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Neutral Hadron Calibration

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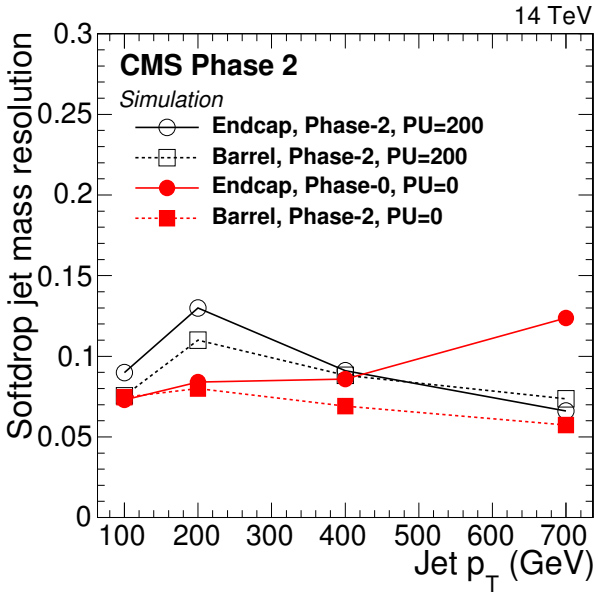
Proposed fix for neutral hadrons

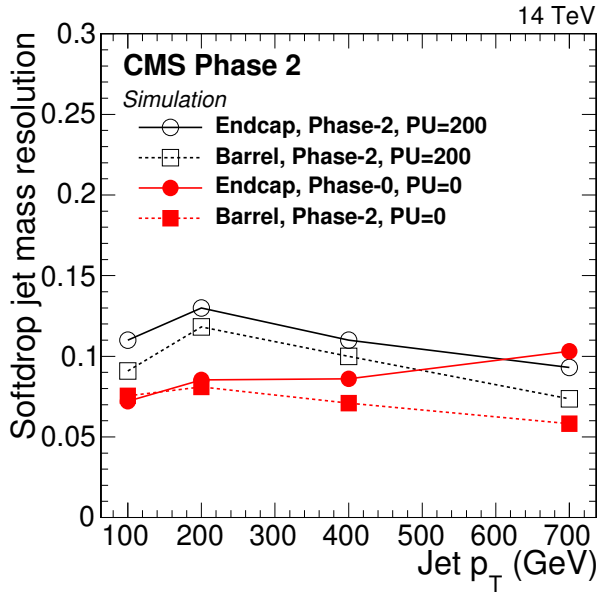
- In the official 93X HGCAL TDR samples
  - realistic HGCAL sim clusters are combined with tracks to form particle flow charged hadrons (and electrons)
  - all remaining HGCAL sim clusters (above a threshold) are turned into neutrals hadrons or photons
- charged hadrons have good energy scale since their momentum is taken from the track
- for neutrals hadrons no calibration is applied to the HGCAL clusters and their energy scale is only 80-90% of the simulated particle
- This can be fixed by applying a hadron calibration to the neutral hadron of order 1.1-1.2 like this:
  - ▸ github code
- We tested the impact of this fix, by applying the calibration to neutral hadrons at MiniAOD-level
  - increases the jet energy response, which was found to be rather low for the 93X HGCAL TDR samples
  - we previously applied the jet energy scale corrections to the jet mass observables
- **not seem to improve** any of the jet substructure/mass issues (see following slides)

QCD SD mass response - Barrel vs Endcap

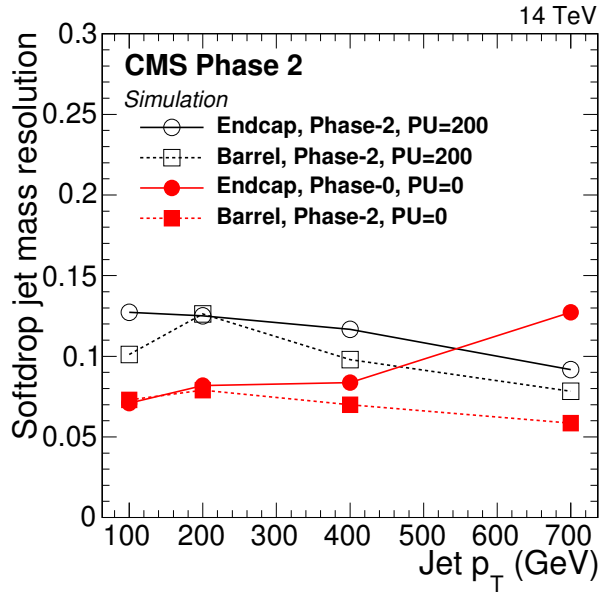
Phase-2 no fix with JEC



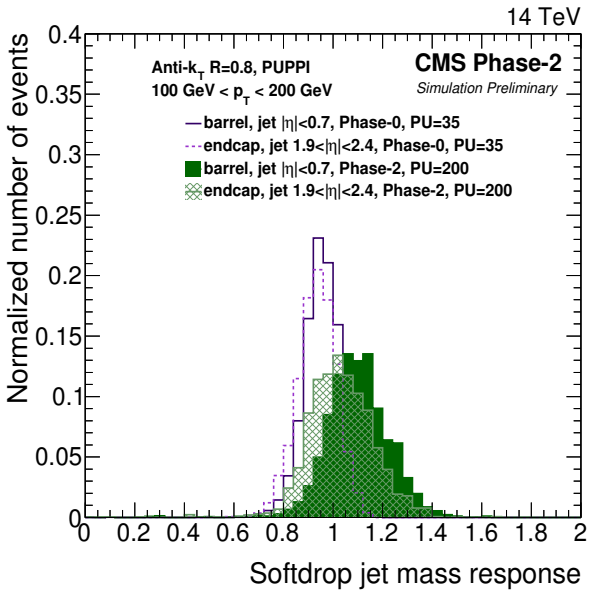
Phase-2 fix & with JEC

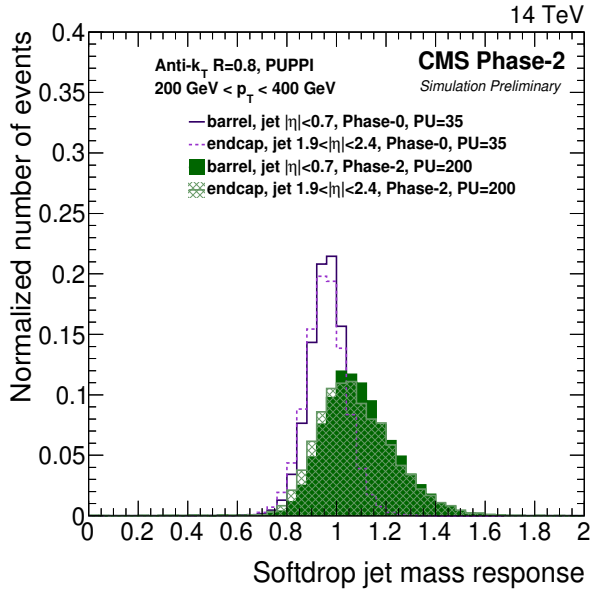


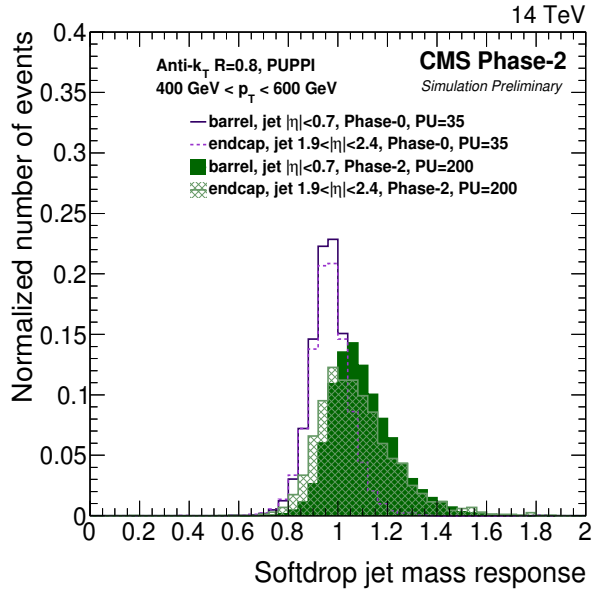
Phase-2 fix & no JEC

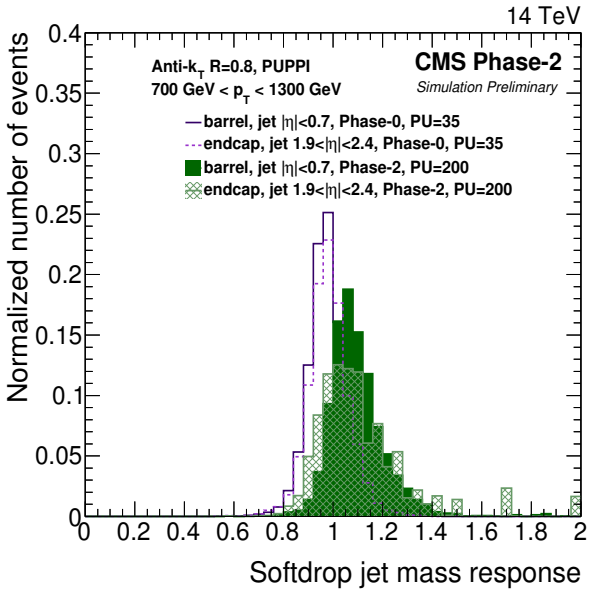


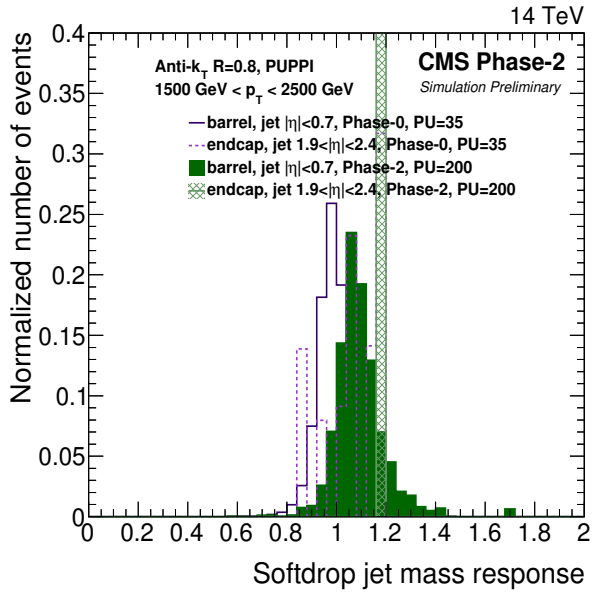
QCD SD mass Reco/Gen response - Barrel vs Endcap

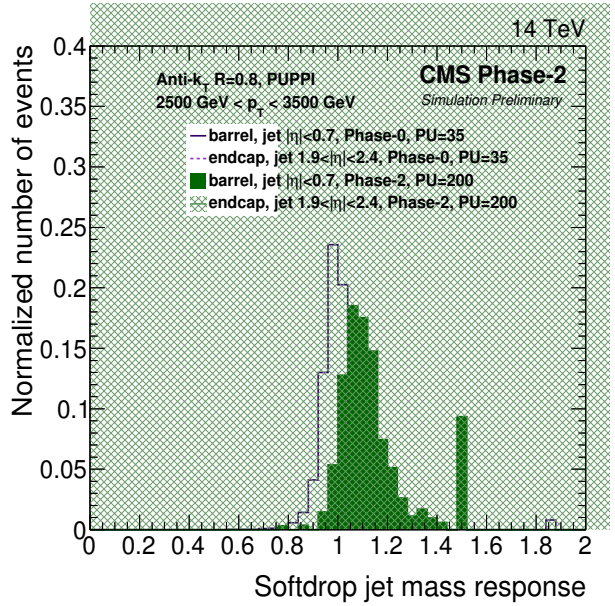




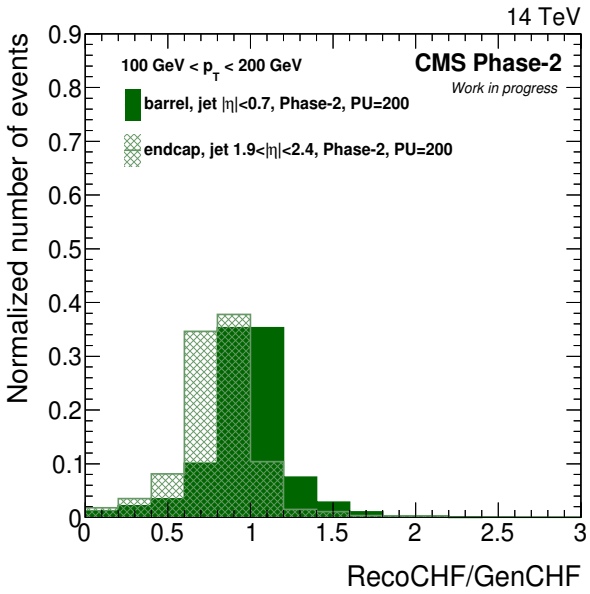


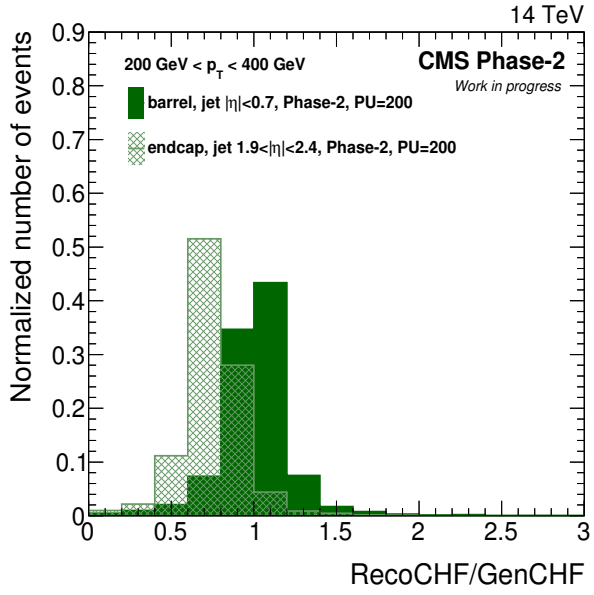


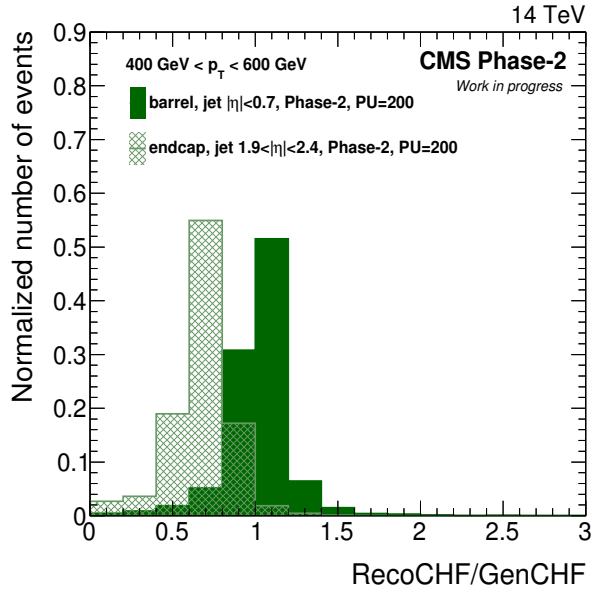


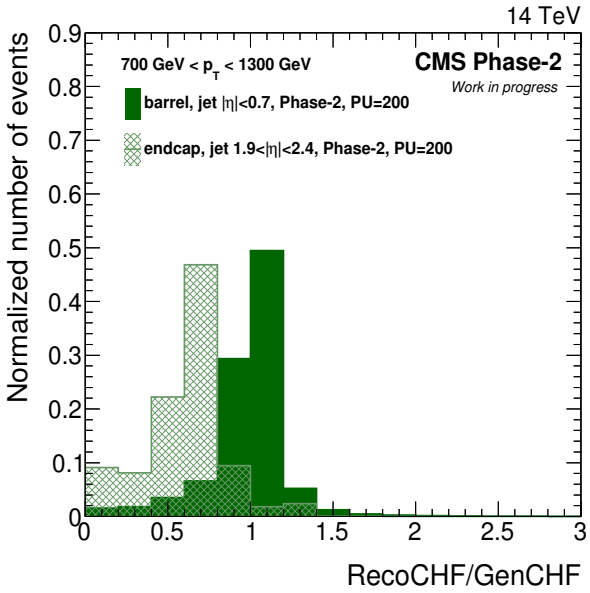


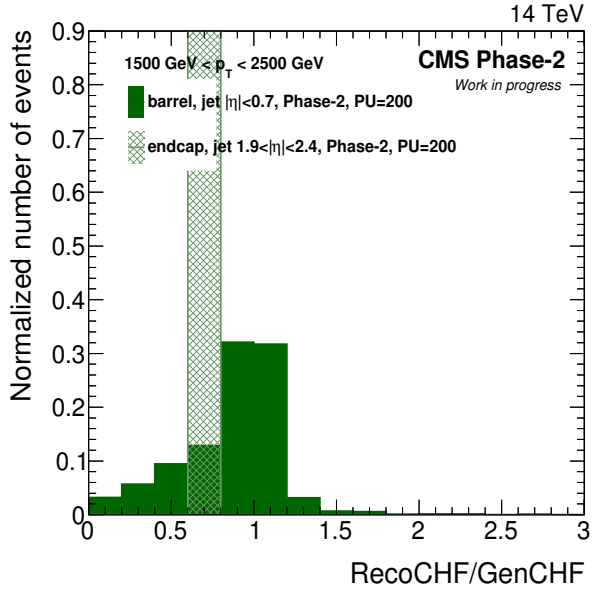
CHF QCD Reco/Gen- Barrel vs Endcap

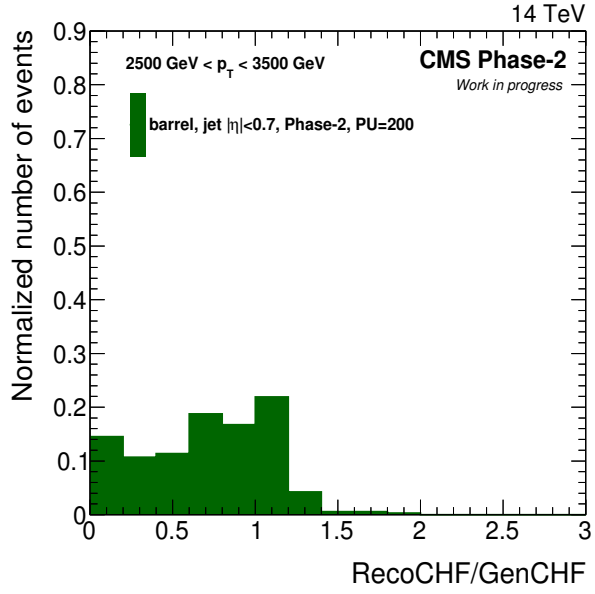




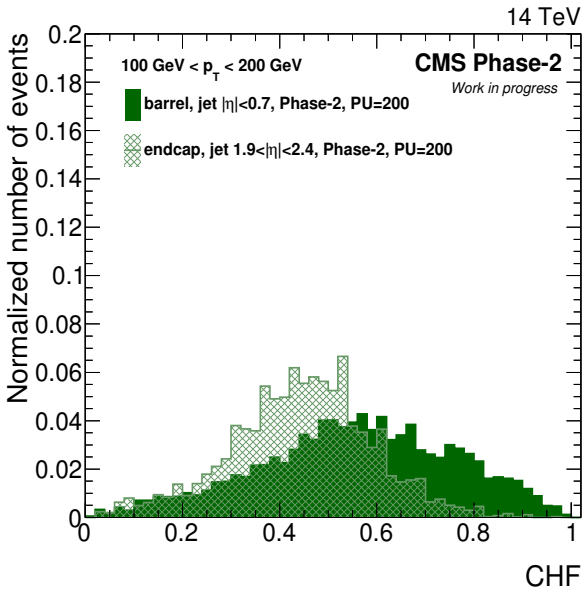


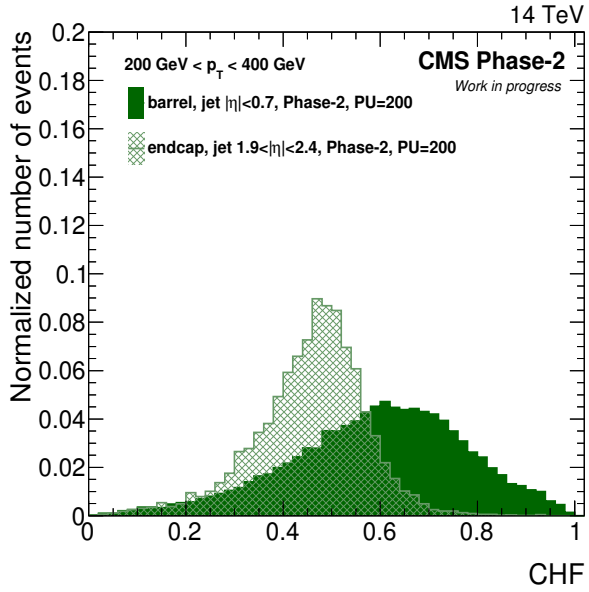


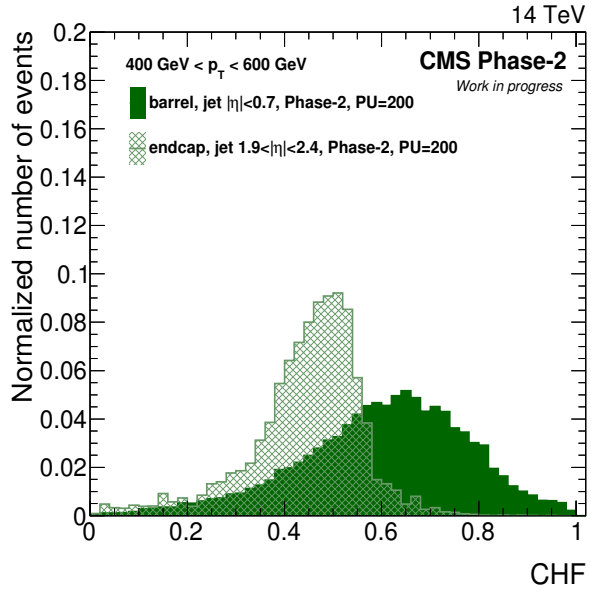


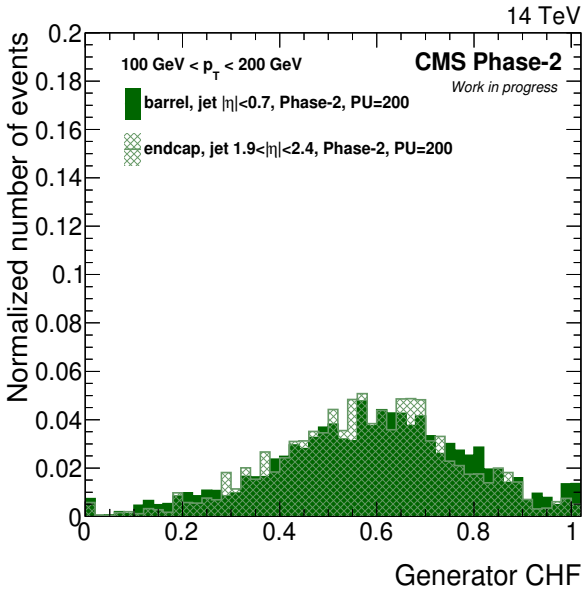


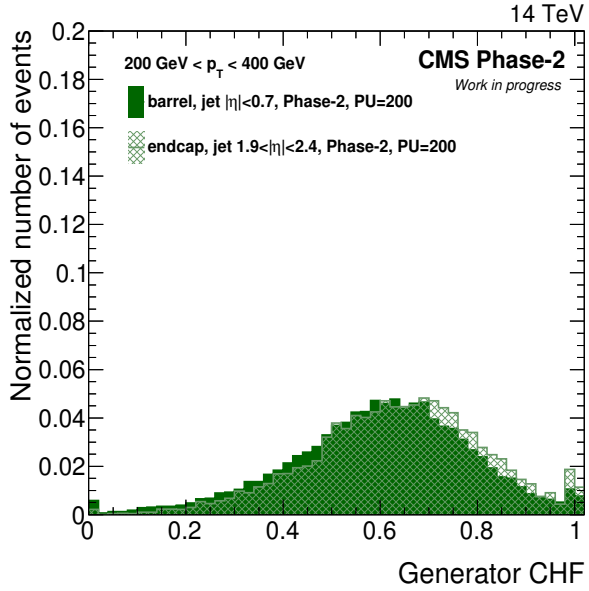
CHF QCD Reco (top) & Gen (bottom) - Barrel vs Endcap

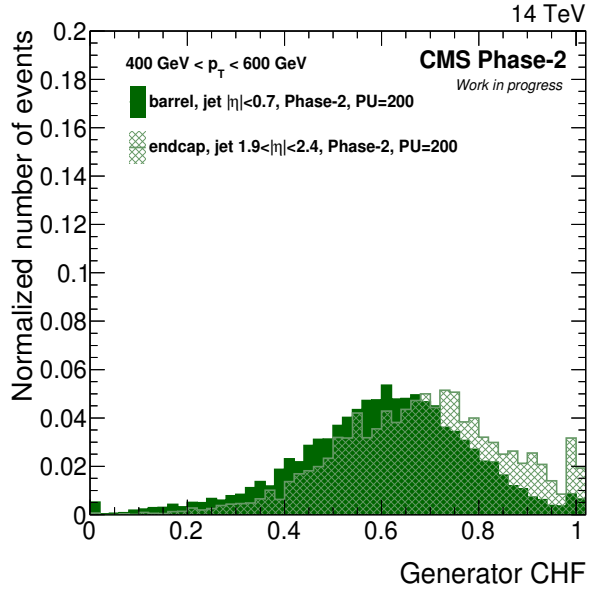




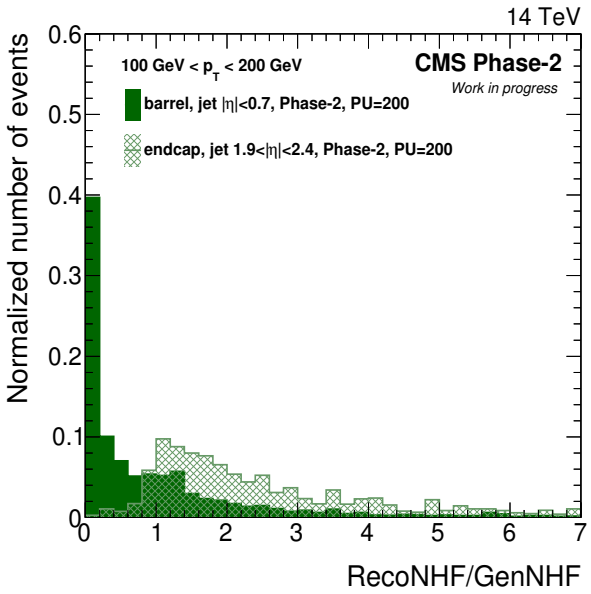


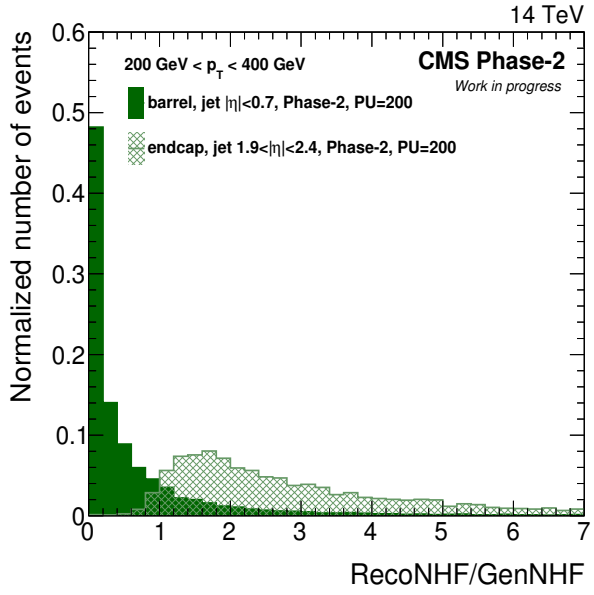


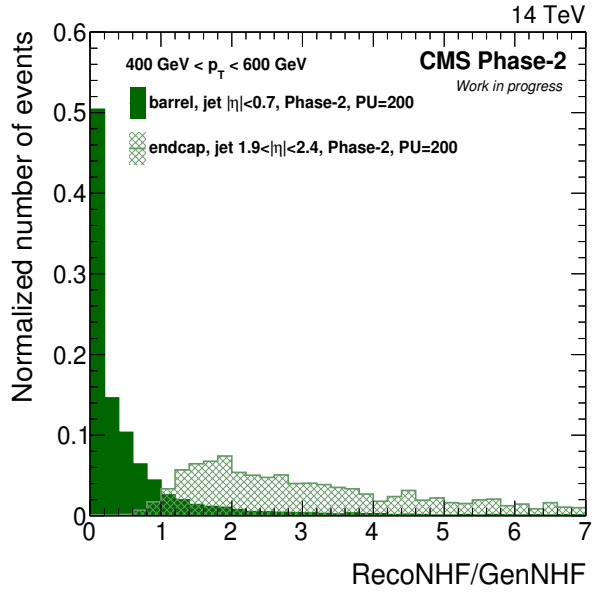


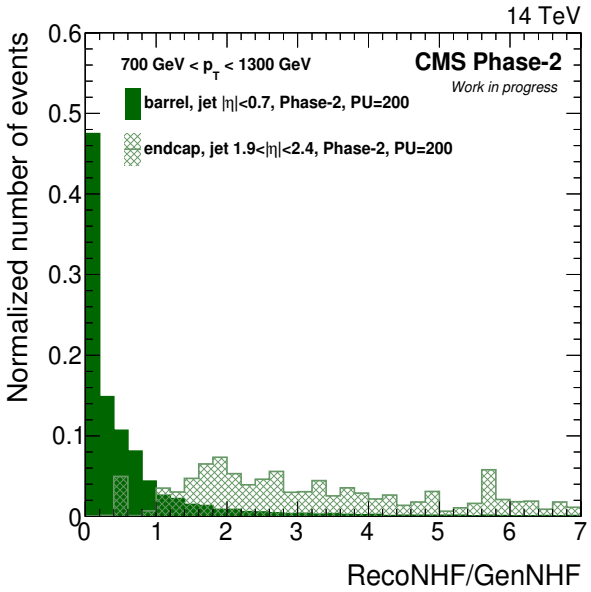


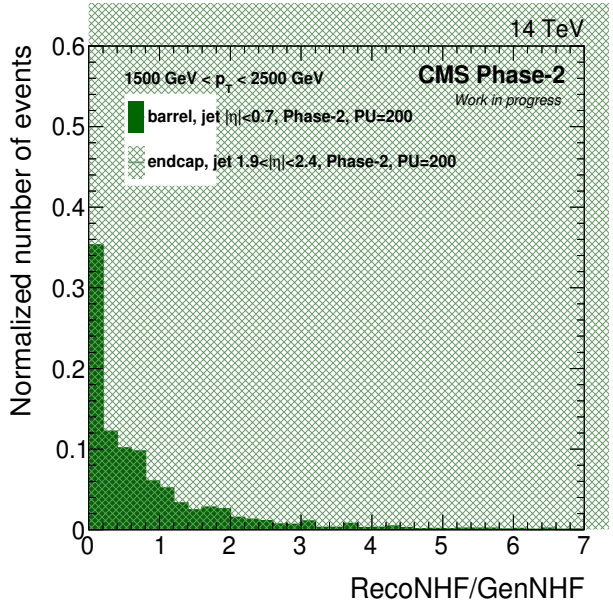
Neutral Hadron Fraction QCD Reco/Gen- Barrel vs Endcap

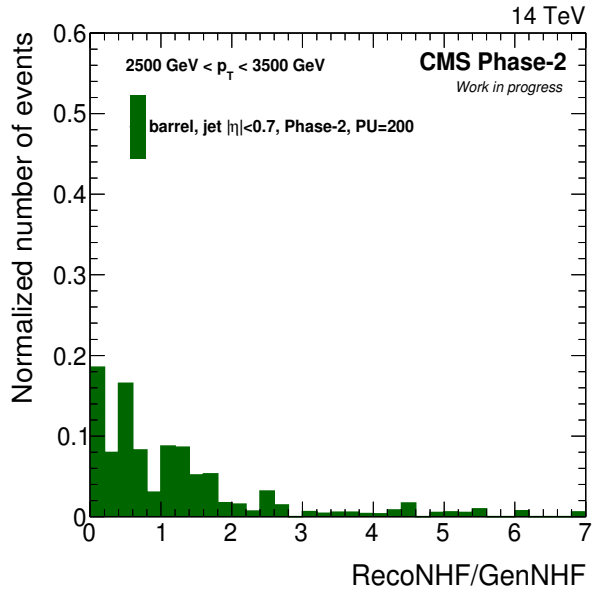




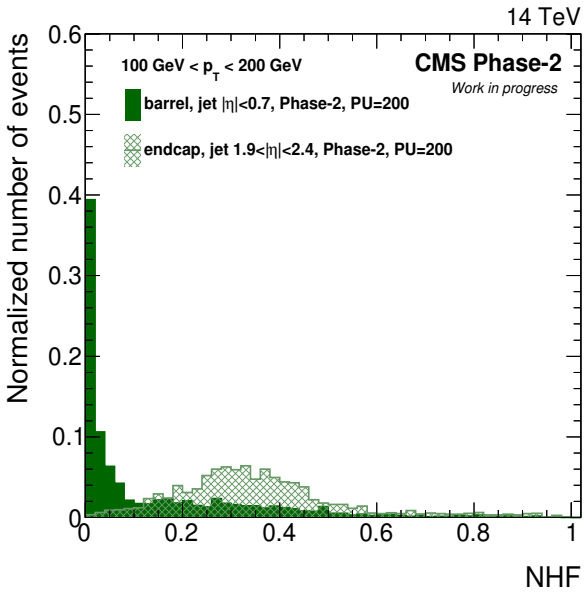


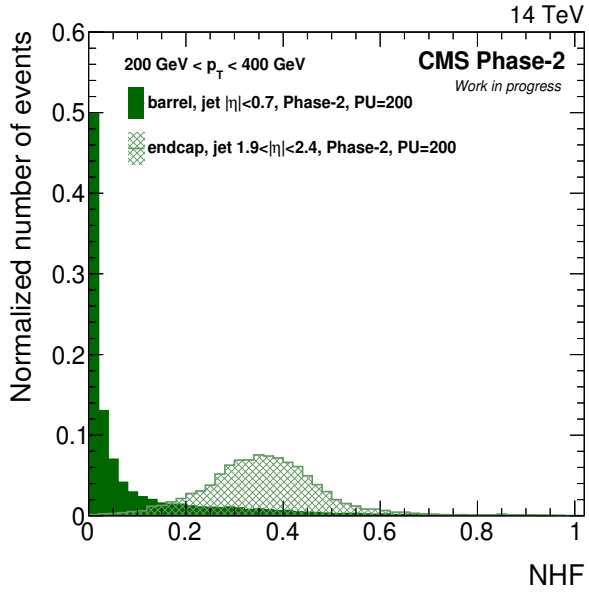


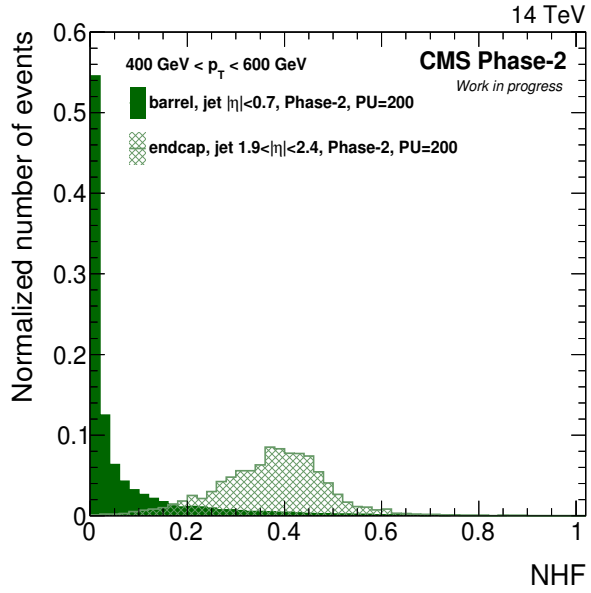


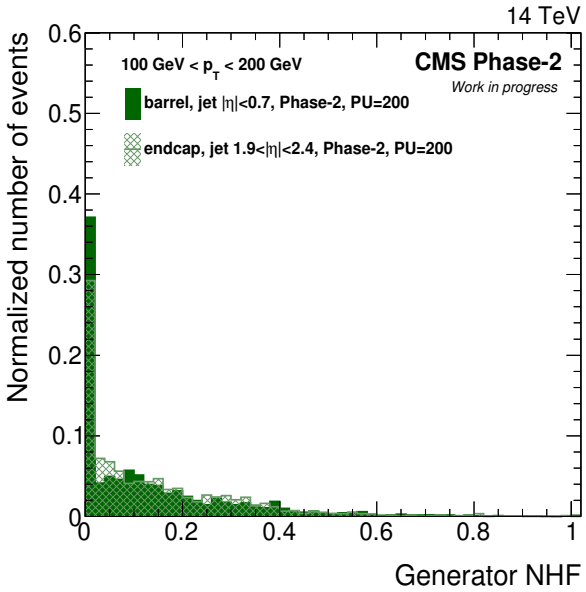


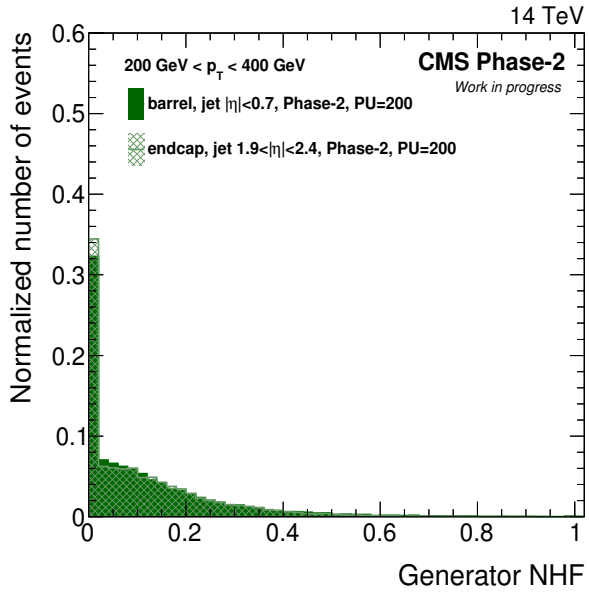
nhf QCD Reco (top) & Gen (bottom) - Barrel vs Endcap

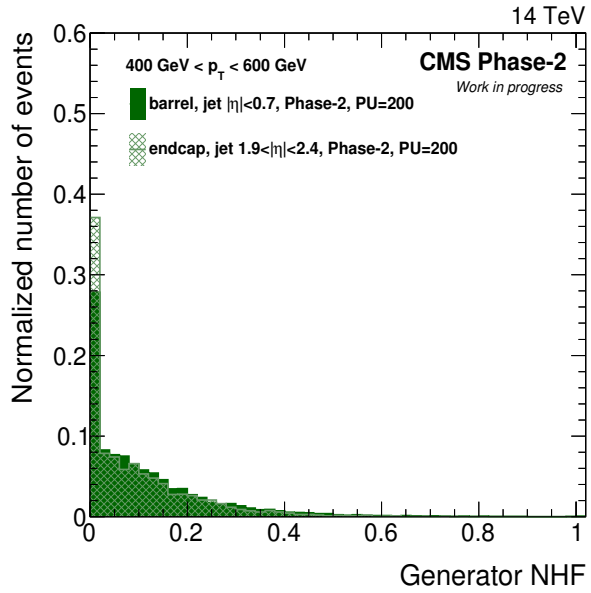




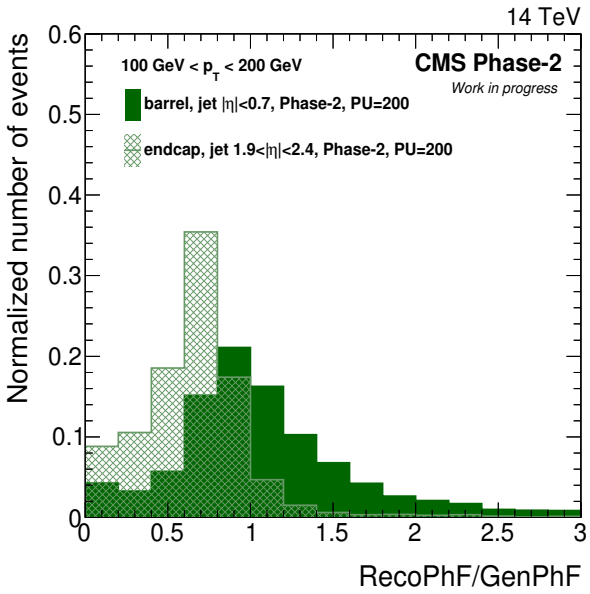


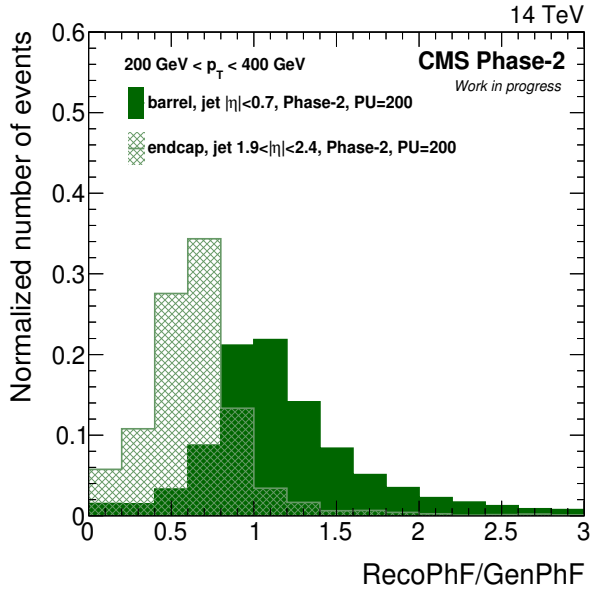


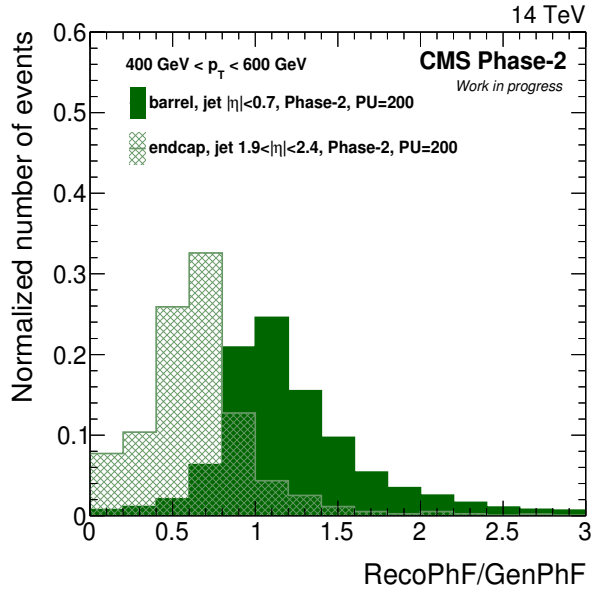


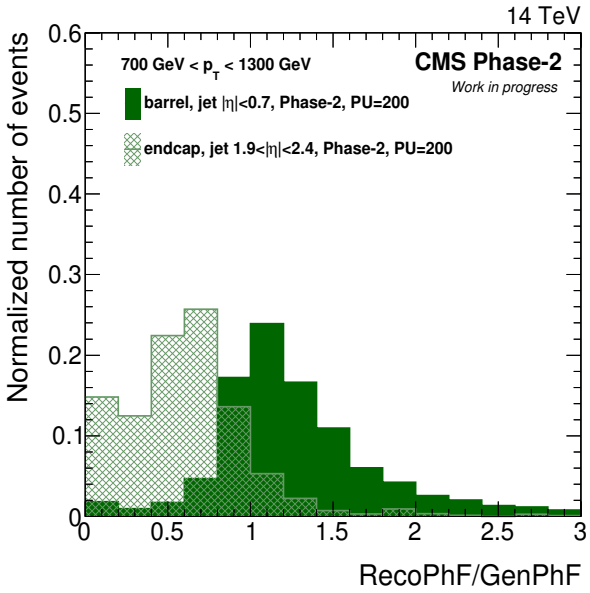


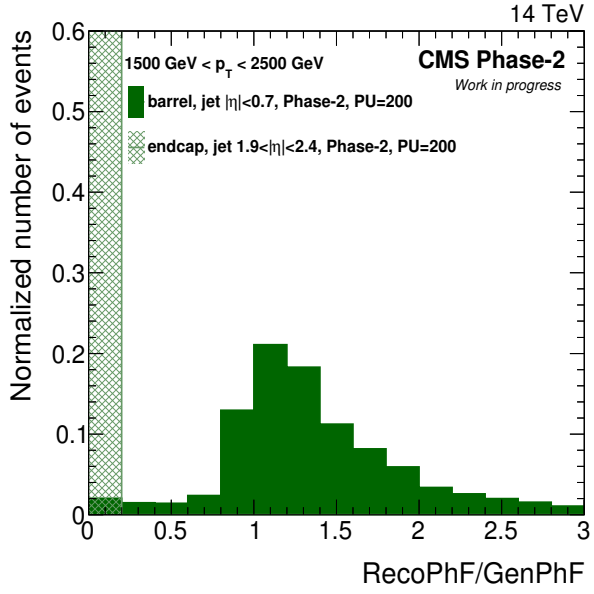
Photon energy Fraction QCD Reco/Gen- Barrel vs Endcap

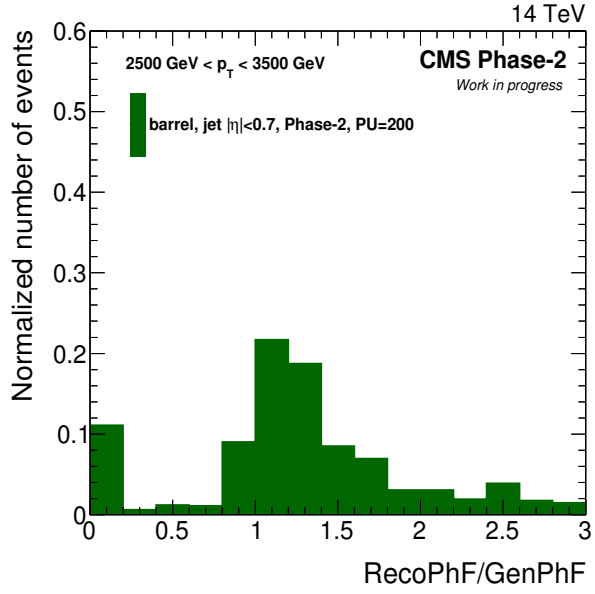




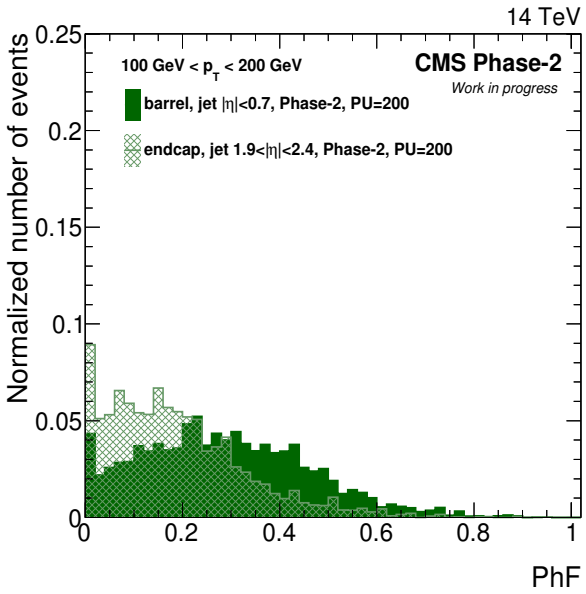


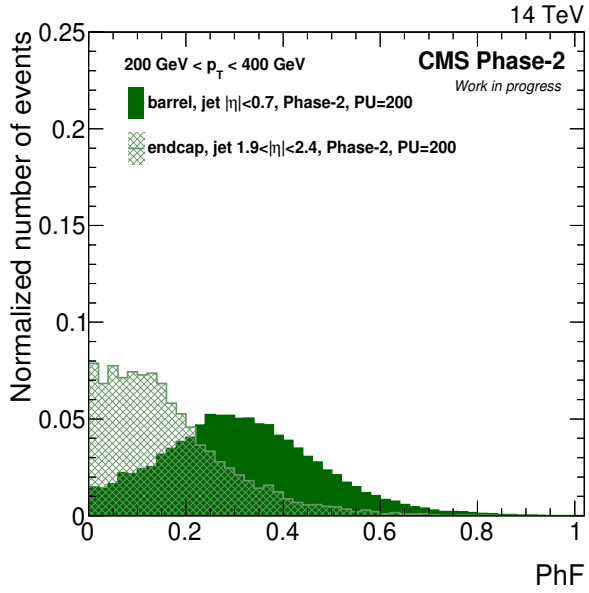


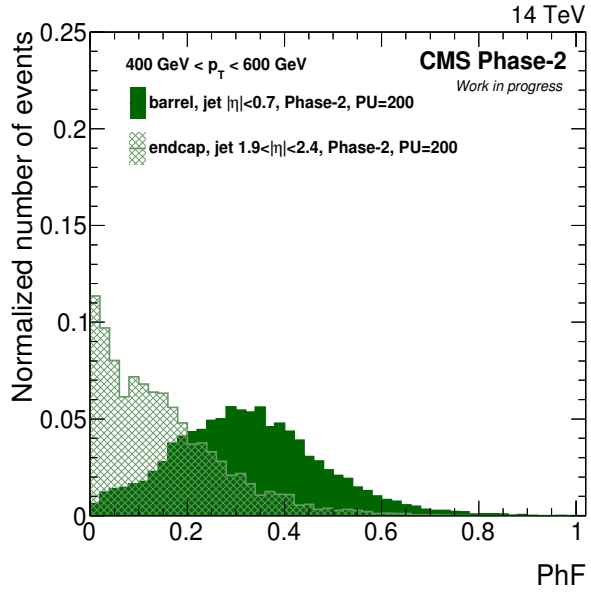


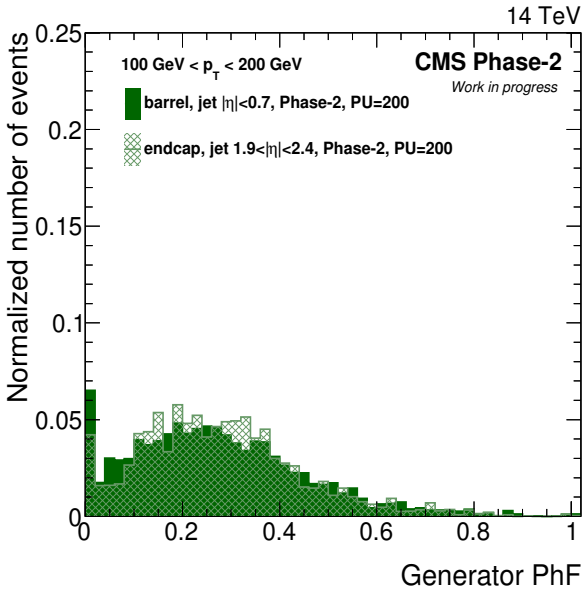


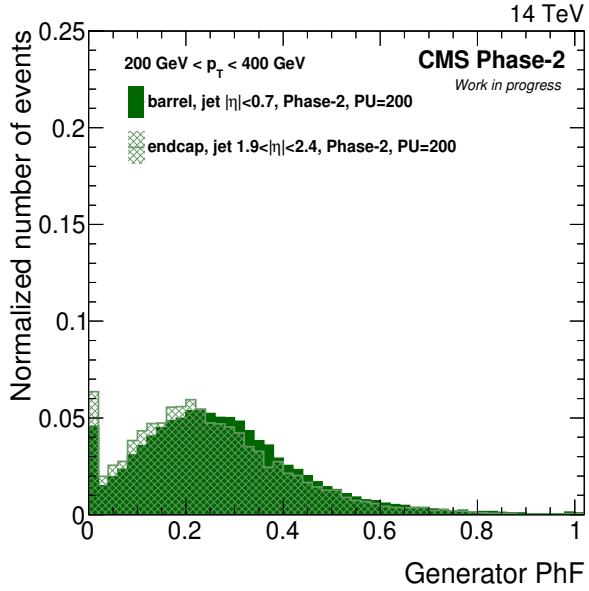
Photon energy fraction QCD Reco (top) & Gen (bottom) - Barrel vs Endcap

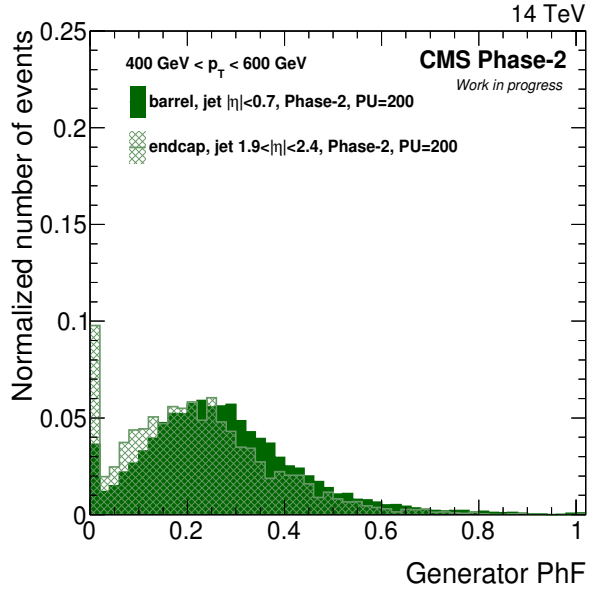












Additional Material

QCD SD mass Reco/Gen performance

barrel, endcap, Top: phase-0, bottom: phase-2 200 PU

p_t (GeV)	Mean (ϵ_μ)	σ (ϵ_σ)	Mean (ϵ_μ)	σ (ϵ_μ)
100< p_T <200	0.96(0.002)	0.071(0.005)	0.94(0.005)	0.076(0.007)
200< p_T <400	0.96(0.0005)	0.069(0.0007)	0.96(0.0008)	0.076(0.001)
400< p_T <600	0.96(0.0004)	0.062(0.0006)	0.96(0.0008)	0.07(0.001)
700< p_T <1300	0.97(0.0002)	0.056(0.0003)	0.98(0.001)	0.064(0.001)
1500< p_T <2500	0.98(0.0003)	0.06(0.0004)	3.6(5)	1.1(1)
2500< p_T <3500	1(0.0007)	0.071(0.0009)	-nan(0)	0.022(3)
100< p_T <200	1.1(0.003)	0.1(0.004)	1(0.006)	0.11(0.006)
200< p_T <400	1.1(0.001)	0.13(0.002)	1(0.003)	0.13(0.003)
400< p_T <600	1.1(0.002)	0.11(0.002)	1(0.004)	0.11(0.004)
700< p_T <1300	1.1(0.001)	0.081(0.002)	1(0.007)	0.093(0.008)
1500< p_T <2500	1.1(0.003)	0.059(0.004)	1.4(1e+02)	0.25(2)
2500< p_T <3500	1.1(0.009)	0.071(0.01)	-nan(0)	0.022(3)

QCD SD mass Reco/Gen performance

barrel, endcap, Top: phase-0, bottom: phase-2 0 PU

p_t (GeV)	Mean (ϵ_μ)	σ (ϵ_σ)	Mean (ϵ_μ)	σ (ϵ_μ)
100< p_T <200	0.96(0.002)	0.071(0.005)	0.94(0.005)	0.076(0.007)
200< p_T <400	0.96(0.0005)	0.069(0.0007)	0.96(0.0008)	0.076(0.001)
400< p_T <600	0.96(0.0004)	0.062(0.0006)	0.96(0.0008)	0.07(0.001)
700< p_T <1300	0.97(0.0002)	0.056(0.0003)	0.98(0.001)	0.064(0.001)
1500< p_T <2500	0.98(0.0003)	0.06(0.0004)	3.6(5)	1.1(1)
2500< p_T <3500	1(0.0007)	0.071(0.0009)	-nan(0)	0.022(3)
100< p_T <200	1.1(0.0009)	0.083(0.001)	0.97(0.001)	0.07(0.002)
200< p_T <400	1.1(0.0004)	0.089(0.0004)	0.95(0.0007)	0.081(0.001)
400< p_T <600	1.1(0.0004)	0.078(0.0006)	0.93(0.002)	0.08(0.002)
700< p_T <1300	1.1(0.0004)	0.064(0.0006)	0.97(0.007)	0.1(0.01)
1500< p_T <2500	1.1(0.0009)	0.053(0.001)	1.5(4)	0.24(1)
2500< p_T <3500	1.1(0.004)	0.059(0.006)	-nan(0)	0.022(3)

QCD SD mass Reco/Gen performance

barrel, endcap, Top: phase-2 200PU, bottom: phase-2 0 PU

p_t (GeV)	Mean (ϵ_μ)	σ (ϵ_σ)	Mean (ϵ_μ)	σ (ϵ_μ)
100< p_T <200	1.1(0.003)	0.1(0.004)	1(0.006)	0.11(0.006)
200< p_T <400	1.1(0.001)	0.13(0.002)	1(0.003)	0.13(0.003)
400< p_T <600	1.1(0.002)	0.11(0.002)	1(0.004)	0.11(0.004)
700< p_T <1300	1.1(0.001)	0.081(0.002)	1(0.007)	0.093(0.008)
1500< p_T <2500	1.1(0.003)	0.059(0.004)	1.4(1e+02)	0.25(2)
2500< p_T <3500	1.1(0.009)	0.071(0.01)	-nan(0)	0.022(3)
100< p_T <200	1.1(0.0009)	0.083(0.001)	0.97(0.001)	0.07(0.002)
200< p_T <400	1.1(0.0004)	0.089(0.0004)	0.95(0.0007)	0.081(0.001)
400< p_T <600	1.1(0.0004)	0.078(0.0006)	0.93(0.002)	0.08(0.002)
700< p_T <1300	1.1(0.0004)	0.064(0.0006)	0.97(0.007)	0.1(0.01)
1500< p_T <2500	1.1(0.0009)	0.053(0.001)	1.5(4)	0.24(1)
2500< p_T <3500	1.1(0.004)	0.059(0.006)	-nan(0)	0.022(3)

QCD SD mass Reco/Gen performance

barrel, endcap, Top: phase-2 200PU, bottom: phase-2 0 PU - no JEC applied

p_t (GeV)	Mean (ϵ_μ)	σ (ϵ_σ)	Mean (ϵ_μ)	σ (ϵ_μ)
100< p_T <200	0.97(0.003)	0.098(0.004)	1.1(0.008)	0.14(0.01)
200< p_T <400	0.95(0.001)	0.12(0.002)	1.2(0.003)	0.15(0.004)
400< p_T <600	0.95(0.002)	0.093(0.002)	1.2(0.005)	0.14(0.006)
700< p_T <1300	0.97(0.001)	0.076(0.002)	1.2(0.01)	0.11(0.01)
1500< p_T <2500	0.99(0.002)	0.055(0.003)	1.5(5)	0.25(2)
2500< p_T <3500	1(0.02)	0.058(0.03)	-nan(0)	0.022(3)
100< p_T <200	1(0.0008)	0.073(0.001)	1.1(0.001)	0.078(0.001)
200< p_T <400	1(0.0004)	0.079(0.0006)	1.1(0.0009)	0.09(0.001)
400< p_T <600	1(0.0005)	0.07(0.0006)	1.1(0.002)	0.092(0.002)
700< p_T <1300	0.99(0.0005)	0.058(0.0007)	1.1(0.01)	0.14(0.01)
1500< p_T <2500	1(0.0008)	0.05(0.001)	1.5(0.08)	0.044(0.3)
2500< p_T <3500	1(0.003)	0.06(0.004)	-nan(0)	0.022(3)