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Subject: Referee Report on the thesis document by Mgr. Vlastimil Kus

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To Whom It May Concern

The PhD of Mgr. Vlastimil Kus was performed in the Institute of Particle and Nuclear Physics under the leadership of Dr. Marek Tasevsky, and is about the Study of Diffractive Processes at the ATLAS Experiment. In general, the subject is treated thoroughfully, and the thesis is well written, all the topics being pedagogically introduced. Diffractive measurements in an hadronic environment such as the Large Hadron Collider is a specially difficult topic and requires a good understanding of the detector as well as of the analysis methods. The work presented in this thesis is original and I am sure that the publication that will follow this study will serve as a reference in the field.

The subject of the thesis deals with the measurement of the dijet cross section in single diffractive events detected by requesting the presence of a "rapidity" gap in the direction of the outgoing proton. This is the first time that single diffractive hard events are measured in the ATLAS collaboration. This analysis also leads to the first measurement of the so-called survival probability, even it it still shows a large error bar.

After a short introduction, the two first chapters present in a clear and concise way the strong interactions and diffraction as well as the Large Hadron Collider (LHC) and the ATLAS detector. Some general results about diffraction and the results from the HERA (QCD fits to the diffractive structure functions and the extraction of the parton distributions in the Pomeron) and from the ATLAS (recent results on soft diffraction) experiments are given. A discussion about the ratio of the double diffractive to the single diffractive components could be also of interest since this is a background discussed in the following of the thesis. The LHC machine and the ATLAS detectors are also very nicely described, stressing the most relevant aspects of the detector for this thesis. Concerning the heavy ion runs, some requests will be made to use proton oxygen runs in order to tune the Monte Carlo especially in the forward region that is need for cosmic ray analysis.

Chapters 3 and 4 deal with a general presentation of the ATLAS software and the Monte Carlo used in this analysis. The description of the Monte Carlo is general and pedagogical despite being a non-trivial task. Some more details might be given about the different fluxes used for diffraction in PYTHIA8 (the different formulae). Mgr. Kus also describes in this section the amount of work that he had to perform in order to get enough MC events for his analysis, and especially the private production.

Chapter 5 is dedicated to Jet Energy Scale studies that will lead to one of the leading systematics of the measurement. Traditionally, getting a precise Jet Energy Scale is an important and difficult challenge in hadron-hadron colliders. The author was member of the jet eta-intercalibration subgroup and was responsible for testing the quality of jet energy calibration in 2010 and 2011 data. A global performance study as well as the justification that the standard Jet Energy Scale (determined in mostly non-diffractive events) could be also added during the defense. It is also not perfectly obvious if the effect of low pT jets (below the reconstruction threshold) can be an issue in the inter-calibration method or not. Some more details might also be given about the acronyms used in Jet Energy Scale technics such as EM+JES, LC+JES, GCW+JES…

Chapter 6 describes the general event selection used in the measurement of the single diffractive jet production cross section. An impressive and thorough study about the trigger possibilities is given by Mgr. Kus in order to get as many diffractive events as possible while keeping a high enough trigger efficiency, that leads to a new trigger strategy with respect to the standard jet cross section measurements. The study is well described and justified. My only additional suggestion would have been to exclude by a mask the crack regions shown for instance in Figure 6.9 since they show a significant inefficiency but this would not have an important effect on the analysis.

Chapter 7 and 8 are some of the most important and original chapters of the thesis since that describe the rapidity gap and xi (the proton momentum faction carried by the Pomeron) measurements that are fundamental for any diffractive measurements. This is again a difficult topic that is well mastered by the author of this thesis. Mgr. Kus developped a new original method called “hybrid” within the ATLAS collaboration in order to measure rapidity gaps since the previous one (the “pT method”) was leading to a too large requirement on the cell transverse momentum in the forward region. The correlation between the different methods of defining a gap and the smearing induced in each of the methods are studied in detail. The rapidity gap acceptance allows defining a region that is dominated by single diffractive events and where the smearing effects are under control. I am wondering how precisely the scale factor for pythia8 is known (what are the systematics on that number and is the same factor found in other independent analysis in ATLAS such as jet cross section or multiplicity measurements). This might be one of the leading systematics for this analysis and I did not see it mentioned. The author chose to rescale only the ND component as I understood and to leave the other ones (SD and DD) untouched. I would have thought that it would be more natural to rescale all the different contributions within that model and start computing the survival probabbility from there. I am also wondering if the cluster distributions (Figure 7.3) are similar for diffractive MC such as POMWIG or FPMC. I think that this is indeed the case but I am wondering if this was checked. It is also mentioned that the reconstructed value of xi is always smaller then the one at particle level, which is true, but what is the order of magnitude of these corrections?

Chapter 9 is dedicated to a description of the unfolding method. Despite its complexity, Mgr. Kus managed to describe the method accurately and pedagogically. All the different steps are justified and described in detail, which is remarkable. The 2D method is used for the unfolding and the smearing effects as well as the needed number of iterations are studied in detail. A closure test using purely MC shows the effectiveness of the method. I just have one question concerning the differences between an easier unfolding method (bin-by-bin for instance) and the fully implemented IDS one. I also did not fully understand why the formulae for the reweighting in the MC of the Delta Eta_F and xi distributions are not similar. Probably this is just a technical issue but my guess would have been that the reweighting should be similar if it was due to physics effects.

Chapter 10 evaluates the different systematics related to the meaurement of dijet production in SD events. The uncertainties on the Jet Energy Scale determination certainly leads to the largest systematics. The Cell Significance Threshold uncertainty is sometimes the second highest systematics and some more details about is calculation might be nice.

Chapters 11 and 12 give the final results and the SD jet cross section values. The chapter describes well the final measurements as well as the discussion with respect to the different models given in the thesis. This is the first result in hard diffraction in the ATLAS collaboration and it allows comparing the measurement with the predictions from pythia8 or for diffractive MC such as POMWIG or FPMC. The kinematical domain where the measurement is performed is completely new compared to HERA and the Tevatron, showing the relevance and importance of that measurement. I would just advise the author to present more figures during the defense (with less curves) as in Figures 12.4 to 12.7 so that we can see better which models are favored or disfavored. A short discussion on how the suvival probability depends on the choices of normalisation for pythia8 would be also quite useful. For instance, it clearly depends on the ND normalization but also on the choice of normalization for the SD/ND and DD/ND components, and on the assumptions on proton dissociation. It could be also mentioned how much proton dissociation is expected to be in the measurement if one believes in the MC.

To conclude, Mgr. Kus performed a fundamental study of single diffractive jet production in the ATLAS experiment. This result represents the most important result to date in the ATLAS collaboration and will be for sure published. Mgr. Kus performed this study by himself (including some more technical studies about the Jet Energy Scale determination). The thesis is very well written and pedagogical and I just had a few minor comments that would even improve slightly the written document. As a conclusion, I think that the work of Mgr. Kus is worth defending publicly. The results as well as the thesis is a considerable and remarkable amount of work. From the above, it follows that Mgr. Kus is able to work independently and creatively and that he should be granted the PhD title after a successful defense.

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