Higgs BR study for DBD

ILD group meeting in KILC12

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Higgs study for DBD

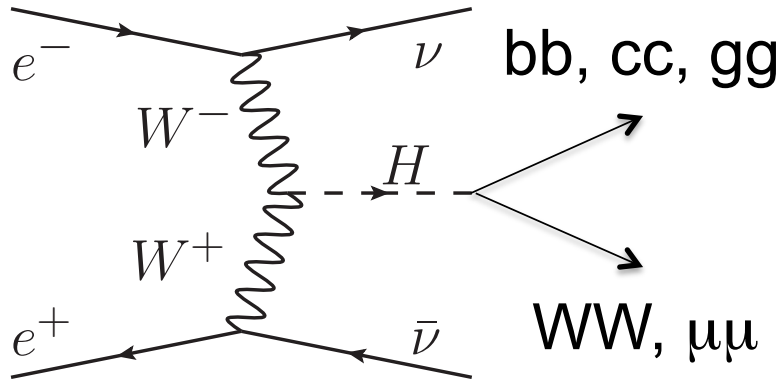
- Detector benchmarking study @1 TeV
  1. $\nu\nu H$ σxBR @1 TeV
  2. $t\bar{t}H$ @1 TeV
  3. W+W- @1 TeV
  4. In addition: Higgs self coupling and $t\bar{t}$ @500 GeV

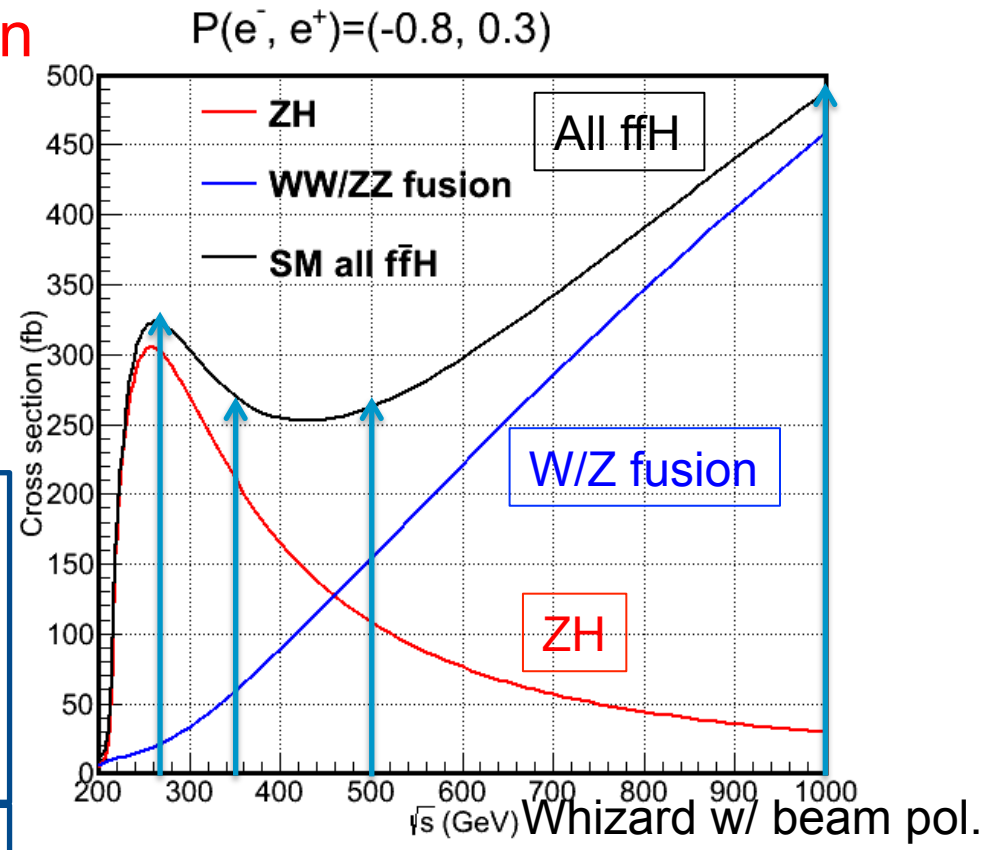
- DBD physics chapter
  - How precisely can we measure Higgs properties in ILC?
    - Compile LOI and post LOI results into RDR results
  - M_h~125 GeV (LHC) and start from low energy (E_{cm}=250 GeV)

ννH @ 1 TeV for DBD

DBD benchmark process: σ*BR for ννH, H→μμ, bb, cc, WW, gg

ννH produced through W-fusion





H→bb, cc, gg (Hadronic decay)
Di-jet reconstruction
Same strategy as LOI 250 GeV
Use flavour-template fitting

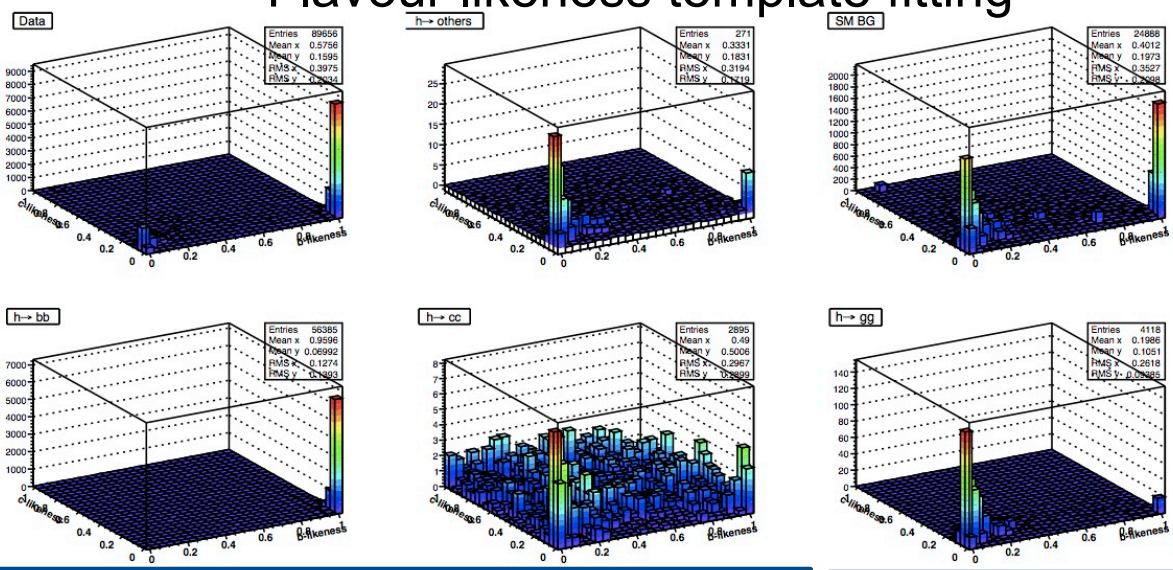
H→WW*, WW→qqqq (4j)
(250 GeV and 500 GeV (Tian))
H→μμ: Muon ID (Not yet)

Main backgrounds (WW,ZZ, ZWW)

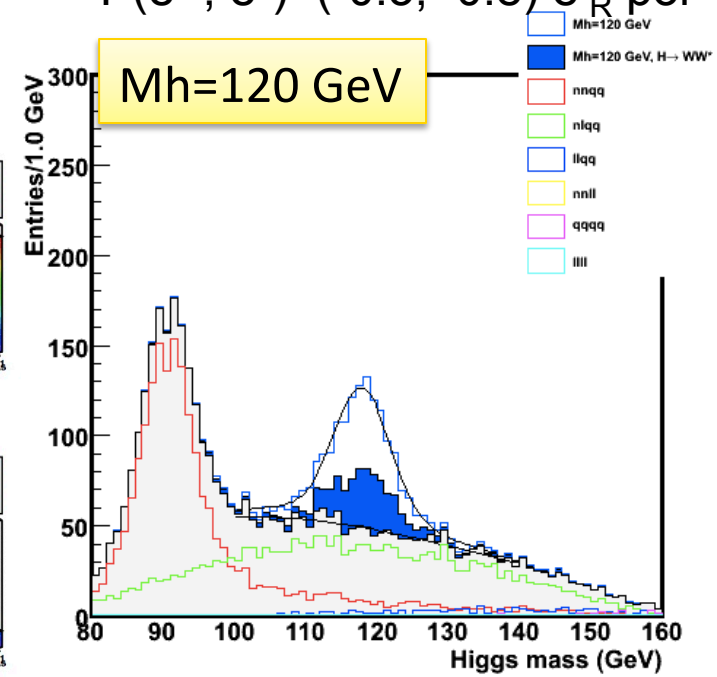
ZH→ννH at E_{cm}=250 GeV (LOI and post)

ZH→ννH (H→bb, cc, gg, WW→qqqq)
L=250 fb^{-1}, M_H=120 GeV

Flavour likeness template fitting



P(e+, e-)=(-0.3,+0.8) e^-_R pol



ννH channel only
ΔσBr/σBr(H→bb)=1.6%
ΔσBr/σBr(H→cc)=13%
ΔσBr/σBr(H→gg)=14%

ZH→ννH, H→WW*→qqqq
ΔσBR/σBR(H→WW→qqqq)~13%
ννH, H→WW @500 GeV is also studied by J. Tian (See 4/25, Physics session)

BR study summary table

P(e+, e-)=(0.3, 0.8), $\Delta\sigma/\sigma$=2.5%, M_H=120 GeV

Ecm	250 GeV (LOI and post)					1 TeV (DBD)		
σ (fb)	354.1 fb (2.5% uncertainty)				vvH only	465.5 fb		
H decay	BR	σxBR	250 fb^{-1}	ΔBr/Br (comb)	$\Delta\sigma$Br/σBr	σxBR	1 ab^{-1}	$\Delta\sigma$BR/σBR
H→bb	64.1%	227.1	56777	2.7%	1.6%	298.6	298552	Ono
H→cc	3.1%	10.8	2703	8.1%	12%	14.2	14211	Ono
H→gg	7.0%	24.9	6225	9.0%	14%	32.7	32733	Ono
H→WW*	15.0%	53.1	13286	8.4%	13%	69.9	69860	Ono
H→$\mu\mu$	0.03%	0.11	28	Ono		0.15	149	Ono
H→$\tau\tau$	8.7%	30.9	7727	To be done		40.6	40632	
H→ZZ*	1.7%	24.6	1516	Ono		8.0	7969	
H→$\gamma\gamma$	0.27%	0.95	236	Constantino		1.2	1243	
H→Zγ	0.13%	0.45	112	Constantino		0.6	591	

1 TeV DBD benchmark **vvH 1 TeV 1 ab^{-1}**

Required vvH signal and BG samples

- Samples request
  - Hopefully 2 ab^{-1} of vvH signal, 2f and 4f backgrounds (~60M) for template fitting procedure
    →Pre-selection should be applied
  - 1 ab^{-1} for 6f (ZWW main) BG for vvH→vvWW→vv+qqqq
    - Generator samples are ready at DESY site
- vvH signal generator sample generation status
  - Production was finished by Tim Barklow, but not yet ready
  - Need to fix file name to new naming scheme
  - File transfer from SLAC site to GRID (a few weeks)
  - H→μμ and others channels will generate separately

Required samples w/ beam pol. (L=1 ab^{-1})

σ*BR	σ(e-L)	σ(e-R)	σ(+0.3,-0.8)	σ(-0.3,+0.8)	N(+0.3,-0.8)	N(-0.3,+0.8)
σ(ννH)	795.37	5.49	465.48	31.05	465483	31049
σ*BR(bb)	510.13	3.52	298.55	19.91	298552	19914
σ*BR(cc)	24.28	0.17	14.21	0.95	14211	948
σ*BR(gg)	55.93	0.39	32.73	2.18	32733	2183
σ*BR(WW*)	119.37	0.82	69.86	4.66	69860	4660
σ*BR(μμ)	0.25	0.00	0.15	0.01	149	10
νlqq	12955	21	7580	466	7.6 M	0.47 M
qq	8749	4862	5288	3151	5.4 M	3.2 M
qqqq	6740	257	3952	386	4.0 M	0.39 M
llll	6537	6454	4050	4004	4.1 M	4.0 M
ννll	5731	117	3357	269	3.4 M	0.27 M
llqq	2671	2311	1643	1445	1.6 M	1.4 M
ννqq	2490	71	1459	129	1.5 M	0.13 M
tt	578	258	347	171	0.35 M	0.17 M
ZWW	228	1	134	9	0.13 M	0.09 M

DBD benchmarking

BG channel 2f, 4f (ZZ, WW)

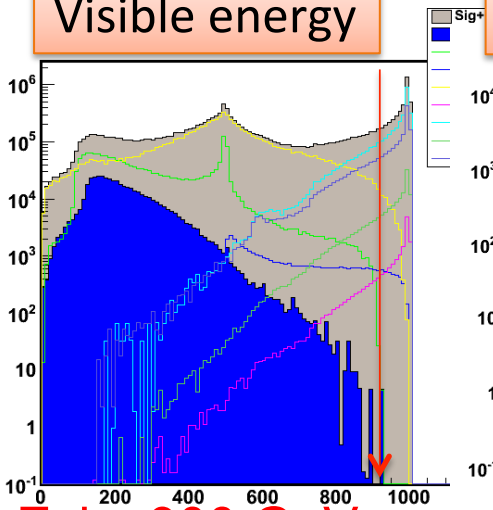
6f (ZWW, tt)

Calculate by Whizard

For template fitting, request 2 ab^{-1} sample, 2f, 4f

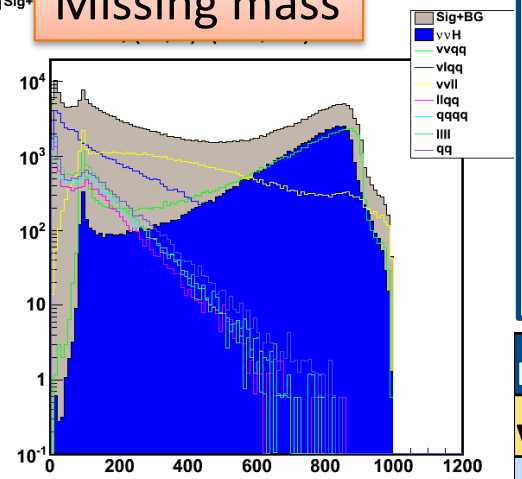
vvH @ 1 TeV pre-selection (MC only)

Visible energy



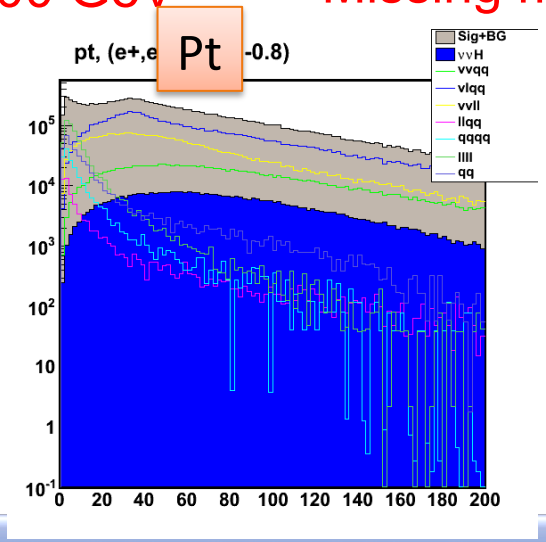
Evis<900 GeV

Missing mass



Missing mass

Pt



vvH

$(e^+,e^-)=(+0.3, -0.8)$

E_{cm}=1 TeV, L=1ab^{-1}

Require Evis < 900 GeV

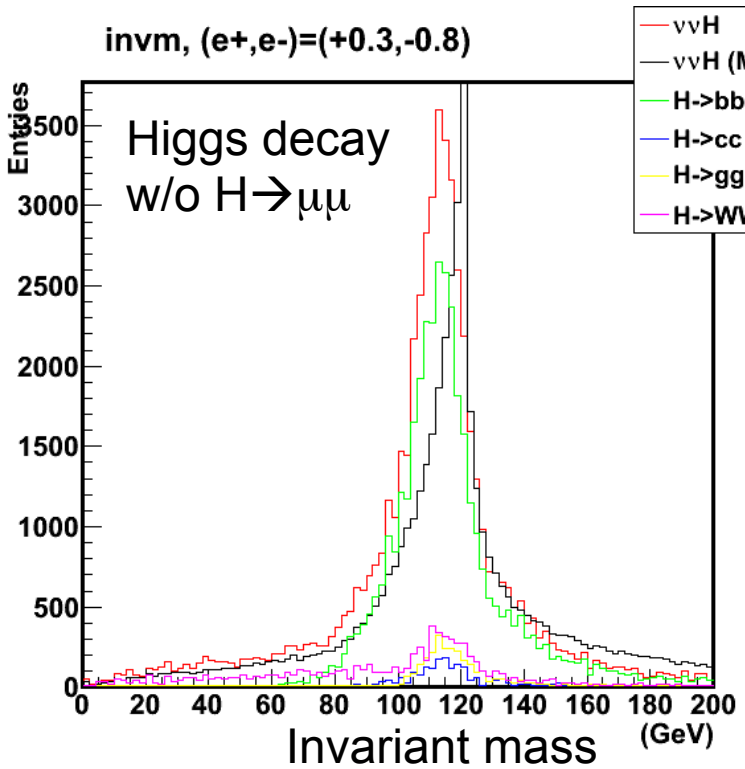
Suppress 4f BG

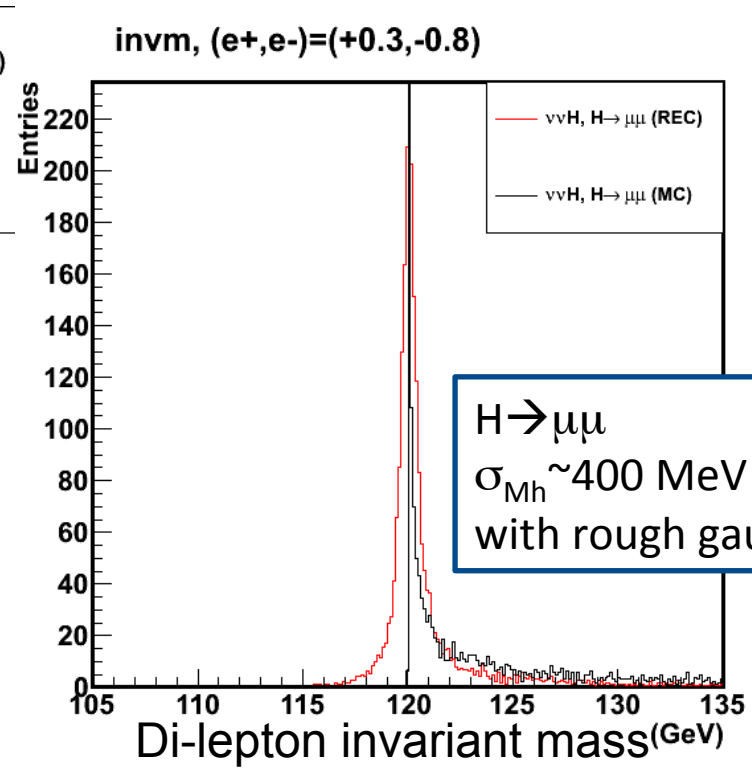
Need to improve for vvqq, vlqq

mode	xsec	No cut	Evis<900	Cut eff.
vvh	465.48	465483	465478	100.0%
vlqq	7580	7637450	6835470	89.5%
qq	5288	5670560	1612630	28.4%
qqqq	3952	3951660	947843	24.0%
llll	4050	4050220	1058720	26.1%
vvll	3357	3329550	3295990	99.0%
llqq	1643	1643230	316901	19.3%
vvqq	1459	1416430	1416310	100.0%
tt	347	347310		
ZWW	134	134000		

Test sample reconstruction

Invariant mass distribution of vvH test sample produced by Tim.
vvH@1 TeV with one older beam parameter set (Aug 2010)
mokka-07-07-p05 tag and the ILD_O1_v01 detector model (Thanks Frank, Jan)





H→μμ
σ_{Mh}~400 MeV
with rough gaussian fitting

Try to test latest version of ilcsoft v01-13-05 and latest beam parameter set after samples become ready. (or reconstruct by my self)

Summary

- DBD physics study at 1 TeV
  - $\nu\nu H$ σxBr at 1 TeV as benchmark process
  - Extend 250 GeV, 500 GeV analysis procedure to 1 TeV
  - Evaluating required samples and pre-selections

- DBD physics chapter (Best accuracies)
  - Need to cover all Higgs properties and couplings
  - ffH coupling: BRs are covered, except $H \rightarrow \tau\tau$ at now
  - Compile latest results into RDR results

Backup

E_{cm}=250 GeV Br(H→bb, cc, gg) analysis

Assuming L=250 fb^{-1}, P(e+, e-)=(+0.3, -0.8), M_H=120 GeV
$\Delta\sigma/\sigma$=2.5% from recoil study

	$\nu\bar{\nu}H$	$q\bar{q}H$	e^+e^-H	$\mu^+\mu^-H$	comb.
$r_{b\bar{b}}$	1.000±0.0161	1.0001±0.0153	0.999 ± 0.0393	1.000 ± 0.334	1.000±0.0103
$r_{c\bar{c}}$	0.998±0.120	1.002 ±0.121	0.98 ± 0.29	1.010 ± 0.237	0.999±0.077
r_{gg}	0.993±0.139	1.002±0.121	0.991 ± 0.352	0.998 ± 0.207	0.995±0.086
$\frac{\Delta(\sigma\cdot Br)}{\sigma\cdot Br}(H\to b\bar{b})$ (%)	1.64	1.53	3.93	3.34	1.03
$\frac{\Delta(\sigma\cdot Br)}{\sigma\cdot Br}(H\to c\bar{c})$ (%)	12.00	12.07	29.24	23.47	7.71
$\frac{\Delta(\sigma\cdot Br)}{\sigma\cdot Br}(H\to gg)$ (%)	13.98	13.84	35.54	20.72	8.86
$\frac{\Delta Br}{Br}(H\to b\bar{b})$ (%)	2.99	2.93	4.66	4.17	2.70
$\frac{\Delta Br}{Br}(H\to c\bar{c})$ (%)	12.24	12.32	29.35	23.61	8.11
$\frac{\Delta Br}{Br}(H\to gg)$ (%)	14.20	14.06	35.62	20.87	8.97

Physics chapter in DBD

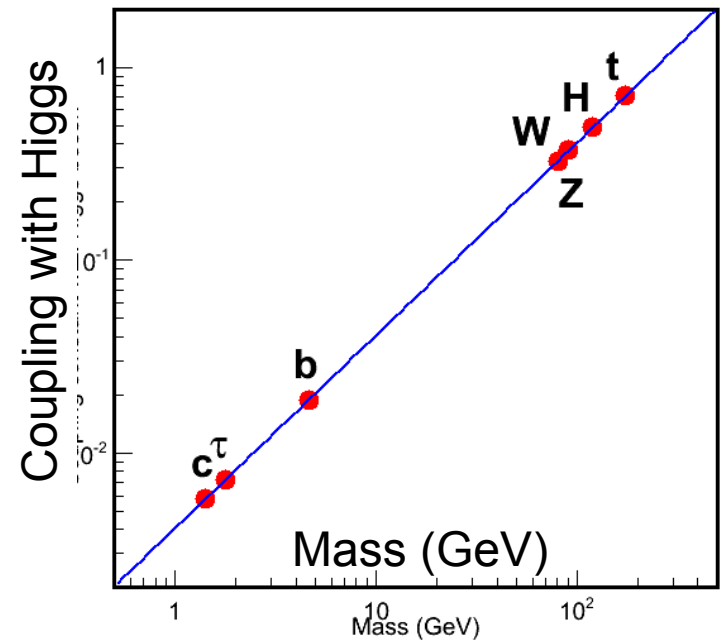
Higgs coupling with each particle

- ffH (ttH): Branching fraction
  $\mathrm{Br}(H \to f\bar{f}) \propto \left(g_{f\bar{f}H}\right)^2$
- WWH, ZZH: Cross section
- HHH: Self coupling

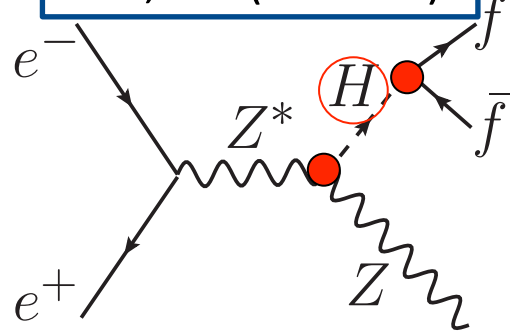
Higgs properties

- Mass
- Spin
- CP
- Natural width
- …

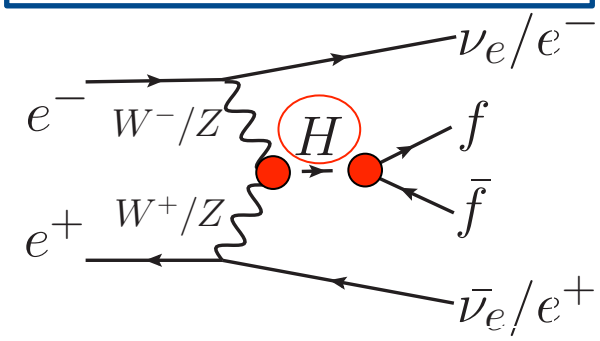
Update coupling precision



ZZH, ffH (ee→ZH)

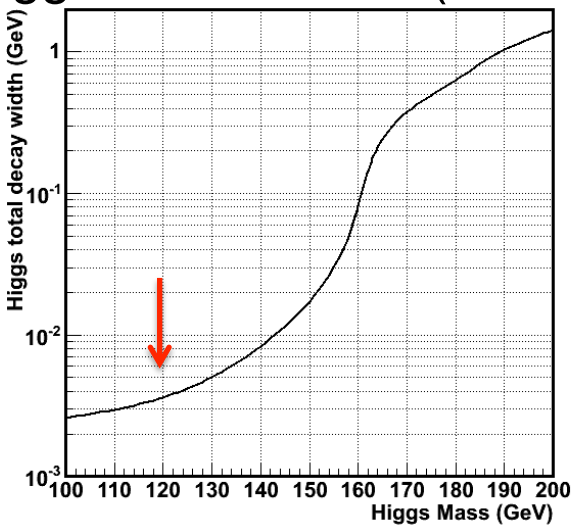


WWH, ZZH (ee→νν/eeH)

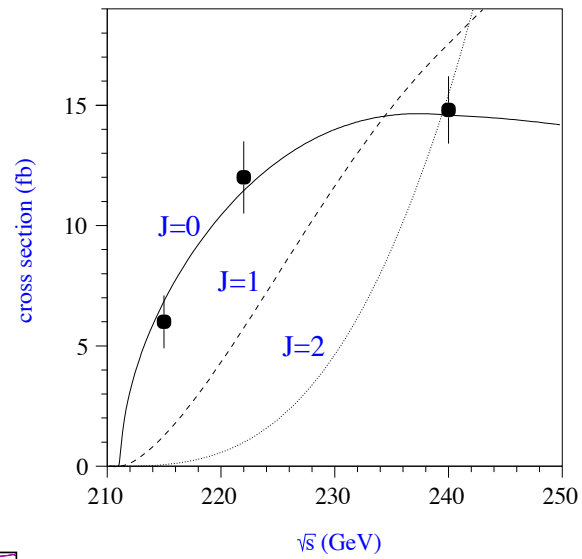


Higgs properties to be measured

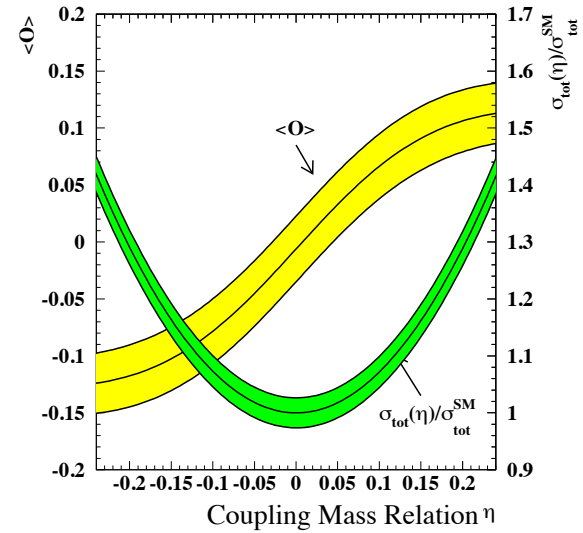
Higgs natural width (HDECAY)

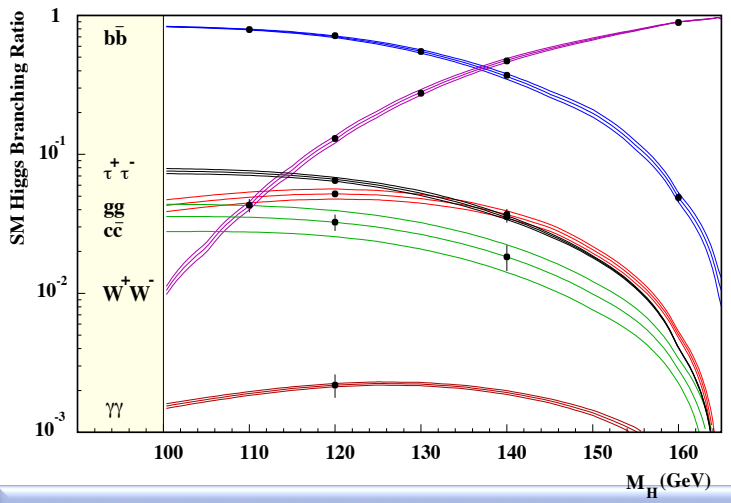


Spin (xsec scan)

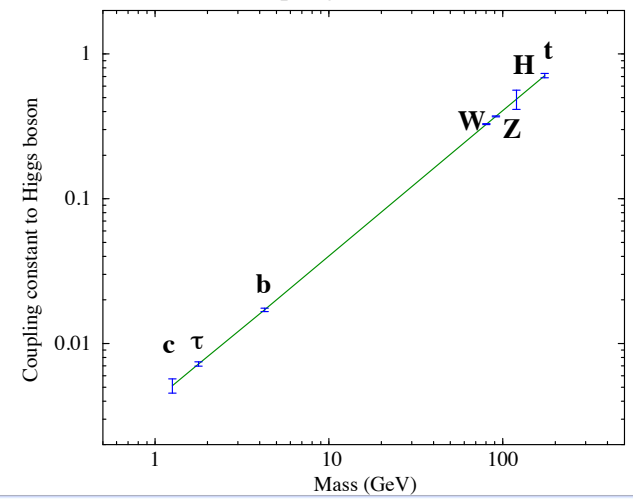


CP (Angular dist)





Update from RDR
Compile results
from LOI and post



Higgs physics status table

Analysis	Observable	Physics	Energy	Status	Results	Assing and schedules
Mh	Mass	Mass	250 GeV	LOI, Z->ll recoil	30 MeV	new beeam pram at 250 GeV
Total width	WWH, Br(WW*)	Total width	500 GeV	vvH (fusion) WWH	5%	Tian
spin	angular distribution	Spin		not yet		
spin	sigma_ZH(E), all ZH, H->bb	Spin	210~250 (2 points)	need calculation	RDR	Scale from 250 GeV
CP	angular distribution	CP		RDR, not yet	RDR	
CP	sigma_tot	CP	250 GeV	need calculation	RDR	Ono
Z->ll recoil	Mh, sigma_ZH	ZZH coupling, Mh	250 GeV	LOI	2.5%	Tian Include ZH/eeH @500 GeV
Z->qq recoil	Mh, sigma_ZH	ZZH coupling, Mh	250 GeV	not yet		
Br(bb)	Branch	Yukawa coupling ffH	250,350,500,1TeV	prepare publish (250,350), DBD	2.7%, 2.7%	Ono, publish 2012.04
Br(cc)	Branch	Yukawa coupling ffH	250,350,500,1TeV	prepare publish (250,350), DBD	8.1%, 7.3%	Ono, publish 2012.04
Br(gg)	Branch	Loop coupling, NP in loop	250,350,500,1TeV	prepare publish (250,350), DBD	9.1%, 7.9%	Ono, publish 2012.04
Br(ττ)	Branch	Yukawa coupling ffH	250, 500, 1TeV	RDR, not yet		Find somebody
Br(μμ)	Branch	Yukawa coupling ffH	250, 500, 1TeV	not yet, DBD		Calancha
Br(WW*)	Branch	WWH coupling, Spin	250, 500, 1TeV	qqqq (250) done, lvqq (250) on going DBD	13.4%	Ono, ACFA 2012.04
Br(ZZ*)	Branch	ZZH coupling, spin	250, 500, 1TeV	stand by (250)		Ono
Br(Zγ)	Branch	Loop coupling	250, 500, 1TeV	stand by (250)		Calancha
Br(γγ)	Branch	Loop coupling	250, 500, 1TeV	on going (250)		Calrancha, ACFA 2012.04
ZHH	sigma_ZHH	Self coupling	500 GeV	LOI, DBD, prepare publish	57%	Tian, Suehara
ttH	sigma_ttH	Yukawa coupling ffH	500, 1TeV	LOI, published, DBD	11%	Yonamine, Tanabe
vv/eeH (fusion)	sigma_vv/eeH	WWH, ZZH coupling	500 GeV	on going		TIan
tt	sigma_tt	Yukawa ttH (Higgs exchange)	350 GeV	not yet		Rohman