LO Mechanical Considerations

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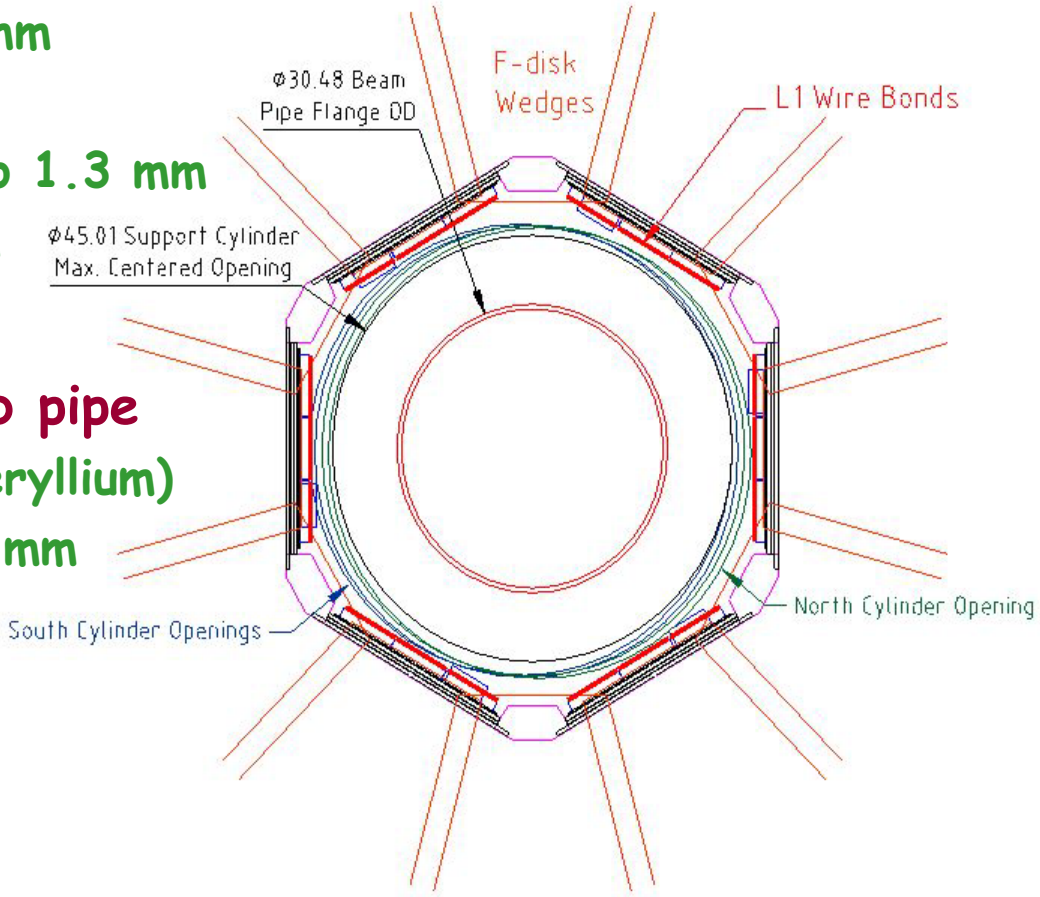
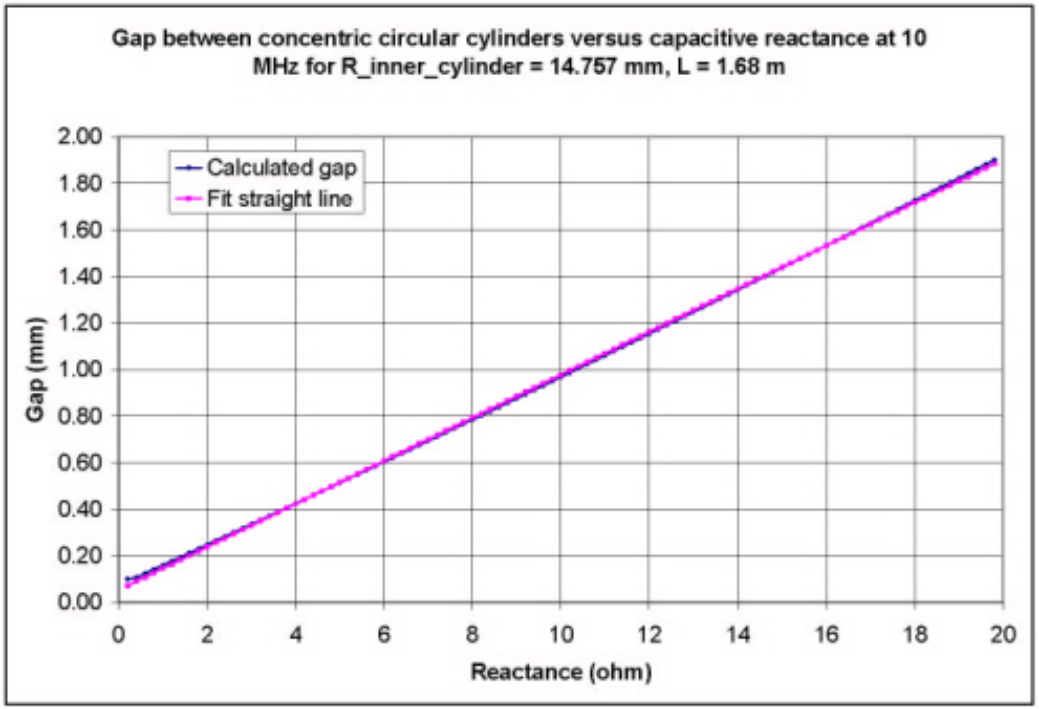
L0 Space Limitations

- OD limit: Run IIa detector
  - Openings in support cylinders
    - Z=±0, ±540, ±830 mm
    - 47.63 mm diameter
    - Centers offset up to 1.3 mm
    - Available OD 45 mm
- ID limit: beam pipe
  - Plan is to use Run IIb pipe
    - OD is 29.46 mm (beryllium)
    - Flange OD is 30.48 mm



Capacitive Coupling to Tevatron

- Inner support of silicon is conductive so it will couple to the Tevatron beam pipe (R = 14.73 mm).
- Desired isolation is >10 Ω at 10 MHz.
  - Implies a radial gap of 1mm is required (R = 15.73 mm)
  - Linear in R, so this is the average gap (radius) required



Installation Clearances

- Must have 0.5 mm radial clearance to outer screen which encloses L0 detector
  - Maximum radius of outer screen 22.0 mm
  - L1 R_{min} = 24.7 mm, L1 silicon R = 25.7 mm
- Outer screen wall thickness of 0.3 mm
  - Inner radius at 21.7 mm
- Clearance of 0.2mm for installation of outer screen over L0 at SiDet
  - Maximum L0 component radius 21.5 mm
- Clearance to beam pipe flange 0.1 mm radial
  - Minimum R for CF structure is 15.34 mm
  - CF structure etc. 0.7 mm thick $\Rightarrow$ R_{Si} = 16.04 mm

➢ Available space for L0: 16 mm < R < 22 mm

Analog Cable Stacks

- Cables are 50-70 micron thick (Cu on Kapton)
- Want ~150 micron spacers for low capacitance
- Two cables required per sensor $\Rightarrow$ 0.4 mm/sensor
- Need ~0.5 mm below stack to reduce capacitance to ground plane formed by carbon fiber structure
- Need ~1.35 mm to clear bonds on sensors

➢ Stack thickness

  - At Sensor 4: 6 x .05 mm + 5 x .15mm + 1.35 mm = 2.40 mm
  - At Hybrid 1: 6 x .05mm + 6 x .15mm + 0.5 mm = 1.70 mm
  - At Hybrid 4: 0 mm

Digital Cable Stacks

- Cables are 250 micron thick (Cu on Kapton)
- Want ~150 micron spacers for low capacitance
- One cable required per readout ⇒ 0.4 mm/readout
- Need ~1.5 mm to clear bonds on hybrids

➢ Stack thickness
  - At Hybrid 1: 1 x .25mm + 1.5 mm = 1.75 mm
  - At Hybrid 4: 4 x .25mm +3 x 0.15 mm + 1.5 mm = 2.95 mm

➢ Total Analog + digital stack-up
  - At Sensor 4: 2.40 + 0 = 2.40 mm
  - At Hybrid 1: 1.70 + 1.75 = 3.45 mm
  - At Hybrid 4: 0 + 2.95 = 2.95 mm

Hybrids and Connectors

- Use existing Run IIb hybrid with minimal changes.
  - 17.9 mm wide x 35 mm long x 0.78 mm thick
    - Width fits hexagon with R = 16 mm with ~0.57 mm gaps
    - Length is not an issue for this device
    - Thickness needs to be minimized, but 0.78 mm works
  - Uses AVX 5082 2.0 mm tall, 0.5 mm x 50 pin connector
    - This connector is too tall for L0
    - AVX 5602 1.5 mm, 0.4 mm pitch connector
      - + Only 12.1 mm wide
      - – Hybrid and cable pad layouts need modification for finer pitch
    - AVX 5645 1.5 mm, 0.5 mm pitch connector
      - – Width is 18.8 mm, but may be possible to trim down to fit
      - + Matches existing pad layouts on hybrid and cable

HV Issues

- Expect operation at < 300 V through Run II
  - Silicon temperature < +5 C required (easy!)
  - Can use existing HV distribution
  - Will make all inaccessible components rated for 700 V
- Two layers of Kapton used to isolate from carbon fiber structure (one on structure, one on sensor)
  - Prototyped successfully in R&D phase of Run IIb
- Pay attention to air gaps to HV for arcing
  - Nominally 1 mm gaps desired, but trade-off with azimuthal coverage needs to be considered

Resulting Sensor Geometry

- Silicon at R=16.04 mm and 17.61 mm
  - Hexagonal layout
  - Azimuthal coverage of 94.7%
  - HV gaps at sensors only 0.68 mm (want 1mm)
    - Go to 3 readouts in Z or 91% coverage to get 1mm
- Sensors with 256 strips at 71 micron pitch
- Four readouts at each end
  - Sensor lengths 7.5, 7.5, 12, 12 cm
  - Balance capacitance: short sensors to long cables
- Radial extent at worst point (sensor 4)
  - R_{max} = 21.5 mm (w = 14 mm at R = 20.33 mm)

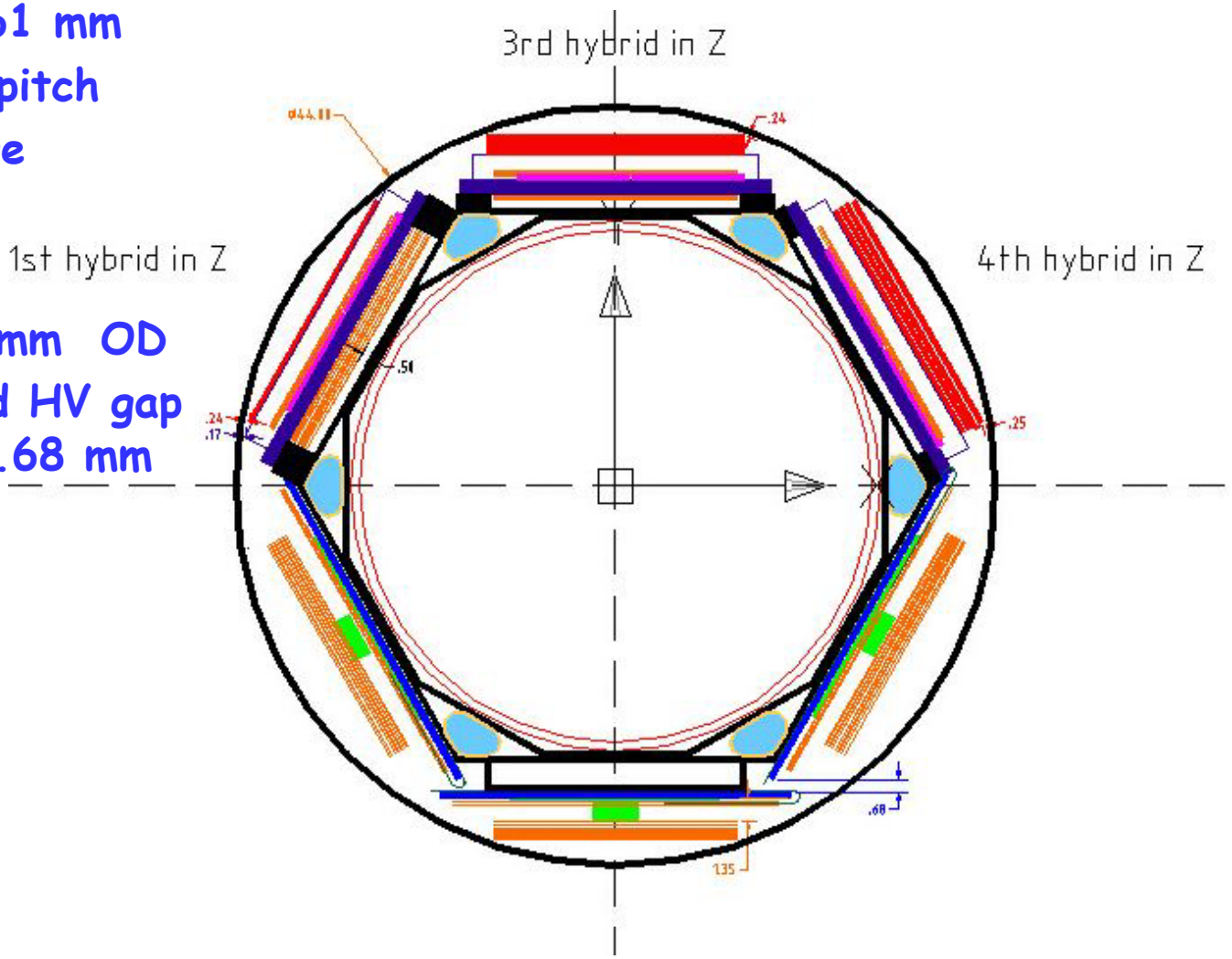
Hybrid Geometry

- Hybrids at R=16.44 mm to 17.64 mm
  - Hexagonal layout
  - Hybrids step in radially 0.4 mm as analog cable stack gets thinner under and digital cable stack gets thicker over hybrids – OD remains fixed
- Radial extent in hybrid region
  - R_{max} = 21.5 mm (w = 14.7 mm at R = 20.17 mm)

Proposed Layout

- R = 16.04/17.61 mm
- 256 ch x 71 μ pitch
- 94.7 % coverage

- Satisfies 21.5 mm OD
- Violates desired HV gap of 1mm - only .68 mm

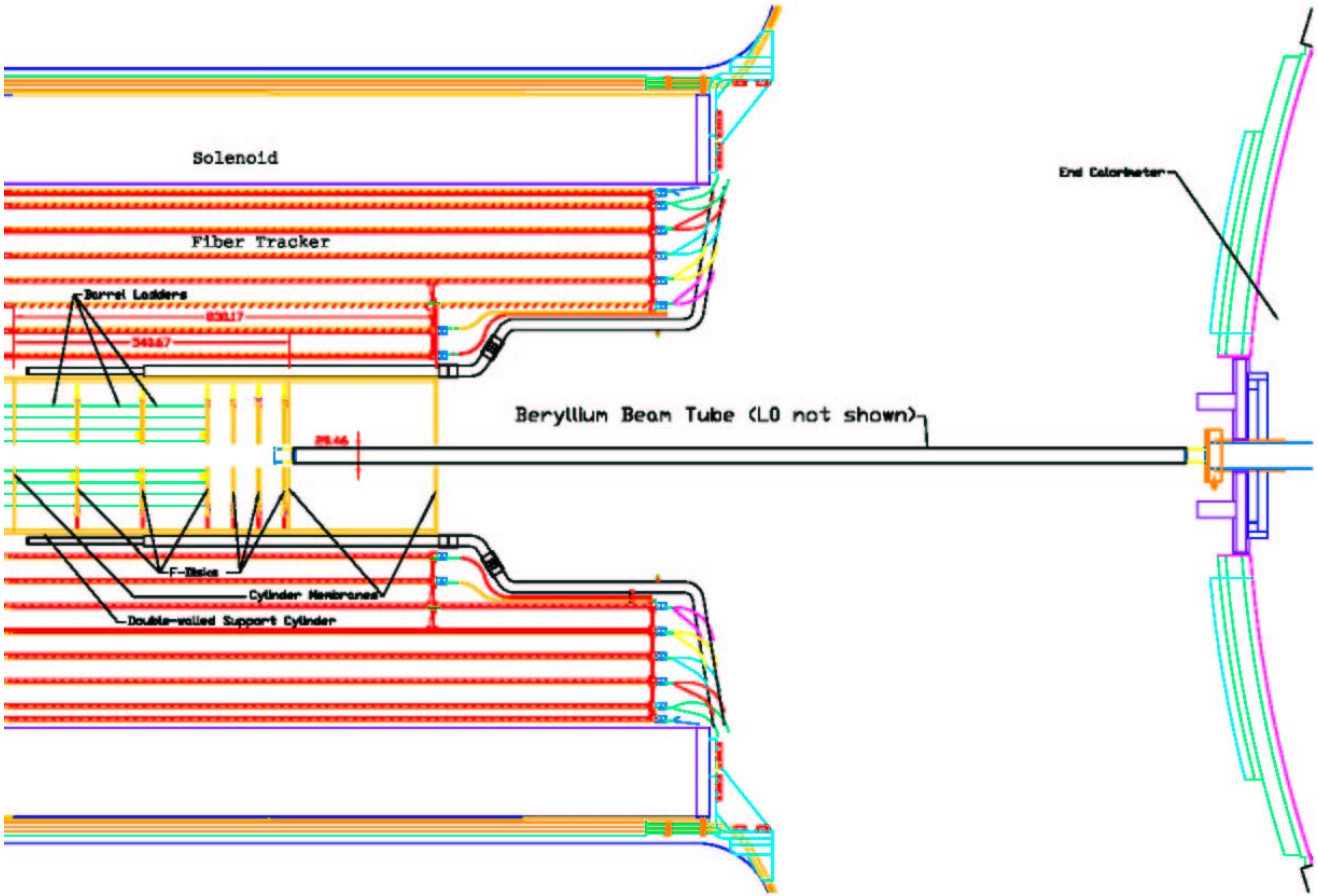


Installation Outline

- Silicon Package assembled and tested at SiDet
  - Includes Be beam tube and outer screen
  - All cooling passages leak tested
  - All modules electrically tested
  - Beam tube leak free and clean
- Remove Run IIa beam tube through EC
  - Decouple flanges at EC's
  - Cut bellows from one EC pipe
- Bring L0 in through EC
  - Clearance through EC pipe is OK (~1.8 mm radial)
  - Can remove EC pipe for greater clearance
  - L0 would be supported from a temporary stand until its outer end clears the end calorimeter; end of beam tube engages end F-disk
- Complete installation L0 using Be pipe as cantilever beam
  - Deflections and stresses look OK
  - Equipment is similar to that used for the Run IIa beam pipe

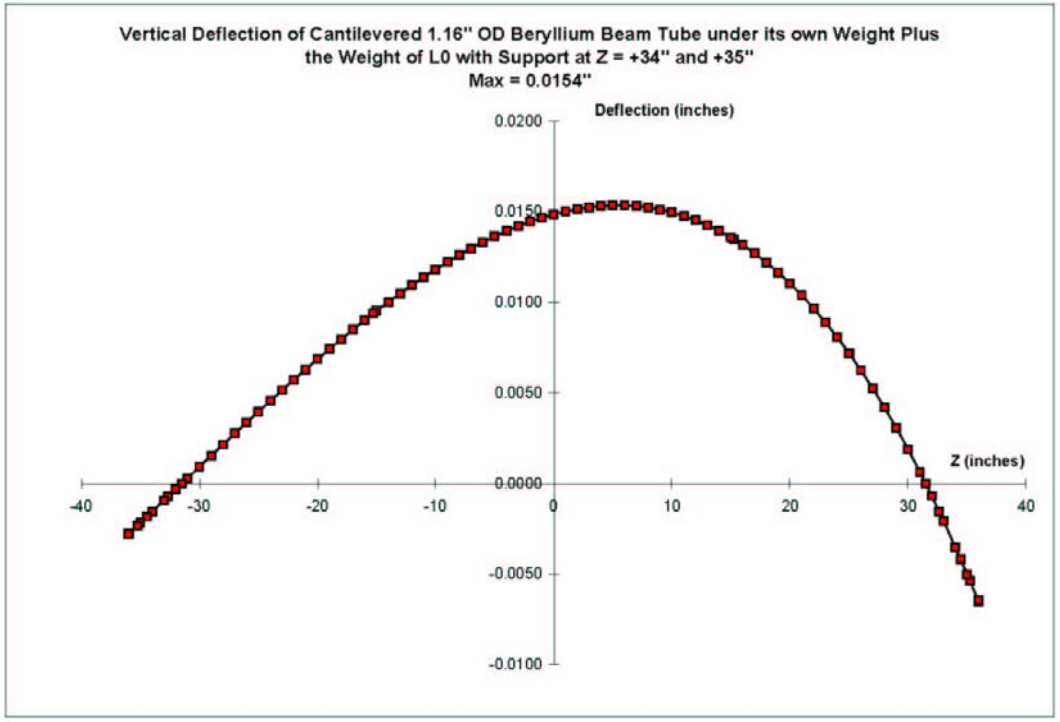
Installation Figure

- Beam tube position when EC is cleared (EC opened 39")



Beam Pipe Deflection During Installation

- Upward cantilevered deflection of beam tube ~ 0.015".
  - Clearance to L0 inner bore ~ 0.008".



Summary

- Geometry is highly constrained by existing detector
- Trade-offs to be considered in final design
  - Assembly gaps (~0.5 mm)
  - HV arc gaps (~0.7 mm)
  - Azimuthal coverage (90-95%)
  - Sensor pitch (~70 micron)
  - Sensor radii (~16.0 and ~17.5 mm)
  - Z segmentation (3 or 4 segments per end)
  - Analog cable capacitance (spacers under and between cables)
- Design must be buildable and installable first and foremost
  - We are confident we can design a detector that we can build
  - We are confident we can build it quickly (~1.5 years)
  - We are confident we can install it safely