Searching for heavy neutral lepton in B meson decay at LHCb experiment

Anna Ossowska
Institute of Nuclear Physics PAN
Poland
The Standard Model - Motivation

Questions:

- dark matter/dark energy
- nature of gravity,
- bariogenesis,
- three generations of fermions
- neutrino masses/oscillations

Heavy neutral leptons like Majorana neutrino can help to explain:

✓ neutrino masses/oscillations
✓ dark matter
✓ matter – antimatter asymmetry (Bariogenesis via Leptogenesis)
LHCb experiment

- a single arm spectrometer designed for precision studies of b and c hadrons in the forward direction
- angular coverage from 10 mrad to 300 (250) mrad
- the B meson decays
- Pseudorapidity range $2 < \eta < 5$

**Vertex Locator**
A silicon-strip vertex detector surrounding the $pp$ interaction region. It is used to measure the particle trajectories.

**Magnet**
The spectrometer magnet, required for the momentum measurement of charged particles, is a warm dipole magnet providing an integrated field of about 4 Tm, which deflects charged particles in the horizontal plane. The field of the spectrometer magnet also has an impact on the trajectory of the LHC beams.

**Calorimeters**
The electromagnetic and hadronic calorimeters provide measurements of the energy of electrons, photons, and hadrons. These measurements are used at trigger level to identify the particles with large transverse momentum.

**RICH**
Charged hadrons are identified using two ring-imaging Cherenkov detectors. It is used for particle identification of low-momentum and high-momentum tracks.

**Tracking System**
It is used to reconstruct the trajectories of charged particles and to measure their momenta. The tracker consists of three subdetectors: The Tracker Turicensis, The Outer Tracker, The Inner Tracker.

**Muon System**
The muon system is used to identify and trigger muons in the events.
\[ B^- \rightarrow \pi^+ \mu^- \mu^- \]

- Center-of-mass energy of 7 TeV for 2011 data and 8 TeV for 2012 data – two stripping lines
- 3 fb^{-1} of data collected with LHCb
- Neutrinos with mass in range 250-5000 MeV and lifetimes 0-1000 ps
- Normalisation channel \( B^- \rightarrow J/\psi K^- \)

Two strategies:
- Short \( \tau_N \) (S)
- Long \( \tau_N \) up to 1000 ps (L)

Selection criteria gave a good reconstruction efficiency for the signal while keeping the background suppressed.

LHCb analysis

Lepton Flavour Violation & Lepton Number Violation

No signal found → Upper Limit
$B^- \rightarrow \pi^+ \mu^- \mu^-$

- $C_L_s$ method $\rightarrow$ Upper Limit on BR ($B^- \rightarrow \pi^+ \mu^- \mu^-$) for N with lifetimes up to 1000 ps
- Upper limit on the coupling of a single 4$^{th}$ generation Majorana neutrino to $\mu$.

Short neutrino lifetimes of 1 ps or less:

BR ($B^- \rightarrow \pi^+ \mu^- \mu^-$) $< 4.0 \times 10^{-9}$ at 95 % C.L.
$B \rightarrow \mu N \ (\rightarrow \pi e)$

- 1.67 $fb^{-1}$ of data from Run2 (2016)
- Center-of-mass energy 13 TeV
- Mass range 150 MeV – 4500 MeV
- Lifetime 1 – 100 ps

Lepton Flavour Violation &
TOTAL LEPTON NUMBER IS CONSERVED

Analysis started recently:
- first MC samples ready
- preselection algorithm ready

Majorana neutrino decay searched inside VELO and outside VELO (tracker behind the magnet to improve acceptance)
Thank you for your attention