



Searching for dark matter in dilepton production processes at the LHC

The Nuclear Physics Section of the Department of Physical
Sciences of the Russian Academy of Sciences

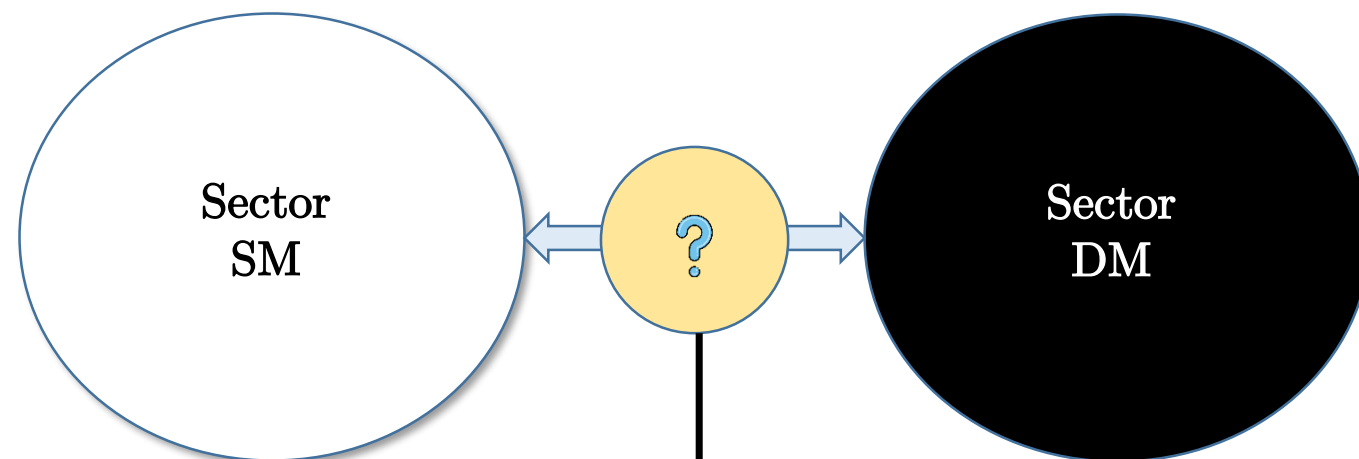
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¹Meshcheryakov Laboratory of Information Technologies, JINR

²Veksler and Baldin Laboratory of High Energy Physics, JINR

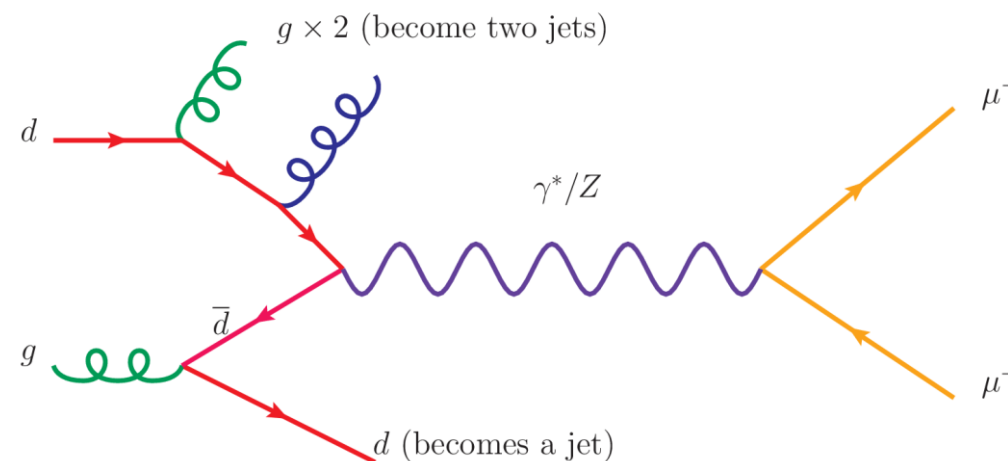
³The Bogoliubov Laboratory of Theoretical Physics, JINR

Simplified dark matter scenario



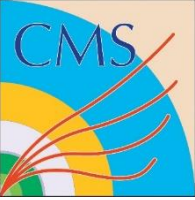
Axial-vector mediator	Vector mediator
$g_q = 0.1,$	$g_q = 0.01,$
$g_l = 0.01.$	$g_l = 0.01.$
$g_{DM} = 1.0$	$g_{DM} = 1.0$

The Drell-Yan process is the main background in the search for signals of new physics beyond the Standard Model (SM), particularly in the search for candidate particles for the role of the Dark Matter





Generated event samples and leptons selections



The signal is modeled with the convolution of a Breit–Wigner function to model the intrinsic decay width of the resonance

Muon selections

high accuracy of the p_T calculation: $\delta p_T/p_T < 0.3$

Isolation: $(\text{IsoPt} < 0.1)$

Identification: “Global” and “Tracker” muons, Tracker layers > 6 , PixelHits > 1 , MuonHits > 1

Kinematic cuts: $|\eta| < 2.4$, $p_T > 53$ GeV

HLT trigger: HLT Mu50, HLT OldMu100, HLT TkMu100

Electron selections

Isolation: $\text{IsoPt} < 5$ GeV

Identification: $|d_{xy}| < 0.02$

Kinematic cuts: $E_T > 35$ GeV, $|\eta_{\text{Barrel}}| < 1.4442$ and $1.566 < |\eta_{\text{Endcap}}| < 2.5$

HLT trigger: HLT_DoubleEle33_CaloIdL_MW, HLT_DoubleEle33_CaloIdL_GsfTrkIdVL

Z'_{SSM} and Z'_{ψ}

PYTHIA 8

Drell-Yan

POWHEG v2

FEWZ 3.1.b2

$t\bar{t}$, tW , $t\bar{t}W$

POWHEG v2

PYTHIA 8

TOP++ NNLO

WW, ZZ, WZ

POWHEG v2

PYTHIA 8

MADGRAPH5 aMC@NLO version 2.2.2

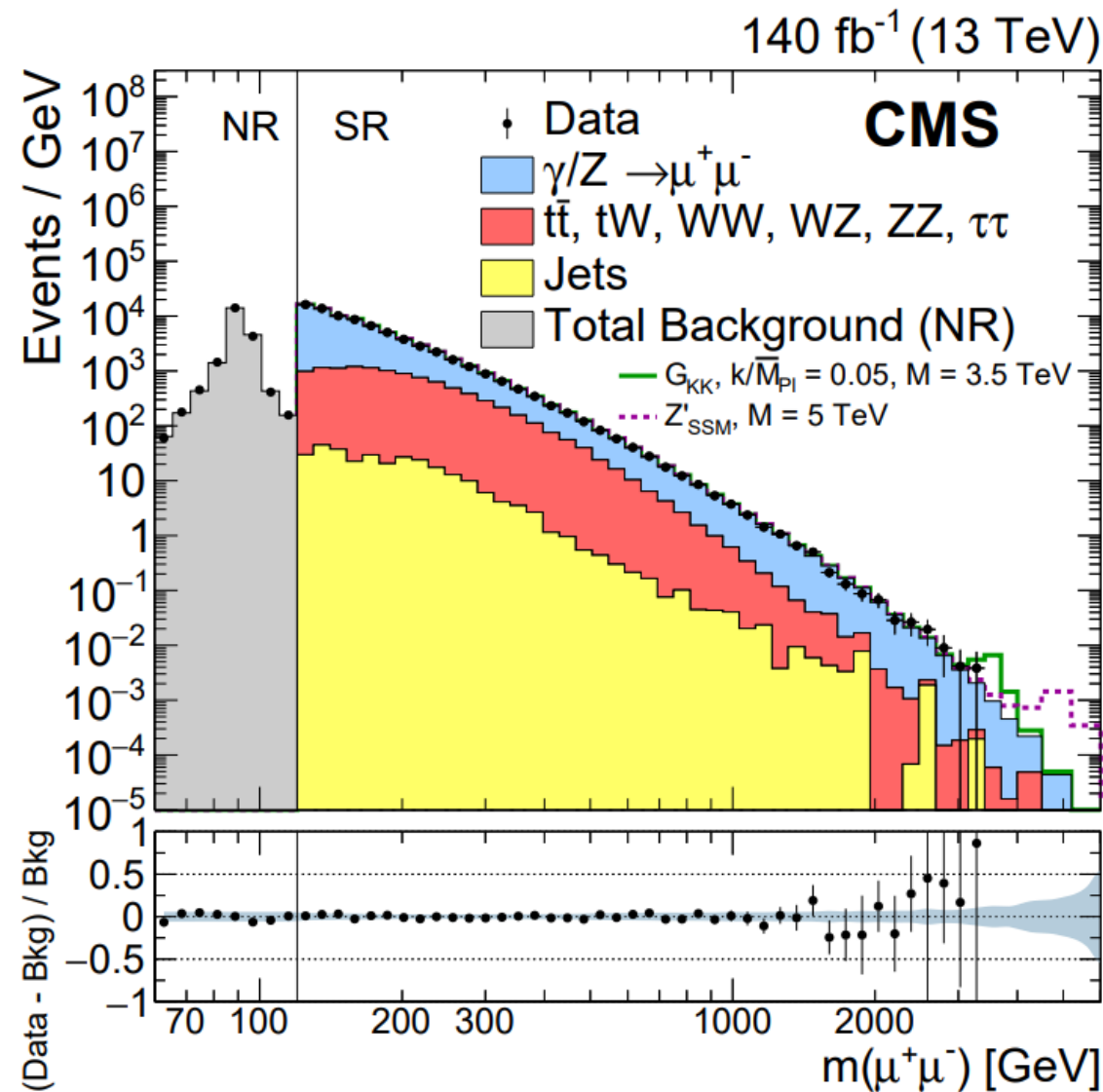
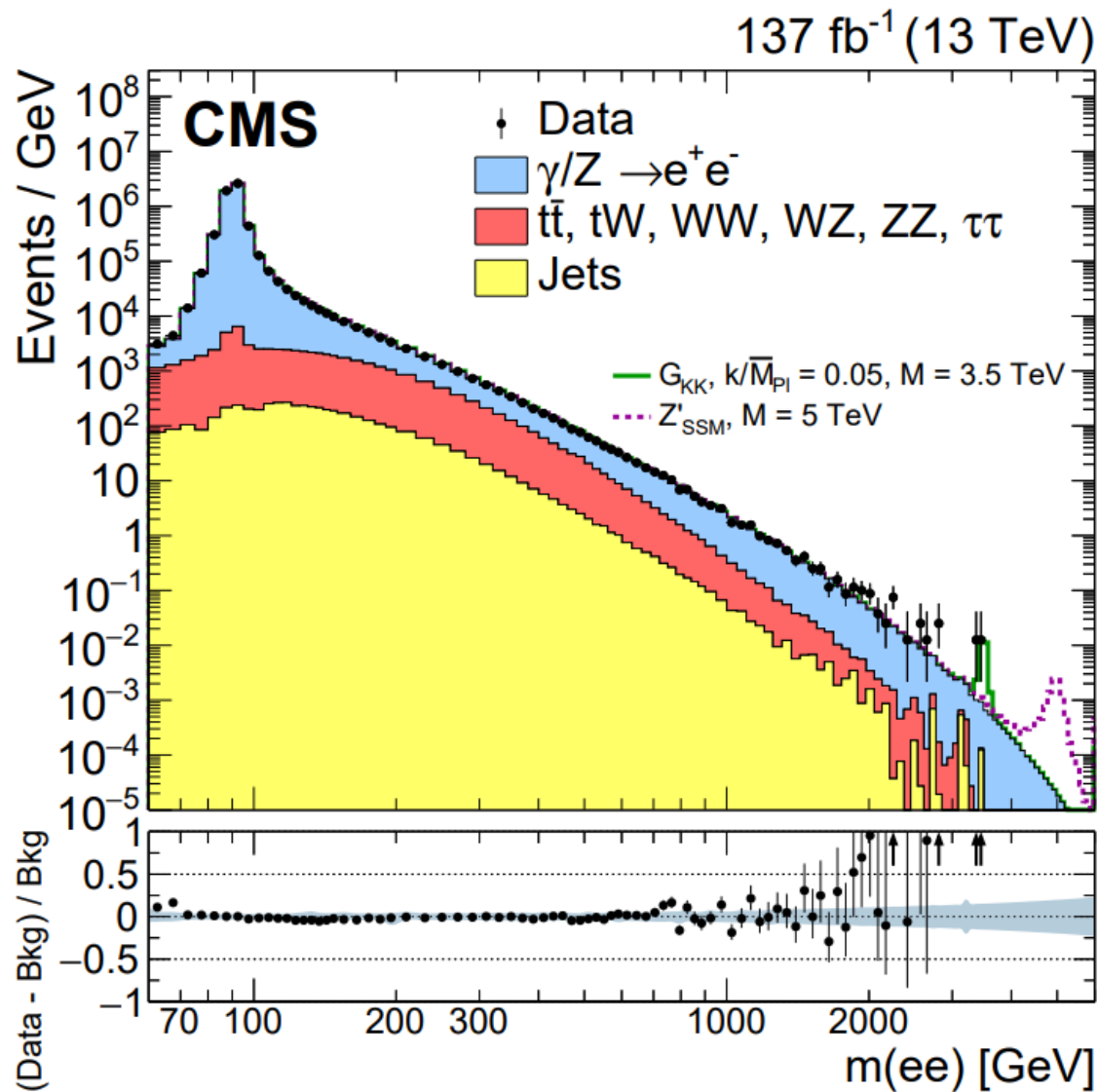
$t\bar{t}$

POWHEG v2

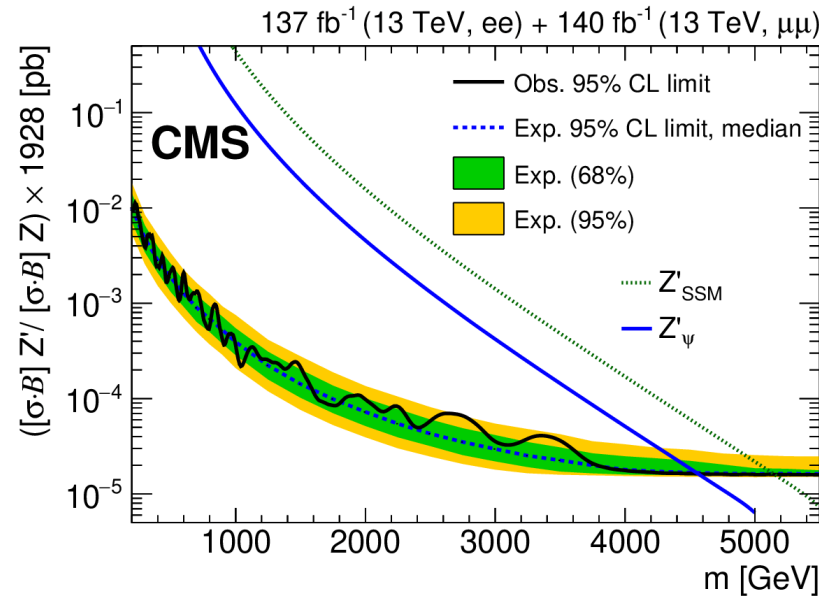
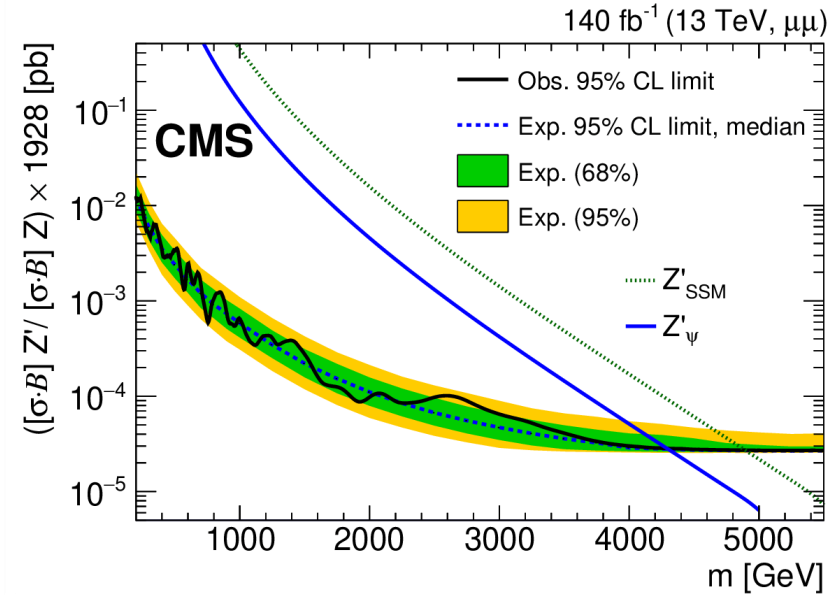
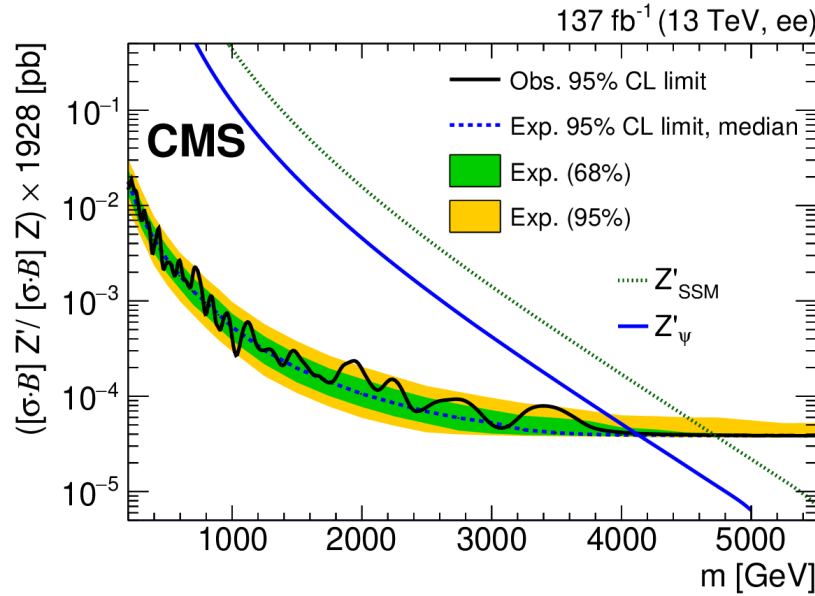
W+jets

MADGRAPH5 aMC@NLO version 2.2.2

MCFM 6.6



Upper limits on the ratio $\sigma_{Z'}/\sigma_{Z0}$

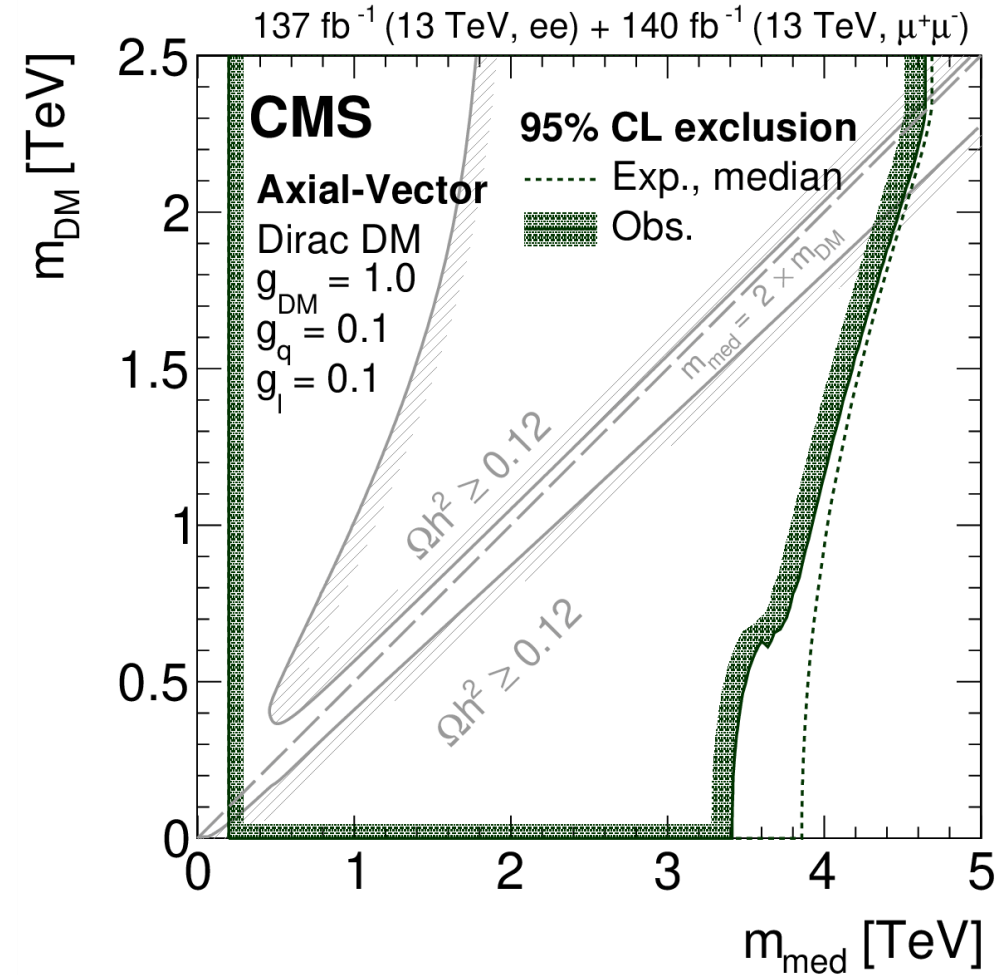
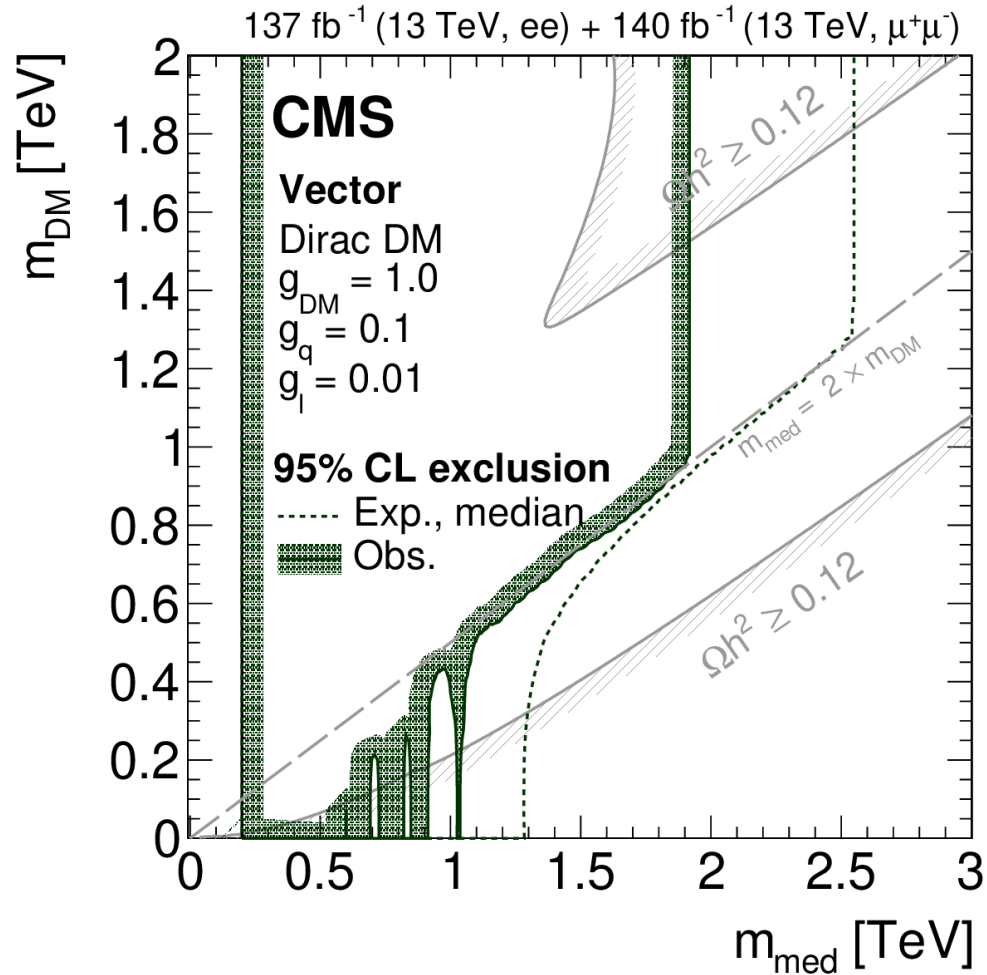


Channel	Z'_{SSM} [TeV]		Z'_ψ [TeV]	
	Obs	Exp	Obs.	Exp
ee	4.72	4.72	4.11	4.13
$\mu\mu$	4.89	4.9	4.29	4.3
ee + $\mu\mu$	5.15	5.14	4.56	4.55

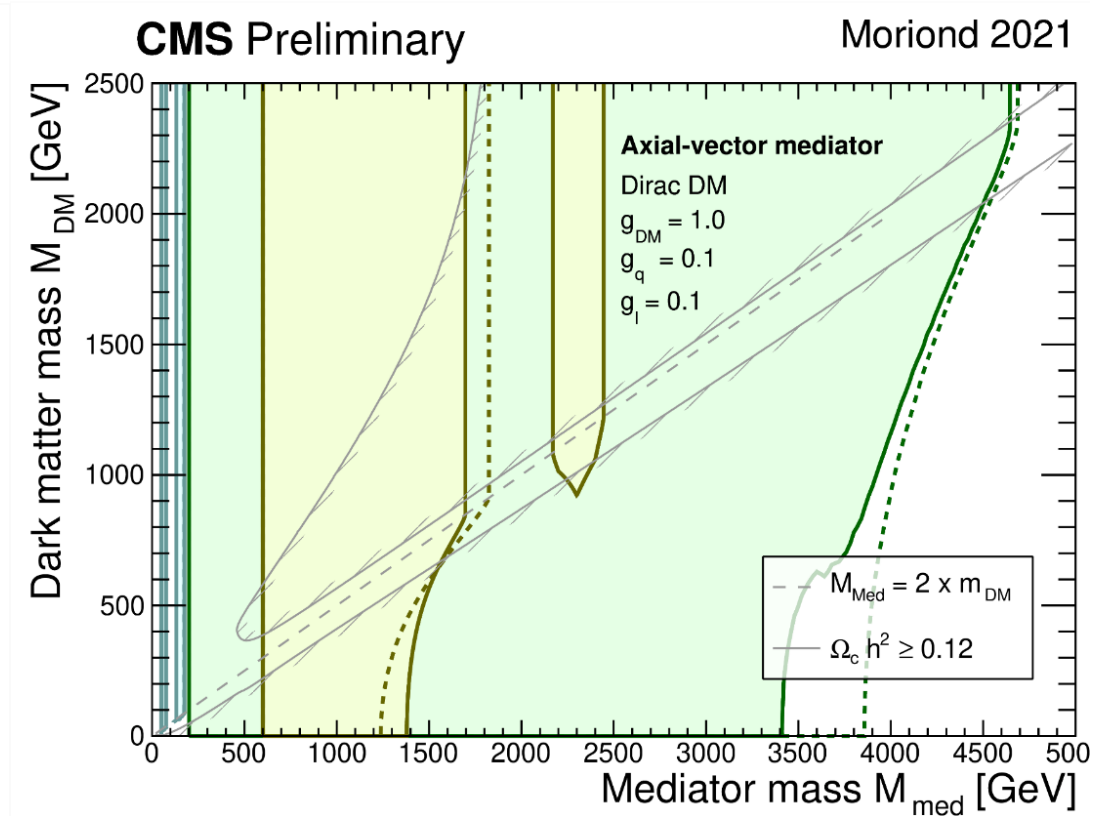
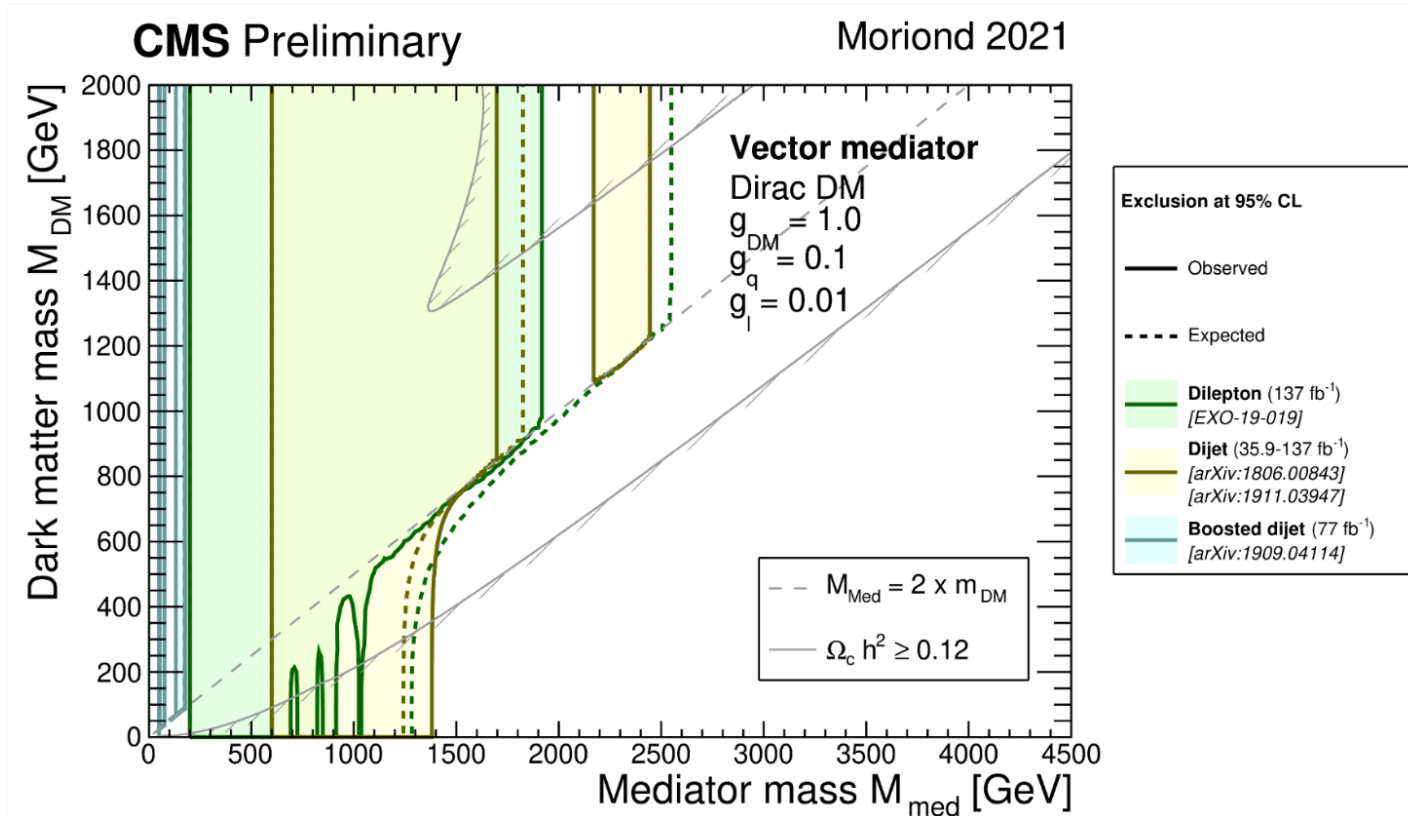
$$R_\sigma = \frac{\sigma(pp \rightarrow Z' + X \rightarrow ll + X)}{\sigma(pp \rightarrow Z + X \rightarrow ll + X)}$$

This method allows to study the mass limits for dark matter in any theoretical scenarios that predict new mediators with spin 1 (as example we consider here a simplified dark matter scenario)

Limits on the mass of the DM particle

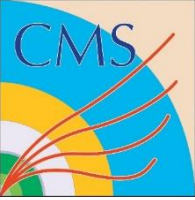


For spin-1 resonances that act as a mediator between SM particles and dark matter (DM), exclusion limits are set in the mass plane of the mediator and DM particles. For large values of m_{DM} , mediator masses below 1.92 (4.64) TeV are excluded in a model where the mediator is a vector (axial vector) with small (large) coupling to leptons. For $m_{\text{DM}} = 0$, these limits are reduced to 1.04 and 3.41 TeV, respectively





Conclusions



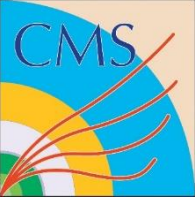
- A search for resonant new phenomena in the dilepton invariant mass spectrum in proton-proton collisions at $\sqrt{s} = 13$ TeV corresponding to an integrated luminosity of up to 140 fb^{-1} has been presented
- Limits on the mass of a dark matter particle have been obtained
- For spin-1 resonances that act as a mediator between SM particles and dark matter (DM), exclusion limits are set in the mass plane of the mediator and DM particles. For large values of m_{DM} , mediator masses below 1.92 (4.64) TeV are excluded in a model where the mediator is a vector (axial vector) with small (large) coupling to leptons. For $m_{\text{DM}} = 0$, these limits are reduced to 1.04 and 3.41 TeV, respectively
- No significant deviation from SM expectation is observed
- Currently, research is being conducted within this scenario with dark matter based on open CMS data.



Thanks for your attention!



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The list of validated runs, which must be applied to all analyses, either with the full validation or for an analysis requi...

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The list of validated runs, which must be applied to all analyses, either with the full validation or for an analysis requi...

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/Jet/Run2010B-v1/RAW
A sample from Jet primary dataset in RAW format from RunB of 2010. Run range [146807, 147043].

Articles using CMS open data

1. Search for the production of dark matter candidates in association with heavy dimuon resonance using the CMS open data for pp collisions at $\sqrt{s} = 8$ TeV [arXiv:2109.11274v3](#)
2. Disentangling Quarks and Gluons with CMS Open Data [arXiv:2205.04459v2](#)
3. Jet Substructure Studies with CMS Open Data [arXiv:1704.05842v3](#)

News & Updates

2022-12-09 by LHCb Collaboration

LHCb releases first set of data to the public

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2022-12-05 by CMS Collaboration

CMS completes the release of its entire Run-1 proton-proton data

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2020-12-21 by CMS Collaboration

CMS releases heavy-ion data from 2010 and 2011

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2021-12-20 by CMS Collaboration

First CMS open data from LHC Run 2 released

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2020-12-11 by CERN

CERN Open Data Policy for the LHC Experiments

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<https://opendata.cern.ch/docs/cern-open-data-policy-for-lhc-experiments>