SiD

A Detector for the ILC

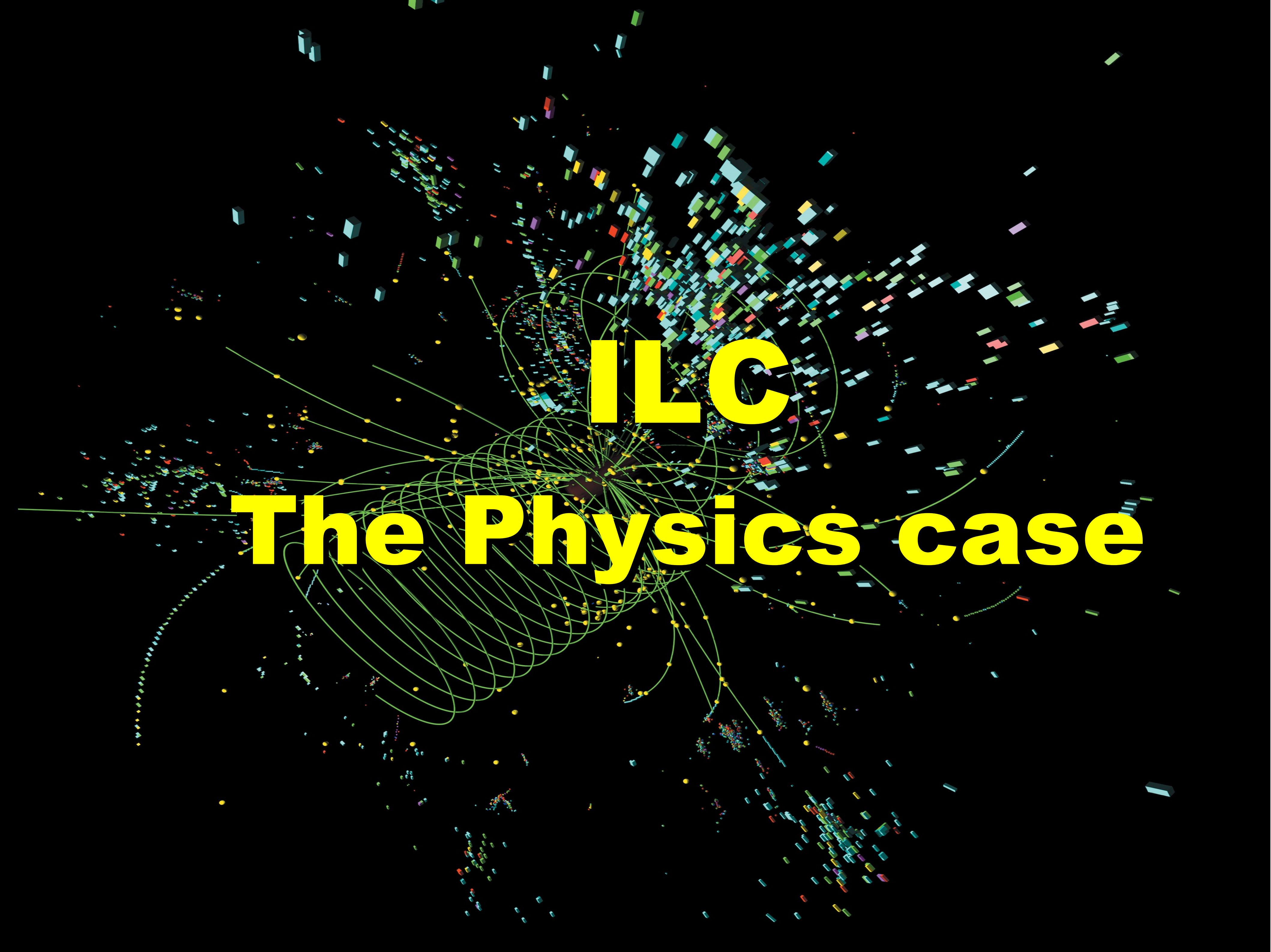
Marcel Stanitzki

DESY

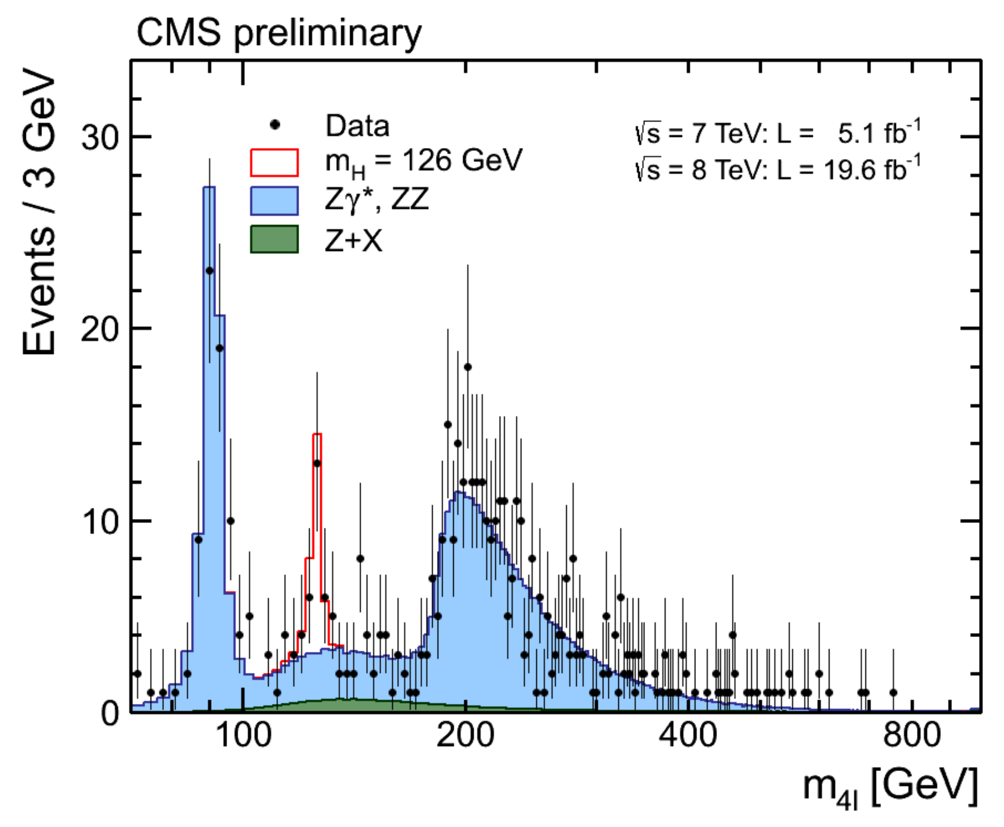
Göttingen

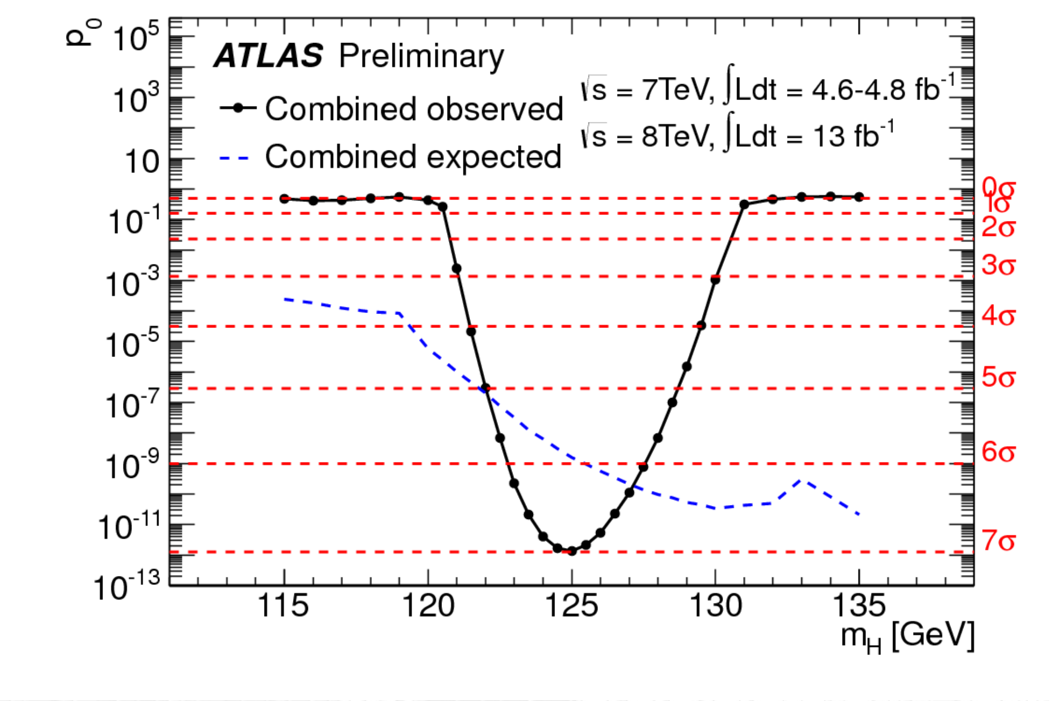
ILC

The Physics case



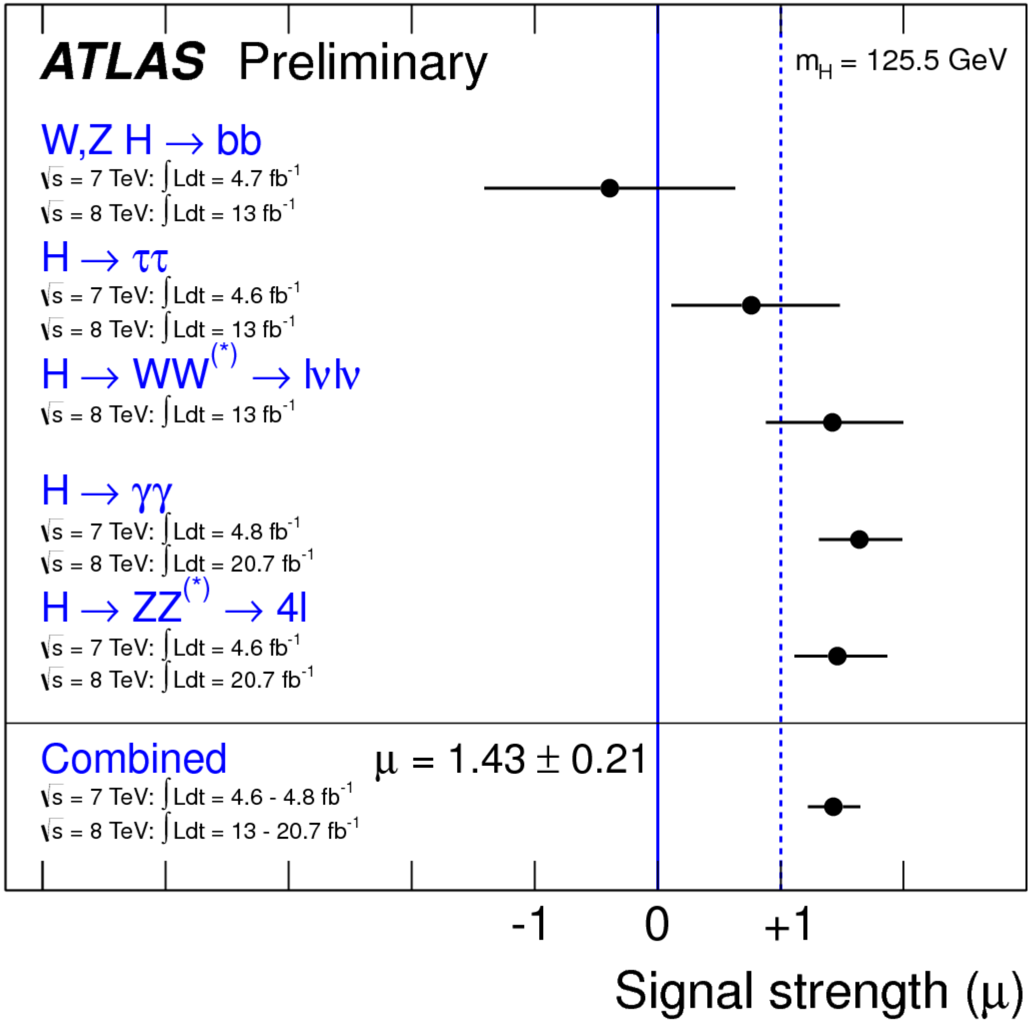
The Higgs discovery

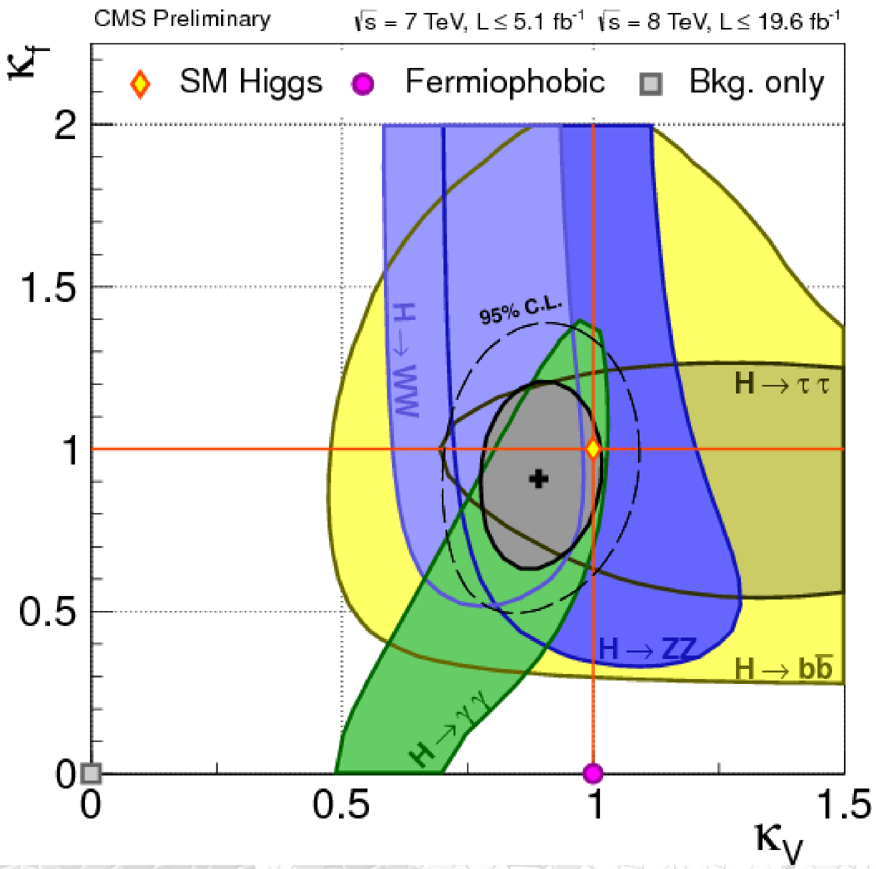




ATLAS and CMS have established the existence of a Higgs-like particle at ~ 125 GeV

However ...



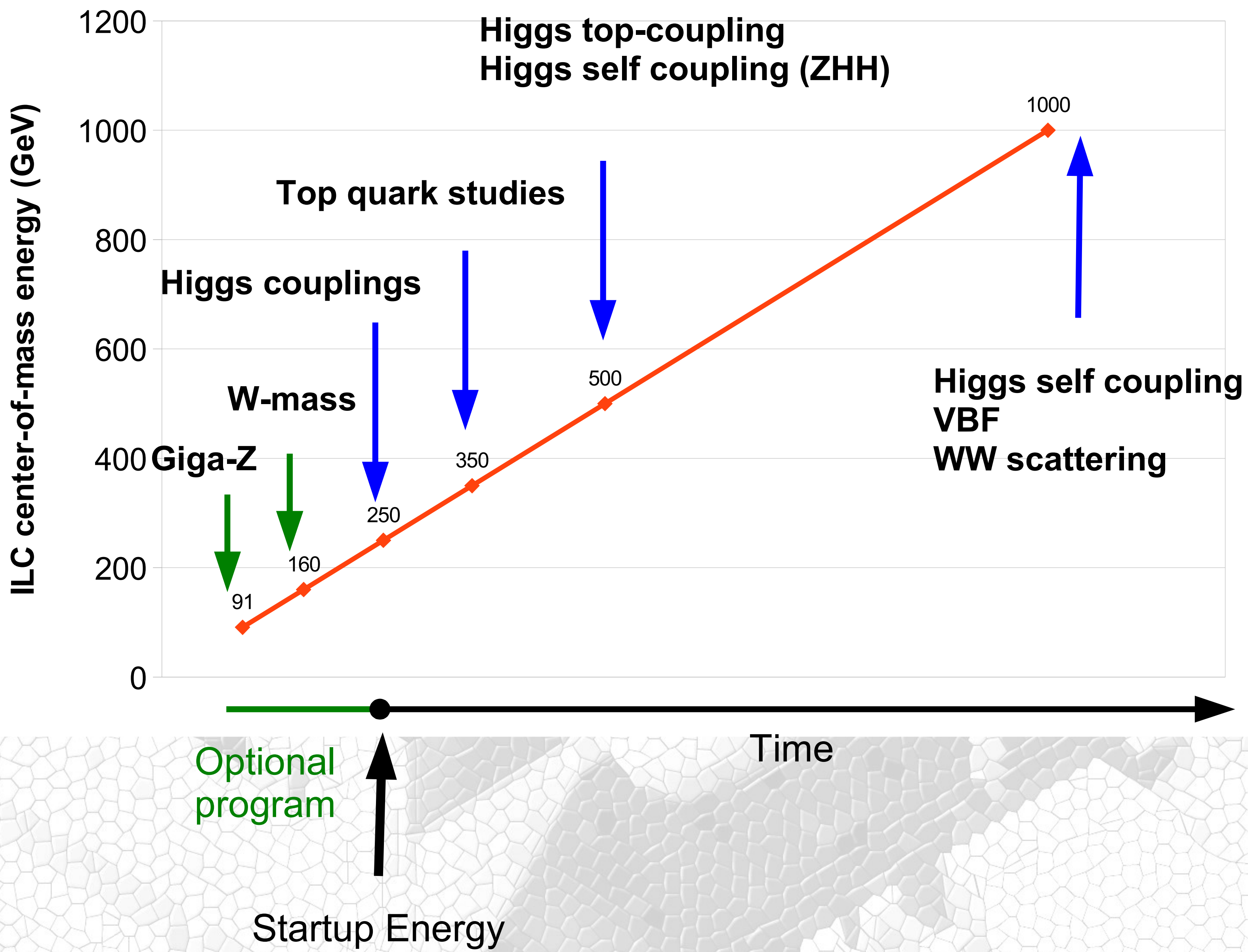


The effort of understanding this new particle have just started

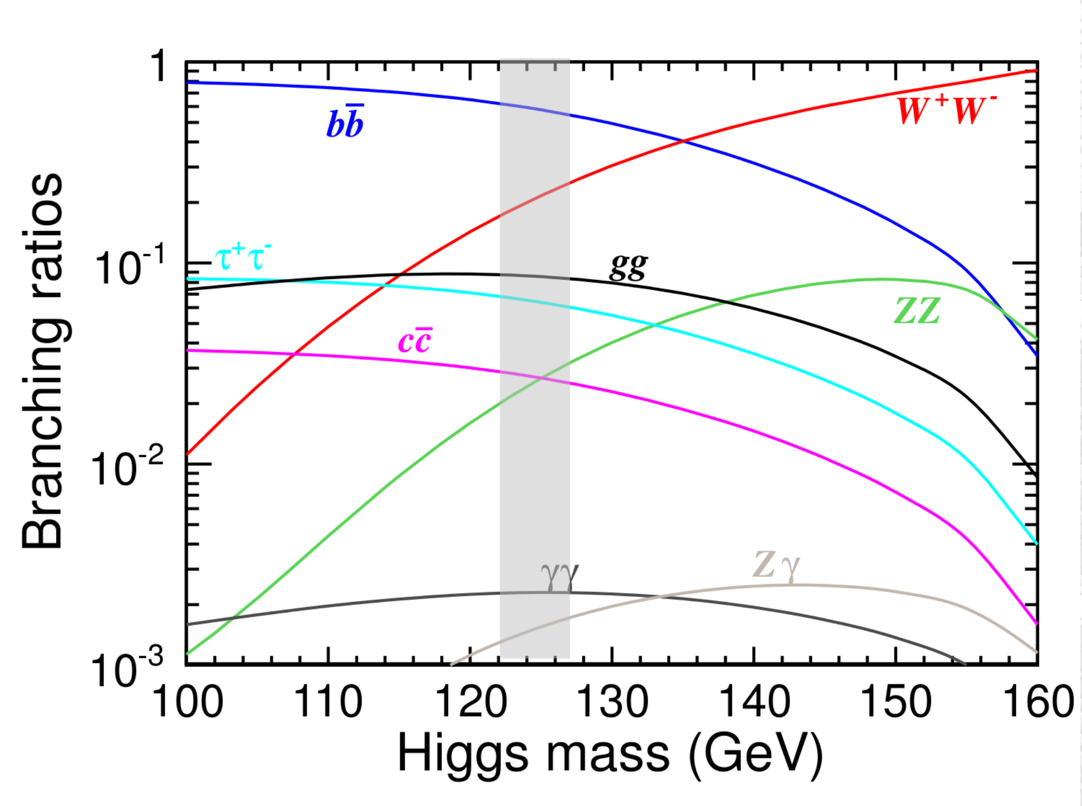
The ILC Physics case

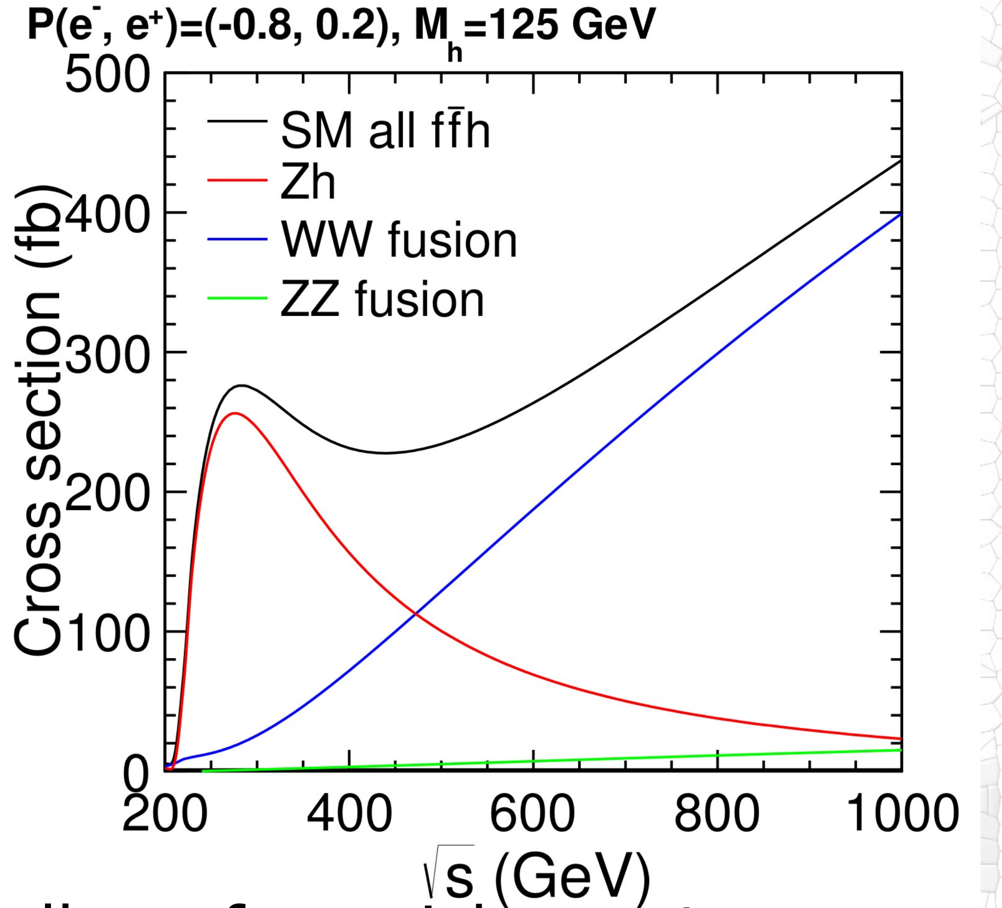
- The ILC Physics case comprises three flagships
- Higgs
  - Mass, Branching ratios, properties
- Top quark
  - Mass, cross-sections, decays, properties
- Search/study for new physics
  - Directly or indirect searches
  - Depends on what the LHC might find
- But there is more
  - Electroweak physics, flavor physics …

The ILC program



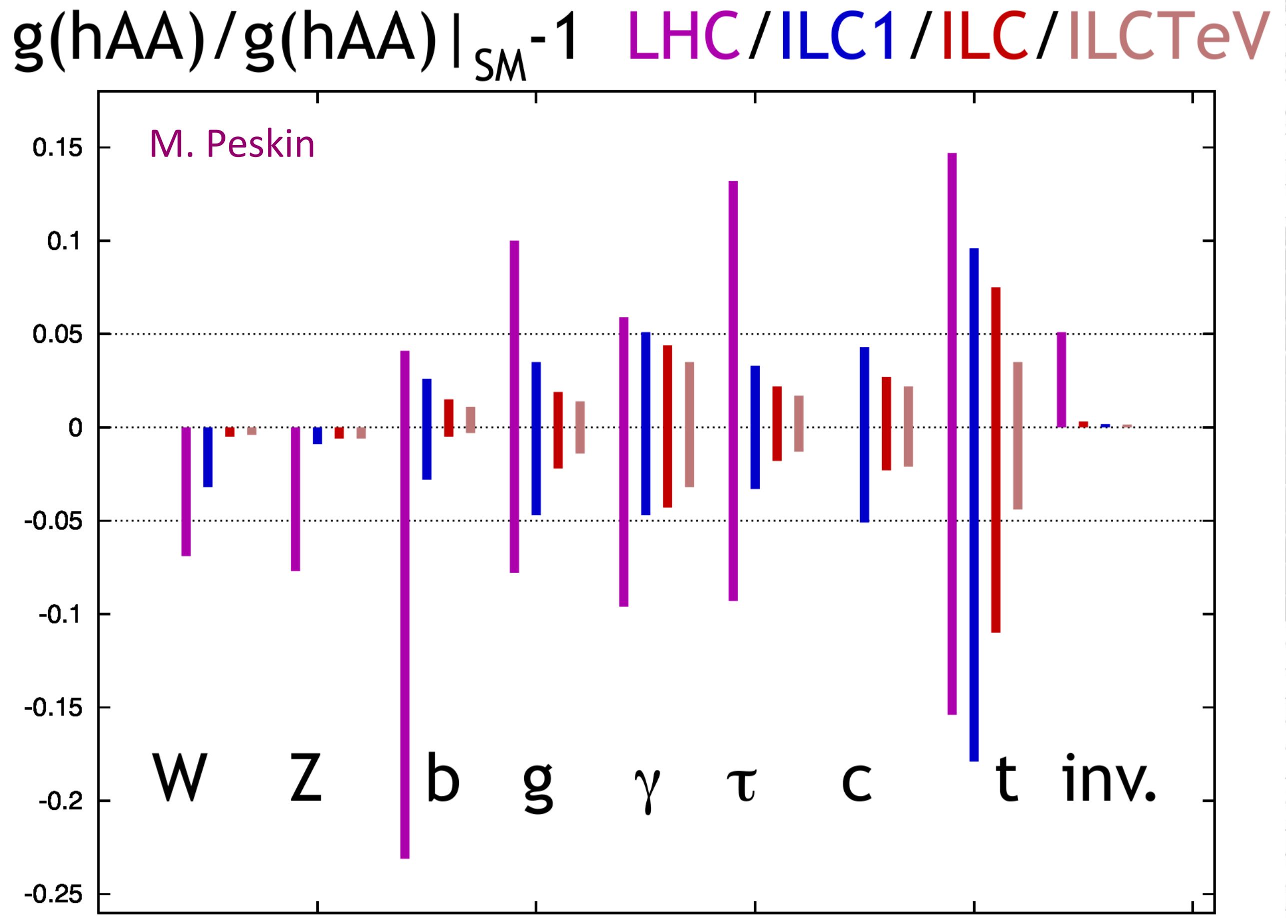
Understanding the Higgs





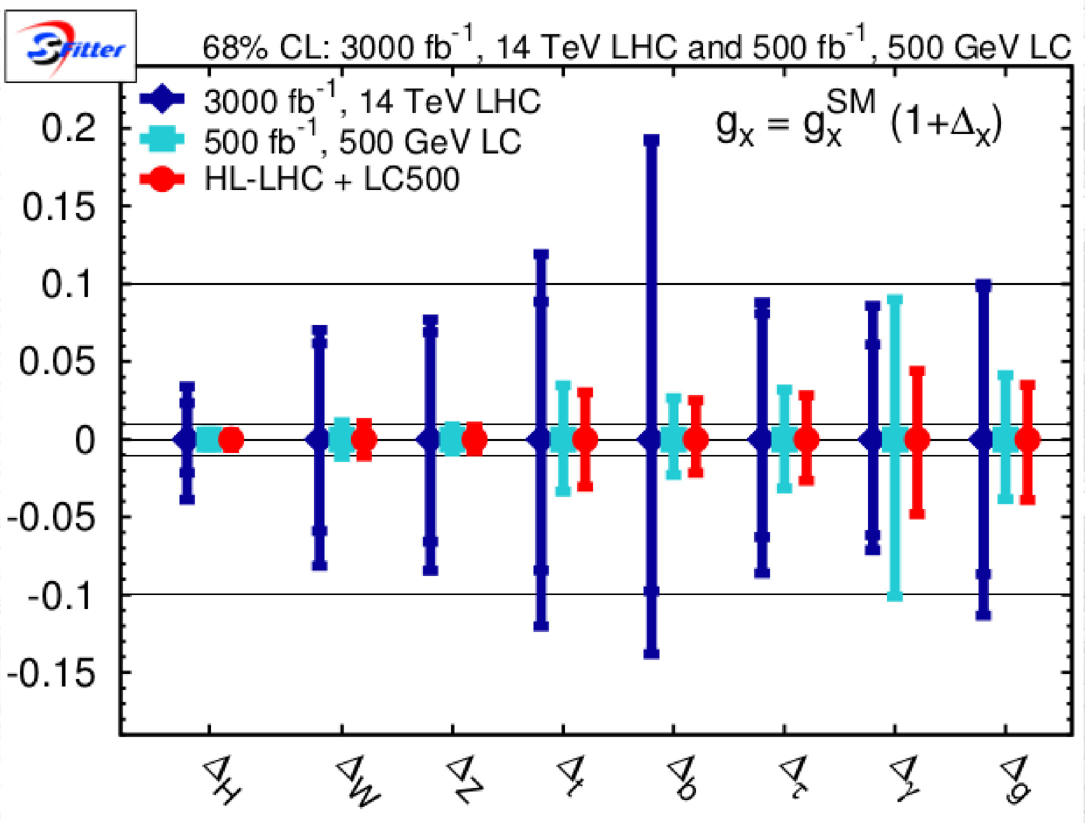
- The Higgs mass of 125 GeV allows for a rich spectrum of Higgs decays
- Also ILC studies different production modes
  - Essential for measuring the total width (ILC-exclusive)

Higgs couplings



- At the End of the ILC program
  - Precise knowledge of all couplings (< 5%)
  - Will allow to disentangle if it is a SM Higgs or not

Comparing with HL-LHC



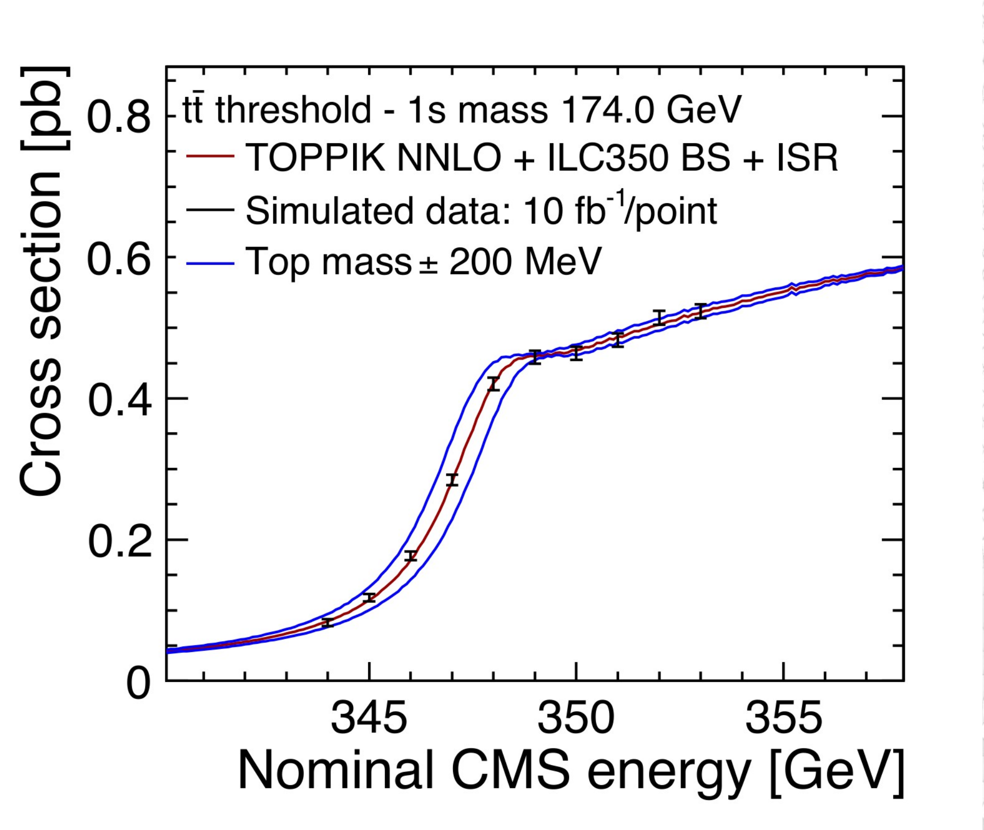
SFitter Study

HL-LHC ~ 8% accuracy (gauge bosons)
ILC ~ Order of magnitude better

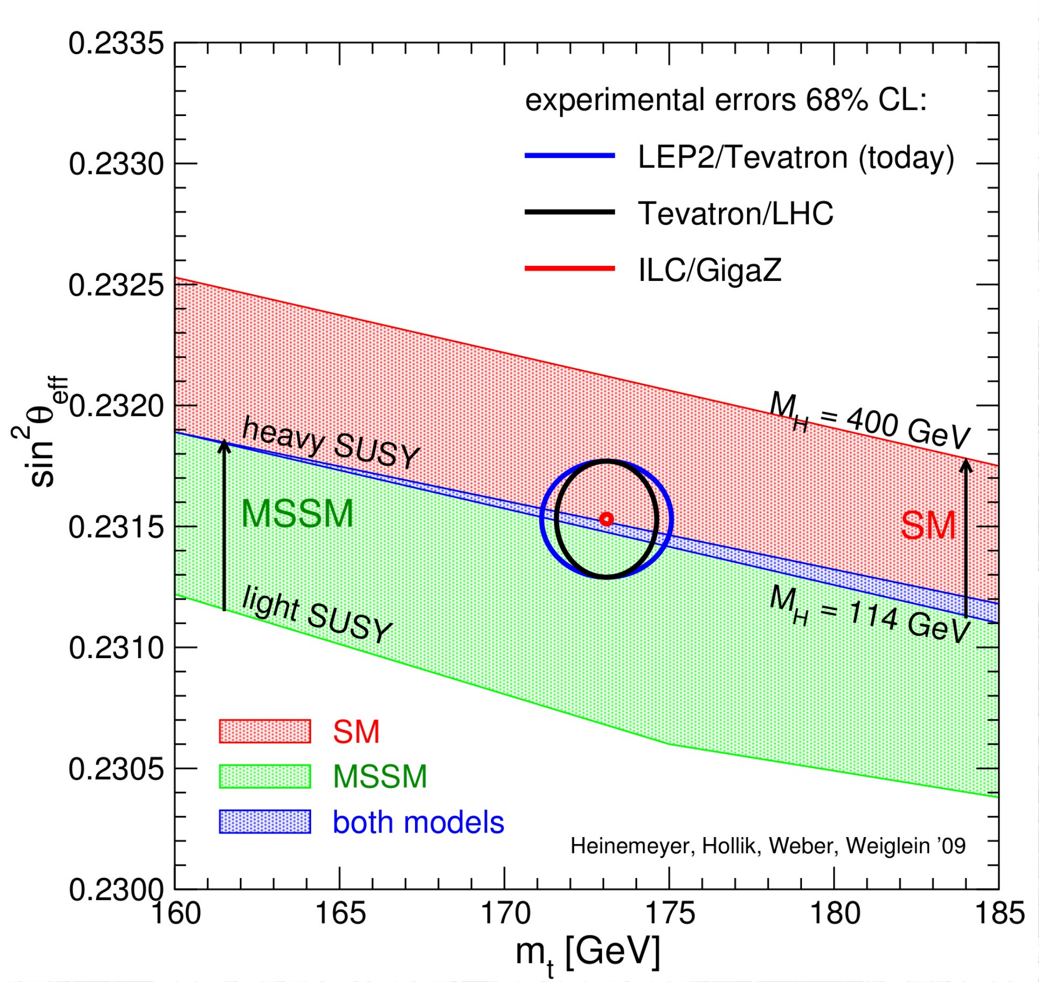
- Take them with a grain of salt
- Everything based on
  - Studies, Extrapolations
  - Analyses in an early stage
  - Some "theoretical" assumptions
  - Personal views
- Clear ILC Advantages
  - Total Width measurement
  - H->$c\bar{c}$ measurement

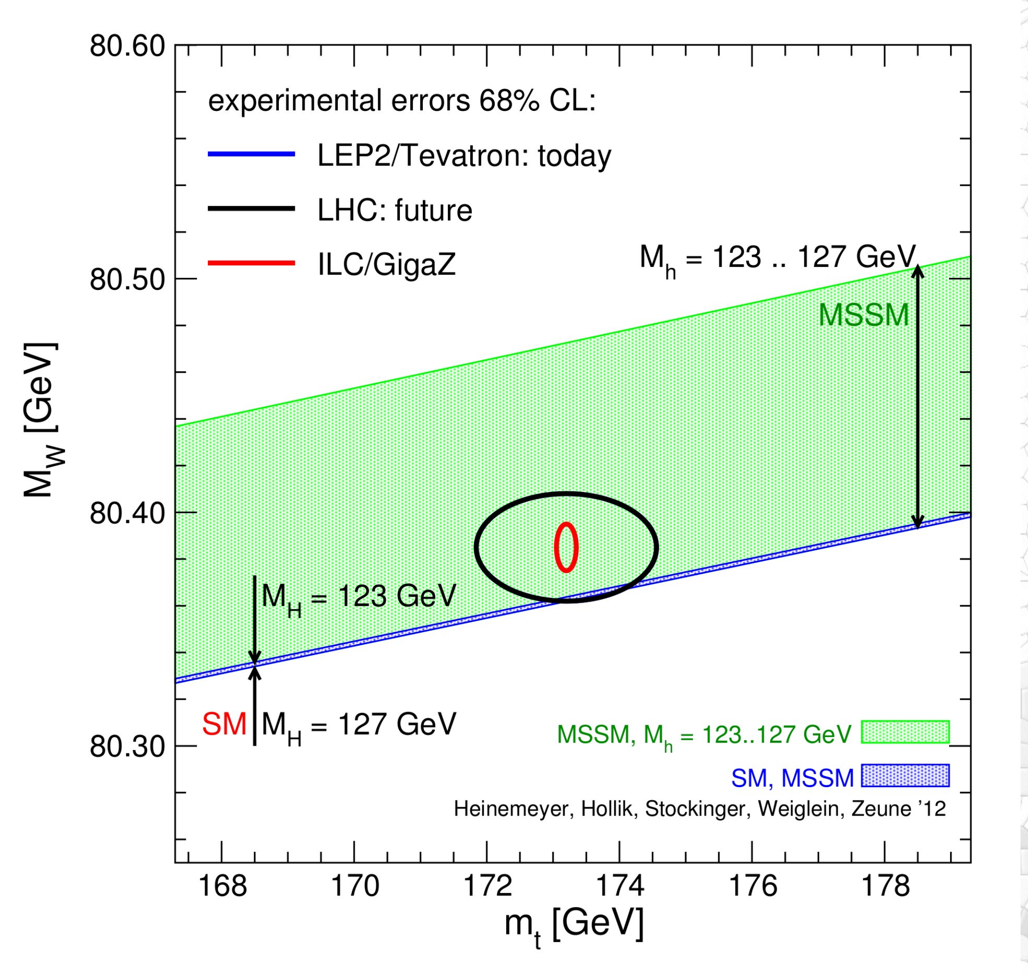
Top Physics

- Top Threshold scans
  - $\Delta m_{top} < 40$ MeV
- Conversion to $\overline{\text{MS}}$ scheme
  - Measured top mass at ILC can easily be converted to $\overline{\text{MS}}$ mass
  - This yields an total error of $\Delta m_{top} \sim 100$ MeV
  - Theory/ α_s limited
- Compared to LHC
  - Mass is Monte-Carlo Mass
  - Conversion is non-trivial



Electroweak Precision fits





Challenging the Standard Model with ultimate precision measurements

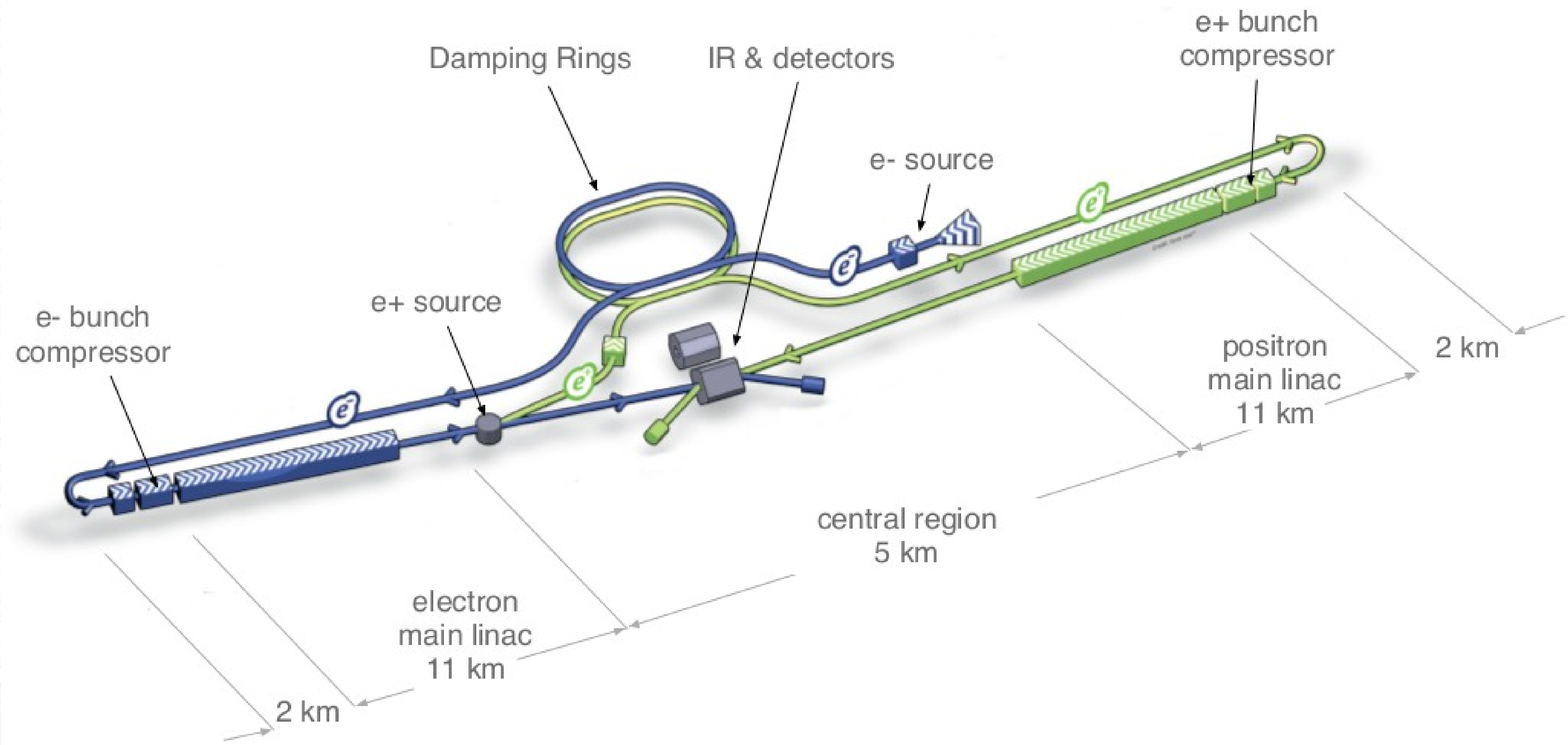
Physics case summary

- The ILC machine offers unique advantages
  - Clean environment
  - Well defined initial states
  - Possibility to do threshold scans
  - Beam Polarization
- This allows
  - Precise studies of the Higgs & Top
  - Ultraprecise Electroweak precision studies
  - Search and Study for new physics

ILC

The Accelerator

The ILC machine



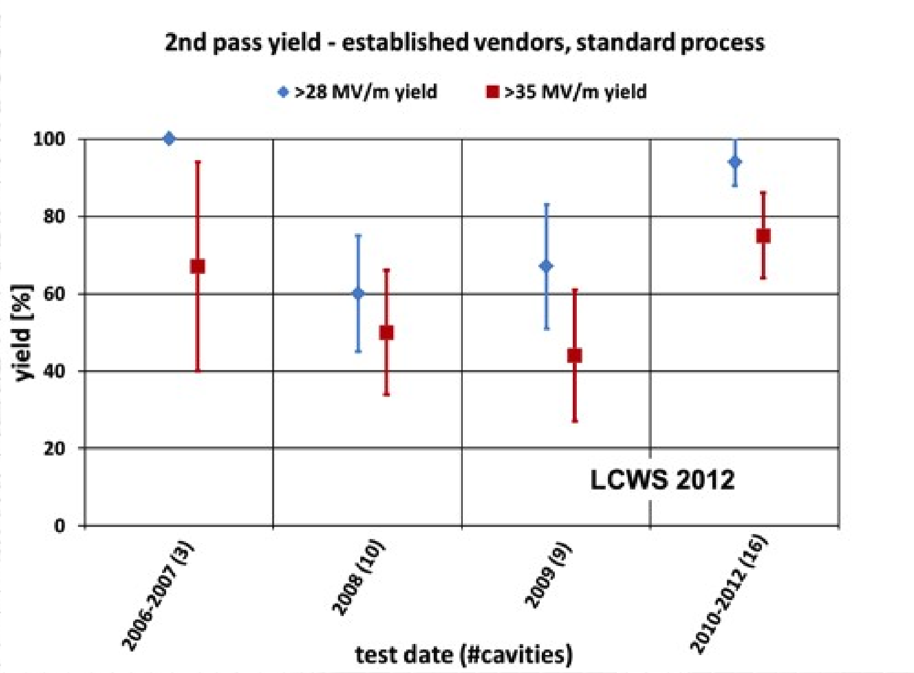
- Total length ~ 31 km
- Energy range
  - Baseline Design 250-500 GeV
  - Upgrade for 1 TeV

Marcel Stanitzki

TDR Machine parameters

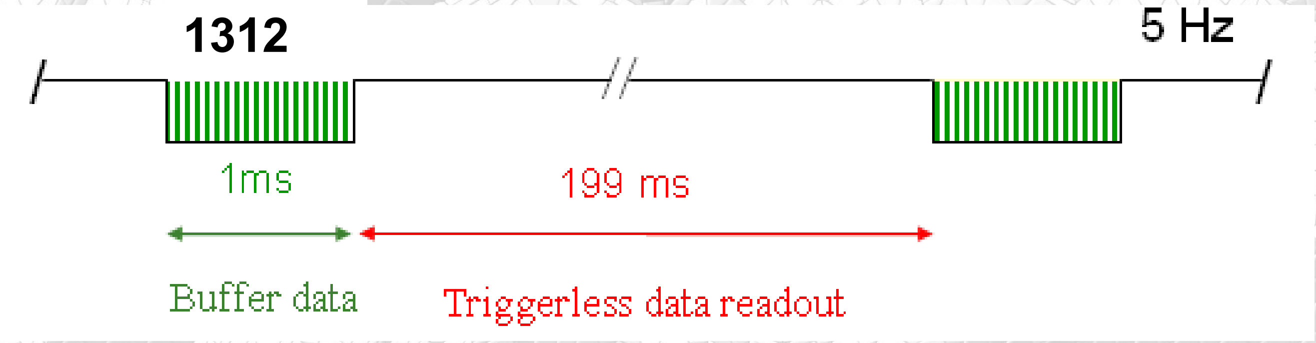
			Baseline 500 GeV Machine			1st Stage	L Upgrade	E_{CM} Upgrade	
Centre-of-mass energy	**ECM**	**GeV**	**250**	**350**	**500**	**250**	**500**	**A 1000**	**B 1000**
Collision rate	f_{rep}	Hz	5	5	5	5	5	4	4
Electron linac rate	f_{linac}	Hz	10	5	5	10	5	4	4
Number of bunches	nb		1312	1312	1312	1312	2625	2450	2450
Bunch population	N	$\times10^{10}$	2.0	2.0	2.0	2.0	2.0	1.74	1.74
Bunch separation	Δtb	ns	554	554	554	554	366	366	366
Main linac average gradient	G_a	$\mathrm{MV\ m^{-1}}$	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	$\times10^{34}\ \mathrm{cm^{-2}\ s^{-1}}$	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}	$\times10^{3}$	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

Superconducting Cavities



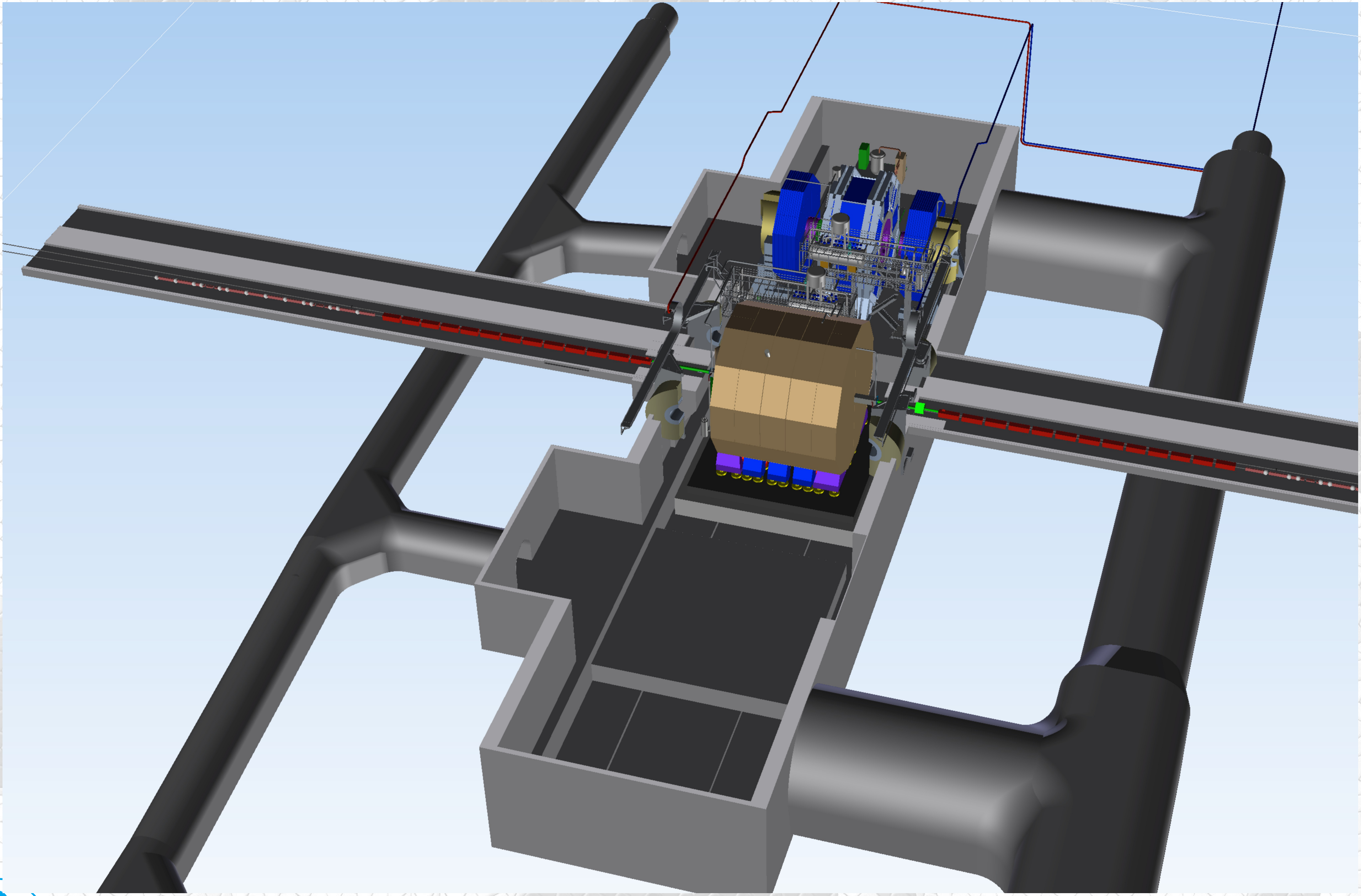
- Tesla-Style Niobium Cavities for the Main Linac
  - Required Gradient 31.5 MV/m
- Production yield:
  - 94 % at > 28 MV/m,
  - Average gradient: 37.1 MV/m
  - Record 46 MV/m

ILC Environment

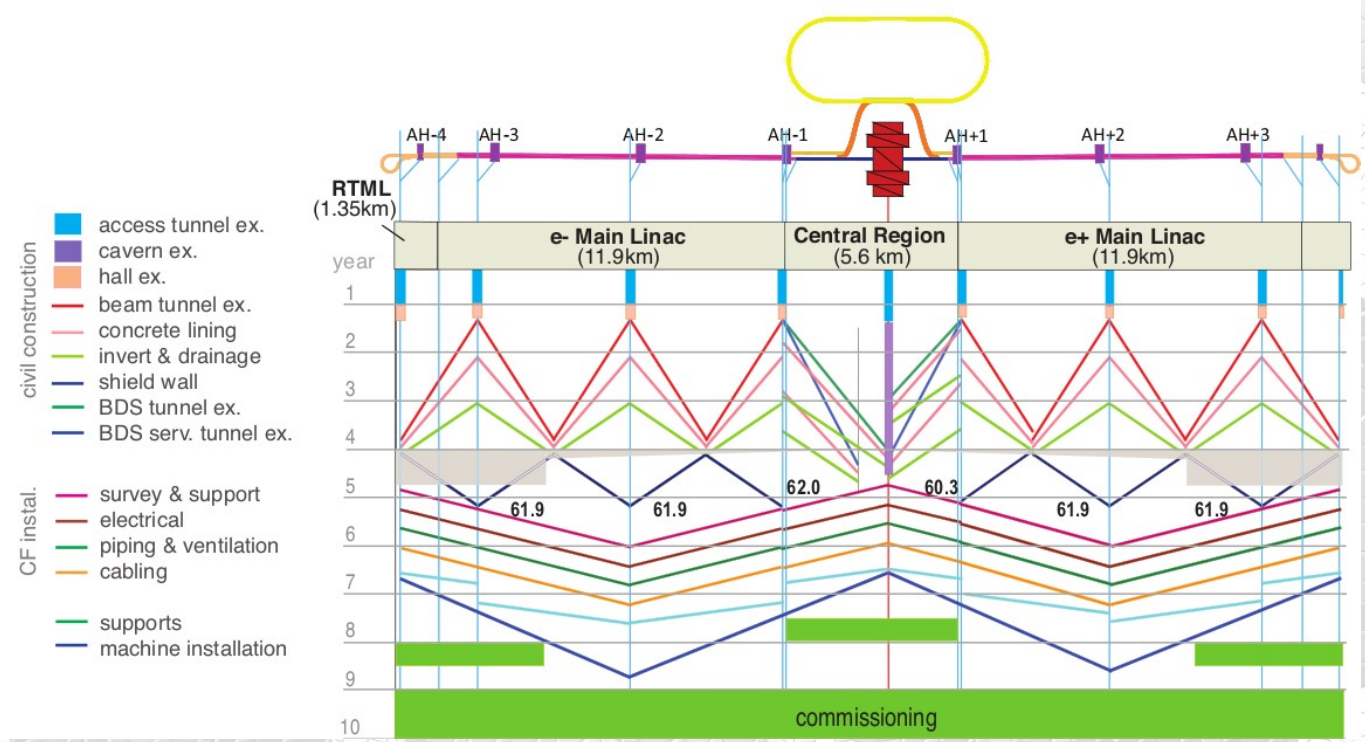


- ILC environment is very different compared to LHC
  - Bunch spacing of ~ 554 ns (baseline)
  - 1312 bunches in 1 ms
  - 199 ms quiet time
- Occupancy dominated by beam background & noise
  - ~ 1 hadronic Z ($e^+e^- \rightarrow Z \rightarrow q\bar{q}$) per train ...
- Readout during quiet time possible
- No Triggers, no pile-up ...

The Interaction region



ILC costs & readiness



- Construction
  - 10 years till physics
- ILC project costs (2012)
  - ~ 8 billion USD for 500 GeV machine
  - ~70 %of the cost is in the main linac

The SiD Detector

Detector Requirements

- Exceptional precision& time stamping
  - Single Bunch resolution
- Vertex detector
  - < 4 μm precision
  - $\sigma_{r\phi} \approx 5 \ \mu m \oplus 10 \ \mu m / p \sin^{\left(\frac{3}{2}\right)}(\theta)$
- Tracker
  - $\sigma(1/p) \sim 2.5 \times 10^{-5}$
- Calorimeter
  - $\frac{\sigma_{E_{Jet}}}{E_{Jet}} = 3-4\%, E_{Jet} > 100 \ GeV$

primary vertices in tt events

ZH → μ+μ- + anything

ILC 1 TeV

W-Z separation

250 GeV

Different challenges

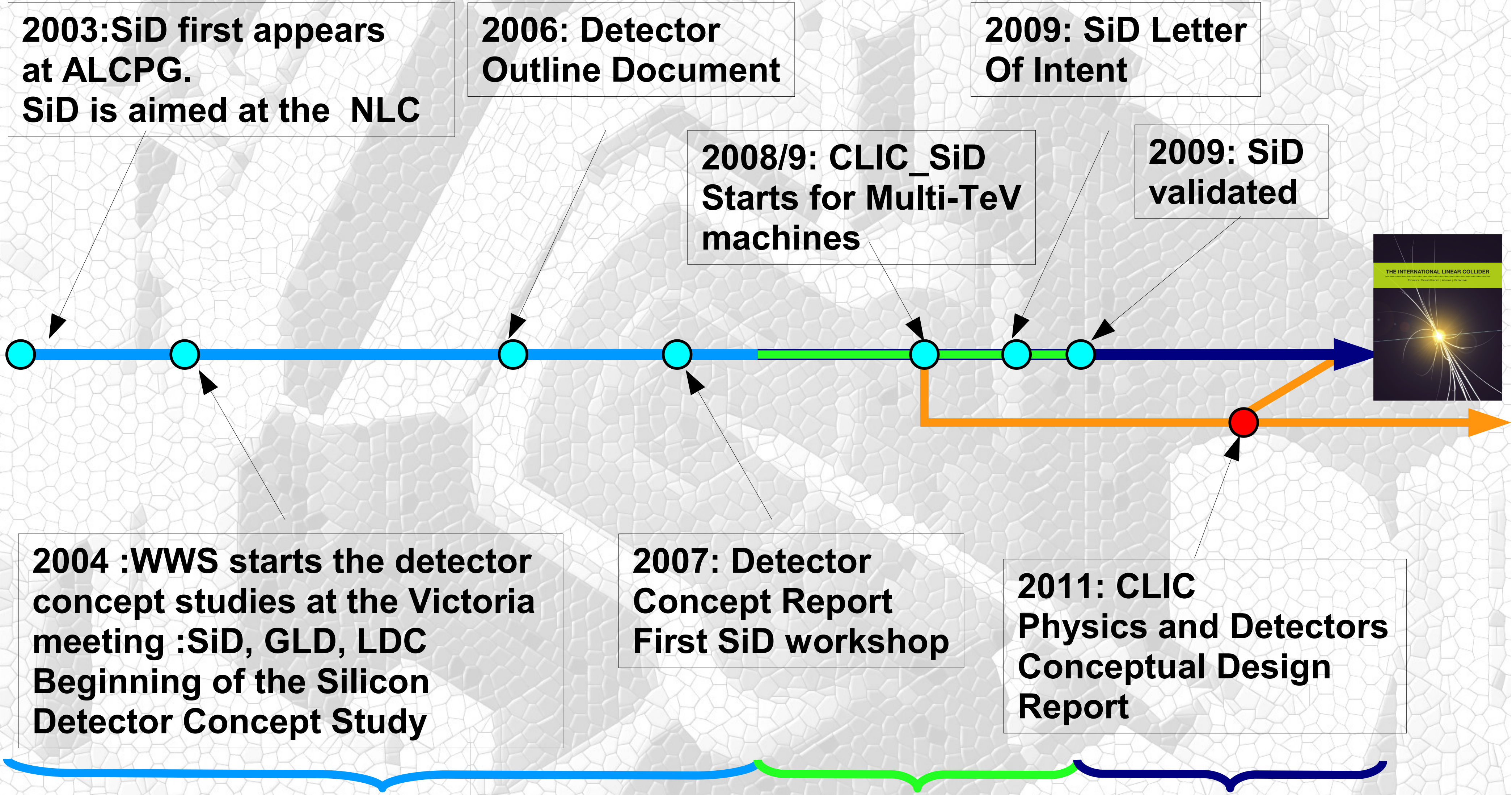
- Calorimeter granularity
  - Need factor ~200 better than LHC
- Pixel size
  - Need factor ~20 smaller than LHC
- Material budget, central tracking
  - Need factor ~10 less than LHC
- Material budget, forward tracking
  - Need factor ~ >100 less than LHC

Requirements for Timing, Data rate and Radiation hardness are very modest compared to LHC

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 5 T 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 – A short History



2003:SiD first appears at ALCPG.
SiD is aimed at the NLC

2004 :WWS starts the detector concept studies at the Victoria meeting :SiD, GLD, LDC
Beginning of the Silicon Detector Concept Study

2006: Detector Outline Document

2007: Detector Concept Report
First SiD workshop

2008/9: CLIC_SiD Starts for Multi-TeV machines

2009: SiD Letter Of Intent

2009: SiD validated

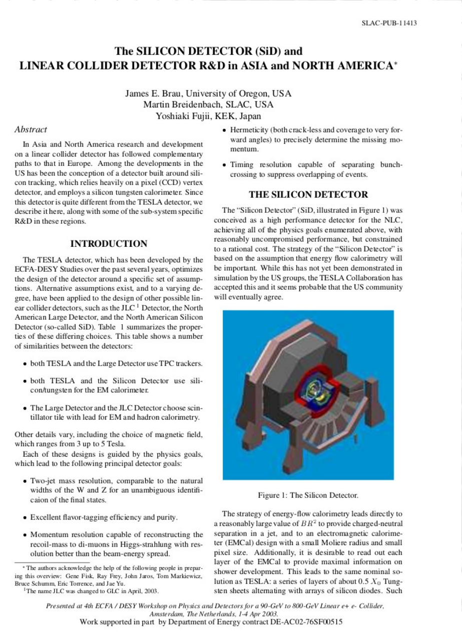
2011: CLIC Physics and Detectors Conceptual Design Report

Concept Phase

LoI Phase

DBD Phase

Many reports



SLAC-PUB-11413

The SILICON DETECTOR (SiD) and LINEAR COLLIDER DETECTOR R&D in ASIA and NORTH AMERICA*

James E. Brau, University of Oregon, USA
Martin Breidenbach, SLAC, USA
Yoshiaki Fujii, KEK, Japan

Abstract

In Asia and North America research and development on a linear collider detector has followed complementary paths to that in Europe. Among the developments in the US has been the conception of a detector built around silicon tracking, which relies heavily on a pixel (CCD) vertex detector, and employs a silicon tungsten calorimeter. Since this detector is quite different from the TESLA detector, we describe it here, along with some of the sub-system specific R&D in these regions.

INTRODUCTION

The TESLA detector, which has been developed by the ECFA-DESY Studies over the past several years, optimizes the design of the detector around a specific set of assumptions. Alternative assumptions exist, and to a varying degree, have been applied to the design of other possible linear collider detectors, such as the JLC[1] Detector, the North American Large Detector, and the North American Silicon Detector (so-called SiD). Table 1 summarizes the properties of these differing choices. This table shows a number of similarities between the detectors:

- both TESLA and the Large Detector use TPC trackers.
- both TESLA and the Silicon Detector use silicon/tungsten for the EM calorimeter.
- The Large Detector and the JLC Detector choose scintillator tile with lead for EM and hadron calorimetry.

Other details vary, including the choice of magnetic field, which ranges from 3 up to 5 Tesla.

Each of these designs is guided by the physics goals, which lead to the following principal detector goals:

- Two-jet mass resolution, comparable to the natural widths of the W and Z for an unambiguous identificaion of the final states.
- Excellent flavor-tagging efficiency and purity.
- Momentum resolution capable of reconstructing the recoil-mass to di-muons in Higgs-strahlung with resolution better than the beam-energy spread.
- Hermeticity (both crack-less and coverage to very forward angles) to precisely determine the missing momentum.
- Timing resolution capable of separating bunch-crossing to suppress overlapping of events.

THE SILICON DETECTOR

The "Silicon Detector" (SiD, illustrated in Figure 1) was conceived as a high performance detector for the NLC, achieving all of the physics goals enumerated above, with reasonably uncompromised performance, but constrained to a rational cost. The strategy of the "Silicon Detector" is based on the assumption that energy flow calorimetry will be important. While this has not yet been demonstrated in simulation by the US groups, the TESLA Collaboration has accepted this and it seems probable that the US community will eventually agree.

Figure 1: The Silicon Detector.

The strategy of energy-flow calorimetry leads directly to a reasonably large value of BR^2 to provide charged-neutral separation in a jet, and to an electromagnetic calorimeter (EMCal) design with a small Moliere radius and small pixel size. Additionally, it is desirable to read out each layer of the EMCal to provide maximal information on shower development. This leads to the same nominal solution as TESLA: a series of layers of about 0.5 X_0 Tungsten sheets alternating with arrays of silicon diodes. Such

---

[*] The authors acknowledge the help of the following people in preparing this overview: Gene Fisk, Ray Frey, John Jaros, Tom Markiewicz, Bruce Schumm, Eric Torrence, and Jae Yu.

[1] The name JLC was changed to GLC in April, 2003.

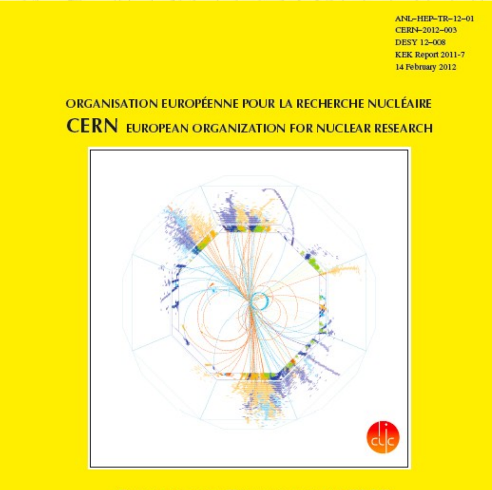
Presented at 4th ECFA / DESY Workshop on Physics and Detectors for a 90-GeV to 800-GeV Linear e+ e- Collider, Amsterdam, The Netherlands, 1-4 Apr 2003.

Work supported in part by Department of Energy contract DE-AC02-76SF00515

international linear collider

Reference Design Report

Detectors



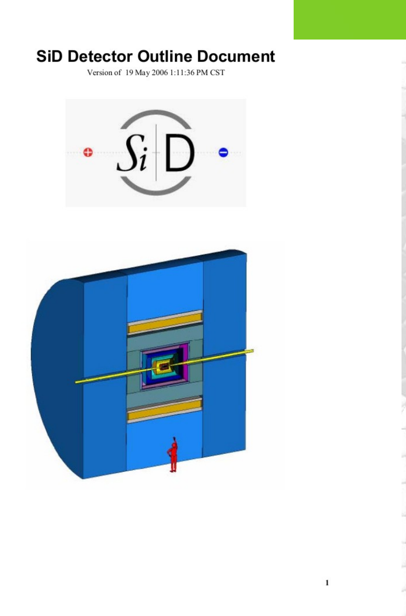
ANL–HEP–TR–12–01
CERN–2012–003
DESY 12–008
KEK Report 2011-7
14 February 2012

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

…ND DETECTORS AT CLIC

CONCEPTUAL DESIGN REPORT

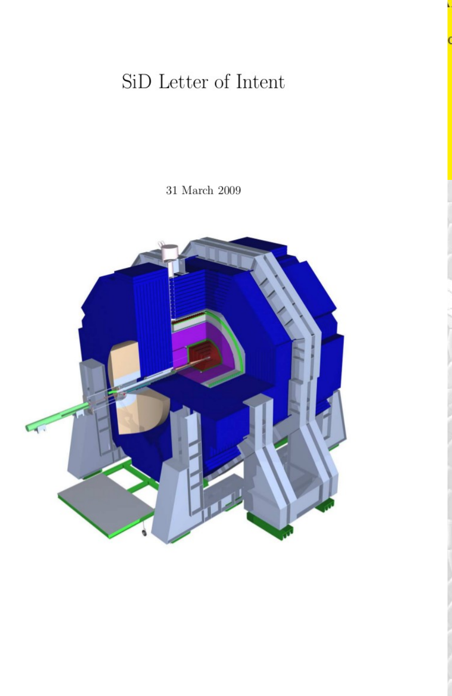
GENEVA
2012



SiD Detector Outline Document

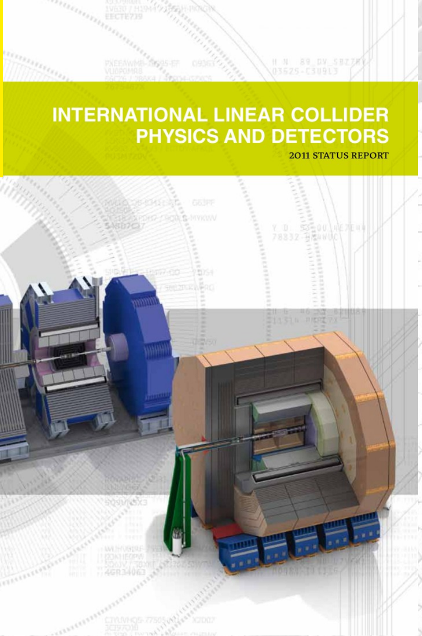
Version of 19 May 2006 1:11:36 PM CST

1



SiD Letter of Intent

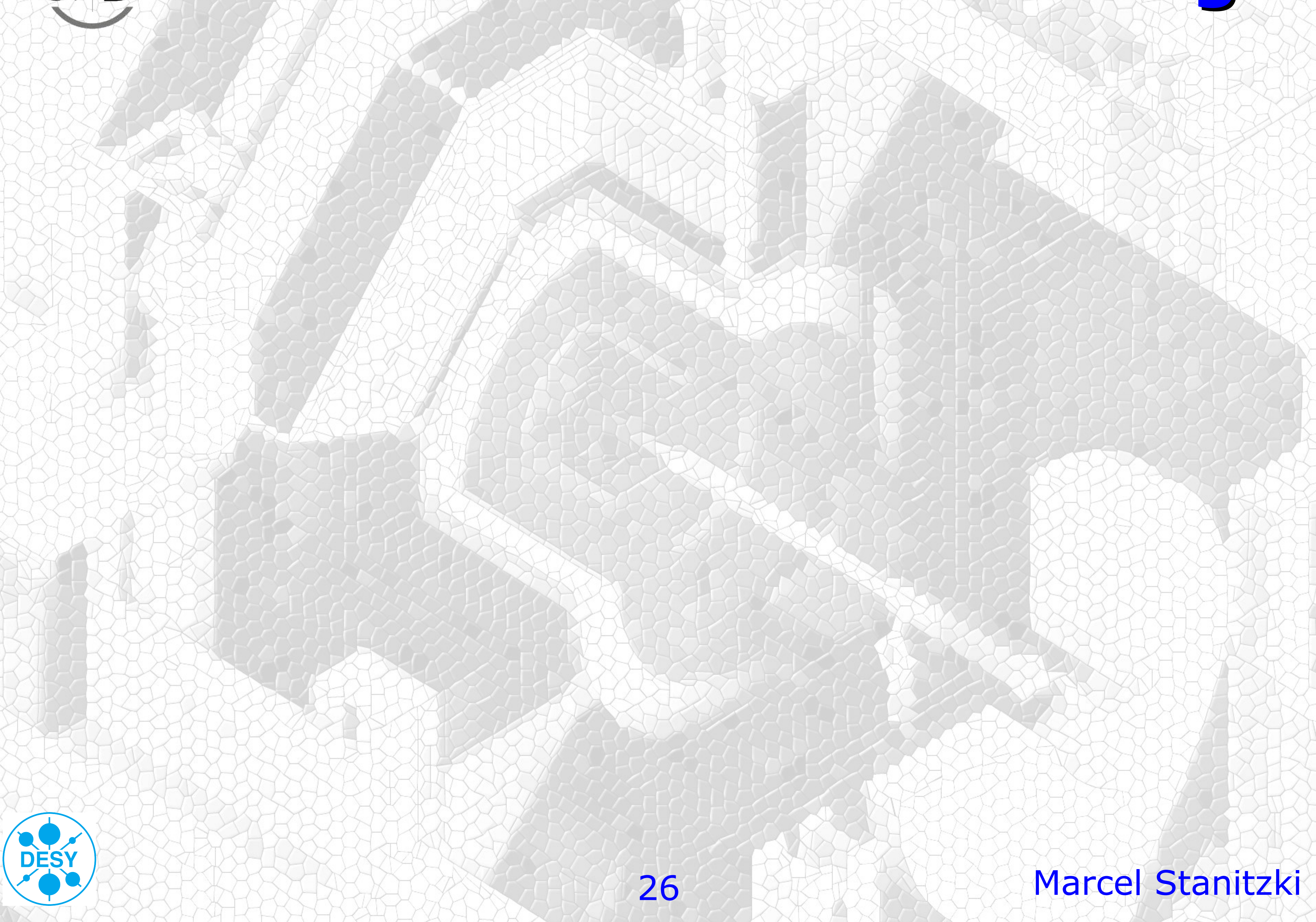
31 March 2009



INTERNATIONAL LINEAR COLLIDER
PHYSICS AND DETECTORS

2011 STATUS REPORT

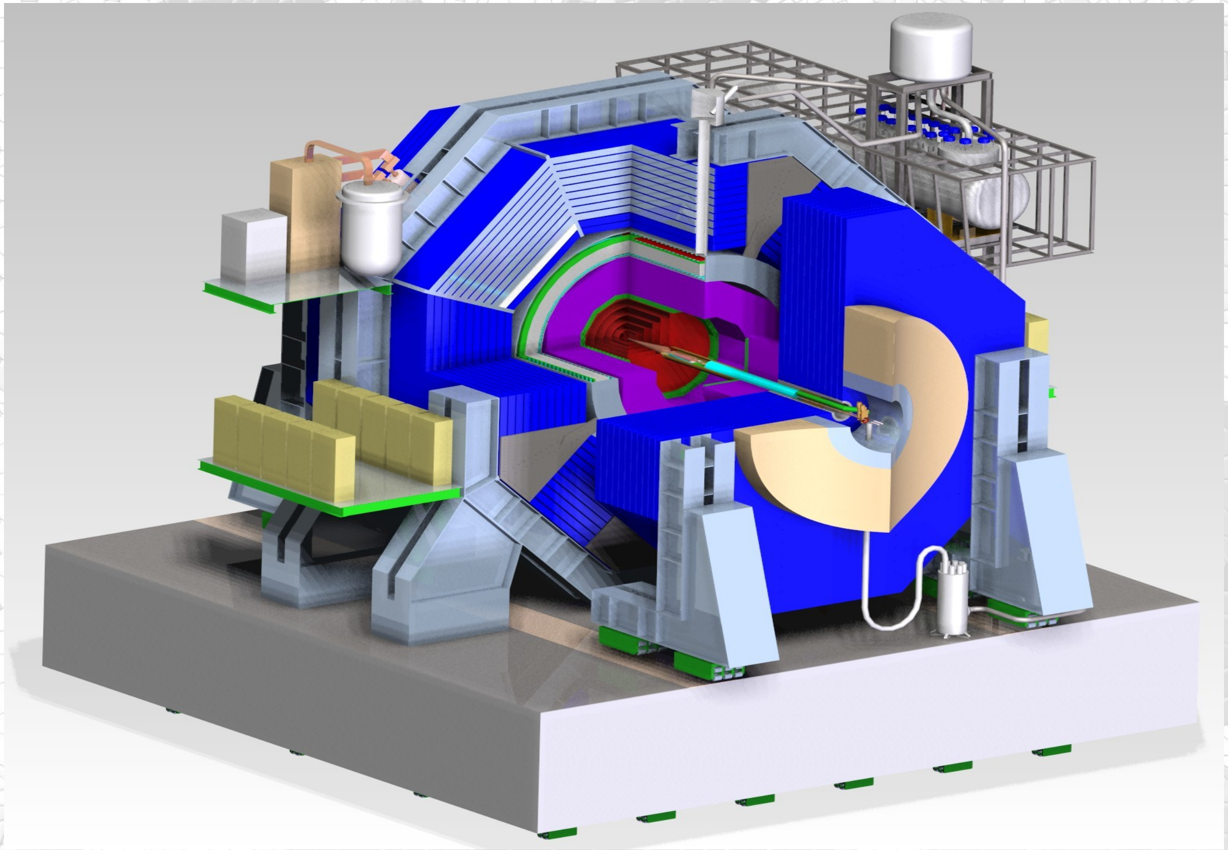
SiD Detailed Baseline Design

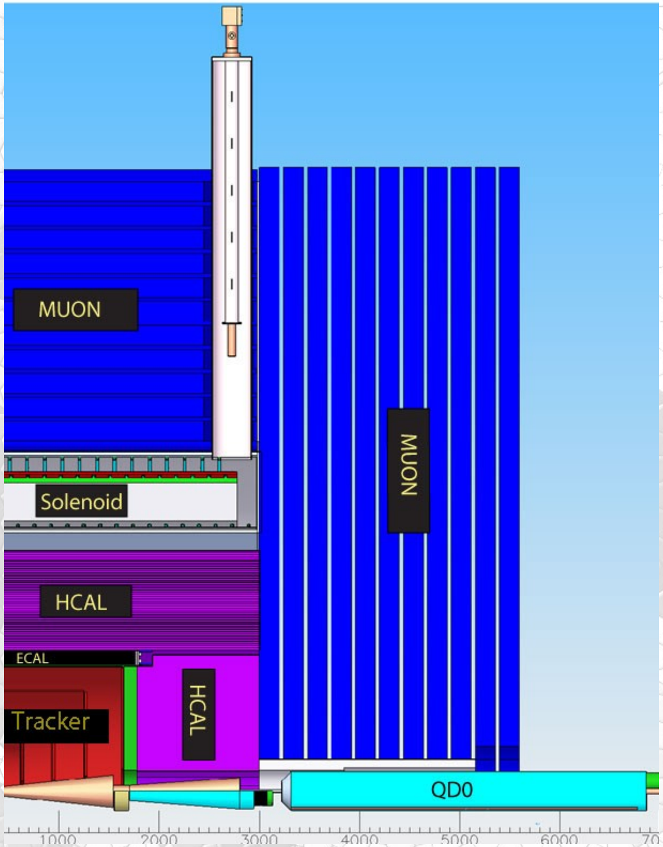


The SiD DBD

- The DBD describes a baseline of SiD for the ILC
  - Choices have been made for all subsystems besides the Vertex detector
  - Options for various subsystems have been considered
  - The detector is fully costed
- The DBD is not a TDR
  - Engineering effort not sufficient
  - Not all R&D has been completed
- In SiD's view the subsystem options offer
  - Improved performance or lower cost
  - Not as mature as the baseline choices yet

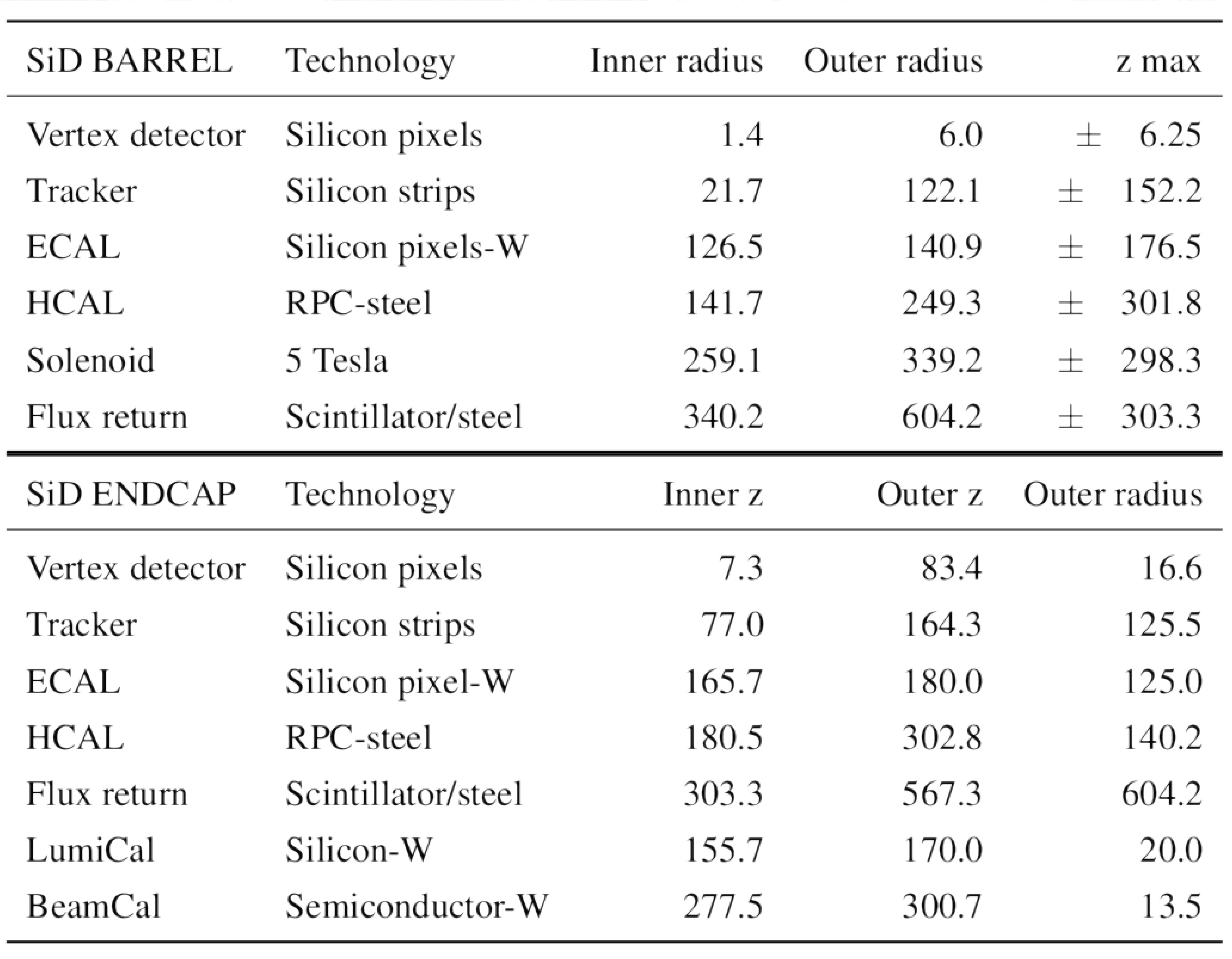
The DBD detector





- SiD is fully designed for push-pull (using a platform)
- Particle flow paradigm has driven design choices

DBD baseline parameters

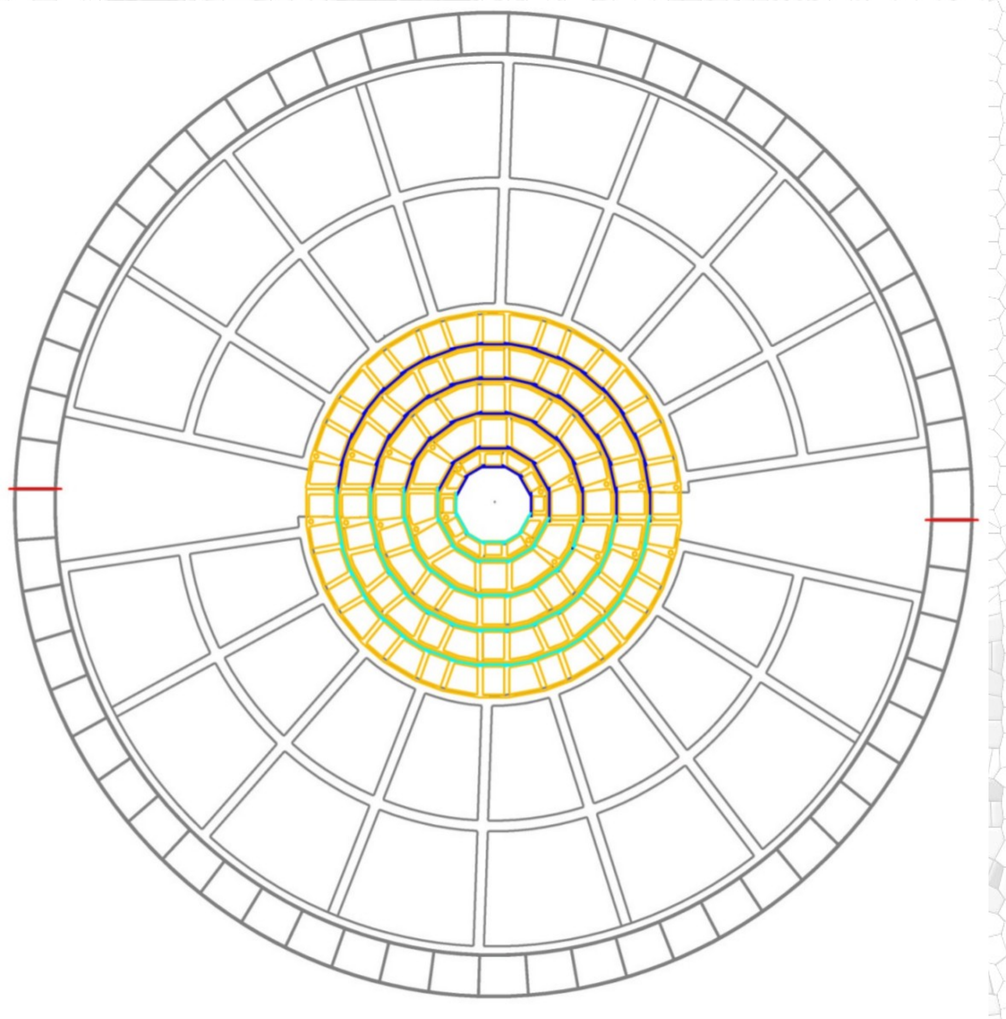


SiD BARREL	Technology	Inner radius	Outer radius	z max
Vertex detector	Silicon pixels	1.4	6.0	± 6.25
Tracker	Silicon strips	21.7	122.1	± 152.2
ECAL	Silicon pixels-W	126.5	140.9	± 176.5
HCAL	RPC-steel	141.7	249.3	± 301.8
Solenoid	5 Tesla	259.1	339.2	± 298.3
Flux return	Scintillator/steel	340.2	604.2	±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

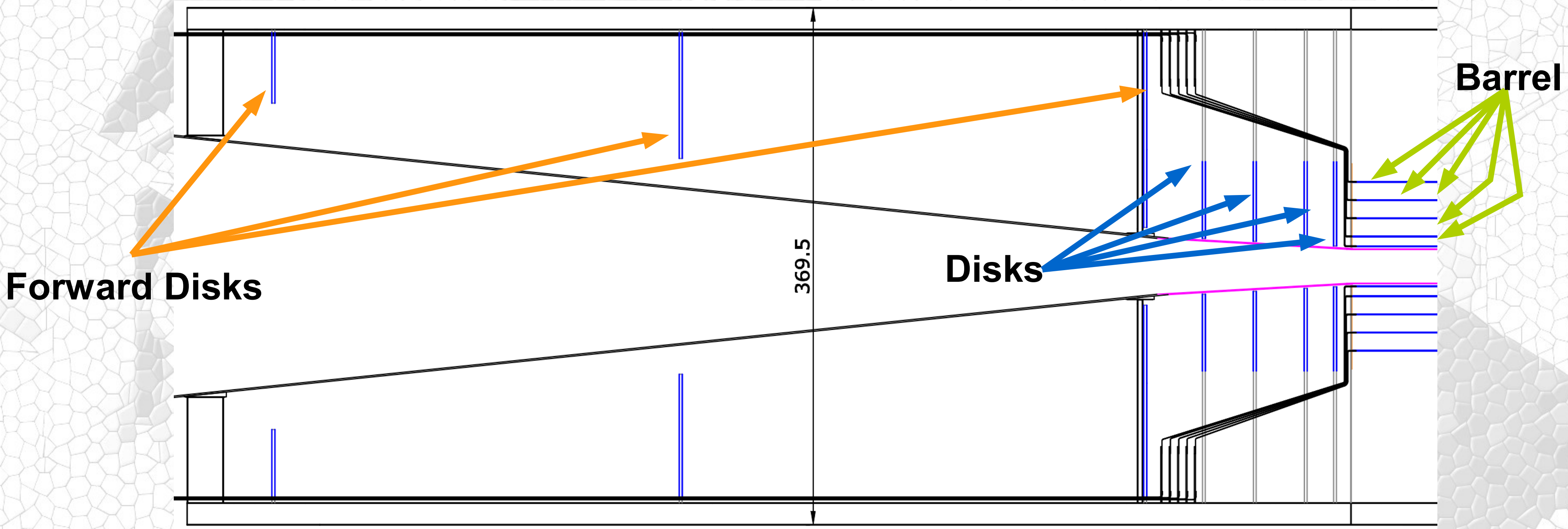
SiD ENDCAP	Technology	Inner z	Outer z	Outer radius
Vertex detector	Silicon pixels	7.3	83.4	16.6
Tracker	Silicon strips	77.0	164.3	125.5
ECAL	Silicon pixel-W	165.7	180.0	125.0
HCAL	RPC-steel	180.5	302.8	140.2
Flux return	Scintillator/steel	303.3	567.3	604.2
LumiCal	Silicon-W	155.7	170.0	20.0
BeamCal	Semiconductor-W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

Vertex Detector

- Many potential technology choices
  - No baseline selected yet
  - Technology "not there" yet
- Requirements
  - <5 μm hit resolution
  - ~ 0.1 % X_0 per layer
  - < 130 μW/mm^2
  - Single bunch timing resolution
- Insertion of Vertex straightforward
  - Allows to make late technology choice

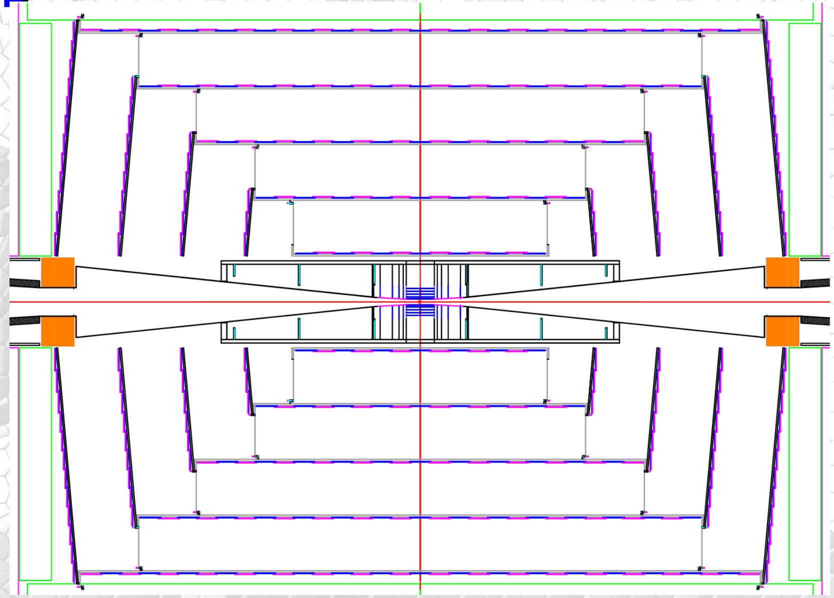


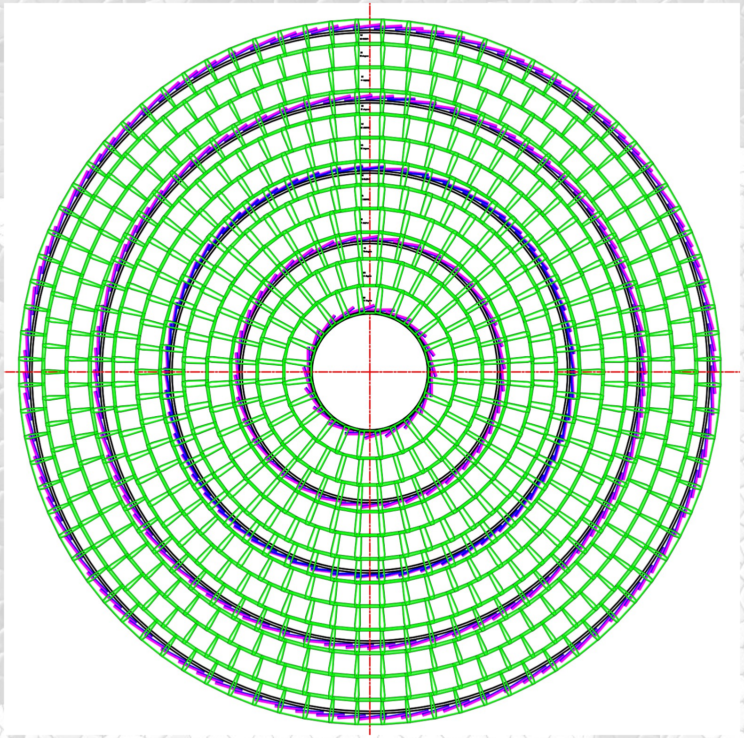
Vertex Mechanics



- 5 Barrel Layers, 4 Disks, 3 Forward Disks
- Total power consumption ~ 20 W
- Air-cooled
- Powering using DC-DC or serial powering
  - Learn from LHC upgrade experiences

Silicon Strip Tracker

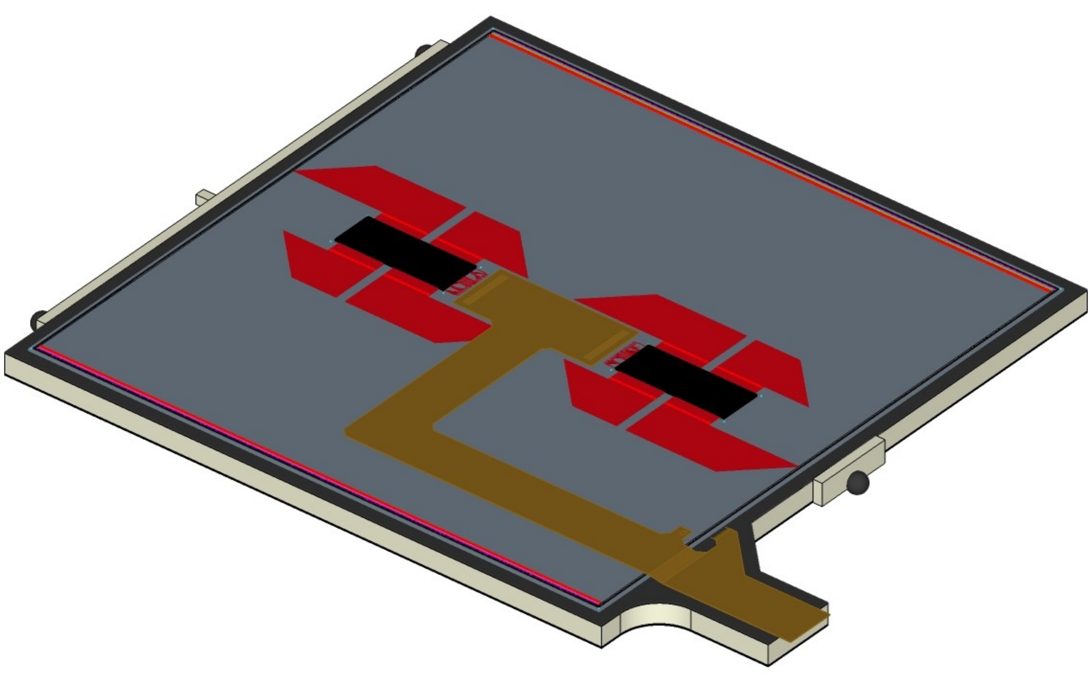


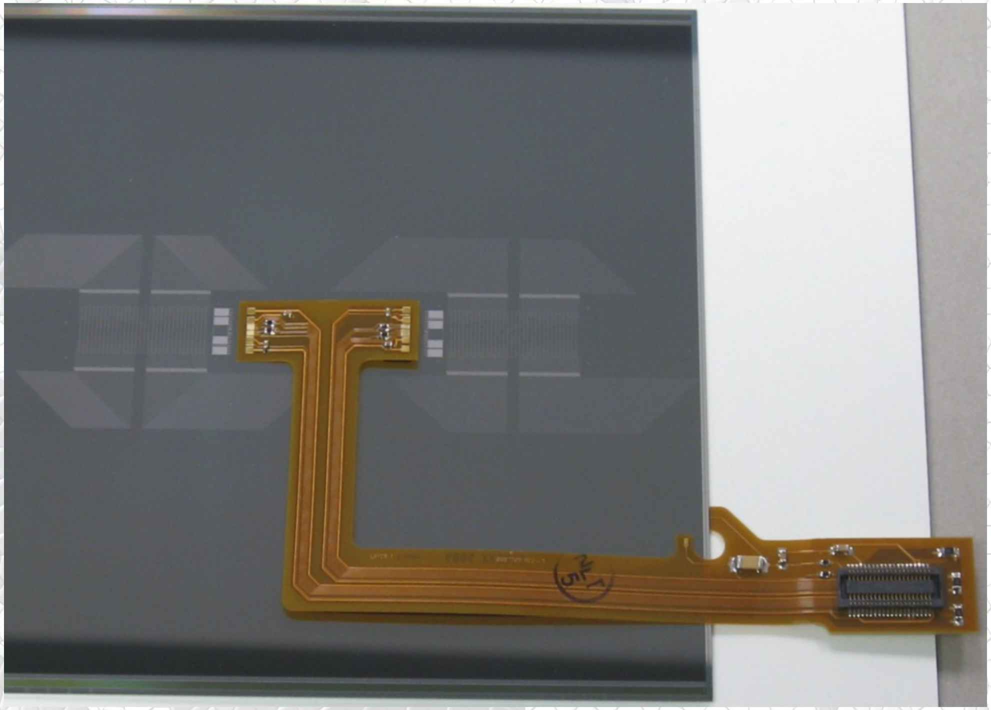


- All silicon tracker
  - Using silicon micro-strips
  - Double metal layers
- 5 barrel layers and 4 disks
- Cooling
  - Gas-cooled
- Material budget

  less than 20 % X_0 in the active area
- Readout using KPiX ASIC
  - Bump-bonded directly to the modules

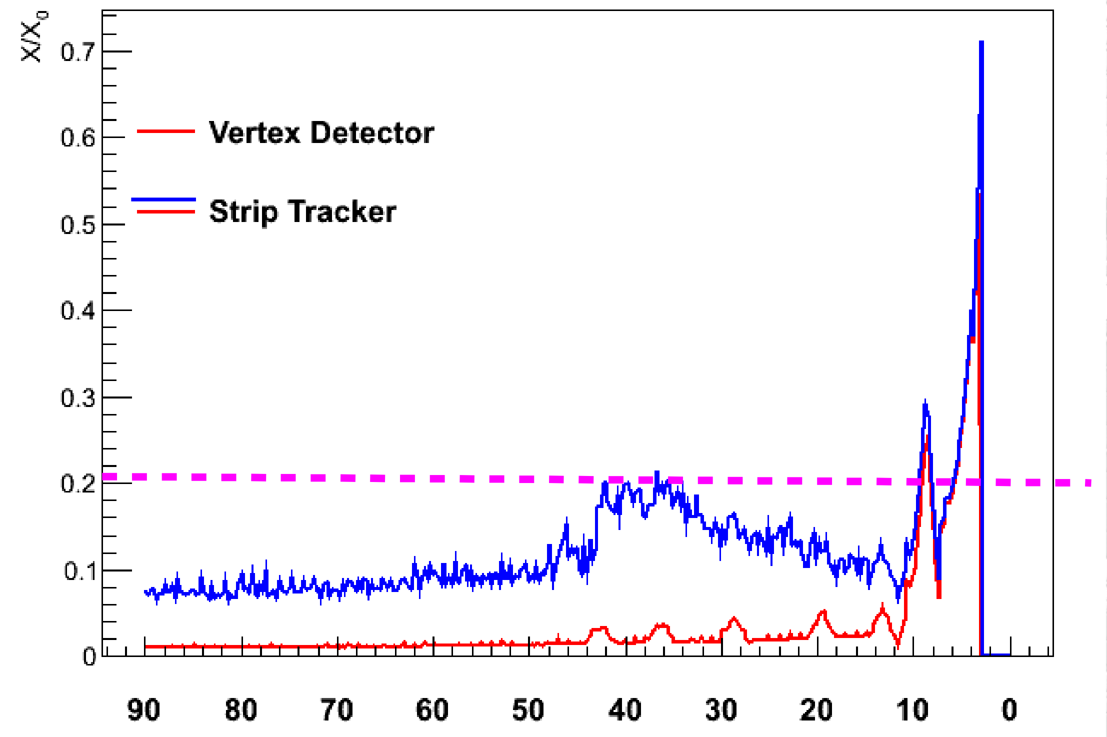
Tracker Module

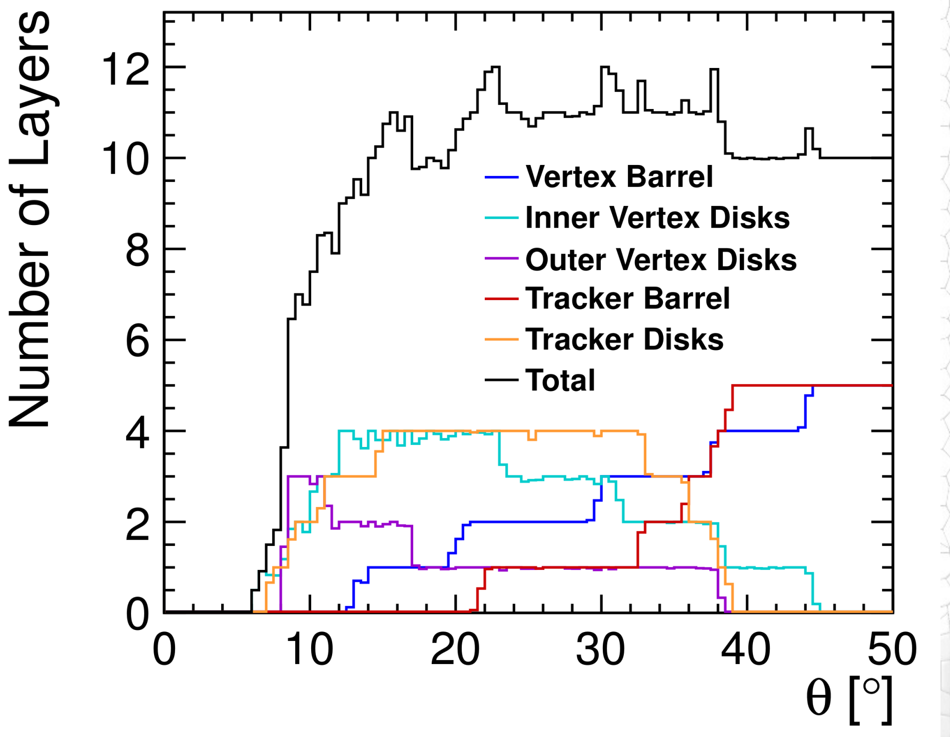




- Track module
  - 25/50 µm strip pitch
  - Double metal layers
  - Two KPiX per sensor
  - Hybrid-less design

SiD Tracking System

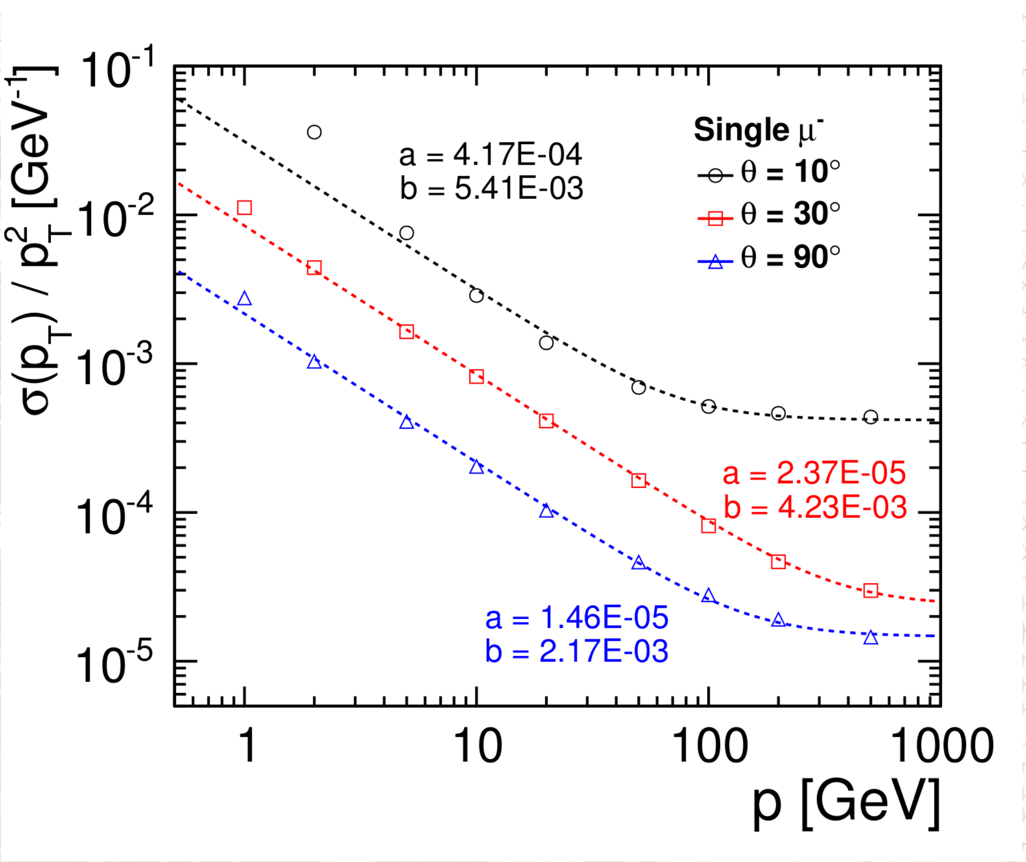




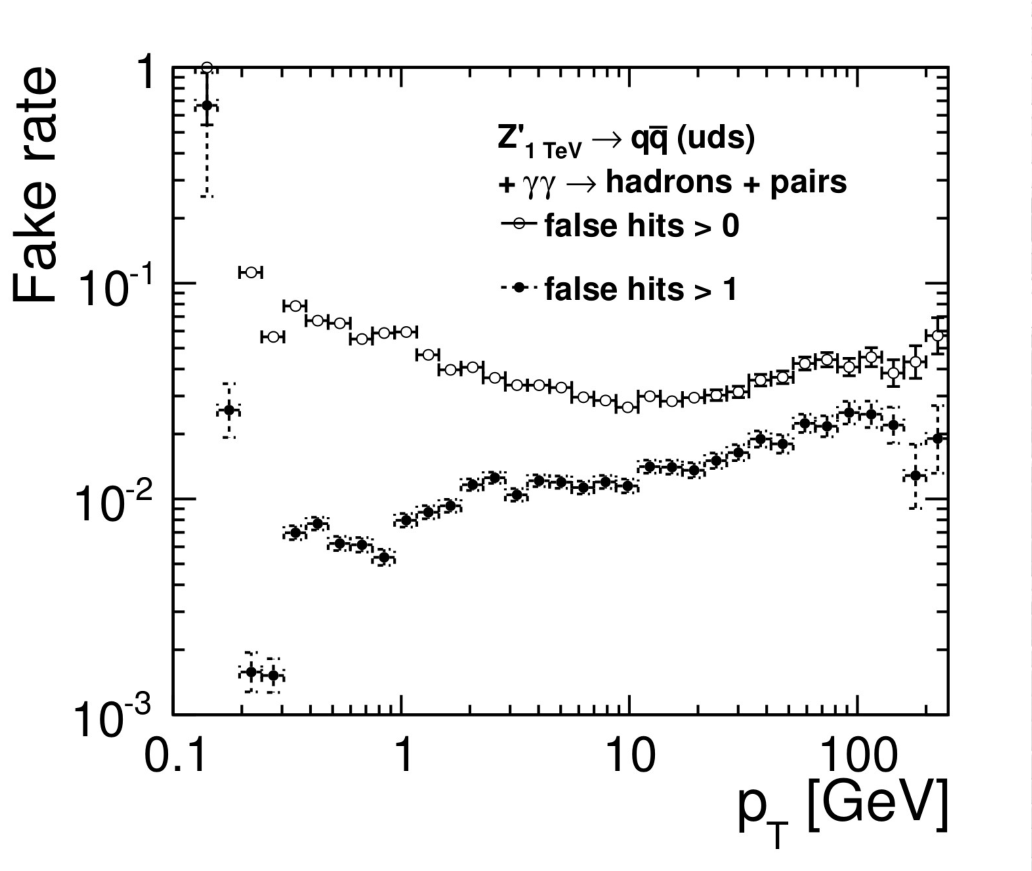
- Track seeding and fitting uses entire tracking system
  - 7 hits required (6 in second pass)
  - Calorimeter seeding (V_0 finder)

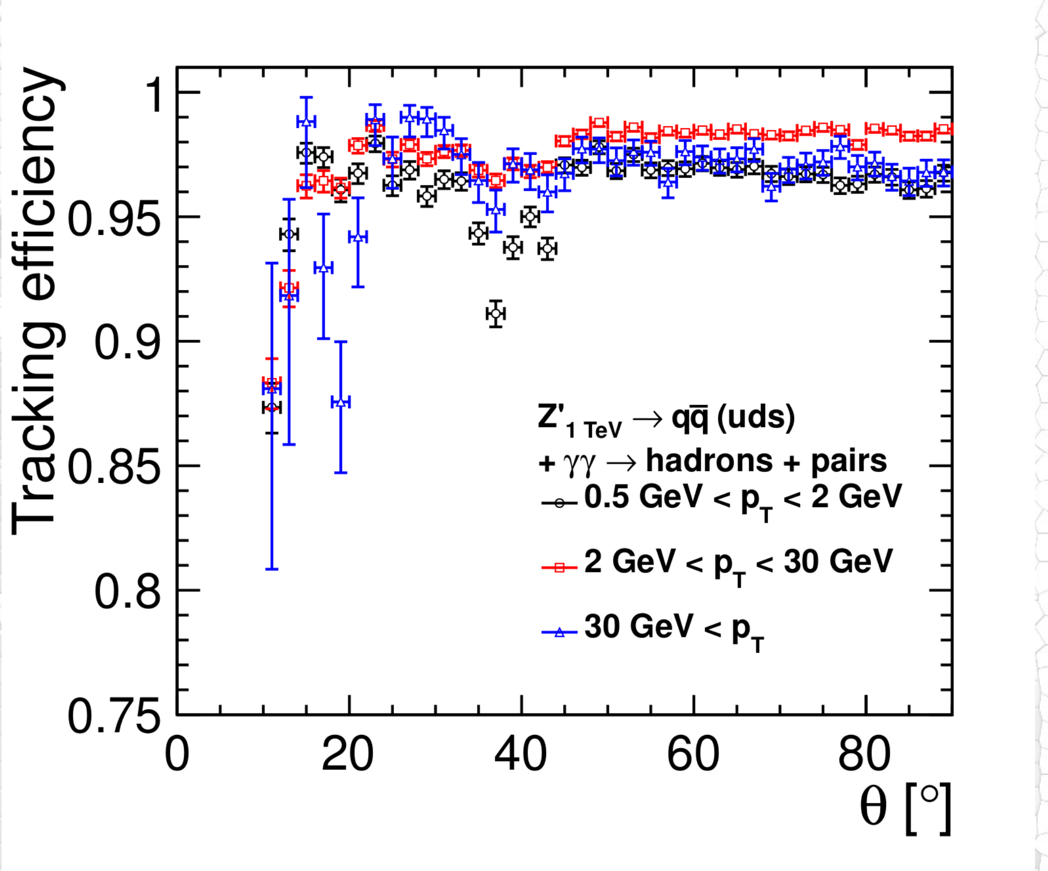
Tracking Performance

- SiD tracking is integrated
  - Vertex and Tracker
  - 10 Hits/track coverage for almost entire polar angle
- Tracking system
  - Achieves desired $\Delta p_T/p_T$ resolution of $1.46 \cdot 10^{-5}$
  - >99 % efficiency over most of the phase space
  - Impact parameter resolution of ~ 2 μm demonstrated



Robustness vs. backgrounds





- Z' → uds at 1 TeV with one bunch crossing of background overlaid
- Demonstrates robustness of SiD Tracking

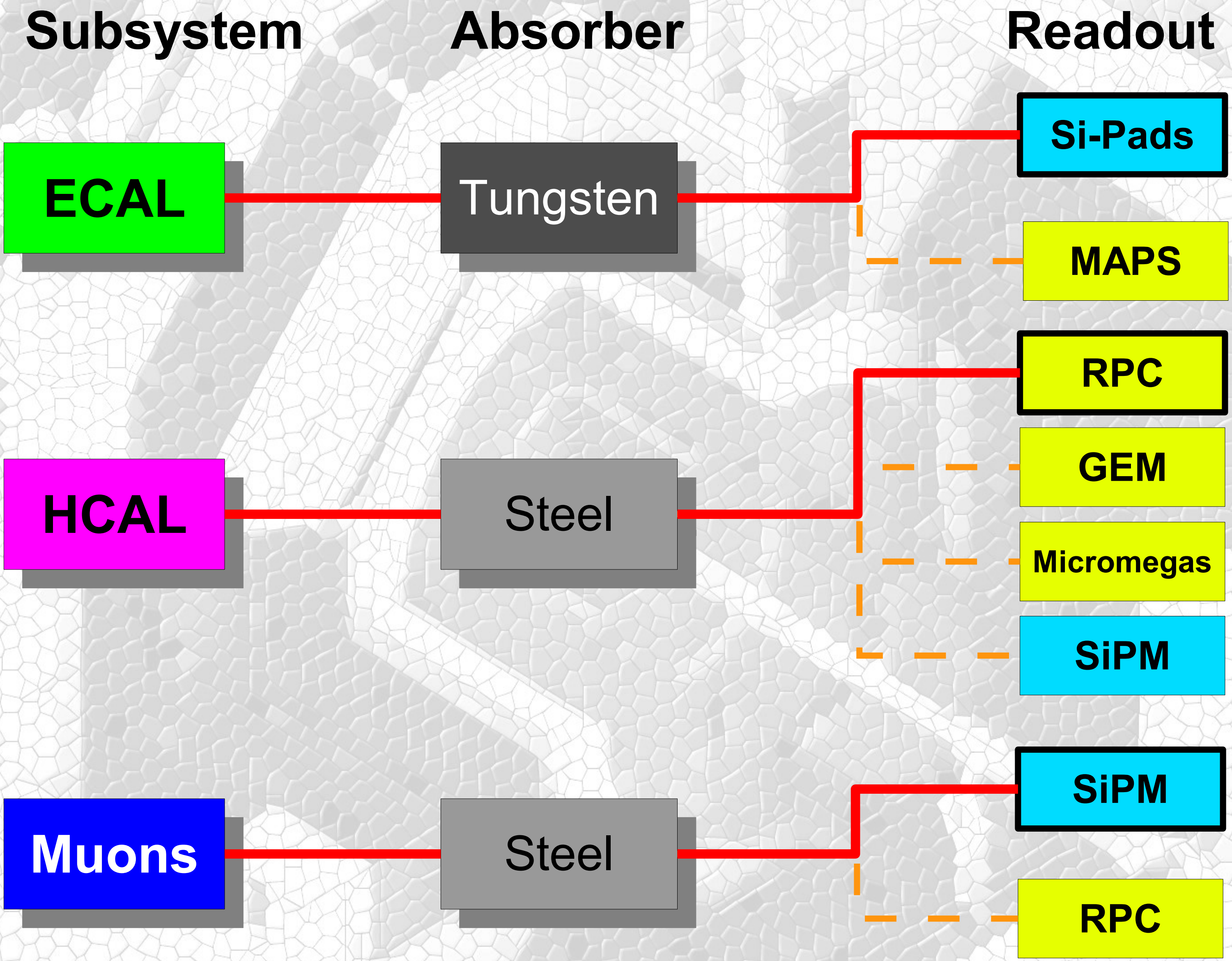
Calorimetry

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

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

- SiD has selected baseline choices for its Calorimeter
  - Options are being considered
- Lots of test beam activities (past, present and future)
  - Parts of the program done as part of the CALICE effort

Calorimetry Tree



🟦 *Analog Readout*

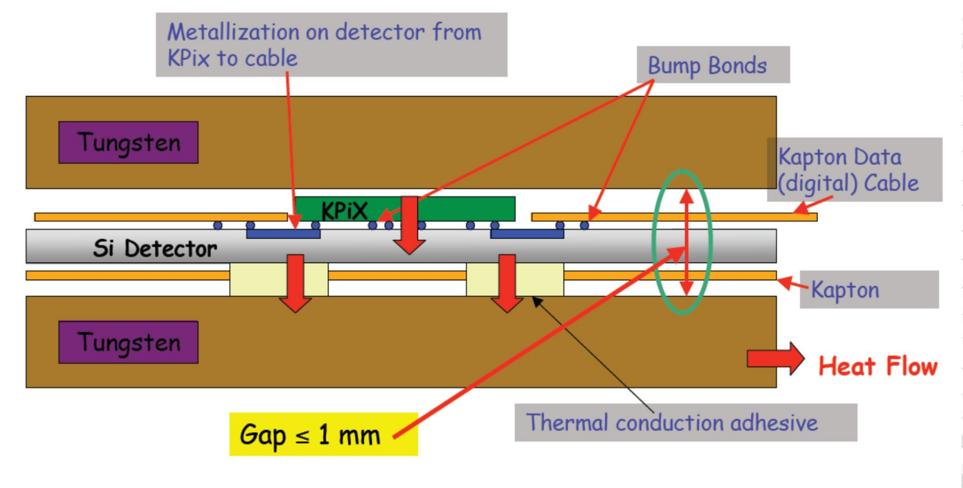
🟨 *Digital Readout*

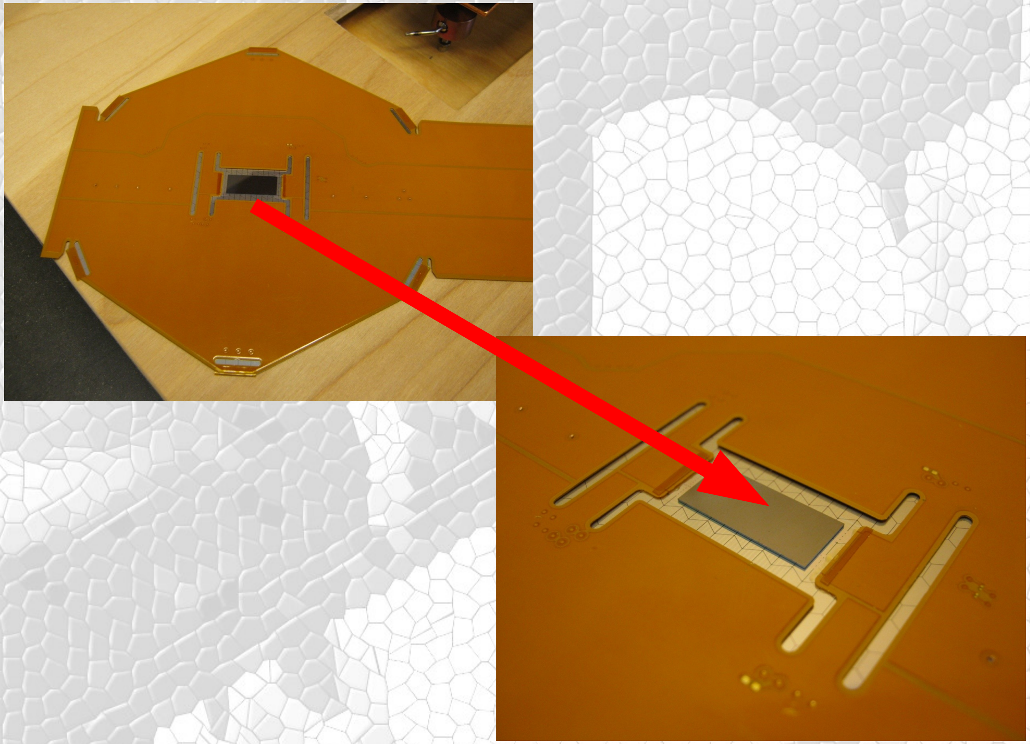
━━ *Baseline*

╍╍ *Option*

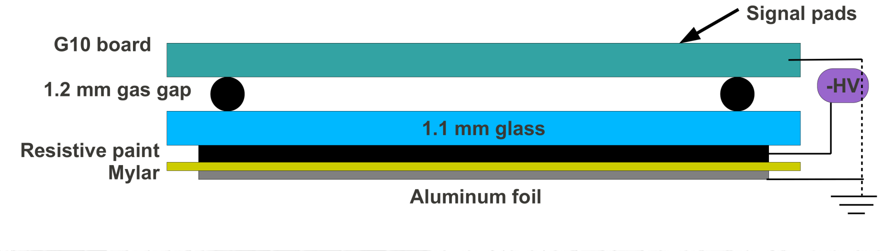
The SiW ECAL

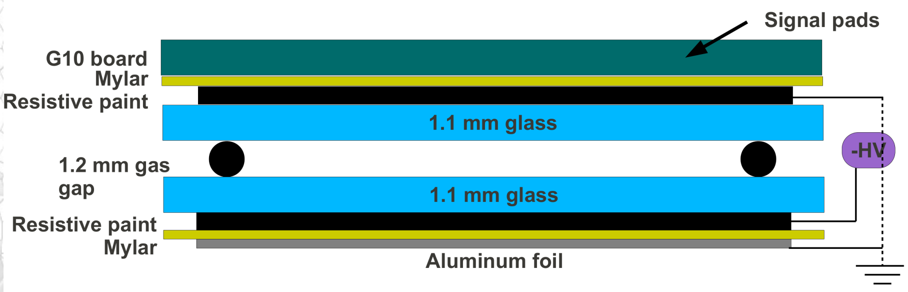
- One ECAL Si sensor
  - 1024 hexagonal pixel
  - Readout by 1 KPiX
- KPiX and cable bump-bonded to the sensor
- Analog Readout
  - Deposited charge
- Aim: minimize gap size
- Tungsten plates used as heatsink



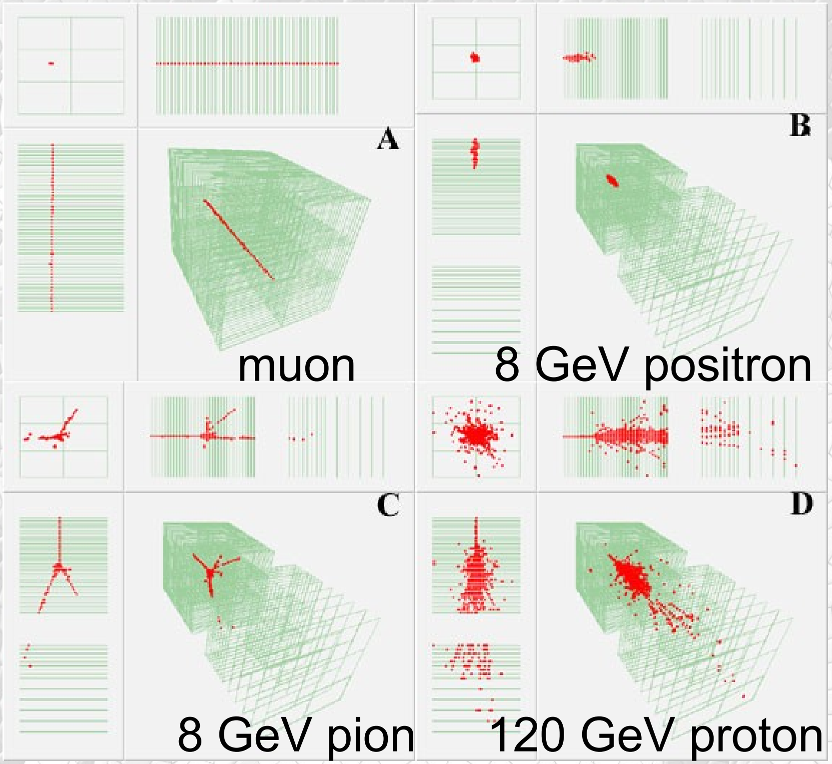


HCAL Baseline

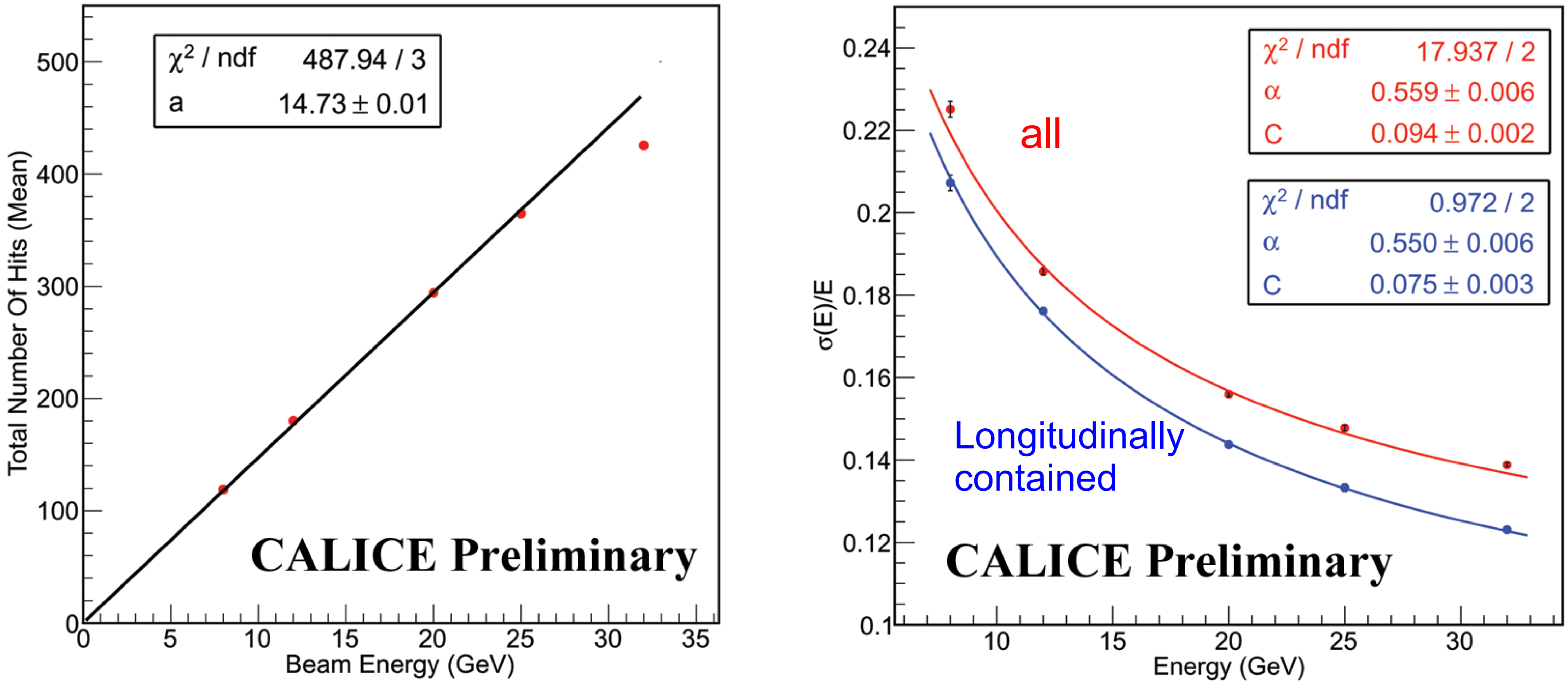




- Digital HCAL
  - Counting shower particles
  - $N_{particles}$ ~ Energy
- Using Glass RPCs
  - 1 x 1 cm^2
- 1 m^3 prototype built
  - 500.000 channels
  - Largest Calorimeter by channel so far

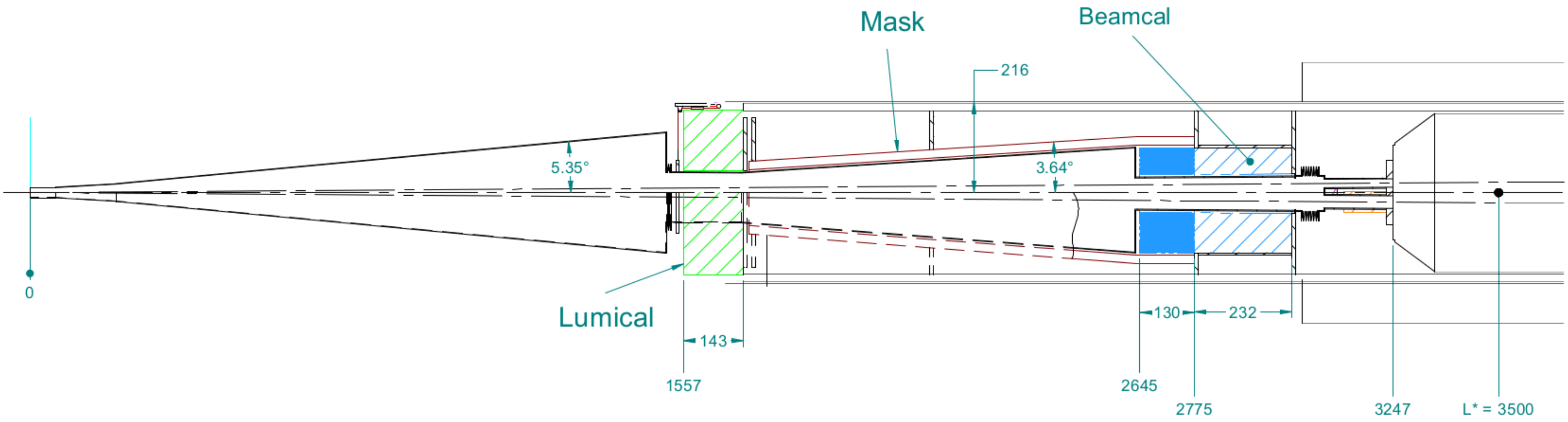


RPC DHCAL



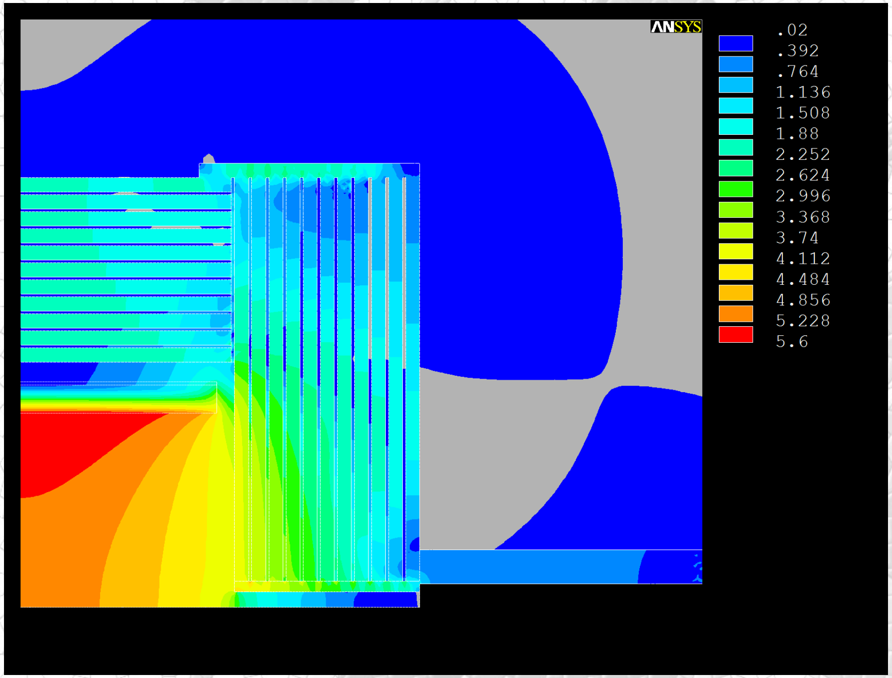
- After an extensive Test beam campaign
  - The RPC technology is a great candidate for the readout of a highly segmented calorimeter.
  - The dark rate in the DHCAL is very low
  - The response is linear up to about 30 GeV/c.

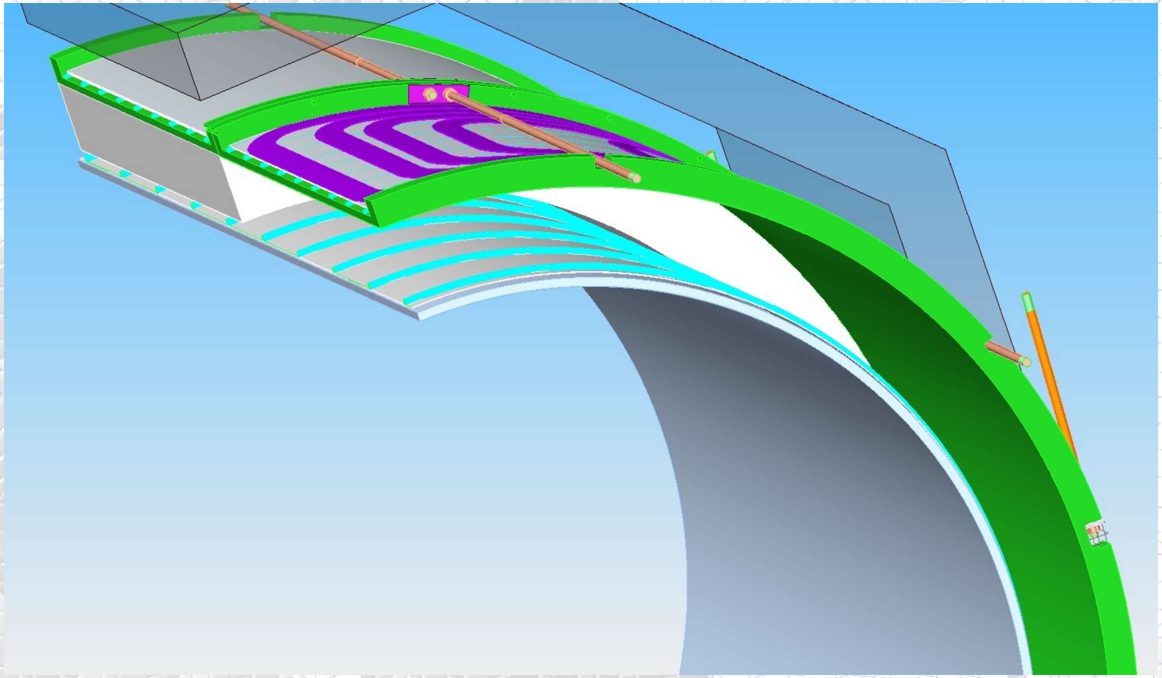
Forward Systems



- SiD has two detectors in its forward region
  - LumiCal and BeamCal
- LumiCal
  - luminosity measurement using small-angle Bhabhas (accuracy < 10^{-3})
- BeamCal
  - Instantaneous luminosity measurement using beamstrahlung pairs

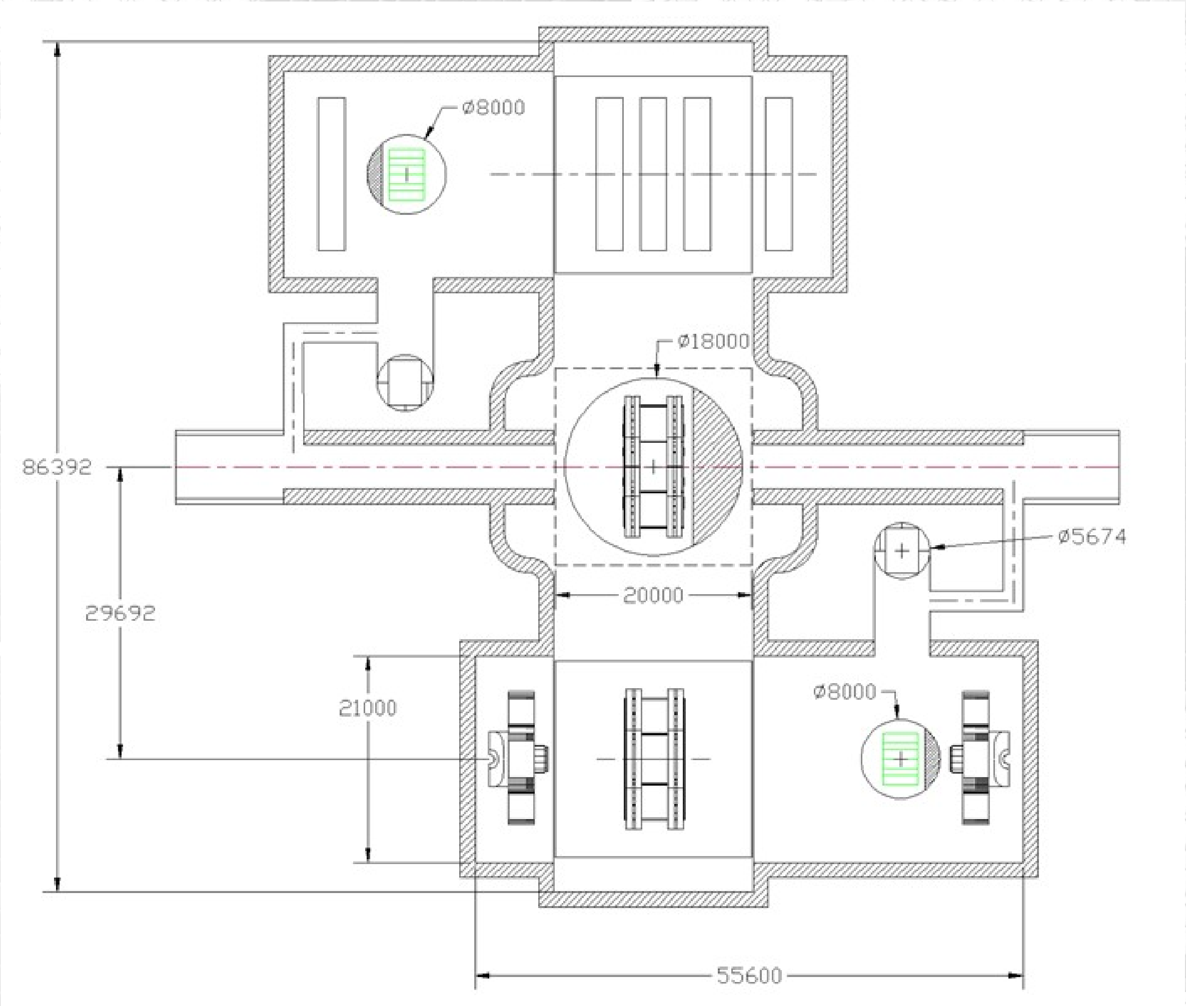
Magnet





- The 5 Tesla coil builds on the CMS experience
  - Especially on the CMS Conductor
- Engineering challenges are well understood
  - Advances in computing ease the design
- Summary: Feasibility of SiD design demonstrated

Push-Pull Concept

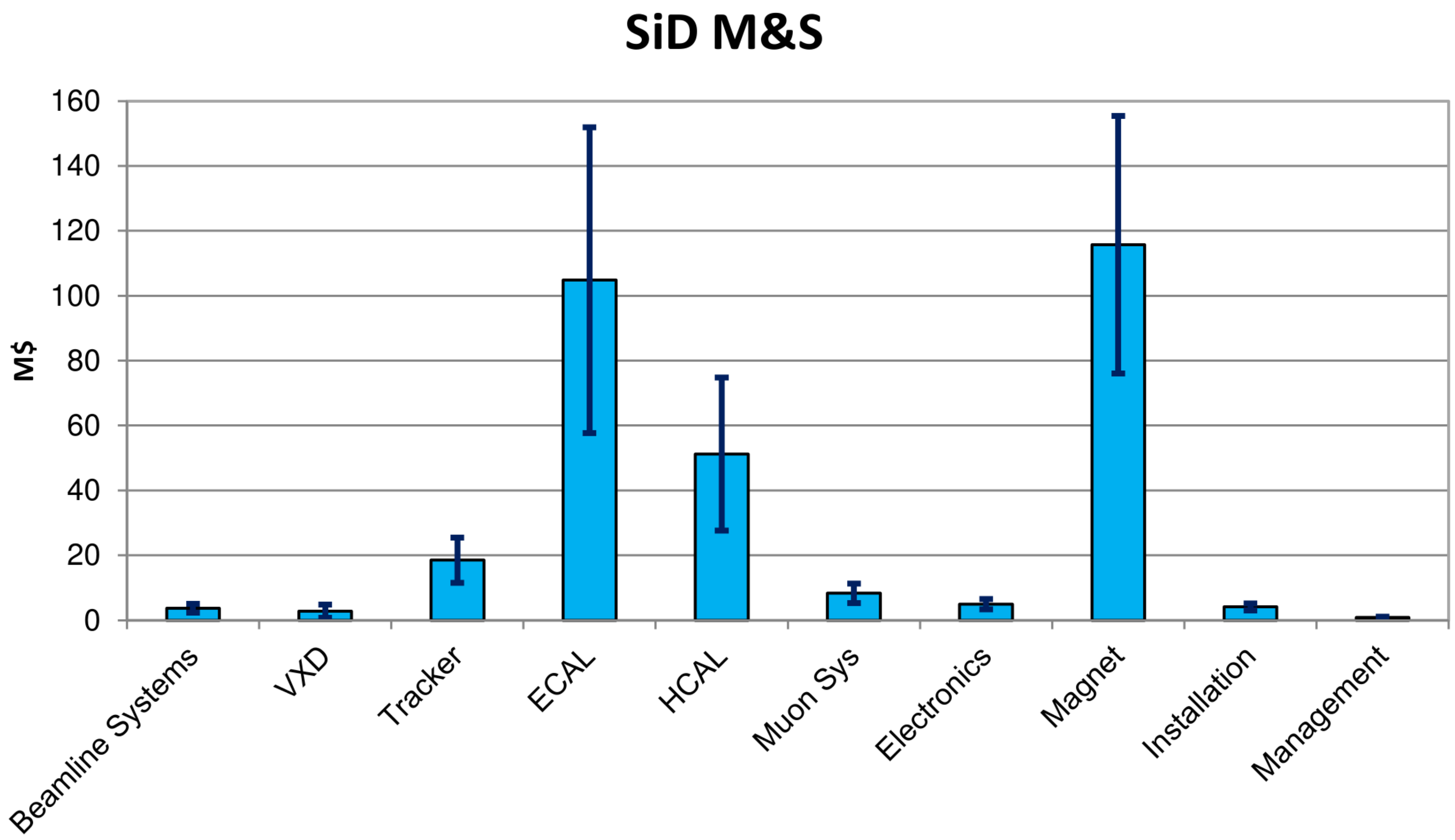


- Push-Pull using concrete platform
- SiD is optimistic to do Push-pull in a few days
  - Minimum estimate is 32 hours

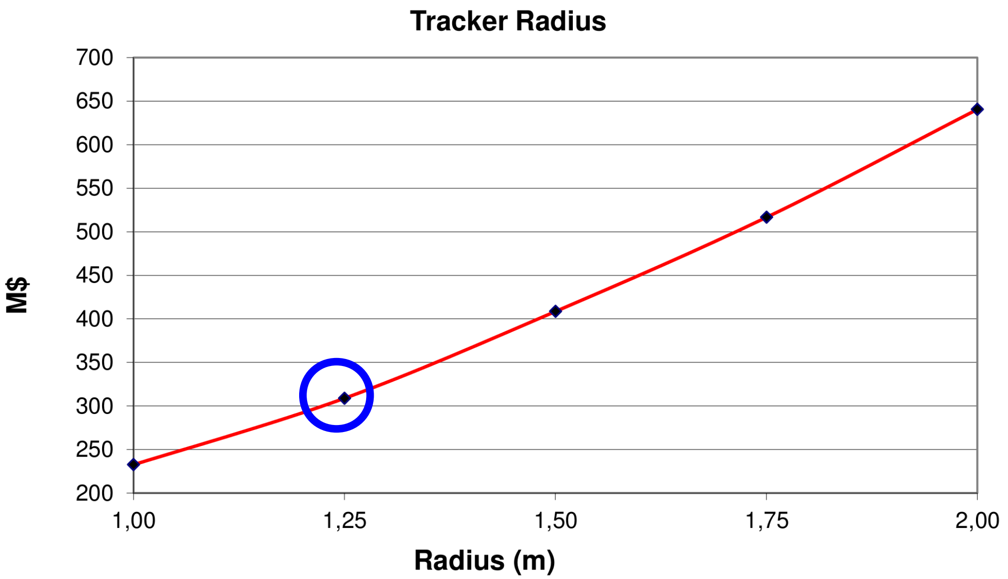
SiD Costing

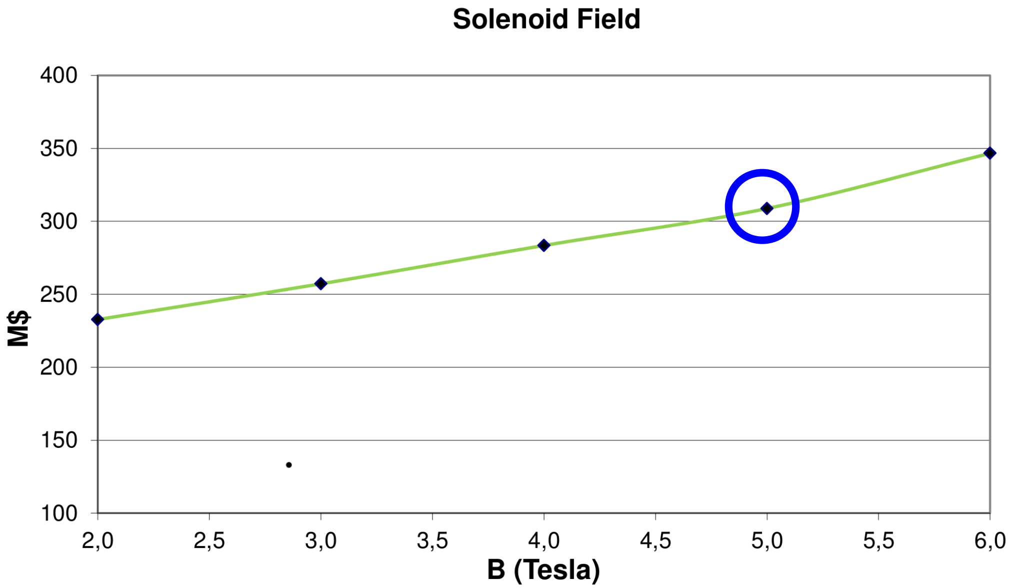
- SiD assumes common unit costs
  - As agreed by all groups
- Assuming "almost everything beyond the platform" is machine cost
- Follows machine costing model
- Costs in 2008 US-S
  - M&S : 315 M$
  - Contingency: 127 M$
  - Effort: 748 MY

Costing M&S

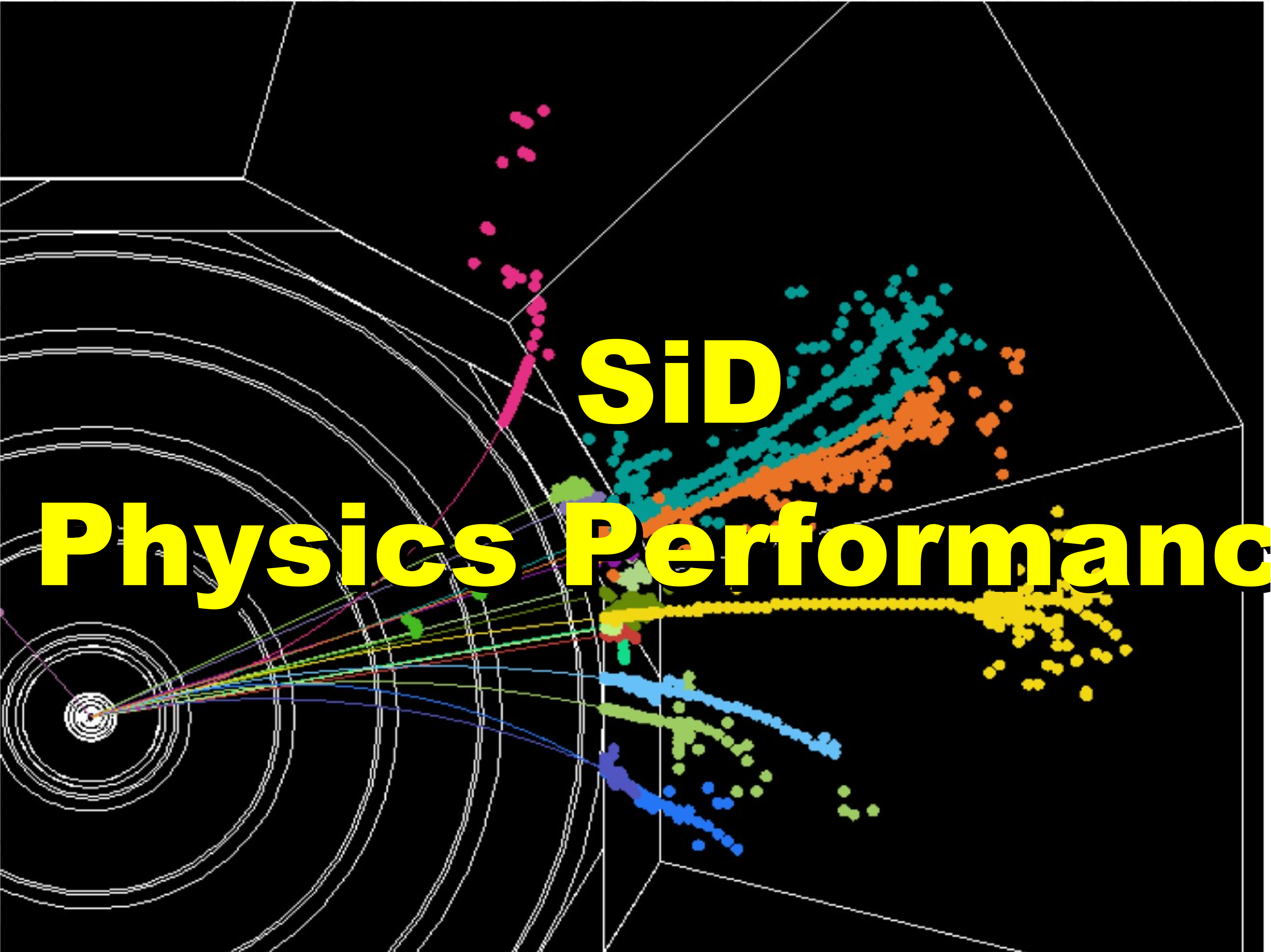

SiD M&S
M$
160
140
120
100
80
60
40
20
0
Beamline Systems
VXD
Tracker
ECAL
HCAL
Muon Sys
Electronics
Magnet
Installation
Management

Cost Dependence





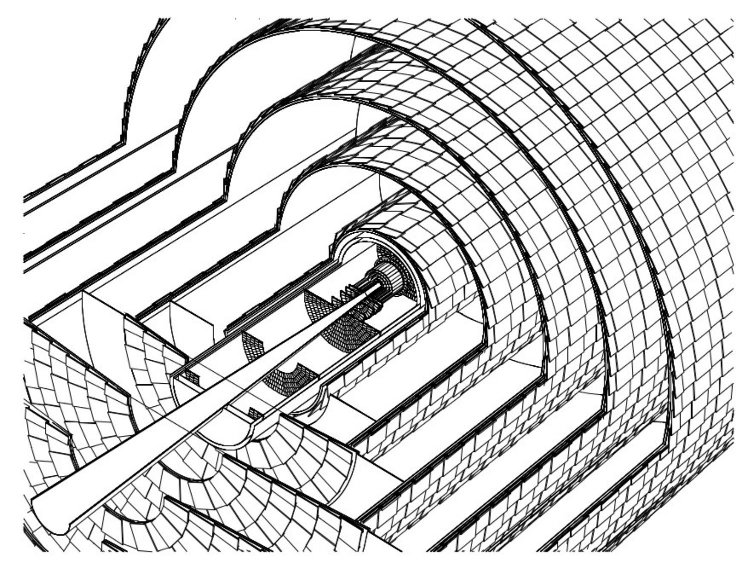
- Parametric Detector costing model allows study of main parameter dependencies
- Shown is Base M&S cost
  - Labor and Contingency excluded

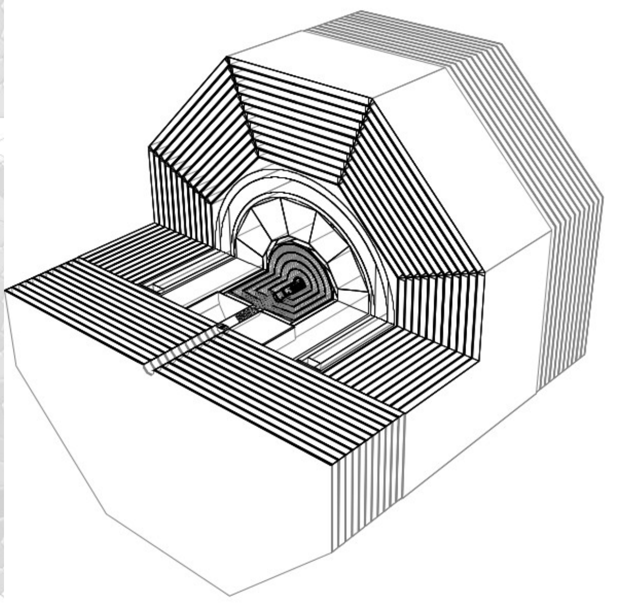


SiD
Physics Performanc

Simulation & Reconstruction

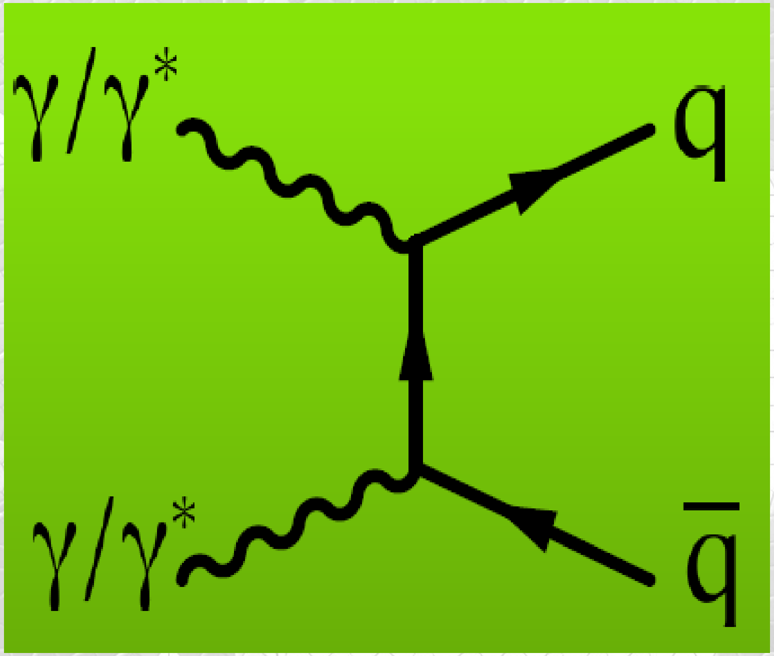
- Full Simulation& Reco
  - Including full beam backgrounds
- Simulation
  - Detailed GEANT4 detector simulation
  - Including "dead areas"
- Reconstruction
  - Digitization, Tracking, Particle Flow, Flavor Tagging
  - No cheating at all



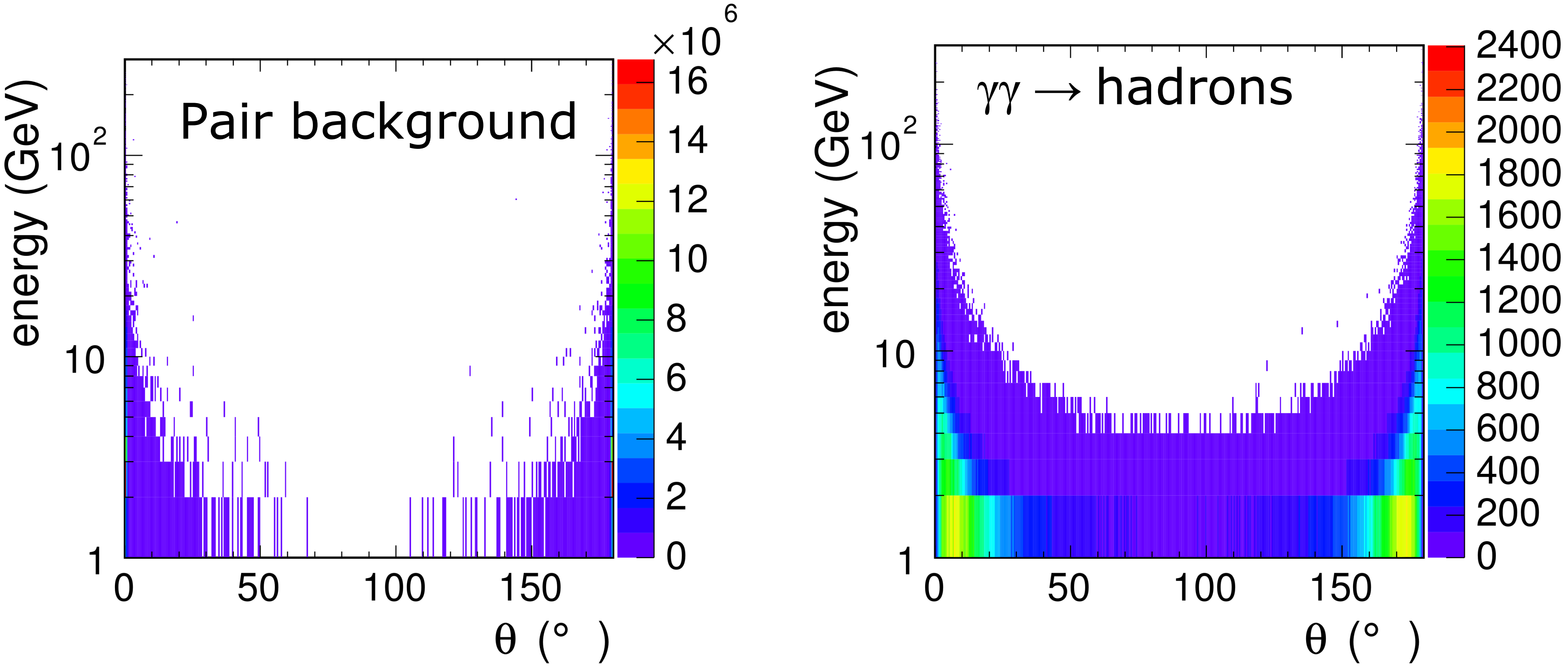


Simulating backgrounds

- Pair background
  - ~ 400k/ BX @ 1 TeV
  - Very forward
- $\gamma\gamma \rightarrow$ hadrons
  - 4.1 events per BX @ 1 TeV
  - 1.7 events per BX at 500 GeV
  - More central
- Overlays these over "physics events"

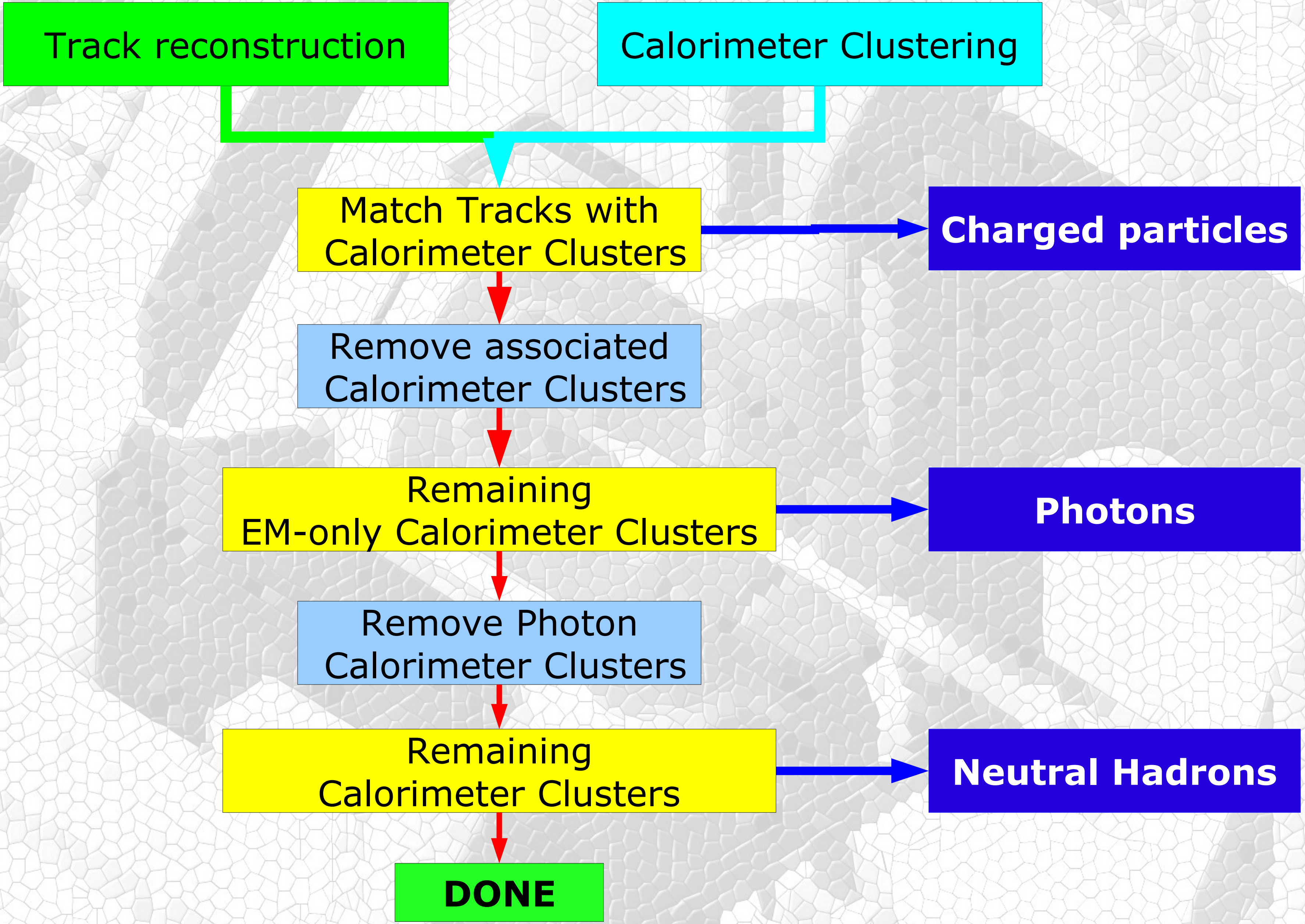


Simulated pairs



- Backgrounds with the current design
- Improvements possible (Final Focus optimizations)

PFA in a nutshell



Track reconstruction

Calorimeter Clustering

Match Tracks with Calorimeter Clusters

Charged particles

Remove associated Calorimeter Clusters

Remaining EM-only Calorimeter Clusters

Photons

Remove Photon Calorimeter Clusters

Remaining Calorimeter Clusters

Neutral Hadrons

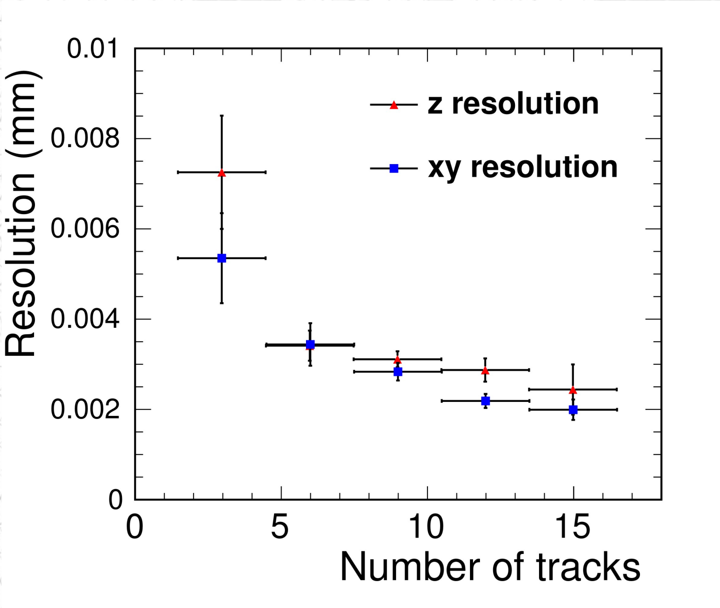
DONE

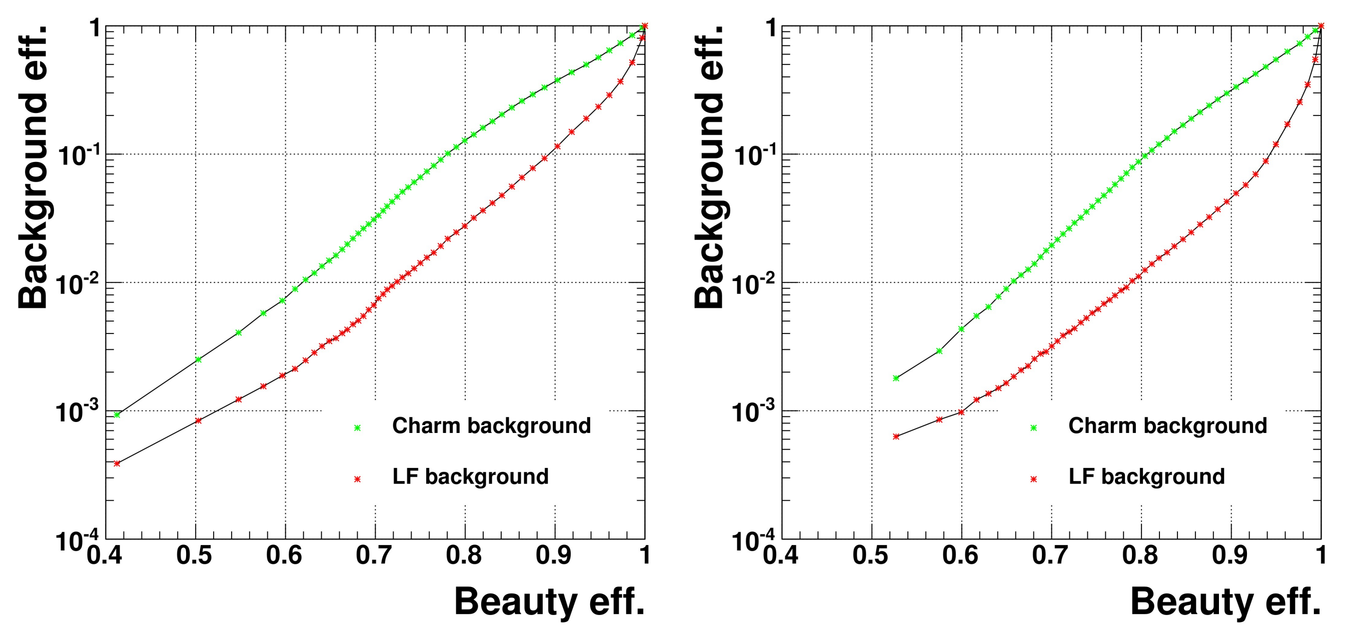
Jet Resolutions

Particle Class	SubDetector	Jet energy fraction	Particle Resolution	Jet Energy Resolution
Charged	**Tracking**	**60%**	**$10^{-4}\ \sqrt{E}_{charged}$**	**neg.**
Photons	**ECAL**	**30%**	**$11\ \%\ \sqrt{E}_{EM}$**	**$6\ \%\ \sqrt{E}_{jet}$**
Neutral Hadron	**HCAL (+ECAL)**	**10%**	**$40\ \%\ \sqrt{E}_{hadronic}$**	**$13\ \%\ \sqrt{E}_{jet}$**

- Energy resolution about 14% (driven by HCAL)
- Confusion terms have bigger impact
  - $\sigma_{jet}{}^2 = \sigma_{charged}{}^2 + \sigma_{EM}{}^2 + \sigma_{hadronic}{}^2 + \sigma_{confusion}{}^2 + \sigma_{threshold}{}^2 + \ldots$
- Performance not limited by Calorimetry
  - Need high granularity calorimetry to reduce confusion !
- Current best PFA ~25 % /√E for 100 GeV Jets

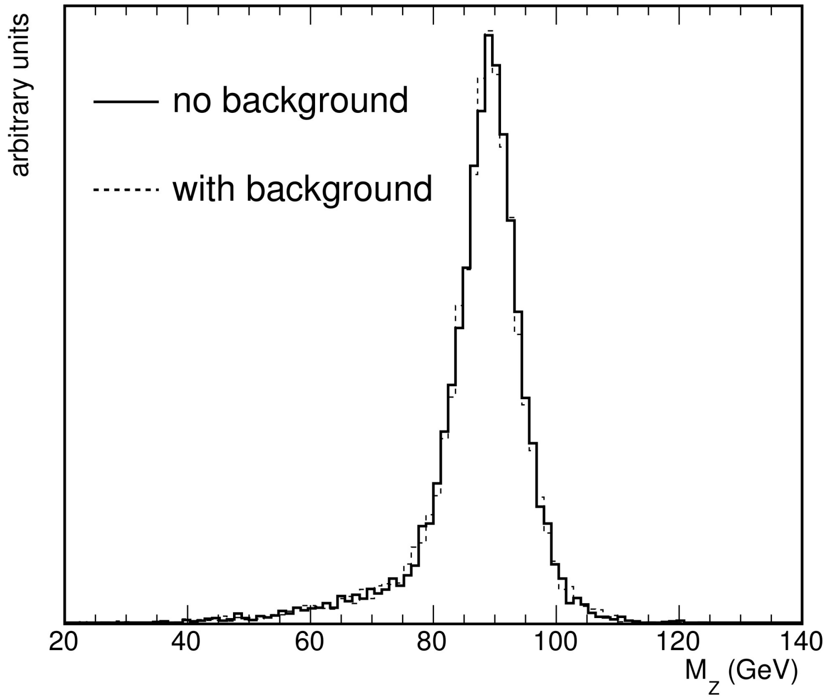
Performance: Vertexing

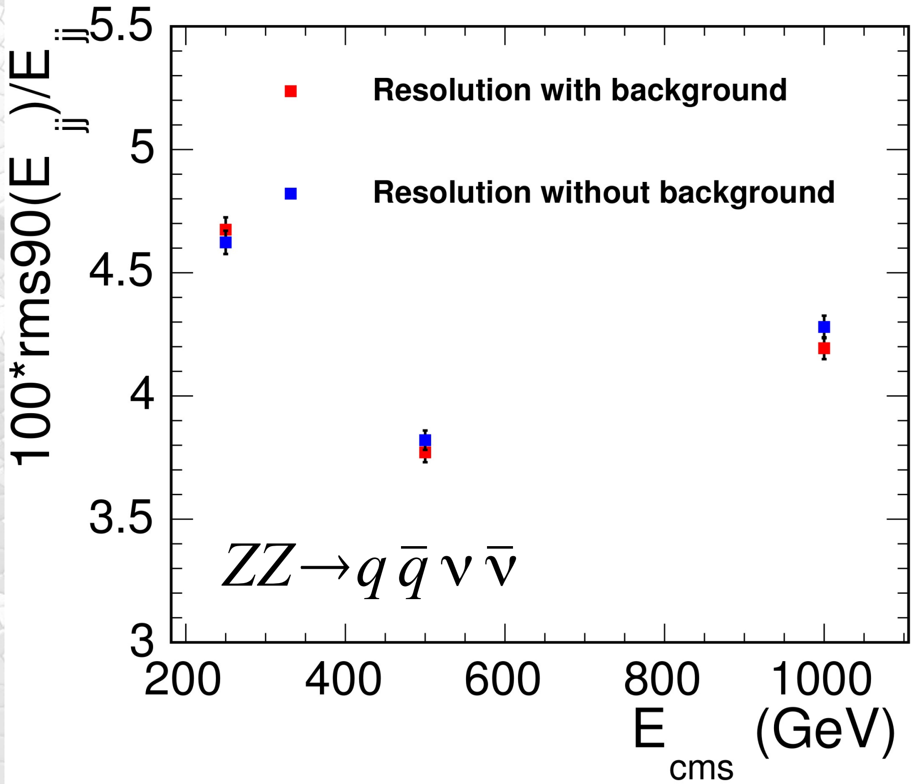




- SiD vertex detector design allows
  - High resolution vertexing
  - Robustness against backgrounds
  - b and c-tagging
  - Using LCFIplus package

Performance: PFA





- SiD PFA performance is excellent
  - Fulfills ILC physics goals
- Robust against backgrounds
  - Driven by all-Silicon approach and single-bunch time-stamping

Benchmarking SiD

- As part of the validation process, SiD was asked
  - to perform “physics benchmarks” to illustrate “readiness for ILC physics”
  - Two sets of benchmarks for both Letter of Intent and DBD
  - Done with full simulation and reconstruction

- $\sqrt{s}$ = 250 GeV
  - Higgs BR and recoil
- $\sqrt{s}$ = 500 GeV
  - $t\bar{t}$ cross section
  - $\tau\tau$ polarization
  - Gaugino pairs

LoI

- $\sqrt{s}$ = 500 GeV
  - $t\bar{t}$ cross section
- $\sqrt{s}$ = 1 TeV
  - vvH Higgs BR
  - $t\bar{t}H$
  - WW

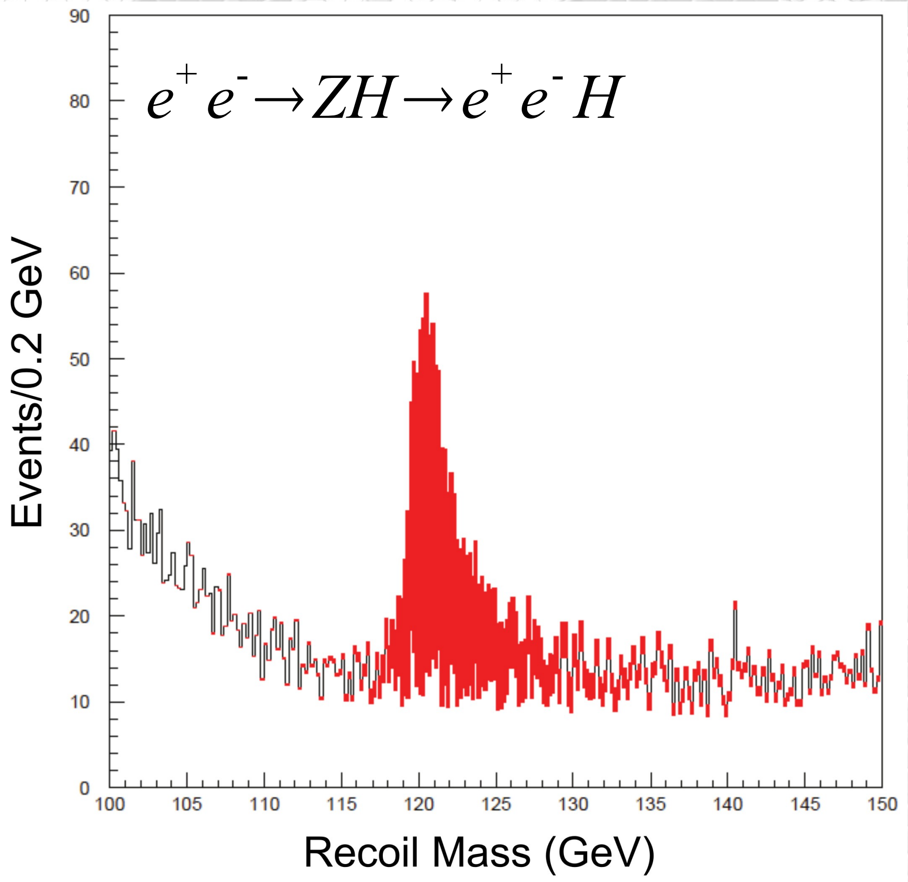
DBD

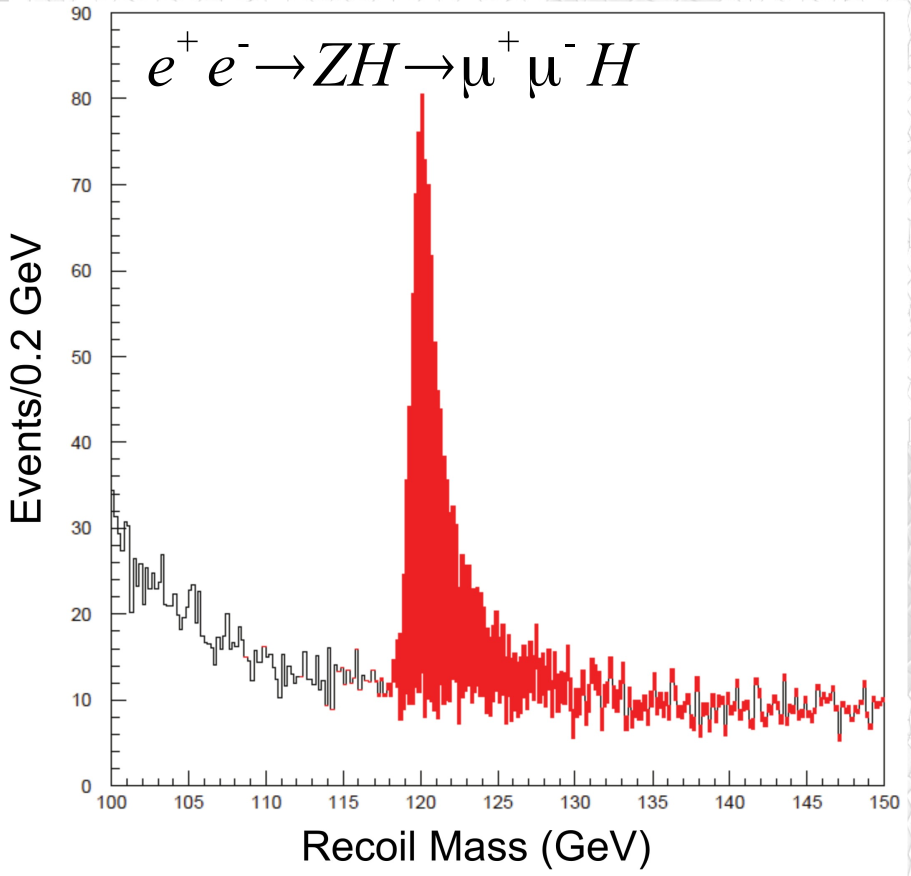
DBD event production

- 50.7 million events at 1 TeV
  - 4.7 million $\gamma\gamma \rightarrow$ hadrons
- 6.55 million events at 500 GeV
  - 4.4 million $\gamma\gamma \rightarrow$ hadrons
- In Total
  - 180 TB data
  - 211 CPU years

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

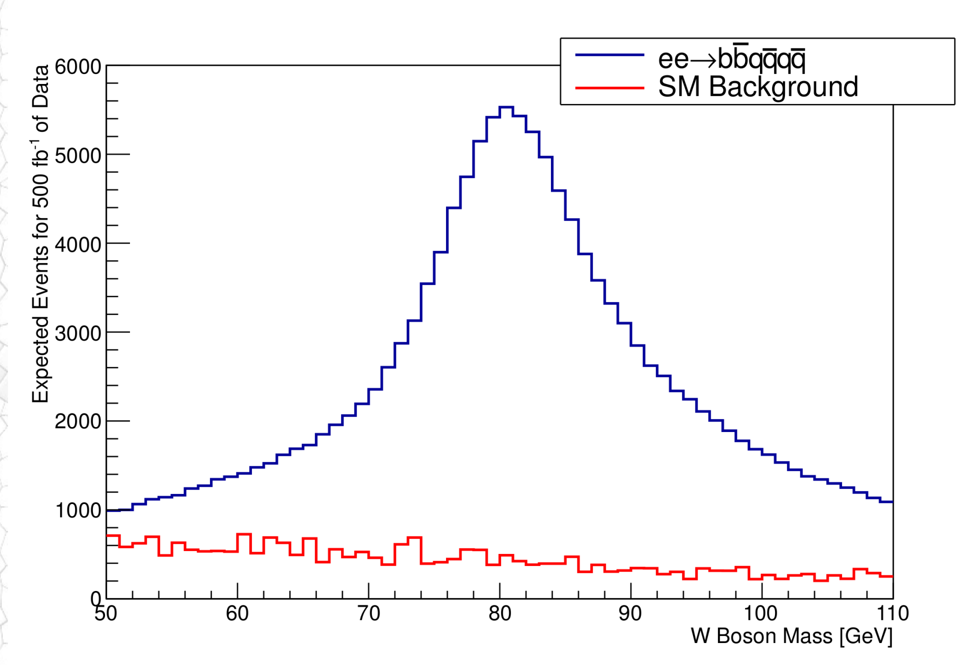
Higgs Recoil Benchmark

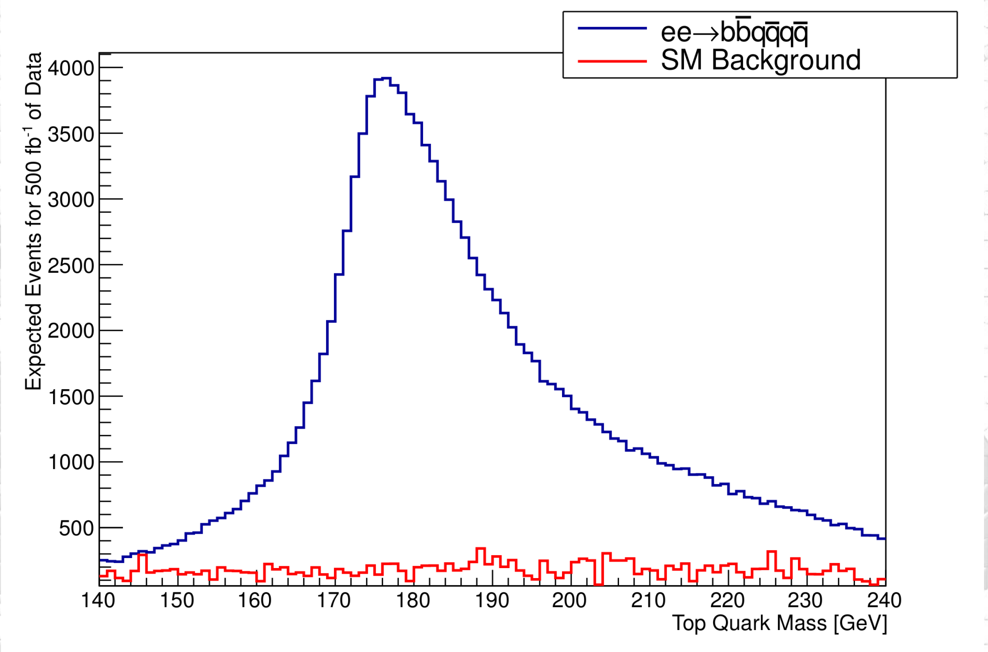




- Measuring σ_{ZH}, m_H at $\sqrt{s}$ =250 GeV
  - Δm_H=40 MeV, $\Delta\sigma_{ZH}$=2.7%
  - Decay-mode independent
  - Constraining “invisible” decay modes

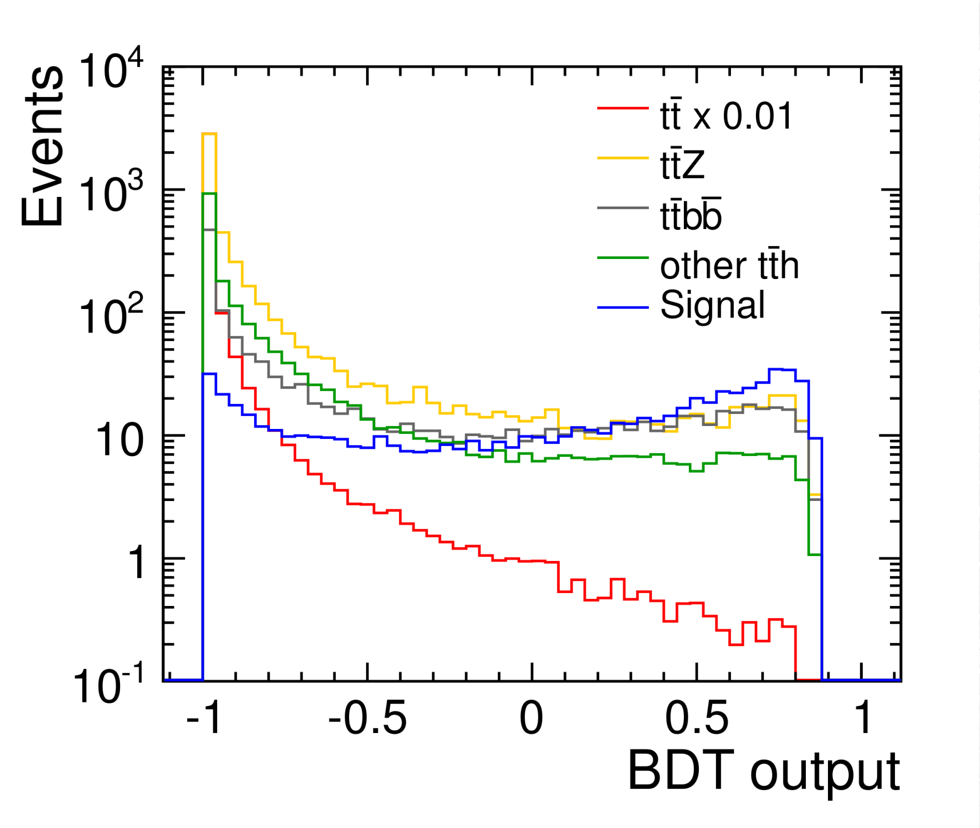
$t\bar{t}$ production

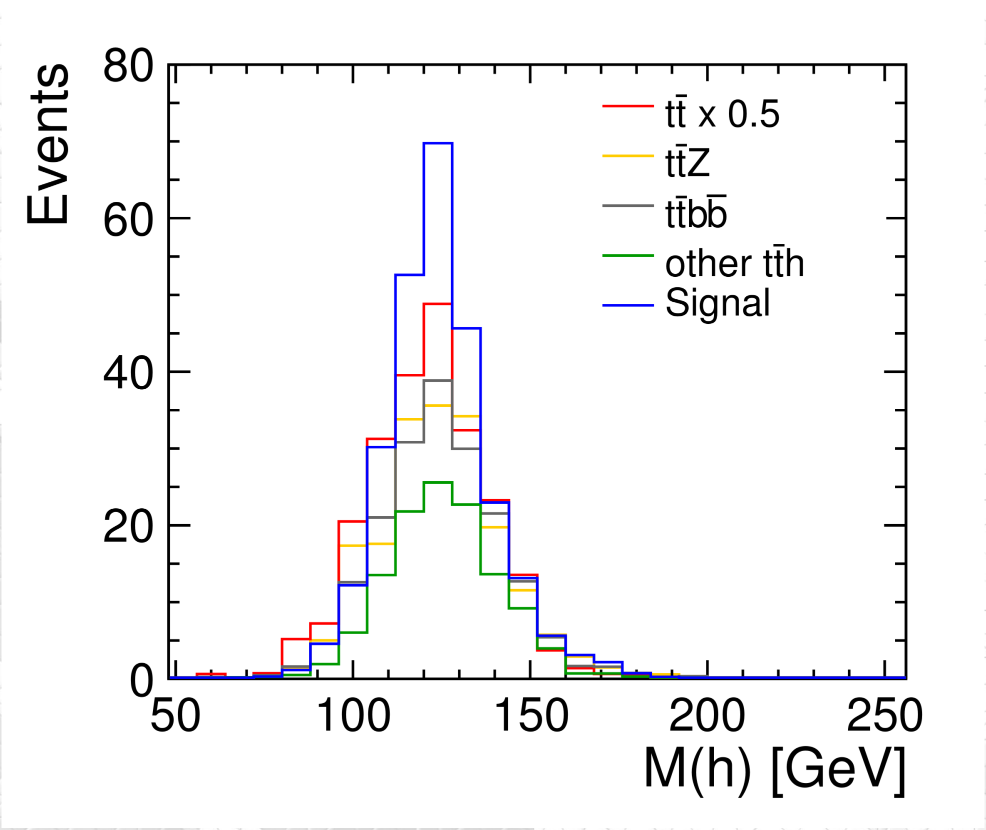




- Measuring σ_{tt} at $\sqrt{s}$ =500 GeV
  - Test of SM
  - Handling six jet final states
  - Benchmark is using both beam polarization states
  - $\Delta\sigma_{tt}$=0.47/0.69 %

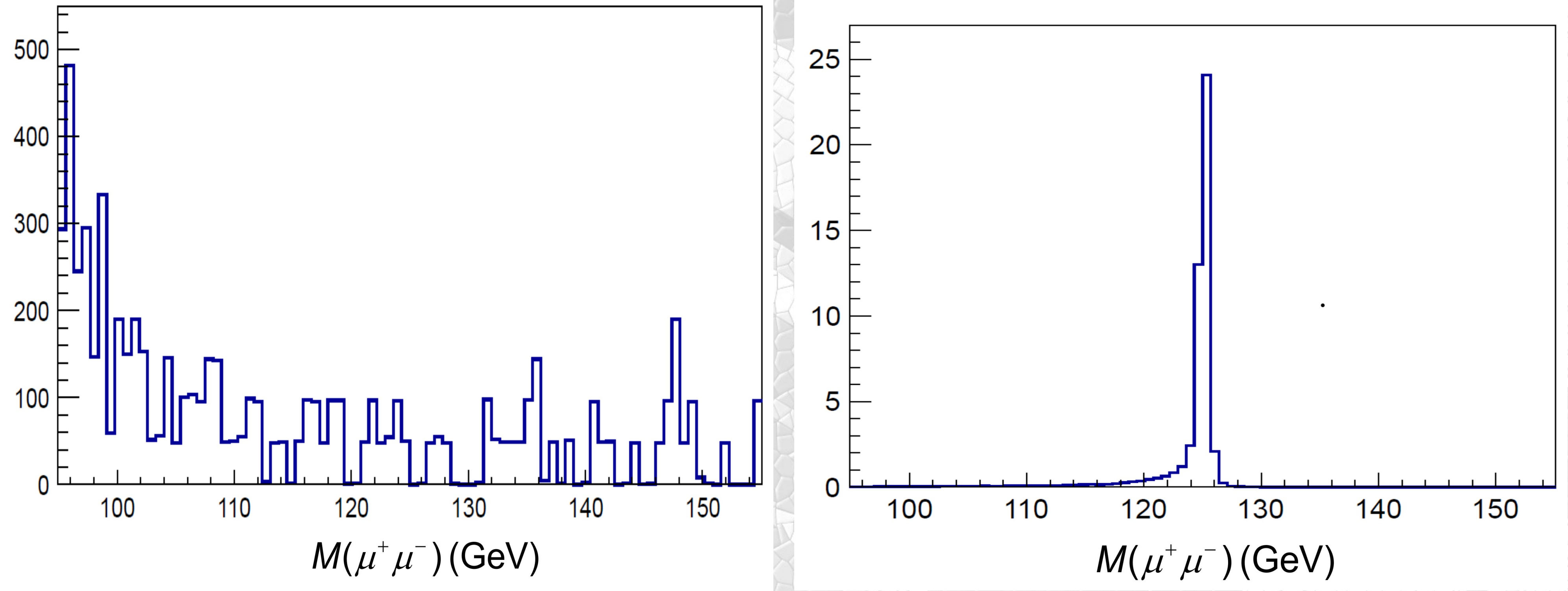
Top-Yukawa Coupling





- Measuring Y_{top} at $\sqrt{s}$ =1 TeV
  - Using six and eight jet final states with 4 b jets
  - Stressing PFA and b-tagging
  - Combined measurement: ΔY_{top}4.5 %

H→μμ Branching ration



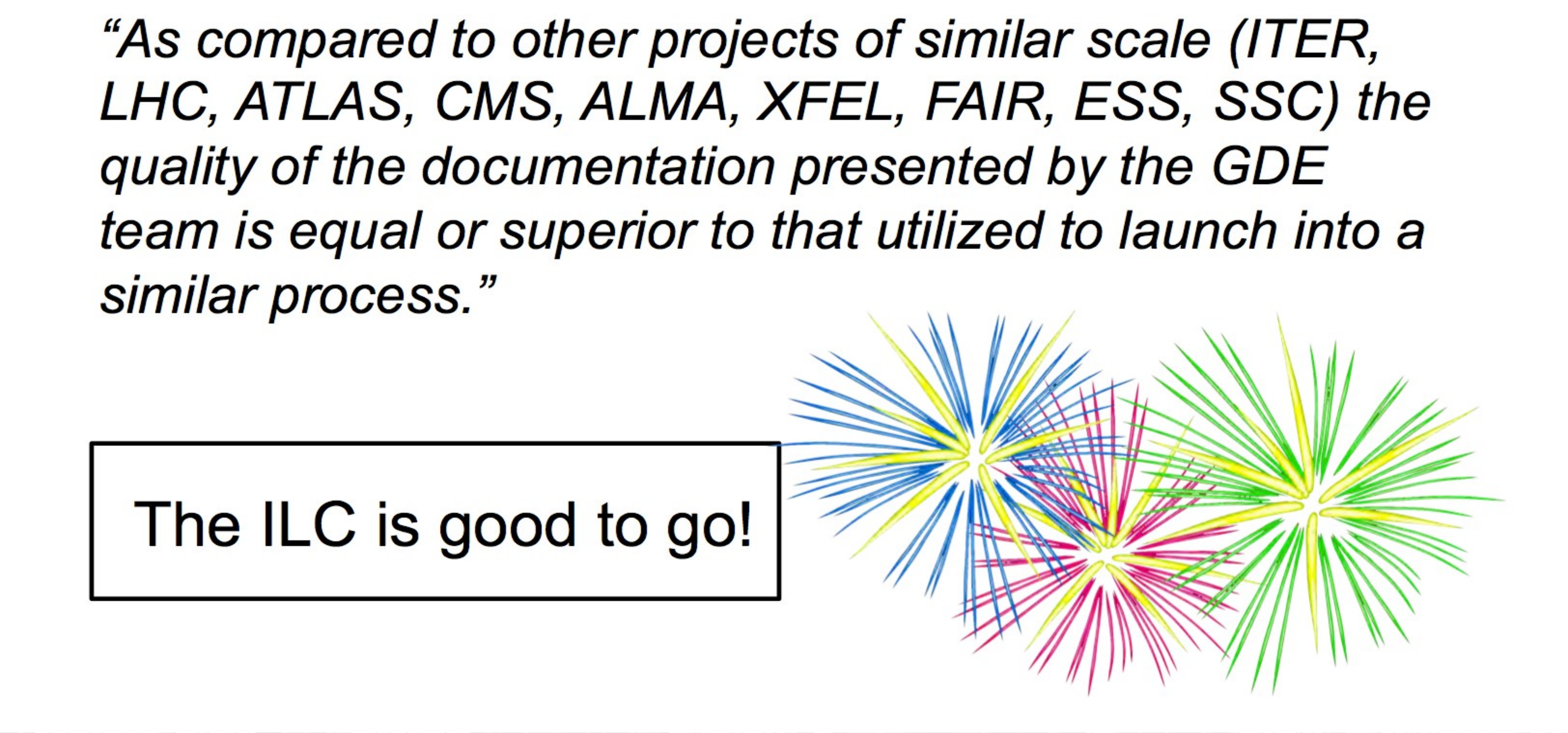
- Measuring BR H → $\mu^+\mu^-$ at $\sqrt{s}$ =1 TeV
  - Challenging channel
  - Relies on excellent tracking
  - Accuracy achieved : ΔBR=32%

Recent developmen

TDR completed !

- Mandate of the Global Design Effort for the ILC (2005-2012)
  - Deliver a TDR document by the end of 2012
- Goal has been achieved
- TDR with 5 volumes
  - Exec Summary, Physics, Accelerator, Detectors, Outreach
- TDR was funding/effort limited
  - Not everything we had planned is in
- Detector went from TDR to DBD
  - Detailed Baseline Design
- Physics case summarized in one volume

Final TDR Review Outcome



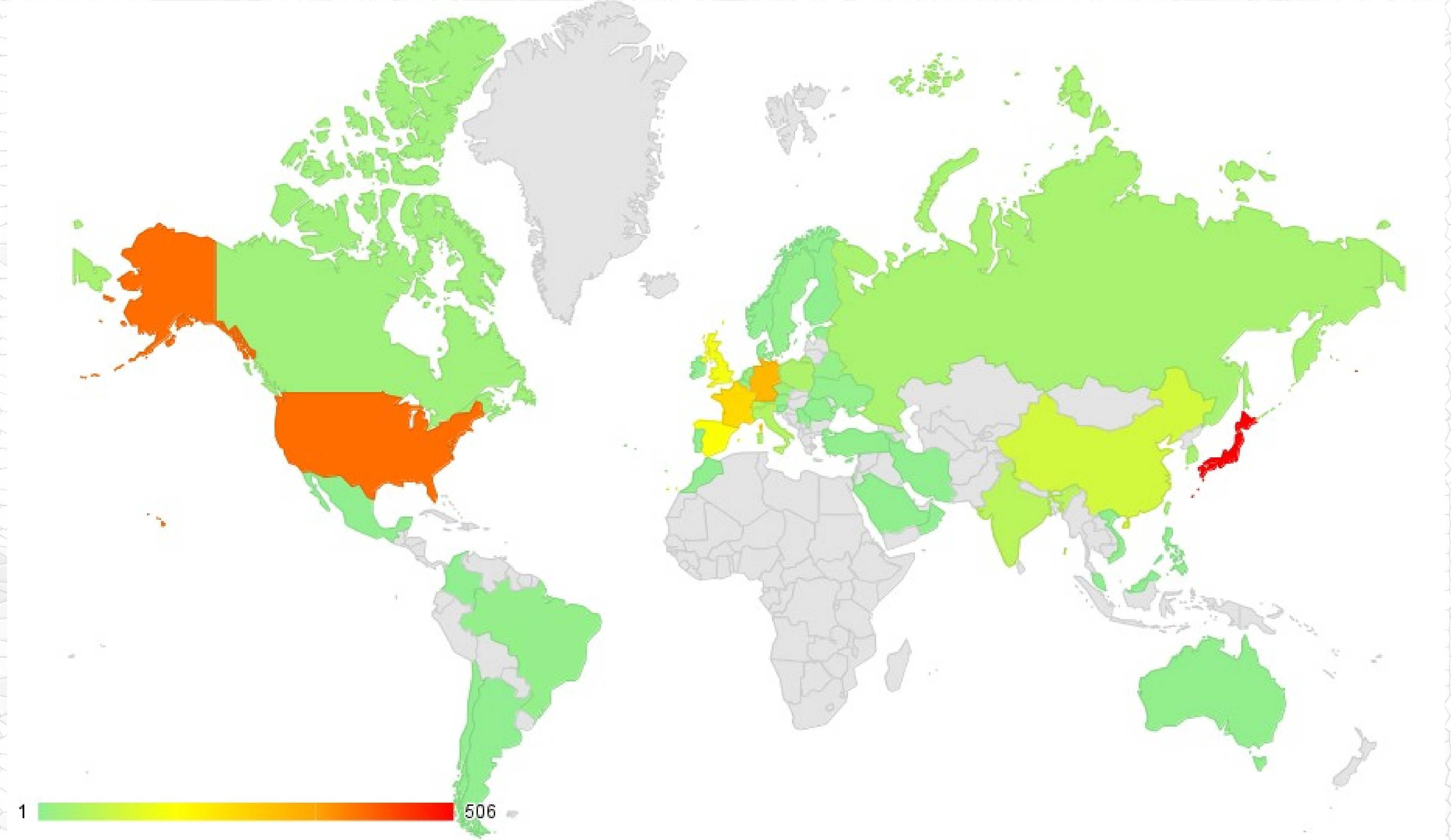
"As compared to other projects of similar scale (ITER, LHC, ATLAS, CMS, ALMA, XFEL, FAIR, ESS, SSC) the quality of the documentation presented by the GDE team is equal or superior to that utilized to launch into a similar process."

The ILC is good to go!

TDR/DBD Signatories

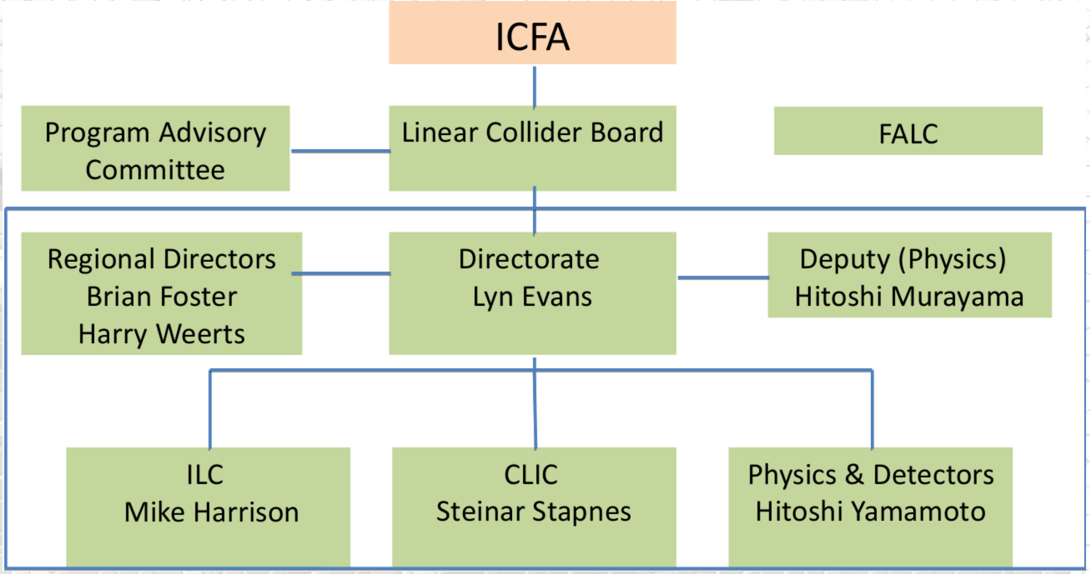
- A Call for signatories has been made, inviting
  - Everyone who was contributed
  - Everyone interested or supporting the case for the ILC
- Overall statistics
  - 48 countries
  - 392 Institutes
  - 2400 signatories
- Largest
  - Signatories per Country : Japan (506)
  - Institutes per Country : USA (75)
  - Institute worldwide: DESY (HH+ZN), KEK: 185/184
  - Region: Europe (1185)

The ILC world



The LCC organization

- Mandate of GDE is complete
- ICFA has created the "Linear Collider Collaboration"
- Three pillars
  - ILC
  - CLIC
  - LC physics and Detectors
- LCC is lead by Lyn Evans



ICFA

Program Advisory Committee

Linear Collider Board

FALC

Regional Directors
Brian Foster
Harry Weerts

Directorate
Lyn Evans

Deputy (Physics)
Hitoshi Murayama

ILC
Mike Harrison

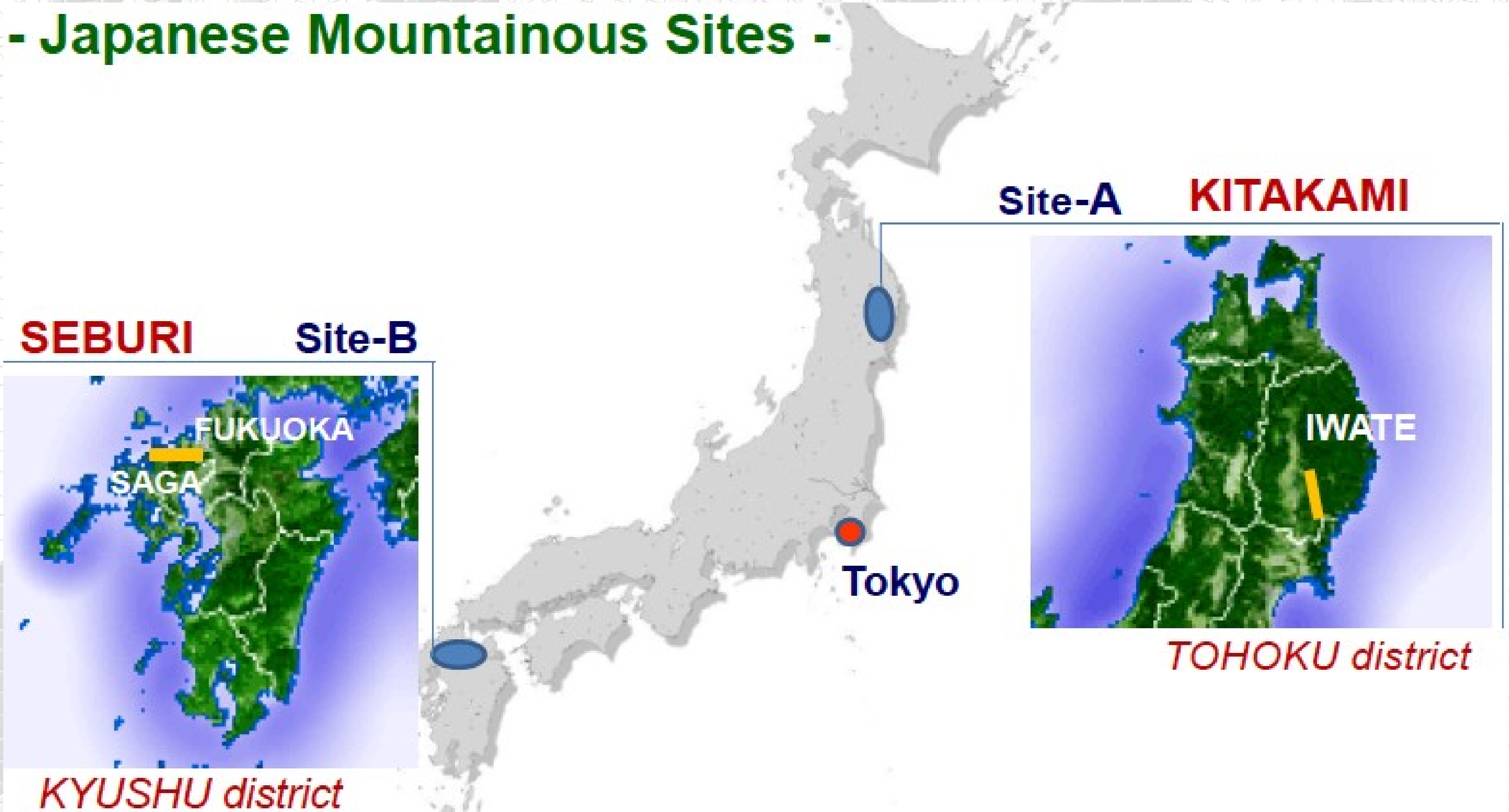
CLIC
Steinar Stapnes

Physics & Detectors
Hitoshi Yamamoto

Developments in Japan

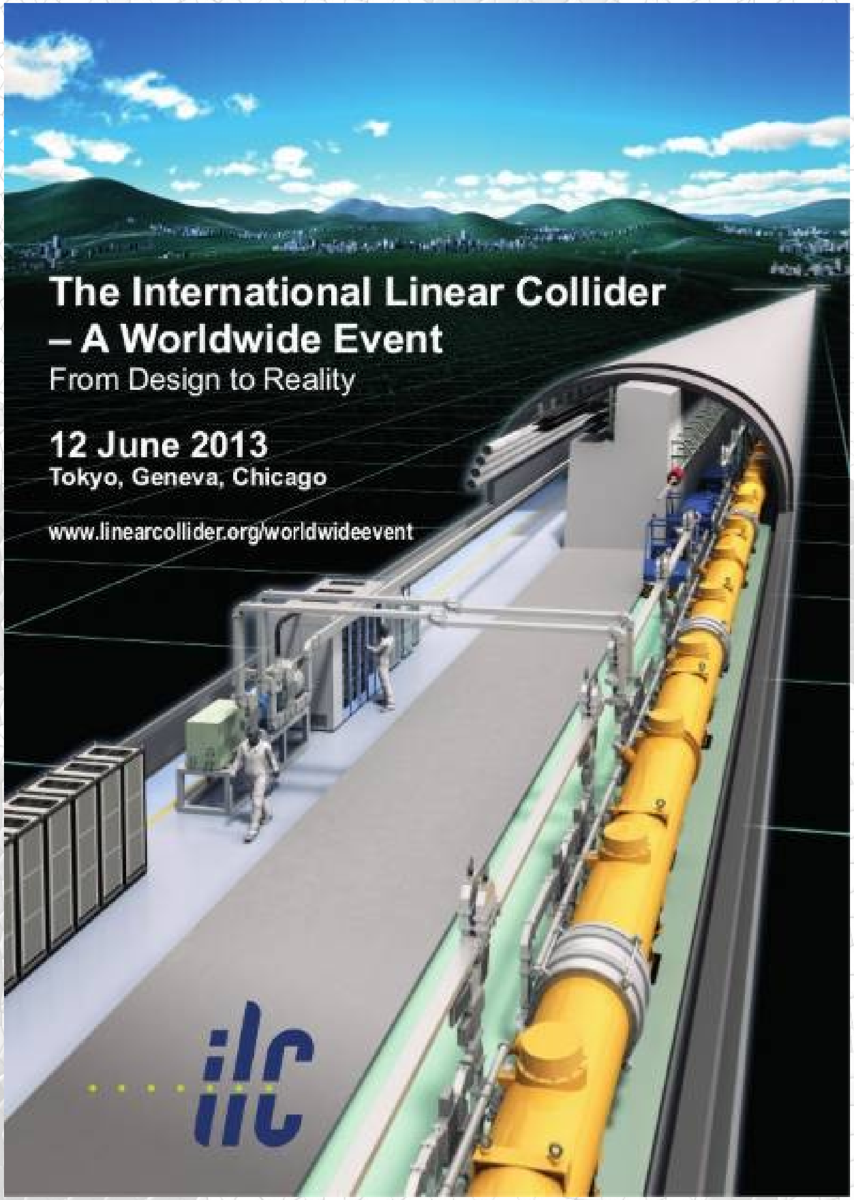
- LCC director has meet with PM Abe in March
- More than 150 Japanese MPs lobby for the ILC
- High-ranking Japanese delegations visits Washington
  - ILC is major agenda item
- Japan plans to select a potential host site by the end of this summer

The two candidate sites



Upcoming ILC events

- June 12th, 2013
  - Official hand-over of the TDR in all three regions
  - Events at Tokyo, CERN, FNAL
- November 11th -15th 2013
  - International Linear Collider Workshop in Tokyo



The International Linear Collider
– A Worldwide Event
From Design to Reality

12 June 2013
Tokyo, Geneva, Chicago

www.linearcollider.org/worldwideevent

How can I get involved ?

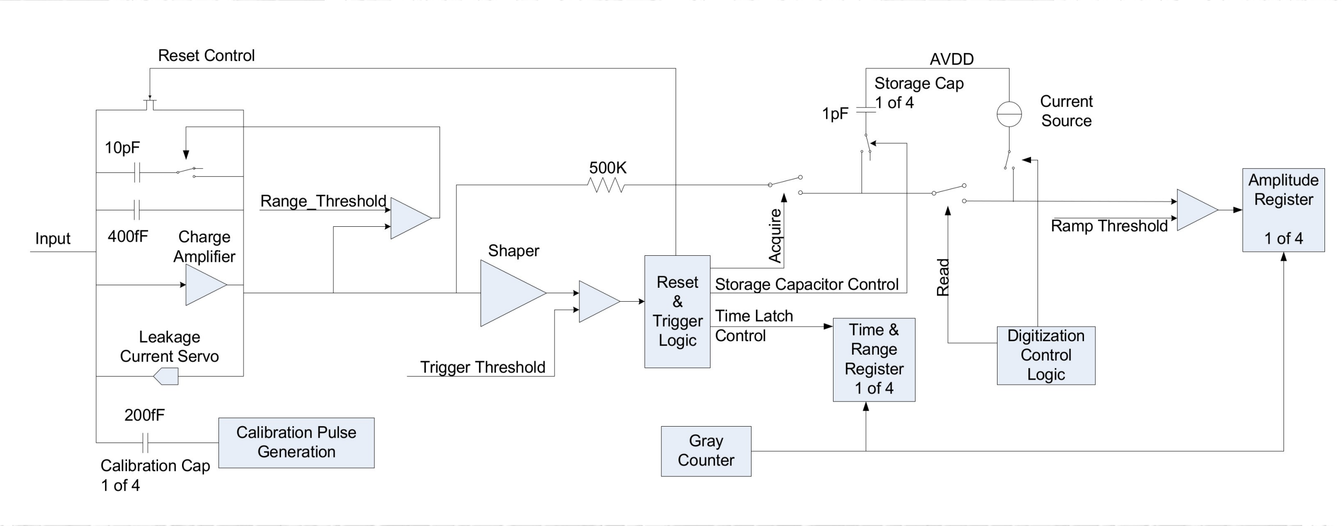
- The finalization of the DBD is a great opportunity
  - To refine the current design
  - To test new ideas
- There are still many things to do to make SiD a reality
  - Please get in touch with the SiD spokespeople Andy White (UTA) or myself
  - We'll point you to the right contacts in SiD
- Participate in the workshops
  - Best opportunity to know what is going on
- Also software studies are very welcome
  - Easy way to start contributing to SiD

Summary

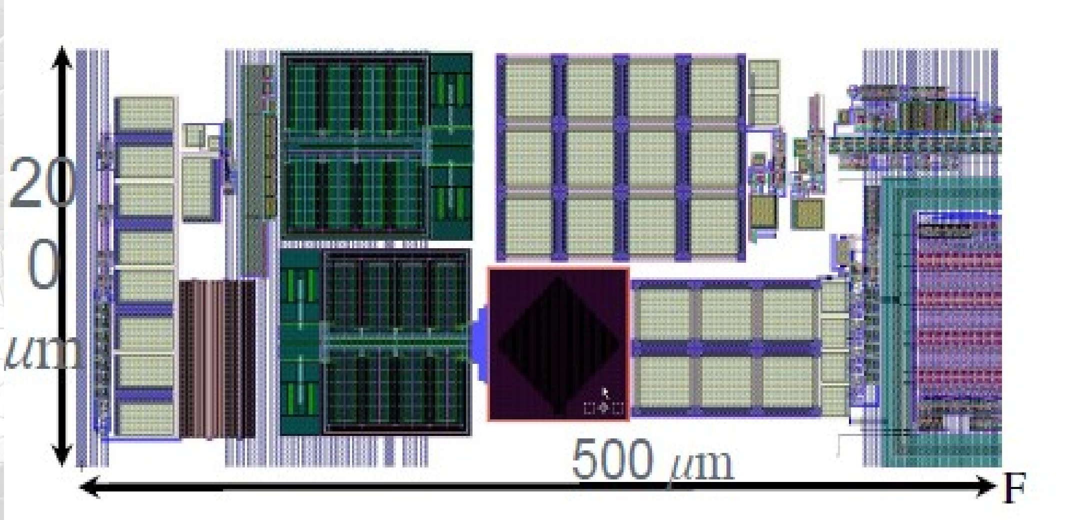
- ILC physics case has been made
- ILC machine status
  - TDR finalized, technology is ready
- SiD
  - A compact high-field all silicon detector
  - Demonstrated readiness for ILC physics
- Japan
  - Developments there are very encouraging
- ILC is prominently mentioned in the Japanese and European strategy
  - Hoping for similar support from US Snowmass process


That's all Folks!

KPiX- System on a chip

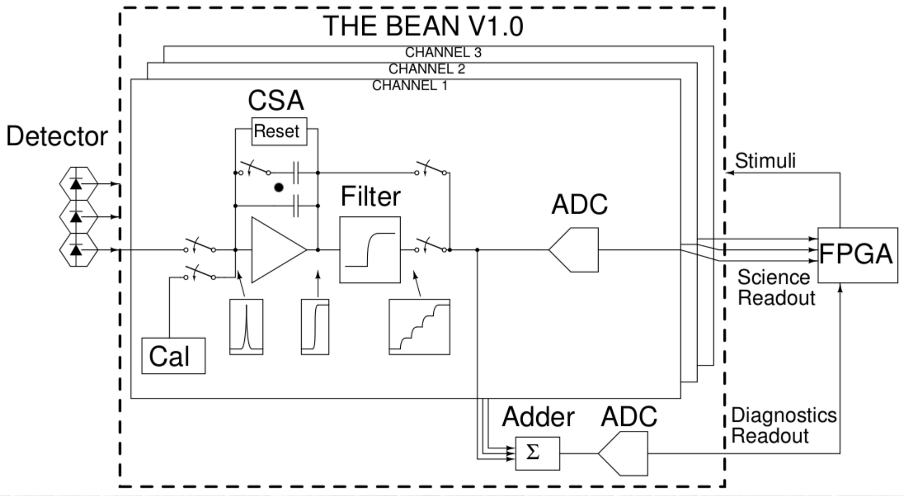


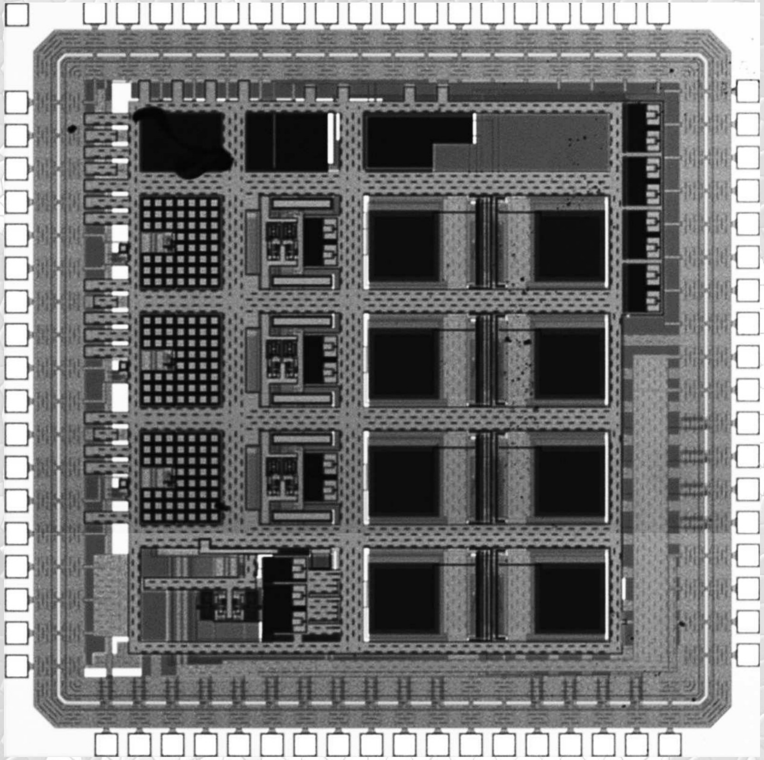
- KPiX
  - Aimed at ILC
  - 1024 channel, 4 buffers/channel
- Key Feature
  - Low noise dual range charge amplifier w 17 bit dynamic range.
  - Power modulation average power <20 µW/channel
  - Noise Floor: 0.15 fC



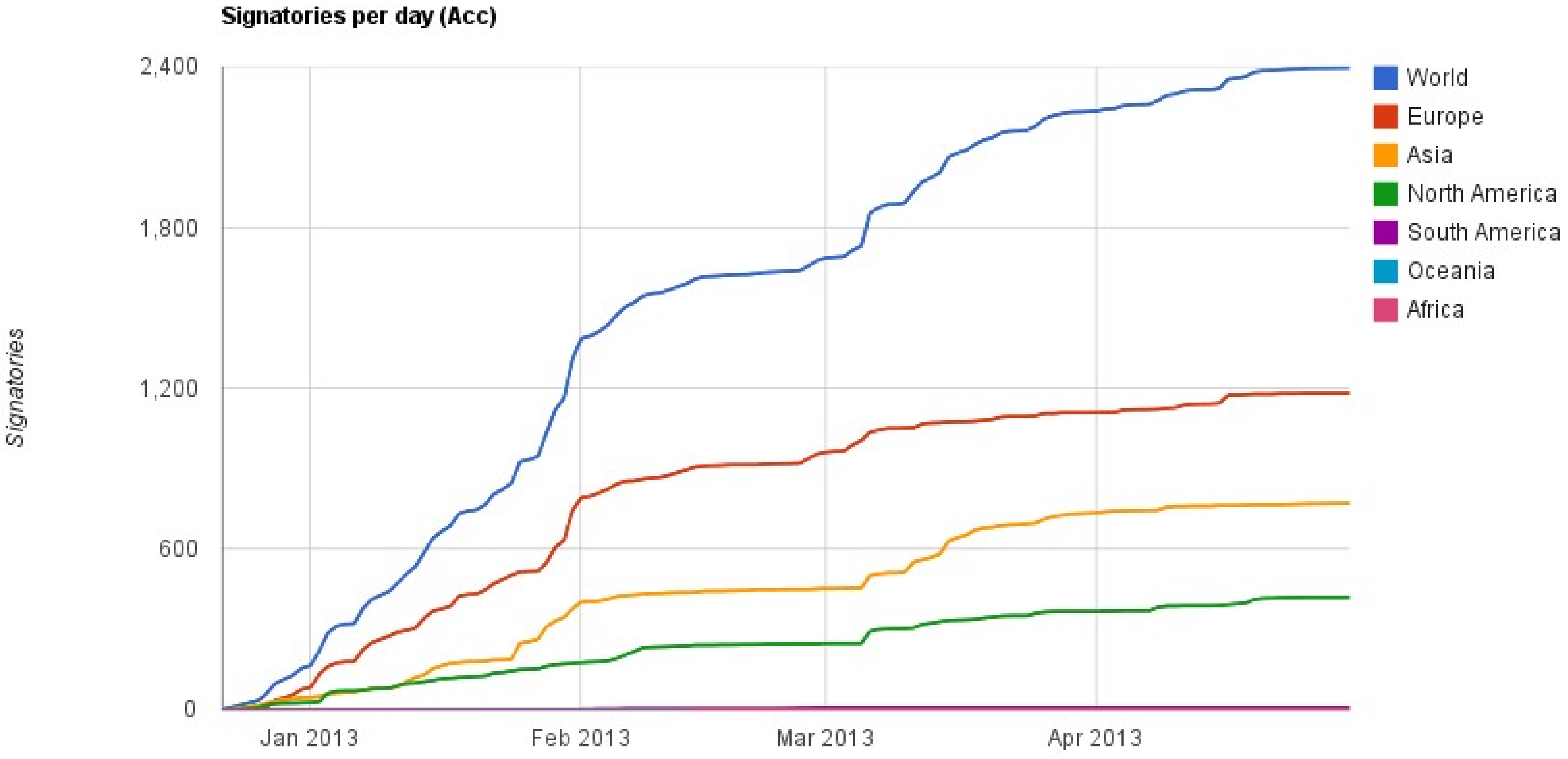
The Bean Chip

- Bean V1.0
  - Dedicated chip for the high-occupancy environment
- Specs
  - 32 channel
  - 2820 Buffers
  - 10 bit ADC/ channel
  - Fast analog adding
- Successful Test phase just finished





Gaining momentum



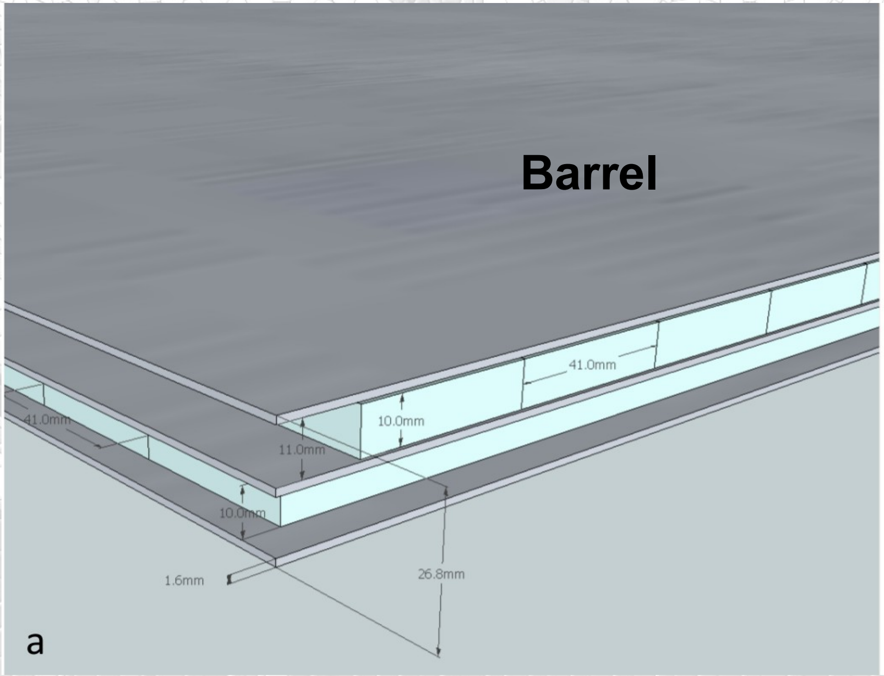
Vertex Technology

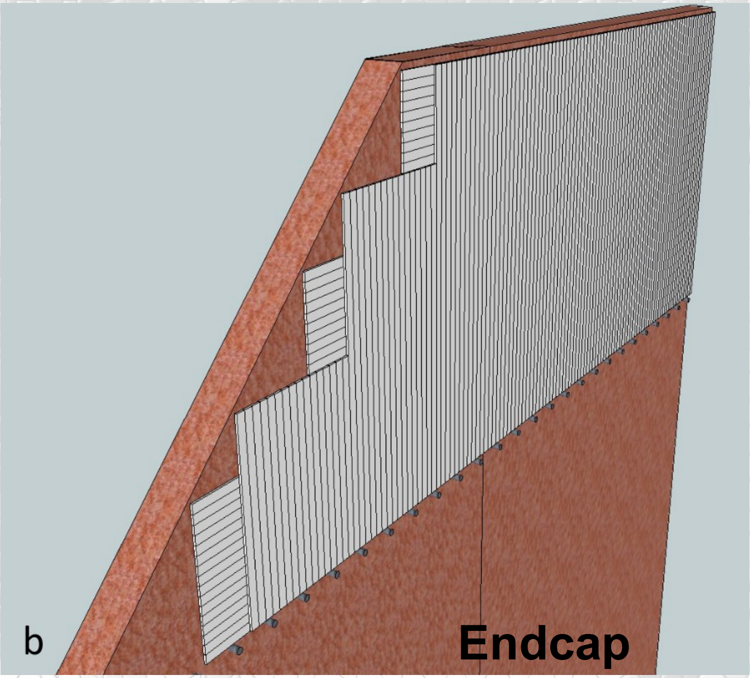
- Vertex Pixel has unique requirements
  - Small pitch
  - Single-bunch time-stamping
  - Low power consumption
- In-pixel intelligence
  - Zero suppression
  - ADC
  - Trim & Mask
  - Storage

- MAPS technology can fulfill these requirements
  - It's not there yet, but …
  - The way ahead is clear
- RAL MAPS programme
  - Has key building blocks
  - Large sensors
  - In-pixel intelligence
  - In-pixel Storage
- Still leading player
  - Although other have caught up

Muons

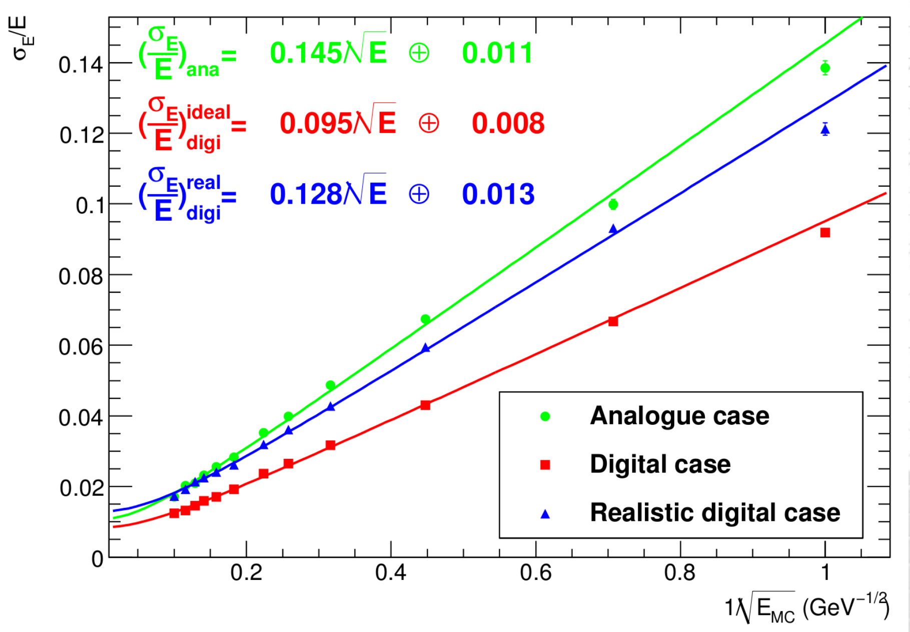
- Major change in baseline option
  - Readout technology
- New baseline option
  - Scintillator bars
  - SiPM readout
  - First engineering desing of the muon layers
- RPC remains an option
  - Still actively being pursued

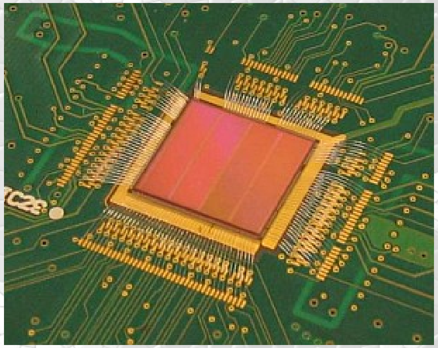


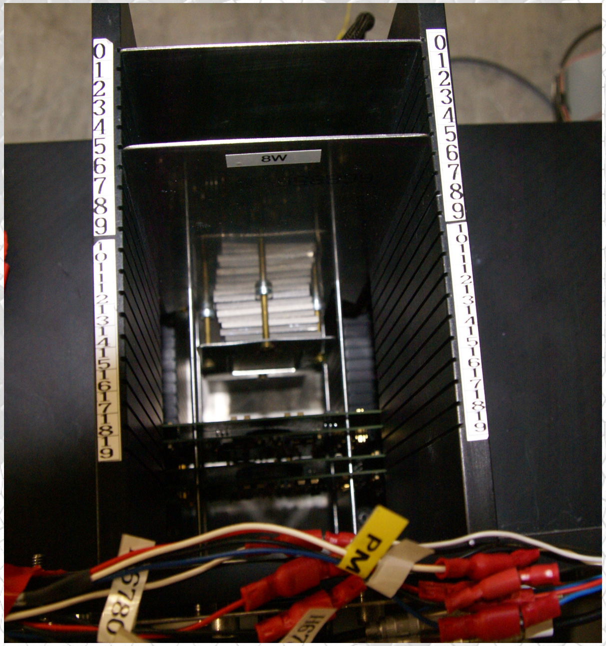


Digital ECAL option

- DECAL = Shower particle counter
  - $N_{particles}$ ~ Energy
  - Eliminating landau tails
  - Ultimate granularity
- Using pixel sensors for the readout
  - UK Idea
  - TPAC MAPS designed at RAL
  - Successful Testbeams at DESY, CERN
- Since UK pulled out
  - Project Stalled







Cost Sensitivity

- How the magnet is costed
  - SiD assumes magnet made by industry (risk is with vendor)
  - Change to CMS-style model (Collaboration takes risk)
- Cost Sensitivity analysis (double unit costs)
  - Silicon sensors and magnet have largest impact
  - 26 and 14 % cost increase respectively
- "Optimizing costs"
  - Half the price of silicon, CMS-style magnet pricing, reducing RPC costs
  - Total SiD cost changes from 315 to 222 M$

SiD Assembly