THESIS SUPERVISOR'S REPORT

I. IDENTIFICATION DATA

Thesis title:	Leptoquark Search Using Machine Learning in the Multilepton Channel with ATLAS Run-2 Data
Author's name:	Ondrej Matousek
Type of thesis:	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Measurement
Thesis reviewer:	doc. Dr. André Sopczak
Reviewer's department:	IEAP CTU in Prague

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	**challenging**

The project was challenging for different reasons: 1) while Leptoquarks are theoretically predicted, they are not part of the Standard Model of particle physics. In particular, the investigated model is novel, and production and decay modes had to be understood; 2) provided simulated data had to be prepared for further analysis and a new software release was used; 3) the challenge for the ML development was to test a range of deep learning models 4) and to determine the expected detection sensitivity with specific statistical tools.

Fulfilment of assignment	**fulfilled**

All tasks have been fulfilled. The thesis demonstrates a good understanding of the underlying process of the Leptoquark production and decay. The provided simulated data was prepared for the ML application. Different ML were developed to detect the specific signature, separating it from a large set of different background processes. All technical aspects were solved. To demonstrate the performance of the developed ML algorithm and its optimization, besides the standard indicators, also the expected detection significances were determined. A feature importance study was included. A direct comparison with previous results was not possible, as the signal model is novel, however, compared to previous models, similar sensitivities were achieved.

Activity and independence when creating final thesis	**A - excellent.**

Throughout the whole thesis project, the student had a very positive approach, keeping time limits very well and followed regular consultations and presented constantly progress being well prepared. The student has taken initiatives to improve the analysis based on literature research and has a very good ability to perform independently research.

Technical level	**B - very good.**

The development of the ML algorithms has been well executed, and the thesis documents this. The programming skills are very good and technical challenges have been addressed efficiently. Further documentation would have been useful.

CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS SUPERVISOR'S REPORT

Formal level and language level, scope of thesis	**A - excellent.**
The thesis has been written in a high standard, notations are well explained, and also a reader who is not familiar with the topic can follow the analysis. The thesis is logically very well organized and the technical details are explained sufficiently. The language meets high standards in correct scientific English.	

Selection of sources, citation correctness	**B - very good.**
The thesis provides adequate references to earlier work on the topic, and the selection of sources is adequate. The student's work is clearly distinguished from previous work in the field. The citations meet the standard.	

Additional commentary and evaluation (optional)
The quality of the thesis result is very good, the goal to use the new software release with better calibration has been successfully accomplished. Compared to previous results with the old software release, the performance seems limited by the smaller set of features. The student worked very well together in an international environment and skillfully addressed technical challenges. The student also took the possibility to present his results at the German Physical Society meeting in Goettingen in the student session. The student answered questions after his presentation.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

The student worked independently and made continuous progress. He presented his progress in group meetings and at a Meeting in Germany, and he discussed it appropriately. The thesis is well written and easy to follow. All technical challenges have efficiently been solved. The ML algorithms performed well, and optimizations were included. The results are sound, and the software is useful for future developments.

The grade that I award for the thesis is **A - excellent.**

Question:

Table 5.4 and ranking plots (Figs. 5.23 to 5.26): The process is symmetric with respect to electric charge, how can the charge be a useful feature? Similarly, the ATLAS detector is rotationally symmetric, how can the _phi features contribute?

Date: **28.5.2025** Signature: