SiD Optimization Studies

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The Road Ahead

Tohoku Expressway to Ichinoseki

Our task for the coming years
is to **secure the required resources** to build a detector

- that can deliver the physics we want to learn
- at the ILC with 250 GeV <= sqrts <= 1 TeV
  - preferably with an upgrade path
  - competing with another detector
- in the Kitakami mountain site in Japan
  - given the constraints of transport paths and the construction site
- that delivers competitive physics
- for 20+ years in a push-pull scenario

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Resources

Resources come in different forms

- Financial Resources
  - Optimize cost performance of the detector
- Expertise
  - Make sure we don’t fall into a generation gap
  - Single point of contact should not be a person
- Workforce
  - Productivity
  - Outreach

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Interlude – Collaborative Tools

- http://forum.linearcollider.org/
  - Email is a very exclusive medium. Use the online forum for asking questions.
- https://confluence.slac.stanford.edu
  - Use the wiki to document workflows.
  - If you are just learning a new workflow, use this to jot down notes.

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Goals for the Group

- To support members of the working group in their studies
- To disseminate working knowledge
  - Of the software and computing infrastructure
  - Of detector development activities
- To collaborate with the Physics group on defining the goals for optimization
  - Including use of analysis/reconstruction tools
  - Had talks on new jet finders, PID
- To coordinate efforts of optimizing SiD

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Work Items -- Tracker

- Air Cooling considerations in tracker design
- Tracker barrel should be longer
  - Identified benefit during LOI, not implemented in simulation
- KPIX buffer size in the forward region might be too small

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Work Items -- Calorimeters

- RPC simulation is inconsistent with beam test analysis
- Forward region layout leads to back-scatters into the FCAL (at 1 TeV. Needs to be studied at lower energies)
- MAPS for the ECAL silicon might allow synergies with ATLAS Hi-Lumi detector developments
  - If this helps to avoid range switching in the KPIX needs to be studied

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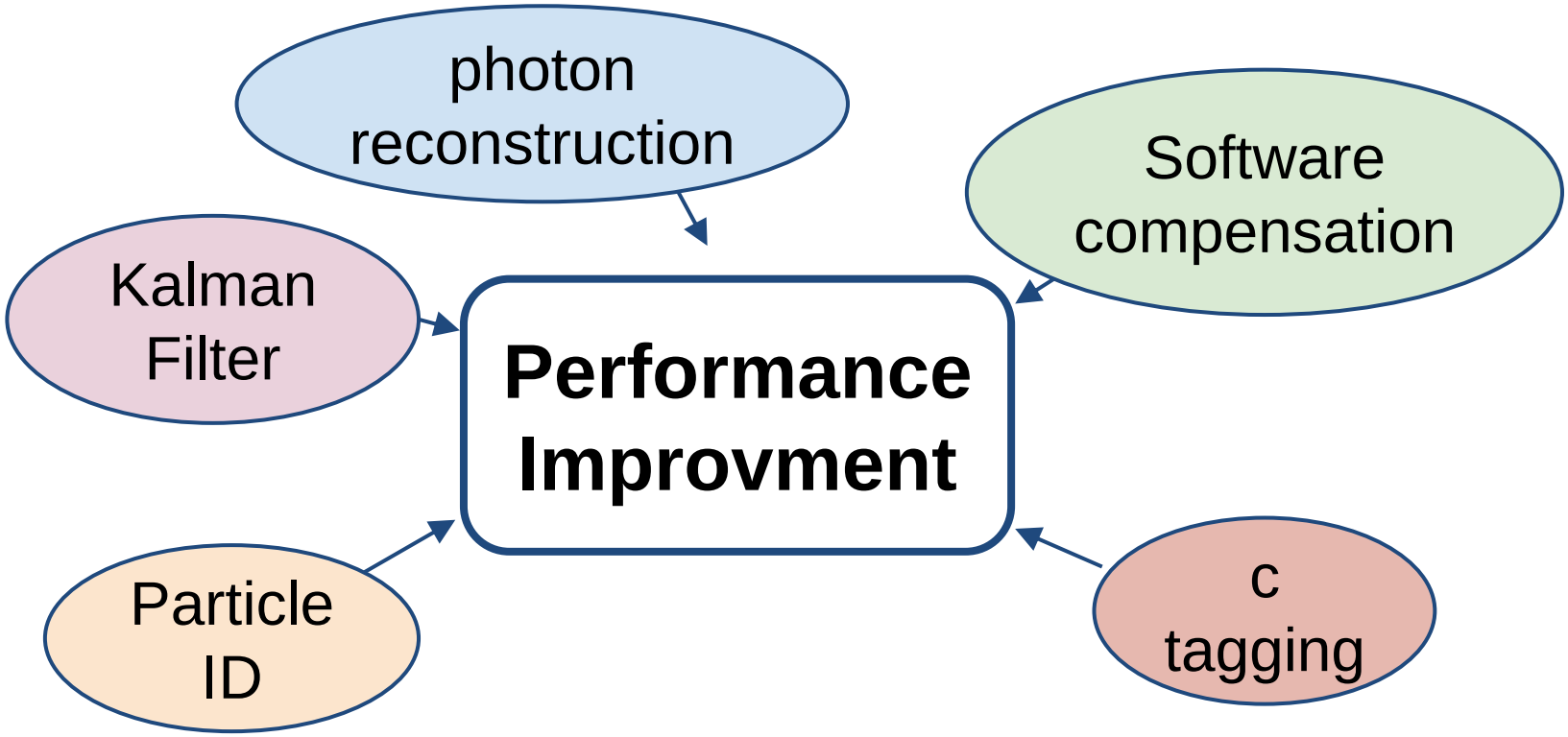
Reconstruction Improvements



The ILC detectors are advertised as having unprecedented resolution. We currently don't take full advantage of this information!

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Goals for Physics Performance

- LOI and DBD analyses have shown very little difference between ILD and SiD
  - Partly due to simplifications in the simulation
    - Vertexing in ILD
    - HCAL in SiD
  - Partly due to choice of benchmarks. Covering the mainstay of the ILC physics program. Where are the corners?
  - Partly just because the detectors are very comparable.
  - Going forward we have to do a better job of mapping out the limitations of our detector to understand what to optimize.

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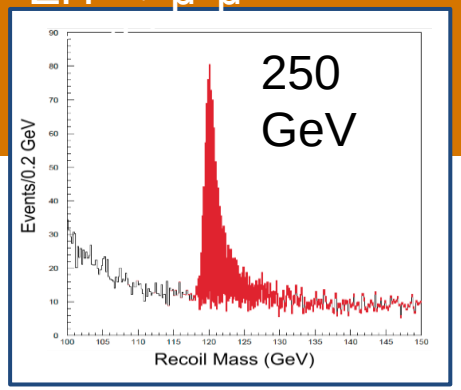
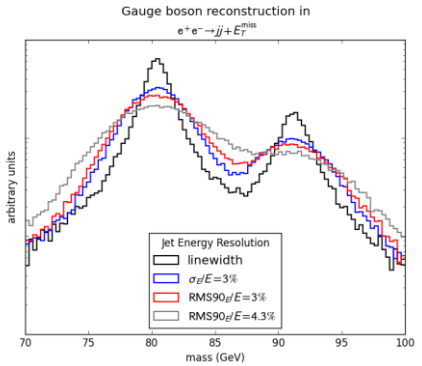
Physics Requirements

$ZH \rightarrow \mu^+\mu^- +$

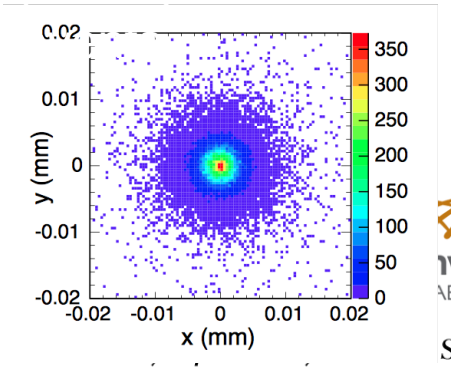


<u>Momentum resolution</u>
Higgs Recoil (at 350 GeV and above)
$\sigma(p_T)/p_T^2 \sim$ 2-5 x 10^{-5} GeV^{-1}



<u>Jet Energy Resolution</u>
Separation of W/Z/H bosons:
Gauginos, Triple Gauge Coupling
$\sigma(E)/E$ = 3.5%-5%

<u>Flavor Tagging</u>
Higgs Branching ratios
$\sigma_{r\varphi} \approx 5\ \mu m \oplus 10\ \mu m / (p[GeV] \sin^{3/2}\theta)$



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Reality Check

- Where are we on the physics performance curve with these parameters. Is there a cliff?
- Tracking performance:
  - Higgs recoil @ 250 GeV not limited by pT resolution (→Tim)
  - Impact of low-pt tracks on vertex charge?
- Calorimeter Performance:
  - In physics events, jet clustering often times limits performance.
  - This might or might not improve in the future.
- Vertexing:
  - Excellent for b-tagging.
  - Should expand more into c-tagging and tau-vertexing.

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Infrastructure

- Our current sim/reco infrastructure would take us probably to, but not through the TDR
  - Some investment needed NOW
  - → Norman's talk
- Computing for DBD happened mostly at RAL/CERN
  - Going forward PNNL will improve integration of resources into standard workflows.

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RECAP OF ACTIVITIES

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Topics Recap

- Single Particle studies – DESY
  - Proof-of-principle comparison of scintillator vs. RPC HCAL
- ECAL optimization studies – SLAC
  - Performance with different number and dimensions of W
- Tracking studies – ANL
  - 5 single layers → 3 double layers
- Vertex reconstruction studies – Bristol
  - Longer VTX barrel
- Forward region – UCSC

- New Jet Finders – Valencia
- Particle ID – Tokyo

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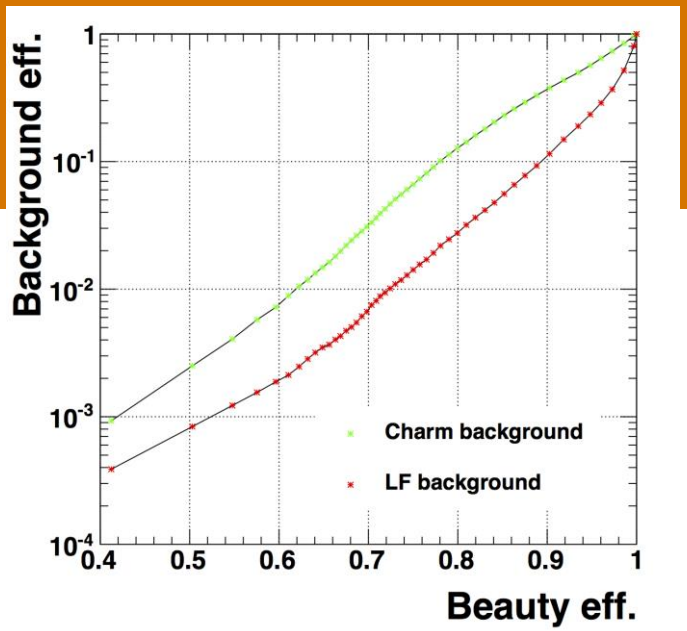
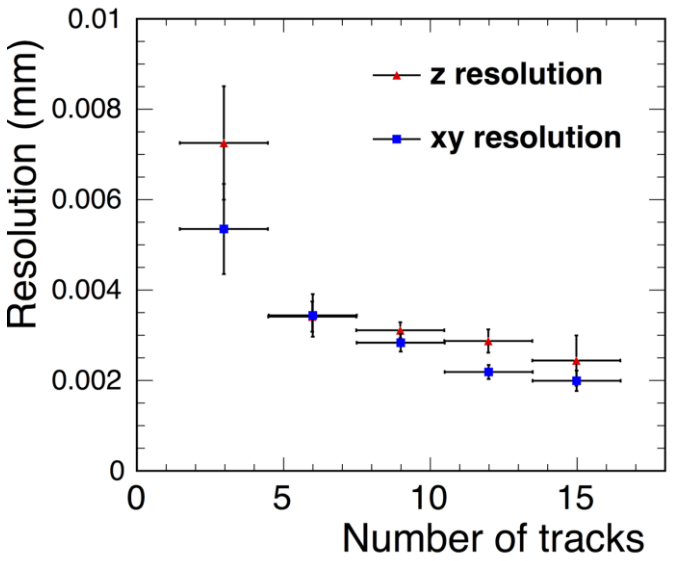
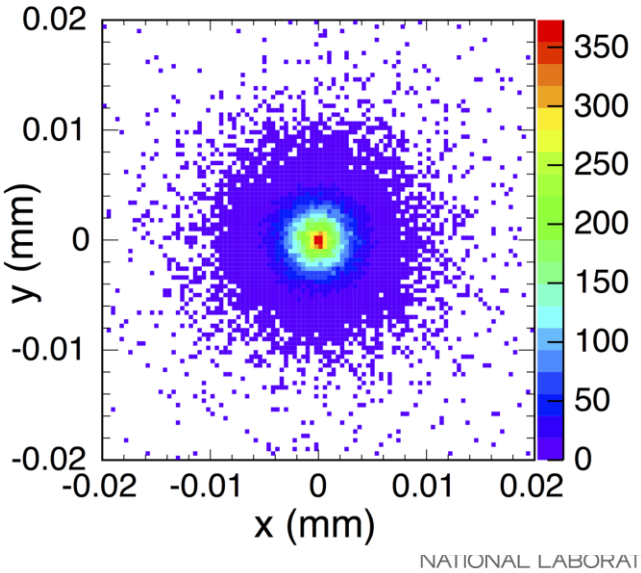
SiD Vertexing in the DBD

Excellent Flavor tagging performance at 1 TeV even in presence of background from production of e^+e^- pairs and hadrons from the beams.







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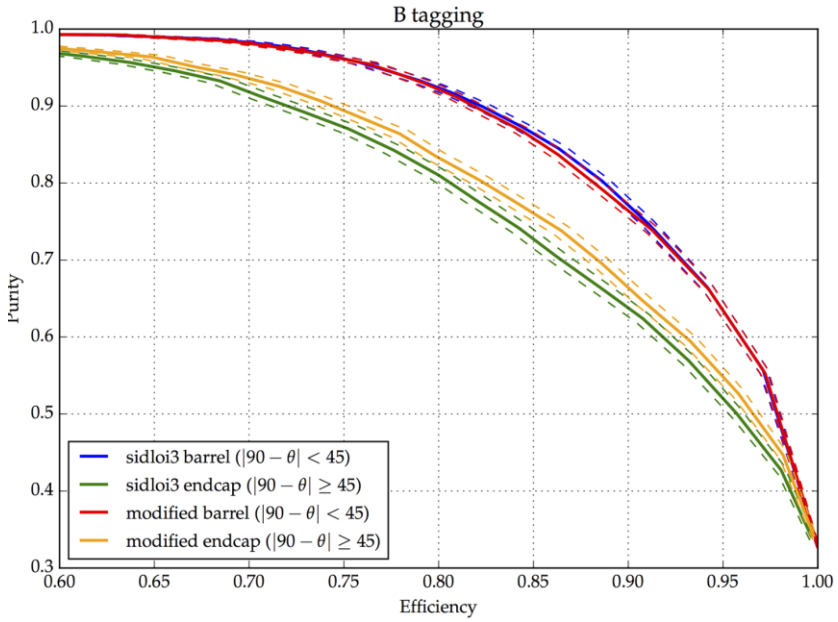
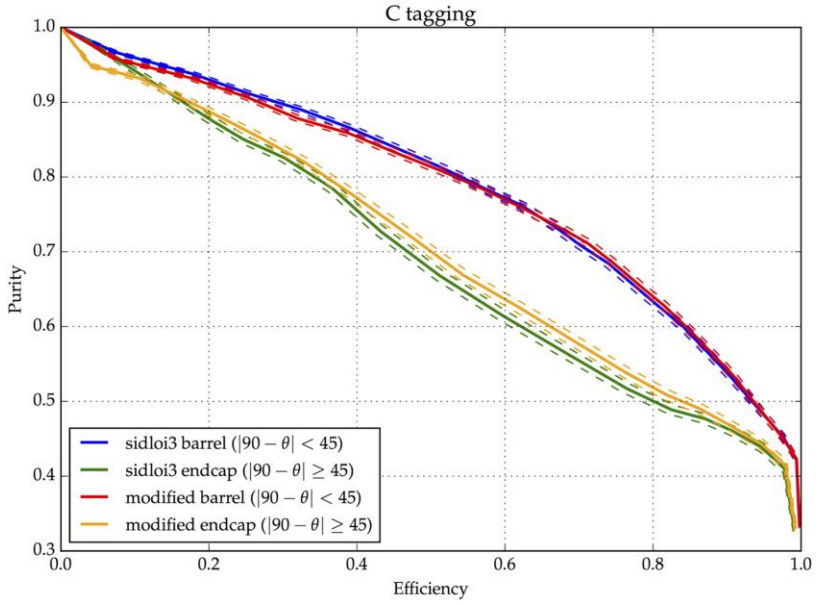
Vertexing -- Optimization

Changing the Vertex Barrel length, moving the disks out.





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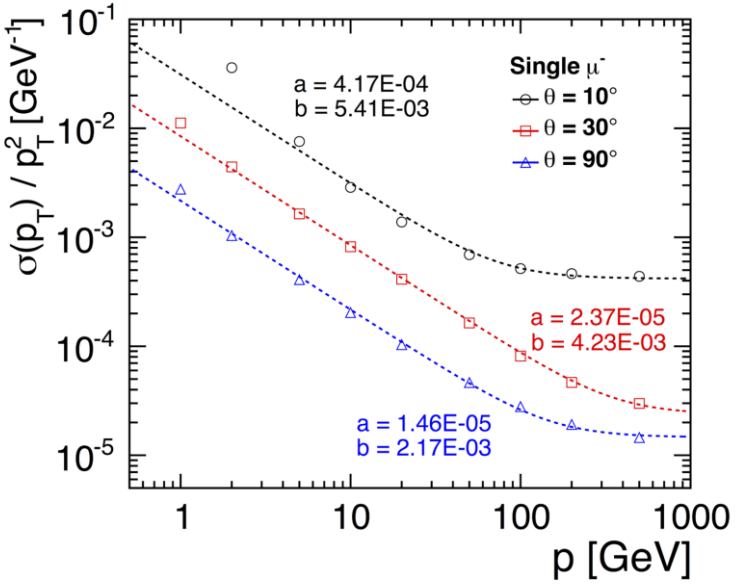
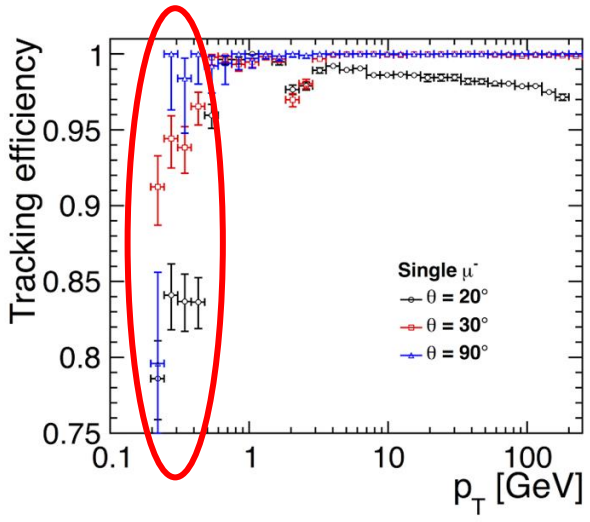
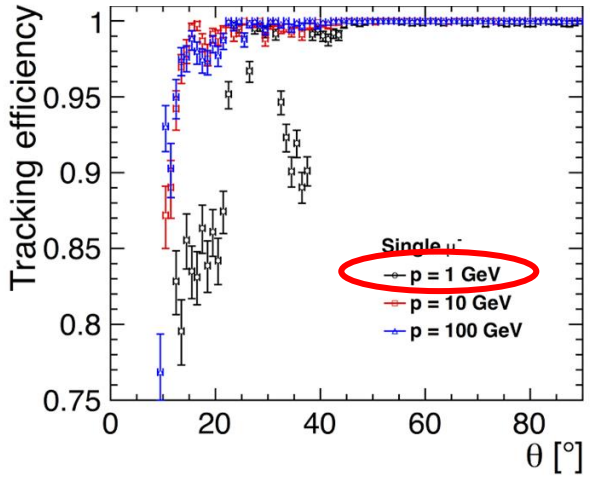
SiD Tracking in the DBD

Excellent impact parameter resolution and tracking efficiencies for high energies down to low angles (~10º).

Obvious weaknesses exist in the low-pt region.







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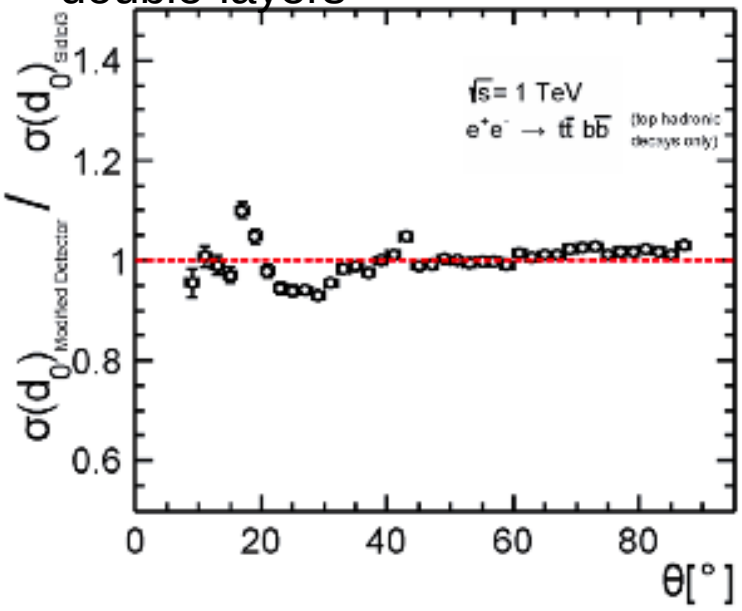
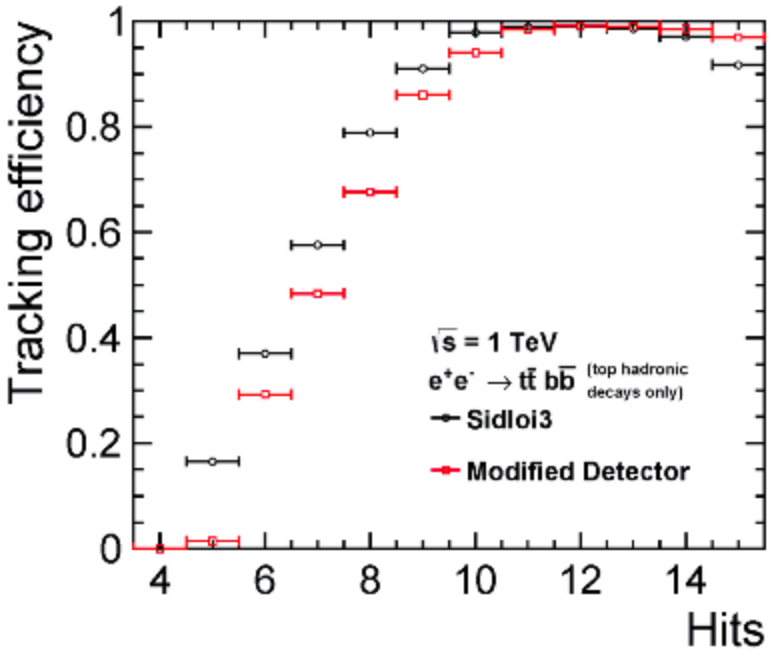
Tracking -- Optimization

Changed the layout of the vertex detector barrel from 5 single layers to 3 double-layers





Impact parameter resolution shows no significant change with 3 double layers

Tracking efficiency vs. number of hits decreases for 3 double layers in the VTX

From Sagar Setru, ANL

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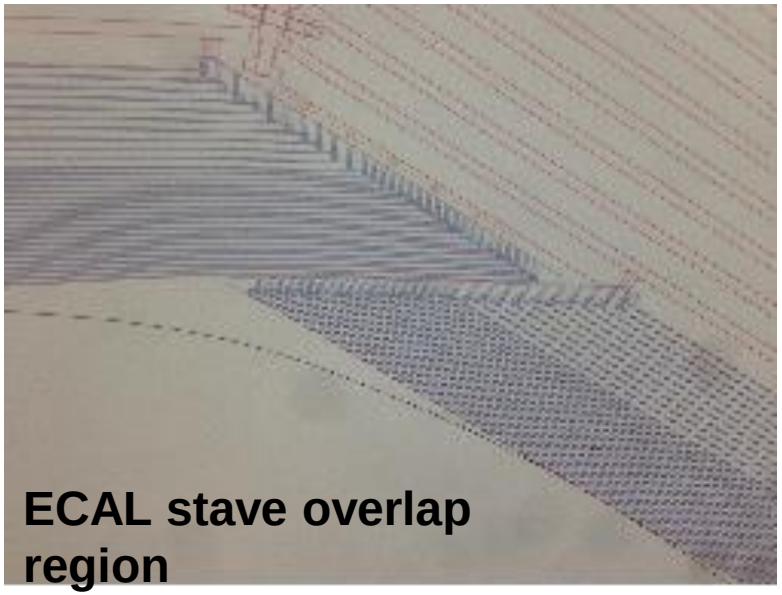
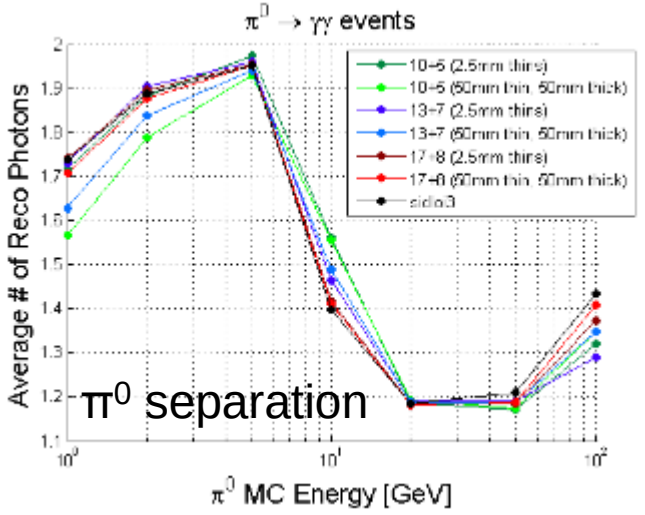
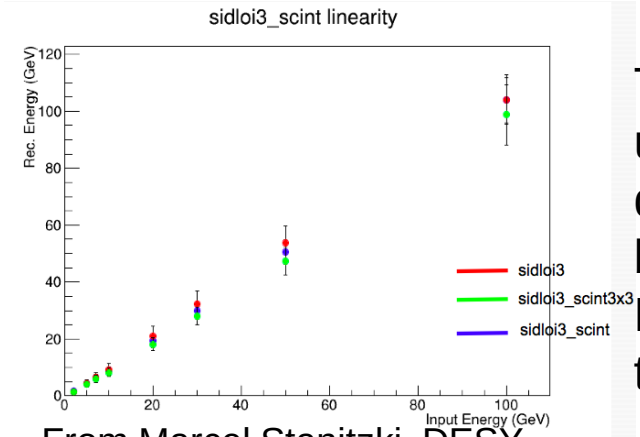
Calorimetry -- Optimization



ECAL stave overlap region

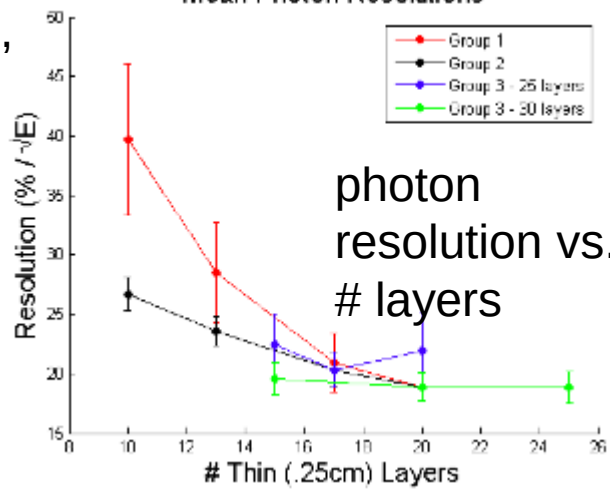


From Da An, SLAC



From Marcel Stanitzki, DESY

Trying to understand differences between HCAL technologies



photon resolution vs. # layers

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Summary

- SiD is in a transitional state towards a real project
  - We have a site, but no host nation
  - We have a detailed cost estimate, but no budget
- The detector is a crucial part to help make the physics case
  - Better technology (hardware or software) leads to better performance
  - We have weekly meetings where we exchange ideas. New members are welcome!
- For the next year, we should think about a document that would help streamline our efforts and lead into the TDR.

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Studies of different calorimeter variants

Jan Strube (PNNL)

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Introduction

- The current baseline of our RPC-HCAL simulation meets the performance requirements for an ILC detector
  - We know that the simulation does not adequately reproduce beam test performance
- Reducing the requirements for high voltage and gas lines simplify engineering
- The CALICE scintillator tile HCAL shows good performance in beam tests.
  - Investigate performance in SiD

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The Setup

- Some simplistic study done during DBD (April 2012)
  - Replace RPC with scintillator (6 mm), 1 cm and 3 cm tiles
  - Simplistic digitization (Gaussian smearing)
  - Basic calibration
- This time:
  - More realistic dimensions of the active layers.

SLIC 3.0.1 (latest version found to work)

lcsim-3.0.3

slicPandora from July 2013

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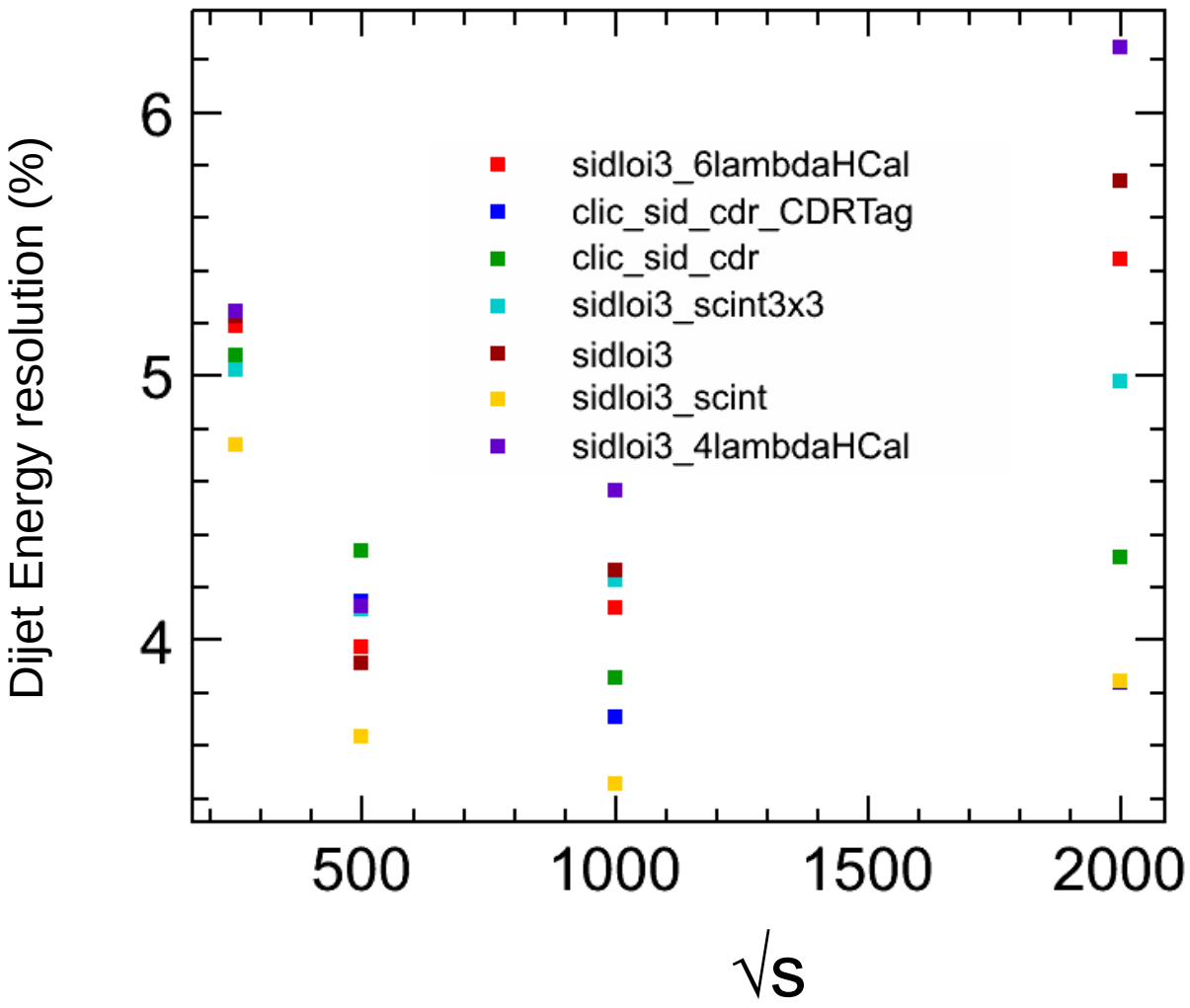
Overview

- Evaluate the performance of a scintillator AHCAL variant
  - square tiles, 0.5, 1, 2, 3, 4, 5 cm side length
- Evaluate performance of a “generic DHCAL”
  - using scintillator tiles with a threshold
- Using DESY AHCAL prototype dimensions
  - only varying tile size

http://agenda.linearcollider.org/event/6389/session/5/contribution/78/material/slides/0.pdf

Reminder: Studies during DBD



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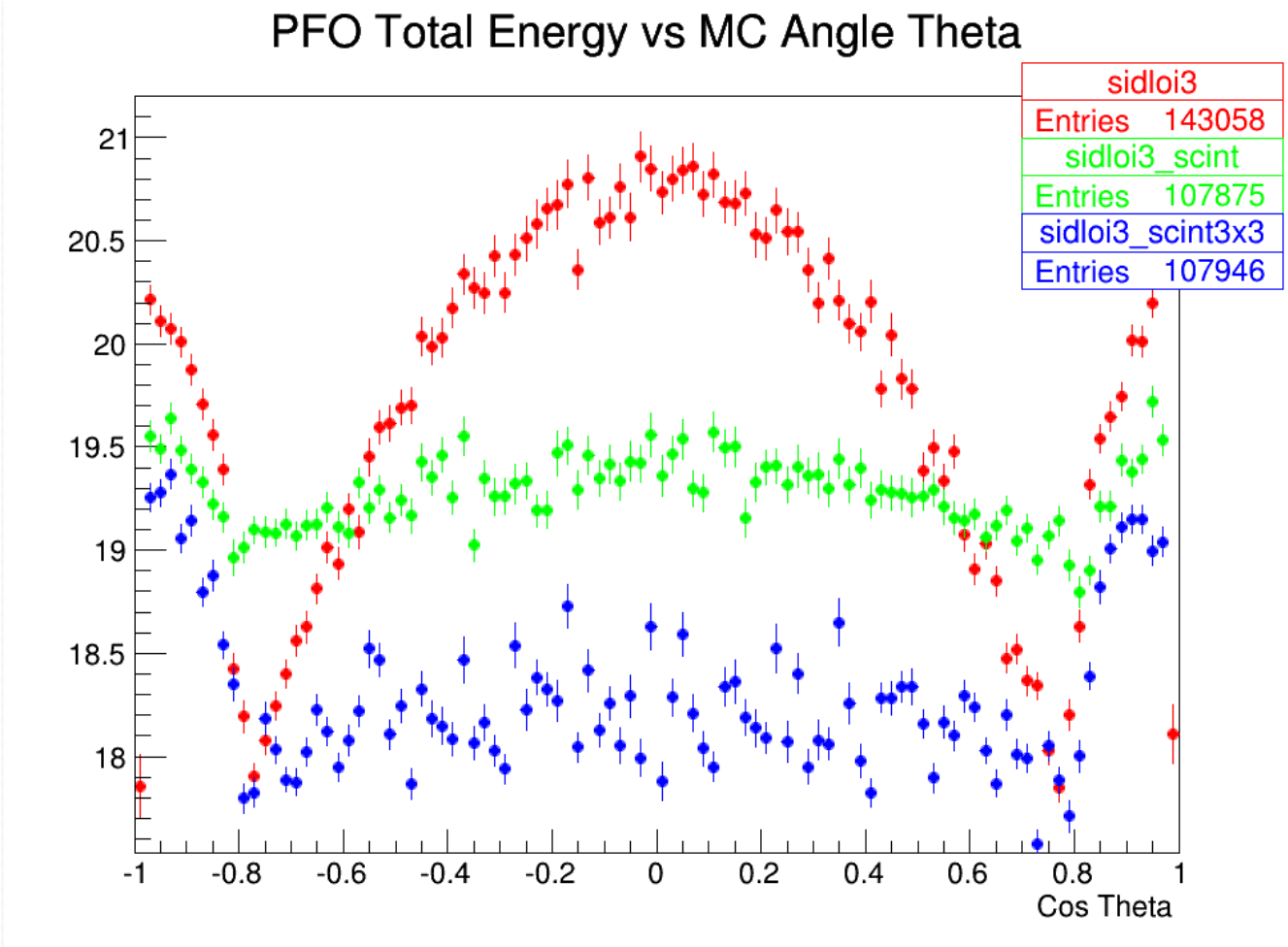
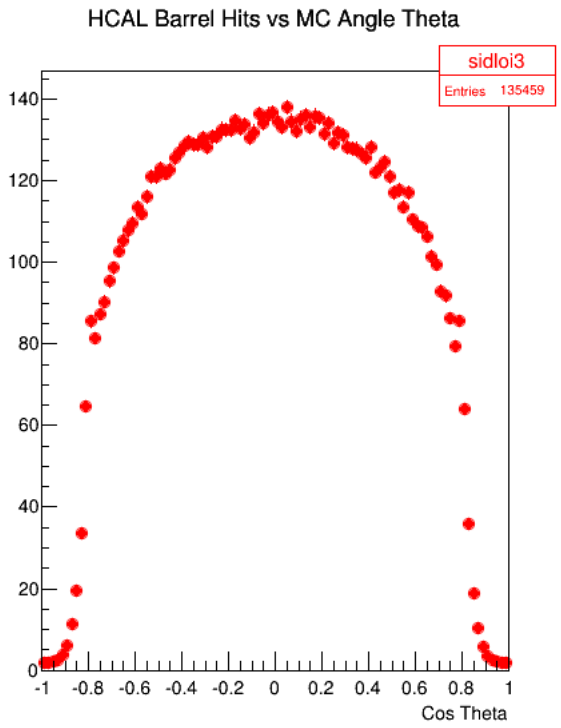
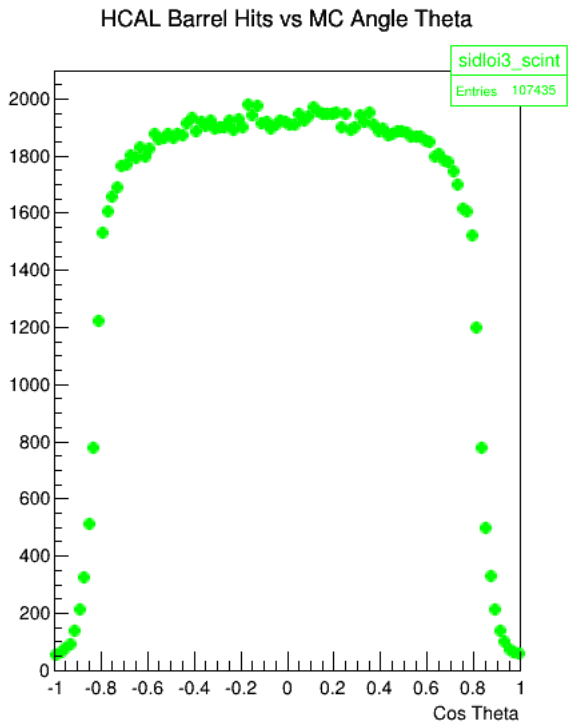
20 GeV Neutrons

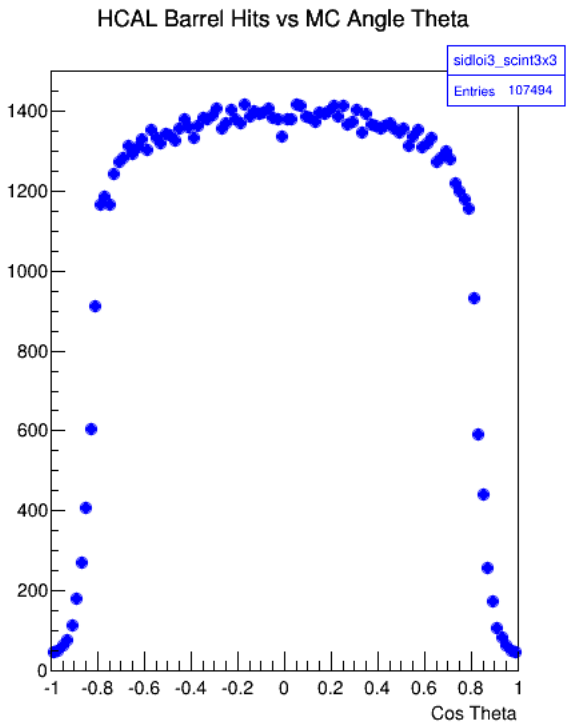


From Marcel Stanitzki, DESY

20 GeV Neutrons II







From Marcel Stanitzki, DESY

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New Scintillator variants

- During DBD scintillator variants were just implemented for cross-checking the reco
  - Was the first time Digital HCAL was used in PandoraPFA
  - It worked well enough
- For evaluating an AHCAL as a serious option, we need to go to a more realistic design

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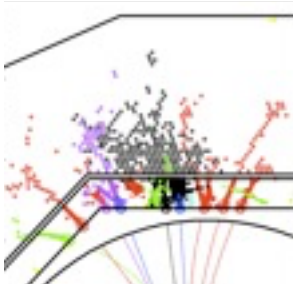
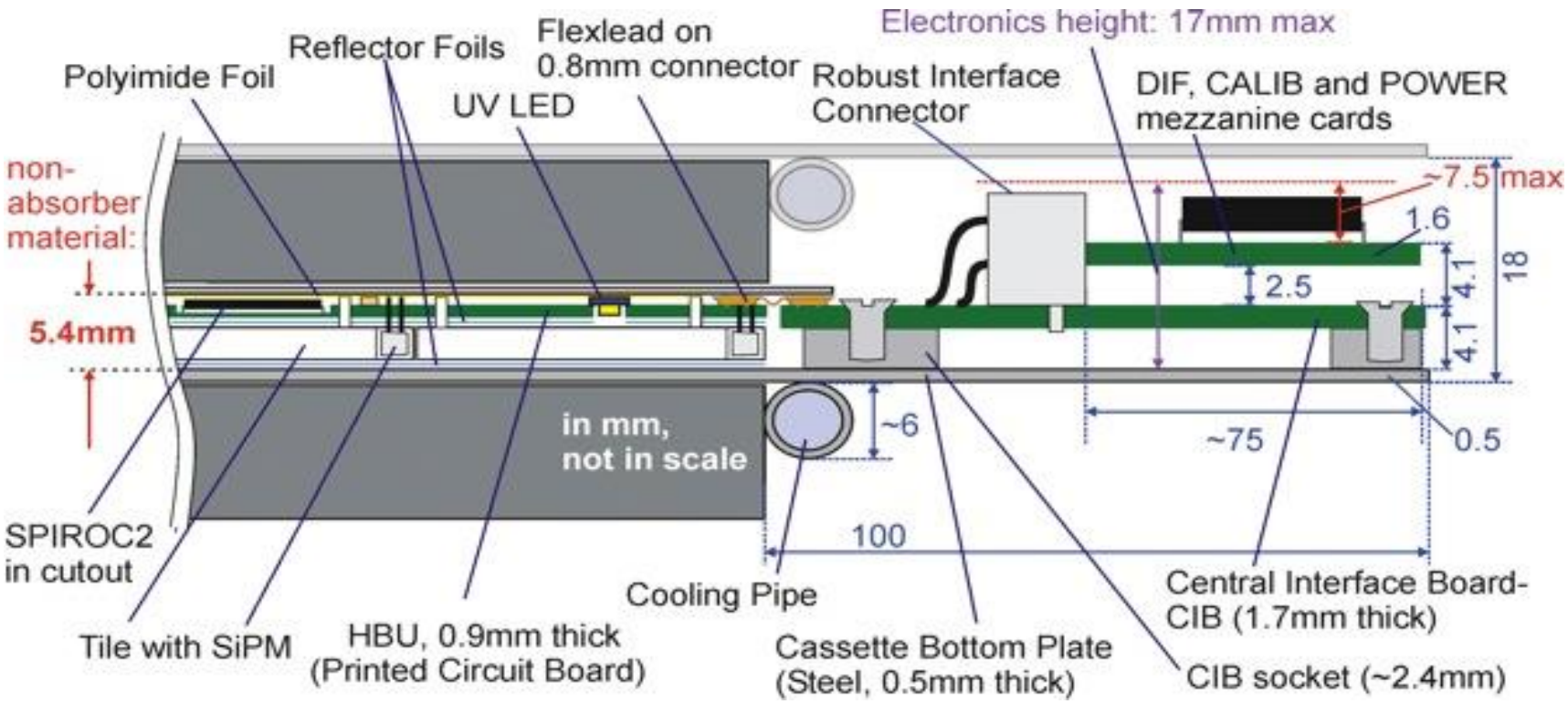


Layer cross section



http://agenda.linearcollider.org/event/6389/session/5/contribution/78/material/slides/0.pdf

HCAL Barrel Comparison

Before:

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After:

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Status and Plans

- Calorimeter Variants:
- Pad sizes 0.5, 1, 2, 3, 4, 5 cm implemented and calibrated.

- Validation has started
- For a serious evaluation, we need a better understanding of
  - Reco software performance
  - Noise simulation
- Remove the air in the AHCAL

- How do we evaluate a choice of DHCAL and AHCAL given the current status of the simulation?

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