A study of Higgs self-coupling measurement at about 1 TeV

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1. introduction
2. a quick simulation study
3. measurement sensitivity
4. summary

Introduction

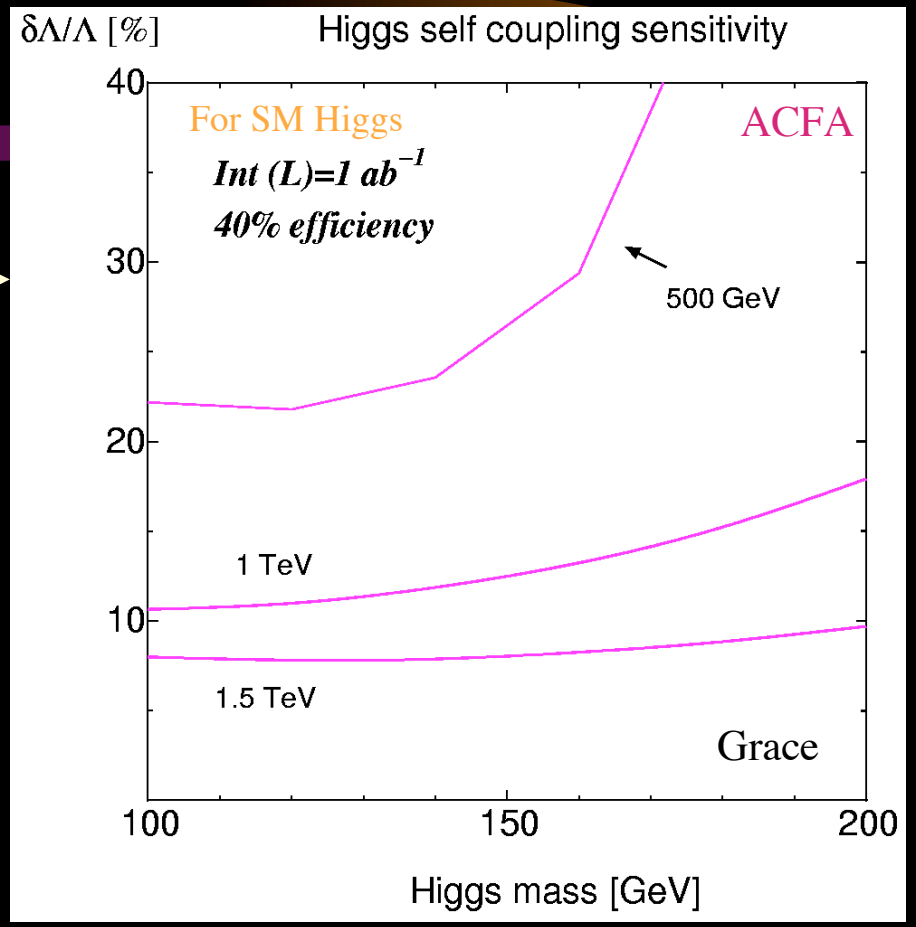
@LCWS'02

Theoretical evaluation of Higgs Self-coupling (Λ) sensitivity

Assumption:

- Overall signal efficiency of 40%
- No Background effect considered
- Beam polarization Pol e^- ~ -100 %

Analyses:
use only total cross-section



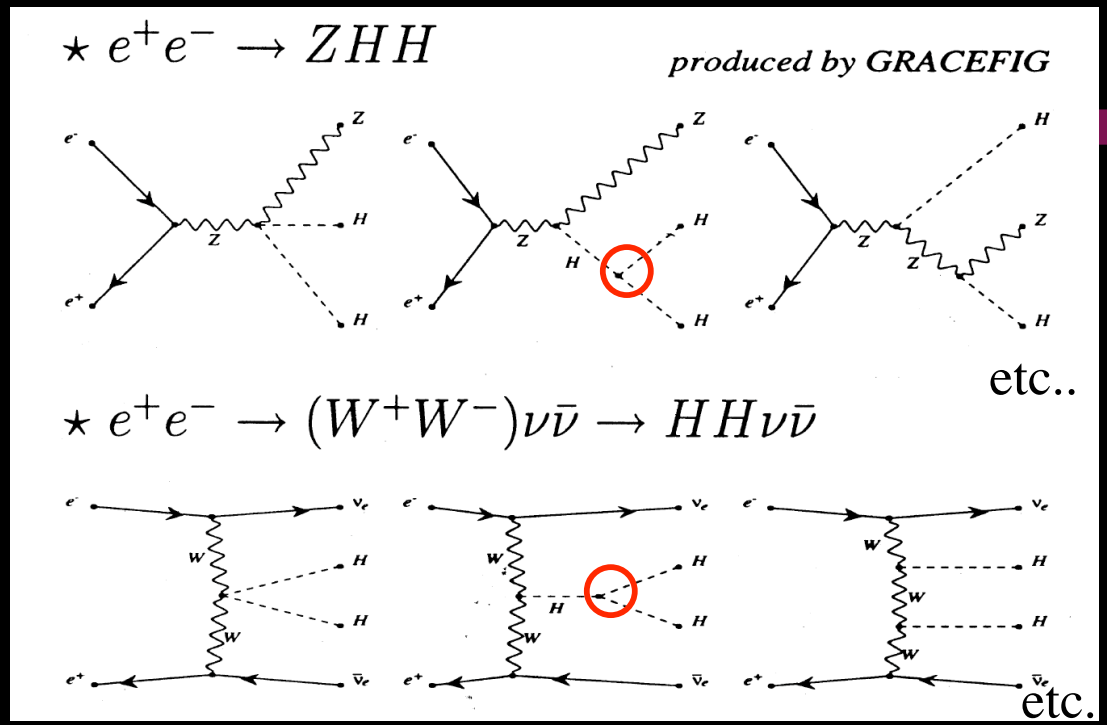
@LCWS'04

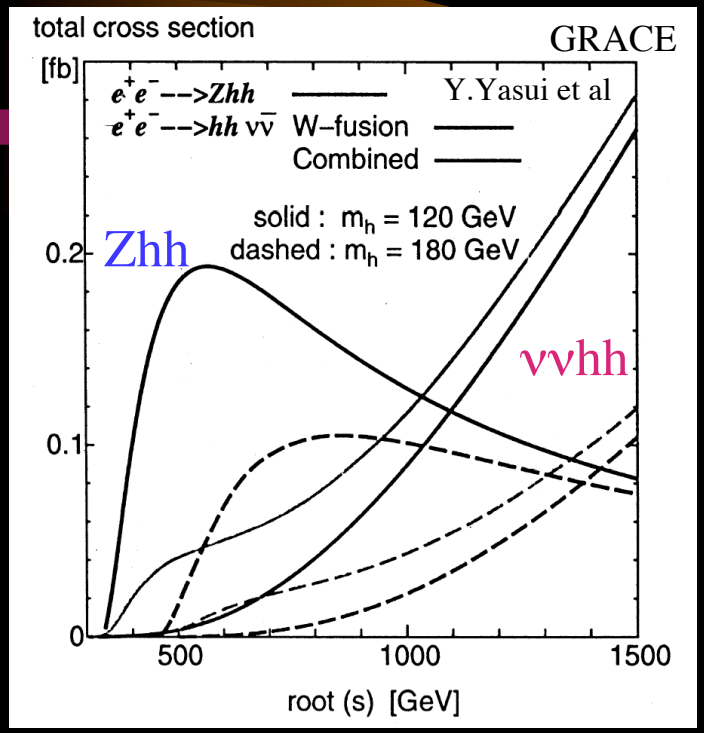
Simulation (include bkg.) study

- parton level + reasonable smearing
- check for
  @1TeV
  M_h=120 GeV

Multi-Higgs (Signal) production cross-section

@1TeV 2 main modes





Both processes are important @ 1 TeV

Note: when polarized electron beam is used,
WW-fusion process increases by a factor ~ 2

Simulation Study

- E_{cm} = 1 TeV
- ISR/BSR included

- Signal & bkg event generator
  GRACE (BASES+SPRING)

- Higgs mass = 120 GeV
  SM decay Br

- Signal MC: X + hh
  Λ/Λ_{SM} from 0.0 to 2.0 with 0.2 step

- Smearing simulation at parton level
  Jet energy resolution ~ $30\%/\sqrt{E}$ (GeV)
  (detector R&D target value)

ννhh quick analyses

Present analysis is only for **hh decaying to 4b**

Br(hh→4b) ~ 47 % for 120 GeV SM Higgs

Signal characteristics:

- Large missing energy, missing Pt
- No isolated lepton
- Only 4 b jets
- M_1 jj ~ M_h M_2 jj ~ M_h

4 b-quark tagging (3 out of 4, ANN etc..)

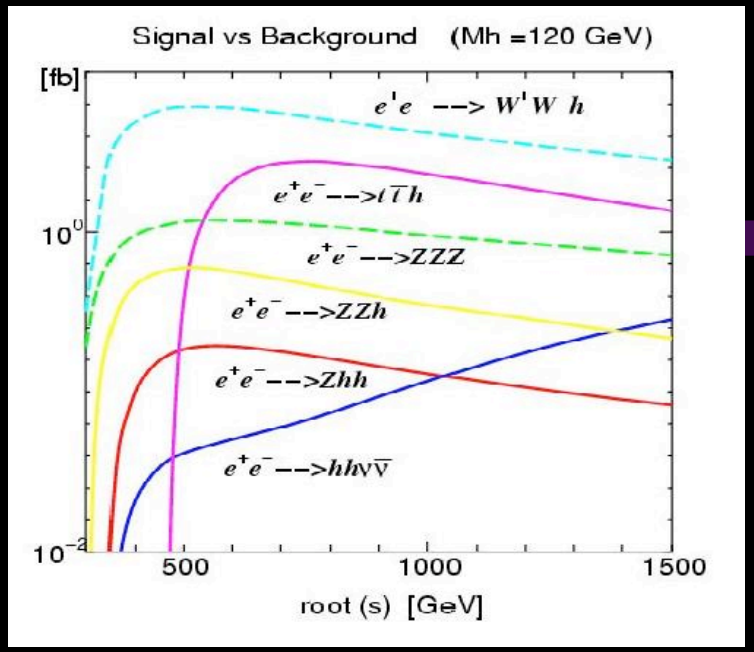
assuming: 80% eff. for 4b final state
with enough purity
(eff. for non-4b < a few %)

+ A loose pre-cut for kinematics

⟶ Next step

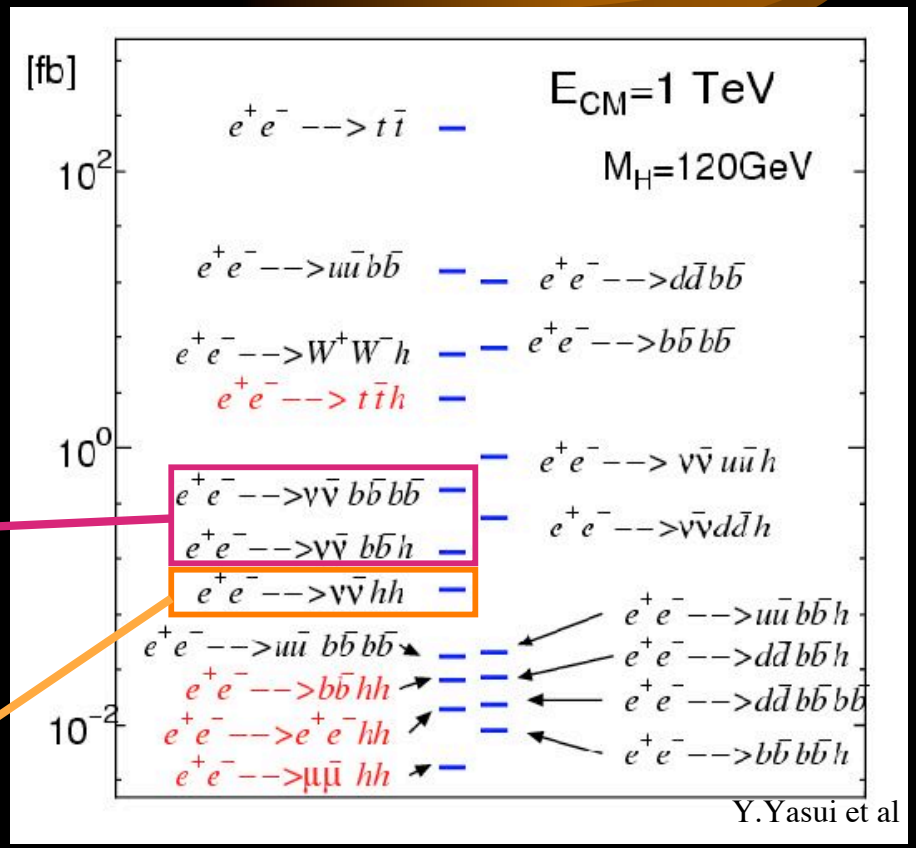
Background processes

Cross-section vs E_{cm}



@1TeV

All processes are generated by GRACE



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Main bkg processes

4b+missing

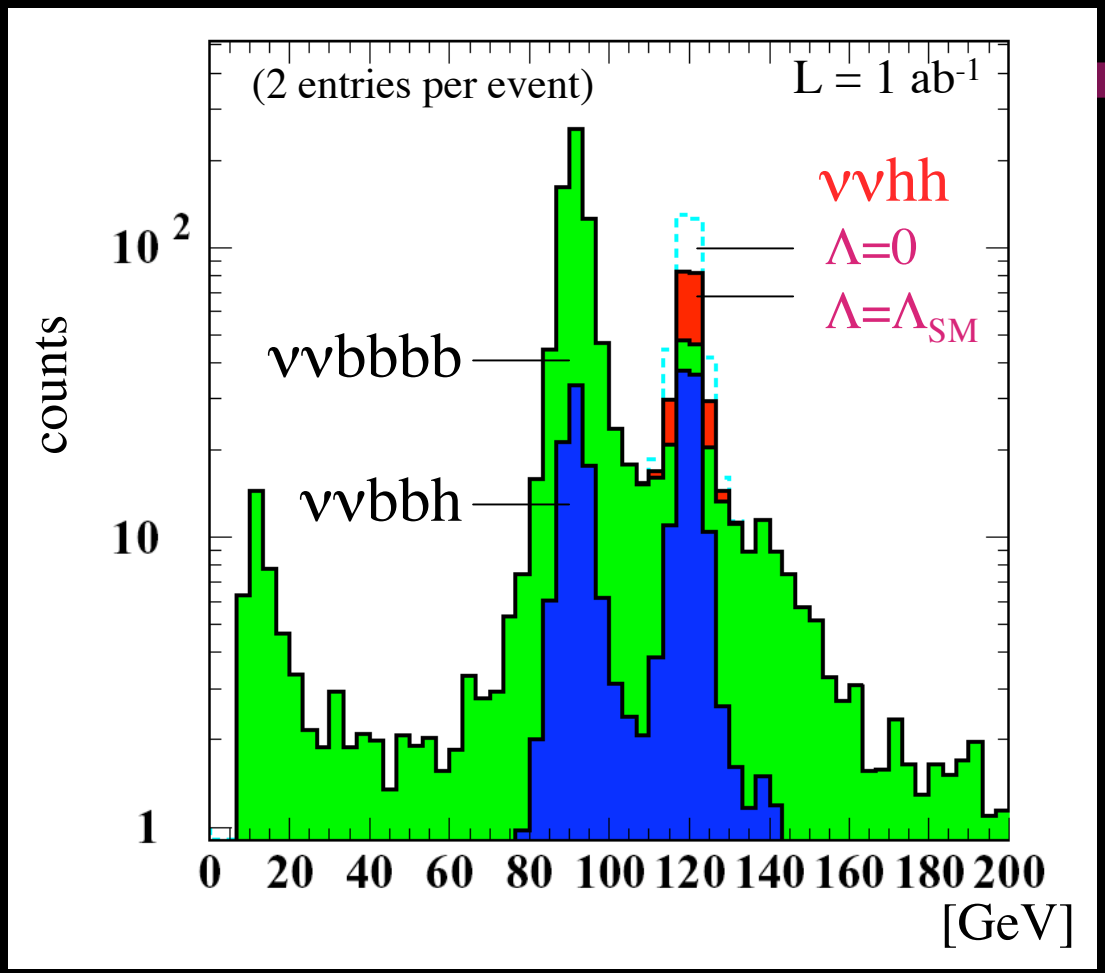
ννbbbb (~ ννZZ, ννZγ*)

ννbb**h** (~ ννZh)

Signal (for SM)

After 4b-tag & pre-cuts

Reconstructed 'Higgs' mass



Next step

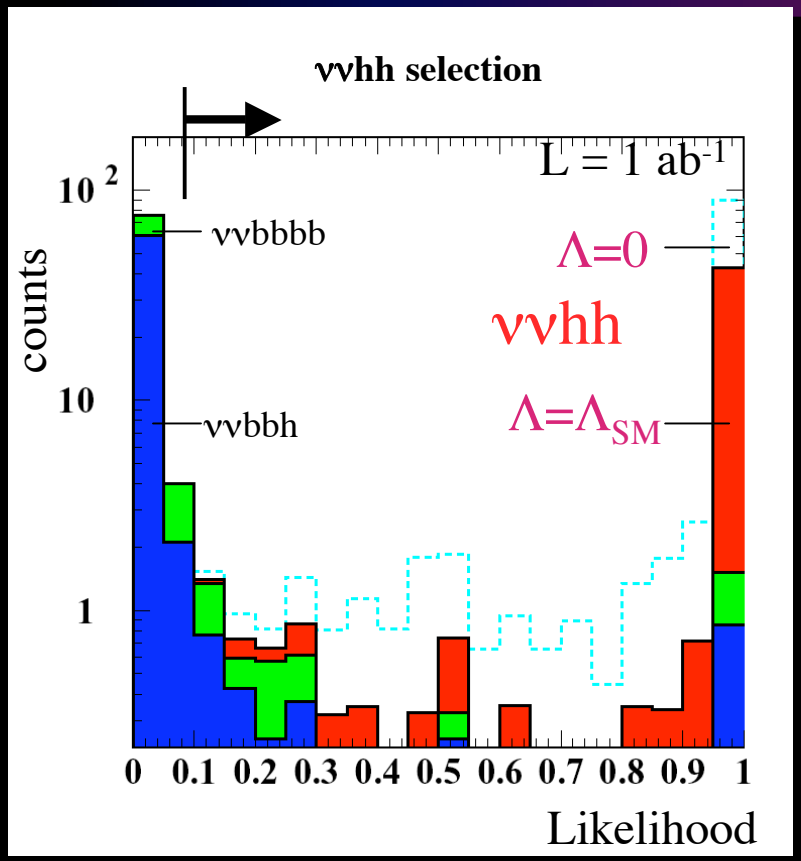
ννhh Analysis Flow

1. Likelihood selection
   bkg further reduction
2. Separate Zhh & fusion
   * different Λ dependence
   (positive/negative interferences)
3. Combine with Zhh analyses
   for s-channel process
4. Check hh invariant mass
5. Λ measurements

Likelihood selection

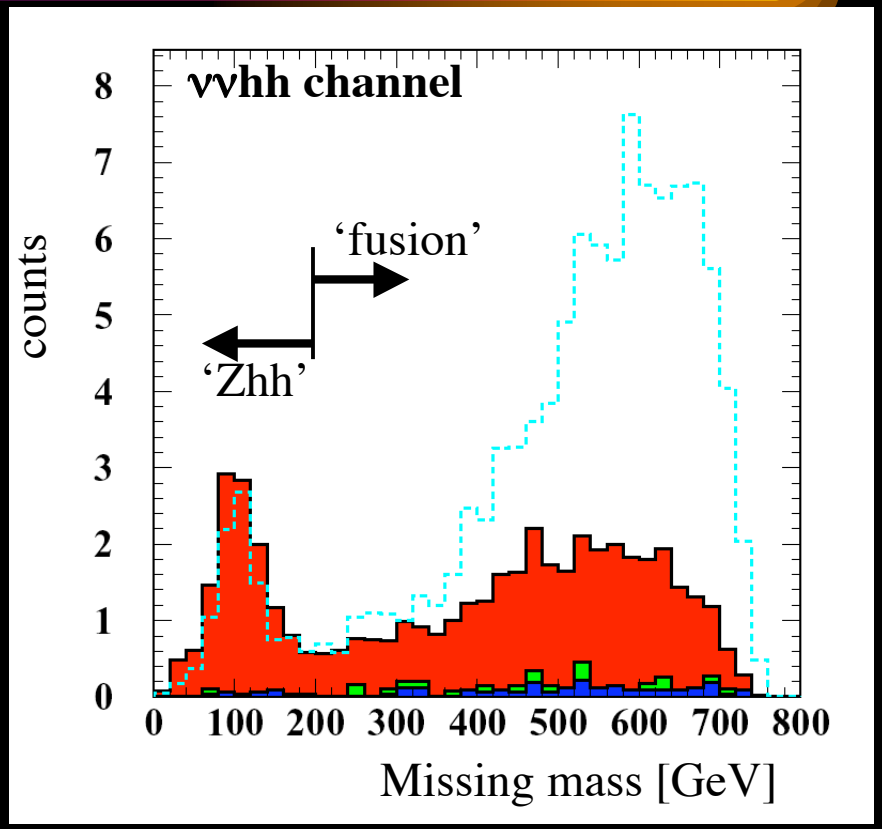
(~ OPAL Higgs scheme)

Using:
Compatibility to ννhh ννZZ ννZh etc..

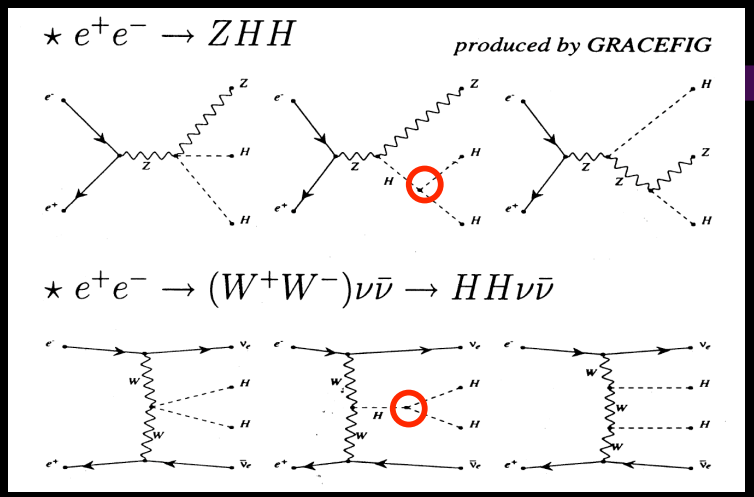


After Likelihood selection

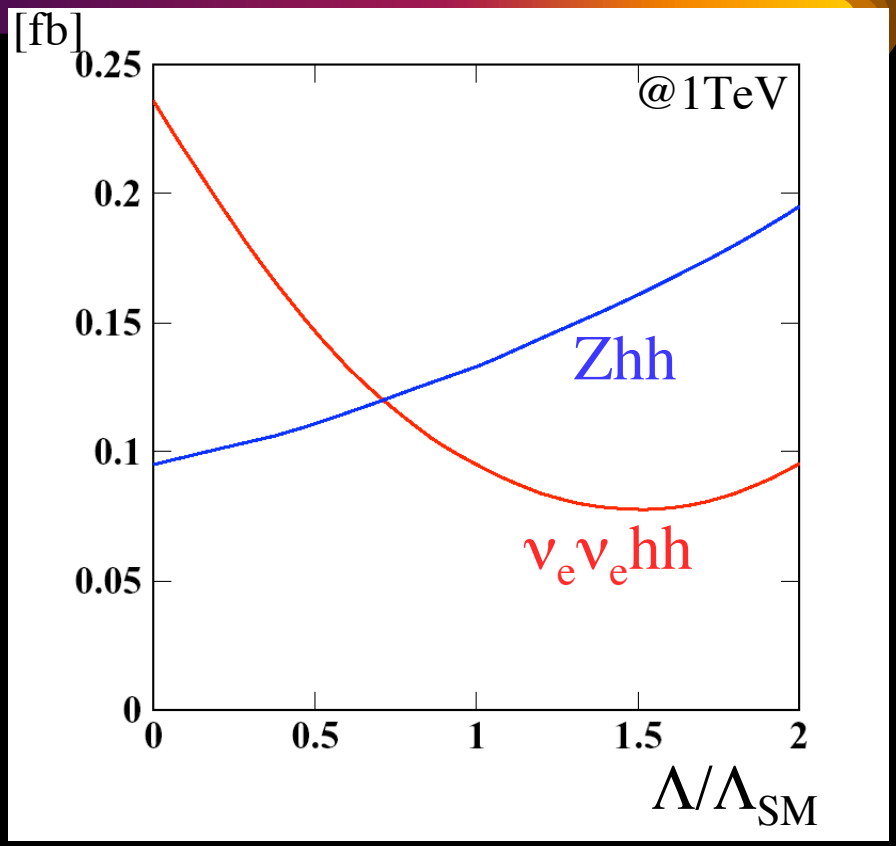
Separate 'Zhh' & 'fusion-channel'



Interference among processes



Λ dependence of cross-section

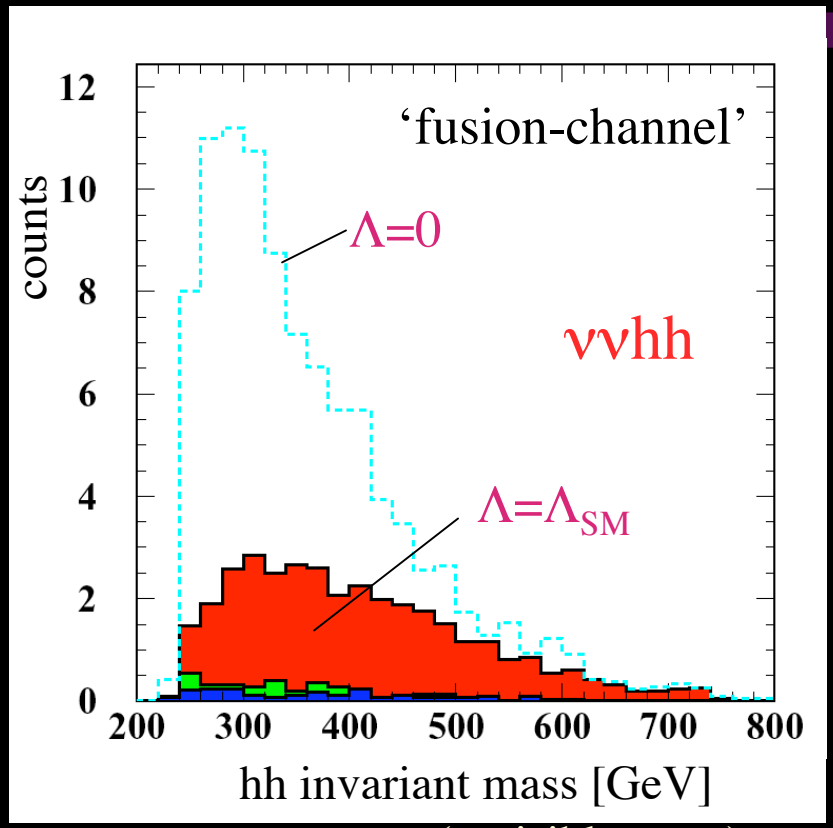


@1TeV

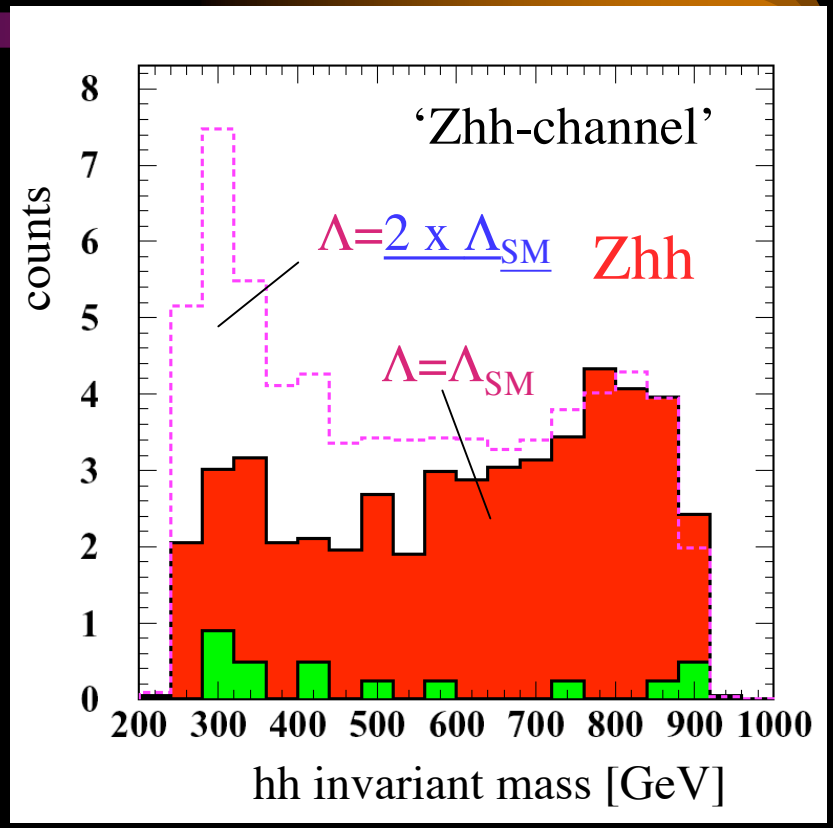
Zhh: Positive interference

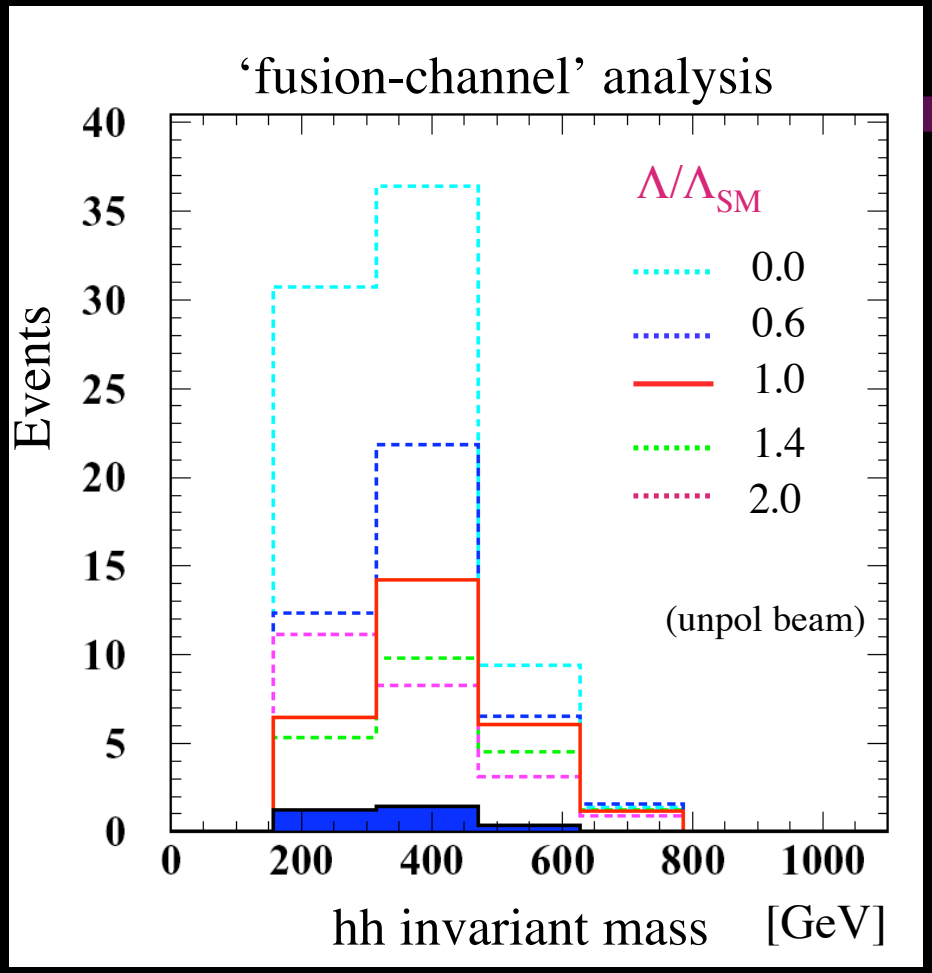
ννhh: Negative interference

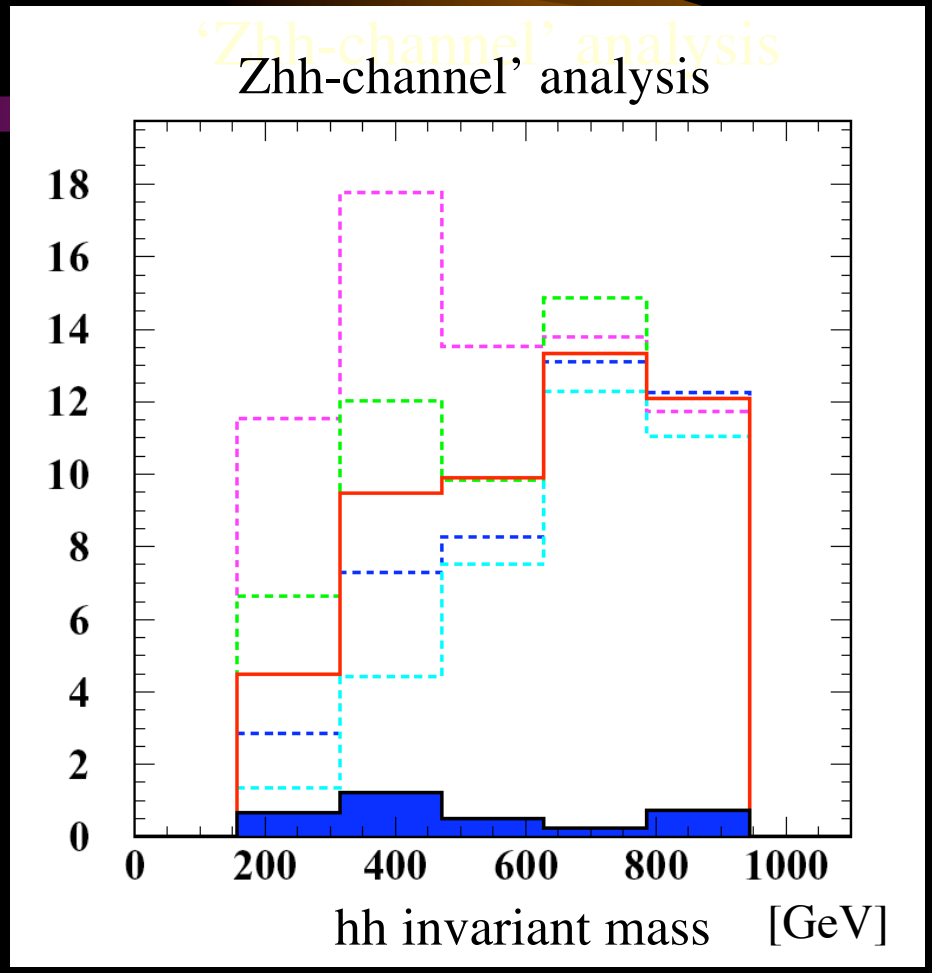
hh invariant mass distributions



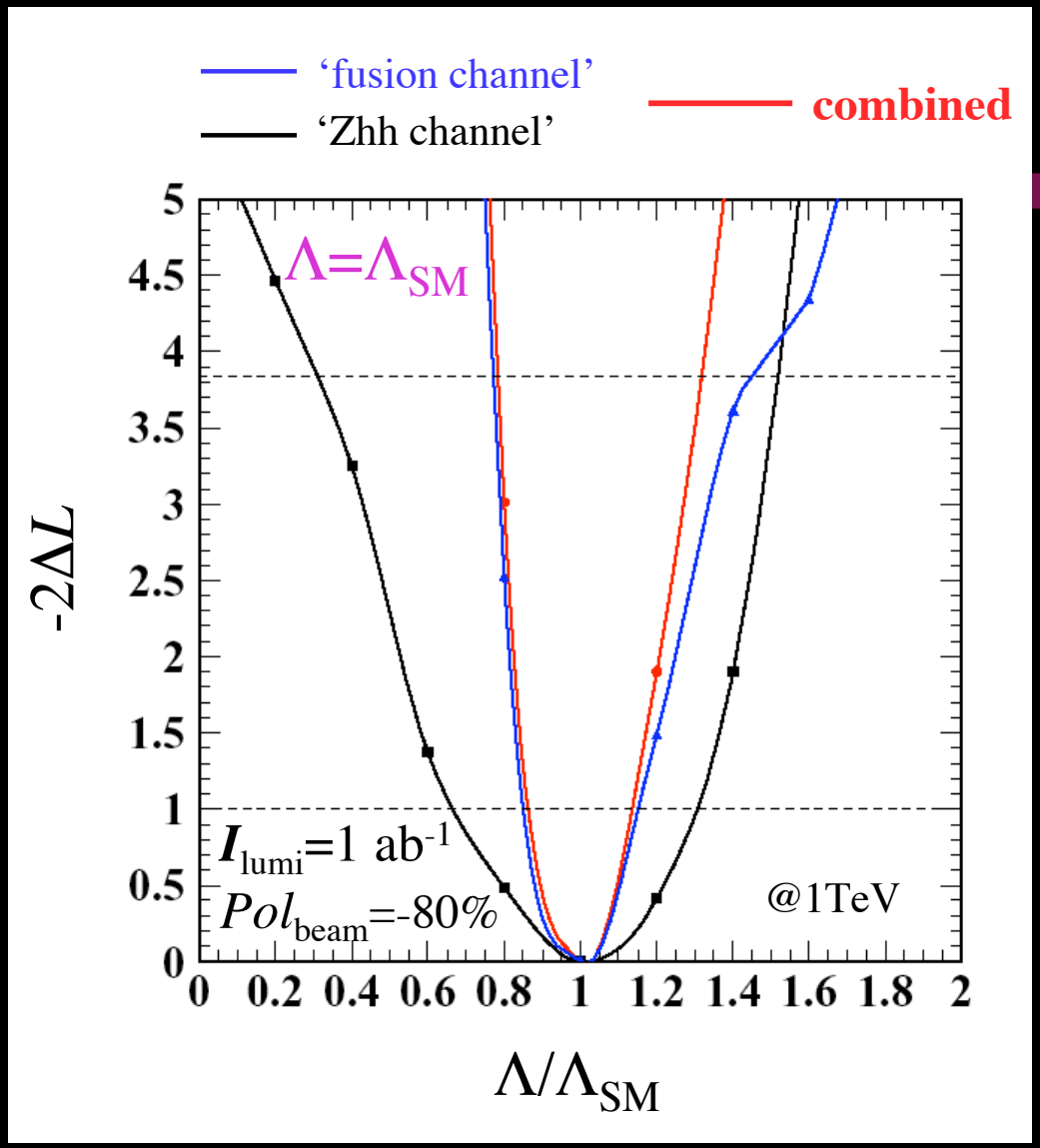
(= visible mass)

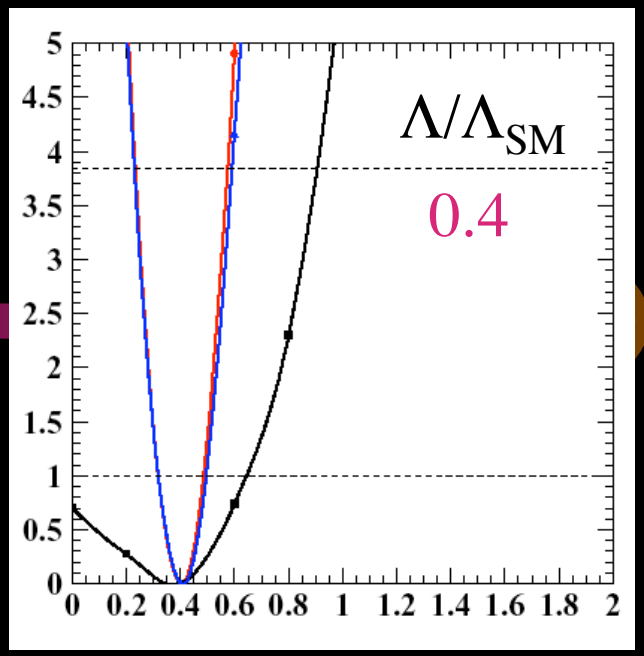


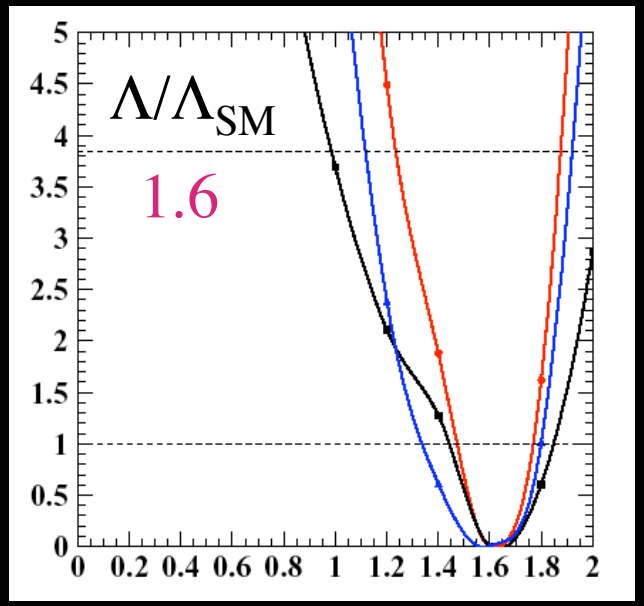

'fusion-channel' analysis
Events
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
hh invariant mass [GeV]
Λ/Λ_SM
0.0
0.6
1.0
1.4
2.0
(unpol beam)


Zhh-channel' analysis
18
16
14
12
10
8
6
4
2
0
0
200
400
600
800
1000
hh invariant mass [GeV]

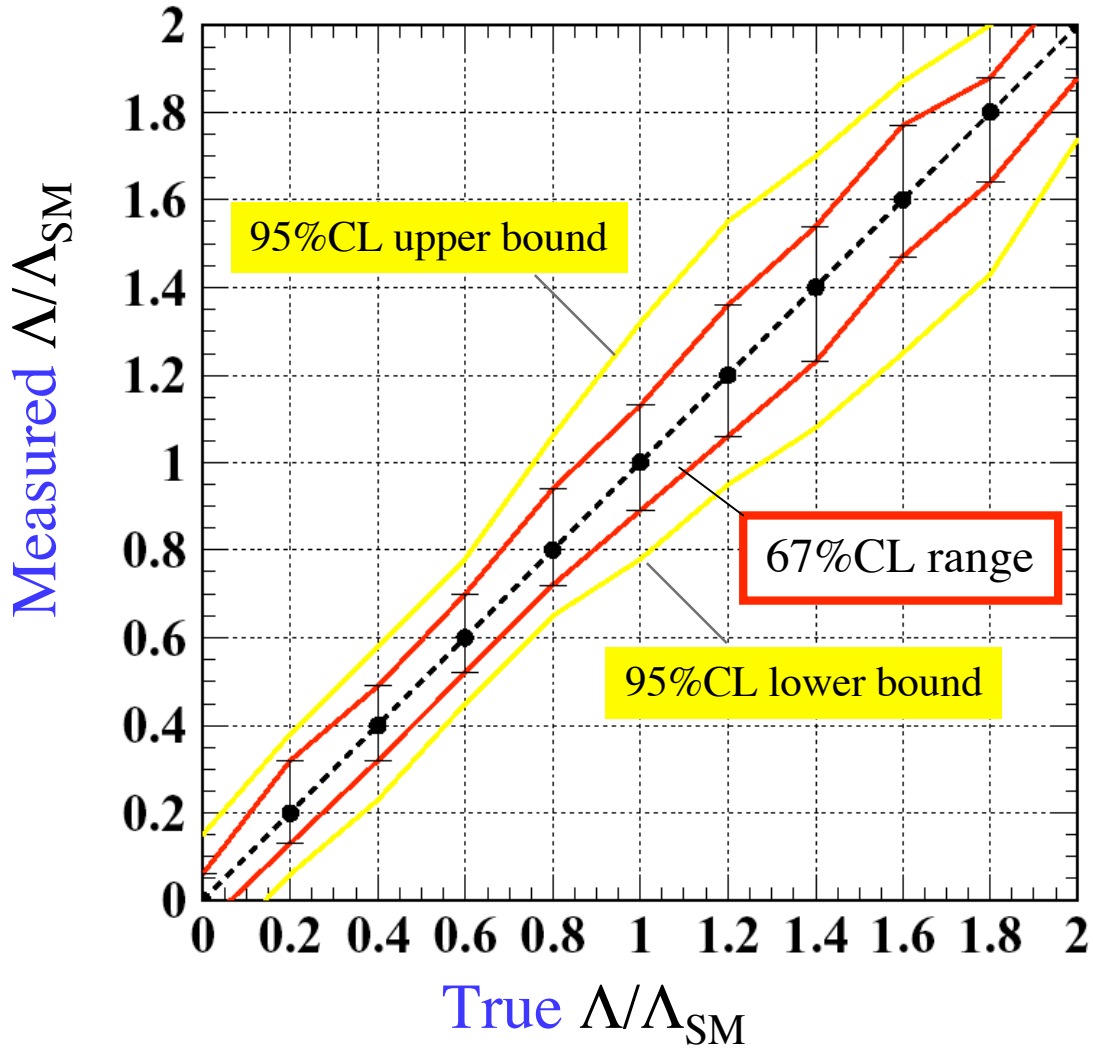
Λ measurement sensitivity







Result



@1TeV

I_{lumi}=1 ab^{-1}

Pol_{beam}= -80%

M_h=120 GeV

(SM Higgs Br)

Use only hh→4b

(Br(hh→4b)~47%)

Eff.(4b) 80%

Summary

- A quick simulation study has been performed for E_{cm}=1 TeV under the condition:
  - $\delta E_{jet}/E_{jet} \sim 30\%/\sqrt{E_{jet}(\mathrm{GeV})}$
  - 4b tag efficiency ~ 80%, eff for non-4b < a few %
  - $\boldsymbol{I}_{lumi}$=1 ab^{-1} e^- beam Pol ~ - 80 %

  only hh→bbbb decay mode (Br(hh→bbbb)~47%) analyzed.

- Likelihood selection → overall signal eff ~ 32 % for ννhh
  ~ 22 % for Zhh ($Z \to qq, l^+l^-$)

- For M_h=120 GeV: Λ measurement sensitivity (only hh→bbbb only)

for $\Lambda = \Lambda_{SM}$	Λ/Λ_{SM}=1.0	+0.13 -0.11 (1σ)	0.78 - 1.32 (95%CL)
Λ/Λ_{SM}=0.6	0.6	+0.10 -0.07 (1σ)	0.45 - 0.77 (95%CL)
Λ/Λ_{SM}=1.4	1.4	+0.14 -0.18 (1σ)	1.08 - 1.70 (95%CL)

- Analysis is premature, and can increase the sensitivity. - e.g. when non-b decay of Higgs is included (especially important for M_h>130 GeV)

- Relative phase (and sign) of Λ can be measured using interference comparing results from Zhh and fusion processes, or results of different E_{cm}'s.