The International Linear Collider

Precision physics at the energy frontier

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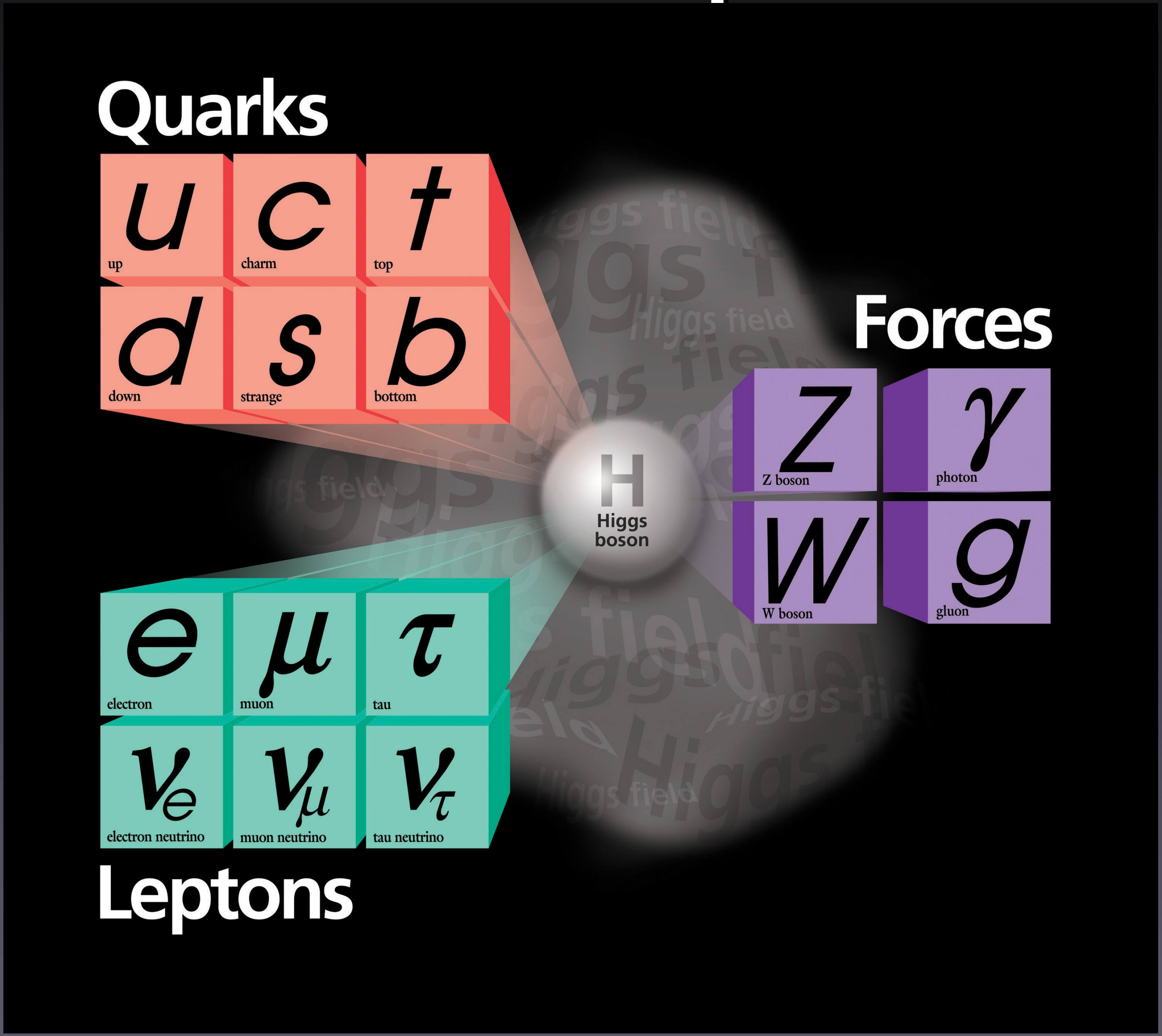
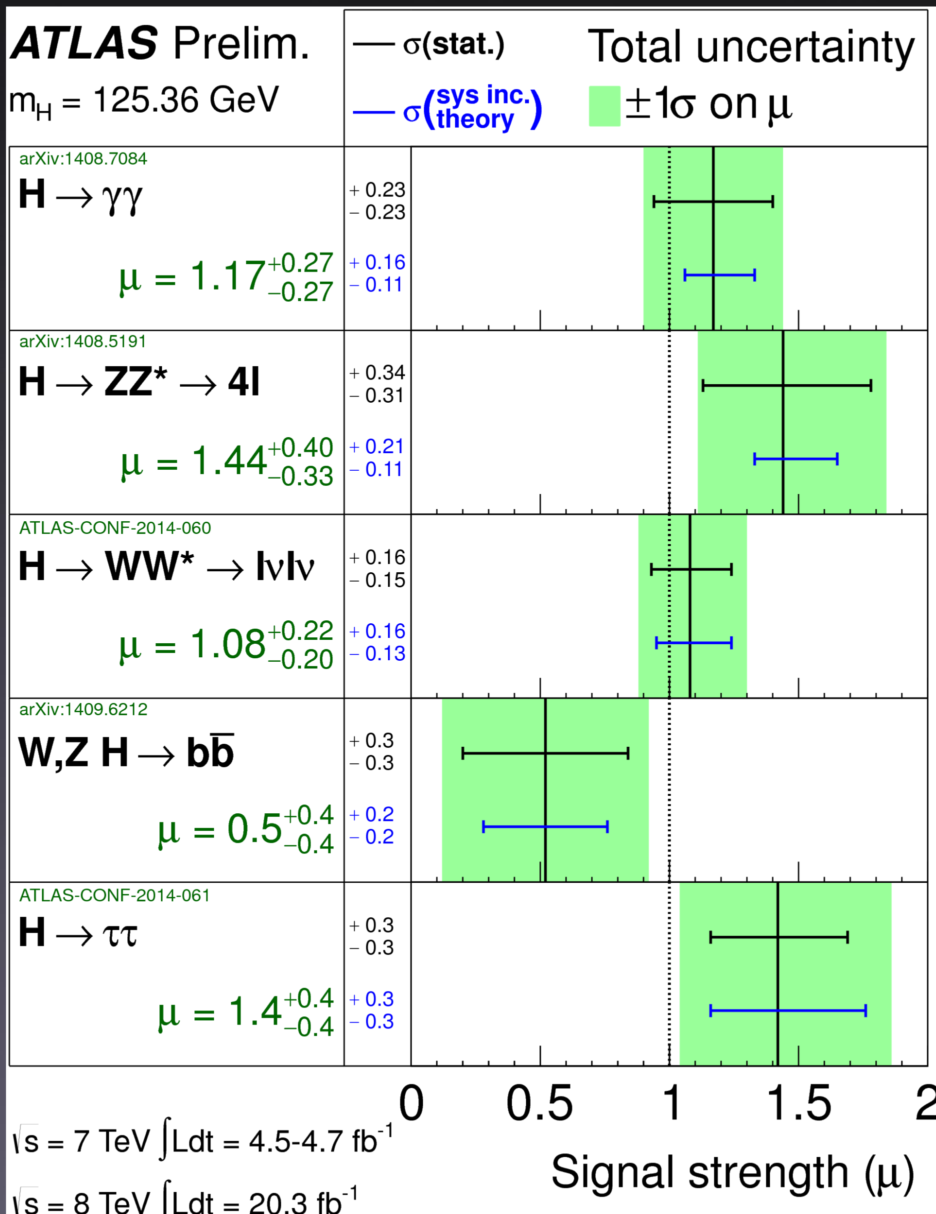
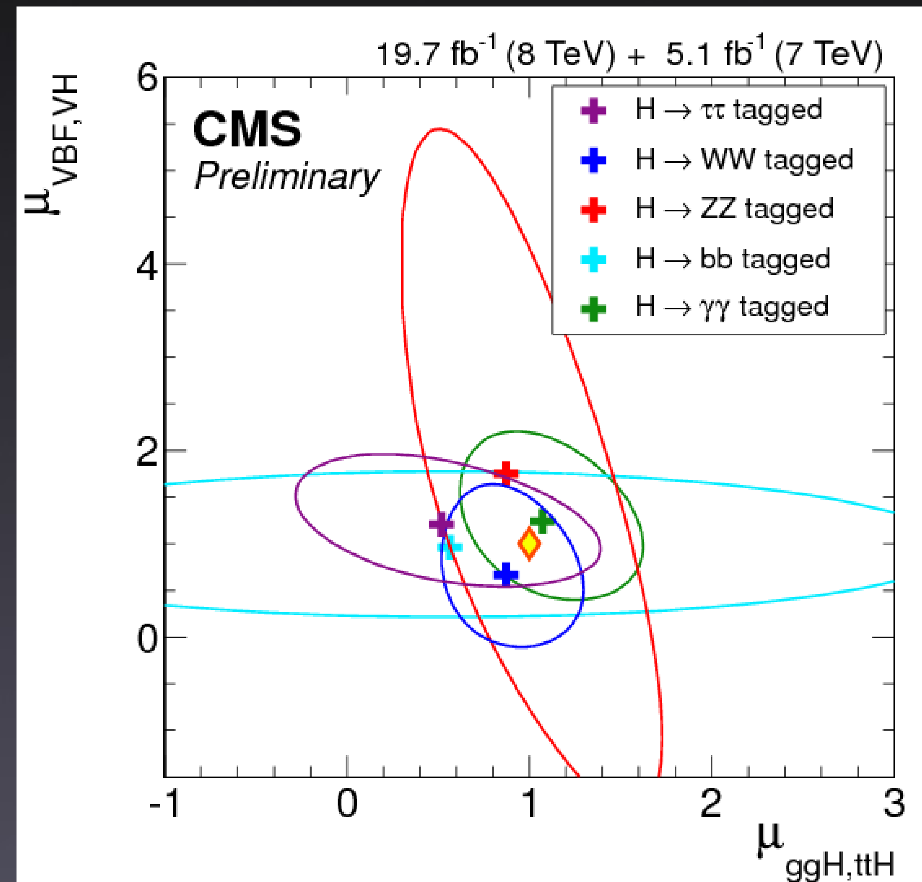
Mission Accomplished ?



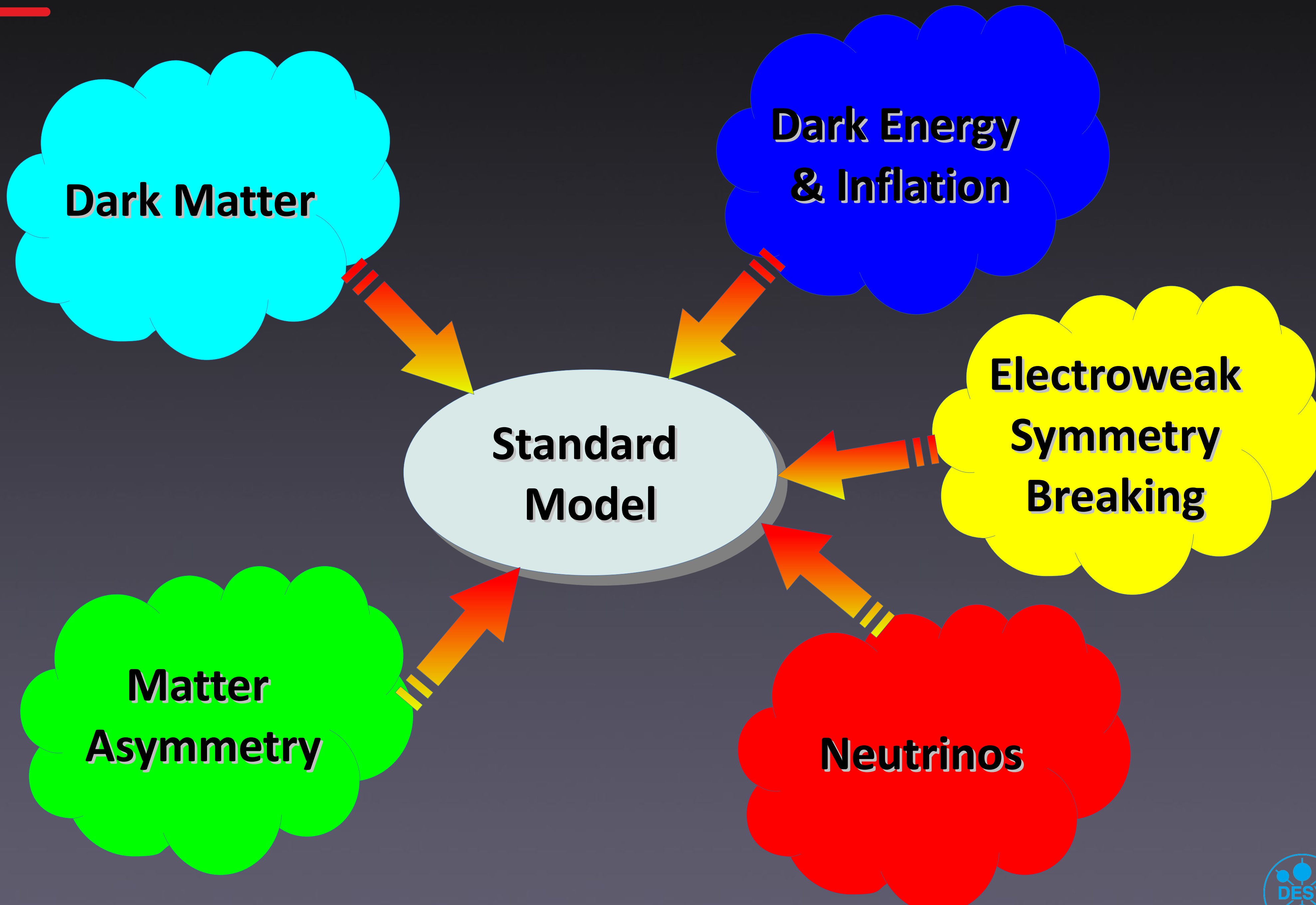
The Higgs -What do we know …





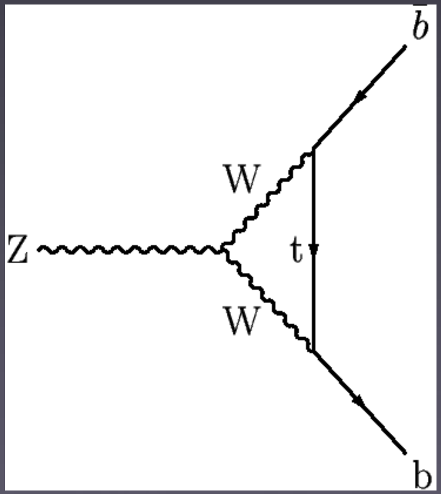
Looks like the Standard Model Higgs Boson…

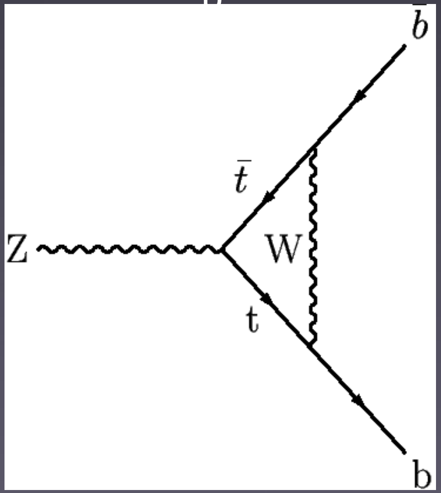
Now what ?

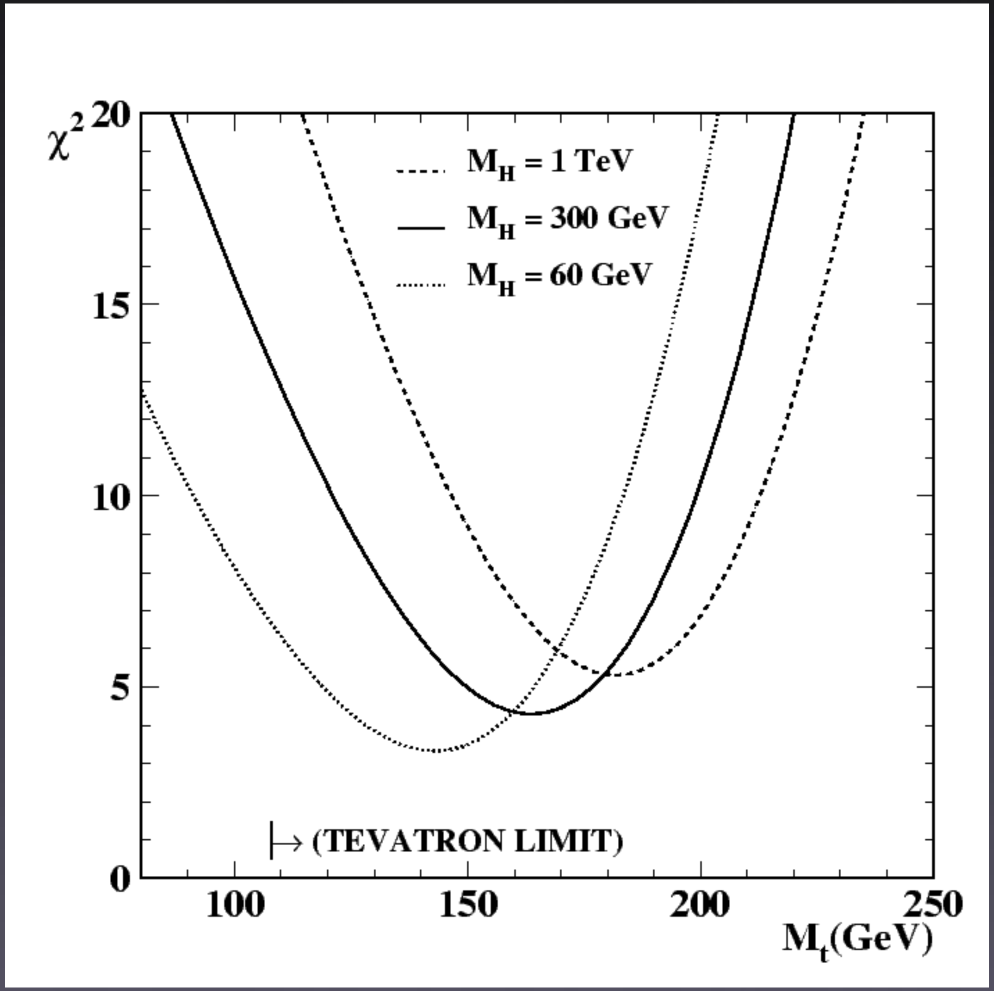

Dark Matter
Dark Energy & Inflation
Standard Model
Electroweak Symmetry Breaking
Matter Asymmetry
Neutrinos

A bit of History -Top Prediction

- Measuring R_b
  - $Z \rightarrow b\bar{b}$
- Even $m_t >> m_Z$
  - Corrections to R_b

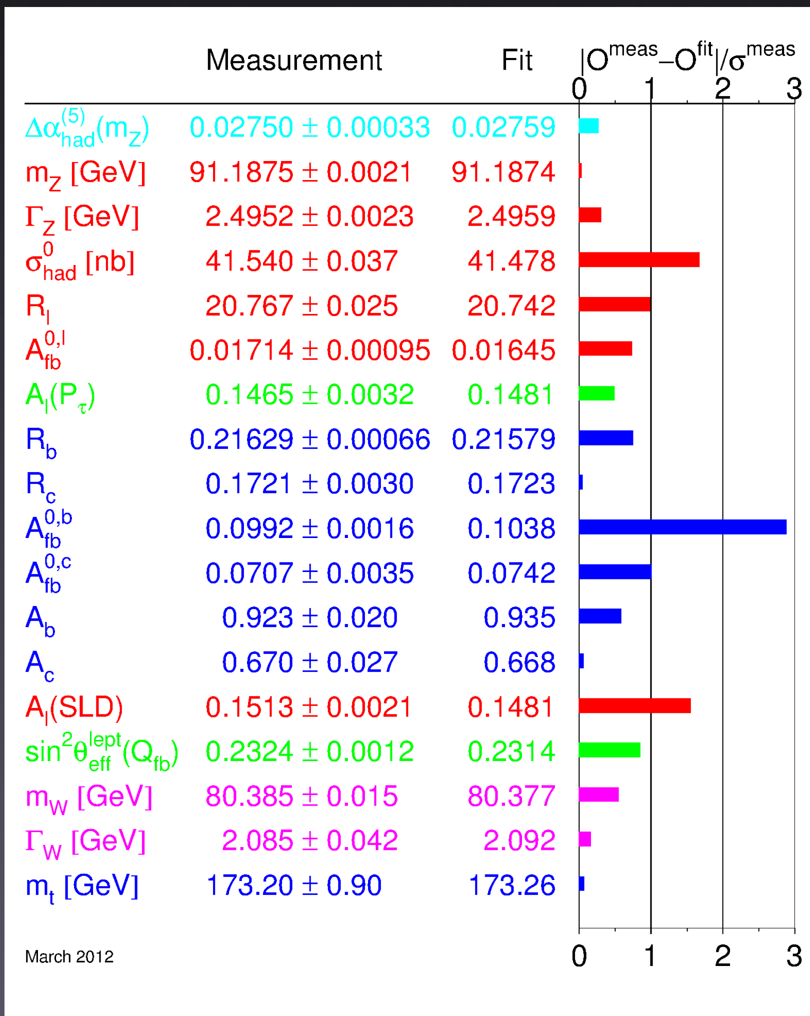


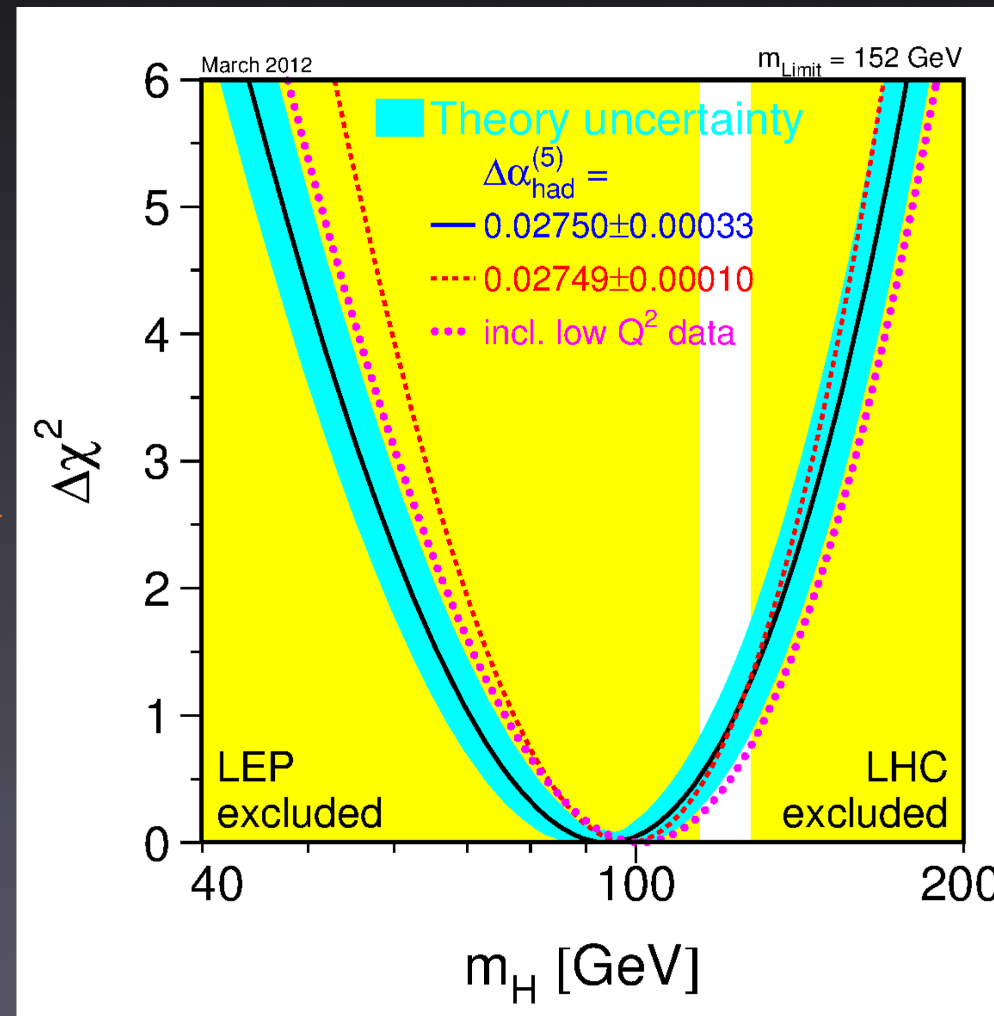




LEP-EWWG Plot from 1993, before Top evidence from the Tevatron.

SM precision constraints the Higgs

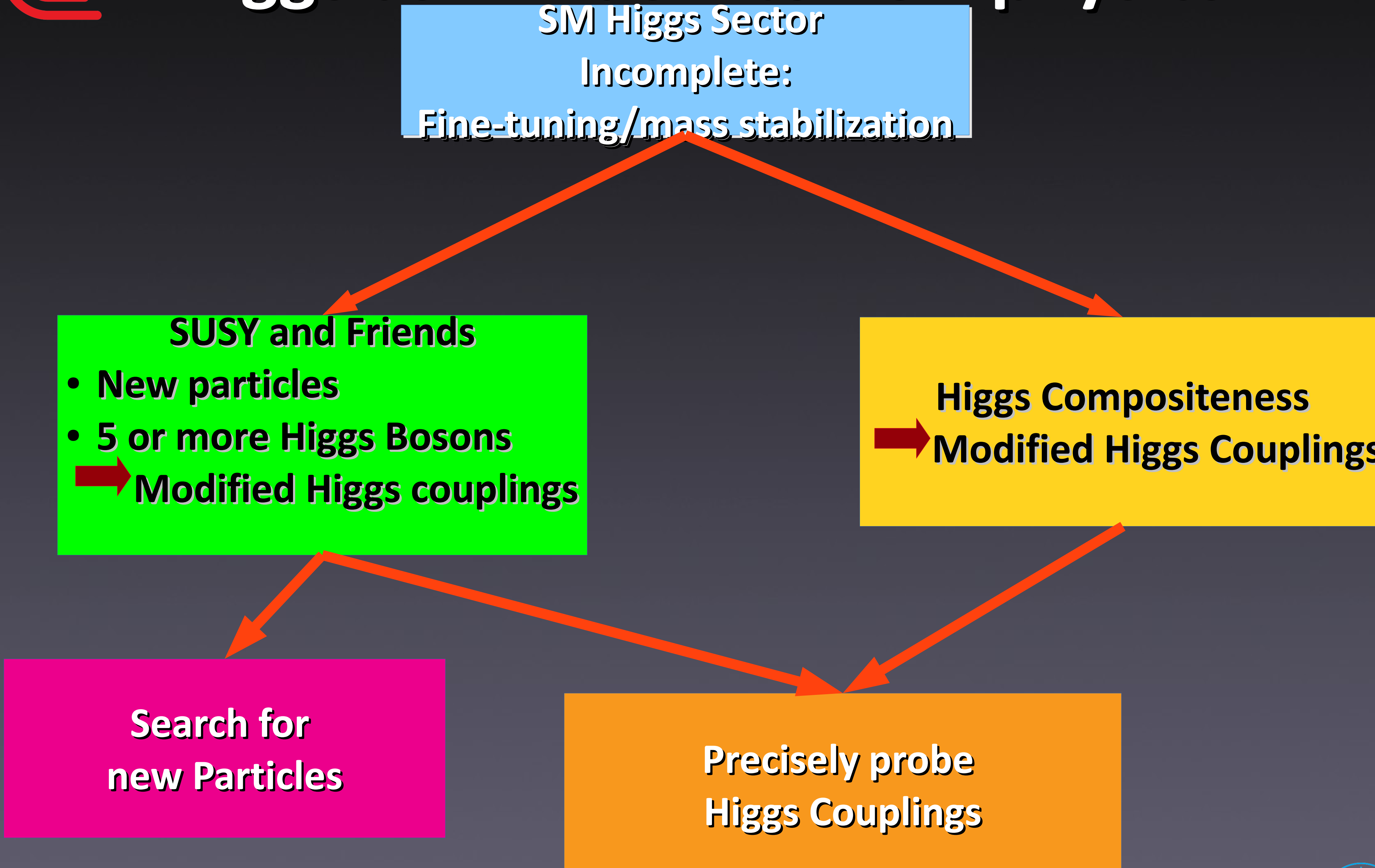




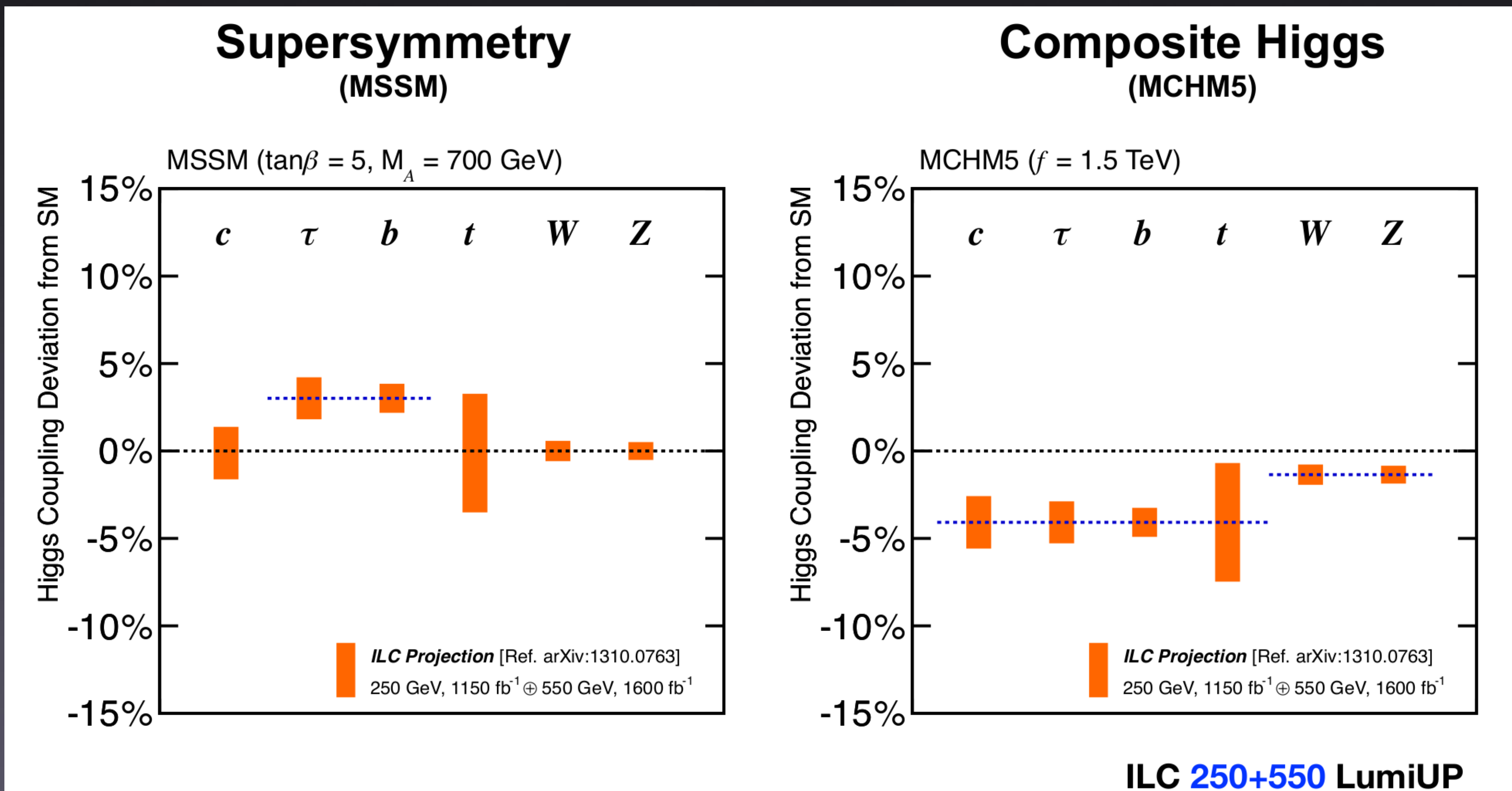
Measurements from LEP (and SLD, Tevatron)

M_H = 94 GeV +29 GeV/- 24 GeV

Higgs as Window to new physics



Probing new physics



Percent-level accuracy on Higgs Couplings essential !

Precision for the Terascale

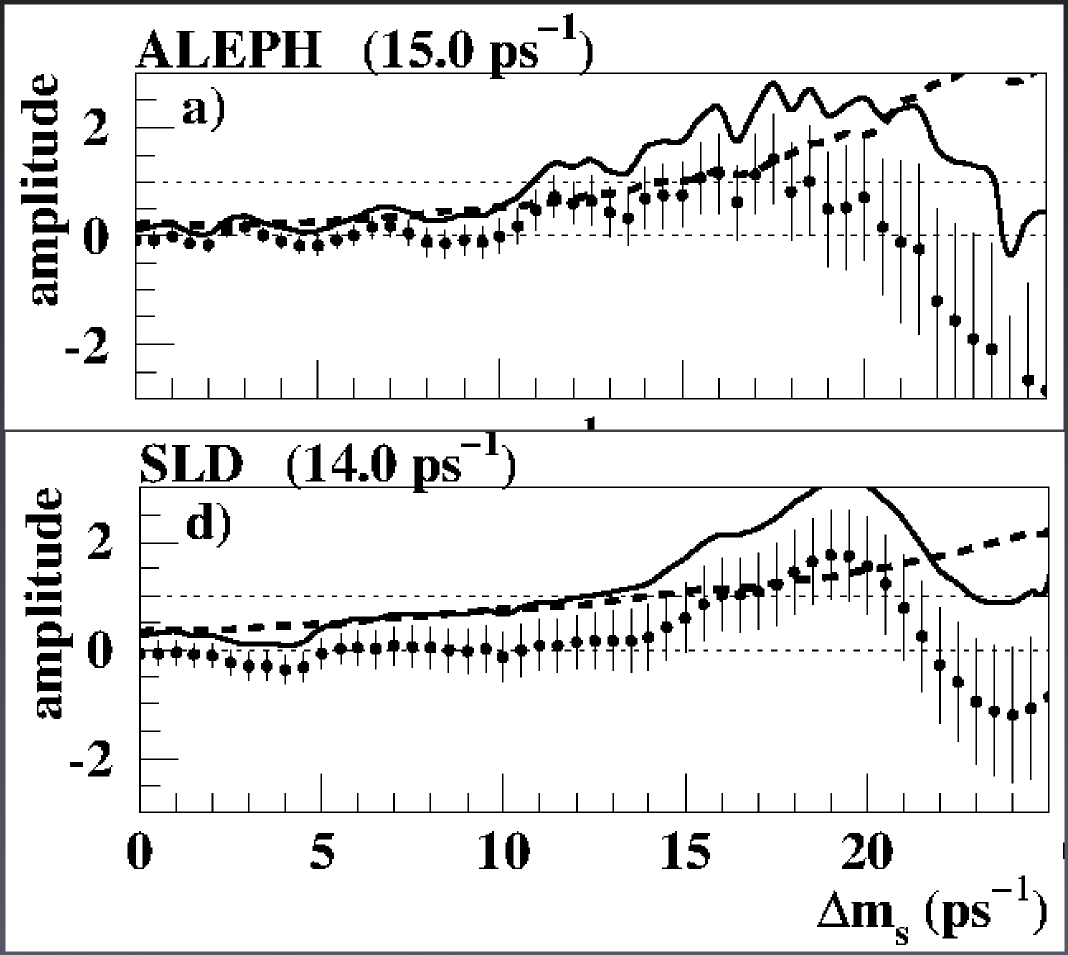
- To complement the LHC/HL-LHC a precision machine is required
  - Only e^+e^- colliders offer the required precision (1%)
- e^+e^- Advantages
  - Well defined initial state and tunable E_{CMS}
  - Clean environment, no QCD backgrounds
  - All background process can be calculated with high precision
  - low radiation environment

Why a Linear Accelerator

- Basic Limitations e^+e^- synchrotons
  - Synchrotron radiation loss ~ E^4/r
  - Synchrotron cost ~ quadratically with Energy (B. Richter 1980)
    - E_{CMS}=~ 200 GeV as upper limit
- A Linear Accelerator offers a clear way to higher energy
  - Not limited by synchrotron radiation
  - Cost ~ linear with Energy
  - Polarization of both beams

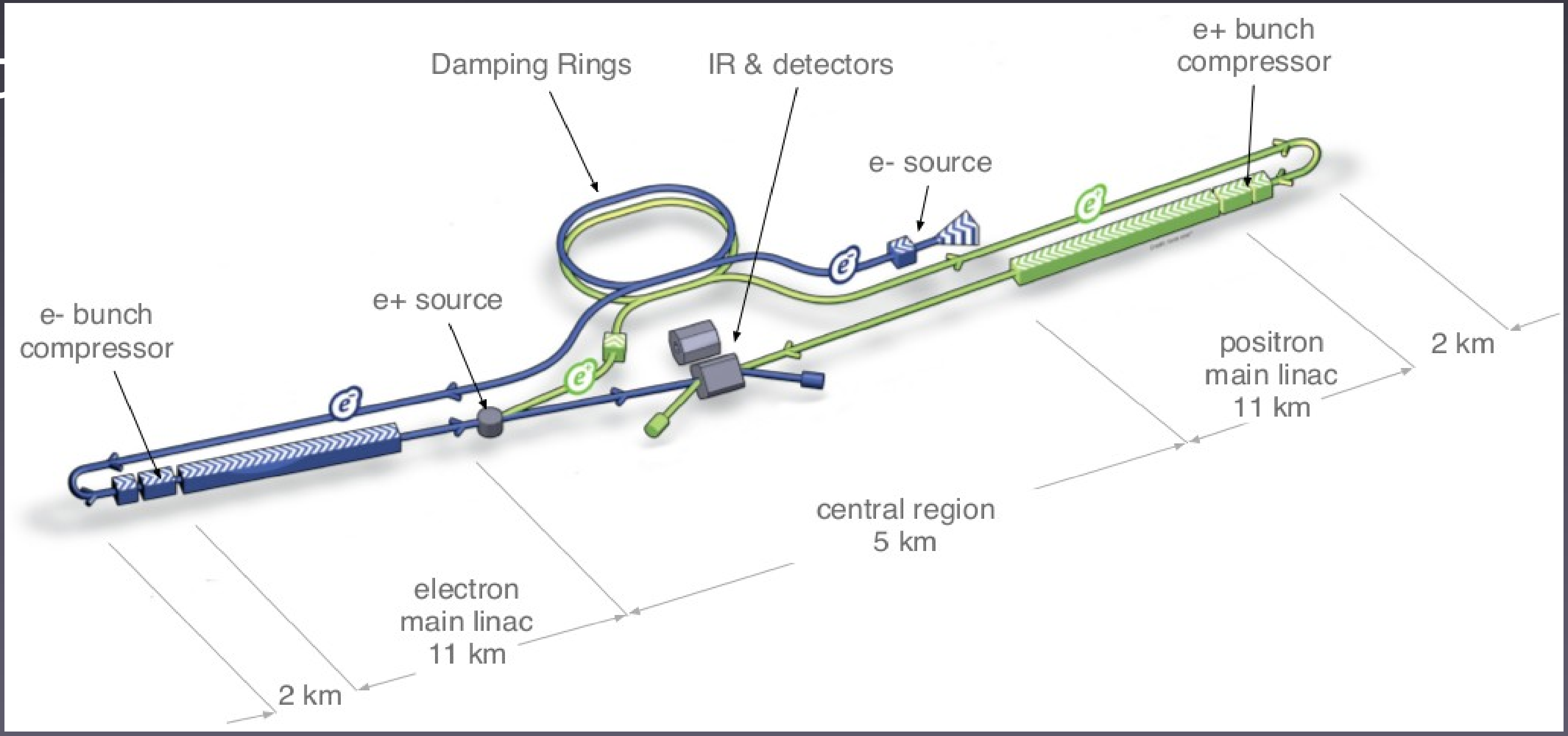
It is not just the luminosity

- B_s Oscillations
- ALEPH (LEP)
  - ~ 6 million Z's
- SLD
  - ~ 300000 Z's
- Main advantage of SLD:
  - Pixel Vertex detector
  - Much closer to the IP



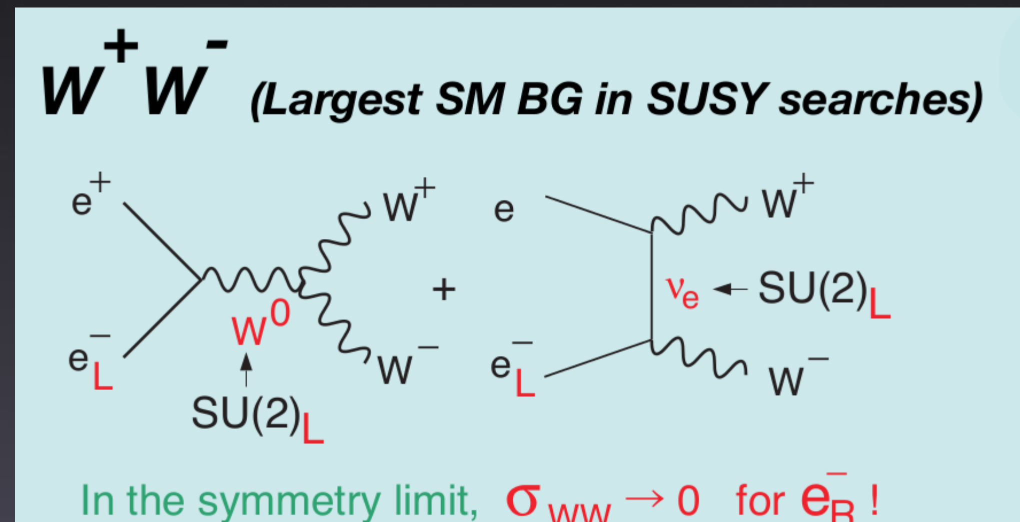
The ILC Project

- The ILC (International Linear Collider)
  - A 500 GeV (baseline) GeV e+e- Linear Collider
  - Upgrade Path to 1 TeV
  - Polarization of both beams
- Int

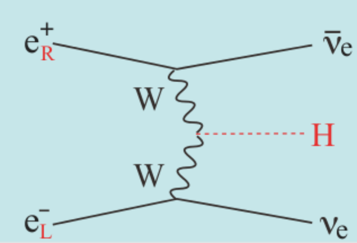


Power of polarization at the ILC

- The ILC offers polarized e^+/e^- beams
- Baseline
  - 80 % polarization for e^-
  - 30 % polarization for e^+
- Upgrades possible
  - 90 % polarization for e^-
  - 60 % polarization for e^+
- Unique capabilities
  - Controlling Backgrounds

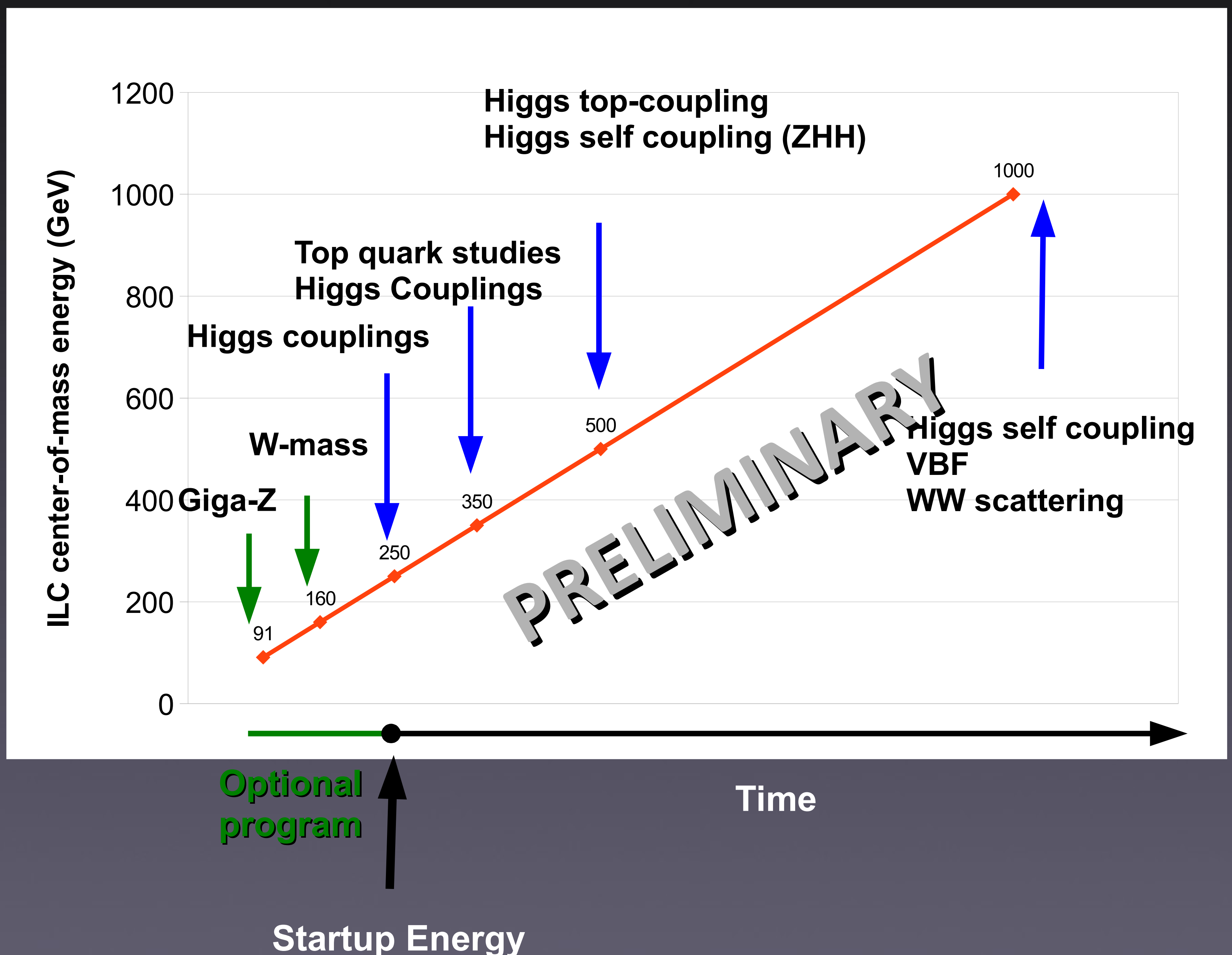


WW-fusion Higgs Prod.

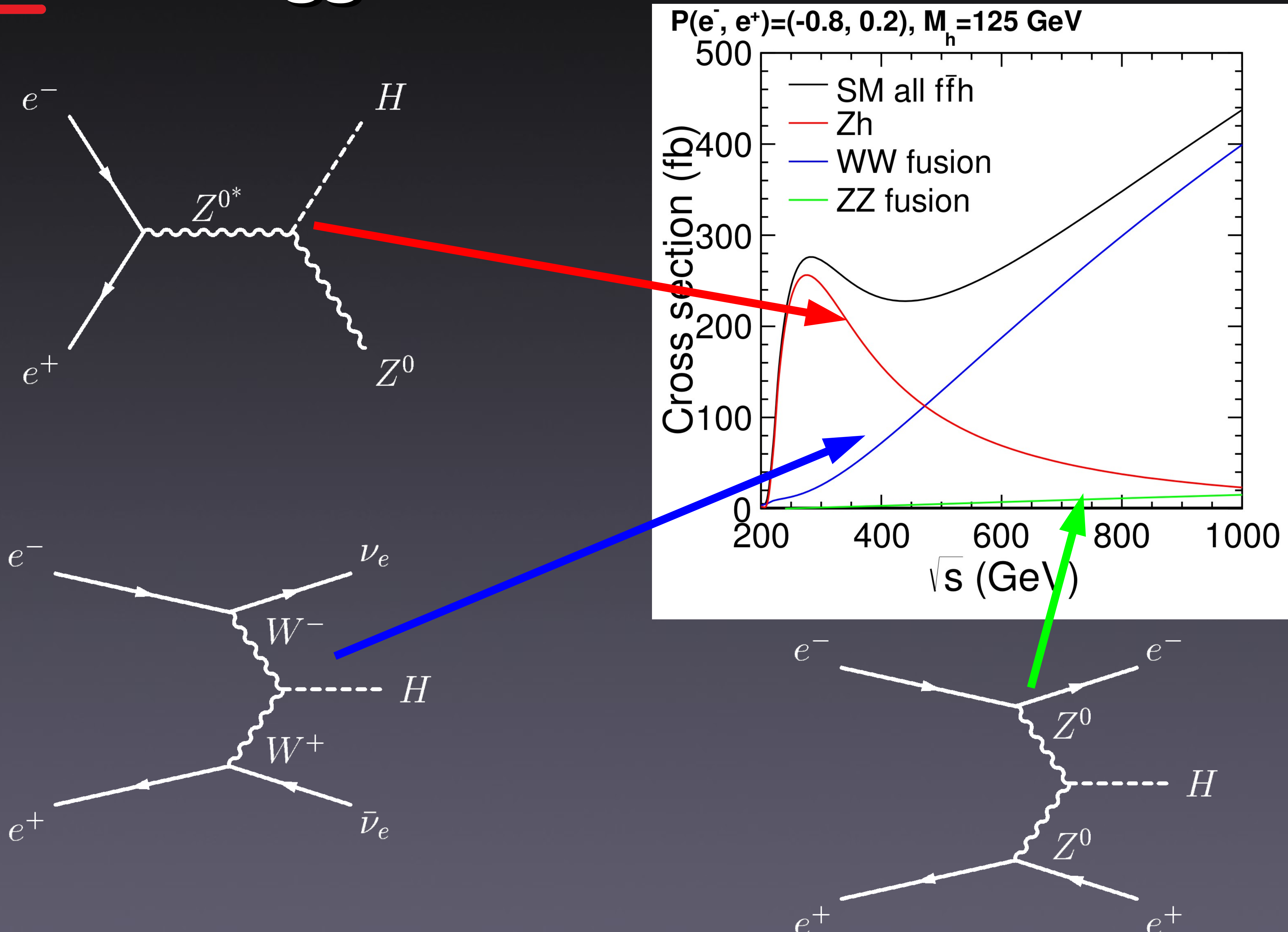


[redacted]	ILC
[redacted]	-0.8
[redacted]	+0.3
(σ/σ	1.8x1.3=2.34

ILC physics program

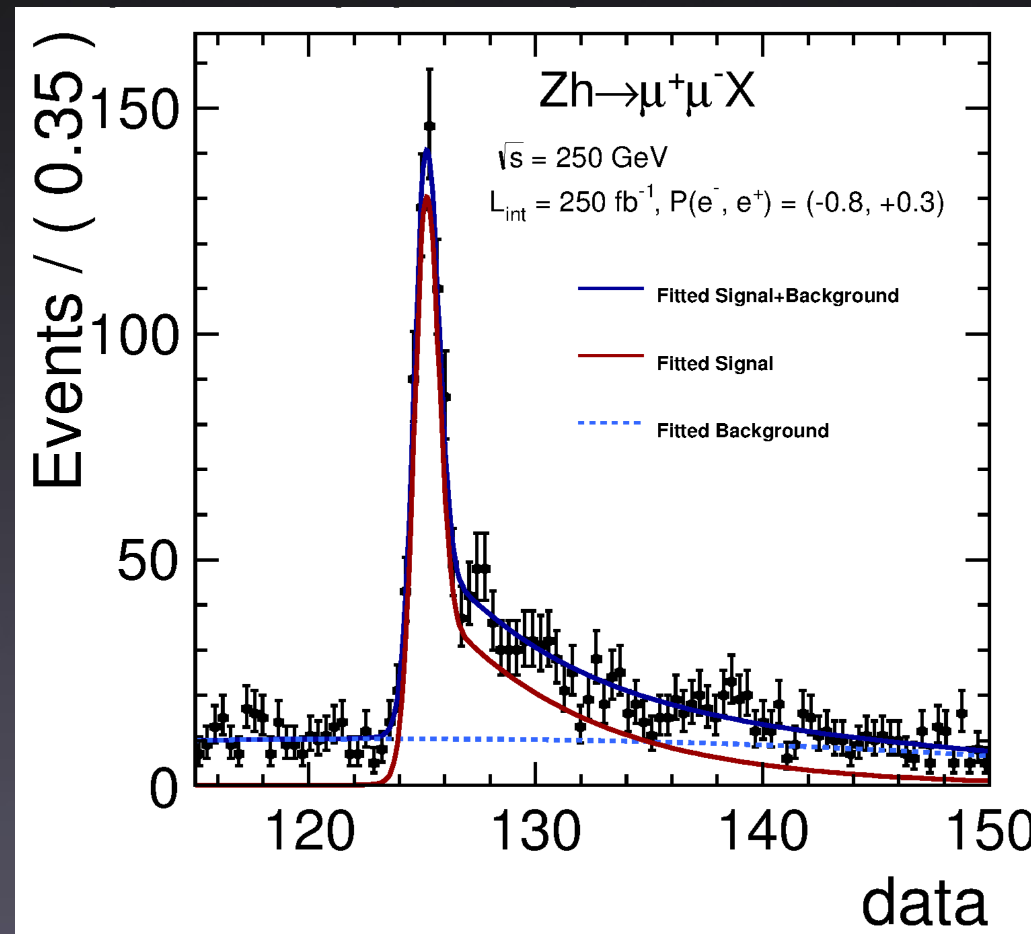


Higgs Production at the ILC



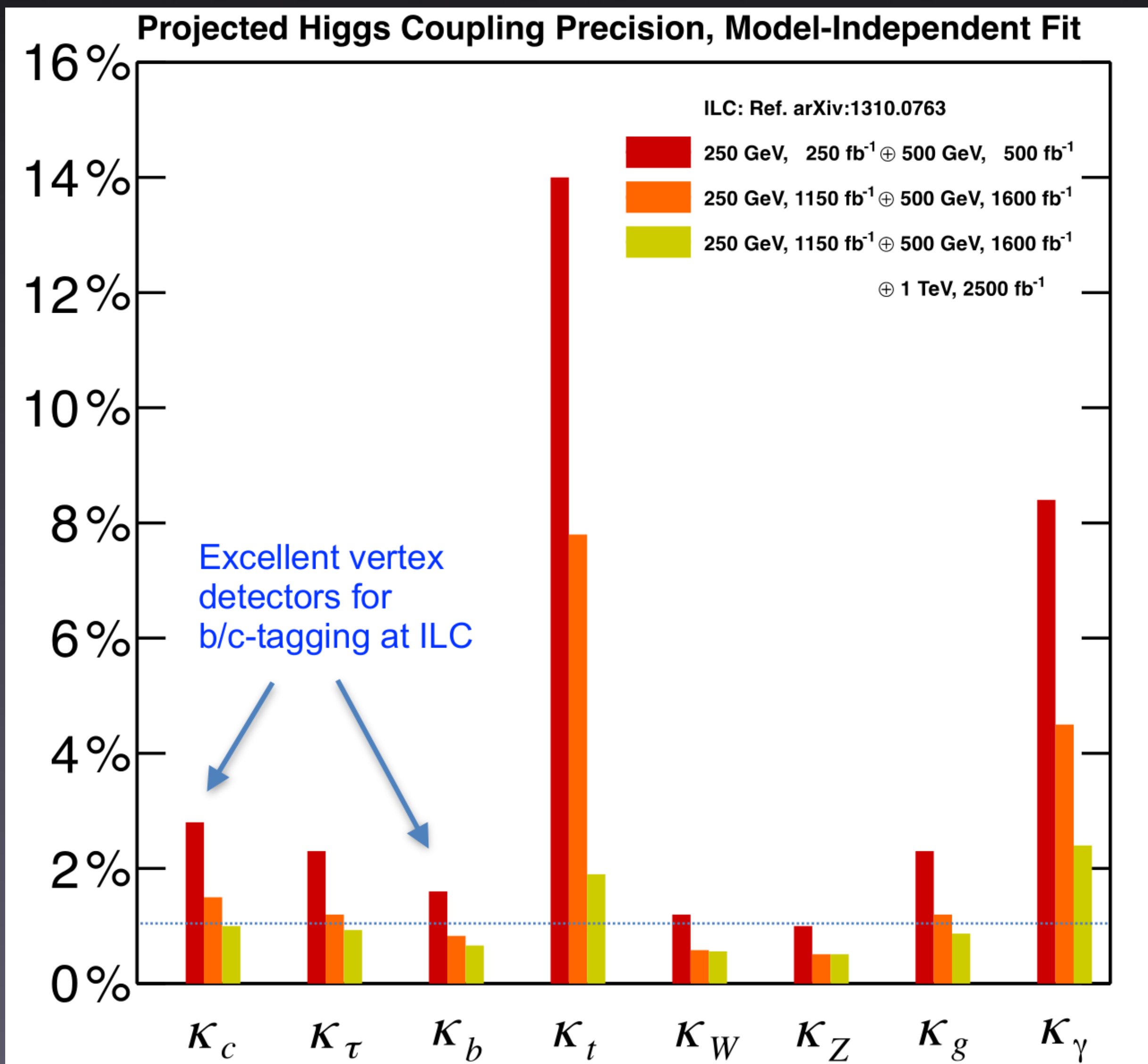
Higgs physics at the ILC

- ILC will do everything the LHC/HL-LHC does
  - Couplings, Mass, Spin
- ILC does Model-independent measurements
- Unique at the ILC
  - Total Higgs Width
  - $H \rightarrow c\bar{c}/gg$
- Higgs-Selfcoupling
  - ILC will establish its



Model-independent Measurement of σ_{HZ} at 250 GeV

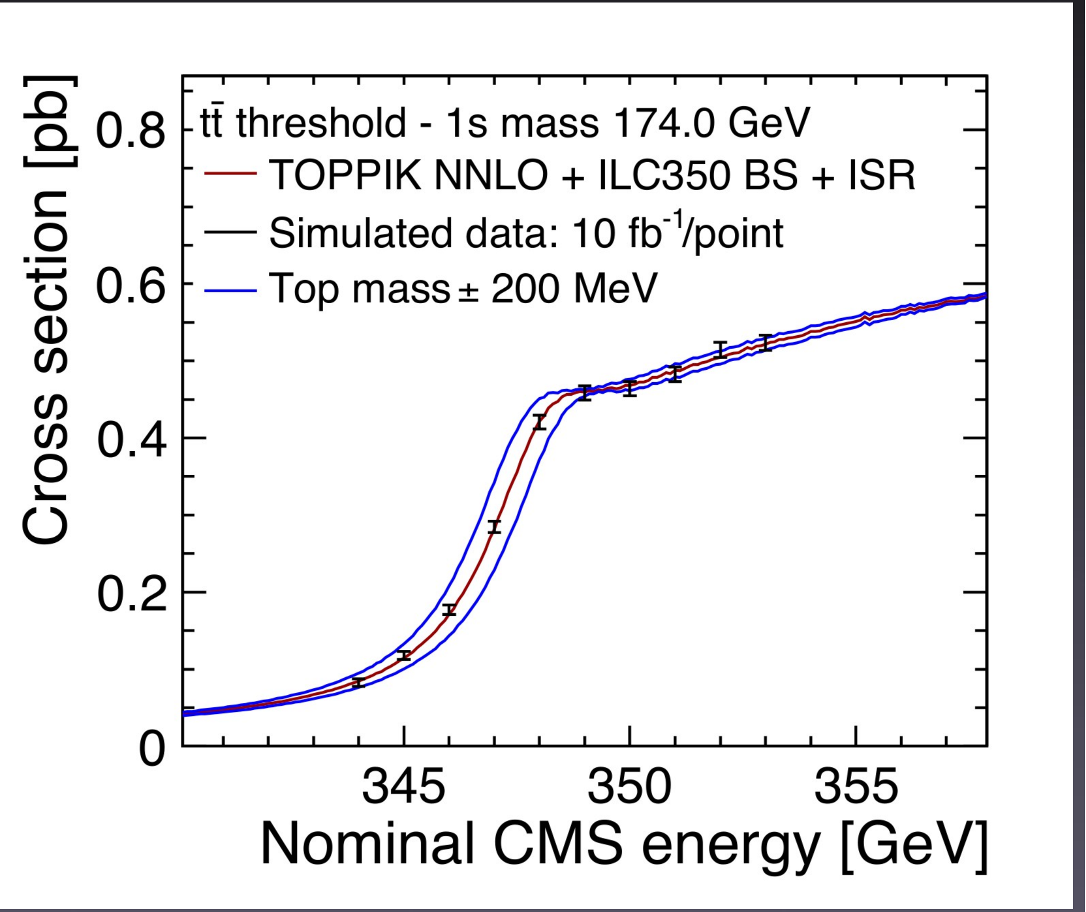
ILC BR Measurements



- Most couplings
  - Approaching 1% accuracy
- Derived in a model-independent way
- Accuracy on top-coupling
  - Improves with higher E_{CMS}
- H→γγ

ILC – A Top Factory

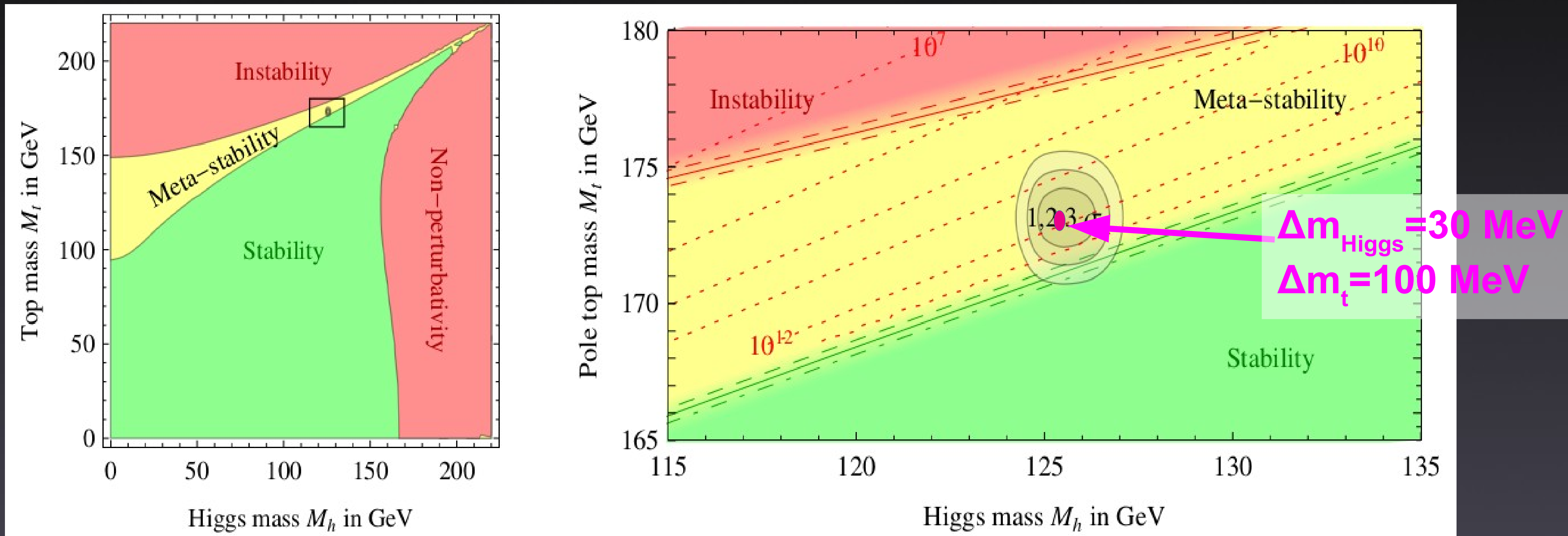
- Top Threshold scans
  - $\Delta m_{top} < 40$ MeV
- Conversion to $\overline{\text{MS}}$ scheme
  - Measured top mass at ILC can easily be converted to $\overline{\text{MS}}$ mass
  - This yields an total error of $\Delta m_{top} \sim 100$ MeV
  - Theory/ α_s limited



Top as a window to new physics

- Probing the $t\bar{t}Z$ and $t\bar{t}\gamma$ Vertices at the ILC with high precision
- This allows also access to $(g-2)_t$
  - Currently almost unconstrained
  - $(g-2)_t \sim m_t/M$
  - M being the compositeness-scale
  - Expected ILC accuracy of 0.1%
- ILC probes compositeness up to 100 TeV

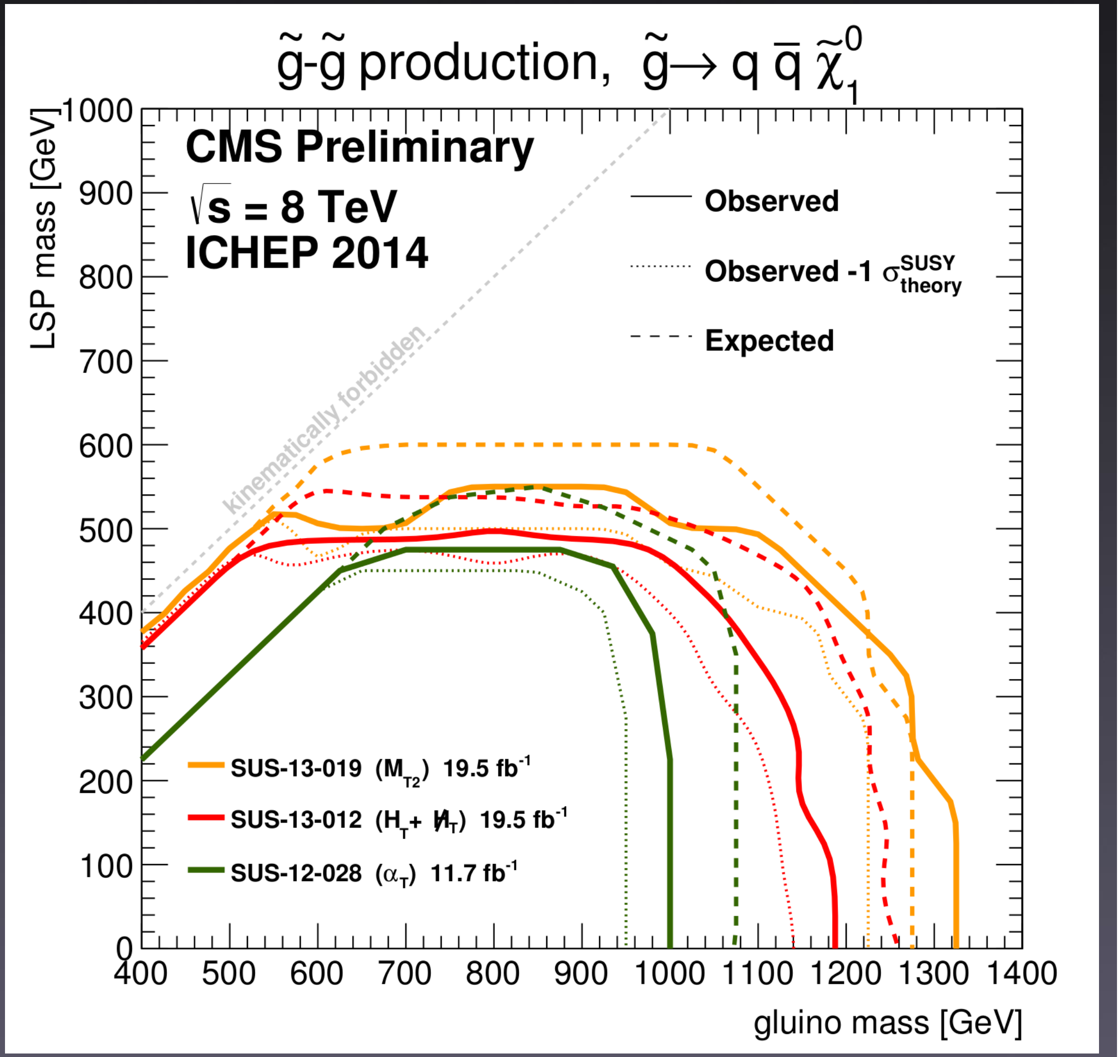
Probing SM Vacuum Stability



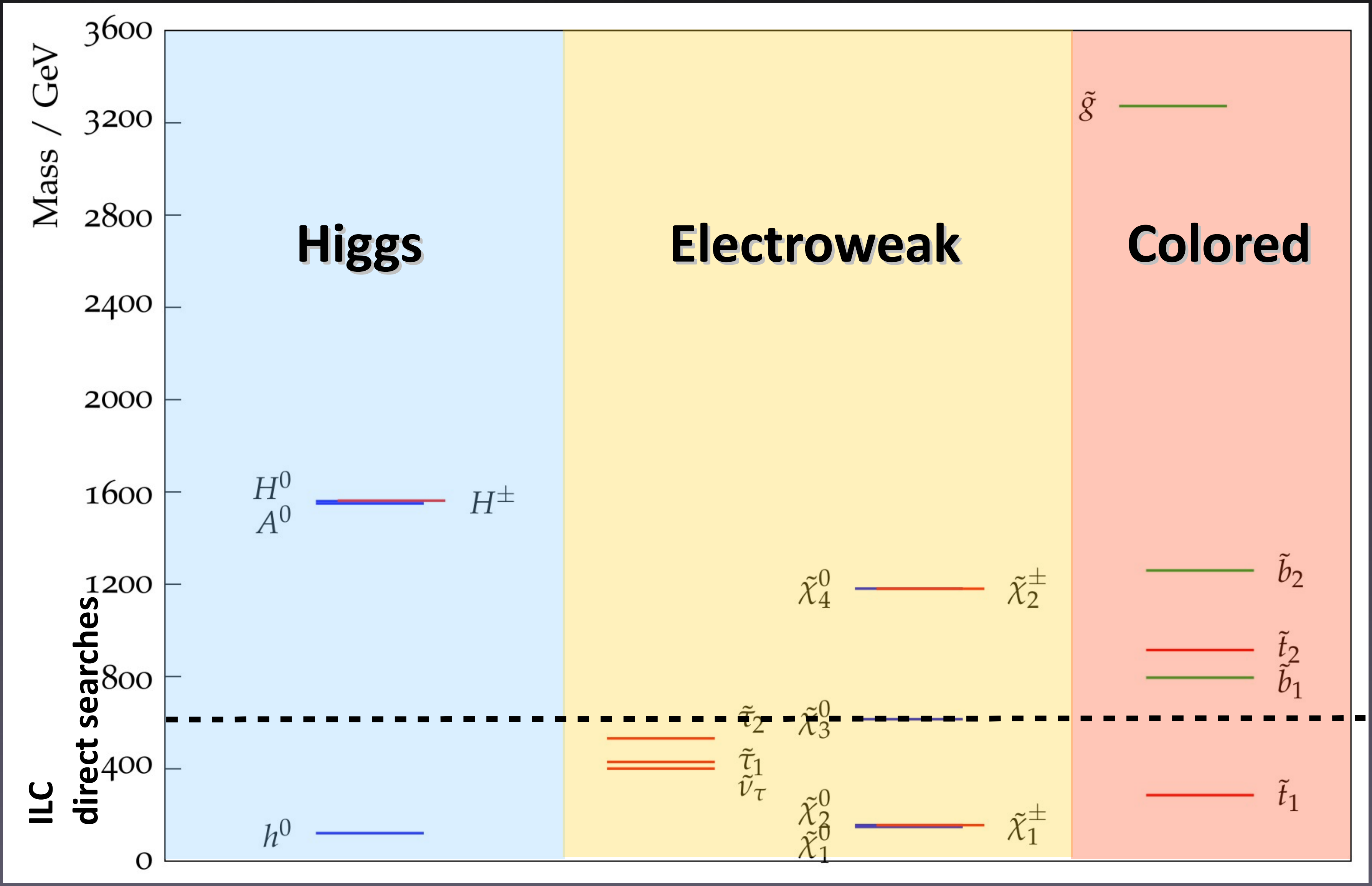
- m_{Higgs}=125 GeV (LHC)
  - Quite close to the minimum M_{Higgs} value that ensures absolute vacuum stability within the Standard Model
- Current measurements indicate we're in a meta-stable universe
- ILC will settle this question

In Search for Supersymmetry

- Supersymmetry (SUSY)
  - Still very popular
  - Comes in many flavors
- Rich SUSY spectrum expected at the TeV scale
- Direct Searches at the LHC
  - No evidence so far
  - Limits for colored SUSY

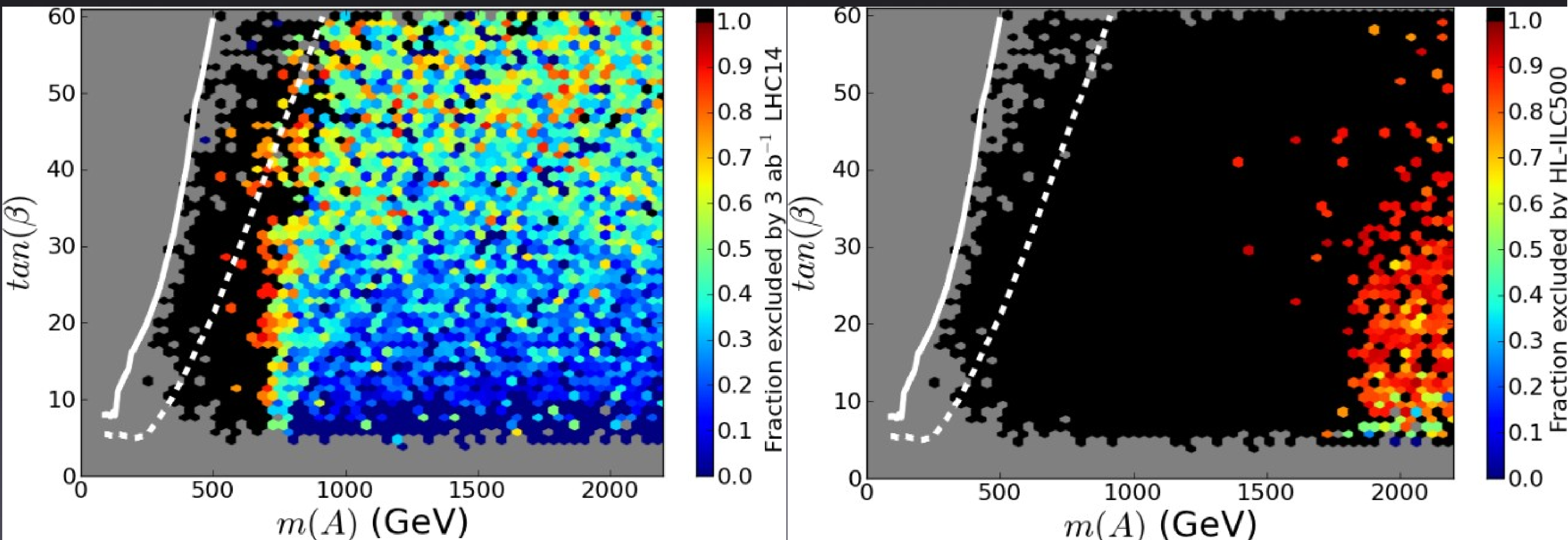


A potential SUSY spectrum



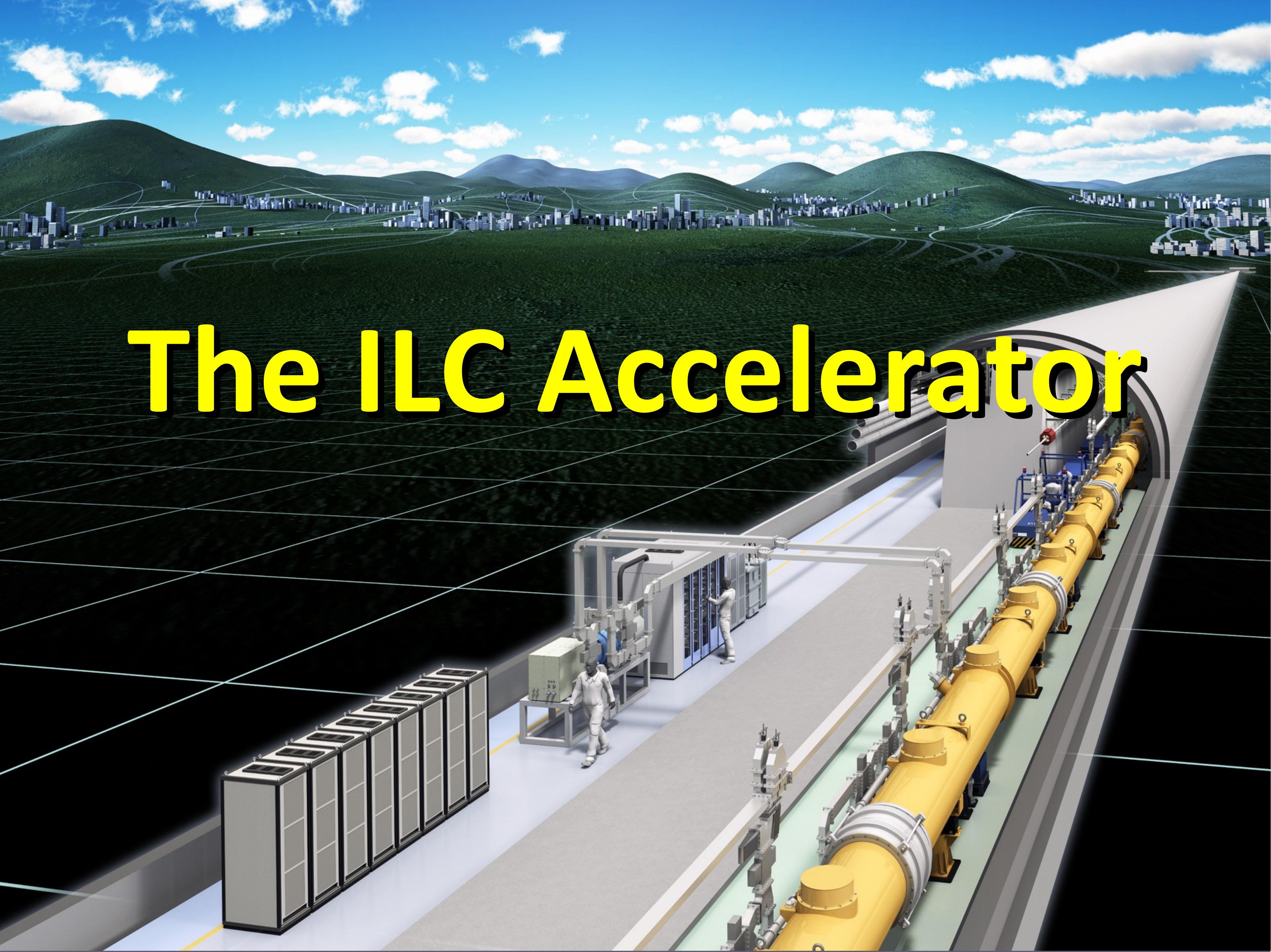
What's left for the ILC

HL-LHC **ILC**



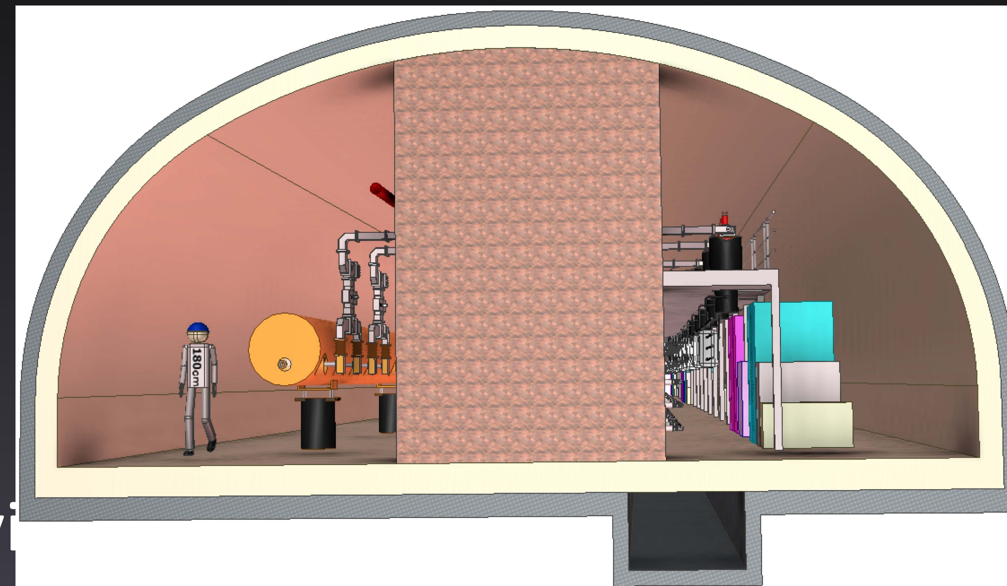
- For the pMSSM
  - A lot of room left even after HL-LHC
- ILC is required to exclude the parameter space or it will discover SUSY, even if HL-LHC does not

The ILC Accelerator



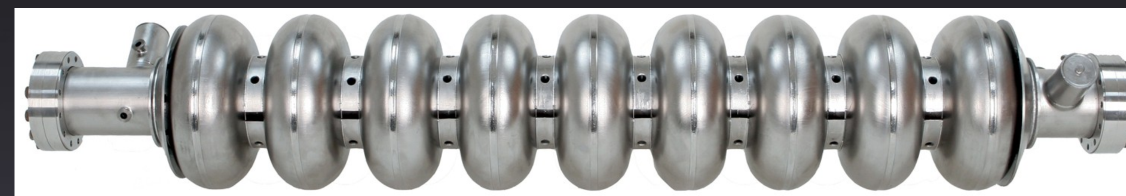
The ILC Machine

- 500 GeV Linear collider
  - 31 km long
- Acceleration
  - 7400 superconducting Cavi
    in
    850 Cryo Modules
  - Gradient 31.5 MV/m
  - 1.3 GHz RF
  - 163 MW power consumpti
- Beam parameters
  - $2x10^{10}$ particles/bunch

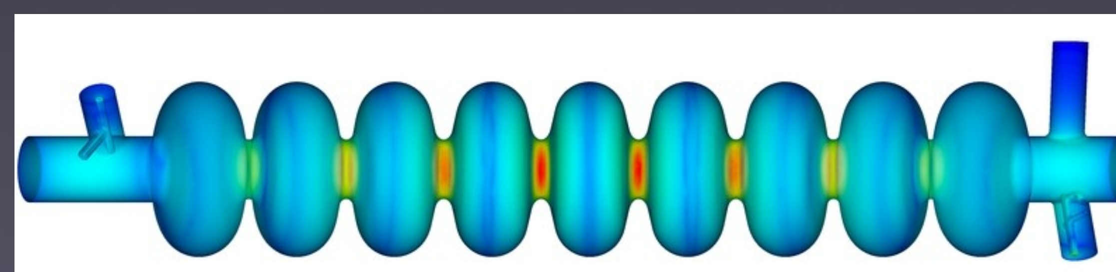


Why going cold?

- High RF ->Beam-power efficiency
  - low-loss cavities



- Ease of RF power generation
  - low frequency (1.3 GHz)
  - Long pulse / fill time (1 ms / 0.6 ms)



- Emittance preservation
  - Large cavity iris

TDR Machine parameters

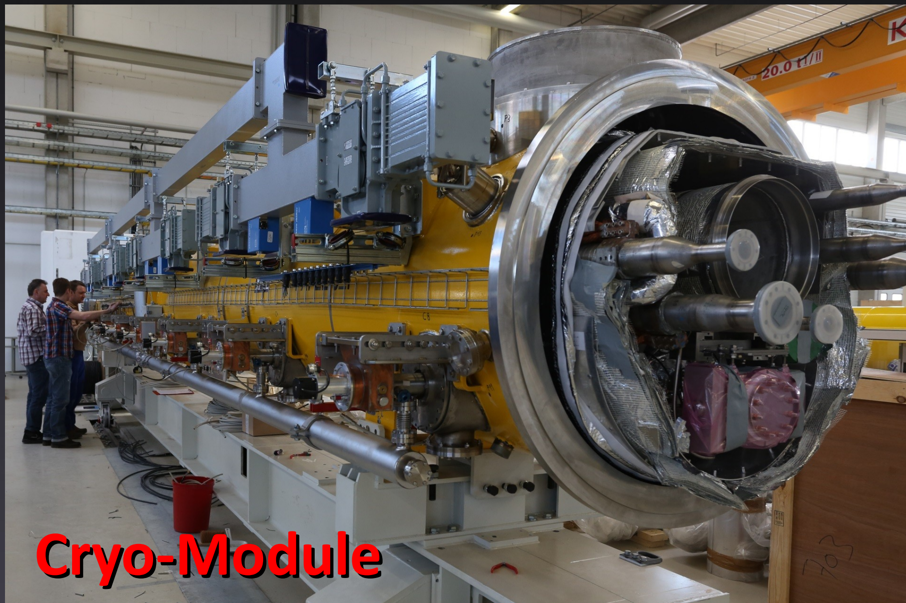
			Baseline 500 GeV Machine			1st Stage	L Upgrade	E_{CM} Upgrade	
Centre-of-mass energy	**E_{CM}**	**GeV**	**250**	**350**	**500**	**250**	**500**	**A 1000**	**B 1000**
Collision rate	f_{rep}	Hz	5	5	5	5	5	4	4
Electron linac rate	f_{linac}	Hz	10	5	5	10	5	4	4
Number of bunches	nb		1312	1312	1312	1312	2625	2450	2450
Bunch population	N	$\times 10^{10}$	2.0	2.0	2.0	2.0	2.0	1.74	1.74
Bunch separation	$\Delta t b$	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	$\sigma_x *$	nm	729.0	683.5	474	729	474	481	335
IP RMS veritcal beam size	$\sigma_y *$	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

The European XFEL

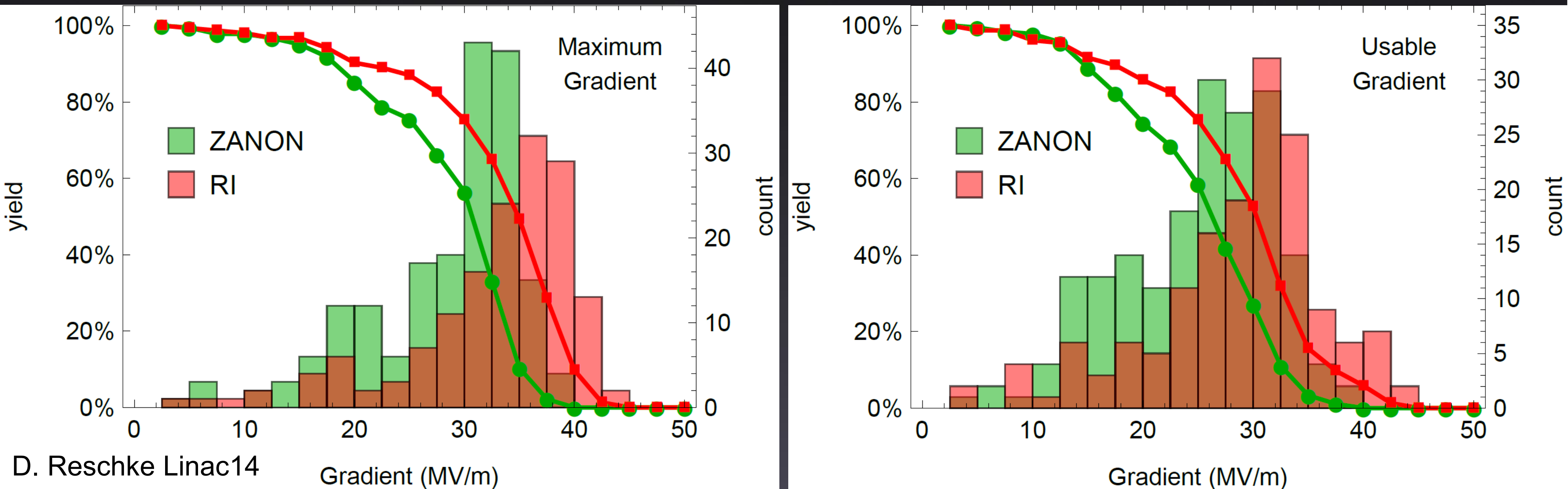
- Free Electron Laser
  - Photon energy 0.3 - 24 keV
  - Pulse duration ~ 10 - 100 fs
  - Pulse energy few mJ
- Superconducting linac. 17.5 GeV
  - 10 Hz (27 000 b/s)
- 5 beam lines / 10 instruments

The European XFEL
Built by Research Institutes from 12 European Nations

European XFEL Construction



Cavity Status



D. Reschke Linac14

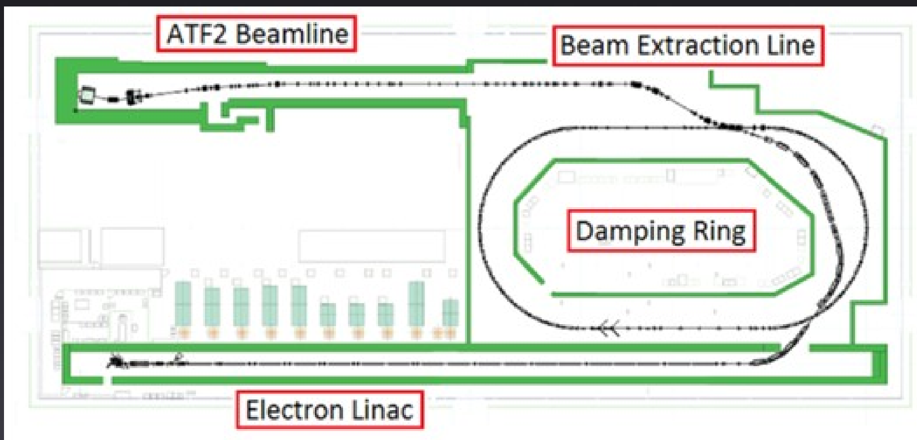
	Tests	Maximum E_{acc} [MV/m]	Usable E_{acc} [MV/m]
Total	339	30.4 ± 7.6	26.6 ± 7.6
EZ	185	28.4 ± 7.1	24.8 ± 7.0
RI	154	32.4 ± 7.6	28.6 ± 7.9

Close to ILC-Style production

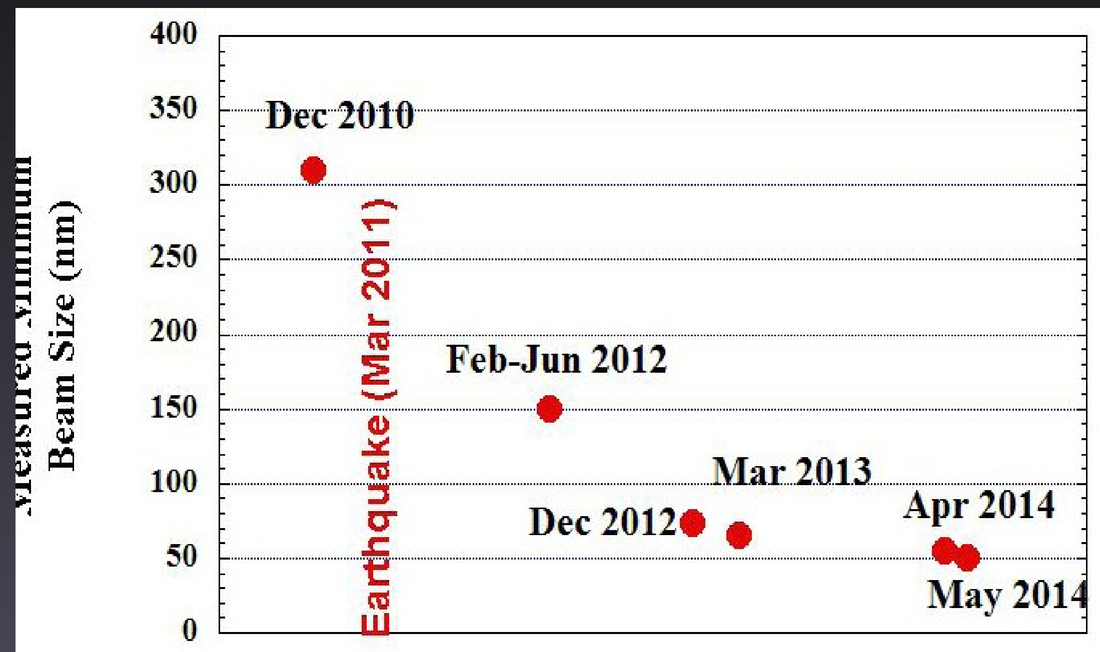
ILC requires 31.5 MV/m

XFEL = a 1/10 ILC Prototype TODAY

Achieving Beamspot sizes

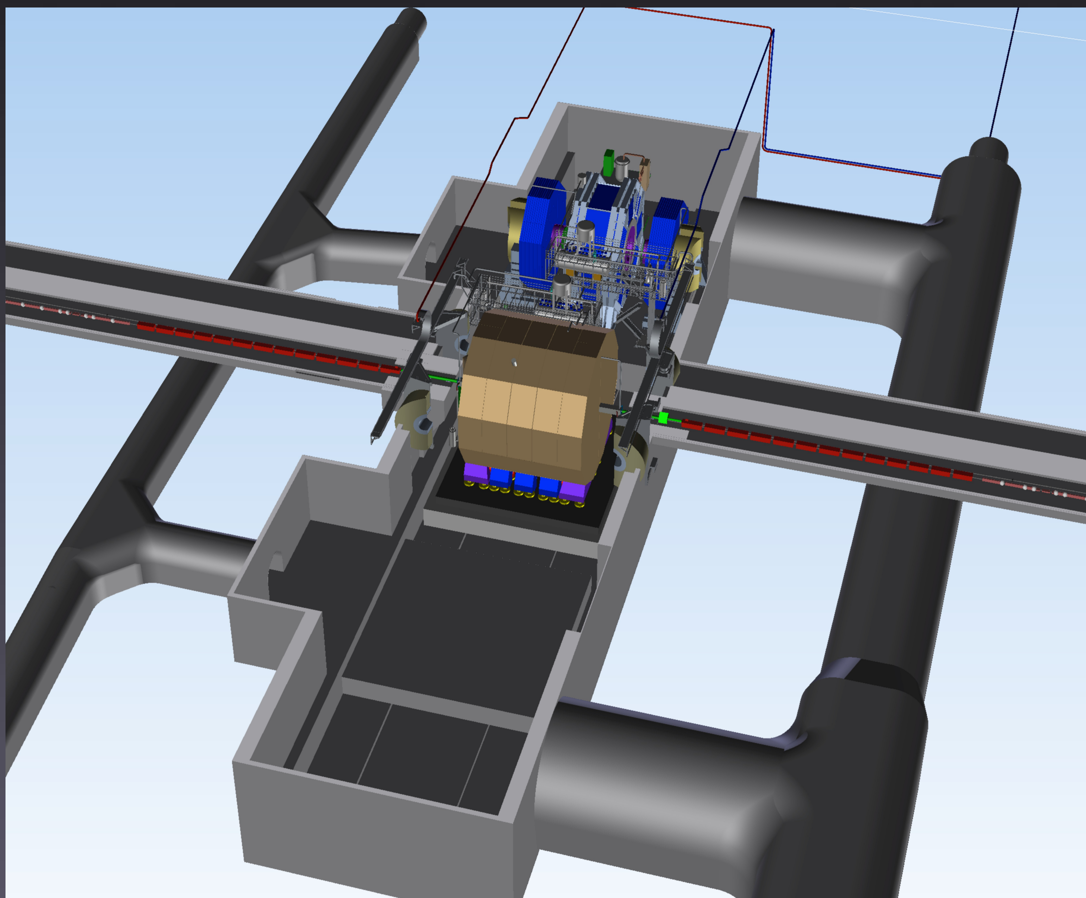


ATF2 Test Facility at KEK



- World Record : 44 nm beam spot size
  - Design goal 37 nm (~ ILC specifications)
- Reproducibility
  - ~32 hrs recovery from 3 wk shutdown
  - ~16 hrs recovery from weekend beam off

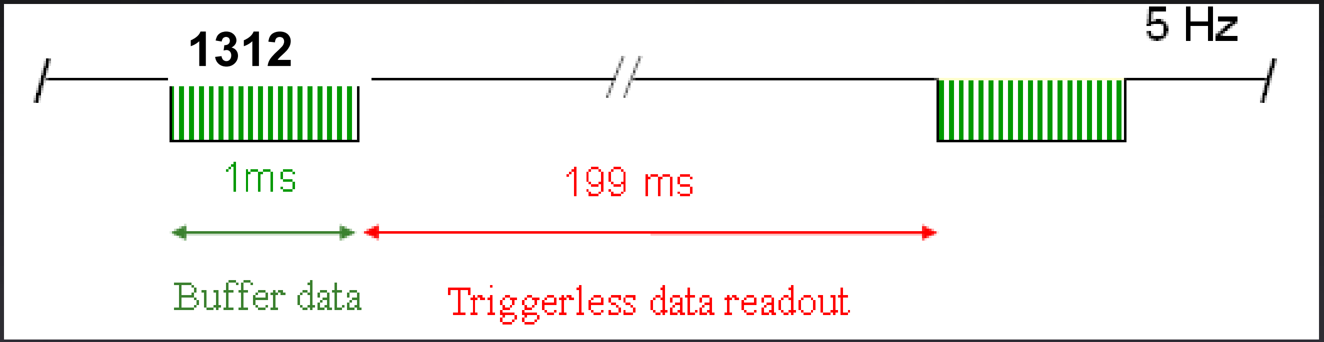
ILC Interaction Region



- ILC
  - 1 Interaction Region
  - 2 Detectors
- Push-Pull
  - Detectors mounted on movable platforms
  - Sharing of beam time
  - Switching time ~ 48 hours
- Push-Pull allows

The ILC Detectors

ILC Environment

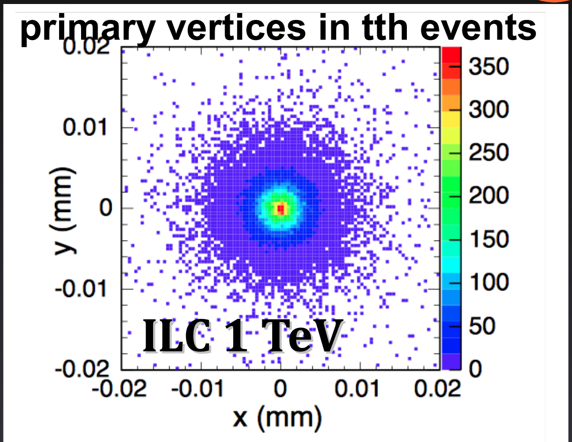


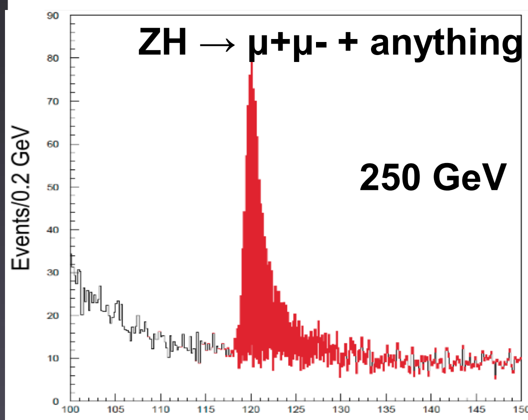
- ILC environment is very different compared to LHC
  - Bunch spacing of ~ 554 ns (baseline)
  - 1312 bunches in 1 ms
  - 199 ms quiet time
- Occupancy dominated by beam background & noise
  - ~ 1 hadronic Z ($e^+e^- \rightarrow Z \rightarrow q\bar{q}$) per train ...
- Readout during quiet time possible

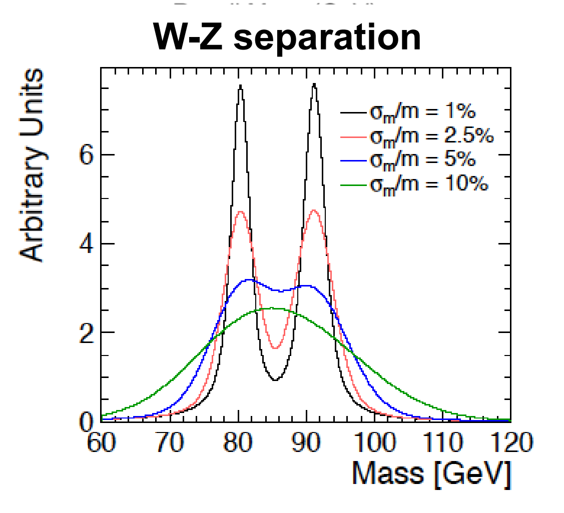
ILC Detector Requirements

- Exceptional precision& time stamping
  - Single Bunch resolution
- Vertex detector
  - ≲ 4 μm precision
  - $\sigma_{r\phi} \approx 5\ \mu m \oplus 10\ \mu m / p \sin^{(\frac{3}{2})}(\theta)$
- Tracker
  - $\sigma(1/p) \sim 2.5 \times 10^{-5}$
- Calorimeter

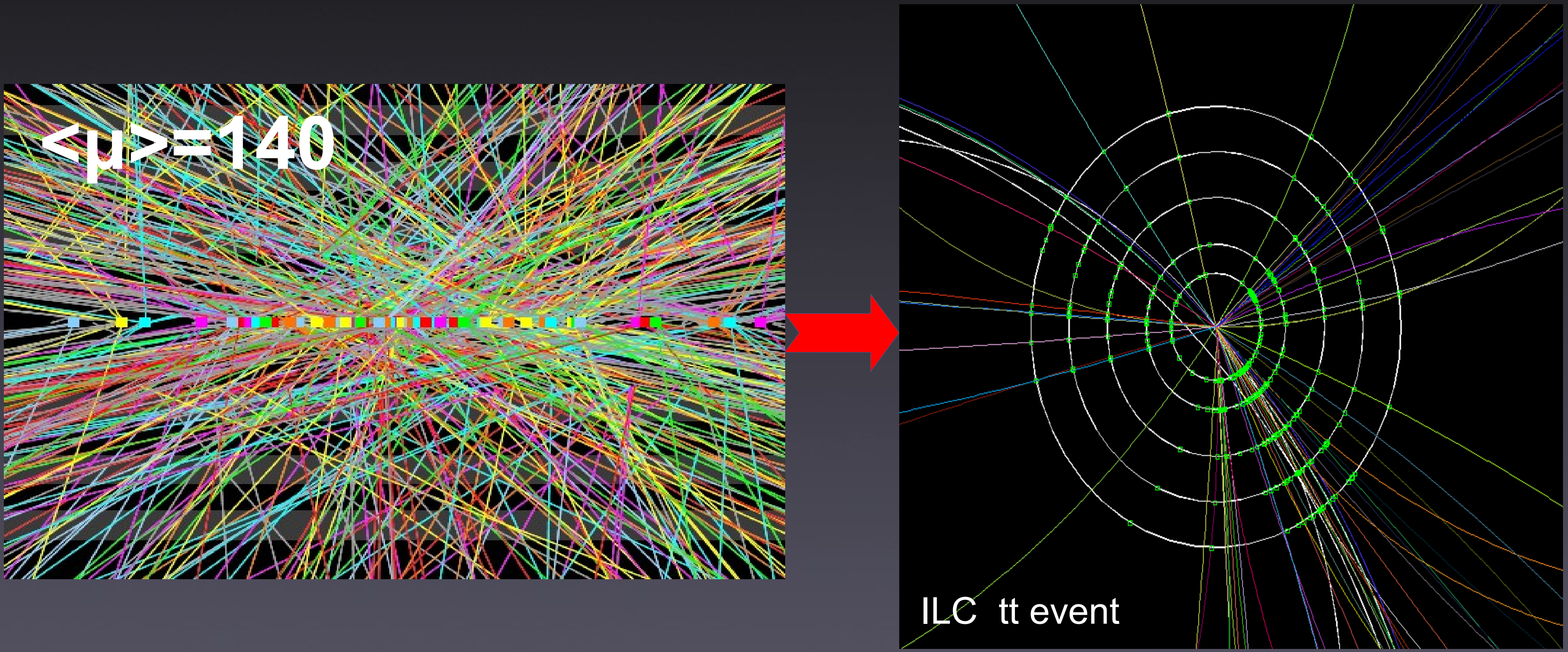
$$\frac{\sigma_{E_{Jet}}}{E_{Jet}} = 3-4\%, E_{Jet} > 100\ GeV$$







From HL-LHC to ILC

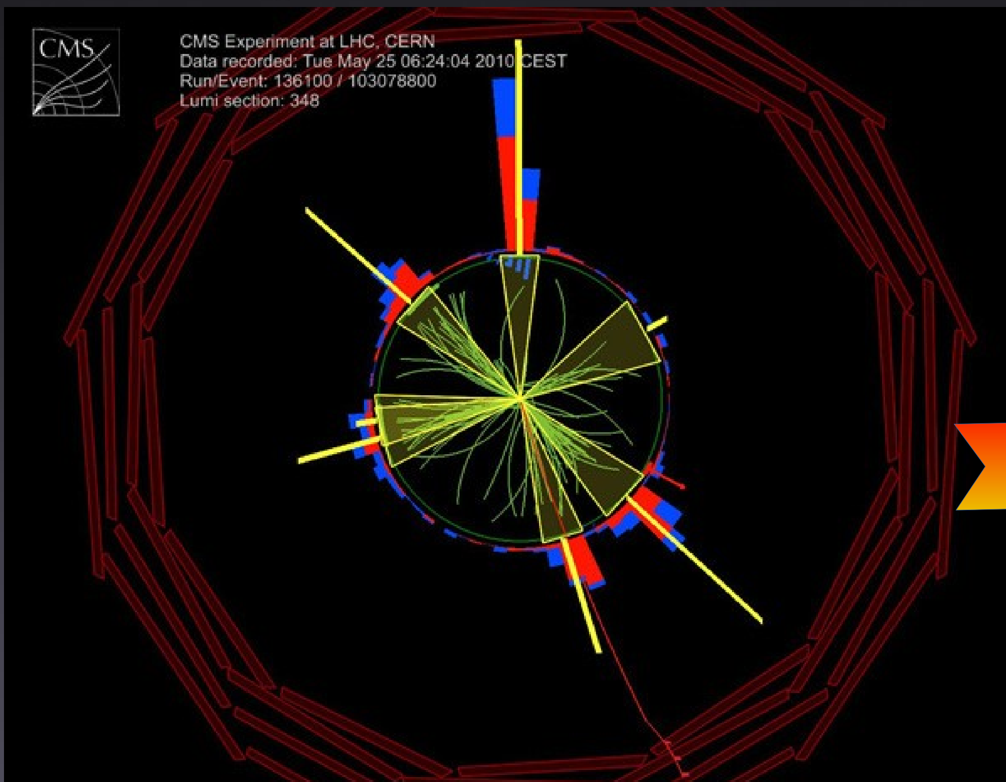


Moving from 140 interactions per crossing to ~1 event/train

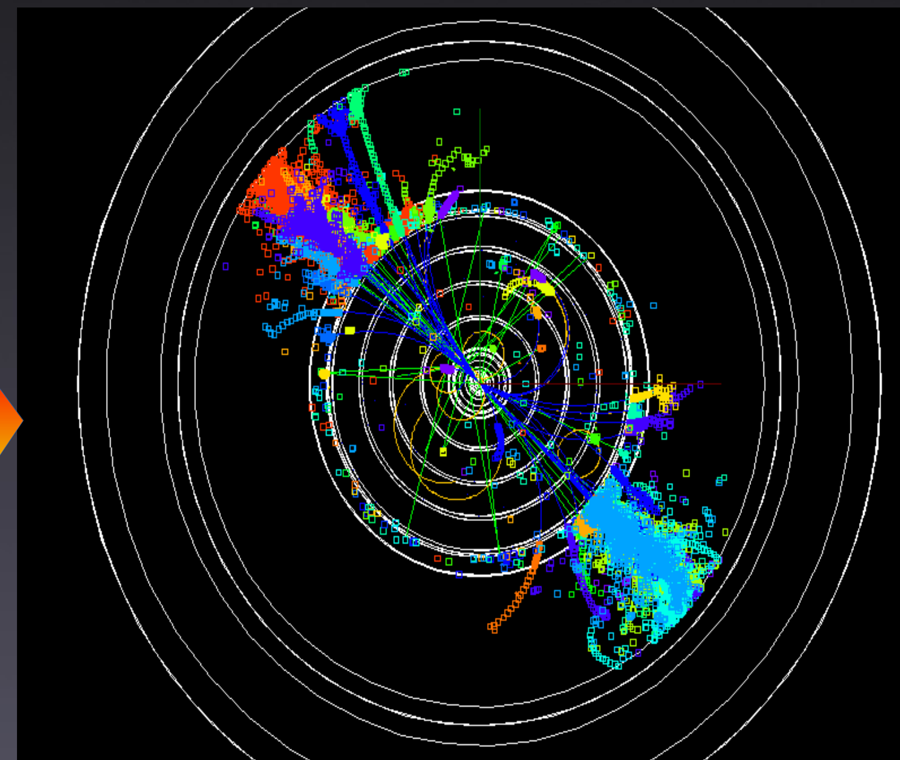
The PFA Approach

- PFA = Particle Flow Algorithm
- Combining all available reconstruction information
  - Momentum (Tracker), Energy (Calorimetry), Particle type (PID)
  - Reconstruction of each particle's four-vector
- Key ideas
  - Charged particles : Tracking resolution >> Calorimetry
  - Typical Jet :
    - 60 % charged particles, 30 % photons, 10% neutrals
- PFA is key to desired Jet Energy Resolution

Calorimetry from LHC to ILC



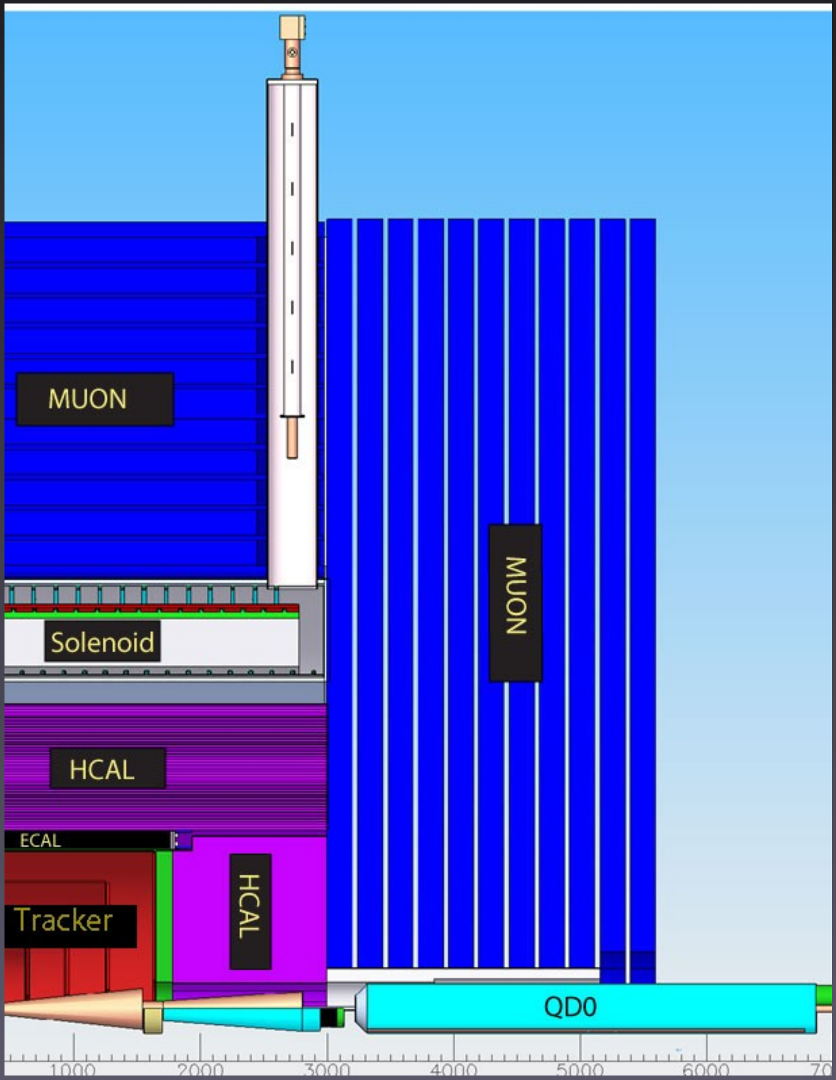
LHC Today



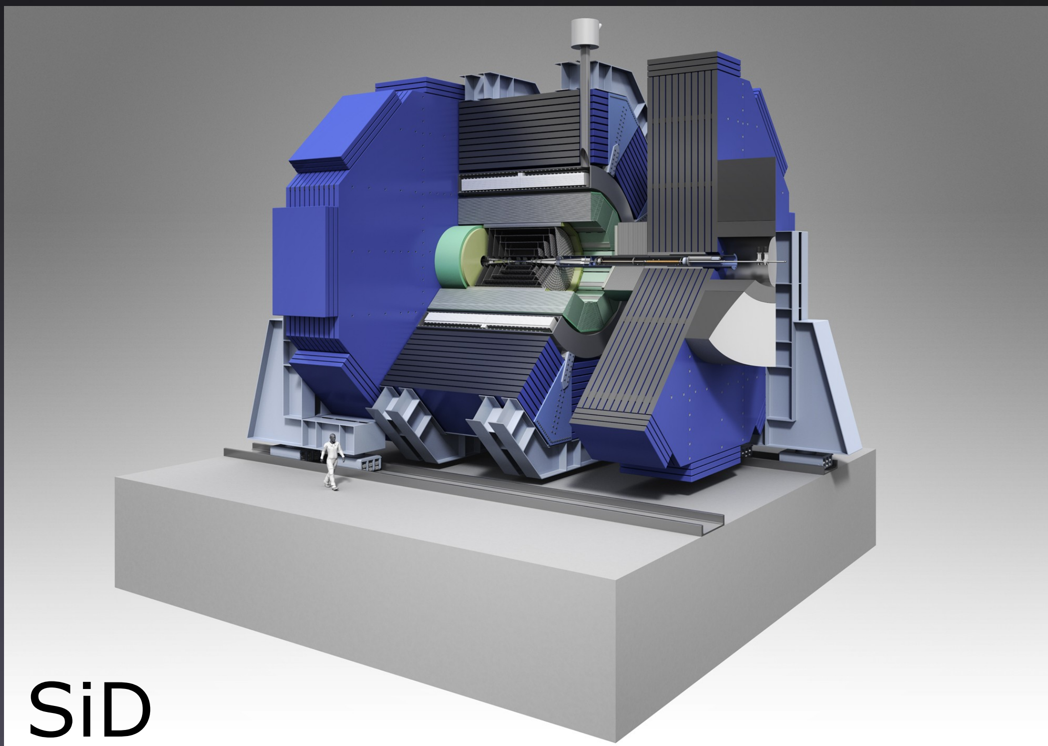
ILC

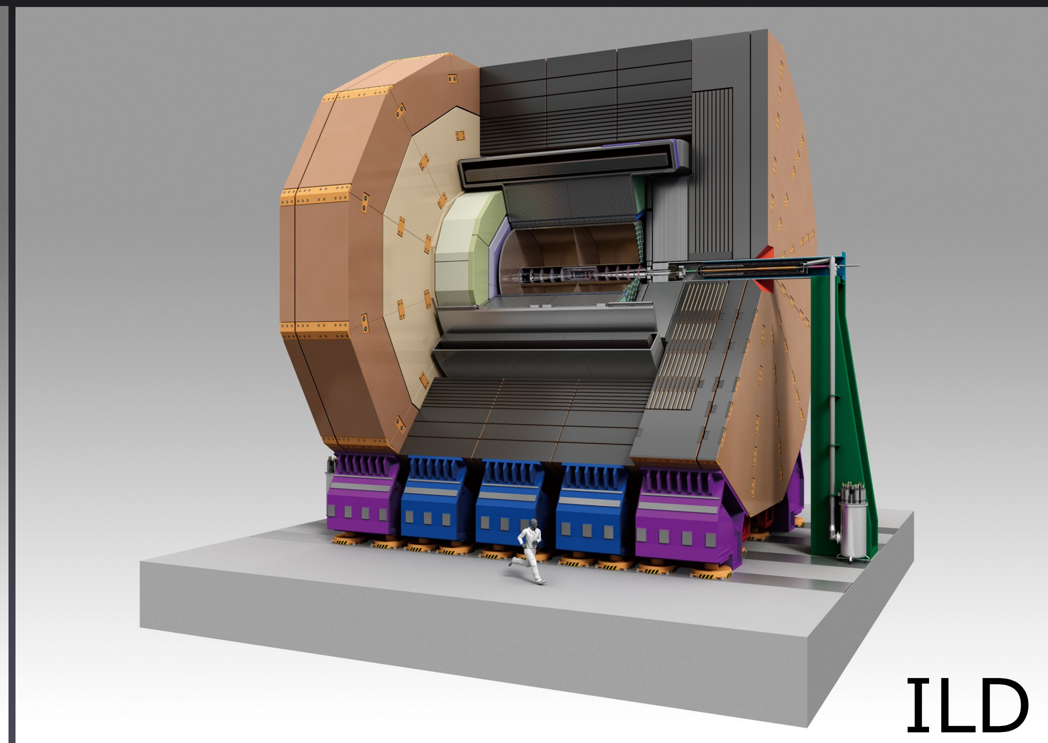
ILC Detectors

- PFA has been used at LEP, HERA and LHC
- Novel Approach at the ILC
  - PFA drives design of the detector
- Consequences
  - Calorimetry inside the Solenoid
  - Highly Granular Calorimetry
  - Low mass tracking



SiD & ILD





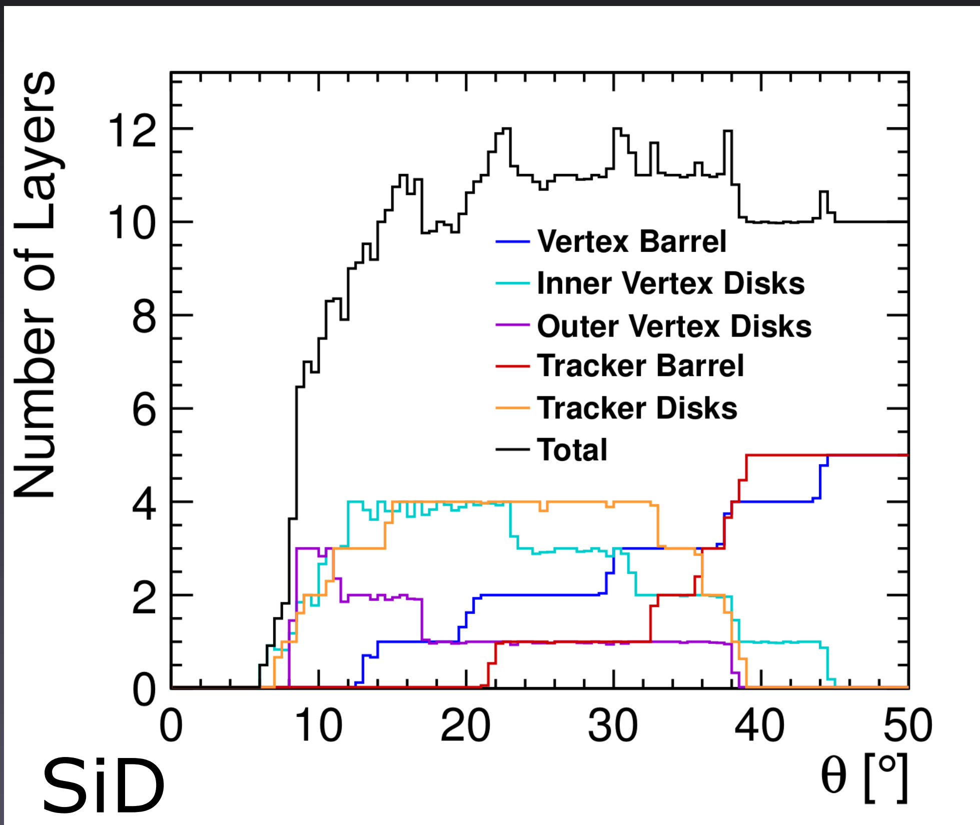
- SiD
  - $r_{Tracker}$=1.25 m
  - B = 5 T
  - All-silicon tracking
- ILD
  - $r_{Tracker}$=1.8 m
  - B = 3.5 T
  - Time Projection

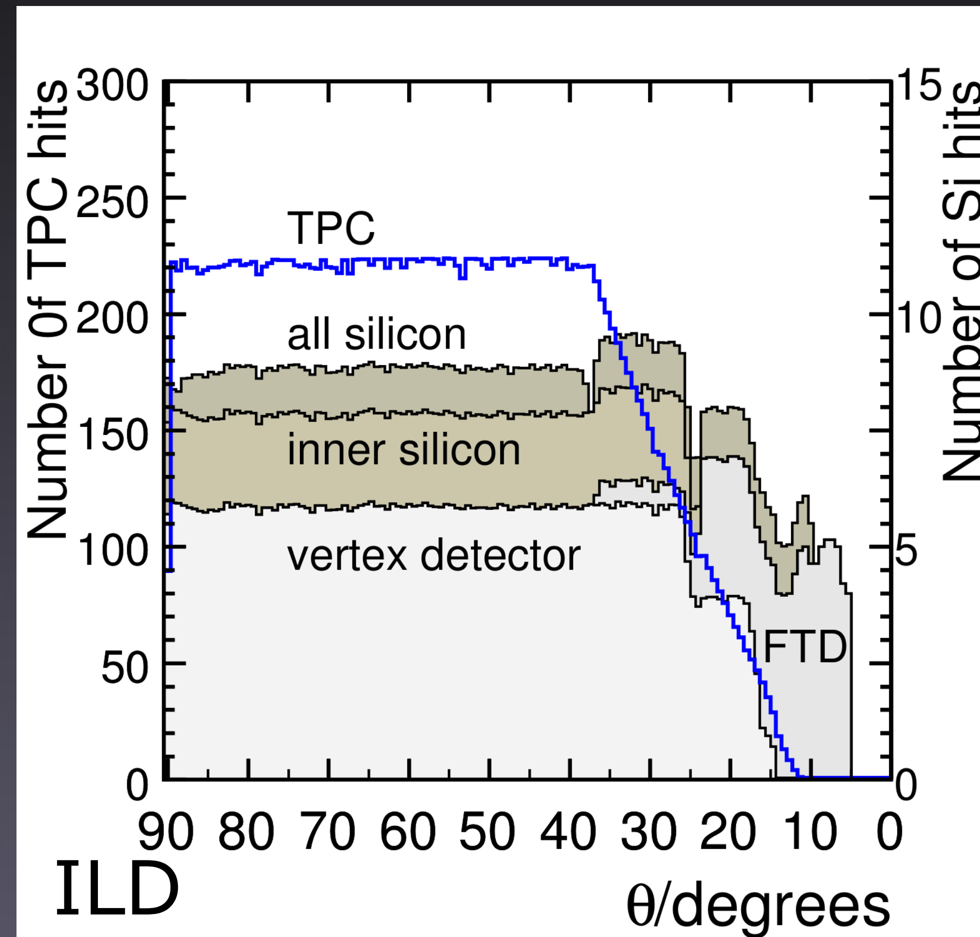
Two Tracking Approaches

- All-silicon Tracking
  - SiD's choice
- Tracking system
  - 5 layer pixel Vertex detector
  - 5 layer Silicon strip tracker
- Few highly precise hits
  - Max 12 hits
- Low material budget
- Concept proven by CMS

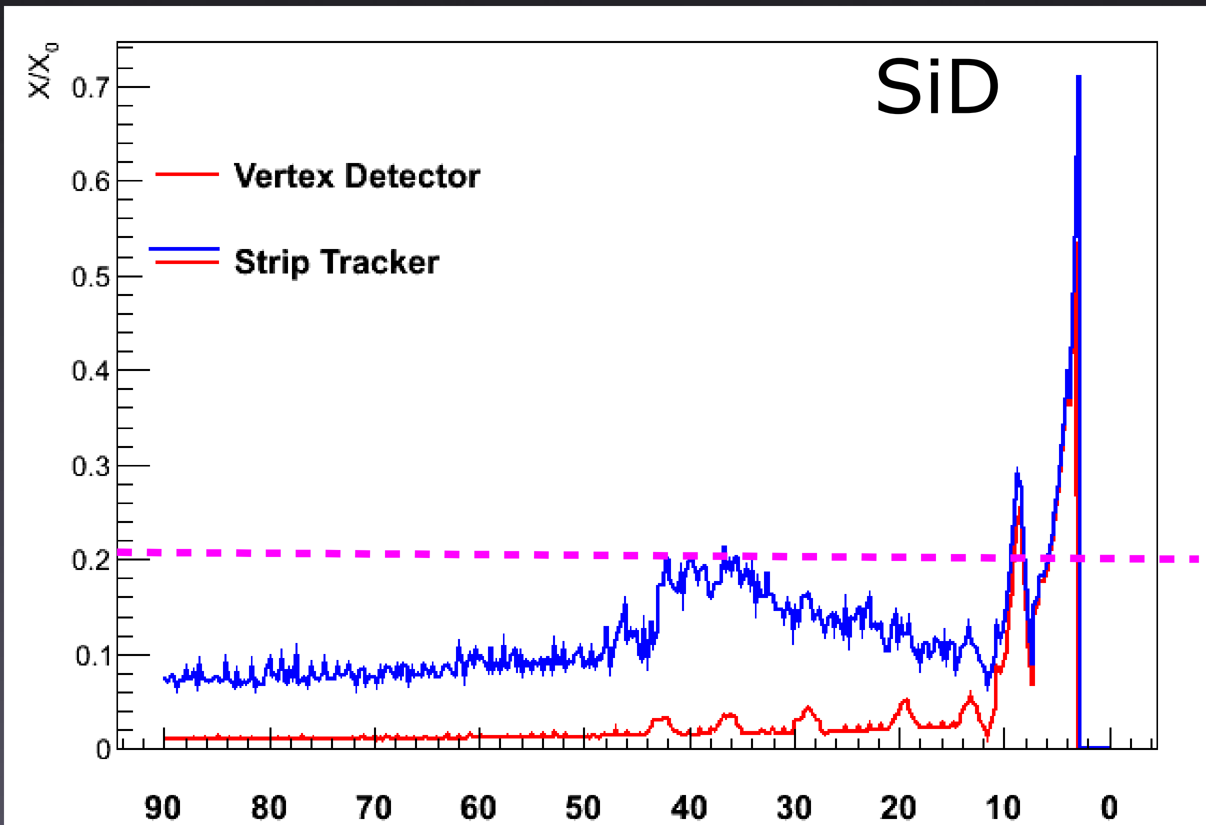
- Gaseous Tracking
  - ILD's choice
- Tracking System
  - 3 double layer Vertex detector
  - Intermediate silicon layers
  - TPC
- Max number of hits
  - 228
- High hit redundancy
- Classical approach

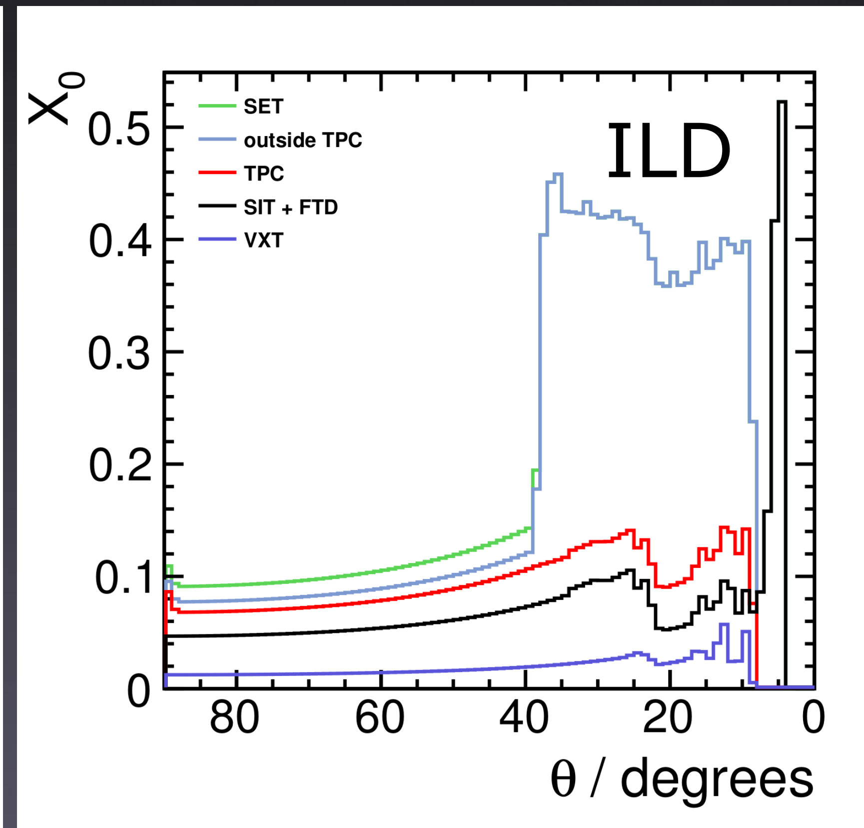
Available Hits





Material Budget





Both concepts have very aggressive goals for the material budget

Calorimetry- Designed for PFA

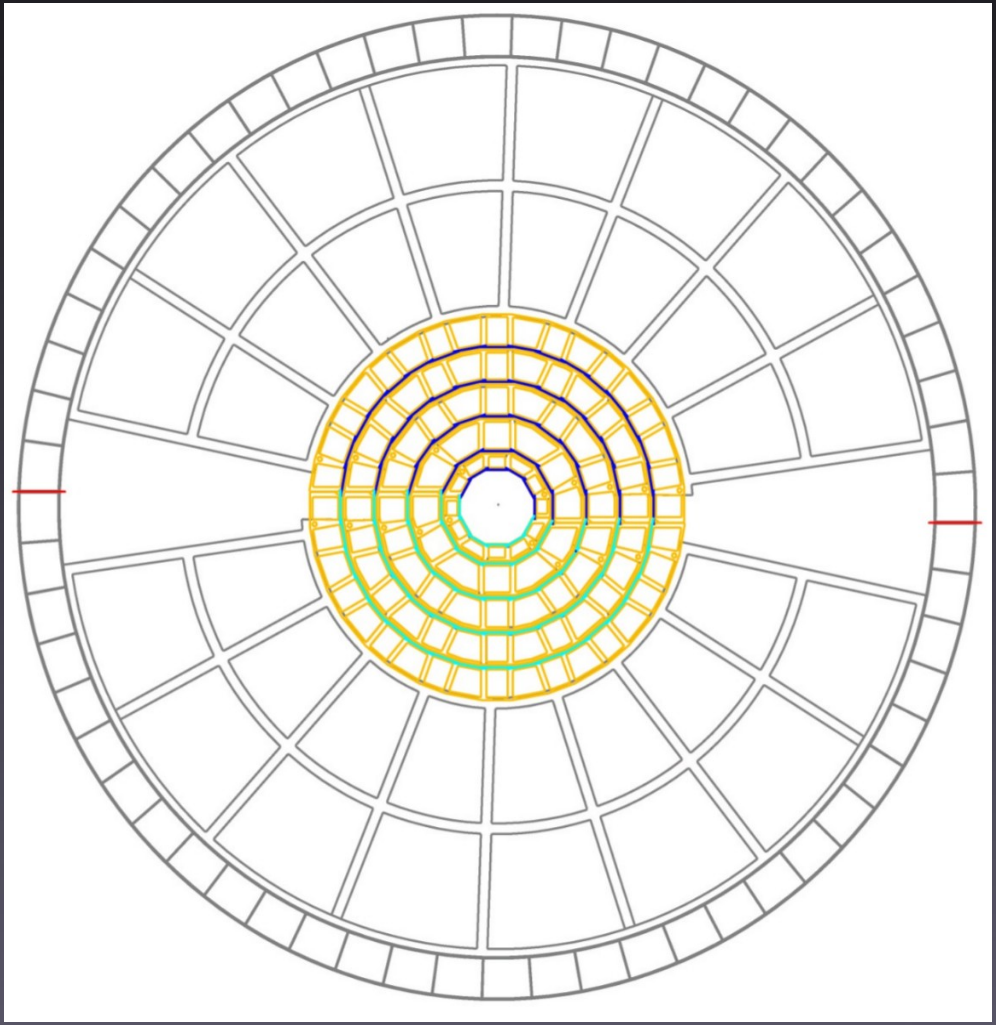
- Both detectors are designed for PFA
- All calorimetry located inside the coil
  - Limits maximum calorimeter depth
- Calorimeter layout
  - Sampling calorimeter
  - Very compact
  - Highly Granular
  - "Imaging the shower"
- ECAL
  - W layers with Si readout

The SiD Detector

- 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
  - Highly granular Calorimetry optimized for Particle Flow
  - Time-stamping for single bunch crossings.
  - Iron flux return/muon identifier is part of the SiD self

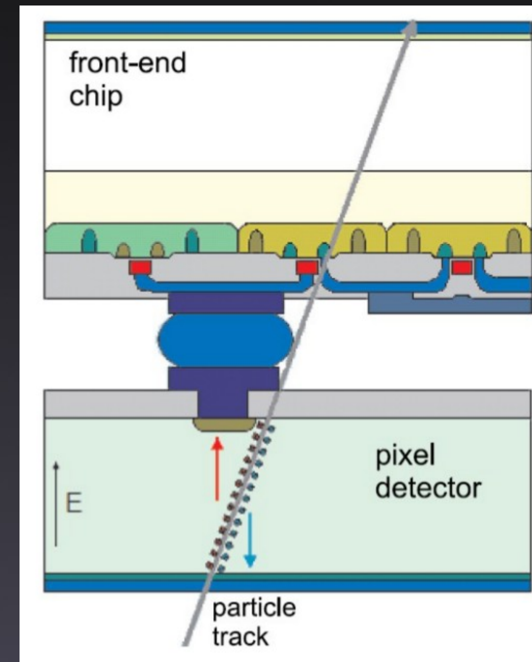
Vertex Detector

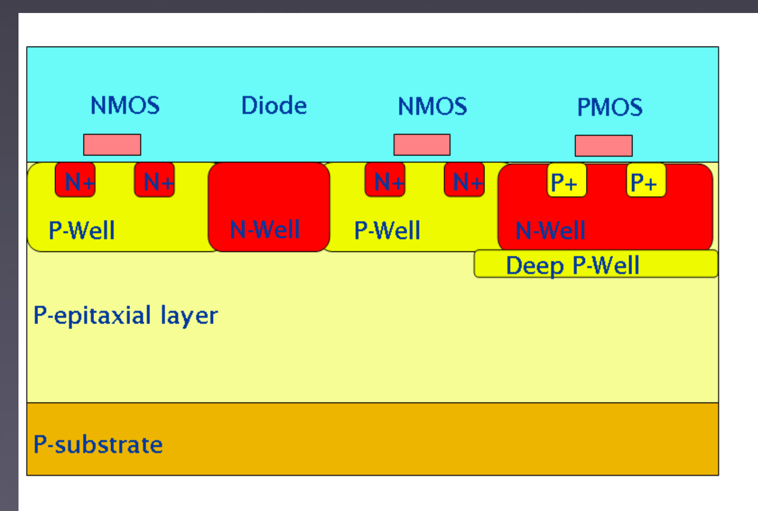
- Many potential technology choices
  - No baseline selected yet
  - Technology “not there” yet
- Requirements
  - <3 µm hit resolution
  - Pixel sizes of O(20 µm)
  - ~ 0.1 % X_0 per layer
  - < 130 $\mu W/mm^2$
  - Single bunch timing resolution



Vertex Detector Pixels

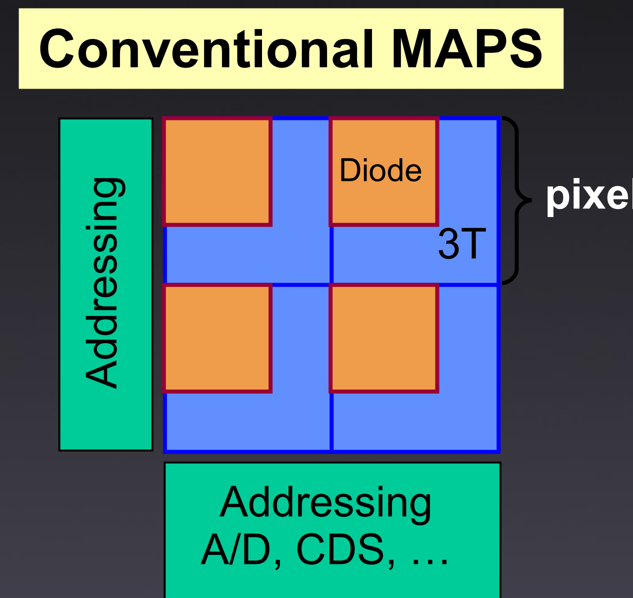
- LHC-Style Hybrid Pixels
  - Too much material
  - Bump-bonding
  - Rad-hard and speed not needed
  - “large pixels (100 μm)”
- Monolithic Pixels are prime candidate
  - Fully integrated electronics

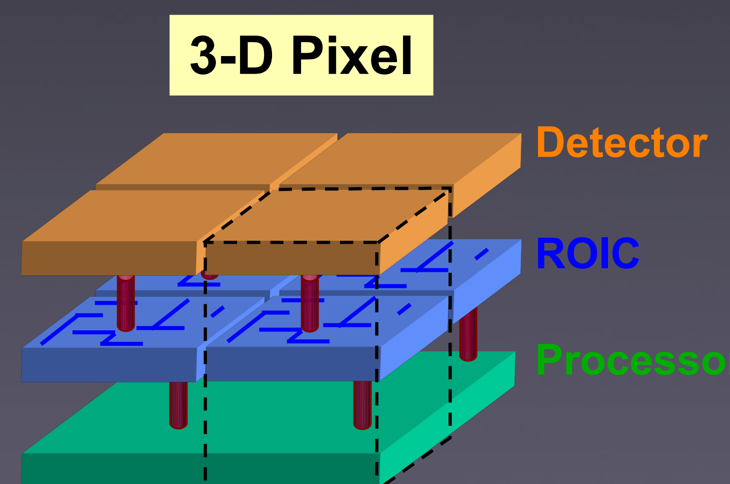




3D Pixels

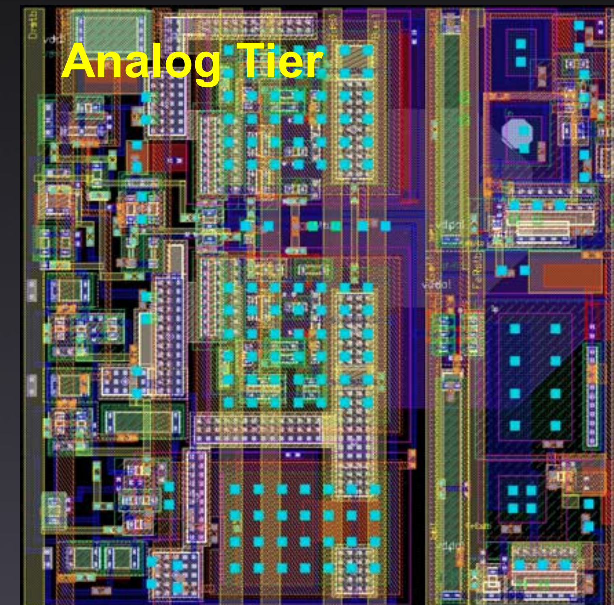
- The ultimate dream of any pixel designer
  - Fully active sensor area
  - Independent control of substrate materials for each of the tiers
  - Fabrication optimized by layer function
  - In-pixel data processing
  - Increased circuit density due to multiple tiers of electronics

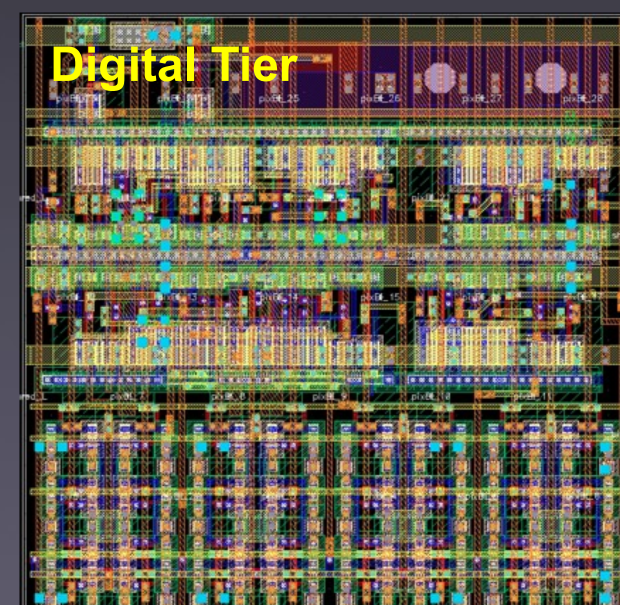




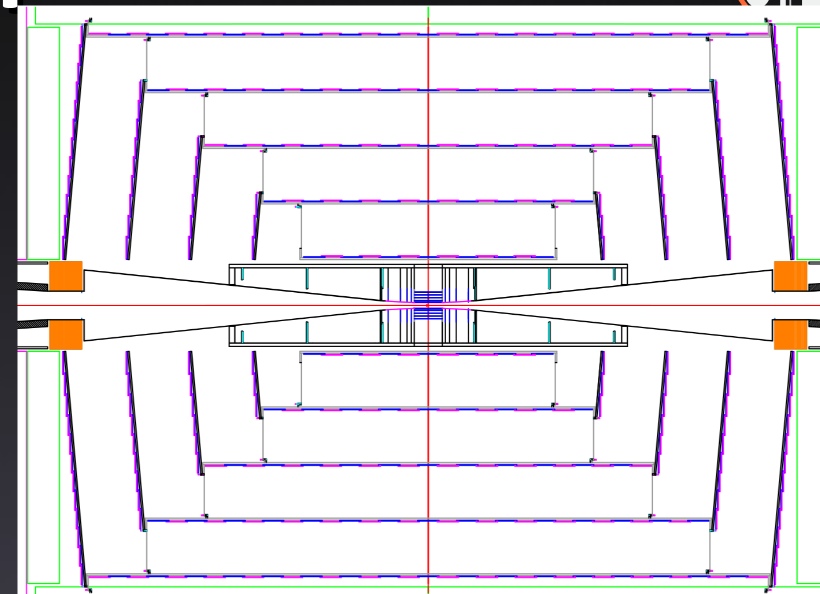
3D Process Developments

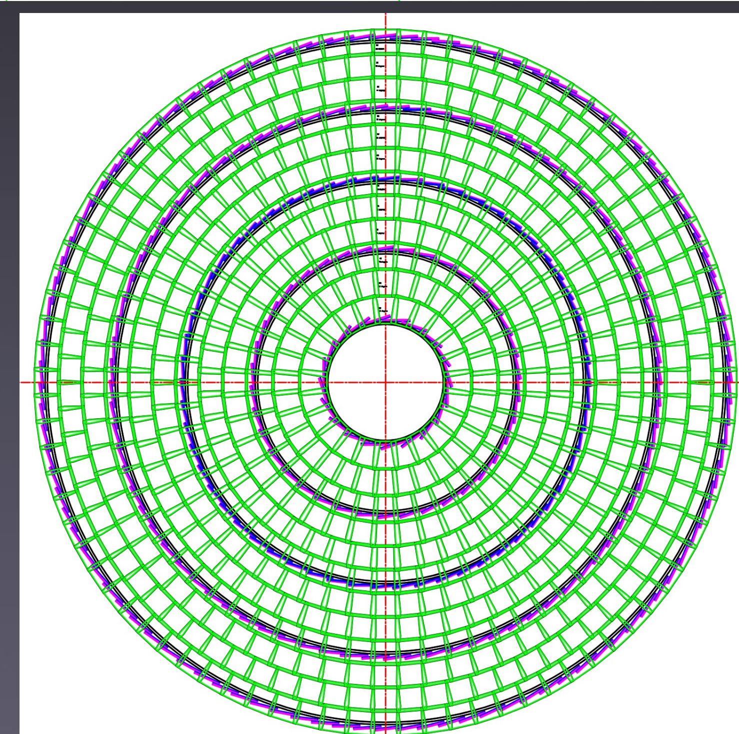
- *Changes continue in the world of 3D electronics. Process improvements are being made. Although we have had some successes there is still much to learn as this field begins to mature. (R. Yarema)*
- Problems encountered
  - Design Tools aren't “there” yet
  - Transistor models “weak”
  - Processing issues
  - Long turn-around times
  - Not a main-stream process
- This is likely to change





Silicon Strip Tracker

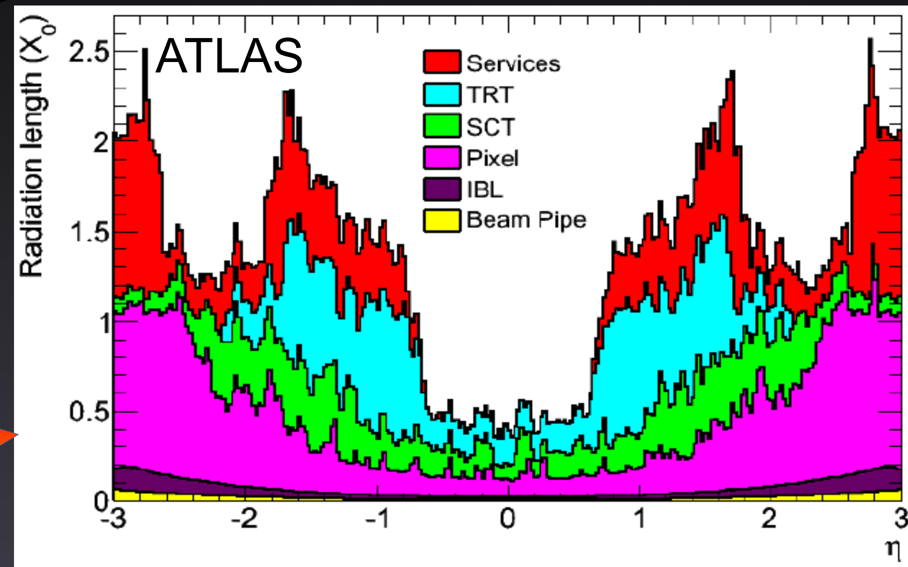




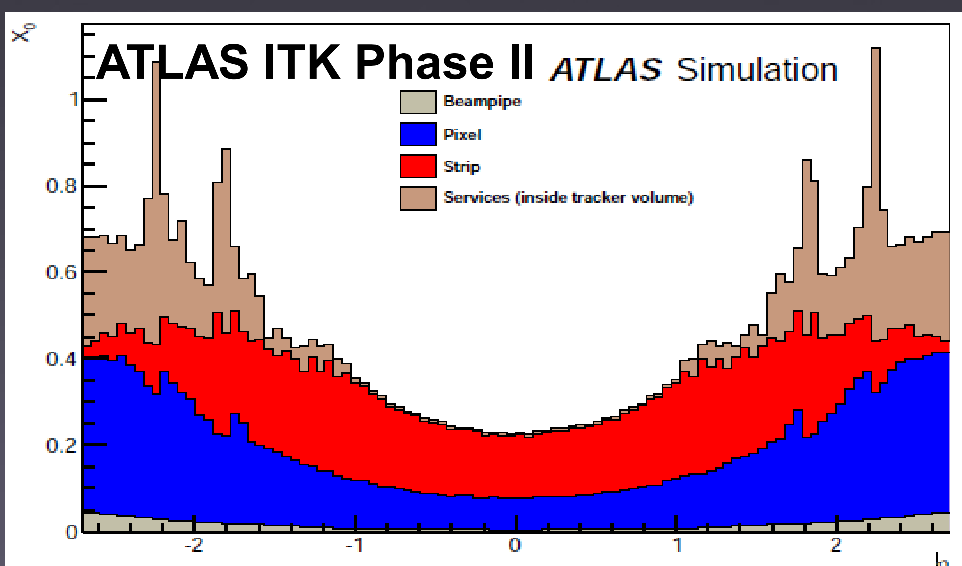
- All silicon tracker
  - Using silicon micro-strips
  - Double metal layers
- 5 barrel layers and 4 disks
- Cooling
  - Gas-cooled
- Material budget

  less than 20 % X_0 in the active area
- Readout using KPiX ASIC

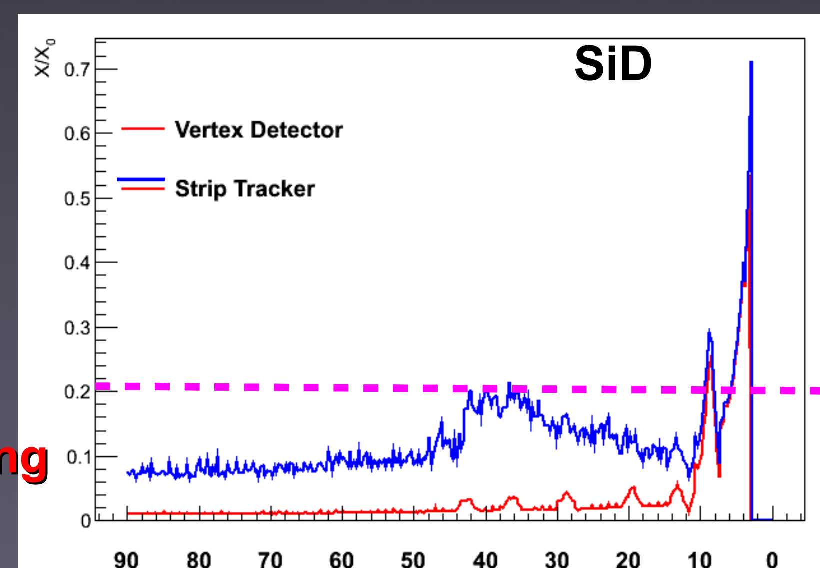
Comparing with LHC/HL-LHC



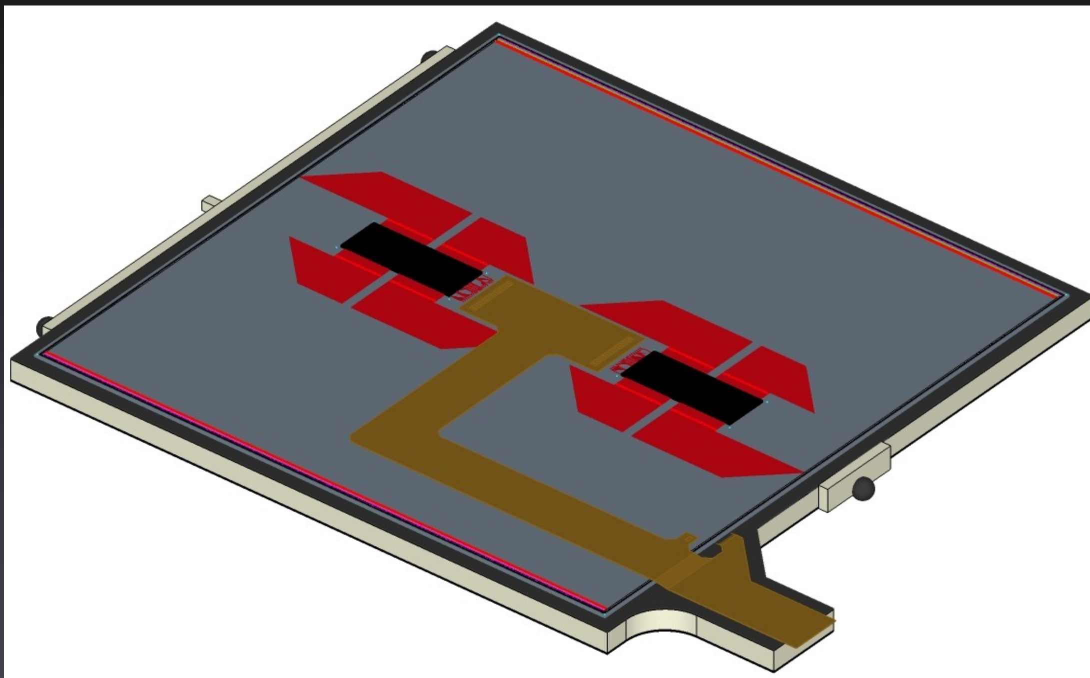
R&D on Services,
Mechanics, Cooling

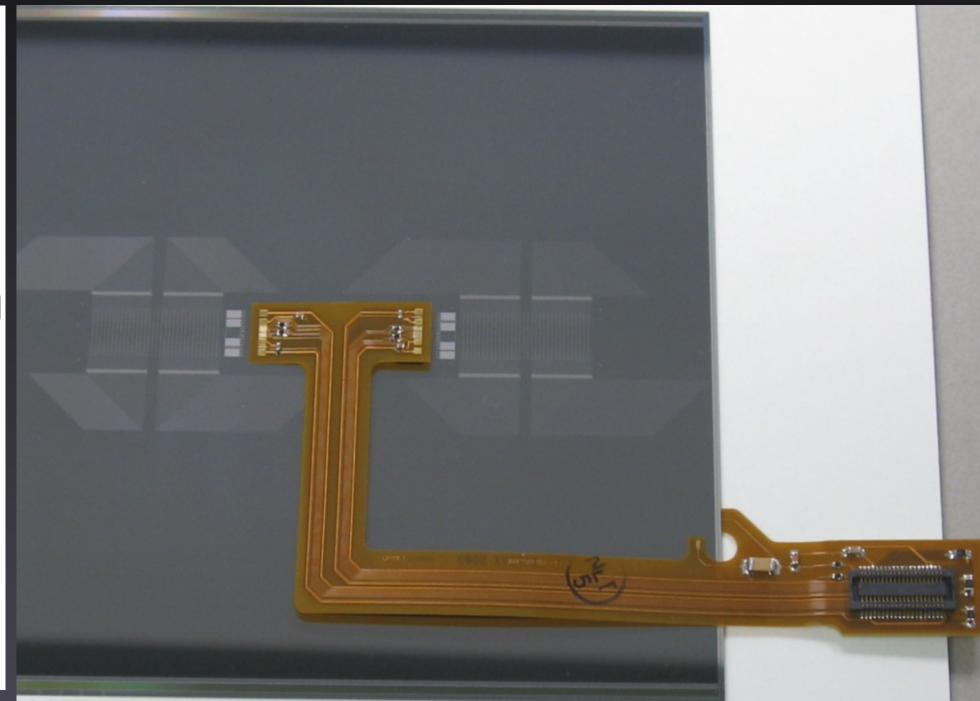


Power pulsing
Air cooling



Tracker Module

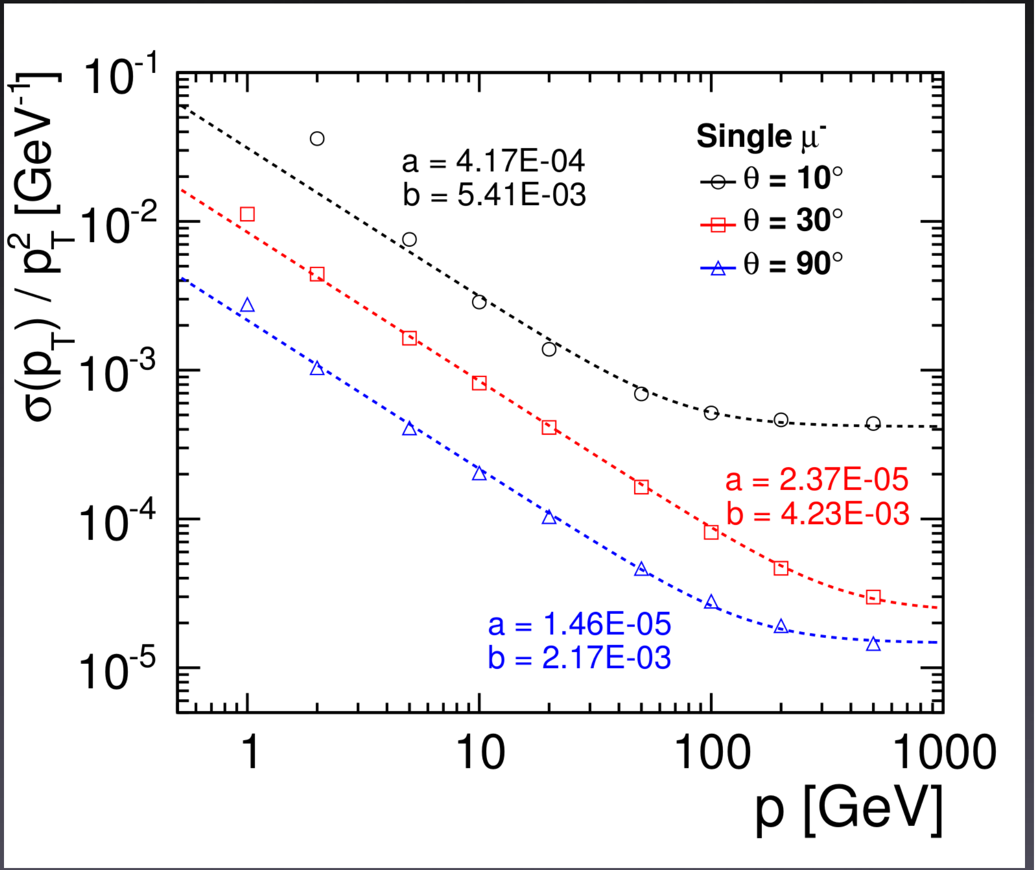




- Silicon Tracker module
  - 25/50 μm strip pitch
  - Double metal layers
  - Two KPiX readout ASICS per sensor
  - Hybrid-less design

SiD 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



$$\frac{\sigma(p_T)}{p_T^{\ 2}} = a \oplus \frac{b}{p \sin\theta}$$

Pointing resolution

Multiple scattering

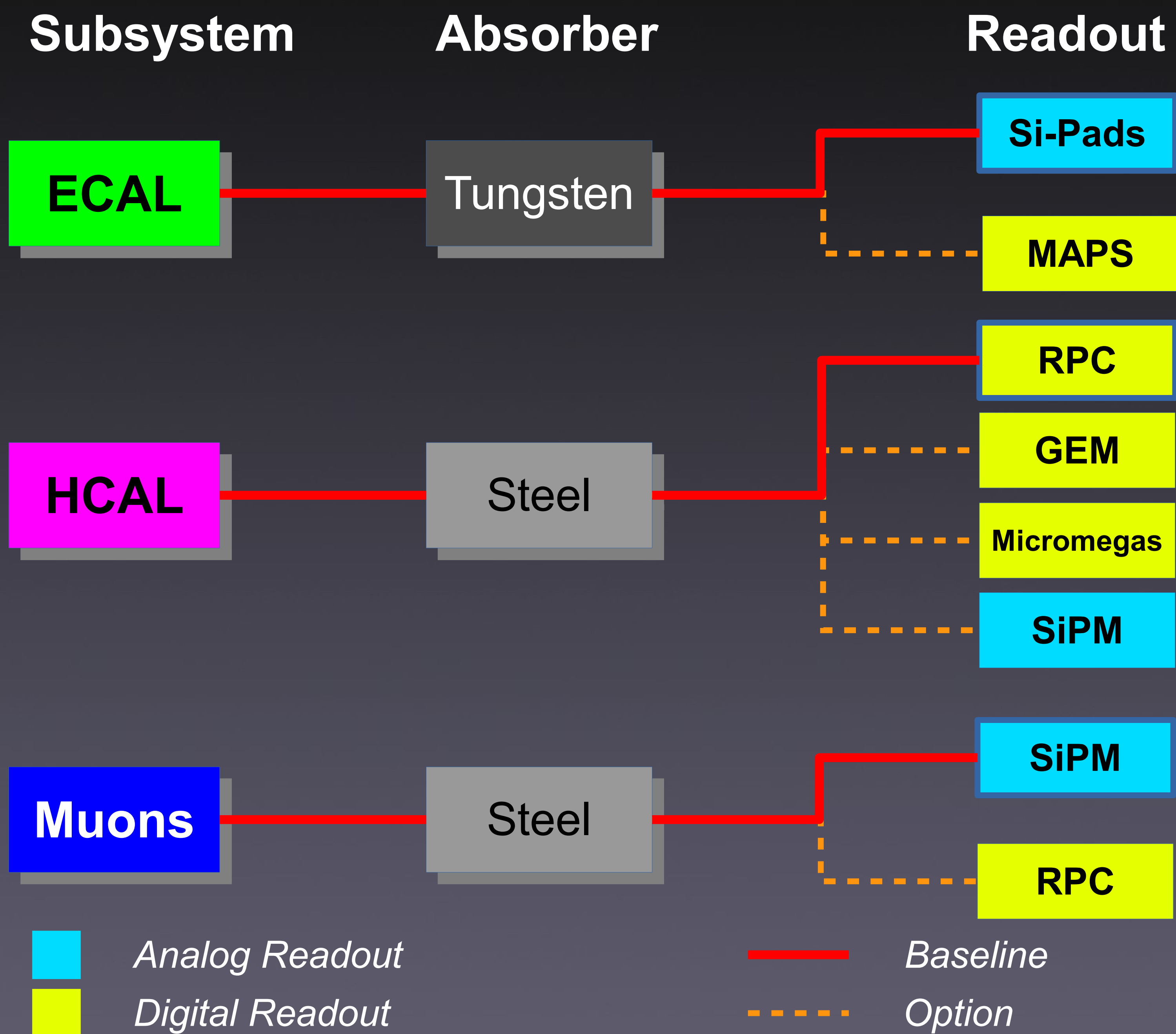
Calorimetry

- SiD ECAL
  - Tungsten absorber
  - 20+10 layers
  - 20 x 0.64 + 10 x 1.30 X_0
- Baseline Readout using
  - 5x5 mm² silicon pads

- SiD HCAL
  - Steel Absorber
  - 40 layers
  - 4.5 Λ_i
- Baseline readout
  - 1x1 cm² RPCs

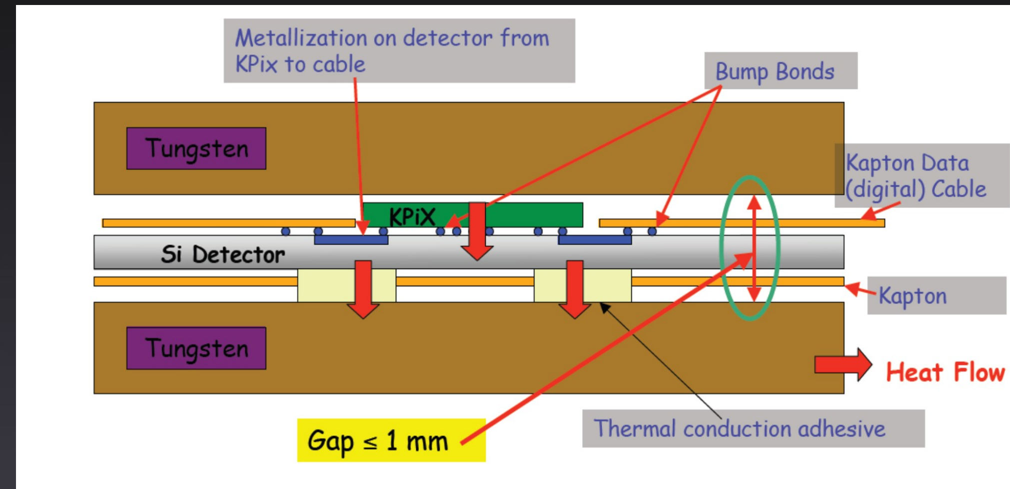
- SiD has selected baseline choices for its Calorimeter
  - Options are being considered
- Lots of test beam activities (past, present and future)
  - Parts of the program done as part of the CALICE effort

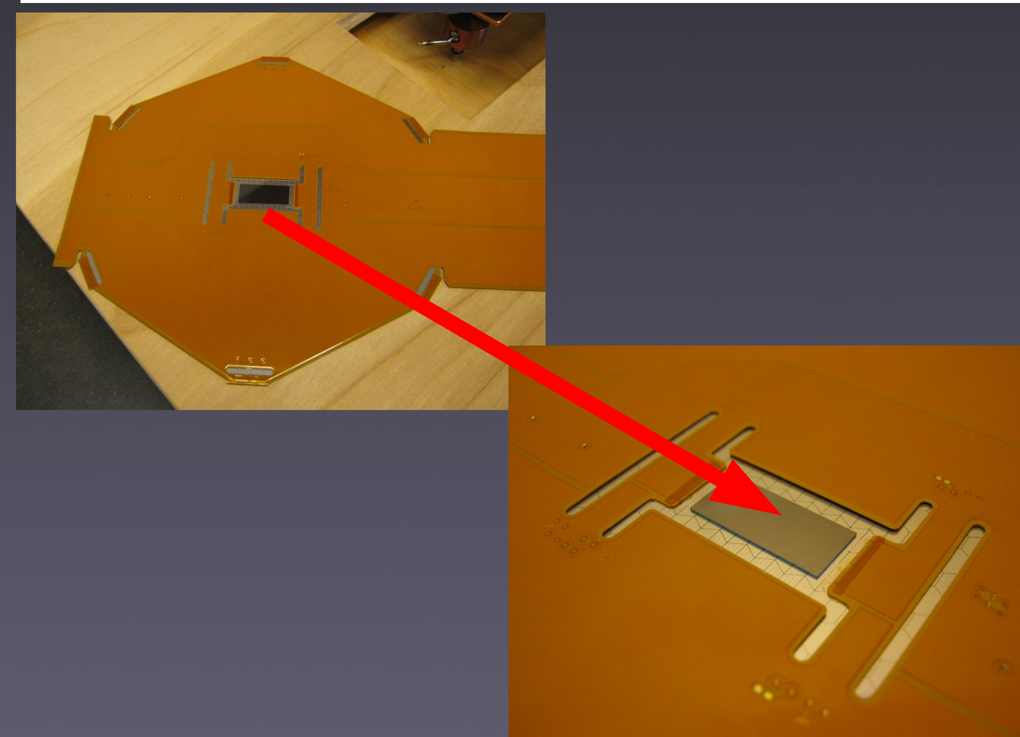
Calorimetry Tree



The SiW ECAL

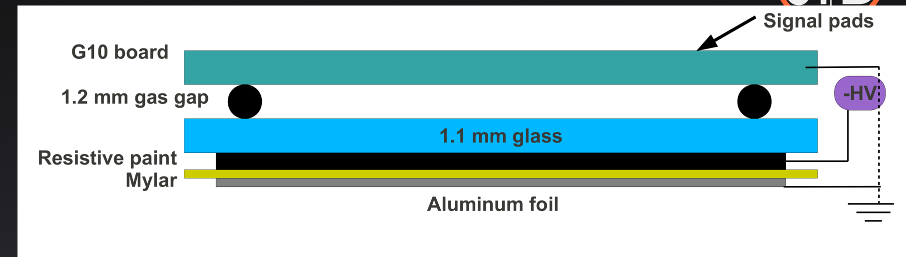
- One ECAL Si sensor
  - 1024 hexagonal pixel
  - Readout by 1 KPiX
- KPiX and cable bump-bonded to the sensor
- Analog Readout
  - Deposited charge
- Aim: minimize gap size
- Tungsten plates used as heat sink

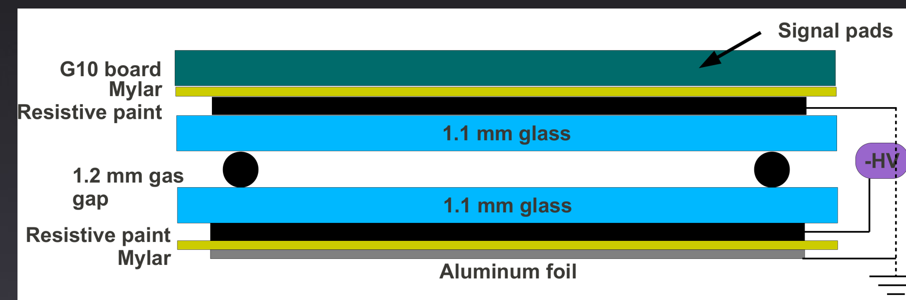


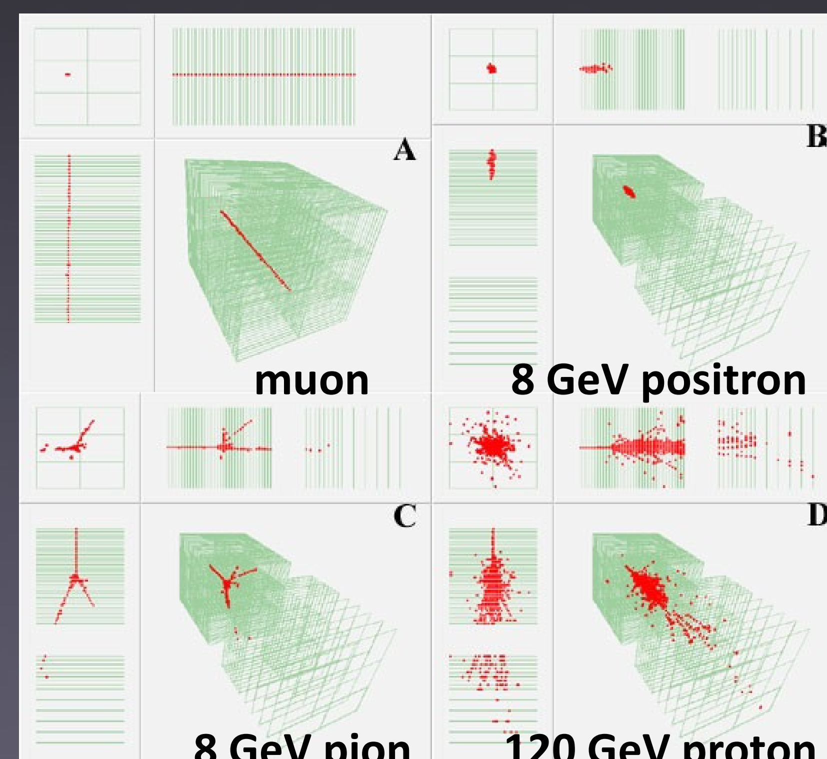


HCAL Baseline

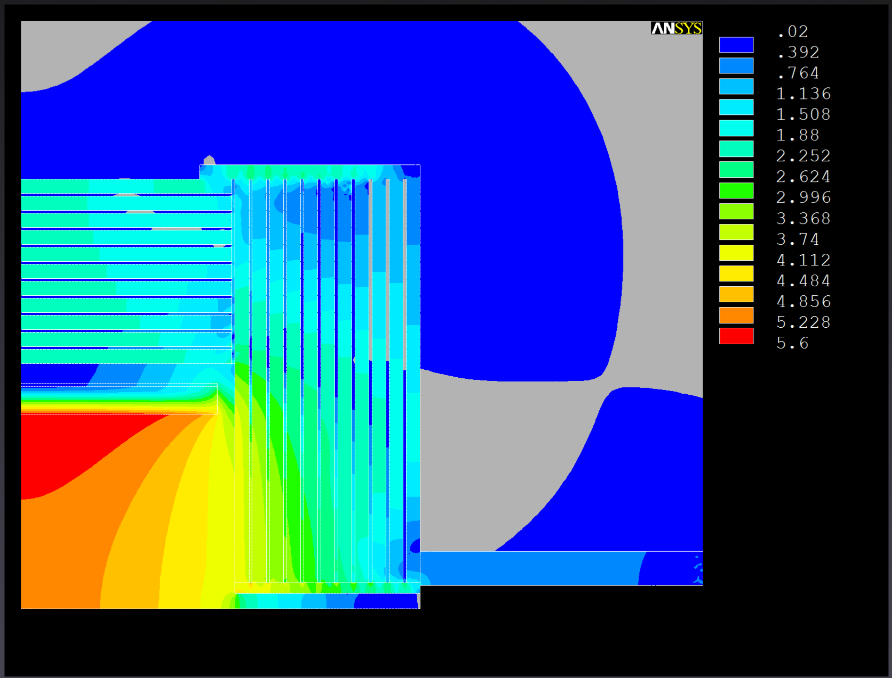
- Digital HCAL
  - Counting shower particles
  - $N_{particles}$ ~ Energy
- Using Glass RPCs
  - 1 x 1 cm^2
- 1 m^3 prototype built
  - 500.000 channels
  - Largest Calorimeter by channel so far

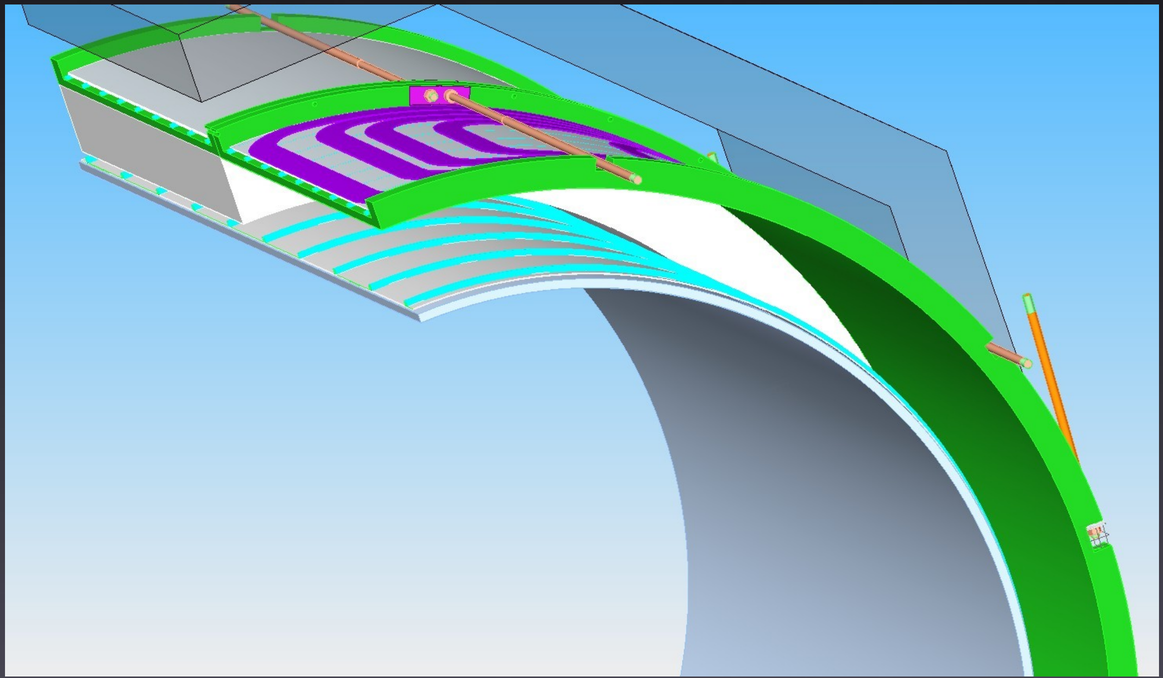






Magnet

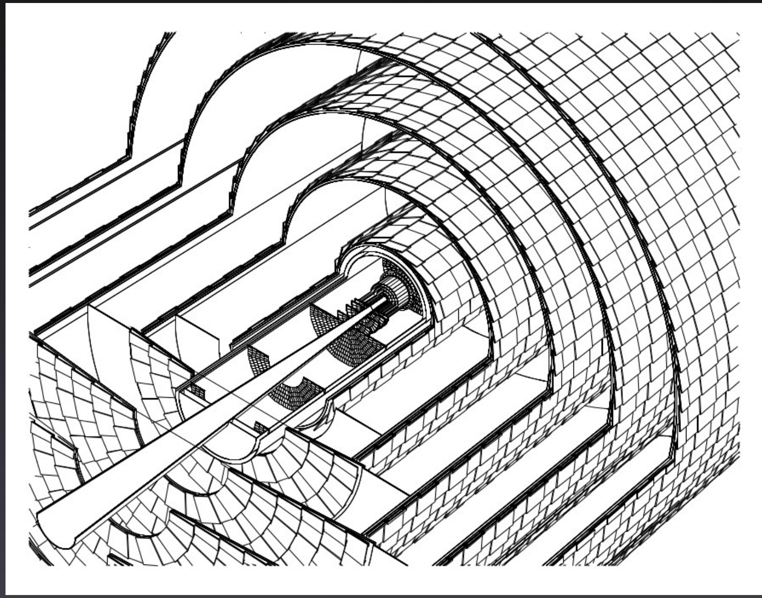


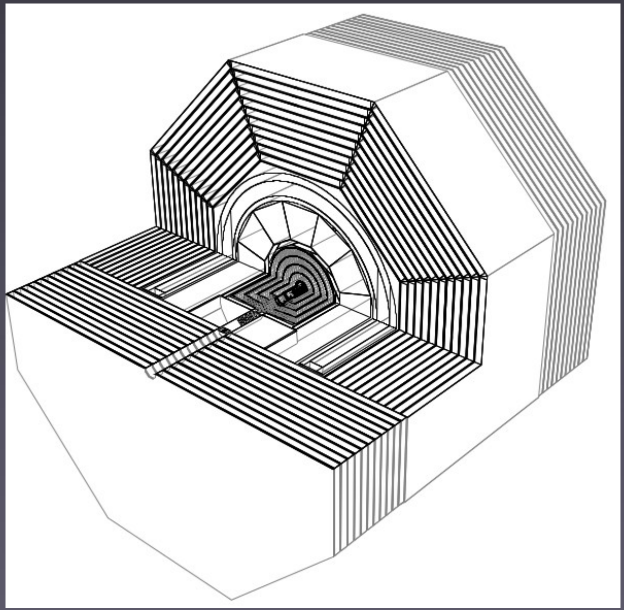


- The 5 T coil builds on the CMS experience
  - Especially on the CMS Conductor
- Engineering challenges are well understood
  - Advances in computing ease the design
  - Feasibility of SiD design has demonstrated

Simulation & Reconstruction

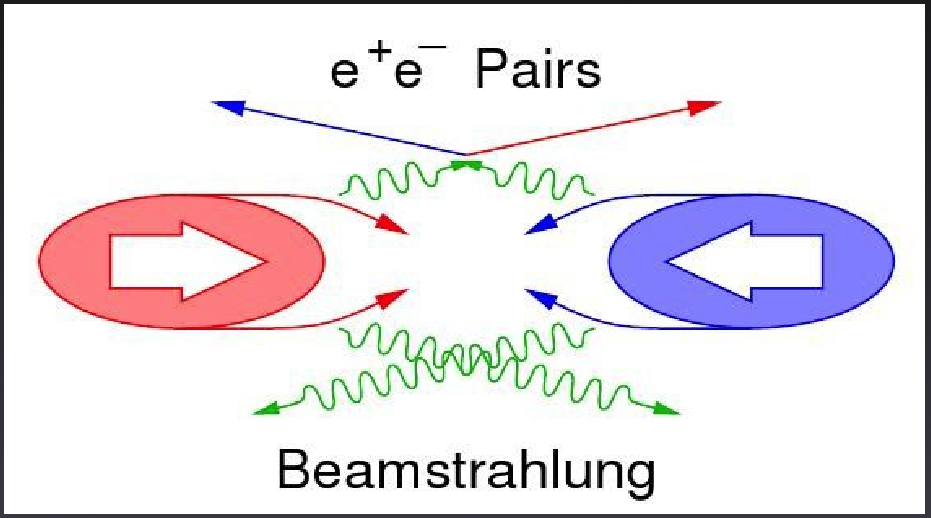
- Full Simulation& Reco
  - Including full beam backgrounds
- Simulation
  - Detailed GEANT4 detector simulation
  - Including “dead areas”
- Full Reconstruction
  - Digitization, Tracking, Particle Flow, Flavor Tagging
  - No cheating at all

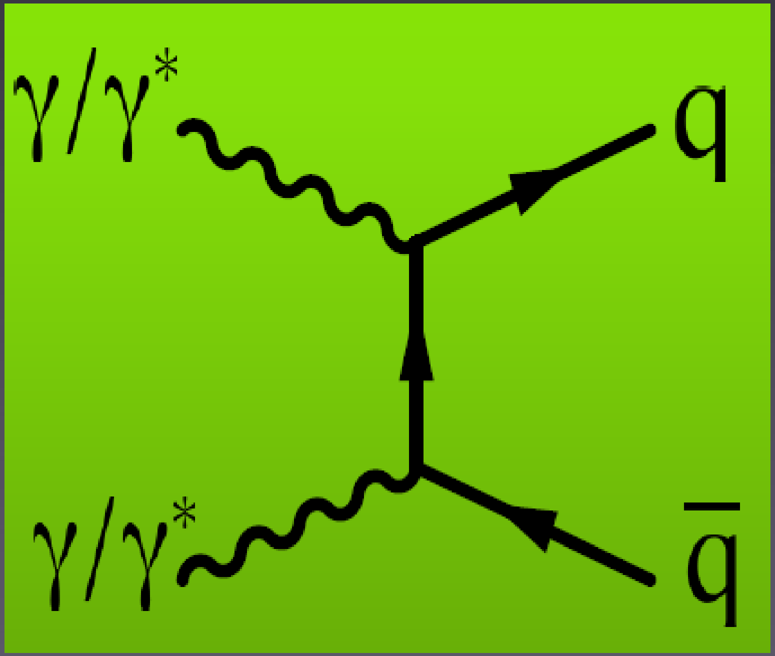




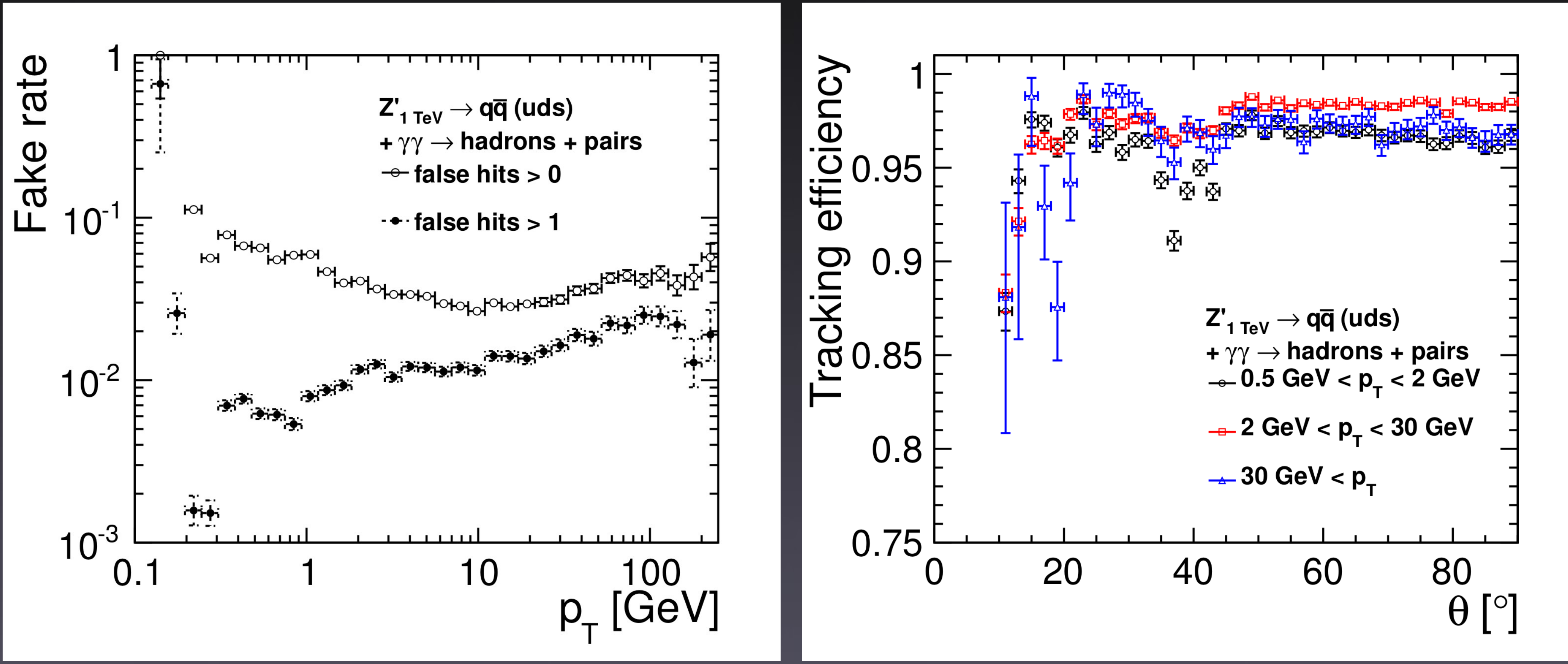
Simulating backgrounds

- 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"



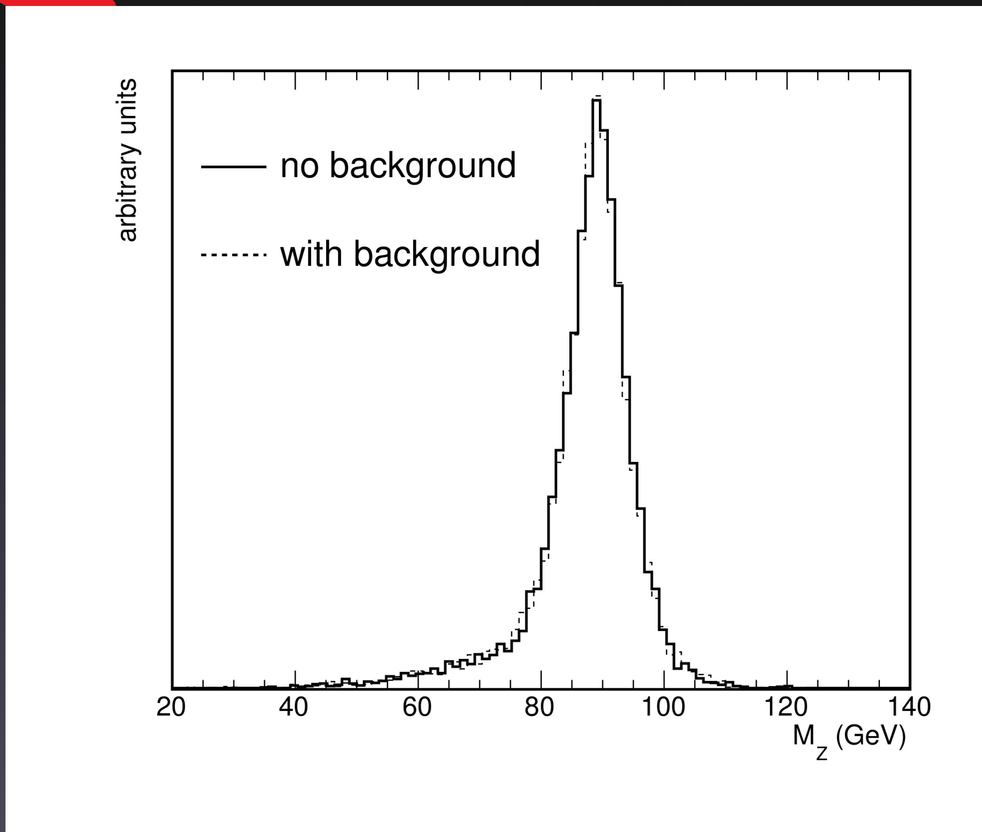


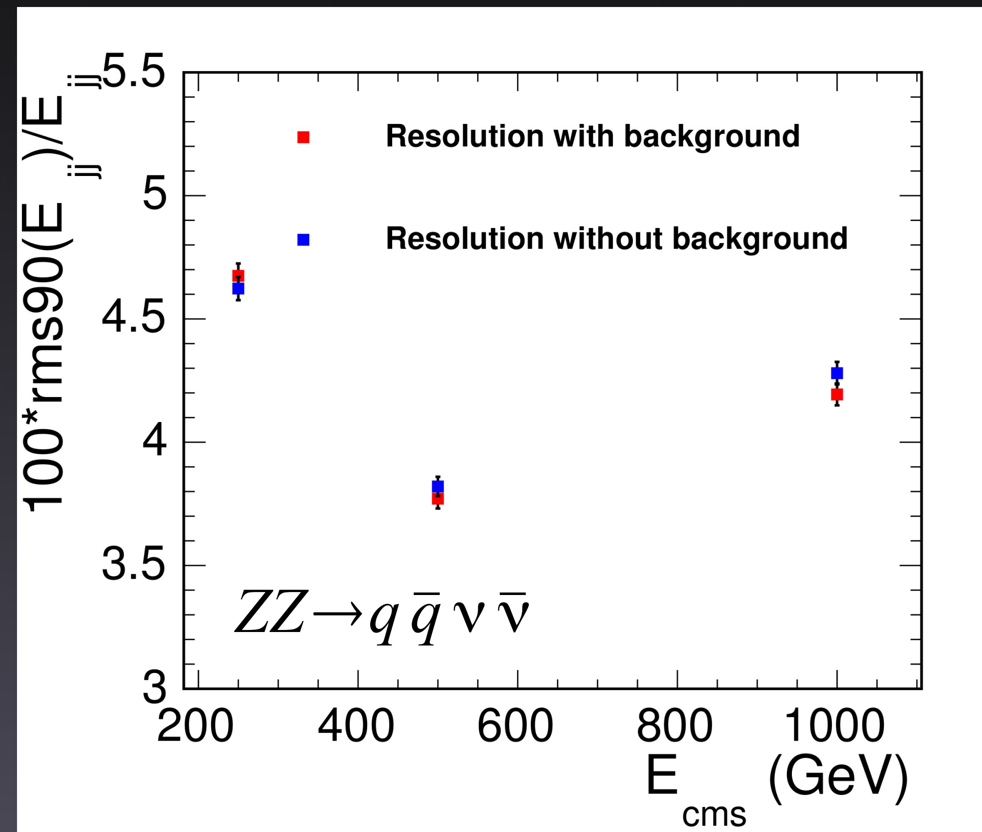
Robustness vs. backgrounds



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

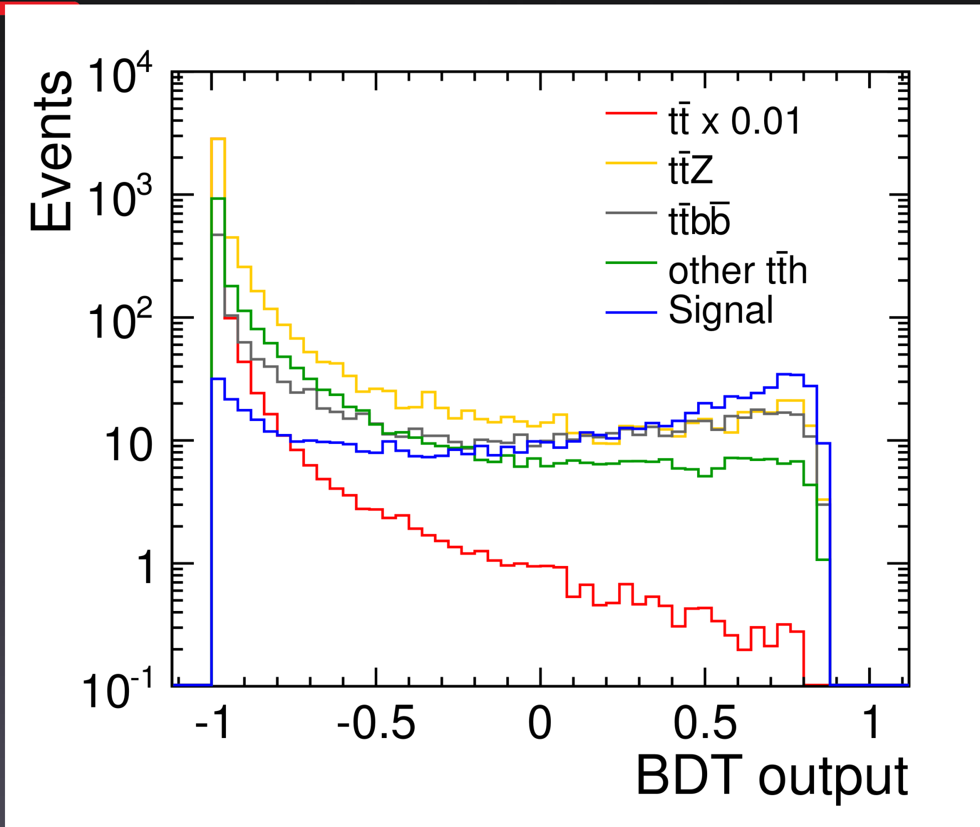
Performance: PFA

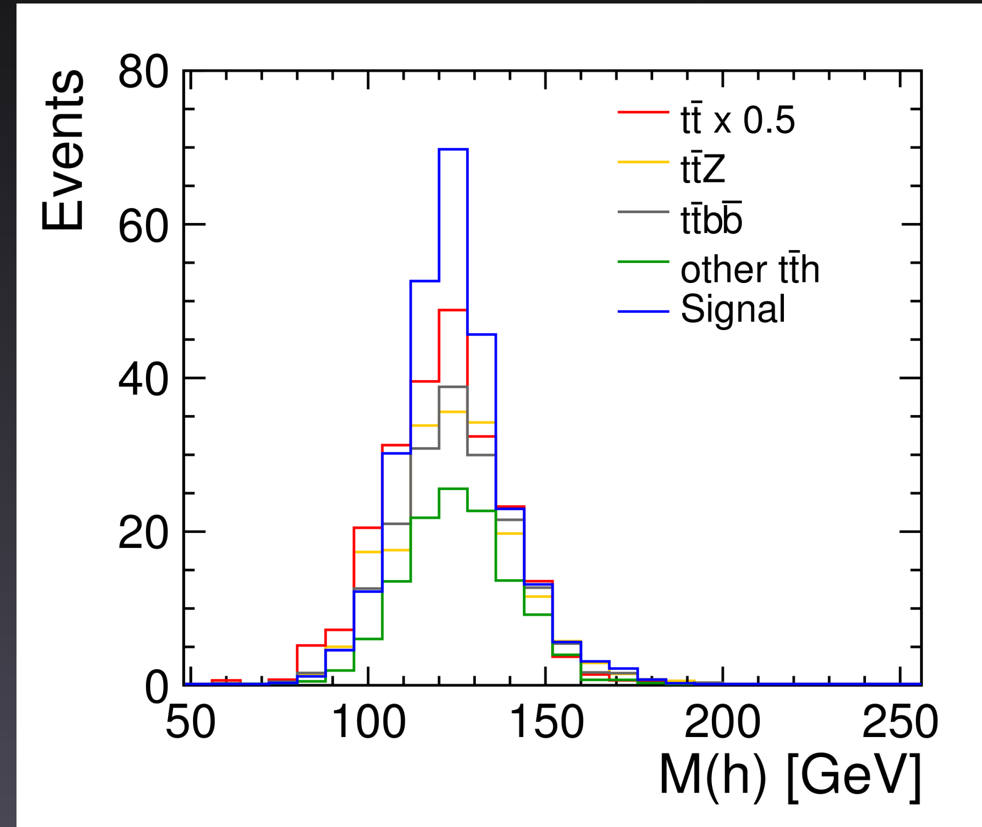




- SiD PFA performance is excellent
  - Fulfills ILC physics goals
- Robust against backgrounds
  - Driven by all-Silicon approach and single-bunch time-stamping

Top-Yukawa Coupling



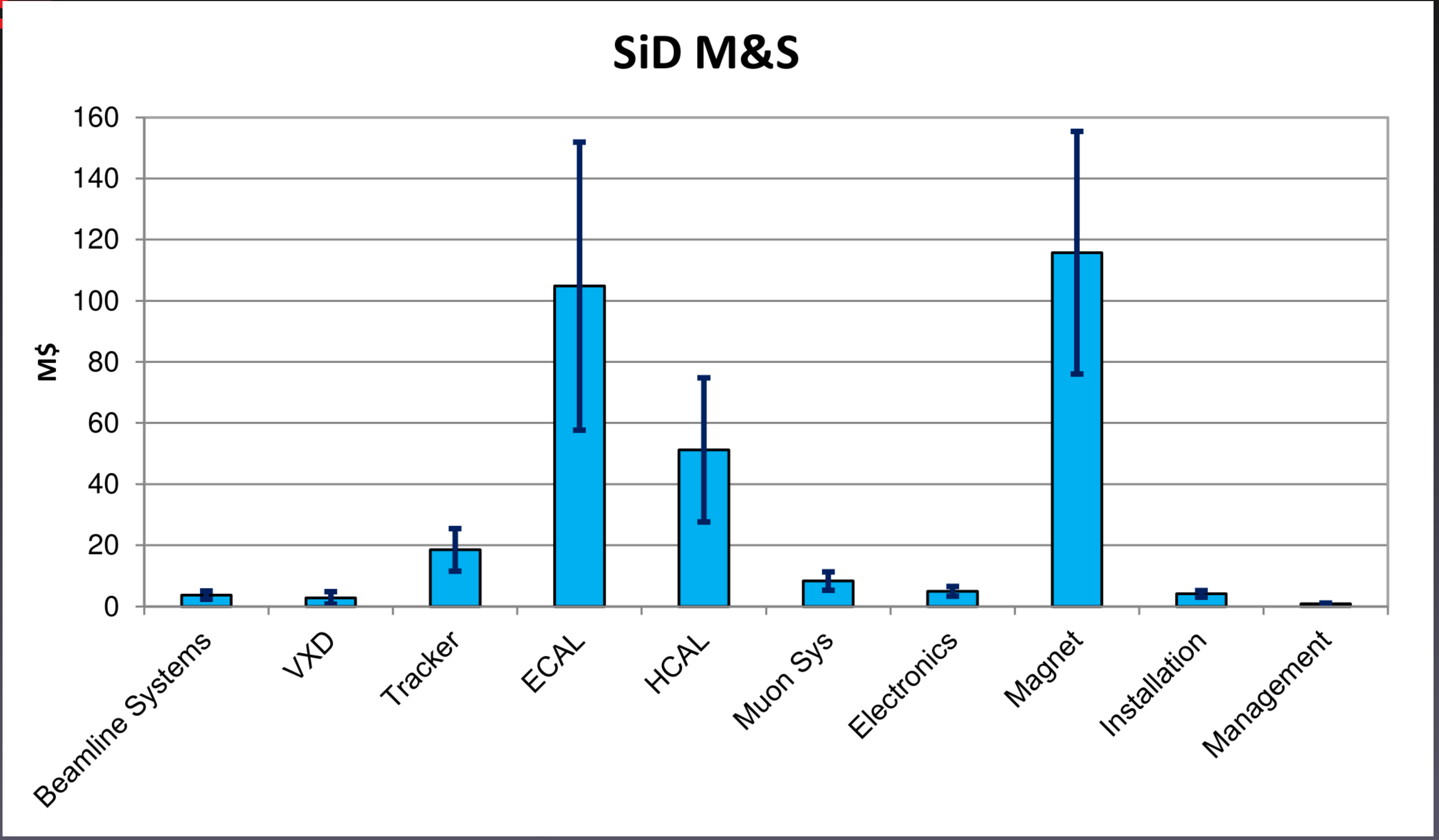


- Measuring Y_{top} at $\sqrt{s} = 1$ TeV
  - Using six and eight jet final states with four b jets
  - Stressing PFA and b-tagging
  - Combined measurement: $\Delta Y_{top} = 4.5$ %

SiD Costing

- SiD assumes common unit costs
  - As agreed by both SiD and ILD
- 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

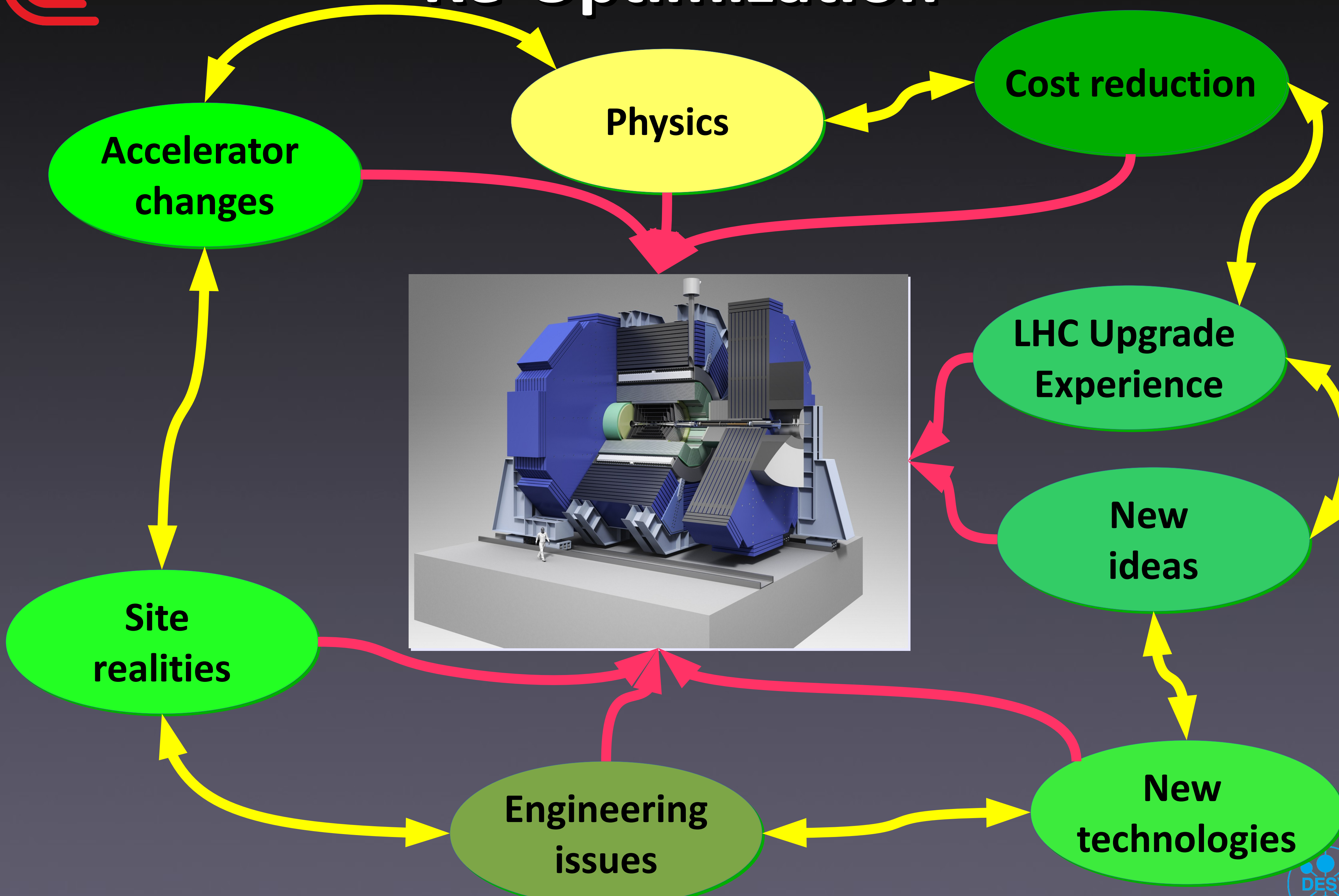


SiD M&S
M$
160
140
120
100
80
60
40
20
0
Beamline Systems
VXD
Tracker
ECAL
HCAL
Muon Sys
Electronics
Magnet
Installation
Management

Current Activities

- Site-Specific Studies
  - Realizing SiD in Japan
- Subsystem R&D
- Re-optimizing the Detector
  - DBD Detector does good physics
  - Can we do better ?
- Making SiD ready to become a collaboration
  - Forming a consortium is a first step towards a more formal organization

Re-Optimization



New Technology Examples

HCAL technology

- Baseline RPC DHCAL witch 1x1 cm cell size
- Big SiPM technology advances
- AHCAL with 1x1 cm cell size
  - Now Feasible & Affordable
- Investigating change

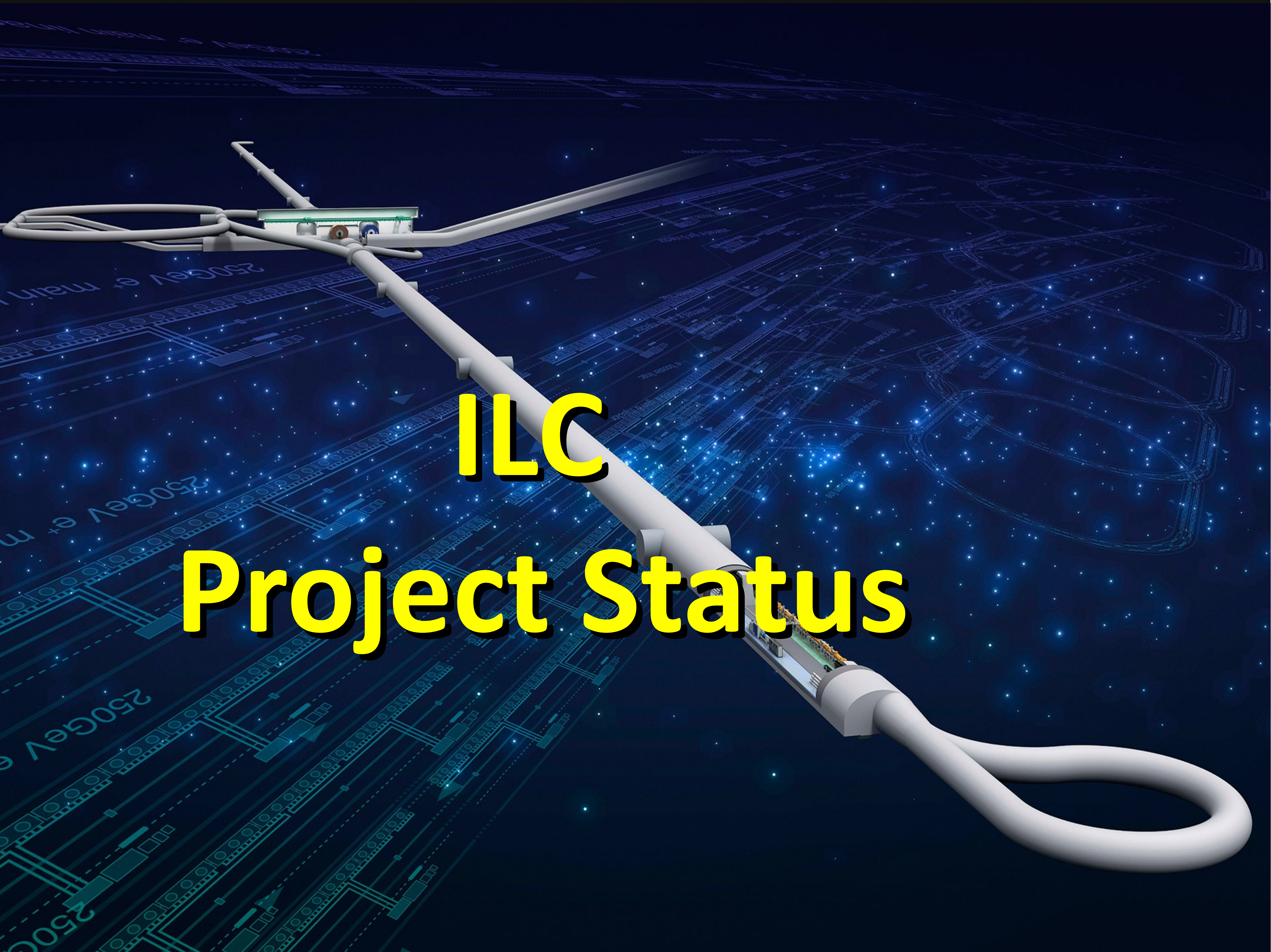
Main Tracker

- Baseline Strips/SAS Strips
- CMOS technology
  - As also considered for LHC
- Large area tracker with pixels
  - Better resolution
  - Less material

Learning from the Upgrades

- ILC may not require radiation hardness, but ..
  - There are many things one can learn from LHC Upgrades
- Electronics/Services
  - DC-DC converter developments
  - High-Speed Optical links
  - 65 nm ASICs
- Detector technology
  - e.g. CMOS Pixel/Strip developments (in ATLAS) very interesting for SiD

ILC
Project Status



Timeline

- Fall 2012
  - Japanese HEP Community expresses interest to host the ILC
- May 2013
  - TDR is published
  - European Strategy for particle physics supports ILC
- August 2013
  - Scientific Site selection

The ILC TDR

"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!

- ILC TDR
  - Five Volumes covering
  - Physics, Accelerator & Detectors
  - Culmination of eight years of effort
- Very favorable review
- Wide Community support
- Global Handover Event
  - Tokyo, Geneva, Chicago

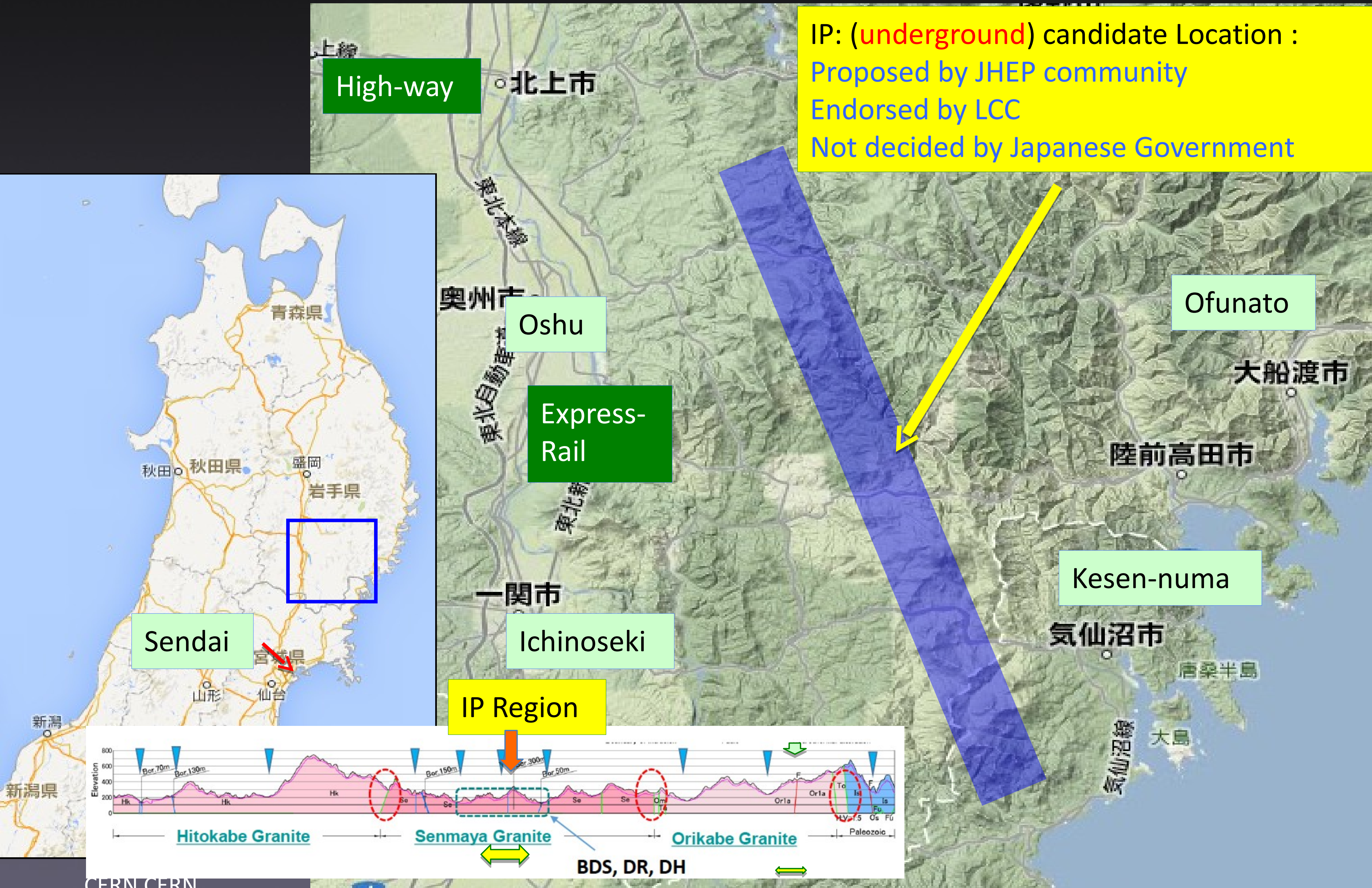
Supporting the ILC - worldwide

48 countries
392 Institutes
2400 signatories

ILC Site Selection

- Japan proposed two sites
  - Kitakami, Honshu “Northern Site”
  - Sefuri, Kyushu “Southern Site”
- Expert Panel Review on Scientific merits of each site
  - Geology, Infrastructure
  - Economic impact

ILC Site – Kitakami Mountains



Kitakami Mountains

ILC Detector and Machine experts

Visit

September 2014

Timeline (II)

Japanese Visit to Washington

- Fall 2013
  - Science Council of Japan reviews ILC
  - MEXT establishes ILC taskforce
- November 2013
  - Site-specific Studies commence
- May 2014
  - US P5 Strategy supports ILC

Reviews ...

European Strategy for Particle Physics 2013

There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. Europe looks forward to a proposal from Japan to discuss a possible participation.

US P5 Statement 2014

“Motivated by the strong scientific importance of the ILC and the recent initiative in Japan to host it, the U.S. should engage in modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise. Consider higher levels of collaboration if ILC proceeds.”

Science Council of Japan

The Committee suggests that the government of Japan should (1) **secure the budget** required for the **investigation of various issues to determine the possibility of hosting the ILC**, and (2) **conduct intensive studies and discussions among stakeholders**, including authorities from outside high-energy physics as well as the government bodies involved for the next two to three years.

In parallel, it is **necessary to have discussions** with the research institutes and the responsible funding authorities of key countries and regions involved outside of Japan, and to **obtain clear understanding of the expected sharing of the financial burden**.

MEXT's Organization for Studying ILC

SCJ

Recommendation in 2013

ased on Science C of Japan's

MEXT

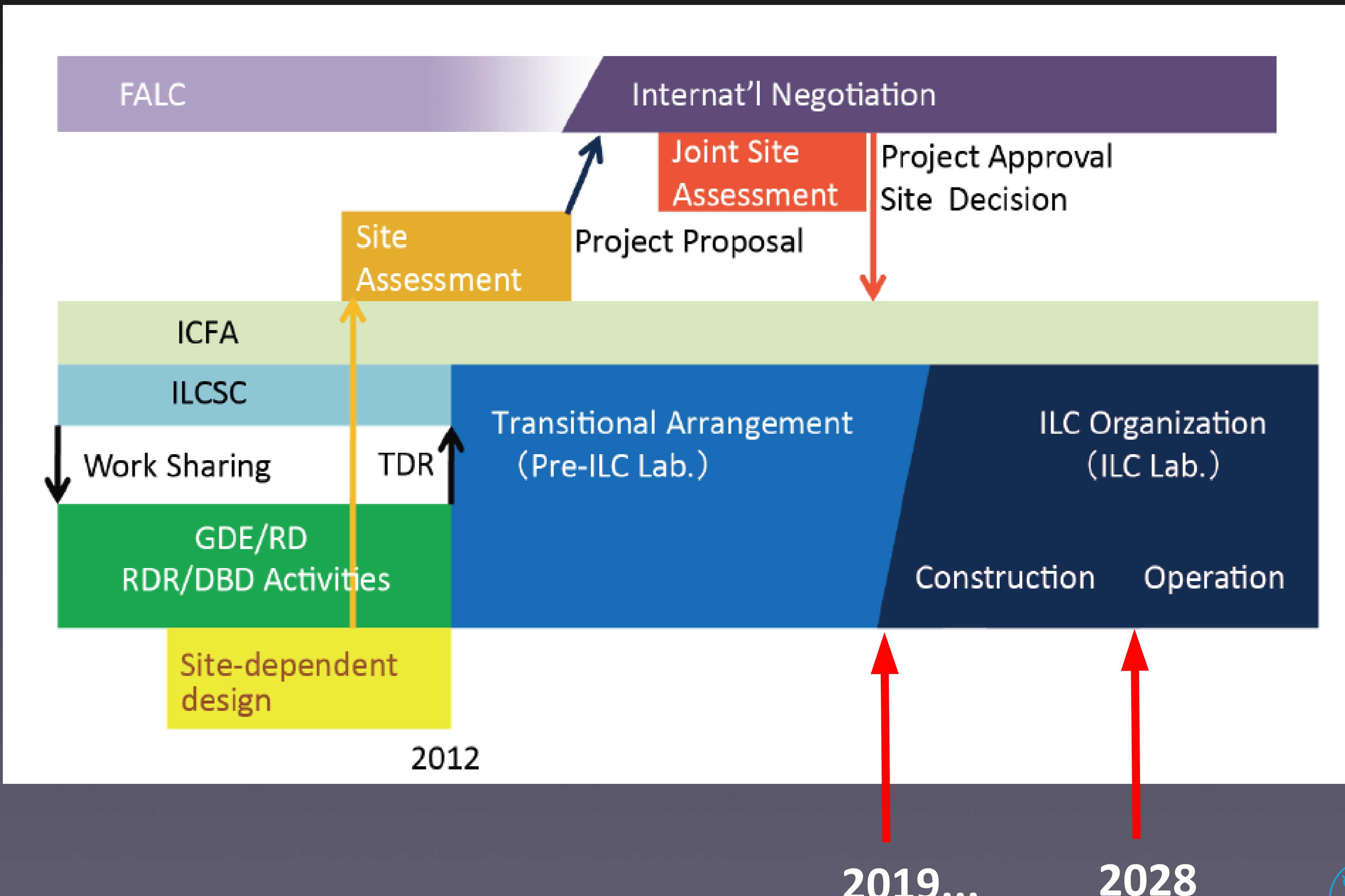
ILC Taskforce
formed in 2013

Academic Experts Committee
formed in 2014

Particle & Nuclear **Phys.** Working Group
formed in 2014

TDR Verification Working Group
formed in 2014

The way forward



Keeping updated

- Webpage: http://silicondetector.org
- We have a new *sid-general* mailing list
  - Easy to subscribe to
  - Send a mail with `subscribe sid-all John Doe` in the body to **`listserv@slac.stanford.edu`**
  - https://listserv.slac.stanford.edu/cgi-bin/wa?SUBED1=SID-ALL&A=1
- List will be used for
  - Meeting and Workshop announcements
  - General SiD news

How to get involved

- SiD Webpage
  - http://silicondetector.org/
- Linear Collider Newsline
  - http://newsline.linearcollider.org
  - News, Announcements
- Come to the next SiD Workshop
  - Jan 12th-14th at SLAC

Joining the SiD Consortium

- As a next step towards project realization, we are going ahead with establishing the "SiD Consortium" as a precursor to a full collaboration. This gives us the working structure and representation we need to be part of the new LCC.
- The SiD Consortium is open to any group or individual wanting to contribute to the development of SiD:
- To join – send an Email to Professor Phil Burrows (Chair of the SiD Institute Board) at p.burrows1@physics.ox.ac.uk

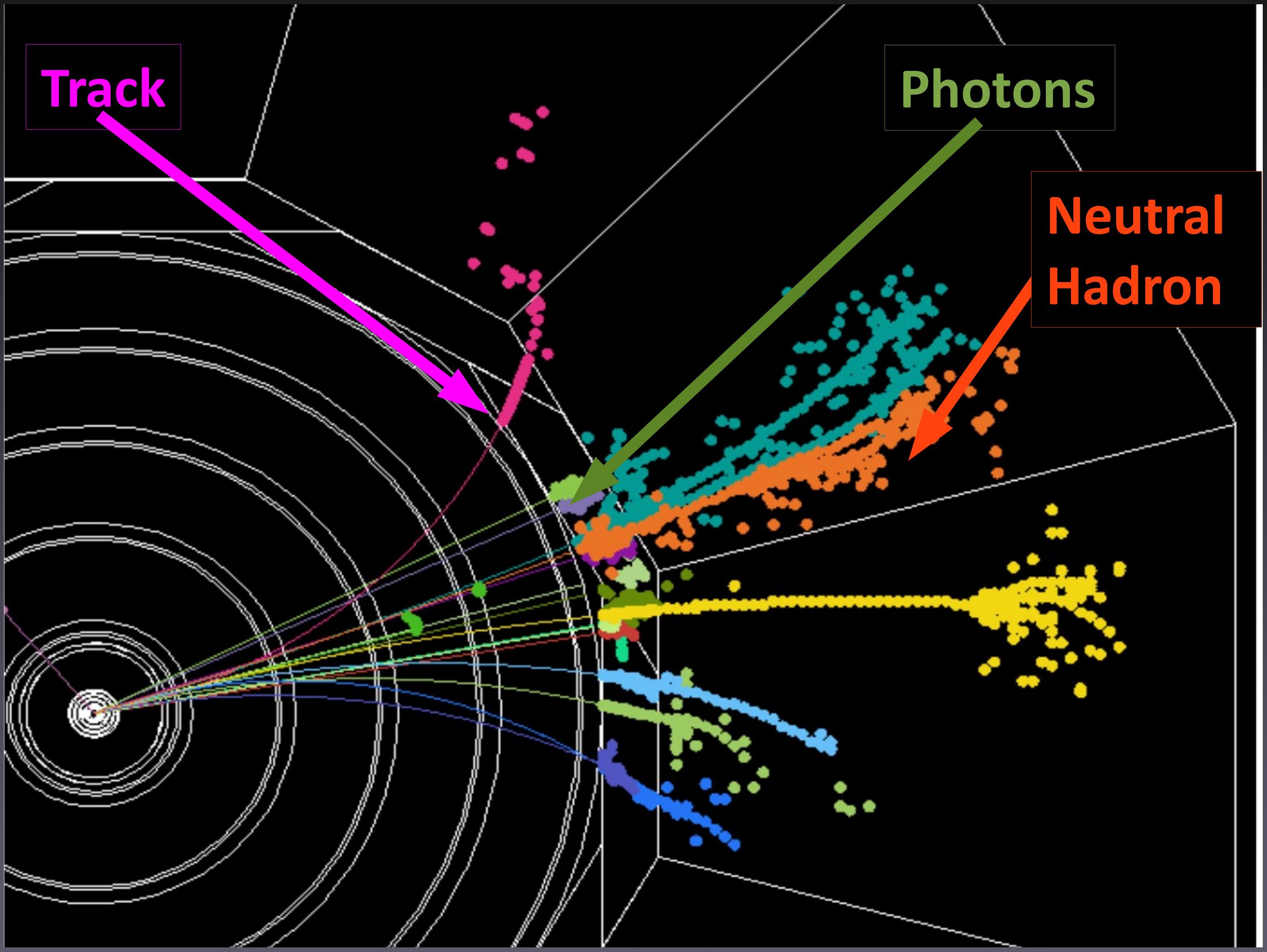
Summary

- A Precision machine is necessary to complement the LHC
- ILC is the right machine to do this
  - Accelerator technology is ready for prime time
  - The European XFEL provides invaluable experience
  - ILC Detector Design have been validated
- SiD
  - Compact detector for precision physics at the ILC
  - Advanced Design, moving towards a TDR
- Japanese Interest in hosting the ILC

Acknowledgements

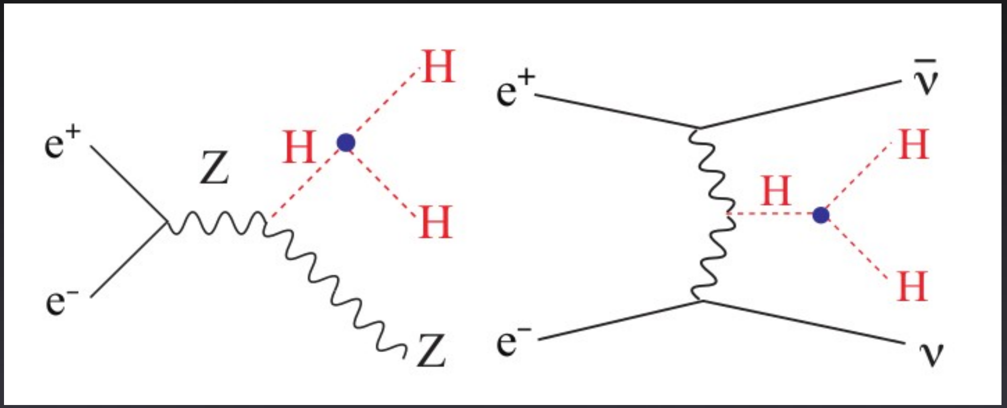
- A big thanks for useful discussion and material
  - B. List, D. Reschke, F. Sefkow, N. Walker, H. Weise (DESY), K. Fuji (KEK), J. Strube (Tohoku), T. Tanabe (Tokyo), A. White (UT Arlington)

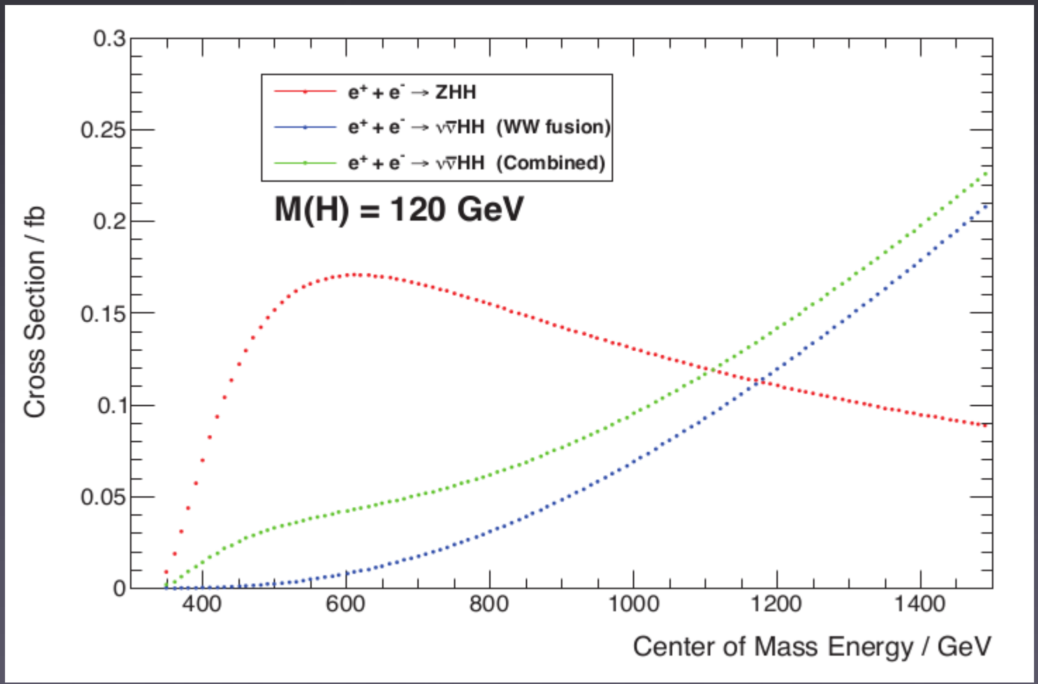
PFA Reconstruction



Higgs Self-coupling

- This measurement is one of the most difficult ones at both LHC and ILC
- ILC cross-section
  - 10^4 smaller than the Higgs cross-section
- ILC will be able to establish its existence
  - But it won't be a precision result





Snowmass/P5

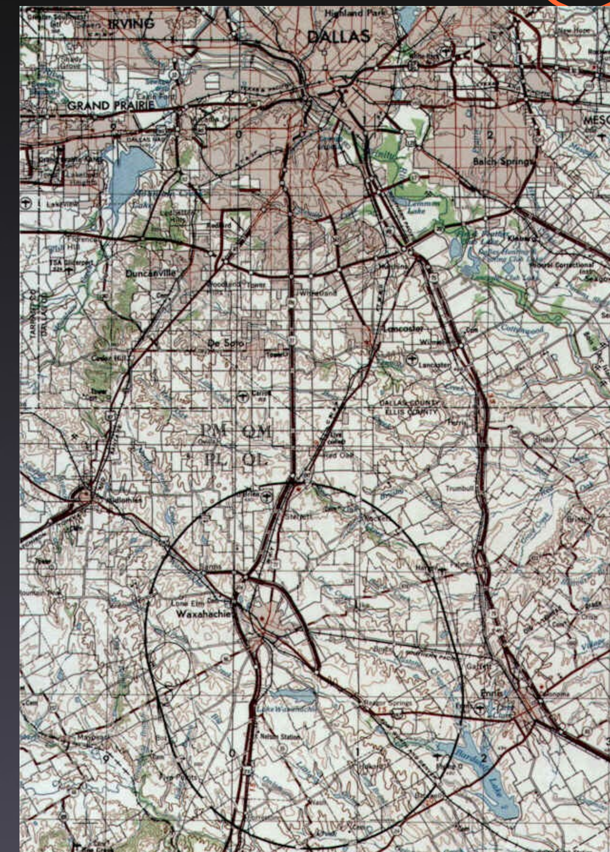
- **P5 Report**
  Longer-term future-generation accelerators bring prospects for even better precision in Higgs properties and hence discovery potential. Circular e+e– accelerators, such as the FCC-ee project being studied at CERN and the CepC project in

- Snowmass Accelerator Summary
- Circular e+e- in very large tunnel (50 – 100 km)
  - Substantial extrapolation albeit from large experience base
  - Energy reach & luminosity are very strongly coupled

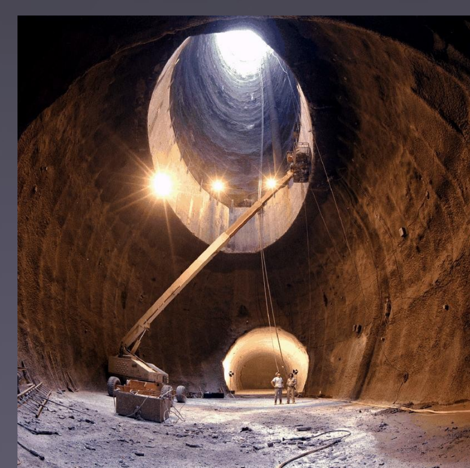
ICFA Statement

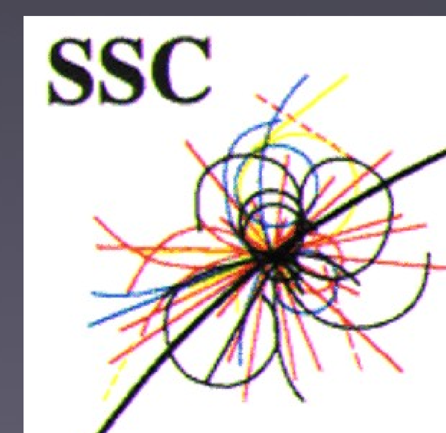
- ICFA endorses the particle physics strategic plans produced in Europe, Asia and the United States and the globally aligned priorities contained therein. Here, ICFA reaffirms its support of the ILC, which is in a mature state of technical development and offers unprecedented opportunities for precision studies of the newly discovered Higgs boson. In addition, ICFA continues to encourage international studies of circular colliders, with an ultimate goal of proton-proton collisions at energies much higher than those of the LHC.

The SSC ...



- SSC (1987-1993)
  - pp Collider
  - 87 km tunnel
  - 40 TeV center-of-mass energy
- Located in Waxahachie, Texas
- US Congress terminated this project in 1993
  - After about half of the tunneling was done





Comparison with LHC

- Calorimeter granularity
  - Need factor ~O(100) better than LHC
- Vertex Detector Pixel size
  - Need factor ~ O(20) smaller than LHC
- Material budget, central tracking
  - Need factor ~ O(10) less than LHC
- Material budget, forward tracking
  - Need factor ~O(100) less than LHC

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