



**To:** Prof Jiří Chýla, Charles University

**From:** Prof Ulrik Egede

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## Examination report for Dr. Pavel Řezníček

This is the examination report for the habilitation thesis of Dr Pavel Řezníček, titled *Search for New Physics in  $b$ -hadron decays at the ATLAS experiment*. While the ATLAS experiment was not optimised for the physics performance in the area of  $b$ -hadron physics, it is still able to contribute significantly to the area by utilising triggers dedicated for those analyses.

### Overview of thesis

The thesis is written in the style where a relatively short introduction is followed by the papers/reports where Dr Řezníček has been a main contributor. The papers are divided into journal papers in the area of  $b$ -hadron physics, reports on the performance of the upgraded ATLAS detector in the area of  $b$ -hadron physics following upgrades, finally followed by more technical reports on the basic performance of the ATLAS detector and the development of software tools used. The papers and reports have all undergone extensive review and I will not comment on specific aspects of them but rather on what they cover in terms of scientific development. There will be some comments on the initial chapters that introduce the papers.

### Specific comments

The comment on page 19 that the production ratio of the different  $b$ -hadrons only depend slightly on  $p_T$  has been invalidated by recent measurements. In fact there is a very strong enhancement of  $b$  baryons relative to  $B$  mesons at low  $p_T$  which has to be carefully accounted for in measurements involving production cross-sections or ratios of branching fractions.

The latest measurement of the decay  $B_s^0 \rightarrow J/\psi \varphi$  from ATLAS has a measurement of the average decay width (inverse of lifetime) which shows a  $3\sigma$  tension with the world average measurement of the same quantity. Unfortunately the figures chosen to illustrate the analysis do not show this. I find it disappointing that there is not a further discussion of this aspect of the analysis. This is not a matter of theoretical uncertainties or possible new physics as in the rare electroweak penguin decays but a disagreement between different experiments. While I have no *a-priori* opinion about the source of the discrepancy I would have expected a discussion rather than just a statement.

Figure 29 tries to illustrate how the ATLAS upgrade with the full high-luminosity runs will be able to "resolve" the  $P'_5$  anomaly in rare decays. While this will most likely be the case, it in my mind tries to answer the wrong question. The main steps for the analyses of electroweak penguin decays in the future will not be about statistical precision of the so-called "optimised" observables but will be to move beyond those. We need in a data driven way to understand what the theoretical limitations are such as the influence of intermediate charmonium states (even well below threshold) and how open charm states are influencing the final states through rescattering. If the ATLAS upgrade will have the mass resolution and background rejection capability to answer those questions is not addressed.

## Overall impression

Overall the thesis represents a massive amount of work for a habilitation thesis. The overview and the breadth in topics of the submitted papers illustrates that Dr Řezníček has a very comprehensive overview of  $b$ -hadron physics at hadron colliders and have contributed in a major way to the scientific progress in the area. While the results from the ATLAS experiment are rarely the best in the world in this area, they form an extremely important role in terms of cross-checking other results by using different methods and having different systematic uncertainties.

As requested I have looked through the plagiarism reports of the thesis. There is nothing in that report that makes me worry about the originality of the text.

Based on the above review, I recommend that the candidate should be awarded the habilitation unconditionally. The minor issues identified in the report are not at a level where further issues should be addressed.

Ulrik Egede