

Strategie per nuove misure nel canale VH , $H \rightarrow bb$

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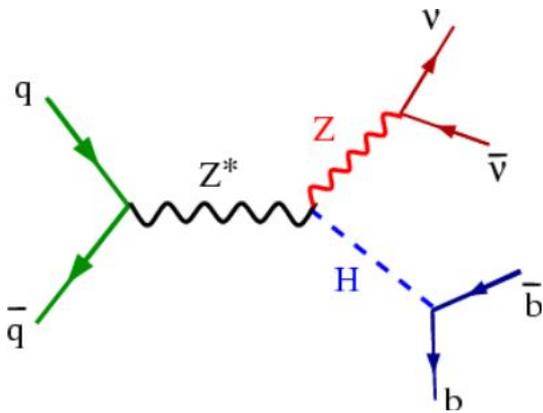
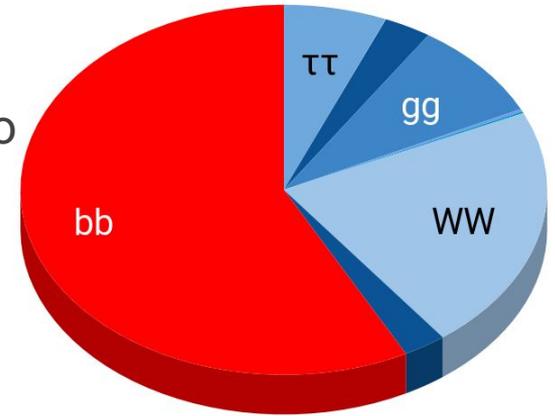
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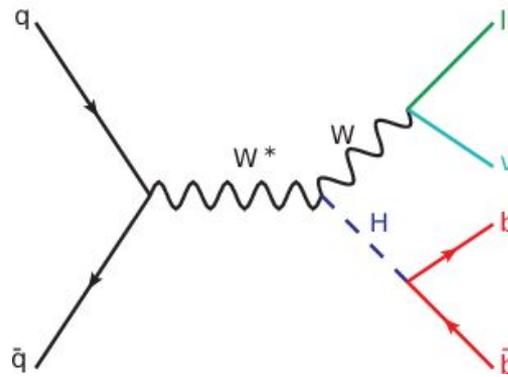
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Contesto: canale $VH, H \rightarrow bb$

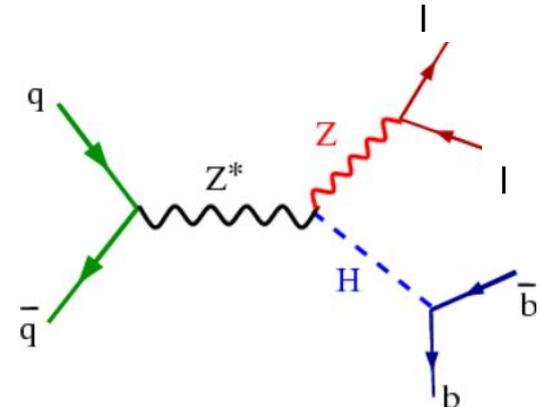
- accoppiamento diretto ai quark non ancora osservato
- $BR(H \rightarrow bb) \sim 58\%$ (atteso, PDG)
- reiezione del fondo difficile
- Produzione associata $VH \rightarrow$ reiezione fondo più semplice



$H \rightarrow bb \quad Z \rightarrow \nu\nu$



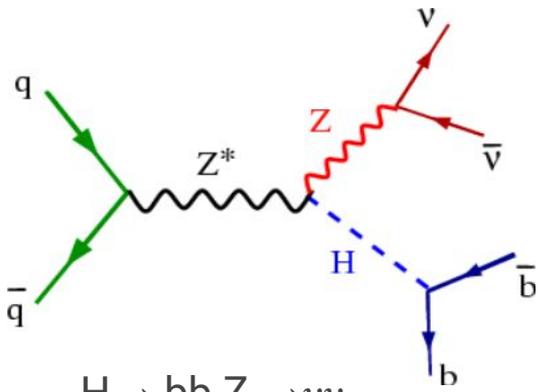
$H \rightarrow bb \quad W \rightarrow l\nu \quad (l=e, \mu)$



$H \rightarrow bb \quad Z \rightarrow ll \quad (l=e, \mu)$

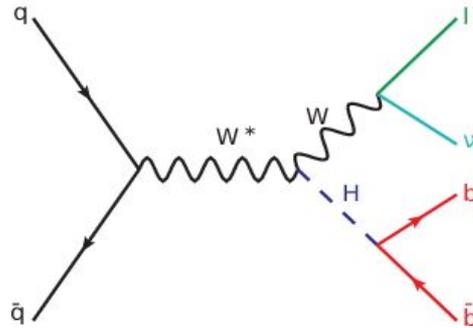
Selezione degli eventi

- 2 o 3 jet
- Esattamente due b-jet
- $p_{TV} > 150 \text{ GeV}$ (+ $75 < p_{TV} < 150 \text{ GeV}$ per $Z \rightarrow ll$)



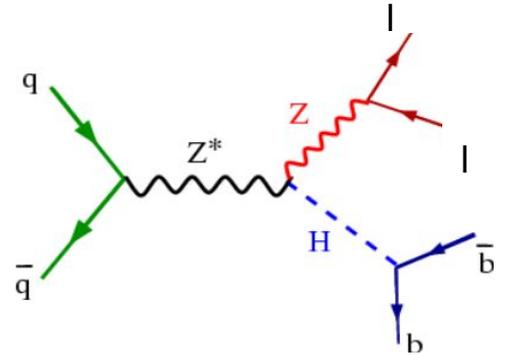
$H \rightarrow bb \quad Z \rightarrow \nu\nu$

- Trigger: p_T^{miss}
- 0 leptoni



$H \rightarrow bb \quad W \rightarrow l\nu \quad (l=e, \mu)$

- Trigger: elettrone o p_T^{miss}
- 1 leptone



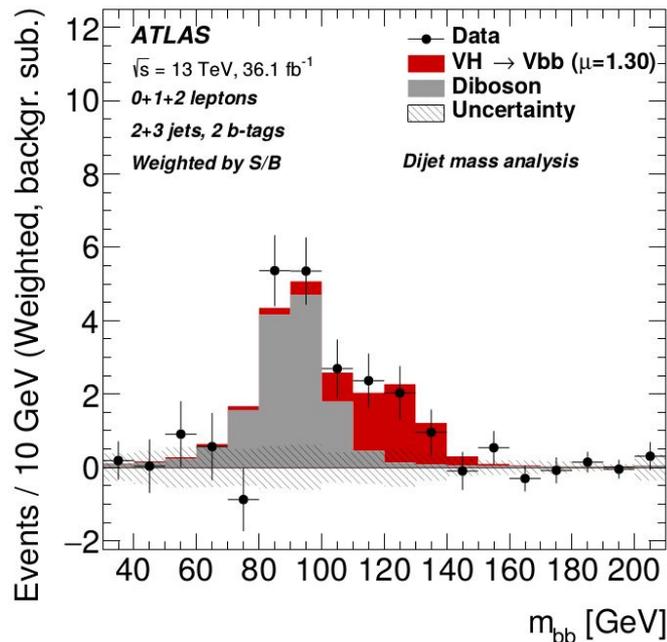
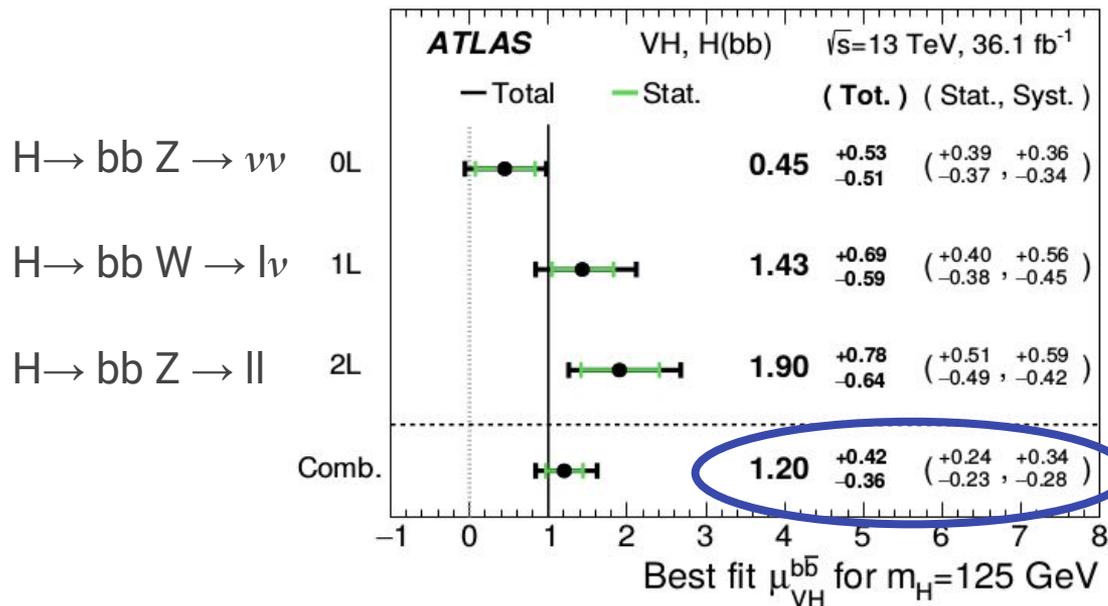
$H \rightarrow bb \quad Z \rightarrow ll \quad (l=e, \mu)$

- Trigger: leptone
- 2 leptoni dello stesso sapore e carica opposta

Risultati

- Analisi multivariata
- Fit variabile MVA in regioni di segnale e di controllo

$$\mu = \frac{\sigma_{\text{misurata}}}{\sigma_{\text{attesa (SM)}}$$



Run 2: 3.5σ (atteso 3.0σ)

Evidence for the H → bb decay with the ATLAS detector

Che sezione d'urto stiamo misurando...

$$\sigma(VH) \times B(H \rightarrow b\bar{b}) = 1.58^{+0.55}_{-0.47} \text{ pb}$$

Process	Acceptance [%]		
	0-lepton	1-lepton	2-lepton
$qq \rightarrow ZH \rightarrow \ell\ell b\bar{b}$	< 0.1	< 0.1	7.0
$gg \rightarrow ZH \rightarrow \ell\ell b\bar{b}$	< 0.1	< 0.1	15.7
$qq \rightarrow WH \rightarrow \ell\nu b\bar{b}$	0.2	1.0	–
$qq \rightarrow ZH \rightarrow \nu\nu b\bar{b}$	1.9	–	–
$gg \rightarrow ZH \rightarrow \nu\nu b\bar{b}$	3.5	–	–

Source of uncertainty	σ_μ
Total	0.39
Statistical	0.24
Systematic	0.31
Theoretical and modelling uncertainties	
Signal	0.17

Selezione degli eventi (in particolare $p_{TV} > 150 \text{ GeV}$)

Estrapoliamo la misura della sezione d'urto

...e cosa potremmo misurare

Restringere lo spazio delle fasi

Esempio:

- misura per $\sigma (p_{TV} >150 \text{ GeV})$ e $\sigma (p_{TV} <150 \text{ GeV})$
- Segnale MC diviso in $p_{TV} >150 \text{ GeV}$ e $p_{TV} <150 \text{ GeV}$ al livello truth
- Estraggo dal fit due sezioni d'urto

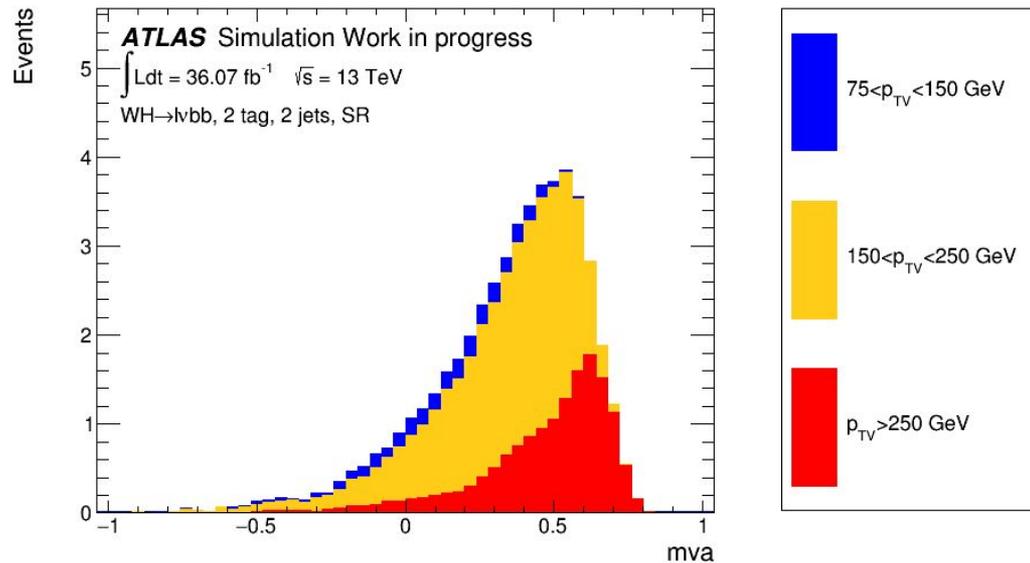
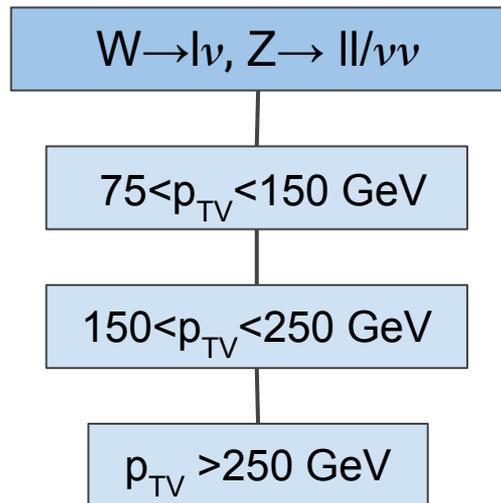
Sezioni d'urto in regioni cinematiche circoscritte

Pro:

- Più informazione
- Combinazione più semplice
- Dipendenza dalla teoria ridotta

Contro:

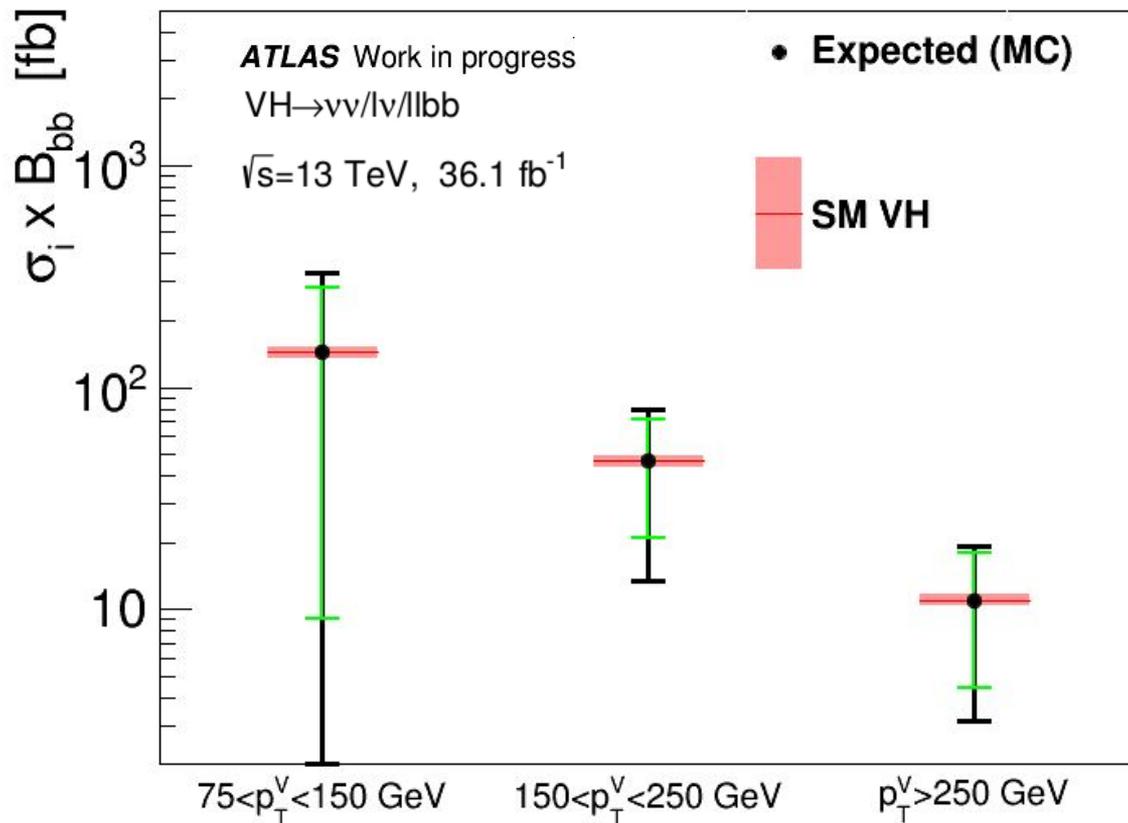
- Incertezza statistica maggiore



Esempio: separazione a 250 GeV per il canale con 1 leptone

Al momento lo spazio delle fasi è diviso solo in base a p_{TV}

Risultati attesi con VH, H→bb



Oltre il modello standard: teorie di campo efficaci

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \sum_i c_i^{(6)} \mathcal{O}_i^{(6)} / \Lambda^2.$$

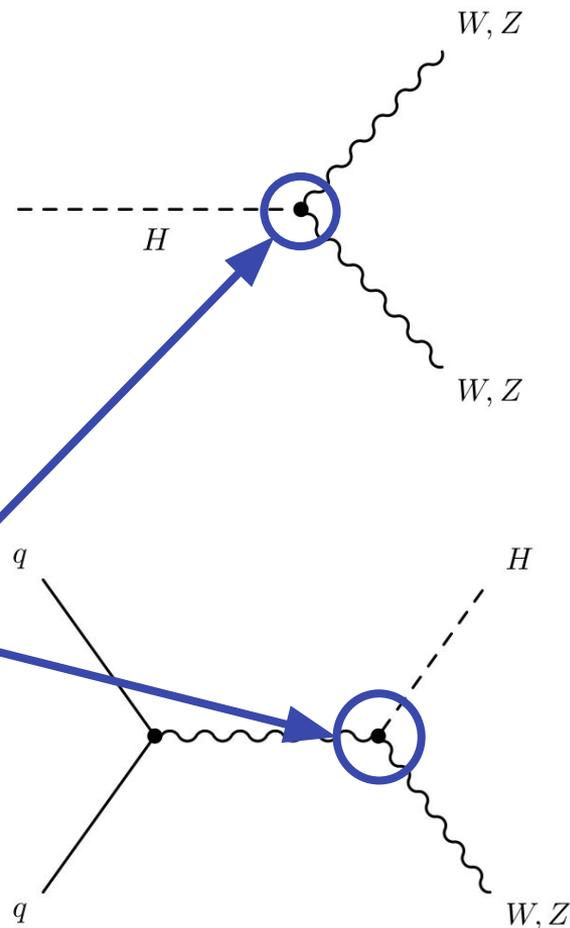

Operator	Expression	HEL coefficient	Vertices
O_g	$ H ^2 G_{\mu\nu}^A G^{A\mu\nu}$	$c_G = \frac{m_W^2}{g_s^2} \bar{c}_g$	Hgg
O_γ	$ H ^2 B_{\mu\nu} B^{\mu\nu}$	$c_A = \frac{m_W^2}{g'^2} \bar{c}_\gamma$	$H\gamma\gamma, HZZ$
O_u	$y_u H ^2 \bar{u}_l H u_R + \text{h.c.}$	$c_u = v^2 \bar{c}_u$	$Ht\bar{t}$
O_{HW}	$i (D^\mu H)^\dagger \sigma^a (D^\nu H) W_{\mu\nu}^a$	$c_{HW} = \frac{m_W^2}{g} \bar{c}_{HW}$	HWW, HZZ
O_{HB}	$i (D^\mu H)^\dagger (D^\nu H) B_{\mu\nu}$	$c_{HB} = \frac{m_W^2}{g'} \bar{c}_{HB}$	HZZ
O_W	$i (H^\dagger \sigma^a D^\mu H) D^\nu W_{\mu\nu}^a$	$c_{WW} = \frac{m_W^2}{g} \bar{c}_W$	HWW, HZZ
O_B	$i (H^\dagger D^\mu H) \partial^\nu B_{\mu\nu}$	$c_B = \frac{m_W^2}{g'} \bar{c}_B$	HZZ

- fisica oltre il modello standard (es. Nuova risonanza) → possibili deviazioni
- Come estrarre informazioni dalle misure di sezioni d'urto?

Oltre il modello standard

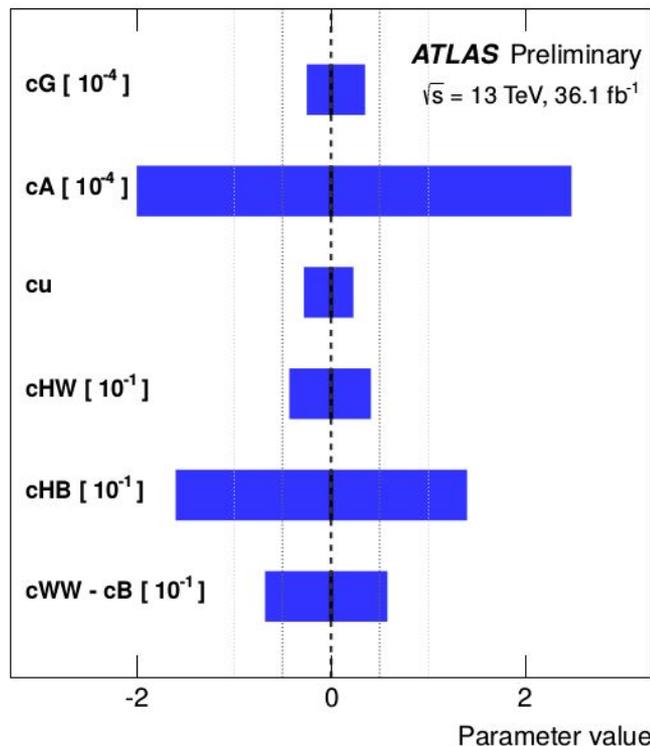
$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \sum_i c_i^{(6)} \mathcal{O}_i^{(6)} / \Lambda^2$$

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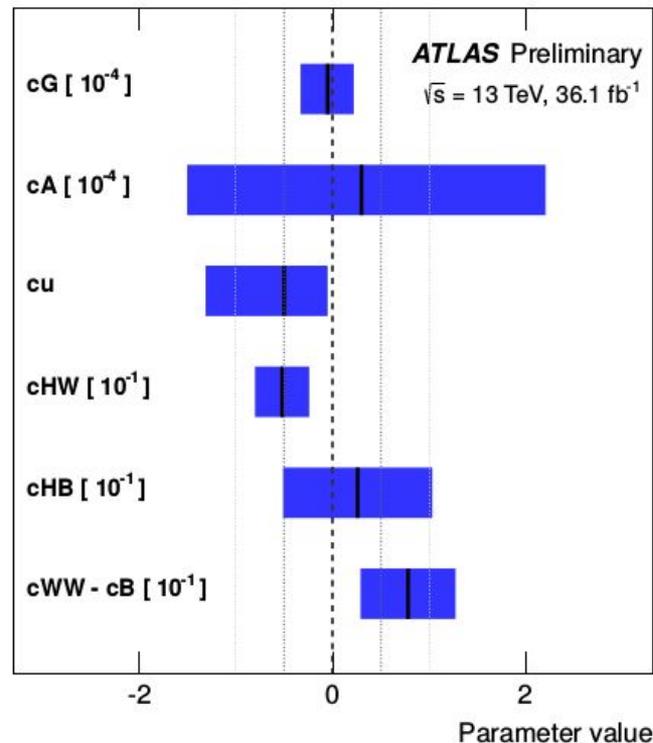


Risultati ATLAS ($H \rightarrow 4l$, $H \rightarrow \gamma\gamma$)

SM expected HEL constraints with $H \rightarrow ZZ^*$ and $H \rightarrow \gamma\gamma$

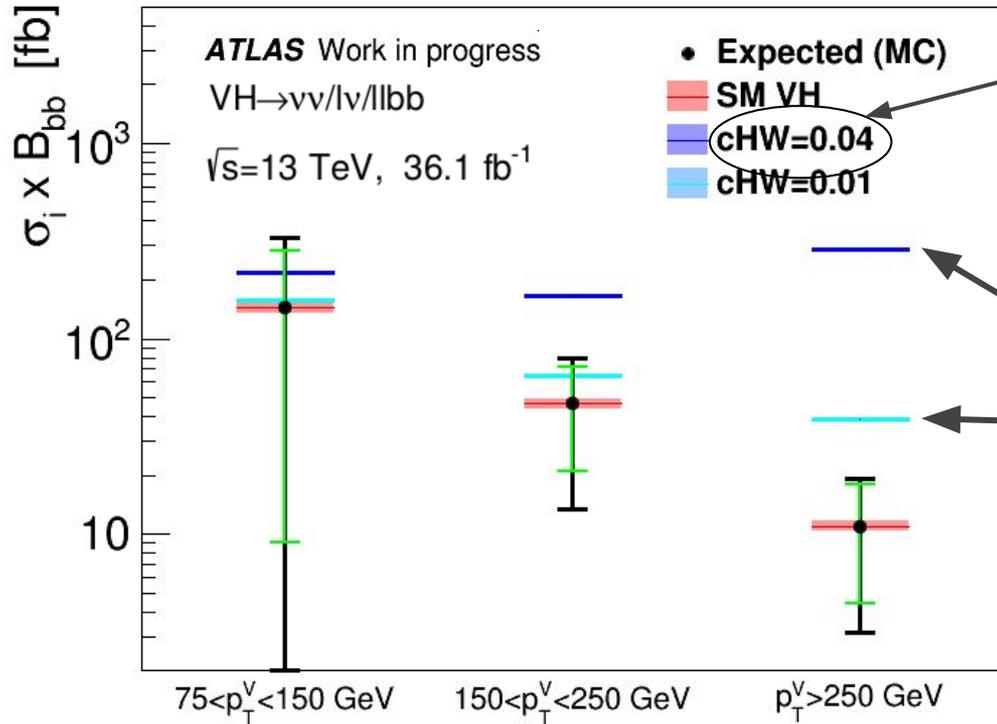


Observed HEL constraints with $H \rightarrow ZZ^*$ and $H \rightarrow \gamma\gamma$



Constraints on an effective Lagrangian from the combined $H \rightarrow ZZ^* \rightarrow 4l$ and $H \rightarrow \gamma\gamma$ channels using 36.1 fb^{-1} of $\sqrt{s}=13 \text{ TeV}$ pp collision data collected with the ATLAS detector

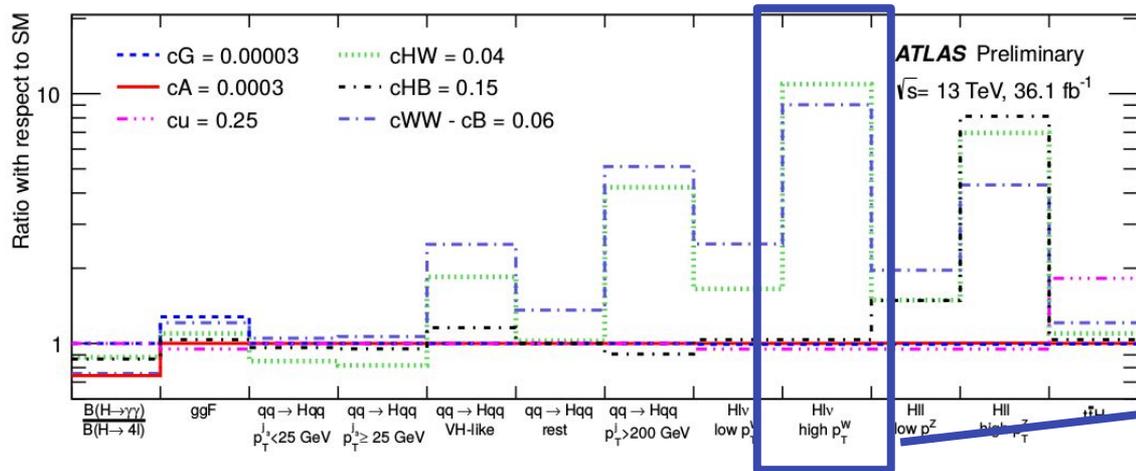
Risultati attesi con VH, H→bb



Atteso da H→4l + H→γγ

Le deviazioni aumentano ad alte energie

Prospettive e conclusioni



Constraints on an effective Lagrangian from the combined $H \rightarrow ZZ^ \rightarrow 4l$ and $H \rightarrow \gamma\gamma$ channels using 36.1 fb^{-1} of $\sqrt{s}=13 \text{ TeV}$ pp collision data collected with the ATLAS detector*

$Hl\nu$ $p_T > 150 \text{ GeV}$

- Miglioramenti con 100 fb-1?
- Quanto in alto in p_{TV} possiamo andare?

Misure della sezione d'urto in spazi delle fasi circoscritti

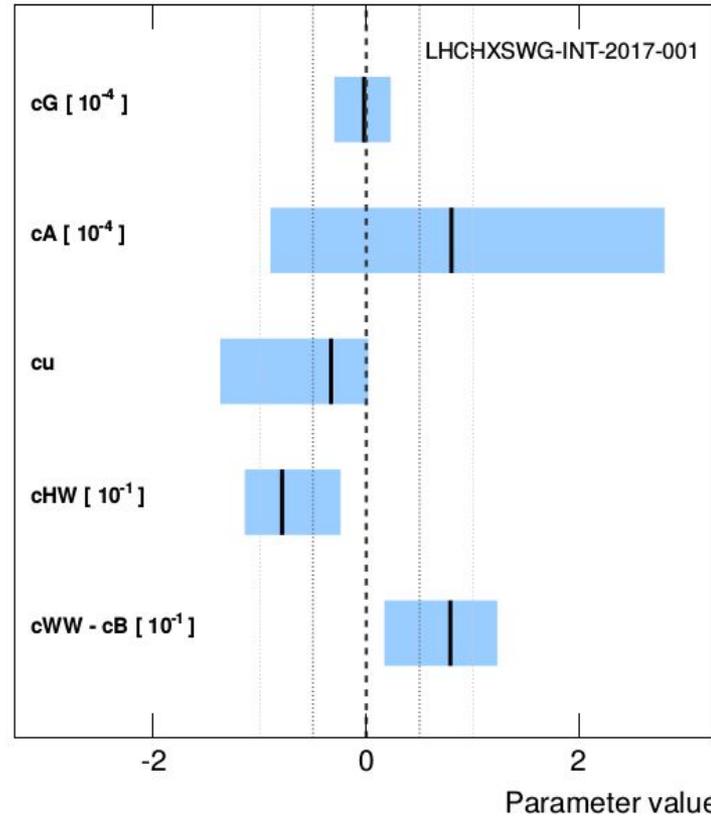
- Aumentano le informazioni
- Varie possibili interpretazioni
- Informazioni sulla fisica oltre il modello standard

Backup

Details of event selection

Selection	0-lepton	1-lepton		2-lepton
		e sub-channel	μ sub-channel	
Trigger	E_T^{miss}	Single lepton	E_T^{miss}	Single lepton
Leptons	0 loose leptons with $p_T > 7$ GeV	1 tight electron $p_T > 27$ GeV	1 medium muon $p_T > 25$ GeV	2 loose leptons with $p_T > 7$ GeV ≥ 1 lepton with $p_T > 27$ GeV
E_T^{miss}	> 150 GeV	> 30 GeV	–	–
$m_{\ell\ell}$	–	–	–	$81 \text{ GeV} < m_{\ell\ell} < 101 \text{ GeV}$
Jets	Exactly 2 or 3 jets			Exactly 2 or ≥ 3 jets
Jet p_T	> 20 GeV			
b -jets	Exactly 2 b -tagged jets			
Leading b -tagged jet p_T	> 45 GeV			
H_T	> 120 (2 jets), > 150 GeV (3 jets)	–	–	–
$\min[\Delta\phi(E_T^{\text{miss}}, \mathbf{jets})]$	$> 20^\circ$ (2 jets), $> 30^\circ$ (3 jets)	–	–	–
$\Delta\phi(E_T^{\text{miss}}, \mathbf{bb})$	$> 120^\circ$	–	–	–
$\Delta\phi(\mathbf{b}_1, \mathbf{b}_2)$	$< 140^\circ$	–	–	–
$\Delta\phi(E_T^{\text{miss}}, E_{T,\text{trk}}^{\text{miss}})$	$< 90^\circ$	–	–	–
p_T^V regions	> 150 GeV			$(75, 150]$ GeV, > 150 GeV
Signal regions	✓	$m_{bb} \geq 75$ GeV or $m_{\text{top}} \leq 225$ GeV		Same-flavour leptons Opposite-sign charge ($\mu\mu$ sub-channel)
Control regions	–	$m_{bb} < 75$ GeV and $m_{\text{top}} > 225$ GeV		Different-flavour leptons

Fit to ATLAS STXS measurements (ATLAS-CONF-2017-047)



[Constraining EFT parameters using simplified template cross sections, Hays, Chris and Sanz Gonzalez, Veronica and Zemaityte, Gabija](#)