Opponent's review of doctoral thesis of Mgr. Pablo Rodríguez Ramos

„Experimental results in pion induced reaction with with carbon and polyethylene targets obtained by HADES-GSI“

In this thesis author presents results of his work at the HADES experiment with the main emphasis on measurements of production of dielectrons in pion-induced reactions with nuclear targets with the aim to extract information about baryonic resonances and their interaction with vector mesons. Such results would be of high interest as it can help us to understand modification of vector mesons in nuclear medium.

First thing that needs to be mentioned is the formal part of the thesis which affects the whole work. The thesis is rather long and the author has clearly put a significant effort to include as much information as possible including the theoretical aspects. However, the thesis is very poorly structured. From chapter 5 on it looks as if it was written backwards. It starts from discussion of efficiency corrections and systematic errors then it discusses background reconstruction, signal reconstruction and after that pair selection cuts. The final results are afterwards shown in last chapter dedicated to theoretical models. Moreover, the text from the point of language quality, is very bad. The text is riddled with mistakes. While grammar problems could be blamed on the author being non-native speaker, there are numerous occasions when a word is put redundantly twice in the sentence. The initial impression is spoiled right on the first page of the thesis where quark flavors are mistaken for particle generations and d quark is assigned charge of positive 1/3. All this makes the text very hard for reading. Clearly more effort should have been put intoproof reading.

The first chapter of the thesis tries to give a comprehensive introduction in to the problematics of in-medium vector meson modification and dilepton measurements. It show that author has a good understanding of the topic and available results, but again the readability is hindered by the text quality and occasional mistakes such as description in figure 1.10.

Following two chapters on HADES experiment and data reconstruction are very useful for understanding the rest of the thesis and it is clear the author has a very good knowledge of technical and software functionalities of the experiment. The fourth chapter describes author's own contribution to the calibration of the TOF detector. Questions on topics related to the described calibration procedure are included in appendix of the review.

Regarding the dilepton physics analysis itself the information is scattered illogically across different chapters starting in chapter 3.7 with description of single particle selection continuing by pair selection procedure and background rejection in chapter 6 and the efficiency correction in chapter 5. and finally results in chapter 9. From the descriptions it is clear the author himself preformed significant work on the data. However, I find some important information missing in the text. Especially the part about efficiency corrections is extremely brief although this is one of the most important parts of the work.

There are multiple mistakes which make harder to understand the text and plots, for example y-axis of plots 5.2 and 5.3.. It is often unclear how different plots are normalized. Most importantly the text contains no information upon which one could judge the quality of the agreement of data and simulation used for the efficiency extraction and hence final systematic errors. There is no information about single particle efficiencies and purities and no information about acceptance. It makes very hard to judge the reliability of the obtained results. For example the overall correction factor in figure 5.2 is on average ~100 at m_inv=100 MeV/c^2 and steeply rising towards low m_inv. Considering that the single particle efficiency of HADES is likely high there must be quite significant acceptance effects that need to be explained (the effects possibly show in figure 9.5), but this cannot be judged from the text. More detailed questions are included in the appendix.

In chapter 7 the procedure of extracting the number elastic pion-proton collisions is well described. The part describing the normalization procedure is very brief and at this point I would actually expect to see the overview of final normalized results. There is clearly some discrepancy between the two models used to get the input angular distribution, but there is no discussion about systematic errors. It is not clear how big contribution comes from the pion beam momentum spread and from input distribution. One can only find a number in chapter 5. What is not clear is why the simulation was done with input from ref [111], but the resulting normalization factor was obtained by comparison to different source (SAID database). More questions are again in the appendix.

Chapter 8 would perhaps better fit as a part of the initial theoretical introductory chapter. In chapter 9 are first described components of the simulation used to obtain the dilepton yields. Afterwards the simulations are compared to the data. This is actually the first place where the experimental results are presented which is very confusing. It seems from figure 9.5 that there is a significant problem at low p-pt region which basically means a difference of about three orders in total production cross section of dileptons. It is not very clear from the text what is the origin and mainly how it can be guaranteed that it does not influence higher-pt and m_inv distribution. Moreover there seems to be either inconsistency in plots or in text description between the differential cross sections and their pt and m_inv dependencies in figures 9.7 and 9.8. Since the text does not mention any imposed low-pt cut in figure 9.8 I'd expect both distributions to give the same total cross section. I'd like to ask the author for clarification. The text gets very hard to read when it gets to the topic of exclusive production. It is hard to disentangle what precisely was done. Albeit the problems with readability the chapter presents physics results on dilepton production showing an excess at a region of higher invariant mass which can be qualitatively explained with VDM model through production of off-mass shell rho meson.

Final chapter describes the ECAL calorimeter upgrade, its design and testing. It is clear that the author took significant part in the testing of the calorimeter modules. This is also likely the most readable chapter of the thesis.

Summary:

The presented thesis summarizes the work done by the author on the HADES experiment, both detector and physics oriented. There is a clear evidence that the author has done significant amount of work on calibration and testing of detectors. The thesis presents original results on inclusive dilepton production from in pion-polyethylene collisions and exclusive production in pi-proton collisions. The initial aim of subtracting out the carbon interactions in inclusive production was not achieved due to low statistics, but that is no fault of the author. On the other hand what can be ascribed to the author is the very poor quality and structure of the text of the thesis which makes it very hard to read and also undermines the obtained results. The author certainly obtained original results of his own, however there are parts of the analysis that are not clearly described and hence look questionable. This hence leads to the big number of questions I have to the author. Assuming those are satisfactorily answered I would conclude that the author has fulfilled the criteria for successful defense of the thesis.

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Appendix – Questions:

Chapter 3

- Was pre-shower detector used for the electron identification?
- It seems that in Fig 3.13 there is a higher efficiency for detecting negative particles, mainly at low-pt. Why is it so?
- What is the purity of your final lepton sample? Does it influence efficiency corrections and final results?

Chapter 4

- If I understood correctly in Figure 4.2 the difference between top and bottom should be in the shift of the mean. Why is there also the difference in the spread?

Chapter 5

- How well does your simulation (PLUTO+GEANT) describe the measured data, ie. single particle distributions (angular distributions, rapidity, pt)? In case of any disagreement how does it translate into systematic errors?
- As function of what variables do you consider/extract you efficiencies?
- What percent of dilepton yield falls out of your geometrical acceptance according to eq 5.1. ? What is the dependence on pt and m_inv?
- In chapter 9 there is a discussion that PLUTO does not describe properly angular distribution of pion decays. Can this possibly have an impact on the extracted efficiencies (via different acceptance). Similarly does it matter for the efficiency extraction which processes are included in the simulation such as the off-shell rho production?
- Did you consider how would angular anisotropy in dilepton production (such as arXiv:1802.00062) affect your acceptance and final results?

Chapter 6

- Since you claim that above m_inv>100MeV/c^2 the combinatorial background for pairs is uncorrelated, have you tried to use the mixed-event technique? I believe, this was done by HADES before.
- Figure 6.3 – is it understood what causes the difference between positive and negative pairs. Is there any systematic error related to this?
- You reject the photo conversions by cutting on the opening angle of 9°. Why do you in your simulations first cut in this angle and then propagate through GEANT and not vice versa? Can momentum smearing during simulation effect final efficiency of this cut?
- Have you tried to vary this cut in your analysis to see if there is any related systematic error?
- Have you checked for any effects related to hit sharing between the reconstructed tracks any other tracking related effects?

Chapter7

- When selecting the candidates for elastic scattering do you need to consider efficiency of selection in Figure 7.1?
- Is there any systematic error related to the difference in Figure 7.6?

Chapter 9

- Do I understand correctly that the corrected pt-dependent differential cross section in figure 9.5-right is obtained from figure 9.6 by multiplication by the blue curve of figure 5.2? If not, can you show the efficiency used for the correction?
- How do you know that the huge excess at low-pt in figure 9.5 does not transfer into any other of the observed excesses as function of m_inv?
- Figure 9.9 What exactly do you mean by “contribution of unknown source”?
- Page 123 line 4: What do you mean that the contribution overestimates yield in the right peak?
- Page 123 last paragraph: I’m confused by the description of what is in figure 9.15 which says that there is a cut on missing mass > 140 MeV for the study of exclusive production. I understand from previous paragraph that the exclusive production was selected by cutting missing mass around ~1 GeV/c^2. Can you elaborate on this?
- Is there any plan or outlook for publishing these results?