Adding timing to the VELO

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Summer Student Project

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LHCb - CERN

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Outline

Outline

About me

- Bachelor student at Ss. Cyril and Methodius University, Skopje, Macedonia
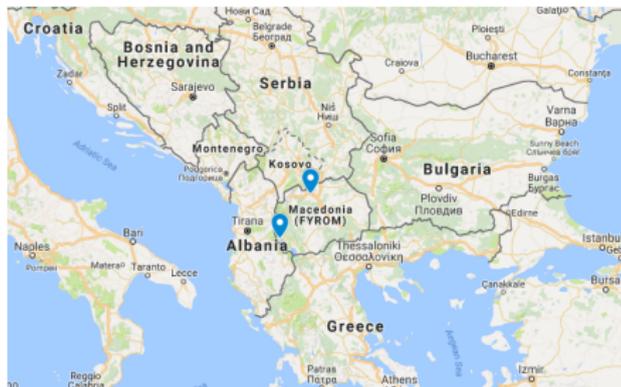
- beside physics... swimming, biking and running
- enthusiastic about hiking

Outline

VELO

LHCb experiment

# VELO-Vertex Locator

- locating primary vertices(PVs)
- decay product - secondary vertex(SV)
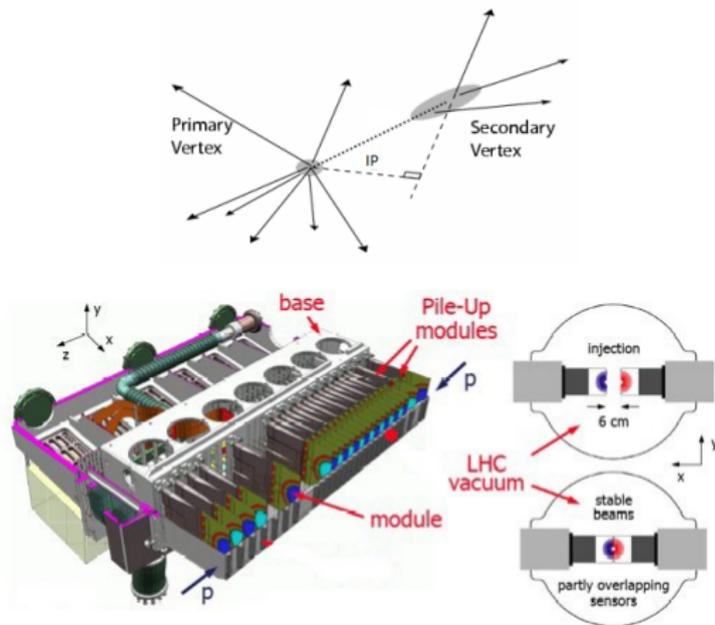
VELO upgrade plan
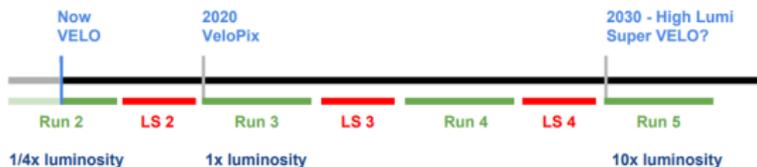


- Phase 1
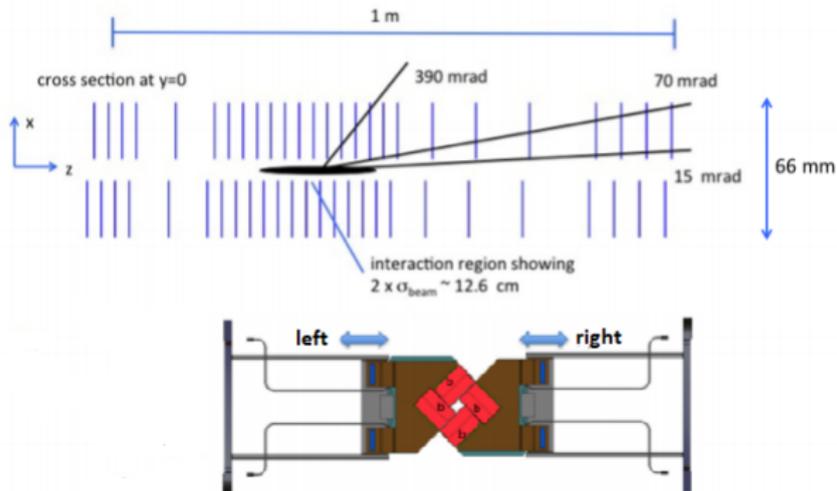
VELO upgrade plan

- Phase 2
  - For this study Phase-I VELO design was used:
    - 55 μm pixels
    - module positions are based on previous upgrade - Phase 1
    - modules have timing information of different precision

Outline

VELO

Project goals

- study the VELO performance at 50x current luminosity(10x Phase-I luminosity)
- perform a Monte Carlo simulation to study the PV mis-association
- using spatial + timing information
- determine the PV mismatch fraction for b mesons

Outline

Event generation

- generate primary vertices along the beam line

PVs
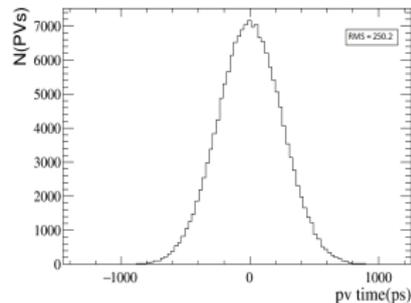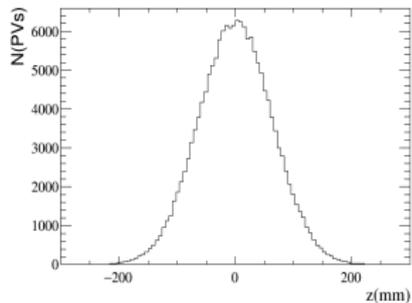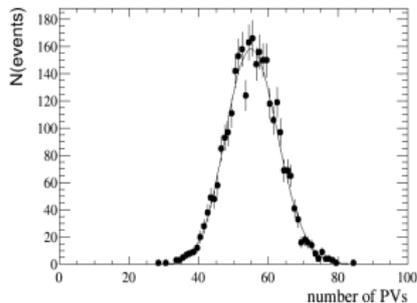
# Event generation

- generation of particles from each PV
  - η values between 2 and 5(taken from full LHCb simulation)
  - ϕ uniform distribution

VELO
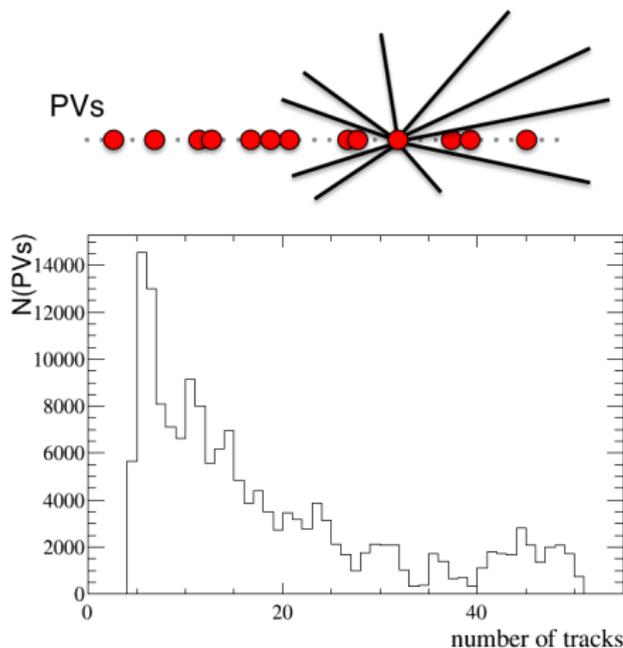
Event generation

- one PV is chosen as the SV parent (b hadron parent)
- distribution of the SV lifetime
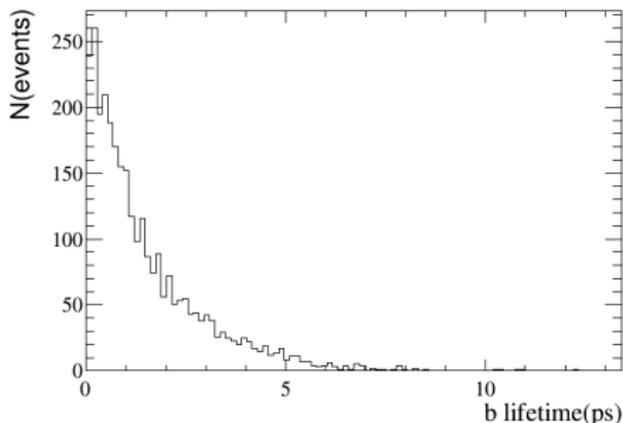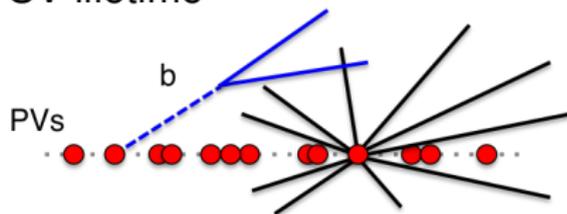
Event generation

- All tracks with hits > 3 are reconstructed
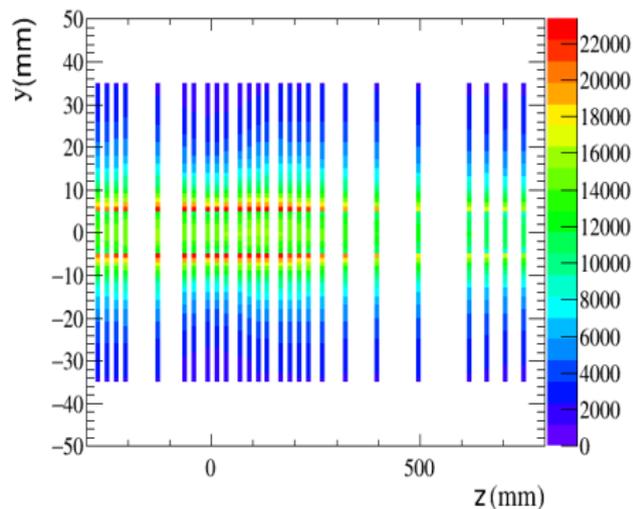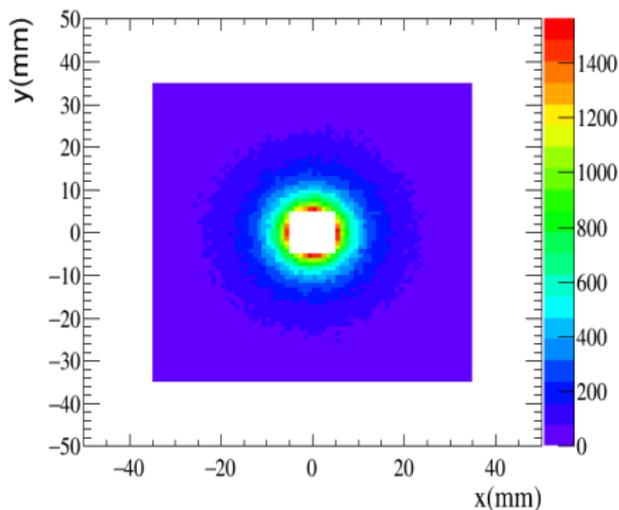
Event generation

- PVs and SV reconstructed using track sample
- The Impact parameter(IP) of every PV is calculated
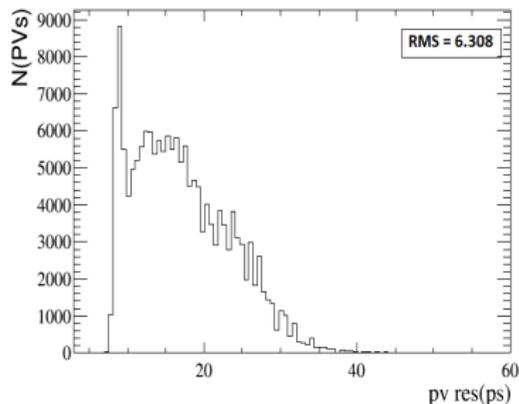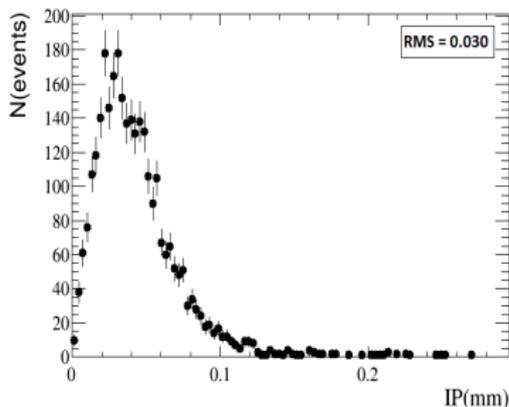
Event generation

Compare two methods to associate b to PV

1. using IP
$\Rightarrow$ PV with min IP
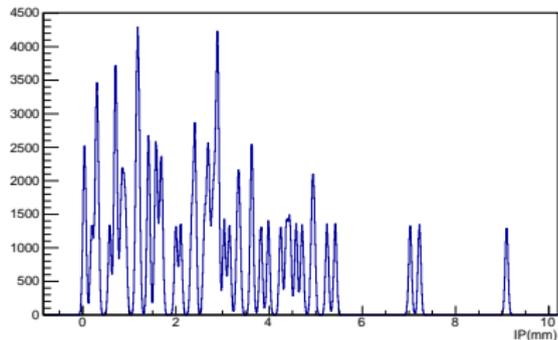
2. using IP + timing
$\Rightarrow$ PV with min
$$\sqrt{\frac{(IP)^2}{\sigma_{IP}^2} + \frac{(\delta t)^2}{\sigma_t^2}}$$
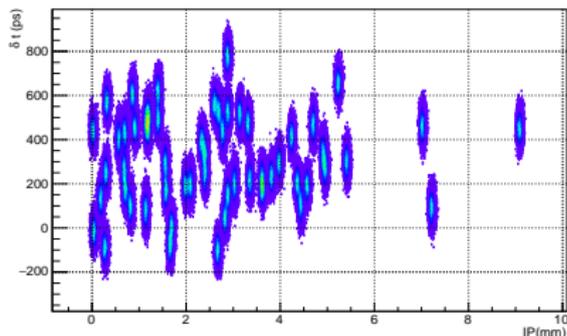
Outline

1. About me

2. Introduction

3. Project details

4. Simulation procedure

5. **Results and discussion**

6. Conclusion and future work

PV mismatch comparison (without timing)

- During Phase 1 upgrade 1% mis-association predicted

- During Phase 2 expected results are $\approx$15 % mismatch

- **How to improve this?**

Adding timing information...

- inner and outer part of the detector have precise timing resolutions

Adding timing information...
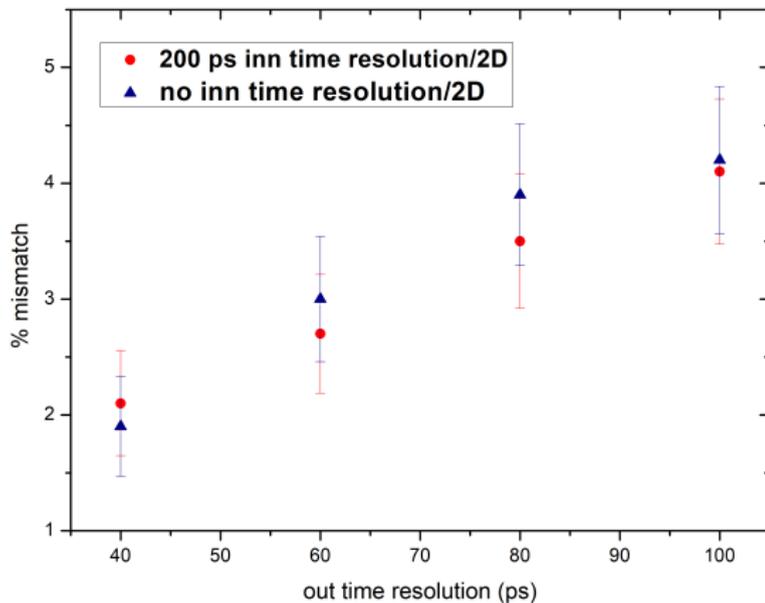
Adding timing information...
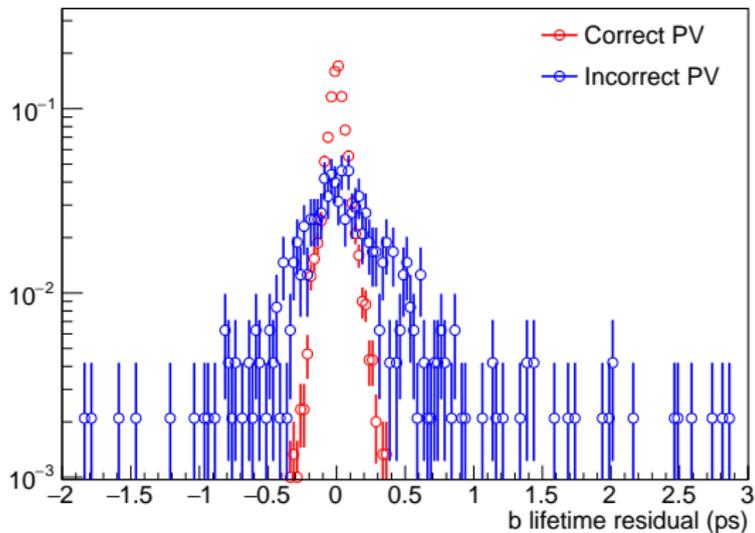
Adding timing information...

- Expected < 5 % mismatch under HL conditions using spatial + timing info

Outline

Summary

- a Monte Carlo study was conducted
- new detector model was developed
- pixel detector with timing resolution(inner and outer region)
- Adding modest timing precision to the detector at large radius reduces PV mis-association rate from 15% to 5%

Future work

- accounting for different pixel sizes in the inner/outer detector region
- optimising the PV selection algorithm by improving the 2D distance approach
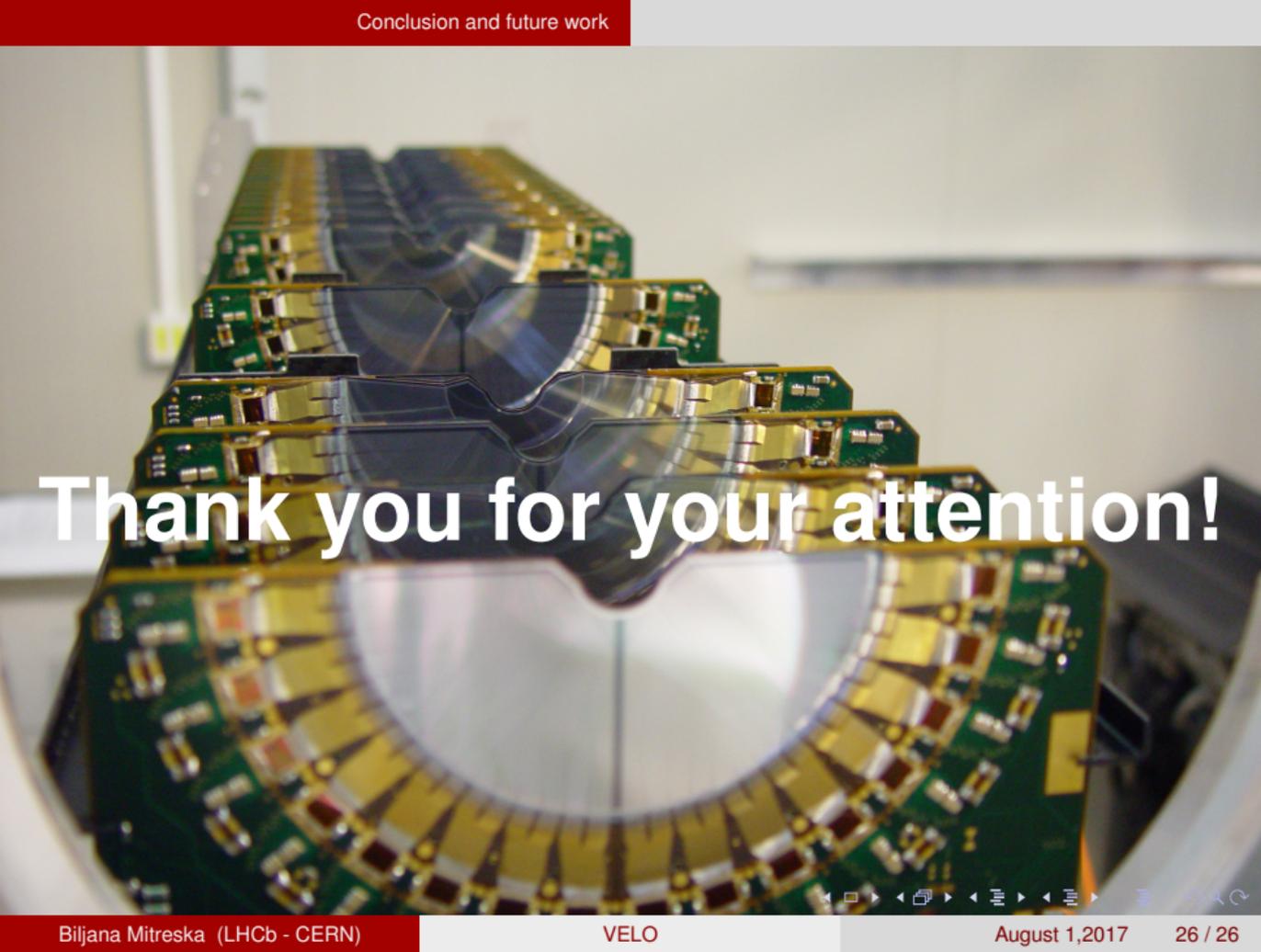
Thank you for your attention!