Dark showers @ LHCb:
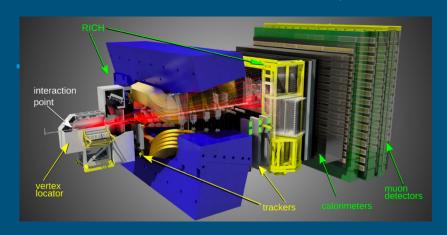## capabilities and prospects

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LHCb cheatsheet (or 'what can LHCb do?')

Acceptance:
- $2 < \eta < 5$, $pT > 0.5$ GeV
- forward region, complement ATLAS and CMS

Lifetimes: O(1-10) ps
- Limited by VELO volume: $z < 500$ mm, $\rho < 30$ mm
- Can be extended by using "downstream" tracks
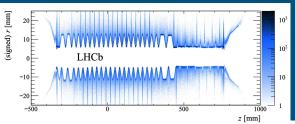

- **Key features:**
  - Good vertex resolution (VELO)
  - Charged hadron ID (RICH)
  - Both ECAL and HCAL
  - Nice and soft trigger, our typical signatures:
    - Hadrons, muons, electrons, photons,
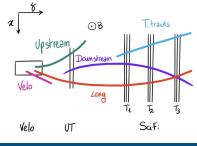   - Displaced from PV (int. point), with high PT

We do search for displaced (see Igor's talk):

pseudo-scalar $\hat{\eta}$ ... vector ... μ^+ ... μ^- ... through photon mixing

h_{SM} ... $\hat{b}$ ... $\hat{b}$ ... $\hat{\omega}$ ... Cheng, Jung, Salvioni, YT (2015)

$\hat{\chi}_0, \hat{G}_{0^{++}}$ scalar ... f ... $\bar{f}$ ... through Higgs portal

Craig, Katz, Strassler, Sundrum (2015)
Curtin, Verhaaren (2015)
Cheng, Jung, Salvioni, YT (2015)

Credit: Yuhsin Tsai

- **(b-, c-)jets (*e.g.* EPJC 77 812):**
  - Removal of **hardware trigger** (softer tracks for clustering).
  - Jet substructure for Run 3?
- **Muons (*e.g.* PRL 124 041801):**
  - Recast the results in your favorite model, see JHEP 10 (2020) 156.

- **Hadron (K, π) vertices (e.g. low mass dark showers):**
  - Higgs → dark (scalar) hadrons → … → SM hadrons
  - Dark hadron mass range ~ O(GeV), final states considered: K+K-, π+π-
    * very hard for ATLAS and CMS
  - **Physical backgrounds (other than material interactions and fakes):**
    - Strange (Ks, Lambda) - long-lived, **easy to veto**
    - Charm and beauty - displaced, tau ~ O(ps) (too many different decays - **hard to veto**)
  - Good sensitivity to large (>2) dark hadron multiplicities in LHCb acceptance!

Run 3 is coming...

- Improved vertex and IP resolution due to VeloPix
- Improved ECAL energy saturation → calo photons up to 20 GeV!
- Fully software trigger, first stage carried by GPUs
- Special signatures need dedicated trigger lines in place...
- ... hence new ideas are **VERY** welcome:
  - Special algorithms,
  - Use of non-VELO tracks (very LLPs),
  - Special event topologies, etc.

tl;dr – if your model predicts a low mass (less than 100 GeV) LLP, with soft final state particles – O(MeV) for leptons, O(GeV) for hadrons, and no invisibles (not more than one 😋) – LHCb is your friend!