



Report from Physics WG

Keisuke Fujii
on behalf of the Physics WG
April 4, 2017

ILD Physics Coordination Meeting

on March 21 (Tue.) 7:00-8:00 JST

Agenda

1. EPS (July 5-12) talks (abstract deadline: April 15)
 - Precision Higgs Measurements at the 250 GeV ILC: in light of staging
 - The Potential of the ILC for Discovering New Particles: ICFA support document
 - Toward Precision Top Quark Measurements in e^+e^- collisions: ILC/CLIC combined
 - Precision EW (incl. TGC, etc.) if we have enough manpower to put into this
 - “Semi-private” talks
 - Higgs: HVV
 - Higgsinos
 - $e^+e^- \rightarrow bb$
 - ...
- APS DPF (1st week of Aug.) (abstract deadline: May 12)
 - to be handled by Kiyotomo and Jim?

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continued

2. Papers in preparation

- CP mixture in $H \rightarrow \tau^+ \tau^-$: Daniel
- $e^+e^- \rightarrow bb$: Roman / Francois
- CPV in Top : Marcel
- Higgsinos : Jackie / Suvi
- Higgs self-coupling : Claude / Jumping / Masakazu
- Anomalous HVV couplings : Tomohisa / Junping
- ...

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continued

3. Subgroup meetings

- 1st BSM WG meeting on March 1
- regular subgroup meetings are probably overkill → have one as needed
- effective use of confluence

4. MC production → Hiroaki's talk on Mar.22 S&A Mtg.

5. Staging

6. Physics/optimization session of the Lyon meeting

- status reports from individual benchmark studies
- complementary to SLAC WS
- high level rec. session to be co-organized with the software WG

Staging Discussion

- In LCWS 2016, Nov. in Morioka, it was agreed to start seriously considering a staging scenario of the ILC ***to significantly reduce the initial construction cost.***
 - 1st stage as a Higgs factory
 - and later stages taking advantage of flexible energy expandability of a linear collider.
- LCB/LCC started working on possible staging scenarios to build consensus among the worldwide HEP community.

The staging option resurfaced again during LCWS 2016!

Following this ILC Parameters Joint WG met on Jan. 4

- Our goal is to consider the physics potential for an ILC that starts operations at low energy, either 250 GeV, or 350 GeV.
- ***We need to make the 1st stage as attractive as possible.***
 - as high Luminosity as possible for the 1st stage.
- We could consider a different choice for the machine parameters.
- **Official request sent to Shin Michizono for some machine manpower to investigate the possibility.**
 - Kaoru Yokoya, Takashi Okugi, Toshiaki Tauchi, Daniel Jeans started a study. Needs modification of DR design to reduce horizontal emittance.
- Lyn has asked us to provide a first update on the physics impact of the staging possibilities by mid February.

Jim Brau, as the LCC associate director for physics and detector, requested the LCC ILC Physics WG to define the physics goals of the initial stage.

- A short (2-page) report (*a straw man staging scenario*) handed to Jim Brau, shown on Feb.16 at the ICFA annual meeting in Valencia:
 - <https://indico.fnal.gov/conferenceTimeTable.py?confId=13386#20170216.detailed>
- Feed back from Jim to LCC Physics WG.

ILC Parameters Joint WG met on Mar. 8 → action plan formulated.

- ***Luminosity optimization at 250 GeV → >50% luminosity increase by halving the horizontal emittance.***
- ***Realistic run scenarios being prepared: starting from 250 GeV then after lumi-up either to 350 or directly to >500 GeV***
- ***Final report expected in late May to early June***

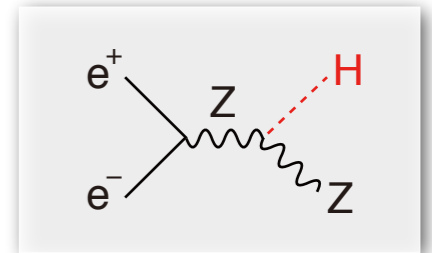
**We need to make
the 1st 250 GeV
stage as attractive
as possible!**

Higgs-related Physics at $E_{cm} \approx 500 \text{ GeV}$

Three well know thresholds

ZH @ 250 GeV ($\sim M_Z + M_H + 20 \text{ GeV}$) :

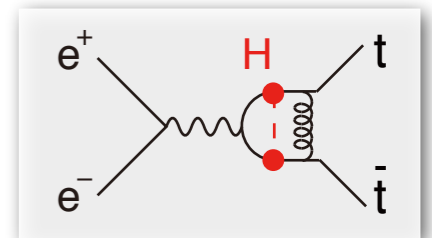
- Higgs mass, width, J^{PC}
- Gauge quantum numbers
- Absolute measurement of HZZ coupling (**recoil mass**) \rightarrow **Higgs couplings (other than top)**
- BR($h \rightarrow VV, qq, ll, \text{invisible}$) : $V=W/Z(\text{direct}), g, \gamma$ (loop)



ttbar @ 340-350 GeV ($\sim 2m_t$) : ZH meas. Is also possible

- Threshold scan \rightarrow **theoretically clean mt measurement:** $\Delta m_t(\overline{MS}) \simeq 100 \text{ MeV}$
 \rightarrow test stability of the SM vacuum
 \rightarrow **indirect meas. of top Yukawa coupling**
- A_{FB} , Top momentum measurements
- Form factor measurements

$\gamma\gamma \rightarrow HH$ @ 350 GeV possibility



vvH @ 350 - 500 GeV :

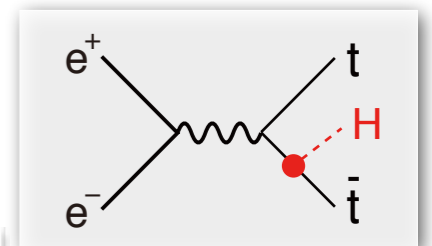
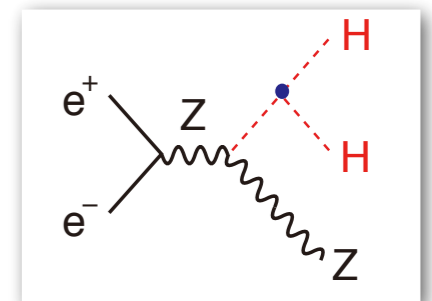
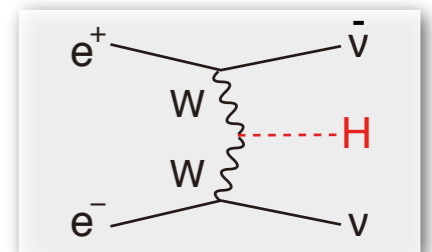
- **HWW coupling** \rightarrow **total width** \rightarrow absolute normalization of Higgs couplings

ZHH @ 500 GeV ($\sim M_Z + 2M_H + 170 \text{ GeV}$) :

- Prod. cross section attains its maximum at around 500 GeV \rightarrow **Higgs self-coupling**

ttbarH @ 500 GeV ($\sim 2m_t + M_H + 30 \text{ GeV}$) :

- Prod. cross section becomes maximum at around 800 GeV.
- QCD threshold correction enhances the cross section \rightarrow **top Yukawa** measurable at 500 GeV concurrently with the self-coupling



We can access all the relevant Higgs couplings at $\sim 500 \text{ GeV}$ for the mass-coupling plot!

Issues and Possible Handles to Address Them

Fully model independent Higgs total width determination needs WW fusion (small at 250GeV)

- **Improve σ BR($h \rightarrow WW^*$) precision**
- Use **ratios of BR's**
- Assume **Custodial Symmetry** that relates $\Gamma(hWW)$ and $\Gamma(hZZ)$
- Note that **WL and ZL are from the Higgs sector.** → **Global analysis including PEWO** (mW, TGC) in **EFT**

Self coupling measurement needs 500 GeV. How to address EWBG in the 1st stage?

- Precision hZZ coupling measurement? (EWBG models with singlet mixing)
- **Synergy with GW measurements?**
- CPV in Higgs sector, but we need to know **amount of CPV needed?**

Top/QCD: 1st stage is below tuba threshold

- **Use bottom** as the other member of the 3rd generation: $\sigma(bb)$, $A_{FB}(bb)$
- Single top production?

BSM: Direct search limited by Ecm

- **Exotic Higgs decays** to new light particles, FCNC decays?
- **Dark Matter** (Z portal, leptophilic DM)
- **Extra light states** (spin-less bosons, dark photon, ..)
- Higgsinos
- Indirect searches using **2-fermion processes** (Z')

Physics interpretations/implications with inputs from theorists

Synergies with LHC (assuming that ILC will be concurrently running with HL-LHC) and other experiments.

Ongoing and Planned 250 GeV Analyses

Higgs

- **Improve σ BR($h \rightarrow WW^*$) precision: Mila?**
- EFT analyses: Tomohisa
- $H \rightarrow \tau\tau$: Daniel
- $H \rightarrow$ invisible: Yu Kato
- $H \rightarrow$ exotic (new light particles, FC/LFV): ?

Precision EW

- m_W : Robert
- 2-fermion processes: $\mu\mu$: Yamashiro
- **TGC: ?**

Top/QCD

- **bb: Sviat**
- Single top production: ?

BSM: Direct search

- **Dark Matter**: Moritz, Tomohiko, Masakazu, ..
- **Extra light states** (light extra higgses, dark photon, ..)
 - ZX ($m_X < 125$ GeV): Yan Wan
- Higgsinos: Jackie

Physics focus schedule

Apr 4: ***General ILD meeting (today)***

Apr 5: Higgs/EW (Jenny)

Apr 11: Physics coordination meeting

May 3 or 10: BSM (KF)

Conveners' ML:

ild-physics-conveners@desy.de

Use this mailing list to send your talk request.