Searches for long-lived heavy particles at LHCb

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Introduction

Despite its experimental success, the Standard Model (SM) has its limitations. In particular, it cannot explain the matter-antimatter asymmetry observed in the Universe, inferred dark matter or dark energy. Efforts to solve these issues result in a large variety of new models. Many of them predict the existence of long-lived heavy particles (LLP) that decay into SM particles. A few examples are discussed below.

In the context of **minimal supergravity** (mSUGRA) allowing R-Parity Violation, the lightest neutralino $\tilde{\chi}_1^0$ decays through baryon number violation into three quarks [1].

[1] Phys. Rev. Lett. 99 (2007) 211801
[2] arXiv:hep-ph/9801271v2
[3] Phys. Lett. B 651 (2007) 374

The **Minimal Gauge Mediated Supersymmetry Breaking** (mGMSB), proposes that its next to lightest supersymmetry particle, the stau, is charged, massive and long-lived [2].

Another example is the **Hidden Valley** (HV) model, which predicts the existence of a new non-abelian gauge group hidden at large energy scales [3]. The hidden region may be accessible at the LHC, resulting in the decay of hidden particles into SM particles.
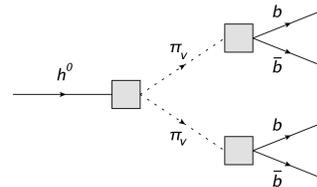

For instance, a SM-like Higgs boson may decay as $h^0 \to \pi_v \pi_v$, where π_v is the new v-particle that decays mostly to a $b\bar{b}$ pair.

LHCb detector

LHCb [4] is a single-arm forward spectrometer covering the pseudorapidity range $2 < \eta < 5$.

The vertex locator (VELO) is designed for the detection of primary and displaced secondary vertices (SV). Together with the flexible LHCb trigger, optimized to select events with displaced vertices, it provides an ideal scenario to search for long-lived particles.

[4] JINST 3 (2008) S08005
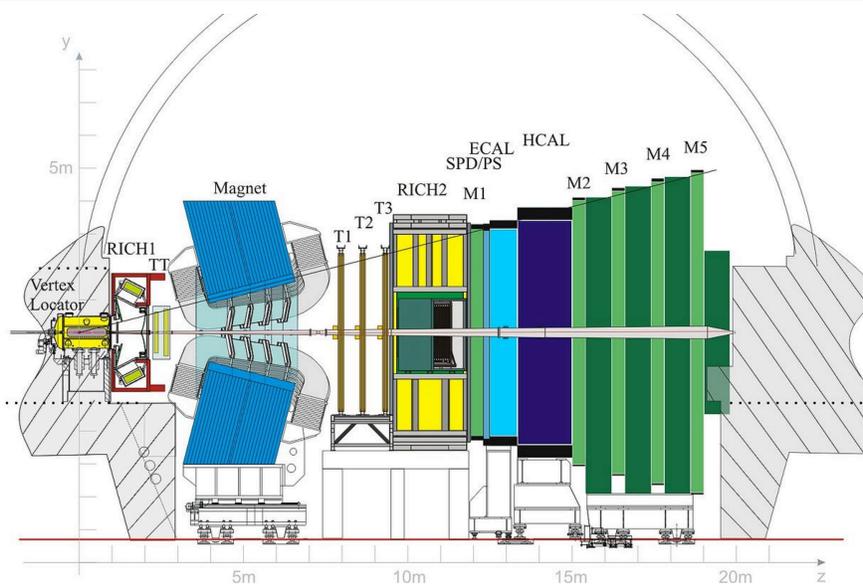
Photon, electron and hadron candidates are measured by a calorimeter system with an ECAL resolution of 1% + 10%/√(E[GeV]).

Charged hadrons are identified using two ring-imaging Cherenkov (RICH) detectors.

Muons are identified by a muon system. The muon overall identification efficiency is 97 % for 1-3 % pion mis-identification probability.

Search for Higgs-like bosons decaying into long-lived exotic particles [LHCb-CONF-2012-014]

A search for $h^0 \to \pi_v \pi_v (\tilde{\chi}_1^0 \tilde{\chi}_1^0) \to b\bar{b}b\bar{b}$ in the sensitivity range: τ_{LLP} from 3 to 25 ps, m_{LLP} from 30 to 55 GeV and m_h from 100 to 125 GeV is performed using 35.8 pb^{-1} of LHCb data at √s = 7 TeV.

Selection:	Loose	Tight	Units
n Tracks SV	≥ 4	≥ 6	
m_h	≥ 3	≥ 6	GeV
$|\Delta\phi|$	> 2.8	> 2.8	rad
SV σ_r	-	< 0.05	mm
SV σ_z	-	< 0.24	mm
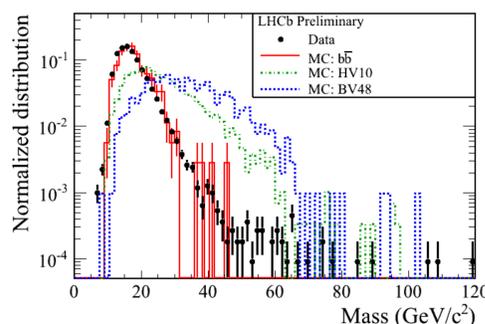
The data after the loose selection is compatible with $b\bar{b}$ events only.

A tight selection is then applied to fully suppress this background. No candidates are found and 95% CL upper limits are set for the production cross-section.

Updated results with 1 fb^{-1} data to be published very soon.

LHCb Preliminary

m_{LLP}	30	35	40	48	55
m_{h^0}					
100	101	58	44	58	
105	100	75	44	39	
110	132	75	56	34	
114	128	91	47	32	46
120	148	93	58	34	31
125	179	90	61	41	29

Cross-section (in pb) upper limits at τ_{LLP} = 10 ps. Masses are given in GeV.

Stau search prospects

A search for stau pairs with mass from 124 to 309 GeV is performed using the full LHCb dataset of 3 fb^{-1} recorded at √s = 7 and 8 TeV.
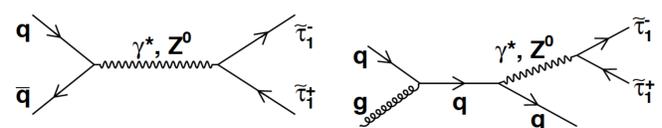
[arXiv:hep-ph/0701202v3]

Staus interact only electromagnetically with the detector, behaving as very massive muons. Therefore, they are selected by the muon trigger.

Discrimination from muons is achieved with a Neural Network using the amount of energy deposited in the VELO and calorimeters (lower for staus) and the threshold to trigger the Cherenkov effect in the RICHes (much higher for staus).

Results to be published very soon.