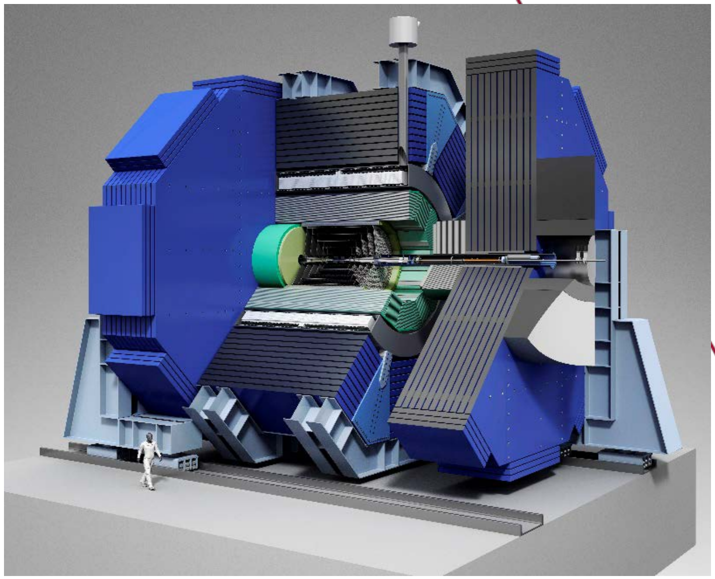


The SiD Detector at ILC

Tim Barklow (SLAC), On Behalf of the SiD Consortium

EPS-HEP 2017, Venice, Italy

Jul 08, 2017

SiD Consortium

SiD Consortium Member Institutions

- Argonne National Laboratory
- Universitat de Barcelona
- University of Bergen
- Bristol University
- University of California, Davis
- University of California, Santa Cruz
- Cornell University
- Fermi National Accelerator Laboratory
- University of Glasgow
- University of Iowa
- LAPP Annecy
- Lawrence Livermore National Laboratory
- University of Manchester
- The Open University
- University of Oregon
- Oxford University
- Pacific Northwest National Laboratory
- Queen Mary University of London
- Rutherford-Appleton Laboratory
- SLAC National Accelerator Laboratory
- University of Texas, Arlington
- Tohoku University
- University of Tokyo
- Yale University

Spokespeople:

Andy White awhite@uta.edu

Marcel Stanitzki marcel.stanitzki@desy.de

The SiD Design Rationale

A compact, cost-constrained detector designed to make precision measurements and be sensitive to a wide range of new phenomena.

Design basics:

Robust * silicon vertexing and tracking system – excellent momentum resolution, live for single bunch crossings.

Highly segmented “tracking” calorimeters optimized for Particle Flow.

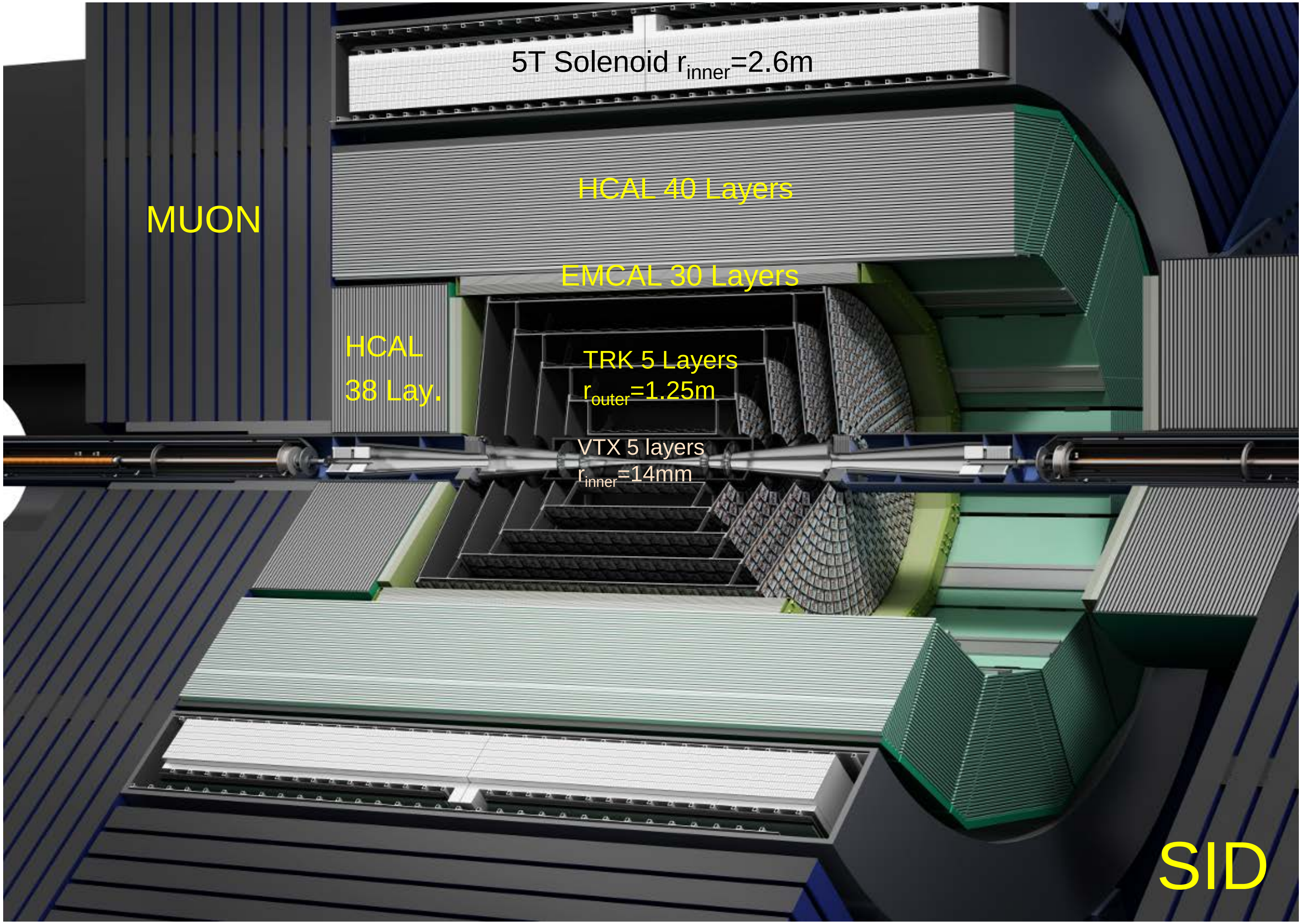
Compact design with 5T field.

Iron flux return/muon identifier – component of SiD self-shielding.

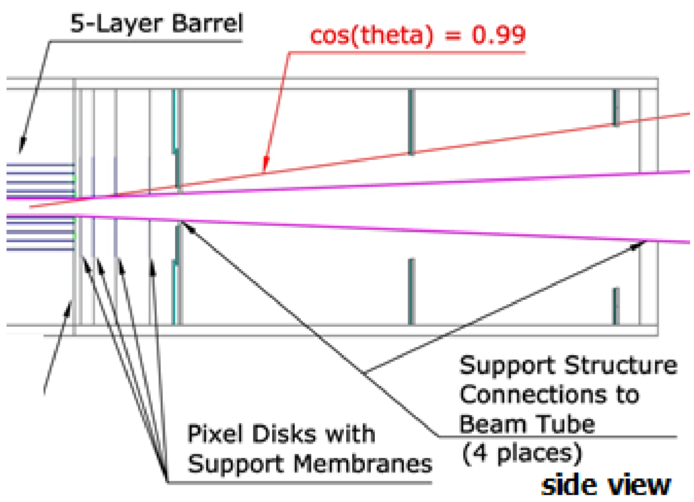
Detector is designed for rapid push-pull operation.

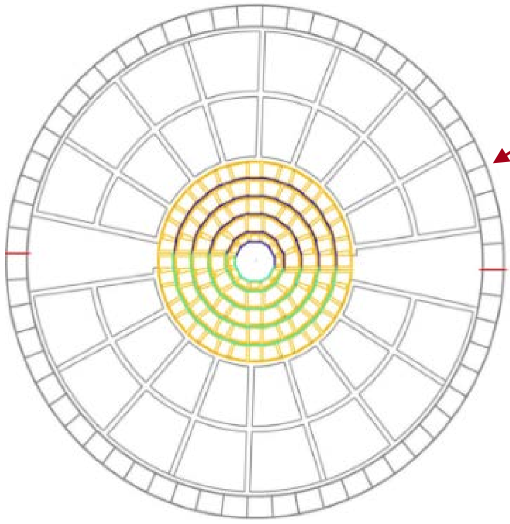
***tolerant of high <background> and large fluctuations in background**

SiD Detector Baseline



SiD Tracking – Vtx Detector





5 layer barrel & support structure

Very challenging requirements

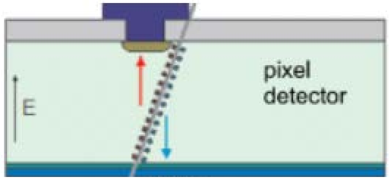
- < 3 μm hit resolution
- Feature size ~20 μm
- ~0.1% X_0 per layer material budget
- < 130 μW / mm^2
- Single bunch time resolution

SiD Tracking – Vtx Detector

What options are considered for the SiD Vertex Detector?

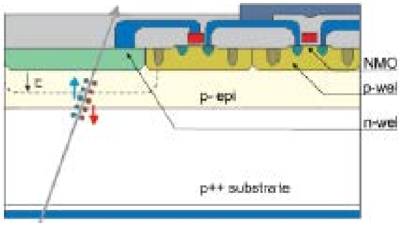
The Vertex Detector is the size of a Coke can – late installation – no reason to choose implementation now – wait for advances in technology

- Si diode pixels ("standard" technology)

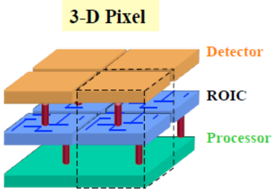


- Monolithic designs (MAPS, Chronopix)

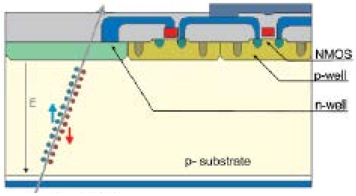
Baseline, v3 prototype



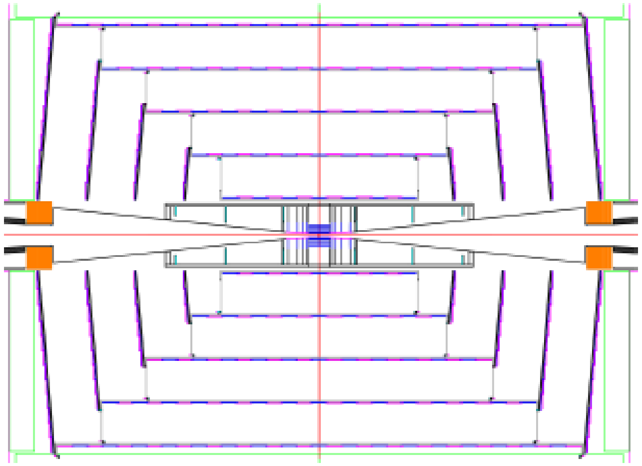
- Vertically Integrated ("3D") Approaches (VIP Chip)

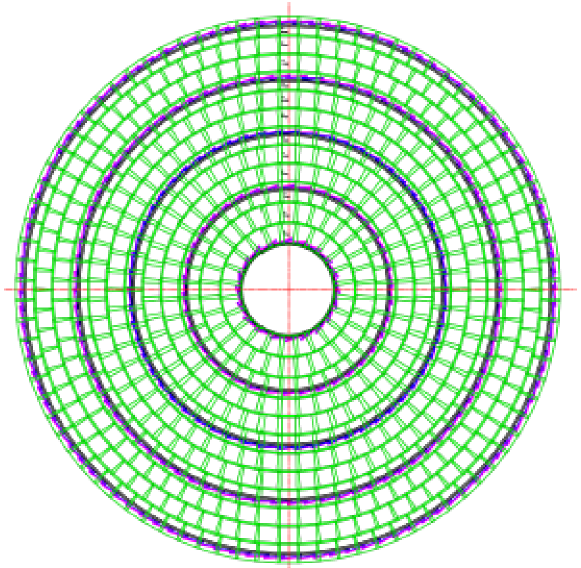


- High Voltage CMOS



SiD Tracking – Silicon Strip Tracker





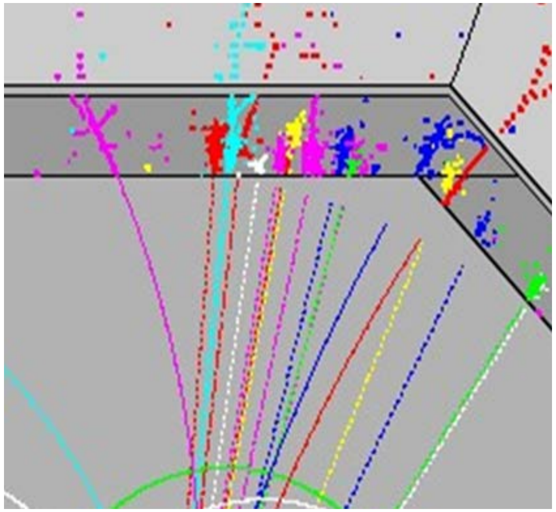
- All Silicon Tracker
  - Using Silicon micro-strips
    - 25 µm pitch / 50 µm readout
    - v2 sensor prototype July 2017*
- 5 barrel layers / 4 disks
- Tracking unified with vertex detector
  - 10 layers in barrel
- Gas-cooled
- Material budget < 20% X_0 in the active region
- Readout using KPiX ASIC
  - Same readout as ECAL
  - Bump-bonded directly to the module

KPiXM: R&D on CMOS monolithic front-ends

Integrate sensors and front-end electronics on the same substrate

*Tracker Sensor R&D is supported by EU-Horizon2020 Project AIDA2020

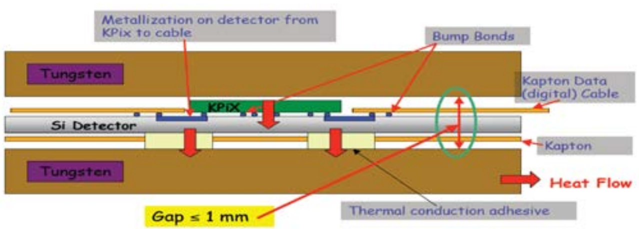
EMCal

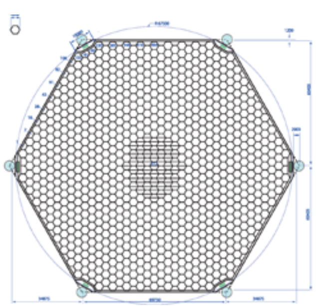


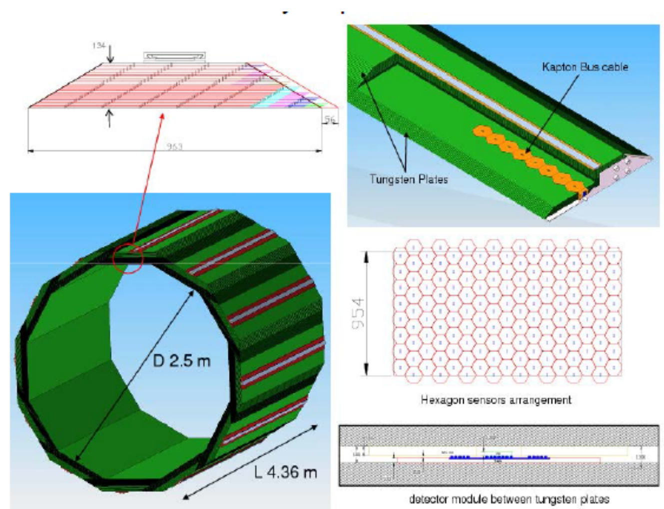
Highly granular “imaging” calorimetry essential for ILC physics program:

- Particle id/reconstruction
- Tracking charged particles
- Integral part of Particle Flow detector design

Baseline design: Silicon/Tungsten





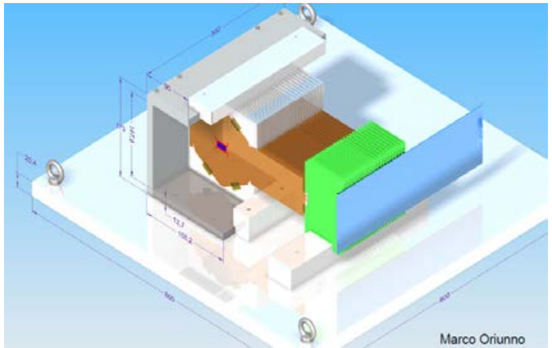


Baseline configuration:

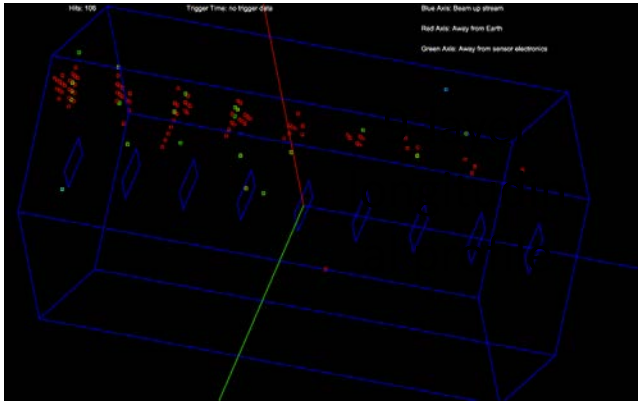
- transverse: 12 mm^2 pixels
- longitudinal: (20 x 5/7 X_0) + (10 x 10/7 X_0) $\Rightarrow$ 17%/sqrt(E)
- 1 mm readout gaps $\Rightarrow$ 13 mm effective Moliere radius

EMCal – beam tests

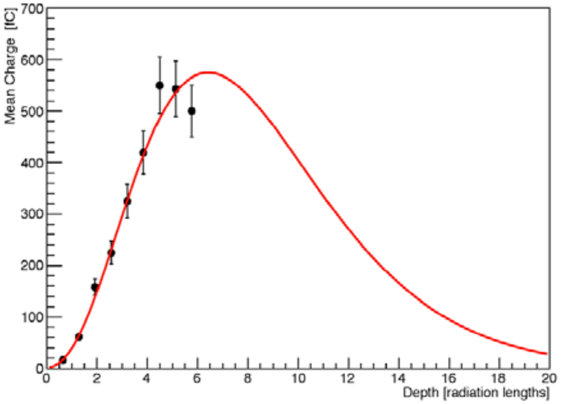
U of Oregon, SLAC, UC Davis



Single electron in 9-layer prototype



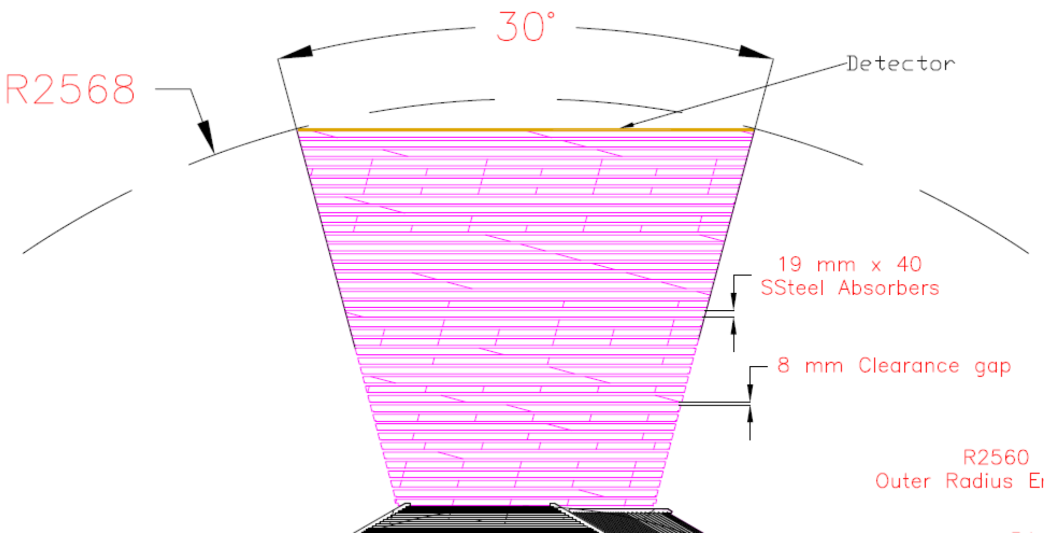
Longitudinal charge deposition

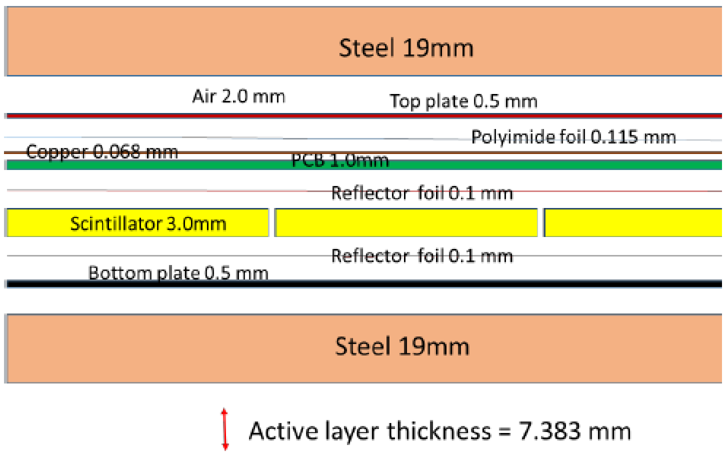


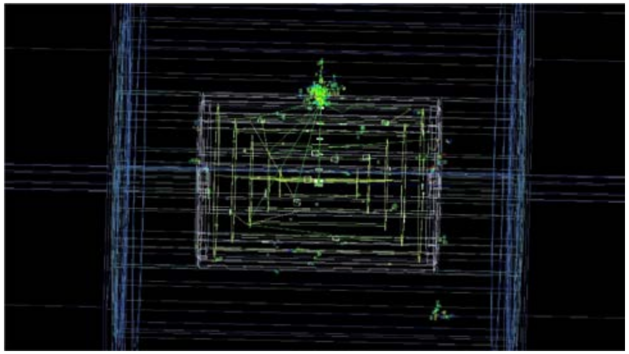
- Parasitic crosstalk – new design has additional shield layer
- Issue with KPiX resets causing “monster events” – understood/small change
- Move from aluminum bond pads to gold for next sensors

HCal

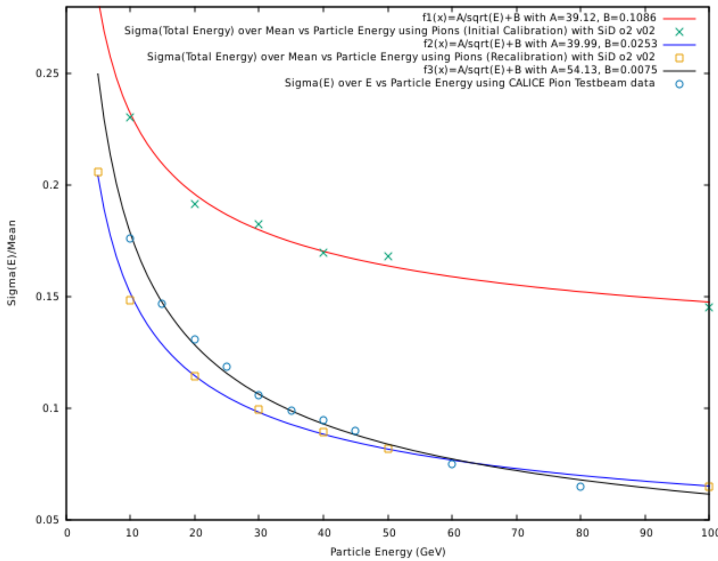
New baseline technology (w.r.t. DBD) for the SiD HCal is Scintillator/SiPM/Steel



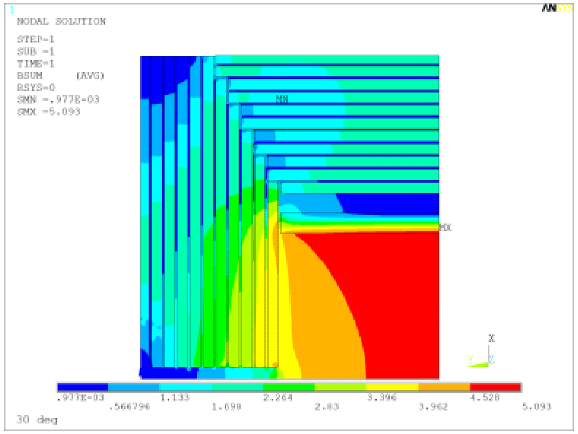


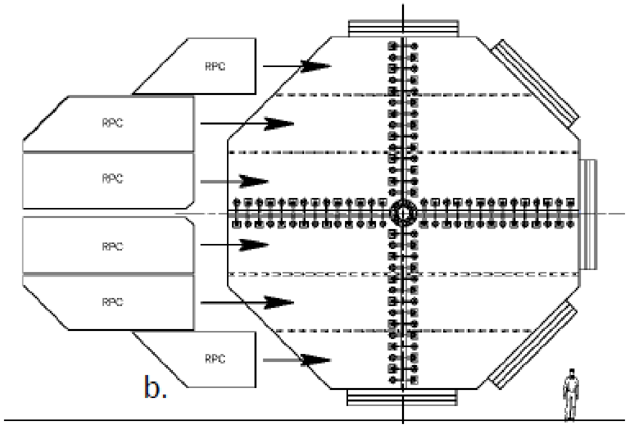


Initial goal: compare simulated single particle energy resolution with actual CALICE test beam results



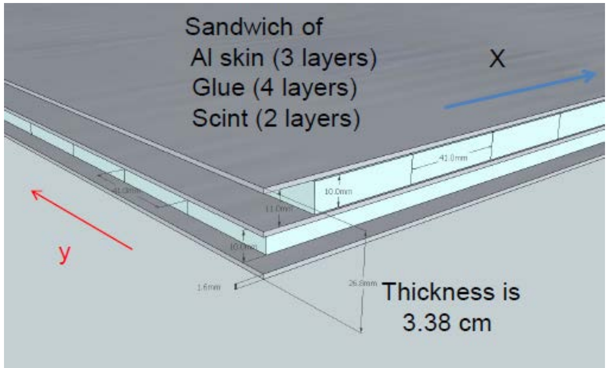
Muon System

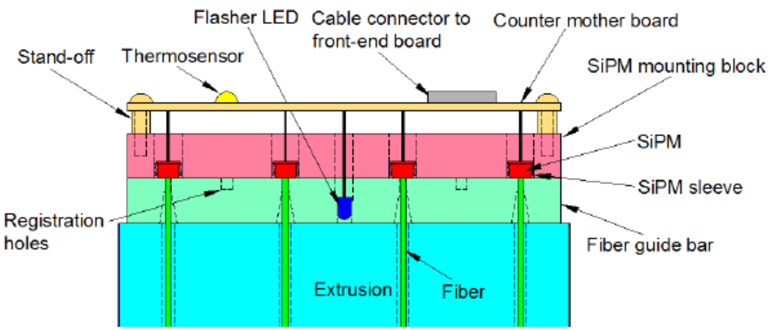




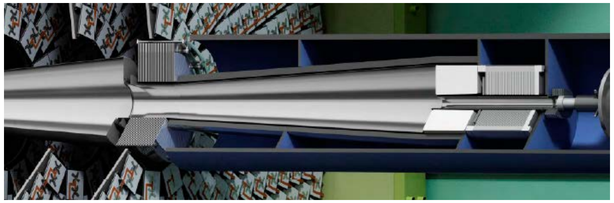
SiD Baseline – long scintillator strips with WLS fiber and SiPM readout

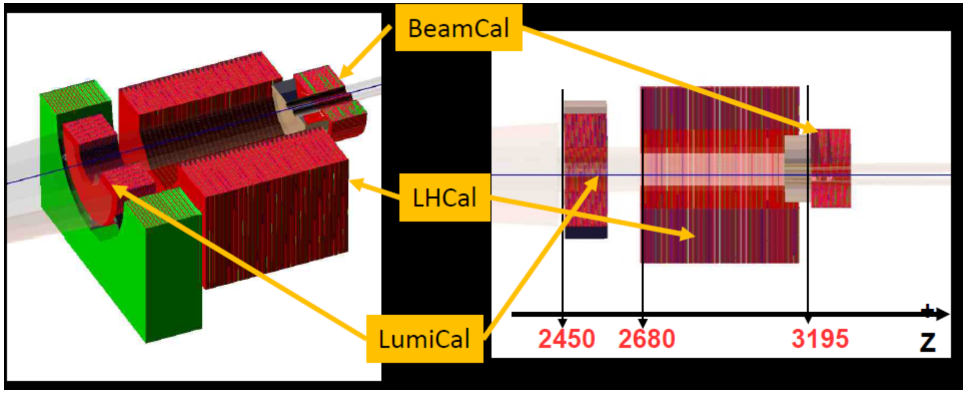
- Consistent extension of the baseline HCal scintillator technology
- Need to optimize number of layers, strip dimensions.





Forward Region





LumiCal :

- Precise integrated luminosity measurements (Bhabha events)
- Extend calorimetric coverage to small polar angles. Important for physics analysis

LHCal :

- Extend the hadronic calorimeter coverage

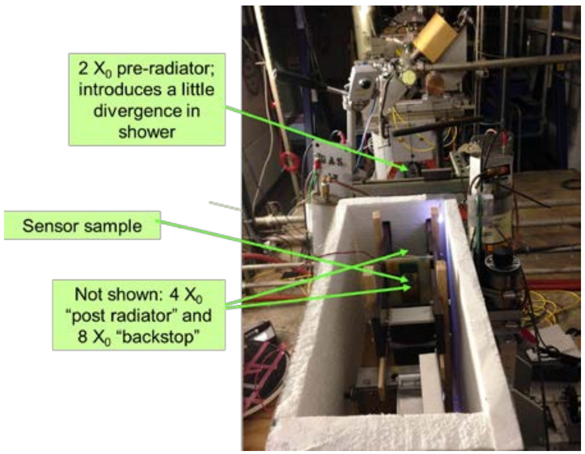
BeamCal :

- Measure instant luminosity
- tagging of high energy electrons to suppress backgrounds to potential BSM process
- shielding of the accelerator components from the beam-induced background
- providing supplementary beam diagnostics information extracted from the pattern of incoherent-pair energy depositions

Forward Region

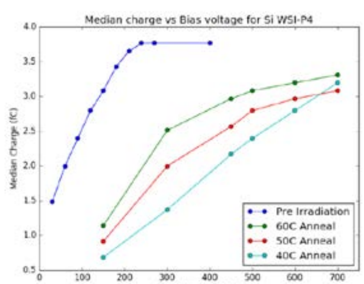
- **Sensor irradiation studies for Forward Calorimetry** (B. Schumm et al. – SLAC Expt. T-506)

BeamCal radiation dose at inner radius ~100 Mrad/year

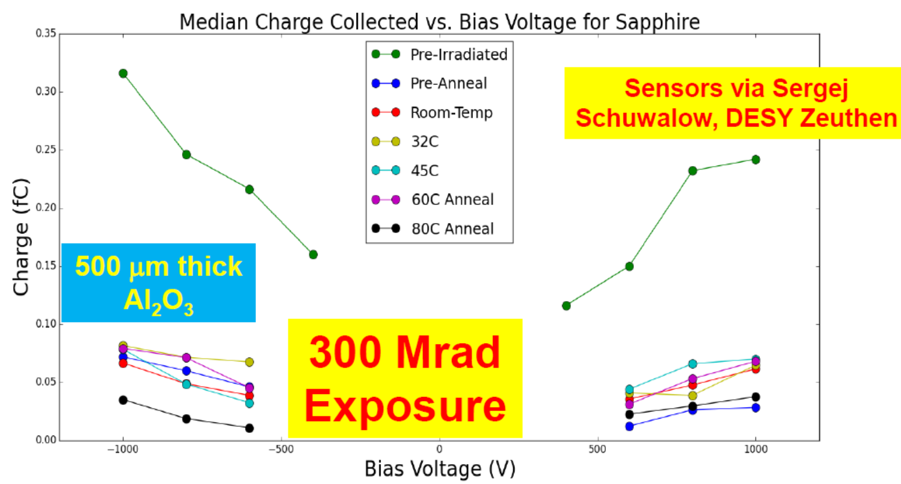


Sensor	Dose (Mrad)	Median CC Before Irradiation (fC)	Median CC After Irradiation (fC)	Fractional Loss (%)
PF05	5.1	3.70	3.43	7
PF14	20	3.68	3.01	18
PC08	20	3.51	3.09	12
NF01	3.7	3.76	3.81	0
NF02	19	3.75	3.60	4
NF07	91	3.75	4.00	0
NC01	5.1	3.71	3.80	0
NC10	18	3.76	3.74	1
NC03	90	3.68	3.55	4
NC02	220	3.69	3.06	17
WSI-P4 (PF) (@600 V)	269	3.77	3.17	16
GaAs18 (@600 V)	5.7	6.41	5.22	19
GaAs09 (@600 V)	20.8	4.74	2.02	57

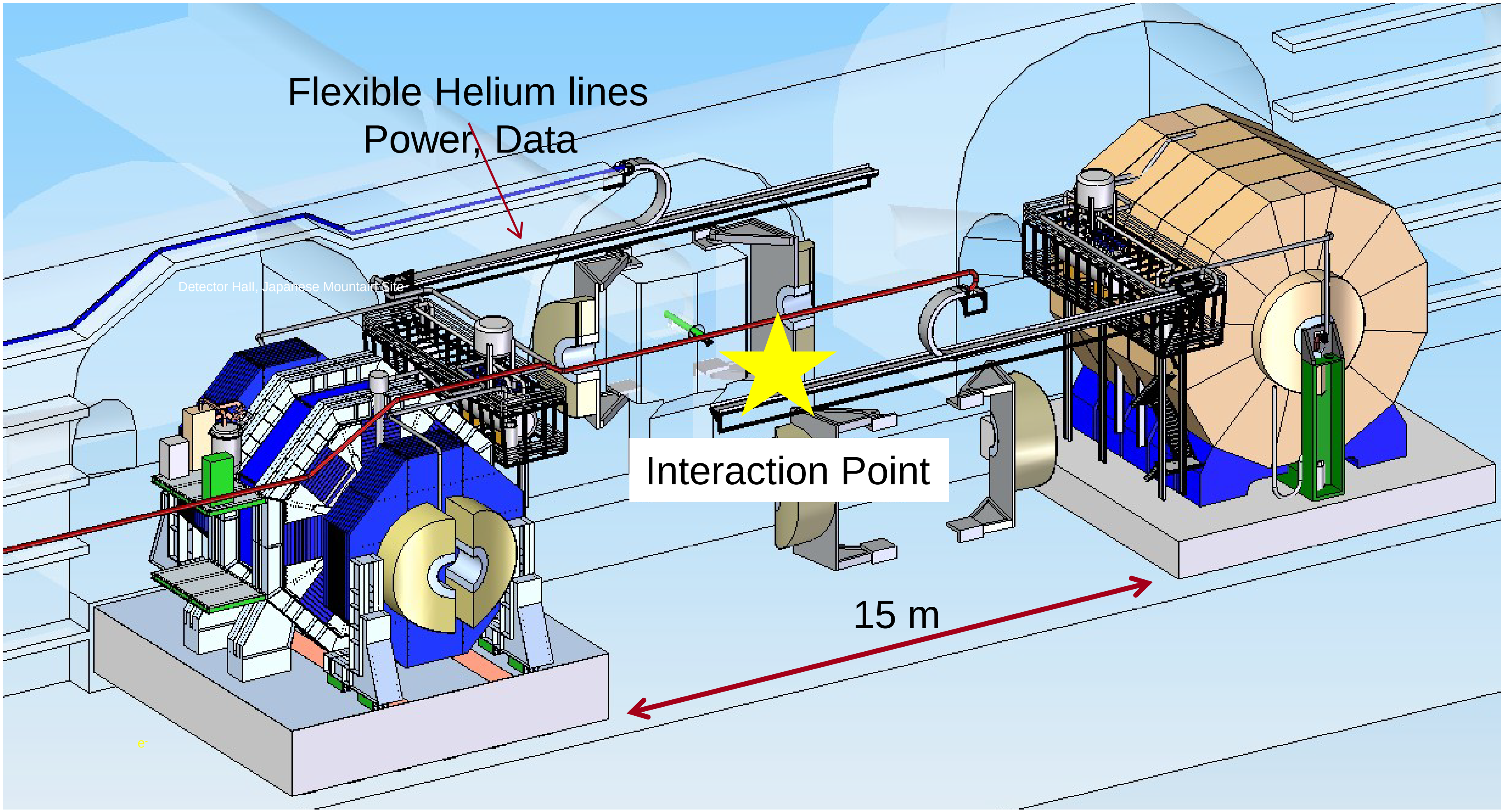
PF, PC, NF, NC. "P" or "N" refers to p-type or n-type bulk; "F" is float-zone and "C" is magnetic Czochralski.



@600 V, ~20% charge collection loss (60C annealing)



MDI Push-Pull : Engineering Concept



Platform on Rollers

Recent SiD Activities

- The basic SiD design has been in place for an extended period, but we are always open to:
  - New technologies
  - Design optimization
  - Performance improvements
  - Cost reduction

- Design optimization and performance studies, led by Jan Strube (PNNL) and Aidan Robson (Glasgow) have seen significant and sustained efforts during the past year. Irregular participation 1.5 years ago developed into regular weekly meetings with many contributions and a high level of student participation.

- Design variations, simulation development, background studies, subsystem performance studies are all activities that SiD can pursue in the present situation of minimal funding. However, Detector R&D continues to be challenging, e.g. building and testing significant prototypes in a pre-TDR phase.

- U.S. – Japan Science and Technology Cooperation Program in HEP helps support our activities

Summary of SiD Activity in 2017 (1)

VTX – Oregon/Yale – continue studies with prototype #3, minimum ionizing particles, radiation hardness

- Follow development of various technologies: 3-D, HV CMOS,…

TRK - SLAC, UNM - next generation of tracker sensors (Hamamatsu)

- SLAC, UO – kPixM development, test structure
- U. Bristol – Continue development of Pixel tracker option, develop alignment procedures
- Follow CF structures development in UK (Oxford, Lancaster, Liverpool)
- Glasgow – tracking software development

ECal – U. Oregon/SLAC/UC Davis – new sensors (shielding layer), new prototype module next round of beam tests

- SLAC – kPixM development, test structure

HCal – UTA – continue Scintillator/SiPM/Steel technology implementation in new simulation framework. Start SiD-specific HCal module design – follow CALICE activities.

Work towards SiD HCal design and prototype modules (barrel, endcap).

Summary of SiD Activity in 2017 (2)

FCal – UCSC – continue radiation hardness studies (more beam tests?)

- Finish collision parameters study/beam cal geometry
- BeamCal reconstruction/new framework/fast MC
- FLUKA study of neutron production from BeamCal

Computing/Software – PNNL – computing support, Glasgow - DD4HEP simulation commissioning - (with many SiD groups contributing subsystem implementations). Pandora, jet studies,…

MDI – SLAC – Interface to ILC/MDI

- DESY/SLAC – Muon background/spoilers, FLUKA beam dump study

Physics studies – PNNL (J. Strube) & Glasgow (A. Robson) leading optimization studies, SLAC (T. Barklow) – general ILC physics studies, backgrounds, MC generator support

- Students: A. Schuetz(DESY), Bogdan(Glasgow), A. Steinhebel (UO, h ->$\tau\tau$), UCSC (degenerate stau), C. Potter (UO, light MSSM)

General – Engineering (Mechanical, electronics) as support allows.