

Dark Sectors @ LHCb

Mike Williams
on behalf of the LHCb collaboration

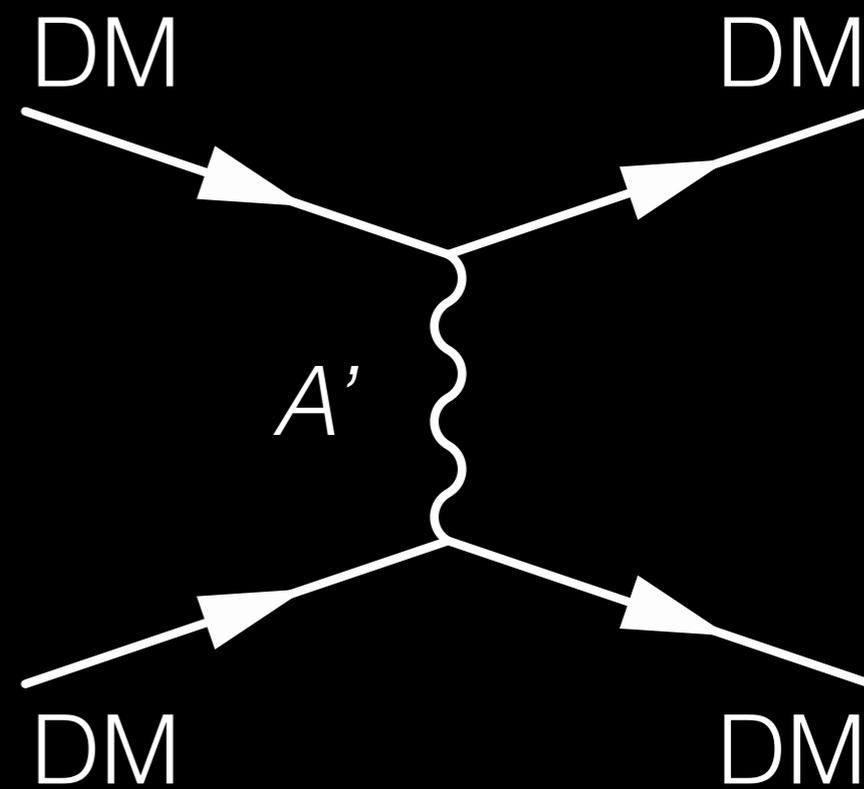
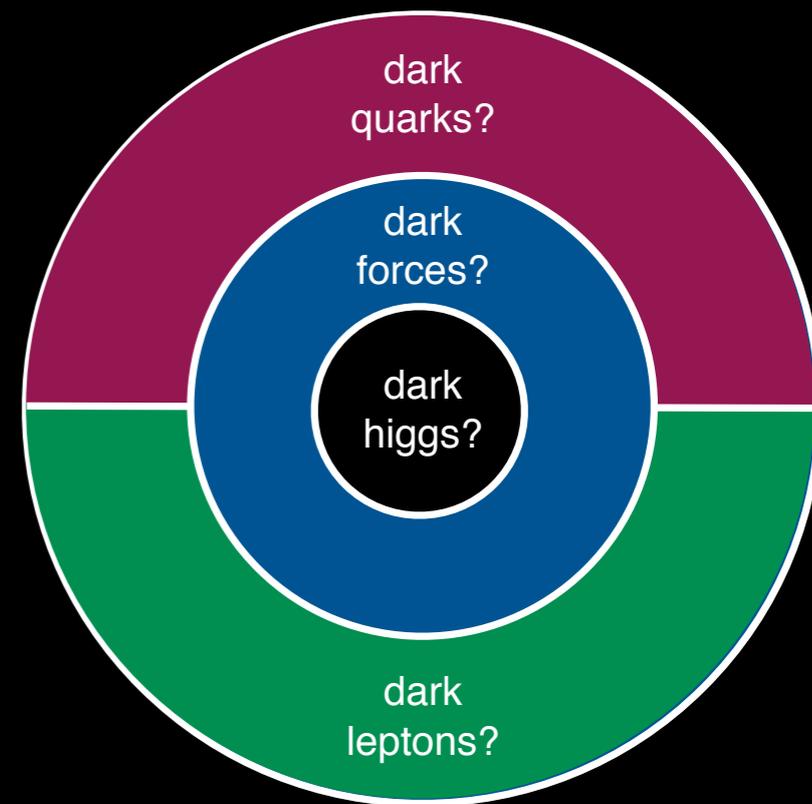
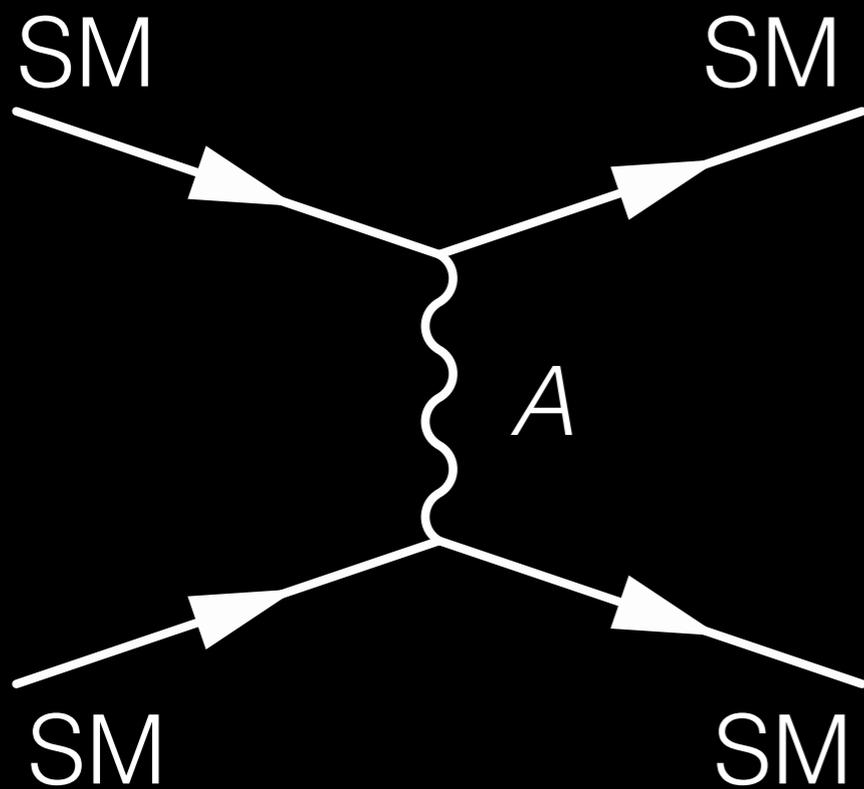
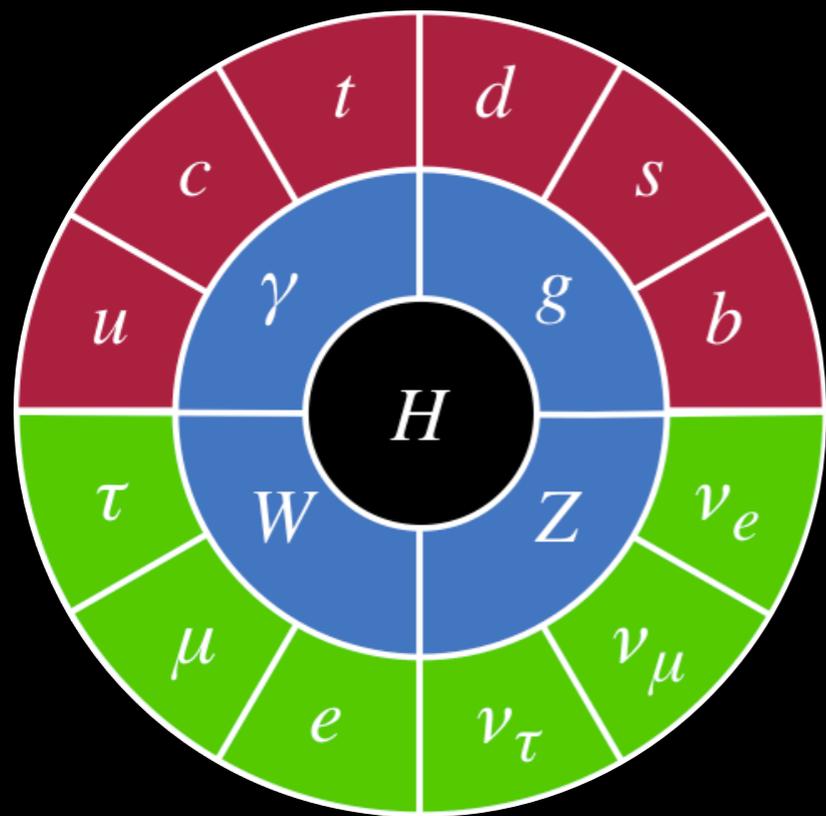
Department of Physics & Laboratory for Nuclear Science
Massachusetts Institute of Technology



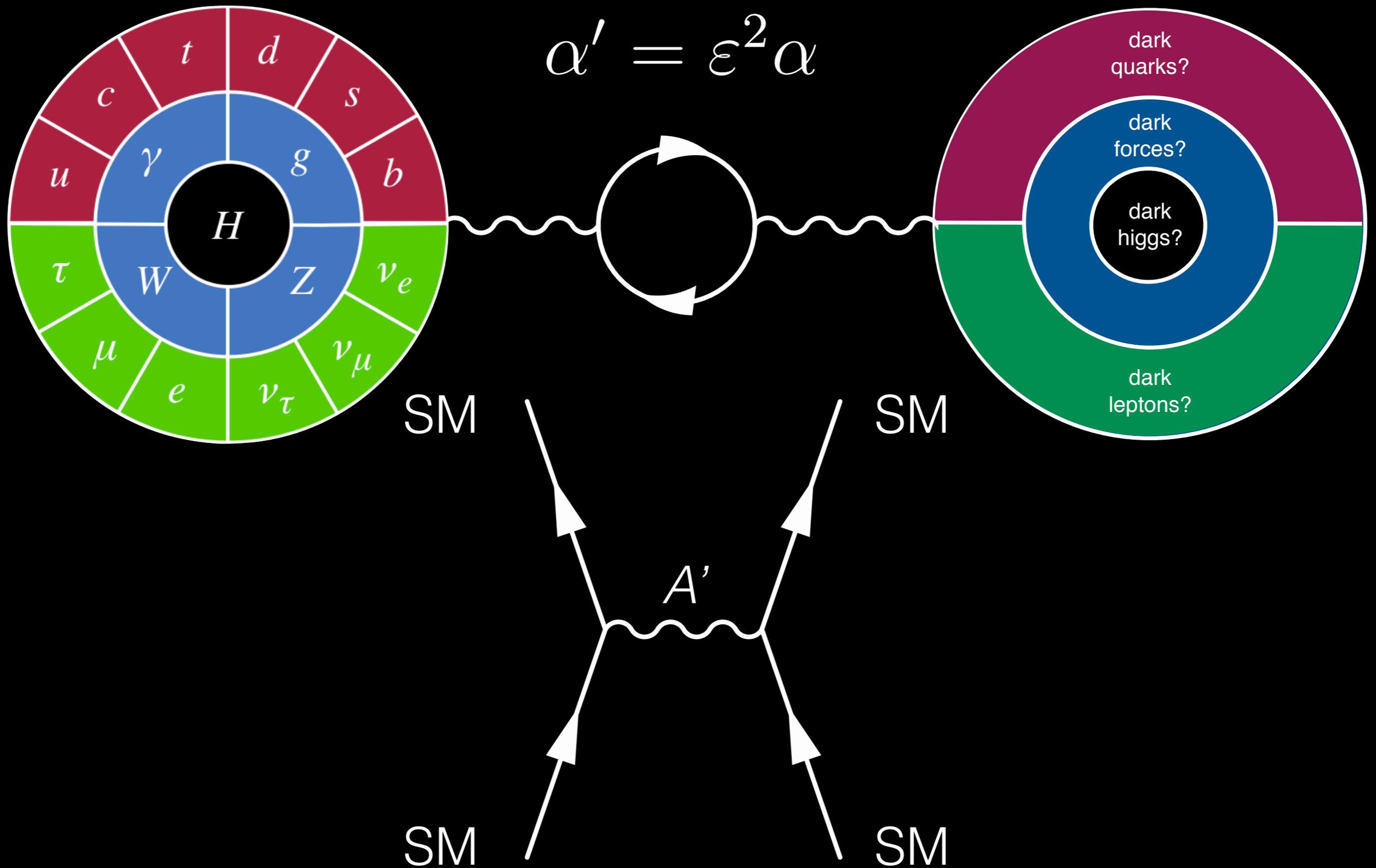
April 4, 2018



Dark Photons



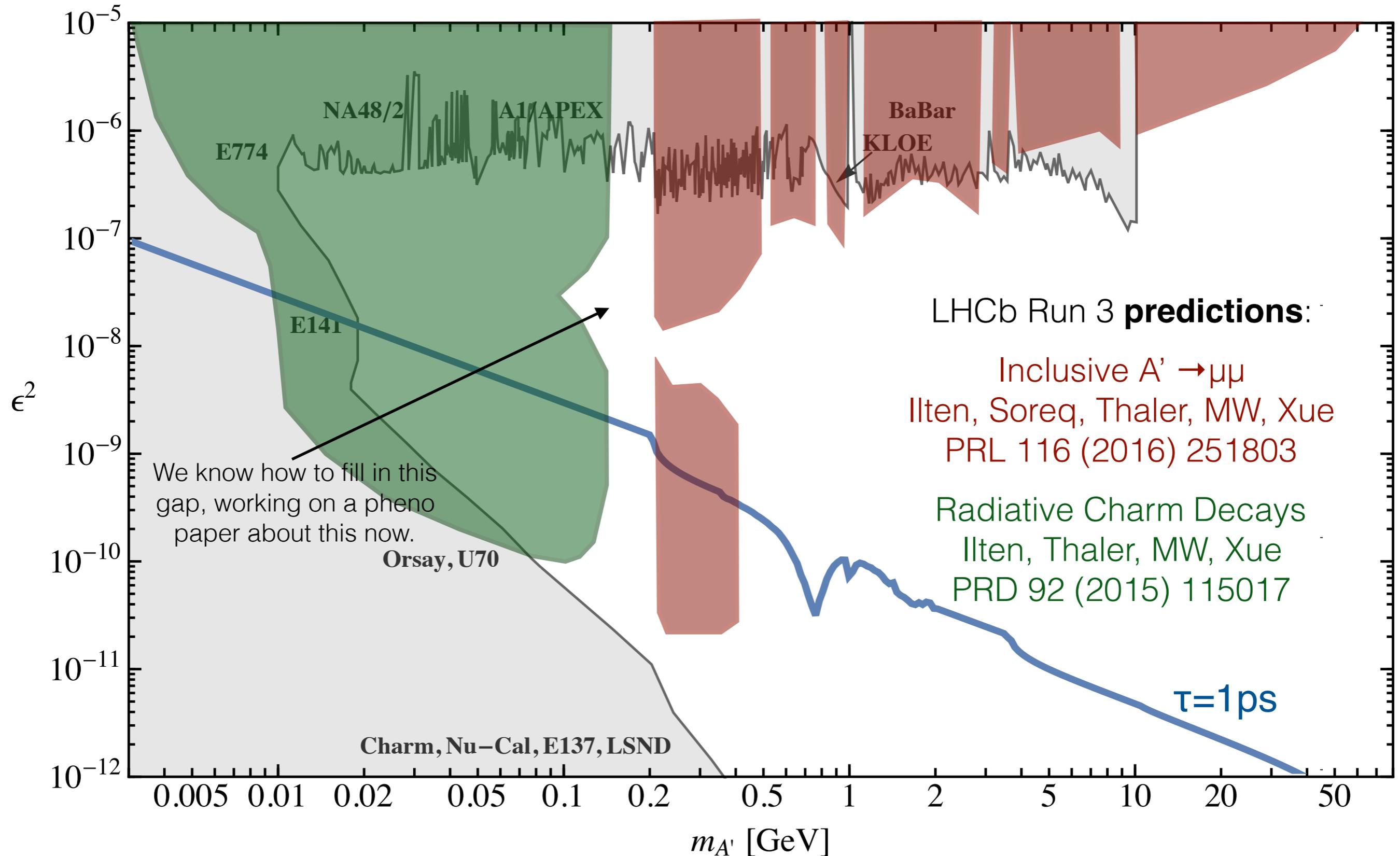
Dark Photons



See Okun, 1982; Galison, Manohar, 1984; Holdom, 1986; etc.; Arkani-Hamed, Finkbeiner, Slatyer, Weiner, 2008; Pospelov, Ritz, 2008; etc.

Visible A' Decays

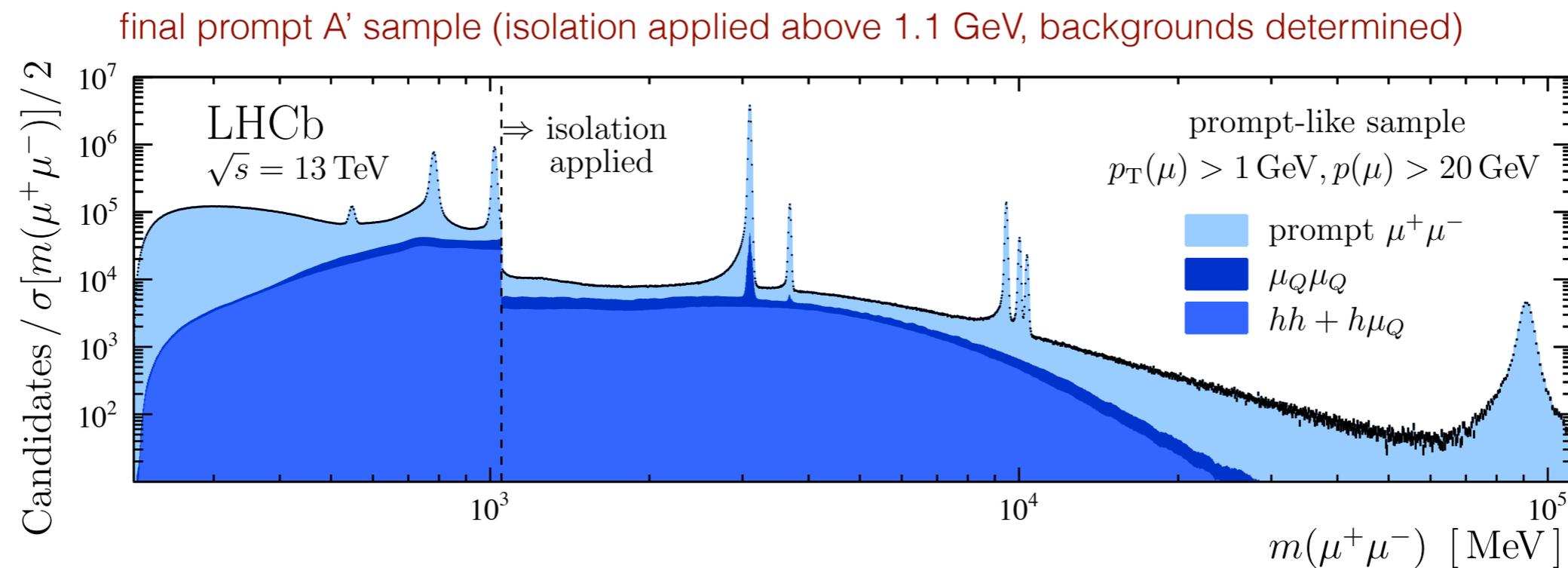
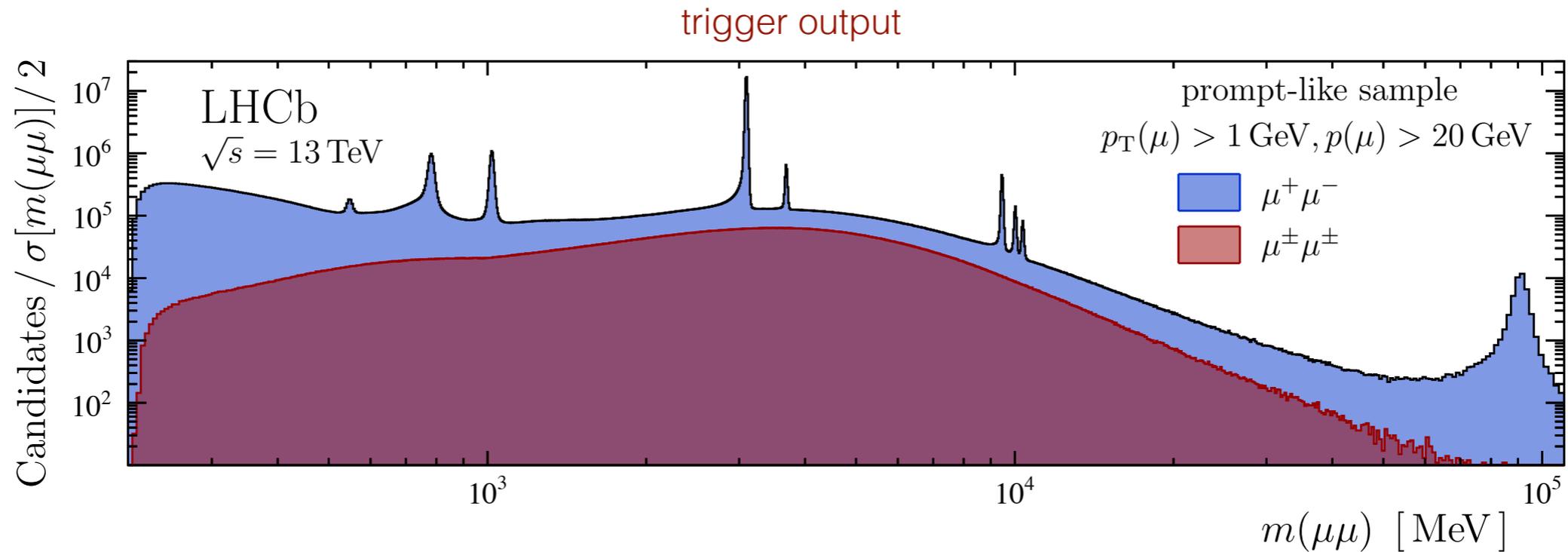
Leverage LHCb's world-leading τ resolution and planned move to a triggerless readout.



Prompt A'

LHCb-PAPER-2017-038

Major hurdles: suppressing misidentified (non-muon) backgrounds and reducing the event size enough to record the prompt-dimuon sample. Accomplished these by moving to real-time calibration in Run 2—but hardware trigger is still there, and $\sim 10\%$ efficient.

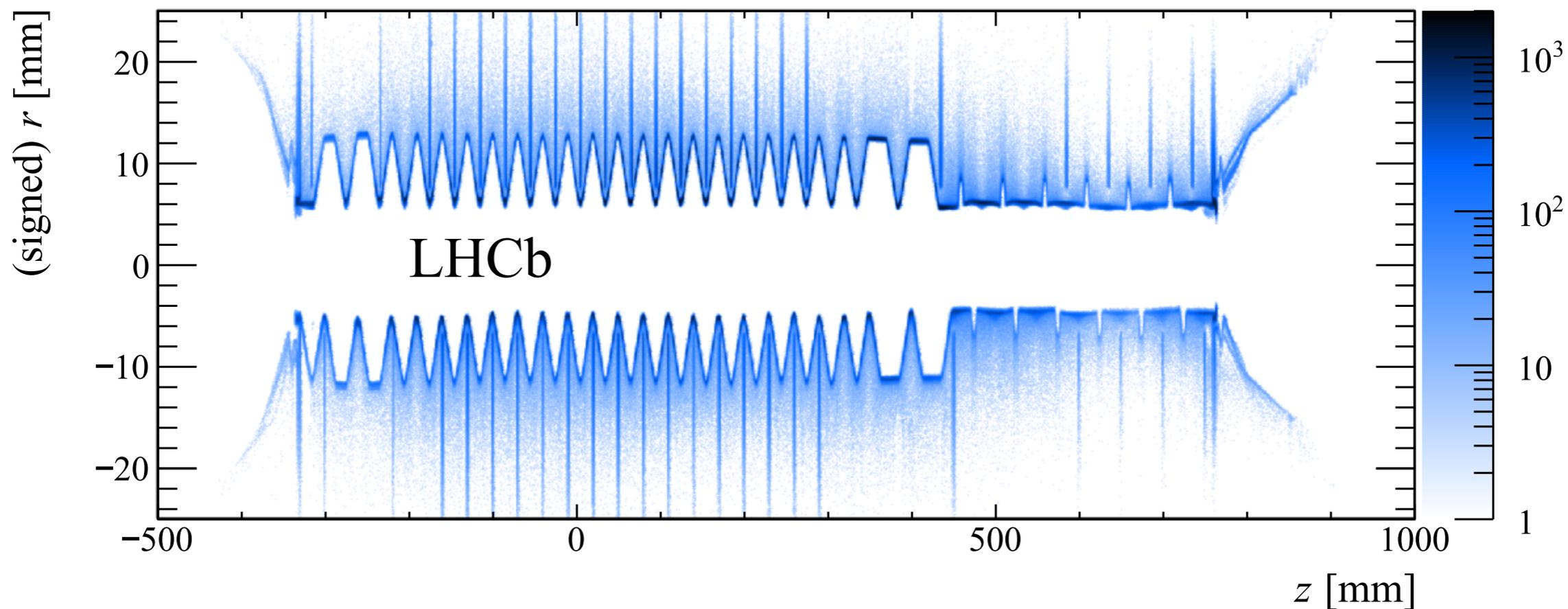
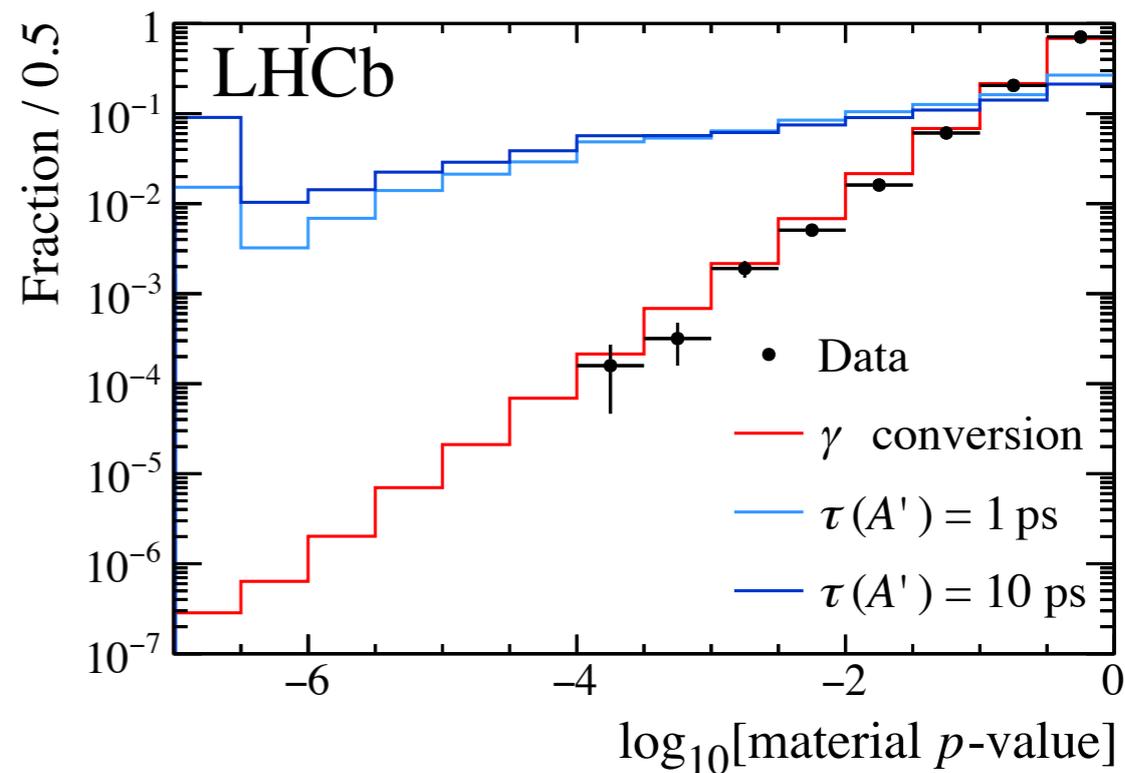
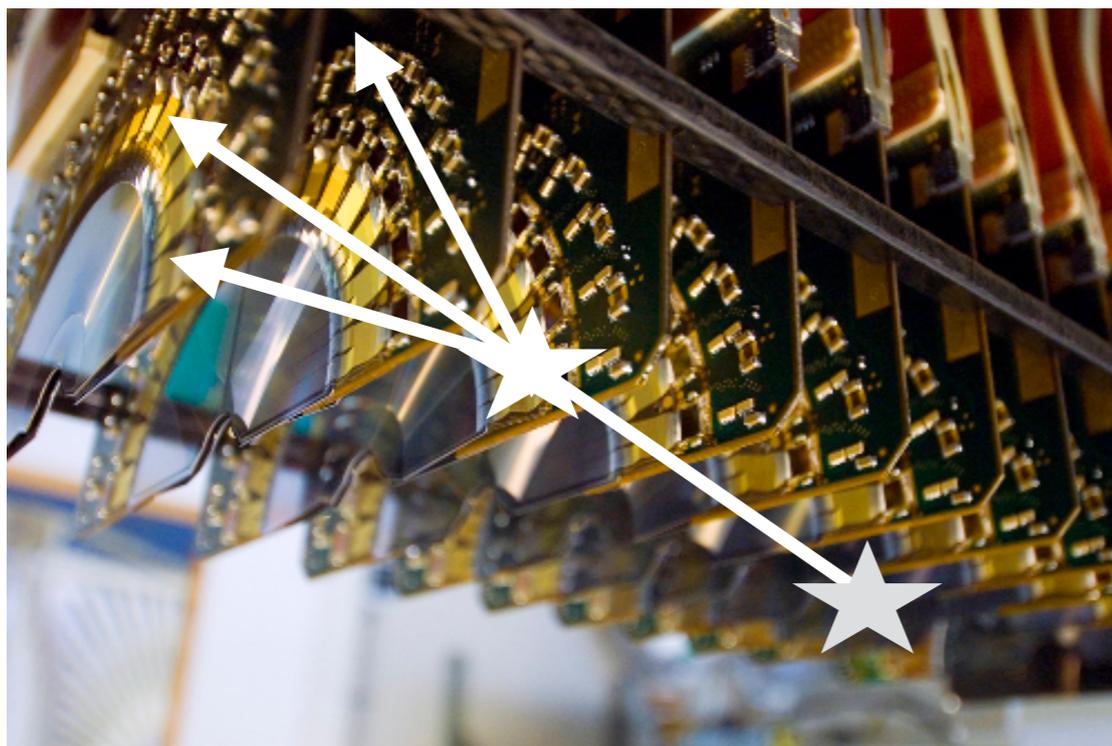


N.b., bump hunt follows MW, 1705.03587.

Long-Lived A'

LHCb-DP-2018-002
[1803.07466]

Major hurdle: building a high-precision map of the VELO material.

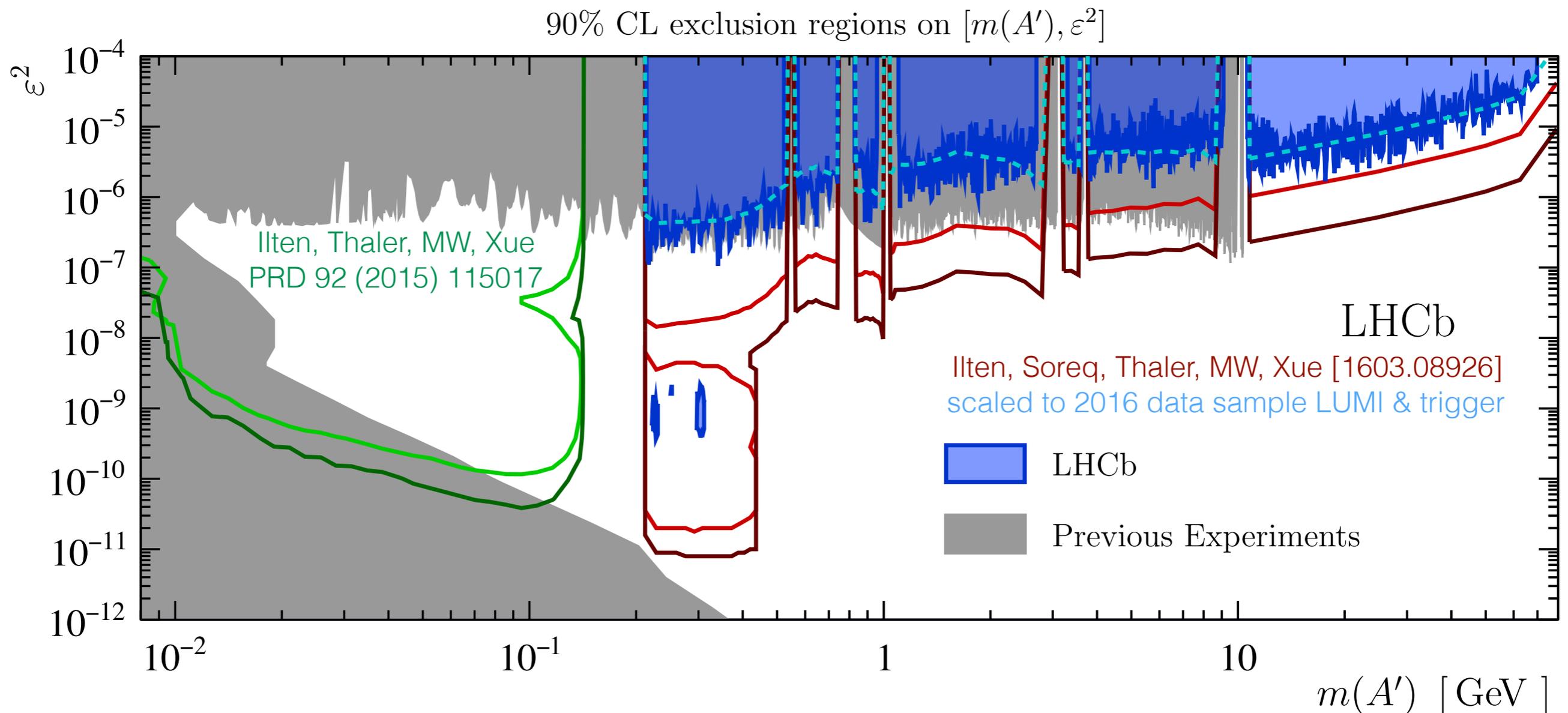


Dark Photons

LHCb-PAPER-2017-038

PRL 120 (2018) 061801

The 2016 dimuon results are consistent with (better than) our predictions for prompt (long-lived) dark photons. We implemented huge improvements in the 2017 triggers for low masses, so plan quick turn around on 2017 dimuon search — then onto electrons.



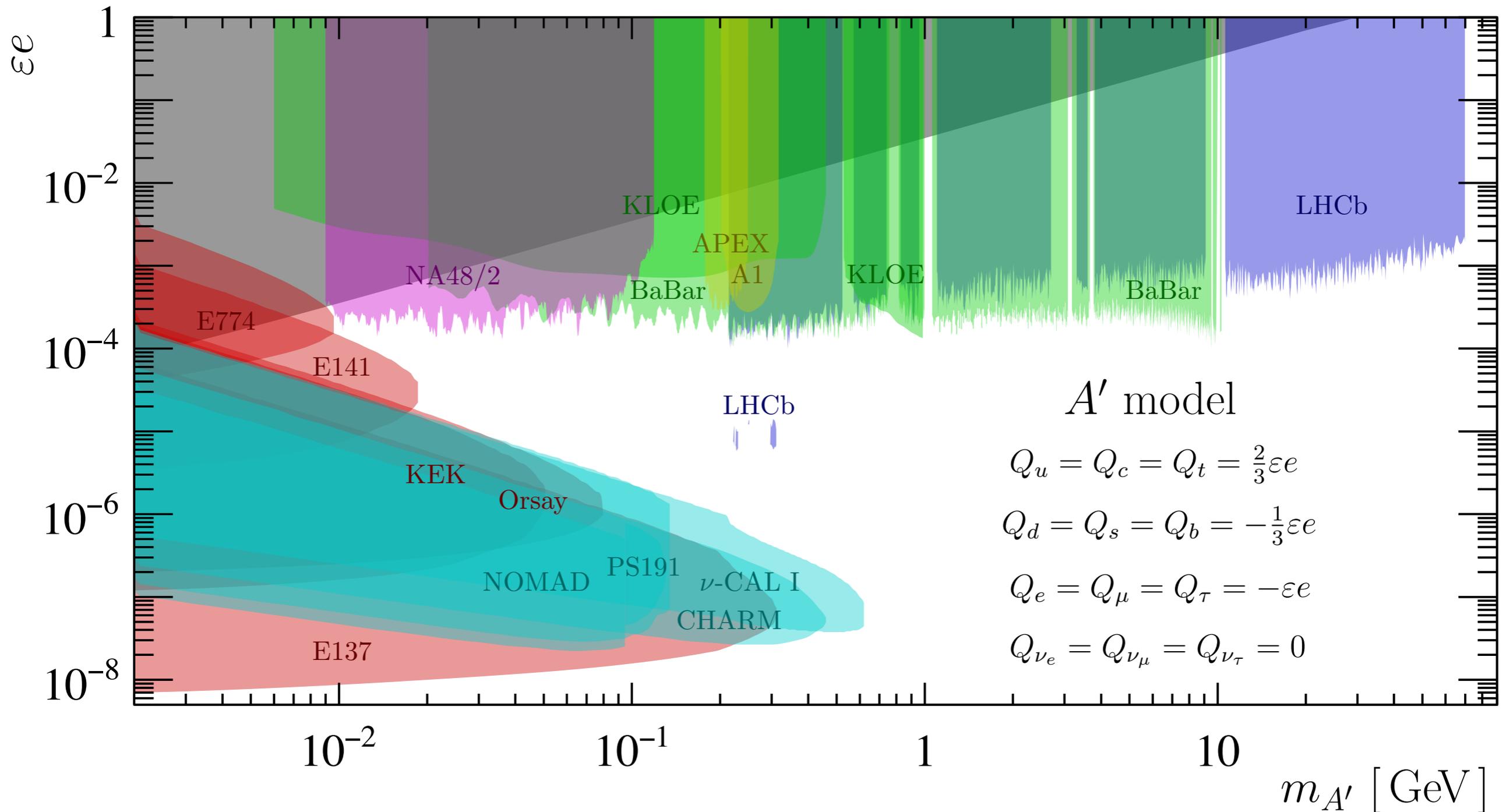
Proves LHCb has unique potential to search for A' using muons. Assuming we can make electrons work, we can cover all of the remaining low-mass parameter space (eventually).

See LHCb-PAPER-2018-008 for a search that fills in most of the gaps near the Upsilon's.

Recasting for other Models

Dark photon searches provide sensitivity to (many) other models.

Ilten, Soreq, MW, Xue [1801.04847]

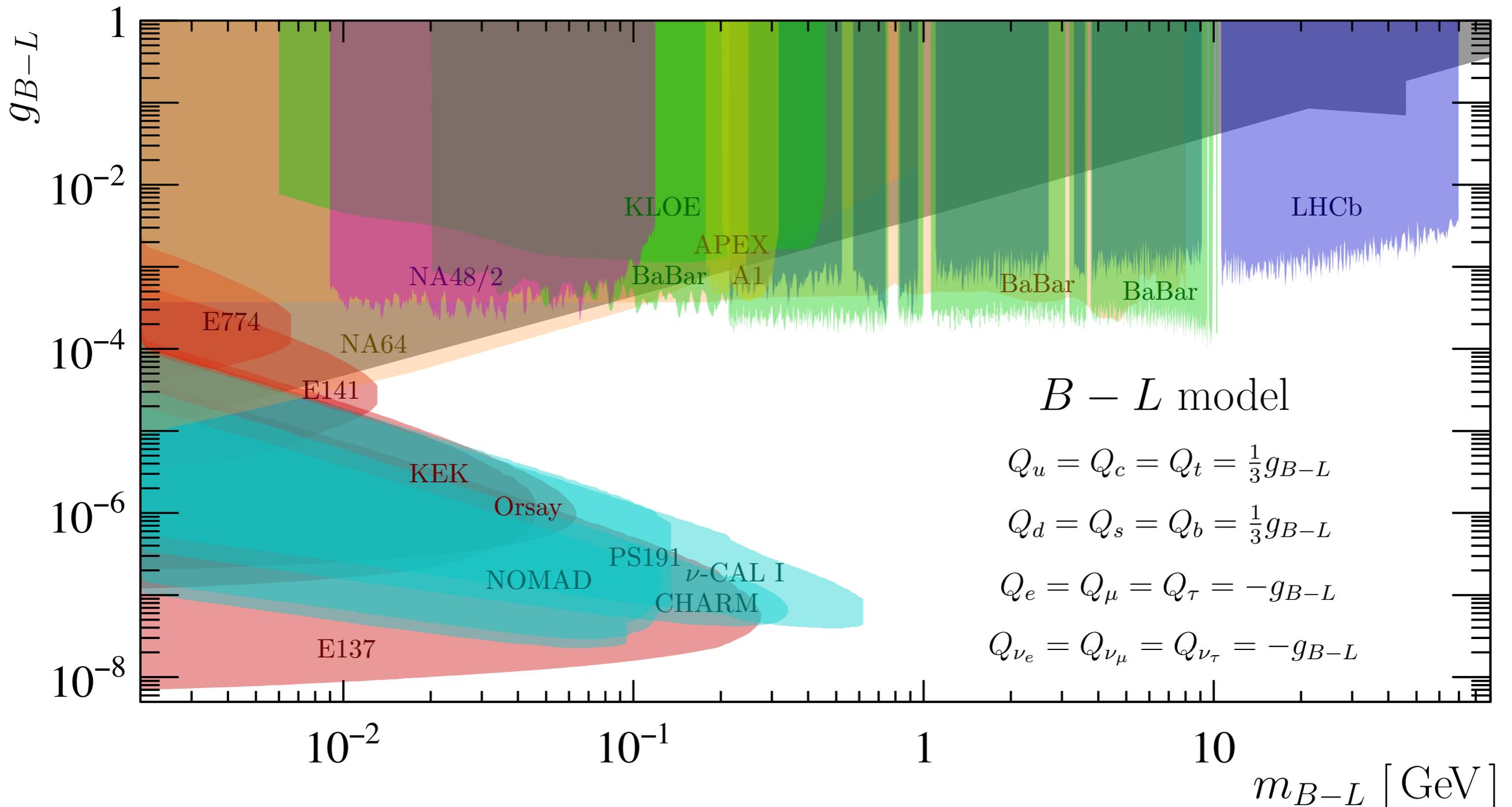


We developed a data-driven way to easily recast any dark photon search to obtain limits on any other vector model (auto-calculates hadronic decay rates for all masses).

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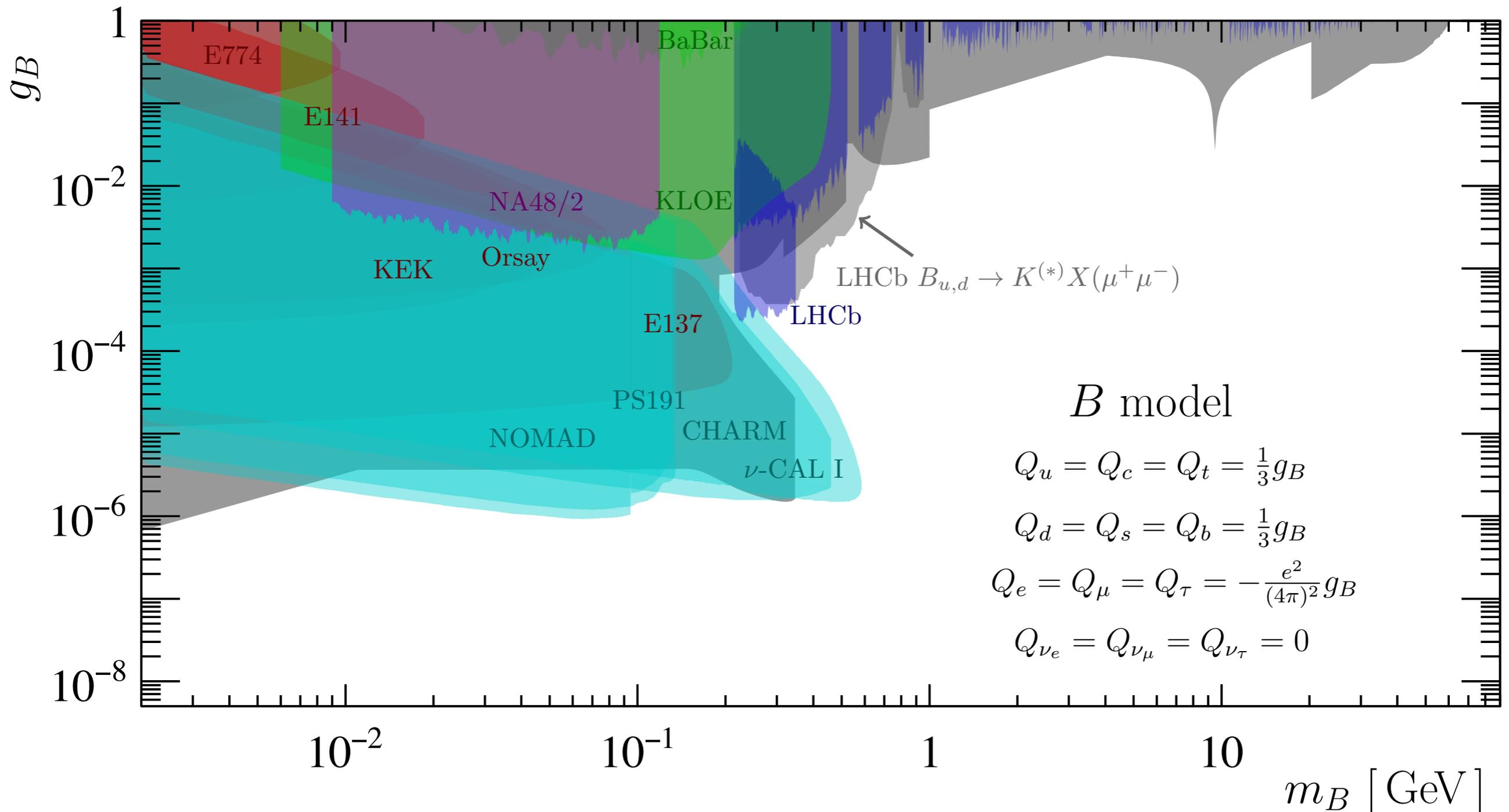


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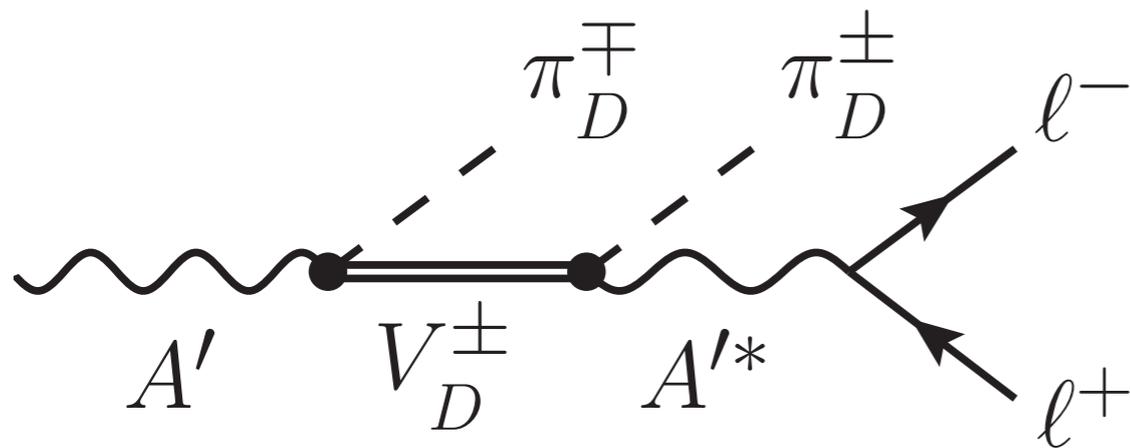
N.b., this search also provided the best limits on pseudo-scalars above ~ 7 GeV, etc.

Haisch, Kamenik, Malinauskas, Spira [1802.02156]

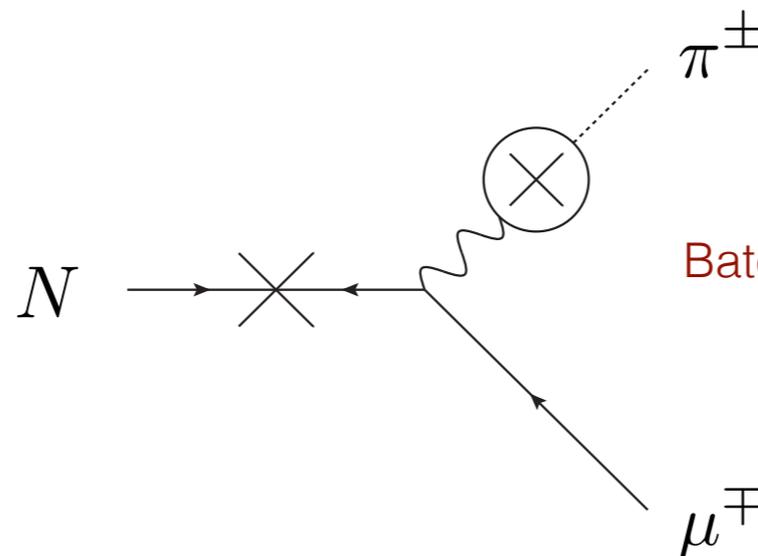
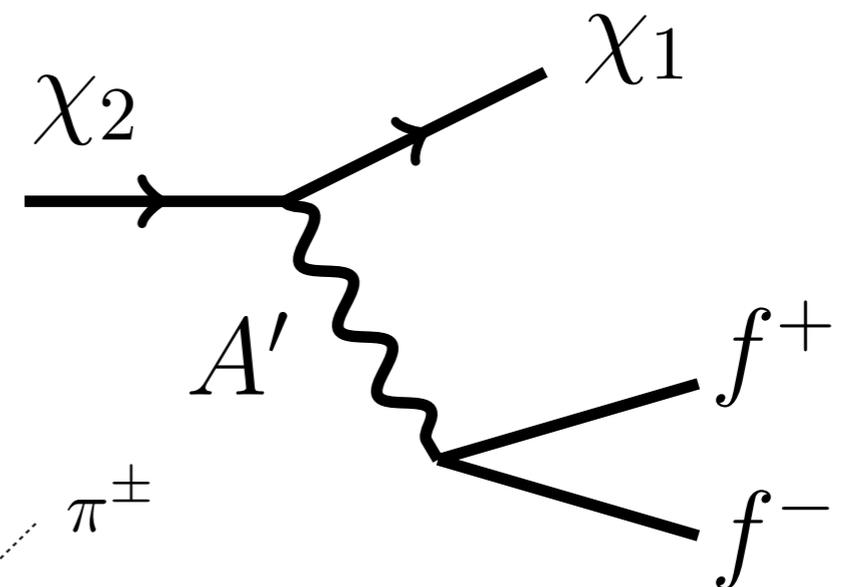
Coming Soon

Triggers produced for non-standard decay topologies, RH neutrinos, etc., in 2016. Plan to produce these searches using 2016-2018 data. New triggers for $A' \rightarrow ee$ in 2018.

Berlin, Blinov, Gori, Schuster, Toro
[1801.05805]



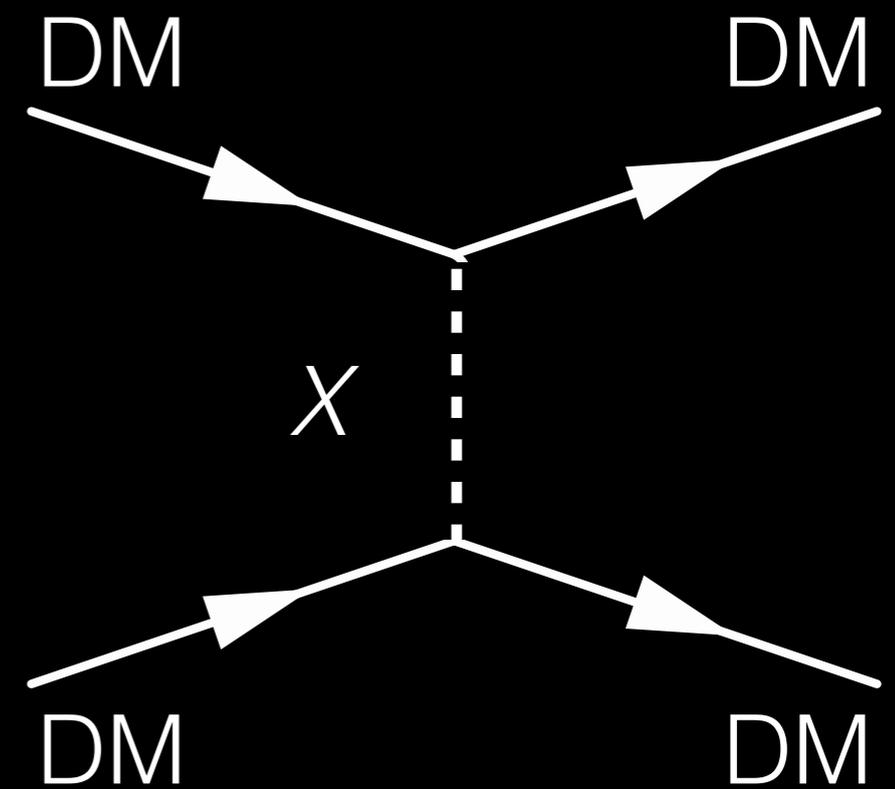
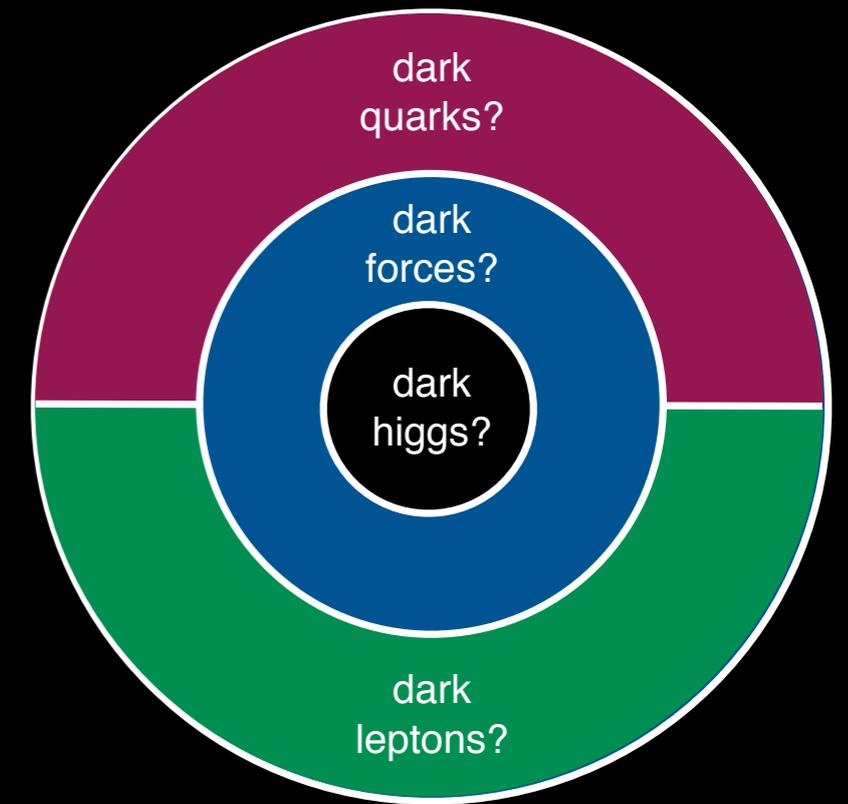
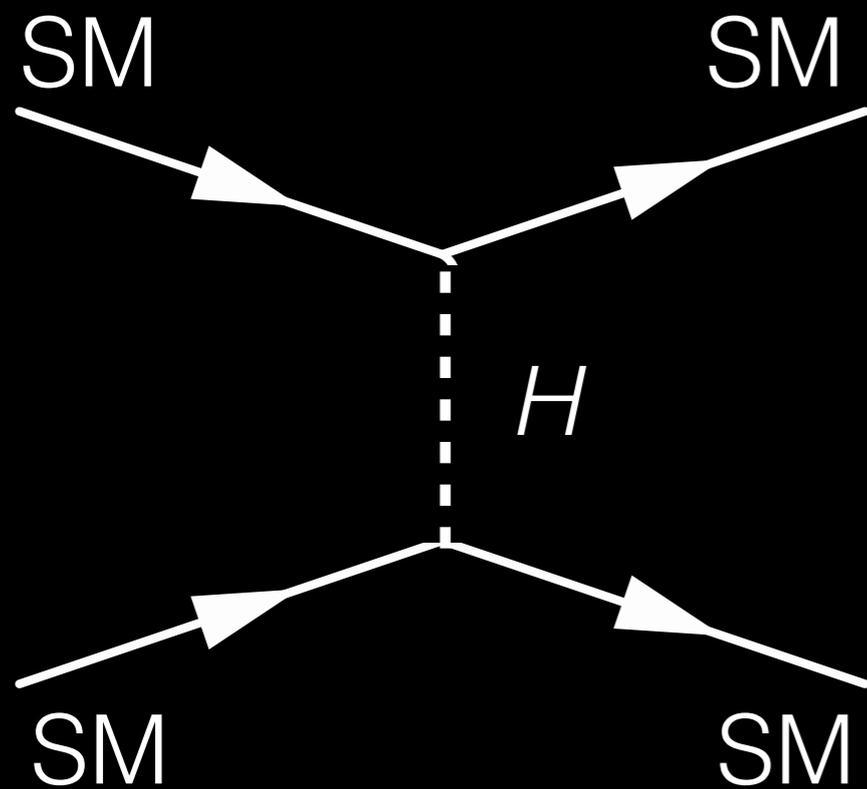
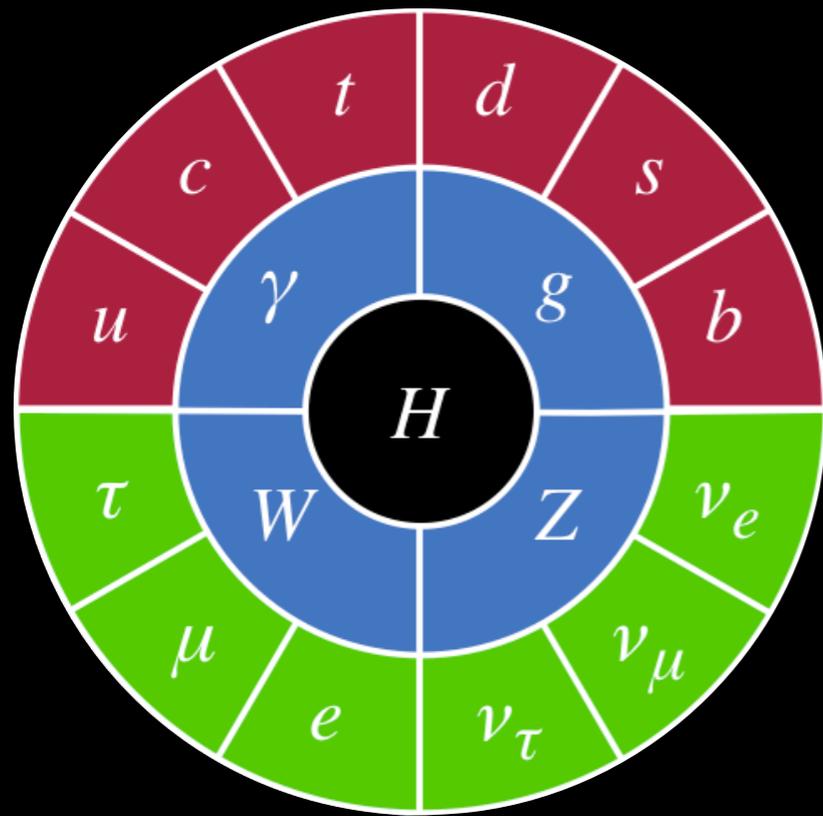
Izaguirre, Kahn, Krnjaic, Moschella
[1703.06881]



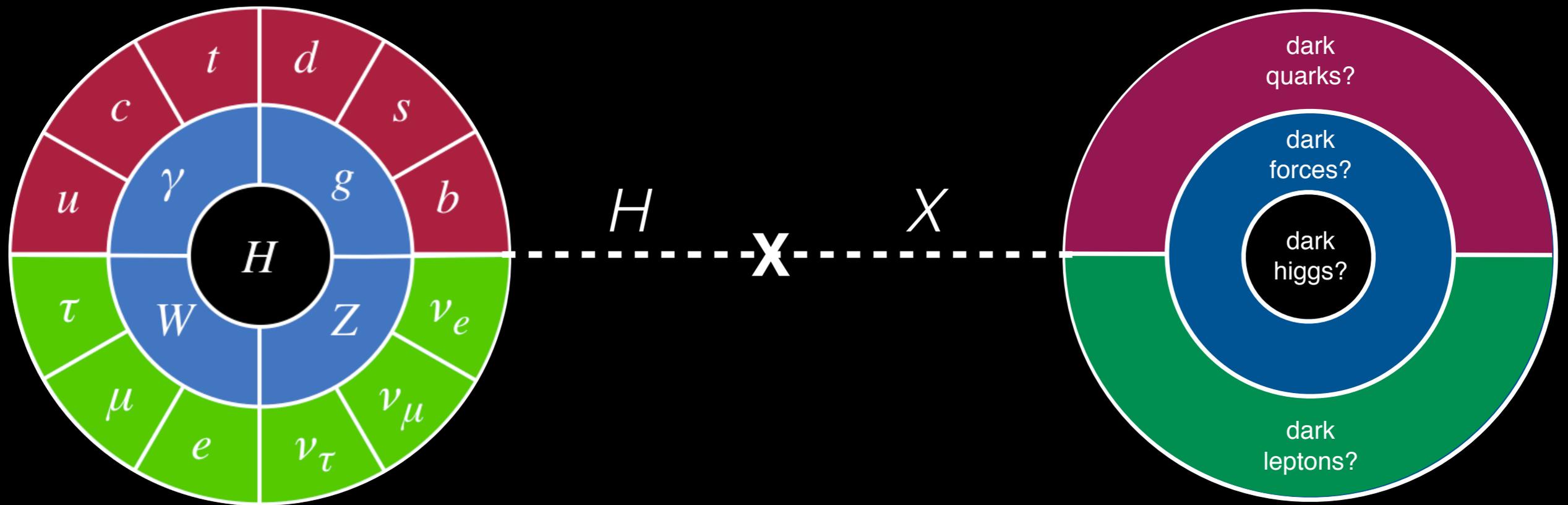
Batell, Pospelov, Shuve
[1604.06099]

The future of dark-sector searches at LHCb is bright (dark?).

Higgs Portal



Higgs Portal



$$\begin{pmatrix} H \\ \chi \end{pmatrix}_{\text{physical}} = \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} H \\ \chi \end{pmatrix}_{\text{ideal}}$$

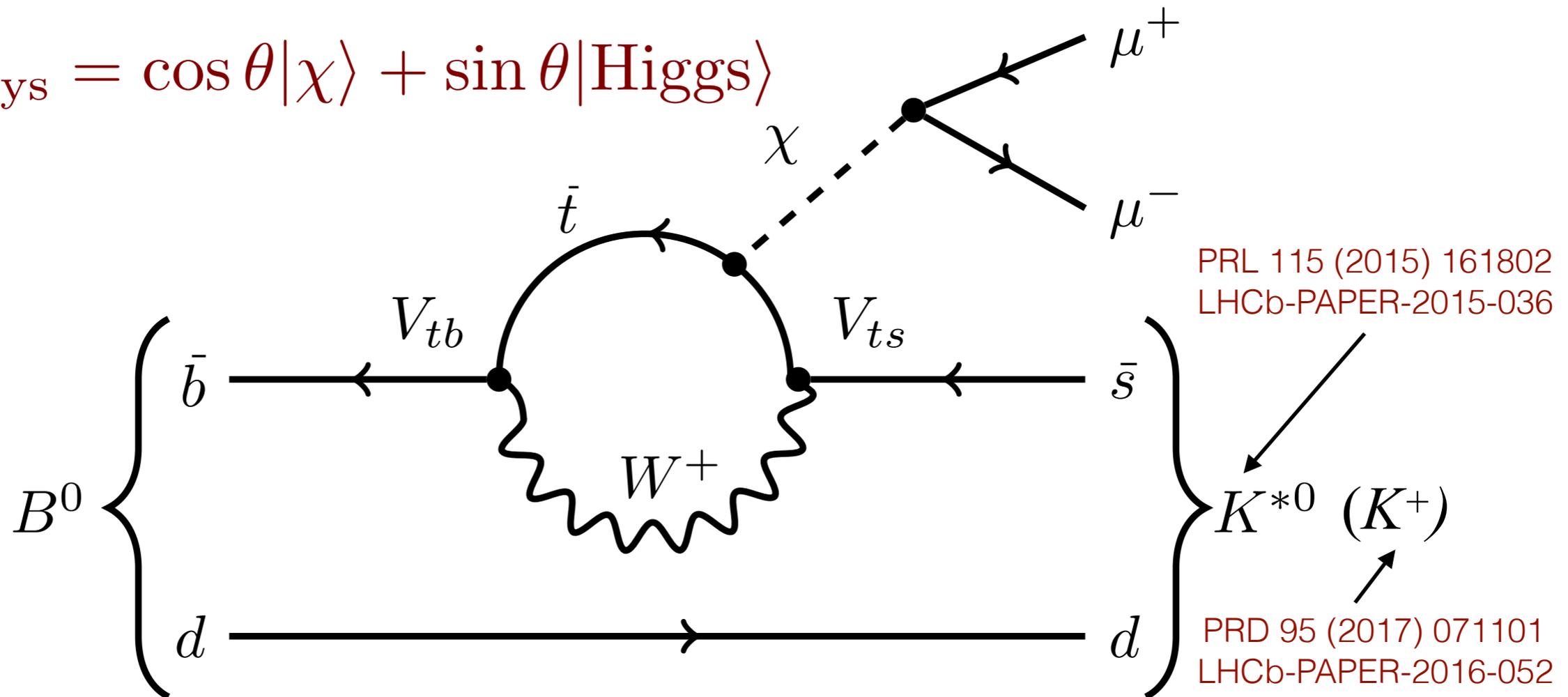
The X particle picks up couplings to SM particles proportional to mass, just like the Higgs. N.b., many non-DM theories also predict X fields.

Higgs Portal

$b \rightarrow s$ penguin decays are an excellent place to search for low-mass hidden-sector particles (e.g., anything that mixes with the Higgs sector).

$$|\text{Higgs}\rangle_{\text{phys}} = -\sin\theta|\chi\rangle + \cos\theta|\text{Higgs}\rangle$$

$$|\chi\rangle_{\text{phys}} = \cos\theta|\chi\rangle + \sin\theta|\text{Higgs}\rangle$$



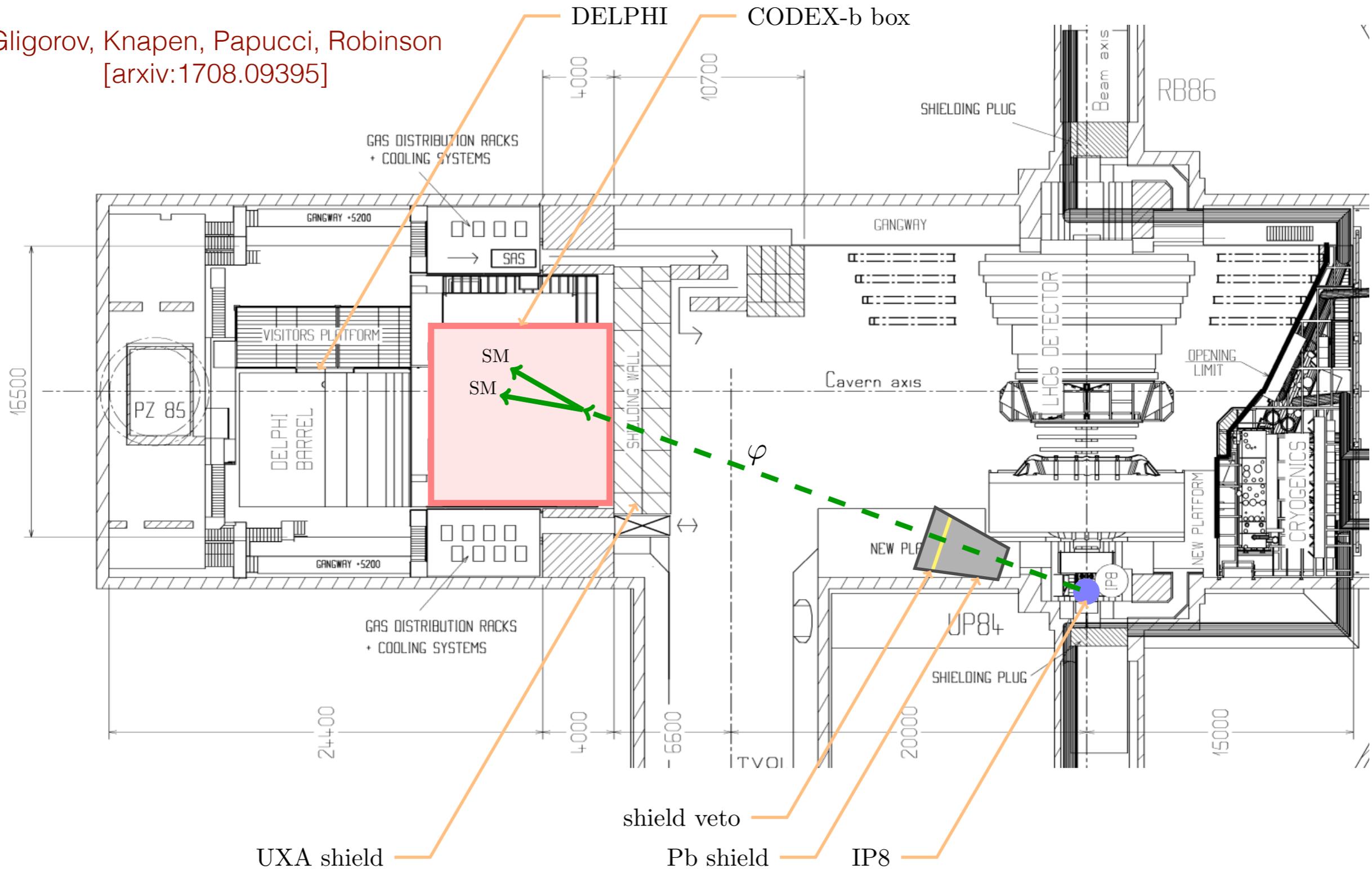
Model-independent limits set on $B(B \rightarrow K^* X) B(X \rightarrow \mu\mu)$ translate into model-dependent constraints on the H-X mixing angle of $O(\mathbf{mrad})$ (rules out nominal inflaton here), and $O(\mathbf{PeV})$ on ALP decay constants.

See also MW [1503.04767]; J.Stevens, MW [1305.7248]; Freytsis, Ligeti, Thaler [0911.5355]; Batell, Lange, McKeen, Pospelov, Ritz [1606.04943].

CODEX-b

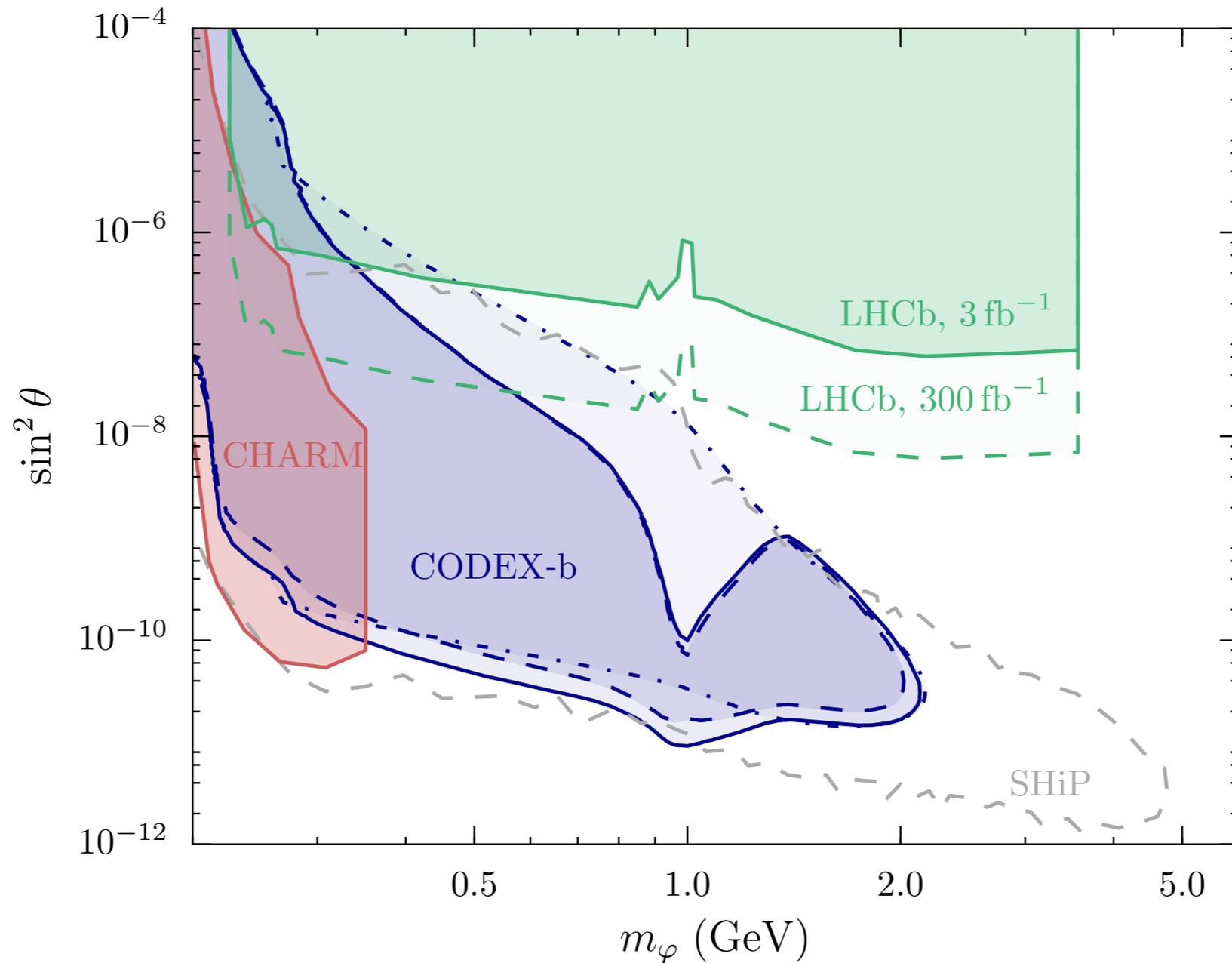
Proposed new detector element at LHCb to search for long-lived particles.

Gligorov, Knapen, Papucci, Robinson
[arxiv:1708.09395]



CODEX-b

Excellent sensitivity to inclusive Higgs portal production.



LHCb projections assume only decays in the VELO are used. Studies ongoing that would extend the fiducial decay volume within LHCb itself.

Sensitivity studies for other models, e.g. Higgs decays to dark photons, are provided in 1708.09395. Additionally, studies on boost/mass resolution are provided.

Sensitivity also demonstrated for Higgs decays to dark photons. Should have excellent sensitivity to most hypothetical long-lived particles.

Summary

LHCb
LHCb

LHCb is a general-purpose detector in the forward region.