Higgs and SFitter

LHC2TSP
Orsay
November 23, 2011

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LAL Orsay

On behalf of:
SFitter: R.Lafaye, T.Plehn, M.Rauch, D.Zerwas
and Higgs friends: M. Duehrssen, P.Zerwas

- Introduction
- 14TeV results
- new 7TeV results
- Conclusions

Measuring the Higgs Sector,R. Lafaye, T. Plehn, M. Rauch, D. Zerwas, M. Duhrssen
Published in JHEP 0908 (2009) 009.

Measuring Hidden Higgs and Strongly-Interacting Higgs Scenarios.
S.Bock, R. Lafaye, T. Plehn, M. Rauch, D. Z., P.M. Zerwas
Phys.Lett. B694 (2010) 44-53

The Higgs sector: SFitter setup

Gluon fusion and VBF in well defined final states (many authors and papers)

Example for M_H=120GeV

production	decay	$S+B$	B	S	$\Delta S^{(\mathrm{exp})}$	$\Delta S^{(\mathrm{theo})}$
$gg \to H$	ZZ	13.4	6.6 ($\times$ 5)	6.8	3.9	0.8
qqH	ZZ	1.0	0.2 ($\times$ 5)	0.8	1.0	0.1
$gg \to H$	WW	1019.5	882.8 ($\times$ 1)	136.7	63.4	18.2
qqH	WW	59.4	37.5 ($\times$ 1)	21.9	10.2	1.7
$t\bar{t}H$	$WW(3\ell)$	23.9	21.2 ($\times$ 1)	2.7	6.8	0.4
$t\bar{t}H$	$WW(2\ell)$	24.0	19.6 ($\times$ 1)	4.4	6.7	0.6
inclusive	$\gamma\gamma$	12205.0	11820.0 ($\times$ 10)	385.0	164.9	44.5
qqH	$\gamma\gamma$	38.7	26.7 ($\times$ 10)	12.0	6.5	0.9
$t\bar{t}H$	$\gamma\gamma$	2.1	0.4 ($\times$ 10)	1.7	1.5	0.2
WH	$\gamma\gamma$	2.4	0.4 ($\times$ 10)	2.0	1.6	0.1
ZH	$\gamma\gamma$	1.1	0.7 ($\times$ 10)	0.4	1.1	0.1
qqH	$\tau\tau(2\ell)$	26.3	10.2 ($\times$ 2)	16.1	5.8	1.2
qqH	$\tau\tau(1\ell)$	29.6	11.6 ($\times$ 2)	18.0	6.6	1.3
$t\bar{t}H$	$b\bar{b}$	244.5	219.0 ($\times$ 1)	25.5	31.2	3.6
WH/ZH	$b\bar{b}$	228.6	180.0 ($\times$ 1)	48.6	20.7	4.0

Duehrssen et al.: Phys.Rev.D70:113009,2004. hep-ph/0406323

ttH→bb: 50% signal reduction

Hbb: J. M. Butterworth, A. R. Davison, M. Rubin, G. P. Salam Phys.Rev.Lett.100:242001,2008
ATLAS: ATL-PHYS-PUB-2009-088.

Experimental Errors

Measurement of luminosity	5 %
Detector efficiency	2 %
Lepton reconstruction efficiency	2 %
Photon reconstruction efficiency	2 %
WBF tag-jets / jet-veto efficiency	5 %
b-tagging efficiency	3 %
τ-tagging efficiency (hadronic decay)	3 %
Lepton isolation efficiency (decay $H \to ZZ \to 4l$)	3 %

Theory Errors (flat)

σ (gluon fusion)	13 %
σ (weak boson fusion)	7 %
σ (VH-associated)	7 %
σ ($t\bar{t}$-associated)	13 %

BR($H \to ZZ$)	1 %
BR($H \to WW$)	1 %
BR($H \to \tau\bar{\tau}$)	1 %
BR($H \to c\bar{c}$)	4 %
BR($H \to b\bar{b}$)	4 %
BR($H \to \gamma\gamma$)	1 %
BR($H \to Z\gamma$)	1 %
BR($H \to gg$)	2 %

Correlated measurements and parameters: apply SUSY search techniques for parameter extraction

Difficulty to be mastered: convolution of Gaussian+Poisson+Flat errors

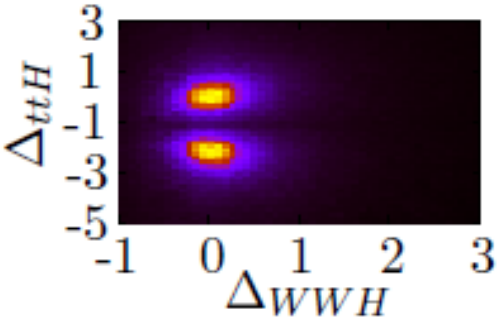
The Higgs sector: likelihood maps

Definition: ΔjjH deviation of jjH coupling from SM value:

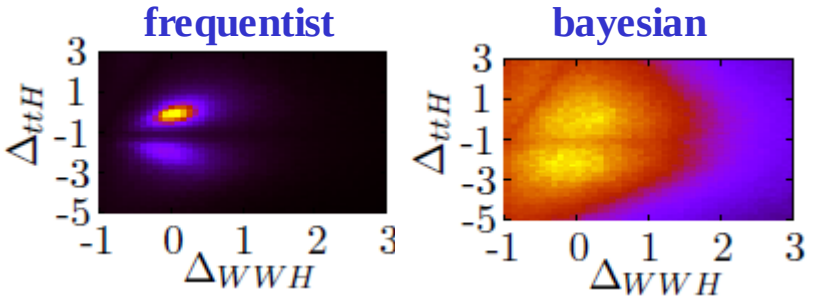
$$g_{jjH} \longrightarrow g_{jjH}^{\mathrm{SM}} \left(1 + \Delta_{jjH}\right)$$

Loop induced coupling:

$$g_{jjH} \longrightarrow g_{jjH}^{\mathrm{SM}} \left(1 + \Delta_{jjH}^{\mathrm{SM}} + \Delta_{jjH}\right)$$

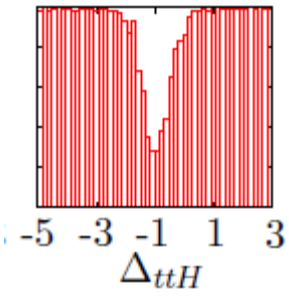


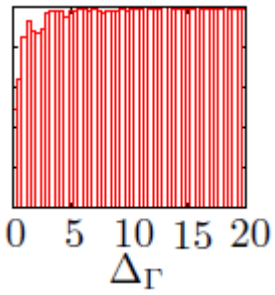
Add ΔHgg and ΔHγγ: sign preference power of H→γγ disappears



- **general positive correlation among non-Hbb couplings due to total width ≈ Hbb**
- **frequentist approach better adapted (no real secondary minima)**

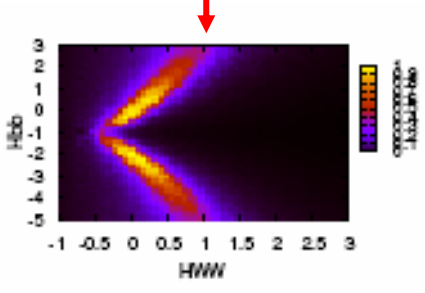
Measurements at LHC:
$\sigma \cdot BR \cdot L \cdot \sim g^2 \cdot g^2/\Gamma$
blind to simultaneous coupling/√width changes:



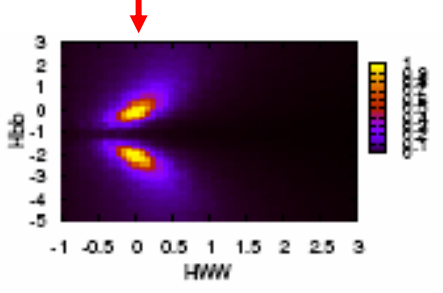


The Higgs sector: precision

Hbb: without subjet



Hbb: full power



Coupling ratios

	with effective couplings		
	σ_{symm}	σ_{neg}	σ_{pos}
$\Delta_{ZZH}/\Delta_{WWH}$	± 0.41	-0.40	$+0.41$
$\Delta_{t\bar{t}H}/\Delta_{WWH}$	± 0.51	-0.54	$+0.48$
$\Delta_{b\bar{b}H}/\Delta_{WWH}$	± 0.31	-0.24	$+0.38$
$\Delta_{\tau\bar{\tau}H}/\Delta_{WWH}$	± 0.28	-0.16	$+0.40$
$\Delta_{\gamma\gamma H}/\Delta_{WWH}$	± 0.30	-0.27	$+0.33$
$\Delta_{ggH}/\Delta_{WWH}$	± 0.61	-0.71	$+0.46$

Profile likelihood 14TeV 30fb-1 theory errors

Coupling	without eff. couplings			including eff. couplings		
	σ_{symm}	σ_{neg}	σ_{pos}	σ_{symm}	σ_{neg}	σ_{pos}
Δ_{WWH}	± 0.23	-0.21	$+0.26$	± 0.24	-0.21	$+0.27$
Δ_{ZZH}	± 0.50	-0.74	$+0.30$	± 0.44	-0.65	$+0.24$
$\Delta_{t\bar{t}H}$	± 0.41	-0.37	$+0.45$	± 0.53	-0.65	$+0.43$
$\Delta_{b\bar{b}H}$	± 0.45	-0.33	$+0.56$	± 0.44	-0.30	$+0.59$
$\Delta_{\tau\bar{\tau}H}$	± 0.33	-0.21	$+0.46$	± 0.31	-0.19	$+0.46$
$\Delta_{\gamma\gamma H}$	—	—	—	± 0.31	-0.30	$+0.33$
Δ_{ggH}	—	—	—	± 0.61	-0.59	$+0.62$

- **30fb-1 precision 30% to 50% (absolute)**
- **slightly higher precision for ratios (cancellation of errors, but dominated by stat errors)**

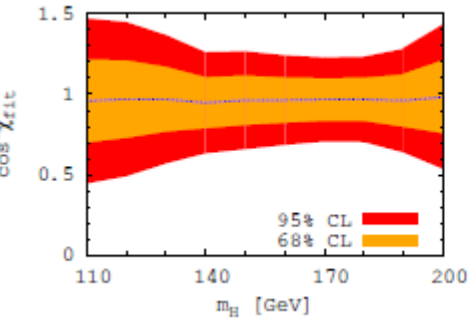
Hidden sector/strong Higgs: 14TeV

Higgs portal:
- **hidden sector**
- **all widths modified by the same parameter**

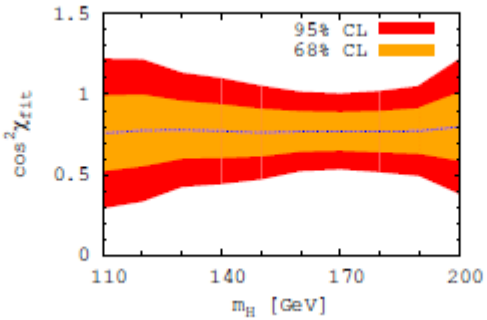
$$\sigma = \cos^2\chi\,\sigma^{\rm SM}$$
$$\Gamma_{\rm vis} = \cos^2\chi\,\Gamma^{\rm SM}_{\rm vis}$$
$$\Gamma_{\rm inv} = \cos^2\chi\,\Gamma^{\rm SM}_{\rm inv} + \Gamma_{\rm hid}\,.$$

Patt, Wilczek

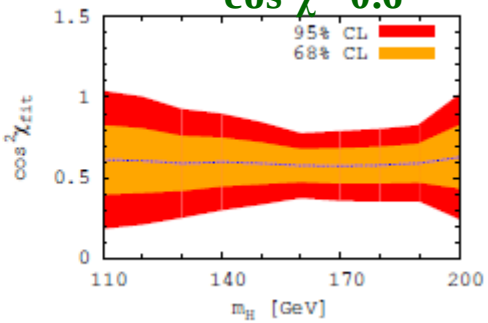
$\cos^2\chi$ =1



$\cos^2\chi$ =0.8



$\cos^2\chi$ =0.6



Typical precision: 10-20% better than cpls

well reconstructed (step=10GeV)

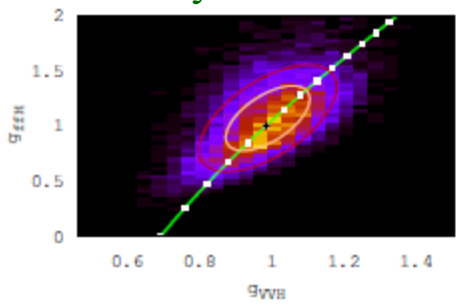
Strongly interacting light Higgs:

$$\kappa_V = 1 - \left[1(3) - 2\,{\rm BR}^{\rm SM}_{\rm f}\right]\,\xi$$
$$\kappa_f = 1 - \left[3(5) - 2\,{\rm BR}^{\rm SM}_{\rm f}\right]\,\xi$$

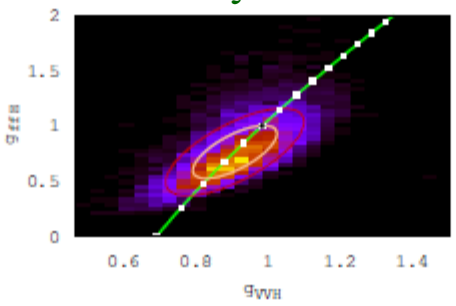
EW (GF)

Giudice, Pomarol, Rattazzi, Espinosa,Grojean,Mühlleitner

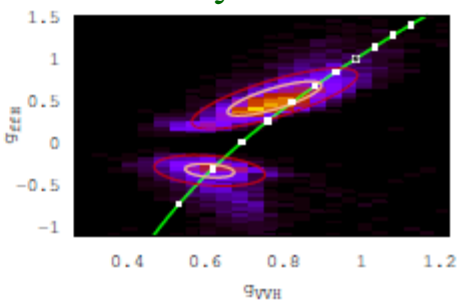
ξ =0



ξ =0.2



ξ =0.6



Model prediction in steps of 0.1

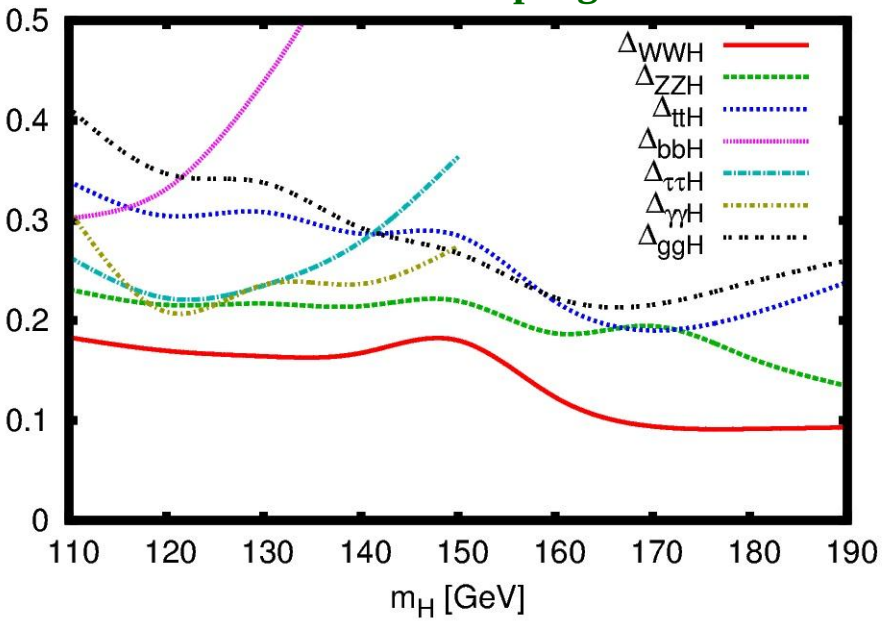
Fermions: ambiguity small/large ξ

From 14TeV to 7TeV

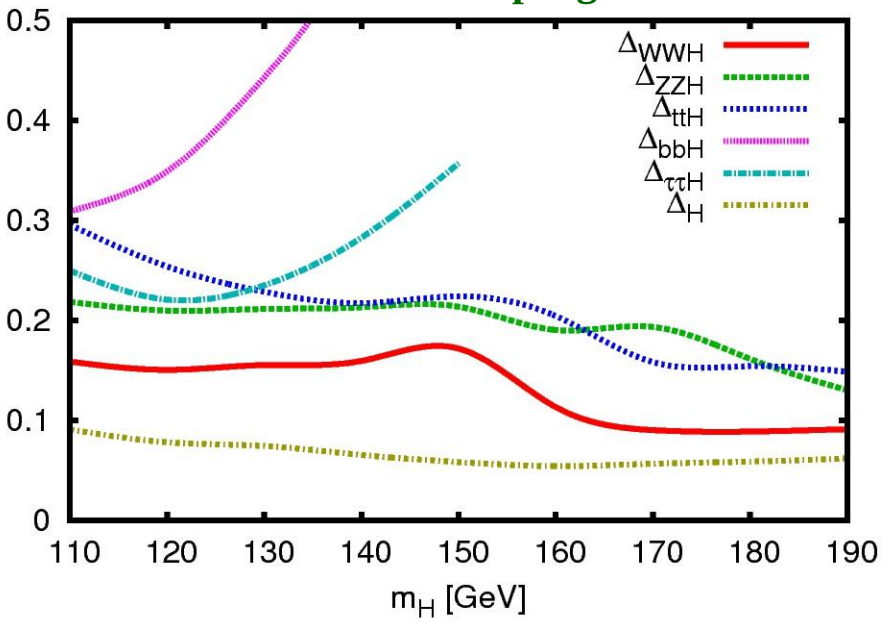
Higgs sector:

- **no effective couplings**
- **signal cross sections from LHC Xsection WG**
- **Background cross sections: scaled with SHERPA**

14TeV with effective couplings:

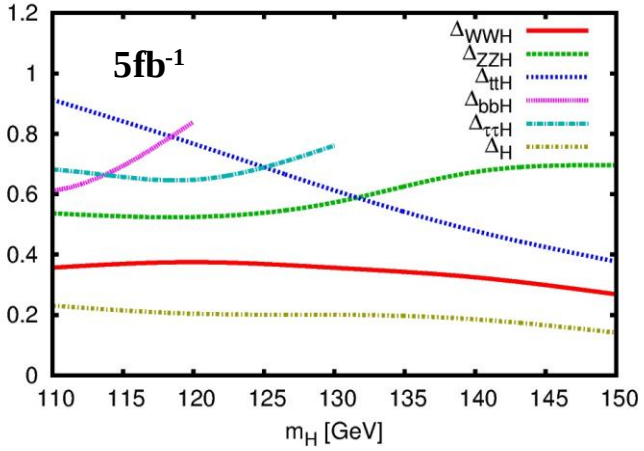


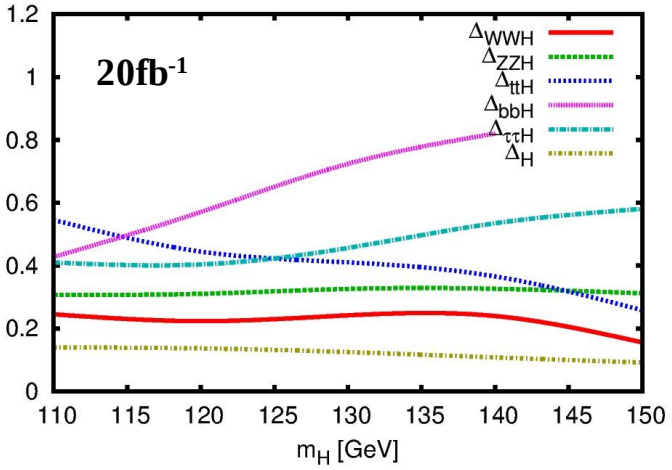
14TeV no effective couplings:



- **no effective couplings lead to a slight increase of precision**
- **coupling precision in general better than about 0.3**
- **portal precision better than 0.1**

The Higgs sector precision: 7TeV



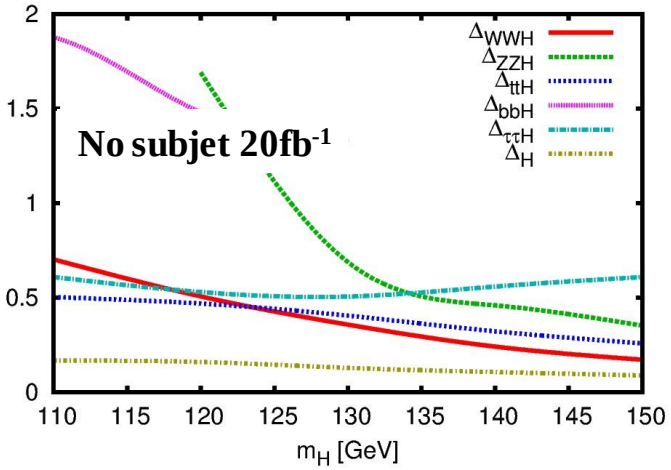


5fb^{-1}:

- **all errors on couplings <1**
- **portal precision: 20%**

20fb^{-1}

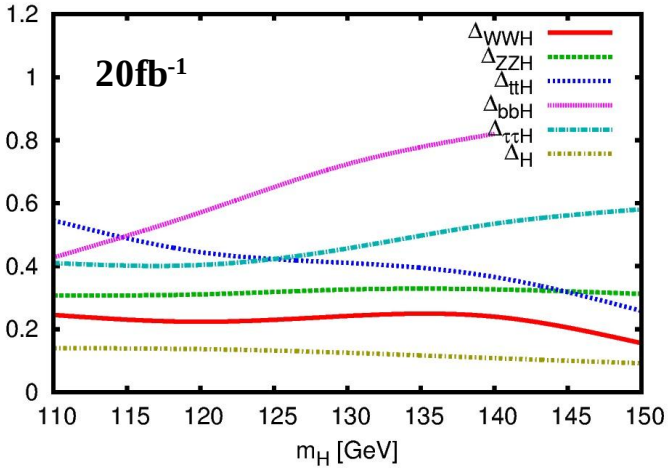
- **most errors on couplings <0.5**
- **portal precision 10%**
- **scaling roughly statistical as expected**



20fb-1 without subjet

- **precision similar for most couplings**
- **b-coupling (decay side) undetermined**
- **Z coupling (production side) undetermined**

Conclusions



- **2012: Higgs between 115-140GeV**
- **couplings known to better than 0.5 ☺**
- **portal precision: 10%**

Non-discovery of Higgs (<140GeV) does not mean non-existence (Englert et al, Phys.Lett. B703 (2011) 298-305):

	# observable Higgs bosons	
$\sin^2\chi \lesssim 0.2$	1	SM-type Higgs H_1 $(\sigma_{H_1} \geq 3,\ \sigma_{H_2} \leq 1)$
$0.3 \lesssim \sin^2\chi \lesssim 0.4$	0	neither SM-type nor hidden-type Higgs H_1, H_2 $(\sigma_{H_1,H_2} < 3)$
$0.4 \lesssim \sin^2\chi \lesssim 0.6$	2	SM + hidden-type Higgs H_1, H_2 $(\sigma_{H_1,H_2} \geq 3)$
$\sin^2\chi \gtrsim 0.6$	1	hidden-type Higgs H_2 $(\sigma_{H_1} \leq 1,\ \sigma_{H_2} \geq 3)$