Searches for Exotic Particles at LHCb

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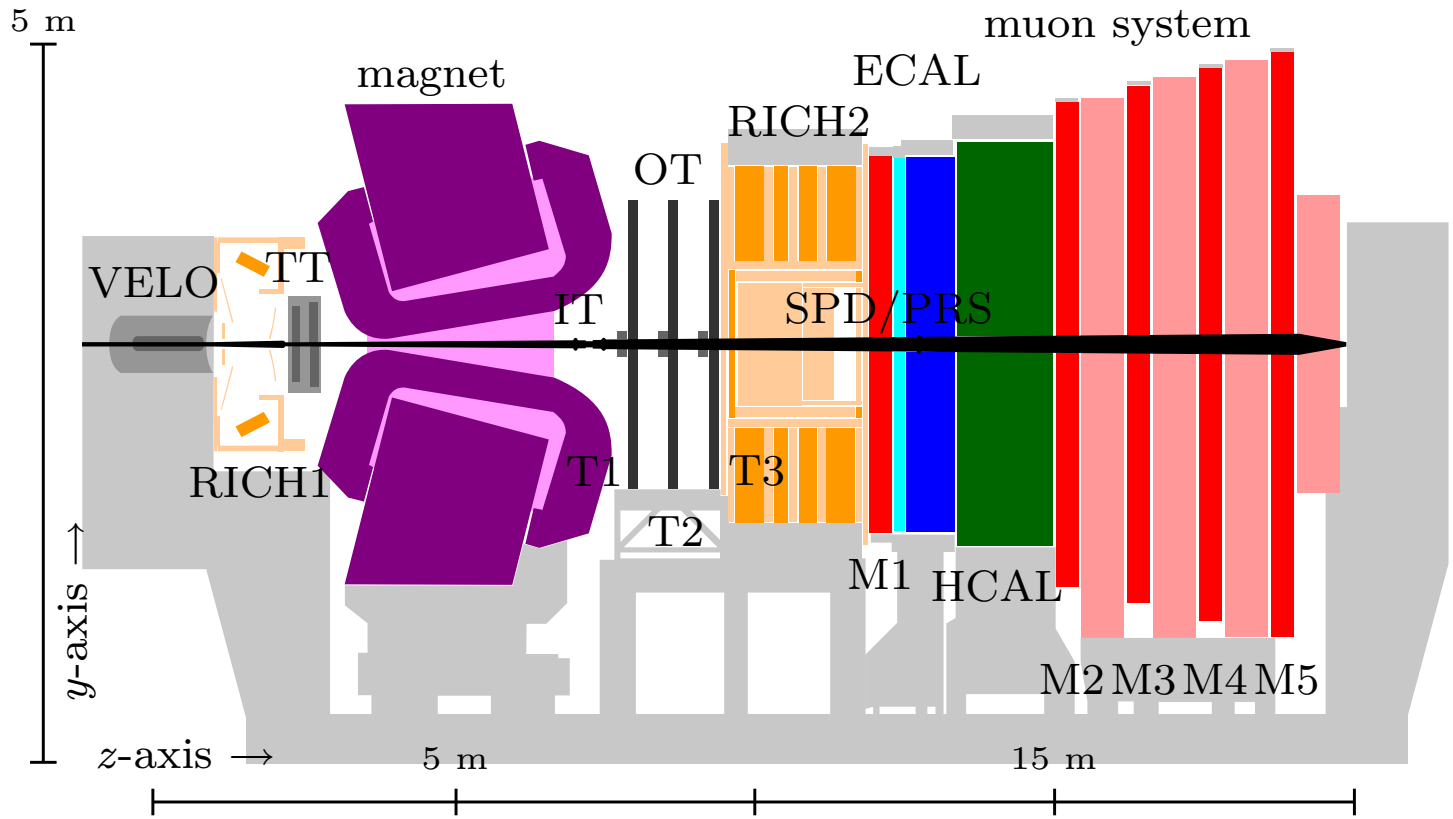
Dark Interactions

Overview

title	reference
exotic hadronic structure	
Observation of the resonant character of the $Z(4430)^-$ state	PRL 112 (2014) 222002
Measurement of the resonant and CP components in $\bar{B}^0 \to J/\psi\pi^+\pi^-$ decays	arXiv:1404.5673
anomalous decays	
Search for Majorana neutrinos in $B^- \to \pi^+\mu^-\mu^-$ decays	PRL 112 (2014) 131802
Search for the lepton-flavor violating decays $B_s^0 \to e^\pm\mu^\mp$ and $B^0 \to e^\pm\mu^\mp$	PRL 111 (2013) 141801
Searches for violation of lepton flavour and baryon number in tau lepton decays at LHCb	Phys. Lett. B 724 (2013)
direct searches	
Updated measurements of exclusive J/ψ and $\psi(2S)$ production cross-sections in pp collisions at $\sqrt{s} = 7$ TeV	J. Phys. G 41 (2014) 055002
Limits on neutral Higgs boson production in the forward region in pp collisions at $\sqrt{s} = 7$ TeV	JHEP 05 (2013) 132
Measurement of the forward-central $b\bar{b}$ production asymmetry	LHCb-CONF-2013-001
Search for Higgs-like bosons decaying into long-lived exotic particles	LHCb-CONF-2012-014

LHCb Detector

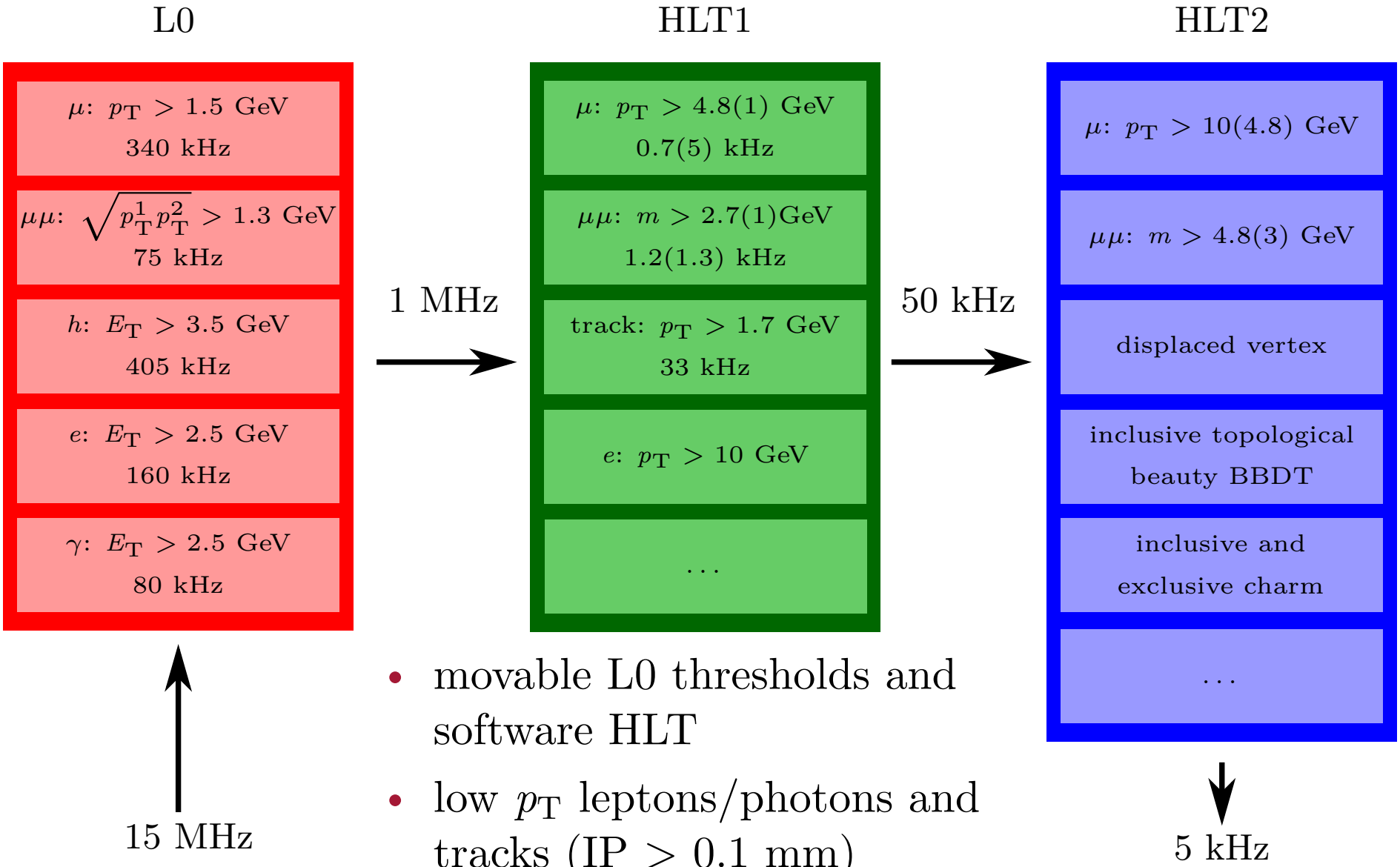
[JINST 3 (2008) S08005]



- fully instrumented between $2 < \eta < 5$
- momentum resolution between 0.4% at 5 GeV to 0.6% at 100 GeV
- impact parameter resolution of $13 - 20$ μm for tracks
- secondary vertex reconstruction with precision of $0.01 - 0.05(0.1 - 0.3)$ mm in $xy(z)$

LHCb Trigger

[JINST 8 (2013) P04022]



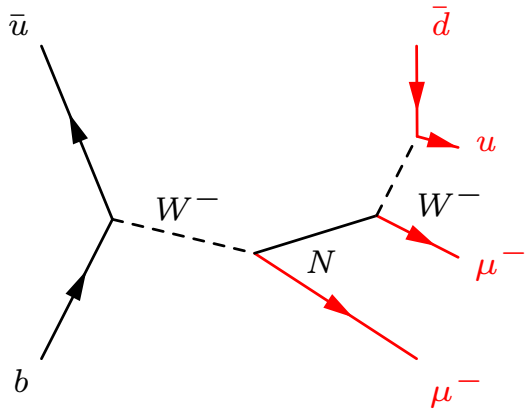
- movable L0 thresholds and software HLT
- low p_T leptons/photons and tracks (IP > 0.1 mm)

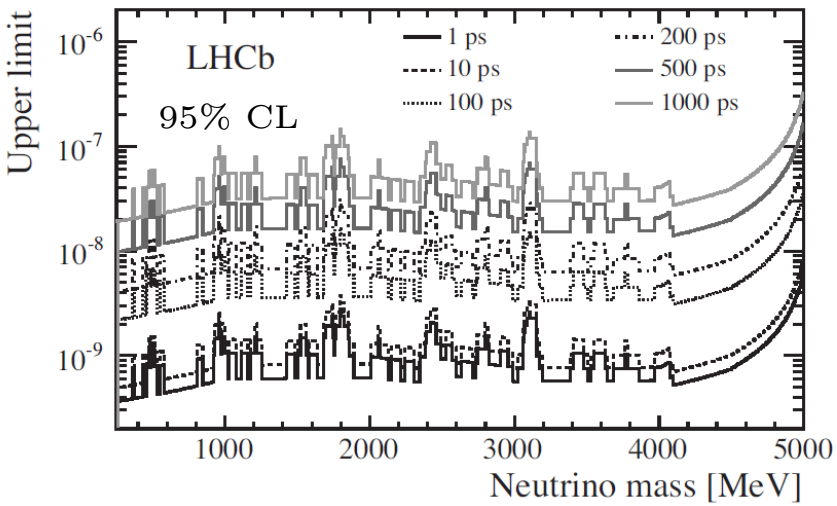
Anomalous Decays

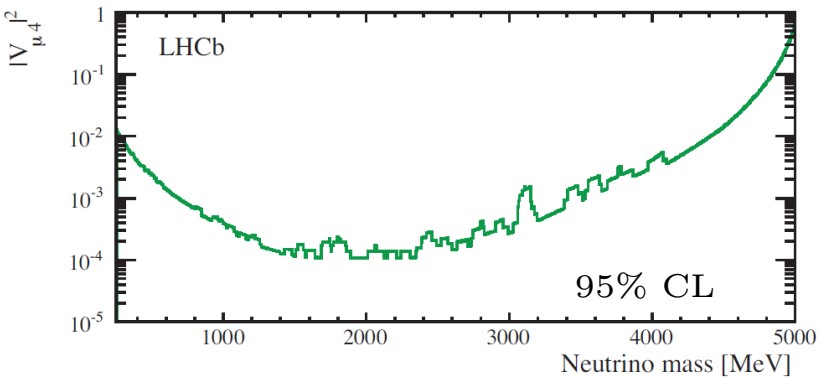
Search for Majorana Neutrinos

[PRL 112 (2014) 131802]

- search for massive Majorana neutrino in $B^- \to \pi^+ \mu^- \mu^-$
- test neutrino lifetimes between 1 and 1000 ps
- 1(2) fb^{-1} at $\sqrt{s} = 7(8)$ TeV



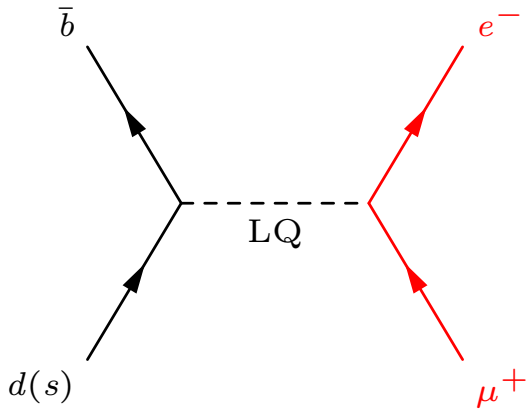




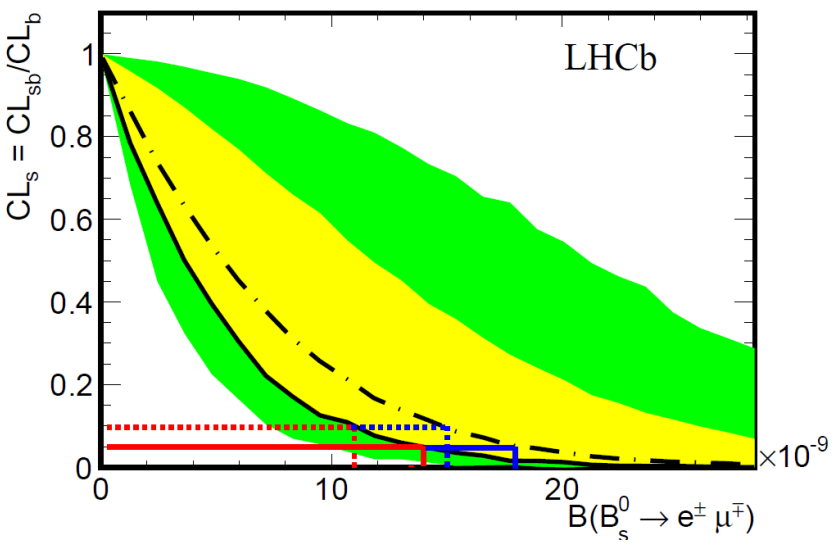
Lepton Violation in B^0 Decays

[PRL 111 (2013) 141801]

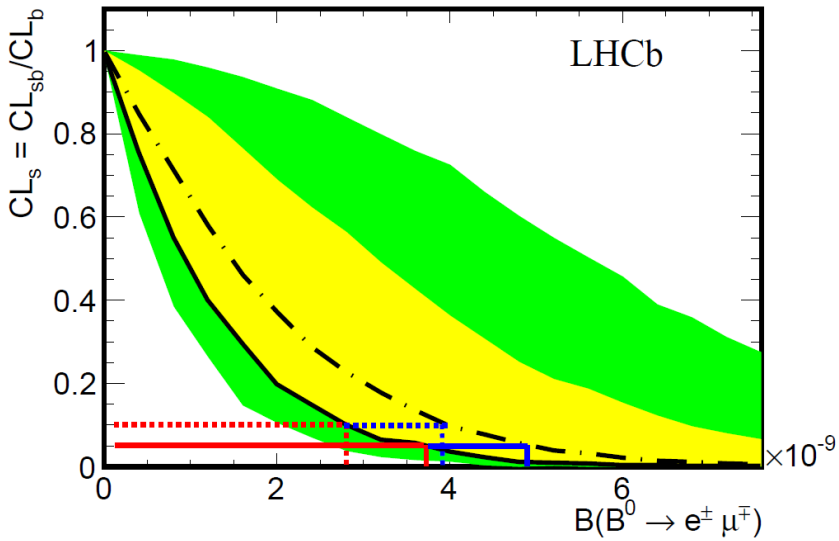
- search for lepton violation in $B_s^0 \to e^\pm \mu^\mp$ and $B^0 \to e^\pm \mu^\mp$
- possible with Dirac neutrinos, SUSY, and leptoquarks
- 1 fb^{-1} at $\sqrt{s} = 7$ TeV



$\mathcal{B}_{B_s^0} < 1.4 \times 10^{-8}$ (95% CL$_s$)



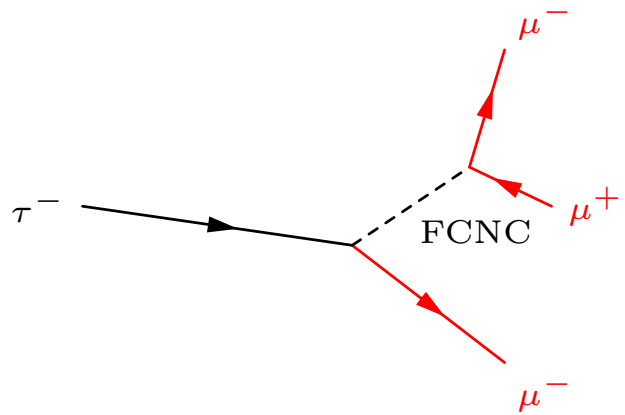
$\mathcal{B}_{B^0} < 3.7 \times 10^{-9}$ (95% CL$_s$)



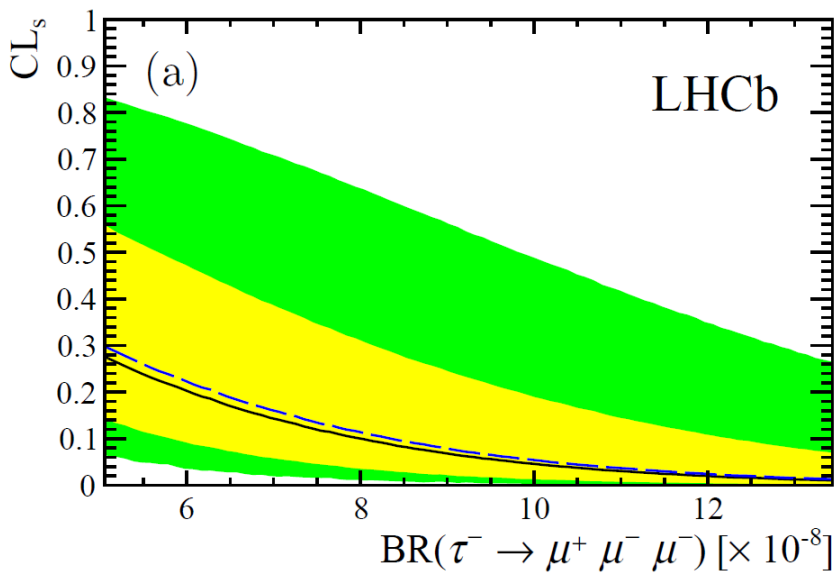
Lepton Violation in τ Decays

[Phys. Lett. B 724 (2013)]

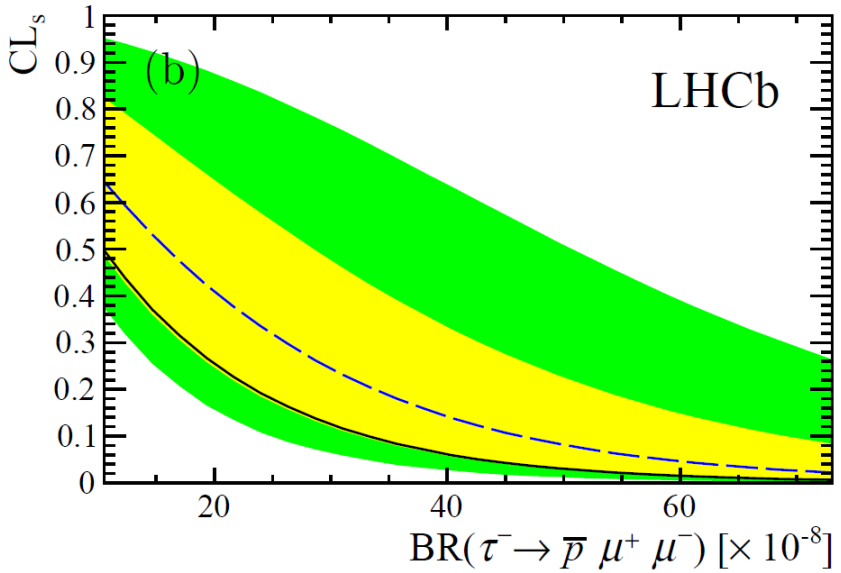
- search for both lepton and baryon violation in $\tau^- \to \mu^-\mu^-\mu^+$, $\tau^- \to \bar{p}\mu^-\mu^+$, $\tau^- \to p\mu^-\mu^-$
- $\approx 80\%$ from $D_s^- \to \tau\bar{\nu}_\tau$
- 1 fb^{-1} at $\sqrt{s} = 7$ TeV



$\mathcal{B}_{\mu\mu\mu} < 9.8 \times 10^{-8}$ (95% CL$_s$)



$\mathcal{B}_{\bar{p}\mu\mu} < 4.3 \times 10^{-7}$ (95% CL$_s$)

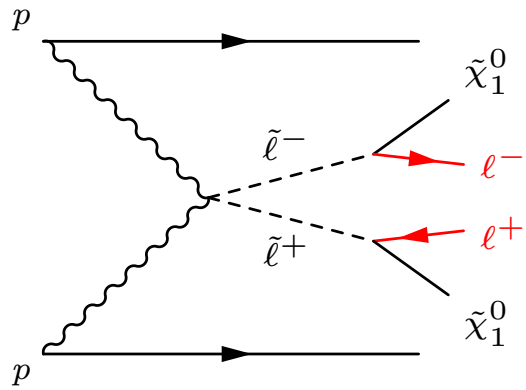


Direct Searches

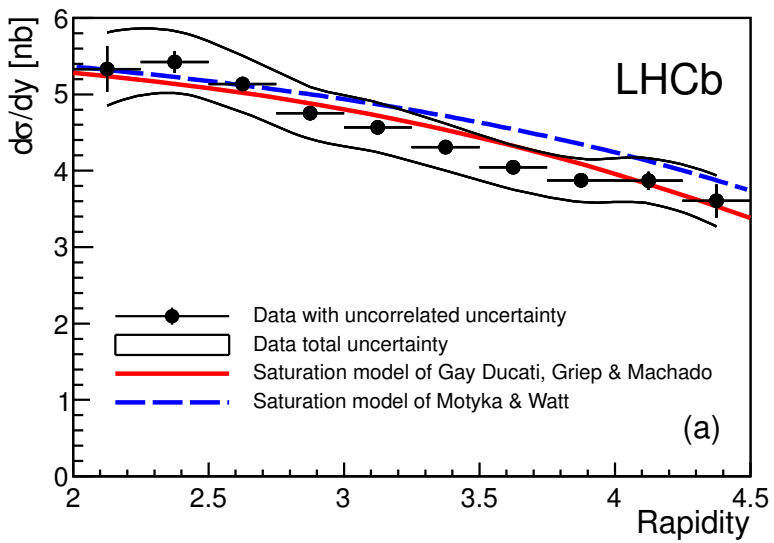
Central Exclusive Production

[J. Phys. G 41 (2014) 055002]

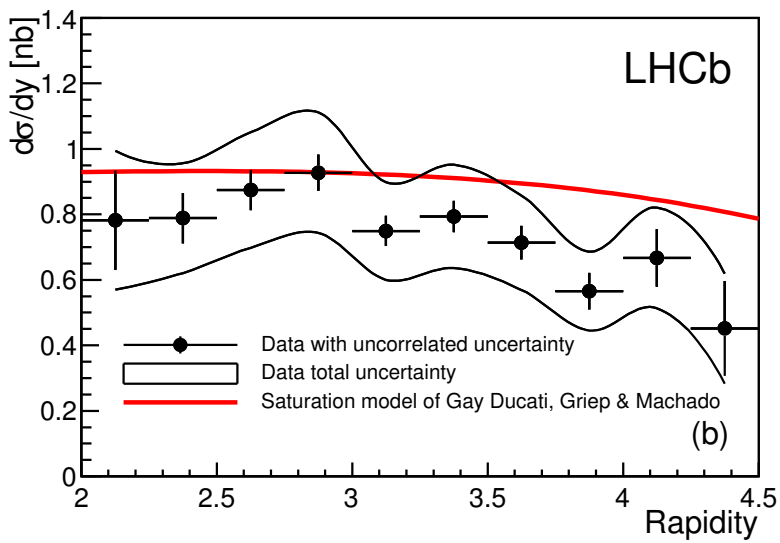
- measurement of J/ψ and $\psi(2S)$ cross-section
- sensitive to $X_1^+ X_2^-$ production, *e.g.* sleptons [arXiv:1110.4320]
- also sensitive to pomeron-odderon production [arXiv:hep-ph/0702134]



J/ψ



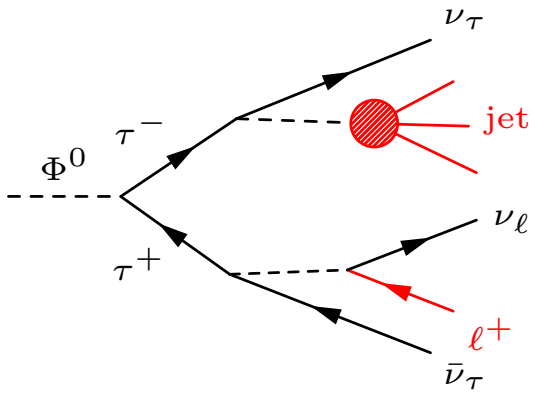
$\psi(2S)$

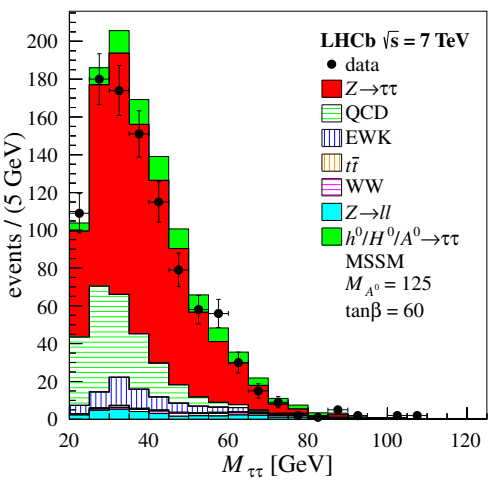


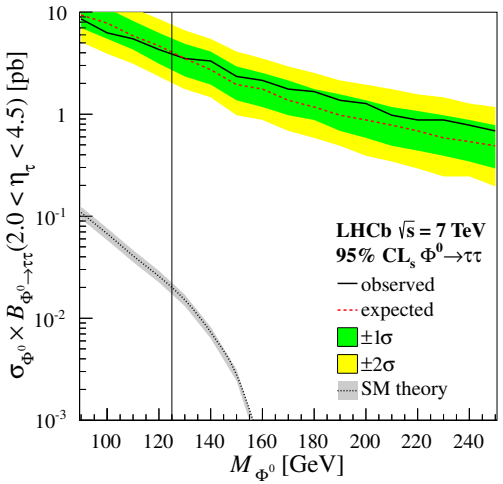
Limits on Neutral Higgs to $\tau\tau$

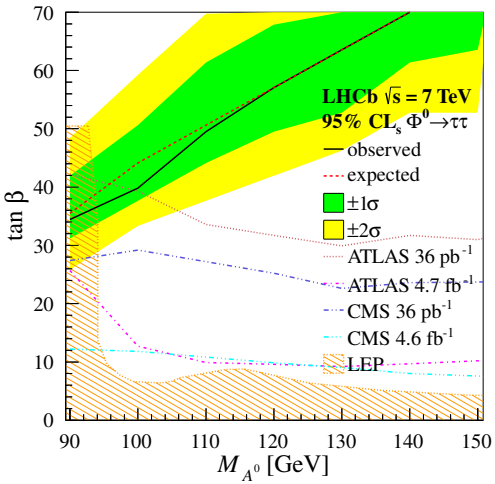
[JHEP 05 (2013) 132]

- extension of $Z \to \tau\tau$ cross-section measurement
- $\tau_\mu\tau_\mu$, $\tau_\mu\tau_e$, $\tau_\mu\tau_h$, and $\tau_e\tau_h$ final states
- 1 fb^{-1} at $\sqrt{s} = 7$ TeV





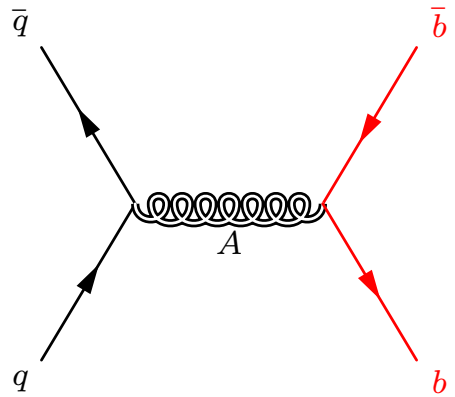




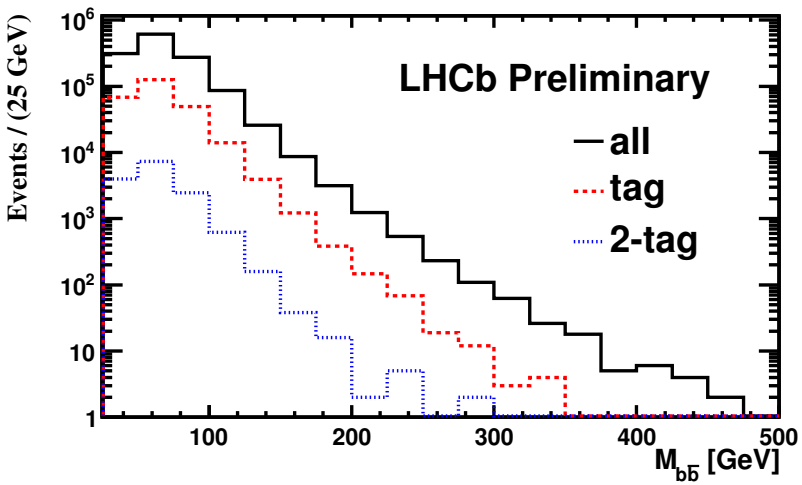
Forward-Central $b\bar{b}$ Asymmetry

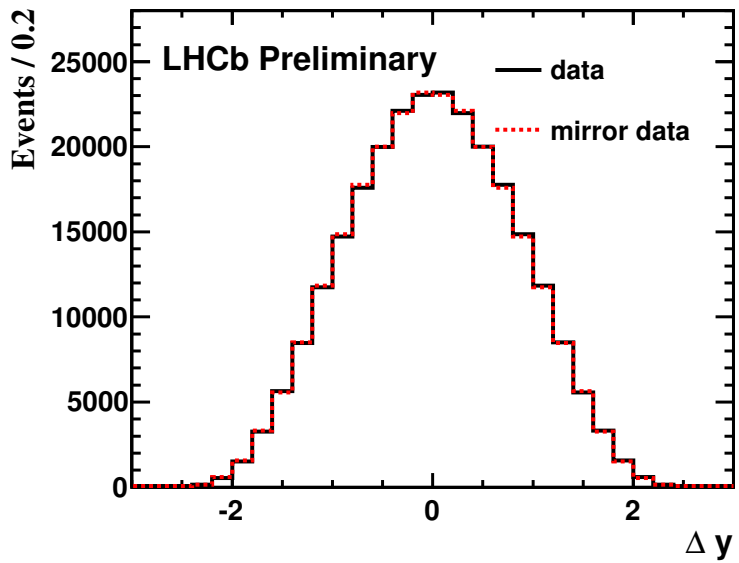
[LHCb-CONF-2013-001]

$$A_{\mathrm{FC}}^{b\bar{b}} = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)}$$



- sensitive to many BSM models for enhanced $t\bar{t}$ asymmetries, *e.g.* axigluons [arXiv:1108.3301]
- update to be released soon

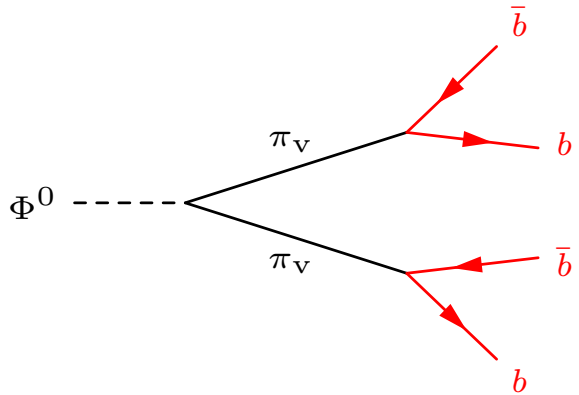


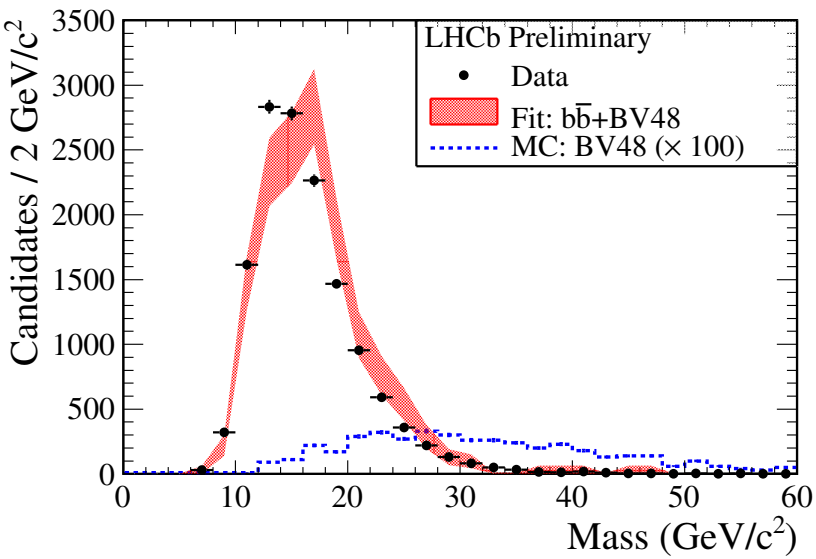


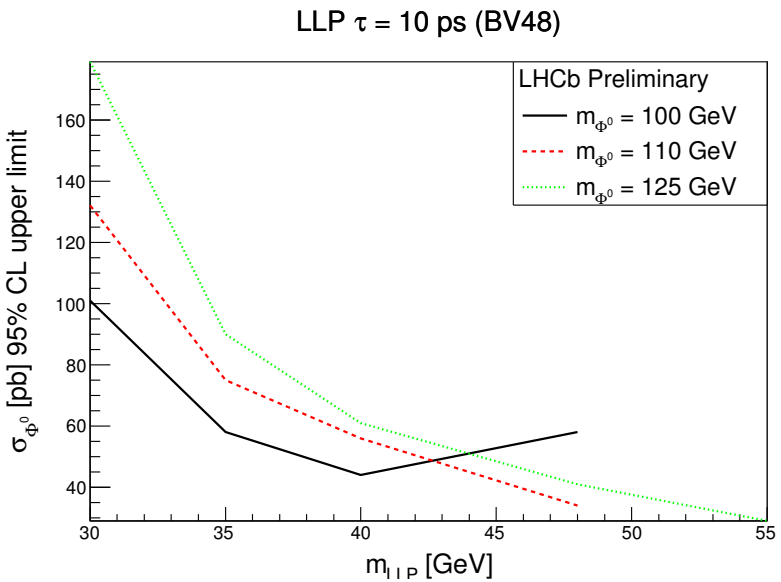
Search for Long-Lived Particles

[LHCb-CONF-2012-014]

- search for Higgs decays into $\tilde{\chi}_1^0$ or unknown scalar, π_v
- 39 pb^{-1} at $\sqrt{s} = 7$ TeV
- analysis of full dataset underway







Conclusions

- LHCb has a very diverse range of exotic searches
  - not just direct searches but also anomalous decays (and hadron structure)
  - some searches only possible in LHCb, others complement ATLAS and CMS results
- LHCb has many unique features to utilize
  - reduced pile-up, $\nu = 1.8(2011), 2.5(2012), 1.5 - 4.8(\text{Run} - \text{II})$
  - flexible trigger with low thresholds, $p_{\text{T}\,\mu} > 1.5$ GeV
  - full forward instrumentation, $2 < \eta < 5$
  - good di-muon mass resolution
  - excellent secondary vertex reconstruction, $0.01 - 0.05(0.1 - 0.3)$ mm $xy(z)$
- looking forward to 13 TeV data!
  - need to think about what triggers we might be missing
  - always welcome to new ideas