Searching for dark matter in dilepton production processes at the LHC

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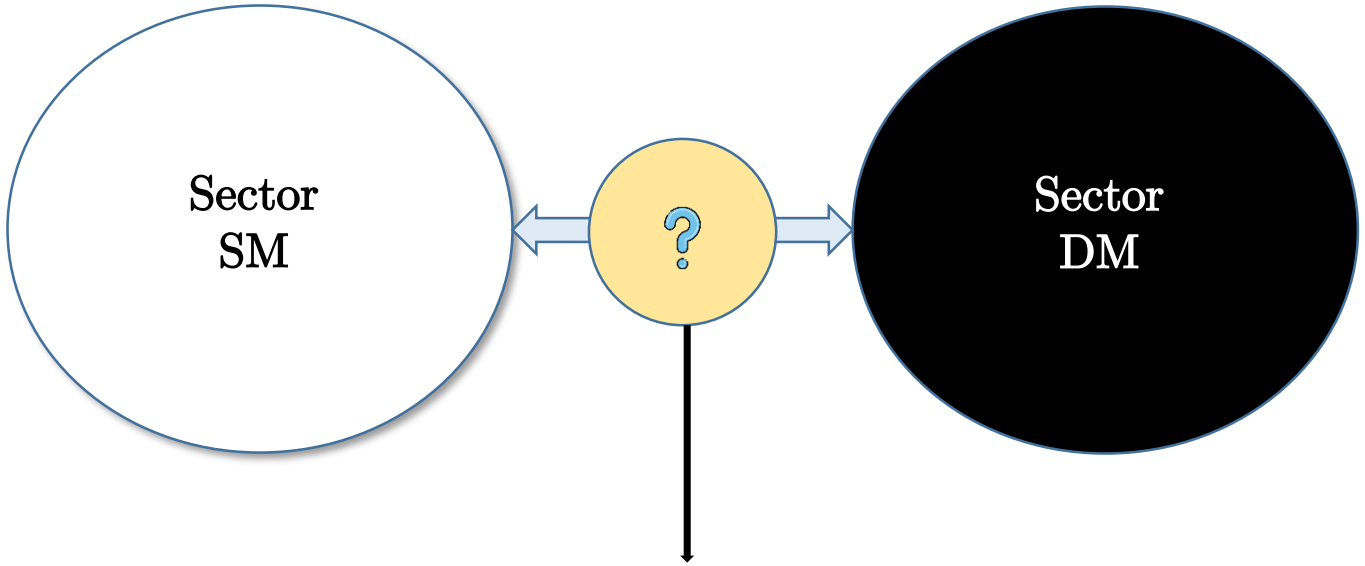
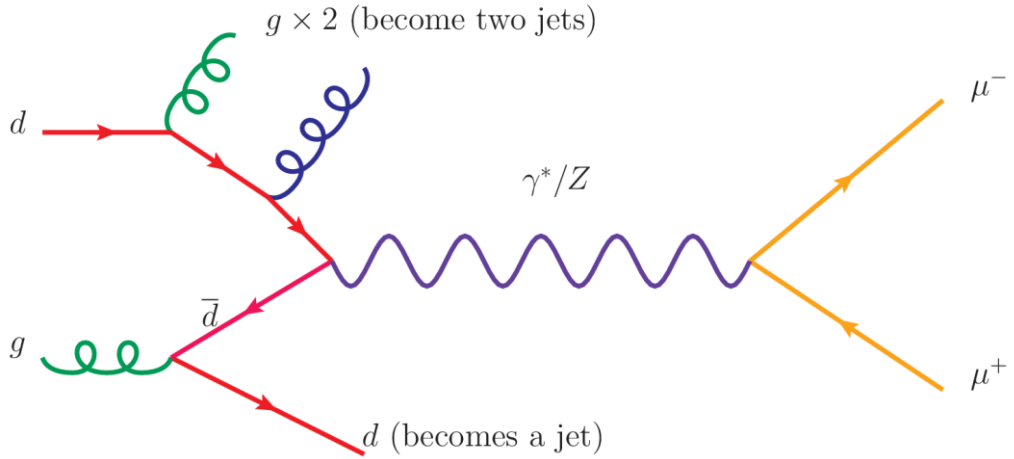
Simplified dark matter scenario



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

Vector mediator
$g_q = 0.01$,
$g_l = 0.01$.
$g_{DM} = 1.0$

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



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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

Z'_{SSM} and Z'_{ψ}
PYTHIA 8

Drell-Yan
POWHEG v2
FEWZ 3.1.b2

ttbar, tW, tbarW
POWHEG v2
PYTHIA 8
TOP++ NNLO

WW, ZZ, WZ
POWHEG v2
PYTHIA 8
MADGRAPH5 aMC@NLO version 2.2.2

tautaubar
POWHEG v2

W+jets
MADGRAPH5 aMC@NLO version 2.2.2
MCFM 6.6

Muon selections

- high accuracy of the p_T calculation: $\delta p_T/p_T < 0.3$
- Isolation: (IsoPt < 0.1)
- Identification: "Global" and "Traker" 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: IsoPt < 5 GeV
- Identification: $|d_{xy}|<0.02$
- Kinematic cuts: $E_T > 35$ GeV, $|\eta_{Barrel}| < 1.4442$ and $1.566<|\eta_{Endcap}| < 2.5$
- HLT trigger: HLT_DoubleEle33_CaloIdL_MW, HLT_DoubleEle33_CaloIdL_GsfTrkIdVL

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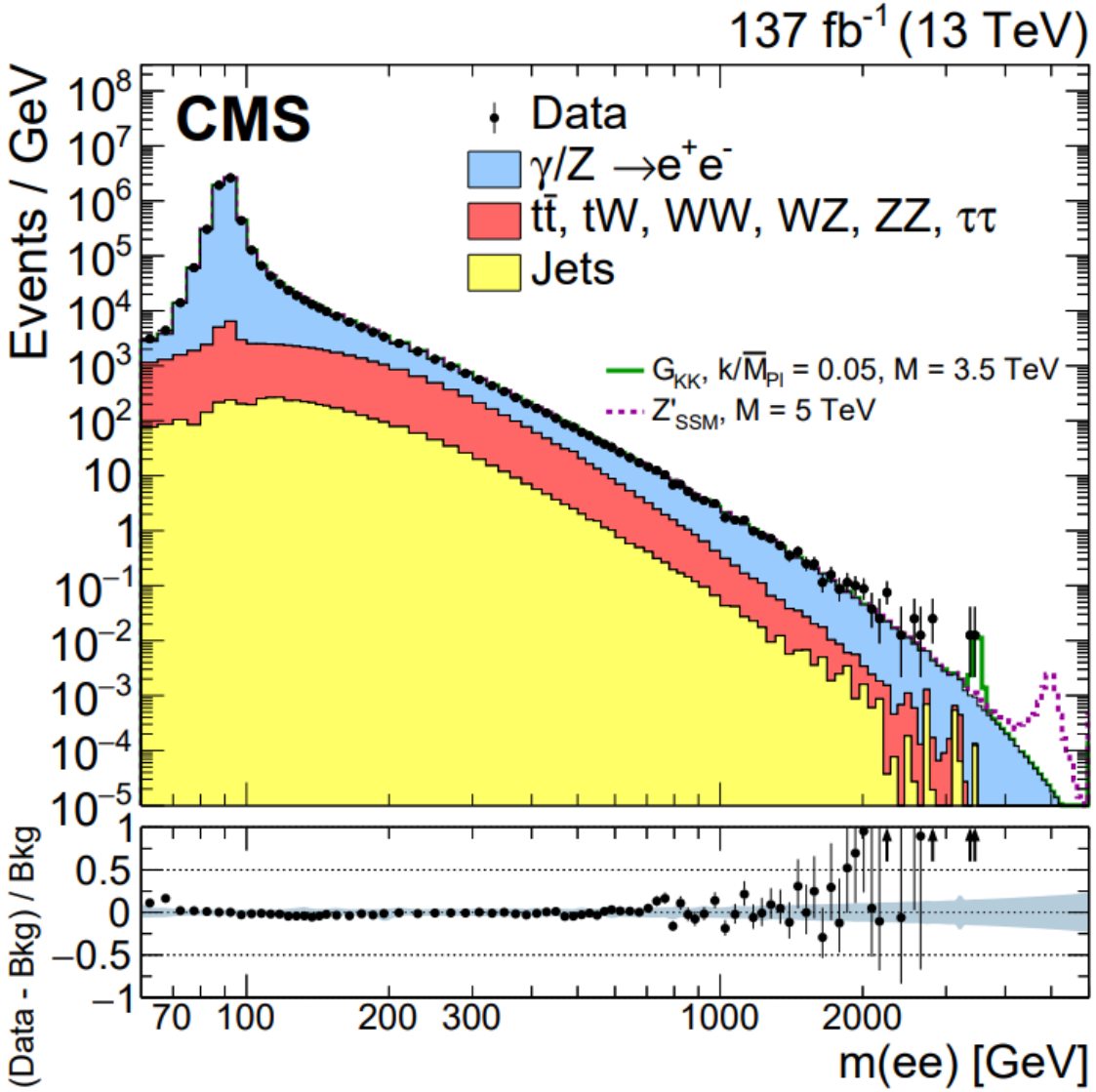
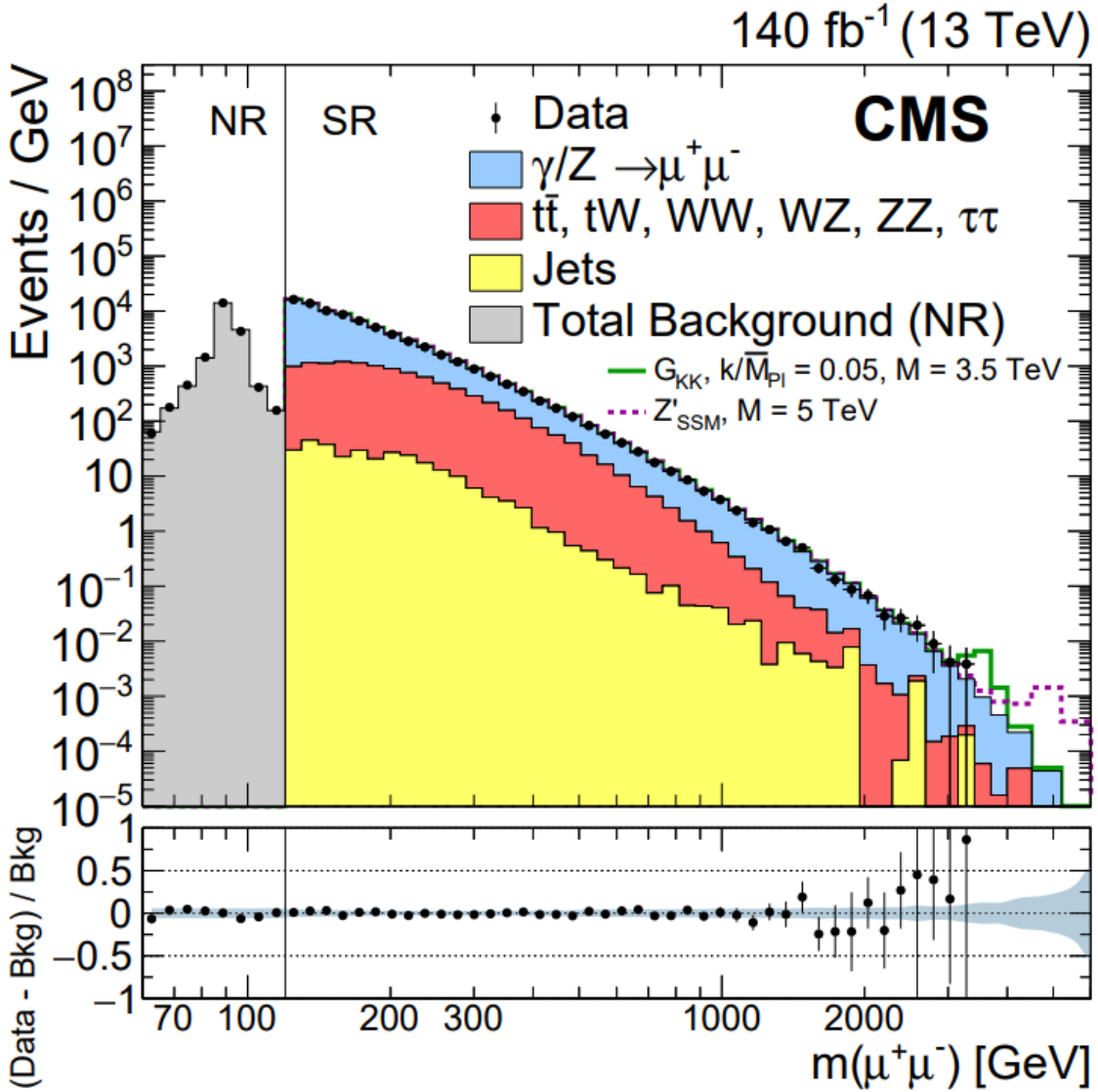
Distribution by invariant mass





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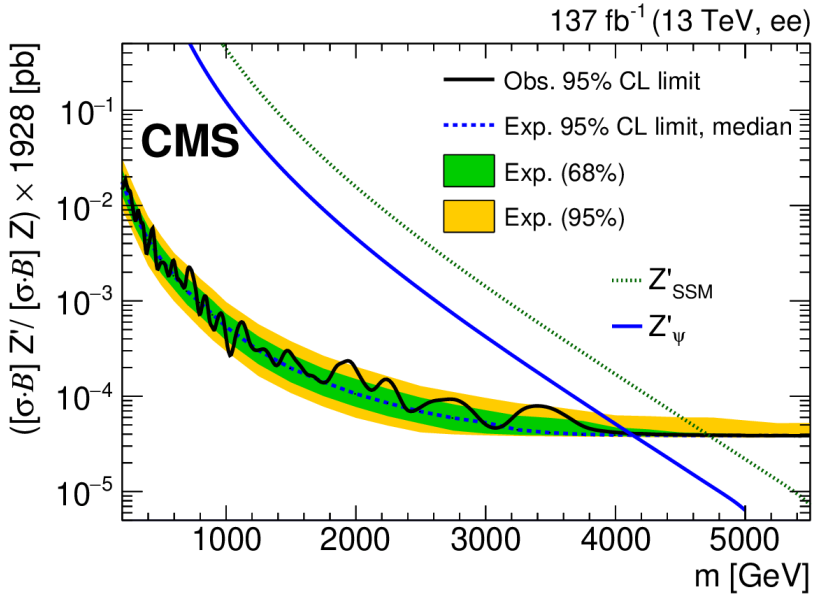
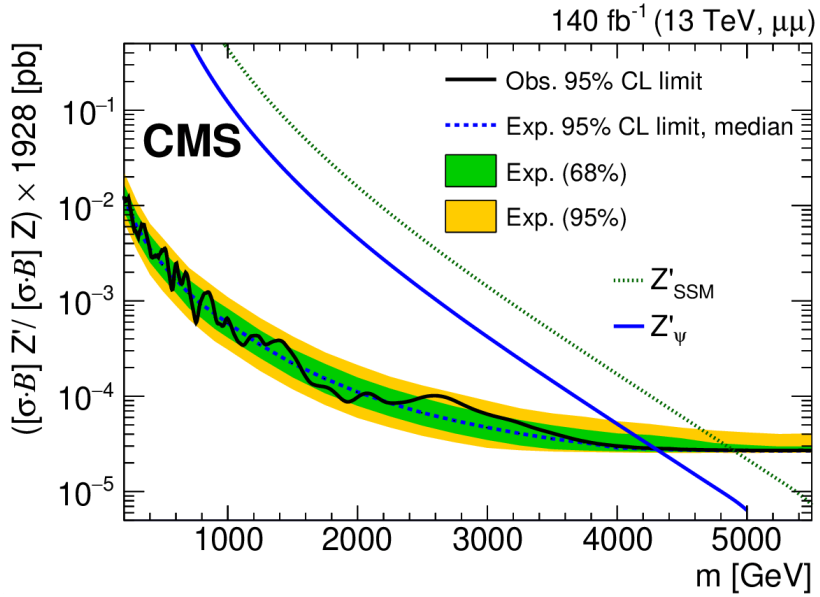
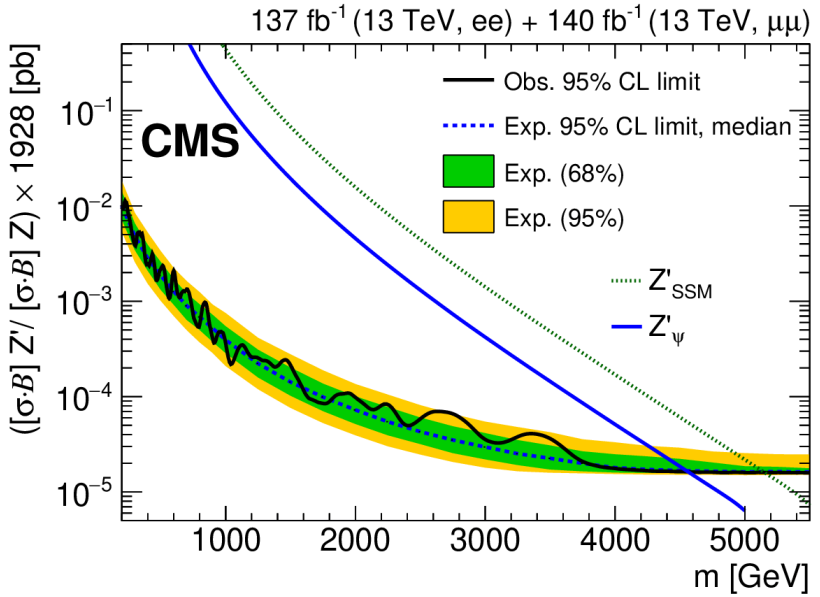
Upper limits on the ratio $\sigma_{Z'}/\sigma_{Z0}$





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



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

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)

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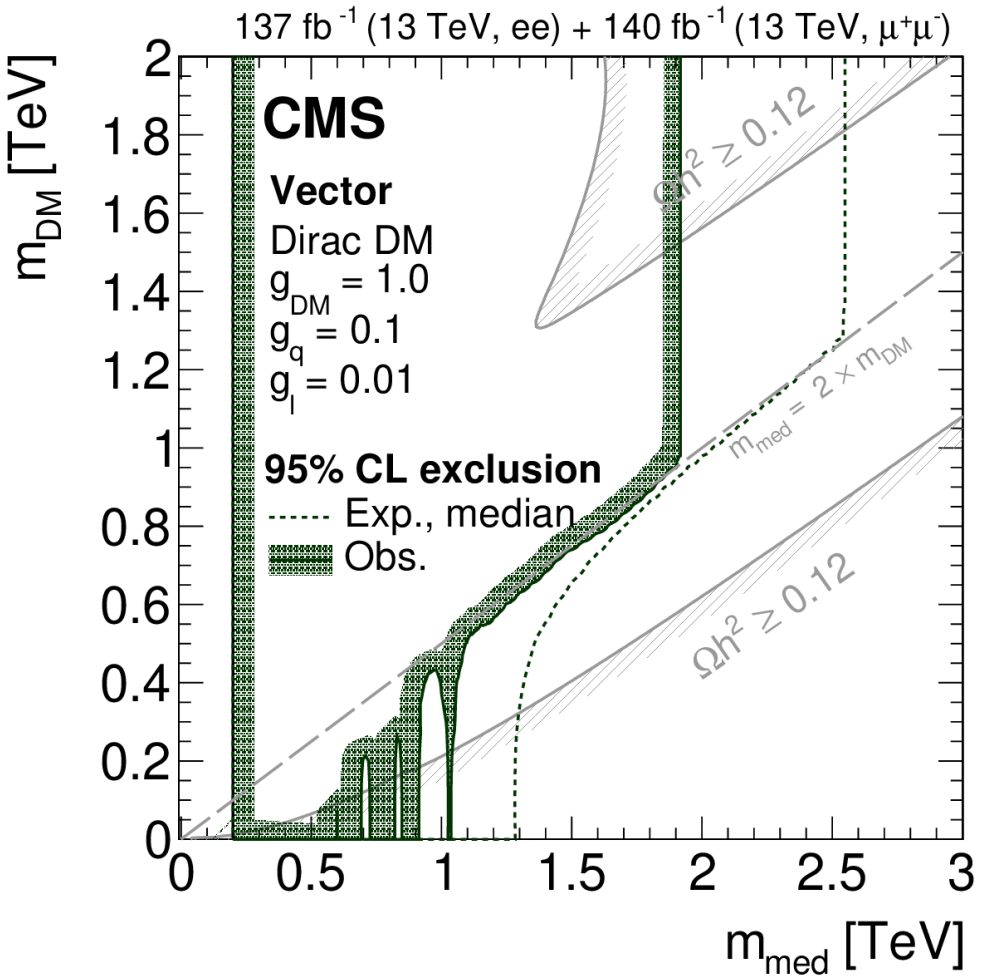
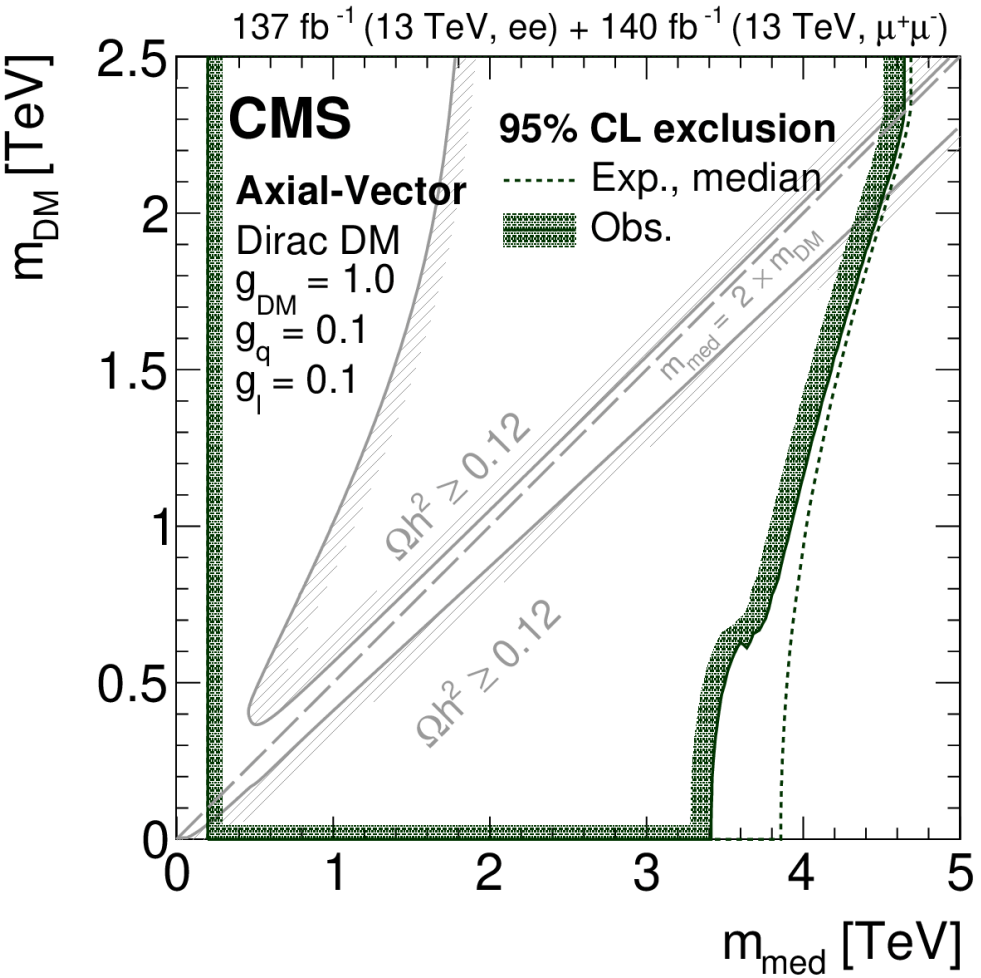
Limits on the mass of the DM particle





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 $m_{DM} = 0$, these limits are reduced to 1.04 and 3.41 TeV, respectively

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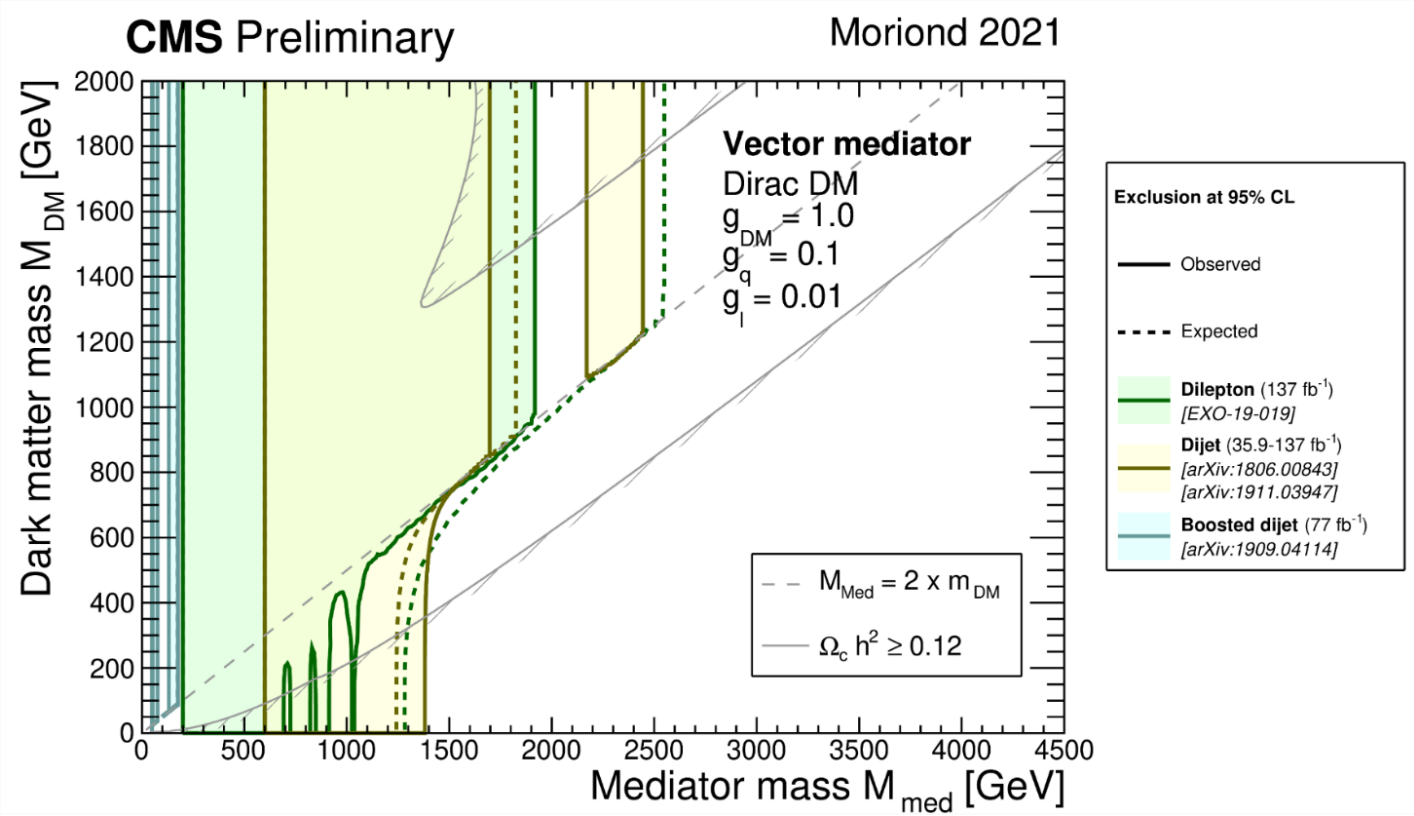
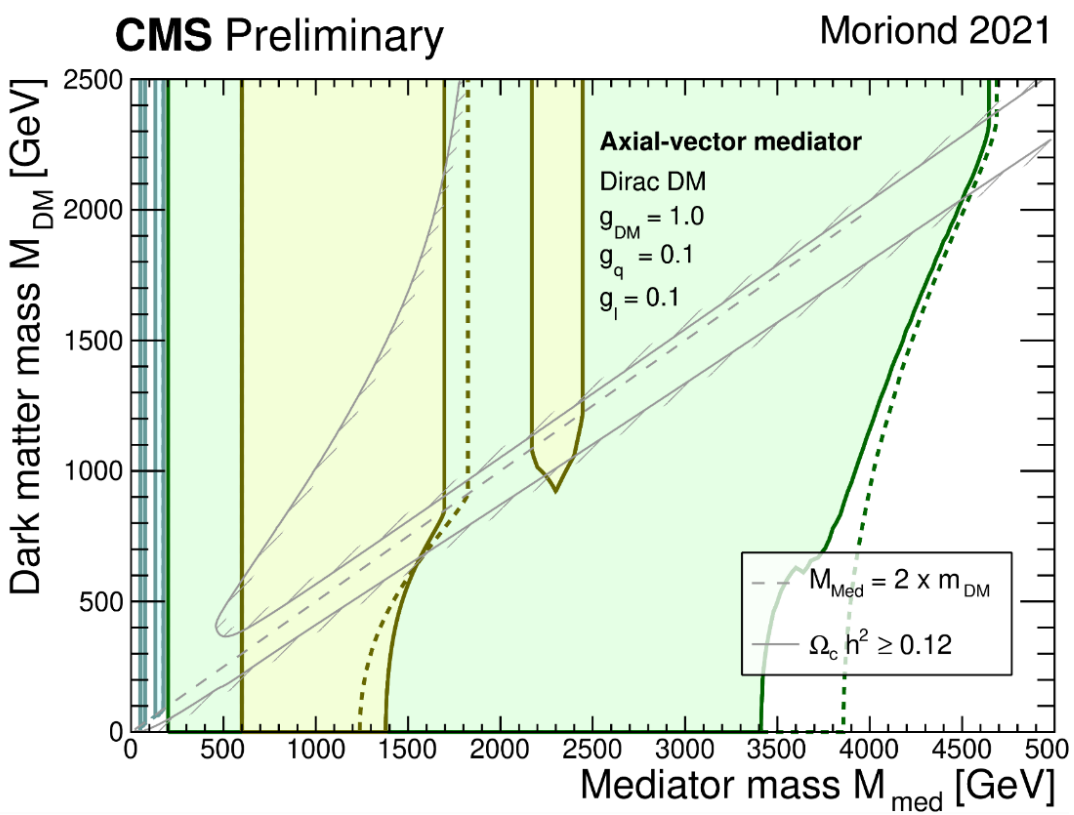
Limits on the mass of the DM particle





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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 $m_{DM} = 0$, 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.

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Thanks for your attention!

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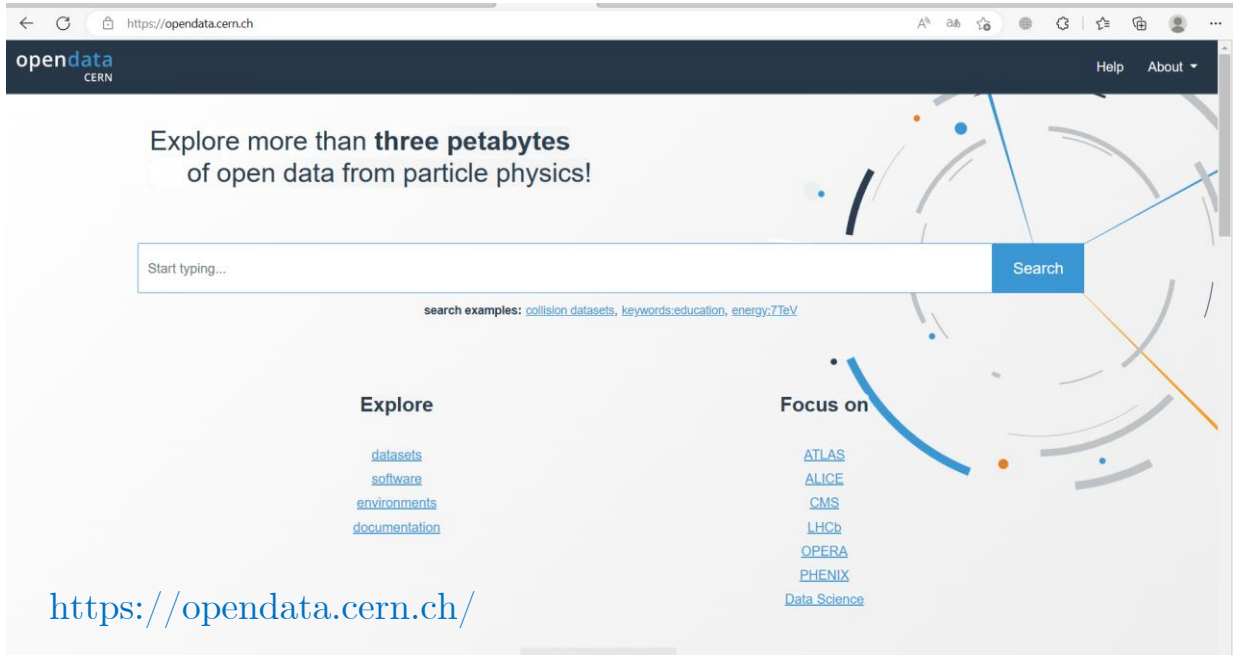
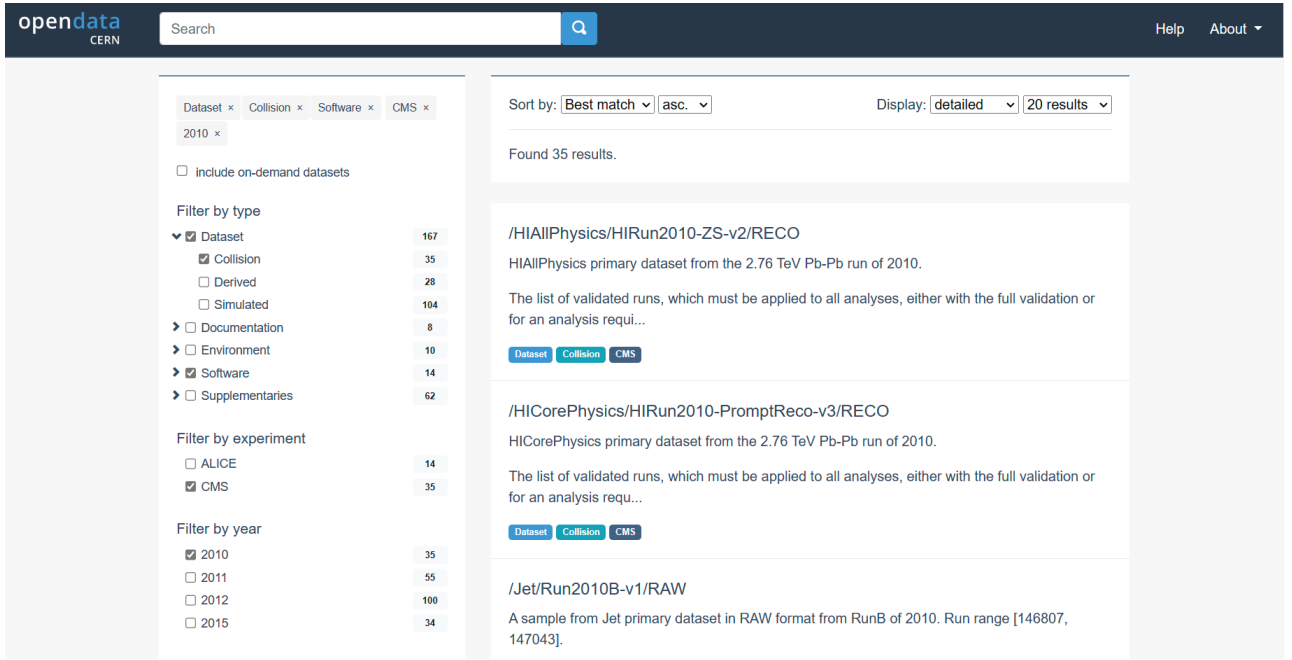
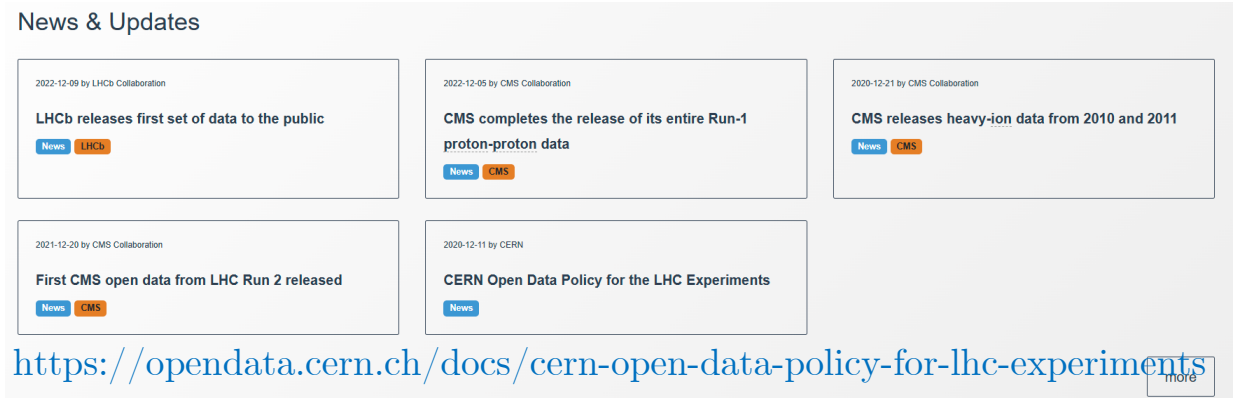
Back up
Open Data CMS



https://opendata.cern.ch/





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

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 √ 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