LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Flavoured mediators and dark matter

Rute Pedro

DM t-channel white paper meeting, 20th February 2023

Current section line-up

5 Flavoured mediators and dark matter

5.1 Top-philic dark matter and its connection with flavour physics

[M. Blanke and collaborators; R.C. Batalha Pedro]

- Minimal flavour violation and t-channel dark matter. Connection with the model description in 2.
- Connection with flavour physics and consequent single top signatures.
- See [9] and [10].

5.2 Boosted top probes of top-philic dark matter

[N. Castro, M. Moreno Llacer, M.J.Costa Mezquita, J.E. Garcia , R.C. Batalha Pedro, B. Maier, A. Moreno Briceño]

- HL-LHC sensitivity study using a signature made of a boosted top and missing transverse energy (à la [11])

5.3 Charm-philic dark matter

[F. Benoit, B. Fuks, F. Parraud, R.C. Batalha Pedro, D. Tuckler]

- Current reach.
- Exploring the possibilities of using charm tagging.

5.4 Strange-philic dark matter

[R.C. Batalha Pedro, D. Tuckler]

- Exploring the impact of strange tagging.

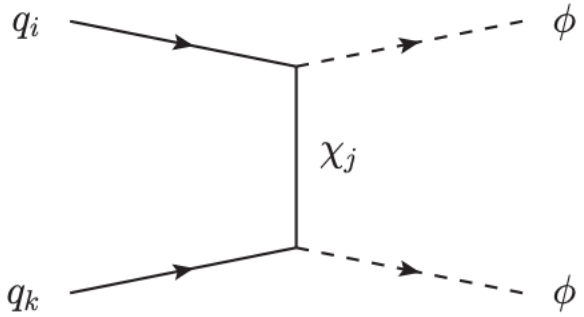
Top-philic Dark Matter

M. Blanke, G. Polesello, H. Acaroglu, M. Krämer

$$\lambda^{ij}\bar{q}_i\chi_j\phi$$

q_i SM quarks
χ_j DM fermion, flavoured
ϕ coloured scalar mediator
λ flavour-violating coupling matrix

- **Models of flavoured DM beyond Minimal Flavour Violation**
  - 1702.08457 1702.08457
  - Flavour carried by the DM candidate and not by the mediator
  - DM is either a Dirac or Majorana fermion
  - Quark-flavoured DM coupling to the SM quarks
    - Lepton-flavoured models may link to the $(g-2)_\mu$ anomaly 2212.08142
- **Constrains from LHC for top-philic scenario**
  - Mainly on mediator pair production
  - $tj + \not{E}_T$ and $t\bar{t} + \not{E}_T$ final states (common to searches for SUSY squarks)
- **Majorana-specific phenomenology**
  - t-channel ϕ-pair-production leading to same-sign $tt + \not{E}_T$
  - Enhanced cross-section at the LHC due to the *up*-quark PDF in the protons



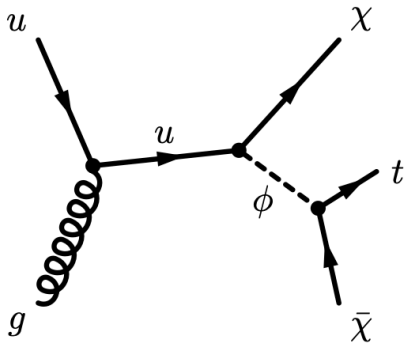
(b) $\phi\phi$ production

Majorana-specific

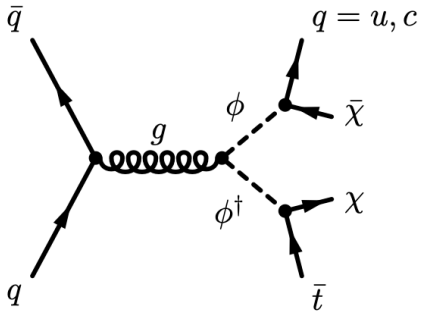
M. Blanke, G. Polesello, H. Acaroglu, M. Krämer

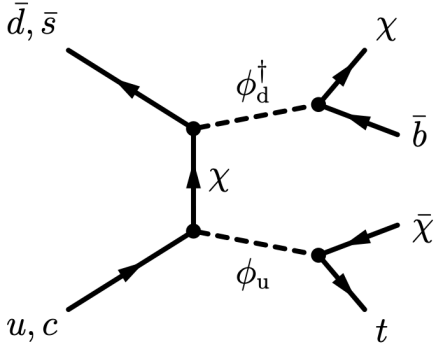
Single top signatures

- **Simplified models of top-flavoured Dark Matter**
  - 2010.10530
  - Within the framework of Minimal Flavour Violation
  - ϕ coloured mediator
    - Right-handed model: couplings to up-type quarks only
    - Left-handed model: couplings to up/down-type quarks (more constrained by flavour physics)



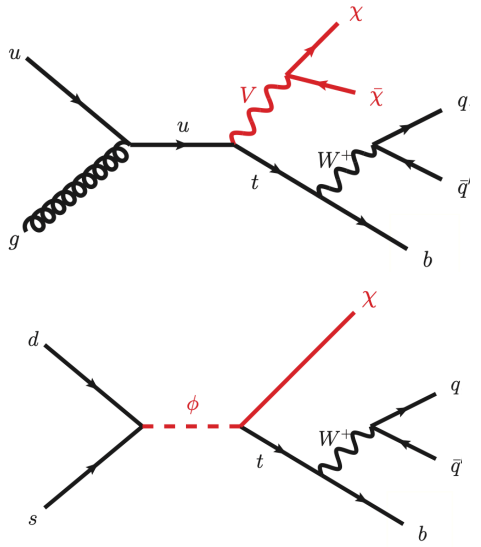
- **Single top signatures**
  - $t + \not{E}_T$
  - $tq + \not{E}_T$, where $q = \{u, d, s, c\}$
  - $tb + \not{E}_T$





Boosted top probes for top-philic DM

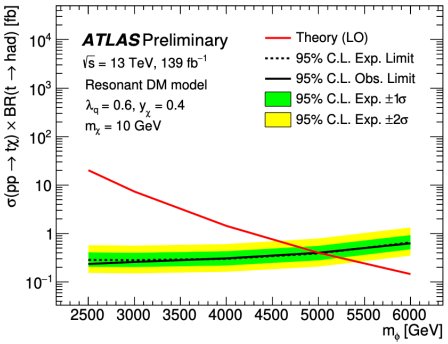
N. Castro, M. Moreno Llacer, M.J.Costa Mezquita, J.E. Garcia , R.C. Batalha Pedro, B. Maier, A. Moreno Briceño

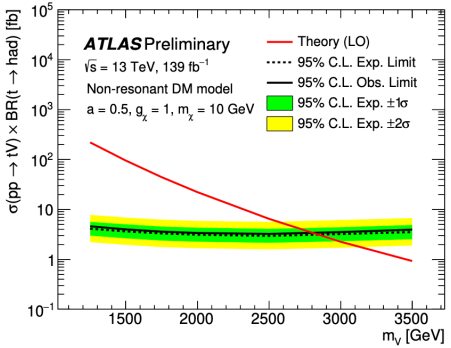


- **Recent ATLAS search in $t + \not{E}_T$ final state, with boosted hadronic top**
  ATLAS-CONF-2022-036
  - Probes Simplified Models of Dark Matter 1106.6199
  - Non-resonant production of vector V mediator
  - Resonant production of coloured scalar ϕ mediator

- **Current upper limits on the production cross-section**
  - m_ϕ > 5 TeV, m_V > 2.8 TeV
  - Assuming specific couplings and m_χ=10 GeV

- **HL-LHC sensitivity study drawn from this analysis**





Charm/Strange-philic DM

F. Benoit, B. Fuks, F. Parraud, D. Tuckler

- **Review/draw constrains on charm flavoured DM**
  - LHC searches, flavour physics, …
- **Explore the use of *c* - tagging at the LHC**
  - Review *c* - tagging efficiencies
  - Sensitivity studies for charm-flavoured DM
- **Similar content for strange-philic subsection**

Backup

Flavoured Dark Matter beyond Minimal Flavour Violation

Assumption:

dark matter carries flavour and comes in multiple generations

➢ *reconciles WIMP hypothesis with non-observation of DM*

New coupling to quarks:

$$\lambda^{ij}\bar{q}_i\chi_j\phi$$

q_i	SM quarks
χ_j	DM fermion, flavoured
ϕ	coloured scalar mediator
λ	flavour-violating coupling matrix

Phenomenological implications:

- liquid Xe experiments require suppressed DM coupling to first quark generation
- thermal freeze-out possible due to enlarged parameter space
- structure of λ strongly constrained by neutral meson mixings, but MFV not required
- LHC constraints mainly from mediator pair production ➢ SUSY squark searches
- flavour-violating LHC signatures predicted
- altered phenomenology for Majorana DM (vs. Dirac)

also lepton-flavoured DM models – potential link to $(g-2_\mu$ anomaly

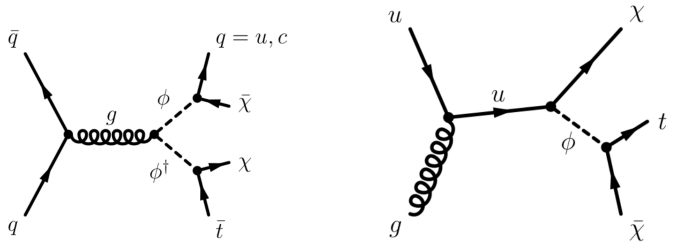
From Monica Blanke

Flavoured Dark Matter – LHC Highlights

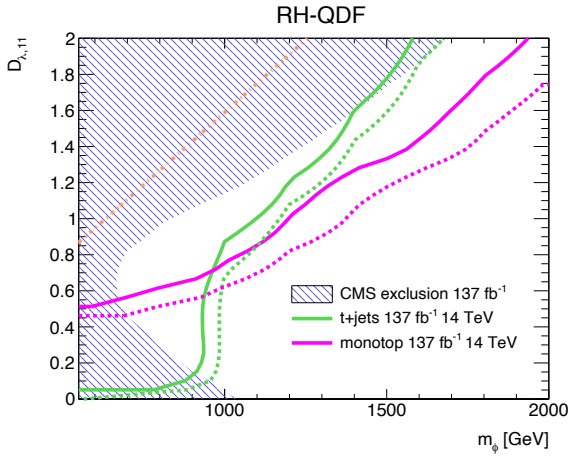
From Monica Blanke

Blanke, Pani, Polesello, Rovelli (2020)

Single-top LHC signatures



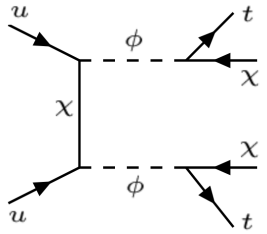
$tj + \not{E}_T$ and $t + \not{E}_T$ increase LHC reach



Acaroglu, Blanke (2021)
Acaroglu, Blanke, Heisig, Krämer, Rathmann (...)

Majorana-specific flavoured DM signals

Majorana nature of DM induces same-sign mediator pair-production



- enhanced cross-sections for standard squark searches
- same-sign $tt + \not{E}_T$ signature
- single-top final states with charge asymmetry

+ suppressed contribution to $D^0 - \bar{D}^0$ mixing

- large CP-violating effects in charm decays (c.f. ΔA_{CP}) possible