The EFT samples for each parameter S0, M0, M1, T0, T1, T2 are fitted against the combined SM and GM Resonance data. It is assumed that the coefficients are only affected by anomalous QGC (aQGC) couplings. Only one coefficient is fitted at once while the other coefficients are set to zero. As discussed in section **??** good fits are expected for sufficiently high resonance mass. The fit can't identify small energies or high energy with small cross-sections resonances as shown in 0.1[1].


(a)   **(b)**   **(c)**
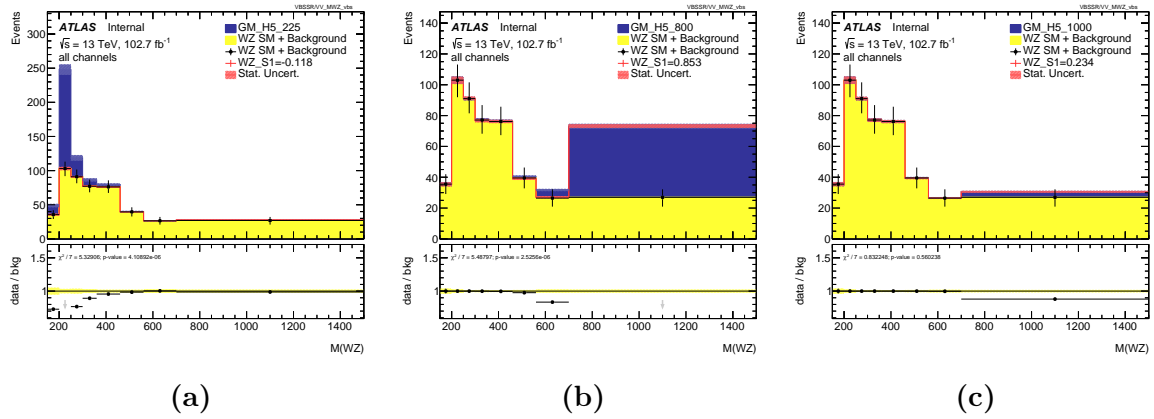
Figure 0.1: a) The invariant Mass of the resonance has approximately the same energy as the WZ peak but for the WZ peak the EFT prediction should be the SM therefore EFT can't describe the 225 GeV Resonance and the coefficient fit diverges. **b)**800 GeV has a high cross-section and the energy is in the region where SM and EFT deviate therefore the coefficients can be fitted accurately. **c)**1000 GeV the cross-section(scaled by 0.5) is to low the fit can produce a significant result even though the Resonance is in the right Energy region.

Evaluating which fit is good can be done qualitative by simply looking at the invariant mass plots if the EFT sample scaled with the best fit value is able to describe the resonance one can argue that the fit is good. But this is not accurately possible for resonances peaks that are higher energy than the $W^\pm Z$ peak, but the start of the peak is still part of the $W^\pm Z$ peak.

For a quantitative analysis the significance quotient has to be calculated from the likelihood ratio $f(\mu) = -2\Delta log(L)$ where μ is the signal strength. The significance can be calculated using $Z(\mu) = \sqrt{f(\mu)}$ resulting in $S = \frac{Z_{GM}(0)}{Z_{EFT}(0)}$. Here Z_{GM} is the significance when the GM sample is used as coefficient in EFTFun [1] and fitted with SM as measurement and as prediction. The Z_{EFT} is the fit of an EFT coefficient for the SM combined with the GM model as measurement against the SM as prediction. $f(0)$ can be interpreted as the difference to the SM, if $f(0) = 0$ only the SM was measured. If $f(0) > 0$ there is an EFT, GM which is more likely than the SM. For $f(0) > 4$ the SM is excluded. The value of $\mu = 0$ can be read off from the log-likelihood ratio plot in 0.2. The scale is dependent on the operator as well as the allowed range making it difficult to estimate a read off error. The error can be minimized by

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[1]Technical reasons cause the ratio plot to display the wrong errors

looking at positive and negative extrema and limiting the range to zero as well as the shape including both extrema. Since the likelihood-function is continuous all plots give the same $f(0)$ value. All three ranges should be used in case only an extremum exists, or only one is recognized by the fit this is often the case for low energy resonances. Using this the error becomes small compared to the statistical errors. All EFT coefficients in 0.3 with $S > 0.8$ are able to reproduce the statistical significance of the GM model to more than 80% certainty.


(a) S1 Asmiov fit   **(b)** 700 GeV GM   **(c)** S1 for 700 GeV
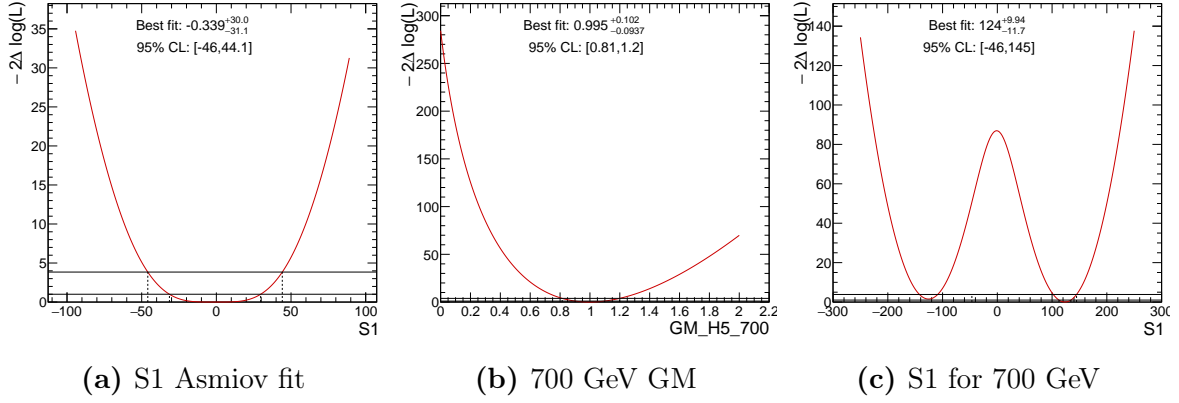
Figure 0.2: a) The best fit value is zero since the SM is reproduced in the Asimov fit. **c)** The SM is excluded, and two extrema emerge from the inclusion of the quadratic operator therm.

(a)   **(b)**
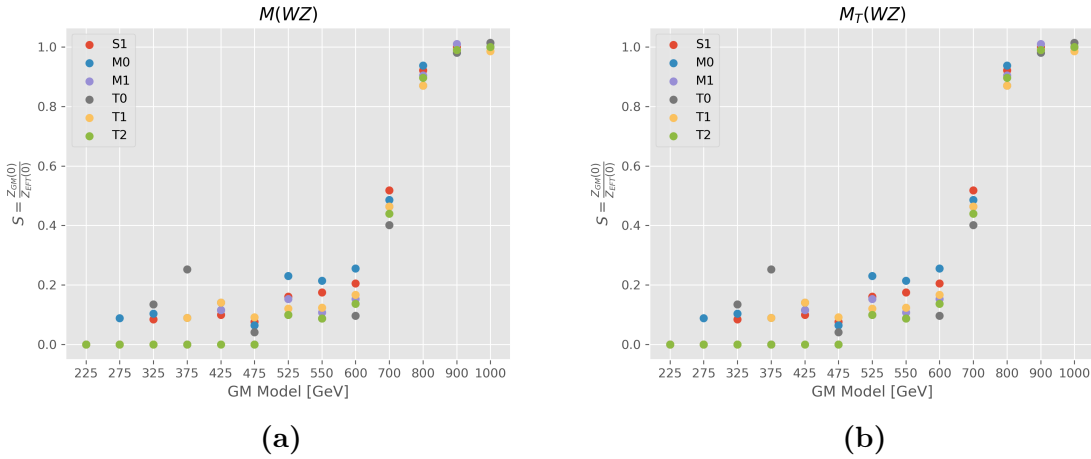
Figure 0.3: a) EFT coefficients significance for invariant Mass b) EFT coefficients significance for transverse Mass. Plots for all operators indiviualy are shwon in appendix **??**

The result is independent of the resonance cross-section. This can be shown by scaling the resonance, in 0.4 the cross-section is scaled with 2 and 0.5 which results in equal significance compared to the non-scaled resonances. The cross-section can not be scaled higher without breaking the fitting-tool as the values get unreasonably high. In the invariant mass plot for 0.5 times the cross-section, the cross-section becomes too low to be picked up by the fitting tool. In the transverse mass plot the resonance is shown to be picked up and described by the coefficients M0, T0, T1 this however is falls as these did not pass a qualitative analysis without scaling.
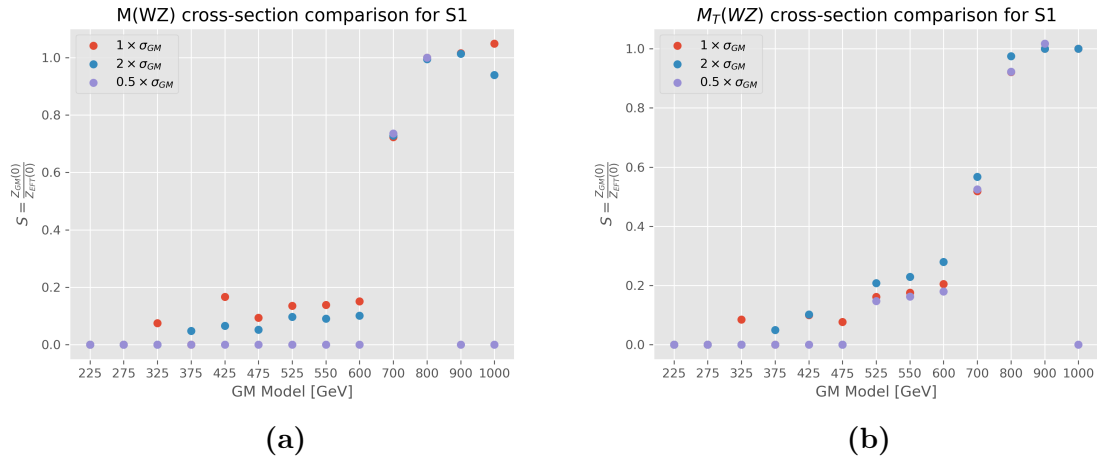
Figure 0.4: a) EFT coefficients significance for invariant Mass **b)** EFT coefficients significance for transverse Mass. The comparison for all operators is shown in **??**

The 700 GeV sample has a significance of $0.7-0.8$ making it irrelevant for this analysis but with the high dependence on the binning one may be able to get a significant result by optimizing the binning. The EFT limits for relevant resonance masses are shown in tabular 0.1. The limits for both extrema should be equivalent but the EFTFun only expects one extremum when fitting and therefore includes the second extremum in the 95%CL if the second extremum is to close to the first extremum. In order to find both extrema the range from a minimal range to zero for the negative extremum and from zero to a positive minimal range. The minimal range should leave space for the fit to find the best fit value. T0 doesn't show this behaviour which is likely caused by the larger uncertainties shown in 0.5 and 0.6. A full set of all parameters and both invariant mass and transverse mass are shown in 0.5 and 0.6 for an 800 GeV resonance as this is the resonance with the lowest energy and statistical significance. Other significant resonances are shown in the appendix **??**. For the 1000 GeV resonance the coefficients T1, T0 in the invariant mass plot as well as M0, T0, T1 in the traverse mass plots could not be fitted as the cross-section is too small.

			$M(WZ)$			
Mass	S1	M0	M1	T0	T1	T2
positive extrema						
800 GeV	[89,129]	[20,28.4]	[29,42.4]	[2.1,2.8]	[1.4,2.01]	[4.1,6.03]
900 GeV	[-10,76.8]	[1.1,17.2]	[-0.41,25.3]	no extrema	[-0.057,1.18]	[0.035,3.56]
1000 GeV	[-447,71.7]	[281,16.2]	[-207,23.6]	no extrema	[-0.5,1.1]	[-8.2,3.32]
negative extrema						
800 GeV	[-130,-90.4]	[-27,-18.4]	[-43,-29.6]	[-1.9,-1.11]	[-2.1,-1.48]	[-6.3,-4.37]
900 GeV	[-78,248]	[-16, -0.115]	[-26,0.329]	[-0.89,0.109]	[-1.3,0.0591]	[-3.8,0.186]
1000 GeV	[-73,1096]	[-15,5.52]	[-24,9.92]	[-0.81,0.231]	[-1.2,14.3]	[-3.6,1.04]

			$M_T(WZ)$			
Mass	S1	M0	M1	T0	T1	T2
positive extrema						
800 GeV	[75,113]	[16,24.2]	[24,36.2]	no extrema	[1.1,1.73]	[3.2,5.0]
900 GeV	[15,68.4]	[3.4,14.8]	[4.9,22.2]	no extrema	[0.22,1.06]	[0.6,3.06]
1000 GeV	[-19,64.7]	[220.45,14]	[-23,21]	no extrema	[-0.33,1.0]	[-0.45,2.89]
negative extrema						
800 GeV	[-115,-76.3]	[-24,-15.5]	[-36,-23.8]	[-1.5,-0.792]	[-1.5,-0.792]	[-5.2,-3.41]
900 GeV	[-70,-16.4]	[-14,-2.99]	[-22,-4.97]	[-0.77,-0.0389]	[-1.1,-0.256]	[-3.3,-0.798]
1000 GeV	[-66,78.6]	[-14,6.69]	[-21,82.6]	[-0.71,0.0189]	[-1.0,0.97]	[-3.1,37.9]

Table 0.1: Invariant mass lower and upper 95% confidence level limits for a fit with linear and quadratic operators in WZ with all other aQGC parameters set to zero
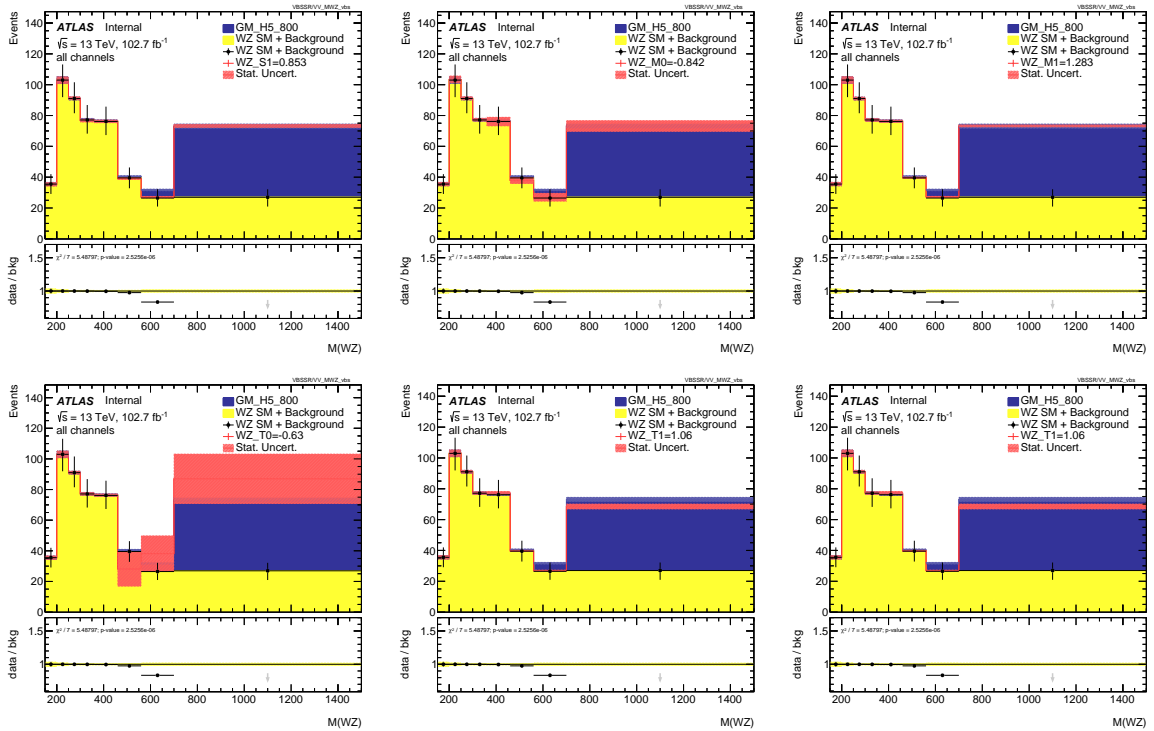
Figure 0.5: Invariant mass for parameters S1, M0, M1, T0, T1, T2 with best fit value for 800 GeV resonance
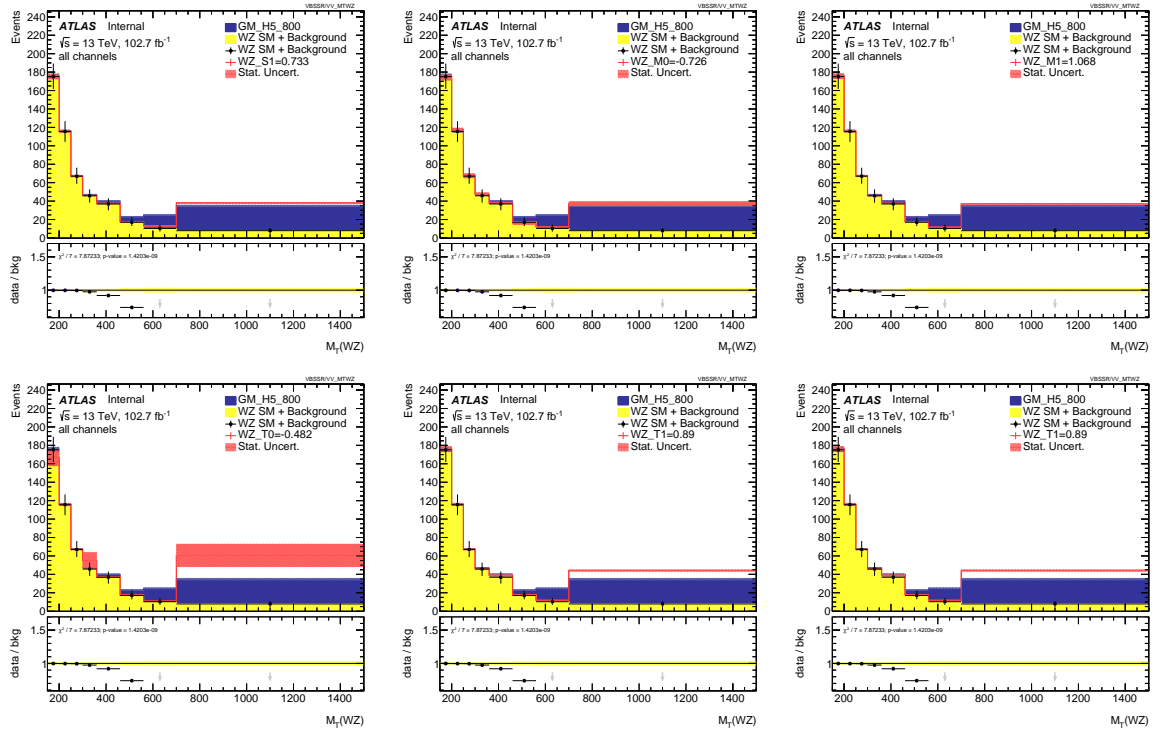
Figure 0.6: transverse mass for parameters S1, M0, M1, T0, T1, T2 with best fit value for 800 GeV resonance