

Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

Search for dimuon Higgs decays in the SM

Rowina Caspary, Adrian Perieanu,
Oliver Rieger, Peter Schleper

Universität Hamburg, Institut für Experimentalphysik



Bundesministerium
für Bildung
und Forschung

PAS HIG-17-019

Search for standard model Higgs production decaying into two muons in pp collisions at $\sqrt{s} = 13$ TeV

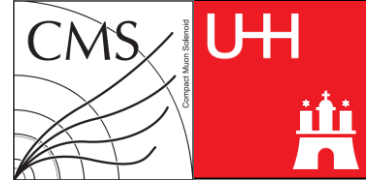
<http://cds.cern.ch/record/2292159>

- 1 | Higgs Physics at the LHC
- 2 | Analysis Concept
- 3 | Expected & Observed Limits
- 4 | Conclusion / Outlook



http://phdcomics.com/higgs/darkmatters2_06s.gif

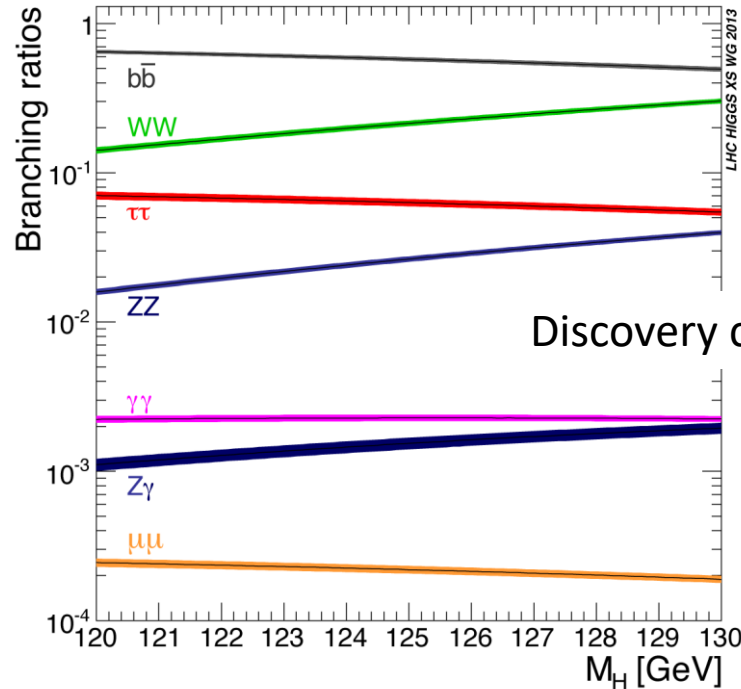
Higgs Physics at the LHC



Search for Higgs decays at CMS

- Higgs sector studied intensively in the last years
- Coupling to 3rd generation & gauge bosons
- no significant deviations from SM found

SM like coupling or new physics?!



$Zh(bb) | 3.8 \sigma$

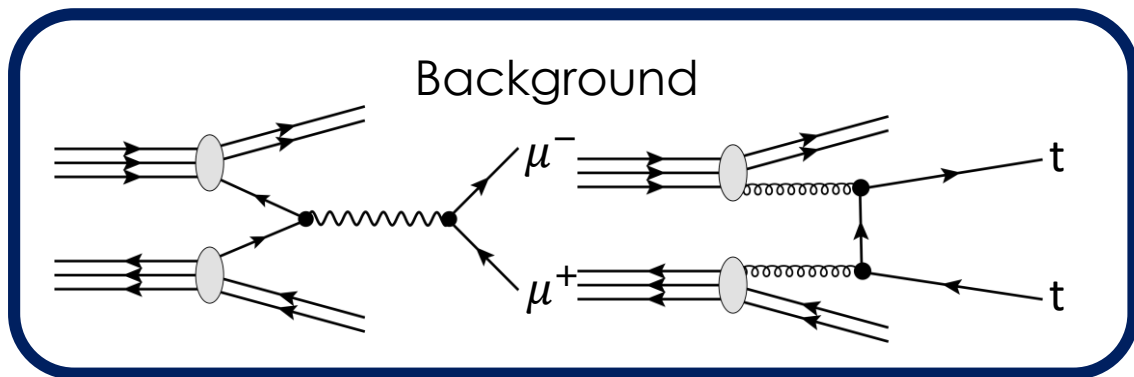
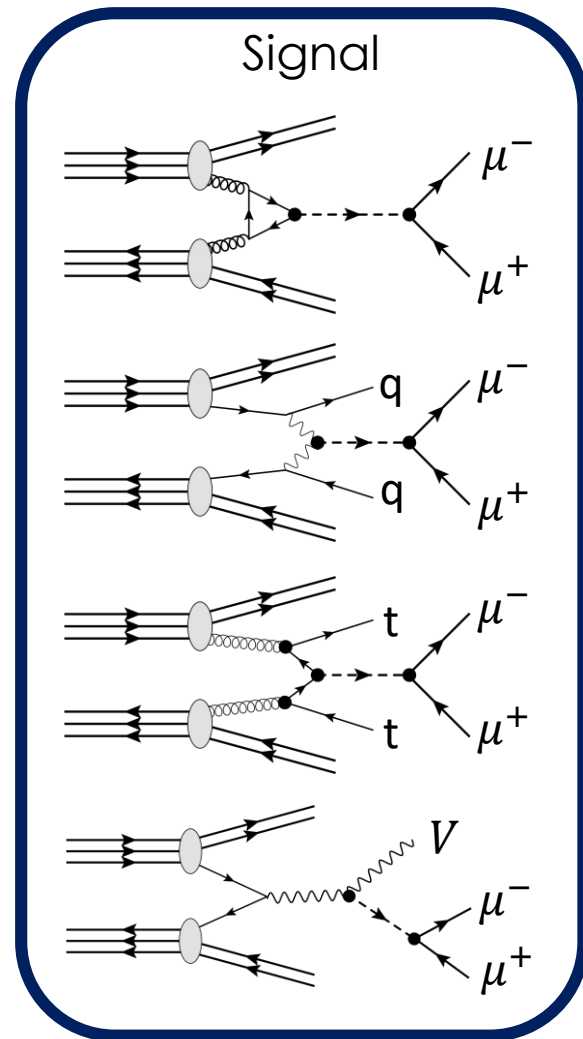
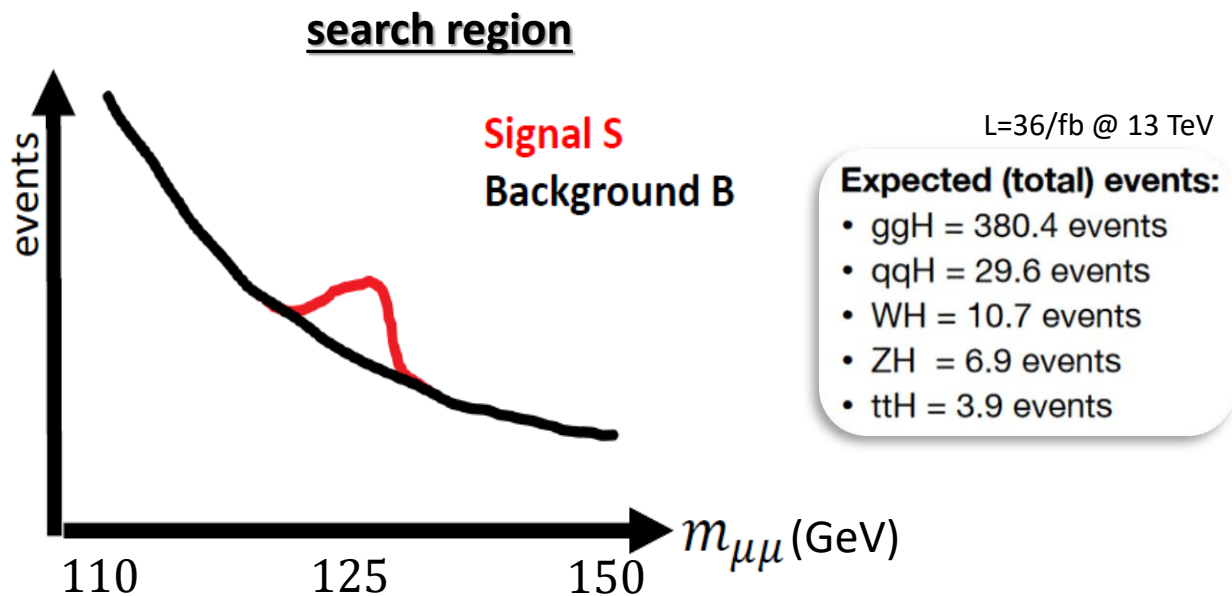
$h \rightarrow \tau\tau | 5.9 \sigma$

Discovery channels $4l$ & $\gamma\gamma$

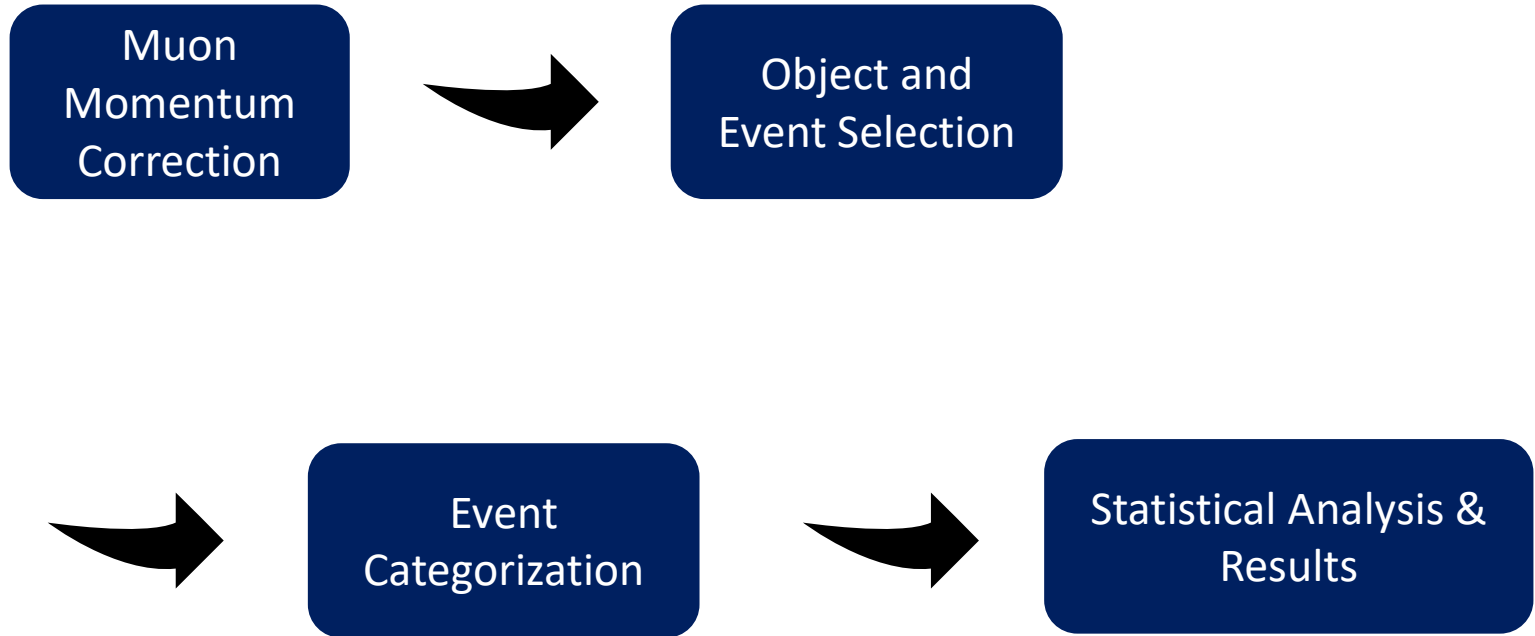
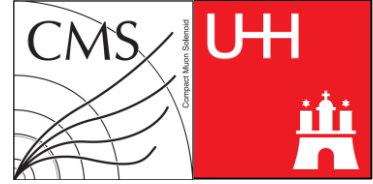
- test direct coupling to fermions
- confirm coupling of Higgs boson to 2nd gen

Higgs Physics at the LHC

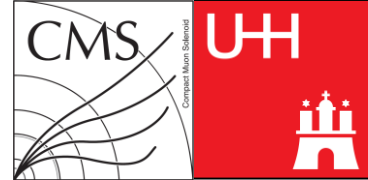
- very precise mass resolution of dimuon pair
- irreducible background from Drell Yan events



Analysis Concept



Muon Momentum Calibration



muon momentum is influenced by:

- detector misalignments
- reconstruction software
- uncertainties in the magnetic field
- differences between data/MC

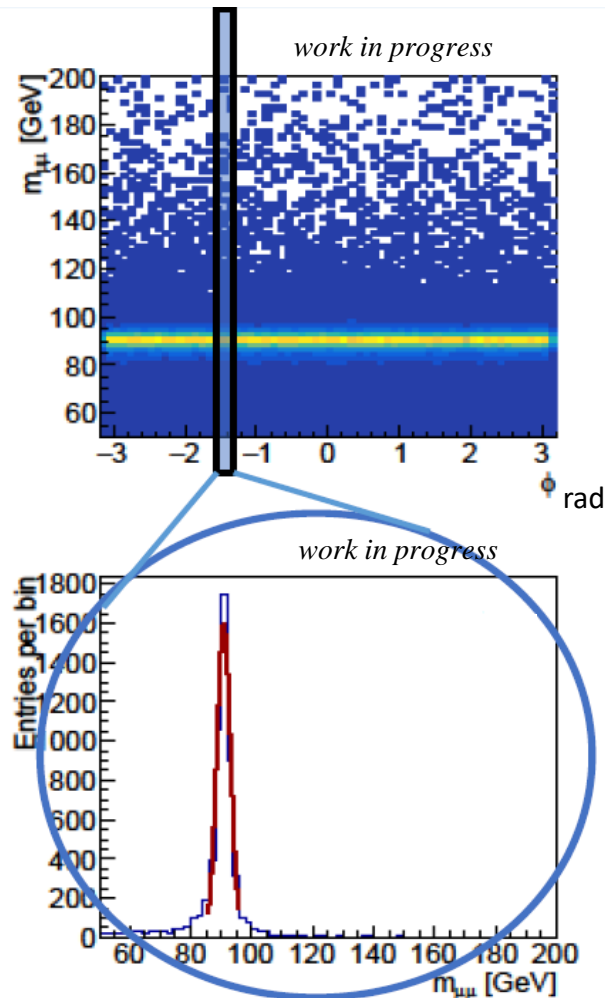
Correction method by Rochester University

References for the method :

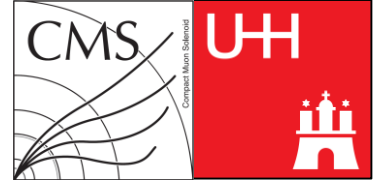
[EPJC V72, 10.2194 \(2012\) \(arXiv:1208.3710\[hep-ex\]\)](#)

test corrections:

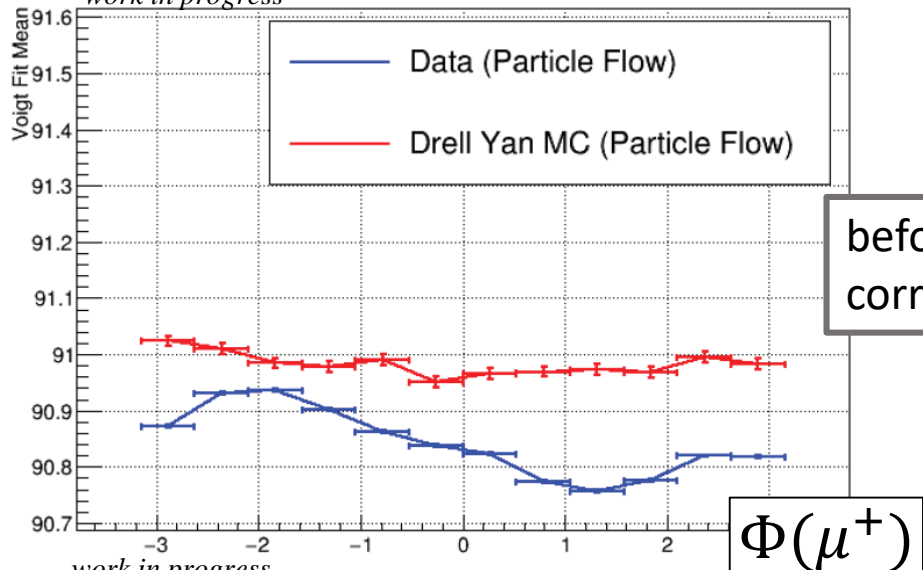
- select events in data: $Z \rightarrow \mu\mu$
- probe figure of merit Φ vs $m_{\mu\mu}$



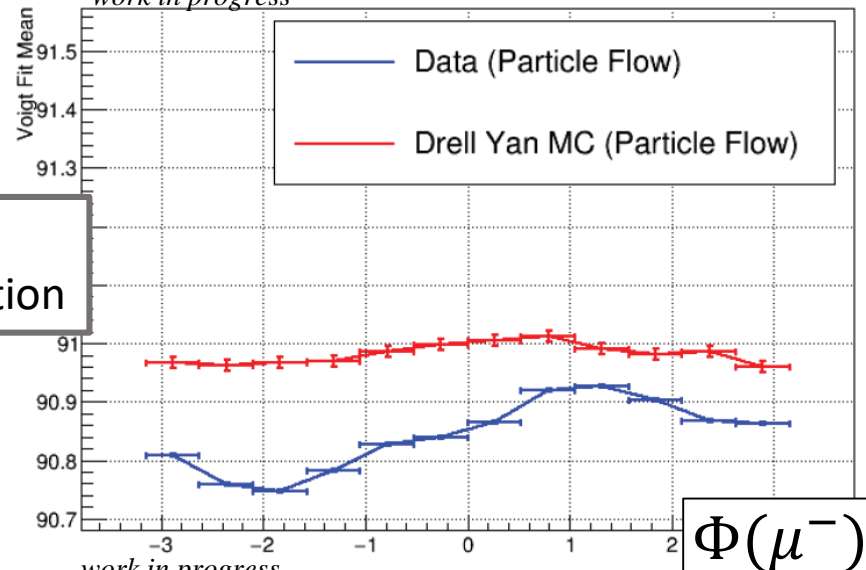
Muon Momentum Calibration



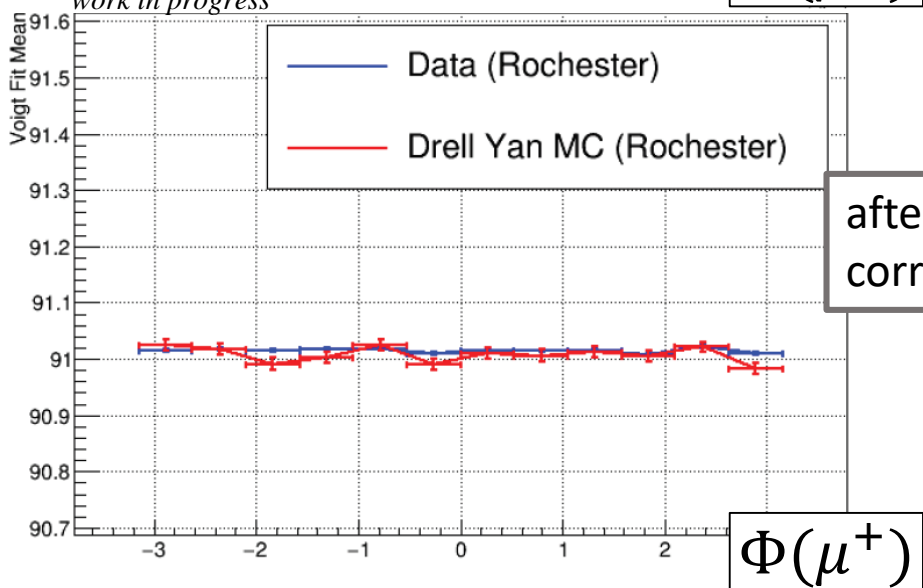
work in progress



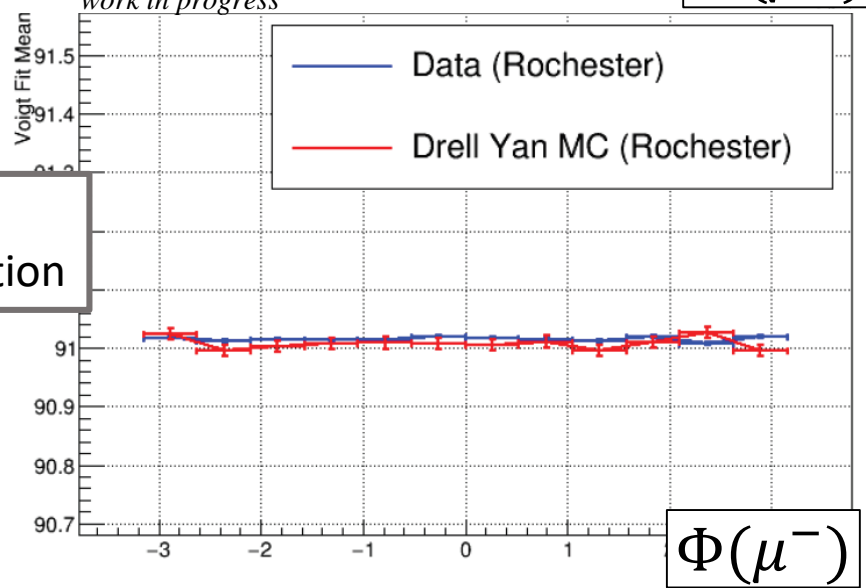
work in progress



work in progress



work in progress



Physics Objects Selection

Muons

- medium ID
- Loose Iso 0.25
- $\text{Eta} < 2.4$ & $\text{Pt} > 20$ GeV
- Global
- Trigger/ID/Iso SF

Jets

- Loose ID
- $\text{Eta} < 4.7$ & $\text{Pt} > 30$ GeV
- B-tag medium
(secondary vertex algorithm)
- Cleaned against muons ($R < 0.4$)

Event Selection and Corrections

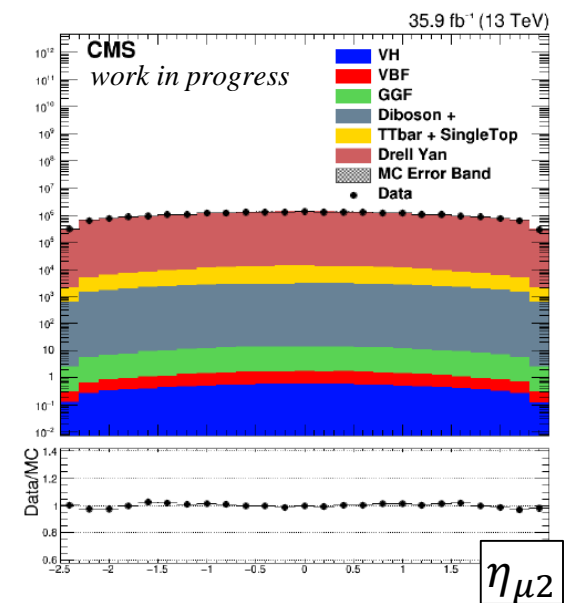
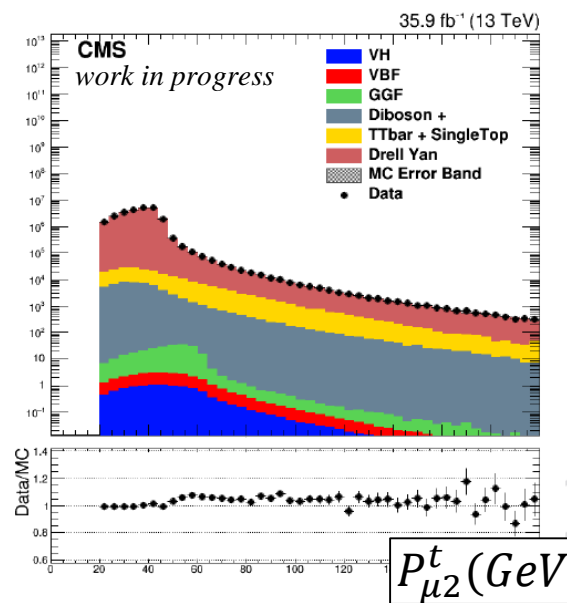
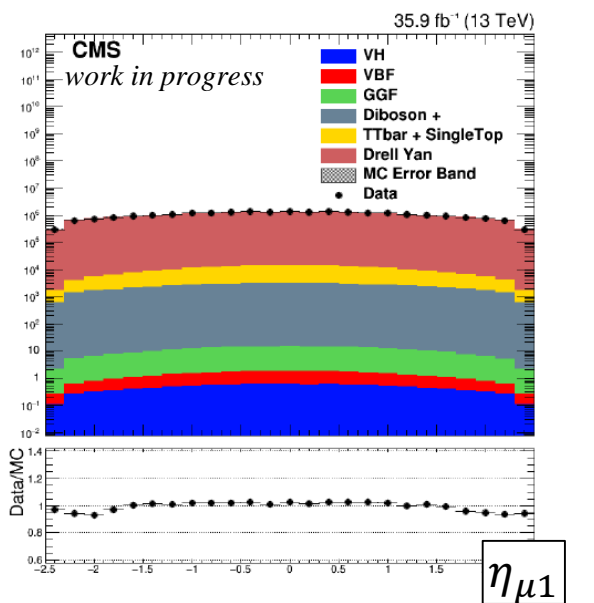
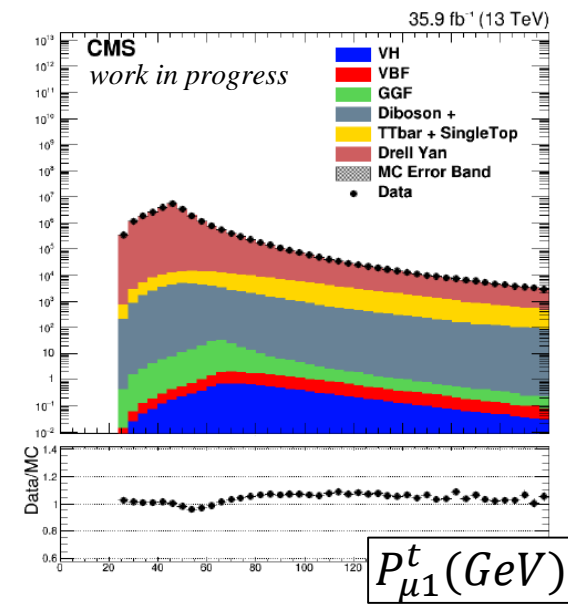
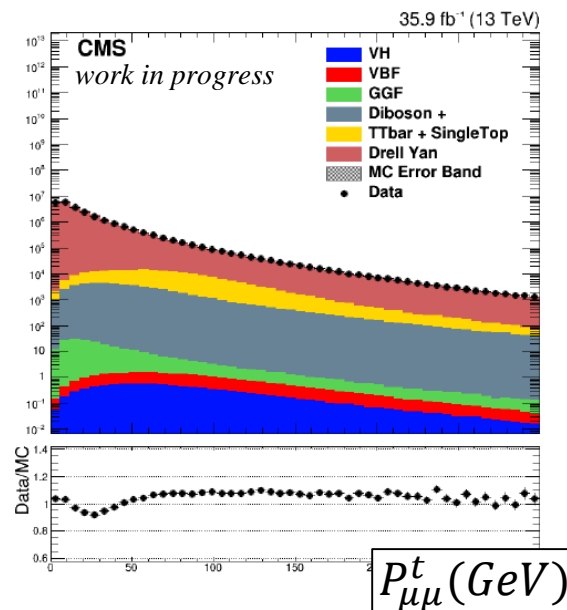
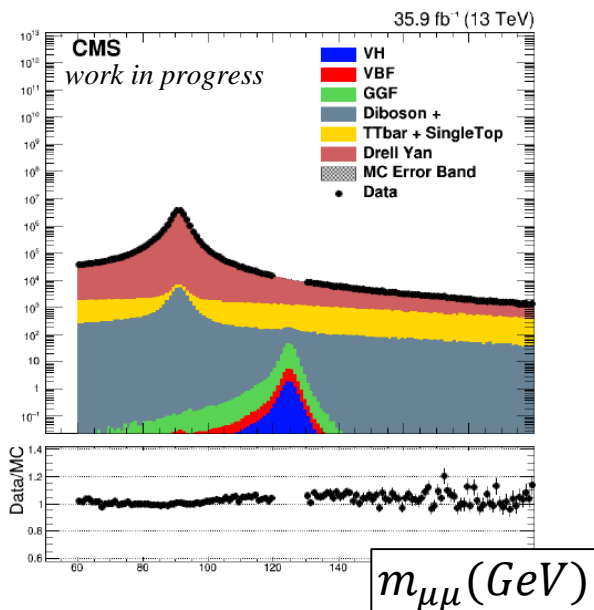
Preselection

- 2 opposite charged muons
- $\text{Pt} > 26, 20$ GeV
- Isolated single muon trigger ($\text{Pt} > 24$ GeV)
- Isolated track trigger ($\text{Pt} > 24$ GeV)
- Trigger matching

Corrections

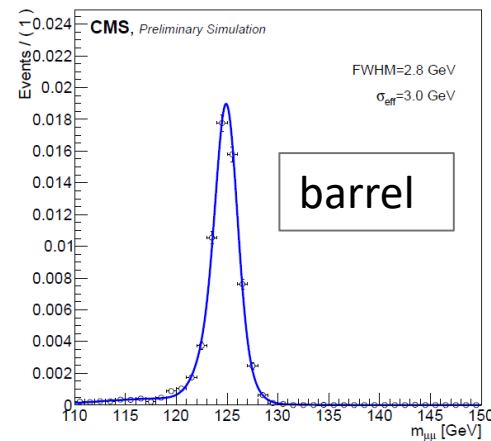
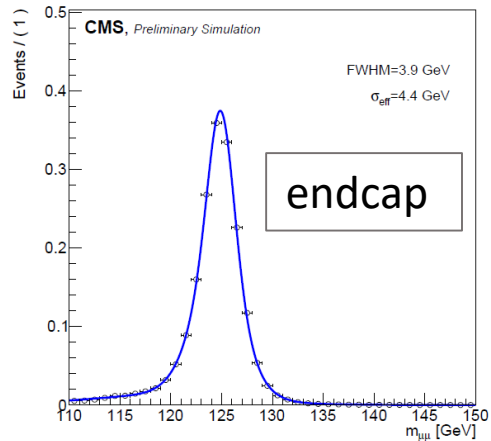
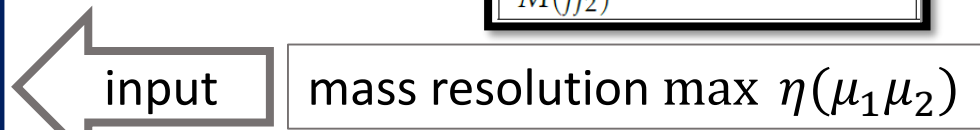
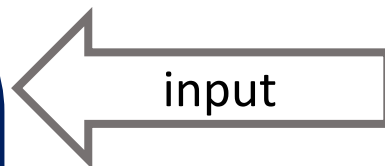
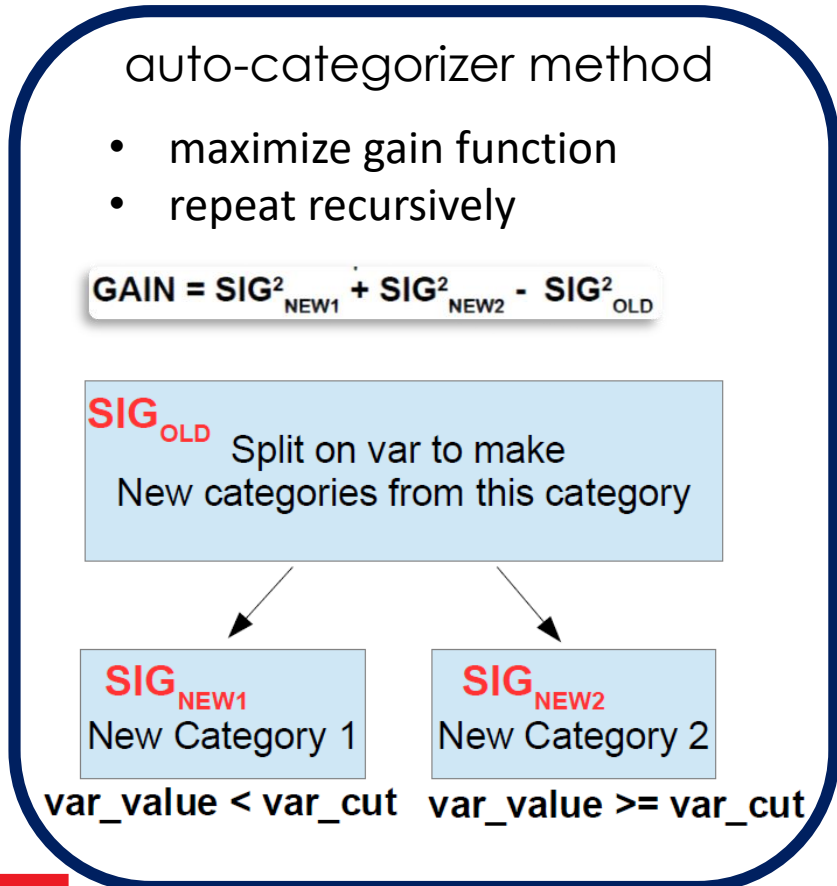
- PileUp reweighting
- Lepton & B-Tag SF from POG
- Muon Momentum Calibration

Object Validation

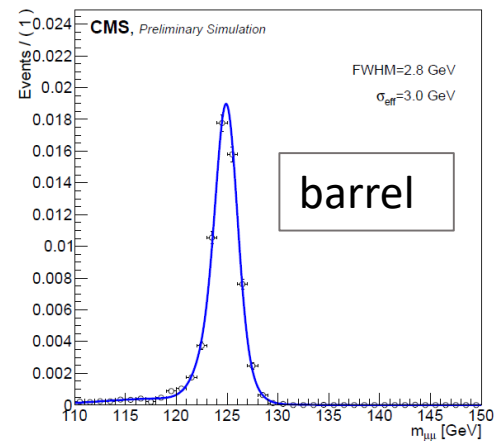
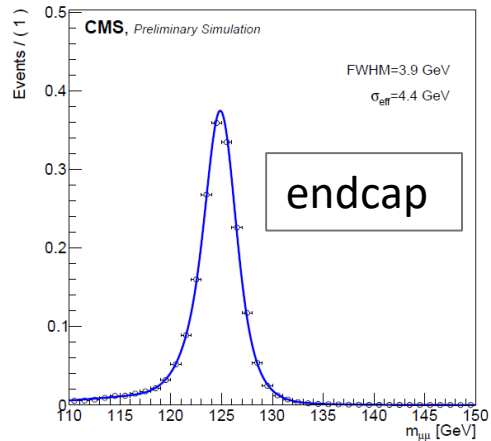
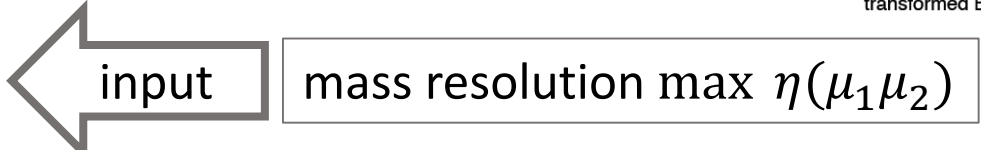
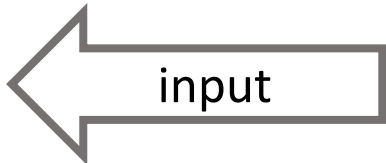
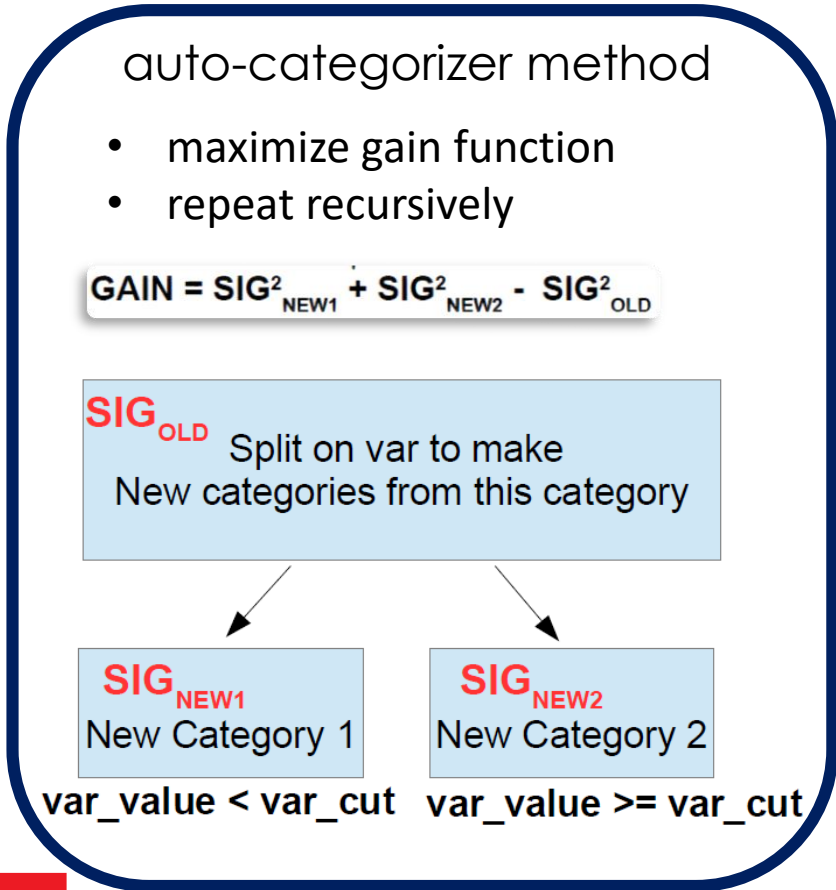
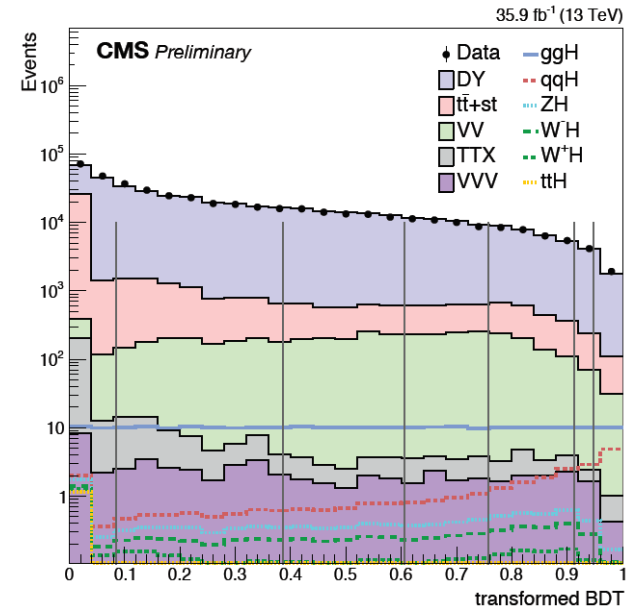


- small number of expected events
→ categorization
- auto-categorizer algorithm to enhance limits

Feature	BDT
Dimuon p_T	
Dimuon η	
$ \delta\phi(\mu\mu) $	
Number of medium b-tags	
$\eta(jet1)$	
E_T^{miss}	
Number of forward jets	
$ \delta\eta(jj_1) $	
Number of central jets	
$\eta(jet2)$	
$ \delta\eta(\mu\mu) $	
$M(jj_1)$	
$ \delta\eta(jj_2) $	
$M(jj_2)$	

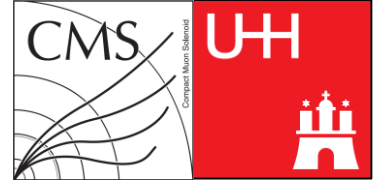


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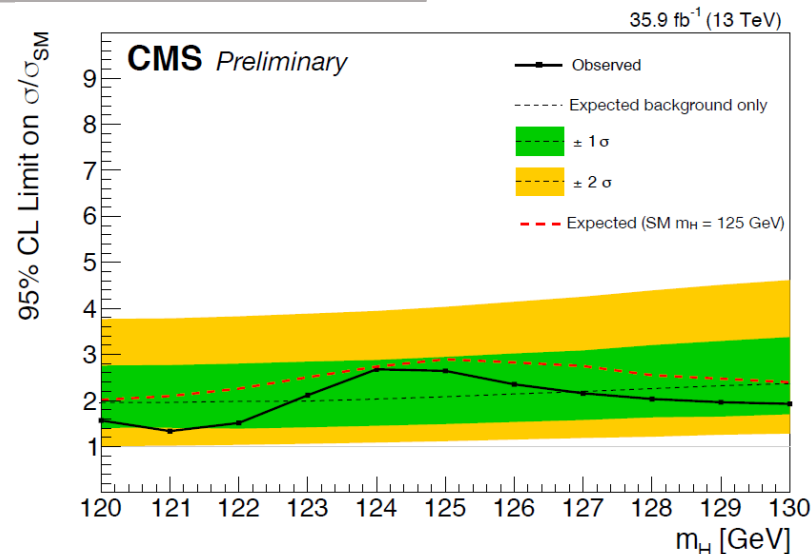
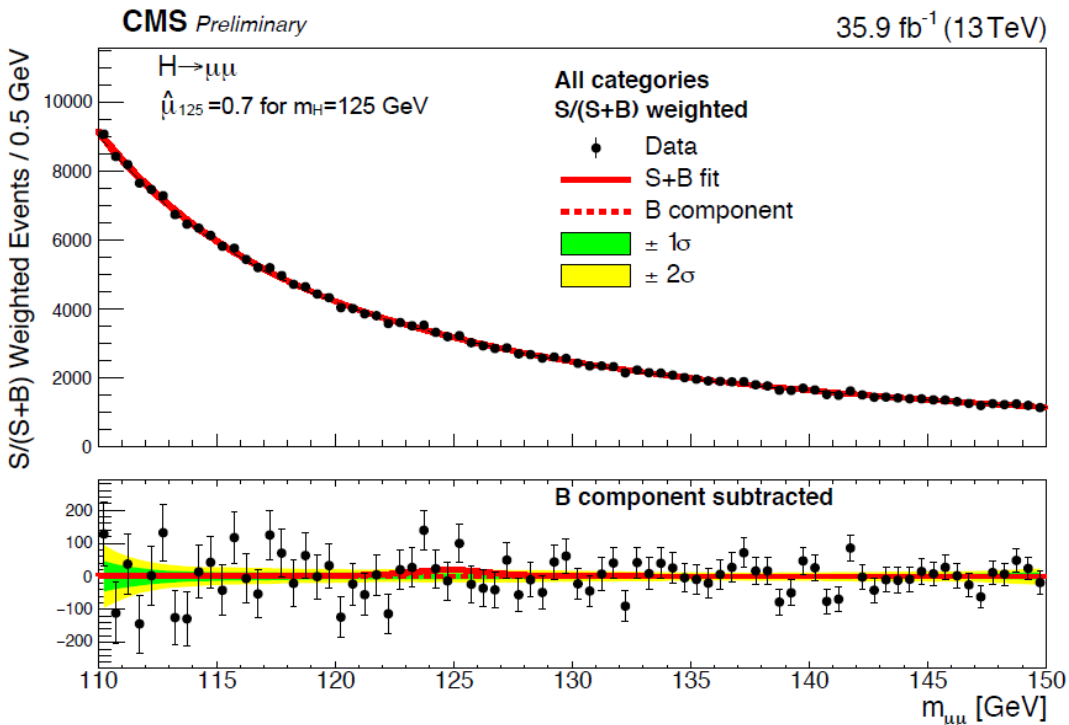


Event Categorization

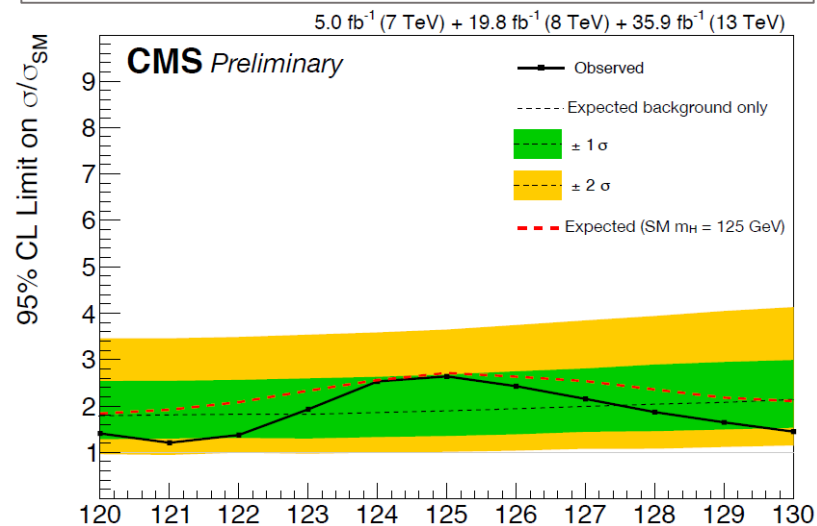
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Index	BDT quantile	Max. muon $ \eta $	ggH [%]	VBF [%]	WH [%]	ZH [%]	ttH [%]	S/\sqrt{B} @ FWHM
0	0 – 8%	$ \eta < 2.4$	4.9	1.3	3.3	6.3	31.9	0.12
1	8 – 39%	$1.9 < \eta < 2.4$	5.6	1.7	3.9	3.5	1.3	0.16
2	8 – 39%	$0.9 < \eta < 1.9$	10.3	2.8	6.5	6.4	5.2	0.29
3	8 – 39%	$ \eta < 0.9$	3.2	0.8	1.9	2.1	3.5	0.17
4	39 – 61%	$1.9 < \eta < 2.4$	2.9	1.7	2.7	2.7	0.3	0.14
5	39 – 61%	$0.9 < \eta < 1.9$	7.2	3.3	6.1	5.2	1.3	0.31
6	39 – 61%	$ \eta < 0.9$	3.6	1.1	2.6	2.2	0.9	0.26
7	61 – 76%	$1.9 < \eta < 2.4$	1.2	1.5	1.8	1.7	0.2	0.11
8	61 – 76%	$0.9 < \eta < 1.9$	4.8	3.6	4.5	4.4	0.7	0.29
9	61 – 76%	$ \eta < 0.9$	3.2	1.6	2.3	2.1	0.6	0.28
10	76 – 91%	$1.9 < \eta < 2.4$	1.2	3.1	2.2	2.1	0.2	0.14
11	76 – 91%	$0.9 < \eta < 1.9$	4.4	8.7	6.2	6.0	1.1	0.34
12	76 – 91%	$ \eta < 0.9$	3.1	4.0	3.8	3.6	0.9	0.34
13	91 – 95%	$ \eta < 2.4$	1.7	6.4	2.5	2.6	0.5	0.28
14	95 – 100%	$ \eta < 2.4$	2.0	19.4	1.5	1.4	0.7	0.47
overall			59.1	61.1	51.8	52.3	49.2	



Observed (expected) Limit $\mu < 2.68$ (2.08)



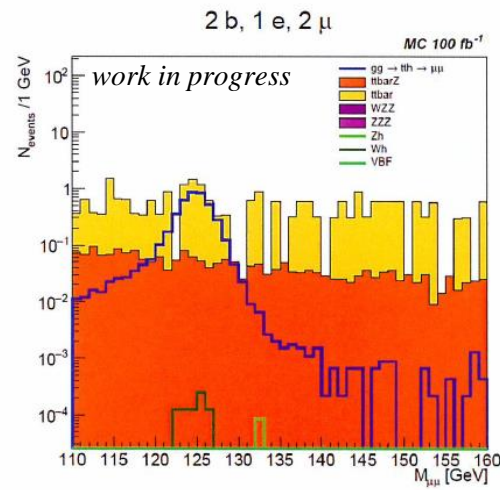
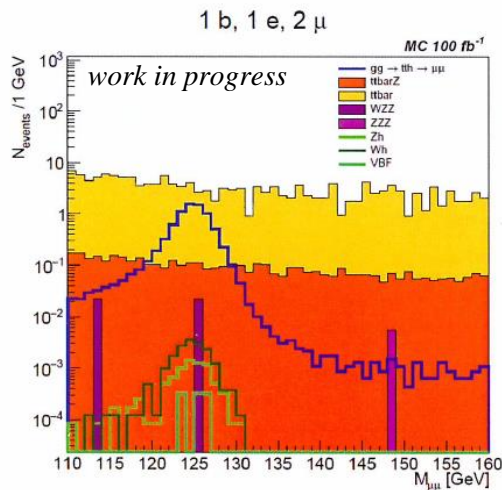
Combination | Observed (expected) Limit $\mu < 2.68$ (1.89) → 0.98σ

- no excess observed

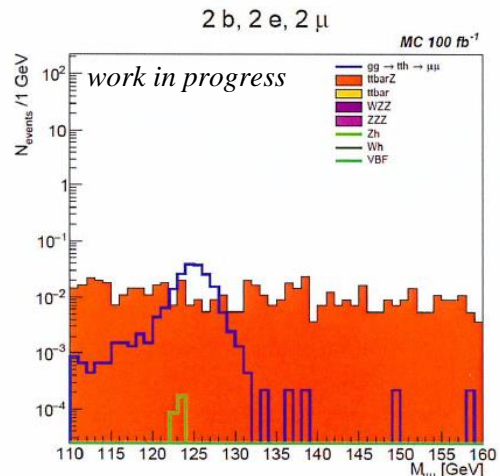
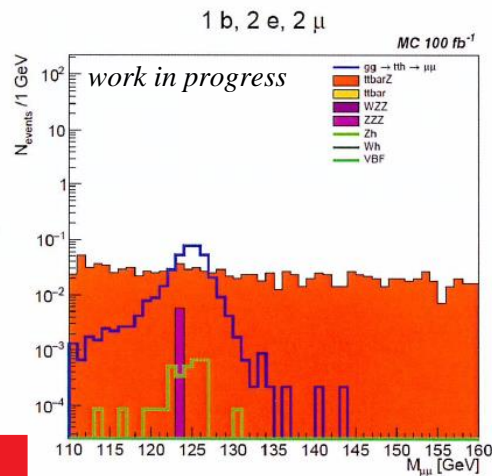
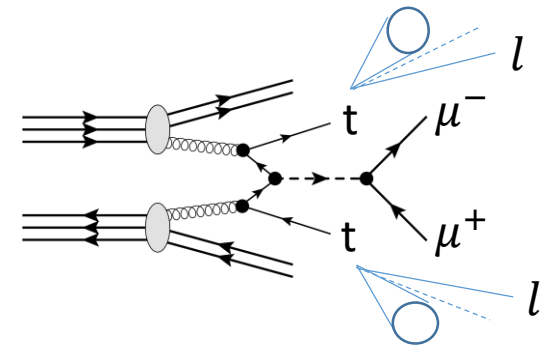
- limit on signal strength $\mu = \frac{\sigma}{\sigma_{SM}}$

Outlook

- test possible improvement by extracting tth events
- optimize analysis tailored to specific kinematics

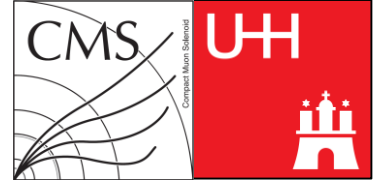


First studies on tth optimized analysis to increase the overall sensitivity



- L = 100/fb @ 13 TeV
- analogue selection
- four exclusive categories
- exploited sensitivity of BDT

Conclusion



- analysis concept for the search for dimuon Higgs decays
- two main features:
 - muon momentum calibration
 - auto event categorization
- results for run2 (13 TeV, 2016) with $L = 35.9/\text{fb}$ and combination
 - run2 | $\mu < 2.68$ (2.08)
 - combination | $\mu < 2.68$ (1.98)