SiD Design Updates
Parts 1 & 2

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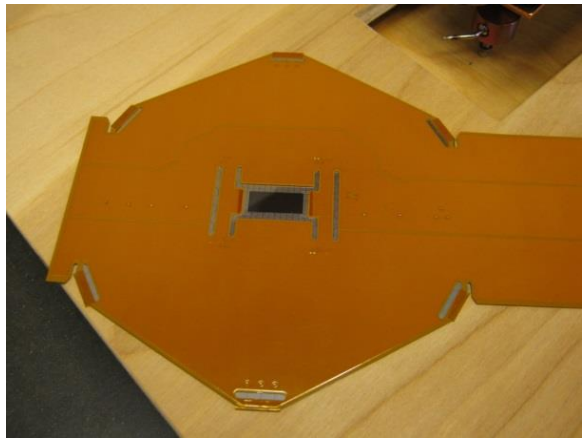
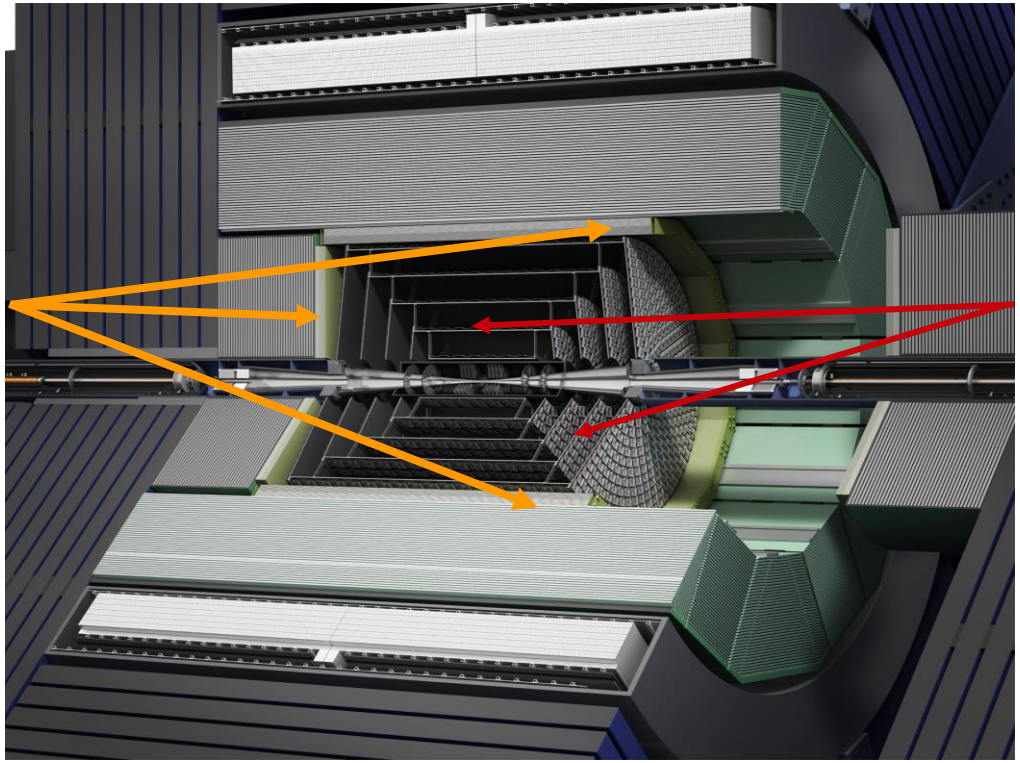
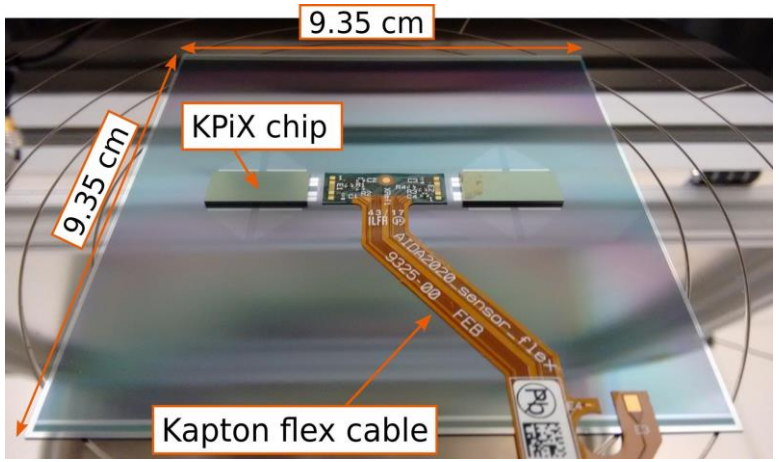
DESY

LCWS 2021
March 17, 2021



ECAL:
1200 m^2 sensor area





Tracker:
67 m^2 sensor area

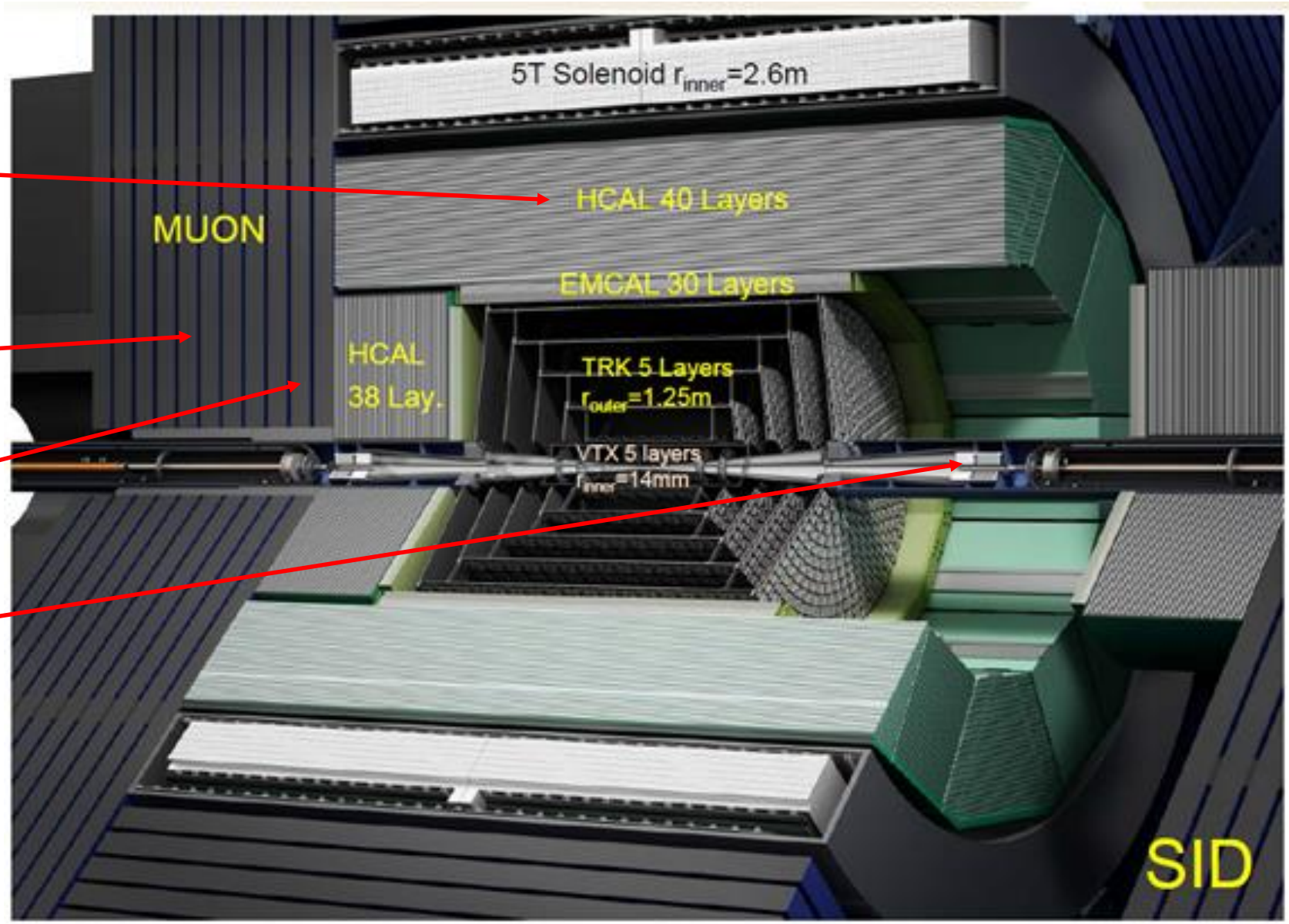
MAPS for SID

- Moving from “classical” silicon to MAPS brings many benefits
- MAPS from the Vertex to the ECAL
  - Potential synergies
- Things that would need to be studied
  - What is the ideal pixel size for the Tracker/ECAL
    - 25 x 100 μm ?
  - Pixel readout Analog(ADC) or Digital(binary) ?
  - Revisit DBD studies for digital ECAL
  - Buffer sizes, occupancies → how do they change ?
- What does 65 nm technology offer ?
  - Electronics integration
  - Stitching

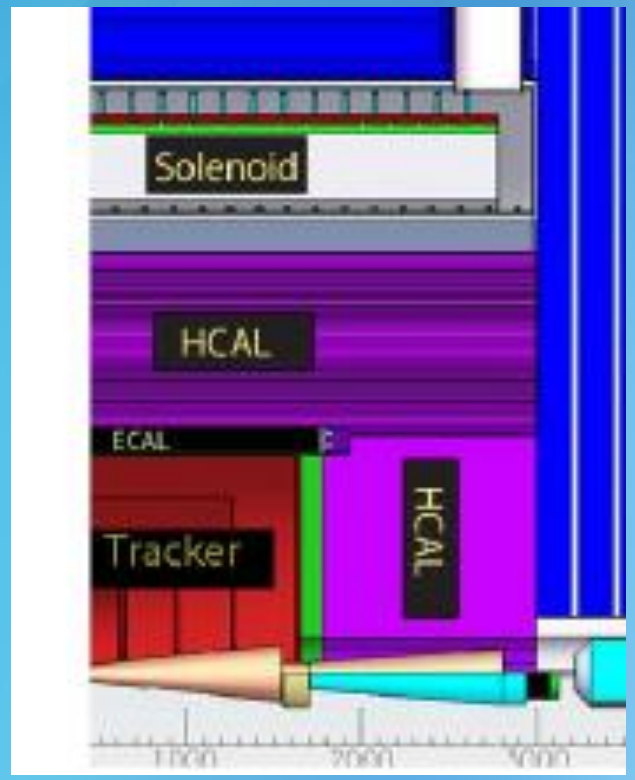
Timing layers

- The area with most open question
- Time-stamping
  - Assigning each hit to an ILC bunch (554 ns) – SiD baseline
- Intra-bunch timing
  - Hit timing relative to BCO – ns resolution
- Precision timing
  - Time-of-flight
  - Full-blown 4D Tracking
  - Here we're talking of 10 ps as a goal – Factor 4-5 better than HL-LHC
- Room for new ideas and studies

- Hadron Calorimeter
- Return yoke
- Muon detector
- Forward systems
- MDI

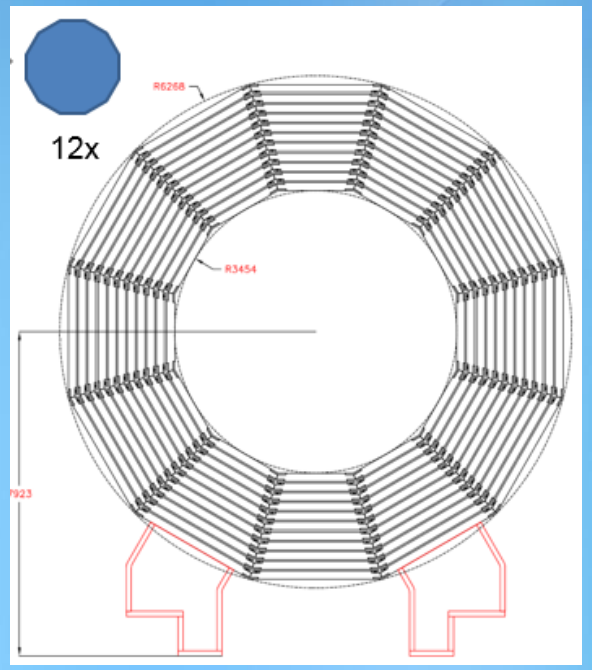


SiD Hadron Calorimeter



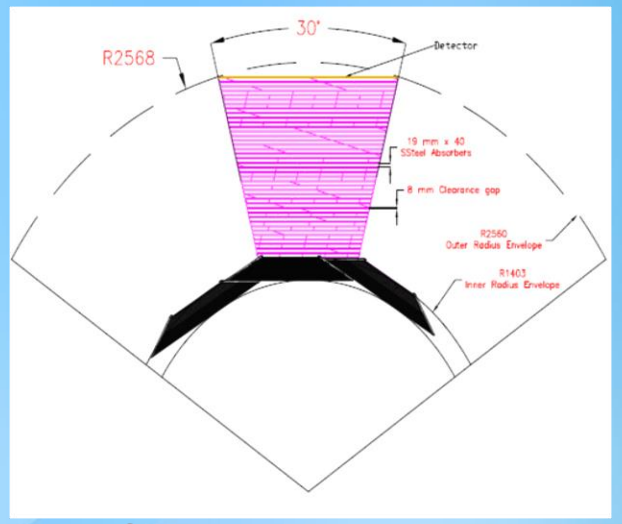
12-fold barrel geometry

Marco Oriunno (SLAC)



Baseline technology for the SiD HCal is Scintillator/SiPM/Steel

UTA, SLAC



Hadron Calorimeter

- Baseline is Scintillator tiles/Steel/SiPM.

- Inclusion of timing layers to assist the particle flow algorithm in separating the delayed shower components from slow neutrons from the prompt components.

- potential cost saving by making some of the outer layers thicker if there is no significant degradation in energy resolution.

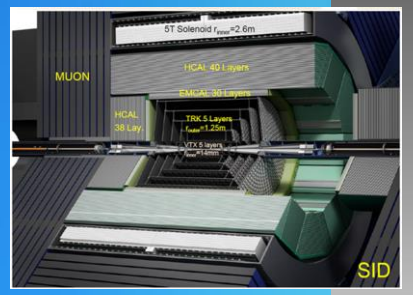
- optimization of the boundary region between the ECAL and the HCAL and optimization of the first layers of the HCAL to best assist with the measurement of electromagnetic shower leakage into the HCAL.

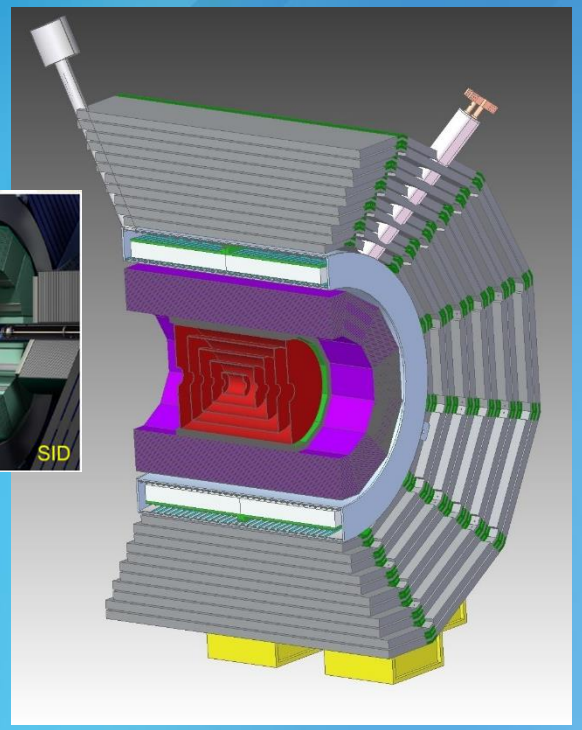
- reconsideration of the effects of projective cracks between modules.

- exploration of alternative layouts for HCAL sectors in the end-caps.

- optimization of the boundary between the HCAL barrel and end-caps.

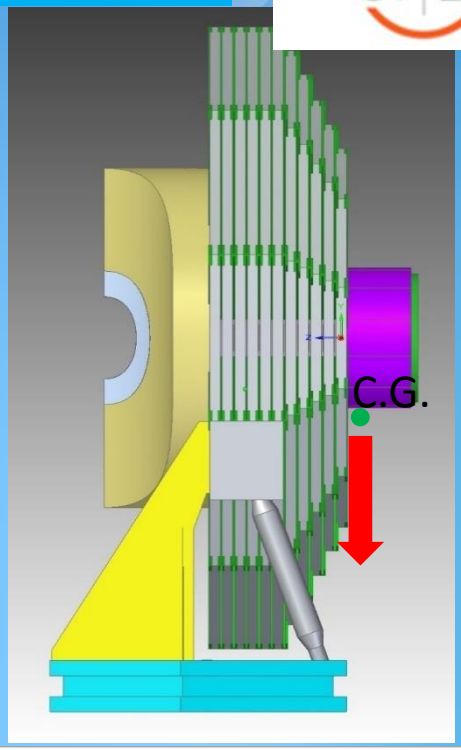
Muon identifier/Calorimeter Tail Catcher

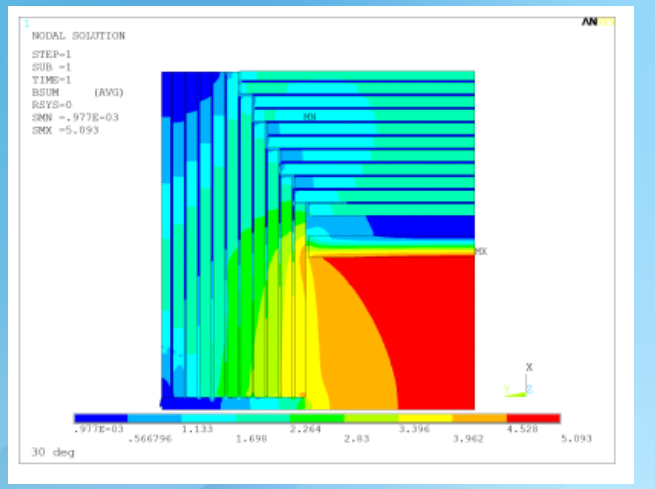


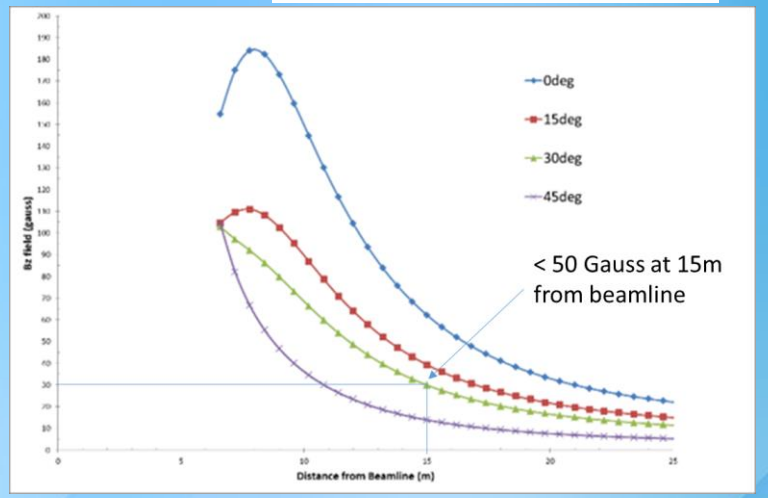


Redesign of barrel/door junction
More efficient flux return
Easier transport/handling

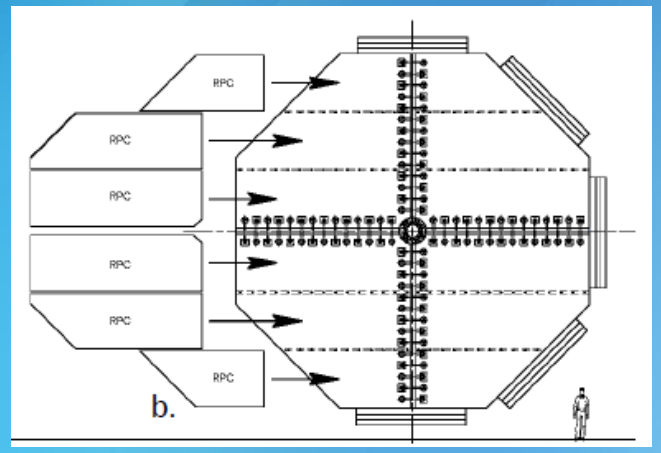
Marco Oriunno
(SLAC)

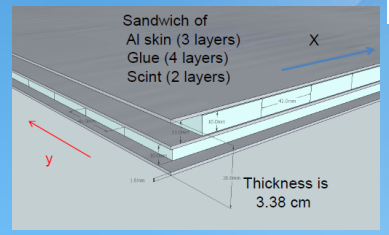


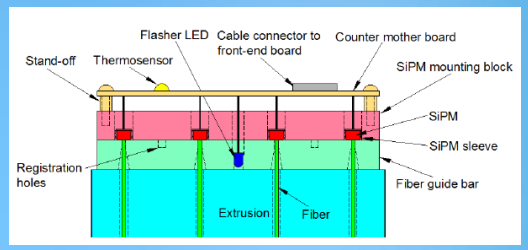




Muon identifier/Calorimeter Tail Catcher



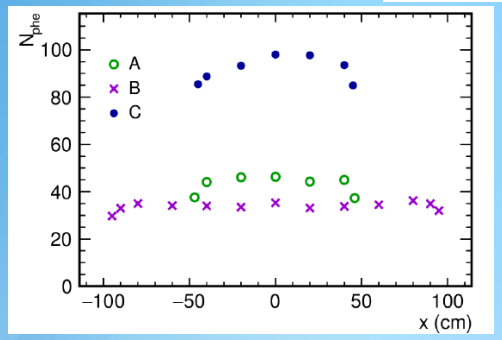




SiD Baseline – long scintillator strips with WLS fiber and SiPM readout

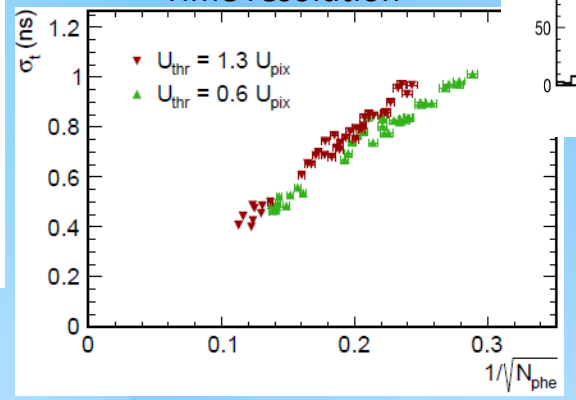
- Consistent extension of the baseline HCal scintillator technology
- Need to optimize number of layers, strip dimensions.

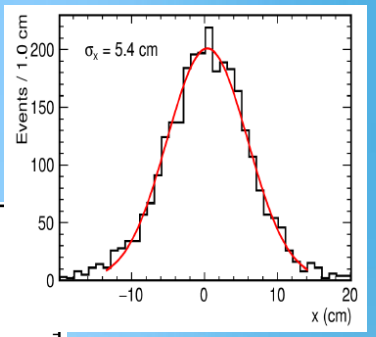
Development work at Fermilab:



Paper published:
NIMA, **848**, 54-59, 2017

Time resolution





Position resolution

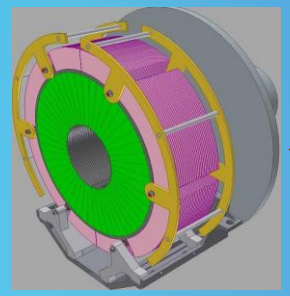
Muon identifier/Calorimeter Tail Catcher

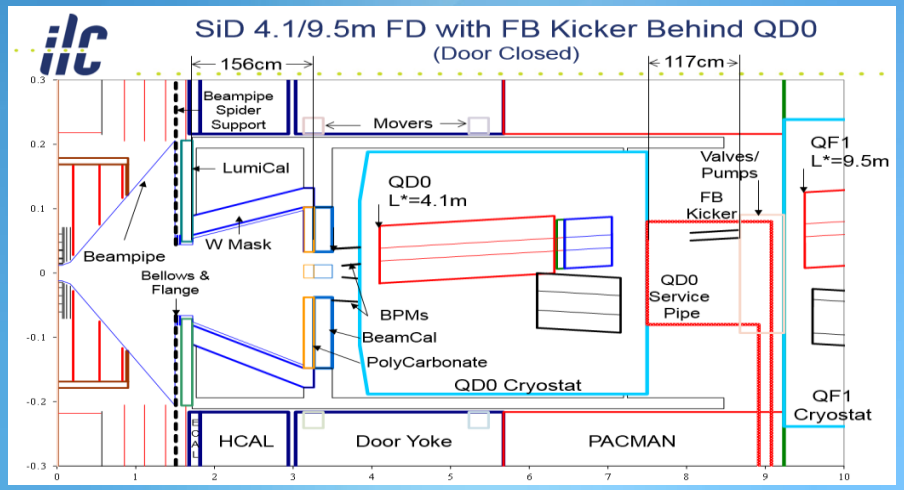
- Potential for use of muon system in search for long-lived particles; timing and pointing capabilities.
- Role of muon system as tail-catcher for HCAL. Consideration and implications of CALICE ECAL + HCAL + Tail-catcher test beam results.
- Optimization of number of instrumented layers, barrel and end-caps.
- Optimization of strip lengths, mainly for barrel system.
- Design for muon endcaps - twelve-fold geometry.
- Occupancies at inner radius of muon end-caps versus strip widths.

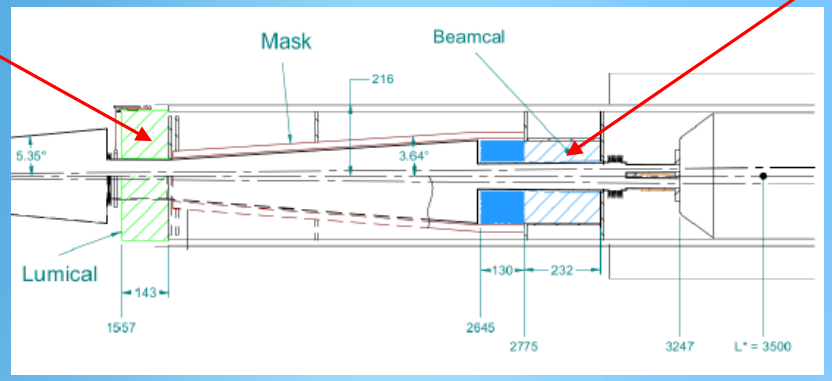
Forward calorimetry

Lumi Cal

Luminosity to 10^{-4}

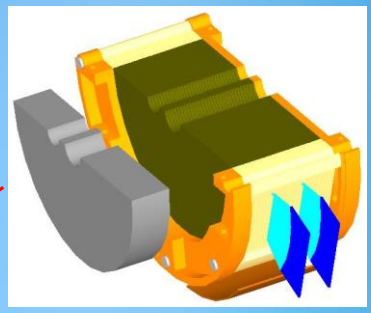






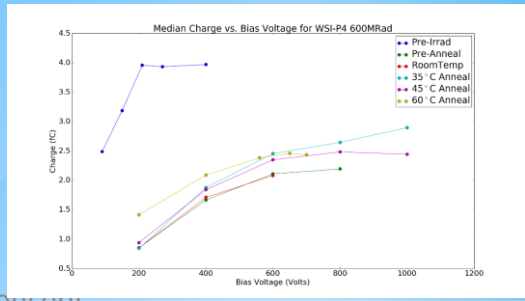
- Luminosity from low angle Bhabhas
- Reduce bkgd/mask
- e/γ i.d. to few mrad

Beam Cal



- Improve hermeticity
- Reduce backscatter
- Assist beam diagnostics

- **Sensor irradiation studies for Forward Calorimetry**
  (B. Schumm et al. UCSC – SLAC Expt. T-506)
  BeamCal radiation dose at inner radius ~**100 Mrad/year**



Forward calorimetry

- Complete the development of large dynamic range readout electronics.

- Develop and demonstrate the ability to position and maintain the position of the calorimeter, particularly at the inner radius, in view of the steep dependence of the rate of Bhabha events on polar angle.

- Continue the search for and testing of suitable sensor technology(s) capable of sustained performance in the very high radiation environment.

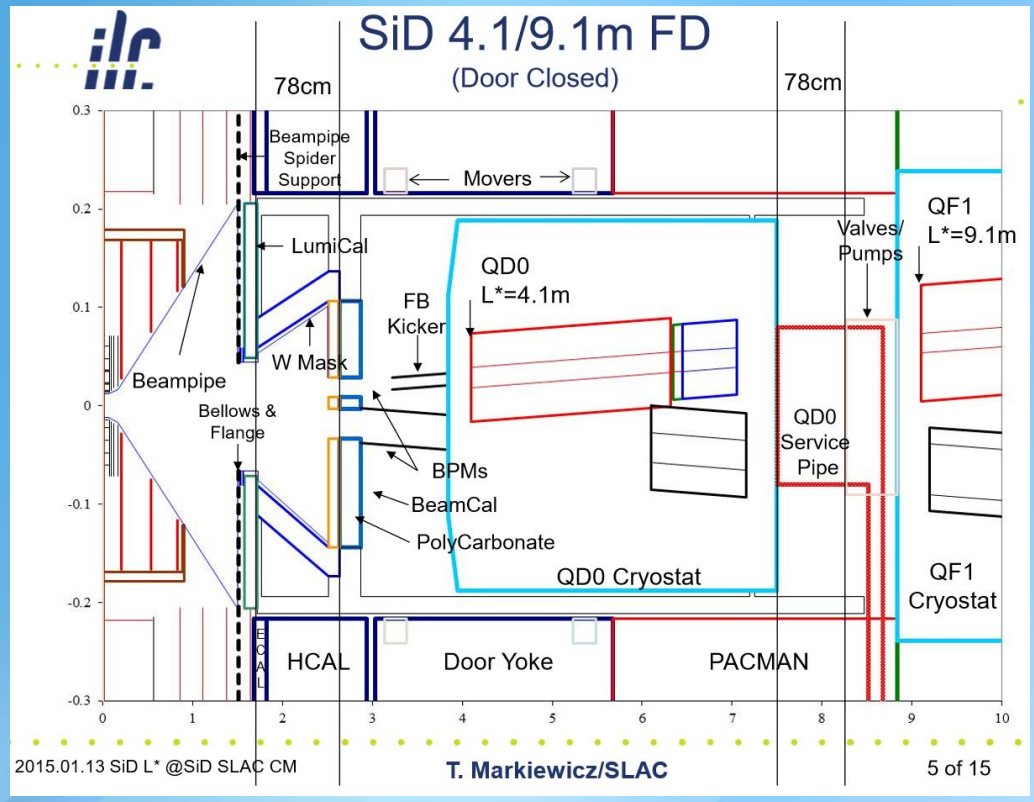
- Continue the study of recognizing single electron shower patterns for tagging for physics studies in the face of high radiation background.

Machine-Detector Interface

- Potential change to L*

  2015 – Agreement to common L* (4.1m) between SiD and ILD

- Issues – Last quadrupole is currently inside detector volume.
  - Moving out could give more stability, simplify push-pull
  - *but* – could lead to lower luminosity (see session PD7/A3/A4)



SiD Moving Forward

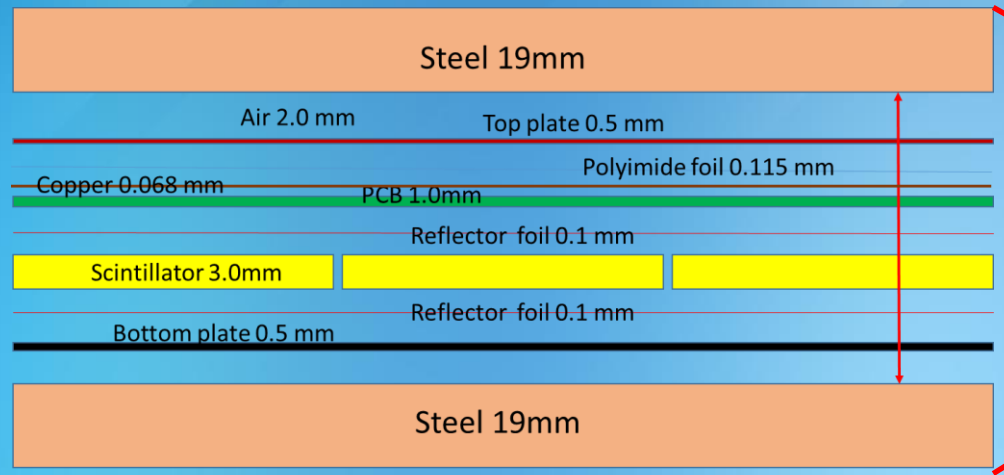
SiD has a validated baseline design that can deliver the performance required for the ILC Physics program.

However, there are new ideas, new technologies that could improve the performance, potentially reduce costs, and give greater reliability.

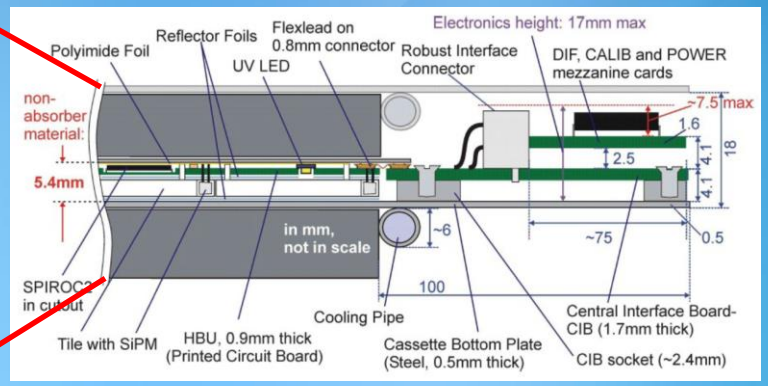
SiD is very open to new ideas and very welcoming of new colleagues – please consider making SiD part of your future research!

Extra Slides

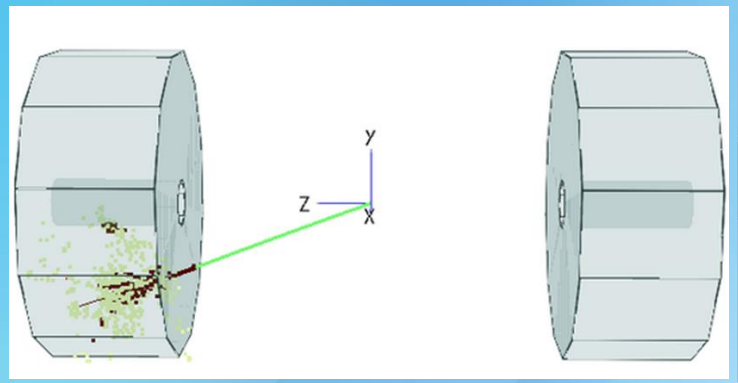
SiD Hadron Calorimeter

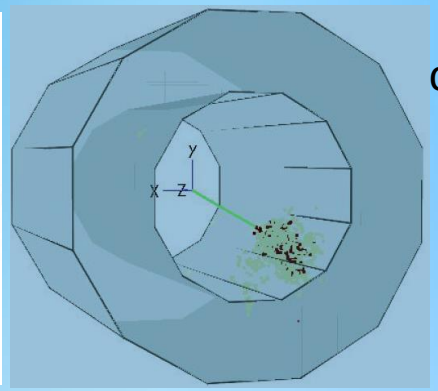


CALICE design

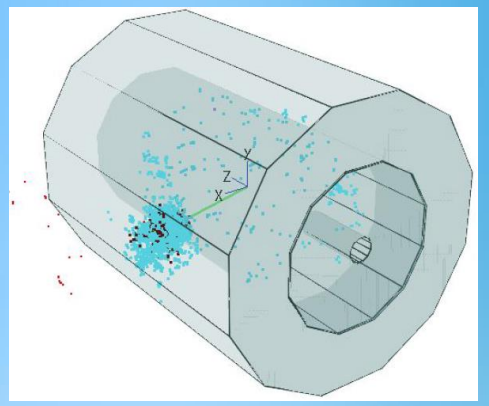


Ongoing: single particle studies.
Next: full event studies with PANDORA as prelude to next round of physics studies



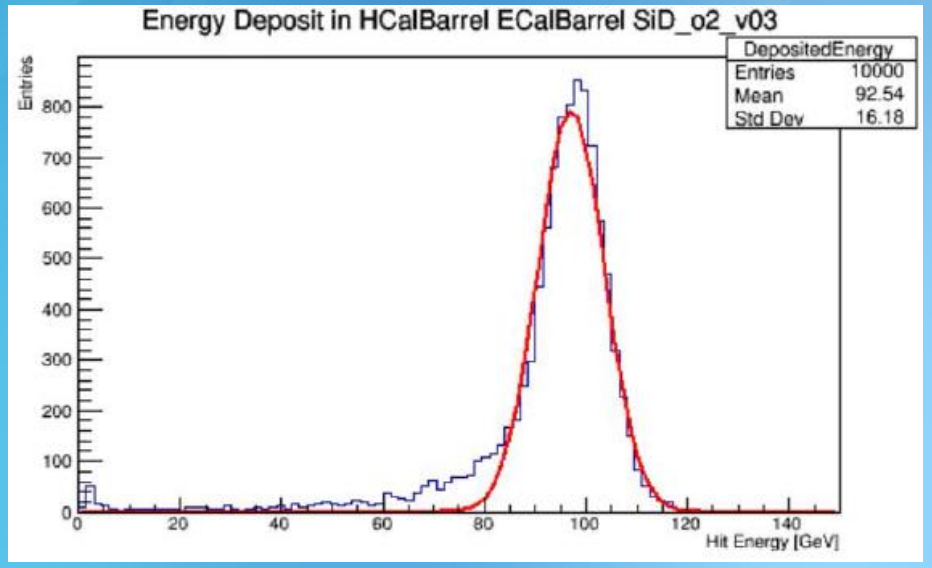


70 GeV charged π



UTA, SLAC

SiD Hadron Calorimeter

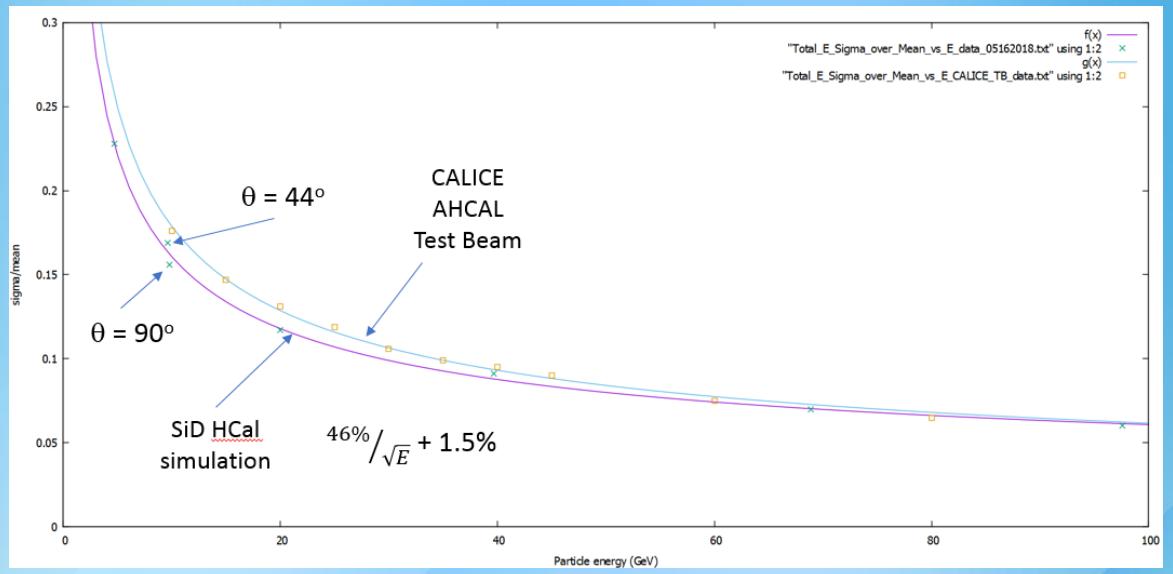


10,000 100 GeV charged pions

Sum of energies in the ECal + HCal.

Checking new SiD simulation: compare simulated single particle energy resolution with actual CALICE test beam results

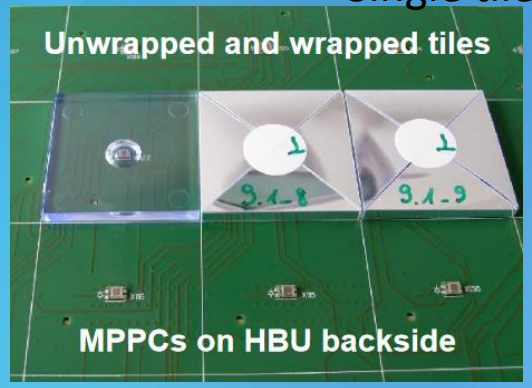
A. Myers, AW - UTA

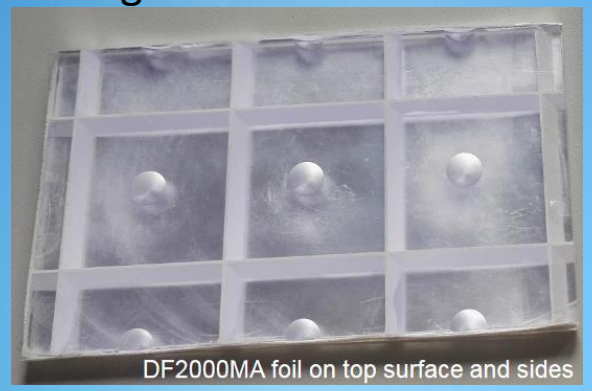


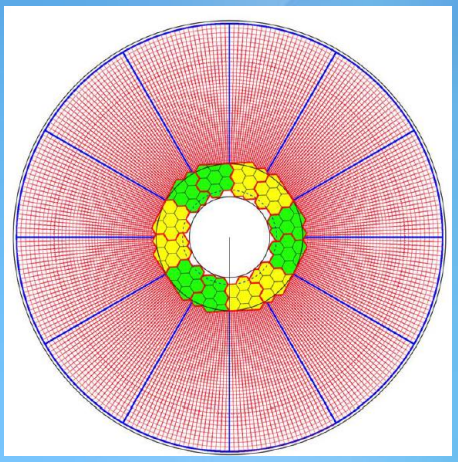
SiD Hadron Calorimeter

Following CALICE developments for AHCAL

Single tiles or mega-tiles?



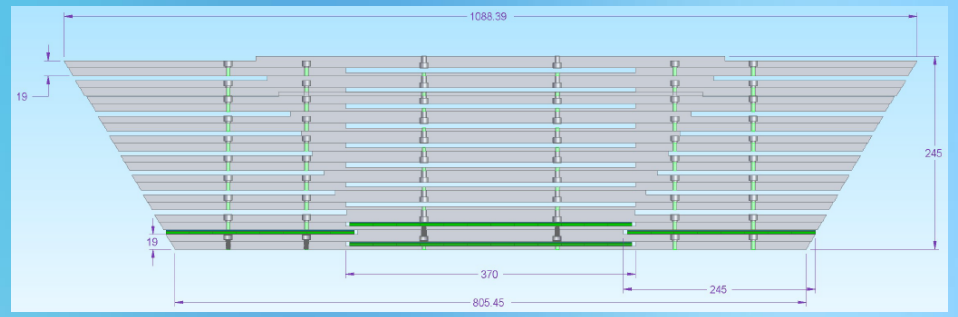


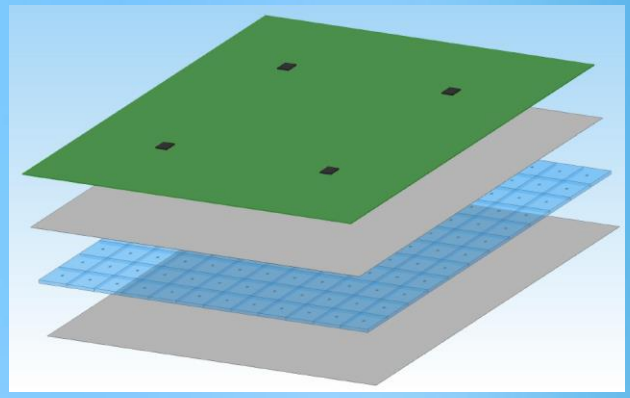


Same issue for CMS HGCAL

Initial SiD Hcal design ideas

(for barrel – endcaps next)





Marco Oriunno

(SLAC)