Physics and Detectors at Linear Colliders

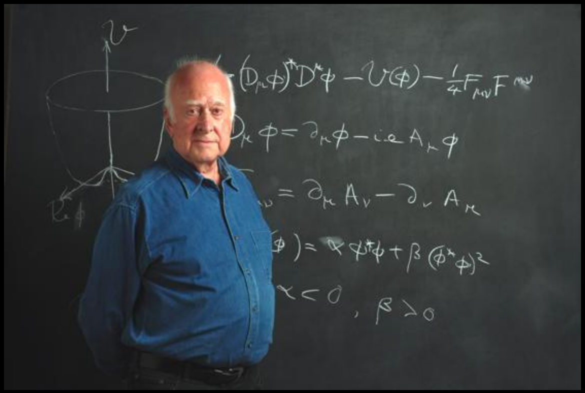
Jan Strube
CERN

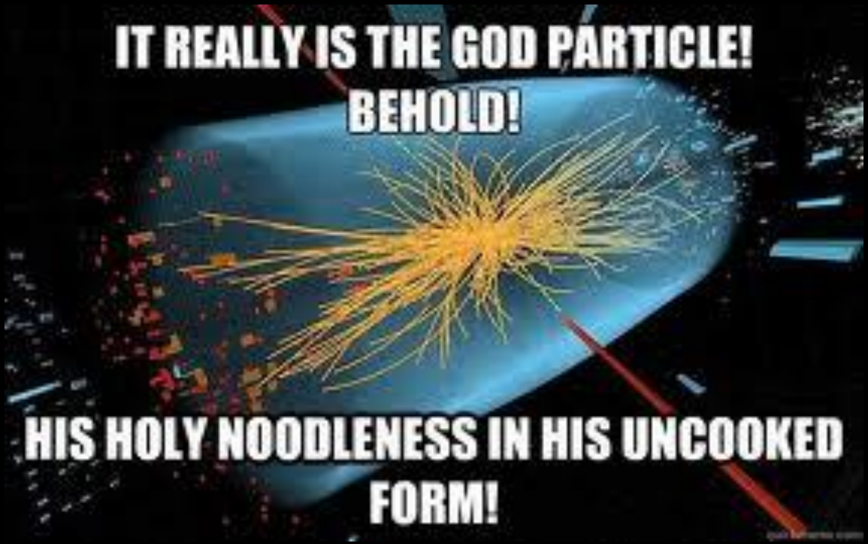
on behalf of the SiD detector concept

Outline

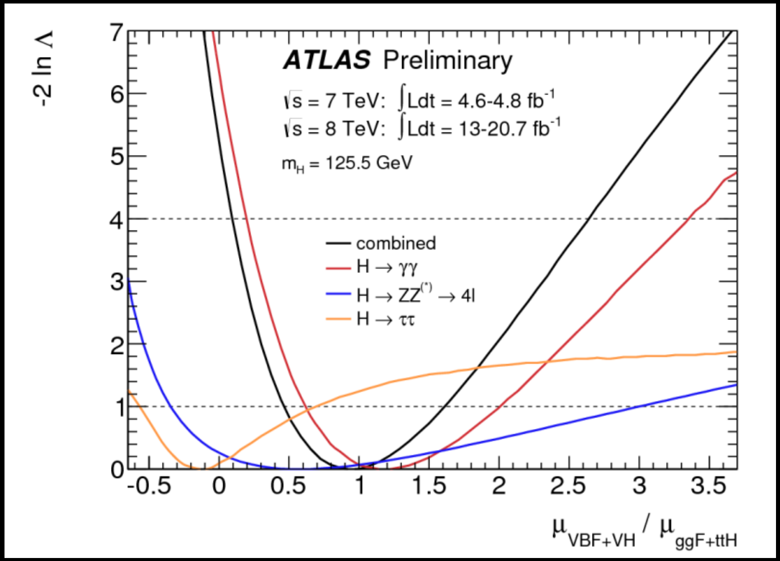
- Physics Motivation
- The ILC Accelerator
- Requirements for Detectors
- SiD - a Detector for the ILC
- Simulation Studies
- Summary / Outlook

The Higgs

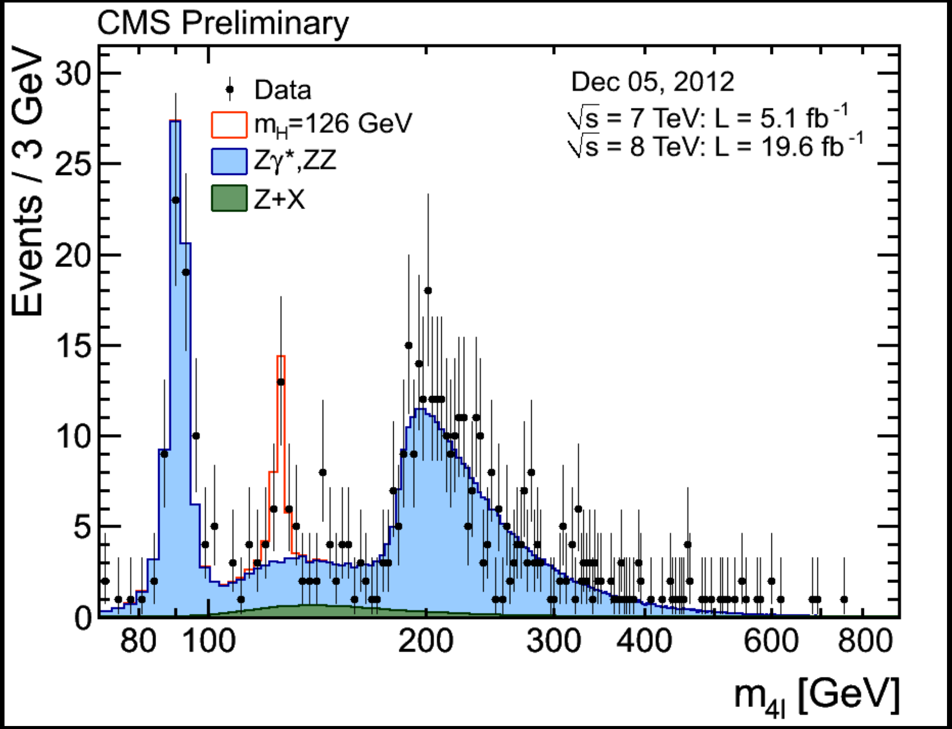


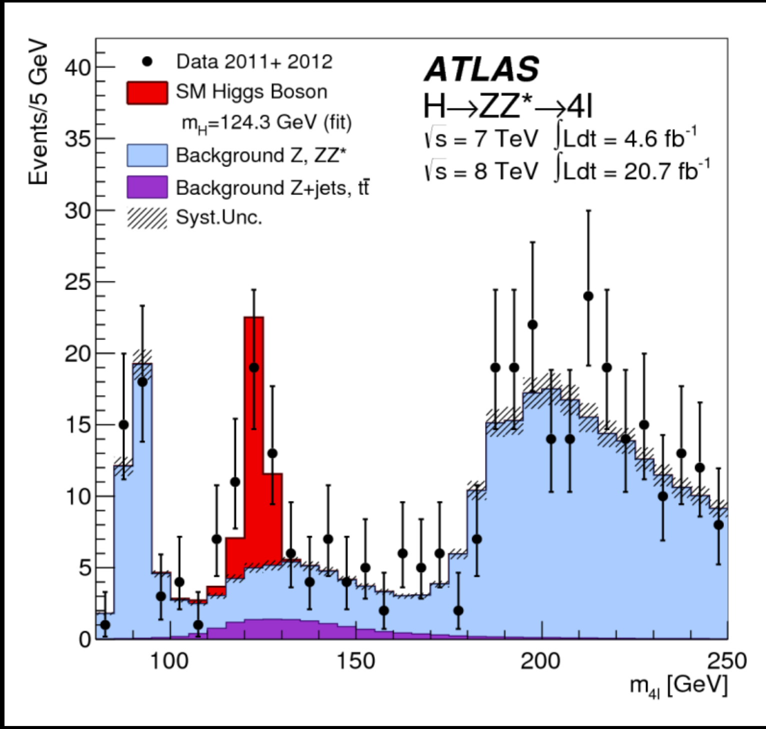

IT REALLY IS THE GOD PARTICLE!
BEHOLD!
HIS HOLY NOODLENESS IN HIS UNCOOKED FORM!


HIGGS BOSON
H
The HIGGS BOSON is the theoretical particle of the Higgs mechanism, which physicists believe will reveal how all matter in the universe gets its mass. Many scientists hope that the Large Hadron Collider in Geneva, Switzerland, which collides particles at 99.99% the speed of light, will detect the elusive Higgs Boson
Higgs boson
$10.49 PLUS SHIPPING
LIGHT
HEAVY
Wool felt, fleece with gravel fill for maximum mass.
The PARTICLE ZOO

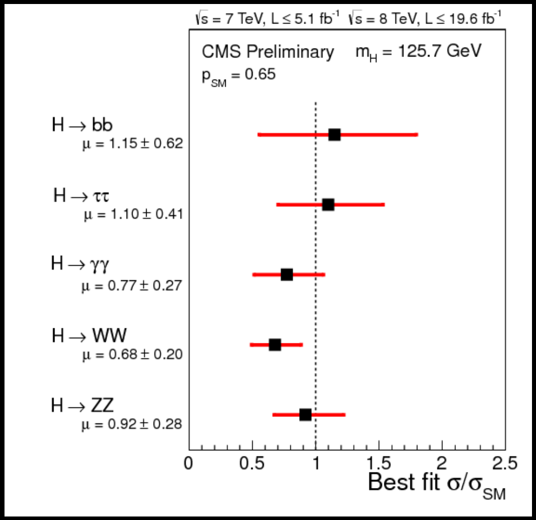

ATLAS Preliminary
√s = 7 TeV: ∫Ldt = 4.6-4.8 fb⁻¹
√s = 8 TeV: ∫Ldt = 13-20.7 fb⁻¹
m_H = 125.5 GeV
combined
H → γγ
H → ZZ(*) → 4l
H → ττ
-2 ln Λ
μ_VBF+VH / μ_ggF+ttH
0
1
2
3
4
5
6
7
-0.5
0
0.5
1
1.5
2
2.5
3
3.5

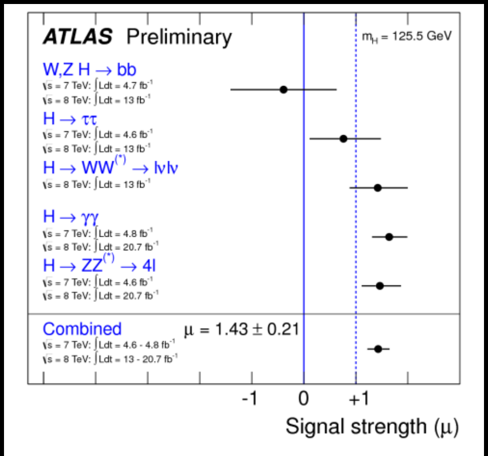
The Discovery of a Higgs Boson

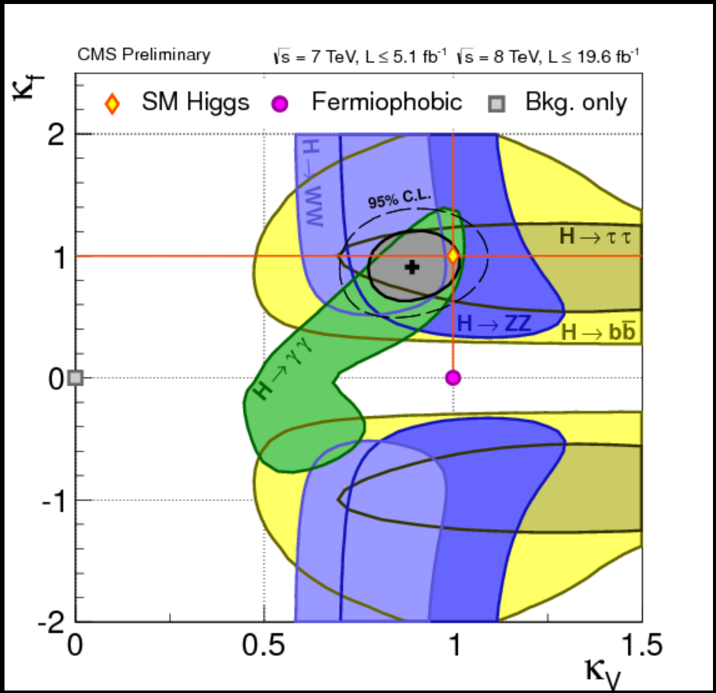


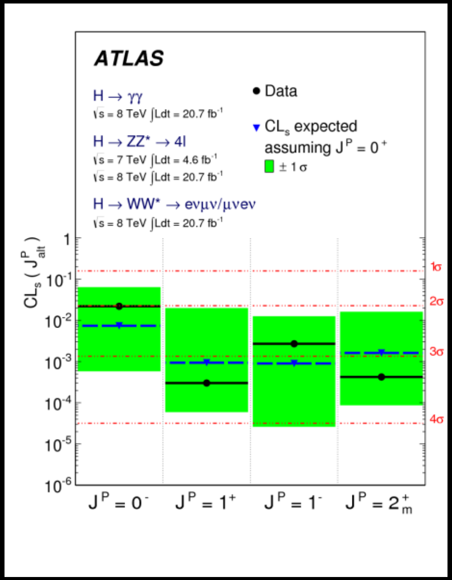


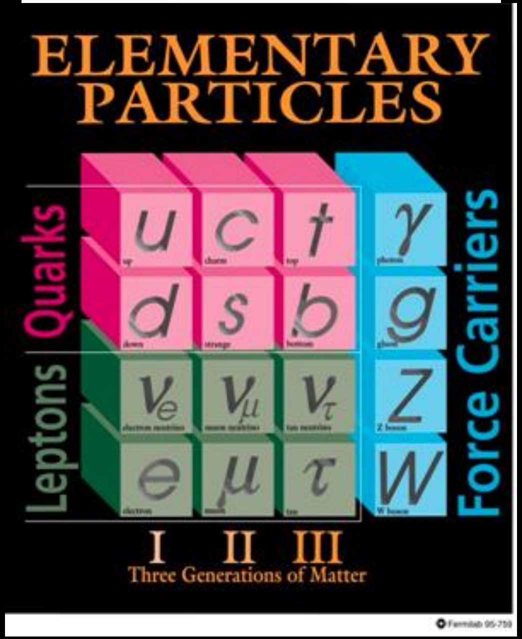
Measurements of Higgs Couplings Now...









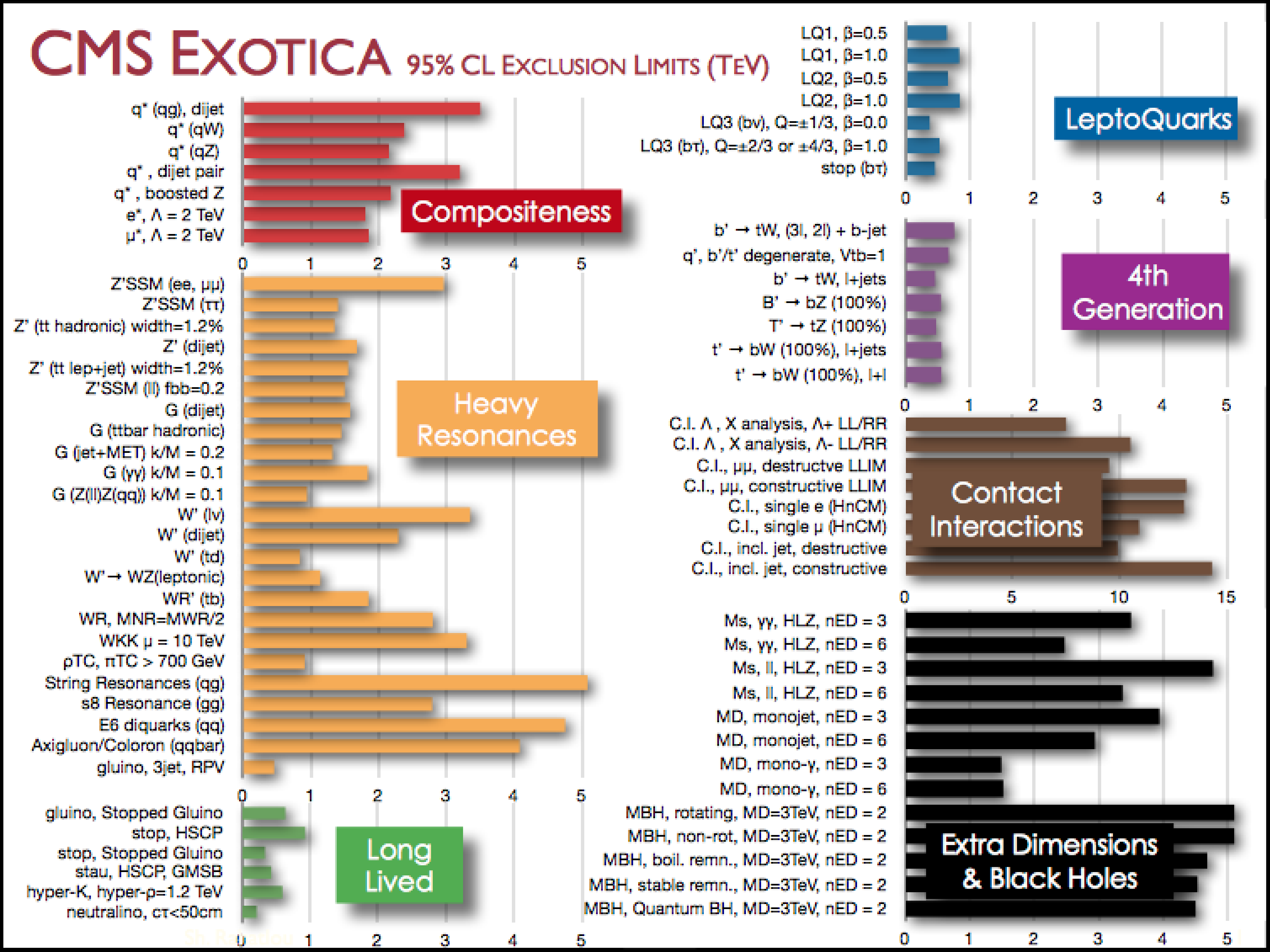


Focus changes from searches of Higgs bosons to measurements of Higgs properties:

Spin

Coupling to other Standard Model particles

What else is there?



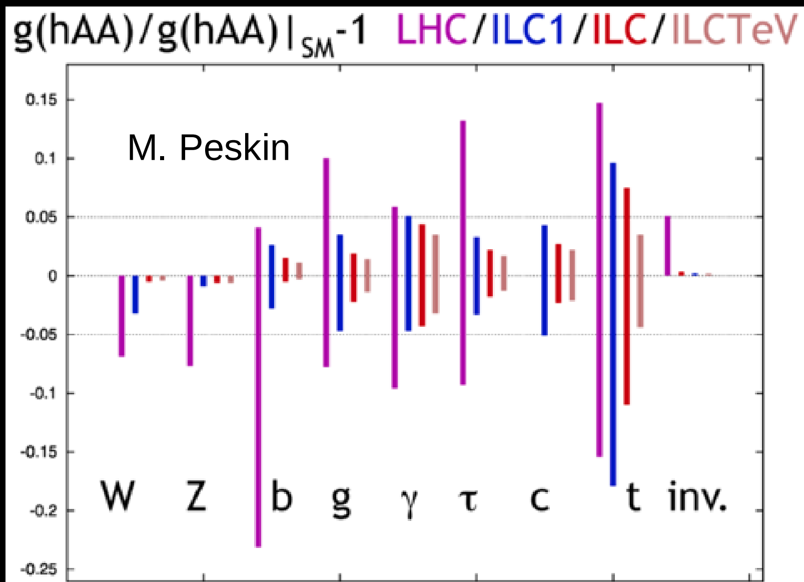
Premise:

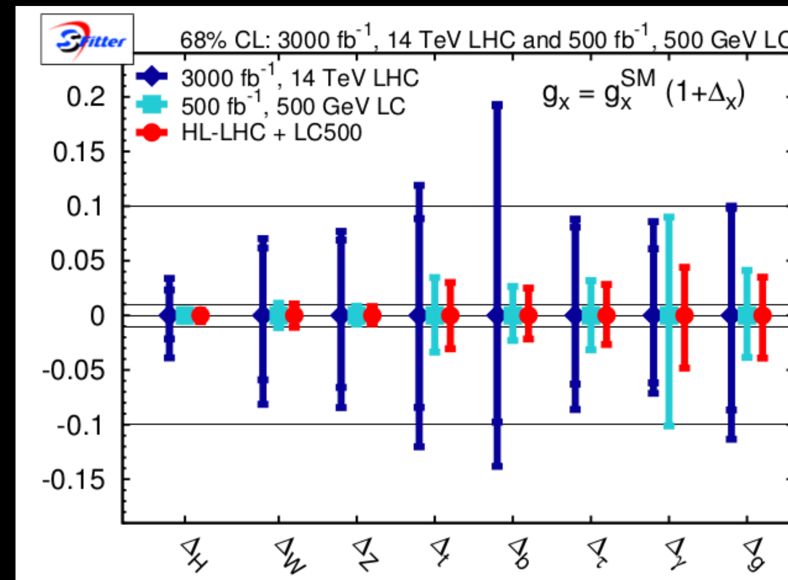
~~bottom line~~

This Higgs Boson changes everything.

We're obligated to understand it using all tools.

Measurements of Higgs Couplings … in the future





Extrapolation from Snowmass submissions.

ILC has clear advantage in measurement of Higgs branching ratios to b, c and invisible.
Total width directly accessible, measurements are absolute

How well do we need to measure the Higgs boson couplings?

Conclusion

How large can the maximal deviations from the SM Higgs couplings be if no new physics is discovered by the LHC?

The answer in the context of 3 different models:

	$\lvert\Delta hVV\rvert$	$\lvert\Delta h\bar{t}t\rvert$	$\lvert\Delta h\bar{b}b\rvert$	$\lvert\Delta hhh\rvert$
Mixed-in Singlet	6%	6%	6%	18%
Composite Higgs	8%	tens of %	tens of %	tens of %
MSSM	$< 1\%$	3%	10%, 100%	2%, 15%

$\tan\beta > 20$
no superpartners

all other cases

A: It depends… see [Gupta, Rzehak, Wells, arXiv:1206.3560] for details

ILC Physics Case

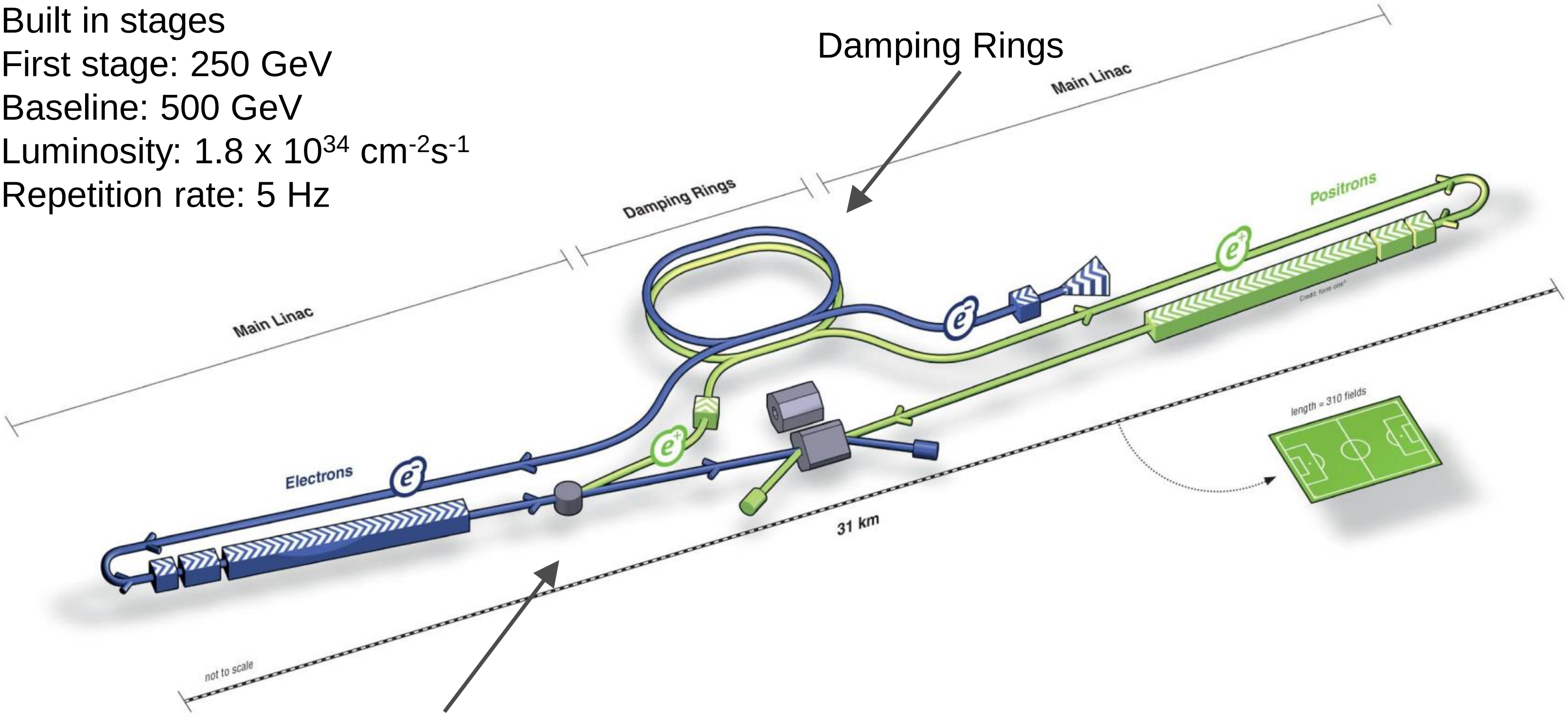
- Precision measurements of Higgs Boson properties and interactions with the rest of the Standard Model will be one of the cornerstones of particle physics for the foreseeable future
- The ILC offers **significant** and **important** advantages over existing facilities for Higgs physics
- Physics potential is maximized in staged construction, (91 GeV/)250 GeV - 1 TeV: SM precision, top, Higgs, SUSY

The ILC accelerator

Superconducting technology:
8000 cavities, cooled to 2K

Built in stages
First stage: 250 GeV
Baseline: 500 GeV
Luminosity: 1.8 x 10^{34} $cm^{-2}s^{-1}$
Repetition rate: 5 Hz

Damping Rings



Undulator for
positron production

Technology proven to work:
FLASH (DESY)
XFEL (DESY)

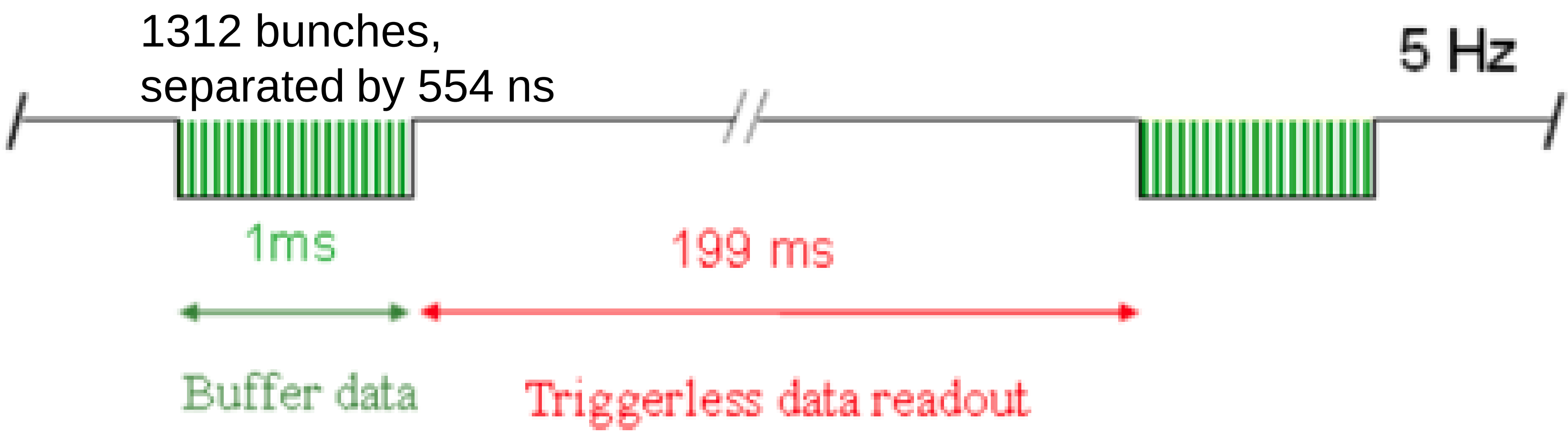
Japanese Candidate Site Chosen

Announcement on 23rd Aug. 2013:
Kitakami site chosen for Japan's bid to host the ILC
Sites were scored on technical and sociological aspects

ILC Machine Parameters

			Baseline 500 GeV Machine			1st Stage	L Upgrade	E_{CM} Upgrade	
Centre-of-mass energy	**ECM**	**GeV**	**250**	**350**	**500**	**250**	**500**	**A 1000**	**B 1000**
Collision rate	f_{rep}	Hz	5	5	5	5	5	4	4
Electron linac rate	f_{linac}	Hz	10	5	5	10	5	4	4
Number of bunches	nb		1312	1312	1312	1312	2625	2450	2450
Bunch population	N	$\times 10^{10}$	2.0	2.0	2.0	2.0	2.0	1.74	1.74
Bunch separation	Δfb	ns	554	554	554	554	366	366	366
Main linac average gradient	G_a	MV m^{-1}	14.7	21.4	31.5	31.5	31.5	38.2	39.2
Estimated AC power	P_{AC}	MW	122	121	163	129	204	300	300
Electron polarisation	P−	%	80	80	80	80	80	80	80
Positron polarisation	P+	%	30	30	30	30	30	20	20
IP RMS horizontal beam size	σ_x*	nm	729.0	683.5	474	729	474	481	335
IP RMS veritcal beam size	σ_y*	nm	7.7	5.9	5.9	7.7	5.9	2.8	2.7
Luminosity	L	$\times 10^{34}$ cm^{-2} s^{-1}	0.8	1.0	1.8	0.8	3.6	3.6	4.9
Fraction of luminosity in top 1%	L0.01/L		87.1%	77.4%	58.3%	87.1%	58.3%	59.2%	44.5%
Number of pairs per bunch crossing	N_{pairs}	$\times 10^3$	62.4	93.6	139.0	62.4	139.0	200.5	382.6
Total pair energy per bunch crossing	E_{pairs}	TeV	46.5	115.0	344.1	46.5	344.1	1338.0	3441.0

ILC Beam Structure



- Beam structure allows high granularity design.
- Accumulate data during bunch train
- Read out in quiet time.
- No trigger needed: Expect one hadronic Z decay per train
- Background and radiation low compared to LHC. Allows to build low-mass tracking systems.

The ILC Physics Program

First Stage: 250 GeV

- Higgs recoil mass
- Higgs BR

Second Stage: 500 GeV (baseline)

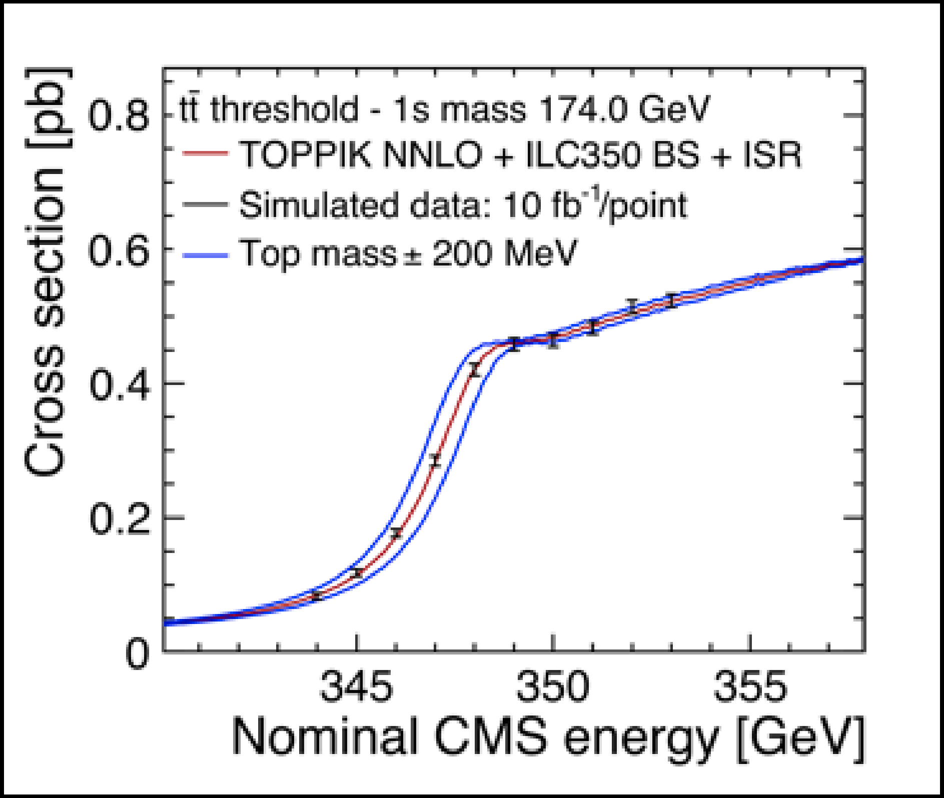
- Higgs BR
- Higgs width
- top physics (threshold scan)
- Higgs self-coupling

Third Stage: 1000 GeV

- Top Yukawa coupling
- Maximum discovery potential for new physics

Top threshold scan

Unique feature of lepton colliders: Threshold scan



Top mass at LHC:

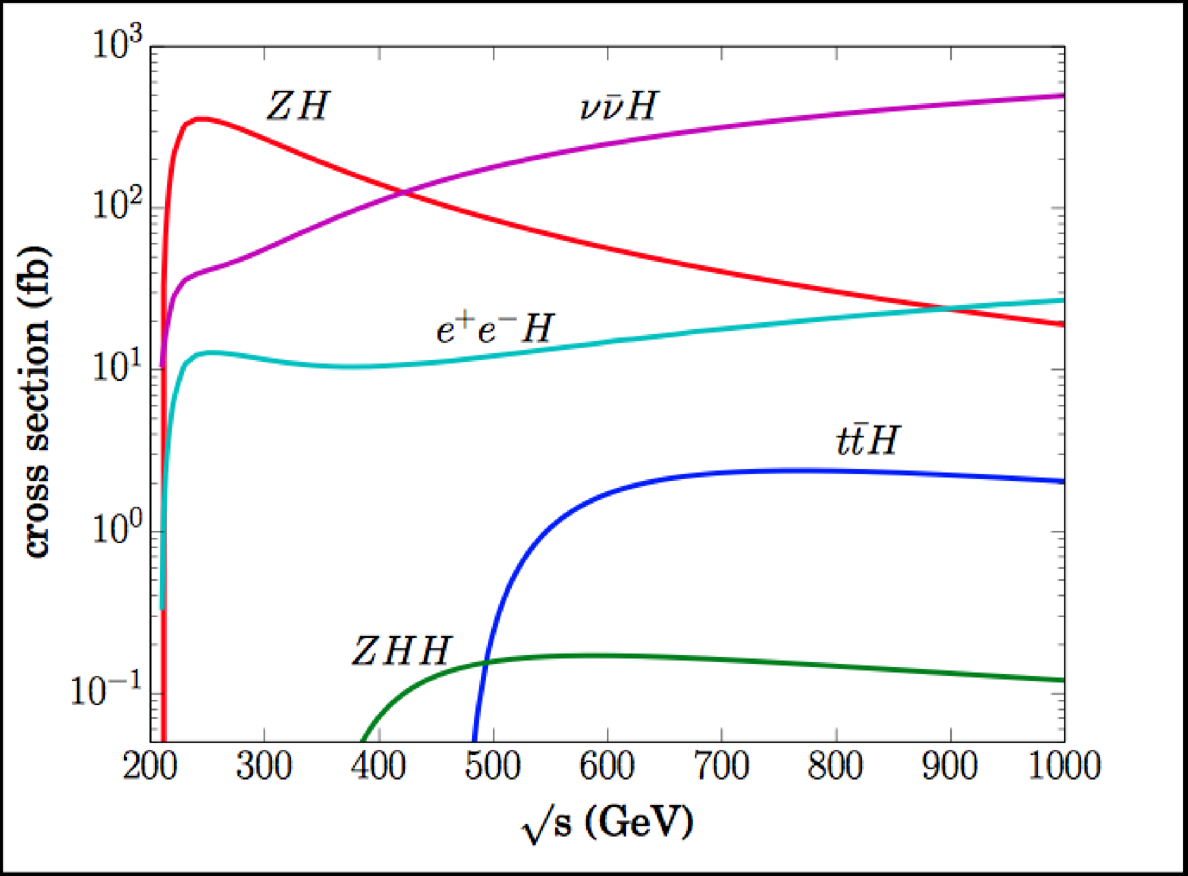
Pythia templates

Translation to theoretically well-defined quantity difficult

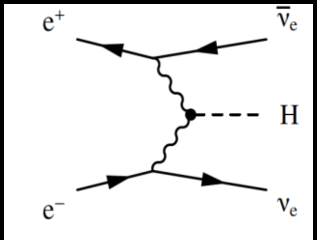
Top mass measured in threshold scan at ILC translates directly to well-defined $\overline{\text{MS}}$ mass.

$\Delta m_{top} < 100$ MeV, dominated by theory uncertainty

Higgs Physics at the ILC



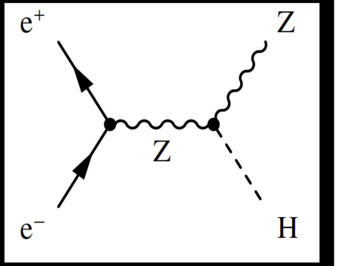
Higgs Physics at the ILC

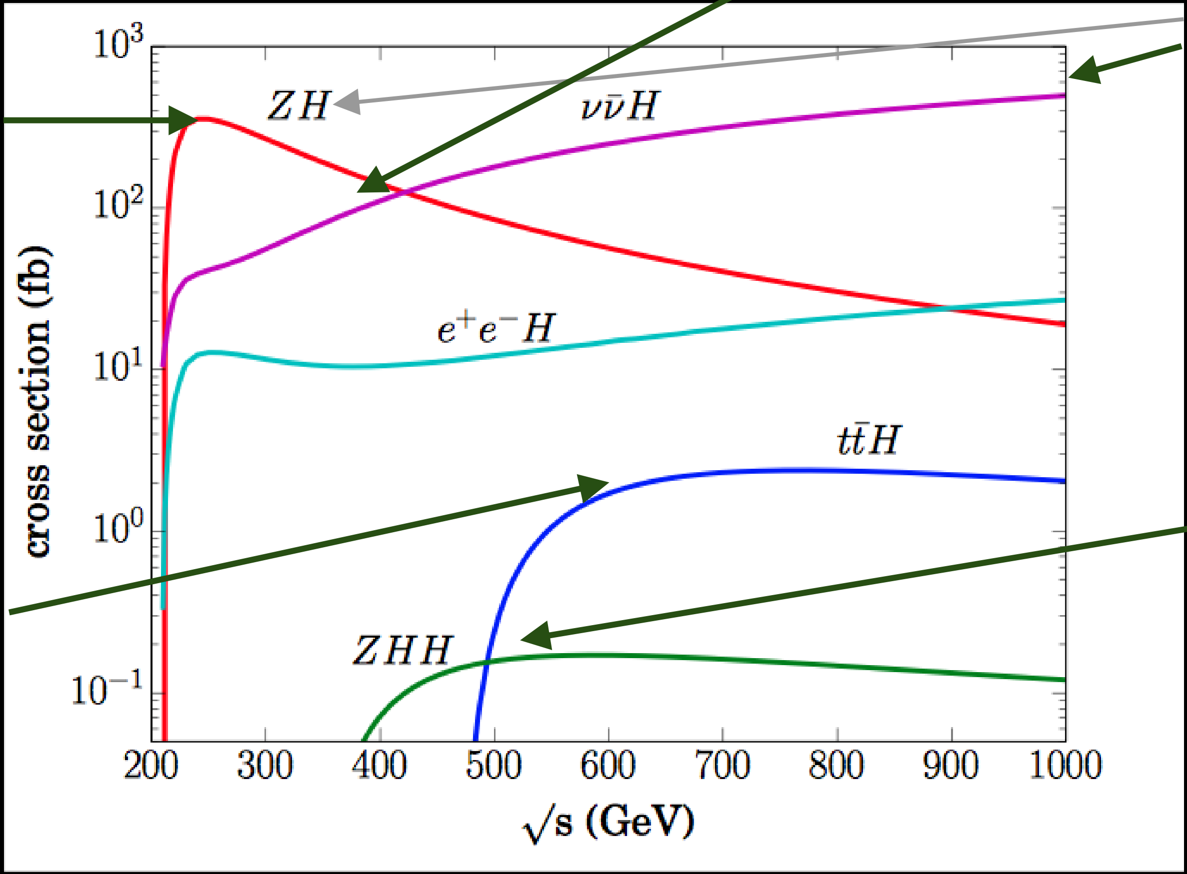


Higgs width

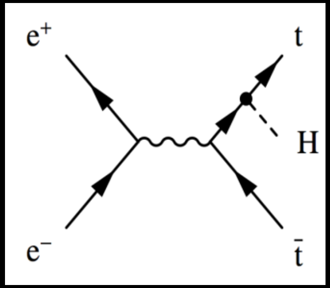
Higgs BR:
second generation fermions
c quarks, muons

Higgs Recoil method: First sensitivity to invisible decays

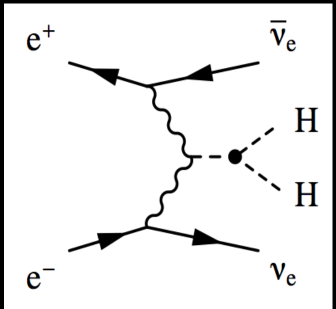




Top Yukawa coupling

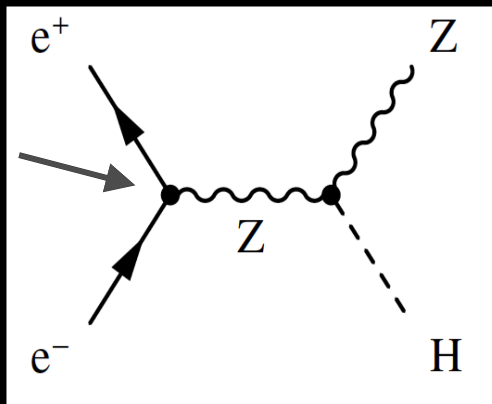


Higgs self-coupling:

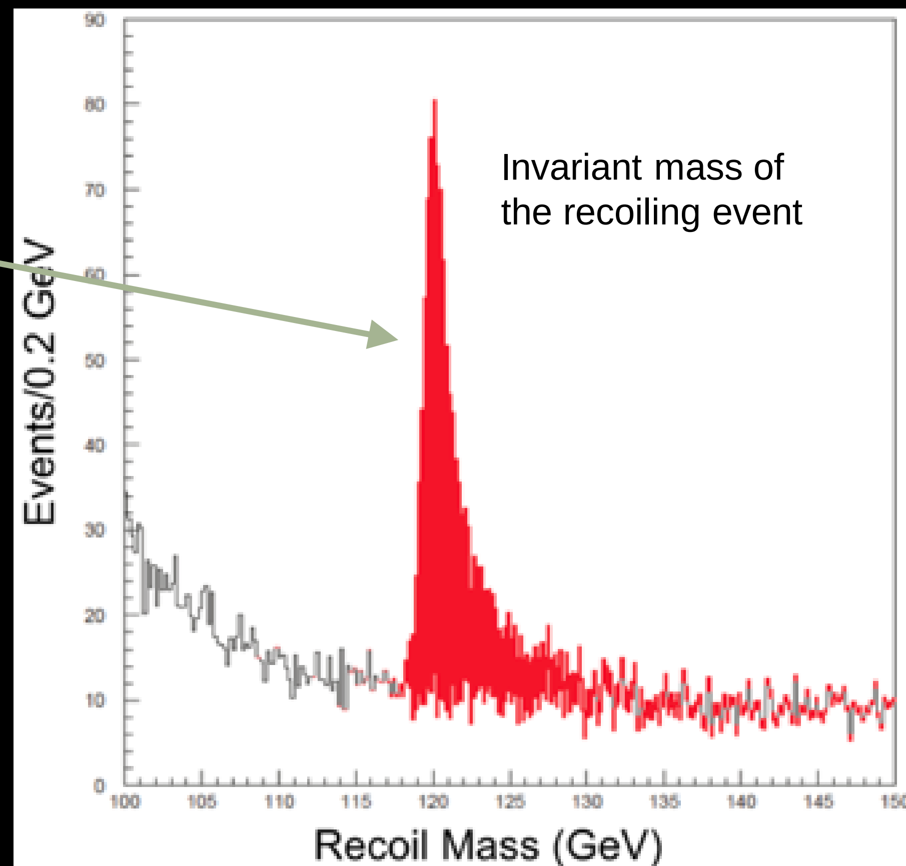


Recoil Mass measurement

Known √s



Reconstruct the Z boson



ZH → $\mu^+\mu^-$ + anything, 250 GeV, 250 fb^{-1}

Unique capability of lepton colliders:

Well-known initial state

Reconstruct the Z boson, the invariant mass of the recoiling event peaks at the Higgs mass

Physics Requirements

Momentum resolution

Higgs Recoil

$\sigma(p_T)/p_T^2 \sim 2\text{-}5 \times 10^{-5}\ \mathrm{GeV}^{-1}$

Jet Energy Resolution

Separation of W/Z/H bosons:

Gauginos, Triple Gauge Coupling

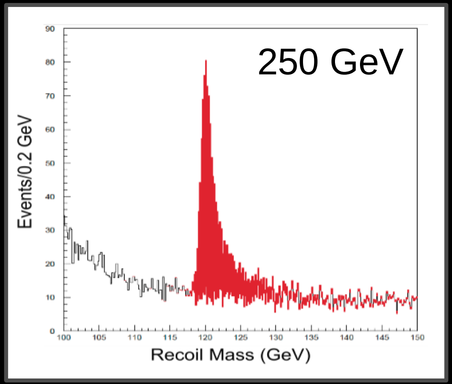
$\sigma(E)/E = 3.5\%\text{-}5\%$

Flavor Tagging

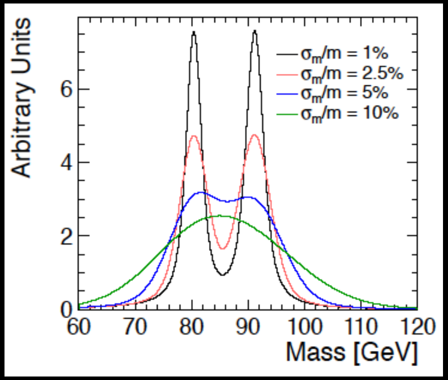
Higgs Branching ratios

$\sigma_{r\varphi} \approx 5\ \mu m \oplus 10\ \mu m / (p[\mathrm{GeV}] \sin^{3/2}\theta)$

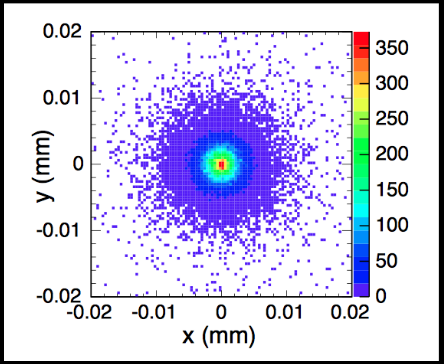
ZH → $\mu^+\mu^-$ + anything



W-Z separation



primary vertices in tth events



ILC
1 TeV

Goals for Detector Design

ILC environment allows to optimize for resolution

Calorimeter Granularity:

~ 200x better than LHC

Pixel Size:

~ 20x smaller than LHC

Material budget, central region:

~ 10x less than LHC

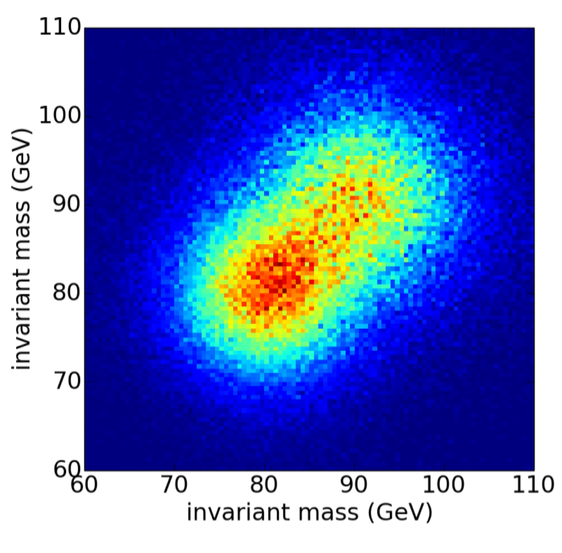
Material budget, forward region:

~ 100x less than LHC

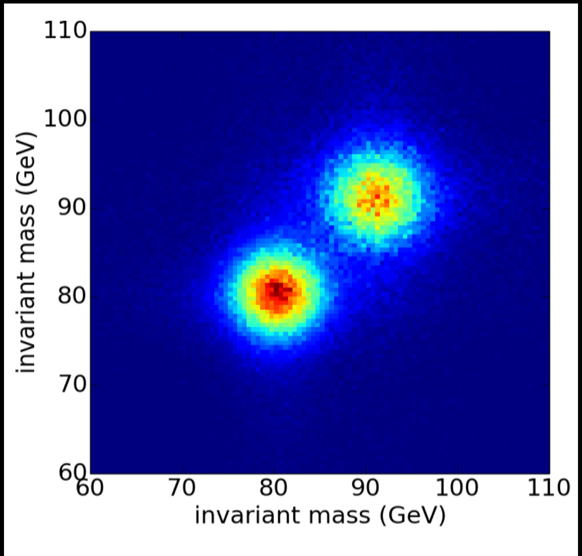
Motivation for Particle Flow Reconstruction

High resolution is key to precision measurements

Jet energy resolution	W / Z separation
perfect	3.1σ
5%	2σ
10%	1.1σ



10% Jet energy resolution

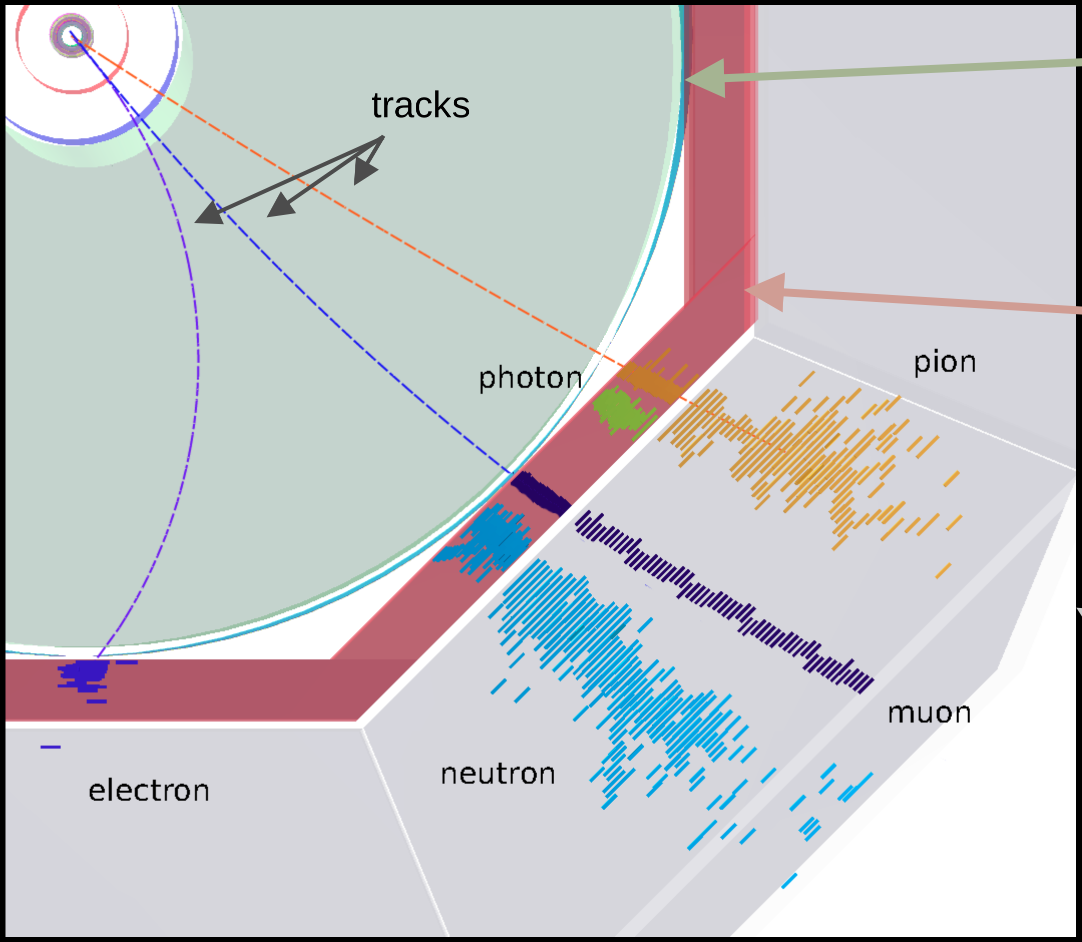


5% Jet energy resolution

<u>Goals:</u>

- equivalent luminosity
- W / Z separation for gaugino analyses and anomalous triple gauge coupling measurement

Introduction to Particle Flow Reconstruction I



Tracker: low material, high momentum resolution, high impact parameter resolution

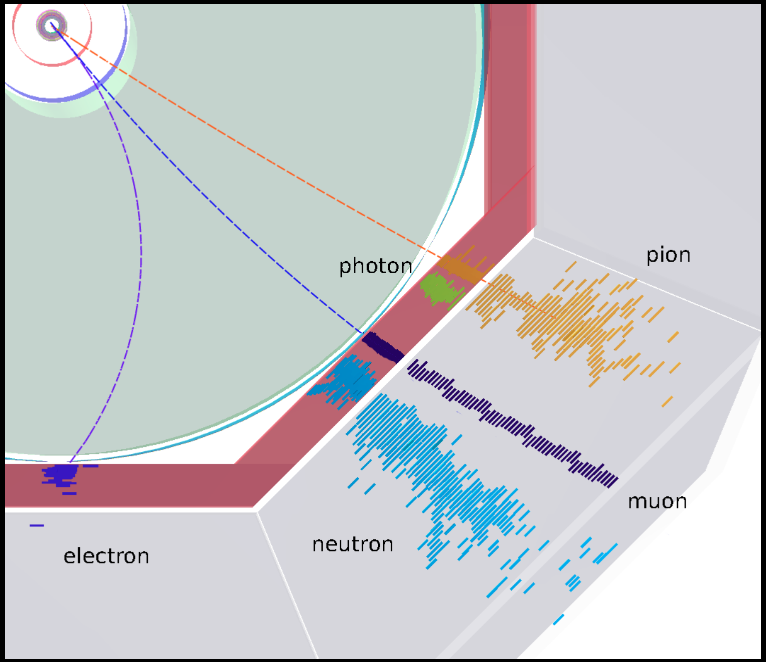
ECAL:
- High number of radiation length (typically 15-30 X_0)
- good energy resolution (typically $\sigma_E/E \approx 5\text{-}20\%/\sqrt{E}$)

HCAL:
- High number of interaction lengths (typically 5-8 λ_0)
- good energy resolution (typically $\sigma_E/E \approx 50\text{-}100\%/\sqrt{E}$)

Introduction to Particle Flow Reconstruction II

Typical jet contents:

60% charged particles	$\sigma(p_T)/p_T^2 \sim 2\text{x}10^{-5}\ \text{GeV}^{-1}$
30% photons	$\sigma(E)/E < 20\% / \sqrt{E}$
10% neutral hadrons	$\sigma(E)/E > 50\% / \sqrt{E}$



Ideally, fully reconstruct the shower for each particle and match tracks to showers.

At higher jet energies, confusion (mis-matching of energy depositions and particles)
deteriorates the resolution.

At even higher energies, leakages becomes a factor in the jet energy resolution.

PFA possible without high granularity
At CLIC: High granularity essential for background reduction

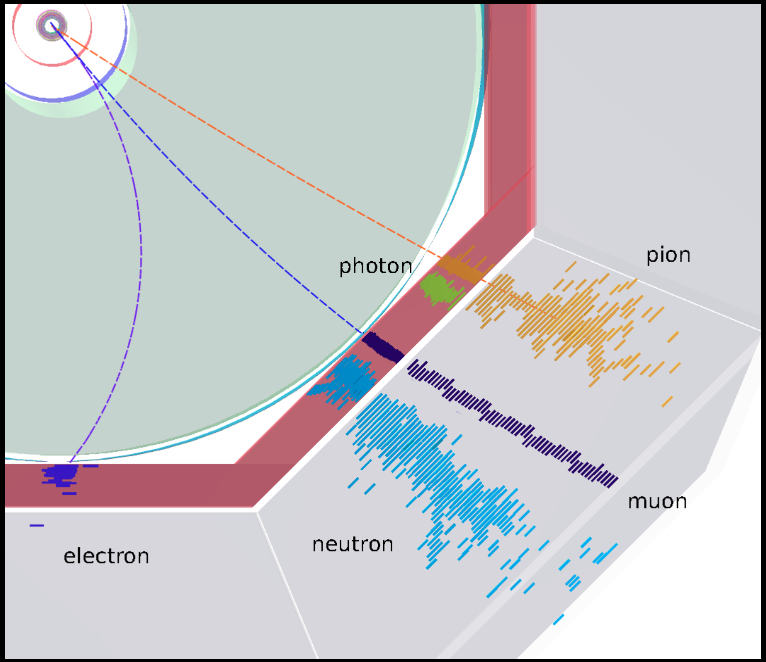
Introduction to Particle Flow Reconstruction III

<u>Typical jet contents:</u>

60% charged particles $\sigma(p_T)/p_T^2 \sim 2\text{x}10^{-5}$ GeV^{-1}

30% photons $\sigma(E)/E < 20\% / \sqrt{E}$

10% neutral hadrons $\sigma(E)/E > 50\% / \sqrt{E}$



1. Find muons, subtract hits from calorimeter
2. Find tracks
3. Match tracks to clusters in the ECAL
4. Iterative re-clustering to ensure consistency between track and cluster energy
5. Remove hits matched to a track
6. Photon finding in the ECAL
7. Rest is neutral Hadrons

SiD - A detector for the ILC

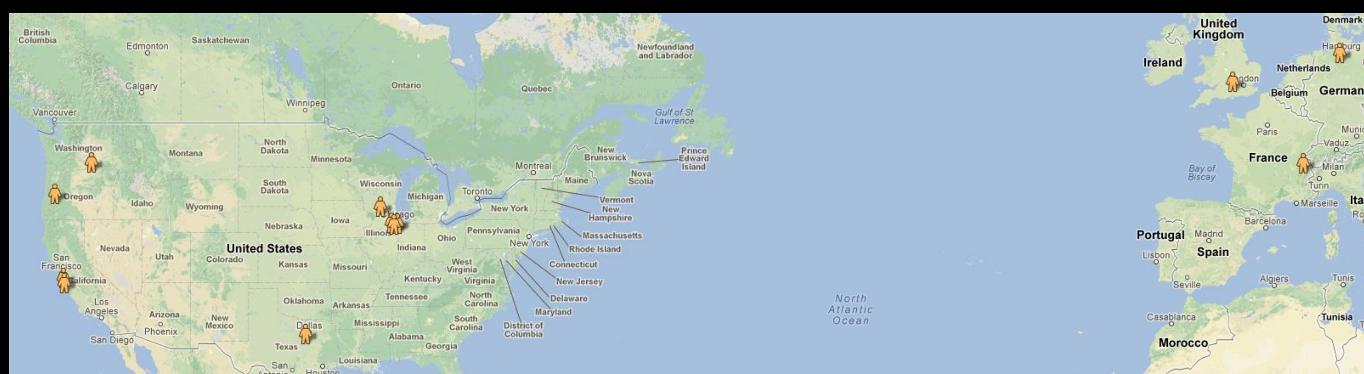
Introducing SiD

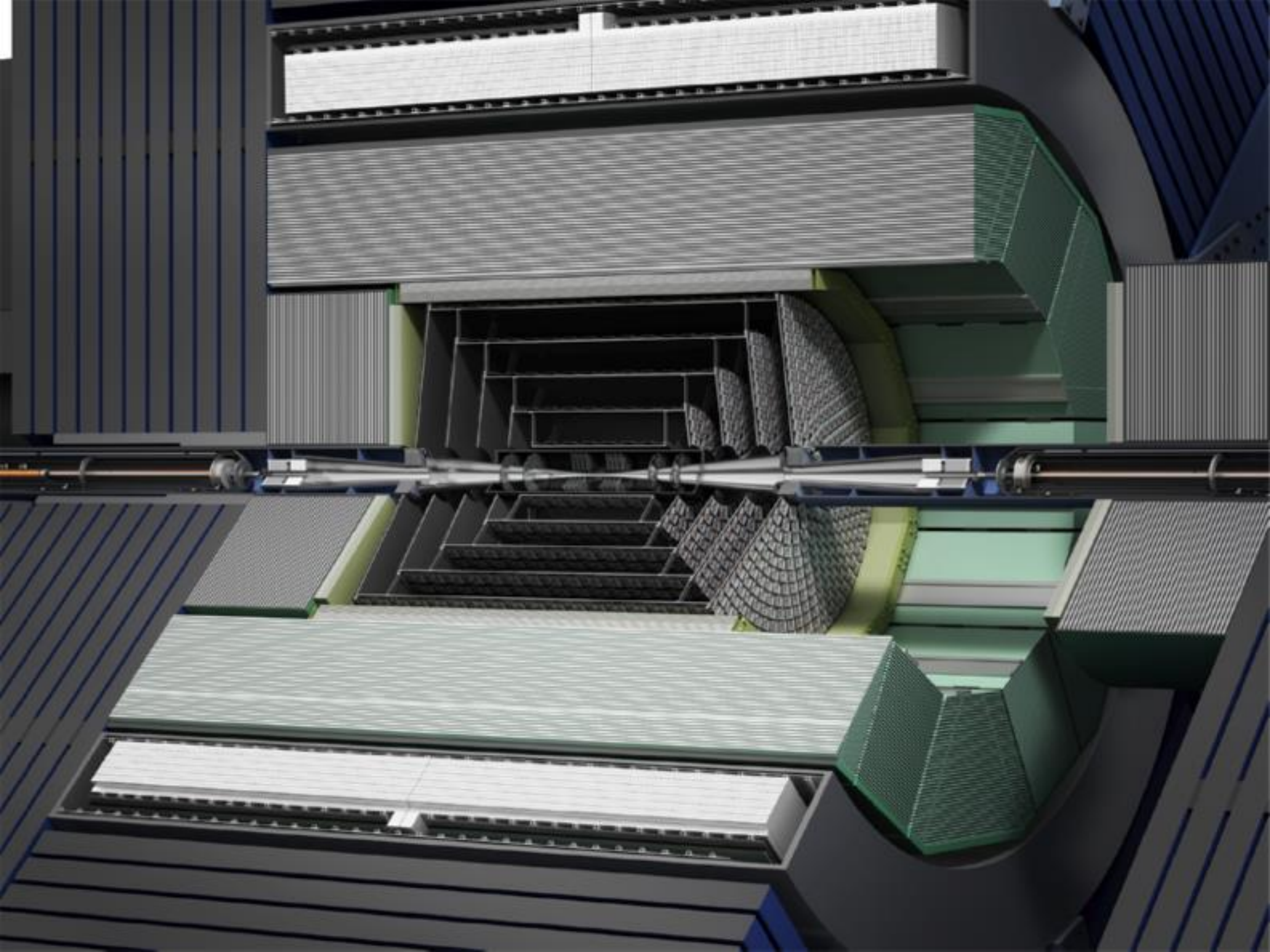
Co-spokesperson
A. White
UT Arlington

Co-spokesperson
M. Stanitzki
DESY

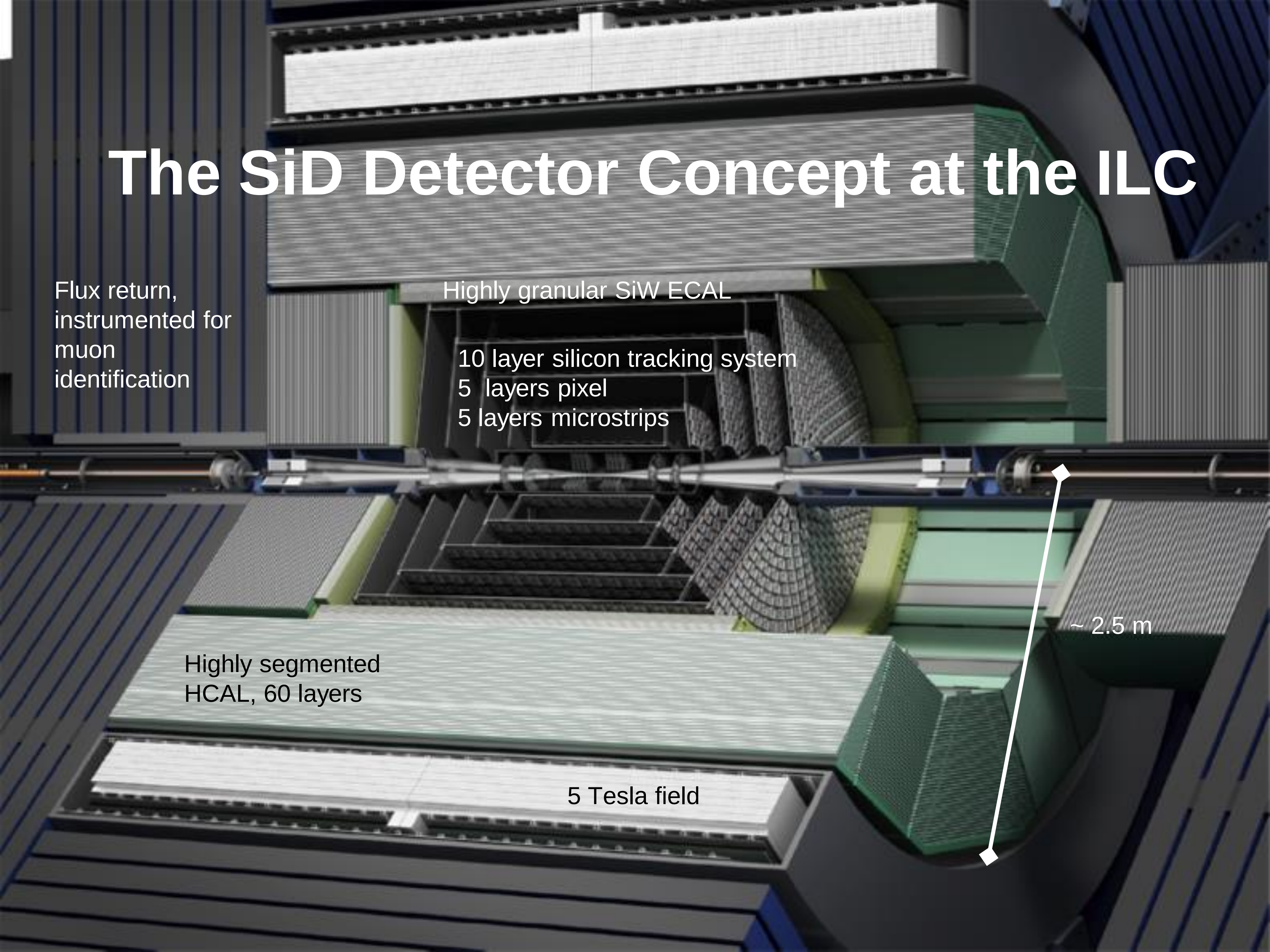
An international group studying a detector concept for LCs

Home Institutions for Editors of the SiD Detailed Baseline Report





The SiD Detector Concept at the ILC

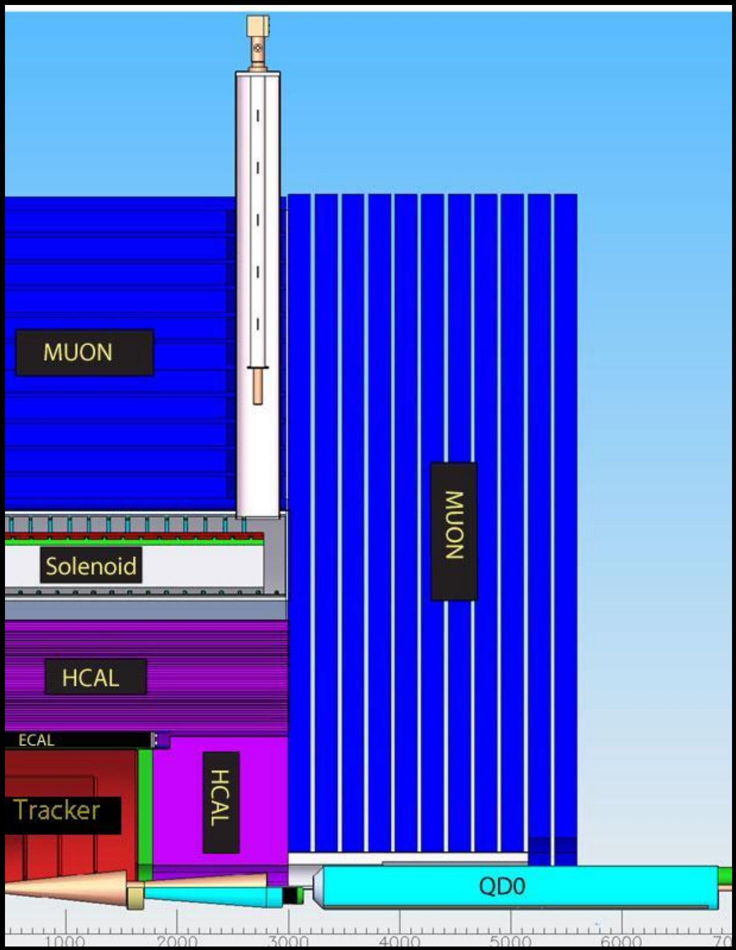


The SiD Detector Concept at the ILC

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

<u>Design Choices:</u>

- Compact Design in a 5 T field
- Robust all-Silicon tracking with excellent momentum resolution
- Time-stamping for single bunch crossings
- Highly granular calorimetry optimized for Particle Flow
- Integrated Design: All parts work in tandem
- Iron flux return / muon identifier is part of SiD self-shielding



Milestones

Concept and its performance at various collision energies documented in several documents.
SiD was validated by IDAG in 2009.

The DBD

will
event
disks
momentum
SiD
pixel
module
inner
jets
backgrounds
requirements
track
tracks
material
beamcal
polarisation
reconstructed
support
different
sensors
solenoid
power
hits
theta
integrated
jet
signal
particle
benchmarking
tracker
events
silicon
readout
calorimeter
chip
disk
performance
physics
design
beam
noise
barrel
results
muon
system
calorimetry
magnet
energy
alignment
sensor
detector
luminosity
mass
tracking
resolution
layer
modules
size
high
background
detectors
efficiency
layers
full
strips
charge
particles
region
baseline
reconstruction
endcap
model
precision
active
measured
ilc
single
data
process
prototype
Higgs
measurement
vertex
time
cost

The DBD

The DBD describes the baseline choices for all sub-detectors (except the vertex detector)

Options have been kept

This baseline is fully costed

Options offer better performance and/or lower cost

Not as mature as baseline choices

The DBD is a waypoint on the road to the SiD TDR and beyond.

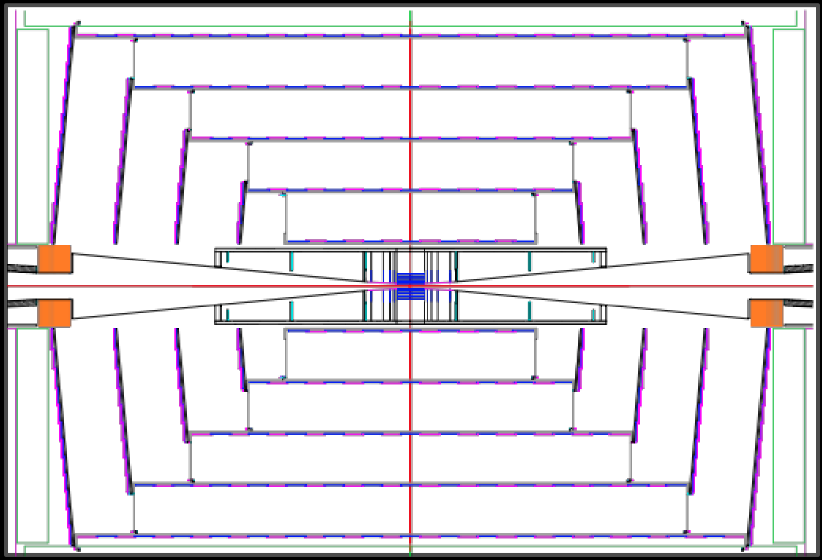
R&D continues.

Overview of Detector Baseline

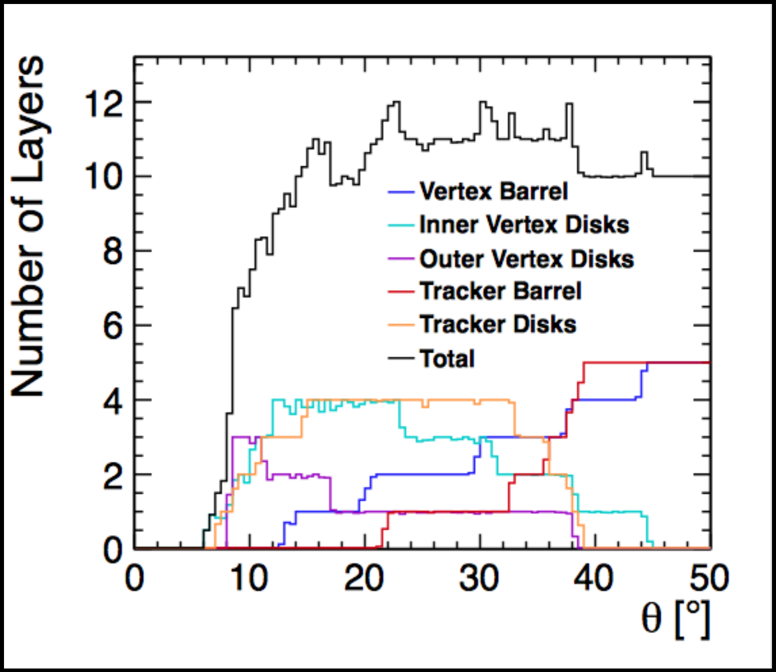
Outer Tracker

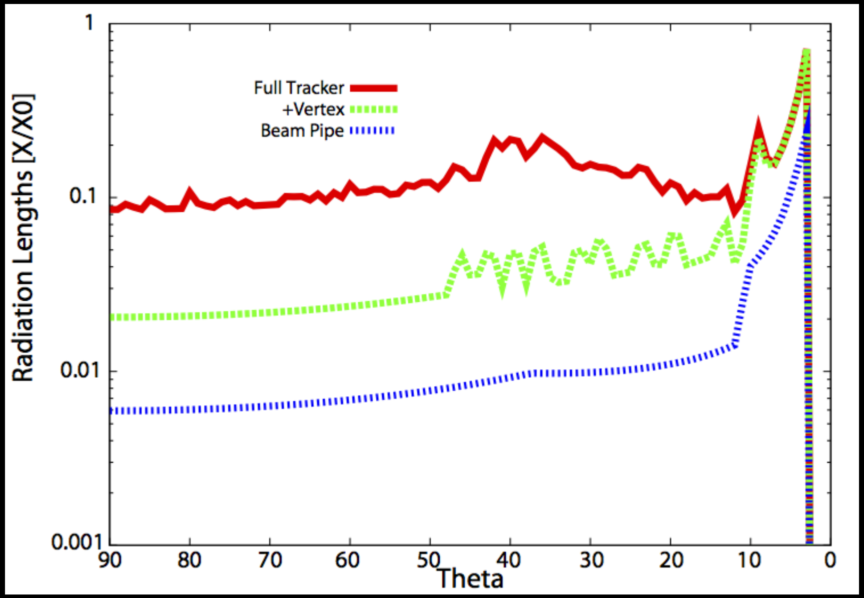
Low material budget ↔ excellent momentum resolution
In an all-silicon tracker, this means:

1. thin sensors
2. advanced integrated electronics
3. low-mass support
4. low power ↔ low-mass cooling



Hermetic coverage





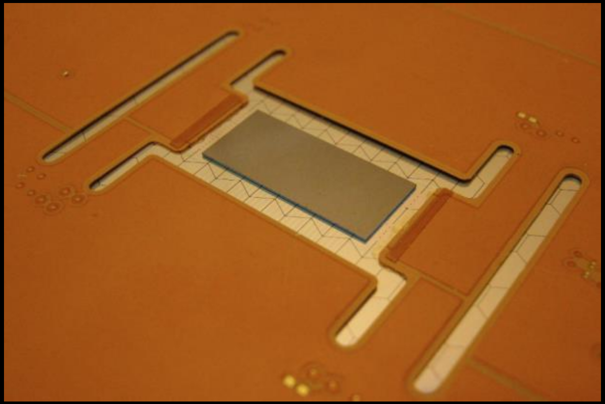
KPiX - System on a chip

1024 channels prototype under test
- optimized for ILC (1 ms train, 5 Hz train repetition rate)

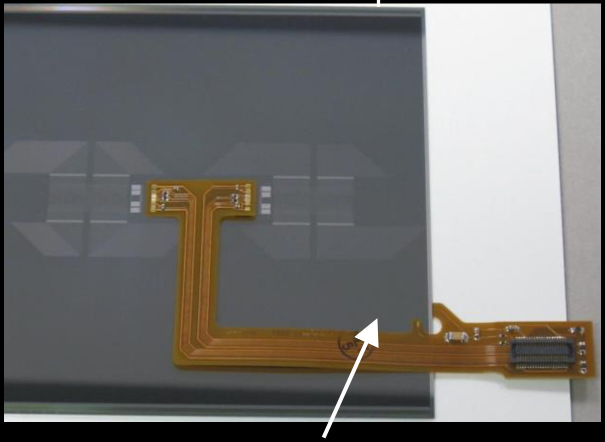
- Low noise dual range charge amplifier with 17 bit dynamic range
- Low noise floor 0.15 fC (1000 e^-)
- Designed for power modulation, average power < 20 μW / channel
- Internal calibration system
- Up to four measurements per channel per train
- Versatile

Baseline for Tracker and ECAL.

KPiX as a Calorimeter chip



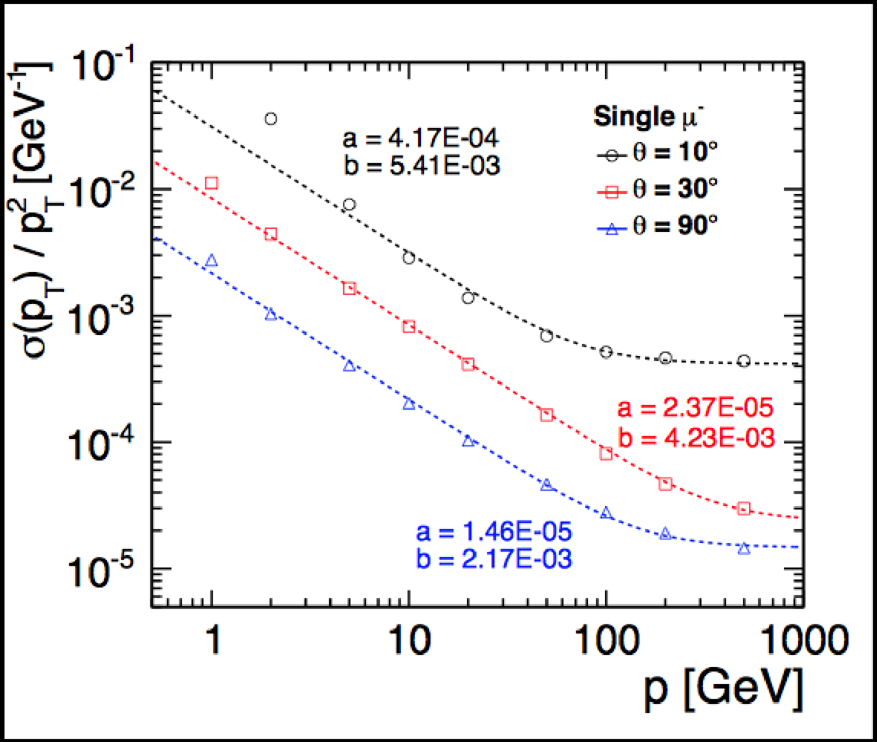
KPiX as a Tracker chip

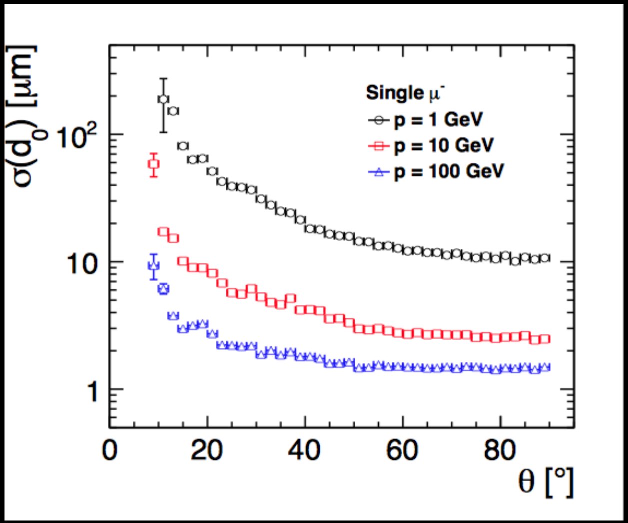


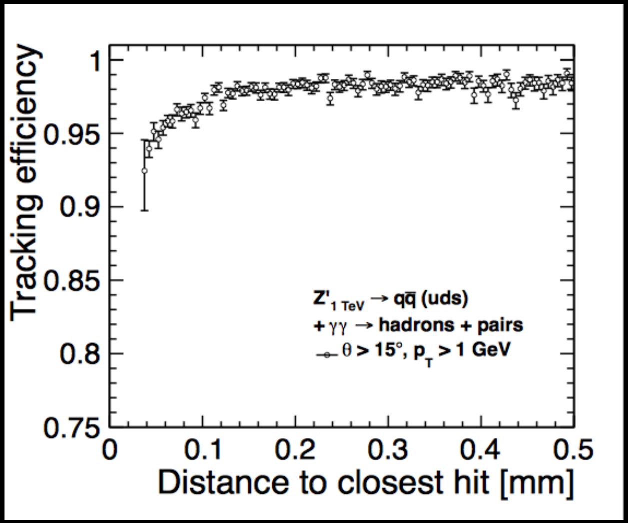
First revision of pigtail cable has been tested.
Second revision has been ordered.

Tracking Performance

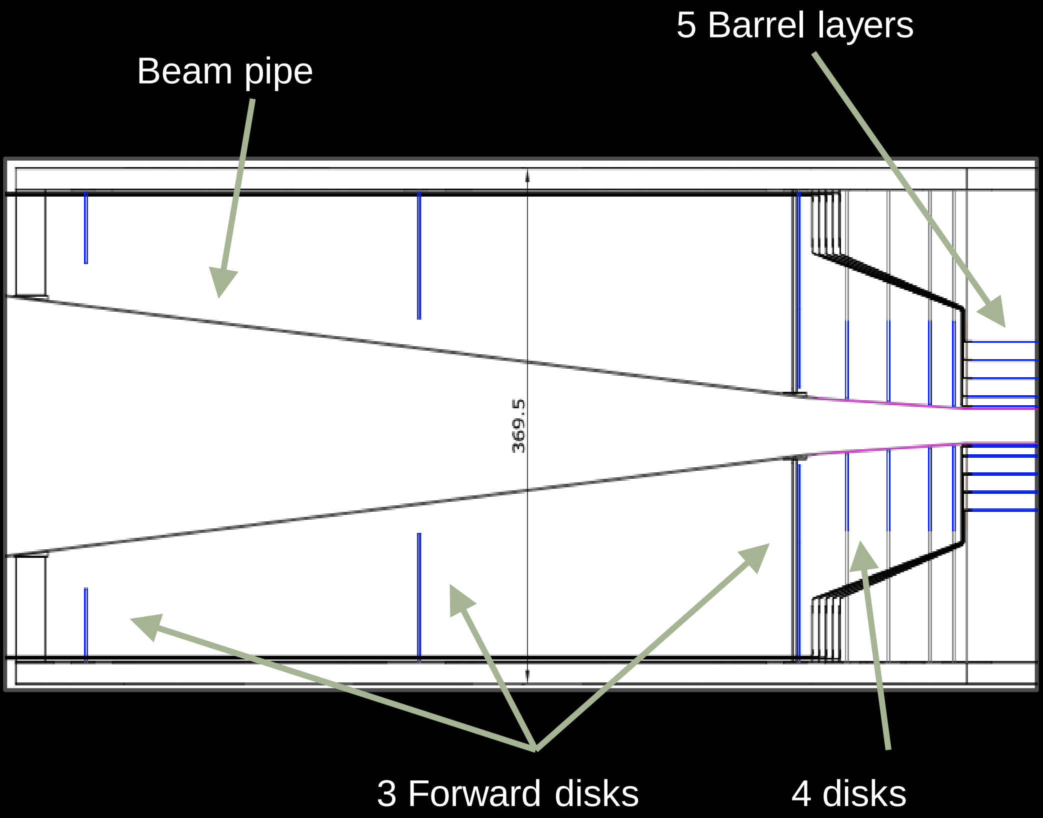
Excellent momentum resolution, impact parameter resolution and track finding efficiency even in high-energy jets







Vertex Tracker



Excellent impact parameter resolution for reconstruction of secondary and tertiary vertices

Several technologies potentially meet the requirements: 3D, SOI, MAPS, hybrid pixels, DEPFET

5 pixel layers in barrel
Innermost layer at 14 mm
4 disks
~ 20x20 μm^2 pixels
3 forward disks
~ 50x50 μm^2 pixels

R&D for extremely low-mass support structures:
All-silicon assembly, foam-based ladders (PLUME collaboration), carbon fibre supports

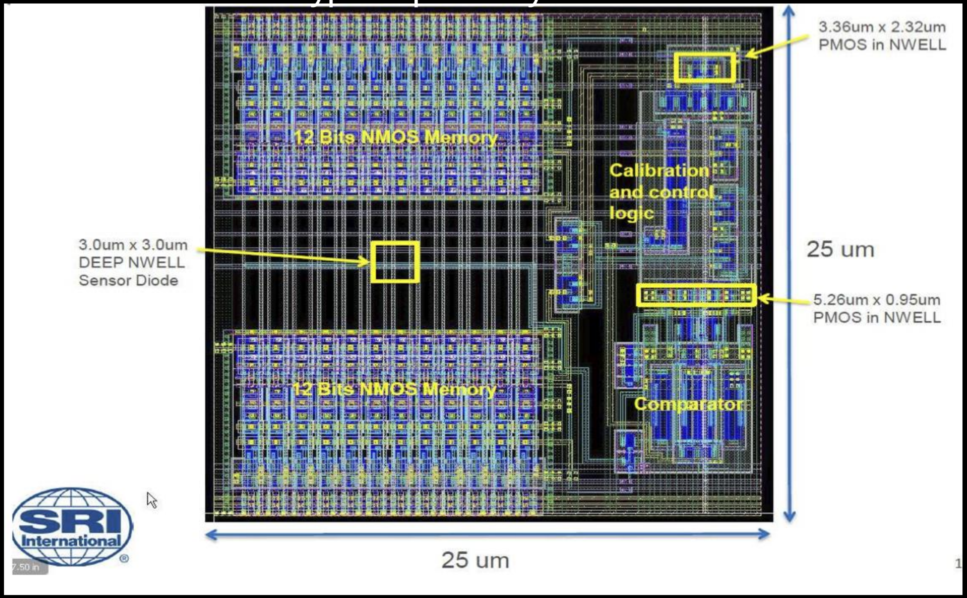
SiD is designed to make insertion and removal of the Vertex Detector straightforward.
Allows to take advantage of the best possible technology.

Pixel Technology Examples

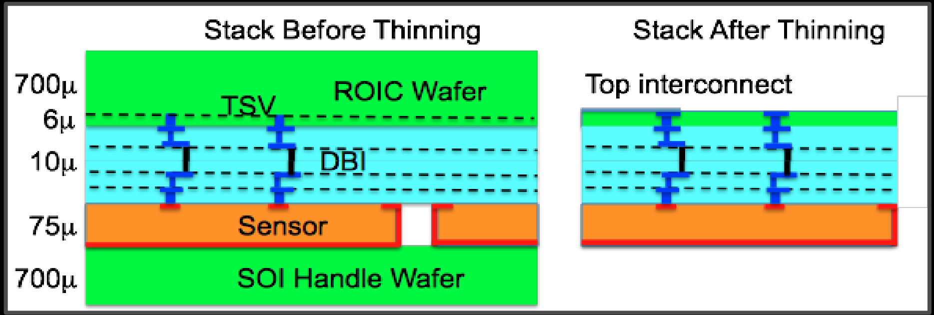
Chronopix: Monolithic CMOS chip with time stamp memory for a whole bunch train.
25x25 μm^2 pixels currently, 90 nm technology.

Full prototype to have 10x10 μm^2 or 15x15 μm^2, will go to 45 nm technology.

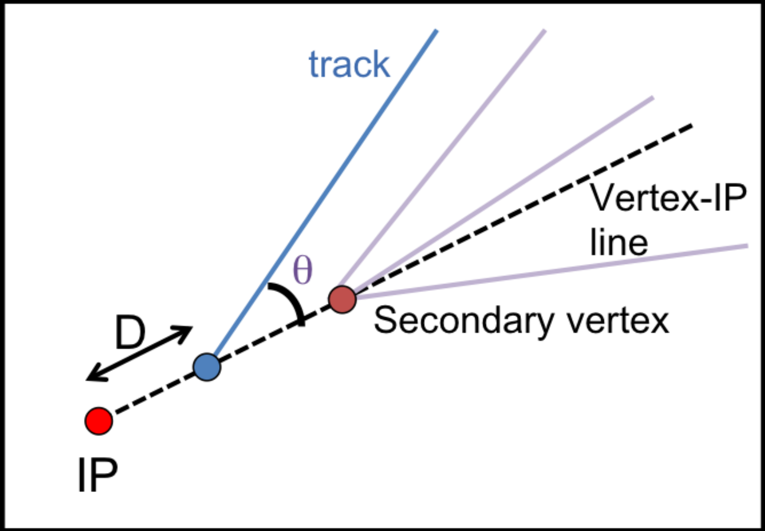
Prototype 2 pixel layout

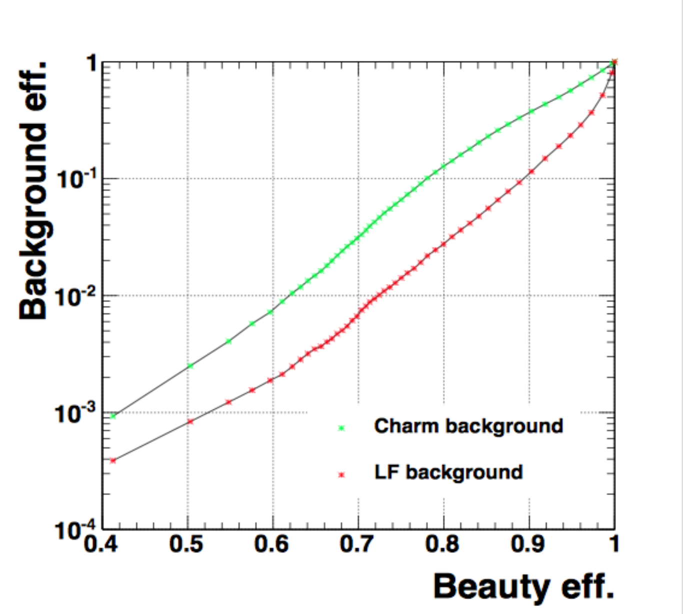


3D technology:
Top interconnect can be done in final topside aluminum patterning with low mass.
Cables bump-bonded to end of ladders. Allows for all-silicon design.

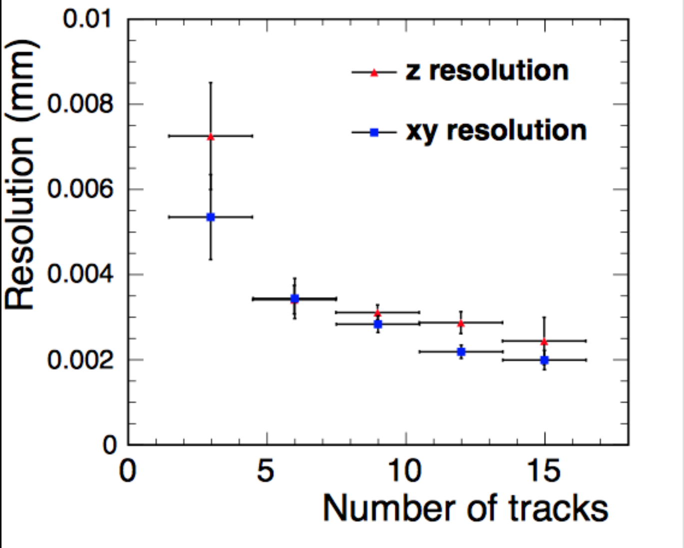


Vertex Finding and Flavor Tagging performance



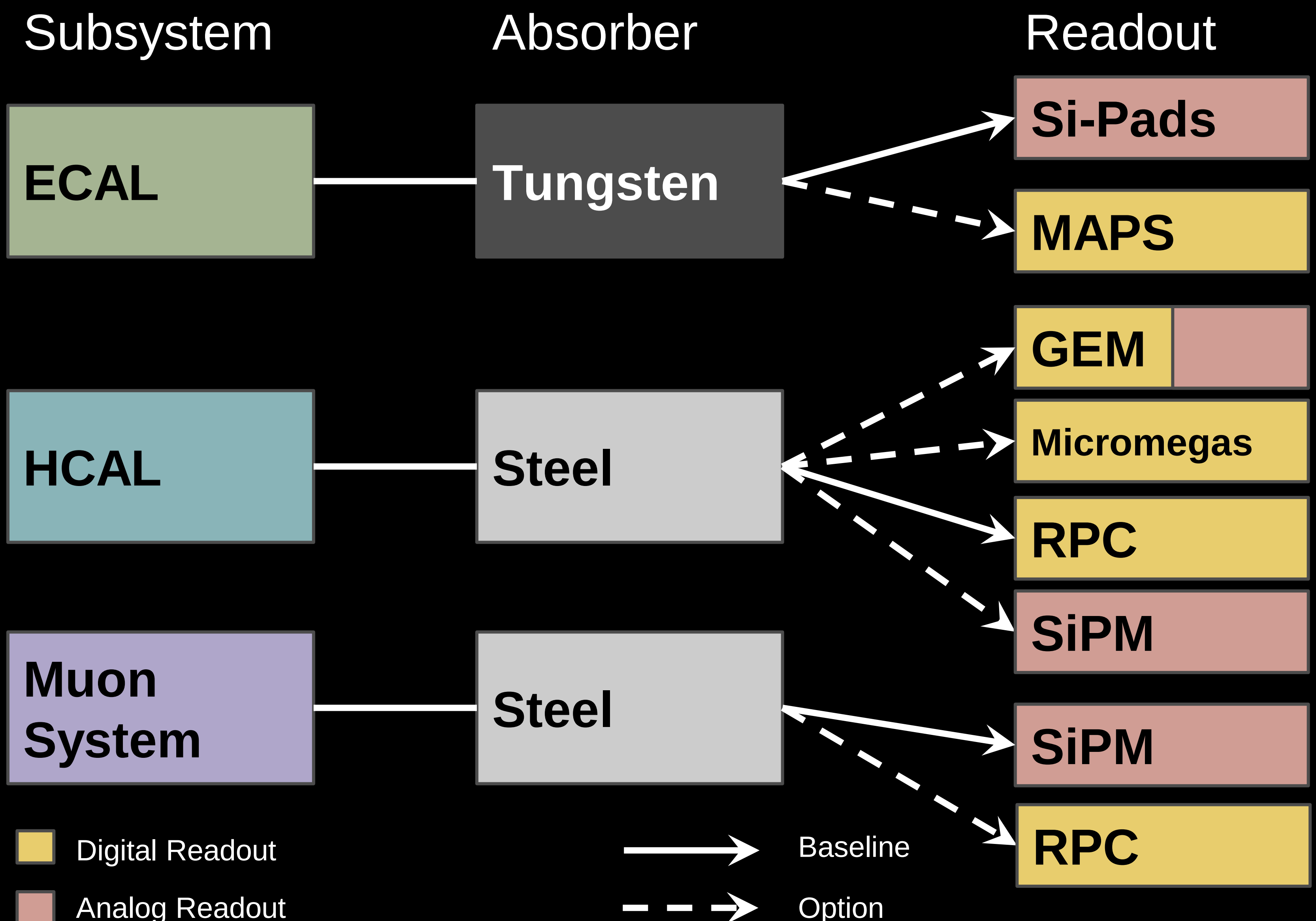


Vertex detector to find decay point of long-lived particles (vertices): b and c quarks, τ leptons

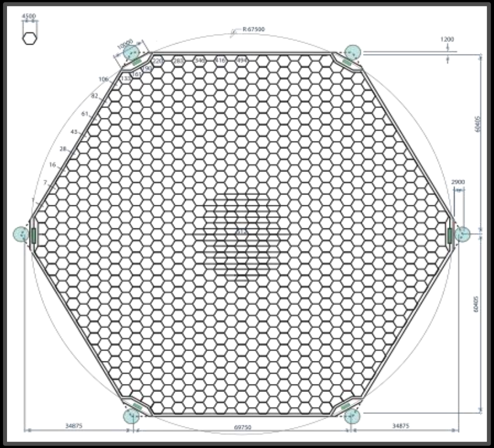


Flavor tagging is the identification of b, c or light quark jets.

Calorimetry Tree

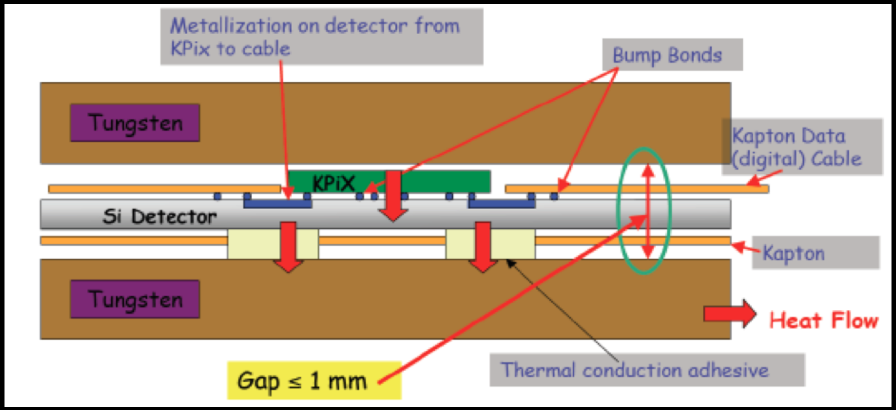


Si-W ECAL



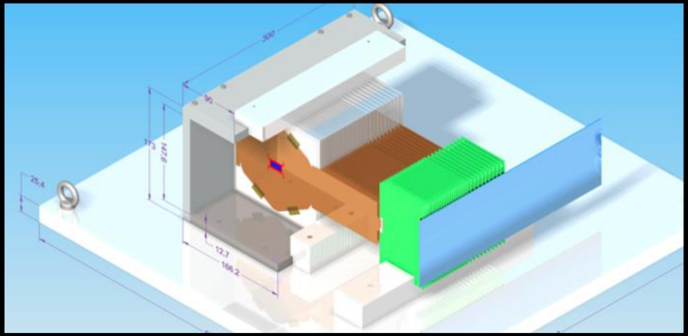
Highly segmented in lateral and transverse directions
Hexagonal shapes
Readout with KPiX chip

20 layers 2.5 mm W (5/7 X_0),
10 layers 5 mm W (10/7 X_0)
1.25 mm gaps → 29 X_0, 1 λ
$\Delta E / E \approx 17\% / \sqrt{E}$



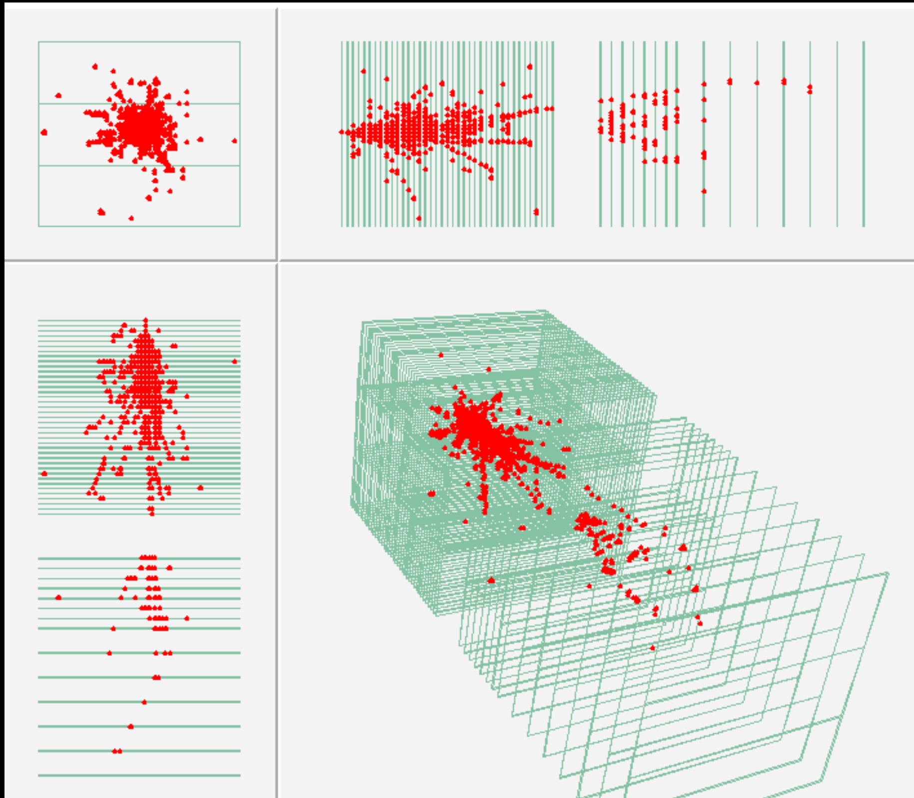
Test in SLAC ESA beamline in July 2013, <15 of the full 30 layers; All layers for later running in 2013-14

The R&D provides the required baseline ECal components (except large-scale mechanics) – now nearly completed



Digital HCAL

~ 500,000 channels
World record for hadronic calorimetry



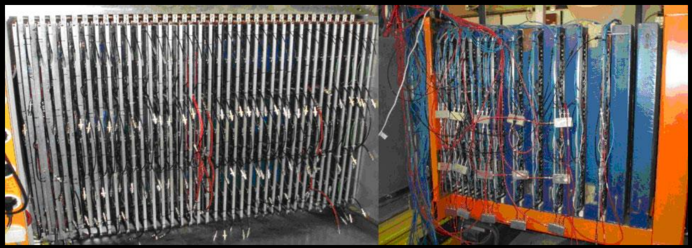
W-DHCAL π^- at 210 GeV (SPS)

54 glass RPC chambers, $1 m^2$ each
PAD size 1×1 cm^2
Digital readout (1 threshold)
100 ns time-slicing
Fully integrated electronics
Main DHCAL stack (39) + tail catcher (15)

CERN test setup includes **fast readout RPC (T3B)**

HCAL

HCAL in the Steel absorber stack at FNAL



Highly granular calorimeter - 1x1 cm^2 readout pads. World record for number of channels in hadron calorimetry already in test stack.

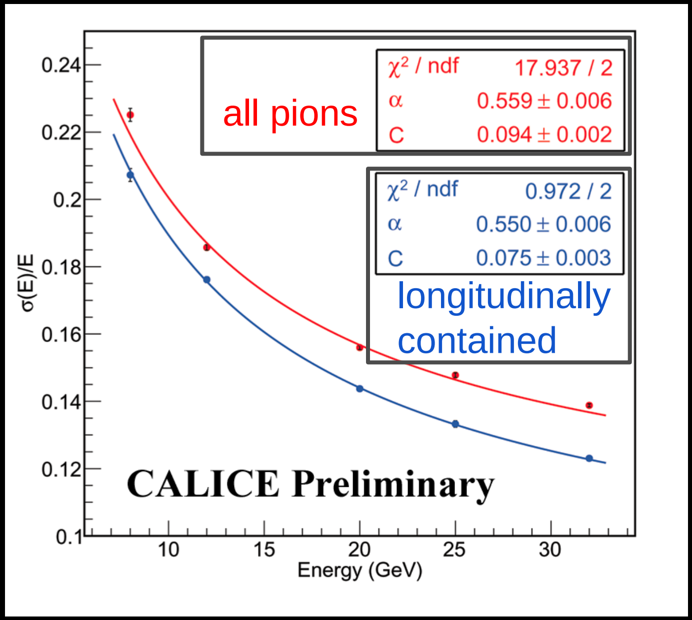
Baseline: Glass RPC, digital readout

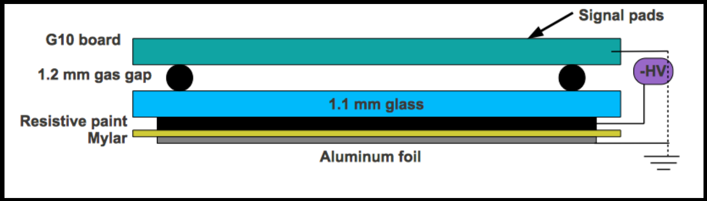
Technology successfully tested in beam tests in steel absorber stack at FNAL and in tungsten absorber stack at CERN

Data analysis is underway

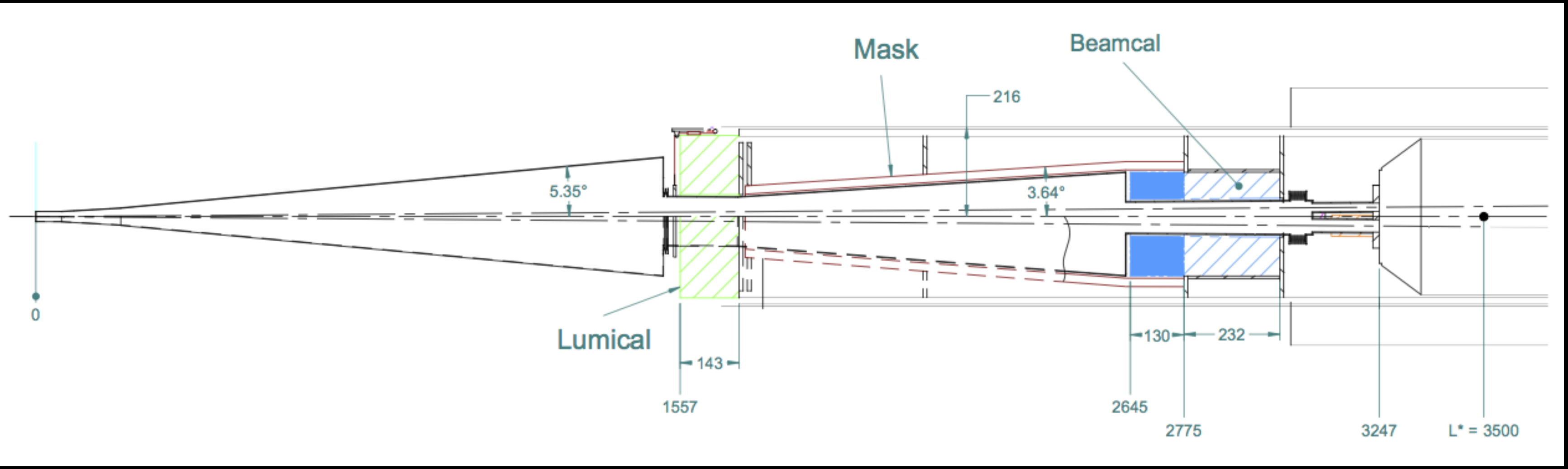
Operational experience drives further R&D:
Single-glass RPC, low-resistivity glass
for lower multiplicity, higher rate

Energy resolution of pions





Forward Systems

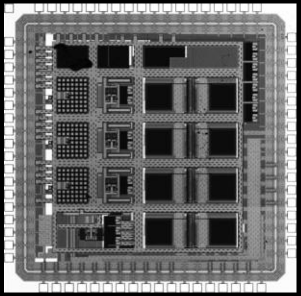


LumiCal: 40 mrad < θ < 90 mrad

- to measure integrated luminosity to better than 10^{-3}
- read out by Bean, KPiX

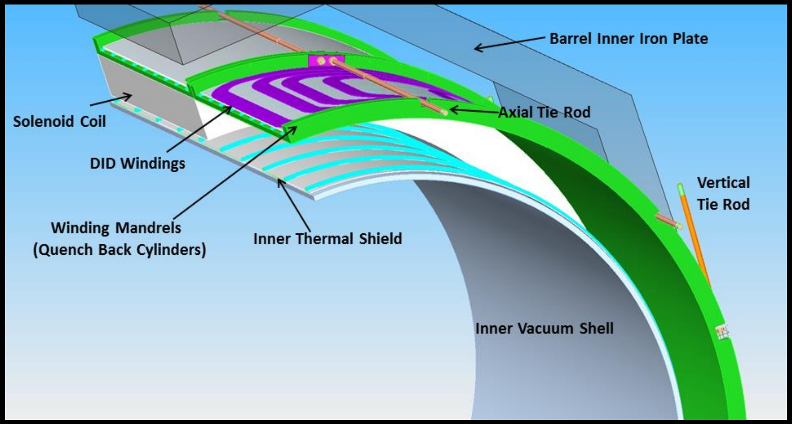
BeamCal: 3 mrad < θ < 40 mrad

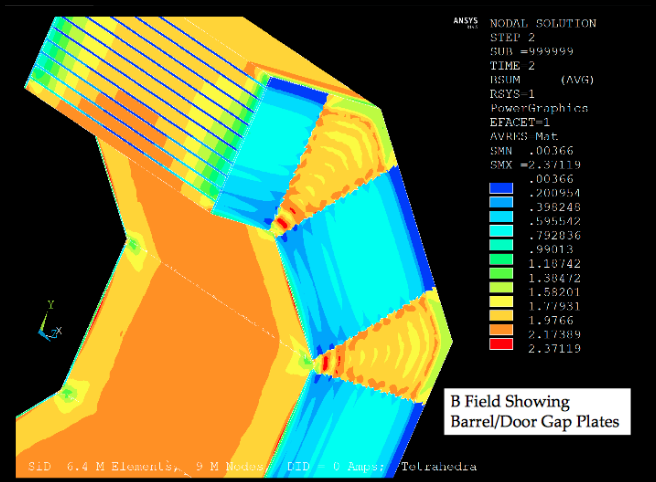
- to measure instantaneous luminosity using pairs
- read out by Bean chip



Bean Chip developed for higher radiation dose, high occupancy in far forward region
180 nm CMOS

Solenoid

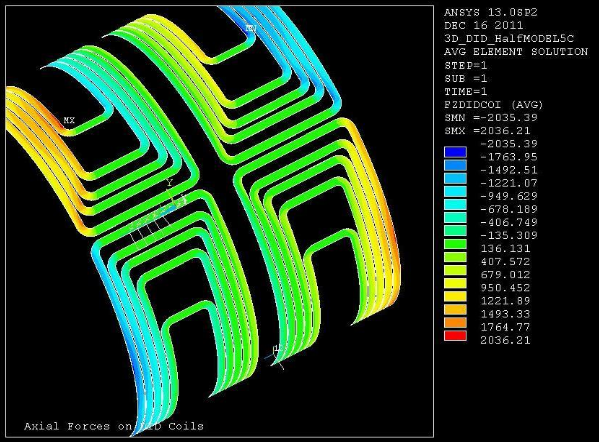




Wes Craddock, SLAC, SiD Workshop, Jan. 2013

5 T coil with Detector Integrated Dipole (DID)
Coil Design builds on CMS experience.
Advances in computation give a significant advantage to the SiD design as compared to prior CMS design work

- Magnetic field calculations in 3D ANSYS model
- Conservative choice of material. Feasibility demonstrated.
- Further conductor R&D could lead to cost savings.



Muon

Instrumented Flux Return. Main purpose:

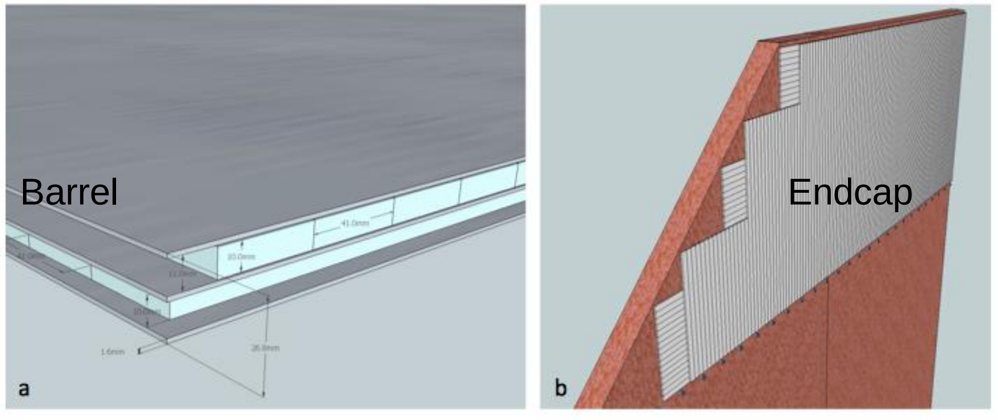
- Identification of muons
- Rejection of hadrons

10 layers in barrel,
 9 in each endcap

Major change since LOI:

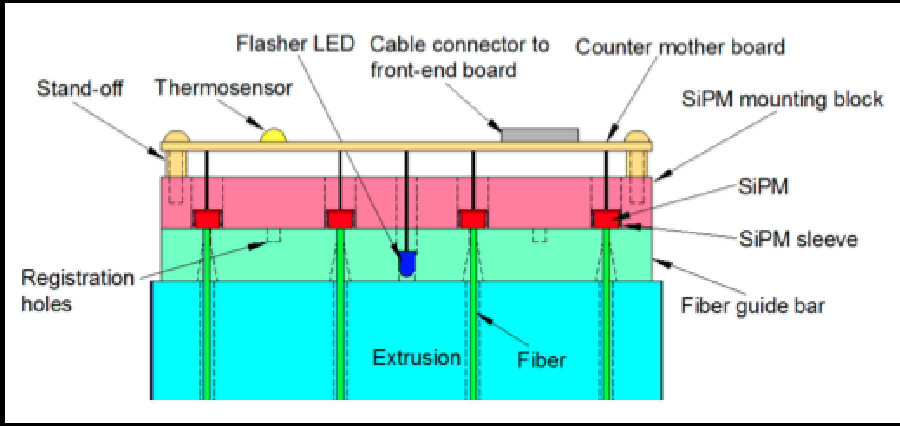
RPC → Extruded Scintillator bars, SiPM readout

Technology successfully tested in FNAL beam.

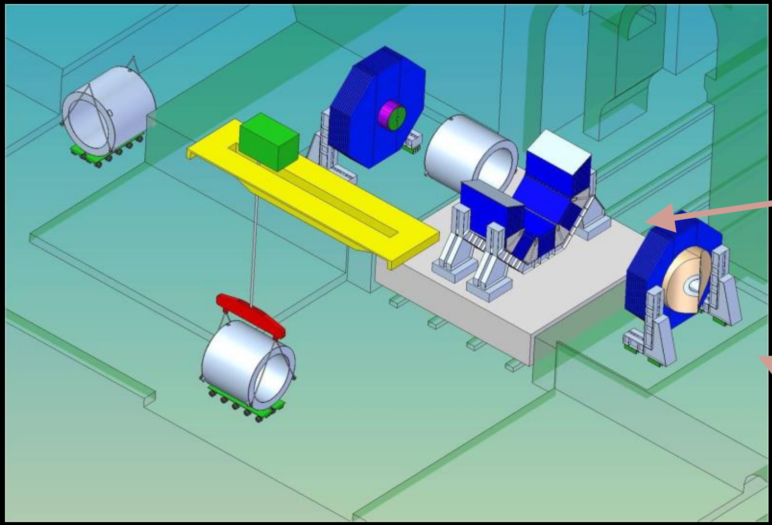


Barrel: Double layers of orthogonal strips, glued together with aluminum sheets
Endcap: Strip size adjusted to fit between spacers

Wavelength-shifting fibers read out by SiPM in a mounting block

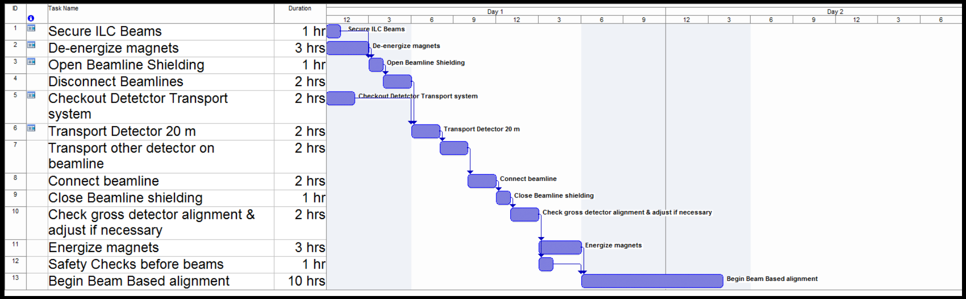


Engineering and Push-Pull



Horizontal access site

- SiD barrel fixed on 3.8 m concrete platform for push-pull
- Endcaps can be routinely opened for service



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

Specific push-pull planning depends on IR layout

"Fastest turnaround that is safely achievable": estimated 32 hrs

Data Rates

"Back-of-the-envelope" calculations:

- ILC 1 TeV: 1.06 GB / train data rate from detector,
  ~ 5.3 GB / s RAW data
- CLIC 3 TeV: ~ 200 GB / s RAW data from detector
  ~ 10 GB/s sustained data rate to be written to disk (using today's EDM and file format and estimating potential for data reduction)
- LHC: Alice farm (2011) able to achieve ~ 5 GB / s sustained data rate to disk

Farm size (CLIC 3 TeV): Estimated at 19k nodes of today's nodes with today's software.

Size of CMS online farm (2011): 7.5k nodes

Costing

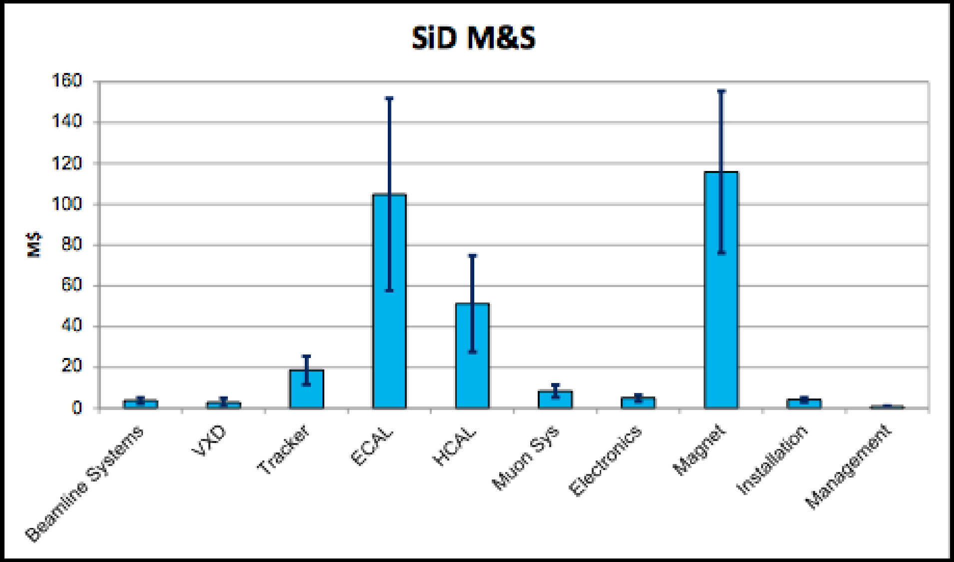
Costing units agreed between SiD, ILD, CLIC: 2008 USD
SiD uses central values of agreed costs
Cost of baseline:

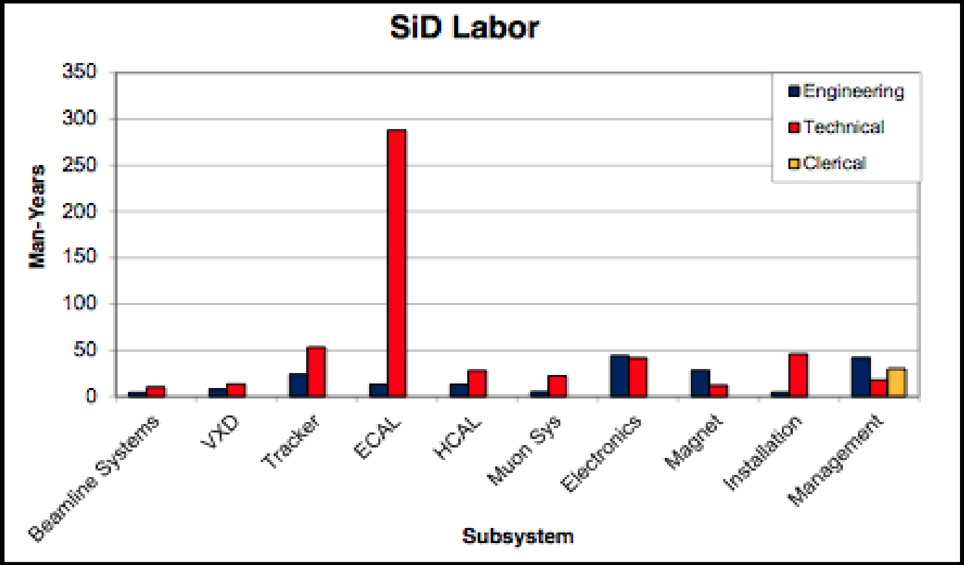
- M&S: 315 MCU
- Contingency: 127 MCU
- Effort: 748 person-years

Parametric detector costing
→ cost sensitivity analysis

<u>Baseline</u>: 6 CU / cm^2 Si
Coil costed as being made by industry

3 CU / cm^2 Si, coil made in-house, 6000 CU / m^2 HCAL:
M&S: 315 MCU → 222 MCU



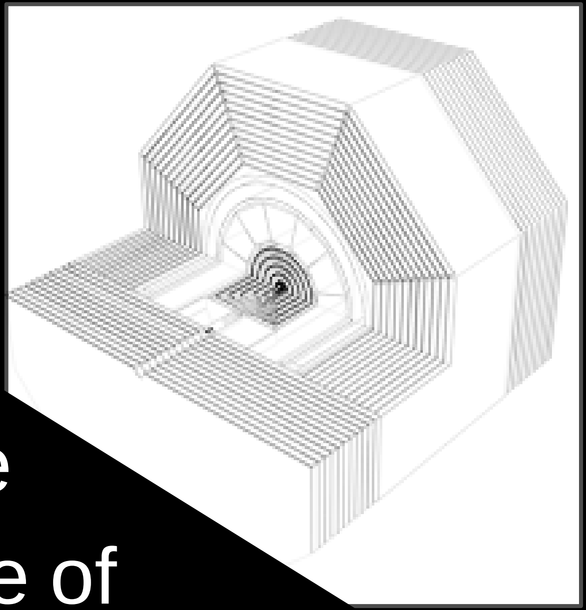


Detector Baseline Summary

- SiD is designed for precision physics
  - Designed to perform well in worse environment than planned
- Technological feasibility has been shown
  - Detailed studies ongoing
- SiD is fully costed
  - Solid foundation for a TDR
- All the cornerstones are in place
  - We're ready to start a TDR process

SiD's
Physics Performance

Simulation



SLIC - developed at SLAC

- Geometry definable at runtime
- XML file allows easy exchange of geometries between collaborators
- Now integrated in ILCSOFT

Centerpiece for the DD4HEP project to unify detector description for simulation and reconstruction

Reconstruction

Major change since LOI:

Moving to common tools

- PandoraPFA: Calorimeter reconstruction and sophisticated Particle Flow Algorithms
- LCFIPlus: Vertex reconstruction and flavor tagging
- MarlinReco: Collection of analysis tools, e.g. isolated lepton identification
- New OverlayDriver to mix in two kinds of background

Seamless transition enabled by the common LCIO format

DBD Production in Numbers

Production summary on SLAC confluence

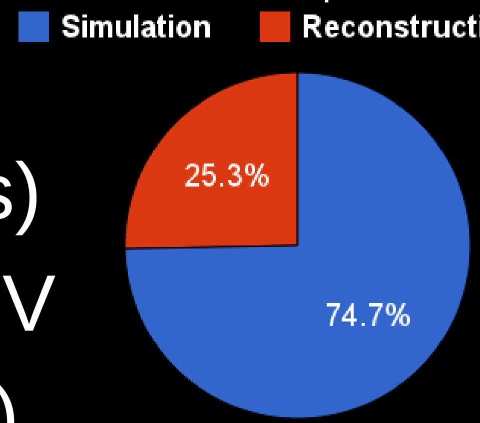
50.7 million events at 1 TeV

(+ 4.7 million gghadrons)

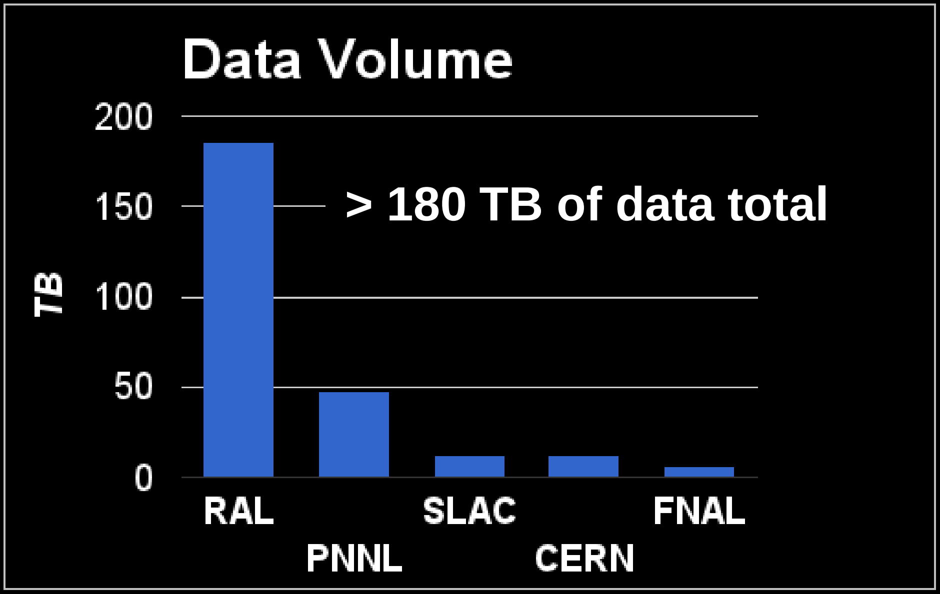
6.55 million events at 500 GeV

(+ 4.4 million gghadrons)

CPU time of different processing stages



detailed simulation dominates CPU time budget



Country	Total CPU Time (years)
UK	100.2
CH	68.2
FR	15.0
US	28.2
TOTAL	211.6

SiD on the Grid

Open Science Grid (OSG) resources are new addition to the SiD resource pool

dedicated resources: PNNL, SLAC, CERN
temporary quota increase: FNAL, RAL Tier 1
opportunistic use: all others

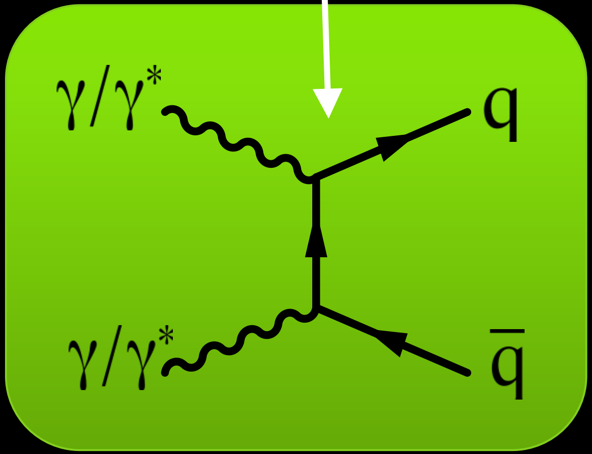
Worldwide LHC Computing Grid (WLCG) resources have been established during LOI and CLIC CDR efforts

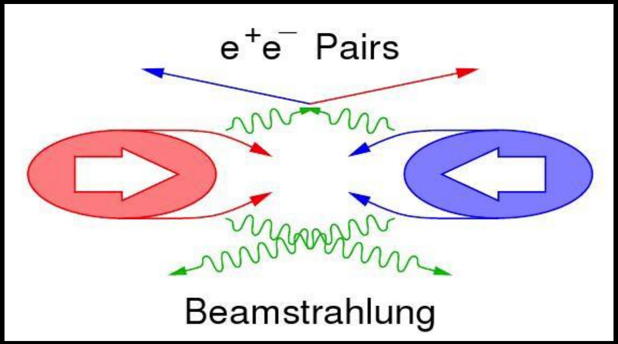
SiD takes advantage of the international computing grid infrastructure

DBD Benchmarking Analyses

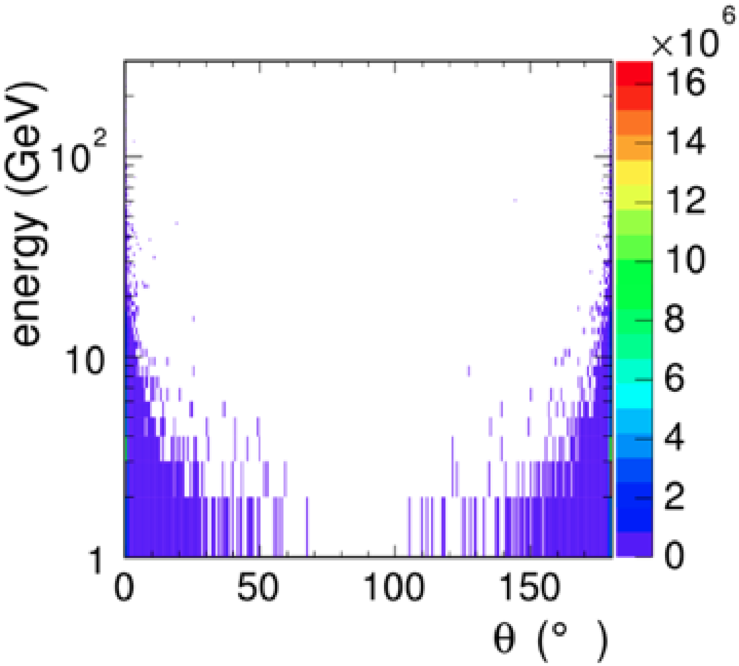
All analyses with detailed detector simulation

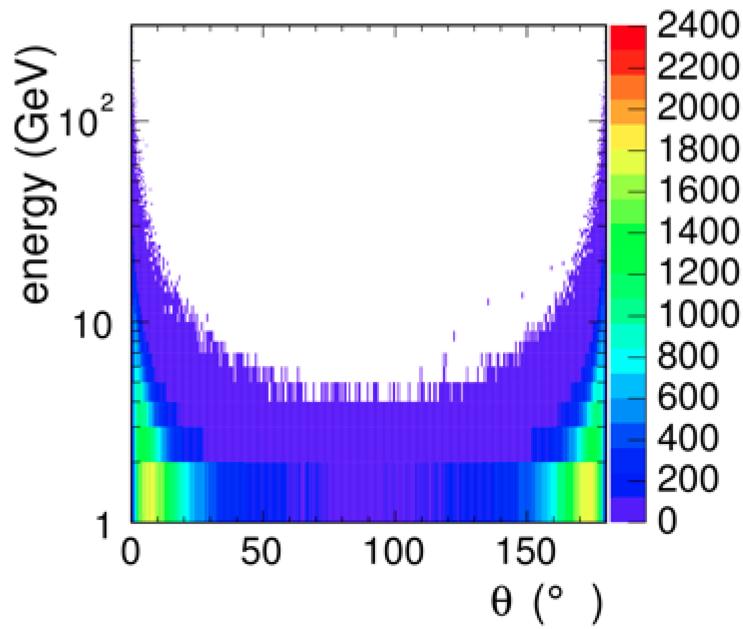
- SLIC with realistic (conservative) z distribution of events across luminous region
- Taking into account background from
- γγ interactions and incoherent pairs





Kinematic Properties of Beam-Induced Background

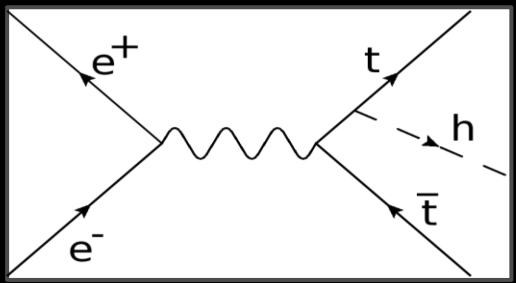


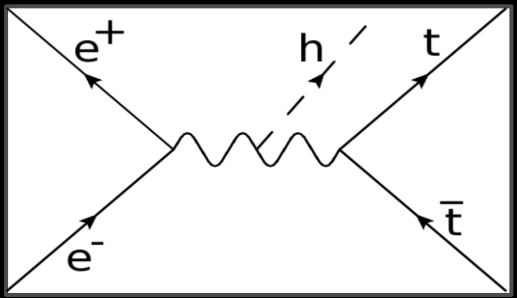


incoherent pairs
~ 450k particles / BX
low energy, increase occupancy in forward region and inner tracking layers

γγ → hadrons
4.1 events / BX
reach the barrel detectors and have an effect on reconstruction

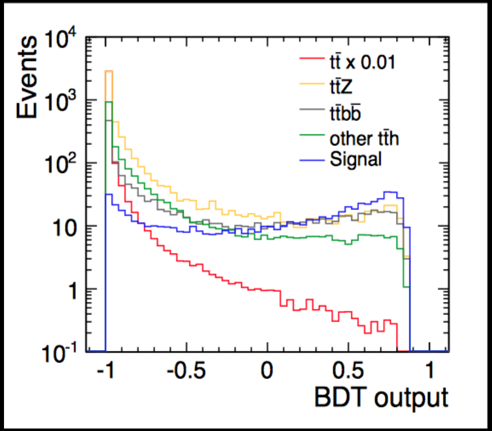
Top Yukawa Coupling





Dominant tth production diagrams

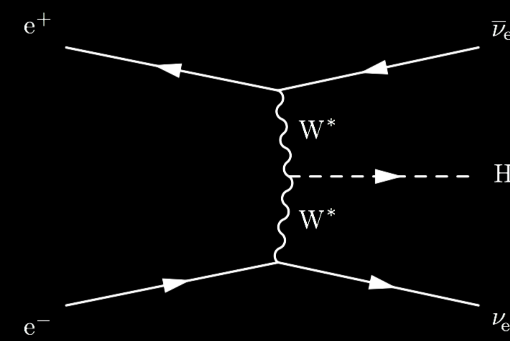
Direct measurement of the top Yukawa coupling by measuring the tth cross section at 1 TeV



analysis in 6-jet + 1 lepton and in 8-jet channel;
candidates formed from jets by minimizing χ^2

DBD Result:
13.2% cross section uncertainty in 6-jet channel
11.5% cross section uncertainty in 8-jet channel
combined uncertainty on the top Yukawa coupling (1 ab^{-1}): 4.5%
with only P_{e-}, P_{e+} = -80%, +20%: uncertainty about 4%

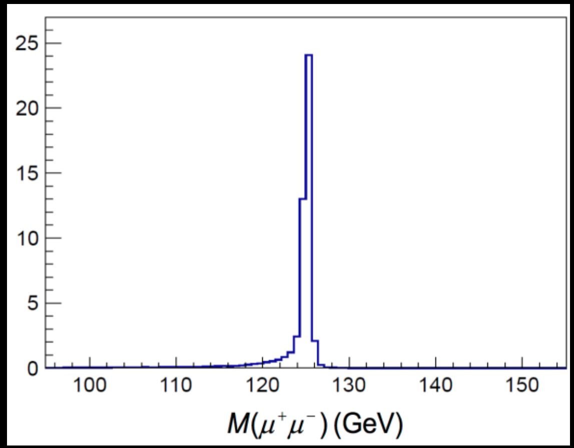
Higgs Branching Ratios



Measurement of the Higgs branching ratios to b, c, g, W, μ pairs (3 separate analyses) in direct production at 1 TeV

Relative uncertainties on the cross section times Higgs BR

Energy	1 TeV		
Luminosity	$\mathcal{L}$ = 500 fb^{-1}		$\mathcal{L}$ = 1000 fb^{-1}
P(e$^-$) P(e$^+$)	− 80% + 20%	+ 80% − 20%	− 80% + 20%
h → bb	0.0065	0.026	0.0046
h → cc	0.100	0.733	0.071
h → gg	0.040	0.234	0.028
h → WW	0.042	0.260	0.030
h → μμ			0.32



Results do not take into account results from stages below 1 TeV.

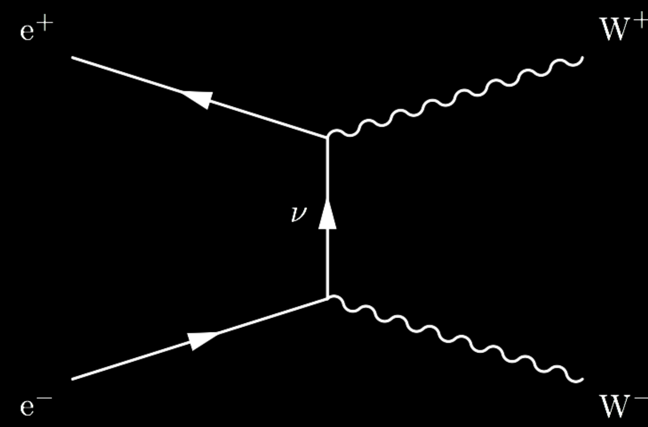
For example, h → cc at 250 GeV, 250 fb^{-1} ≈ 6 %

some analyses still being updated

quoted uncertainties statistical only

Measurement of Beam Polarization

$e^+e^- \rightarrow W^+W^-$ production in the forward region
Sensitive to polarization,
insensitive to new physics.



Four jet topology: $0.8 < \cos(\theta) < 1$
Two jets + lepton: $0.8 < \cos(\theta) < 1$ and
$-1 < \cos(\theta) < 1$

Result:

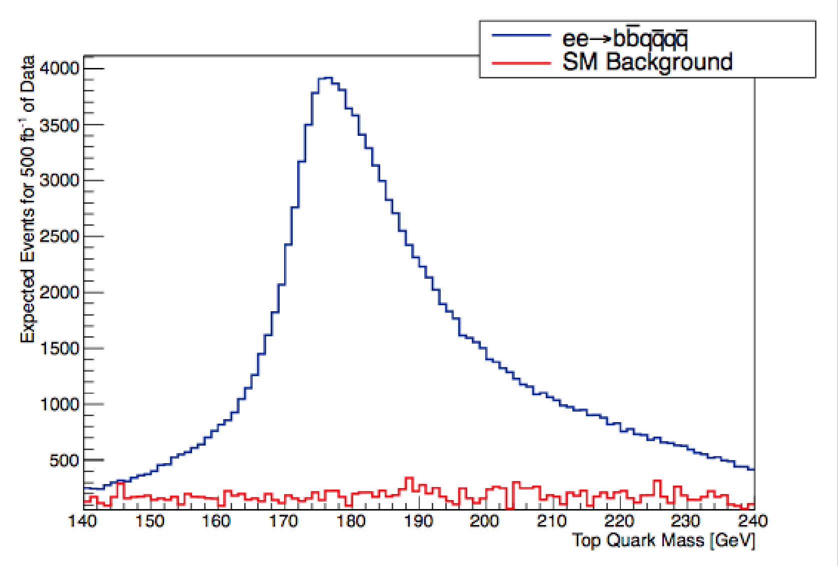
assuming 500 fb^{-1} in each polarization state	Pol.	$\Delta\lvert P_{e-}\rvert$	$\Delta\lvert P_{e+}\rvert$
$0.8 < \cos(\theta) < 1$	−80%,+20%	0.12	0.077
$0.8 < \cos(\theta) < 1$	+80%,−20%	0.0046	0.023
$-1 < \cos(\theta) < 1$	sum	0.0020	0.0029

assuming SM production of W^+W^-

Top Pair Production at 500 GeV ILC

Repetition of a LOI background with updated detector description:

Measurement of top mass and forward-backward asymmetry in top pair production at 500 GeV.



Reconstructed top mass in the fully hadronic channel.

Result with 500 fb^{-1}, P_{e-}, P_{e+} = +80%, -30%:

statistical uncertainty only

- top production cross section: < 1%
- measurement of forward-backward asymmetry: ± 2%

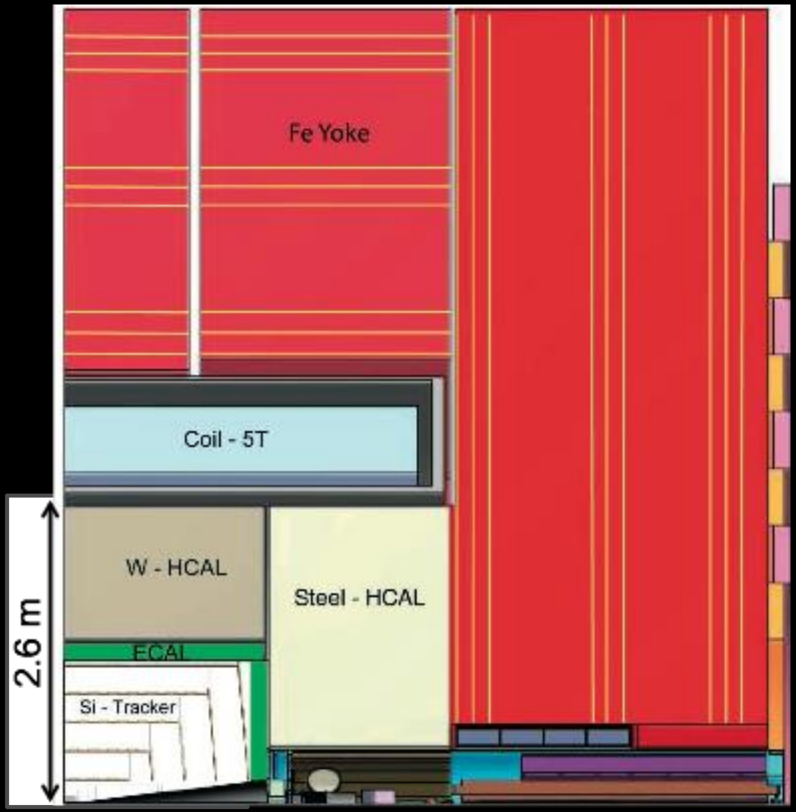
Summary of Physics Performance

- SiD baseline performance has been demonstrated in realistic simulation studies of precision measurements.
- Excellent b- and c-tagging as well as momentum and jet energy resolution allow to measure the Higgs couplings also to second generation fermions.
- Physics Performance with baseline has been studied up to 1 TeV.

The SiD Detector Concept at CLIC

Main differences wrt. ILC:

- Larger r_{inner} of the vertex detector
- Tungsten absorber in HCAL
- RPC-based muon system
- More complex forward region
- More precise time stamping in the active layers
- Faster power cycling: 50 Hz



Summary

- The SiD concept is a compelling option for a detector at a linear collider
- The SiD concept (with appropriate adjustments of technology) has been successfully used for physics analyses in extensive simulation studies 250 GeV up to 3 TeV
- The DBD is a snapshot of the SiD road to a TDR
- **R&D continues**
- **Now is an ideal time to contribute**
  - Join the SiD Workshop, Oct. 15-17, SLAC https://ilcagenda.linearcollider.org/conferenceOtherViews.py?confId=6161
  - Join the SiD session at LCWS13, 14/11, 9.00-10.30

LCWS13 will be held at The University of Tokyo

11-15 November 2013 (registration is ongoing)

http://www.icepp.s.u-tokyo.ac.jp/lcws13/

Thank you for your attention

Backup