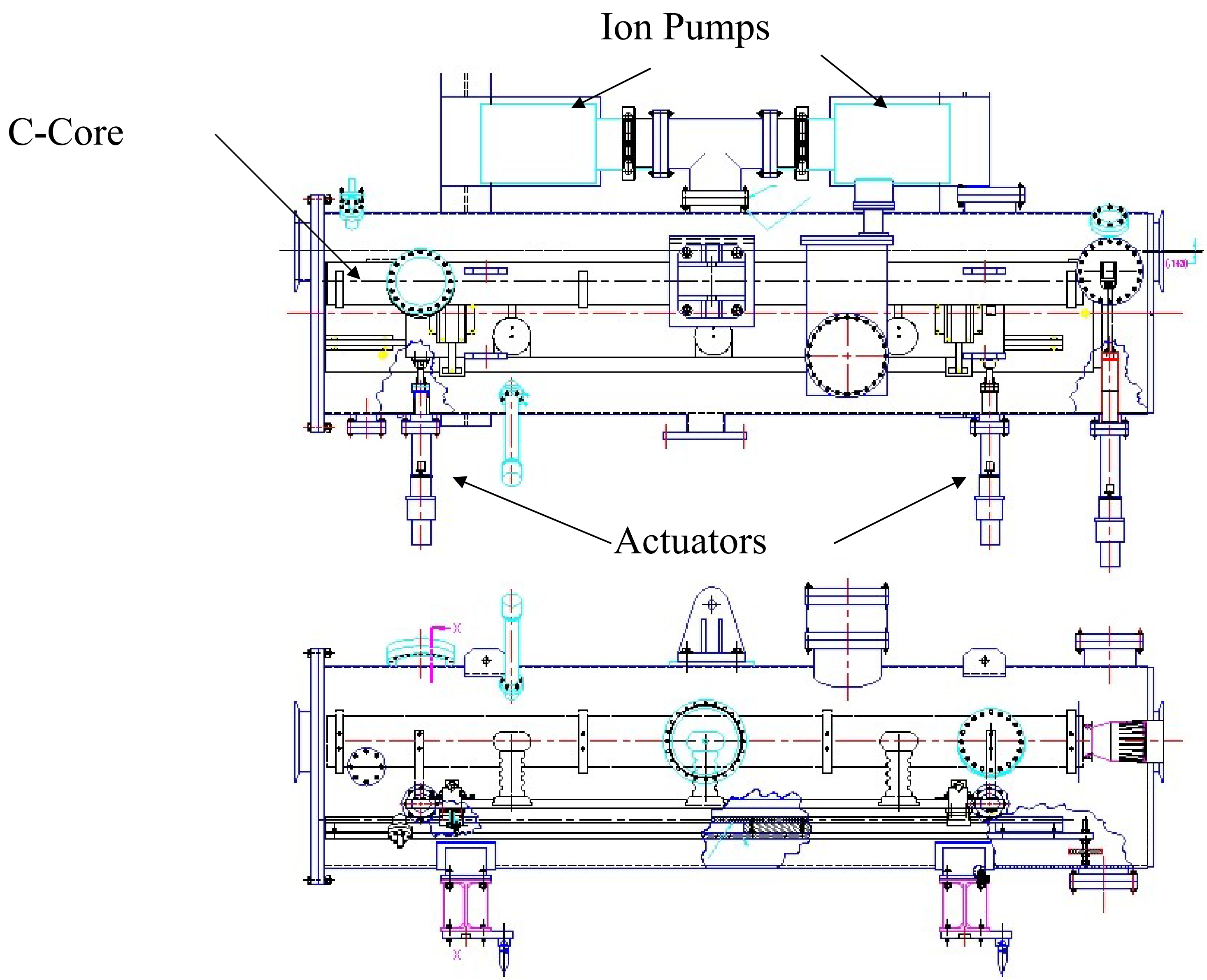


Foils in H20 Electrostatic Septum



Ceramic standoff and C-Core support

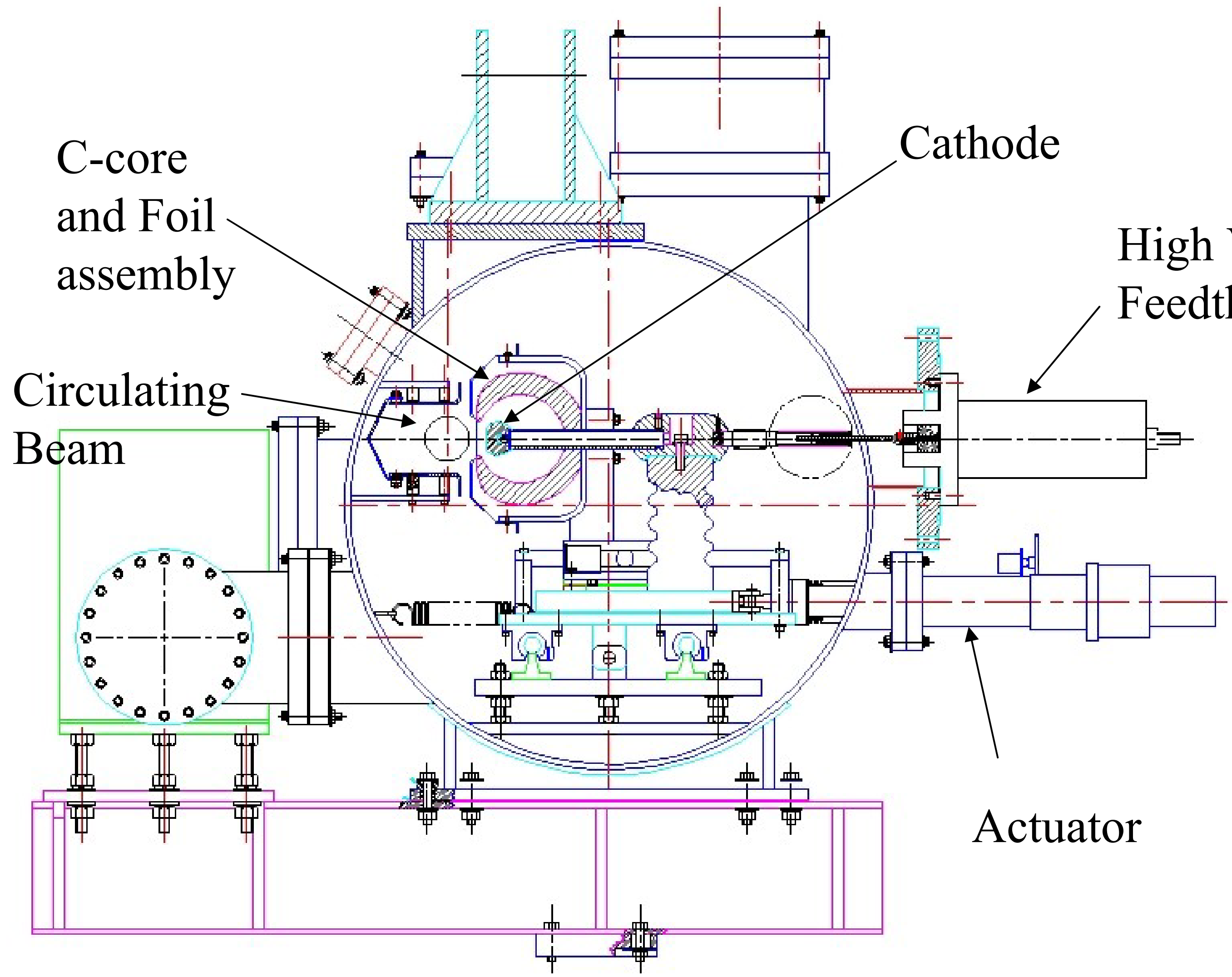
Layout of Current H20 Electrostatic Septum



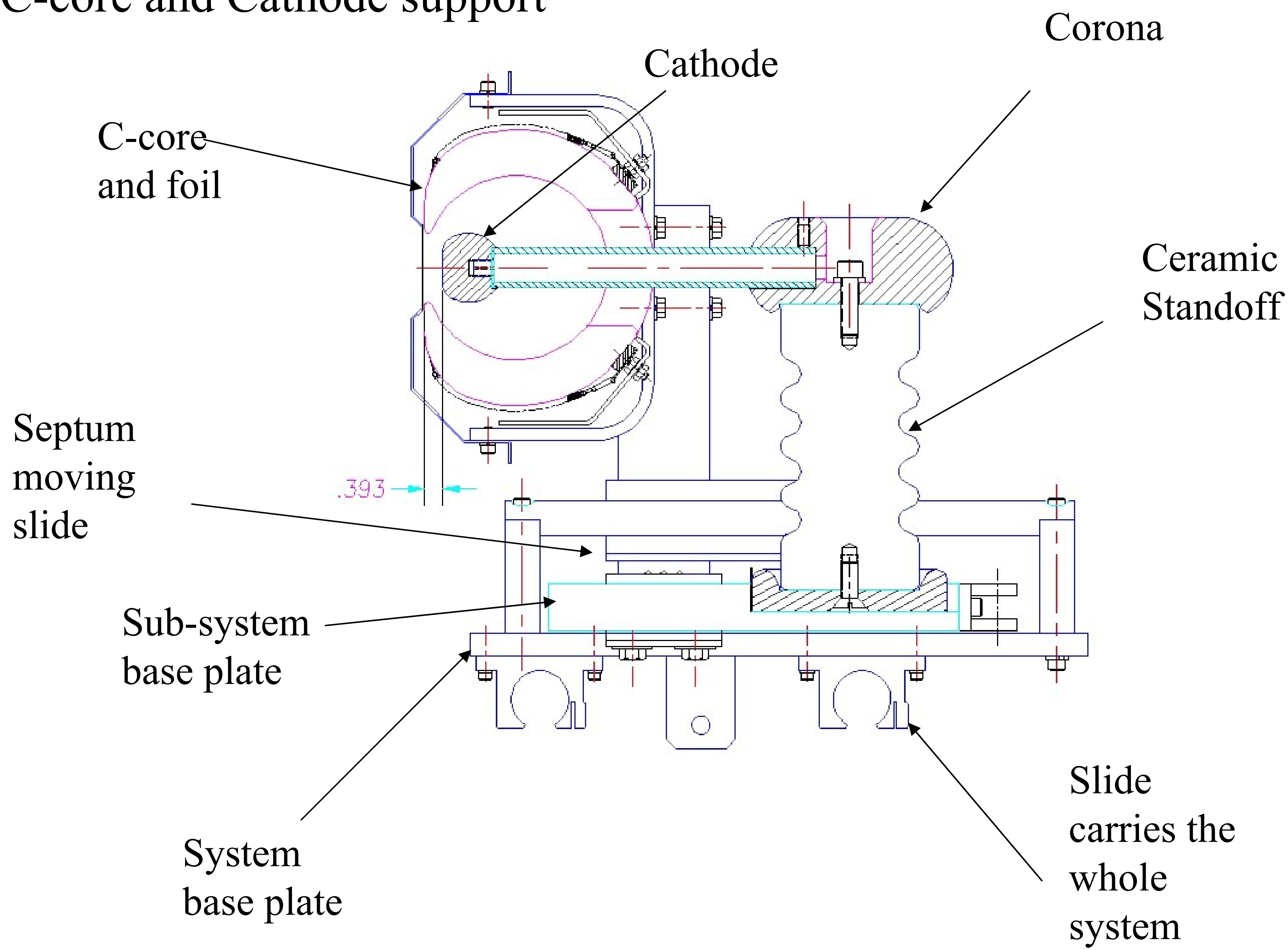
Vacuum chamber

1. High vacuum quality without bake out
   a. 24" Stainless Pipe with all metal Knife edge seals.
   b. All materials used are high vacuum compatible.
   c. All mating surfaces and blind holes are vented.
   d. All hardware are silver plated and vented.
   e. Pump down Time: 1 Hour
2. Easy and quick installation:
   a. Helico-Flex seal is used in large flange to reduce bolt number.
   b. Actuators are attached to the septum with Pins
   c. Whole system is sitting in a slide.

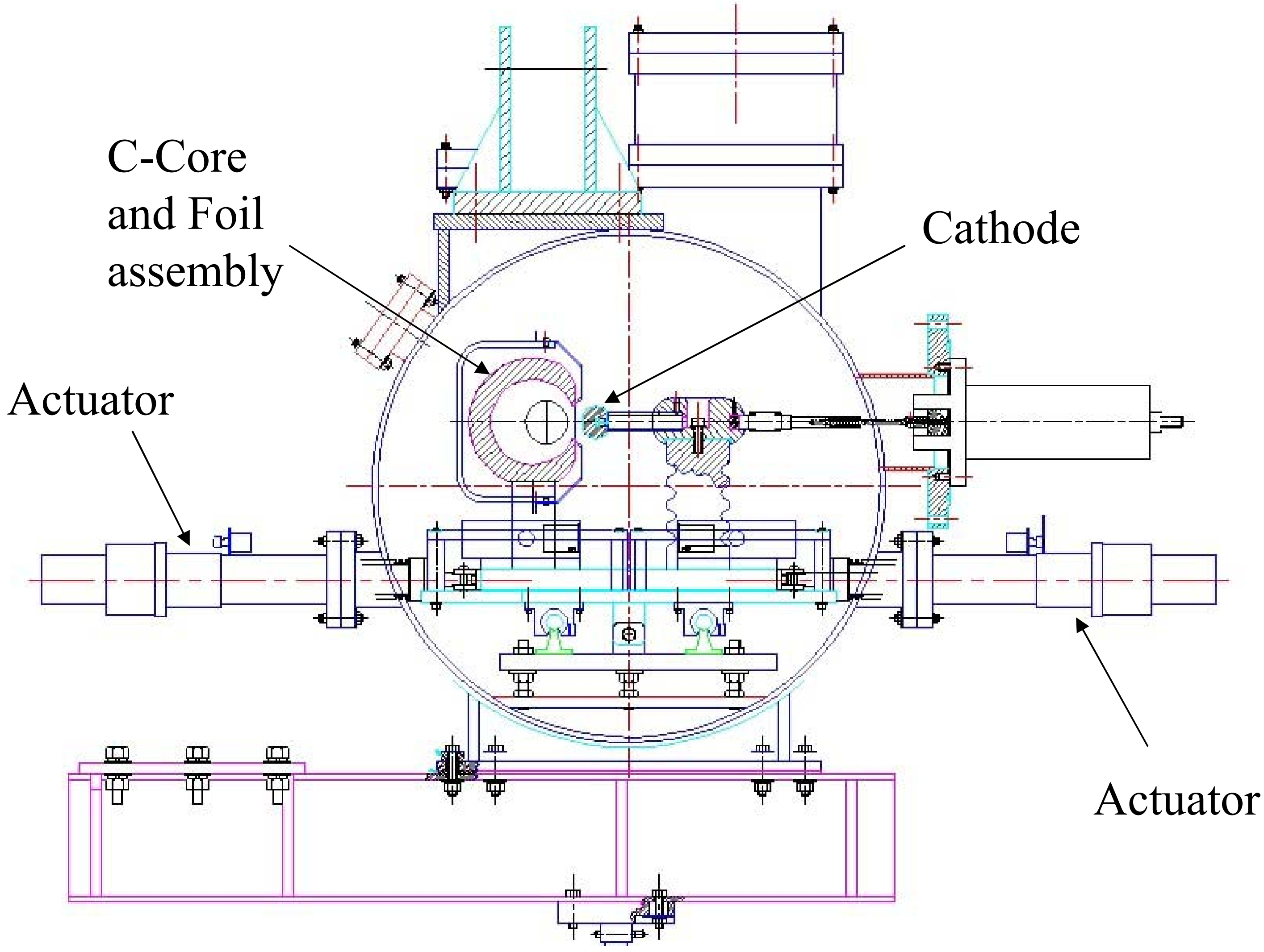
Cross section View of Current AGS H20 Septum



C-core and Cathode support



Cross Section View of Proposed Septum For RSVP



Advantages of Separated Cathode and Foil/C-Core Design

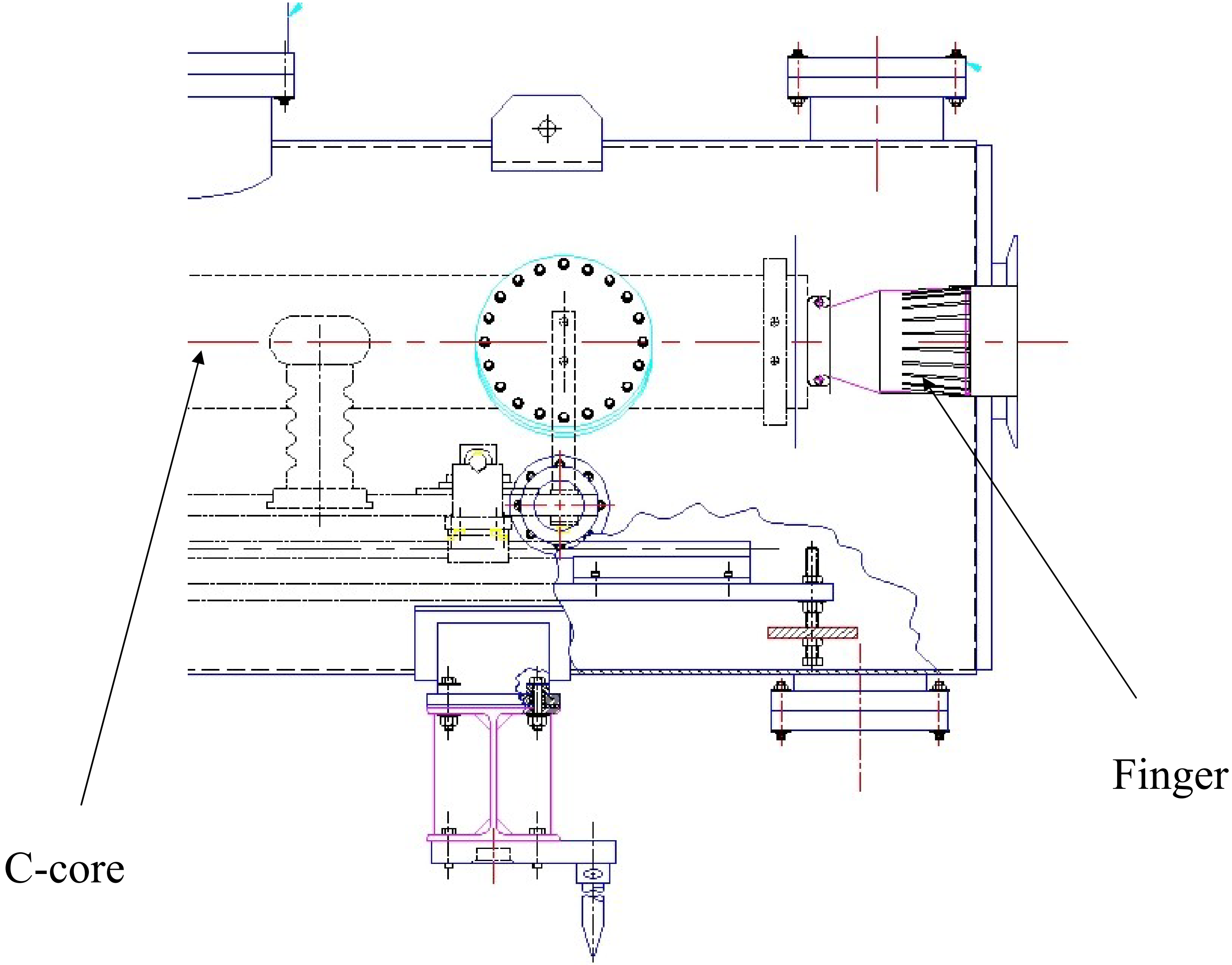
Flexible Gap Adjustment:

When the Foil/Core and Cathode can be moved separately, the strength of the electrical field can be adjusted by changing the gap size to match the extraction needs. The voltage of the cathode can be kept low.

Image Current Path:

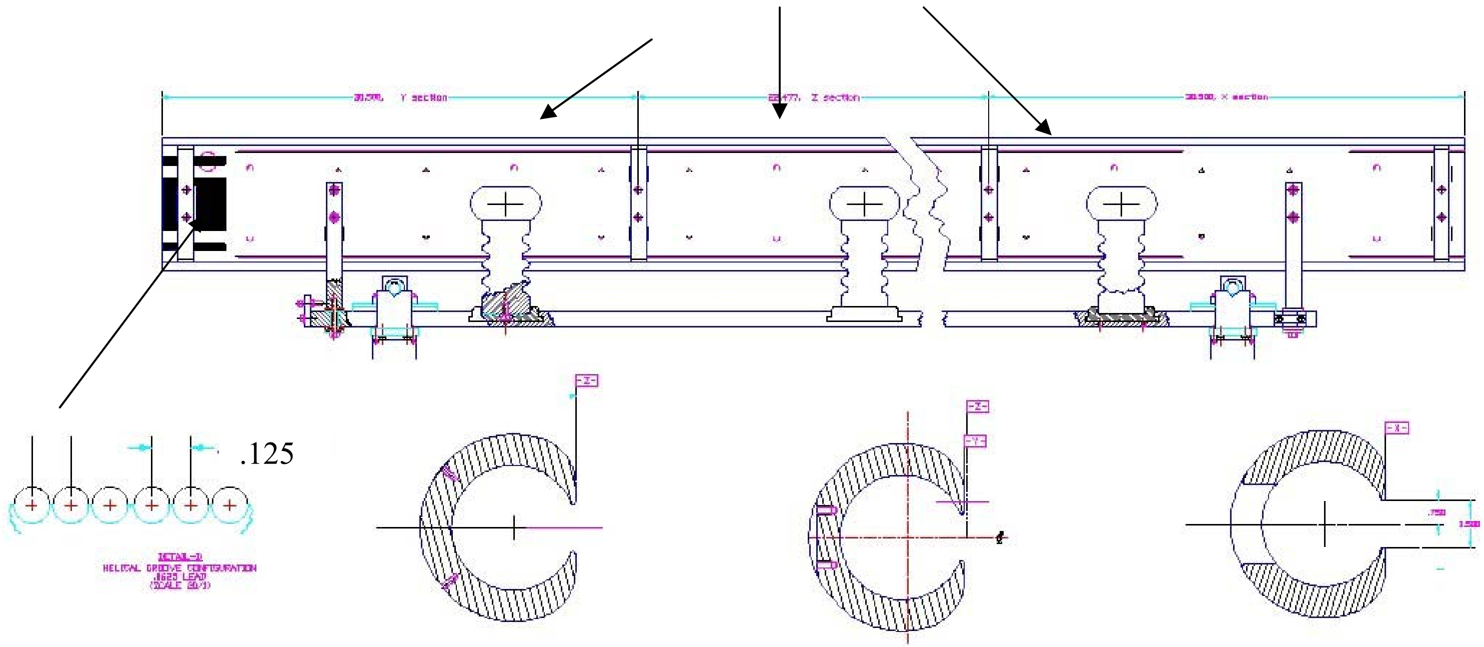
With C-core surrounding circulating beam, the C-core can be linked to the end flanges to provide a image current path and reduce the beam impedance.

Sliding fingers in the two ends to reduce Beam impedance



C-core structure

90” long in 3 step



Grooves for Springs in full surface,

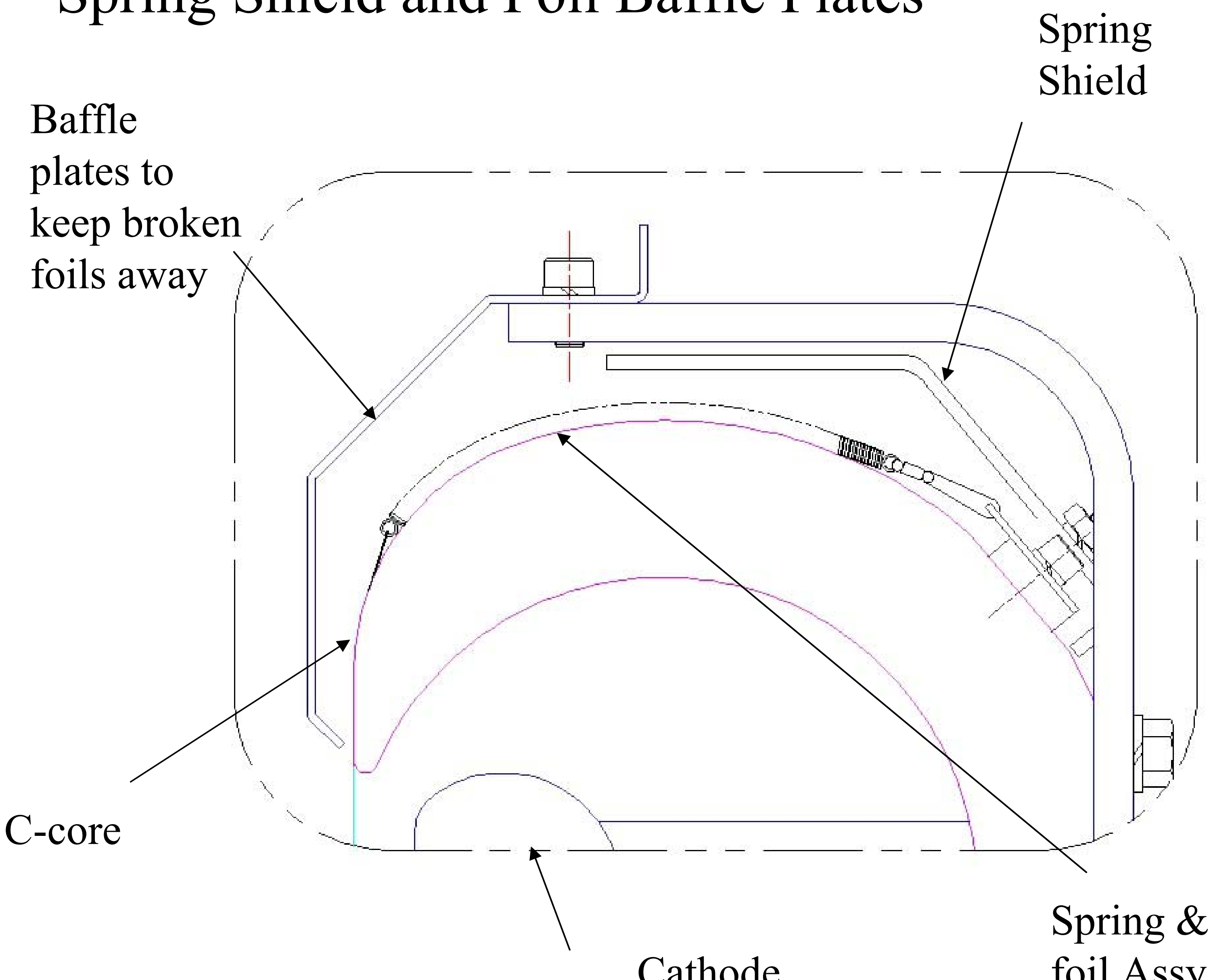
Groove Spacing:.125”

Surface in middle Section is .080” under to match the radius of the beam.

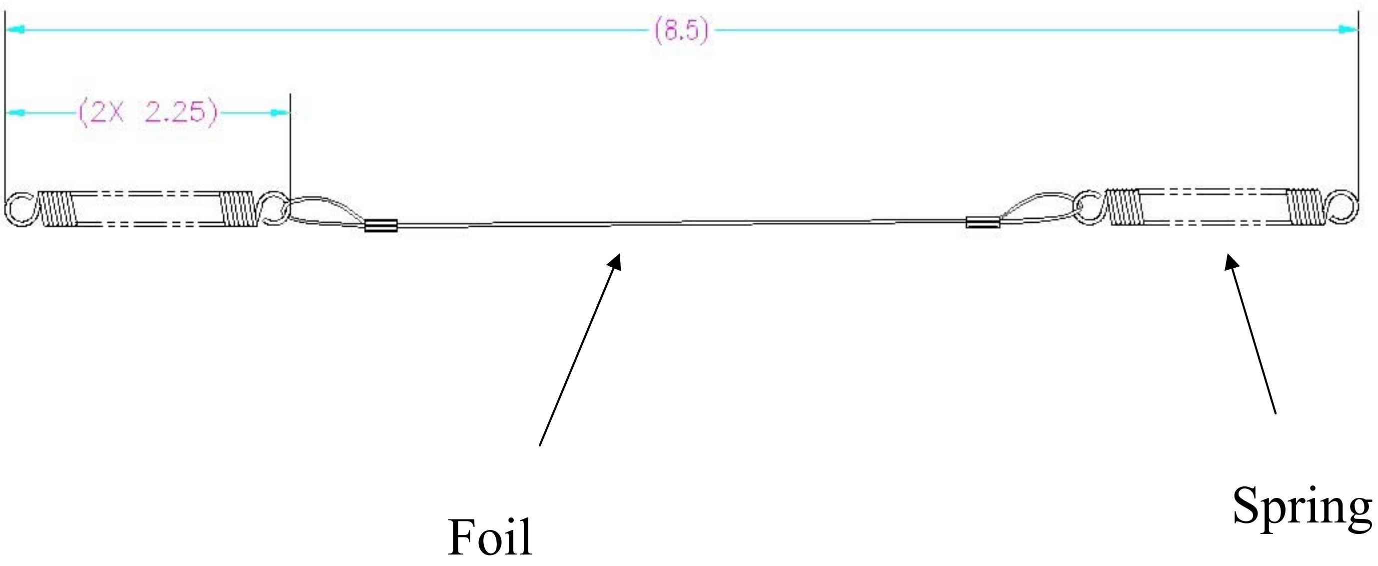
High voltage Cathode and C-core

1. Cathode material: Solid Titanium Rod
2. Cathode size: 1.5” Diameter, 90” long
3. Standoff: Alumina Ceramic Al_2O_3
4. C-core material: Aluminum Pipe, Al6061T6
5. C-core size: 6.0” Diameter, 1” wall, 90” long
6. C-core Support: 3 supports along the length.
7. 3 step foil surfaces to compensate sagitta (.080”)
8. Grooves in the C-core face for spring positioning

Spring Shield and Foil Baffle Plates



Foil and Spring assembly



Properties of Septum Foil

1. Material : 75% Tungsten and 25% Rhenium
   (75W 25 Re).
2. Special property: Ductile in High Temperature
3. Size: .035”x .001” thick
4. Mechanical Strength: (.2% yield)

   at 20 ^{o}C, 249,000 psi

   at 1200 ^{o}C, 59,000 psi to 78,000 psi

   at 2000 ^{o}C, 6,000 psi to 7,000 psi

Comparison of Foil and Wire

	Foil	Wire
1. Material :	75 W 25 Re	75 W 25 Re
2. Size:	.035”w x .001” thick	.002 diameter
3. Total width:	26.25” (720)	3” (1440)
4. Beam Loss:	Higher	Less
5. Spacing:	.125”	.0625”
6. Cross section Area:	3.5×10^{-5} in	3.14×10^{-6} in
7. Strength Ratio:	11	1
8. Spring load:	2 lb.	.25 lb
9. Spring tension:	Consistent	Various

Heat Load Test on Foil and Wire

Test method: Defocused Electron beam to simulate Proton beam.

Type of foils and wires tested:

a. .002”x.035” Foil, 75W25Re

b. .001”x.035” Foil, 75W25Re, (used in AGS)

c. .002” Dia. Wire, 75W25Re

d. .002”x.035” Foil, 3AL-2.5 V Ti

e. .001”x.035” Foil, 3AL-2.5 V Ti

Test results: Type b, 001”x.035” 75W25Re foil has only one failure in 5 tests.

Most of other type wire/foils are failed.

Spring load and tension in the Foil and C-core

Spring rate: 1.7 lb/in

Spring Initial Stretch: 1.2 in (long stroke)

Spring preload: 2 lb.

Initial tension stress in the foil: 60,000 psi

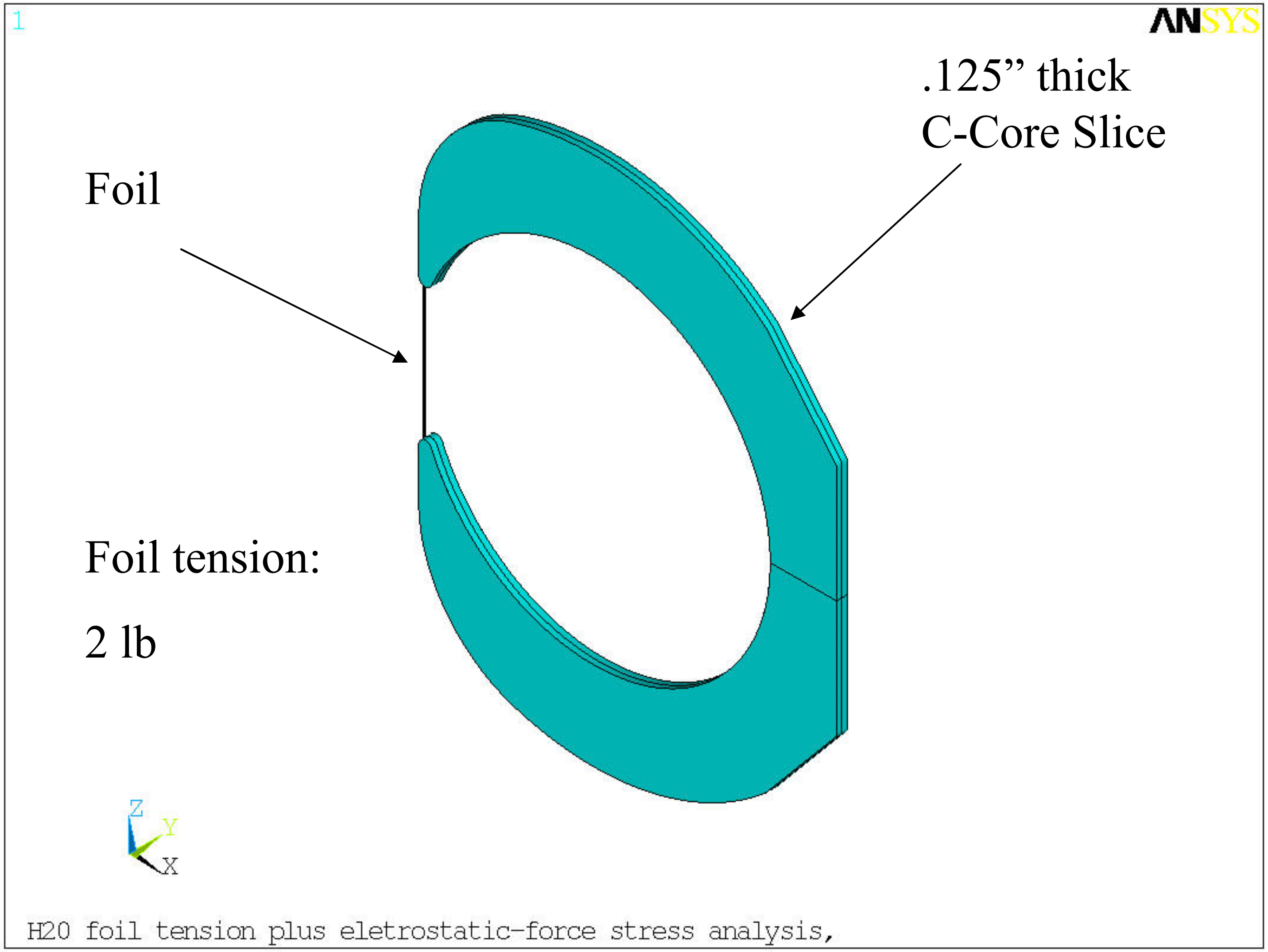
C-core vertical deflection under spring load:

$\Delta = 3.4 \times 10^{-5}$ in.

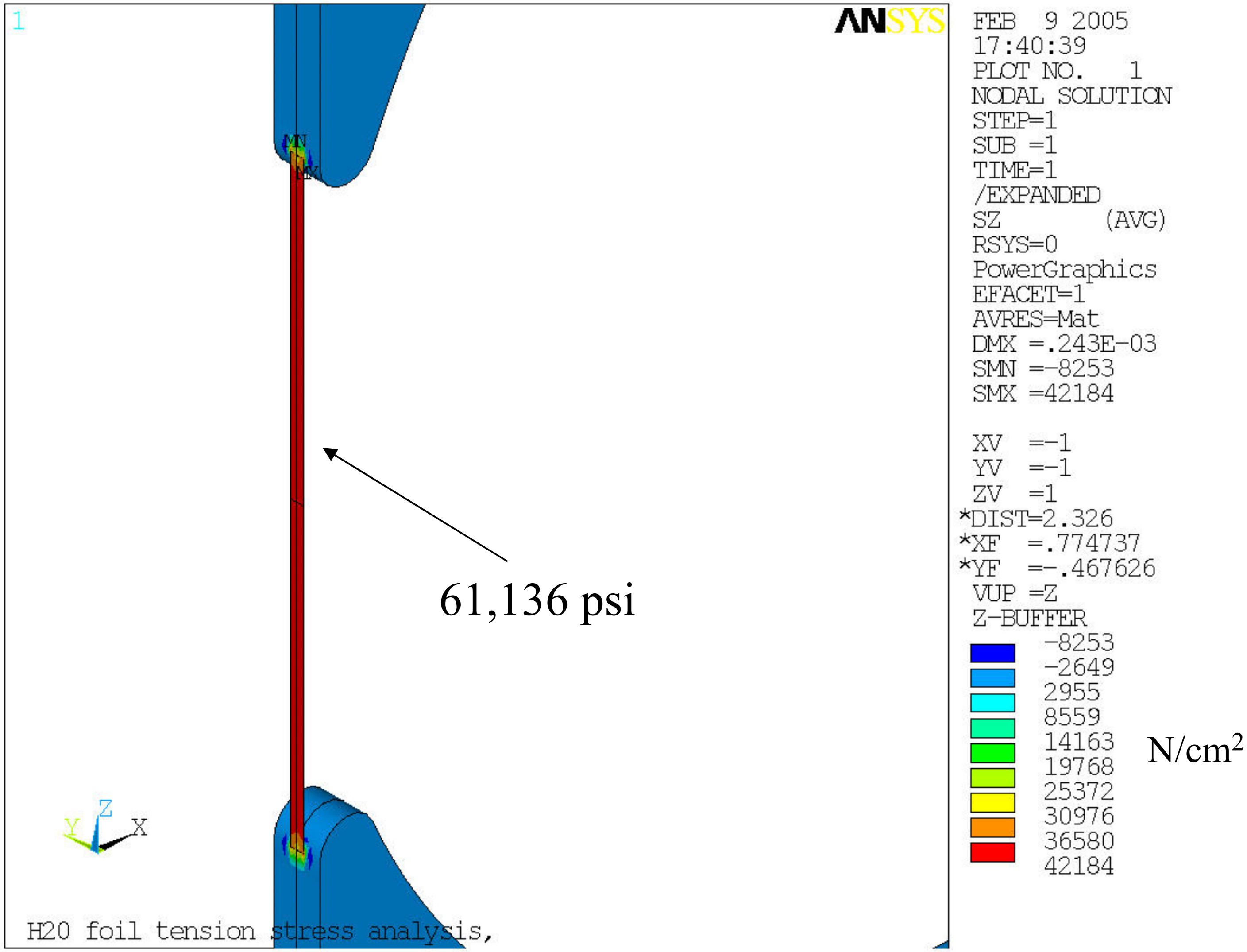
Spring load reduced by thermal expansion

in the foil: $\Delta F = .01$ lb at 1500 K. (Δ=.004")

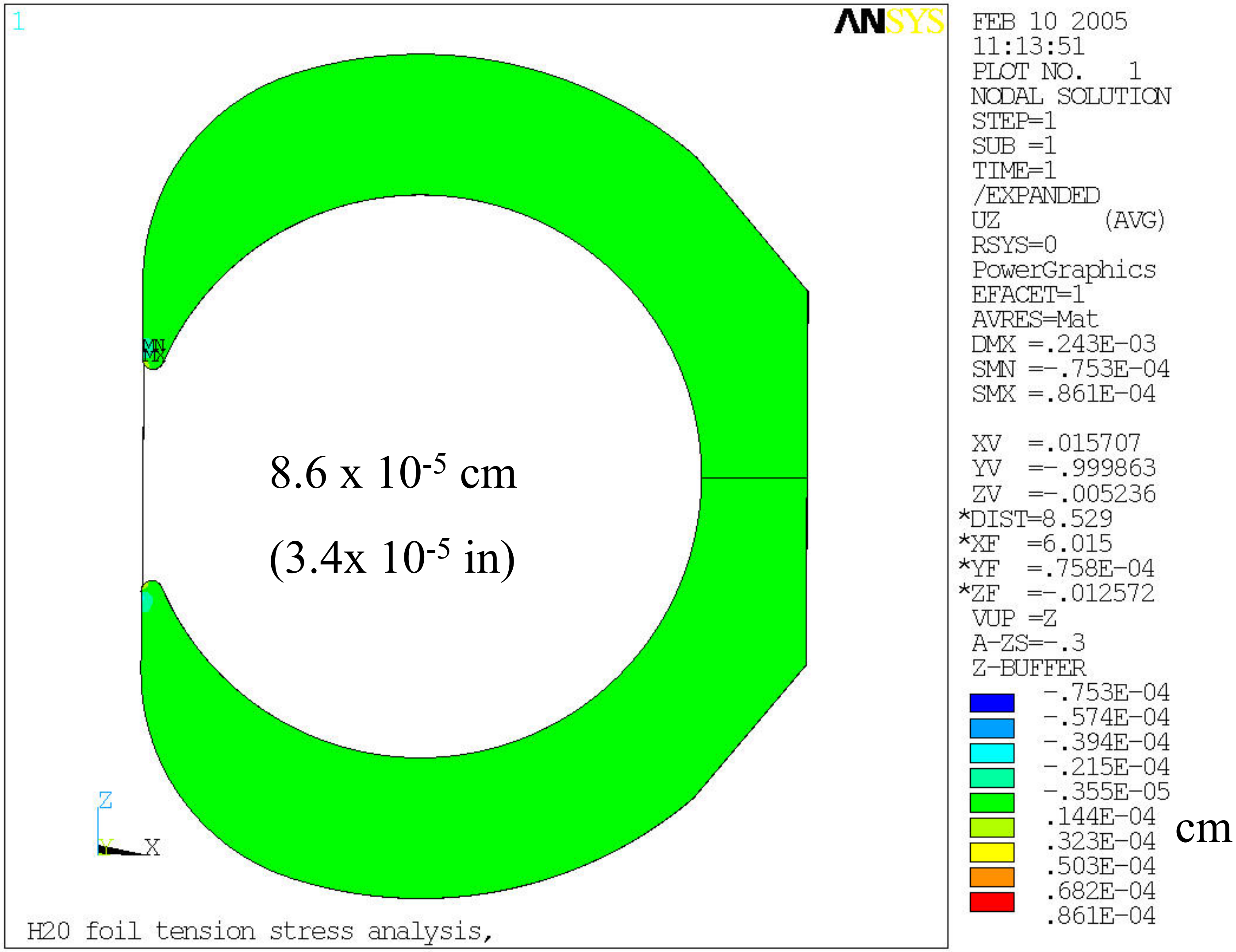
C-Core and foil model



Stress from 2 lb of Spring tension



Vertical deflection of C- core under 2 lb of Spring tension



Electrostatic force in the foil

1. Electrostatic force:

$$F := \frac{\varepsilon \cdot V^2 \cdot A}{d^2}$$

Where:

ε is Faraday's constant

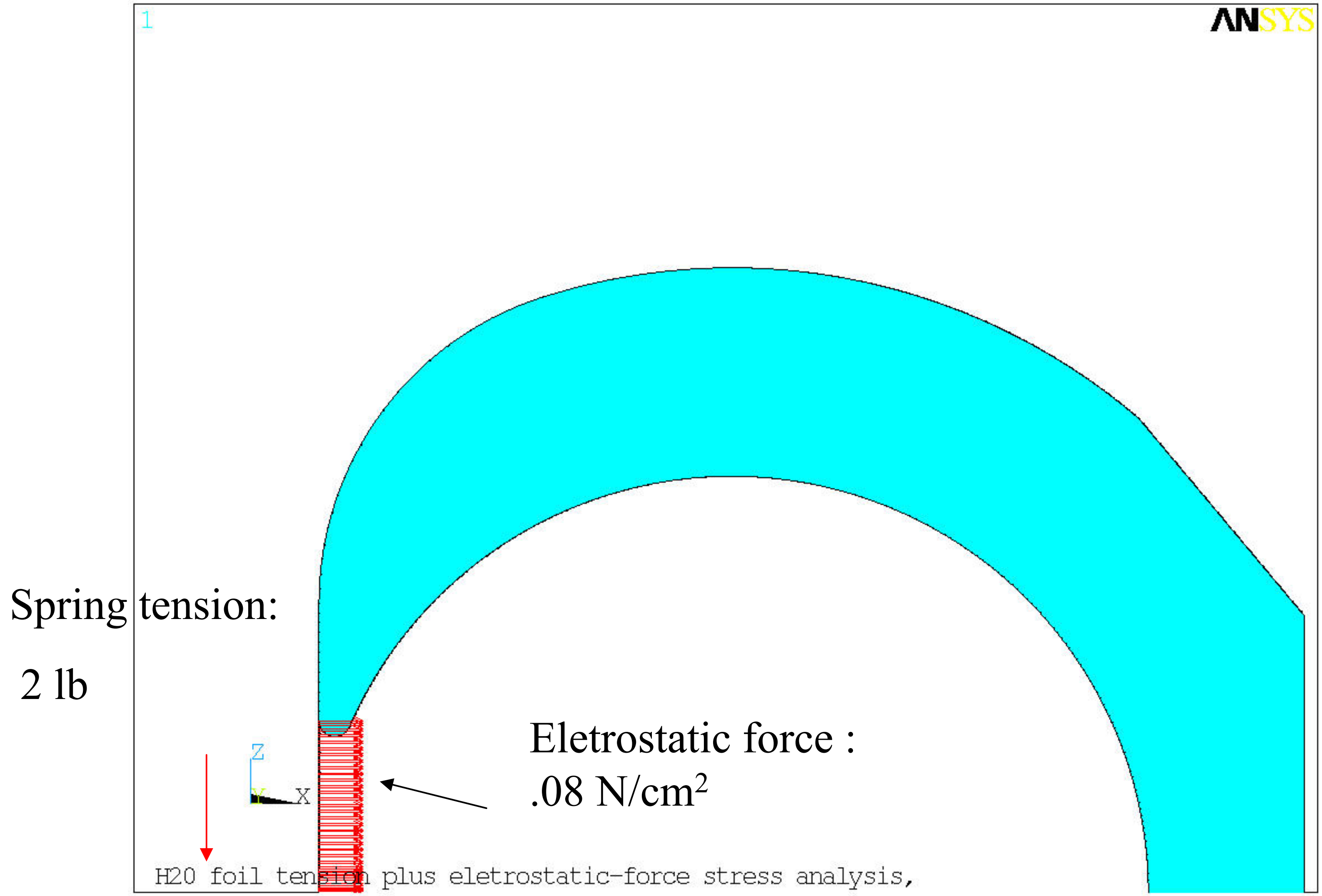
V is applied Voltage, V=80 KV

d is gap distance between Foil and Cathode: d= 1 cm

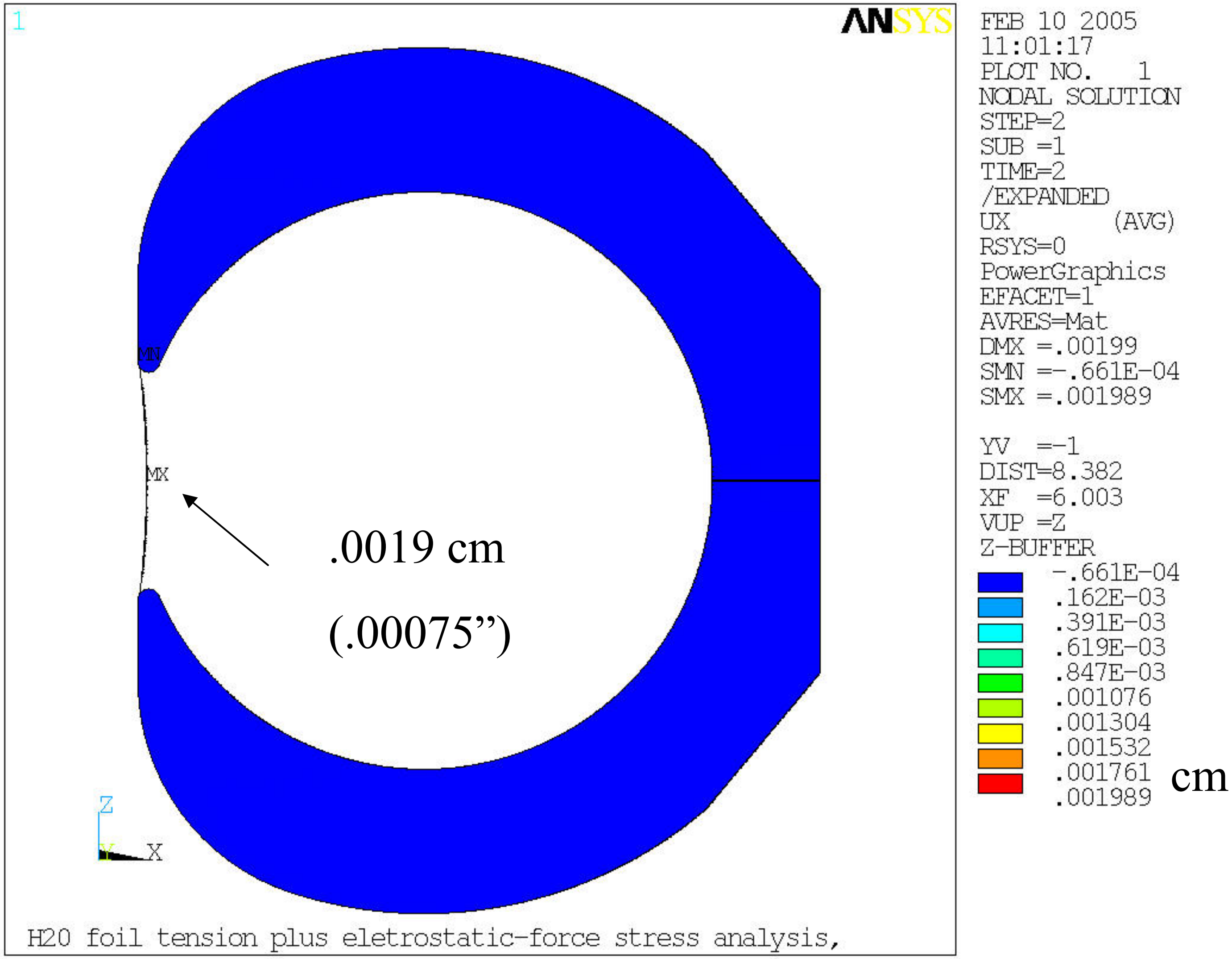
A is area of the gap in 1 unit length, A= 1.5 cm^2

2. Force in a unit length is F= .217 Newton
3. Force in each foil is .027 Newton (8 foils/in)

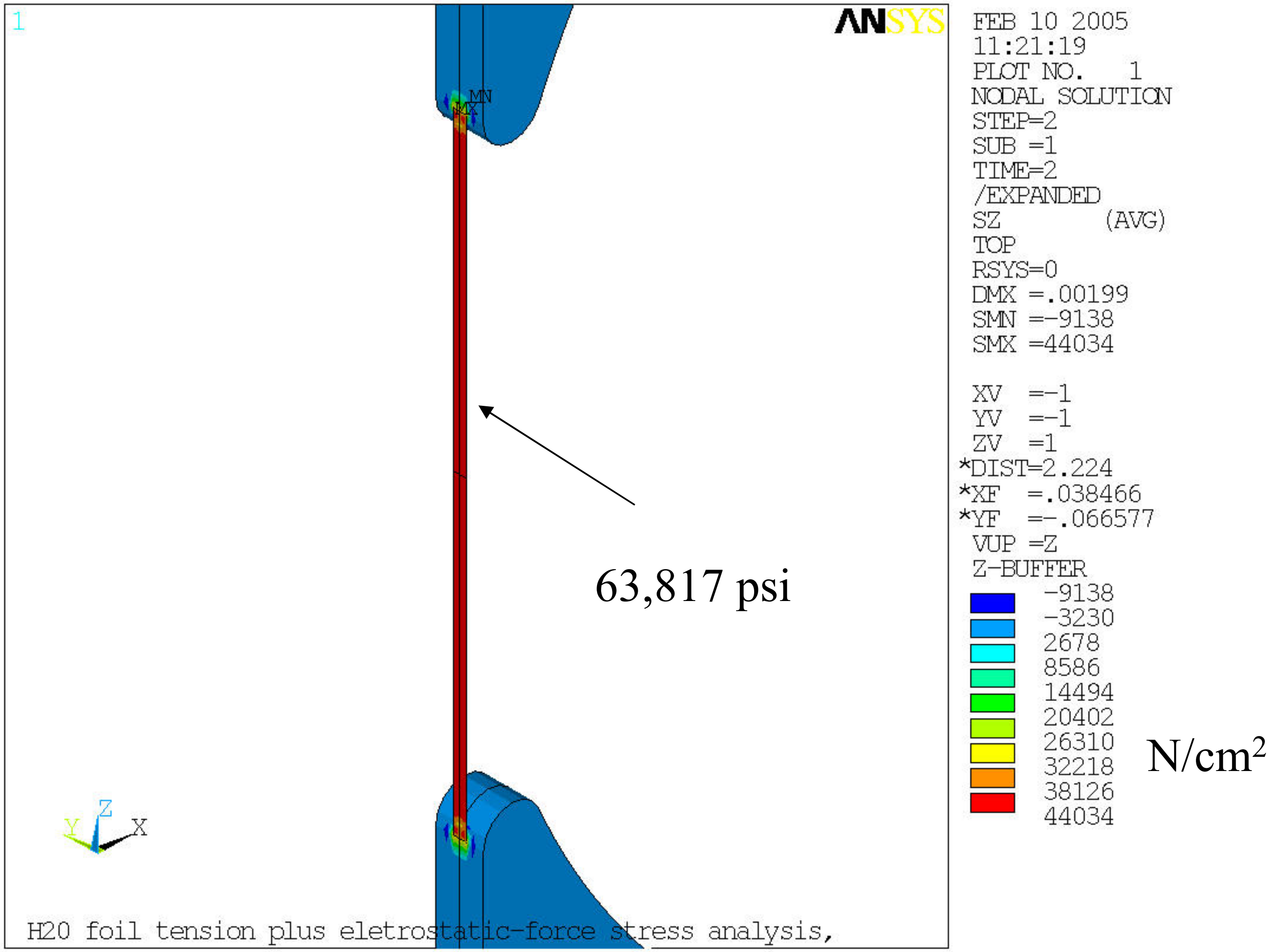
Electrostatic force plus 2 lb of spring tension



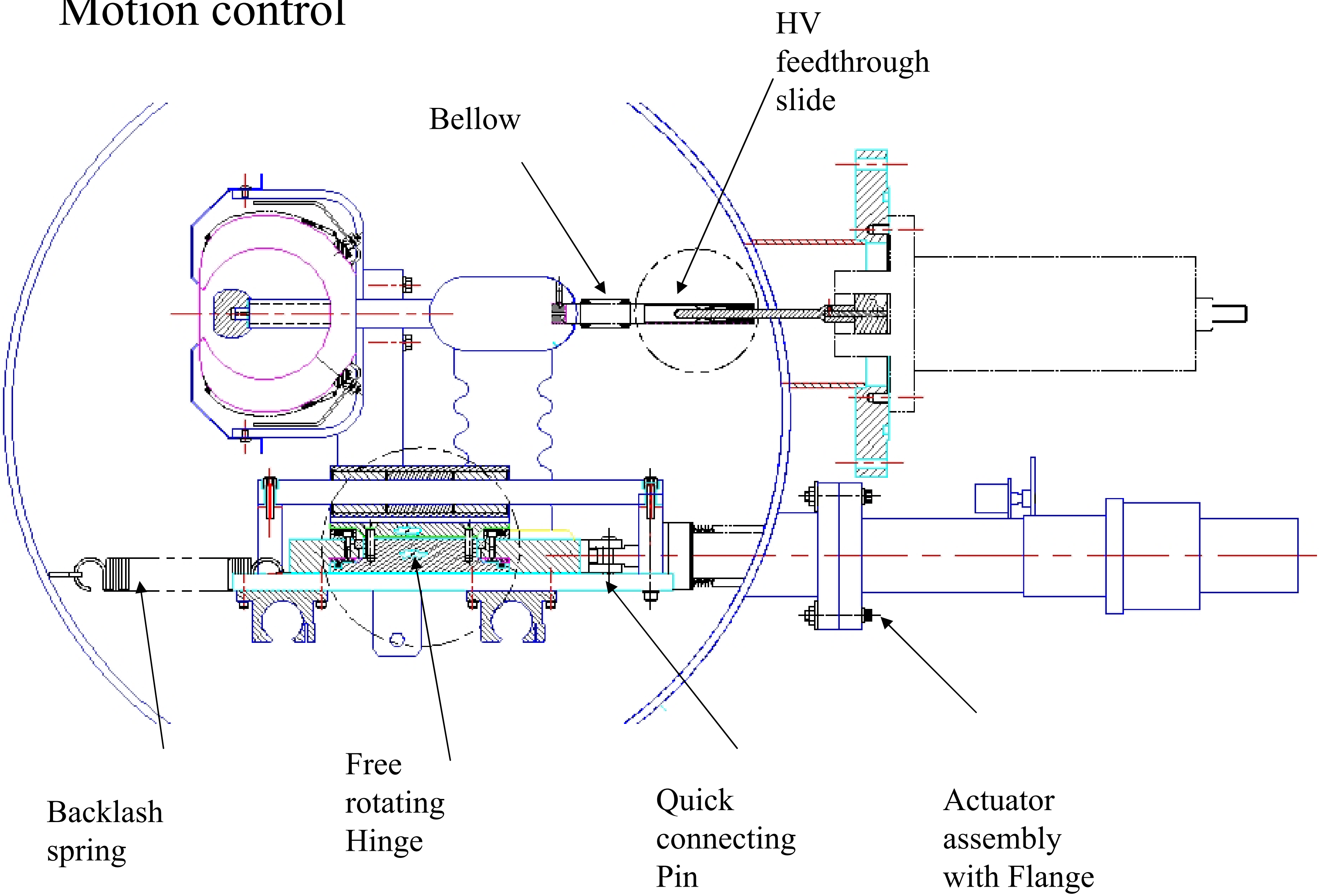
Deflection of foil under Electrostatic force and spring tension



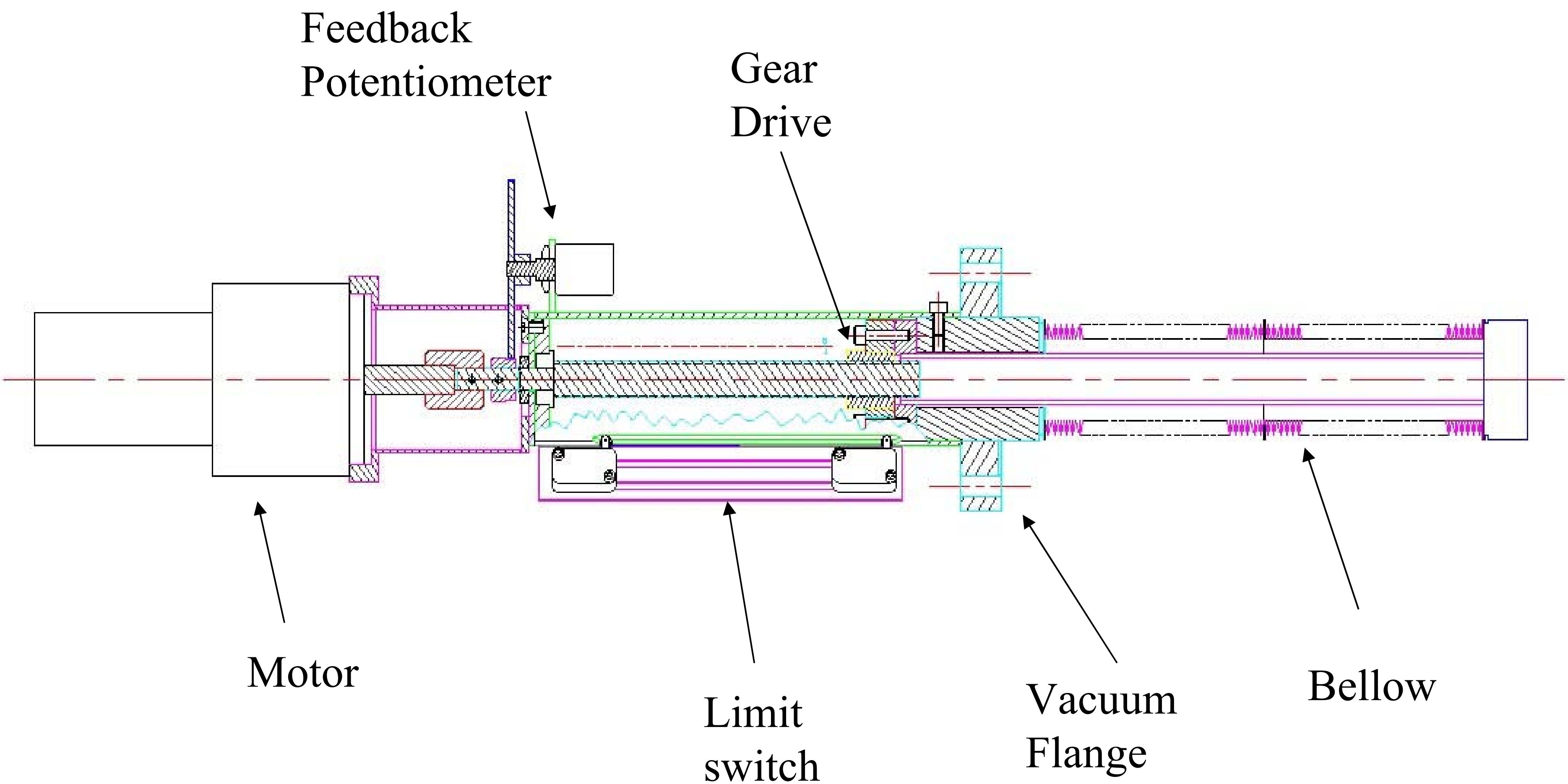
Tensile stress of foil under Electrostatic force and spring tension



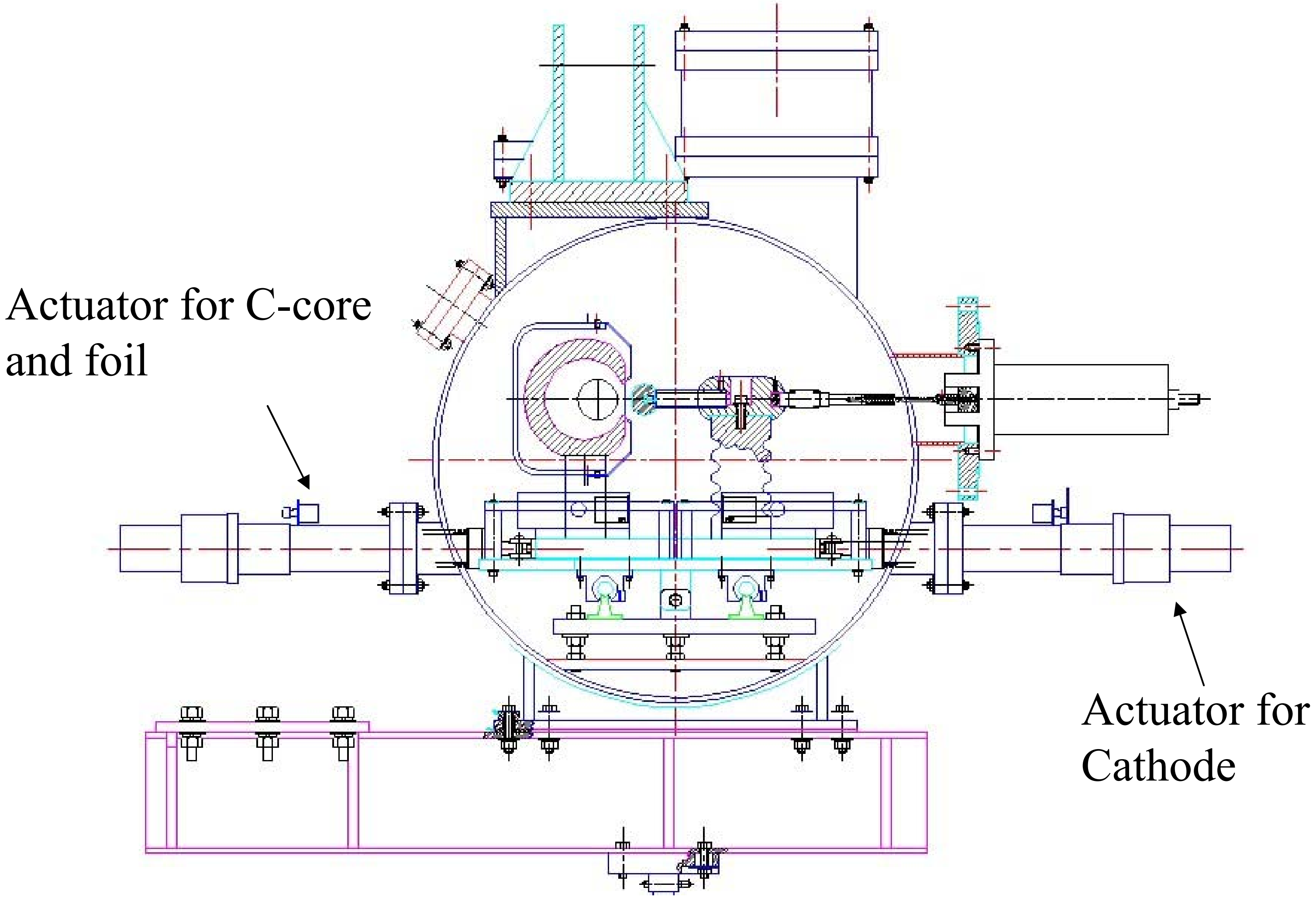
Motion control



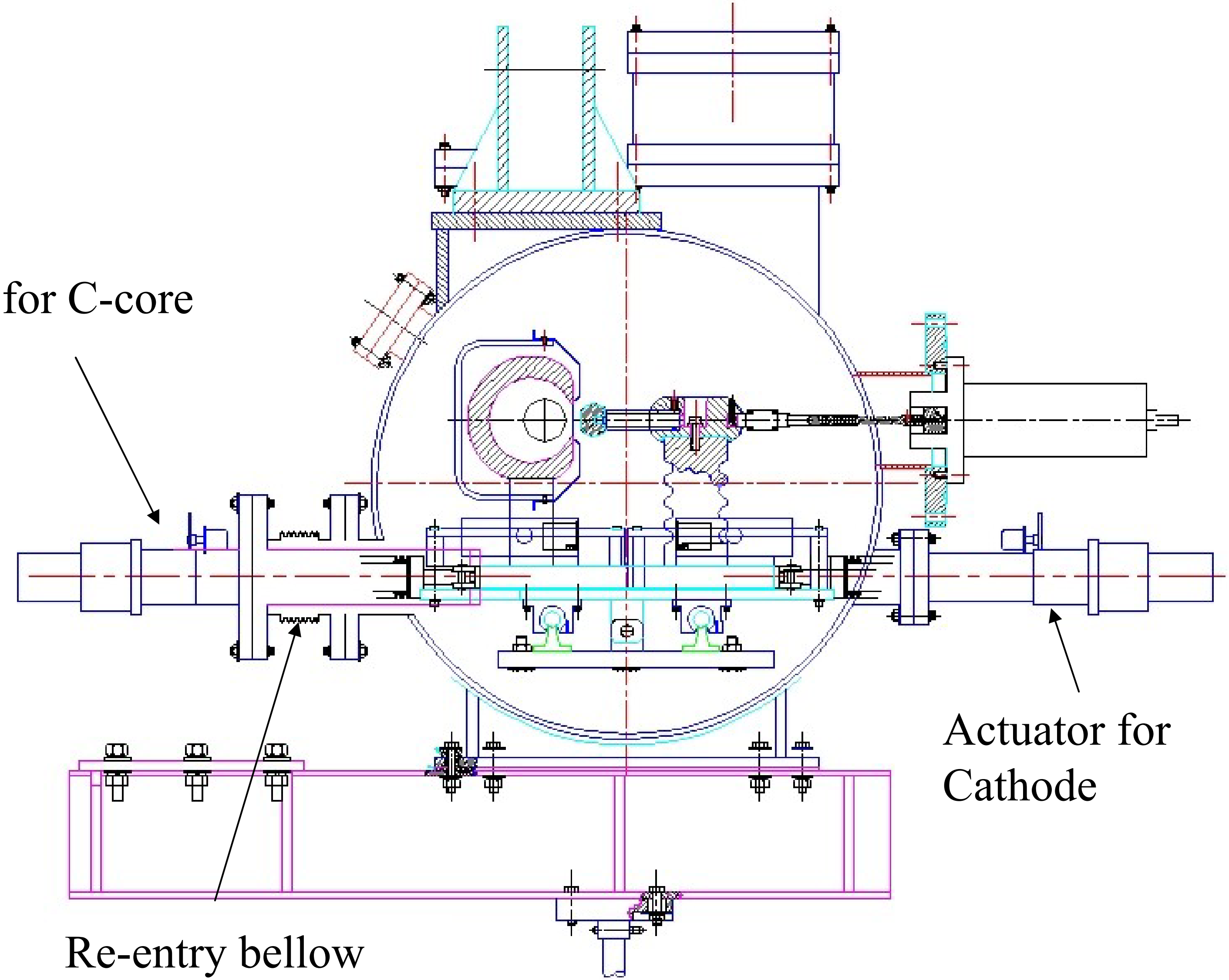
Actuator assembly



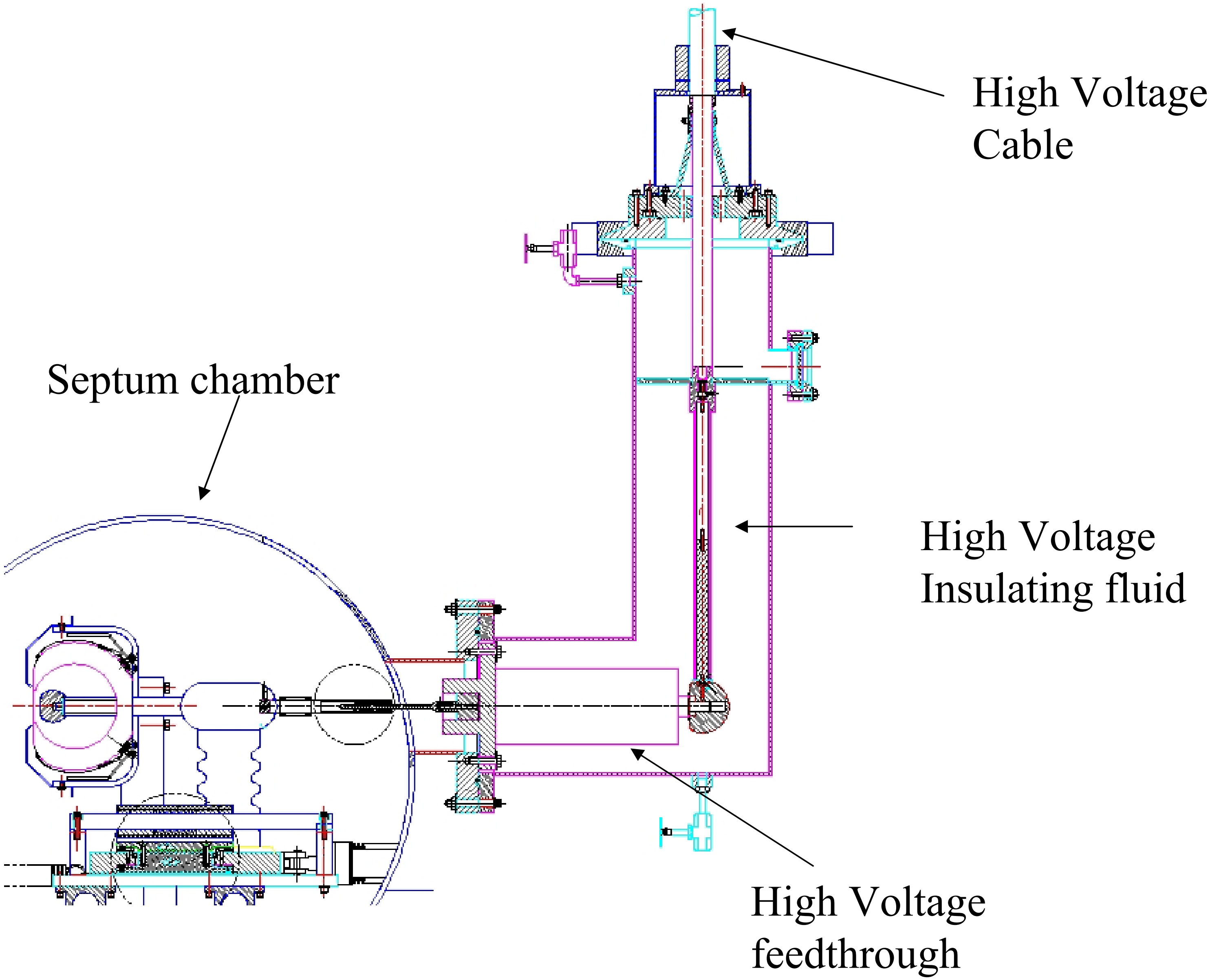
Septum for RSVP with two actuators (Separate but synchronized control)



Septum for RSVP with two actuators
Piggy back but independent control



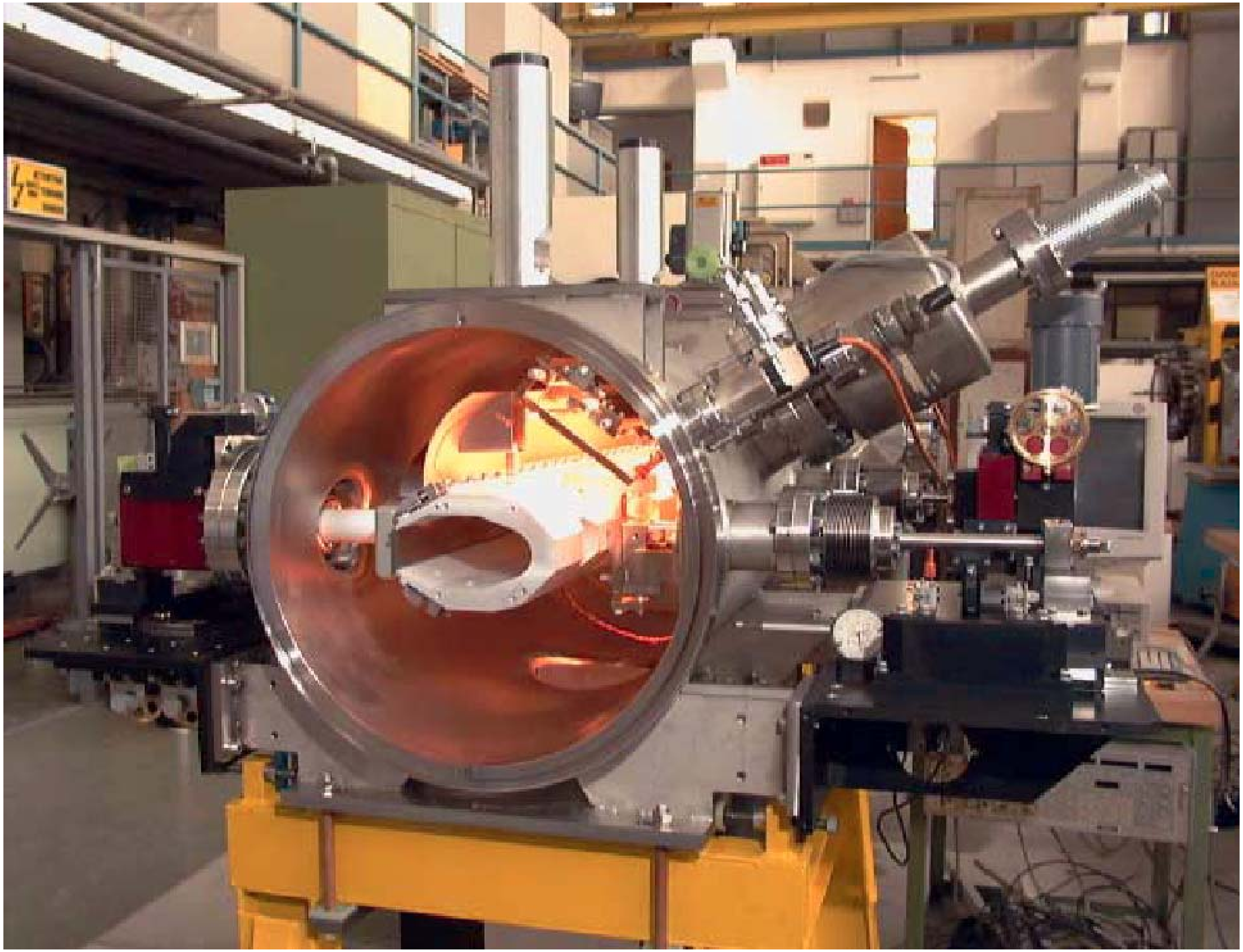
High Voltage Feedthrough



Summary

1. The foil septum works well in slow beam extraction.
2. Beam loss in the foil is slightly increased, but beam losses in the down stream devices are reduced. Overall efficiency is unchanged.
3. The foil septum is more reliable and easy to maintain.
4. The septum will be upgraded with larger aperture for RSVP operation.
5. Foil will be separated from cathode with separate motion control for adjustment.

Electrostatic Septum used in CERN



Inside view of CERN’s Electrostatic Septum