H(jj) couplings at FCCee

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Updates on Zll & Z$\nu\nu$

At 240 and 365 GeV

Changes on Zll and $Z\nu\nu$

Fixed an issue related to MCstats uncertainty.

Updated Luminosity to **10.8ab-1** for 240GeV and **3.0ab-1** for 365GeV

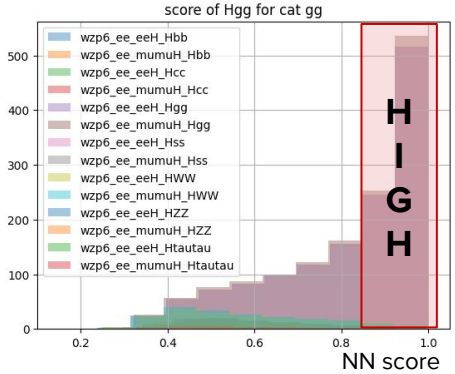
Modified the binning strategy to ensure better convergence of the fit:

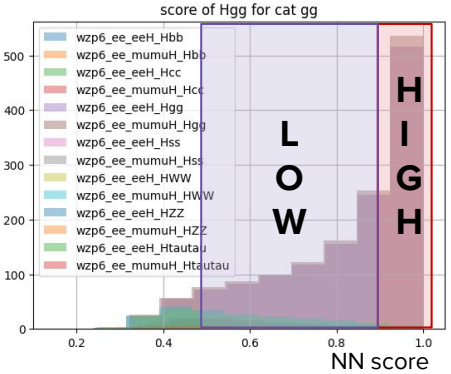
- Merged empty bins in the *data_obs* (sigs + bkgs) hist to the closest one, forcing at least **1 generated MC event** in each bin
- Fill empty bins in *processes* hist with 1e-6 events

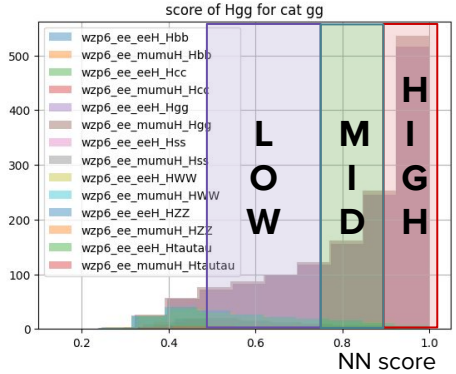
Additionally changed the binning of Zll and $Z\nu\nu$ from fixed size binning to custom size bins (smaller around signal region, larger around the tails)

	bb	cc	gg	ss	zz	ww	tautau
Znunu_npur3_240(MCst.)old	0.35	2.22	1.09	167.76	15.53	1.55	10.79
Znunu_npur3_240(MCst.)new	0.35	2.18	1.10	151.42	14.46	1.50	10.80
Znunu_npur3_365(MCst.)old	1.09	5.78	3.23	224.55	37.32	4.12	17.48
Znunu_npur3_365(MCst.)new	1.08	5.52	3.17	107.26	28.01	3.87	19.48

Purity categories







	bb	cc	gg	ss	zz	ww	tautau
Zll_npur1_240(MCst.)	0.68	4.17	2.29	309.73	14.21	1.75	3.62
Zll_npur2_240(MCst.)	0.67	3.98	2.17	234.47	12.77	1.70	3.74
Zll_npur3_240(MCst.)	0.67	3.93	2.16	229.23	12.52	1.70	3.73
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Zll_npur1_365(MCst.)	1.74	11.66	6.00	1545.43	57.32	5.60	12.88
Zll_npur2_365(MCst.)	1.72	11.09	5.80	1341.34	50.52	5.48	11.57
Zll_npur3_365(MCst.)	1.71	10.96	5.69	1117.70	41.84	5.37	12.59

For $Z\nu\nu$, all categories yield the best precision with 3 purity categories

From now background norms are now free in the fit. No syst.

Fitting and results

We fit :

- For **Zll** : 1D hist of the **recoil mass**
- for **Z$\nu\nu$** : 2D hist of **visible mass** and **missing mass**

We use CombineTF to perform the fit.

The table on the next slides summarize the results of the fit :

- **100*err_mu** given in output of combine for each category where *mu* is $\sigma^{*}BR/(\sigma^{*}BR)_{SM}$

Results for ZllZ$\nu\nu$ at 240 and 365

Precision (%)	bb	cc	gg	ss	WW	ZZ	ττ
Z(ll)H 240	0.68	4.02	2.18	234.84	1.78	13.66	4.08
Z(ll)H 365	1.74	11.29	5.74	1168.75	5.61	44.01	13.15
Z(ll)H 240+365	0.63	3.77	2.03	228.42	1.65	12.87	3.83
Z($\nu\nu$)H 240	0.36	2.18	1.10	151.68	1.51	15.29	11.0
Z($\nu\nu$)H 365	1.09	5.53	3.17	108.14	3.88	28.23	19.49
Z($\nu\nu$)H 240+365	0.34	2.03	1.04	87.89	1.40	13.38	9.58
Z(ll+$\nu\nu$)H 240	0.32	1.91	0.98	126.18	1.12	9.78	3.79
Z(ll+$\nu\nu$)H 365	0.92	4.94	2.77	107.64	3.15	23.47	10.90
Z(ll+$\nu\nu$)H 240+365	0.30	1.78	0.92	81.77	1.06	8.94	3.55

365GeV are still **WIP.** All expected yields available in Backup

Combination of Zll, Z$\nu\nu$ and Zqq

At 240 GeV

Combination elements

All channels (**Zqq, Z$\nu\nu$, Zll**) follow the same binning conventions (no empty bins, ghost events....)

Combination performed using both the **Z$\nu\nu$** analysis from **APC** (Marchiori/Maloizel) and **BNL** (Iakovidis) (There might be an issue with BNL Znunu templates)

Precision (%)	bb	cc	gg	ss	WW	ZZ	$\tau\tau$
Z(ll)H(jj)	0.68	4.02	2.18	234.84	1.78	13.66	4.08
Z(qq)H(jj)	0.32	3,28	3.06	438.23	8.68	50.09	110.71
Z($\nu\nu$)H(jj) [APC]	0.36	2.18	1.10	151.68	1.51	15.29	11.0
Z($\nu\nu$)H(jj) [BNL]	0.71	4.38	5.60	132.86	258.98	514.51	14.81
Combination ($\nu\nu$ APC)	0.22	1.65	0.93	121.70	1.11	9.56	3.79
Combination ($\nu\nu$ BNL)	0.26	2.19	1.65	111.07	1.67	12.34	3.84

Next steps

Perform the separation of **Z($\nu\nu$)H** and **VBF** events at 365 (and 240) GeV

Perform the Combination at 365 GeV

Obtain BR and kappas sensitivity :

- Assuming first the value of ZH coupling from the dedicated analysis
- by performing simultaneous analysis with the coupling measurement and σ(ZH)

BACKUP

Yields for Zll at 240 GeV

Expected yields (significance s/√tot) for Zll at E = 240

	bb	cc	gg	ss	WW	ZZ	tautau	bkg	TOTAL
bb_low	8043.0 (76)	0.6 (0)	61.5 (1)	0.0 (0)	5.5 (0)	103.0 (1)	0.0 (0)	2895.1	11108.7
bb_mid	7330.8 (77)	0.2 (0)	13.9 (0)	0.0 (0)	1.1 (0)	16.2 (0)	0.0 (0)	1775.7	9137.9
bb_high	32970.0 (175)	0.0 (0)	3.8 (0)	0.0 (0)	0.2 (0)	4.1 (0)	0.0 (0)	2389.3	35367.4
cc_low	57.8 (1)	458.0 (7)	79.0 (1)	0.1 (0)	230.6 (4)	62.1 (1)	0.0 (0)	3342.0	4229.5
cc_mid	19.7 (0)	474.4 (10)	12.8 (0)	0.0 (0)	17.6 (0)	5.8 (0)	0.0 (0)	1693.6	2223.9
cc_high	5.0 (0)	1487.7 (27)	3.7 (0)	0.0 (0)	1.2 (0)	0.9 (0)	0.0 (0)	1632.5	3131.2
gg_low	418.6 (6)	16.3 (0)	1812.0 (26)	0.8 (0)	596.6 (9)	84.7 (1)	0.0 (0)	1970.2	4899.3
gg_mid	92.4 (2)	4.4 (0)	2525.4 (43)	0.3 (0)	170.1 (3)	23.5 (0)	0.0 (0)	712.1	3528.1
gg_high	9.2 (0)	0.7 (0)	1628.7 (39)	0.0 (0)	14.8 (0)	2.1 (0)	0.0 (0)	96.7	1752.1
ss_low	2.0 (0)	10.2 (0)	318.8 (5)	5.0 (0)	134.1 (2)	64.5 (1)	0.1 (0)	4241.1	4775.8
ss_mid	0.2 (0)	3.9 (0)	41.8 (1)	5.2 (0)	4.4 (0)	4.1 (0)	0.0 (0)	2207.7	2267.4
ss_high	0.0 (0)	1.0 (0)	7.1 (0)	9.4 (0)	0.1 (0)	0.1 (0)	0.0 (0)	1668.6	1686.4
WW_low	33.7 (0)	41.3 (1)	100.2 (1)	0.1 (0)	2132.6 (30)	94.6 (1)	4.0 (0)	2637.1	5043.5
WW_mid	14.5 (0)	15.7 (0)	30.7 (1)	0.0 (0)	1583.8 (30)	36.4 (1)	1.2 (0)	1051.2	2733.5
WW_high	16.8 (0)	14.5 (0)	26.1 (0)	0.0 (0)	5689.0 (65)	43.0 (0)	1.0 (0)	1855.4	7645.9
ZZ_low	2117.1 (19)	44.9 (0)	116.4 (1)	0.2 (0)	733.4 (7)	411.2 (4)	1.8 (0)	9017.1	12442.1
ZZ_mid	295.7 (4)	4.5 (0)	17.7 (0)	0.0 (0)	144.6 (2)	208.1 (3)	0.4 (0)	4087.8	4758.8
ZZ_high	75.8 (1)	0.9 (0)	4.2 (0)	0.0 (0)	109.4 (1)	524.1 (5)	0.1 (0)	10477.7	11192.2
tautau_high	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	262.6 (2)	29.1 (0)	3777.6 (26)	16444.0	20513.3
TOTAL	51502.2	2579.2	6803.8	21.1	11831.8	1717.6	3786.2		

Yields for $Z\nu\nu$ at 240 GeV

Expected yields (significance s/√tot) for Znunu at E = 240

	bb	cc	gg	ss	WW	ZZ	tautau	bkg	TOTAL
bb_low	37028.7 (72)	6.4 (0)	337.8 (1)	0.0 (0)	15.1 (0)	423.7 (1)	0.4 (0)	226228.0	264040.2
bb_mid	39730.1 (113)	1.7 (0)	40.8 (0)	0.0 (0)	1.4 (0)	61.9 (0)	0.1 (0)	83828.9	123664.9
bb_high	129708.7 (289)	0.3 (0)	10.1 (0)	0.0 (0)	0.1 (0)	8.7 (0)	0.1 (0)	71205.7	200933.7
cc_low	130.5 (0)	1776.9 (3)	343.7 (1)	0.1 (0)	812.4 (1)	261.4 (0)	0.1 (0)	332054.7	335379.7
cc_mid	47.5 (0)	1665.6 (5)	74.0 (0)	0.0 (0)	71.5 (0)	29.9 (0)	0.0 (0)	93776.2	95664.6
cc_high	24.2 (0)	7168.4 (27)	25.8 (0)	0.0 (0)	12.9 (0)	6.4 (0)	0.0 (0)	64817.7	72055.3
gg_low	744.0 (3)	44.1 (0)	4432.3 (16)	1.8 (0)	977.3 (4)	133.6 (0)	0.0 (0)	66351.5	72684.4
gg_mid	339.9 (2)	21.0 (0)	4754.8 (25)	0.9 (0)	472.2 (3)	65.4 (0)	0.0 (0)	29167.5	34821.6
gg_high	162.9 (1)	13.7 (0)	14473.8 (76)	0.7 (0)	368.8 (2)	48.2 (0)	0.0 (0)	21558.8	36627.0
ss_low	3.1 (0)	33.5 (0)	1045.4 (3)	7.3 (0)	460.5 (1)	199.7 (1)	0.0 (0)	131829.1	133578.8
ss_mid	1.0 (0)	11.9 (0)	283.9 (1)	4.0 (0)	98.5 (0)	54.4 (0)	0.0 (0)	44494.3	44948.0
ss_high	1.2 (0)	41.8 (0)	641.1 (2)	77.2 (0)	107.1 (0)	83.5 (0)	0.0 (0)	161135.3	162087.2
WW_low	170.9 (0)	186.5 (0)	756.6 (1)	0.4 (0)	9842.1 (11)	523.1 (1)	0.2 (0)	813993.5	825473.4
WW_mid	91.0 (0)	96.5 (0)	199.4 (0)	0.1 (0)	7634.3 (9)	164.0 (0)	0.1 (0)	788286.0	796471.4
WW_high	84.0 (0)	55.4 (0)	112.0 (0)	0.1 (0)	16290.3 (13)	130.0 (0)	0.2 (0)	1546240.7	1562912.7
ZZ_low	9765.6 (10)	203.9 (0)	738.2 (1)	1.1 (0)	2723.3 (3)	1678.1 (2)	1.9 (0)	970946.3	986058.3
ZZ_mid	1112.0 (1)	12.1 (0)	108.0 (0)	0.2 (0)	352.4 (0)	789.1 (1)	0.1 (0)	639893.7	642267.5
ZZ_high	57.4 (0)	0.7 (0)	10.1 (0)	0.0 (0)	80.9 (0)	453.4 (1)	0.0 (0)	652726.7	653329.3
tautau_low	1.2 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.7 (0)	2.5 (0)	29.3 (0)	14886.1	14919.8
tautau_mid	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.1 (0)	0.1 (0)	16.8 (0)	3182.0	3198.9
tautau_high	0.5 (0)	0.0 (0)	0.0 (0)	0.0 (0)	2.3 (0)	1.8 (0)	5358.7 (9)	328666.1	334029.3
TOTAL	270706.6	13919.7	35191.6	115.1	52155.9	6836.2	9194.2		

Yields for Zll at 365 GeV

Expected yields (significance s/√tot) for Zll at E = 365

	bb	cc	gg	ss	WW	ZZ	tautau	bkg	TOTAL
bb_low	546.9 (18)	0.2 (0)	6.9 (0)	0.0 (0)	1.2 (0)	11.0 (0)	0.0 (0)	410.1	976.4
bb_mid	2117.2 (40)	0.3 (0)	8.7 (0)	0.0 (0)	0.8 (0)	10.9 (0)	0.0 (0)	710.9	2848.8
bb_high	5392.6 (69)	0.1 (0)	0.6 (0)	0.0 (0)	0.0 (0)	1.0 (0)	0.0 (0)	686.7	6081.1
cc_low	7.5 (0)	63.1 (2)	11.9 (0)	0.0 (0)	35.5 (1)	9.2 (0)	0.0 (0)	516.3	643.5
cc_mid	3.8 (0)	109.9 (4)	3.6 (0)	0.0 (0)	5.5 (0)	2.3 (0)	0.0 (0)	518.7	643.9
cc_high	1.0 (0)	234.4 (9)	0.6 (0)	0.0 (0)	0.4 (0)	0.2 (0)	0.0 (0)	468.2	704.6
gg_low	39.9 (1)	2.6 (0)	312.9 (11)	0.1 (0)	87.3 (3)	12.4 (0)	0.0 (0)	412.8	868.1
gg_mid	9.8 (0)	0.8 (0)	385.1 (16)	0.0 (0)	25.9 (1)	3.8 (0)	0.0 (0)	168.6	594.2
gg_high	0.6 (0)	0.2 (0)	248.5 (14)	0.0 (0)	3.1 (0)	0.5 (0)	0.0 (0)	70.8	323.7
ss_low	0.4 (0)	2.2 (0)	70.7 (2)	1.3 (0)	22.1 (1)	10.8 (0)	0.0 (0)	1733.8	1841.3
ss_mid	0.0 (0)	0.1 (0)	1.6 (0)	0.3 (0)	0.1 (0)	0.1 (0)	0.0 (0)	220.6	222.8
ss_high	0.0 (0)	0.1 (0)	1.2 (0)	1.2 (0)	0.1 (0)	0.1 (0)	0.0 (0)	490.2	492.8
WW_low	5.4 (0)	12.4 (0)	36.6 (1)	0.0 (0)	746.2 (17)	28.4 (1)	0.4 (0)	1071.7	1901.0
WW_mid	0.3 (0)	0.5 (0)	0.8 (0)	0.0 (0)	64.6 (5)	1.0 (0)	0.0 (0)	81.6	148.8
WW_high	0.8 (0)	1.5 (0)	2.4 (0)	0.0 (0)	468.0 (12)	3.8 (0)	0.0 (0)	1008.8	1485.2
ZZ_low	333.6 (7)	6.4 (0)	14.7 (0)	0.0 (0)	73.9 (2)	46.5 (1)	0.1 (0)	1753.1	2228.2
ZZ_mid	111.3 (2)	0.6 (0)	4.6 (0)	0.0 (0)	34.8 (1)	59.1 (1)	0.0 (0)	3604.8	3815.2
ZZ_high	1.5 (0)	0.0 (0)	0.1 (0)	0.0 (0)	2.2 (0)	22.3 (1)	0.0 (0)	493.8	520.0
tautau_low	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	8.6 (0)	1.1 (0)	140.4 (4)	1275.9	1426.1
tautau_high	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.2 (0)	0.2 (0)	244.4 (8)	813.0	1057.8
TOTAL	279279.4	14355.0	36303.2	118.0	53736.2	7060.9	9579.6		

Yields for $Z\nu\nu$ at 365 GeV

Expected yields (significance s/√tot) for Znunu at E = 365

	bb	cc	gg	ss	WW	ZZ	tautau	bkg	TOTAL
bb_low	612.4 (12)	0.7 (0)	11.9 (0)	0.0 (0)	0.6 (0)	17.6 (0)	0.0 (0)	1960.5	2603.7
bb_mid	2277.7 (25)	0.9 (0)	19.2 (0)	0.0 (0)	1.5 (0)	25.0 (0)	0.0 (0)	6114.6	8438.8
bb_high	15474.2 (114)	0.5 (0)	7.0 (0)	0.0 (0)	0.2 (0)	8.6 (0)	0.0 (0)	2837.1	18327.4
cc_low	17.3 (0)	238.4 (2)	46.8 (0)	0.0 (0)	129.7 (1)	29.1 (0)	0.0 (0)	14911.8	15373.2
cc_mid	2.2 (0)	200.6 (4)	5.0 (0)	0.0 (0)	4.5 (0)	3.0 (0)	0.0 (0)	2405.1	2620.5
cc_high	1.1 (0)	659.4 (15)	1.6 (0)	0.0 (0)	0.4 (0)	0.5 (0)	0.0 (0)	1289.1	1952.2
gg_low	141.9 (2)	10.8 (0)	1459.5 (19)	0.5 (0)	346.1 (4)	44.8 (1)	0.0 (0)	4155.9	6159.4
gg_mid	6.0 (0)	0.7 (0)	561.0 (20)	0.0 (0)	23.7 (1)	3.4 (0)	0.0 (0)	203.7	798.6
gg_high	1.3 (0)	0.2 (0)	679.6 (25)	0.0 (0)	9.0 (0)	1.3 (0)	0.0 (0)	56.5	747.9
ss_low	0.3 (0)	6.2 (0)	224.4 (2)	3.5 (0)	60.8 (1)	27.5 (0)	0.0 (0)	8322.5	8645.2
ss_mid	0.0 (0)	0.7 (0)	7.8 (0)	2.0 (0)	0.3 (0)	0.3 (0)	0.0 (0)	593.0	604.2
ss_high	0.0 (0)	0.2 (0)	1.6 (0)	2.5 (0)	0.0 (0)	0.0 (0)	0.0 (0)	251.6	255.8
WW_low	5.7 (0)	16.4 (0)	43.5 (0)	0.0 (0)	1195.4 (8)	32.4 (0)	0.0 (0)	23020.3	24313.7
WW_mid	0.2 (0)	2.7 (0)	5.9 (0)	0.0 (0)	640.3 (7)	6.2 (0)	0.0 (0)	8361.2	9016.5
WW_high	0.1 (0)	0.2 (0)	0.4 (0)	0.0 (0)	175.9 (5)	0.7 (0)	0.0 (0)	1151.5	1328.8
ZZ_low	348.6 (2)	12.8 (0)	40.5 (0)	0.1 (0)	164.5 (1)	77.0 (1)	0.0 (0)	19706.9	20350.5
ZZ_mid	133.1 (1)	2.5 (0)	8.3 (0)	0.0 (0)	18.5 (0)	37.3 (0)	0.0 (0)	14417.9	14617.6
ZZ_high	16.0 (0)	0.5 (0)	1.8 (0)	0.0 (0)	6.7 (0)	15.4 (0)	0.0 (0)	50616.6	50657.1
tautau_low	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.1 (0)	552.9	553.1
tautau_mid	0.1 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	1.4 (0)	156.9	158.3
tautau_high	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	109.5 (4)	692.0	801.5
TOTAL	298317.4	15509.6	39429.2	126.6	56514.3	7390.8	9690.6		