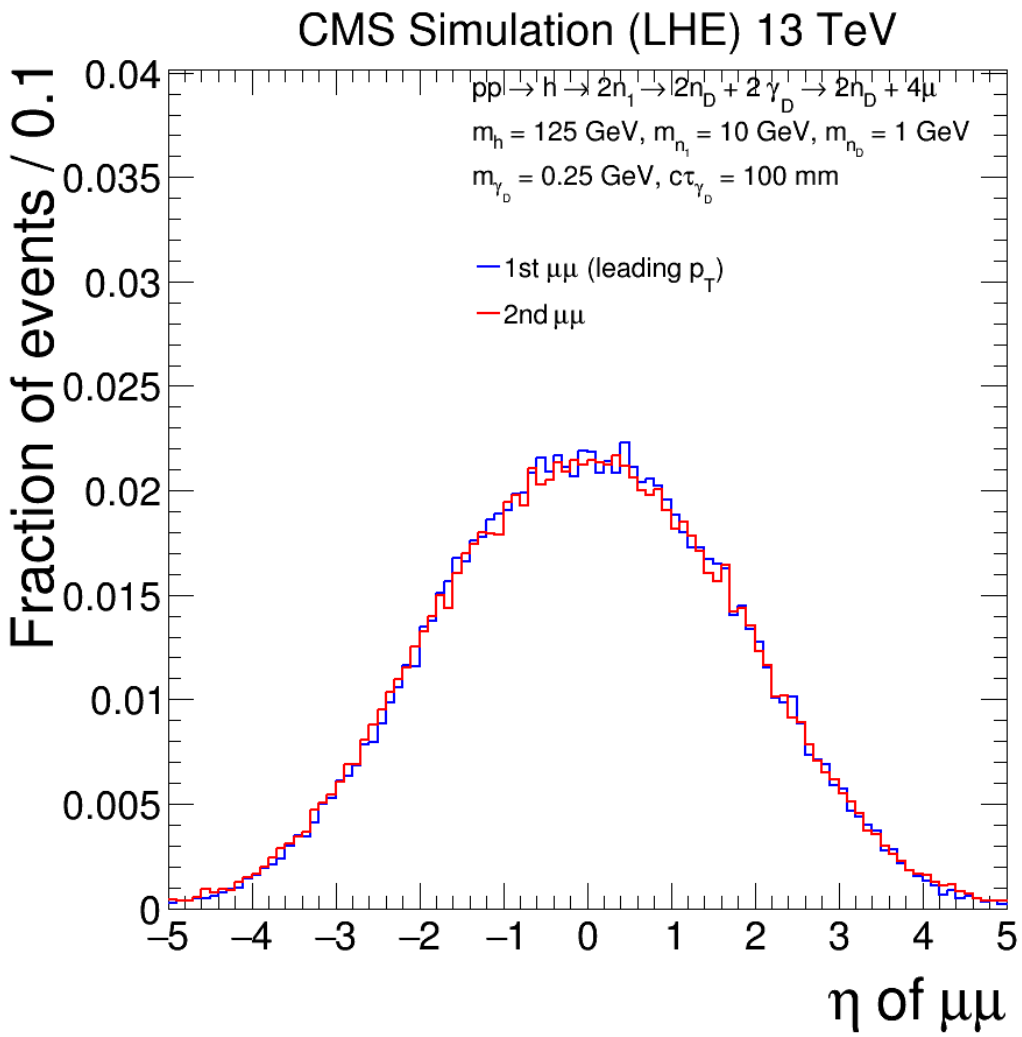
MG5 LHE Validation

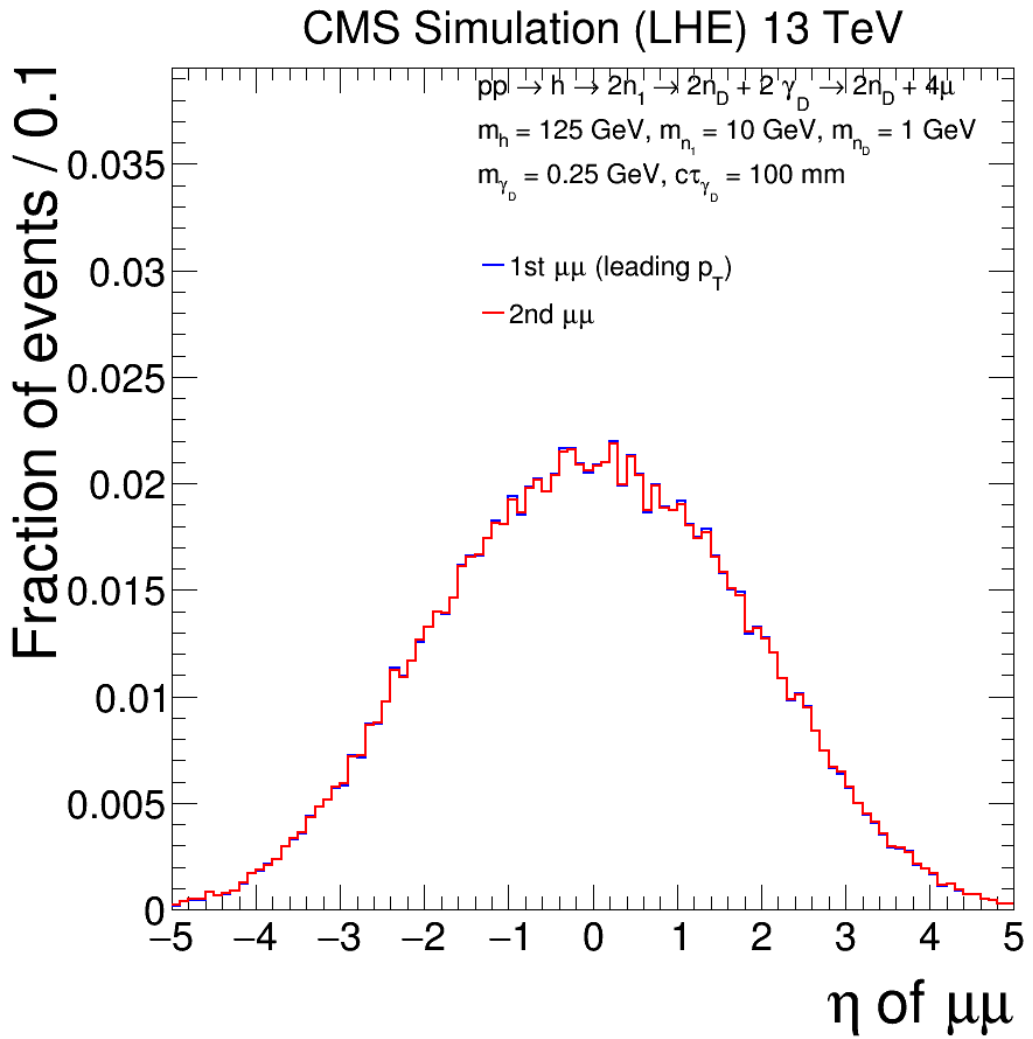
Wei Shi

TAMU+RICE working meeting

MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 0.1
η of μμ

MG5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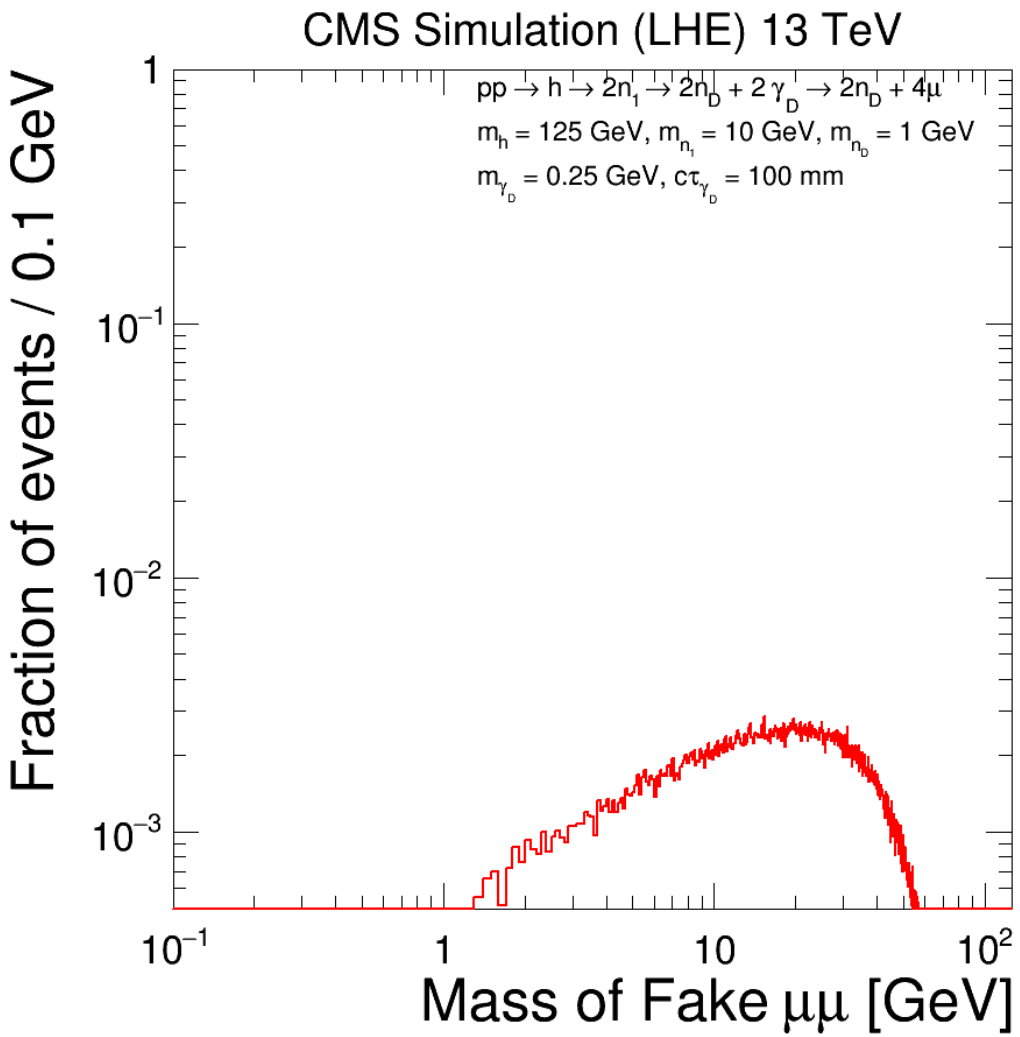
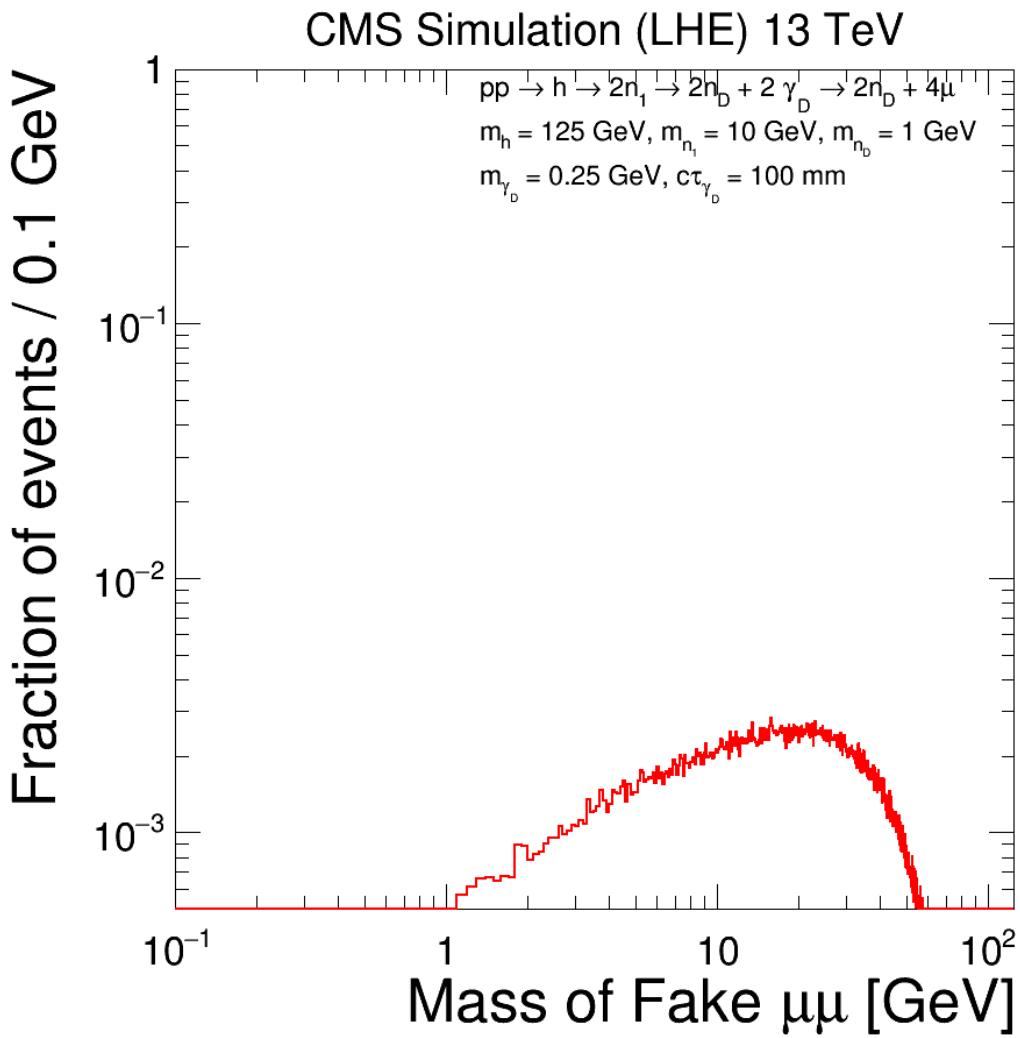
1st μμ (leading p_T)
2nd μμ
Fraction of events / 0.1
η of μμ

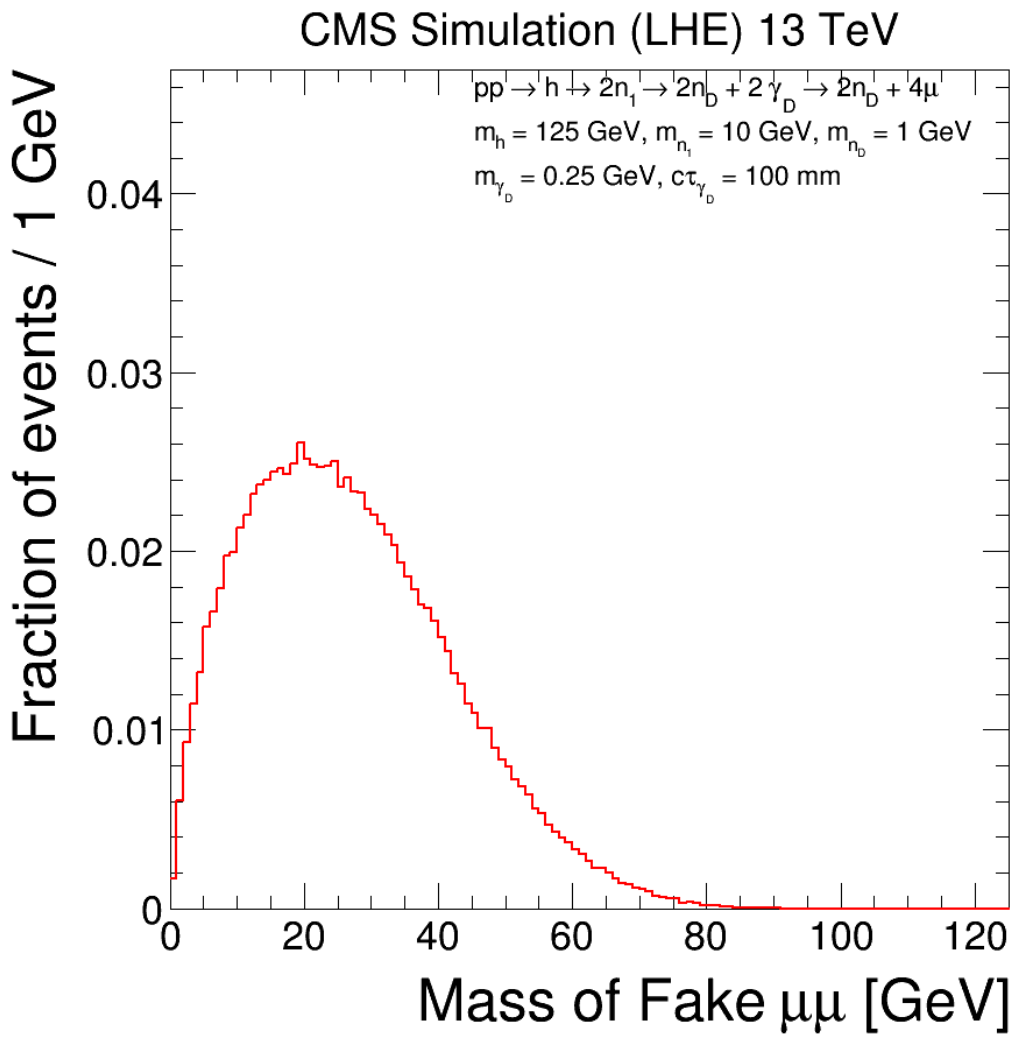
MG4

MG5

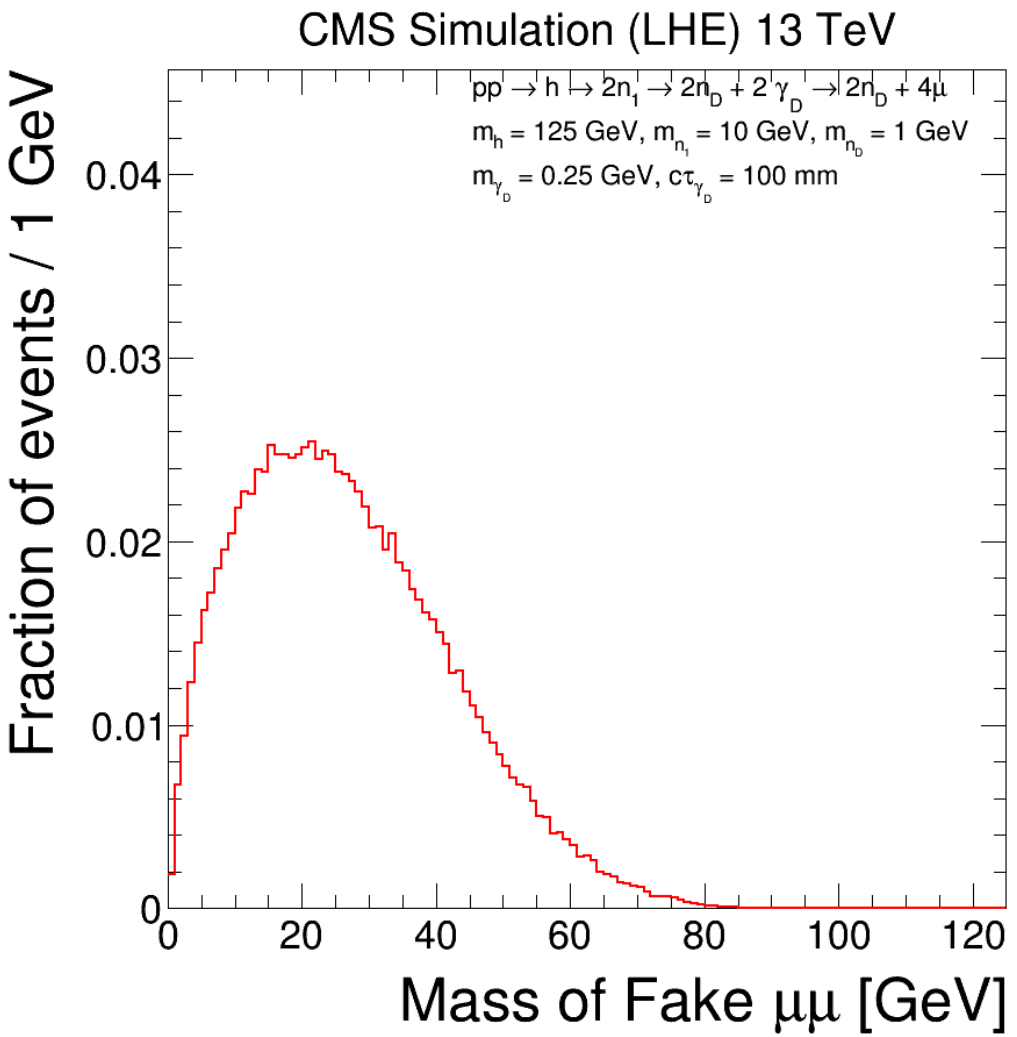

CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
Fraction of events / 0.1 GeV
Mass of Fake μμ [GeV]


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
Fraction of events / 0.1 GeV
Mass of Fake μμ [GeV]

MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0
0.01
0.02
0.03
0.04
0
20
40
60
80
100
120
Mass of Fake μμ [GeV]

MG5


CMS Simulation (LHE) 13 TeV
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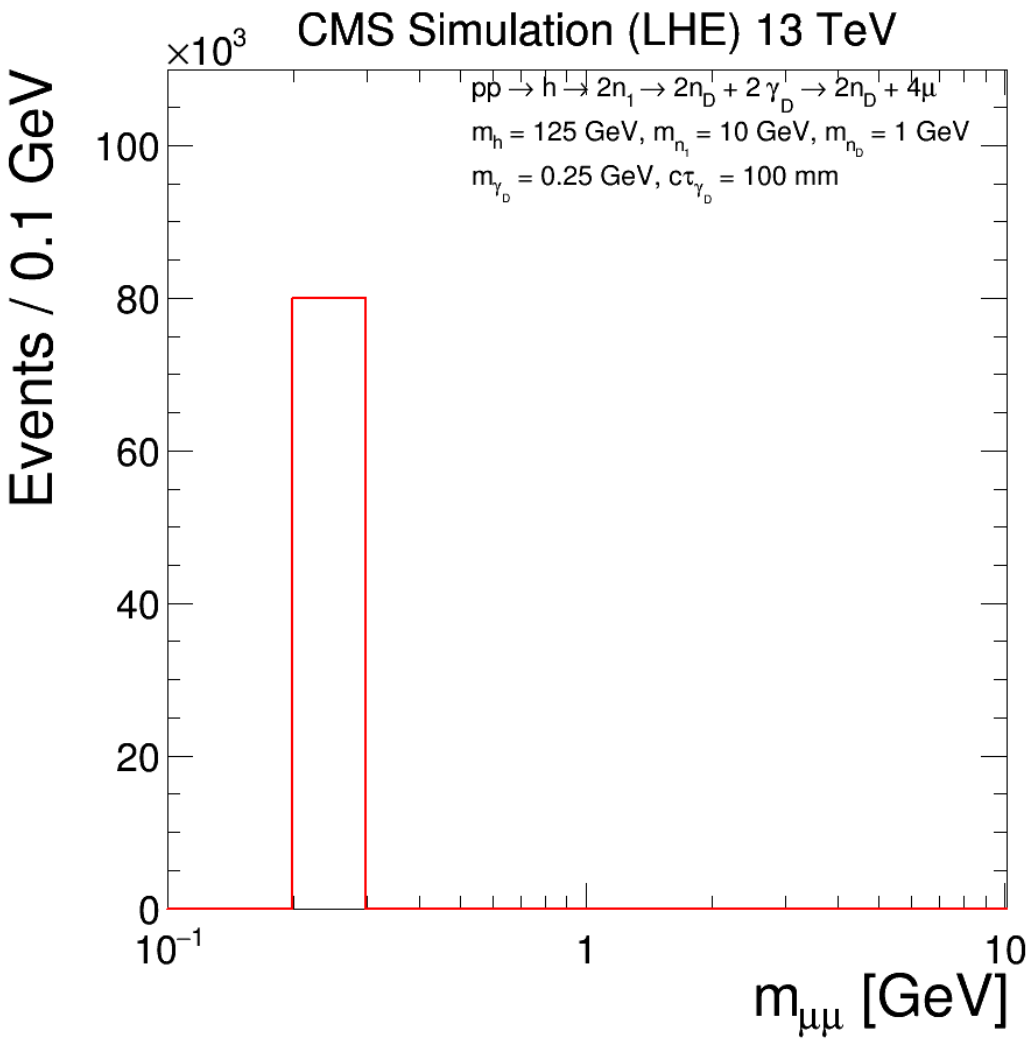
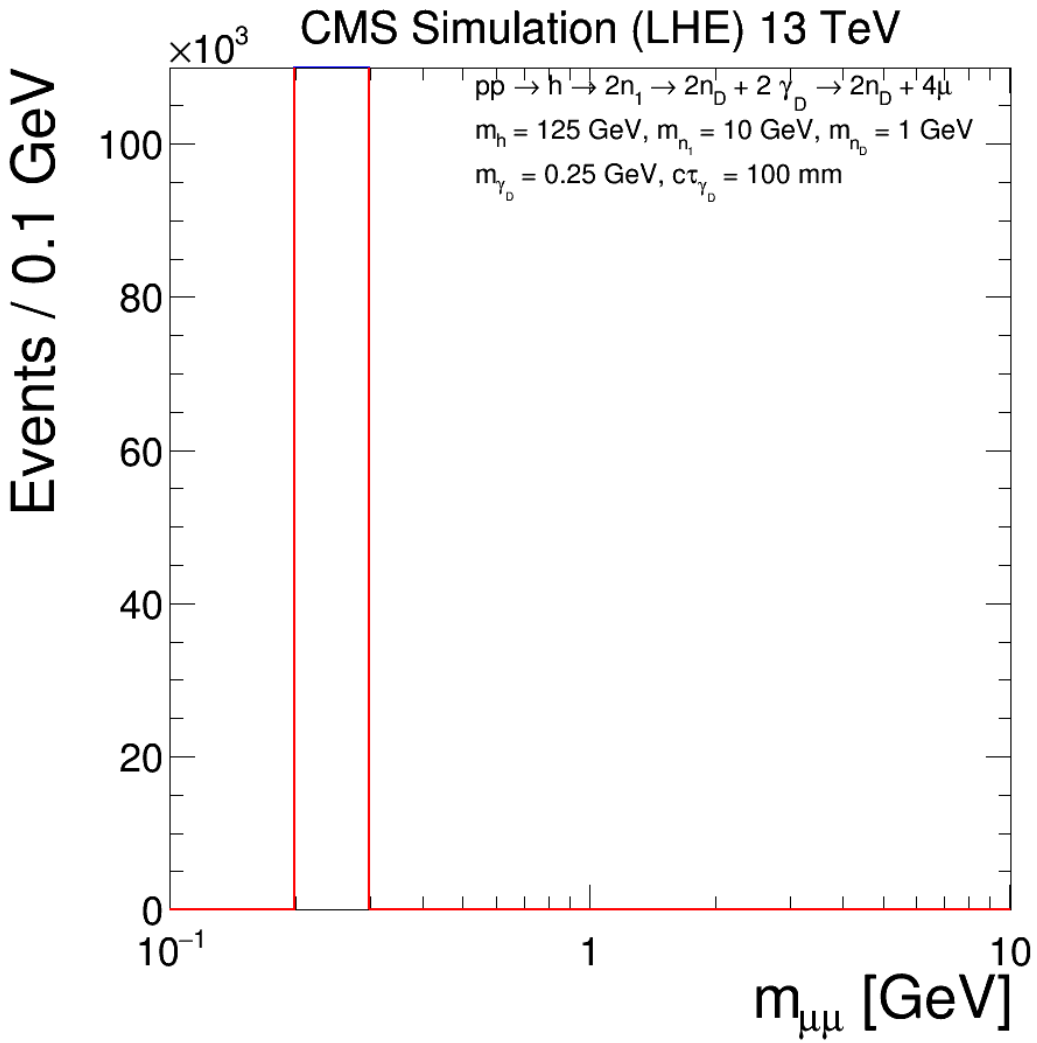
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0
0.01
0.02
0.03
0.04
0
20
40
60
80
100
120
Mass of Fake μμ [GeV]

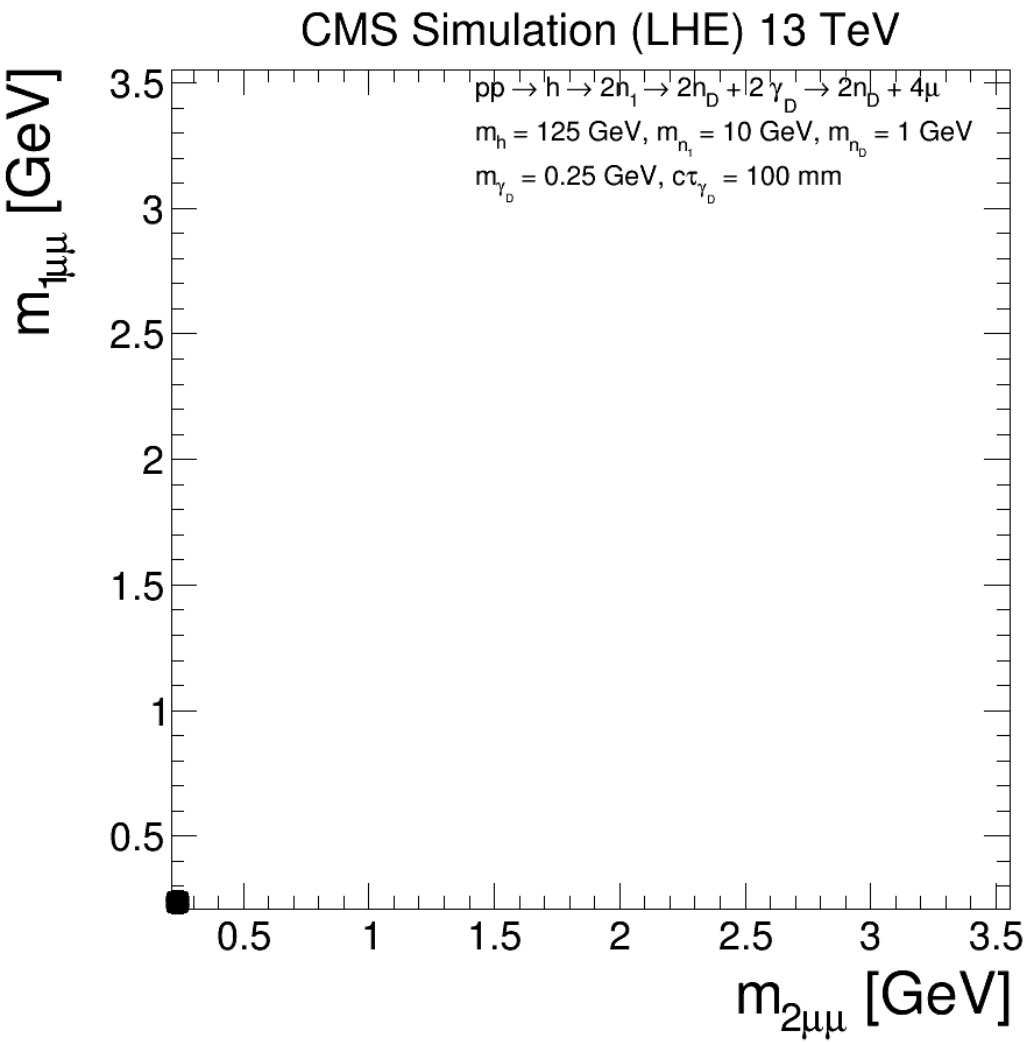
MG4


CMS Simulation (LHE) 13 TeV
×10^3
Events / 0.1 GeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
100
80
60
40
20
0
10^−1
1
10
mμμ [GeV]

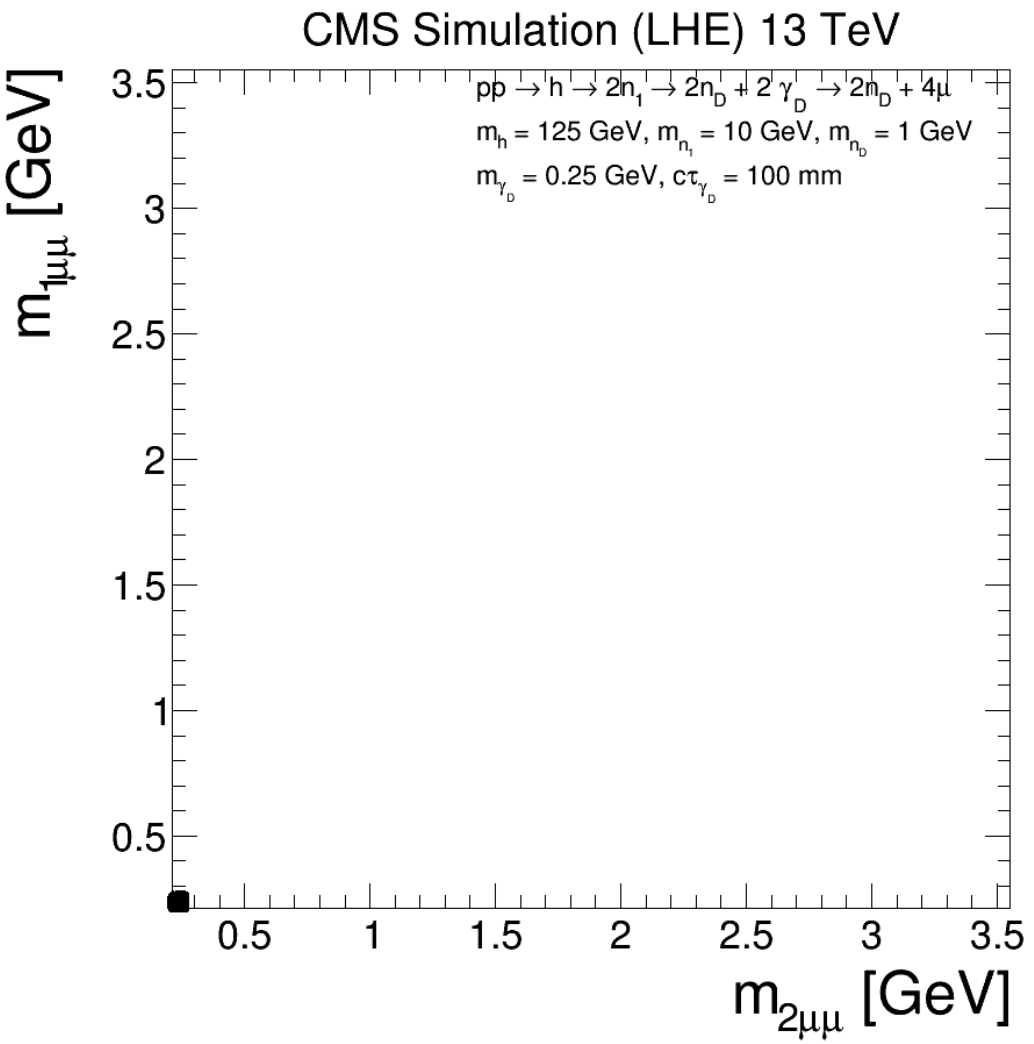
MG5


CMS Simulation (LHE) 13 TeV
×10^3
Events / 0.1 GeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
100
80
60
40
20
0
10^−1
1
10
mμμ [GeV]

MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
$m_{1\mu\mu}$ [GeV]
$m_{2\mu\mu}$ [GeV]
0.5
1
1.5
2
2.5
3
3.5

MG5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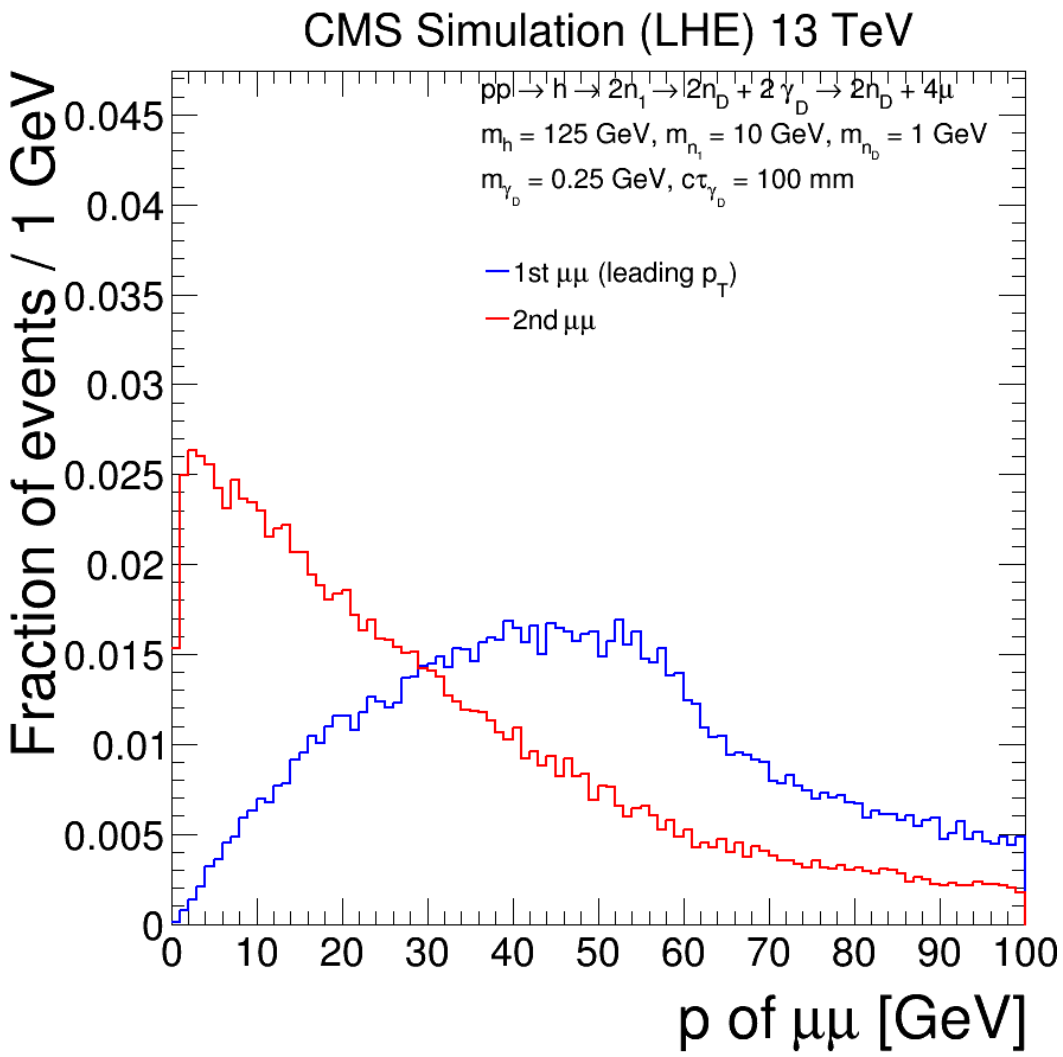
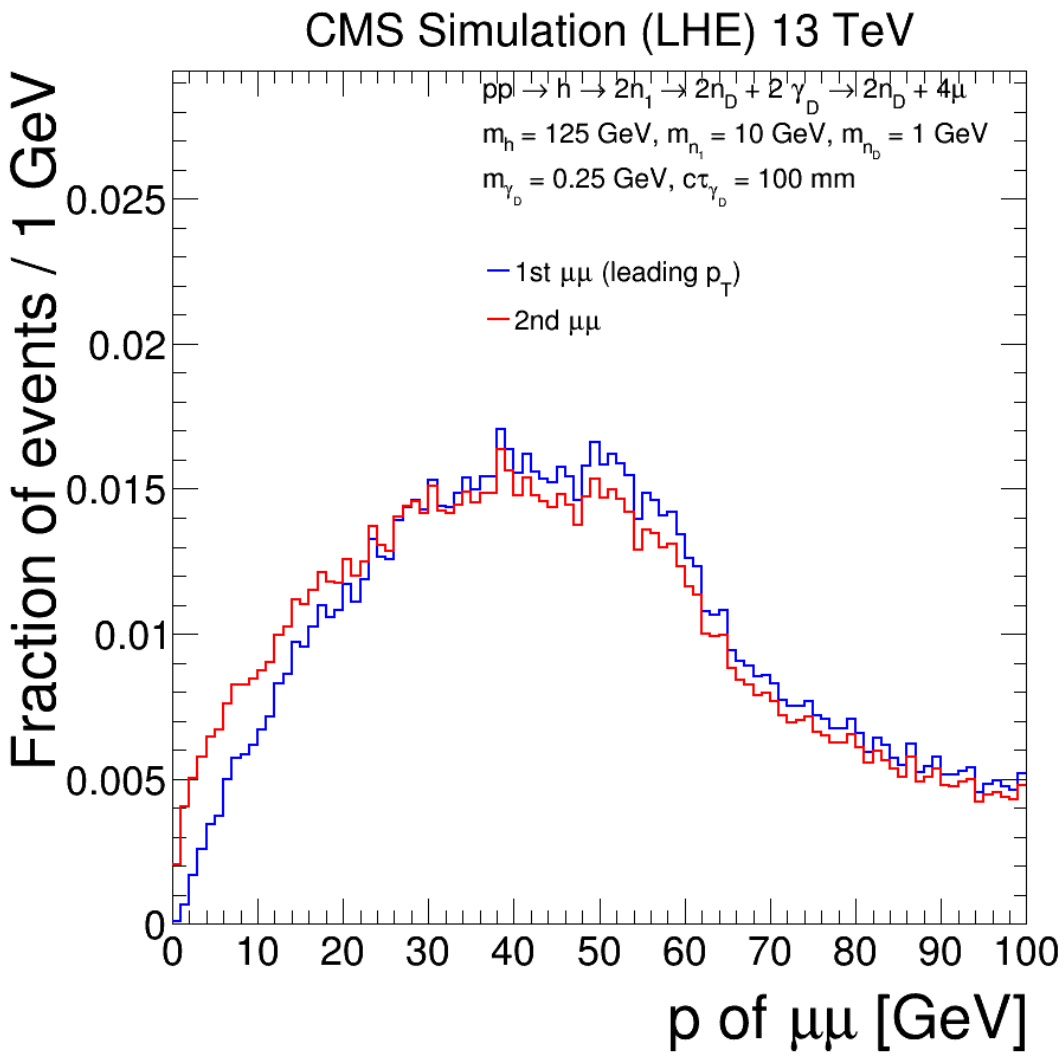
$m_{1\mu\mu}$ [GeV]
$m_{2\mu\mu}$ [GeV]
0.5
1
1.5
2
2.5
3
3.5

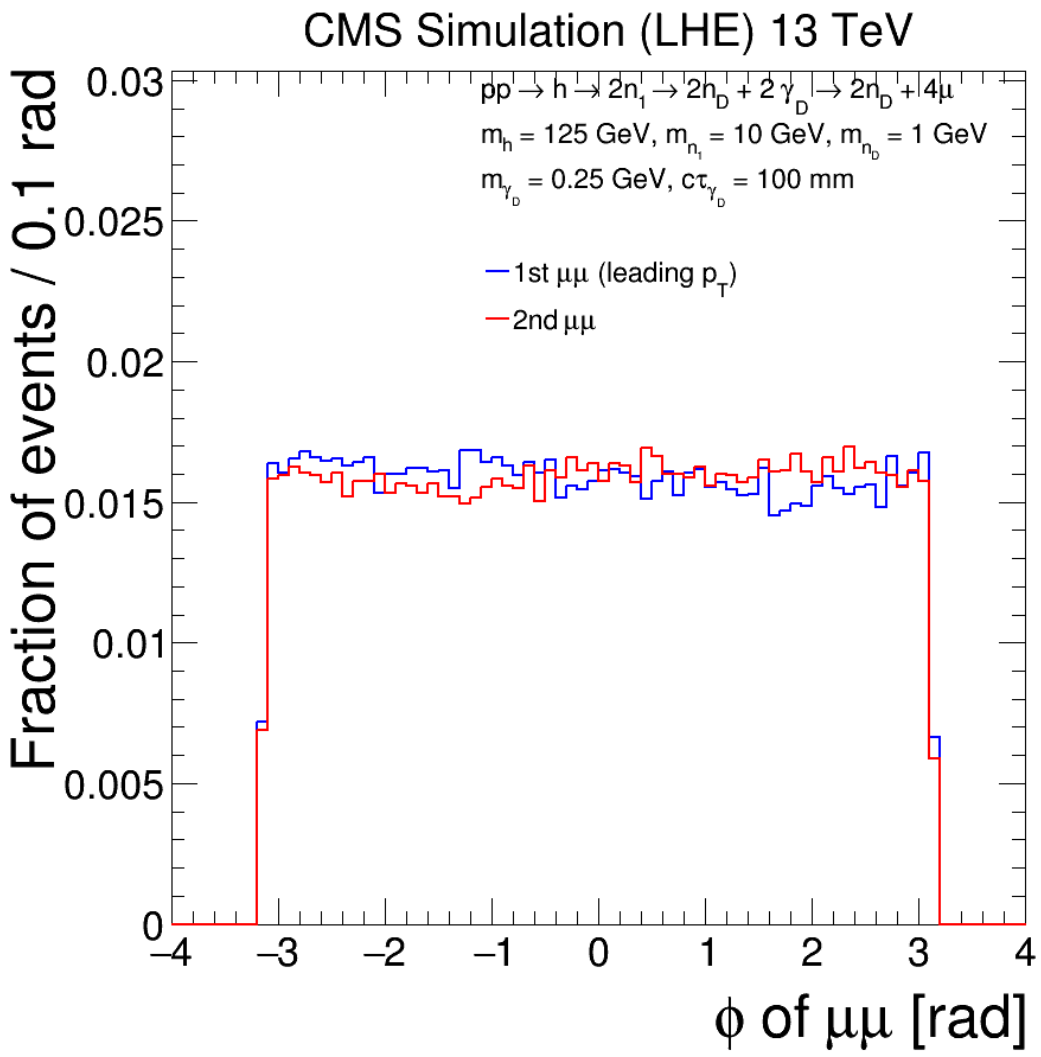
MG4

MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
p of μμ [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
p of μμ [GeV]

MG4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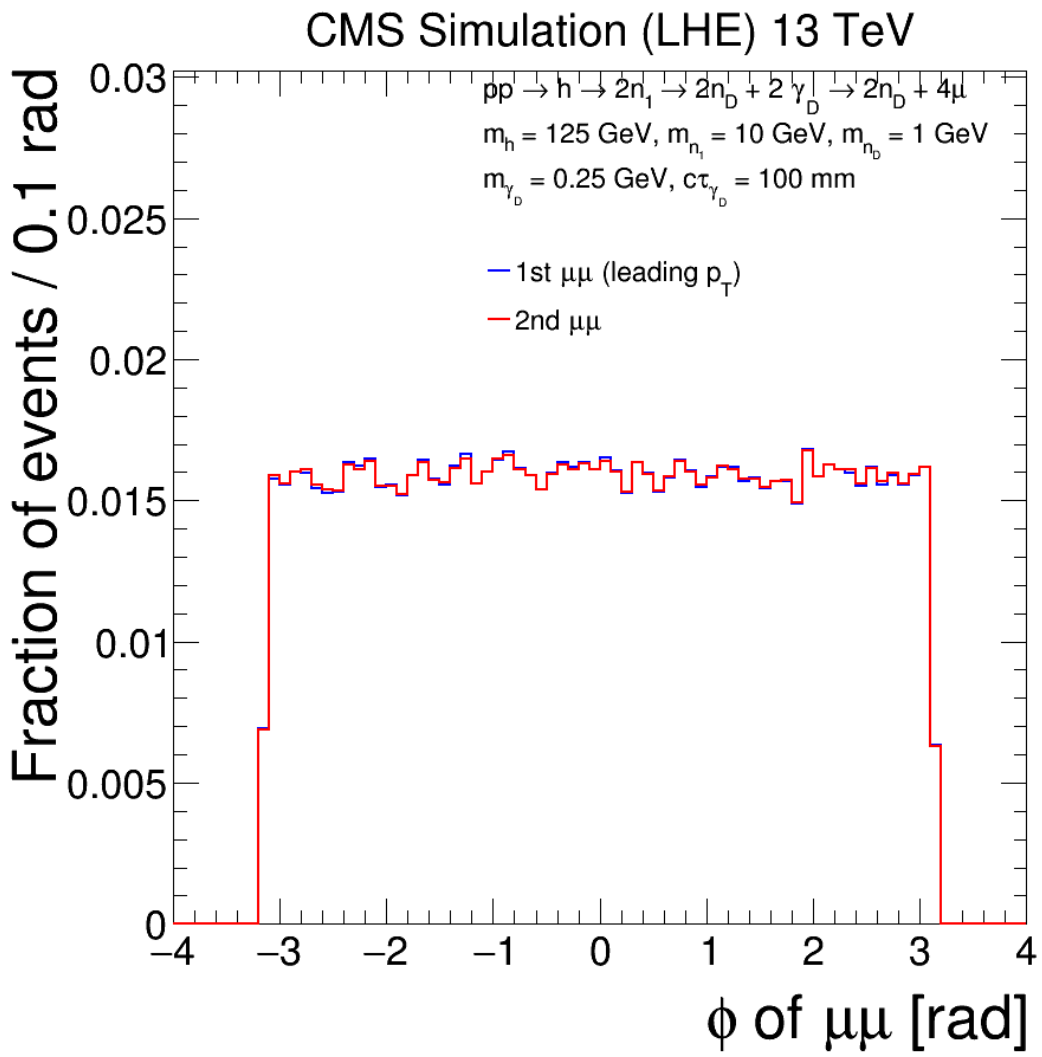
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 0.1 rad
0.03
0.025
0.02
0.015
0.01
0.005
0
−4
−3
−2
−1
0
1
2
3
4
ϕ of μμ [rad]

MG5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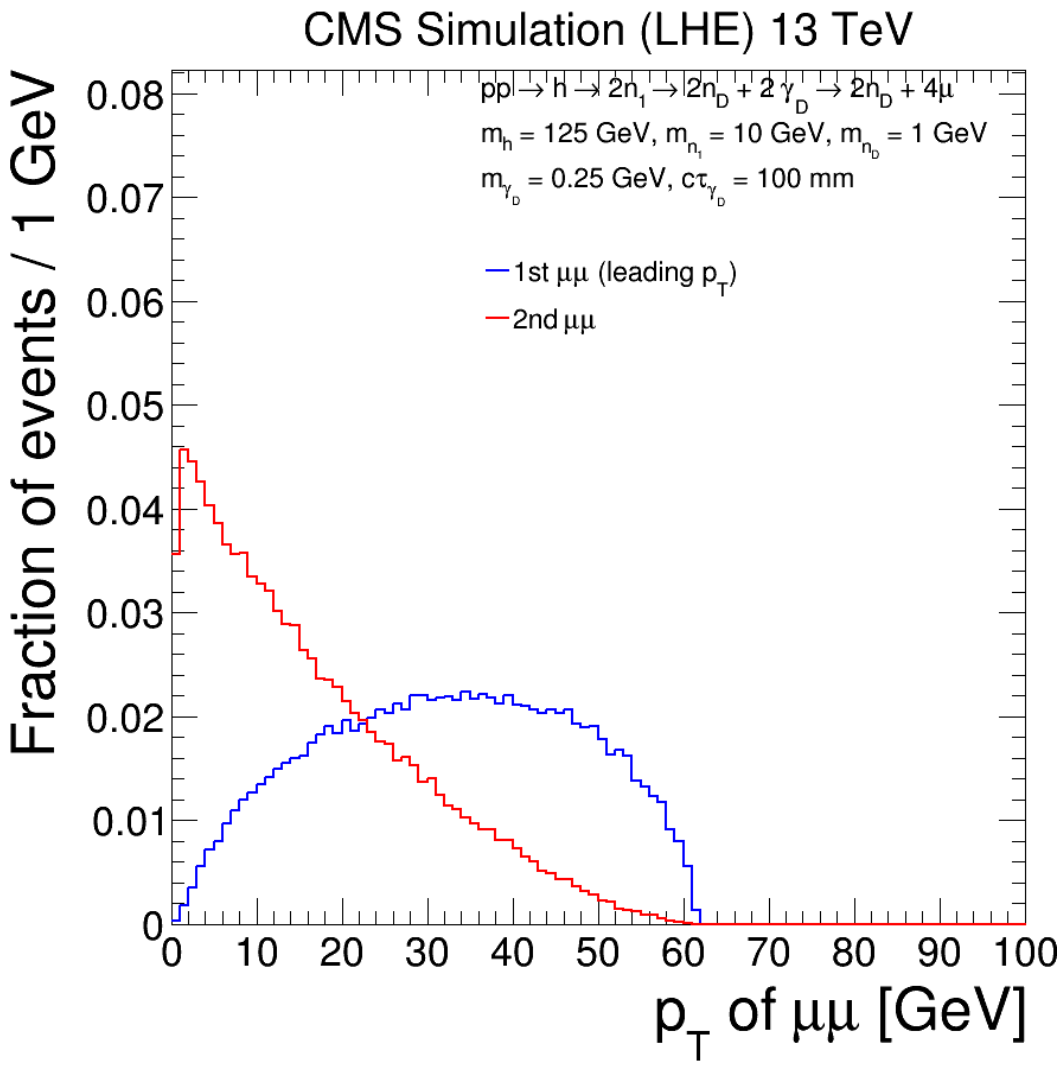
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 0.1 rad
0.03
0.025
0.02
0.015
0.01
0.005
0
−4
−3
−2
−1
0
1
2
3
4
ϕ of μμ [rad]

MG4

MG5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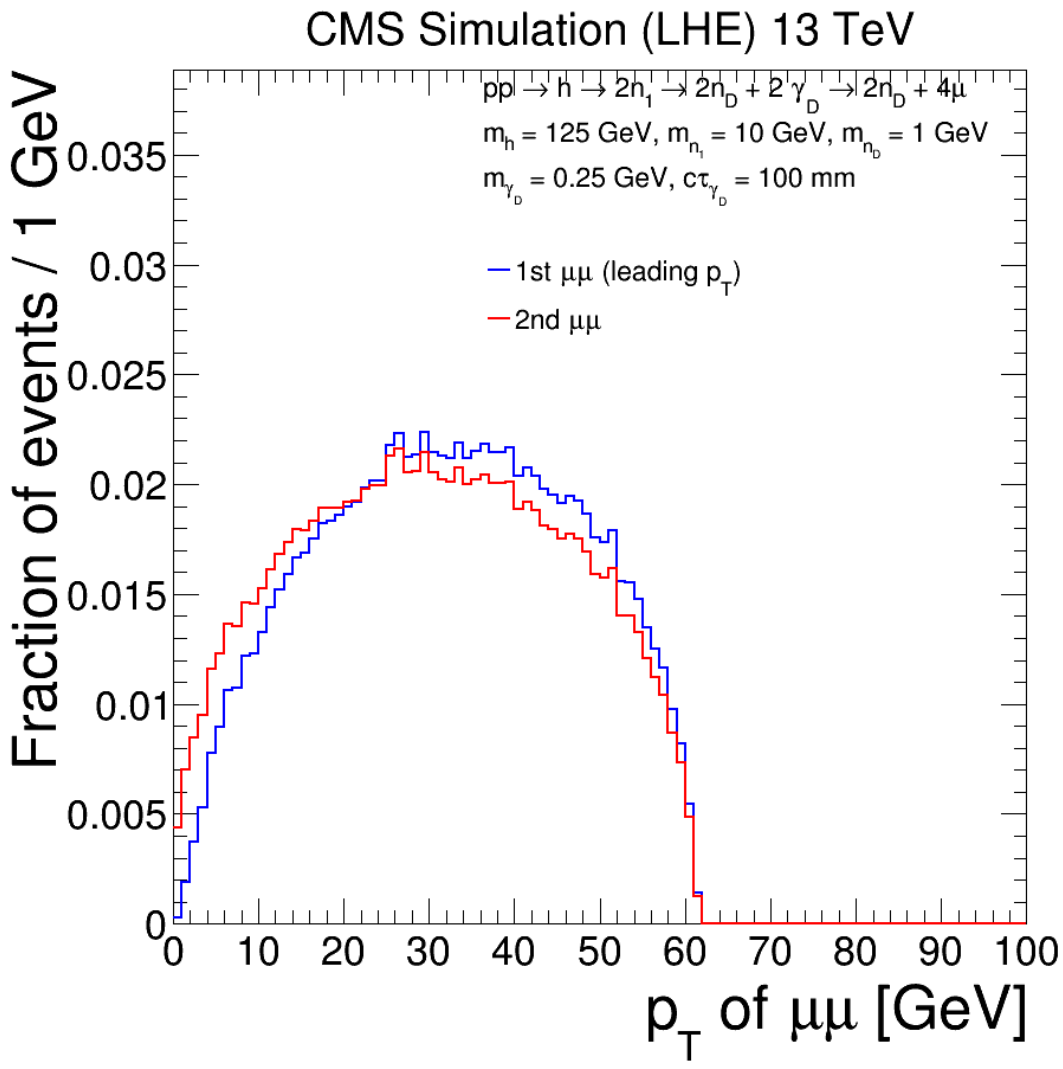
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
p_T of μμ [GeV]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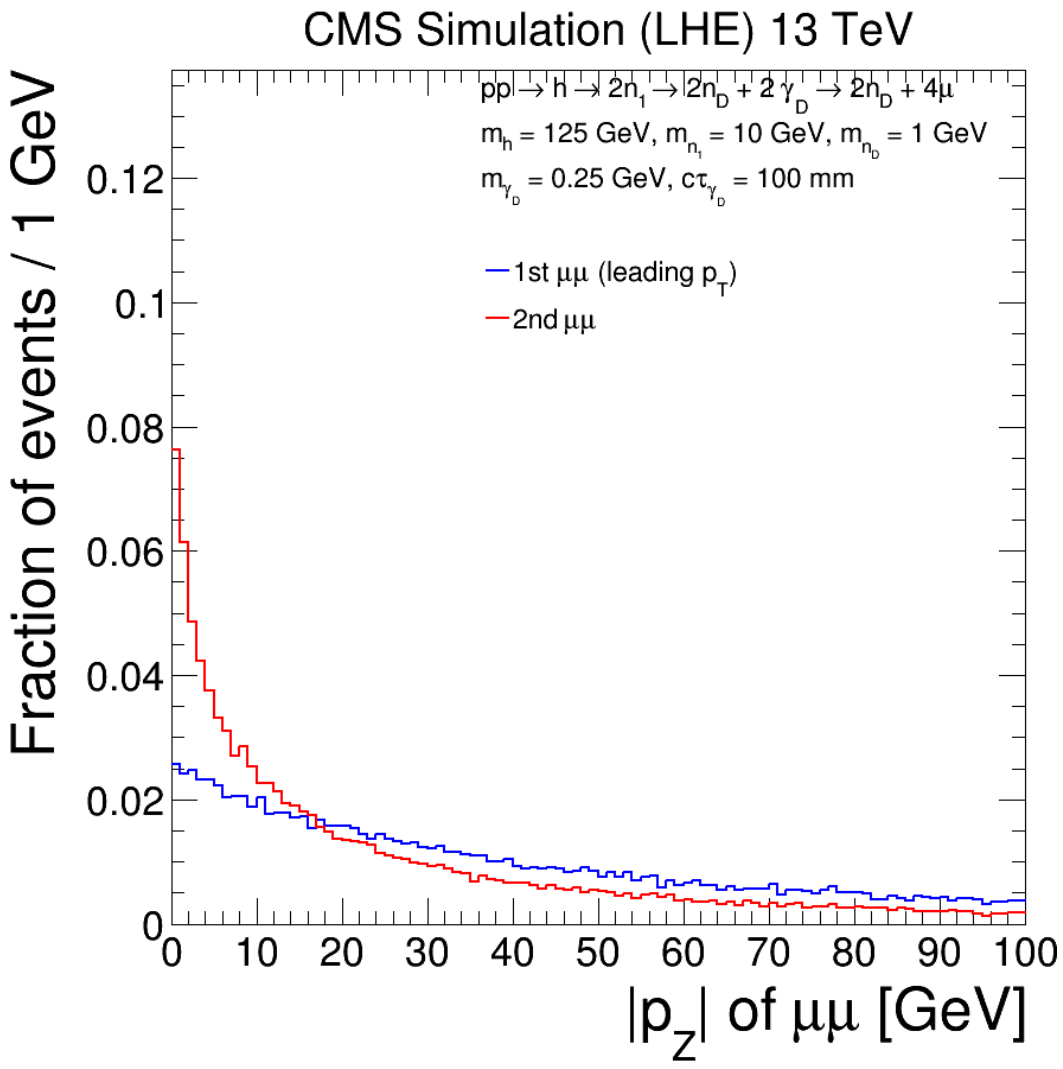
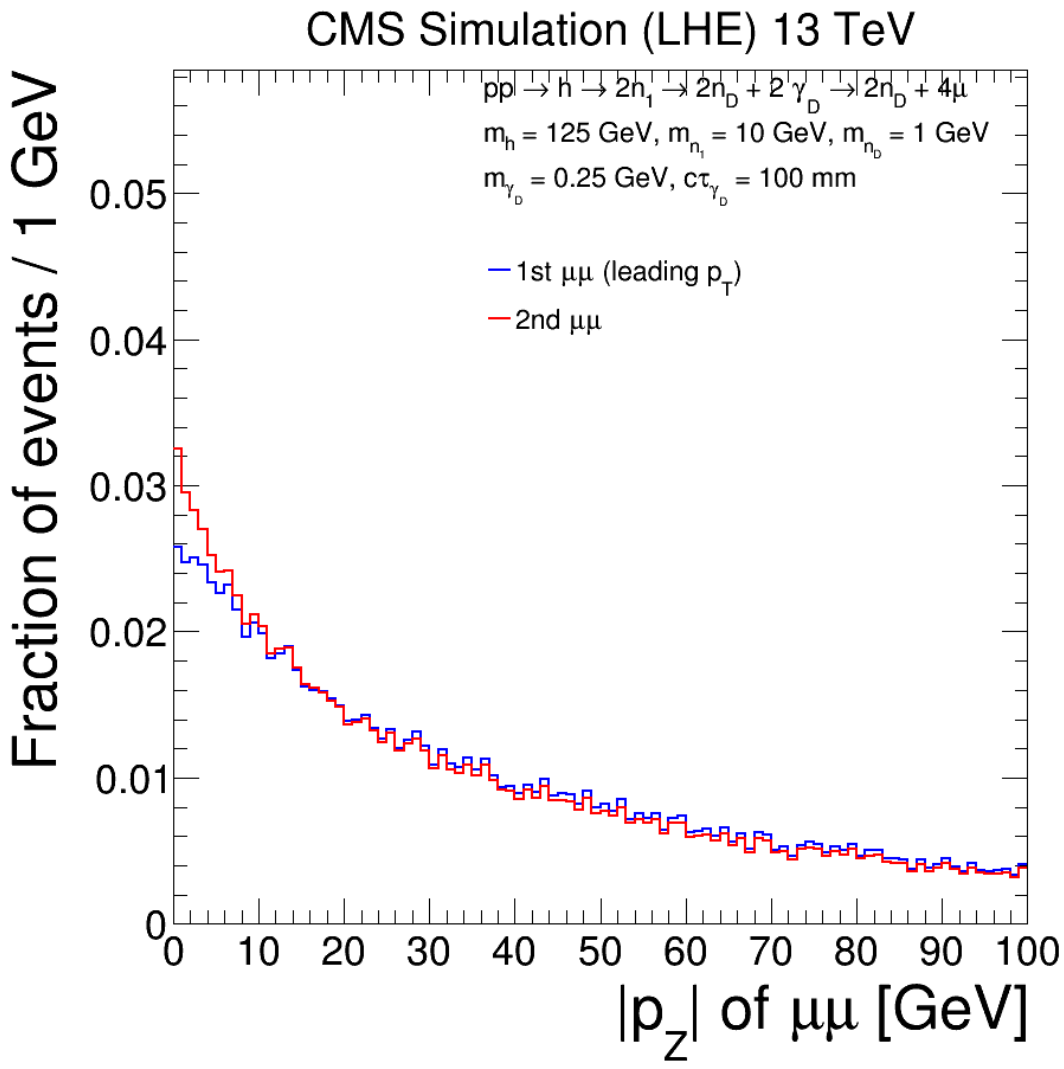
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
p_T of μμ [GeV]

MG4

MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
$|p_z|$ of μμ [GeV]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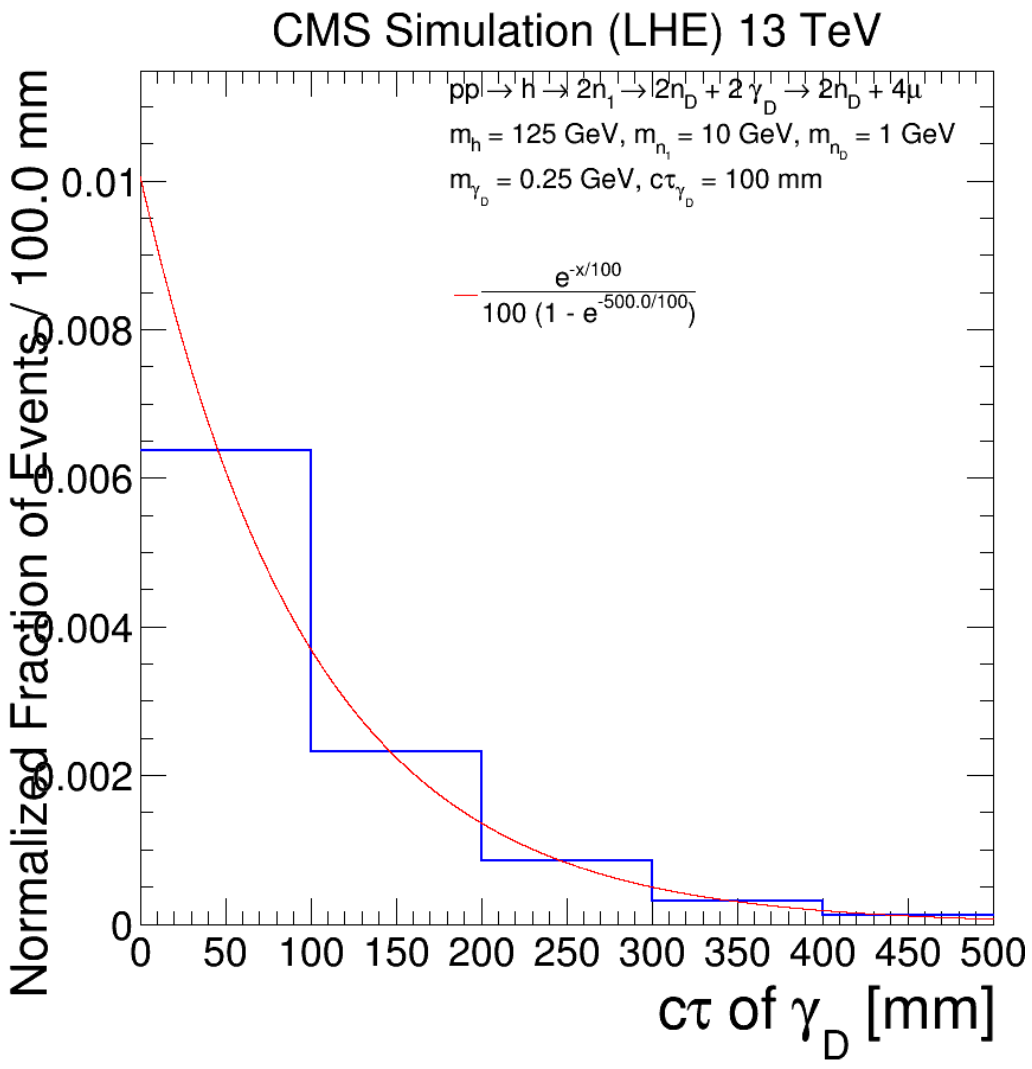
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st μμ (leading p_T)
2nd μμ
Fraction of events / 1 GeV
$|p_z|$ of μμ [GeV]

MG4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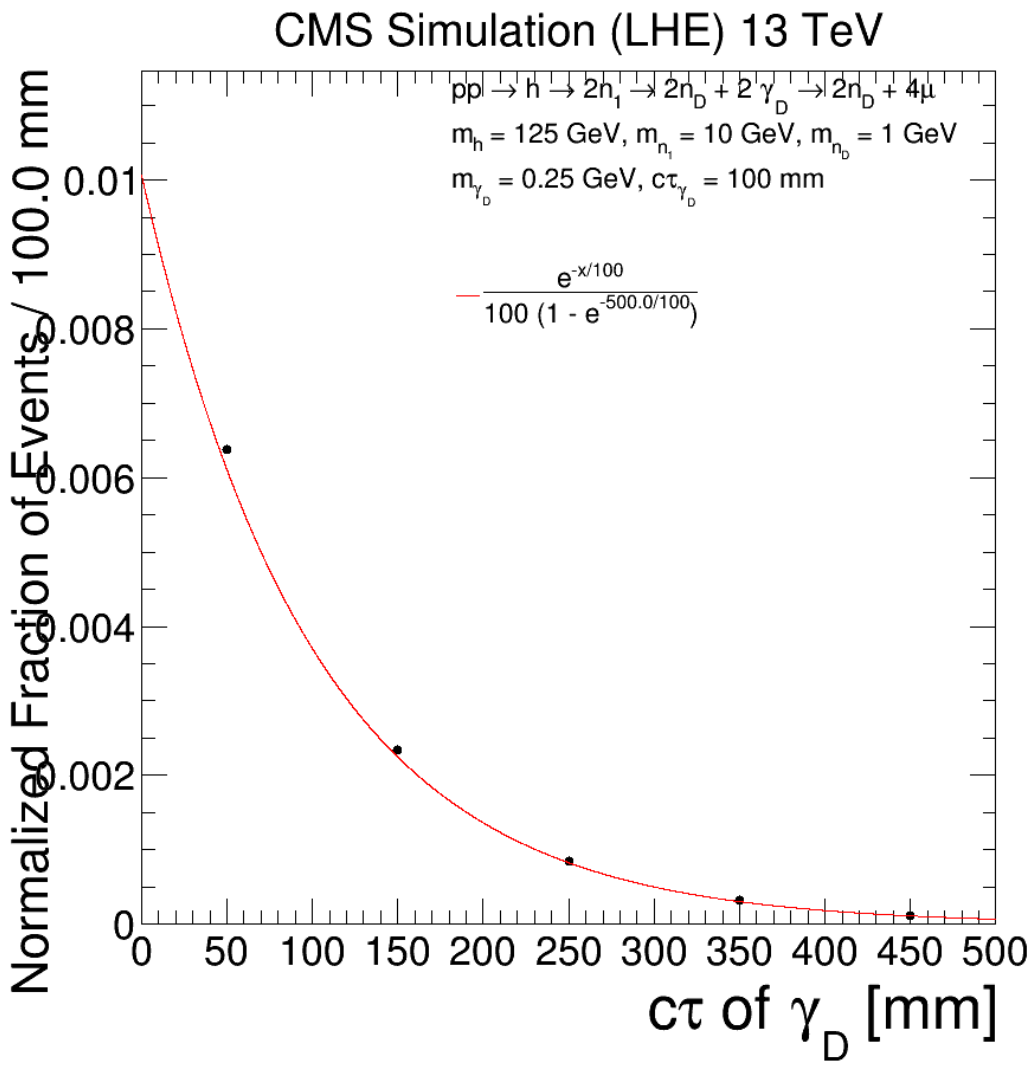
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
$\frac{e^{-x/100}}{100\,(1 - e^{-500.0/100})}$
Normalized Fraction of Events / 100.0 mm
0
0.002
0.004
0.006
0.008
0.01
0 50 100 150 200 250 300 350 400 450 500
$c\tau$ of γ_D [mm]

MG5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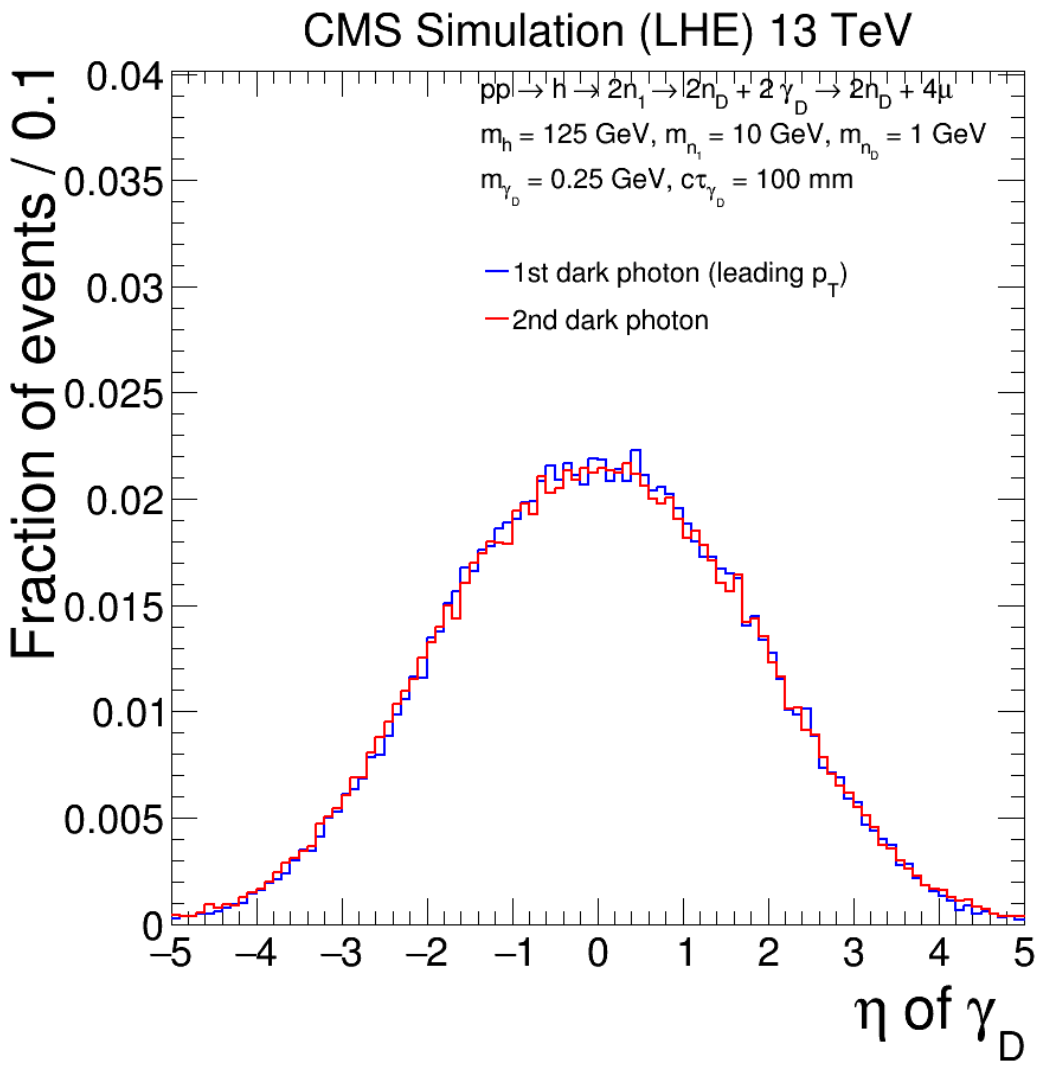
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
$\frac{e^{-x/100}}{100\,(1 - e^{-500.0/100})}$
Normalized Fraction of Events / 100.0 mm
0
0.002
0.004
0.006
0.008
0.01
0 50 100 150 200 250 300 350 400 450 500
$c\tau$ of γ_D [mm]

MG4

MG5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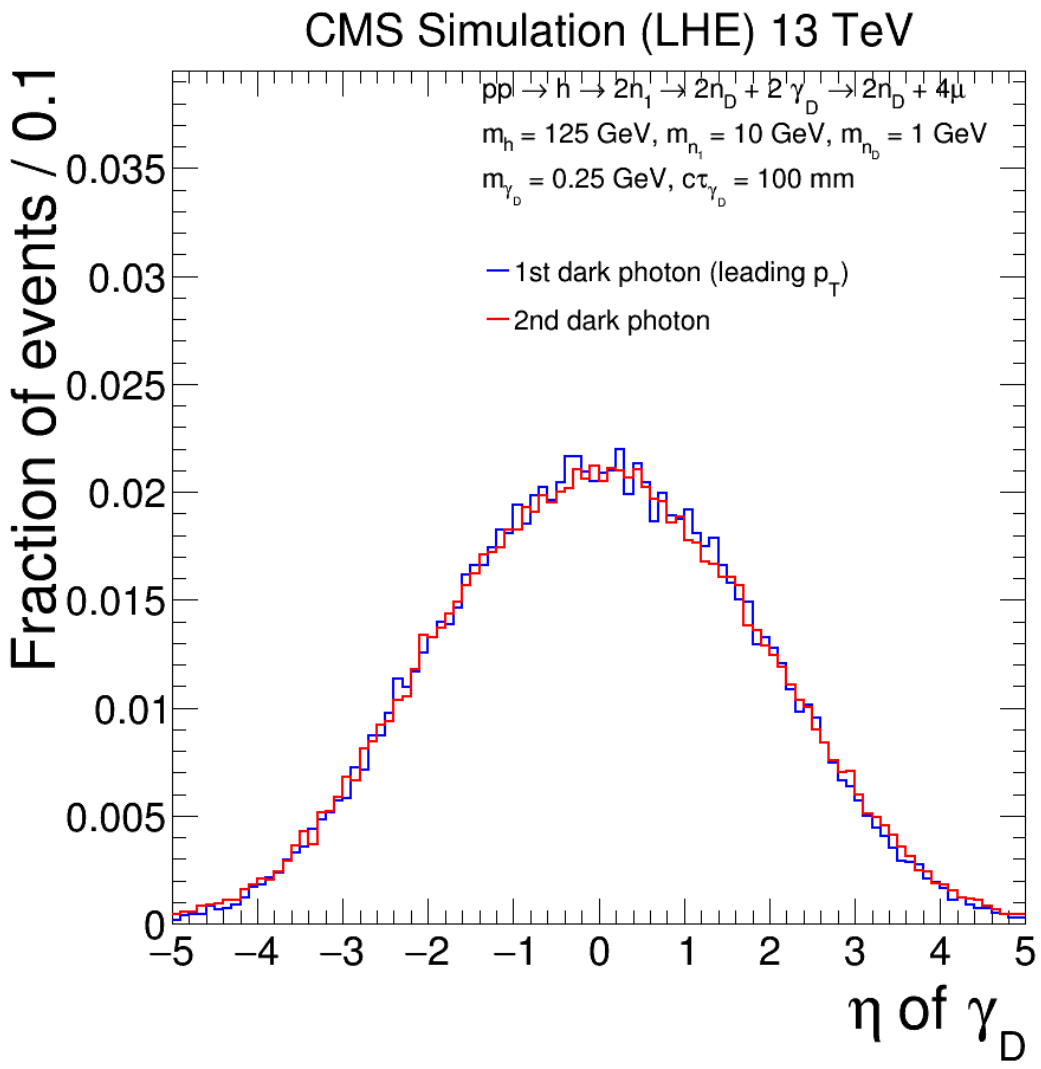
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 0.1
η of γ_D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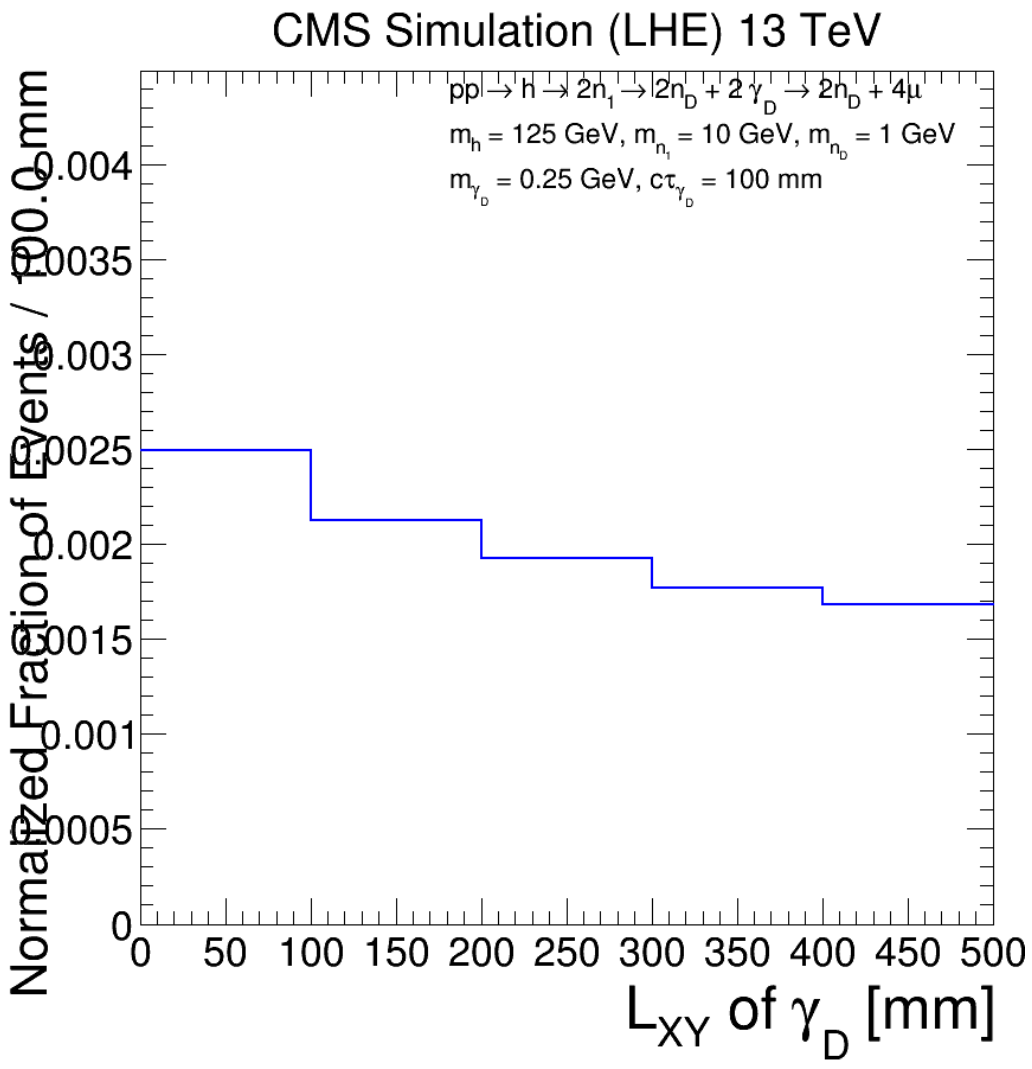
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 0.1
η of γ_D

MG4

MG5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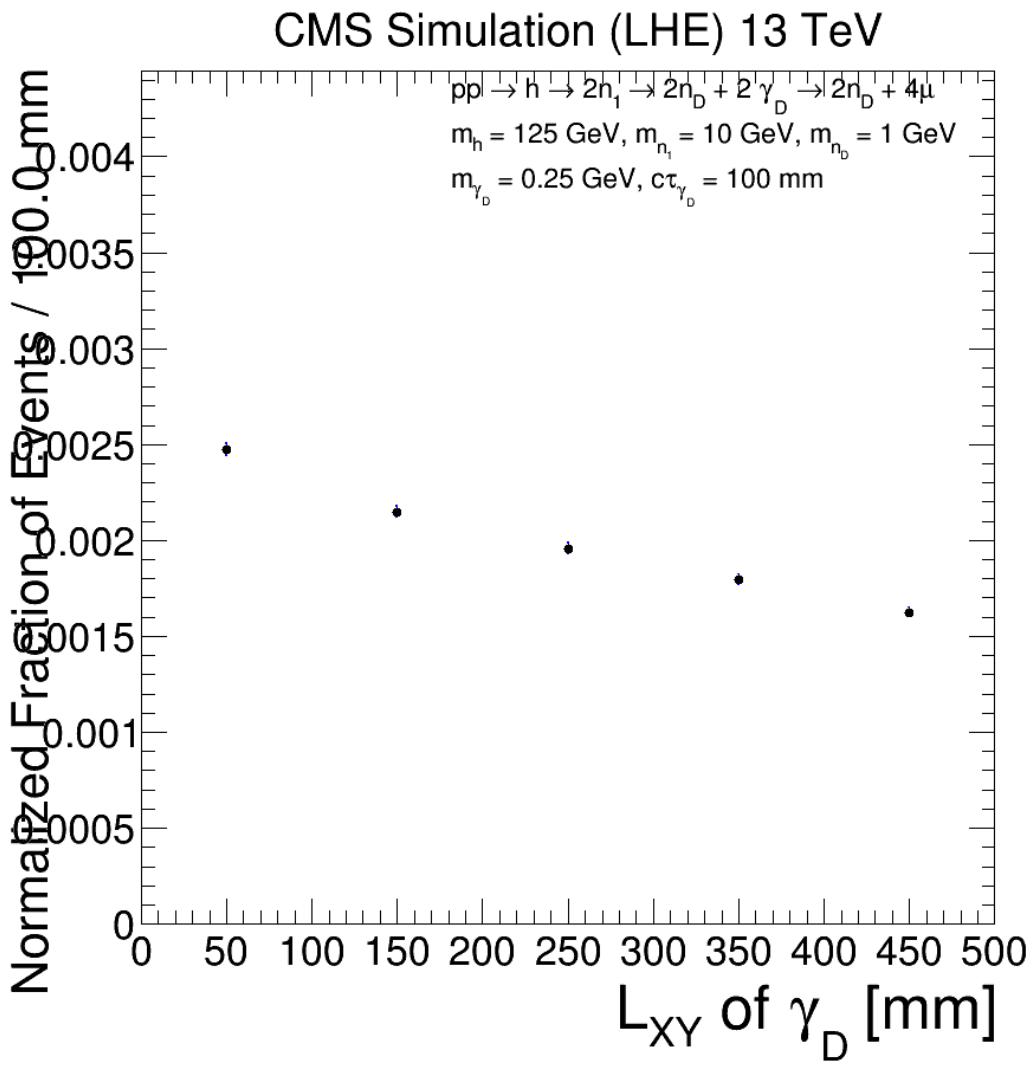
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Normalized Fraction of Events / 100.0 mm
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035
0.004
0 50 100 150 200 250 300 350 400 450 500
L_{XY} of γ_D [mm]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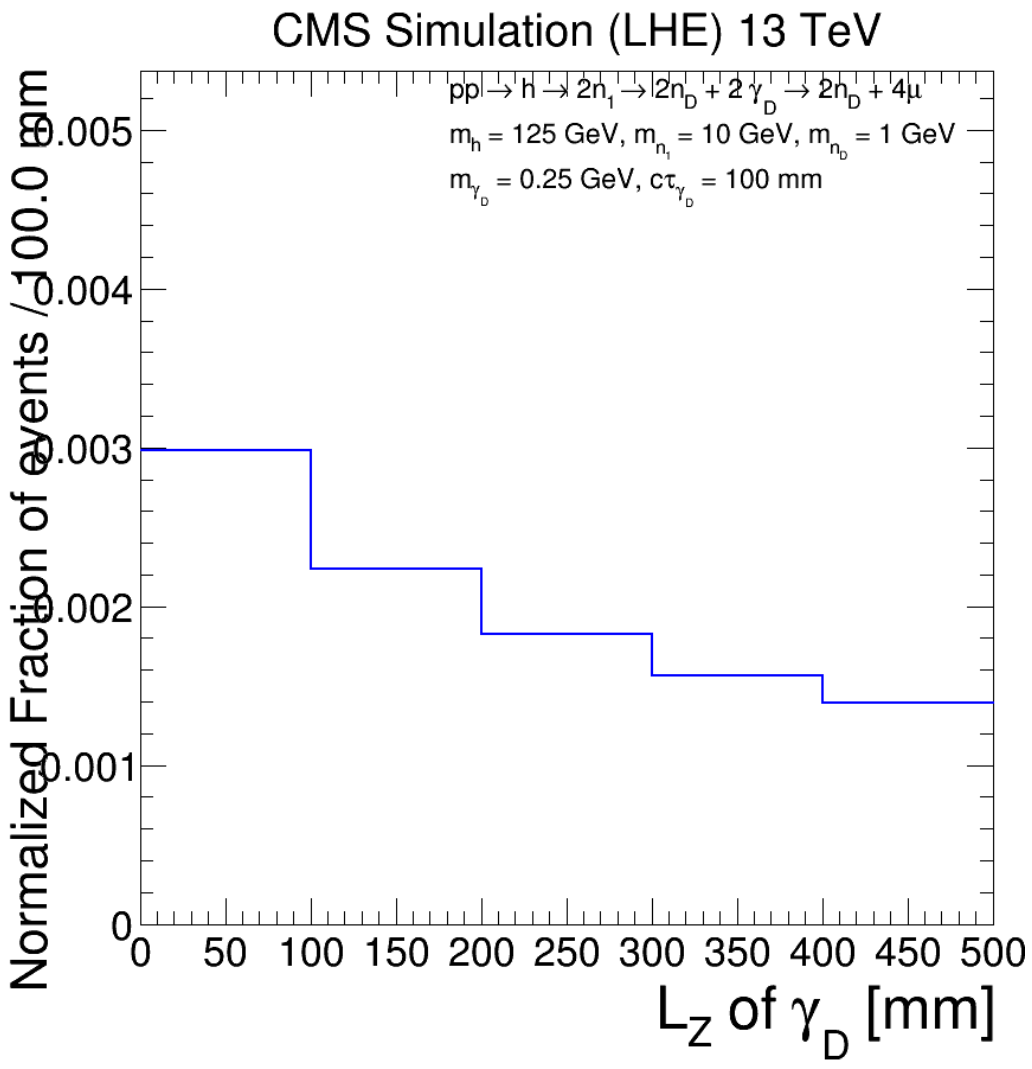
Normalized Fraction of Events / 100.0 mm
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035
0.004
0 50 100 150 200 250 300 350 400 450 500
L_{XY} of γ_D [mm]

MG4

MG5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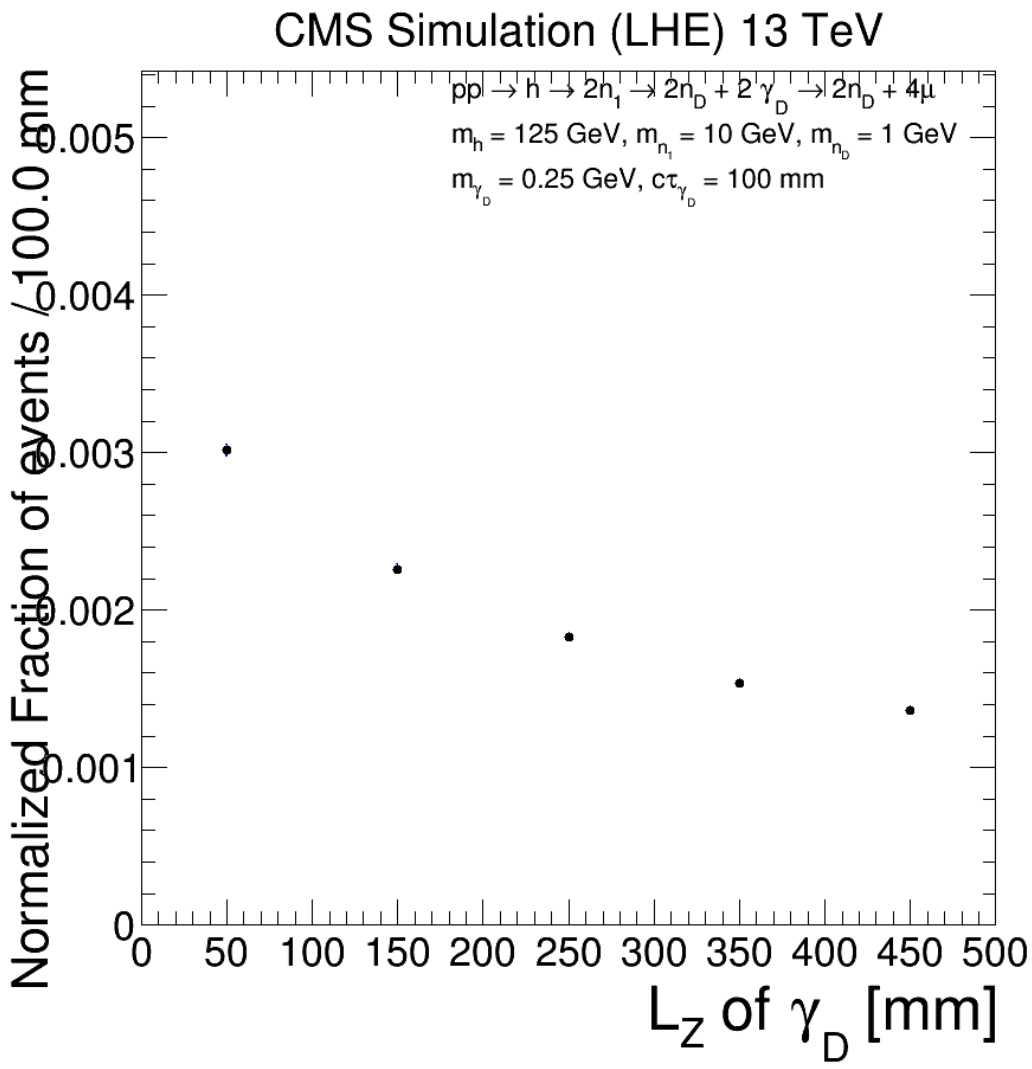
Normalized Fraction of events / 100.0 mm
0
0.001
0.002
0.003
0.004
0.005
0 50 100 150 200 250 300 350 400 450 500
L_Z of γ_D [mm]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Normalized Fraction of events / 100.0 mm
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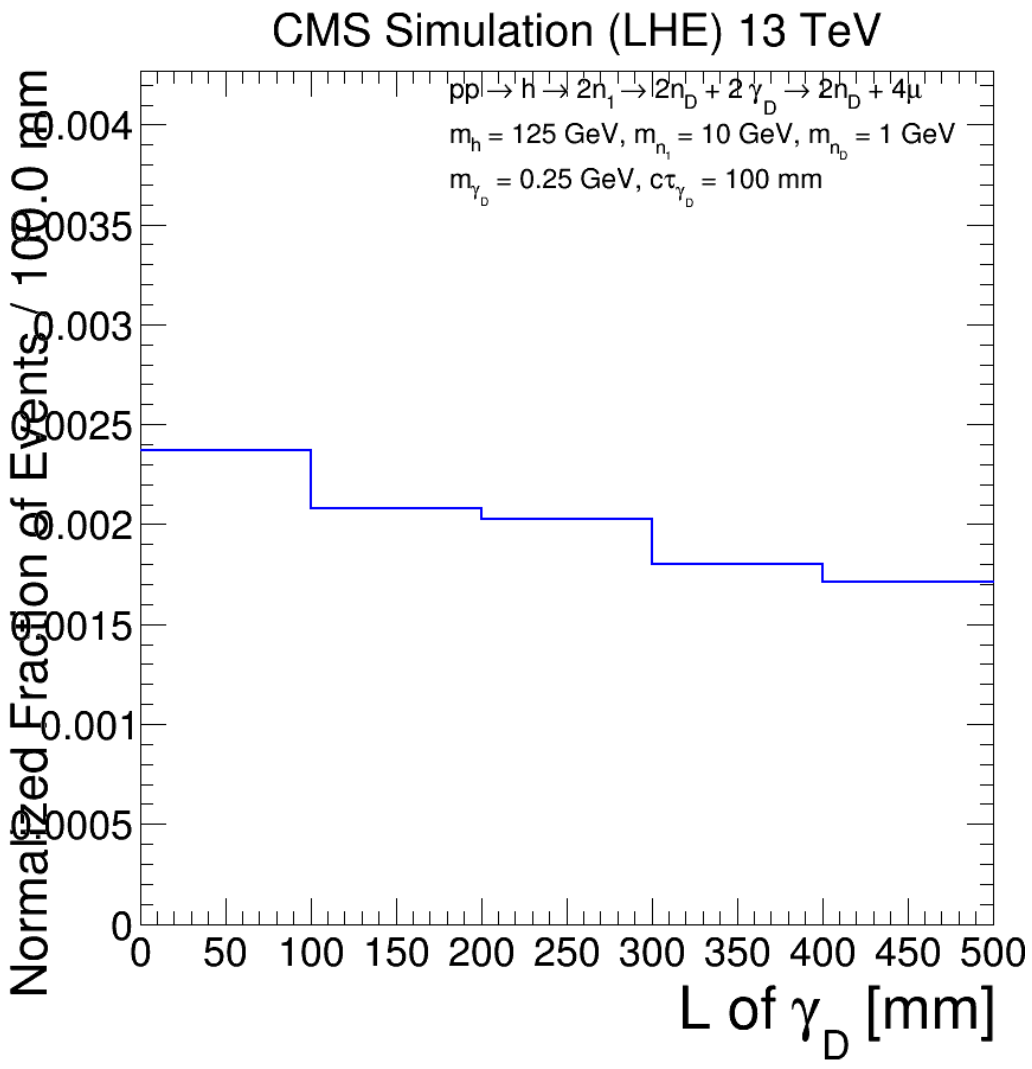
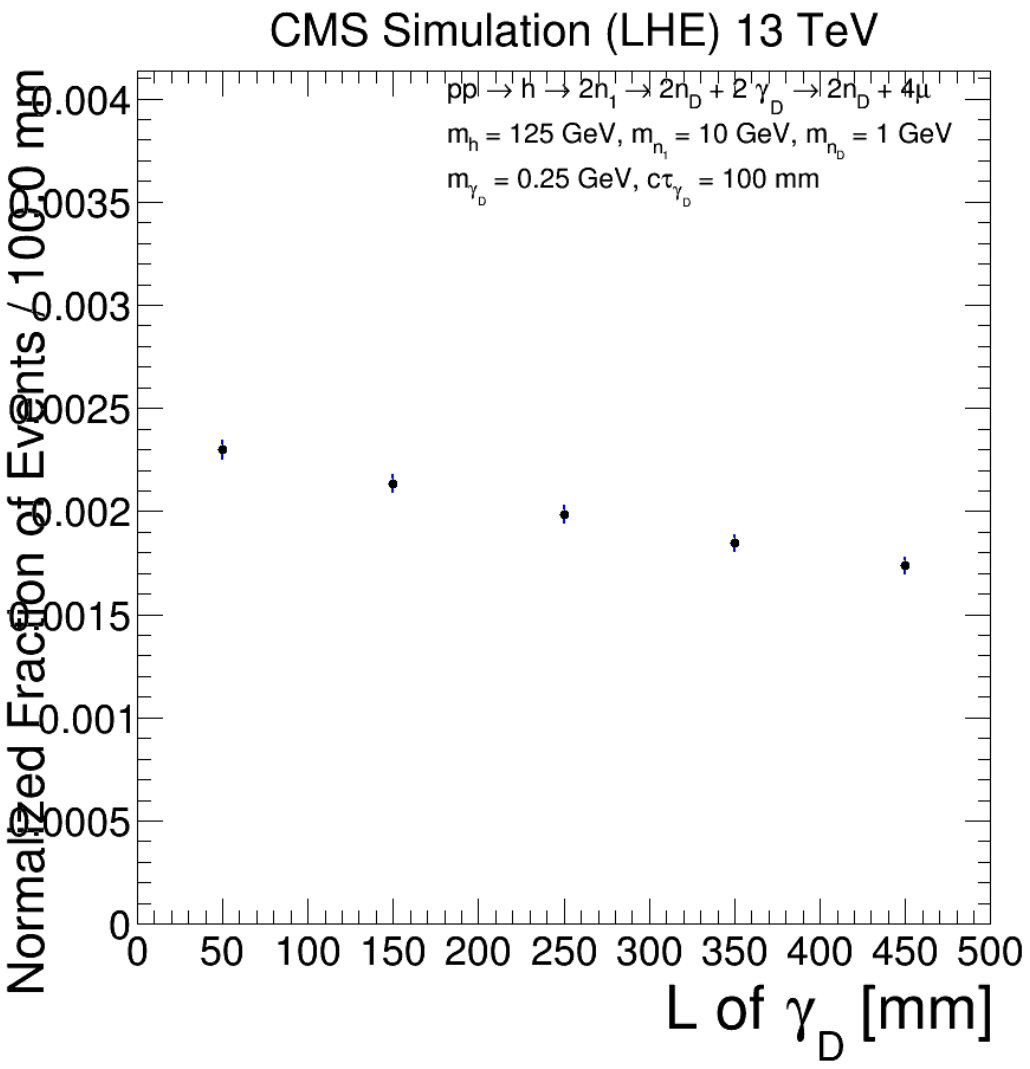
0.001
0.002
0.003
0.004
0.005
0 50 100 150 200 250 300 350 400 450 500
L_Z of γ_D [mm]

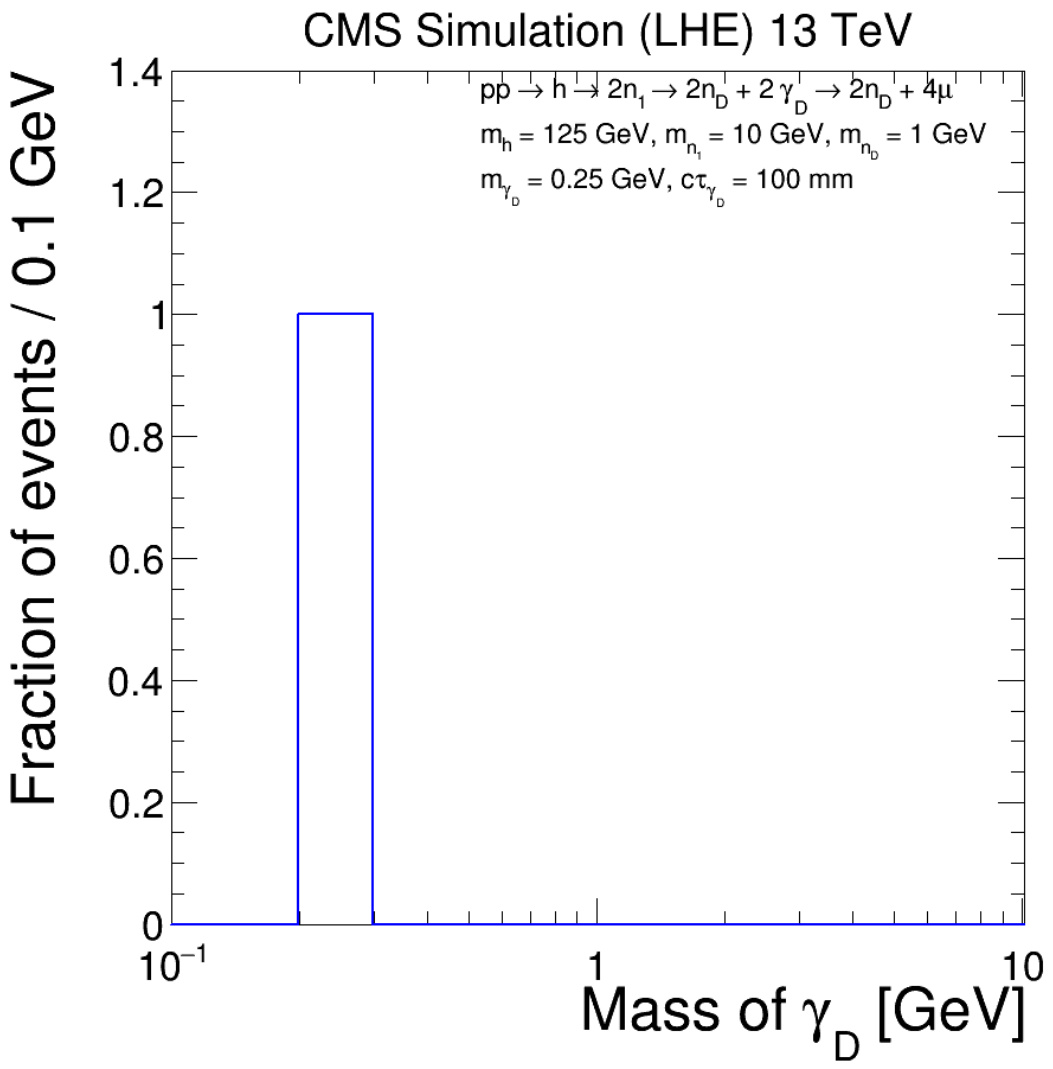
MG4

MG5

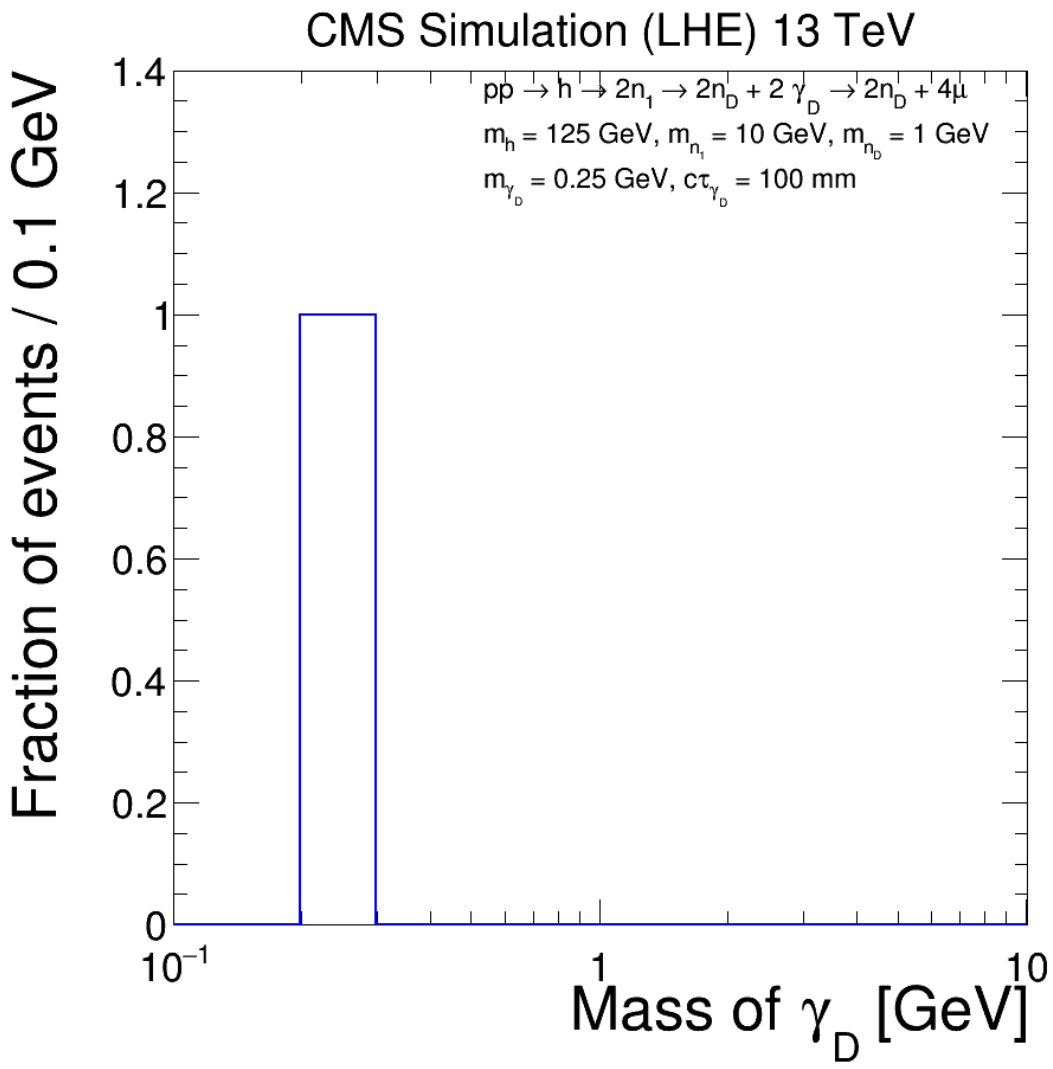

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Normalized Fraction of Events / 100.0 mm
L of γ_D [mm]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Normalized Fraction of Events / 100.0 mm
L of γ_D [mm]

MG4

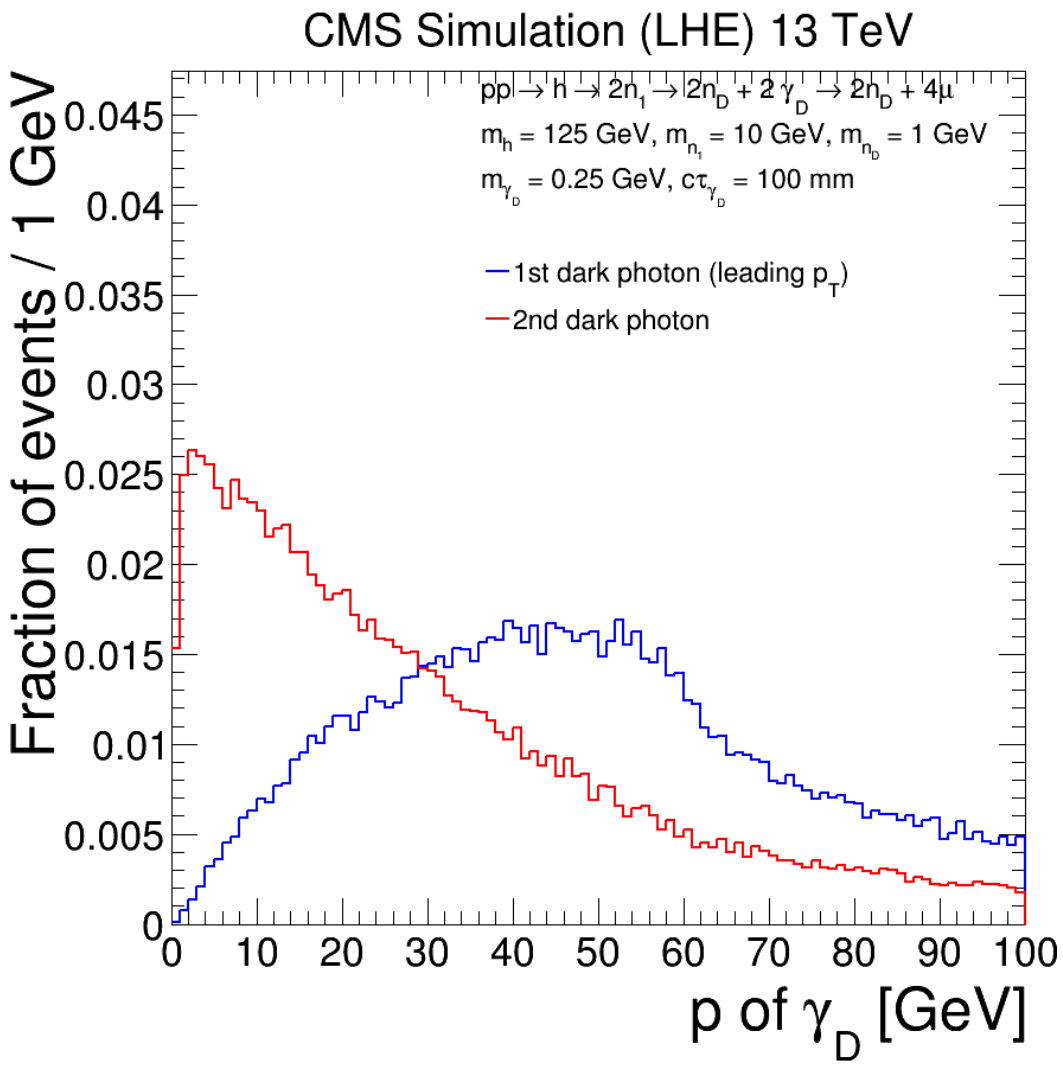

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of γ_D [GeV]

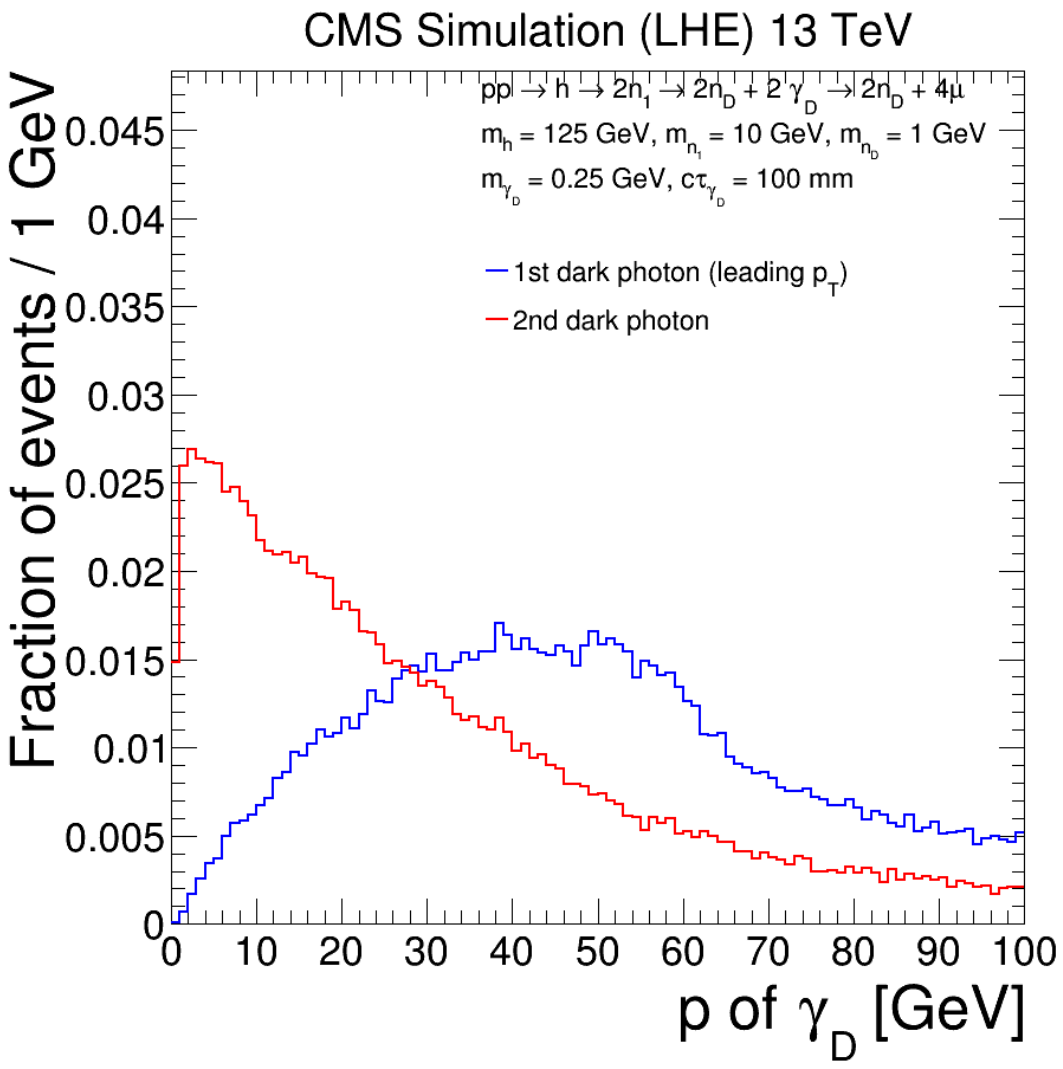
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of γ_D [GeV]

MG4

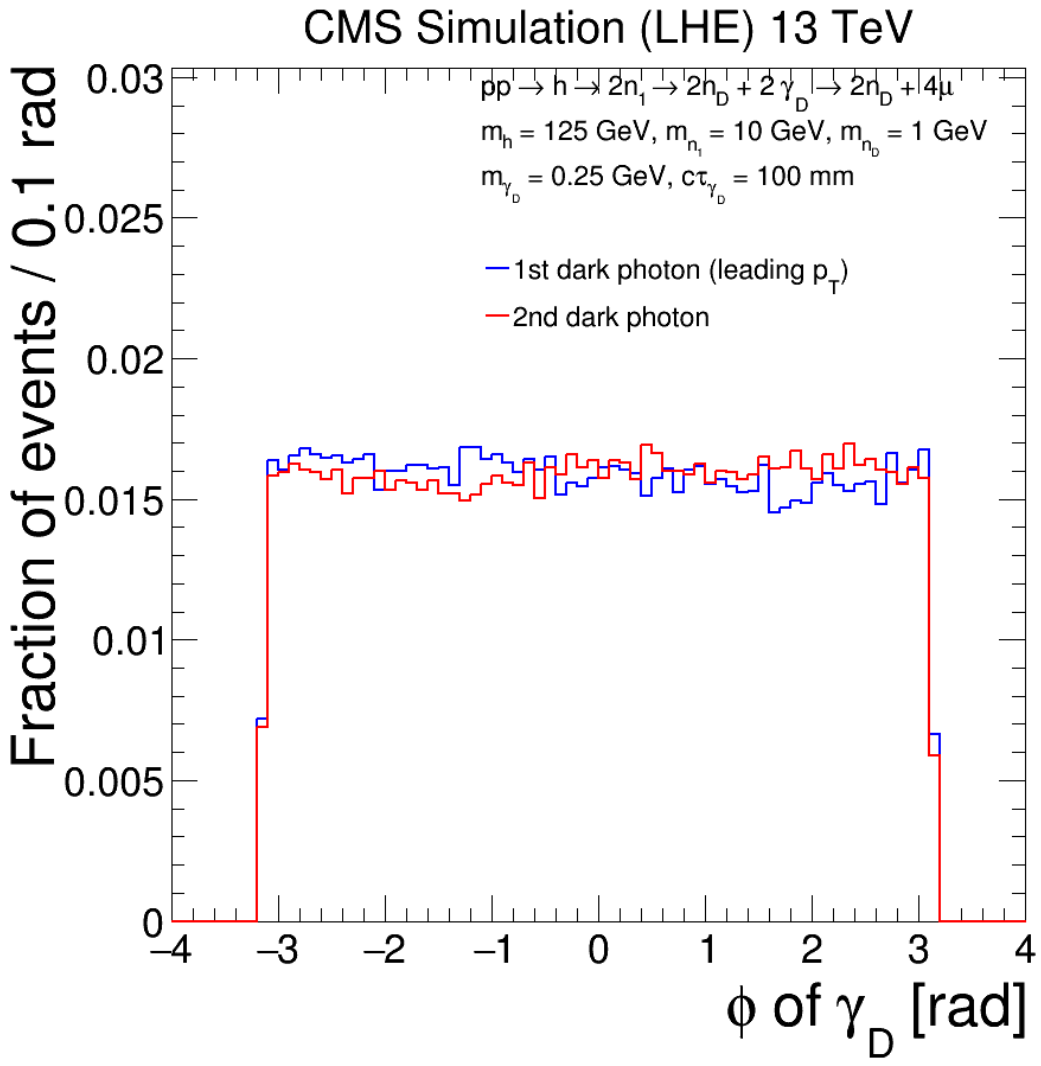
MG5

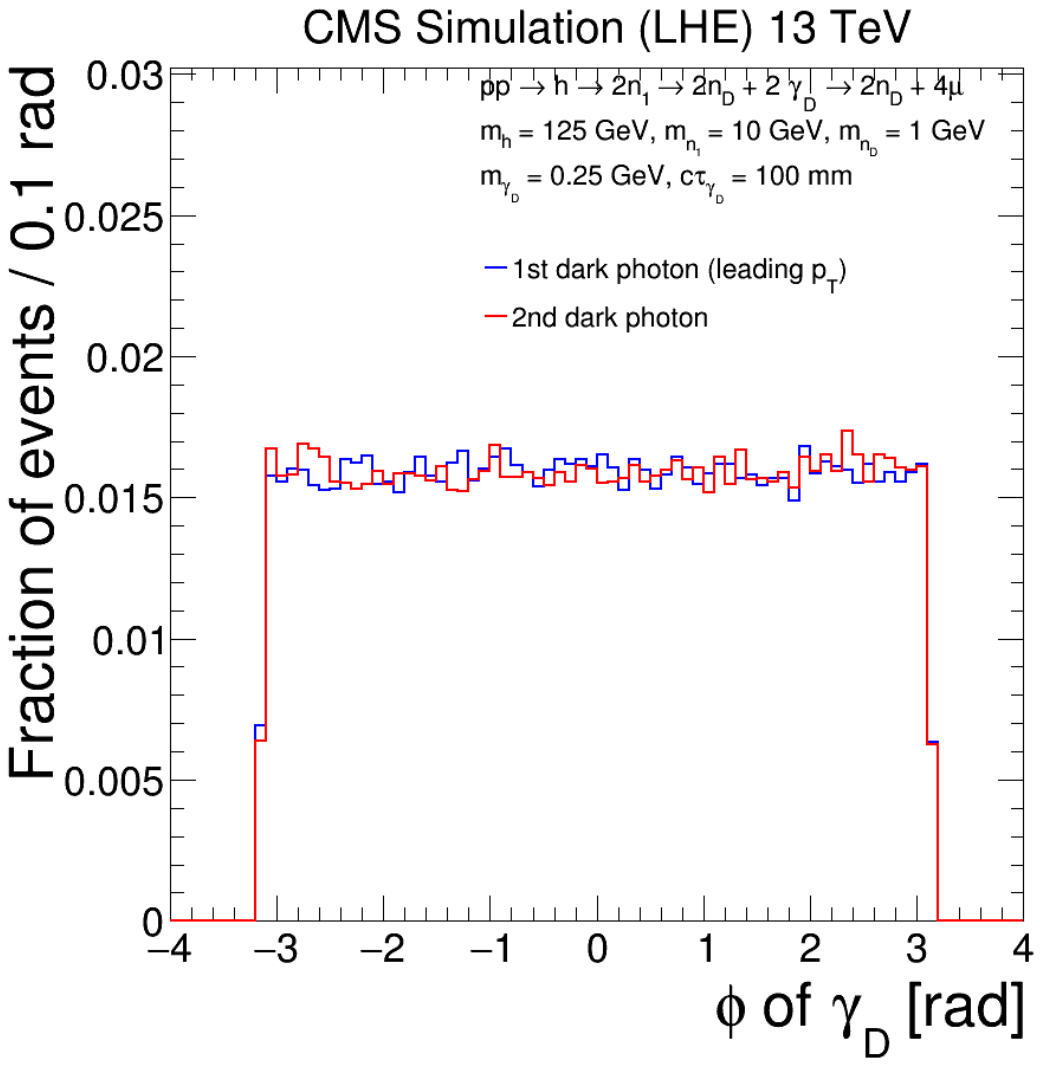

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
p of γ_D [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
p of γ_D [GeV]

MG4

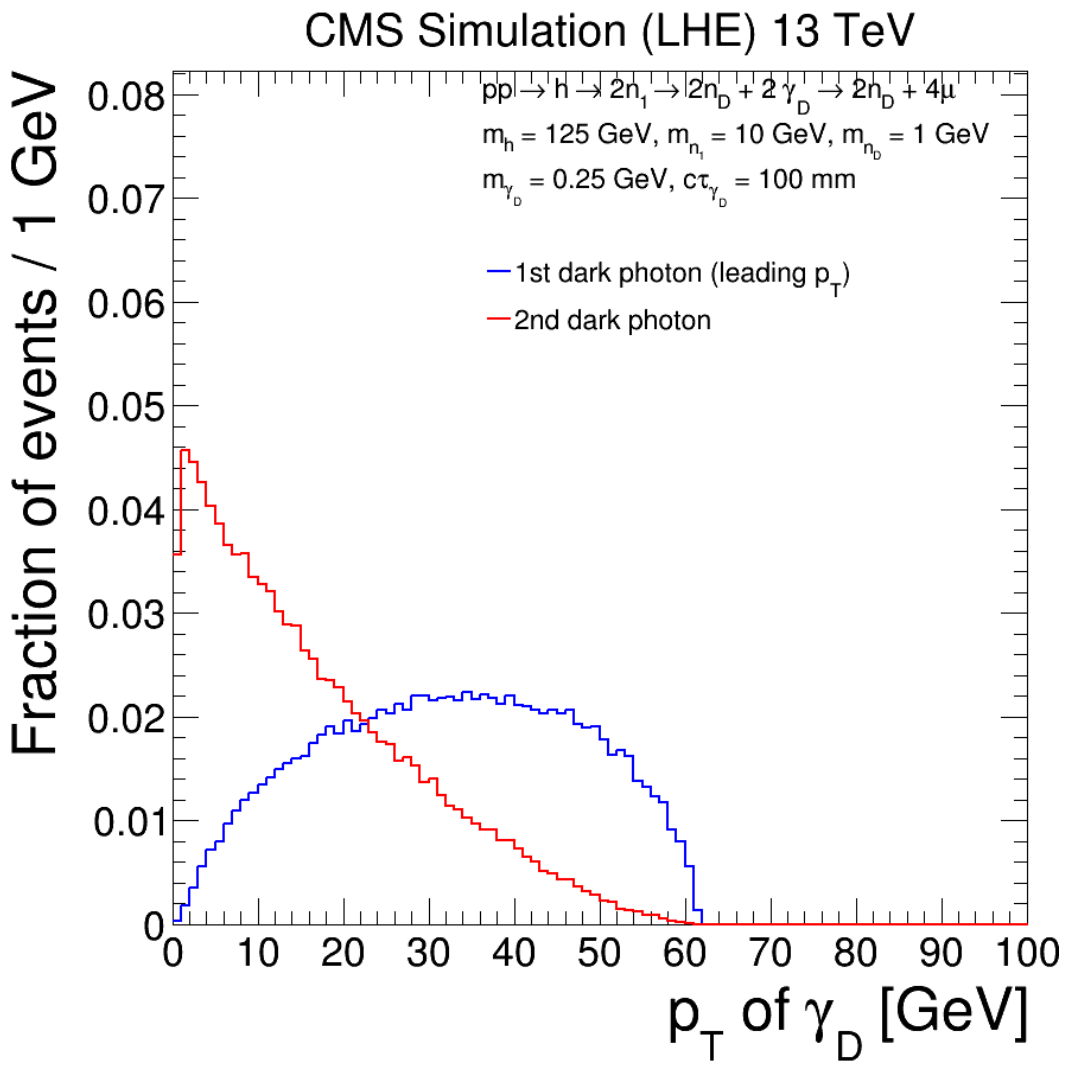
MG5

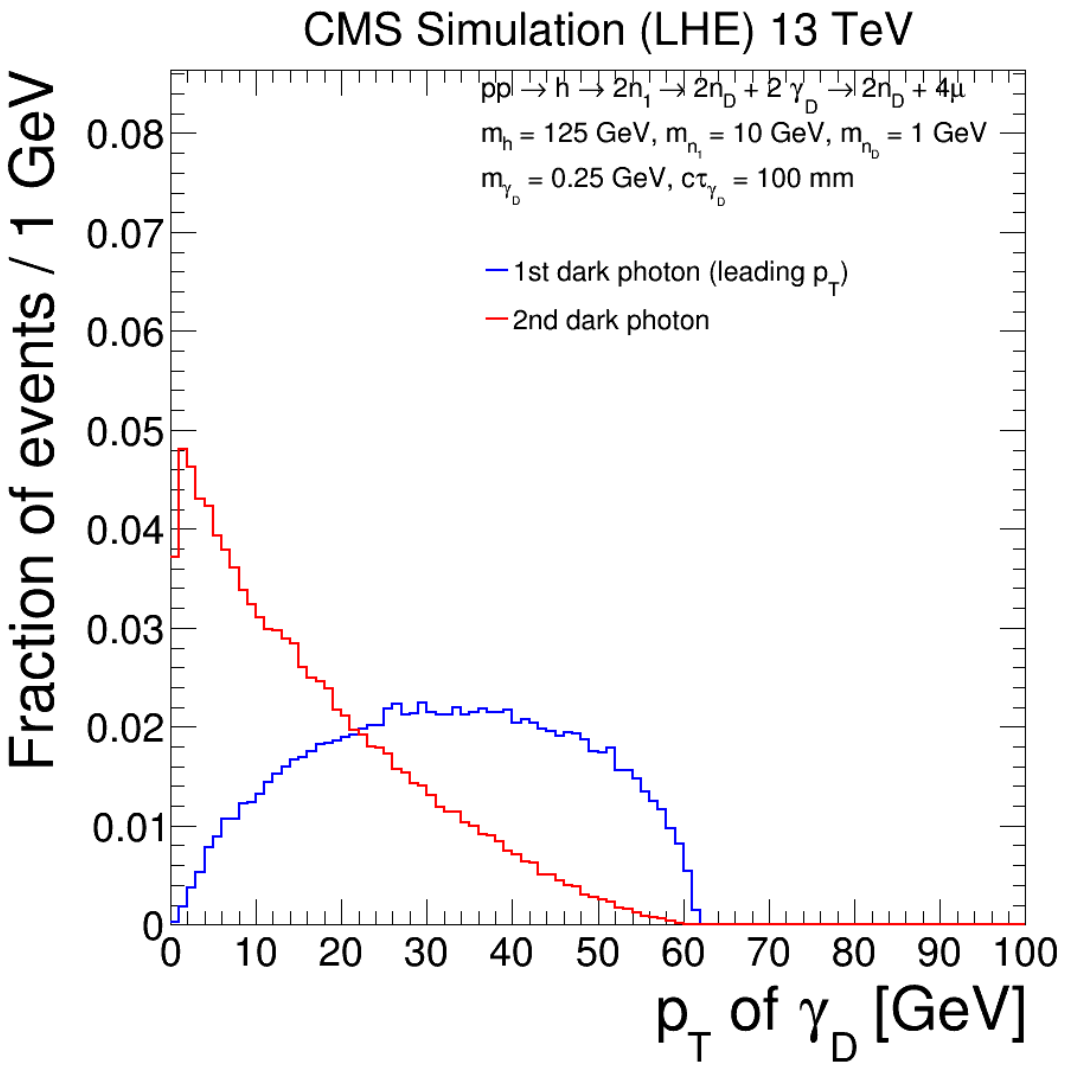

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 0.1 rad
ϕ of γ_D [rad]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 0.1 rad
ϕ of γ_D [rad]

MG4

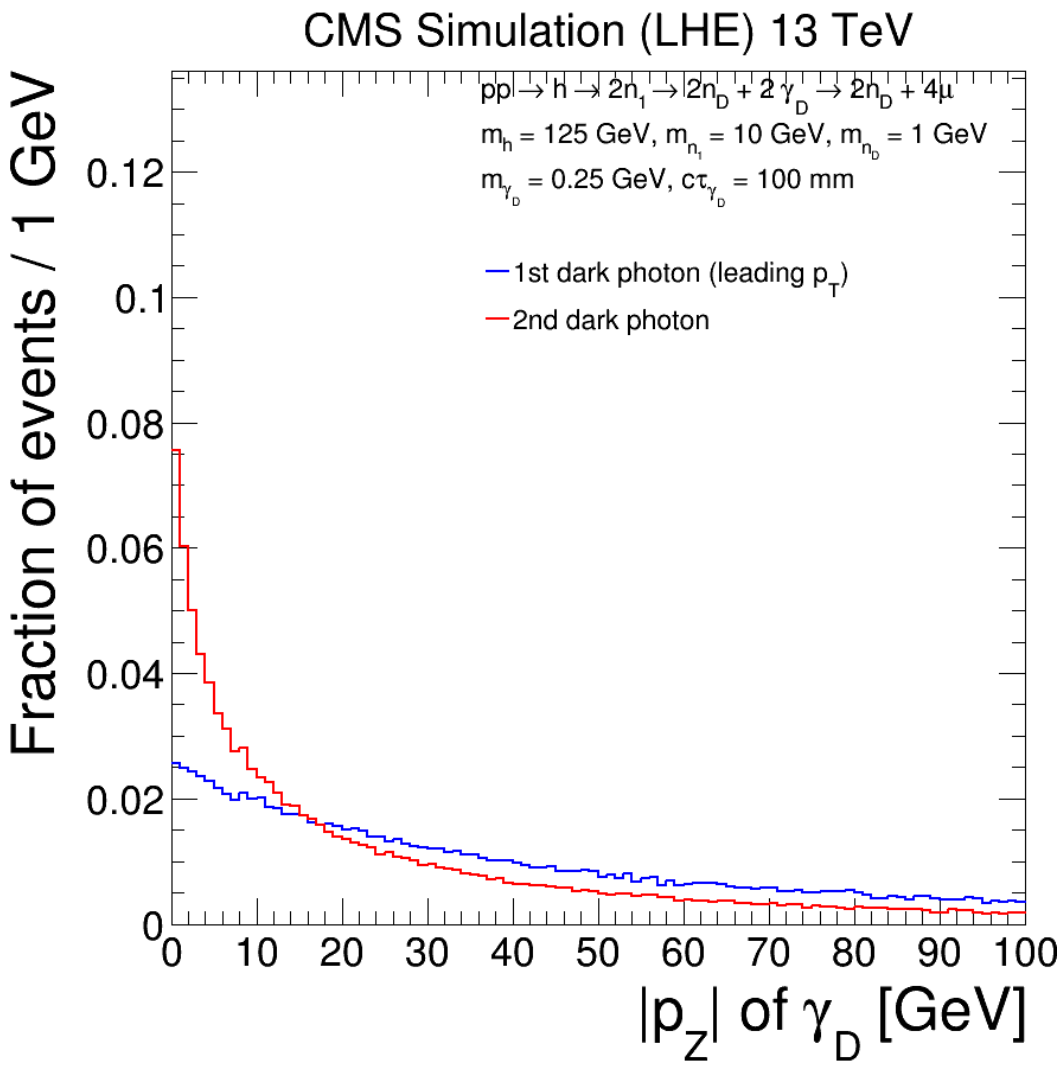
MG5

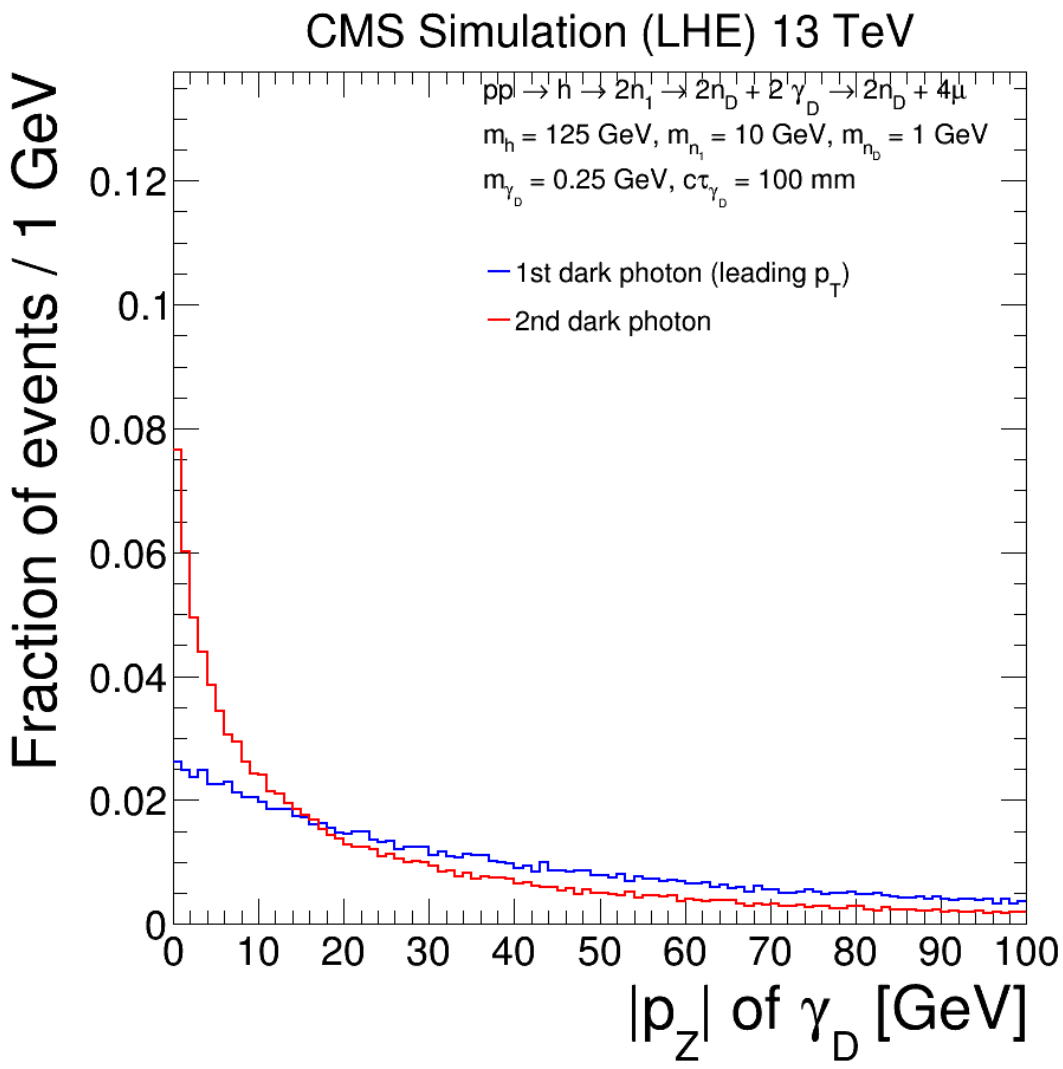

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
p_T of γ_D [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
p_T of γ_D [GeV]

MG4

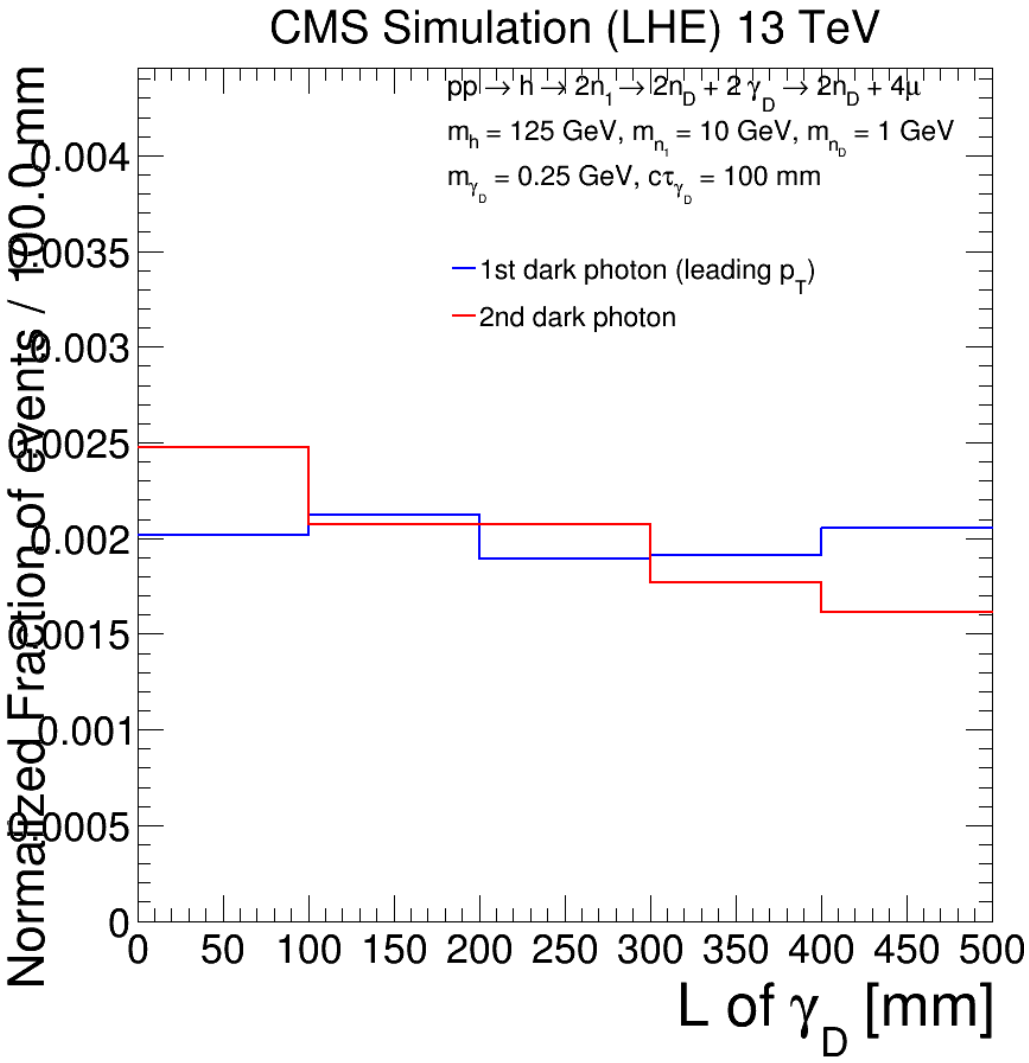
MG5

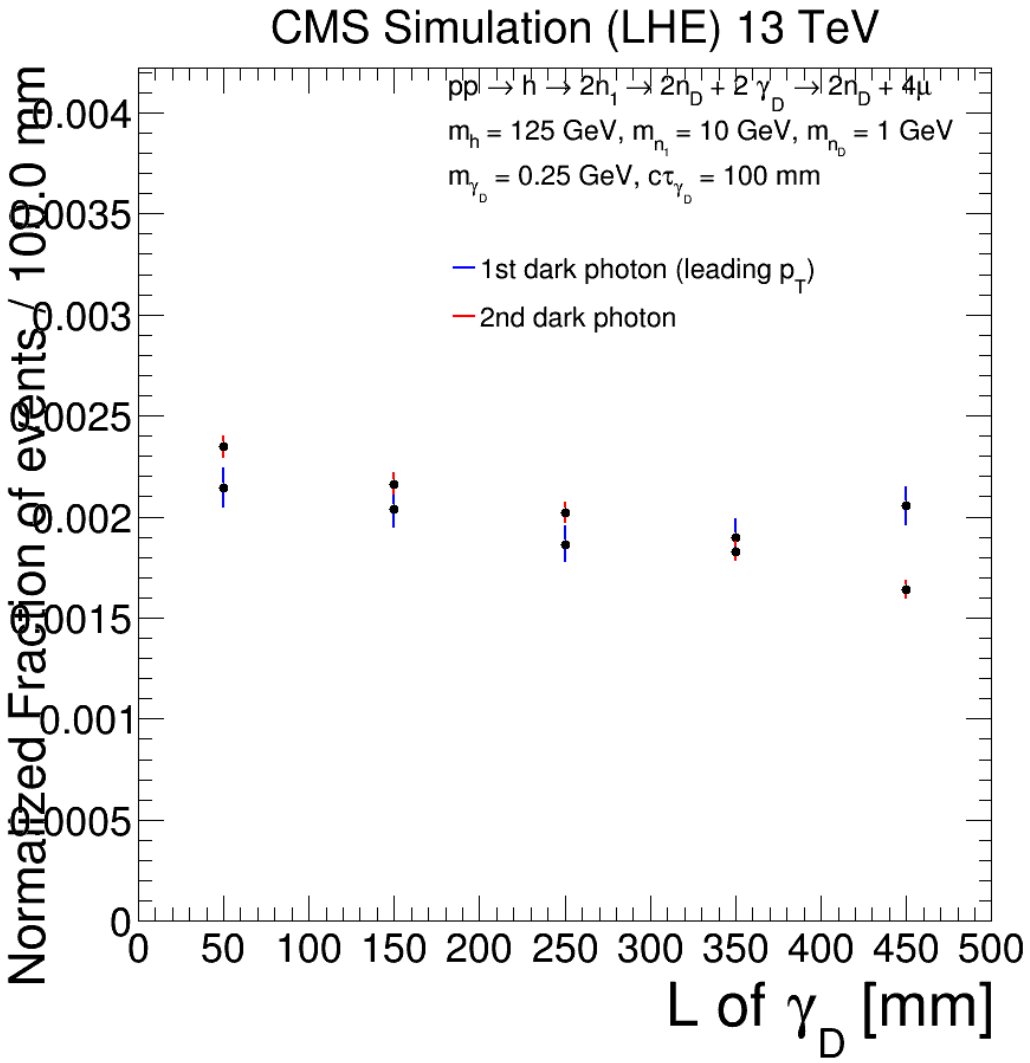

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
$|p_Z|$ of γ_D [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Fraction of events / 1 GeV
$|p_Z|$ of γ_D [GeV]

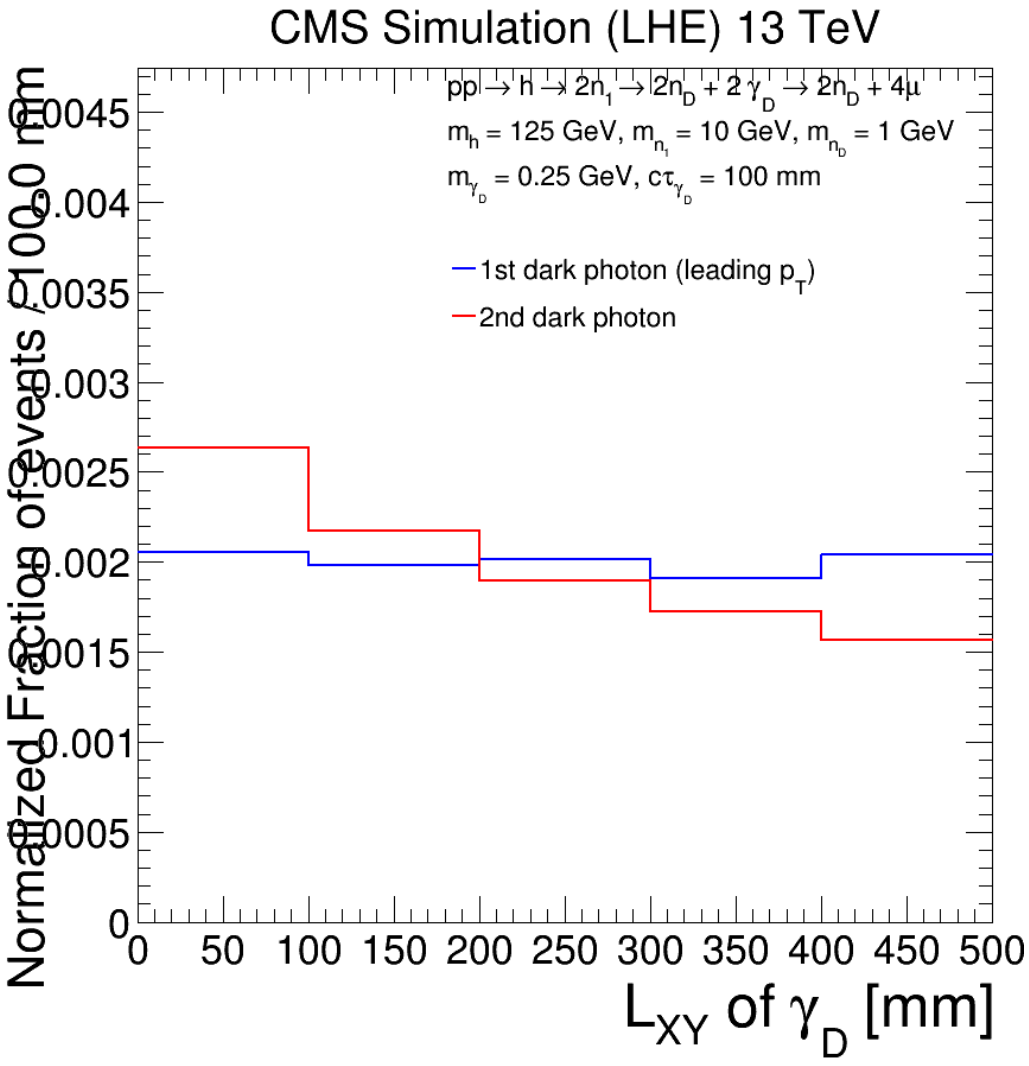
MG4

MG5

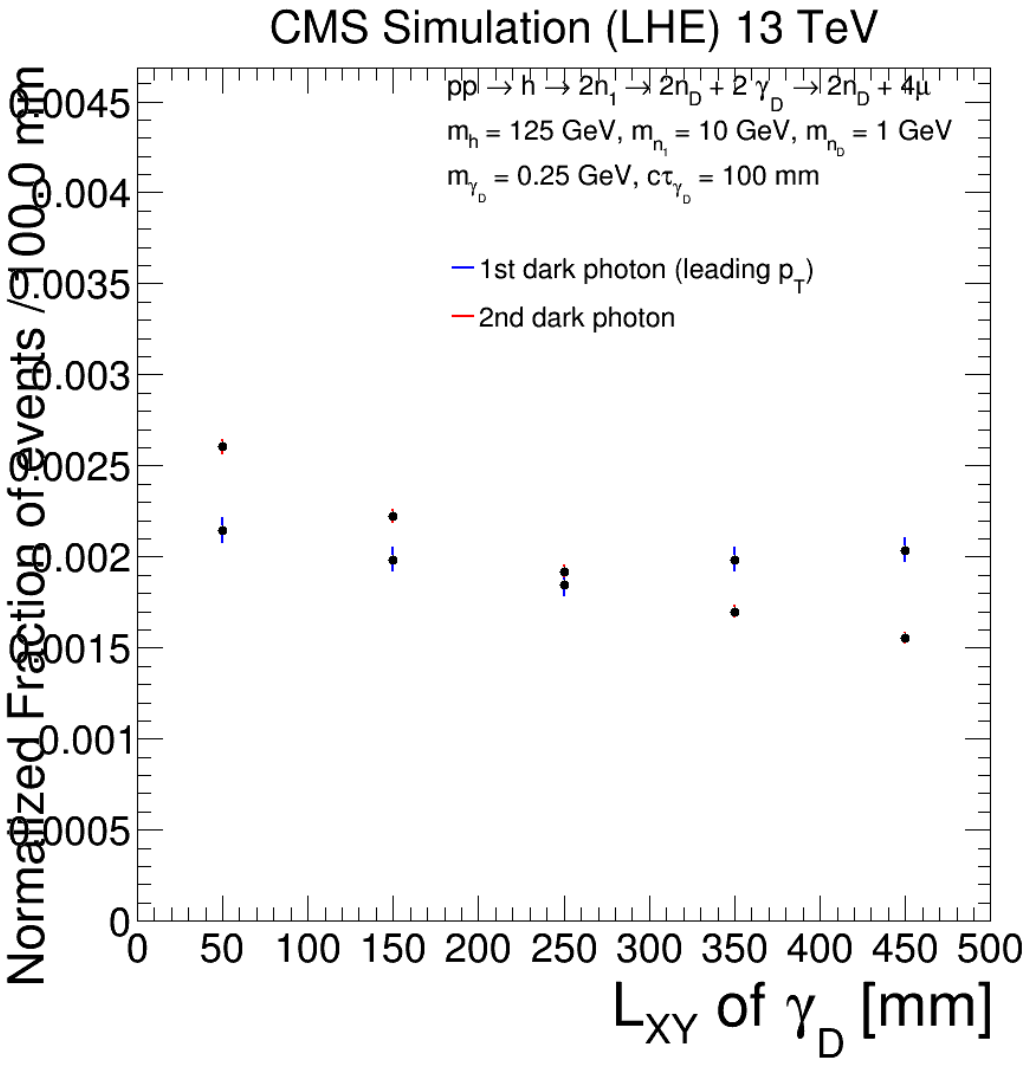

CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st dark photon (leading pT)
2nd dark photon
Normalized Fraction of events / 100.0 mm
L of γD [mm]


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st dark photon (leading pT)
2nd dark photon
Normalized Fraction of events / 100.0 mm
L of γD [mm]

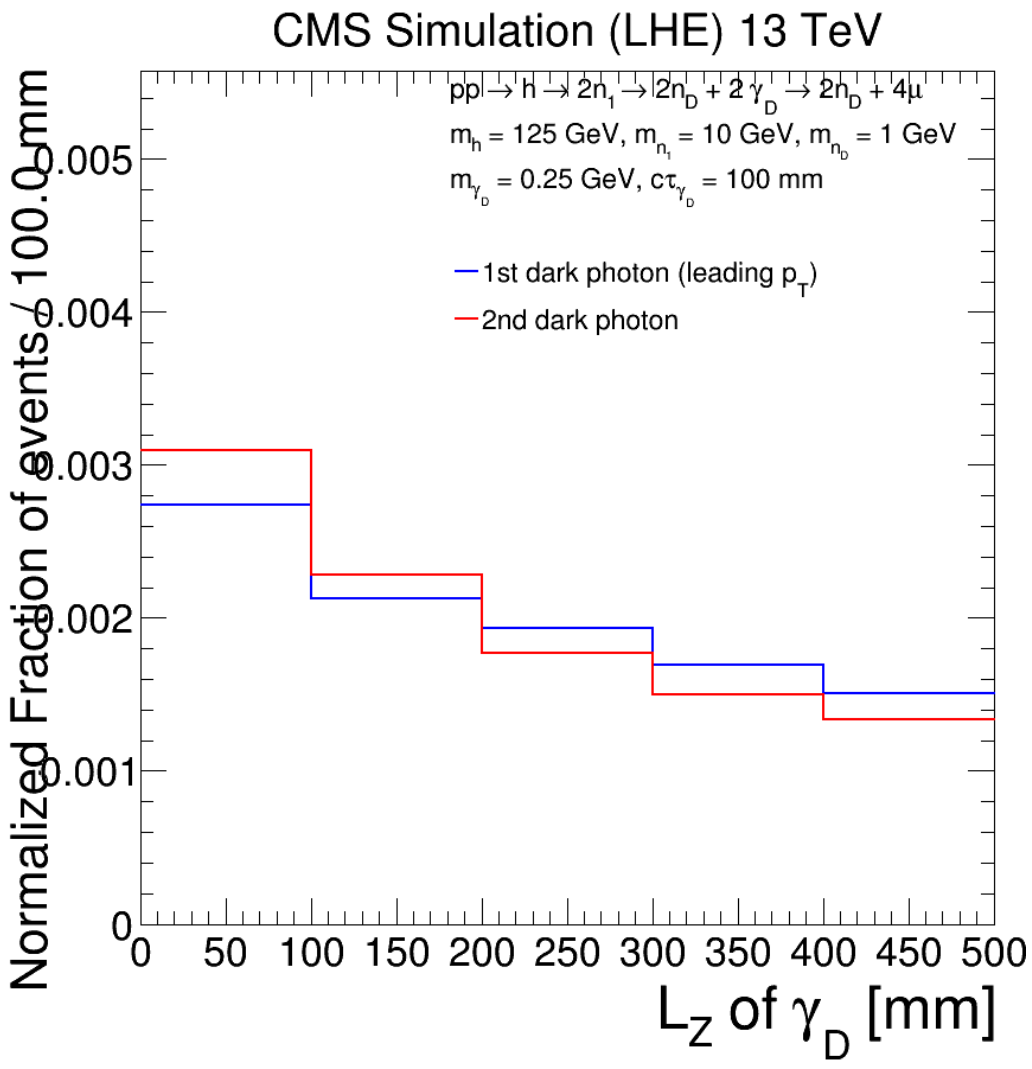
MG4


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st dark photon (leading pT)
2nd dark photon
Normalized Fraction of events / 100.0 mm
LXY of γD [mm]

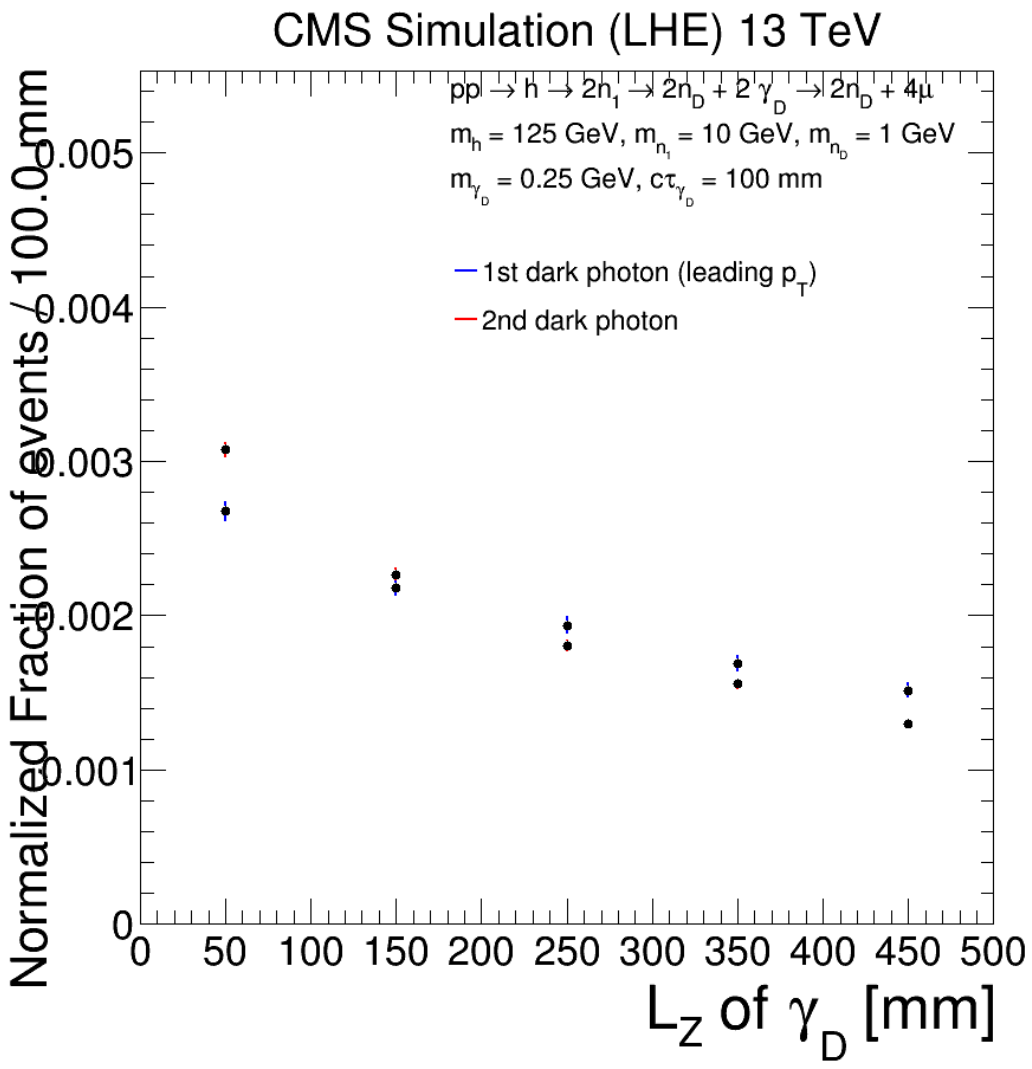
MG5


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st dark photon (leading pT)
2nd dark photon
Normalized Fraction of events / 100.0 mm
LXY of γD [mm]

MG4

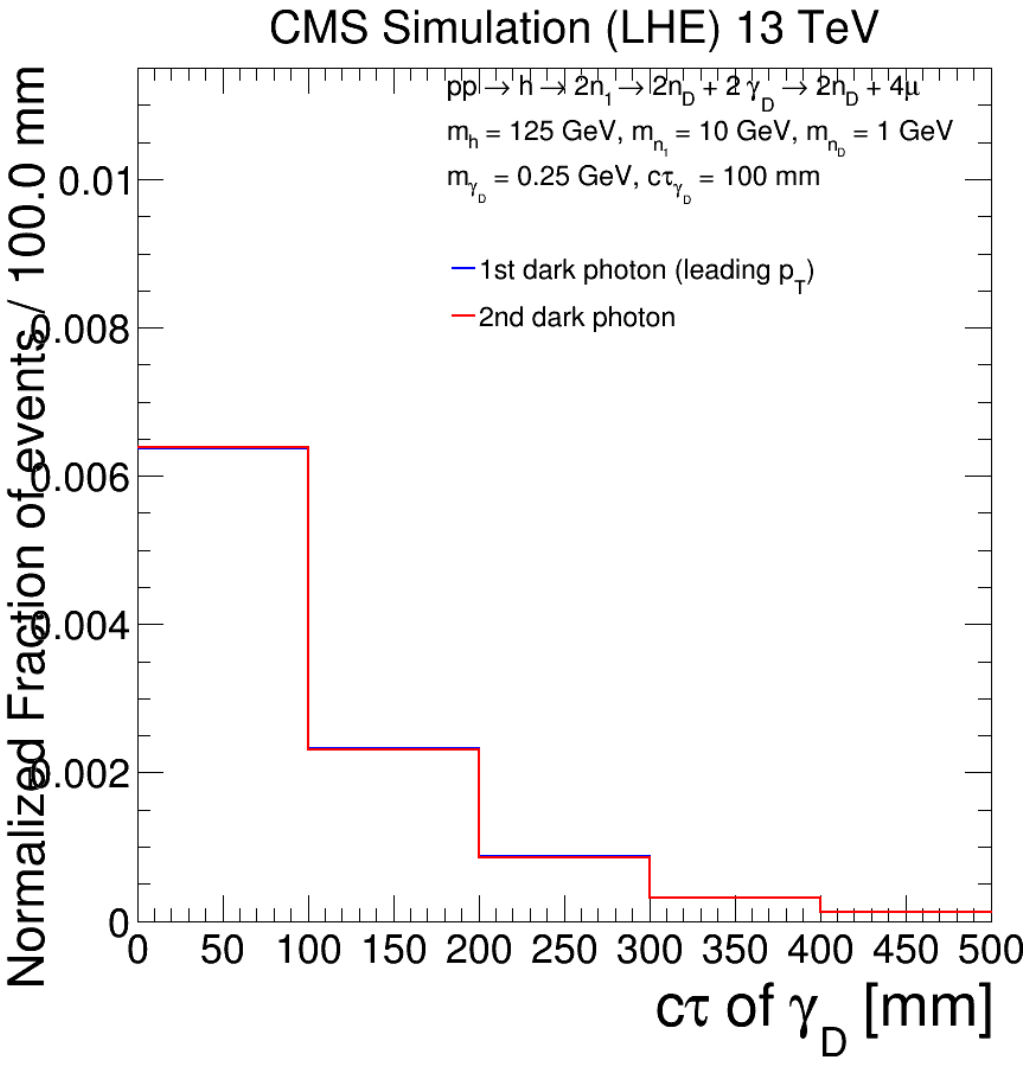

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Normalized Fraction of events / 100.0 mm
0
0.001
0.002
0.003
0.004
0.005
0 50 100 150 200 250 300 350 400 450 500
L_Z of γ_D [mm]

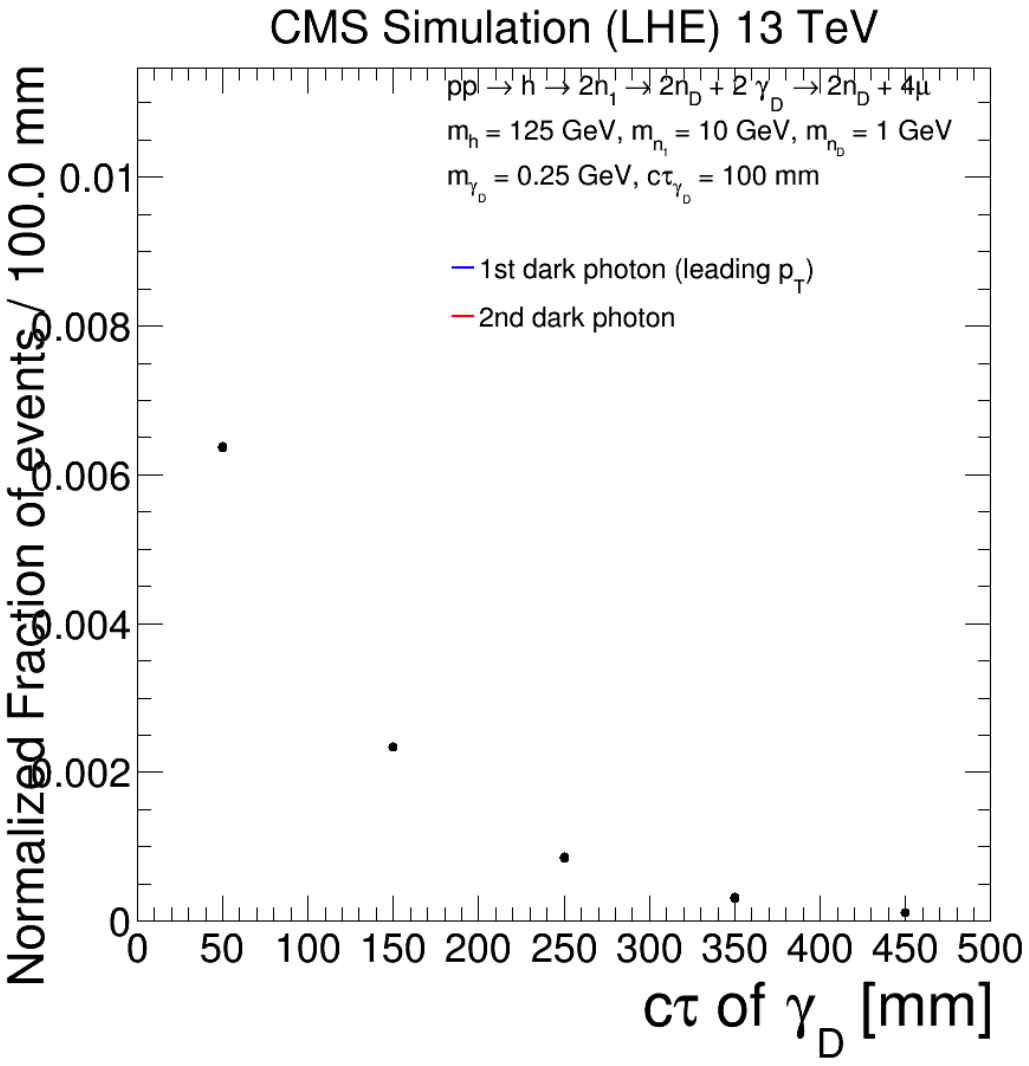
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Normalized Fraction of events / 100.0 mm
0
0.001
0.002
0.003
0.004
0.005
0 50 100 150 200 250 300 350 400 450 500
L_Z of γ_D [mm]

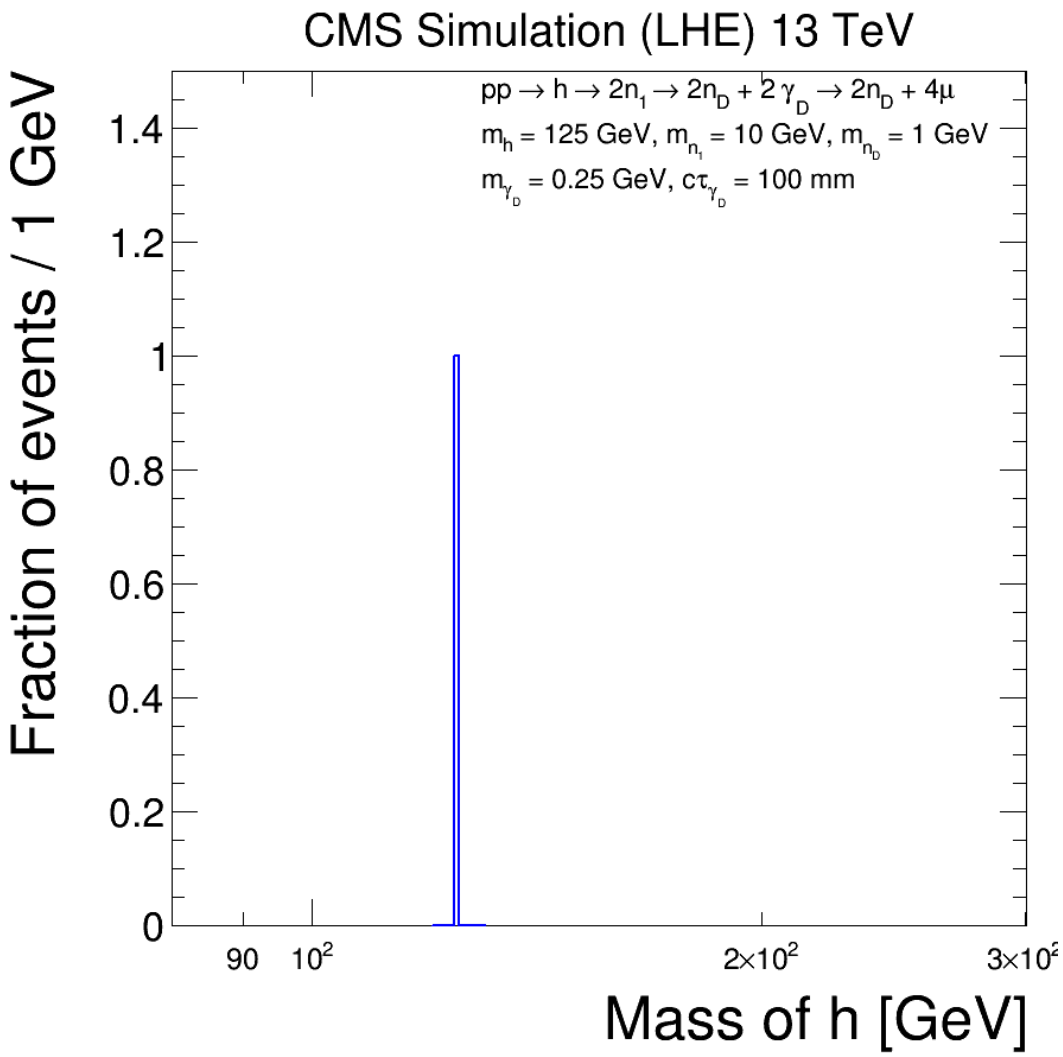
MG4

MG5

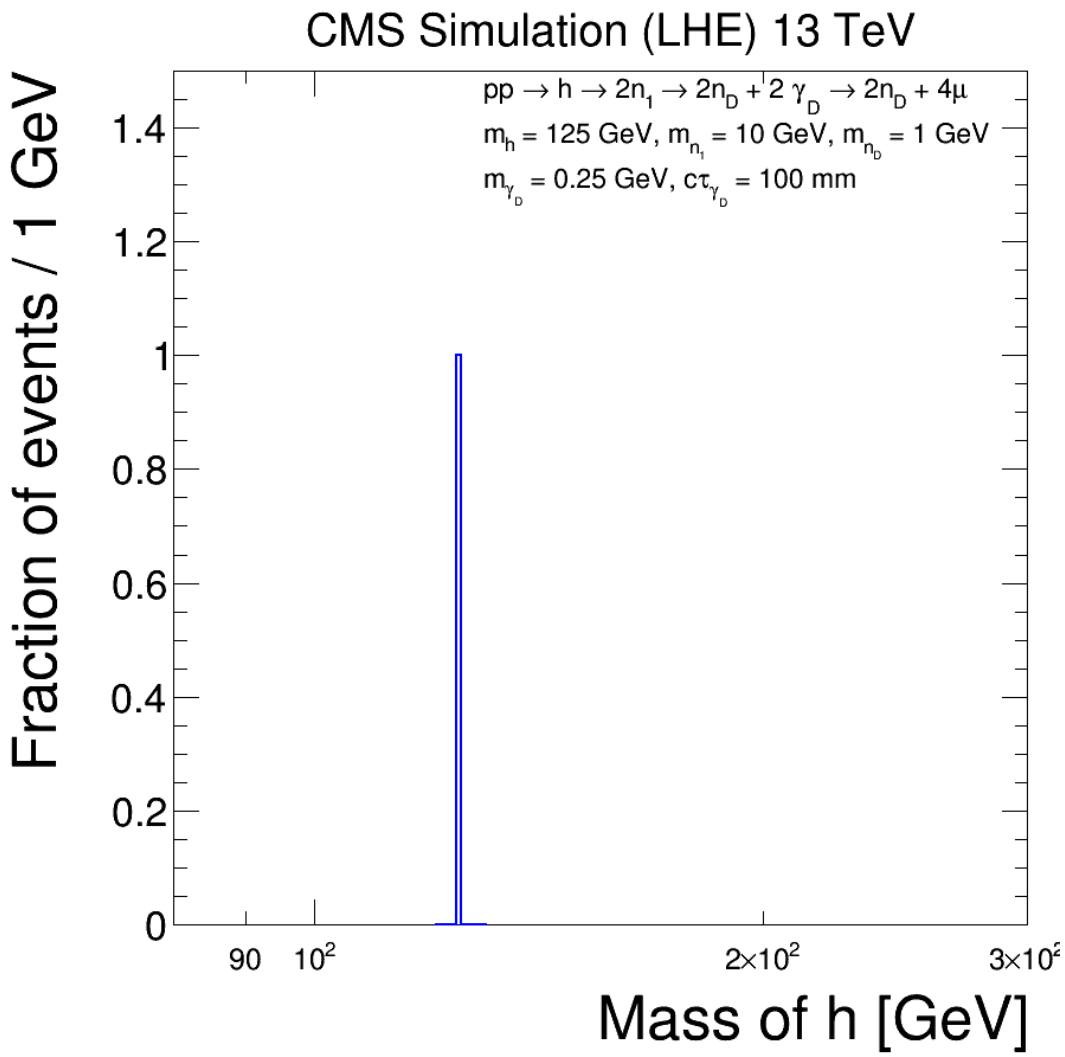

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Normalized Fraction of events / 100.0 mm
0
0.002
0.004
0.006
0.008
0.01
0 50 100 150 200 250 300 350 400 450 500
$c\tau$ of γ_D [mm]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st dark photon (leading p_T)
2nd dark photon
Normalized Fraction of events / 100.0 mm
0
0.002
0.004
0.006
0.008
0.01
0 50 100 150 200 250 300 350 400 450 500
$c\tau$ of γ_D [mm]

MG4

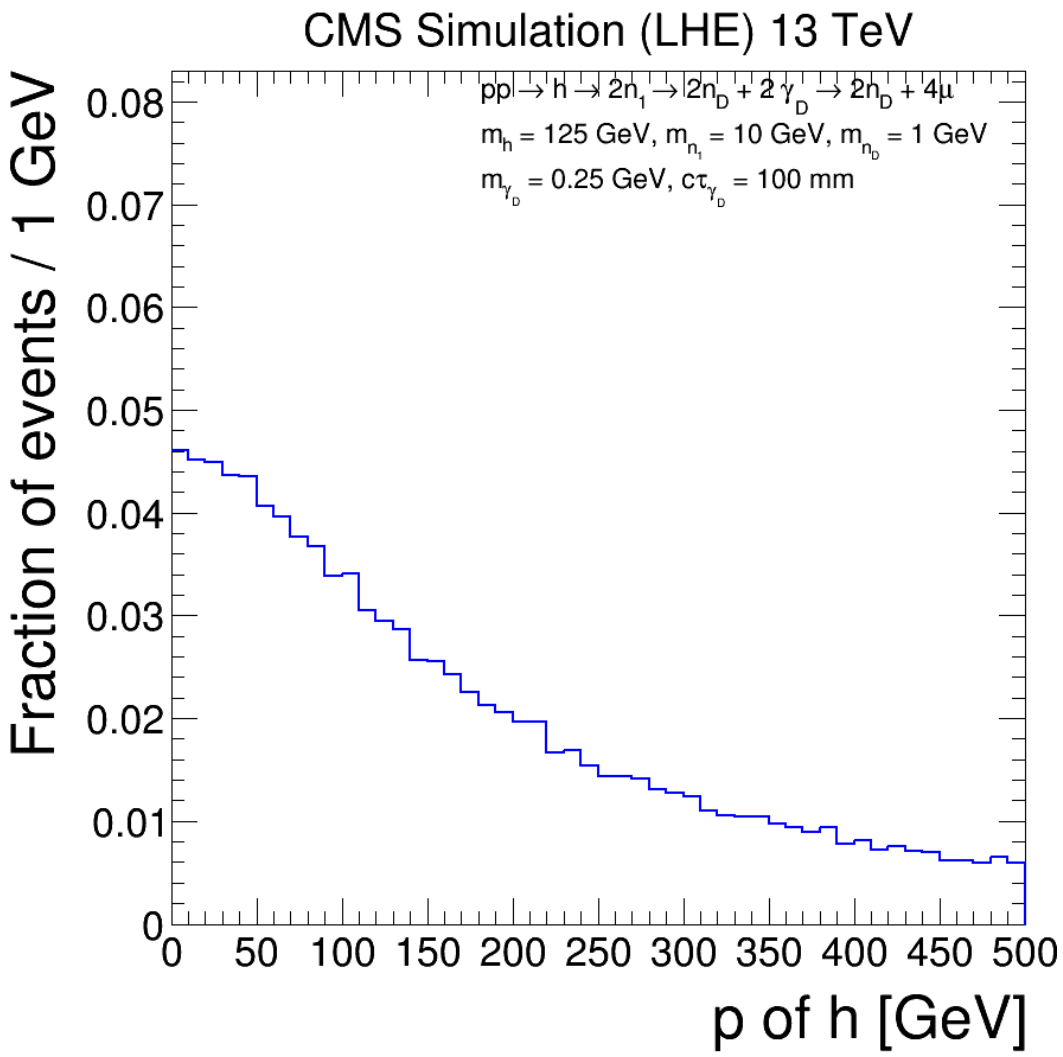

CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
Fraction of events / 1 GeV
0
0.2
0.4
0.6
0.8
1
1.2
1.4
90
10²
2×10²
3×10²
Mass of h [GeV]

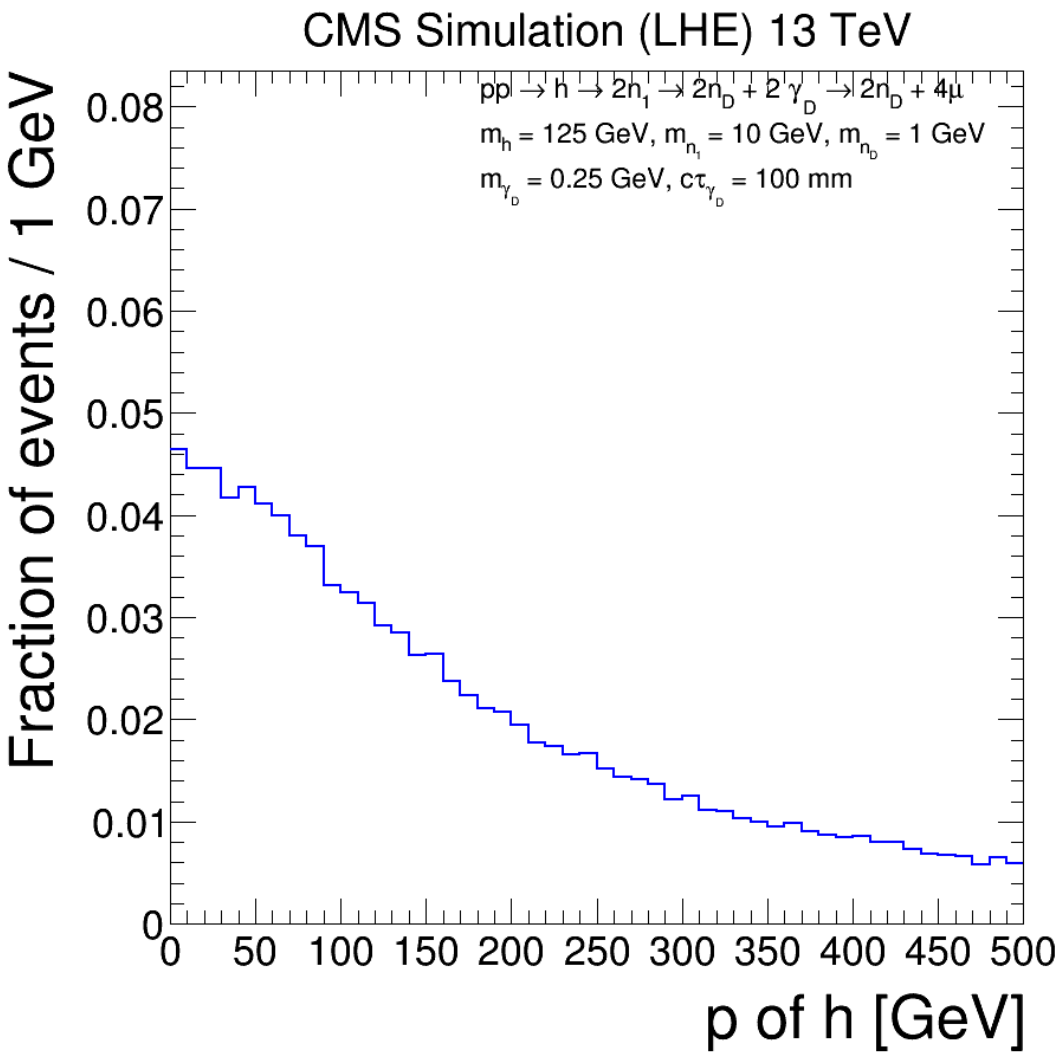
MG5


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
Fraction of events / 1 GeV
0
0.2
0.4
0.6
0.8
1
1.2
1.4
90
10²
2×10²
3×10²
Mass of h [GeV]

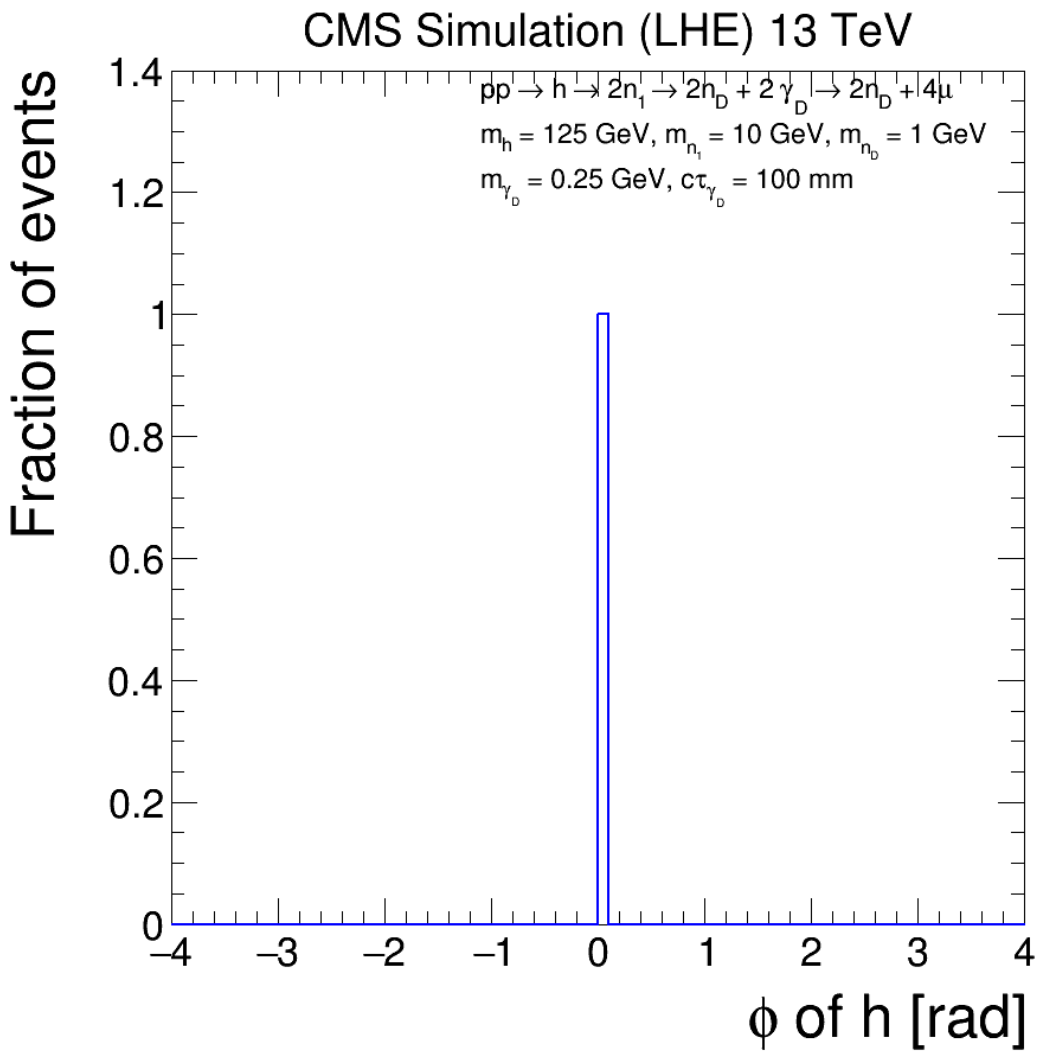
MG4

MG5

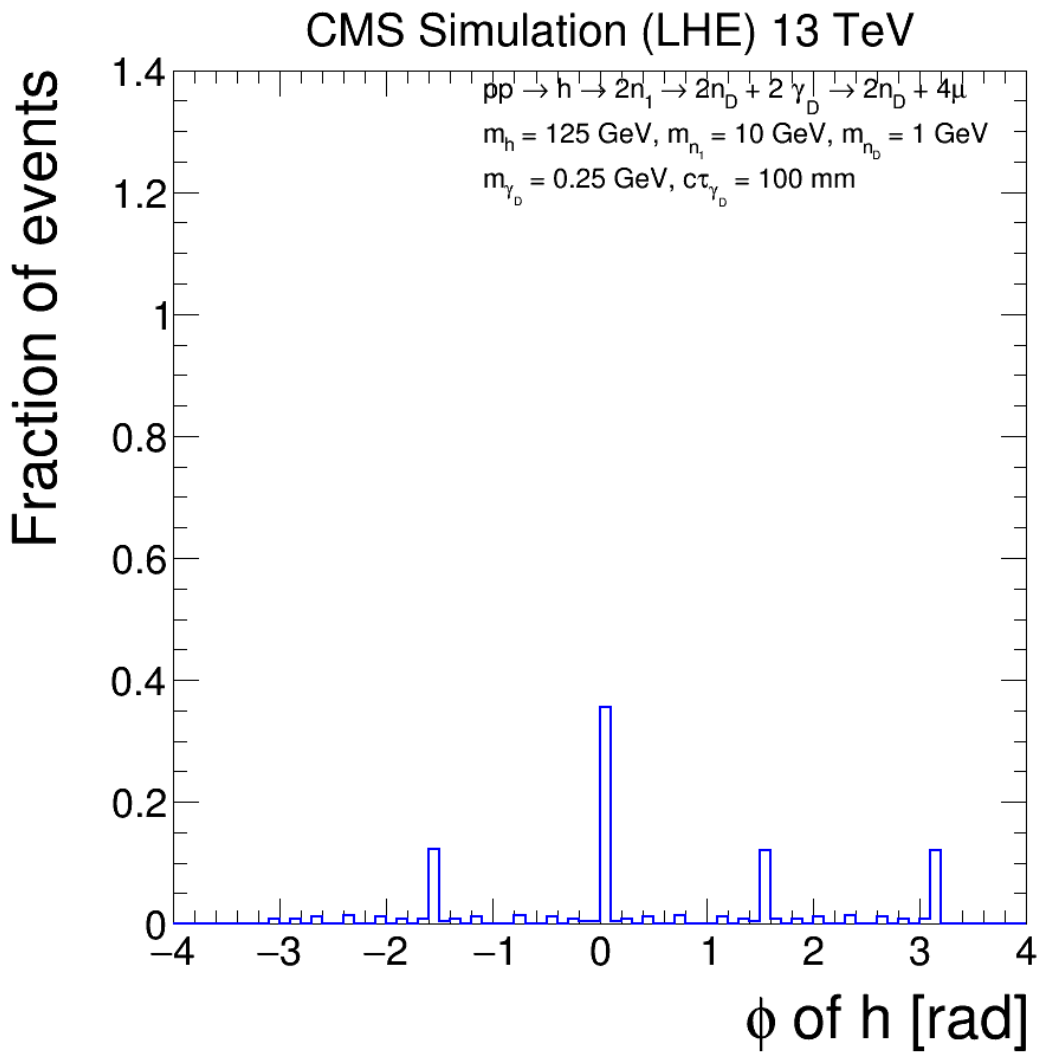

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 50 100 150 200 250 300 350 400 450 500
p of h [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 50 100 150 200 250 300 350 400 450 500
p of h [GeV]

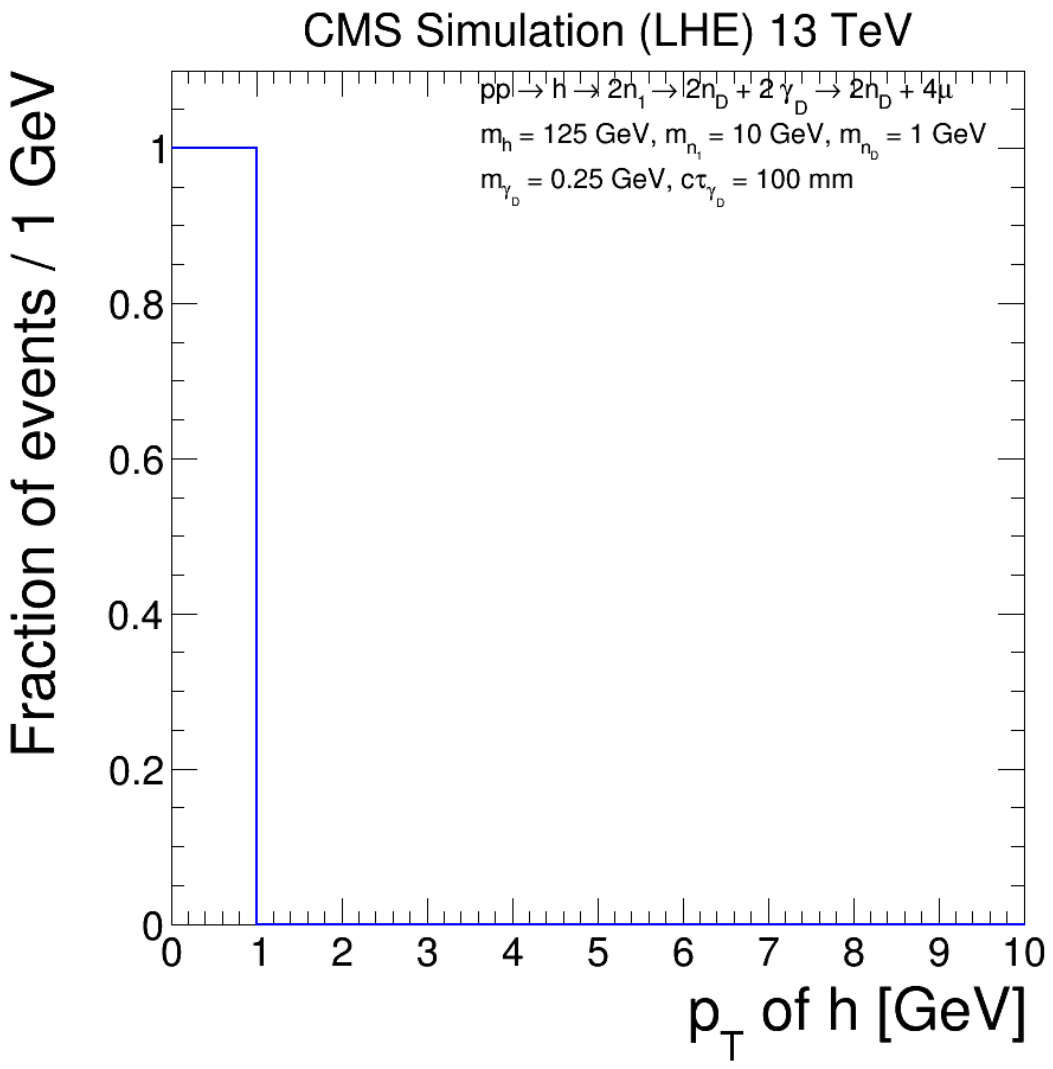
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events
ϕ of h [rad]

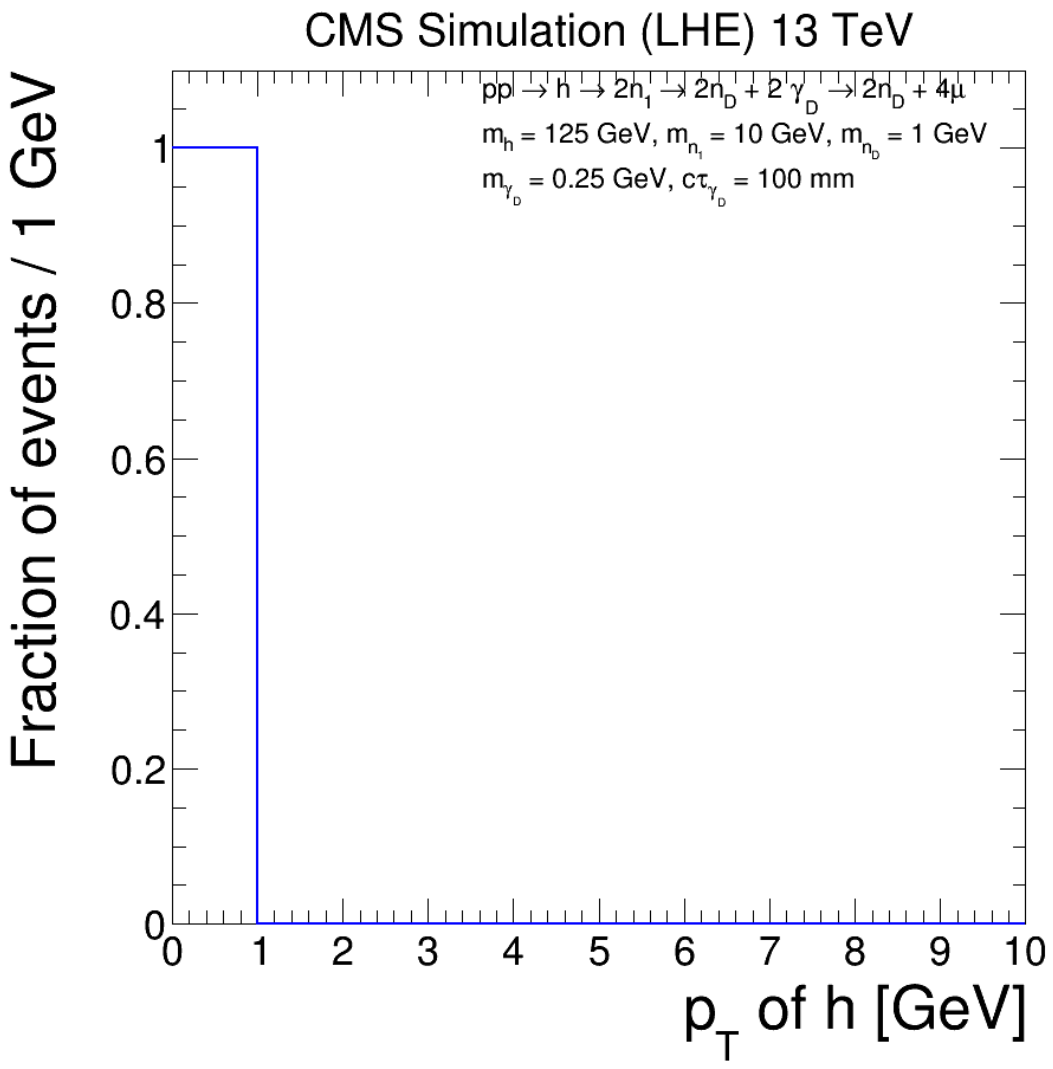
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events
ϕ of h [rad]

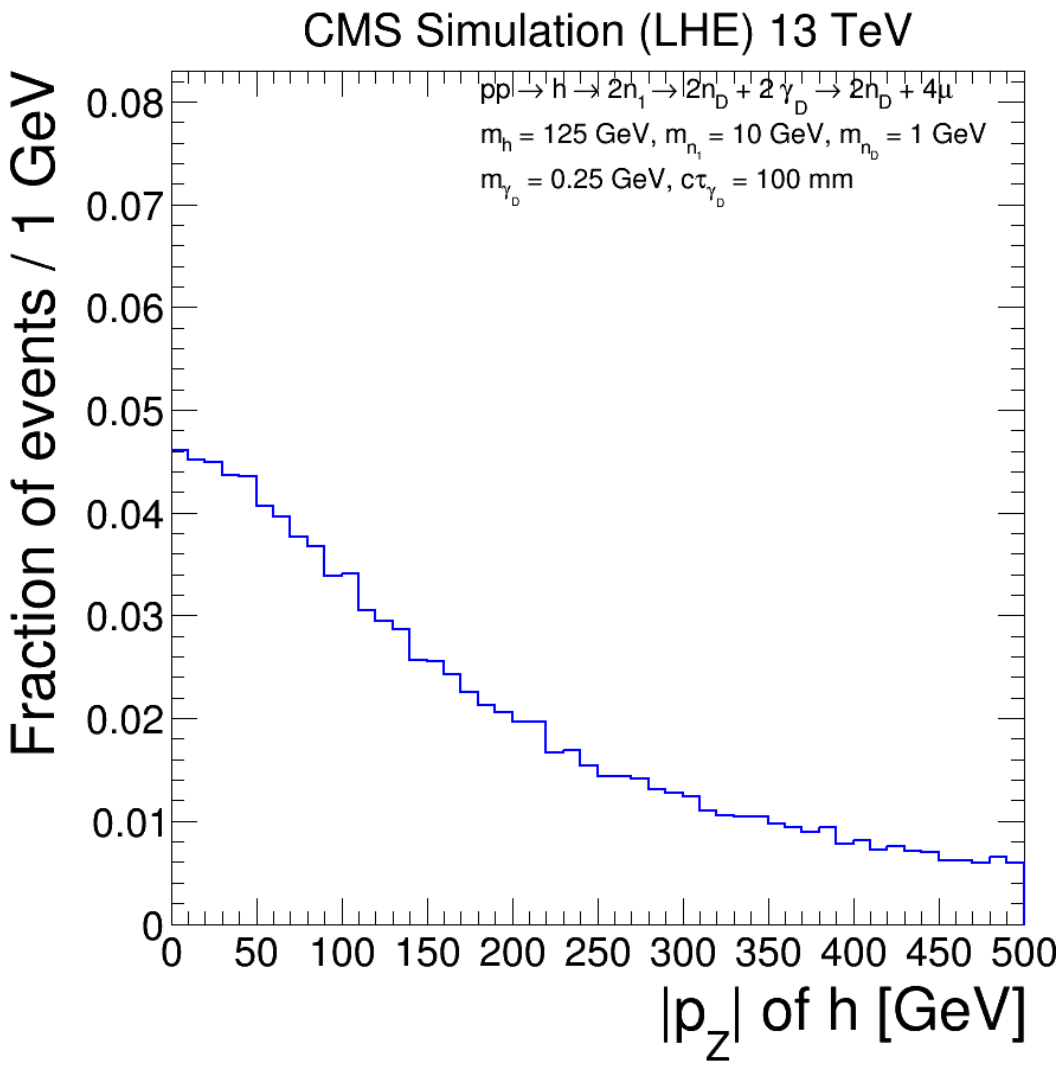
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
p_T of h [GeV]

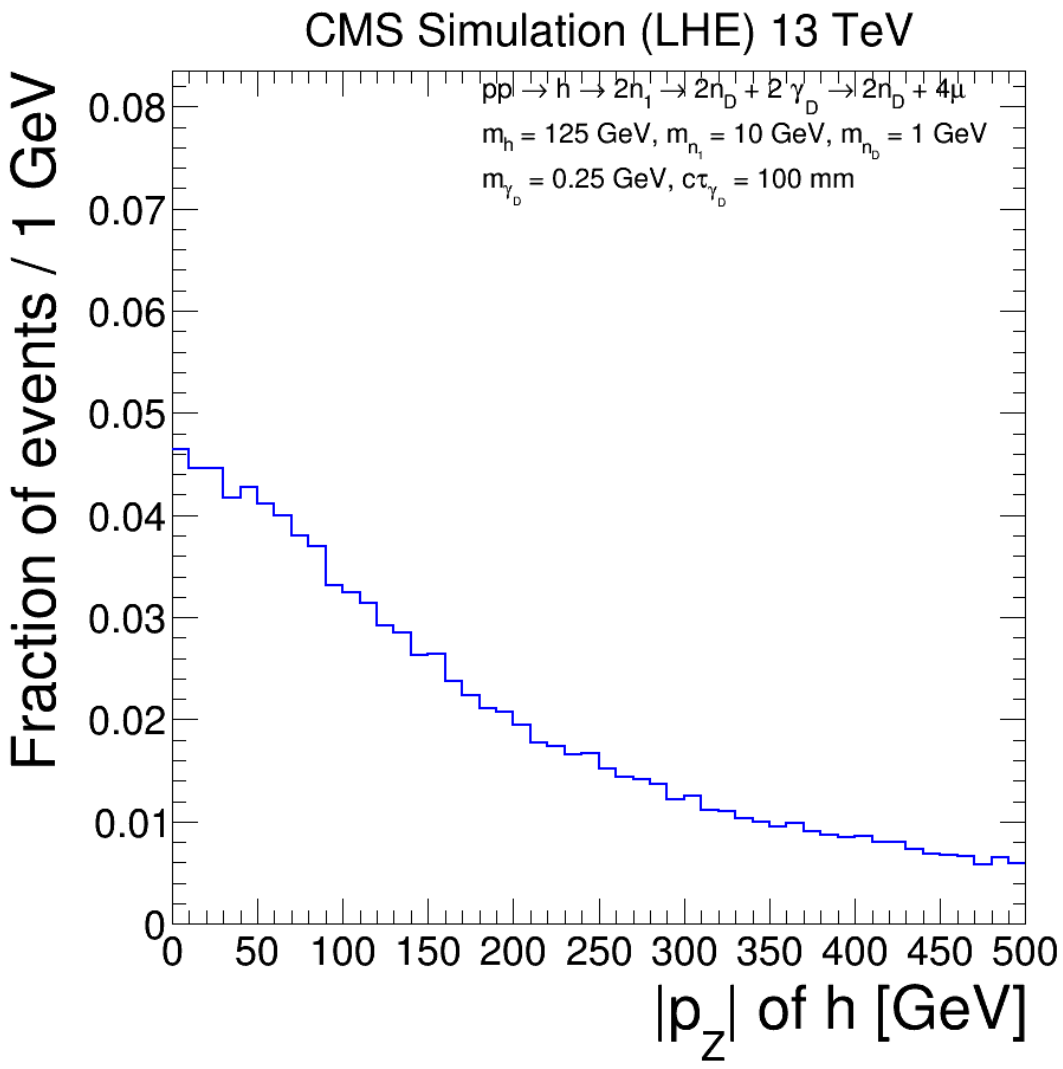
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
p_T of h [GeV]

MG4

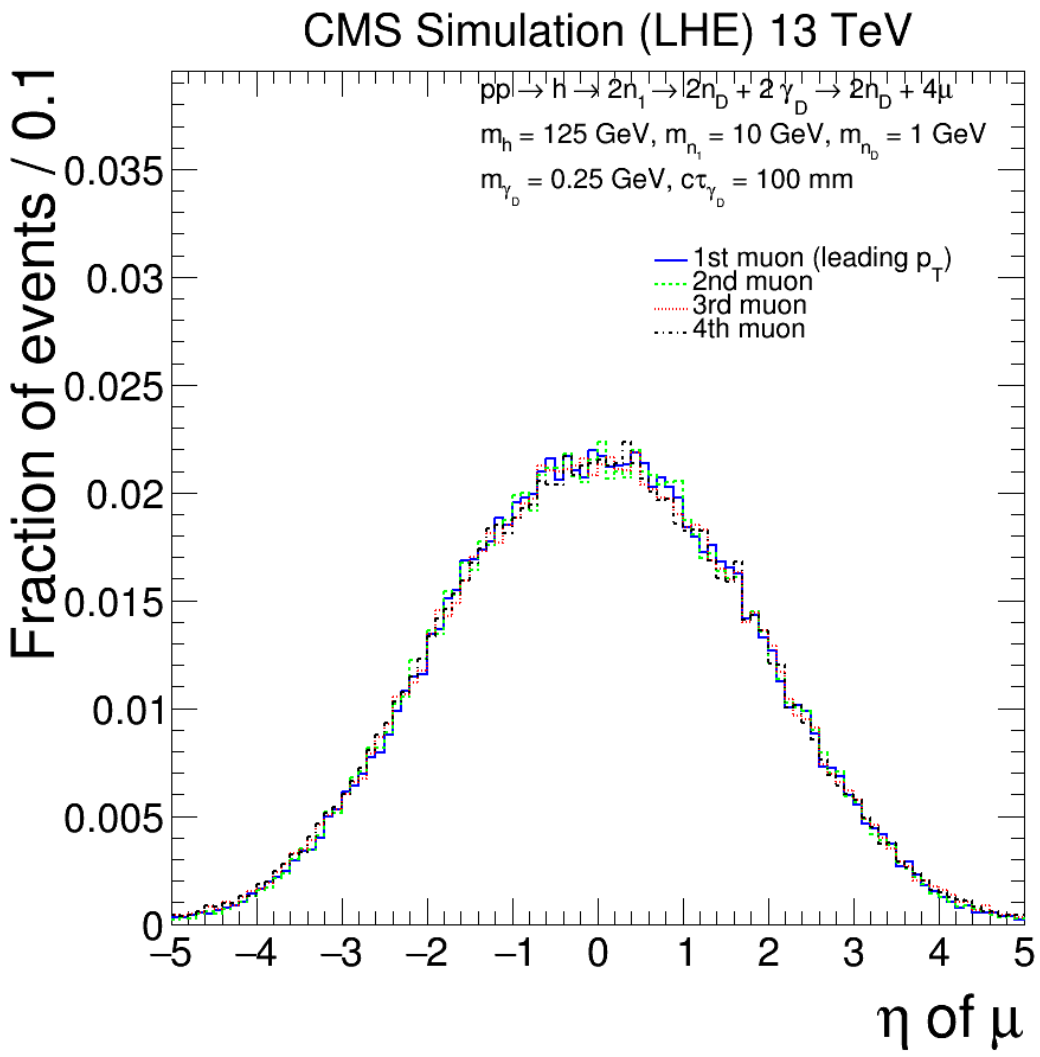

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 50 100 150 200 250 300 350 400 450 500
$|p_z|$ of h [GeV]

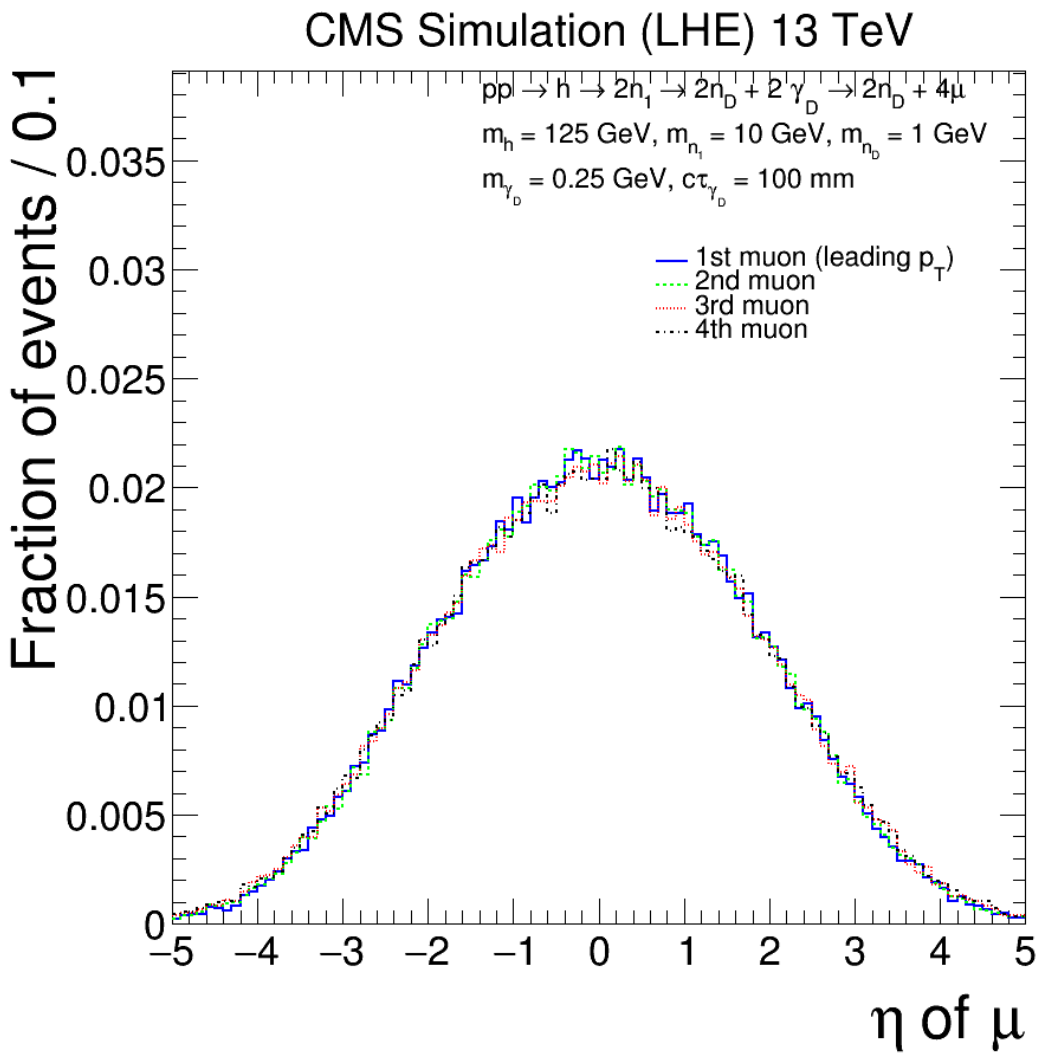
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 50 100 150 200 250 300 350 400 450 500
$|p_z|$ of h [GeV]

MG4

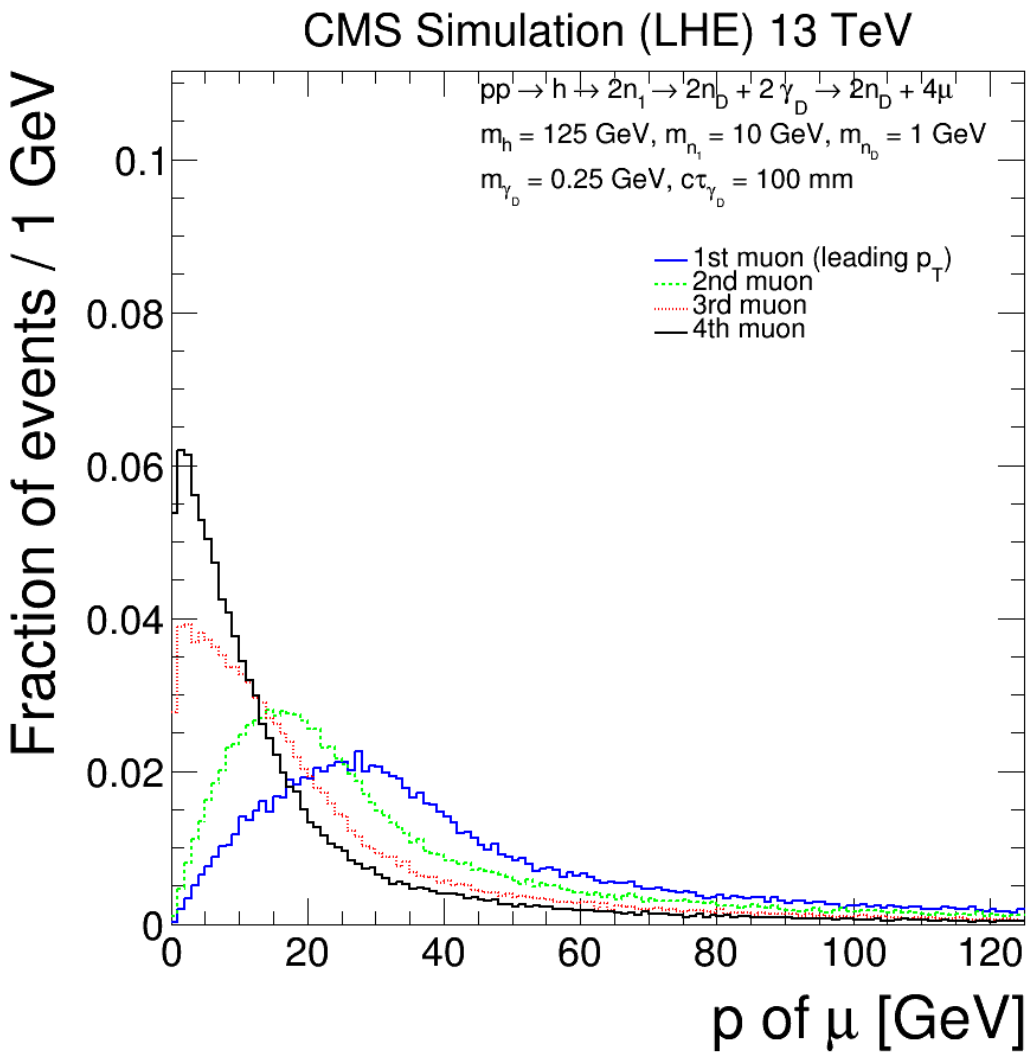
MG5

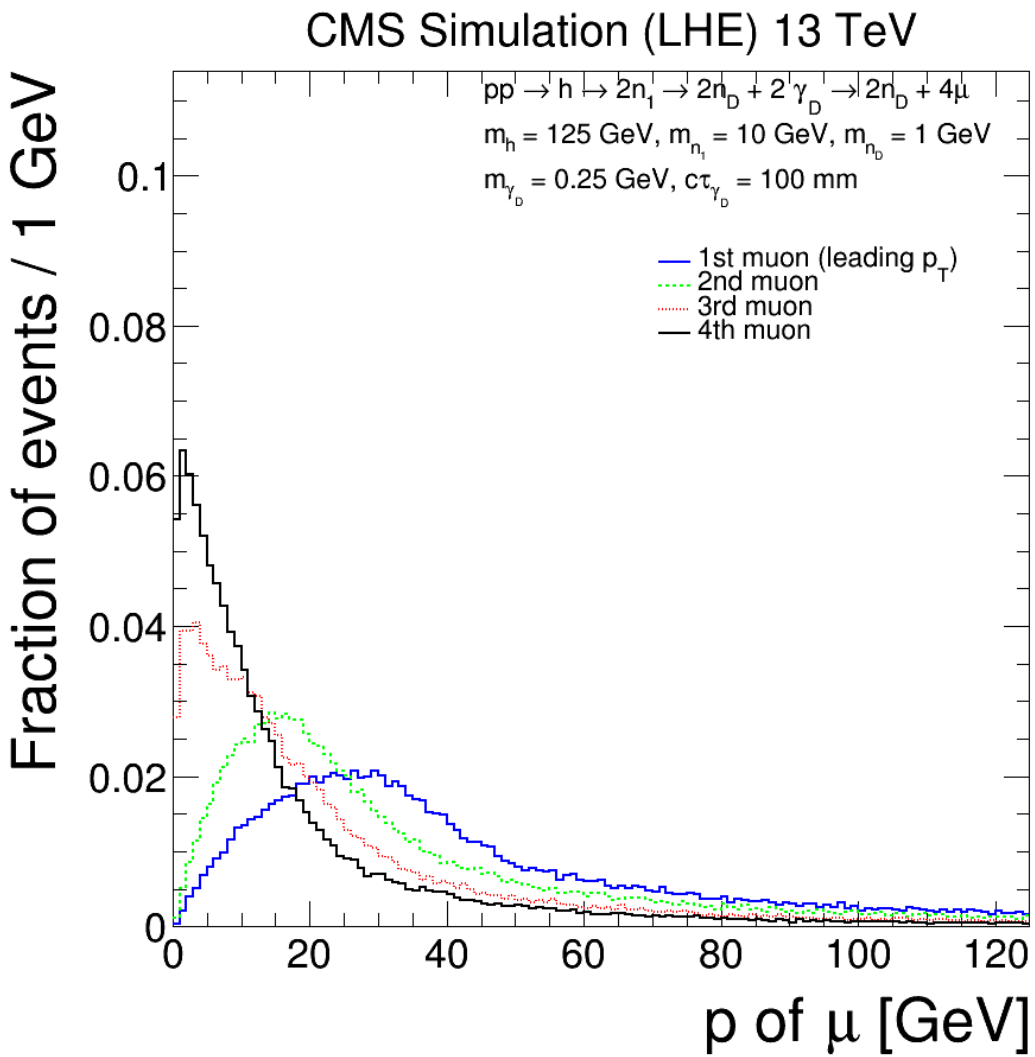

CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st muon (leading pT)
2nd muon
3rd muon
4th muon
Fraction of events / 0.1
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of μ


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st muon (leading pT)
2nd muon
3rd muon
4th muon
Fraction of events / 0.1
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of μ

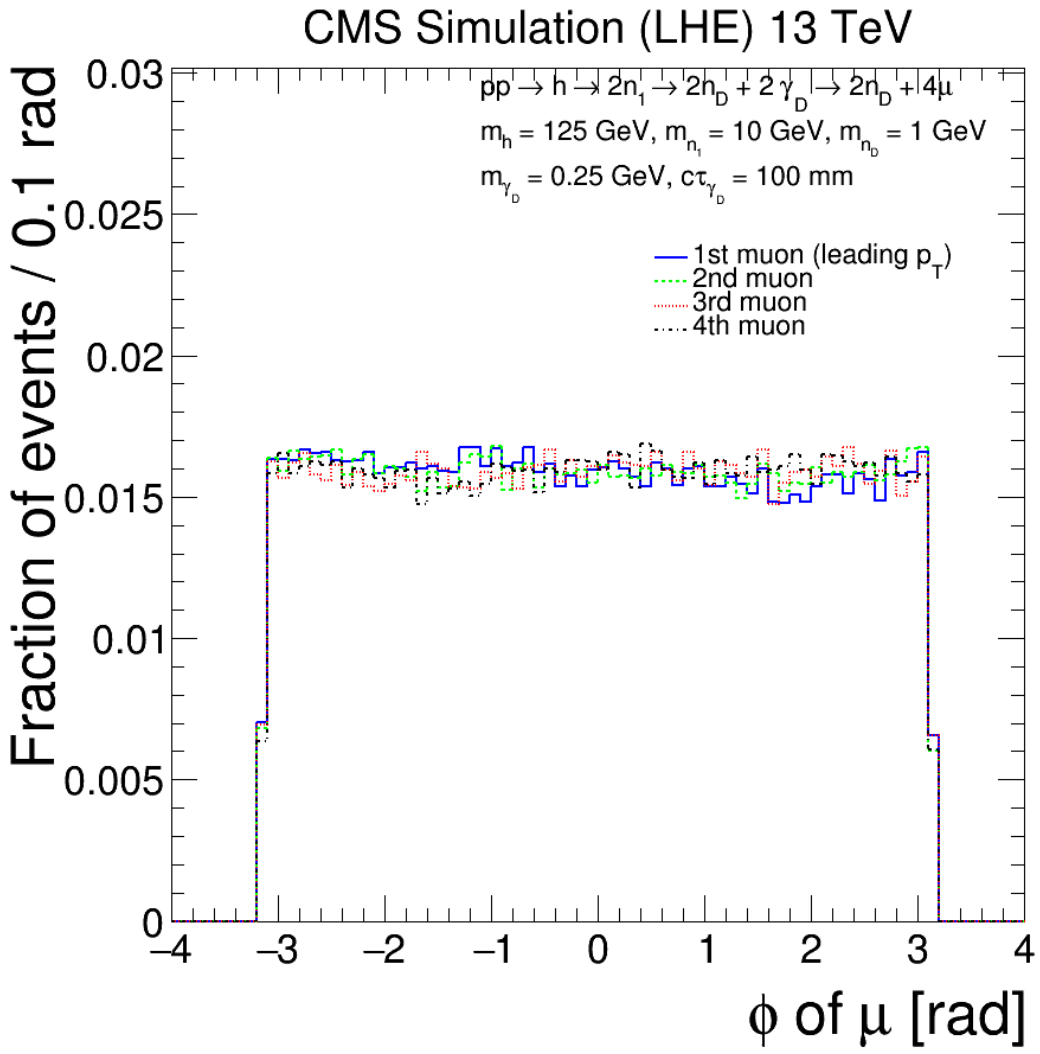
MG4

MG5

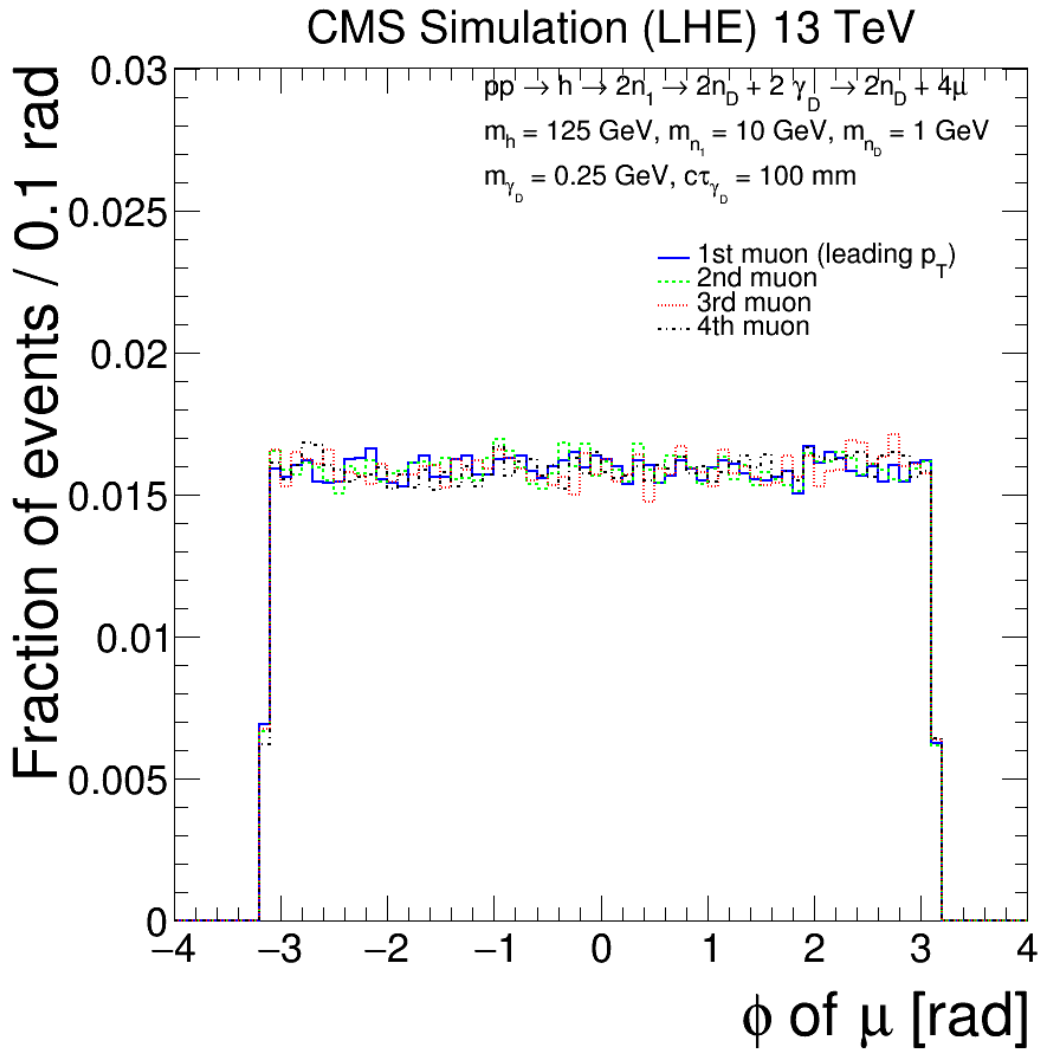

CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
p of μ [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
p of μ [GeV]

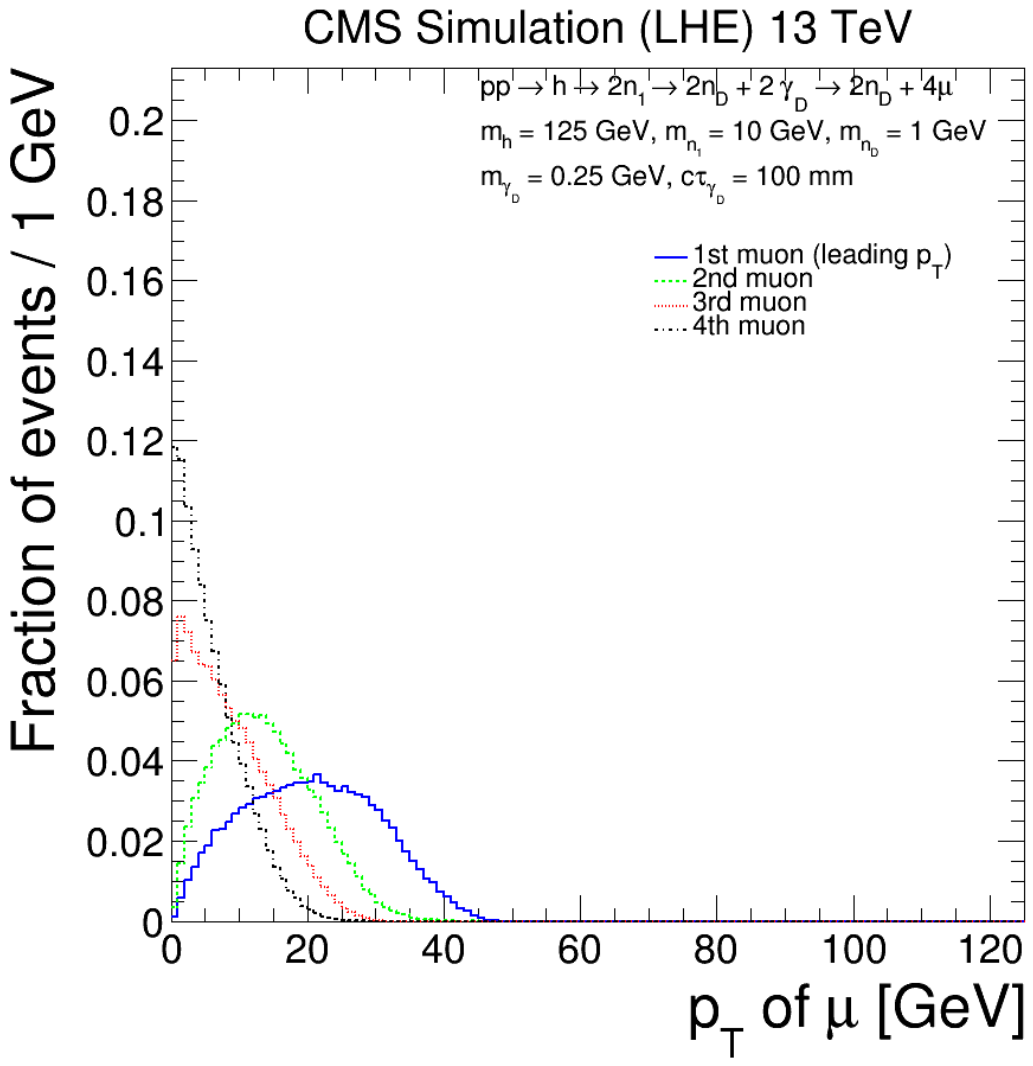
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 0.1 rad
ϕ of μ [rad]

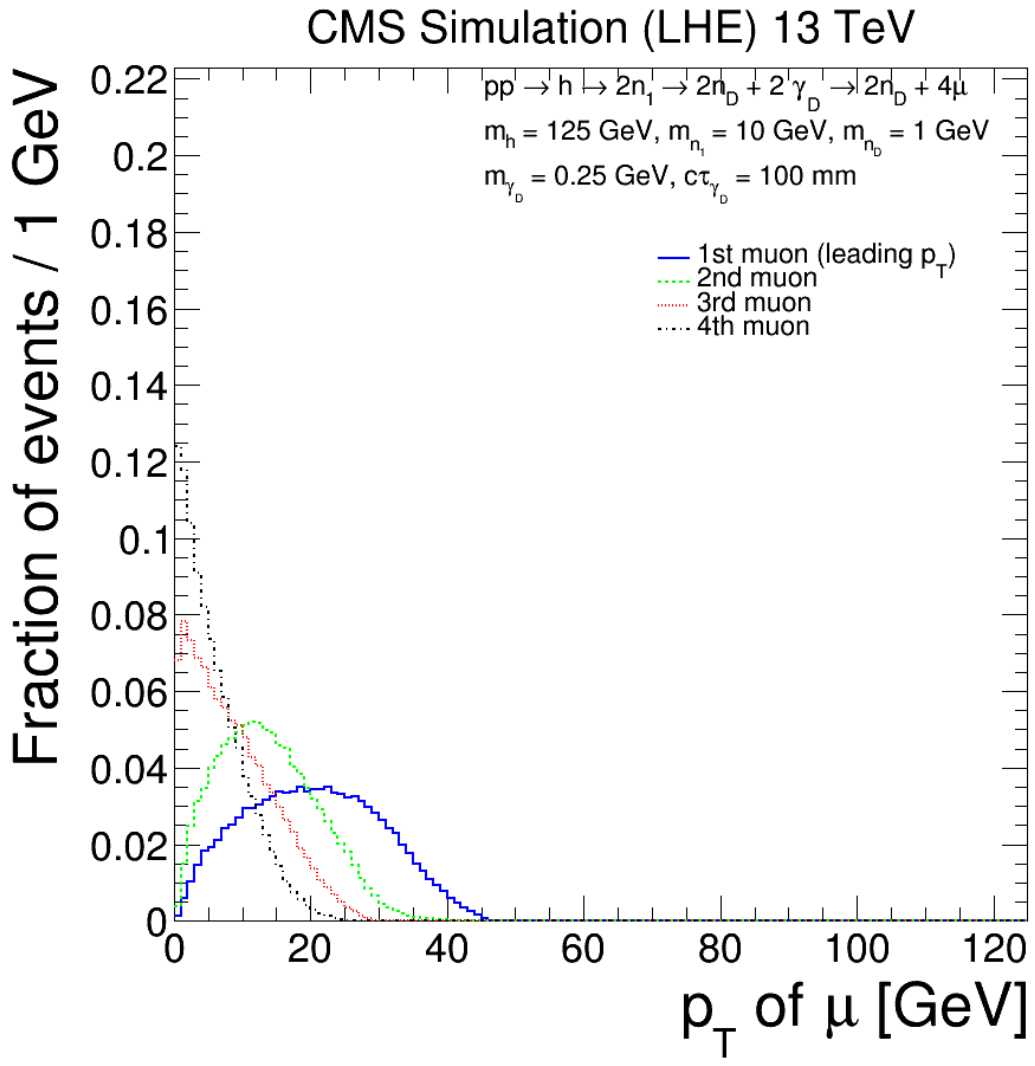
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 0.1 rad
ϕ of μ [rad]

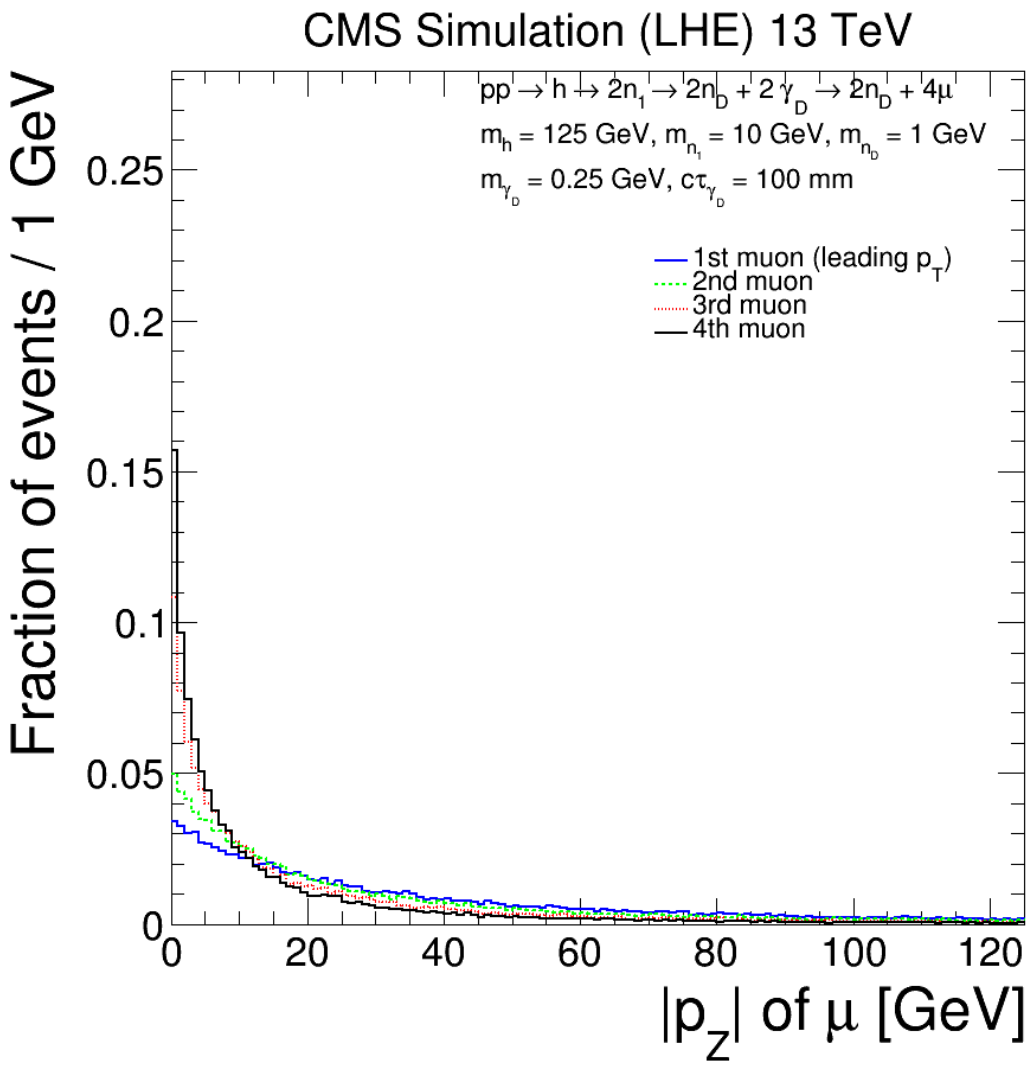
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
p_T of μ [GeV]

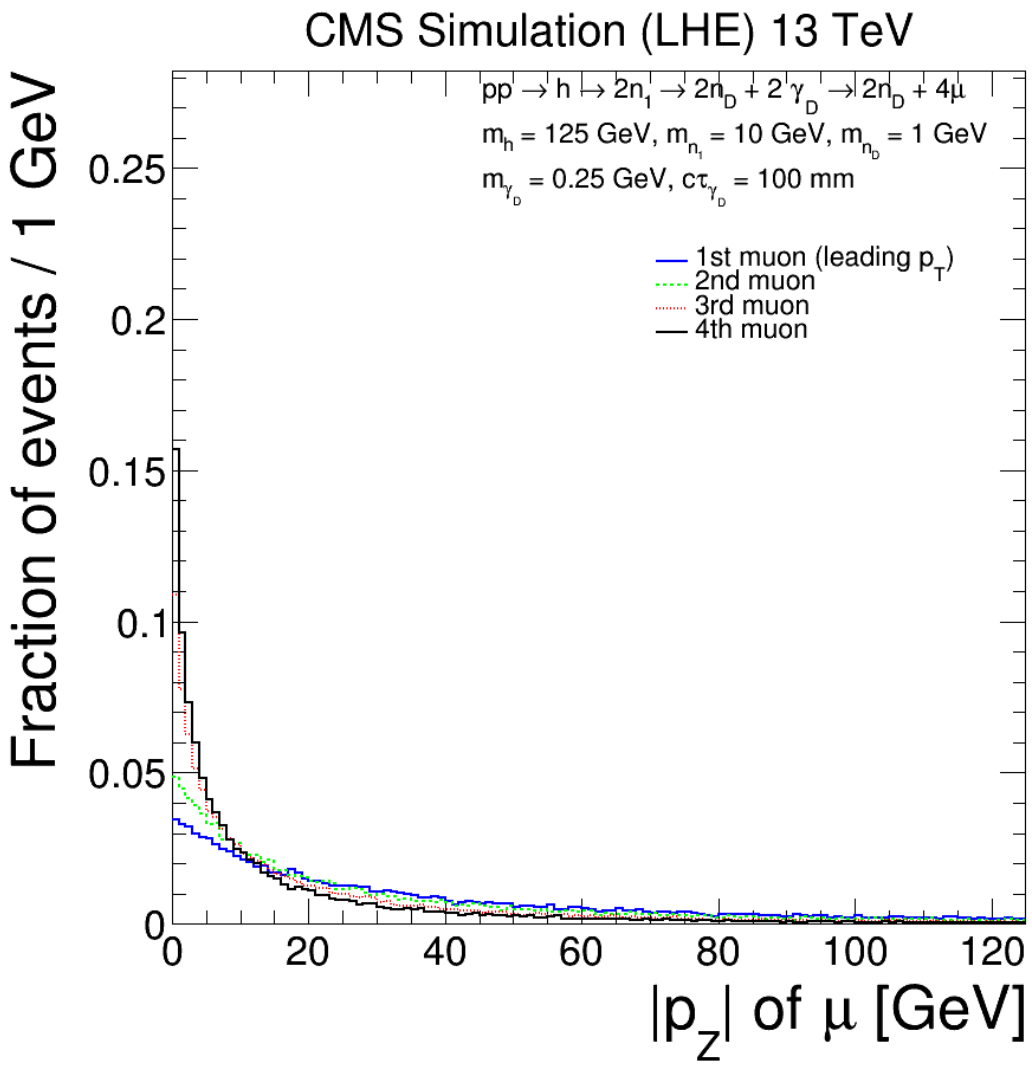
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
p_T of μ [GeV]

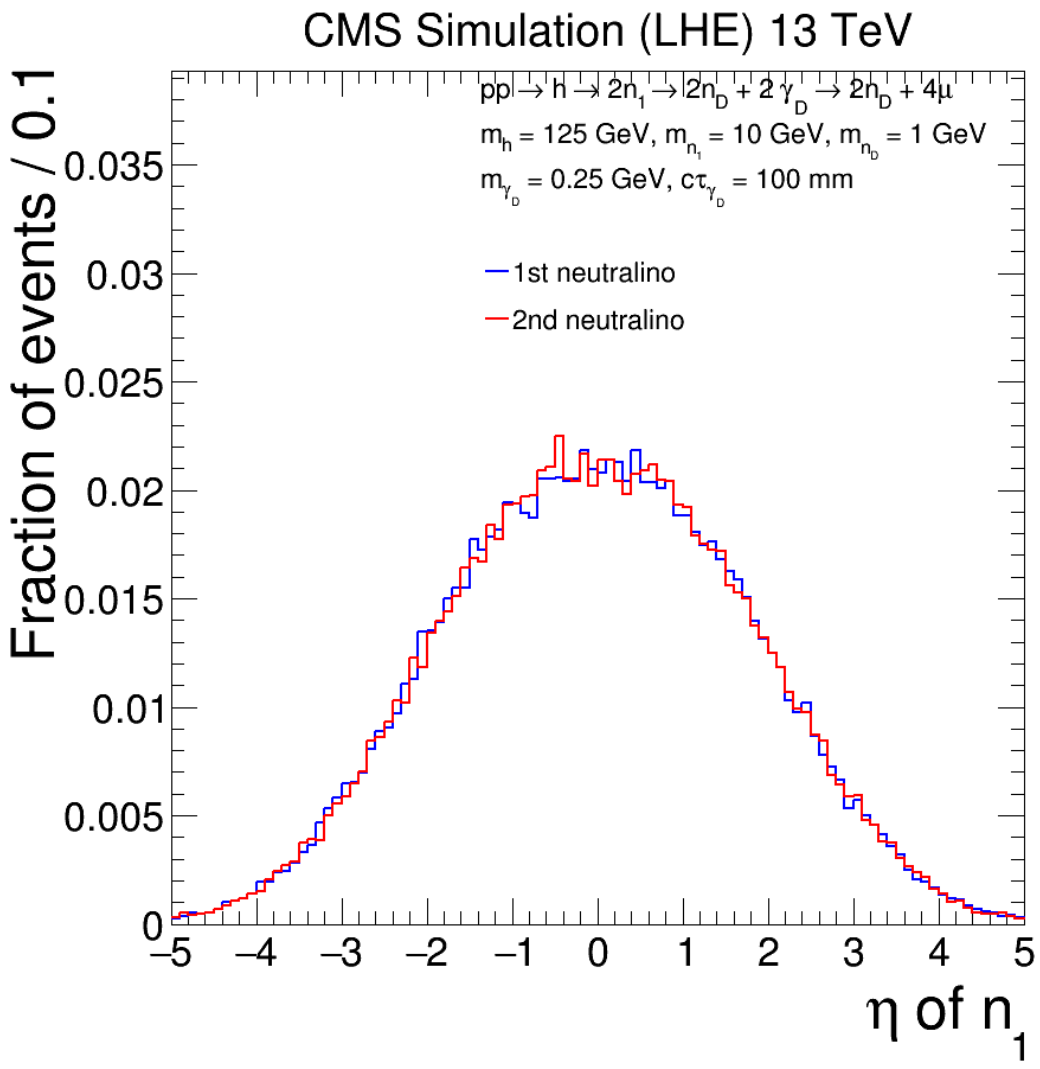
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
$|p_z|$ of μ [GeV]

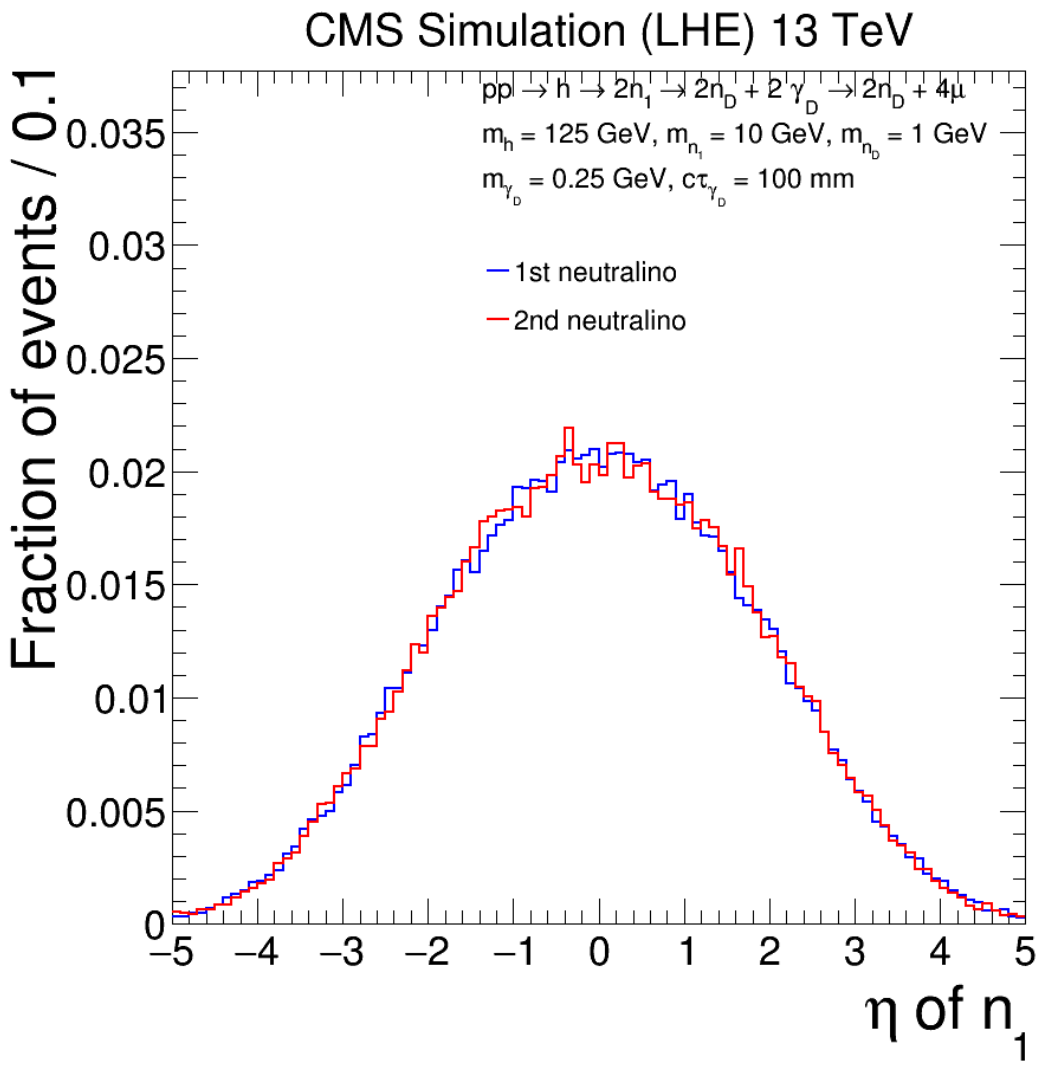
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st muon (leading p_T)
2nd muon
3rd muon
4th muon
Fraction of events / 1 GeV
$|p_z|$ of μ [GeV]

MG4

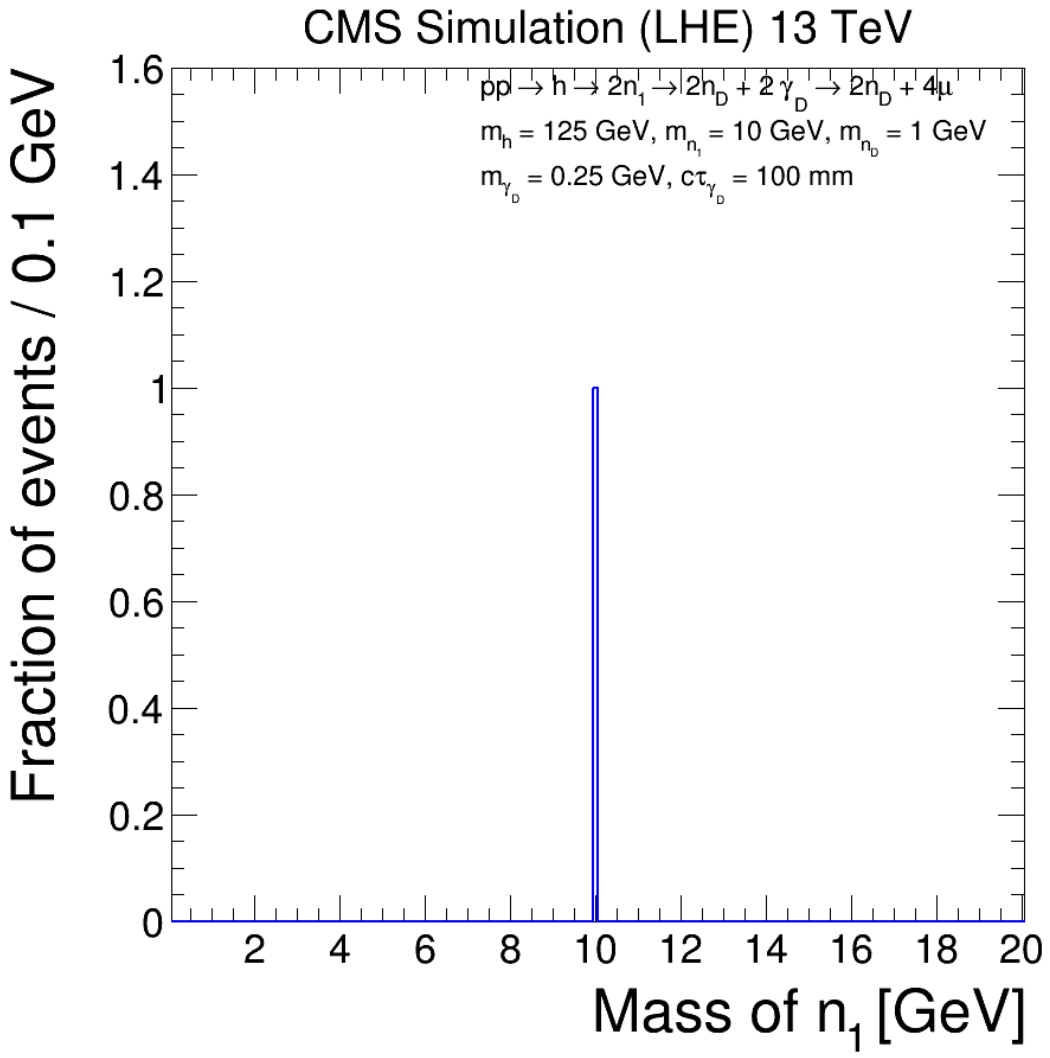

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 0.1
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of n_1

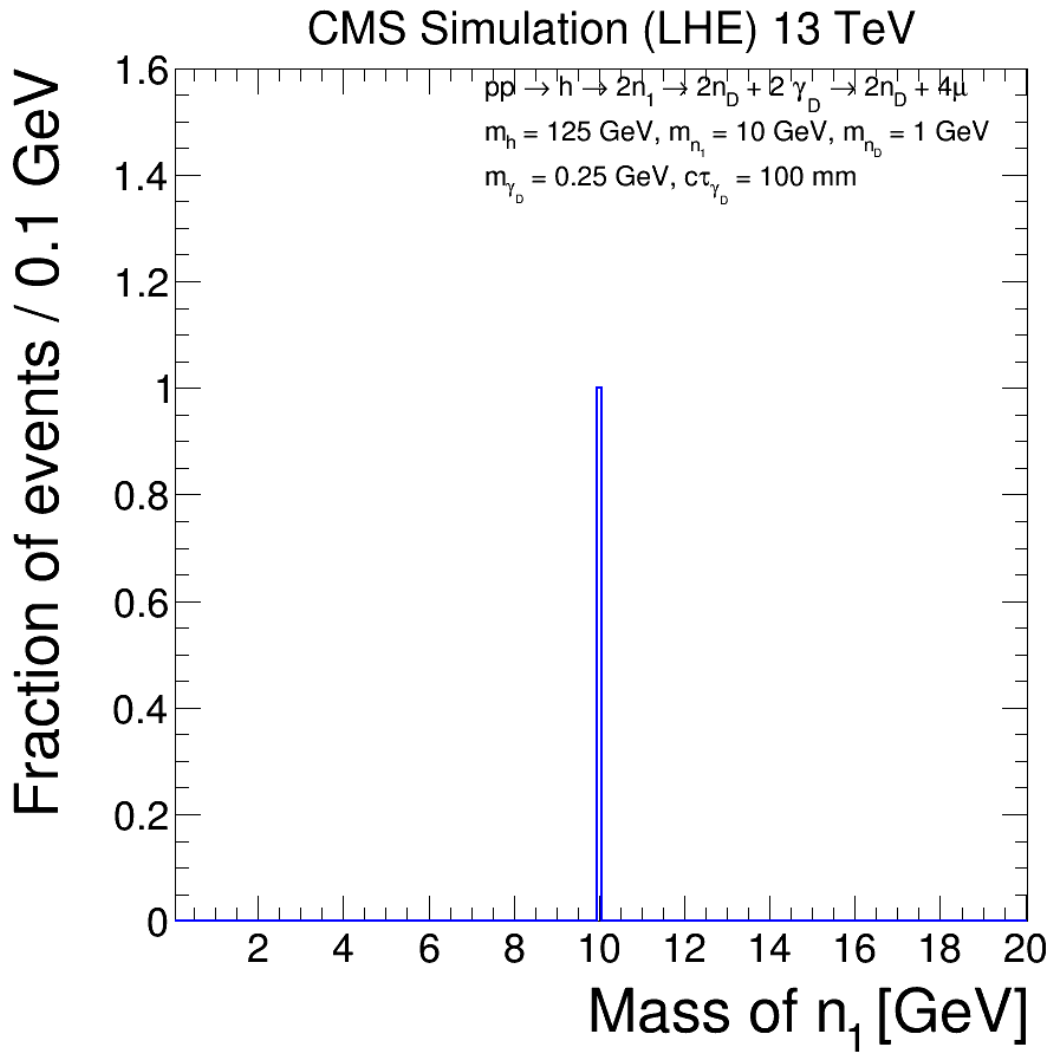
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 0.1
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of n_1

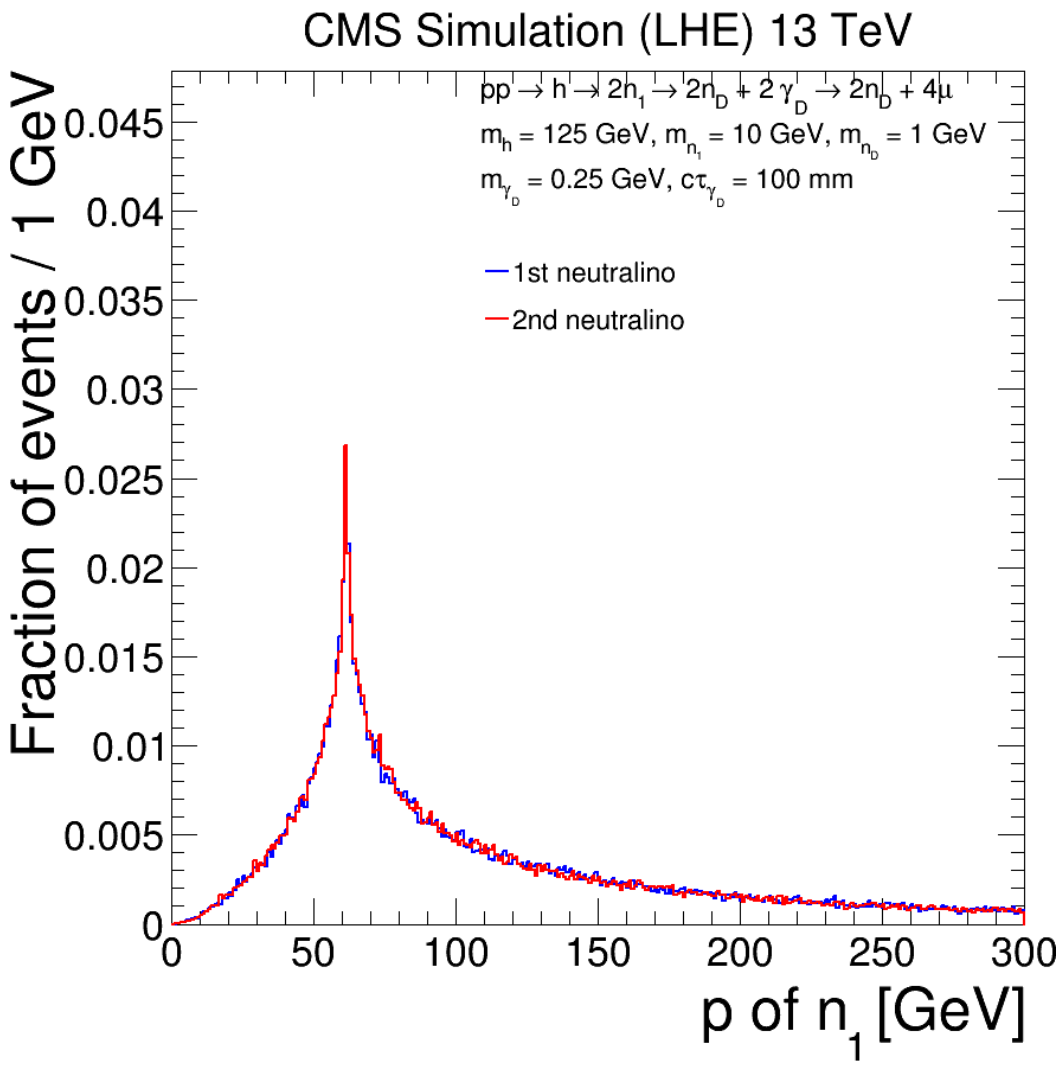
MG4

MG5

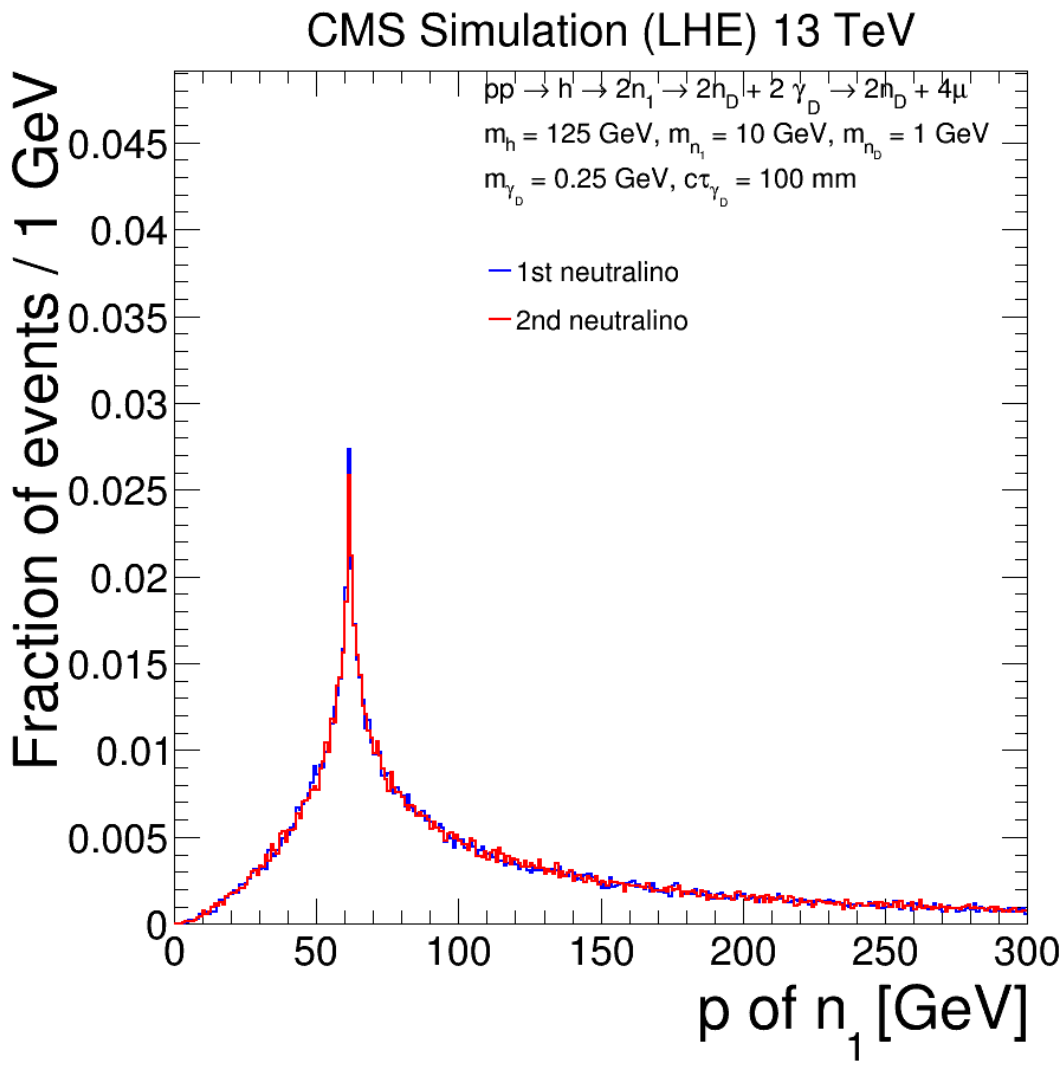

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of n_1 [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of n_1 [GeV]

MG4

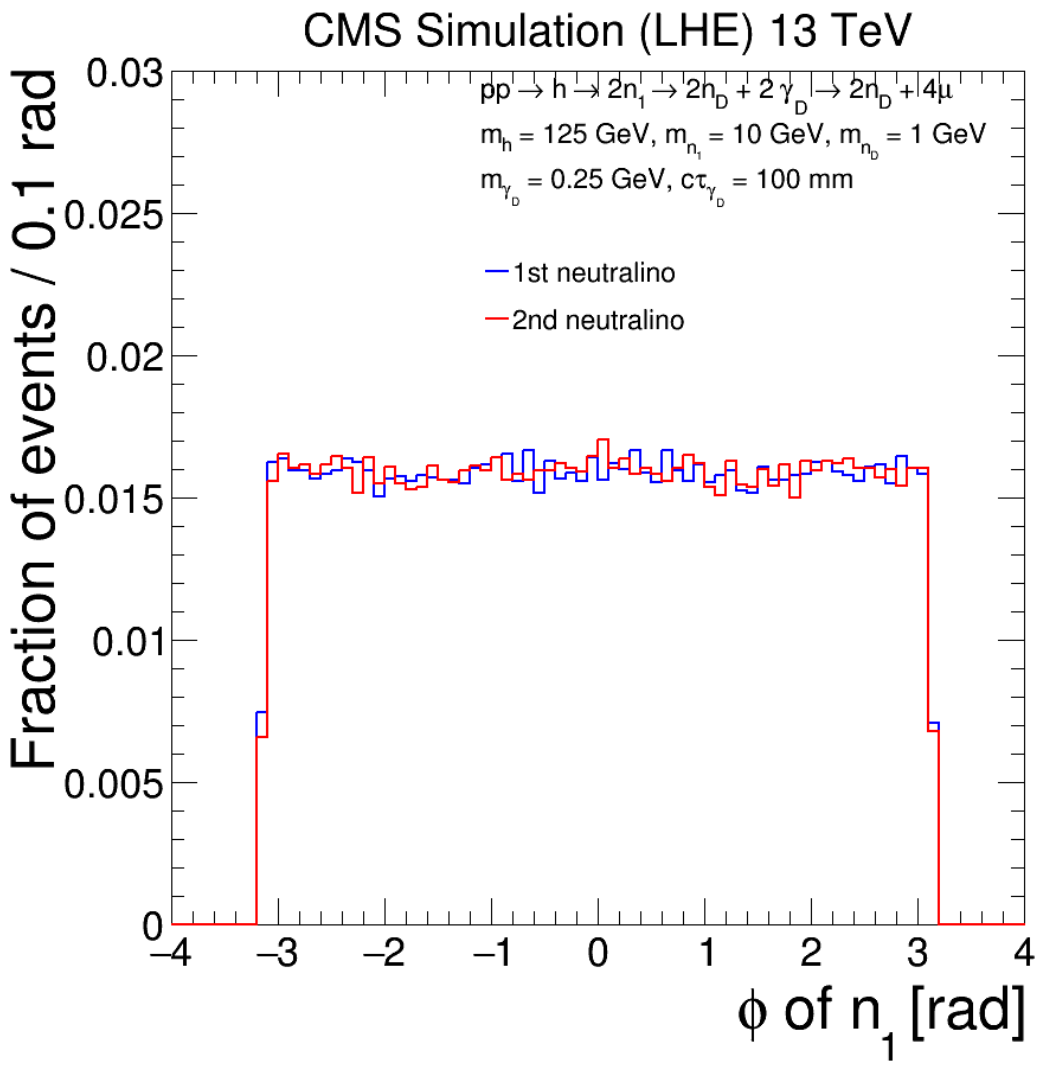

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
p of n_1 [GeV]

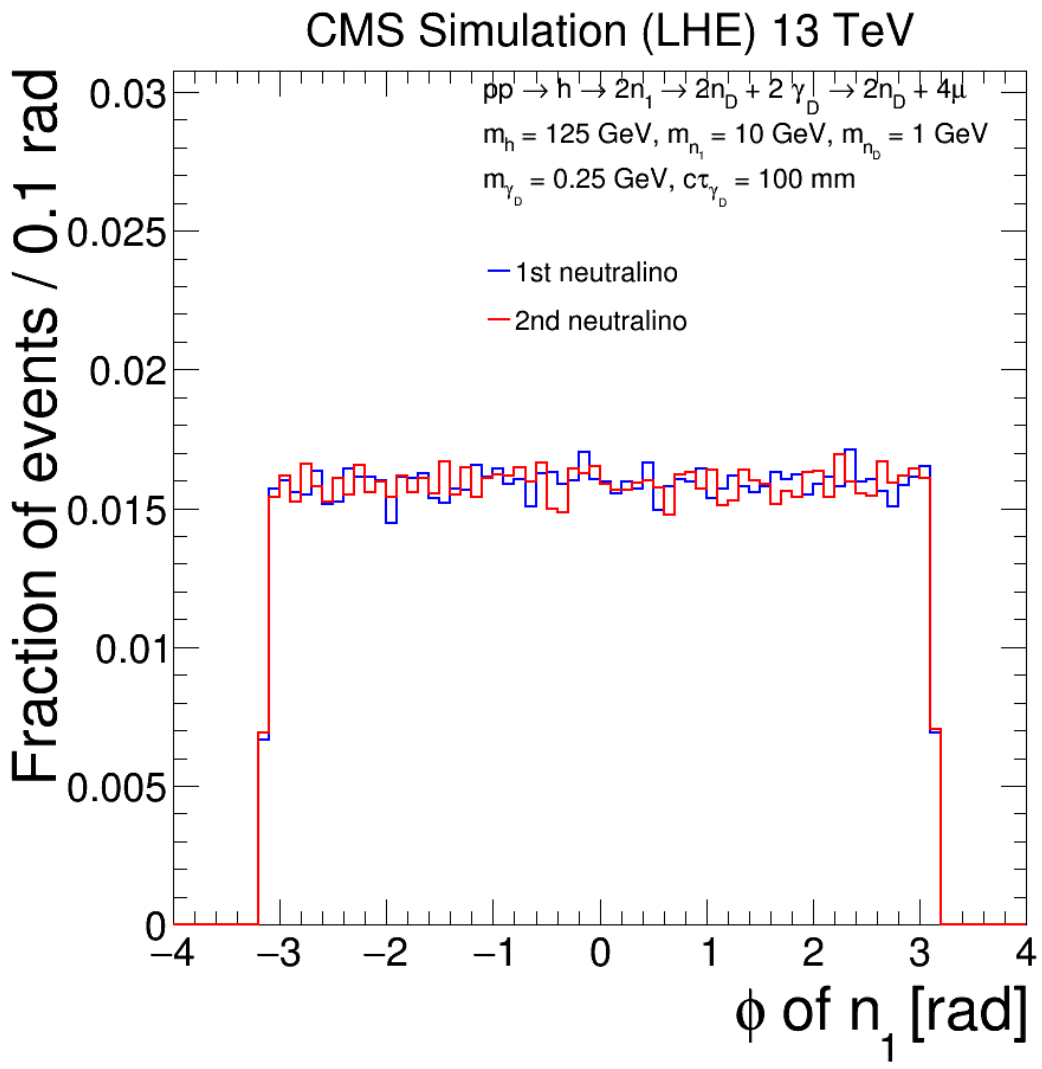
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
p of n_1 [GeV]

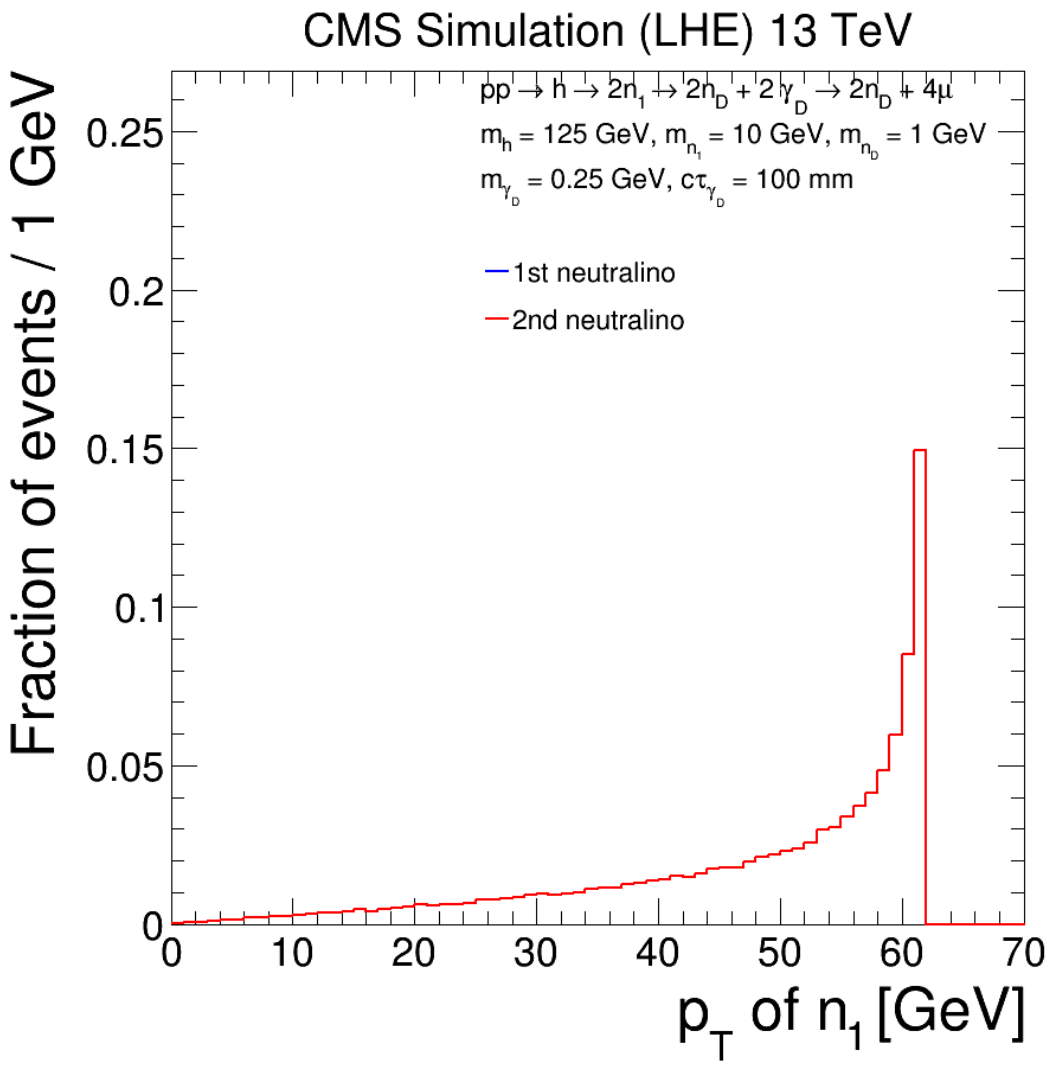
MG4

MG5

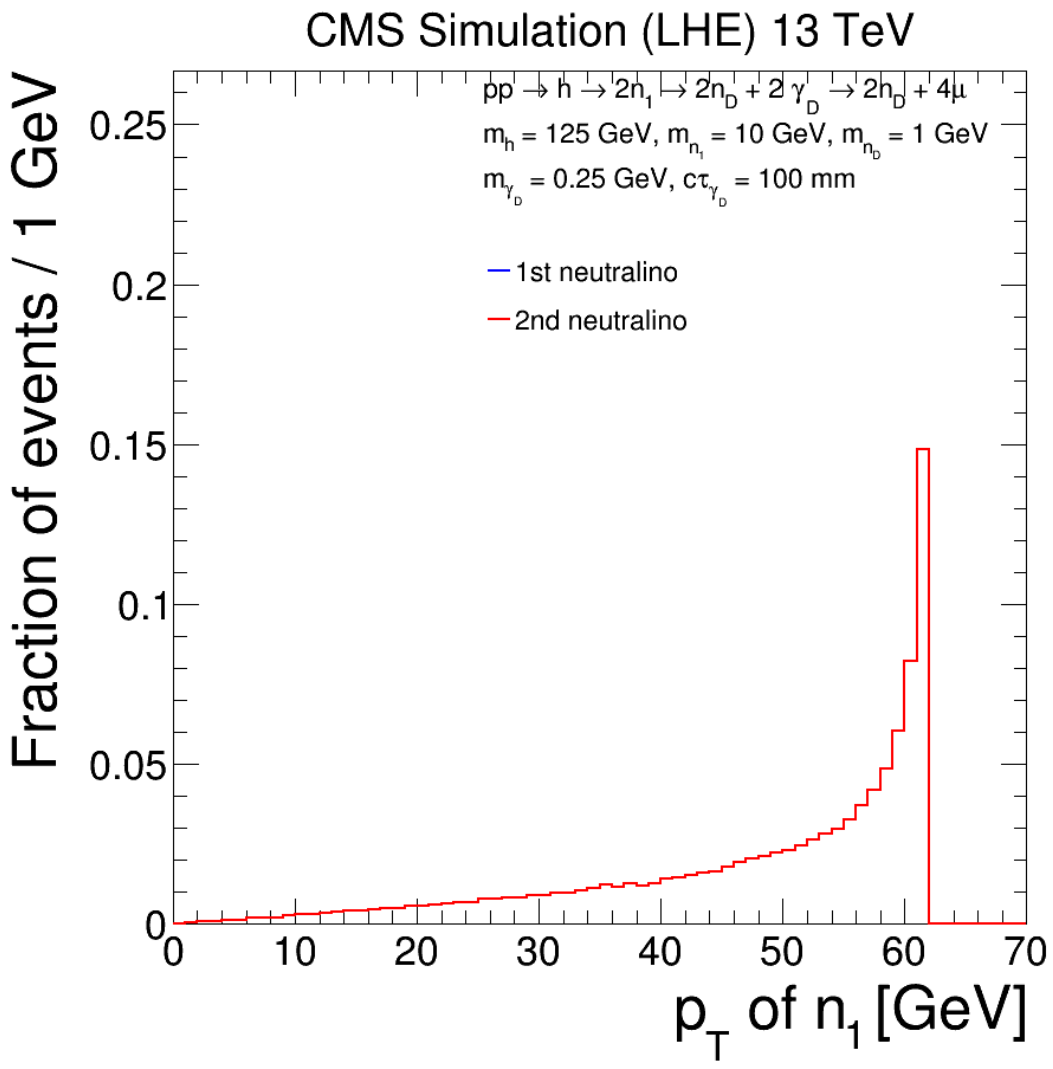

CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 0.1 rad
0.03
0.025
0.02
0.015
0.01
0.005
0
−4
−3
−2
−1
0
1
2
3
4
ϕ of n1 [rad]


CMS Simulation (LHE) 13 TeV
pp → h → 2n1 → 2nD + 2 γD → 2nD + 4μ
mh = 125 GeV, mn1 = 10 GeV, mnD = 1 GeV
mγD = 0.25 GeV, cτγD = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 0.1 rad
0.03
0.025
0.02
0.015
0.01
0.005
0
−4
−3
−2
−1
0
1
2
3
4
ϕ of n1 [rad]

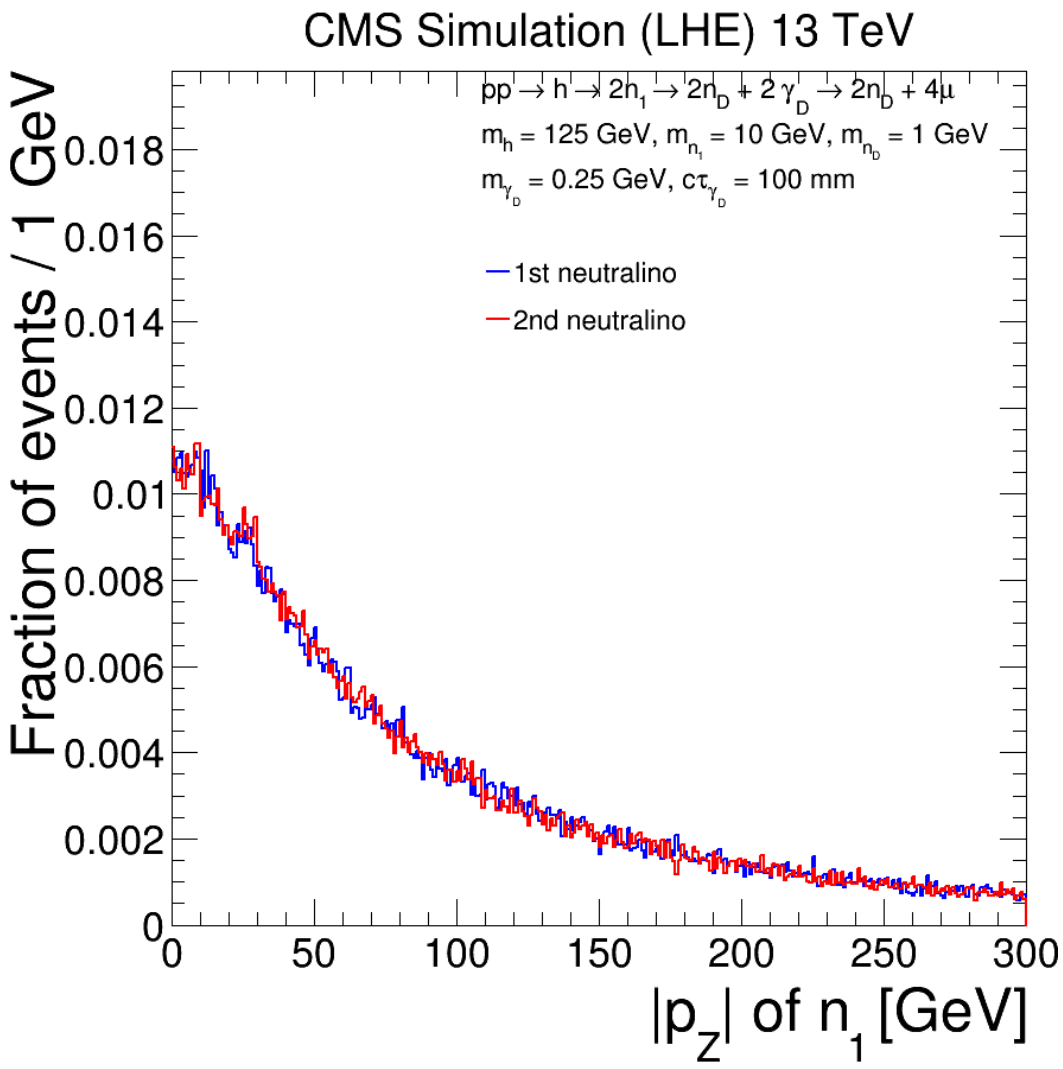
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
p_T of n_1 [GeV]

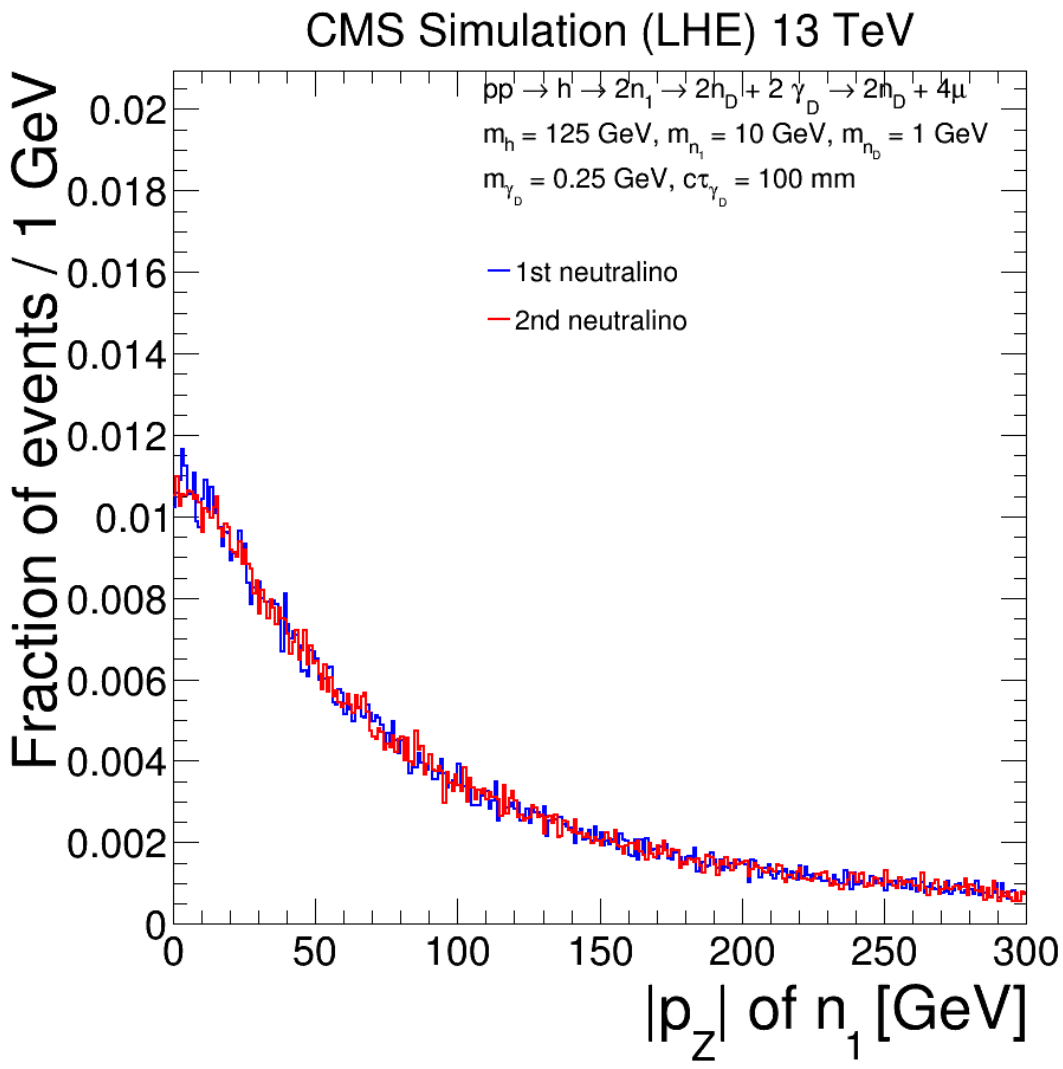
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
p_T of n_1 [GeV]

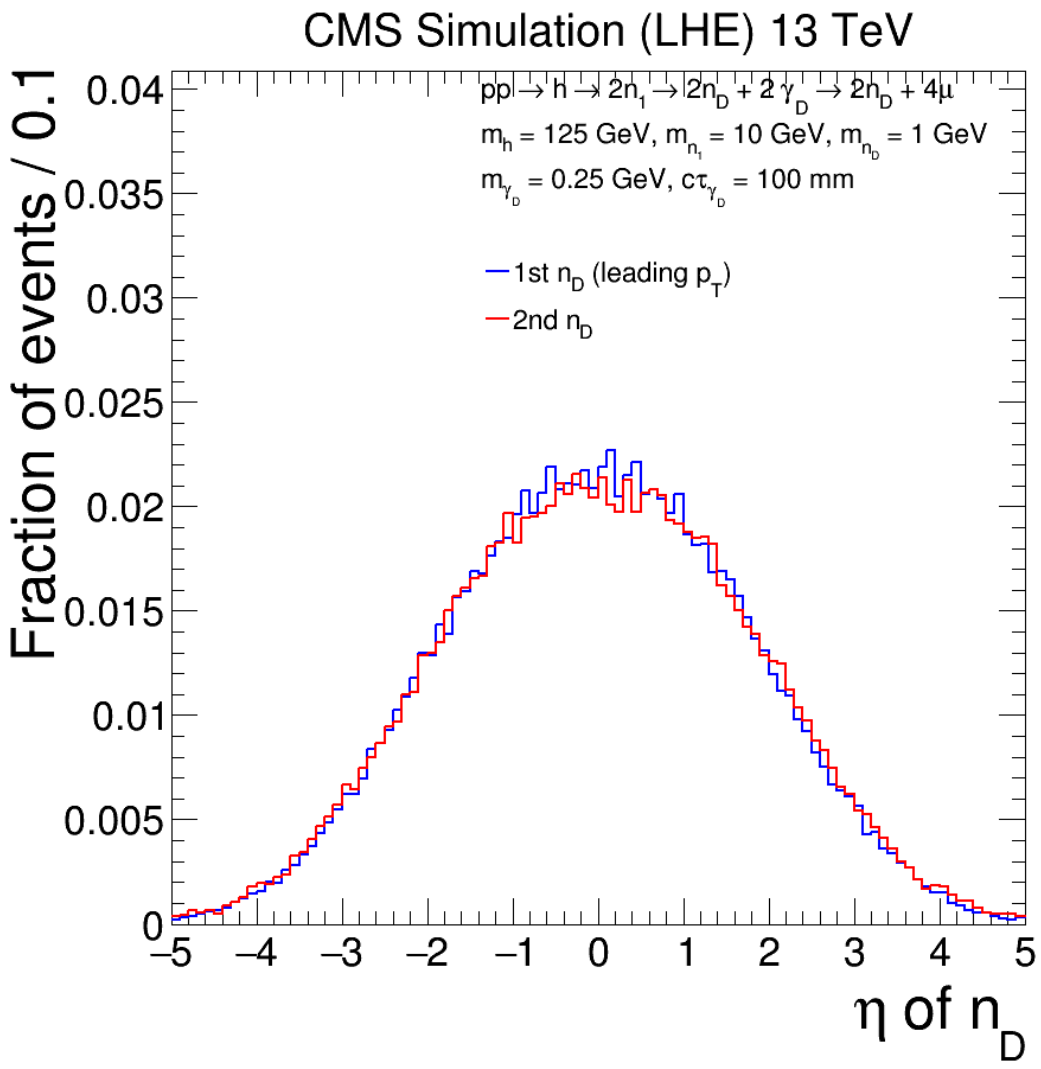
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
$|p_z|$ of n_1 [GeV]

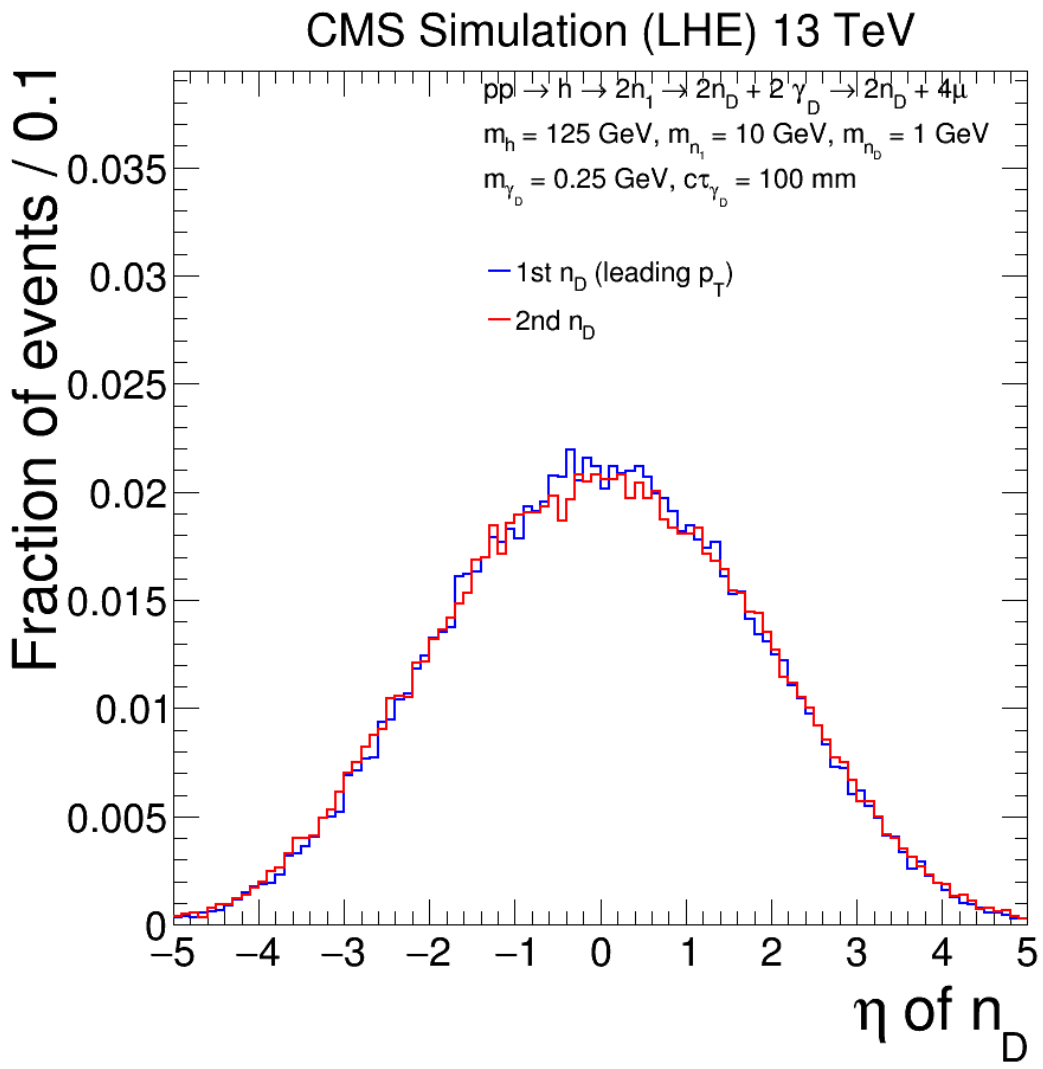
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st neutralino
2nd neutralino
Fraction of events / 1 GeV
$|p_z|$ of n_1 [GeV]

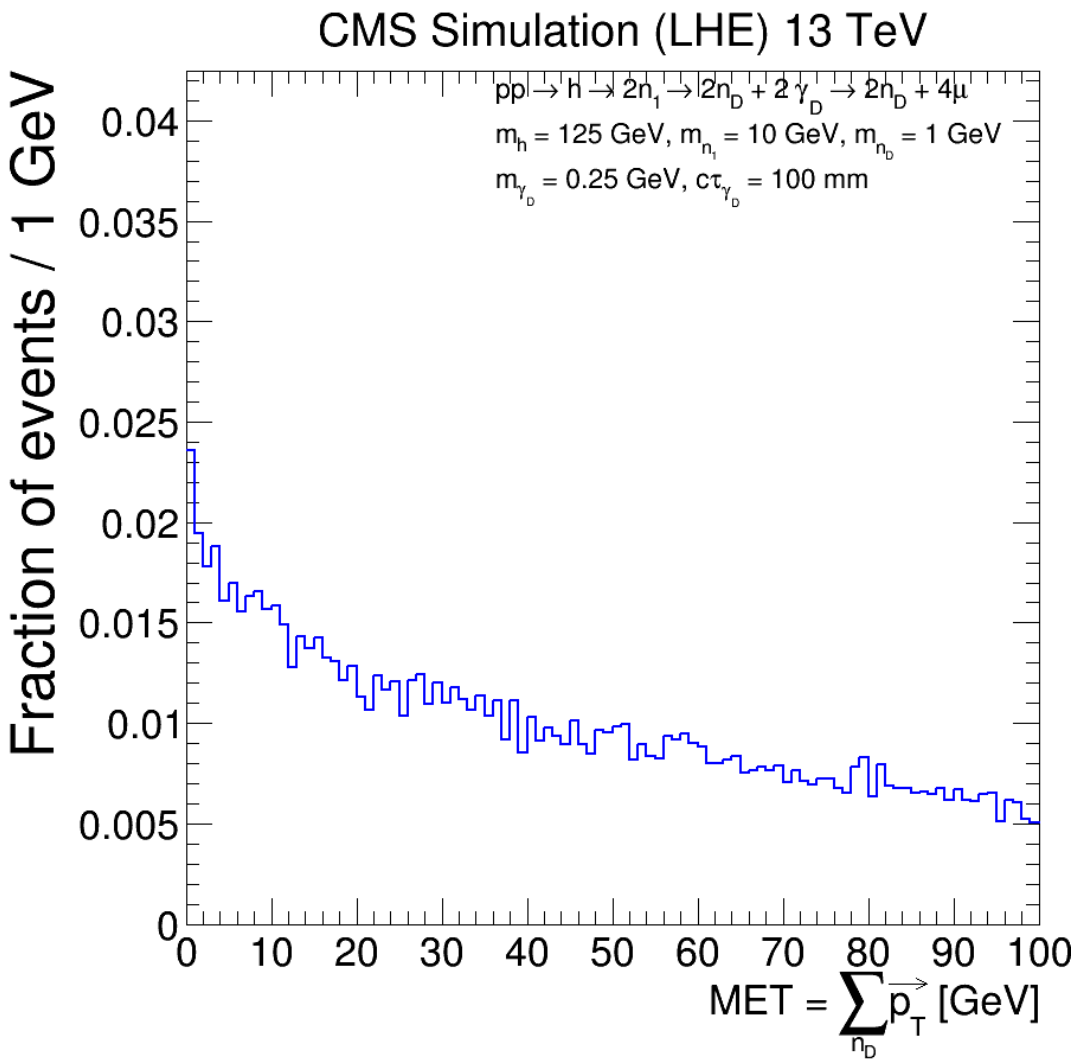
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 0.1
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of n_D

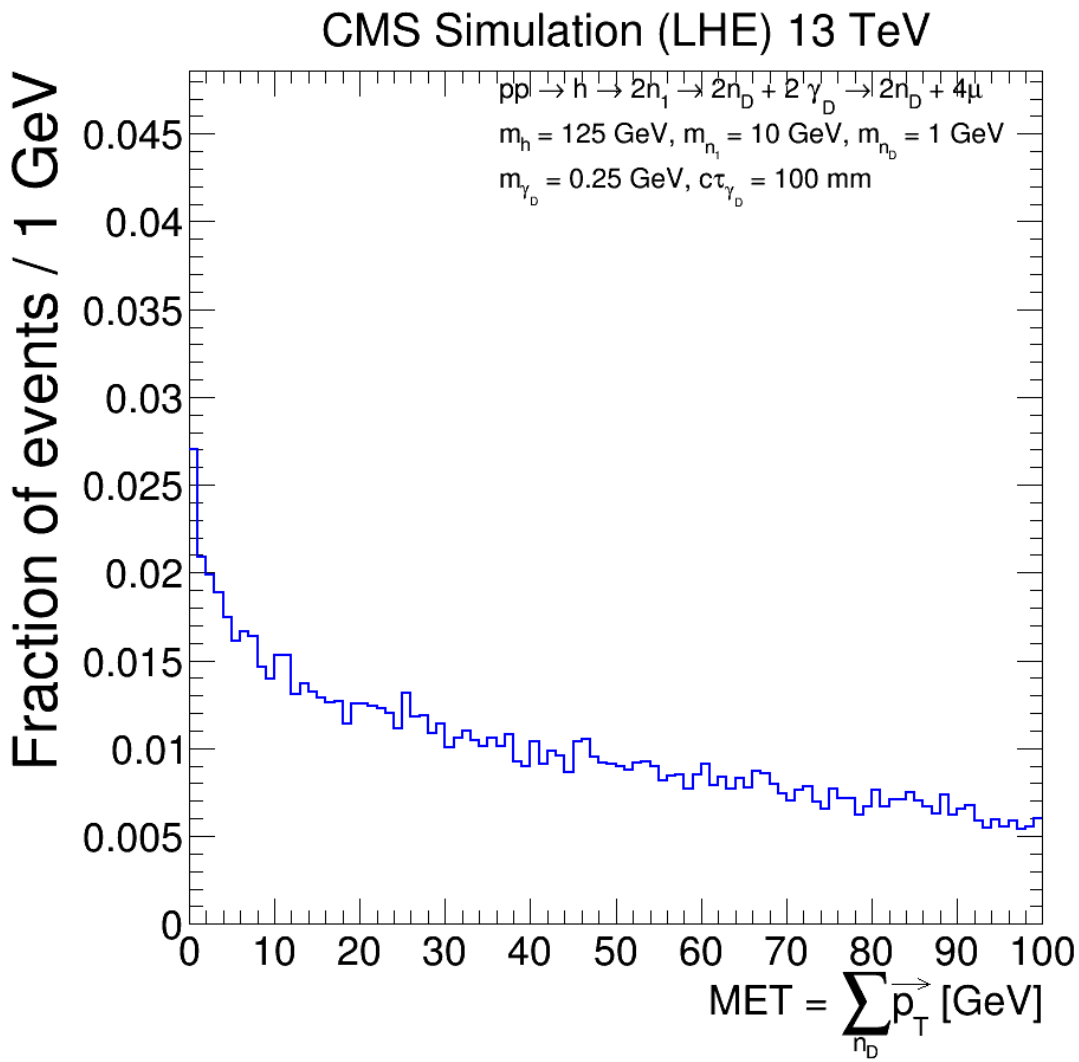
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 0.1
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
η of n_D

MG4

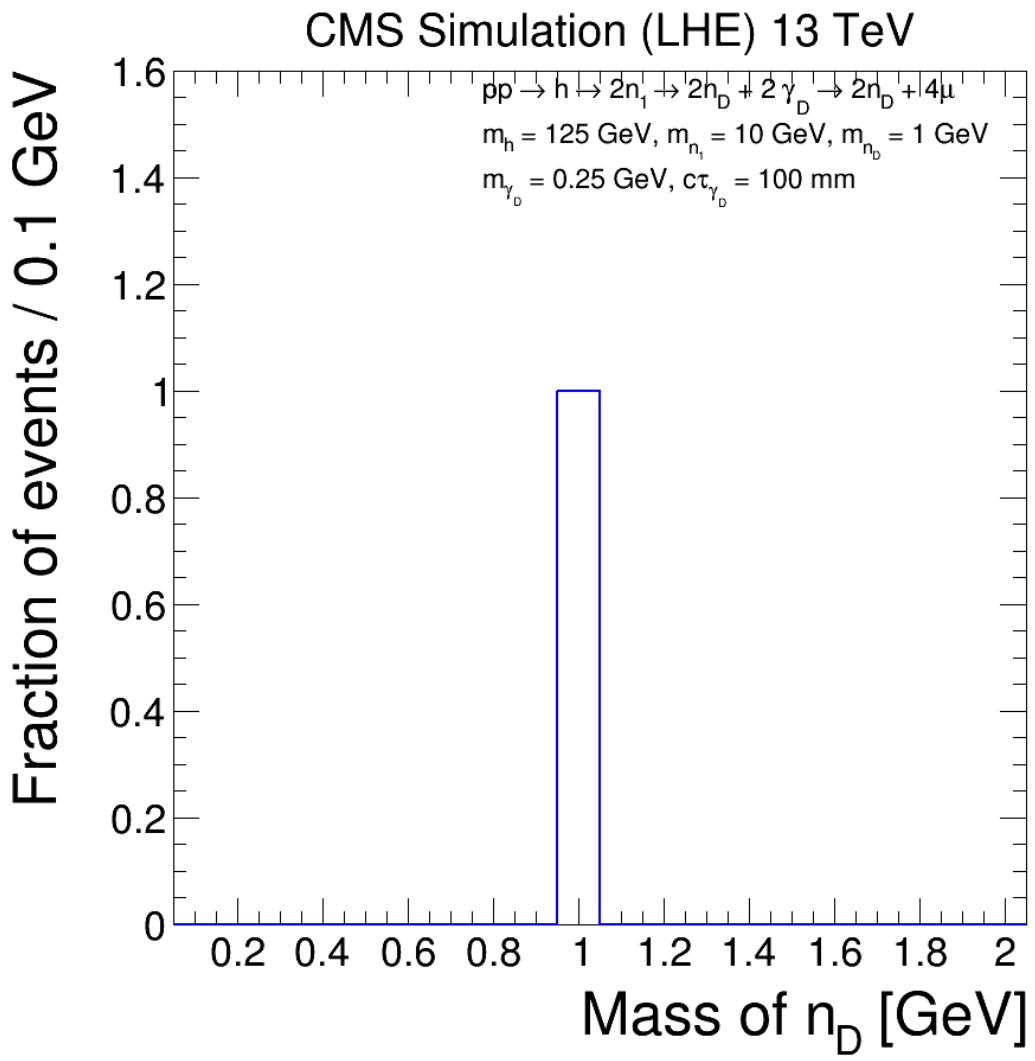

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0 10 20 30 40 50 60 70 80 90 100
MET = $\sum_{n_D} \vec{p}_T$ [GeV]

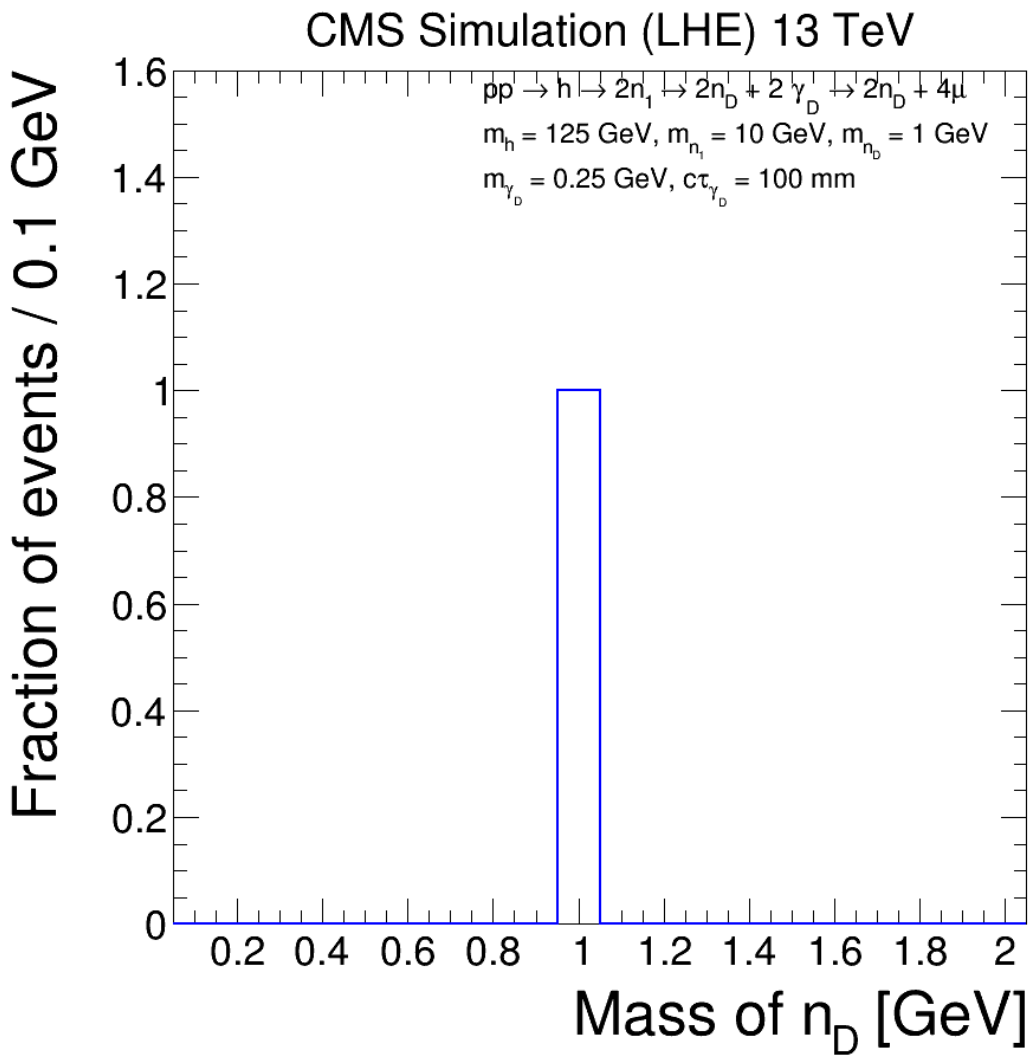
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 1 GeV
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0 10 20 30 40 50 60 70 80 90 100
MET = $\sum_{n_D} \vec{p}_T$ [GeV]

MG4

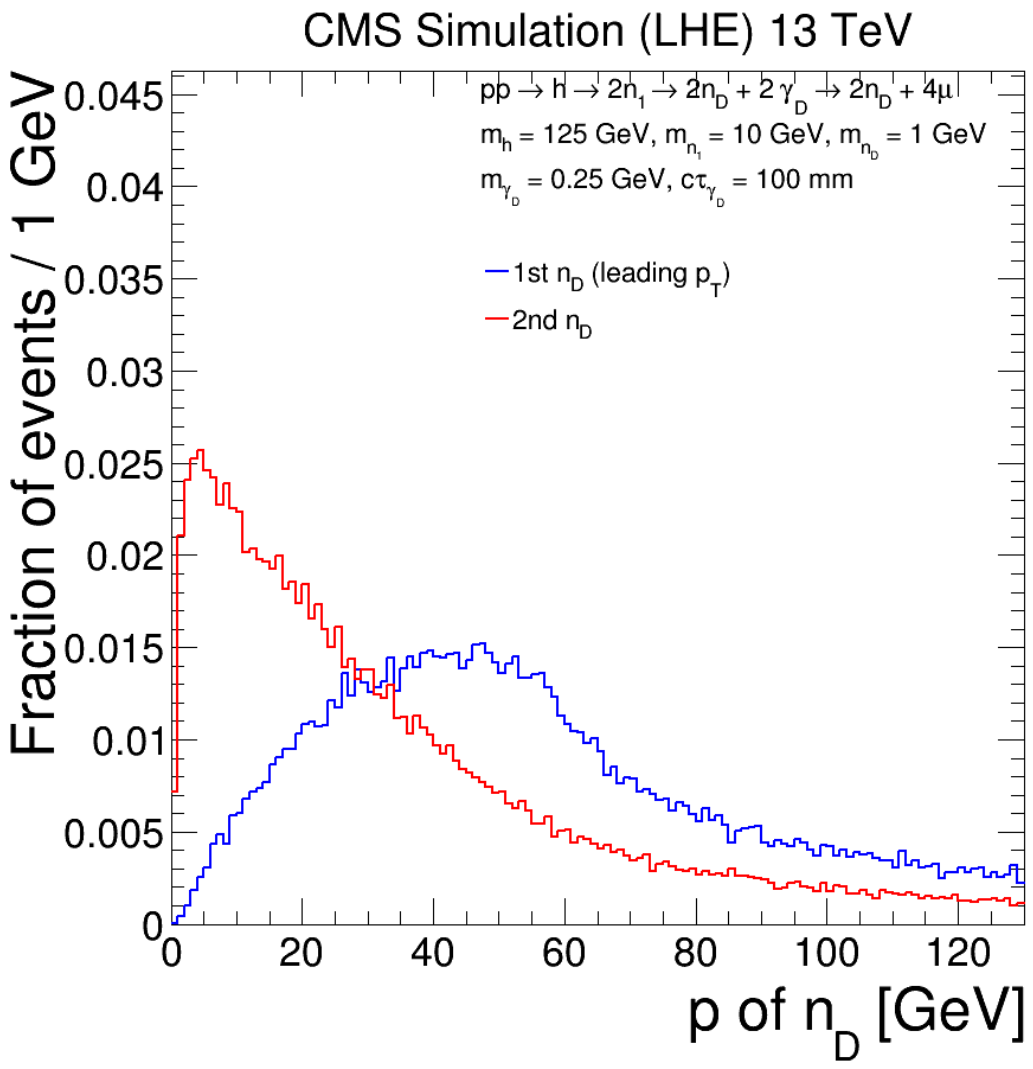
MG5

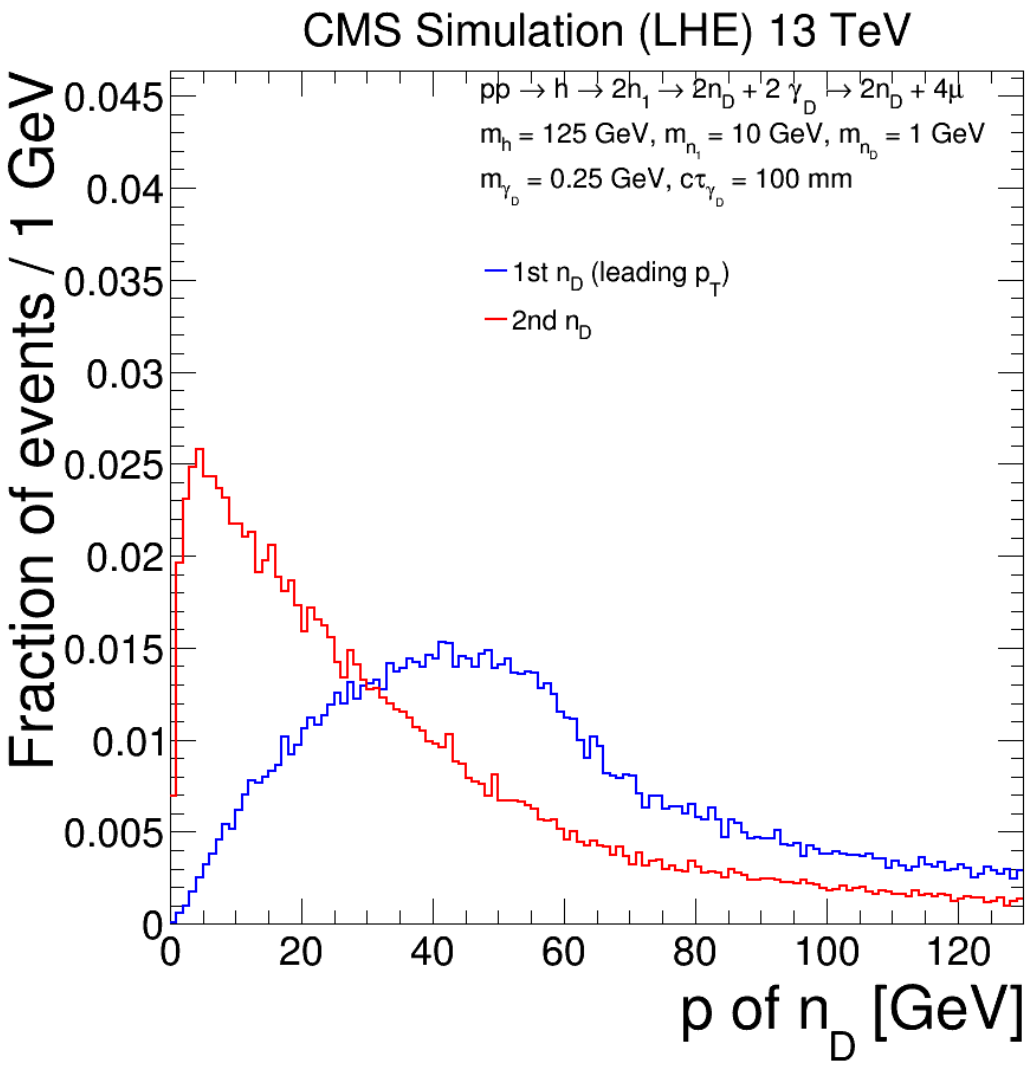

CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \mapsto 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of n_D [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \mapsto 2n_1 \mapsto 2n_D + 2\gamma_D \mapsto 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
Fraction of events / 0.1 GeV
Mass of n_D [GeV]

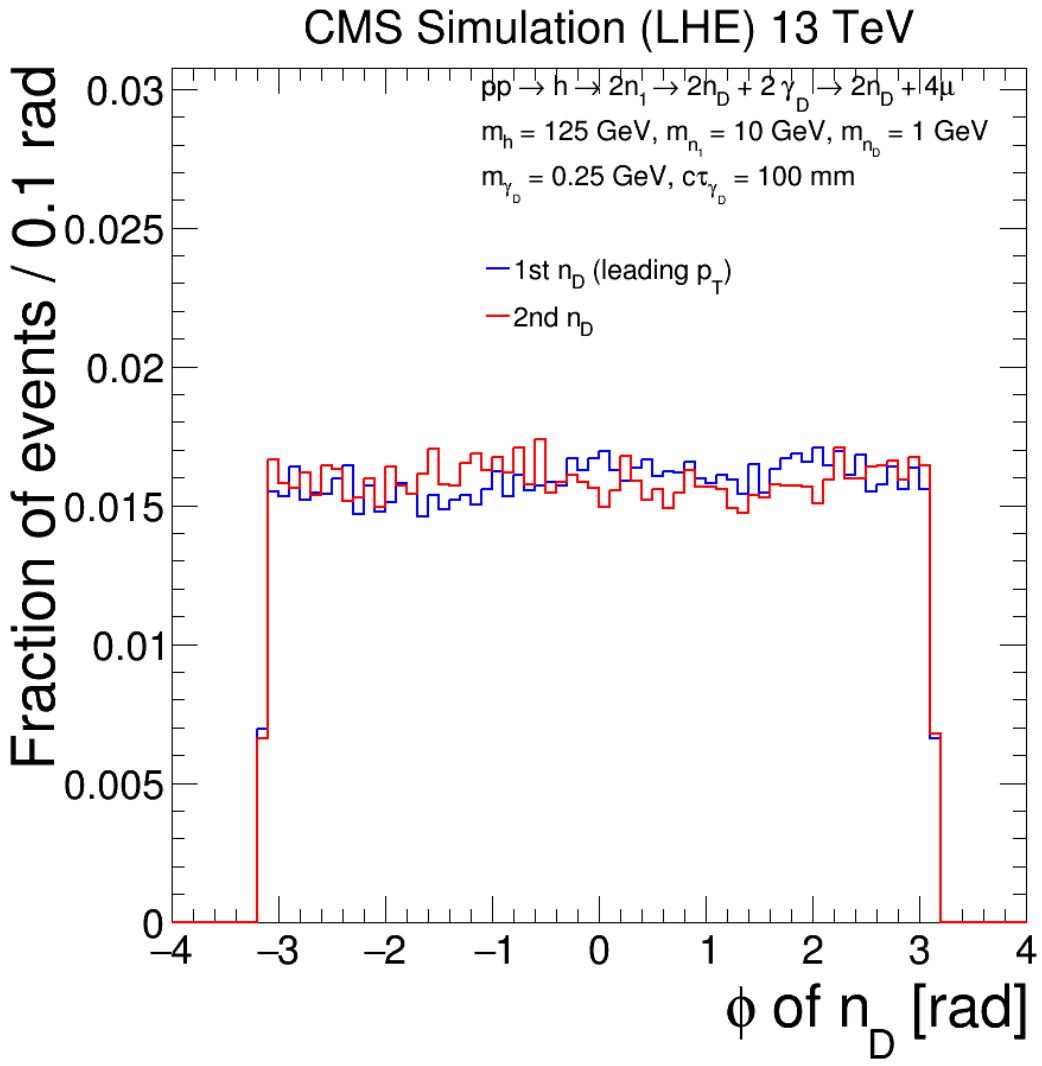
MG4

MG5

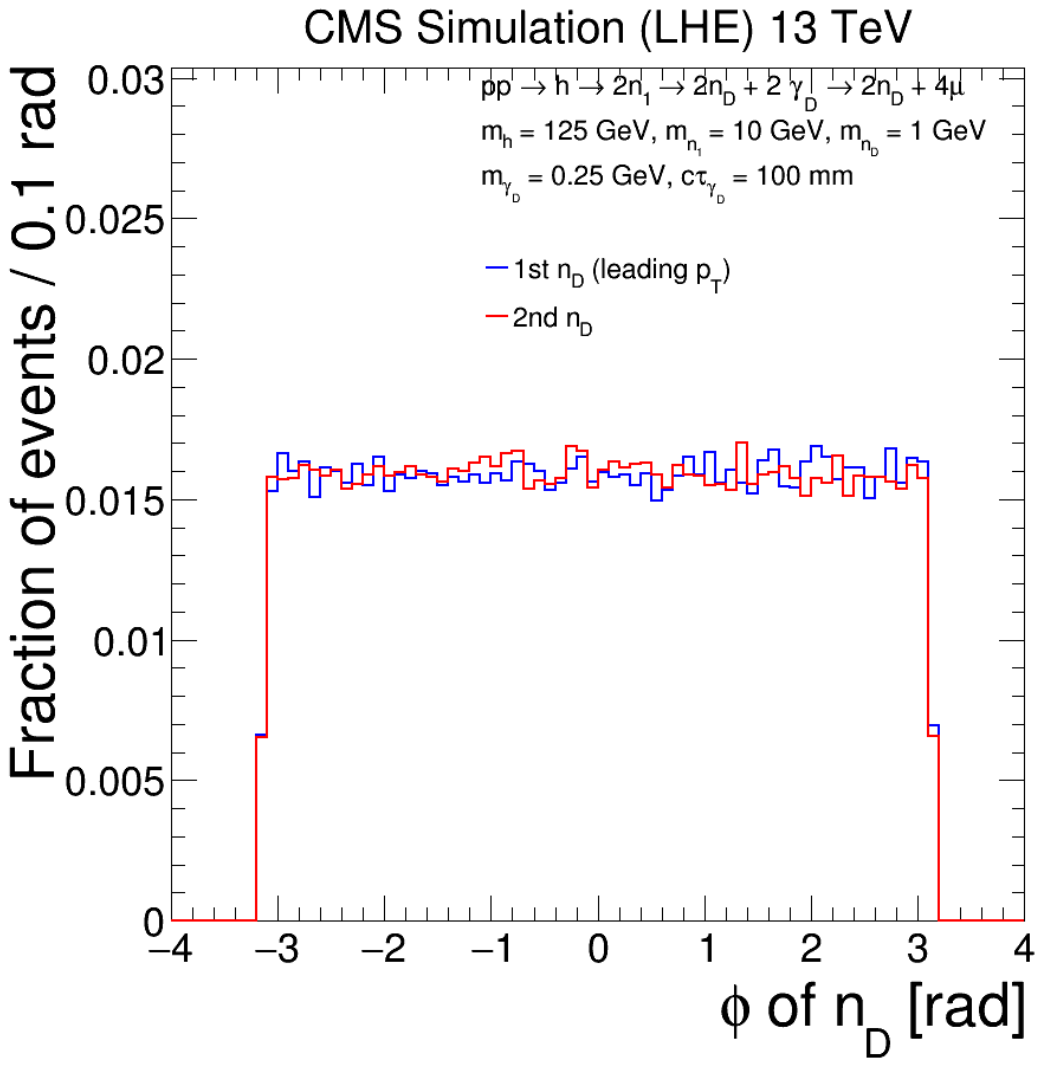

CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
p of n_D [GeV]


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
p of n_D [GeV]

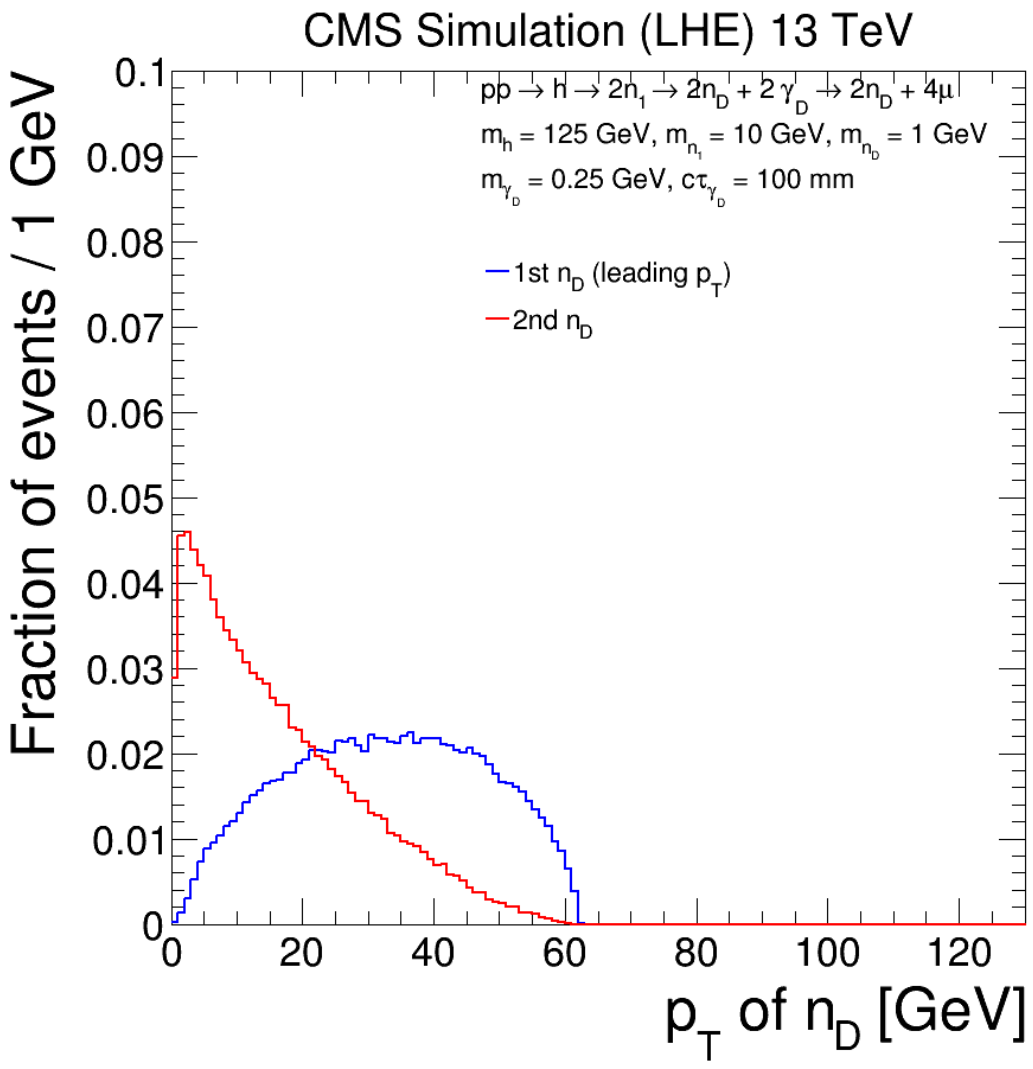
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2h_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 0.1 rad
ϕ of n_D [rad]

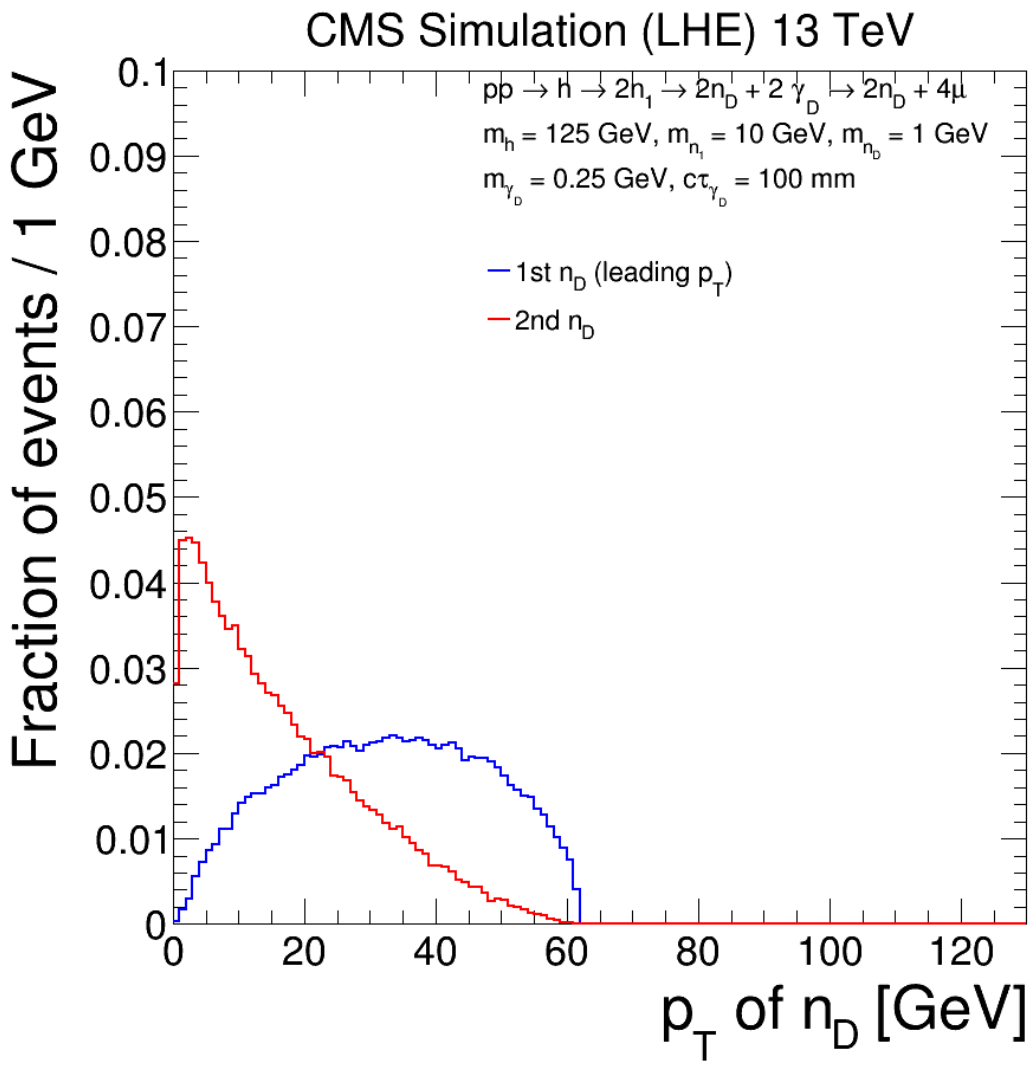
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 0.1 rad
ϕ of n_D [rad]

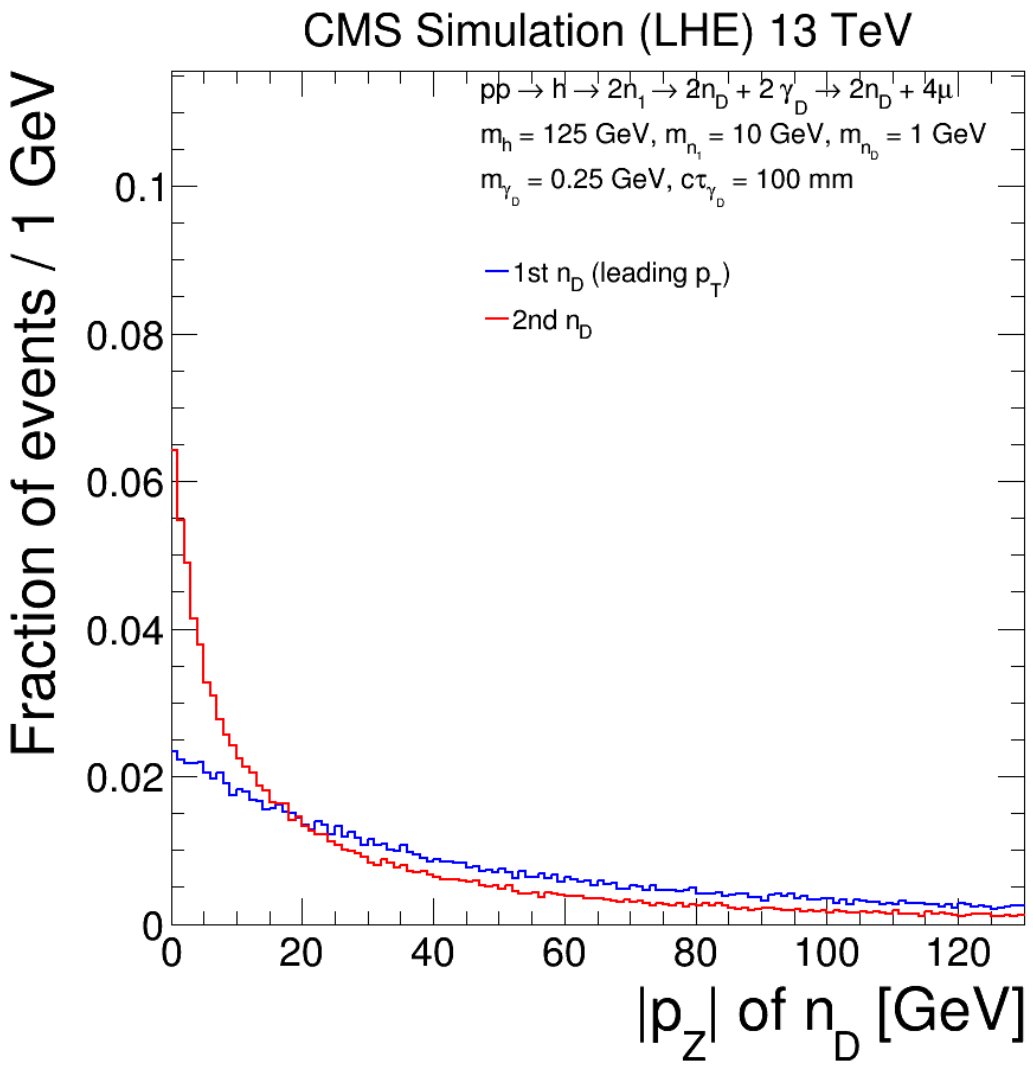
MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
p_T of n_D [GeV]

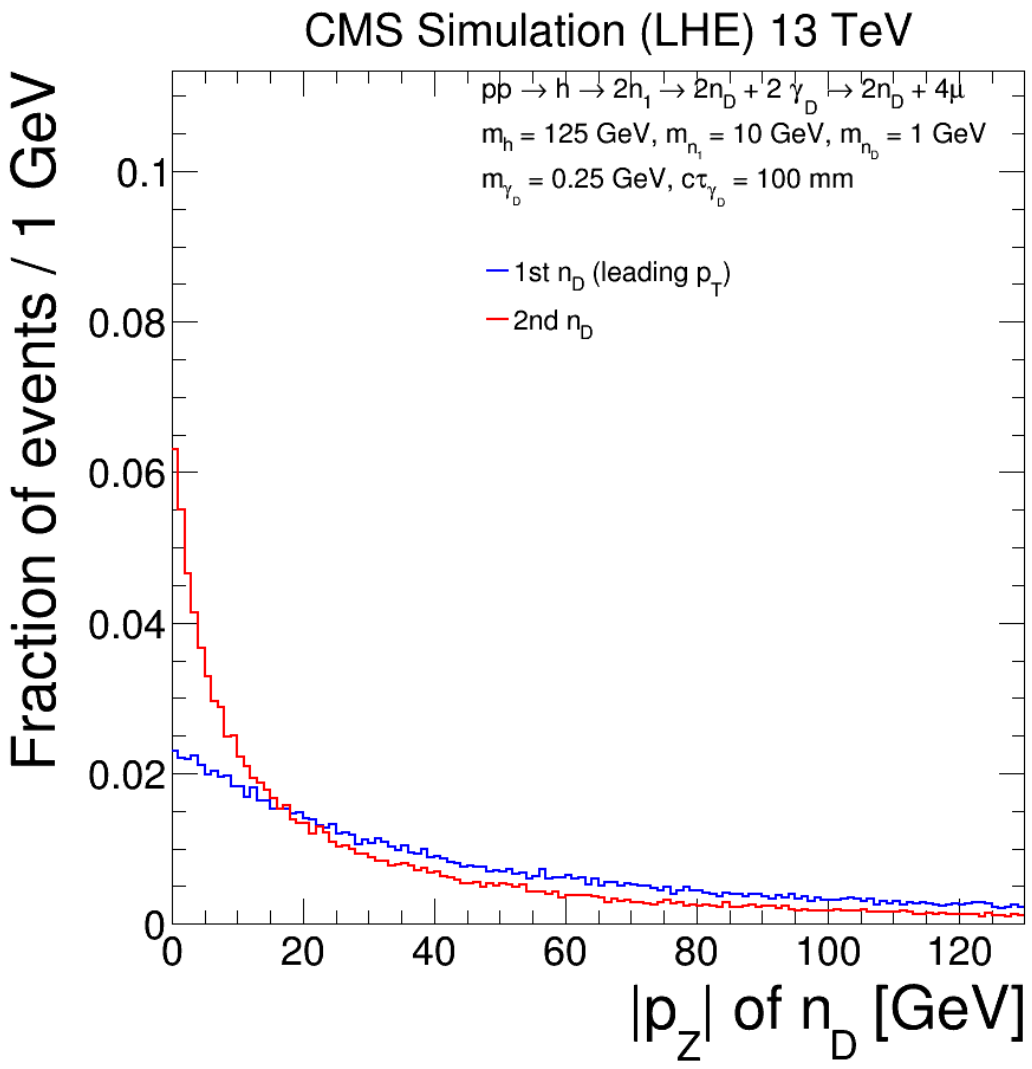
MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
p_T of n_D [GeV]

MG4


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
$|p_z|$ of n_D [GeV]

MG5


CMS Simulation (LHE) 13 TeV
$pp \to h \to 2n_1 \to 2n_D + 2\gamma_D \to 2n_D + 4\mu$
m_h = 125 GeV, m_{n_1} = 10 GeV, m_{n_D} = 1 GeV
m_{γ_D} = 0.25 GeV, $c\tau_{\gamma_D}$ = 100 mm
1st n_D (leading p_T)
2nd n_D
Fraction of events / 1 GeV
$|p_z|$ of n_D [GeV]

BACK UP

MadGraph5

- Import dark SUSY model
  - UFO format
  - python files containing coupling, parameters, vertex, etc
  - Output by FeynRules2.0 package
- Implement dark SUSY model in FeynRules
  - Current strategy: MSSM+U1D
    - Base on MSSM, add new particles and vertexes in our dark SUSY benchmark model
    - https://github.com/weishi10141993/DarkSUSY_MC_MG5/tree/master/MSSMDarkSector