Follow-up studies for questions raised during the closure talk

Abdualazem Fadol

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Signal injection test

Setting the value of the POI to 1 fb, 5 fb, or 10 fb, then perform the fit with Asimov data generated with the same POI value. The numbers on the tables represent the POI best fit value with the errors.

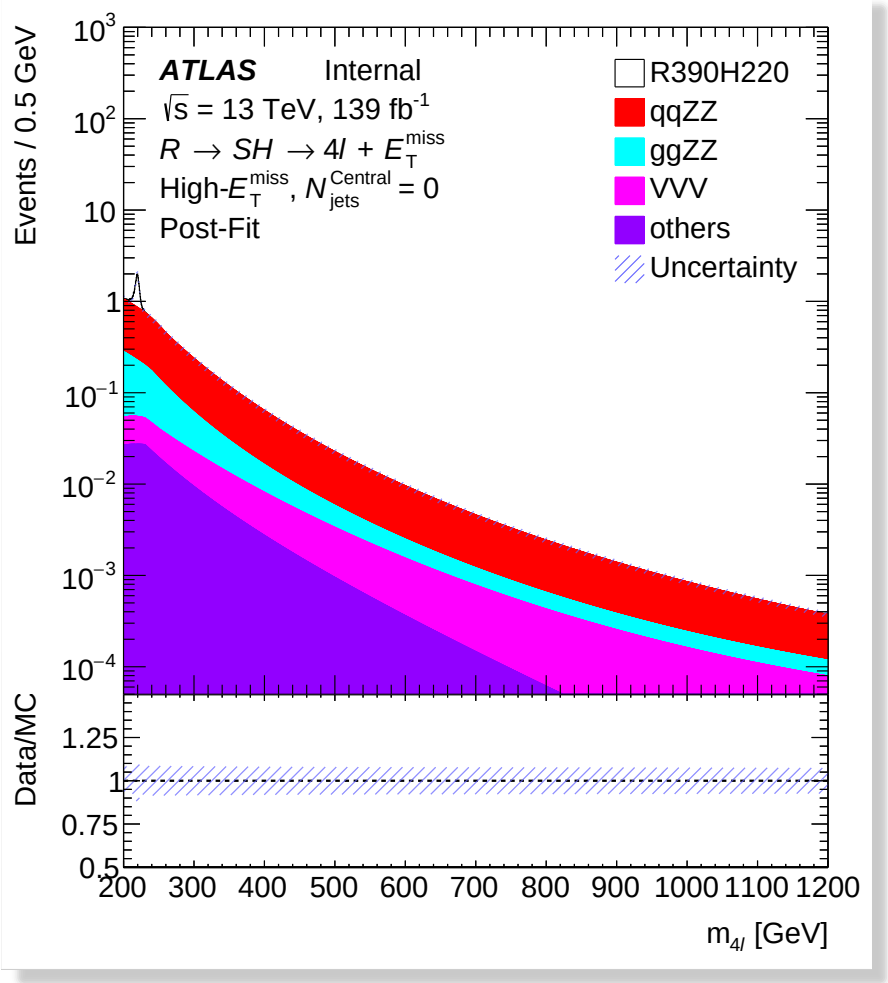
- For the $A \to ZH \to 4\ell + X$ signal:

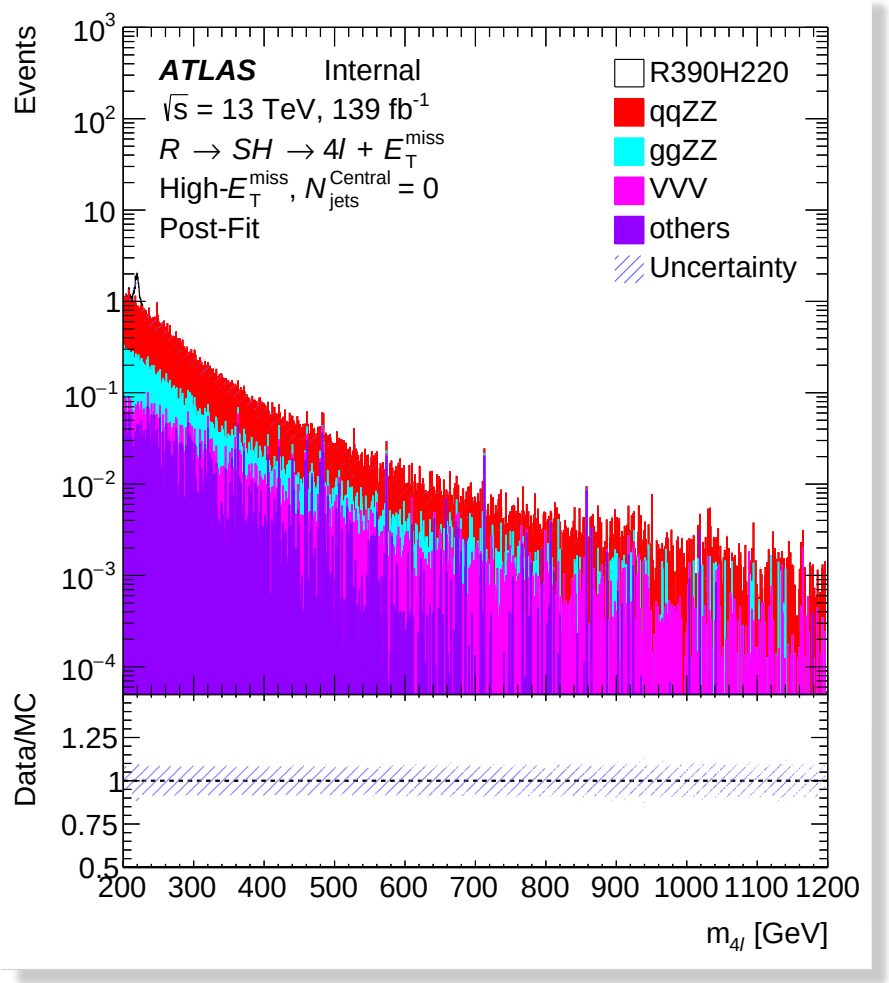
(m_A, m_H) GeV	The fit result for the POI in fb		
	POI=1.0	POI=5.0	POI=10.0
(320, 220)	$1.0^{+0.20}_{-0.19}$	$5.0^{+0.39}_{-0.37}$	$10.0^{+0.62}_{-0.58}$
(500, 400)	$1.0^{+0.16}_{-0.15}$	$5.0^{+0.34}_{-0.32}$	$10.0^{+0.55}_{-0.53}$
(2090, 1000)	$1.0^{+0.11}_{-0.10}$	$5.0^{+0.30}_{-0.29}$	$10.0^{+0.52}_{-0.50}$

- For the $R \to SH \to 4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ signal:

(m_A, m_H) GeV	The fit result for the POI in fb		
	POI=1.0	POI=5.0	POI=10.0
(390, 220)	$1.0^{+0.25}_{-0.23}$	$5.0^{+0.49}_{-0.46}$	$10.0^{+0.73}_{-0.71}$
(500, 300)	$1.0^{+0.17}_{-0.15}$	$5.0^{+0.41}_{-0.39}$	$10.0^{+0.65}_{-0.64}$
(1340, 250)	$1.0^{+0.15}_{-0.14}$	$5.0^{+0.39}_{-0.37}$	$10.0^{+0.66}_{-0.64}$

The fit result using MC histograms

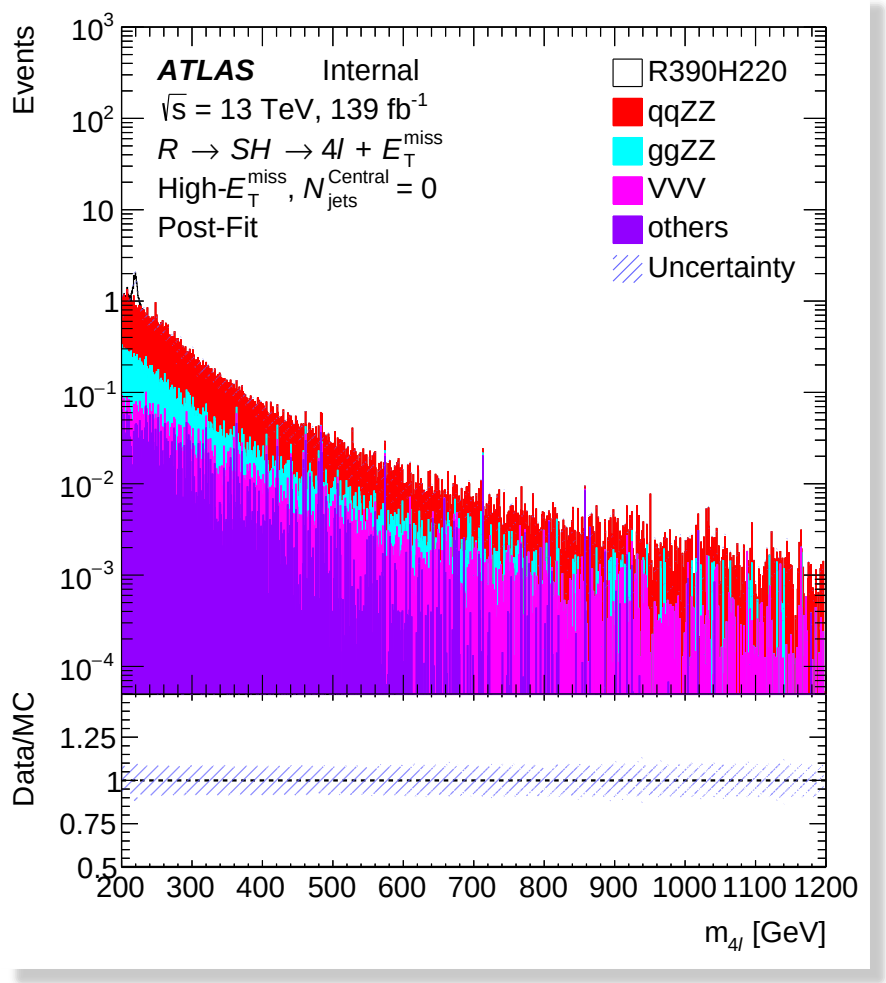


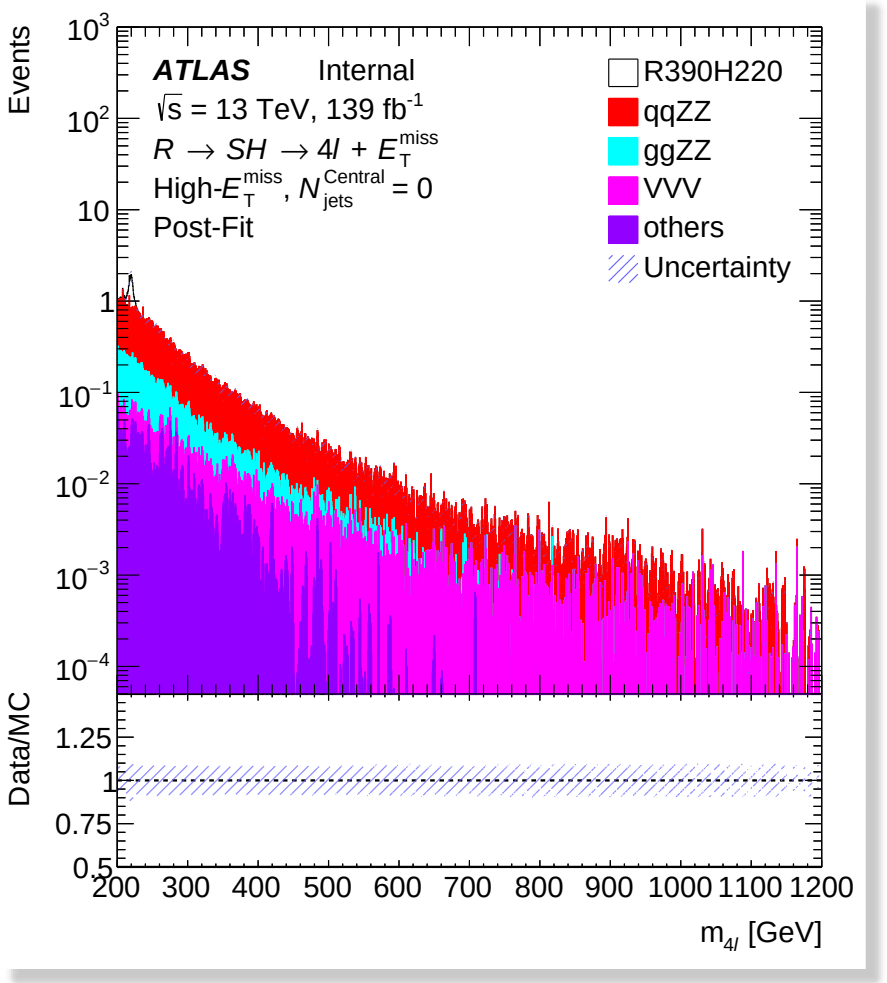


- Using analytical function to describe the backgrounds (left) and MC histogram (right)
- Fine binning is used in both cases (bins, xmin, xmax) = (2000, 200, 1200)

The fit result using MC histograms

Smoothing background histograms with 2000 bins

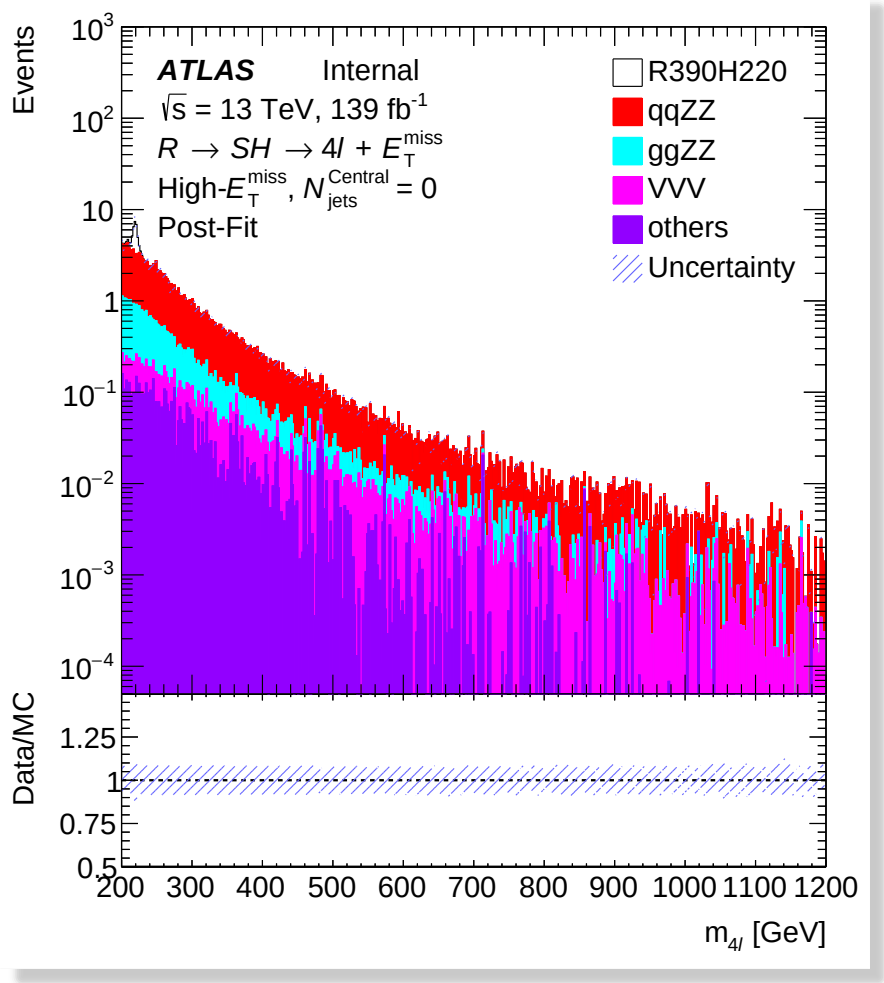


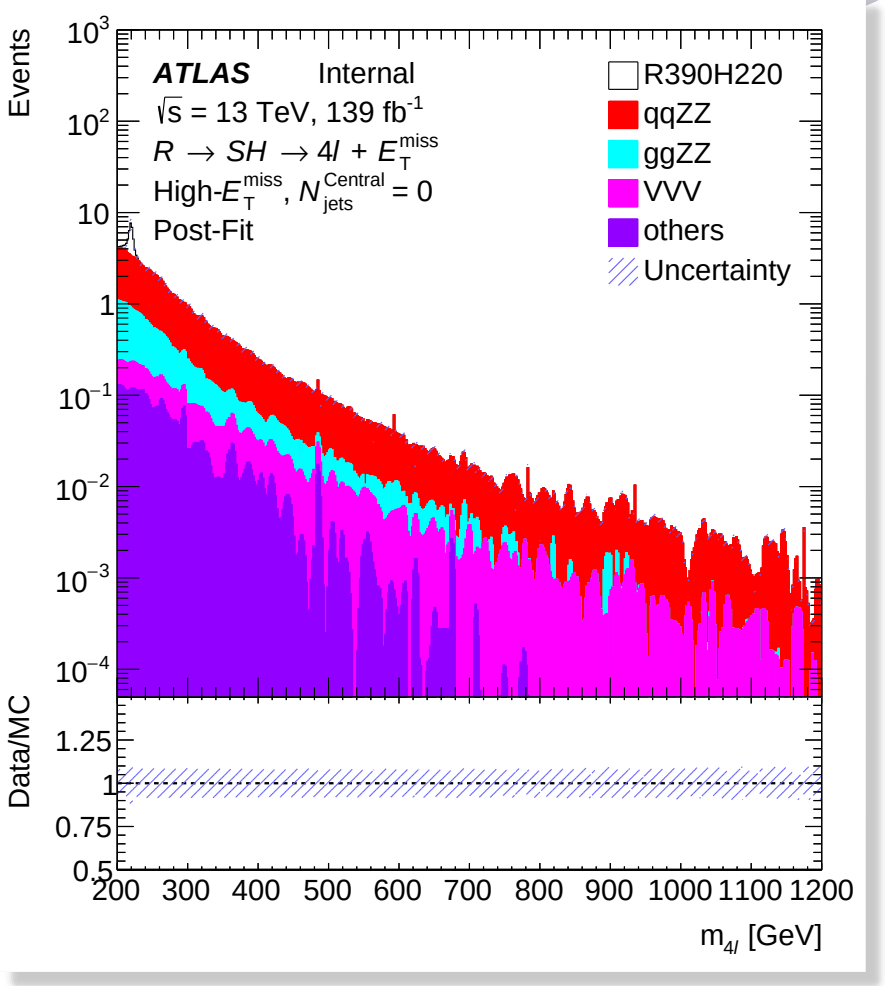


- The upper limit for the left (right) plot is 0.301 fb (0.307 fb) at 95% CL

The fit result using MC histograms

Smoothing background histograms with 500 bins

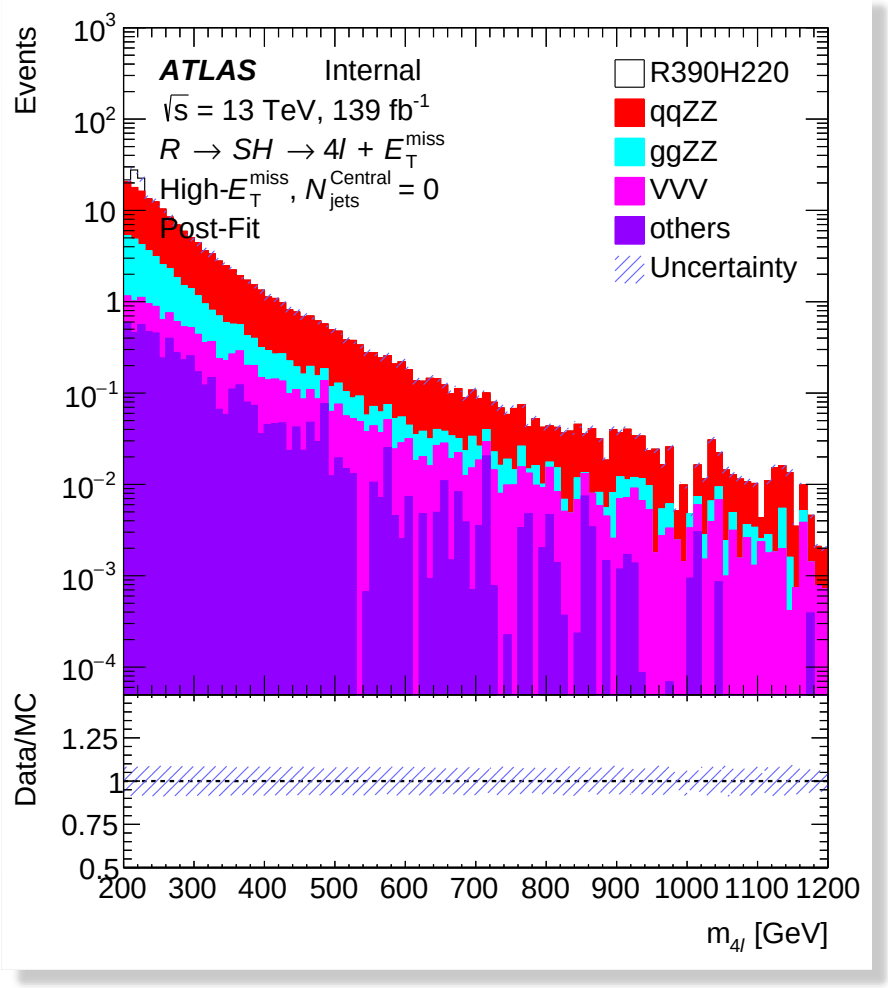


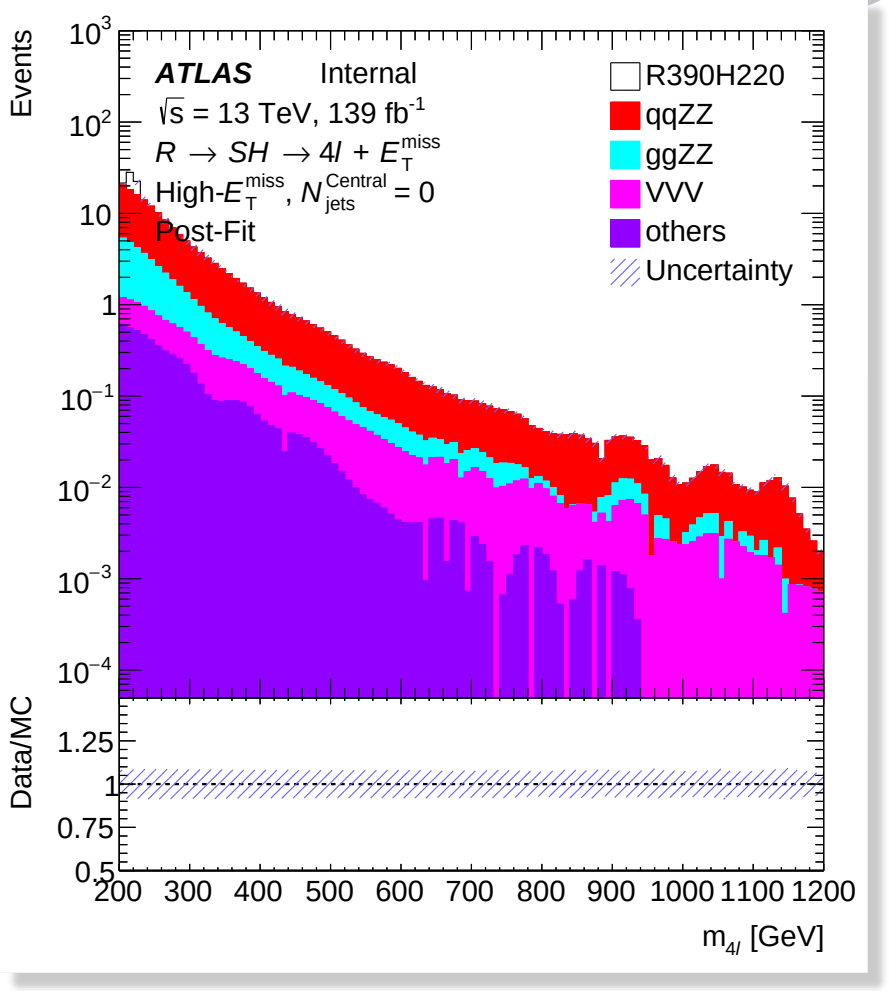


- The upper limit for the left (right) plot 0.306 fb (0.305 fb) at 95% CL
- For 2 GeV per bin in both cases as in (bins, xmin, xmax) = (500, 200, 1200)

The fit result using MC histograms

Smoothing background histograms with 100 bins

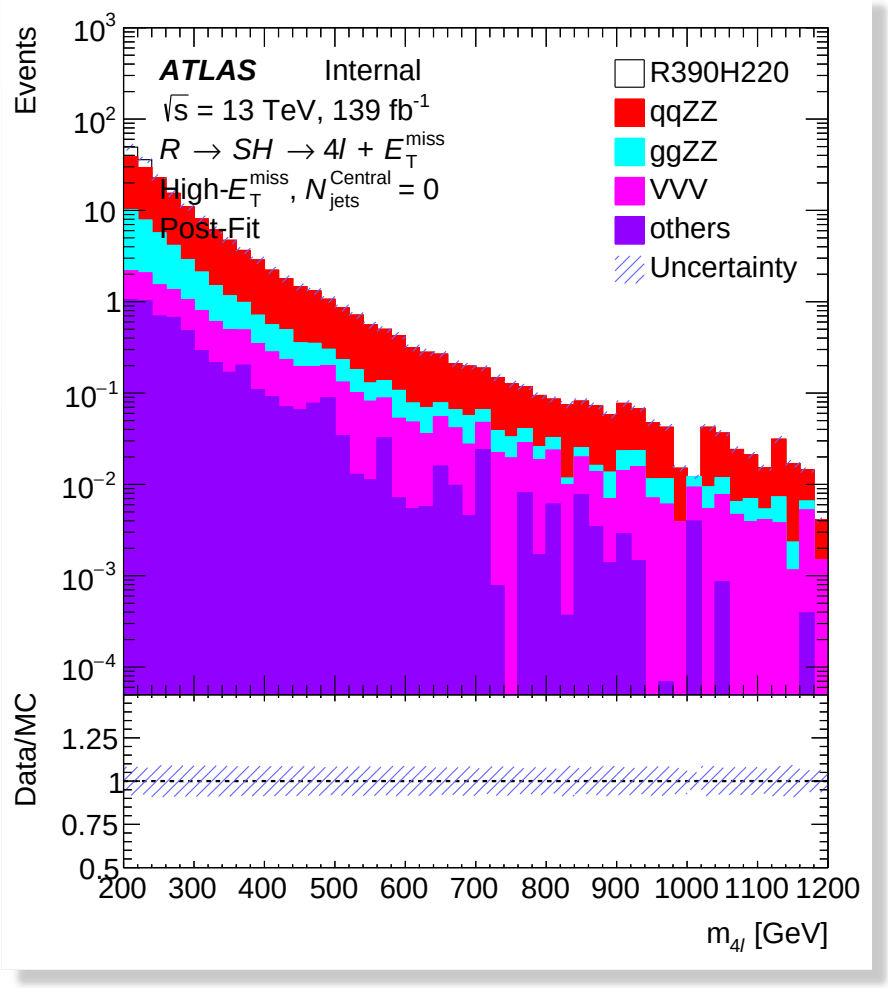


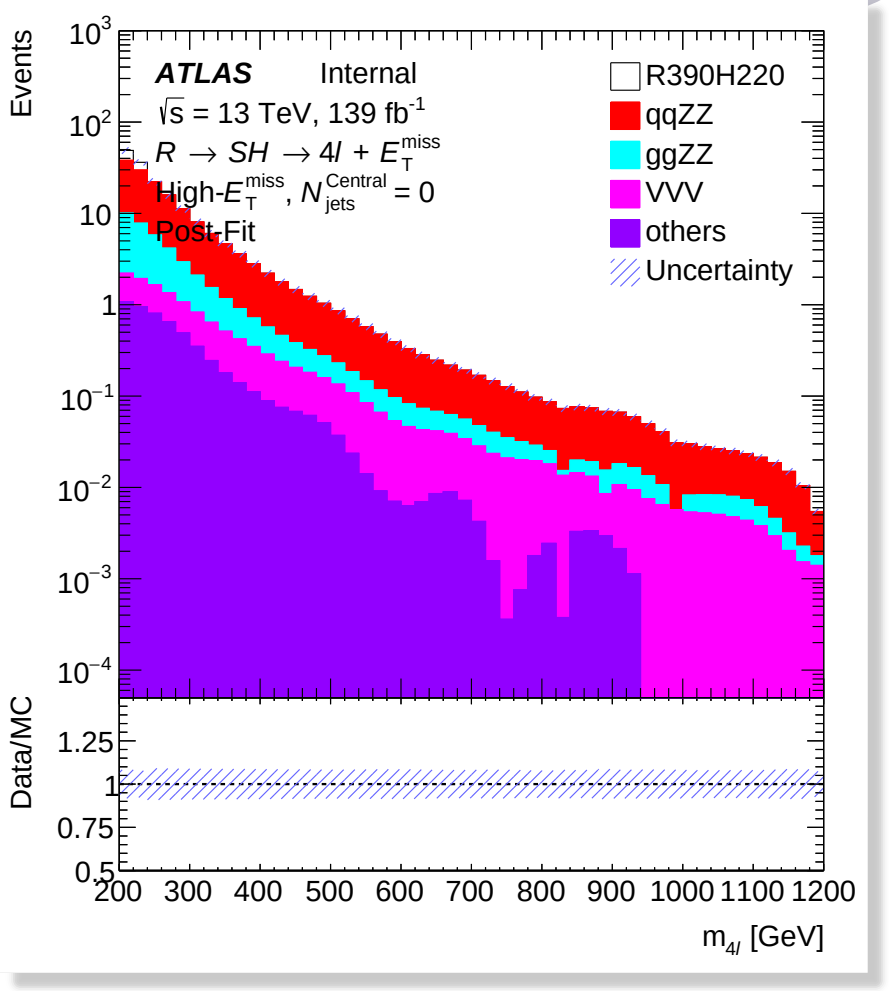


- The upper limit for the left (right) plot 0.388 fb (0.391 fb) at 95% CL
- For 10 GeV per bin, but the resolution of the signal is around 4.5 GeV

The fit result using MC histograms

Smoothing background histograms with 50 bins

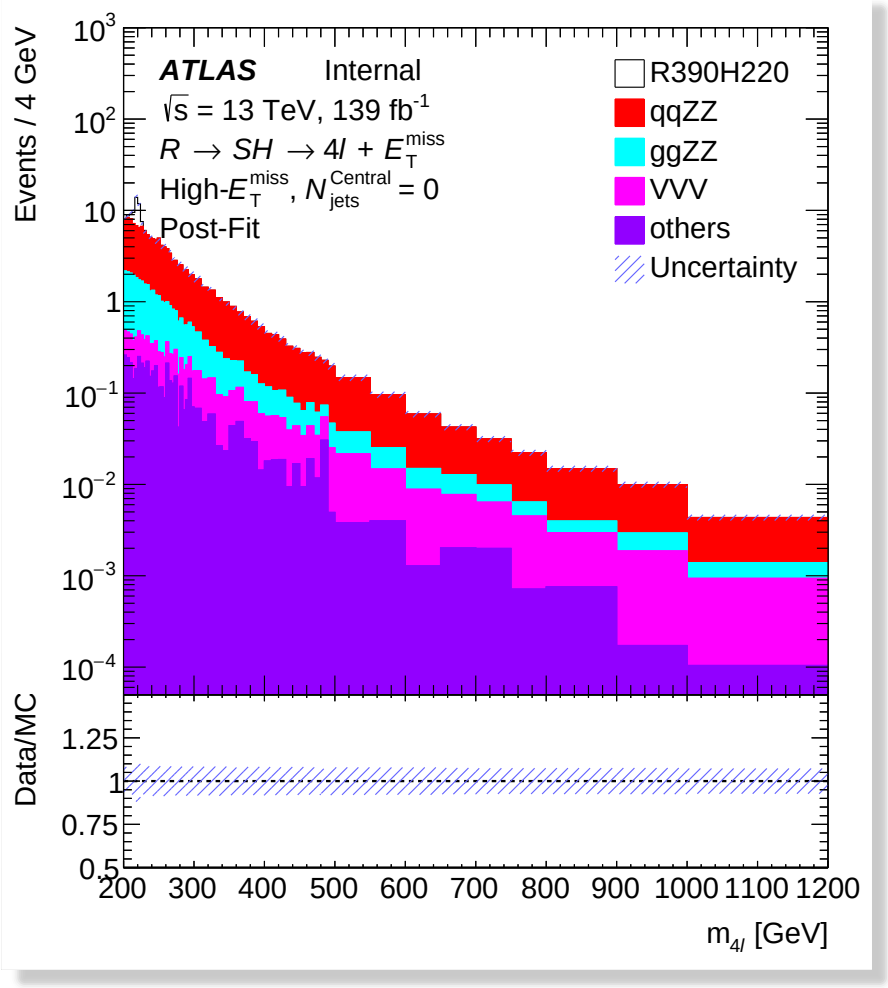


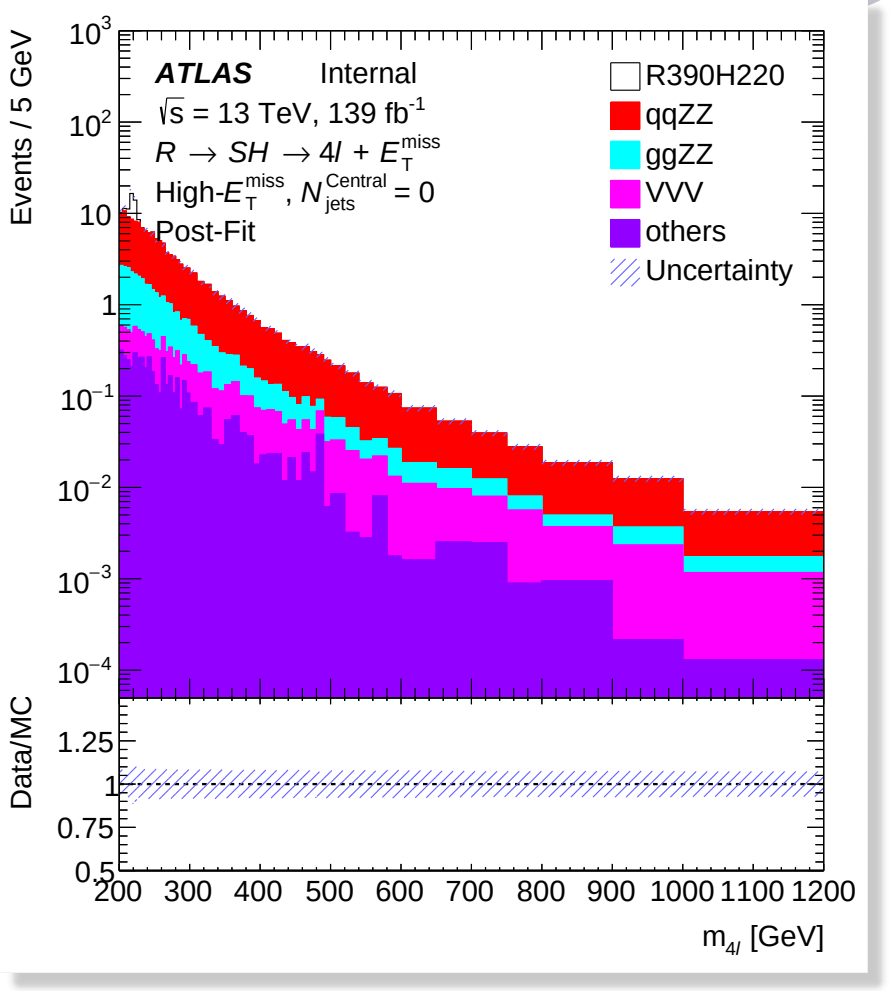


- The upper limit for the left (right) plot 0.563 fb (0.558 fb) at 95% CL
- This is not a good choice since the signal will be absorbed in the wider bins.

The fit result using MC histograms

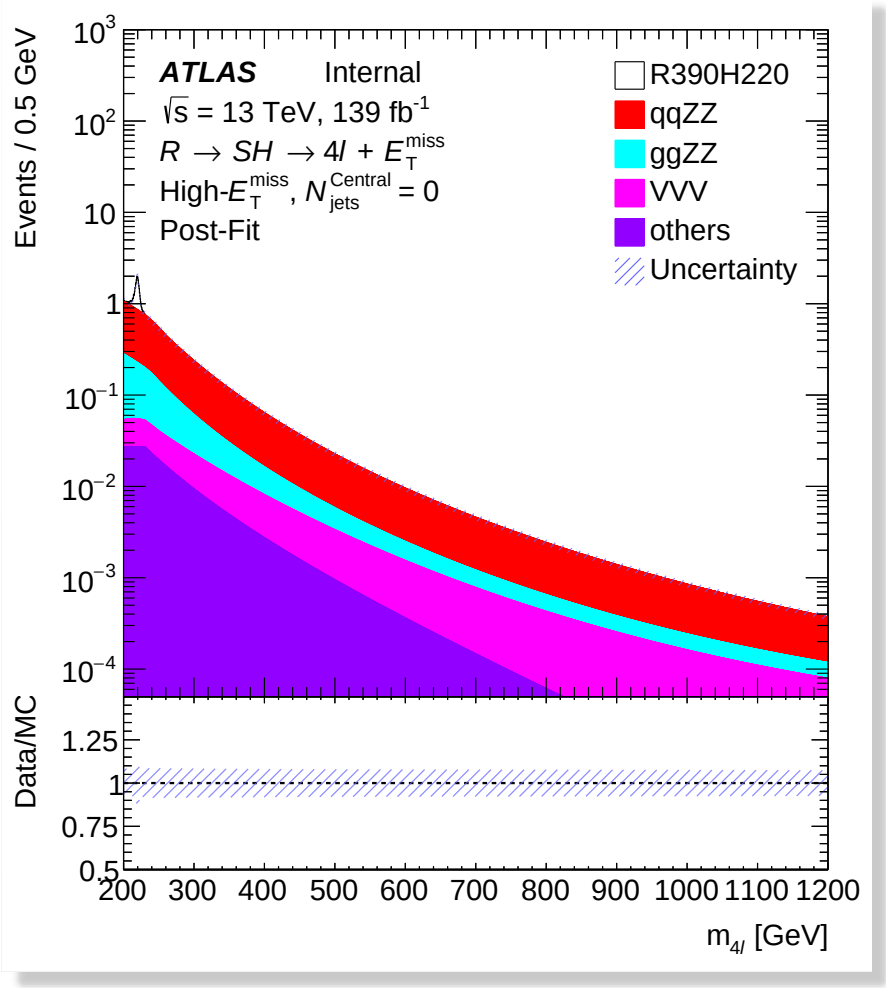
Using variable binning with finer bins around the signal

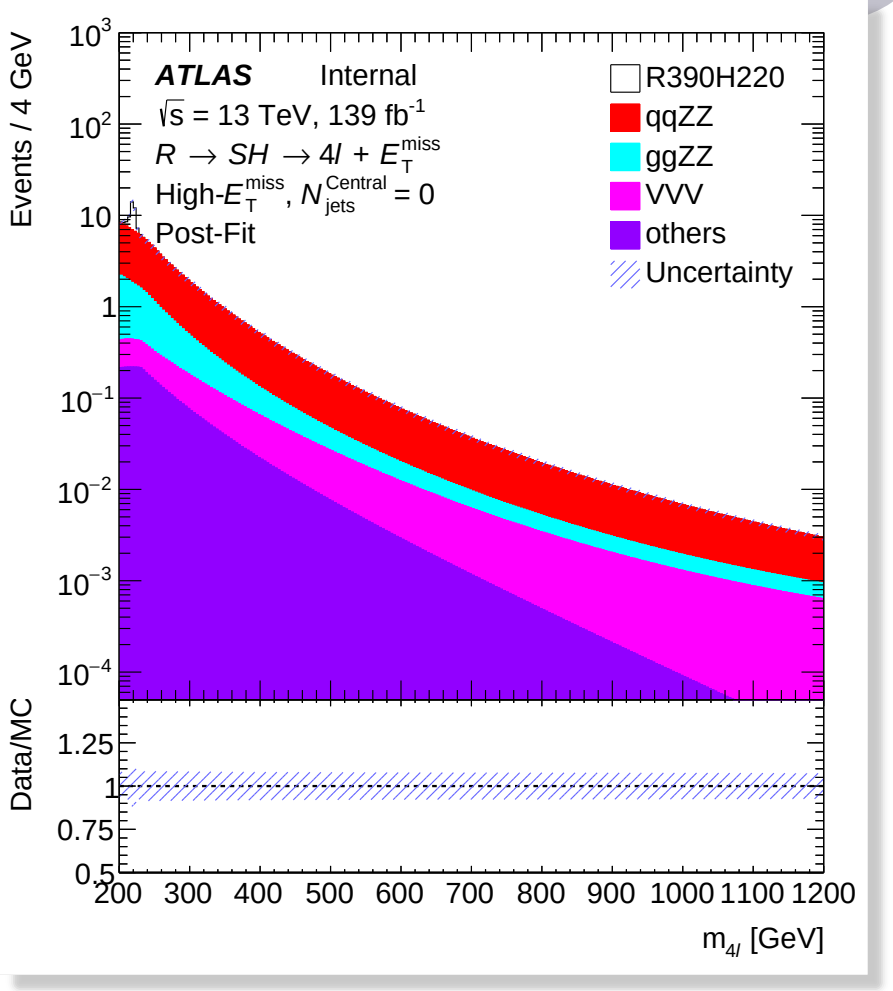




- The upper limit for the left (right) plot 0.315 fb (0.324 fb) at 95% CL
- This looks good, but it cannot be used with signals on the high mass tail.

The fit result using an analytical function





- The upper limit for the left (right) plot 0.305 fb (0.316 fb) at 95% CL
- We are currently using the left plot with 0.5 GeV per bin.
- The right one is with 4 GeV per bin but the limit becomes worse.

Signal Cut-flow starting from raw numbers

for the $(m_R, m_H) = (390, 220)$ GeV signal

	$2e2\mu$	$2\mu2e$	$4e$	4μ
Total	140000.0	140000.0	140000.0	140000.0
Preselection	99342.0	99342.0	99342.0	99342.0
Trigger	98962.0	98962.0	98962.0	98962.0
Lepton	40806.0	40806.0	16176.0	25743.0
SFOS	19107.0	21279.0	15631.0	25616.0
Kinematics	19088.0	21261.0	15622.0	25592.0
TriggerMatch	19088.0	21261.0	15622.0	25592.0
Z1Mass	19335.0	21356.0	28071.0	46736.0
Z2Mass	18799.0	20999.0	20730.0	34571.0
DeltaR	18720.0	20871.0	20706.0	34325.0
Iso	16392.0	18877.0	18831.0	30096.0
D0Sig	16088.0	18549.0	18701.0	29365.0
Vertex	16059.0	18516.0	18660.0	29270.0
Final	16054.0	18477.0	13985.0	21859.0

- Discussed this with Hadier:
  - All quadruplets at the Z1Mass are kept; that's why the numbers do not follow descending order.
  - It is just a convention we use and it will require a lot of changes to fix it in the cut-flow.
  - The HZZ fiducial selection is already added to Rivet as a code.

Summary

- Showing the signal injection test for the best fit μ instead of the upper limit.
- The analytical function describes the background better on the high-mass tail.
- Since the resolution of the signal is small fine binning is a better option.
- Although using variable binning with finer bins around the signal performs well for background histograms, this method will not work for signals peaking around 800 GeV, 900 GeV, or 1000 GeV.
- The upper limit degraded with a fewer bins.
- So the current configuration we use for the background is the best choice:
  - describe the backgrounds with an analytical function
  - using fine binning with 0.5 GeV per bin, and xmin=200 GeV and xmax=1200 GeV
- The cut-flow table is shown for (390, 220) GeV signal:
  - Still there's a problem with the Z1Mass cut.
  - It's a technical problem in the HZZ framework;
  - and it needs lots of changes to fix "Haider said".

Additional slides
Signal resolution