Beam Pipe and VXD Mechanical Considerations

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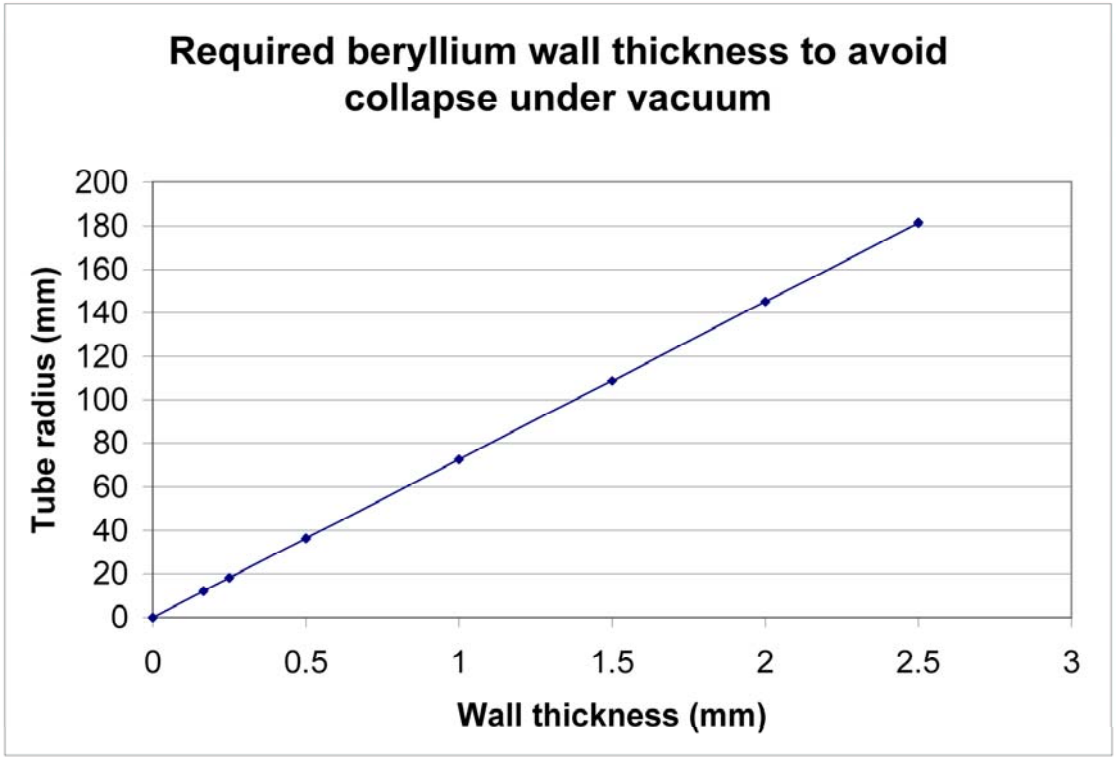
Overview

- This talk is based upon portions of a talk given at one of the Snowmass SiD VXD sessions.
- Topics:
  - Beam pipe issues
  - Servicing
  - VXD and small radius forward disks
  - Short-term work plan

Beam Tube

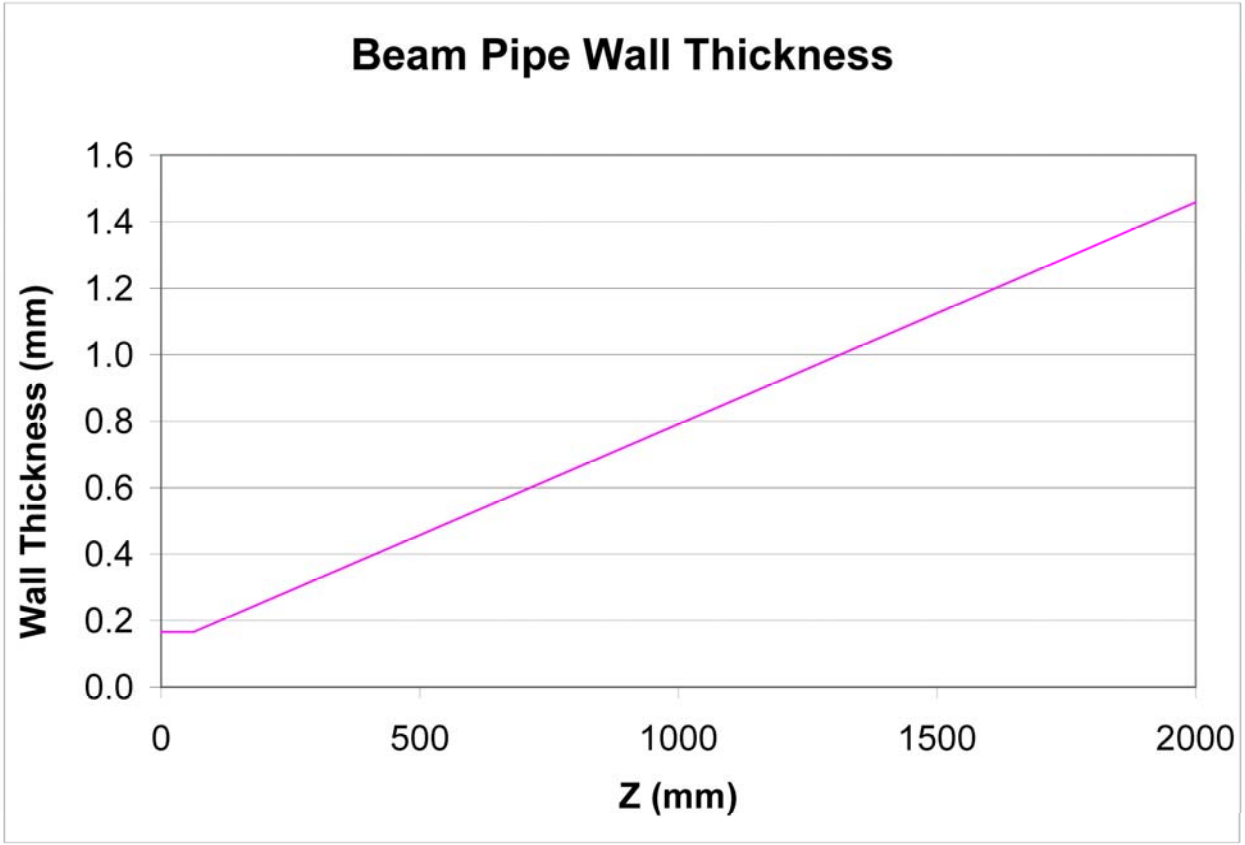
- For guidance, I've assumed an all beryllium, thin-walled beam tube and made standard Rourke and Young collapse calculations.
- The wall thickness to avoid collapse under 30 psid external pressure (a reasonable requirement for vacuum design) is shown below.
- R = 12 mm <—> t = 0.165 mm (a familiar number)

R varies linearly with t



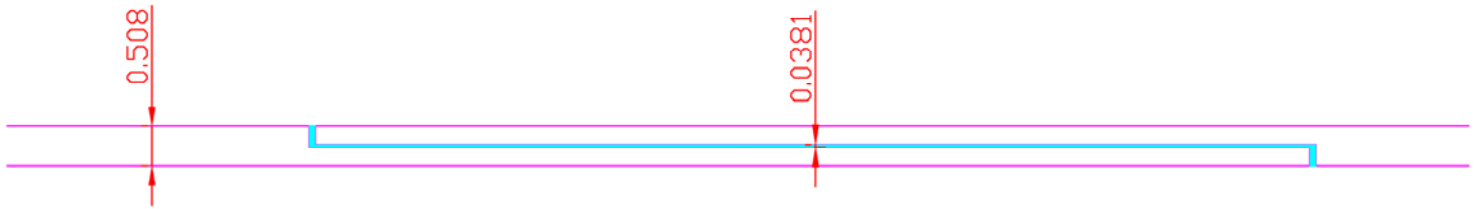
Beam Tube

- For a cone angle with dR/dZ = 17/351 starting at (R,Z) = (12 mm, 62.5 mm), the wall thickness to address vacuum is shown below. For SS, the wall thickness would increase by a factor of 1.145.

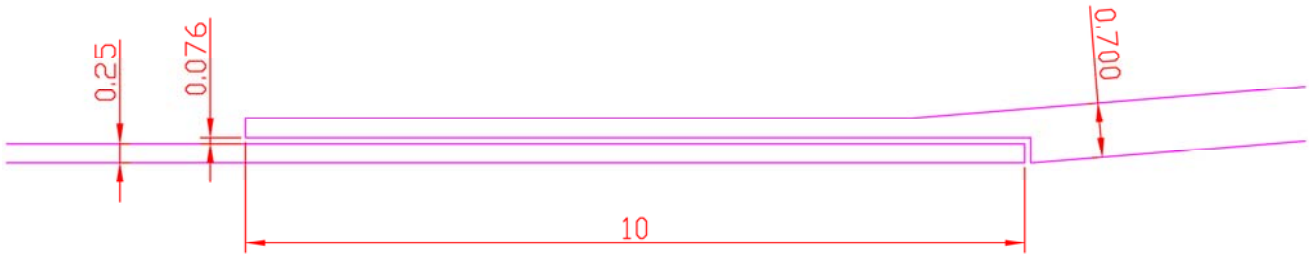


Beam Tube Joints

- 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:

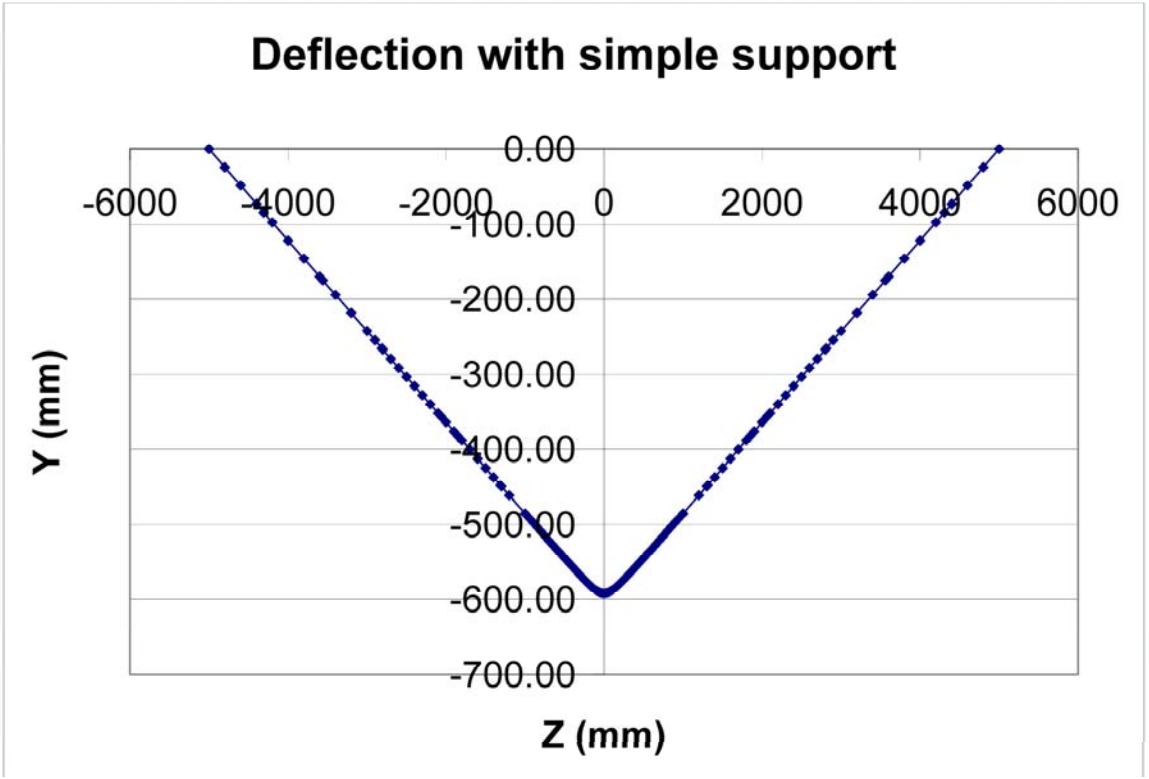


- Similar concept for ILC:



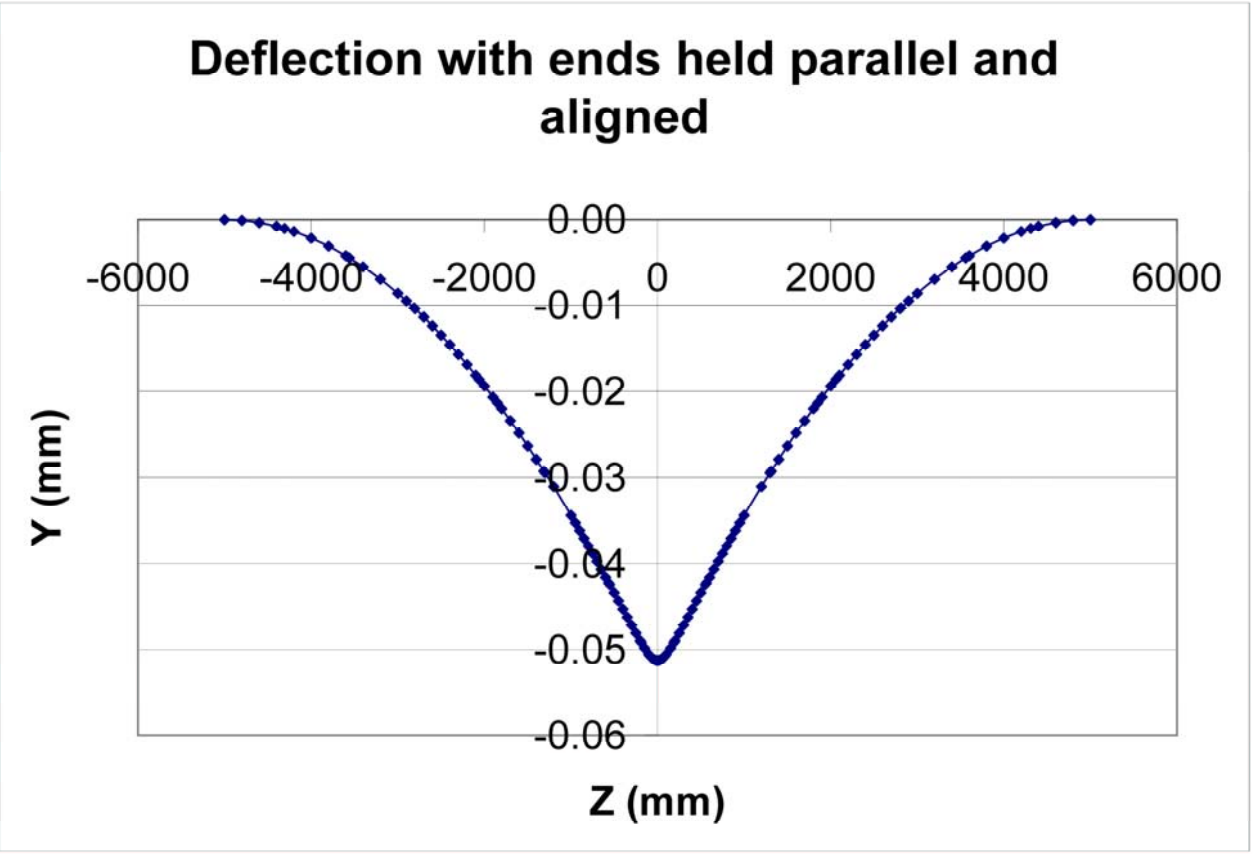
Beam Tube Deflection (Preliminary)

- Wall thickness has been taken to be the minimum to avoid collapse.
  - We might learn later that that isn't sufficient.
- Weight of a 10 m (conservatively long) beam tube ≈ 34.7 Kg.
- Simple support from ends doesn't work.
- Stresses and deflections are unacceptable: 436 KSI and 590 mm.



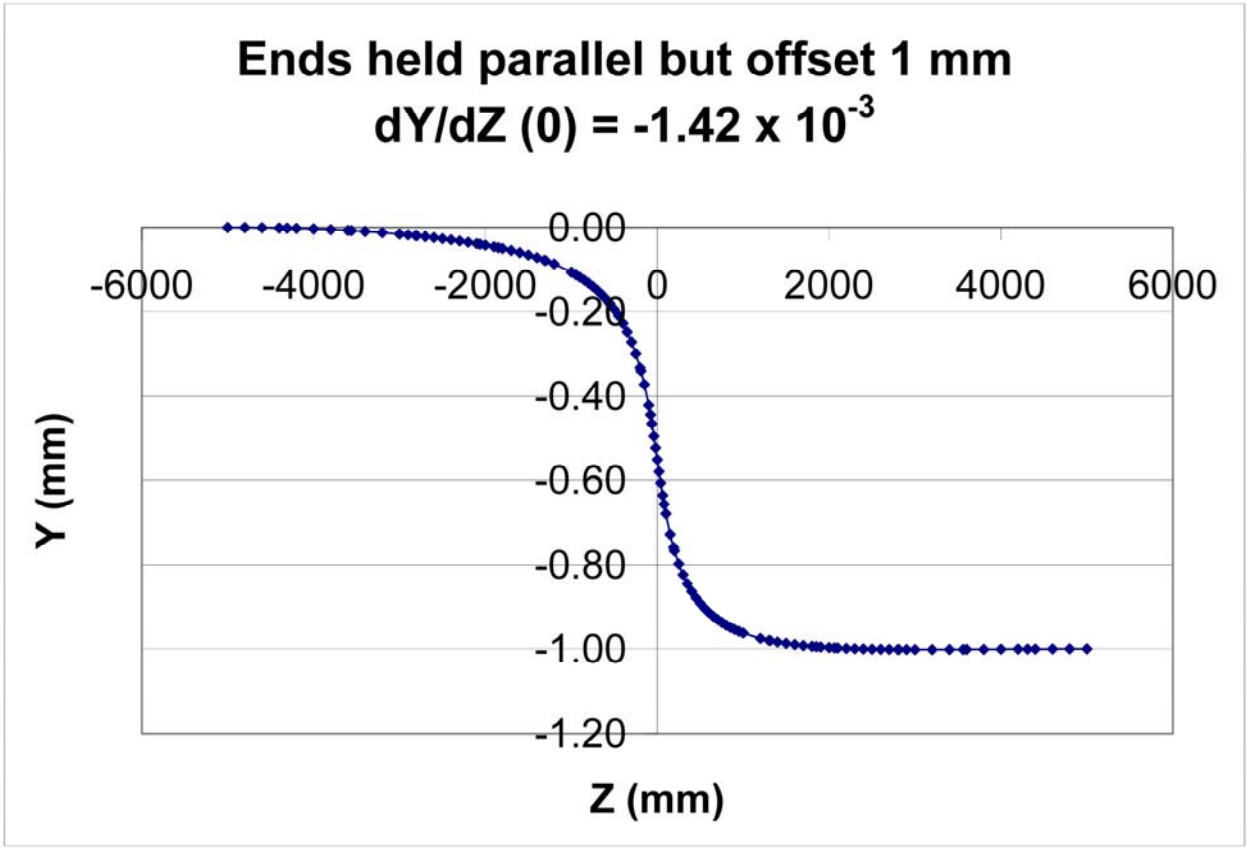
Beam Tube Deflection (Preliminary)

- Deflection of the same beryllium beam tube under its own weight with the ends held aligned
- Deflections and stresses are negligible.

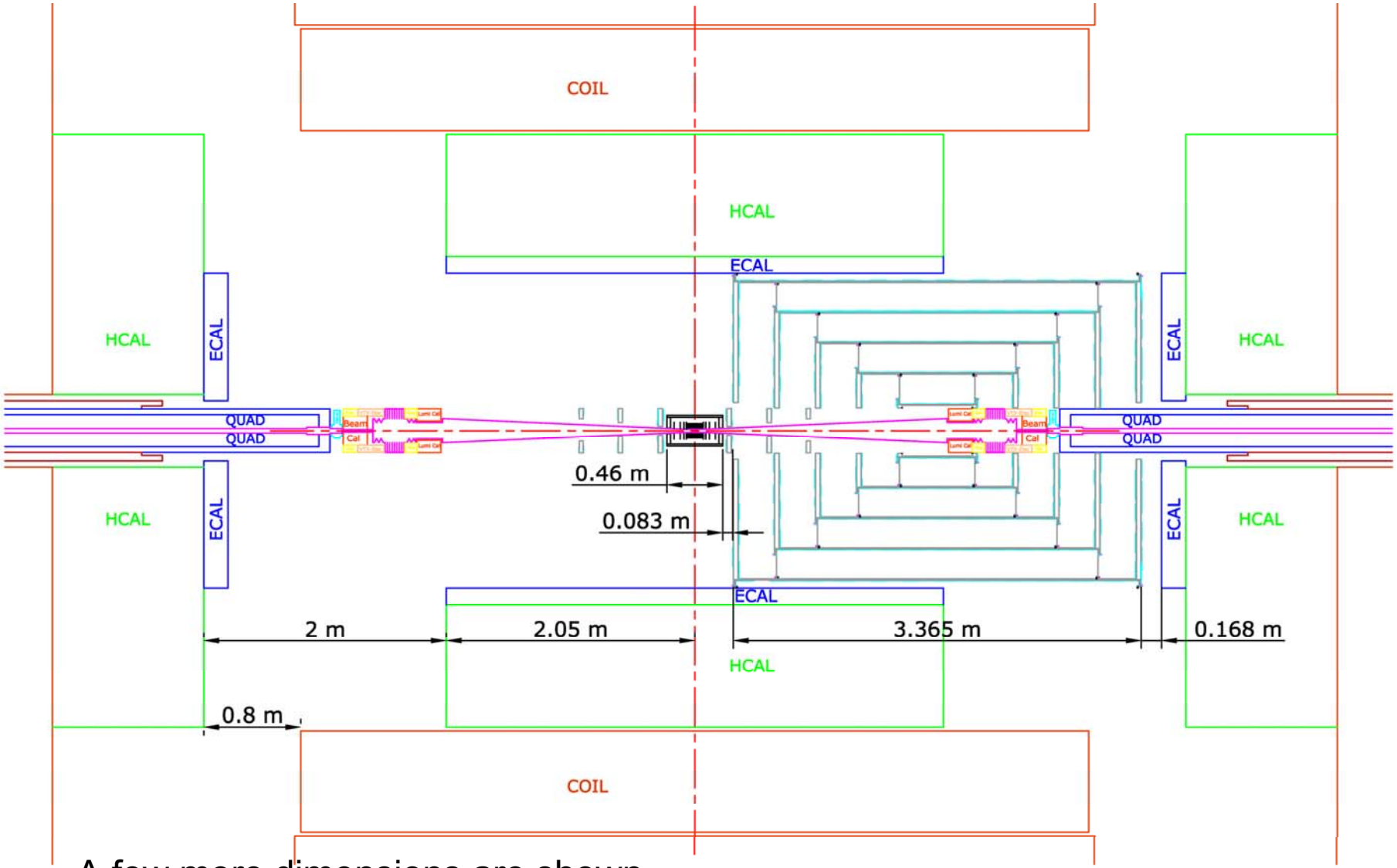


Beam Tube Deflection (Preliminary)

- With ends reasonably guided, beam tube stresses are OK.
- Maximum stress ≈ 2.9 KSI for a parallel offset of 1 mm.
- Braze joint stresses appear to be OK; need to check more carefully.



March 2005 Concept of an Open Tracker



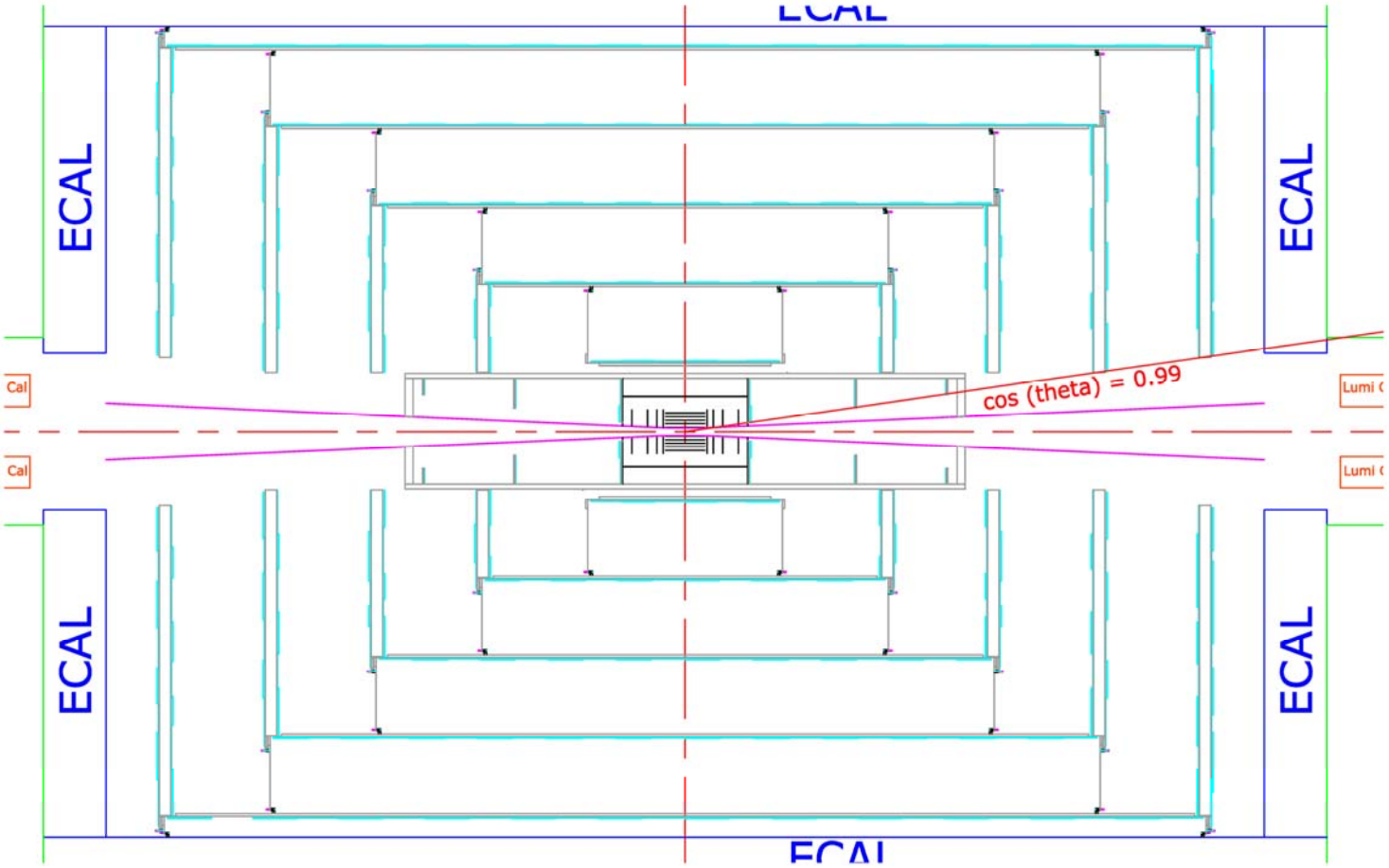
A few more dimensions are shown.

Comments on the March Layout

- The minimal geometrically-required end cap motion to service the VXD (ignores forward, small-radius disks) is half the outer tracker length plus half the VXD length, or 1.91 m.
- Motion has been rounded up to 2 m to allow a slight clearance.
- Forward, small radius disks are exposed only one end at a time.
  - The outer tracker would need to be moved the opposite direction to service the remaining small-radius disks.
- Support structure details for the VXD and small-radius disks are under study and have not been shown.
- Quads are cantilevered a significant amount with the detector open.
  - Given a limited knowledge of quad details, quad deflections have been assumed to be adequately represented by those of a longer beryllium beam pipe.
  - Rolling support of the quads from the HCAL and end irons needs to be understood.
  - Beam pipe bellows were assumed to be located near the ends of the quads.

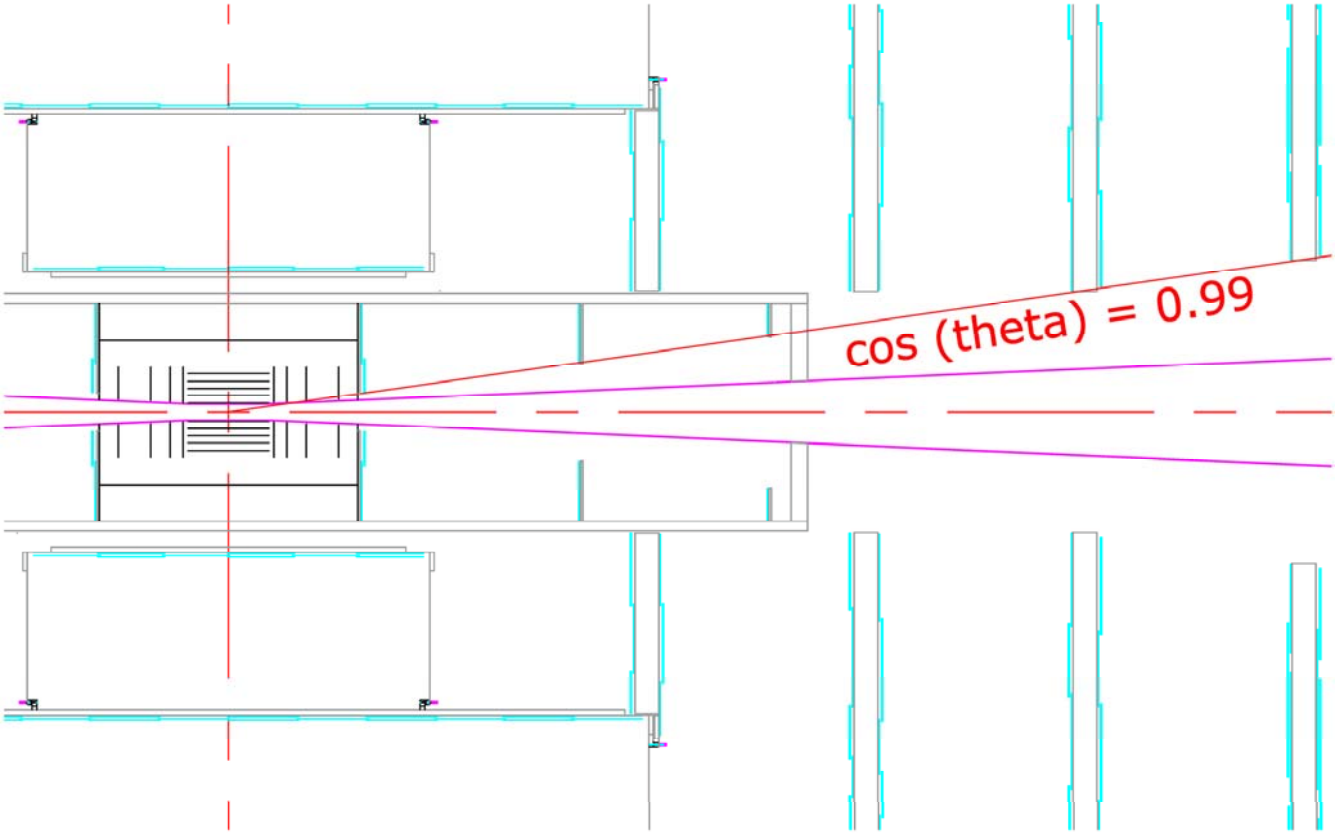
Concept of Inner Tracker (VXD) Support

- The previously discussed VXD plus disks beyond each end of it are shown supported within an insulating, double-walled cylinder.
- Note that the outer tracker geometry has not been updated.



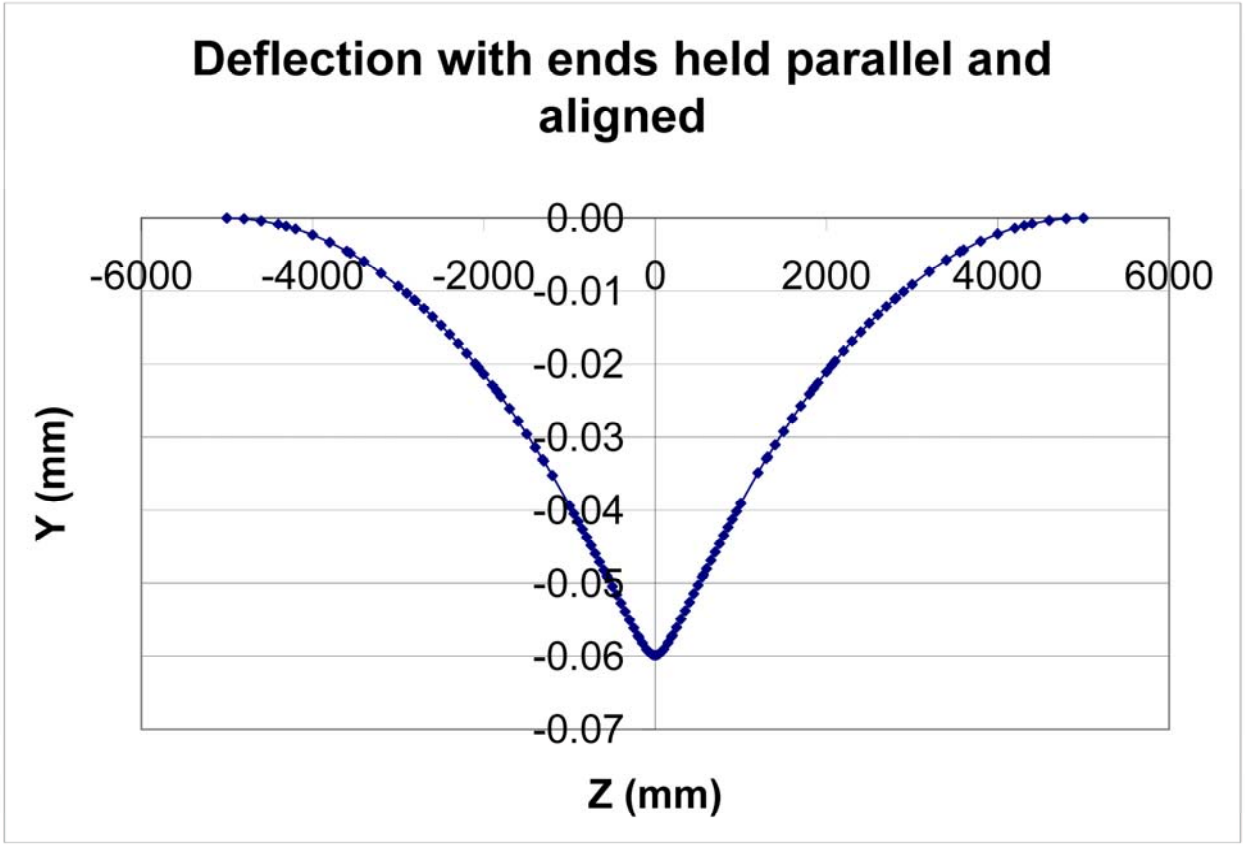
Concept of Inner Tracker (VXD) Support

- The cylinder is coupled to the beam tube at Z = ± 880 mm and Z = ± 200 mm.
- In addition to supporting detector elements, the cylinder aids in keeping the beam tube straight.



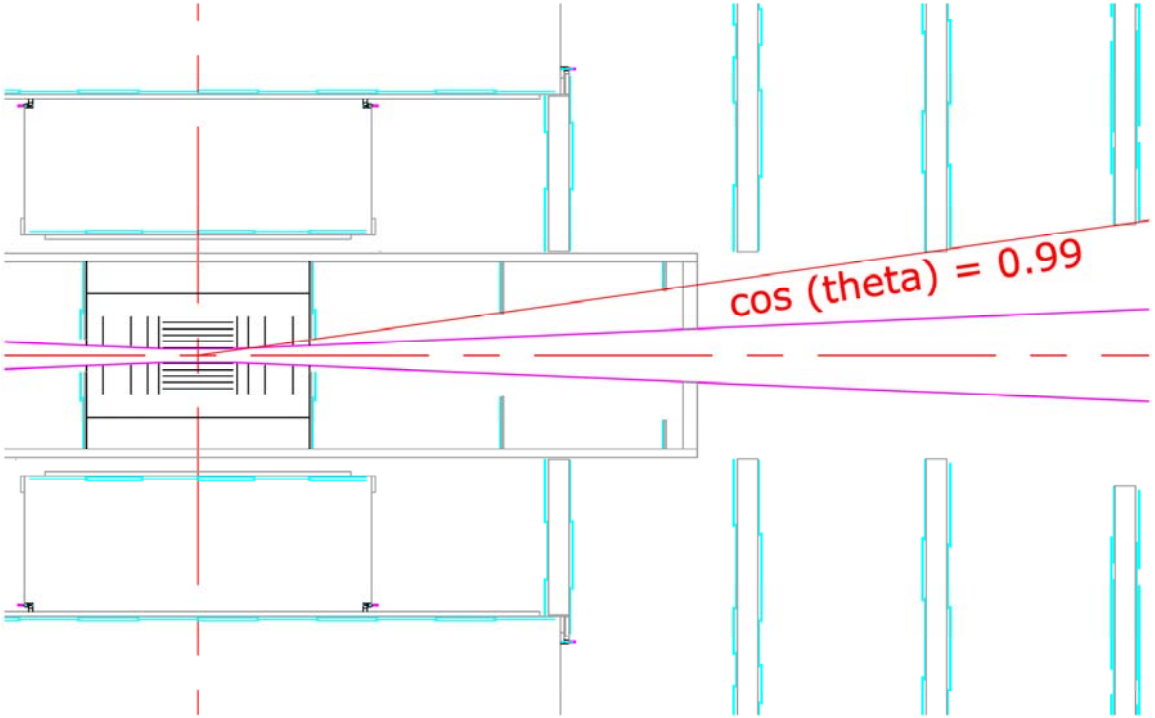
Beam Tube Deflection (Preliminary)

- Deflection with additional symmetric loads of 250 grams at Z = ± 900 mm and beam tube ends aligned.
- Additional deflection from the 250 gram loads is negligible (~8 μm).



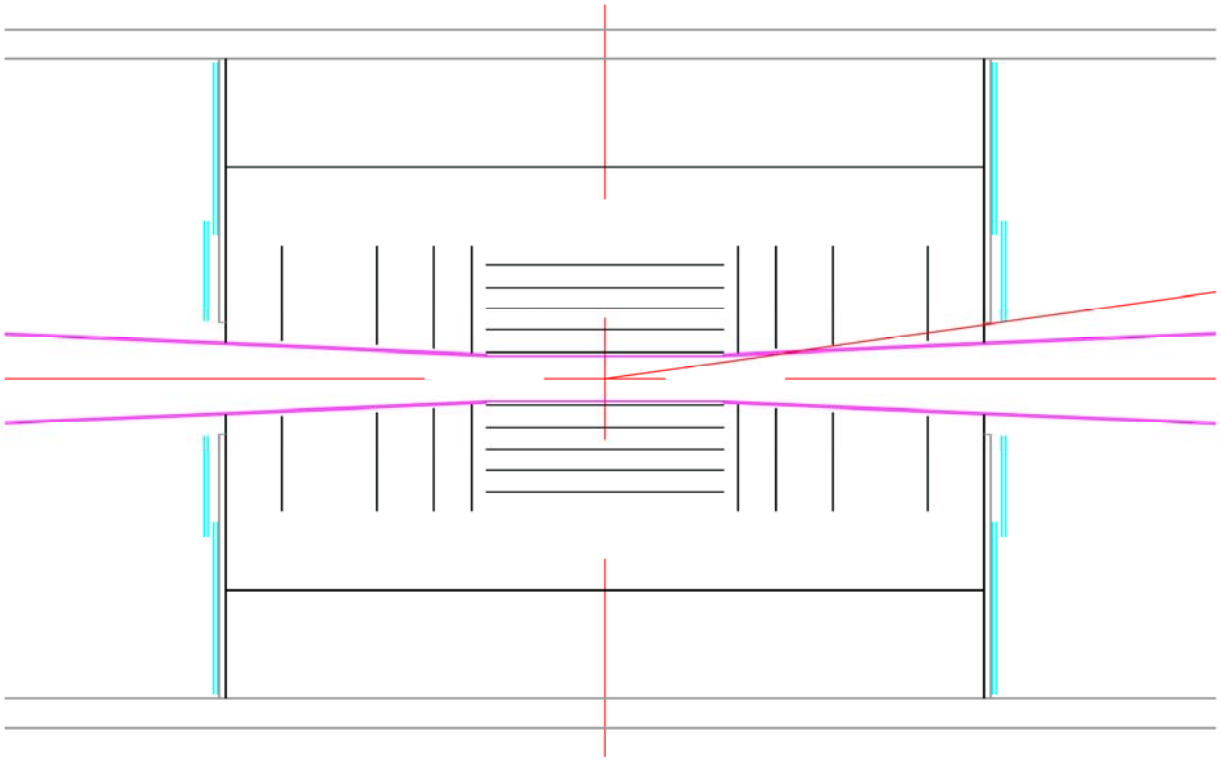
Concept of Inner Tracker (VXD) Support

- Beam tube deflection calculations taking into account all four connection locations remain to be completed.
- Note that:
  - Cables can be dressed along the beam tube but need to avoid one disk.
  - “Forward disks” are in a thermal enclosure
  - Some space along the beam tube is available for readout.



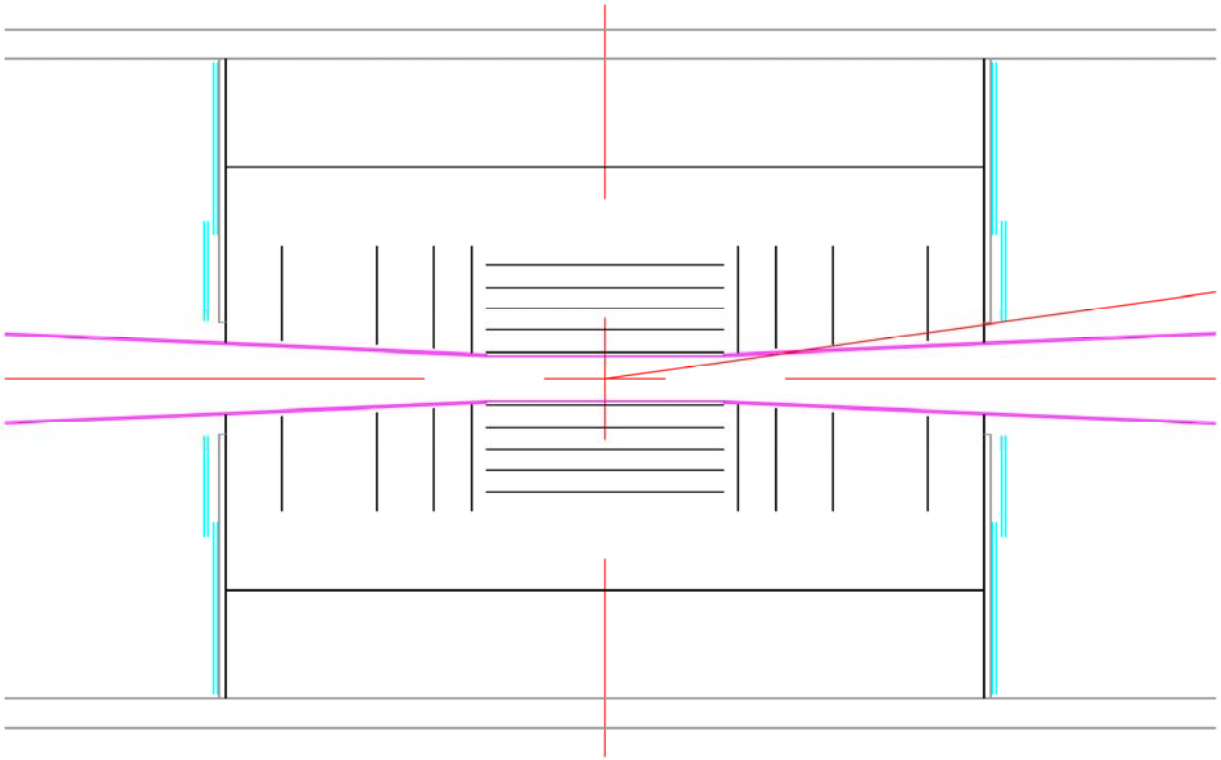
Concept of Inner Tracker (VXD) Support

- An additional cylinder is shown to aid in VXD support.
  - We may not need it.
  - We should be able to match longitudinal thermal contraction of a carbon fiber cylinder to that of silicon.
  - Leaf spring fingers in end membranes of the cylinder can provide longitudinal compliance.

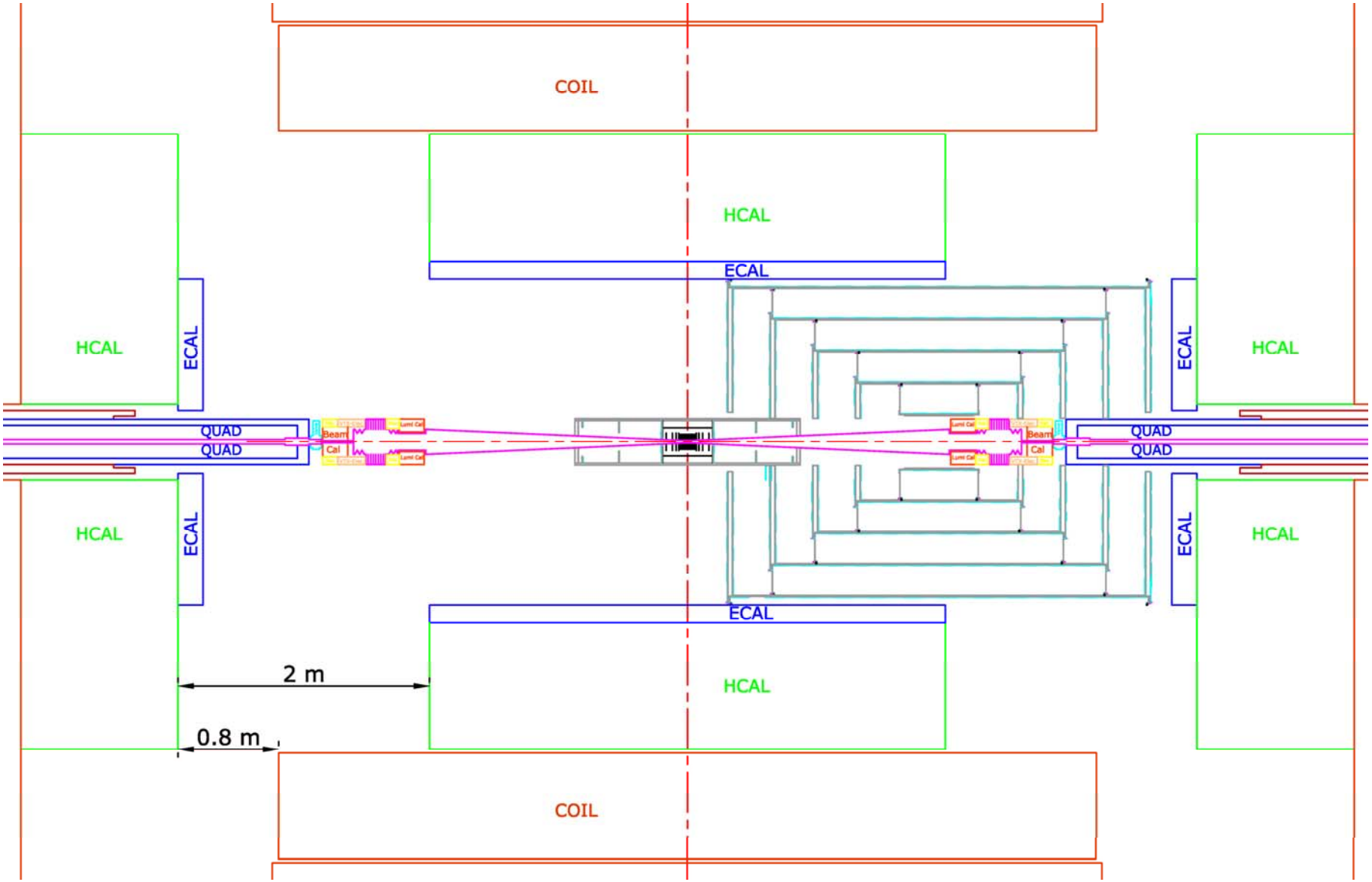


Concept of Inner Tracker (VXD) Support

- We will need to consider implications of the beam pipe joint details on the inward extension of the first disk.
  - Central beam pipe OR = 12.25 mm corresponds to an OR = 12.576 mm in the braze region and 13.336 mm at Z = 70.3 mm (ignoring fabrication tolerances).
- We are beginning to work on barrel and disk support details.



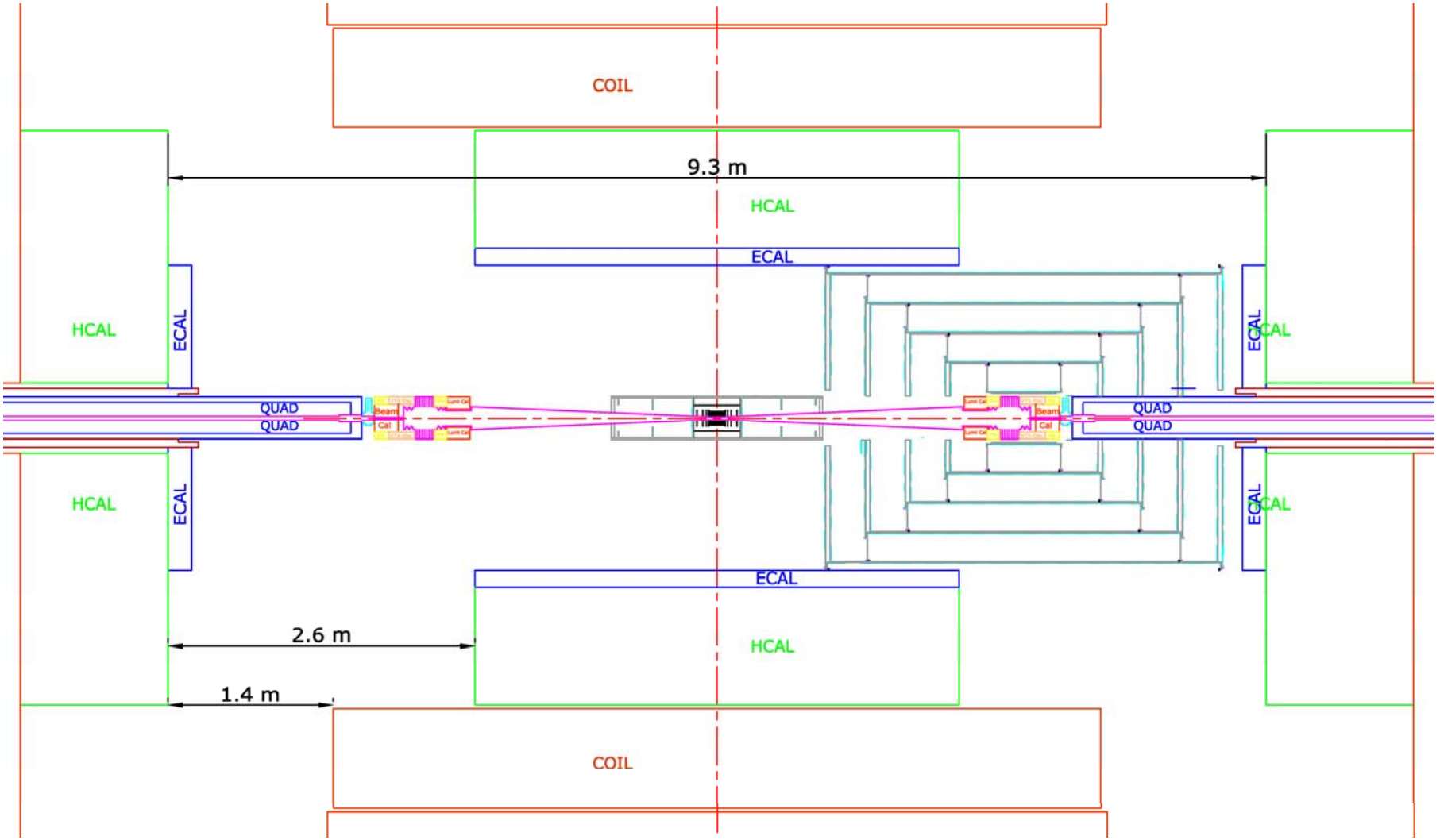
Open Tracker with this Concept



Comments on Updated Open Detector

- With end-cap motion limited to 2 m, it appears necessary to segment the VXD support in Z for servicing.
- That may not allow material to be used so efficiently, since VXD internal support replicates portions of the outer cylinder to beam pipe mechanical connections.
  - However, the four outer cylinder to beam pipe mechanical connections could consist of spokes, which represent relatively little material.
  - The amount of material in rings at the outer ends of spokes will need to be evaluated.

Open Tracker with Full Access to VXD Elements



Comments Regarding Full Access

- Allows true half-cylinder sub-assemblies which include VXD and associated small radius disks
- Quad cantilever distance is increased, as is the required hall length.
- Greater longitudinal motion has implications for cable, optical fiber, and outer tracker rail support.

Snowmass Suggestions

- Develop two semi-independent VXD structural designs, one for operation at room temperature and the second for operation at -90^{o} C.
- Consider whether spoked wheels can be incorporated in the design, particularly for VXD, in order to reduce material. (Spokes were suggested in Justin Albert's Snowmass talk).
- Comments:
  - Design constraints may lead to quite different structures for the two temperatures.
    - Room temperature operation eliminates the need for thermal insulation, may simplify paths for cooling air flow and cabling, and may be more consistent with spoked support.
    - Low temperature operation requires nearly continuous thermal barriers and is more consistent with longer, insulating support cylinders.
  - If a Faraday cage is needed, that could lead to more similar designs.
  - Spoked design constraints are different with half-cylinders and full-cylinders.
    - For a half-cylinder, spokes act in compression and not just tension.

Short-term Work Plan

- Justin Albert is beginning to look at how much material can be removed from outer tracker support cylinders and support disks by cutting openings.
  - That was partly motivated by a suggestion from Dave Hitlin, who has become interested in SiD support structures, to consider a space frame.
  - Removing material from double-walled support cylinders and disks may allow them to approximate a space frame while retaining ease of fabrication.
  - That work could have implications for VXD support.
- I've begun to look at spoked structures for VXD support.
- We expect to consider VXD cooling constraints, dry gas flow paths, insulation for low temperatures, and temperature distributions during in the next few weeks.