**Theoretical motivation**

Several models for Physics beyond the Standard Model predict the existence of new massive particles decaying into Standard Model particles. Two examples:
- Neutralinos in mSUGRA with baryon or lepton number violation
- Neutralinos in the Hidden Valley (HV) framework with a non-abelian gauge symmetry (benchmark model)

Massive particles with a lifetime between 1 ps and 1 ns can be identified by their decay to Standard Model particles. Two examples:
\[ H \rightarrow \pi^0, \pi^0 \rightarrow q\bar{q} \]

\[ B \rightarrow \pi^0 v \]

\[ \text{Long-lived particles can be produced in pairs through Higgs decay } H \rightarrow m^0, m^0, m^0 \rightarrow q\bar{q} \]

HLCb has a unique coverage for long-lived particles with small mass and lifetime.

**Event selection and analysis**

Search for \( m^0 \), with a mass between 25 and 50 GeV/c\(^2\) and a lifetime between 1 and 200 ps for a SM-like Higgs particle mass of 120 GeV/c\(^2\). Measurement performed with 0.62 fb\(^{-1}\) of data collected in 2011.

**Displaced vertex (DV) selection:**
- DV are identified by combining charged tracks.
- DV are selected with a minimal distance \( R_{min} \) from the beam line and a minimal invariant mass \( m_{m} \).
- Vertices are rejected when reconstructed in the detector material (Matter Veto MV).
- At least 6 tracks per vertex, with a sum of the scalar \( p_T \) of tracks > 3 GeV/c

**Jet reconstruction:**
- Anti-\( k_{T} \) algorithm with a cone size of 0.7
- Two jets with \( p_T > 5 \) GeV/c
- Only candidates with \( \Delta m_{jet}/m > 0.7 \) and a distance between the two jets of \( \Delta R < 2.2 \) are selected

\[ \Delta m_{jet} = \sqrt{1 + \left( \frac{E_{m} \sin \theta}{m} \right)^2 + \frac{E_{m} \sin \theta}{m}} \]

Data compatible with the expected background from bbbar production.

**Results**

The shape of the background invariant mass distribution, the selection efficiency and the background yield depend on the radial displacement \( R_y \).

Therefore, the signal yield is extracted by a fit of the invariant mass distribution in five bins of \( R_y (0.4-4.8 \text{ mm}) \) and with a minimal \( m_0 \).

- Background is modelled by an exponential convolved with a bifurcated Gaussian.
- The signal is modelled by a bifurcated Gaussian (parameters obtained from simulation).

![Mass distribution](image)

**Limits**

The systematic uncertainty on the selection efficiency and integrated luminosity for the different models is in the range of 12.6% to 13.3%.

Upper limits on the production cross-section at 95% CL are extracted using the CLs method.

The results cover an unexplored region at the LHC and the limits are more restrictive than results from the Tevatron in the same mass and lifetime range.

Branching fractions of greater than 25% are excluded for a SM Higgs to pair produce \( m^0 \) particles that decay to two hadronic jets.