Study of the Spin/CP properties of the Higgs coupling to W bosons with ATLAS at the LHC

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TÉCNICO LISBOA

LIP

ATLAS EXPERIMENT

FCT Fundação para a Ciência e a Tecnologia

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Outline

1) Precision Higgs studies

2) ATLAS Jet Trigger

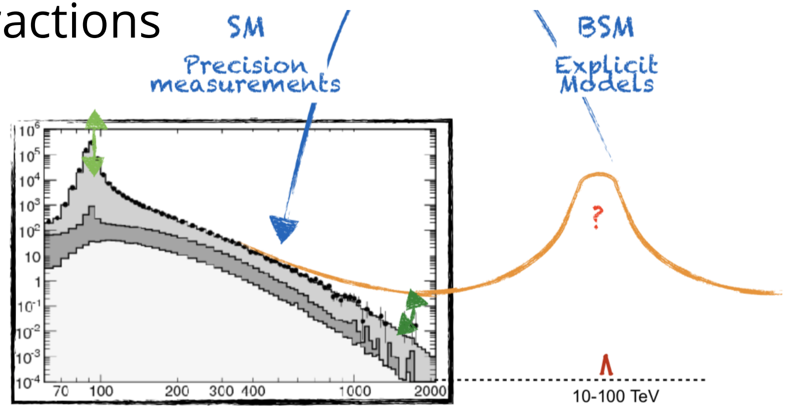
1.
Precision Higgs studies

Precision studies of the Higgs sector

What we know about the Higgs:

- Mass ≈ 125 GeV ± 0.2%, spin 0 state
- Interactions with SM particles follow SM expectation

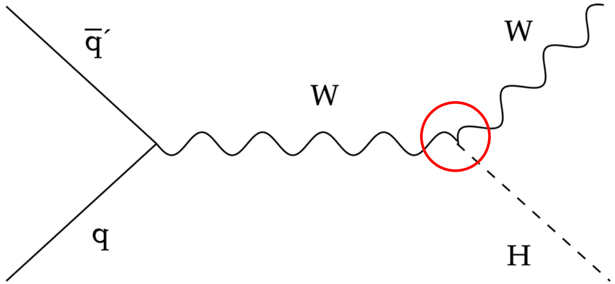
New physics at an energy scale Λ » v may have an indirect **(small)** effect on Higgs boson interactions



The HWW interaction vertex and boosted WH production

HWW vertex, studied in **associated WH production**

- Allows separate reconstruction of W and Higgs

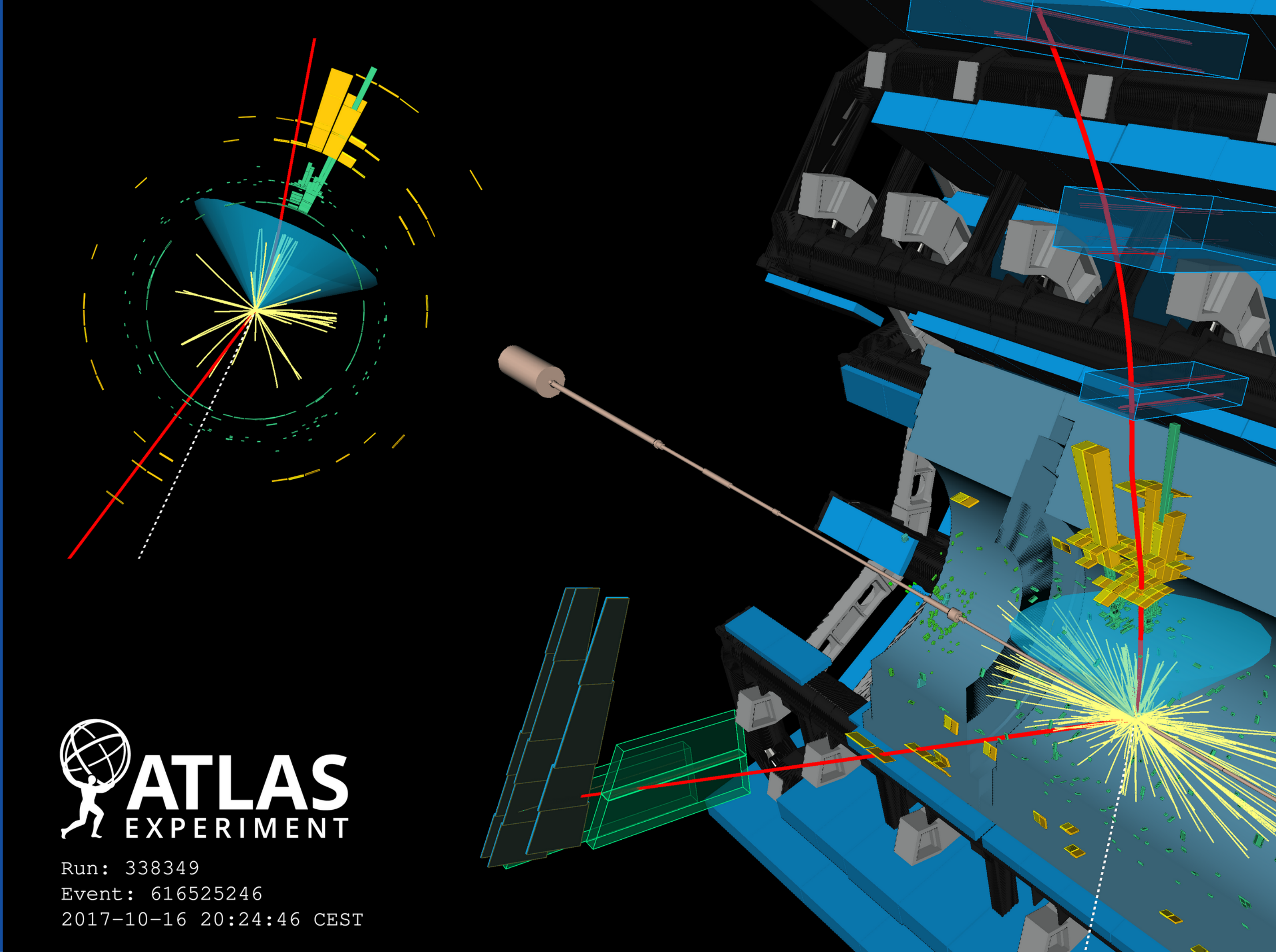


New physics in the interaction pushes p_T distributions to higher values

- **Higher sensitivity in the boosted (high p_T) regime**

First ATLAS search for boosted V(V=W,Z)H production

(ATLAS-CONF-2020-007)



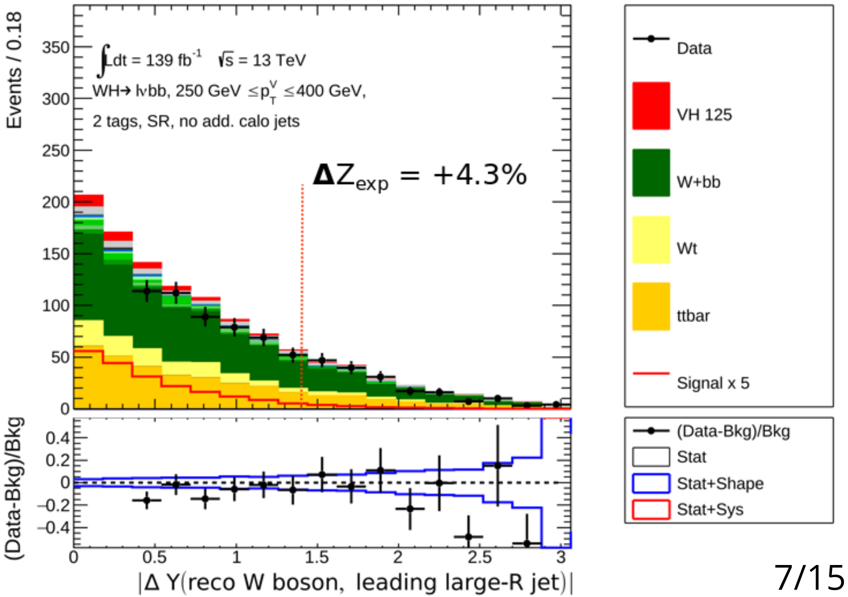
Main contributions

Definition of boosted Higgs identification strategy

	Fixed-radius	Variable-radius
Signal efficiency (%)	43.7	39.1
$t\bar{t}$ rejection factor	100.0	142.9
W+jets rejection factor	184.3	219.5
Z_{med}	0.861	0.898

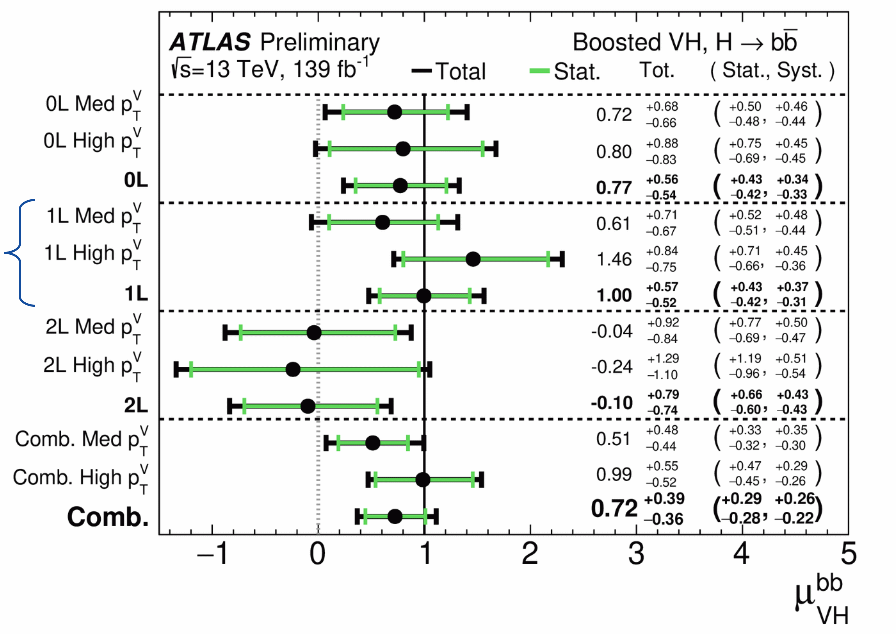
	Leading 2 subjets	All subjets
Signal efficiency (%)	39.7	42.6
$t\bar{t}$ rejection factor	142.9	83.3
W+jets rejection factor	219.5	144.5
Z_{med}	0.898	0.766

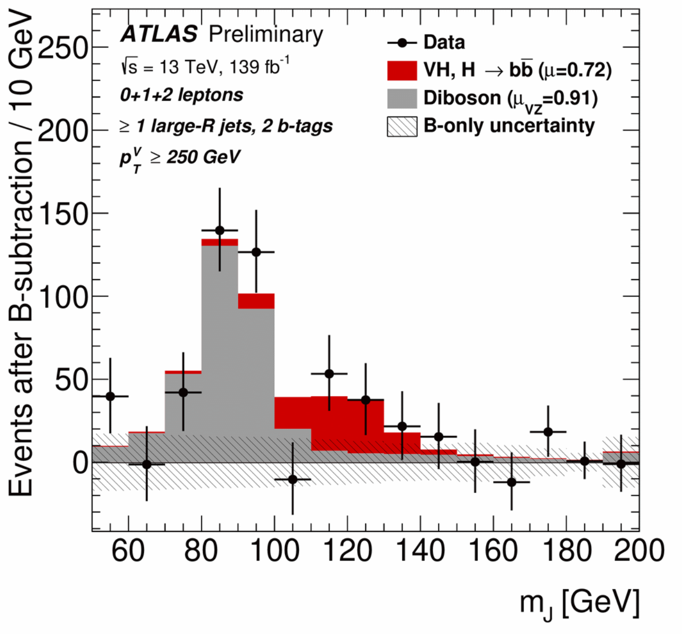
Optimization of event selection



Results

WH





Combined significance: 2.1σ (2.7σ) observed (expected)

Consistent with SM expectations

Effective Field Theory as a tool for new physics studies

New physics can be parametrized using Effective Field Theory

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{d>4}\sum_{i}\frac{c_i O_i^{(d)}}{\Lambda^{4-d}}$$

Can be obtained from models with new particles

Advantage: **(almost) model-independent**

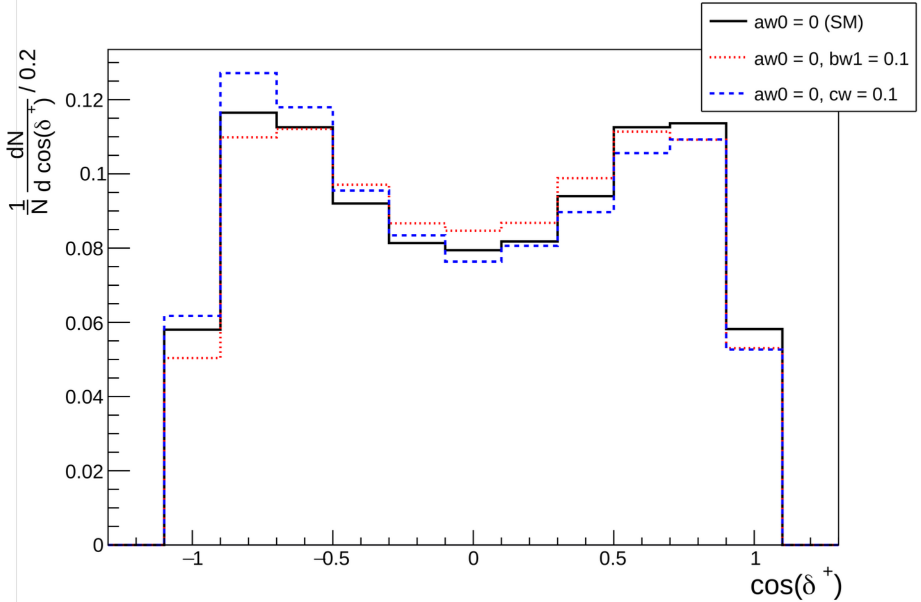
anomalous components

$$i\Gamma^{\mu\nu}_{HWW}(k_1,k_2) = \underbrace{i(g_2 m_W)}_{\textbf{SM}}\left[g^{\mu\nu}\left((1+a_W) - \underbrace{\frac{b_{W1}}{m_W^2}(k_1\cdot k_2)}_{\textbf{CP-even}}\right) + \underbrace{\frac{b_{W1}}{m_W^2}\, k_1^{\nu}k_2^{\mu}}_{\textbf{CP-even}} + \underbrace{\frac{c_W}{m_W^2}\epsilon^{\mu\nu\rho\sigma}k_{1_\rho}k_{2_\sigma}}_{\textbf{CP-odd}}\right]$$

Angular observables – why ?

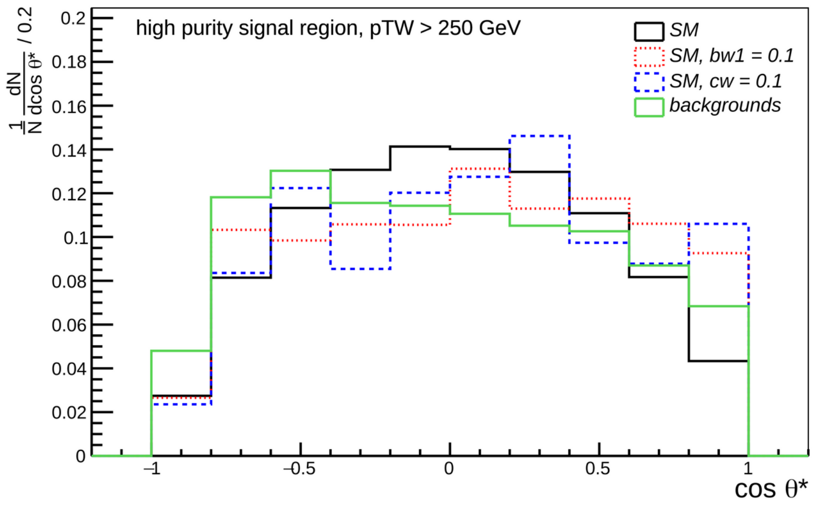
Cross-section measurements:

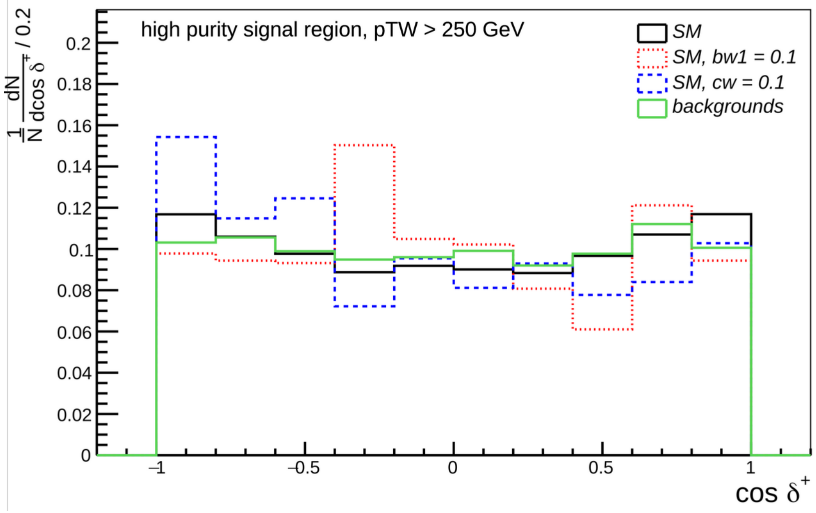
- Insensitive to small couplings of CP-odd components
- can't disentangle between anomalous components with different Spin/CP properties



Previous work: studied a set of angular observables defined in [arXiv:1409.5449]

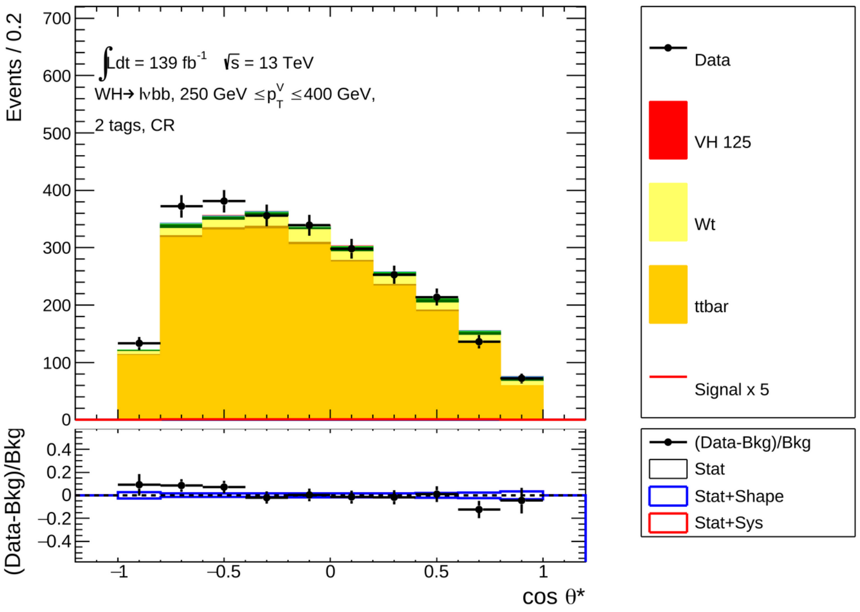
Results I

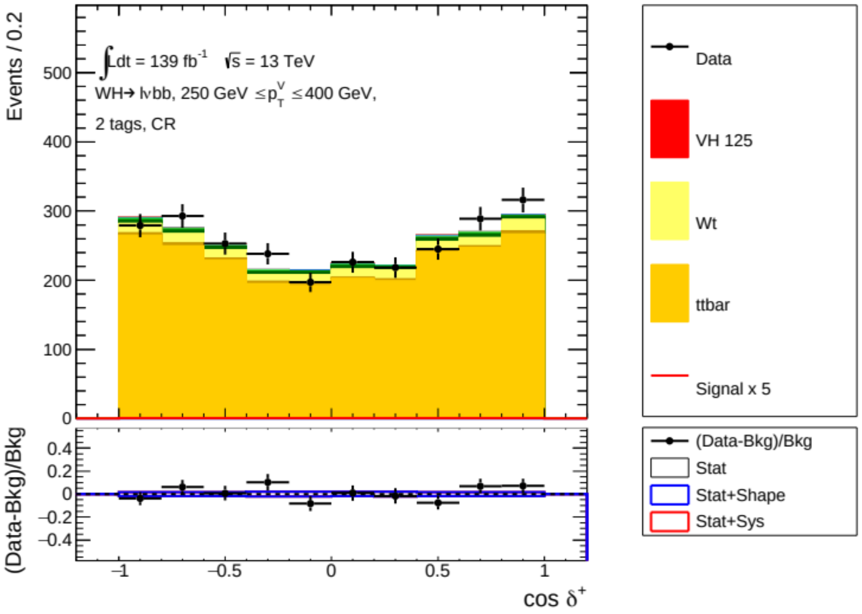




- *cos* θ^* distinguishes between SM and anomalous components
- *cos* δ^+ needs more luminosity to distinguish between CP-even and CP-odd components

Results II





Both variables are **well modelled** for the main background

2.
ATLAS Jet Trigger

Jet Trigger

The ATLAS jet trigger selects (in real time) events based on the existence of high p_T jets.

Present: working on development and maintenance of tool used to calculate efficiency of jet-based trigger algorithms

- will be contributing to paper of jet trigger performance with the LHC Run 2 dataset

Future: study and validate jet trigger performance with first Run 3 data

Thanks!

Any questions?

Backup

Operators and angular observables

$$\mathcal{O}_{HW} = \Phi^\dagger \Phi W^{i\mu\nu} W^i_{\mu\nu} \text{ (CP-even)} \quad \mathcal{O}_{H\tilde{W}} = \Phi^\dagger \Phi \tilde{W}^{i\mu\nu} W^i_{\mu\nu} \text{ (CP-odd)}$$

$$\cos\theta^* = \frac{p_\ell^{(W)} \cdot p_W}{|p_\ell^{(W)}||p_W|} \qquad \cos\delta^+ = \frac{p_\ell^{(W)} \cdot (p_H \times p_W)}{|p_\ell^{(W)}||p_H \times p_W|}$$

$p_l^{(W)}$: 3-momentum of electron or muon in W rest frame

- All other 3-momenta defined in the lab frame