Silicon Detector Design Study

The Starting Point

plus some progress.....

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Intro & history

"Once upon a time" SiD effort started at SLAC

A lot of effort, start & study basic concept

ALCPG , with approval of WWS, initiated Silicon based detector design study based on above

John Jaros and Harry Weerts were asked to launch it

For last few months have attended meetings in different regions to "launch" this concept study and engage participants from all regions of world.

Have started to put some organization in place and more about that later

Need to do some work on detector concept now.....

WEB pages

http://www-sid.slac.stanford.edu

http://sid.fnal.gov or http://ilc.fnal.gov

If you are interested …….. sign up here

Guess you already have…..

Basic Idea & Assumptions for SiD

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(NOT: to study a small detector)

- ILC detector based on a integrated, optimized and hermetic design
- Aggressive & High performance detector
- Constrain cost and use that from the beginning as a constraint
- Optimize the integrated physics performance of the subsystems
- Assume PFA(particle/energy flow algorithm) concept in overall detector design (needed to achieve physics performance)

- Use silicon as the main detector element for all tracking
- Identify or time stamp energy deposit/hits on bunch by bunch in all subsystems

This is a "non-standard" e^+e^- detector

(can it be done a different way ???)

SiD starting point (1)

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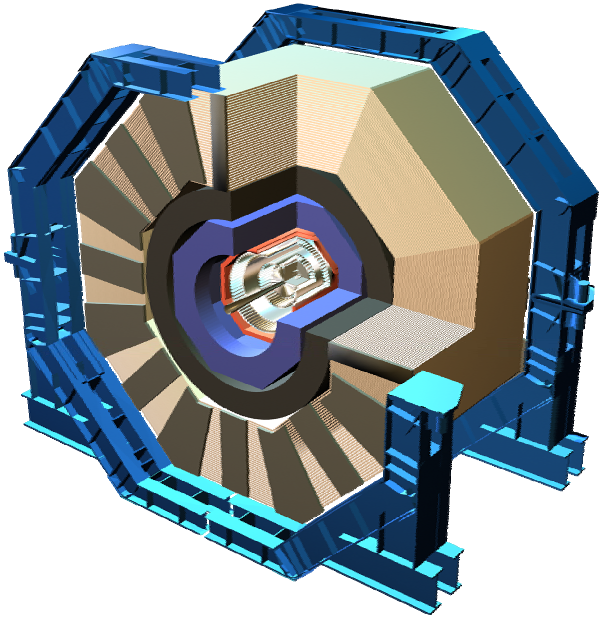

Starting point: SiD concept

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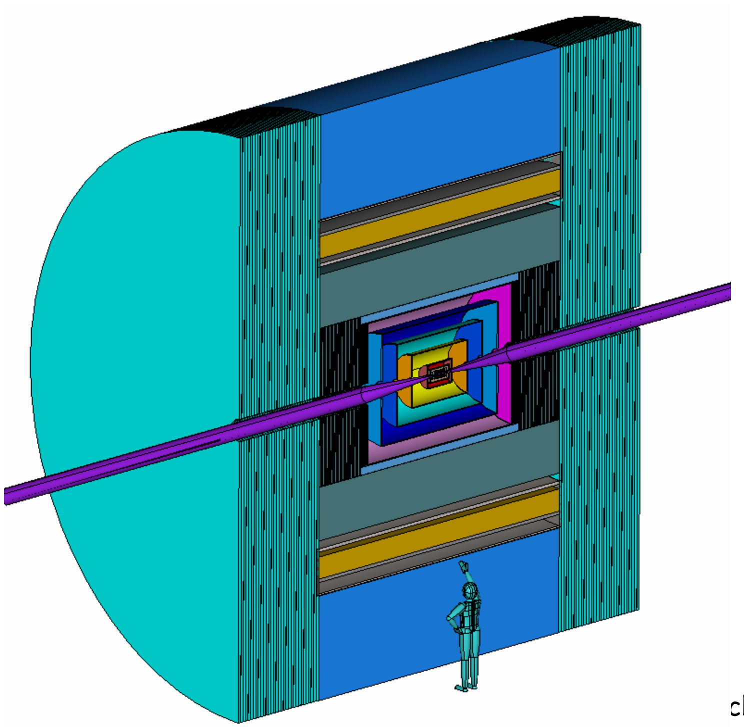
• *Accept* notion that excellent energy flow calorimetry is required, and explore optimization of a Tungsten-Silicon EMCal and the implications for the detector architecture…



Drawings shown are from a model, based on upcoming simulation

SiD starting point/motivation (2)

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- Robustness of silicon against unexpected beam conditions/loss
- Silicon is expensive, so limit area by limiting radius of EMCAL
- Get back BR^2 by pushing B up (~5T)
- Maintain tracking resolution by using silicon strips in tracker
- Make full use of 5 VXD space points for pattern recognition
- Buy safety margin for VXD with the 5T B-field (limit radial extent of pair background; smaller radius for VXD.)

SiD concept overview

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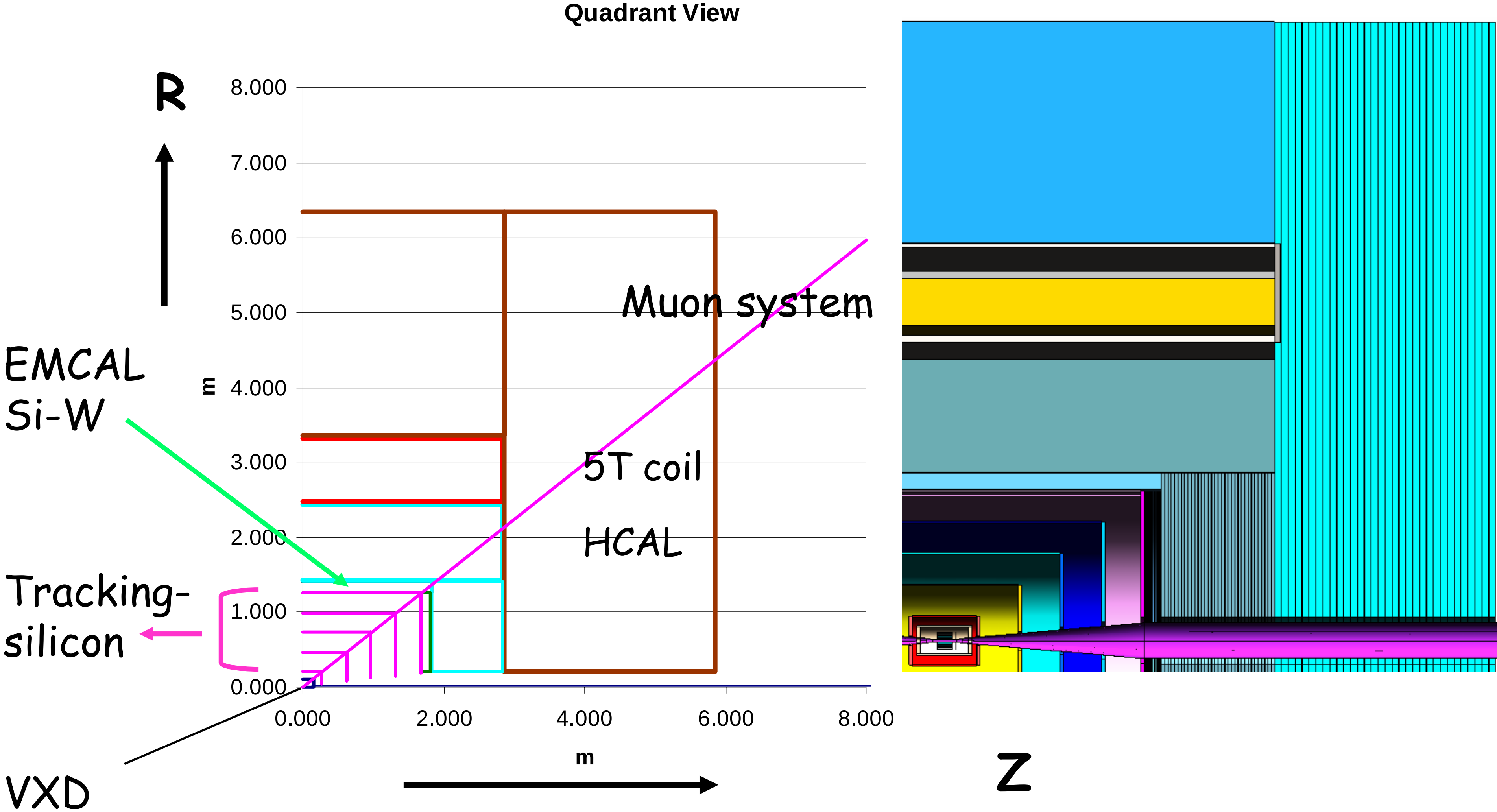
Very schematic drawing



NOT A SMALL DETECTOR

SiD Concept sizes simulation(1)

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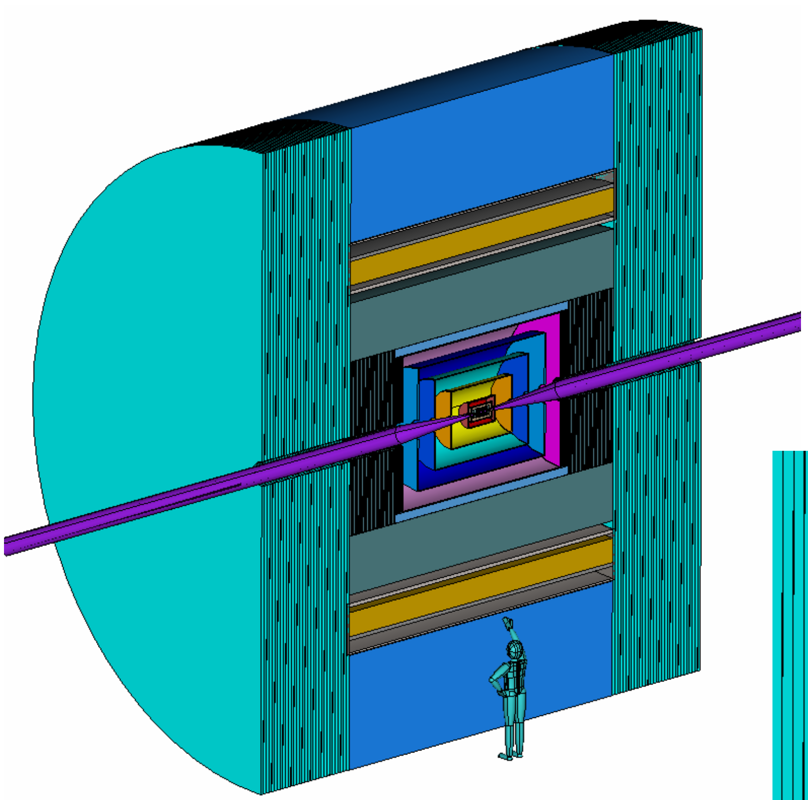

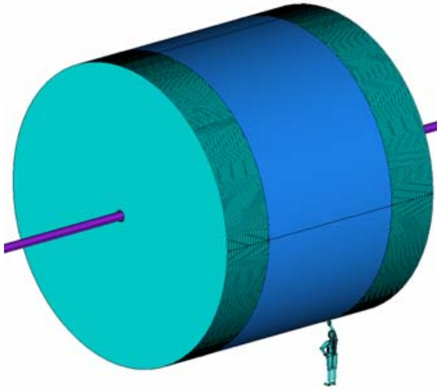

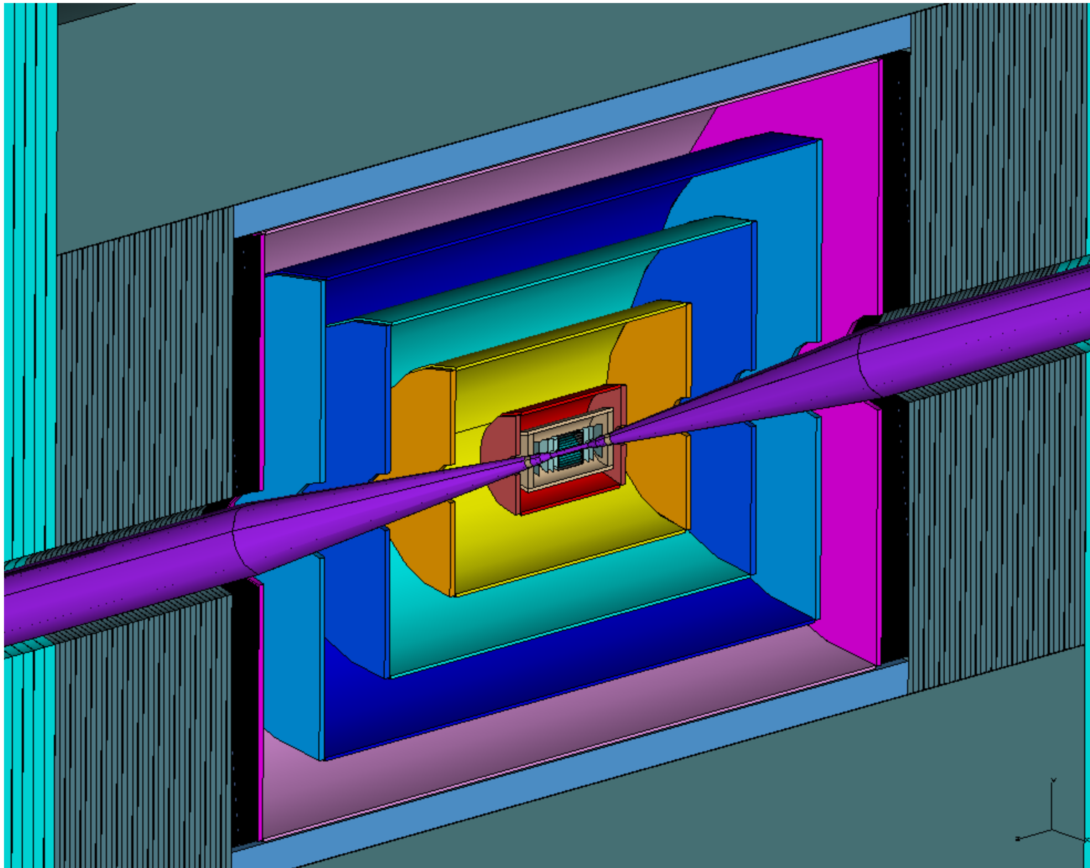

Vertex detector

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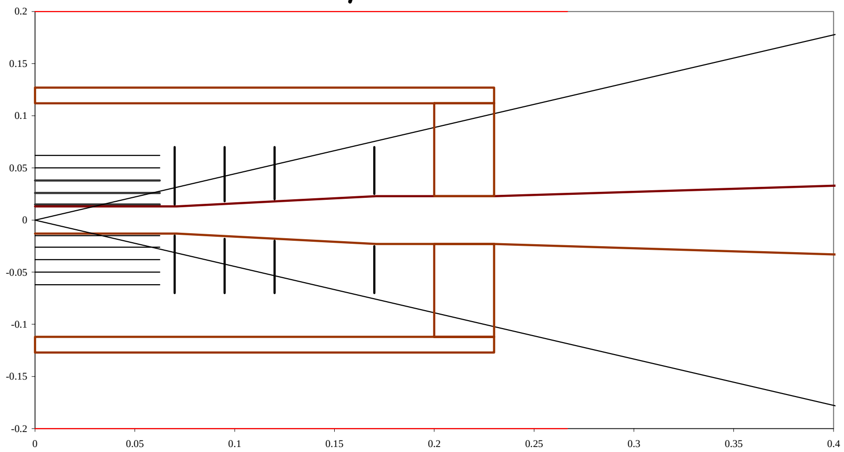
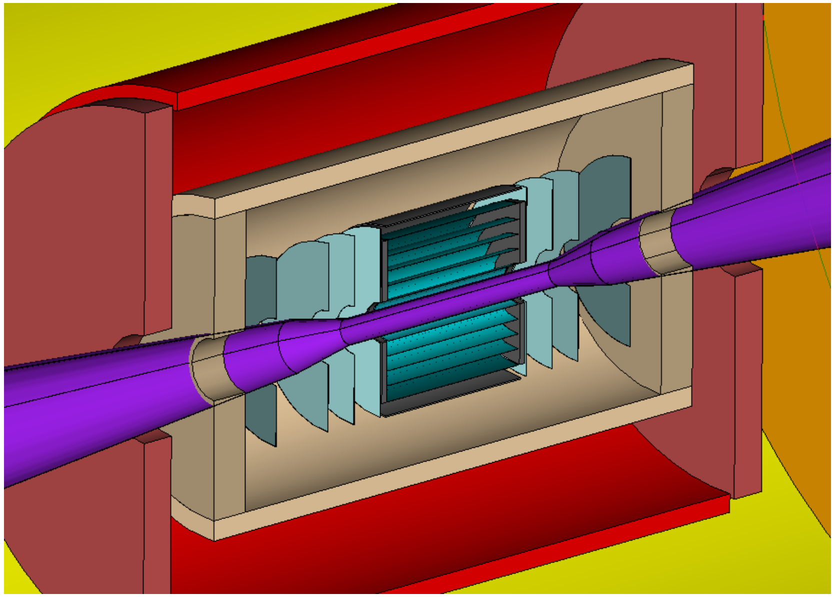
SiD early



current



Build on SLD/VX3 success

Radius: inner ~1 –1.5cm outer 10cm, 0.2% X_0

Extend 5 layer tracking over max Ω (5 barrel + 4 forward layers)

→improve Ω Coverage, improve σ_{xy}, σ_{rz}

5 layers	cos θ < .97
4 layers	cos θ < .98

Minimize area/cost

→ Shorten Barrel layerss to 12.5 cm (vs. 25.0cm)

Thin the barrel endplate

Tracking

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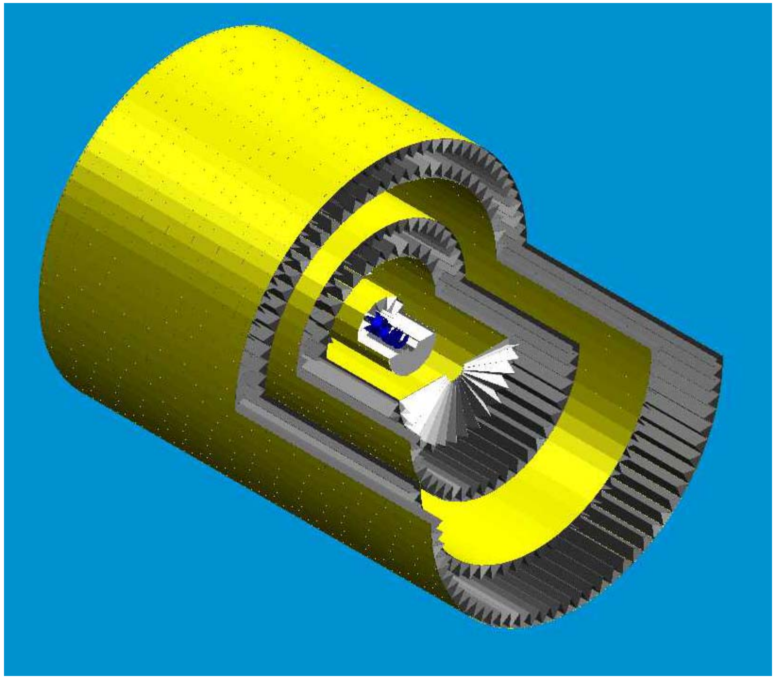
- Silicon; Inner radius 20cm outer radius 125cm; 5 layers
- **SLC/SLD Prejudice**: Silicon is robust against machine mishaps; wires & gas are not.
- Silicon should be relatively easy to commission – no *td* relations, easily modeled Lorentz angle, stable geometry and constants.
- SiD as a *system* should have superb track finding:
  - 5 layers of highly pixellated layers (vertex) plus
  - 5 layers of Si strips, outer layer measures 2 coordinates
  - EMCAL provides extra tracking for V finding - ~1mm resolution!
- Minimize material before endcap calorimeter
- Simulation Studies have been and are underway
- Hardware developments (just starting)
  - Effort on ASIC…….. adapting for long bunch trains
  - Structure design work starting at FNAL

Silicon Tracking (cont'd)

Structure and mechanical considerations

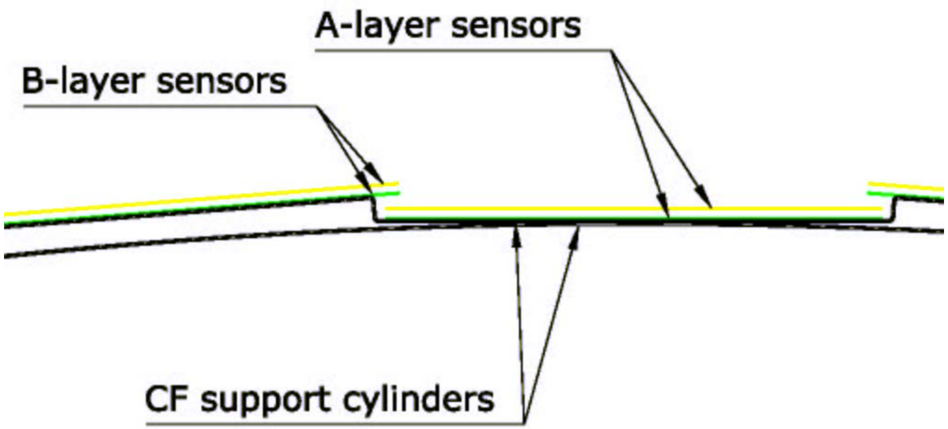
- Ladder configurations under study.
- Minimal electronics and power pulsing make gas cooling easy. No liquids, leaks or associated mass.

Initial thoughts on support structure



Long ladders evolving; consider shorter structures & cylinders

Support structure by Fermilab



Use double carbon fiber support cylinders for each barrel

Moving beyond the starting point

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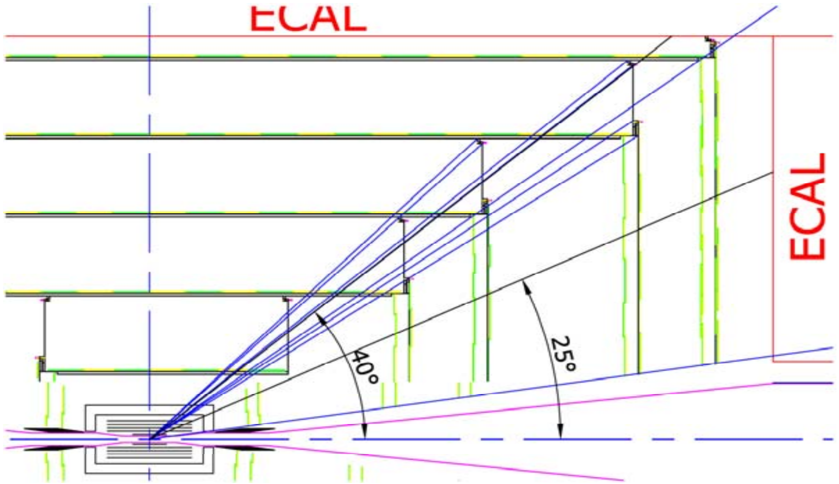
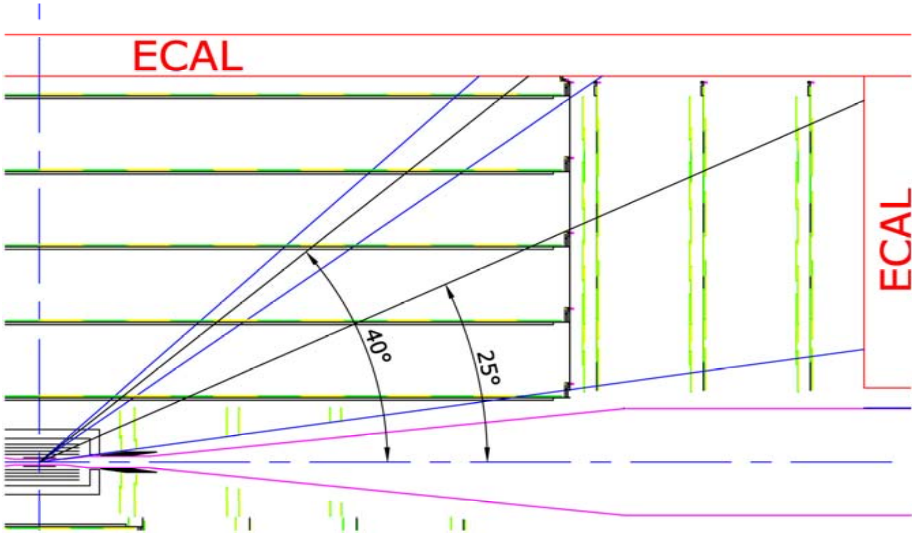
- Options 1 & 2 ---B. Cooper, FNAL
- Support Si on C fiber/Rohacell sandwich cylinders and disks
- Whole assembly rolls out along beamline VXD/beampipe access
- Very forward tracking system mounted on beam pipe
- Stagger layers to avoid material overlap
- Pattern recognition questions remain
  Barrel: axial only? A + S ?
  Endcap: 2 single sided Si/layer





More from W. Cooper this afternoon

Silicon tracker currently in simulation

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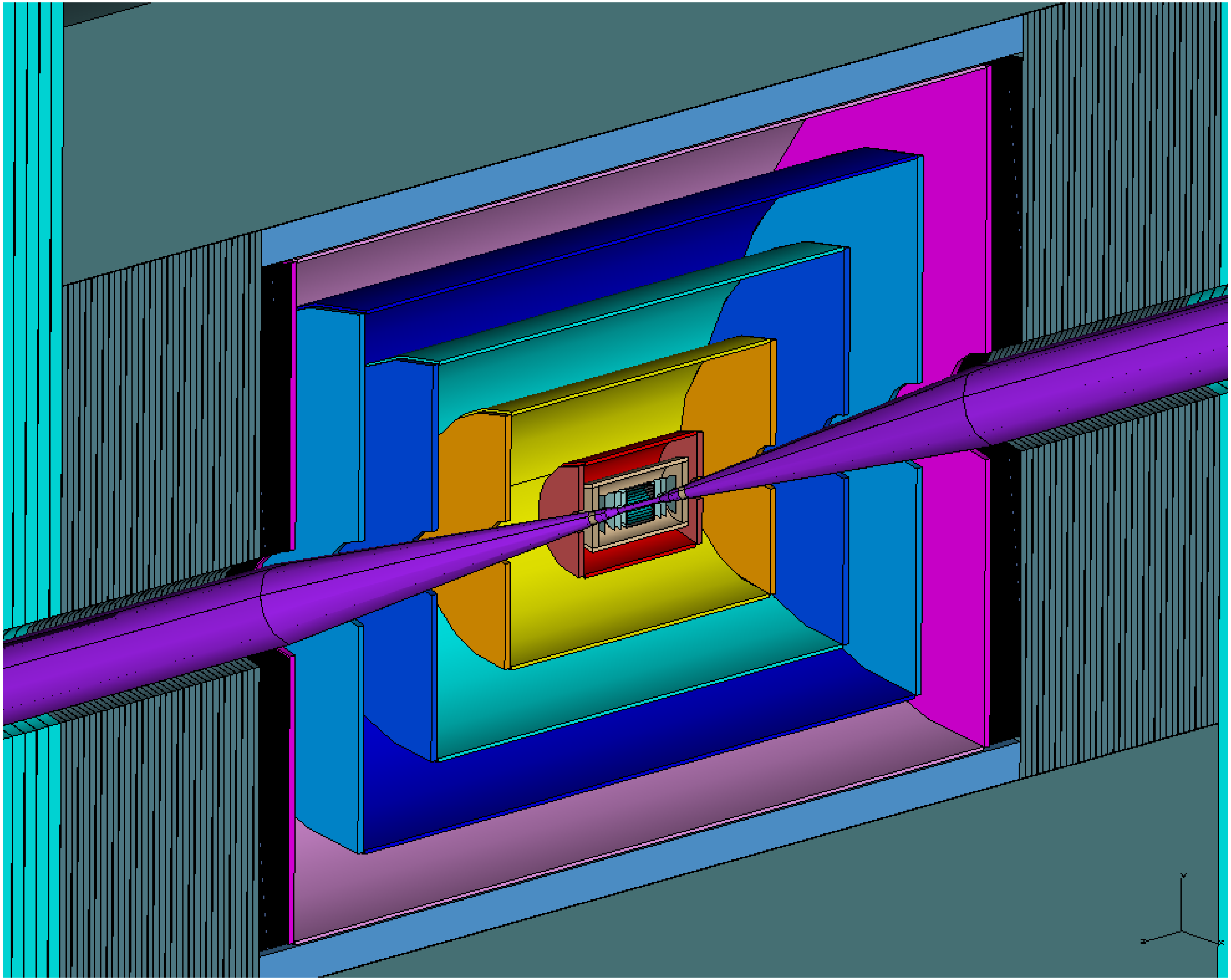

SiD EMCal concept(1)

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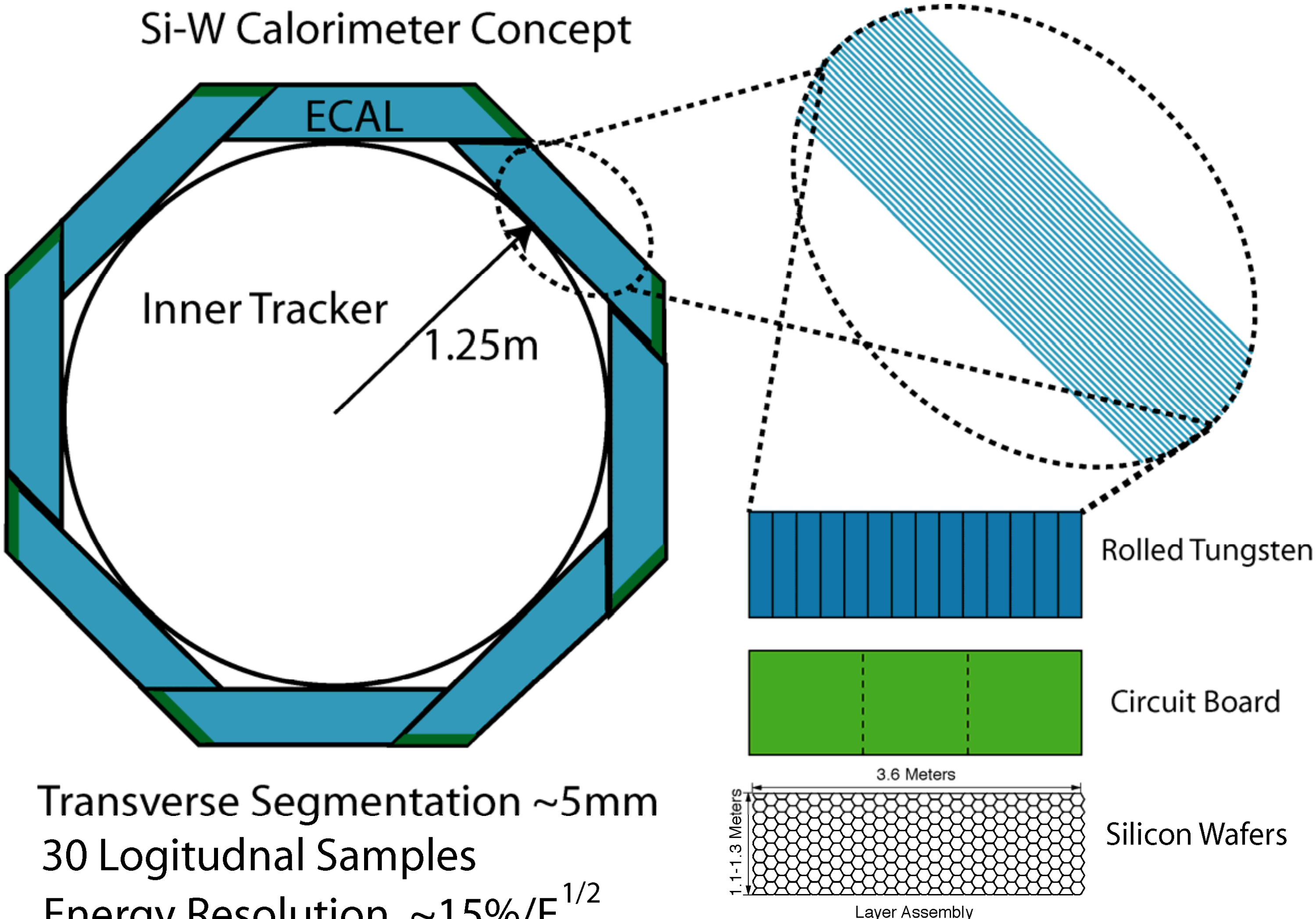
Design driver

Inner radius: 1.25m , outer radius 1.41 m; 29 X_0

20 layers of 2.5mm W and 10 layers of 5.0mm W; 1.25mm gap;

0.3mm Si in gap; W X_0= 3.5mm



Transverse Segmentation ~5mm

30 Logitudnal Samples

Energy Resolution ~15%/$E^{1/2}$

SiD concept EMCal (2)

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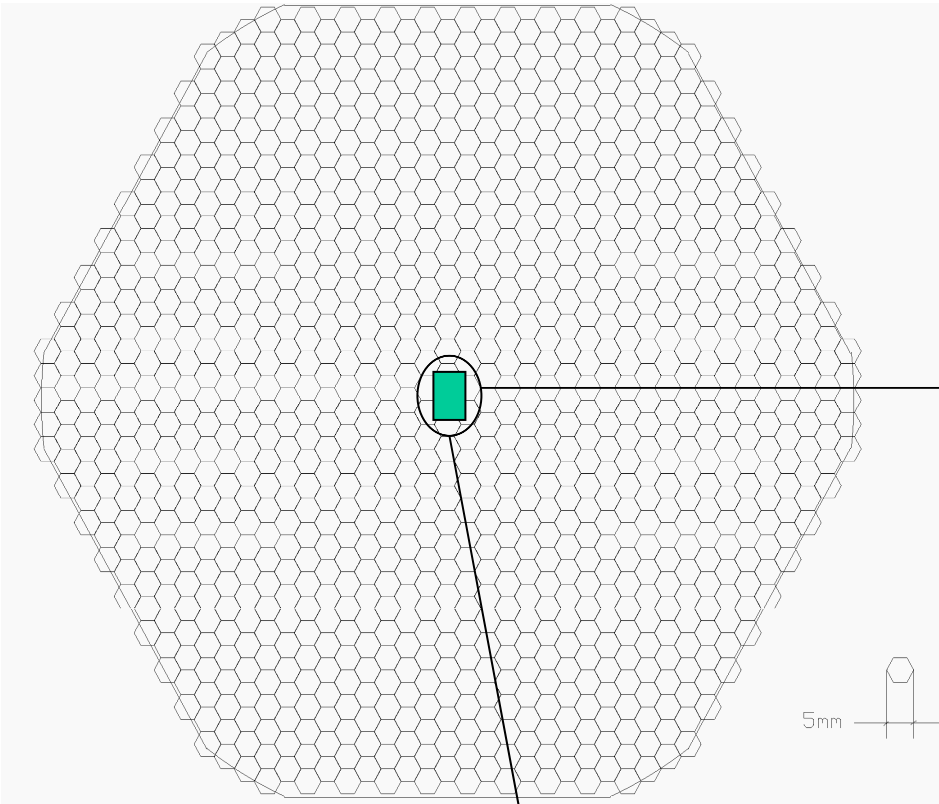
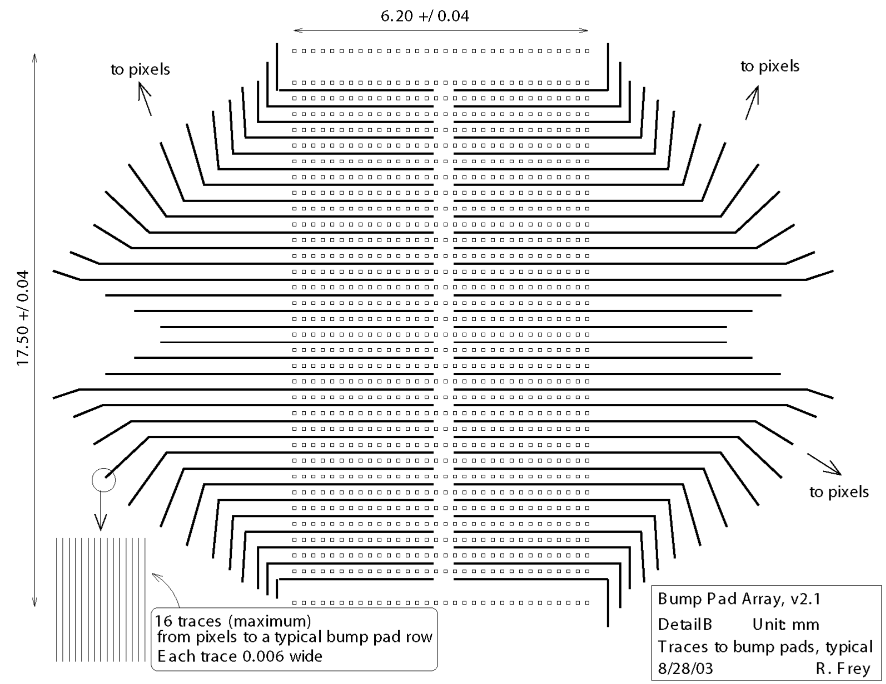
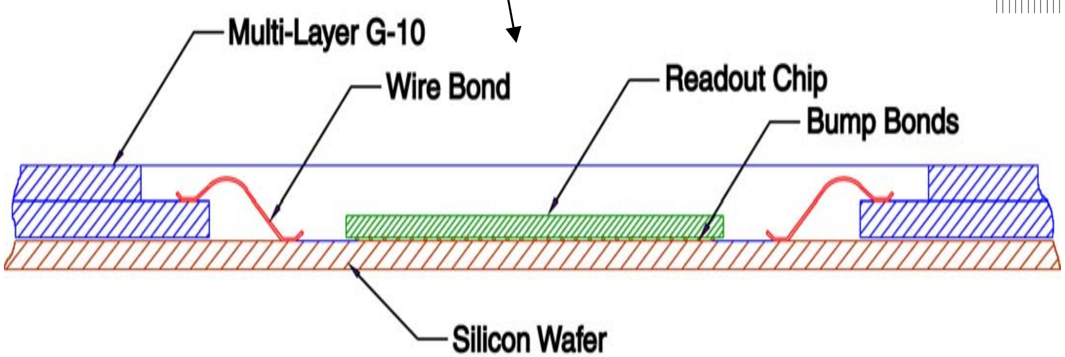


Wafer and readout chip





Concept: many channels (1-2K) on one ASIC

HCAL

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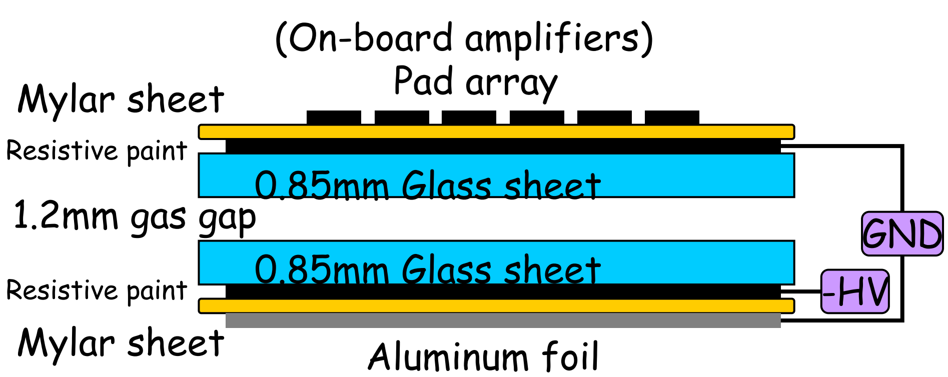
Inside the coil

Inner Radius ~ 1.42m, outer radius ~ 2.37m; thickness ~4Λ
34 samples; 2cm Fe, 8 mm gap

Several technologies being tested in ongoing, worldwide vibrant Calorimeter R&D program

Several possibilities:
- Digital or Analog or mix
- RPC's
- GEM's
- Scintillator (SiPM, APD,……)

Initial starting assumption: use Fe as absorber & RPC for detector



Example of a one layer RPC @ ANL

Calorimetry progress

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Calorimeter group organized a SiD PFA workshop at Argonne in January

Main agenda item: a PFA algorithm tuned for SiD detector

Agenda and talks can be found at:

http://nicadd.niu.edu/cdsagenda//displayLevel.php?fid=24

Solenoid

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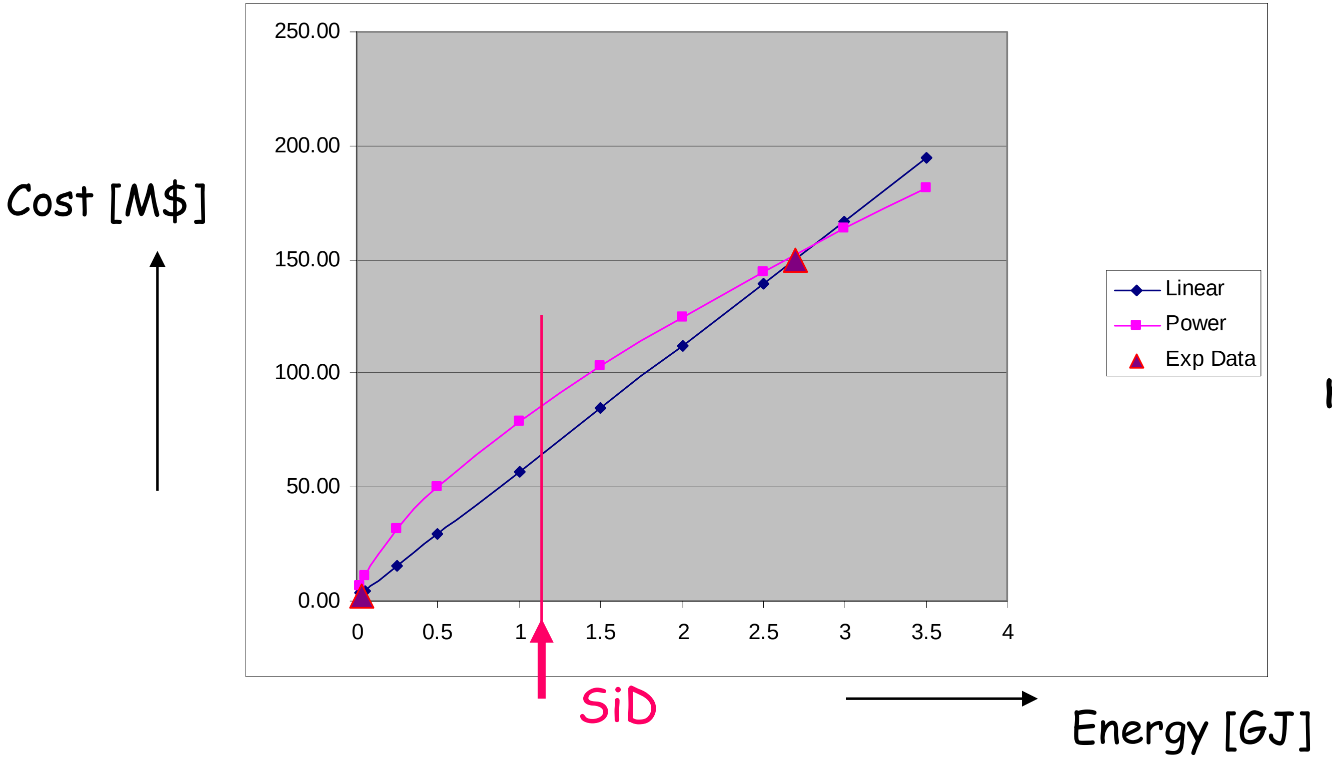
Inner radius: ~ 2.5m to ~3.32m, L=5.4m; Stored energy ~ 1.2 GJ

Need feasibility study in next year to at least convince ourselves that 5T can be built .

Expertise not readily available. CMS solenoid sets current scale.



Cost model

Does physics really require 5T?

More this afternoon

Muon system/Flux return

Inner Radius ~ 3.35m, outer radius ~ 6.34m;
32 layers; thickness ~14Λ
5 cm Fe with 8 mm gap

Flux return and muon ID, as well as tail catcher for HCal

Ongoing Muon R&D on layout (flux return) and detector technologies

Possibilities:
- RPC
- GEM
- Scintillator (PMT and Si-PM)

For SiD simulation assume RPC as the detector medium

Detector overview (1)

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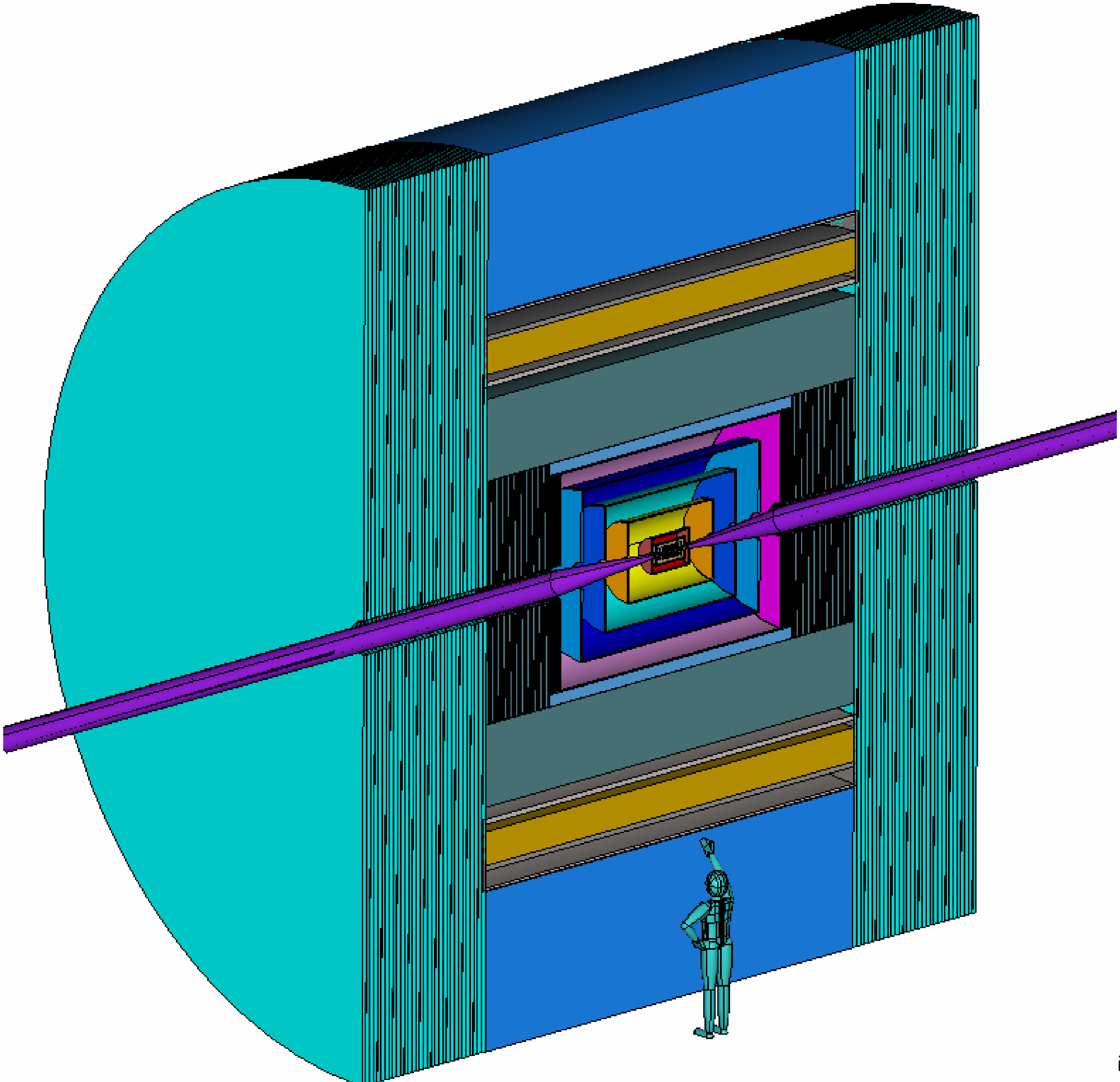
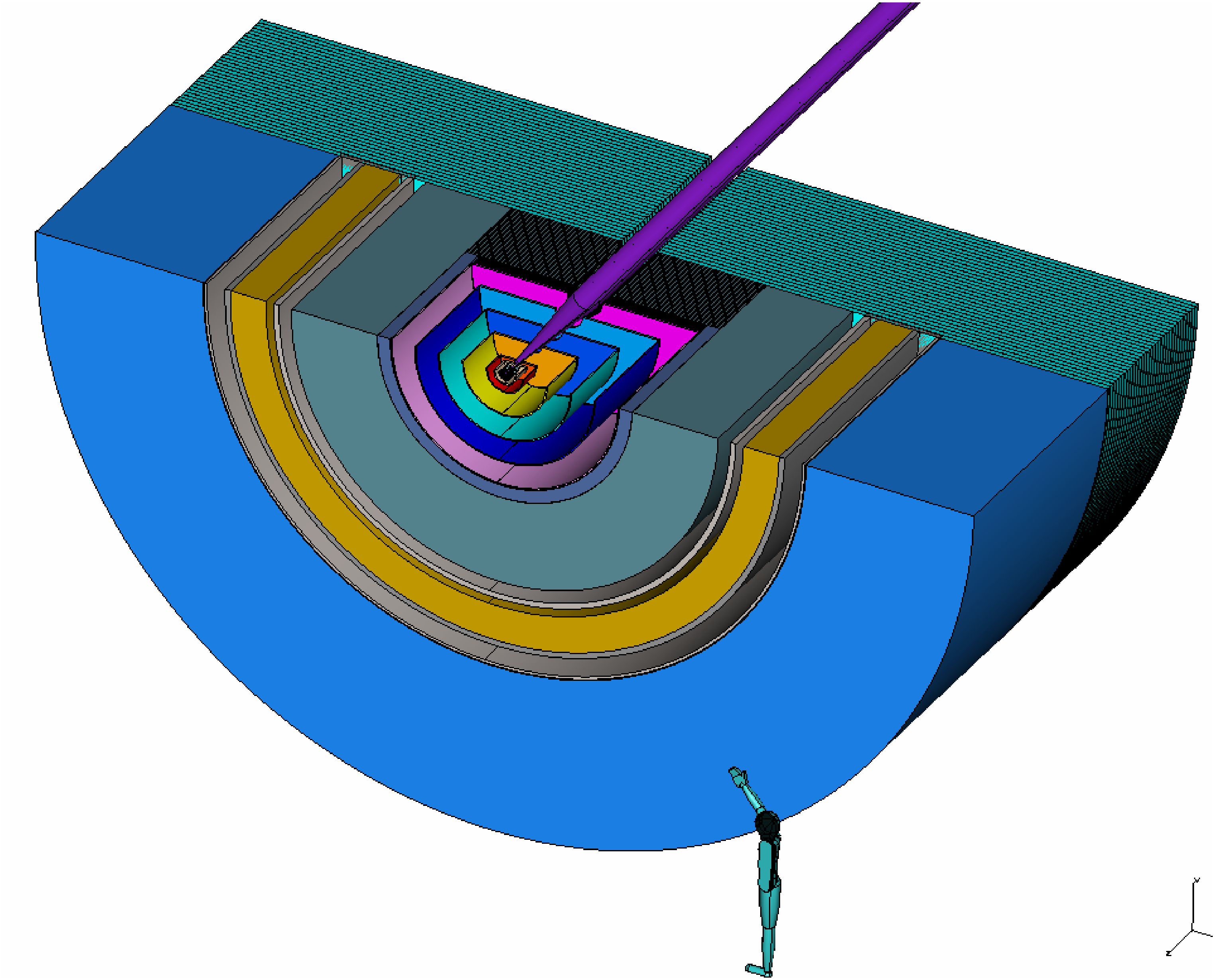


Overview (2)



Simulation

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Strawman version of detector (described here) is going into simulation.
Details are still be ironed out
Approximate detectors by cylindrical shapes for now, with correct segmentation---- seems adequate for now
Need this current and "up-to-date" version of detector as starting point for simulation (example: PFA algorithm)

More on this later from Norman

BDIR/MDI

Beam delivery and machine detector interface

Strawman designs for interaction regions exist
Close interaction with BDIR group at SLAC
Layouts of forward for SiD exist

My ignorance at this point……. More from Tom later

SiD on a spreadsheet (1)

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Tool by M. Breidenbach

Parameterize the major subdetector boundaries and parameters
Put in cost for materials (per kg for absorber)
Cost for detector elements (per m^2)
A solenoid cost model
Create sliders to change parameters like absorbers, gaps, barrel/forward transition, BR^2, HCAL in or out of coil, etc

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Allows one to:

Make a simple drawing detector
Track components/material needed for options
Do simple cost comparisons of options
Identify cost drivers

Very useful tool for overall detector concept/design

SiD Design Study endpoint

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Even though we have a starting point, the resulting final optimal detector configuration is not clear.

Will depend on results of study, new ideas, inputs, simulations and last but not least you, the participants in the study

Obviously no conclusions yet

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We have started

....

because work is ahead of us

END

Relative Detector Configurations

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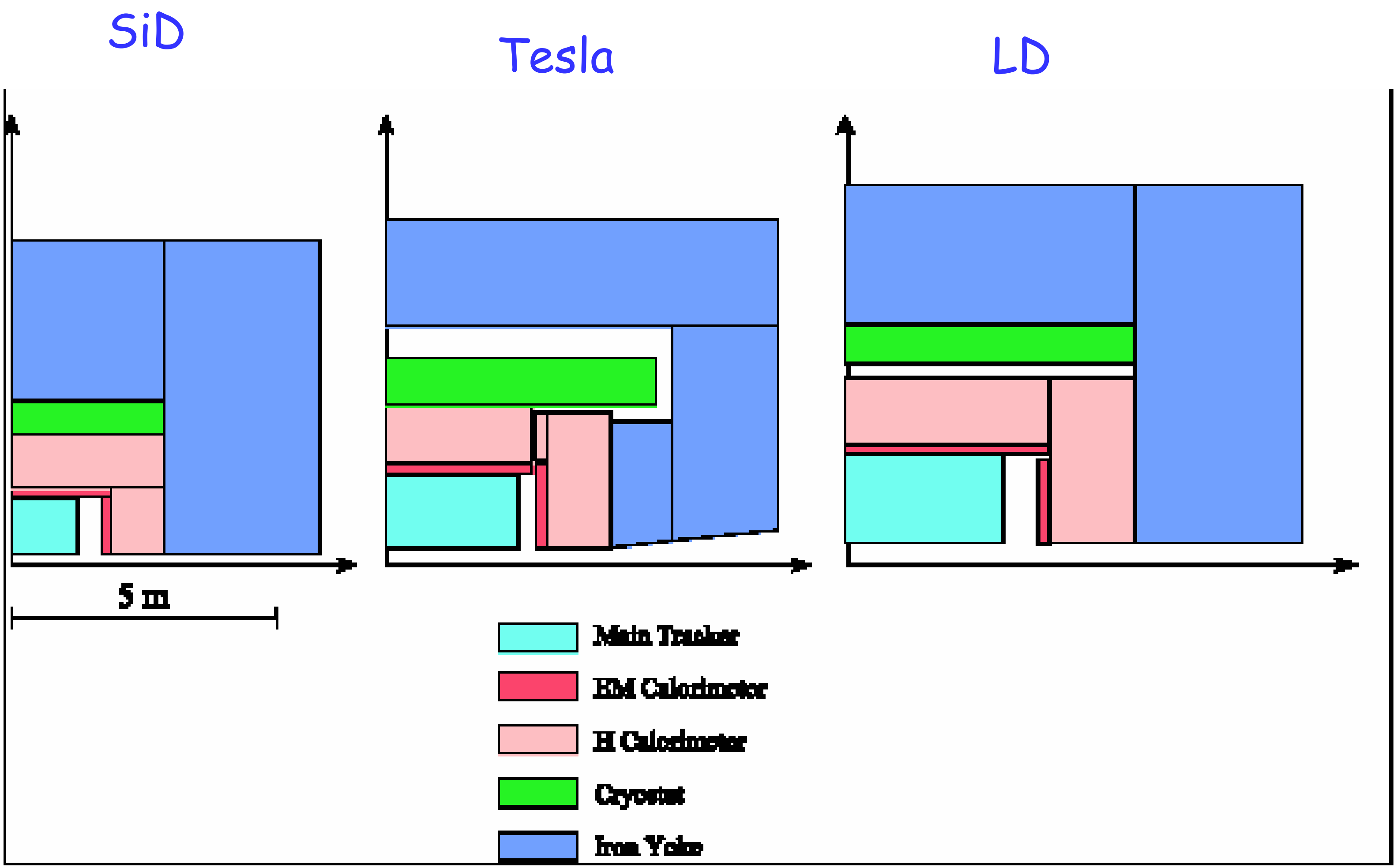

From Sachio Komamiya

SiD model pictures (2)

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