



# **The US Particle Accelerator School Supports and Alignment**

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Lawrence Livermore National Laboratory  
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# Vacuum System Structural Support Stands

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- Structural stands must provide deadweight support for the accelerator and beam line.
- Stands must provide support during seismic events.
- Stands must provide adequate freedom of movement during thermal cycles (operational and bake-out).
- Stands must constrain the accelerator and beamline to maintain positional requirements.



# Categories of Support Stands

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**Kinematic Supports** - support system that provide six degrees of freedom (x, y, z, roll, pitch, and yaw).

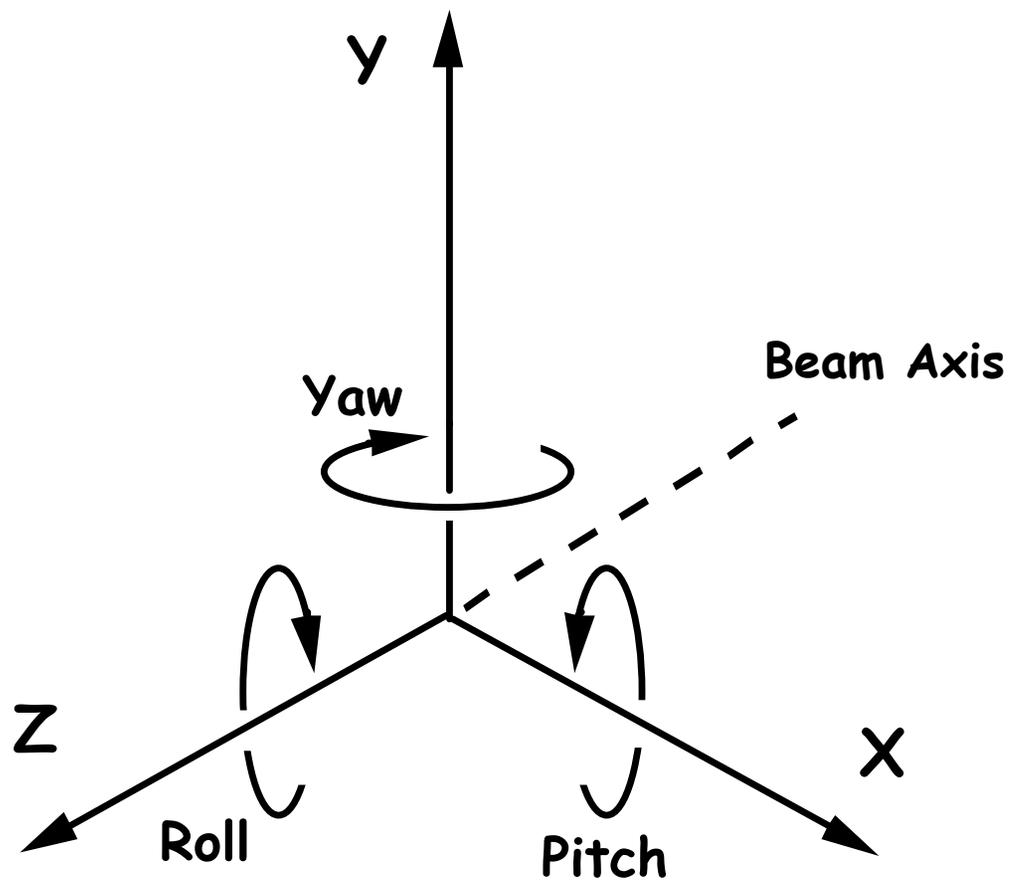
**Overconstrained Supports** - support system that deforms the vacuum system to control its position.

In reality, most support designs are somewhere in between these two categories.

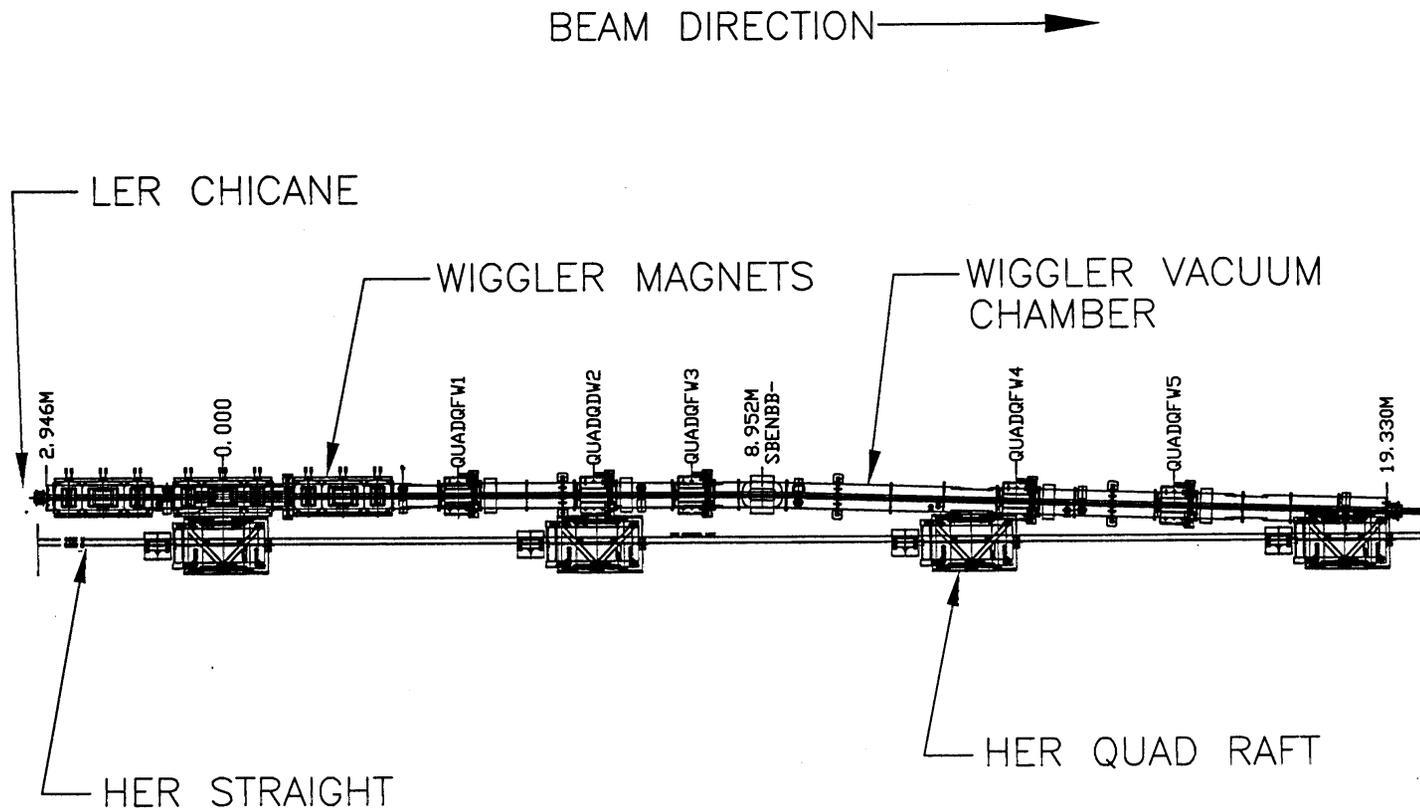


# Six Degrees of Freedom

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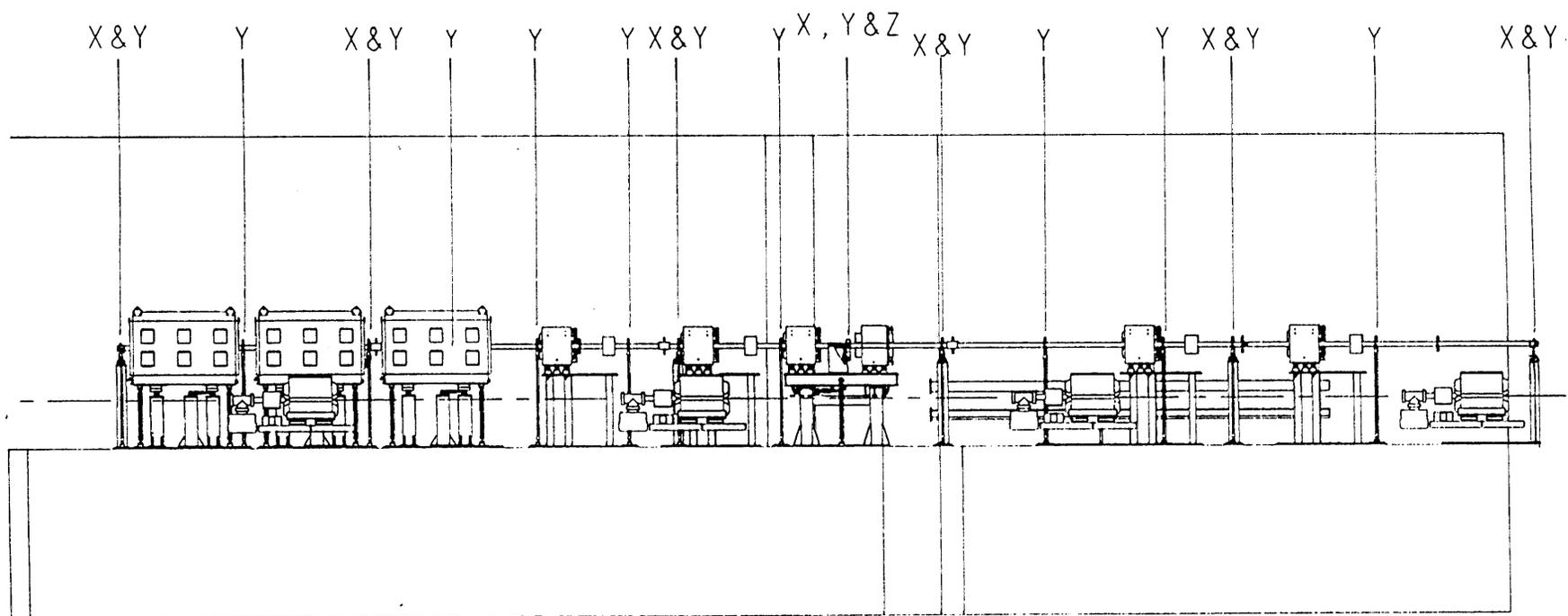


# Example - PEP-II LER Wiggler Section Supports

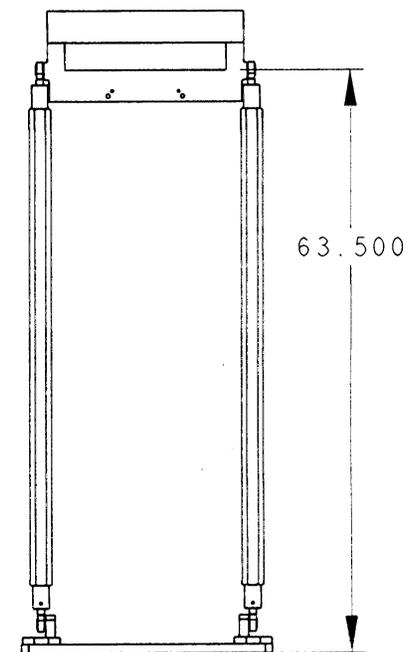
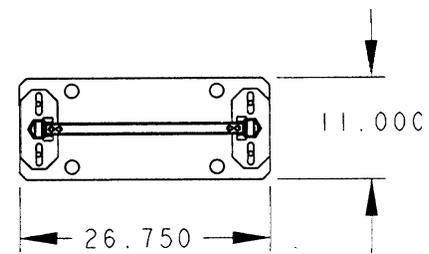
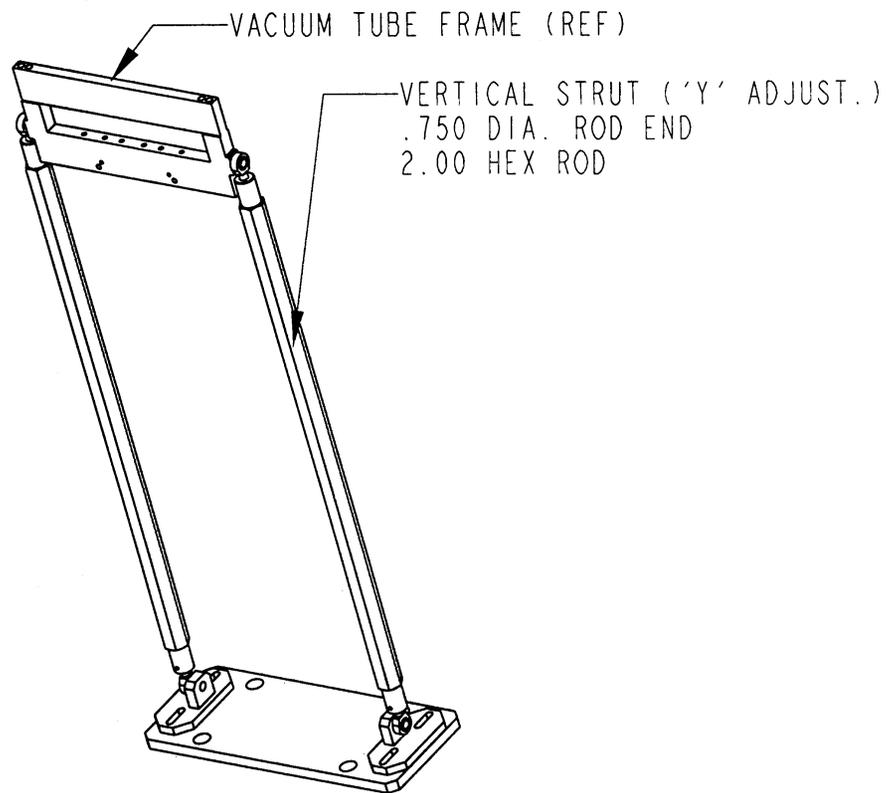




# Wiggler Section, X & Y Support Locations



# Y-direction Stand for Wiggler Chamber



**This stand provides support and adjustment capability in the y-direction and roll.**

# PEP-II Wiggler Vacuum Chamber Y-direction Support

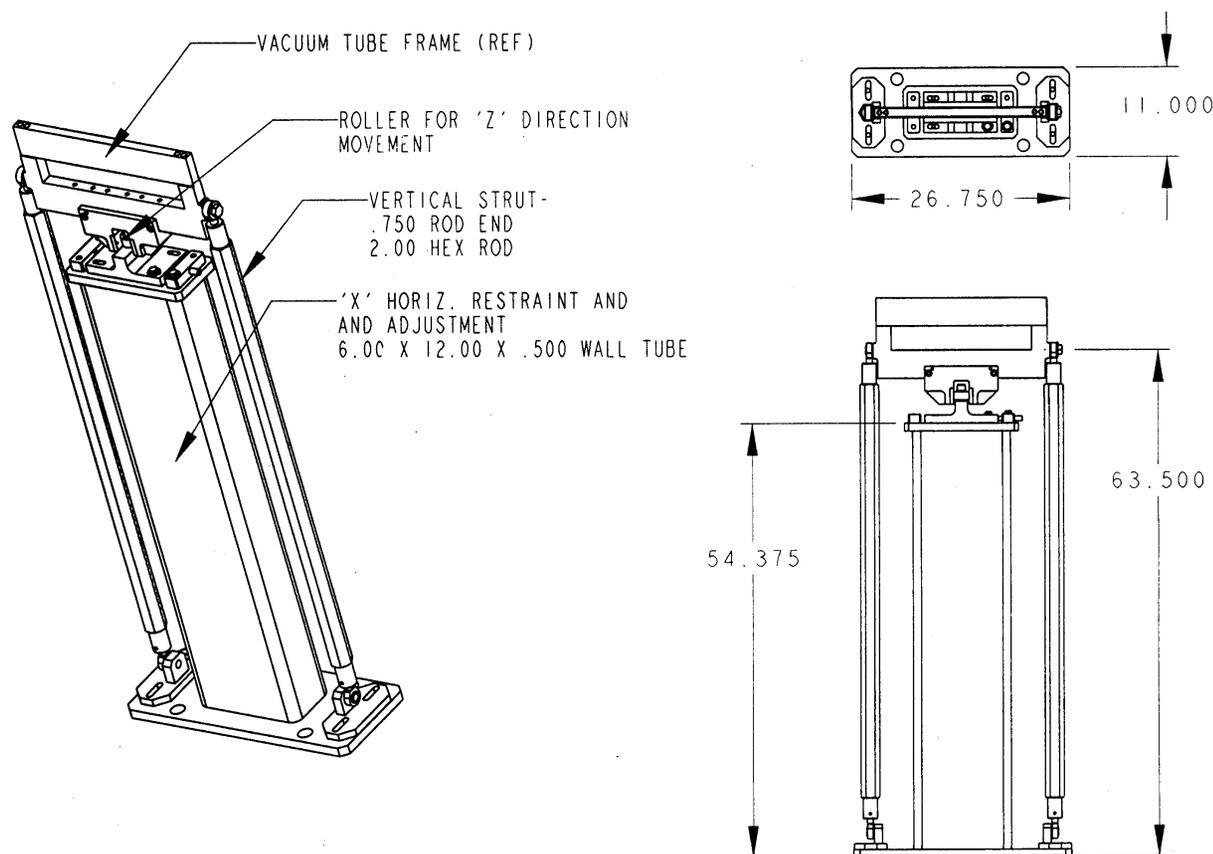
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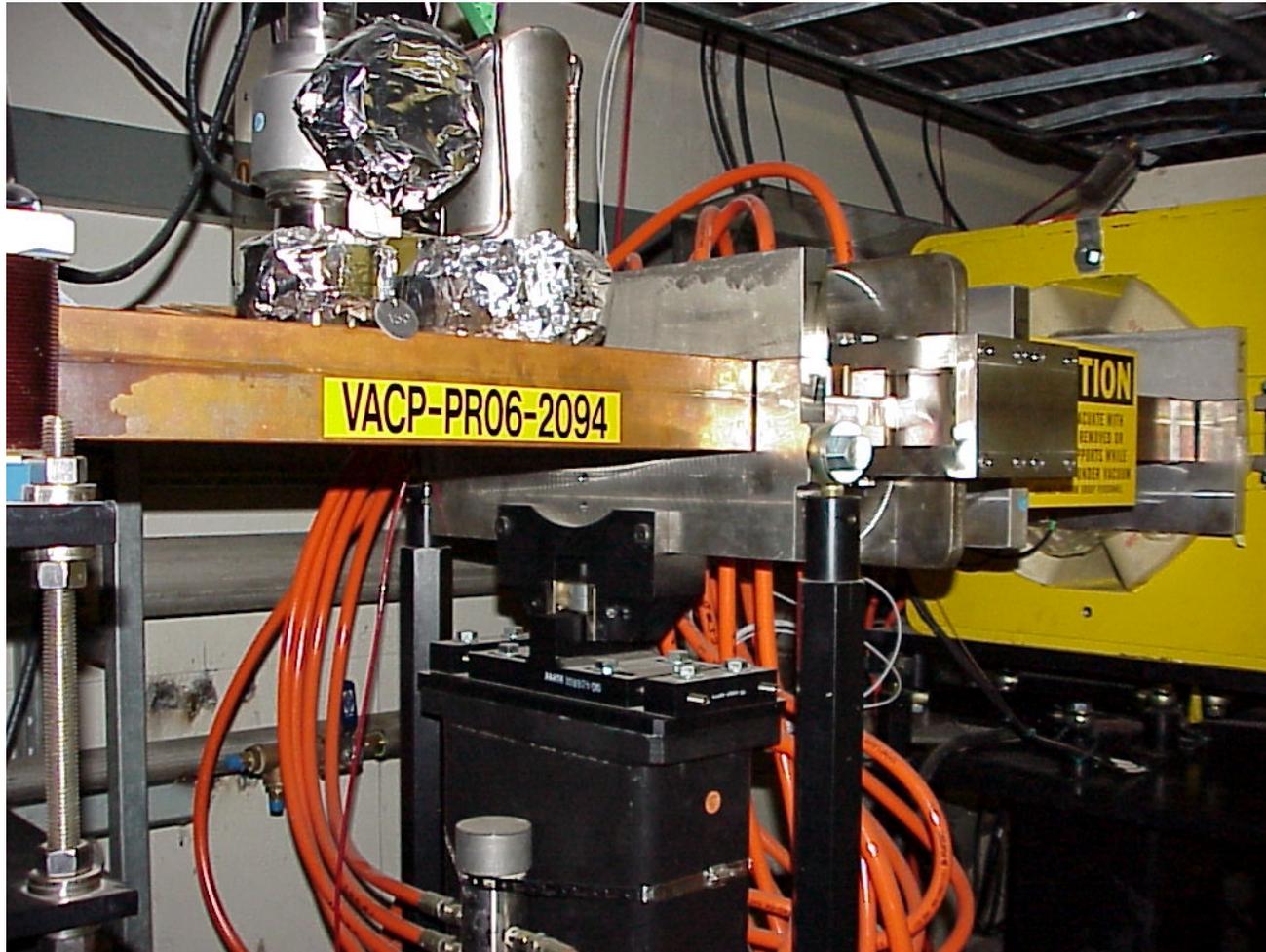


# Example of an XY-direction Support Stand

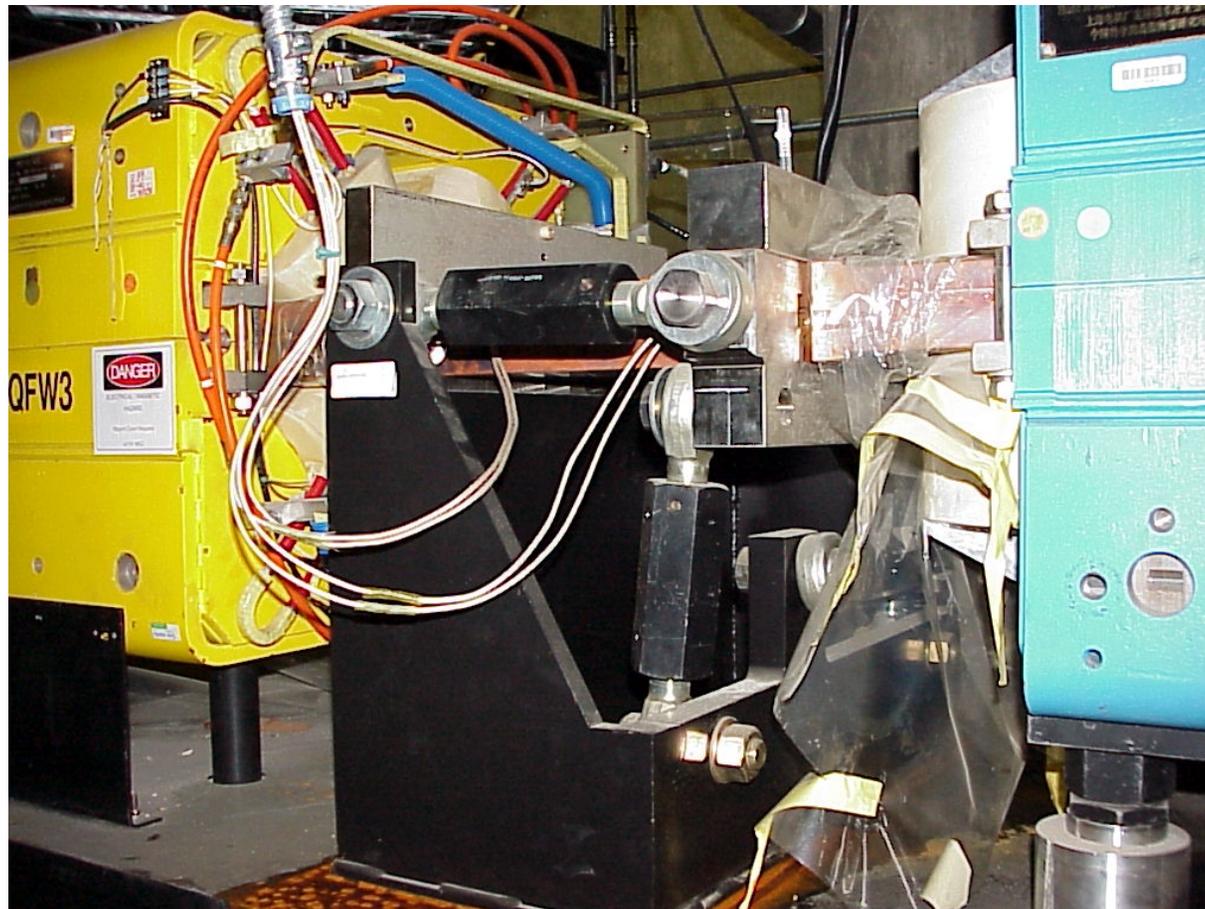
The stand provides support and adjustment capability in the X- and Y-directions as well as roll.



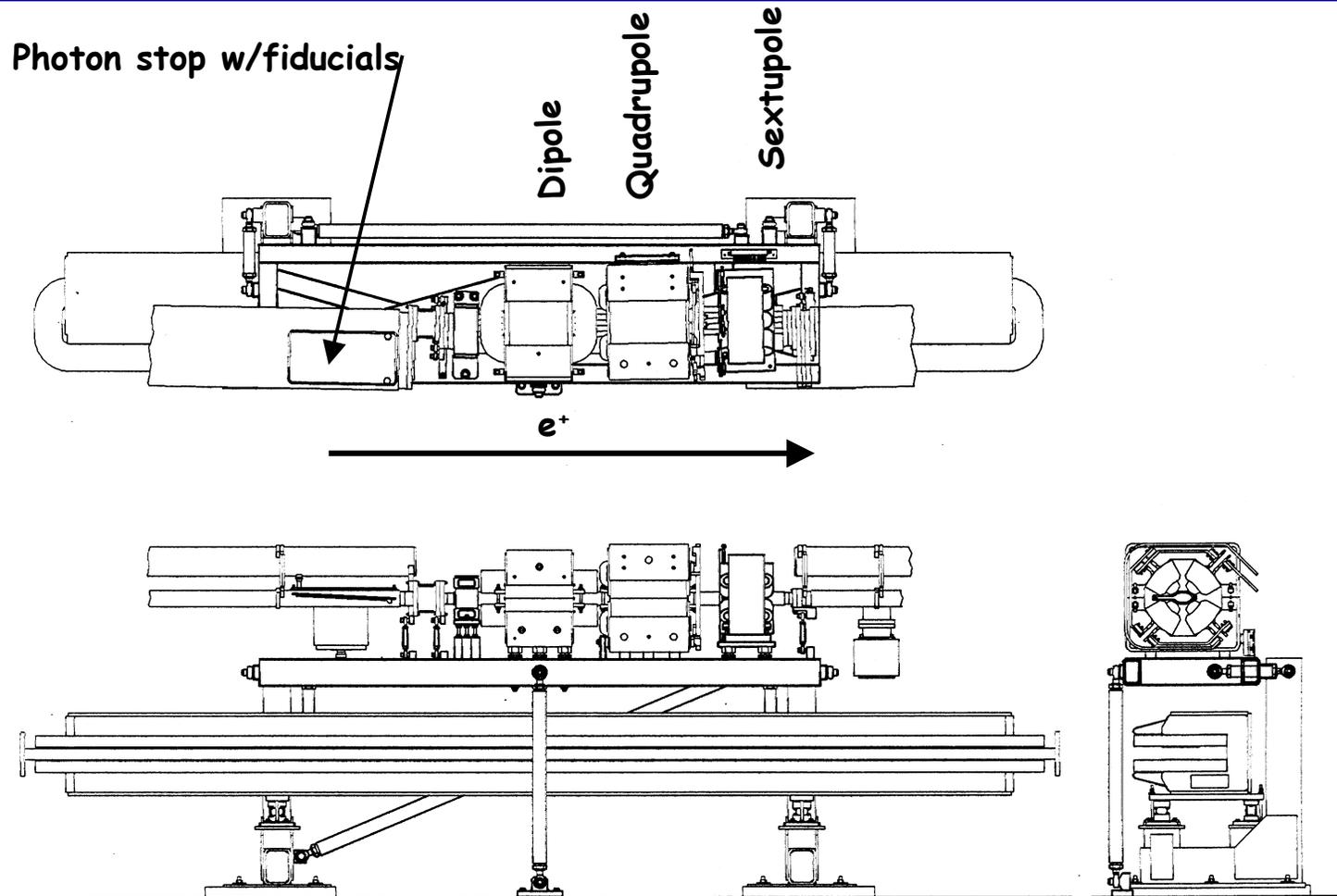
# PEP-II Wiggler Vacuum Chamber XY-direction Support



# PEP-II Wiggler Vacuum Chamber XYZ-direction Support

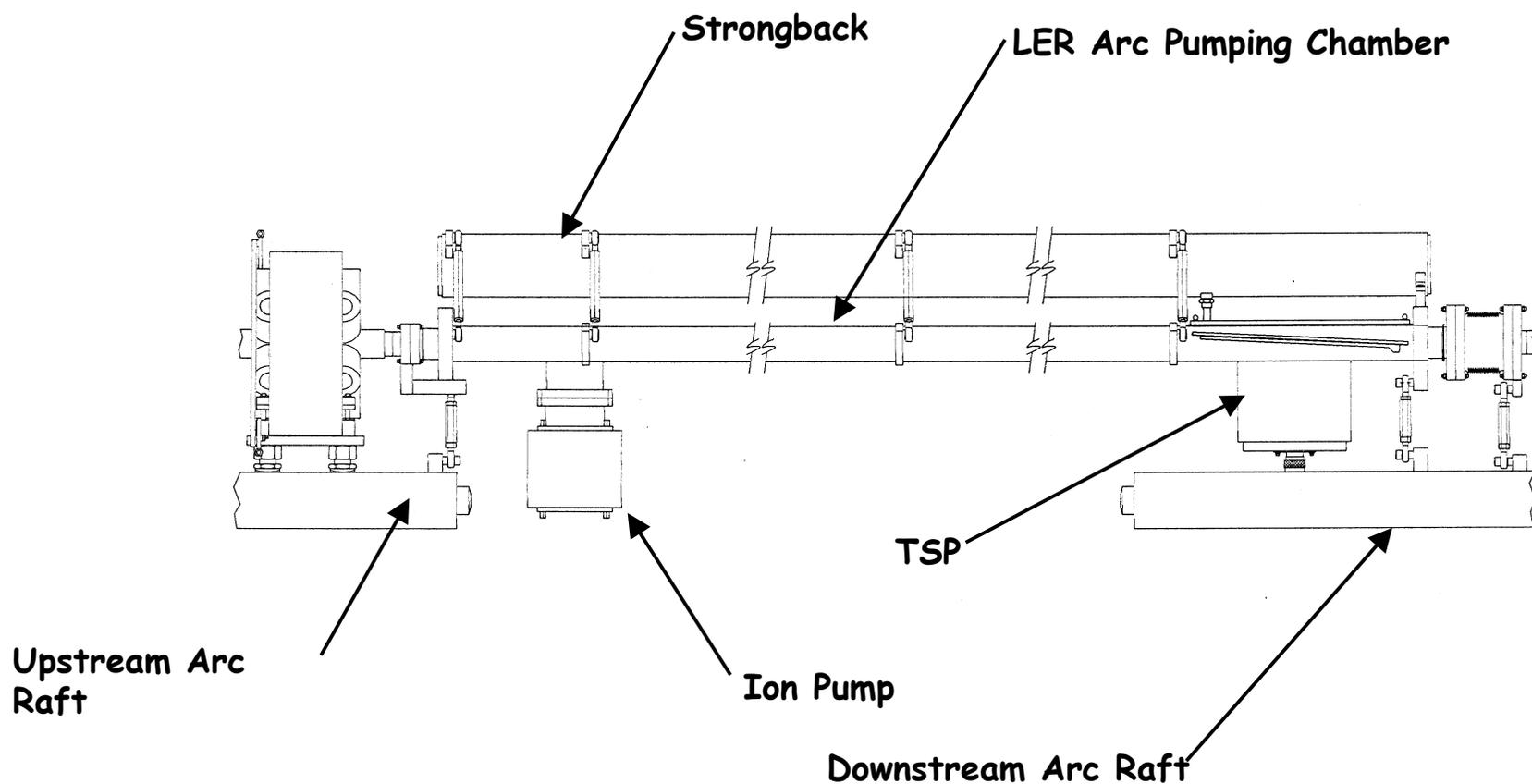


# LER Arc Raft Components and Supports



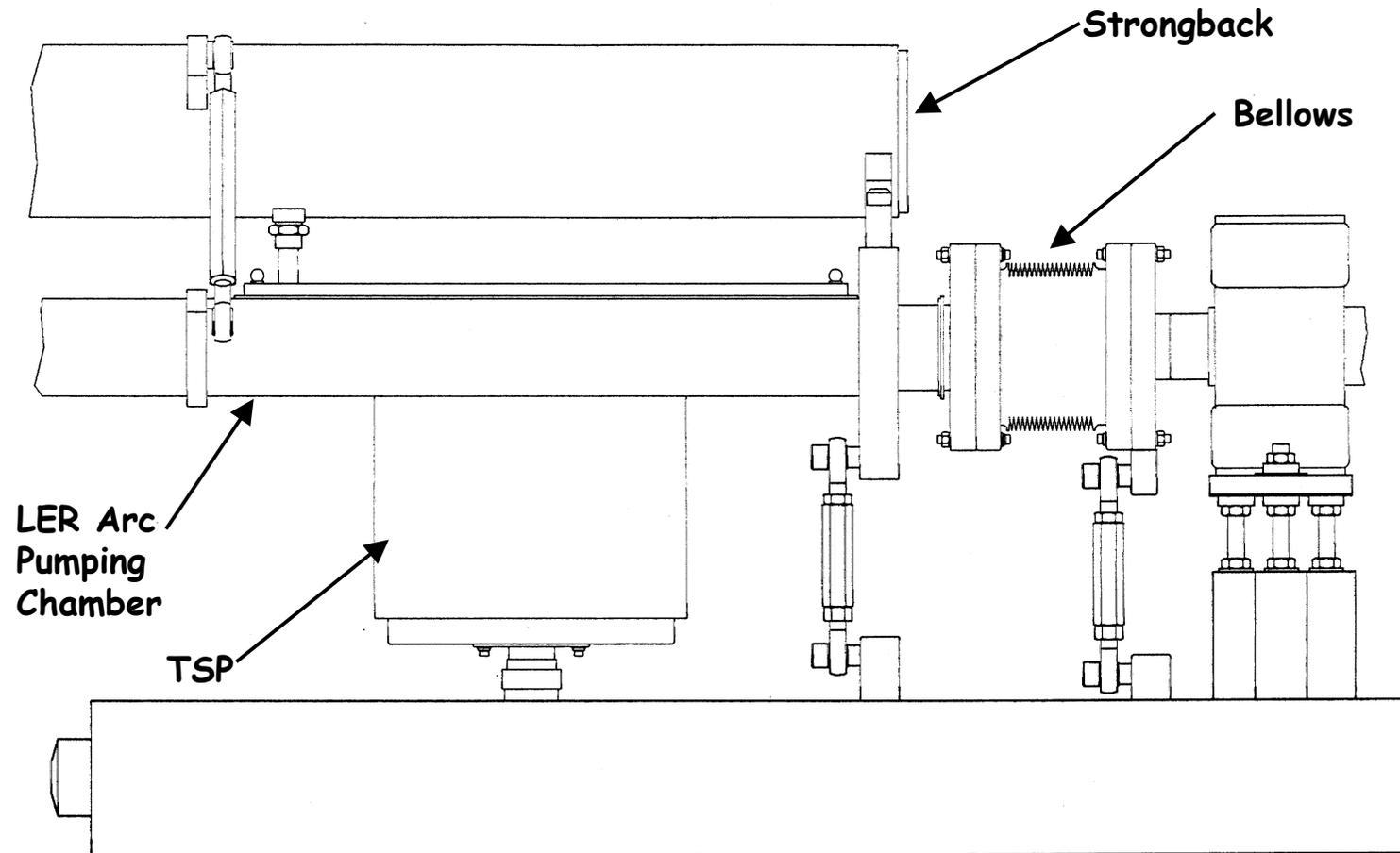


# LER Arc Pumping Support Chamber

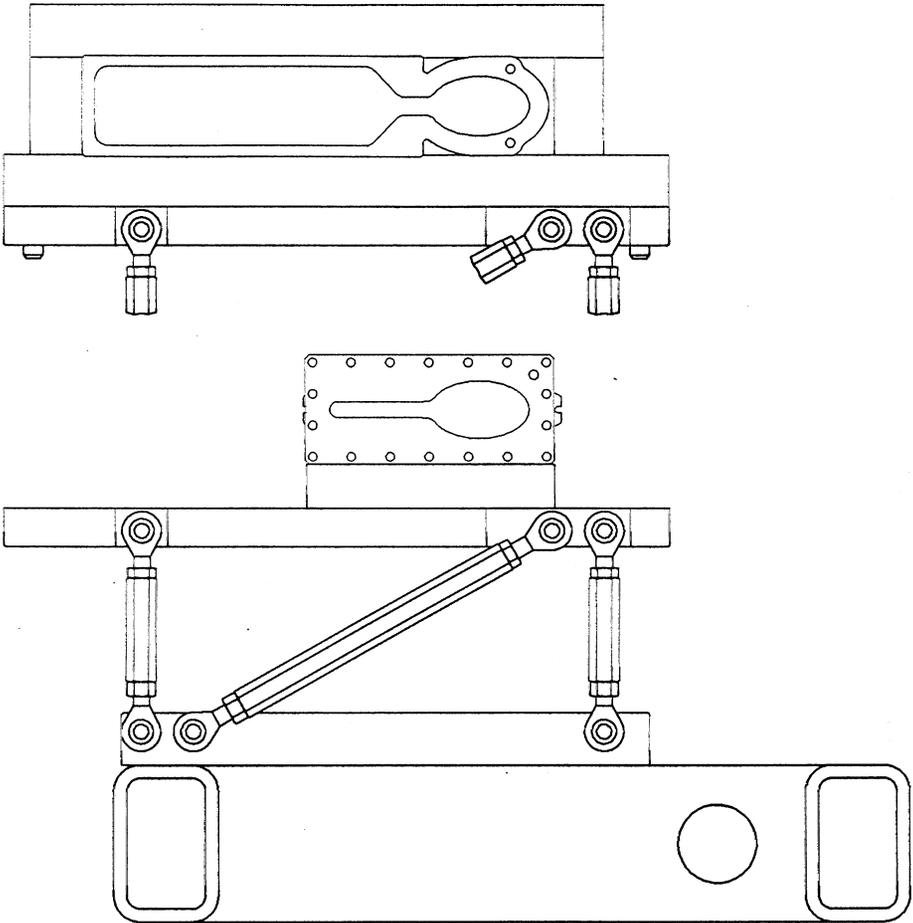




# LER Downstream Raft Support



# LER Magnet and Pump Chamber Support



# PEP-II LER Arc Pump Chamber "Strongback" Support



Strongback



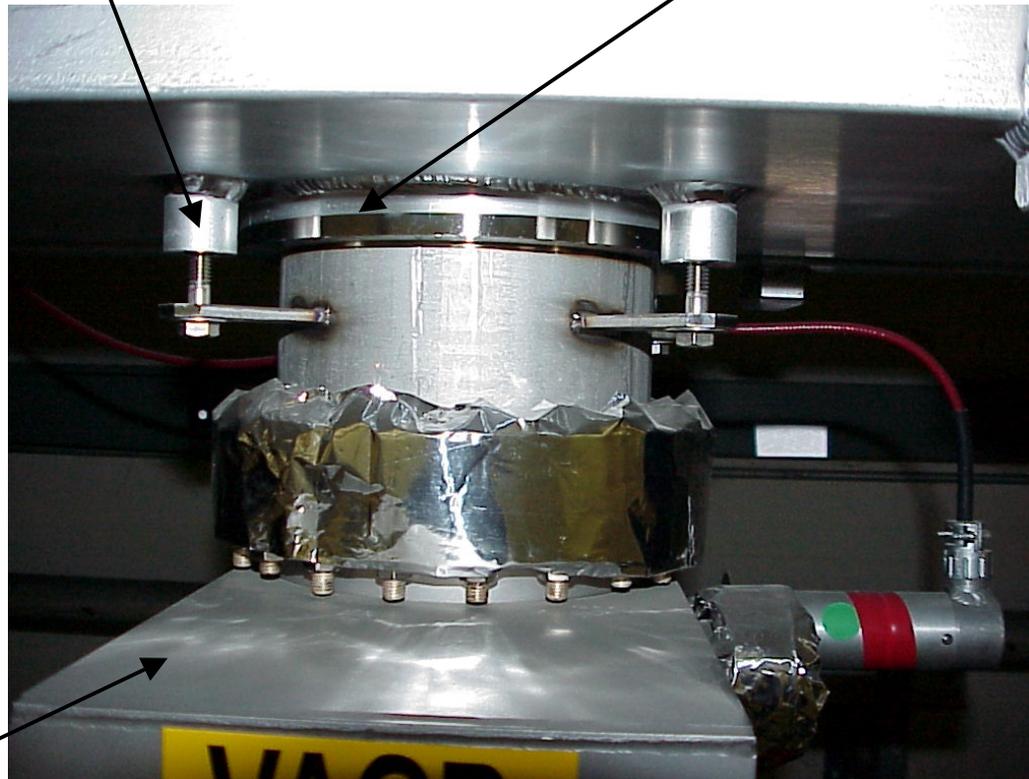
Struts adjust in  
Y-direction &  
Roll

# PEP-II LER Pump Chamber Y-direction Support



Aluminum Half-Coupling

Al-SS Transition



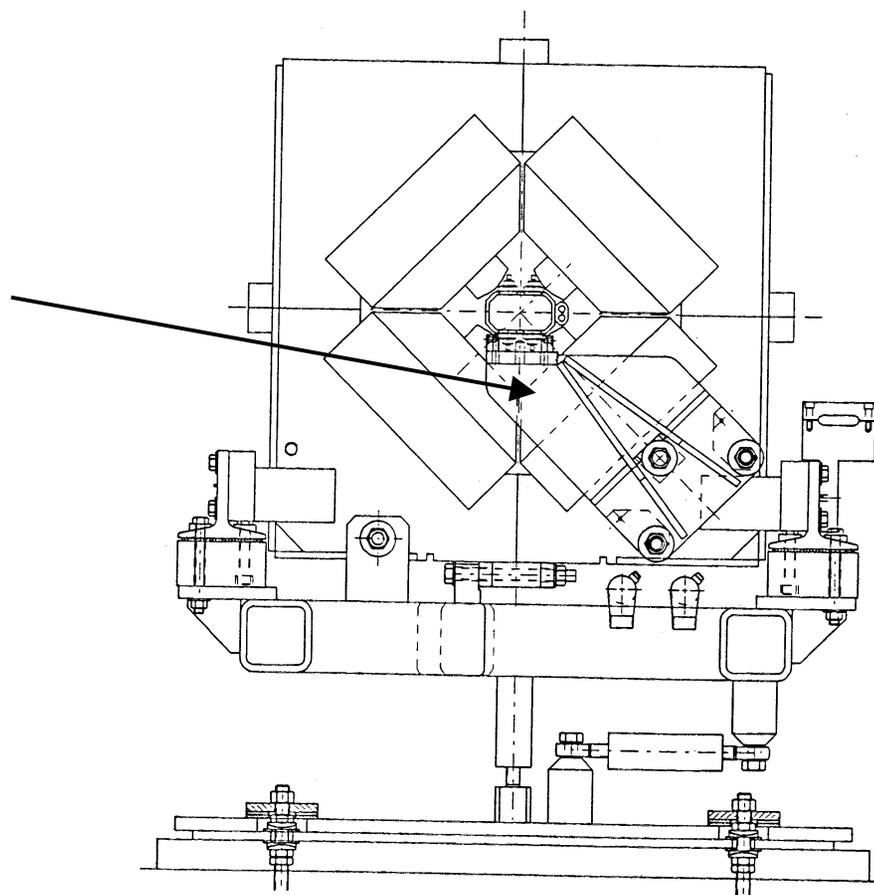
Ion Pump



# Example of a XYZ-direction Support

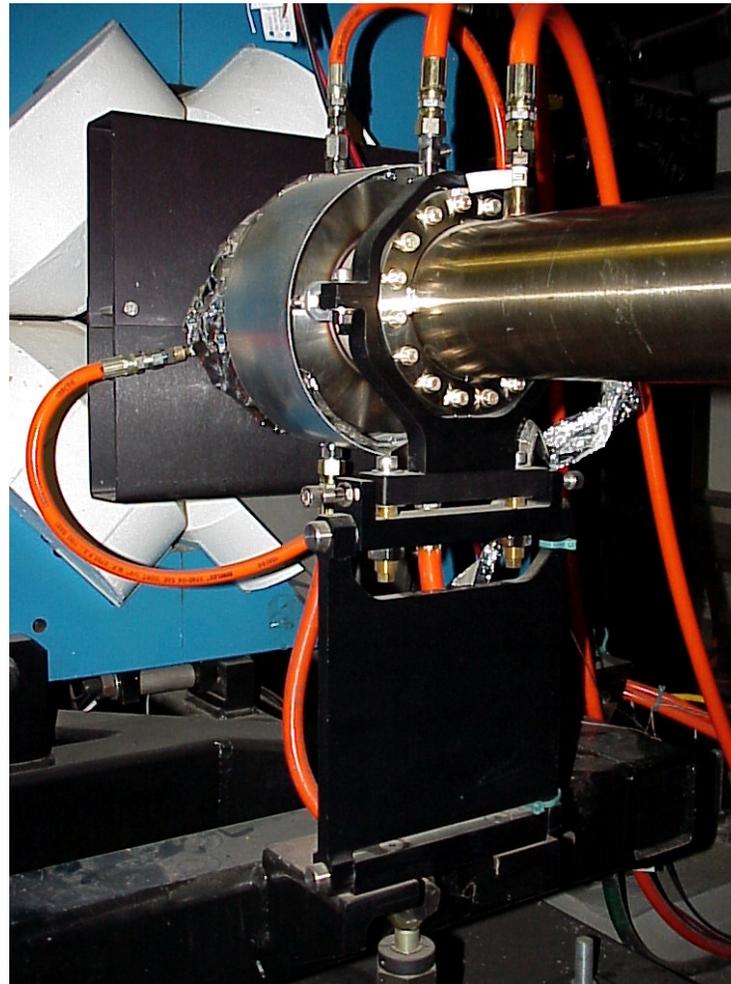
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The stand provides support in the X-, Y-, and Z-directions. An XYZ-direction support stand fixes the beamline in all directions.



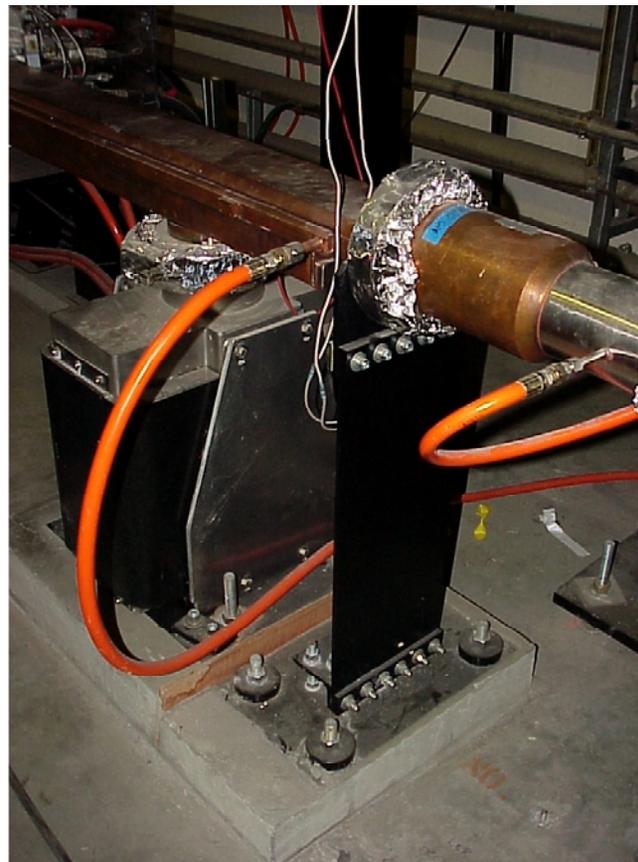
# PEP-II HER Straight Section XY-direction (Rotational) Support

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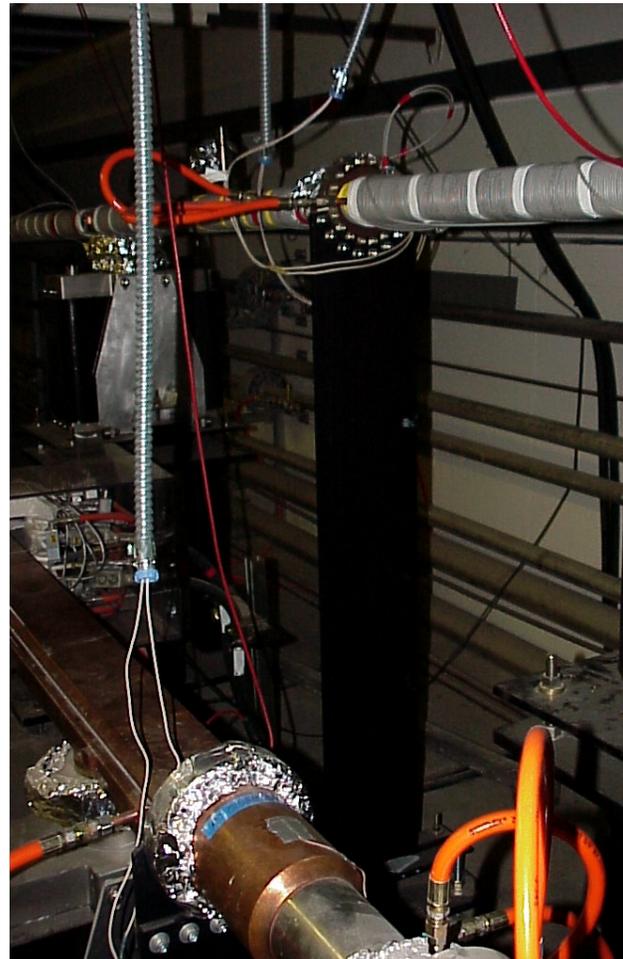
# PEP-II HER Interaction Region XY-direction (Flex) Support

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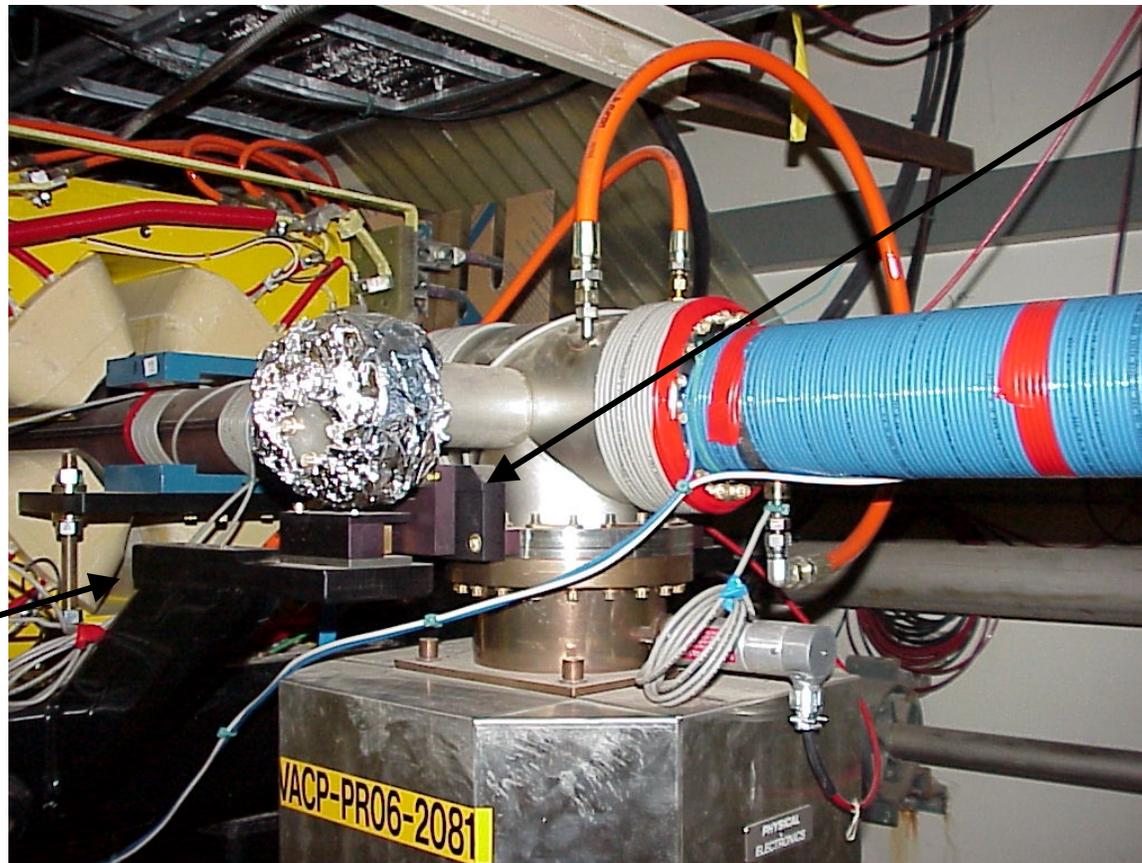


# PEP-II LER Interaction Region XY-direction (Flex) Support

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# PEP-II LER Straight Section XY-direction Pump Support



Bracket & Cam  
Follower attached to  
Pump Cross

"Diving Board"  
attached to Quad  
Magnet Raft

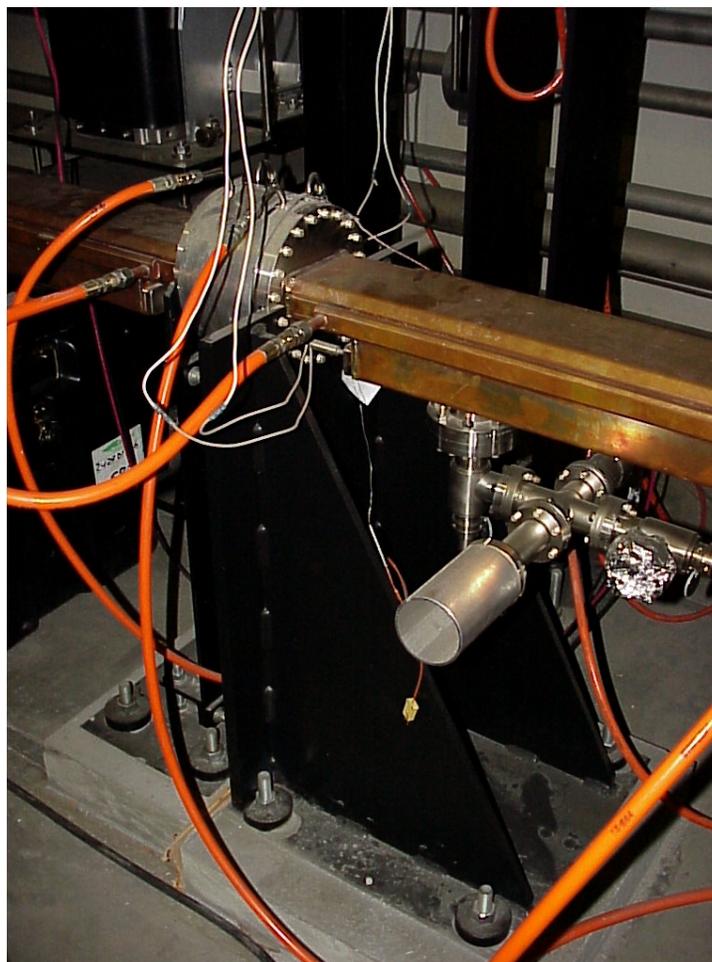
# PEP-II Interaction Region Y-direction Pump Support

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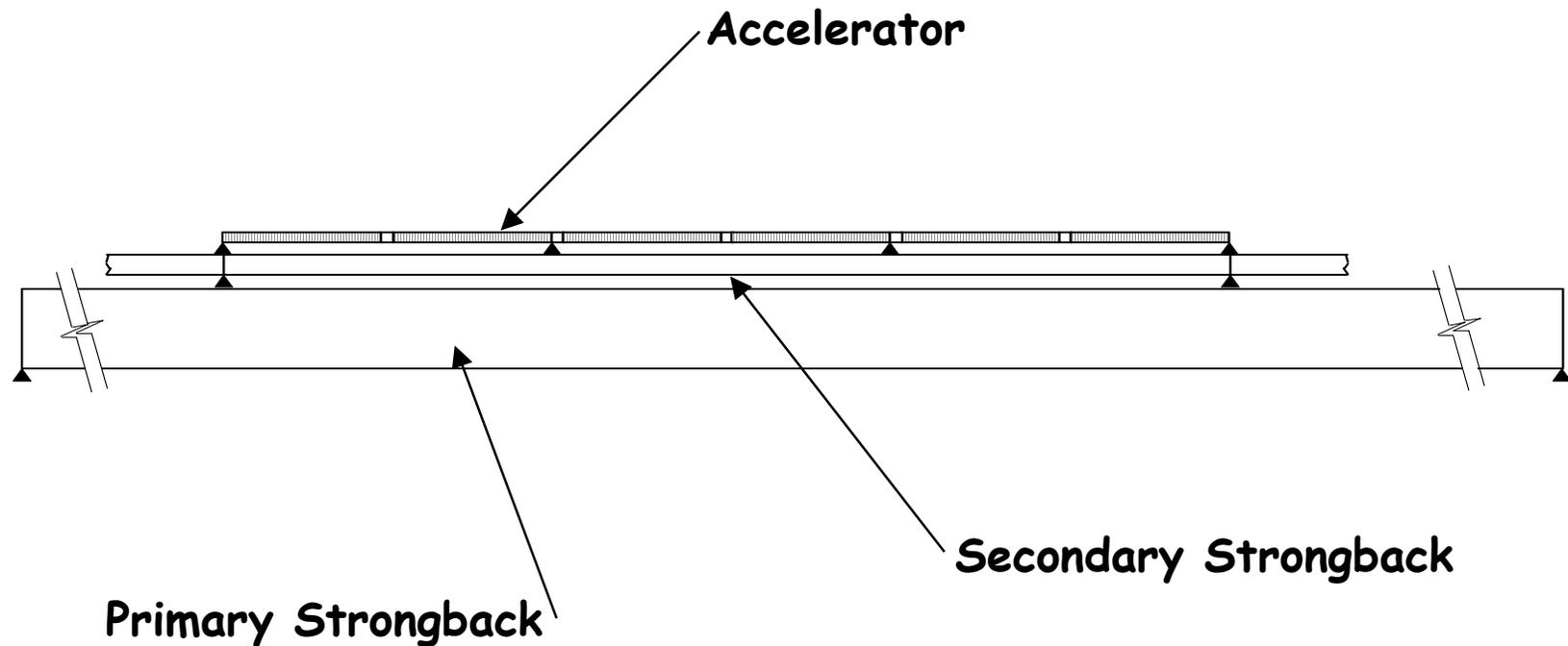


# PEP-II Interaction Region XYZ-direction (Fixed) Support

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# "Strongbacks" Constrain Vacuum Chambers to Control their Position



# SLAC Linac "double strongback" Support





# Six-Strut Support Systems

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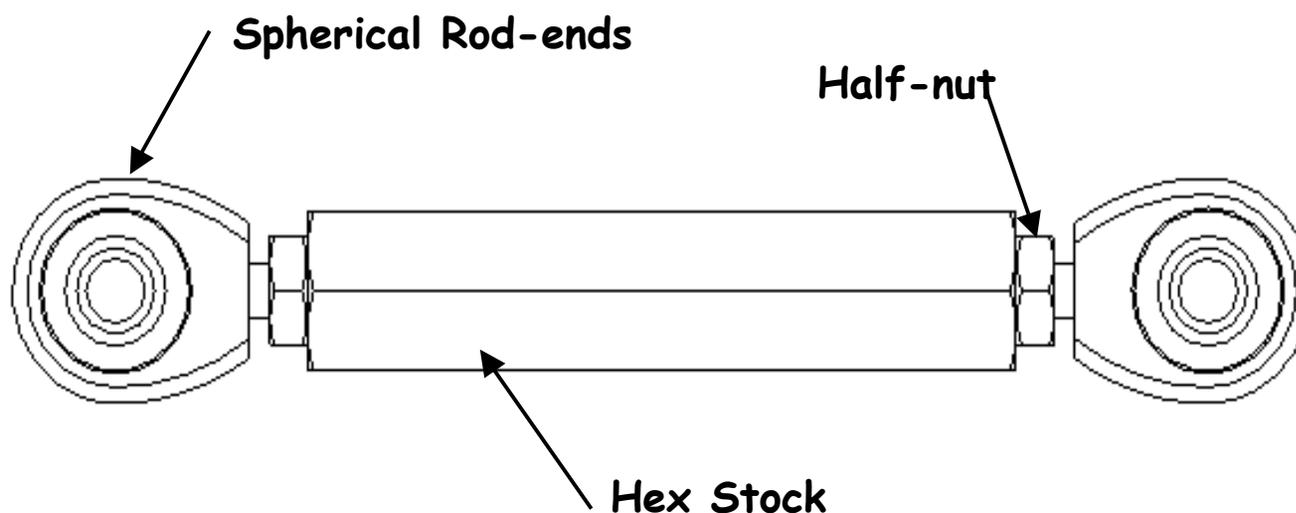
- A support system that uses six orthogonal struts to provide a “kinematic” support (just enough support with no additional constraints).
- Struts have spherical ball joint end connections.
- Each strut is extremely strong and rigid.
- Together the six struts can usually provide a support system with a natural frequency greater than 20 Hz.
- An excellent reference for this style of support system is:  
“Rigid, Adjustable Support of Aligned Elements via Six Struts”,  
W. Thur et al, Fifth Int. Workshop on Accelerator Alignment,  
1997



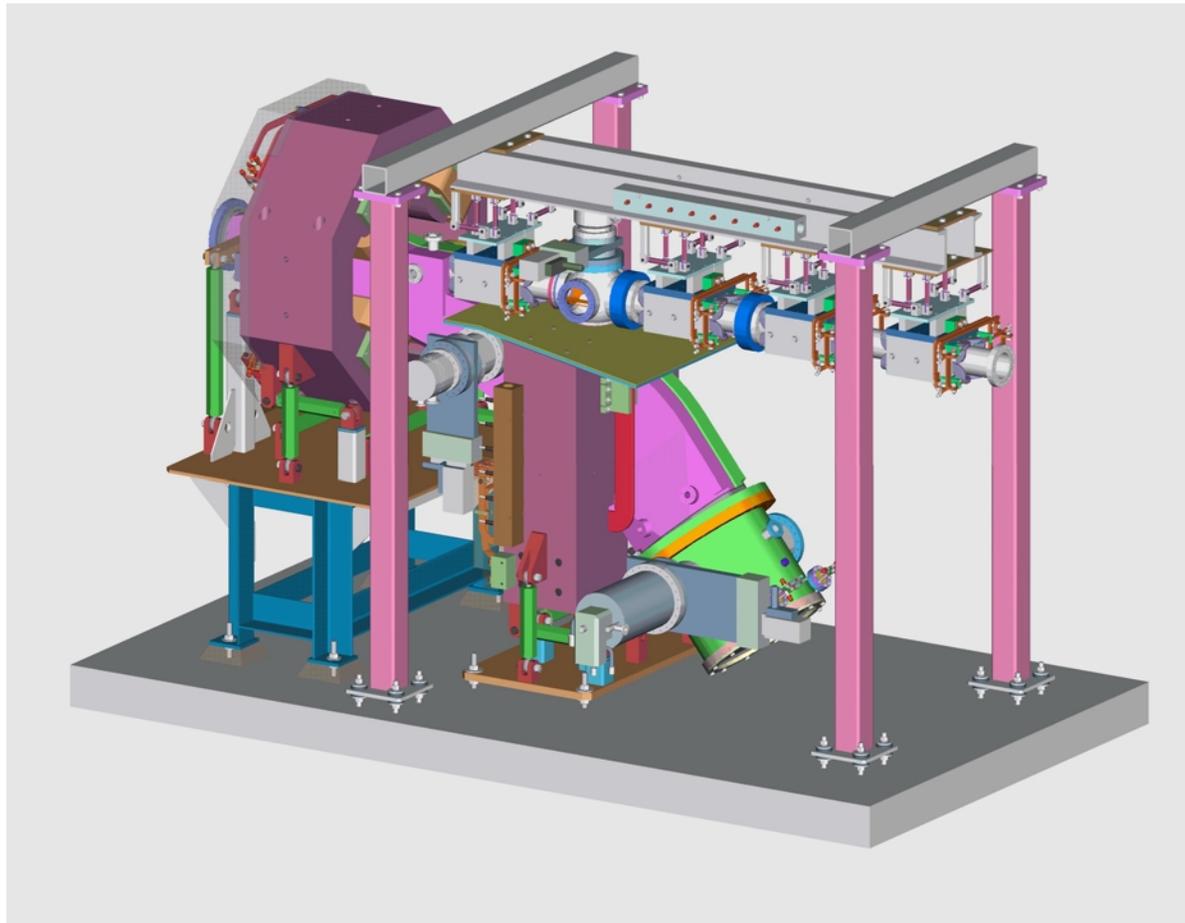
# A Typical Strut

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- Struts can be made several ways:
  - Opposing spherical rod-ends both with right-handed threads (one fine thread, one coarse threads)
  - Opposing spherical rod-ends, right- and left-handed threads (fine threads or coarse threads).



# Example of Kinematic Supports (six-strut)

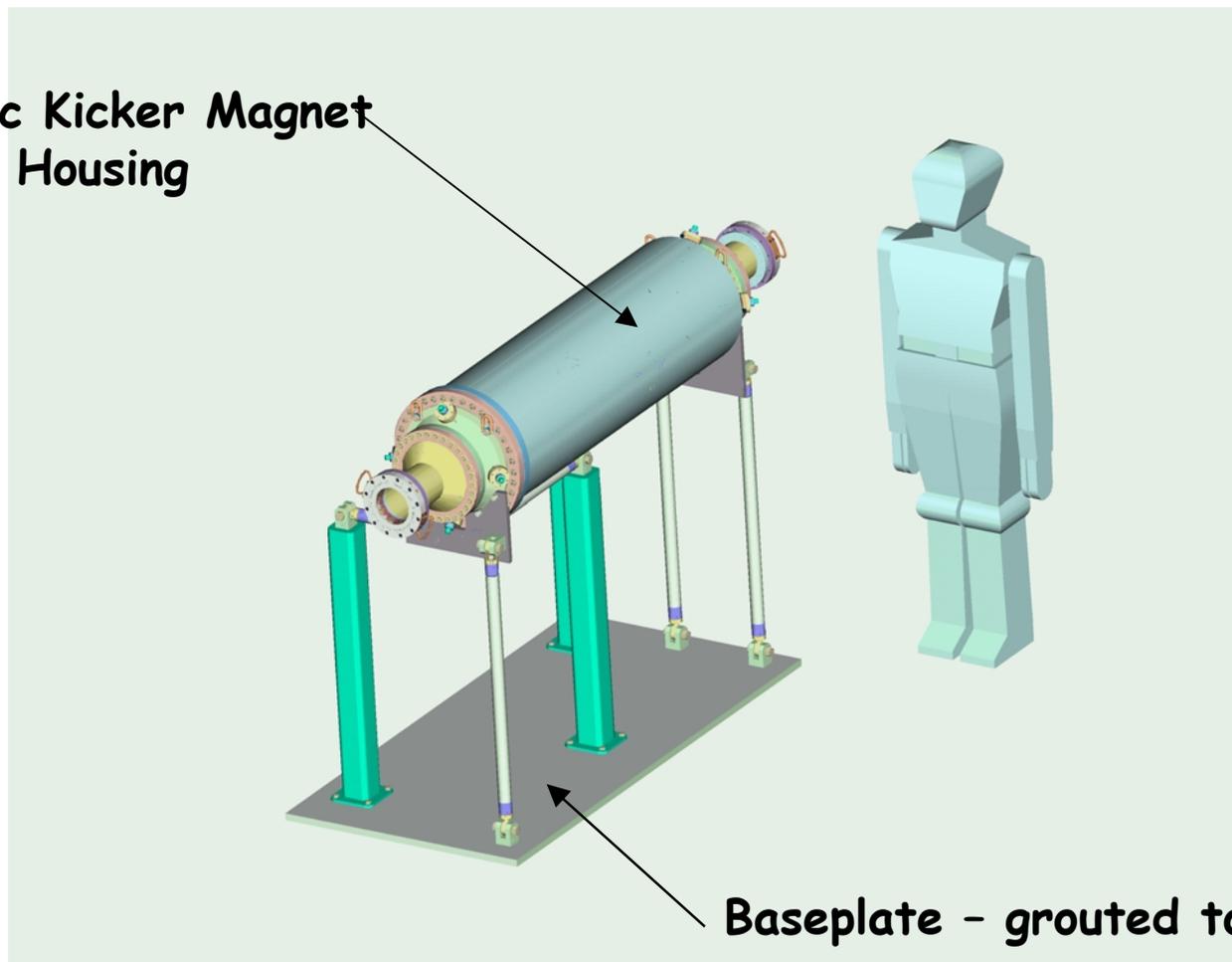


**DARHT II Septum Chamber & Magnets, each supported on six struts**



# DARHT II Kicker Six-Strut Supports

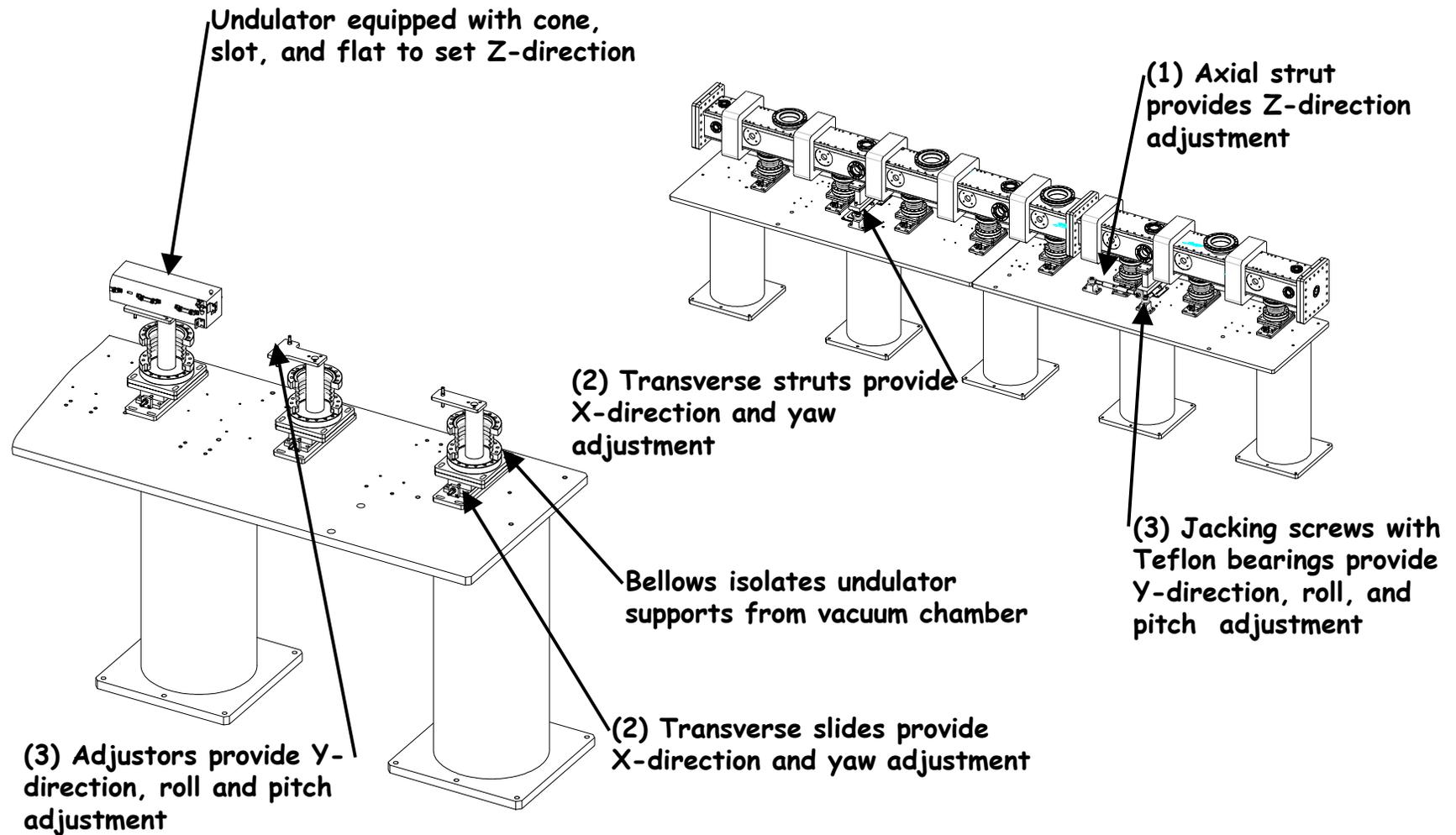
Electrostatic Kicker Magnet  
and Vacuum Housing



Baseplate - grouted to floor

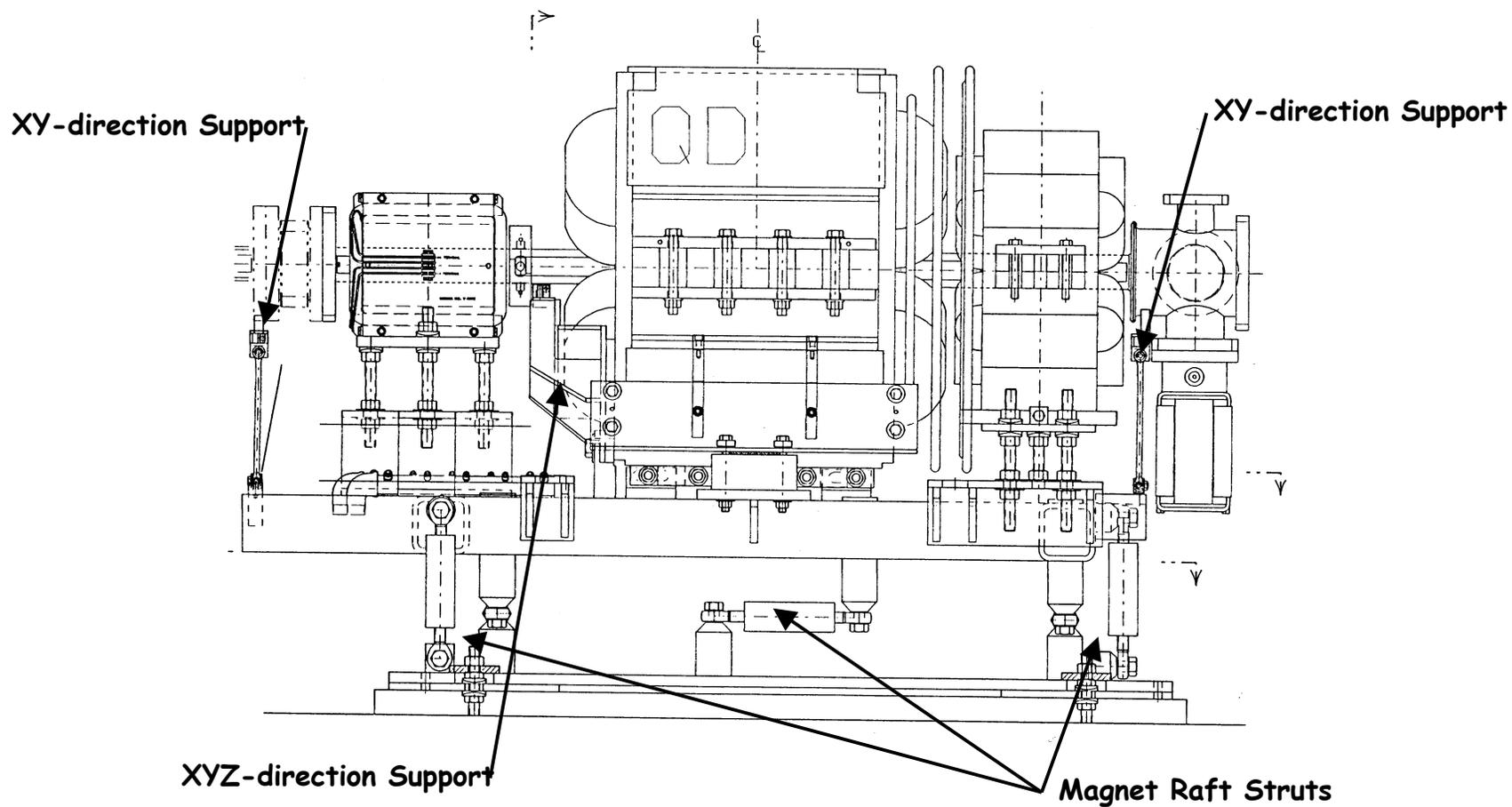


# Two Kinematic Supports in One Design





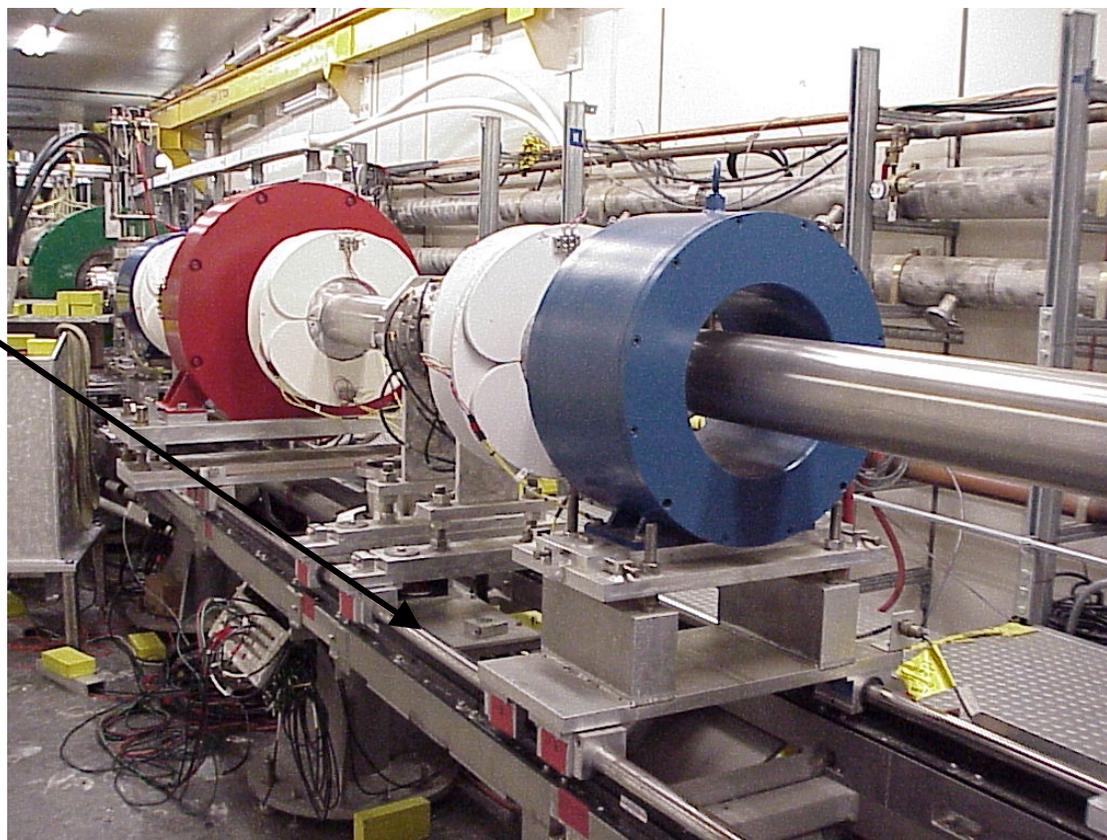
# Magnet Raft





# Support System with Flexibility Built-in

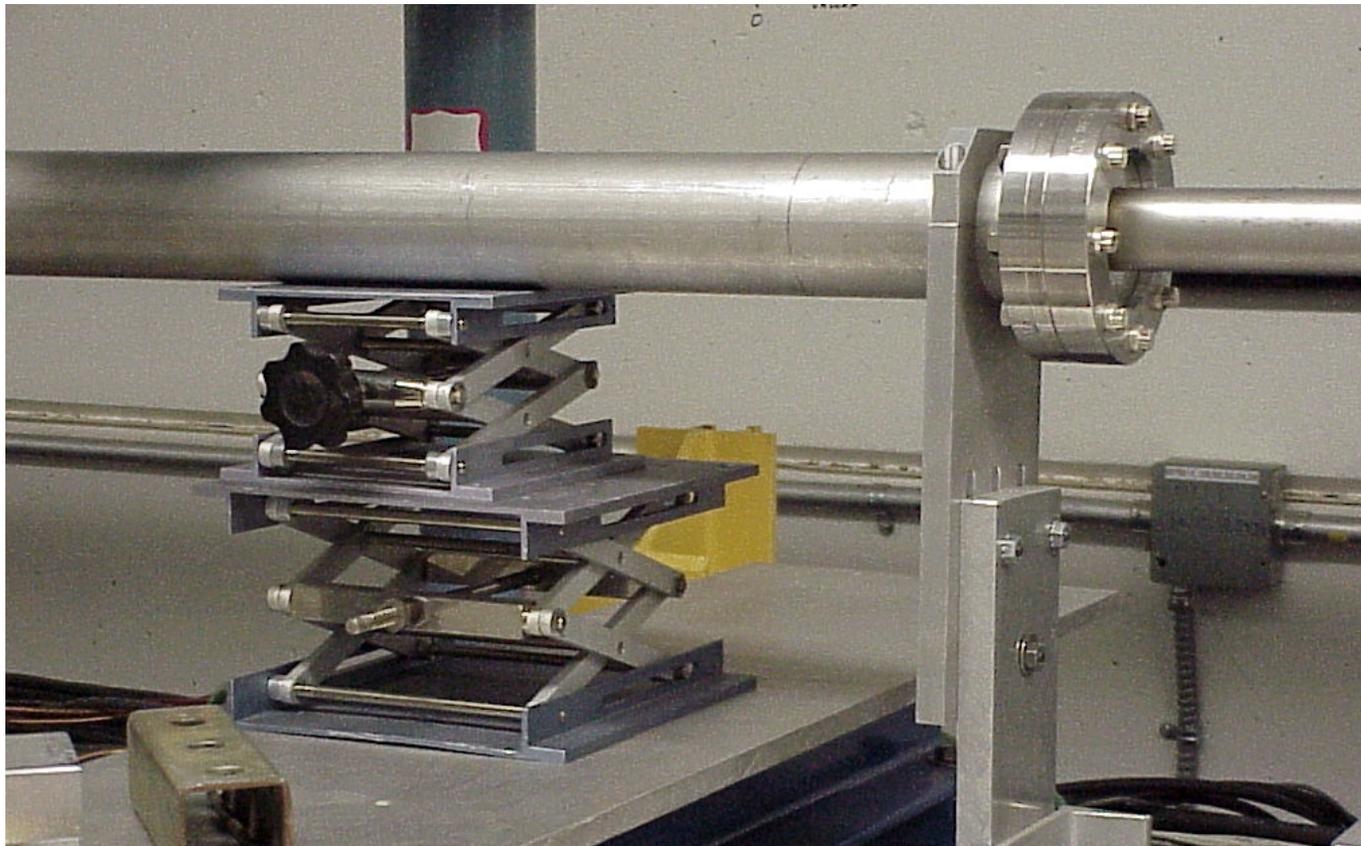
**Magnet and Beampipe  
Supports mounted to  
Thompson Rails**





# When all else fails ...

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# Typical areas of accelerator vacuum systems that require accurate positioning

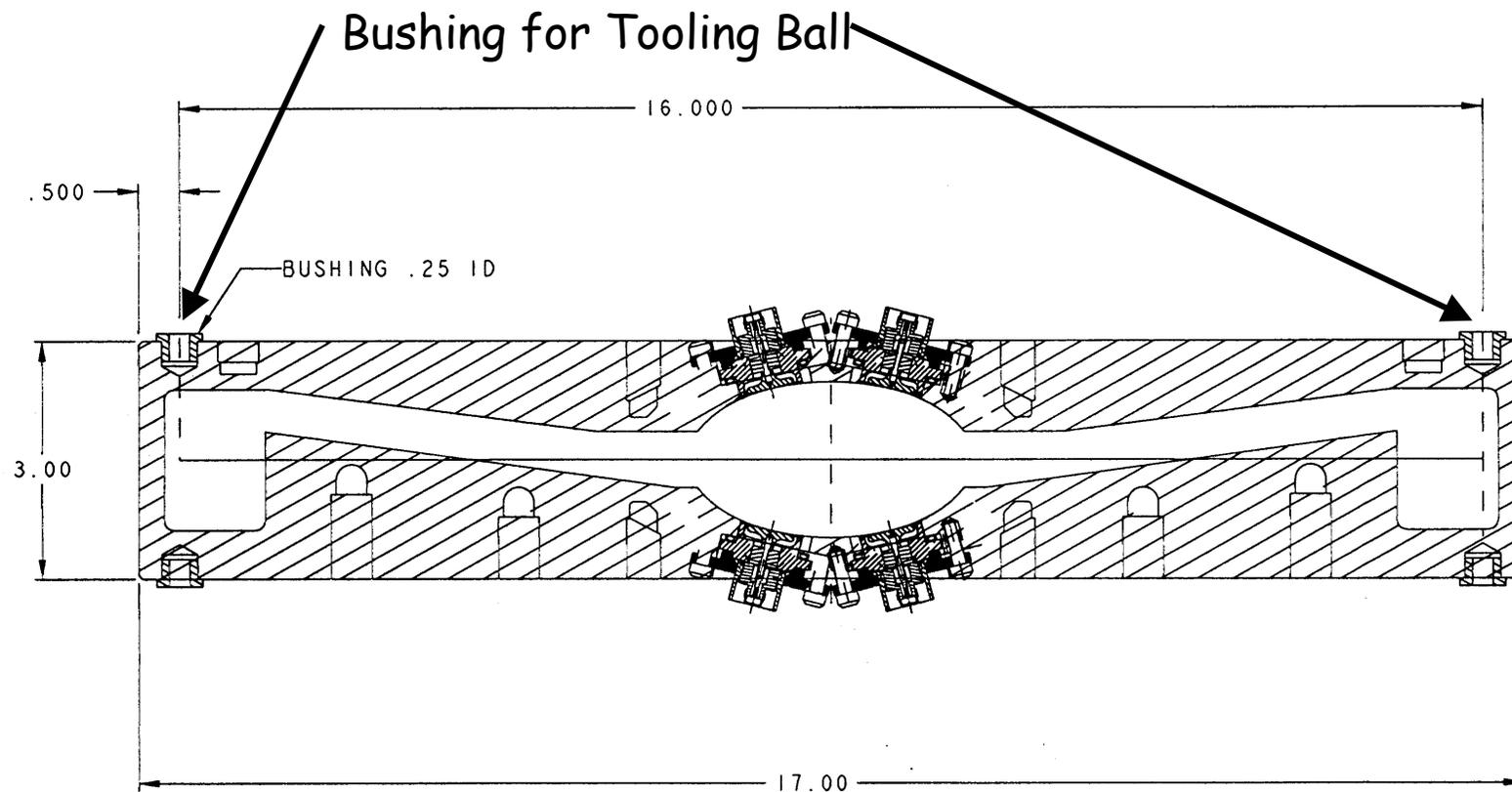
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- RF Cavities
- Beam position monitors (BPM)
- Synchrotron radiation adsorbers or masks

Fiducials are usually located near these components to aid in alignment.

# Fiducials on a Wiggler Chamber (near BPM)



# Fiducial on Quadrupole Chamber (near BPM)



BPM Buttons

Fiducial Mounts  
(reamed holes for tooling balls)

