AZh Unblinding

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Unblinding

We open the box and . . .

- We found a bug in signal templates morphing, due to the introduction of variable binning for 4-body mass;
- mostly affects the 1D fit (cross-check), negligible for the 2D fit (standard);
- Bug fixed and we looked at data.

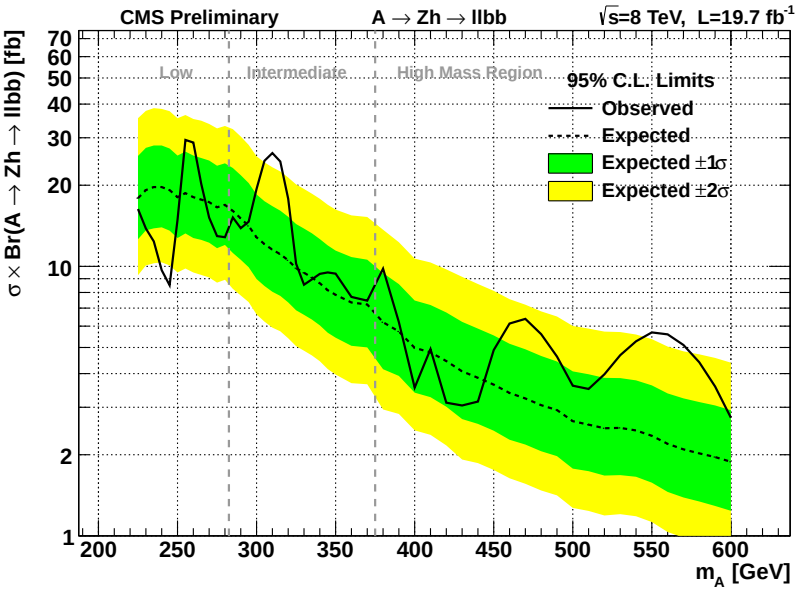
In the following, we show results for:

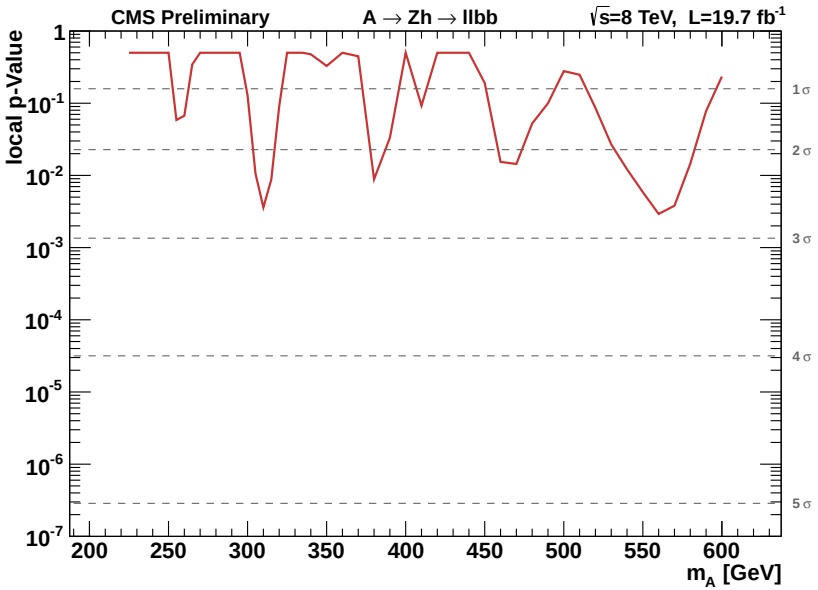
2D fit (BDT vs $M_{\ell\ell bb}$) - standard;

1D fit (cut on $BDT > 0.8$, and fit $M_{\ell\ell bb}$ only) - cross-check;

MA fit (cut on $M_{\ell\ell bb}$ close to M_A, and fit on BDT only) - cross-check.

2D fit



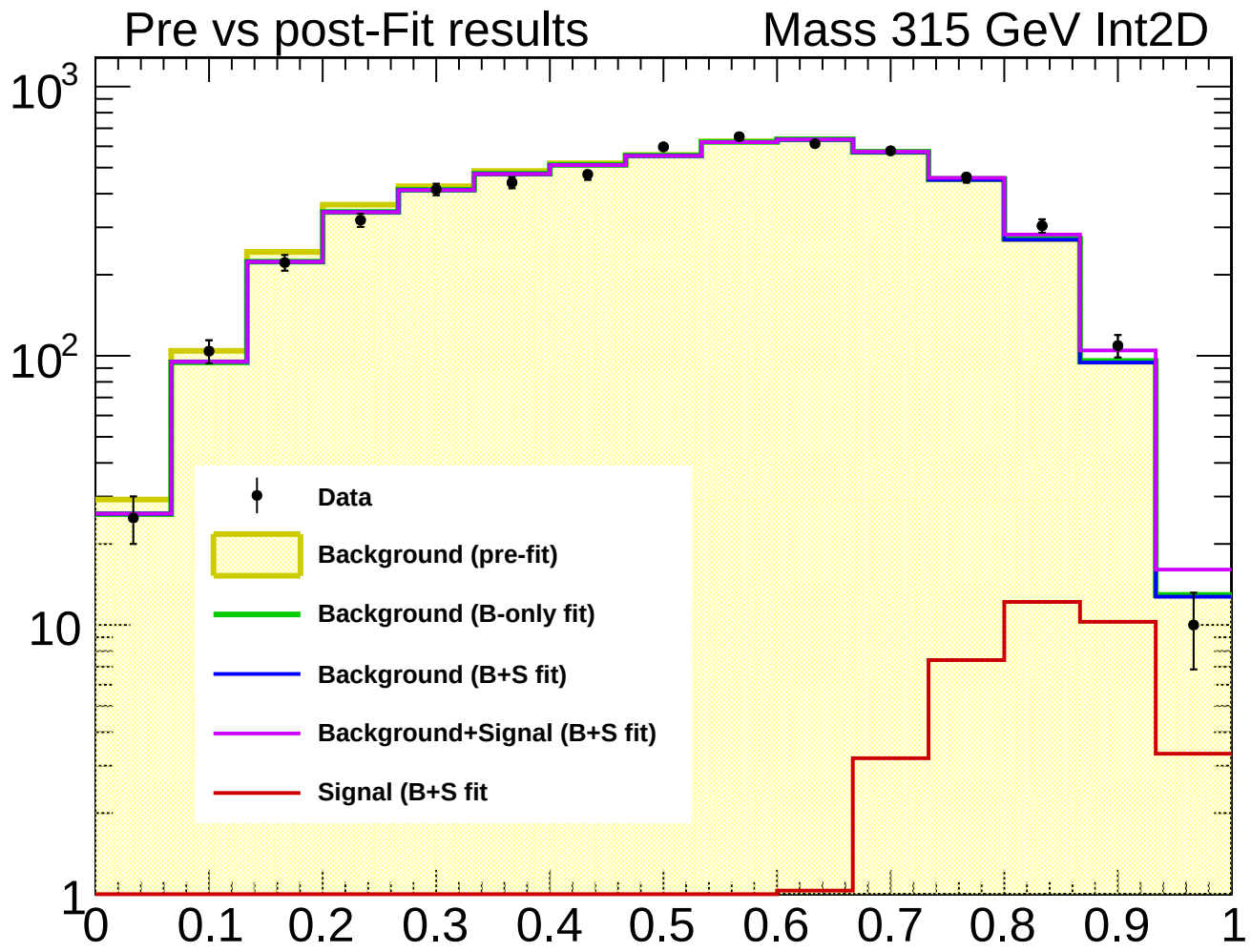


- $> 2\sigma$ fluctuations for $M_A = 315, 560$ (and 240)
- local p-value has 4 masses with p-value $> 2\sigma$
  - in two cases (380 and 450) where limit is well within 2σ from expected
- local p-value shows effect significantly larger than those seen in exclusion plot
- Pre and Post-fit results for interesting masses in next slides
- More mass points in separate slides slides [link] and web site [link][a]

[a] You need to filter by mass, since there are many plots

$M_A = 315\ GeV$: Pre and post-fit results 2D

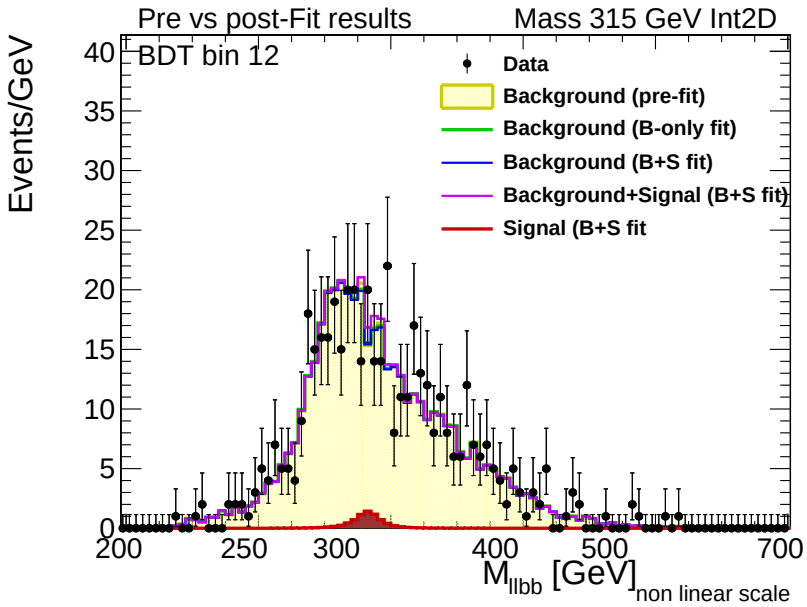
BDT distribution

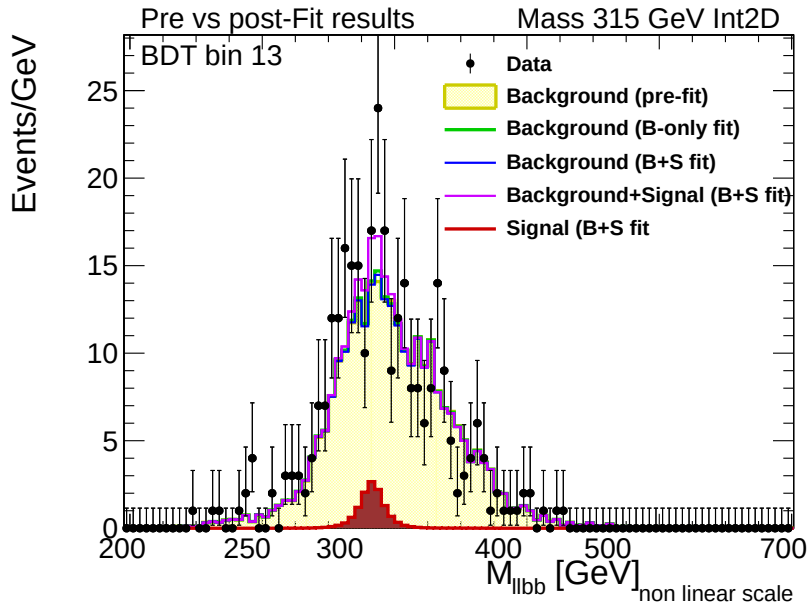


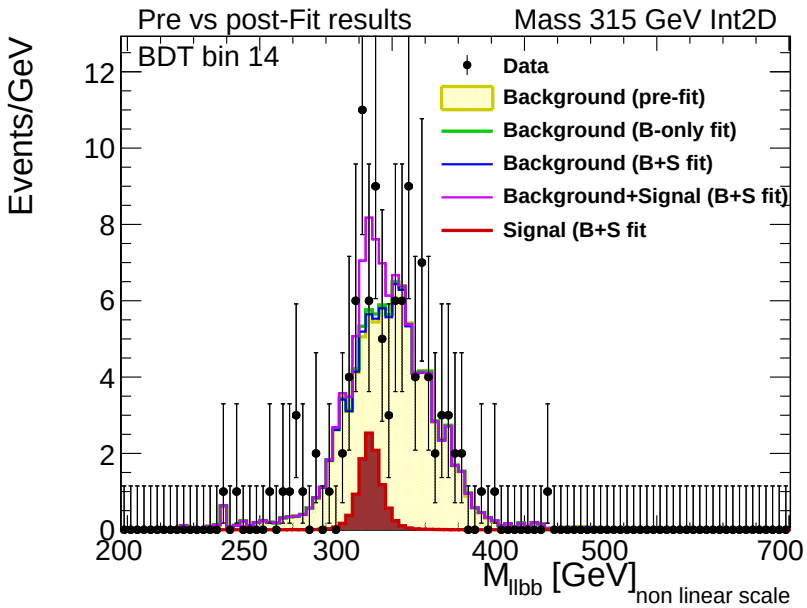
local p-value $\sim 2.7\sigma$

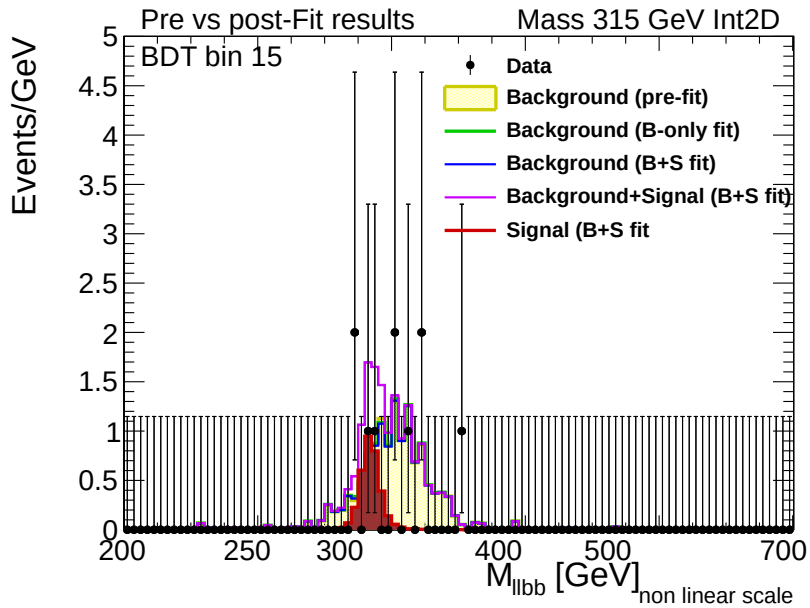
$M_A = 315\ GeV$: Pre and post-fit results 2D

$M_{\ell\ell bb}$ distribution for 4 last BDT bin





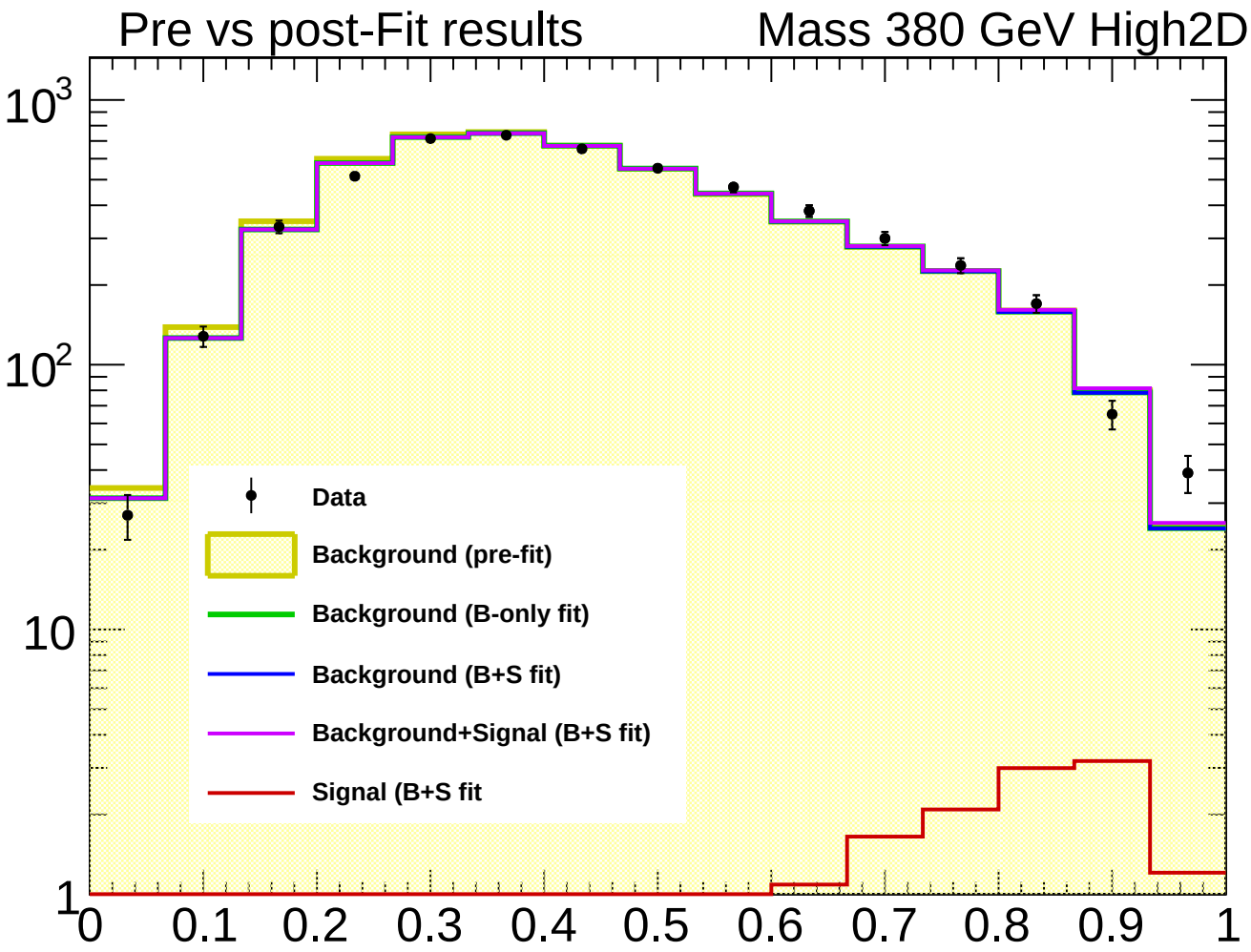




WARNING: x-axis labels are approximate!

$M_A = 380\ GeV$: Pre and post-fit results 2D

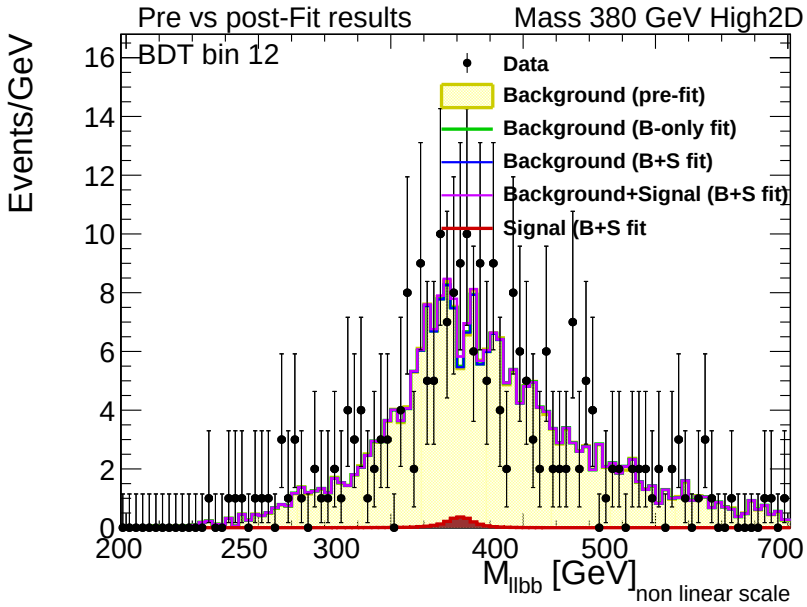
BDT distribution

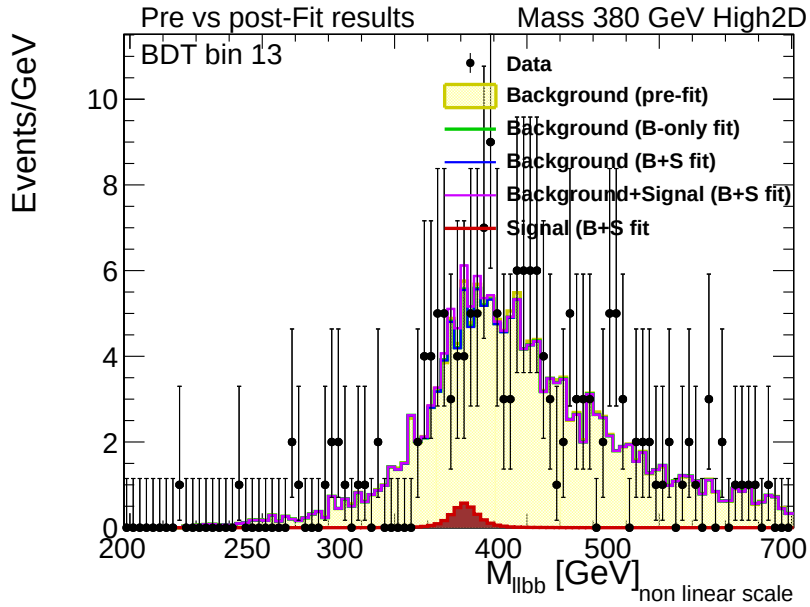


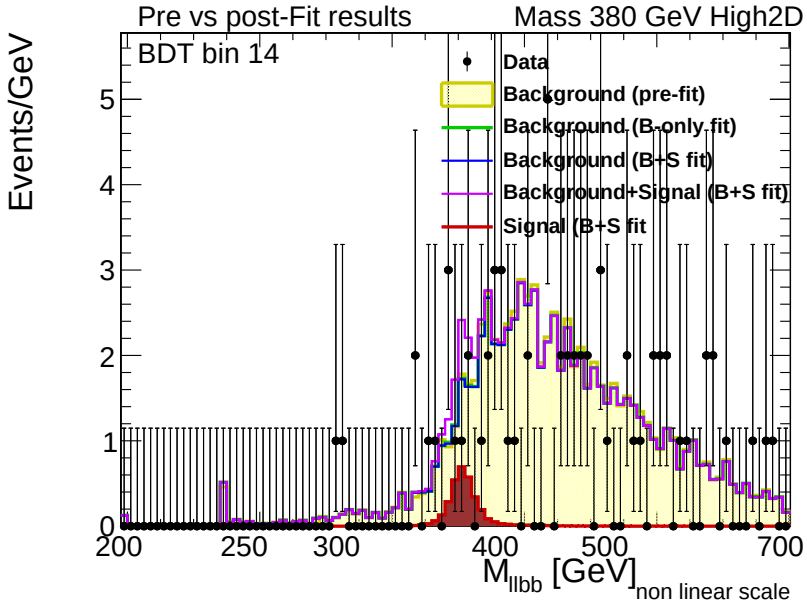
local p-value $\sim 2.3\sigma$

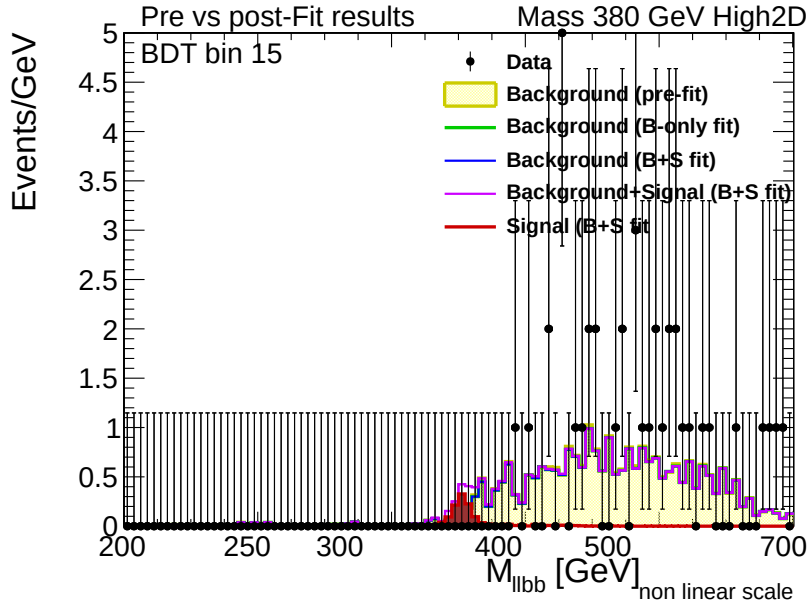
$M_A = 380\ GeV$: Pre and post-fit results 2D

$M_{\ell\ell bb}$ distribution for 4 last BDT bin



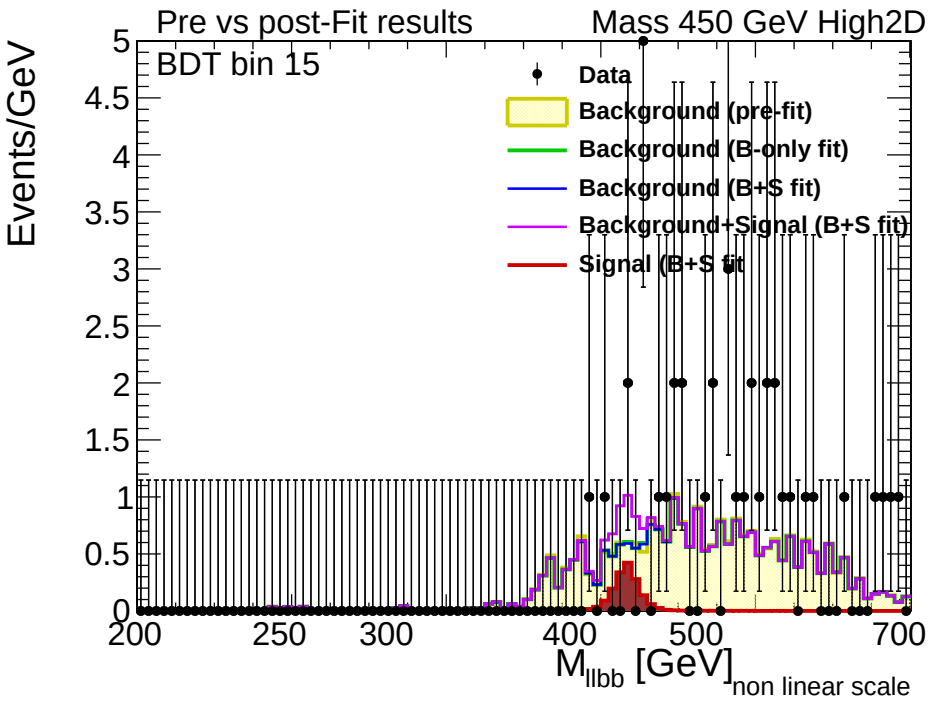


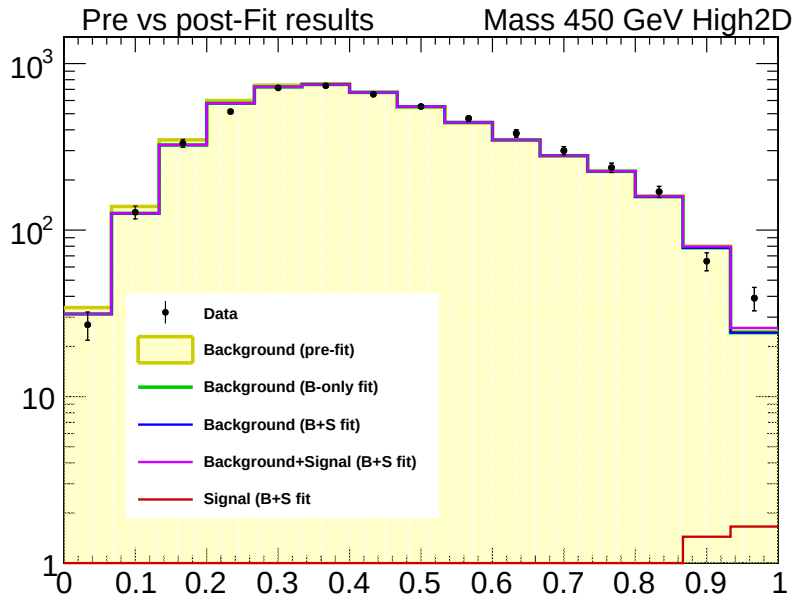


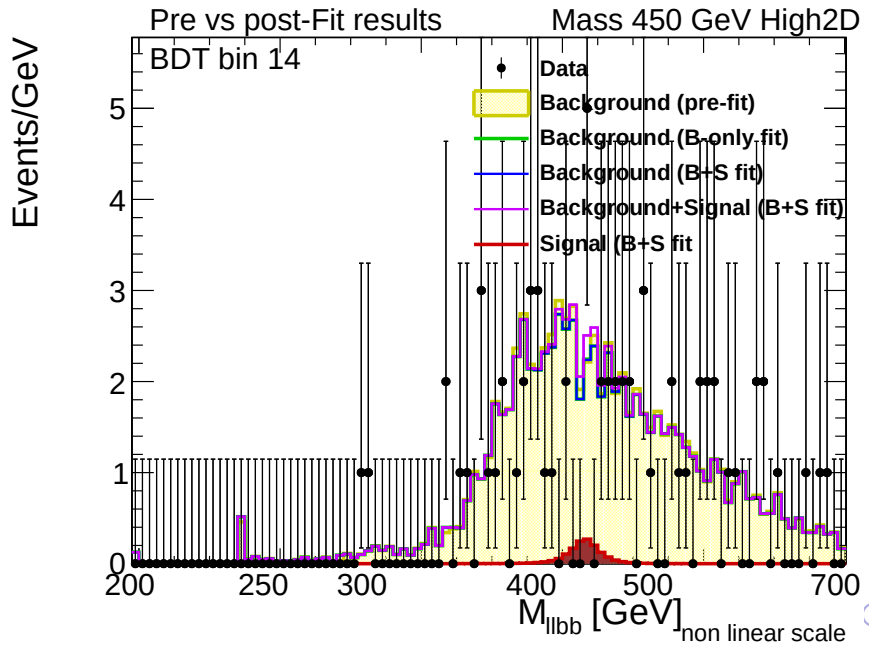


$M_A = 450\ GeV$: Pre and post-fit results 2D

BDT distribution and $M_{\ell\ell bb}$ distribution for 2 last BDT bin



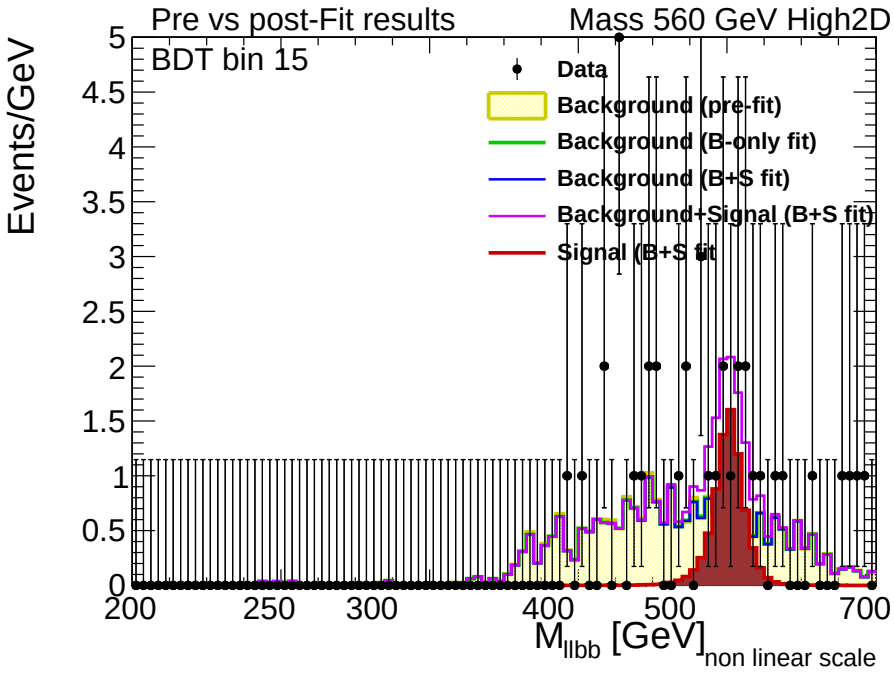


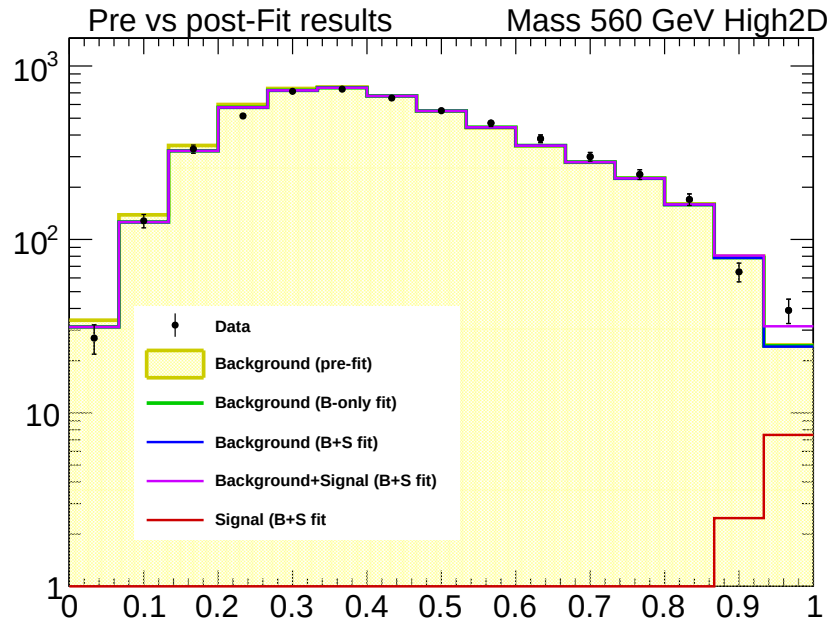


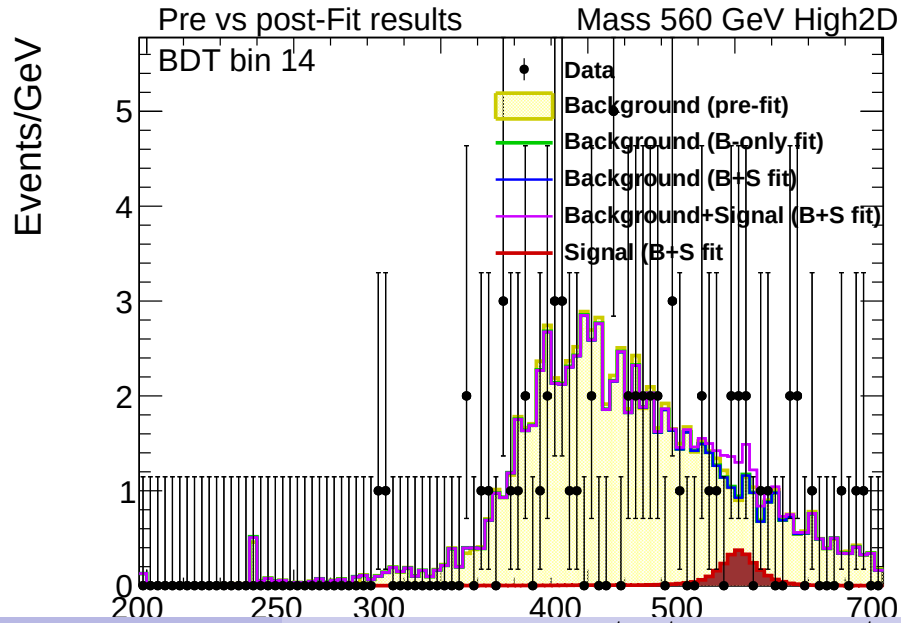
local p-value $\sim 2.1\sigma$

$M_A = 560\ GeV$: Pre and post-fit results 2D

BDT distribution and $M_{\ell\ell bb}$ distribution for 2 last BDT bin





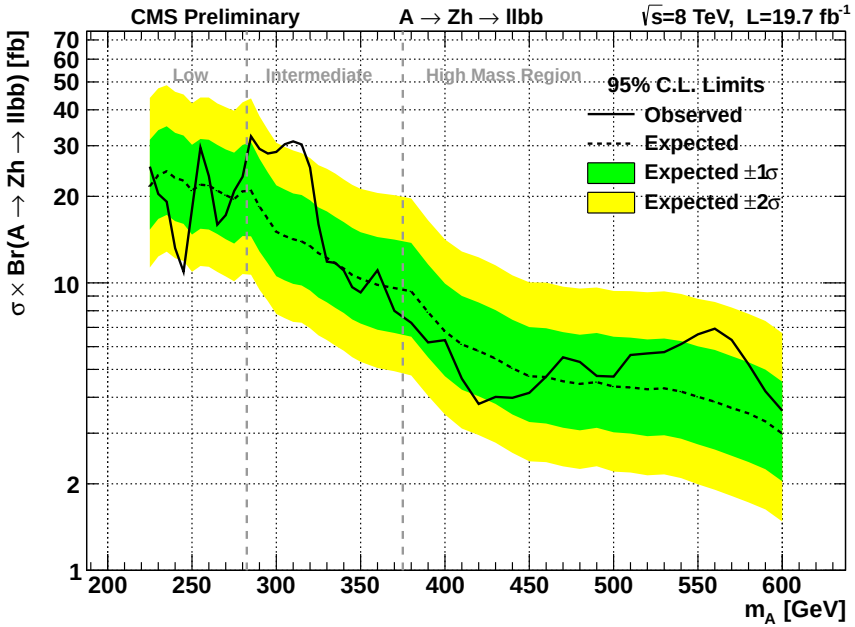


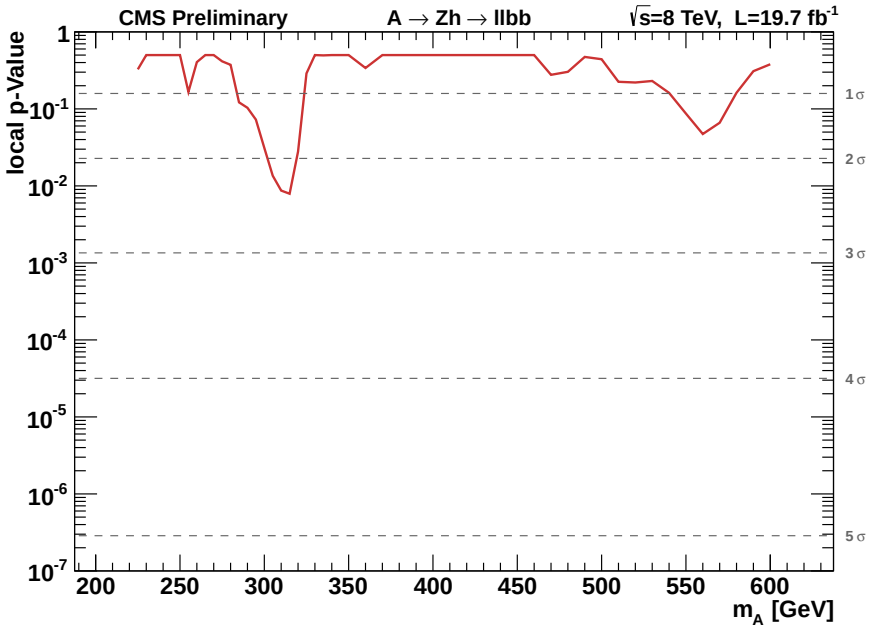
Signal only seen in last BDT bin

local p-value $\sim 2.8\sigma$

1D fit

cut on $BDT > 0.8$, and fit $M_{\ell\ell bb}$ only

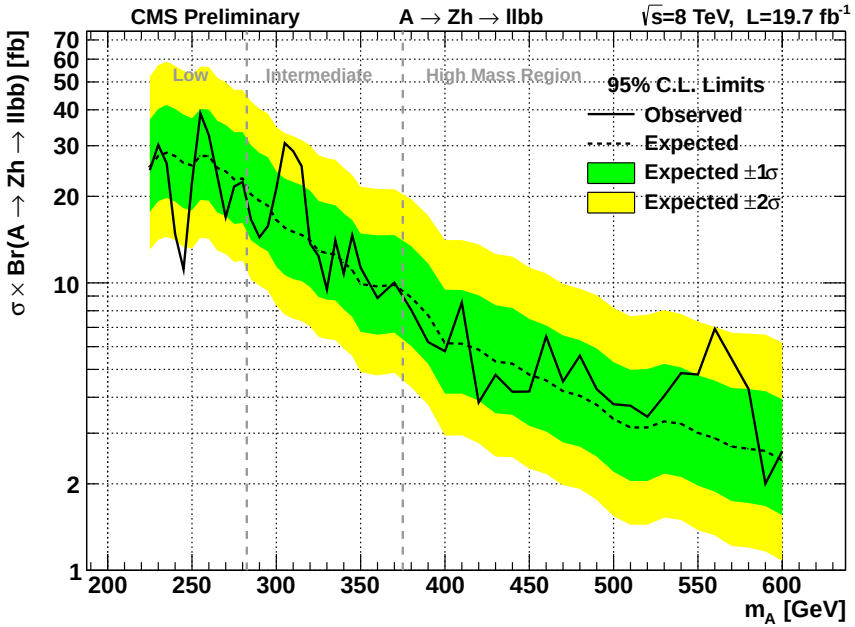


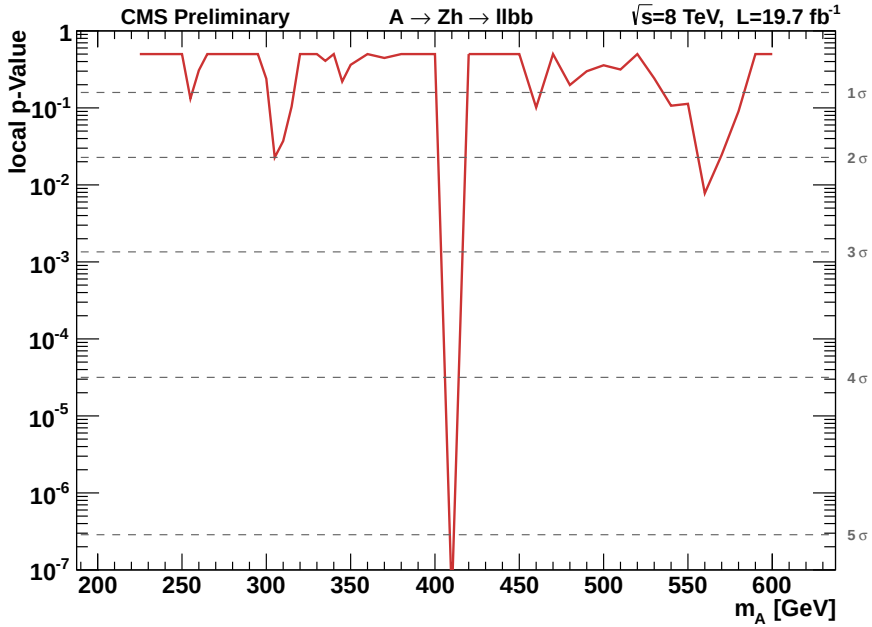


- Only 1 fluctuations around 2σ (315 GeV)
- local p-value coherent;
  - 550 is now about 1.5σ from expected.

MA fit

cut on $M_{\ell\ell bb}$ close to M_A, and fit on BDT only



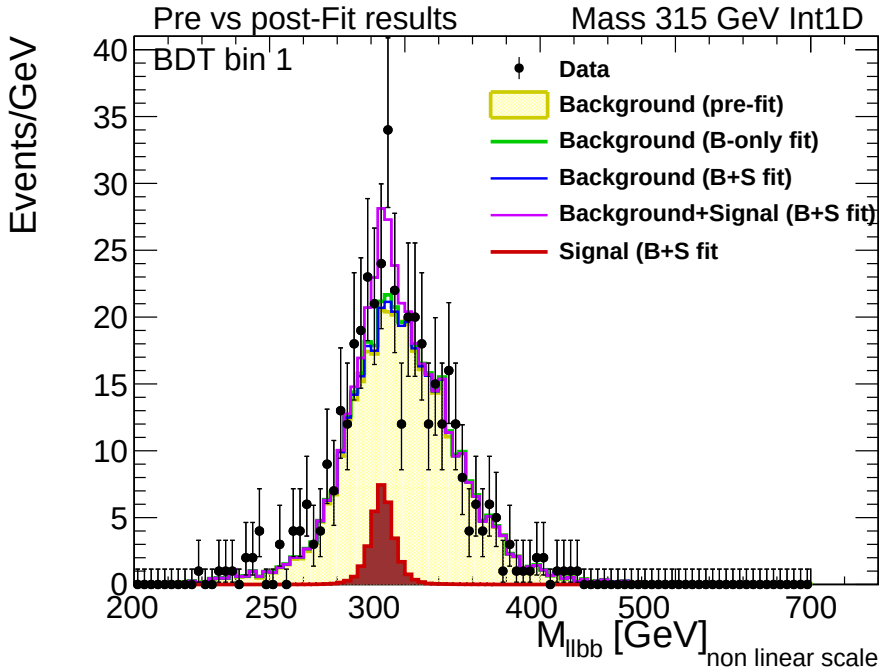


- Observed value on limit less smooth;
- 240 under-fluctuate, 310 is lower than 2σ, 550 about at 2σ;
- p-value coherent;
  - clearly a fit failure at $M = 410$: we did not investigate, as this is a cross-check.

$M_A = 315\ GeV$: Pre and post-fit results 1D and MA

1D fit

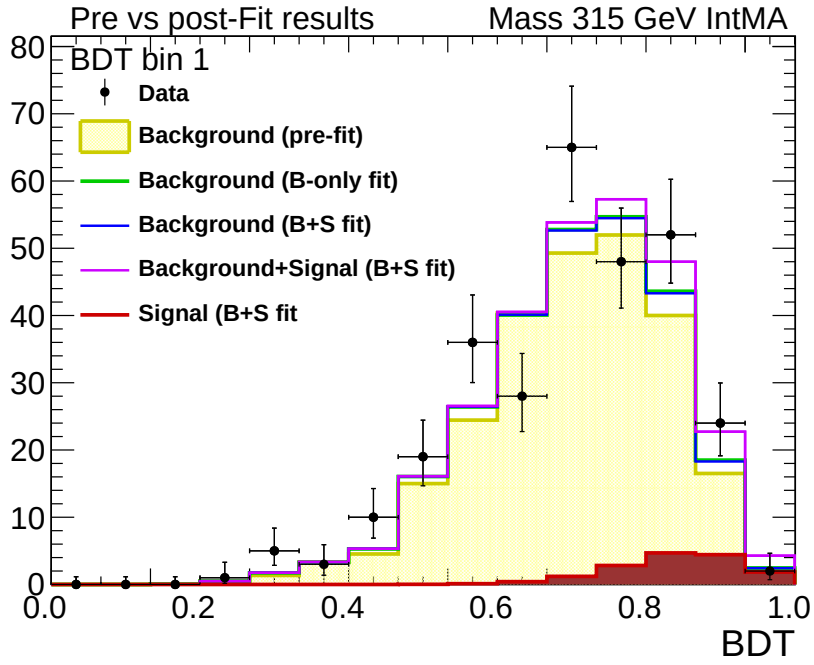
local p-value $\sim 2.3\sigma$



$M_{\ell\ell bb}$ distribution with $BDT > 0.8$

MA fit

local p-value $\sim 2\sigma$



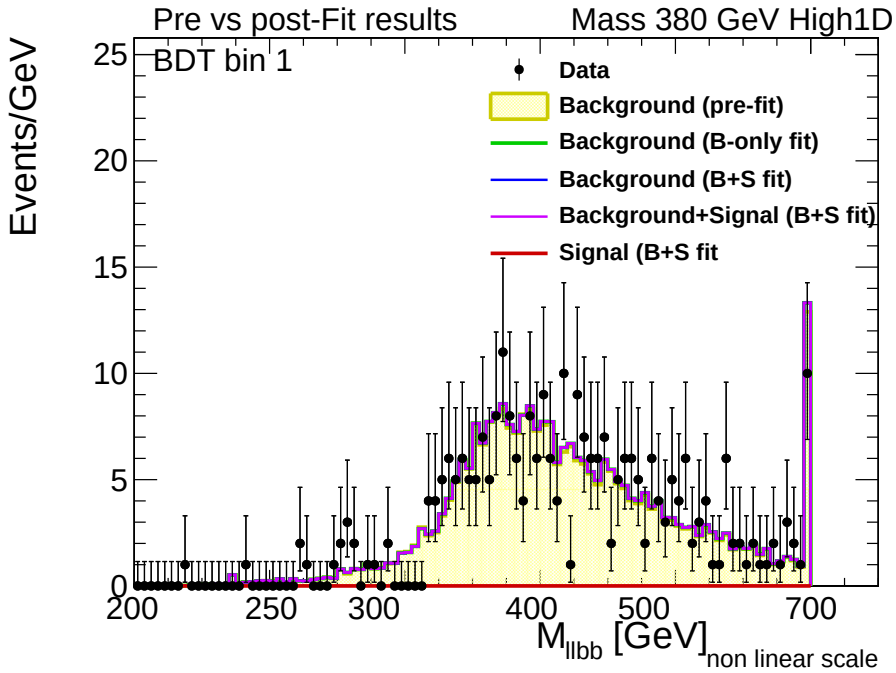
BDT distribution with $M_{\ell\ell bb}$ close to M_A

2D fit: local p-value $\sim 2.7\sigma$

$M_A = 380\ GeV$: Pre and post-fit results 1D and MA

1D fit

local p-value $\sim 0\sigma$

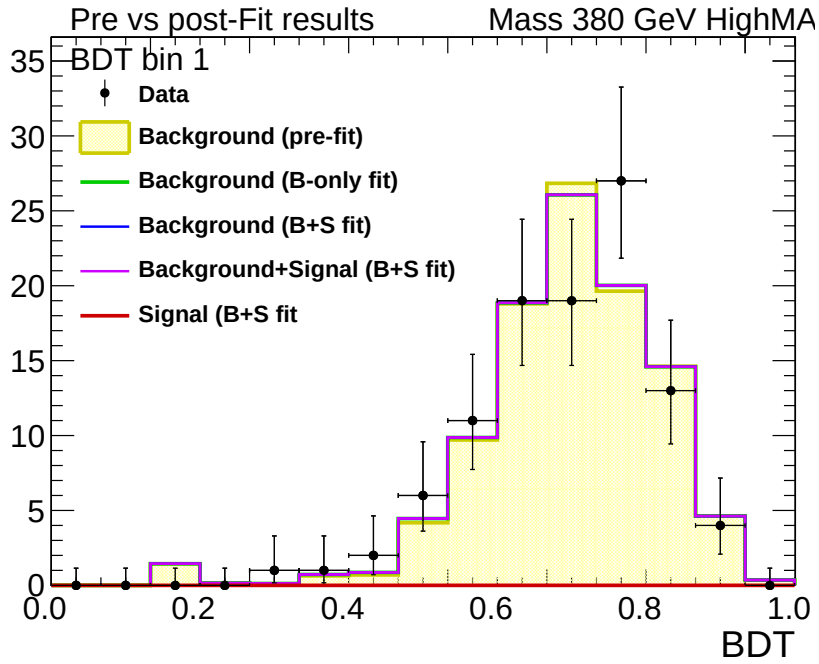


$M_{\ell\ell bb}$ distribution with $BDT > 0.8$

last bin is overflow bin

MA fit

local p-value $\sim 0\sigma$



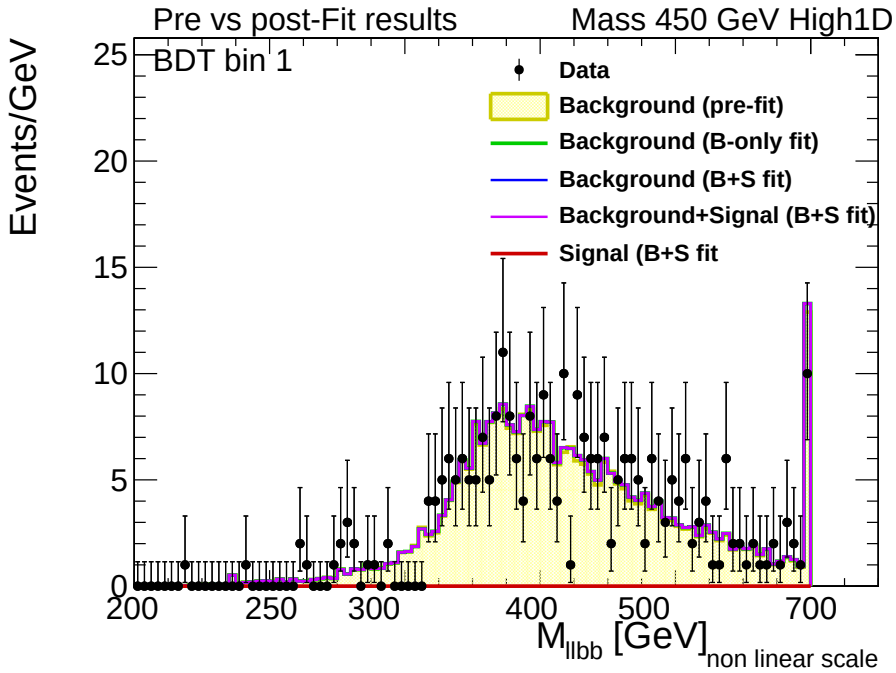
BDT distribution with $M_{\ell\ell bb}$ close to M_A

2D fit: local p-value $\sim 2.3\sigma$

$M_A = 450\ GeV$: Pre and post-fit results 1D and MA

1D fit

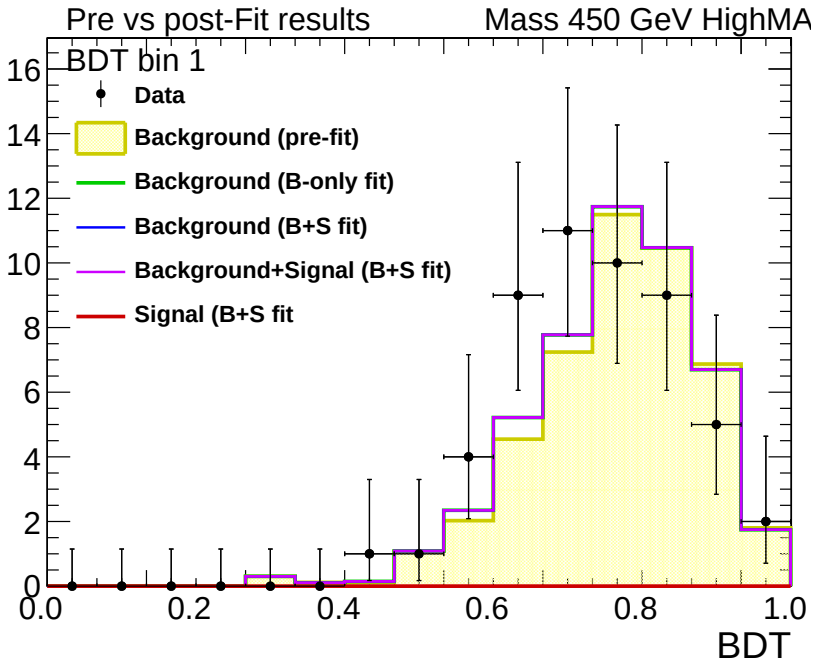
local p-value $\sim 0\sigma$



$M_{\ell\ell bb}$ distribution with $BDT > 0.8$

MA fit

local p-value $\sim 1\sigma$



BDT distribution with $M_{\ell\ell bb}$ close to M_A

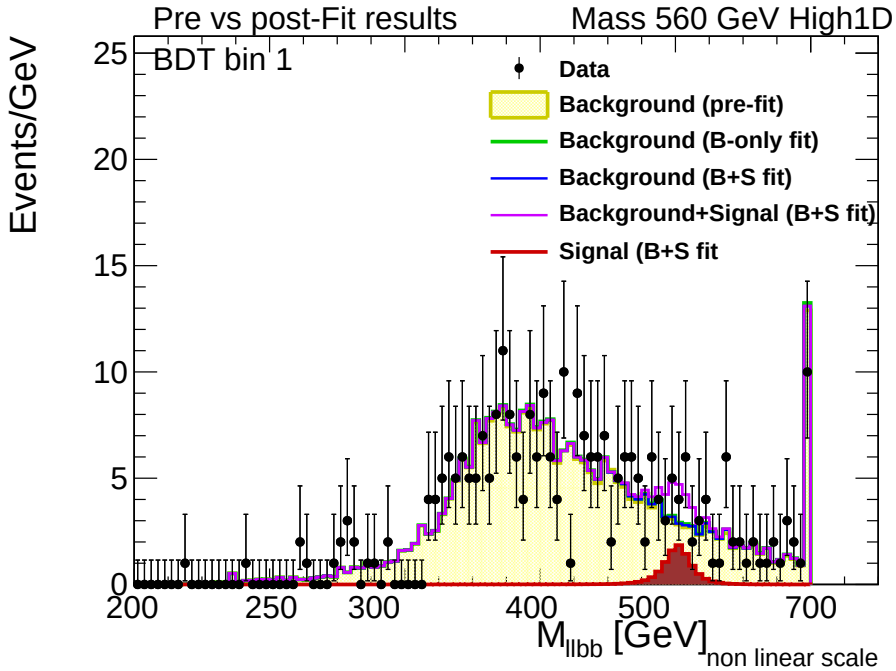
data and background pre-fit as before

2D fit: local p-value $\sim 2.1\sigma$

$M_A = 560\ GeV$: Pre and post-fit results 1D and MA

1D fit

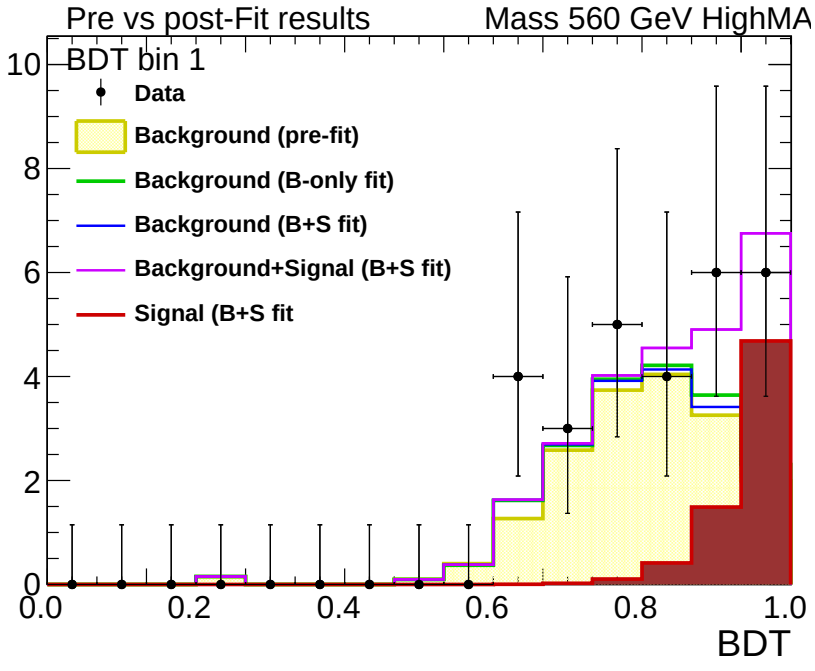
local p-value $\sim 1.5\sigma$



$M_{\ell\ell bb}$ distribution with $BDT > 0.8$

MA fit

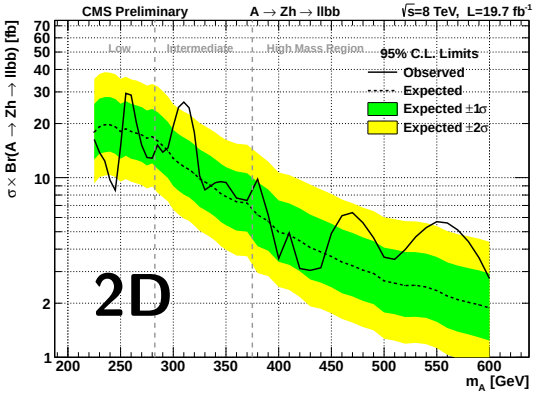
local p-value $\sim 2.4\sigma$

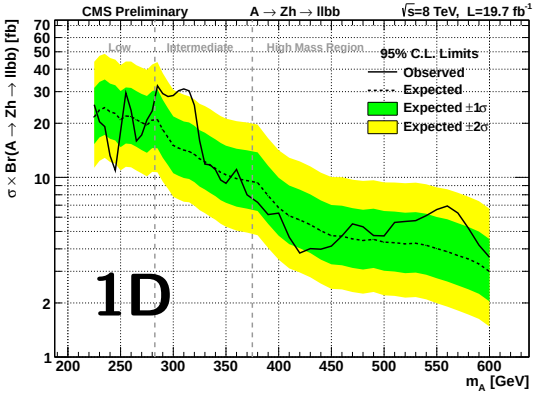


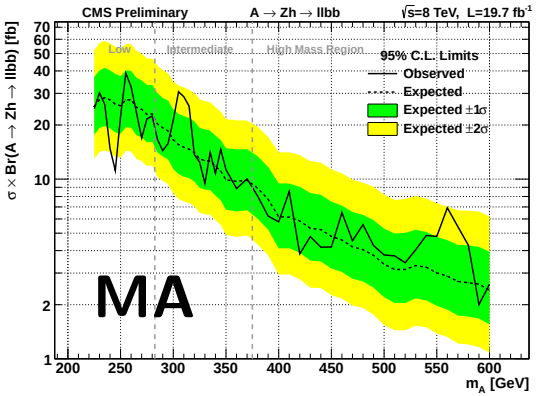
BDT distribution with $M_{\ell\ell bb}$ close to M_A

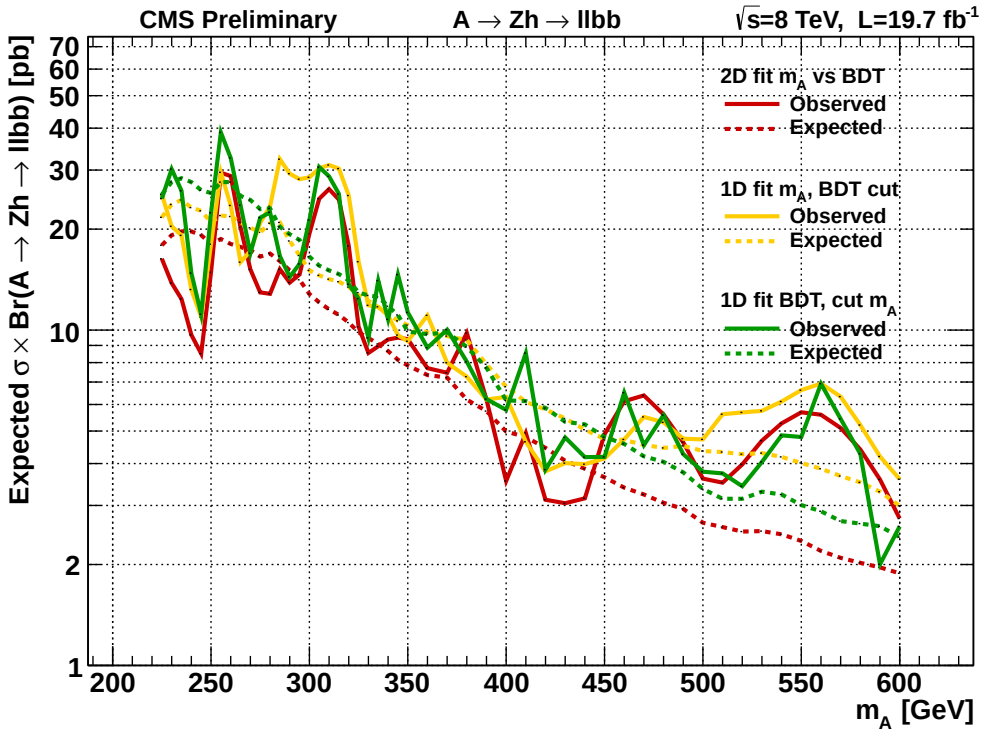
2D fit: local p-value $\sim 2.8\sigma$

Comparing 2D, 1D, and MA









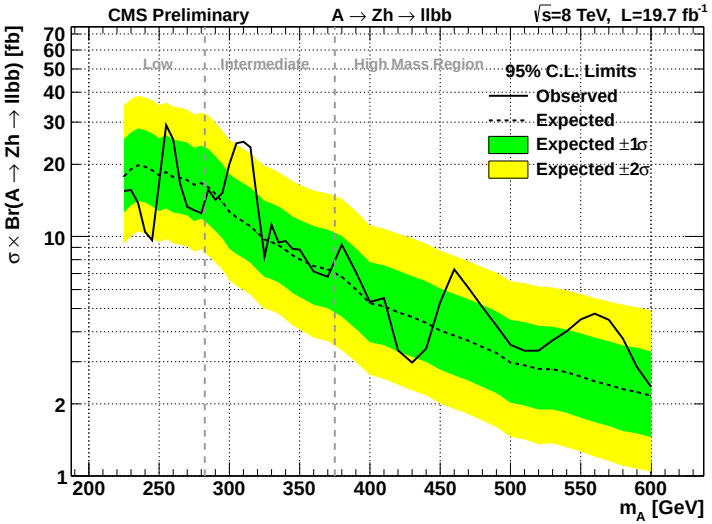
Within statistical fluctuation, the main features of the observed limits are similar for the 2D fit and the two cross-checks

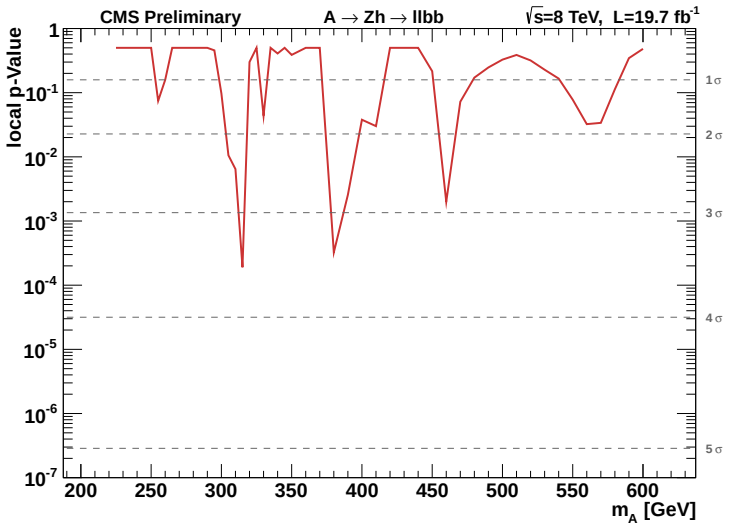
Something interesting (but not enough to be excited about) at $M_A \sim 310$, and maybe at 550

Issue with low populated bins

- The fit procedure `combine` produced a number of warning about bins where data where present but **all** background templates have no entries; A known problem for the fit.
- Looking at the raw histograms, we saw that the problematic bins are mostly in the last (highest) BDT bin and in the tail of the M_A distributions;
- To cure it, we tried to rebin the BDT histograms in order to populate more the last bin.
- Results in the next slides.

2D fit

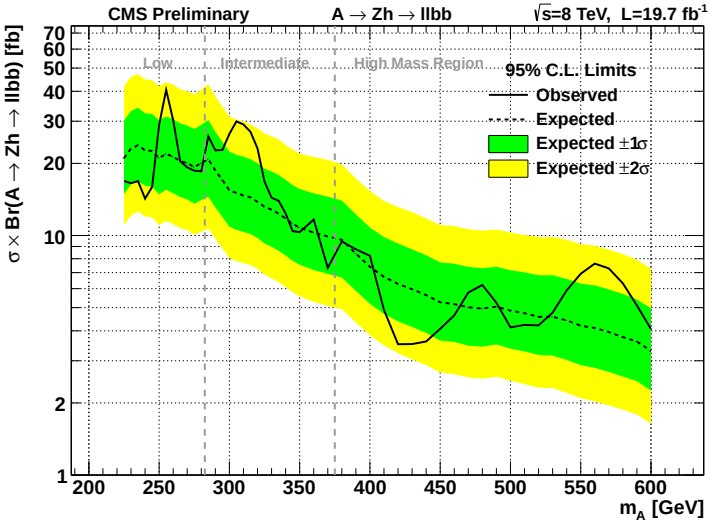


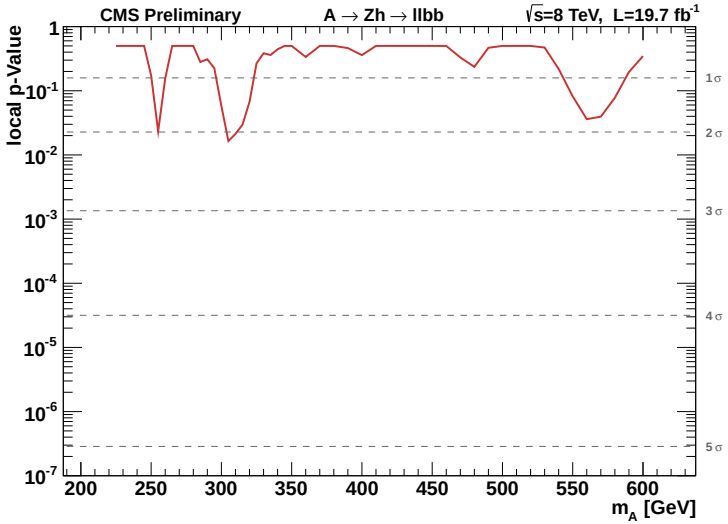


- Only one mass close to 2σ
- p-value has 3 masses with p-value $\gtrsim 3\sigma$!
  - at 315, the limit is $\sim 2\sigma$ (not 3!) above the expected one;
  - at 380, the limit is about the expected;
  - at 460, the limit is $\sim 1.5\sigma$ above the expected;
- local p-value are unreasonably small!
- Pre and Post-fit results in a separate slides [link] web site [link]

1D fit

cut on $BDT > 0.8$, and fit $M_{\ell\ell bb}$ only

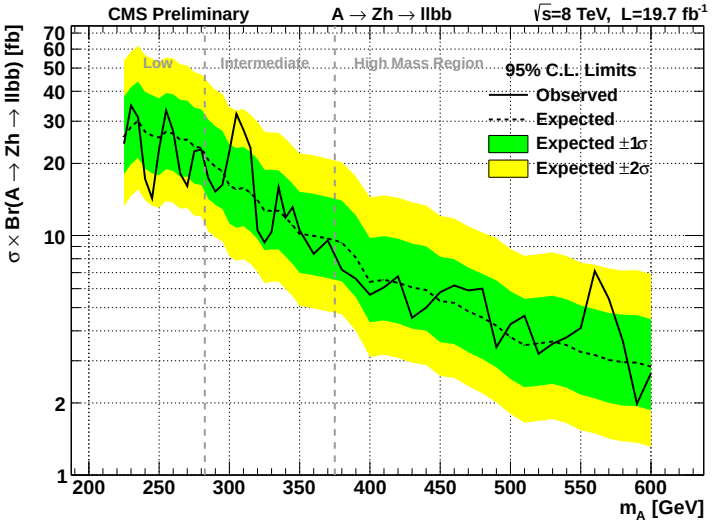


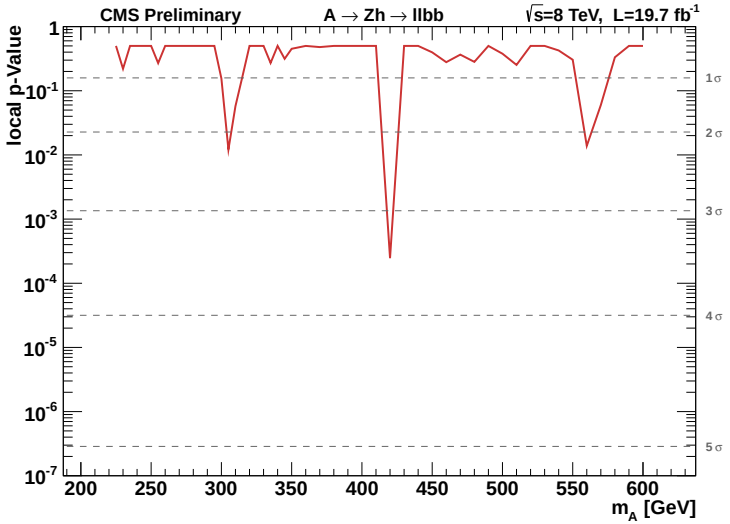


- More fluctuating than the original 1D limit;
- 2 fluctuations around $+2\sigma$ and one at -2σ;
- p-value coherent, around 2σ;

MA fit

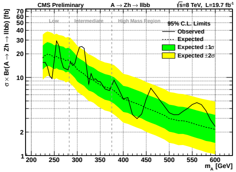
cut on $M_{\ell\ell bb}$ close to M_A, and fit on BDT only

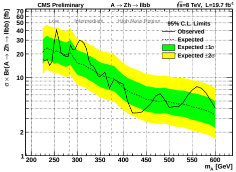


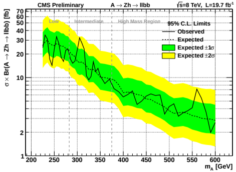


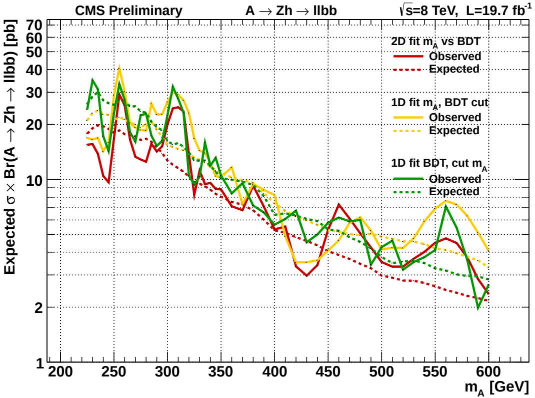
- As before, observed value fluctuate up and down quite rapidly;
- 240 under fluctuate, 310 is lower than 2σ, 550 about at 2σ;
- p-value coherent;
  - Strange $< 3\sigma$ for 420, where the limit is as expected.

Comparing 2D, 1D, and MA









As before, within the statistical fluctuation, the three observed limits behaves coherently

Conclusion

- We found a bug in signal templates interpolation after unblinding: fixed it, no major effect;
- We performed the requested cross-check with 1D fit (in two different ways) and found coherent results;
- For same mass points, local p-value are not coherent with the observed/expected exclusion limit
- We did also a rebinning test on BDT to check if it makes a difference, but again the results are coherent;
- We have some fluctuation at $M_A \sim 310\ GeV$, not big enough to be really excited about.