Background Modeling Studies In V6 Samples

Kang Liu

on behalf of TDLI, SJTU

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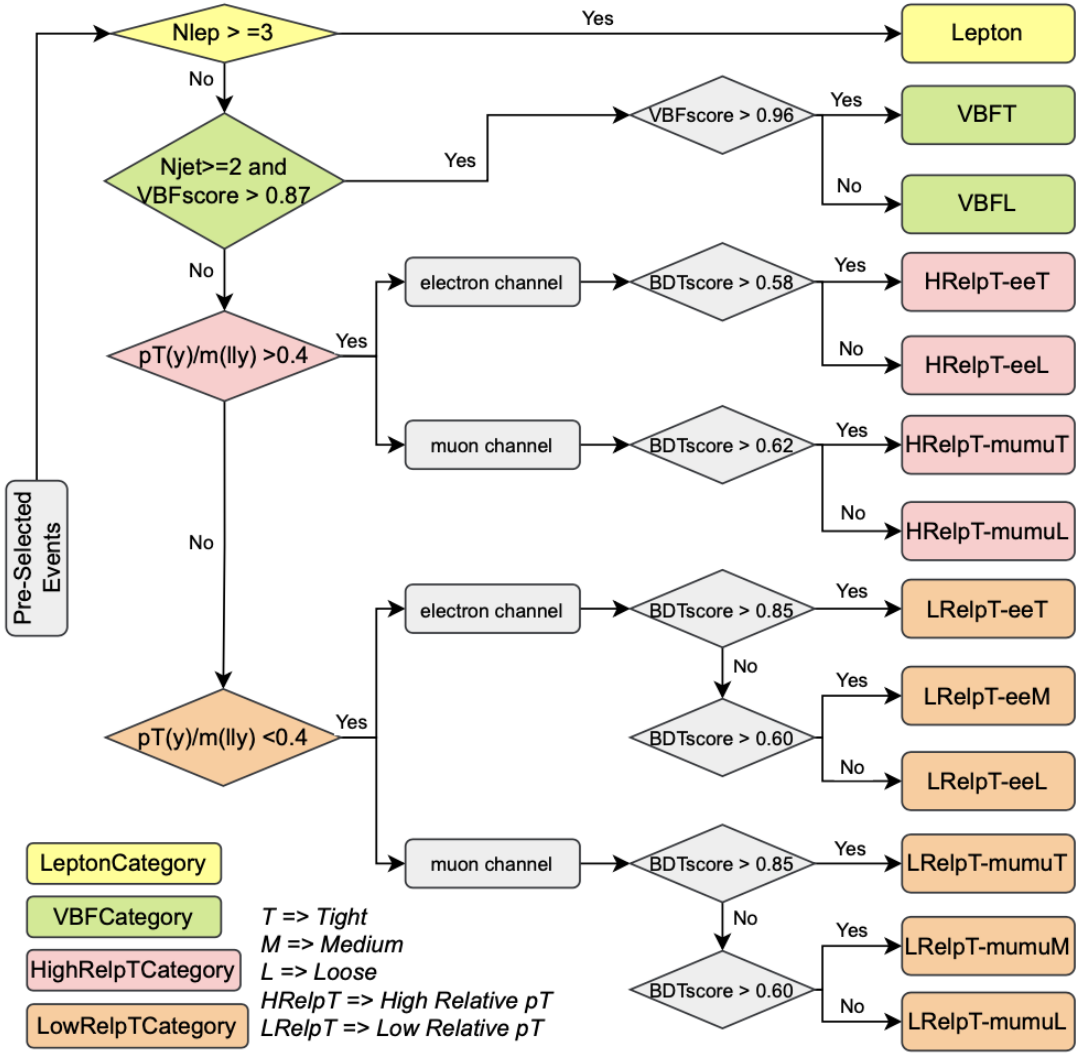
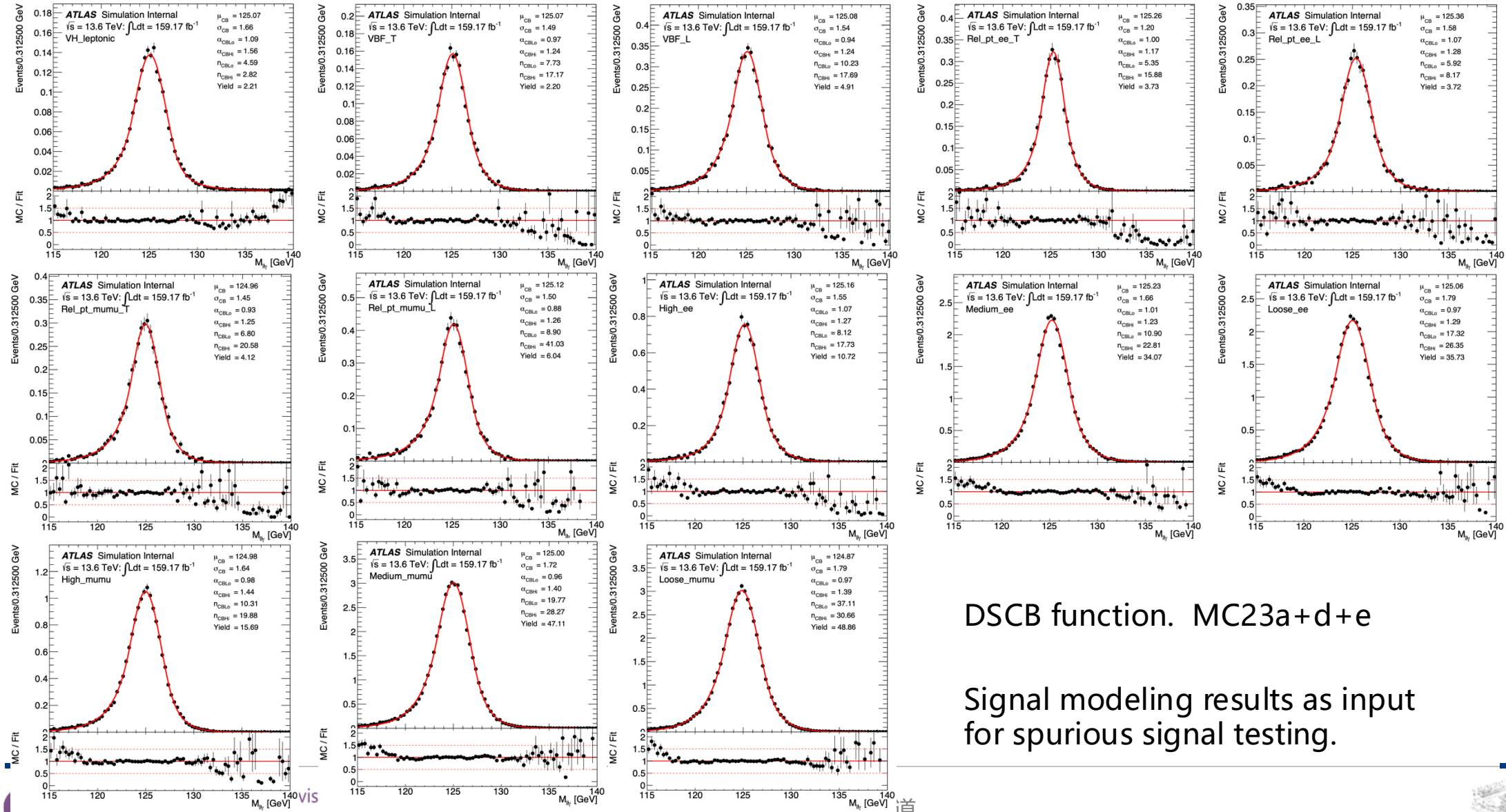
H → Zγ categorization In V6 samples



From HZy Run3 note

Background modeling and spurious signal testing in multiple mass ranges for 13 categories are investigated.

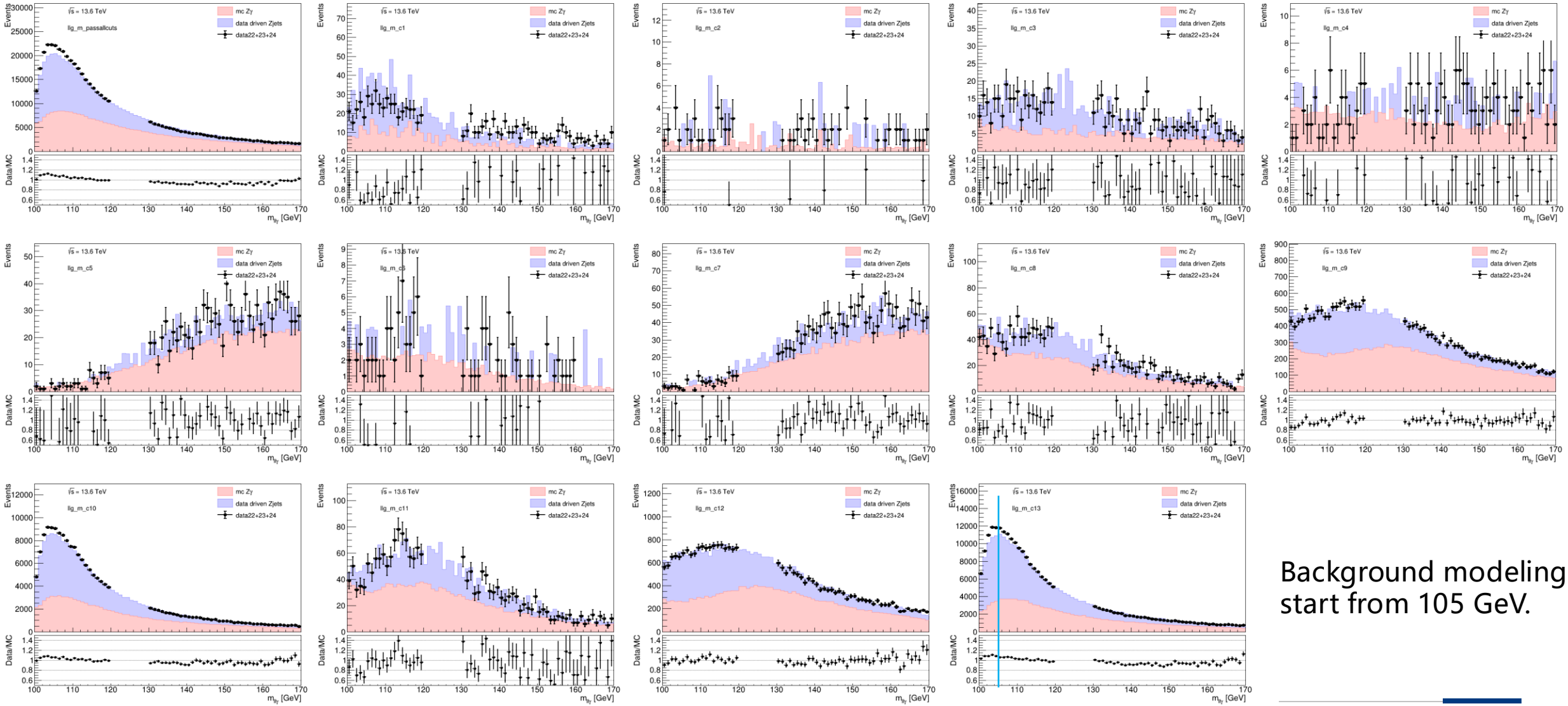
Signal modeling in v5 samples



DSCB function. MC23a+d+e

Signal modeling results as input for spurious signal testing.

M_lly distributions of data and bkg template



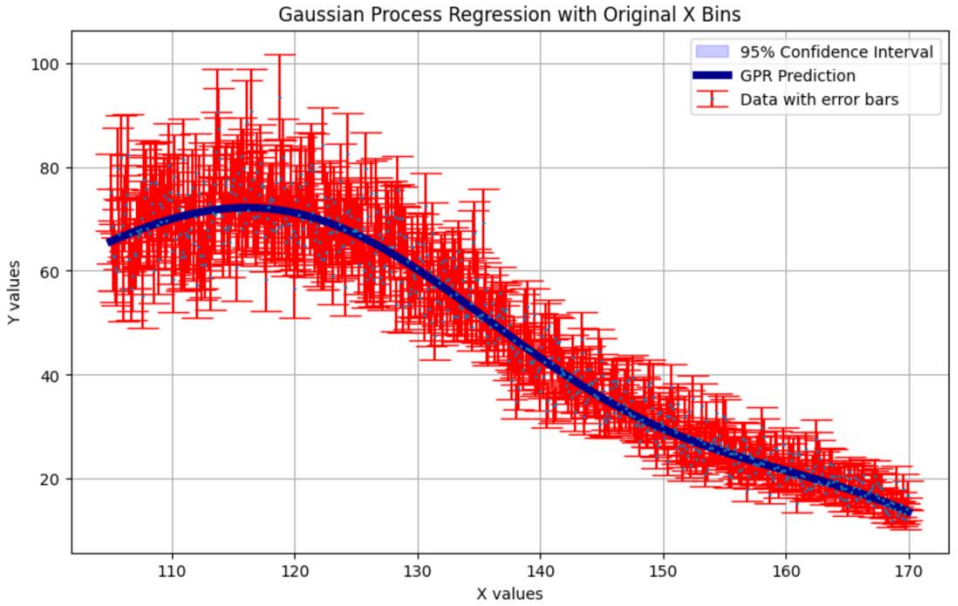
Background modeling start from 105 GeV.

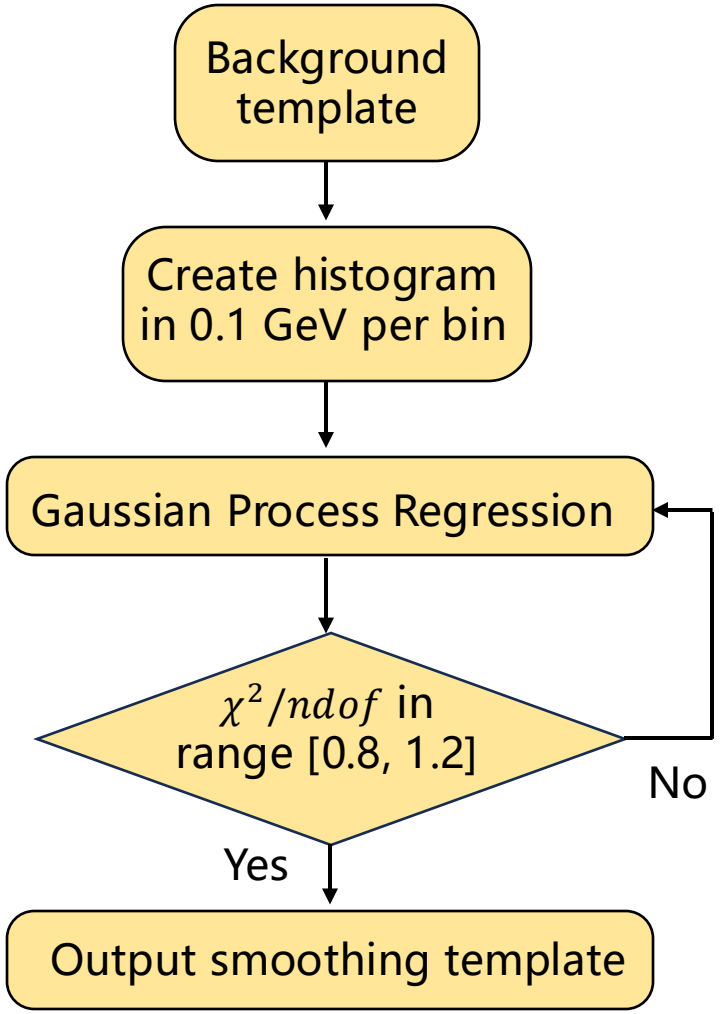
V6 background template smoothing

Refer to the analysis strategy of run2:
[ATLAS Note ANA-HIGG-2018-42-INT1.]

Gaussian Process Regression used for background smoothing

```
Optimized kernel parameters:
39.5**2 * RBF(length_scale=26.6)
Chi-squared: 647.12
Degrees of freedom: 648
Chi-squared per degree of freedom: 1.00
Original yield: 30689.95
GPR yield: 30303.41
The smoothed distribution has been saved to the 'llg_m_c12_smoothed.txt' .
```



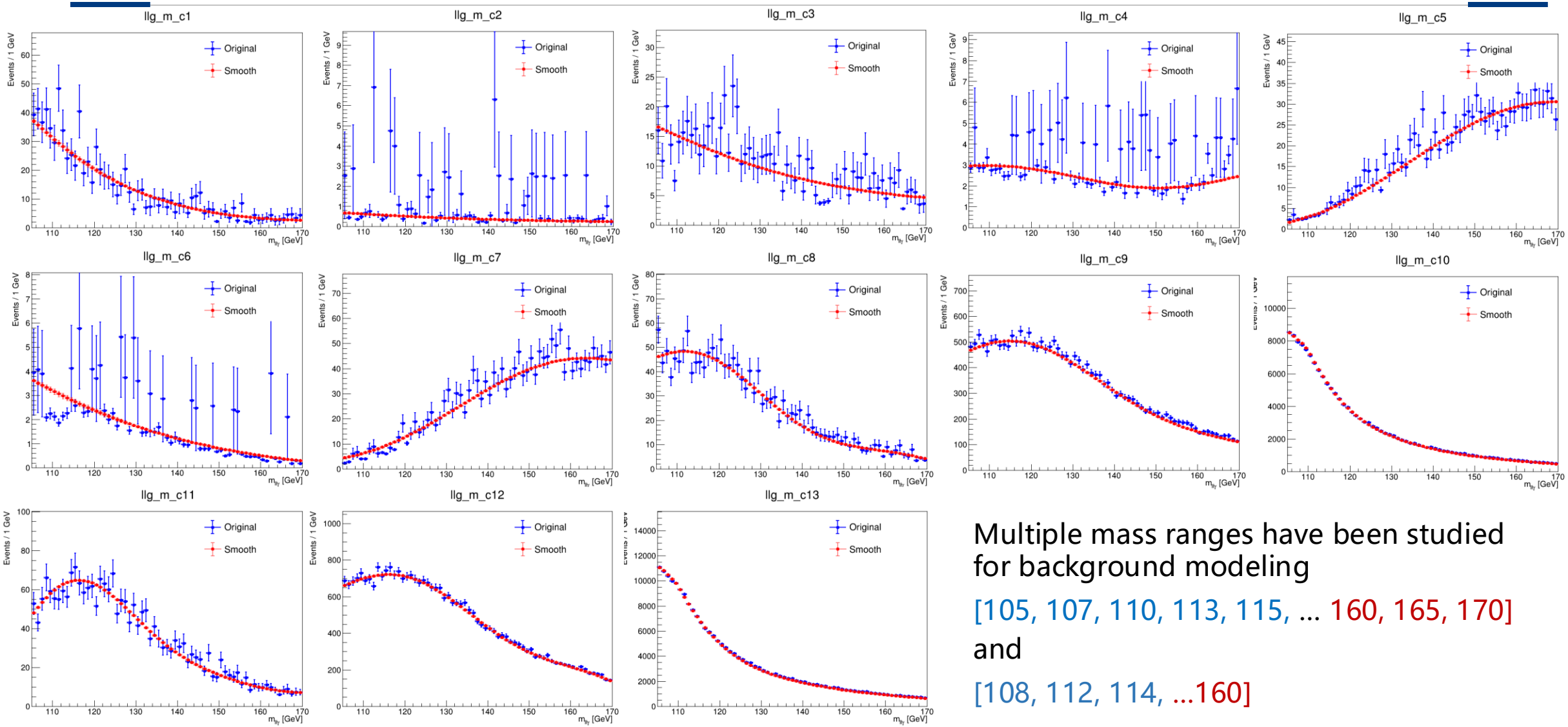


Scale $mc_{z\gamma} * purity$ +
Scale $Zjets * (1 - purity)$

RBF Kernel Function

$$k(x_i, x_j) = \exp\left(-\frac{d(x_i, x_j)^2}{2l^2}\right)$$

V6 background template smoothing



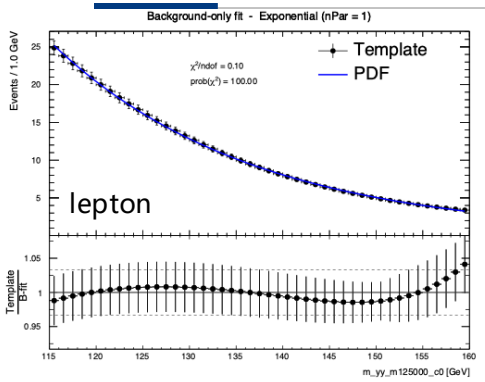
Multiple mass ranges have been studied for background modeling

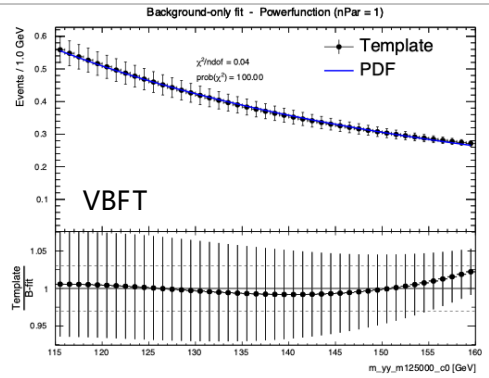
[105, 107, 110, 113, 115, … 160, 165, 170]

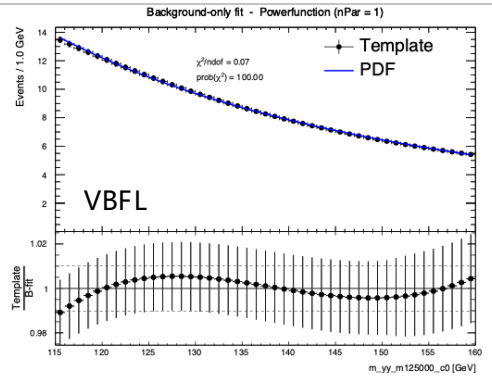
and

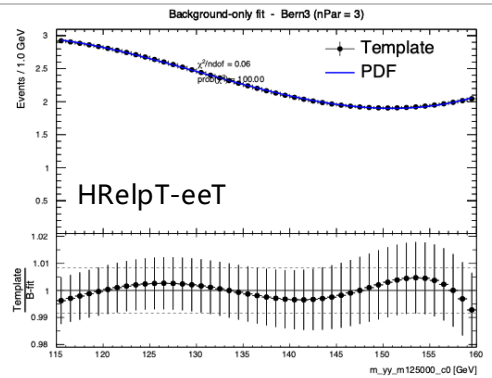
[108, 112, 114, …160]

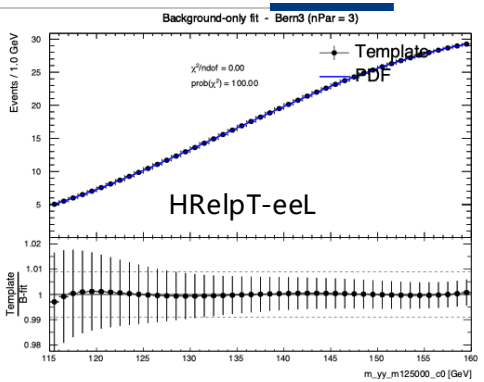
Background modeling in mass window [115, 160]

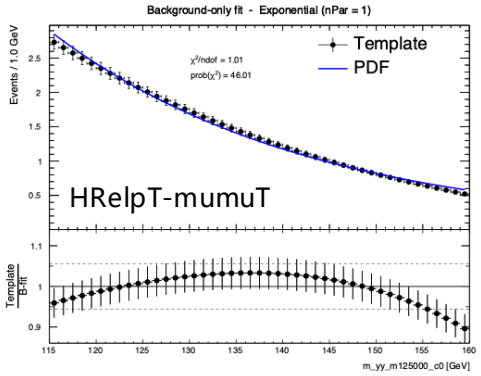


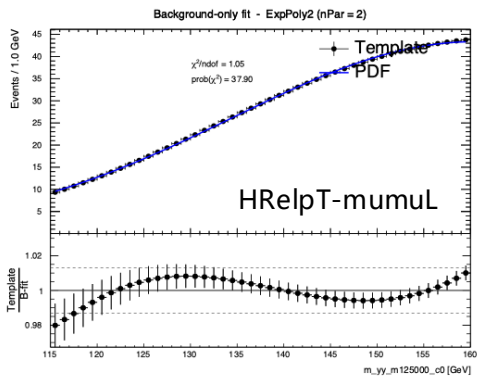


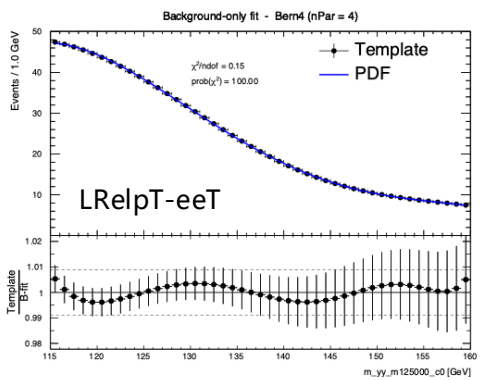


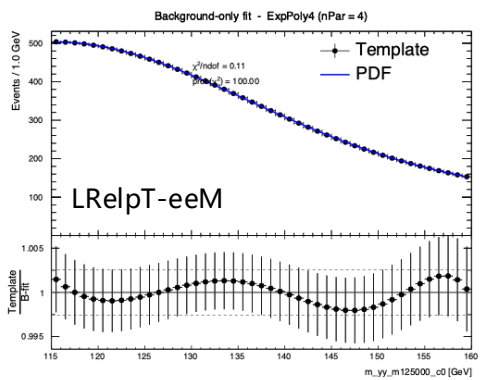


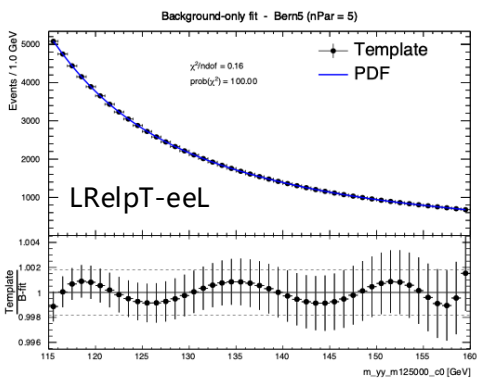


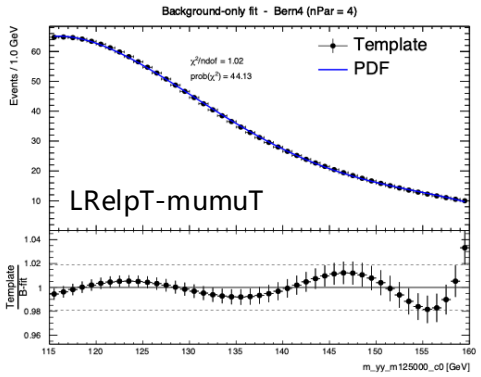


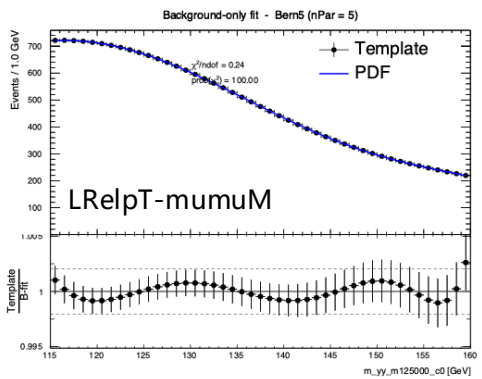


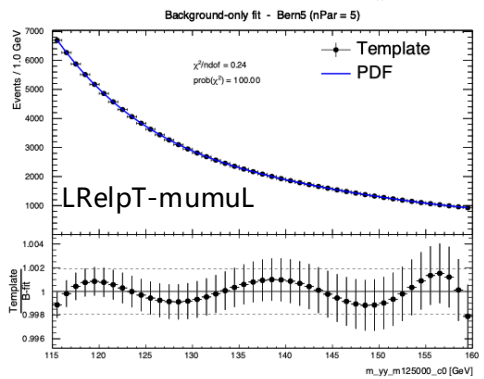












At least one function can pass the spurious signal test in each categories.

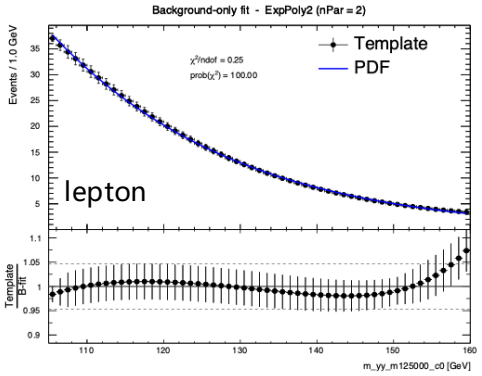
Spurious signal test results [115, 160]

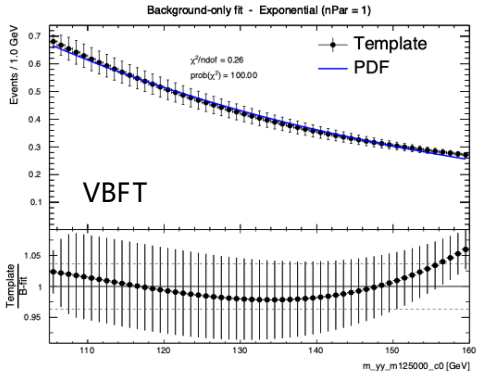
max(S) | selected | Pass spurious signal test

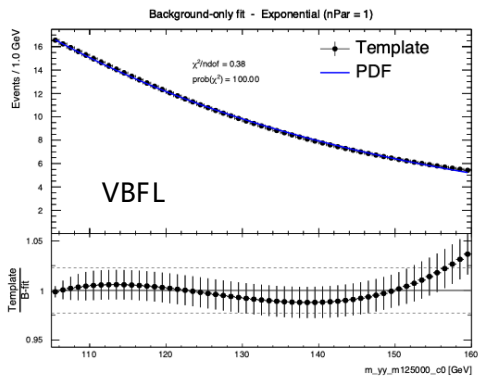
	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton	1.18	3.83									0.308	-0.46
c2	VBFT	0.0911	0.0265		0.0293				0.0609		-0.0659		
c3	VBFL	0.982	0.624										
c4	HRelpT_eeT						0.136				0.256	-0.135	0.175
c5	HRelpT_eeL						0.159					0.281	-0.388
c6	HRelpT_mumuT	-0.48			-0.102		-0.0595		0.284		-0.256	-0.612	-0.201
c7	HRelpT_mumuL				1.54		0.066					0.498	-0.53
c8	LRelpT-eeT											-1.63	-1.35
c9	LRelpT-eeM										6.04	-11.5	-3.12
c10	LRelpT-eeL												-38.4
c11	LRelpT-mumuT											3.83	-2.84
c12	LRelpT-mumuM												-8.03
c13	LRelpT-mumuL												58.9

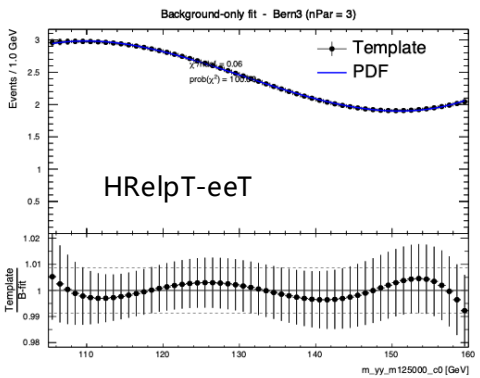
nPars: 1 2 3 4 5

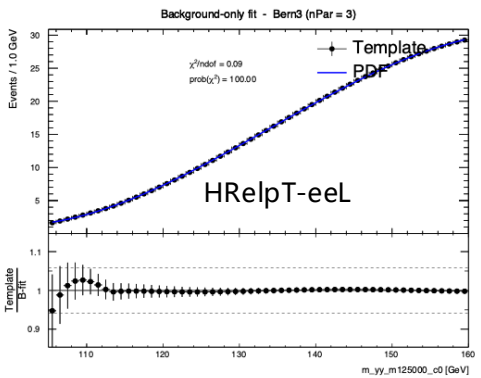
Background modeling in mass window [105, 160]

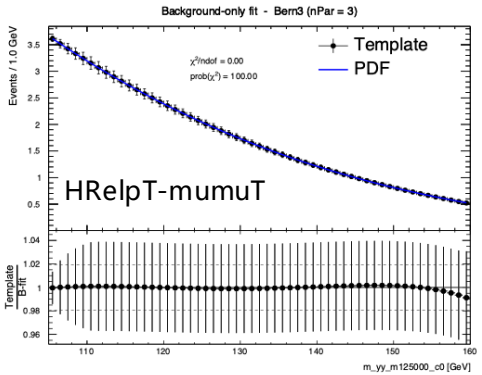


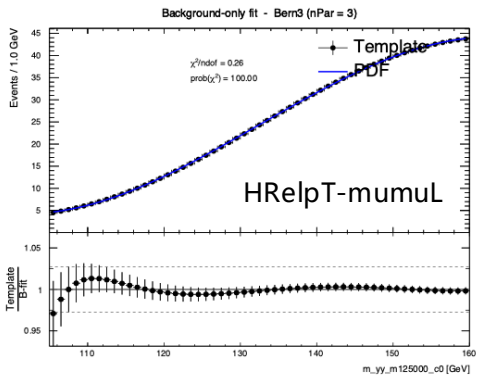


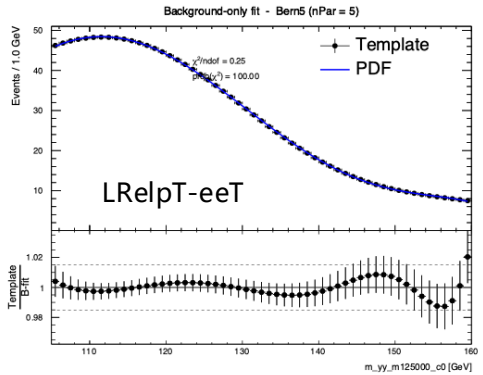


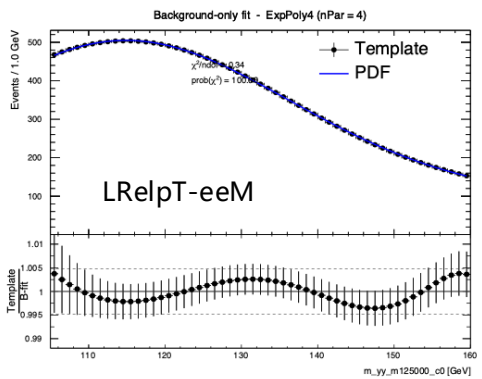






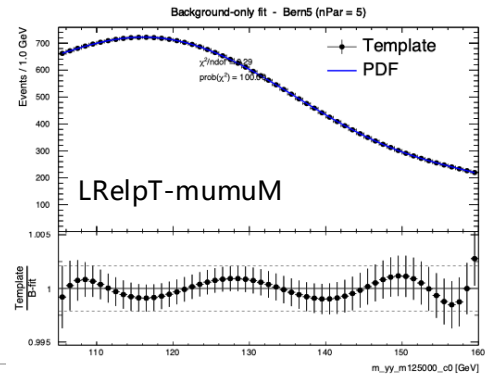






LRelpT-eeL

LRelpT-mumuT



LRelpT-mumuL

A blank space indicates that this category does not pass the spurious signal test.

Spurious signal test results [105, 160]

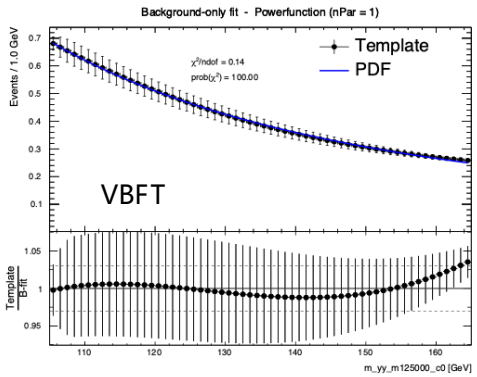
max(S) | selected | Pass spurious signal test

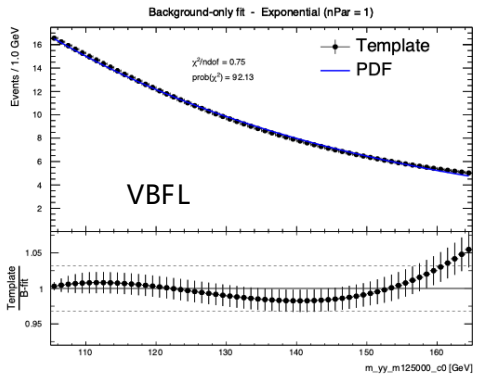
	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton				2.15		-1.4					-1.07	0.694
c2	VBFT	-0.0709			0.0437				-0.0968		-0.0747		
c3	VBFL	-0.73	1.57									-0.411	0.35
c4	HRelpT_eeT						0.0849					0.0513	0.0685
c5	HRelpT_eeL						-0.446					-0.218	0.387
c6	HRelpT_mumuT						-0.133					0.0581	0.17
c7	HRelpT_mumuL						-0.954					-0.485	0.205
c8	LRelpT-eeT												1.47
c9	LRelpT-eeM										10.6		2.08
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												6.32
c13	LRelpT-mumuL												

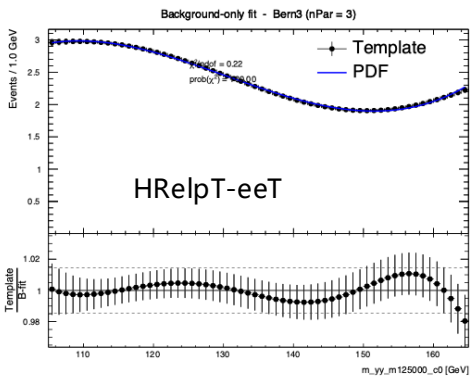
nPars: 1 2 3 4 5

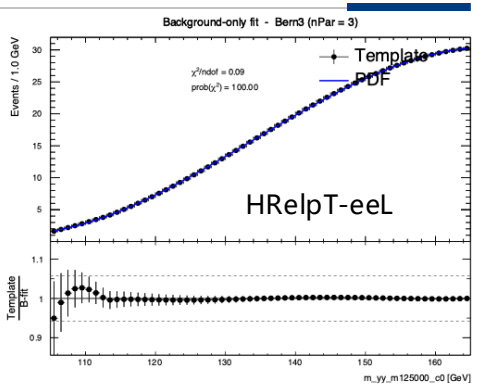
Background modeling in mass window [105, 165]

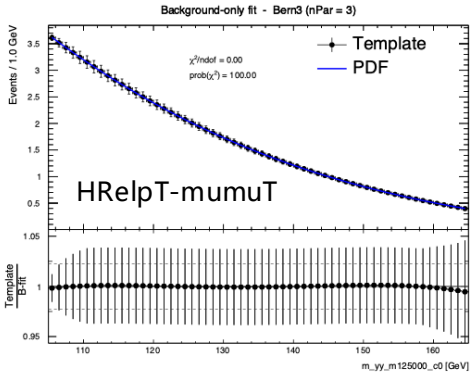
lepton

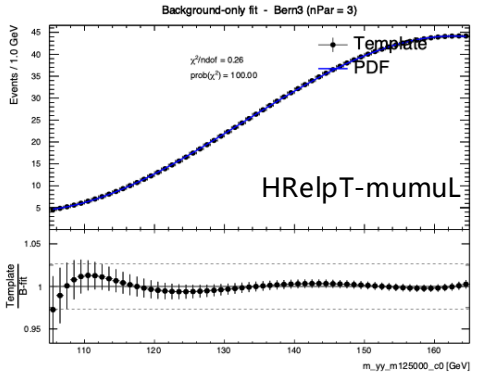


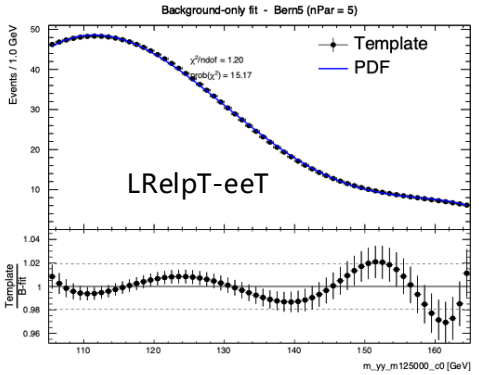


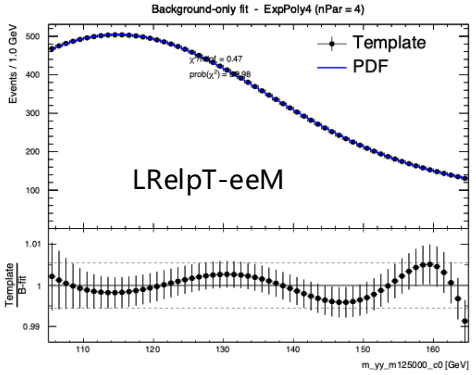












LRelpT-eeL

LRelpT-mumuT

LRelpT-mumuM

LRelpT-mumuL

A blank space indicates that this category does not pass the spurious signal test.

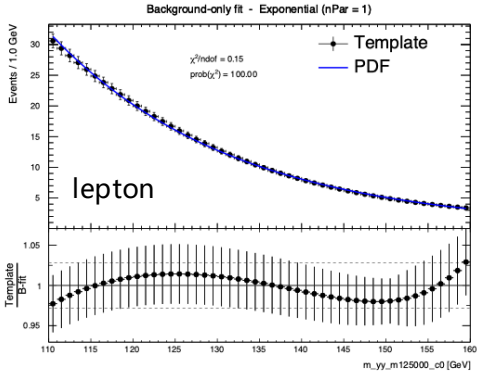
Spurious signal test results [105, 165]

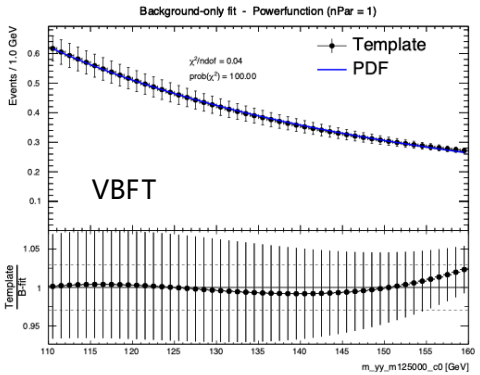
max(S) | selected | Pass spurious signal test

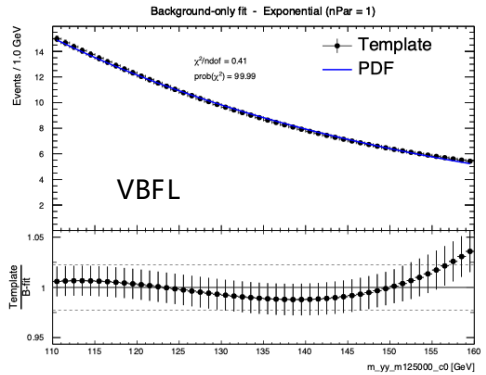
	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton												
c2	VBFT	-0.0776	0.0434		0.0567				0.0241		0.0648	0.0381	0.058
c3	VBFL	-0.857	1.61						-0.172			0.181	0.303
c4	HRelpT_eeT						0.0918					0.116	0.0949
c5	HRelpT_eeL						-0.477					-0.3	0.38
c6	HRelpT_mumuT						-0.0518		-0.0828		-0.0846	0.0808	0.0782
c7	HRelpT_mumuL						-1.07					-0.768	0.131
c8	LRelpT-eeT												3.27
c9	LRelpT-eeM										10.1		5.86
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

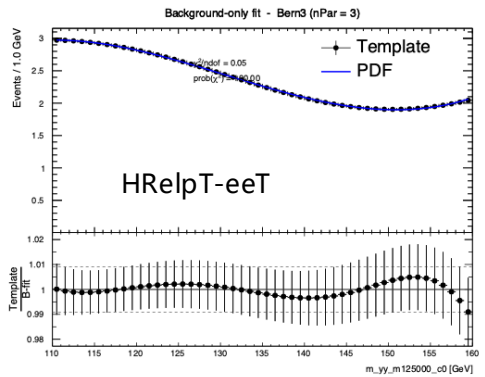
nPars: 1 2 3 4 5

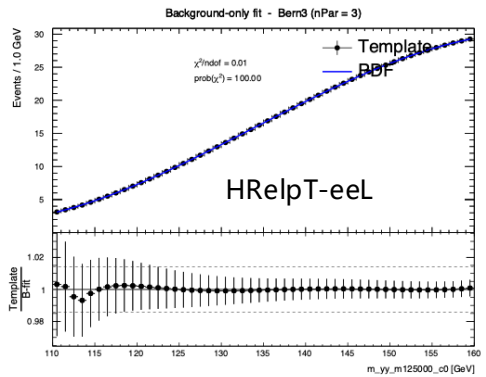
Background modeling in mass window [110, 160]

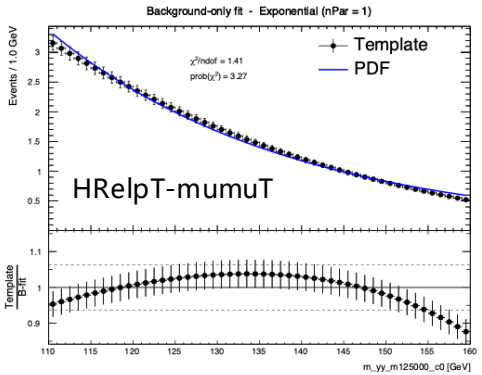


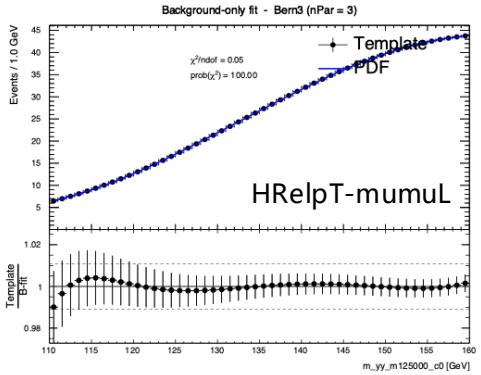


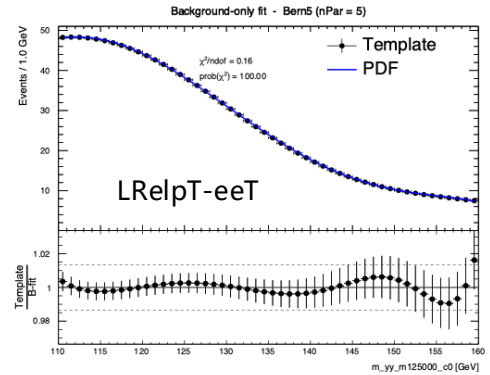


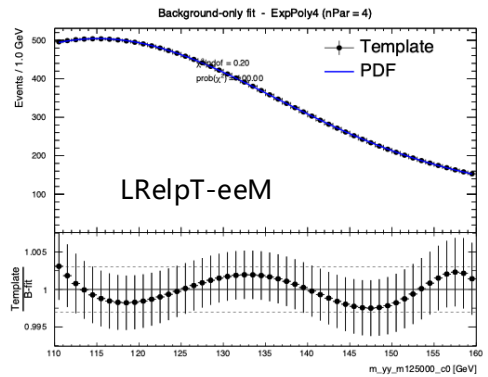




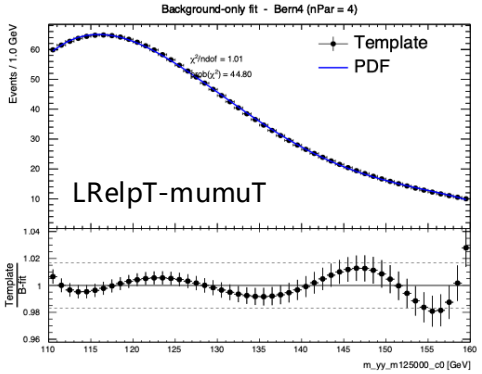


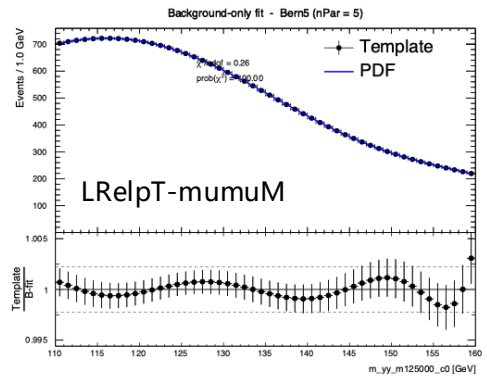






LRelpT-eeL





LRelpT-mumuL

A blank space indicates that this category does not pass the spurious signal test.

Spurious signal test results [110, 160]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton	2.38										-0.366	
c2	VBFT	-0.0678	-0.0456		-0.209				0.109		-0.0722		
c3	VBFL	-0.567	0.936				-3.42					0.337	0.352
c4	HRelpT_eeT						0.0732					0.043	0.0839
c5	HRelpT_eeL						-0.217					0.155	-0.14
c6	HRelpT_mumuT	0.476			-0.0859		0.0718						
c7	HRelpT_mumuL						-0.496					-0.355	0.353
c8	LRelpT-eeT												1.01
c9	LRelpT-eeM										-7.79		2.02
c10	LRelpT-eeL												
c11	LRelpT-mumuT											3.65	3.82
c12	LRelpT-mumuM												4.37
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [105, 170]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton												
c2	VBFT		-0.0176		0.0519		0.0546		0.0246		-0.0654		0.0658
c3	VBFL	-1.18	1.58										
c4	HRelpT_eeT						0.231					0.124	-0.0451
c5	HRelpT_eeL						-0.495					-0.384	0.335
c6	HRelpT_mumuT						-0.222					-0.141	0.173
c7	HRelpT_mumuL						-1.08					-1.14	0.175
c8	LRelpT-eeT												
c9	LRelpT-eeM												11.8
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [107, 160]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton				1.88		-0.718					-0.537	0.33
c2	VBFT	-0.0772	-0.028		0.0353				0.123		-0.0694		
c3	VBFL	-0.589	1.25				-0.385		0.0324		-0.273	-0.356	0.362
c4	HRelpT_eeT						0.11				0.046		0.122
c5	HRelpT_eeL						-0.176				-0.0528		0.353
c6	HRelpT_mumuT						0.0572		-0.469			0.0706	0.131
c7	HRelpT_mumuL				2.21		-0.699					-0.427	0.335
c8	LRelpT-eeT												1.32
c9	LRelpT-eeM										9.26		1.87
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												5.23
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [107, 165]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton	3.19			2.91				0.419		1.38		0.836
c2	VBFT	-0.0679	-0.0203		0.0354				-0.0263		0.0556		0.0692
c3	VBFL	-0.985	1.29		0.903							0.113	1.14
c4	HRelpT_eeT						0.0841					0.0818	0.0713
c5	HRelpT_eeL						-0.145					-0.14	0.23
c6	HRelpT_mumuT						-0.0761					0.0779	-0.0453
c7	HRelpT_mumuL						-0.695					-0.674	0.263
c8	LRelpT-eeT												2.86
c9	LRelpT-eeM										9.81		5.47
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [107, 170]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton										-0.676		
c2	VBFT		0.0368		0.0414				0.0522		-0.051	0.0281	-0.0838
c3	VBFL	-0.97	1.25		0.884		-0.41						0.273
c4	HRelpT_eeT						0.218					0.111	-0.0942
c5	HRelpT_eeL						-0.219					-0.285	0.236
c6	HRelpT_mumuT						-0.154					-0.128	-0.119
c7	HRelpT_mumuL						-0.853					-1.01	0.192
c8	LRelpT-eeT												
c9	LRelpT-eeM												10.8
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [108, 160]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton											-0.268	-0.234
c2	VBFT	-0.0626	0.0272		0.0352				0.0705				
c3	VBFL	-0.517	1.16		0.697		-4.84						-1.62
c4	HRelpT_eeT						0.0774					0.0489	-0.125
c5	HRelpT_eeL						-0.123					-0.109	0.382
c6	HRelpT_mumuT						0.0729					-0.451	0.182
c7	HRelpT_mumuL				2.21		-0.59				0.83	-0.438	0.383
c8	LRelpT-eeT												1.26
c9	LRelpT-eeM											8.64	1.71
c10	LRelpT-eeL												
c11	LRelpT-mumuT												4.76
c12	LRelpT-mumuM												5.03
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [110, 165]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton				1.92				-0.314			0.935	-0.524
c2	VBFT	-0.0742	-0.0339		0.0367				-0.0489		-0.089	0.041	
c3	VBFL		0.897		0.658							-0.389	0.335
c4	HRelpT_eeT						0.117					-0.0764	0.0702
c5	HRelpT_eeL						-0.252					-0.162	0.29
c6	HRelpT_mumuT						0.0561		-0.445			-0.107	0.978
c7	HRelpT_mumuL						-0.584					-0.58	0.379
c8	LRelpT-eeT												2.17
c9	LRelpT-eeM										7.83		4.5
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [110, 170]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton								-1.46				-1.2
c2	VBFT		0.0313		0.04				0.0171		-0.0691		
c3	VBFL	-0.912	0.958		0.767		-3.71						-0.197
c4	HRelpT_eeT						0.196					0.0843	-0.105
c5	HRelpT_eeL						-0.327					-0.263	0.292
c6	HRelpT_mumuT				-0.22		-0.112		-0.491				-0.632
c7	HRelpT_mumuL						-1.07					-0.794	0.304
c8	LRelpT-eeT												
c9	LRelpT-eeM												9.14
c10	LRelpT-eeL												
c11	LRelpT-mumuT												
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [112, 160]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton	1.76			1.46		-0.338					0.338	1.6
c2	VBFT	-0.0533	-0.0234		-0.165				0.114		-0.0809		
c3	VBFL	0.941					-5.76					-0.773	
c4	HRelpT_eeT						0.118		0.28			1.96	0.153
c5	HRelpT_eeL						0.157					0.198	0.265
c6	HRelpT_mumuT	0.44					0.0904		-0.315		0.462	-0.392	0.0959
c7	HRelpT_mumuL						-0.234					-0.312	-0.258
c8	LRelpT-eeT											-2.38	1.02
c9	LRelpT-eeM										-9.92	-13.8	-2.72
c10	LRelpT-eeL												
c11	LRelpT-mumuT											3.29	2.72
c12	LRelpT-mumuM												-5.39
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Spurious signal test results [113, 160]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton											0.566	
c2	VBFT	0.0874	0.061		0.0504				0.0891				
c3	VBFL	0.671	0.666				-5.81					0.0738	-0.282
c4	HRelpT_eeT						0.0517				0.337	0.797	-0.106
c5	HRelpT_eeL						0.18					0.21	0.345
c6	HRelpT_mumuT	0.376			-0.203		0.068				-0.375	-0.327	-0.0863
c7	HRelpT_mumuL				1.68		0.15					0.397	-0.361
c8	LRelpT-eeT											-2.7	-1.14
c9	LRelpT-eeM											-13.7	-2.92
c10	LRelpT-eeL												
c11	LRelpT-mumuT												-2.38
c12	LRelpT-mumuM												-6.3
c13	LRelpT-mumuL												64.1

nPars: 1 2 3 4 5

Spurious signal test results [115, 170]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c1	Lepton				0.949							-0.184	
c2	VBFT		0.0498		0.0466				0.0422		-0.259		-0.0944
c3	VBFL						0.204					0.151	
c4	HRelpT_eeT						0.283					-0.0981	
c5	HRelpT_eeL						-0.124					-0.269	-0.409
c6	HRelpT_mumuT				0.166		0.0621				-0.233	-0.296	0.266
c7	HRelpT_mumuL						-0.751					-0.432	-0.573
c8	LRelpT-eeT												-2.78
c9	LRelpT-eeM												
c10	LRelpT-eeL												
c11	LRelpT-mumuT												-2.56
c12	LRelpT-mumuM												
c13	LRelpT-mumuL												

nPars: 1 2 3 4 5

Summary

- Background modeling in multiple mass ranges for v6 samples (categorized into 13 categories) have been studied.
- Mass ranges including
  [105, 107, 110, 113, 115, … 160, 165, 170] and [108, 112, 114, …160]
- At least one function can pass the spurious signal test in each categories in mass window [115, 160].

Next

- Re-try background modeling after new mc Zy samples with sufficient statistics have been available.

Backup

Data-driven ABCD method Selection

Isolation gap

C ph_isEM_Tight && 0x04fc01 ph_passiso_FixedCutLoose	⟷	**D** ph_isEM_Tight && 0x04fc01 ph_topoetcone20>0.065*ph_pt*1000 + 2000 ph_ptcone20<0.05*ph_pt*1000
A ph_isTight ph_passiso_FixedCutLoose		**B** ph_isTight ph_topoetcone20>0.065*ph_pt*1000 + 2000 ph_ptcone20<0.05*ph_pt*1000

A

Signal region

B,C,D

Control region

Data-driven ABCD method Selection

$$N_A^{Z\gamma} = N_A^{data} - (N_B^{data} - c_B N_A^{Z\gamma}) \frac{(N_C^{data} - c_C N_A^{Z\gamma})}{(N_D^{data} - c_D N_A^{Z\gamma})} R^{Zj}$$

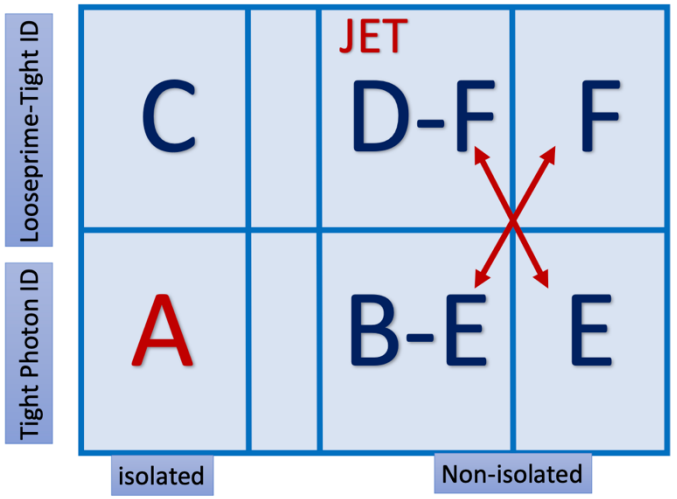
$c_K \equiv N_K^{Z\gamma} / N_A^{Z\gamma}$ are *signal leakage fractions*

Extracted from mc $Z\gamma$

$$R^{Zj} \equiv \frac{N_A^{Zj} N_D^{Zj}}{N_B^{Zj} N_C^{Zj}}$$

Extracted from data
4 prime regions:
B-E, D-F, E, F

$(E_{\mathrm{T}}^{\mathrm{iso}} > 0.065 \times p_T + 3.5\ \mathrm{GeV})$



GPR smooth

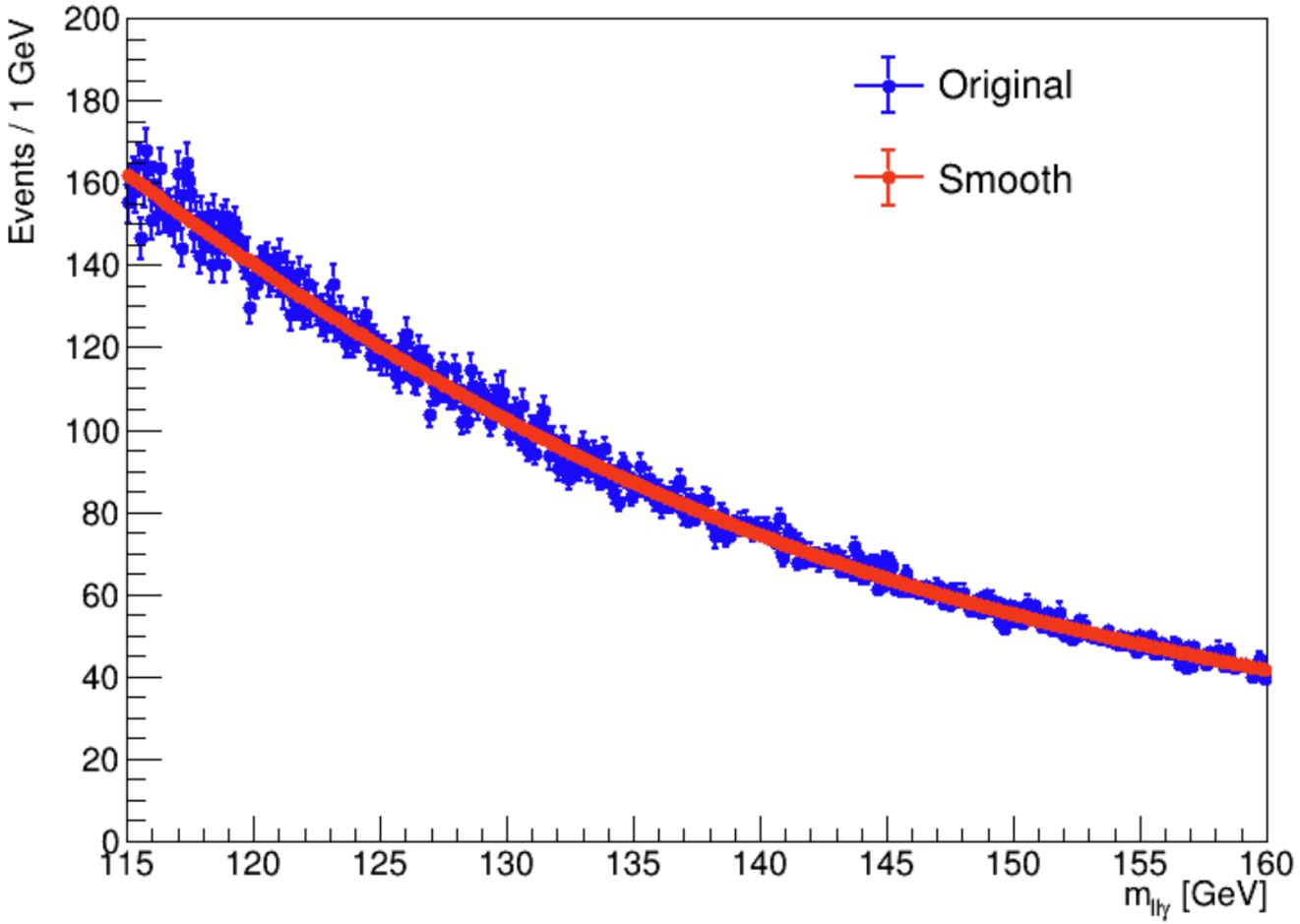
Refer to the analysis strategy of run2: ATLAS Note ANA-HIGG-2018-42-INT1

Here is an attempt to smooth the background templates using the Gaussian Process Regression.

Gaussian Process Regression

$$k(x_i, x_j) = \exp\left(-\frac{d(x_i, x_j)^2}{2l^2}\right)$$

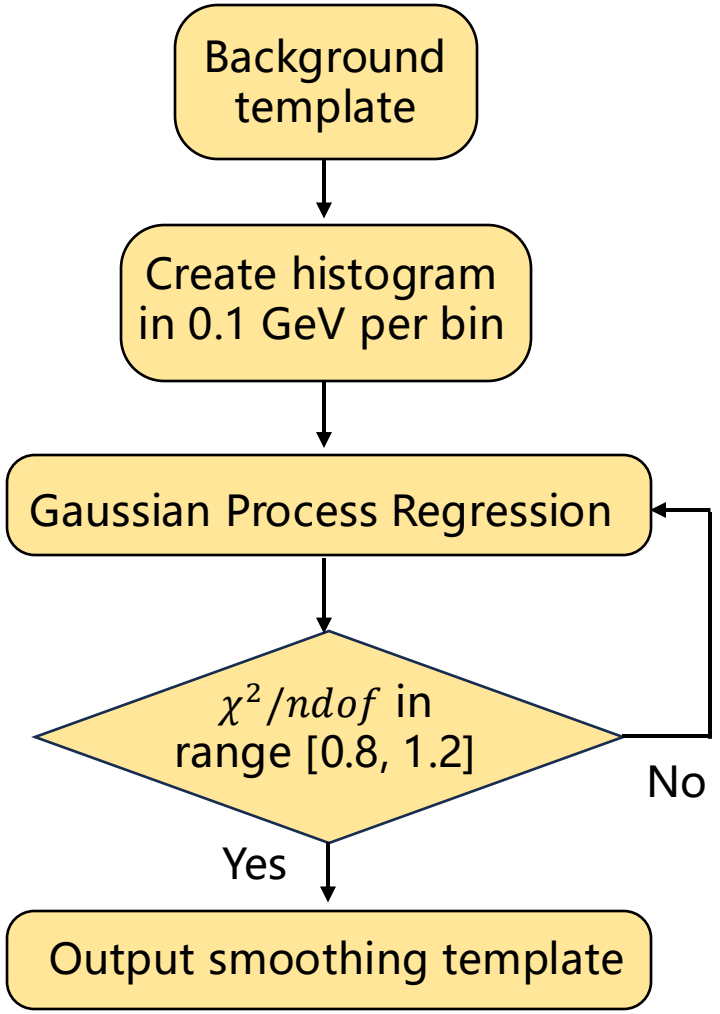
Background template



$$bkg\ temp = mc_{Z\gamma}(scale\ to\ N_{data} * purity) + Zjets_{data-driven}(N_{Zjets-sideband}\ scale\ to\ N_{data-sideband} * (1 - purity))$$

GPR smooth

Gaussian Process Regression



Scale $mc_{z\gamma} * purity$ +
Scale $Zjets * (1 - purity)$

RBF Kernel Function

Spurious signal test setup and requirements

Background template Observable range: **[115, 160] GeV**

Number of background template bins: **450**

Number of chi-square bins: **45**

Maximum allowed value for **S/delta_S: 0.2**

Maximum allowed value for **(S+1sigmaS)/delta_S: 0.2**

Minimum **chi-square P value: 0.01**

Spurious signal test results [105, 165]

max(S) | selected | Pass spurious signal test

	Categories	Exponential	Powerfunction	FK0	ExpPoly2	Fk1	Bern3	Pow2	ExpPoly3	FK2	ExpPoly4	Bern4	Bern5
c2	VBFT	-0.0776	0.0434		0.0567				0.0241		0.0648	0.0381	0.058
c3	VBFL	-0.857	1.61						-0.172			0.181	0.303

Name	max(S/δS) [%]	max(1sigma/δS) [%]	max(S)	S[125]	Sref[125]	δS[125]	sigmaS[125]	nPars	chi2/ndof	Prob(chi2) [%]	Result
Powerfunction	2.07	0	0.0434	0.0244	100	1.96	0.0904	1	0.139	100	PASS <== Selected
Exponential	-4.08	0	-0.0776	-0.0588	100	1.95	0.0901	1	0.743	92.8	PASS
ExpPoly2	2.7	0	0.0567	0.0567	100	2.1	0.0905	2	0.0225	100	PASS
ExpPoly3	1.17	0	0.0241	-0.0188	100	2.06	0.0903	3	0.0004	100	PASS
Bern4	1.72	0	0.0381	-0.015	100	2.22	0.0904	4	0.00097	100	PASS
ExpPoly4	3.18	0	0.0648	0.0103	100	2.09	0.0902	4	0.115	100	PASS
Bern5	2.41	0	0.058	0.0535	100	2.37	0.0905	5	0.0859	100	PASS
Fk0	254	249	223	156	100	69.5	3.2	2	0.141	100	FAIL
Fk1	258	253	223	156	100	68.6	3.22	3	0.107	100	FAIL
Pow2	inf	inf	223	156	100	0	3.2	3	0.144	100	FAIL
Bern3	-4.07e+05	-4.07e+05	-381	0.0345	100	2.23	0.0905	3	0.00086	100	FAIL
Fk2	267	262	223	156	100	66.3	3.2	4	0.0865	100	FAIL

==> PDF Powerfunction is selected

Name	max(S/δS) [%]	max(1sigma/δS) [%]	max(S)	S[125]	Sref[125]	δS[125]	sigmaS[125]	nPars	chi2/ndof	Prob(chi2) [%]	Result
Exponential	-9.33	-4.41	-0.857	-0.279	100	9.65	0.48	1	0.75	92.1	PASS <== Selected
Powerfunction	15.9	10.9	1.61	1.46	100	9.64	0.481	1	1.29	6.86	PASS
Pow2	inf	0	7.11e-14	7.11e-14	100	0	0.5	3	1.23	11.8	PASS
ExpPoly3	-1.72	0	-0.172	7.11e-14	100	108	0.48	3	0.00198	100	PASS
Bern3	-59.6	-55	-6.86	0.0453	100	11	0.48	3	0.022	100	PASS
Bern4	1.59	0	0.181	0.0441	100	11.1	0.48	4	0.00344	100	PASS
Bern5	2.67	0	0.303	-0.141	100	11.8	0.48	5	0.0147	100	PASS
ExpPoly2	-156	-151	-15.7	0.672	100	10.3	0.48	2	0.365	100	FAIL
Fk0	-4.7e+03	-4.69e+03	-663	-638	100	21.7	0.498	2	1.31	5.75	FAIL
Fk1	-4.37e+03	-4.37e+03	-666	-641	100	22.5	0.496	3	1.29	6.97	FAIL
ExpPoly4	-2.98e+03	-2.98e+03	-641	0.0742	100	10.4	0.48	4	0.0496	100	FAIL
Fk2	-4.6e+03	-4.6e+03	-671	-645	100	22.9	0.494	4	1.02	42.4	FAIL

==> PDF Exponential is selected

Cutflow in H2Zy framework

Meaning of Cutflow (to use the final selected events, please require EventInfo.cutflow >= 23)

Cutflow	Meaning
1	events/sumweight in AOD (book keeper)
2	events/sumweight in DAOD (book keeper)
3	events/sumweight in DAOD
4	events/sumweight in DAOD (no pileup weight)
5	pass GRL
6	pass Primary-Vertex
7	pass Event-Quality
8	pass Triggers
9	Initial cuts (no cut here)
10	pass 2-lepton selection
11	pass lepton ID
12	pass lepton ISO
13	object level overlap removal
14	pass 2-lepton opposite sign selection
15	1 loose photon selection
16	trigger Match
17	event level overlap removal on photon and jets
18	di-lepton mass final cut
19	photon pT low-mass cut
20	photon ID final cut
21	photon isolation final cut
22	three body mass cut
23	photon pT high-mass cut