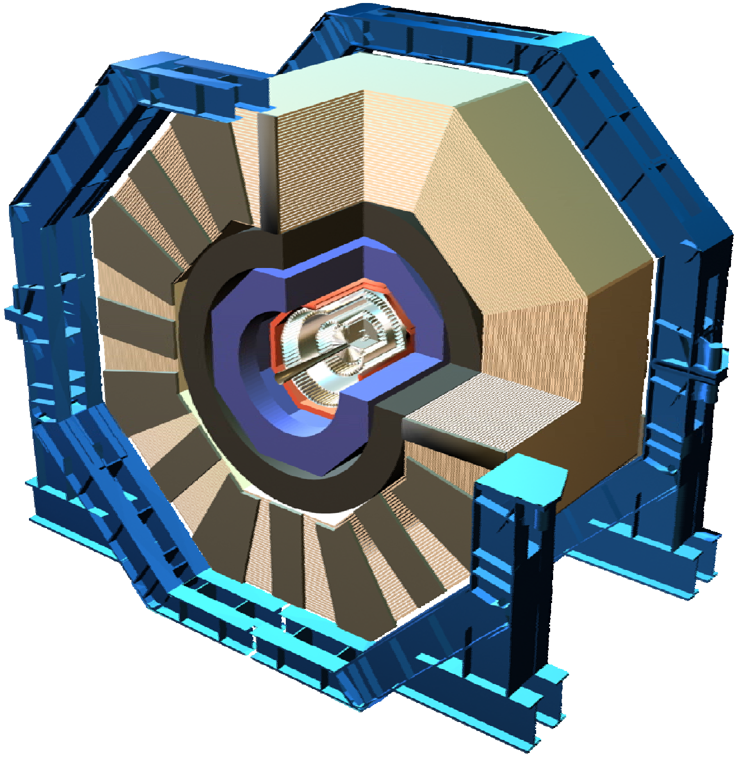
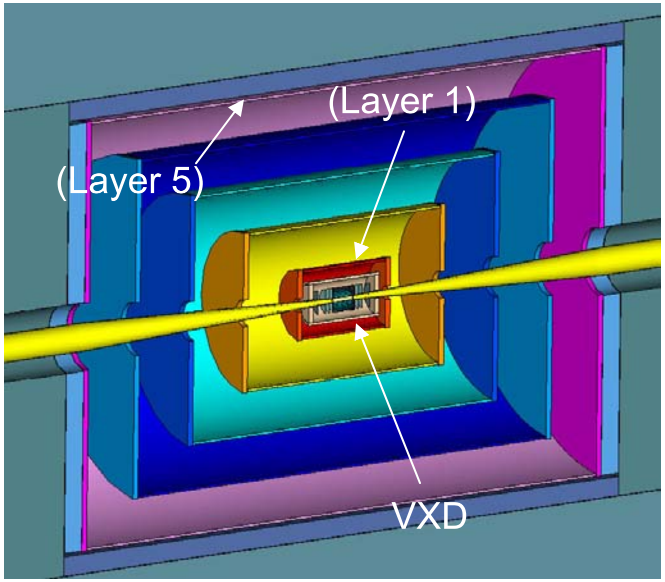
Inner Silicon Mechanical Status



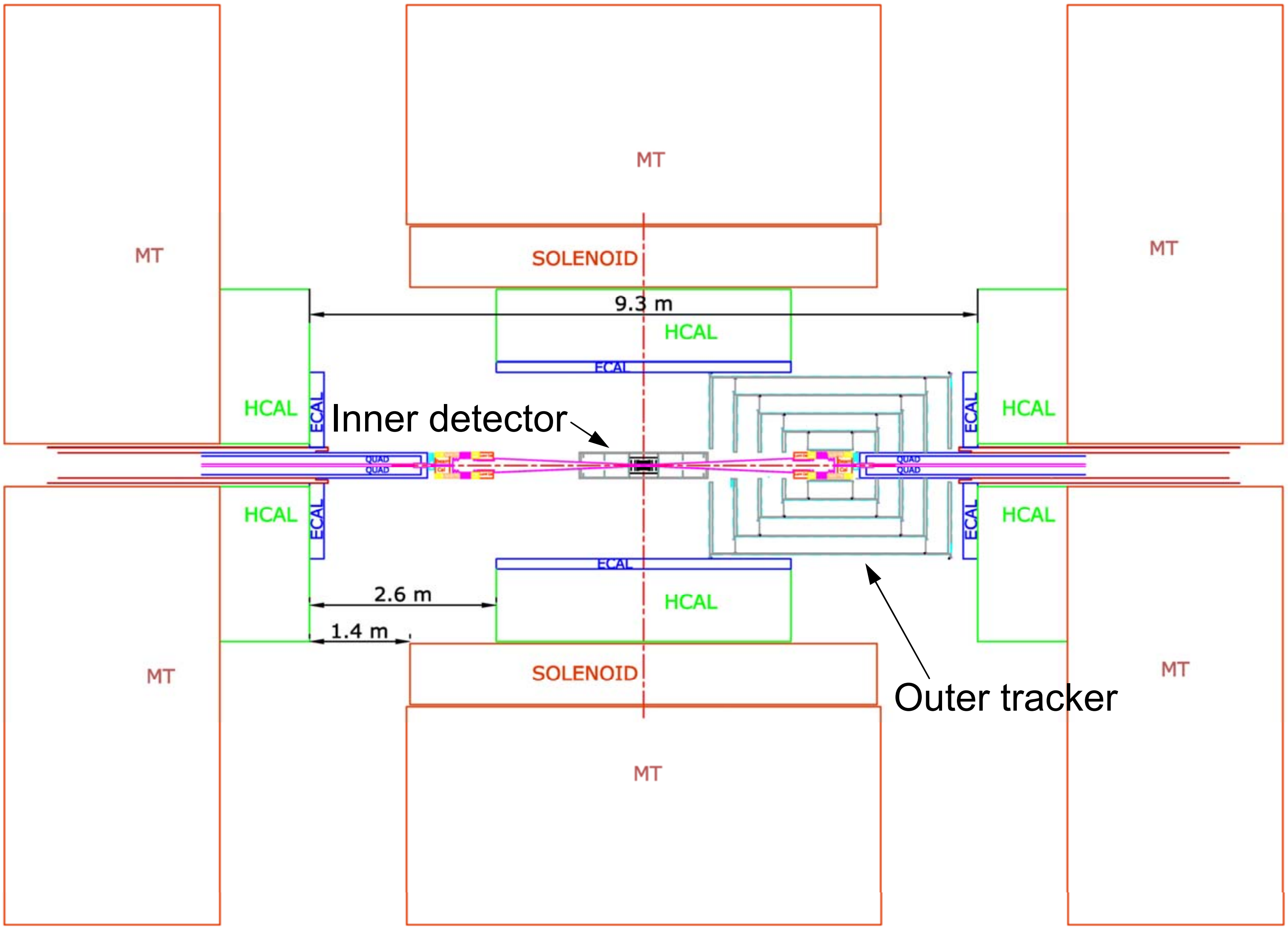
Bill Cooper
Fermilab



Outline

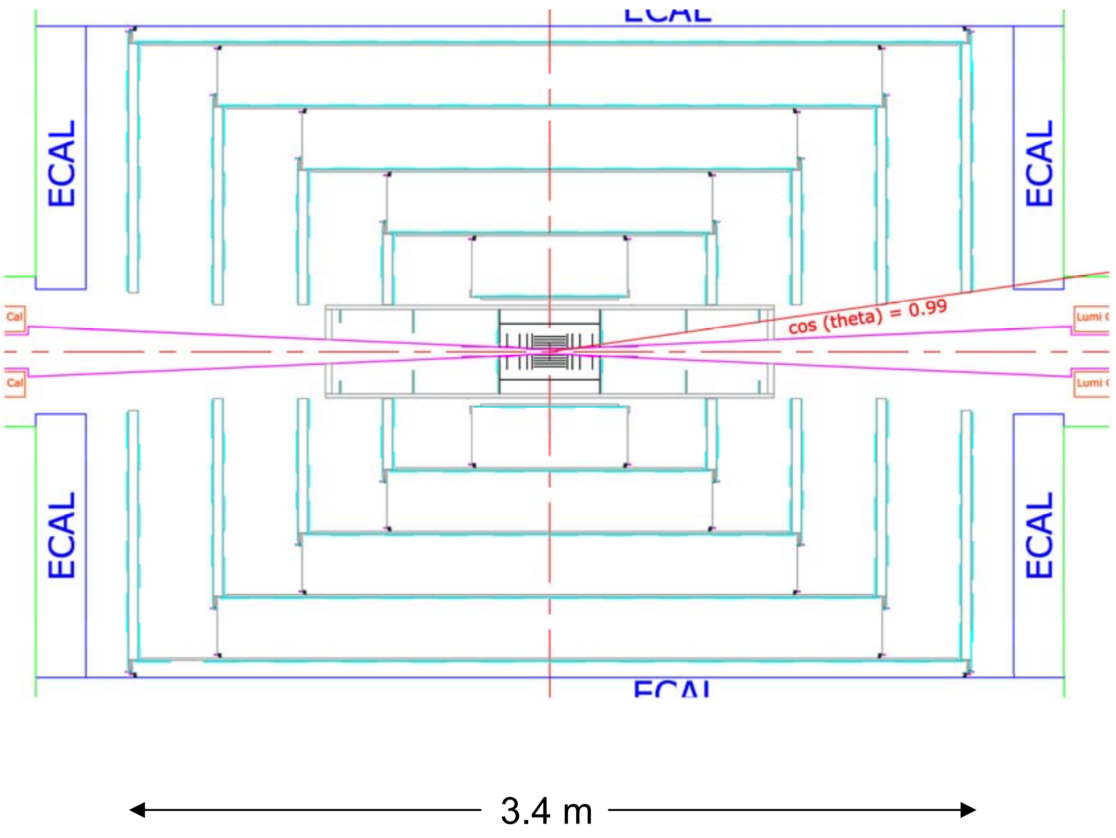
- Overall layout of outer and inner silicon
  - Provisions for servicing inner silicon
- Beam pipe considerations
  - Will skip most of those transparencies unless there is specific interest
- Structures to support VXD and associated disks from the beam pipe
- VXD barrel concepts
  - Barrel mechanical structure
  - R-Phi arrangement of a barrel
  - Ladder deflections
- Issues remaining to be addressed
- Summary

Detector Open with Full Access to Inner Detector



Silicon Tracking Layout

- Outer tracker (micro-strips)
  - 5 barrel layers
  - 5 disks per end
  - OR = 1.25 m
  - IR = 0.2 m
    - May need to adjust inner radius to match beam-line elements
  - Supported from ECAL
- Inner detector (pixels)
  - VXD
    - 5 barrel layers (may increase to 6)
    - 4 disks per end
  - Additional "forward" disks
  - Supported from conical portions of beam pipe



Beam Pipe

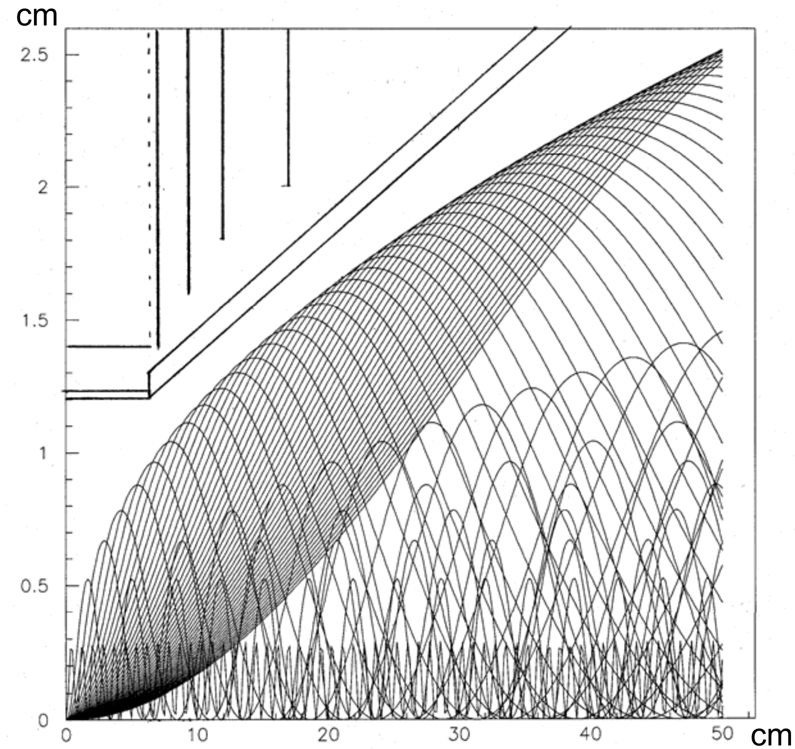
- An all-beryllium beam pipe was assumed for design purposes.
  - Portions of cones could be SS.
- Avoidance of pair backgrounds leads to a conical beam pipe shape beyond the central region.
- sidaug05 assumes a beam pipe inner radius of 1.2 cm within the region Z = ±6.251 cm. Beryllium wall thickness = 0.04 cm.
  - Sonja Hillert and Chris Damerell have stressed the importance silicon at a small radius.

http://nicadd.niu.edu/cdsagenda//askArchive.php?base=agenda&categ=a0562&id=a0562s4t2/moreinfo#262

- Beam pipe liners are under study.
  - sidaug05 assumes a 0.0025 cm titanium shield in the central region and 0.0075 cm titanium shields in the conical regions to absorb low energy (<50 keV) photons and fluorescent x-rays. Tungsten masks were assumed in the conical regions, but consequences of tungsten weight will need to be examined.

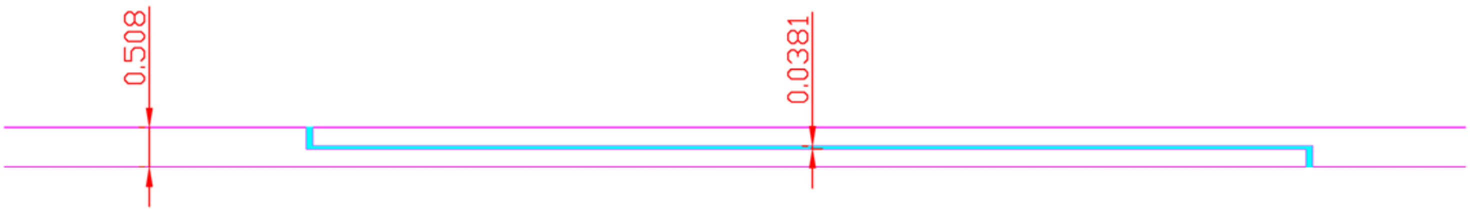
Takashi Maruyama

500 GeV Nominal 5 Tesla + 20 mrad xing

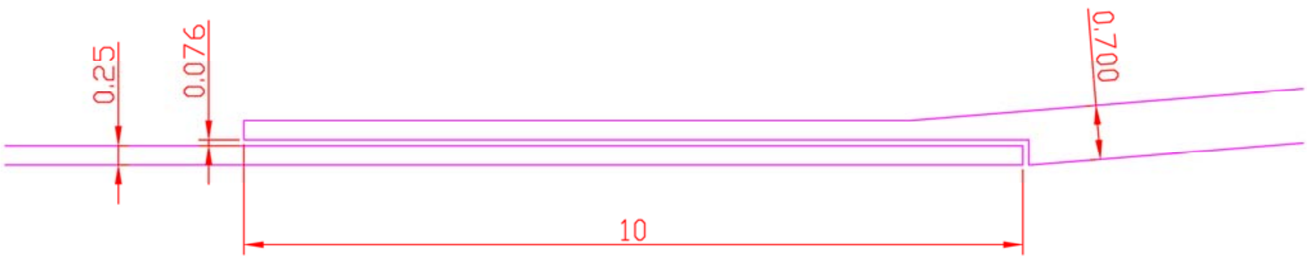


Beam Tube Joints

- Brush-Wellman Electrofusion developed a proprietary electron beam brazing technique for beryllium to beryllium joints. The braze material is thought to be aluminum.
- Joint concept for 1.16” OD (14.7 mm OR) DZero beam pipe:



- Similar concept for ILC (note that sidaug05 assumed 0.4 mm, rather than 0.25 mm in the straight portion):

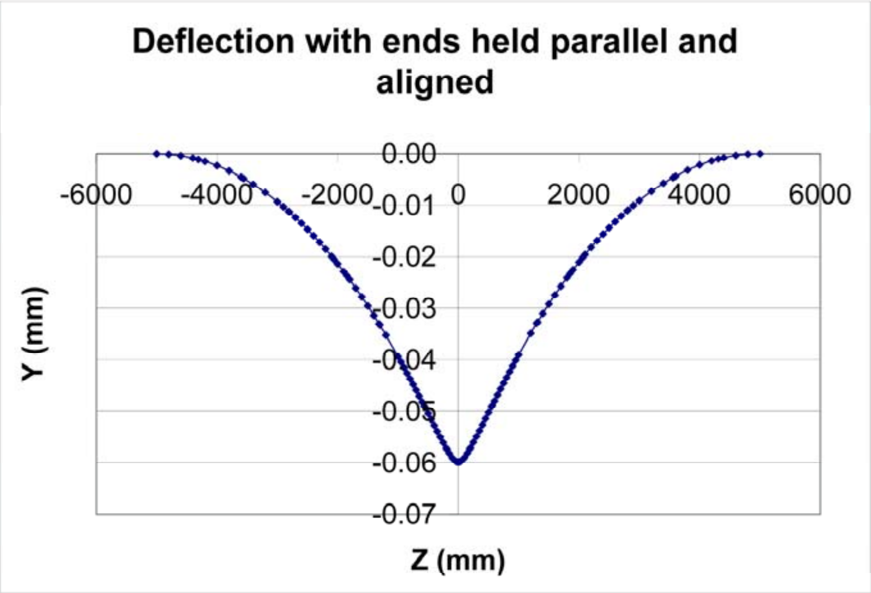


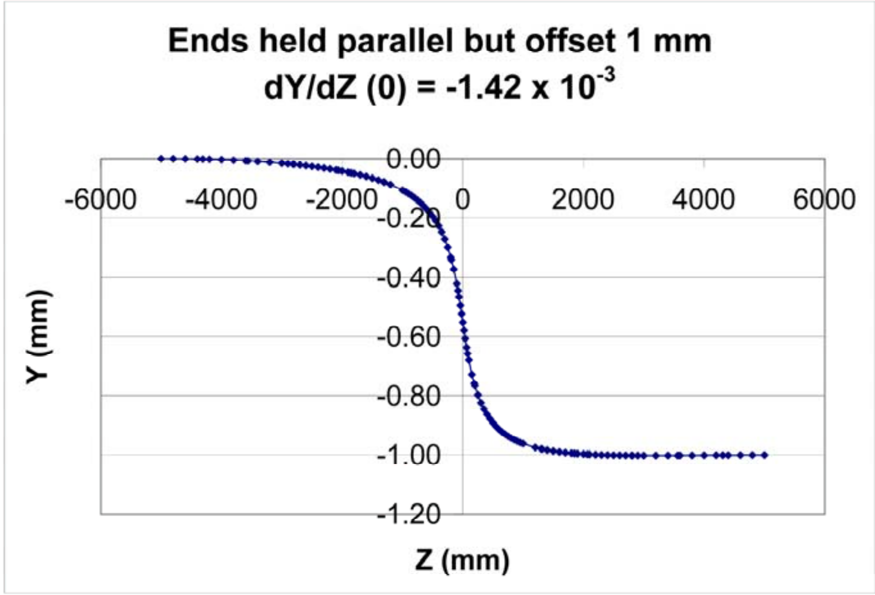
Beam Pipe Deflections Due to Inner Detector

- A wall thickness of 0.25 mm was assumed in the central, straight portion.
- The radius of conical portions was assumed to increase with dR/dZ = 17/351.
  - Wall thickness in the conical portions was chosen to correspond to collapse at slightly over 2 Bar external pressure.
- An inner detector mass of 500 g was assumed to be simply supported from the beam pipe at Z = ± 900 mm.

Inner detector weight contributes ~ 0.008 mm.

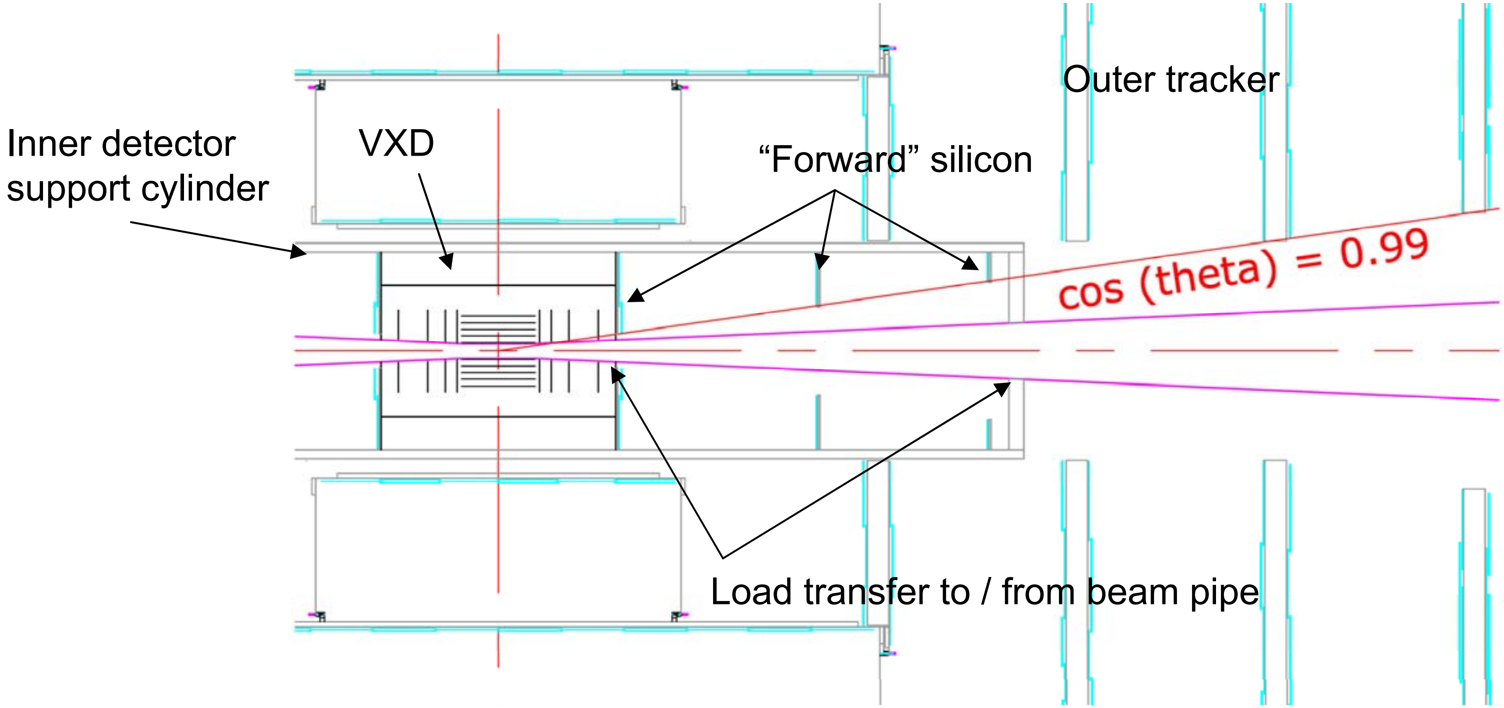
Maximum stress ~ 20 MPa





Concept of Inner Detector (VXD) Support

- To allow installation on the beam pipe, the inner detector and its support structures are based upon half-cylinders.
- Outer support half-cylinders could be thermally insulating
  - Detector elements are supported from those half-cylinders.
- Support half-disks couple to the beam pipe at approximately Z = ± 0.2 m and Z = ± 0.9 m and aid in maintaining beam pipe straightness.
- To reduce material, many of the support structures could be lattice-like.



VXD Barrel Concepts (1)

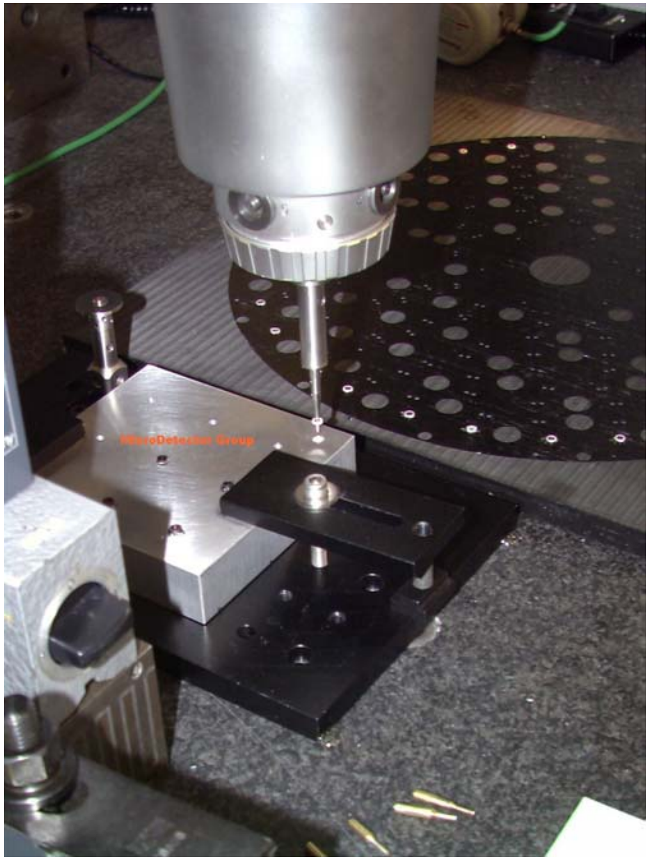
- Ladders are designed taking into account support from two or four CF membranes.
  - Thickness of each membrane ~ 0.26 to 0.39 mm (0.11% to 0.16% of a radiation length for membranes with no holes.
- Ladders pass through openings in the membranes.
  - 1.8 mm of material is retained at nearest membrane openings.
  - We know that is sufficient to allow membrane fabrication.
- Flexibility of the membranes is tuned to provide good x and y positioning and to allow a difference between ladder thermal contraction and thermal contraction of an outer support cylinder.
  - CF thickness and geometry of openings determine flexibility.
  - Between the outermost ladders and the inner surface of that support cylinder, membranes can be mostly holes.

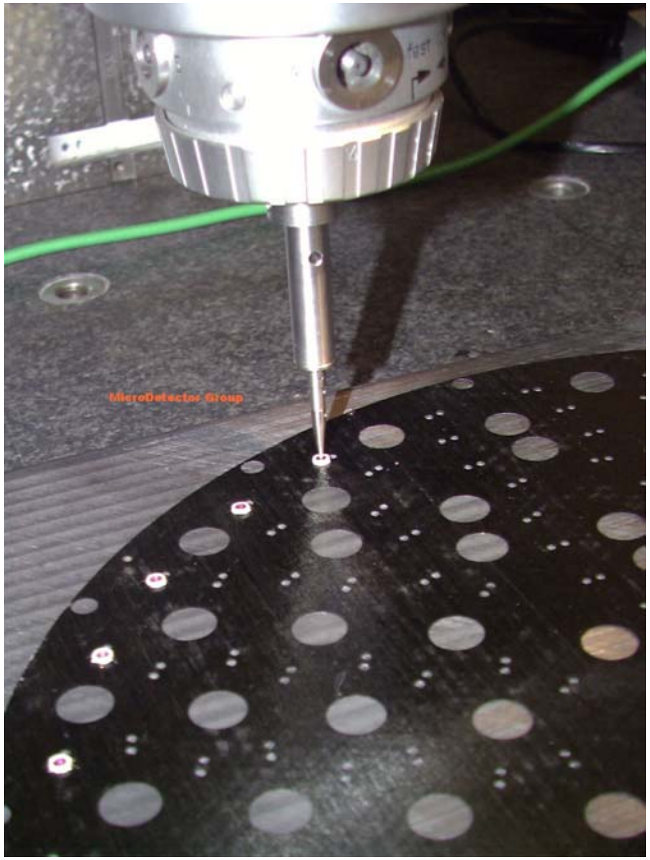
VXD Barrel Concepts (2)

- There are clear advantages in being able to remove ladders from a completed barrel, but:
  - Pin a socket or equivalent connections are likely to be needed.
    - They do not appear to be needed to accommodate thermal contraction.
    - They add significant material.
- An alternative which reduces material would be to glue ladders into place.
  - For that option, a barrel could be divided in phi into six mating pieces.
    - Must split into two halves in any case to allow assembly on beam pipe.
  - For the geometry drawn, each piece would include 16 ladders
    - D0 has recently assembled a L0 silicon detector with 48 sensors glued into place. ~0.025% channels damaged during assembly

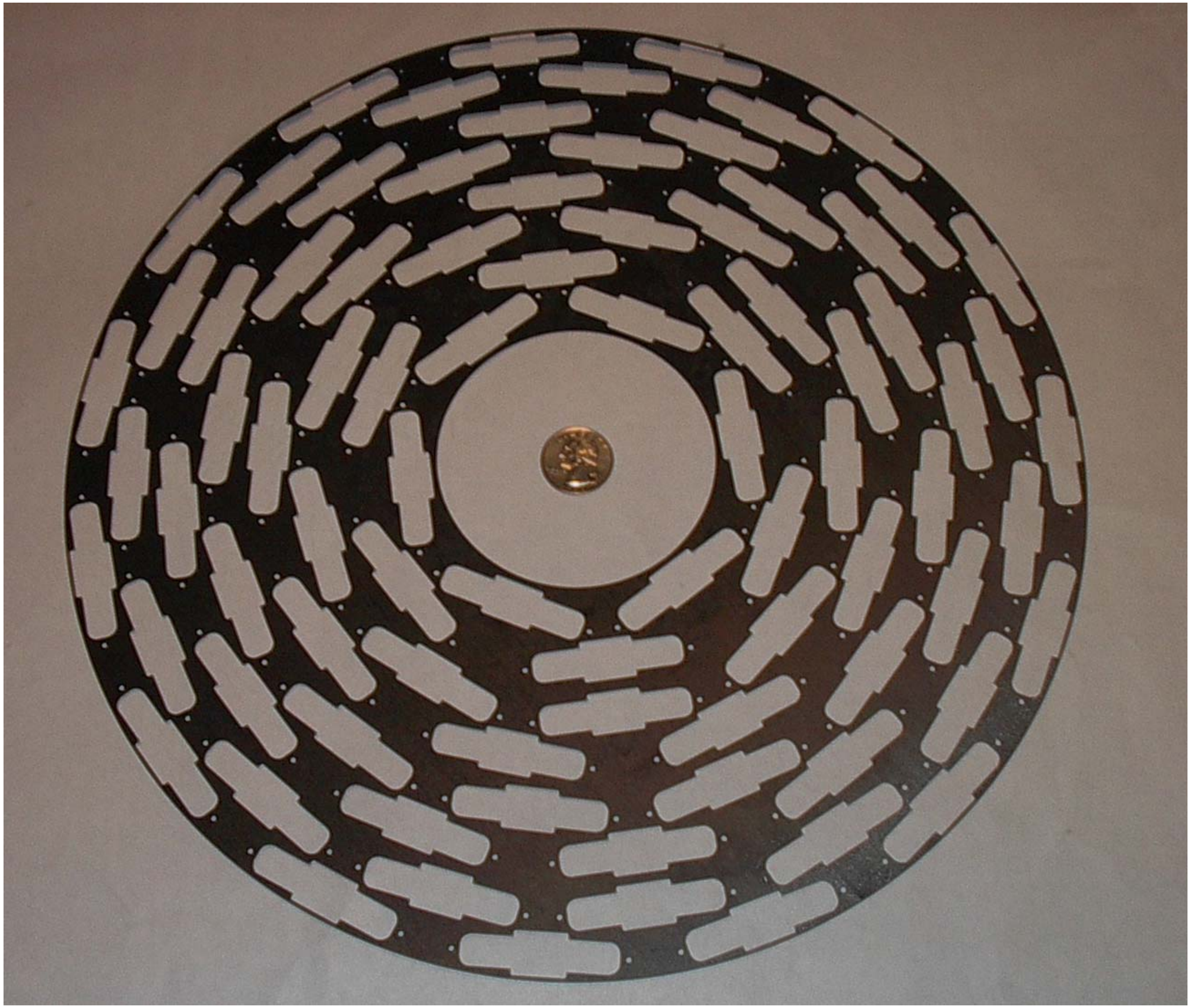
D0 Run IIb CF Membrane (Pins and Sockets)

- A Zeiss CMM was used to place sapphire bearings. Sapphire pins engage the bearings.
- Placement precision was within a window of approximately ±10 μm, so improvement would be needed.



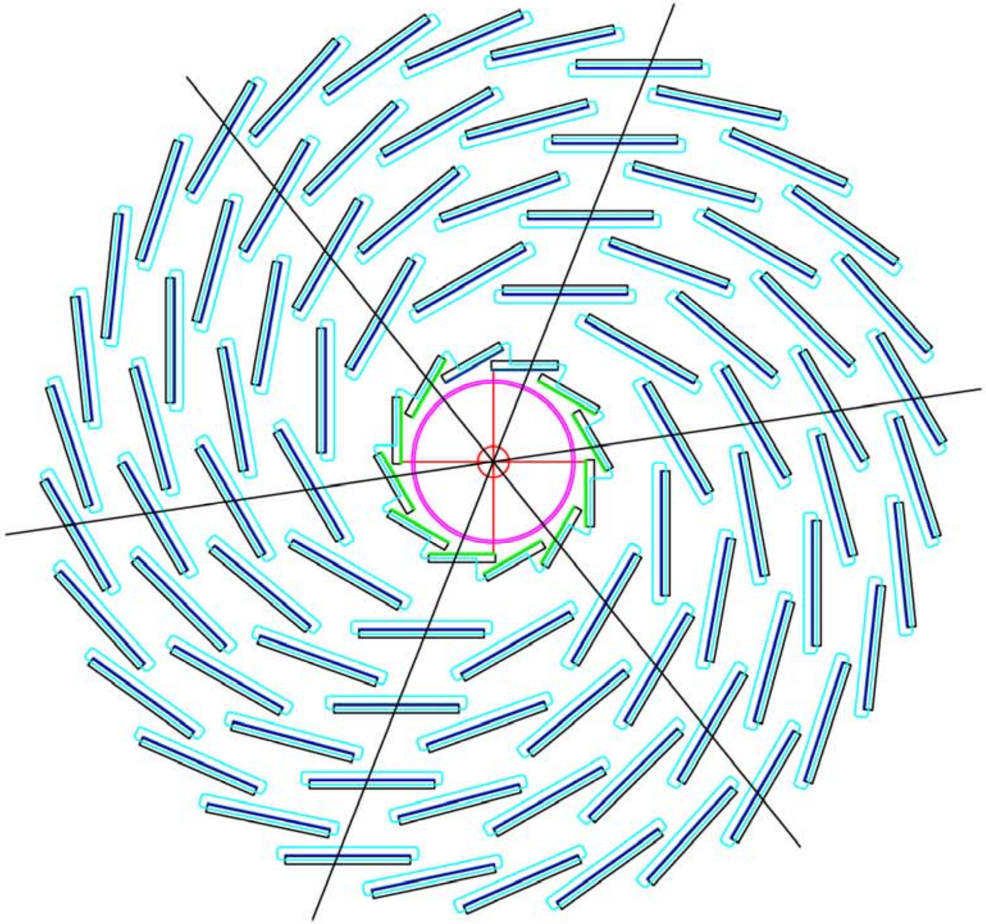


D0 Run IIb Outer CF Membrane



Revised End View of the VXD Barrel Array

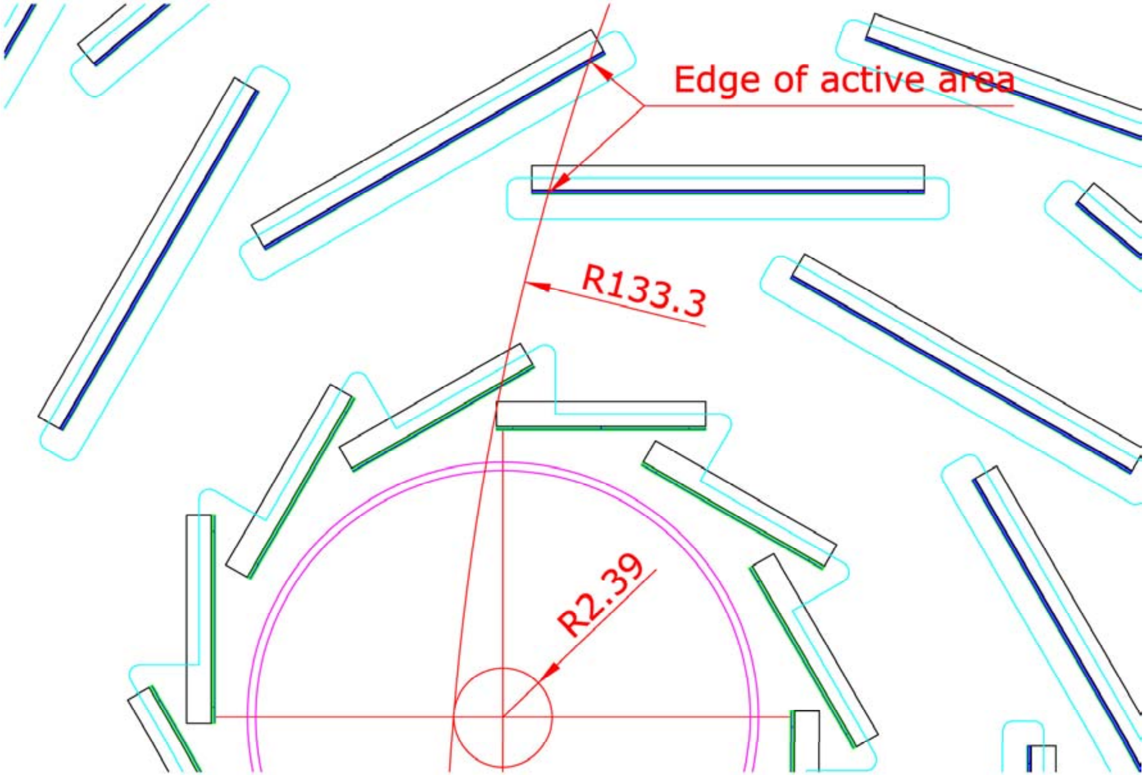
- Ladders with inward facing sensors are shown.
- Sensors could equally well face outward.
- Note that 6-fold symmetry is shown.



Sensors:
IR = 14, 25.5, 37, 48.5, 60 mm
Active widths: 8.549, 17.443 mm
Cut widths: 10.149, 19.043 mm
Tilt angles: 18.8, 23.2, 21.7, 20.9, 20.3 degrees
Beam pipe IR: 12 mm
Beam pipe OR: 12.4 mm
December 7, 2005

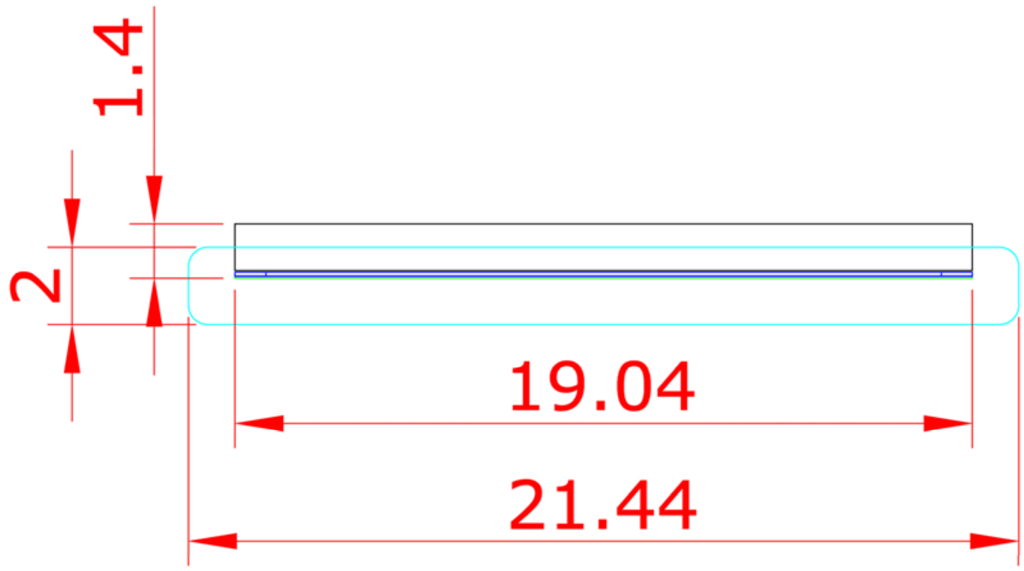
Example of Sensor Overlap

- Considerations:
  - Pt below which a trajectory can pass between sensor active areas (0.2 GeV/c shown for B = 5 T)
  - Closest approach of trajectory to x = y = 0 (2.388 mm shown)



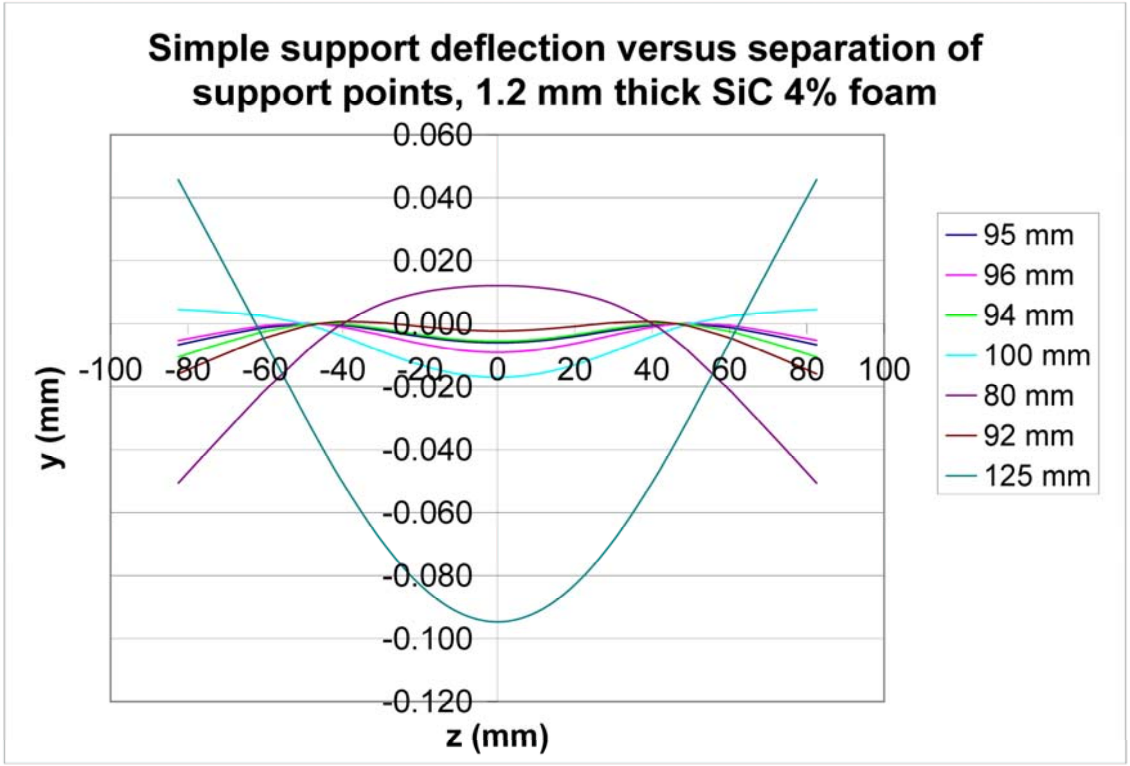
Basic Ladder Dimensions

- 0.1 mm thick x 125 mm long sensors
- 0.15 mm thick x 20 mm long readout regions
- 0.05 mm glue thickness
- 1.2 mm thick x 165 mm long foam (SiC foam presently assumed)
- Ladder and membrane opening dimensions are shown below



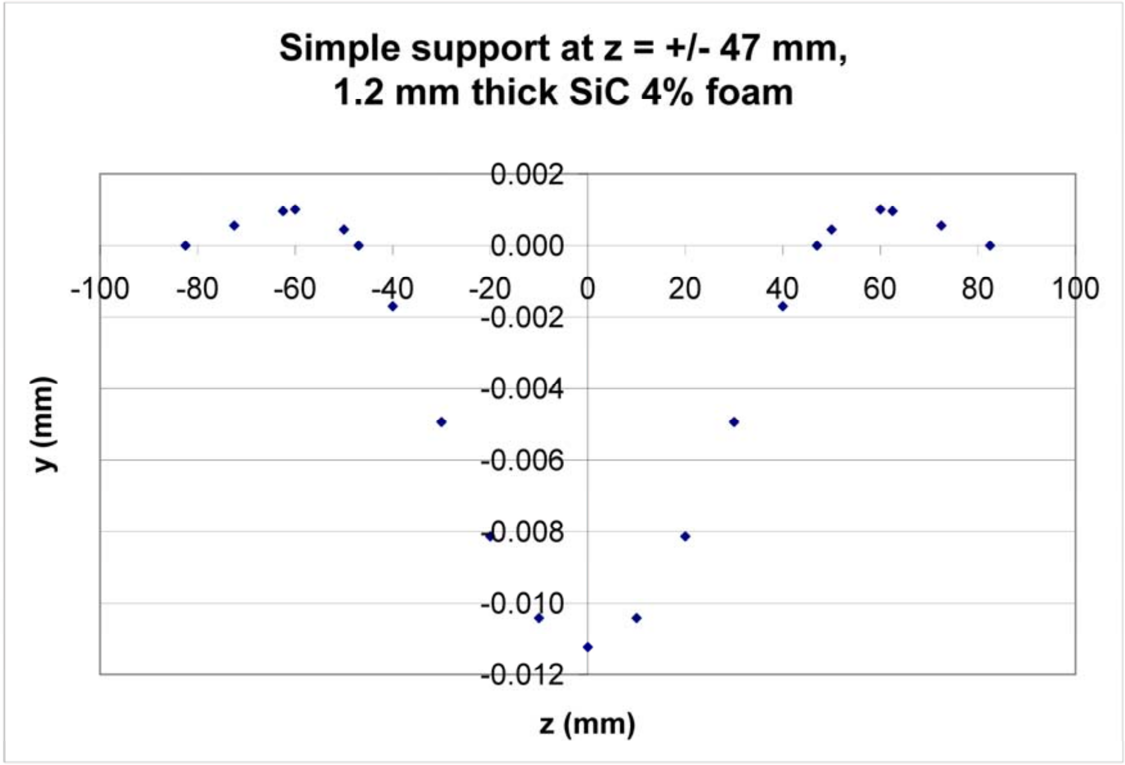
Deflections under Gravity (1)

- Assumes simple support of ladder by two membranes
- Deflection OK with support points moved inward
- Forces from cables are an issue which could argue for four, rather than two, membranes.



Deflections under Gravity (2)

- Assumes support of ladder by four membranes
  - Inserting through holes would require good fixturing.
- Deflections are forced to 0 at the support points.
- Inner membranes would be floated from ladders.
  - Only the outer membranes would tie to an outer support cylinder.



Issues Remaining to be Addressed

- Disk support
  - Disk support could rely upon CF membranes similar in thickness to those of the barrel.
    - We should not neglect searching for membrane materials other than CF.
  - CF membranes would need to provide in-plane compliance unless thermal contraction were accommodated by sensor mounts.
  - SiC or other foam may be applicable to sensor modules.
- Geometry details to ensure barrel and disk hermeticity.
- Cooling with dry gas
  - Power to be removed
  - Flow paths and flow distribution
  - Restrictions to flow presented by cabling
  - Vibration

In Summary

- The basic concepts of supporting VXD elements from the beam pipe and opening the outer tracker to service VXD elements remain unchanged.
  - At some point, we will need to update the interface between outer and inner silicon detectors to match beam delivery and MDI elements.
- Estimates of beam pipe deflection appear to have remained valid.
- A concept has been investigated for the VXD barrel.
  - Barrel geometry has been revised.
  - Ladder deflections and ladder support have been investigated.
- Work remains to be done on disk structures, geometry to ensure hermeticity, and cooling.

Back-up Slides Follow

VXD Barrel Material

	SLD VXD3	SiD VXD
Beampipe liner	Ti 50μm 0.14%	Ti 25μm 0.07%
Beampipe	Be 760μm 0.22%	Be 400μm 0.07%
Inner gas shell	Be 560μm 0.16%	(Note 1) 0
Ladder/layer	0.41%	0.11%
Outer gas shell	Be mesh 0.48%	0.28%
Cold N2 Gas	0.05%	0.05%
Cryostat coating	Al 500μm 0.58%	0.22%
Cryostat foam	Urethane 0.44%	NilFlam 0.12%

Su Dong

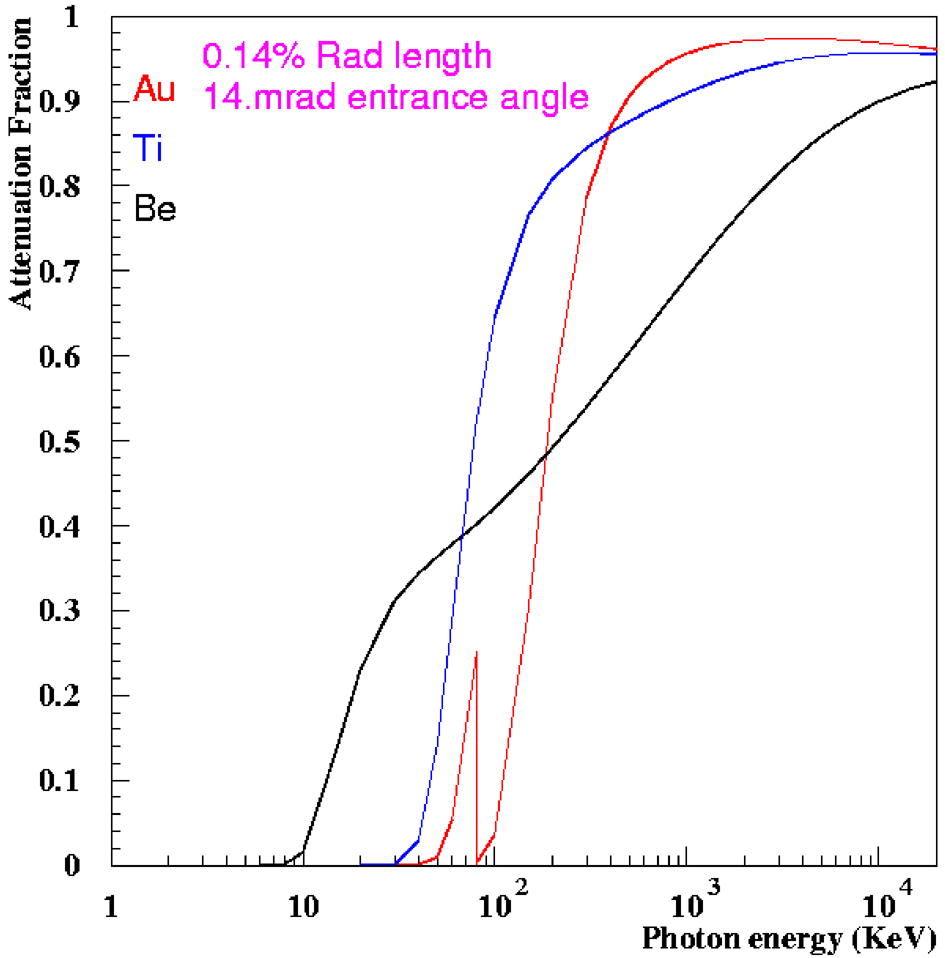
Note 1) Cooling gas can be brought in from two ends

Endcap Region Material

	SLD VXD3		SiD VXD
Barrel Endplate	Be/Fe/gap 3mm	1.5%	Composite ? 0.5%
Barrel support annulus	Be	~2.4%	1.0% ?
Ladder blocks	Al_2O_3 (smeared)	3.0%	1.0% ?
Striplines	Kapton/Cu (face on)	0.5%	0.2%
Stripline clamp support	Be plate with holes	~1.0%	0
Stripline connectors	Hit it 0.4%; smear	0.14%	0
Cryostat	Foam	0.4%	0.4%

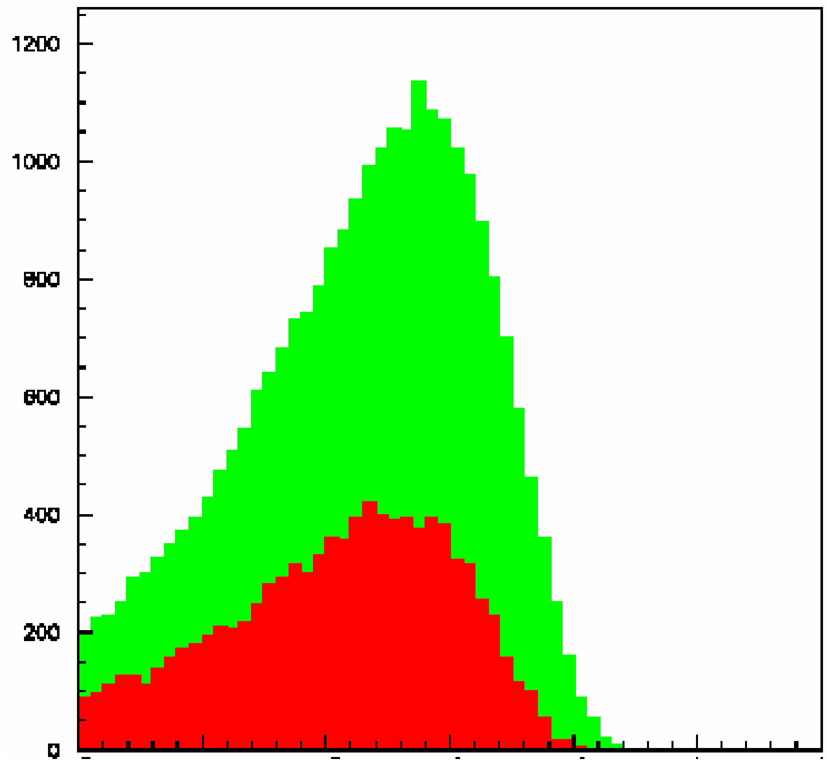
- **What to replace the sliding blocks ?**
- **Readout can be replaced by optical system similar to ATLAS (T>-10C)**
- **with a very small transceiver and very thin fibers.**
- **Still needs power strips**
- **No need of clamp and connectors in active fiducial volume.**

Beampipe Liner



Direct synchrotron

(backscatter spectrum to be calculated)



From Takashi Maruyama

Liners help taking out low energy synchrotrons, but is the attenuation adequate for high energy synchrotrons ?