Beam Pipe, Silicon Tracker, and VXD Mechanical Considerations

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Summary of Issues

• The present SiD concept for servicing the VXD and associated small radius disks is to open the end-caps longitudinally and to roll the outer silicon tracker longitudinally.
• The beam pipe and beam line elements are assumed not to move.
• For optimal access, each end-cap should open at least 2.6 m from its normal, closed position.
  – That value could grow slightly.
  – Options requiring slightly less motion may be possible, but have disadvantages.
• Since beam line elements extend well within the outer silicon tracker during servicing, we would like to understand their transverse profile and the way in which they are supported.
• Beam pipe support, wall thickness and detailed shape, beam pipe deflections, and shielding integral with or associated with the beam pipe are also of interest.
• Operation of VXD at -90° C appears to imply beam pipe bellows.
  – Where should they be?
Caution

• Dimensions should be taken with a grain of salt.
  – Particularly for the calorimeters and muon system, they reflect early design concepts.
  – Beam delivery elements shown on sketches are clearly out of date.
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
• Cantilever distance of beam line elements is greater than for other options, as is the required hall length.
• Greater longitudinal motion has implications for cable, optical fiber, and outer tracker rail support.
• Estimates of beam pipe deflections are shown later.
  – Given a limited knowledge of beam line details, deflections of beam line elements were 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 have been assumed to be located near the ends of the beam delivery system.
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 pipe at $Z = \pm 880$ mm and $Z = \pm 200$ mm.

• In addition to supporting detector elements, the cylinder aids in keeping the beam pipe straight.
Beam Tube

- Needed wall thickness was based upon an all beryllium, thin-walled beam pipe and 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.
- \( R = 12 \text{ mm} \rightarrow t = 0.165 \text{ mm} \) (a familiar number)

\[
\text{Required beryllium wall thickness to avoid collapse under vacuum}
\]

\[
\begin{array}{c|c|c|c|c}
\text{Wall thickness (mm)} & 0 & 0.5 & 1 & 1.5 & 2 & 2.5 & 3 \\
\hline
\text{Tube radius (mm)} & 0 & 20 & 40 & 60 & 80 & 100 & 120 & 140 & 160 & 180 & 200 \\
\end{array}
\]

\( R \) varies linearly with \( t \)
Beam Tube

• For a cone angle with \( \frac{dR}{dZ} = \frac{17}{351} \) starting at \((R,Z) = (12 \text{ mm}, 62.5 \text{ mm})\), 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 Pipe 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 \( \approx 34.7 \) Kg.
- Simple support from ends doesn’t work.
- Stresses and deflections are unacceptable: 436 KSI and 590 mm.

![Deflection with simple support]
Beam Pipe Deflection (Preliminary)

- Deflection of the same beryllium beam pipe under its own weight with the ends held aligned
- Deflections and stresses are negligible.
Beam Pipe Deflection (Preliminary)

- With ends reasonably guided, beam pipe stresses are OK.
- Maximum stress $\approx 2.9$ KSI for a parallel offset of 1 mm.
- Braze joint stresses appear to be OK; need to check more carefully.
Beam Pipe Deflection (Preliminary)

- Deflection with additional symmetric loads of 250 grams at $Z = \pm 900$ mm and beam pipe ends aligned.
- Additional deflection from the 250 gram loads is negligible (~8 µm).
Comments on this Option

- 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.
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 was rounded up to 2 m to allow a slight clearance.

• Forward, small radius disks were 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 were under study and were not shown.