

The search for the Dalitz Higgs decay in CMS

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H → llγ in CMS (1/2)

- H → llγ can arise from two processes:
 - H → Zγ → llγ : BR(l=e/μ) = 0.051 × 10⁻³
 - H → γ*γ → llγ : BR(l=μ) = 3.83 × 10⁻⁵ [BR(l=e) ≈ 2 × BR(l=μ)]

$$\frac{\mathcal{B}(H \rightarrow \gamma^* \gamma \rightarrow \mu\mu\gamma)}{\mathcal{B}(H \rightarrow \gamma\gamma)} = (1.69 \pm 0.10)\%, \quad \frac{\mathcal{B}(H \rightarrow Z\gamma \rightarrow e^+e^-\gamma/\mu\mu\gamma)}{\mathcal{B}(H \rightarrow \gamma\gamma)} = (2.27 \pm 0.14)\%$$

- The analysis for looking into these two processes are mutually exclusive
 - m_{ll} threshold at 50 GeV is used to separate the two processes

H → llγ in CMS (2/2)

2.9 < m_{μμ} < 3.3 GeV and 9.3 < m_{μμ} < 9.7 GeV are rejected



1.5 GeV

20 GeV

50 GeV



Run-I

↔ H → γ*γ → eeγ (8 TeV)



H → γ*γ → μμγ (8 TeV)

PLB 753 (2016) 431

H → Zγ → eeγ/μμγ (7 + 8 TeV)



PLB 726 (2013) 587

H → γ*γ → μμγ (13 TeV)

Run-II (2016)



H → Zγ → eeγ/μμγ (13 TeV)



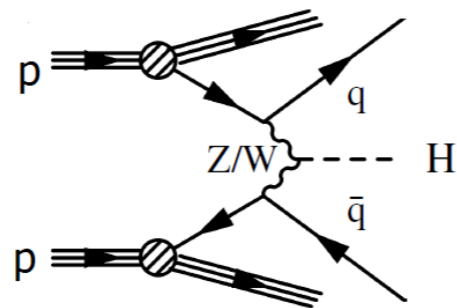
JHEP 11 (2018) 152

Event selection for the Dalitz Higgs decay in CMS

- unique event topology \rightarrow two collimated leptons from γ^* decay
 - challenge in trigger and identification
 - smaller signal yield but better sensitivity than $H \rightarrow Z\gamma$
- trigger: $\mu(17)-\gamma(30)$
- leading $p_{T\mu} > 20$ GeV, subleading $p_{T\mu} > 4$ GeV, $p_{T\gamma} > 33$ GeV
- μ and γ are asked to be well identified and isolated
- $\Delta R(\mu, \gamma) > 1.0$
- $p_{T\gamma}/m_{\mu\mu\gamma} > 0.3$, $p_{T\mu\mu}/m_{\mu\mu\gamma} > 0.3$

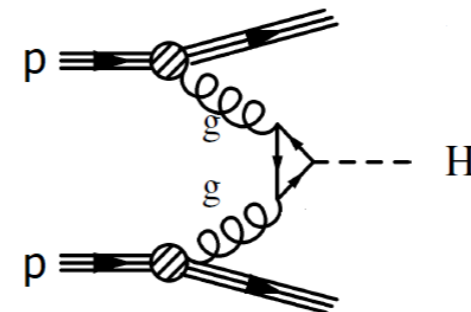
Event categorization

- 4 mutually exclusive categories used to differentiate production modes, increase S/B, and enhance the peak resolution
- the search sensitivity is improved by 11%



di-jet tag

$\Delta\eta_{jj} > 3.5, m_{jj} > 500 \text{ GeV}$
Zeppenfeld < 2.5
 $\Delta\Phi(l\gamma, jj) > 2.4$



3 untagged categories

depend on η^ν and γ shower shape
enhance $l\gamma$ mass resolution and S/B

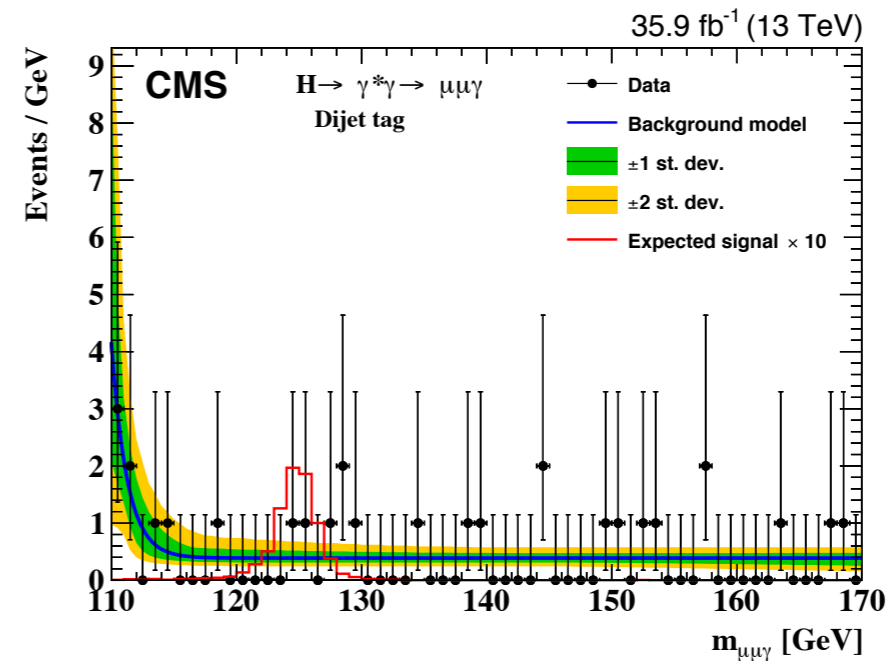
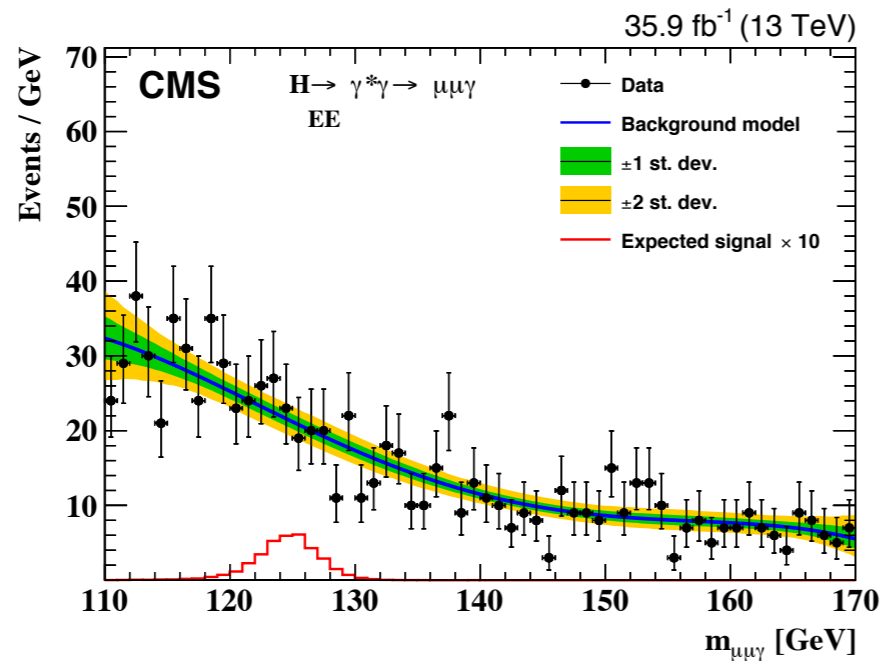
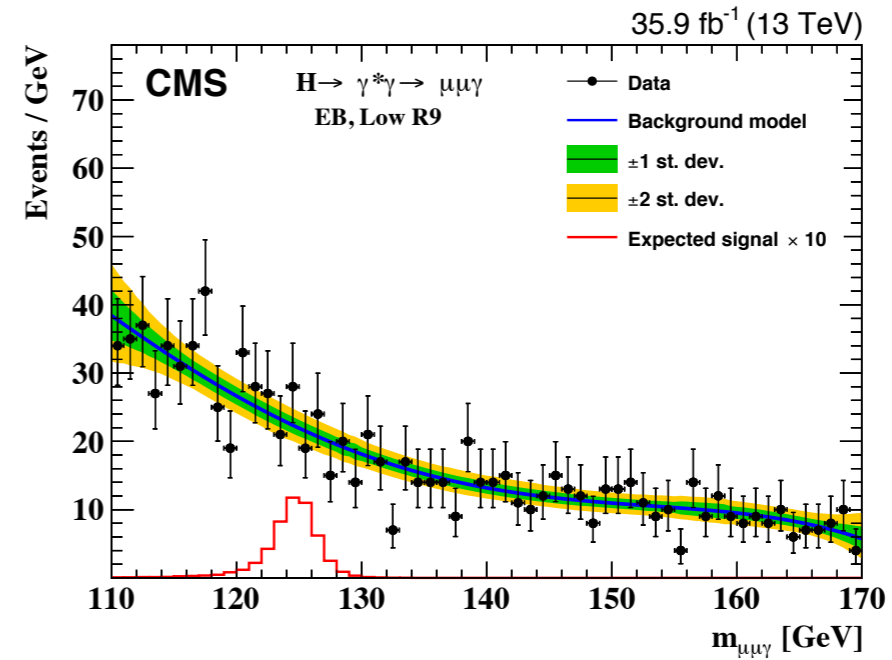
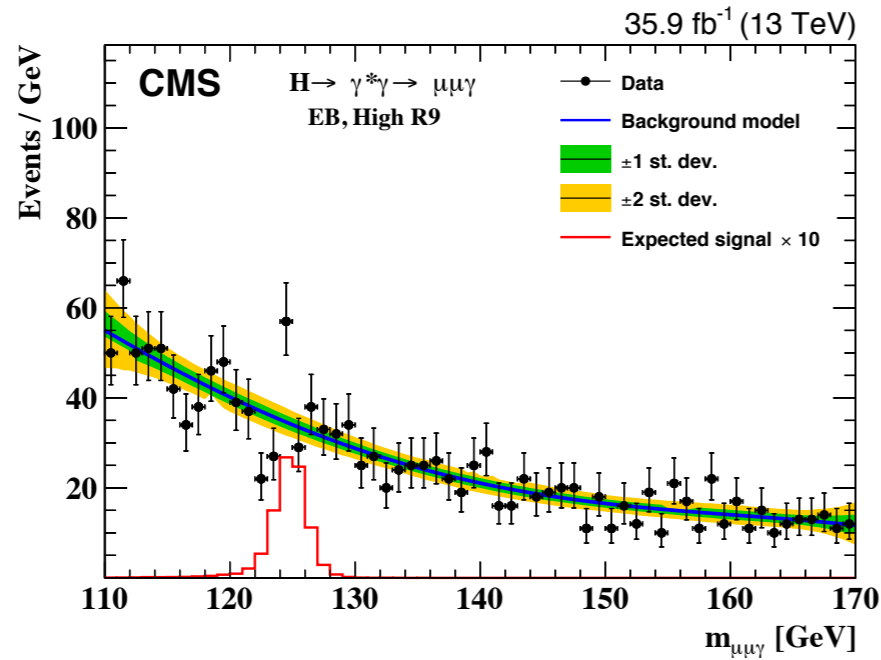
Expected signal yield

Analysis	Channel	Category	Number of signal events for $m_H = 125$ GeV		
			ggH	VBF	VH + ttH
$H \rightarrow \gamma^* \gamma \rightarrow \mu\mu\gamma$	$\mu\mu$	EB, high R_9	9.18	0.47	0.33
	$\mu\mu$	EB, low R_9	5.17	0.27	0.18
	$\mu\mu$	EE	3.80	0.20	0.25
	$\mu\mu$	Dijet tag	0.45	0.39	0.01

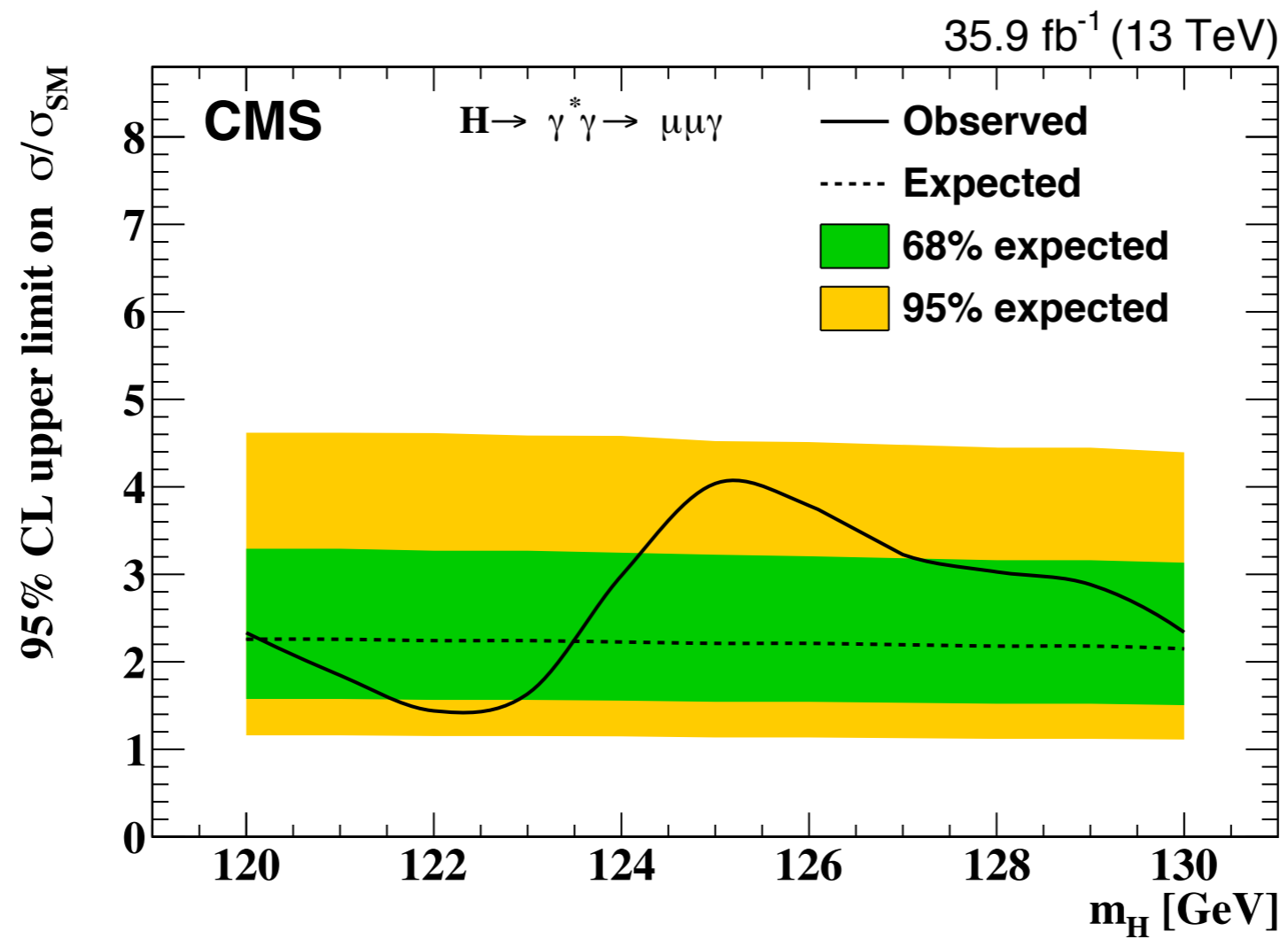
13TeV, L = 35.9/fb

the resulting acceptance times efficiency is ~26%

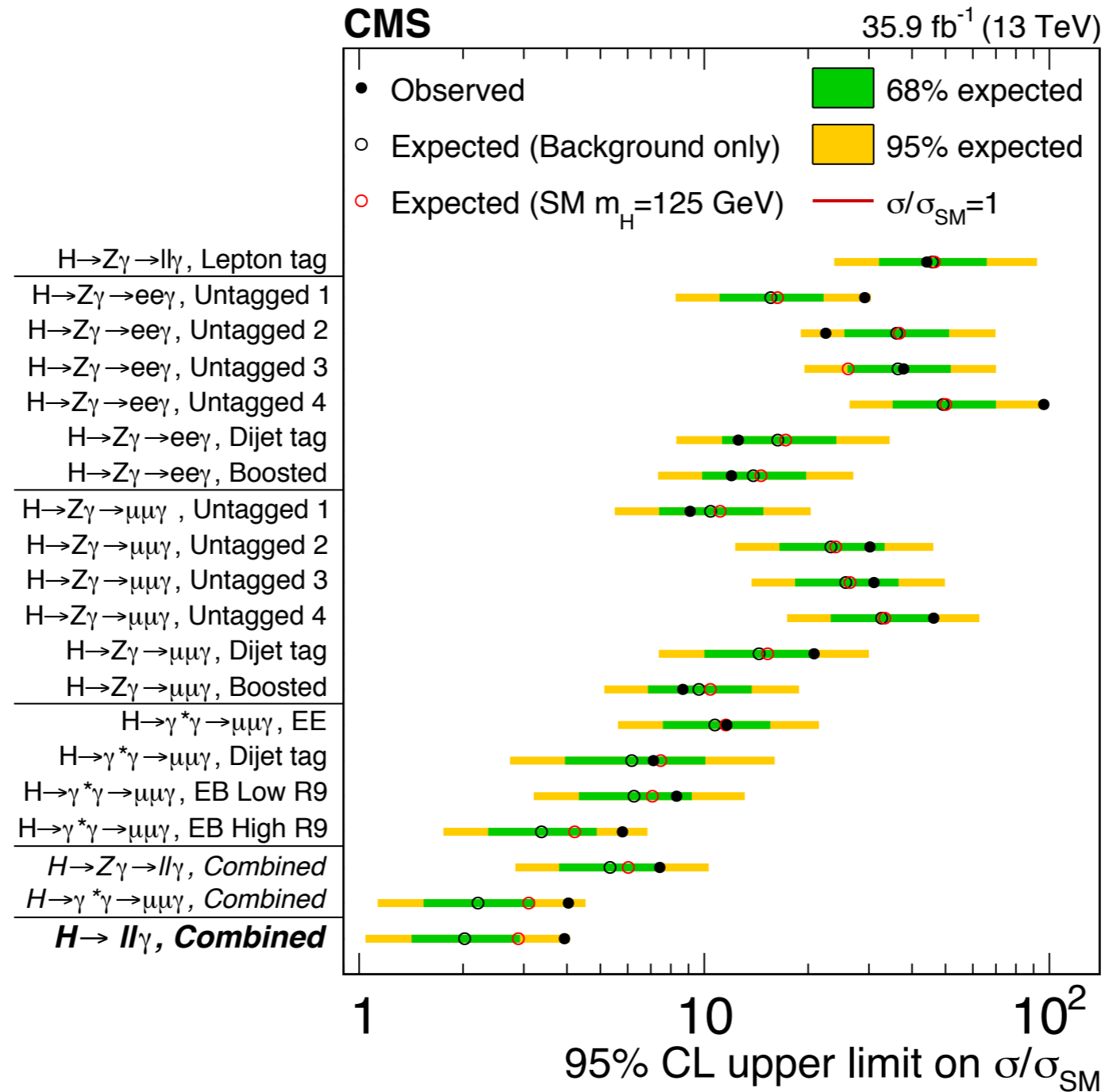
Background model fits



Exclusion limit (1/2)



Exclusion limit (2/2)



Summary

- In CMS, we have looked into the Dalitz Higgs decay since Run-1
- The observed (expected) limit is at $\sim 4(\sim 2)$ with 2016 data
- The limit on $\sigma/\sigma_{\text{SM}}$ may approach 1 or lower with full Run-2 dataset
- Stay tuned!