
# Update on 4.7 fb$^{-1}$ analysis

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*On behalf of H→WW (lvjj) working group*

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# Overview

Recall that using pre-selection cuts we were dominated by syst error ➜ exclusion limit from full 4.7 $fb^{-1}$ data was ~ same as 2.1 $fb^{-1}$

To improve this we have

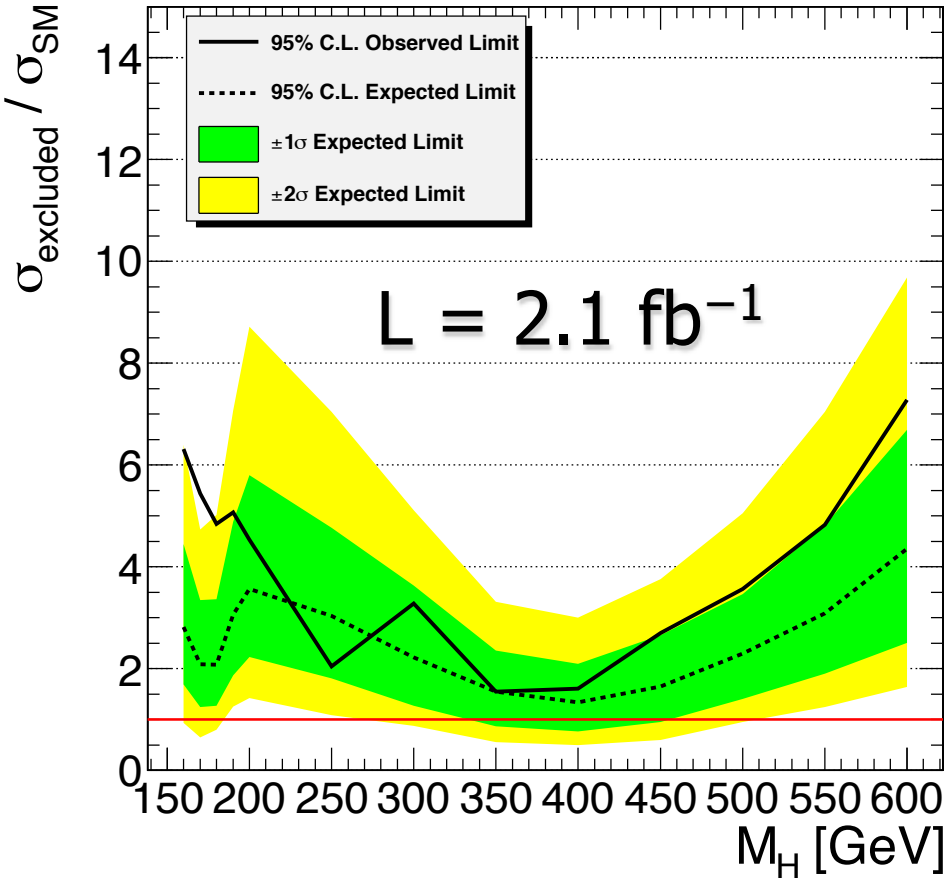
- ☑ Optimized a simple likelihood (for each $M_H$) to reduce syst
- ☑ Finalized optimized cuts for each $M_H$, nJet, lepton category
- ☑ Computed trigger efficiency and data/MC efficiency SFs
- ☑ Recomputed systematics and exclusion limits

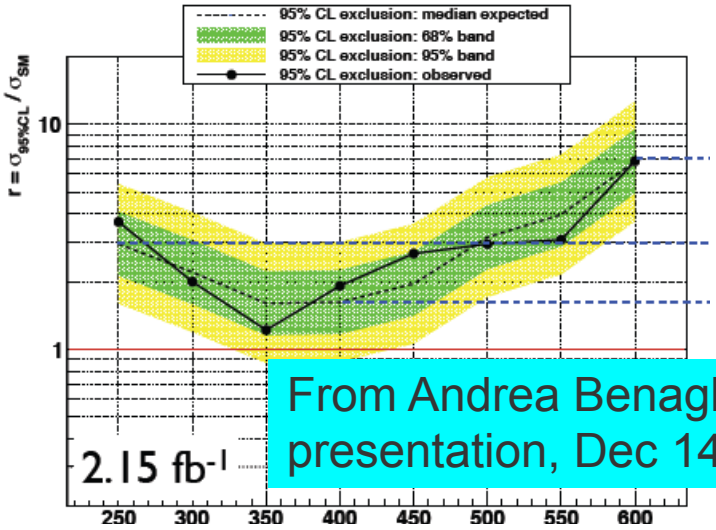
I will show a very short summary & limits in the next slides.

Pratima was able to copy/produce the entire "V5" PAT-tuples. We plan to reproduce the results/limits using these PAT-tuples in the next one week.

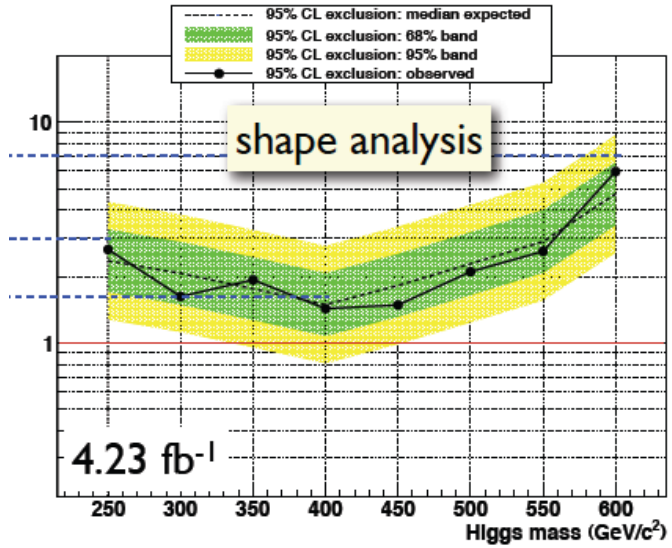
# Recall where we were with 2.1 fb$^{-1}$

From SVN repository of AN-2011/110 (Sept '11)




From Andrea Benaglia presentation, Dec 14



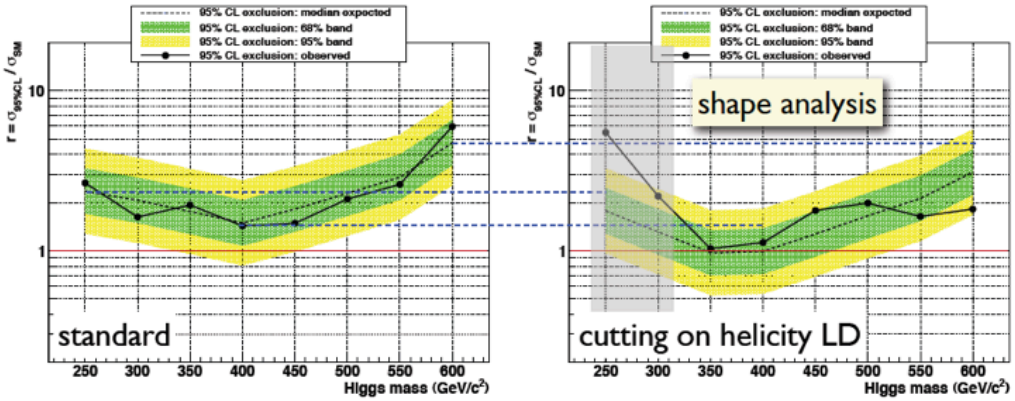
# Clearly we needed to improve S/B ...

Dan presented a detailed rationale for this including several illustrated examples during the last CMS week. His slides are at

https://indico.cern.ch/conferenceDisplay.py?confId=157054

## Results with helicity LD applied

- LD calculated for H→ZZ→ll jj analysis has been used
- **Sizable improvement** wrt standard analysis
- The fit has some pathologies for low masses (~one-sideband fit)
  - need to extend the fitting range to low mass values
  - functional form has to take into account an initial turn-on




Verified by Andrea in his presentation on December 14.

Conclusion in Dec: Tightening cuts helps

We decided to pursue this in a systematic way

# Optimization of likelihood

**CMS AN AN-12-008**

## Multivariate optimization and background estimation for the Standard Model Higgs boson search in H→WW→ $\ell\nu jj$ decay

See Fan's presentation in this forum last week for details


**Abstract**

We present a study of the multi-variate optimization for the Higgs boson search in the H →WW→ $\ell\nu jj$ final state in the gluon fusion production mechanism. Using a complete set of mostly un-correlated variables we optimize each Higgs mass points separately to distinguish between the Higgs signal and the dominant W+jets background. We are able to achieve S/B ∼ 7% at the most optimal mass value $M_H = 400$ GeV in 2-jets events. This optimization corresponds to Higgs signal efficiency of about 32% and background rejection rate of about 95%. We also develop a data-driven technique to derive 4-body $m_{\ell\nu jj}$ invariant mass shape for W+jets background. For this we use events in the upper and lower sidebands of the $m_{jj}$ distribution to extract the 4-body mass shape for events in the signal region 65 GeV $< m_{jj} <$ 95 GeV. Using this data-driven technique we are able to keep the systematic uncertainties (dominated by background shape systematics) to within 4%. This analysis note complements the documentation of the main analysis in AN-11/110.

# An example: from Fan's slides of last week

Optimize the quantity:

$$\frac{S}{\sqrt{B + (\delta_{\text{sys-background}} \times B)^2}}$$

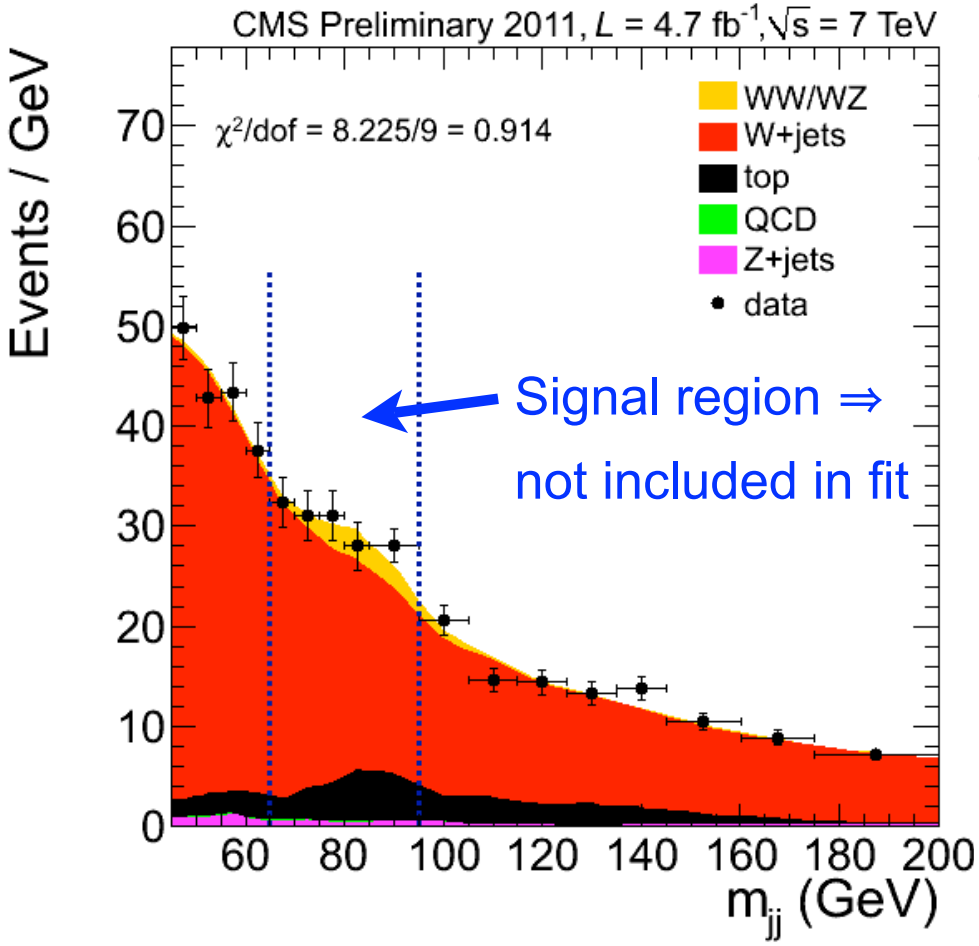
Muon, 2-jets category

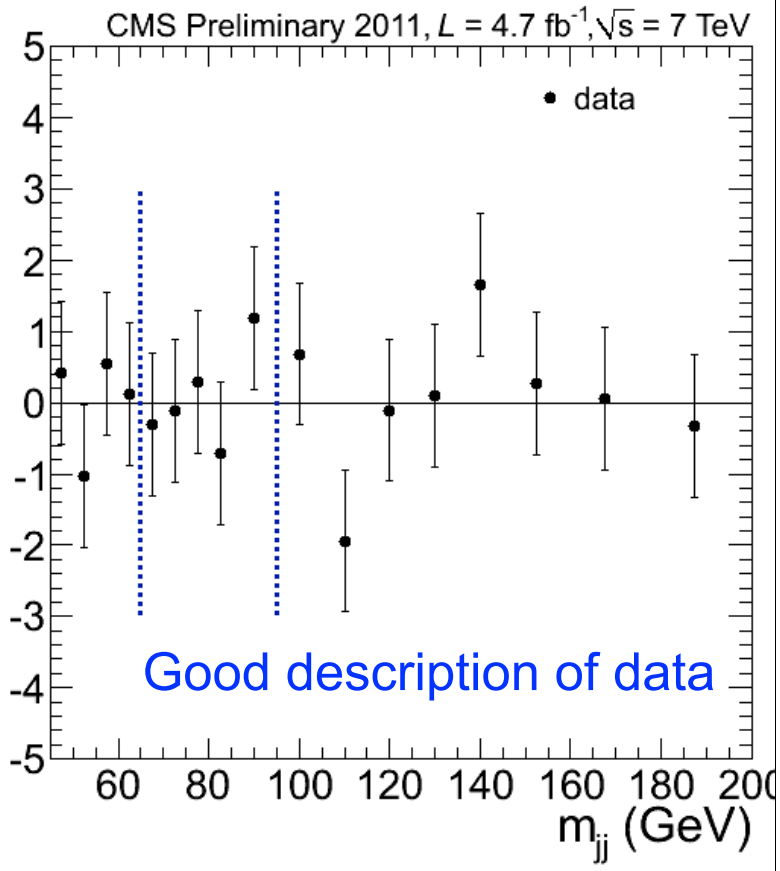
| Mass Point | Win GeV | Cut | $S/\sqrt{\cdots}$ | $\epsilon$ (%) | RJ-Wjets (%) | RJ-Tot (%) | $N$ Sig | $N$ Bkg | $\alpha$ C | $\alpha$ L | $\alpha$ H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2j170mu | [165, 180] | 0.63 | 0.340 | 27.15 | 85.27 | 84.99 | 42.11 | 2802.47 | 0.13 | 0.10 | 0.15 |
| 2j180mu | [170, 200] | 0.76 | 0.344 | 16.69 | 95.06 | 94.83 | 26.33 | 1627.43 | 0.00 | 0.00 | 0.04 |
| 2j190mu | [185, 210] | 0.82 | 0.340 | 14.48 | 97.16 | 96.95 | 12.60 | 666.05 | 0.01 | 0.00 | 0.07 |
| 2j200mu | [190, 220] | 0.82 | 0.317 | 21.27 | 95.47 | 95.03 | 18.37 | 1169.95 | 0.00 | 0.00 | 0.12 |
| 2j250mu | [226, 287] | 0.87 | 0.442 | 18.30 | 97.14 | 96.59 | 18.06 | 756.28 | 0.05 | 0.00 | 0.13 |
| 2j300mu | [265, 347] | 0.85 | 0.562 | 24.51 | 96.01 | 95.26 | 21.58 | 697.19 | 0.17 | 0.14 | 0.21 |
| 2j350mu | [308, 401] | 0.87 | 0.925 | 26.59 | 96.08 | 95.19 | 24.65 | 423.20 | 0.15 | 0.11 | 0.20 |
| 2j400mu | [346, 457] | 0.85 | 1.018 | 32.59 | 95.40 | 94.24 | 23.39 | 341.34 | 0.22 | 0.18 | 0.26 |
| 2j450mu | [381, 512] | 0.85 | 0.841 | 33.17 | 95.79 | 94.39 | 14.96 | 230.95 | 0.21 | 0.16 | 0.25 |
| 2j500mu | [415, 568] | 0.76 | 0.664 | 52.99 | 90.52 | 88.39 | 15.20 | 339.33 | 0.20 | 0.17 | 0.22 |
| 2j550mu | [440, 617] | 0.89 | 0.529 | 26.80 | 98.29 | 97.13 | 4.53 | 66.31 | 0.12 | 0.06 | 0.17 |
| 2j600mu | [462, 663] | 0.89 | 0.396 | 29.24 | 98.44 | 97.28 | 2.95 | 51.44 | 0.12 | 0.07 | 0.17 |
| 3j170mu | [165, 190] | 0.59 | 0.305 | 33.85 | 84.00 | 82.96 | 8.12 | 423.62 | 0.24 | 0.19 | 0.29 |
| 3j180mu | [170, 210] | 0.60 | 0.220 | 38.44 | 79.60 | 77.78 | 9.78 | 840.62 | 0.27 | 0.21 | 0.33 |
| 3j190mu | [185, 220] | 0.59 | 0.217 | 41.04 | 83.33 | 80.82 | 7.32 | 588.08 | 0.29 | 0.22 | 0.37 |
| 3j200mu | [190, 230] | 0.57 | 0.177 | 52.19 | 77.19 | 73.22 | 8.16 | 884.43 | 0.27 | 0.22 | 0.33 |
| 3j250mu | [216, 300] | 0.75 | 0.243 | 40.61 | 89.25 | 84.03 | 10.11 | 773.20 | 0.39 | 0.30 | 0.48 |
| 3j300mu | [241, 355] | 0.78 | 0.300 | 34.70 | 92.28 | 87.52 | 9.93 | 571.61 | 0.44 | 0.30 | 0.56 |
| 3j350mu | [269, 407] | 0.79 | 0.412 | 36.71 | 91.58 | 86.22 | 12.69 | 519.09 | 0.15 | 0.05 | 0.28 |
| 3j400mu | [300, 465] | 0.77 | 0.497 | 38.69 | 92.65 | 86.41 | 12.75 | 400.52 | 0.17 | 0.09 | 0.25 |
| 3j450mu | [332, 518] | 0.76 | 0.421 | 42.99 | 92.62 | 86.32 | 9.05 | 309.79 | 0.42 | 0.29 | 0.54 |
| 3j500mu | [362, 569] | 0.72 | 0.357 | 48.75 | 92.24 | 84.49 | 6.97 | 266.79 | 0.43 | 0.35 | 0.51 |
| 3j550mu | [398, 616] | 0.68 | 0.245 | 55.76 | 88.94 | 80.87 | 4.43 | 236.92 | 0.24 | 0.15 | 0.35 |
| 3j600mu | [419, 660] | 0.78 | 0.178 | 48.80 | 93.46 | 85.78 | 2.40 | 147.09 | 0.36 | 0.28 | 0.44 |

A detailed documentation of these is in progress, so that people can take a look and provide comments/ feedback.

# An example of $m_{jj}$ fit (for normalization)

Muons, 2-jets category, $M_H$ = 600 GeV

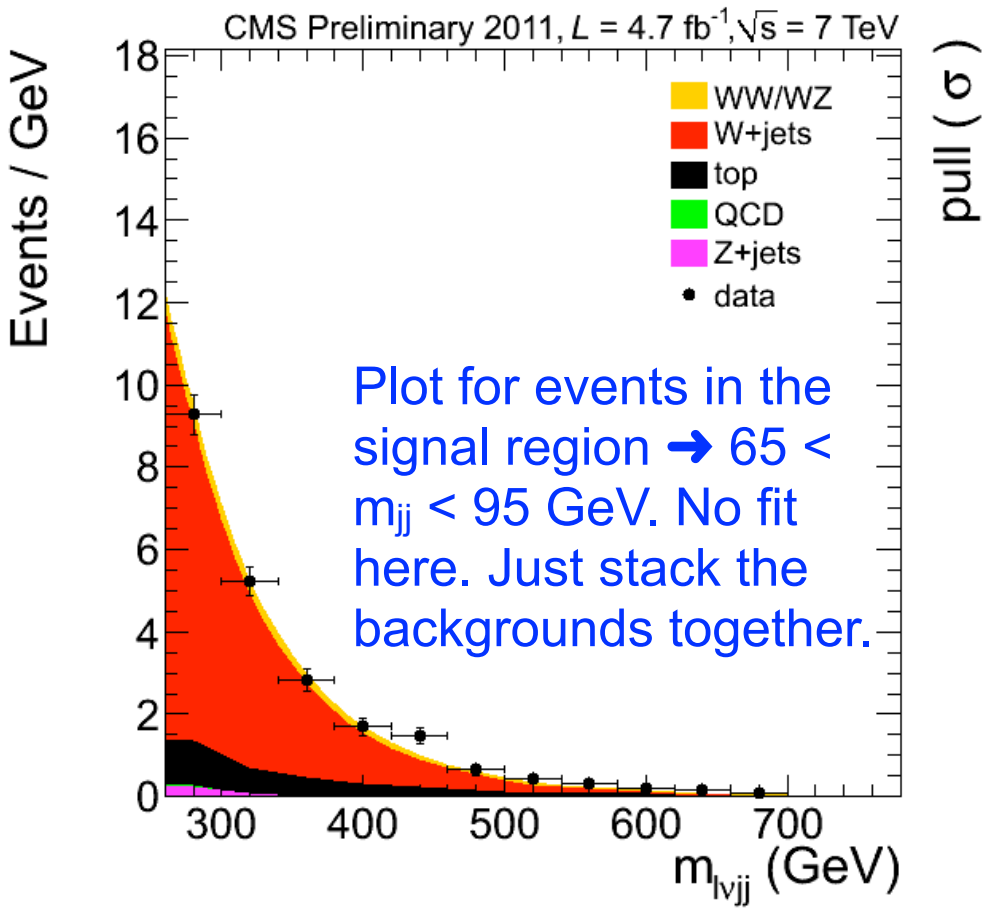


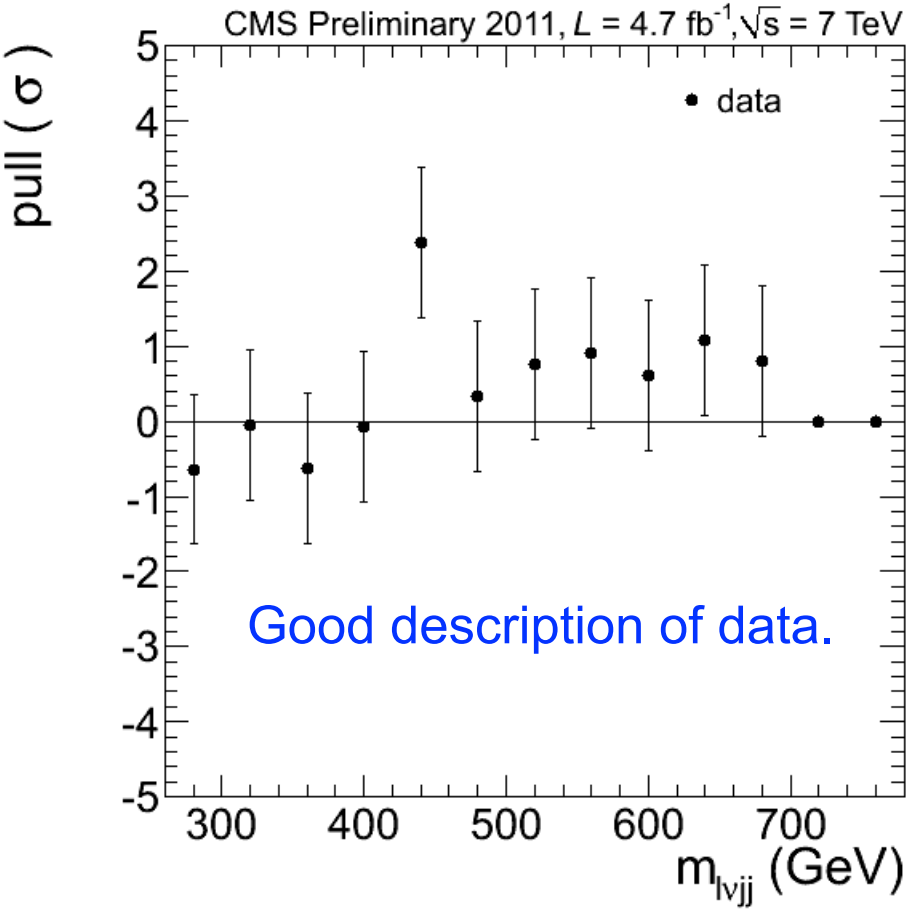




Efficiency corrections applied: see my presentation in this forum on December 7.

# Example of $m_{WW}$ distribution (for limit setting)

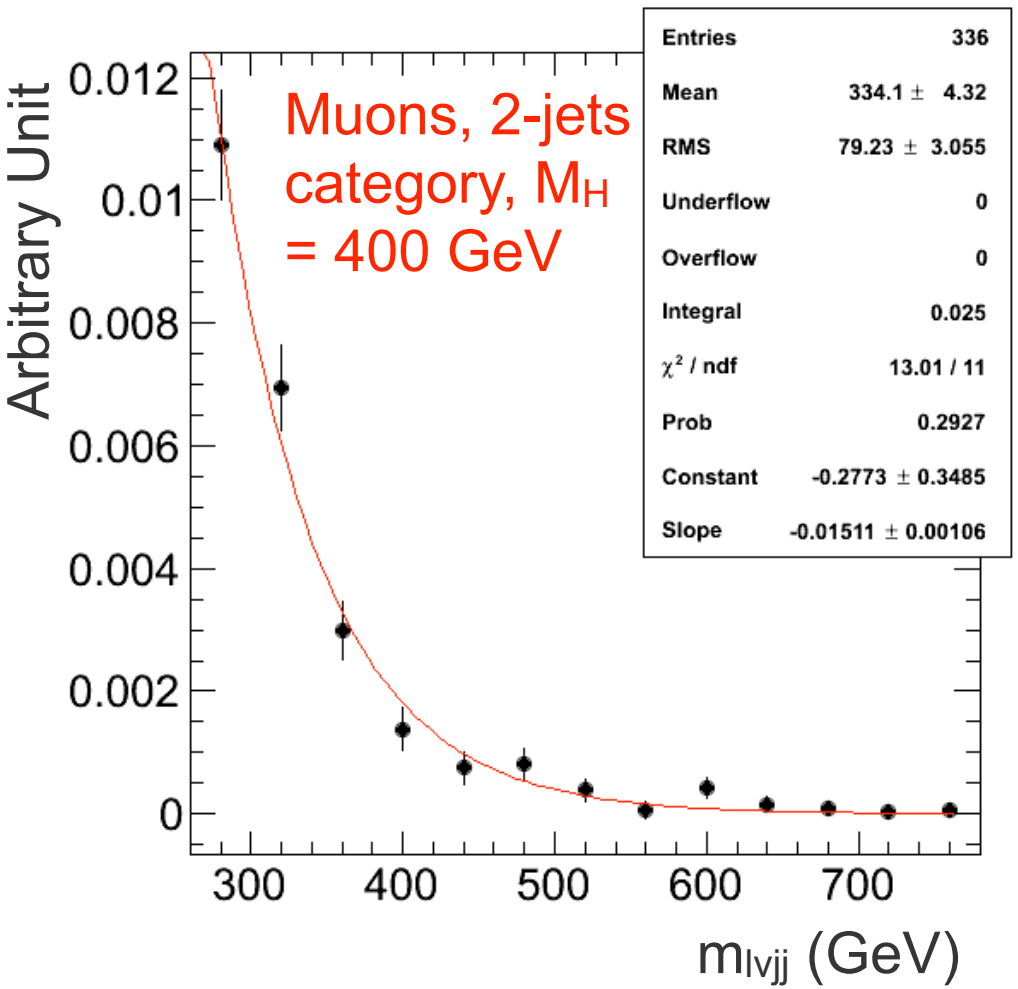
## Muons, 2-jets category, $M_H$ = 600 GeV




Normalization of each component came from $m_{jj}$ fit of the previous slide. W+jets shape in the above plot is derived from data sidebands. Efficiency applied.

# Improvement in W+jets shape from data



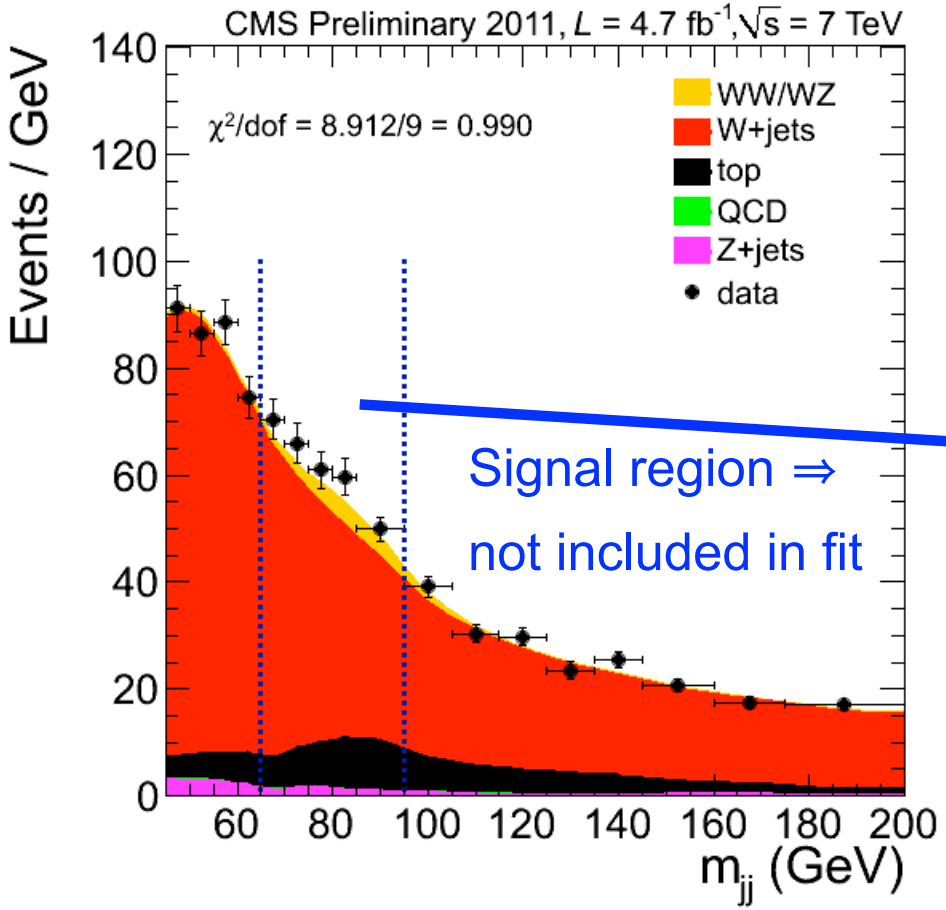

Still derive W+jets shape from data sidebands as before:

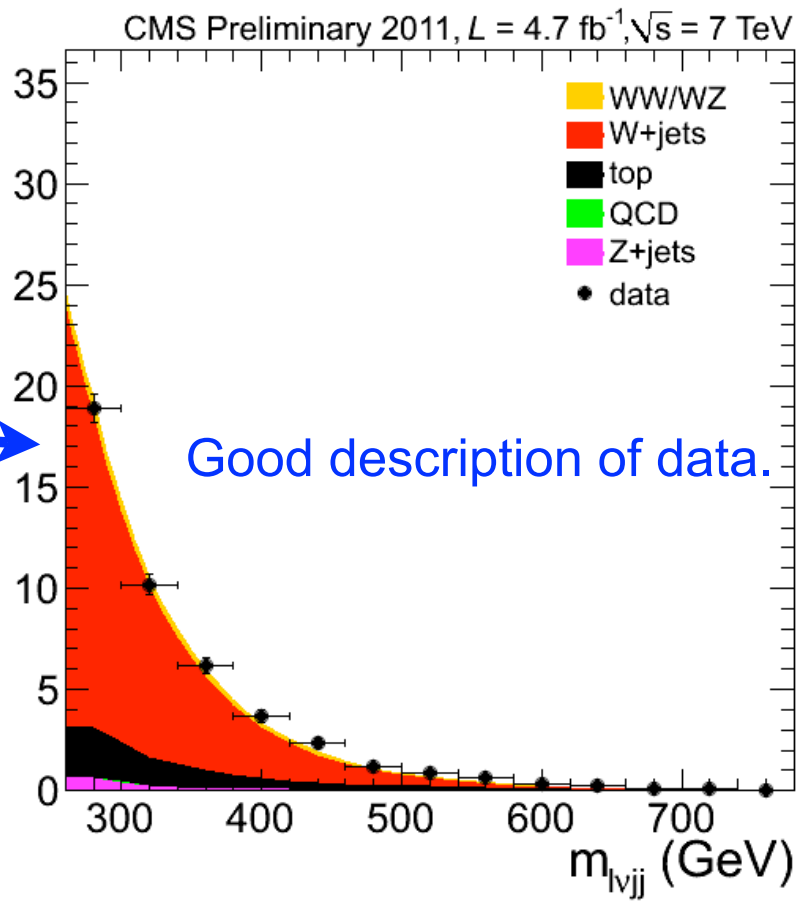
$$\alpha \cdot SB_{Low} + (1-\alpha) \cdot SB_{High}$$

But, now parametrize this shape (using an exponential) to get smooth curve. Uncertainty in the exponential parameter determines the systematic uncertainty due to shape. To compute systematics we take extreme values of α: [0, 1].

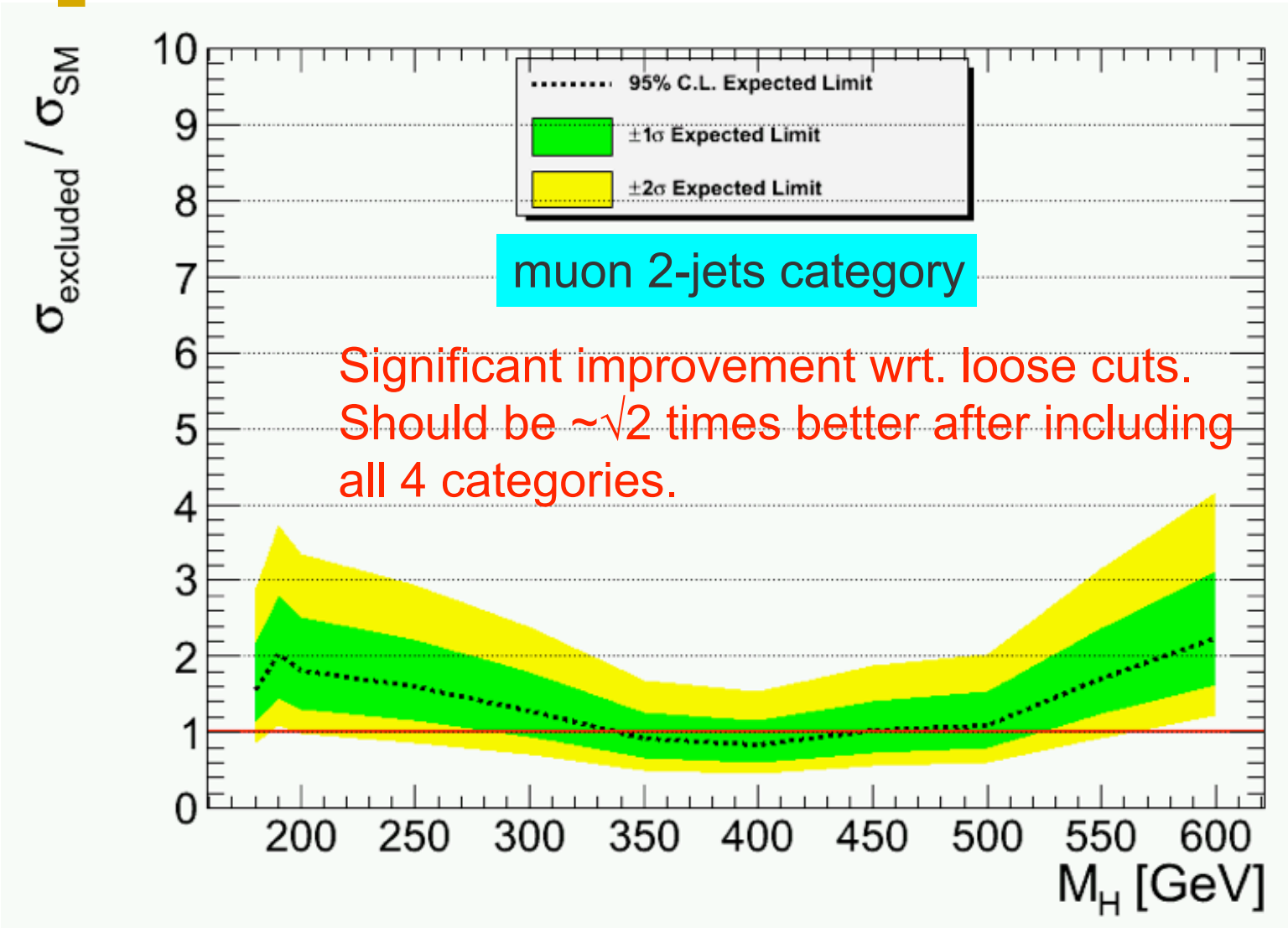
# Second example: another mass point

## Muons, 2-jets category, $M_H$ = 400 GeV

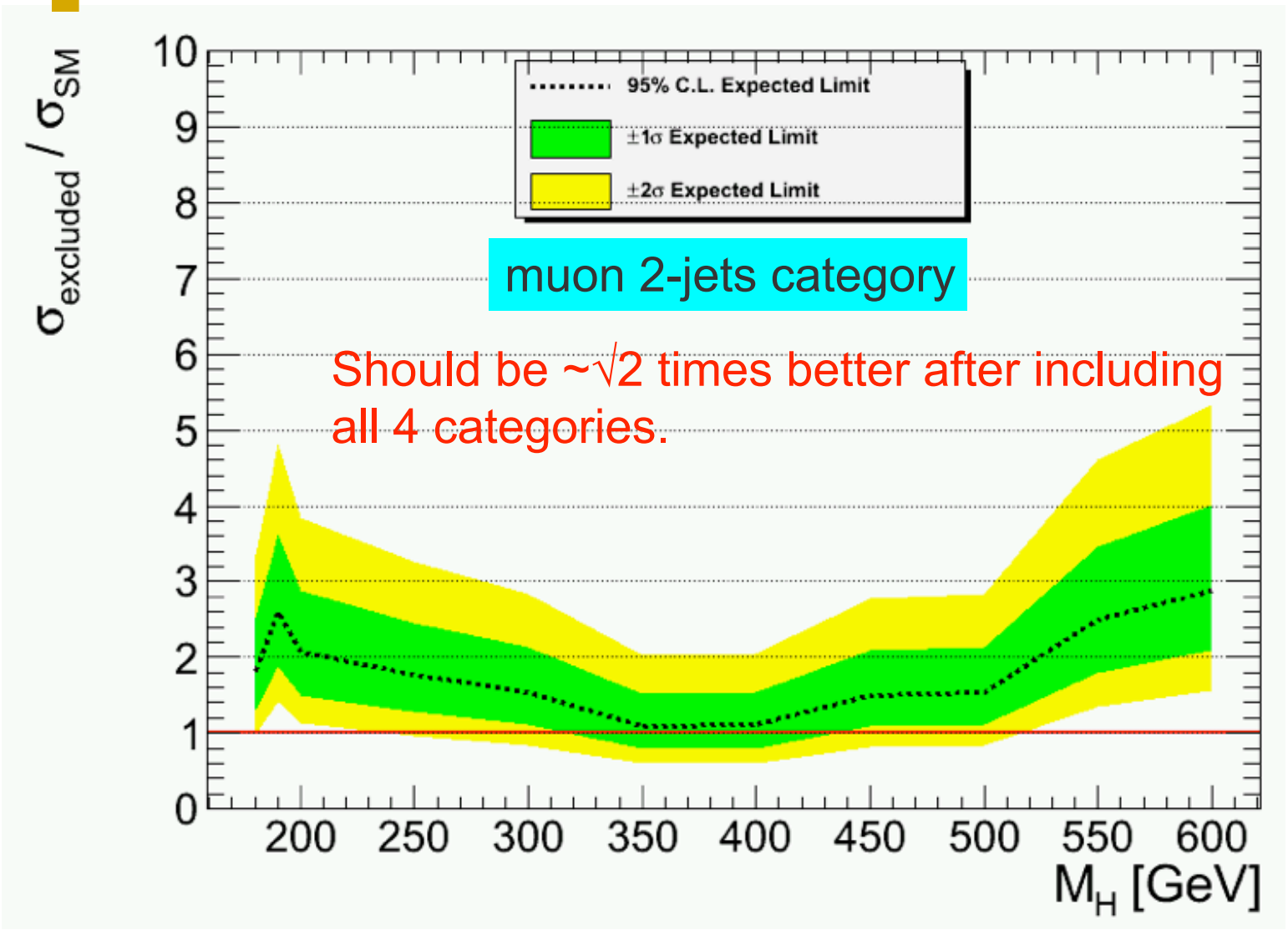


# Statistics-only limit: muon 2-jets only



# Limit after full syst: muon 2-jets only



# Summary


☑ This time we do not want to miss the Moriond deadline. We were stuck so far due to large systematic uncertainties. Focus sharply on reducing the syst error.

- Optimized a simple likelihood (for each $M_H$) to reduce syst
- Use dijet mass ($m_{jj}$) to derive normalization as before
- Improved data-driven estimation of W+jets shape for $m_{WW}$

☑ Reduced systematic uncertainty ➜ improved exclusion limits

- have preliminary result for muon channel 2-jets category
- work ongoing to complete analysis of other three categories

☑ Working on documentation of all the work in parallel

☑ Will repeat / reproduce all results using the agreed-upon PAT-tuples, hopefully in a week's time scale.

# backup slides