LHCb perspective

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Introduction

- LHCb is capable of **very soft pT** and **mass** objects (few GeV).
- Very **good vertexing (few ps)** and **good PID capabilities.**
- **No hardware trigger in Run 3** - purely software-based:
  - “Turbo” trigger - select and reconstruct on-the-fly (quickly available for analysis).
- LHCb typically look for LLPs decaying decay within VELO region:
  - Use “long” tracks - tracks with hits in all detector substations (best resolution).
  - Driven by our sensitivity capabilities - obviously no theory motivation behind.
- Efforts to integrate “downstream” tracks in trigger:
  - Tracks with hits in all substations but VELO (LLPs decaying beyond VELO, ~2 m).
  - Efforts dedicated for Ks and Λ (but no studies for an extended lifetime range).
- Plenty of ideas for new triggers in Run 3:
  - Main problem with LLPs @ LHCb is **manpower** (unfortunately a day only has 24 h).

Disclaimer

This is just a collection of own ideas, considered potentially feasible, discussed with some colleagues (do not take these proposals as statements from LHCb).

Feel free to interrupt me, criticise me, etc.

Displaced light hadron triggers

- Displaced **light object (X)** decaying into **pairs of light hadrons** (K, π),
- Production is relevant: selection is different if X comes from PV or not.
- Already some works for offline processing on-going (not published yet):
  - Cuts on p(X), minimum displacement for X,
  - Good particle identification for (K, π), minimum displacement for (K, π),
  - Possible to require X to come from a decay of another particle (*i.e.* B, D, Ks),
  - If expected average X multiplicity ➔ ask for a **minimum multiplicity** of X objects.
- Fairly easy to implement - but studies are needed.
- Typical signature of a low-mass (below $c\bar{c}$ threshold) neutral LLP decaying hadronically:
  - Most obvious model: dark showers (hidden valley).

Displaced jet triggers

- Displaced **“light” object (X)** decaying into **pairs of heavy quarks** (c, b),
- Main idea - **select displaced tracks** (also minimum pT cut) and **reconstruct jets,**
- Reconstruct **decay vertices inside the jet cone** (use jet tracks),
- Cut on vertex displacement, number of daughters per vertex, etc.
    - Already proven to be quite efficient (kills background, keeps signal efficiency).
- If expected average jet multiplicity ➜ ask for a **minimum multiplicity** of jets.
- Idea to explore: run jet substructure when X mass is close to kinematic threshold.
- Typical signature of a “low”-mass (above$c\bar{c}$ threshold) neutral LLP decaying hadronically:
    - Most obvious model (again): dark showers (hidden valley).
    - Consider also occupancy in ECAL/HCAL? Useful to trigger soft bombs?

Displaced tau triggers

- Displaced mu/e triggers developed for Run 3, but what about tau leptons?
- Not easy for LHCb (missing particles), single tau triggers probably not feasible,
- Displaced **light object (X)** decaying into **pairs of tau leptons**,
- Combinations of (tau ➔ lepton)(tau ➔ lepton) or (tau ➔ lepton)(tau ➔ 3 hadrons)?
    - One tau decays into leptons, the other decays into hadrons,
    - Both tau decays into leptons, **but** different flavours,
- Require X displacement + daughters displacement and good PID,
- Require both tau candidates to be associated to the same PV (see JHEP 09 (2018) 159).
- Not so easy to implement (but tau triggers are fairly important - worth the effort):
    - Low mass LLPs to pair of taus? HNLs (two different flavour leptons)?

Other ideas

- **Fractional charged objects:**
  - Number of photons at RICH, proportional to Q^2 (1/3 charge ➔ 1/9 photons).
  - Need simulation, never done before in LHCb trigger.
- **Charged Massive Stable Particles (CMSP):**
  - Absence of signal in RICH (slow particles, low β)?
  - LHCb published an analysis (proof of concept) - see Eur. Phys. J. C75 (2015).
- **Trigger on jets with a soft pT muon:**
  - Additional isolated soft pT muon (mu + jet (with mu)) ⇀ useful for HNLs (from HI)?
  - Honestly not sure if this exist already (guess not).
- **Displaced di-photons:**
  - Run-2 line for ALPs (prompt) into γγ (MVA, up to 10 GeV, paper in preparation).
  - Re-tune the selection for displaced objects? Extend the mass reach?
- **Any other ideas? Please do not hesitate to contact us!**

(No) questions?