Analysis of the current trigger and selection efficiency for the process $H \to J/\psi\gamma \to \mu\mu\gamma$ at CMS and comparison with new trigger proposals

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Outline

Introduction

A word on physics motivations

The Higgs boson is considered to be discovered in 2012, when a new particle with the properties predicted by Standard Model (SM) was observed by CMS and ATLAS collaborations. Yukawa couplings to first and second-generation quarks are still to be measured.

- Rare exclusive decays of the Higgs boson to mesons in association with a photon can be used to explore these couplings.
- $H \to J/\psi\gamma$ can be used to explore the Higgs boson coupling to the charm quark $\Rightarrow$ test of SM predictions.
- $Z \to J/\psi\gamma$ can be used as an experimental benchmark.

Introduction

- Both decays receive contributions from direct and indirect processes

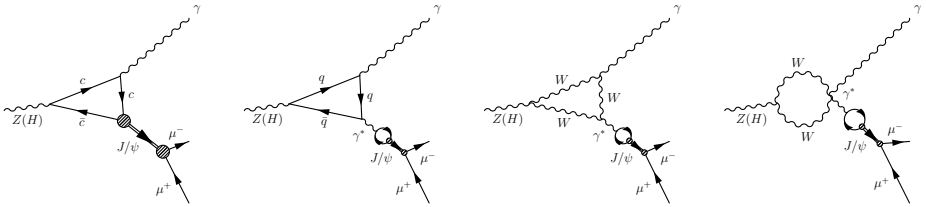

Figure: Lowest order Feynman diagrams for the Z (or H) $\rightarrow$ J/$\psi\gamma$ decay. The left-most diagram shows the direct and the remaining diagrams the indirect processes[†].

- The cumulative yield of the decay is proportional to the branching ratio (BR).

[†]Sirunyan et al., "Search for rare decays of Z and Higgs bosons to J/ψ and a photon in proton-proton collisions at $\sqrt{s} = 13$ TeV".

Introduction

- Experimental efforts have only established an upper bound 200 times the SM predicted value.
- The main challenge is the discrimination between background and signal ⇒ higher luminosity and more efficient trigger needed.

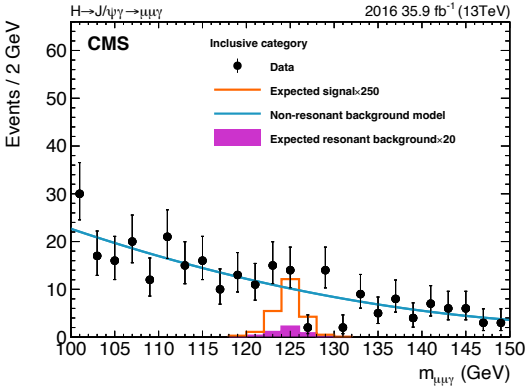

Figure: $m_{\mu\mu\gamma}$ in Higgs boson exotic decay[‡].

[‡]Sirunyan et al., "Search for rare decays of Z and Higgs bosons to J/ψ and a photon in proton-proton collisions at $\sqrt{s} = 13$ TeV".

Objectives

Trigger

In order to filter the amount of data that is recorded from each collision at the LHC, triggers are used. Current High Level Trigger requires the presence of a muon and a photon exceeding 17 and 30 GeV in the final state.

- The goal is then to design a new trigger that can outperform *HLT_Mu17_Photon30*.

Trigger and selection efficiencies

The trigger efficiency:

$$\varepsilon_{\text{trigger}} = \frac{\#\text{ events passing HLT \& selection}}{\#\text{ events passing selection}}$$

The selection efficiency:

$$\varepsilon_{\text{selection}} = \frac{\#\text{ events passing selection}}{\#\text{ total events}}$$

Muons	**Photons**
nMuon ≥ 2	nPhoton ≥ 1
Opposite charges: μ^-, μ^+	-
$\lvert\eta\rvert < 2.4$	$\lvert\eta\rvert < 2.4$
Retain pair with min. $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$	-
$p_{\text{T}}^{\mu_1} > 10$ GeV, $p_{\text{T}}^{\mu_2} > 5$ GeV	$p_{\text{T}}^{\gamma} > 15$ GeV
mediumId	mvaID_WP90
-	pixel_Seed = 0

Figure: Kinematic, charge and quality selection criteria imposed to the muons and photons in the final state.

Example calculation of ε for *HLT_Mu17_Photon30*

References

Sirunyan, Albert M et al. "Search for rare decays of Z and Higgs bosons to J/ψ and a photon in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: *The European Physical Journal C* 79.2 (2019), pp. 1–27.


Thanks for your attention!