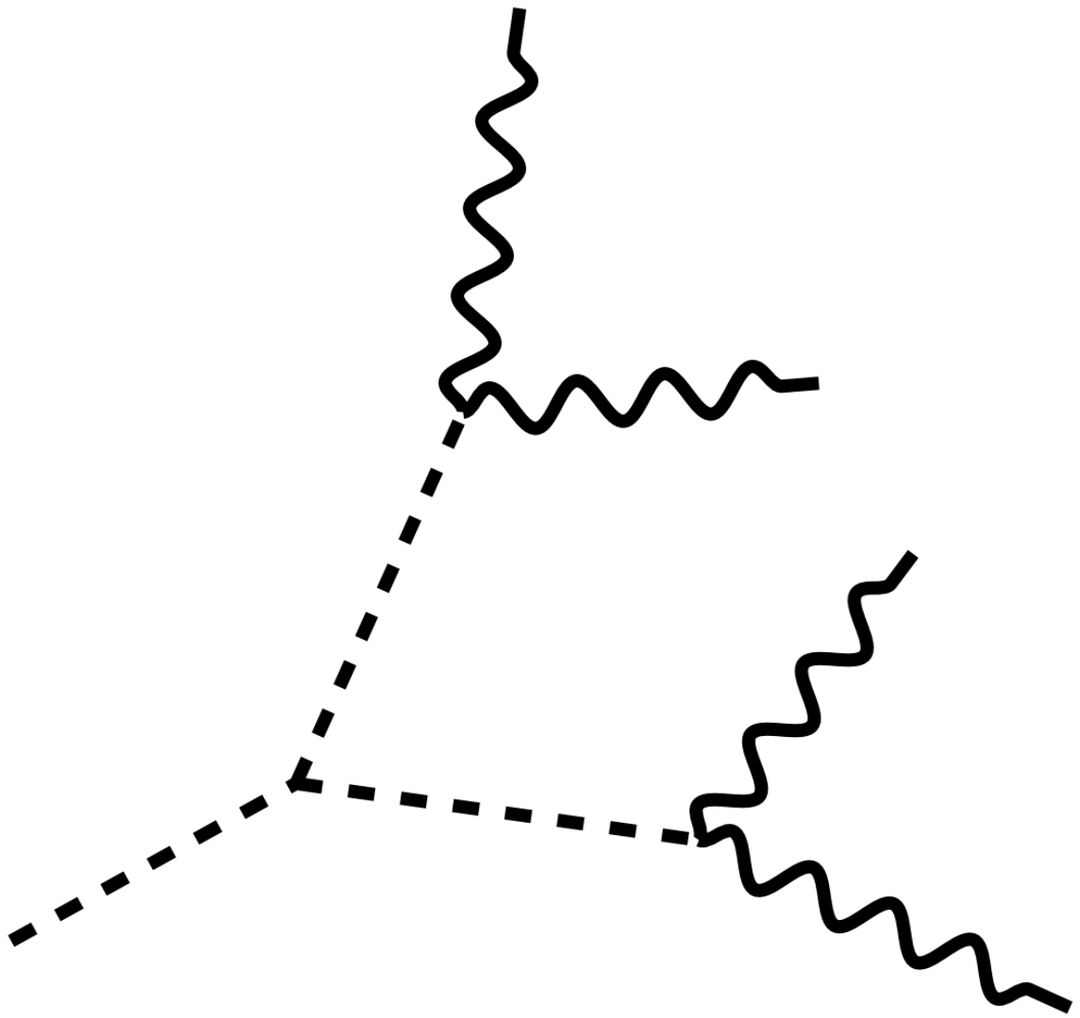
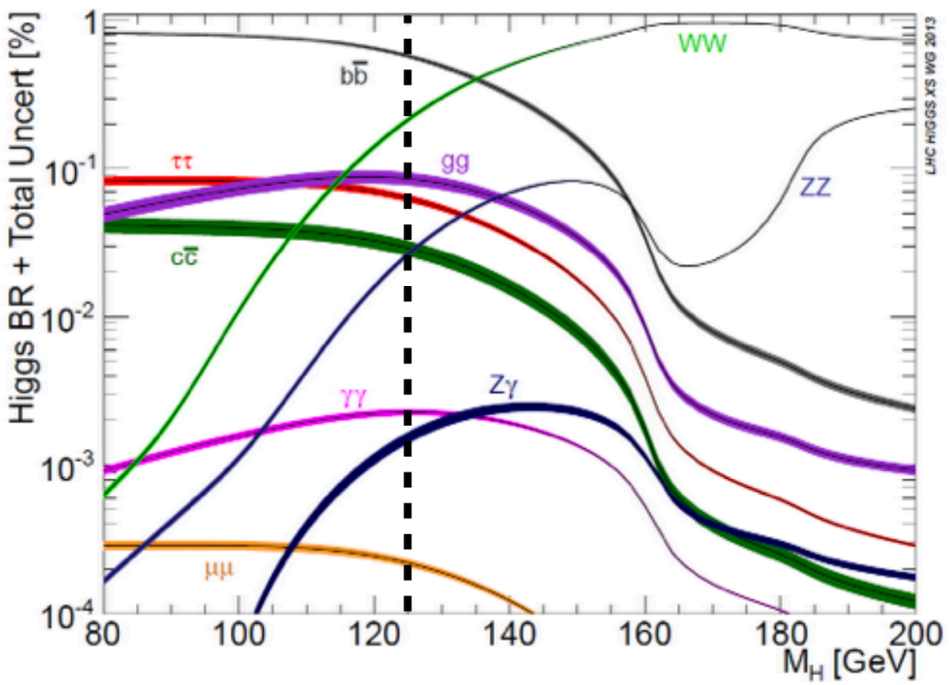


h(125)→aa→ϑϑϑϑ

TOYOKO ORIMOTO
ANDREA MASSIRONI
TANVI WAMORKAR

14th September 2017
Northeastern Meeting

MOTIVATION - Photons @ LHC



$h(125) \rightarrow aa \rightarrow \gamma\gamma\gamma\gamma$

Bad News Small branching ratios

Good News Excellent Photon isolation

Well established scenario:

Many extensions of the SM Higgs sector include CP-odd particles (**a**) with couplings to the Higgs and branching ratios into photons visible at LHC

- (N)MSSM , SM + Singlet, etc have a subdominant BR (a -> γγ)
- Non trivial extensions can suppress a -> fermions and lead to dominant Br(a -> γγ)
  See details at Exotic Higgs Decays website
- The 4γ final state is SM background free and we take advantage of the high online/offline reconstruction + identification efficiency
- Existing study from ATLAS - h→γγ analysis reinterpreted as h→aa→4γ search with M(a) < 1 GeV (collimated photons) (only 7 TeV data) [ATLAS-CONF-2012-079]
- **New to CMS!**

ANALYSIS STRATEGY

Pre-selection: require at least 4γ ’s with Et > 15 GeV and |η| < 2.5 - **Good γ’s**

γ-ID: at least 4 good γ ’s that pass the γ MVA ID requirement

- Used **H->γγ MVA ID:** good signal efficiency
- photonIDMVA > -0.9 for both EB and EE - eliminates a significant fraction of non prompt photons + conserves ~99% efficiency for prompt photons

Trigger Selection: choose 2 γ ’s that pass trigger requirements + 2 other ID-ed γ ’s ordered in Et

- Low Mass Diphoton Triggers
- Trigger Paths: One for γγ in EBEB, one for !EBEB

  - HLT_Diphoton30EB_18EB_R9Id_OR_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55
  - HLT_Diphoton30_18_R9Id_AND_IsoCaloId_AND_HE10p0_R9Id_DoublePixelVeto_Mass55

SAMPLES BEING USED

DATA:

- Double EG re-Mini AOD dataset
- Corresponds to 35.86 fb^{-1} for 2016

Signal MC:

- Generated using PYTHIA 8
- Officially produced Summer16 samples - DAS Link

Background:

- **DiPhotons + Jets**

  DiPhotonJetsBox_M40_80-Sherpa
  DiPhotonJetsBox_MGG-80toInf_13TeV-Sherpa

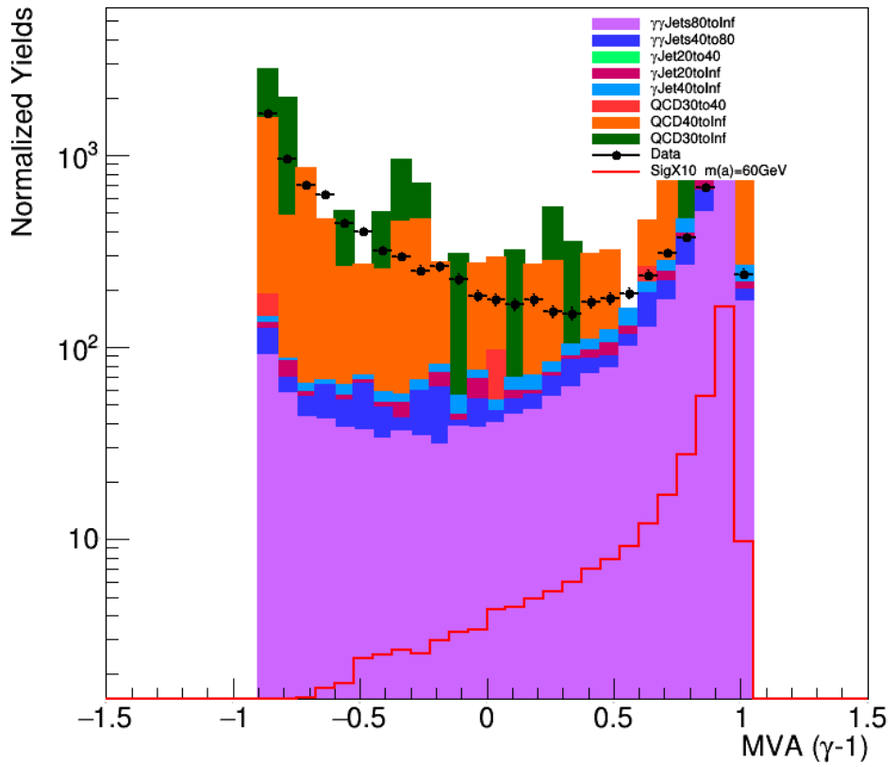
- **Photons + Jets**

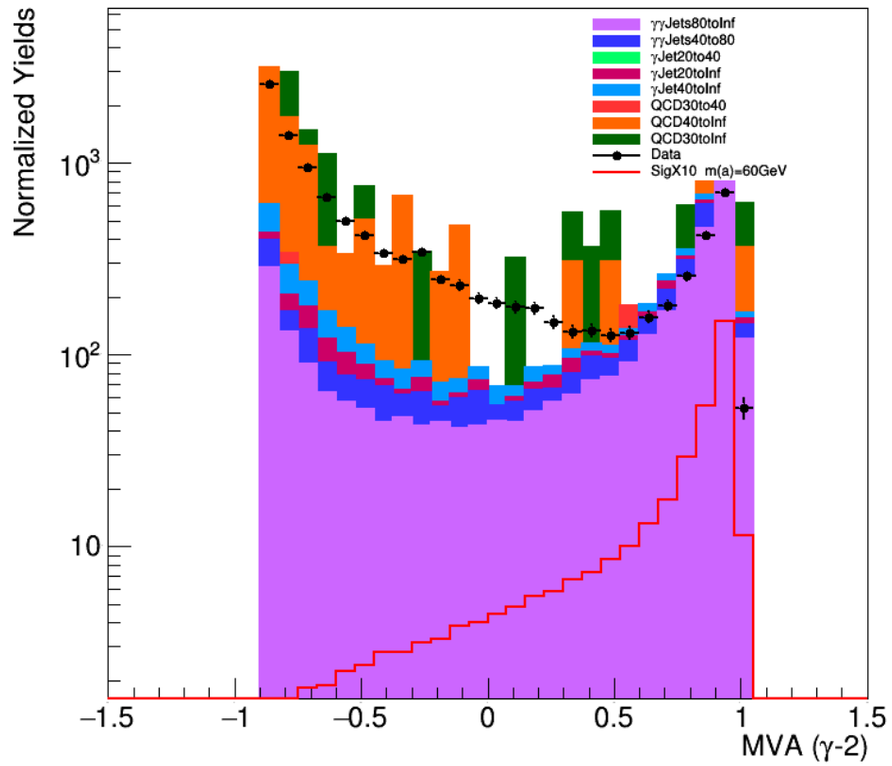
GJet_Pt-20toInf_DoubleEMEnriched_MGG-40to80_TuneCUETP8M1_13TeV_Pythia8
GJet_Pt-20to40_DoubleEMEnriched_MGG-80toInf_TuneCUETP8M1_13TeV_Pythia8
GJet_Pt-40toInf_DoubleEMEnriched_MGG-80toInf_TuneCUETP8M1_13TeV_Pythia8

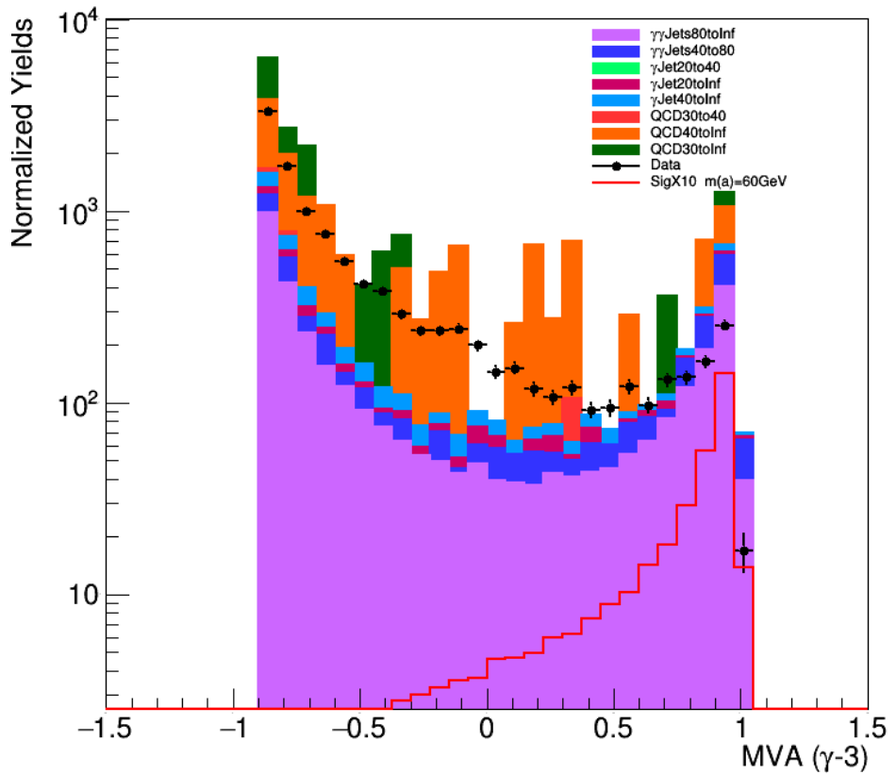
- **QCD**

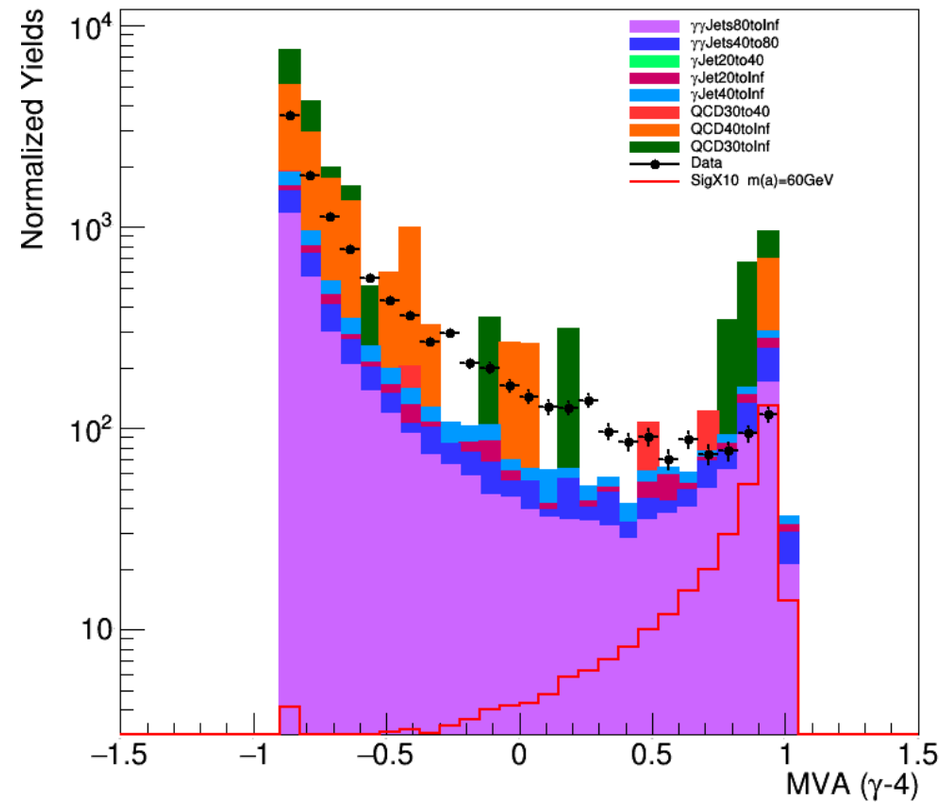
QCD_Pt-30to40_DoubleEMEnriched_MGG-80toInf_TuneCUETP8M1_13TeV_Pythia8
QCD_Pt-40toInf_DoubleEMEnriched_MGG-80toInf_TuneCUETP8M1_13TeV_Pythia8
QCD_Pt-30toInf_DoubleEMEnriched_MGG-40to80_TuneCUETP8M1_13TeV_Pythia8

PHOTON MVA

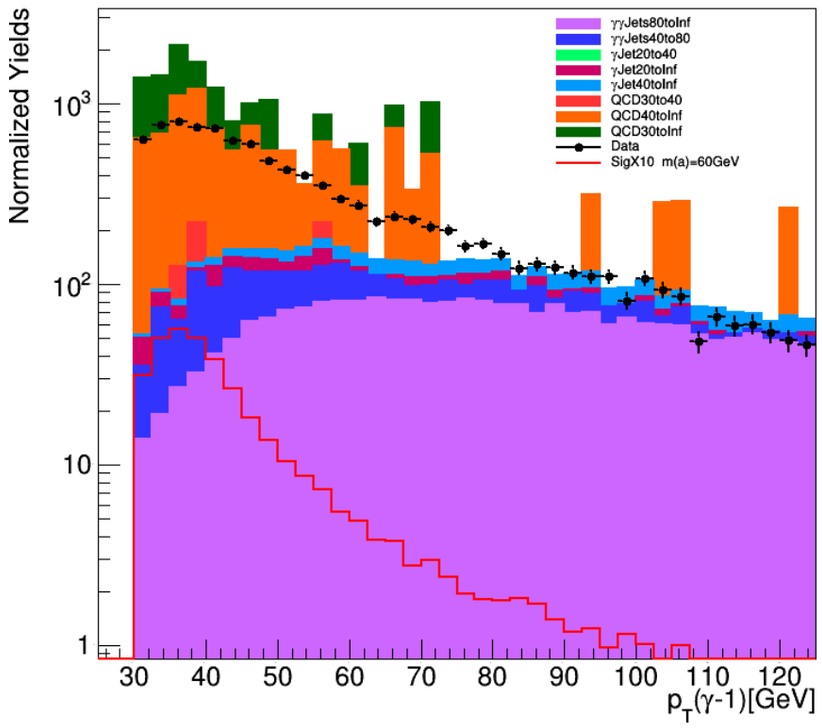

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
MVA (γ-1)

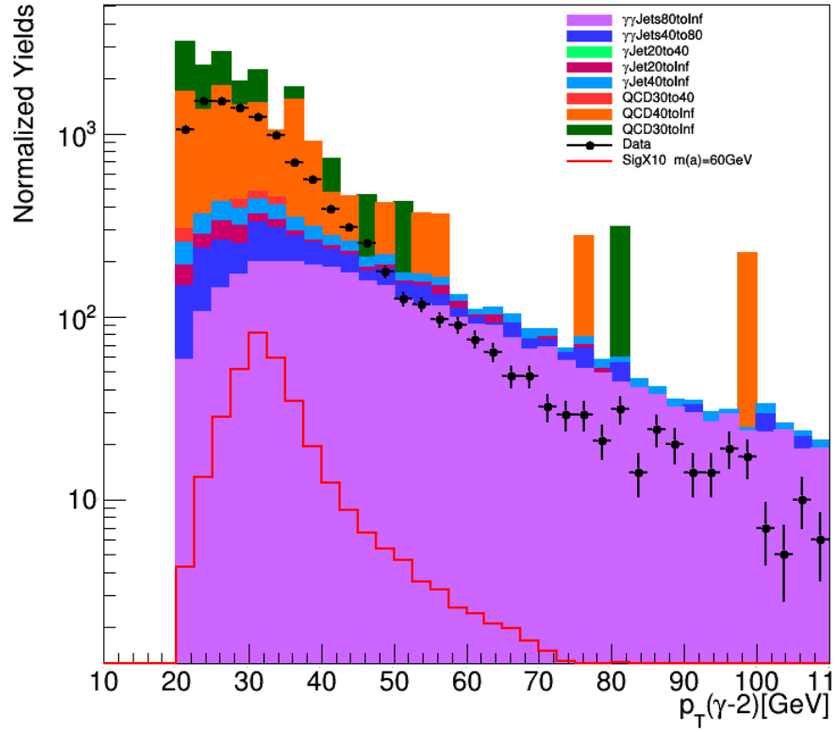

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
MVA (γ-2)

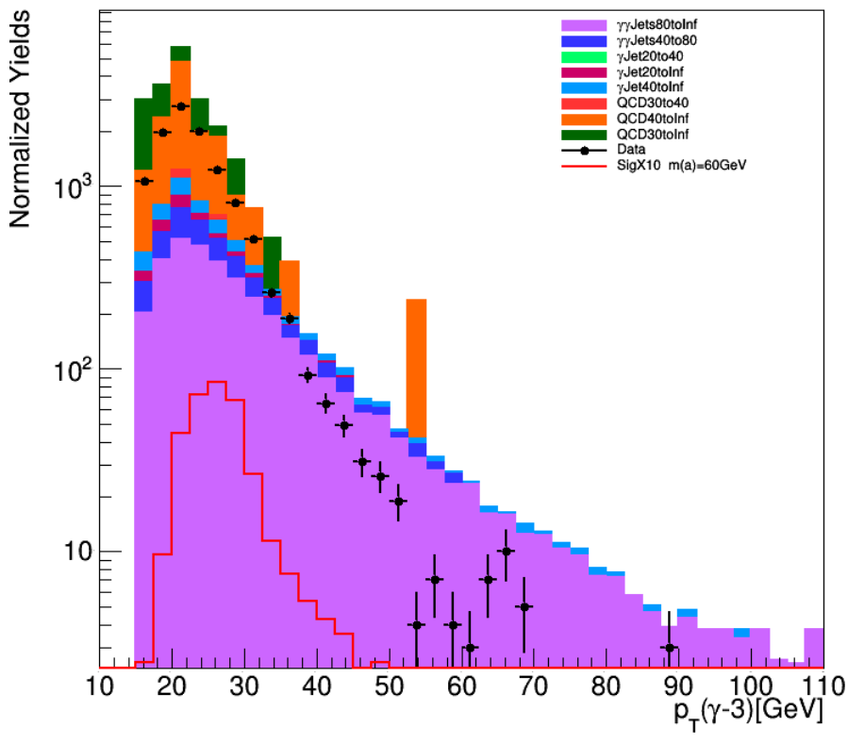

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
MVA (γ-3)

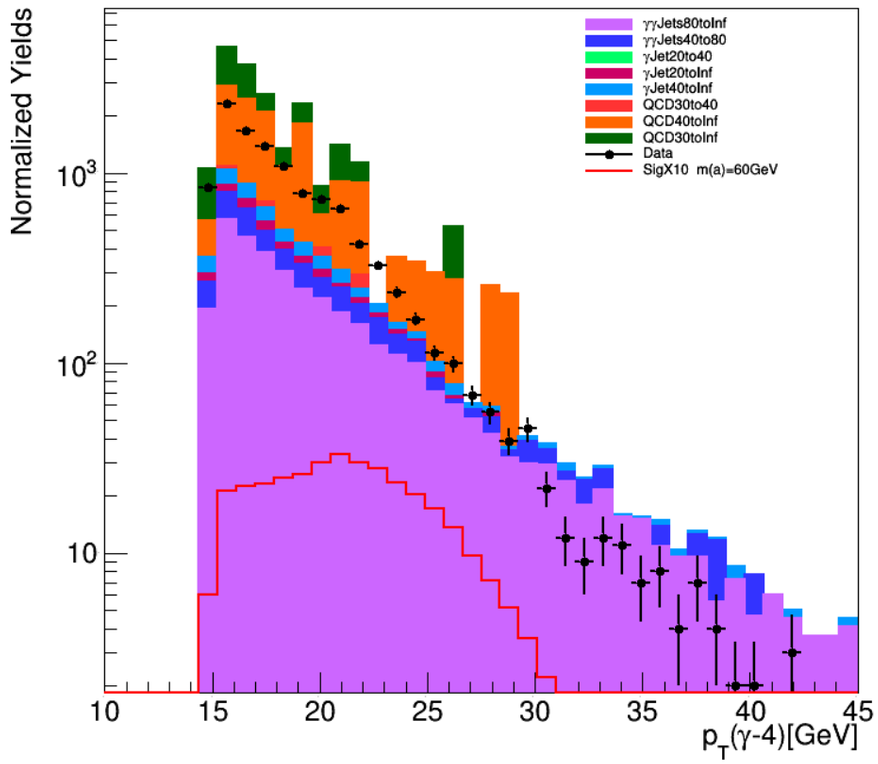

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
MVA (γ-4)

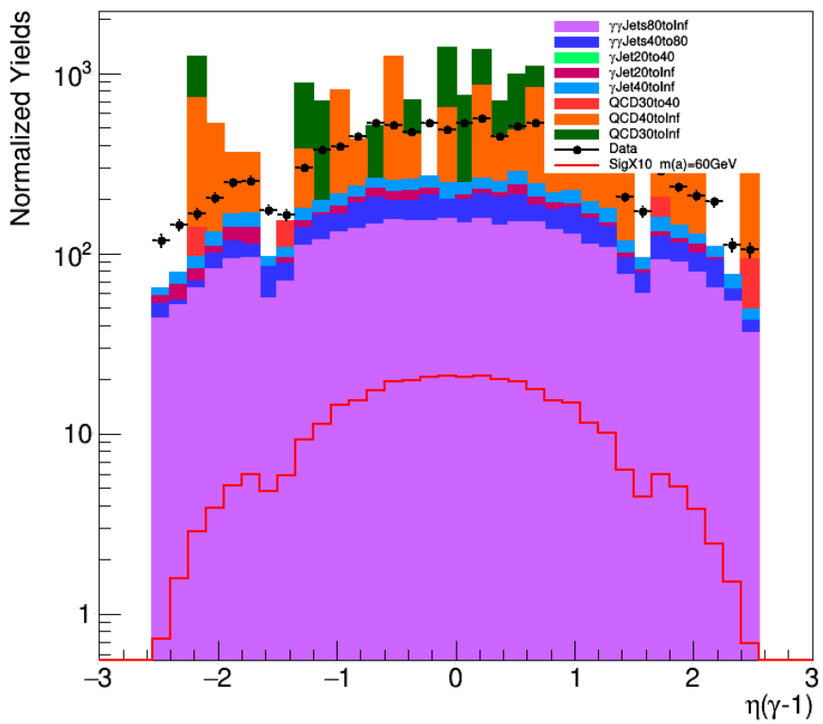
KINEMATIC DISTRIBUTIONS

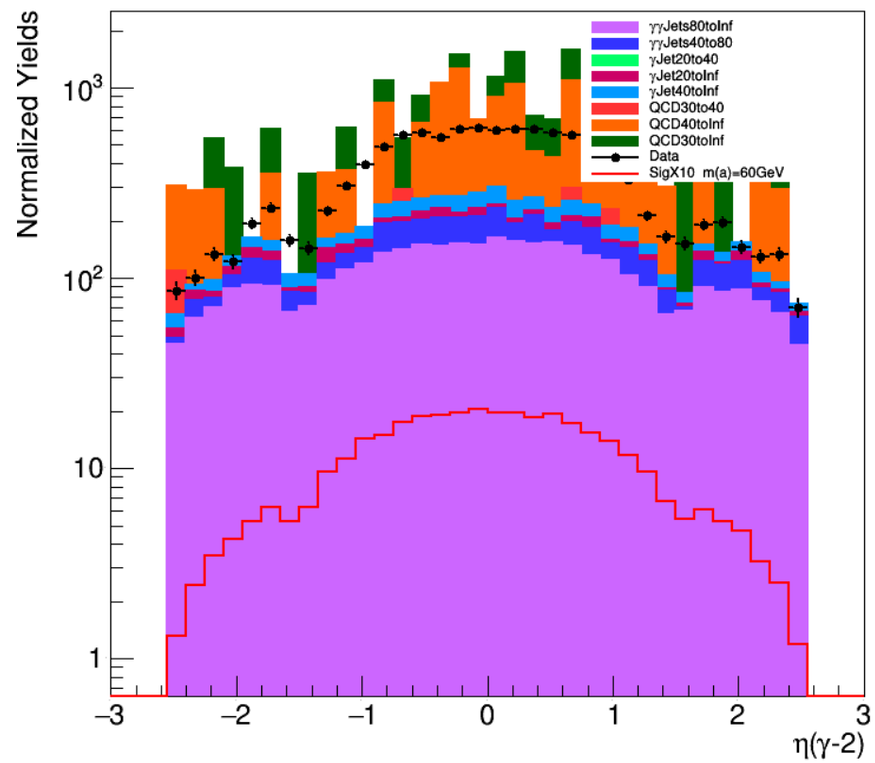


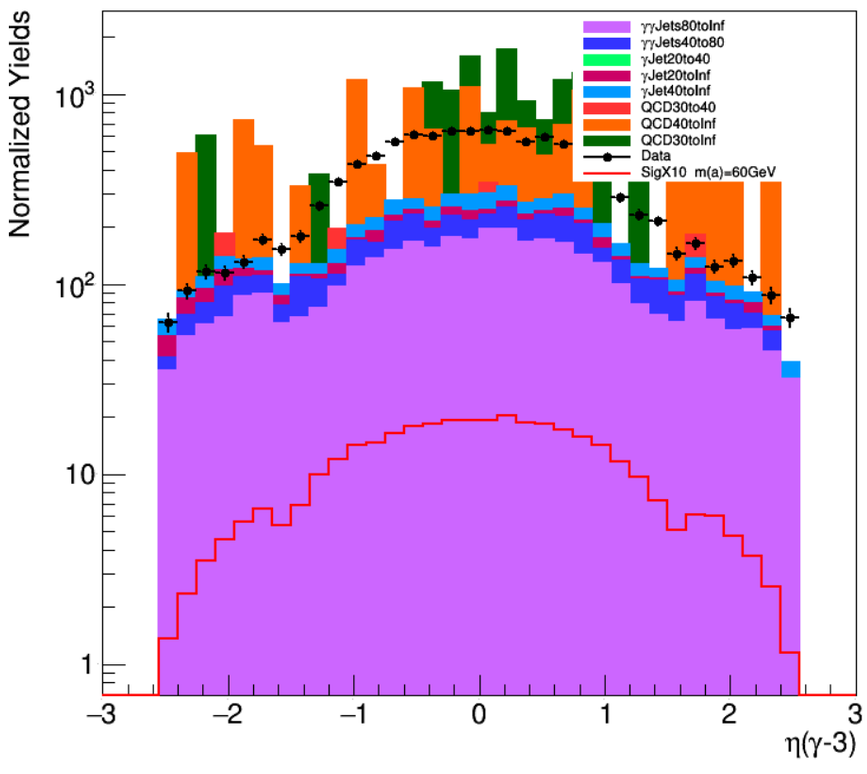


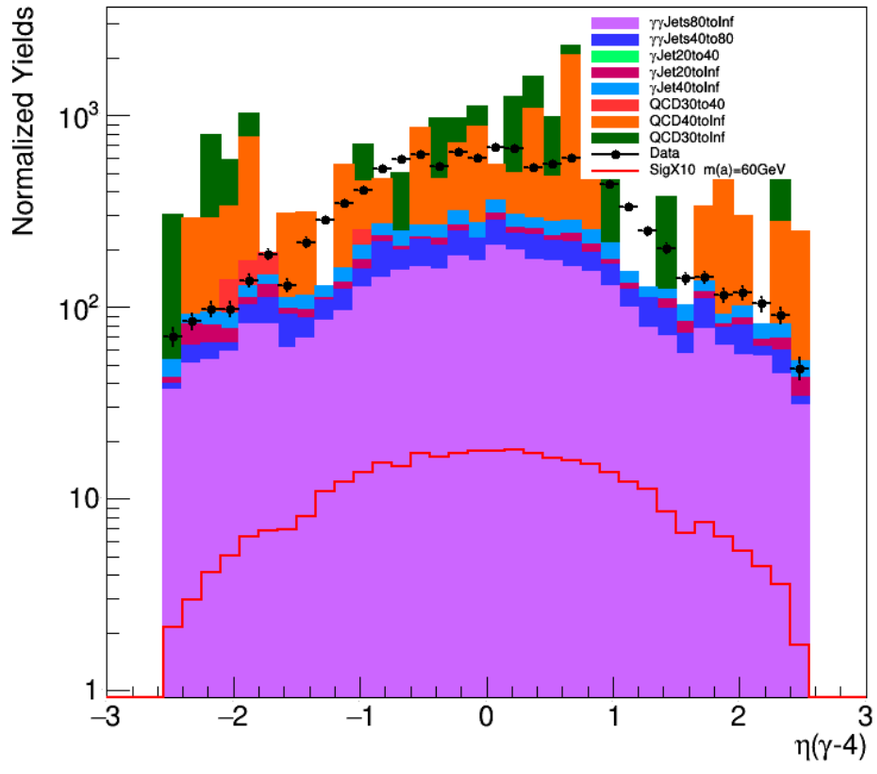




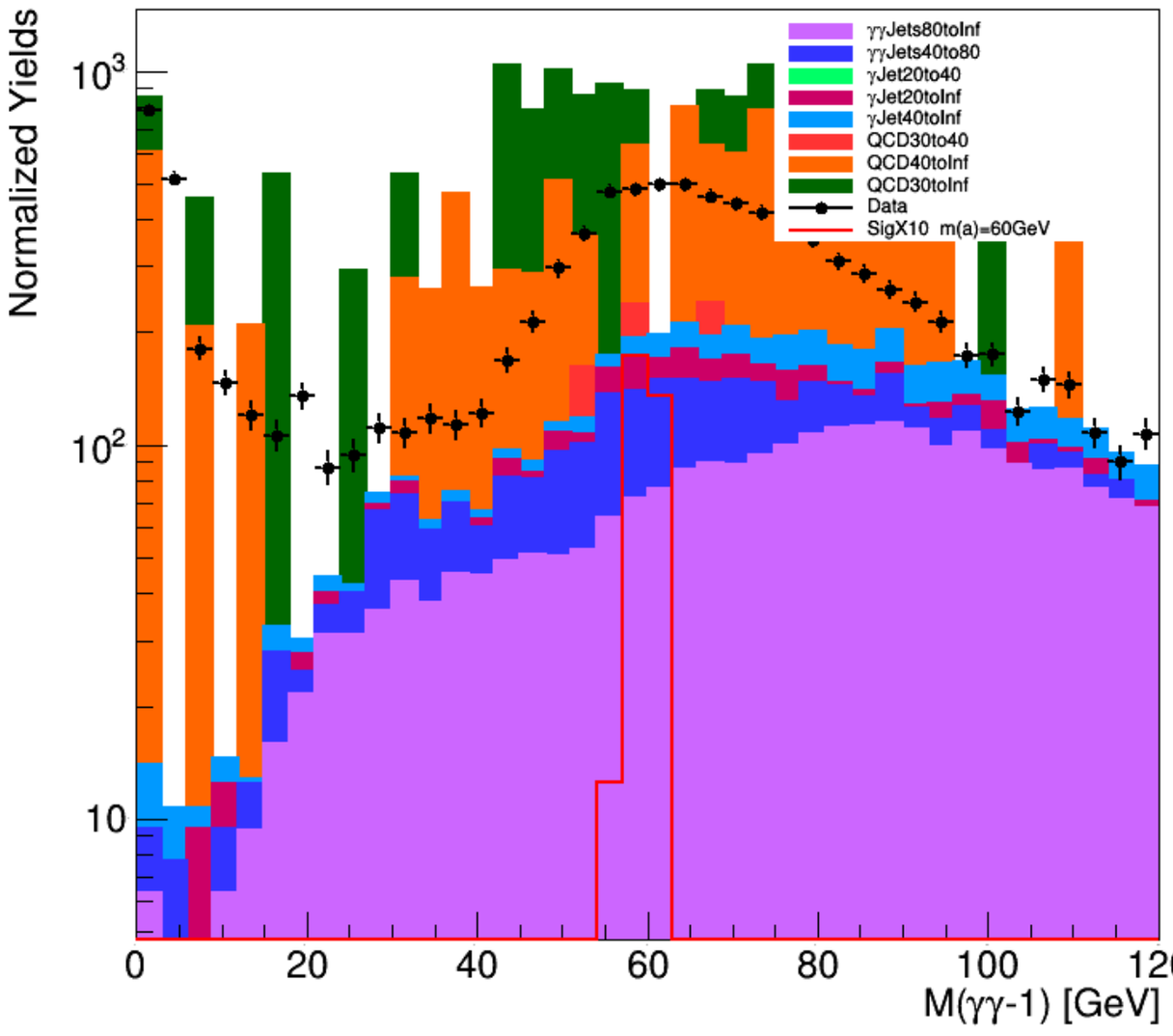

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
η(γ-1)

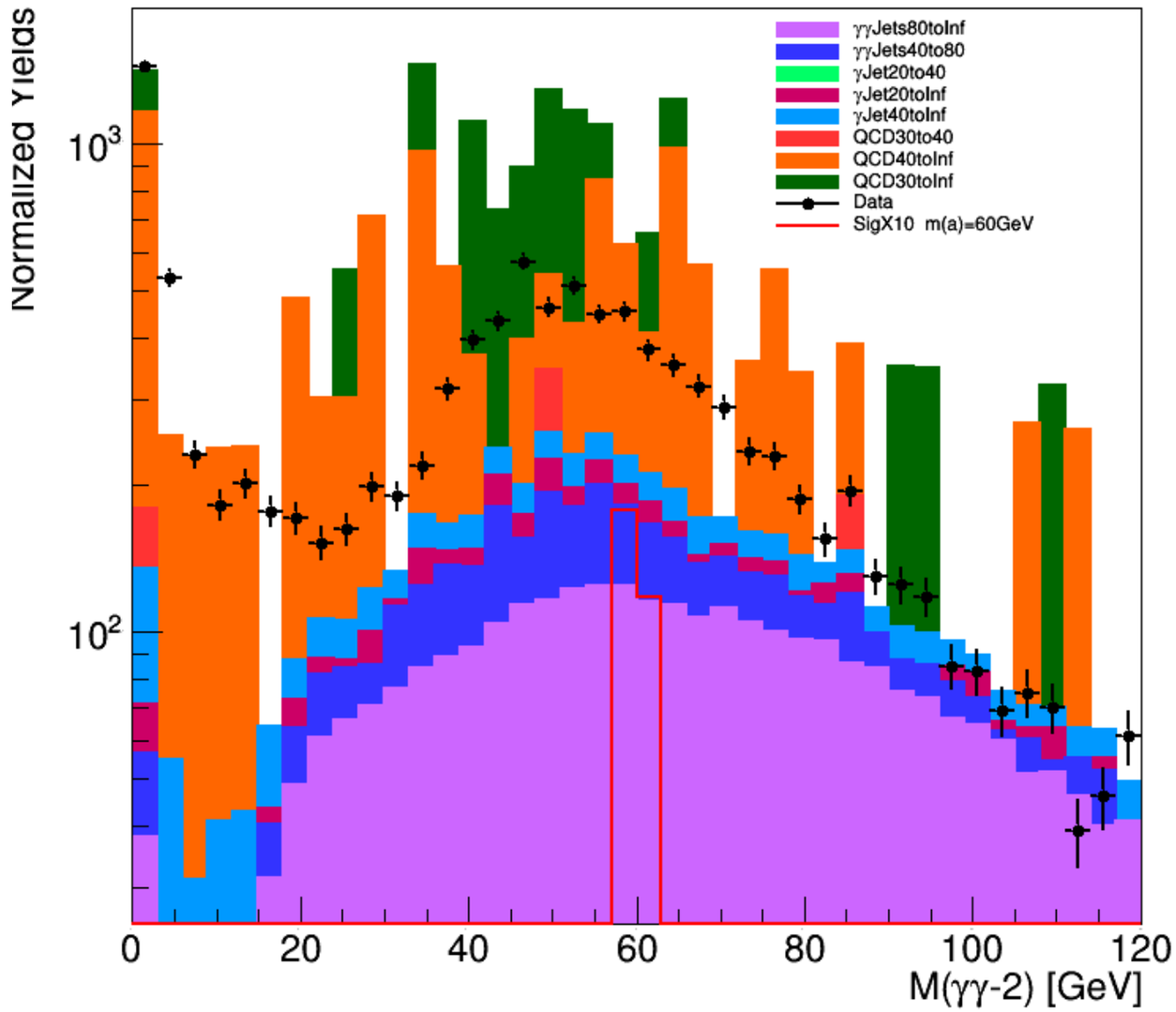

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
η(γ-2)


Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
η(γ-3)

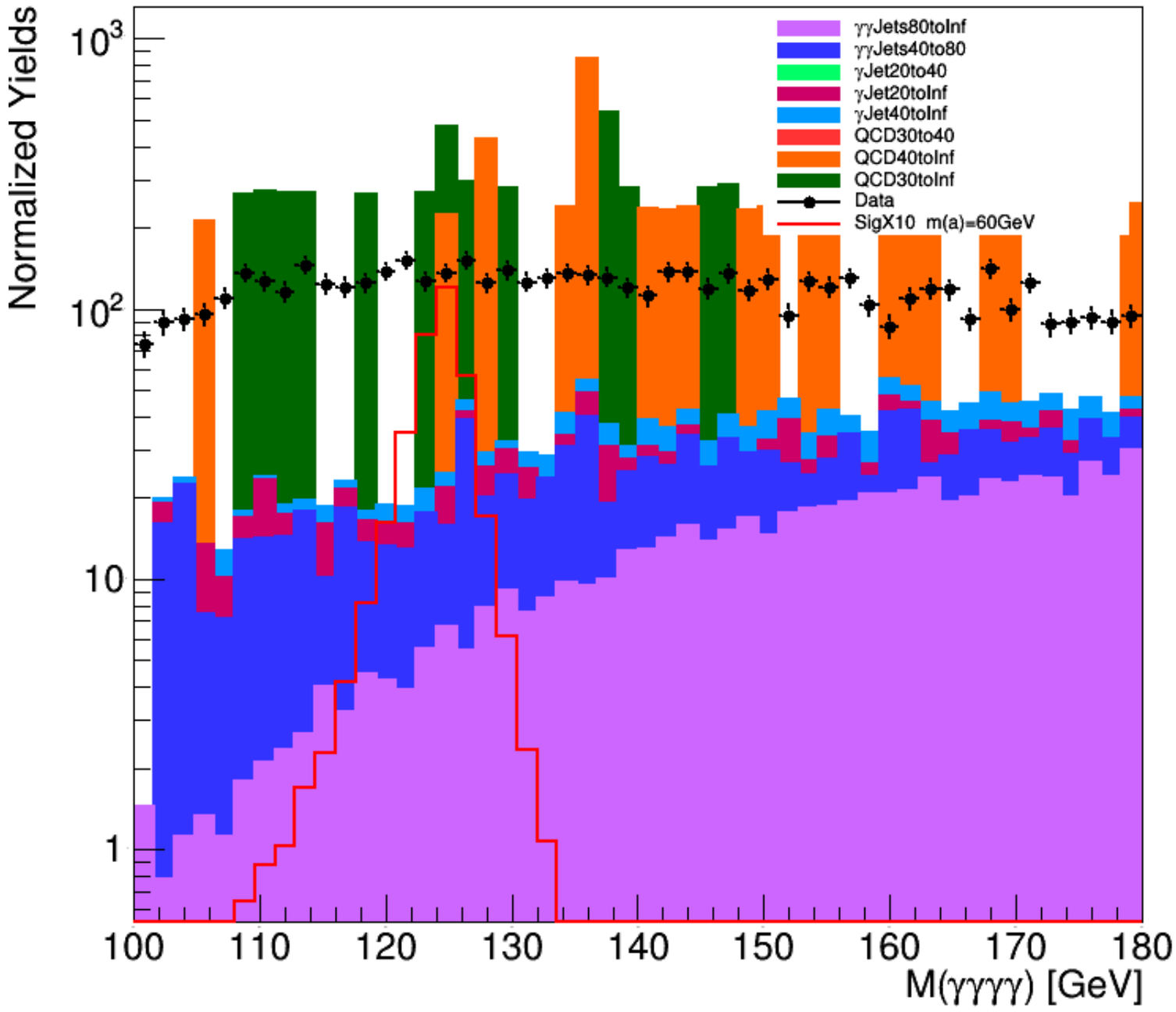

Normalized Yields
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
SigX10 m(a)=60GeV
η(γ-4)

DIPHOTON MASS

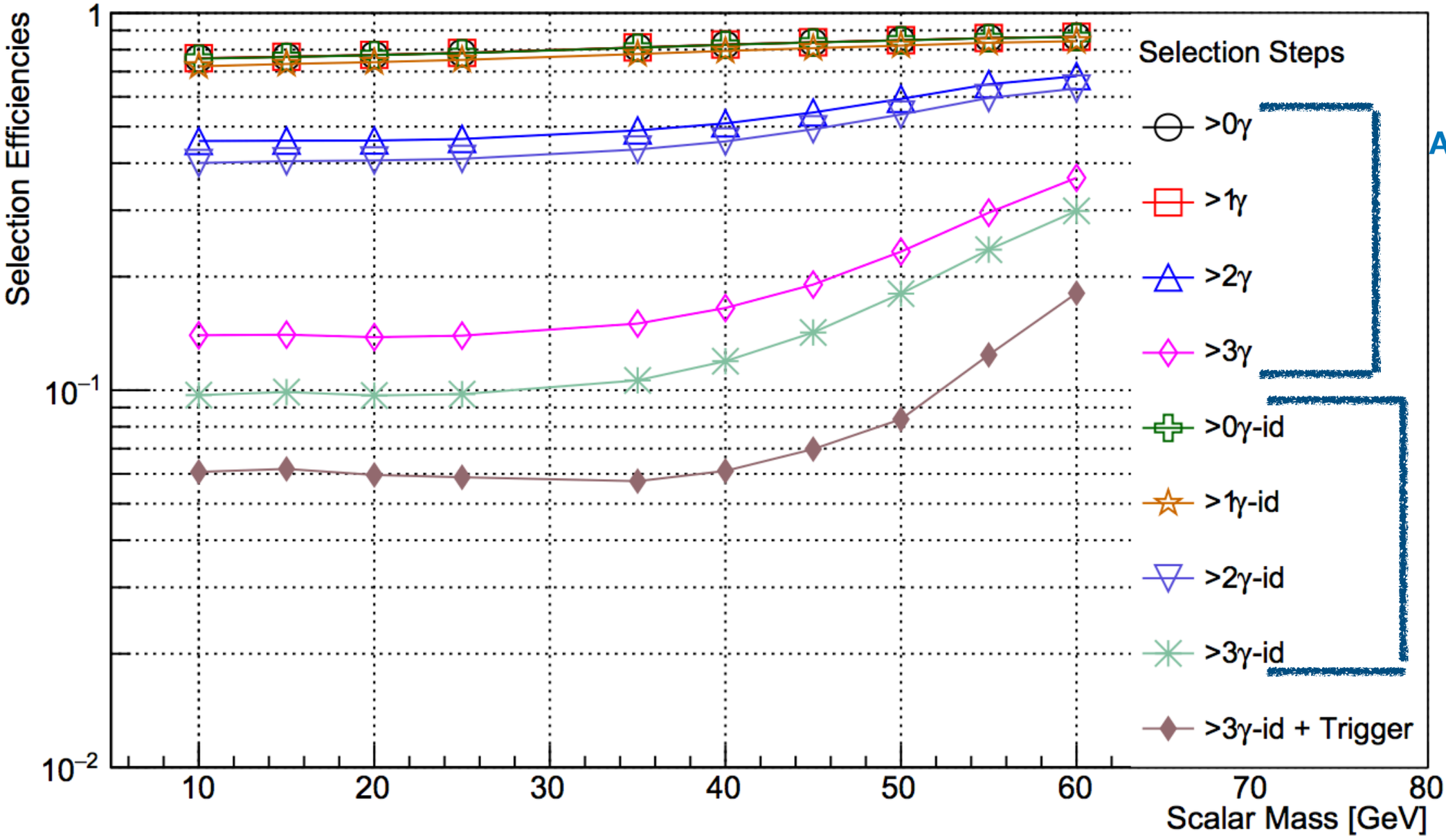




TETRAPHOTON MASS



SIGNAL EFFICIENCIES



At least N γ's with Et > 15 GeV and |η| < 2.5

Good γ's

Good γ's + Photon MVA requirement

ID'ed 4γ's + Trigger

TO - DO LIST

- Closure tests for Signal Efficiency
  - Gen - Reco matching for Photons
  - Plot efficiency of Gen matching as a function of m(a)

- Photon ID improvement
  - Can try to develop different cuts for different photons

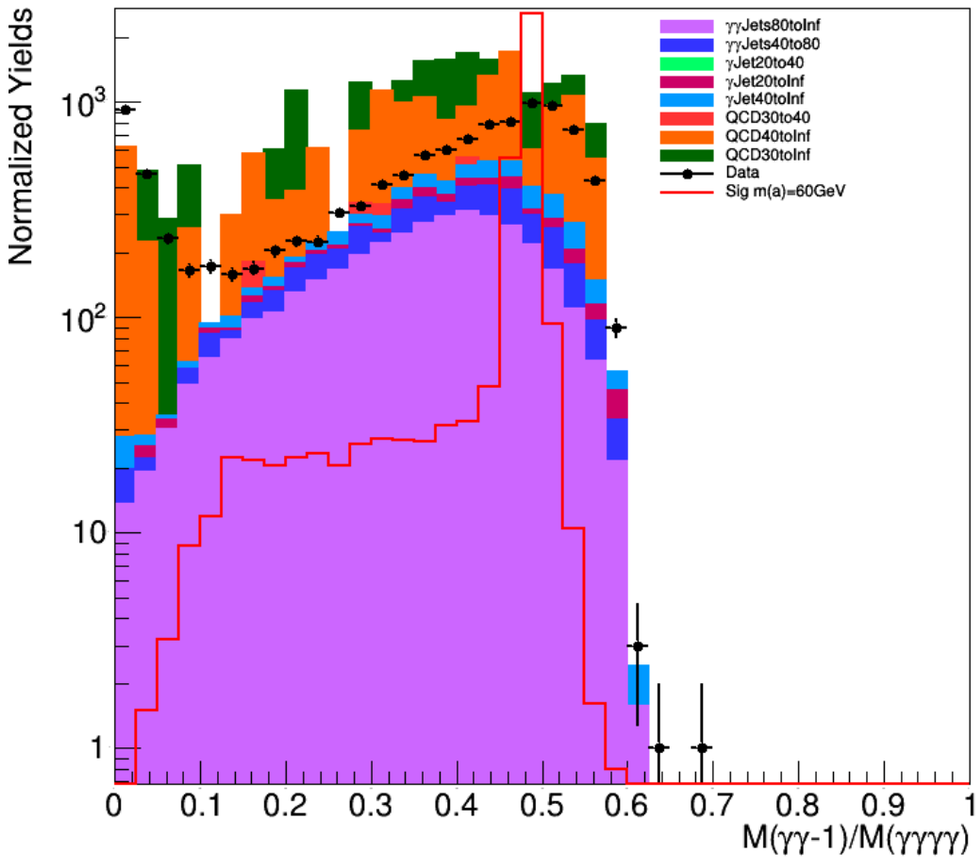
- Develop a separate 3γ category

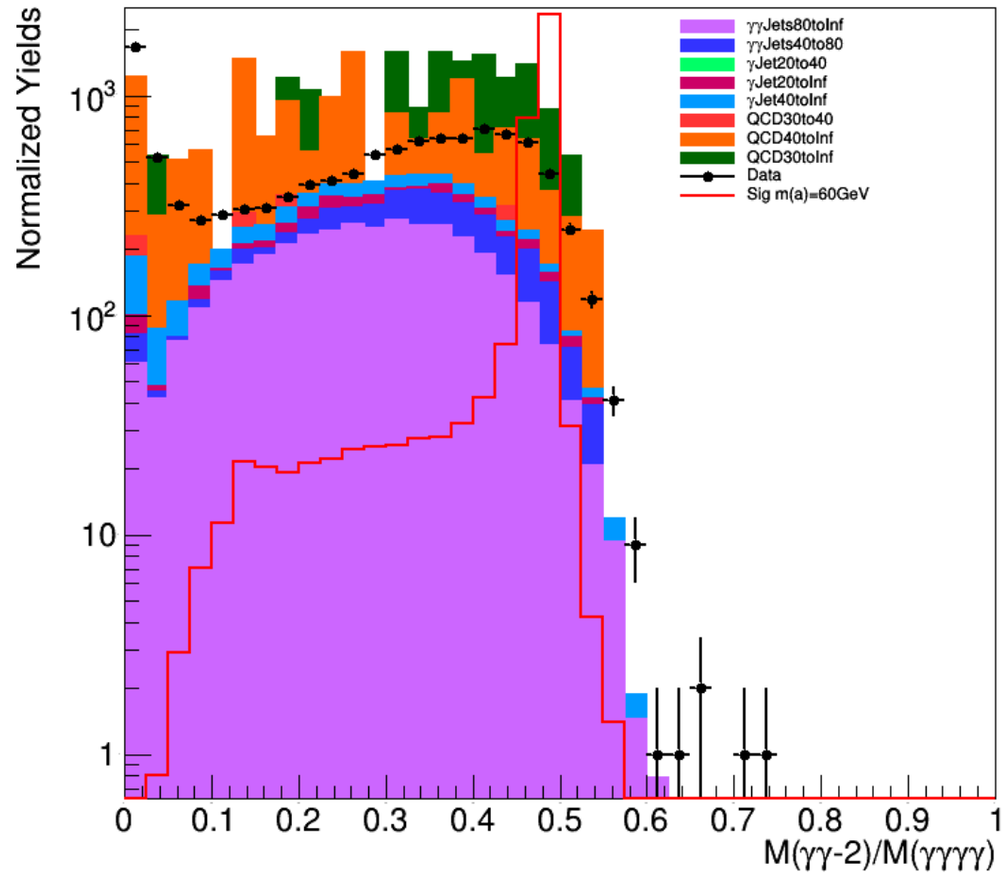
- Perform Signal and Background fits

SUMMARY

- **Analysis is being built upon expertise of similar analyses**
- **Converge the analysis with 2016 data and start looking at 2017 data**

BACK UP


Normalized Yields
10^3
10^2
10
1
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
Sig m(a)=60GeV
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
M(γγ-1)/M(γγγγ)


Normalized Yields
10^3
10^2
10
1
γγJets80toInf
γγJets40to80
γJet20to40
γJet20toInf
γJet40toInf
QCD30to40
QCD40toInf
QCD30toInf
Data
Sig m(a)=60GeV
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
M(γγ-2)/M(γγγγ)