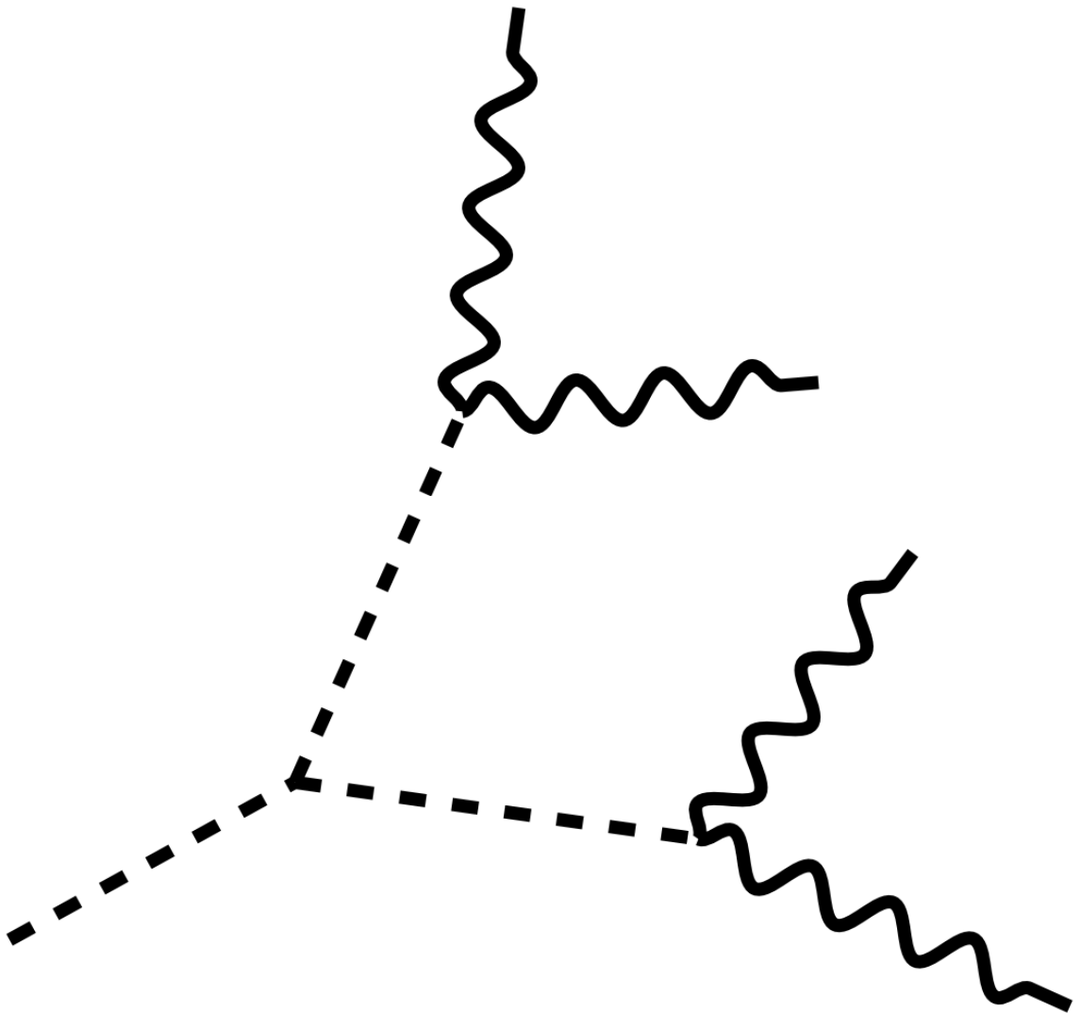


h(125)→aa→γγγγ

TOYOKO ORIMOTO
ANDREA MASSIRONI
TANVI WAMORKAR

30th October 2017
HGG Meeting

4γ IN A NUTSHELL

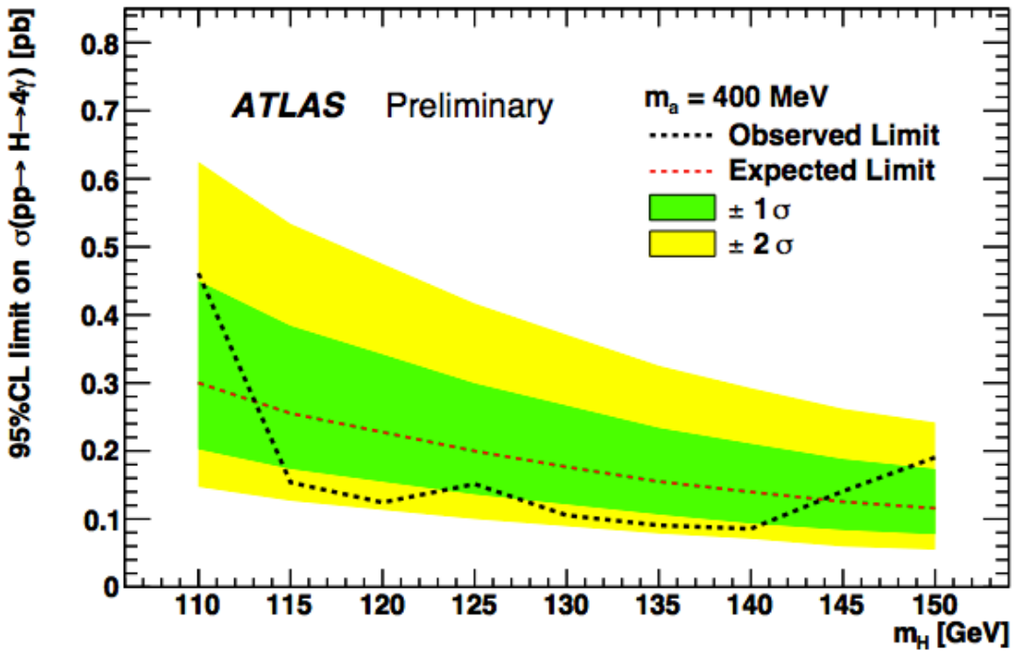
h(125)→aa→γγγγ

The possibility of light scalars is a very well established scenario

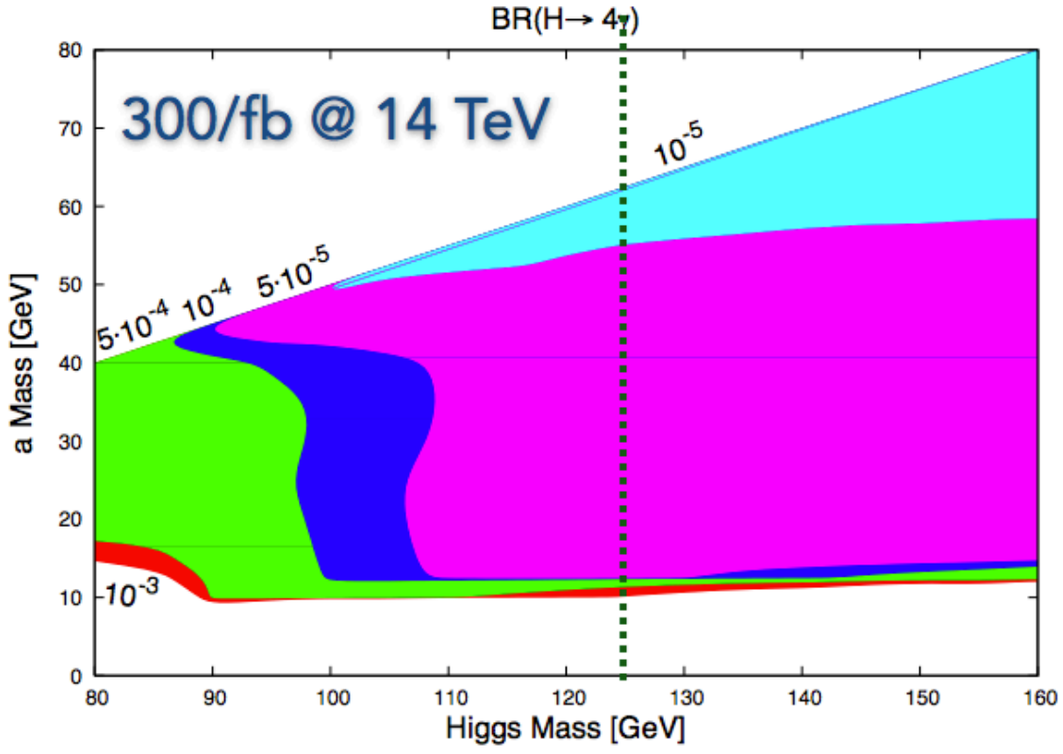
- **The usual suspects (N)MSSM, SM +Singlet ,etc have a subdominant BR (a -> γγ)**
  - Non trivial extensions can suppress a -> fermions
  - The 4γ final state is SM background free and we take advantage of the high online/offline reconstruction + identification efficiency

- The existing studies show sensitivity for discovery down to Br(h(125)→aa→γγγγ) ~ 10^{-5} for 300/fb@14TeV [hep-ph/0608310]

- 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]



(c) $m_a = 400$ MeV



SAMPLES BEING USED

DATA:

- Double EG re-Mini AOD dataset
- Corresponds to 35.87 fb^{-1} for 2016

Signal MC:

- Generated using PYTHIA 8
- Officially produced Summer16 samples - DAS Link
- m(a) = 0.1 GeV and 1GeV - 60 GeV in steps of 5 GeV

Background:

- **DiPhotons + Jets**

DiPhotonJetsBox_M40_80-Sherpa
DiPhotonJetsBox_MGG-80toInf_13TeV-Sherpa

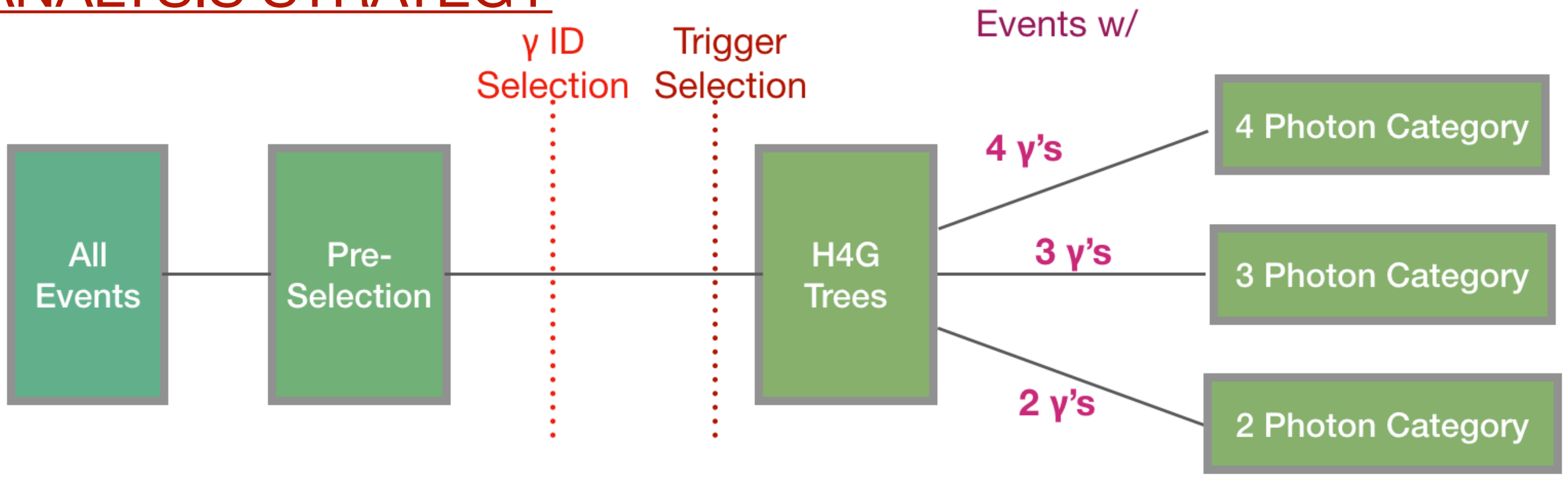
- **Photons + Jets**

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

ANALYSIS STRATEGY



- Pre-Selection : At least 4γ with E_T > 15 GeV and |η| < 2.5 - **Good γ's**

- γ-ID Selection : At least 4 good γ's that pass the Hgg MVA ID requirement
  - photonIDMVA > -0.9 for both EB and EE : eliminates a significant fraction of non prompt photons + conserves ~99% efficiency for prompt photons

- Signal extraction to be done by means of Parametric fit to the M(4γ) distribution

TRIGGER

- Online selection is identical to the Low mass h→ɣɣ search

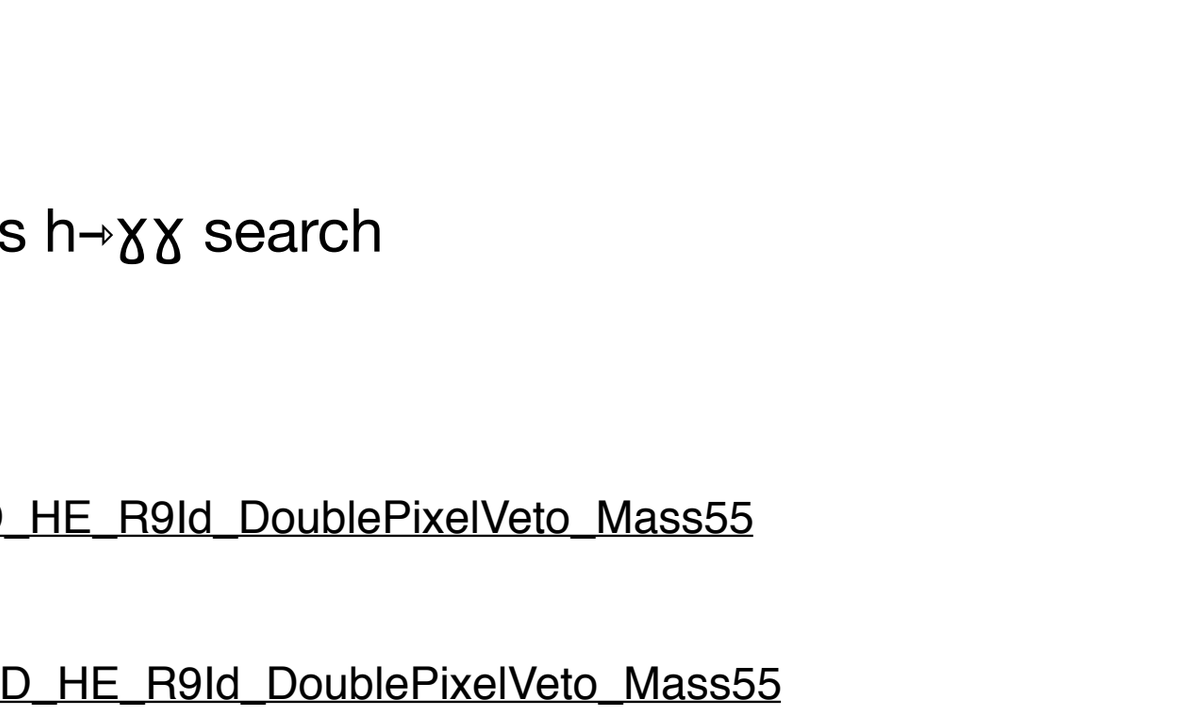
- Trigger Paths:

  - HLT_Diphoton30EB_18EB_R9Id_OR_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55
    - Fired by γ's only reconstructed in the Barrel

  - HLT_Diphoton30PV_18PV_R9Id_AND_IsoCaloId_AND_HE_R9Id_DoublePixelVeto_Mass55
    - γ's reconstructed in the Barrel and Endcap

- 4 Photons in the final state - 6 Di Photon combinations

- At-least one of the combinations has M(γγ) > 55GeV

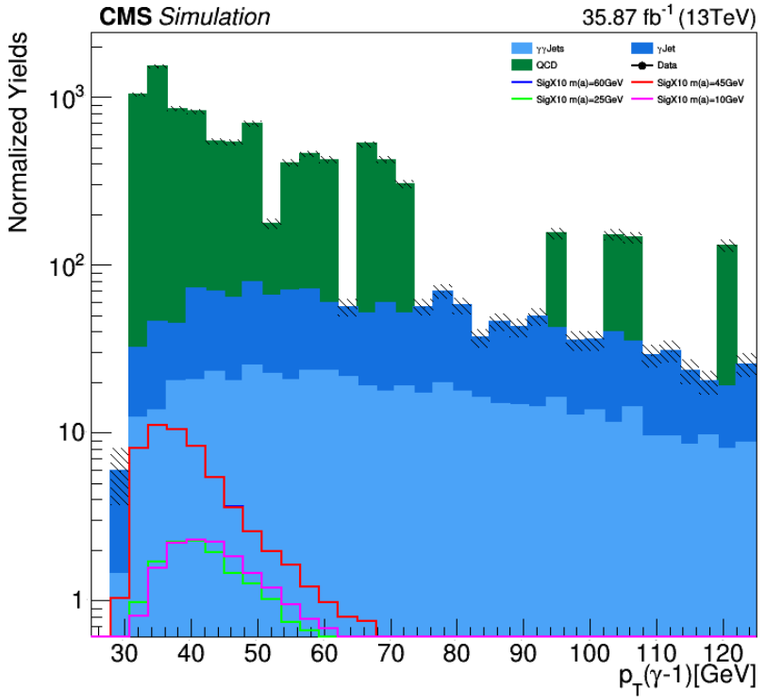


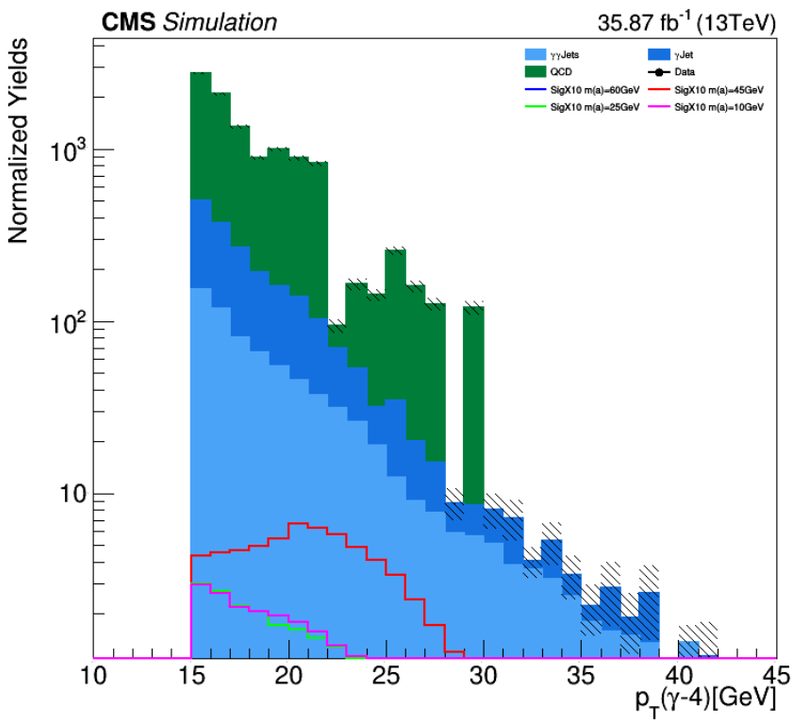
Trigger requirement of M(γγ) > 55GeV

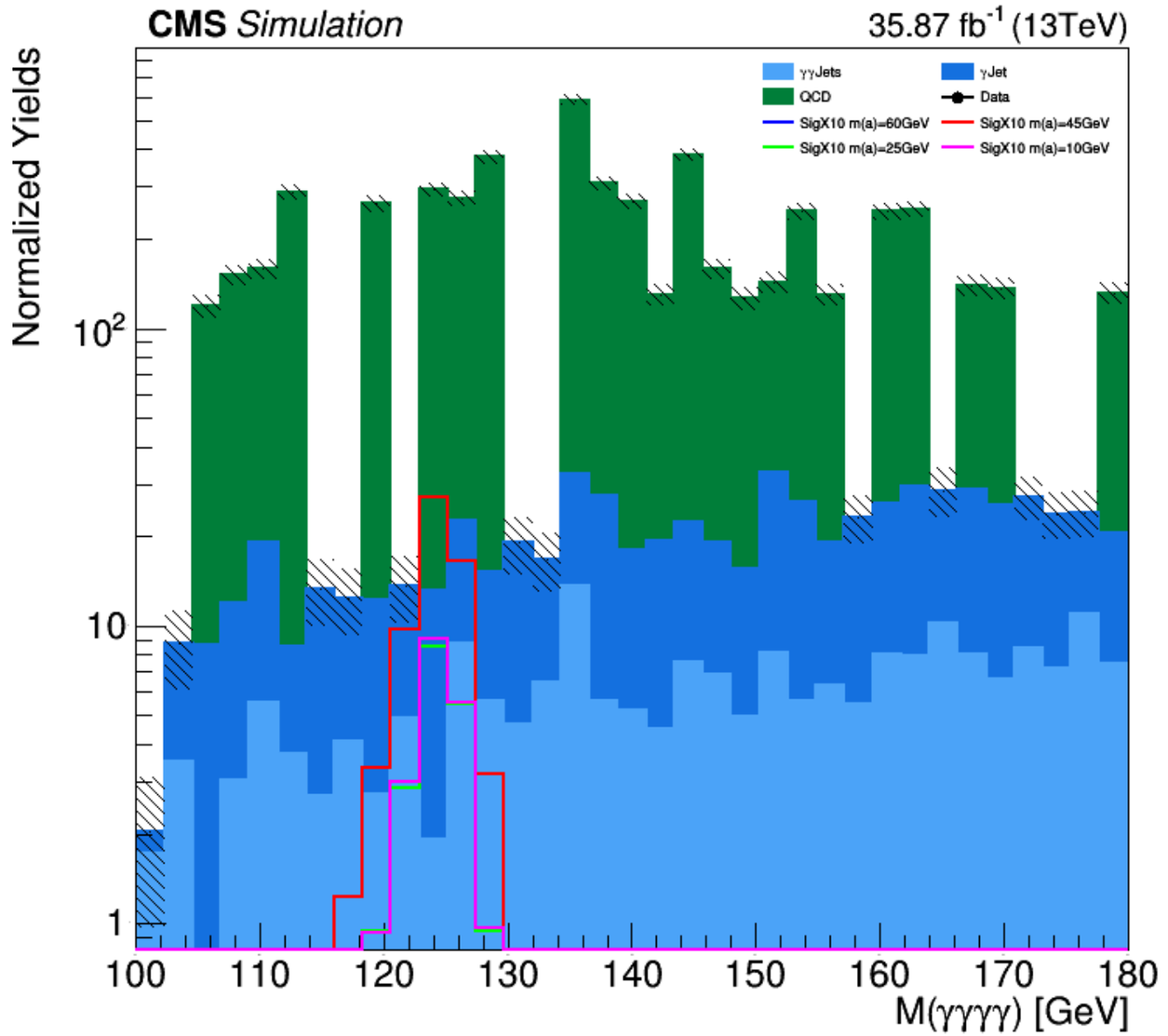
4 PHOTON CATEGORY

m(a) = 60GeV
45GeV
25GeV
10 GeV

- All 4 γ's are well isolated
- Plots showing Background and Signal MC comparison





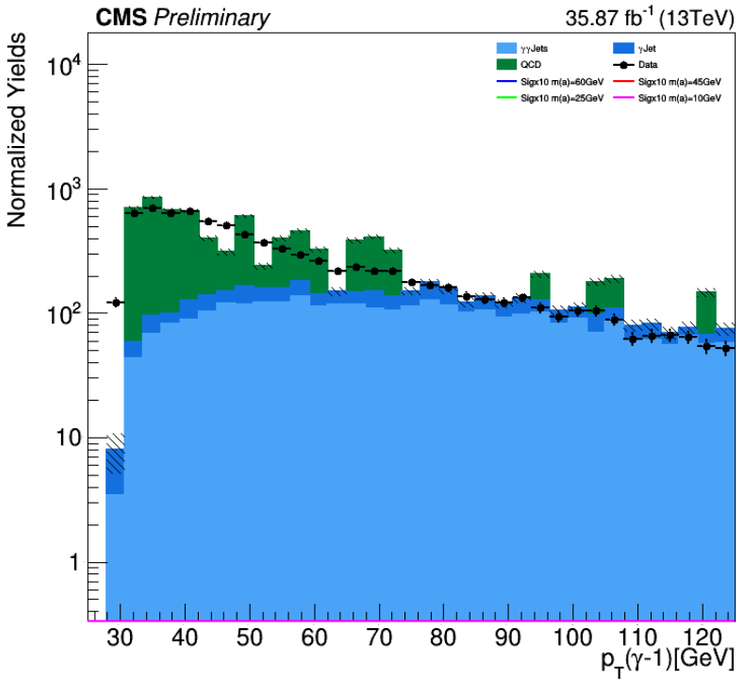


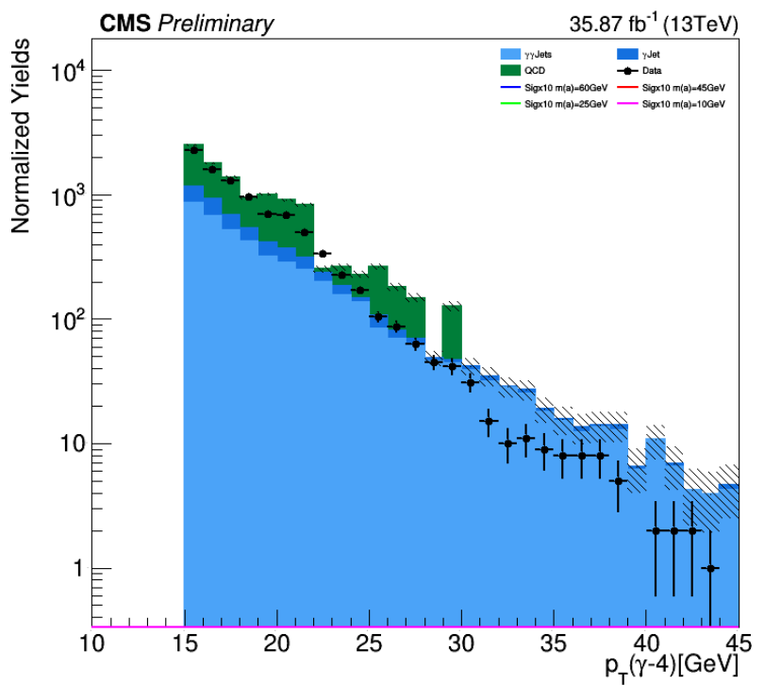
4 PHOTON CATEGORY (2)

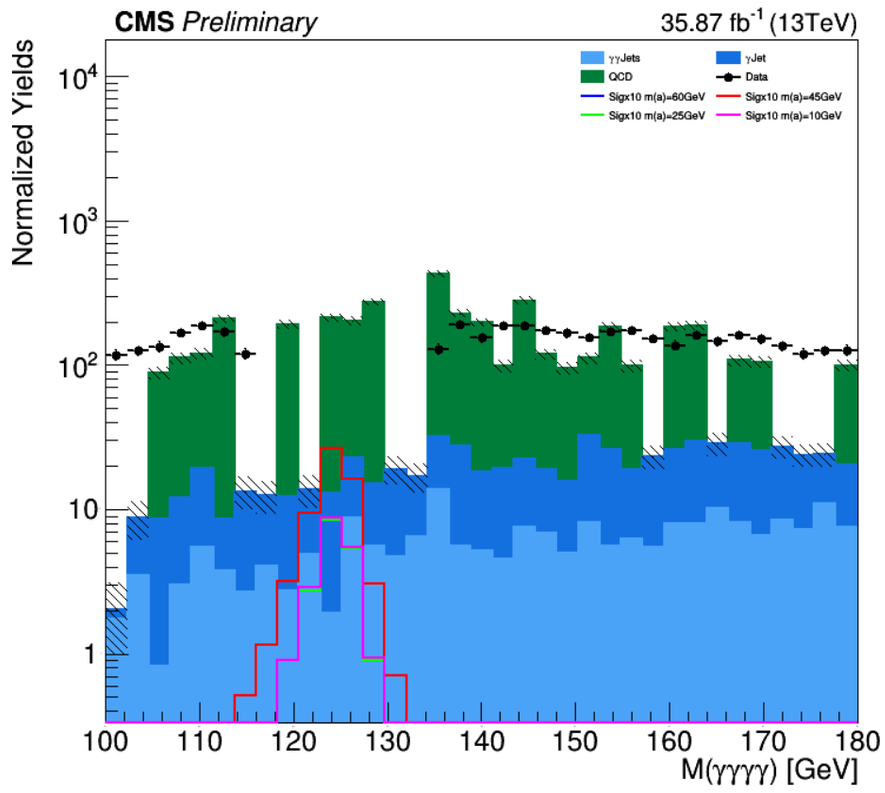
Blinding region: 115 < M(γγγγ) < 130 GeV

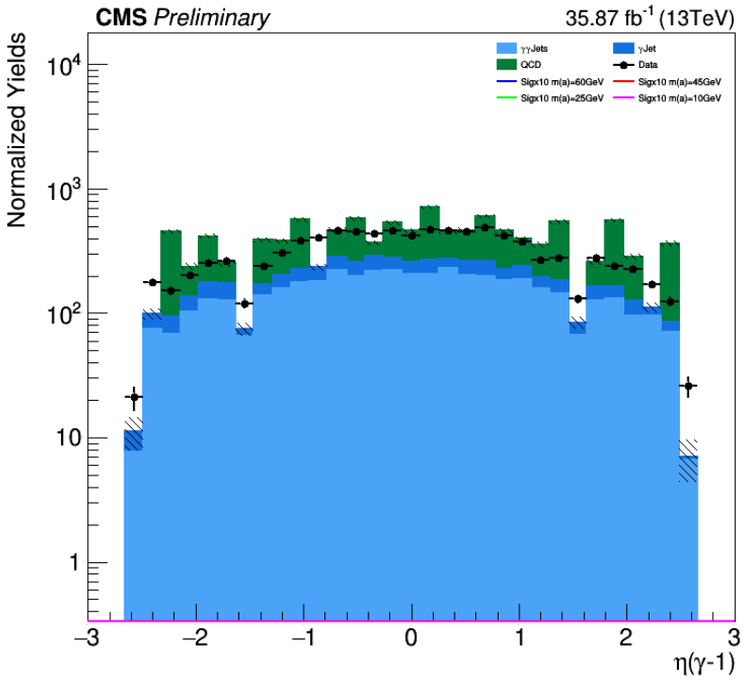
- Signal region plots

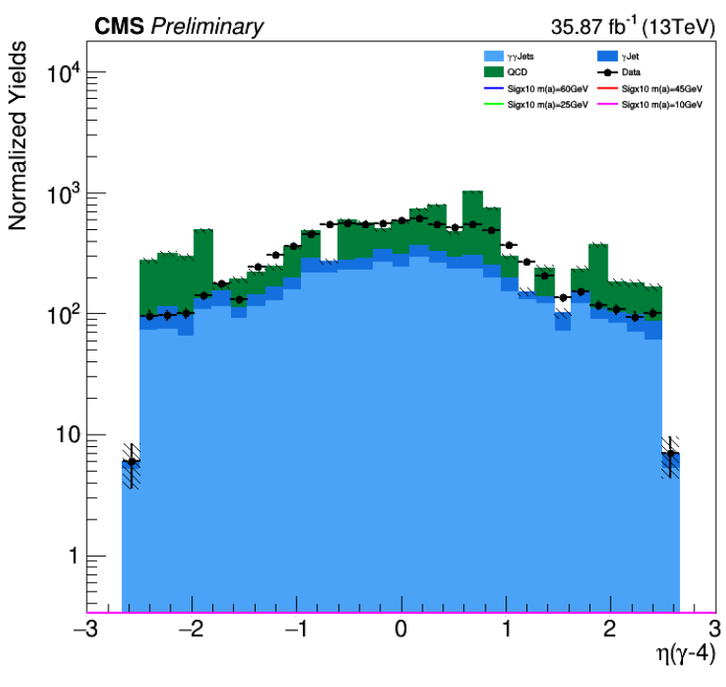
m(a) = 60GeV
45GeV
25GeV
10 GeV











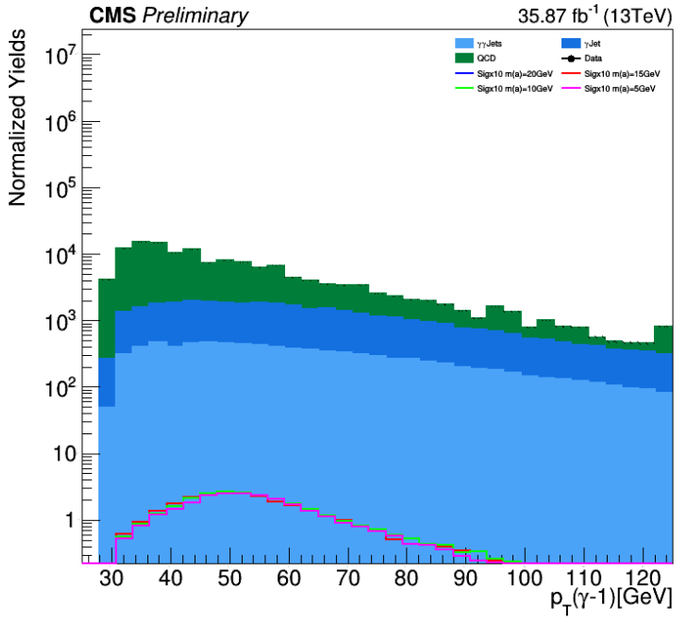
QCD contribution scaled to match Data

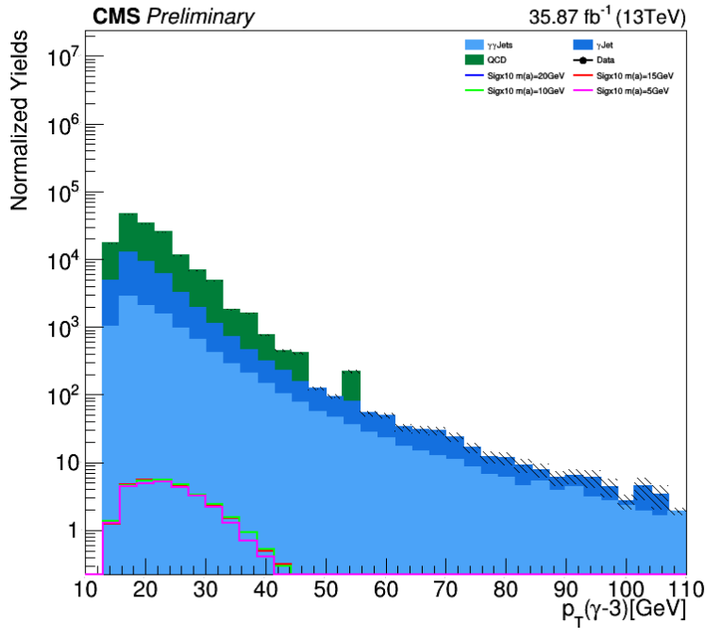
3 PHOTON CATEGORY

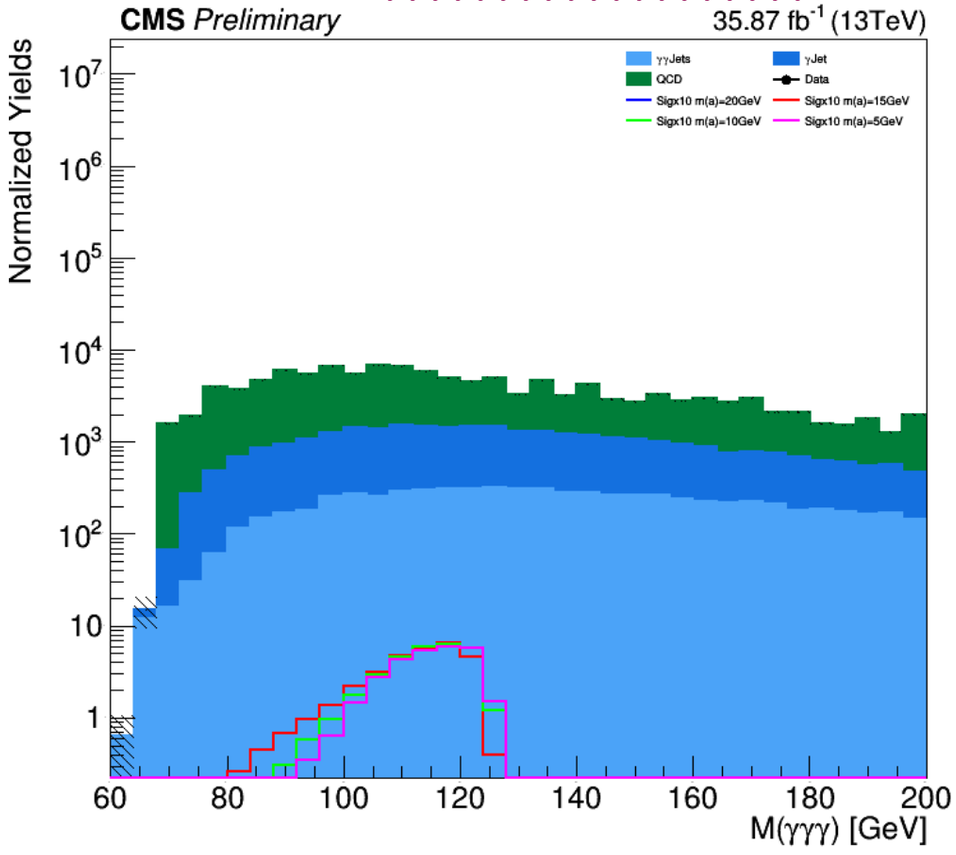
- Plots showing Background and Signal MC comparison

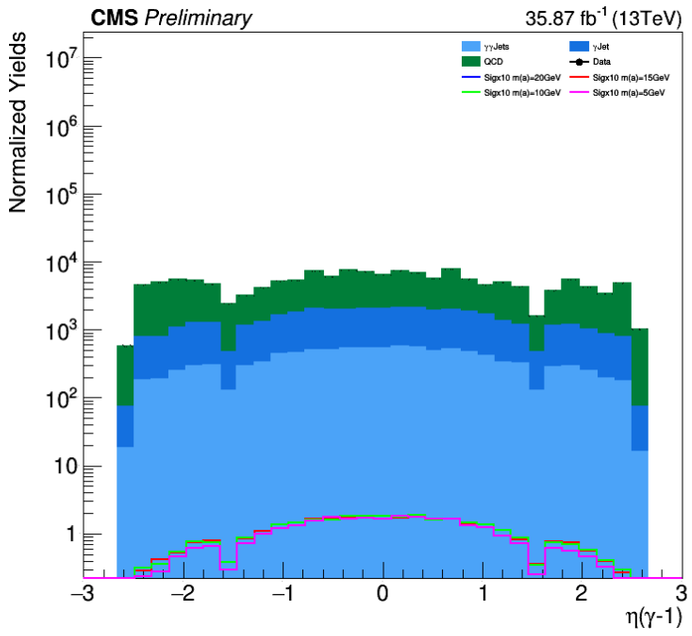
m(a) = 20,15,10,5 GeV

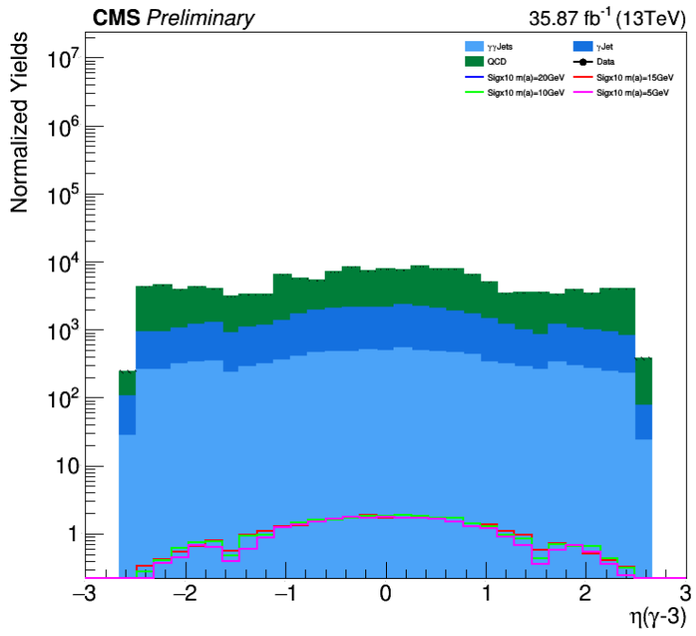
m(a) = 20GeV
15GeV
10GeV
5 GeV









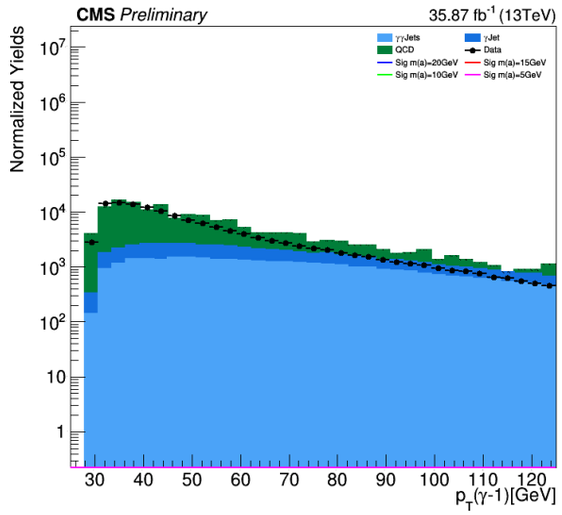


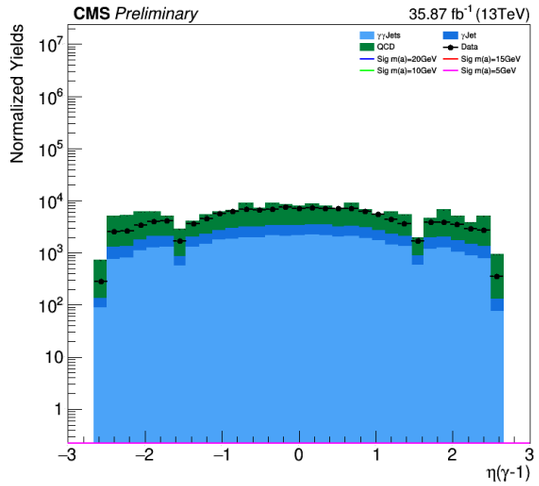
3 PHOTON CATEGORY (2)

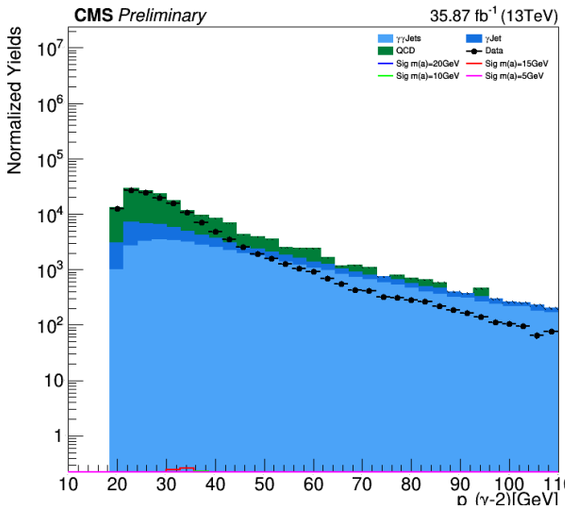
- Signal region plots

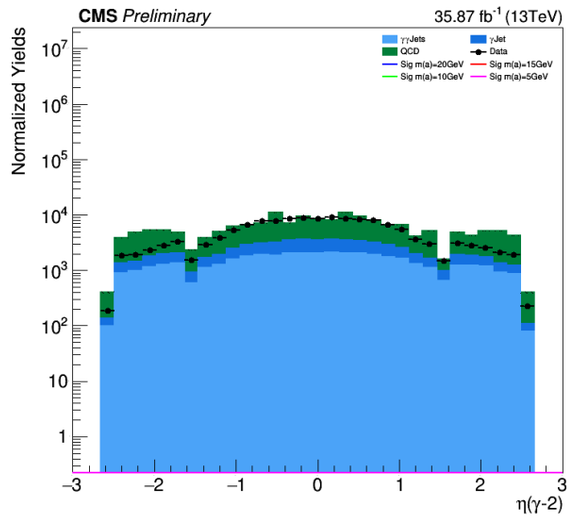
Blinding region: M(ɣɣɣ) < 130 GeV

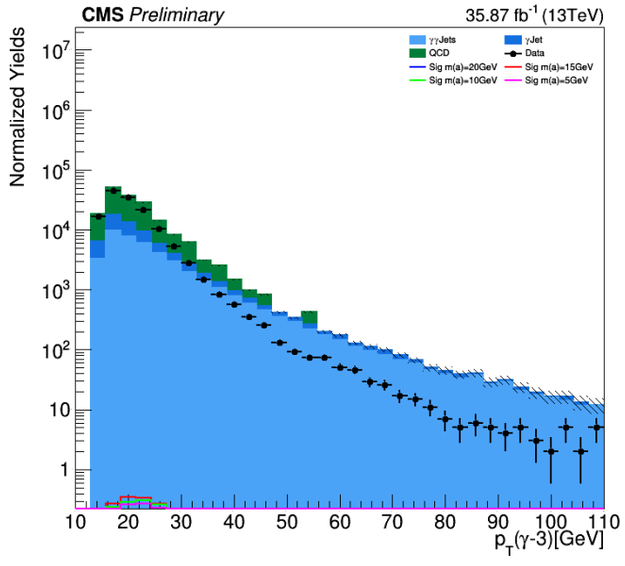
m(a) = 20GeV
15GeV
10GeV
5 GeV

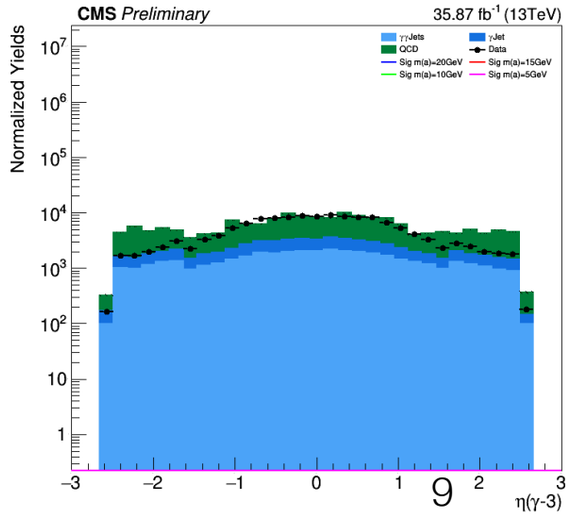


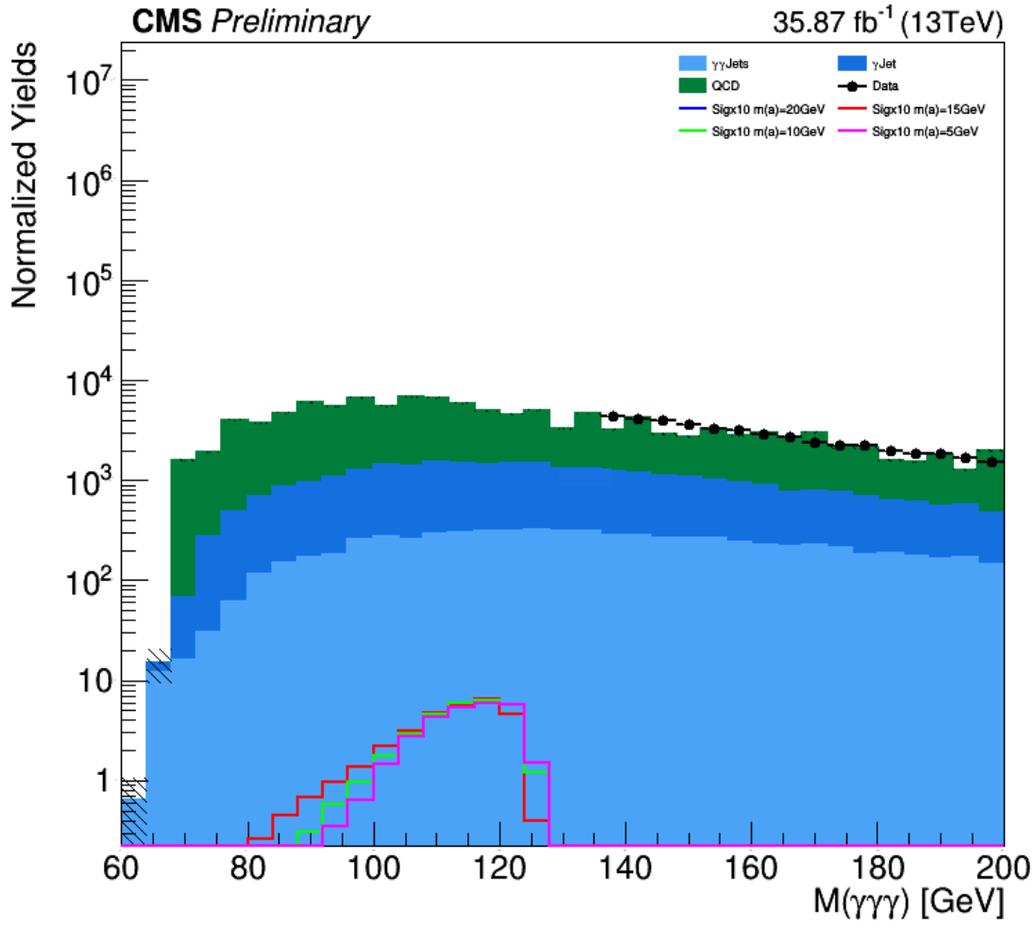










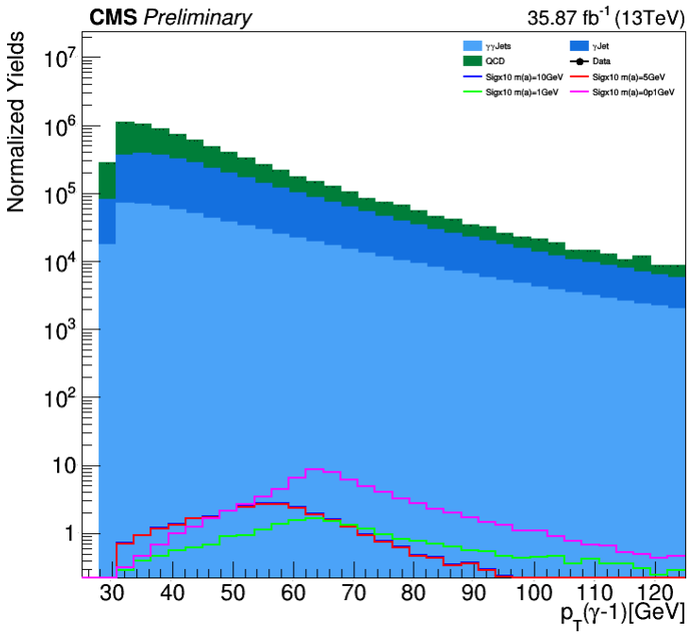


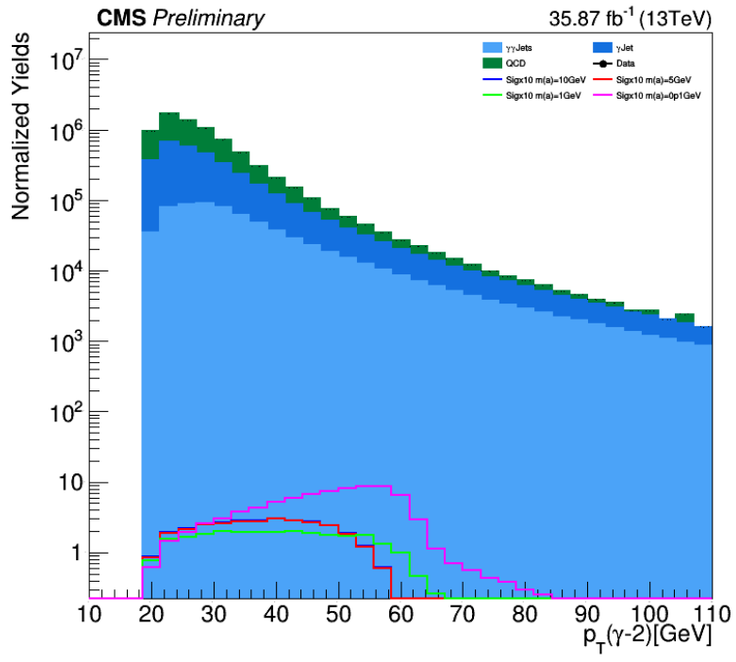
QCD contribution scaled to match Data

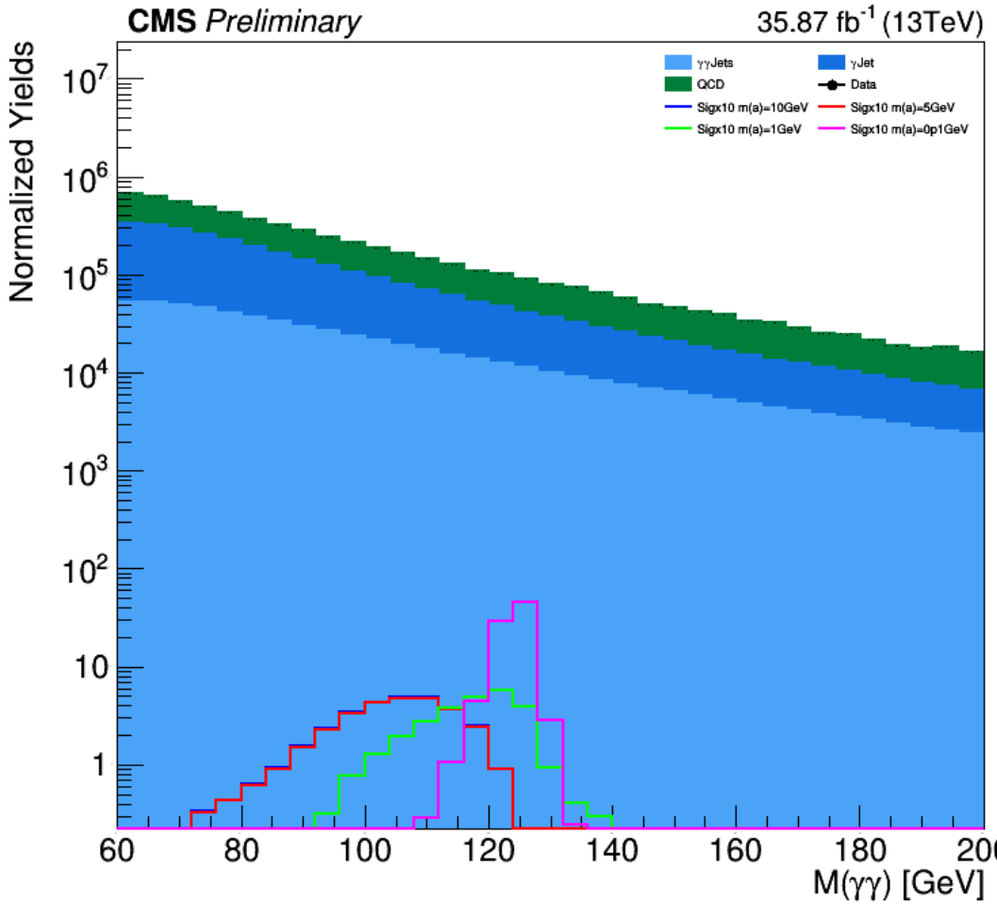
2 PHOTON CATEGORY

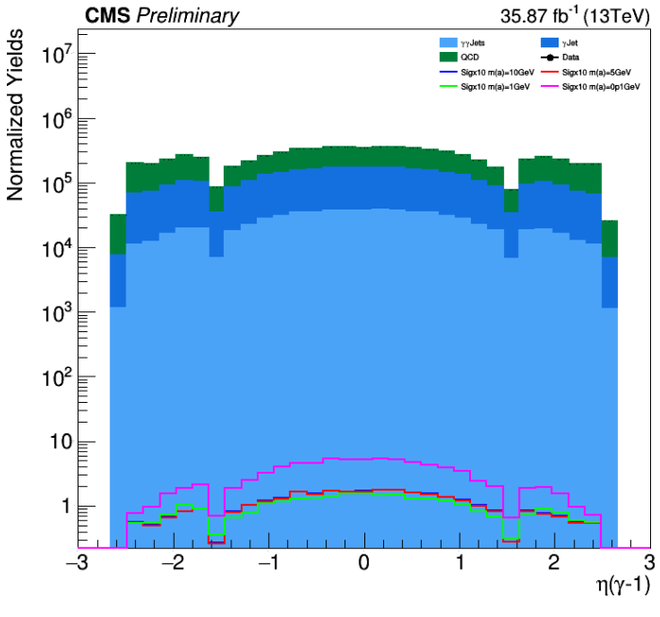
- Plots showing Background and Signal MC comparison

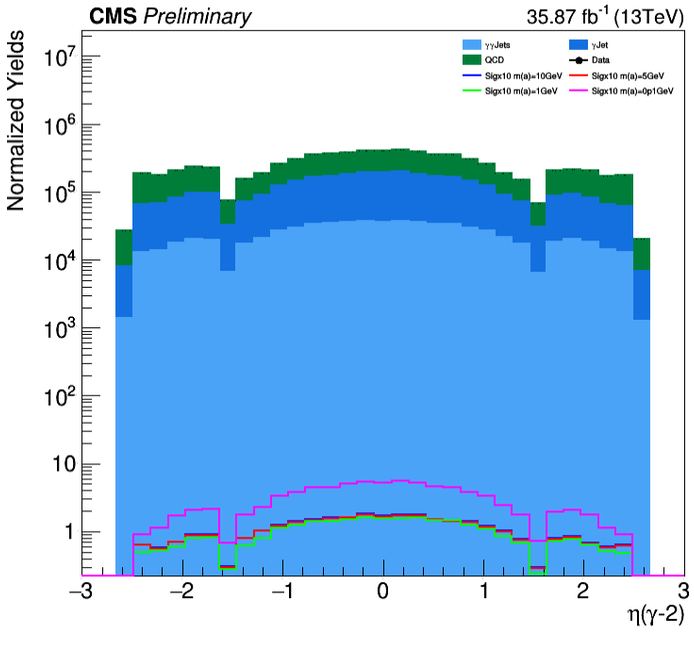
m(a) = 10 GeV
5 GeV
1 GeV
0.1 GeV









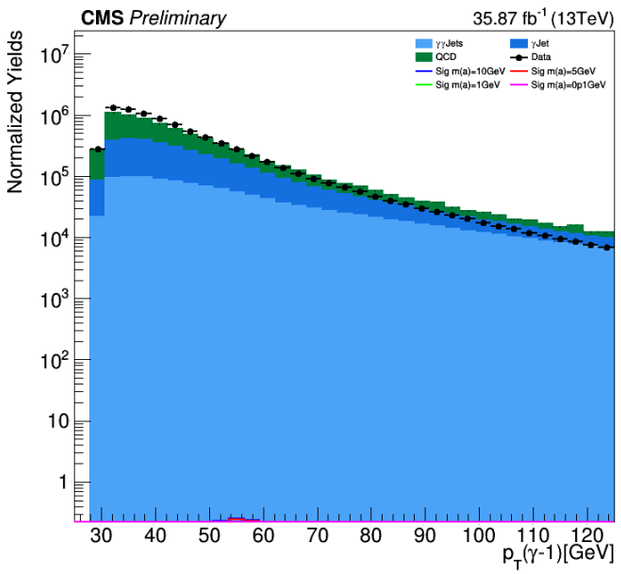


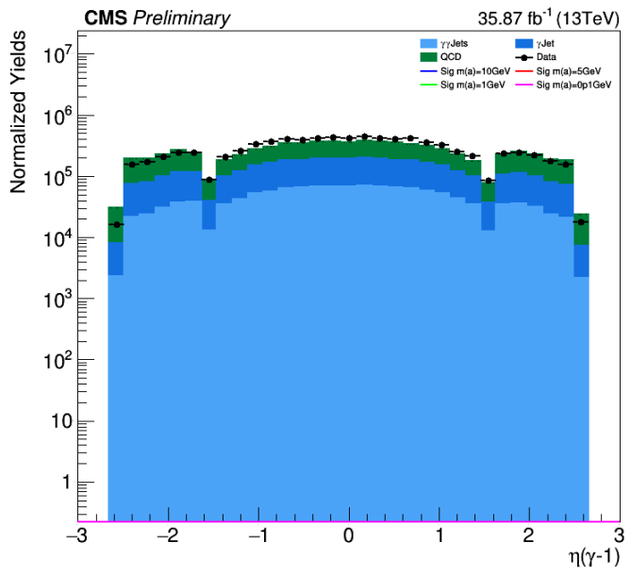
2 PHOTON CATEGORY (2)

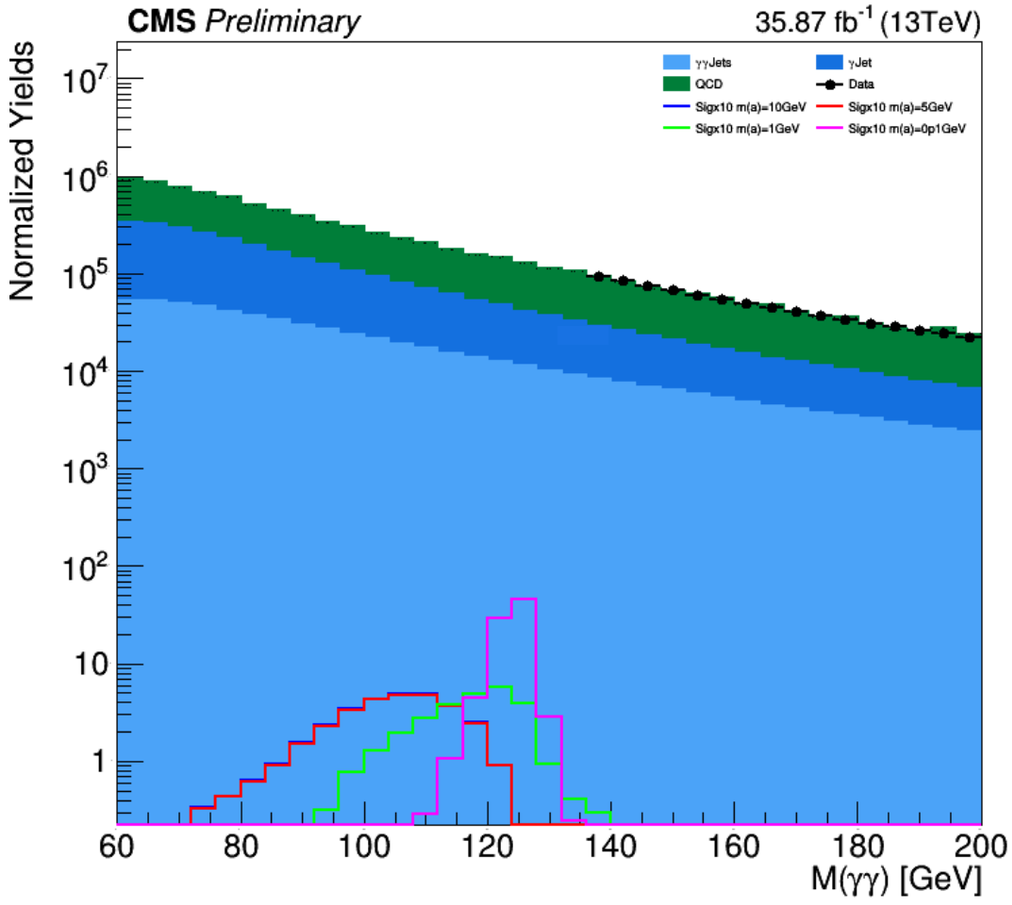
- Signal region plots

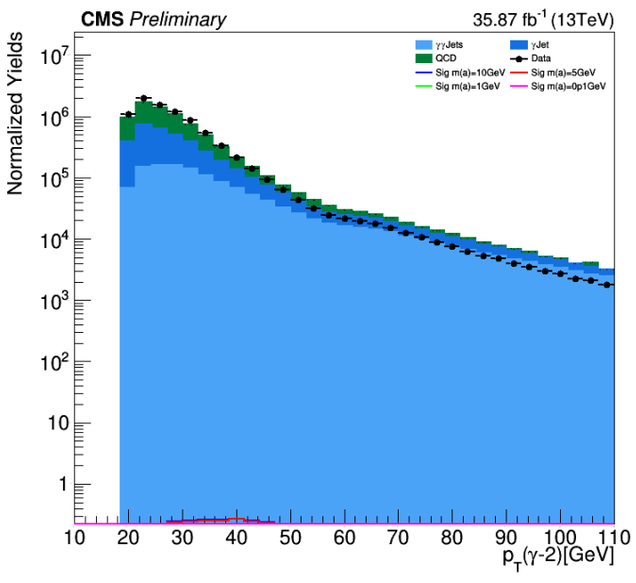
Blinding region: M(γγ) < 130 GeV

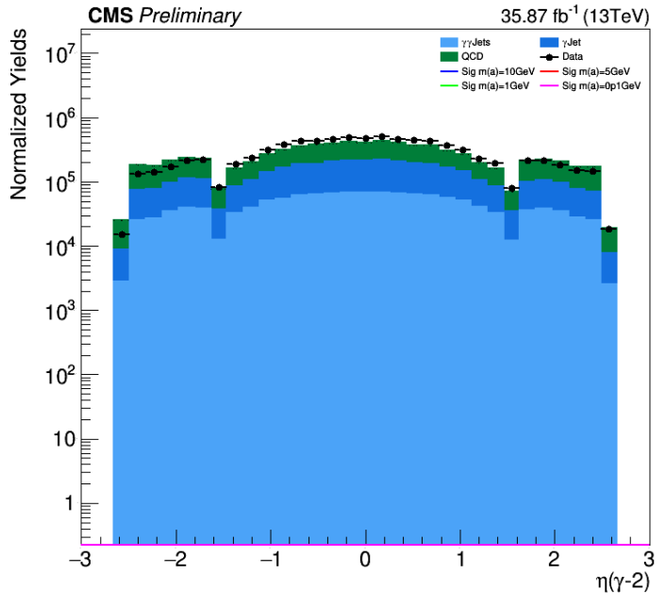
m(a) = 10 GeV
5 GeV
1 GeV
0.1 GeV





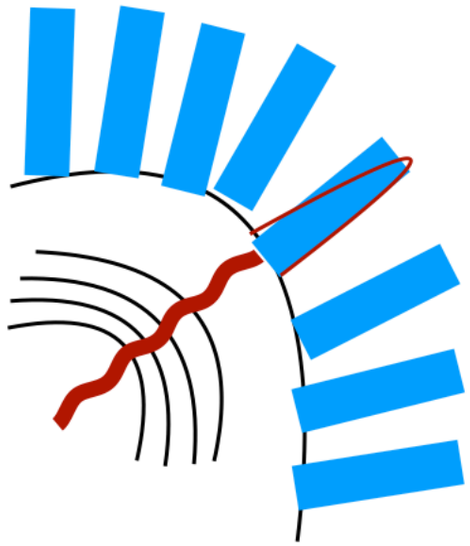




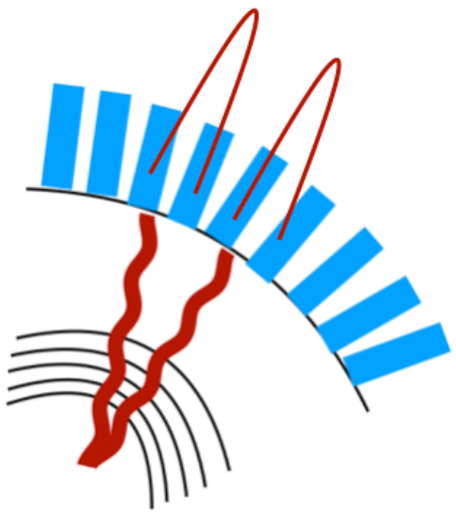


Distinguish 2 Photon category signal from the H(125)→γγ

- Compare shower shape variables for m(a) = 0.1 GeV (2 photon category) signal and H(125)→γγ signal

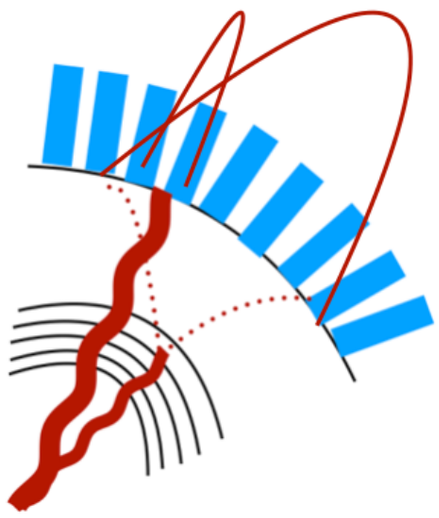


H(125)→γγ signal



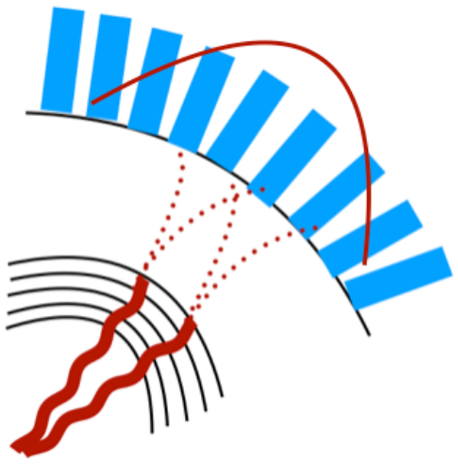
Case A

Both γ's are unconverted



Case B

1 converted +1 unconverted γ



Case C

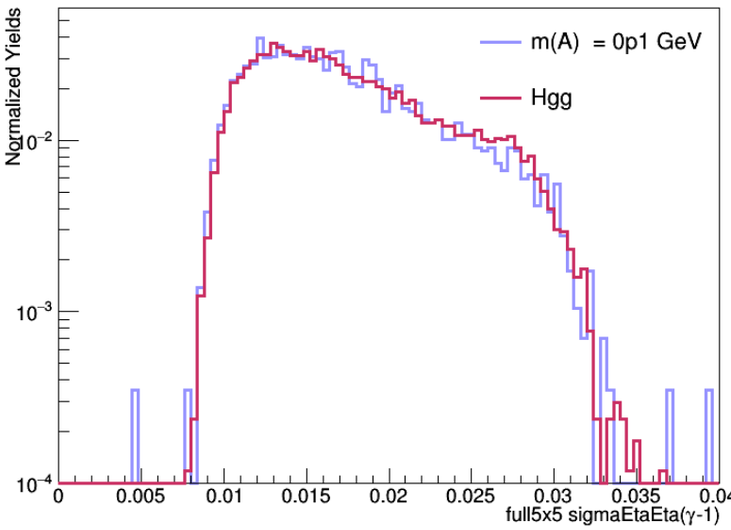
Both γ's are converted

Distinguish 2 Photon category signal from the H(125)→γγ (2)

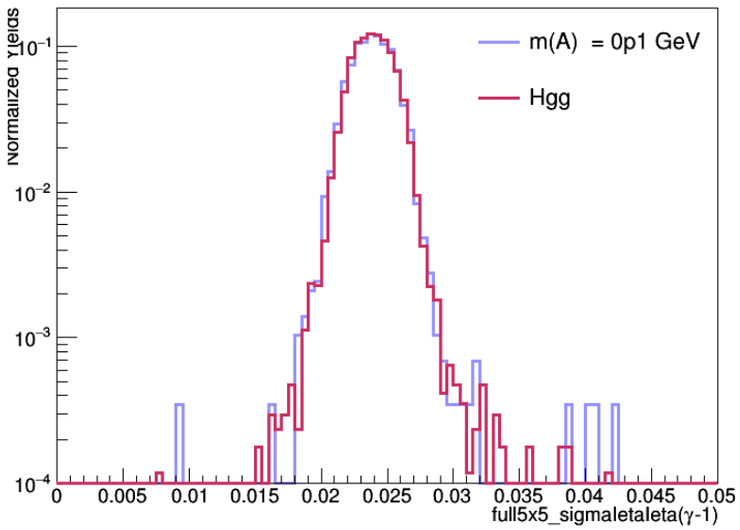
- Compare shower shape variables for m(a) = 0.1 GeV (2 photon category) signal and H(125)→γγ signal

EE

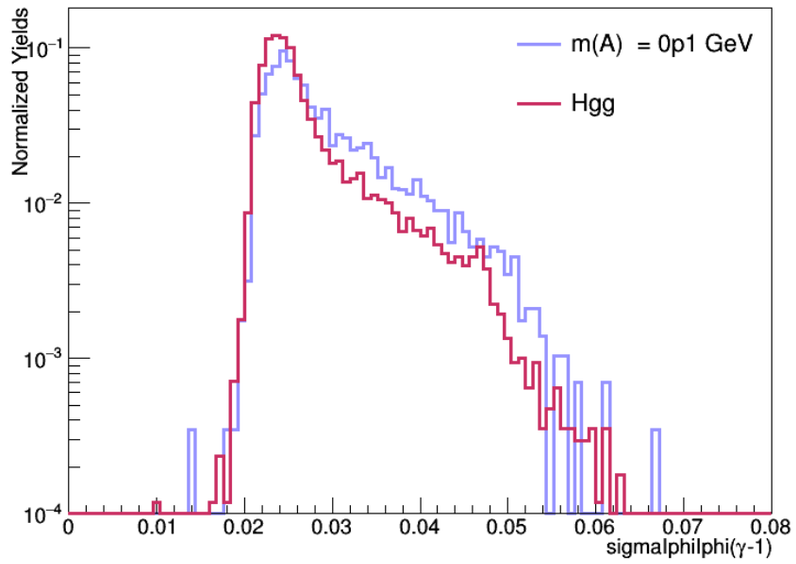
Full 5x5 $\sigma_{\eta\eta}$



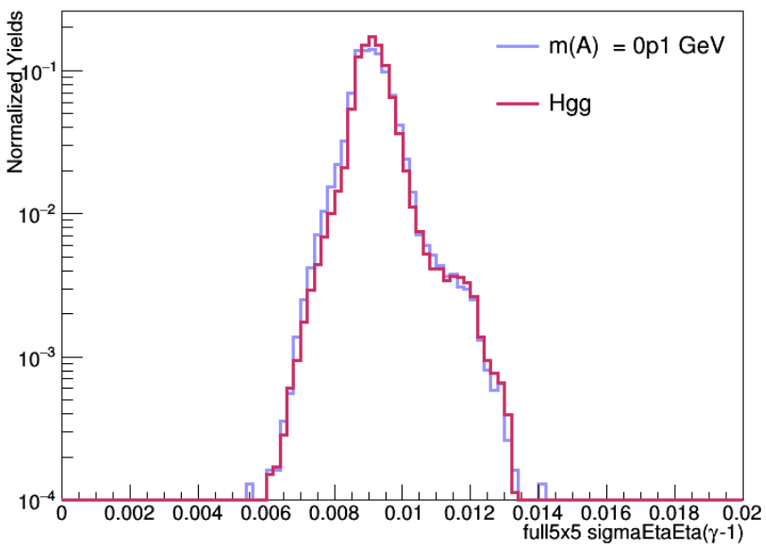
Full 5x5 $\sigma_{i\eta i\eta}$

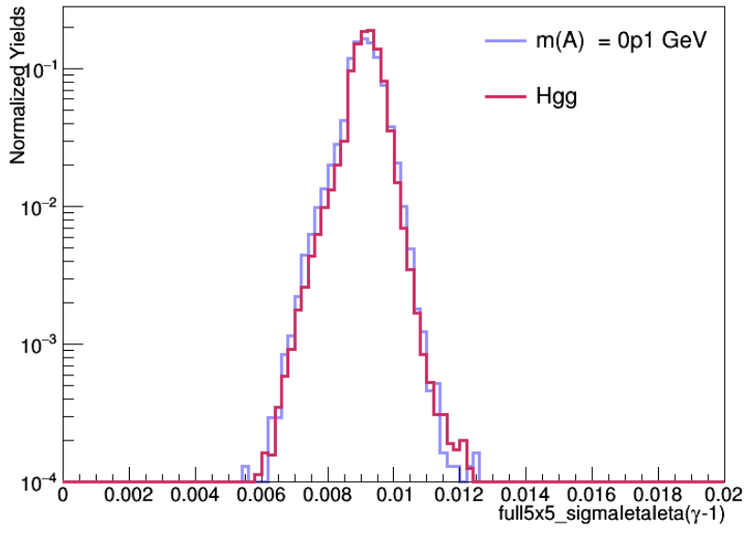


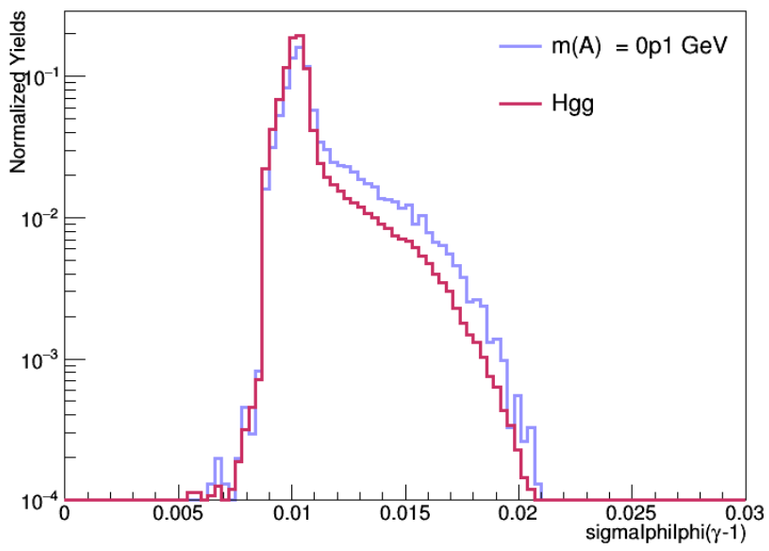
Full 5x5 $\sigma_{i\phi i\phi}$



EB





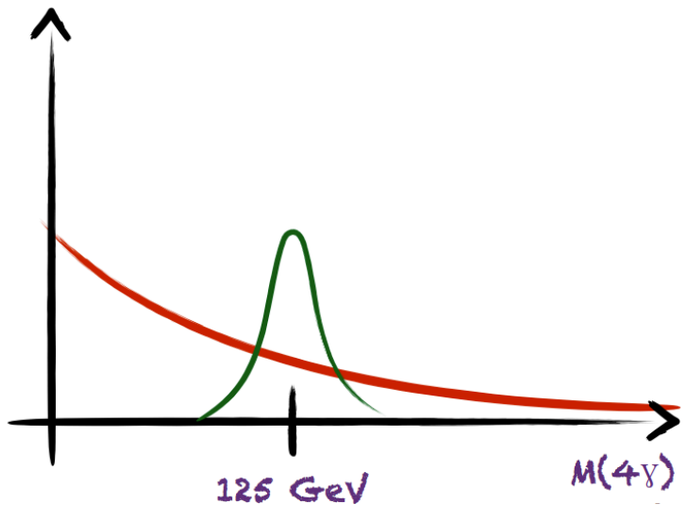


SUMMARY

- Analysis strategy for Higgs decay into 4 photons h(125)→aa→γγγγ was presented
- 4 photon, 3 photon and 2 photon category Background MC and Data comparison plots shown
- Background MC will be used to validate the simulation of our signal description and for analysis development
- Signal extraction and background modeling to be done based on data

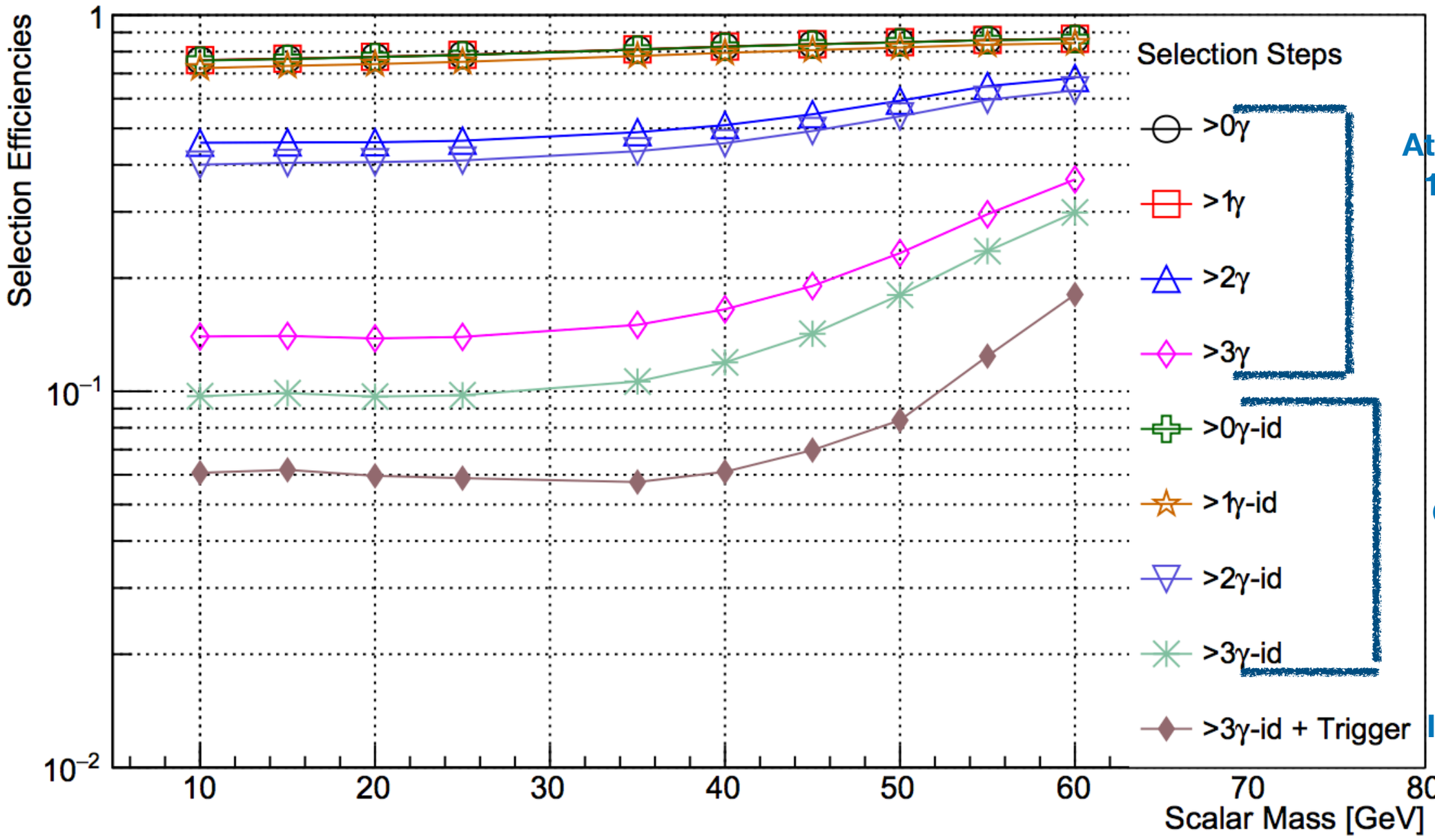
TO DO

- To distinguish 2 Photon category from H(125)→γγ
  - Train an MVA variable using the shower shape variables
- For background and Signal Modeling
  - Use the Discrete profiling method (directly on data)
- Start Documentation



BACKUP

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