

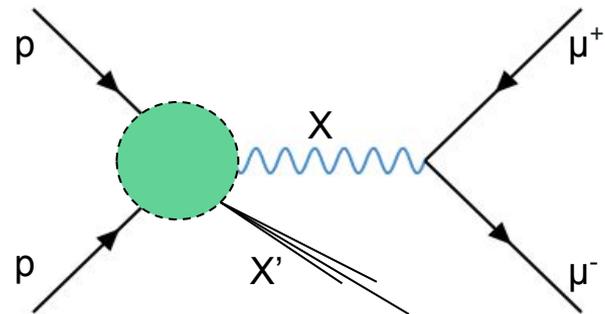
Search for Production of GeV Scale Dimuon Resonances with CMS Scouting

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Analysis Summary

- Searching for a light (1-8 GeV) BSM mediator decaying into a pair of opposite sign muons using Run II scouting data collected by CMS
- Such a particle could act as a portal between Standard Model fields and unknown dark sectors
- We perform a bump hunt in discrete windows on the dimuon mass spectrum from 2017 and 2018 in both an inclusive and boosted dimuon category

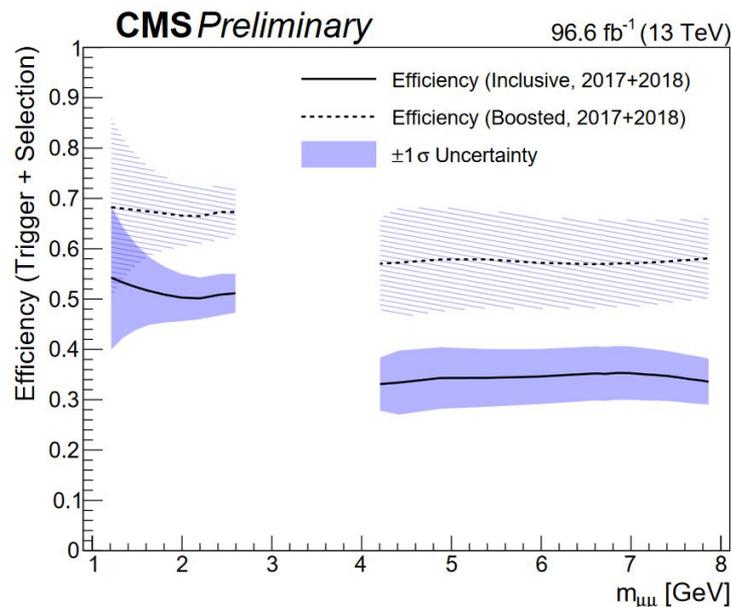


<https://cds.cern.ch/record/2851121>

<https://cms.cern/news/looking-invisible-literally>

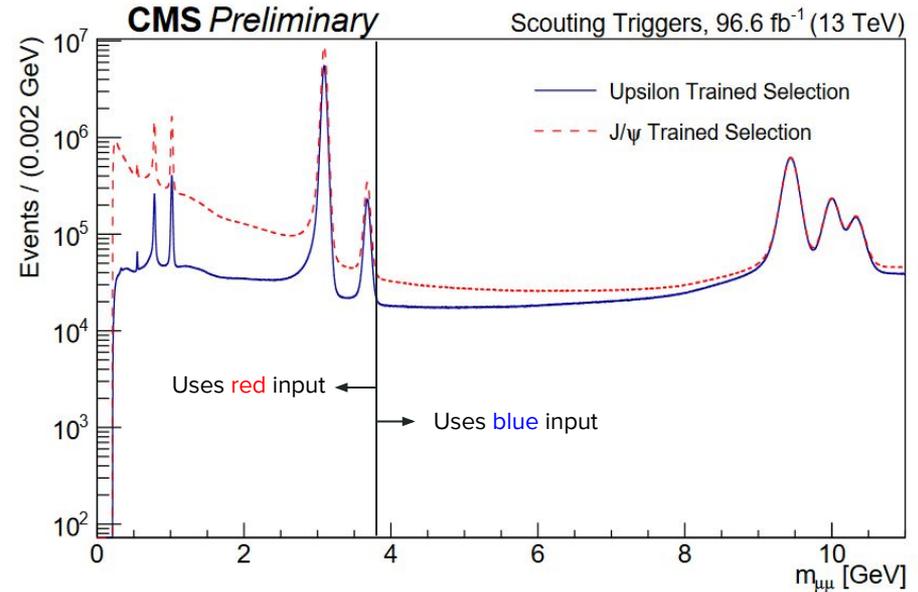
Object and Event Selection

- The search is enhanced by using the **dimuon scouting triggers**, which reduce the information saved in each event, but **allows for much higher rates** (up to 3k Hz), which provides us with a wealth of statistics
- Events are required to contain a pair of opposite sign muons, which pass the dimuon scouting trigger, and satisfy the following offline requirements:
 - Muon $p_T > 4$ GeV
 - $|\eta_\mu| < 1.9$
 - Dimuon vertex constraints (per category)
 - BDT identifier trained on SM peaks (depending on mass)
- Additional cuts are imposed for the boosted category, to **maximize sensitivity for the targeted scalar production mode**:
 - Muon $p_T > 5$ GeV
 - $p_{T,\mu\mu} > 35$ GeV, ($m < 4$)
 - $p_{T,\mu\mu} > 20$ GeV, ($m > 4$)



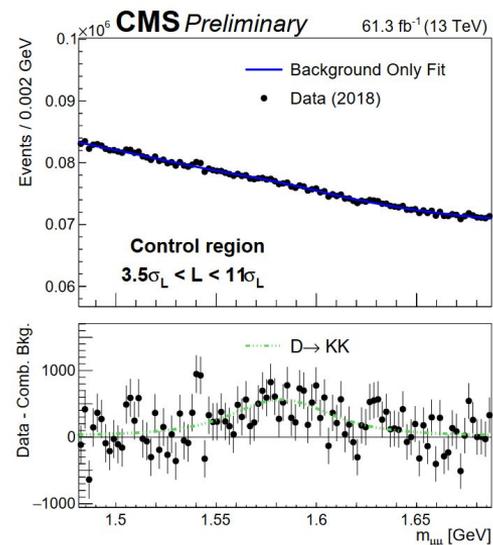
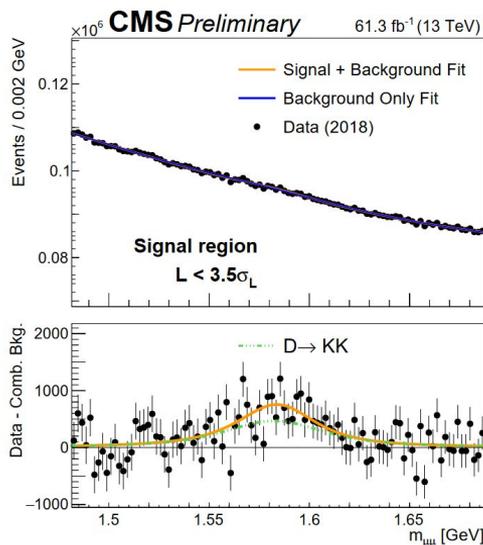
Signal and Background Model

- Signal shape is a sum of double Crystal Ball and a Gaussian functions
 - Width is constant, determined as a function of mass using fits to SM resonances
- Background is modelled by a sideband fit around signal shape, using empirical, polynomial-like functions
 - Carefully studied to ensure they cannot introduce spurious signals or flex to hide real signals



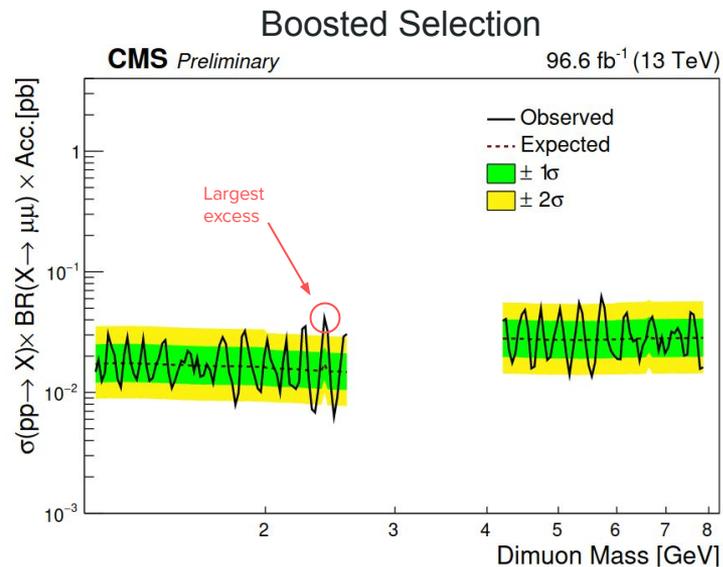
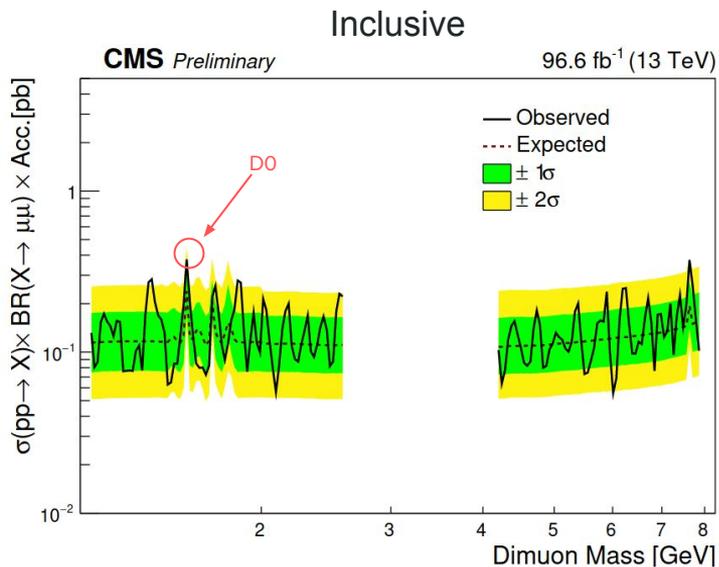
Unexpected Peaking Background from $D_0 \rightarrow KK/K\pi$

- A signal like background emerges from decays of D_0 mesons to charged kaons/pions which faked muons.
- Accounted for by adding signal-like shape to background pdf, and constraining its normalization via an inverted displacement cut control region



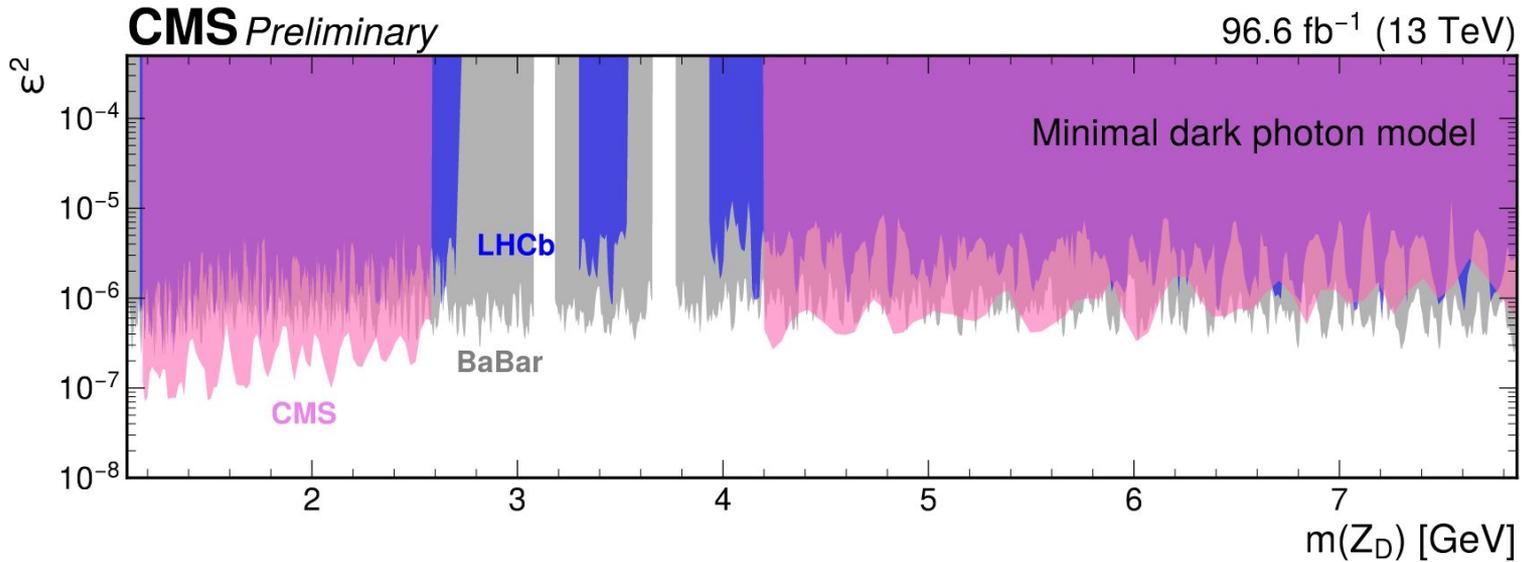
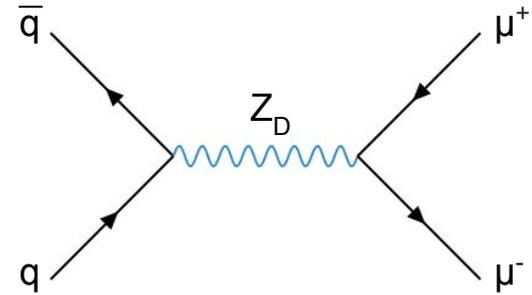
Model Independent Results

- Limits on model-independent cross section times branching fraction times acceptance at 95% CL
- The most significant excess is at 2.41 GeV in the boosted category
 - Local significance: 3.24σ , global significance 1.27σ



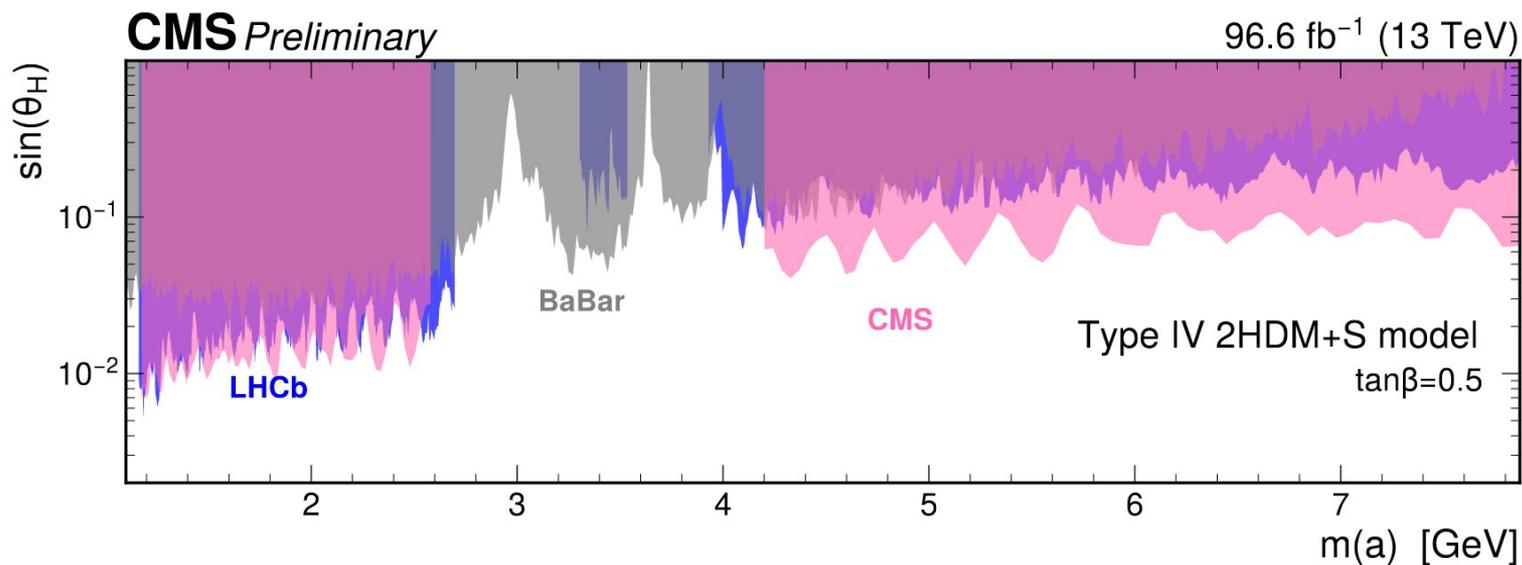
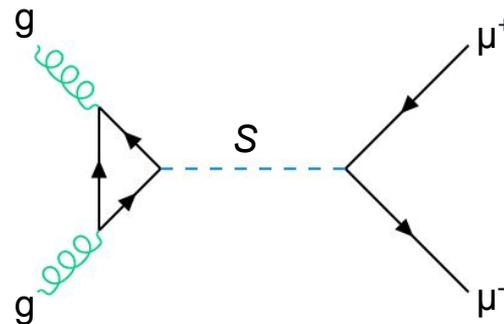
Dark Photon Results

- Upper limit on dark photon coupling (ϵ^2) at 90% CL
 - Compared with results from LHCb (blue) and BaBar (grey)



2HDM+S Results

- Upper limit on the 2HDM+S mixing angle ($\sin(\theta_H)$) at 90% CL
 - Compared with results from LHCb (blue) and BaBar (grey)



Outlook

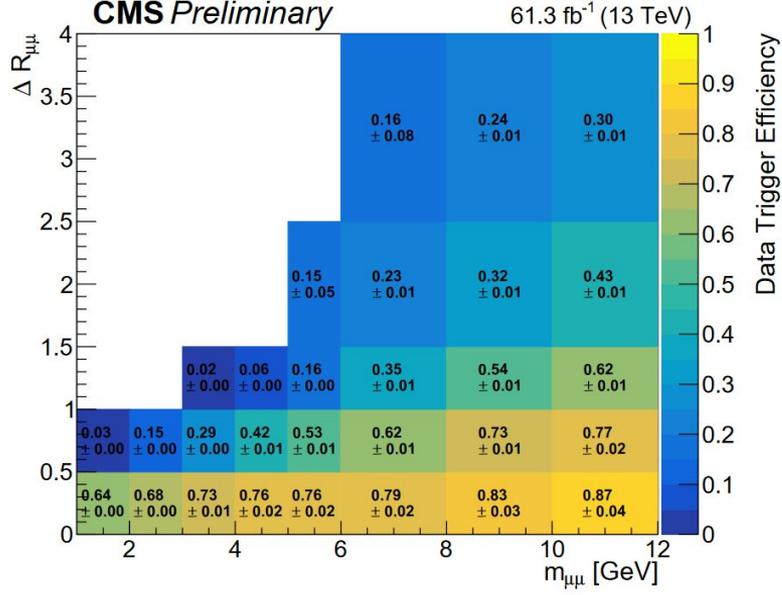
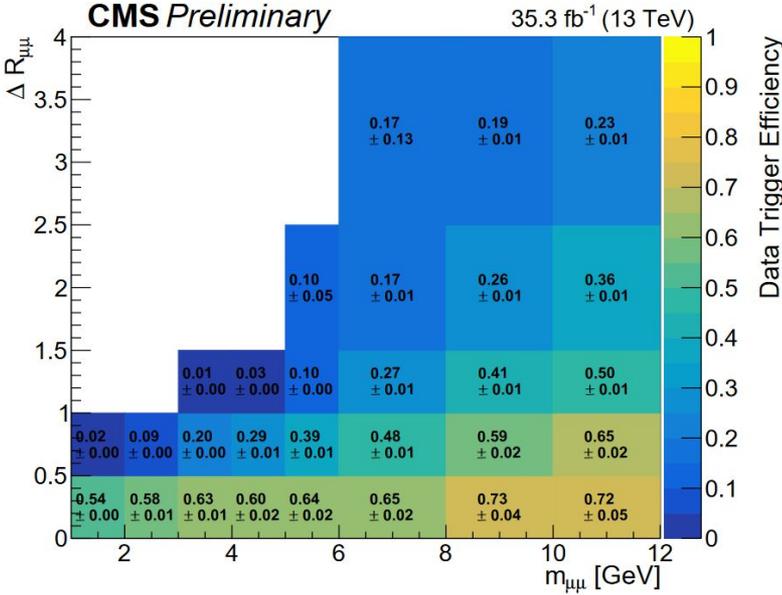
- Data scouting in 2017 and 2018 has enabled CMS to set strong limits on BSM dimuon production between 1 and 8 GeV.
- Run III data will contribute yet more statistics, and will enhance these results further when this analysis is revisited.
- Excesses will be monitored to see if they could represent new physics with the addition of more data

Thank you!

Questions?

Backup

Dimuon Scouting Trigger Efficiency



Uncertainties Summary

- All detector-based systematic uncertainties for both categories:

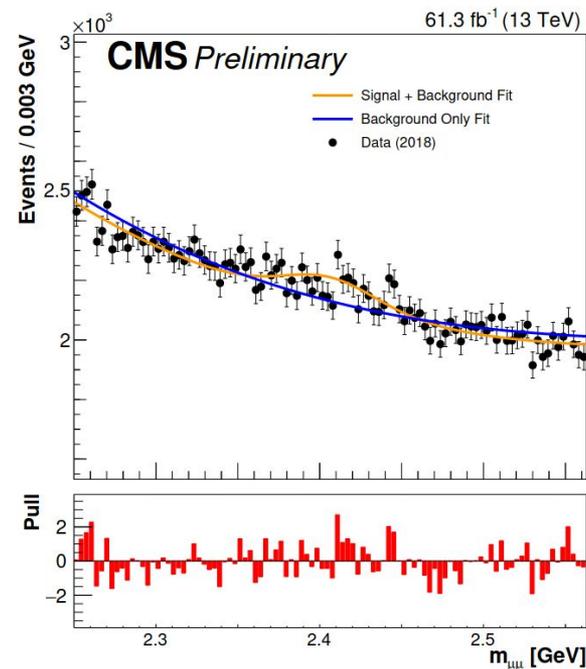
Effect	$m_{\mu\mu} < 4 \text{ GeV}$	$m_{\mu\mu} > 4 \text{ GeV}$
Integrated Luminosity	2.3 – 2.5%	
Mass Resolution	20%	
Trigger Efficiency	1-20%	
Muon ID Efficiency	4-9%	12-20%
Vertex Selection	-	3%
Efficiency Application	8%	4%
D Meson Normalization TFs	20-25%	-

Datasets and Triggers

- /ScoutingCaloMuon/Run2018[A,B,C,D]-v1/RAW (61.3 fb⁻¹)
- /ScoutingCaloMuon/Run2017[C,D,E,F]-v1/RAW (35.5 fb⁻¹)
 - HLT Path: DST_DoubleMu3_noVtx_CaloScouting_v*
 - L1 Seeds:
 - L1_DoubleMu4p5er2p0_SQ_OS_Mass7to18
 - L1_DoubleMu_15_7
 - L1_DoubleMu0er1p5_SQ_OS_dR_Max1p4
 - L1_DoubleMu4_SQ_OS_dR_Max1p2 (2017)
 - L1_DoubleMu4p5_SQ_OS_dR_Max1p2 (2018)

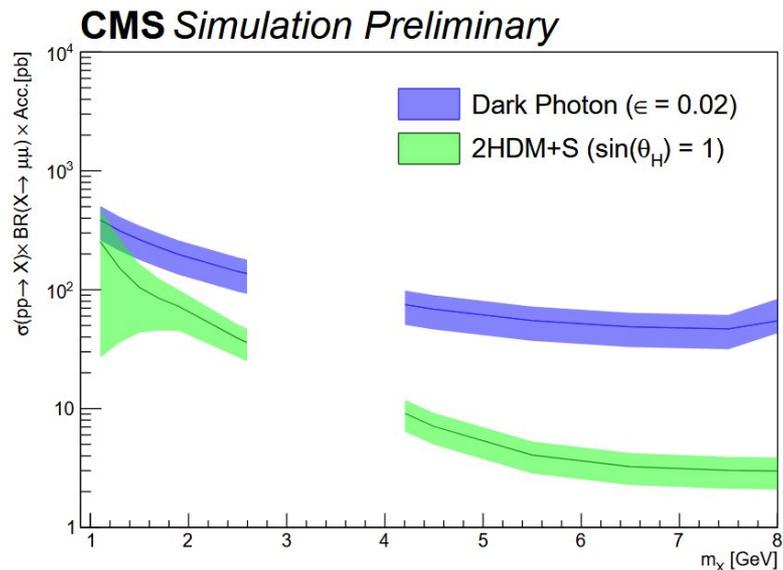
Boosted Excess (2.41 GeV)

- Boosted excess at 2.41 coincides with an excess observed at the same mass by LHCb in a comparable analysis
 - 3.1σ local significance at 2.42 GeV in X+b search
 - <https://arxiv.org/pdf/2007.03923.pdf>



Theory Cross-Sections x Acceptances

- All theoretical quantities of interest for model dependant limits are included in the plot on the right; the product of:
 - the **theory cross section** for that mediator
 - the **branching fraction** to muons
 - the **acceptance** into our fiducial volume
- Limits are scaled relative to reference coupling in legend

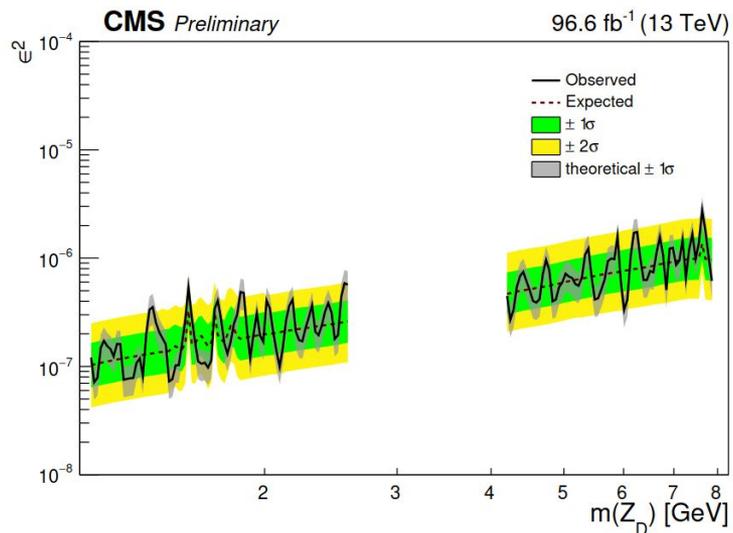


- Theory uncertainties for both models are extracted by varying QCD scales up and down [0.25,1.0] about the nominal value [0.5]
 - The **difference between the DYTurbo Generator and Madgraph acceptance measurement** is treated as an additional uncertainty on the dark photon theory values

Limits with Theory Uncertainties

- Model dependant parameter results, with previously shown $\pm 1\sigma$ theory uncertainties added to observed limit

Dark Photon



2HDM+S

