Overview of SiD

Toshinori Abe
University of Tokyo
for the SiD study group

Introduction

- SiD is a detector for a future linear collider experiment.
- SiD is proposed based on the experience of SLC.
- In this talk, we will review the design concept of the SiD detector.
- SiD is a world wide community and Hiroaki Aihara (Tokyo) is the contact person for Asian countries.

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

Contents of this talk

- Detector requirements
- SiD design concept
    1. Jet flavor tag
    2. Jet reconstruction
    3. Machine environment
- Detector components
    1. Tracking system
    2. Calorimeters
    3. Others
- Summary

Requirements from physics

- Target physics → **Higgs** and **Top**

  $e^+e^- \to ZH$; $Z \to q$ qbar, $H \to b$ bbar (or WW)

  4jets final state

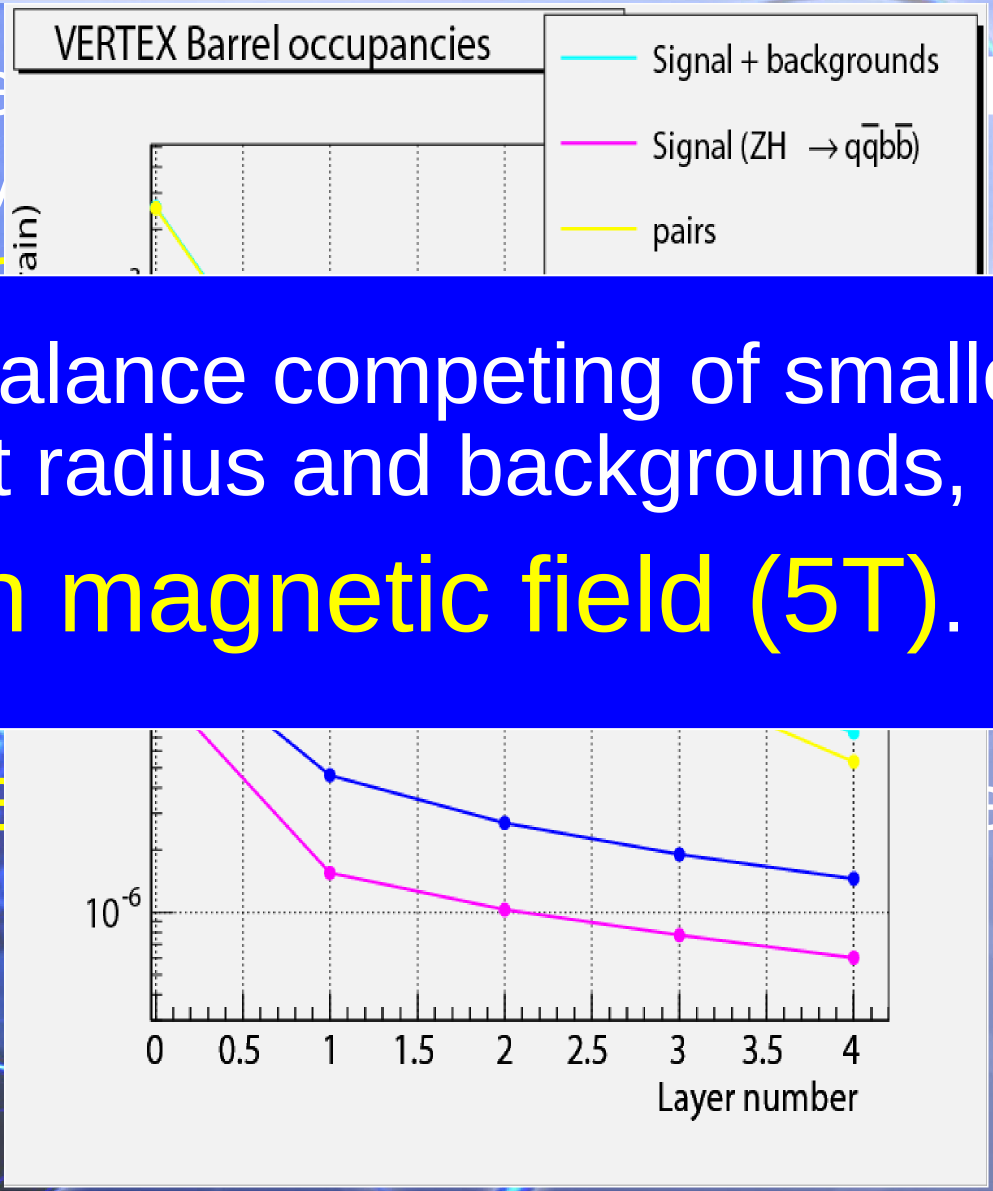
  $e^+e^- \to$ tt-bar; $t \to b+W$, $W \to qq'$

  6jets final state

→b-jet, c-jet and anti-b-jet tags are very important!

→Multi-jet reconstruction is very important!

SiD approach for b-jet tag



- To balance competing of smaller inner most radius and backgrounds, SiD takes high magnetic field (5T).

SiD approach for multi Jet reconstruction

- We believe Energy flow method is the right way to obtain best jet reconstruction performance.
- Charged particles (60% of jet energy)
  →Tracker
  Photons (20% of jet energy)
  →ECAL
  Neutral hadrons (10% of jet energy)
  →HCAL

SiD approach for jet reconstruction

- You can not make a large detector with such high magnetic field (5T).

  →relatively small calorimeter (R~1.25m)

- For good jet reconstruction, we need **efficient particle separation** in the calorimeter.

  Average number of particles is 40~50

  →High segmented calorimeter

SiD approach for machine oriented problem

- The experience at SLC tells LC is not easy to operate.

  →There were unstable beams, beam losses, ...

- The detector components have to be robust against them.

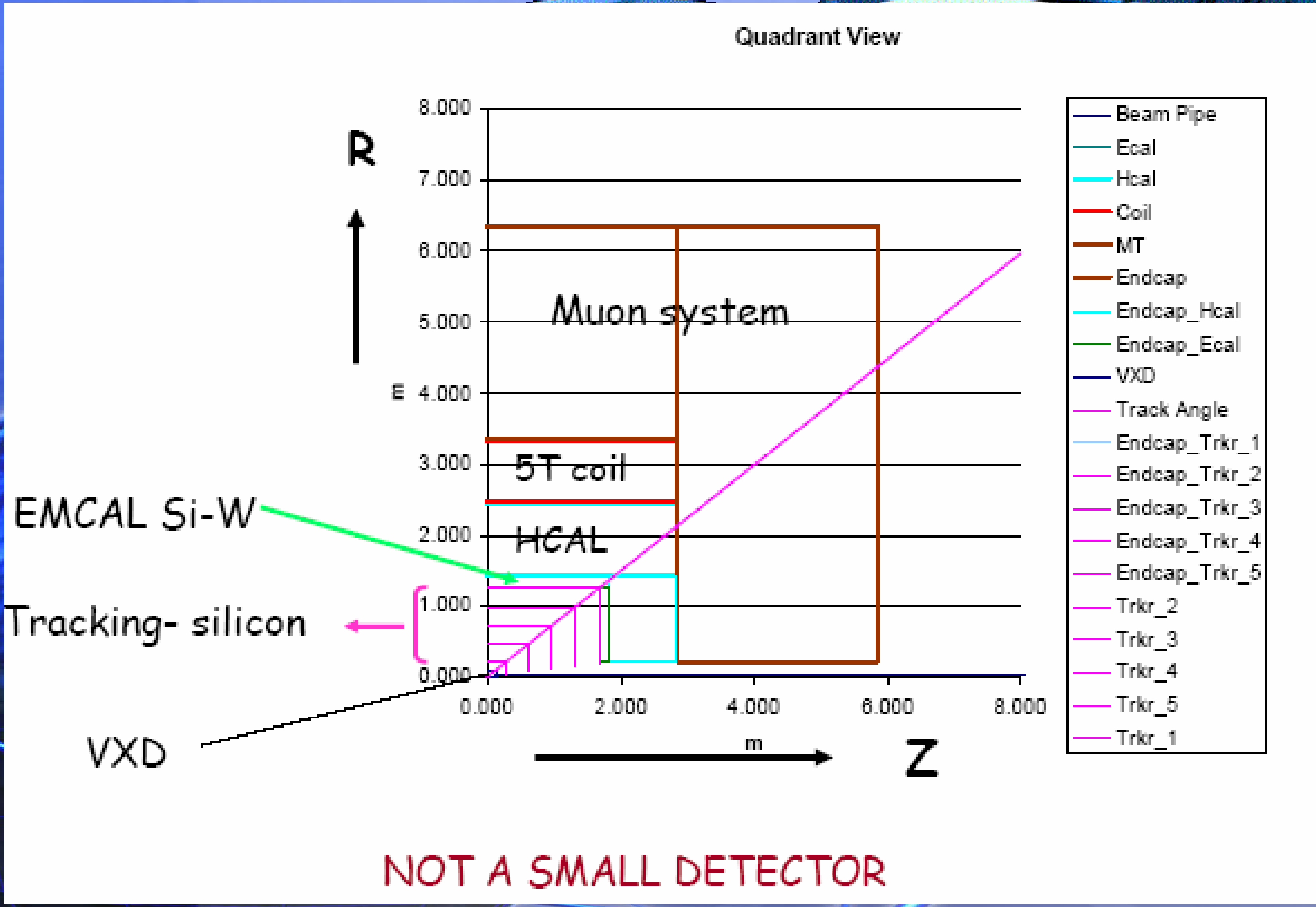
  (LC is not a machine like KEK-B because of single pass operation.)

- We favor Si over wires/gas for tracker.

Summary on SiD detector concept

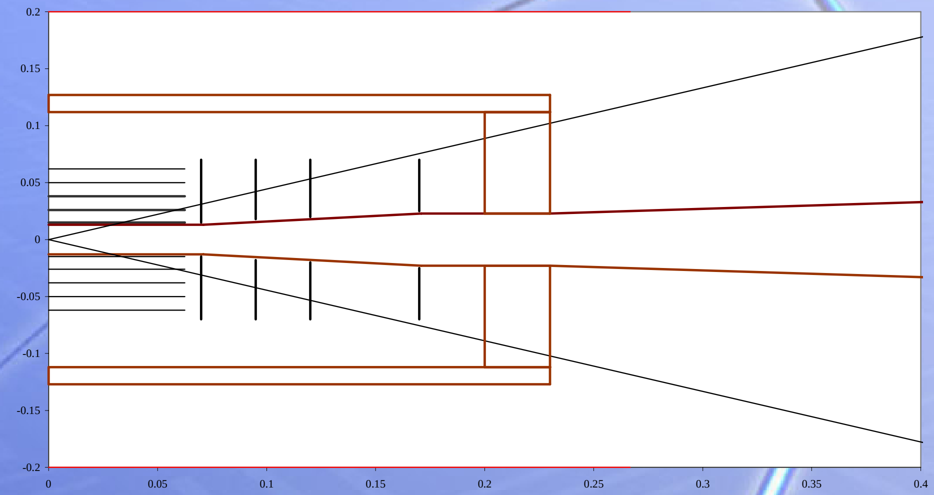
- The followings are SiD detector concepts.
  1. High magnetic field,
  2. Very fine segmented calorimeter, and
  3. Si based tracker
- SiD takes aggressive approach to a compact LC detector.
- SiD contains many technically challenging technologies, which encourage our detector R&D activities.

SiD detector



Muon
Magnet
HCAL
ECAL
Tracker
Vertex

SiD vertex detector



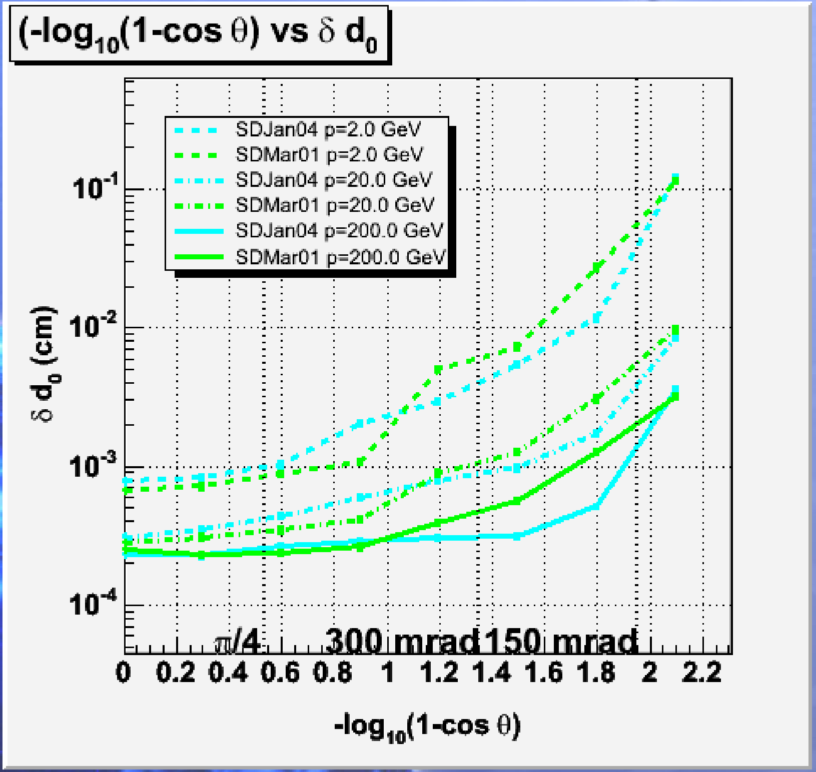
- CCD pixels
- Barrel 12.5cm+300μm end-caps (self supporting)
- Radius: inner ~1-1.5cm outer 10cm, 0.2% X_0

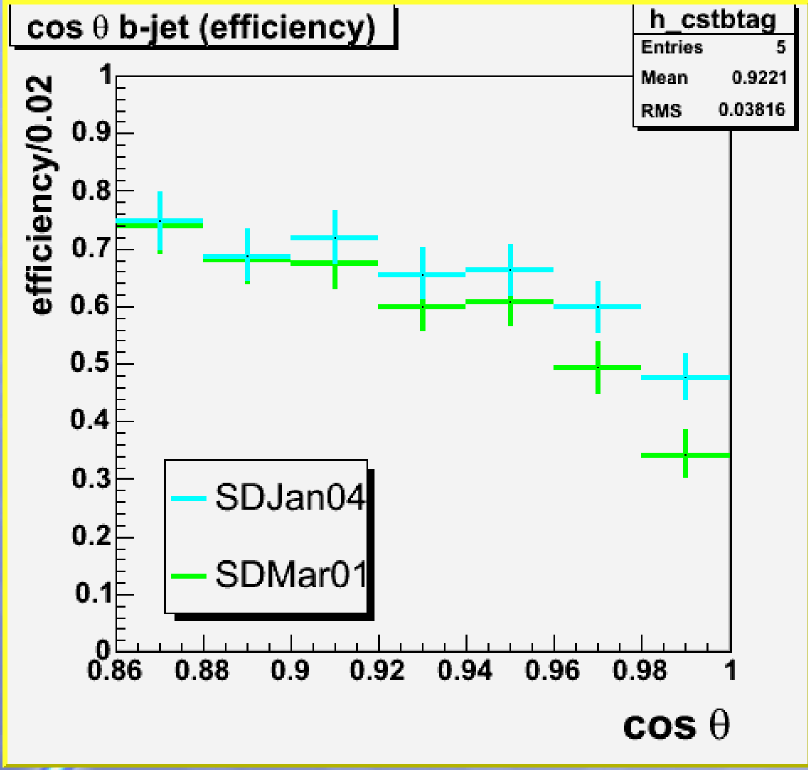
Extend 5layer tracking over max Ω (5 barrel+4 forward layers) → improve Ω coverage, improve σ_{xy}, σ_{rz}

- 5 CCD layers 0.97

- 4 CCD layers 0.98

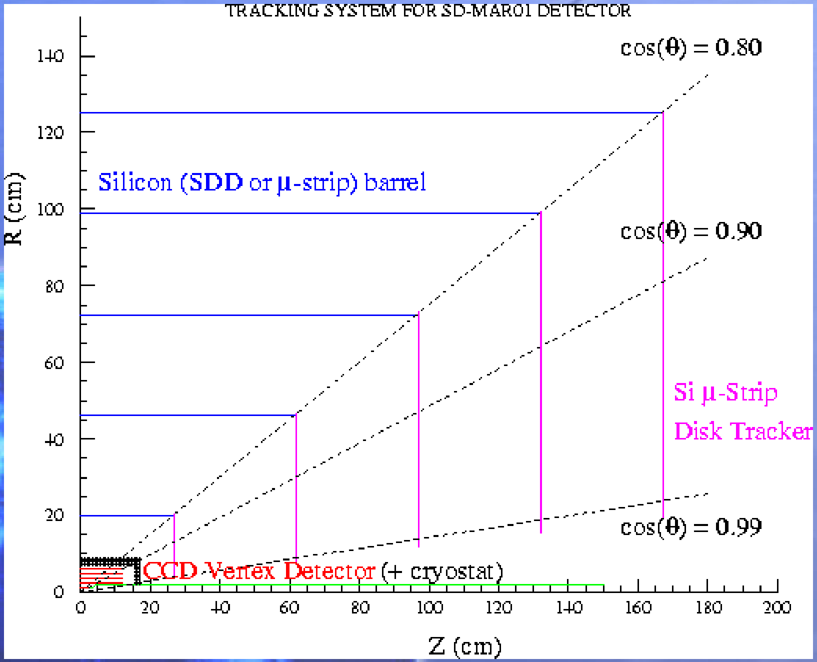
SiD vertex detector (cont.)

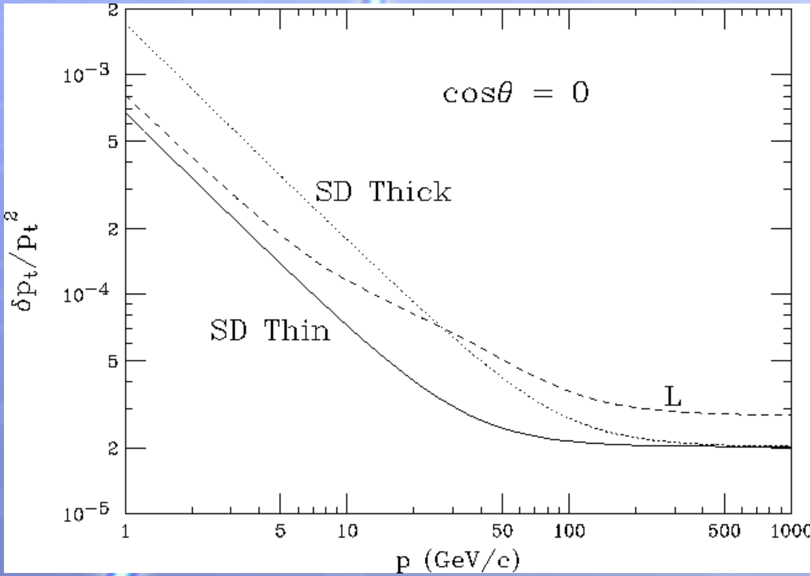




SiD tracking detector

Overall SiD design requires compact tracker with high point resolution





Excellent momentum resolution ($\Delta p/p^2 \sim 2 \times 10^{-5}$)

SiD tracking detector

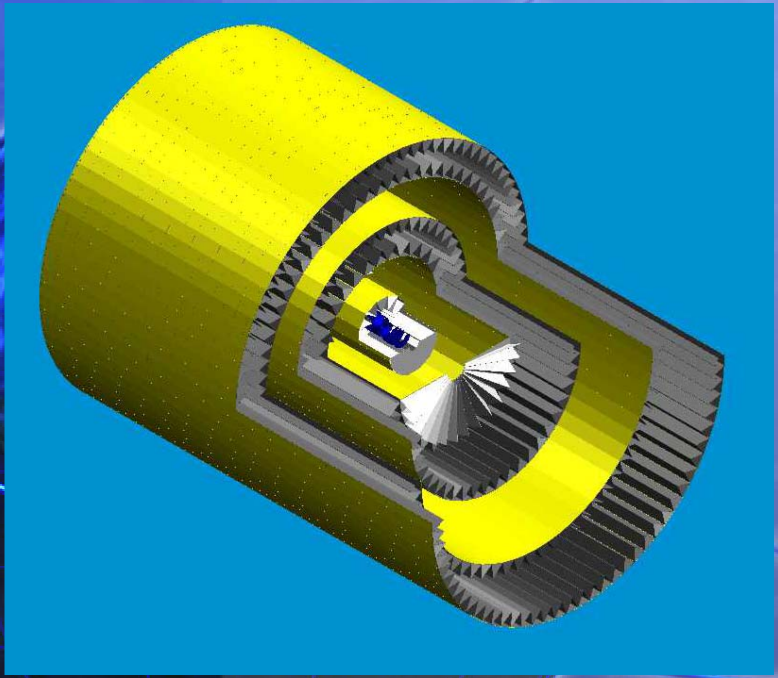
- Features:
  - Compact, 5 layers inside R = 1.25m
  - Point resolution O(10μm)
  - Thin: disks in forward direction – preserve ECAL performance
  - Stable calibration/alignment (vs. time/dist for wires)
  - Robust – SLC/SLD experience

SiD tracking detector

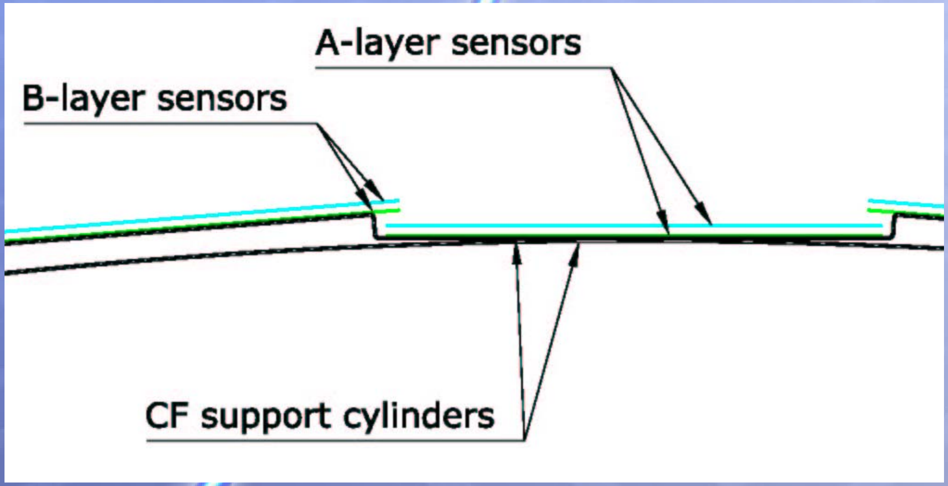
Structure and mechanical considerations (H.Weerts)

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

Initial thoughts on support structure



Support structure by Fermilab

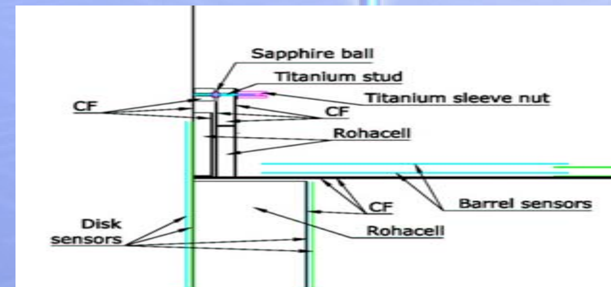


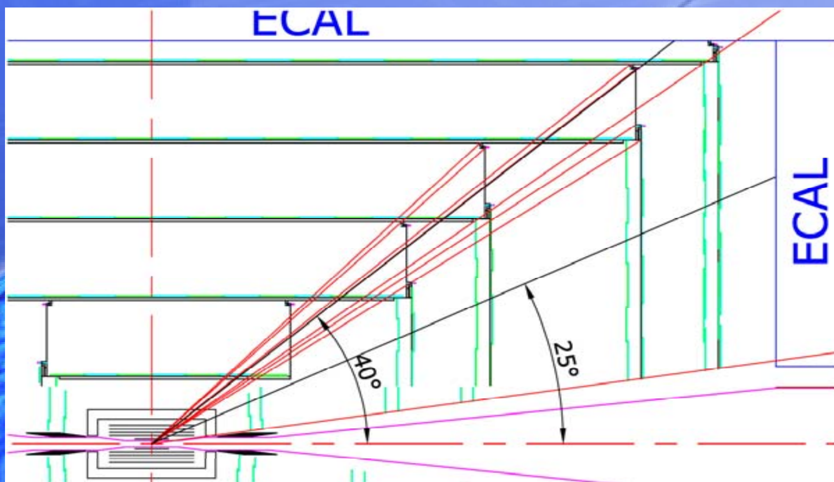
Use double carbon fiber support cylinders for each barrel

Long ladders evolved to shorter structures & cylinders

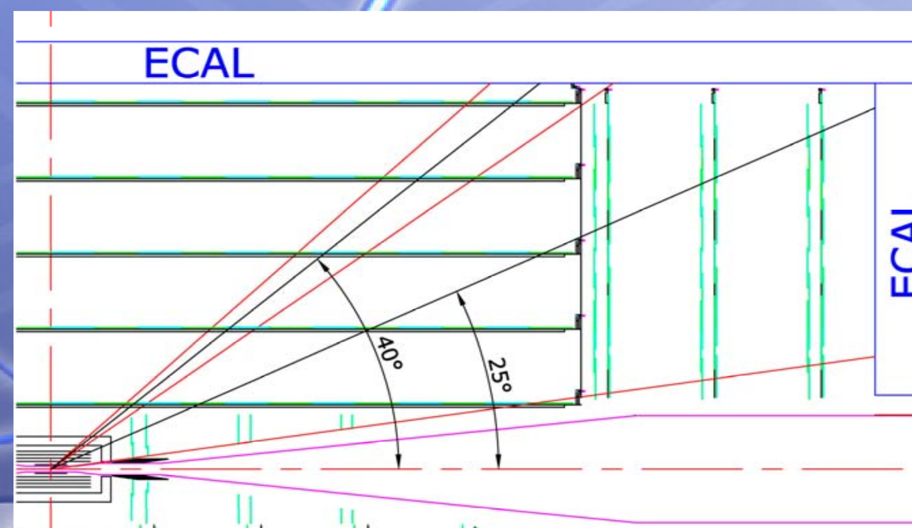
SiD tracking detector

Work at Fermilab (Bill Cooper), Brown on design options e.g.

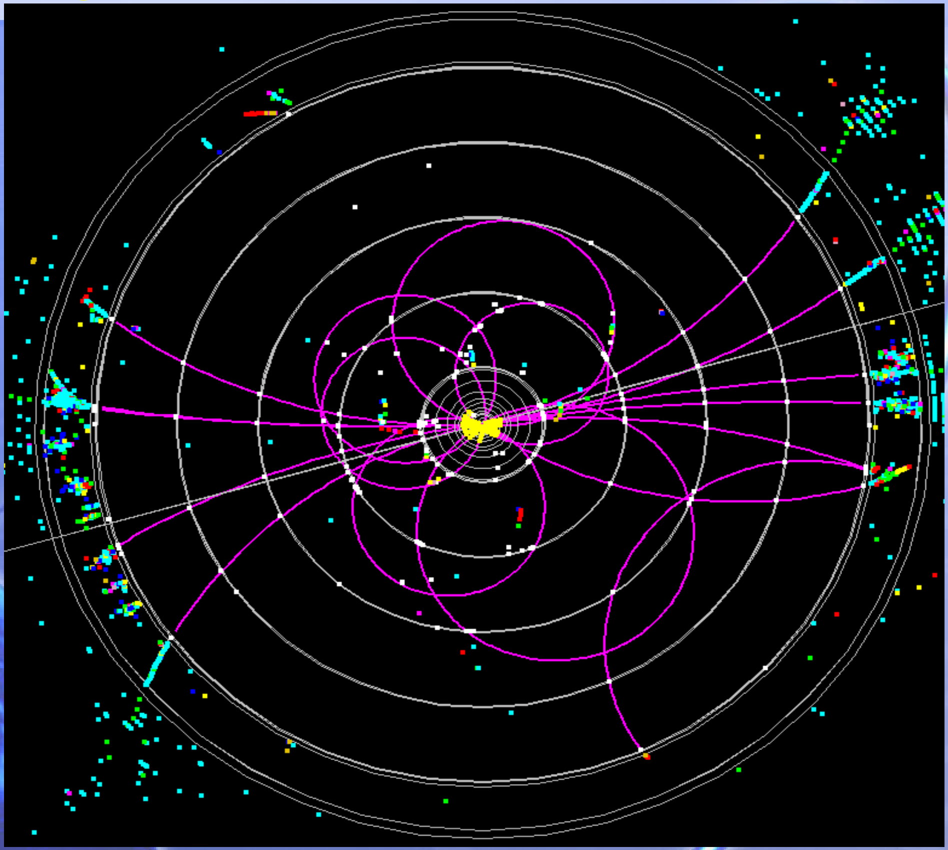




Very forward tracking elements mounted on beam pipe



SiD tracking system



Track finding -> high efficiency for 5-layer pixel VXD

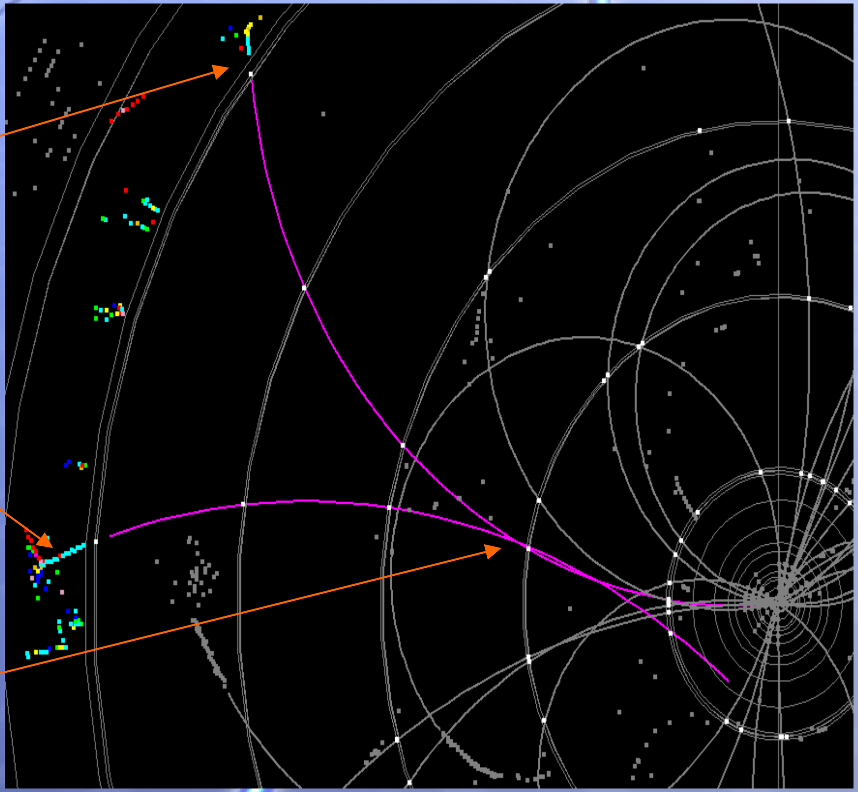
-> high efficiency for VXD+5 axial layer tracker

in the presence of backgrounds.

SiD tracking system

Interesting use of ECAL to find K^0s

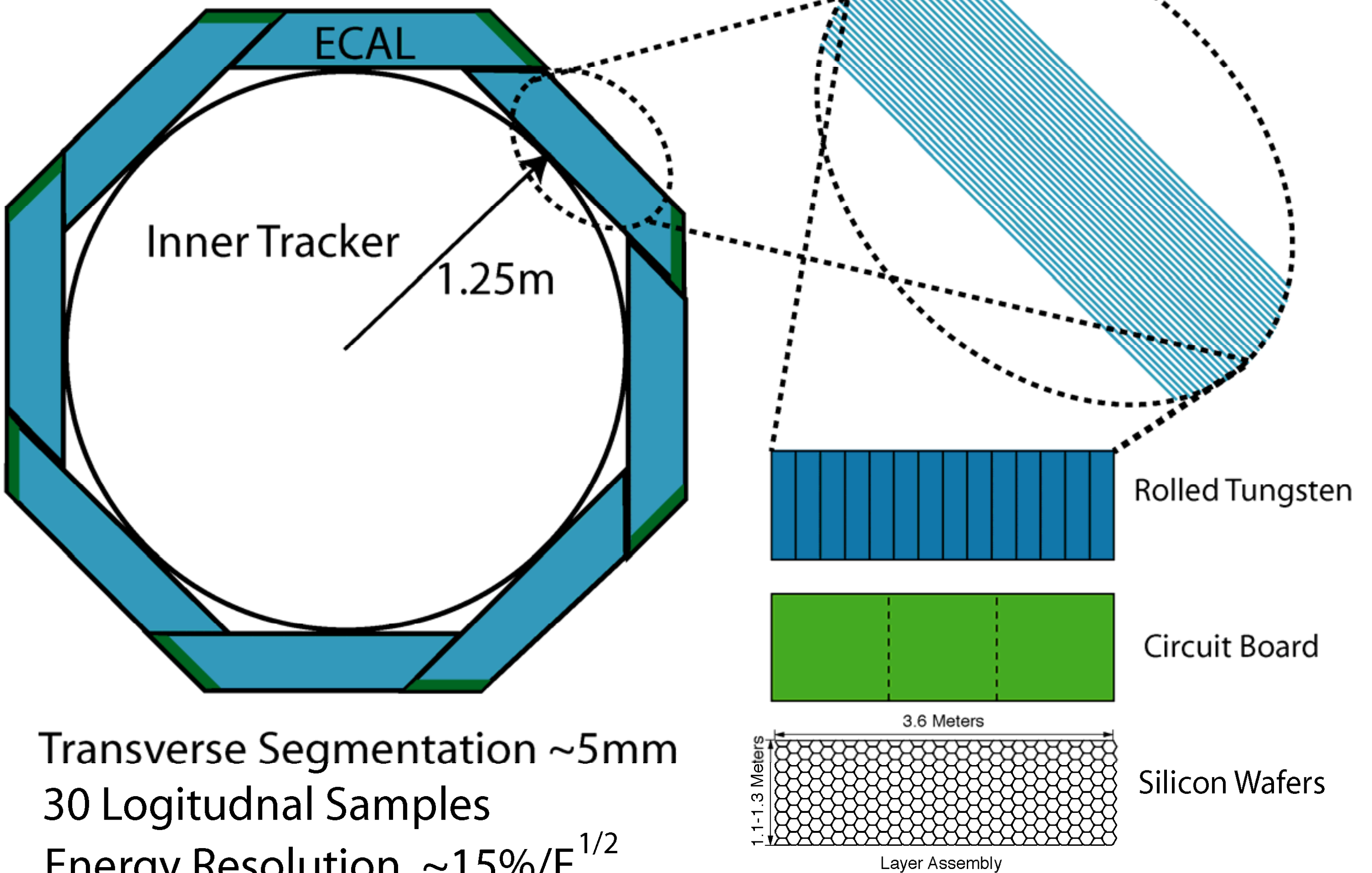
Track segments in ECAL



Extrapolation to tracker

(von Toerne, Ooprienko)

SiD ECAL



Transverse Segmentation ~5mm

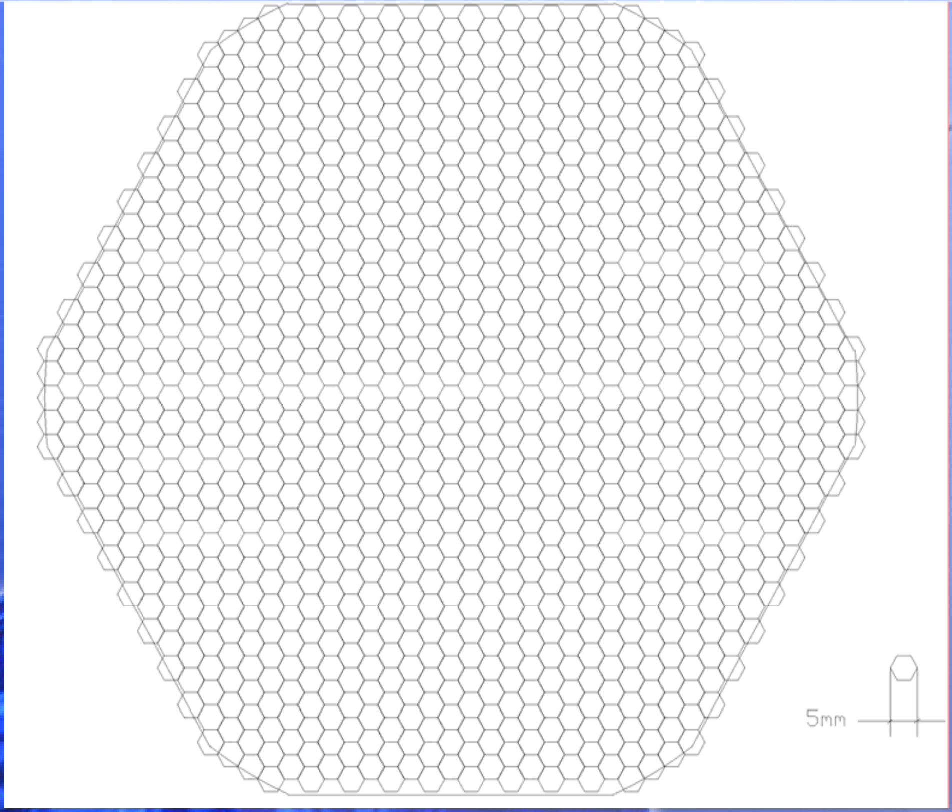
30 Logitudnal Samples

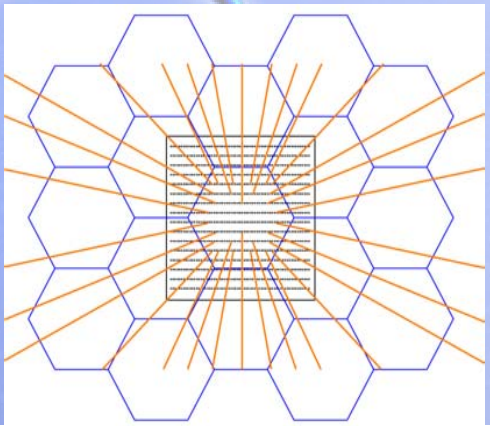
Energy Resolution ~15%/$E^{1/2}$

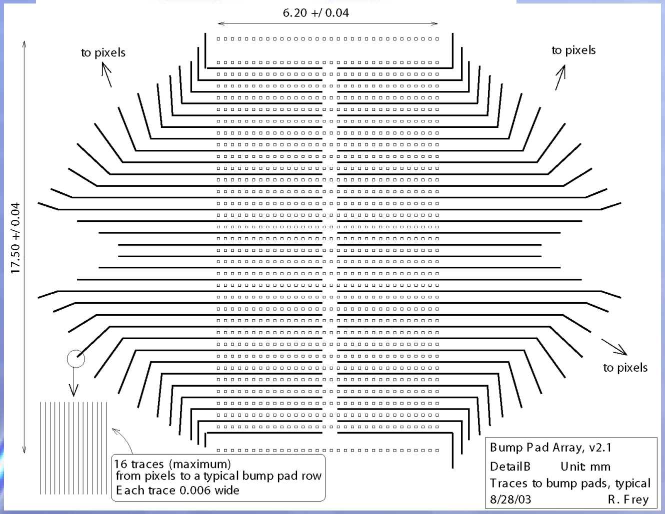
$5X5mm^2$ segmentation + absorber with small Moliere radius

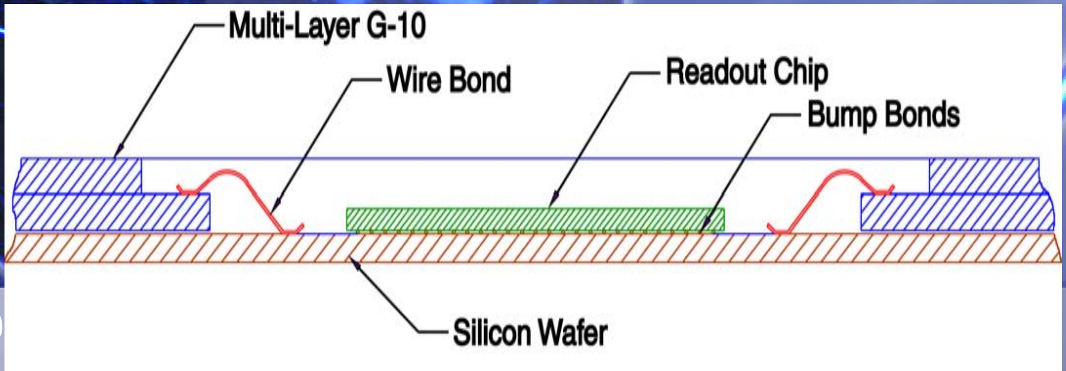
SiD ECAL

Wafer and readout chip





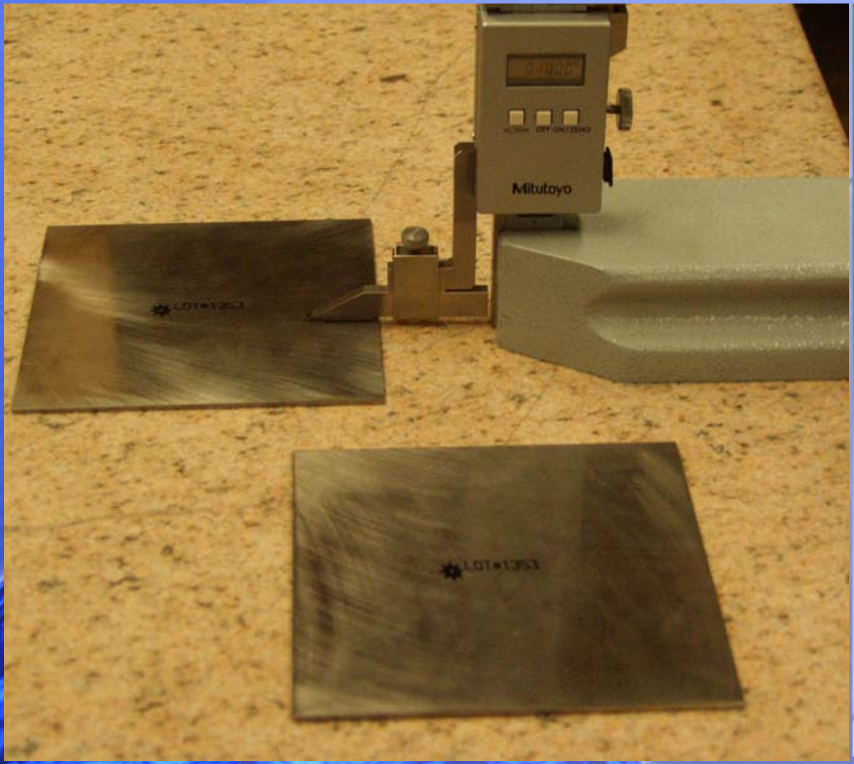


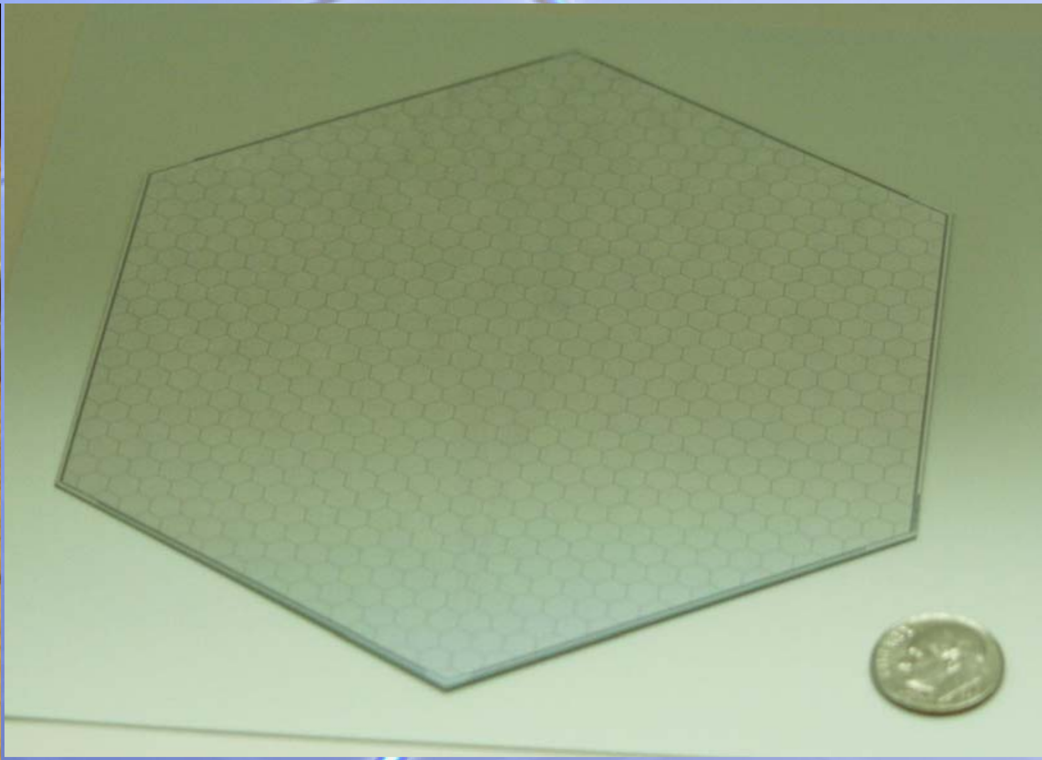


Concept: many channels (1-2K) on one ASIC

SiD ECAL

Components in hand





Tungsten

- Rolled 2.5mm
  - down to 1mm OK
- Very good quality
  - < 30 μm variations
- 92.5% W alloy
- Pieces up to 1m long possible

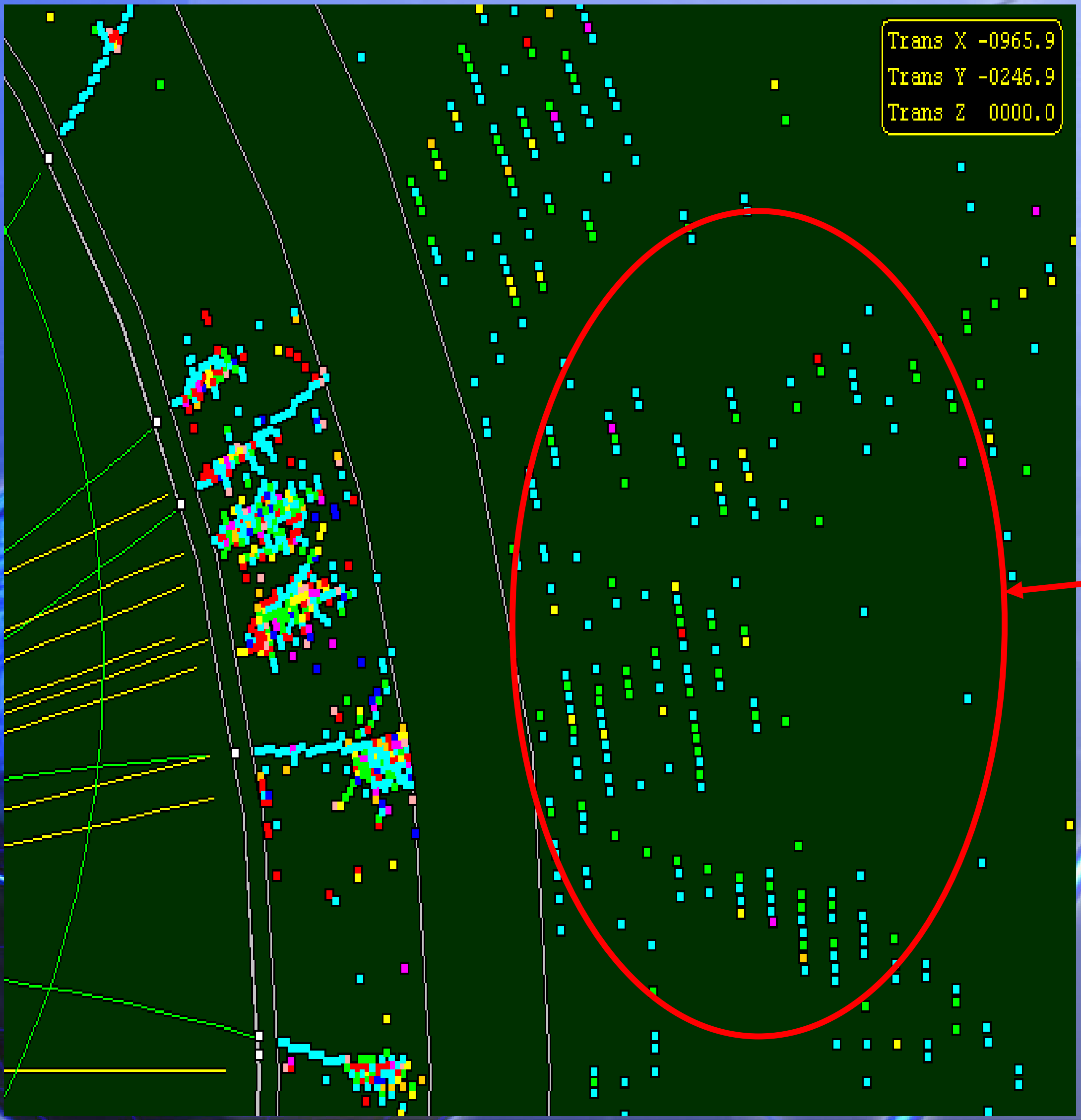
Silicon

- Hamamatsu detectors (10)
- Compatible with design concept for LC ECal (pixel size, traces, bump-bonding pads, etc)
- Lab tests look fine

SiD ECAL

- Issues:
- keep effective Moliere radius small – minimize gap.
- cold technology => use 4 deep buffering.
- # layers (30, 25, 20)? #X0 ?
- power cycling - passive cooling.
- If cost can be constrained, would increasing R (with BR2 fixed) improve physics performance?
- alternative technologies??
- Engineering is underway: U Oregon, BNL, SLAC

SiD HCAL

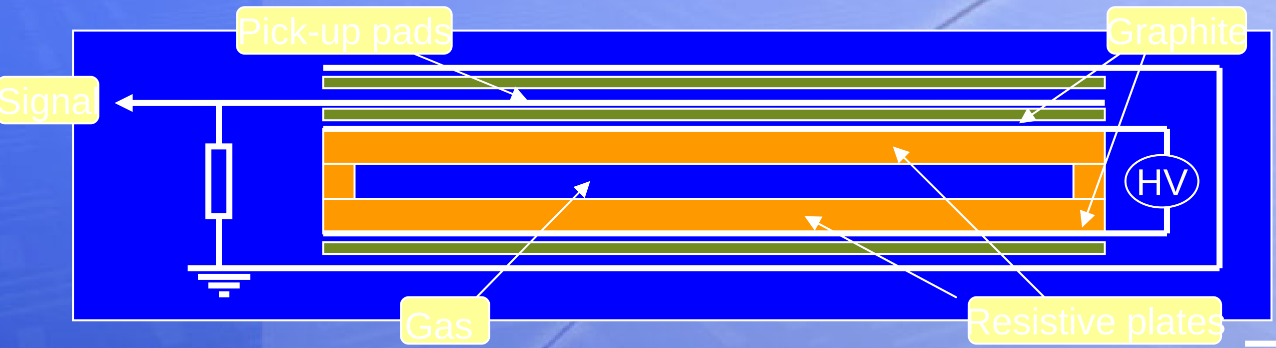


Major challenge – pattern recognition of energy clusters for EFA

SiD HCAL

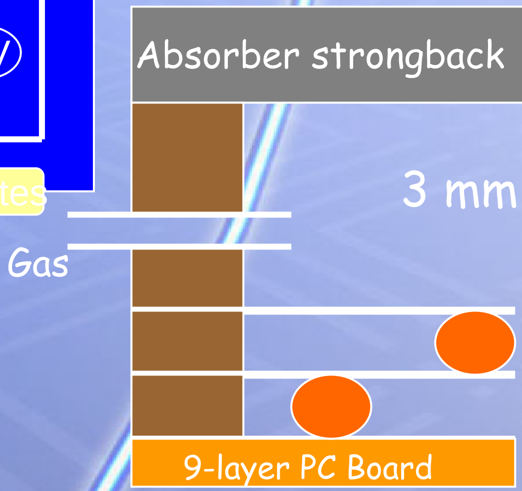
- Must operate with ECAL as integrated calorimeter system for EFA.
- Initial parameters:
-   - Inner radius 1.25m, Outer radius 2.44m
-   - HCAL is INSIDE the solenoid
-   - Steel absorber, 4λ thick (alternative: W absorber?)
-   - High degree of segmentation – is 1cm x 1cm correct?
-   - ~40 longitudinal samplings
-   - gap size < 1cm

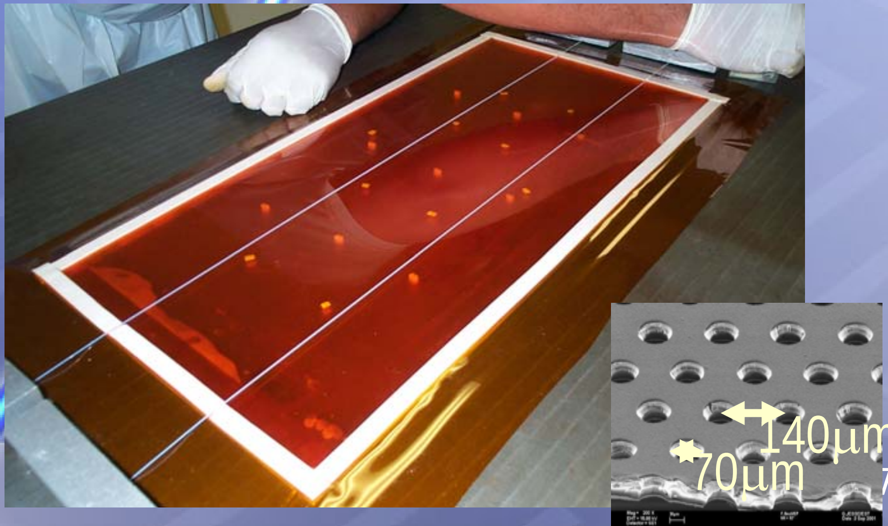
SiD HCAL



RPC

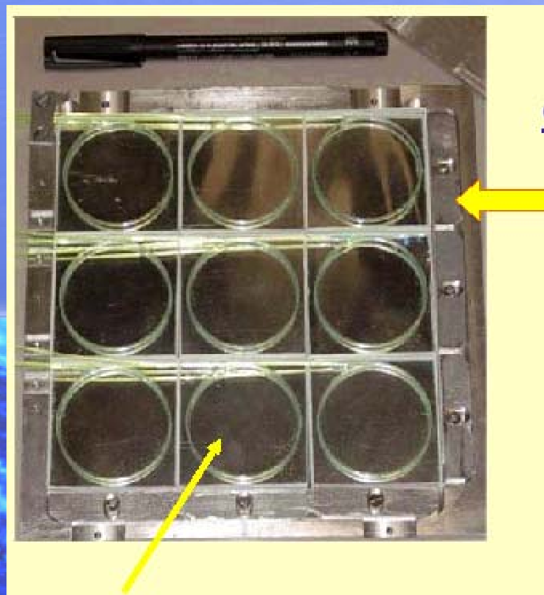
GEM

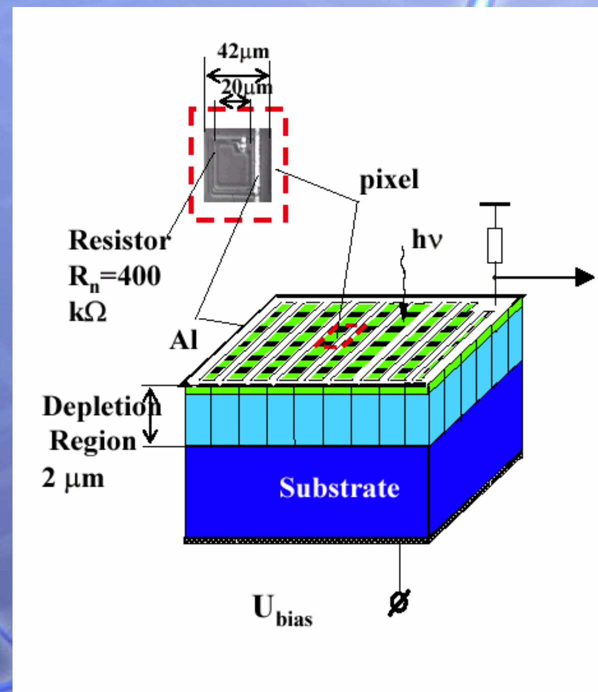




SiD HCAL – Digital/Analog

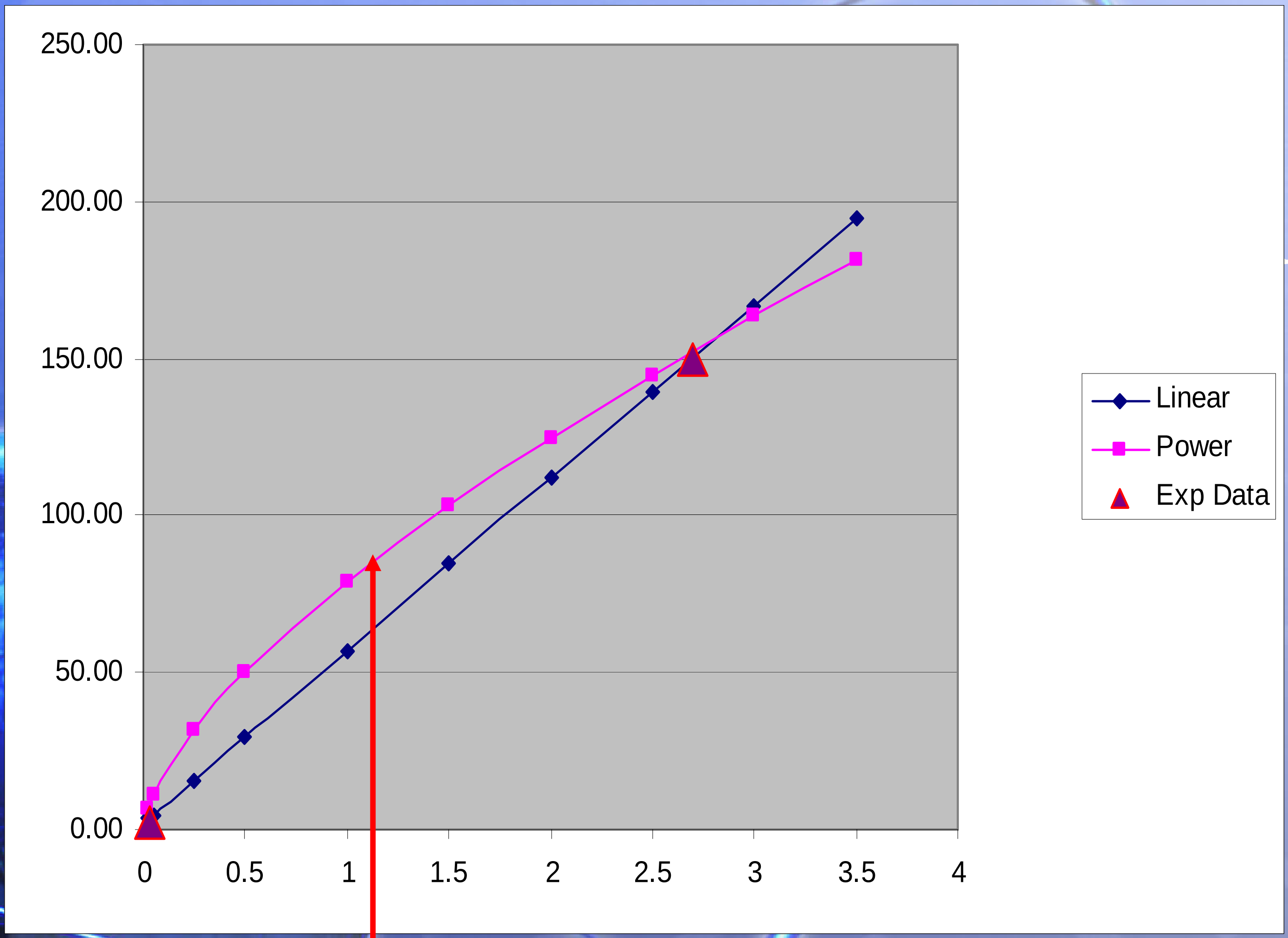
Scintillator/SiPM





SiD Solenoid

Cost
M$



SiD 1.1GJ

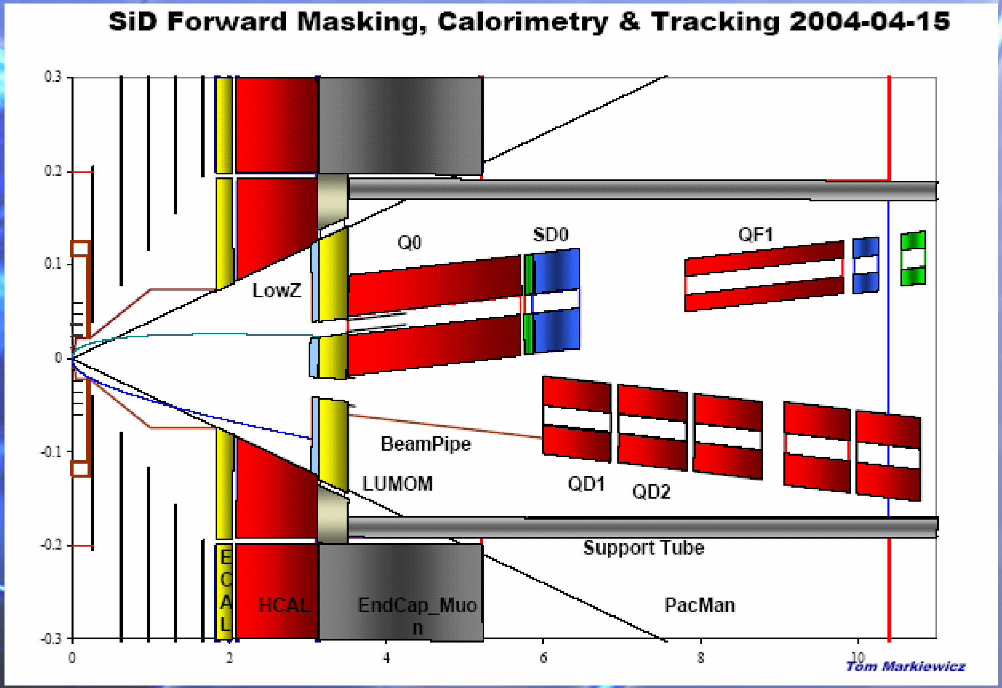
Stored energy GJ

SiD muon system/tail-catcher/flux return

- Initial parameters:
- R(inner) = 3.35m, R(outer) = 6.34m
- 44 layers, about 14λ
- Implementation: Scintillator/GEM/RPC?

Other subsystems

- Tracking in very forward direction.
- Calorimetry in very forward direction.



Summary

- SiD takes aggressive approach.
- It is technically challenging, but encourages the detector R&D activity.

  (and we have enough time to do…)
- Much work to be done on all systems.
- All those interested are very welcome to join in!

  Contact person : Hiroaki Aihara (Tokyo)

  e-mail: aihara@hep.phys.s.u-tokyo.ac.jp

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