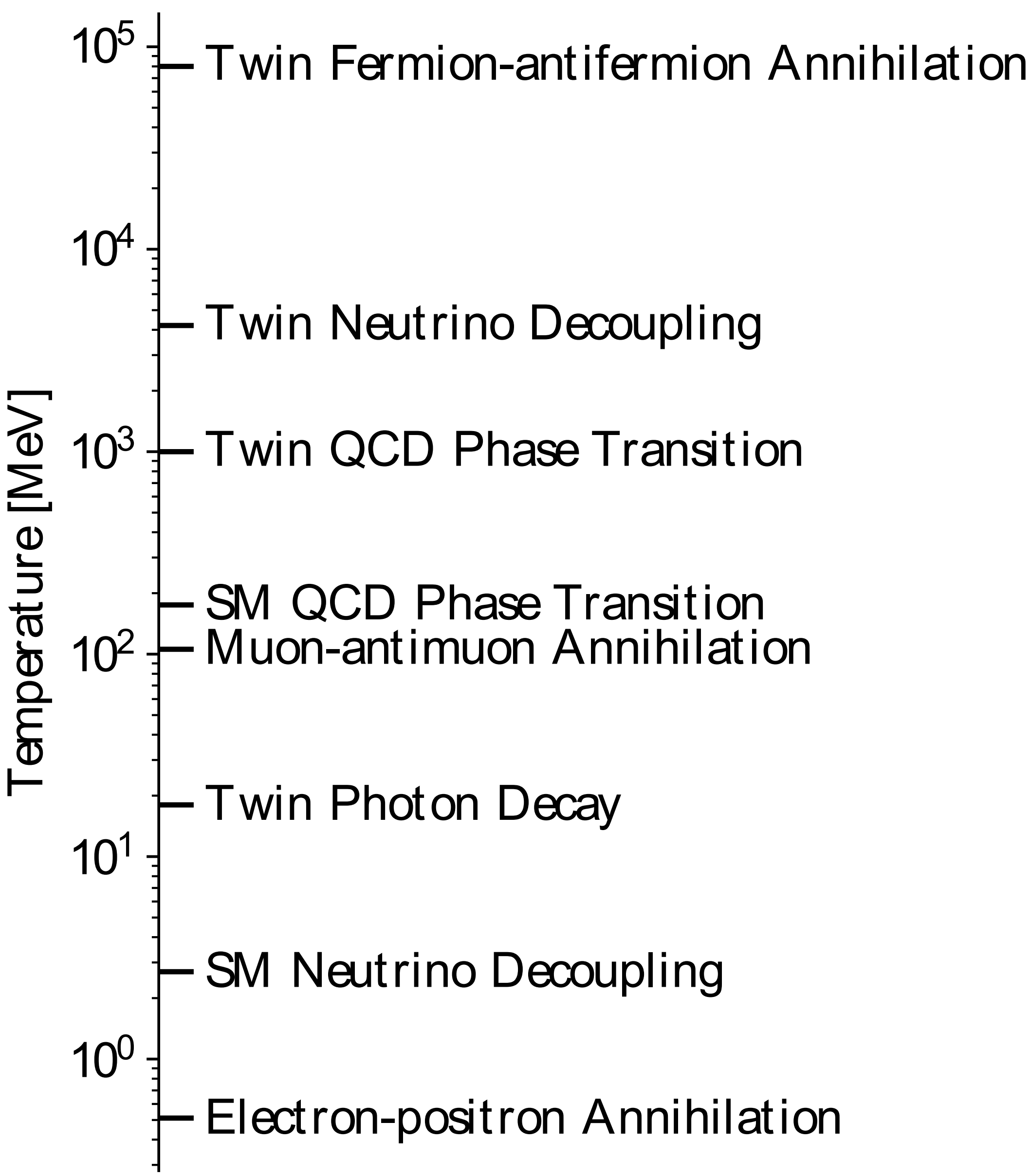
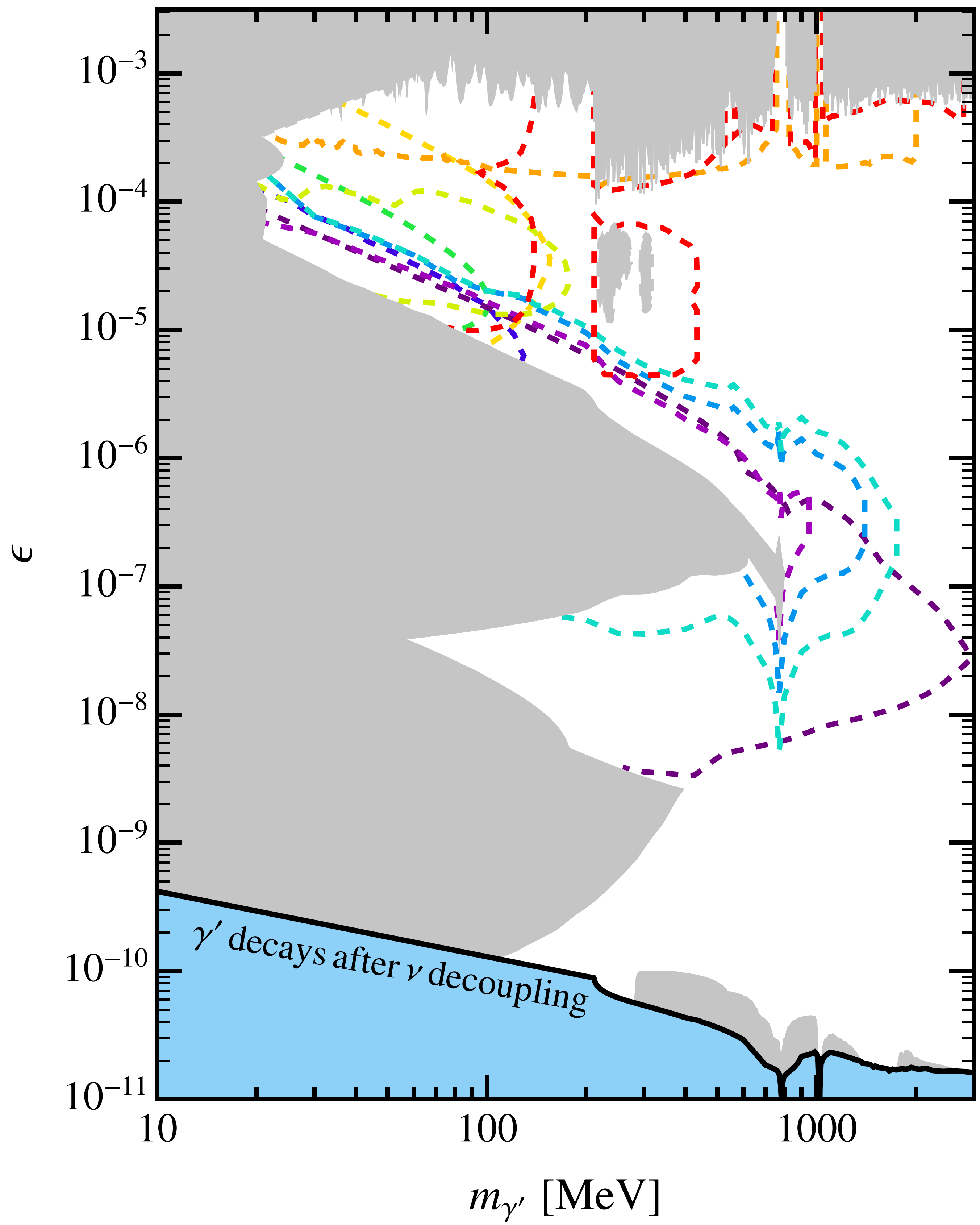
Non-Vanilla Dark Sectors

Robert McGehee





Robert McGehee

Models Discoverable @ Belle II!

Dark Matter

[Y. Hochberg, E. Kuflik, RM, H. Murayama, K. Schutz PRD 2018]

[Y Tsai, RM, H. Murayama
L 2022]

Kondo, RM, T. Melia, H.
urayama JHEP 2022]

Baryogenesis

[E. Hall, T. Konstandin, RM, H. Murayama, G. Servant JHEP 2020]

[E. Hall, RM, H. Murayama, B. Suter PRD 2022]

[E. Hall, T. Konstandin, RM, H. Murayama, PRD 2023]

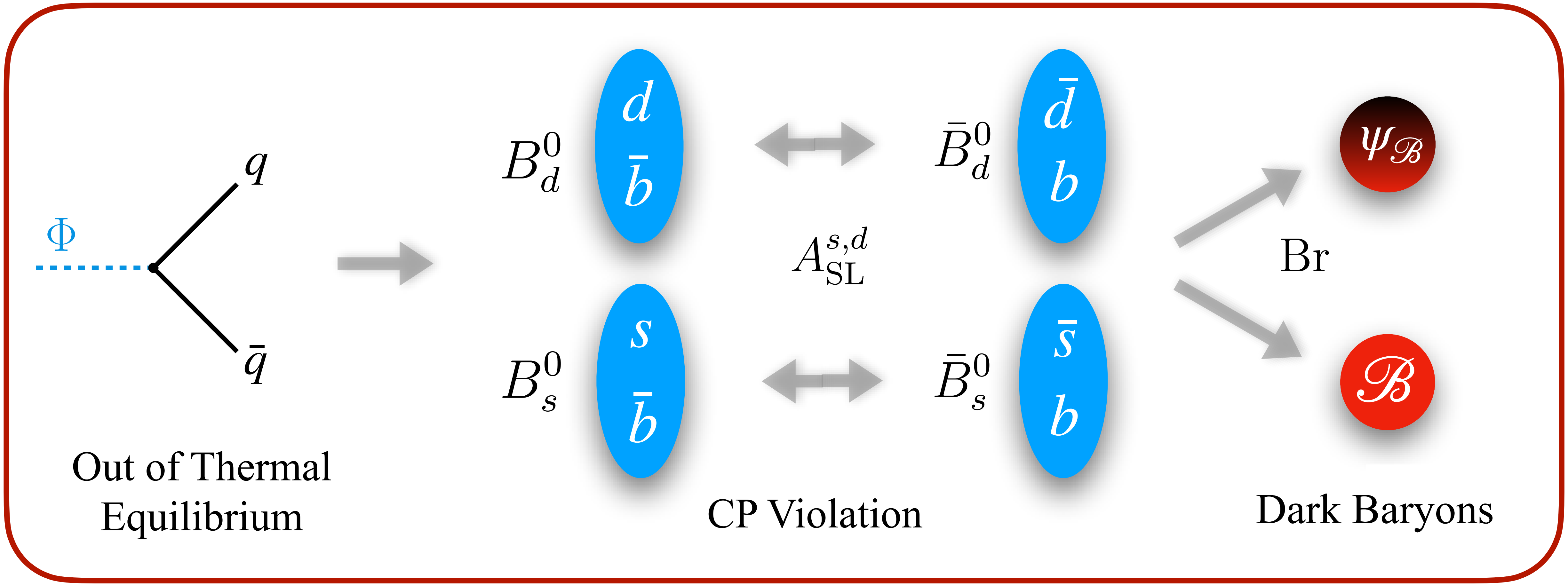
Naturalness

[K. Harigaya, RM, H. Murayama, K. Schutz JHEP 2020]

R McGehee

Gilly Elor

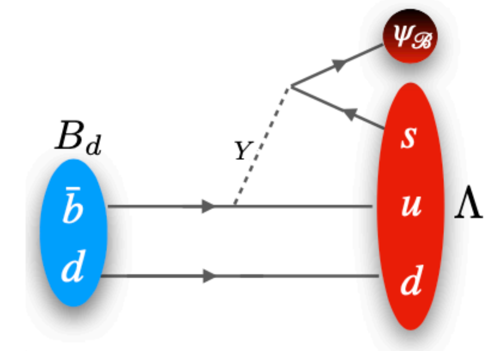
Neutral B Mesogenesis [GE, M. Escudero, A. E. Nelson, PRD, 1810.00880]



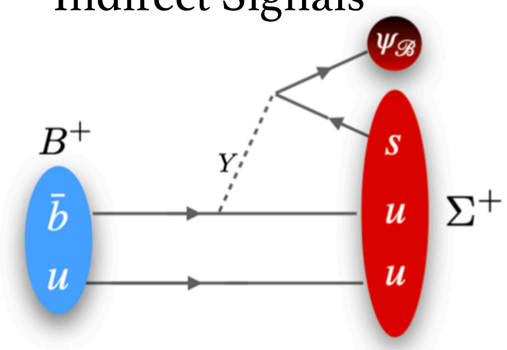
Gilly Elor

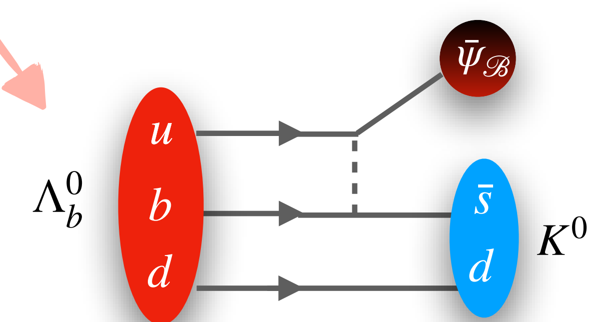
Operator/Decay	Initial State	Final state
$\mathcal{O} = \psi\, b\, u\, d$ $\bar{b} \to \psi\, u\, d$	B_d	$\psi + n\,(udd)$
	B_s	$\psi + \Lambda\,(uds)$
	B^+	$\psi + p\,(duu)$
	Λ_b	$\bar{\psi} + \pi^0$
$\mathcal{O} = \psi\, b\, u\, s$ $\bar{b} \to \psi\, u\, s$	B_d	$\psi + \Lambda\,(usd)$
	B_s	$\psi + \Xi^0\,(uss)$
	B^+	$\psi + \Sigma^+\,(uus)$
	Λ_b	$\bar{\psi} + K^0$
$\mathcal{O} = \psi\, b\, c\, d$ $\bar{b} \to \psi\, c\, d$	B_d	$\psi + \Lambda_c + \pi^-\,(cdd)$
	B_s	$\psi + \Xi_c^0\,(cds)$
	B^+	$\psi + \Lambda_c\,(dcu)$
	Λ_b	$\bar{\psi} + \overline{D}^0$
$\mathcal{O} = \psi\, b\, c\, s$ $\bar{b} \to \psi\, c\, s$	B_d	$\psi + \Xi_c^0\,(csd)$
	B_s	$\psi + \Omega_c\,(css)$
	B^+	$\psi + \Xi_c^+\,(csu)$
	Λ_b	$\bar{\psi} + D^- + K^+$

Directly related to the baryon asymmetry



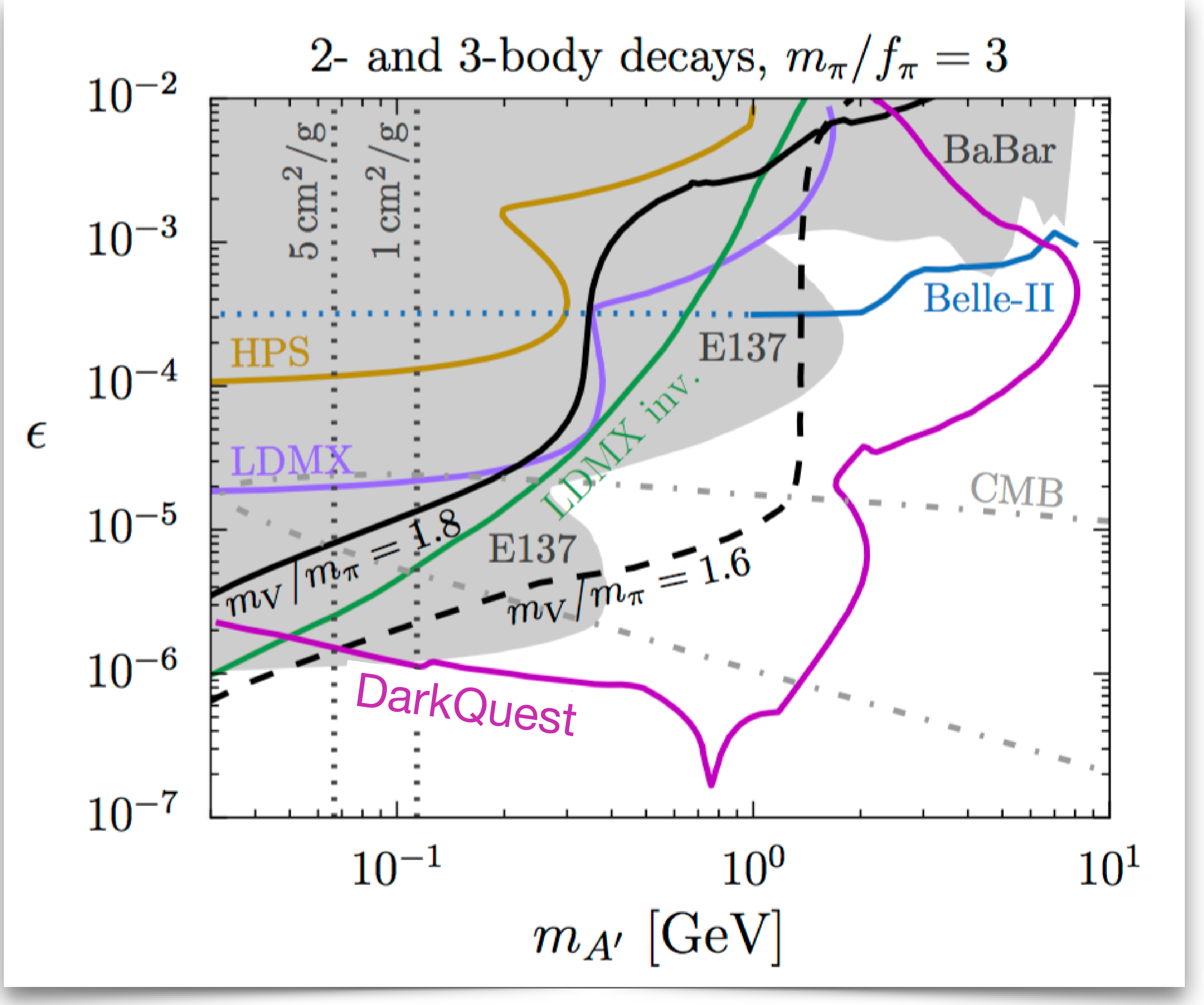
Indirect Signals





Stefania Gori

Berlin, Blinov, SG, Schuster, Toro, 1801.05805



$\alpha_D = 10^{-2}$, $m_{A'}/m_\pi = 3$

Outlook

Many different leptonic signatures arise in dark sector models

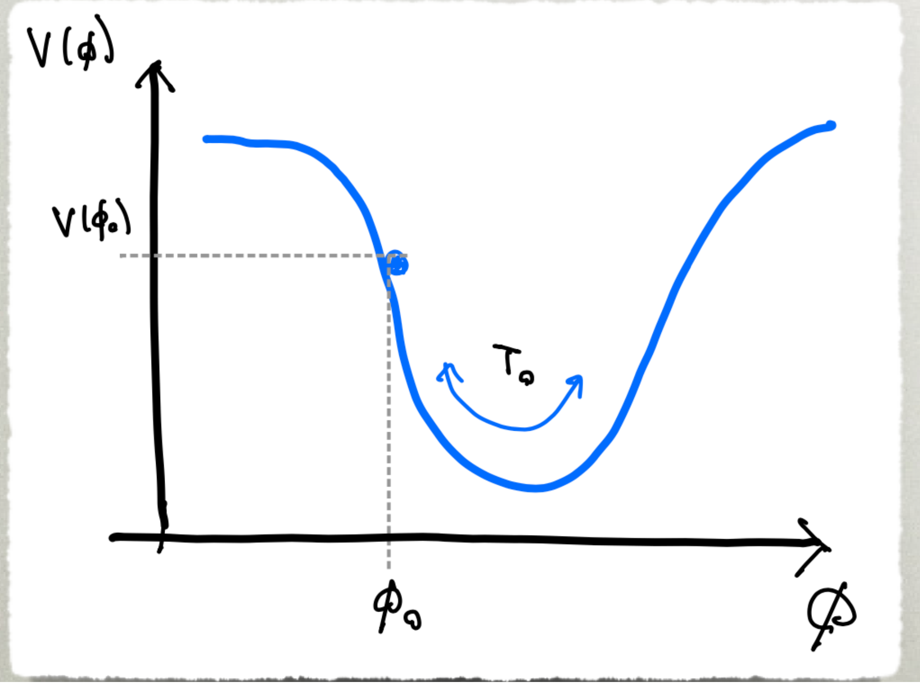
Several searches have been already performed at Belle II probing new interesting regions of parameter space

Several new signatures to look for

- 1photon + 2 charged tracks (prompt or displaced) — **dark photon**
- 3 charged leptons from B meson decays — **axions**
- broader coverage of 1 photon+missing + 2 (or more) displaced charged tracks — **IDM + SIMP**

COHERENT OSCILLATIONS

- local DM density $\rho_\phi = 0.4\,\mathrm{GeV/cm^3} \approx 3 \times 10^{-42}\,\mathrm{GeV}^4$
- bosonic DM of mass $m_\phi \lesssim 30\,\mathrm{eV}$
  - highly degenerate: many DM particles per de Broglie volume, $n_{\mathrm{DM}}(m_\phi v)^3 \gg 1$
  - well approximated by oscillating wave $\phi_{\mathrm{cl}}(t)$



Amplitude:

$$\rho_\phi = V(\phi_0),$$

Oscillation period:

$$T_0 = 2\sqrt{2}\int_0^{\phi_0} \frac{d\phi}{\sqrt{V(\phi_0) - V(\phi)}}.$$

TIME DEPENDENT $\tau \to \mu\phi$

- interaction: $\phi\partial_\alpha\phi\bar{\tau}\gamma^\alpha\mu$
  - induces $\tau \to \mu\phi\phi$
    - three body decay, large background from $\tau \to \mu\nu\bar{\nu}$
    - very poor bound on f
  - DM background induces time dependent $\tau \to \mu\phi$
    - two body decay: mono-energetic μ in tau rest- frame
- tau decays additional complication
  - $e^+e^- \to \tau^+\tau^-$, at least one neutrino on tag side
  - not possible to reconstruct tau rest frame $\Rightarrow$ use pseudo rest-frame
  - time dependence of the signal helps
- same for $\tau \to e\phi$