



Monophoton Dark Matter Studies at Muon Colliders

DELPHES Simulation

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Motivation

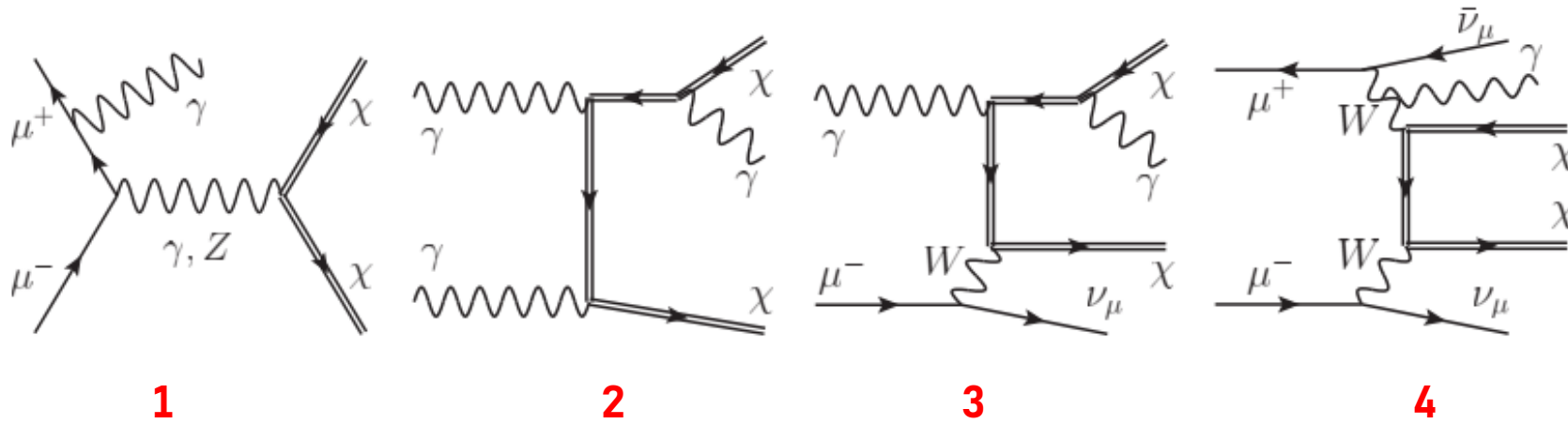
- Weakly Interacting Massive Particles (WIMP) are natural cold DM candidates
- Muon Colliders offer great potential in discovering new physics, particularly in probing WIMP dark matter
- With a large event sample, the monophoton channel of production offers good prospects

Theory

- Theory from “WIMPs at High Energy Muon Colliders” *
- Results in paper produced from signal and background events generated through MadGraph
- Events generated with COM energy = 14 TeV and two DM masses = 1 TeV, 3 TeV

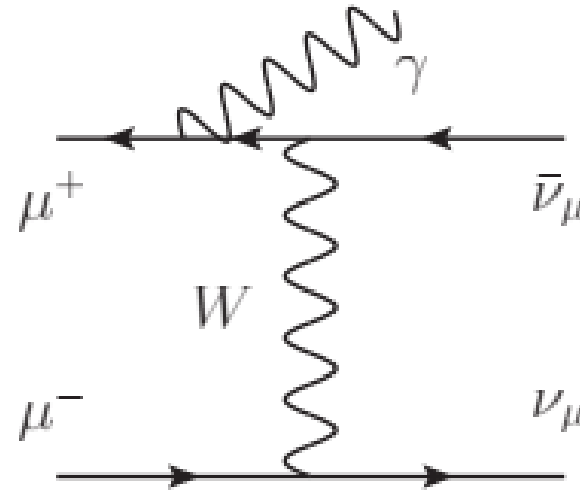
* <https://arxiv.org/abs/2009.11287>

Monophoton Channel - Signal



- 1 $\mu^+ \mu^- \rightarrow \gamma \chi \chi$
- 2 $\gamma \gamma \rightarrow \gamma \chi \chi$
- 3 $\gamma \mu^\pm \rightarrow \gamma \nu \chi \chi$
- 4 $\mu^+ \mu^- \rightarrow \gamma \nu \nu \chi \chi$

Monophoton Channel - Background



Most significant background:

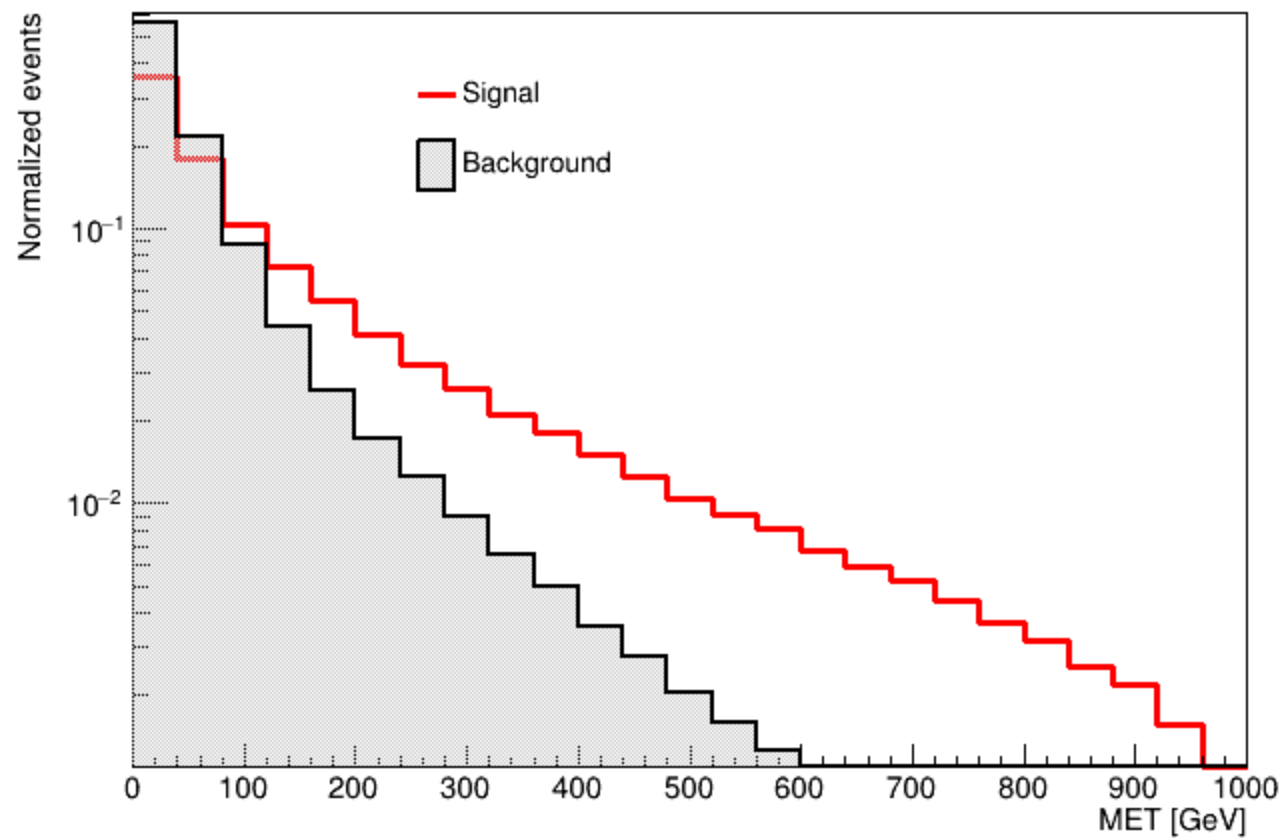
$$\mu^+ \mu^- \rightarrow \gamma \nu \bar{\nu}$$

Current progress

- Studying the primary signal process: $\mu^+ \mu^- \rightarrow \gamma \chi \chi$
- Using the major SM background: $\mu^+ \mu^- \rightarrow \gamma \nu \bar{\nu}$
- Generating 500,000 events with MadGraph, hadronizing with Pythia and simulating detector response with DELPHES
- Currently working with COM energy = 3 TeV and DM mass = 0.8 TeV

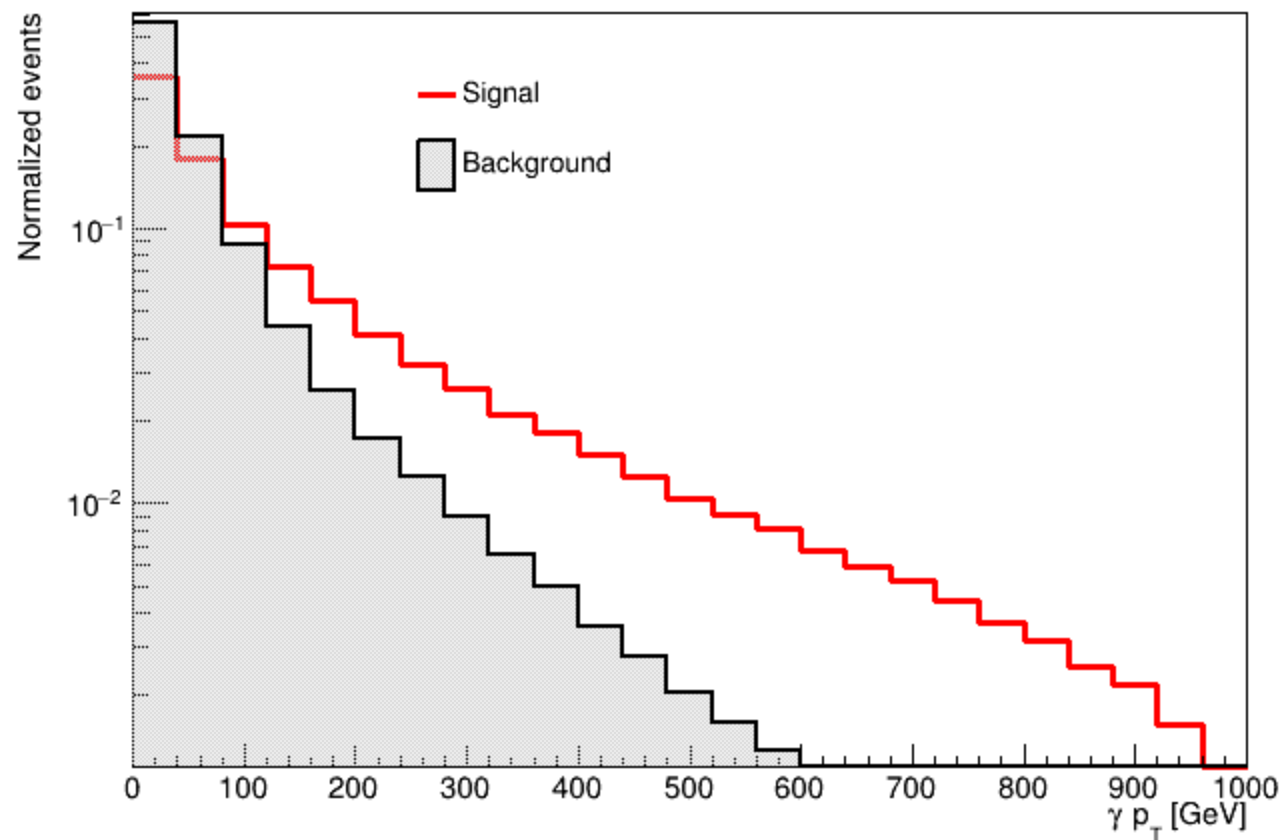
MET

$\sqrt{s} = 3 \text{ TeV}$

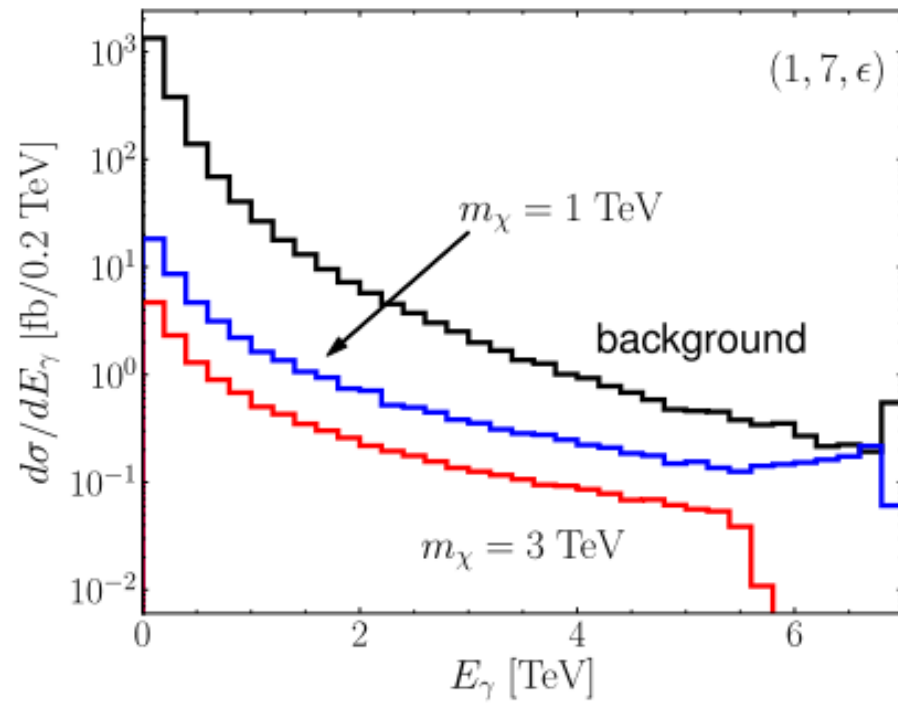


Photon p_T

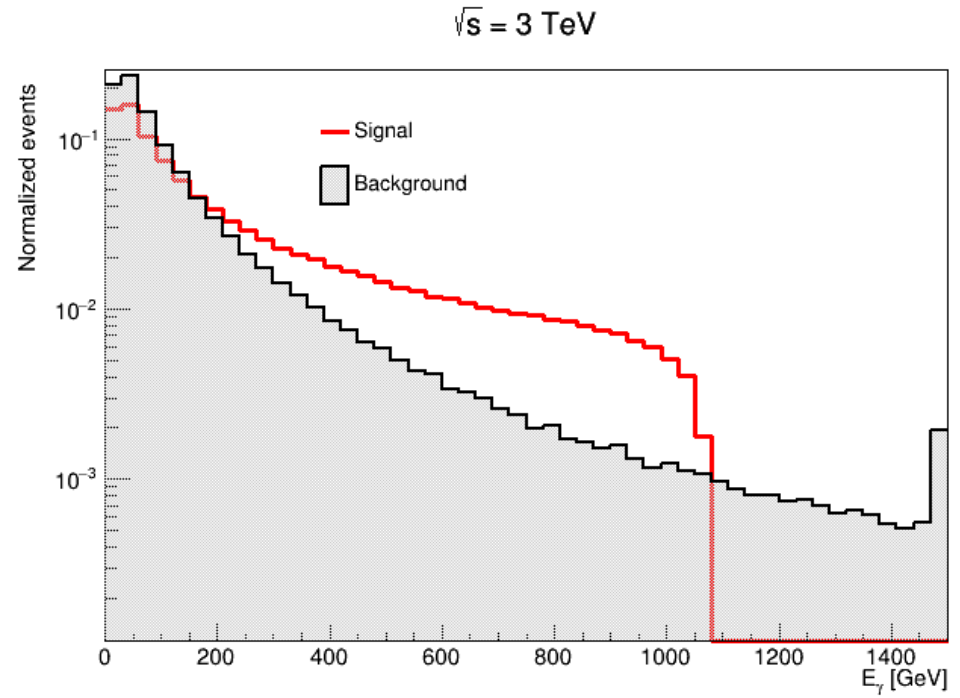
$\sqrt{s} = 3 \text{ TeV}$



Energy of photon



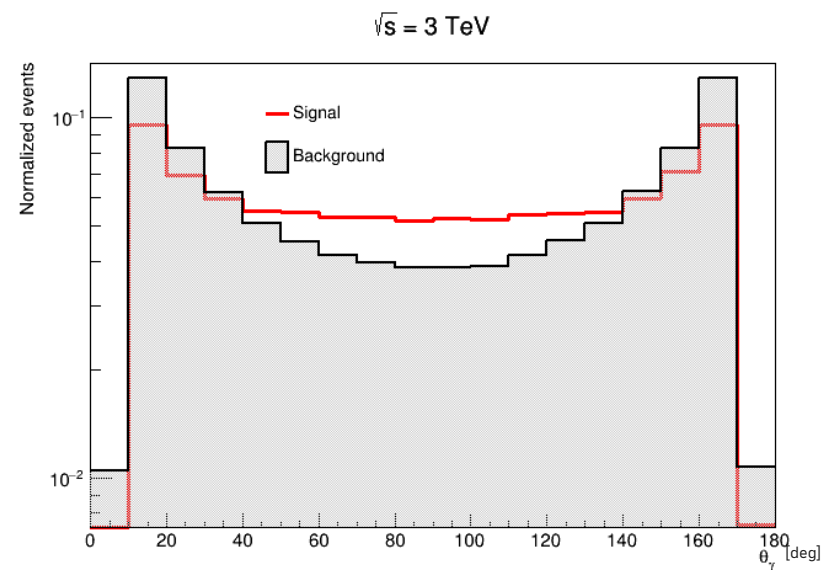
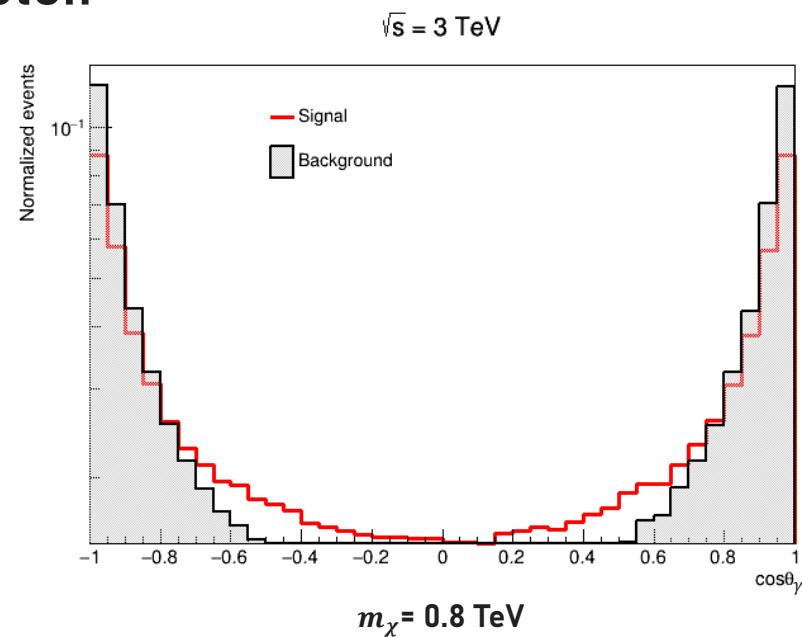
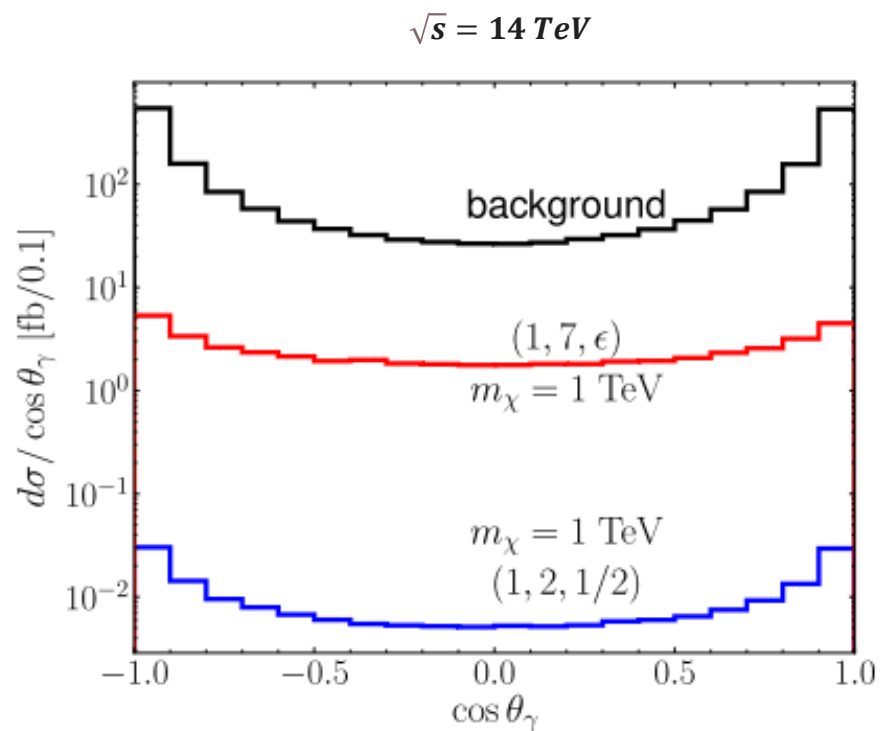
COM energy = 14 TeV



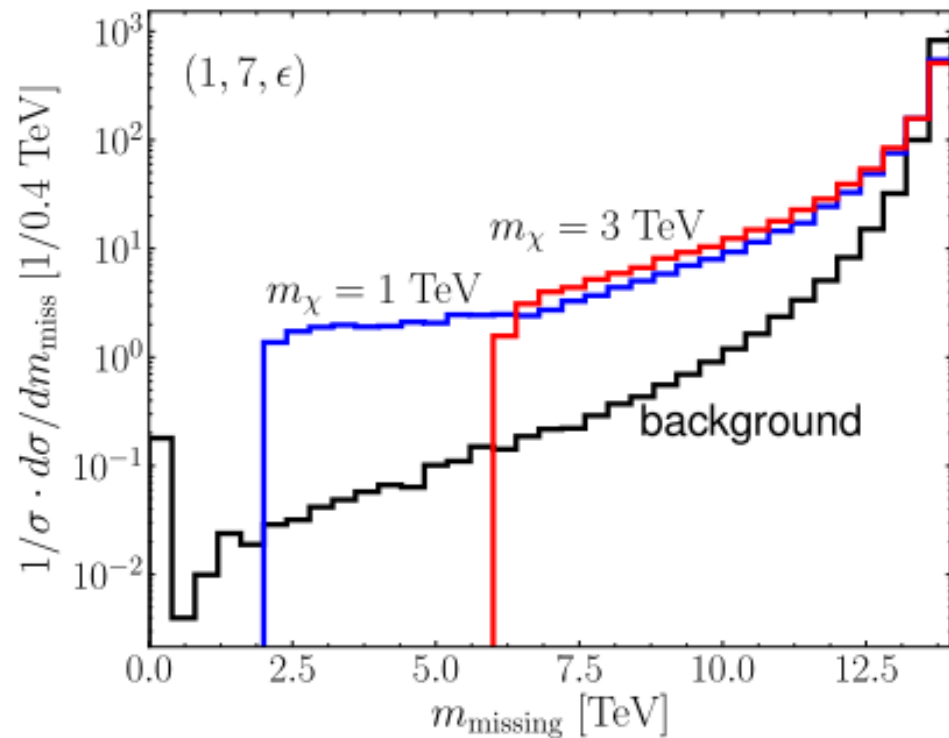
COM energy = 3 TeV

$m_\chi = 0.8$ TeV

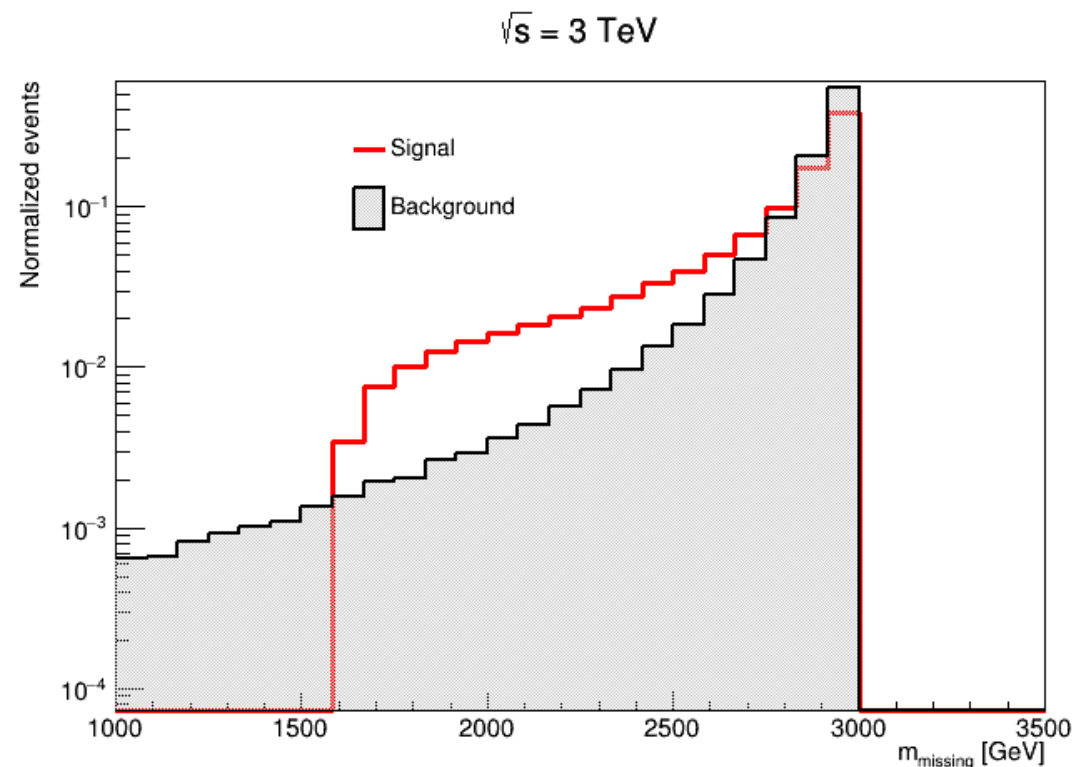
$\cos \theta$ of photon



Missing mass



COM energy = 14 TeV



COM energy = 3 TeV

$m_\chi = 0.8$ TeV

Conclusions and next steps:

- Comparing produced and theoretical distributions verifies the private production
- Increase number of events
- Use different DM masses
- Use higher COM energies
- Include additional signal processes
- Apply selections to improve signal sensitivity (Selections on energy of photon, missing mass and photon θ applied in the paper)

Timeline

- 1 million events at $\sqrt{s} = 14$ TeV with DM mass = 0.8 TeV → 0.5 weeks
- 1 million events at $\sqrt{s} = 3$ TeV with DM mass = 3 TeV → 0.5 weeks
- 1 million events $\sqrt{s} = 14$ TeV with DM mass = 3 TeV → 0.5 weeks
- Selections and additional processes → 1.5 weeks
- Signal sensitivity analyses (Figure of merit = $Signal/\sqrt{Background}$) → 1.5 weeks