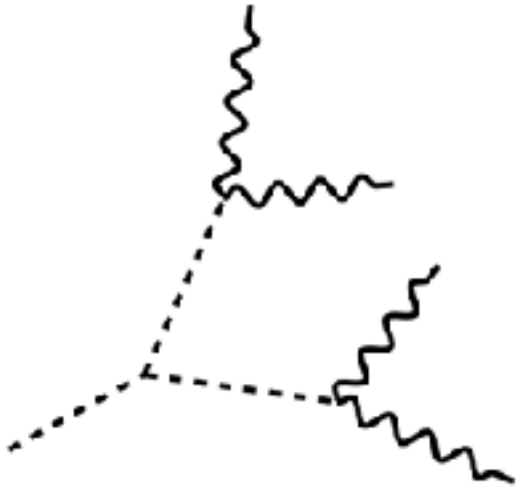


Northeastern Group Meeting

12/08/16

4 Gamma Analysis

Toyoko Orimoto
Andrea Massironi
Rafael Teixeira De Lima
Tanvi Wamorkar

Analysis Steps

- Select events which fulfill the following conditions:
  - Transverse momentum P_t > 15 GeV and abs(Eta) < 2.5
  - At least 4 Photons
- Assign Photons to “Mother a’s”
- Plot angular variables that have good discriminating power between signal and background

What does the background consist of? → In our case it is mostly made up of events in which 2 Photons are being produced by two colliding Quarks or Gluons

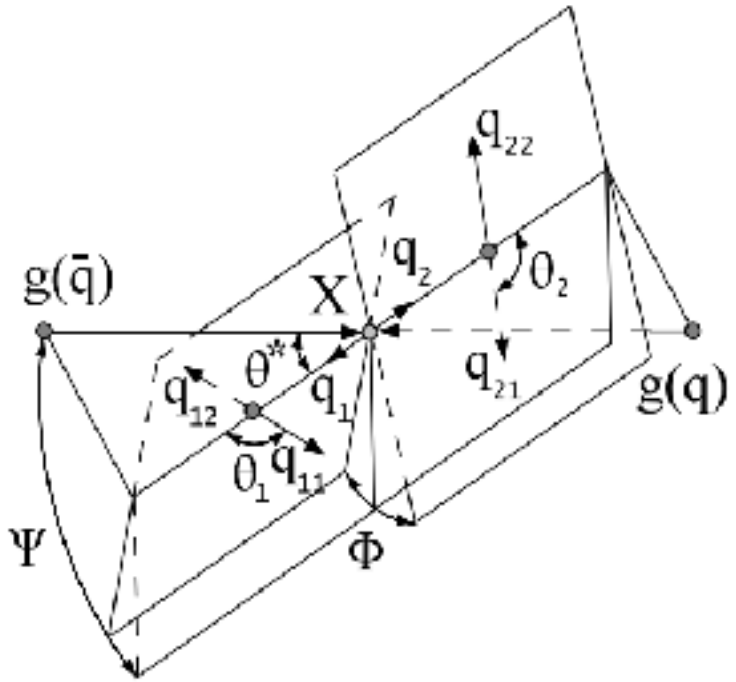
Angular variables to be studied

Sequence of processes:

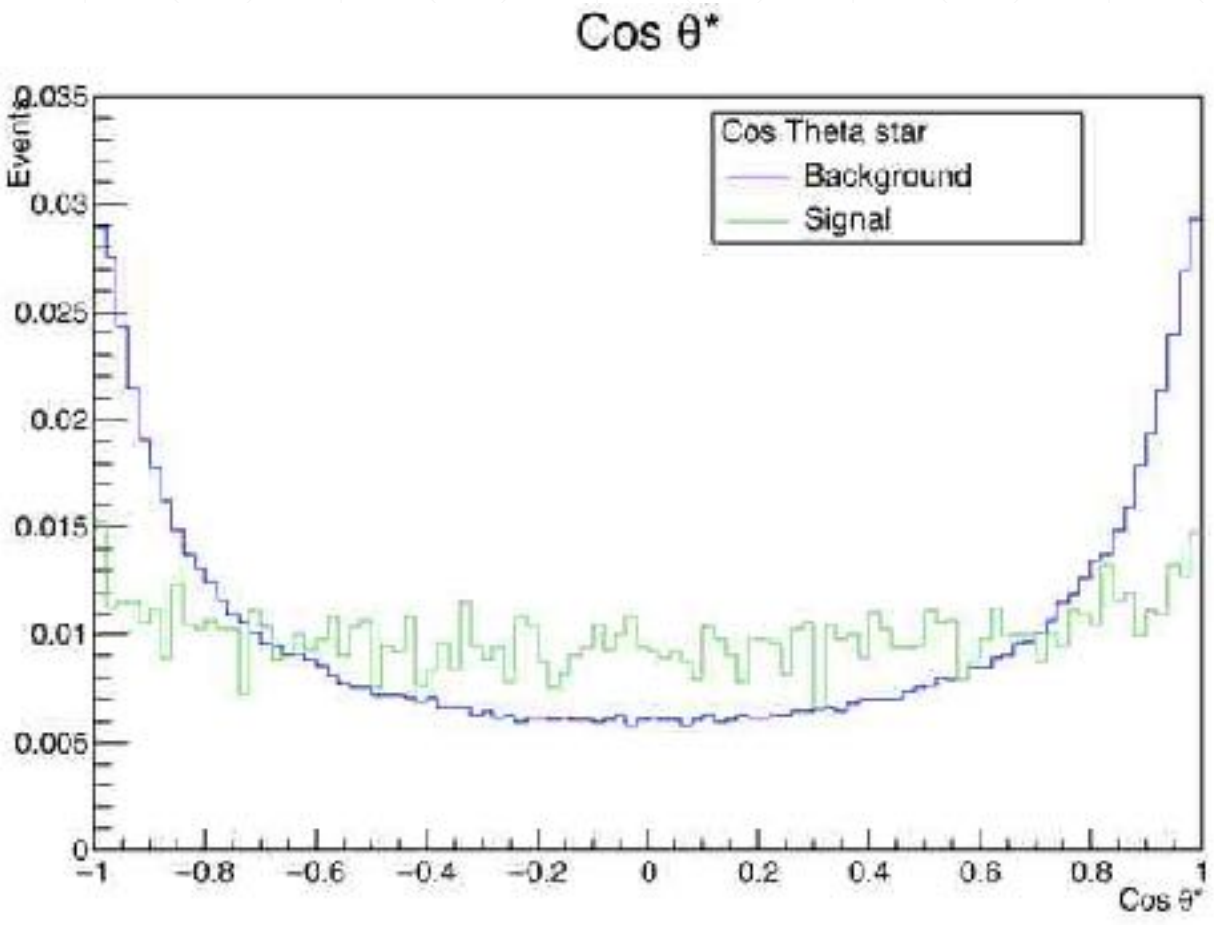
$$H(q) \rightarrow a1(q1) + a2(q2)$$

$$a1(q1) \rightarrow \gamma_1(q11) + \gamma_2(q12)$$

$$a2(q2) \rightarrow \gamma_1(q21) + \gamma_2(q22)$$

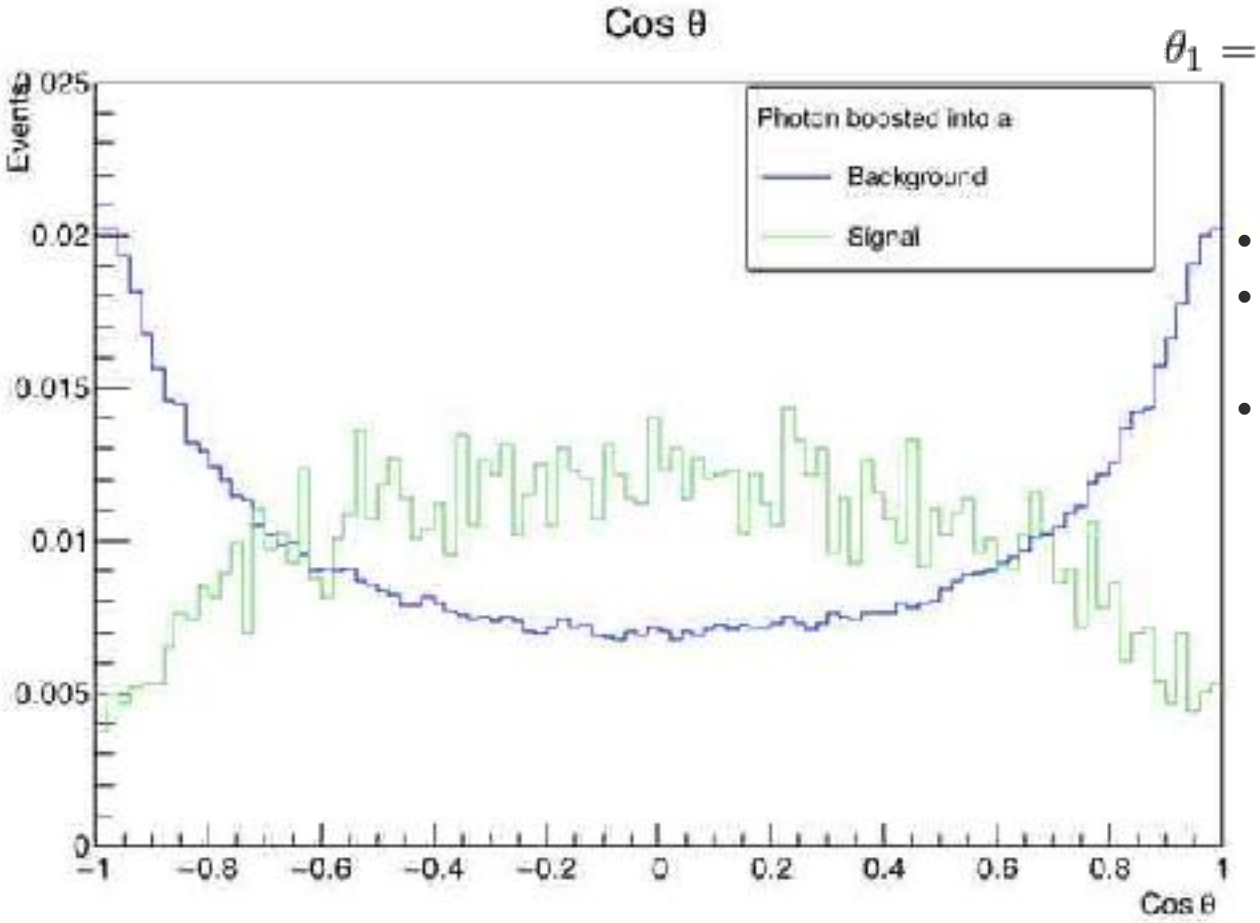


Cos Theta star



- Defined through the unit vector of a1 direction in the Higgs Rest frame
- Reverse boost a1 and a2 in the Higgs rest frame and find CosTheta of a1 and a2
- There is one detail!
  - Since a1 and a2 are defined based on kinematics(a1 will have more energy than a2), this can bias the distribution
  - The angles are described for a1 and a2 defined with respect to the decay channels
  - Need to remove the kinematic bias by randomizing the process of finding and plotting CosTheta
- The background and signal look different
- The signal looks flat because in the Higgs rest frame there should be no preferred direction for a's

Cos Theta

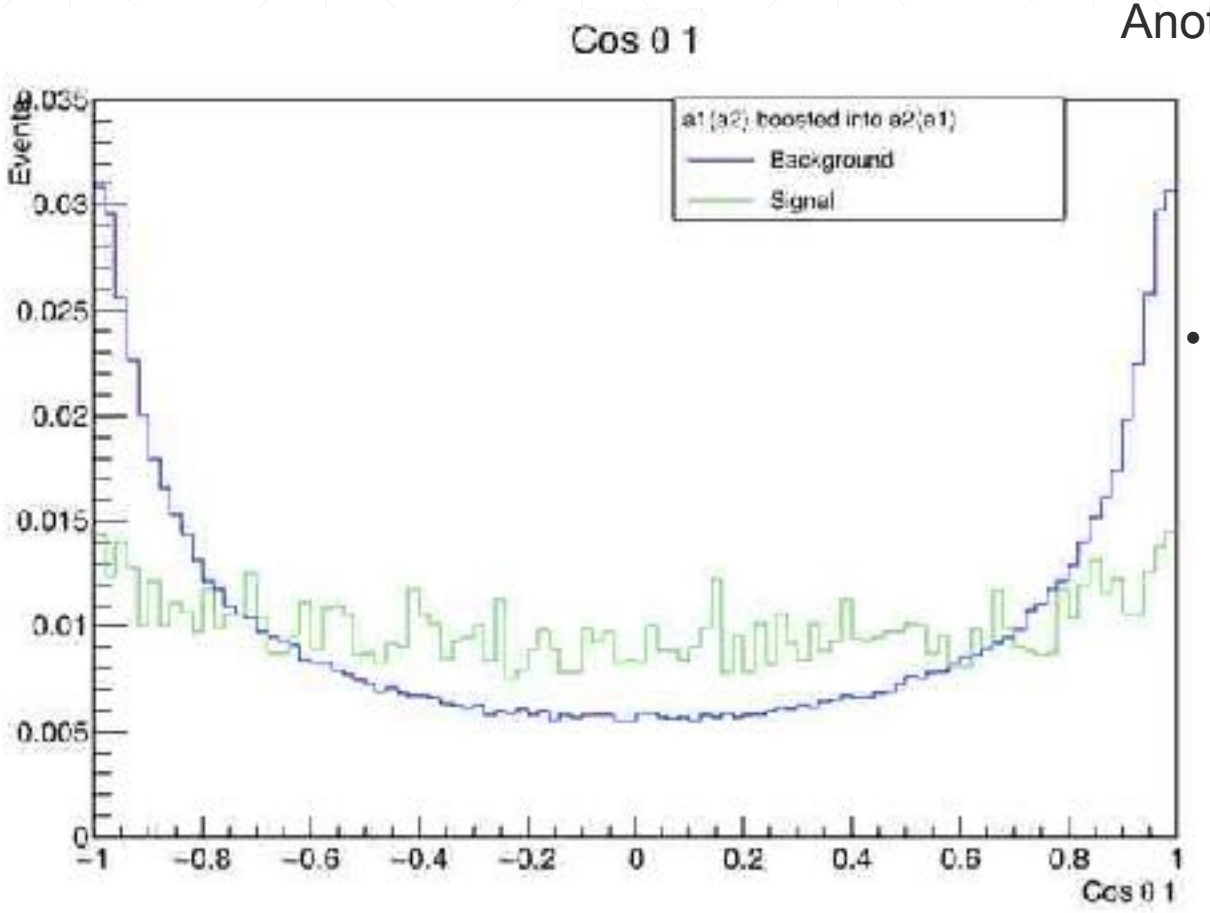


$$\theta_1 = Cos^{-1}\left(\frac{-q_2 \cdot q_{11}}{|q_2||q_{11}|}\right) \qquad \theta_2 = Cos^{-1}\left(\frac{-q_1 \cdot q_{21}}{|q_1||q_{21}|}\right)$$

- Angle between Photon and a
- Boost one of the Photons from one of the a's into a's rest frame
- In this case since a1 and a2 is indistinguishable, the whole process should be randomized

- Since there should be no preference for direction of photon decay in the 'a' rest frame, the signal looks flat

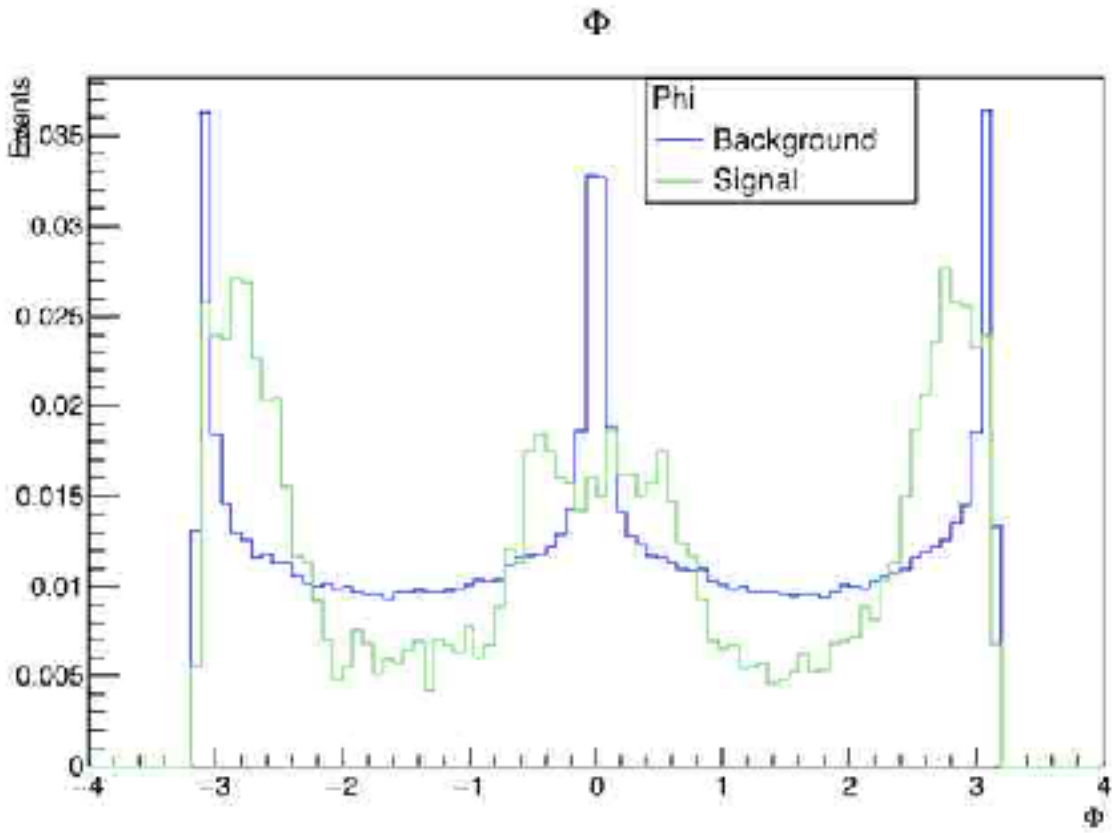
Cos Theta 1



Another angle that is interesting to look at is Cos Theta 1

- Boost a1(a2) into the Rest frame of a2(a1) and calculate Cos Theta of a1(a2)

Phi



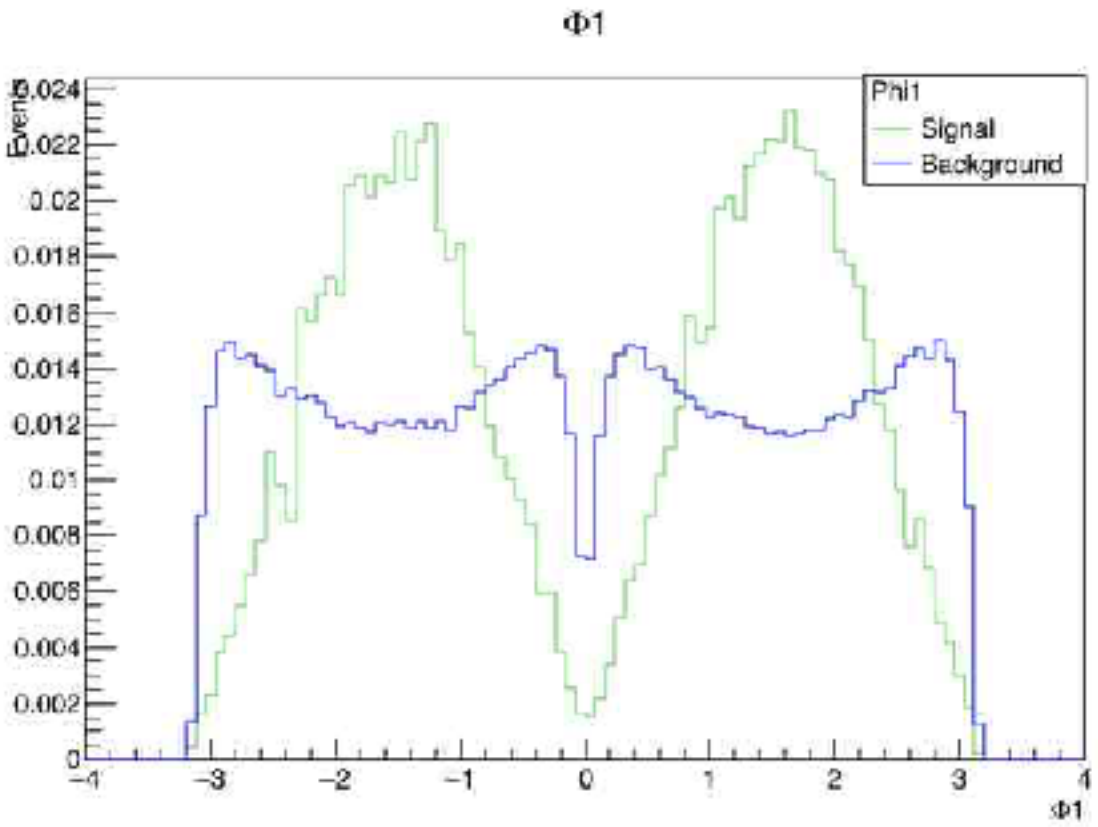
Construct planes normal to Photon 3 momenta

$$\hat{n_1} = \frac{q_{11} \times q_{12}}{|q_{11} \times q_{12}|} \qquad \hat{n_2} = \frac{q_{21} \times q_{22}}{|q_{21} \times q_{22}|}$$

Phi is the azimuthal angle between the planes and the a's

$$\Phi = \frac{q_1.(\hat{n_1} \times \hat{n_2})}{|q_1.(\hat{n_1} \times \hat{n_2}|} \times Cos^{-1}(-\hat{n_1} \times \hat{n_2})$$

Phi 1



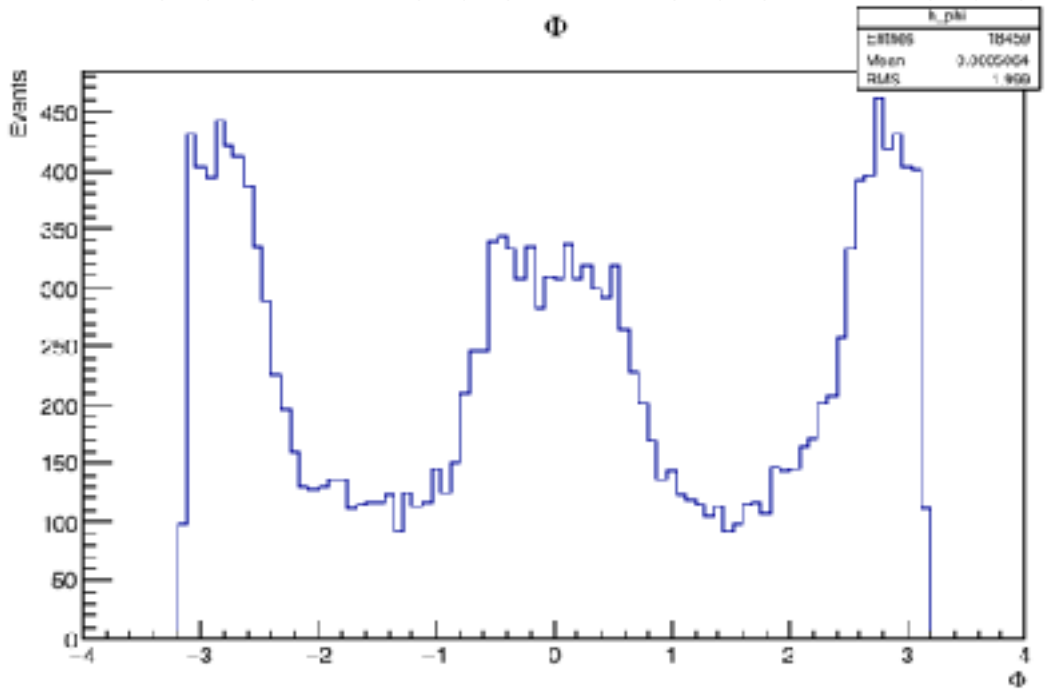
$$\hat{n_{sc}} = \frac{\hat{n_z} \times q_1}{|\hat{n_z} \times q_1|}$$

$$\Phi_1 = \frac{q_1.(\hat{n_1} \times \hat{n_{sc}})}{|q_1.(\hat{n_1} \times \hat{n_{sc}})|} \times Cos^{-1}(\hat{n_1}.\hat{n_{sc}})$$

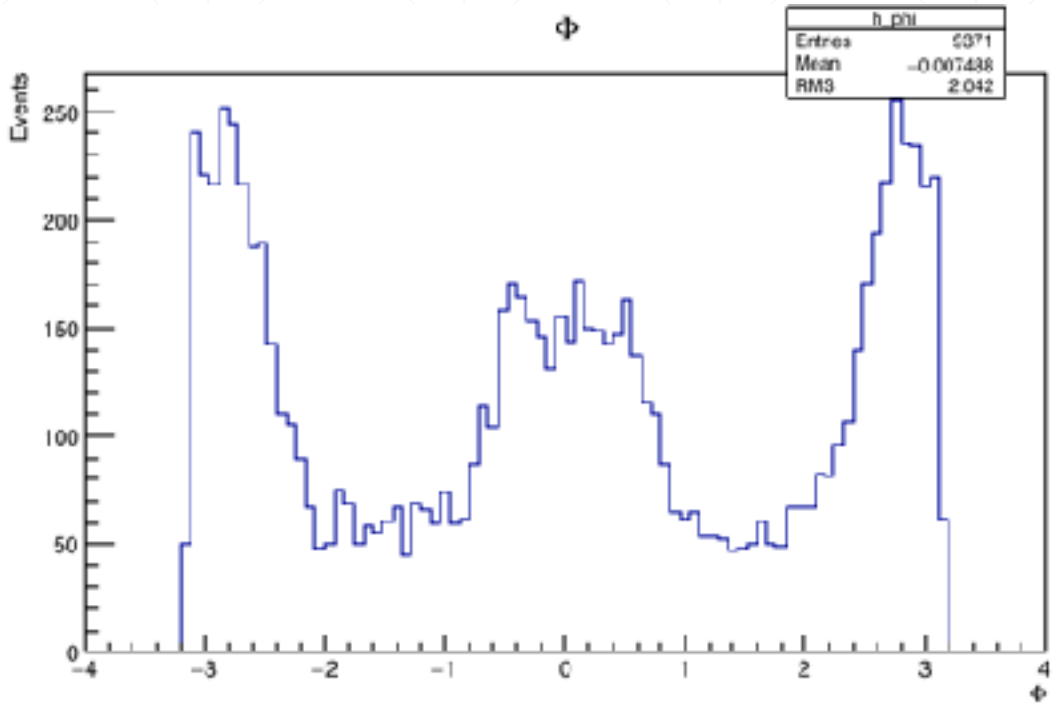
Next Steps

- The angular variables have good discriminating power between signal and background
- Train ‘algorithm’ to classify signal from background by feeding it these distributions(Multivariate Analysis using Boosted Decision Trees

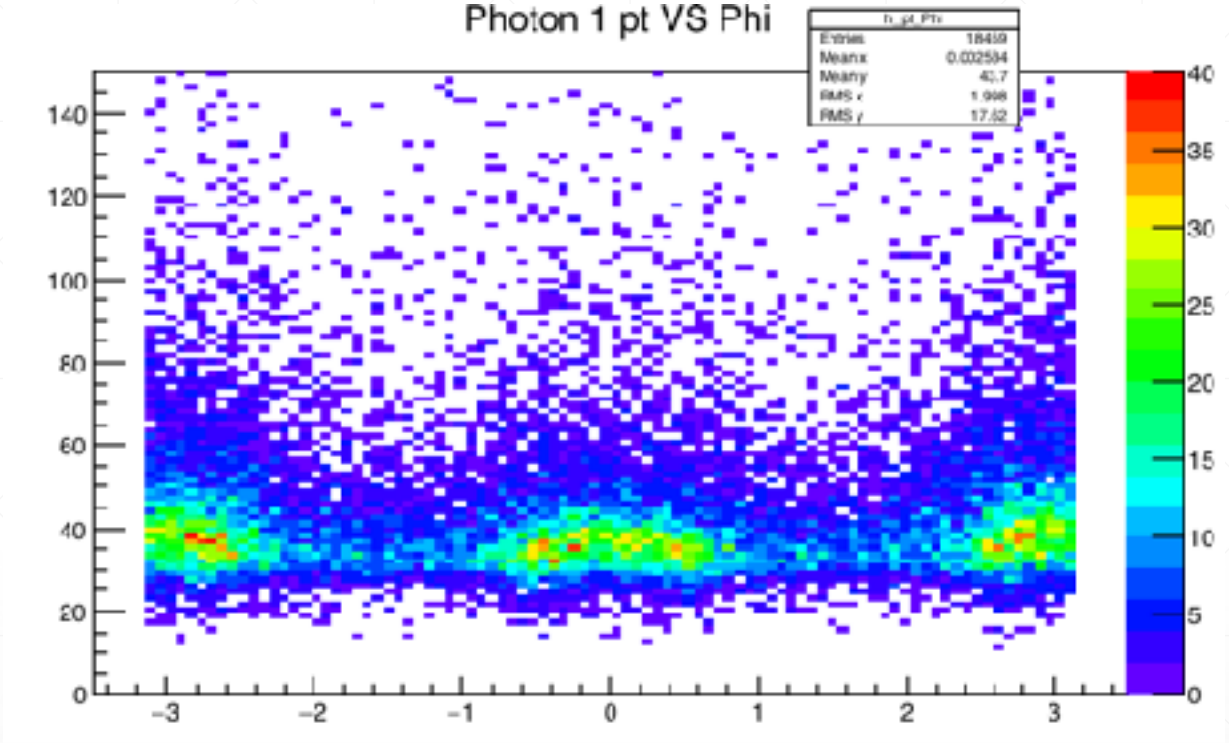
Without selection criterion applied on Pt and Eta



With selection criterion applied on Pt and Eta



Without selection criterion applied on Pt and Eta



With selection criterion applied on Pt and Eta