39. Search for $H \to \mu^+\mu^-$

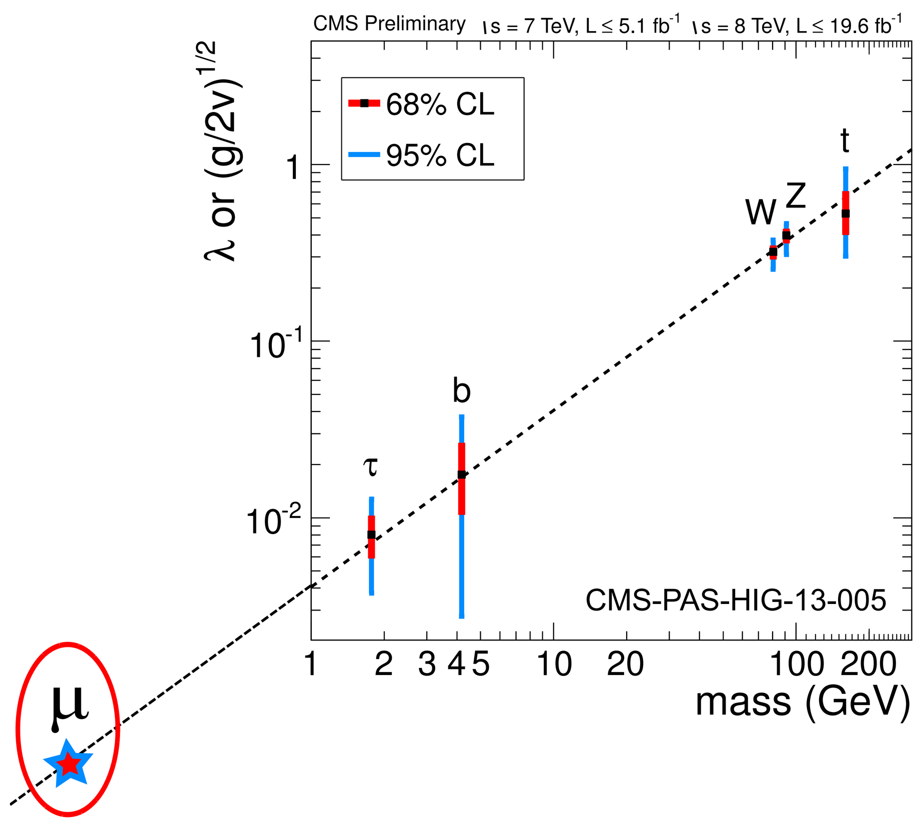
Justin Hugon

On Behalf of the CMS Collaboration

UF UNIVERSITY of FLORIDA

Why Search for $H \to \mu^+\mu^-$?

- **Smallest Higgs Coupling Directly Observable at LHC**



- Probe 2nd Generation Fermion Coupling
- Precisely Predicted in SM
- Enhanced in Some New Physics Models
- **Very Clean Final State**
  - **Narrow Peak on Smoothly Falling Background**

Search Overview

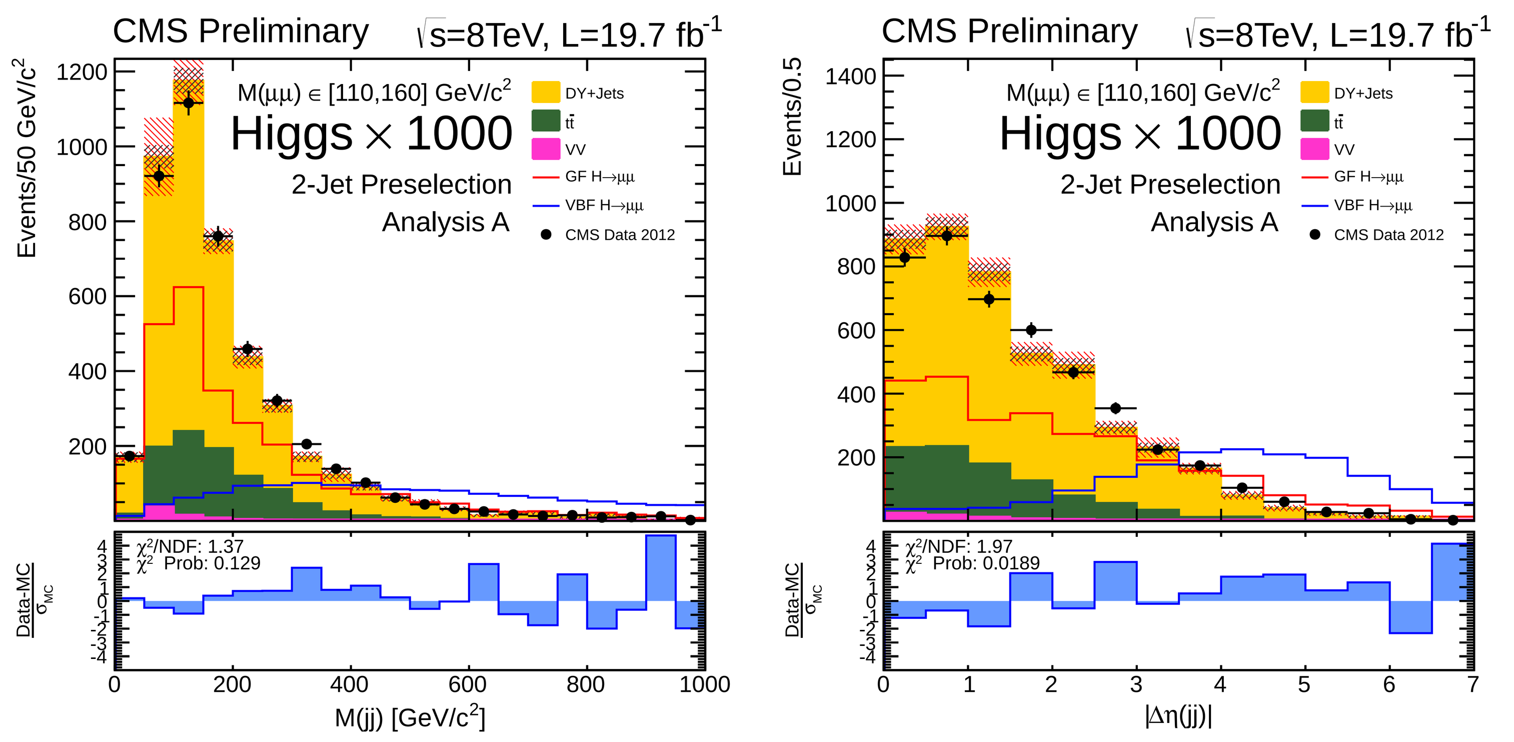
- Analyze CMS Data:
  - 5.0 ± 0.1 fb^{-1}at 7 TeV from 2011
  - 19.7 ± 0.5 fb^{-1}at 8 TeV from 2012
- Trigger on Single Isolated Muon: $p_T > 24$ GeV/c, $|\eta| < 2.1$
- Require 2 Opposite Sign, Isolated Muons
  - $p_T > 25$ GeV/c, $|\eta| < 2.1$
- Divide Events into 2 Categories:
  - 0 or 1 Jet: Large Acceptance for Gluon Fusion (GF) Higgs Production
  - 2 Jet: Larger S/B for Vector Boson Fusion (VBF) Higgs Production
- Further Sub-categorize to Increase Sensitivity
- Perform Shape Fit in Each Subcategory
  - Signal Yield & Shape Estimated from Simulation Corrected to Match Data
  - Background Yield & Shape Estimated from Fit to Data

0,1-Jet Subcategories

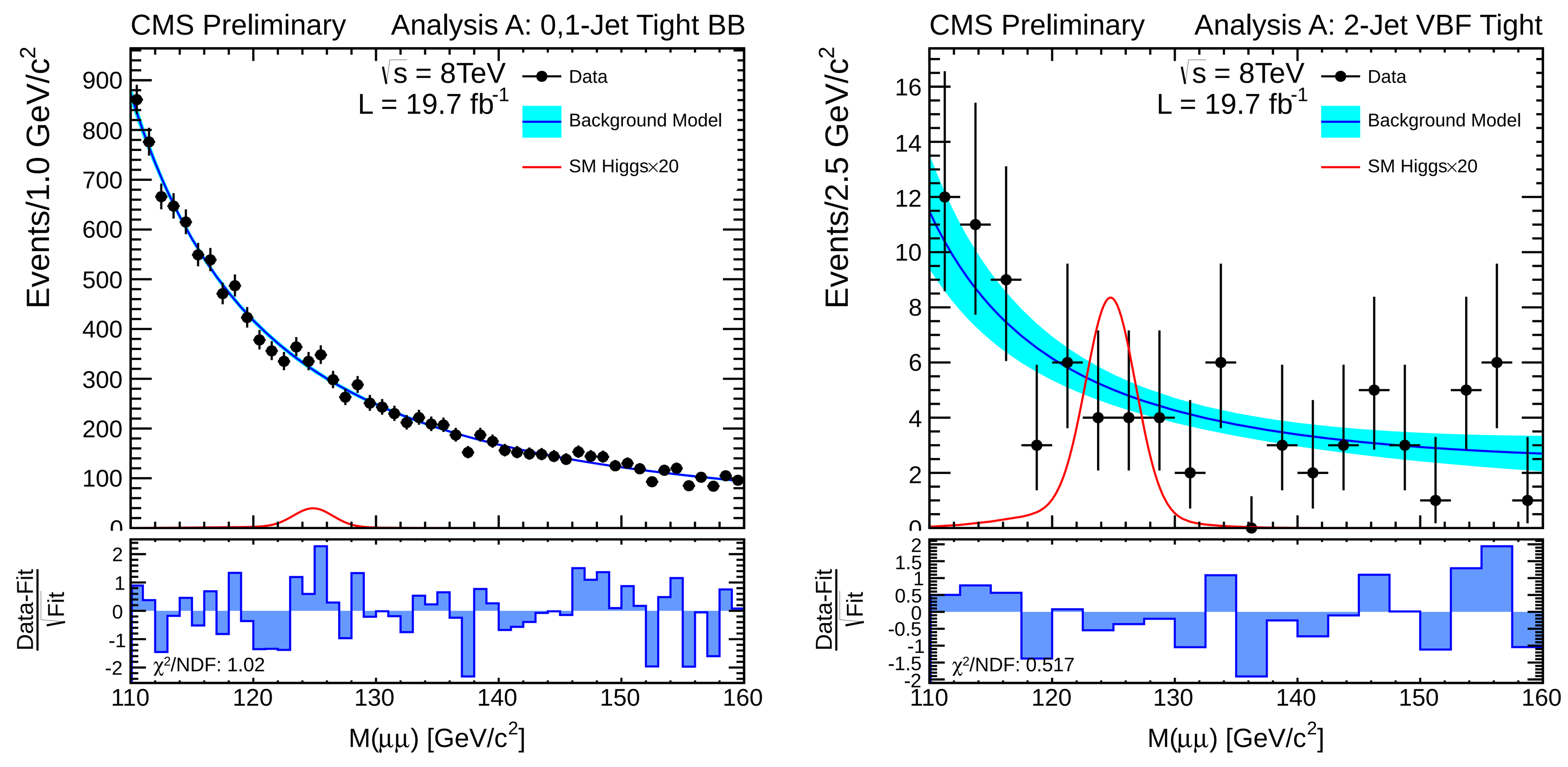
- First, Split by $p_T(\mu\mu)$
  - 0,1-Jet Tight: $p_T(\mu\mu) \geq 10$ GeV/c
  - 0,1-Jet Loose: $p_T(\mu\mu) < 10$ GeV/c
  - Reduced Drell-Yan Background in 0,1-Jet Tight
- Sub-categorize by Muon $|\eta|$, Which is Related to $\mathrm{M}(\mu\mu)$ Resolution
  - Central Dimuons Have Better Mass Resolution
  - Signal Peak FWHM at $m_H = 125$ GeV/c^2: 3.8-5.9 GeV/c^2

2-Jet Subcategories

- VBF Higgs Production Mode Enhanced in 2-Jet Category
- VBF Tight Sub-Category:
  - M(jj)> 650 GeV/c^2
  - $|\Delta\eta(\mathrm{jj})| > 3.5$
- GF Tight Sub-Category:
  - M(jj)> 250 GeV/c^2
  - $p_T(\mu\mu) > 50$ GeV/c^2
- Loose: All Remaining Events



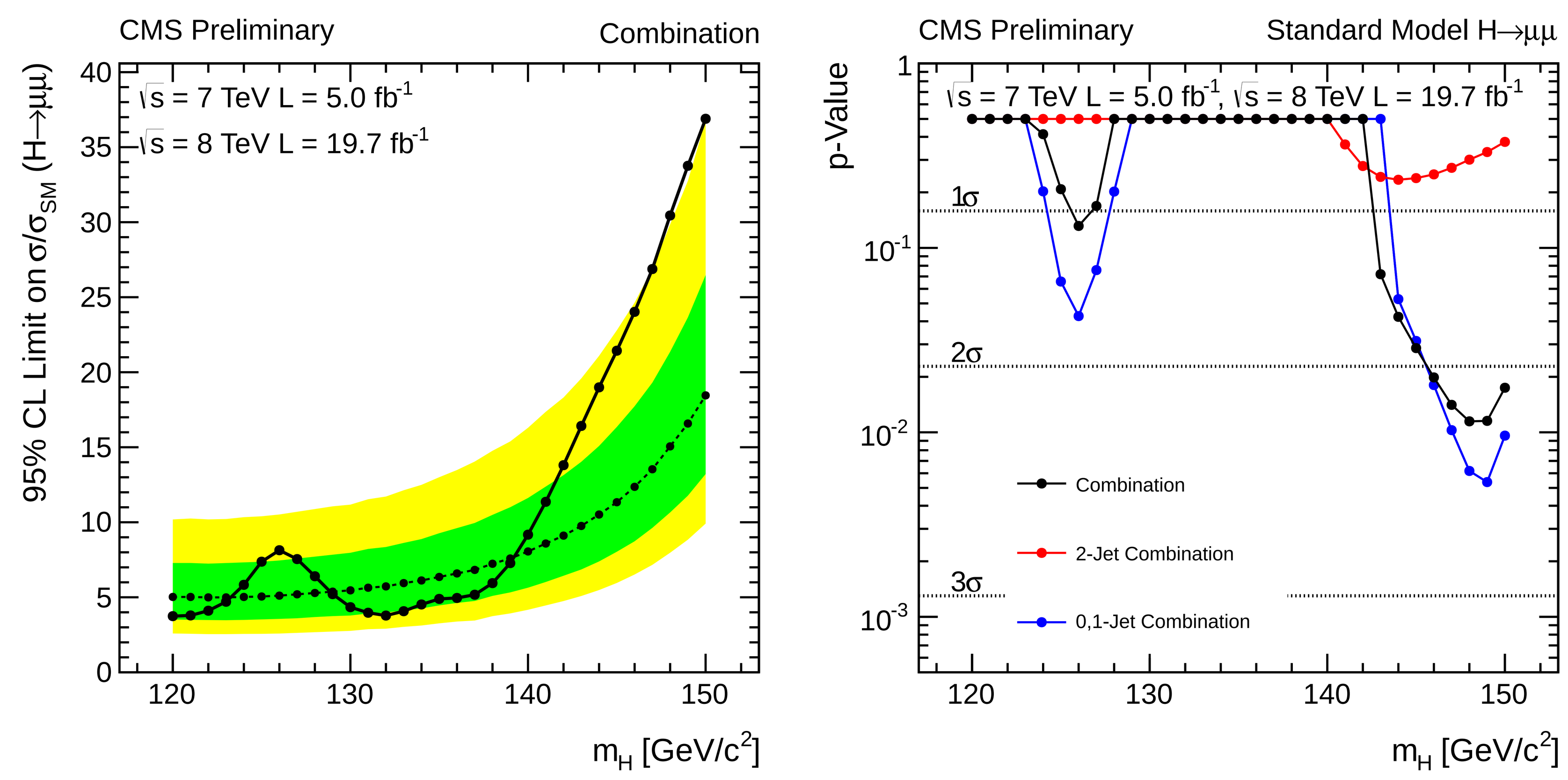
Dimuon Mass Distributions



Signal PDF: Gaussian + Gaussian; Background PDF: $\frac{\exp(p_1 m_{\mu\mu})}{(m_{\mu\mu}-p_2)^2}$

Results

- **95% CL$_s$ Upper Limits for $\mathbf{m_H = 125}$ GeV/c^2**:
  - **Expected Limit: $5.1^{+2.3}_{-1.5}\times$SM**
  - **Observed Limit: $7.4\times$SM**
- **Best Fit $\sigma/\sigma_{\mathrm{SM}} = 2.9^{+2.8}_{-2.7}$** for CMS Higgs Mass Estimate 125.7 GeV/c^2 (CMS-PAS-HIG-13-005)



- 1σ Excess Observed Near 125 GeV/c^2
- Maximum Local Significance: 2.3σ
- Global Significance: 0.8σ
- **No Significant Excess Found**

Projections to $\sqrt{s} = 14$ TeV – arXiv:1307.7135

- Method:
  - Use 8 TeV Analysis & Samples
  - Rescale Cross-Sections to $\sqrt{s} = 14$ TeV
- Systematics Scenarios:
  - Scenario 1: All Uncertainties Same as Current Analysis
  - Scenario 2: Experimental Uncertainties Scale $1/\sqrt{\mathcal{L}}$, Theoretical Uncertainties Cut in Half
- **Exclude SM with 175^{+150}_{-75} fb^{-1}**

	300 fb^{-1}	3000 fb^{-1}
Significance	2.5σ	7.9σ
Error on σ/σ_{SM} Scenario 1	42%	20%
Error on σ/σ_{SM} Scenario 2	40%	14%
Error on Muon Coupling Scenario 1	23%	8%
Error on Muon Coupling Scenario 2	23%	7.5%

Conclusions

- Search Performed for Higgs Decays to $\mu^+\mu^-$
- Increase Sensitivity by Categorizing Events According to Production Mode, $p_T(\mu\mu)$, Muon $|\eta|$, and Di-jet Variables
- **Most Significant Excess Found $\sim 1\sigma$**
- **95% CL$_s$ Limit on $\sigma/\sigma_{\mathrm{SM}}$ for $\mathbf{m_H = 125}$ GeV/c^2:**
  - **Expected: $5.1^{+2.3}_{-1.5}\times$SM**
  - **Observed: $7.4\times$SM**
- **Best Fit $\sigma/\sigma_{\mathrm{SM}} = 2.9^{+2.8}_{-2.7}$ for $\mathbf{m_H = 125.7}$ GeV/c^2**

justin.hugon@cern.ch