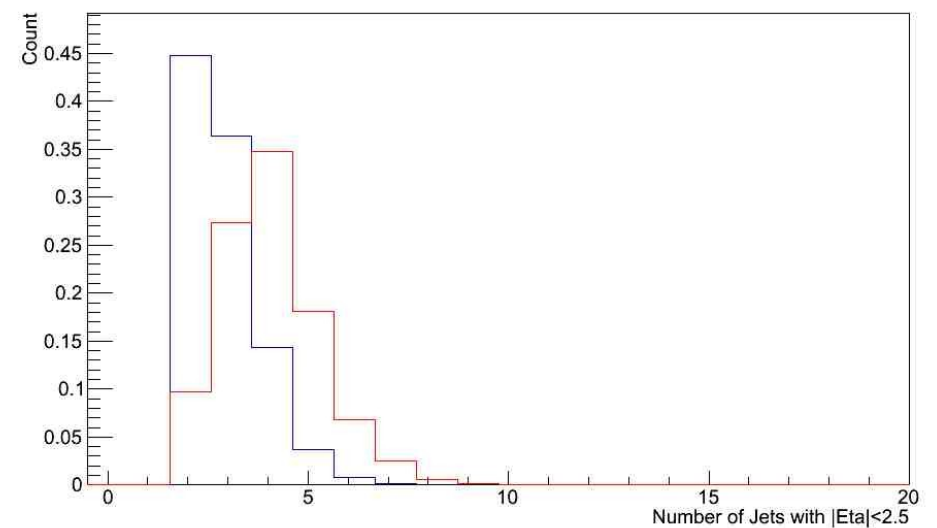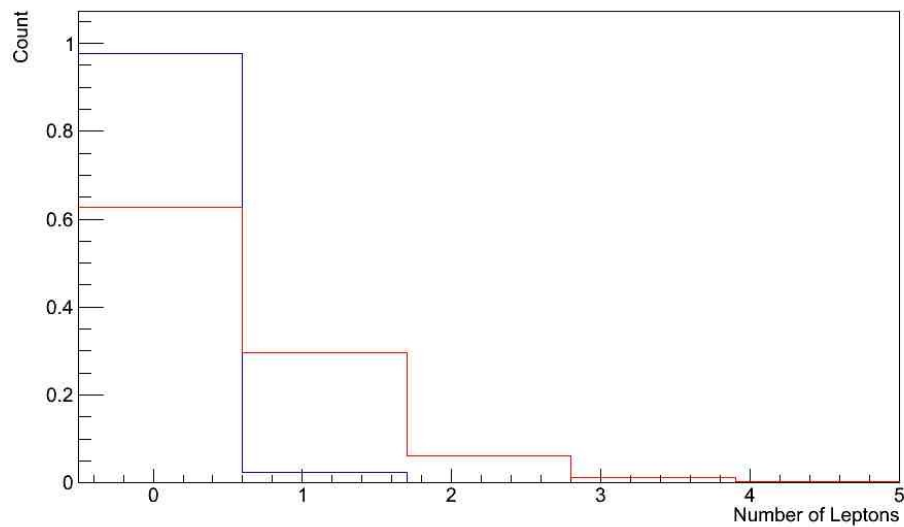# Progress in the bbgg study

Andres Rios

Object selection

The following are distributions of variables used in the object selection.

I don't have a plot for photon isolation, but it just has to be pointed out that a cut requiring no photons with IsolationVar > 0.5 works remarkably well.

Object selection

The basic selection requires events to have two photons with pt > 25 and |eta| < 5, and two bjets with pt > 30 and |eta| < 2.4.

The distributions of pt of each object are shown in the following plots:
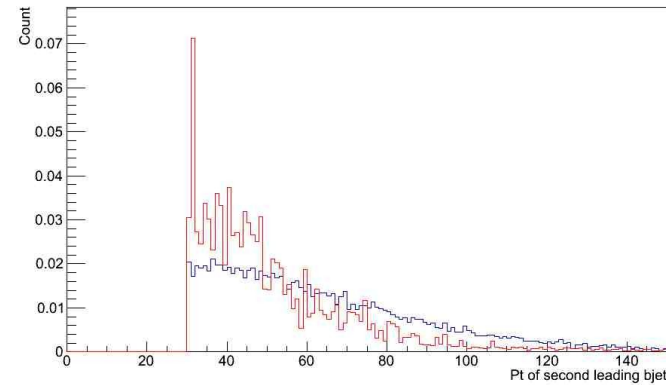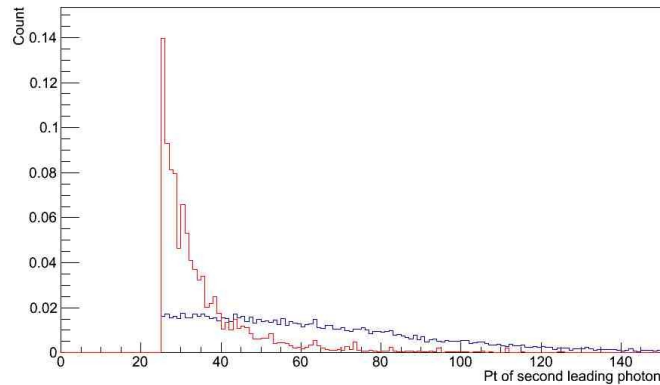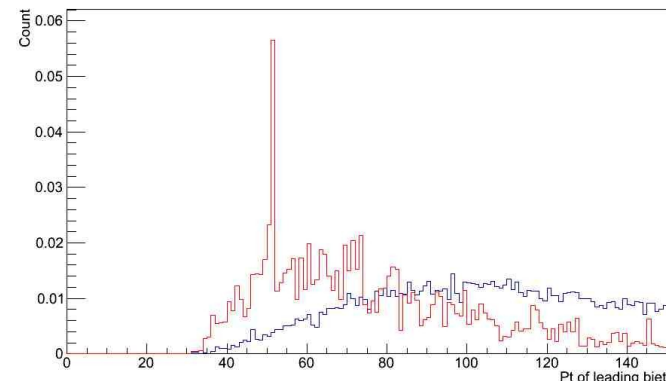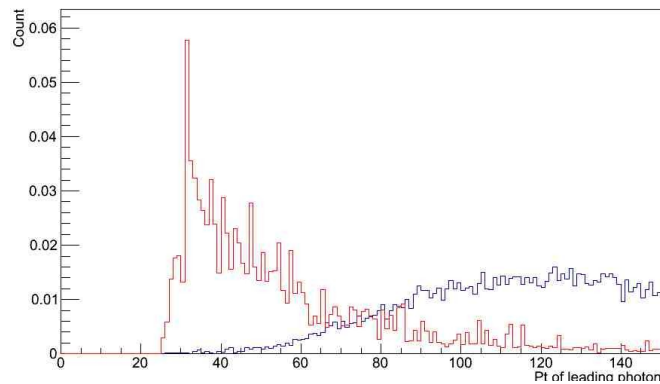
As shown above, signal events tend to have objects with higher pt than background events. For this reason it is useful to require a reasonably hight pt for all objects. However, to minimize loss of signal events, low pt events are also taken into account in a separate category.

Categories

The events are split into the following two categories:

Category 1 (High pt)

- **Object selection**
  - Leading photon pt > 80
  - Second leading photon pt > 50
  - Leading bjet pt > 80
  - Second leading bjet pt > 50
  - |Eta| < 2.5 for photons
  - |Eta| < 2.4 for bjets
  - No photons with IsolationVar > 0.5
  - No reconstructed leptons
  - Less than 4 jets (pt > 30, |Eta| < 2.5)

- **Kinematic cuts**
  - $0.5 < \Delta R_{gg} < 1.25$
  - $0.5 < \Delta R_{bb} < 1.25$
  - $1.75 < \min(\Delta R_{bg}) < 3$

- **Mass cuts**
  - $120 < M_{gg} < 130$
  - $100 < M_{bb} < 135$
  - $400 < M_{HH} < 1000$

Category 2 (Low pt)

- **Object selection**
  - Leading photon pt > 40
  - Second leading photon pt > 25
  - Leading bjet pt > 30
  - Second leading bjet pt > 30
  - |Eta| < 2.5 for photons
  - |Eta| < 2.4 for bjets
  - No photons with IsolationVar > 0.5
  - No reconstructed leptons
  - Less than 4 jets (pt > 30, |Eta| < 2.5)
  - Not satisfy pt requirements of category 1

- **Kinematic cuts**
  - $1 < \Delta R_{gg} < 1.5$
  - $0.75 < \Delta R_{bb} < 2$
  - $0.5 < \min(\Delta R_{bg}) < 2.25$

- **Mass cuts**
  - $122.5 < M_{gg} < 127.5$
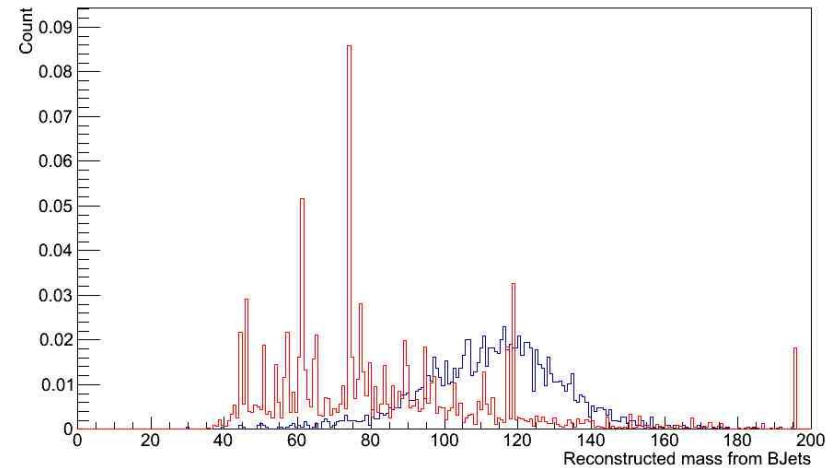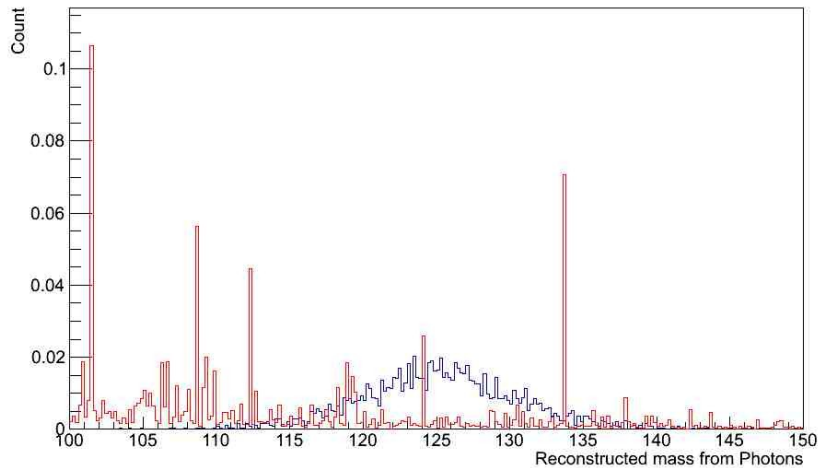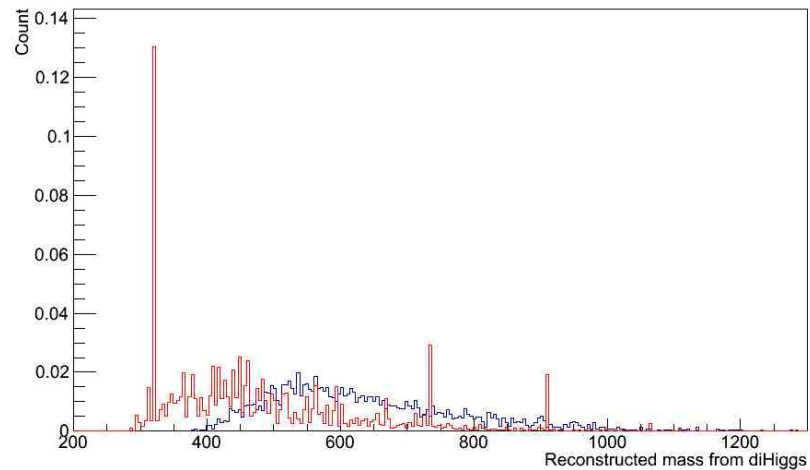 - $80 < M_{bb} < 130$
  - $350 < M_{HH} < 600$

Category 1 - Kinematic cuts

The following plots show the distributions of the kinematic variables used for cuts.
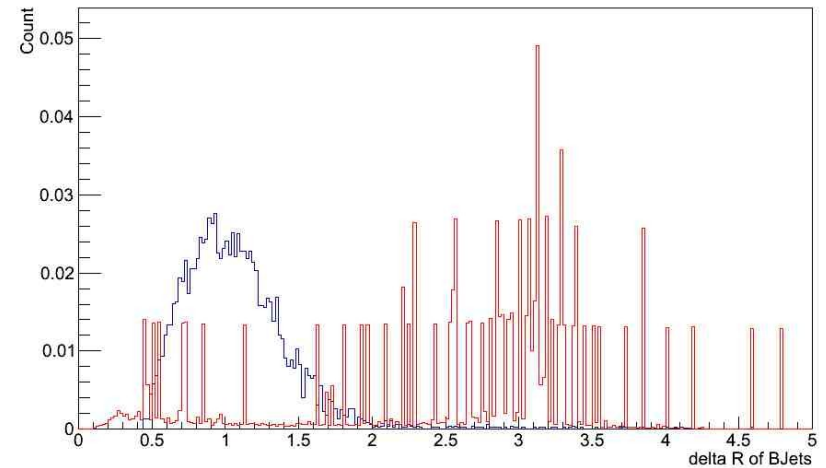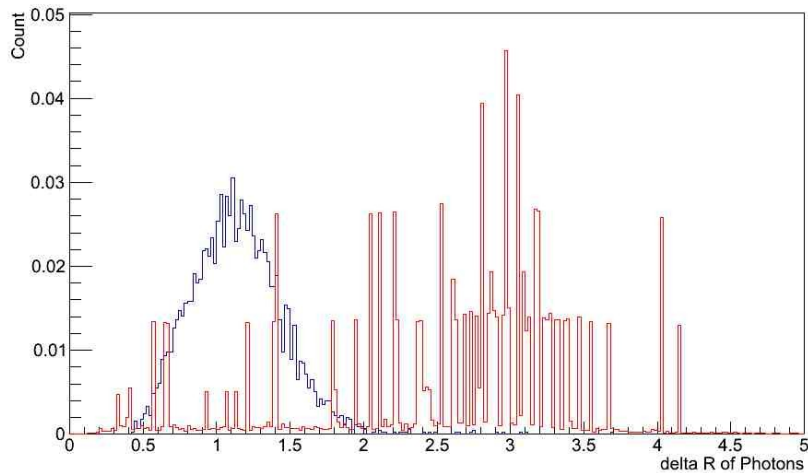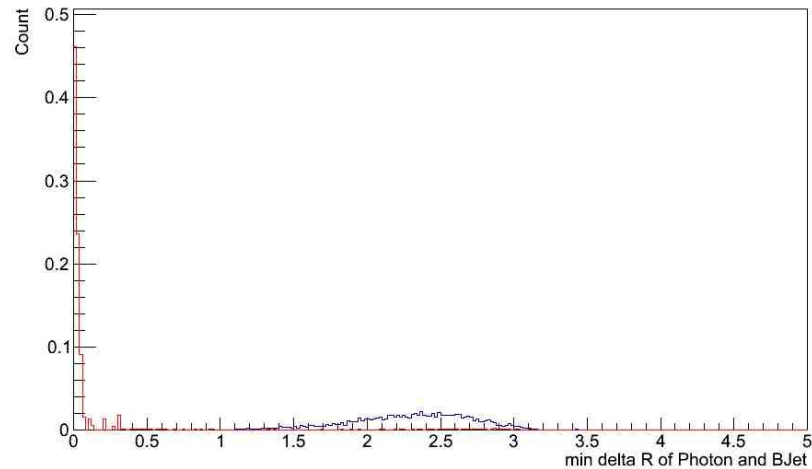
Category 1 - Mass cuts

The following plots show the distributions of reconstructed masses used for cuts.

Category 1 - Event yields

The following are the event yields of category 1.

	HH->bbgg	B	BB	BBB	Bj	Bjj	H	LL	LLB	tB	tj	tt	ttB
Total	3.07E+02	6.03E+11	8.69E+08	8.21E+06	8.82E+08	2.73E+08	6.83E+07	4.63E+09	8.98E+06	2.16E+08	3.48E+08	1.74E+09	8.83E+06
Object selection	14.05 ± 0.21	0 ± 0	734.9 ± 148.5	6.59 ± 2.04	38585 ± 5438	466.8 ± 120.2	16.46 ± 13.14	1.59 ± 1.47	0 ± 0	12.56 ± 6.74	214.5 ± 76.1	89.82 ± 61.80	15.24 ± 3.96
Kinematic selection	7.77 ± 0.15	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Mass windows	3.38 ± 0.10	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0

	bbgg	bbjj	ccgg	ccjg	ccjj	jjgg	jjjj
Total	4.08E+05	1.83E+12	3.88E+06	7.50E+09	1.95E+12	6.60E+07	6.00E+13
Object selection	983.4 ± 1.9	2861 ± 23	90.64 ± 1.31	872.3 ± 3.7	322.4 ± 1.3	139.3 ± 0.7	189.6 ± 4.94
Kinematic selection	37.38 ± 0.38	122.6 ± 4.8	3.91 ± 0.27	30.81 ± 0.61	12.03 ± 0.24	6.19 ± 0.11	38.35 ± 2.53
Mass windows	0.69 ± 0.05	0.0028 ± 0.0009	0.018 ± 0.018	0.016 ± 0.005	0.084 ± 0.013	0.099 ± 0.012	0 ± 0

$S/B = 3.38/0.91 = 3.71$ $S/\sqrt{B} = 3.54$ $S/\sqrt{(S+B)} = 1.63$

Category 2 - Kinematic cuts

The following plots show the distributions of the kinematic variables used for cuts.

Category 2 – Mass Cuts

The following plots show the distributions of reconstructed masses used for cuts.

Category 2 - Event yields
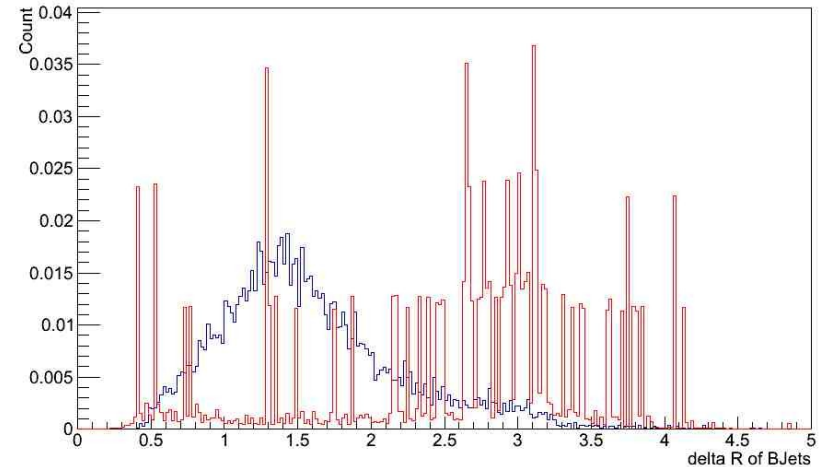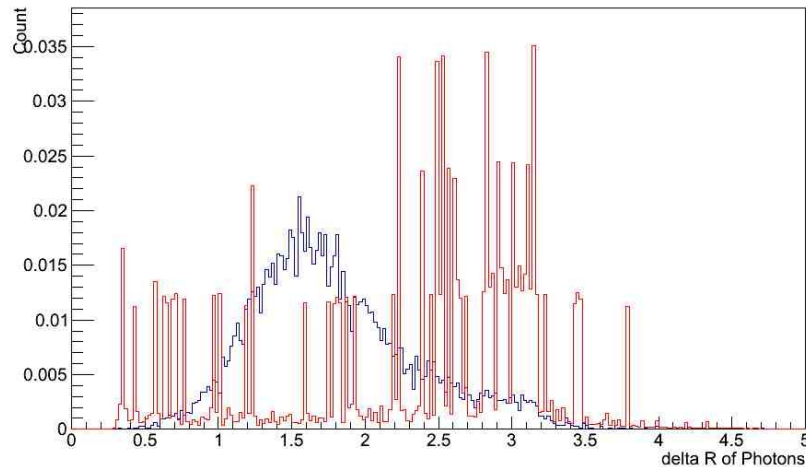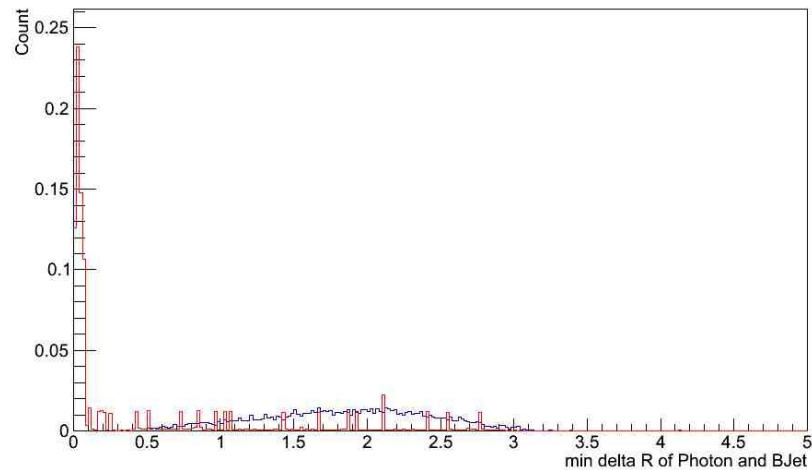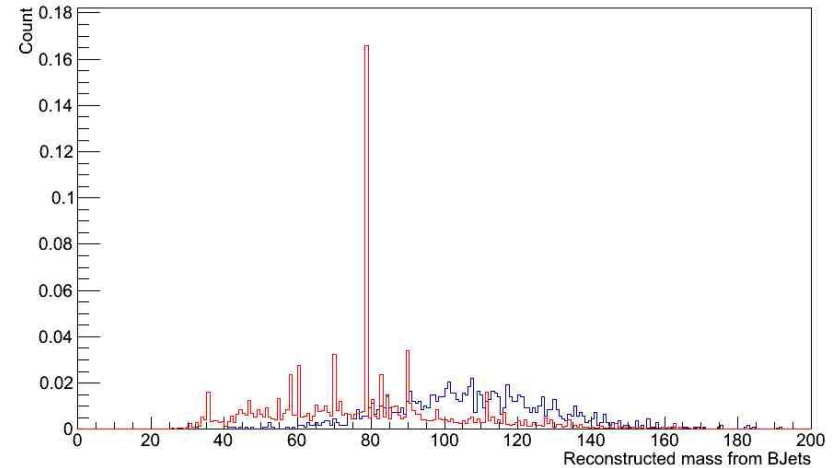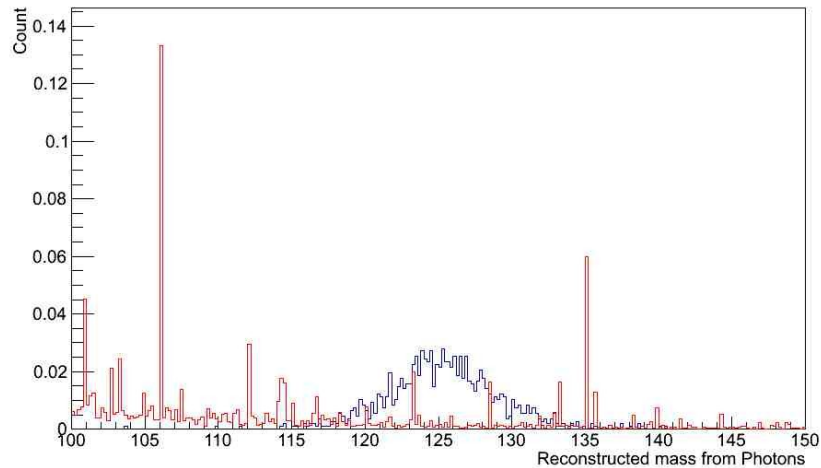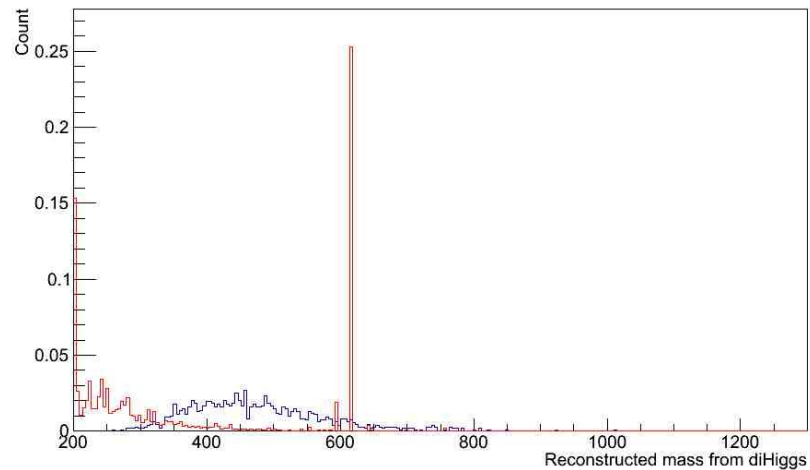
The following are the event yields of category 2.

	HH->bbgg	B	BB	BBB	Bj	Bjj	H	LL	LLB	tB	tj	tt	ttB
Total	2.67E+02	6.03E+11	8.69E+08	8.21E+06	8.82E+08	2.73E+08	6.83E+07	4.63E+09	8.98E+06	2.16E+08	3.48E+08	1.74E+09	8.83E+06
Object selection	23.86 ± 0.27	0 ± 0	12902 ± 805	120.7 ± 8.79	954415 ± 110183	3359 ± 318	288.6 ± 57.7	117.6 ± 79.8	0 ± 0	1749 ± 770	4382 ± 337	16450 ± 2347	213.2 ± 14.5
Kinematic selection	3.39 ± 0.10	0 ± 0	179.8 ± 93.5	1.83 ± 1.05	596.5 ± 596.5	28.83 ± 28.83	10.39 ± 10.39	0 ± 0	0 ± 0	341.0 ± 341.0	3.89 ± 3.89	0 ± 0	4.70 ± 2.15
Mass windows	1.14 ± 0.06	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0

	bbgg	bbjj	ccgg	ccjg	ccjj	jjgg	jjjj
Total	4.08E+05	1.83E+12	3.88E+06	7.50E+09	1.95E+12	6.60E+07	6.00E+13
Object selection	16873 ± 8	32834 ± 63	6657 ± 11	11398 ± 12	4354 ± 4	9233 ± 7	17227 ± 27
Kinematic selection	152.1 ± 0.8	585.9 ± 5.9	38.25 ± 0.85	155.5 ± 1.0	94.38 ± 0.47	58.77 ± 0.46	470.1 ± 2.9
Mass windows	0.46 ± 0.04	0.91 ± 0.19	0 ± 0	0.11 ± 0.02	0.015 ± 0.003	0.053 ± 0.007	0 ± 0

$$S/B = 1.14/1.56 = 0.73 \quad S/\sqrt{B} = 0.91 \quad S/\sqrt{(S+B)} = 0.69$$