

# $Z^0$ decay into $\mu^+$ and $\mu^-$

Nikolajus Elkana Eimutis  
Taikomoji fizika, Fizikos fakultetas, Vilniaus Universitetas

2023 m. liepos 3 d.

**Goal:** Using LHCb open data measure Z boson mass and other important variables (observables?).

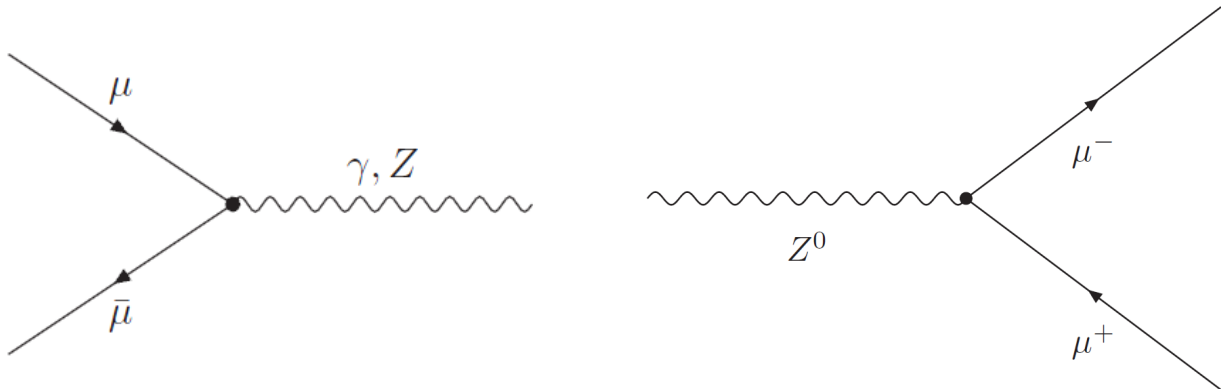
## 1 Milestones

1. Data is downloaded and ready for local analysis.
2. Theoretical understanding of how LHCb gathers its data is developed.
3. Theoretical understanding of how two muons arise from two protons is developed.
4. Practical skill to write root macros is learned.
5. The data is filtered in such a manner that there is only one evident peak in the Z boson mass graph.
6. A boson mass graph is drawn, the data is fitted against appropriate theoretical function.

## 2 Theory

### 1. Feynman diagrams

They are figurative depictions of contributions from interactions between particles, which are described by quantum field theory[1].



(a) Muon-antimuon annihilation [1].

(b)  $Z^0$  decay into muon-antimuon pair [1].

1 pav.: Feynman diagrams for the processes with Z boson and muon-antimuon pair.

[TODO: maybe add more complicated diagrams, if something is relevant]

[TODO: maybe address the Drell-Yan process here]

### 2. Processes mimicking Z boson signal

Due to its short lifetime Z boson is detected by analysing the decay products. Hence, any process producing (in this case) muon-antimuon pair of a mass in the range that we would expect to find the boson ([TODO: how was that range calculated]) would result in fake signal.

A few processes that produce muons (albeit probably not important for Z boson decay):

- (a) *pion decay* [TODO: find out whether this is of any relevance since we are detecting the muon-antimuon pairs instead of individual muons]
- (b) *W boson decay* [TODO: find out relevance - only one muon could be made]
- (c) *cosmic rays...*

Probably ([TODO: find out, if true]) more "fake signals" could come from high mass photons.

[TODO: maybe jets could come into picture with this question]

### 3. Main graphs drawn when analysing Z boson decay into two muons. What properties are usually analysed?

Most accurately known parameters (at least back in 1999) are  $G_\mu$ ,  $\bar{\alpha}$ ,  $m_Z$  [2];

Possibly useful, since the paper is very similar to this one: muon, Z-boson momentum, pseudorapidity [3];

[TODO: add more descriptions and explanations here]

4. Theoretical calculation of Z boson mass from two muons.

Born approximation model[[**TODO: ???**]] [3]

5. LHCb detector structure, trigger, reconstruction, data validity and error.

[**TODO: answer**]

6. Data types used in LHCb.

[**TODO: answer**]

### 3 Results

#### Literatūra

- [1] K. Jende, M. Kobel, G. Pospiech, U. Bilow, M. Pedersen, F. Ould-Saada, E. Gramstad, Hands on particle physics.
- [2] V. Novikov, L. Okun, A. N. Rozanov, M. Vysotsky, Theory of z boson decays, Reports on Progress in Physics **62**(9), 1275 (1999).
- [3] M. D. Khodaverdian, Accuracy and precision of the z boson mass measurement with the atlas detector (2019).