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/cm², 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 $300 \times 300$ 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 < 50$\mu$m, reproducible < 50$\mu$m, stability < 2$\mu$m
- Material budget – X0=1.25% per plane in active area
- RF shield required for adequate impedance
Pixel Station

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

Substrates move horizontally for beam injection

Substrates offset along beam 4.25 cm from each other
Substrate Material

- “Fuzzy carbon” material (ESLI, San Diego, CA) - baseline
  - Carbonized fibers
  - Material $X_0=0.02\%$ for $t=0.88\text{mm}$
  - 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

50 flex cables per substrate

Top support bracket

Assembled substrate

Cooling tube

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

50 flex cables per substrate
Main cooling manifold

Cable heat-sink/
Strain relief

Assembly of Half cylinder

Pixel 2002 Conference
10 September 2002
Fermilab
Mayling Wong
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

Seal of PCB leak tight (1e-10 std-cc/sec for He)
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\(_2\)O 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
- $L = 1.65 \text{ m}$
- $H = 0.6 \text{ m}$
- $W = 0.6 \text{ m}$
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