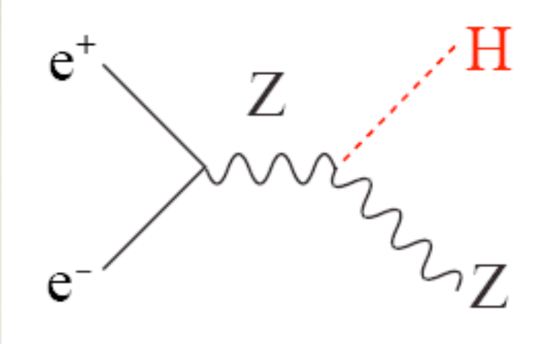
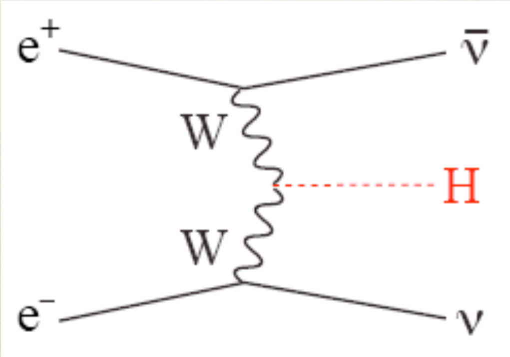
ILC Physics & Detectors

- REFINING LHC DISCOVERIES
  - Precision probe in clean, low background environment reveals details of underlying physics
  - 'Higgs' and any other discoveries
- DIRECT DISCOVERIES
  - Color neutral states
  - Extended Higgs sector
- DISCOVERIES THROUGH PRECISION
  - Precision tests of SM particles highly sensitive to new physics - higher mass reach than LHC in specific cases
  - beam polarization plays important role

Energy Evolution

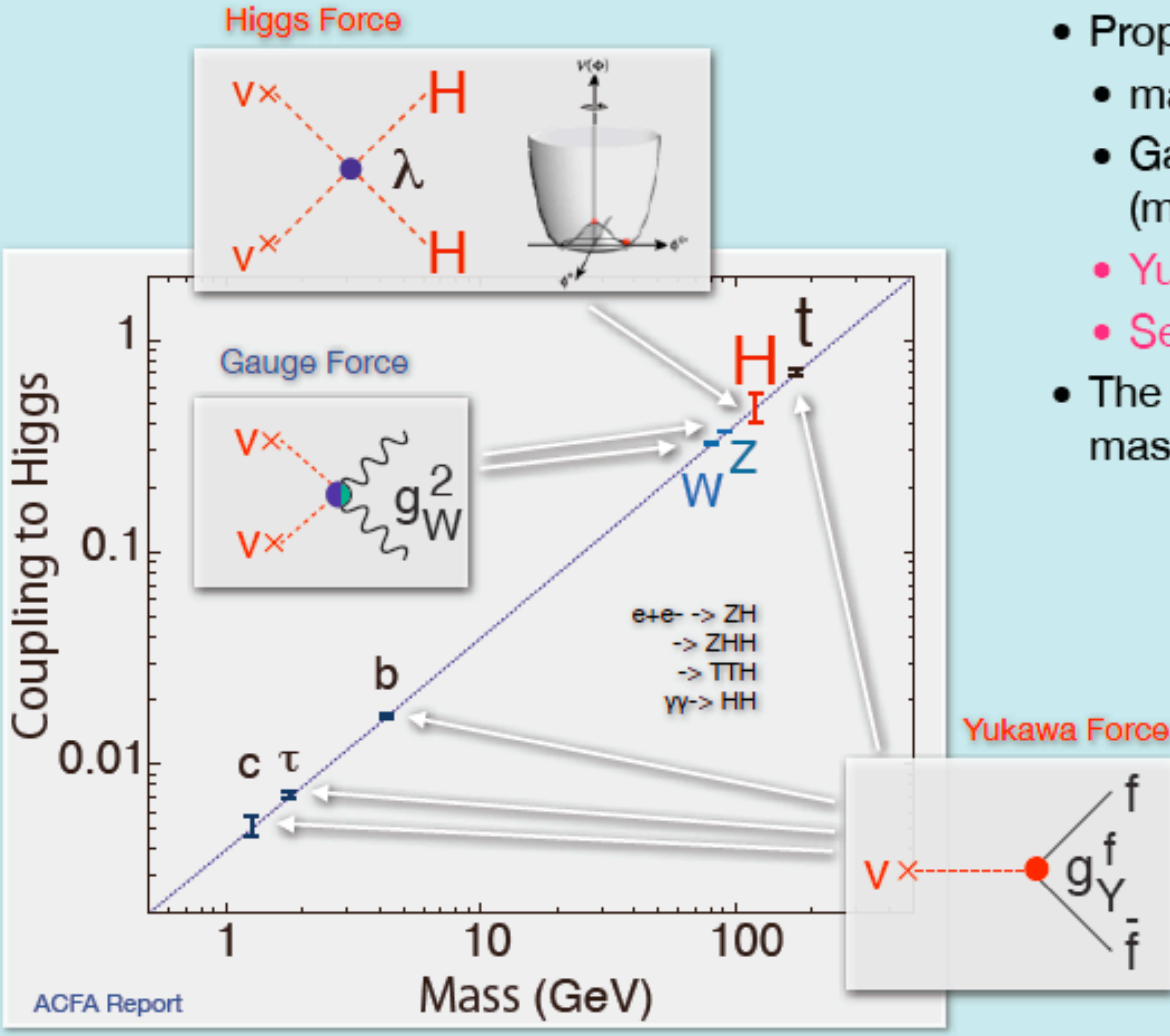


- ~ 250 GeV - Higgs threshold
  - tagged events, measure branching ratios
  - sensitive to invisible and all unexpected decay modes at 1% level
- 500 GeV - add $e^+e^- \rightarrow \nu \bar{\nu} h$, $e^+e^- \rightarrow t\,t\,h$, $e^+e^- \rightarrow Z\,h\,h$
  - absolute normalization of couplings, begin t and h couplings
- 1000 GeV - add $e^+e^- \rightarrow \nu \bar{\nu} h\,h$, $e^+e^- \rightarrow \nu \bar{\nu} h\,(h \rightarrow \mu^+ \mu^-)$
  - high statistics, refined t (4%), μ (20%), and h (24%) (self-) couplings



The Mass Coupling Relation

Uncover the secret of the Electroweak Symmetry Breaking



- Properties to measure are
  - mass, width, J^{PC}
  - Gauge quantum numbers (multiplet structure)
  - Yukawa couplings
  - Self-coupling
- The key is to measure the mass-coupling relation

If the 125GeV boson is the one to give masses to all the SM particles, coupling should be proportional to mass.

Any deviation from the straight line signals BSM!

K. Fujii

The Higgs as a window to BSM physics!

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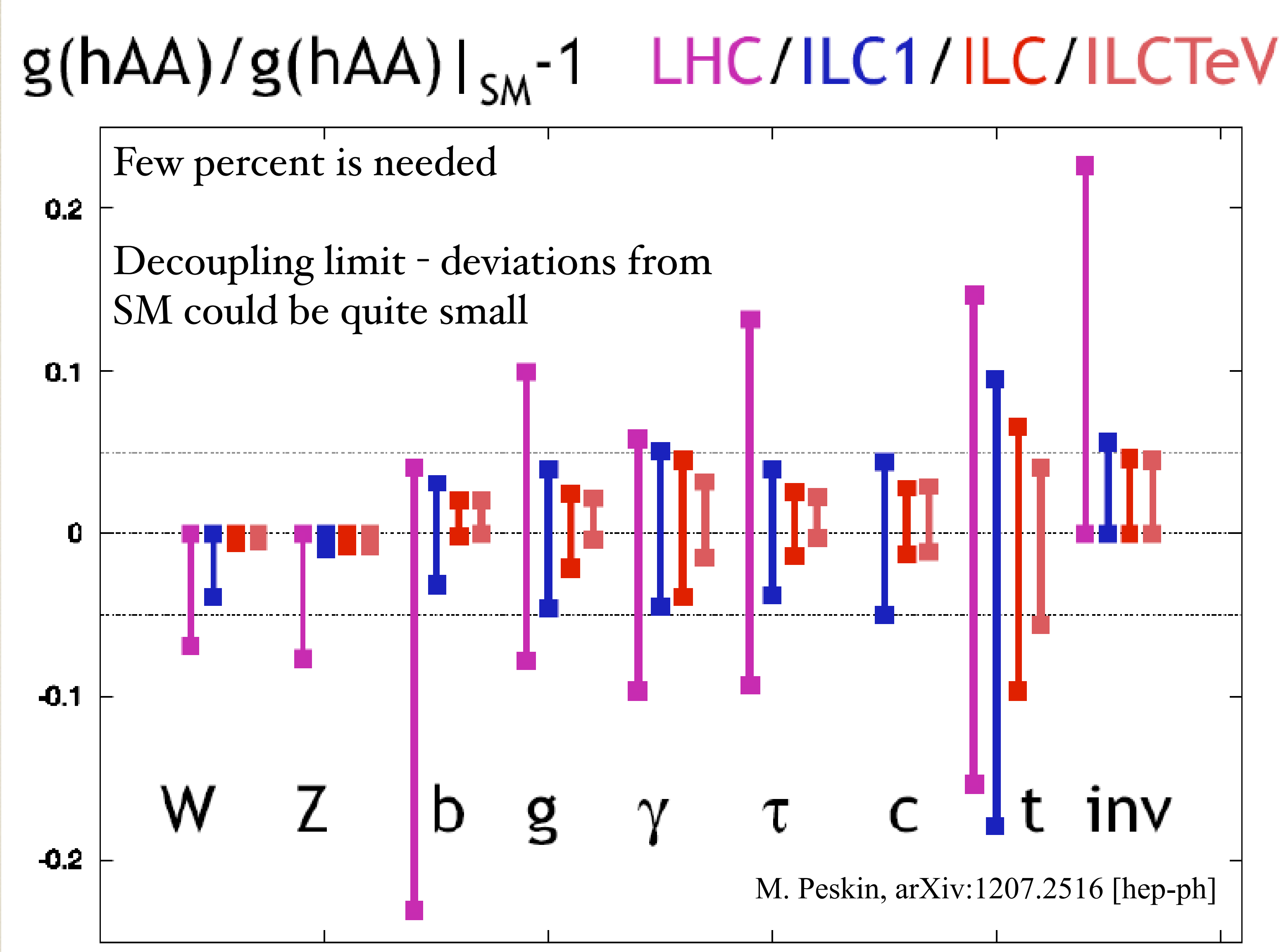
12年10月25日木曜日

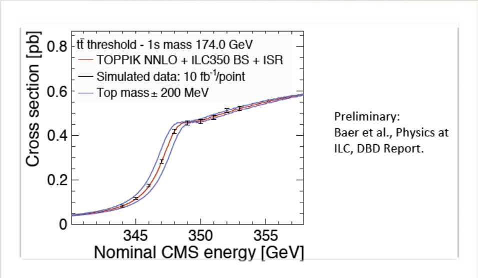


LHC, 300 fb^{-1}, 1 experiment
ILC1 at 250 GeV, 250 fb^{-1}
ILC at 500 GeV, 500 fb^{-1}
ILCTeV at 1000 GeV, 1000 fb^{-1}

For each decay channel, a succeeding generation measurement includes also all the previous measurements.
The symbol "inv" indicates limits on the coupling to invisible decay modes of the Higgs; the final 95% CL limit on the branching ratio is 0.3%.

Some Key ILC Physics

- HIGGS - precision coupling measurements
  - Higgs mass – < 50 MeV; Higgs width – 4-5%
  - Sensitive to mixing of CP-even and CP-odd to 3-4%
- TOP
  - Top quark mass <100 MeV (statistical precision of 20 MeV)
    - stability of the vacuum
  - Top quark width ~30 MeV
  - Asymmetries ~5%
  - Precise tests of Top couplings to Gauge bosons



- LOW MASS DARK MATTER SEARCH
  - LHC insensitive to - color singlet particles
    - particles with small mass differences
    - particles of an extended Higgs sector

Intense R&D Created Detector Concepts with Unprecedented Precision

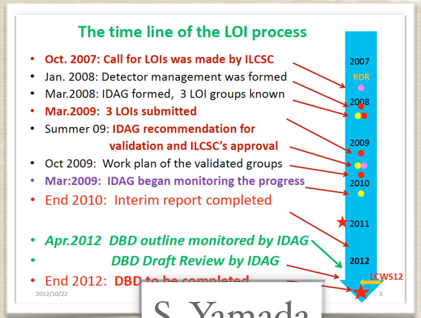
- Clean events with low backgrounds benefit from unprecedented detectors
- Detector R&D critical to develop needed technology
- Many advances by LC community - especially,
  - calorimetry - notably SiW ECal, PFA HCal
  - tracking - Silicon and TPC
  - vertex detector
  - forward detectors
- Global collaboration has achieved significant progress on component R&D and integrated detector designs - ready for project engineering design

Detector Challenges Addressed

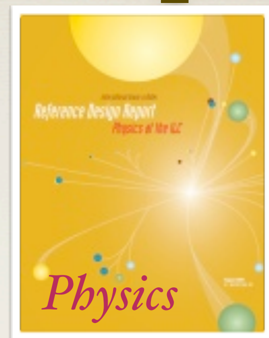
Physics Process	Measured Quantity	Critical System	Critical Detector Characteristic	Required Performance
$H \to b\bar{b}, c\bar{c}, gg$ $b\bar{b}$	Higgs branching fractions b quark charge asymmetry	Vertex Detector	Impact parameter ⇒ Flavor tag	$\delta_b \sim 5\mu m \oplus 10\mu m/(p\sin^{3/2}\theta)$ Precise
$ZH \to \ell^+\ell^- X$ $\mu^+\mu^-\gamma$ $ZH + H\nu\bar{\nu}$ $\to \mu^+\mu^- X$	Higgs Recoil Mass Lumin Weighted E_{cm} BR ($H \to \mu\mu$)	Tracker	Charge particle momentum resolution, $\sigma(p_t)/p_t^2$ ⇒ Recoil mass	$\sigma(p_t)/p_t^2 \sim few \times 10^{-5} GeV$ Superb
ZHH $ZH \to q\bar{q}b\bar{b}$ ZH→ZWW* $\nu\bar{\nu}W^+W^-$	Triple Higgs Coupling Higgs Mass BR (H → WW*) σ(e+e- → νν W+W-)	Tracker & Calorimeter	Jet Energy Resolution, σ_E/E ⇒ Di-jet Mass Res.	~3% for E_{jet} > 100 GeV $30\%/\sqrt{E_{jet}}$ for E_{jet} < 100 GeV Excellent
SUSY, eg. $\tilde{\mu}$ decay	$\tilde{\mu}$ mass	Tracker, Calorimeter	Momentum resolution, Hermiticity ⇒ Event Reconstruction	Maximal solid angle coverage Full

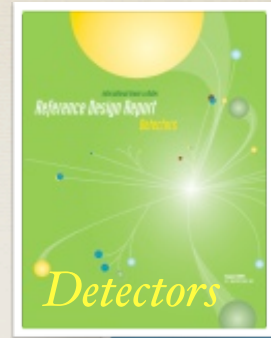
✳ High granularity, dense integration, super light materials, low power, air cooling, power pulsing

ILC Detector Roadmap

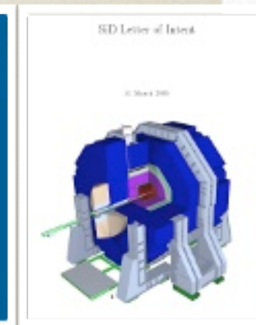


S. Yamada





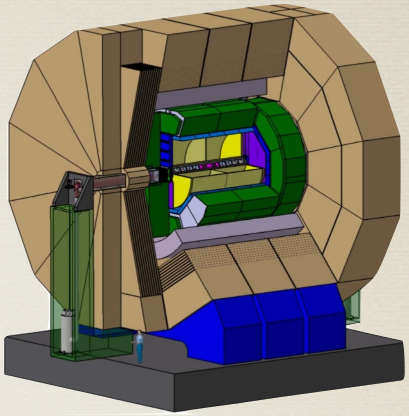
- ✳ Apr 2003 "Consensus Document"
  - ✳ Signed by more than 2700 (exp+theo+acc)
- ✳ Aug 2007 Detector Concept Report (RDR)
  - ✳ Four (4) detector concepts
  - ✳ LDC, GLD, SiD, 4th
- ✳ Oct 2007 ILCSC calls for LOIs / appoints Research Director
- ✳ Jan 2008 RD forms detector management
- ✳ Mar 2008 IDAG formed, Three (3) LOI groups identified
- ✳ Mar 2009 Three (3) LOIs submitted
  - ✳ detailed detector description, status of critical R&D, full GEANT4 simulation, benchmark analysis, costs
- ✳ Aug 2009 IDAG recommends validation of 2 / ILCSC approves
- ✳ Oct 2009 Work plan of the validated groups
- ✳ Mar 2009 IDAG began monitoring the progress
- ✳ 2011 Interim Report
  - ✳ http://www.linearcollider.org/about/Publications/interim-report
- ✳ 2013 Detailed Baseline Design Report (w/TDR)
  - ✳ (more than 1500 signatories)

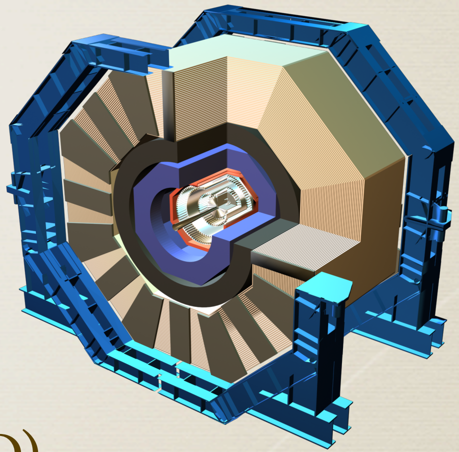


Validated LOIs

Validated Detectors - ILD & SiD

- Both 4π detectors - complementary designs
  - common sys. - thin pixel vxd, Si-W Ecal
- ILD
  - TPC tracking aided by silicon
  - Scintillator-steel hadron calorimeter
  - Excellent tracking and calorimetry for best possible event reconstruction
- SiD
  - Silicon tracking
  - Gaseous (RPC) digital hadron calorimeter
  - Fast tracking and calorimeter for robustness
- Detailed description in Detailed Baseline Design (DBD) volume - companion to ILC TDR
  - DBD signed by more than 1500 - 224 USA - so far
- These detectors ready for project engineering design





Detailed simulation models in GEANT for BENCHMARK STUDIES

Detector Cost Estimates

- Both detectors have studied costs and present estimates in the DBD
- For example, SiD (by M. Breidenbach)

Table 12.3.1: Summary of Costs per Subsystem.

	M&S Base (M US-$)	M&S Contingency (M US-$)	Engineering (MY)	Technical (MY)	Admin (MY)
Beamline Systems	3.7	1.4	4.0	10.0	
VXD	2.8	2.0	8.0	13.2	
Tracker	18.5	7.0	24.0	53.2	
ECAL	104.8	47.1	13.0	288.0	
HCAL	51.2	23.6	13.0	28.1	
Muon System	8.3	3.0	5.0	22.1	
Electronics	4.9	1.6	44.1	41.7	
Magnet	115.7	39.7	28.3	11.8	
Installation	4.1	1.1	4.5	46.0	
Management	0.9	0.2	42.0	18.0	30.0
	314.9	126.7	186.0	532.1	30.0

SiD designed
with cost constraint
in mind

Preliminary,
but serious
attempt to
include everything
from grounds up