Di-photon production in ultra-peripheral PbPb Collisions at 5.02 TeV using the 2015 CMS data

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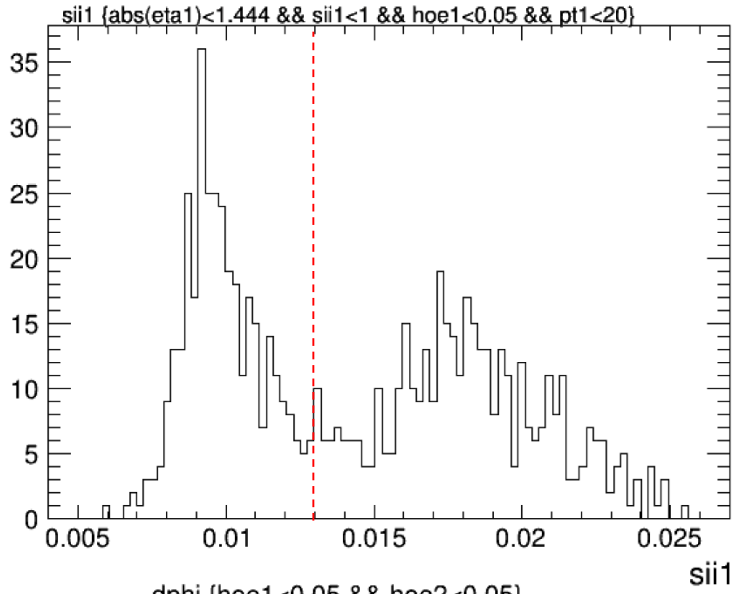
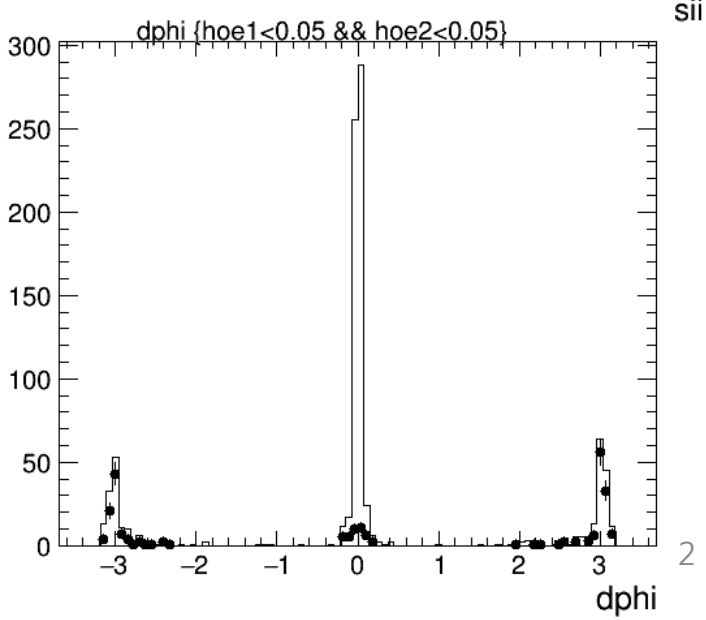
Modification

- The bugs in the macro have been fixed.
- $|\eta| < 1.444$ cut has been applied.
- In the Ecal Noise masking, the condition "phoSigmaIEtaIEta_2012 < 0.013" is added.
  - There is much noise at phoSigmaIEtaIEta_2012 > 0.013.
  - With this condition, most of the peak around $\Delta\phi \sim 0$ is removed.
- "No jets" condition has been modified.
  - When there is a jet close to photon($\Delta\phi < 0.5$ & $\Delta\eta < 0.5$), the jet is considered as it is not a jet actually.





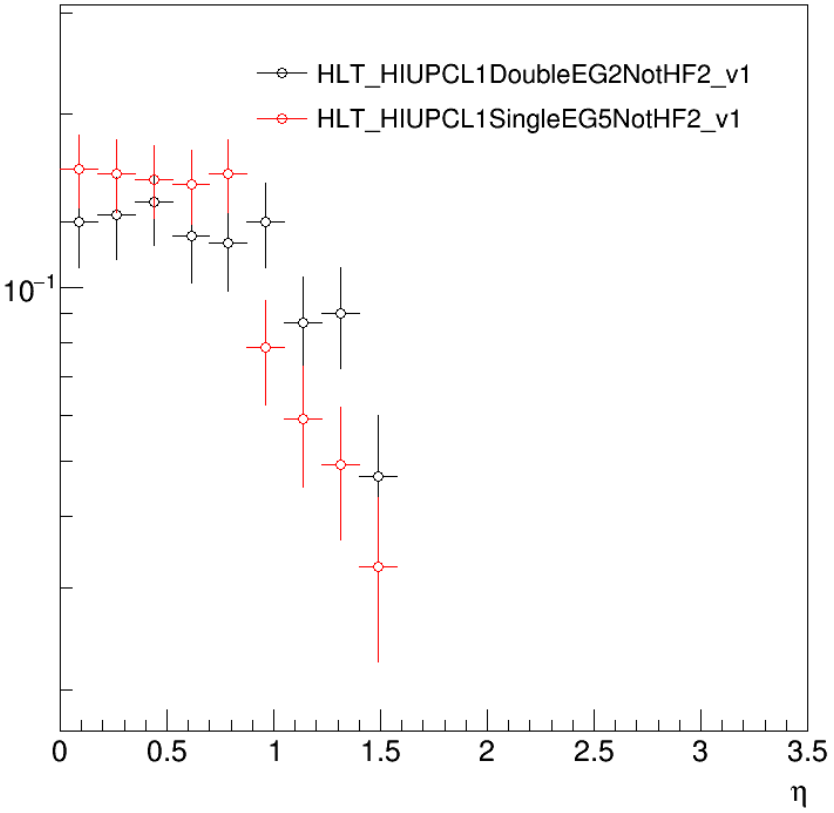
The Number of UPC Trigger Passed Photons

- All data have been analyzed, corresponding to $L \sim 0.4\ \mathrm{nb}^{-1}$
- Global Event Description (GED): particle flow algorithm
  - Combines and links signals from the different sub-detectors.
  - Provides the optimal event description in form of a list of particles: electrons, muons, charged hadrons, photons, neutral hadrons
  - pT is higher than 5 GeV/c
- Ecal Noise masking
  - (phoSigmaIEtaIEta_2012>=0.002) && (**phoSigmaIEtaIEta_2012<0.013**) && (pho_swissCrx<=0.9) && (abs(pho_seedTime)<=3)
  - !((phoE3x3/phoE5x5 > 2/3-0.03 && phoE3x3/phoE5x5 < 2/3+0.03) && (phoE1x5/phoE5x5 > 1/3-0.03 && phoE1x5/e5x5 < 1/3+0.03) && (phoE2x5/phoE5x5 > 2/3-0.03 && phoE2x5/phoE5x5 < 2/3+0.03)): It was defined by Alex and photon group.
- Photon isolation is not applied.

UPC Di-photon η Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.

- Most of photons are going through barrel.
  - Barrel has better energy resolution than endcap.
  - It seems it will be better to give the cut $|\eta| < 1.444$



Without η cut:
HLT_HIUPCL1DoubleEG2NotHF2: 284
HLT_HIUPCL1SingleEG5NotHF2: 331

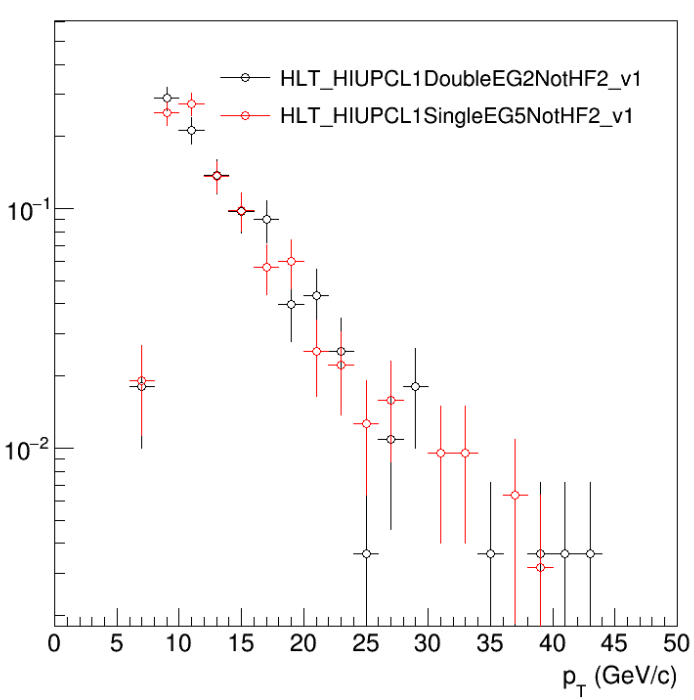
With η cut:
HLT_HIUPCL1DoubleEG2NotHF2: 278
HLT_HIUPCL1SingleEG5NotHF2: 317

UPC Di-photon p_T Distribution

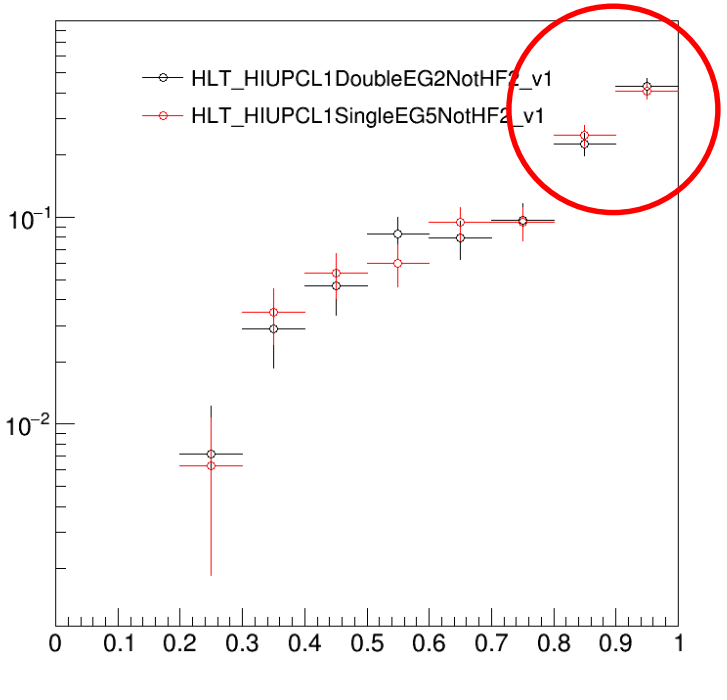
- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- Good agreement between the two UPC triggers

HLT_HIUPCL1DoubleEG2NotHF2: 278
HLT_HIUPCL1SingleEG5NotHF2: 317

Two photons
Balanced events



Leading photon p_T

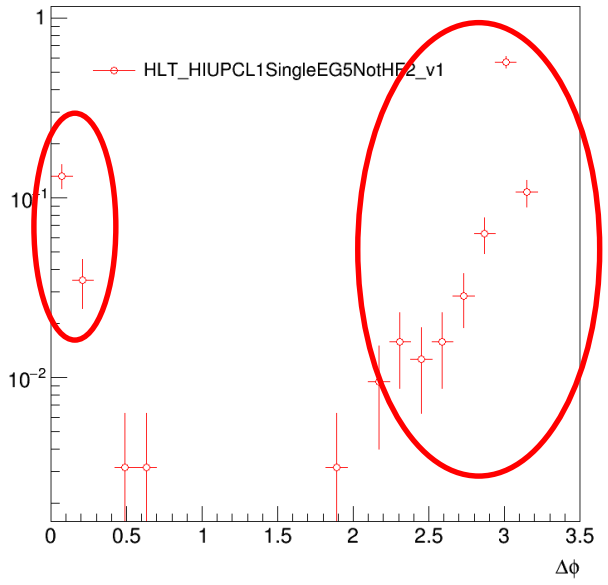


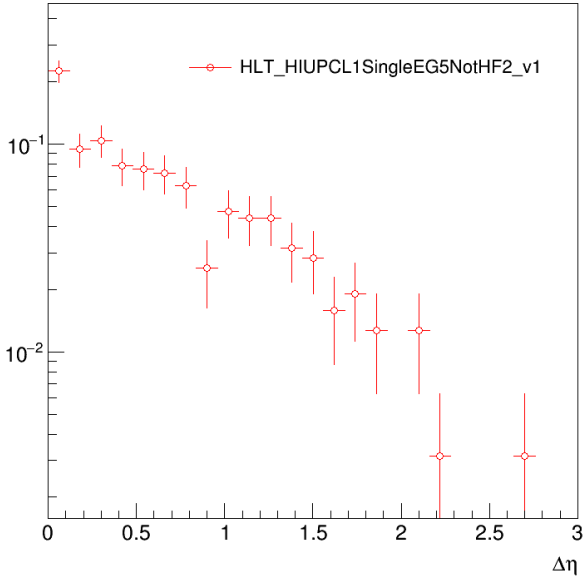
(Sub-leading p_T)/(Leading p_T)

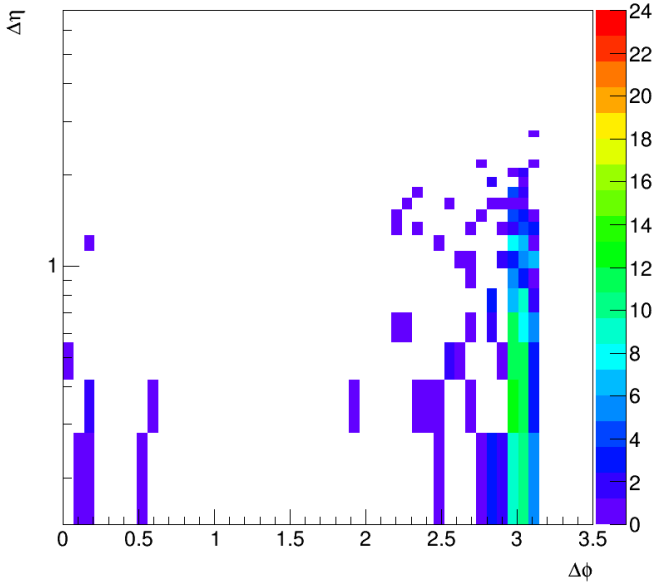
UPC Di-photon $\Delta\varphi$ & $\Delta\eta$ Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$

HLT_HIUPCL1SingleEG5NotHF2: 317







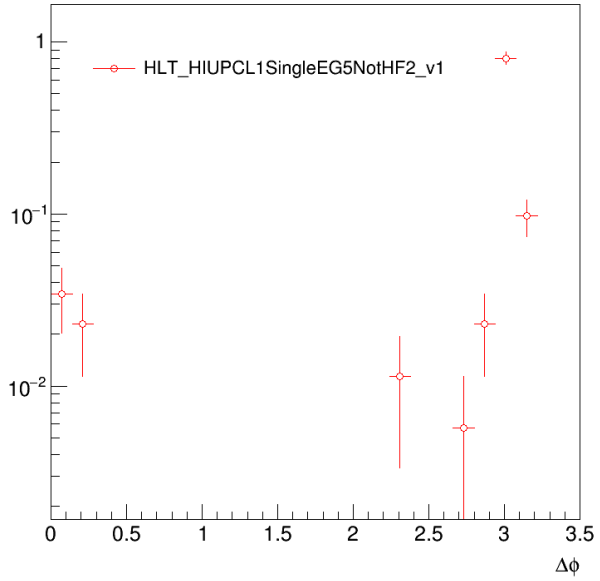
Collinear

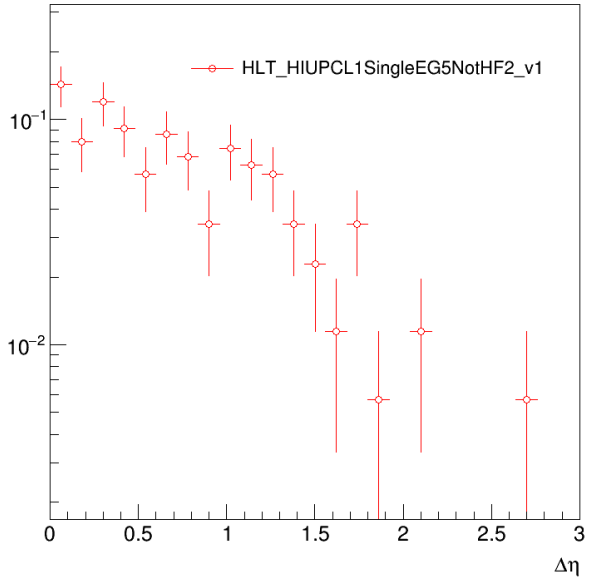
Back-to-back

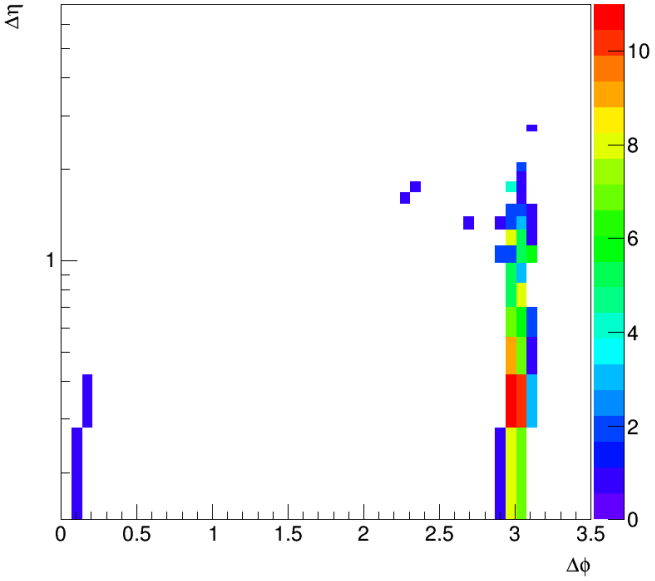
UPC Di-photon $\Delta\varphi$ & $\Delta\eta$ Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- HFplus < 5 GeV & HFminus < 5 GeV

HLT_HIUPCL1SingleEG5NotHF2: 175



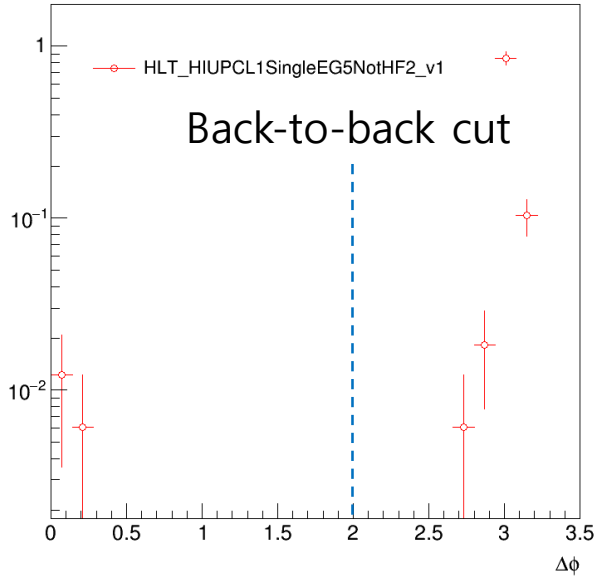


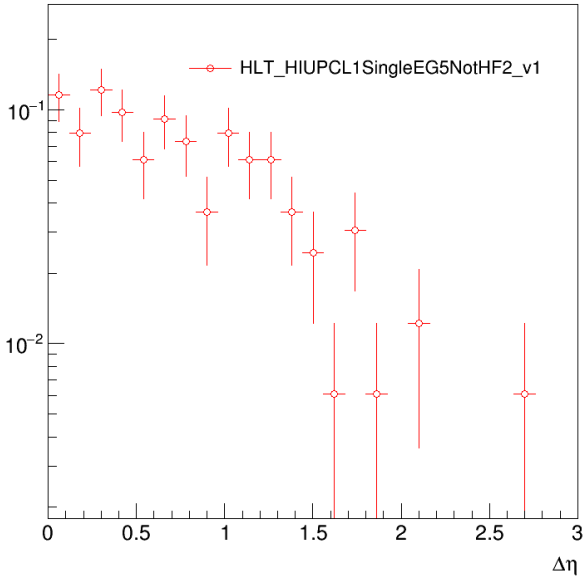


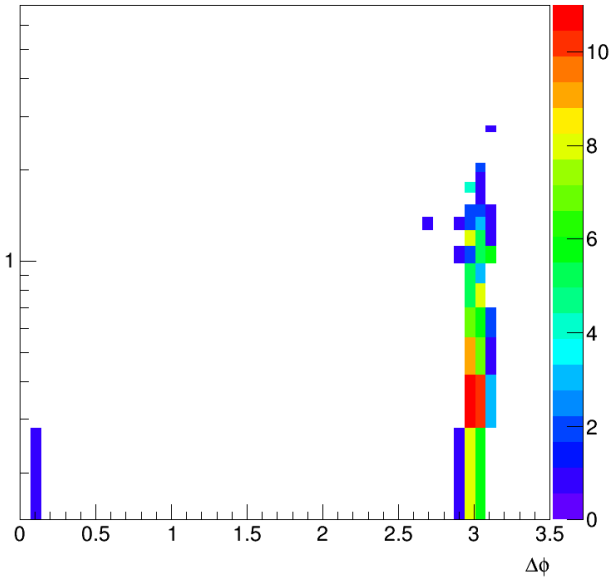
UPC Di-photon $\Delta\varphi$ & $\Delta\eta$ Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- HFplus < 5 GeV & HFminus < 5 GeV
- No jets

HLT_HIUPCL1SingleEG5NotHF2: 164



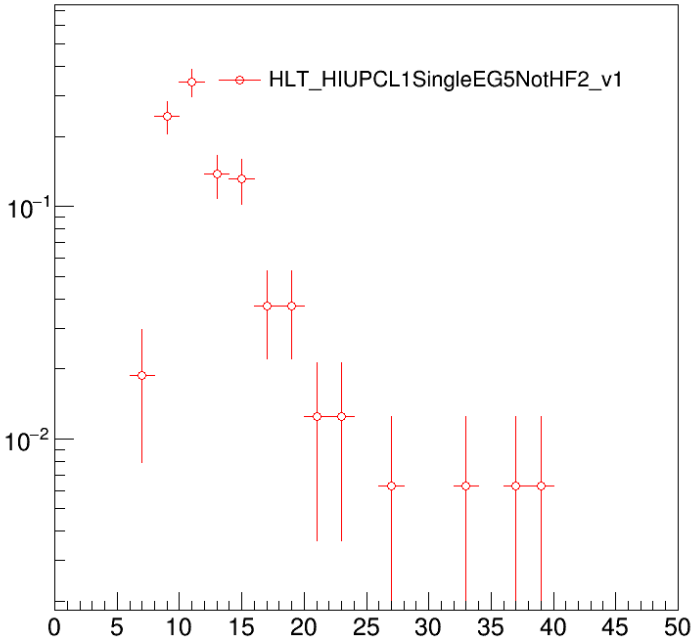




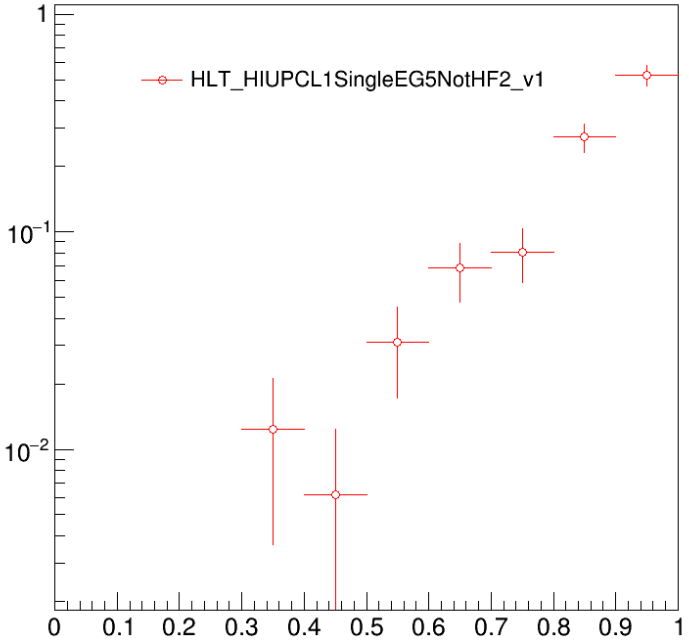
UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- HFplus < 5 GeV & HFminus < 5 GeV
- $\Delta\phi > 2$
- No jets

HLT_HIUPCL1SingleEG5NotHF2: 161



Leading photon p_T

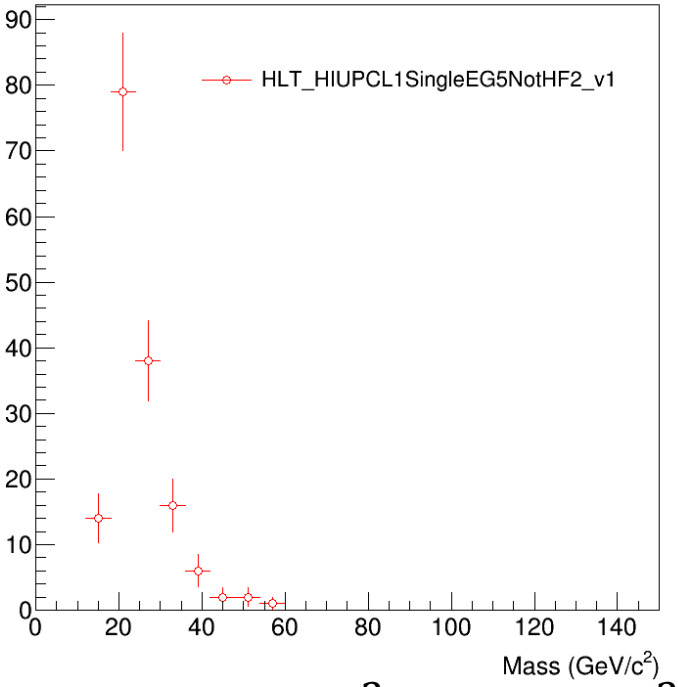


(Sub-leading p_T)/(Leading p_T)

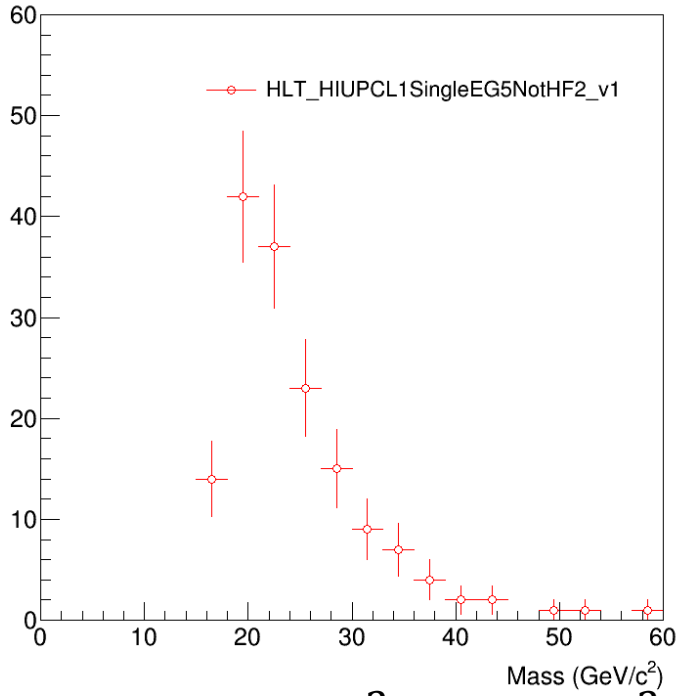
UPC Di-photon Invariant Mass Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- HFplus < 5 GeV & HFminus < 5 GeV
- $\Delta\phi > 2$
- No jets

HLT_HIUPCL1SingleEG5NotHF2: 161



$m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 150 $\mathrm{GeV/c^2}$

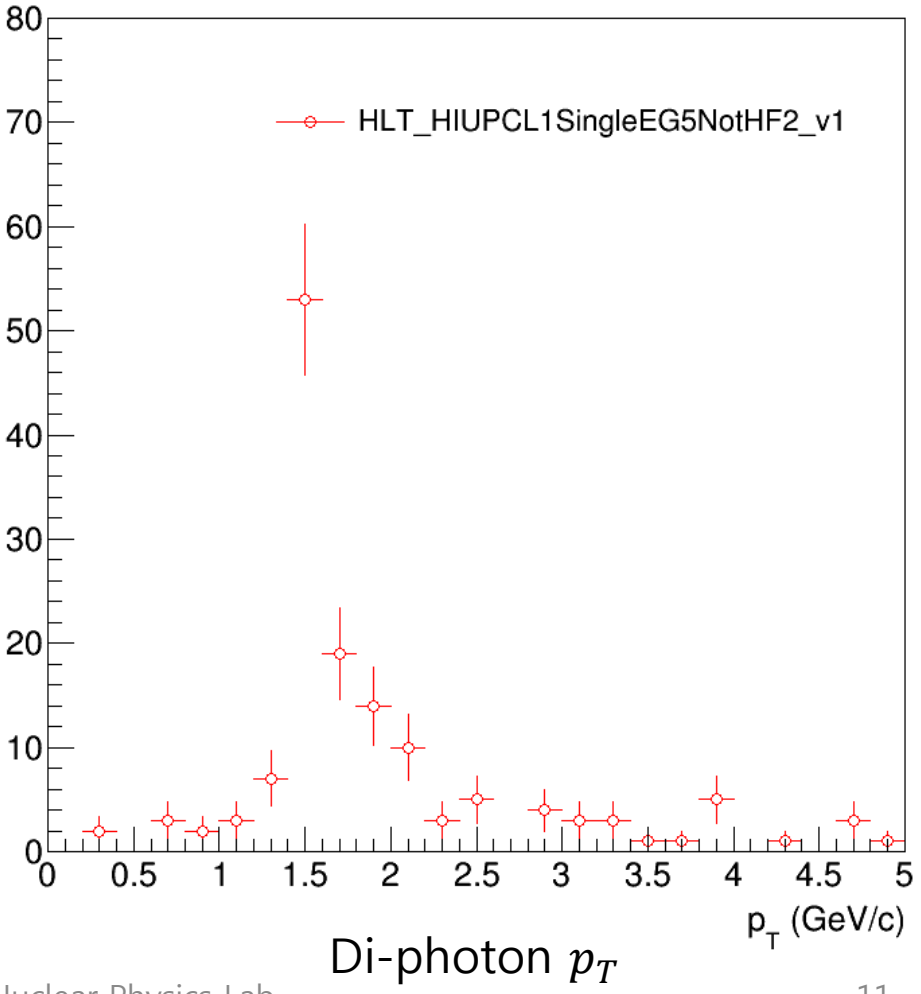


$m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- HFplus < 5 GeV & HFminus < 5 GeV
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$

HLT_HIUPCL1SingleEG5NotHF2: 158

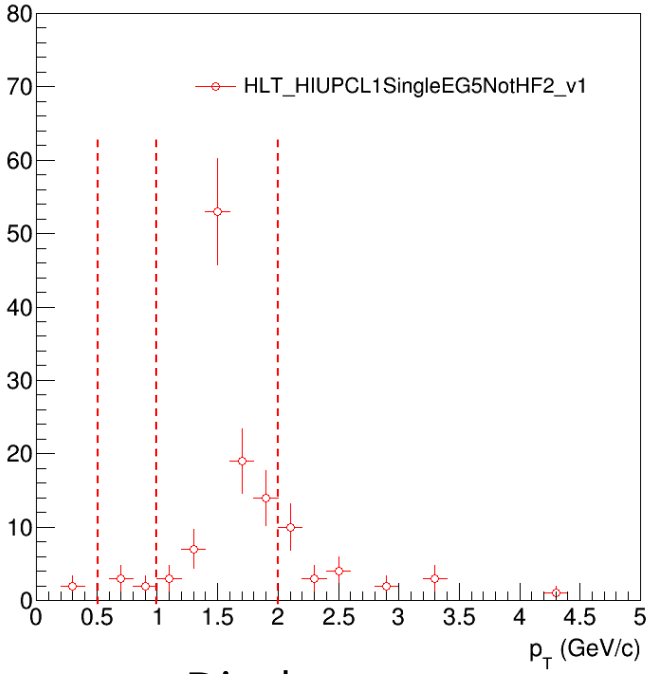


Di-photon p_T

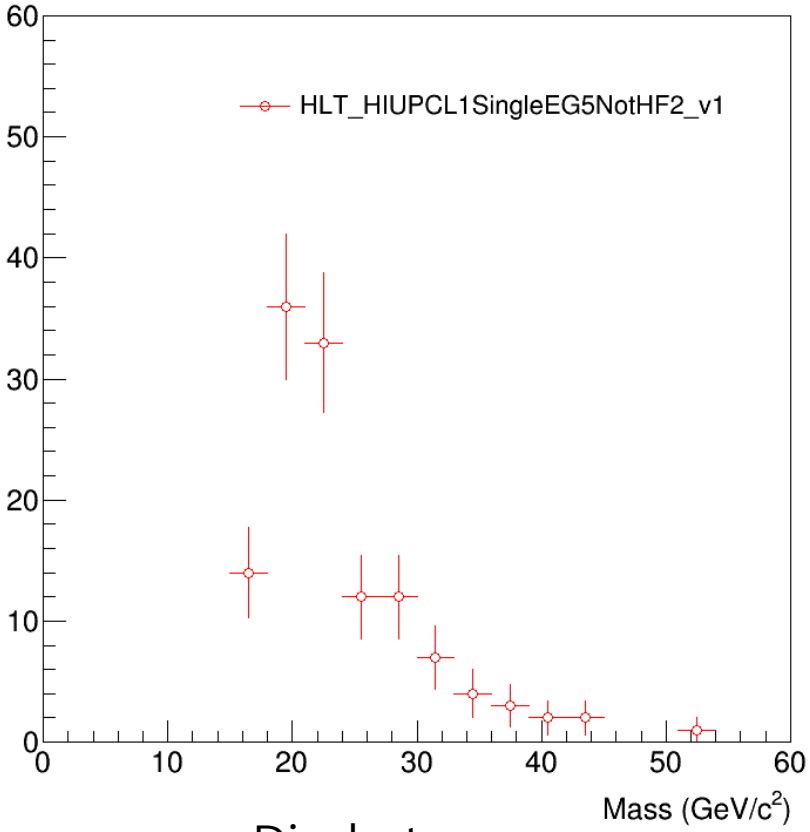
UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$

HLT_HIUPCL1SingleEG5NotHF2: 126



Di-photon p_T

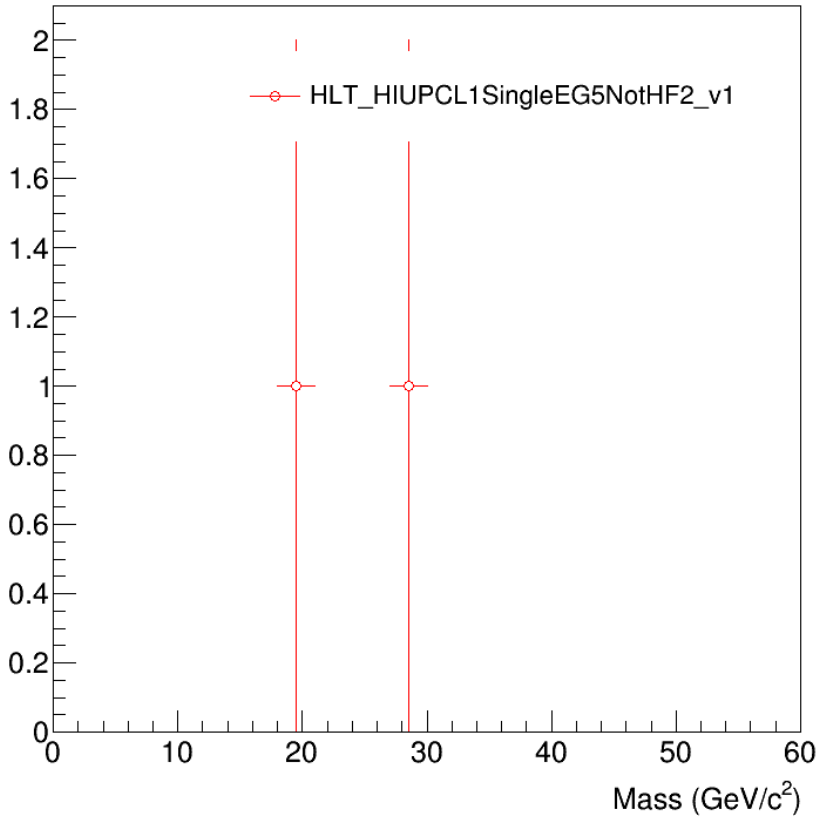


Di-photon $m_{\gamma\gamma}$

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$
- Di-photon $p_T < 0.5\ \mathrm{GeV/c}$

HLT_HIUPCL1SingleEG5NotHF2: 2

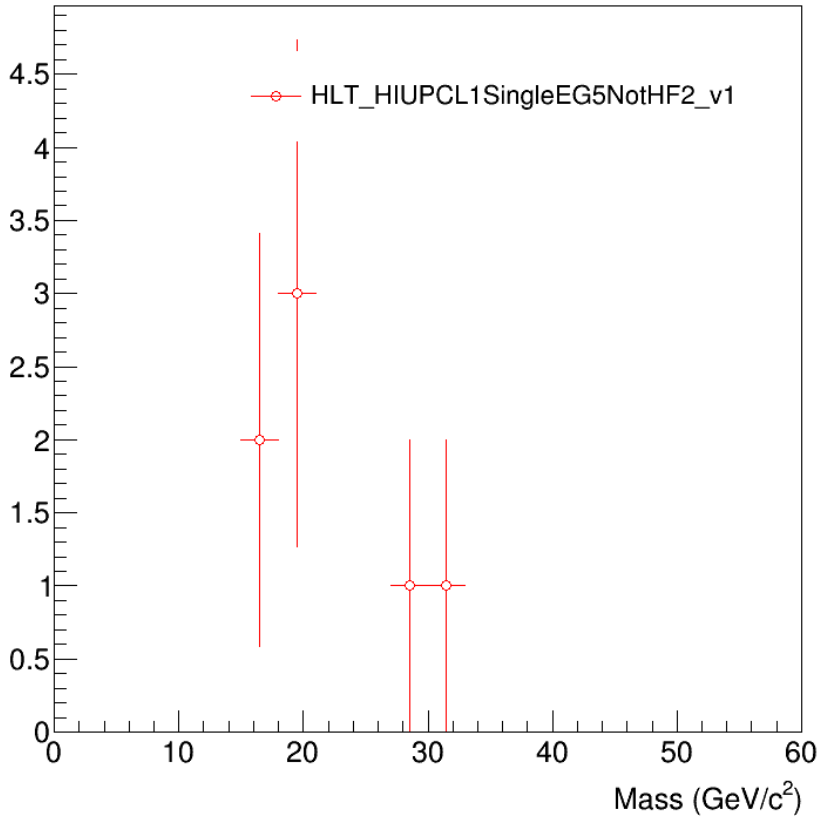


Di-photon $m_{\gamma\gamma}$

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$
- Di-photon p_T < 1 $\mathrm{GeV/c}$

HLT_HIUPCL1SingleEG5NotHF2: 7

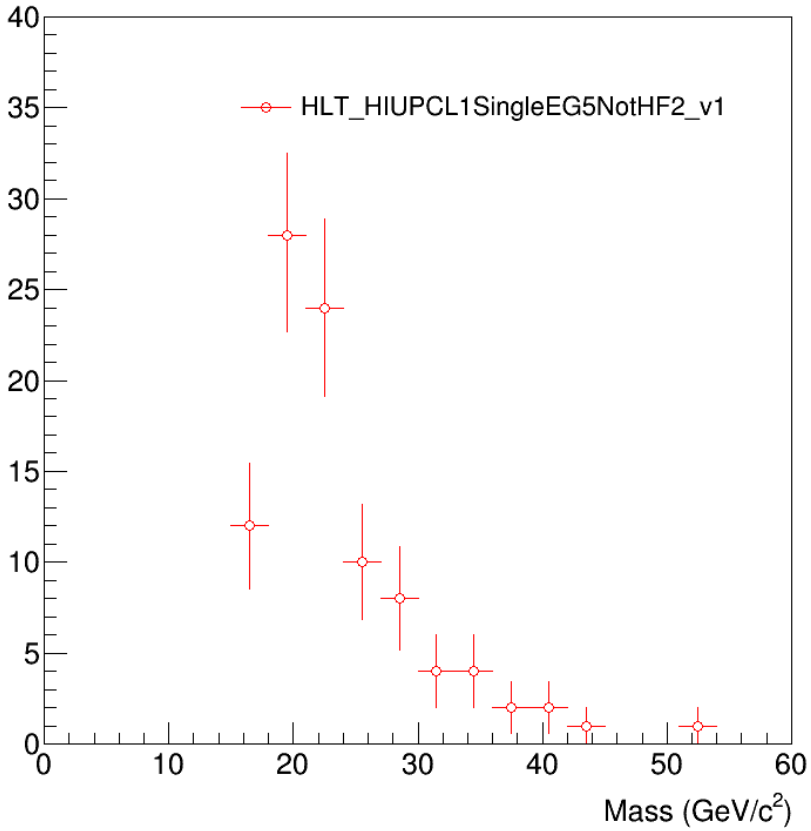


Di-photon $m_{\gamma\gamma}$

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from $0\ \mathrm{GeV/c^2}$ to $60\ \mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$
- $1\ \mathrm{GeV/c} <$ Di-photon $p_T < 2\ \mathrm{GeV/c}$

HLT_HIUPCL1SingleEG5NotHF2: 96

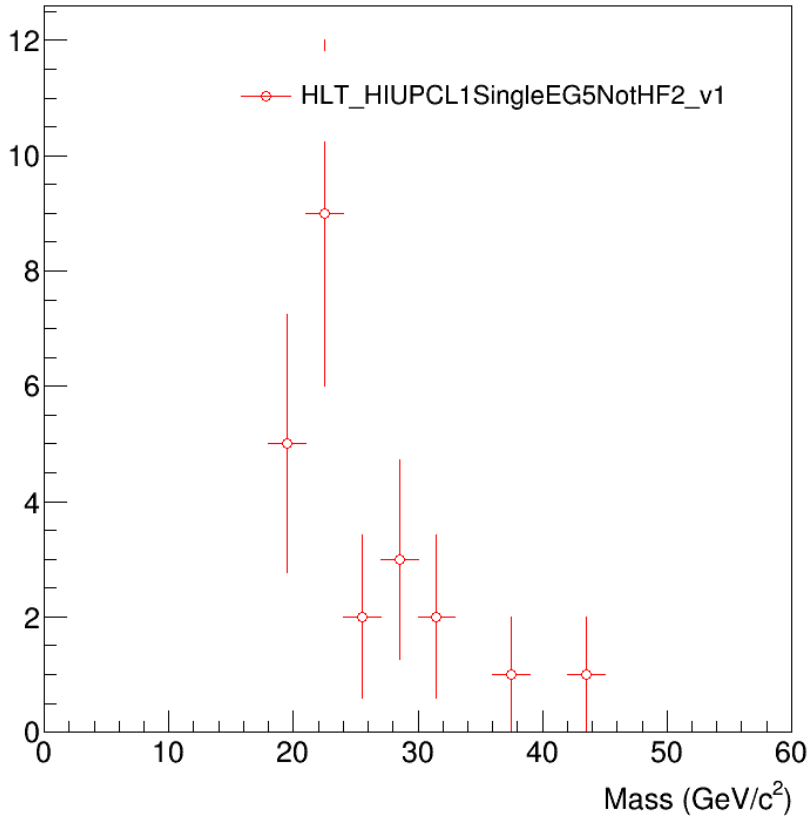


Di-photon $m_{\gamma\gamma}$

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$
- Di-photon $p_T > 2\ \mathrm{GeV/c}$

HLT_HIUPCL1SingleEG5NotHF2: 23



Di-photon $m_{\gamma\gamma}$

Next Step

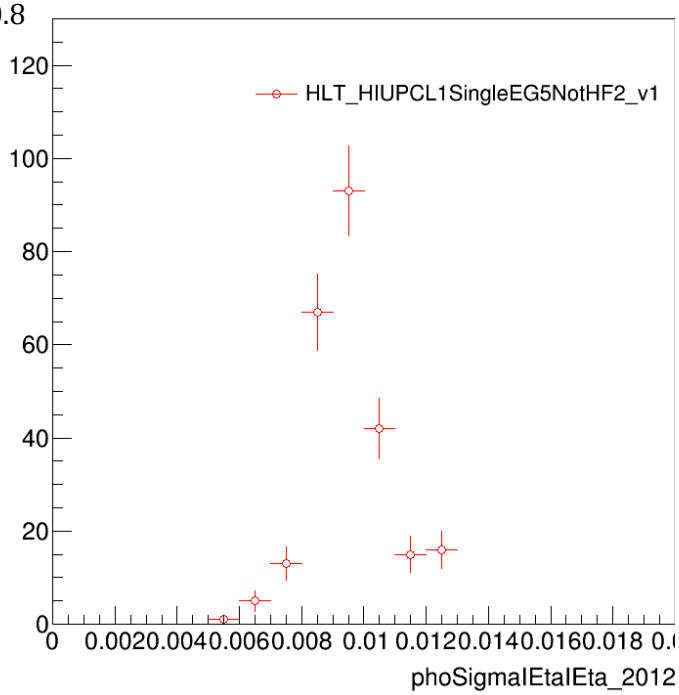
- Study ZDC signals to study events with no neutrons on both sides of the interaction point and events with low neutron activity.
- Study MC signals.

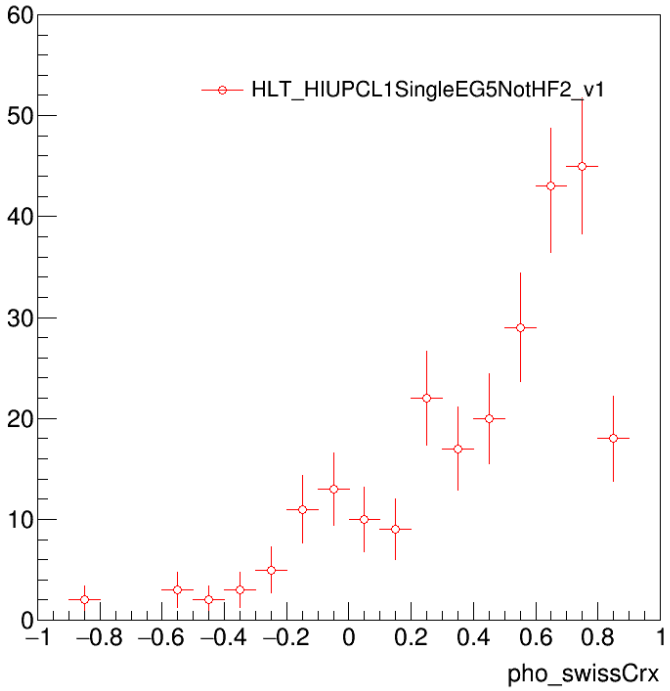
Back Up

UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$

HLT_HIUPCL1SingleEG5NotHF2: 126

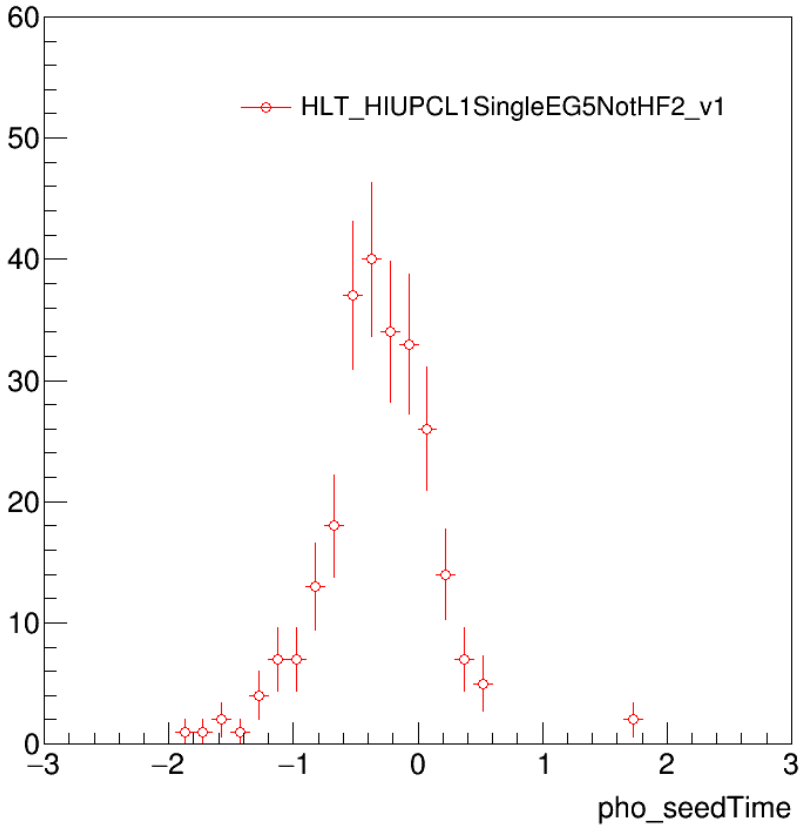




UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}\ \&\ \mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$

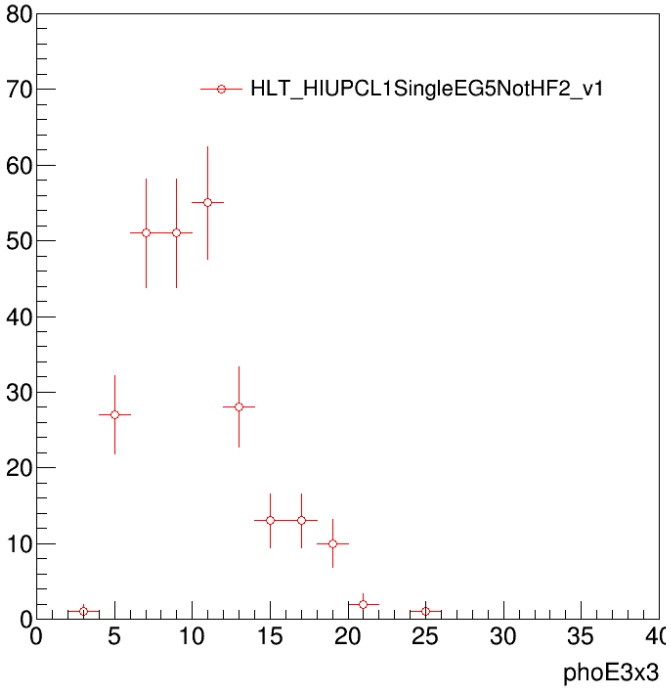
HLT_HIUPCL1SingleEG5NotHF2: 126

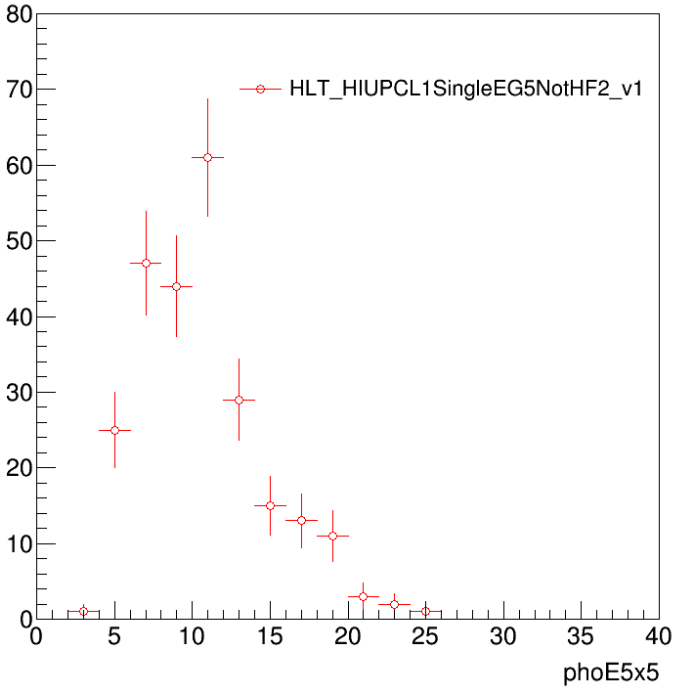


UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}$ & $\mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$

HLT_HIUPCL1SingleEG5NotHF2: 126





UPC Di-photon p_T Distribution

- The events have exactly 2 photons.
- Ecal noise masking applied.
- $|\eta| < 1.444$
- $\mathrm{HFplus} < 5\ \mathrm{GeV}$ & $\mathrm{HFminus} < 5\ \mathrm{GeV}$
- $\Delta\phi > 2$
- No jets
- $m_{\gamma\gamma}$ from 0 $\mathrm{GeV/c^2}$ to 60 $\mathrm{GeV/c^2}$
- $p_{T,2}/p_{T,1} > 0.8$

HLT_HIUPCL1SingleEG5NotHF2: 126