Search for dark matter produced in association with a leptonically decaying Z boson with the CMS Detector at the LHC

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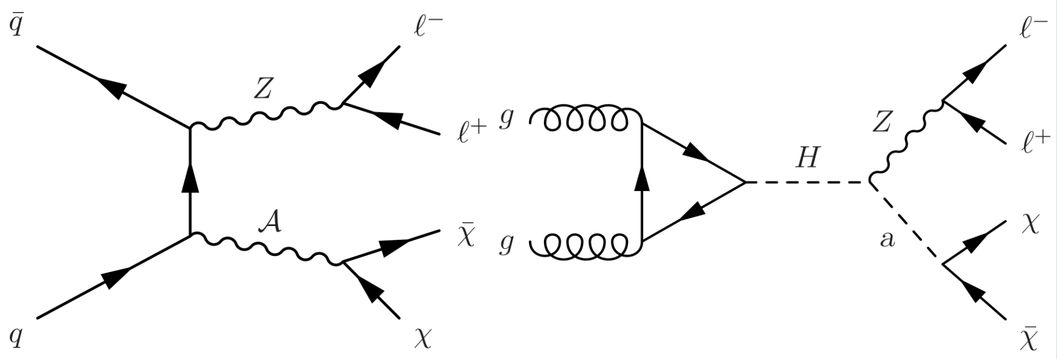
INTRODUCTION

We explore a models for the production of DM that can contribute to final state with Z boson that subsequently decay into a pair of leptons and a pair of dark matter (DM) particle that are interpreted as large transverse momentum.



Feynman diagrams illustrative of the BSM processes that produce a final state of a Z boson that decays into a pair of leptons and missing transverse momentum

THEORETICAL MODELS

One of the research model is two-Higgs-doublet model (2HDM) with an additional pseudoscalar(scalar) boson a(S), that serves as the mediator between DM and ordinary matter.

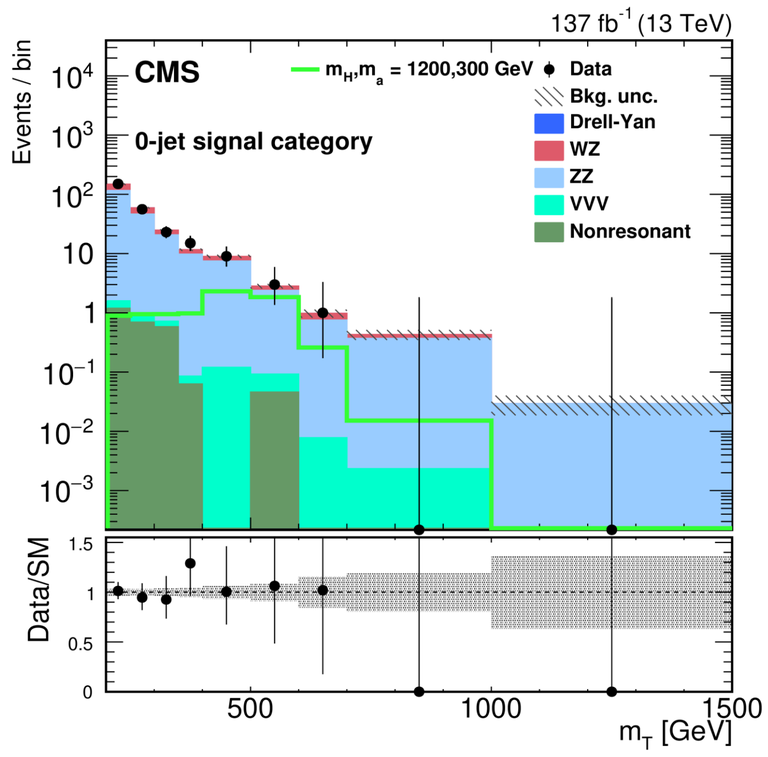
The Yukawa couplings are explicitly given by

$$\mathcal{L}_Y = -\sum_{i=1,2}\left(\bar{Q}Y_u^i\tilde{H}_i u_R + \bar{Q}Y_d^i H_i d_R + \bar{L}Y_\ell^i H_i \ell_R + \text{h.c.}\right)$$

The couplings of pseudoscalar mediator P with DM given by

$$\mathcal{L}_\chi = -iy_\chi P\bar{\chi}\gamma_5\chi$$

CMS RUN2 RESULTS



The m_T distributions for events in the signal region without jets

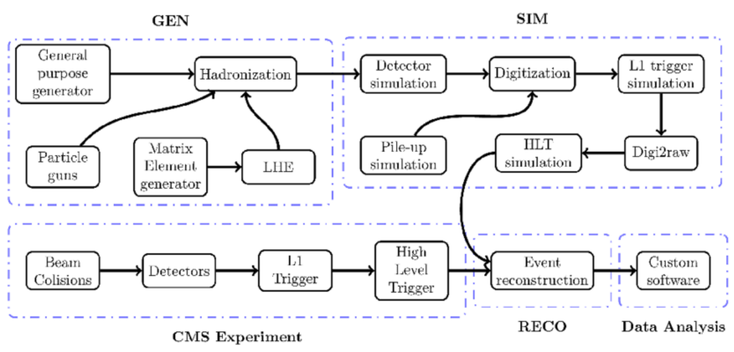
Process	0-jet category	1-jet category
$WZ \to 3\ell\nu$	1479 ± 53	389 ± 16
ZZ	670 ± 27	282 ± 13
Nonresonant background	384 ± 31	263 ± 22
DY	502 ± 94	1179 ± 64
Other background	6.3 ± 0.7	6.8 ± 0.8
Total background	3040 ± 110	2120 ± 76
Data	3053	2142

Observed number of events and post-fit background estimates.

- The search utilizes a data set collected by the CMS experiment in 2016 – 2018, corresponding to an integrated luminosity of 137 fb^{-1} at $\sqrt{s}$ = 13 TeV.
- There is no signal above the background

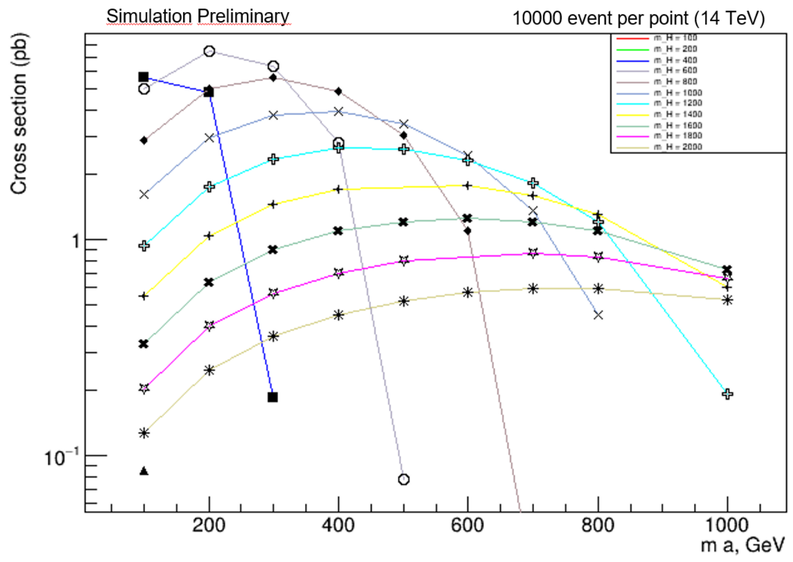
PREPARING FOR CMS RUN3 DATA ANALYSIS

Simulating a detector response involves the following steps:

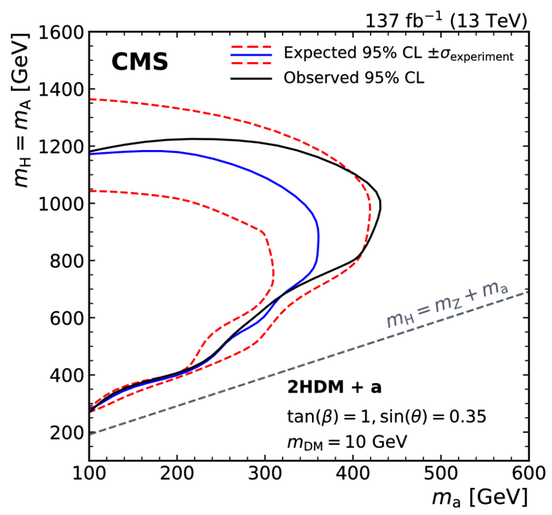


For Monte Carlo (MC) simulation used:

- Generator: MadGraph5MC@NLO.2.9.2 (PS, frag./hadr. - Pythia 8)
- Detector response simulation: CMSSW_12_4_5 (based on Geant4, using HTCondor)



The total cross section of the process pp → Z χχ in 2HDM+s



The upper limits on the 2HDM+a model parameters

SUMMARY

- A search for dark matter particles can be performed using events with a Z boson and large missing transverse momentum
- Analysis of CMS RUN2:
  - no evidence of physics beyond the standard model is observed
  - limits are set on dark matter particle production in the context of a two-Higgs-doublet model with an additional pseudoscalar mediator.
- Preparation for CMS RUN3:
  - the cross section of the process was calculated for various points in the space of model parameters