Search for Higgs boson in the final state with two leptons and a photon produced in pp collisions at √s=13 TeV with the ATLAS detector.

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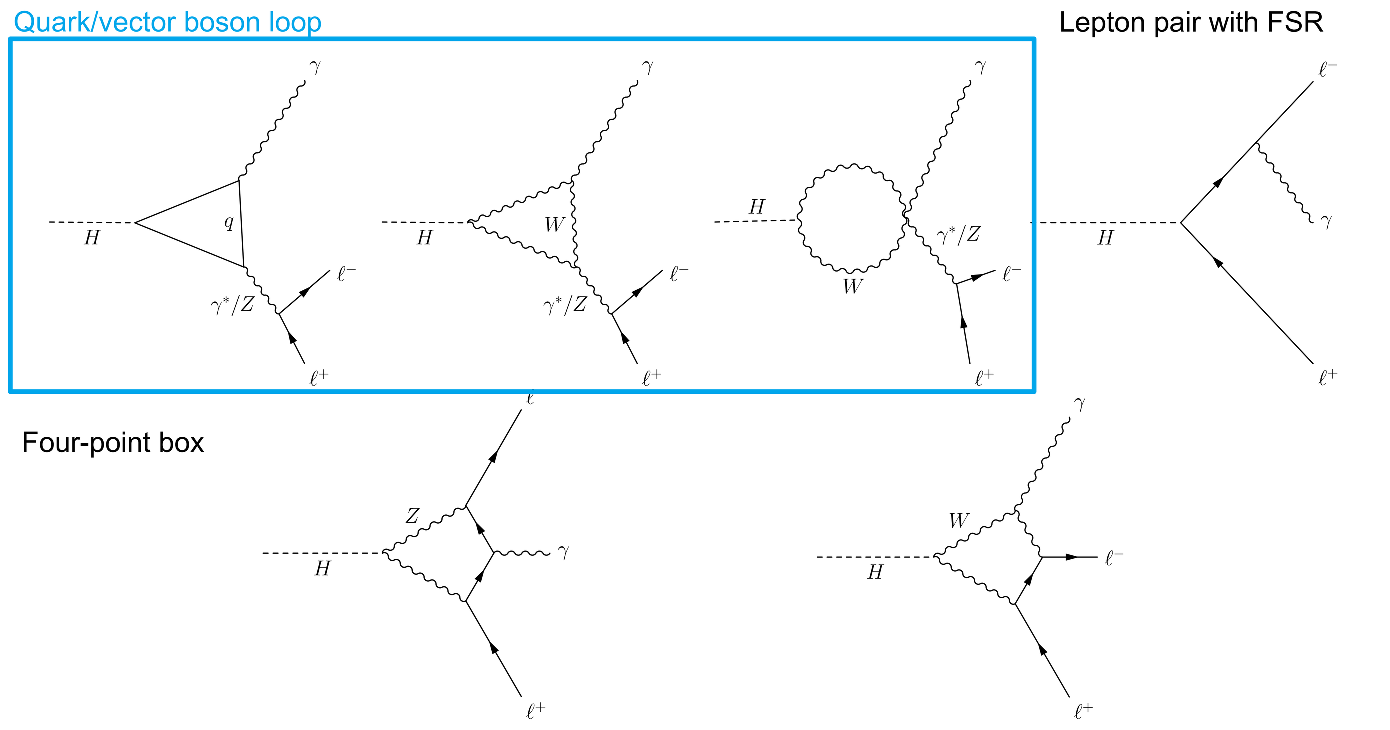
Higgs in the llγ final state



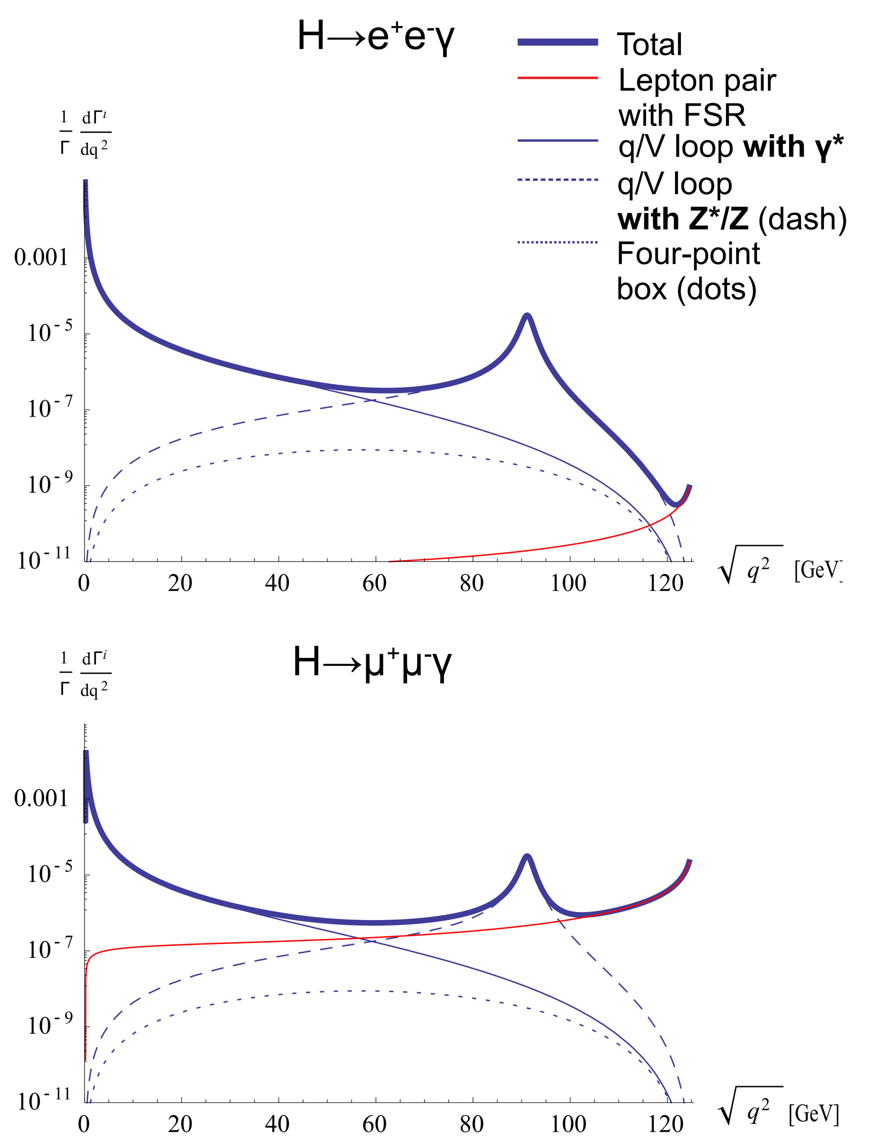
Feynman diagrams with significant contribution for the Standard Model Higgs boson decay into two leptons and a photon (llγ final state) [1].

Quark/vector boson loop diagrams are **dominating** in llγ but still **very rare**:

- Branching ratio: BR(H→γ*/Zγ→llγ) ~ **0.0002***
  - Of this, decays through γ* or Z have comparable BR

*Here and throughout the poster „**leptons**" refer to **muons and electrons only**. See [2] for BR(H→Zγ) and [3] for BR(Z→ll). See [4] for BR(H→γ*γ→llγ).

Contributing diagrams vs dilepton mass



Source: [5]

- **Z*/Z** is concentrated mostly in **higher** dilepton masses (close to Z mass pole);
- **γ*** dominates in **low** dilepton masses.

► Two complementary searches possible: **H→Zγ** and **H→γ*γ**

Zγ and γ*γ decays allow for **probing SM at higher** order due to the loop in diagrams.

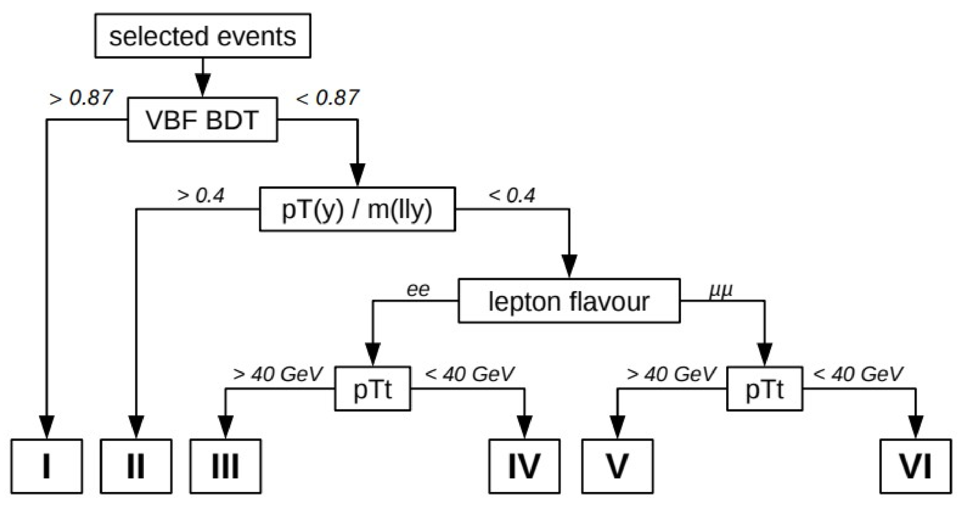
Three bodies in llγ final state: possible to probe **probe CP and CPT invariance** by measuring **forward-backward assymetry** [6] in H decays.

H→Zγ→llγ

Event selection and classification

Selecting events:

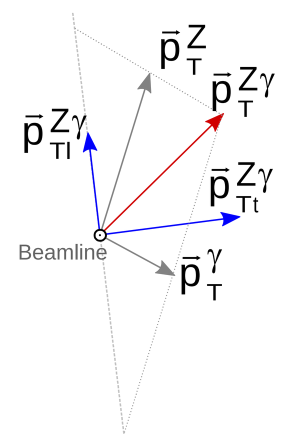
- Containing **two** well-isolated **opposite-sign muons** or **electrons** and a **photon** with high-quality tracks
  - Objects that are too close (overlap) are removed
- Containing a **Z boson candidate** (within 10 GeV of the Z boson mass).
  - Mass resolution of Z → μμ candidates is improved by muon momenta correction for a collinear final state radiation (FSR) and a kinematic fit to the Z boson.



H produced mainly via **gluon-gluon fusion** but **vector-boson fusion (VBF)** has much less background contamination.

Classifying events into 6 categories to increase overall sensitivity:

- The most sensitive VBF-like category is optimized using **BDTs**
- 5 additional categories based on **relative p_T of the photon to H candidate** mass and **p_T thrust** of the Zγ system



p_T thrust: in the plane transverse to the beam, projection of **$p_T^{Z\gamma}$** perpendicular to **p_T^{Z}** - **p_T^{γ}** (close to $p_T^{Z\gamma}$ when back to back)

Signal and background estimation

- ►Estimated in the Zγ invariant mass distribution
- ►Represented as **analytical functions**

Signal:

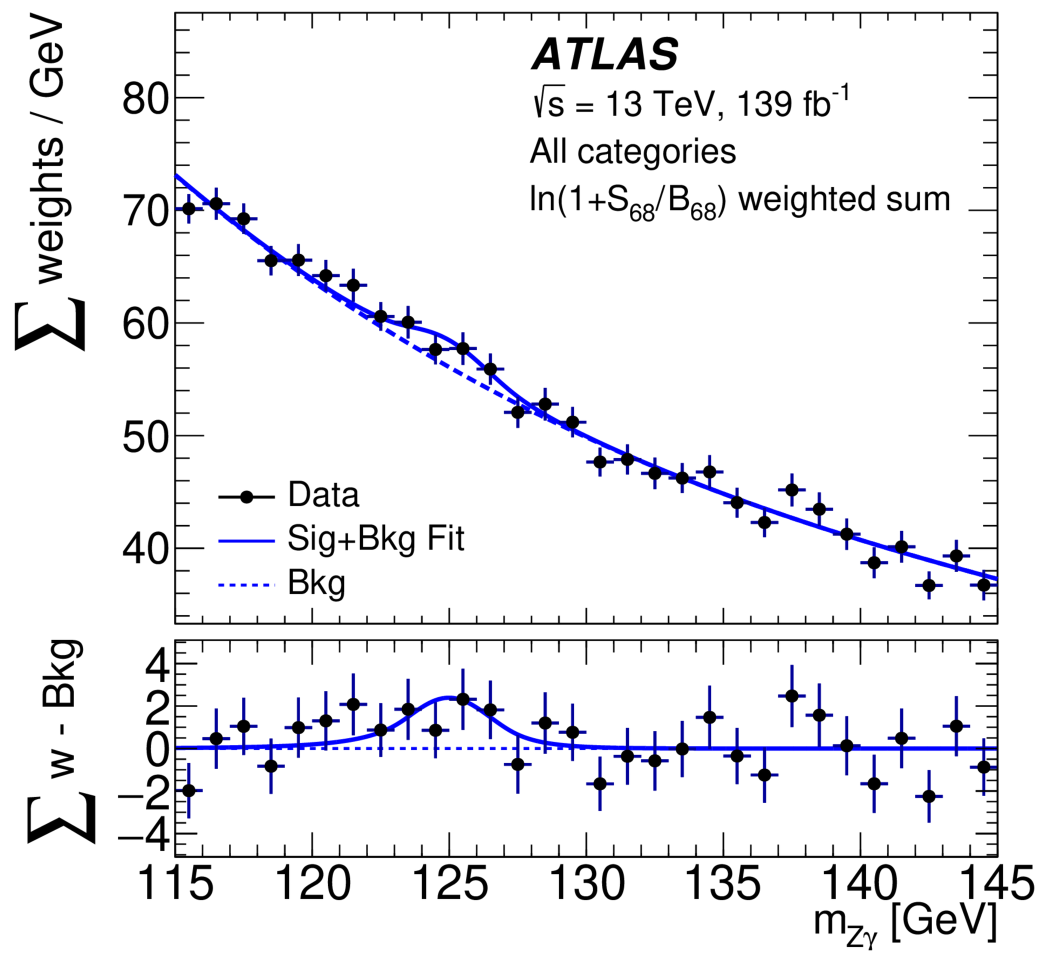
- template from **Monte-Carlo (MC) simulation**
- fit template with a **Double-Sided Crystal Ball** function.

Background:

- choose a function type using template:
  - **MC simulated Zγ** and **electroweak Zγjj**
  - **Zjets** contribution estimated **from data** by relaxing photon identification criteria (obtaining a **sample enriched in Z+jets**)

Category	Function type
I: VBF-enriched	Second-order power function
II: High relative p_T	Second-order exponential polynomial
III: ee high p_{Tt}	Second-order Bernstein polynomial
IV: ee low p_{Tt}	Second-order exponential polynomial
V: μμ high p_{Tt}	Third-order Bernstein polynomial
VI: μμ low p_{Tt}	Third-order Bernstein polynomial

Comparison of expected signal plus background fit (blue line) with data (dots). Background-only fit shown with dashed line.



In a window containing **~70% of expected signal**:
Expected signal: **110.2**
Expected background: **16701.9**

Total data events selected in full range [105,160] GeV: **192571**

Uncertainties and results

The analysis is **dominated by statistical uncertainties** (~80%) due to very low branching ratio and high irreducible background.

Dominating **systematic uncertainties** affecting the analysis:
28%: background model choice bias
5.7%: on theoretical prediction of BR
5.3%: missing **higher order QCD corrections** in theoretical prediction

- **Observed 95%CL upper limit on the σ(pp → H)·B(H → Zγ) is 3.6 times the SM prediction**
  - **Expected, assuming SM Higgs: 2.6 ×SM**
- **Best-fit value for the signal yield normalised to the SM prediction is $2.0^{+1.0}_{-0.9}$**

Potential in Run 3 and beyond:

- Go from limits to **observation**
- **Combination** in llγ and with other H searches
- **Measurement** of H properties

References

H→Zγ→llγ search: arXiv:2005.05382

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3. P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
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