



# Weekly report

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June 1, 2020



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- EMPFlow bug is fixed on 21.2.124 release.
- We're working on checking the fix and it needs a lot of work.
- Higher release needs p-tag > p4062, not sure about that.
- We managed to build a private p-tag for qqZZ sample for testing.
- Now we're working on updating the code to accommodate the new tag.

# Minitrees validation

	Non-Res	$qq \rightarrow ZZ$	$t\bar{t}Z$	$t\bar{t}$	VVV	Z
$4\ell$	0.34±0.02	2770.42±5.53	163.75±1.00	2790.86±39.43	23.30±0.17	0.0045±0.0006
Total charge = 0	0.32±0.02	2696.51±5.45	144.69±0.94	2204.25±35.04	21.72±0.16	0.0045±0.0005
Trigger Match	0.32±0.02	2608.47±5.39	143.47±0.93	2018.67±33.43	21.64±0.16	0.0046±0.0005
Iso FixedCutLoose	0.25±0.02	2201.41±4.98	111.29±0.81	79.98±6.73	19.78±0.15	0.0051±0.0001
$m_{\ell\ell}$ (SFOS) > 12 GeV	0.24±0.02	1958.99±4.79	108.25±0.79	54.35±5.69	19.63±0.15	0.0052±0.0000
0-SFOS	0.01±0.00	0.04±0.02	0.28±0.05	6.51±1.87	0.03±0.01	0.0051±0.0013
1-SFOS	0.10±0.00	29.91±0.58	54.29±0.56	26.02±4.04	8.77±0.11	0.0093±0.0006
2-SFOS	0.13±0.01	1929.04±4.76	53.69±0.56	21.82±3.54	10.83±0.11	0.0028±0.0000

	Non-Res	$qq \rightarrow ZZ$	$t\bar{t}Z$	$t\bar{t}$	VVV	Z
$4\ell$	0.39±0.02	3350.84±6.14	197.37±1.13	1764.14±8.63	25.34±0.18	0.0054±0.0000
Total charge = 0	0.37±0.02	3241.84±5.99	166.38±1.02	1393.84±7.67	23.59±0.17	0.0053±0.0000
Trigger Match	0.34±0.01	3067.18±5.87	163.70±1.01	1254.98±7.28	23.45±0.17	0.0051±0.0000
Iso FixedCutLoose	0.26±0.01	2521.02±5.25	117.04±0.83	43.73±1.36	21.22±0.16	0.0050±0.0000
$m_{\ell\ell}$ (SFOS) > 12 GeV	0.25±0.01	2179.49±5.00	113.41±0.81	28.23±1.09	21.06±0.16	0.0051±0.0000
0-SFOS	0.02±0.00	0.05±0.02	0.43±0.06	3.44±0.38	0.04±0.01	0.0077±0.0001
1-SFOS	0.11±0.00	37.57±0.66	56.88±0.57	12.77±0.73	9.42±0.11	0.0099±0.0000
2-SFOS	0.13±0.00	2141.87±4.95	56.10±0.57	12.02±0.71	11.61±0.11	0.0027±0.0000

	Non-Res	$qq \rightarrow ZZ$	$t\bar{t}Z$	$t\bar{t}$	VVV	Z
$4\ell$	9269.00±96.28	1865433.00±1365.81	136483.00±369.44	10573.00±102.83	64541.00±254.05	6.4267±7.0428
Total charge = 0	8690.00±93.22	1822714.00±1350.08	121157.00±348.08	8347.00±91.36	54128.00±232.65	6.1306±6.7308
Trigger Match	8577.00±92.61	1772255.00±1331.26	120198.00±346.70	7715.00±87.84	53934.00±232.24	6.1312±6.7296
Iso FixedCutLoose	5972.00±77.28	1459485.00±1208.09	92826.00±304.67	305.00±17.46	49451.00±222.38	4.7153±5.1800
$m_{\ell\ell}$ (SFOS) > 12 GeV	5798.00±76.14	1302411.00±1141.23	90297.00±300.49	192.00±13.86	49136.00±221.67	4.8250±5.2929
0-SFOS	445.00±21.10	32.00±5.66	150.00±12.25	23.00±4.80	57.00±7.55	22.6640±20.1588
1-SFOS	2548.00±50.48	18810.00±137.15	45095.00±212.36	92.00±9.59	11526.00±107.36	9.2203±9.6575
2-SFOS	2805.00±52.96	1283569.00±1132.95	45052.00±212.25	77.00±8.77	37553.00±193.79	2.3989±2.6499

	Non-Res	$qq \rightarrow ZZ$	$t\bar{t}Z$	$t\bar{t}$	VVV	Z
$4\ell$	9988.00±99.94	2200610.00±1483.45	154879.00±393.55	44424.00±210.77	68375.00±261.49	6.3531±6.9540
Total charge = 0	9397.00±96.94	2144398.00±1464.38	132842.00±364.47	35092.00±187.33	57800.00±230.42	6.1098±6.6925
Trigger Match	9231.00±96.08	2049740.00±1431.69	131080.00±362.05	31615.00±177.81	57515.00±239.82	6.1228±6.7155
Iso FixedCutLoose	6233.00±78.95	1650956.00±1284.90	95629.00±309.24	1101.00±33.18	51988.00±228.00	4.6435±5.1072
$m_{\ell\ell}$ (SFOS) > 12 GeV	6020.00±77.59	1437511.00±1198.96	92617.00±304.33	710.00±26.65	51624.00±227.21	4.7825±5.2512
0-SFOS	467.00±21.61	41.00±6.40	209.00±14.46	90.00±9.49	65.00±8.06	20.0868±18.4181
1-SFOS	2637.00±51.35	22358.00±149.53	46117.00±214.75	318.00±17.83	12023.00±109.65	9.2262±9.6467
2-SFOS	2916.00±54.00	1415112.00±1189.58	46291.00±215.15	302.00±17.38	39536.00±198.84	2.3791±2.6296

□ Top tables are the old samples

- 4-lepton with total charge equal zero
- Trigger
- Trigger match
- $p_T^\ell > 10$  GeV
- $|\eta^e| < 2.47$  excluding  $1.37 < |\eta^e| < 1.52$  and  $|\eta^\mu| < 2.5$
- Loose ID and Loose ISO
- $m_{\ell+\ell^-}$  (SFOS)  $> 12$  GeV
- Events categorized depending on the SFOS lepton pairs
  - 2-SFOS
    - veto b-tagged as jet,  $|m_{Z_1} - m_Z| > 25$  GeV and  $E_T^{\text{miss}} > 50$  GeV
  - 0/1-SFOS
    - $|m_{Z_2} - m_Z| < 25$  GeV
    - $|m_{Z_2} - m_Z| > 25$  and  $E_T^{\text{miss}} > 50$  GeV

# DiHiggs to 4-lepton analysis

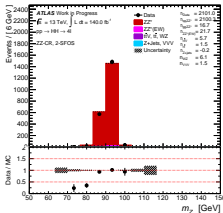
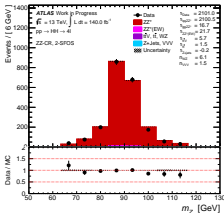
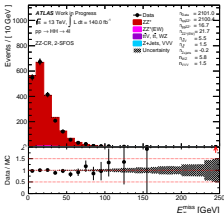
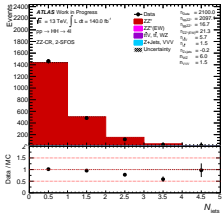
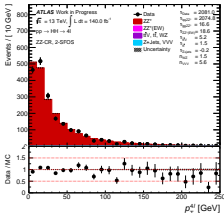
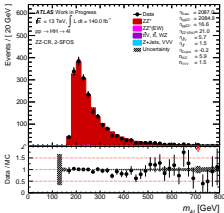
## Cutflow tables

	Non-Res	$q\bar{q} \rightarrow ZZ^*$	$g\bar{g} \rightarrow ZZ^*$	$q\bar{q} \rightarrow ZZ^*(EW)$	$t\bar{t}Z$	$t\bar{t}$	VVV	Z+jets	WZ	Significance
4l	0.65±0.02	5757.21±8.79	34.54±0.07	105.95±31.45	336.93±1.46	3008.11±11.12	43.79±0.25	3405.70±79.45	172.34±1.78	0.0057±0.0014
$\sum_i Q = 0$	0.61±0.02	5569.18±8.60	34.05±0.07	104.49±31.45	284.19±1.32	2375.62±9.88	40.84±0.25	3055.61±74.35	105.00±1.39	0.0056±0.0014
Trigger	0.58±0.01	5271.19±8.43	31.74±0.06	102.53±31.45	279.83±1.31	2141.38±9.38	40.62±0.25	2676.03±68.79	98.05±1.35	0.0056±0.0013
Trigger Match	0.50±0.01	4265.14±7.38	26.20±0.05	88.84±31.45	244.59±1.22	1697.73±8.39	36.02±0.24	1863.23±64.35	80.05±1.22	0.0055±0.0014
$p_T^1 > 10$ GeV	0.47±0.01	3931.09±7.06	24.38±0.05	84.86±31.45	228.46±1.18	1529.54±7.96	33.33±0.23	1630.72±59.45	70.64±1.15	0.0054±0.0013
$ \eta $ requirement	0.43±0.01	3638.35±6.80	23.32±0.05	81.29±31.45	215.19±1.14	1173.70±6.97	32.45±0.23	1084.01±49.38	56.44±1.03	0.0054±0.0011
Loose ID	0.43±0.01	3638.35±6.80	23.32±0.05	81.29±31.45	215.19±1.14	1173.70±6.97	32.45±0.23	1084.01±49.38	56.44±1.03	0.0054±0.0011
Loose ISO	0.33±0.01	3077.37±6.22	20.99±0.05	38.40±0.29	161.03±0.96	37.52±1.24	29.67±0.22	31.81±11.12	13.88±0.51	0.0057±0.0001
$m_{\ell\ell} (SFOS) > 12$ GeV	0.32±0.01	2783.11±6.03	20.50±0.04	36.31±0.28	156.73±0.94	25.82±1.03	29.46±0.22	13.30±9.89	13.20±0.50	0.0058±0.0001
0-SFOS	0.02±0.00	0.05±0.02	0.00±0.00	0.00±0.00	0.53±0.07	2.97±0.36	0.06±0.01	0.00±0.00	0.02±0.02	0.0121±0.0002
1-SFOS	0.14±0.01	42.62±0.71	0.23±0.00	0.48±0.03	81.25±0.68	11.93±0.70	13.88±0.18	6.59±3.01	6.91±0.36	0.0108±0.0003
2-SFOS	0.16±0.01	2740.44±5.98	20.27±0.04	35.83±0.28	74.96±0.65	10.91±0.67	15.51±0.13	6.71±9.42	6.27±0.34	0.0030±0.0000
0 $\bar{1}$ -SFOS	0.16±0.01	42.67±0.71	0.23±0.00	0.48±0.03	81.77±0.68	14.90±0.78	13.95±0.18	6.59±3.01	6.94±0.36	0.0125±0.0003
b-veto	0.16±0.01	41.46±0.70	0.23±0.00	0.45±0.03	22.55±0.36	13.08±0.73	13.63±0.18	6.59±3.01	6.74±0.36	0.0152±0.0007
$m_{\ell\ell} > 10$ GeV	0.15±0.01	40.76±0.70	0.22±0.00	0.45±0.03	22.47±0.36	12.90±0.73	13.59±0.18	5.09±2.61	6.47±0.35	0.0152±0.0005
$ m_{Z_1} - m_{Z_2}  < 25$ GeV	0.08±0.00	37.75±0.66	0.21±0.00	0.39±0.02	20.22±0.34	7.51±0.55	13.14±0.18	5.09±2.61	5.91±0.33	0.0086±0.0003
$ m_{Z_1} - m_{Z_2}  > 25$ GeV	0.07±0.00	3.01±0.21	0.01±0.00	0.05±0.01	2.25±0.12	5.39±0.48	0.45±0.02	0.00±0.00	0.56±0.10	0.0208±0.0002
$E_T^{miss} > 20$ GeV	0.08±0.00	2.74±0.20	0.01±0.00	0.06±0.01	2.54±0.13	6.53±0.53	0.59±0.03	0.00±0.00	0.69±0.11	0.0222±0.0002
2-SFOS	0.16±0.01	2740.44±5.98	20.27±0.04	35.83±0.28	74.96±0.65	10.91±0.67	15.51±0.13	6.71±9.42	6.27±0.34	0.0030±0.0000
b-veto	0.15±0.01	2682.22±5.95	19.92±0.04	34.43±0.27	21.06±0.35	9.16±0.61	15.15±0.12	4.88±9.24	6.04±0.33	0.0028±0.0000
$m_{\ell\ell} > 10$ GeV	0.15±0.01	2682.22±5.95	19.92±0.04	34.43±0.27	21.06±0.35	9.16±0.61	15.15±0.12	4.88±9.24	6.04±0.33	0.0028±0.0000
$ m_{Z_1} - m_{Z_2}  > 25$ GeV	0.14±0.00	581.95±12.67	3.24±0.03	12.73±1.17	15.34±0.30	7.69±0.56	9.08±0.11	5.03±9.14	4.51±0.29	0.0054±0.0004
$E_T^{miss} > 50$ GeV	0.09±0.00	57.45±0.71	0.37±0.01	2.18±0.06	13.11±0.27	5.66±0.48	7.03±0.09	6.32±6.32	2.27±0.21	0.0094±0.0020

- mc16a, mc16d and mc16e are used for the cutflow table
- The combined significance is 0.0256 (new) and 0.0176 (old)

# DiHiggs to 4-lepton analysis

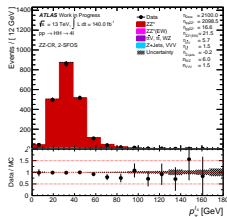
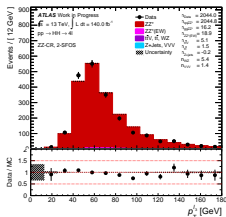
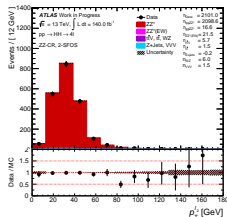
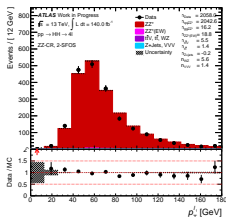
Kinematic distributions of the  $m_{4\ell}$ ,  $p_T^{4\ell}$ ,  $N_{\text{jets}}$ ,  $E_T^{\text{miss}}$ ,  $m_{Z_1}$  and  $m_{Z_2}$



- The  $ZZ^*$  background purity is 99%
- It's calculated by  $N^{ZZ^*} / N^{\text{bkg}}$

# DiHiggs to 4-lepton analysis

## Kinematic distributions of the leptons



- The normalisation of  $ZZ^*$  is 0.98
- It's calculated by  $(N^{\text{Data}} - N^{\text{Non-}ZZ^*}) / N^{ZZ^*}$



**Thank you!**

