The SiD Detector Concept for the ILC

Andy White
University of Texas at Arlington

for the SiD Detector Concept

Outline

- Introduction
  - Detector design
  - Design Study Organization
  - DBD Editors

- Area-by-area summary for detector components

- Physics Benchmarks

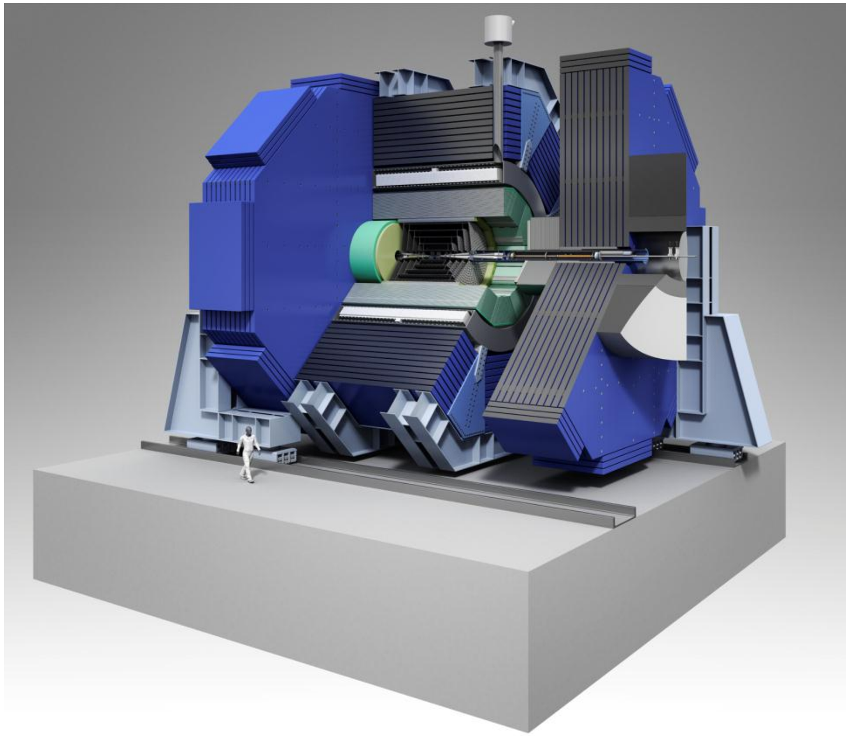
- Costs

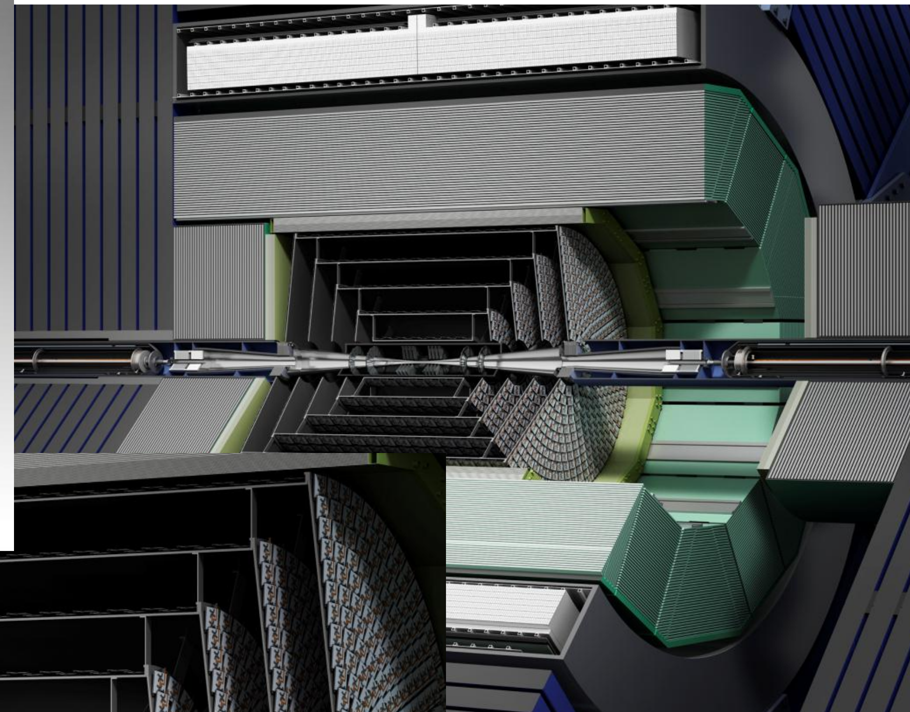
- Summary

- The ILC Project - U.S. issues.

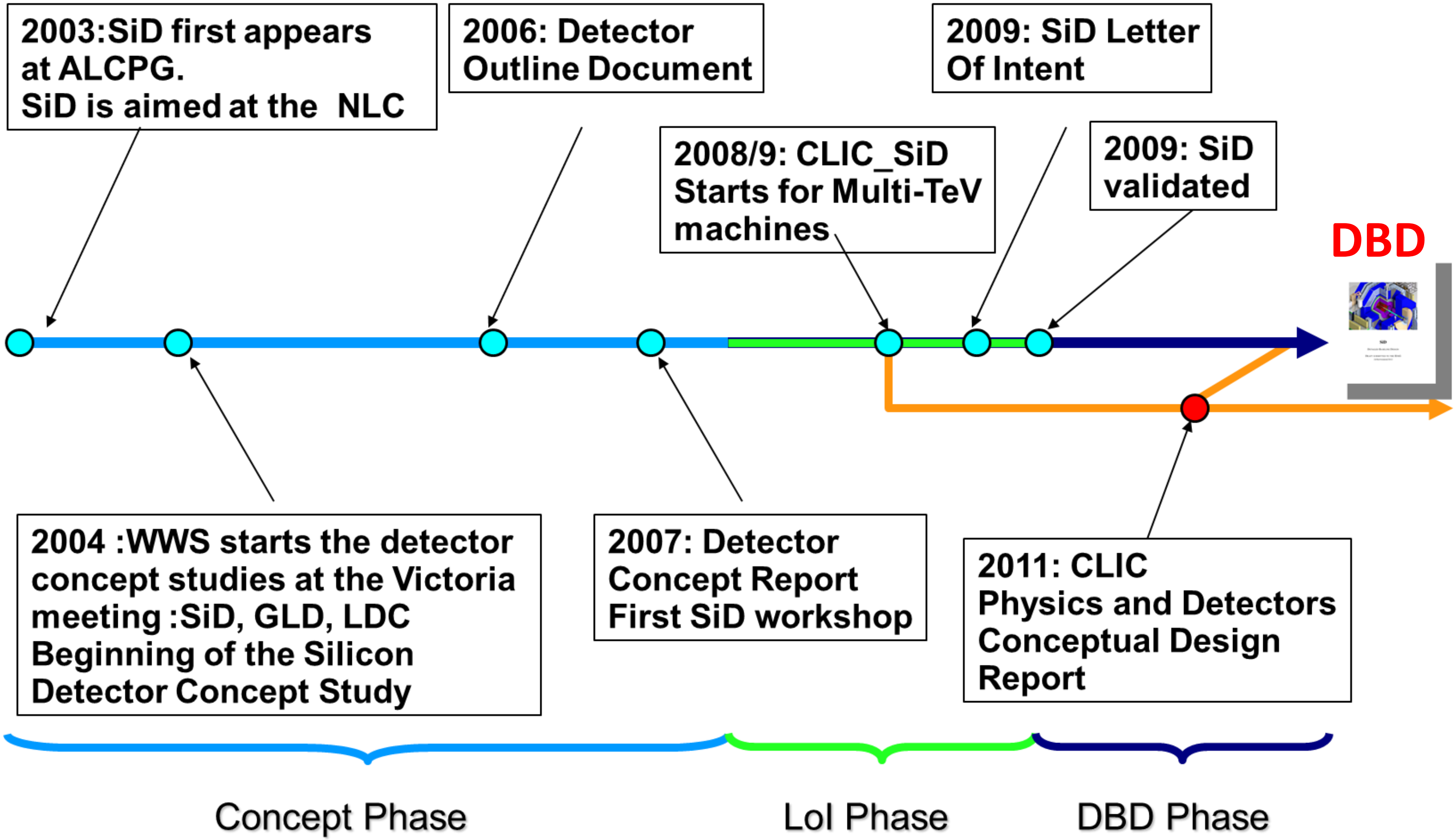
SiD Detector overview

- SID Rationale
  - *A compact, cost-constrained detector designed to make precision measurements and be sensitive to a wide range of new phenomena*
- Design choices
  - Compact design with 5T field.
  - Robust silicon vertexing and tracking system with excellent momentum resolution
  - Time-stamping for single bunch crossings.
  - Highly granular Calorimetry optimized for Particle Flow
  - Iron flux return/muon identifier is part of the SiD self-shielding
  - Detector is designed for rapid push-pull operation



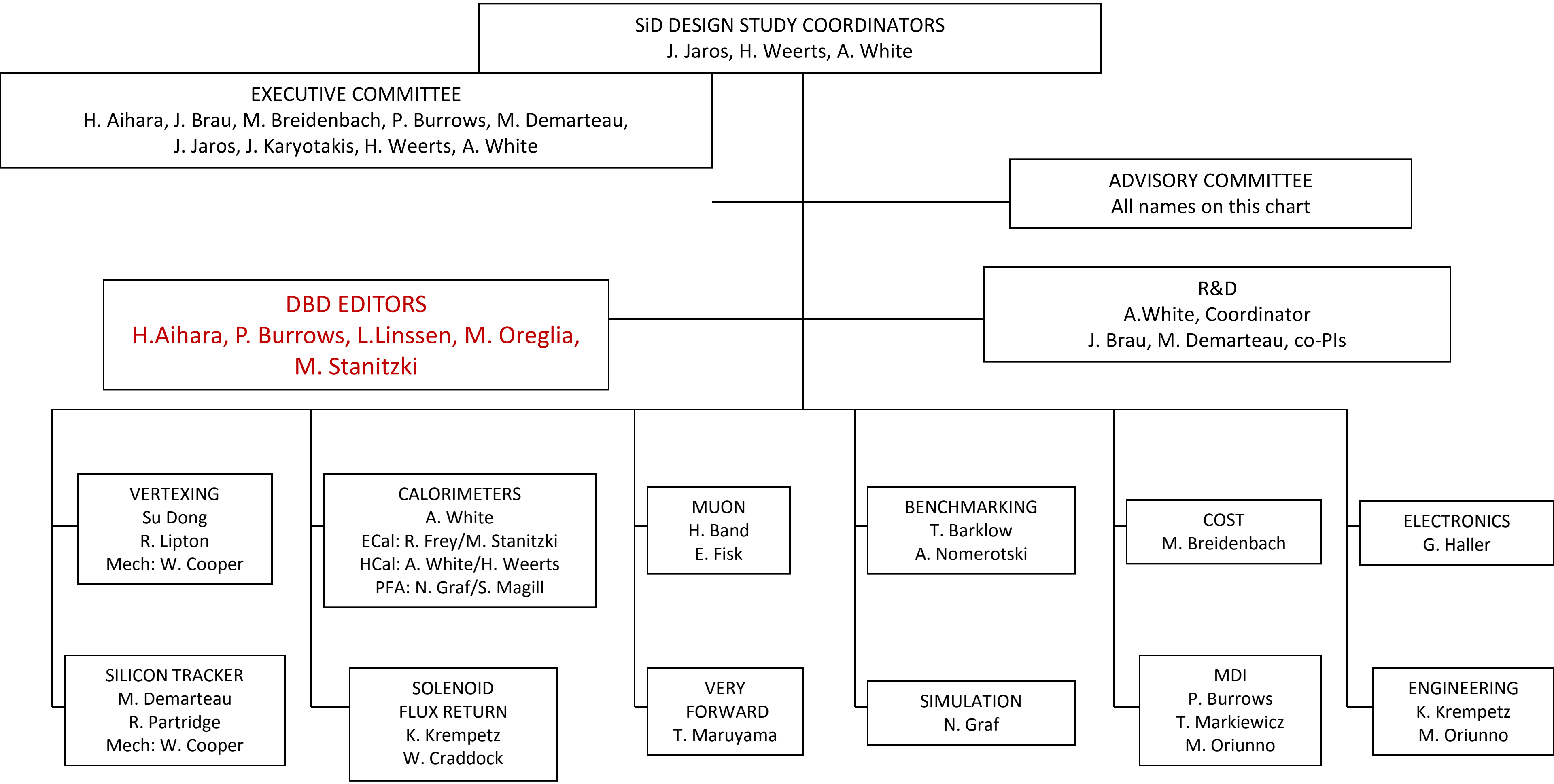


SiD Detailed Baseline Design – History



Marcel Stanitzki, LCWS 2012

SiD Design Study Organization



Creating the SiD DBD

Main DBD Editors:

Phil Burrows
Lucie Linssen
Mark Oreglia
Marcel Stanitzki
A. W.

CHAPTER EDITORS

Vertex Detector
W. Cooper[6], R Lipton[6]

Silicon Tracking
W. Cooper[6], M. Demarteau[7], T. Nelson[8]

Calorimetry
R. Frey[9], A. White[5], L. Xia[7]

Muon System
H. Band[10], G. Fisk[6]

Superconducting Magnet System
W. Craddock[8], M. Oriunno[8]

Engineering, Integration and the Machine Detector Interface
P. Burrows[1], T. Markiewicz[8]

Forward Systems
T. Maruyama[8], B. Schumm[11]

Electronics and DAQ
G. Haller[8]

Simulation and Reconstruction
N. Graf[8], J. Strube[2]

Benchmarking
D. Asner[12], T. Barklow[8], P. Roloff[2]

Costs
M. Breidenbach[8]

SiD Detailed Baseline Design

- The DBD is a detailed description of a detector design concept, with examples of performance for selected ILC physics processes.

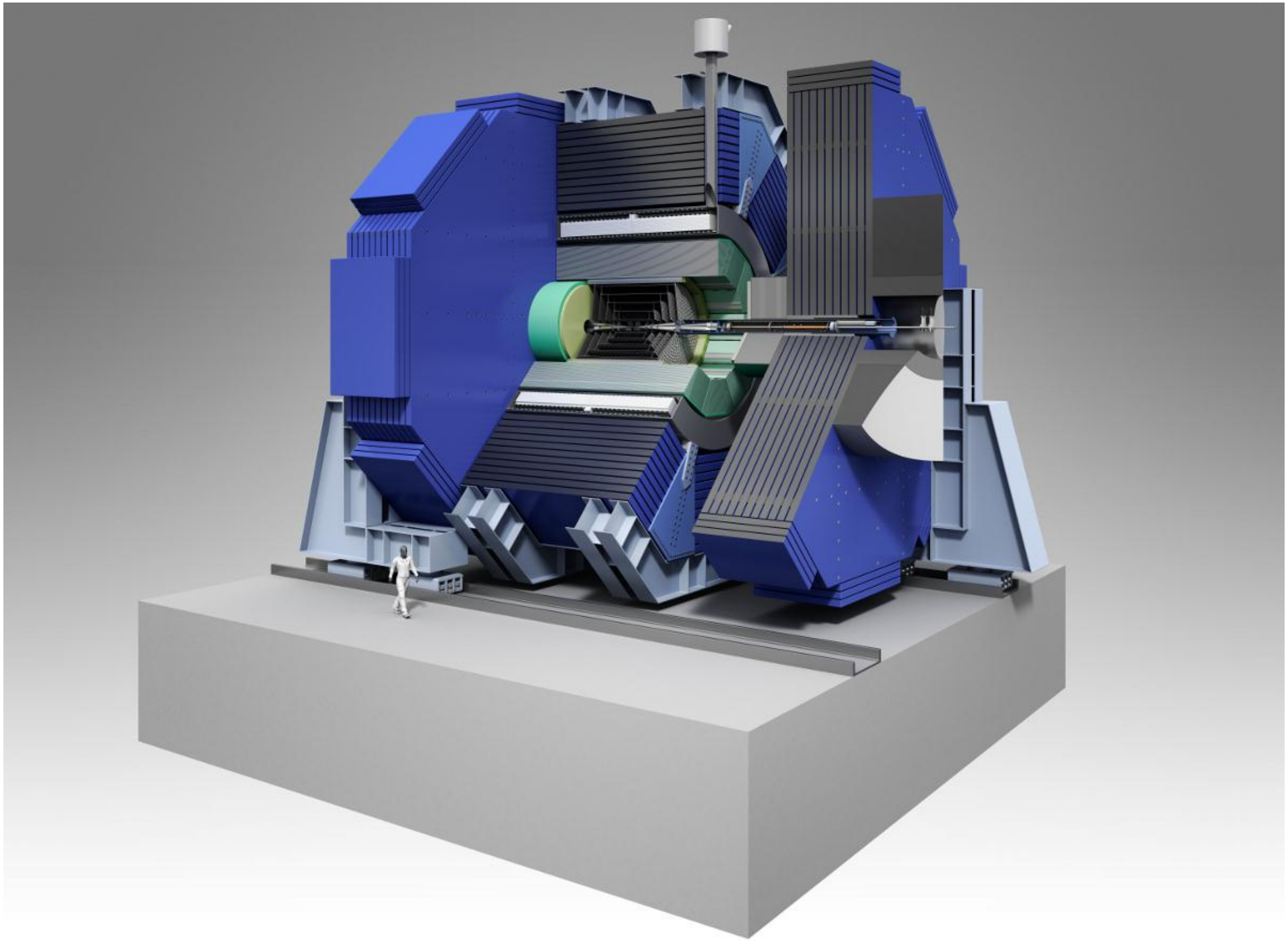
- The DBD is not at the level of a TDR – only limited engineering effort was available.

- It includes a large R&D effort, but this is not yet complete.

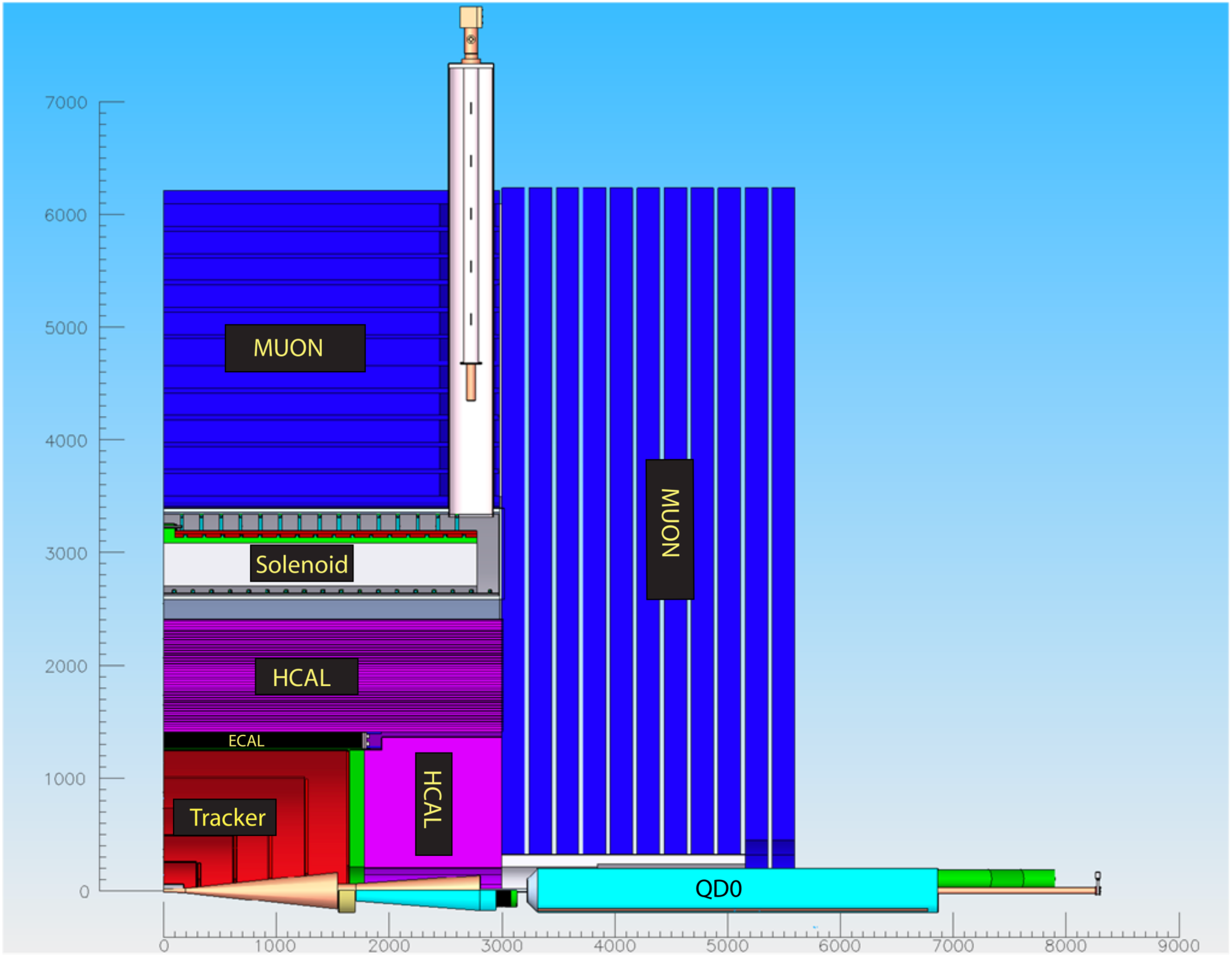
- Baseline choices have been made for all subsystems except the vertex detector; options are also included.

- We provide a full cost evaluation for the detector.

The SiD DBD Detector



The SiD DBD Detector

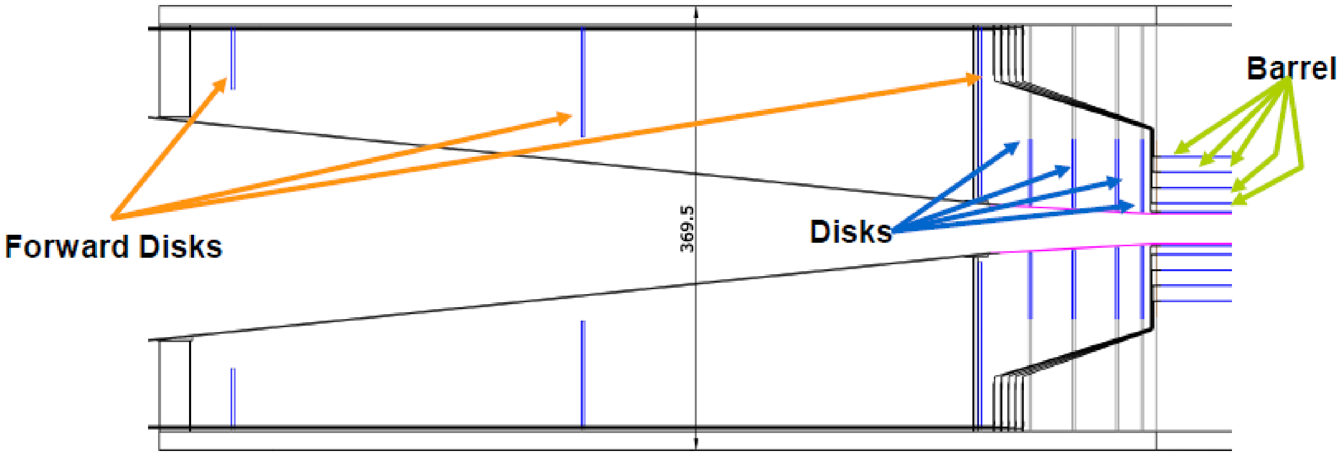


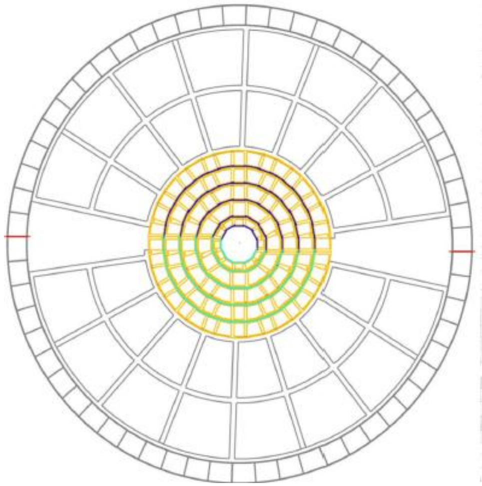
The SiD DBD Detector - parameters

SiD BARREL	Technology	Inner radius	Outer radius	z max
Vertex detector	Silicon pixels	1.4	6.0	± 6.25
Tracker	Silicon strips	21.7	122.1	± 152.2
ECAL	Silicon pixels-W	126.5	140.9	± 176.5
HCAL	RPC-steel	141.7	249.3	± 301.8
Solenoid	5 Tesla	259.1	339.2	± 298.3
Flux return	Scintillator/steel	340.2	604.2	± 303.3

SiD ENDCAP	Technology	Inner z	Outer z	Outer radius
Vertex detector	Silicon pixels	7.3	83.4	16.6
Tracker	Silicon strips	77.0	164.3	125.5
ECAL	Silicon pixel-W	165.7	180.0	125.0
HCAL	RPC-steel	180.5	302.8	140.2
Flux return	Scintillator/steel	303.3	567.3	604.2
LumiCal	Silicon-W	155.7	170.0	20.0
BeamCal	Semiconductor-W	277.5	300.7	13.5

Vertex Detector





Split-cylinder support structures

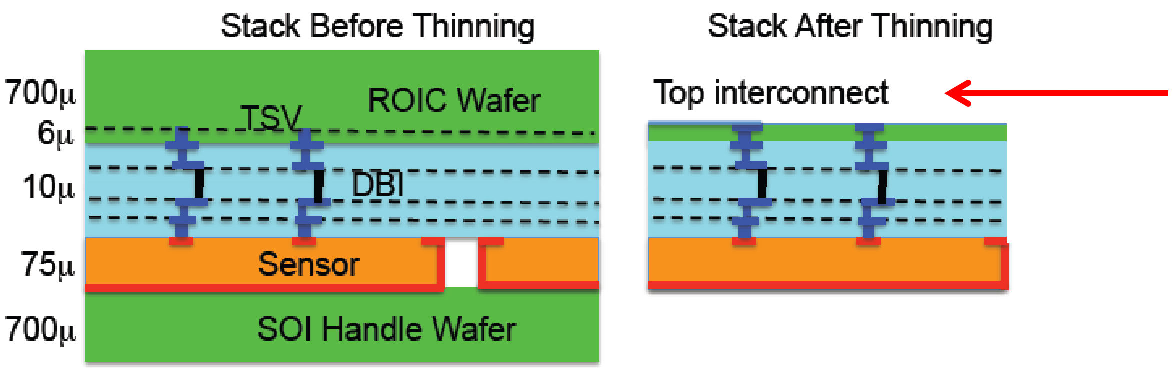
- Requirements
  - <5 µm hit resolution
  - ~ 0.1 % X_0 per layer
  - < 130 µW/mm²
  - Single bunch timing resolution

- ILC bunch timing and low radiation environment allows very light, low power vertex system
- Pulsed power/DC-DC conversion
- Forced dry air cooling

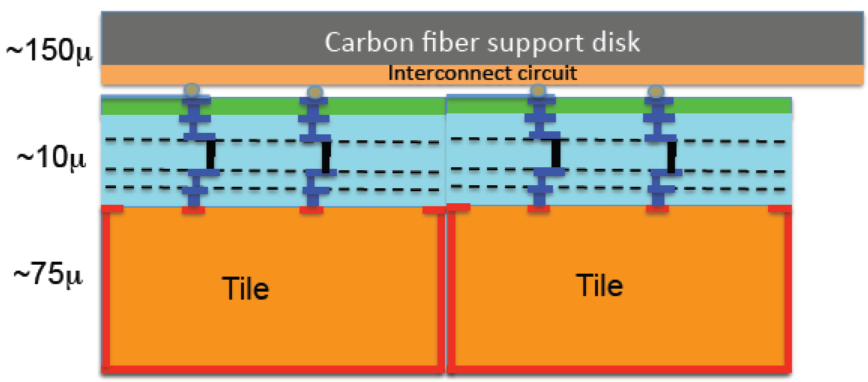
Vertex Detector

No preferred technology – many choices/still an evolving picture

Example 3-D/active edge design:



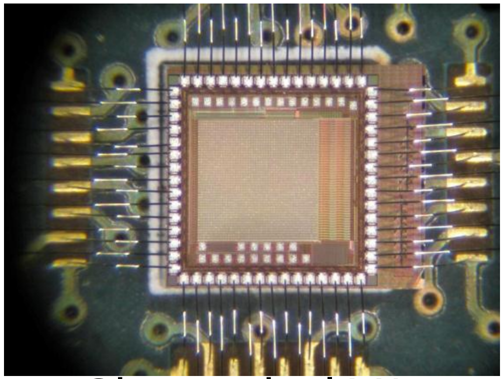
Barrel
Readout and power connections on top layer



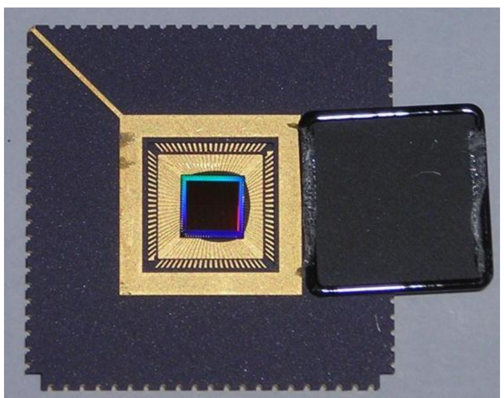
Disk tiling

Vertex Detector – R&D

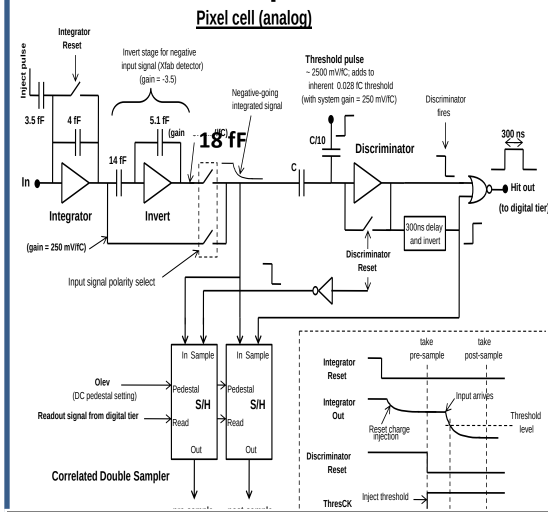
VIP 2a – 3 tier MIT-LL

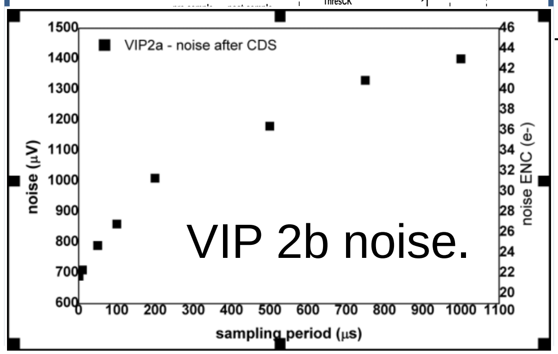


Chronopixel V1



VIP 3D chip





VIP

- VIP2a (3-tier MIT-LL chip) is produced and tested
- Both analog and digital sections work well, solving problems found in VIP1
- VIP2b (2-Tier Tezzaron/Global foundries) is in process.
- Initial tests of 2D test devices shows good analog performance.

noise = 8e + 0.5 e/ fF

- Sensors for 3D integration of VIP2b produced and tested.

Chronopixel

- Measured noise of 24 e, specification is 25 e.
- Sensitivity measured to be 35.7μV/e, exceeding design spec of 10μV/e.
- Comparator accuracy 3 times worse then spec, need to improve this in prototype 2.
- Sensors leakage currents ($1.8 \cdot 10^{-8}$ A/cm^2) is not a problem.
- Readout time satisfactory
- Prototype 2 late 2011, 65nm TSMC

Next: Full sized ladder for barrel, wedge segment for disks, support structures, cooling. power pulsing, cabling.

Silicon Tracking

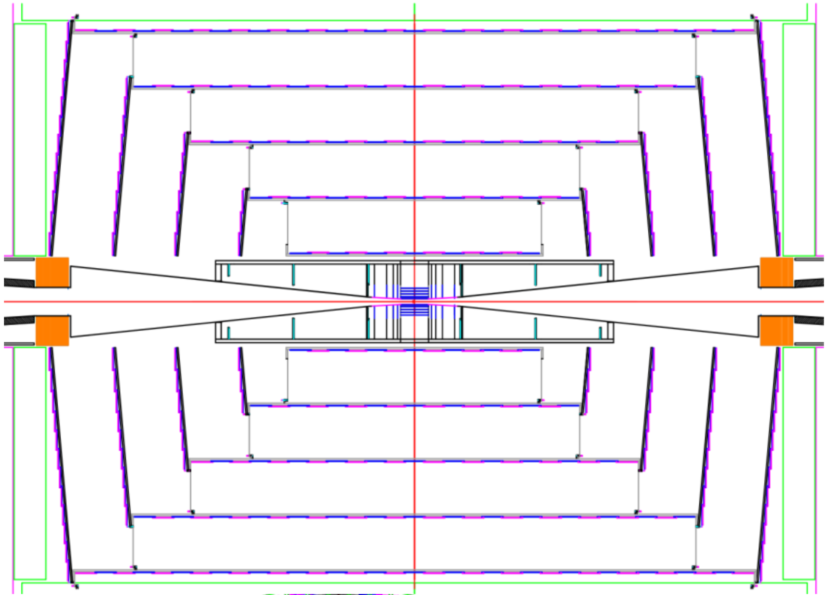
ILC Physics requires:

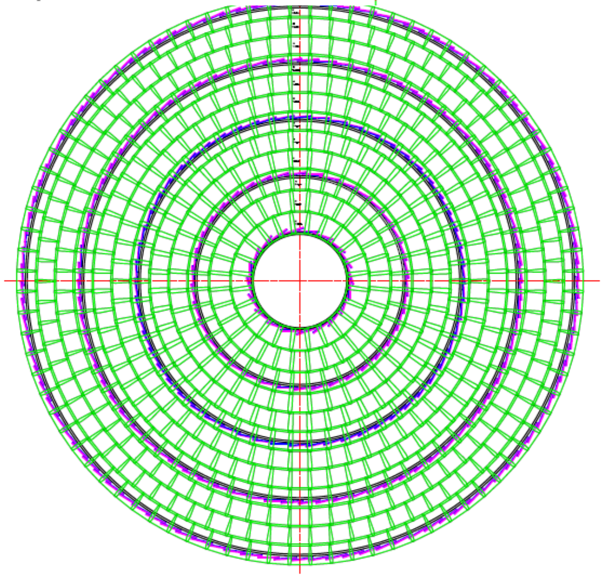
- excellent momentum resolution over wide P_T range
- high point precision, mechanical stability for high P_T
- low material budget for low P_T
- high efficiency for all momenta/angles

-> Performance goals

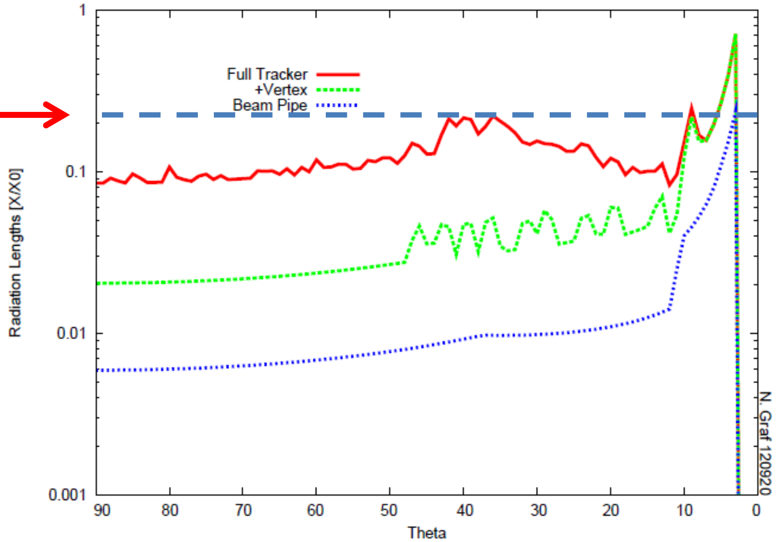
Parameter	Design Goal
coverage	hermetic above $\theta \sim 10^\circ$
momentum resolution $\delta(1/p_T)$	$\sim 2-5\times10^{-5}/GeV/c$
material budget	$\sim 0.10-0.15X_0$ in central region
	$\sim 0.20-0.25X_0$ in endcap region
hit efficiency	$> 99\%$
background tolerance	Full efficiency at $10\times$ expected occupancy

Silicon Tracking





Below 20% X_0 for whole VTX/TRK system

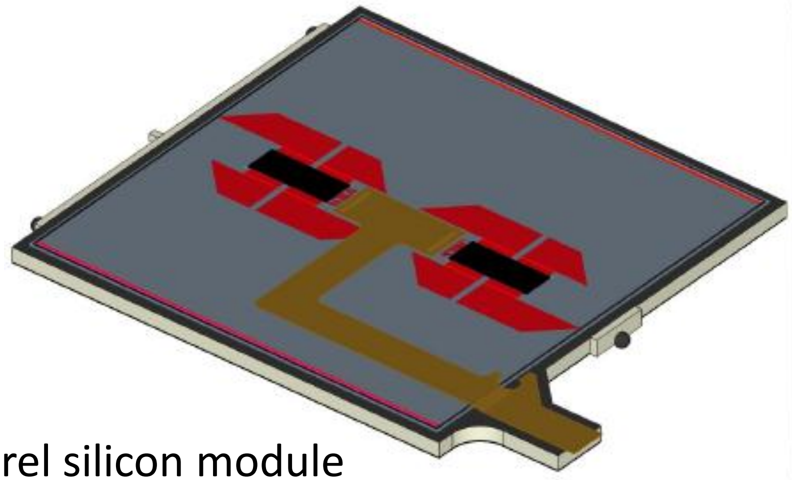


Silicon Tracking

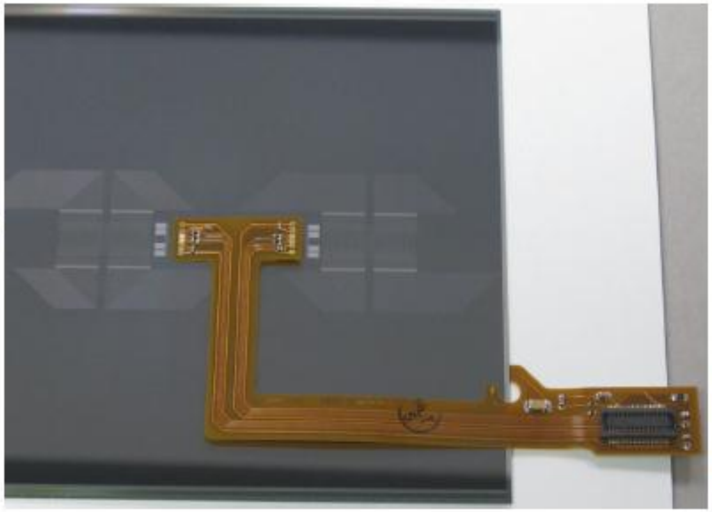
Design features:

- Single-sided silicon micro-strips, double metal layer
- KPiX readout, with time stamping
- Gas cooling
- DC-DC converters supply high instantaneous current

Realization:



Barrel silicon module
300μm Si, 25(50)μm
sense(readout) pitch

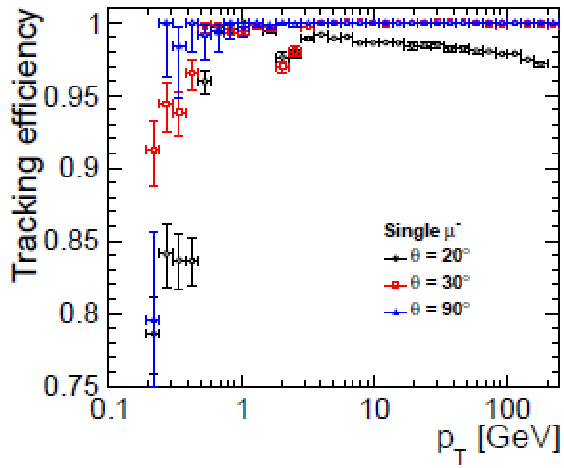


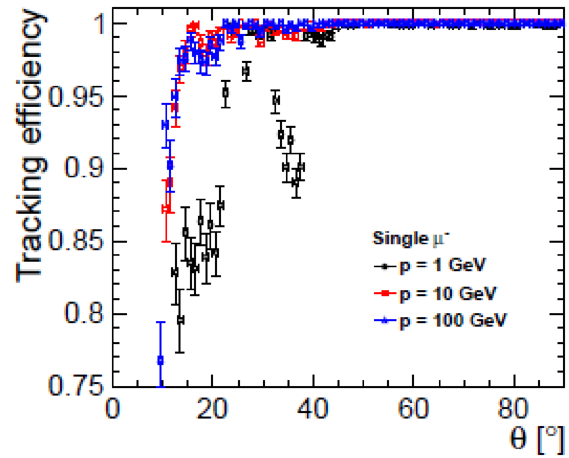
Barrel sensor with prototype pigtail cable.

Silicon Tracking

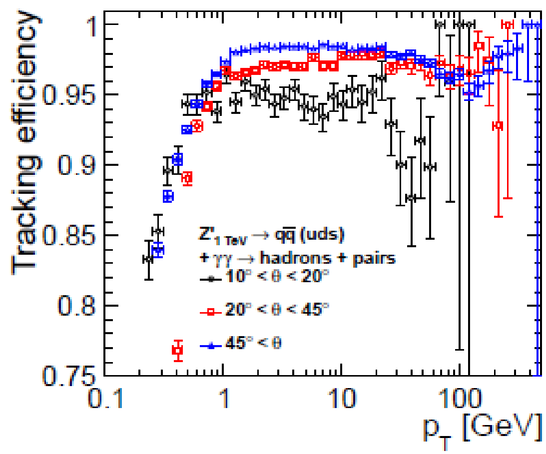
Performance - efficiency

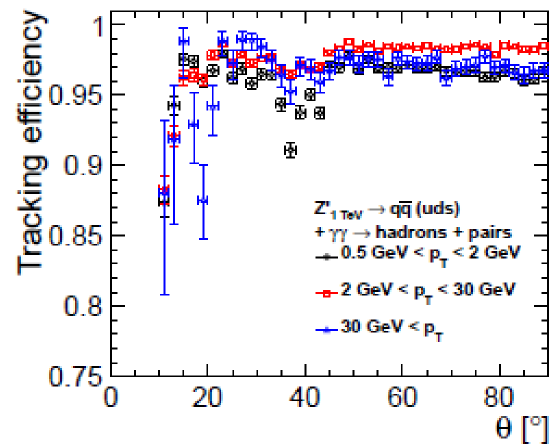
Single muons





Di-jet Z'
(M = 1 Tev/c^2)

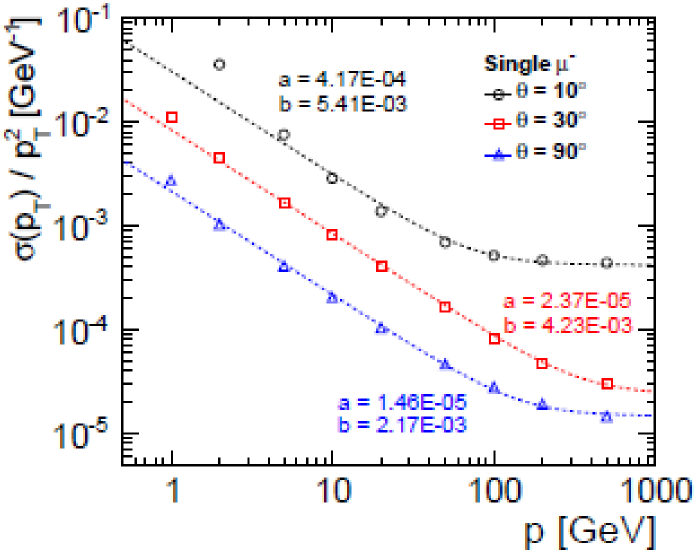




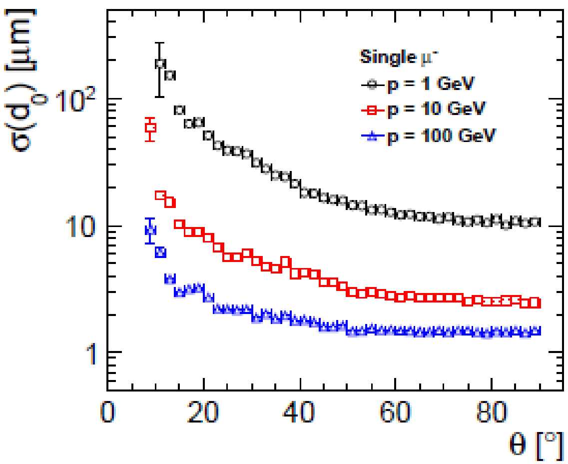
Silicon Tracking

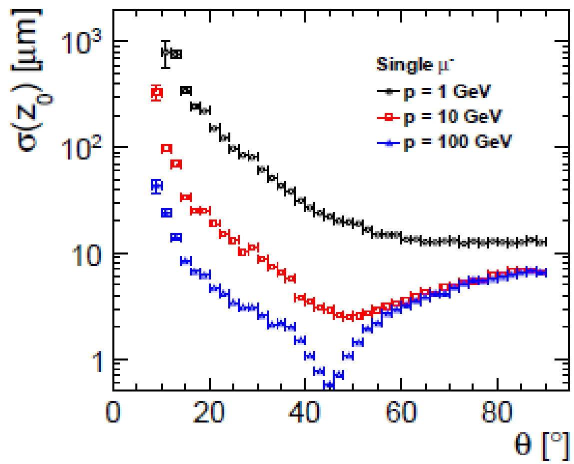
Performance

Momentum resolution



Impact parameter



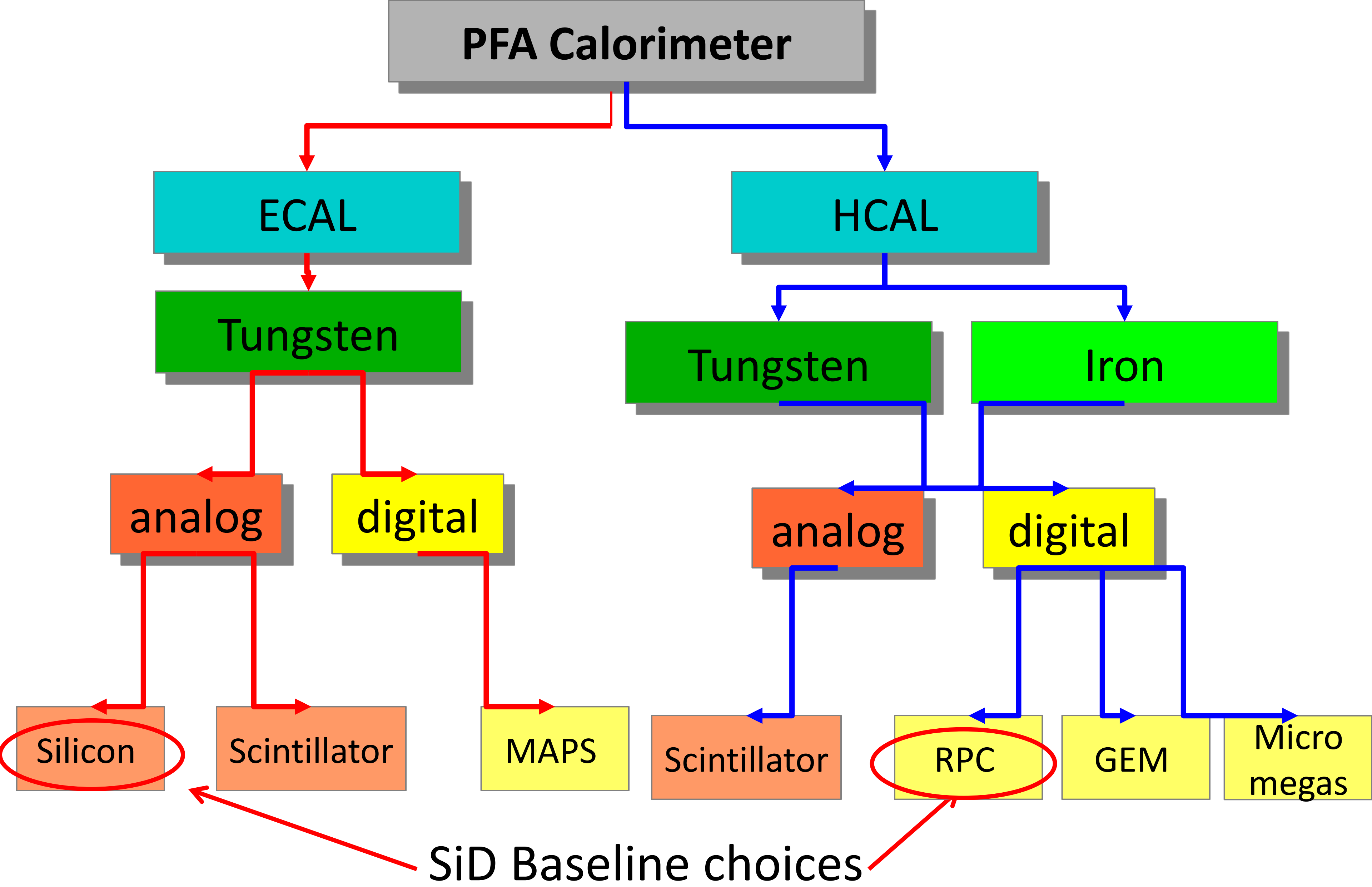


Calorimetry

SiD Calorimetry is designed for the PFA approach:
-> ECal and HCal must be “imaging”: high granularity
-> Small Moliere radius for ECal – separate e^-/charged h
-> Minimize gap between tracker and ECal
+ sufficient overall depth

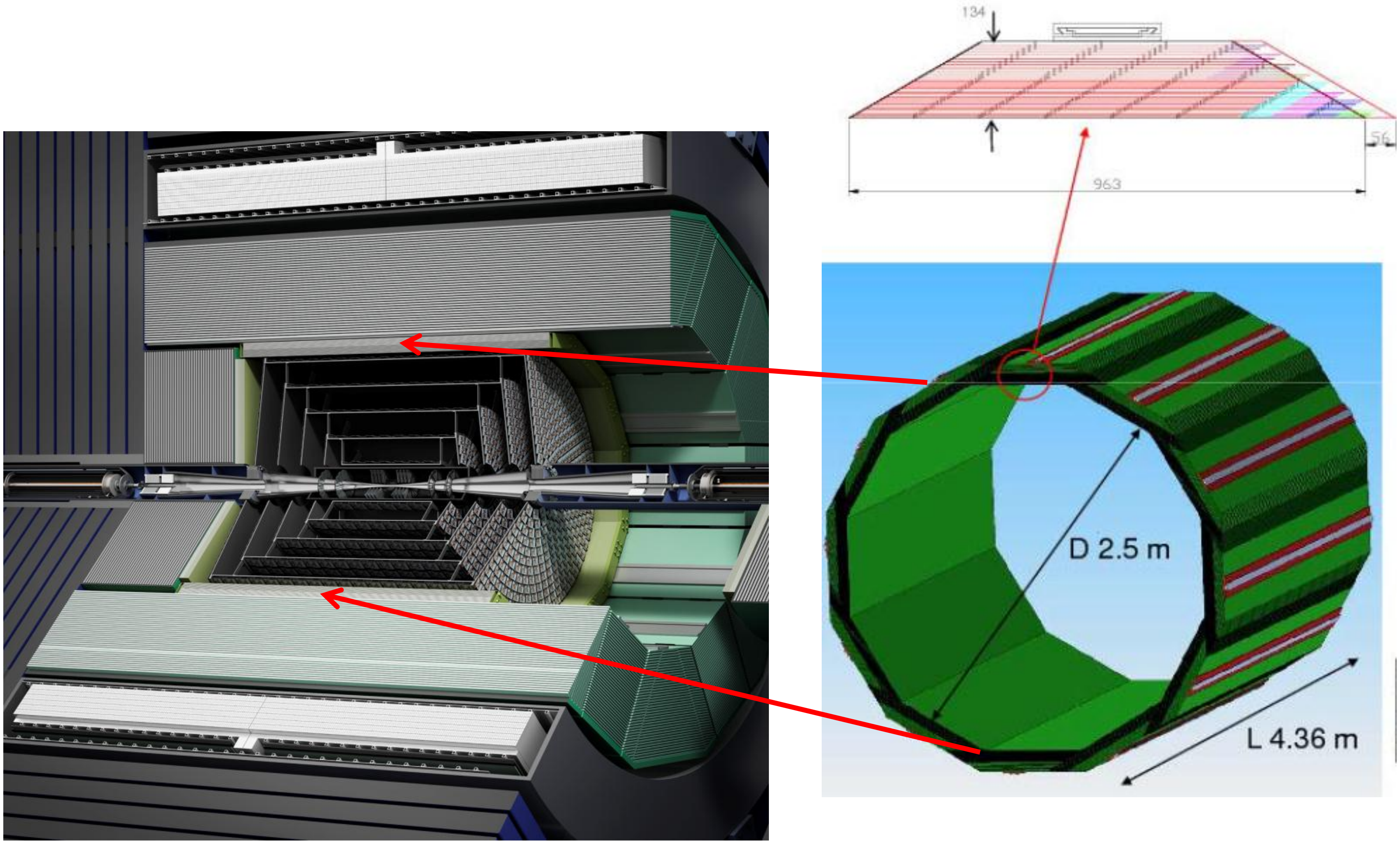
- SiD ECAL
  - Tungsten absorber
  - 20+10 layers
  - $20 \times 0.64 + 10 \times 1.30\ X_0$
- Baseline Readout using
  - 5x5 mm^2 silicon pads

- SiD HCAL
  - Steel Absorber
  - 40 layers
  - $4.5\ \Lambda_i$
- Baseline readout
  - 1x1 cm^2 RPCs

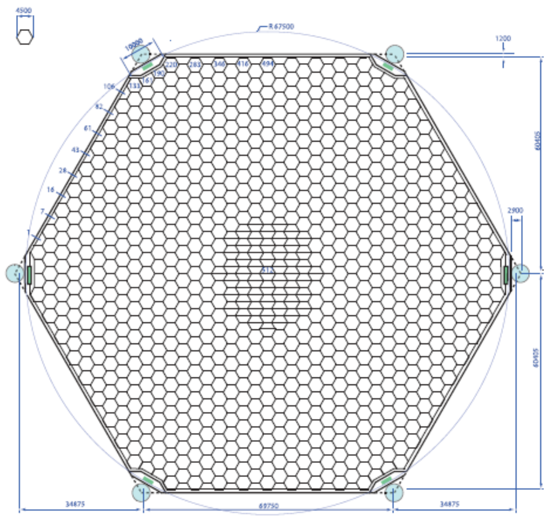


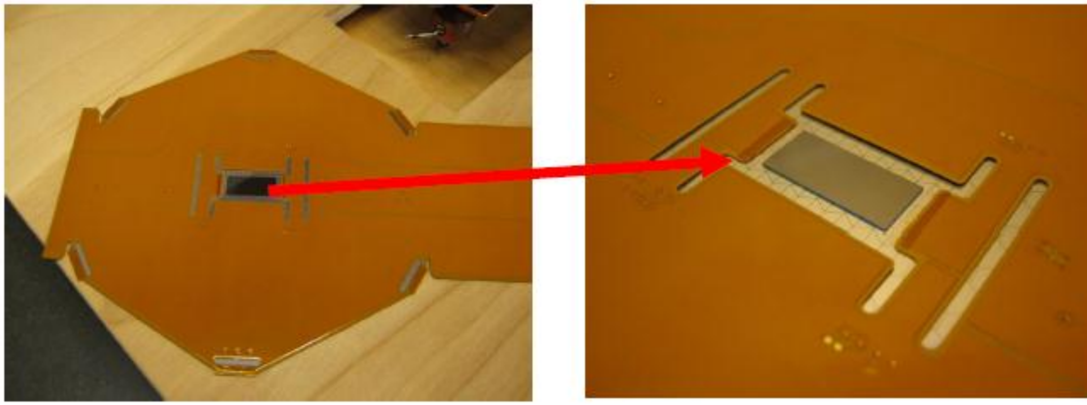
All other options (except a scintillator ECAL) are being considered

Electromagnetic Calorimetry



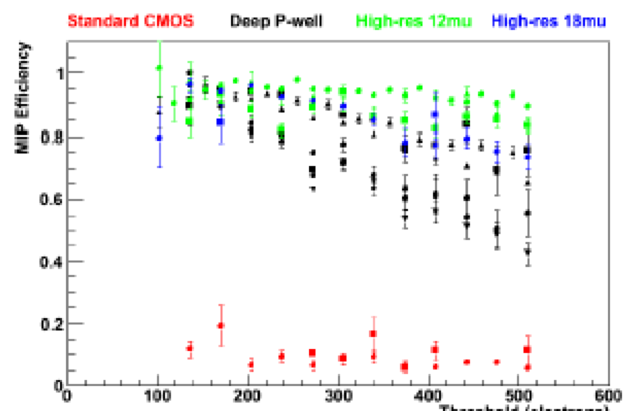
Electromagnetic Calorimetry



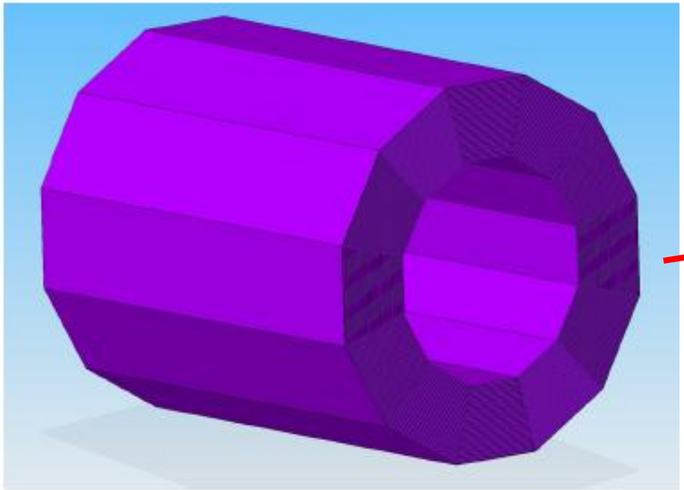


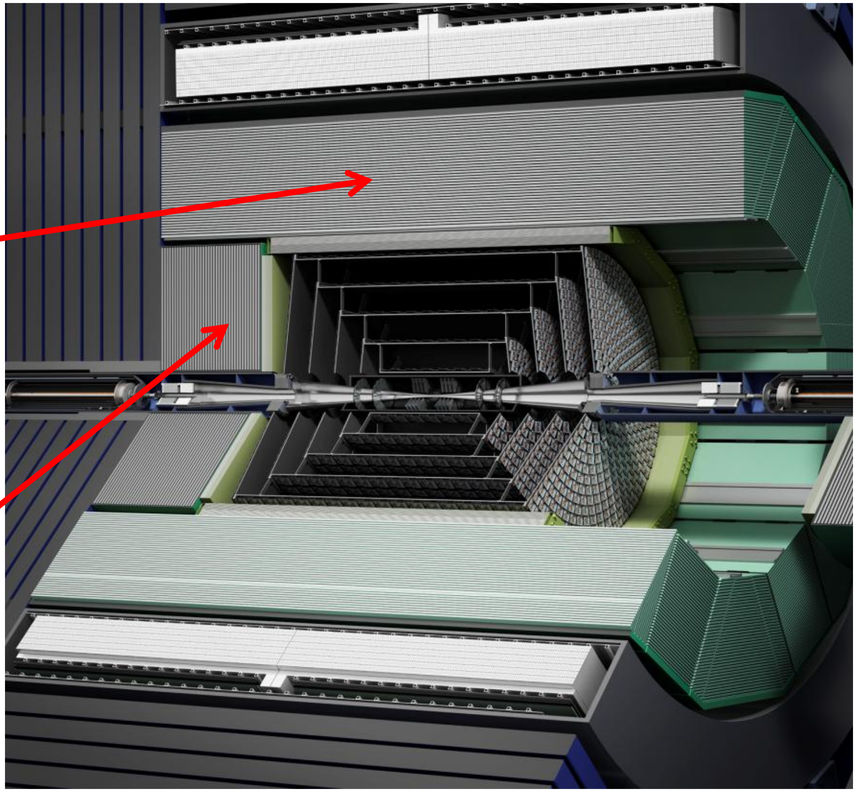
	Baseline
pixel size	13 mm^2
readout gap	1.25 mm
	(incl. 0.32 mm thick Si sensors)
effective Molière radius	14 mm
pixels per silicon sensor	1024
channels per KPiX chip	1024
dynamic range requirement	$\sim$ 0.1 to 2500 MIPs
heat load requirement	20 mW per sensor

Option: Monolithic Active Pixels (MAPS) 50µm x 50µm pixels



Hadronic Calorimetry

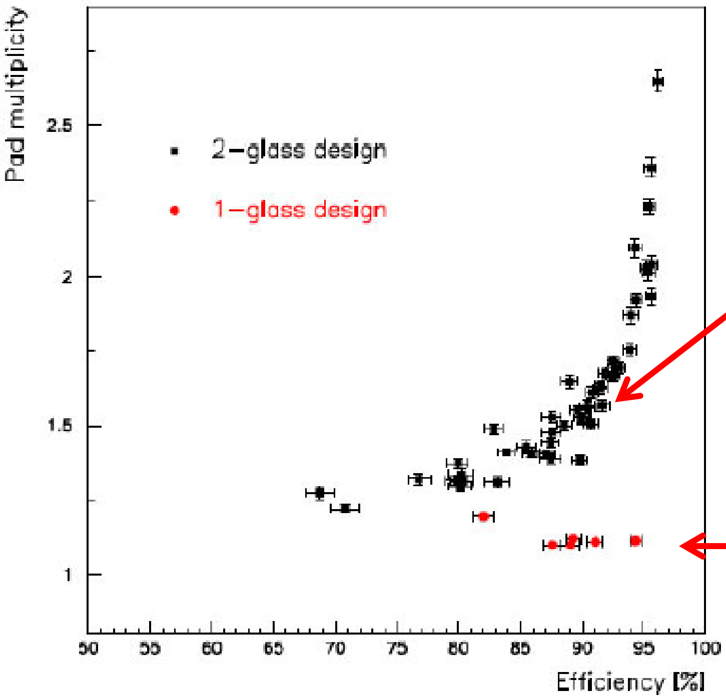




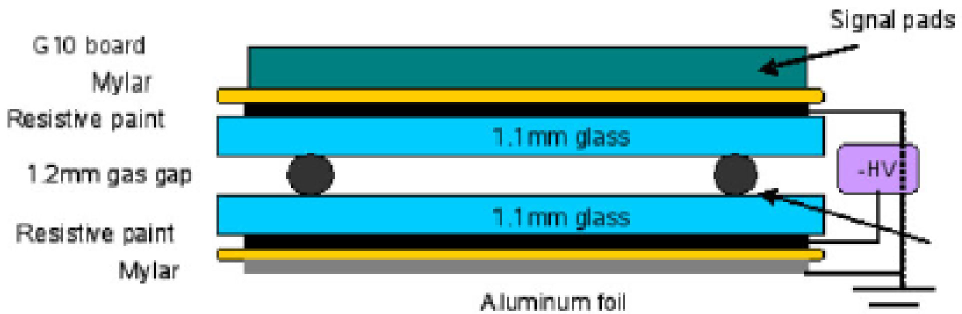
Steel absorber
40-layers, 4.5 λ_I
Tracking calorimeter
RPC Baseline. 1x1 cm^2 cells

Hadronic Calorimetry

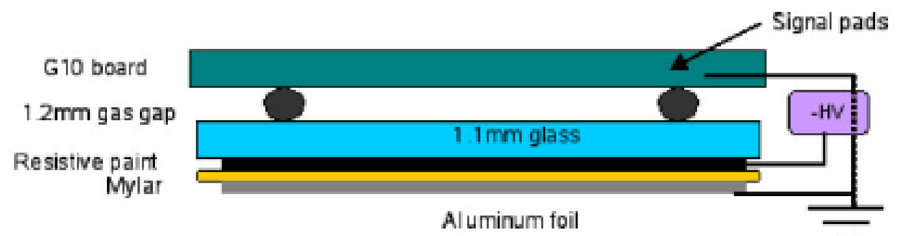
Baseline: RPC DHCAL



Default "two-glass" RPC



Special "one-glass" RPC

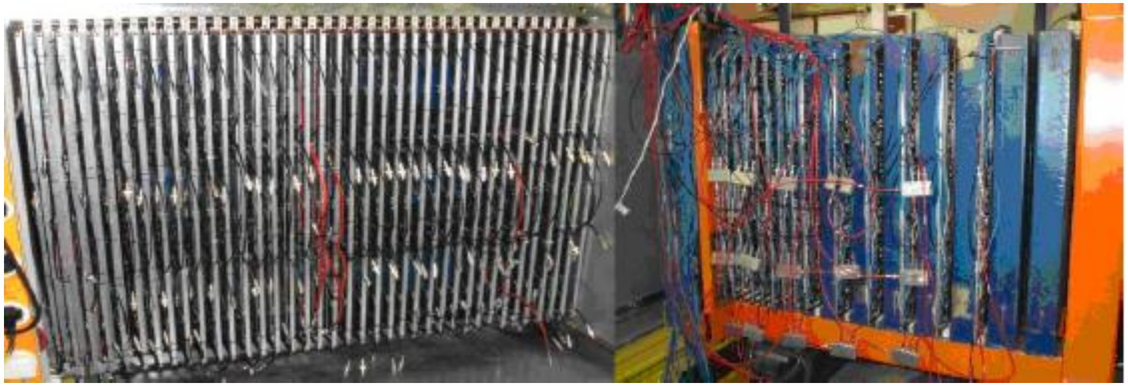


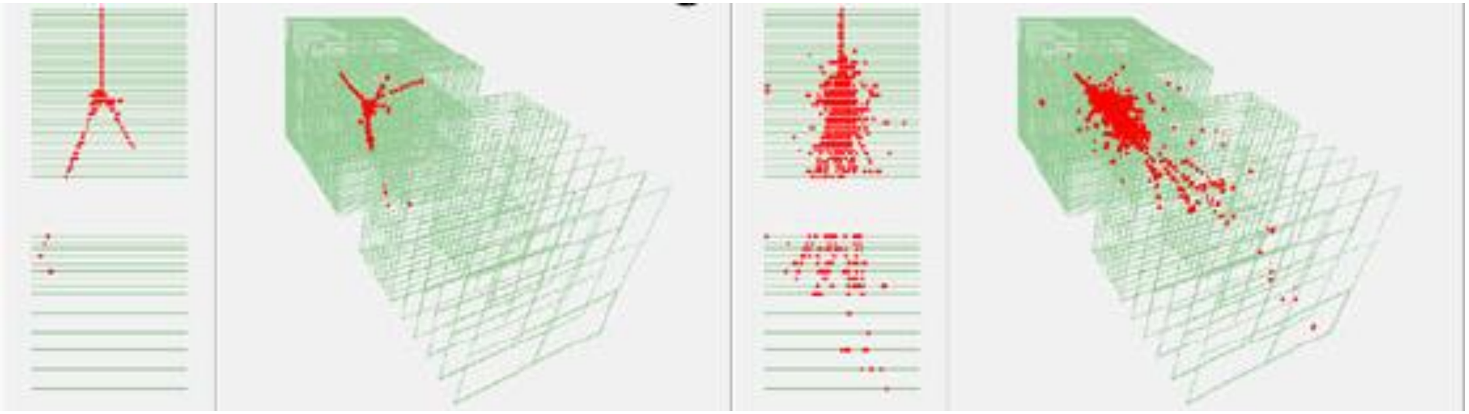
- 2-glass design can operate at good efficiency *and* low multiplicity
- 1-glass design has flat multiplicity vs. efficiency - still being understood/under development)

Hadronic Calorimetry

Baseline: RPC DHCAL

Test beam
1 m^3 stack

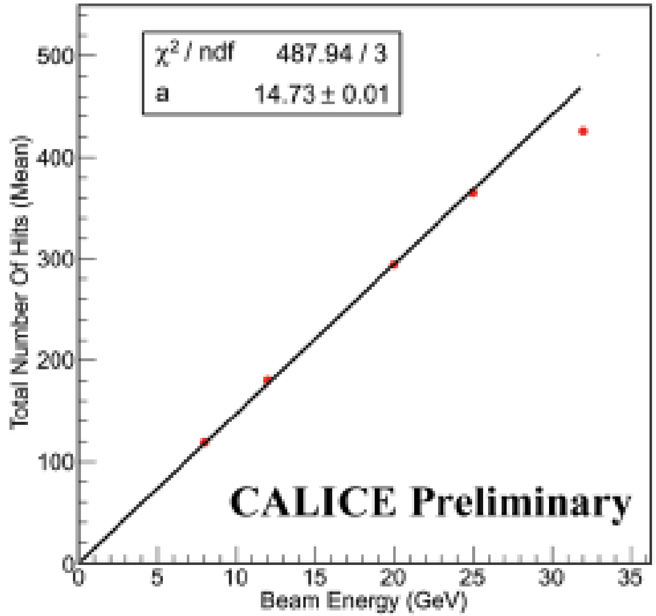


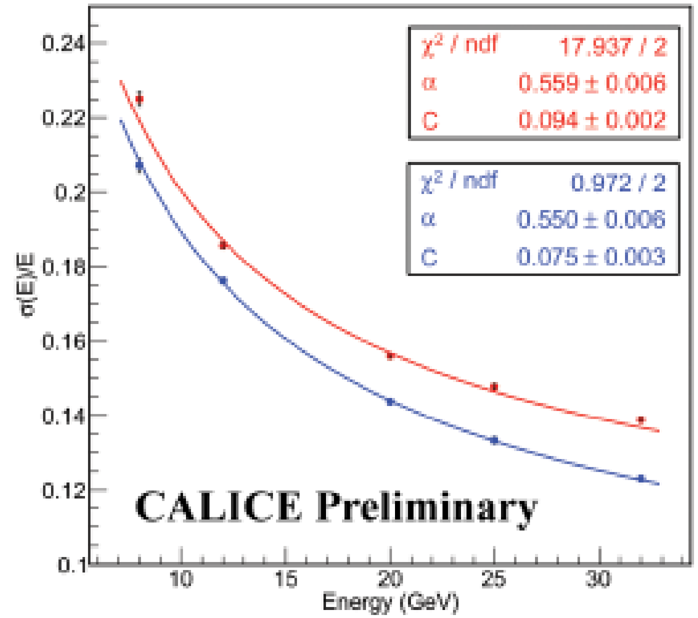


8 GeV pion shower   120 GeV proton shower.

Hadronic Calorimetry

Baseline: RPC DHCAL





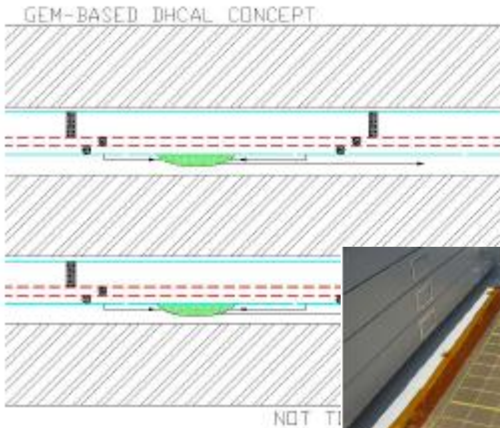
- The RPC technology is a great candidate for the readout of a highly segmented calorimeter.
- The dark rate in the DHCAL is very low
- The response is linear up to about 30 GeV/c.

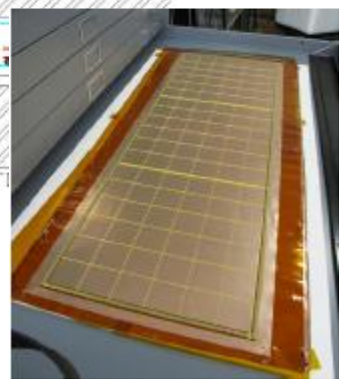
Hadronic Calorimetry

CALICE Calorimeter for ILC

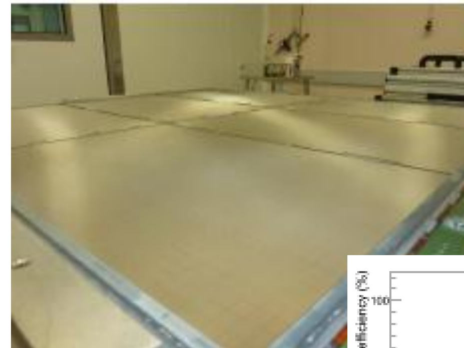
Options: GEM, Micromegas, Scintillator

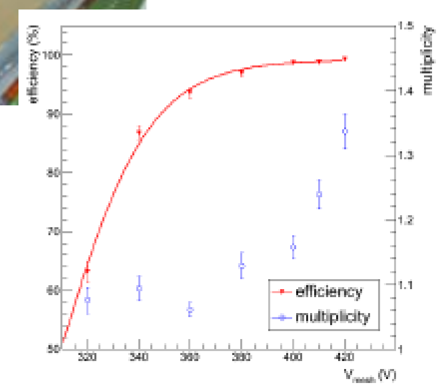
GEM



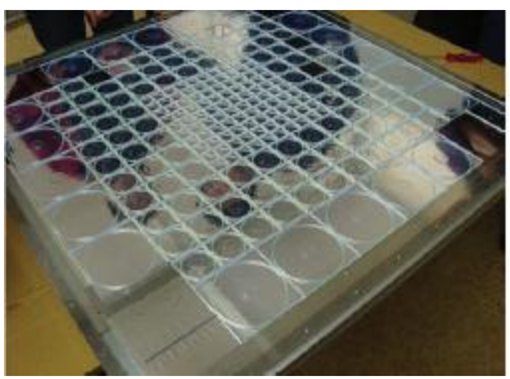


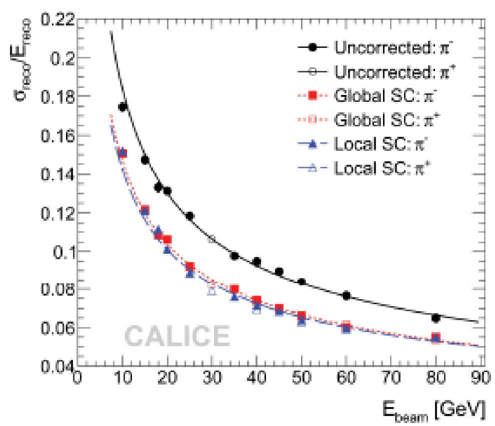
Micromegas

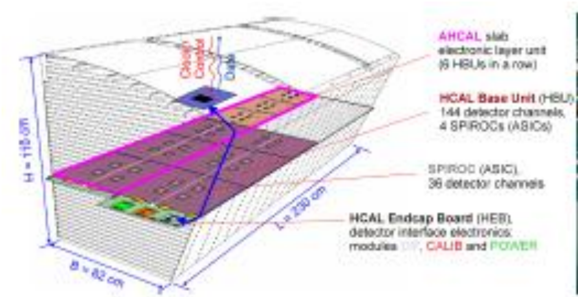




Scintillator

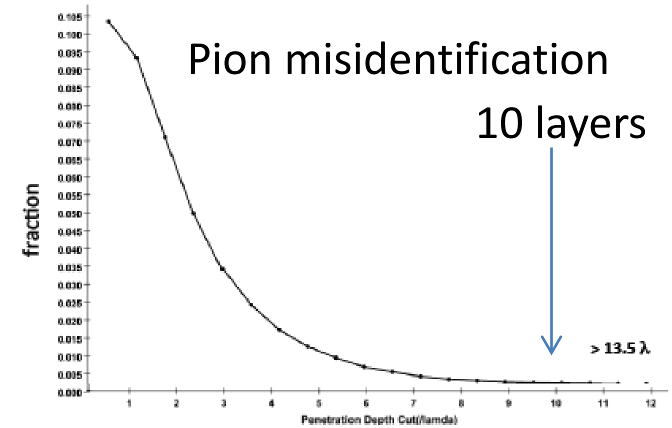


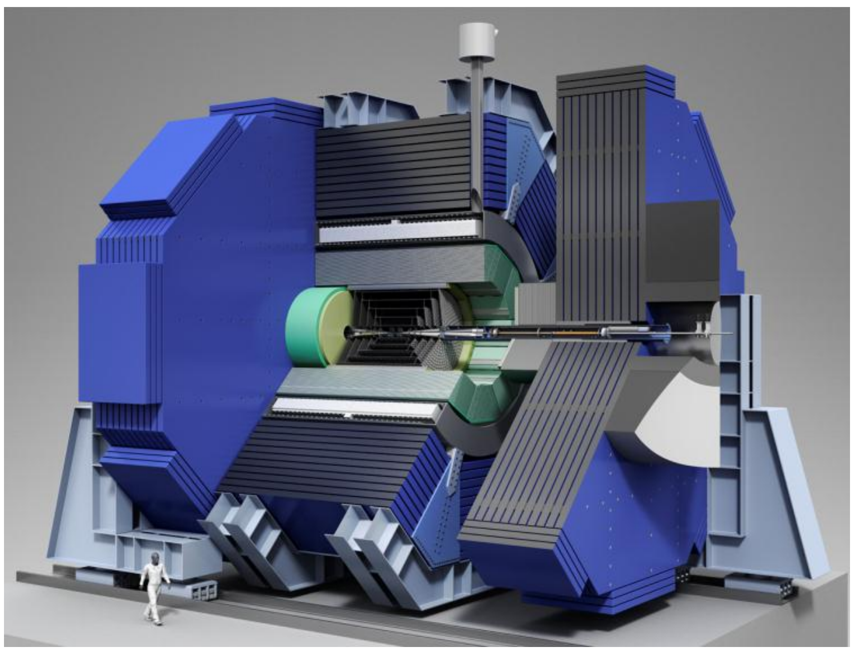


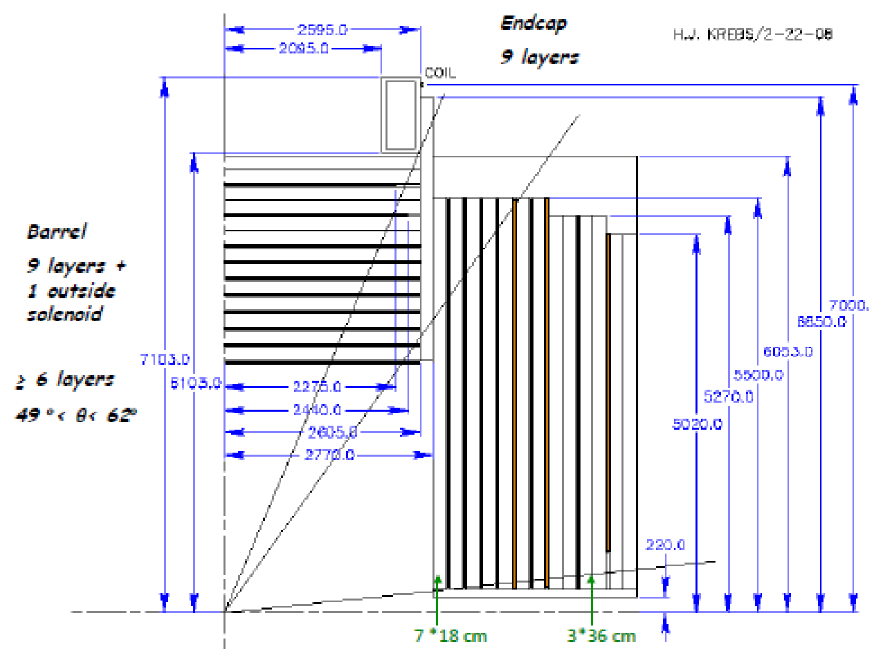


Muon System

- Muon identification/hadron rejection
- Flux return
- Tail catcher for calorimeter system
- Low rates/large area





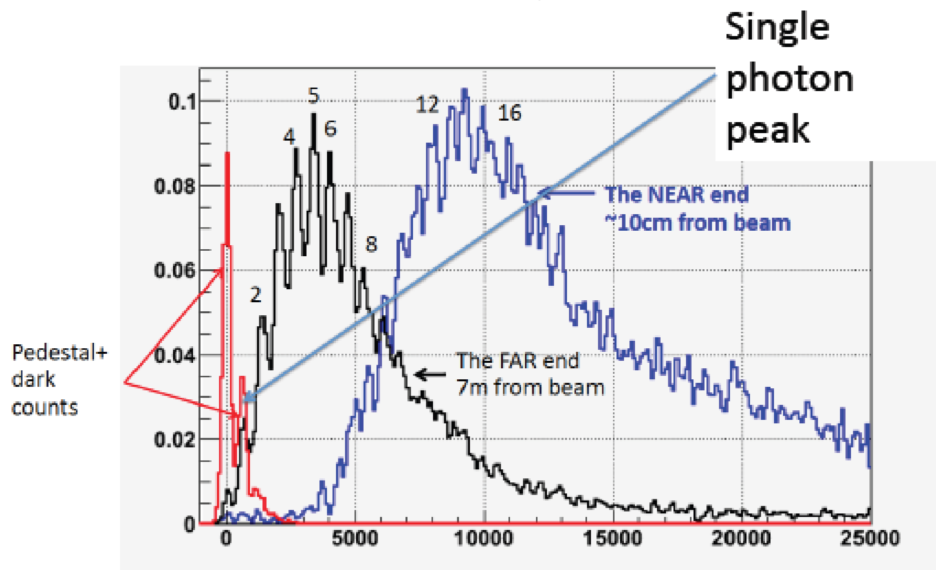


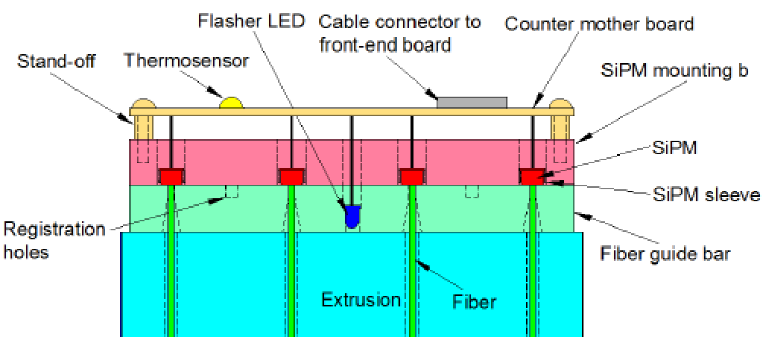
Muon System

Major change of baseline vs. LOI:

Scintillating strips/wavelength shifting fibers

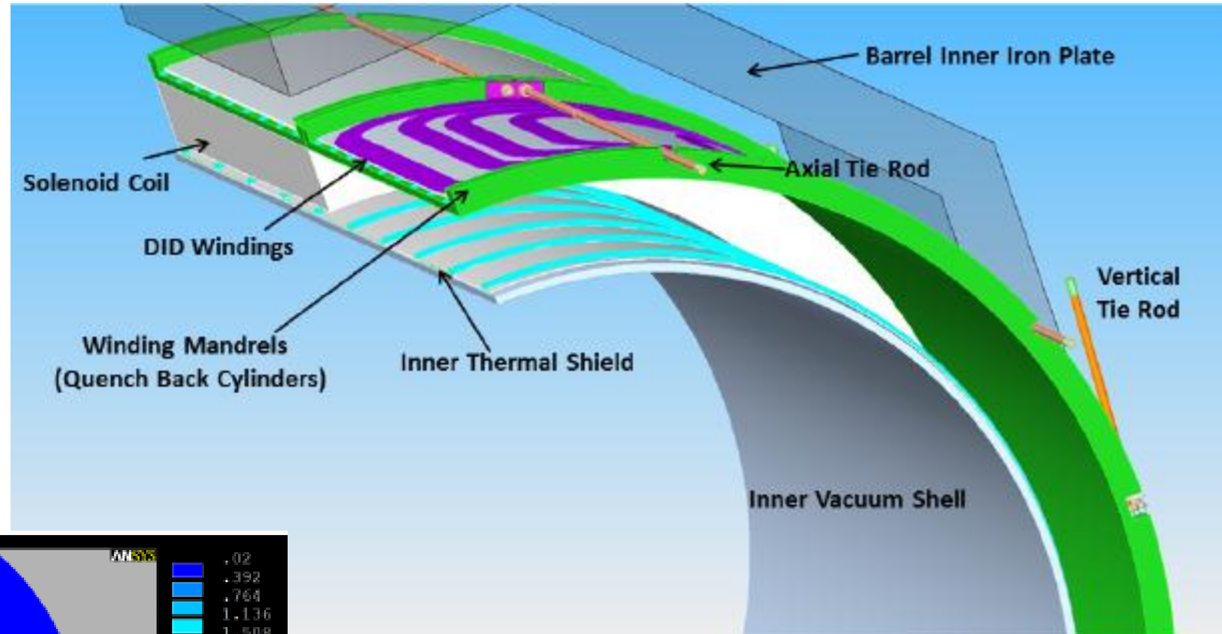
(RPC remains as an option)

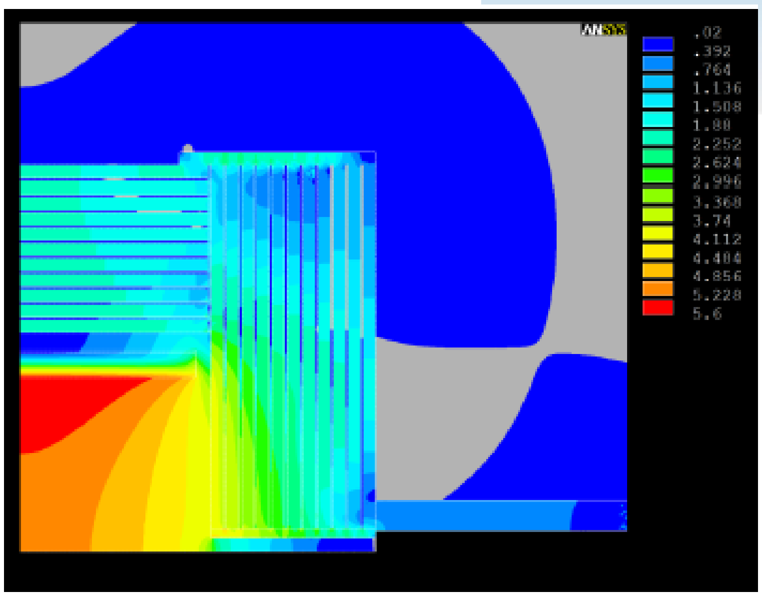




Development of system to position SiPM at the end of a fiber

Magnet System





- 5 T design based on 4 T CMS solenoid
- Muon system flux return
  - ANSYS 2-D and 3-D models used in design work
  - Benefitted from cryo engineering at SLAC and BNL and advances in computation

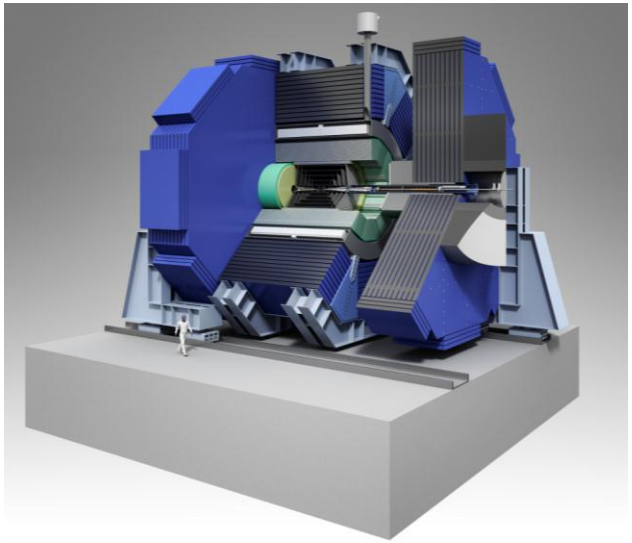
Electronics and DAQ - Rates

- SiD Electronics and DAQ builit around KPiX approach
  - Maximize common components

	cell size (mm^2)	number of channels (10^6)	av. to max. occ. (%)	approx. # bits per hit (bit)	data volume (Mbyte)
VTX barrel	0.02×0.02	408	50 - 60	32	1600
VTX disks inner	0.02×0.02	295	4 - 70	32	100
VTX disks outer	0.05×0.05	980	0.5 - 20	32	40
TRACKER barrel	0.05×100	16	12 - 300	32	20
TRACKER disks	0.05×100	11	4 - 500	32	4
ECAL barrel	3.5×3.5	72		40	
ECAL endcap	3.5×3.5	22	-	40	
HCAL barrel	10×10	30		40	
HCAL endcap	10×10	5	-	40	
LumiCal	$2.5\times$var.	0.061	-	40	
BeamCal	$2.5(5.0)\times$var.	0.076		40	
MUON barrel	$41\times$var.	0.026	-	32	
MUON endcap	$41\times$var.	0.022	-	32	

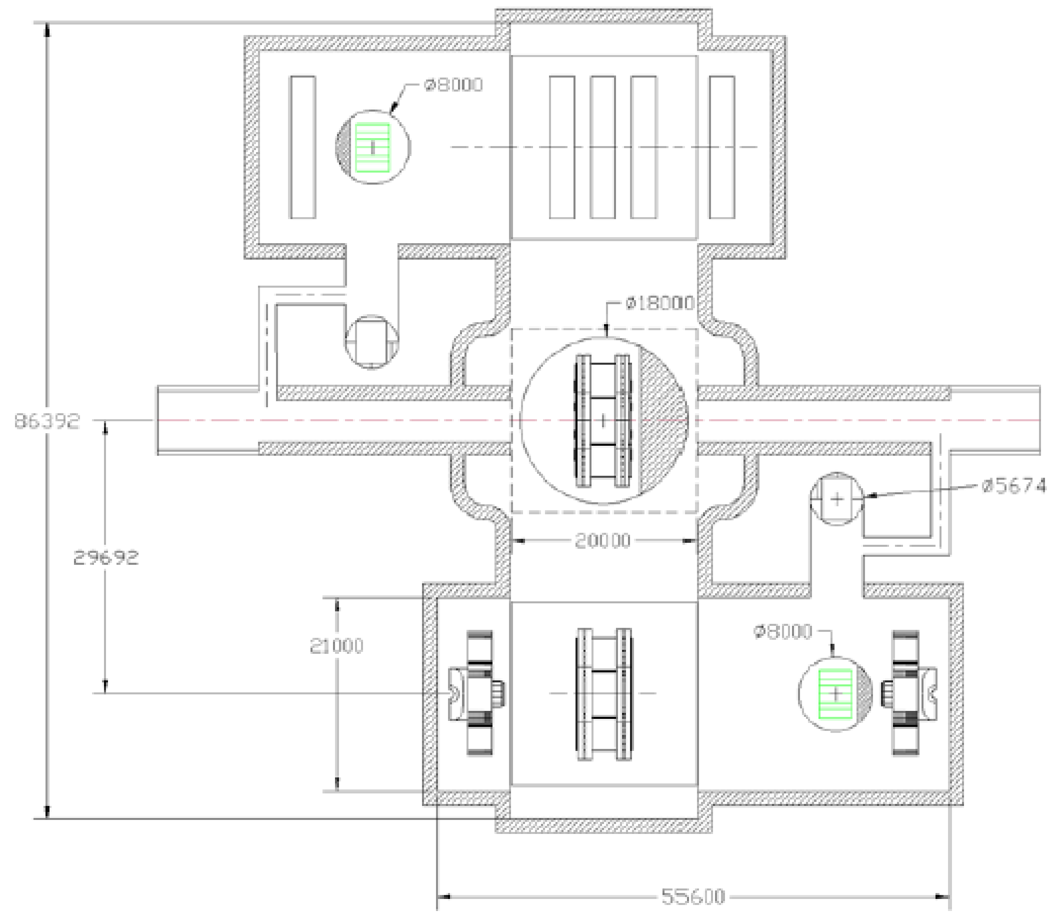
To be updated

Detector Integration and MDI

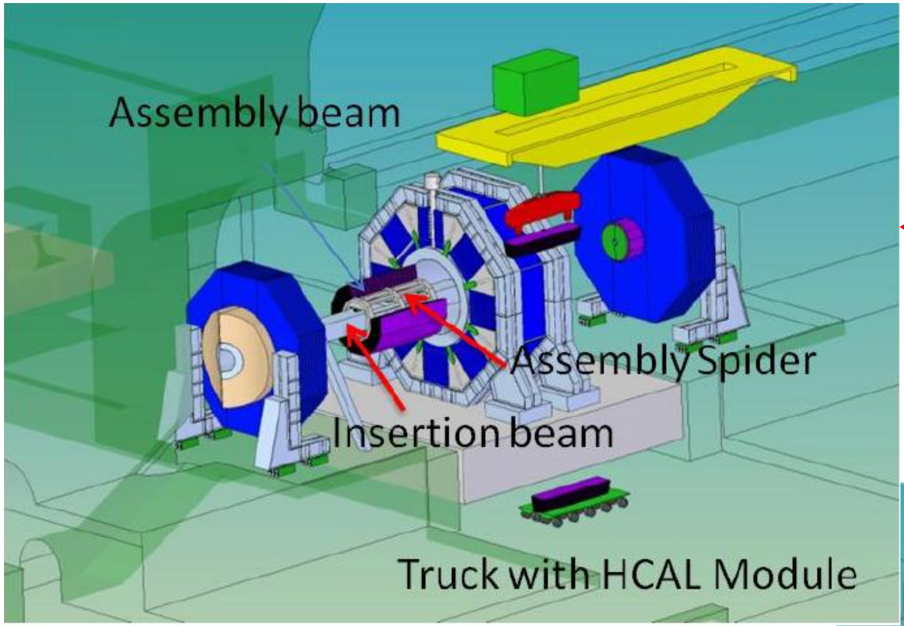


3 m thick concrete push-pull platform:
- 30 m travel for detector swap
- ~1 mm max static deflection at detector support points

IR Hall configuration (vertical access)

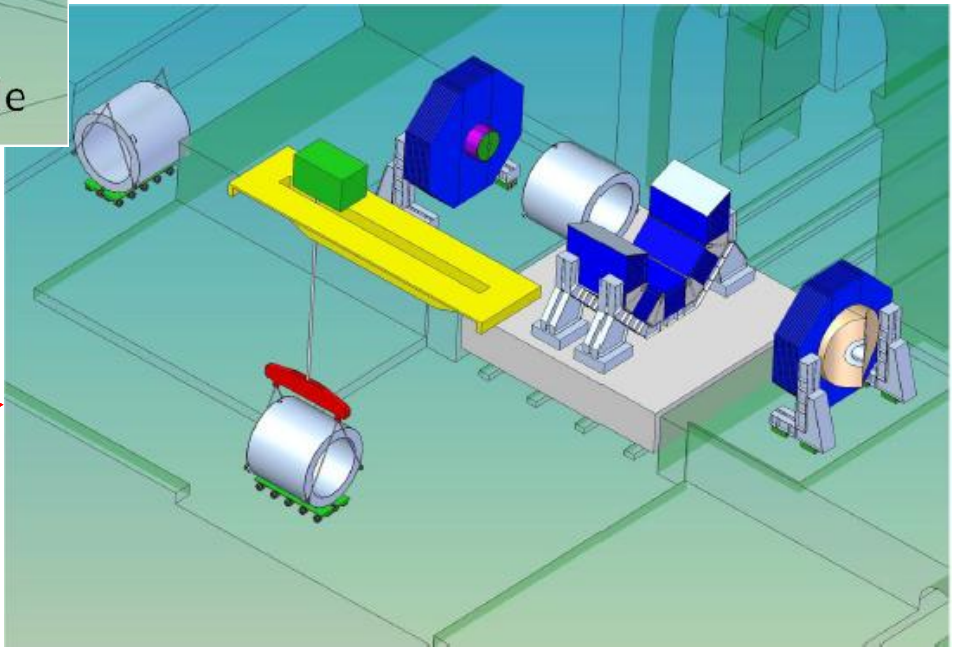


Detector Assembly - examples

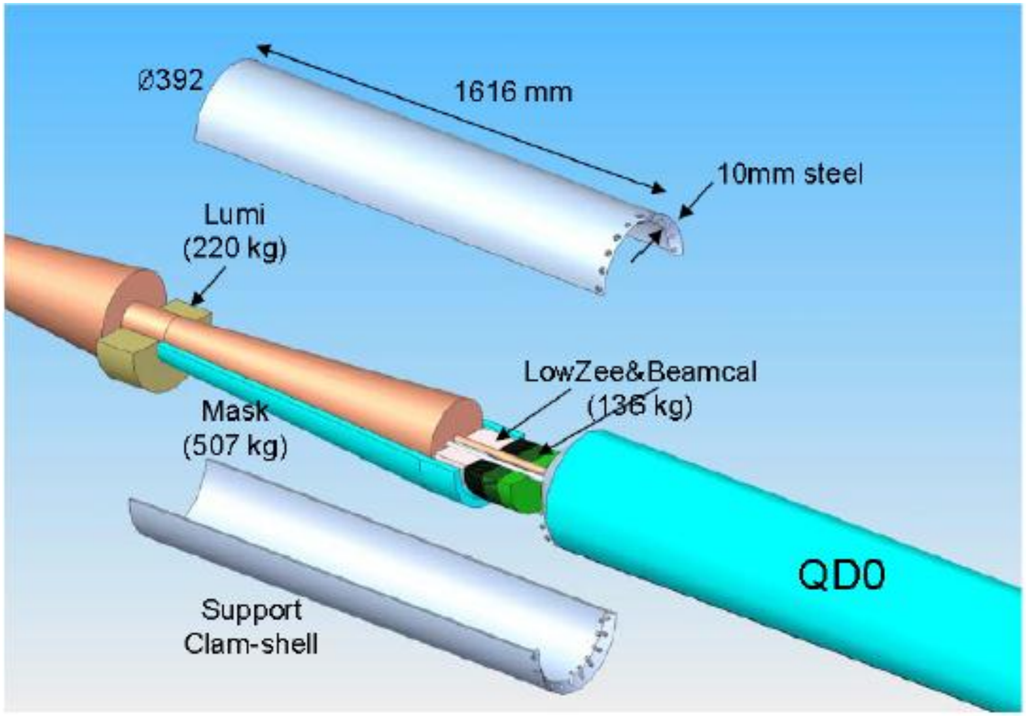


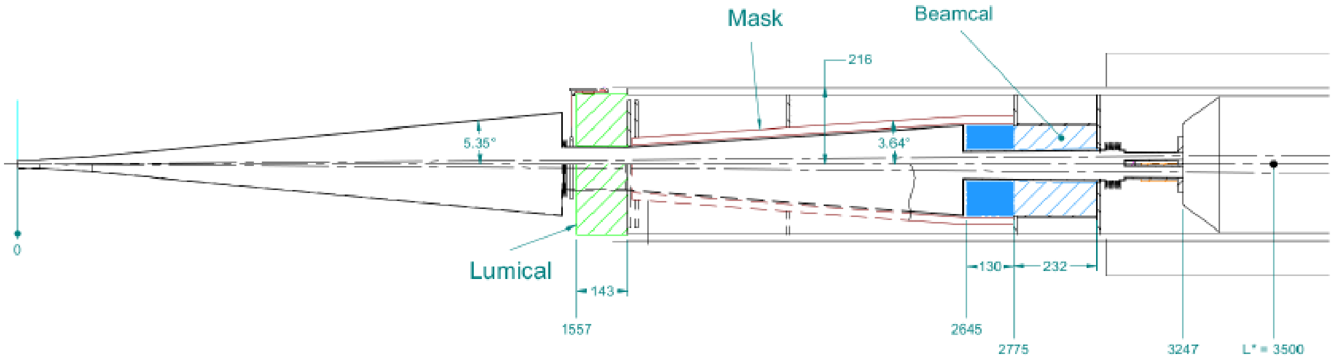
Assembling the Hadron Calorimeter

Horizontal access – moving the solenoid

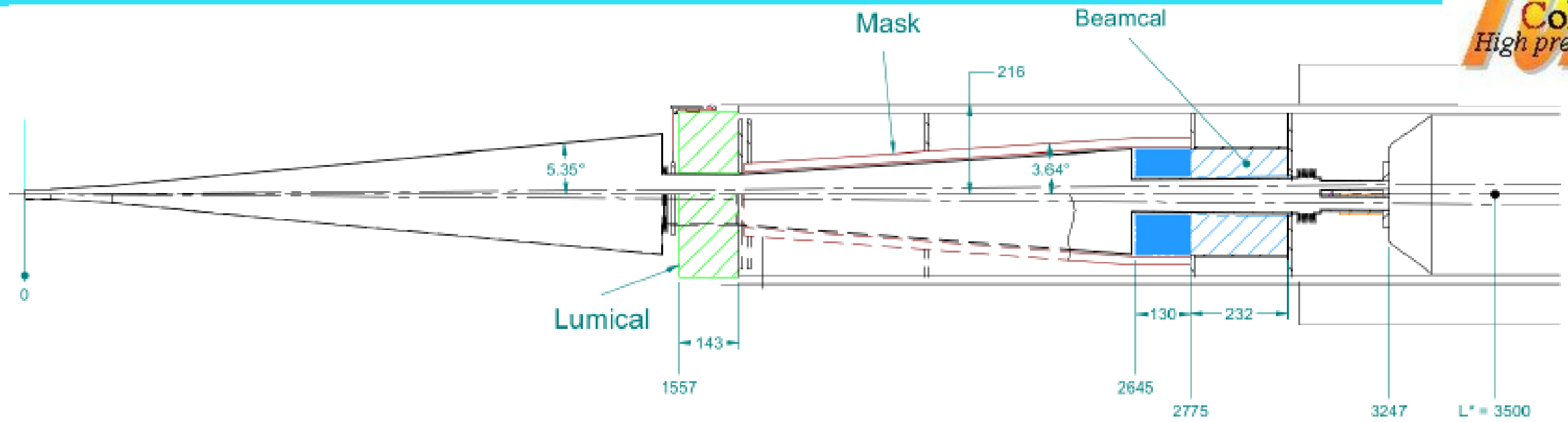


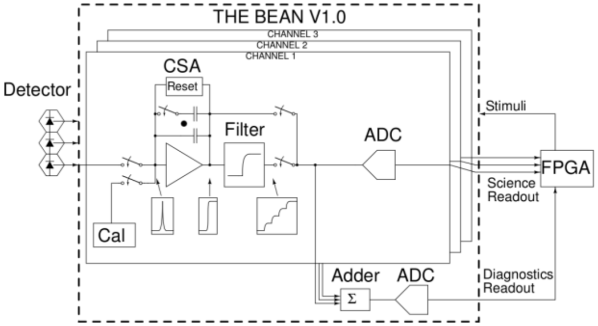
Beampipe/Forward Region





Beampipe/Forward Region

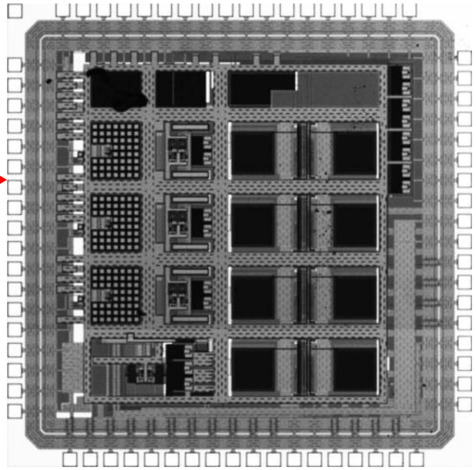




LumiCal - integrated luminosity and luminosity spectrum

BeamCal – small angle coverage (with LumiCal), instantaneous luminosity

Dedicated ASIC (Bean chip) for high luminosity region



SiD Costs

- Costing is based on SiD Parametric Model
- Basic items have agreed cost (SiD, ILD and CLIC):

	agreed unit cost (US-$)	agreed error margin (US-$)
Tungsten for HCAL	105/kg	45/kg
Tungsten for ECAL	180/kg	75/ kg
Steel for Yoke	1000/t	300/t
Stainless Steel for HCAL	4500/t	1000/t
Silicon Detector	6 / cm^2	2 / cm^2

- Costs in 2008 U.S. $

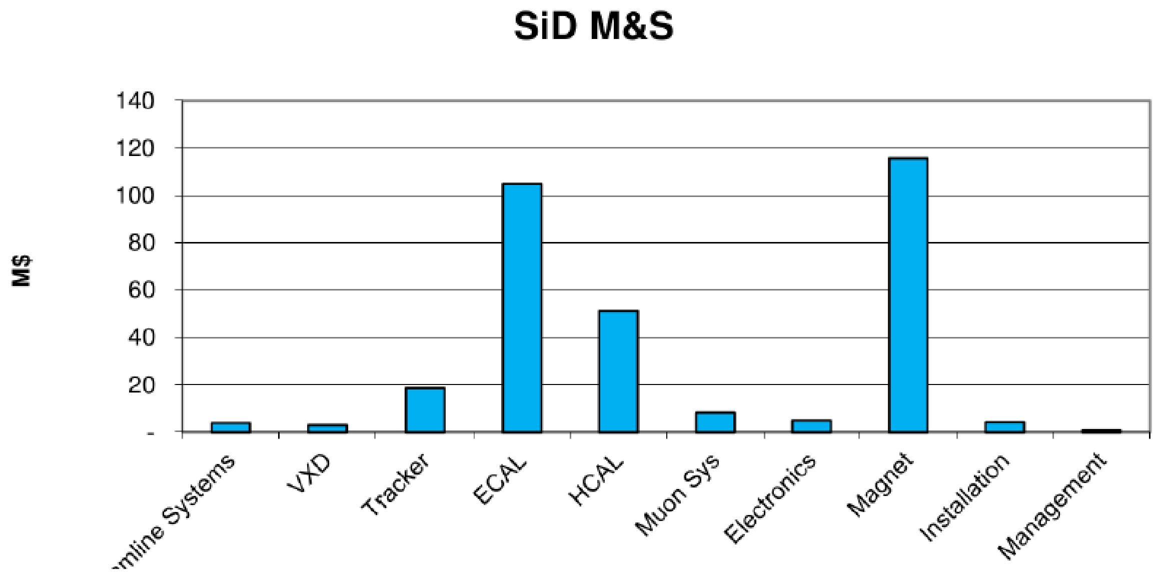
M&S 315 $M

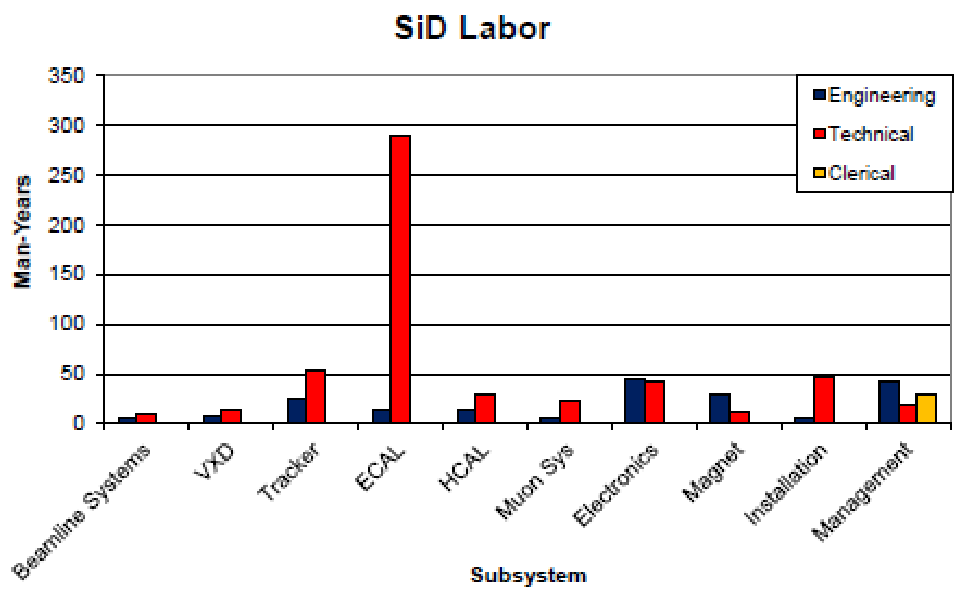
Contingency 127 $M

Labor 748 MY

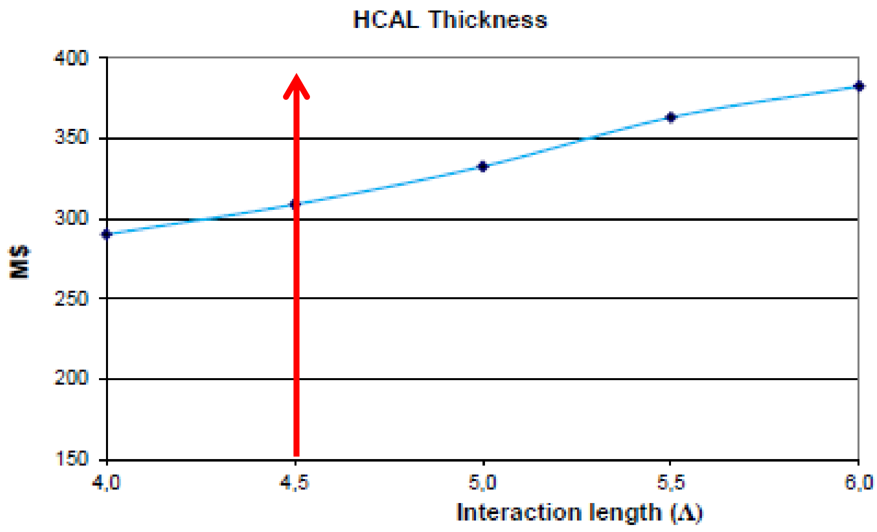
- Model allows exploration of sensitivity to cost increase and detector parameter changes

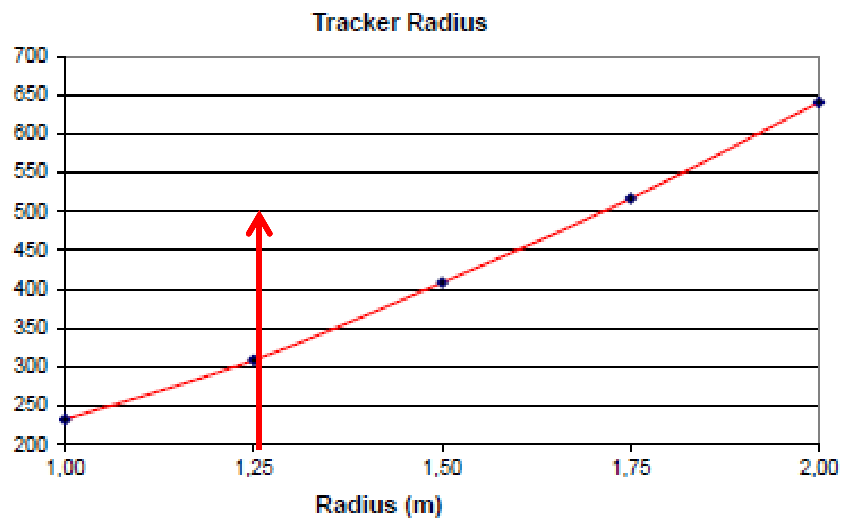
SiD Costs


SiD M&S
M$
140
120
100
80
60
40
20
-
VXD
Tracker
ECAL
HCAL
Muon Sys
Electronics
Magnet
Installation
Management


SiD Labor
Man-Years
350
300
250
200
150
100
50
0
Engineering
Technical
Clerical
Beamline Systems
VXD
Tracker
ECAL
HCAL
Muon Sys
Electronics
Magnet
Installation
Management
Subsystem

SiD Costs





Note: For the LOI an optimal cost point was found near the baseline parameters:

R(tracker) = 1.25m, B = 5T, HCAL λ_I = 4.5

Cost of Tungsten HCAL has been evaluated (requested by IDAG)

No potential for savings

SiD Benchmarking

Three processes at 1 TeV:

t tbar h   Philipp Roloff and Jan Strube (CERN)

WW   Tim Barlow (SLAC)

[h nu nubar   Homer Neal (SLAC)   ]   not reported in this talk

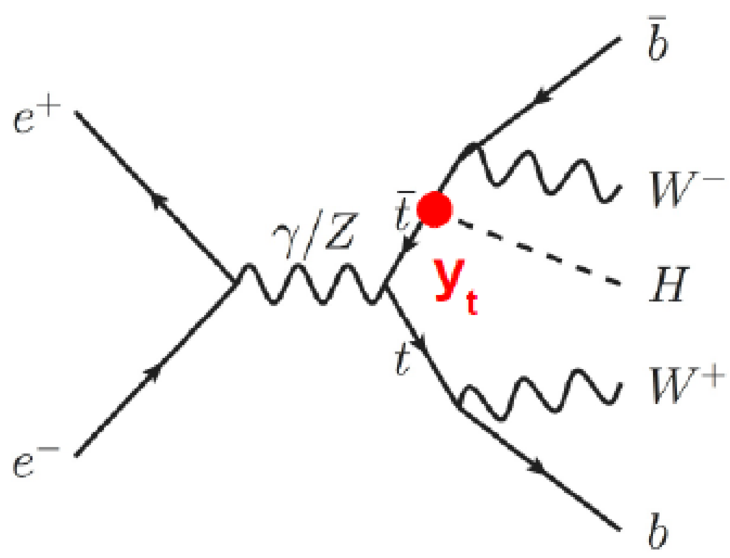
One 500 GeV process:

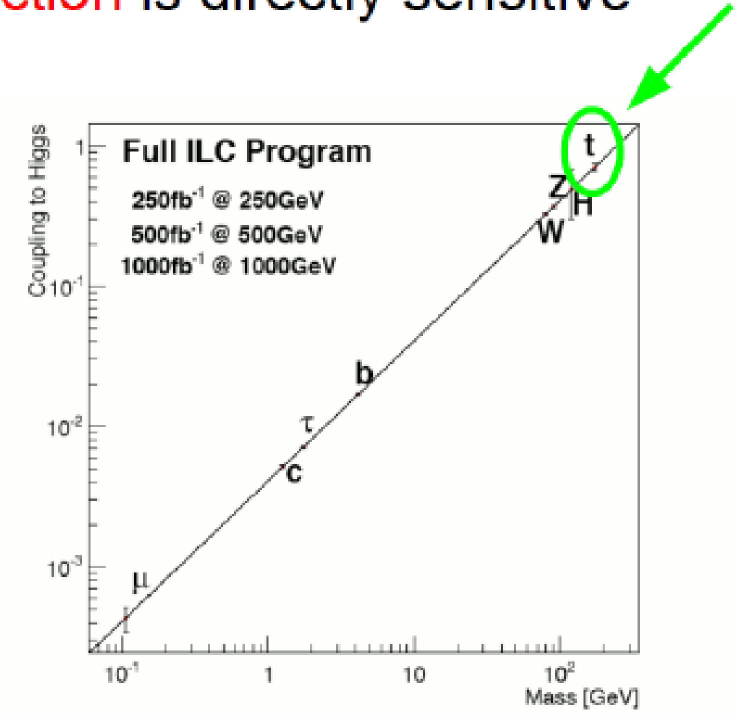
t tbar   Malachi Schram (PNNL)

Measurement of the top Yukawa coupling

- **Final states:**
  - "6 jets": $t(\to qqb)\bar{t}(\to l\nu\bar{b})H(\to b\bar{b})$, m_H = 125 GeV
  - "8 jets": $t(\to qqb)\bar{t}(\to qq\bar{b})H(\to b\bar{b})$, m_H = 125 GeV

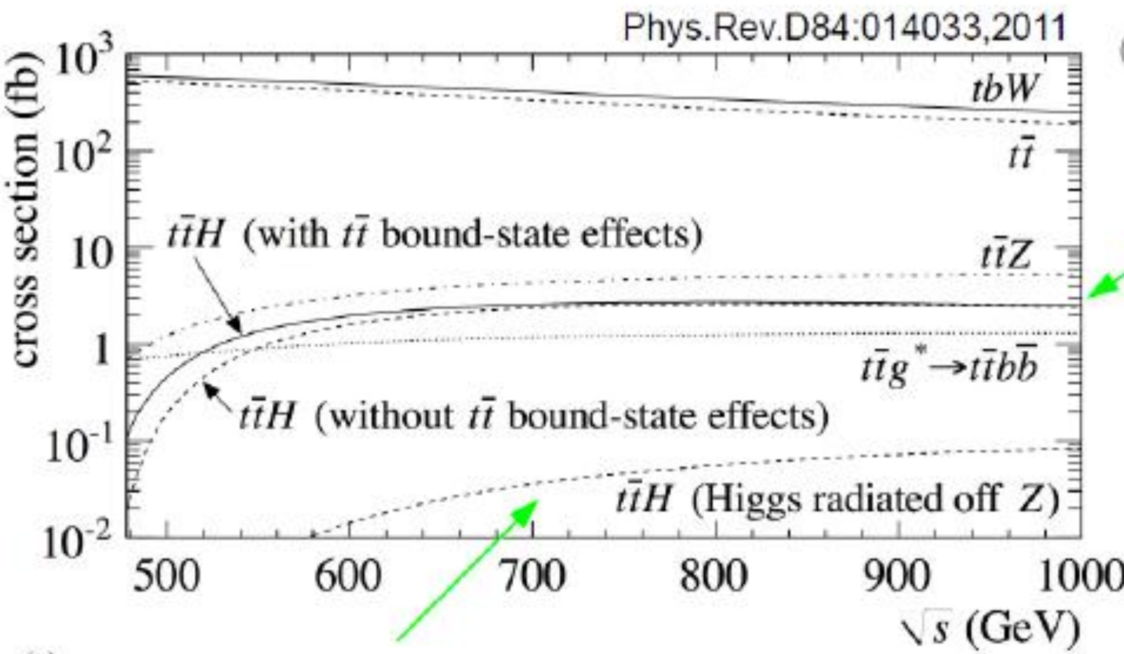
- **Motivation:** Cross section for $t\bar{t}H$ production is directly sensitive to the top Yukawa coupling, y_t:

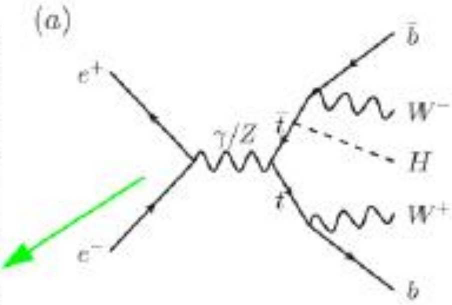




This study tests jet clustering, missing energy reconstruction, flavor tagging, and reconstruction/identification of high energy leptons.

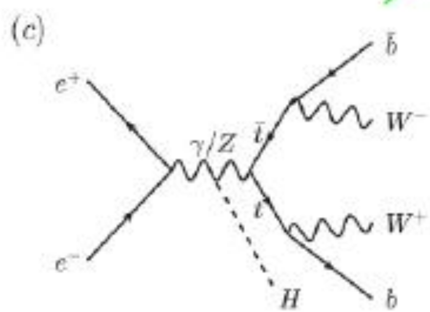
Cross sections





At 1 TeV:

- $\sigma \approx 2.2$ fb
- $t\bar{t}$ bound-state effects can be neglected



Small correction

Higgs radiated off Z:

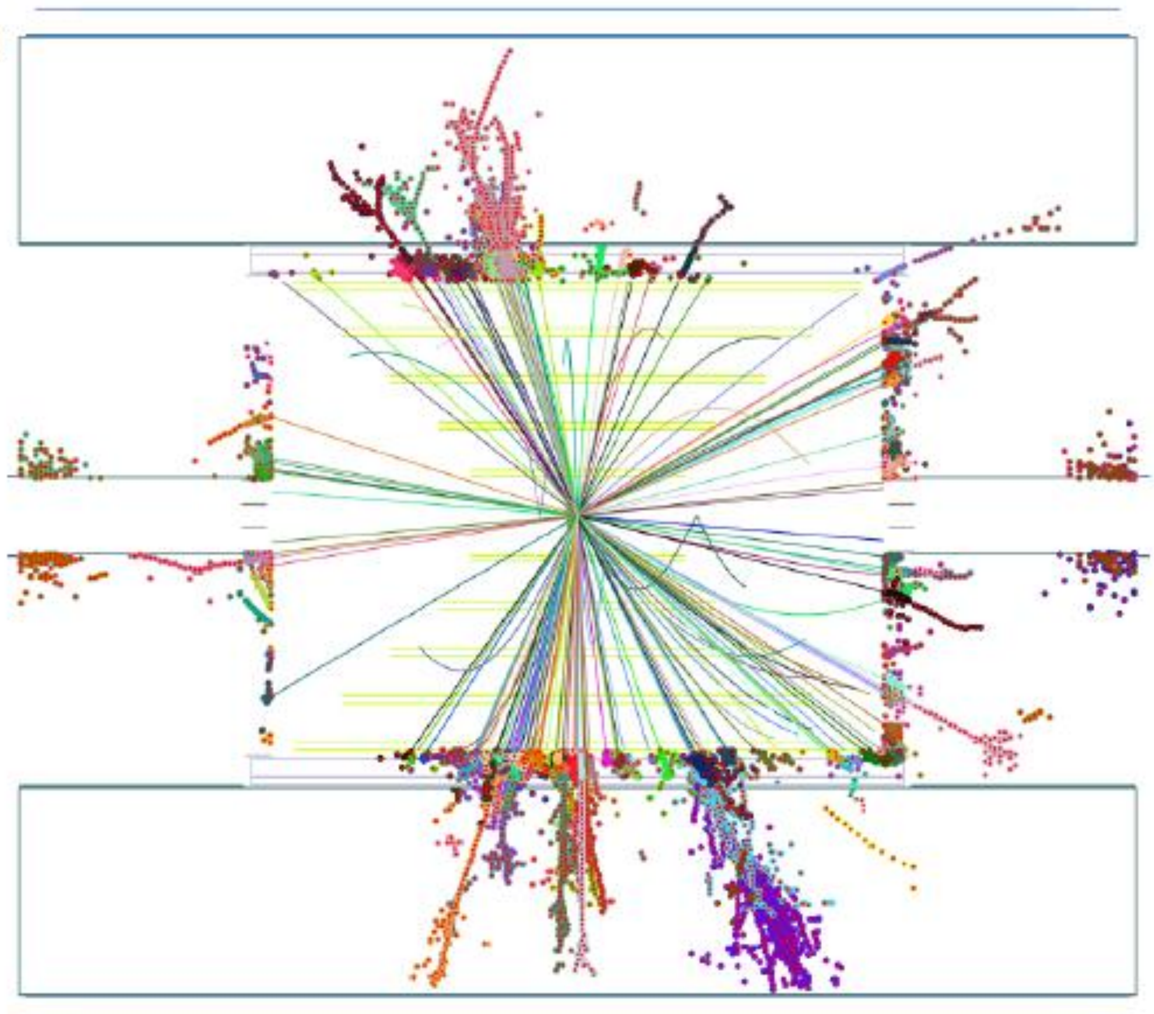
- $\sigma \approx 0.08$ fb
- Not sensitive to y_t

Event reconstruction I

1.) Remove all PFOs with:

- $p_T < 500$ MeV
- $\Theta < 20°$
- $\Theta > 160°$

2.) Remove identified isolated leptons from PFO list



8jet signal event

Event reconstruction II

3.) Perform jet clustering using the Durham algorithm in the exclusive mode with 6 or 8 jets

4.) Obtain b-tag value for each jet using LCFIPlus

5.) Group jets into $W^{\pm}$, H and top pairs by minimising:

6jets: $$\frac{(M_{12}-M_{W\pm})^2}{\sigma^2_{W\pm}}+\frac{(M_{123}-M_t)^2}{\sigma^2_t}+\frac{(M_{45}-M_H)^2}{\sigma^2_H}$$

8jets:

$$\frac{(M_{12}-M_{W\pm})^2}{\sigma^2_{W\pm}}+\frac{(M_{123}-M_t)^2}{\sigma^2_t}+\frac{(M_{45}-M_{W\pm})^2}{\sigma^2_{W\pm}}+\frac{(M_{456}-M_t)^2}{\sigma^2_t}+\frac{(M_{78}-M_H)^2}{\sigma^2_H}$$

Event selection

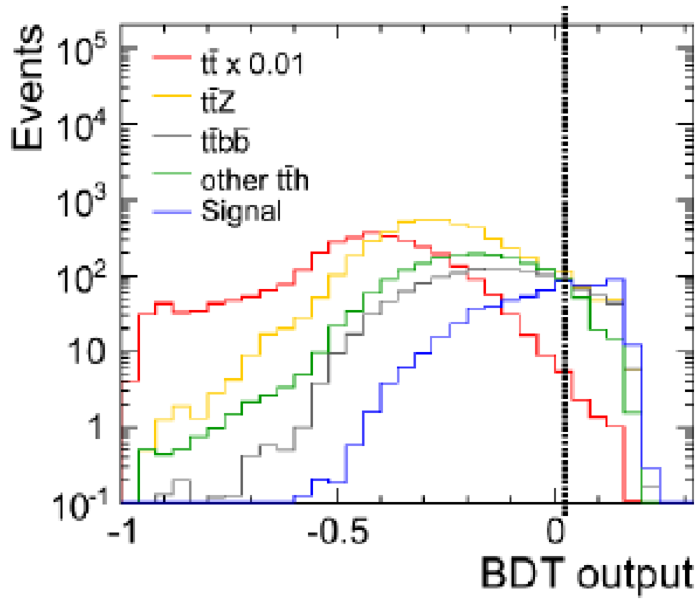
Signal events were selected using Boosted Decision Trees (BDTs) as implemented in TMVA.

Input variables for the 6-jet final state:
M_{12}, M_{123}, M_{45}, four highest b-tags values, Thrust, $Y_{5\to6}$,
number isolated leptons, number of PFOs, missing transverse momentum, visible energy
→ 13 variables

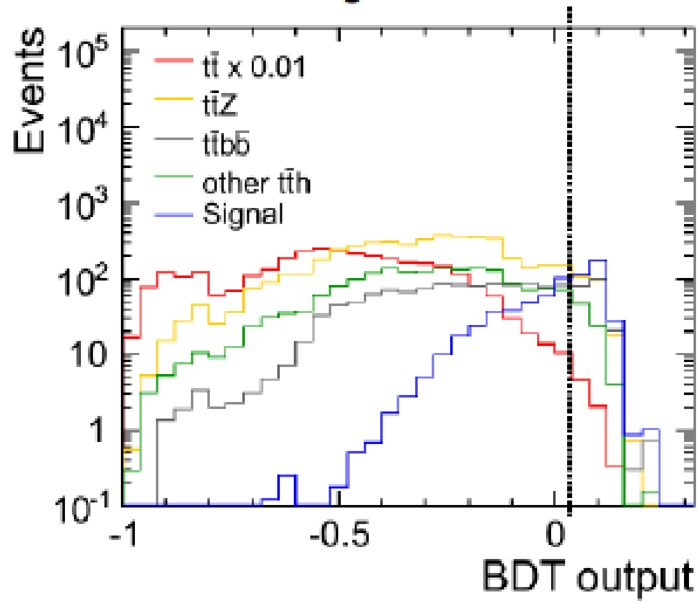
Input variables for the 8-jet final state:
M_{12}, M_{123}, M_{45}, M_{456}, M_{78}, four highest b-tags values, Thrust, $Y_{7\to8}$,
number isolated leptons, number of PFOs, missing transverse momentum, visible energy
→ 15 variables

BDT outputs and results

6 jets: BDT > 0.0266



8 jets: BDT > 0.0363



Using cut on BDT output with best $S / (S + B)^{1/2}$

$\Delta\sigma / \sigma = 13.6\% \rightarrow \Delta y_t / y \approx 6.8\%$	$\Delta\sigma / \sigma = 12.3\% \rightarrow \Delta y_t / y \approx 6.2\%$

Combined: $\Delta y_t / y \approx 4.6\%$ 500 fb^{-1} each pol. L_{int} = 1 ab^{-1}

$\Delta y_t / y \approx 4.1\%$ **all 1 ab^{-1} at $P(e^- / e^+) = -.8 / +.2$**

$e^+e^- \rightarrow W^+W^- \quad \sqrt{s} =$ **1 TeV**

Four Jet Topology (0.8<cosΘ<1 only)

Two Jets Plus Lepton Topology (0.8<cosΘ<1 and -1<cosΘ<1)

Beam Polarization Measurement Only

Use 50%/50% lumi at $Pol(e^- / e^+) = (-0.8/+0.2)/(+0.8/-0.2)$

500 fb^{-1} each

This study tests jet reconstruction of boosted W-bosons in forward regions, jet energy resolution, differential luminosity measurement, and reconstruction and identification of leptons in the forward region.

$e^+e^- \to W^+W^- \quad \sqrt{s} =$ **1 TeV**

Count events in bins of $(\cos\Theta, \cos\theta)$
where Θ **is polar angle of** W^- **in lab frame and**
θ **is either the polar angle of the lepton in** W^- **rest frame or an average of all four quark angles in their parent** W **rest frame in the case of the fully hadronic topology.**

To account for detector efficiency and resolution do template fit of parameters a **&** b **where for each bin** i

$$N_i = a\int d\vec{x}_i d\vec{x}'\eta(\vec{x}')\Omega(\vec{x},\vec{x}')\frac{d\sigma_{LR}}{d\vec{x}'} + b\int d\vec{x}_i d\vec{x}'\eta(\vec{x}')\Omega(\vec{x},\vec{x}')\frac{d\sigma_{RL}}{d\vec{x}'}$$

$$a = \frac{(1-P(e^-))(1+P(e^+))}{4}$$

$$b = \frac{(1+P(e^-))(1-P(e^+))}{4}$$

(then convert a **&** b **meas. to** $P(e^-)$ **&** $P(e^+)$ **)**

Analysis for $e^+e^- \to WW \to \nu\mu qq$

Require 1 isolated muon, 0 isolated electron & 0 isolated photon

Set isolated muon aside and perform jet analysis on remaining PFO's using the kt-algorithm in exclusive mode with 2 jets with ΔR=0.7. This algorithm will identify beams jets and group everything else into 2 jets.

The 2 jets that remain after discarding the beam jets represent the jets from the hadronically decaying W.

Require

$N_{PFO}(remaining)$ **> 12**

$60 < M_{2j} < 100$ **GeV** $E_{2j} > 300$ **GeV**

$$e^+e^- \rightarrow WW \rightarrow \nu lqq$$

Table 11.4.3: Number of events passing semileptonic W^+W^- cuts for 500 fb^{-1} luminosity.

Type	Solid Angle	$P(e^-)$	$P(e^+)$	Number of events
Signal	$0.8 < \cos\Theta < 1.0$	-80%	+20%	122300
Signal	$-1 < \cos\Theta < 0.8$	-80%	+20%	37040
Signal	$0.8 < \cos\Theta < 1.0$	+80%	-20%	8490
Signal	$-1 < \cos\Theta < 0.8$	+80%	-20%	3216
Background	$0.8 < \cos\Theta < 1.0$	-80%	+20%	3547
Background	$-1 < \cos\Theta < 0.8$	-80%	+20%	5050
Background	$0.8 < \cos\Theta < 1.0$	+80%	-20%	3985
Background	$-1 < \cos\Theta < 0.8$	+80%	-20%	3699

Analysis for $e^+e^- \to WW \to qqqq$

Require 0 isolated muons, electrons, & photons

Perform jet analysis using the kt-algorithm in exclusive mode with 4 jets with ΔR=0.7. This algorithm will identify beams jets and group everything else into 4 jets.

The 4 jets are divided into two 2-jets systems using a chisquare minimization similar to that used in $t\bar{t}h$ analysis

Require

N_{PFO} **> 28**

55 $< M_{2j} < 105$ **GeV** $E_{4j} > 600$ **GeV**

Analysis for $e^+e^- \to WW \to qqqq$

Table 11.4.4: Number of events passing fully hadronic W^+W^- cuts for 500 fb^{-1} luminosity.

Type	Solid Angle	$P(e^-)$	$P(e^+)$	Number of events
Signal	$0.8 < \lvert\cos\Theta\rvert < 1.0$	-80%	+20%	293250
Signal	$0.8 < \lvert\cos\Theta\rvert < 1.0$	+80%	-20%	23720
Background	$0.8 < \lvert\cos\Theta\rvert < 1.0$	-80%	+20%	32971
Background	$0.8 < \lvert\cos\Theta\rvert < 1.0$	+80%	-20%	7851

$$e^+e^- \to W^+W^- \quad \sqrt{s} = \textbf{1 TeV}$$

Beam Polarisation Measurements

The effective polarisation parameters a and b are extracted by counting events in bins of $(\cos\Theta, \cos\theta)$ and fitting for a and b with a linear least squares fit:

$$\chi^2 = \sum_i \frac{(N_i - (a\mu_i + b\nu_i)L)^2}{N_i}$$

where N_i is the number of events in bin i, L is the integrated luminosity

$$\mu_i = \int d\vec{x}_i d\vec{x}' \eta(\vec{x}') \Omega(\vec{x}_i, \vec{x}') \frac{d\sigma_{LR}}{d\vec{x}'}$$

$$\nu_i = \int d\vec{x}_i d\vec{x}' \eta(\vec{x}') \Omega(\vec{x}_i, \vec{x}') \frac{d\sigma_{RL}}{d\vec{x}'}$$

Let M_{ki} be the number of events in bin i from a Monte Carlo sample produced with effective beam polarisations a_k and b_k and luminosity L_k.

$$\mu_i = \frac{1}{a_1 b_2 - a_2 b_2}\left[b_2 \frac{M_{1i}}{L_1} - b_1 \frac{M_{2i}}{L_2}\right], \qquad \nu_i = \frac{1}{a_1 b_2 - a_2 b_2}\left[-a_2 \frac{M_{1i}}{L_1} + a_1 \frac{M_{2i}}{L_2}\right]$$

$$e^+e^- \to W^+W^- \quad \sqrt{s} = \mathbf{1\ TeV}$$

Table 11.4.5: Polarisation errors assuming 500 fb^{-1} luminosity for each initial state polarisation configuration.

$\cos\Theta$ range	P_{e^-}, P_{e^+}	Δa	Δb	ΔP_{e^-}	ΔP_{e^+}
$0.8 < \cos\Theta < 1$	-0.8,+0.2	0.0011	0.62	3.77	2.51
$0.8 < \cos\Theta < 1$	+0.8,-0.2	0.00030	0.20	0.13	0.27
$-1 < \cos\Theta < 1$	-0.8,+0.2	0.0010	0.084	0.51	0.32
$-1 < \cos\Theta < 1$	+0.8,-0.2	0.00027	0.032	0.020	0.08
$\cos\Theta$ range	P_{e^-}, P_{e^+}	$\Delta\alpha$	$\Delta\beta$	$\Delta\lvert P_{e^-}\rvert$	$\Delta\lvert P_{e^+}\rvert$
$-1 < \cos\Theta < 1$	sum	0.00097	0.00027	0.0017	0.0027

$t\bar{t}$ at $\sqrt{s} = 500$ GeV

preselection

- Reject events with isolated lepton
- Requires 6 jets
- Sum of the jet energy > 400 GeV
- Track multiplicity > 30
- Jet particle constituents > 5
- Sum of the jet particle constituents > 80

Further Event Selection $e^+e^- \to t\bar{t}$

Using LCFI to identify b-jets require one jet with a b-tag>0.9 and one other jet with b-tag>0.4

Associate other jets with W bosons and perform kinematic fit using these constraints. Use a χ^2 minimization to resolve combinatorics.

$$e^+e^- \to t\bar{t}$$

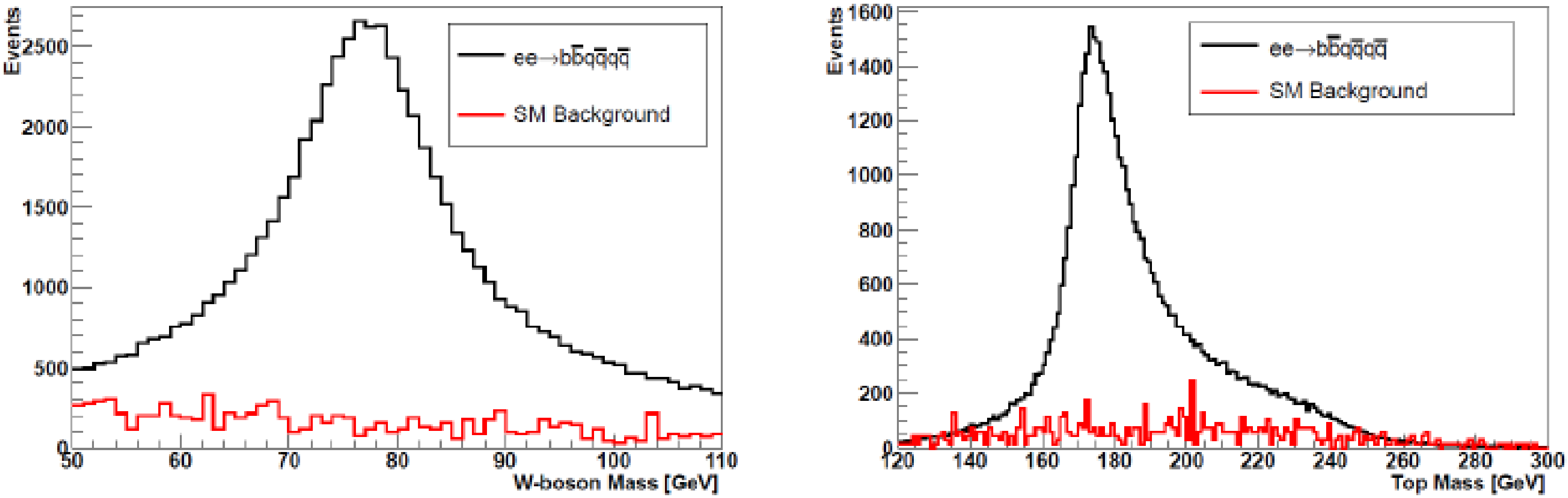


Figure 11.4.9: Mass distribution of the W boson candidates (left) and top quark candidates (right).

For a top mass cut of 145 GeV $< M_t <$ 195 GeV we obtain an efficiency of $27.2 \pm 0.1\%$, and a cross section error of 354.3 $\pm$ 1.4 fb for the polarization $P(e^- / e^+) = +0.8 / -0.2$

SiD DBD Summary and Beyond

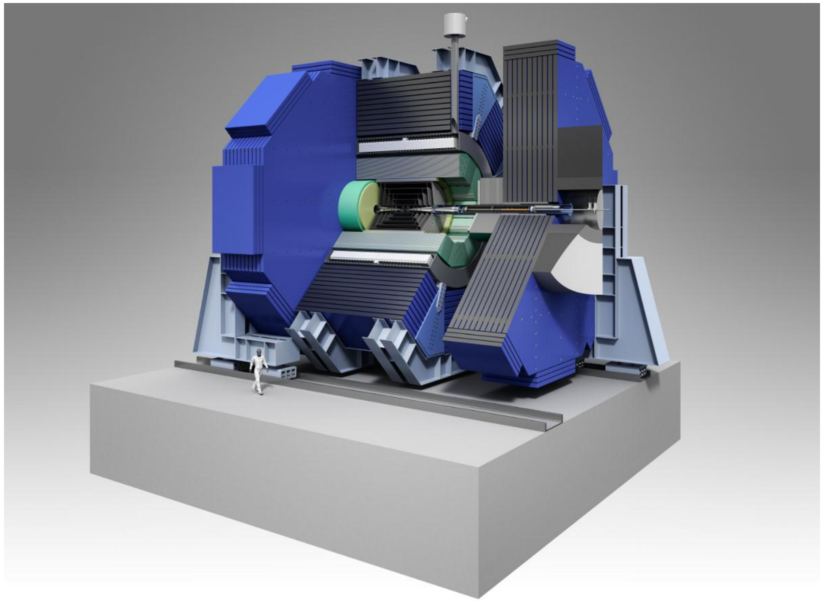
- We have presented a detailed design for a detector capable of high precision physics studies and discoveries at the ILC.

- Our technology choices are based on the currently available R&D results from SiD, CALICE, FCAL and other sources.

- We will continue to study/develop the SiD concept and pursue additional physics studies.

- As the ILC moves towards realization, we will expand SiD globally and work energetically with the new Linear Collider Organization to promote the ILC project.

SiD Workshop
SLAC, January 16-18, 2013



This will be a critical meeting as we move forward from the DBD towards the next phase of the realization of the ILC and the SiD detector concept

ILC Project - U.S. issues

- The U.S. HEP community is engaged in a wider ranging discussion about the future program: "**Snowmass 2013**".

http://www.snowmass2013.org

- After (hopefully) agreeing on the most important physics to pursue, there will be a new High Energy Physics Advisory Panel Project Prioritization Panel (P5) to set the future program.

- SiD colleagues (and ILD in U.S. !) are engaging in the Snowmass exercise – to be discussed at the January 16-18 SiD Workshop.

- Two general "Energy Frontier" meetings pre-Snowmass:

April 3-6 at Brookhaven National Lab
June 30 - July 3, just after Lepton-Photon 2013,
(at a West Coast location TBA)

ILC Project - U.S. issues

- A central issue is the relative capabilities of the ILC and LHC to exploit the Higgs discovery and fully explore this sector.

- Discussion with U.S. Department of Energy/HEP indicate that the ILC project is "*being kept open as an option*".

- HEP research is being "taxed" -2% a year to build a fund for new facilities.

Need to have case for new projects ready in the 2015-2016 timeframe.

Jim Siegrist – HEPAP meeting 12/2012

Fiscal realities indicate that single project expenditure should not exceed $1B per stage.

ILC Project - U.S. issues

-For SiD, we will:

- Develop plans to progress from our DBD to a Technical Design Report.

- Work with the new Linear Collider Organization to promote the realization of the ILC in Japan

- Complete detector R&D projects and identify other areas needing work (alignment, power pulsing, mechanical stability,…)

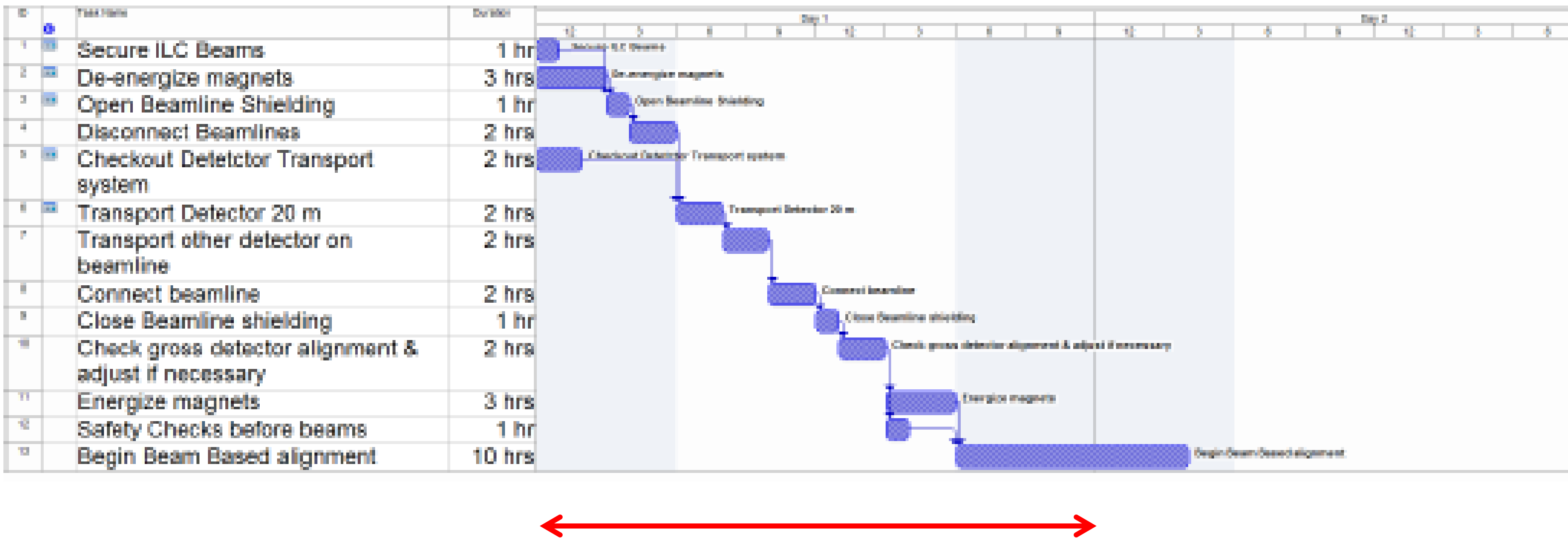
- Work to expand our Concept to be more globally inclusive.

Extra slides

SiD Elements, Masses and Sizes

Name	Mass (10^3 kg)	# Subcomponents	Mass (10^3 kg)	Size (m×m)
Barrel	4220			
ECAL	60	12	5.0	2.8×3.5
HCAL	367	12	31.7	5×5.9
Tracker	3	1	3	2.5×3.3
Coil	180	2	90	6.8×5.9
Magnet Yoke	3360	8	420	12×5.9
Yoke Arch Supports	150	2	75	12×1
Peripherals	40			
Each of Two Endcaps	2450			
ECAL	10	1	10	0.15×2.5
HCAL	23	1	23	1.2×2.8
Muon System	30			2.6×12
MDI Components	10			
Endcap Steel Plates	2200	11	200	0.2×12
Endcap Leg Supports	140	2	70	2.6×6
Infrastructure	37			

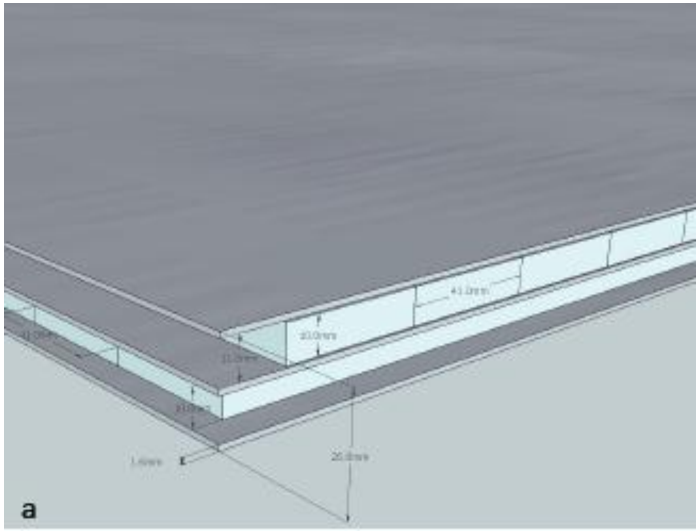
SiD Push-Pull detector exchange



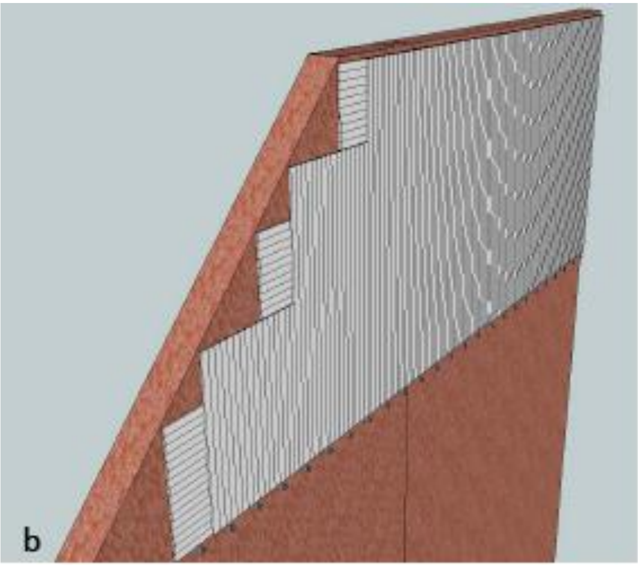
ID	Task Name	Duration
1	Secure ILC Beams	1 hr
2	De-energize magnets	3 hrs
3	Open Beamline Shielding	1 hr
4	Disconnect Beamlines	2 hrs
5	Checkout Detetctor Transport system	2 hrs
6	Transport Detector 20 m	2 hrs
7	Transport other detector on beamline	2 hrs
8	Connect beamline	2 hrs
9	Close Beamline shielding	1 hr
10	Check gross detector alignment & adjust if necessary	2 hrs
11	Energize magnets	3 hrs
12	Safety Checks before beams	1 hr
13	Begin Beam Based alignment	10 hrs

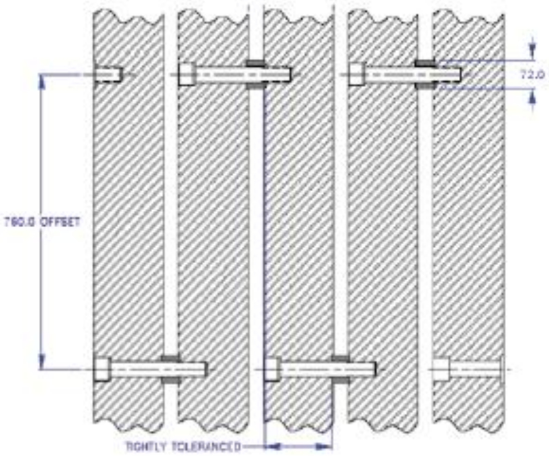
Muon System

Barrel - two orthogonal planes of strips

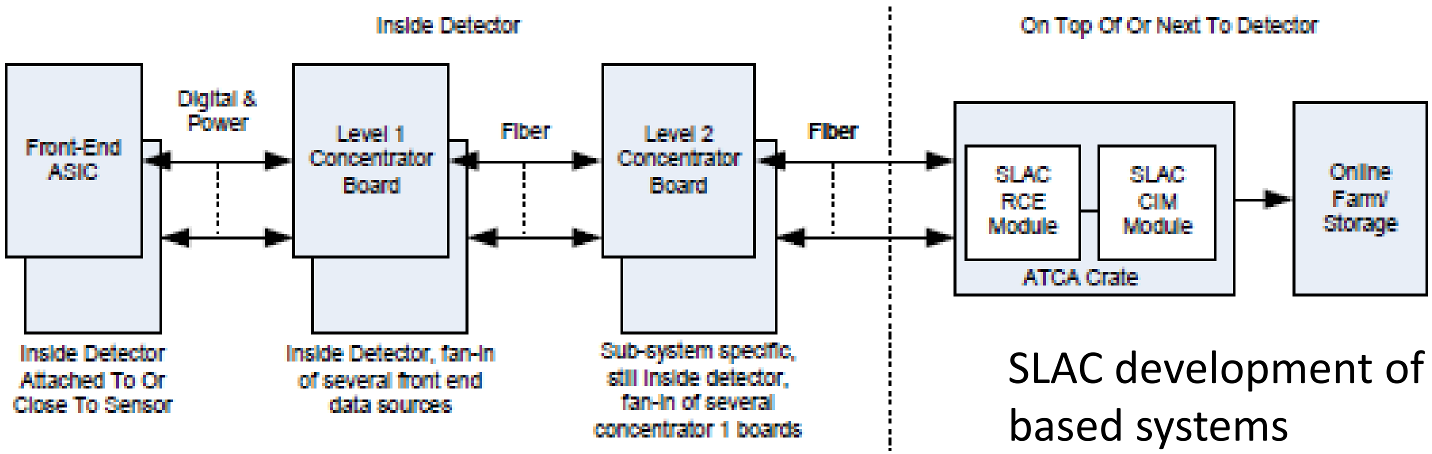


Endcaps – modules slide between spacers/steel layers



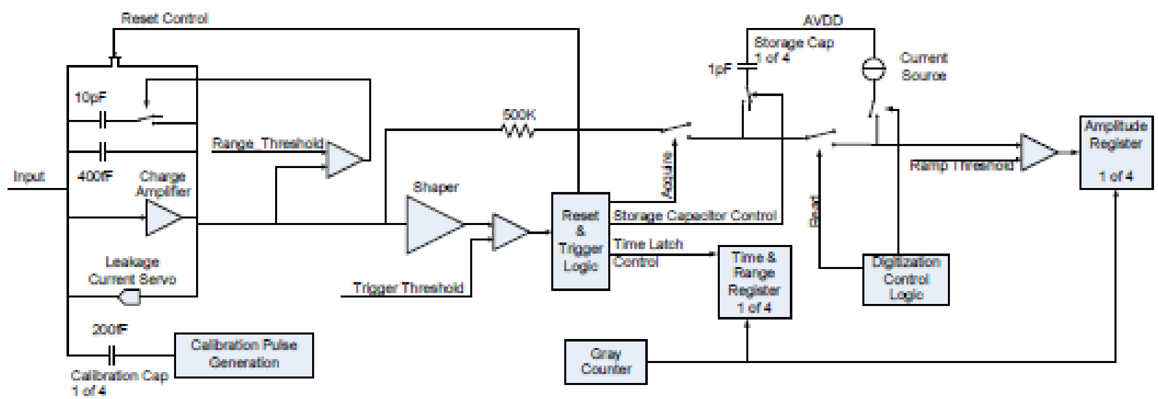


Electronics and DAQ

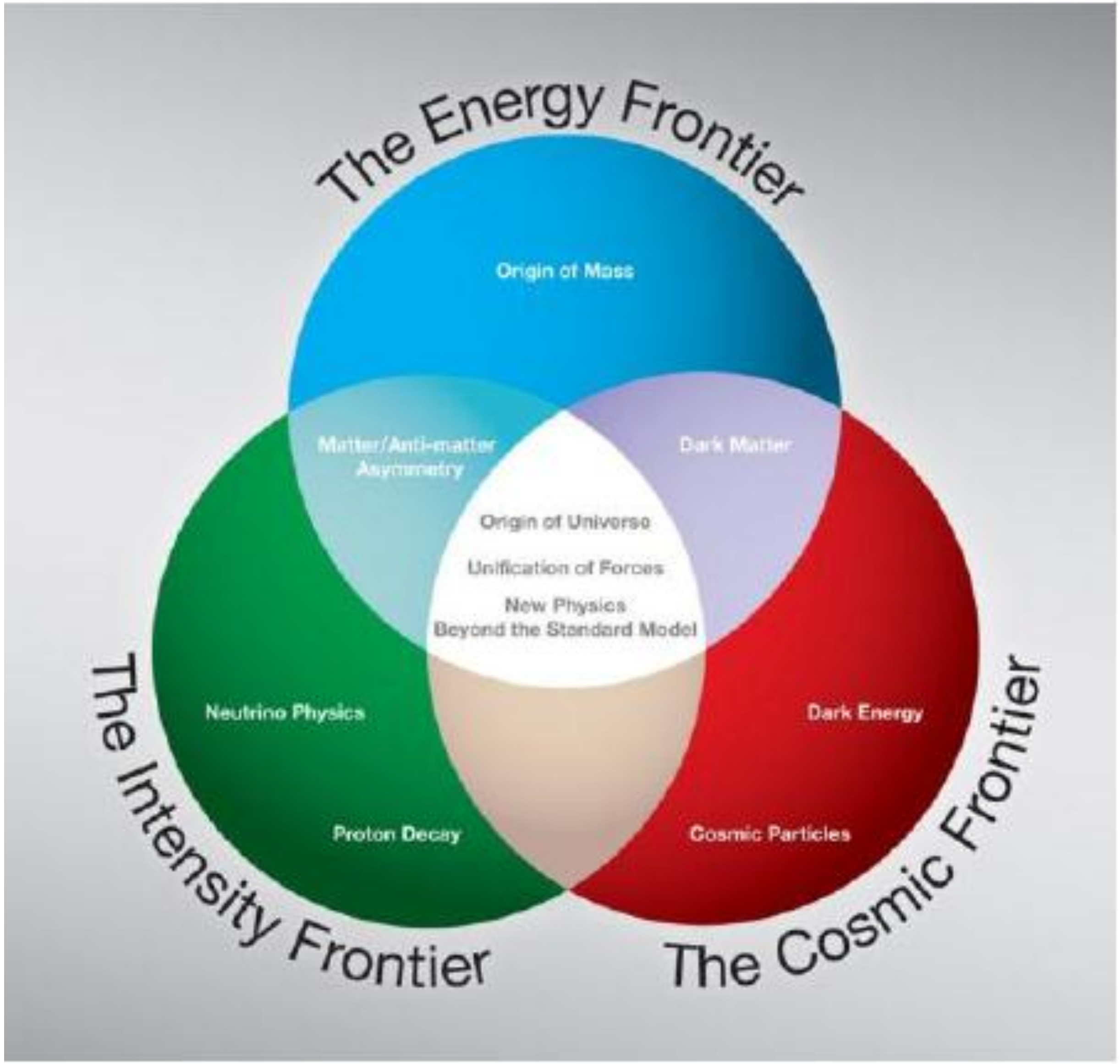


SLAC development of ATCA-based systems

KPiX schematic



Versions of KPiX will be used for all subsystems except VTX and the high occupancy forward regions.


The Energy Frontier
Origin of Mass
Matter/Anti-matter Asymmetry
Dark Matter
Origin of Universe
Unification of Forces
New Physics Beyond the Standard Model
Neutrino Physics
Dark Energy
Proton Decay
Cosmic Particles
The Intensity Frontier
The Cosmic Frontier

Major Recommendations of P5

- The panel recommends that the US maintain a leadership role in world-wide particle physics. The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.
- The panel recommends support for the US LHC program, including US involvement in the planned detector and accelerator upgrades. (highest priority)
- The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.
- The panel recommends funding for measurements of rare processes to an extent depending on the funding levels available... (Mu2e)
- The panel recommends support for the study of dark matter and dark energy as an integral part of the US particle physics program.
- The panel recommends a broad strategic program in accelerator R&D, including work ..., along with support of basic accelerator science.