The LHC Searches for The Heavy Higgs via Two B-jets plus Di-photon

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SM background

We analyze the LHC searches for H via the $b\bar{b}\gamma\gamma$ final states.

1. The dominant SM background processes include the $b\bar{b}\gamma\gamma$ and $t\bar{t}\gamma\gamma$.

2. Contributions from $h(\to \gamma\gamma)Z(\to b\bar{b})$ and $h(\to \gamma\gamma)t\bar{t}$: negligible.

3. Reducible QCD backgrounds with jets to fake either b-jets and/or photons.

Following the ATLAS detector performance:

- The photon identification efficiencies:

$$\epsilon_{q\to\gamma} \approx 3.6 \times 10^{-4}\,, \quad \epsilon_{g\to\gamma} \approx 3.6 \times 10^{-5}\,,$$

with q and g representing the quark-jet and gluon-jet respectively.

- The b-jet mis-tag rates:

$$\epsilon_{c\to b} \approx 0.2\,, \quad \epsilon_{j\to b} \approx 0.01\,,$$

with j representing the light jets.

SM background

• For the $b\bar{b}\gamma\gamma$ background, the relevant reducible QCD background contributions include:

$$c\bar{c}\gamma\gamma\,,\quad jj\gamma\gamma\,,\quad b\bar{b}g\gamma\,,\quad c\bar{c}g\gamma\,,\quad jjg\gamma\,,\quad b\bar{b}q\gamma\,,\quad c\bar{c}q\gamma\,,\quad jjq\gamma\,,$$
$$b\bar{b}gg\,,\quad c\bar{c}gg\,,\quad jjgg\,,\quad b\bar{b}gq\,,\quad c\bar{c}gq\,,\quad jjgq\,,\quad b\bar{b}qq\,,\quad c\bar{c}qq\,,\quad jjqq\,;$$

• For the $t\bar{t}\gamma\gamma$ background, the relevant reducible QCD background contributions include:

$$t\bar{t}g\gamma\,,\quad t\bar{t}q\gamma\,,\quad t\bar{t}gg\,,\quad t\bar{t}gq\,,\quad t\bar{t}qq\,.$$

Background corss section for 8TeV

Draft version 1.2

ATLAS NOTE

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Search for resonant and enhanced non-resonant dihiggs production in the $\gamma\gamma b\bar{b}$ channel with 20.3 fb^{-1} of data at 8 TeV

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Background corss section for 8TeV

• Truth D3PDs(Major background processes, allowing for light-flavor jets to fake photons photons and b-tagging: $b\bar{b}\gamma\gamma$, $b\bar{b}j\gamma$, $b\bar{b}jj$, $bj\gamma\gamma$, $bjj\gamma$, $jj\gamma\gamma$.)

Sample	Xsection [fb]
$bb\gamma\gamma$	8.30
$bbj\gamma$	39.58e3
$bbjj$	8.66e6
$bj\gamma\gamma$	79.8
$bjj\gamma$	1.83e5
$jj\gamma\gamma$	1510

Table 4: Samples and generator-level cross sections and samples used for the background decomposition studies. The k-factor of 1.5 or 2.0 is applied on top of these numbers.

Background corss section for 8TeV

D.1 bbaa

```
#*********************************************************************
#                       MadGraph/MadEvent                            *
#                    http://madgraph.hep.uiuc.edu                    *
#                                                                    *
#                         run_card.dat                               *
#                                                                    *
#  This file is used to set the parameters of the run.               *
#                                                                    *
#  Some notation/conventions:                                        *
#                                                                    *
#   Lines starting with a '# ' are info or comments                  *
#                                                                    *
#   mind the format:   value    = variable     ! comment             *
#*********************************************************************
#
#*******************
# Running parameters
#*******************
#
#*********************************************************************
# Tag name for the run (one word)                                    *
#*********************************************************************
  tag_1     = run_tag ! name of the run
#*********************************************************************
# Run to generate the grid pack                                      *
#*********************************************************************
  .false.     = gridpack  !True = setting up the grid pack
#*********************************************************************
# Number of events and rnd seed                                      *
# Warning: Do not generate more than 1M events in a single run       *
# If you want to run Pythia, avoid more than 50k events in a run.    *
#*********************************************************************
  50000 = nevents ! Number of unweighted events requested
      0       = iseed   ! rnd seed (0=assigned automatically=default))
#*********************************************************************
# Collider type and energy                                           *
# lpp: 0=No PDF, 1=proton, -1=antiproton, 2=photon from proton,      *
#                                         3=photon from electron     *
#*********************************************************************
        1     = lpp1    ! beam 1 type
        1     = lpp2    ! beam 2 type
     4000     = ebeam1  ! beam 1 total energy in GeV
     4000     = ebeam2  ! beam 2 total energy in GeV
#*********************************************************************
# Beam polarization from -100 (left-handed) to 100 (right-handed)    *
#*********************************************************************
        0     = polbeam1 ! beam polarization for beam 1
        0     = polbeam2 ! beam polarization for beam 2
```

```
#*********************************************************************
   0  = nhel          ! Number of helicities used per event
#*******************
# Standard Cuts
#*******************
#
#*********************************************************************
# Minimum and maximum pt's (for max, -1 means no cut)                *
#*********************************************************************
  20  = ptj       ! minimum pt for the jets
  20  = ptb       ! minimum pt for the b
  20  = pta       ! minimum pt for the photons
  10  = ptl       ! minimum pt for the charged leptons
   0  = misset    ! minimum missing Et (sum of neutrino's momenta)
   0  = ptheavy   ! minimum pt for one heavy final state
 1.0  = ptonium   ! minimum pt for the quarkonium states
  -1  = ptjmax    ! maximum pt for the jets
  -1  = ptbmax    ! maximum pt for the b
  -1  = ptamax    ! maximum pt for the photons
  -1  = ptlmax    ! maximum pt for the charged leptons
  -1  = missetmax ! maximum missing Et (sum of neutrino's momenta)
#*********************************************************************
# Minimum and maximum E's (in the lab frame)                         *
#*********************************************************************
   0  = ej     ! minimum E for the jets
   0  = eb     ! minimum E for the b
   0  = ea     ! minimum E for the photons
   0  = el     ! minimum E for the charged leptons
  -1   = ejmax ! maximum E for the jets
  -1   = ebmax ! maximum E for the b
  -1   = eamax ! maximum E for the photons
  -1   = elmax ! maximum E for the charged leptons
#*********************************************************************
# Maximum and minimum absolute rapidity (for max, -1 means no cut)   *
#*********************************************************************
 3.0  = etaj    ! max rap for the jets
 3.0  = etab    ! max rap for the b
 2.7  = etaa    ! max rap for the photons
 2.5  = etal    ! max rap for the charged leptons
 0.6  = etaonium ! max rap for the quarkonium states
   0  = etajmin ! min rap for the jets
   0  = etabmin ! min rap for the b
   0  = etaamin ! min rap for the photons
   0  = etalmin ! main rap for the charged leptons
#*********************************************************************
# Minimum and maximum DeltaR distance                                *
#*********************************************************************
 0.2 = drjj    ! min distance between jets
 0.2 = drbb    ! min distance between b's
 0.0 = drll    ! min distance between leptons
```

Background corss section for 8TeV

MG5	Xsection[fb] 8TeV	Xsection[fb] 14TeV
$bb\gamma\gamma$	8.28	20.13
$bbj\gamma$	39.55e3	104.6e3
$bbjj$	8.68e6	24.27e6
$bj\gamma\gamma$		
$bjj\gamma$		
$jj\gamma\gamma$	1510	3131