Second Semester Report

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1 Introduction

This semester has been very productive in my PhD journey. It was marked by challenging coursework, participation in advanced schools, and focused research.

2 Courses

I completed two PhD-level courses at ELTE this semester.

2.1 Experimental methods in particle physics

This was my first introduction to experimental particle physics. While I found it challenging, I also found it fascinating and it is essential for a career in particle physics phenomenology. The course covered particle accelerators and detectors. I achieved a *Satisfactory* grade which is lower than I had hoped, but understandable given my lack of prior exposure.

2.2 Jet physics in hadron-hadron and in heavy ion collisions

This course covered the theoretical side of jet physics in both hadron-hadron and in heavy ion collisions. For the final exam, I gave a presentation on the *Proton Spin Crisis*, an ongoing puzzle in particle physics. Although significant progress has been made, it remains unresolved. I received a grade of *Excellent*.

3 Schools

I attended two different advanced schools this semester.

3.1 CAPP School

I attended the CAPP school in March 2025 at DESY, Hamburg. It was an intensive program on computer algebra applications in particle physics, combining theoretical lectures with hands-on practical exercises using modern computational tools. The courses covered FORM, Feynman Integrals, Mathematica, FeynArts, FormCalc, Multi-loop Feynman Diagrams and Symbolica. The

hands-on exercises significantly improved my computational skills and deepened my understanding of advanced computer algebra methods in theoretical physics.

3.2 MCnet school

I attended MCnet in June 2025 at Stirling University in Scotland. It focused on Monte Carlo event generation and parton shower algorithms. This was directly related to my field of research and was therefore very relevant. The lectures covered Monte Carlo event generators, parton showers, Monte Carlo event analysis, neutrino interactions, electroweak physics, machine learning, matrix-element/parton shower matching and merging, and Heavy-Ion Monte Carlo. The tutorials covered using PYTHIA to generate the evolution of hard processes into complex multi-hadronic final states. We also covered how to write a simple parton shower algorithm from scratch. Discussion sessions were also held every evening with experts in the field, allowing us to deepen our understanding of the topics.

4 Research

My research this semester was focused on understanding several different phase-space mappings used in subtraction schemes. I studied

- The FKS mapping [3], a general subtraction scheme for massless momenta involving boosts.
- A DIS specific modification to FKS [2] that keeps the lepton momenta invariant.
- A massive generalisation of the Catani-Seymour phase-space mapping [1].

I have been developing a specific combination of these mappings for the implementation over the summer. To validate this, I am using a Monte Carlo integrator written in Fortran 90 to numerically compare the mapped and unmapped phase spaces.

5 Conclusion

Overall, this semester has been a success. I stepped outside my comfort zone, broadened my expertise, and made progress toward becoming a more well-rounded physicist. I have also gained momentum in my research and feel well-prepared for a productive summer and third semester.

References

[1] Paolo Torrielli Gloria Bertolotti, Giovanni Limatola and Sandro Uccirati. Advances in local analytic sector subtraction: massive nlo and elements of nnlo automation. 2025.

[2] Paolo Nason Luca Buonocore, Giovanni Limatola and Francesco Tramontano. An event generator for lepton-hadron deep inelastic scattering at nlo+ps with powheg including mass effects. 2024.

[3] Paolo Nason Stefano Frixione and Carlo Oleari. Matching nlo qcd computations with parton shower simulations: the powheg method. 2007.