

# H- $\rightarrow$ bb/cc/gg at 350 GeV

CLIC Detector and Physics Collaboration Meeting - 11 June 2014  
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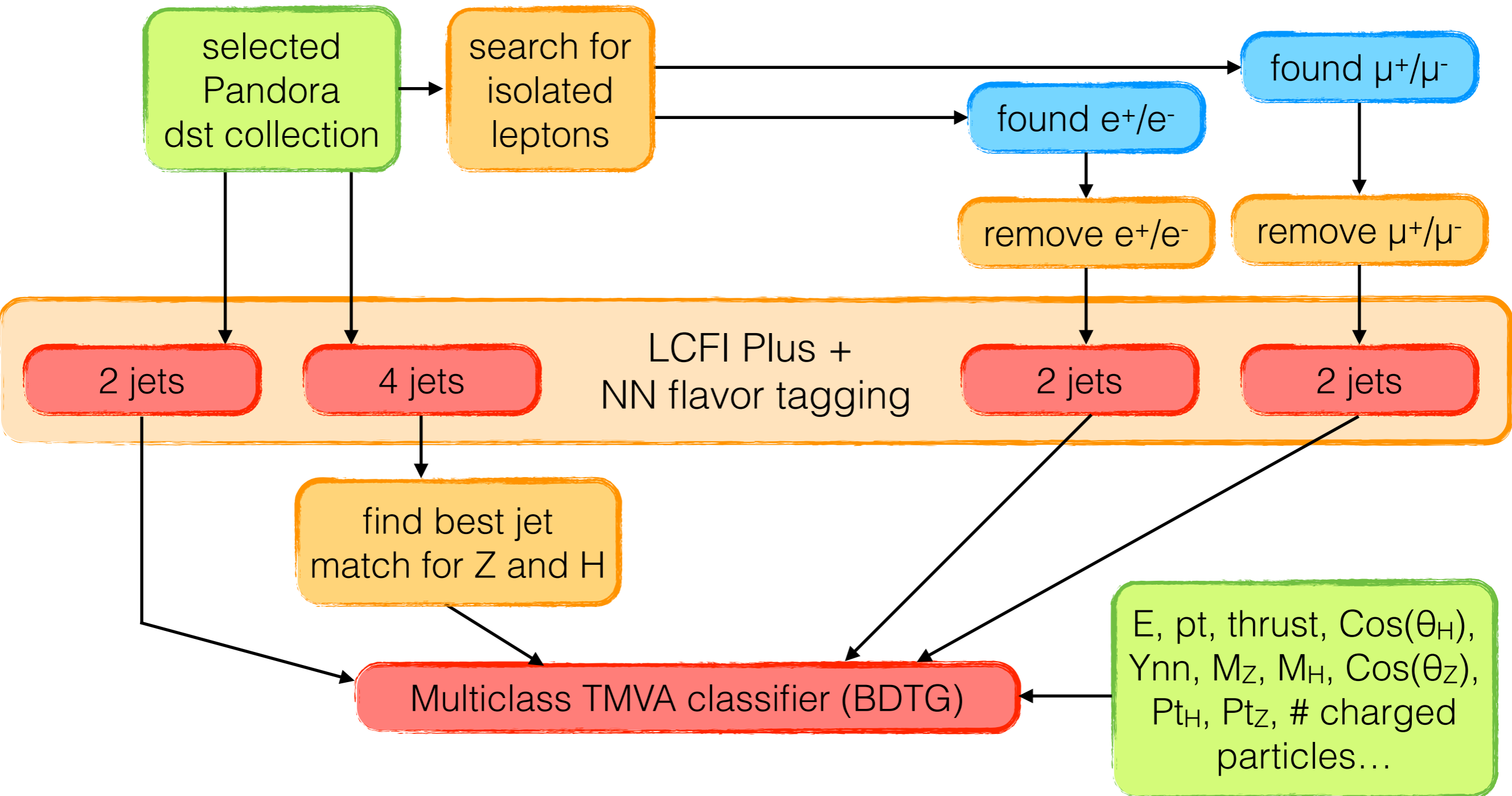
Max-Planck-Institut für Physik  
(Werner-Heisenberg-Institut)



# Outline

- Introduction
- (new) Higgs BDT event filter
- Template Fit
- Conclusions

# Signal Extraction



# Signal Extraction - MVA

## Problem:

- Signal has many different final states with completely different topology
- A simple binary classifier does not perform well enough

## Solution:

- multiclass classifier

BUT: TMVAmulticlass does not perform very well (trains only one set of weights) + a nasty bug in TMVA (v4.2) gives unreliable results when running more than 1 reader.

# Signal Extraction - MVA II

- 8 binary classifiers, each of them optimized for one ProdID.
- Events is assigned  $\langle \Rightarrow \rangle$  BDT response for that classifier is higher than threshold AND response for all other is lower than threshold

$$\mathbf{MVA_{thresh} = 0.95}$$

# Higgs Filter

	nunu	ep	mumu	jets
<b>H_NUNU</b>	7.02E-01	2.86E-05	3.43E-05	2.29E-06
<b>H_EP</b>	1.22E-05	5.11E-01	9.31E-04	1.40E-02
<b>H_MUMU</b>	1.20E-06	5.46E-04	7.28E-01	3.81E-04
<b>H_JETS</b>	2.47E-06	2.14E-02	6.44E-03	4.95E-01
<b>QQVV</b>	7.38E-05	4.92E-06	4.92E-06	4.92E-06
<b>QQLV</b>	6.21E-07	1.25E-03	1.94E-04	4.16E-03
<b>QQLL</b>	8.70E-07	1.43E-02	5.61E-03	3.92E-05
<b>QQQQ</b>	5.68E-07	5.33E-04	4.55E-05	5.52E-02

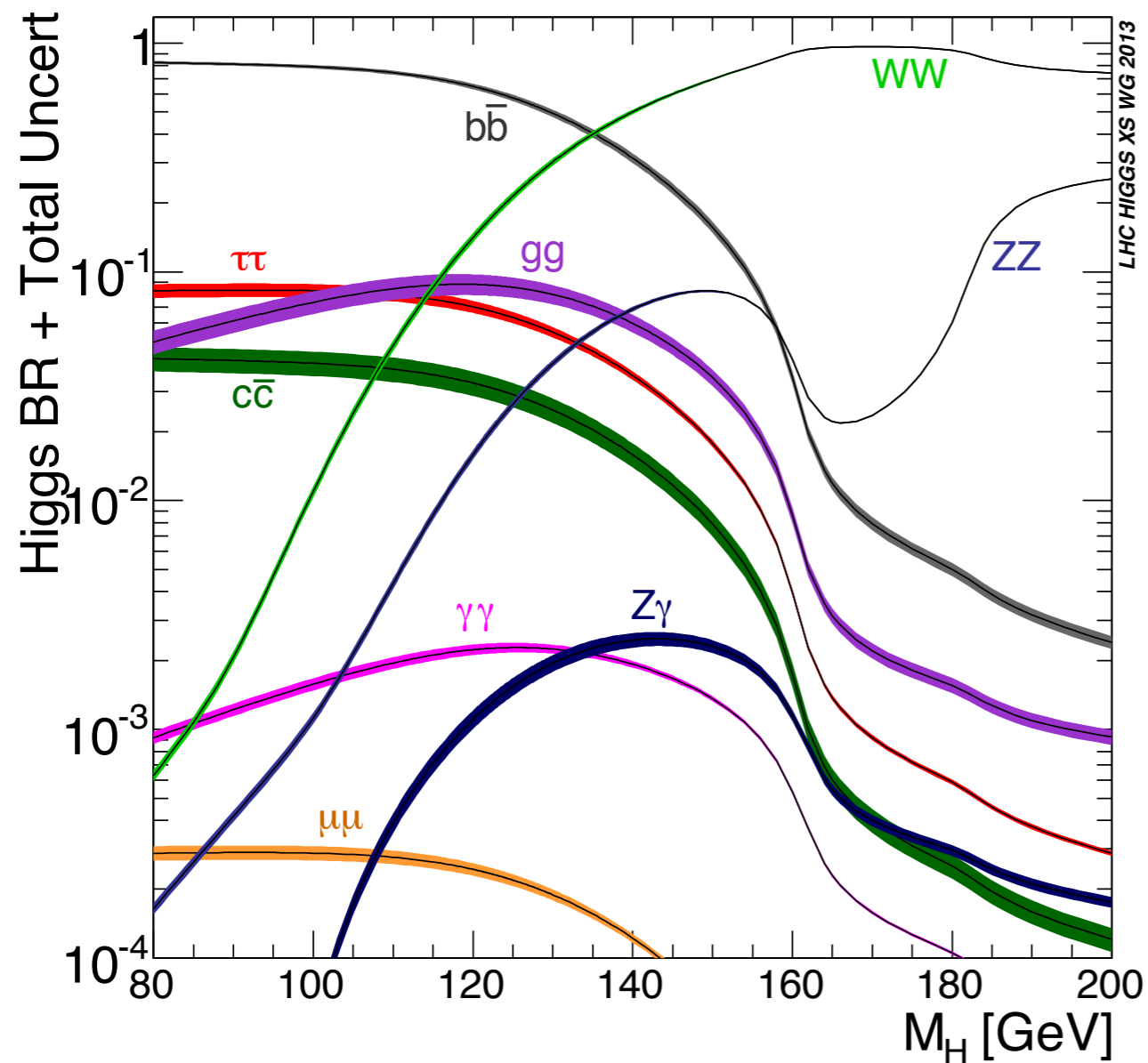
# Higgs Filter II

@ 500 fb<sup>-1</sup>:

	TOT	nunu	ep	mumu	jets
H_NUNU	25770	1.81E+04	7.36E-01	8.84E-01	0.00E+00
H_EP	2460	3.01E-02	1.26E+03	2.29E+00	3.44E+01
H_MUMU	2465	0.00E+00	1.35E+00	1.79E+03	9.39E-01
H_JETS	46700	0.00E+00	9.98E+02	3.01E+02	2.31E+04
QQVV	162300	1.20E+01	0.00E+00	0.00E+00	2.00E+00
QQLV	2957000	0.00E+00	3.68E+03	5.74E+02	1.23E+04
QQLL	852000	0.00E+00	1.22E+04	4.78E+03	3.34E+01
QQQQ	2923500	0.00E+00	1.56E+03	1.33E+02	1.61E+05
Significance		1.34E+02	8.96E+00	2.06E+01	5.21E+01

Overall  $S/\sqrt{S+B} = 89.9$

# Higgs Branchings



For 125.5 GeV Higgs boson:

57%  $bb$ , 22.3%  $WW$ ,

8.5%  $gg$ , 6.2%  $\tau\tau$ ,

2.8%  $ZZ$ , 2.7%  $cc$ ,

0.23%  $\gamma\gamma$ , 0.02%  $\mu\mu$



# Higgs Branchings II

- Multiple binary classifier (BDTG). Training is done on the full available statistics, without cuts.
- observables:  $B_{tag1}$ ,  $B_{tag2}$ ,  $C_{tag1}$ ,  $C_{tag2}$ ,  $B1+B2$ ,  $C1+C2$ ,  $C1/(B1+C1)$ ,  $C2/(B2+C2)$ ,  $M_{jet1}$ ,  $M_{jet2}$ ,  $\theta_{jet1}$ ,  $\theta_{jet2}$ ,  $\phi_{jet1}$ ,  $\phi_{jet2}$ ...
- Fit their response on a data sample, with templates generated on the full statistics, applying the H filter cut shown before.
- weights for templates of non Higgs events and  $H \rightarrow xx$  (other than  $bb/cc/gg$ ) are fixed.

# Template Fit



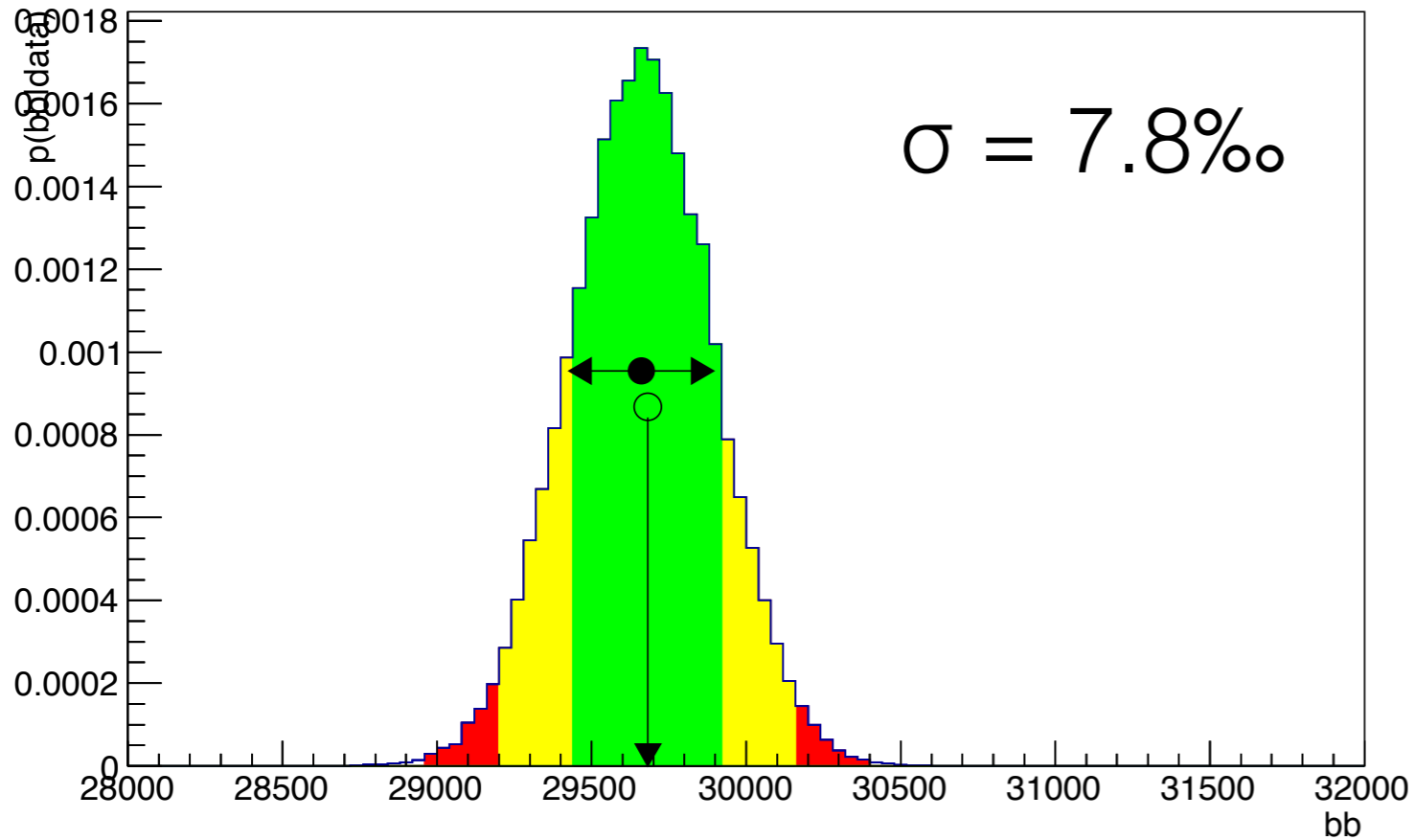
Bayesian analysis toolkit,  
developed at MPI München

arXiv: 0808.2552v1 Caldwell, Kollar, Kröninger

- Statistical analysis software package
- Implements Bayesian statistics
- Using Markov Chain MC methods

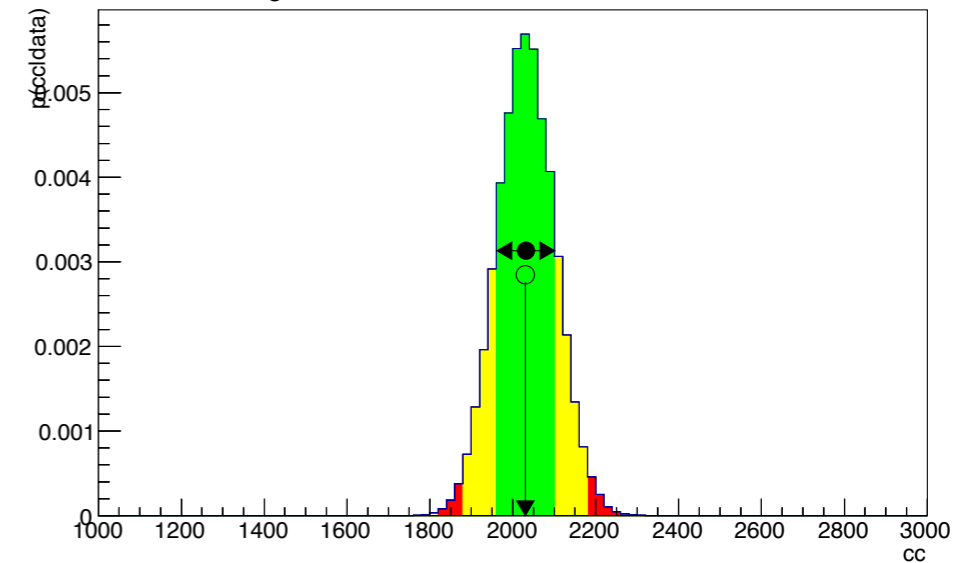
# Template Fit II

█ smallest 99.7% interval(s)  
█ smallest 95.5% interval(s)  
█ smallest 68.3% interval(s)  
 ○ global mode  
 ● mean and standard deviation



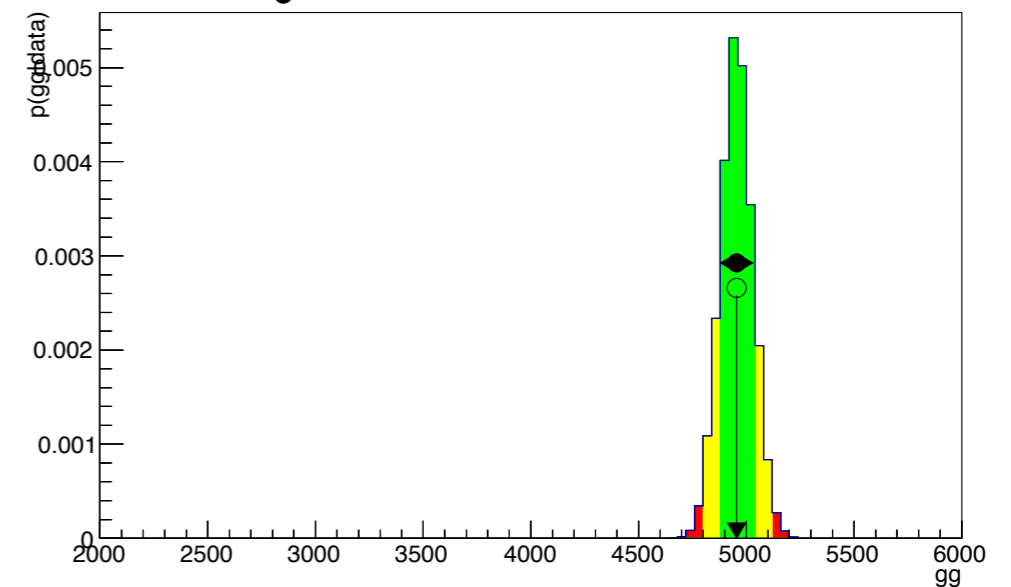
█ smallest 99.7% interval(s)  
█ smallest 95.5% interval(s)  
█ smallest 68.3% interval(s)  
 ○ global mode  
 ● mean and standard deviation

$\sigma = 4\%$

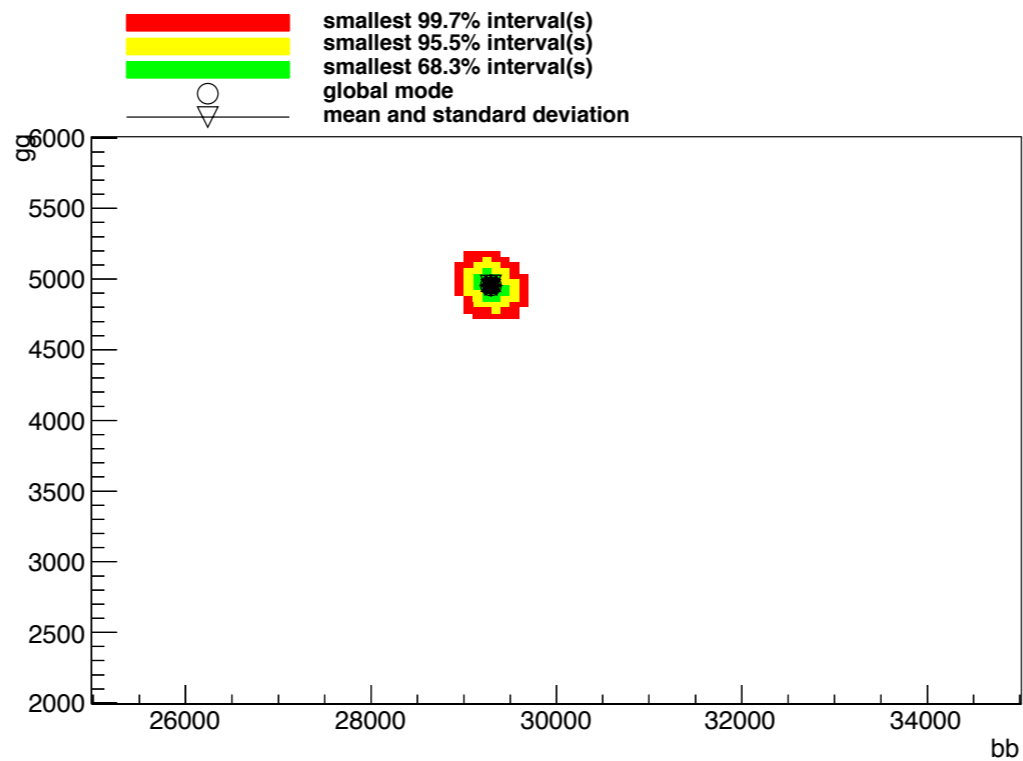
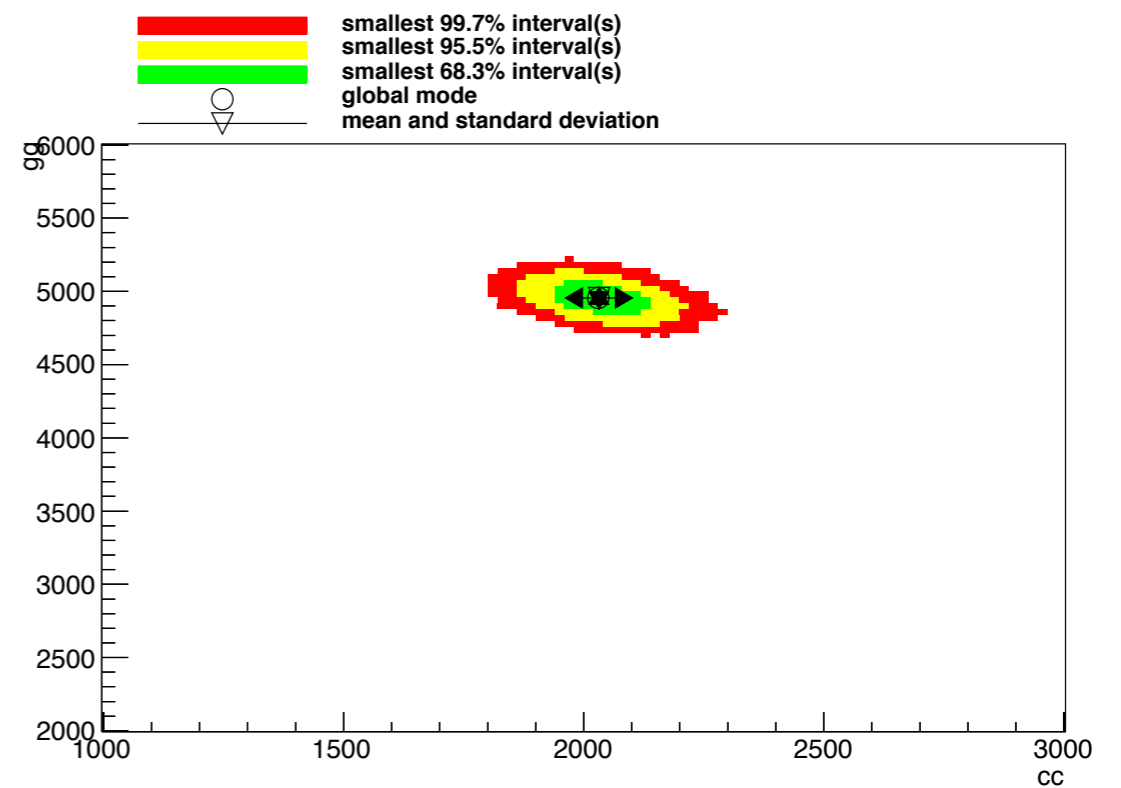
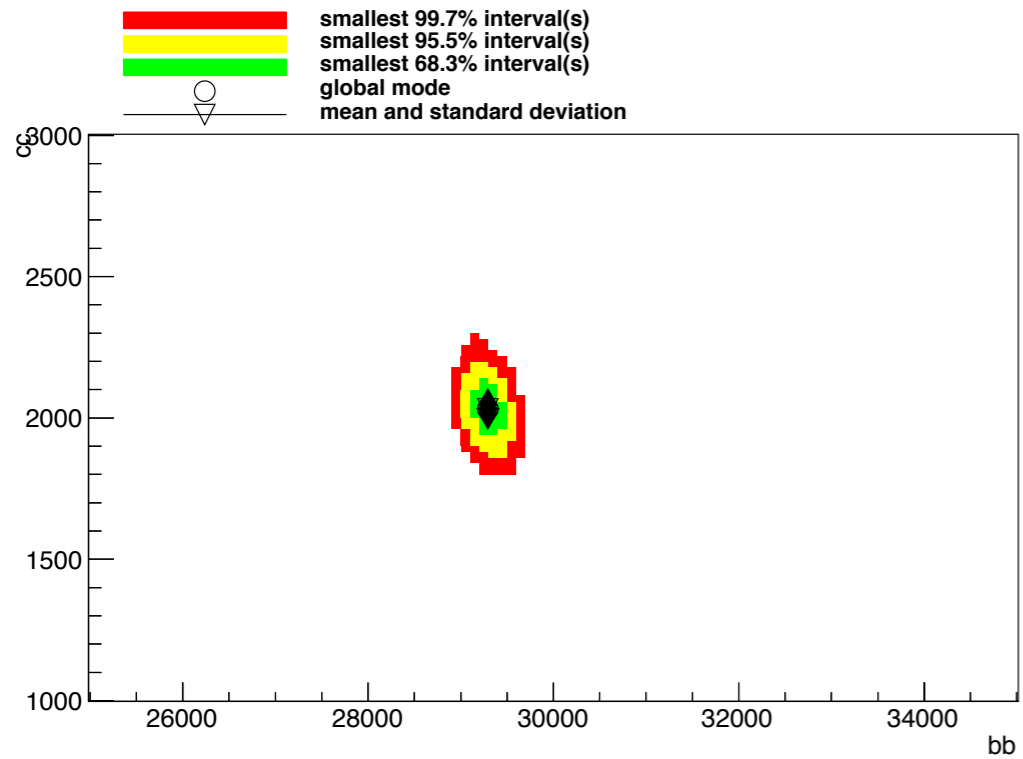


█ smallest 99.7% interval(s)  
█ smallest 95.5% interval(s)  
█ smallest 68.3% interval(s)  
 ○ global mode  
 ● mean and standard deviation

$\sigma = 3.5\%$



# Template Fit III



# Conclusions

- Higgs filter works efficiently. Workaround for TMVA bug is implemented, but time consuming.
- Template fit performs well
- Still need to separate, event by event, H<sub>vv</sub> inclusive sample