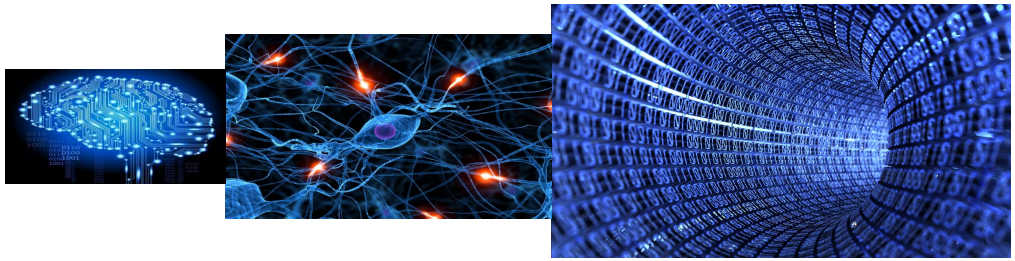
Search for Higgs to Dimuons

Sergei V. Gleyzer on behalf of CMS Collaboration



DPF Meeting

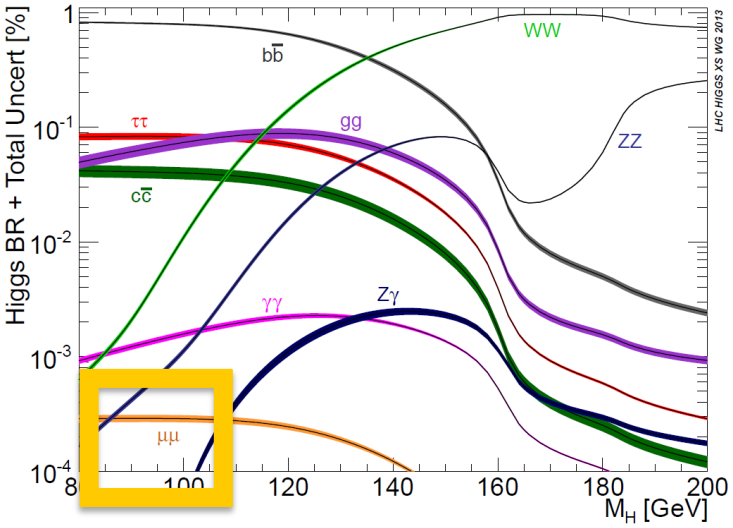
July 31, 2017

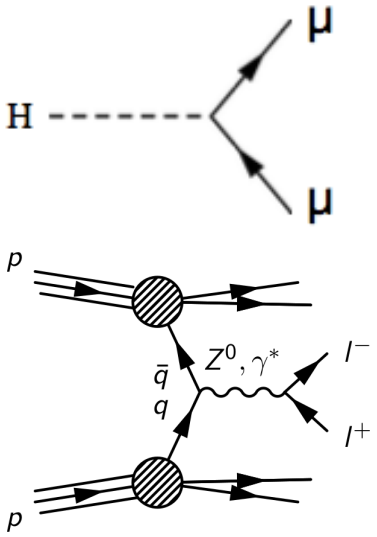
Outline

- Run 1 $H^0 \rightarrow \mu^+\mu^-$ Analysis
- Run 2 $H^0 \rightarrow \mu^+\mu^-$ Analysis improvements

Motivation

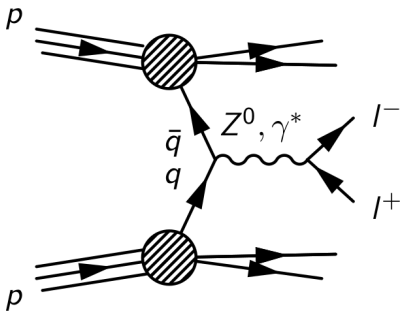
- **Higgs couples to muons**
  - **Precise mass resolution**
  - **Test of direct coupling to fermions**

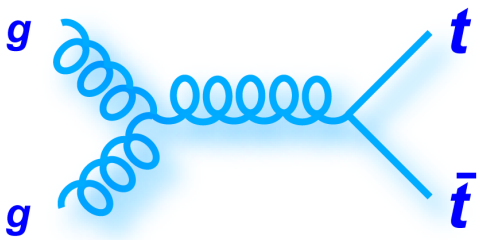




Run 1

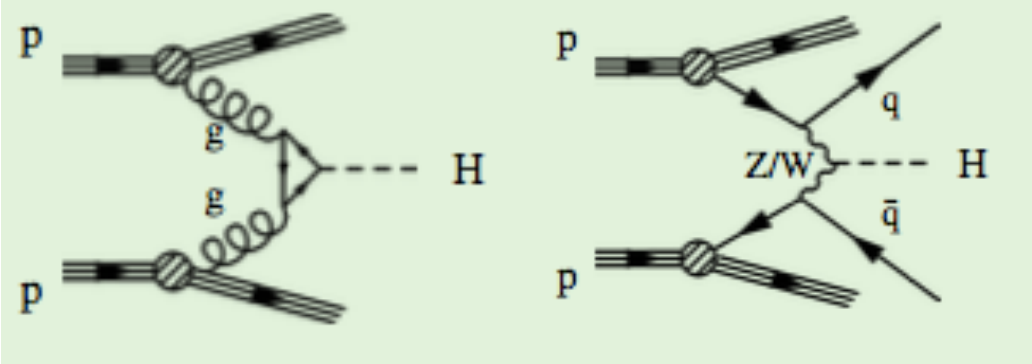
- 5 fb^{-1} at 7 TeV + 19.7 fb^{-1} at 8 TeV
- Search for a narrow peak in the di-muon spectrum
  - Main backgrounds: Drell-Yan and ttbar





Run 1

- **Signal production: ggH and qqH**



- **Separate by jet multiplicity into exclusive categories to maximize sensitivity**

Object Selection

- **Trigger**
  - **At least one isolated muon**
    - $p_T > 24$ GeV
    - $|\eta| \leq 2.1$
- **Offline**
  - **"Triggered" muon $p_T > 25$ GeV**
  - **Sub-leading $p_T > 15$ GeV**
  - **Tight muon selection**
  - **Jet pt > 30 GeV, $|\eta| < 4.7$**

Run 1 Categories

- VBF Tight
  - $p_T^J(1,2) > 40, 30$ GeV
  - Mjj > 650 GeV
  - bjet veto
  - $\Delta\eta(1,2) > 3.5$
- GF Tight
  - $p_T^J(1,2) > 40, 30$ GeV
  - Mjj > 250 GeV
  - bjet veto
  - $p_{T\mu\mu} > 50$ GeV
- Muon Categories:
  - $|\eta| < 0.8$ (B); <1.6 (O) <2.4 (E)
- 2Jet Loose
  - $p_T^J(1,2) > 40, 30$ GeV
  - bjet veto
- 0,1 Jet Tight
  - $p_{T\mu\mu} > 25$ GeV
  - bjet veto
- 0,1 Jet Loose
  - Fail all others

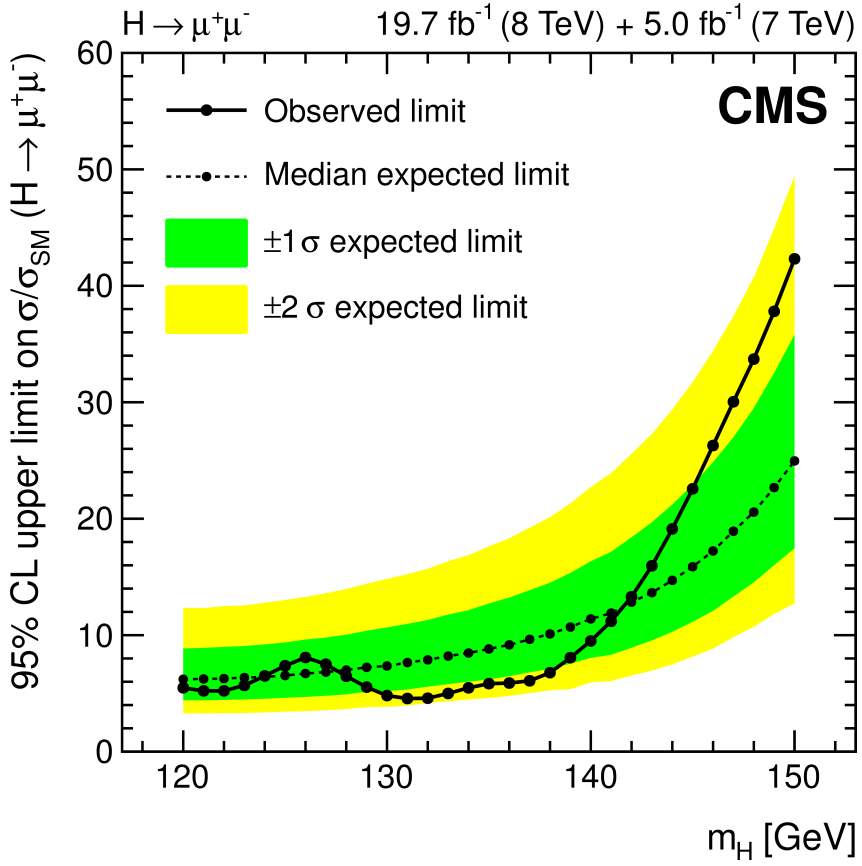
Systematics

Source	GF [%]	VBF [%]
Higher-order corrections [18]	1–25	1–7
PDF [18]	11	5
PS/UE	6–60	2–15
$\mathcal{B}$ (H $\to \mu^+\mu^-$) [18]	6	6
Integrated luminosity [39, 40]	2.2–2.6	2.2–2.6
MC statistics	1–8	1–8
Muon efficiency	1.6	1.6
Pileup	< 1–5	< 1–2
Jet energy resolution	1–3	1–2
Jet energy scale	1–8	2–6
Pileup jet rejection	1–4	1–4

Link to paper

Results

- **Expected and observed limits**



7.4 x SM
(6.5 + 2.8 -1.9)

Run 2 Analysis

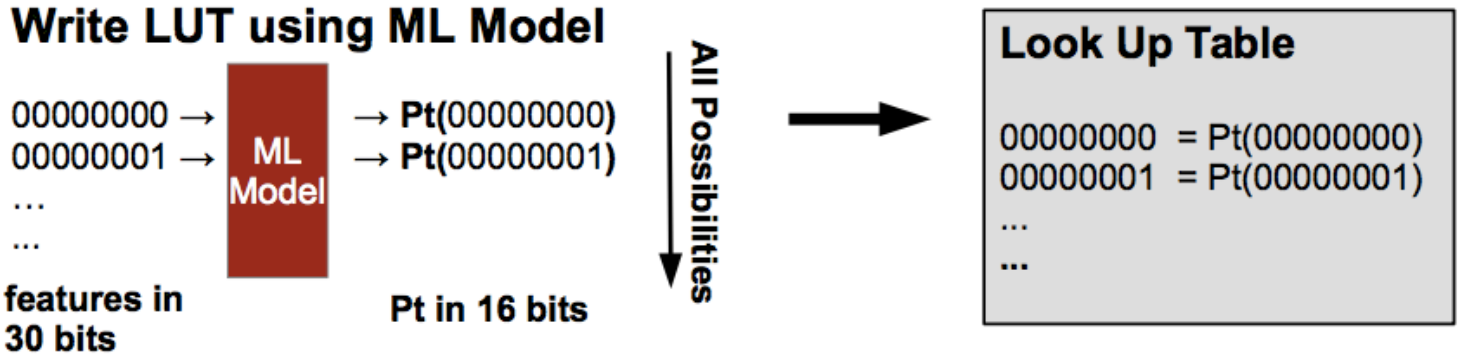
35.9 fb^{-1} at 13 TeV

- **Trigger**
  - **Isolated muon p_T > 24 GeV**
- **Offline**
  - **2 opposite sign muons**
  - **Triggered muon p_T > 26 GeV**
  - **$|\eta| < 2.4$**
  - **p_T > 10GeV**
  - **Jets p_T > 30GeV $|\eta| < 4.7$**

Analysis Improvements

Muon Trigger

- Improved muon trigger
  - Machine learning algorithm trained to better approximate muon momenta
  - Boosted regression trees encoded in lookup table in FPGA



Background Model

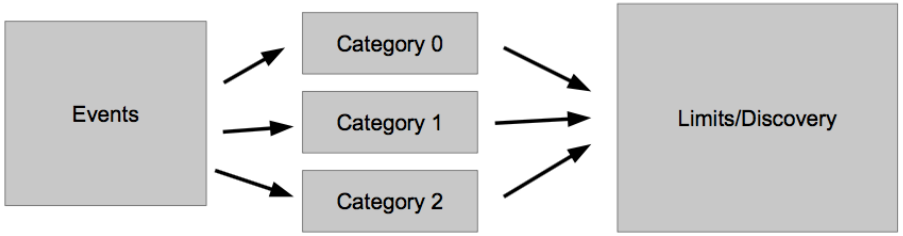
- **FEWZ NNLO generator**
  - **better model the shape of the Drell-Yan background**
  - **Reduce the systematic uncertainty**
    - **Better agreement with the data**

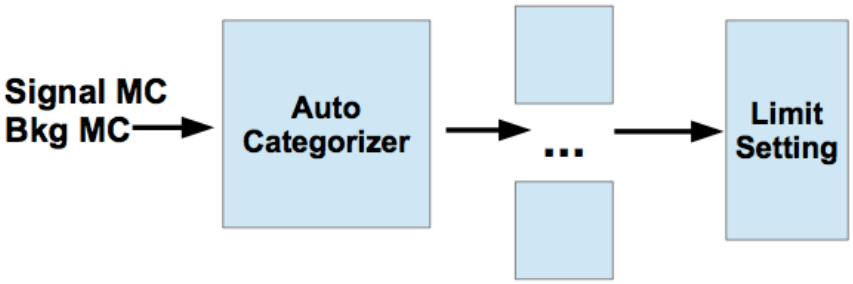
FEWZ 2.0: A code for hadronic Z production at next-to-next-to-leading order

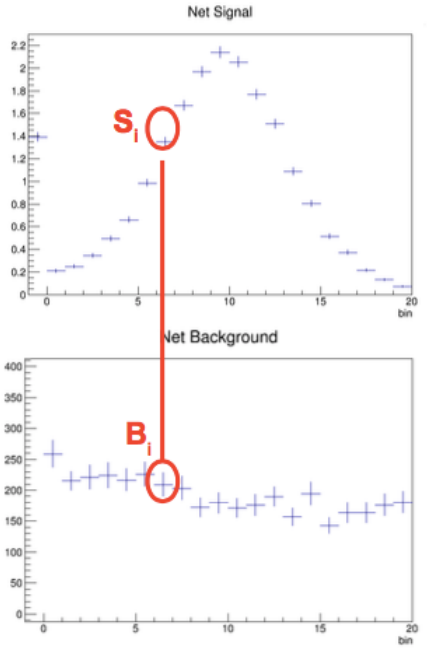
Ryan Gavin[1], Ye Li[1], Frank Petriello[2,3], and Seth Quackenbush[2]

Categorizer

- **Use machine learning to find better categories**
  - **~10% improvement in expected limits**

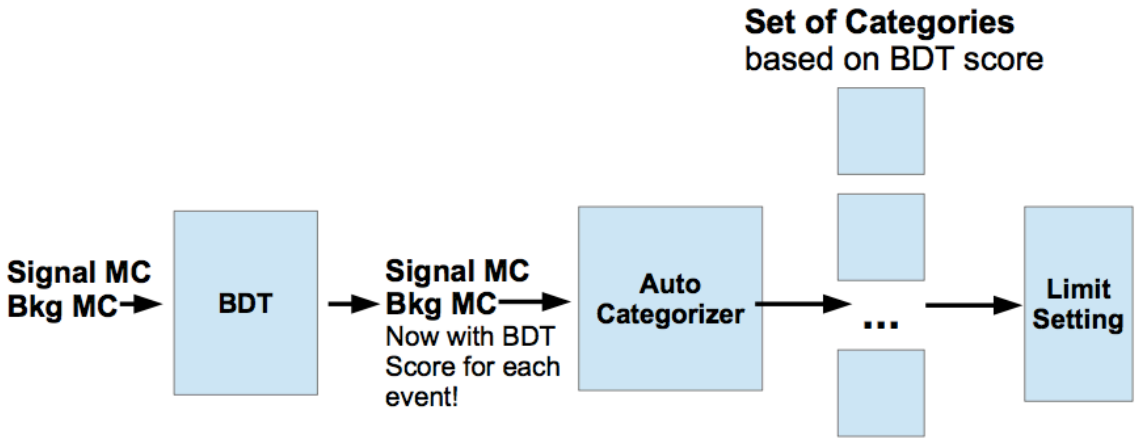






ML+ Categorizer

- Use machine learning upstream for event selection
- Plus categorization
  - ~25% improvement in expected limits



Results

- To be released in ~month

CMS PAS HIG-17-019

DRAFT

CMS Physics Analysis Summary

The content of this note is intended for CMS internal use and distribution only

2017/05/23
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Archive Date: 2017/05/22
Archive Tag: trunk

Stay Tuned

Search for standard model Higgs boson production in the $\mu^+\mu^-$ final state at CMS in pp collisions at $\sqrt{s} = 13$ TeV

Thank You

Di-muon event