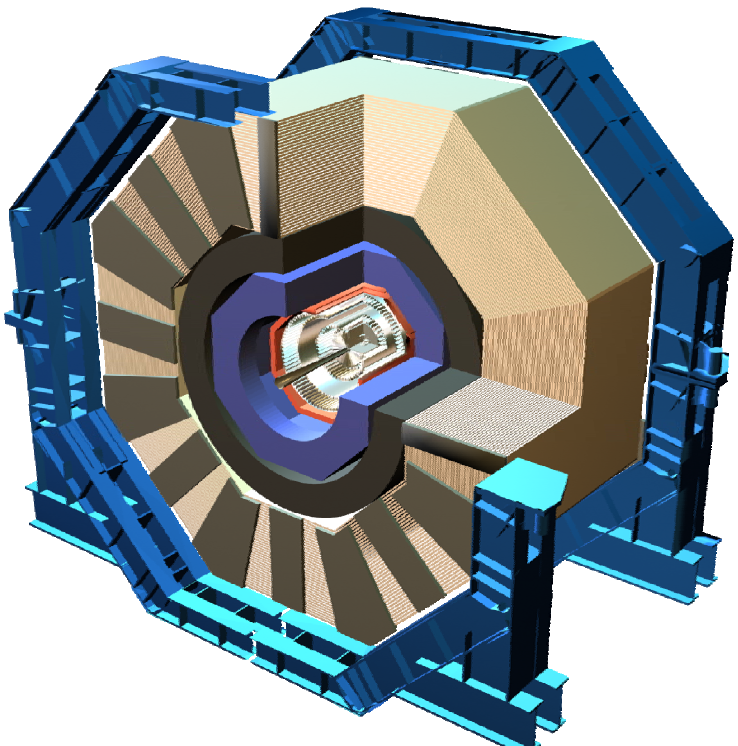
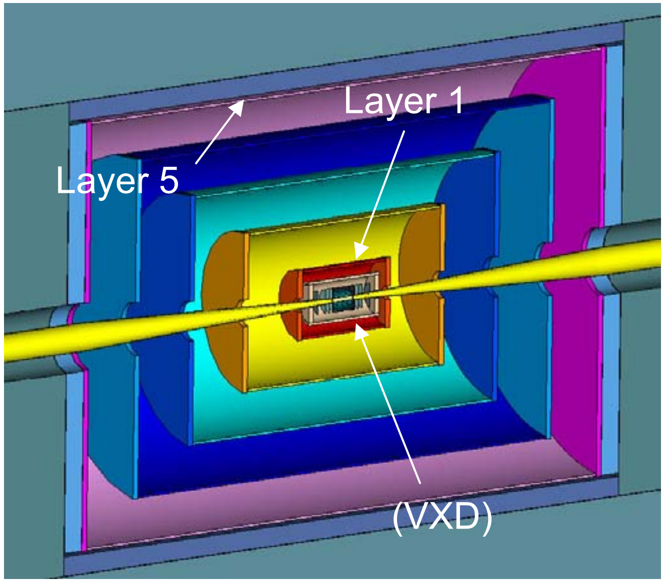
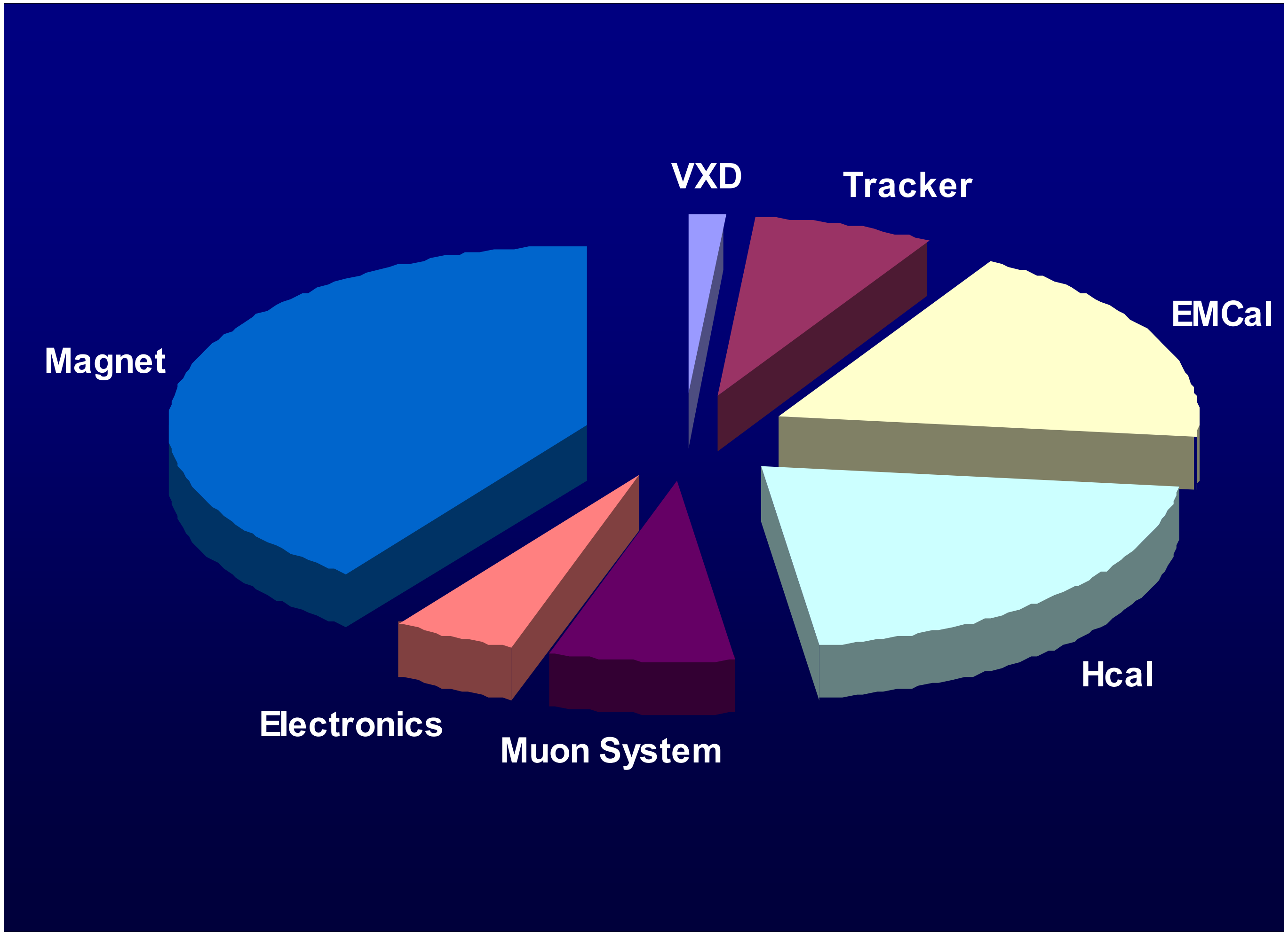
Outer Silicon Mechanical Status



Bill Cooper
Fermilab



Cost by Subsystem

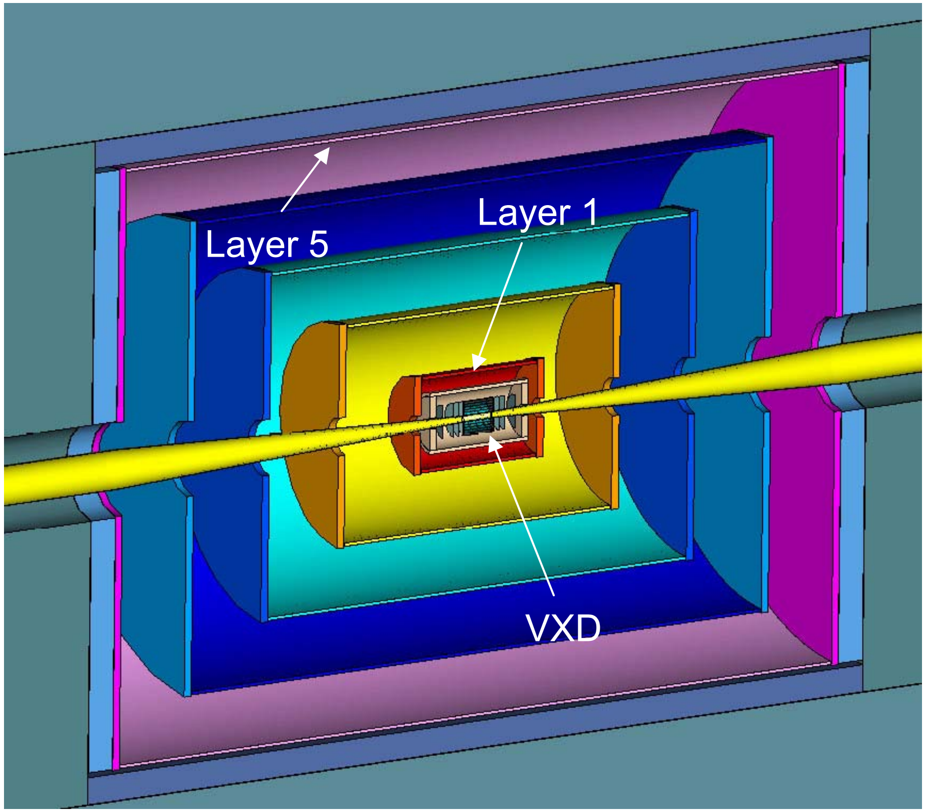


Outline

- Review of design, with emphasis on areas needing attention
  - Overall layout of outer and inner silicon
  - Outer silicon layout
  - Provisions for servicing inner silicon
  - Module design (from Tim Nelson)
- Remaining, near-term work
- Summary

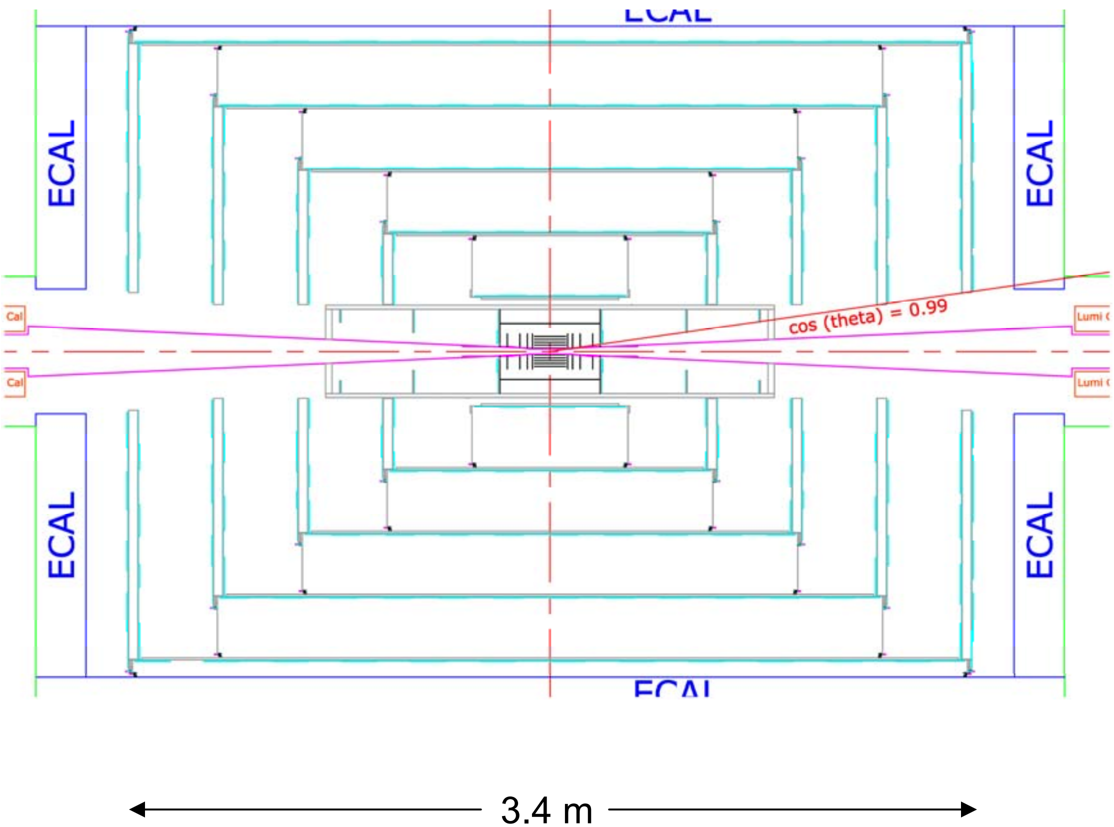
Vertexing and Tracking

- Conceived and optimized as an integrated detector
  - Inner tracking (Vertex detector)
  - Central tracking
  - Forward tracking
  - EM calorimeter
- 5 T solenoidal field
- Outer silicon
  - 5 axial barrel layers
  - 5 double-layer disks per end

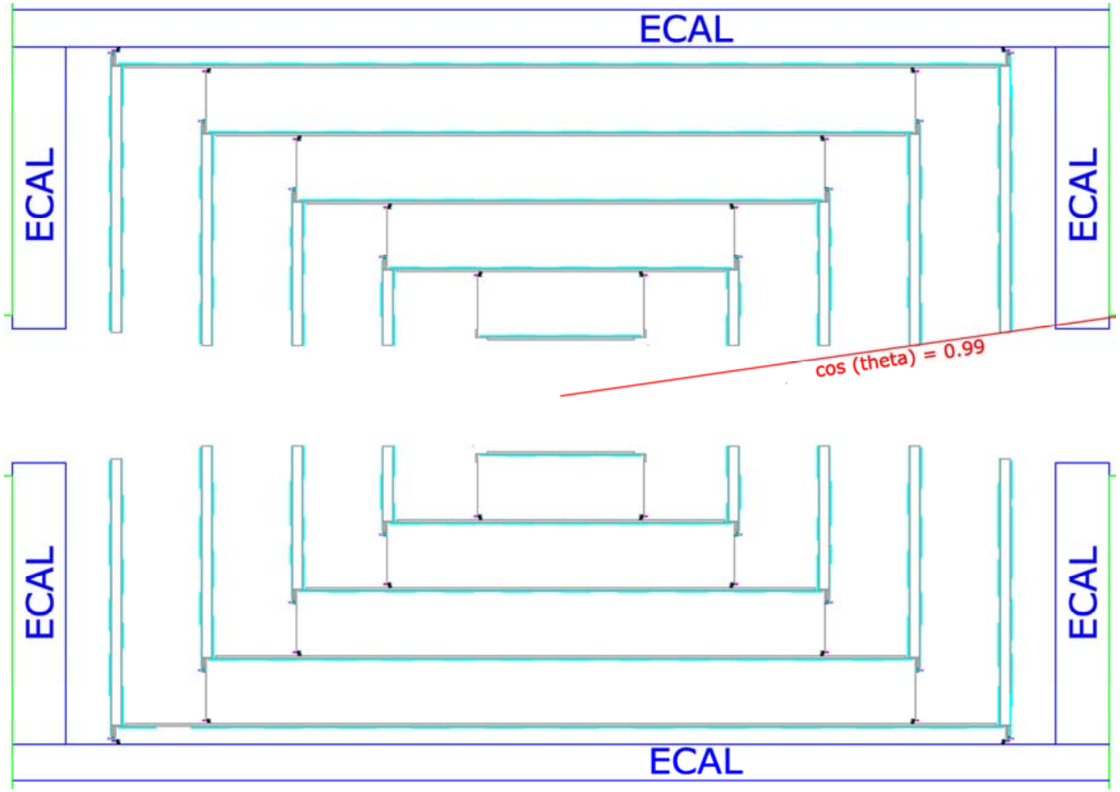


Silicon Detector Layout

- Outer tracker (micro-strips)
  - OR = 1.25 m
  - IR = 0.2 m
    - May need to adjust inner radius to match beam-line elements
  - In barrels, knowledge of Z comes from the inner detector and the location of the sensor in which a hit occurred.
  - 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

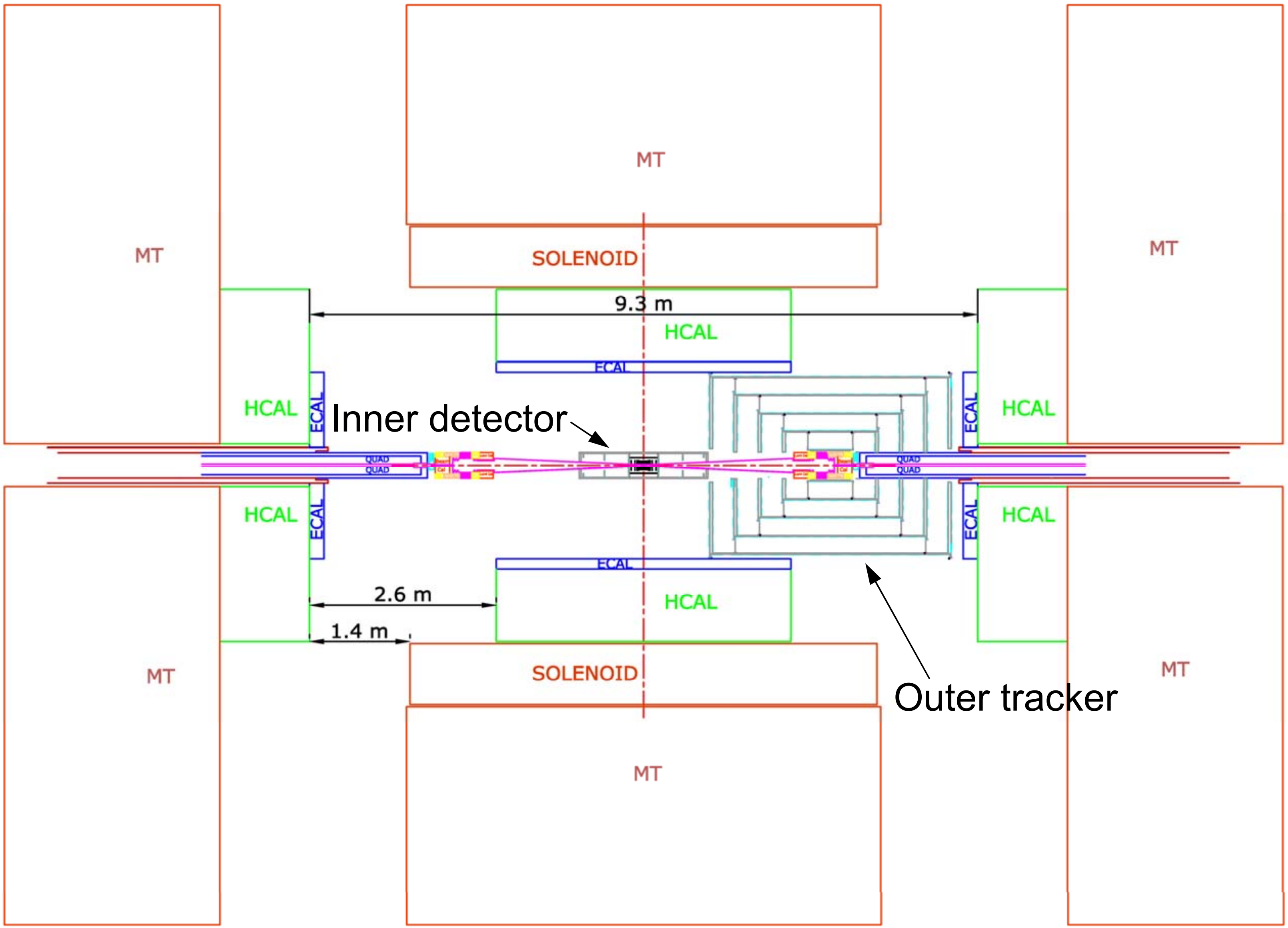


Outer Silicon Layout



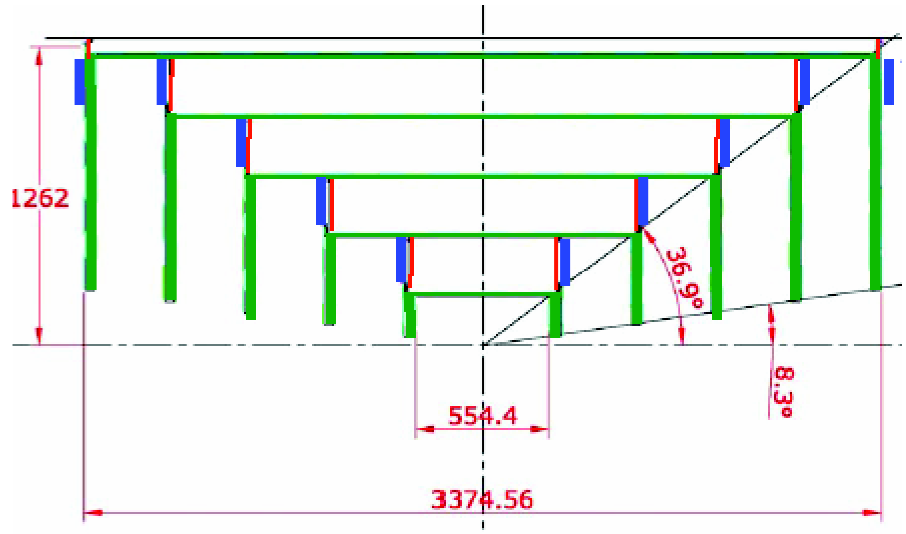
- Drawing features awaiting update:
  - Detailed geometry of modules, including module mounts
  - Details of disk and barrel overlaps
  - Inner radii of disks
  - Barrel foam thickness
  - Disk foam thickness
  - Paths and handling mechanisms for readout cables and fibers
  - Provisions for distributing dry gas flow
  - Details of ECAL inner surface
  - Reproducible, rolling support from ECAL

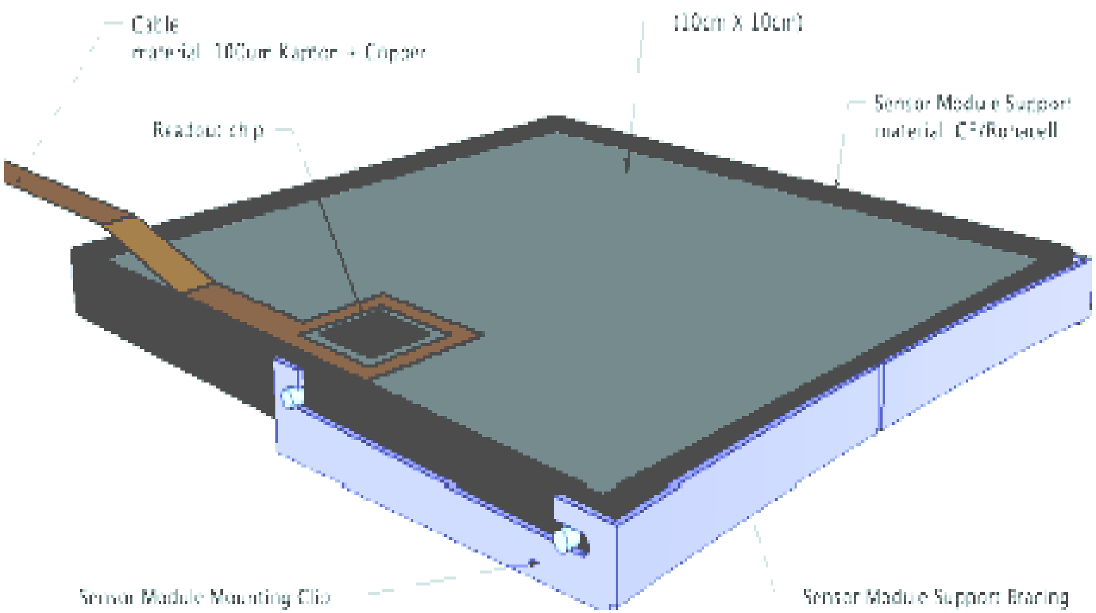
Detector Open with Full Access to Inner Detector



Outer Tracker as Modeled in SiD_{00}

- Closed CF/Rohacell cylinders
- Nested support via annular rings
- Power/readout motherboard mounted on support rings
- Bus cables connect single-sensor modules to motherboards

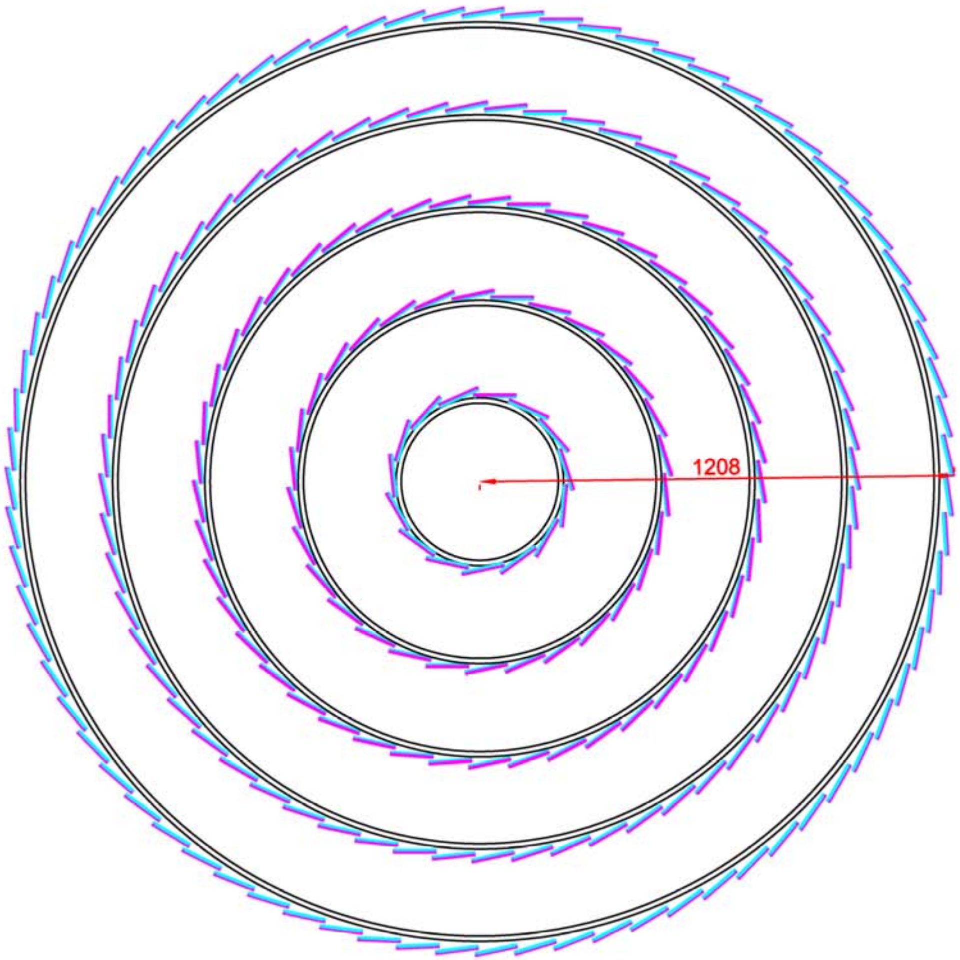




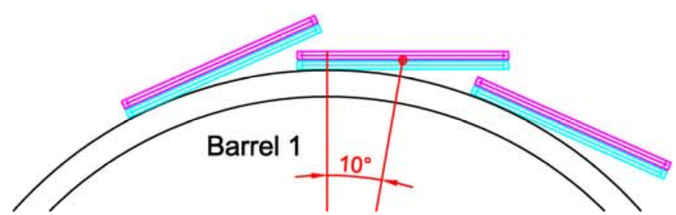
- Cylinders tiled with 10x10cm sensors with readout chip
- Single sided (ϕ) in barrel
- R, ϕ in disks
- Modules mainly silicon with minimal support (0.8% X_0)
- Overlap in ϕ and *Z*

T. K. Nelson, SLAC

Outer Barrels with a Single Type of Module



Sensors:
Cut dim's: 104.44 W x 84 L
Active dim's: 102.4 W x 81.96 L
Boxes:
Outer dim's: 107.44 W x 87 L x 4 H
Support cylinders:
OR: 213.5, 462.5, 700, 935, 1170
Number of phi: 15, 30, 45, 60, 75
Central tilt angle: 10 degrees
Sensor phi overlap (mm):
Barrel 1: 5.3
Barrel 2: 0.57
Barrel 3: 0.40
Barrel 4: 0.55
Barrel 5: 0.63
Cyan and magenta sensors and boxes are assumed to be at different Z's and to overlap in Z.
Within a given barrel, cyan sensors overlap in phi as do magneta sensors.



0.025 mm strip pitch, 0.050 mm readout pitch

Overlap of modules

Barrel Modules

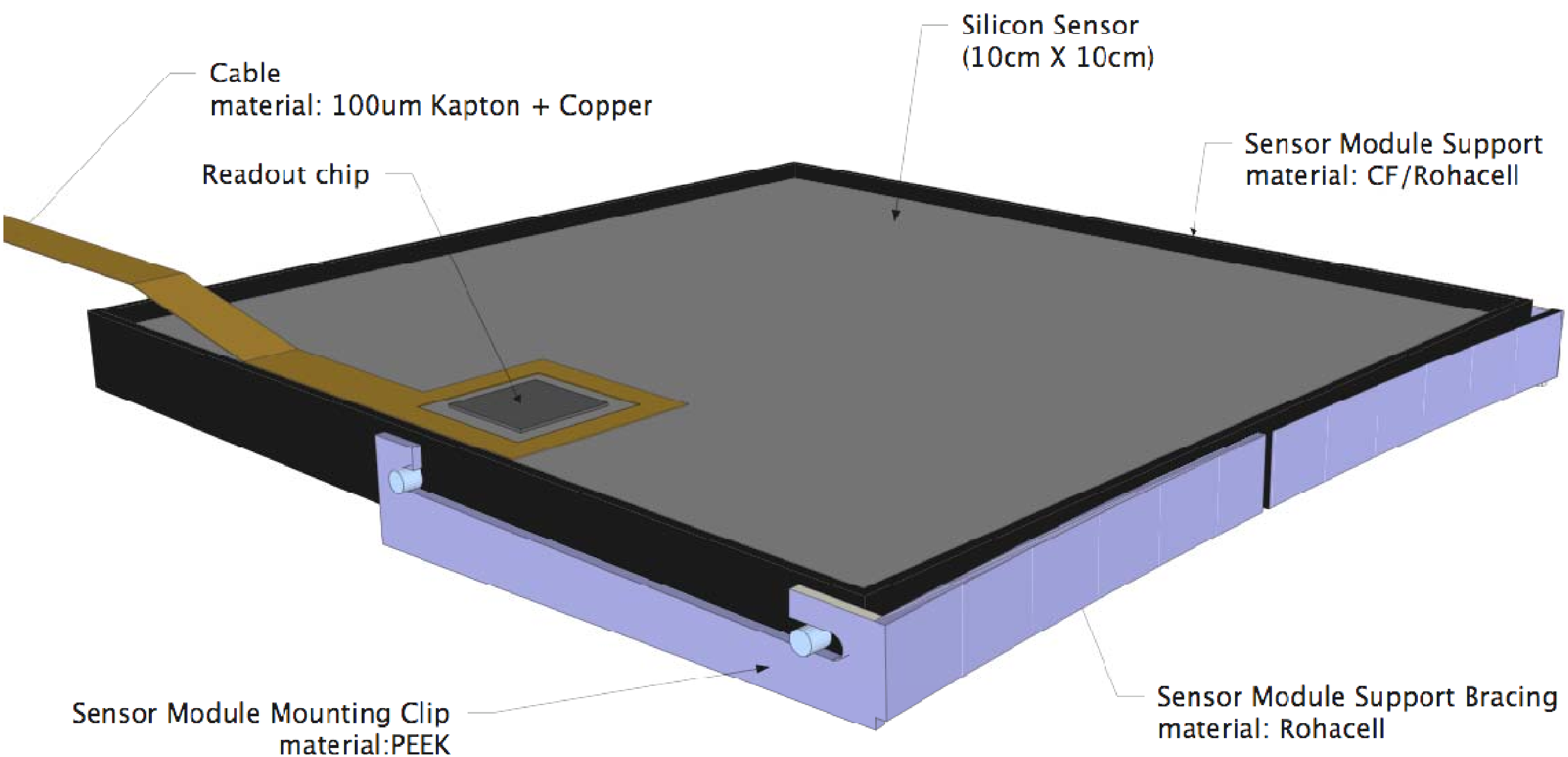
- A primary advantage of support cylinders: *they enable very short modules*
- Short modules are nice because they...
  - have high S/N
  - provide *z* information for pattern recognition
  - can be universal and are easy to assemble, install and replace
- Downside? Lots of readout... is mass a problem?

Tracker Material: rules-of-thumb

- Sensor material and support material are similar and relatively insensitive to module length.
- The most massive components in large silicon trackers are those that support the readout:
  - hybrid electronic boards
  - cooling
  - cables

The readout chip is the key: take advantage of ILC machine timing to design a chip that eliminates/minimizes these.

Barrel Module Design

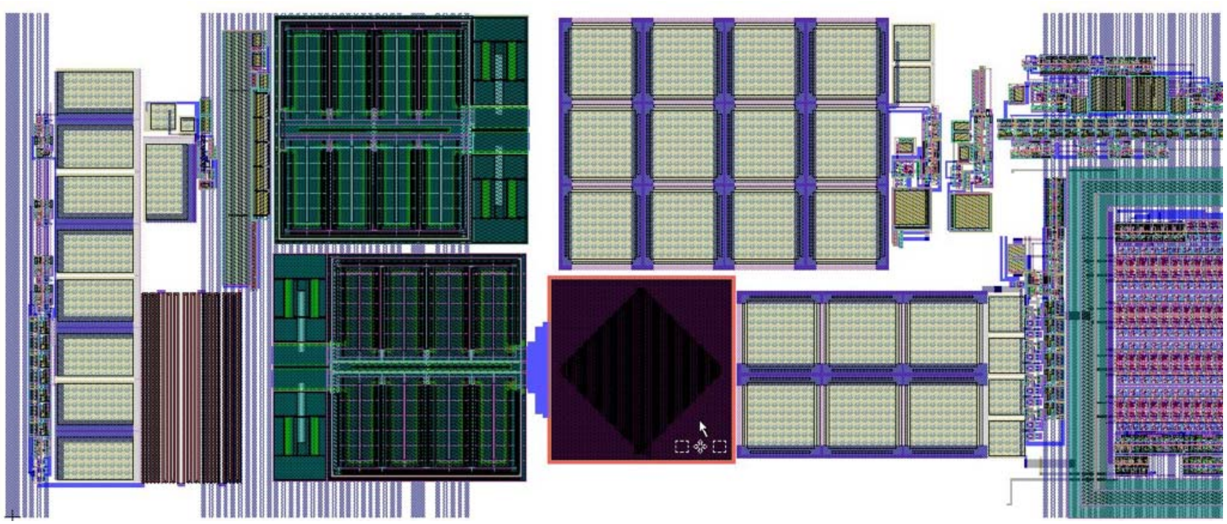


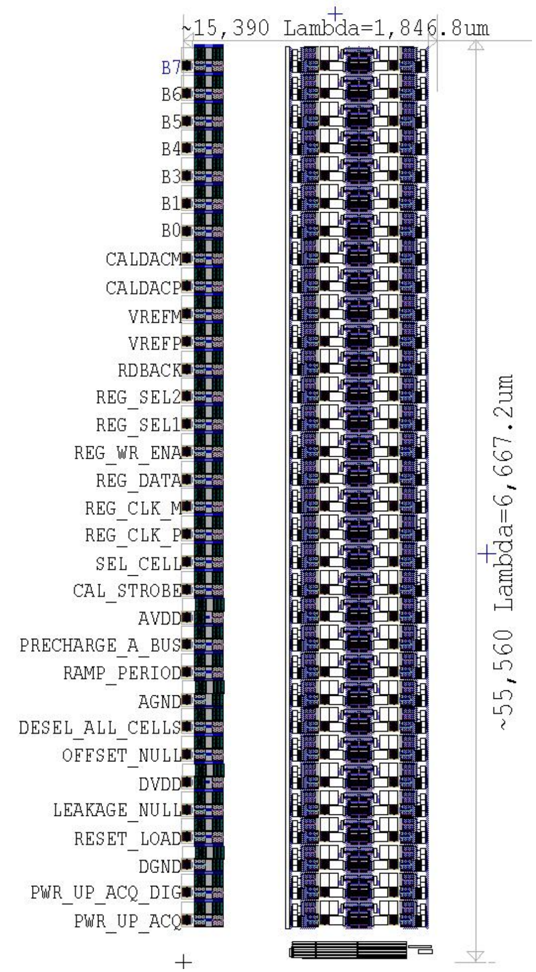
KPiX-T Readout Chip

- Tracker variant of chip developed at SLAC for SiW ECAL
  - no hybrid: the chip bump bonds directly to silicon
  - digital section quiet during entire train:
    only activity is synchronous clock
  - pulsed power eliminates need for active cooling
  - 4 buffers/channel with beam-crossing stamp
    preserves event identity for reconstruction

KPiX-T Readout Chip

- First submission (2X32 array) should arrive at SLAC any day
- Will test with silicon by wirebonding to spare CDF Layer 00 sensors
- If successful, hope to submit full-scale version as the next step.



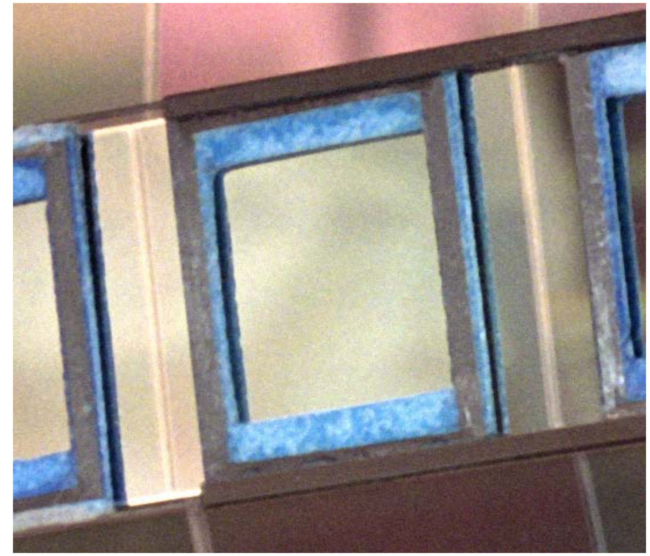


Module Implications for Sensors

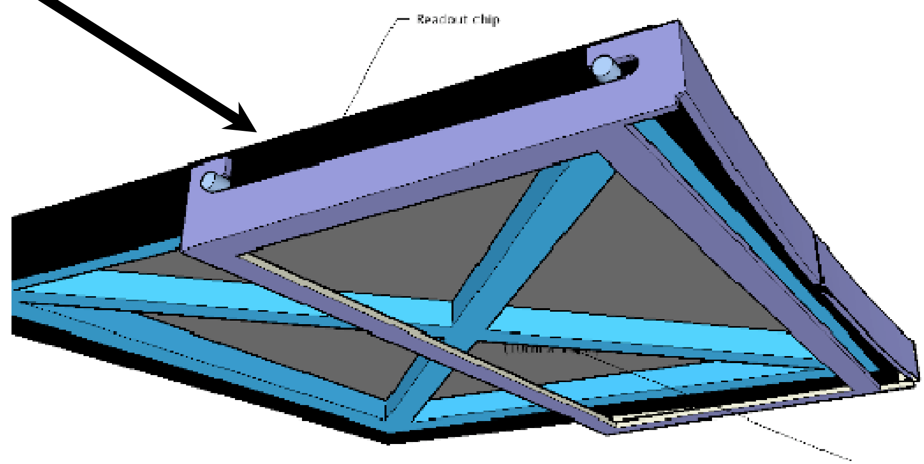
- Must develop bump-bondable silicon microstrip sensors
- Double-metal:
  - used to route signals to bonding array
  - used as via between cable and chip for power and control
- Conceptual design and development of specs underway... time to initiate discussion with HPK for production of prototypes

Sensor Support

- CF-composite frame with Rohacell cross-bracing based upon similar frames used for CDF ISL
- Frames clip into mounts on support cylinders



Investigating CF-filled injection-molded PEEK for mounts and possibly also support frames: there is a major advantage to making these components mass-producible

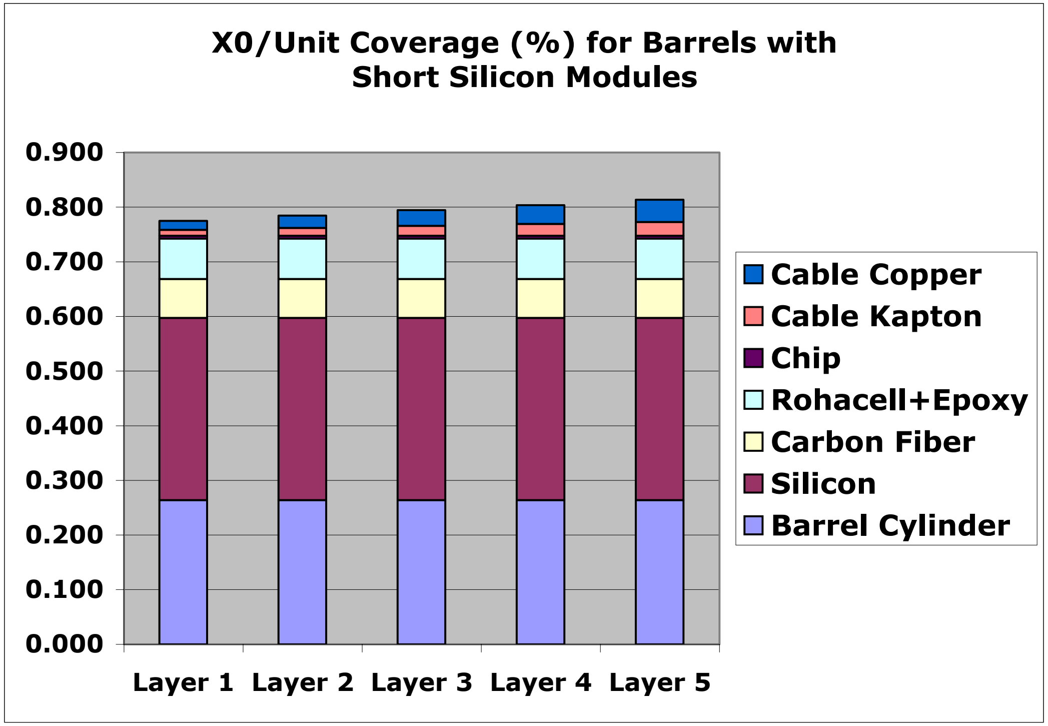


Barrel Cables

- Many cables in short-module tracker, important to minimize material:
  - Pulsed-power scheme can accept 1 ohm for power+return
  - Only six other lines needed for control
    - Using 1/4 oz. copper on 100 micron Kapton, cables are ~5mm wide: copper covers less than 1/2 of area
- Each module has a short (~10cm) “pigtail” that bonds directly to the sensor: rather complicated but small
- Pigtail connects to longer cable that extends to power/data concentrator boards: rather long but simple
- No showstoppers expected, but must produce detailed design for fabrication of prototypes

Barrel Tracker Material

- Total is ~0.8% X_0, roughly equal parts silicon and support
- Readout material is negligible by comparison, <0.1% X_0 in all layers

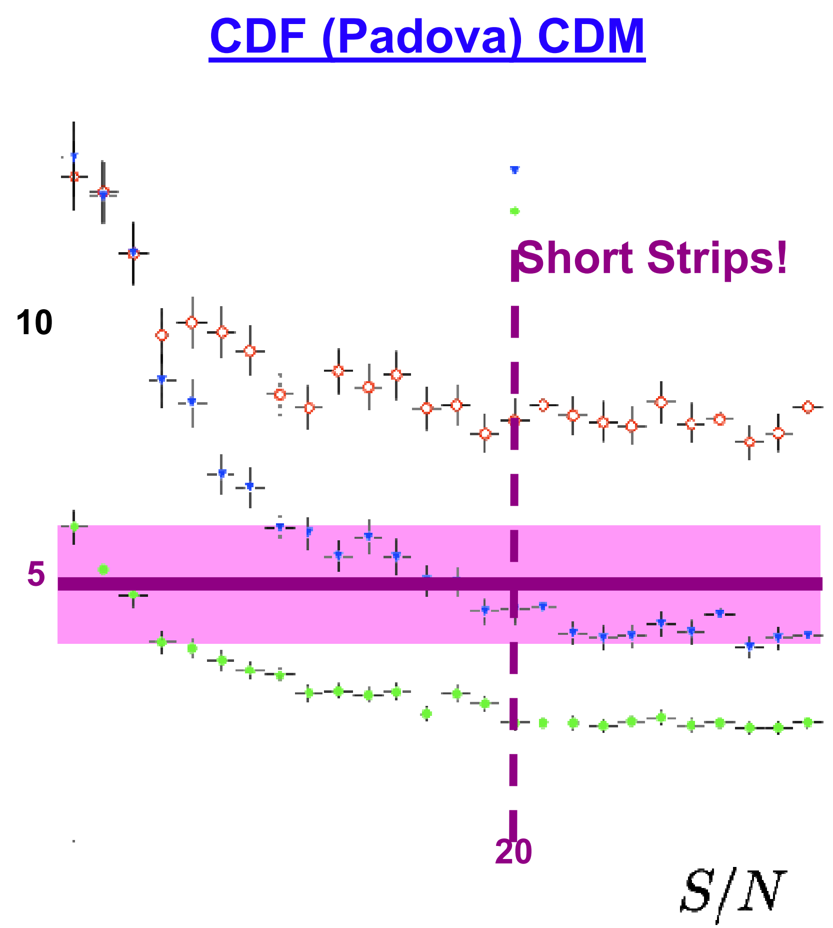


Expected Performance

- *Capacitance should be ≈15pf*
- S/N ≈ 20
- Profit enormously from floating intermediate strips (50/25 µm)

$$\Rightarrow \sigma_{hit} \approx 5\mu m$$

- Could consider thinner silicon if deemed advantageous



Outer Silicon Disks (1)

- All elements of the concept carry over to modules for the forward disk, be they wedges, squares or hexagons.
- Modules can trivially be made double-sided using single-sided silicon on both sides of support: doubles silicon and readout material
- If there is real interest in using double-sided silicon in the forward disks, some changes will be necessary.
- Not much additional thought going into forward modules until simulation points to a particular tiling scheme.

Outer Silicon Disks (2)

- Overall layouts which take into account module design, tiling, mounts, overlaps, and paths for services will be updated once a tiling arrangement has been selected.
  - Potential overall layouts may help with tiling selection.

Remaining Work (1)

- Barrel sensors
  - Number of varieties
  - Signal to noise (has been estimated for single-sensor modules)
  - Sensor dimensions
  - Phi and longitudinal overlaps
  - Effective thickness, including mounting and readout
  - Overall geometric arrangement
  - Barrel power (per unit area and per barrel)
- Disk sensors
  - Number of varieties
  - Signal to noise
  - Sensor dimensions
  - Phi and radial overlaps
  - Effective thickness, including mounting and readout
  - Overall geometric arrangement
  - Disk power (per unit area and per disk)

Remaining Work (2)

- Support cylinders and disks
  - Optimum foam thickness
  - Optimum wall thickness
  - Portions of foam and wall that can be removed
- Mechanical connection details
  - Modules to barrels and disks
  - Barrel to barrel annular rings
  - Readout motherboards to annular rings
  - Outer barrel to ECAL
- Cooling
  - Flow paths
  - Calculations of heat transfer rates versus flow
  - Analysis of the potential for vibrations

Summary

- The overall design has been updated to more realistically address servicing.
  - The overall design allows a clean separation between outer detector and inner detector elements.
- Single-sensor module designs have been developed by SLAC (T. K. Nelson).
- Portions of design work await guidance from simulations.
- We do have enough information to proceed with design efforts in many areas.