Report on the PhD thesis by Mrs. Kristina Mihule

The dissertation thesis of Mrs. Kristina Mihule deals with one of the most important physics topic at the LHC, the Higgs boson, in a highly interesting channel of its decay to a pair of oppositely charged tau leptons.

The first major part described in Chapters 8 – 9 covers author's contributions to the reconstruction of the di-tau system mass using extensions to the Missing Mass Calculator, and applications to signal-background separation using various selection criteria. An important part of author's own work are also simulation verification studies, and studies of backgrounds.

The second major part, Chapter 10, represents author's contributions to the search for excited tau leptons (ETL), ranging from signal studies to event preselection, optimisation of the choice of the sensitive variable and control and validation regions to constrain backgrounds of various sources, and also the signal-background separation.
Also presented is the main fit for the signal strength, using the HistFitter framework, pre-fit and post-fit results, and limits set to the particular BSM process cross-section.

While some graphics may have deserved more changes, *e.g.* in making sure legends do not overlap with presented curves, presenting fitted parameters not directly in a formula but rather in a stat. box or a table; and also some parts of the text would profit from one more proof read (*e.g.* in a cut-off sentence, a reference left in the state of a label name), the thesis is still well readable and written in clear English of a good level.

Author's own list of contributions is quite robust, ranging from ATLAS analysis with her direct involvement, to conference notes and proceedings, demonstrating that the author has become a full member of the ATLAS collaboration with visible and important contributions to the experiment's physics programme, but also to indispensable performance and calibration campaigns.

Concerning the presented physics analyses, I have the following main comments

1. Pg. 95 mentions extraction of some nuisance parameters from the Asimov dataset – is this true, or CRs were used to constrain key backgrounds in a fit with actual data? Related: pg. 125 mentions a fit in CRs, and application of the fitted normalizations to the SR – is this what was used, *i.e.* not a simultaneous fit in SR and Crs? Also, I am not sure I understand the fit to real (Asimov) data in CRs (SR) mentioned on page 129 for the *observed* cross-section? Also the same stated at the bottom pf page 129. So in this regard, is this a sensitivity study in the SR, with data-driven inputs from CRs?
2. Pg. 104: Is the method really mode-independent while the ROC curves are evaluated on a particular signal?

3. In Figs. 10.31 and 10.38 (middle), the ttbar background in the ttbar control region exhibits a slope in almost all energy related variables, especially in the S_T. This mismodelling may affect the fit. Can you please comment? One finds useful remarks in this regard only later on pg. 125 and 126 but I would appreciate a summary on this topic in a compact answer/slide.
4. Section 10.11.4 mentions the 5-sigma potential of the analysis, referring to Fig. 10.43, where I see the red p-value line at 0.05. How does one get convinced of the 5-sigma sensitivity?

and a few remarks, not crucial nor to be discussed in detailed slides

- Pg. 84: meson scalar and vector octets differ in spin, not in isospin.
- Fig 9.10: the correlation in the core of the distribution is not visible and would deserve also a zoomed version of the plot.
- I think that student ATLAS plots should not bear ‚ATLAS internal' but rather no label at all.
- Fig. 9.17 results would benefit from graphical representation of the results.
- Fig. 10.15 does not convince reader about the different mass resolutions, a zoomed and same-binned version of the (a) and (b) plots would be needed.
- It is only in the text or table below where one finds that in Fig. 10.23 the different colours are ETL tau* samples of masses as indicated in the numbers, in TeV.
- The ABCD method is based on the assumption of a zero correlation between the selections along the x and y axes; this seems not mentioned and it is unclear this was actually checked.
- Pg. 125: blinded is usually used not with the Asimov fit but rather with not showing data points in signal-dominated SR of a sensitive variable.
- Markov chain method is first mentioned on pg. 47 but not referenced nor explained.

I regard the author's work in several areas presented as a demonstration of her own ability to pursue scientific research and I fully recommend her thesis to be accepted in fullfilment of the PhD degree.

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Mgr. Jiří Kvita, Ph.D.
Joint Laboratory of Optics of Palacký University
and Institute of Physics AS CR
Faculty of Science, Palacký University, Olomouc, Czech Republic
17. listopadu 50A, 772 07 Olomouc
jiri.kvita@upol.cz
+420774365167
+420585631585