

Study of the Higgs boson decaying into tau pairs and muon pairs

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FH Fellow Meeting



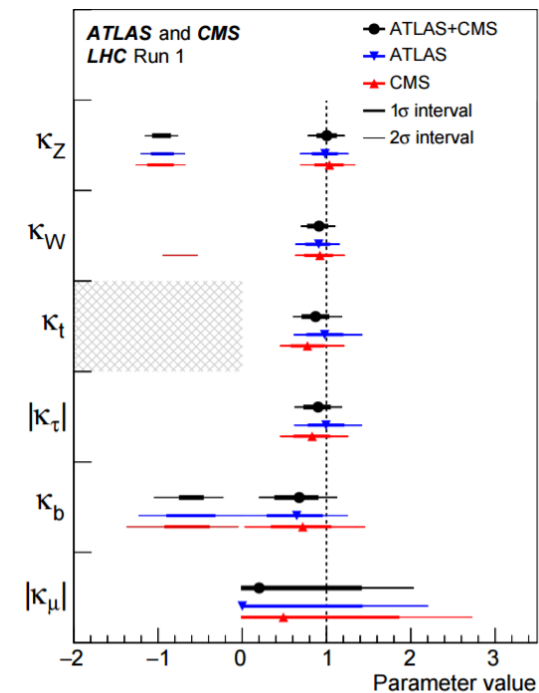
Introduction

Discovery of Higgs-like boson at the LHC
---> last particle of SM? or beyond SM?

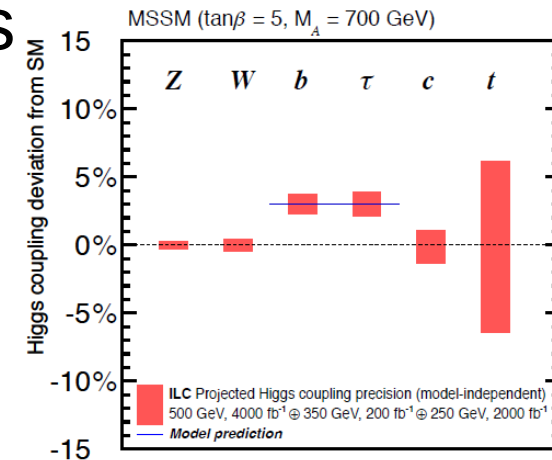
Goal: **model-independent** determination of
EWSB sector with **precise** measurements

- mass-coupling relation
- any deviation shows the existence of BSM

Model-independent and precise measurements of
the Higgs boson are needed to achieve the goal. ---> **ILC**



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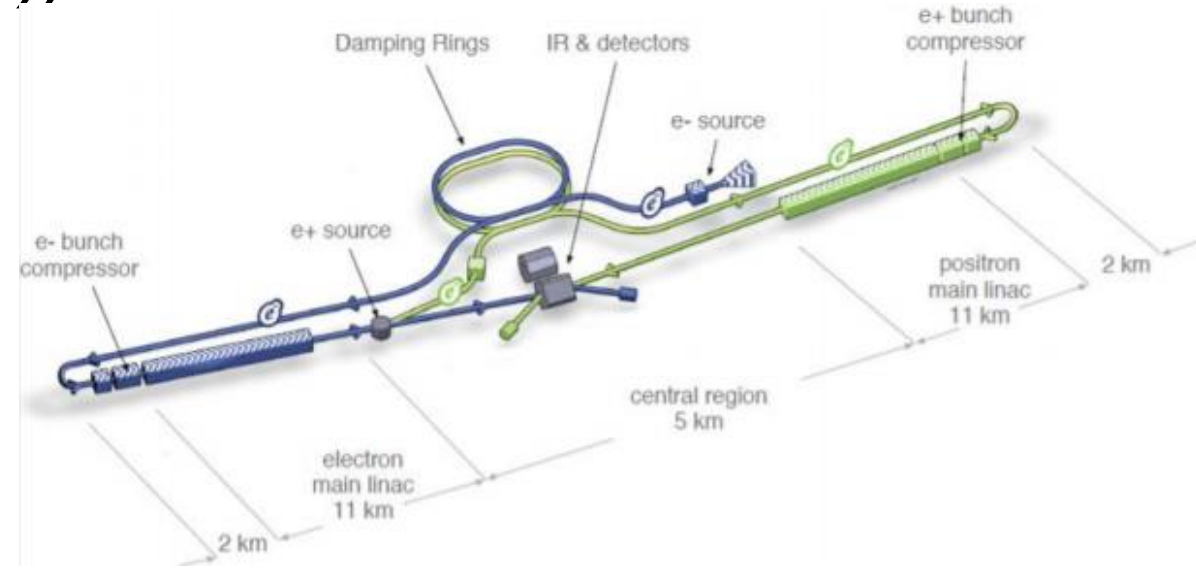
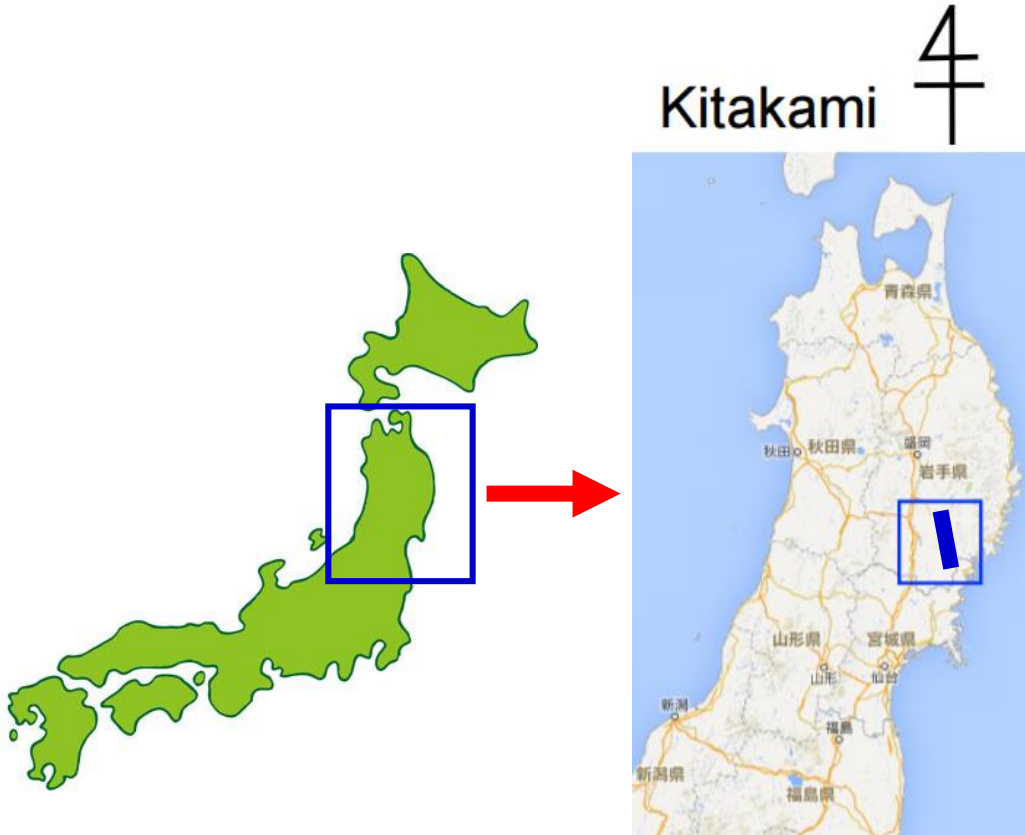
arXiv:
1506.05992
[hep-ex]

The International Linear Collider (ILC)

electron-positron collider

$\sqrt{s} = 250 - 500$ GeV (upgradable to 1 TeV)

polarized beam (e^- : 0.8, e^+ : $\geq 0.3(0.6)$)



Japan shows great interest to host ILC

Political status in Japan

---> S. Yamashita's talk

@10th Helmholtz Alliance Meeting (DESY seminar)

ILC Running Scenario

optimized scenario with considering

- Higgs precise measurements
- Top physics
- New physics search

20 years running with
energy range [250-500] GeV
---> then possible 1 TeV upgrade

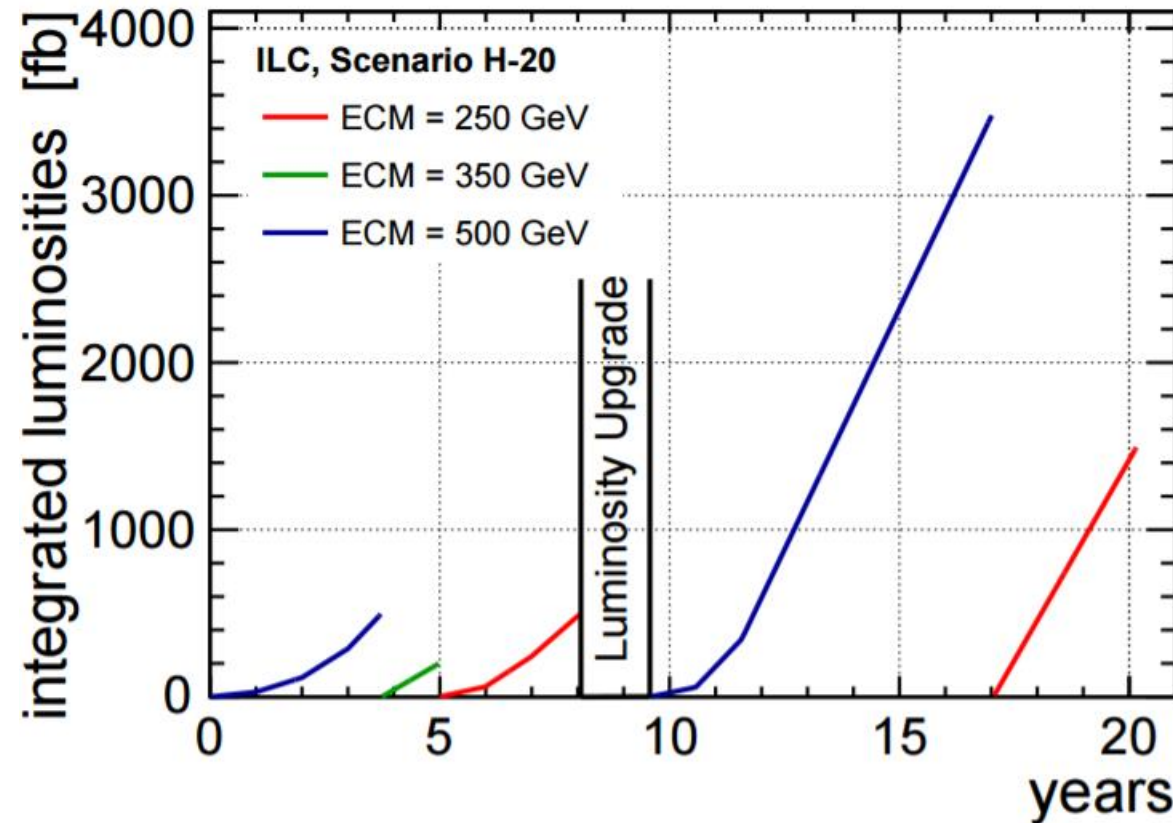
preferred scenario:

2000 fb⁻¹ @ 250 GeV

200 fb⁻¹ @ 350 GeV

4000 fb⁻¹ @ 500 GeV

Integrated Luminosities [fb]



✂ will depend on physics results
from LHC and early ILC

What I worked

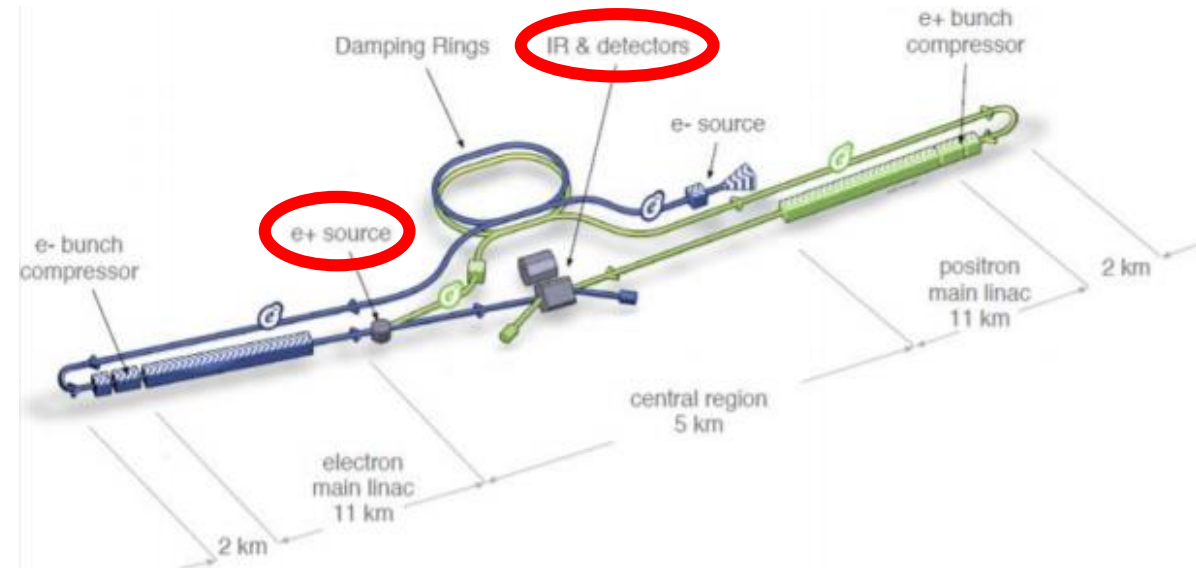
Positron source

Development of positron source

NIMA **672** (2011) 52-66
NIMB **319** (2013) 17-23

Physics & Detectors

- TPC development JINST **8** C11023 (2013)
JINST **9** C03002 (2014)
- $\gamma\gamma \rightarrow hh$ PRD **85** 113009 (2012)
- $h \rightarrow \tau^+\tau^-$ (PhD thesis) EPJC **75**:617 (2015)
- $h \rightarrow \mu^+\mu^-$ (now working)



Higgs production at the ILC

$\sqrt{s} = 250$ GeV

Higgs-strahlung (Zh) dominant

highest cross section

important for Higgs coupling study

$\sqrt{s} = 350$ GeV

sizable contribution from **WW-fusion**

$t\bar{t}$ threshold

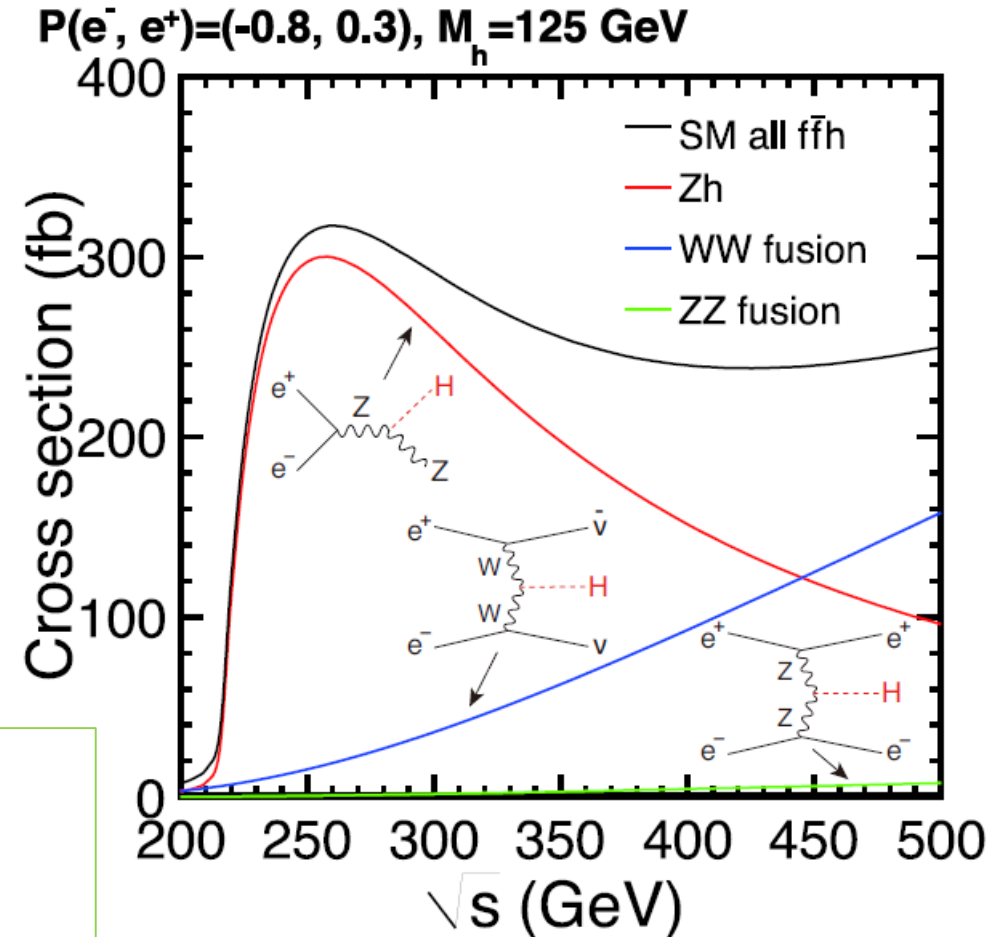
$\sqrt{s} = 500$ GeV

WW-fusion dominant

more data of Higgs

access to $e^+e^- \rightarrow t\bar{t}h$ and Higgs self-coupling

studied at 250 GeV and 500 GeV

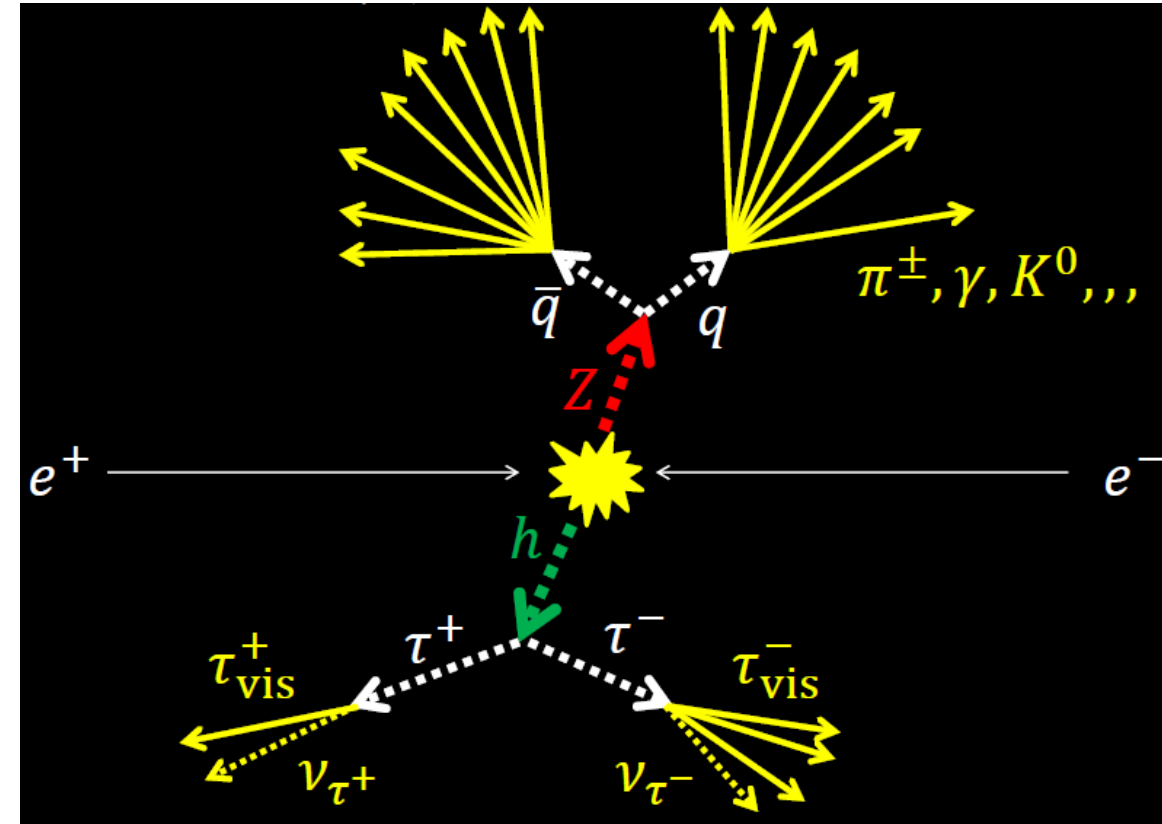


Study of $h \rightarrow \tau^+ \tau^-$

- Tau is heaviest lepton ---> large BR, large statistics
- Tau mass is well determined ---> small theoretical uncertainty, good probe for precise measurement
- ILC can measure the Higgs boson precisely. But how much?
 - Previous studies were too old arXiv:hep-ph/9910271 (1999)
LC-PHSM-2002-003 (2002)
- Need realistic/reliable study with considering...
 - running scenario
 - detector model
 - good analysis tools

Example: $e^+e^- \rightarrow Zh \rightarrow q\bar{q}\tau^+\tau^-$ at 250 GeV

- (1) Tau clustering
developed tau finder
tuned for $q\bar{q}\tau^+\tau^-$
- (2) Collinear approximation
reconstruct tau pair mass
- (3) Durham clustering
reconstruct jets

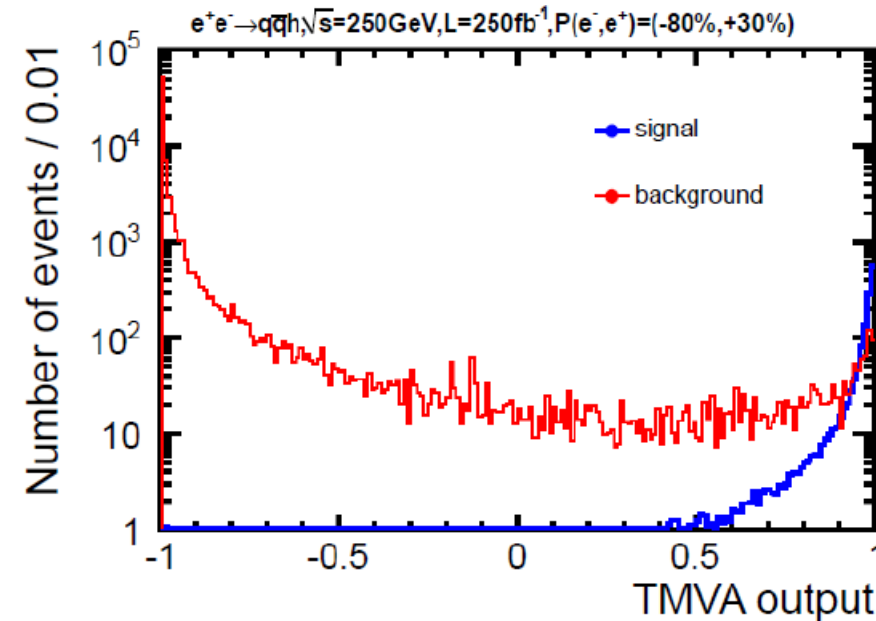
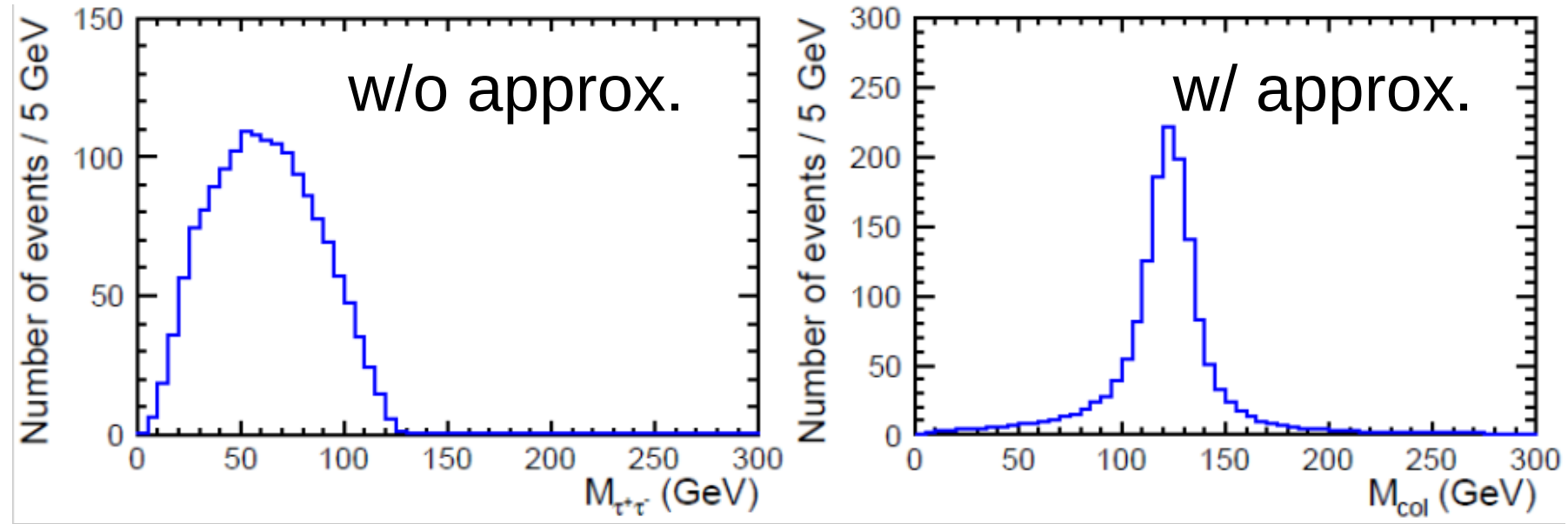


Results

Nice peak at
~125 GeV

Good signal/background
separation using TMVA

$$\frac{\Delta(\sigma \times \text{BR})}{(\sigma \times \text{BR})} = 1.0\% \text{ with full scenario}$$



Precision of Higgs Couplings

Inputs

(direct, model-independent measurement)

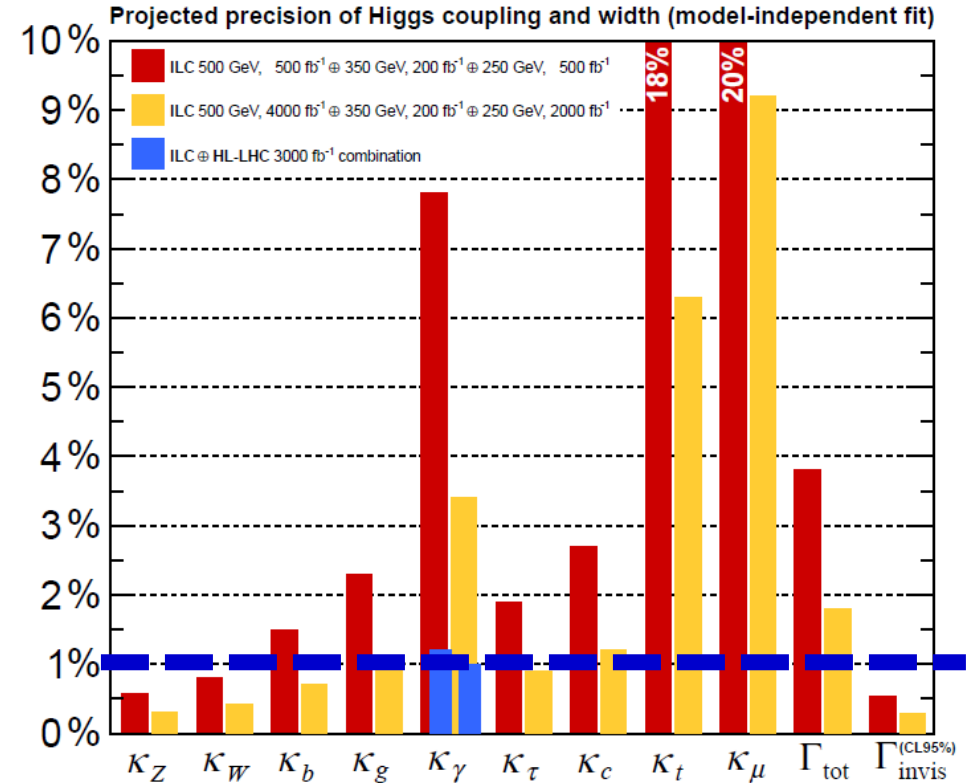
σ_{Zh} and $\sigma \times \text{BR}(h \rightarrow XX)$

Couplings and total width are obtained from model-independent global-fit (systematic errors included)

most couplings reach $\lesssim 1\%$

$\Delta g_{htt} \sim 3\%$ with 550 GeV running

Completely model-independent measurement



Study of $h \rightarrow \mu^+ \mu^-$

- 1 TeV analysis is done with fully-simulated samples.
- But current preferred running scenario has lots of integrated luminosities at 500 GeV.
- Very challenging study due to small BR of $h \rightarrow \mu^+ \mu^-$
 - $\sim 2.2 \times 10^{-4}$
 - # events ~ 60
 - But muon gives clean signal signature
- Currently my main work: work in progress

Summary

- Precise measurement of the Higgs boson is very important to uncover not only the last piece of SM but also BSM.
- Working on ILC, especially Higgs physics analysis
 - Obtained reliable results for $h \rightarrow \tau^+ \tau^-$ channel
 - Work in progress for $h \rightarrow \mu^+ \mu^-$ channel