Selection comparison

VBFMET vs ZnunuGam VBS

Preselections

Our selection

trigger: HLT_g140_loose

photons: Tight ID, FixedCutTight iso

electrons: pT>7GeV, LooseCutBL ID, FCLoose iso, $|d0|/\sigma(d0) <5$, $|z0 \cdot \sin\theta|<0.5$ mm

muons: pT>7 GeV, Medium ID, FCLoose iso, $|d0|/\sigma(d0) <3$, $|z0 \cdot \sin\theta|<0.5$ mm

jets: anti-kT TopoEM jets, pT>50 GeV, Medium JVT

Tight MET

overlap removal:

- Electrons within $\Delta R < 0.1$ of a muon are removed.
- Photons within $\Delta R < 0.4$ of either a muon or an electron are removed
- Jets within $\Delta R < 0.3$ of a photon, muon, or electron are removed.

VBFMET selection

trigger: HLT_noalg_L1J400, HLT_xe110_mht_L1XE50 (mc16a)

photons: Tight ID, FixedCutTight iso

electrons: pT>4.5GeV, LooseCutBL ID, crack region is not excluded

not removed yet

muons: pT>4 GeV, VeryLoose ID, d0 < 0.2 mm,z0 < 1 mm

not available anymore, Loose instead

not removed yet

jets: anti-kT PFlow jets, pT>25 GeV, JVT medium, fJVT

b-jets, $E_T^{jet,noJVT}$, Loose MET

overlap removal: muons are not used in OR

Table 15: Overlap removal matching criteria.

Reject	Against	Criteria
electron	electron	shared track, $p_{T,1} < p_{T,2}$
~~muon~~	~~electron~~	~~is calo-muon and shared ID track~~
~~electron~~	~~muon~~	~~shared ID track~~
photon	electron	$\Delta R < 0.4$
~~photon~~	~~muon~~	~~$\Delta R < 0.4$~~
jet	electron	$\Delta R < 0.2$
electron	jet	$\Delta R < \min(0.4, 0.04 + 10\ GeV/p_T^e)$
~~jet~~	~~muon~~	~~NumTrack < 3 and (ghost-associated or $\Delta R < 0.2$)~~
~~muon~~	~~jet~~	~~$\Delta R < \min(0.4, 0.04 + 10\ GeV/p_T^\mu)$~~
photon	jet	$\Delta R < 0.4$

10/4.5 is used

switched (typo)

Selections

Our selection

Selections	Cut Value
E_T^{miss}	> 120 GeV
E_T^{γ}	> 150 GeV
Number of tight isolated photons	$N_\gamma = 1$
Number of jets	$N_{jets} \geq 2$
Lepton veto	$N_e = 0, N_\mu = 0$
E_T^{miss} significance	> 12
$\lvert\Delta\phi(\gamma, \vec{p}_T^{\,miss})\rvert$	> 0.4
$\lvert\Delta\phi(j_1, \vec{p}_T^{\,miss})\rvert$	> 0.3
$\lvert\Delta\phi(j_2, \vec{p}_T^{\,miss})\rvert$	> 0.3
$p_T^{SoftTerm}$	< 16 GeV

$Z\gamma jj$ EWK signal region	
$N_{leptons}$	$= 0$
m_{jj}	> 300 GeV
γ-centrality	< 0.6

$$\zeta(\gamma) = \left| \frac{y(\gamma) - \frac{y(j_1)+y(j_2)}{2}}{y(j_1) - y(j_2)} \right|$$

photon pointing criteria wrt primary vertex <250 mm

VBFMET selection

- The event contains no "Veto" electrons nor "Veto" muons.
- The leading jet has $p_T > 60$ GeV with fJVT < 0.4 (Tight criteria).
- The sub-leading jet has $p_T > 50$ GeV with fJVT < 0.4 (Tight criteria).
- The event contains *exactly* two or three jets, with jet counting done with $p_T > 25$ GeV.
- The leading two jets are not back-to-back in the transverse plane to the beamline: $|\Delta\phi_{jj}| < 2.5$.
- The leading two jets lie in opposite longitudinal hemispheres: $\eta(j_1) \times \eta(j_2) < 0$.
- The leading two jets are well separated in η: $|\Delta\eta_{jj}| > 3.0$.
- The leading dijet system has a large invariant mass: $m_{jj} > 0.25$ TeV.
- The leading three jets are well separated from the E_T^{miss}: $\Delta\phi(j_1, E_T^{miss}) > 1$, $\Delta\phi(j_2, E_T^{miss}) > 1$, and $\Delta\phi(j_3, E_T^{miss}) > 1$. See Appendix B.3 for plots.
- The third jet is required to be forward with a selection on the centrality variable $C_3 < 0.7$. See Appendix B.3 for the plot without C_3 applied. (definition is the same as for photon)
- The event contains less than two b-tagged jets with $p_T > 25$ GeV computed with the DLr1 77% operating point (see Appendix K.1).[6] can not be applied yet
- The event has $E_T^{miss} > 150$ GeV. See Appendix B.2.
- The event has $E_T^{jet,no\text{-}jvt} > 130$ GeV. can not be applied yet
- The photon and the E_T^{miss} are back-to-back in the transverse plane to the beamline: $|\Delta\phi(E_T^{miss}, \gamma)| > 1.8$.
- The photon is central amongst the two tagging jets $C_\gamma > 0.4$. $C_\gamma = \exp\left(-\frac{4}{(\eta_1 - \eta_2)^2}(\eta_\gamma - \frac{\eta_1 + \eta_2}{2})^2\right)$.
- Photon pointing: the z coordinate, pointed by the photon with respect to the identified primary vertex, < 250 mm. See modelling in Appendix B.4.

VBFMET results

In this presentation we only consider 2015-2016 pp-data.

Significance is this study is calculated as $N_{Z\gamma\ EWK}/\sqrt{(N_{Z\gamma\ EWK}+N_{Z\gamma\ QCD})}$

Table 67: Yields of signal and major backgrounds 36.2 fb^{-1} selection using the 2015–2016 dataset. The yields prefit.

Samples	SR	$Z(\rightarrow \ell\ell)+\gamma$ CR	$W(\rightarrow \mu\nu)+\gamma$ CR	$W(\rightarrow e\nu)+\gamma$ CR	Fake-e CR
VBFγH125	25.332	0.000	0.000	0.013	0.000
ggFH125	5.093	0.000	0.000	0.000	0.000
$Z\gamma$ QCD	22.164	7.000	0.056	0.513	2.494
$Z\gamma$ EWK	20.476	4.058	0.049	0.140	0.235
$W\gamma$ QCD	16.114	0.000	35.460	9.897	9.201
$W\gamma$ EWK	4.072	0.000	13.083	6.293	3.689
Top/VV/VVV/VBFWW	2.668	0.033	3.448	1.545	1.250
γ+j	0.097	0.000	0.000	0.000	0.000
$e \rightarrow \gamma$	4.868	0.000	0.762	1.098	0.000
$j \rightarrow \gamma$	0.833	0.000	0.350	0.350	0.570
eleFakes	0.000	0.000	0.000	4.000	28.400
data	81	9	46	25	25
total bkg	71.291	11.091	53.207	23.836	45.839
data/bkg	1.136	0.811	0.865	1.049	0.545

This is the table shows event yields VBFMET selection, which has $15<p_T(\gamma)<100$ GeV, which does not overlap with ours. In our approximation significance here is 3.1.

We will compare also our **high-E** MC generated with $p_T(\gamma)>140$(QCD) and 130(EWK) GeV and **low-E** MC generated with $p_T(\gamma)>7$(QCD) and 10(EWK) GeV, which were used by VBFMET analysis. Only MC16a campaign is compared for simplicity, since the event triggers are different for every campaign.

Events with $p_T(\gamma)>150$ GeV are taken for consistency with our analysis.

Preselection and selection comparison

pTgamma>150 GeV	EWK	QCD	EWK/QCD	significance
VBFMET selection, low-E samples	6.8±0.6	5.9±0.6	1.15	1.899
VBFMET selection, our preselection, low-E samples	7.5±0.6	6.7±0.6	1.12 -0.03 (3%)	1.998 +0.09 (5%)
Our selection, VBFMET preselection, low-E samples	11.6±0.8	22.5±1.2	0.52 -0.6 (54%)	1.988 -0.1 (5%)
Our selection, low-E samples	14.23±0.85	29.34±1.43	0.49 -0.03 (6%)	2.156 +0.168 (8%)
VBFMET selection, high-E samples	5.14±0.05	6.04±0.17	0.85	1.537
VBFMET selection, our preselection, high-E samples	5.66±0.06	6.8±0.2	0.83 -0.02 (2%)	1.607 +0.07 (5%)
Our selection, VBFMET preselection, high-E samples	10.49±0.08	25.5±0.4	0.41 -0.42 (51%)	1.749 +0.142 (9%)
Our selection, high-E samples	12.97±0.08	32.3±0.4	0.40 -0.01 (2%)	1.927 +0.178 (10%)

red and green numbers show the difference with the *line above*

It seems like VBFMET event selection is more efficient in terms of EWK/QCD ratio, however, our preselection seem to give higher significance with insignificant loss in EWK/QCD ratio.

Also our current selection seems to be optimal for our high-photon-pT region, since it gives better significance and larger number of signal events.

Comparison with our event selection

difference in significance and EWK/QCD is shown vs 1st line

pTgamma>150 GeV, low-E samples **each cut is changed independently.**	EWK	QCD	EWK/QCD	significance
VBFMET selection, low-E samples	6.8±0.6	5.9±0.6	1.15	1.899
jet1_pT>60 GeV => jet1_pT>50 GeV	6.9±0.6	6.08±0.63	1.13 -0.02 (2%)	1.908 +0.009 (<1%)
N_jets=2,3 (at 25 GeV)=> N_jets>=2 (at 50 GeV)	6.8±0.6	5.9±0.6	1.15	1.899
mjj>250 GeV => mjj>500 GeV	6.8±0.6	5.9±0.6	1.14 -0.01 (<1%)	1.899
dPhi(gamma,MET)>1.8 => 0.4	8.5±0.7	7.05±0.65	1.2 +0.05 (0.4%)	2.163 +0.168 (8%)
dPhi(jet1,MET)>1 => 0.3	7.8±0.6	6.98±0.68	1.12 -0.03 (3%)	2.036 +0.137 (7%)
dPhi(jet2,MET)>1 => 0.3	8.16±0.65	7.08±0.71	1.15	2.089 +0.19 (10%)
dPhi(jet2,MET)>1 removed	6.86±0.59	6.2±0.6	1.11 -0.04 (4%)	1.896 -0.003 (<1%)
fabs(jet.Eta()-jet2.Eta())>3 removed	7.89±0.64	12.56±0.93	0.63 **-0.52 (45%)**	1.745 **-0.154 (8%)**
jet.Eta()*jet2.Eta()<0 removed	6.8±0.6	6.11±0.6	1.11 -0.04 (3%)	1.895 -0.004 (<1%)
fabs(jet.DeltaPhi(jet2))<2.5 removed	9.1±0.7	8.11±0.72	1.12 -0.03 (3%)	2.194 +0.295 (16%)
jet centrality removed	6.8±0.6	6.6±0.6	1.04	1.860 -0.039 (2%)
gamma centrality changed to ours	6.96±0.60	7.02±0.68	0.99 **-0.16 (14%)**	1.862 **-0.037 (2%)**

Proposal

- to add fabs(jet.Eta()-jet2.Eta())>3
- change gamma-centrality definition to the VBFMET one (probably needs re-optimization)

pTgamma>150 GeV	EWK	QCD	EWK/QCD	significance
VBFMET selection, low-E samples	6.8±0.6	5.9±0.6	1.15	1.899
modified our selection, VBFMET preselection, low-E samples	8.06±0.65	8.13±0.70	0.99	2.003
modified our selection, our preselection, low-E samples	**9.9±0.7**	**10.06±0.83**	**0.98**	**2.216**
Our selection, low-E samples	14.23±0.85	29.34±1.43	0.49	2.156

Can achieve better EWK/QCD efficiency and significance, though with less number of events.

See comparison for high-E samples on the next slide.

Improved selection for high-E MC samples

pTgamma>150 GeV	EWK	QCD	EWK/QCD	significance
VBFMET selection, high-E samples	5.14±0.05	6.04±0.17	0.85	1.537
modified our selection, VBFMET preselection, high-E samples	7.38±0.06	8.011±0.207	0.922	1.882
modified our selection, our preselection, high-E samples	**8.998±0.070**	**10.02±0.23**	**0.898**	**2.063**
Our selection, high-E samples	12.97±0.08	32.3±0.4	0.40	1.927

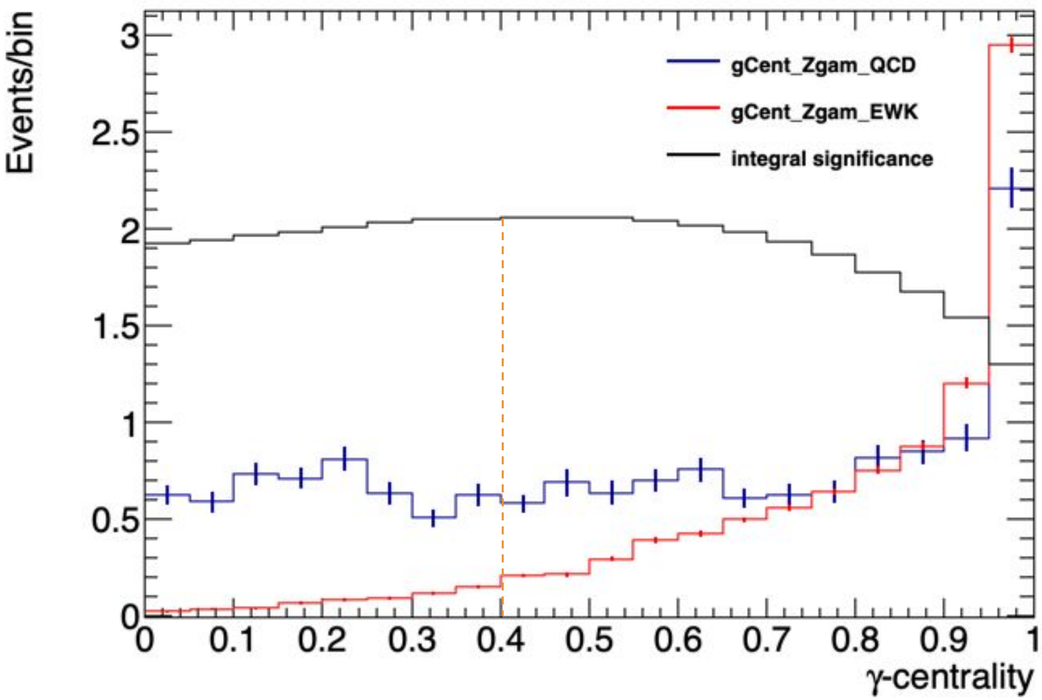
The same results, though achieved efficiency and significance is a bit lower

Further actions:

- Possibly can be improved with gamma-centrality optimization
- Check $E_T^{jet,no-jvt}$,and other minor missing corrections in pre/selection
- check efficiency of b-jet cut
- switch to PFlow jets
- Check if E_T^{miss}, E_T^{miss} significance and E_T^{miss} soft-term cuts can be removed/reoptimized with more backgrounds

gamma-centrality optimization

pTgamma>150 GeV	EWK	QCD	EWK/QCD	EWK/sqrt(EWK+ QCD)
modified our selection, our preselection, high-E samples	**8.998±0.070**	**10.02±0.23**	**0.898**	**2.063**



integral significance
gamma-centrality>X

0.4 is optimal

Summary

The preliminary selection comparison with VBFMET analysis was done on the basis of Zγ EWK and QCD MC.

Our current selection seems to be optimal for our high-photon-pT region.

Further checks are needed to know if our selection can be improved.