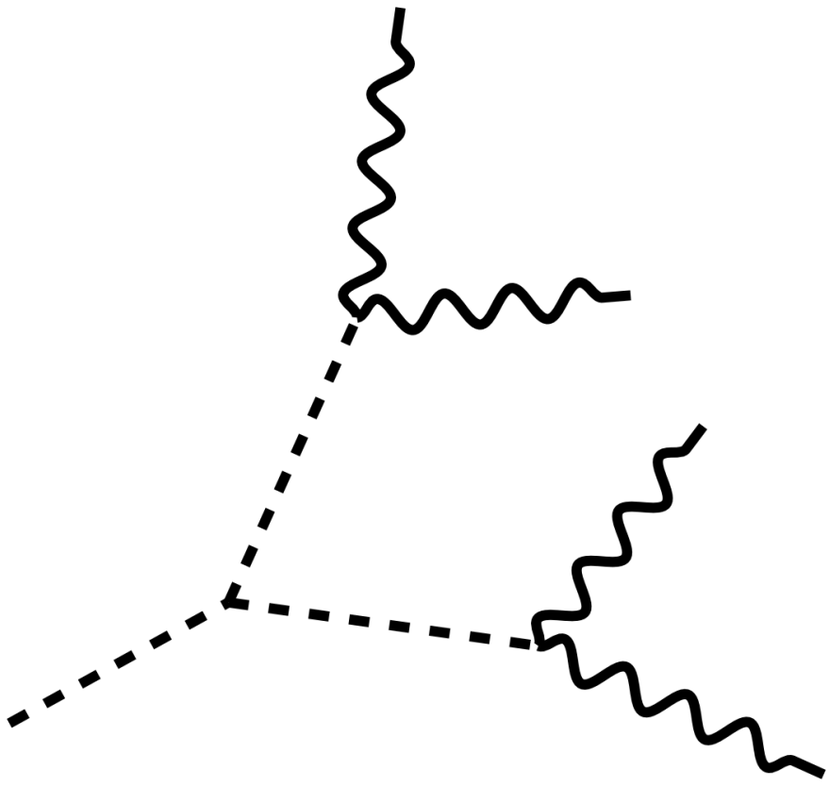
h(125)→aa→γγγγ



Higgs to 4 Gamma Update

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H4G chat
20/02/2018

TRIGGER & PRESELECTION

- Online selection identical to low mass h→γγ search
- Passing the OR of the two Low mass HLT paths
  - OR Path
    HLT_Diphoton30EB_18EB_R9Id_OR_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55
  - AND Path
    HLT_Diphoton30PV_18PV_R9Id_AND_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55

- **Pre-Selection**
  - Loose Photon ID > -0.9
  - Trigger strategy on MC based on offline selection similar to online
  - Different kind of photon pairs being considered according to their η and R9 values

OLD

Offline Trigger like requirements

Category		R9	H/E	$\sigma_{i\eta i\eta}$	Pho Iso	Trk Iso
Both photons in EB		> 0.85	< 0.08	-	-	-
		> 0.5 && < 0.85	< 0.08	< 0.015	4 GeV	6 GeV
At least one Photon in EE	Second photon in EB	> 0.85	< 0.08	< 0.015	4 GeV	6 GeV
	Second Photon in EE	> 0.9	< 0.08	< 0.035	4 GeV	6 GeV

- $m_{\gamma\gamma}$ > 55 GeV, P_T lead γ> 30 GeV, P_T sub-lead γ> 18 GeV, Pixel Veto applied

TRIGGER & PRESELECTION

- Online selection identical to low mass h→ɣɣ search
- Passing the OR of the two Low mass HLT paths
  - OR Path
    HLT_Diphoton30EB_18EB_R9Id_OR_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55
  - AND Path
    HLT_Diphoton30PV_18PV_R9Id_AND_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55

- **Pre-Selection**
  - Loose Photon ID > -0.9
  - Trigger strategy on MC based on offline selection similar to online
  - Different kind of photon pairs being considered according to their η and R9 values

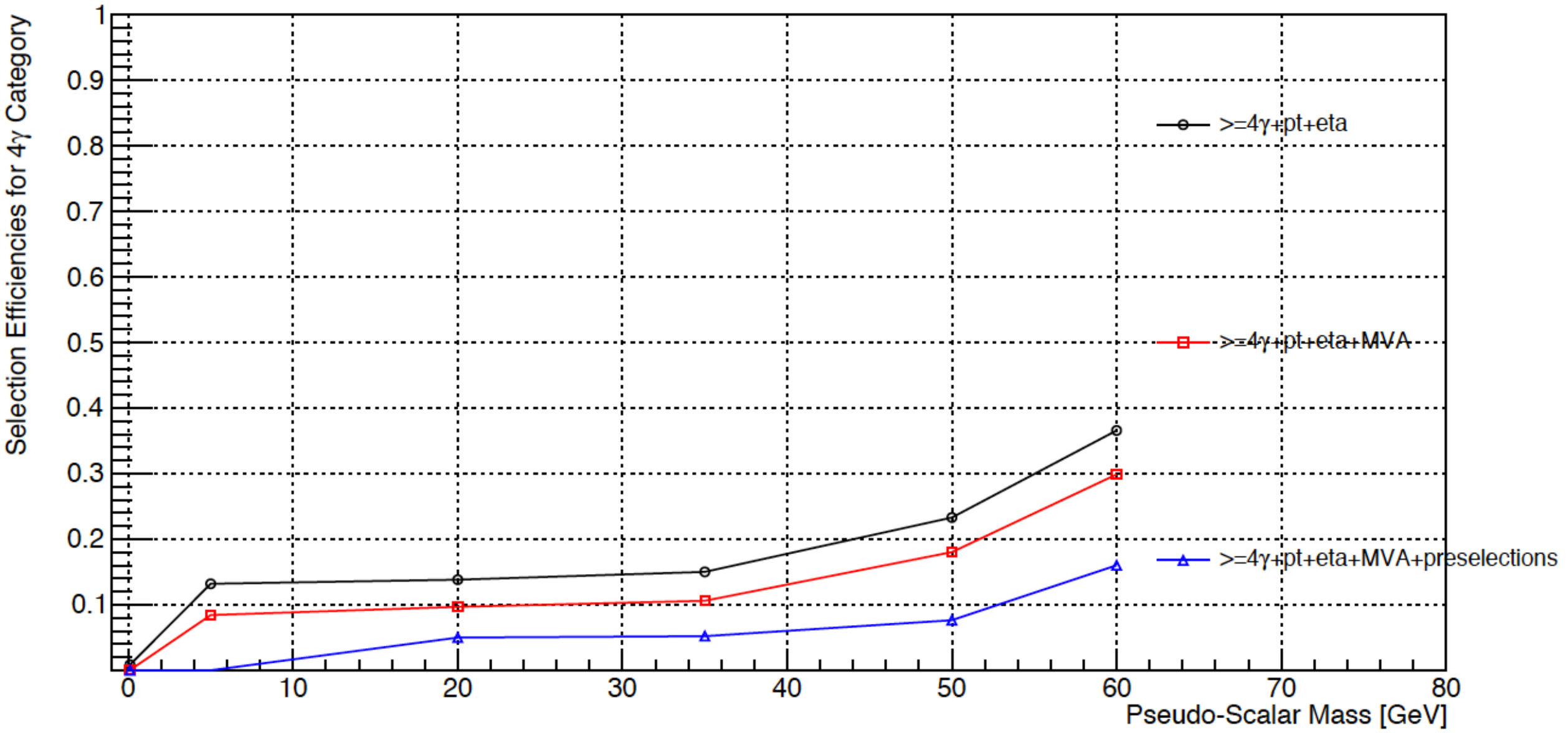
NEW

Offline Trigger like requirements

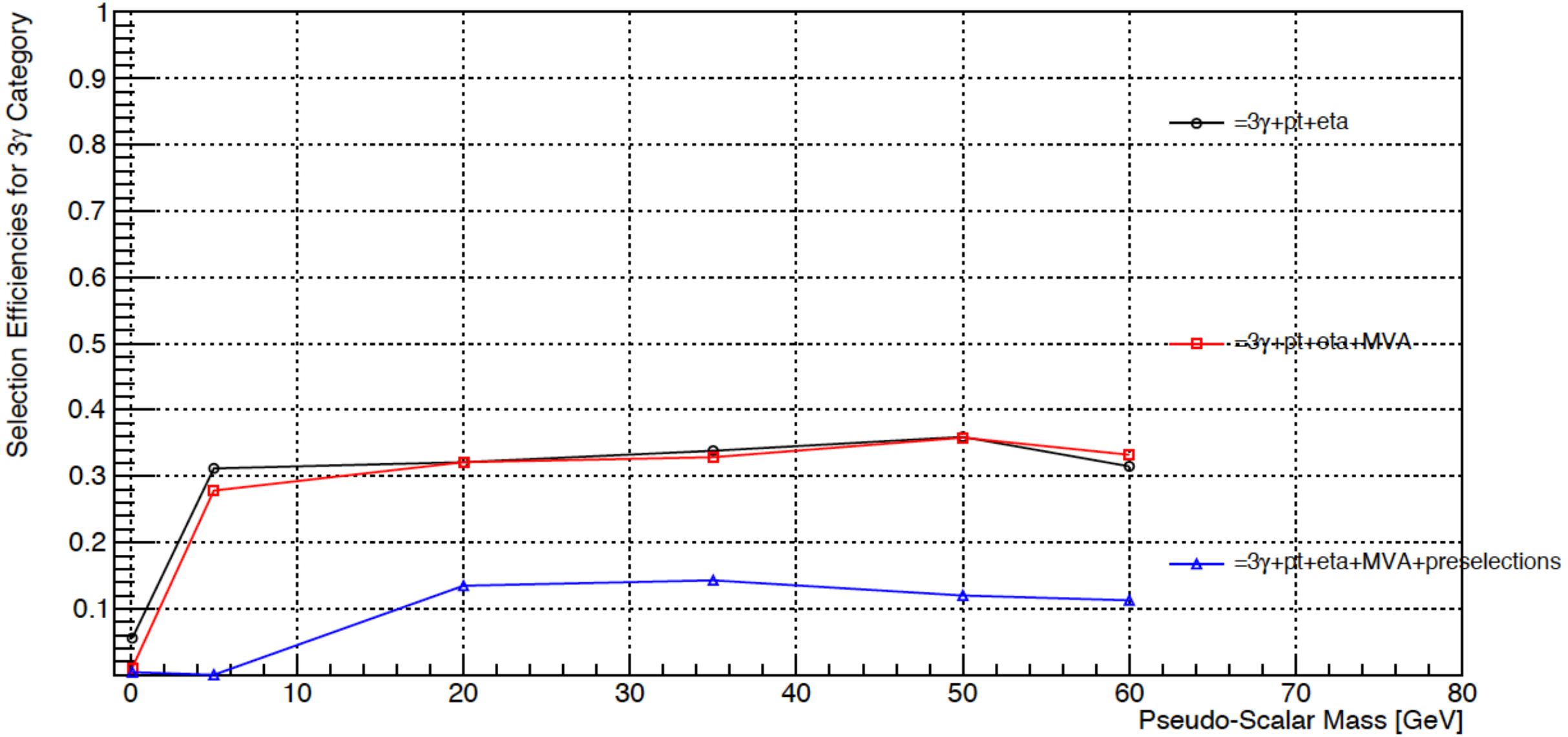
Category		R9	H/E	$\sigma_{i\eta i\eta}$	Pho Iso	Trk Iso
Both photons in EB		> 0.5	< 0.07	< 0.0105	< 4 GeV	< 6 GeV
At least one Photon in EE	Second photon in EB	> 0.85	< 0.07	< 0.0105	< 4 GeV	< 6 GeV
At least one Photon in EE	Second photon in EE	> 0.9	< 0.035	< 0.0275	< 4 GeV	< 6 GeV

- $m_{\gamma\gamma}$ > 55 GeV, P_T lead ɣ> 30 GeV, P_T sub-lead ɣ> 18 GeV, Pixel Veto applied

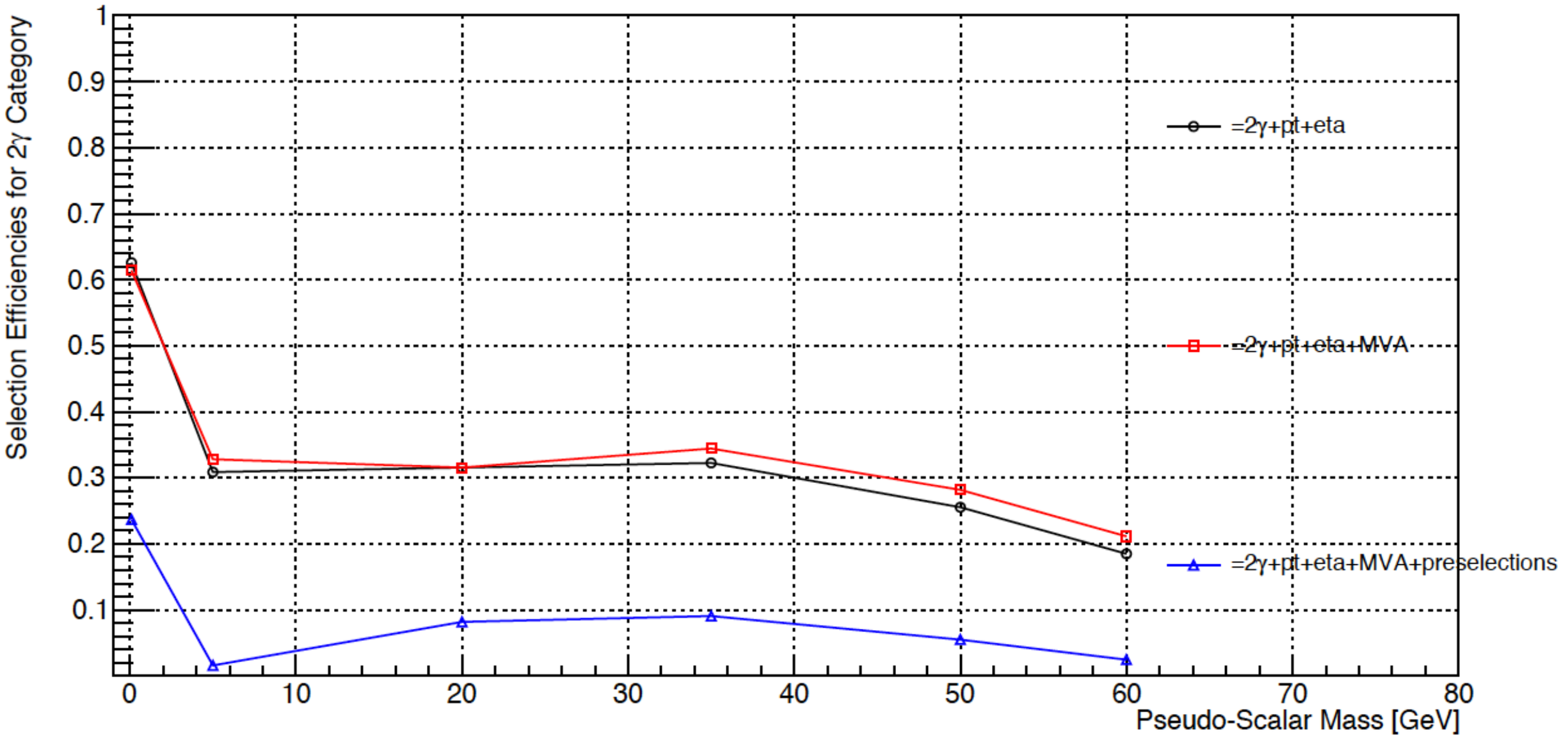
4 Photon category



3 Photon category



2 Photon category



Yields in each category

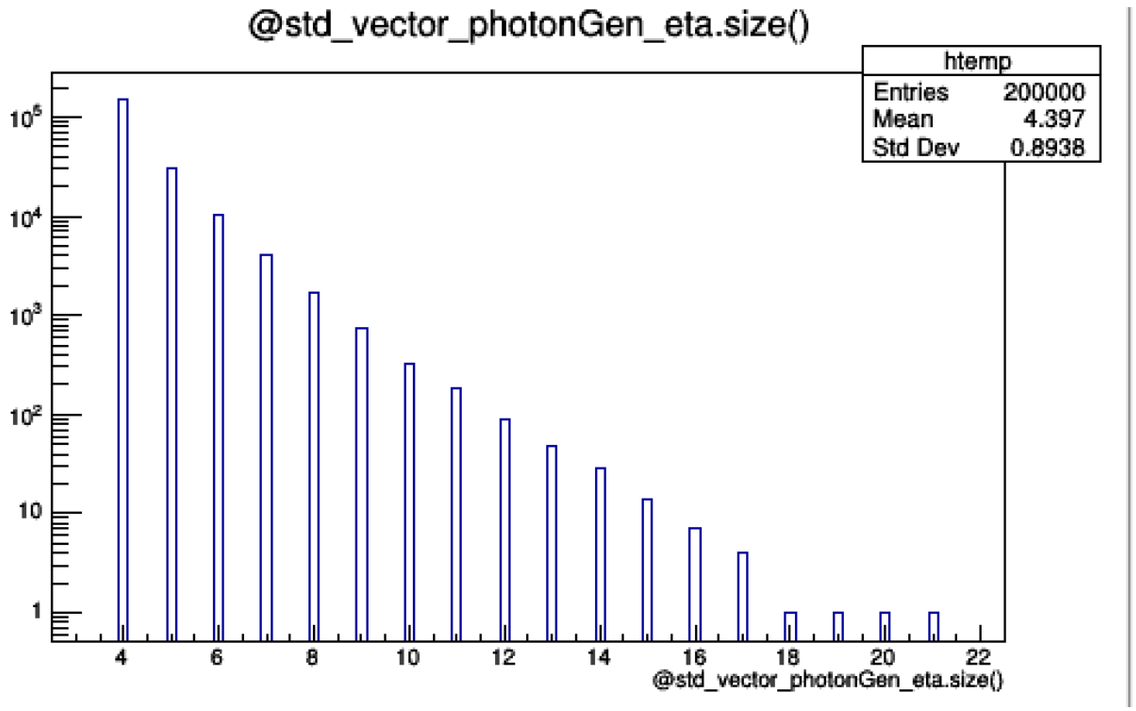
Yield = #of events after selection * ($L*\sigma_{\gamma\gamma} / W$)

Link to spreadsheet

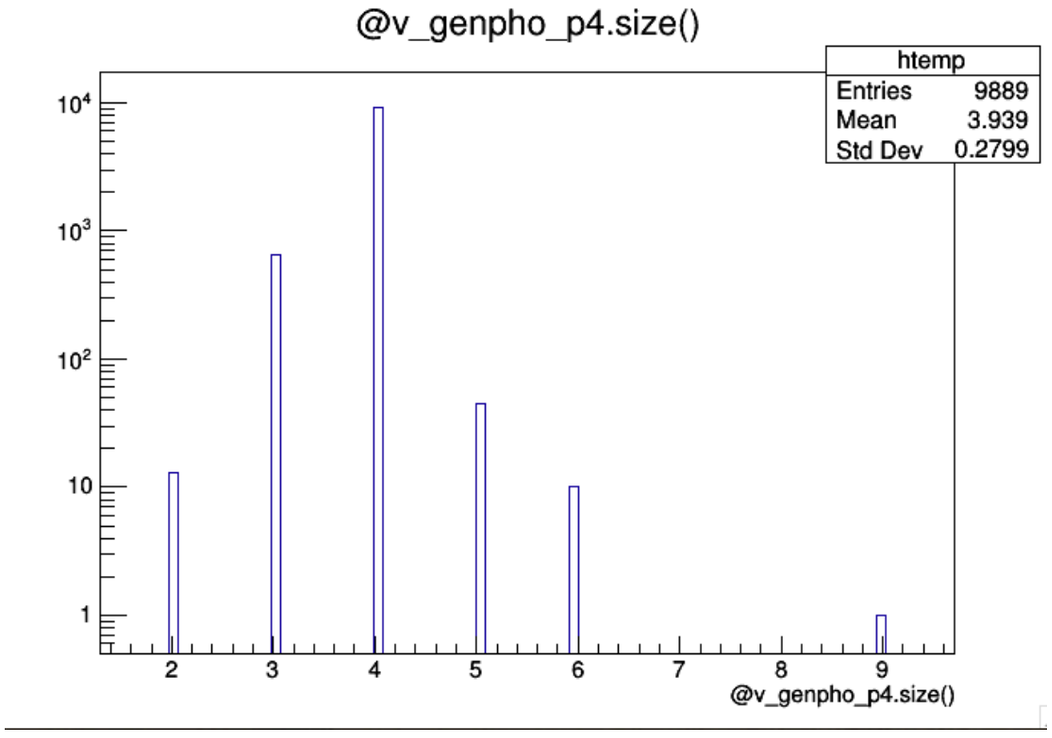
m(a) GeV	4 Photon Cat		3 Photon Cat		2 Photon Cat	
0.1	0.006	0.037	0.159	0.193	8.52	1.57
1	0.002	0.023	0.034	0.089	1.19	0.54
5	0.002	0.022	0.015	0.060	0.57	0.37
10	0.835	0.452	2.788	0.847	2.40	0.78
15	1.674	0.639	4.474	1.083	2.79	0.84
20	1.801	0.664	4.852	1.133	2.94	0.86
25	1.894	0.682	5.067	1.161	3.12	0.89
30	1.841	0.672	5.084	1.163	3.20	0.90
35	1.877	0.679	5.145	1.171	3.26	0.91
40	2.017	0.705	4.987	1.151	3.13	0.89
45	2.263	0.753	4.767	1.128	2.72	0.83
50	2.753	0.831	4.321	1.063	1.97	0.70
55	3.989	1.019	4.207	1.049	1.18	0.53
60	5.766	1.255	4.060	1.032	0.88	0.46

What is going on @Gen level

- @ miniAOD level



- @ micro AOD level



- Are any cuts/selections being applied?
- Pruned gen particle collection is taken from miniAOD and further selections are applied to it

https://github.com/cms-analysis/flashgg/blob/master/MicroAOD/python/flashggPrunedGenParticles_cfi.py#L3-L15

What is going on @Gen level

- Events w/ 2, 3, 4 , 5 ,6, 9 gen photons

- 9 gen photons

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 1} <idx: 3> gamma{status: 1} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 23} <idx: 5>
    |   +-> u{status: 71} <idx: 8>
    |   |   +-> pi0{status: 2} <idx: 10>
    |   |   |   +-> gamma{status: 1} <idx: 13>
    |   |   +-> pi0{status: 2} <idx: 11>
    |   |   |   +-> gamma{status: 1} <idx: 14>
    |   |   +-> pi0{status: 2} <idx: 12>
    |   |       +-> gamma{status: 1} <idx: 15>
    |   +-> ubar{status: 71} <idx: 9>
    |       +-> pi0{status: 2} <idx: 10>
    |       |   +-> gamma{status: 1} <idx: 13>
    |       +-> pi0{status: 2} <idx: 11>
    |       |   +-> gamma{status: 1} <idx: 14>
    |       +-> pi0{status: 2} <idx: 12>
    |           +-> gamma{status: 1} <idx: 15>
    +-> gamma{status: 23} <idx: 6>
        +-> gamma{status: 1} <idx: 7>
```

- 6 gen photons

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 1} <idx: 3> gamma{status: 1} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 23} <idx: 5>
    |   +-> u{status: 71} <idx: 11>
    |   |   +-> pi0{status: 2} <idx: 14>
    |   |       +-> gamma{status: 1} <idx: 15>
    |   +-> g{status: 71} <idx: 12>
    |   |   +-> pi0{status: 2} <idx: 14>
    |   |       +-> gamma{status: 1} <idx: 15>
    |   +-> ubar{status: 71} <idx: 13>
    |       +-> pi0{status: 2} <idx: 14>
    |           +-> gamma{status: 1} <idx: 15>
    +-> gamma{status: 23} <idx: 6>
        +-> gamma{status: 52} <idx: 7>
            +-> e-{status: 1} <idx: 8> gamma{status: 1} <idx: 9> e+
{status: 1} <idx: 10>
```

- 5 gen photons

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 23} <idx: 3>
|   |   +-> gamma{status: 1} <idx: 6> e+{status: 1} <idx: 7> gamma{status: 1} <idx: 8> e-{status: 1} <idx: 9>
|   +-> gamma{status: 23} <idx: 4>
|       +-> gamma{status: 1} <idx: 5>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 10> gamma{status: 1} <idx: 11>
```

- 4 gen photons

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 23} <idx: 3>
|   |   +-> gamma{status: 1} <idx: 5>
|   +-> gamma{status: 23} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 6> gamma{status: 1} <idx: 7>
```

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 1} <idx: 3> gamma{status: 1} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 5> gamma{status: 1} <idx: 6>
```

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 23} <idx: 3>
|   |   +-> gamma{status: 1} <idx: 5>
|   +-> gamma{status: 23} <idx: 4>
|       +-> e-{status: 1} <idx: 6> gamma{status: 1} <idx: 7> e+{status: 1} <idx: 8>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 9> gamma{status: 1} <idx: 10>
```

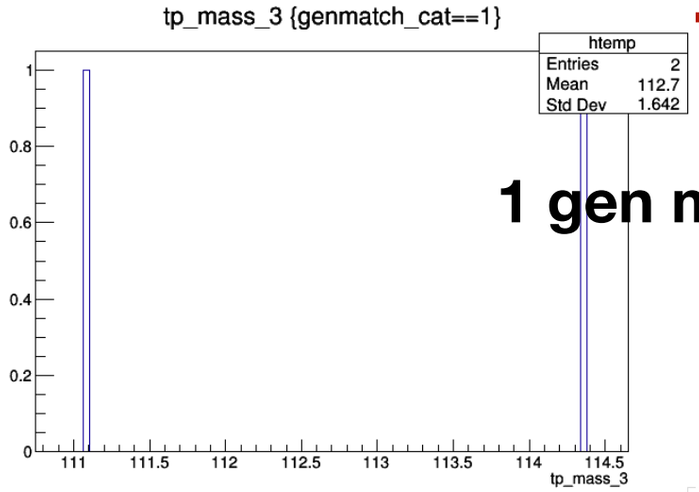
- 3 gen photons

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 23} <idx: 3>
|   |   +-> u{status: 71} <idx: 8>
|   |   |   +-> K_S0{status: 1} <idx: 9>
|   |   +-> K_S0{status: 1} <idx: 9>
|   +-> gamma{status: 23} <idx: 4>
|       +-> gamma{status: 1} <idx: 5>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 6> gamma{status: 1} <idx: 7>
```

```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 23} <idx: 3>
|   |   +-> mu-{status: 1} <idx: 5> mu+{status: 1} <idx: 6>
|   +-> gamma{status: 23} <idx: 4>
|       +-> gamma{status: 1} <idx: 7>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 1} <idx: 8> gamma{status: 1} <idx: 9>
```

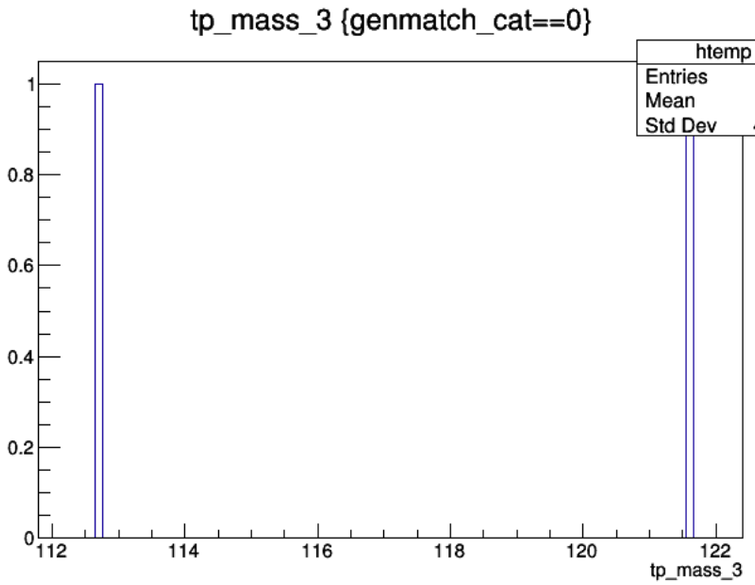
```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 1} <idx: 3> gamma{status: 1} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 23} <idx: 5>
    |   +-> gamma{status: 1} <idx: 9>
    +-> gamma{status: 23} <idx: 6>
        +-> e+{status: 1} <idx: 7> e-{status: 1} <idx: 8>
```

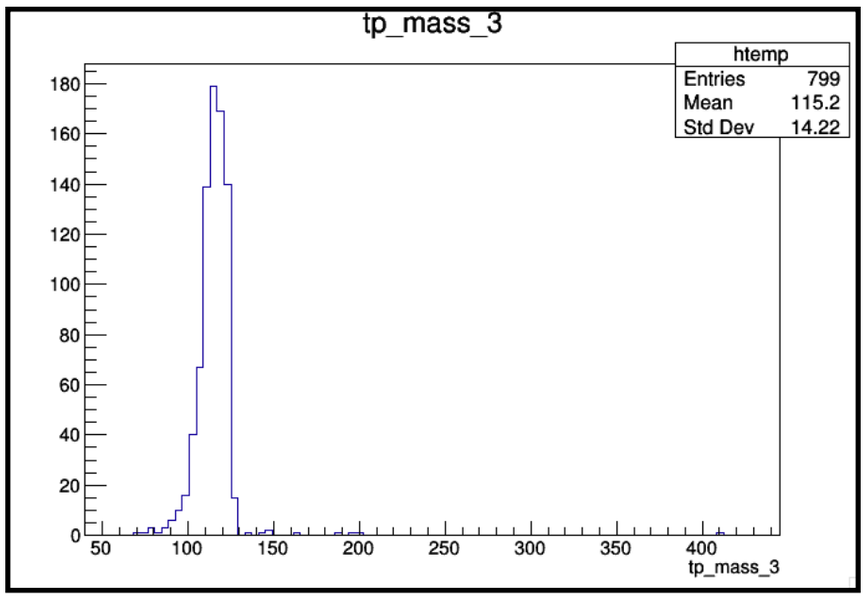
```
H0{status: 22} <idx: 0>
+-> h0{status: 22} <idx: 1>
|   +-> gamma{status: 1} <idx: 3> gamma{status: 1} <idx: 4>
+-> h0{status: 22} <idx: 2>
    +-> gamma{status: 23} <idx: 5>
    |   +-> gamma{status: 1} <idx: 7>
    +-> gamma{status: 23} <idx: 6>
        +-> u{status: 71} <idx: 8> ubar{status: 71} <idx: 9>
```



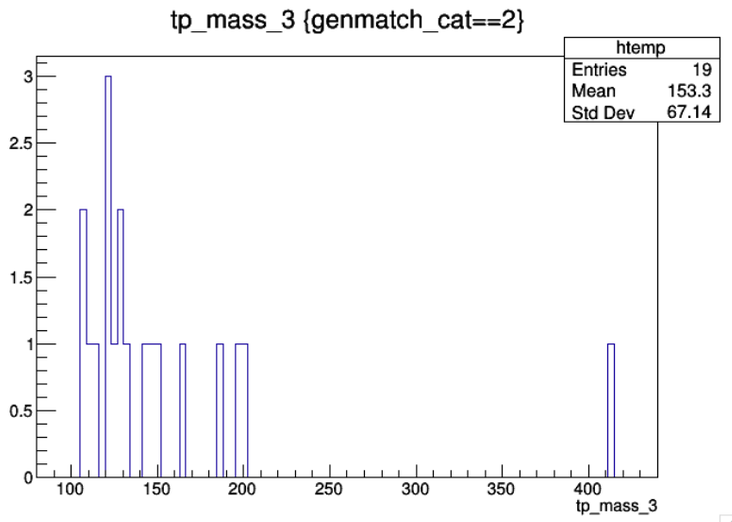
1 gen matched photons

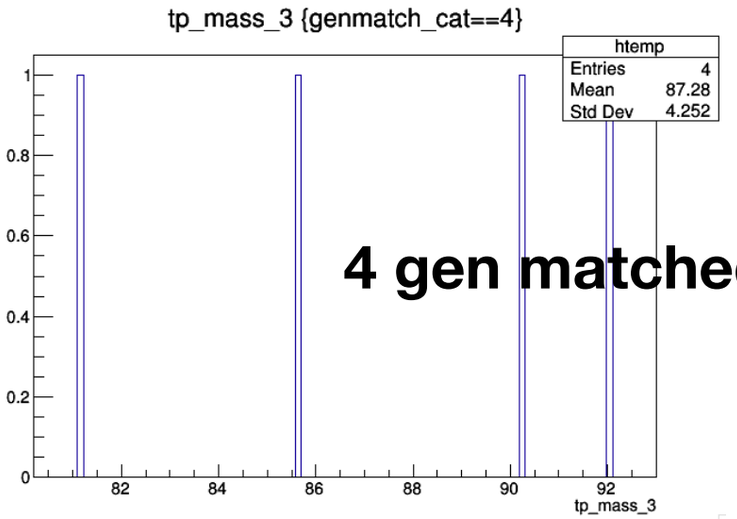
0 gen matched photons

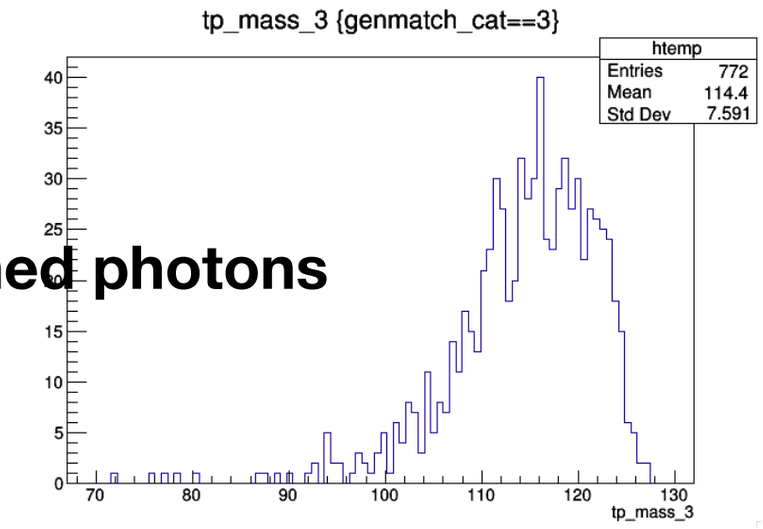




2 gen matched photons





4 gen matched photons

3 gen matched photons