

CERN



SUMMER STUDENT PROGRAMME 2023

รายงานการเข้าร่วมโครงการนักศึกษาภาคฤดูร้อนเซิร์น

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PHYSICS CLASSIFICATION WITH GRAPH NEURAL
NETWORKS IN $2L(SS) + 1\tau_{had}$ CHANNEL
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จุฬาลงกรณ์มหาวิทยาลัย

CERN Summer Student Program 2023 Report

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Foreword

This report serves as a comprehensive overview of the CERN Summer Student Program, detailing its academic and extra-academic components through the perspective of my participation. One of the key elements of this document is an extensive daily log, which chronicles my activities and experiences throughout the duration of the program. This section may prove particularly useful for future Thai students considering participation, as it includes tailored advice and observations.

The main body of the report focuses on the structure of the program itself, detailing the various workshops, lectures, and hands-on opportunities it offers. It also elaborates on my specific research contributions during my time at CERN, providing an example of the substantive work that can be conducted within the confines of a summer internship.

While the primary emphasis of this report is on the academic aspects of the program, it also covers the range of extra-academic activities and community events that contribute to the overall experience at CERN. These elements, although not directly related to the primary academic objectives, enrich the learning environment and offer a well-rounded experience.

This report aims to provide a balanced and thorough account of the CERN Summer Student Program, touching upon both the educational and the experiential aspects. Whether you are a student contemplating future participation, a researcher interested in the program's structure, or a general reader intrigued by the world of particle physics, this report strives to offer valuable insights.

Acknowledgment

I would like to express my deepest gratitude to a number of individuals who have been instrumental in making my journey to Switzerland and my time at CERN an enriching experience.

First and foremost, I extend my heartfelt thanks to Her Royal Highness Princess Maha Chakri Sirindhorn. Her generosity and support were instrumental in making my journey to Switzerland and my time at CERN a reality. I am truly honored and humbled by this opportunity. Furthermore, I would like to express my gratitude to Program Management Unit for Human Resources & Institutional Development, Research and Innovation (PMU-B) as well for the indispensable financial support. I extend my sincere thanks to Dr. Nello Bruscinò and Professor Simonetta Gentile, my esteemed supervisors at CERN. Their invaluable guidance and mentorship have been pivotal in shaping my research and enriching my understanding of the field. I am equally grateful to Professor Norraphat Srimanobhas for his guidance and for extending his hospitality to me during my time at CERN. His insights and warmth have been a constant source of inspiration and comfort. My thanks also go to Ana Dordevic, the Non-Member State Summer Student Coordinator at CERN, whose support and assistance have been crucial in navigating the intricacies of the program. Lastly, but by no means least, I would like to express my heartfelt appreciation to my fellow summer students, the Thai researchers at CERN, and everyone else I have had the pleasure of meeting during this journey. Your companionship and collaboration have made this an experience I will treasure for years to come.

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1 CERN Summer Student Program 2023

1.1 Overview

CERN, the European Organization for Nuclear Research, stands as a beacon of scientific exploration, particularly in the domain of particle physics. But its reach extends beyond just physics. CERN has also made its mark in the technological realm, most notably with the inception of the World Wide Web, designed originally as a data-sharing tool for researchers and has revolutionized the modern world. This establishment brings together not only physicists, but also engineers, computer scientists, and mathematicians. Together, they collaborate to expand our understanding of the universe.

The CERN Summer Student Program serves as a bridge for university students in the fields of Physics, Engineering, Computer Science, and Mathematics to immerse themselves in a genuine research setting. Participants of the program work on distinct projects for eight to thirteen weeks under the mentorship of CERN researchers. The overarching goal is to mold the forthcoming generation of researchers and visionaries, equipping them with the essential tools for future discoveries and problem-solving. Besides hands-on research, the program incorporates a series of lectures. These sessions, delivered by eminent professionals, cover an array of subjects from fundamental physics principles to recent and future developments in Particle Physics, computing, and engineering. Further enriching the program are workshops that offer a practical learning approach, providing students with tools that are vital in a research context. Moreover, participants have a chance to visit CERN's state-of-the-art research facilities, granting them a firsthand look into the world of advanced scientific research. Outside the program, students have opportunities to attend regular seminars, converse with researchers inside CERN, connect with fellow students, and have a good time together.

1.2 Summer Student Research Project

Every participant in the Summer Student Program is paired with a supervisor to collaborate on a research project that aligns with both the student's and the supervisor's interests. The spectrum of available projects is incredibly diverse, encompassing areas such as:

- Advanced data analysis and simulation in Particle Physics
- Development and examination of innovative materials for Future Particle Colliders
- Enhancement and study of control systems in scientific instruments
- Software development for various applications from data analysis to improvement of accessibility of data and knowledge

To facilitate these projects, students are granted access to CERN's High-Performance Computing resources, designed for tasks that require substantial computing power or data processing capabilities. Participants will have the chance to showcase their findings through various avenues, including departmental presentations and the **publicly-accessible CERN website**, where final reports will be published.

Student Session Presentation

The **Student Session** is an exclusive three-day event held in early August. Here, a select number of students—limited to 30 on a first-come, first-served basis—can present their ongoing research to their peers. Each presentation is structured to be ten minutes long, followed by a five-minute Q&A session. The opportunity is open to all summer research projects, irrespective of their focus.

Poster Session

The **Poster Session** offers an alternative platform for students to display their research, using A0-sized posters that are exhibited in a corridor adjacent to the main auditorium. Like the Student Session, this event has a cap of 30 participants and offers a more interactive way for viewers to engage with the students' work. Poster design is left to the students' creativity, and printing costs are covered by the program.

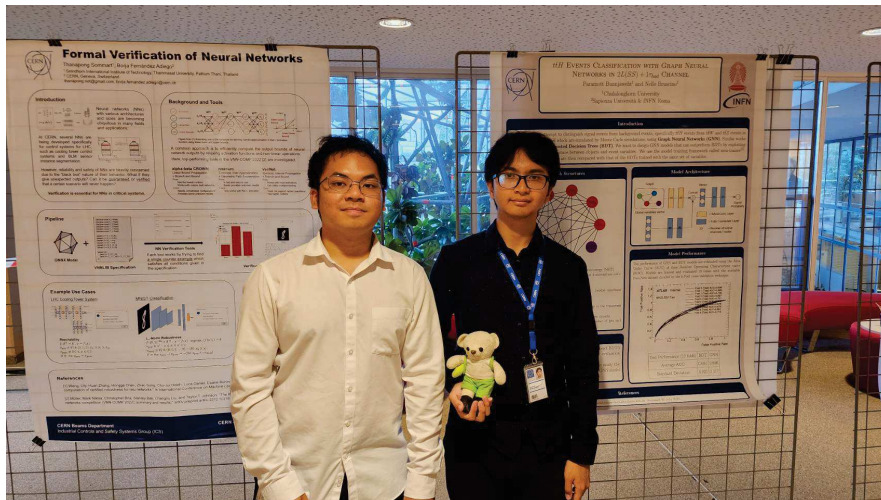


Figure 1: Net and I in the Poster Session

1.3 Lectures in the Summer Student Program

The Summer Student Program boasts a rich lecture series that spans a wide array of topics, from Theoretical and Experimental Particle Physics to Cosmology, Nuclear Physics, and Astroparticle Physics. These also include specialized topics like accelerator engineering, Statistics, and even applications in medical research. The lectures aim to be universally accessible, catering to students from diverse academic backgrounds. Conducted by field experts, including notable figures like David Tong from the University of Cambridge, these lectures are scheduled for weekday mornings over a five-week period. While attendance is optional, all students are encouraged to participate. The full lecture schedule and materials are available [here](#).

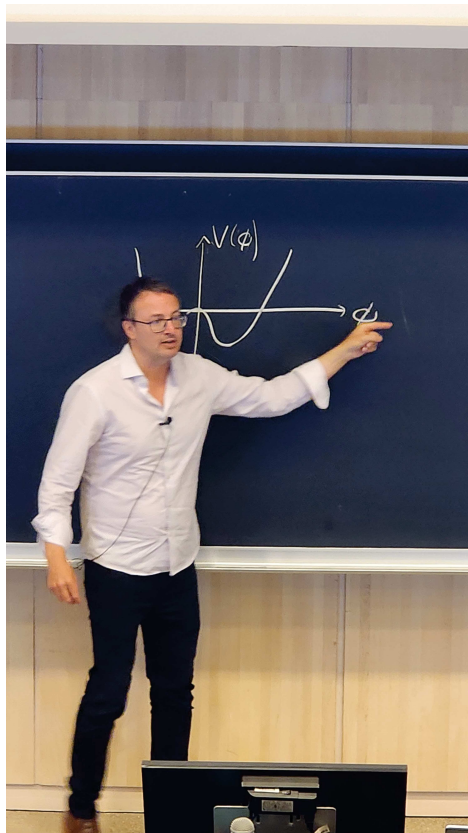


Figure 2: David Tong, known for writing really good lecture notes in Physics.

In tandem with the morning sessions, CERN Openlab also hosts afternoon lectures that are specifically focused on Information Technology and Computer Science. Topics often covered include Artificial Intelligence and Deep Learning, and some sessions offer hands-on programming workshops. Though these lectures are primarily designed for the Openlab Summer Student Program, all participants in the CERN Summer Student Program are welcome to attend. The lecture topics and additional resources can be accessed [here](#).

1.4 CERN Facilities Visits

The CERN Summer Student Program includes guided tours to several key facilities, which complement the theoretical and practical training provided in lectures and workshops. These tours offer students an opportunity to gain insight into the operational aspects of CERN's large-scale experiments and computational infrastructure.

CERN Data Center

This facility serves as the epicenter for data storage and computational tasks at CERN. Housing an impressive array of servers and storage units, the Data Center is integral to the institution's research endeavors. The storage section utilizes both tape libraries and disk storage to archive the colossal amount of raw data generated by experiments. This archival process is meticulous, ensuring that data integrity is maintained for future analysis. In the computational section, a network of high-performance servers undertakes the formidable task of data processing. These servers run specialized algorithms to sift through the raw data, extracting pertinent information that researchers can subsequently utilize. This setup is engineered for both speed and resilience, capable of handling large volumes of data in an efficient manner.



Figure 3-4: Many processing units toiling away in the Data Center

Antiproton Decelerator

The Antiproton Decelerator is a linchpin in CERN's roster of experimental facilities. The lab operates under a unique premise: instead of accelerating the particles (antiprotons), it decelerates them. The facility captures high-energy antiprotons, then exploits a combination of magnetic and electric fields to slow them down to energies ideal for experimentation. The decelerated antiprotons are then distributed to an array of sub-experiments. These include ATRAP, ALPHA, ASACUSA, and AEgIS, each having its own specific research focus. For example, ATRAP and ALPHA aim to trap antihydrogen atoms to study their properties in detail, while ASACUSA focuses on high-precision measurements of the antiproton mass and charge. AEgIS, on the other hand, is designed to measure the effect of gravity on antimatter.



Figure 5-6: The Antiproton Decelerator facility

ATLAS Control Center

Serving as the operational hub for one of the largest particle detectors at CERN, the ATLAS Control Center is a testament to the complexity and precision required in modern particle physics. Here, scientists and engineers monitor the ATLAS detector's performance, manage data acquisition, and troubleshoot any issues in real time. Upon entering the control center, one is immediately struck by the array of monitors displaying a myriad of data, ranging from detector statuses to real-time event displays. These monitors are the windows through which experts keep tabs on the health and efficacy of the ATLAS experiment. The center is typically staffed by a diverse group of experts, including physicists, engineers, and computer scientists. They work in shifts to ensure 24/7 monitoring of the experiment, especially during active data-taking periods. Teamwork is crucial, as the complexity of the experiment often requires interdisciplinary problem-solving.

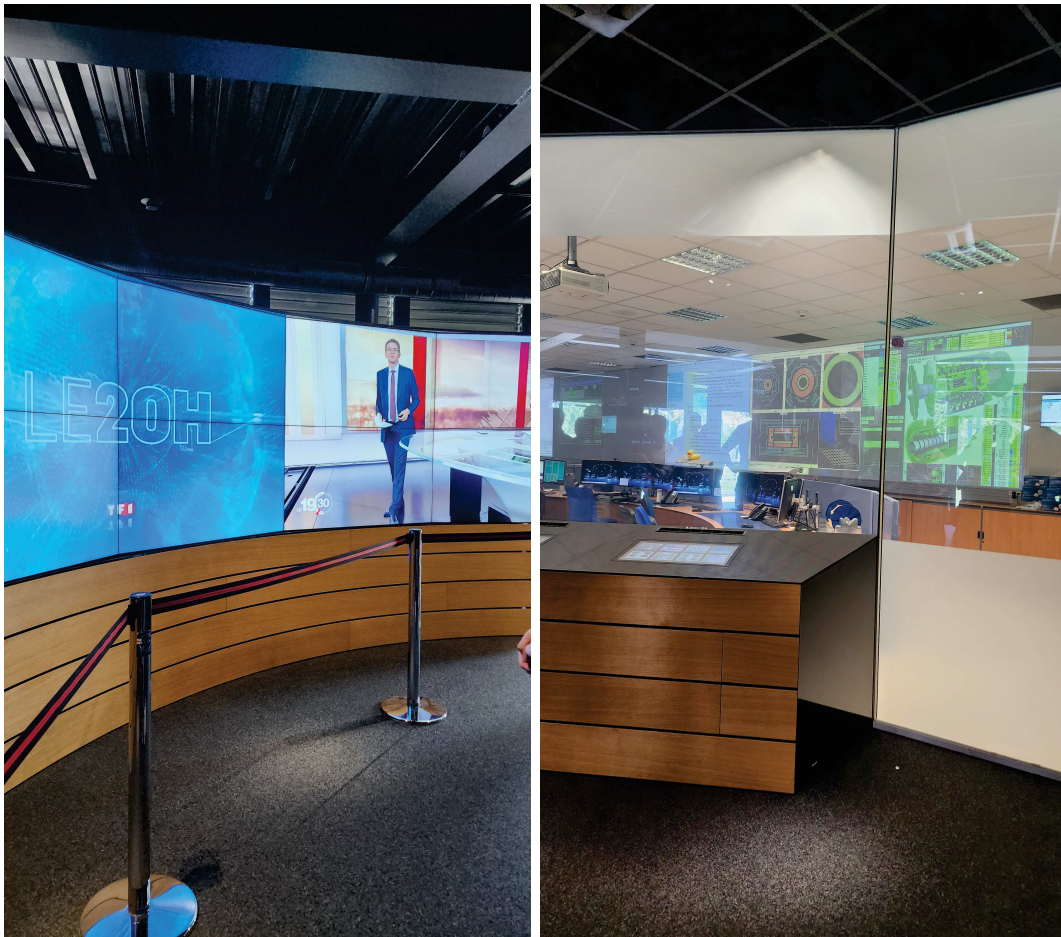


Figure 7-8: The ATLAS Control Center and one of its exhibitions

Synchrocyclotron

This facility houses CERN's first accelerator, which started operating in 1957. The machine was decommissioned in 1990. Now serving as an educational exhibit, the Synchrocyclotron provides a glimpse into the early phases of particle acceleration technology. Upon entering the facility, visitors encounter the original machine with its large magnet and older hardware. It is an informative contrast to the more advanced accelerators used in contemporary experiments. Though less advanced than its successors, the Synchrocyclotron represents an important stage in the development of particle physics. It serves as a reminder of the continuous progress in the field, each new advance building on previous work.

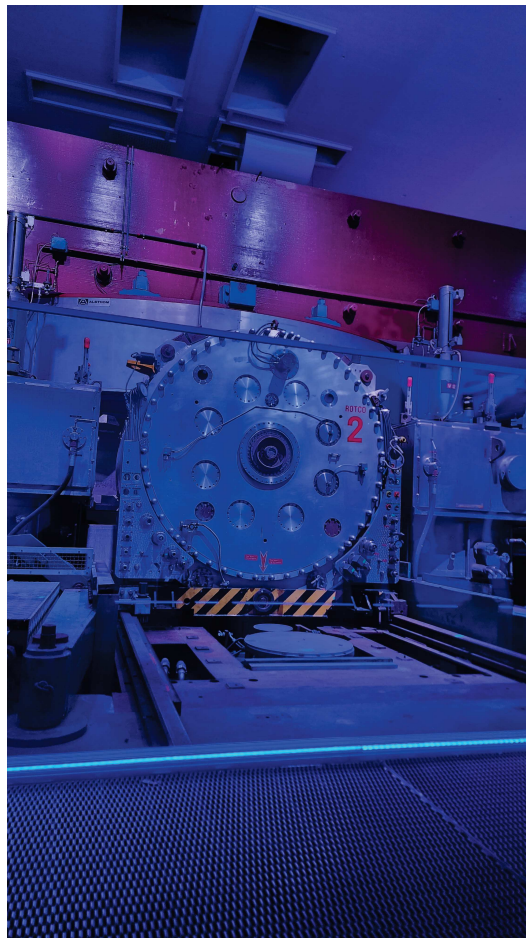


Figure 9: The Synchrocyclotron

While the visits to the facilities mentioned above are arranged by the program, summer students may arrange for visits to other facilities in CERN as well. I had an opportunity to visit ISOLDE.

ISOLDE (Isotope mass Separator On-Line facility)

This facility is a unique source of low-energy beams of exotic isotopes—rare forms of atomic nuclei. ISOLDE plays a pivotal role in multidisciplinary research, from fundamental physics to life sciences. The facility hosts an array of sub-experiments such as COLLAPS (Collinear Laser Spectroscopy At Proton Separator), which aims to measure the nuclear charge radii and electromagnetic moments of isotopes, and CRIS (Collinear Resonance Ionization Spectroscopy), which investigates the properties of exotic isotopes. These sub-experiments utilize the isotopes generated at ISOLDE for various forms of cutting-edge research. Adjacent to ISOLDE is the MEDICIS facility, dedicated to medical research with radioisotopes. It exemplifies how particle physics research can have broad applications, even if the focus at ISOLDE is not medical.

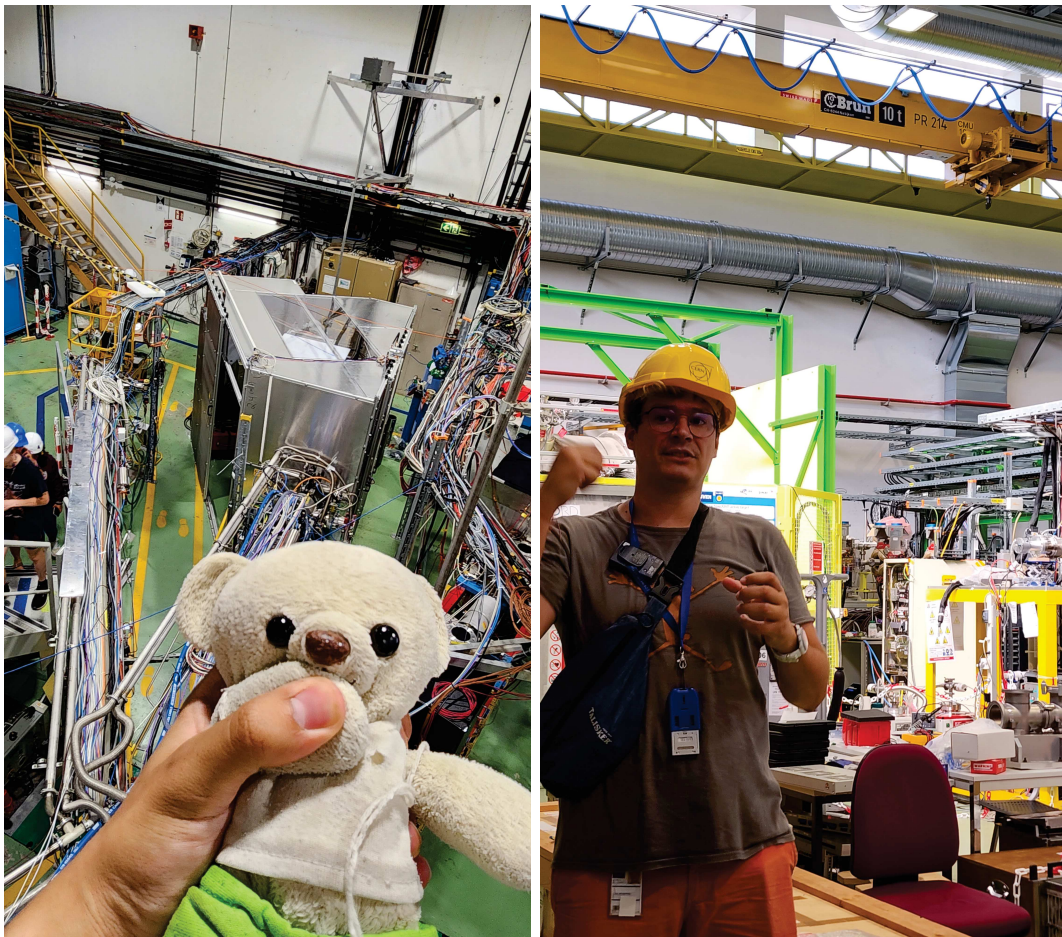


Figure 10-11: ISOLDE Facility

1.5 Workshops at the Summer Student Program

The program offers an engaging line-up of specialized workshops, each crafted to provide students with hands-on experience in their field of interest. Due to the high demand and limited availability, registration slots for these workshops often fill up within mere seconds. The workshops themselves vary in their approach and focus: some are programming-centric, offering a more generous number of slots, while others are geared toward providing physical interactions with specialized scientific equipment, limiting the number of participants to just 10 or fewer per session. Personally, I was able to secure a spot in the "ROOT Summer Student Workshop" as well as the "Hands-on Workshop with Open Data," but had to forgo other intriguing options due to their quick-to-fill nature. The roster of workshops is subject to change each year, though some are recurring mainstays. For a comprehensive list of past and current workshops, you can refer to **this website**.

1.6 Additional Activities

In addition to research and academic events, CERN also offers a range of extra activities for summer students, who are considered full members of the CERN community. Regular seminars are organized on various topics, and students are notified by email so they can attend these informative sessions.

CERN also offers a variety of clubs that cater to different interests outside of the academic realm. Whether it's the Jazz Club for music lovers or the Fitness Club for those looking to stay active, there's something for everyone. I frequently took part in the Games Club activities, which hosts a board games session every Sunday. While some clubs require a small membership fee, it's generally quite affordable, especially when compared to the stipend received by summer students.

Social activities are also a big part of life at CERN. Summer students often organize weekend trips and are even allowed to host parties on CERN property. Official CERN organizations also hold social events, providing opportunities for students to meet and network with other members of the CERN community. To help new students get acquainted, the Summer Student Program organizes a Welcome Drink Party in early July, offering a friendly setting for students to meet each other.

2 Project: $t\bar{t}H$ Events Classification with Graph Neural Networks in $2L(SS) + 1\tau_{had}$ Channel

2.1 Introduction

Some of the problems of particle physics demand an optimal distinction between the null hypothesis (described by a "signal" sample) and the alternative one ("background" sample). Algorithms have been created to automatically perform the task by directly analyzing high-level information such as the 4-momentum of all the objects produced, for instance, by proton-proton collisions at the Large Hadron Collider (LHC), and properties of specific objects like the b-tagging score of the hadron jets. Among these are machine learning algorithms that are first "trained" on data under two or more known hypotheses (aka, supervised mode). Examples are Decision Trees (with subsequent improved counterparts such as Boosted Decision Trees (BDTs)) and Artificial Neural Networks (ANNs).

In this project, we aim to test new machine learning algorithms (Graph Neural Networks) to improve the performances of the current $t\bar{t}H$ analysis carried by the ATLAS Collaboration at a center-of-mass energy of 13 TeV. We focus on the final state (channel) with two lepton same-sign plus one hadronic tau lepton. Precisely, the processes that we study are:

- The production of a Higgs Boson with a top quark pair ($t\bar{t}H$) as signal
- The production of a W Boson with a top quark pair ($t\bar{t}W$) as background
- The production of a Z Boson with a top quark pair ($t\bar{t}Z$) as background

We attempted to design a Graph Neural Networks (GNNs) model that exploits the relational structure of variables in form of a graph to distinguish signal events from background events with performance possibly exceeding that of BDTs. In this project, we trained and compared the performance of BDTs, Fully Connected ANNs and GNNs.

2.2 Variables and Graph Structure

A collision event and its subsequent analysis produce data about the properties of the objects. In the events we studied, there are 14 objects considered, 10 of which are hadron jets ¹, 2 are light leptons, 1 for a tau lepton and 1 being "Missing Energy in the transverse plane (MET)", indicating the portion of energy missing from the observation, supposedly carried by undetected particles like neutrinos. All objects apart from MET have at least 4 variables specifying their 4 momentum (E, p_T, ϕ, η), namely energy, transverse momentum, polar angle and pseudorapidity (amounting to 52 variables). In addition:

- Every jet provides a variable for its b-tagging ² score;

¹There are events with less than 10 jets, the variables of the "placeholder" jets are set to zero. There are also events with more than 10 jets, the variables of such jets will not be used in classification

²The b -tagging score is the output of a multivariate classifier trained to distinguish jets originated from b -quarks w.r.t. jets from c - or light-quarks

- Every light lepton contains information on its charge and type in a single variable;
- The tau lepton contains a variable specifying its charge;
- MET contains 5 variables: The energy missing in the transverse plane of the event and its transverse plane angle, the invariant mass of leptons and the missing object, the invariant mass in the transverse plane of leptons and the missing object, and the invariant mass in the transverse plane of the first lepton and the missing object.

There are also variables that describe the relationship between each object;

- 45 variables are the angular distance between 2 jets, defined by $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$
- 20 variables are the distance between a jet and a light lepton
- 10 variables are the distance between a jet and the tau lepton
- 2 variables are the distance between a light lepton and the tau lepton
- MET has one variable in relation to the jet with the highest transverse momentum, being the difference of transverse angle.
- For the light leptons pair, these are the distance between the two leptons, the sum of their invariant mass and the transverse momentum of two leptons.

These variables form a graph consisting of objects or “nodes” linked together by “edges”, with object variables prescribed to each node in the form of a vector called node attributes and relational variables acting as edge attributes.

On top of these, there are variables that do not belong to any object or form a connection between two objects, called “global variables”. This includes variables such as the number of jets produced, the maximum pseudorapidity, and so on.

In total, there are $60 + 81 + 18 = 159$ variables.

2.3 Learning Algorithms

2.3.1 Boosted Decision Trees

Decision Trees are a popular machine learning algorithm that operates by making decisions based on asking a series of questions. By evaluating the features of data, they recursively split the dataset into subsets, aiming to achieve subsets (or leaf nodes) where all data points belong to a single class or have a similar value. Boosted Decision Trees enhance the basic decision tree algorithm by building an ensemble of trees in a sequential manner. In BDTs, each data point in the dataset is assigned a weight, and after each tree is built, these weights are adjusted to emphasize the points that were mis-classified by the previous tree. This ensures that subsequent trees in the sequence focus more on the harder-to-classify examples. The final prediction is a weighted combination of the predictions from all individual trees,

leading to a more accurate and robust model compared to a single decision tree. Decision trees are intuitive, interpretable, can capture non-linear relationships, and typically require less data to achieve a good performance compared to training an ANNs model.

2.3.2 Artificial Neural Networks

An Artificial Neural Networks (ANNs) model is, in essence, a composite function consisting of a succession of mathematical operations or layers applied to data points, with the final output being interpreted according to the intended usage. In the context of binary classification, an ANNs model transforms the input data into a number to be interpreted as the probability, or the model's confidence, that the object (in our case the event) containing this particular data point belongs to a class of objects (signal events vs background events). The simplest ANNs models are a stack of "Fully Connected" layers; matrix multiplication acting on an input data vector and non-linear "activation" functions applied element-wise to the resulting vector. ANNs models are normally trained using the Gradient Descent method, which allows all parameters in a model (for example, matrix elements in layers) to be tuned at once, improving the model.

2.3.3 Graph Neural Networks

Graph Neural Networks (GNNs) models are a class of ANNs where the input data is in the form of graphs. A graph with N nodes, each node having a d -length feature vector, can be mathematically represented by an adjacency matrix $A = [a_{ij}]_{N \times N}$, an $N \times N$ matrix which characterizes the connections between node i and node j (equals 1 if connected, 0 otherwise), and a "feature matrix" $F = [f_{ij}]_{N \times d}$ which contains data for each node. A layer that processes the input graph takes into account both the adjacency matrix and the feature matrix. To retrieve the signal probability of an event, The graph and its information have to be reduced in an operation called a pooling layer that aggregates the data present together, into either a smaller graph or down to a single vector, which can be processed further by Fully Connected layers to retrieve the final output. The actual form of the graph designed is heterogeneous, meaning there are different types of nodes and edges, allowing for a more flexible arrangement of variables in a graph but the computation is more complex.

2.4 Methods

We trained a BDTs model, a vanilla ANNs model (consisting only of Fully Connected layers) and a GNNs model using the same set of variables to classify the events. The samples used are data generated by Monte Carlo simulations from various frameworks.

We used mva-trainer, a machine learning model training framework. We can create a model by making a configuration file containing the variables used as the model's inputs, the samples used, and the model's architecture. In the case of Graph Neural Networks, the graph structure of the variables involved must be specified. This includes specifying nodes,

Events	Number of MC events
$t\bar{t}H$	24093
$t\bar{t}W$	6947
$t\bar{t}Z$	11437

Table 1: The number of Monte Carlo (MC) events in each event type.

feature vectors belonging to each node, edges connecting pairs of nodes, and edges feature vectors.

The architecture of the GNNs model is described as follows: An input graph is passed through a layer of GATConv (Graph Attention Convolution) which processes both the node attributes and edge attributes together and outputs a graph with the same structure but with transformed node attributes with a length of 10 each. Afterwards, the graph is passed into a pooling layer where all nodes' attributes are used to compute a vector which is the average value of them, reducing the graph into a single vector. Since the graph is heterogeneous, 4 different types of nodes (Jets, Leptons, Tau, MET) are passed into separate GATConv layers and are pooled separately and so there are 4 vectors of length 10 in total. Global attributes form a vector that is transformed by a single Fully Connected layer from 18 input variables to 10 output variables. The resulting vectors are directly concatenated, forming a vector of length 50 which is then passed into 2 Fully Connected layers, resulting in a single number describing the probability that an input event is a signal event.

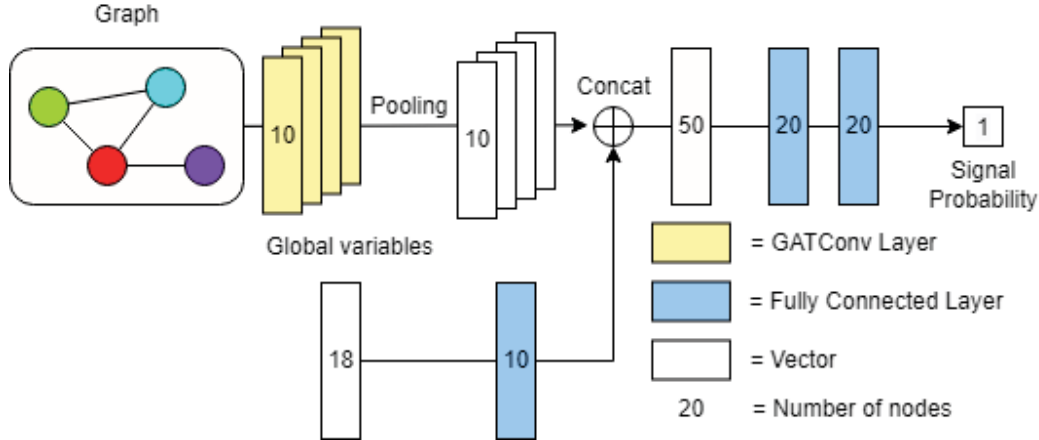


Figure 1 : The GNNs architecture used

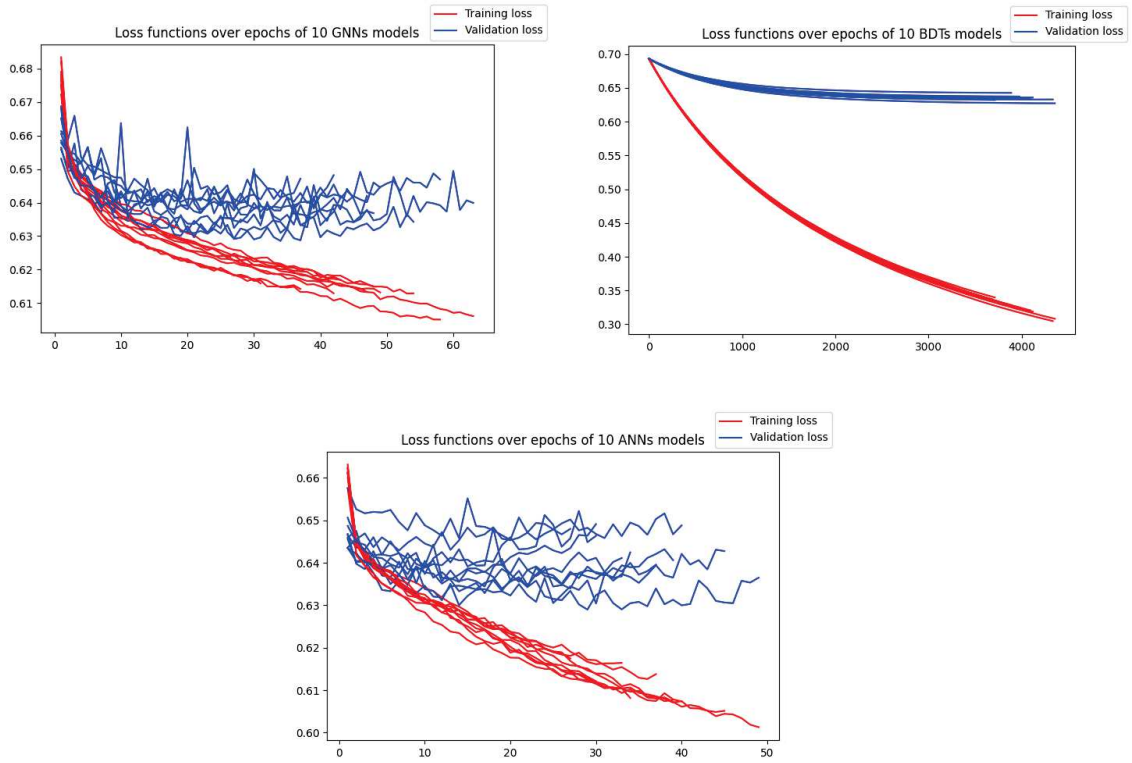
The model uses Rectified Linear Unit (ReLU) function as an activation function for every single layer except in the final layer where the sigmoid function is used instead. In training, the model is optimized with the Nadam algorithm using Binary Cross-entropy as the loss function with a learning rate of 0.002. In each training step, 200 events are processed in a batch before the model's parameters are optimized. 20 percent of the available events are set aside as validation dataset excluded from being used to train the model.

For the BDTs model, the model contains from 3000 to 4000 trees (depending on when the training performed early stopping), with the maximum tree depth of 10 and is trained using Binary Cross-entropy loss function with a learning rate of 0.001.

For the ANNs model, the model is made of 3 layers of 20 nodes Fully Connected layers with ReLU function as an activation function and a final 1 node Fully Connected layer with Sigmoid function as the activation function. The model is trained using Binary Cross-entropy loss function with a learning rate of 0.002.

2.5 Performance Evaluation

Models are trained and evaluated 10 times with the available train/test dataset divided by the k-Fold cross-validation technique.

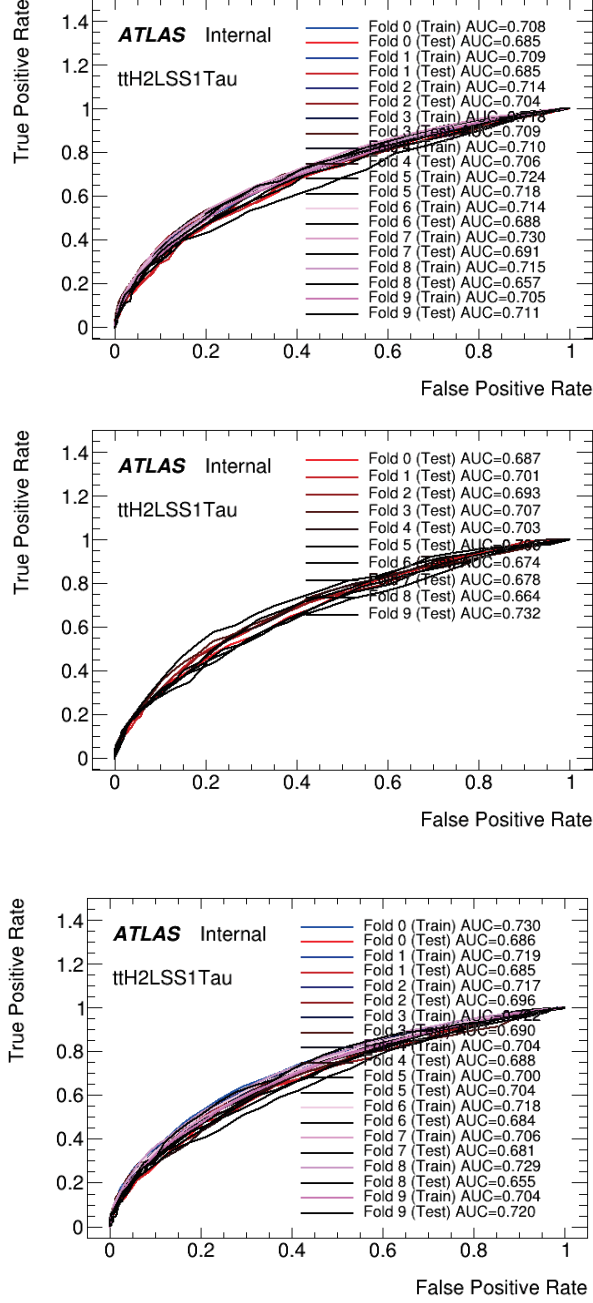


Figures 2-4 : Graph showing the loss function of GNNs, BDTs and vanilla ANNs models, respectively

It appears that overfitting becomes apparent early on in the training. The validation loss functions of all models across three model types are roughly at the same level.

To gauge a model's performance, we look at the Area Under Curve (AUC) of the Receiver Operator Characteristics curve (ROC). The ROC curve characterizes the rate of correctly

predicting signal events (true positive) the model would achieve by allowing incorrect signal prediction as background events (false positive) at a rate. The higher the AUC, the better the model is.



Figures 5-7: Graph showing the ROC curves of GNNs, BDTs and vanilla ANNs models, respectively

	GNNs	BDTs	ANNs
Fold 1	0.685	0.687	0.686
Fold 2	0.685	0.701	0.685
Fold 3	0.704	0.693	0.696
Fold 4	0.709	0.707	0.690
Fold 5	0.706	0.703	0.688
Fold 6	0.718	0.706	0.704
Fold 7	0.688	0.674	0.684
Fold 8	0.691	0.678	0.681
Fold 9	0.657	0.664	0.655
Fold 10	0.711	0.732	0.720
Average	0.695	0.694	0.689
S.D	0.018	0.020	0.017

Table 2: The AUC of models evaluated using the test dataset.

2.6 Conclusion

We found that the Graph Neural Networks’ performance does not significantly improve from the Boosted Decision Trees. It is unclear how we can improve a model’s performance, but it is likely that increasing the number of the samples will improve GNN’s performance which normally require a large amount of data to outperform BDTs and other traditional machine learning methods.

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2.7 Poster



$t\bar{t}H$ EVENTS CLASSIFICATION WITH GRAPH NEURAL NETWORKS IN $2L(SS) + 1\tau_{had}$ CHANNEL

Paramott Bunjaweht¹ and Nello Bruscano²

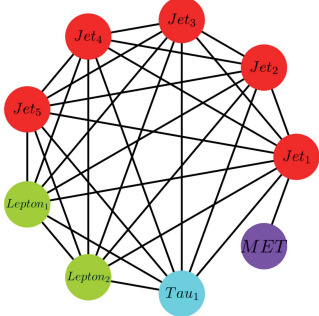
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Introduction

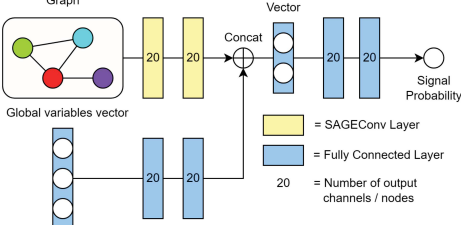
In this work, we attempt to distinguish signal events from background events, specifically $t\bar{t}H$ events from $t\bar{t}W$ and $t\bar{t}Z$ events in $2L(SS) + 1\tau_{had}$ channel which are simulated by Monte Carlo simulations, using **Graph Neural Networks (GNN)**. Similar works have been done using **Boosted Decision Trees (BDT)**. We want to design GNN models that can outperform BDTs by exploiting the underlying graph structure between objects and event variables. We use the model training framework called mva-trainer^[1]. The performance of GNNs are then compared with that of the BDTs trained with the same set of variables.

Graph Structures



Nodes: 5 jets, 2 leptons, 1 tau and missing transverse energy (MET)
Node Features: Jet, Lepton, and Tau nodes contain 4-momentum information. In addition to them,
 • Jets also contain the b-tagging score.
 • Leptons also contain Lepton type, charge and Jet - Lepton minimum distance
 • Taus also contain Charge
 • While MET contains only the Event's Missing Energy in the transverse plane and its Transverse Plane Angle
Edges: Most nodes are connected by the distance between objects.
Global Features: Event-wide variables such as the number of jets and maximum pseudorapidity.

Model Architecture



Graph
Global variables vector
Concat
Vector
Signal Probability

20 20 20 20 20 20 20 20

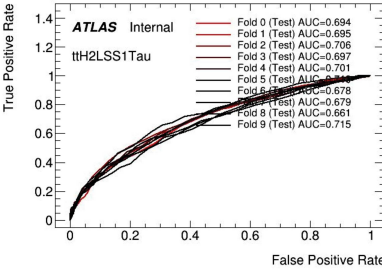
20 = SAGEConv Layer
 20 = Fully Connected Layer
 20 = Number of output channels / nodes

Results

The performance of the GNN model does not exceed BDT's performance significantly while the training and evaluation time for GNNs are much longer than the BDTs. This is still a work in progress, and we continue to study the structure of the variables to build better graphs for GNN model to classify more efficiently.

Model Performance

The performance of GNN and BDT models are evaluated using the Area Under Curve (AUC) of their Receiver Operating Characteristic curve (ROC). Models are trained and evaluated 10 times with the available train/test dataset divided by the k-Fold cross-validation technique.



Test Performance (10 folds)	BDT	GNN
Average AUC	0.691	0.696
Standard Deviation	0.020	0.017

References

[1] Korn, Steffen. *Documentation for Mva-Trainer*, mva-trainer-docs-site.docs.cern.ch. Accessed 20 July 2023.

WTeX 1.12/gentex

3 Daily Logs

Samedi 3/6

We departed from Suvarnabhumi at around 3 am. The airplane has two floors, which is new to me (the second floor is for business/first-class passengers and not for commoners like us). We sat near the plane wing which unfortunately blocked most of the outside view but the plane offered an aerial view of the landscape outside and below through a screen attached to all seats. The flight to Dubai took around 7 hours, during which I slept intermittently, alternating with watching movies (I watched French movies for cultural immersion) and eating meals catered by the flight attendants. It was morning when we reached Dubai and I managed to take a photo of Burj Khalifa standing out among the skyscrapers from what's left of the window view from the plane wing. The Dubai Airport is beautiful and feels similar to Suvarnabhumi Airport. We spent around two hours in the airport before departing for Geneva. The flight took 7 hours. We were received by P'Sure who is Guy's senior from his university. He took us from the airport to CERN via a bus which cost 4.60 CHF. We arrived at CERN to collect the hostel key before taking another bus across the French-Swiss border to Schumann Hostel. The rest of the day involved going to Carrefour for groceries and unpacking the baggage. Most of the cashiers don't speak English so life isn't going to be that easy for us.



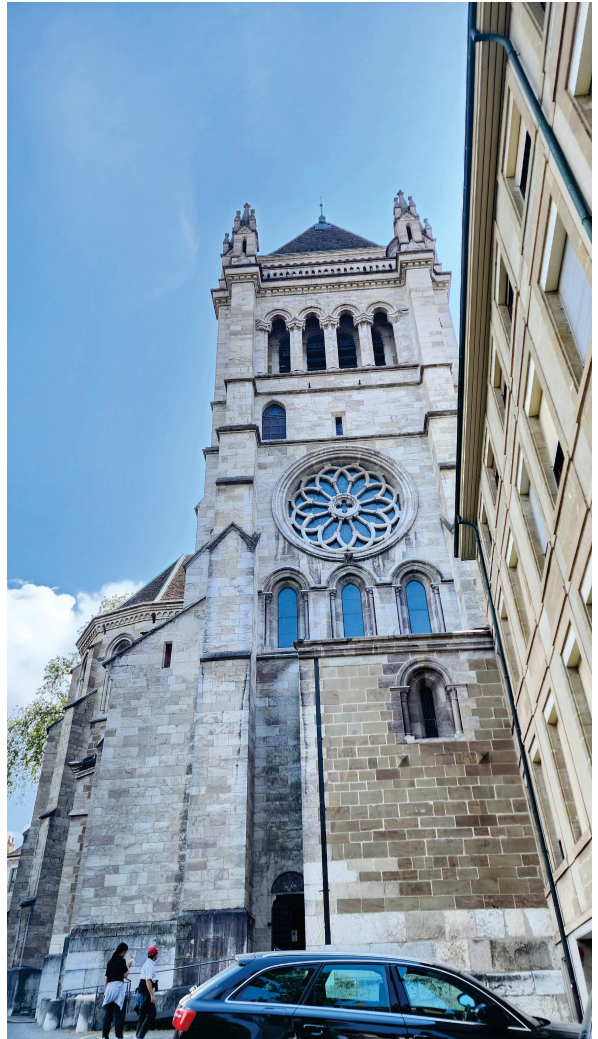
Figures 1-3: My room in Schuman Hostel, with a washbasin and shared restrooms.

Dimanche 4/6

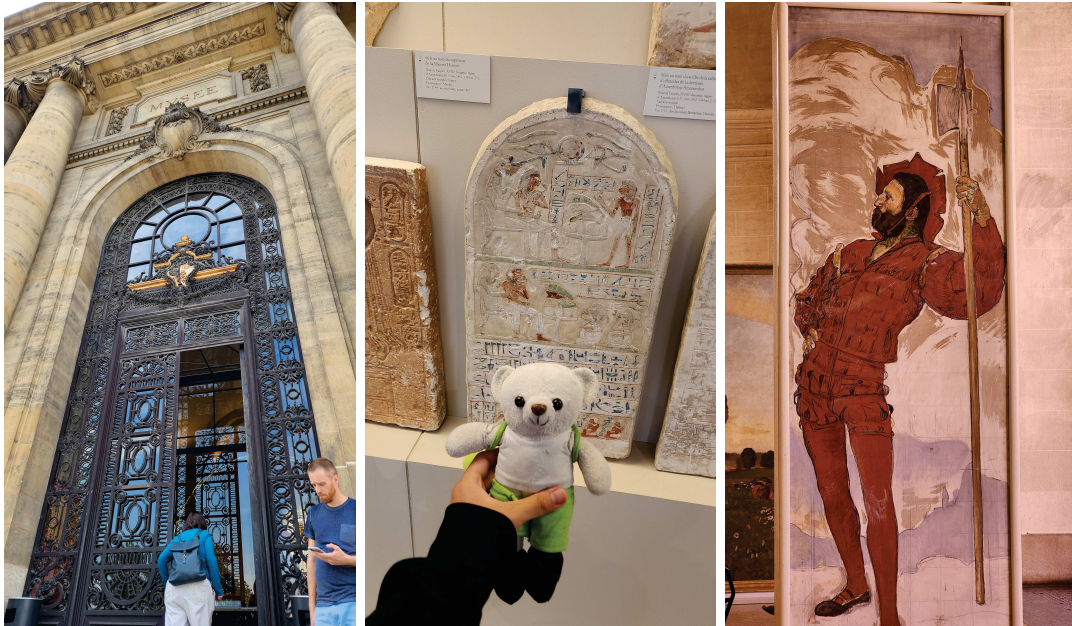
Today, we couldn't think of anything better to do, so we went to the city for some sightseeing. There is this Jet d'Eau that is one of the most famous attractions in Geneva and it is basically a tall water jet that can be seen from far away. I think there are more interesting things to do in Geneva than watching a tall water jet. The day's weather is so nice you can see people running in a park at high noon. We stopped by a restaurant called "Chez Marino" to have an Italian lunch consisting of pizza, pasta, and fried squid (calamari). Apart from pizza, everything made me miss the spicy Thai dishes. We walked through the beautiful, old cityscape of Geneva to the Museum of Art and History where pieces of arts and history (archeological artifacts) are there for display. We toured around for one hour and regretfully had to go before seeing everything in the museum because we had an appointment with Prof. Norraphat. This museum told us to pay as much as we like as the entrance fee, so we paid 5.00 CHF each. I later saw a writing that said the entrance fees for Genevan museums cost 5 - 20 CHF, so we paid the bare minimum for an entry.

I encountered two people at the Gare Cornavin begging for money. I gave them nothing. I later consulted Prof. Norraphat, who told me to stay away from these people. We met Prof. Norraphat at the train station and he took us to Jame's Pub, a Thai restaurant where the professor is practically a stakeholder. To be honest, while the restaurant is hailed as the best Thai food restaurant in the whole of Geneva, it came off as rather disappointing for me; Tom Yum tasted weird and Pad Kaprao wasn't spicy enough. But I shouldn't expect too much from Thai dishes beyond the Thai border anyway.

I went to the "Thu Hang Alimentation Asiatique" near Jame's Pub which sells Asian cooking ingredients. I bought a kg of rice and a bunch of instant noodles from there and I promised that I will return to the shop again.



Figures 4-5: Geneva



Figures 6-8: Geneva Museum of Art and History.



Figure 9: Jame's Pub, as long as Prof.Norraphat work at CERN, everyone coming to Geneva is doomed to come here.

Lundi 5/6

Today is the first day we enter CERN. There was a Welcome Session that we all had to attend as a sort of orientation. We were met by around 30 other students from many corners of the World. I ended up forgetting almost every detail they provided at the session and all that mattered were free croissants and coffees, a debit card, and friends who play Age of Empires.

I tried my hand at CERN cafeteria's salad for around 6 CHF (the average meal at the cafeteria cost 10-15 CHF according to Intelligence) and I still can't tell now if I like the dish or not. CERN cafeteria offers a wide range of food from salad to steak to authentic (judging from the appearance) Italian pizzas to Indonesian Nasi Goreng as well as many delicious looking desserts and even beer and wine, all for Switzerland's price (I'll rather cook my own food from now on)

I appeared in front of the ATLAS secretariat as instructed in the Welcome Session guidebook to introduce myself and make myself aware of things going on. I was told there is no office for me to sit regularly apart from the ATLAS's "Summer Student Space" which will host ATLAS summer students as we work throughout the program. I went there and it was locked so I have no choice but to sit in the cafeteria.

The hostel offers to rent a set of cutlery and kitchenware for 5 EUR a month but they already let us use a pan and a pot for free. I have to rent for the cutlery, obviously.



Figure 10: Building 40

Mardi 6/6

Since I have no office at CERN yet and my supervisor hasn't come from Italy, I spent today at the hostel working because all my work is based on programming and using the software. I'm tasked by my supervisor (Dr. Nello Bruscano from Rome) to construct a graph neural network model to perform the classification of some (simulated) particle collision events. Nello and his team had already implemented a model using Boosted Decision Trees and he wants me to do the same task but with GNN to see if there is room for performance improvement. There is still a lot to make sense of what's going on before I can deliver any good performance on my project.

Mercredi 7/6

The second day I worked at the hostel. Nello wants me to study the problem by first creating a model from Boosted Decision Trees, which was his previous work, albeit with slight changes. While I expected that I'll have to implement the model and code from scratch, I found out that there already exists a training framework where I only have to specify inputs, outputs and the model's properties and I only have to run the software with the configuration file. The rest of the day was spent fixing errors from trying to install the software.

Jeudi 8/6

At 2 pm, we went sightseeing at the Data Center and Antiproton Decelerator (the Antimatter Factory). In the Data Center, the guide showed us how large the amount of data produced by the particle collision events was, with the data being processed and filtered for useful information within seconds. The overall experience felt boring, to be honest, because we can't actually walk down to see the supercomputers, only to watch them from a distance.

The Antimatter factory (which also dedicates itself as an exhibition with illustrations and explanations around) produces antimatter like it's straight out of Angels and Demons (2009). While we still can't contain and store any large amount of antimatter for later use as a Doomsday device, the factory hosted a multitude of experiments using antimatter decelerated through a complex of electromagnetic field to be as slow as possible. The most memorable experiment for me is literally dropping antimatter to the ground just to test if it falls like ordinary matter. From the viewpoint of a visitor, all I saw were lots of wires and tubes. Aside from a huge hexagon on the ground and concrete blocks shielding the radiation, it's not even photogenic.

PS: CERN has a website where it attempts to explain to the general populace the science behind the movie and antimatter as well as dissuading us from believing that CERN doesn't conduct any secret research that might destroy the World.

Vendredi 9/6

I closed this week by still struggling to properly train a BDTs model to get the result and make sense of what's going on and what I should do to make me feel like I'm a physicist. After work, I went to Balexert shopping mall to get a sim card for almost 60 CHF per month. Later, I regretted the decision since the sim card's capability is quite overkill because I'm pretty sure I won't really use its worth (unlimited call and internet usage in Switzerland and the entire EU). As a side quest, I went to a store to buy a pair of socks for my cat. Since I bought them from Switzerland, it cost me almost double the price if I bought them from France or anywhere in the EU (as shown by their price tag).



Figure 11: An example of lunch I make in the morning and take to the workplace.

Samedi 10/6

We thought of where to spend our Saturday yesterday at 8 pm and we settled for Lyon. I was quite reluctant to go out because the weather forecast told me that the whole week will be rainy. And it rained, from waking up until reaching the train station. We reached the train station at 8.30 am to book tickets for a train departing for Lyon at 9.15 am. Had there been no tickets we would have settled for Annecy anyway. The trip lasted around 2 hours. I planned the trip and looked at the tourist attractions and places to eat on Google Maps while we were already on the train which is not something tourists should normally do.

We made a basic mistake of not knowing about something we were going to order. The result was that the lunch was absolutely horrible and we were left traumatized from it.

We walked around the center of the city and found a statue of Andre Marie Ampere, who owns the unit Ampere. Walking in the old city quarter and the older, more cramped city quarter produced bulks of photos as churches and cathedrals dot the city. It rained in the afternoon, exactly as the weather forecasted. But thankfully the rain only lasted briefly.

After a rather beautiful supper, we had to rush back to the train station and walk briskly for almost 2 km to not risk missing the train.

After reaching CERN, I had to walk 1.7 km back to the hostel in France because I didn't want to wait for the next bus in half an hour. Miraculously, we met Prof. Norraphat on the tram from the train station and he walked with me and Net who walked while pulling his bike along.



Figures 12-14: Basilica of Notre-Dame de Fourvière, taken from the outside (left), and the inside (middle and right).

Dimanche 11/6

I understandably woke up very late today. I spent 2 hours in each meal cooking as I have no experience cooking.

I walked for half an hour from the hostel to CERN to attend a board game party, something I willfully committed for my passion. CERN Games Club, who hosted this party, is one of the many clubs in CERN where people gather to do things they like and things like board games do attract lots of people, including me. I stayed until late at night and walked back to the hostel by myself.

Lundi 12/6

I resumed my work on BDTs training today which produced some results. Nello was a bit confused about the results and kept saying that the results are not good, while I was a bit confused about what he was confused about. I discovered a new Schweppes flavor; a vividly red can that contains various kinds of citrus. For 1.6 EUR, it was addictive.

Mardi 13/6

I finally found the Summer Student space unlocked. The room was empty and I was alone, though. The work these days involved sending scripts to run on the supercomputers which takes an hour and studying about the models and whatever machine learning related to fill the waiting hour. After work, Guy and I played Exploding Kittens (a card game) with friends he introduced who arrived this week. The game was ruthless and made people sat out for a long time because they lost the game, a prospect I found worrying as they might not enjoy the game I have.

Mercredi 14/6

Today we had a visit to ATLAS and the retired Synchrocyclotron, the CERN's first particle accelerator. I thought we would get to see the big tunnel and machine of ATLAS that appear everywhere in the media, but unfortunately, the machine has been running and because of the radiation issues, nobody is allowed down there. So we only got to see the control room which is basically some computers and people and an exhibition on ATLAS.

We then moved to the Synchrocyclotron, CERN's first particle accelerator, now retired and serving as an educational artifact. It was a behemoth, its hefty structure holding the weight of scientific history within its metallic shell. Despite the magnitude of its contributions in the early days of particle physics, staring at the cold, inert metal, I found it difficult to connect the dots between this ancient machine and the groundbreaking discoveries it had once facilitated. It was, after all, just an enormous, silent piece of machinery now.

Our guide was enthusiastic, sharing stories of the Synchrocyclotron, the breakthroughs it birthed, and the myriad of scientists it hosted. However, I struggled to feel engaged. I saw

wires, tubes, and age-old technology; the life and the thrill of scientific discovery somehow felt distant.

I visited Carrefour today. I noticed that there was wine in every two aisles. It's like these shelves are empty and they have no idea how to fit thousands of wine bottles into a single aisle. I helped relieve one of them for like 2.5 EUR since I am expected to consume wine in the country of wine but turned out I had no cork opener when I got back.

Jeudi 15/6

I was focused on preventing the program from crashing every time I tried to modify something in the configurations. The struggle was real, and time seemed to stand still as the debugging process ate up most of the hours.

Let's talk about the framework, this program I'm wrestling with is built on Steffen Korn's mva-trainer framework. To give a bit of context, mva-trainer is a software package, specifically designed to streamline the process of constructing machine learning models. It makes model creation easier by handling many tedious tasks in the background, at the cost of losing the fun of coding. You just need to specify the inputs, outputs, and some properties of the model in a configuration file, then the software takes care of the rest. Sounds simple, but when it crashes, it's like trying to find a needle in a haystack to fix it. Frankly, I'd rather enjoy engineering software than using something that already exists and simply writing some configuration files and waiting until the training is done.

Vendredi 16/6

Today, I was met with a sign written in French to "respect yourself, your education level, the other residents, the cleaning maids and properly keep the kitchen clean". Pretty sure most that did the kitchen dirty couldn't read French (I contributed to the dirtiness as well and this struck me hard because I could read French) After producing proving to Nello that I can operate on the training framework, we moved on to training a Graph Neural Networks (GNNs) model that does the exact same job. Now we have to spend time designing a graph and fetching variables to be put into the graph, which Nello helped me a lot in bringing said data. Lots of bugs entailed, as per tradition.

After a day engrossed in code and calculations, a message pinged on the group chat, offering a respite: an evening gathering at a Geneva beach. It was an irresistible proposition for unwinding, and I wasn't alone in thinking so; the beach was thronged with over 20 people, some of whom were unfamiliar faces—summer students like me. Socializing was a refreshing contrast to the day's mental gymnastics, but I cut the outing short. Tomorrow beckons with the promise of a hiking trip, a physical endeavor I'm not particularly enthusiastic about but one that promises a break from the digital world.



Figure 15: Lake Geneva in the evening.

Samedi 17/6

We were planning to go to Annecy today but we went hiking with fellow summer students instead. After meeting in front of the CERN tram stop, we caught a tram straight into town and then caught a bus from town to the eastern edge of Geneva: Mount Saleve. After visiting a local bakery, we went straight into a hiking trail. The trail made me fear for my life because of how narrow it was, and how slippery the ground was due to it being full of small rocks, entertaining the possibility of falling to death at any moment. But we managed to reach the top anyway for a group photo. What a painful experience for some photogenic scenes. After 4 hours of hiking, we made it back to the ground and caught a bus into Geneva to chill with friends in the lake. It was chill, literally, and after half an hour we had to get off because it was too cold, even though the Sun shone brightly.



Figure 16: Me posing in front of a nice view, after a dreadful hike.

Dimanche 18/6

Not much as usual, other than going to CERN for a board game session. Going to clubs is a very good way to make friends and get to know about people from many corners of CERN, from fellow summer students to senior researchers, to people from UN stationing at CERN to do some sort of diplomacy, I don't know. The thing is that I don't feel very comfortable talking and asking about other people's life.

In contrast to most other businesses, Carrefour opens on Sunday, albeit only in the morning, which gives me an opportunity to restock my supplies for the coming week. **Carrefour sells rice.**



Figure 17: Board games in the CERN Games Club.

Lundi 19/6

Next week, there will be a long series of Summer Student lectures with topics ranging from building proper particle accelerators to explaining what the String Theory is. I hope it will live up to my expectation because we all know that CERN hosts some of the brightest minds of the World and so it should host some of the brightest teachers as well. Am I right?

I'm still yet to build a proper configuration file needed to build a GNN model. I need to set aside time for studying GNN on Youtube so that I can make sense of what I'm doing and what I should expect.

I took Exploding Kittens with me to CERN and I played until 10 PM with other summer students who were extremely enthusiastic to play board games with me. After that, I walked back to Schumann to attend another party by Summer Students. It was rainy along the way and I think I may have caught a cold...

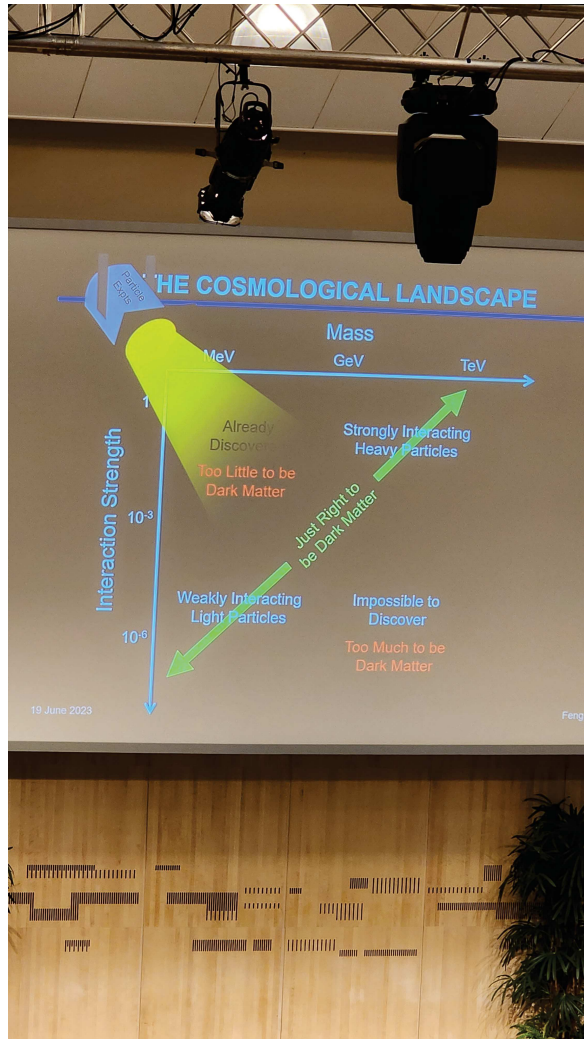


Figure 18: Attending a random weekly seminar.

Mardi 20/6

I stayed at the hostel all day because I had a fever. I didn't have to go to CERN anyway because my supervisor is away and we have always talked via Skype. In case of more serious illness or injuries, I could go to CERN's sort of medical center where they can perform some preliminary diagnoses and send you into a proper treatment process. You also have insurance (mandatory for everyone), but I couldn't bother describing that here like how I couldn't bother reaching out to be treated at a clinic.

Mercredi 21/6

I recovered a lot from the cold. I attended the ROOT course for summer students at the IT amphitheater. ROOT is a program by CERN that handles data analysis in a very large scale (Petabytes scale) and apparently every physicist working at CERN should learn how to use it to secure your career in data analysis in Particle Physics. The lecture was straightforward, starting with talking about how cool ROOT is, and then introducing how data is organized and how to look at it. ROOT automatically builds histograms of data since looking at histograms is a natural way of analyzing data around here. The lecture also served some Jupyter notebooks to showcase the workings of ROOT and make us familiarize with it. These are valuable assets that should help me coming back to it once I forget everything I've learned about it.

Afterwards, I had a half plate of pizza at R2, sharing with Net for 5 CHF (filling but contains little nutritional value).

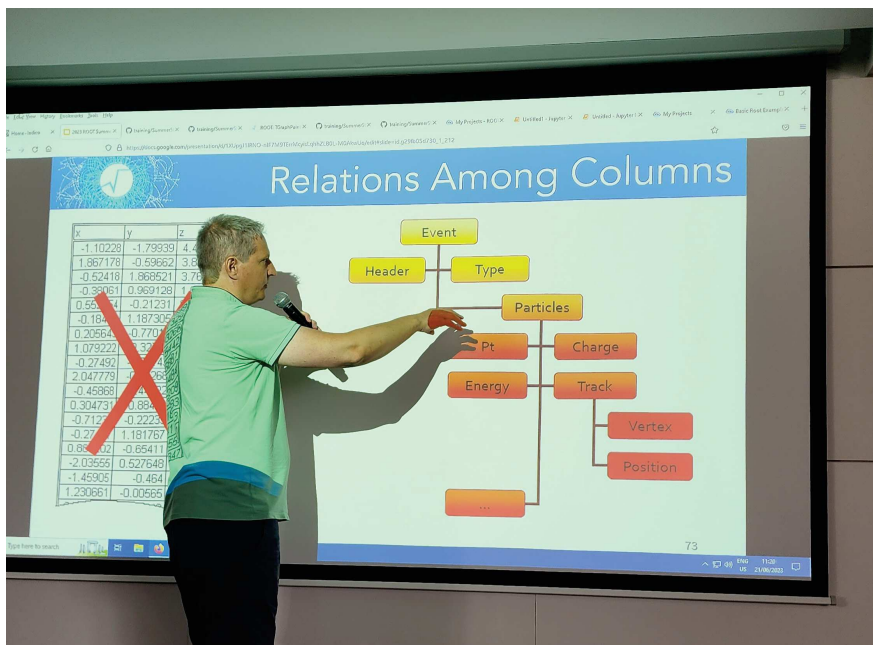


Figure 19: ROOT Summer Student Workshop

Jeudi 22/6

Today, Prof. Chayanit from Chula treated us to a Chinese restaurant in the middle of Geneva (in a sort of Asian quarter of the city). We demanded the all-spicy food (something we deserved but lacked for so long) and we were served all-spicy food as promised, leaving us in tears. She also treated us to good cones of Italian gelato. Her deeds will forever be remembered in this daily log.



Figure 20: Chinese food in Geneva

Vendredi 23/6

There is a music festival in Geneva during these three days and so I took a tram into the city as a teenager seeking fun. It turned out the festival apparently hosted all forms of music I could think of and since nobody in the group of summer students with me knew which place we should go, I led us to a Baroque music theater because Baroque music is love and life (and according to my friends, they enjoyed it as well.). Afterward, I let my friends lead me to whatever concert they found enjoyable, such as the joyous reggae music theater and electronic music concerts. The festival openly sold beer and wine in booths everywhere (I took one pint, of course). There was also a Thai dish booth which I didn't visit because of the price. On my way back, the tram delayed, and I missed a bus which would take me from

CERN back to Schuman, wasting an extra 1.6 CHF I paid for the connection.



Figure 21: Baroque Music. Listen to some Baroque music.

Samedi 24/6

We woke up early as usual to go somewhere, and that place was Annecy. This time, we tried using Blablacar, an application for carpooling arrangements (getting into someone else's car). We arranged for a carpool from Geneva to Annecy for the price of 6 CHF each which was very cheap compared to public transport (it would take around 20 CHF to go there by train). The driver was friendly but we figured that we were simply lucky to have a nice driver at that price. After reaching Annecy at around 8 am, we took a bus from the drop-off point (which was quite far from the town center) to the center of Annecy.

After reaching the town center, we looked around for a coffee shop for coffee and some desserts to start the day. While savoring hot chocolate, macaron, and tart, we were joined by Isiwara and Ronaldo, two of our fellow summer students. We stopped by a cathedral, present in any European city, and were pleased to listen to someone playing Interstellar Theme with an organ as if the universe was brought to the light of the divinity.

I saw the museums on the map which were arguably some of the few attractions in the town, and I led the group to visit the museums which cost us around 4.2 CHF each. Visiting museums was a considerably bland experience, apart from taking photos of the museums' architecture and the views outside. It was nice taking photos of the town center, with a river flowing from the lake through it, but that was it. That's what this whole town have. For lunch, we tried cold cuts with "Raclette" cheese which operates by placing hot rods near the cheese to melt it. This meal was just what I imagined a French and Swiss meal would be: pure meats and cheese. Fondue is the next destination.

Afterward, we used the ticket from the first museum to visit the second museum in an island in the middle of the river which was a prison before (few things to see here), and then enjoyed ourselves in boats riding into the middle of the lake (for like 20 EUR for hour). We took the bus back at around 8 pm which delayed (I was naive to expect European transports to be punctual).



Figures 22-23: Annecy.

Dimanche 25/6

This Sunday was just like the previous two sundays spent playing Board games at Restaurant 1. Among the games I played, Dominion caught my attention the most. After 10pm, I went back to Schuman to hang out more with people there who played some more card games.

Lundi 26/6

There will be lectures tomorrow and I can no longer wait for it. This afternoon, we went to Geneva to meet Thailand's permanent mission diplomat. After a full conversation and bakery treats of butter cake and croissants, we went to Manor, a shopping mall with Central's vibe in the town center. New and Guy bought themselves some wearings while I bought chocolate and peppers. I went with prof. Norraphat to Thu Hang as well to buy veggies and chilis necessary to make a good Tom Yum.



Figures 24-26: A more sophisticated sample of a lunchbox (left), Prof. Norraphat knocking the door of the permanent mission (center), A sample of CERN meal (10 CHF) (right)

Mardi 27/6

Today is the first day of the Summer Student Lectures. After the introduction section, we were greeted by David Tong in "Particle World", a fun talk about what we know about fundamental particles. Then we had a less fun lecture about detectors, illustrating the development of the art of detecting particles from photographing tracks of particles moving

through a medium and employing technicians to analyze the photos to the modern sophisticated electronic devices that can reconstruct the particle paths from electric signals and record millions of particle collision events every second in form of computer data. After lunch at R1 restaurant which was crowded by summer students, I resumed my routine of bringing my laptop to the summer student space and run the model trainer for the entire afternoon.



Figure 27: David Tong

Mercredi 28/6

The second day of the Summer student lecture. David Tong managed to overshadow the other two lectures (Detectors and From Raw Data to Physics Results) with his usual awesomeness and enthusiasm. I was excited about the latter lecture because I became intrigued

with how CERN processes its big data (recently with Machine Learning), but I found myself sleepy throughout the lecture, maybe due to the lack of coffee. I walked back to Schuman to cook my lunch, which was fried rice as usual. After working on the project, I felt so sleepy I spent 2 hours sleeping in the afternoon. I left for O Brasseur (Restaurant and Brewery) 5 minutes away from Schuman hostel to have dinner with Prof. Norraphat and other Thai students in CERN. We stayed for 3 hours, playing some board games that I brought along.

Jeudi 29/6

Summer Student lectures in the morning. I asked David Tong after his lectures about the association between the Higgs Field and the time dimension and the possibility of multiple time dimensions in a universe through the introduction of more Higgs-like quantum fields that give particles mass-like properties, which he denied. When I pointed out that photons don't experience time, he replied that photons do experience time when interacting with the environment (e.g. changing their directions). The lecture on turning raw detection data into physics results sparked interest, partly due to the involvement of machine learning in data processing but also due to the illustrative explanation of what was happening to the detectors. The lecture on detectors was about interactions between particles and the matter constituting the detectors and was just a bunch of math and equations, from what I remembered.

I had an uneventful afternoon of running the model-building software. Though I made more use of the bash utilities which facilitates my work and enable the remote work progress to be saved when I have to turn off my computer.

In the evening, I had a board game session with a guy named Oscar who runs the CERN games club, playing Agricola together with two other CERN students. I won the game despite it being my first time (thanks to Oscar's useful suggestions). Overall, the game is nice and you should try it. Since I get to know the people who run the club, I may have a chance to play the club's board games on weekdays by requesting them to unlock the locker.

Vendredi 30/6

We had the last lecture by David Tong which was basically a Q&A session. Afterward, I took a selfie with David Tong and received an autograph from him on his Quantum Field Theory lecture note on my tablet.

I went to a piano concert with a friend from Turkey. Before going to the theater, I brought my friend to the beloved Thu Hang for an assortment of asian foodstuffs. The concert was supposedly a tribute to Hans Zimmer as seen in the advertisement but the pianist curiously played the Mission Impossible theme which wasn't composed by Zimmer. Regardless, the 1 hour music experience was worth 20 CHF spent. We wandered around Lake Lemman after the concert and went back home at 10 PM.



Figures 28: A selfie with David Tong

Samedi 1/7

Today we went to Chamonix-Mont-Blanc, woohoo! 80 EUR and you'll get a day pass to visit the 3800m tall Aiguille du Midi (you don't actually go to Mont Blanc because there is no cable car to the mountain), as well as a train ride to Mer de Glace, the Ice Sea. We spent the entire morning and a bit of the afternoon up on the mountain, 1.5 hour at the topmost (as allowed) and the rest in the "middle" which featured a nice ground for hiking and a pristine lake. At Mer de Glace, we caught the last train at 3pm to visit the ice cave that is dug into the glacier and we were allowed to stay there until 4.30 pm. The glacier receded so far that it took us nearly 20 minutes to go from the train stop to the ice cave, which didn't have many stuffs apart from a few sculptures and an opportunity to touch ice. The walk there and back was itself a hiking and we were left exhausted.

We got to eat Fondue (with cold cuts and potatoes) and it was one of the Fondues I have ever had, for around 25 EUR. The town looked more modern than expected, with shopping streets looking like an outdoor department store. Guess that's an effect of tourism.

We were joined in the morning by Emerson, a fellow summer student, coming with the same bus we took from Geneva (Flixbus). We went on a separate way and intermittently met, but we did have dinner together (he was a vegan). The Flixbus on our way back to Geneva delayed for half an hour.



Figures 29-30: Aiguille du Midi

Dimanche 2/7

This is the fourth Sunday I walked to CERN and had a good board game party with the CERN folks. Maybe it's better if I spend my Sunday on something else such as spending a night on a trip rather than having day trips. If you want to know what games we played they were "Tsuro" and "7 Wonders". Good stuff, you should play them.

It's a good Sunday so I had to hold myself from thinking about work. I spent the night playing games. By this time, we already have an established gaming community and I am grateful that there are people wanting to play games like Age of Empires.

I want to shout out to the shuttle bus at 10 pm, saving me from having to walk back in the cold air to the hostel.

Lundi 3/7

Today's lectures are on Accelerator Technology challenges, detectors and the Standard Model. The last one caught my attention the most (I want to study theory though not a theorist myself) and some concepts were stuck in my head.

I had some of the first results from the GNNs model training. The results were still not better than the BDTs doing the exact same job. The task boiled down to fidgeting with various parameters and graph settings to push up a number called AUC or Area Under Curve of the Receiver Operating Characteristics curve. I promptly sent another version of the models for training.

Mardi 4/7

More lectures today. We have Statistics for Particle Physicists (finally something easy), a lecture on the Standard Model, and particle accelerators. Perhaps the professor spent too much time on very basic concepts such as introducing conditional probability, he couldn't manage to cover the latter half of the lecture which was to focus on various kinds of probability distributions. For the Standard Model lecture, the professor was unable to cover the whole intended contents and we all felt that he spent too much time on some unnecessary details. The lecture featured even more advanced Quantum Field Theory and Mathematics than the previous lecture and I think less than 20 people in the whole auditorium understood what was going on in the lecture. The lecture on accelerators didn't interest me much, but at least I recalled that it was about engineering and mechanical designs.

I had a talk with my supervisor again, and he suggested to keep playing with the parameters and told me the set of variables suitable for a model.

This evening we had a "Welcome drink" where summer students gathered and conversed with each other, with a little dance at the end. We did expect something beyond soft drinks, but it made sense since many people don't drink for various reasons and probably wanted the party to be as inclusive as possible. Many of us went off for a drink afterward. I brought a set of board games with me in an unusual case where people might want to settle for board

games instead of talking. That wasn't the case. Anyway, I did talk to some people before going back to sleep. Socializing isn't my best skill.

Mercredi 5/7

The lecture on the Standard Model has become even more incomprehensible than yesterday, and I pity computer science students (as well as myself) for having to study a year's worth of advanced Quantum Physics in a few days. For the statistics lecture, we learned about parameter estimation which is to infer some numbers to make a model of the experiment.

Today, they opened a registration for the student poster session happening in late July, where we apparently stand in front of our work's contents printed on an A0 poster and have fellow students and professors passing by to watch us. They opened for 30 students to register and it was full within 10 minutes. I managed to get a place for myself, even though I'm not that confident about my work and whether it will be interesting to other people or have any impact.

Jeudi 6/7

Today's lecture on Probability featured Hypothesis testing which is honestly one of my weakest topics back when I studied probability at the university. I appreciated and re-understood some of the concepts that were left out. I gave up trying to at least appreciate the lecture on the Standard Model.

Vendredi 7/7

Today we have the last lecture on particle acceleration and beam dynamics. The lecturer succeeds in showing that there is much more to particle accelerators than just getting the Lorentz force right and building larger and larger machines; the dynamics between the particles beam and the instruments are very complex and require some of the brightest minds in the world to push the limit even further. While I'm left intrigued by the science of particle acceleration, I merely take an interest in it just to live life to the fullest and I doubt that I'll pursue a scientific career down that path in the future. The probability lecture today featured Machine Learning and Neural Networks. While I always make sense of Neural Networks as a function to be optimized, this lecture presented them on a statistical perspective, something I've been interested in looking at.

I had a talk with Nello today and he presented me with a new set of variables, expanding the graph somewhat. Let's hope we can beat BDTs this time.

Samedi 8/7

Today, we went with Prof. Norraphat and two Thai seniors who are working at CERN for a hike at Aletschglletscher (Aletsch Glacier) which took an entire day and it was exhausting. On the way down from the trails to the glacier, the rocks and waterways were so hazardous

I almost fell over several times with my running shoes, which are not optimized for hiking. I had to make use of Prof's hiking stick to survive the trails. On the other hand, the views were otherwordly. I could have climbed up and walked on ice but I simply couldn't trust my running shoes.

Please save Aletschgletscher as one of your destinations in case you have a chance to be in Switzerland.

You don't go hiking unprepared.



Figures 31-32: Aletschgletscher

Dimanche 9/7

I woke up having an ache over my whole body from hiking (and climbing) yesterday. I continued the tradition of going to CERN to play board games every Sunday Afternoon. We played BANG!, Kingdomino, and Dominion (which I won hehe).

Lundi 10/7

Today I had a meeting with my supervisor who introduced me to my other supervisor Dr. Simonetta Gentile who works in Rome as well as him. I was asked to present my work today (I finished my slide this morning in the lecture room) and so I gave a short and hardly comprehensible presentation of my research work to the supervisors, as I made no preparation for it. As for my work, the more I research the affairs of Machine Learning, the less I become confident that my Graph Neural Network model will perform any better than the existing Boosted Decision Tree. The data we have (from simulation) is very limited and we need to understand the data very well to build the best model. Simonetta simply said “congratulation”, perhaps for keep going on this far. Nello said that it’s pretty normal to not have a good result and that just to keep working is already valued.

This evening, my Turkish friend Furkan came to me asking for help regarding using Machine Learning in his work. He was trying to build an ML model that can automatically segment his sequences of data (signal over time) by learning the structure of the data. I suggested he use Recurrent Neural Network that specializes in processing sequential data. A small problem he had is that he have to label his thousands of data samples by hand.

Mardi 11/7

Today (and yesterday), we had lectures on Future colliders, Nuclear Physics at CERN and Theoretical Concepts in Particle Physics. CERN also researches in medical uses of radioactive isotopes, apart from generic isotopes research. Theoretical Physics preached the concept of symmetry used as a basis of the modern Quantum Theory. While I worked at my office (summer student space), I attended an Openlab lecture on Computer security on zoom. It’s basically a guideline on how to protect your data, and I felt I expected something more from it but I didn’t know what it was.

Mercredi 12/7

In today’s class on Theoretical concepts, the teacher began to put up Feynman diagrams and tell us the rules on which are allowed and which are not. One of the things I learned was that we have much of the knowledge in Quantum Field Theory thanks to lots of approximation and discarding insignificant parts we simply can’t deal with (but isn’t that much of *Physics* itself?).

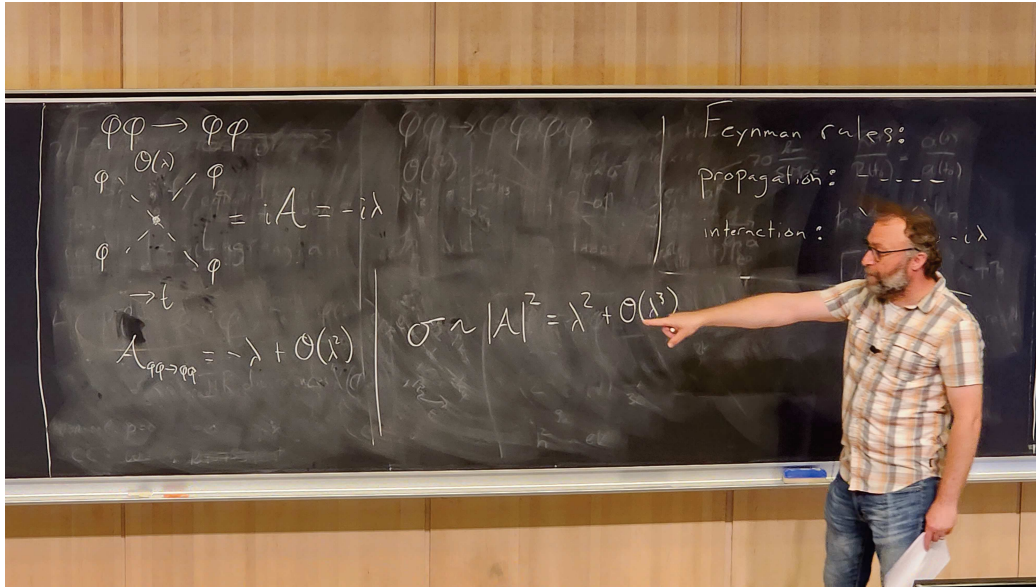


Figure 33: A lecture on theoretical concepts.

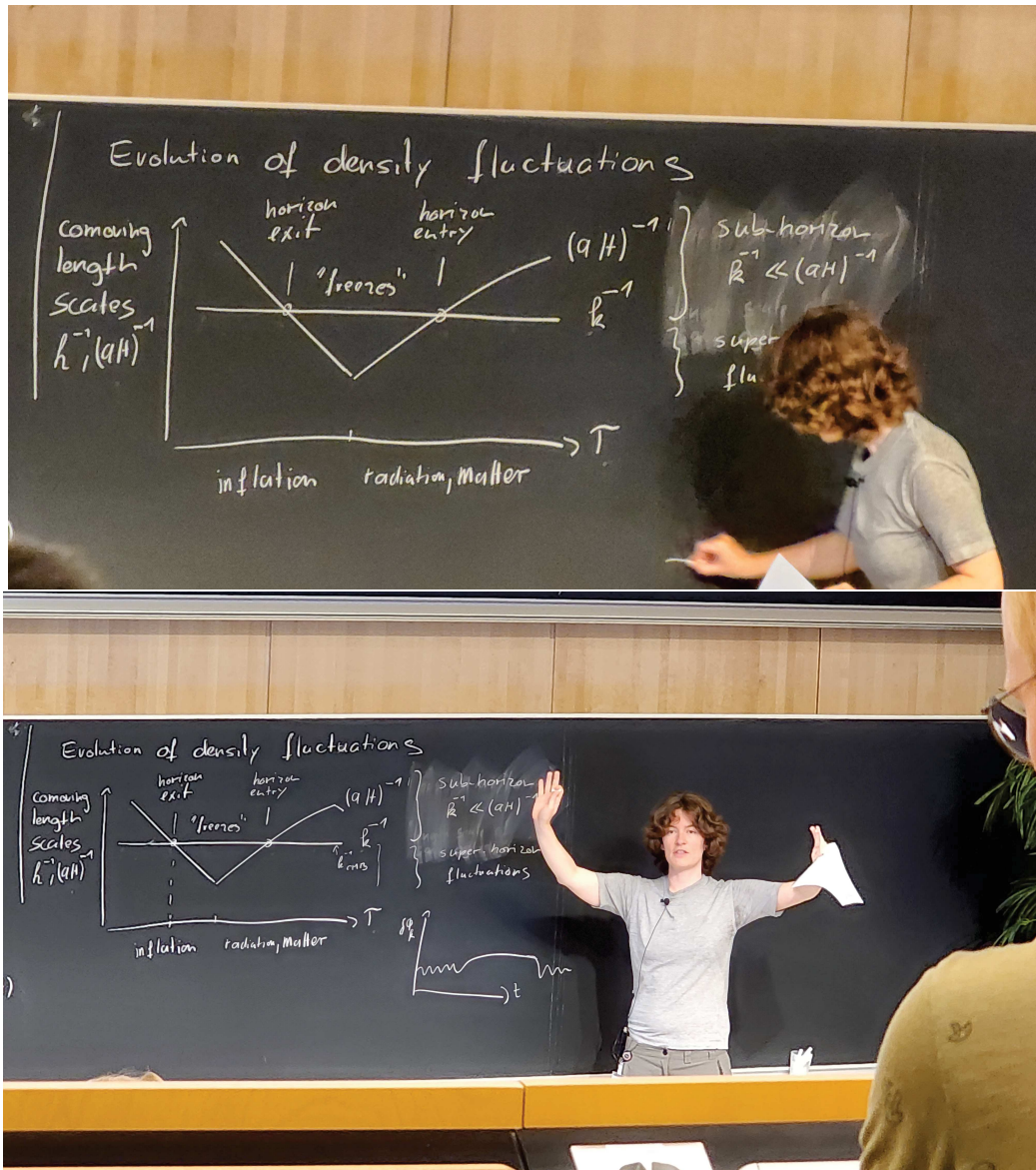
Jeudi 13/7

We have lectures on Cosmology this week which cover conventional topics such as the principles, models of the universe and inflation. CERN does have research related to Cosmology and that's why it is here. Cosmology also finds the answers to the same questions CERN and Particle Physics have.

This afternoon, I attended an Openlab lecture on Neural Networks on Neural Networks. The lecture covered the basics and most types of NNs imaginable. While I'm confident of my basic knowledge, it was nice to learn about more advanced types I haven't looked up before like Variational Autoencoders which could help Furkan's work. Furkan himself also attended this lecture.

Vendredi 14/7

This evening, my Turkish friend came to discuss Machine Learning on his work again. We got to discuss about using models we just learned from the lecture yesterday to generate realistic noise models for his research. The problem was that in the end we still had no idea how we should make it work out.



Figures 34-35: A lecture on Cosmology

Samedi 15/7

Today we and two other foreign summer students went to Milan. While other people took a Flixbus to the city, I took a train since I have an Eurail pass which I bought for 270 CHF and allowed 7 days of unlimited travel within 1 month (around 40 CHF per day). I'm still not very sure if it's worth it or not. Moreover, in many cases such as taking a faster train in France or Italy, you have to spend at least 12 EUR more on reserving seats. Anyway, I shouldn't think much because I've already spent it.

There are many landmarks in this old city, we visited Castello Sforzesco (The Sforzesco Castle), a castle built in the 15th century by Francesco Sforza. Inside it hosted a museum which, for 3 EUR, offered a huge collection of artifacts of all sorts from weapons to jewels to musical instruments, on top of the gorgeous architecture and wall paintings. It's worth at least a whole day, which we spent only 2 hours in and had to miss a lot. When spending time in the courtyard, we have to be aware of people who come to demand a lot of money after tying up a wristband on our hands.

For lunch, we had an Italian food in an Italian restaurant. One of the more impressive dishes is Risotto alla Milanese, a dish of rice in golden cream of cheese. After lunch, we walked around the city and visited Duomo di Milano, a famous cathedral. We didn't go inside as it was late. We wandered around and stopped by a local pasta restaurant by a canal, which made the best pasta (forgot the type I had) I've ever had in my entire life.



Figures 36-38: Milano Centrale station (left), A tower at Sforzesco Castle (middle), and the coat of arms of Duchy of Milan (right)



Figures 39-41: Duomo di Milano (left), The authentic, local pasta (center) and its restaurant (right)

Dimanche 16/7

Today we visited Duomo di Milano again to actually get inside. The cost of climbing to the top was 13 EUR, ridiculously high just for getting a view on top compared to the castle museum yesterday. The cathedral was built to have lots of spikes pointing up which look kinda unique. We also briefly visited the cathedral's inside which looked like a European cathedral. Next to the cathedral is a beautiful department store. Beautiful yes, but it's a department store with really expensive restaurants we elected to avoid. We had Italian gelatos three times during this trip. New and I left Milan by train and went to Montreux, making a stop at Domodossola which is a random quiet town in a valley. We intended to visit a jazz music festival in Montreux but misread the date which ended yesterday so we came here for nothing but a lake.



Figures 42-43: Basilica of St.Ambrose, one of the oldest churches in Milan



Figures 44-45: Duomo di Milano rooftop (left) and interior (right)

Lundi 17/7

Today I started making the poster for the session next week. This is a great opportunity to make sense of each variable comprising the graph to be fed into the model and check if I really understand them, as I need to understand them to be able to explain them to people interested in my poster. While I continuously submit models training sessions, I had to put in what I have right now which doesn't outperform BDTs by any significant margin.

Today I attended an Openlab lecture on Graph Neural Networks (sounds familiar...), I did learned a few tips on what a good model should be to go back to researching. Hopefully, we will beat BDTs this time.

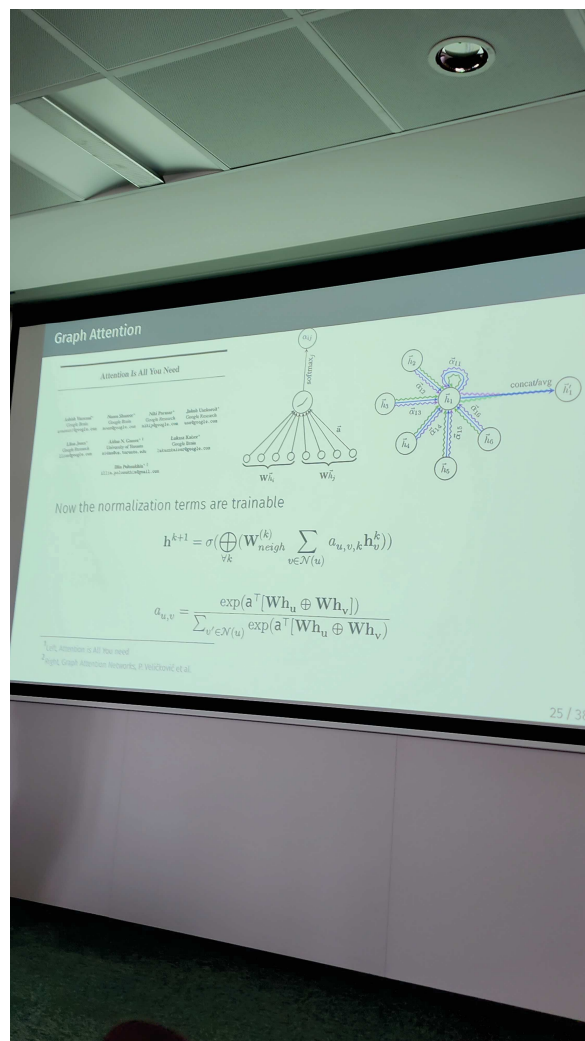


Figure 46: Openlab lecture on Graph Neural Networks

Mardi 18/7

I woke up late this morning. By the time I finished cooking for today's meal, almost two of the morning lectures had already passed. I was deciding if I wanted to rush to catch the bus for the third lecture or not attend the lecture so that I could grab coffee and do some more work here. The idea of responsibility got me and I chose the former. I ended up not paying much attention to the lecture (on the Physics of Hadron Colliders) anyway. This afternoon saw Openlab's lecture on Hyperparameters optimization (how not to make bad Neural Networks). Due to a lack of coffee, I slept through half the lecture and woke up confused. At least I grasped some concepts before leaving the amphitheater. I set my evening doing the poster for next week's session.

Mercredi 19/7

This morning, we, the summer students gathered in front of CERN to take a group picture. Traditionally, the picture is taken in front of the Globe of Science and Innovation but because of ongoing construction, we had to take it in front of the reception building instead. In the end, many of us wanted to retake the group picture later. Today I went to Openlab's lecture on Agent Based Modeling. Much of the lecture was about a specific software that efficiently uses hardware while I'm rather interested in general ideas that can be applied to Particle Physics and possibly my future research beyond this summer.

Jeudi 20/7

Today's morning lectures are on Accelerator technology, Experimental Physics at Hadron Colliders, and Astroparticle Physics. Up until I joined the CERN community, I had no clue that CERN has research instruments and projects in space as well. But then what stopped me from thinking that CERN can go into space? The poster, which I made on Overleaf with an existing template, took longer than I expected, but it's almost done and I should have it printed tomorrow, before going to Paris.

Vendredi 21/7

I went to attend an open lab lecture on Reinforcement Learning in the afternoon. The lecture featured what I have already learned before and what was in the book I have, except from an interesting story on how it was used at CERN to control systems of instruments. Reinforcement Learning is the art of making your robot respond intelligently to what's around it and do what it's supposed to do.

I managed to register for the Student Session, where I'm going to present the results of what I've been doing for two months up to now. It wasn't filled as fast as the poster session but it was already full within half an hour. This weekend, Openlab hosted an event called 'Webfest' where people developed a webapp for research and education and showcase

it within 3 days. I really wanted to attend but I already booked my trip to Paris this weekend since the beginning of the month and so I had to miss this event.

In the evening, I went to the train station and boarded the train to Paris. The train was delayed and chaos ensued when people were running around trying to find the right coach before the train left. After around four hours, we reached Paris at midnight. It took us half an hour to finally arrive at the hostel by subway.

Samedi 22/7

“Generator Hostel” is nice in case future summer students want to visit Paris. After a hostel breakfast, we traveled straight to the city center. We were divided between walking all the way there (around 3 km) and taking a subway, which I and some of my friends decided to walk to enjoy the town. After enjoying the road for an hour, we arrived at the Louvre area. Since we didn’t book tickets in advance, we had to get in a possibly one hour long queue (we didn’t and instead stopped by McDonalds beneath it). While my friends were enjoying iced tea at McDonalds’s, we noticed that online tickets booking became available again (likely someone just cancelled) and we managed to secure the tickets for ourselves (17 EUR each). There are just too much in the Louvre to describe here. So, anyway, I saw Mona Lisa.

After visiting an Italian restaurant for lunch, we went to take a river cruise on the Seine which took one hour for like 15 EUR. While I got some good photos I’m not very sure if it was worth it or not. Lastly, we climbed the Eiffel Tower herself (for 5 EUR), earning ourselves a good view around the city. We went back to the hostel at almost 11 pm.



Figures 47-49: The Louvre and Mona Lisa.

Dimanche 23/7

Today, I went with the same group of friends to the Sacred Heart cathedral at Montmatre for a usual sightseeing. We went to Arc de Triomphe but couldn't get near it because Tour de France reached Paris today and the circuit passed the Arc. We could wait to see the parade of cyclists but we elected not to. I tried Escargot as part of lunch; it's really just like mussels, albeit much more heavily buttered. I don't know why it gets such a bad reputation. We went to what remained of the Bastille prison. We did thought, without googling, that the prison was still there. The rest of the day was just walking around, having a nice dinner and crepes, and departing from Paris back to Geneva at 11 pm with Flixbus (that was delayed). The state of the bus station in Paris was deplorable, so dirty it was something I didn't expect to see from a first-world country.

Lundi 24/7

We reached Geneva at 6 AM. Since I'm too tired to go back to Schuman, I stayed at CERN and attended the lectures with clothes from Sunday on (I had to brush my teeth at CERN hostel). But I doubt I'd understand whatever they taught. Today's lectures were about experiments (Making Predictions at Hadron Colliders, Experimental Physics at Lepton Colliders and Antimatter in the Laboratory).

I submitted my poster in the morning and retrieved my poster today in the afternoon at the printshop right behind the summer student space. Printing was free if you ordered for a single copy of the poster (I would have paid a premium for this A0 poster).

They sent me an email that my registration for the Student Session presentation was canceled because I already had a poster session and they want as many people to present their works as possible.

Mardi 25/7

I presented my work in the Poster Session this evening. The session was hosted in a small corridor in front of the main auditorium. Many people flocked into the booth despite it not being the main walkway; many people are really interested to see our works. I tried my best to explain what's going on in my research and that we don't really do better than the decision trees with what we have now. People apparently showed interest and I hope they genuinely did. I also had chances to converse with viewers who did research in GNNs and I took notes of something to potentially improve my research. After the session, I went to a party by ATLAS Early Career Scientists community, which I registered but overlapped with my poster session, to steal some wine before it ran out.

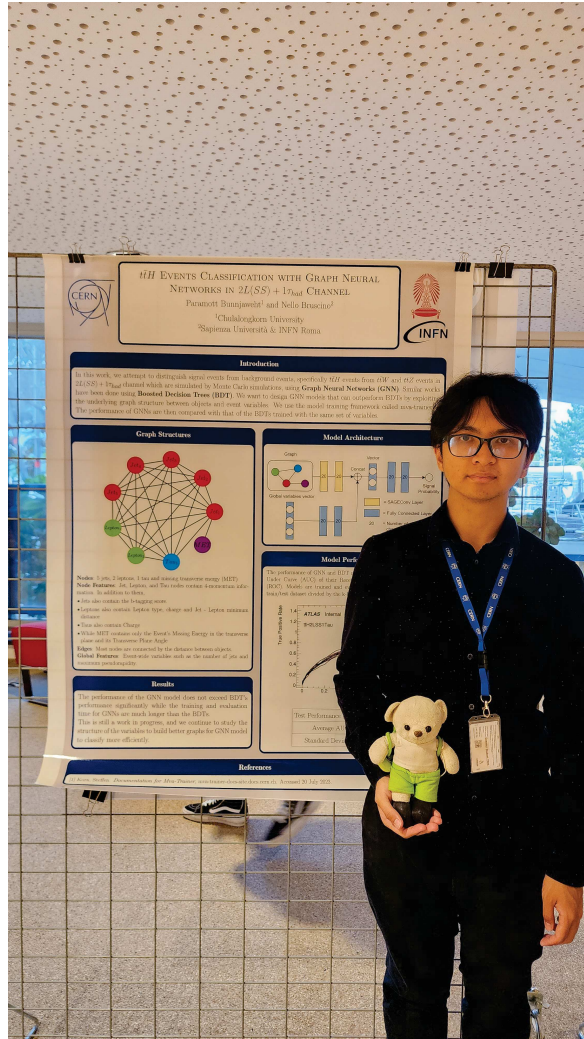


Figure 50: Poster Session

Mercredi 26/7

Today's lectures explored Experimental Techniques in Particle Physics and Physics beyond the standard model. While the topics are complex, the speakers did an admirable job of breaking down the intricate theories. On the research front, Nello and I revisited the parameters for the Graph Neural Networks, inspired by the feedback from yesterday's poster session. The aim is to make a last-ditch effort to outperform the BDTs before the summer ends.

Jeudi 27/7

Today they squeezed two lectures on Physics beyond the Standard Model into one morning, with another lecture on Electronics systems. I simply couldn't understand anything, lost track and resigned myself to working on my project. In the afternoon, I attended an Openlab lecture in Quantum Computing, something CERN wants to exploit as well. I didn't get much from the lecture because it was too basic for me. In the latter half of the lecture, there was a hands-on session to implement quantum algorithms using Qiskit, a popular library for implementing quantum circuits. At least I got to polished my skillset on Quantum Computing I've acquired back in a course the university.

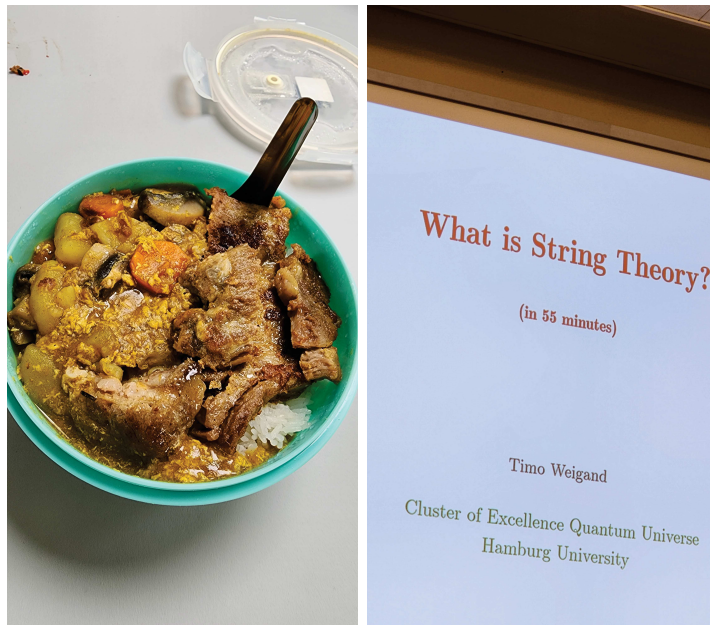


Figure 51: Mont Blanc as seen from CERN

Vendredi 28/7

Today was the last day of the Summer Student lecture. An introduction to String theory was offered as the closing lecture which attempted to explain intuitively in 50 minutes what strings are. Every young physicist, me included, dreamed of being a string theorist at some point. Few would actually be one because reality hits hard.

Nello introduced a largely expanded graph with a new set of variables, bringing the total number to over 150. If we still couldn't beat BDTs we might have to settle down with what we have and begin writing the report. This evening, I went with Guy to see Oppenheimer at a cinema in Balexert, for 28 CHF. It's been said that if you cycled for 10 km to another cinema in Ferney-Voltaire, it would cost around 10 EUR only. But we figured we were just lazy.



Figures 52-53: A sample of lunchboxes (left), Explaining String Theory (a popular challenge) (right)

Samedi 29/7

This time, I went with three other summer students into Switzerland. We shared a Friends' Day Pass which was sold at 80 CHF for 4 people (20 CHF per person) and allowed us to travel with most public transports in Switzerland, save for a few trains and cable cars. We first stopped at Interlaken, a town between two lakes. We didn't visit any of the lakes, however, and spent our time by a pristine river and walking in the town, which is basically a smaller Geneva. We then took another train to Grindelwald, a famous place for natural sightseeing. Unfortunately, it was raining and we didn't spend much time there. We then

paid a sum to get on a cable car up to Wengen, which was heavily clouded and could barely see any view outside. From there, we took trains to Luzern where we got a rest for the day at the Youth Hostel. We didn't have much chance to tour the city apart from walking through it and rain to the hostel 30 minutes away.

Dimanche 30/7

After a good breakfast at the hostel, we set off to Rigi for a hike by a small train from Arth-Goldau up to the top. It was very cloudy and we could barely see anything up there. We then chose a relatively easy path to walk down to a cable car that took us to the Lake Luzern. We then caught a boat to Luzern for aesthetic effects (all these were included in a Friend's Day Pass). Without touring Luzern more, we took a train to Bern, the federal capital. We had no idea what to do and see in Bern but I had an idea, to see a bear, the symbol of Bern, in the Bear Pit. When we got there, the Bear hid in a cavern and we couldn't see it. Bern held the most beautiful sightseeing experience in my opinion. Without much action, we left Bern at 7 PM and returned to Geneva, missing Einstein's house there.



Figures 54-56: Berna of Bern (left), The Bear Pit (middle) and a random but beautiful clock tower (right)

Lundi 31/7

Free of morning lectures, I spent my morning working from Schuman and cooking for lunch and dinner at noon, something I had to do early in the morning. In the afternoon, I attended an Openlab lecture on the applications of Quantum Computing, specifically on Quantum Machine Learning.

Mardi 1/8

This morning, I met Professor Simonetta Gentile for a coffee to have a brief discussion about work. She recommended me a few places in Italy and Switzerland to study in the fields of interest.

This afternoon, the Openlab lecture was on “GPU Programming”. There was a hands-on session of actually hacking into GPU to perform basic computing using C++ language, but I had some problem with my computer and I was unable to do it. When asked about where we (the Physicists) will be using this, the lecturer simply said no, but it’s good to at least have more people outside know about directly manipulating GPUs.

This evening, Prof. Norraphat took us to a Korean BBQ restaurant conveniently named Seoul. The meal was great, far exceeding my expectations (I expected nothing from asian food in Europe), though the price of the meal must have been tough.

Mercredi 2/8

There were no lectures today, so I took my work onboard trains. It was possible thanks to power sockets on each seat and unlimited mobile internet connection so I basically talked to Nello and work on my project there. I rode trains all the way to Lindau, taking almost 5 hours. I hope I get to return to Lindau again in the future; it was such a nice place. The old city was situated on an isle in Lake Constance, and the atmosphere was pleasant. Staying for a few hours, I left Lindau for Vaduz, Liechtenstein. I went there just for the sake of being in a country. And then caught some trains to get back to Geneva. All of these trains were covered by the Eurail pass I have.



Figures 57-58: Lindau

Jeudi 3/8

Today I was in an Openlab lecture on tips on writing good code. Since people here kinda favor C++ language, most examples are in C++ and I found it hard to follow as I have little experience in C++. But as far as I concern, most of them are basic and can be found on websites

This was one of the days I got to play board games with people from Games Club on the weekdays. We usually play Kingdomino when we can't think of what game we should play.

Vendredi 4/8

Nello said that the results we have right now are good enough to make a report and that little more could be done within the remaining time. So today I began thinking about what I should write into the report. It shouldn't be hard considering it should be no more than 5 pages long.

Some students have already left CERN since last week. As a memorial, some have their things, mostly bought from CERN gift shop, signed on by their friends. Mine is a book, which I bought today. I let my friends who had been together on the weekend trips write a farewell message, in one's own language. In Google Translate, I trust.

Samedi 5/8

It was raining the whole day. I went out in the early morning to travel to Munich. I simply intended to go as far as reasonably possible and chose Munich as such destination. I reached Munich at almost 2 PM and spent the remaining day strolling around the city. I actually had no idea what's in Munich and just search it out on Google Maps, learning about a palace-turned-museum called Residenzmuseum (9 EUR) and so I, a museum enjoyer, went there. Despite it being German, the residence has a hall that contains busts of innumerable Roman Emperors. It appears that everyone wanted to be like a Roman Emperor. I only have around one hour of time before the museum closed so the experience was a bit rushed. In the courtyard of the residence, there hosted a wine event from "Pfalz", somewhere in western Germany. I went to taste the wine out of curiosity, in the middle of the rain.



Figures 59-61: A hallway in Residenzmuseum (left), symbol of the house of Wittelsbach (middle) and a bust of Julius Caesar (right)

Dimanche 6/8

Today, I chose to go to the Deutsches Museum in Munich, which cost 15 EUR. It's basically an ordinary science museum for families, albeit of better quality than those of Thailand. The museum contains all forms of science and technology and I got a chance to see a Cyclotron here. I spent roughly 3 hours here since I had the whole day. There is also a lecture hall and a lecture was taking place but it was in German. At 4 pm I caught a bus back to Zurich and stayed there at a hostel in a suburb.



Figures 62-64: Deutsches Museum. Exhibitions include (from left to right) a planetarium projector, the Foucault Pendulum and various plane designs

Lundi 7/8

Today I stayed in Zurich. I went to ETH Zurich to feel its atmosphere so that one day I might have a chance to study there. Einstein studied there too and there was a nice little locker that is turned into an “Einstein was here” exhibition. I spent a lot of time in the library to start thinking about writing a report for my summer student project. I wish I could talk to professors there to converse about research groups in ETH but I sent emails to them and nobody replied, and I was not bold enough to just barge in and initiate the conversation. The Zurich old town quarter was like a Swiss town by a lake, just like countless others, except it’s the biggest city in Switzerland.

Mardi 8/8

Despite having data to be written down on the report, I still wanted to make sure all models are compared fairly and so today I submitted the model training for the three model types (BDTs, ANNs, GNNs), all at once, today.

Mercredi 9/8

Today, Nello and I had an interview with an outreach team from ATLAS to tell about the experience I had when working with Nello and being at CERN in general. Of course, I had to give out a positive comment like “This place is nice and I want to come back if I have a chance.”. It’s not like I lied, though. Who wouldn’t want to come back? Actually, the Student Session presentation began this morning but I didn’t attend because of the interview.

Jeudi 10/8

I attended the second day of the Student Session presentation. Everyone served great presentations and I had chances to understand what they did and ask some questions. Most of these are interesting to me, like reducing a complex magnetic field into a thin lens, et cetera. This evening, I attended the CERN Alumni Summer Students Drink, basically another version of welcome drink (farewell drink?). I brought a bottle of wine in fear of the party lacking drink but the party did have drink and so we all had a good time.

Vendredi 11/8

There was a Summer Student session today too but I didn’t attend as I worked from Schuman the entire day. I retrieved the models’ performance (still didn’t beat BDTs) and wrote down the results section. I wish my work could contribute to the scientific advance in some way (at least Nello can spend time doing something else that matters).

Samedi 12/8

Today, I traveled with my old friend who is studying in Brown University and has come to Germany for an internship. We met at Zurich and went to ETH Zurich and the old town quarter. There is a Zoology museum at ETH Zurich as well which was free of charge. The museum was small and ordinary but had a room full of nice glittering fossils. In the afternoon, we went to the city’s public library and spent some time there seeing what was there. The library had a shelf full of foreign dictionaries, including Thai-German dictionaries. Afterward, we went to the Swiss National Museum by the train station. For 8 CHF, the museum offered lots of stuff related to the history of Switzerland such as archaeological artifacts. There was also an exhibition on the history of Switzerland from its foundation in 1291 to the present, something I’m always passionate to learn about. There was a “Street Parade” today which Zurich hosted the World’s largest techno music party, but we didn’t join and instead left for Basel to stay in a hotel.



Figures 65-67: Art and exhibitions in Landesmuseum

Dimanche 13/8

We went to Freiburg im Breisgau in Germany to go for a small hike into the edge of Schwarzwald (Black Forest). The hiking experience and scenery were like when I went to Saleve despite having journeyed a lot farther to reach here. I enjoyed hanging out with my friend, nonetheless. The train back to Switzerland was delayed because of an incident, causing me to miss a train I was supposed to connect. It took nearly seven hours to get back from Freiburg all the way to Schuman.



Figures 68-70: Freiburg im Breisgau

Lundi 14/8

I made some progress on writing the report, especially on filling out the “Theory” part. This evening, I went to visit ISOLDE (The Isotope mass Separator On-Line facility) which is a facility that takes in proton beams from the beams going to the LHC and forces them on some objects producing various isotopes to be separated for use in many individual experiments. While the scenery was full of concrete blocks, wires, and tubes, the guide managed to keep us interested to know about which tube and concrete block does what. Besides ISOLDE is the MEDICIS facility which contributes to medical research on radioisotopes, another example of CERN contributing to science outside of Particle Physics.

Mardi 15/8

Today I attended a workshop called “Hands-on Workshop with Open Data”, which is to perform data analysis with openly available data in simple file formats. There were actually lots more workshops than this such as working with data acquisition and working with particle detectors but the slots are really really limited (some of them are open for 4 people) and I missed out on applying for most of them as the applications were all full within seconds.

The next three days were spent in a cycle of waking up, writing a report and sleeping.

Samedi 19/8

I went to Avignon in France today. I am a fan of Avignon because I know this city from a game and during a period in the middle ages, it was the place where the popes stayed and ruled. I went straight to visit the Palace of the Popes which also hosted a museum (10 EUR) dedicated to the life of the popes. One thing that distinguishes this place from other museums is that they let you “see into the past” by scanning codes that are available in some rooms with a tablet (borrowed for free from the museum) which would then display what the rooms might have been in the past, including where people sit and do stuffs, as well as objects inspection (there is a treasure hunting aspect going on as well). After the museum, I walked around this walled city (the wall is still in a good shape), stroll by the Rhone river, and left for Marseilles to the south of the city.

I reached Marseilles at 6 PM. The city looks really crowded and littered (the second most populous city). I came here for the Mediterranean Sea and my friend Joseph who I met at GYSS in January. We were very tired and did not go anywhere further than his own house, which he kindly let me stayed at for a night.



Figures 71-72: Avignon



Figures 73-75: Palais des Papes

Dimanche 20/8

Today, Joseph and I went to hike on a hill off Marseilles by a beach. My running shoes could handle this rather easy hike quite well. This hill offered view of white, rocky mountains and the seaside at the same time. Then, of course, we enjoyed ourselves at the beach. The sunlight was so intense I got a sunburn. Apart from the city center, the villages outside the city looked appealing; they are set on a hilly terrain which gives an impression of San Francisco you often see in movies, lacking only trams. The price of food and stuffs in the train stations are on Swiss scale, which I found horrifying.

Lundi 21/8

This is the last Monday I'm staying in Europe and so I actively started to reached out to summer students who I have interacted with to sign my book. I was already in the middle of writing the report when I found out the software I used to train models lack some crucial features which completely disregard the edge information in the event graph and so I put my report on hold and do the jobs from the beginning, with new models.

The next three days were spent in a cycle of waking up, writing a report and sleeping. I must admit that it could have been done sooner if I had been focused on the work more.

Vendredi 25/8

My report is finally finished and I'm ready to submit it, if Nello formally approve it which he didn't today. Today I spent a chunk of time doing paperworks for the departure formalities and contract termination. I had to return my ID card (which is sad because I looked good in it). As an ordinary visitor, I went to the big Globe of Science and Innovation across the street to visit its exhibition "The Universe of Particles". The exhibition is open only on the ground floor and featured some instrument parts and videos of particle accelerators. I then spent a good part of the evening in CERN Gift shop to buy loads of souvenirs for my friends in Thailand.

Samedi 26/8

I decided to go to Lausanne alone to use up the last day of my Eurail pass. I didn't really know what was there; it was probably just another Swiss city by a lake with an old town quarter and cathedrals. Lausanne must have something more than that but I treated and toured the city as just another Swiss city by a lake with an old town quarter and cathedrals. I also came here looking for souvenirs like chocolate and playing cards with unique styles (there is no reason that Geneva won't have things like these) but returned empty-handed. An honorable mention was Läderach, presumably one of the most serene chocolate brands out there. it's so serene the price is like 6 baht per gram of it. I'll just buy bars of chocolate from Carrefour tomorrow. I also spent almost half an hour walking from the city center all the way to the lake which stood a Thai pavilion dedicated to Thai-Swiss diplomatic relations and the late king Rama IX. Some European citizens were seen taking photos in front of this understandably unique landmark. I was also thinking of visiting EPFL (École polytechnique fédérale de Lausanne) but scrapped the idea because of the distance to it (I didn't bother looking up the public transport).

I went back to Meyrin to have one last Italian meal at Academia Lugia with the Thai friends and some other summer students. I randomly picked a pizza that tasted like Phat Kaprao at home. I and some other students in Schuman threw a farewell party which lasted until 4 am consisting of playing card games, just chatting and making pasta because we were all hungry by the end.



Figures 76-77: A stained glass in a cathedral (left) and Thai Pavilion in Lausanne (right)

Dimanche 27/8

I woke up 10 am today, being called by the housemaid as I had to check out by that time. I needed to rush packing my stuff and leave the hostel, without buying additional chocolates to bring back home. My luggage weighted over 28 kg but while I was ready to pay for the extra luggage, they simply let my bag passed without additional charges. We then endured 21 hour journey back to Thailand.

All good things must come to an end.

PARAMOTT BUNNJAWEHT

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EDUCATION

Chulalongkorn University
4th Year, Bachelor of Science
Department of Physics
1st class honor

August 2019 - August 2023
Overall GPA: 3.78

SCHOLARSHIPS

Faculty grants for the student with the highest GPA of Physics Department

2020 - 2023

RESEARCH EXPERIENCE

$t\bar{t}H$ Events Classification with Graph Neural Networks

June 2023 - Present

- CERN Summer Student 2023 research project.
- Supervisor: Dr. Nello Brusino
- Employs Graph Neural Networks in classifying particle collision events producing a top quark pair and a Higgs boson in $2L(SS)+1\tau_{had}$ Channel

Correcting Optical Wavefront Distortion due to Strong Atmospheric Turbulence using Deep Neural Networks

December 2021 - May 2023

- Undergraduate research project.
- Advisor: Prof. Thiparat Chotibut, Dr. Poompong Chaiwongkhot
- Designs a Neural Network model capable of obtaining information on wave distortion from received laser images due to a strongly turbulent atmosphere to assist distortion correction by optical instruments and improve the quality of Free Space Optical Communication.
- Thesis: [Click here](#)

ACADEMIC ACHIEVEMENTS AND AWARDS

Hitachi Trophy Competition 2023, Faculty of Science, Chulalongkorn University

May 2023

- Excellent rating (Gold Medal)
- Presented undergraduate research project in the form of 3-minute pitching on Youtube.
- Video: [Click here](#)

Thailand's Representative in CERN Summer Student Program 2023

January 2023

- Selected by Synchrotron Light Research Institute to be one of Thailand's representatives to participate in CERN Summer Student Program in Geneva, Switzerland between June and August 2023.

Thailand's Representative in the Global Young Scientists Summit 2023

August 2022

- Selected by the National Science and Technology Development Agency to be one of Thailand's representatives to participate in the Global Young Scientists Summit 2023 in Singapore in January 2023.

28th International Philosophy Olympiad

May 2020

- Honorable Mention.

17th Thailand Physics Olympiad

June 2018

- Bronze Medal.

14th Thailand Astronomy Olympiad

April 2017

- Silver Medal.

SCHOOLS/CONVENTIONS ATTENDED

CERN Summer Student Program 2023

June 2023 - Present

- Joins the CERN scientific community in Particle Physics research and studies.

Global Young Scientists Summit 2023

January 2023

- Met distinguished scientists and engaged in discussions with scientists and fellow students regarding scientific research.

IF-NAS Summer School 2022

June 2022

- 2-week course on Mathematical Physics, Relativity, Quantum Information, Quantum Field Theory, and Cosmology.

UCLQ Quantum Technologies Summer School 2021

September 2021

- Learned basics of Quantum technologies, Quantum computing, and algorithms.

SKILLS

Programming skills:

Proficient in Python programming

Experienced in Java and C programming

Languages:

Communicates fluently in English.

IELTS Overall Band Score: 8.0

Extracurriculars:

Peer Tutoring, Programming

