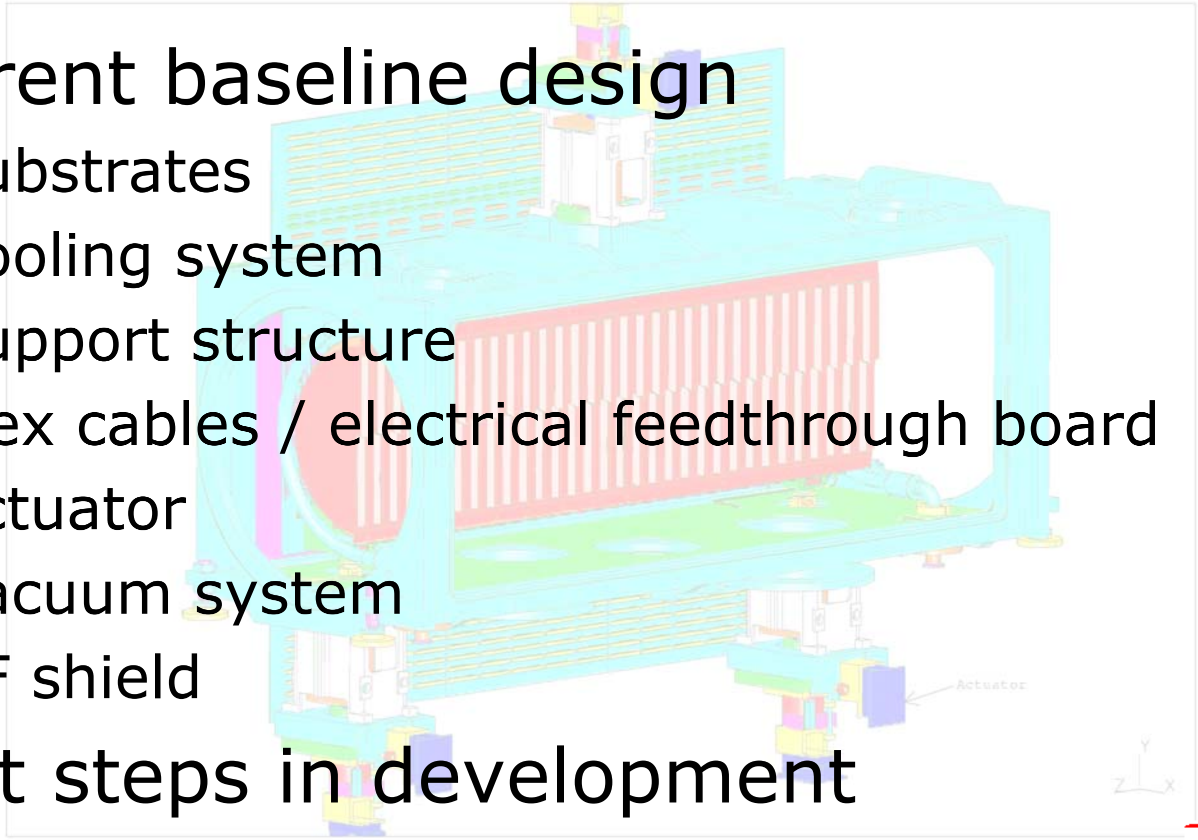
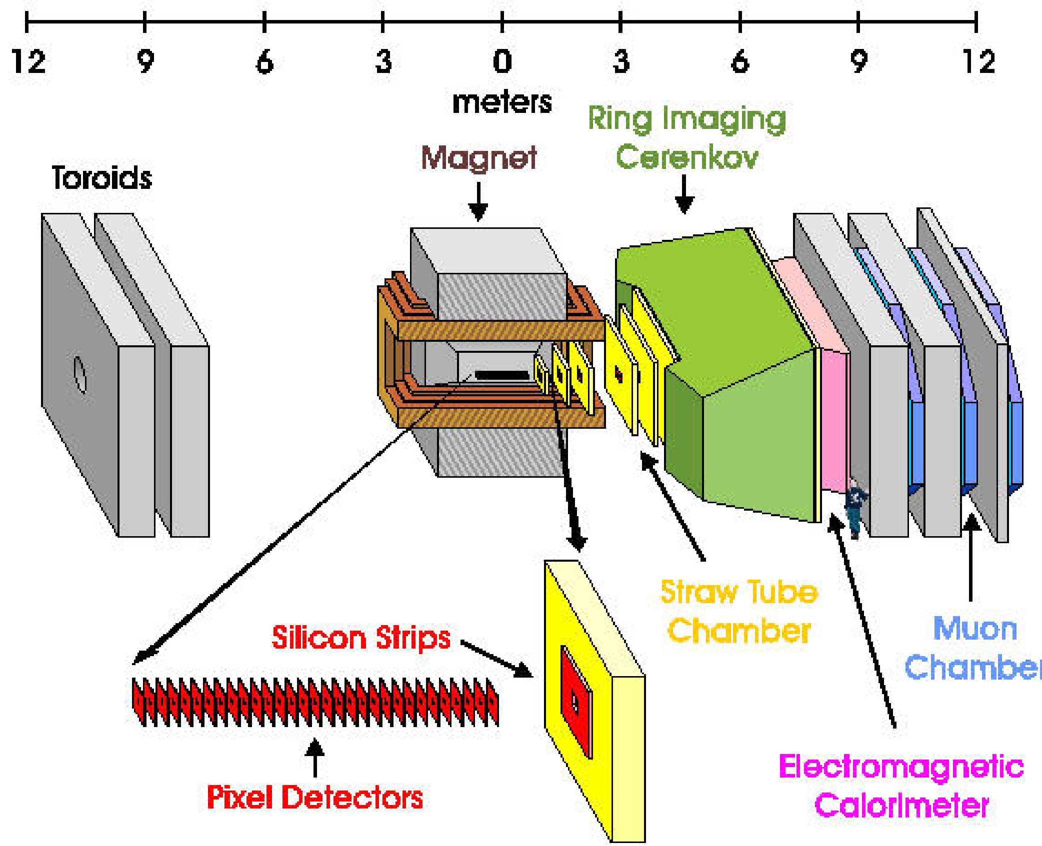
BTeV Silicon Detector Integration Issues



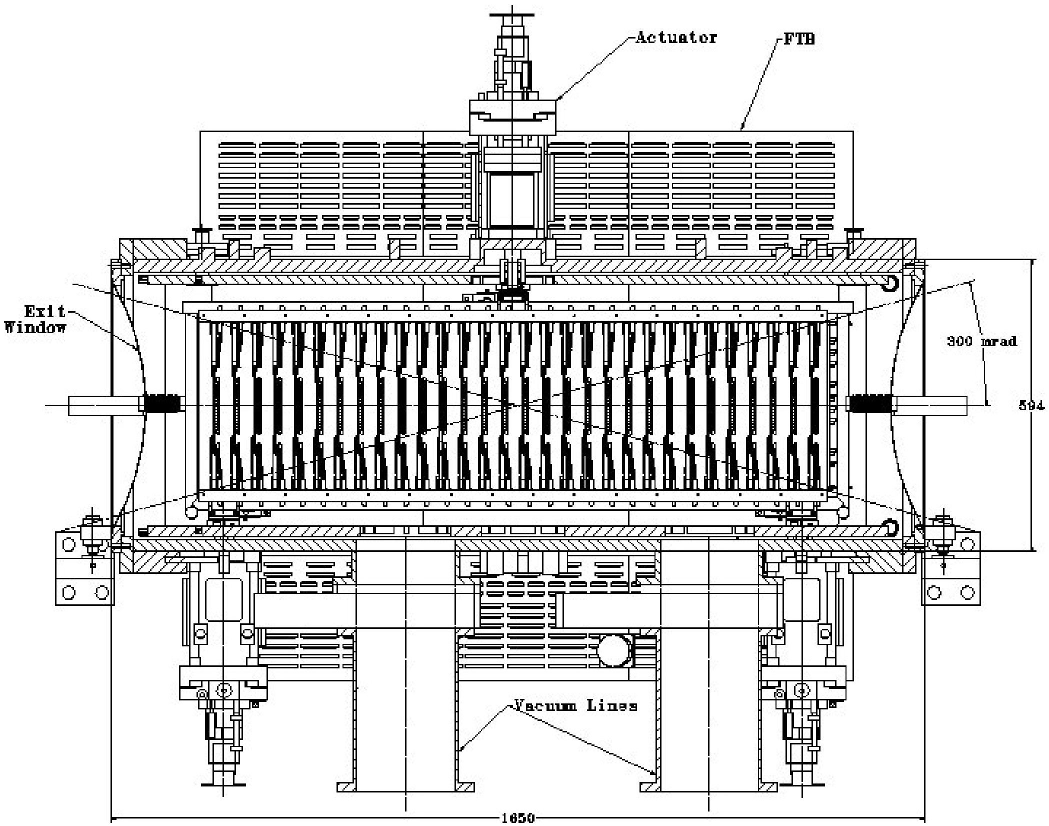
- Current baseline design
  - Substrates
  - Cooling system
  - Support structure
  - Flex cables / electrical feedthrough board
  - Actuator
  - Vacuum system
  - RF shield
- Next steps in development

BTeV Silicon Detector Technical Requirements

- 3000 electrical cables
- Heat load each readout chip 0.5 W/cm^2, total detector load 2.5 kW
- Operational temperature –5°C to –10°C, reproducible +/-2°C
- Pixels reside in beam vacuum (10^{-7} torr)
- Sits within analysis magnet with field 1.6 T



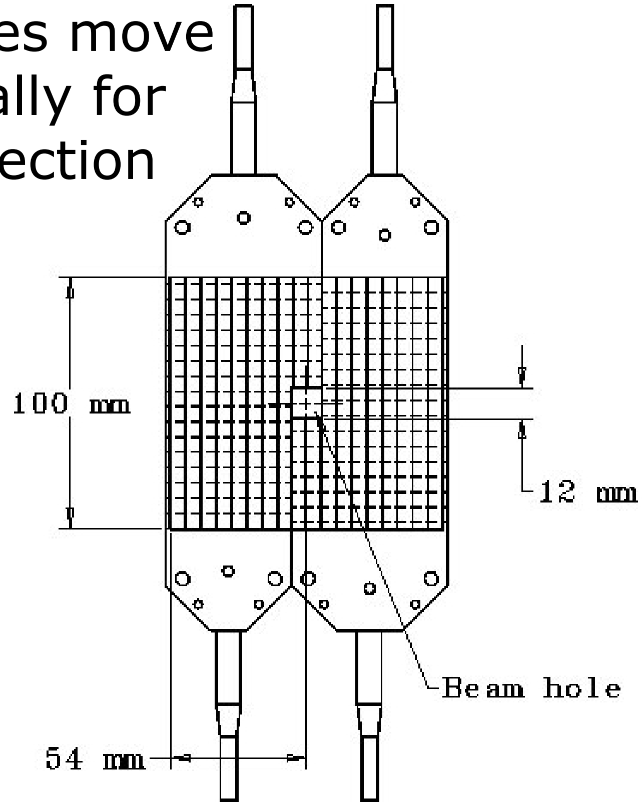
Technical Requirements (cont'd)

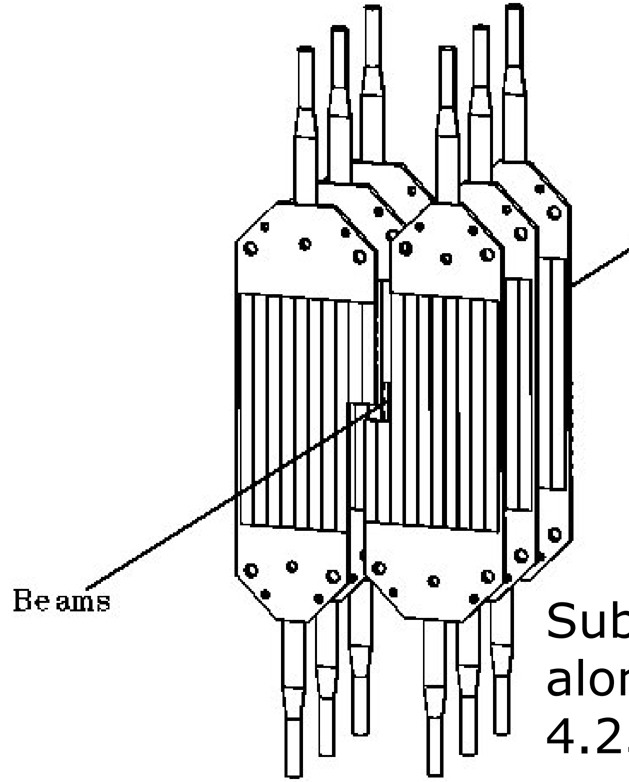


- Acceptance angle 300x300 $mrad^2$
- Pixels lie 6 mm from beam line during operation
- Pixels moved 20 mm away from beam during injection, 1 cycle every 24 hrs
- Alignment <50μm, reproducible < 50μm, stability < 2μm
- Material budget – X0=1.25% per plane in active area
- RF shield required for adequate impedance

Pixel Station

Substrates move horizontally for beam injection

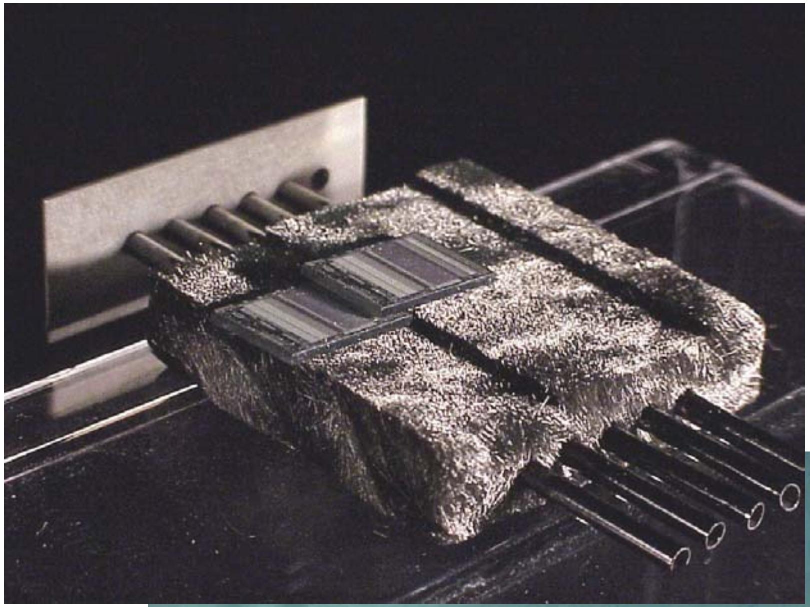


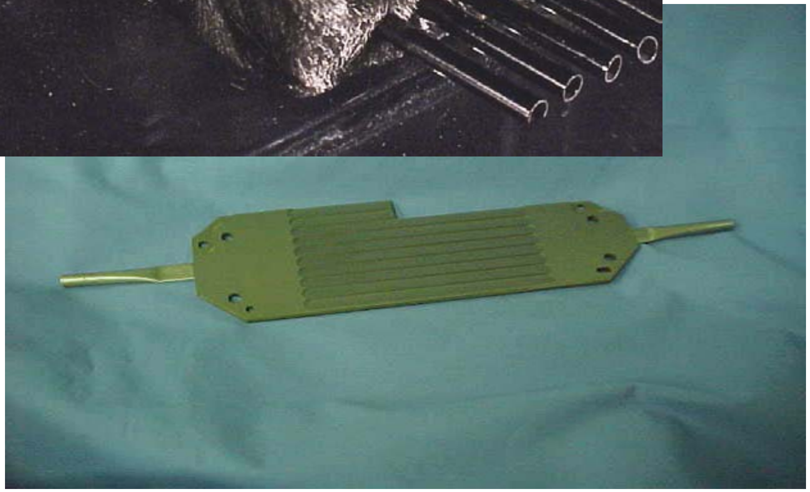


Substrates offset along beam 4.25 cm from each other

- Pixels reside on substrates
- 2 substrates per station, 30 stations total
- Shingled design for full coverage

Substrate Material

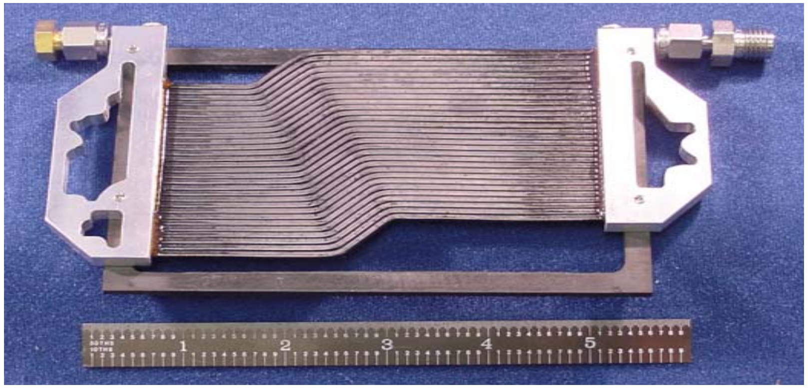


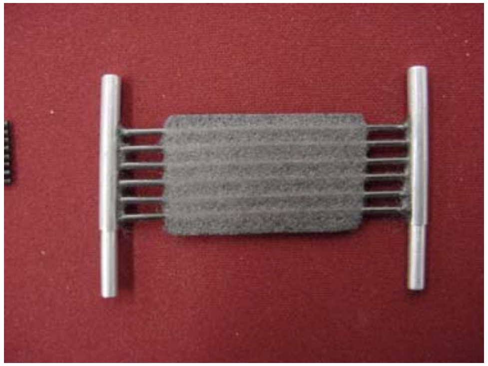


- "Fuzzy carbon" material (ESLI, San Diego, CA) - baseline
  - Carbonized fibers
  - Material X0=0.02% for t=0.88mm
  - Matching CTE w/ silicon
  - Single vendor
- Beryllium – more robust
- Pocofoam
  - Graphite foam - another carbon-based composite

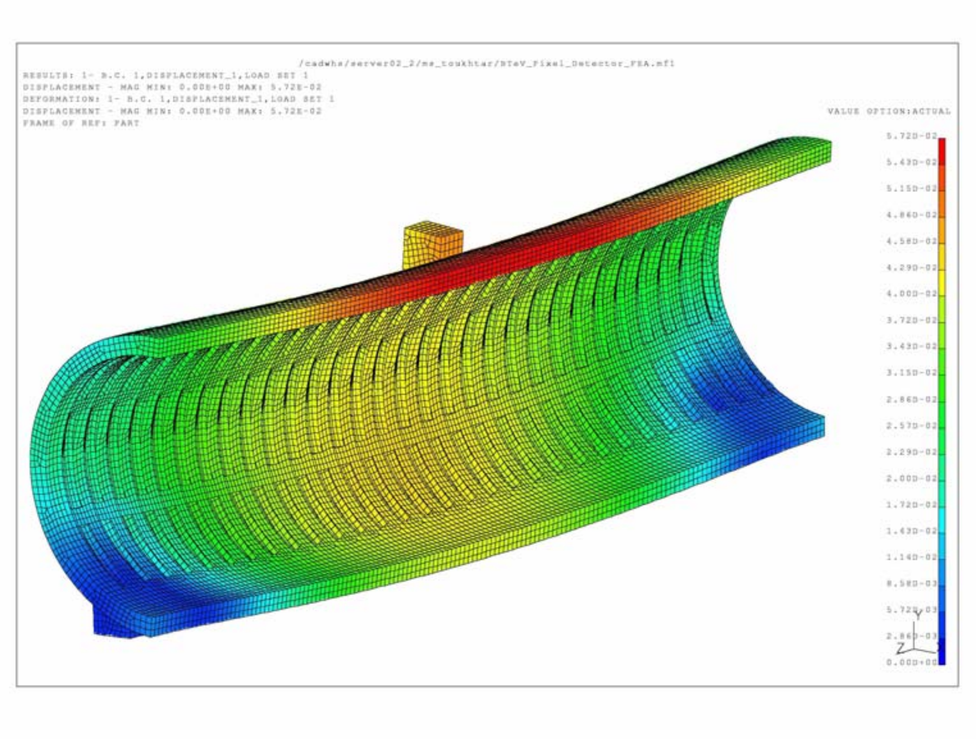
Cooling System

- Water glycol coolant (40% glycol by volume)
- Coolant flow rate 1 L/min through each substrate
- Cooling lines made of glassy carbon tubes
- Cooling lines embedded within fuzzy carbon substrate

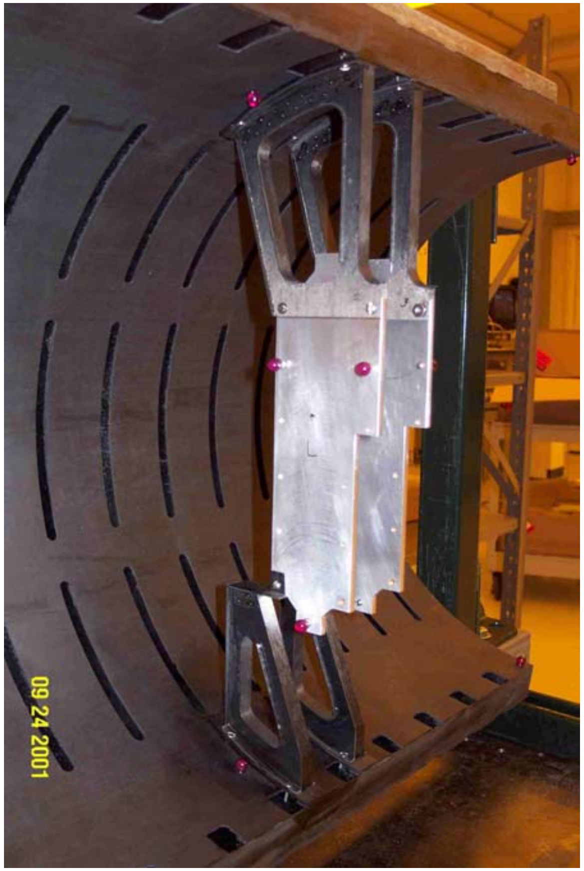




Support Structure



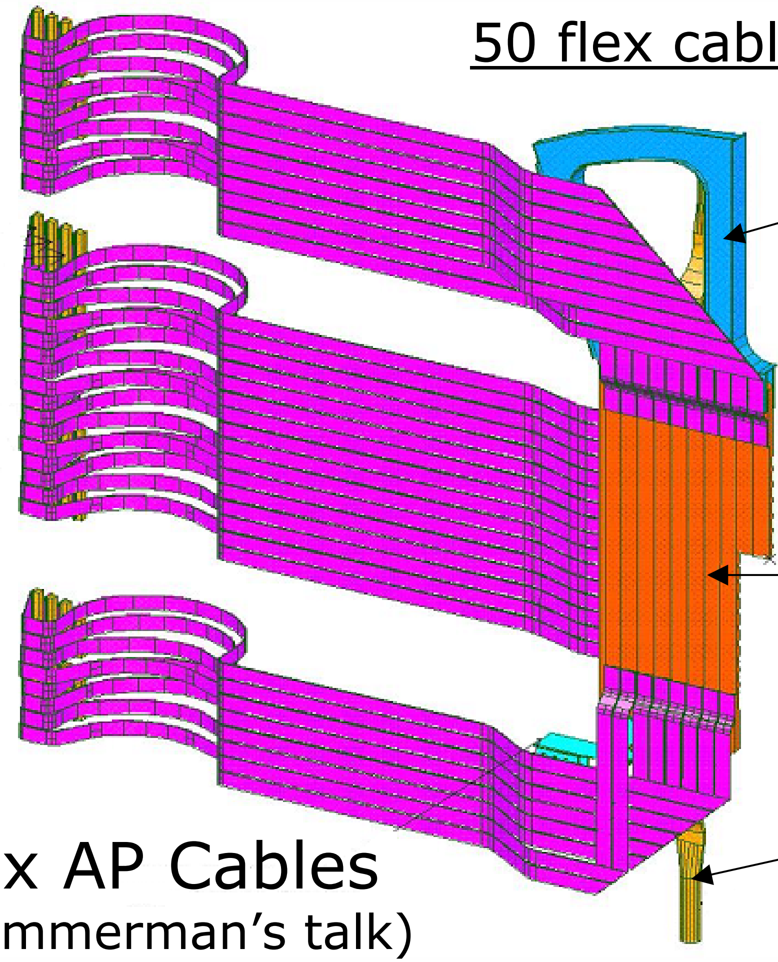
FEA of half cylinder showing max displacement 0.057mm when loaded with its mass and mass of substrate assemblies



Carbon fiber half cylinder holding substrates (aluminum only for prototype) with carbon fiber brackets

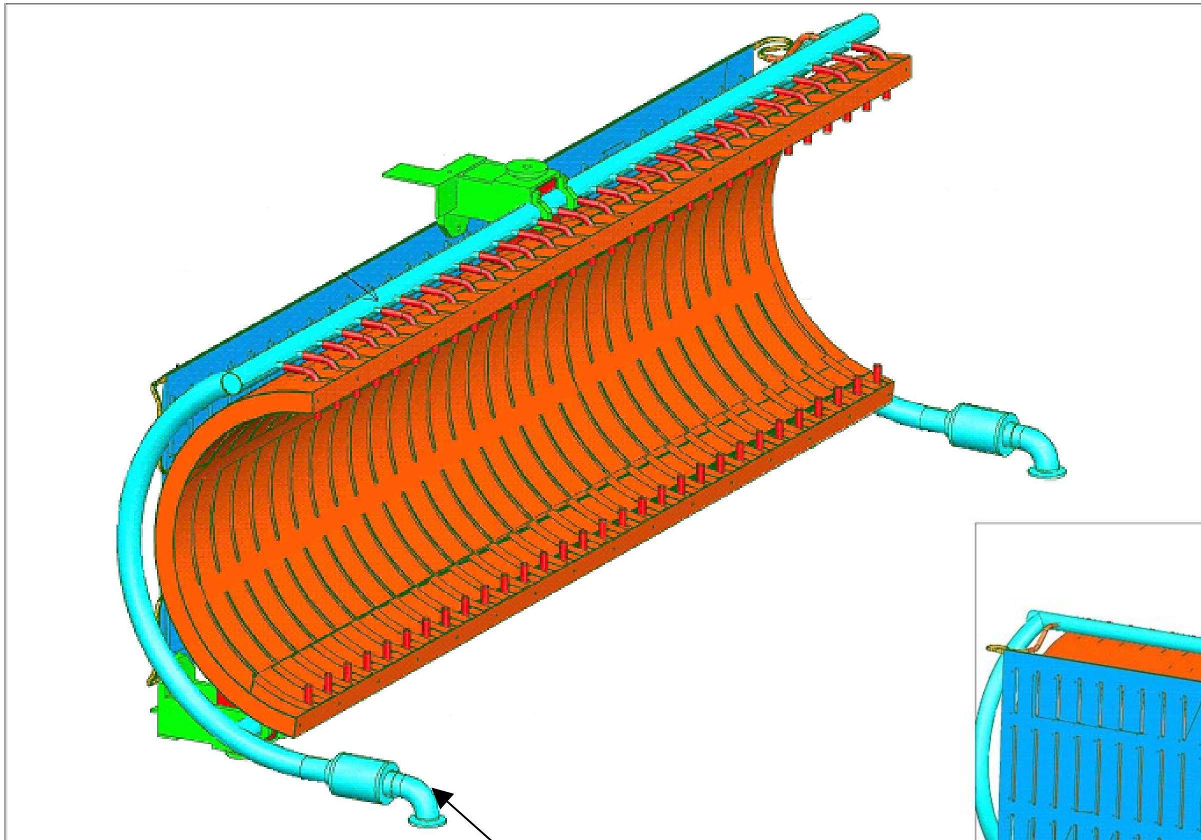
Pyralux Flex Cables

<u>50 flex cables per substrate</u>

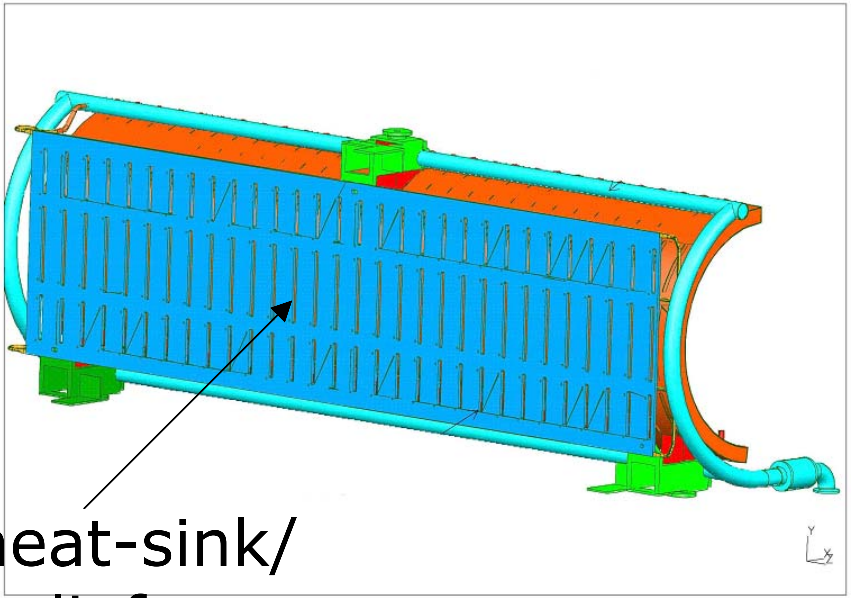


Pyralux AP Cables
(see S. Zimmerman's talk)

Assembly of Half cylinder



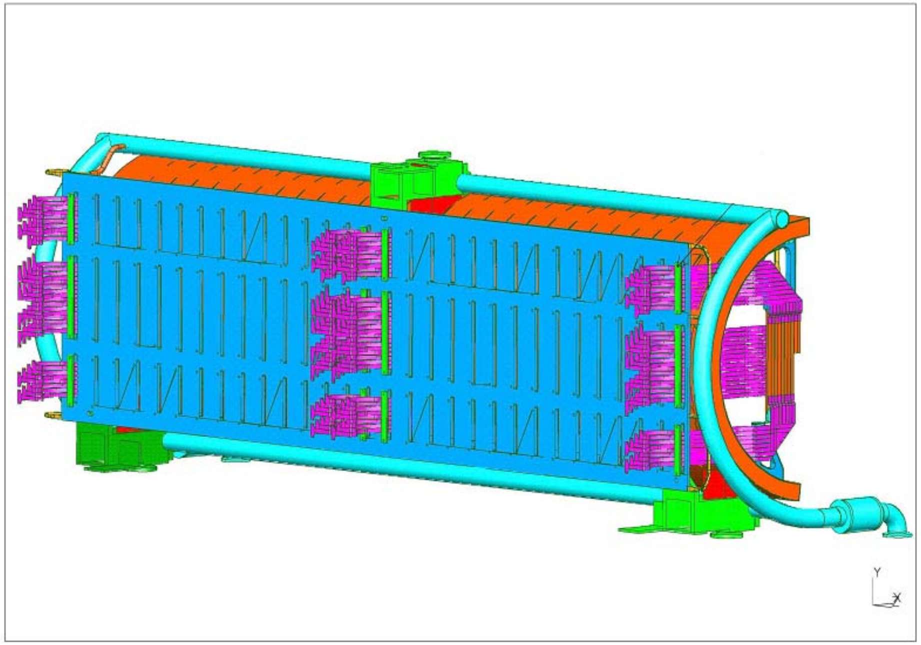
Main cooling manifold



Cable heat-sink/
Strain relief

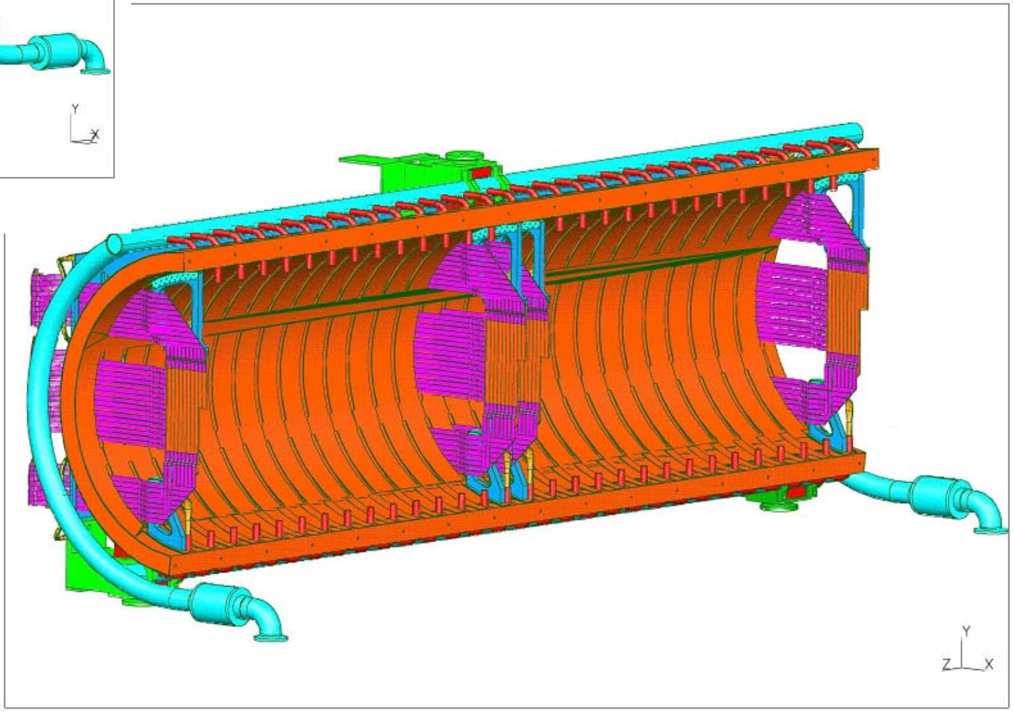
BTEV/C0

4 Substrates Installed



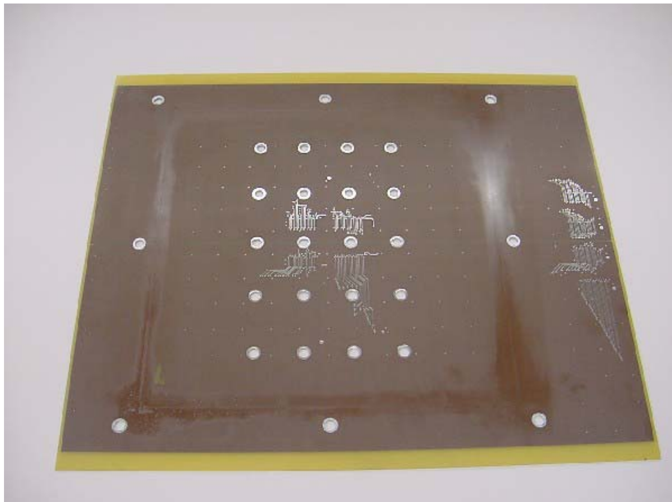
X0=0.17%
for fuzzy carbon substrate,
glassy carbon tubing,
and water glycol coolant
in active area

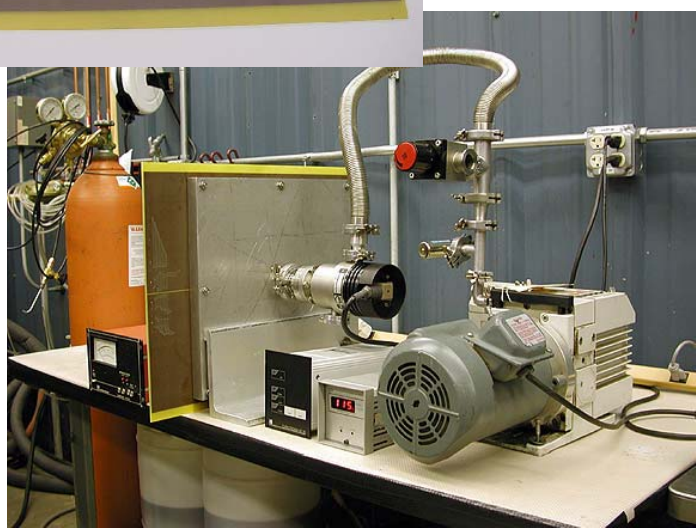
Cables clamped to strain
relief/heat sink

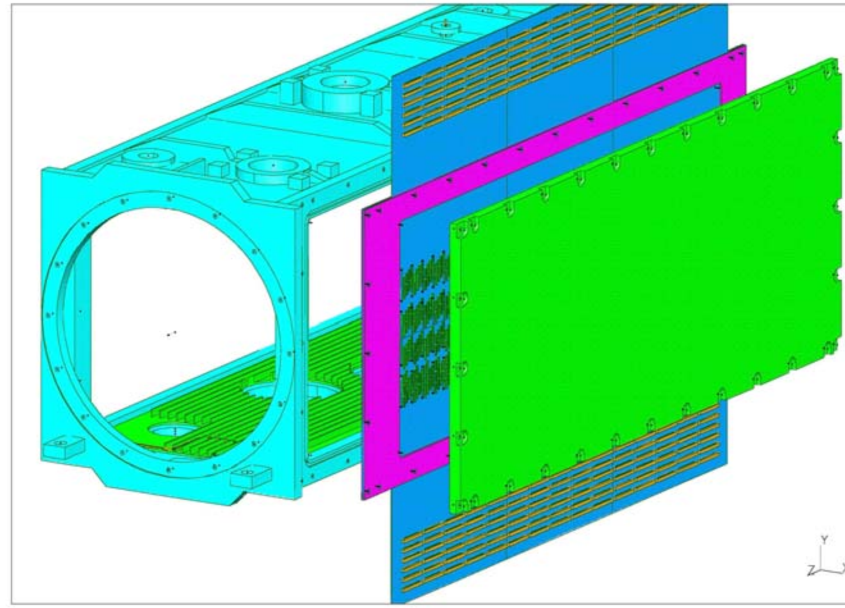


Electrical Feedthrough Board

Each FTB holds 1500 cables







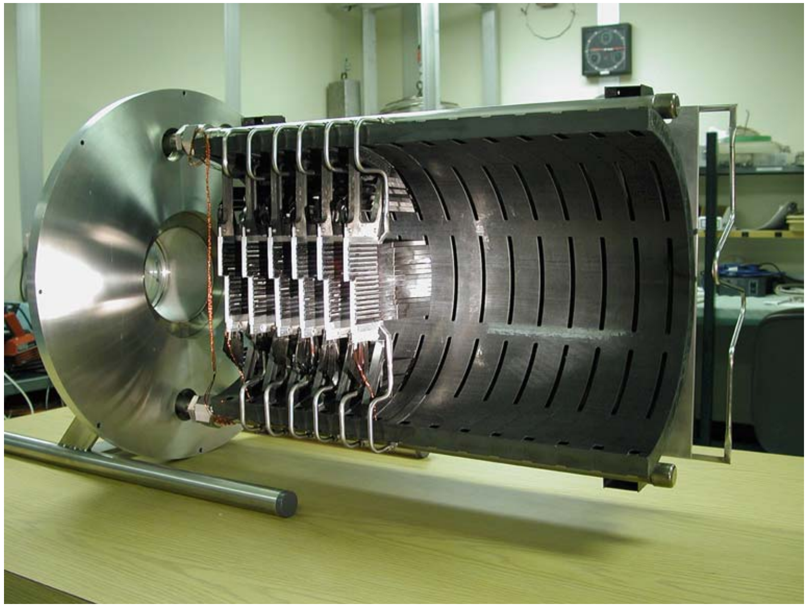
View of one feedthrough board on vessel

Seal of PCB leak tight
(1e-10 std-cc/sec for He)

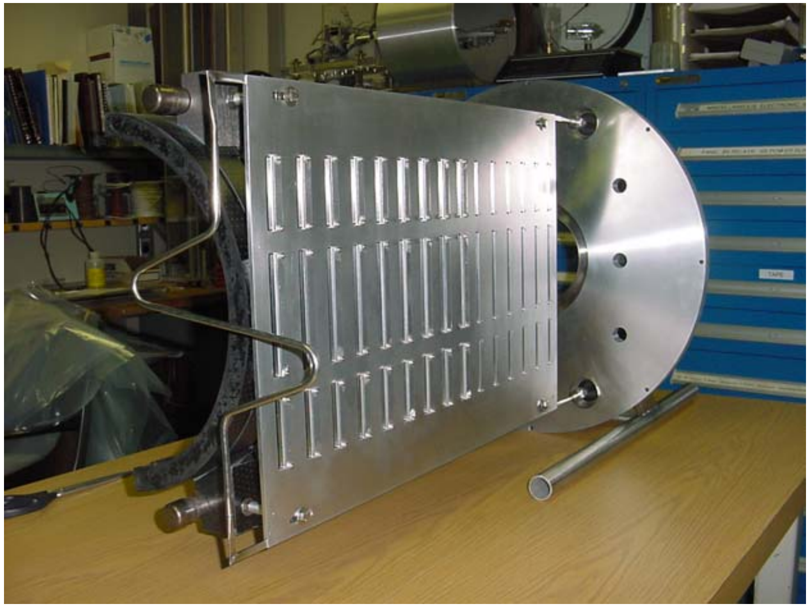
Fermilab
Mayling Wong

5% Model

- 5% model built
  - 6 substrates with dummy modules and cables (10% of total)
  - "Cables" clamped to aluminum plate
  - 5% of total surface area
- Substrates and aluminum plate cooled independently of each other
- Gas load measured at various temperatures

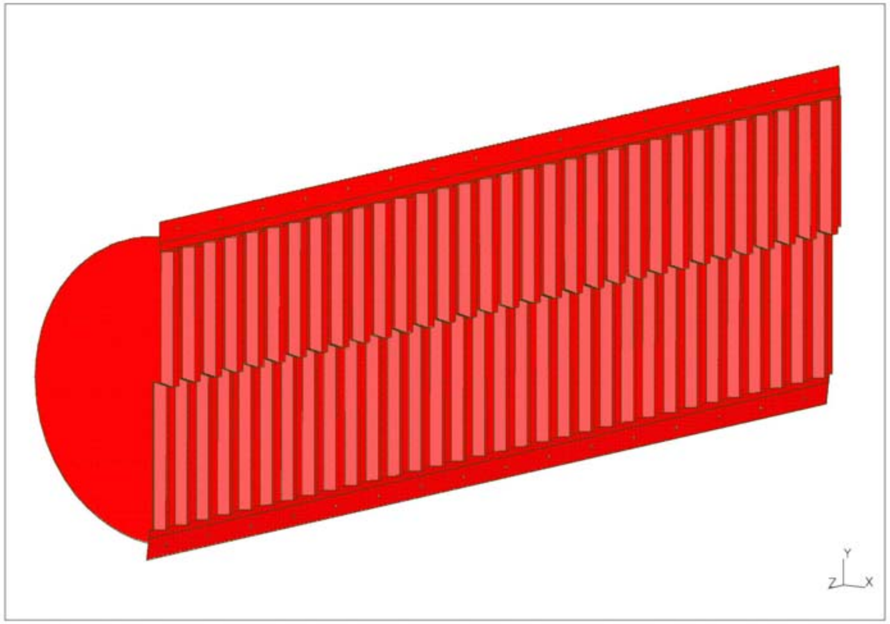


Vacuum System for 5% Model

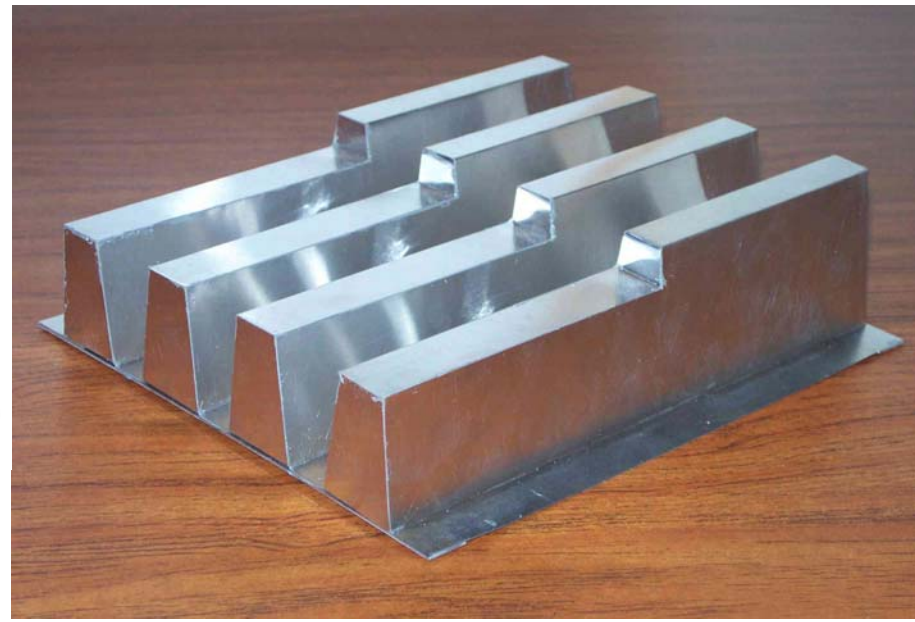


- Cooling aluminum panel to –160°C resulted in vacuum pressure ~10^{-9} torr (regardless of substrate temperature)
- Cryopanel allows detector to reside in single vacuum chamber (H_2O pump speed 19,000 L/sec)
- Additional pumping by turbo pumps (N_2 1300 L/sec)

RF shield



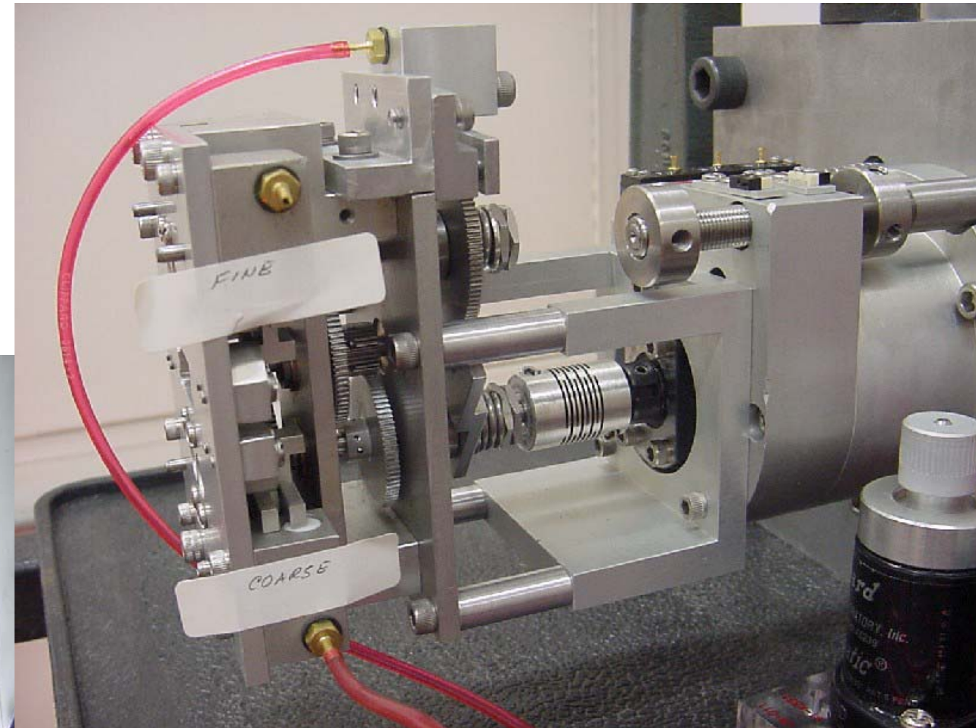
aluminum 0.25 mm thick

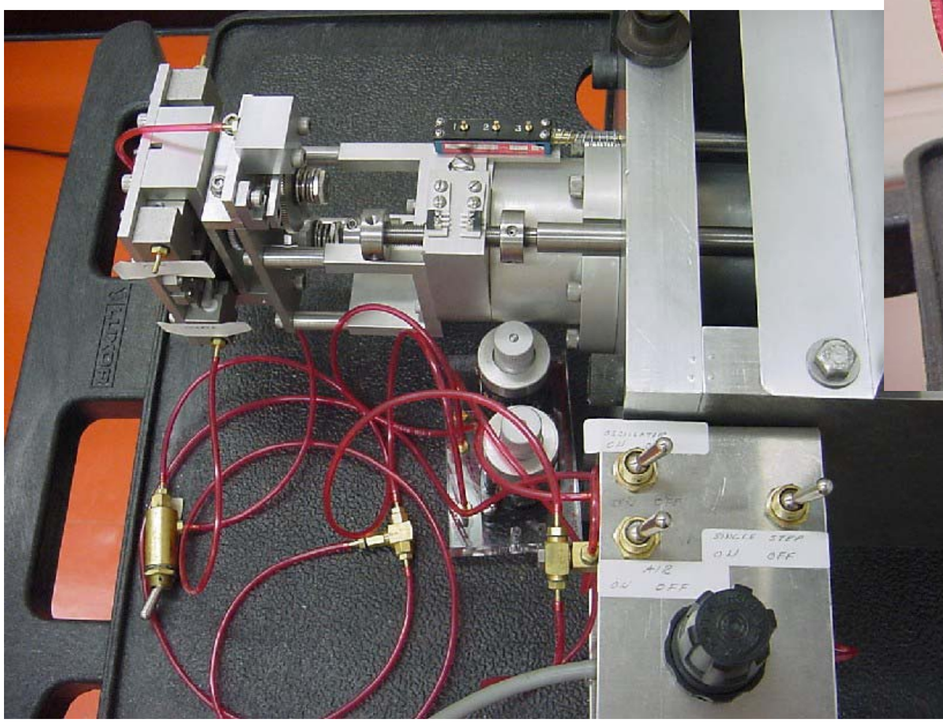


- Baseline design - corrugated RF shield
- Leak-tight shield not needed

Prototype Actuator

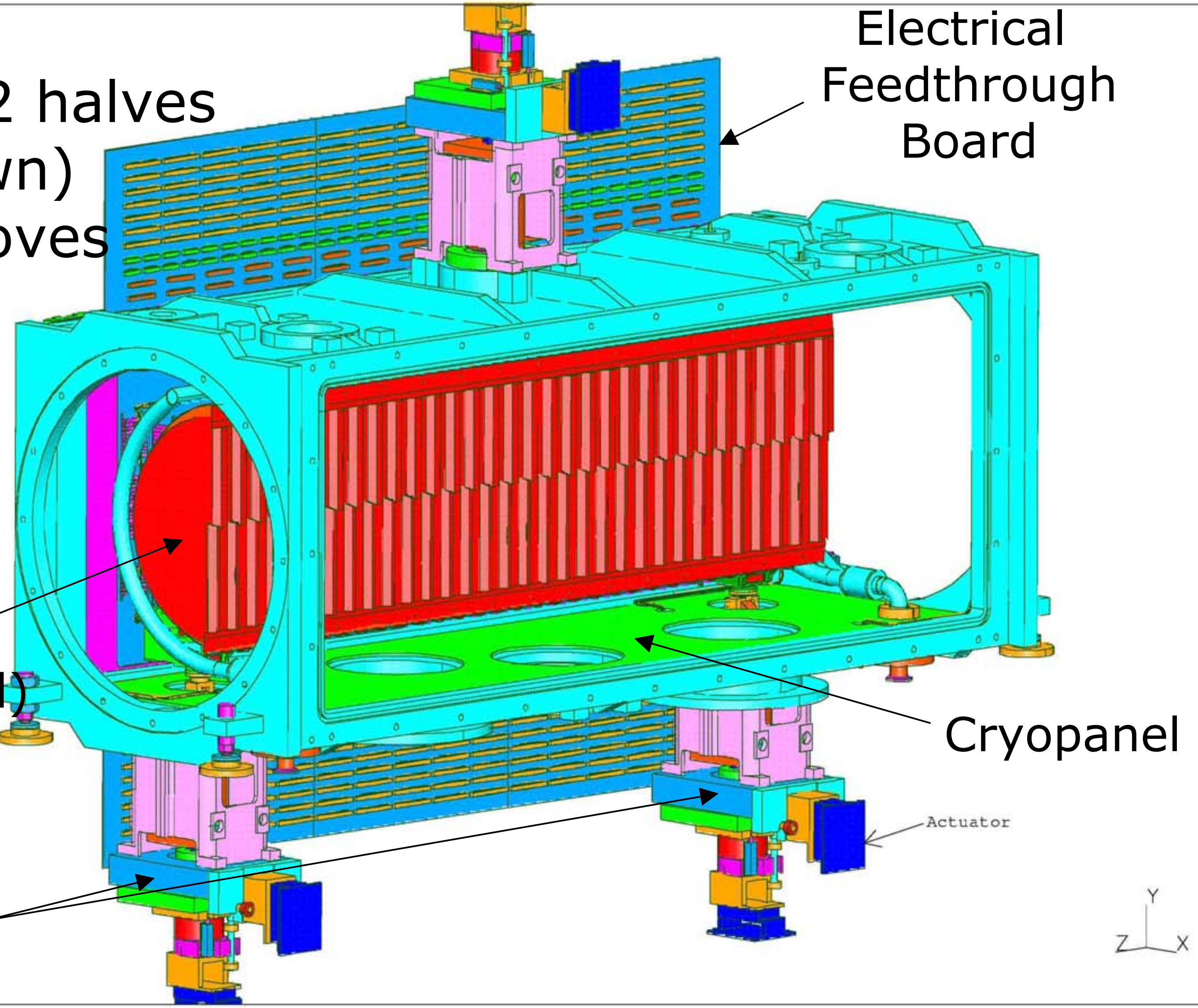
- Step sizes 1 & 10 μm
- 4 minutes to move 2cm
- Air controlled





Features:

- Detector in 2 halves (one half shown)
- Each half moves horizontally
- L = 1.65 m
- H = 0.6 m
- W = 0.6 m



RF shield (substrates behind)

Actuators

BTeV / C0

New Development Steps

- Study and understand EMI issues
- Design new format of RF shield (wires? mesh?) by working with Beams Division
- Assemble large, leak-tight feedthrough board (1.65 m in length)
- Combine cryopanel and substrate cooling systems to cool pixels to $-10°C$