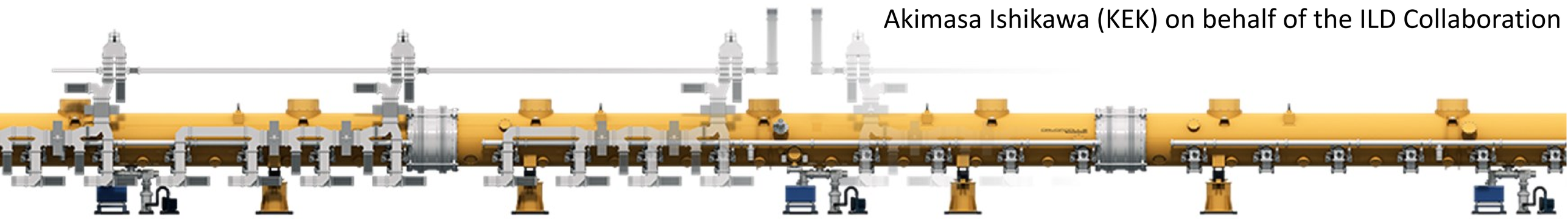
Search for invisible decays of the Higgs boson at the ILC

Akimasa Ishikawa (KEK) on behalf of the ILD Collaboration



Introduction

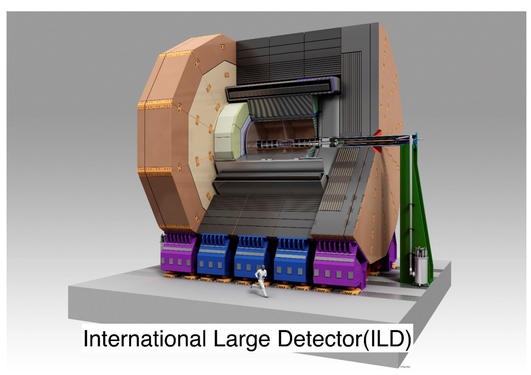
$\Omega_{\mathrm{DM}}h^2 = 0.1188 \pm 0.0010$

Existence of dark matter is established in astrophysics. However there is no dark matter candidate in the SM. If the dark matter is not charged under the SM gauge group, the Higgs boson is only the portal to dark matter.

ILC and ILD

International Linear Collider (ILC)
- electron positron collider
- start from E_{CM}=250GeV. Upgradable to 1TeV.
- length : 20km (initial), 50km (upgrade)
- beam polarization : ±80% for electron, ±30% for positron

International Large Detector (ILD)
- optimized to particle flow algorithm
- good tracking and calorimetry capabilities
  - silicon pixel vertex detector
  - gaseous and silicon tracking
  - both silicon and scintillator EM CAL considered

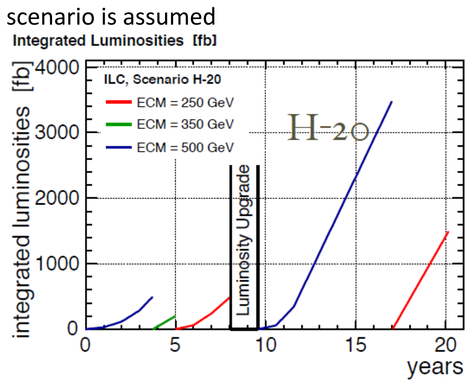


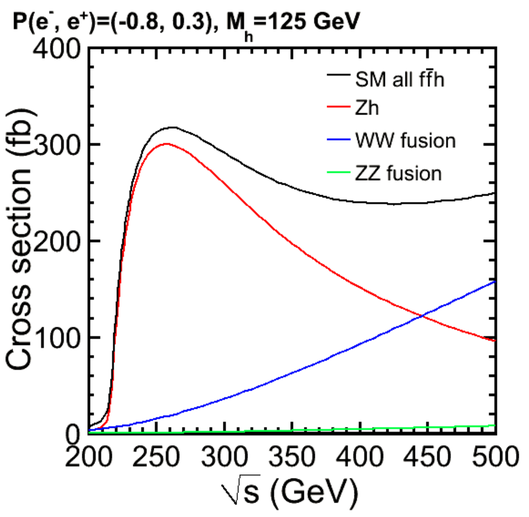
Setup

Beam Energy, Polarization, Luminosity
- "Left" : $(P_{e-}, P_{e+}) = (-80\%, +30\%)$
- "Right" : $(P_{e-}, P_{e+}) = (+80\%, -30\%)$

Int Lumi [fb^{-1}]	"Left"	"Right"
250GeV	1350	450
350GeV	135	45
500GeV	1600	1600

H20 scenario is assumed



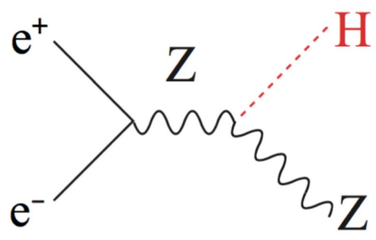


Reconstruction

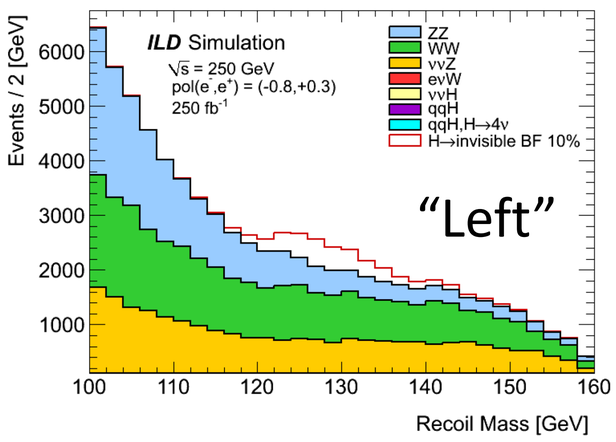
Invisible decays of Higgs boson can be searched for using recoil mass technique with model independent way!
- known initial state
- Z→qq decays measured
- From the two, Higgs mass calculable!

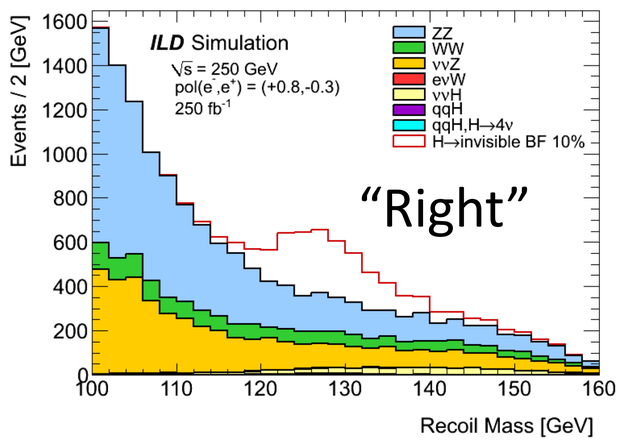
$$P_H = P_{e+e-} - P_Z$$

known measured



Dominant backgrounds
- ZZ→qqνν
- WW→qq'νν (suppressed with "right" polarization)
- ννZ→ννqq





Upper Limits on B(H→invisible)

Only Z→qq [1]

Comparison with the same running time

Right handed pol at 250GeV gives best sensitivity of 0.69%

UL [%]	"Left"	"Right"
250GeV / 250fb^{-1}	0.95	0.69
350GeV / 350fb^{-1}	1.49	1.37
500GeV / 500fb^{-1}	3.16	2.30

H20 Scenario

UL [%]	"Left"	"Right"	combined
250GeV	0.41	0.51	0.32
350GeV	2.40	3.82	2.03
500GeV	1.77	1.29	1.04
all			0.30

< 0.30% possible only with Z→qq

Adding Z→l^+l^- [2]

Comparison with the same running time

UL [%]	"Left"	"Right"
250GeV / 250fb^{-1}	0.86	0.61
350GeV / 350fb^{-1}	1.23	1.10
500GeV / 500fb^{-1}	2.39	1.73

H20 Scenario

UL [%]	"Left"	"Right"	combined
250GeV	0.37	0.45	0.28
350GeV	1.98	3.07	1.66
500GeV	1.34	0.97	0.79
all			0.26

< 0.26% possible by adding Z→l^+l^-

Comparison with LHC results [3,4]

UL [%]	Combined
ATLAS [3]	26
CMS [4]	19
ILC [1,2]	0.26

About two orders of magnitude improvement possible from current model dependent limits.

Conclusion

ILC is the ideal place to search for invisible decays of the Higgs boson with model independent recoil mass technique. With H20 scenario, upper limit on B(H→invisible) < 0.26% can be achieved.

Reference

[1] A. Ishikawa, Search for Invisible Higgs Decays at the ILC, International Workshop on Future Colliders in 2014 (LCWS14), (Belgrade, 2014).
[2] J. Tian, Higgs Projections Using the ILD at the ILC (KEK, Tsukuba, 2015).
[3] The ATLAS Collaboration, Phys. Rev. Lett. 122, 231801 (2019)
[4] The CMS Collaboration, Phys. Lett. B 793, 520 (2019)