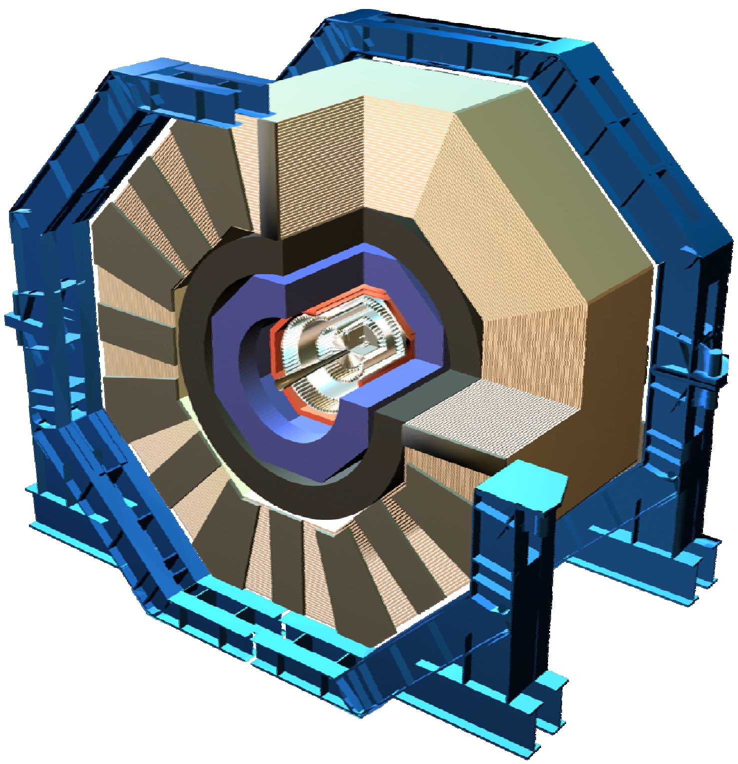
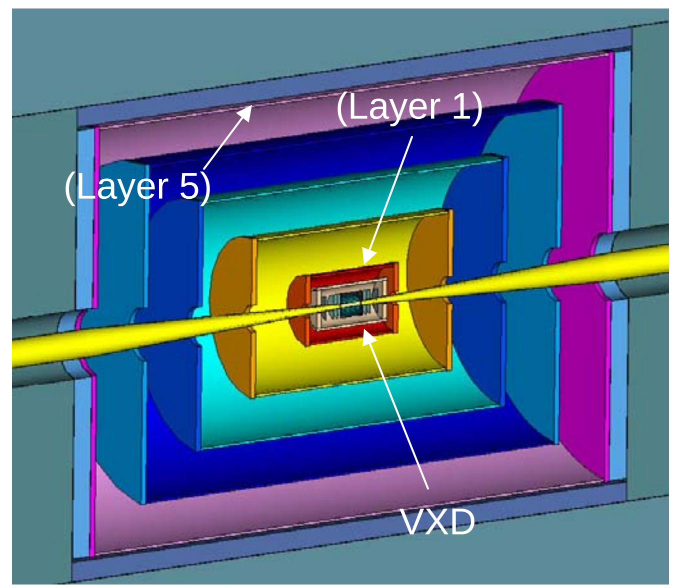
Vertex Detector Mechanical Design: Status and Issues



Bill Cooper

Fermilab



Proposed VXD Barrel Changes

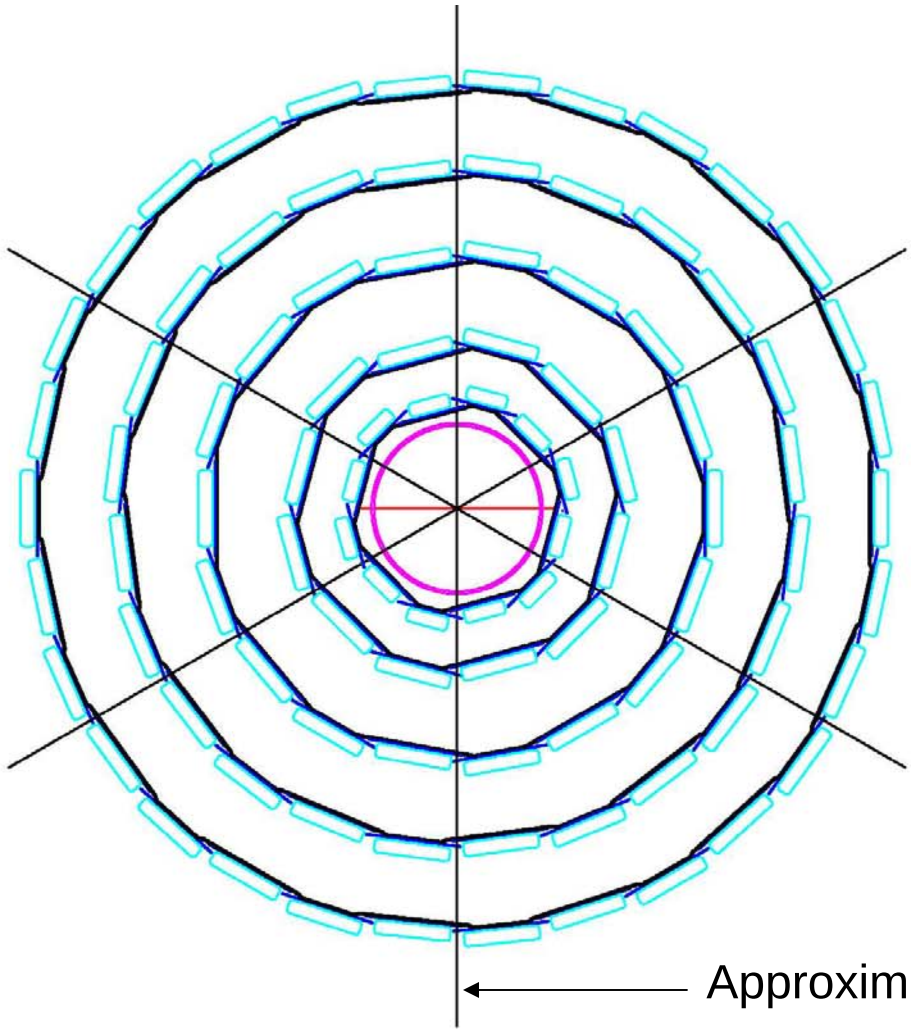
- Changes are proposed to address two comments made in the December SiD meeting.
  - The December geometry was too open.
  - Passing ladders through up to 4 openings could be difficult.
- The idea of gluing, rather than using fasteners, to build sub-assemblies would be retained.
  - Extensive use of fasteners appears to contribute too much material.
  - Fasteners would still be used to join sub-assemblies.
- Operation at $T > -10^{o}$ C has been suggested for the design concept document.
  - A consequence is that the effects of the small CTE mismatch between silicon and carbon fiber are reduced.
  - That allows greater freedom in the ways in which CF can be used.
- VXD still clam-shells as left-right (top-bottom?) halves.

Proposed Changes

- Build CF polygonal support cylinders which cover 180°.
  - Cylinders would be single-walled with 3 or 4 plies.
  - 180° annular rings at each end would control out-of-round.
  - Openings in those rings would be large enough to pass a cable and its connector, but not the full width of a sensor.
  - To control material (~0.11% RL for 4 plies of solid CF), openings would be cut into CF leaving lattice-work.
    - It may be feasible to remove ~75% of material.
  - Sensors would be glued to the CF with required electrical insulation / connections.
  - Up to 15 sensors would be in a cylinder sub-assembly.
- CF end membranes spanning all cylinder radii would form the set of 5 (6?) cylinders into a 180° half-barrel.
  - ~3 fasteners at each end of a cylinder
  - End membranes would have openings to reduce material and provide cable and cooling gas passages.

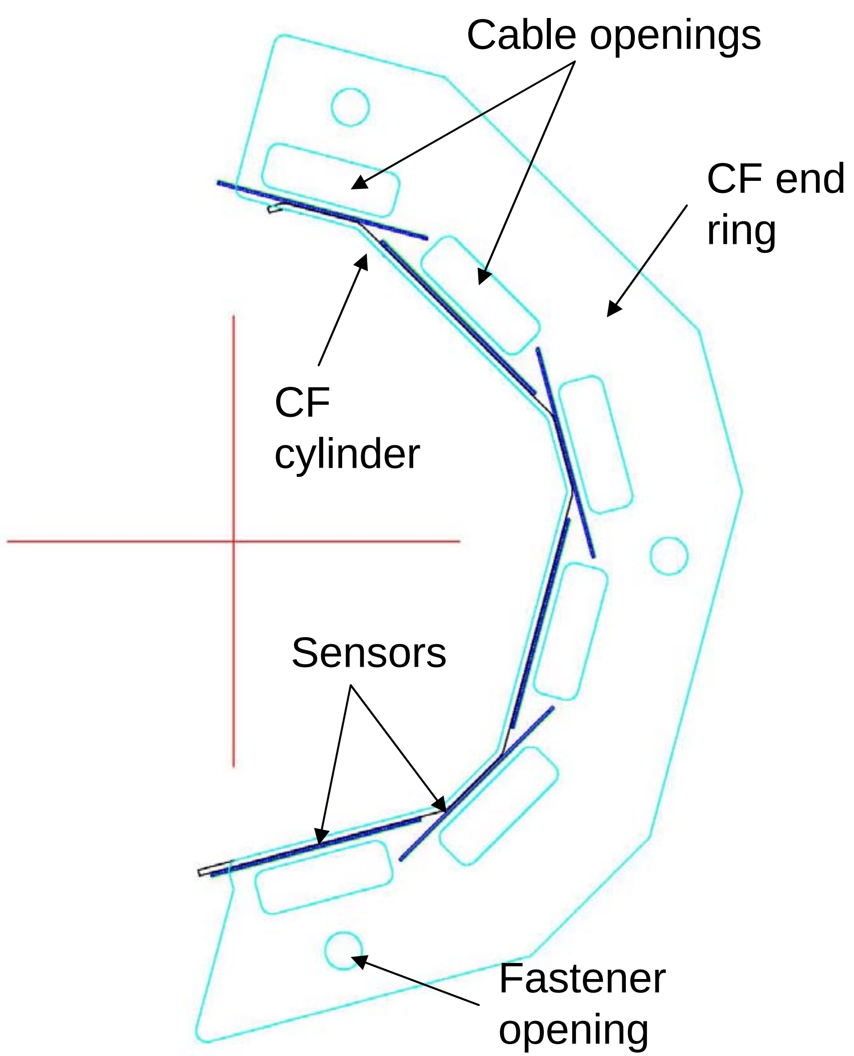
End View

- 2 types of sensors —> some adjustments to radii.



Comments

- All sensors are on the outer surface of CF.
- A & B layer 1 geometry is shown.
  - Spiral geometry will be checked, also.
- A & B layers have been placed leaving 0.5 mm gaps between sensors.
- Other openings would be added in end rings, but their geometry has not been calculated yet.
  - Reduce mass
  - Allow air flow

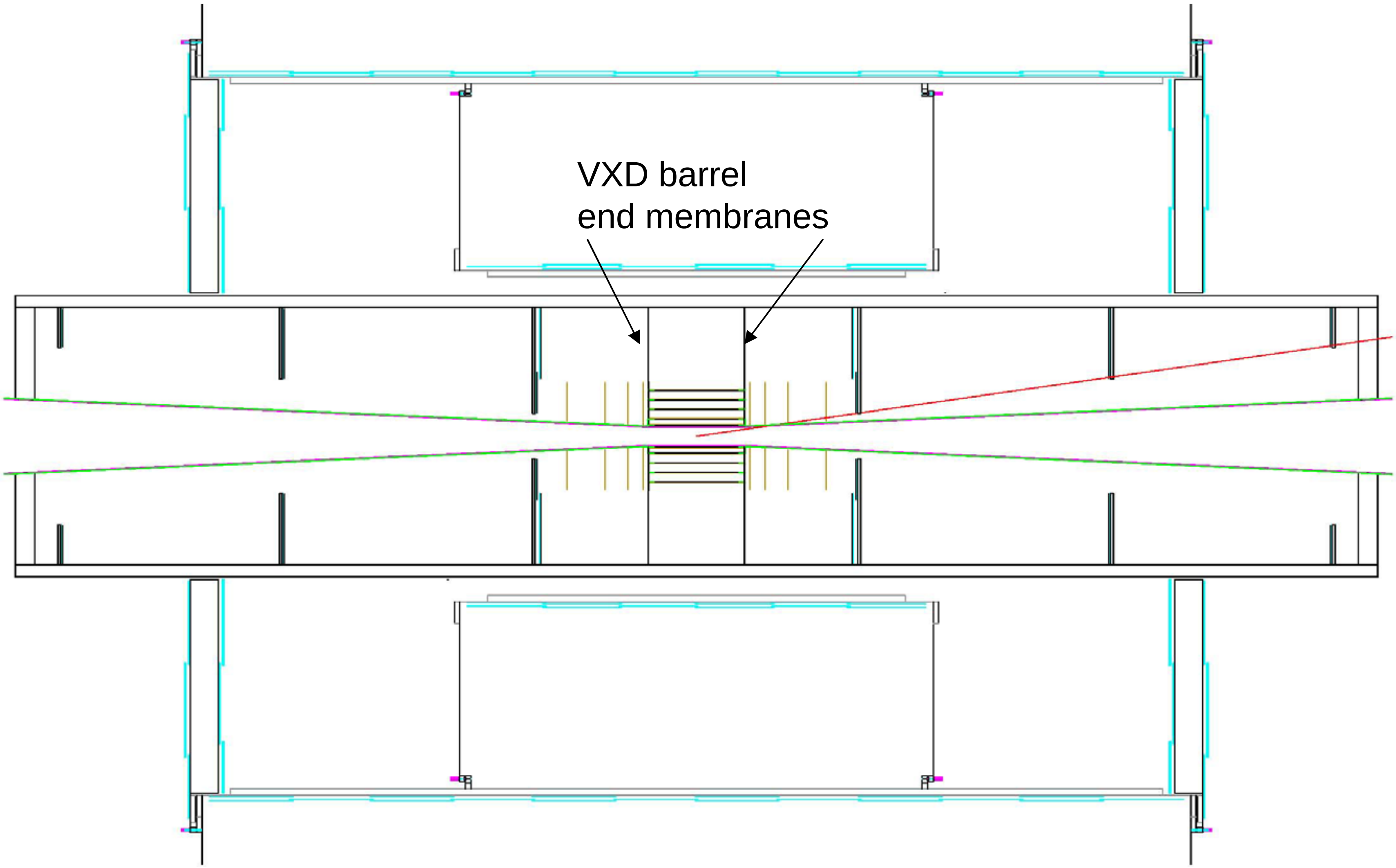


Features

- CF cylinders address beam-like deflection, so sensor assemblies can be thinner.
  - For sensors which are adjacent in phi, that allows the delta R between the edge of one sensor and the surface of the next to be decreased (improves hermeticity).
  - Sensor – sensor gap is drawn as 0.5 mm.
- End rings would be glued to a cylinder while the cylinder is still on a support mandrel.
- We need to optimize the geometry of material which remains after openings have been cut.
  - The U. of Washington will begin FEA to do that.

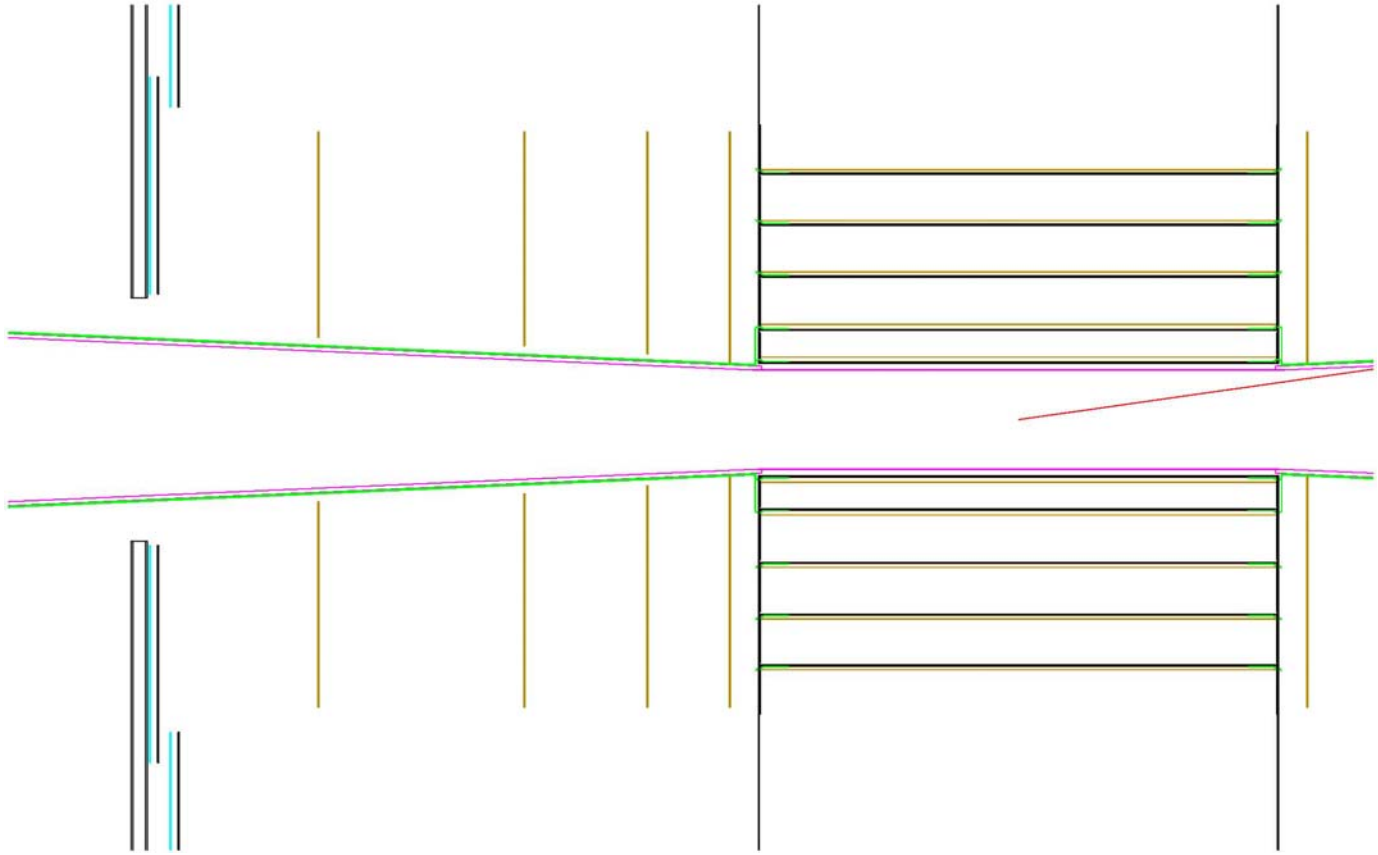
Elevation View

- Barrel sensors are drawn 125 mm long.



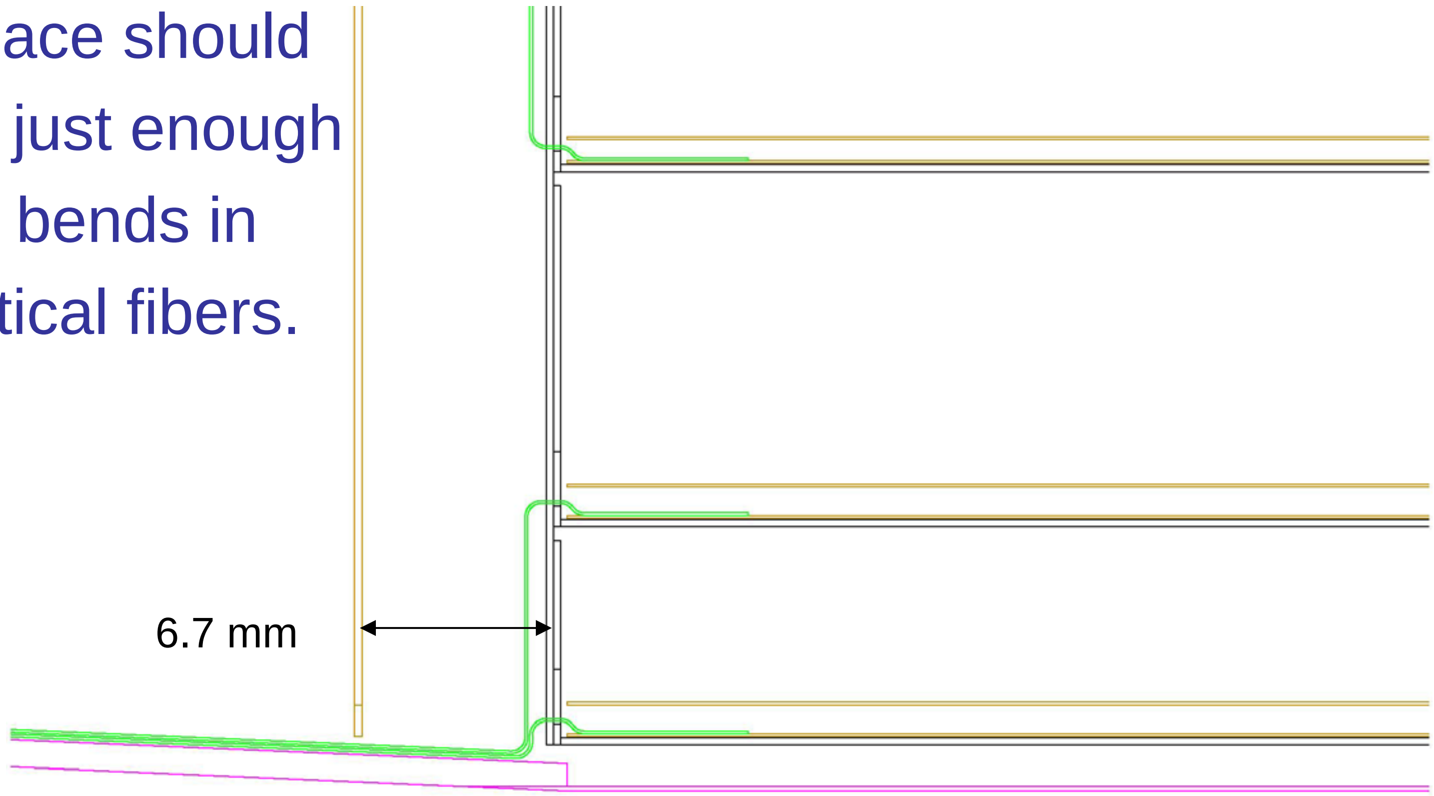
Elevation View

- Longer barrels begin hitting beam pipe and VXD disks.
- Disks may move outward in Z to increase lever arm.
- Outer radii would be adjusted to maintain coverage.



Elevation View

- Only A-layer CF and cables are shown.
- Cables for layers 3 - 5 (& maybe 2) are thought to run outward.
- Space should be just enough for bends in optical fibers.



Questions

- 6 mm x 2 mm openings for cables are shown in layer 1, and 11 mm x 2 mm in other layers.
  - Can opening sizes be reduced or are they already too small?
- A border of 0.25 mm has been drawn between active region and cut edge of each sensor.
  - Can that be reduced, or is it already too small?
- As noted, no extra length is presently drawn for readout.
  - Is that acceptable?
- How much power?
  - Total (could be difficult if > 20 watts)
  - Per location
  - Per unit area

Disks

- A similar design philosophy is assumed, that is, sensors glued to 3 or 4 plies of a CF.
  - Openings would be cut to reduce CF material by a factor of ~¼.
  - To provide overlap, sensors of a half-disk would be at 4 Z-locations.
  - Sensors at a given Z would all be attached to an individual CF membrane, so 4 membranes for a half-disk assembly.
  - Material left after openings are created would be non-aligned to the extent practical from one membrane to the next.
- The assumption is that disk readout connections would originate near the outer edge.
- What are the limitations (if any) on the shape of the active area of a disk sensor?
  - Can true wedges be made?
- Questions for barrels apply to disks.

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

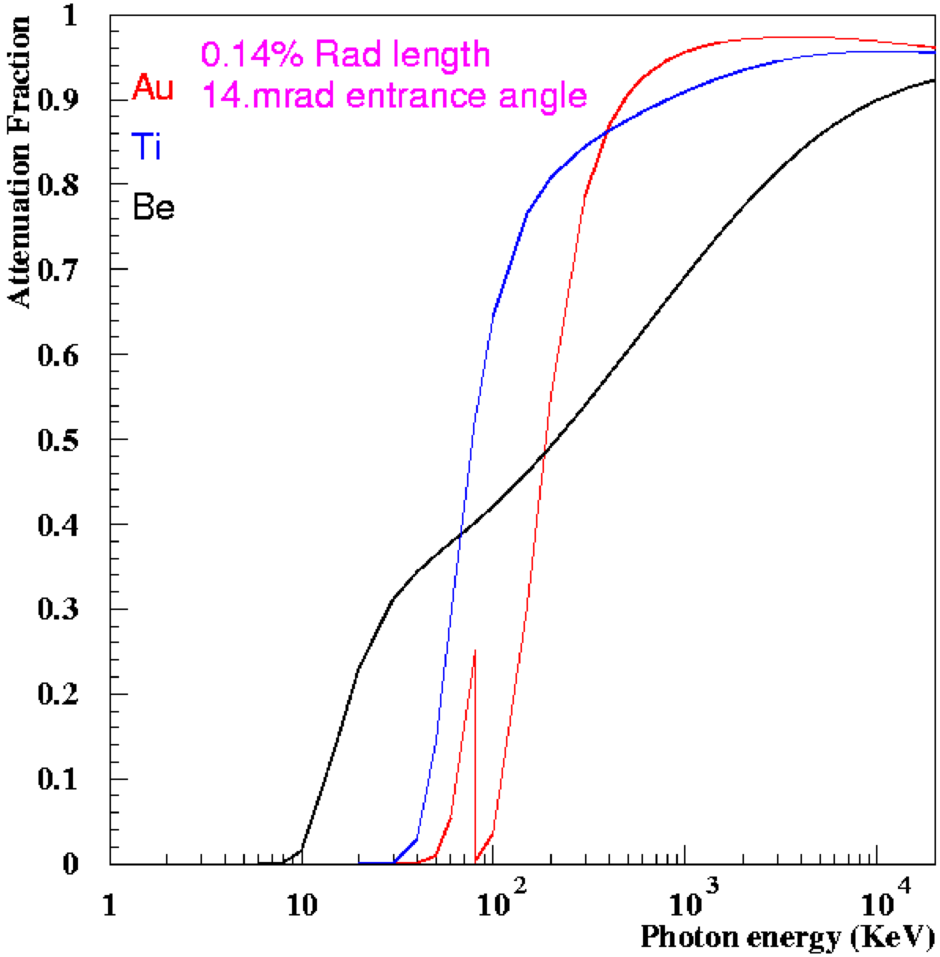
Note 1) Cooling gas can be brought in from two ends

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%

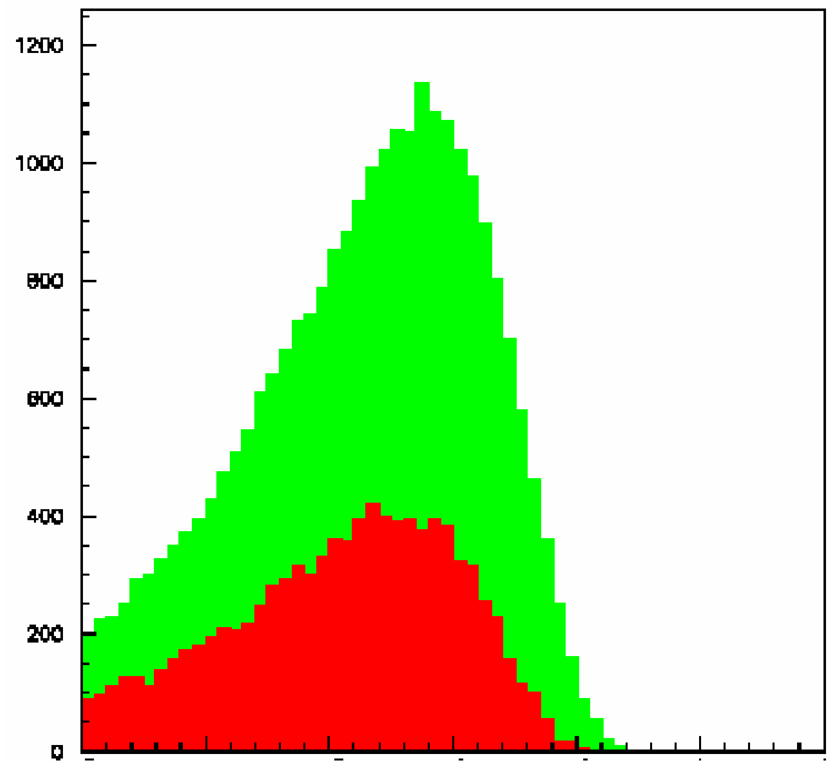
- **What to replace the sliding blocks ?**
- **Readout can be replaced by optical system similar to ATLAS (T>-10C)**
- **with a very small transceiver and very thin fibers.**
- **Still needs power strips**
- **No need of clamp and connectors in active fiducial volume.**

Beampipe Liner



Direct synchrotron

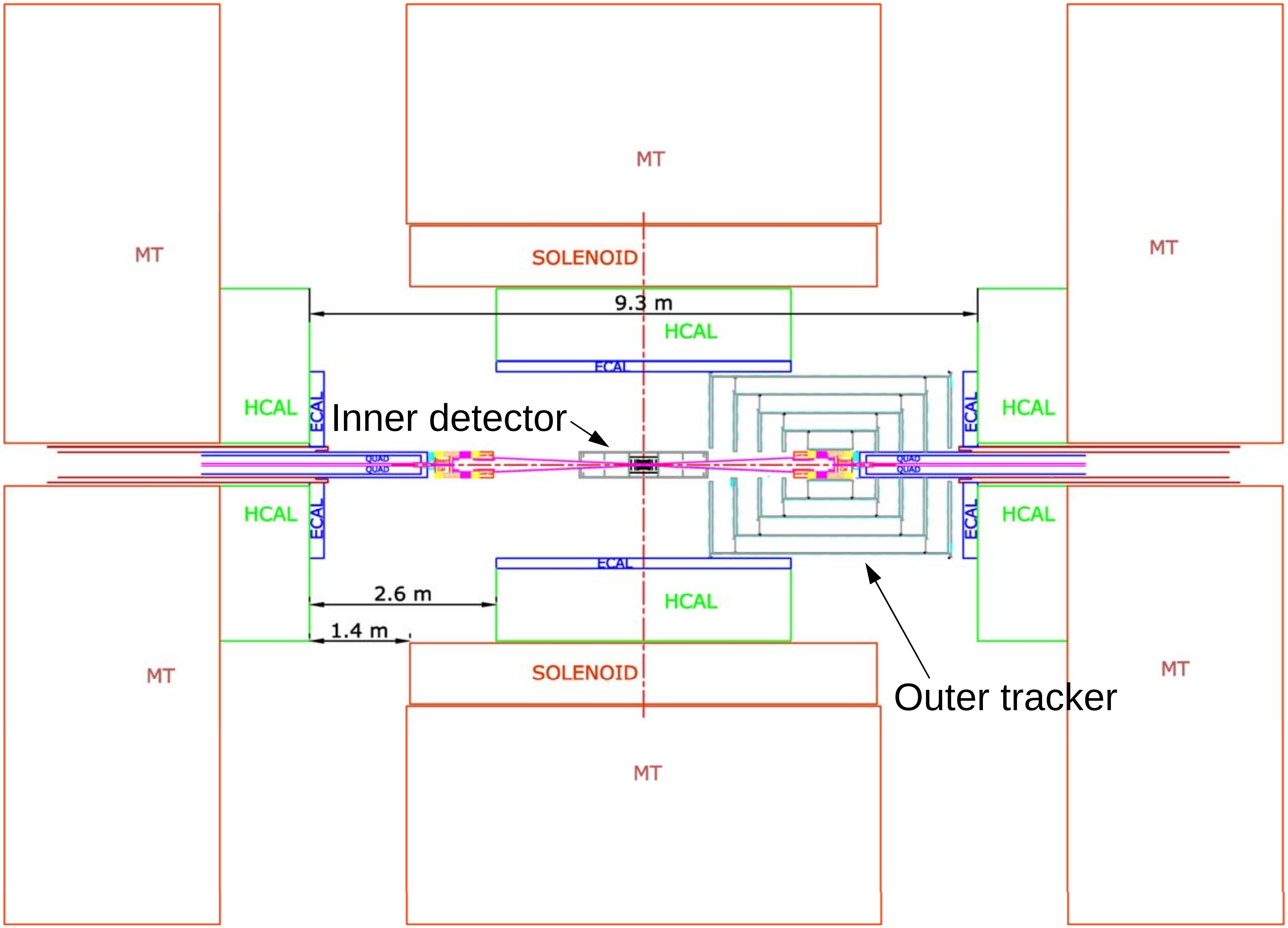
(backscatter spectrum to be calculated)



From Takashi Maruyama

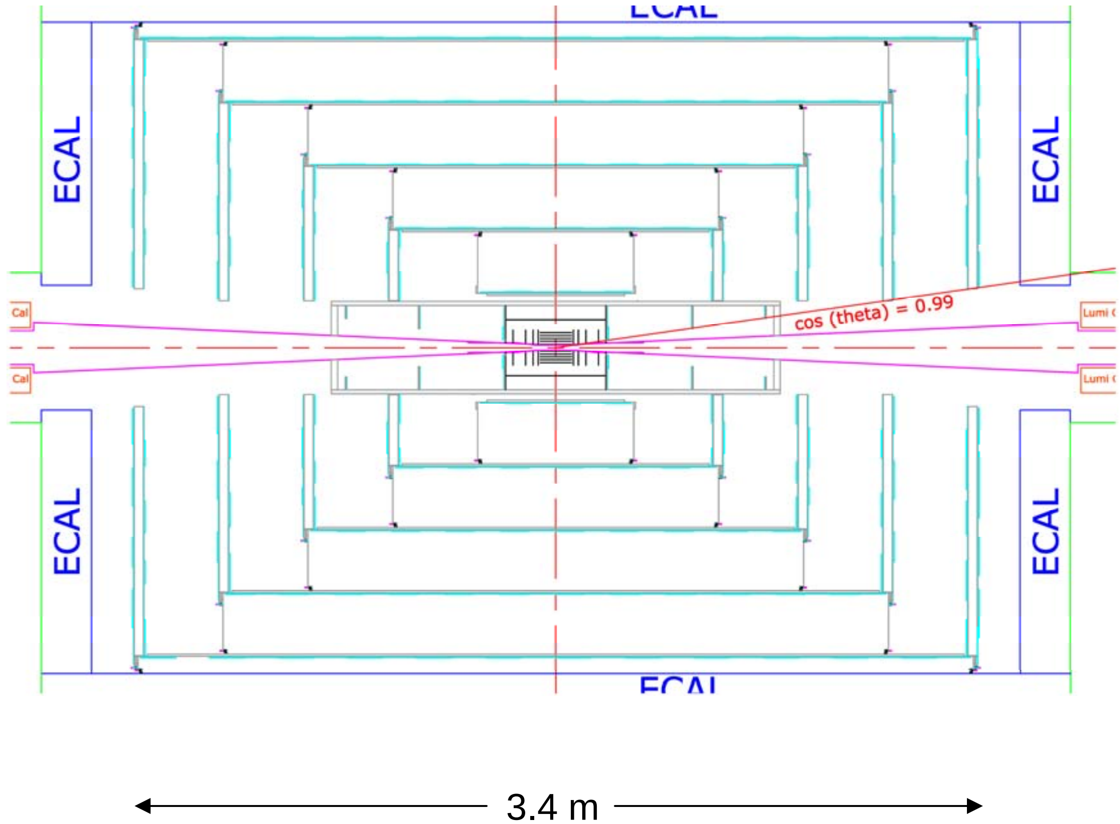
Liners help taking out low energy synchrotrons, but is the attenuation adequate for high energy synchrotrons ?

Detector Open with Full Access to Inner Detector



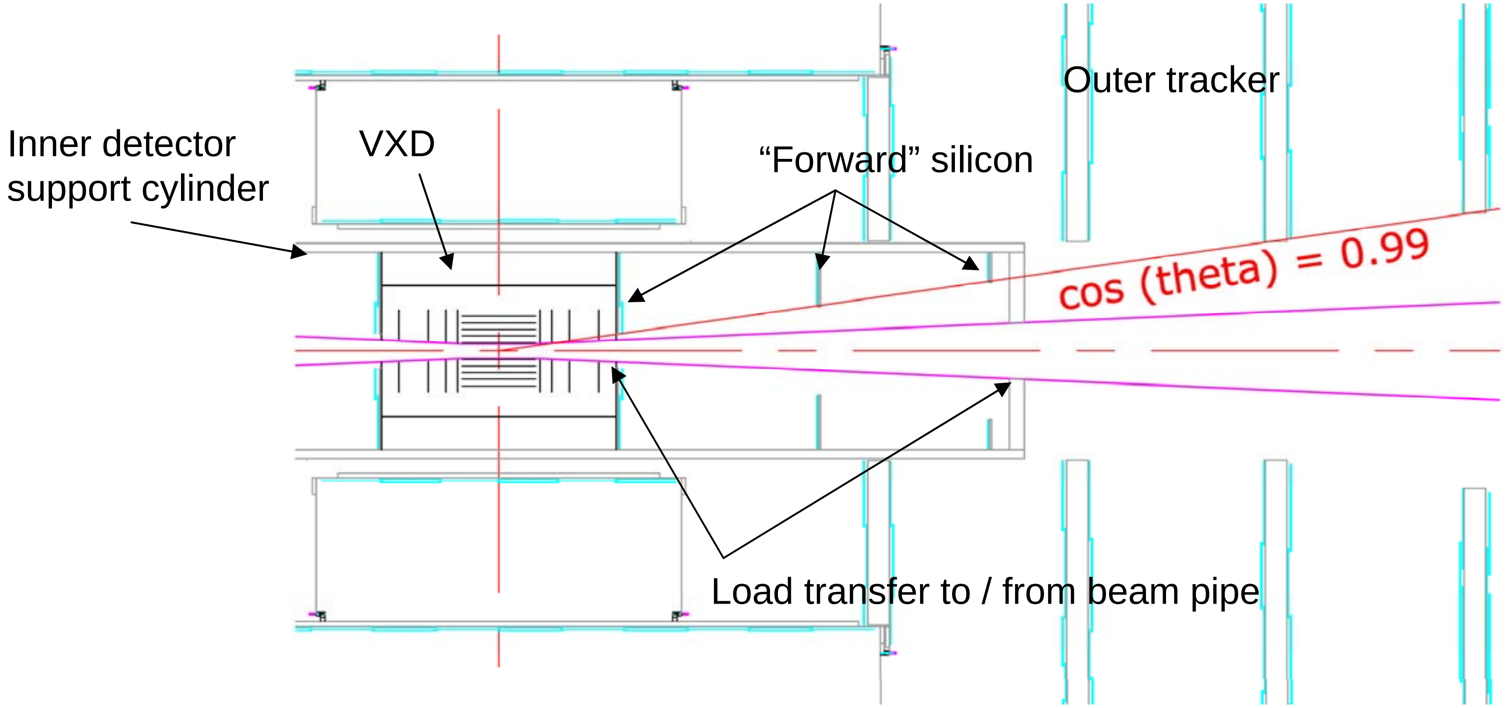
Silicon Tracking Layout

- 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



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)

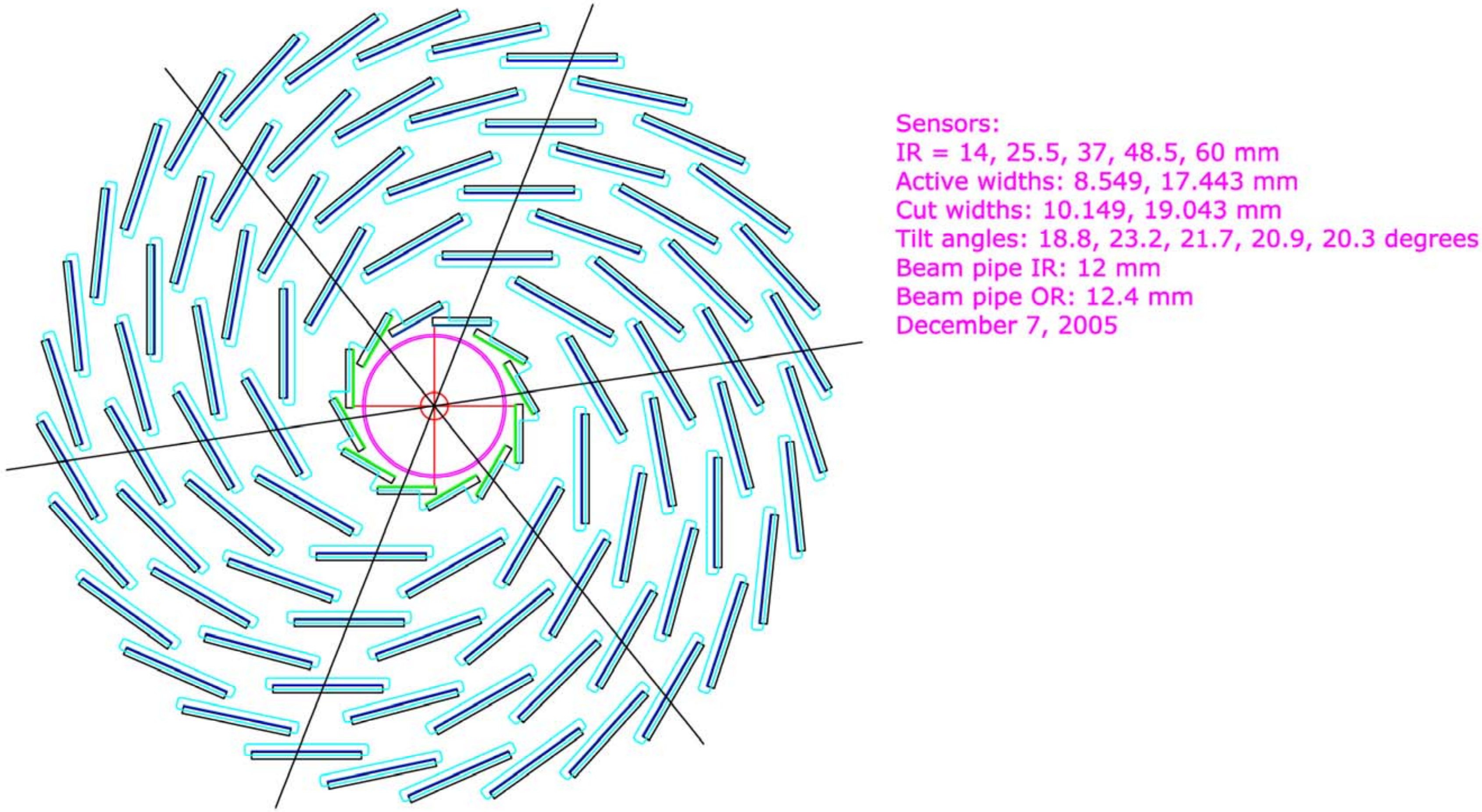
- Ladders are designed taking into account support from two or four CF membranes.
  - Thickness of each membrane ~ 0.26 to 0.39 mm (0.11% to 0.16% of a radiation length for membranes with no holes.
- Ladders pass through openings in the membranes.
  - 1.8 mm of material is retained at nearest membrane 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

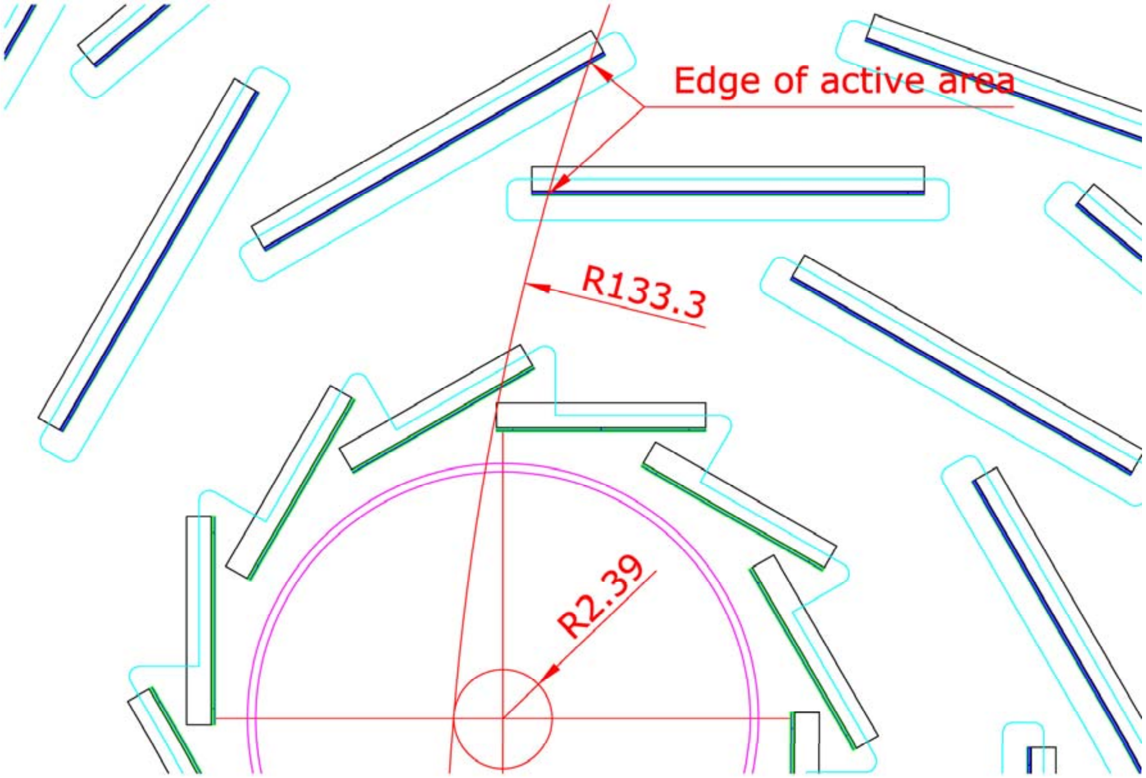
Dec. 2005 End View of the VXD Barrel Array

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



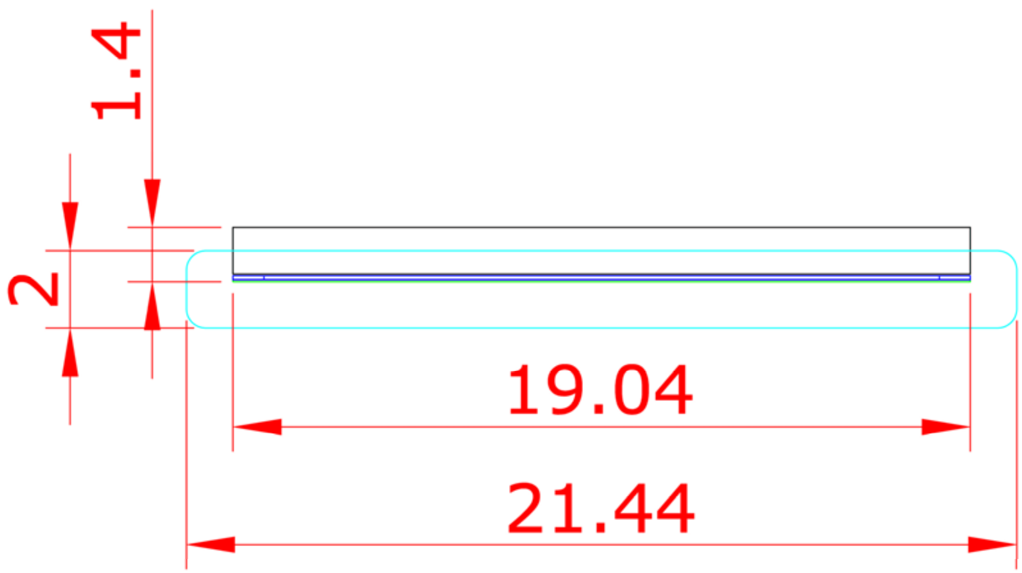
Example of Sensor Overlap

- 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)



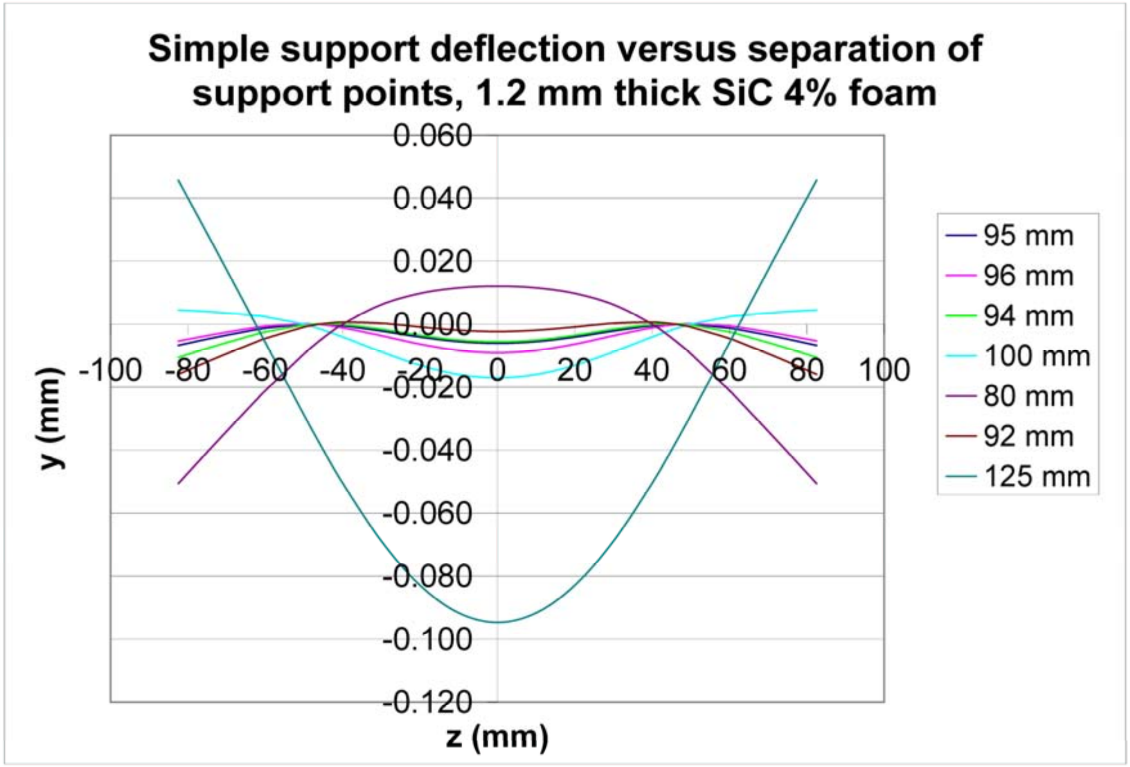
Basic Ladder Dimensions

- 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.