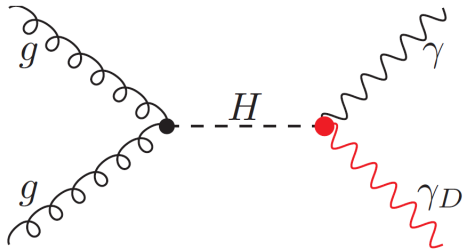
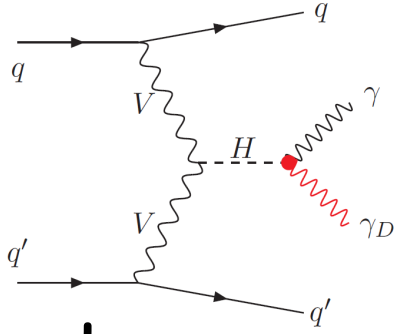
Search for Higgs decay into a photon and a massless dark photon (ggF) in Run 3





Longsheng Tan[1,2], Andrea Malara[1], Laurent Thomas[1], Pascal Vanlaer[1], Li Yuan[2]

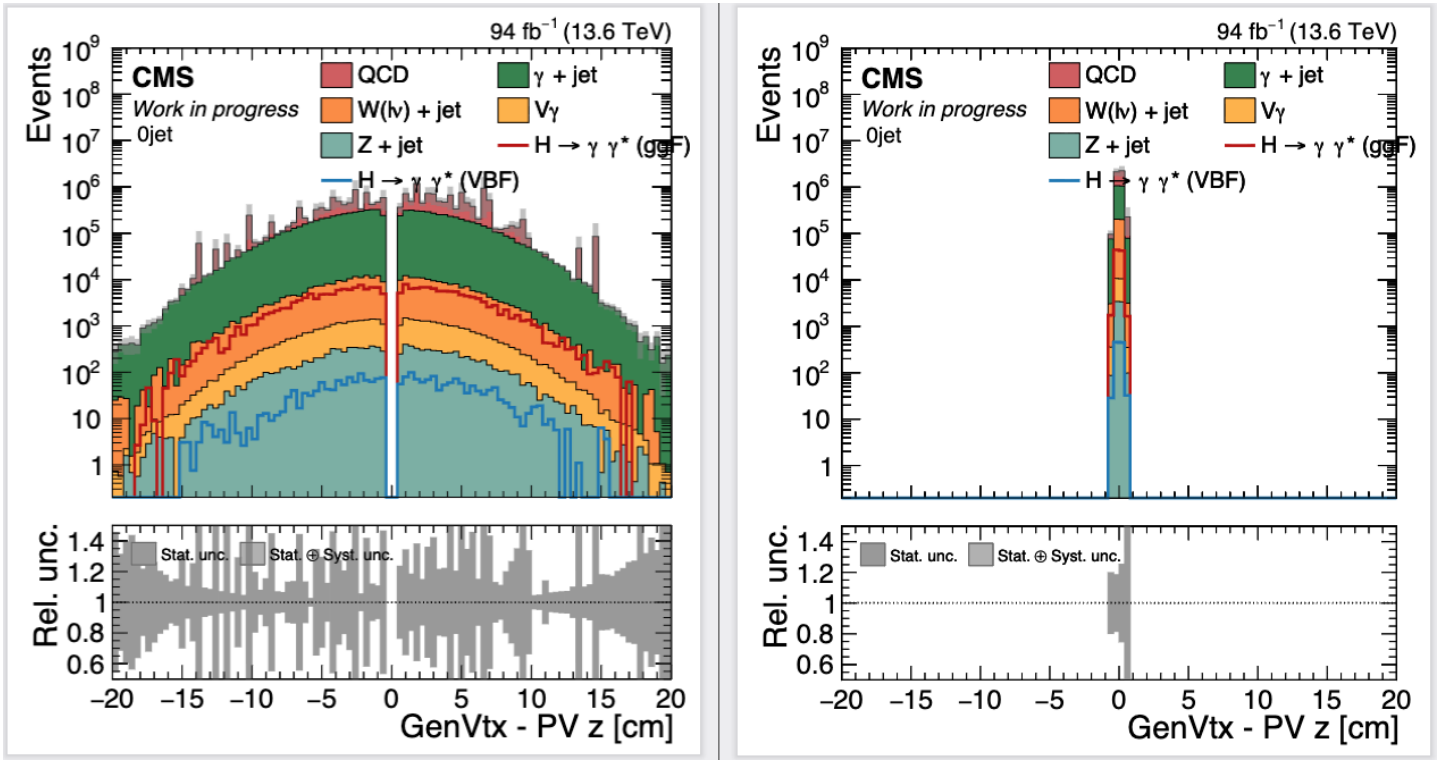
[1] Université libre de Bruxelles / IIHE, Brussels, Belgium

[2] Beihang University, Beijing, China

07,01,2026

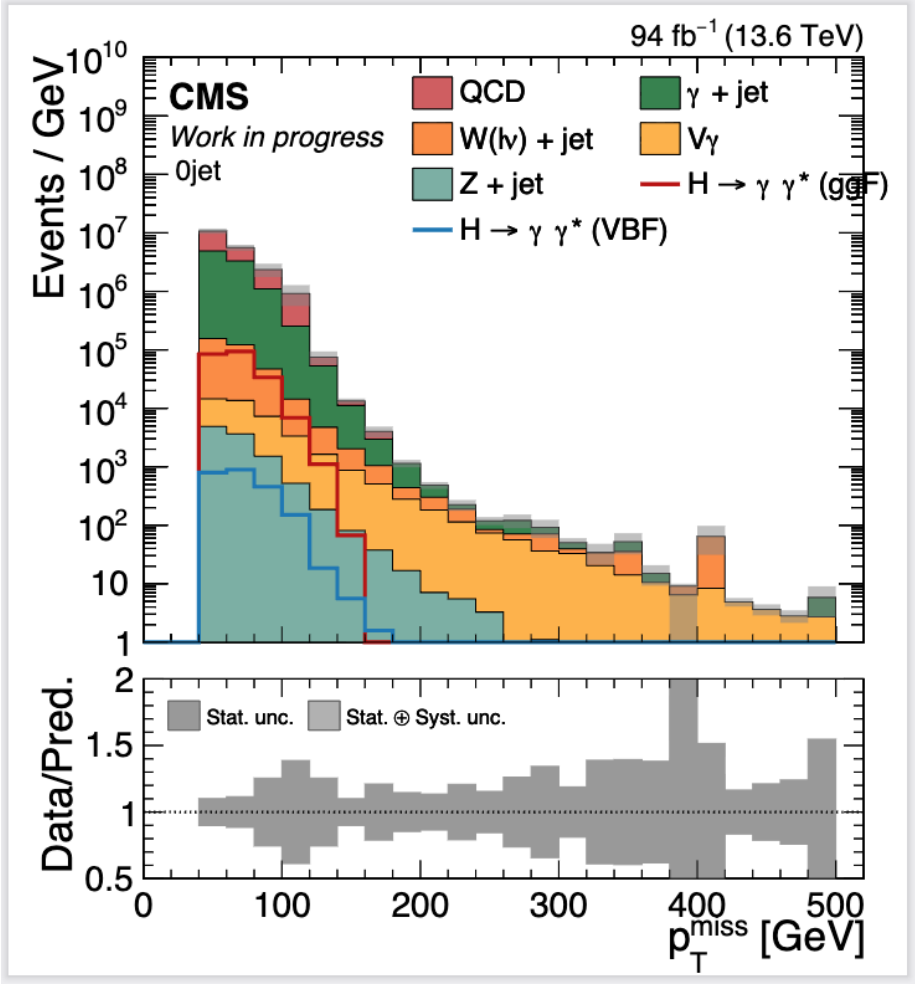
Updates

- GenVtx-PV mismatch study in 0jets SR
  - RunIII2024Summer24, NanoAODv15, photon pT > 45 GeV, MET > 40 GeV
  - Understand whether vertex mismatch drives MET and MT shape differences in MC
  - Split MC by |GenVtx_z - PV_z| <= 0.5 cm and > 0.5 cm
  - All plots in https://lotan.web.cern.ch/pyRATOUTPUT/GenVtx_minus_PV_z_met40_pdf_classified/
- Update AN https://gitlab.cern.ch/tdr/notes/AN-26-115/-/tree/lotan?ref_type=heads
- Investigate upper limits through dark_photon_fit
  - Introduce bin-integrated RooParametricShapeBinPdf

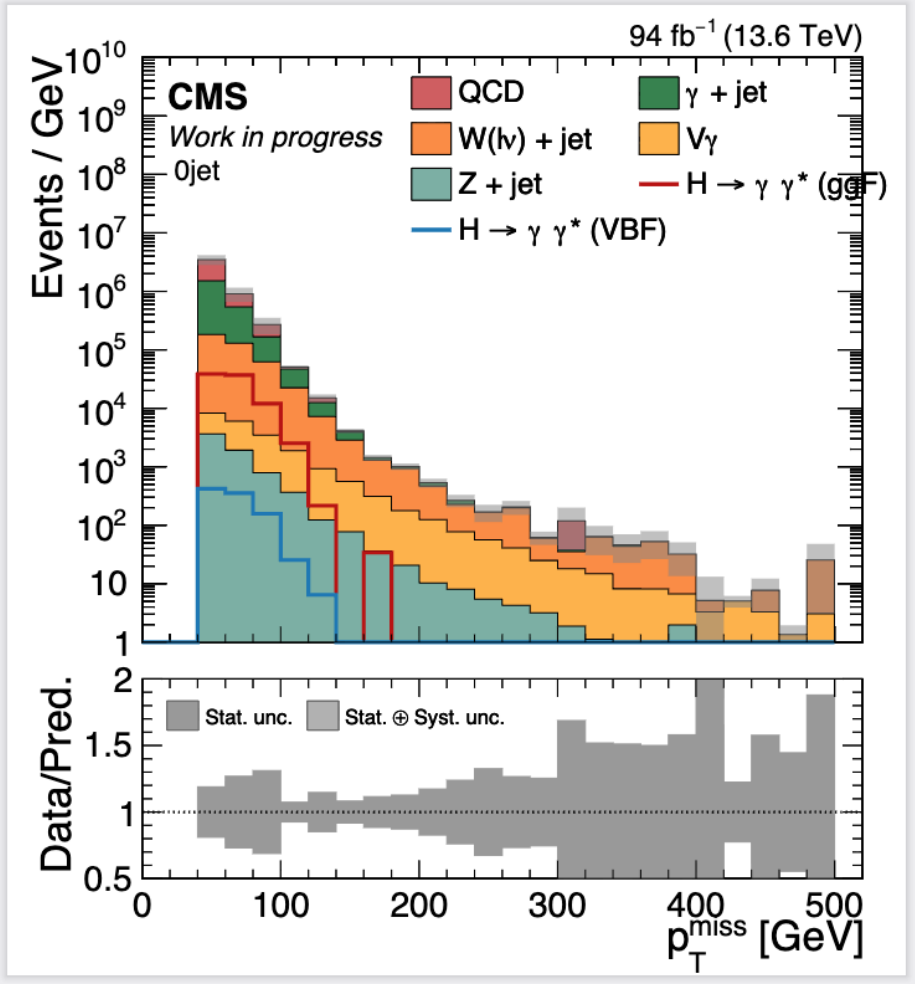


- Background total fraction in |dz| > 0.5 cm: 80.7%
- GJets: 83.2%, QCDJets: 80.5%
- Signals are around 70.7%, lower than GJets and QCDJets

|dz| > 0.5


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
p_T^{miss} [GeV]

|dz| <= 0.5


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
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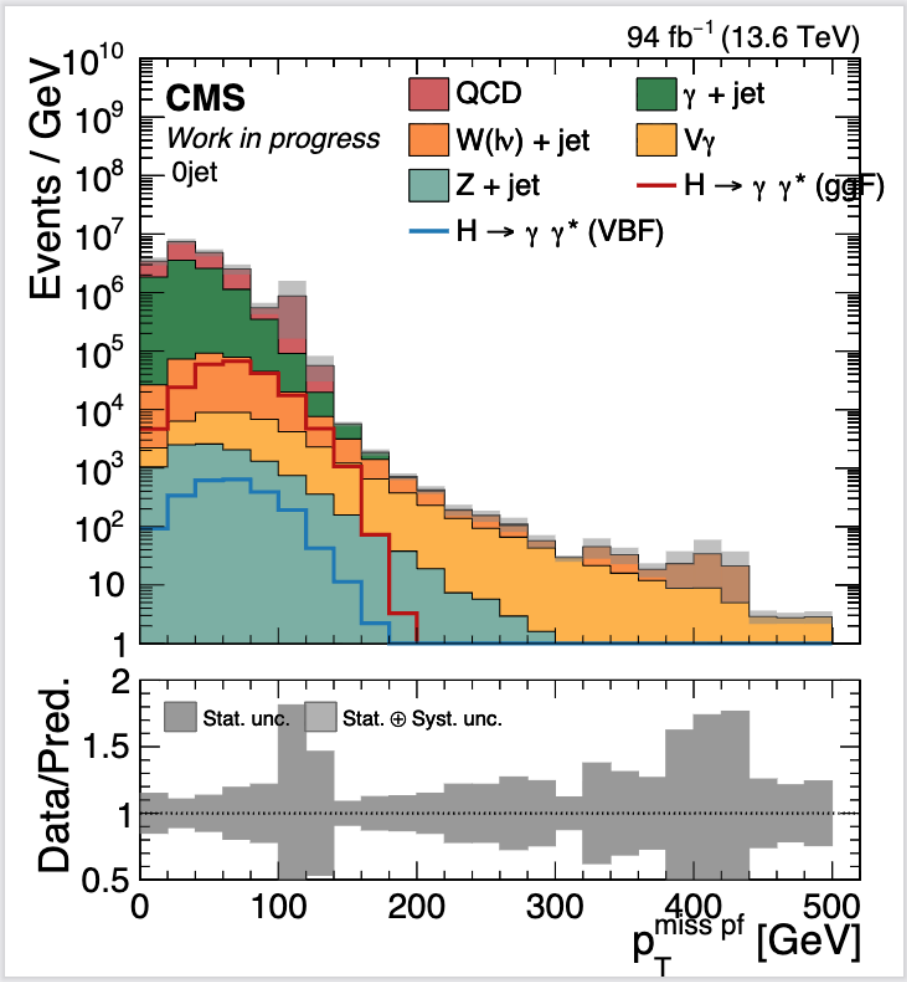
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
p_T^{miss} [GeV]

$|dz| > 0.5$


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
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QCD
γ + jet
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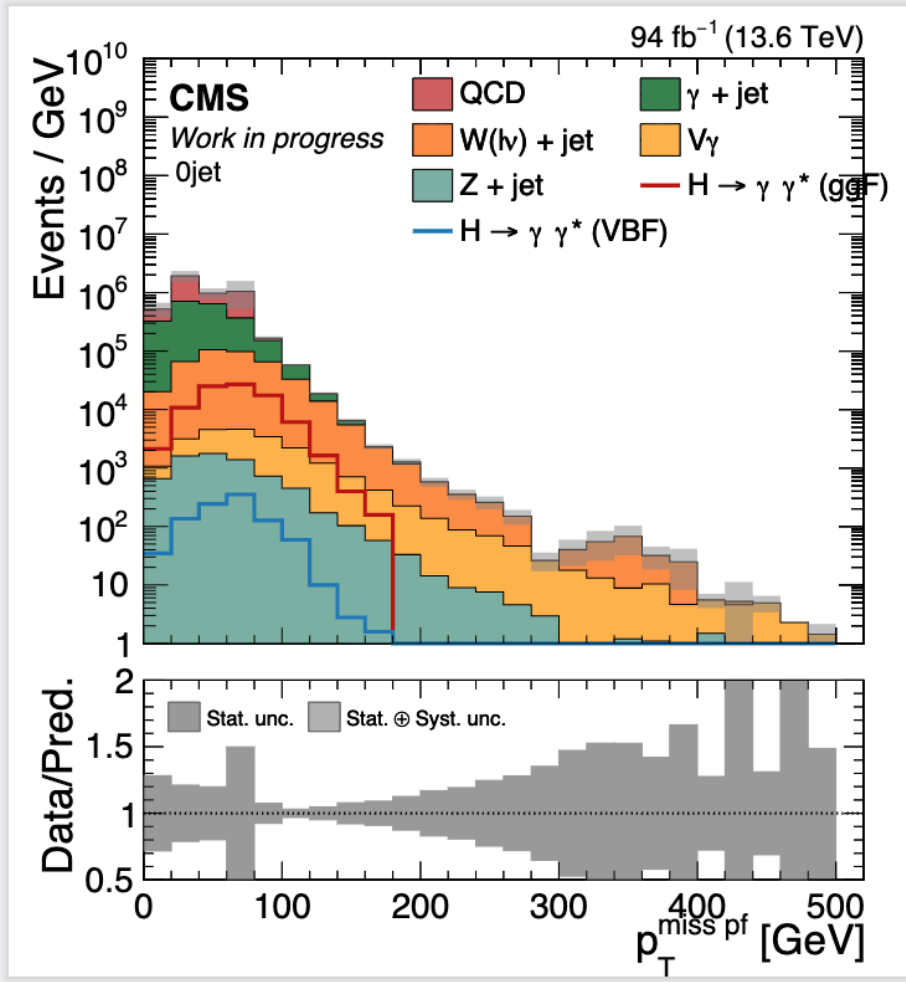
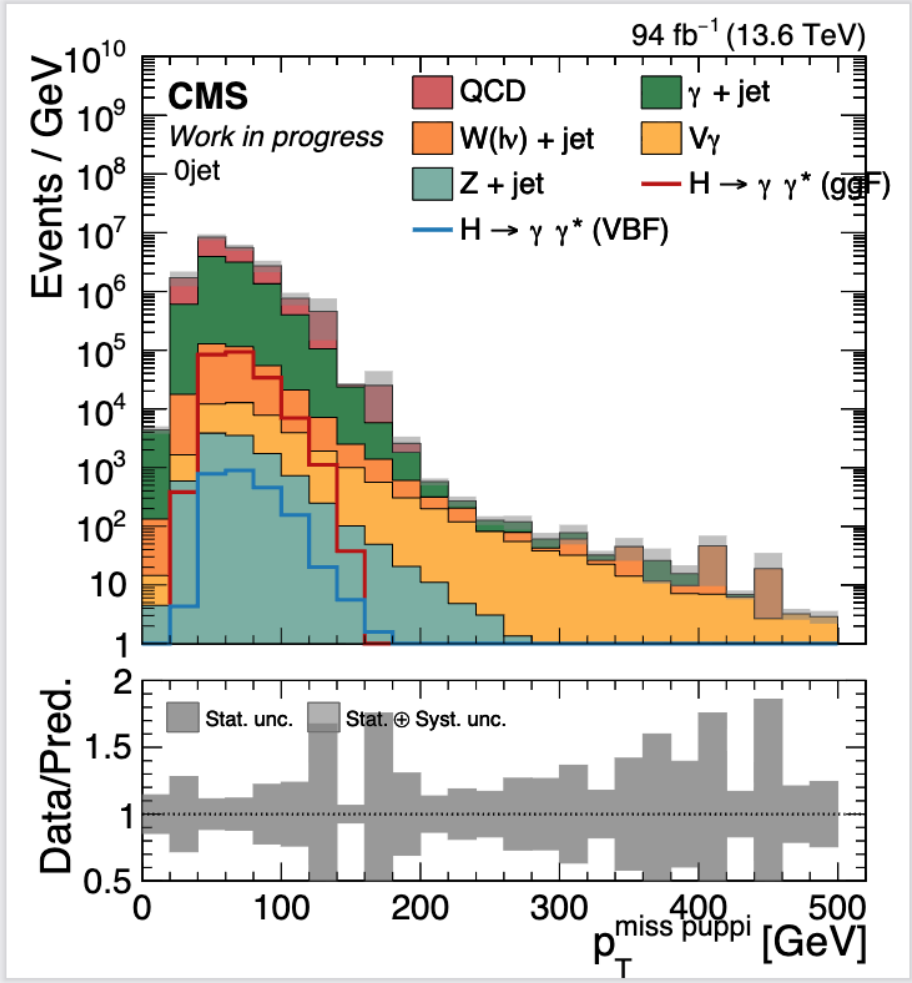
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
$p_T^{miss\ pf}$ [GeV]

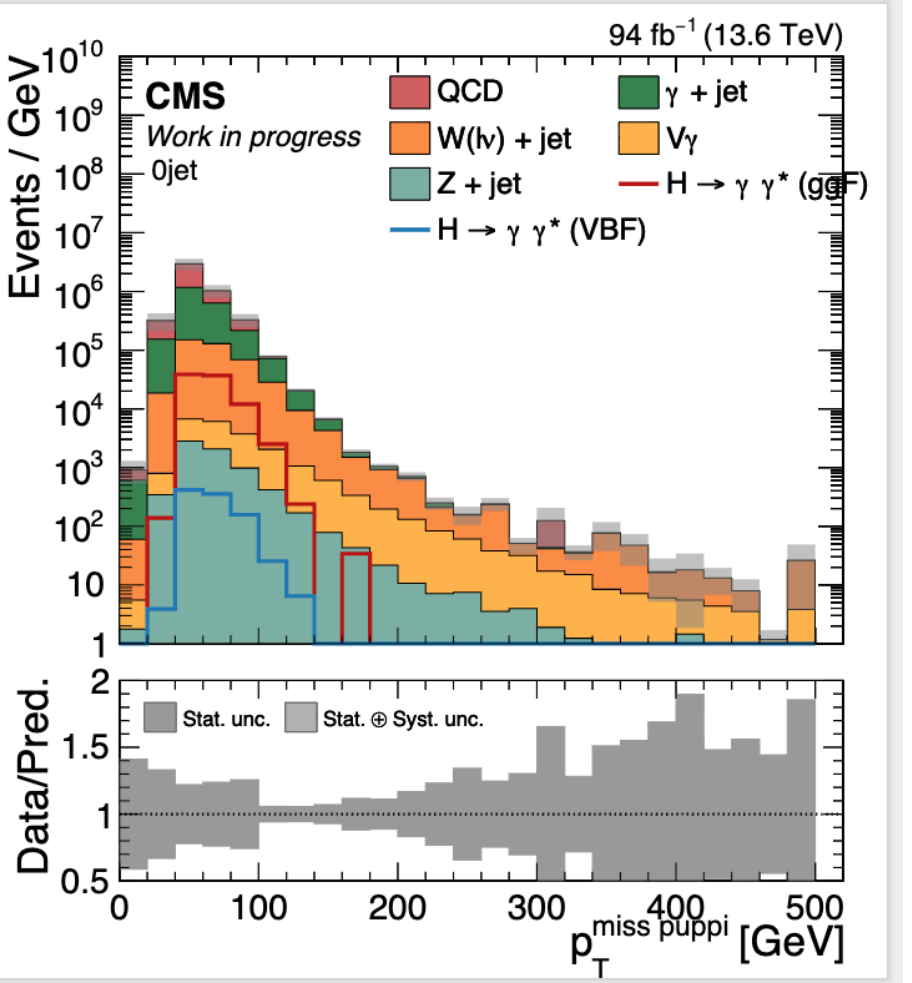
$|dz| <= 0.5$


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
$p_T^{miss\ pf}$ [GeV]

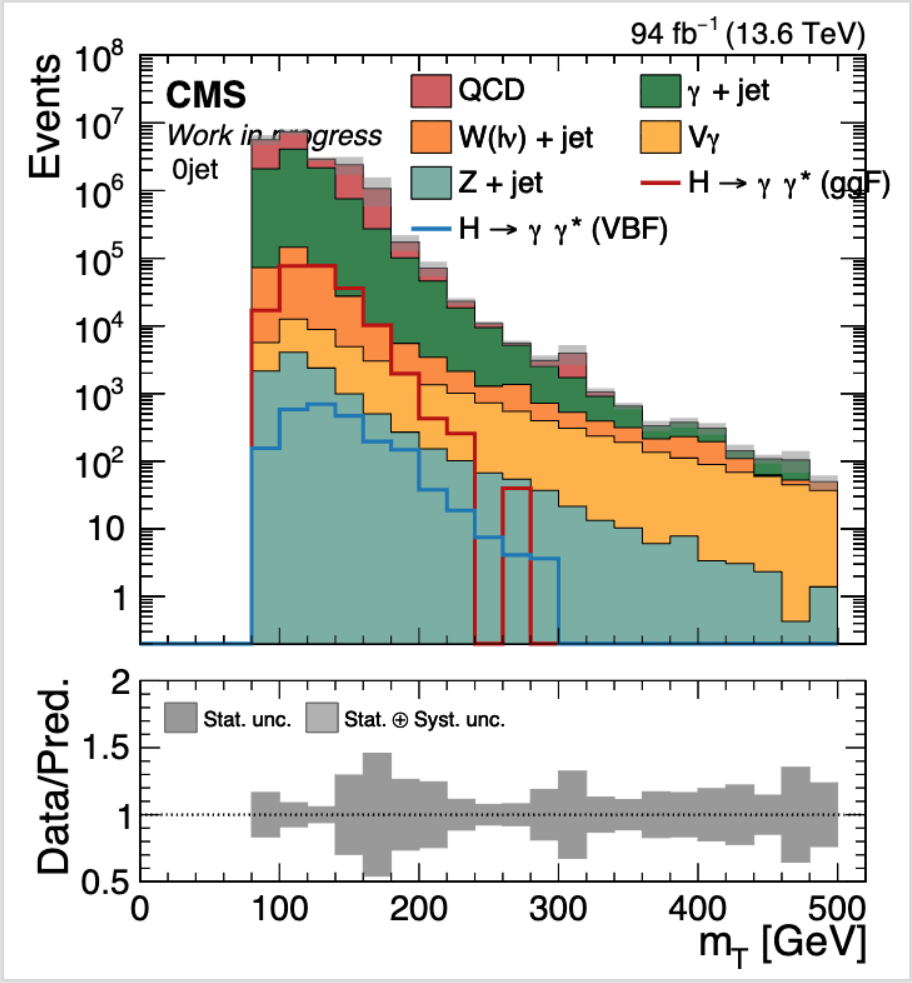
$|dz| > 0.5$


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
$p_T^{miss\ puppi}$ [GeV]

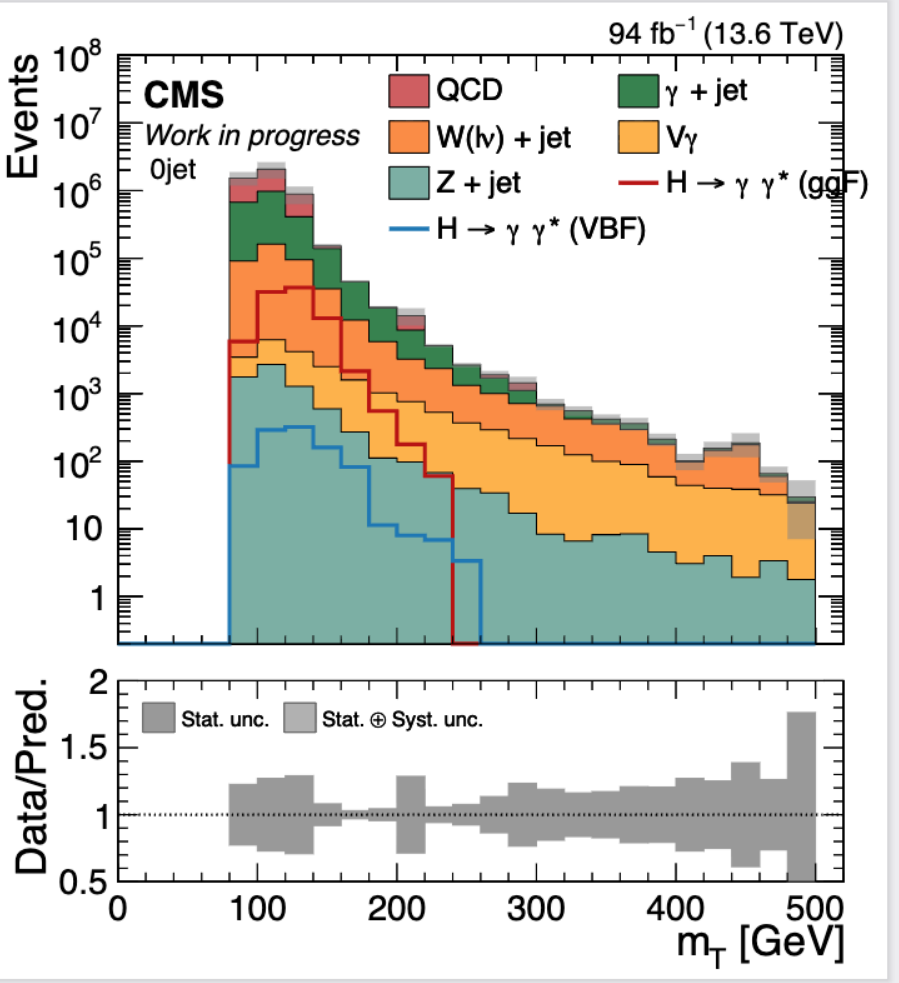
$|dz| <= 0.5$

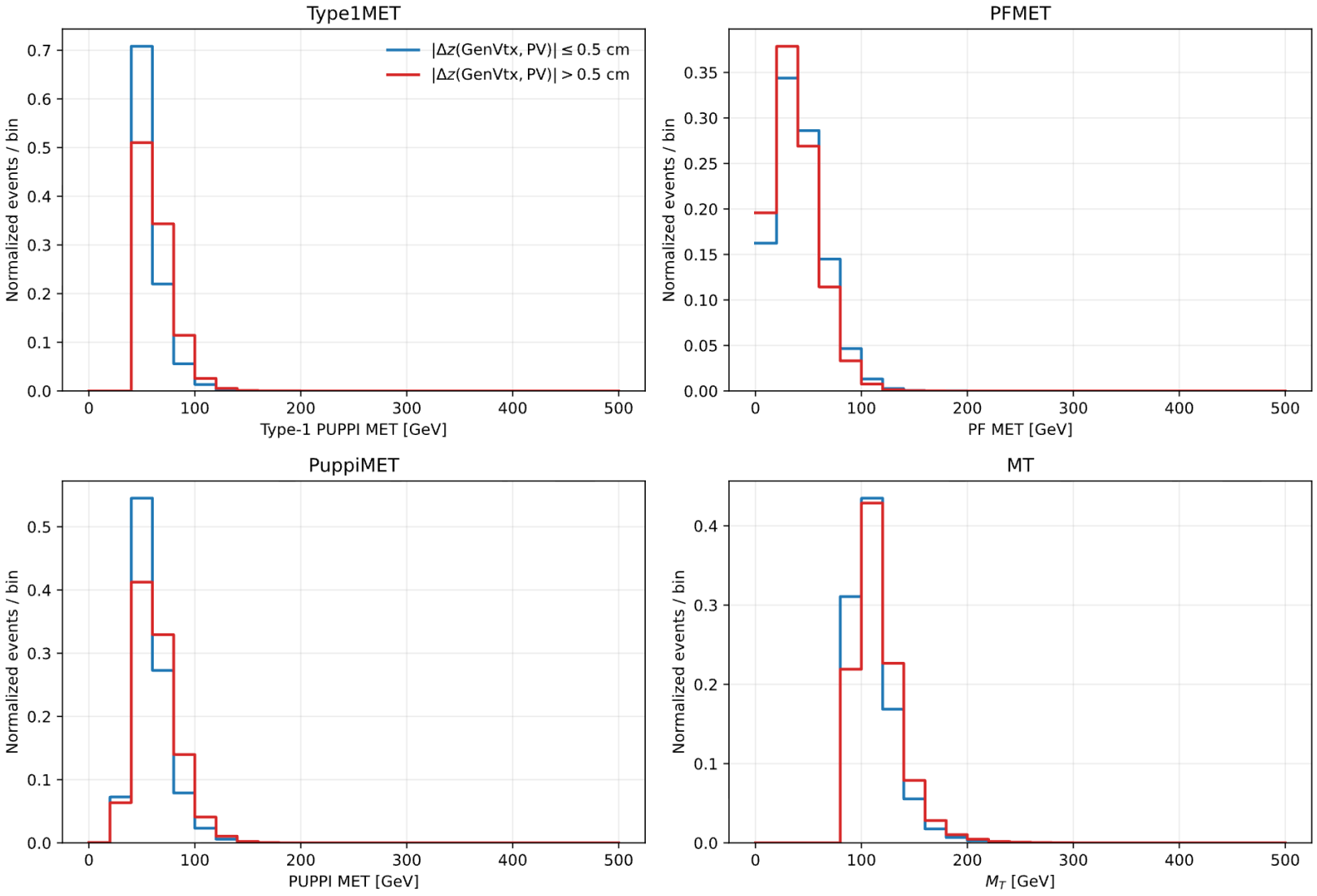

94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events / GeV
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
$p_T^{miss\ puppi}$ [GeV]

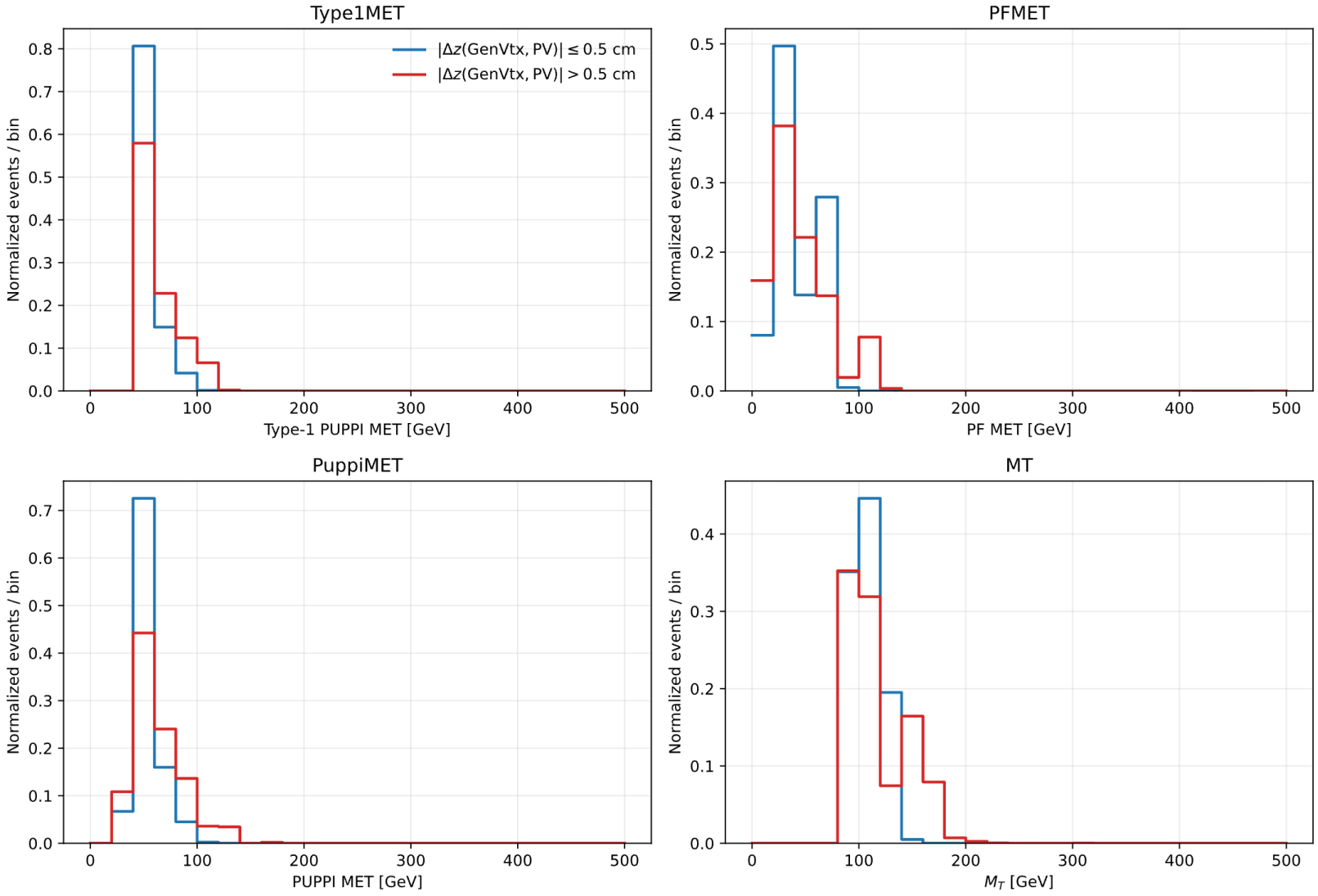
|dz| > 0.5


94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
m$_T$ [GeV]

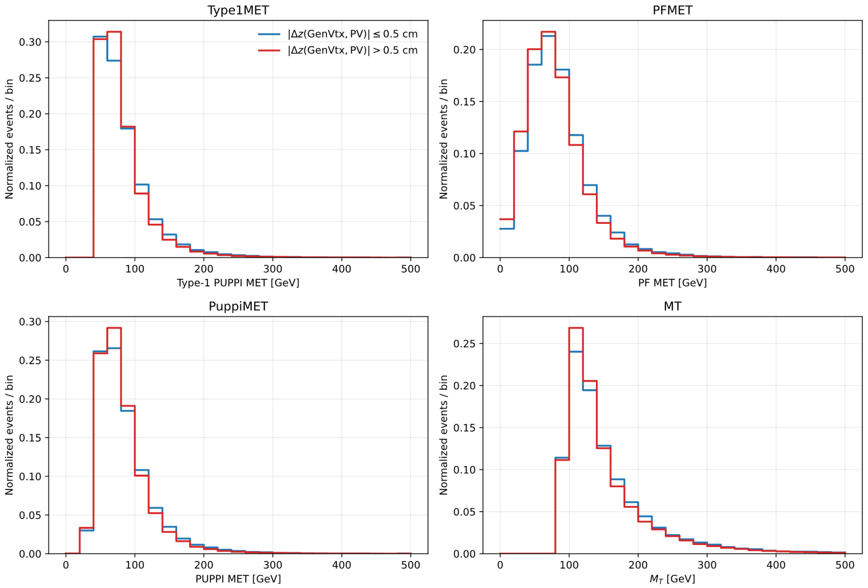
|dz| <= 0.5

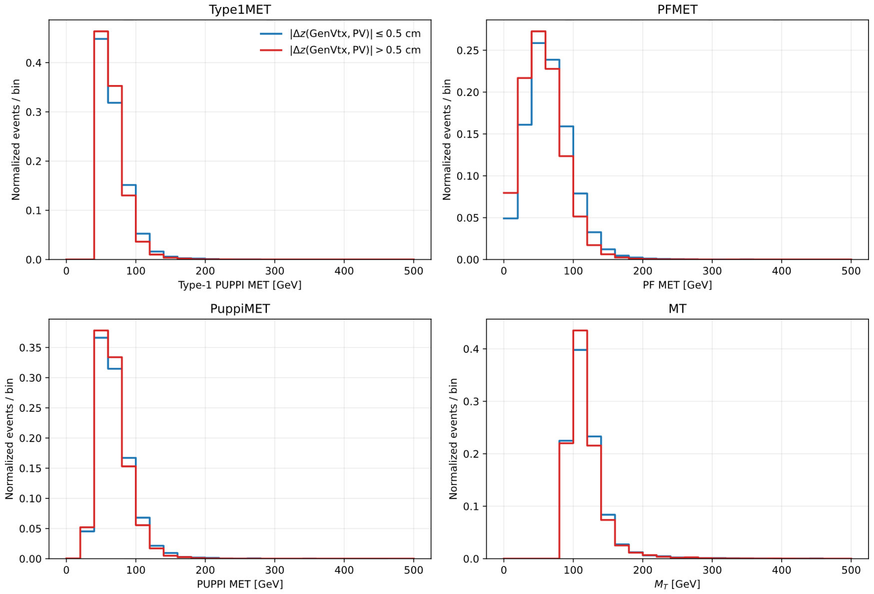

94 fb^{-1} (13.6 TeV)
CMS
Work in progress
0jet
QCD
γ + jet
W(lν) + jet
Vγ
Z + jet
H → γ γ* (ggF)
H → γ γ* (VBF)
Events
Data/Pred.
Stat. unc.
Stat. ⊕ Syst. unc.
m$_T$ [GeV]

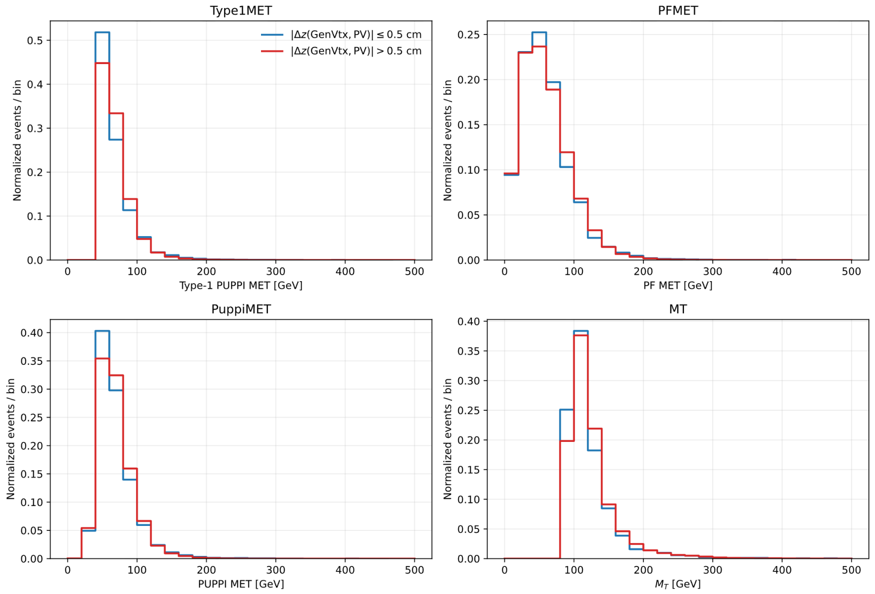

Type1MET
|Δz(GenVtx, PV)| ≤ 0.5 cm
|Δz(GenVtx, PV)| > 0.5 cm
Normalized events / bin
Type-1 PUPPI MET [GeV]
PFMET
PF MET [GeV]
PuppiMET
PUPPI MET [GeV]
MT
M_T [GeV]


Type1MET
|Δz(GenVtx, PV)| ≤ 0.5 cm
|Δz(GenVtx, PV)| > 0.5 cm
Normalized events / bin
Type-1 PUPPI MET [GeV]
PFMET
PF MET [GeV]
PuppiMET
PUPPI MET [GeV]
MT
M_T [GeV]

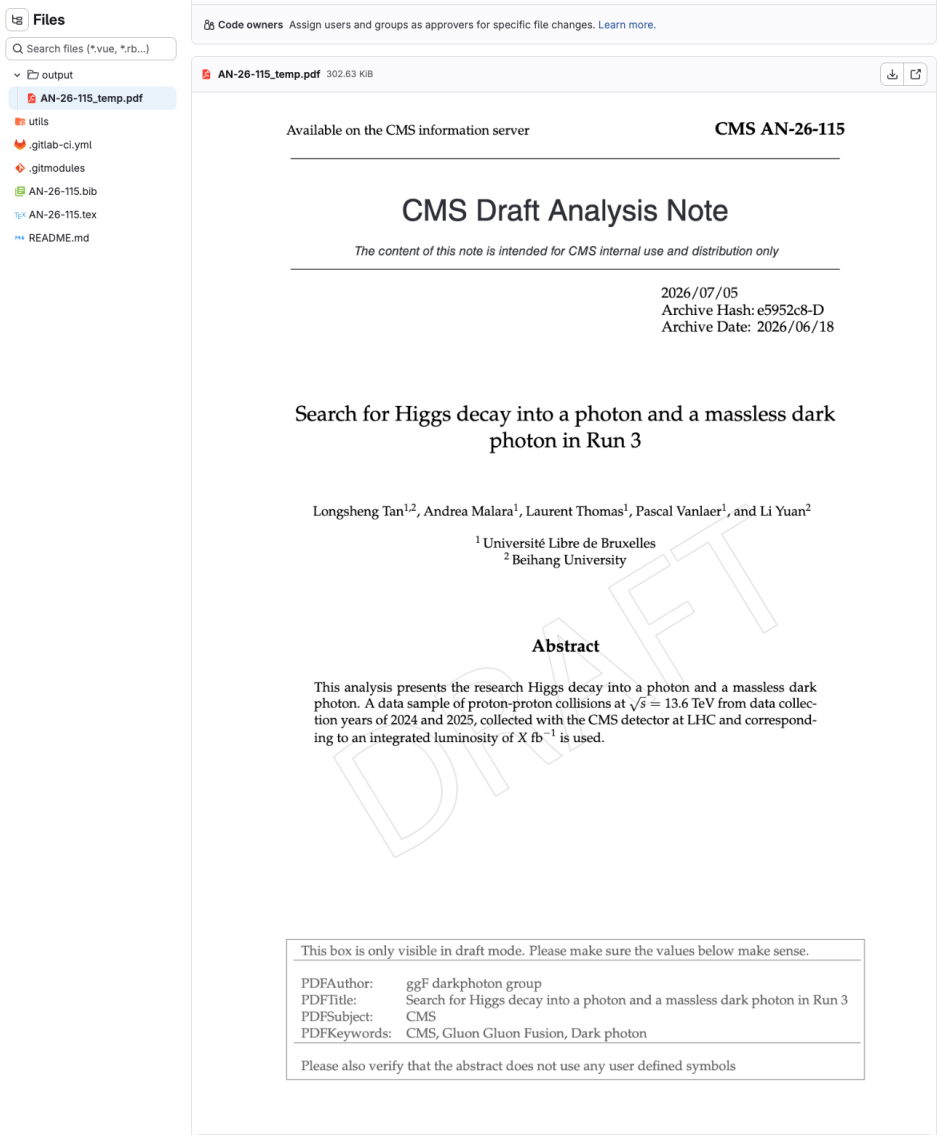
Vgamma Wjets Zjets







Update AN


Files
Search files (*.vue, *.rb...)
output
AN-26-115_temp.pdf
utils
.gitlab-ci.yml
.gitmodules
AN-26-115.bib
AN-26-115.tex
README.md
Code owners Assign users and groups as approvers for specific file changes. Learn more.
AN-26-115_temp.pdf 302.63 KiB
Available on the CMS information server
CMS AN-26-115
CMS Draft Analysis Note
The content of this note is intended for CMS internal use and distribution only
2026/07/05
Archive Hash: e5952c8-D
Archive Date: 2026/06/18
Search for Higgs decay into a photon and a massless dark photon in Run 3
Longsheng Tan[1,2], Andrea Malara[1], Laurent Thomas[1], Pascal Vanlaer[1], and Li Yuan[2]
[1] Université Libre de Bruxelles
[2] Beihang University
Abstract
This analysis presents the research Higgs decay into a photon and a massless dark photon. A data sample of proton-proton collisions at $\sqrt{s} = 13.6$ TeV from data collection years of 2024 and 2025, collected with the CMS detector at LHC and corresponding to an integrated luminosity of X fb^{-1} is used.
DRAFT
This box is only visible in draft mode. Please make sure the values below make sense.
PDFAuthor: ggF darkphoton group
PDFTitle: Search for Higgs decay into a photon and a massless dark photon in Run 3
PDFSubject: CMS
PDFKeywords: CMS, Gluon Gluon Fusion, Dark photon
Please also verify that the abstract does not use any user defined symbols

Investigate upper limits through dark_photon_fit

hist:

data_obs = QCD_Gjet template -> normalized to data_rate -> Poisson pseudo-data

background = QCD_Gjet template -> normalized to data_rate -> RooHistPdf

ordinary analytic:

data_obs = QCD_Gjet -> fitted analytic PDF -> Poisson pseudo-data

background = analytic PDF fitted to that pseudo-data

shapebin:

data_obs = same model-specific pseudo-data as the corresponding analytic card

background = same analytic family wrapped by RooParametricShapeBinPdf (bin-integrated instead of bin center value approximation) and fitted to that pseudo-data

Investigate upper limits through dark_photon_fit

Expected Limits

ch_0jet_dphi_2p9_pi_MET_40_100

Fit	BR limit $^{+1\sigma}_{-1\sigma}$ [%]
exp3	$1.46^{+0.98}_{-0.60}$
hist	$2.55^{+1.05}_{-0.72}$

shapebin_ch_0jet_dphi_2p9_pi_MET_40_100

Fit	BR limit $^{+1\sigma}_{-1\sigma}$ [%]
exp3	$3.75^{+1.20}_{-0.84}$

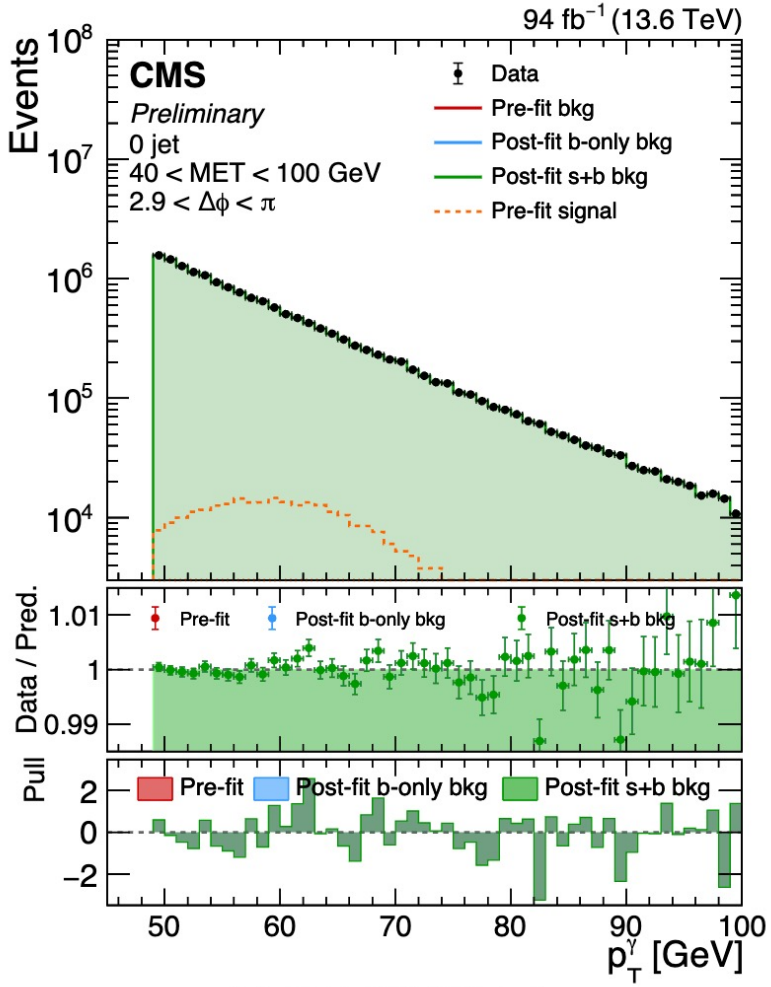
combined

Fit	BR limit $^{+1\sigma}_{-1\sigma}$ [%]
exp3	$1.46^{+0.98}_{-0.60}$
exp3_shapebin	$3.75^{+1.20}_{-0.84}$
hist	$2.55^{+1.05}_{-0.72}$

Investigate upper limits through dark_photon_fit

datacard_hist_ch_0jet_dphi_2p9_pi_MET_40_100

Model: hist **Channel:** ch_0jet_dphi_2p9_pi_MET_40_100 **Expected BR limit [%]:** $2.55^{+1.05}_{-0.72}$



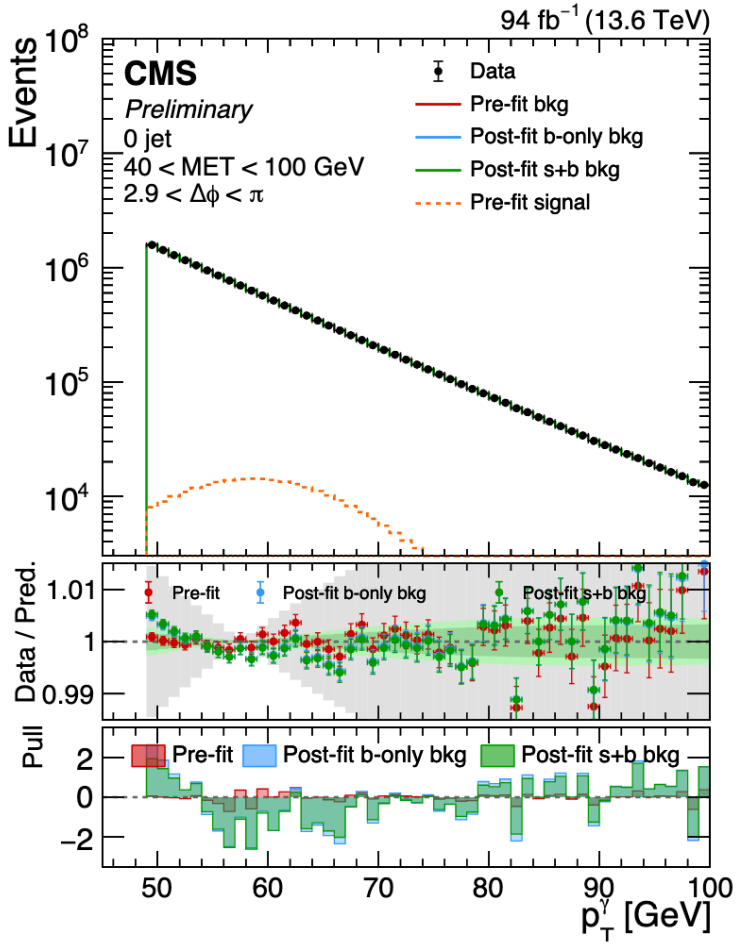
ch_0jet_dphi_2p9_pi_MET_40_100_both.pdf

Investigate upper limits through dark_photon_fit

Combine Results

datacard_exp3_ch_0jet_dphi_2p9_pi_MET_40_100

Model: exp3 **Channel:** ch_0jet_dphi_2p9_pi_MET_40_100 **Expected BR limit [%]:** $1.46^{+0.98}_{-0.60}$

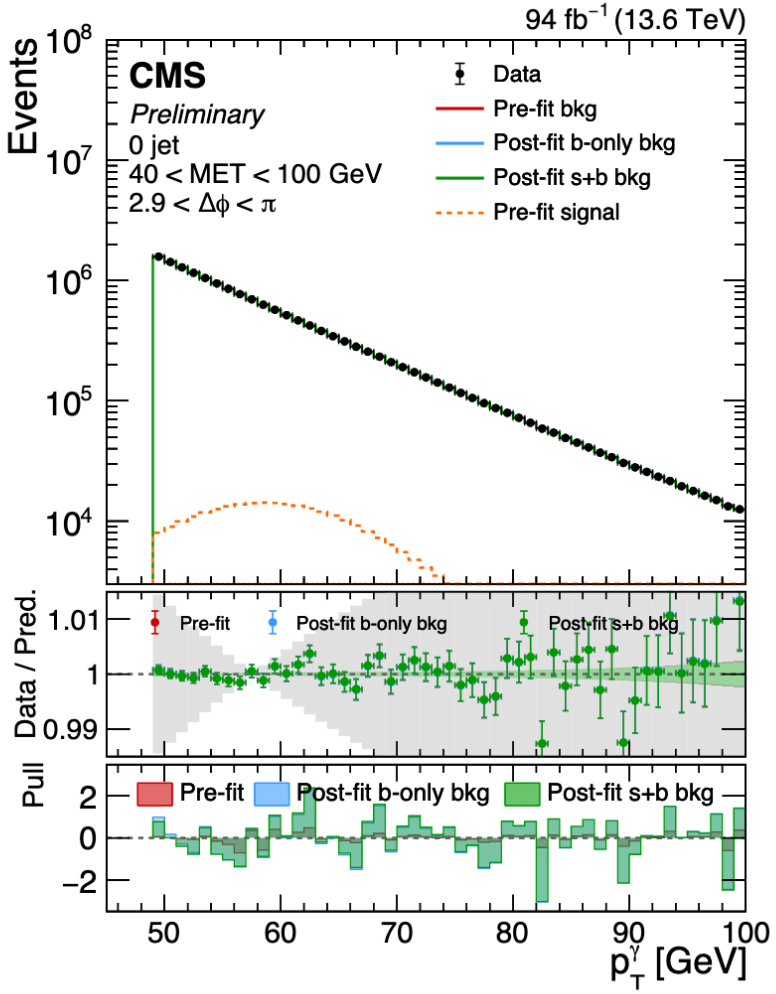


ch_0jet_dphi_2p9_pi_MET_40_100_both.pdf

Investigate upper limits through dark_photon_fit

datacard_exp3_shapebin_ch_0jet_dphi_2p9_pi_MET_40_100

Model: exp3 **Channel:** shapebin_ch_0jet_dphi_2p9_pi_MET_40_100 **Expected BR limit [%]:** $3.75^{+1.20}_{-0.84}$



ch_0jet_dphi_2p9_pi_MET_40_100_both.pdf

Back up

Updates-samples

- Signal
  - Run3Summer23BPix
    - ggF VBF
- Background
  - RunIII2024Summer24
    - QCD_Gjet
      - GJ-4Jets-2NLO2LO_Bin-PTG-25_Par-BiasedPTG_TuneSherpaDef_13p6TeV_sherpaMEPS
    - QCDJets
      - QCD_Bin-PT-{}_TuneCP5_13p6TeV_pythia8
    - QCD_Znunu
      - Zto2Nu-2Jets_Bin-{}J-PTNuNu-{}_TuneCP5_13p6TeV_amcatnloFXFX-pythia8 1 2
    - EWK_Gjet
      - VBFtoG_Bin-PTG-{}_TuneCP5_13p6TeV_madgraph-pythia8
    - TTbar
      - {}_TuneCP5_13p6TeV_powheg-pythia8 TTto2L2Nu TTto4Q TTtoLNu2Q
    - Zgamma
      - ZGto2NuG-1Jets_TuneCP5_13p6TeV_amcatnloFXFX-pythia8
    - Wgamma
      - WGtoLNuG-1Jets_ TuneCP5_13p6TeV_amcatnloFXFX-pythia8
    - QCD_Zjet
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    - QCD_Wjet
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