**RESEARCH DEGREE EXAMINATION BOARD**

**Examiner’s Joint Report**

**Outline of the examination process**

1. Research Degrees Examination Board appoints examiners
2. Thesis submitted by student and sent to examiners
3. Independent report submitted by each examiner within 8 weeks of receipt of thesis
4. Independent reports exchanged by Research Student Administration Office
5. *Viva voce* examination held within 1 month of exchange of reports
6. Joint report completed by examiners immediately following the viva
7. Examiners’ recommendation considered by Research Degrees Examination Board
8. Candidate informed of outcome by Research Student Administration Office

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| Candidate Name | Tom Coates |
| Degree Programme | PhD Physics |
| Thesis Title | Data acquisition software development and physics studies for future lepton colliders |

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| Internal Examiner | Dr L Falk |
| External Examiner | Prof N Watson |
| Third Examiner |  |
| Date of *viva voce* Examination | 12 Sept 2019 |

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| 1. **Report on candidate’s performance during *viva voce*:** |
| Start time: 1315 End time: 1740  The candidate gave a credible and confidence defence of his thesis, starting with a summary of the work carried out and the parts that have the largest impact on the field, primarily the co-development and application of the new DQM4hep monitoring and quality assurance tool, for use at “test beam” projects where the ready availability of a flexible tool that can be easily adapted for each specific data taking campaign. This is followed by a revisited analysis of the precision with which the top-Yukawa coupling can be measured using the full 1.5 ab-1­ integrated lumit that will be collected using the CLIC facility at 1.4 TeV.  There were a small number of areas where the background knowledge of particle physics was less complete than it might have been, but this is entirely reasonable and to be expected given the specialisation of this technical thesis and the areas covered, where we explored topics well outside the core material presented.  During the viva, we covered a wide range of topics that both clarified areas where there was some ambiguity from the thesis itself and allowed the candidate to demonstrate the breadth and depth of his knowledge of the field in general, and specifically on the experimental, theoretical and data analysis areas described.  By way of illustration, a selection of the topics discussed are listed below:   * Fermion pair production in e+e, charm discovery experiments at SPEAR, BNL, differences in signatures * Gluon radiation and fragmentation, final state topologies in e+e * Background to ttH (8 jets) from tt SM decays through higher order processes * Generic aspects of DQM4hep, potential directions to “future proof” the package * Discussion of backgrounds from tt in the ttH analysis, size of simulated samples, training of BDTs * Event shape variables such as thrust (and its axis), alternative formulations using jet axes or particle flow objects * Lepton decays, for τ, μ, and topological differneces * Calorimeter design and comparison of hadronic/electromagnetic shower evolution * Test beam design, data taking strategies, systematic effects, calibration for the IDEA campaign * Linear collider vs. synchrotron in terms of energy, scaling, luminosity, power consumption, beam time structure and implication for detector design |

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| 1. **Basis for recommendation:** |
| All questions answered were given either good or plausible answers, the work described in the thesis is of publishable quality and has been part of articles published by the CLICdp collaboration and the AIDA-2020 EU collaboration. The candidate has been at the forefront of promoting and demonstrating the flexibility and ease with which the DQM4hep package can be adapted to meet the needs of a disparate set of detectors, most notably those of ther vertical slice teset from the IDEA collaboration. It was noted during the viva that there were additional test beams in which the candidate had participated and tested the package, and we encouraged these to be listed in the slightly updated version of the thesis to demonstrate the extent of the impact of his work. |

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| Was an independent chair required for the viva voce examination? | | | |
|  | yes |  | No |
| *If yes, please provide the chair’s comments and feedback on any issues of process or conduct during the examination:* | | | |
| **Name of Chair:** | | | |
| 1. **Chair’s report** | | | |
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**Recommendation of Examiners**

*Please tick the relevant box:*

**Pass Categories (recommendations for the award of PhD)**

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|  | **Unconditional pass**  The thesis is of doctoral quality and may be awarded the degree of Doctor of Philosophy unconditionally. A very small number of minor typographical errors, which can be corrected immediately but do not require checking by the examiners, are permitted.  Tick here to confirm that the candidate has been informed that these typographical corrections must be made in the final version of the thesis submitted to the Research Student Administration Office. |
|  | **Pass with minor corrections**  The thesis is of doctoral quality and will pass pending the completion of minor corrections. This category allows for a period of up to three months (four months and two weeks if the candidate was registered as part-time) during which the candidate may undertake the following types of minor corrections: spelling/typing errors, textual errors, reordering of material, correction of citations, correction of figures, tables and diagrams, and the addition of a small number of paragraphs for clarification or qualification. The criterion for this outcome category is the nature of the corrections requested. The time allowed to complete the corrections is a maximum, and is not a guide to how much work is required. Any request for corrections that goes beyond the kinds specified here requires the selection of outcome 3. The corrections are to be approved by the internal examiner. |
|  | **Pass with corrections**  The thesis is of doctoral quality and will pass pending the completion of a number of more substantial corrections. This category allows for a period of up to six months (nine months if the candidate was registered as part-time) during which the candidate may undertake the following types of corrections in addition to those specified in category 2: more substantial addition of paragraphs, including the incorporation of some new material, reordering and restructuring of chapters, or some additional data analyses. The criterion for this outcome category is the nature of the corrections requested. The time allowed to complete the corrections is a maximum, and is not a guide to how much work is required. This category may be chosen when the examiners have identified deficiencies in the thesis that were adequately compensated for by the candidate’s performance in the viva voce – in this case, please ensure that you have provided adequate documentation in section a) ‘Report on candidate’s performance during viva voce’ above.   The corrections are to be approved by the internal examiner, but may also be sent to the external examiner should that be considered appropriate – **(*tick here if external examiner approval needed* )**. |

**Non-pass Categories (recommendations where the PhD is not to be awarded at this stage)**

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|  | **Major revisions and re-submission for the PhD**  The thesis is not of doctoral standard but may be resubmitted for examination for the award of Doctor of Philosophy. This category allows for a period of up to 12 months (18 months if the candidate was registered as part-time) during which the candidate is required to thoroughly revise their thesis for resubmission, using the guidance set out in the examiners’ joint report. The candidate will be registered on re-submission status for this period. | | |
|  | A further *viva voce* examination may be held if required by the examiners. Note that this decision can only be taken once the revised thesis has been submitted and read by the examiners.  In making a recommendation for major revisions and resubmission, the examiners should be aware that the candidate will be offered the opportunity of accepting the award of the MPhil instead of resubmitting for the PhD. The MPhil may be offered according to one of the three pass categories above, the corrections to be approved by the examiners: | | |
|  |  |  | MPhil unconditionally |
|  |  |  | MPhil with minor corrections |
|  |  |  | MPhil with corrections |
|  | The candidate should be encouraged to discuss the options with their supervisor before deciding whether to resubmit for the PhD or accept the award of MPhil. | | |
|  | **Award of the MPhil**  The thesis is not of doctoral standard and may not be resubmitted for the award of PhD, but the MPhil may be awarded according to one of the three pass categories above, the corrections to be approved by the examiners: | | |
|  |  |  | MPhil unconditionally |
|  |  |  | MPhil with minor corrections |
|  |  |  | MPhil with corrections |
|  | **Fail**  The candidate be failed and not be permitted to revise and re-submit the thesis for examination. | | |

**It is University policy that the joint report of the examiners is released to the supervisor and candidate**

If you do not wish this report to be released to either the supervisor, the candidate, or both, please state this below and outline the reasons why:

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**Corrections**

In the case of corrections (options 2, 3, or 5) please give below any detailed requirements for the correction of the thesis. Pleased provide as full and detailed information as possible in order to assist the candidate in the revision of their thesis.

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| * Detailed comments or a more trivial nature (typos) will be made available online in marked-up .pdf to the candidate and can be made available to exam board on request. * Main requests are   + Give context to DQM4hep by adding a few, short examples of existing test beam monitoring packages in Chapter 2, and commenting on why these are not suitable for wider use – motivate need for DQM4hep.   + References, many more need to be provided and used to support assertions made throughout/   + End of Chapter 4, add a 6x6 'heat map' type plot, showing mean ADC value from the gaussian fit as the z axis, and comment on the results, is there a pattern that could suggest it is related to leakage or the 'cone pattern' of the detectors (green square in Fig.)?   + Related to this and following your suggestion in the viva, recommend that you add this as a monitoring module, and use the fact that this was done quickly to illustrate how easily the DQM4hep architecture allows such an addition to be made. This would be a good way to end the chapter too.   + Chapter 4, add plot showing ADC distribution per tower and run, to complement plots of the mean value of these per tower that are already included.   + Chapter 5, check the content of Fig. 5.9, is this the correct plot? |

**Revise and re-submit**

In the case of a revise and re-submit recommendation (option 4) please give below any detailed requirements for the revision of the thesis in order for the candidate to receive a PhD or MPhil, respectively.

**PhD revisions**

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**MPhil revisions**

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*If corrections or revisions are marked in copies of the thesis, please confirm in the appropriate section above that you have returned those copies to the candidate.*

*Please ensure that any corrections are also listed in the appropriate section above.*

Please provide any general comments you may have on the examination process, or how it might be improved, below:

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| Examination process overall very smooth. The efficiency of dispatching the hard copy of the candidate’s thesis was exemplary, one of the most efficient I have come across and **vastly** more effective than my home institute where there can often be delays of several weeks between candidate submission of bound copies to these being sent to examiners.  The communication with the research admin. has been excellent, very pragmatic and good and keeping examiners informed about procedures, forms and deadlines.  The only negative feedback is the insistence on treating examiners as Univ of Sussex employees and therefore requiring ‘right to work’ evidence. As noted, this evident may not always be available on the day, their default retention schedules are disproportionately long, and most importantly, as the external examiner is invited to take part due to their position, usually holding a permanent post in another UK university, it seems illogical to then require evidence as requested, as this implies that the examiner’s employer has not established this on an ongoing basis. I suggest that you consider treating external examiners for PhD candidates as selt-employed, if this helps. For reference, I was an external PhD examiner in Cambridge in June and no such checks were required. |

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| Internal Examiner Signature |  | Date |  |
| External Examiner Signature |  | Date |  |
| Third Examiner Signature |  | Date |  |

*Once completed, please return to the Research Student Administration Office*