LHCb direct searches at HL-LHC

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on behalf of the LHCb collaboration

Searches at HL-LHC Workshop
June 7th 2016

Introduction

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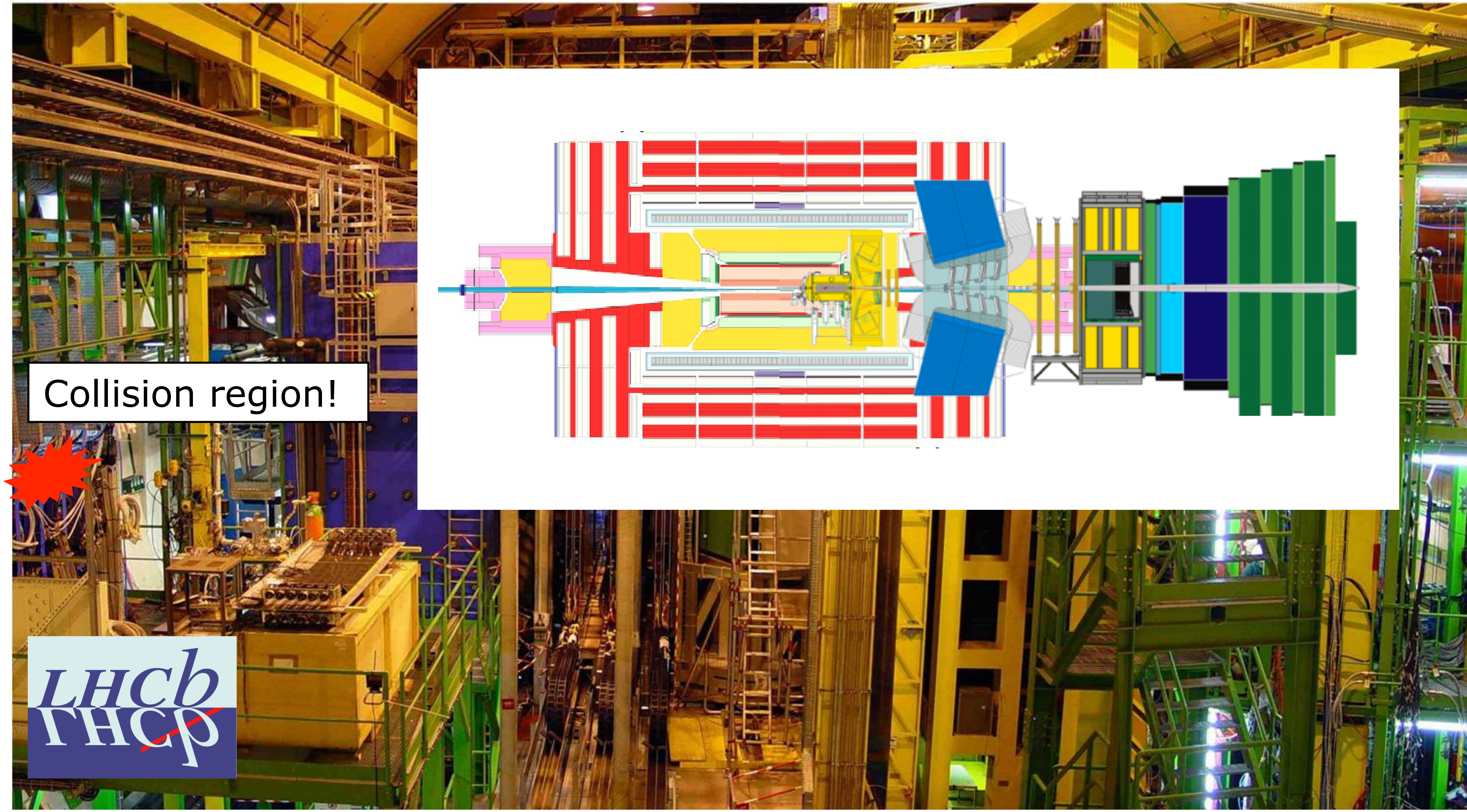
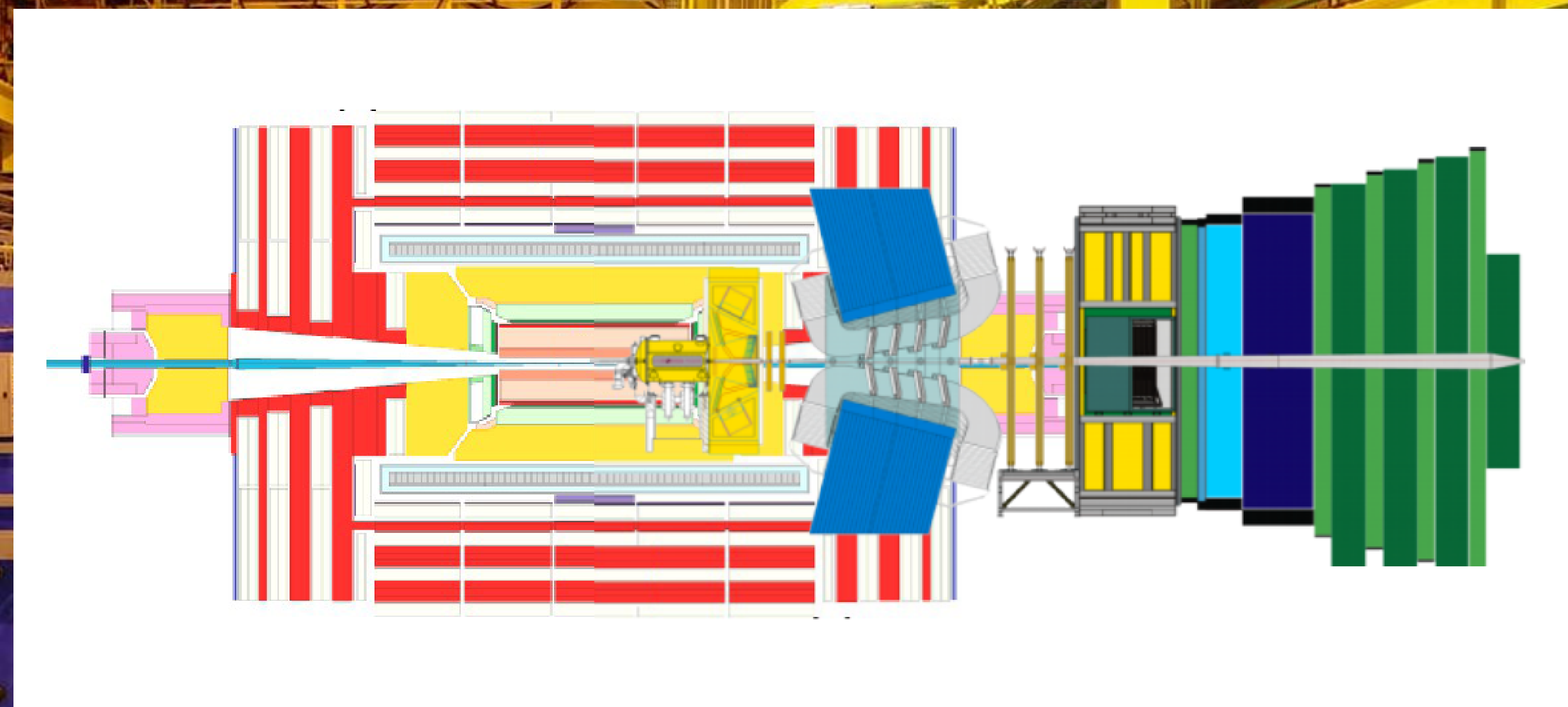


Introduction

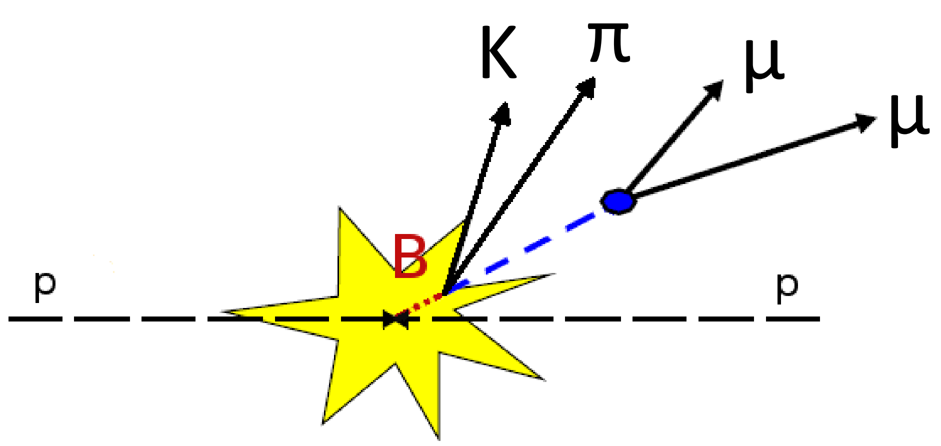


- Not full η coverage
- Taking significantly less data than ATLAS/ CMS (factor of ~8 at Run 1)
- Still complementary for direct searches!

Direct searches at LHCb

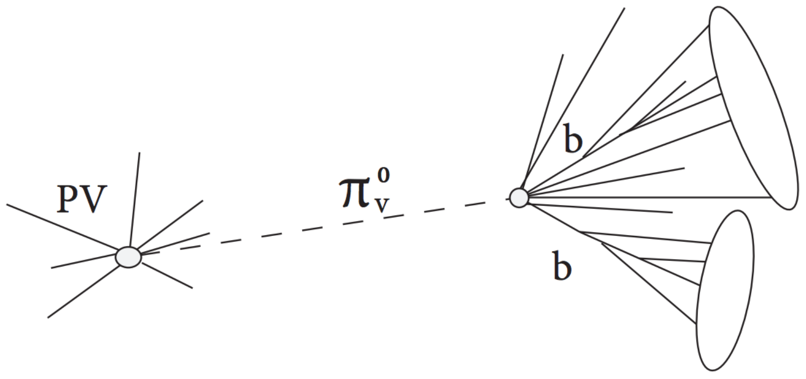
- Increasing interest in direct searches at LHCb
  - Can be competitive in certain domains (specially low mass, low p_T objects)
  - Two main types of searches

Searches for exotic resonances in B/D decays



Phys. Rev. Lett. 115, 161802 (2015)

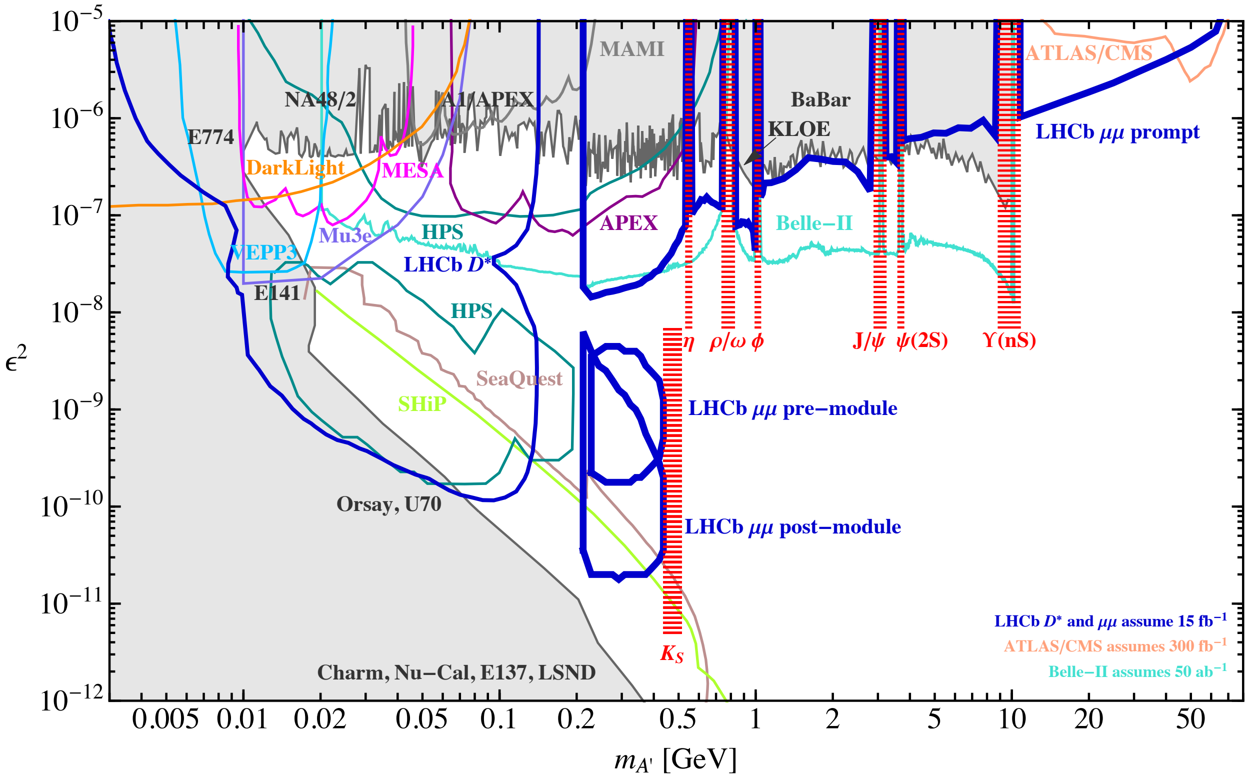
Direct production of new particles



Eur. Phys. J. C75 (2015)

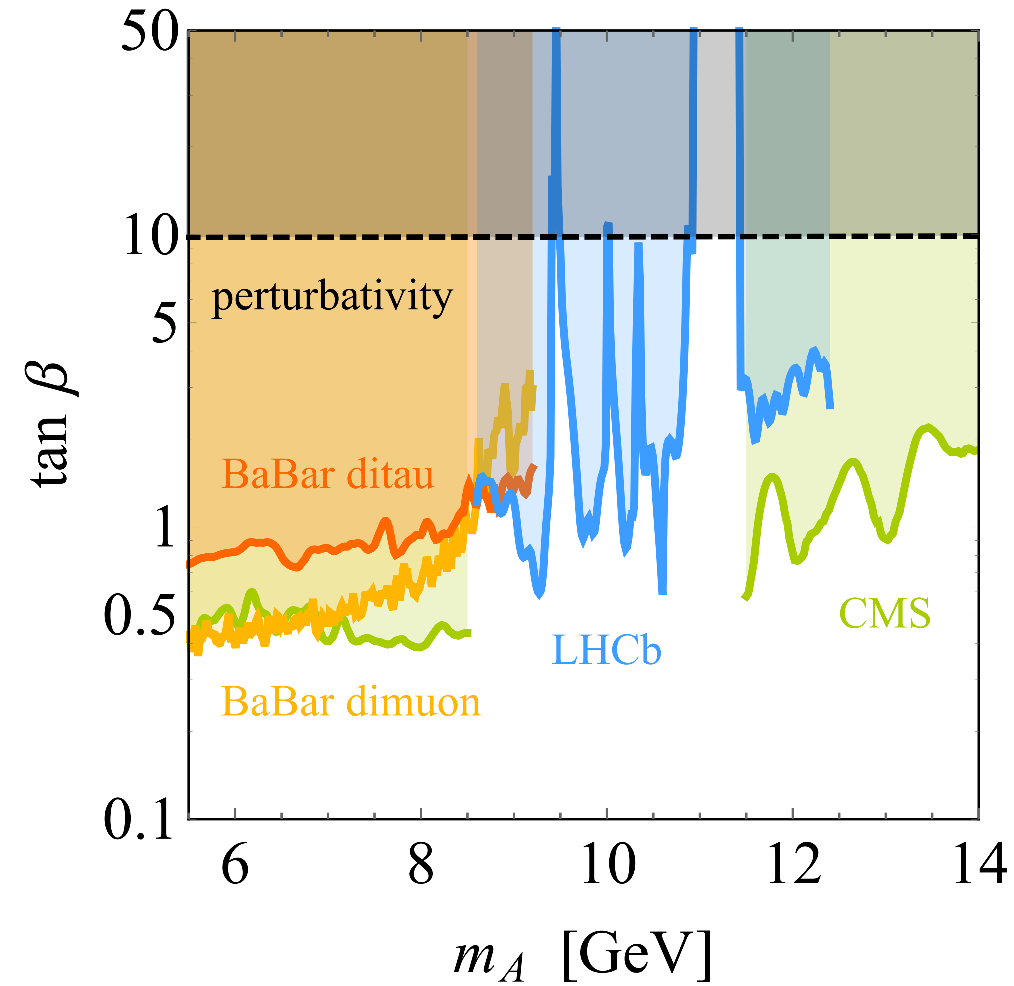
Models (I)

- In general, sensitive to BSM predicting light exotic particles (prompt or detached). Examples
  - Dark photons
    - massive dark sector photon A' couples to SM photon via kinetic mixing
    - signature: resonance in (prompt or displaced) di-lepton spectrum
    - di-muon direct search [arXiv:1603.08926]
    - look for A'→e^+e^- in D^{*0}→D^0 A' decays [arXiv:1509.06765]



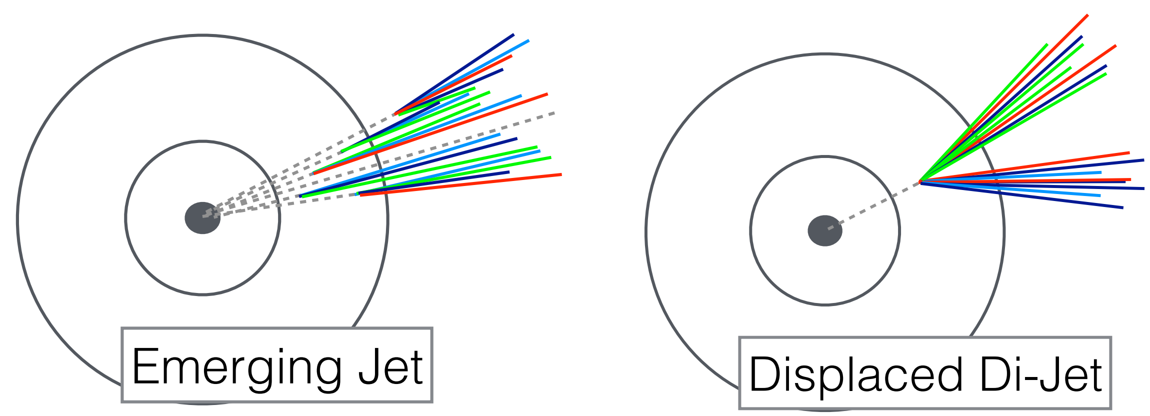
Models (II)

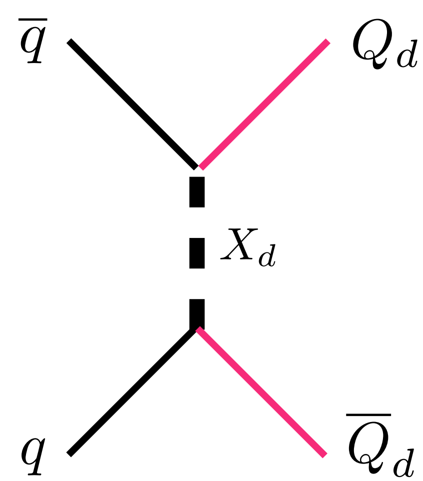
- In general, sensitive to BSM predicting light exotic particles (prompt or detached). Examples
  - Simplified models with spin-0 di-muon light resonances
    - Connects directly with hints from outer-space experiments (Fermi-LAT, AMS, …)
    - Includes dark-photons but also other simple models, such as THDMII, NMSSM
    - In [arXiv:1601.05110], recast using small fraction of LHCb's Run 1 data



Models (III)

- In general, sensitive to BSM predicting light exotic particles (prompt or detached). Examples
  - Models with a composite dark sector
    - parton shower in the dark sector followed by displaced decays of dark pions back to SM jets
    - **Emerging jets** composed of displaced tracks and many different vertices within the jet cone
    - LHCb could also measure exclusively new particles (e.g., dark pions)

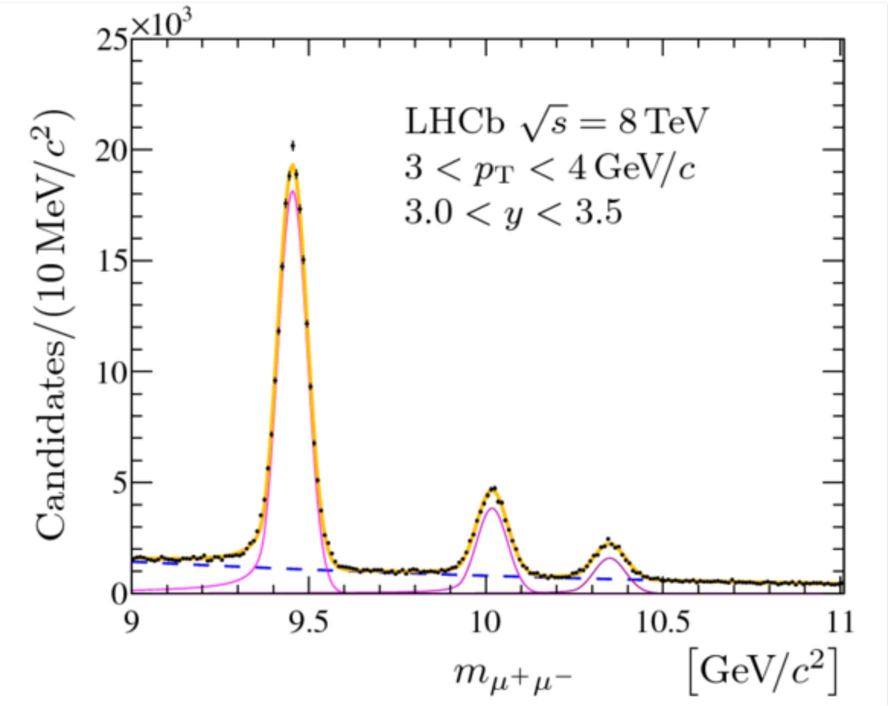




[arXiv:1502.05409]

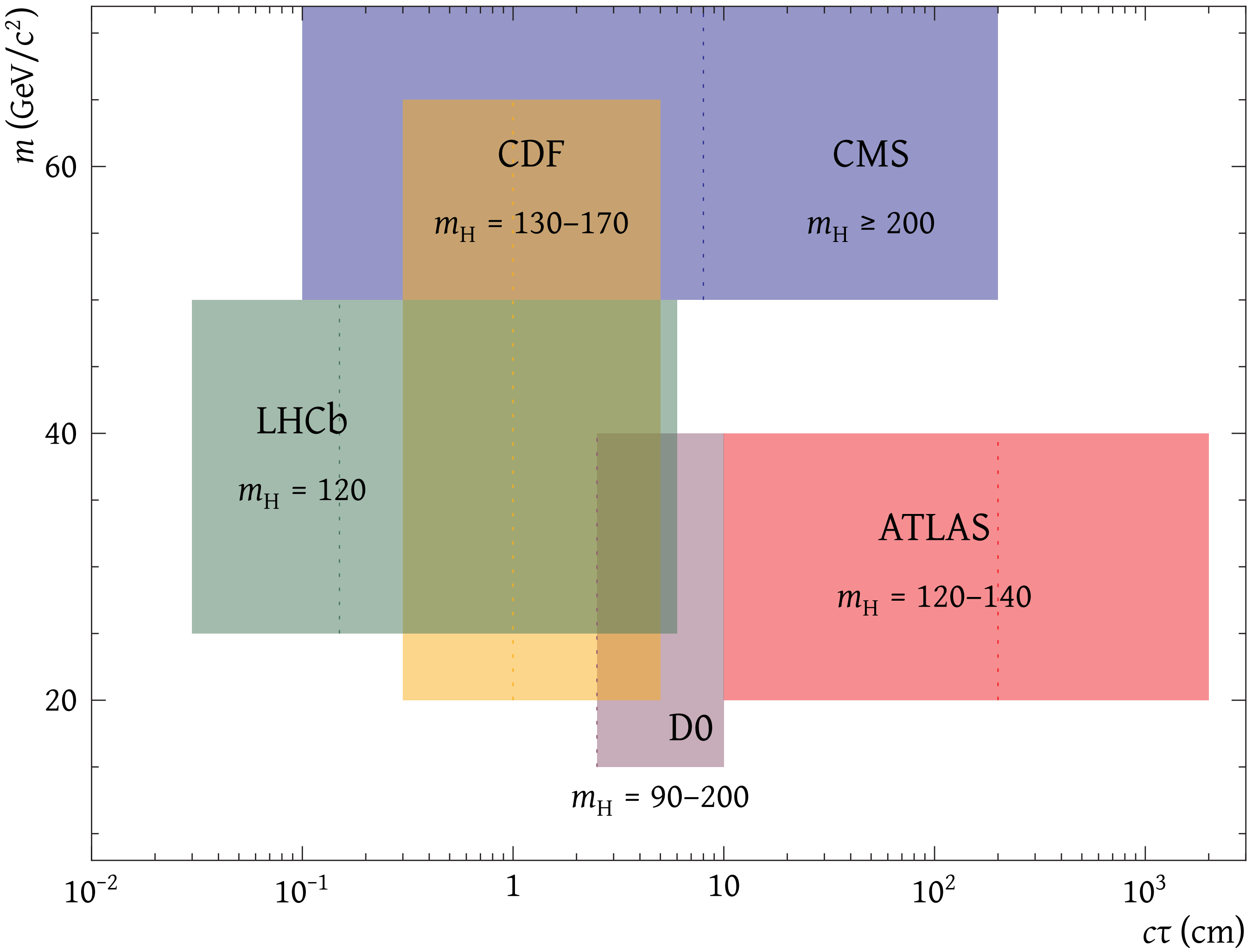
Exp. considerations (I)

- Obvious disadvantage: LHCb collects less data than ATLAS/CMS and has worse acceptance for several searches
- However, advantages in terms of:
  - PID (e.g., RICH to separate K/π)
  - Momentum resolution
  - IP and SV resolution
  - Soft triggers
    - For instance, can trigger detached di-muons with p_T~1 GeV/c
    - Moving towards purely software based trigger (after LS2)



Exp. considerations (II)

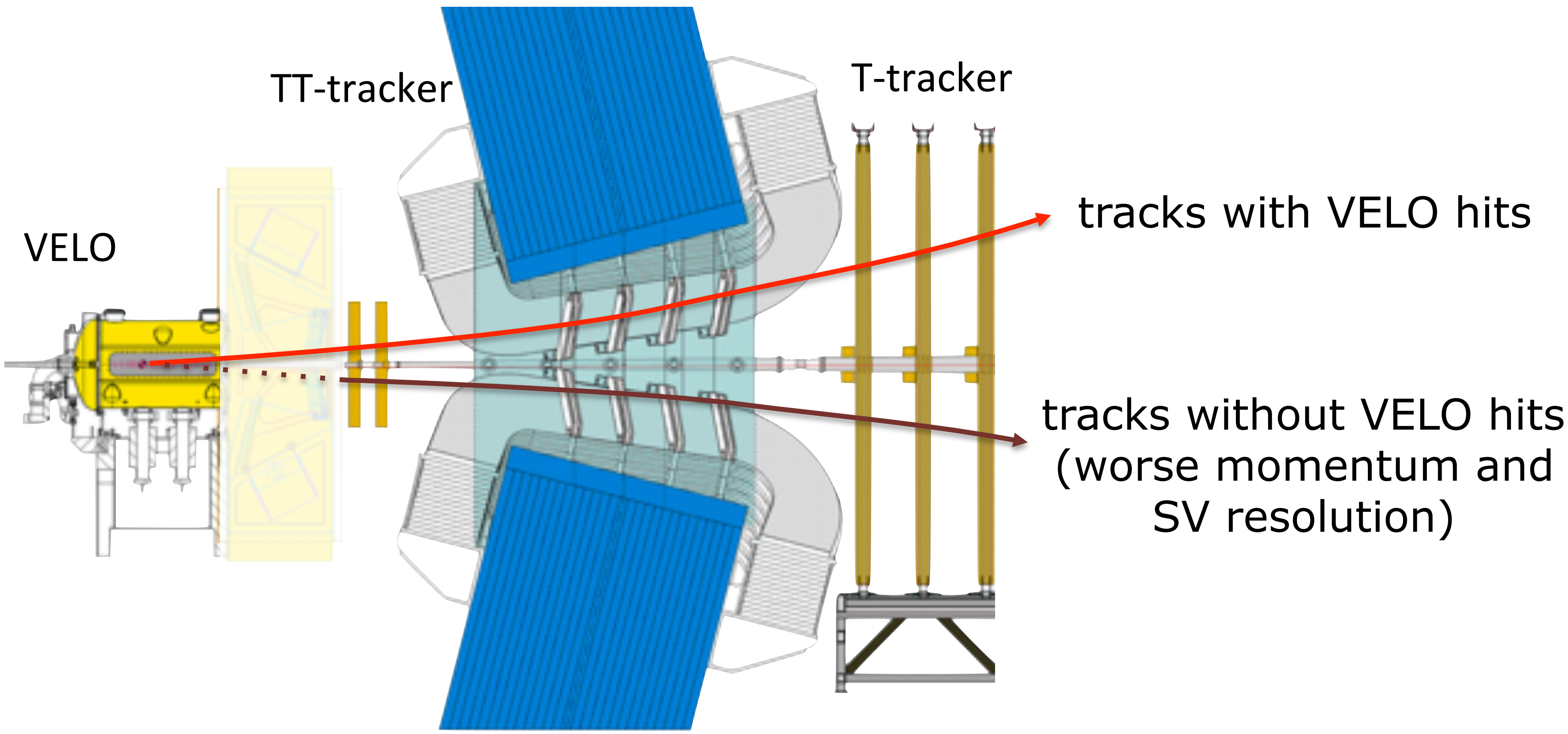
- In practice that means we can look into complementary phase space regions



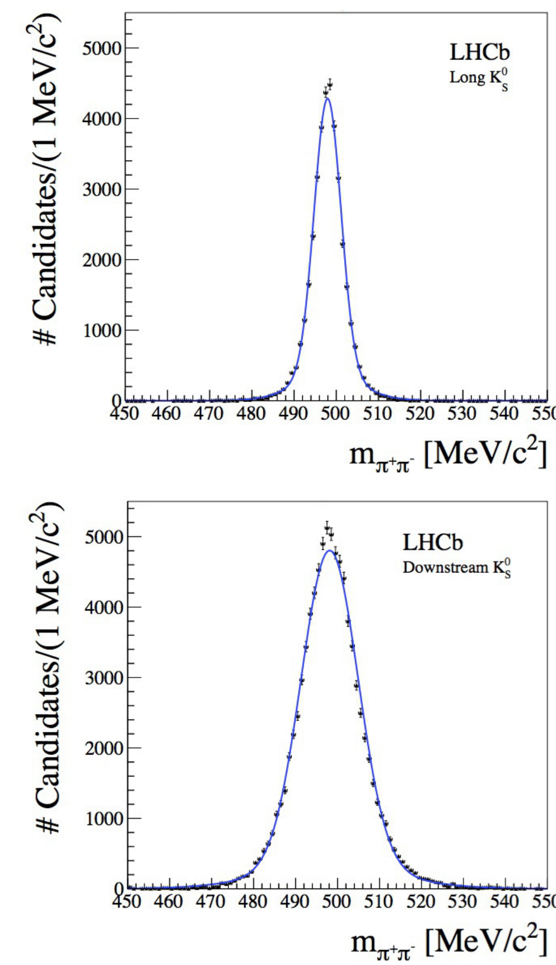
  - For LLP→di-jet analysis [Eur. Phys. J. C75 (2015)]

Exp. considerations (III)

- Sensitivity to long lived particles



K→ππ

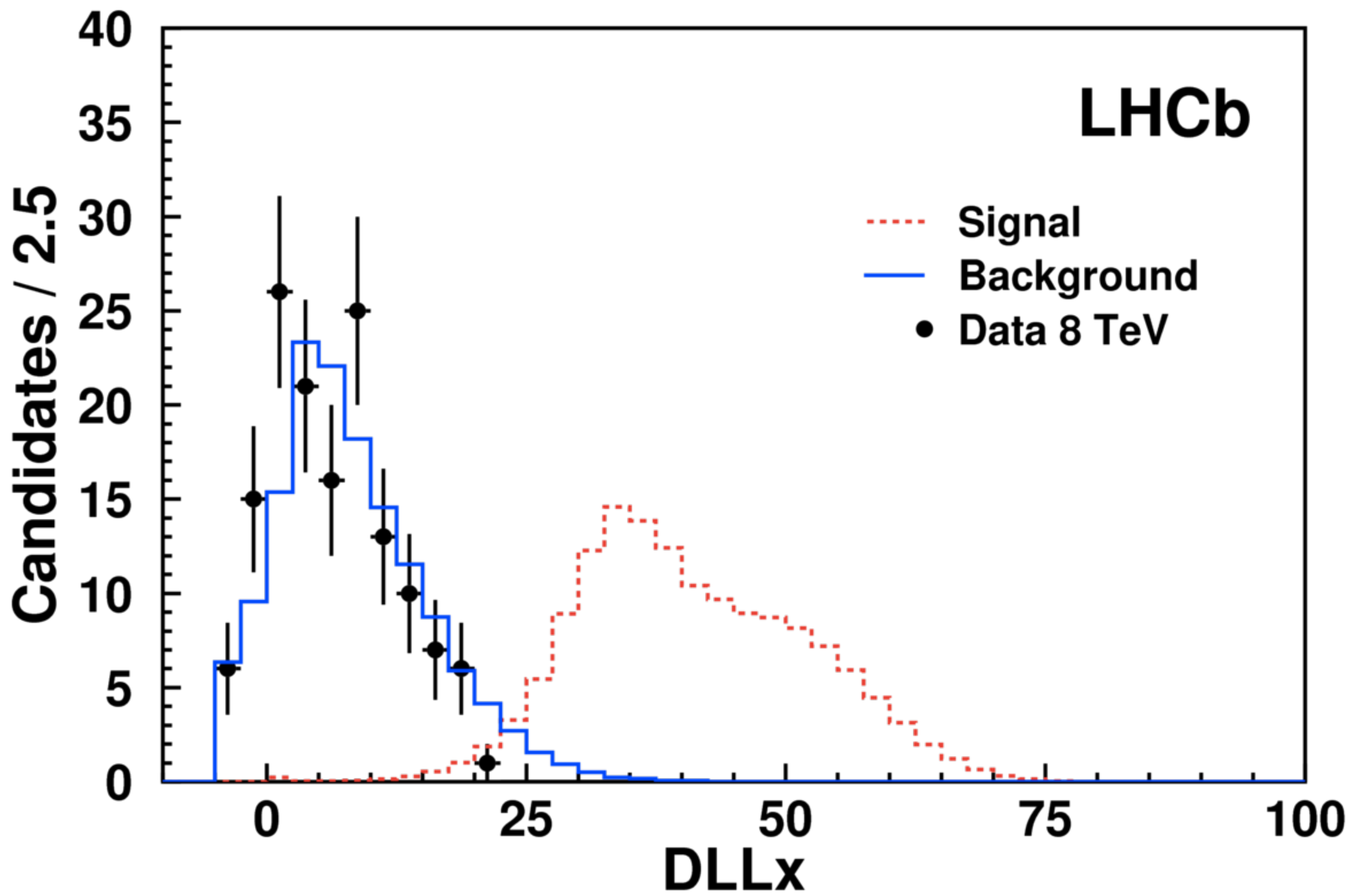


➡ *reconstructable* decay-lengths are:

- within VELO: ideally ~50 cm (*standard* more like ~20 cm)
- up to TT: ~200 cm
- minimum detachment sensitivity ~ around τ lifetime

Exp. considerations (IV)

- Can also use RICH to look for new exotic particles!



- ➡ Likelihood to separate particles according to their masses
- ➡ In this case, separate Exotic heavy particles from Drell-Yan muons

- ➡ Proof-of-concept in [Eur. Phys. J. C75 (2015)]. Powerful technique for several exotic models!

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LHCb future

- Run 1&2: expect collect ~8 fb^{-1} in total
- LS2: upgrade of LHCb detector to allow running at higher luminosity
  - upgrade of vertex detector, tracking system, PID.
  - upgrade of all electronics to allow trigger-less (40 MHz) readout. 100% efficiency on key channels
- 2020~2030: run at ~5x higher luminosity to collect about 50 fb^{-1} (pile-up~1-2)
- Beyond 2030… High Luminosity LHCb? Collect 300 fb^{-1} at pile-up ~50?
  - Would require Phase-2 upgrade (new detectors?). Under discussion...!

Conclusions

- LHCb should be an useful complement to ATLAS/CMS in certain phase space regions
  - very light searches because of trigger
  - anything that requires excellent secondary vertexing
- We expect to take ~50 fb^{-1} of data, hopefully more!
- For us, energy not so important, it's intensity…
- New trigger-less readout will be key: could achieve very efficient trigger for low mass searches!
- Possibility to develop new detectors beyond 2030