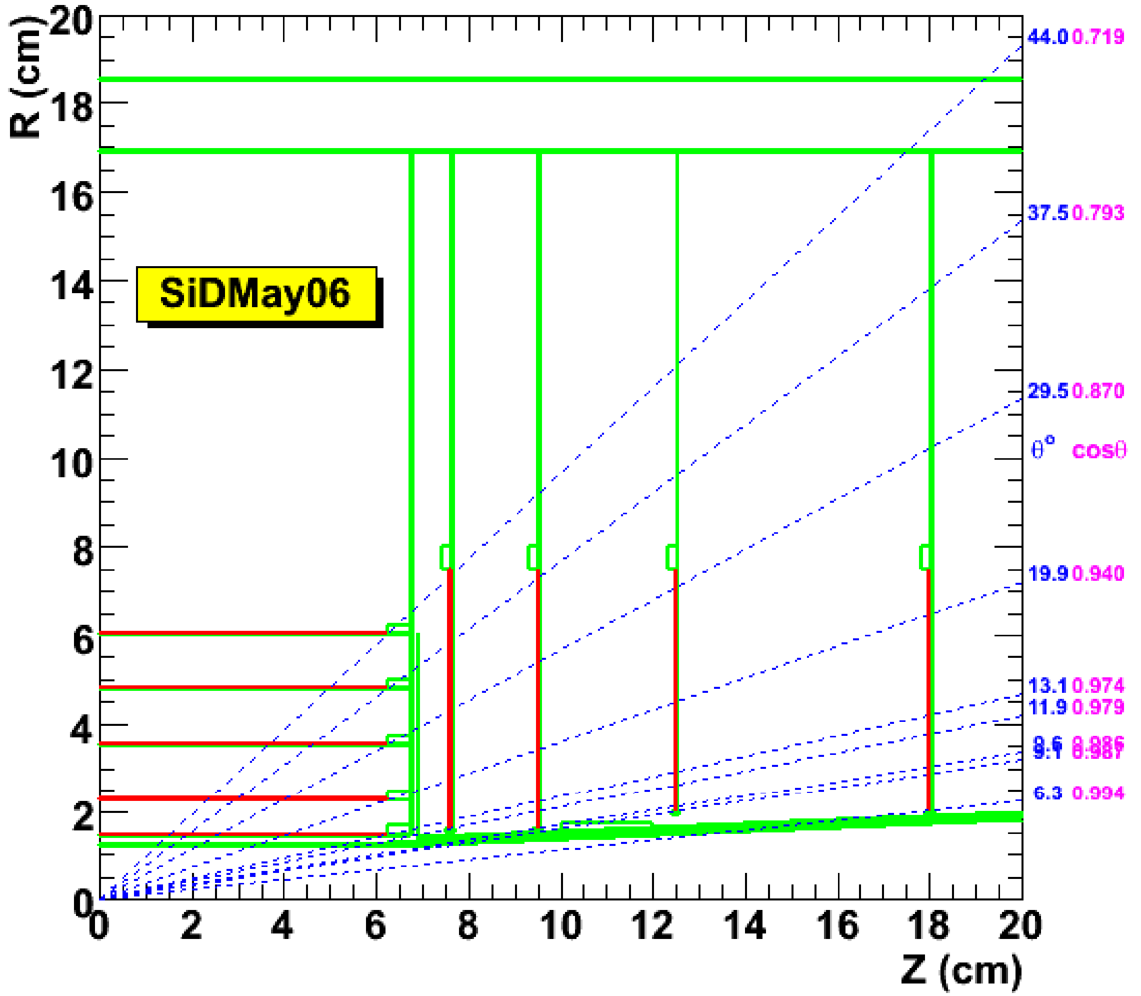
SiD Vertexing Status

Su Dong

SiD VXD Geometry



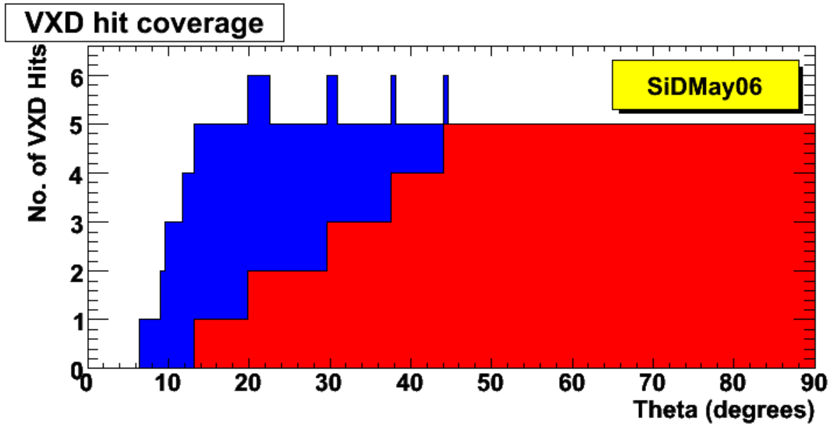
Barrel+endcap geometry to avoid shallow angle entrance:

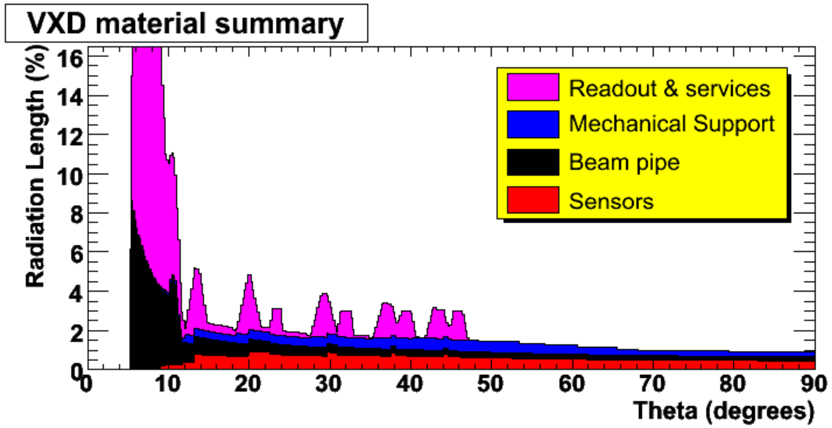
- **sensitivity to hard-to-control radial shape and alignment.**
- **resolution deterioration due to ionization fluctuation.**

Trade-off for light weight service design for barrel.

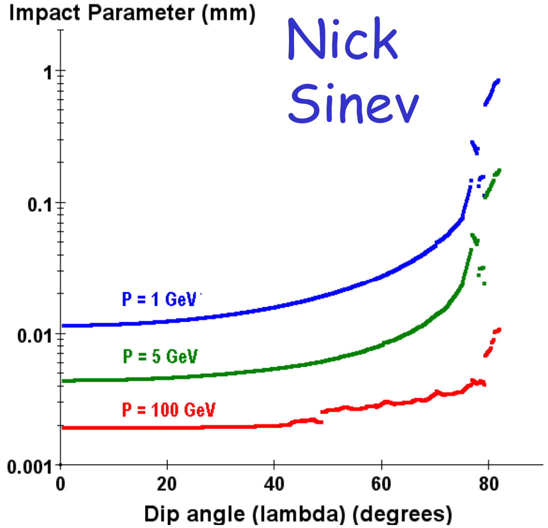
Endcap inner angular coverage consistency needs update.

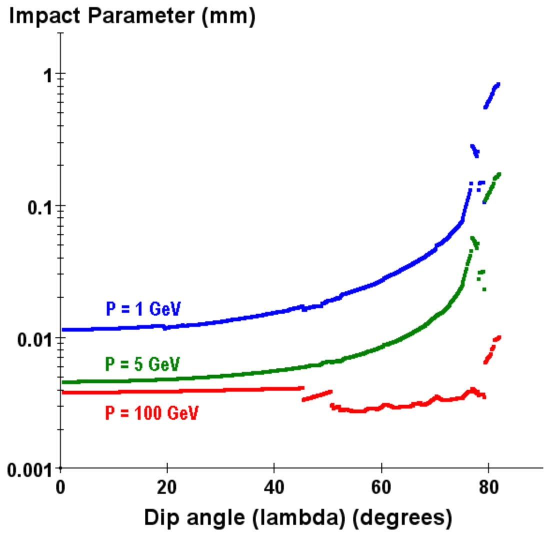
Material and Performance





Nick Sinev





Real mechanical design but services are toy model

SiD Geometry Implications

- No track at very shallow entrance angle. Full coverage of 5 VXD hits up to $|\cos\theta|$~0.98.
  - Sensors has slightly thicker active region would not cause too much resolution degradation.
  - Less fear in barrel wafer shape issues when pushing for thin ladders with a shorter barrel.
  - Endcap sensors don't care much about Lorentz effect.
- Need to work harder on the barrel endplate service material.
  - *The R&D to achieve lightweight power delivery and signal communications are as important as the sensor technology and mechanical design !*

Service Material Model

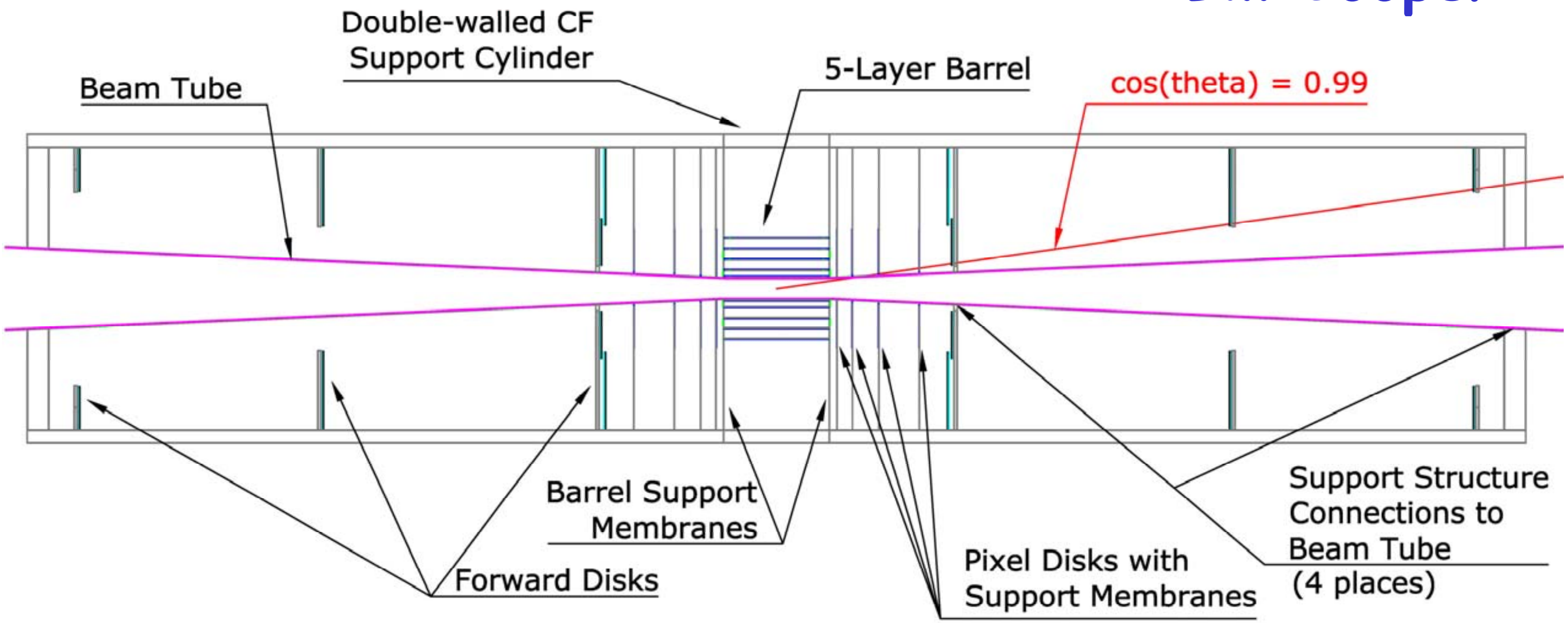
Due to the lack of a real design, this is unfortunately a very crude toy model in GEANT:

1) Readout/service connection at each barrel layer end is represented by a solid ring of G10 5mm wide in Z and 3mm high in radius.
2) The power and signal cables are represented by a 300μm diameter copper wire (leading to DC-DC on coned beam pipe) and 250μm diameter fiber at each end of a ladder. The cables all focus down to the beampipe to exit from there to be out of fiducial volume, but this causes a significant clumping of material at lower radius which may not work mechanically. It suffers Lorentz force at ~1 Newton at peak current in anyway.

The R&D which can lead to a real design that is not far off from the total material of this model will be a crucial step to validate the layout concept.

Mechanical Design

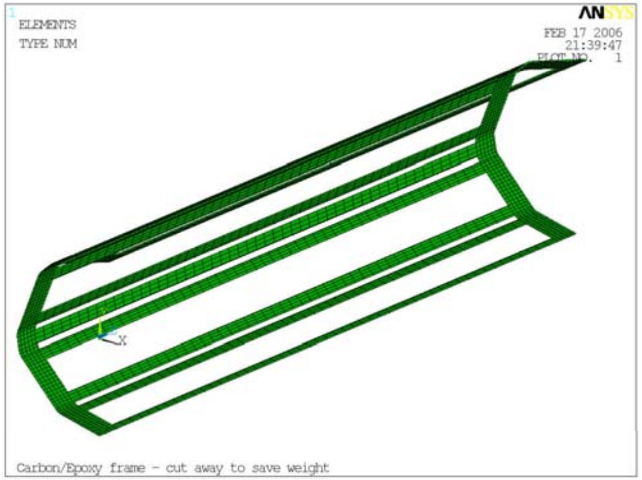
Bill Cooper



Cooling with dry gas (-10 C) through the double wall of the outer support tube. Can also add cooling from beam pipe jacket ?

News: Mechanical design

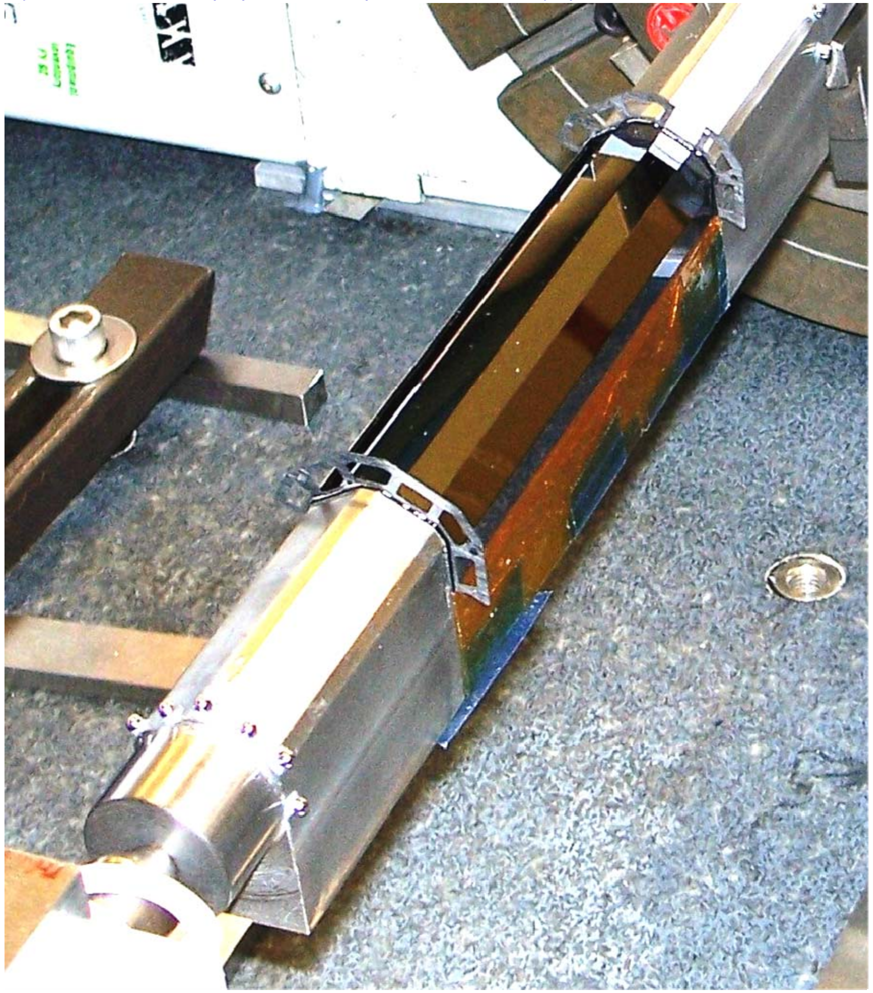
Layer 1 finite element analysis (UW)



Layer 1 support structure with G-10, rather than carbon fiber, end rings

W. Cooper et al, FNAL,U Washington

Layer 1 support proto type



News: Sensors (I)

- **LCFI CCDs:**
  - ISIS in test beam
  - CPCCD driven at design rate of 45MHz
  - CPCCD with bump bonded readout being tested
- **FPCCD:**
  - Hamamatsu producing 12μm pixel sample
- **Short split column CCD (a la MIB)**
  - Simulation from Nick Sinev indicated workable parameter space (readout rate, column width, EPI thickness, pixel threshold) for high efficiency time tag reconstruction. What's next ?
- **SOI/3D:**
  - SOI prototype being tested.
  - 3D circuit prototype due back next week ?

News: Sensors (II)

- **Chronopix:**
  - 50μm pixel prototype design complete. Sample submitted.
- **MAPs**
  - MIMOSA-9 with 25μm pixel reached <2μm resolution with very low noise.
  - Regular thinning down to 50μm at LBNL.
  - Working on sparsified readout. Currently 100μs readout frame.
- **DEPFET**
  - New 24μm pixel sensor with improved charge collection
  - New readout electronics to imporve noise (/2 ?)

Certainly not all the latest activities. Please follow the VXD review talks for details.

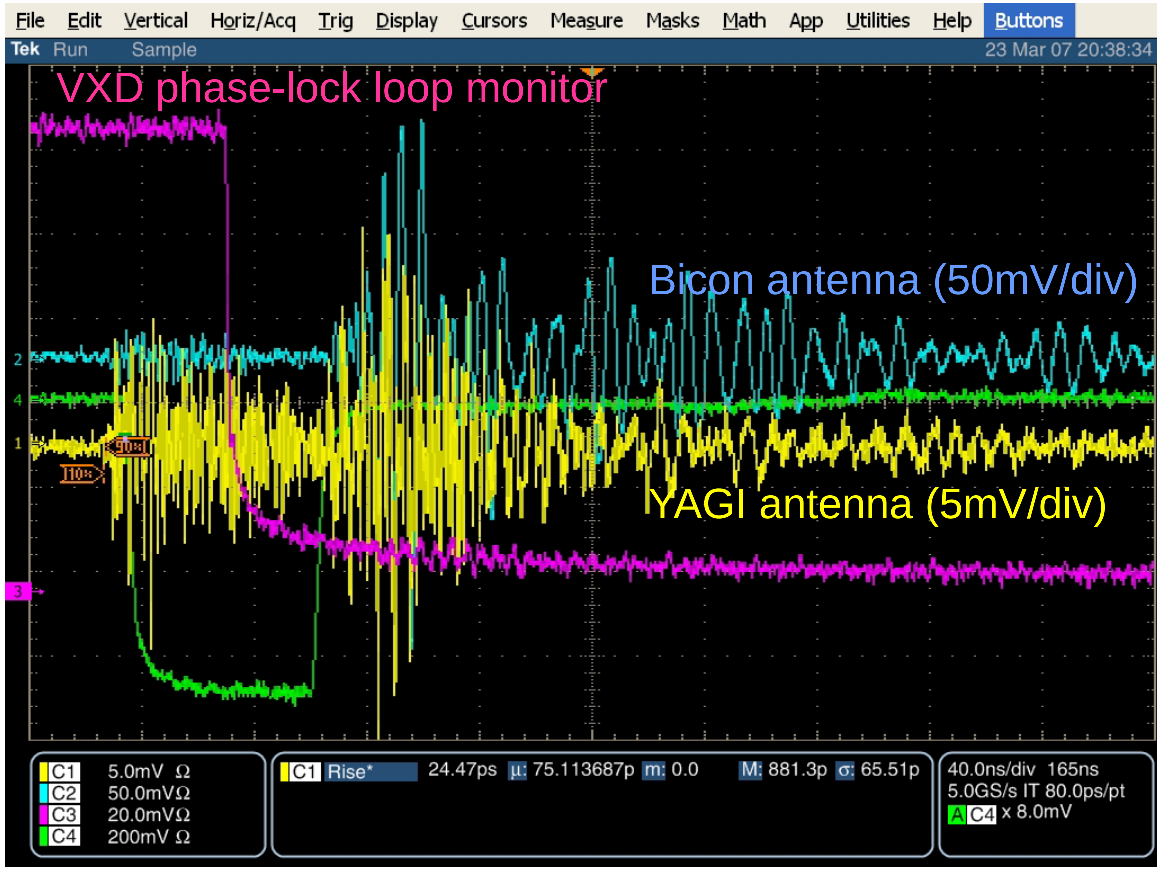
News: EMI tests at SLAC ESA

Gary Bower, Nick Sinev, Yasuhiro Sugimoto
(+ help from Woods, Yamamoto and many others from SLAC

SLD VXD3 elex EMI sensitivity reproduced (Finisar PLL), but frequency ~30 GHz ?

Thin foil shielding sufficient. Problem reappear with a $1cm^2$ hole in Al foil, and go away for a smaller hole of $0.6x0.6cm^2$.

=>Integrated beam line certificaton sufficient to avoid problems here ?

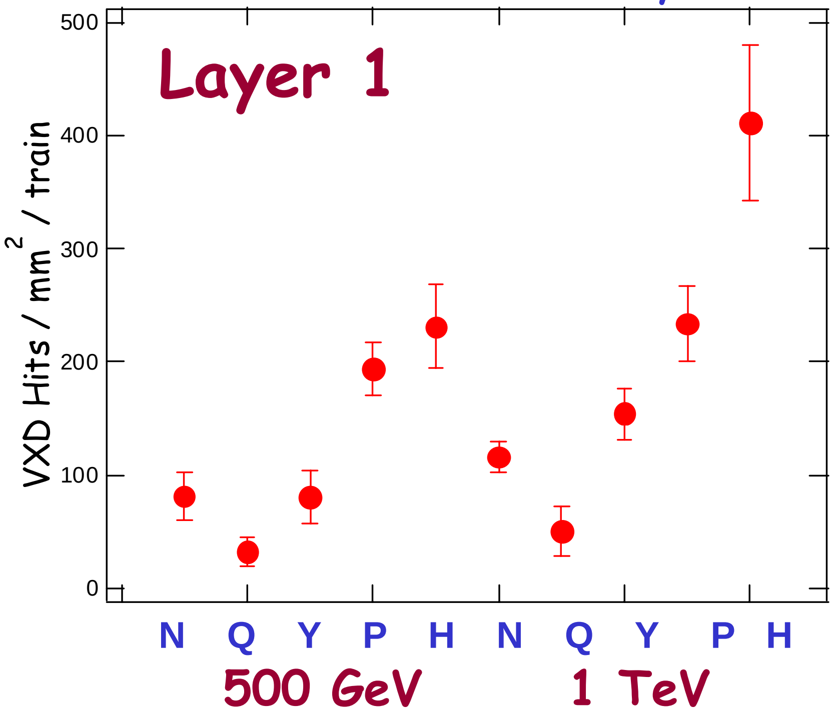


$1cm^2$ hole in Al foil shield over the ceramic gap

VXD Background Rate Variations

Takashi Maruyama

Radius (cm)	Hit density/train/mm² (Mean/RMS)
1.4	80.2 / 16.2
2.2	16.1 / 7.9
3.5	2.3 / 1.7
4.8	1.0 / 0.8
6.0	0.2 / 0.2



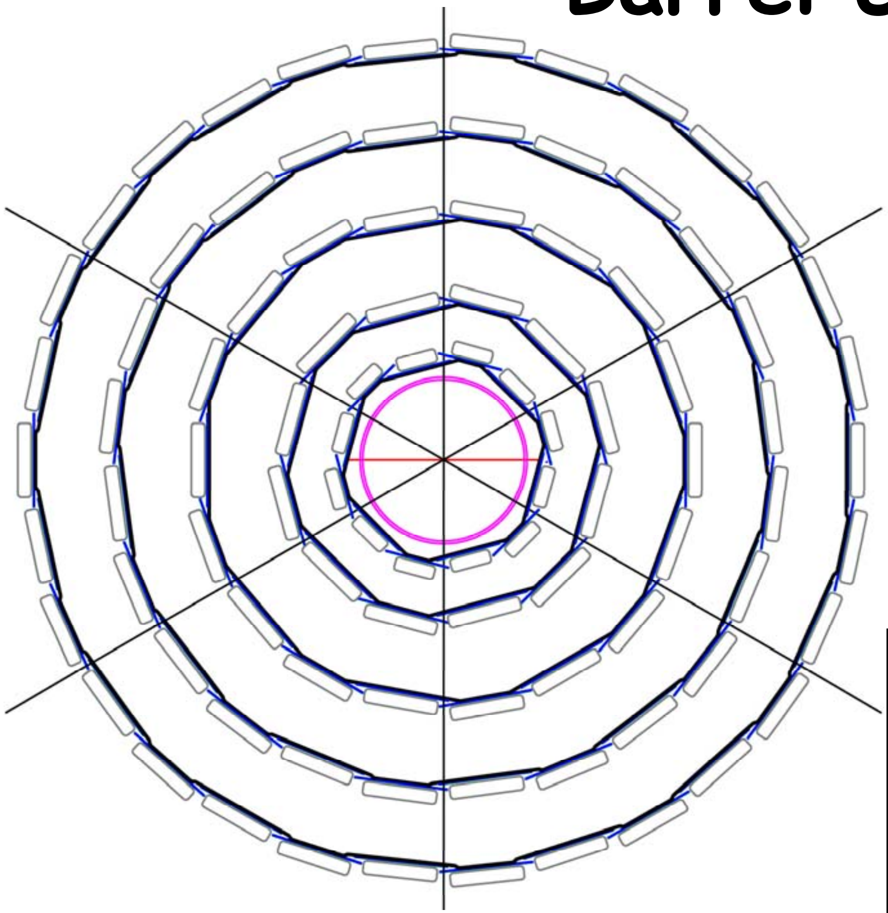
Layer 1's problem is in its own league (Revised estimated based on new RDR design).

Need to be able to deal with ~200 hits/mm²/train –

NLC tracking study by Nick Sinev and TESLA tracking study by Richard Hawkings both point to performance problem at Layer 1 density of ~1-2 hits/mm². Can only get there with time stamping !

Barrel Geometry

Bill Cooper



Bill Cooper

Layer	Ladder	Area (cm²)
1	12	144
2	12	207
3	18	311
4	24	414
5	30	518

Layer 1 sensor has a narrower width

Layer 1 area is 9% of barrel total

A Different View at the Sensor Requirements

So far no `ideal' technology performs best in all categories. In particular, attempts to reduce hit density via faster readout or time stamping seemed to be invariably associated with more power.

Have we dug a hole for ourselves by having the one size shoe fit all requirements ?

We have seen that the problems at inner and outer barrels and the endcap are different in some important aspects.

If we can tolerate the loss of elegance, is it so bad to consider the option of a mixed sensor technology ? Life may get significantly easier if the sensor only need to meet the requirement for a specific region of the detector.

Innermost Barrel

The first layer carries a huge weight in determining the ultimate impact parameter resolution and is in the most hostile environment of highest hit density. So one might desire:

- Small, thin pixels with low noise to gain the ultimate spatial resolution of <3μm (or even 2?)
- Time stamping or other means of tagging bunch crossings to bring the effective hit density down to <1 hits/mm^2.
- Yes it needs more power but we may afford that:
  - The end service section is falling out of fiducial so that a bit more service material may be OK.
  - Power lines still axial along beamline – no Lorentz force.
  - Layer 1 is only 9% of the total barrel area.
  - There is also a possibility of some liquid cooling around the beampipe region out of the fiducial.

Outer Barrels

- Many more sensors and services will suffer Lorentz force and in fiducial region. It is therefore highly preferrable to be a low power technology.
- In exchange, do not have to work as hard for the readout hit density.
- With Layer 1 at very fine resolution, we need to revisit the spatial resolution requirement for outer layers. Larger pixels may not be OK ?
- Still cares about Lorentz angle.
- If service light enough, routing them radially outwards outside the endcap may not be paying too much penalty on material ? This will reduce clutter around beampipe and reduce multiple scattering problem at low angles.

Endcap

- The access to power is in less critical fiducial regions so that there are more sensor options to choose from.
- Tracks are more perpendicular so that thicker sensors may be OK.
- Don't care about Lorentz angle.
- Cooling delivery is also somewhat easier.

We still need to settle the endcap sensor segmentation.
Inner ring and outer ring configuration also naturally permit separate technologies.

Summary on Mixed Sensors

Once lowered the elegance requirement on a single technology, one suddenly has some interesting freedom to consider more options to better optimize for the different regions.

Question/Issues:

- Shared operating temperature for the two sensor types
- Asynchronized readout of mixed technology may interfere ?
- Separate spatial resolution requirements for outer barrel ?

Hopefully a useful starting point for discussions and further thoughts to exploit the extra freedom.

Tasks for LOI

- Power delivery design and R&D.
- Readout scheme details data transmission R&D.
- Mechnical design consolidation with prototype R&D tests.
- Further develop mixed sensor configuration optimization and focused R&D goals for different sensors.
- Endcap sensor segmentation and layout.
- Service routing schemes.
- Additional cooling ?
- Stretched VXD or additional layer for long Vs ?
- Integrating forward tracking with pixel technology ?
- Simulation/reconstruction studies for hit density sensitivity and spatial resolution optimization.
- Higher level vertexing and bench mark studies.

Backups

Old Sensor Requirements

As of the DOD writeup, we have defined the following requirements:

1) Spatial resolution <5μm in all dimension for track entrance angles 15^0-90^0.
2) Two track resolution <40μm.
3) < ~0.1% X0 material per layer.
4) ~30W+30W total power in barrel+endcap. Gas cooled.
5) Operable at 5T with little resolution loss.
6) <5 hits/mm^2 at Layer 1; <1 hit/mm^2 in outer layers.
7) Low noise to allow threshold for >99% hit efficiency and readout noise <30% of all hit data.
8) EMI immunity.
9) Can withstand: >20Krad/year; >10^9/cm^2/yr 1 MeV Neutrons.

Comments on Sensor Requirements

- The 5μm resolution is very generous and one ought to be able to do better. One should still give extra credit for significantly better resolution (which may need the combination of thin EPI, low noise and perhaps not fully depleted).
- The power requirement is not only bound by the need for gas cooling. The necessary copper to deliver the instantaneous current is also an important factor.
- The hit density requirement has some uncertainties. We have not fully explored the tracking robustness at these limiting densities. Given the pivoting role of VXD in SiD tracking, capability for lower density could be important insurance to leave necessary margin to accommodate significant machine background variations.