Constraints on light pseudoscalar mediators from B decays and direct detection experiments

Fatih Ertas

in collaboration with:

Babette Döbrich, Felix Kahlhoefer and Tommaso Spadaro - arXiv:1810.11336

Felix Kahlhoefer - (work in progress)

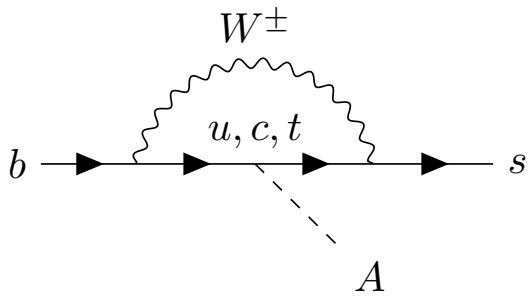
RWTH AACHEN UNIVERSITY

Simplified Model

- Well-motivated from a theory point of view as they can be Pseudo-Goldstone bosons

Flavor physics

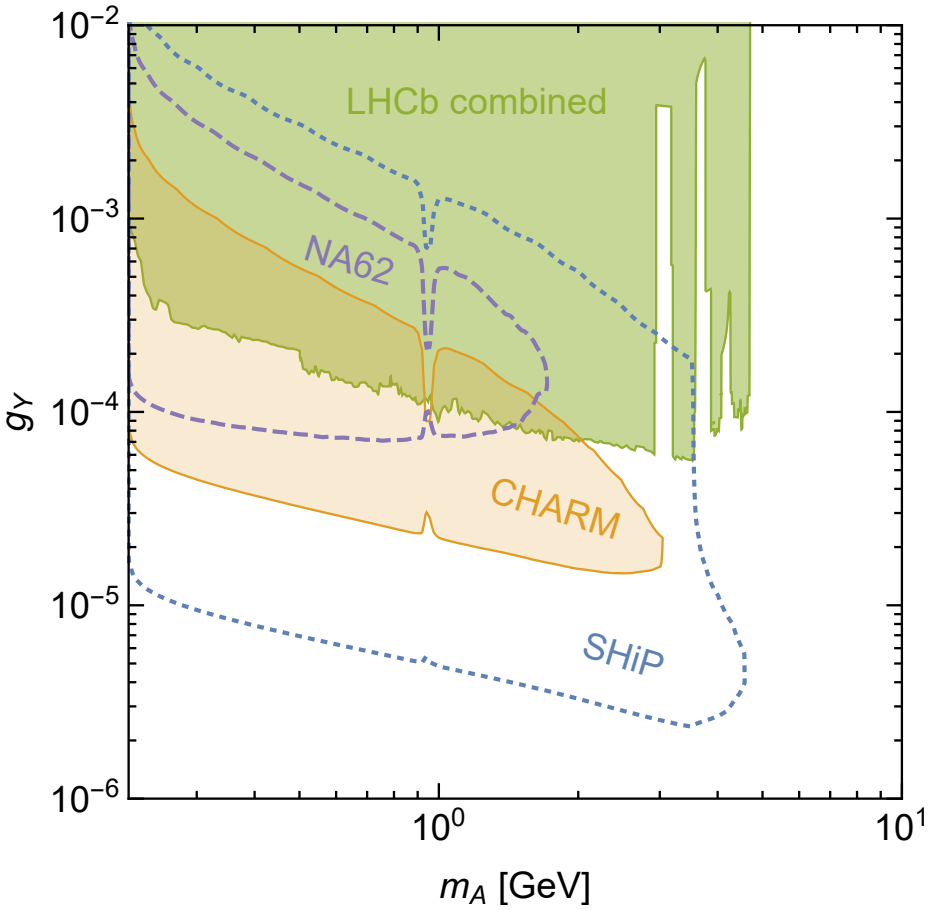
- Good experimental prospects due to potential large enhancements in rare meson decays



- Low-energy description: $\mathcal{L} = i\, g_Y \sum_{f=q,\ell} \frac{m_f}{v_h} A\, \bar{f} \gamma^5 f$

- We focus on the decays $B \to K^{(*)}\, A\, (\to \mu^+ \mu^-)$

Experimental constraints



- 95% C.L. bounds
- LHCb search included displaced vertices
- Revised the CHARM exclusion contour
- LHCb + CHARM $>$ NA62 ?

  $\rightarrow$ No! This is a model-dependent plot

Why a model-independent approach?

- The previous plot does not visualize the potential of a given experiment properly as it is model-dependent

- Loop-calculations and thus bounds depend on UV scale Λ

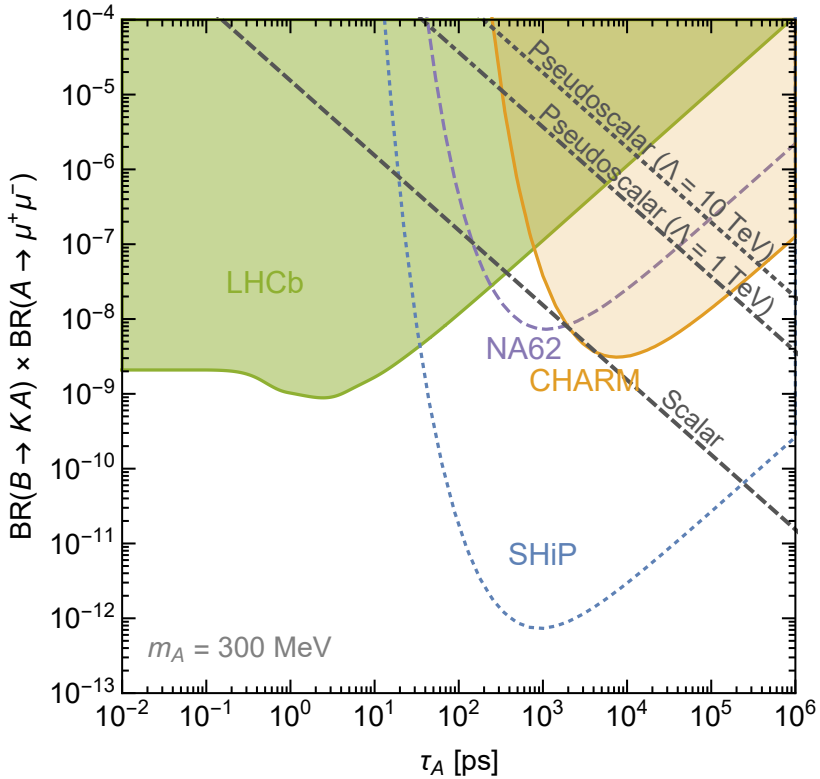
$$\mathcal{L}_{\text{FCNC}} \supset h^S_{sb} A\, \bar{s} b + h^P_{sb} A \bar{s} \gamma_5 b + \text{h.c.}$$

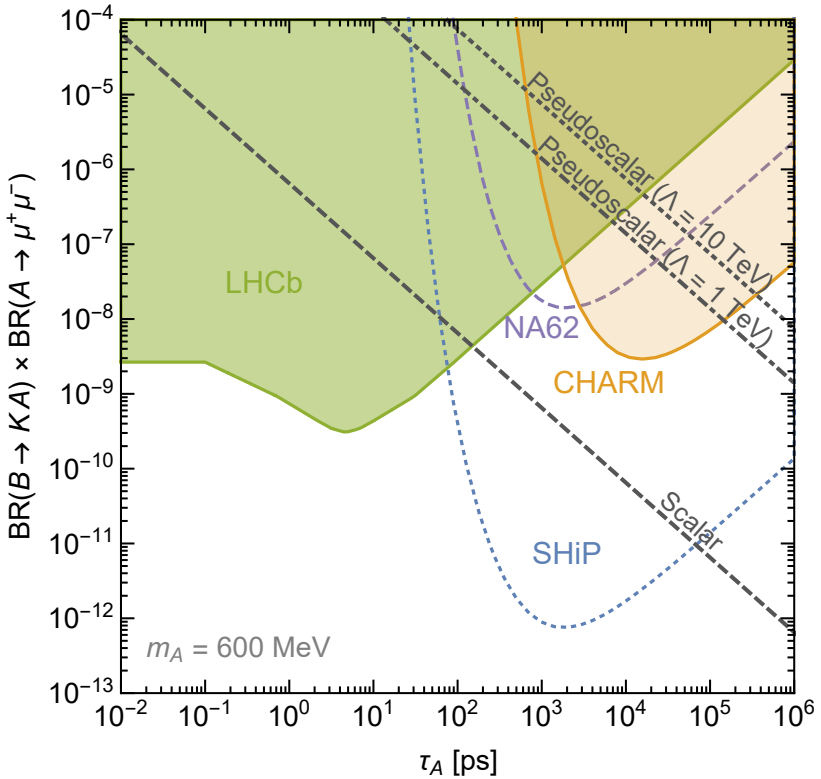
where

$$h^S_{sb} = \frac{i\alpha\, g_Y\, (m_b - m_s)\, m_t^2}{8\pi\, m_W^2\, \sin(\theta_W)^2\, v_h}\, V_{tb} V_{ts}^*\, \log\left(\frac{\Lambda^2}{m_t^2}\right)$$

Model-independent bounds

Maximal sensitivities represent the different geometries of the experiments!





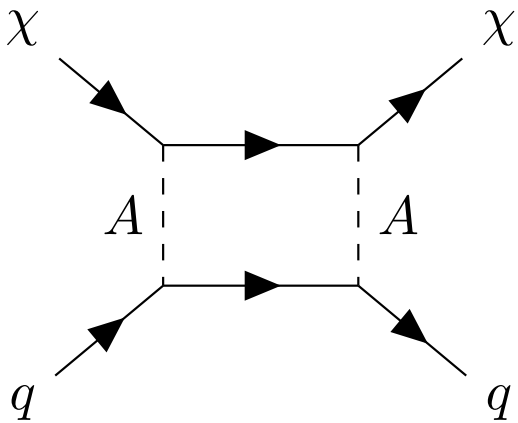
Scalar case: 1809.01876 by Martin Winkler

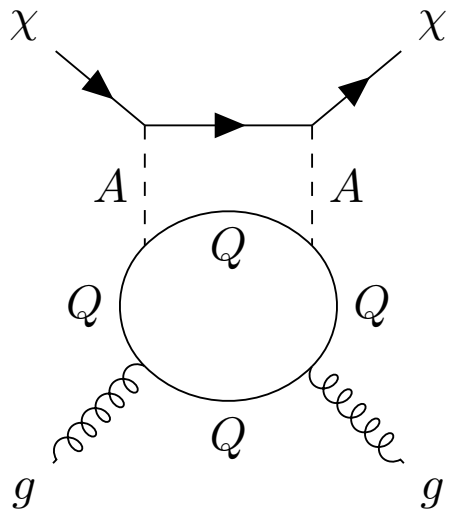
Dark Matter direct detection experiments

- Tree-level diagram is spin-dependent and highly momentum suppressed

- As it turns out, loop-level contributions dominate

  [G. Arcadi et al. 1711.02110, N. Bell et al. 1803.01574, T. Abe et al. 1810.01039]





Thank you for your attention!

Questions?

Backup

Fixed-target experiments

CHARM

- 400 GeV proton beam dumped into copper target with the detector being 480 m far away
- Detector is 35 m long, 3 m $\times$ 3 m in transverse dimension and placed 5 m away from beam axis
- Muon energy required to be greater than 2 GeV
- Protons on target: 2.4×10^{18}

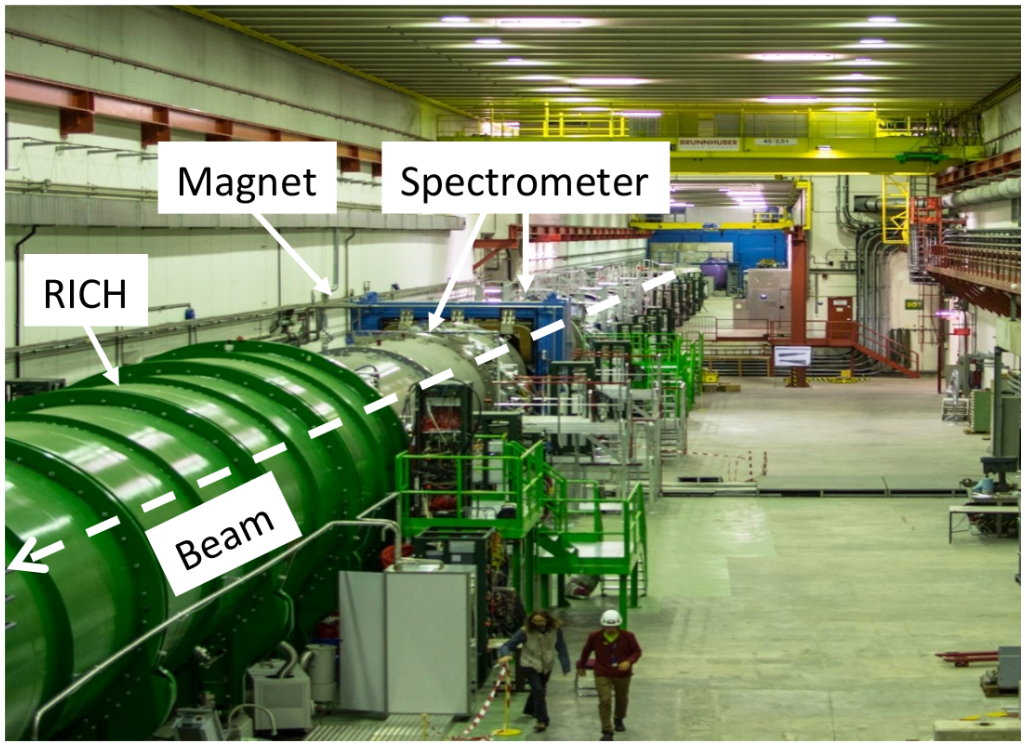
Fixed-target experiments

NA62

- Kaon factory with the aim of measuring $K^+ \to \pi^+ \nu\bar{\nu}$ precisely
- For production of long-lived particles, 400 GeV proton-beam is dumped into copper target just as in CHARM
- Vacuum decay region before spectrometer is 75 m long and at 82 m distance to target
- Muon energy required to be greater than 5 GeV

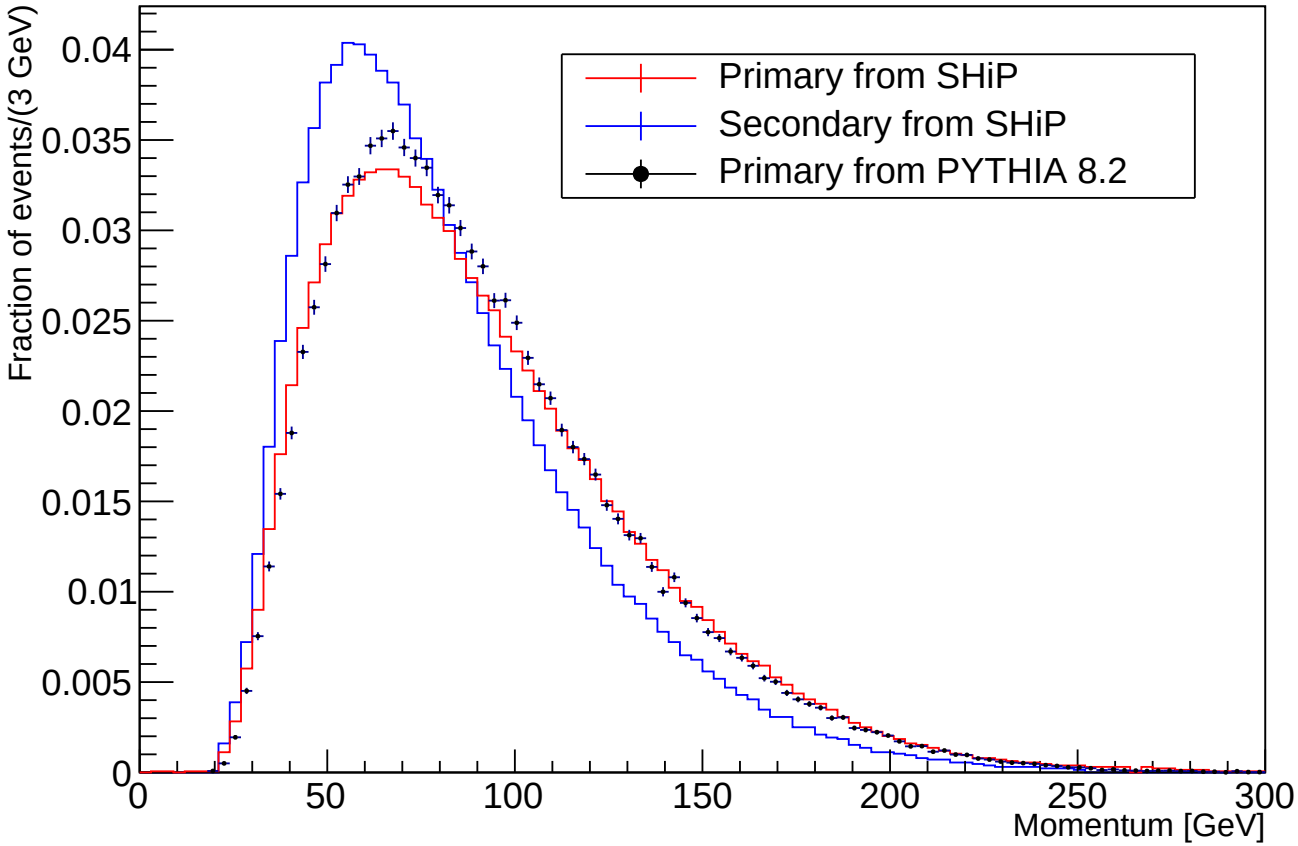
Fixed-target experiments

NA62



$\Longrightarrow$ Protons on target: 1×10^{18}

Comparison of our B-meson spectrum to SHiP



$\Rightarrow$ We did not include secondary production of B-mesons in our calculations as this would be computationally too expensive