Coannihilating Dark Matter and the B-Physics Anomalies

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[M. Baker, D. Faroughy, ST] soon to appear!

B-Physics Anomalies

- $b \longrightarrow s\ell\ell$: Deficit of the neutral-current transition in μ vs. e

$$R_{K^{(*)}} = \frac{\mathcal{B}(B \to K^{(*)}\mu\bar{\mu})}{\mathcal{B}(B \to K^{(*)}e\bar{e})}$$

[LHCb] 1903.09252
1705.05802,
2103.11769

- R_K survived the latest update by the LHCb even after employing the full dataset of Run I and II independently at 3.1σ!
- Fits obtained by including also other anomalous observables in this channel and varying relevant NP WCs yield pulls at a staggering 5σ level!
- $b \longrightarrow c\tau\nu$: Enhancement of the charged-current transition in τ vs. ℓ

$$R_{D^{(*)}} = \frac{\mathcal{B}(B \to D^{(*)}\tau\bar{\nu})}{\mathcal{B}(B \to D^{(*)}\ell\bar{\nu})} \approx 3\sigma$$

[BaBar] 1303.0571,
[Belle] 1612.00529,
1908.01848
[LHCb] 1711.02505,
1903.09252

Vector Leptoquark and 4321!

- Leptoquarks (LQs), i.e. particles that couple to quark-lepton currents, are the only viable candidates to a combined solution to the *B*-physics anomalies.
- In particular, the vector LQ $U_1 \sim (\mathbf{3},\mathbf{1})_{2/3}$ provides the most compelling explanation, since it can simultaneously accommodate both anomalies!
- It is realized as a gauge boson of spontaneously broken gauge symmetries: the so-called '**4321**' models based on the $SU(4)\times SU(3)'\times SU(2)_L\times U(1)_X$ group (originating from the Pati-Salam model).

DM and coannihilation effects

- There are 4321 multiplets that can host a DM candidate!

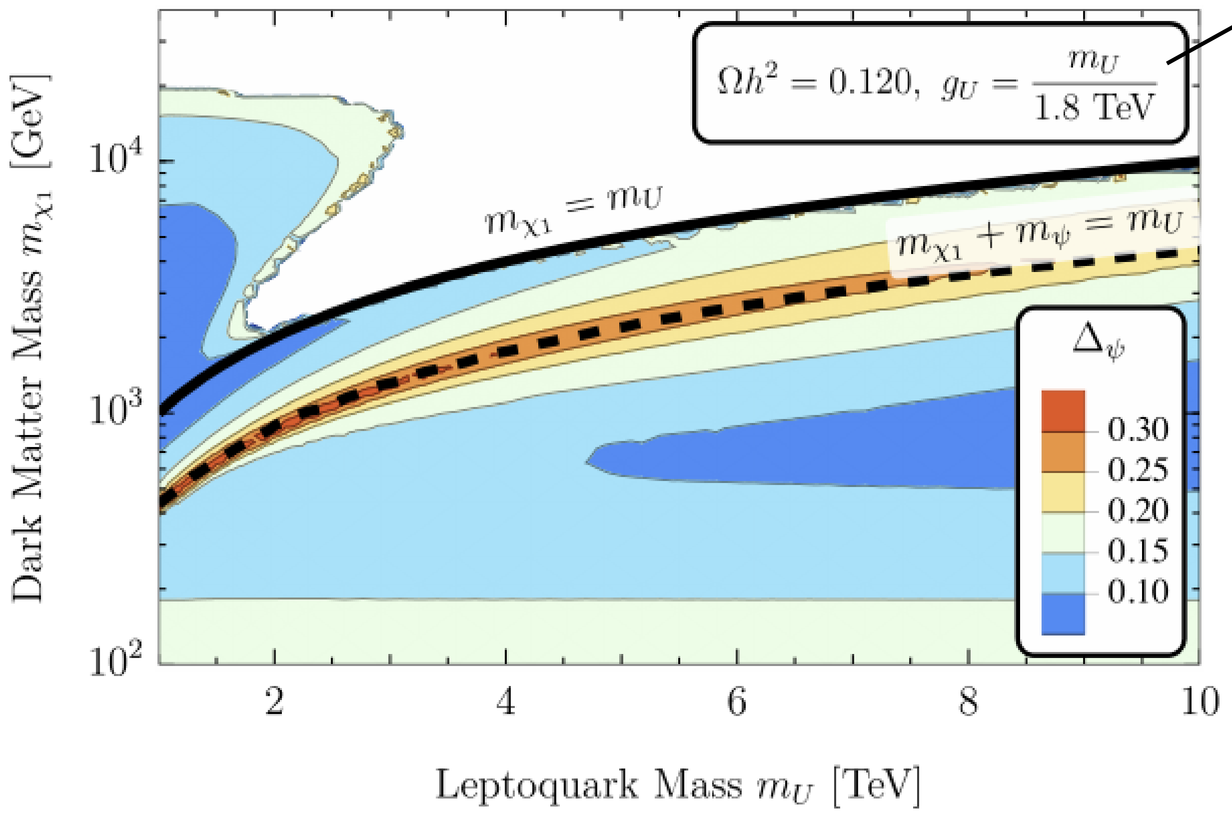
$$\Psi = (\psi^1\ \psi^2\ \psi^3\ \chi)^T \longrightarrow$$ singlet, two Majorana fermions mass eigenstates χ_1, χ_2

top-like partner $\psi \sim (\mathbf{3},\mathbf{1})_{2/3}$

- χ receives a naturally small Majorana mass $\Rightarrow$ $\Delta_\psi \equiv \frac{m_\psi - m_{\chi_1}}{m_{\chi_1}} \lesssim 0.3$
- Coannihilating effects regulate the relic abundance for varying Δ_ψ..
- The dominant process that sets the primordial relic abundance for $m_\chi \sim m_\psi < m_U$ is $\overline{\chi}_1 \psi \to \mathrm{SM}\ \mathrm{SM}$, mediated via U (LQ portal to DM).

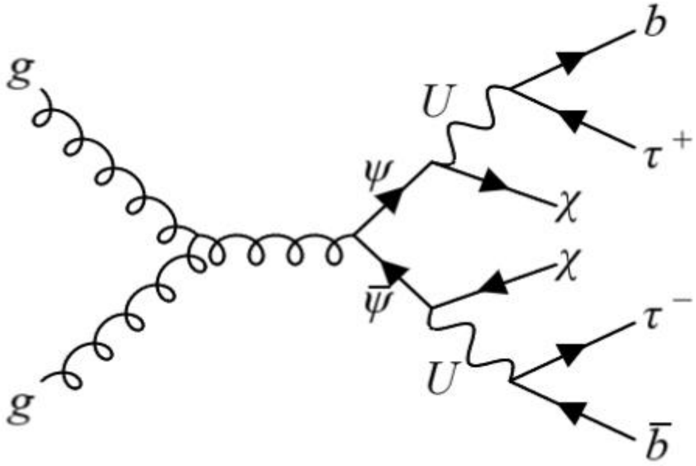
Relic surface

set by the B-physics anomalies



Collider constraints (ψ pair-production)

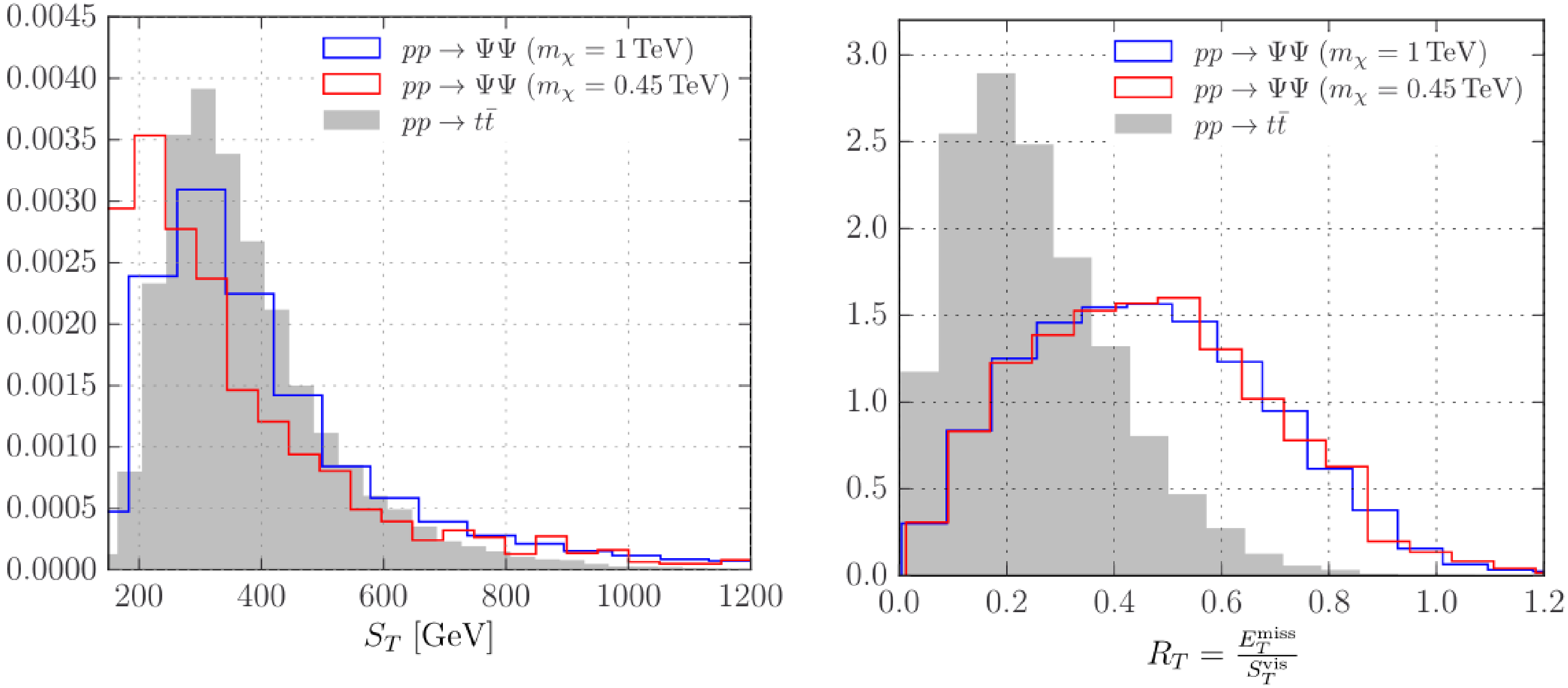
- Direct and indirect DM detection constraints are not relevant. Collider searches for the ψ are the only viable option.



- We study ψ pair-production and find that due to the compression of the mass spectrum, the decay products of the ψ carry low momenta and fail to pass the experimental selection criteria of existing searches.

Collider constraints (ψ pair-production)

- We propose a new search based on a MET-sensitive novel search.



- We estimate that the search will set a lower bound of 500 GeV for m_χ.

Collider constraints (ψ-onium)

- Another important consequence of the compressed spectrum is the tiny decay rate of ψ. These particles are enough long-lived in order to hadronize after their production.
- Bound QCD states $(\bar{\psi}\psi)$ (anologous to quarkonia) may lead to distinguishing signatures via EW decay to dileptons.