CERN
SUMMER STUDENT
PROGRAMME 2023

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CERN SUMMER STUDENT PROGRAM 2023

Ek-ong Atthaphan

Preface

The report is written to record my unique experience I have gotten while I was participating CERN Summer Student Program 2023, at European Council for Nuclear Research(CERN), Geneva, Switzerland. This report consists of the detail of the program, the project report I have done in the program, my experiences and suggestion for next year students, and the diary I wrote while I was in the program. Hope this report will be beneficial for people who interested by the program or the students who will attend the program in the future.

For the great experience in this report, I would like to express my gratitude towards Her Royal Princess Maha Chakri Sirindhorn and the committees for selecting me as one of the summer student.

Dedicate to all great people I have met while I was CERN summer student.

Ek-ong Atthaphan

Contents

Chapter 1

CERN Summer Student Program 2022

CERN summer student program offers an unique opportunity to work under 8-13 weeks paid contract at CERN, along side with an extensive physics lecture program by the experts and scientists from around the world. The details and records of the lecture program this year can be found here. This opportunity is offered for outstanding physics, computer science, engineering, and mathematics students who pursuing bachelor's or master's degrees, regardless of nationality. This program also offers supplementary activities such as

- **Visits**: Students can participate visit sessions organized by CERN. The visits includes ATLAS Visitor Centre, Synchrocyclotron, Antiproton Decelerator, and Data Centre. Additional visits may be scheduled to SM18 and the CMS Cavern.

- **Hand-on workshops**: During the period of contract, students can sign up for several hand-on workshops organized by CERN. The workshops this year are organized in topics; ROOT programming; data acquisition; MADGRAPH; and hand-on on varies types of detector. The records of all the workshops can be found here.

- **Poster session and student session**: CERN organizes two sessions for students to present their project. One is poster session where students will present their work with their poster simultaneously. Another one is student session where each student will present their work on stage, one by one. Both of sessions are limited the available seats for the speakers, where the registration is in a first come, first served manner.
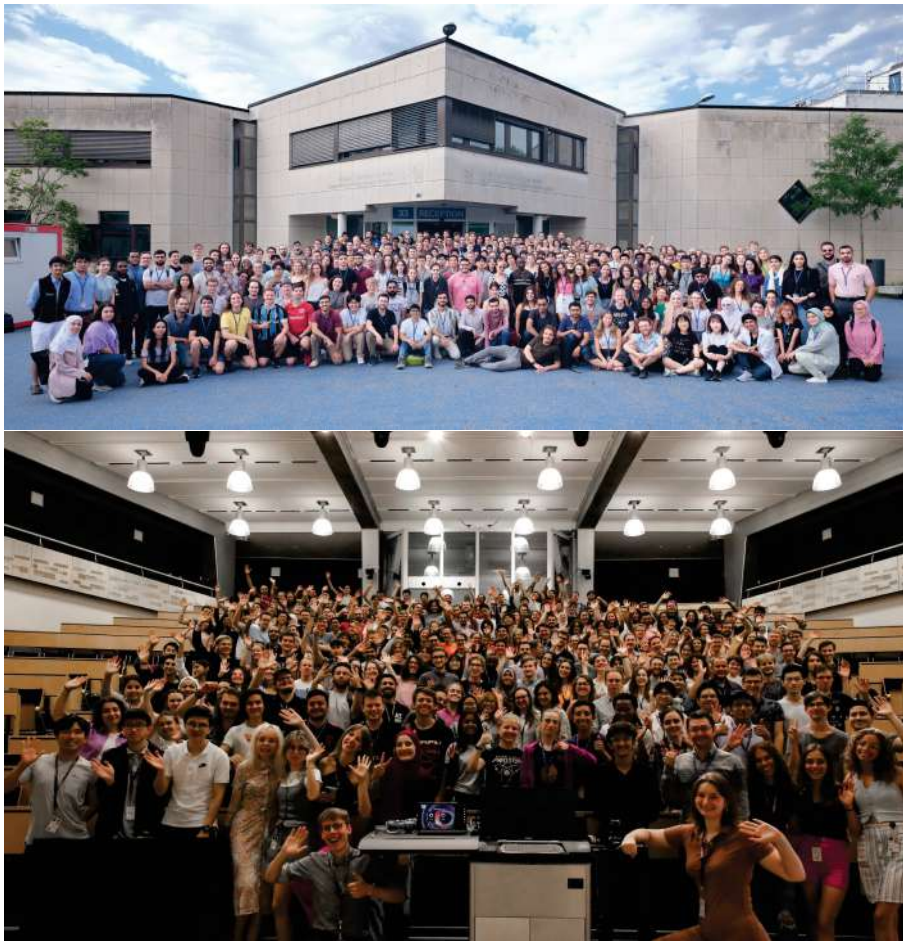
Figure 1.1: Group photos of Summer Student Program 2023

Chapter 2

Project Report

Here will be project report which I have done at the end of the summer program. For the acknowledgment, I would like to express my gratitude towards my supervisors, Dario Mapelli, Stefano Belforte, Thanayut Seethongchuen, without them, this project would not be completed. Thanks for sincere help, guidance, and understanding of my requirement along the program. Also thanks to Nikodemus Tuckus for being my friend and my great colleague, and for offering my private office, this work is much more intriguing with cool office.

Summer Student Report

Building of CRAB Spark Data Pipeline

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Abstract

CMS Remote Analysis Builder (CRAB) has an important role to help CMS users submit analysis jobs to the LHC Computing Grid. CRAB team want to analyze the users usage to prioritize the features, to know which one should be deprecated or should be upgraded. This project focuses on building a the data pipeline to provide a daily update of this kind of information to the CRAB team. The usage data is processed through PySpark, saved into Opensearch and eventually visualized with Grafana. Moreover, manual scripts are provided for the CRAB team to reproduce it later when questions change.

1 Introduction

The data flow in CMS experiment start from data tier so called "RAW", where it is just a snapshot of the position that particles hit detector. After that, RAW data can be mapped to the path(track) of charged particles, this data tier is called "RECO". Even the path of charged particles is known, still, this data type is not good to be used as source of physics analysis, due to the size of it. Therefore, after RECO, there are Analysis Oriented Datasets or "AOD", "MINIAOD", and "NANOAOD", these three types of data are just reduced information versions of RECO, where they are ordered from larger to smaller, respectively. These three data tiers are used as n-tuple objects to do physics analysis, usually, physicists use ROOT to do so.

The processing of transformation from RAW to RECO/AOD/MINIAOD/NANOAOD is usually done by WMAgent in CMS, but when people come up with some radical idea and their want to choose different n-tuple format and different data selection criteria, or let say "when people want to try different way to interpret and classify the data", CRAB (CMS Remove Analysis Builder) team will provide services to allow people to do so. Basically, CRAB enables CMS physicists to exploit remote (Grid) about 30 percent of computing resources in CMS for data analysis in a transparent way.

2 Motivation

Last year, the CRAB team had a summer student who explored with pyspark the condor jobs parameters, looking for patterns in user needs for input datasets that could help the CMS Data Management team plan their improvements.

After getting used to pyspark, this year the CRAB team wanted to build a new complete data pipeline that runs daily and that allows to visualise how many users use specific CRAB features, in order prioritize the maintenance effort, discover which features can be deprecated or improved and understand which new features could be needed.

In order to guide the development of the new pipeline, the CRAB team compiled a list of questions that it should be able to answer,

Rucio

1. How long do tasks stay in "tape recall"?
2. How big are the datasets that are recalled from tape?

CRAB Server

1. How many tasks are using crab features? (Split algorithm, Ignorelocality, ScriptExe, GPU)
2. How many tasks each users submit?

Condor Matric

1. What is wall clock time spent by each CMS data tier and each job type?
2. What is the success rate of the Analysis job type?
3. How many jobs use ignorelocality?

3 Methodology

This is how the project are managed.

1. Understand the set of questions in section 2.
2. Make sure that the necessary data is in HDFS. If not, find the data source and make sure it is dumped daily to HDFS.

3. Explore the data in HDFS with PySpark, what data do we have and what data do we need.
4. Query the set of interested data and save them in Opensearch.
5. Create Grafana dashboard to see the historical data, and visualise to answer the questions.
6. Add cronjob to update data daily.
7. Make data pipeline system to easily to update later when questions change.
8. Write a manual for CRAB team to reproduce it.

4   Result

Four independent pipelines have been developed. Their inputs are HDFS directories and their outputs are indexes in the `es-cms.cern.ch` Opensearch instance:

- **CRAB Task DB**
    - Input: `/project/awg/cms/crab/tasks/{date}`
    - Output: `crab-taskdb*`
- **Condor Raw Metric**
    - Input:
        - `/project/monitoring/archive/condor/raw/metric/{date}`
        - `/project/awg/cms/crab/tasks/{date}`
    - Output: `crab-condor-taskdb*`
- **Rucio Rules History**
    - Input: `/project/awg/cms/rucio/{date}/rules_history`
    - Output: `crab-rucio-taperecall-history*`
- **Rucio Rules**
    - Input:
        - `/project/awg/cms/rucio/{date}/dataset_locks`
        - `/project/awg/cms/rucio/{date}/rses`
        - `/project/awg/cms/rucio/{date}/rules`
    - Output: `crab-rucio-taperecall-rules*`

Each of these datasets has large size of information, personal computer cannot handle it. So, we need to calculate it through Spark cluster. The Grafana dashboard has been shown in following link, where default panels have been shown in Figure 1. This dashboard answers all of the question in section 2, and some extra (good to have) visualisation that suggested by people in CRAB team. All of them are updated daily by running cronjob in a docker container provided on `crab-dev-tw04` machine.

The materials are available on Github. The cronjobs folder contains code for pulling the data today from CMS HDFS and upload to the dashboards, where:

Spark Scripts

- `crab_data_daily.py` - Pulls wanted data from CRAB Task DB,
  to es-index: `crab-taskdb`
- `crab_condor_daily.py` - Pulls wanted data from Condor raw metric,
  to es-index: `crab-condor-taskdb`
- `crab_rules_tape_recall_daily.py` - Pulls wanted data from Rucio rules,
  to es-index: `crab-rucio-taperecall-rules`

– `crab_tape_recall_daily.py` - Pulls wanted data from Rucio rules history, to es-index: `crab-rucio-taperecall-history`
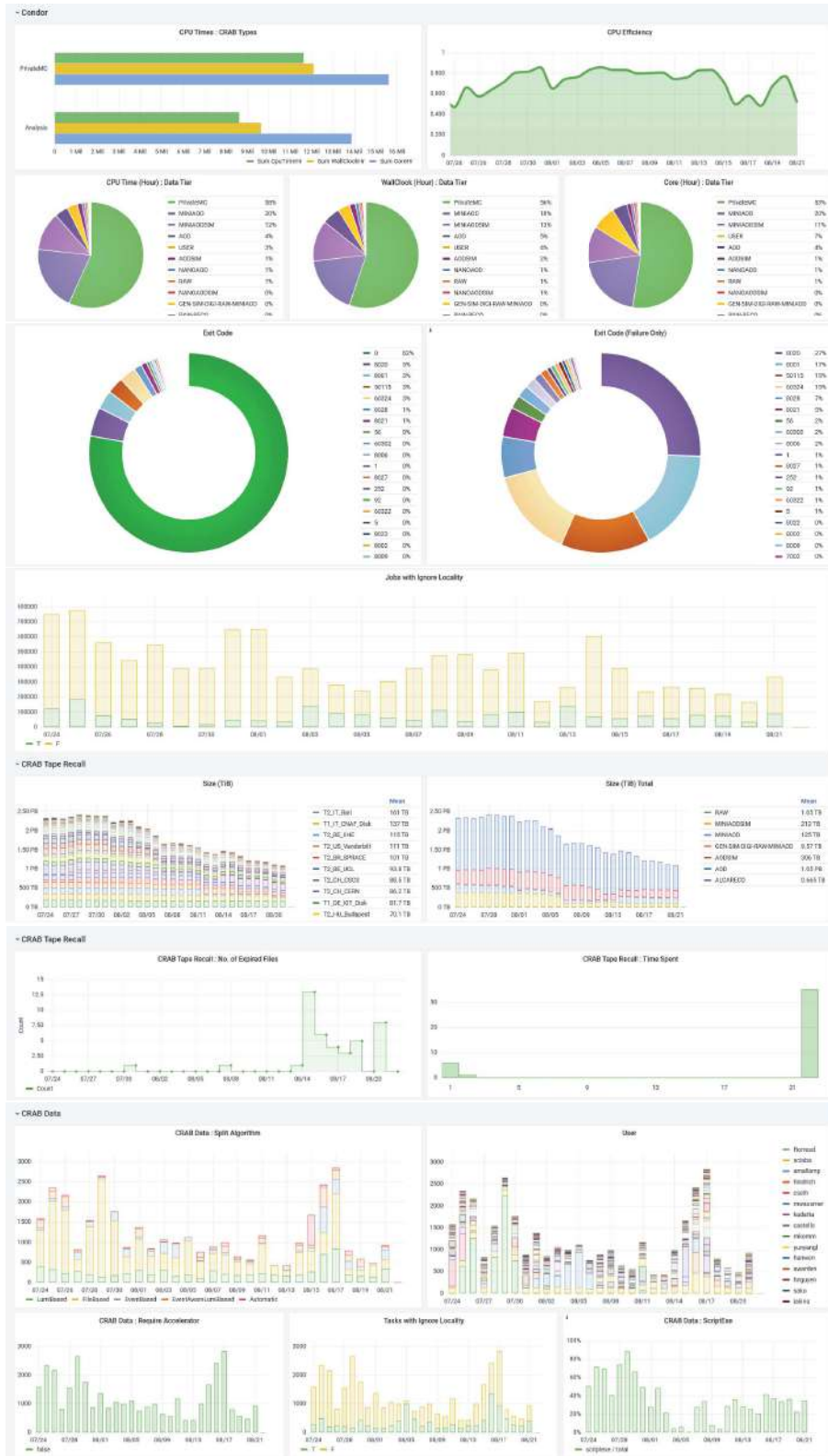

Figure 1: Default panels in Grafana dashboard, it answers all of the question in section 2. Changing the time range and add filter can be done in Grafana.

Wrappers

- run_spark.sh - Shell script for source environment and run spark-submit for $1 file, where $1 in the script supposes to be a Spark script file (.py)
- cron_daily.sh - Shell script for running run_spark.sh in the docker container, for all four Spark script files. Note that the file directory here must be directory in the container, not the host.
- bootstrap.sh, osearch.py and secret_opensearch.txt - Tools for source the environment for spark submit and send data to Opensearch Dashboards, just have it in the work directory of the Spark script file (.py)

To upload all of the data daily, just setup crontab to run cron_daily.sh script everyday.

Since there is no method to delete specific data in Opensearch, when you want to add a new schema(column) into the data frame of an index or there is error occurs such as data duplication or wrong schema is uploaded, you have to delete entire data, and upload them again from the beginning, manually. To do so, you can use material in notebooks folder, which provides the same functions as cronjob. You can upload any wanted data to the any time range by changing only start_date and end_date in the particular notebook.

For the prerequisites, these scripts are for running in crab-dev-tw04 machine. In order to run it on the machine, you need a user or service account keytab that has permissions to access the Spark "Analytix" cluster and that can write to CMS HDFS.
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More elaborate version of manual scripts available here.

5   Discussion

It seem like Spark cluster cannot handle the large size of data very well. There is an error occurs randomly when we try to calculate the data from Condor matric. After all, the work is done. With the material and manual script I provided, people in CRAB team can reproduce it. The work itself is reliable enough to be pushed to production grade, it is now available in CRAB formal repository.

Chapter 3

Experiences and Suggestions

3.1 Experiences

3.1.1 Working

Unfortunately, I got the project I was not interested, even I asked for specific kind of physics project, still, the project I was assigned is not about physics at all. I have to admit that I was not happy with my project as I should. However, it does not mean everything went bad. My supervisors realized my condition well, so they tried so hard to exposed me the physics framework, even it does not really related to my work. And although, my project was out of my interest, but I still learnt something new from its, and I did it so great, said by my supervisors.

3.1.2 Living

Short answer, "These 12 weeks are the best 12 weeks I have ever been." Even though, many Asian people said they did not satisfy with the food here, but I am. I love food here, even it was not fancy and delicious like food in Thailand, but it is decent enough to satisfied me, and the big advantage of the food here is it's healthy. For the accommodation, CERN gave me everything I could ask for. It was clean, safe, not far from restaurant and working place; I can hang out with other summer students every night at restaurant; I can bike to work or even bike under the dark at midnight to see the night sky without concerned about getting robbed. For the traveling, Switzerland is the beautiful country, the nature is incredible, the people here are so nice, and it is surrounded with the gorgeous countries you can easily visit.

3.2 Suggestions

3.2.1 Working

There is nothing to worry about, since you are selected thoroughly by the mighty committees from Thailand. Only one thing you should realized is you are supposed to work for them, not study from them from the beginning. So, for example, if you want to work on physics data analysis from detector, they expect you to know ROOT, or you will not accepted for this kind of work.

3.2.2　Expense

I can assure you that the money you will receive here can cover you everything, if you plan it well. For example, me, I lived in CERN hotel 27 CHF/day, I normally eat at CERN restaurant around 25 CHF/day (I eat 2 meals a day), I never cook by myself, I go for some trip every weekends around 200 CHF/week, still, I can afford some miscellaneous things like shoes and coat, and there are several hundreds CHF left for souvenir.

Chapter 4

Diary

June 3, 2023

Here is the first day in Geneva. We, four students from Thailand, arrived around 2 pm at Geneva airport. Because of some confusion, Aj. Phat cannot be there to receive us from the airport. Anyway, I have appointed my senior, Mr. Tawanchat, who currently works at CERN to welcome us and give us a small tour around CERN. Since, I have reserved CERN hotel while the other Thai students have reserved Schumann hostel, then we had to separate in front of CERN and check-in at our own place. Today is Saturday, the grocery stores are still open. So, after unpacking my stuff, I took a bus to Schumann hostel and joined my friends for shopping at Carrefour market. I bought lasagna and Coke for dinner. Luckily, I can use my debit card from Thailand, because I had no any Euro in my pocket, only Swiss franc. Now, 11pm, I am going to sleep.

June 4, 2023

When I woke up today, I was surprised that I didn't have any jet lack, maybe because I didn't sleep too early yesterday, even I was awake for 24 hours. Today, I went to the downtown with other Thai summer student. We bought day tickets for public transportation. It is quite convenient here to travel around the town with this kind of transportation. On this trip, we walked around downtown, sightseeing around Geneva Lake, park, some monuments, cathedral, and art museum. At the end of the day, Aj. Phat brough us to Thai restaurant, James's pub, and gave some tour around Cornavin train station.

June 5, 2023

Here is the first day of CERN contract. There is a welcome session for summer students in the morning. They told us to-do list and useful information for living in CERN. After the session, I went to my supervisor's, Dario, office to greet him. He showed me my table and helped me set up my laptop. Then, I went back to my room and dealt with my CERN account and booked bike renting.

Figure 4.1: Globe of Science and Innovation

Figure 4.2: Inside CERN

Figure 4.3: In front of my office, inside the building

June 6, 2023

I received my bike in the morning, then I rode my bike to work. Today I met my supervisor's colleague, Wa, he is Thai, and he helped me to deal with my summer project, like he is another supervisor. After we met, they showed me what is my summer project and what I need to know before doing the project. Because I don't have any background in this kind of work I have to do here, I must start at the beginning. My supervisor gave me some homework and exercises to do, it is about database and SQL. At lunch, we went to the cafeteria and had a meal together. After that, I went to the office and did the exercise they gave me until 5 pm, then I backed from work, had a dinner, and finished the exercise.

June 7, 2023

I went to work around 10 am. Today my supervisor and his colleague gave me a lecture about data flow/management in CMS experiment. After 2 hours lecture, we had lunch together and had some conversations. I had a discussion with my supervisor about my working hours. He said he isn't concerned about it, I can work either at the office or somewhere else I want, and not necessarily to work for 8 hours a day as in contract, as long as I can finish my work. Anyway, we agree that I should be at the office at least 4 hours around 10:00 to 14:00 to update or consult with supervisors every day. In the evening I, Tawanchat, Jai, and other Thai summer students went to Thoiry in France to have a dinner in buffet restaurant called Seazen.

June 8, 2023

My supervisor and his colleagues will be busy for these two days, so, I don't have to go to the office today. In the morning, I reviewed things I had learned yesterday. In the afternoon, there is a tour at Antimatter Factory and data center for all summer students. After the tour, I and other two Thai students rode bicycles to Blandonnet to find SIM card and buy goods. Apparently, there is no SIM card there, Blandonnet is just regular supermarket like LOTUS in Thailand. Anyway, I found strawberry and other kind of fruits that cannot be found easily in Thailand. Their tastes are so good. I love strawberry so much, it is so sweet, while most of strawberry in Thailand is sour.

June 9, 2023

There is DPST conference tomorrow, I am one of speaker there. So, today I told my supervisor that I need time to prepare the presentation for tomorrow, I will not work today. My supervisor understands that. After preparing the presentation all day, in the evening, I went to mall, Balexert, to find SIM card. Balexert is big mall; it is like Central or The Mall in Thailand. There are many stores and a movie theater. Finally, after comparing, I got SIM card from Salt company, it is 49.9 francs per month, come with unlimited call, SMS, and internet in Switzerland and EU countries.

Figure 4.4: Outside/inside antimatter factory

June 10, 2023

This is first weekend here, I and other student from Thailand decided to visit Lyon today. I woke up 4 am to have a presentation for DPST conference. At 6 am, we departed from CERN to Cornavin train station. We took the train from Geneva to Lyon, it took around two and a half hours and cost 45 francs. This is a discounted price for students. At Lyon, we walked around downtown and the old villages zone. The highlight of this trip is a big cathedral on the top of mountain, it is old, beautiful, and delicate. I just knew when I arrived that this is the place where my favorite bedtime story, the little prince, was born. I bought some souvenirs about the little prince for myself. I must say, Lyon is a beautiful city, the buildings and the stores here are so charming. Around 20hr30, we took the train back to Geneva. I arrived at my room around midnight. So tired, it is such a long walk today.

June 11, 2023

Sunday, my casual day. I wear pajamas all day. When I went out for my lunch at R1, the restaurant near the hostel, I accidentally met a group of summer students there. I was so nervous, but finally, I joined them. We introduced ourselves to each other and had a discussion together. It was fun and satisfying to meet new people here. But this made me realize that my English is not strong enough, I cannot fully understand what they said, and cannot say what I thought effectively. Then, in the group, I became quiet person, while I am not when I can speak Thai. Although this makes my self-esteem lower, I still want to improve myself anyways. After dinner, I went back to my room, and did my work for discussing with supervisor tomorrow.

June 12, 2023

Today, I went back to work as usual. Went to the office around 10am and discussed the problem with my supervisor and his colleague. By midday, I finished one of the main tasks. So, I came back from work early today. At the evening, I met other summer students at cafeteria, then I hanged out with those people at the cafeteria until late at night. We played table football and ping pong, it was very fun.

June 13, 2023

Today, my supervisor and his colleague gave me a lecture about CRAB system and workflow in CMS. The lecture took almost 3 hours, I am so exhausted. Then, after the lecture, I had lunch and went back to my room for rest immediately. Because I felt so good last night, again, I went to cafeteria to have dinner and hang out with other summer students, including Oak from Thailand. Tonight, we played cards and board games.

June 14, 2023

Today, it is another lecture by supervisor and his colleague. This one is about what is my project and what do I am supposed to do next. After the lecture, I had a lunch, then, went to visit CERN facilities as in schedule for summer student. We

Figure 4.5: Things in Lyon

visited synchrocychrotron and ATLAS control room today. After the visit, I went to CMS summer party. Of course, I met other summer students there. I talked with many people and met someone new at the party. At the end of the party, I and other 4 students cycled around CERN for 30 minutes. It was fun and beautiful, the wind was so good and sky is full of stars.

Figure 4.6: Synchrocychrotron machine

Figure 4.7: ATLAS control room

June 15, 2023

Today is my lazy day. Because my supervisor will be busy for these two days, so, I decided to work at my room in the morning and join group meeting in the afternoon. But in reality, I am so lazy and sleepy, maybe I was in the party too late last night, then I slept for the whole morning, not doing any work today. But I joined the meeting as I should in the afternoon, on time. Anyway, the rest of the day, I spent time watching movie, playing games, and talking with my friend. That is why I called today 'my lazy day'.

June 16, 2023

As I said yesterday, today my supervisor is still busy. So, I worked from my room in the morning. I encountered some problems, but I still can ask my supervisor in Mattermost, he answered so quickly. At the afternoon, I left my computer to run coding, and I went to supermarket, Blandonnet. I bought hiking stuff, prepared for tomorrow, and bought strawberry there. In the evening, some people had an idea for tonight, they were going to explore an old tunnel in CERN. Of course, I joined them. At the tunnel we found that it is actually tunnel for running cables and water/gas pipes, it is very long and complicated. By the way, we have rule among us that said "No matter what, if there is prohibit sign, we will not go in there.", so it is quite safe. Walking along an accessible path in tunnel finally took about 2 hours, and there are still many paths we have not explored yet.

Figure 4.8: Students who explored old tunnel

June 17, 2023

Today, around 20 summer students, including me, went to Schweiz in France for hiking. It is a small one, only 3 hours hiking. But because we are a big group with many people who have never hiked before, and this one is harder than we thought, so we spent almost 5 hours for this hiking. Almost everyone had the same problem, they bring too small amount of water. After hiking, even we all were tired, but we decided to go to the Geneva beach. At the beach, we had a small swimming and then split up to several activities. Some took sunbath, some played card games, and some played volleyball. I am one of people who play volleyball. Around 6.00 pm,

Figure 4.9: Group photo at the top of Schweiz

Figure 4.10: Baby plage or Geneva beach

people started get back to hostel. I and some people came back around 6.30 pm, and we had a dinner at R1 in CERN.

June 18, 2023

I woke up late today with tired body. Hiking yesterday was tough. After taking some stretches, I went to lunch. I met some new summer students there, so I was involved to that group and have some small discussion. After lunch, I and a few friends played table tennis at restaurant. After an hour there are some more people join us. When we started tired, we took a rest and played card games instead. Among us, there was Azerbaijan girl, she taught us how to play Russian game, called Durak. This game card is very complicated, and it is so funny because she is bad at teaching, so we took around an hour to fully understand the rules of the game.

June 19, 2023

My supervisor suggested me to take the CMS induction course that arranged in these two days. So, today I was involved in the induction course all day. This course is for introducing CMS experiment to newcomers who are going to work in

Figure 4.11: Jet d'Eau, near Geneva beach

the experiment. At the end of the day, there is a reception dinner for the participants. I was at the dinner, I am the only summer student there, the rest of people who took the course are Ph.D. Students or CERN fellows. In the dinner, I had a chance to talk with many people, one of them is senior scientist who worked since CMS is created, he told the story when the first signal from LHC was observed and when Higgs boson was discovered in 2012, I am so inspired.

June 20, 2023

As the same as yesterday, I was in the induction course all day. Anyway, in the afternoon, we had opportunity to visit to the P5, which is the area where CMS detector is located. We had to take a bus from CERN around 30 minutes. At P5 we were given information about safety, and then visited the detector in underground. I was a bit disappointed, because I could see only the edge of the detector and it was entirely covered by metal sheet. Any the guide who got along with us spoke quietly, we did not hear much. However, today I met a lady from Spain, who would be here only one week. She is not good at English as same as me. She seems to be a nice person, we talked along the way to P5, even sometimes we did not understand each other but we still laugh. It is nice to meet her today.

June 21, 2023

Today, there is ROOT workshop for summer students arranged from 9.30-12.30. My summer project is about data analysis, but it is not necessary to use ROOT. Anyway, I intend to work on particle physics in the future, so I have to use ROOT one day in the future, then I decided to participate the workshop. In the workshop, there was too much content, and the lecture was too fast, me as a beginner cannot follow the workshop. By the way, I can understand the whole picture about ROOT such as "why ROOT is so popular in CERN", "what is the usage of ROOT", and

Figure 4.12: Back cap of CMS detector

the basis commands for using ROOT, and the lecturer gave us the document to read for learning by ourselves.

June 22, 2023

I woke up early today, 7.30 am, because I wanted to arrive at work at 9.00 am. I realized that I was too lazy for the last week, I did not do work as much as I should, so, today I talked with my supervisor about this. I said I want him to put pressure on me, if he feels I am behind schedule. At 11 am, there is group meeting for CRAB team, I presented my little progress for last week, unexpectedly, the head of CRAB team admire me as having a good progress. After the meeting, I grabbed lunch and came back to work. I did the task that my supervisor gave me so fast, and all my supervisors left the office already, so I left the office early today. At the evening, I and other Thai students had a dinner with Aj. Chayanit from Chulalongkorn. She brought us to Chinese restaurant in the downtown. After dinner, we walked to ice cream store, Manu Gerato, cherry and rum resin became my favorite ice cream flavors since this one.

June 23, 2023

I went to the office in the morning and had an online meeting with my supervisor. Today, he gave me some tasks to test my understanding. Apparently, I did very well. During the day, some summer students informed me in WhatsApp that there will be Geneva music festival tonight, without hesitation, I replied them that I will go either. After I checked the concert schedule, I found that there are many stages and many kinds of music performed. So, I went to my interested stage alone,

Figure 4.13: Old prison in Annecy

because not many people like the same kind of music as me. At the late night, festival still go on but I am so tired, I went back to CERN with the very crowded tram.

June 24 2023

I slept only 4 hours last night. I had to wake up early today to take carpool, going to Annecy, France, with other three Thai students. Here is a very beautiful city. It is not a big city like Geneva, but the city has stories. We went to museum, it is a museum in an old castle from the middle age. After a 2 hour walk around the museum, we went to a local restaurant near the river to have lunch. The meal was so gorgeous, I ordered a local dish here, it is some raw meat with a lot of cheese and potato, I love it. Then we bought ice cream as dessert. Before we left, we walked around Annecy's Lake, and we took a paddle boat to ride around the lake. Because the water is so clear and it is not deep, with the hot weather involved, I jumped into the lake and took a swim around the boat.

June 25, 2023

Sunday, a casual day, and of course, a rest day. But not today. Today, I woke up at 5 am to have an interview for DPST abroad scholarship. I was so nervous, the weather is so cold, and I was so sleepy. It seemed to be the interview would be bad, but when it really started, everything was going smoothly. I could say everything I thought. The committees were so friendly, I felt they liked me. So, after the interview ended, I felt so confident. I think I have high probability to be accepted, if it goes another way, at least I will feel that I did the best I can do, I will not be regret. For the rest of the day, everything goes as usual as normal Sunday, have a lunch, hang out with friends, watch a movie.

June 26, 2023

Today, I went back to work as usual. Anyways, in the afternoon, I and other Thai students went to visit permanent That embassy in Geneva. The ambassador was so friendly with us. She prepared drink and bakery for us, and we had a long conversation for a lot of things, from food, culture, until politic. Everything went very well today. After visiting, we went shopping. I got a coat for our trip in Chamonix, and I also bought some food and whisky to share with my foreign friends.

June 27, 2023

This is the first day of the lecture program, and it will be continuous for 1 month. We had lectures in the morning and went to work in the afternoon. Among many lecturers, there is David Tong, who is very famous in particle physics group. He is a professor at Cambridge university, in the past, he wrote many lecture notes for many subjects in physics. Many lecturers who teach physics use his lecture note as reference. While teaching, Tong was very energetic. His lecture today was very wonderful, everyone seemed to like him. In the evening, I invited a foreign friend to test whisky I just bought yesterday, so he invited me to join the meal he cooked.

June 28, 2023

Today is the second day of the lecture. David Tong still kept his wonderfulness in his lecture. After the lecture, I had to finish lunch quickly or I would miss my supervisor, because he usually leaves the office around 1.30pm. Anyways, his realized that, so he told me that in the lecture day, we should meet at restaurant instead. After work, I and other Thai students went to restaurant in France site together, to meet with Aj. Phat and his colleague. We discussed a lot of things, Aj. Phat also gave me advice and the important thing, he treated us drinks.

June 29, 2023

Everything goes as usual today. I attended lectures, had lunch, met supervisor, and had dinner. The only difference is I did not have to work today, because all I need is to wait for the IT department to fix some problems for me. So, in my free time, I watch movies and play games to relax myself as usual.

June 30, 2023

Still no update from IT department today, so this is another day I don't have to work. Anyway, lecture today is the last lecture from David Tong. So, before I left the lecture room, I asked him to take a picture with me, and he was glad to do it. He is very nice guy. In the afternoon, I played games as usual as I do in my free time. But today, there is some thought in my mind. I realized that it is such a waste of time to play games every time I am free. I knew that in free time we can relax, we can do anything we want, but I just felt like I have so much free time here in summer program and I give it to playing games too much. So, I intended to change my hobby in my free time, I was thinking of reading a book. Anyway,
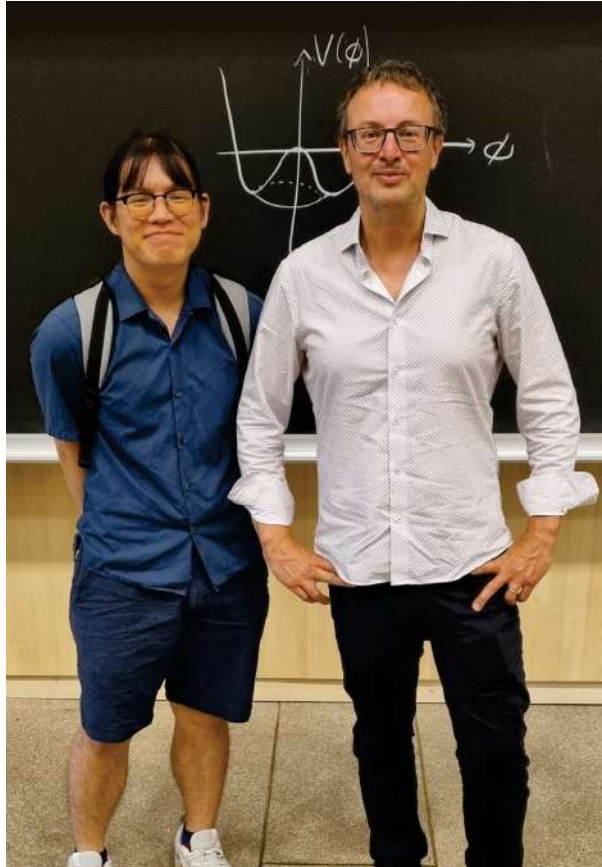
Figure 4.14: David Tong and me

for evening today, I and other three friends went to the downtown to piano concert, it was concert on Han Zimmer pieces, but played by some pianist in Geneva. The show was not bad, but we expect more, she played too short and spoke too much, in French.

July 1, 2023

Finally, this day has come, the day that we go to MONT BLANC!!!! We, four Thai students and other two summer students, took the first bus of the day to Chamonix and took the cable car that we had reserved to Mont Blanc. This place is so amazing, the snowy mountains, wonderful geography, refresh air, everything is good here. For a while, I want to forget everything, just be in the moment, appreciate the nature, lie on the ground, and feel the mother earth.

July 2, 2023

Like every past Sunday, take a rest after long walk trip on Saturday, chill around hostel and the restaurant with a casual outfit.

July 3, 2023

Back to Monday, still don't have any update from IT guy. I attended lectures

Figure 4.15: View of Mont Blanc

in the morning and talked with my supervisor in the afternoon. Since I cannot do anything if the IT guy does not finish his task, my supervisor gave me some tasks to do in parallel and told me to give pressure on the IT guy. Anyways, I decided to meet the IT guy tomorrow. Today, after talking with my supervisor, I went back to my room and do the task he gave me. Anyways, since my work does not satisfy me, it is boring and not challenging, so I have some though that I would like to write a lecture note about the standard model for anyone who has never learnt about it.

July 4, 2023

As usual, I attended the lecture in the morning and met my supervisor in the afternoon. Today, there was some interesting topic in the lecture, so I had discussion with some friends, then I felt like some of them are smart and respectful, so I asked them to review my bachelor's thesis for giving me some advice to modify it into lecture note. At the evening, there was welcome drink session for summer students. I was disappointed, because I expected some alcohol and BBQ, but there were none of these things in the session. By the way, it was nice to meet new people here.

July 5, 2023

As usual, I attended the lecture in the morning and met my supervisor in the afternoon. After then, I went back to work from my room, because there was raining, I could not ride to work. By the way, this was my first time that I seriously do my work in my room, in the past, I usually do nothing in my room, just play game and watch movie. In the evening, I went to supermarket in France, Carrefour. I bought some freezing food for four meals, two packs of drink, and hygiene stuff.

July 6, 2023

Today is just a boring Thursday, just attended lectures, had lunch, worked from my room, and had dinner with freezing food. Anyways, I met a Czech guy who drunk whisky with me, so I invite him to ride a bike this midnight after streetlight is tuned off. At midnight, we rode to restaurant 2, it was quite dark, but that made us see the beautiful light from the city. After a while, security guards walked toward

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Figure 4.16: Party's atmosphere

us, and asked for badges. We were afraid a bit, but they said we did nothing wrong, just triggered alarm system, we can sit there as long as we want. So, we sat there for one and a half hours, we had conservation about a lot of things, including science and life, it was such a good conversation.

July 7, 2023

Today, I did not go to work, because I already cleared all my work yesterday. So, in the afternoon, I did laundry and washed my shoes. Finally, the time had come, the time I had waited for a whole week, the party time!!! I will not write so much about the party, just know that it was chaos party, which is so much fun.

July 8, 2023

Of course, we have a trip every Saturday. For this week, we went to Aletsch glacier, the second biggest glacier in the world. We had to take 5 hours train to Fiesch, take a cable car up to the mountain, hike for 2 hours, climb down the hill, then we could step on the glacier. This is such an exhaustive trip, but it is fun and beautiful, the feeling of touching the glacier is so powerful and concern at the same time, because the glacier melts every year due to the global warming.

July 9, 2023

Like every past Sunday, take a rest after long walk trip on Saturday, chill around hostel and the restaurant with a casual outfit.

July 10, 2023

Today, they started a new series of lectures. This week have many interesting lectures, including my favorite subject, the theoretical framework of particle physics. Moreover, today I had a new office, which is a private room for me and another colleague, come with one extra big curve screen, my favorite part is this office has air conditioner. Now I really love working from my office.

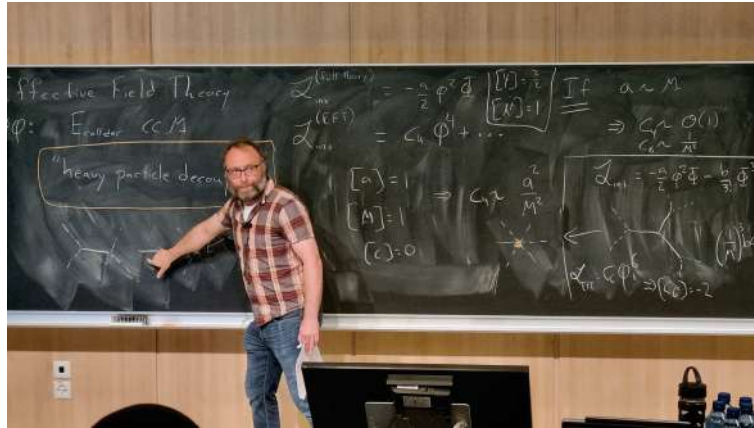Figure 4.17: Pictures from Aletsch glacier trip

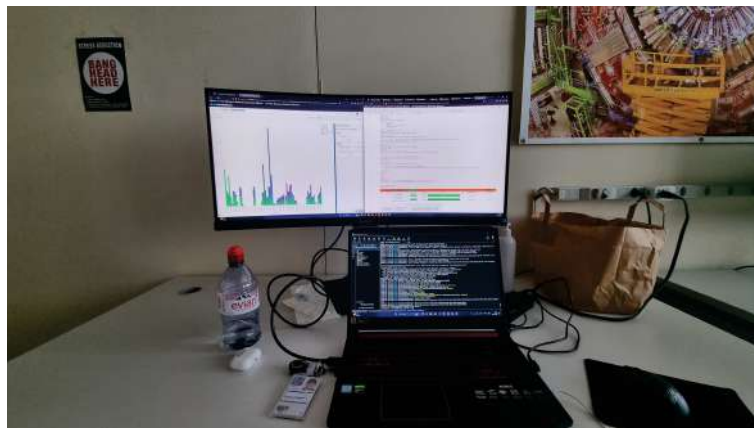Figure 4.18: Theoretical framework of particle physics lecture

Figure 4.19: My desk in my new office

July 11, 2023

I attended the lectures in the morning as the same, but today I met a Chinese girl during the lecture, we introduced ourselves. Apparently, we have so many thing similar, especially we both are interested by theoretical physics. We had a conversation during lunch. From the conversation, she knew that I was working on theoretical physics in university, so she asked me to teach her some topic in theoretical physics, and of course I said yes.

July 12-14, 2023

These three days my diary almost identical, so I merge them together. Everyday, I attended lectures in the morning, went to office after lunch, hanged around with my new friend, the Chinese girl, most of the time we spent together was for discussing on physics and philosophy. The schedule of these three days so simple and constant, anyways, it was delightful.

July 15, 2023

This weekends, we went to Milan, Italy. We traveled by bus and planned to spend a night here. On the first day of the trip, we went to Sforzesco Castle, the place got well maintenance, inside, there is a museum. After that we walked around Duomo, the famous cathedral. Everyone who travels to Milan must have a picture with the one. At lunch, we had a pizza and some Milanian food. At dinner we had some local homemade pasta. I must say that I very like food here, it is the best Europe's food I have ever ate. At night, we walked around the canal in downtown, having some drink over there. During that time, I realized that Milan is so much similar to Bangkok, hot weather, a lot of mosquitos around the canal, and crowded with people.

July 16, 2023

On our second day in Milan, we intend to watch "the last supper" drawing. Unfortunately, when we arrived at the museum, the sign said that it is only for reservation, and the earliest we can reserve is next two months. Anyways, we had a sight-seeing around the town and had a look at some beautiful churches, where the final one is the mighty Duomo. Today, we have pizza again, and I gladly to say that the pizza in Italy is another level, it is different from what I ever ate. However, except for food, I cannot say I impressed here, with the weather, the environment, the experience I got.

July 17-21, 2023

After disappointed on Milan, we immediately planned for Paris, hoping this capital city will be better than the last one. So, after booked everything, I realized I spent so much money and maybe time in the future. Then, I intent to work hard this week before the next big trip to Paris come. So, this week except attending lectures and hanging out with my Chinese friend in the evening, I did nothing but

Figure 4.20: Duomo cathedral in Milan

work and work and work.

July 22, 2023

This weekend, it's time for Paris!! On this trip, we have around 20 summer students travel together. of course we will spend a night here. For the first day, I and New went to the Louve museum together, I really love this museum, we spend time here around 6 hours and spend the money for the souvenir for 150 Euros. After we were done from the museum, we walked to Notre-Dame cathedral, the famous one. Then, we walked along the canal to the Eiffel tower. We arrived at Eiffel tower around 9 pm, so we sat on the grass and wait for Eiffel tower to turn on the light, the atmosphere at that time was so nice, soft grass, thin breeze, and some people was playing jazz music.

July 23, 2023

On the last day in Paris, we traveled around the city to see and have pictures with the well-known landmarks in Paris, which is a lot. At the afternoon, we were so tired, so we find some restaurant to have some drink, snacks, then followed by dinner.

July 24, 2023

After travelling back with bus from Paris, we arrived Geneva in the early morning today. Everyone is so tired so most of us skipped the lectured in the morning, except me and some few students still attended, because the lectures today were intriguing. However, I cannot insist the exhausting, so I decided to skip the work today, and slept in my room for the whole afternoon.
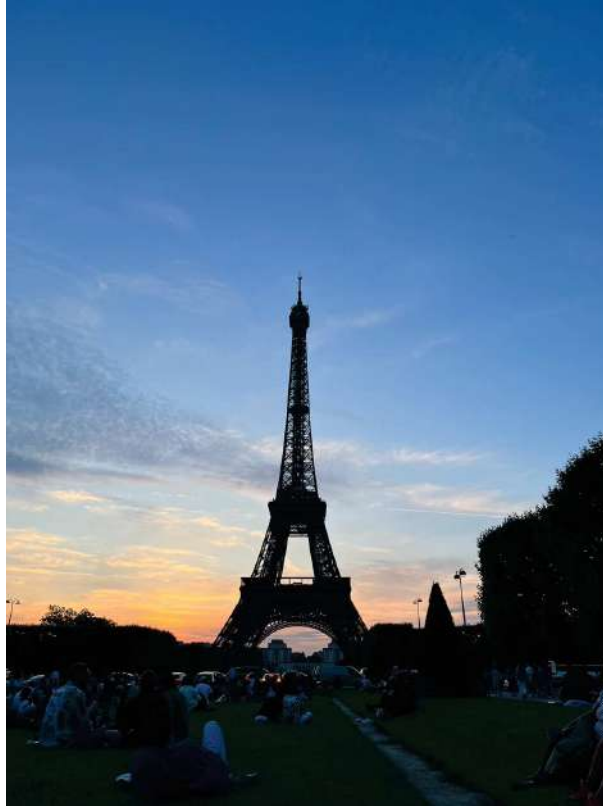
Figure 4.21: Eiffel tower in Paris

July 25-28, 2023

Get back to work!! These four days were rather uneventful, following the same routine as the previous ones. I attended lectures in the morning, spent the afternoons working in my office, and occasionally met up with my friends for more discussions about theoretical physics. The days passed by in a blur of routine.

July 29, 2023

Today, I broke from my regular schedule and explore a local coffee shop in Geneva. I spent a few hours there reading a comic book provided by the coffee shop. In the evening, I met up with my friends, and we had another conversation and played table tennis.

July 30, 2023

Because on there was thunderstorm yesterday, so we postpone our hiking trip to Sunday, today. We left CERN at the early morning and arrived Grindelwald cable car station around 11 pm. From there, we walked through Bachalpsee lake, having lunch there was wonderful. Then, we walked up to Faulhorn. Up there is panorama view, the view was amazing, we spent around 1 hour just for sitting there. The last part of the trip is descending down to Bussalp and taking bus there back to Grindelwald. This trip is everything I could ask for one day hiking. Anyways, the last part is 700 meters descending, it hurts my knees.

Figure 4.22: Me on the peak of Breithorn

July 31 - Aug 3, 2023

These days followed a predictable pattern. I attended lectures during the day, worked on my project, and had regular evening discussions with my friend. The routine was uneventful, and I found comfort in the familiar schedule. Anyways, during these nights, there was a series of farewell parties for the students who were leaving early, after talking with some guy, I was encouraged to do something crazy this weekends, it was climbing the glacier at 4000 meters altitude!!

Aug 4, 2023

After chatting with some experience mountaineer, New was scared by them, so he decided not to go with me for this crazy climbing. Anyways, I resolved to do it alone, I booked the hotel, the guild, the train at the 2 am. Six hours later, I woke up and headed to Zermatt. I prepared for tomorrow climbing; hired the equipment, check the guide, walked around the city, talked with some expert mountaineer. Here was so lovely, the people were nice, building style was so unique, but a bit expensive.

Aug 5, 2023

I woke up at 5, prepared everything for climbing and checked-out the hotel. I met the guide and two other crews. The guide can speak English well, but the other cannot. We started climbing at 9 am, I would not go into the detail, but looking at the pictures should make you feel that this climbing was so AMAZING! It is a unique experience for me, and of course, I will definitely do it again.

Aug 6, 2023

Like every past Sunday, take a rest after long walk trip on Saturday, chill around

Figure 4.23: Breithorn

hostel and the restaurant with a casual outfit.

Aug 7-9, 2023

After wonderful weekends, I switched back to working mode. Therefore, these three days did not have anything much, just doing schedule work and hanging around with my friends after dinner everyday.

Aug 10, 2023

Today I gave presentation to CRAB team in a casual way, they asked me a lot, so this one was quite elaborated presentation. After the presentation two of my supervisors asked me to have lunch together. After lunch, they suddenly told me that today's presentation is the final presentation for me. My work was considered done this week, then they gave me feedback and asked me for feedback. They satisfied with my work, they said I worked so great and deserved entire final week as a free week. So, the only tasks I have now is to clean my code, write the systematic document, and push my work to production grade. All of these should be done by next week, because I had two weeks left, and the last week is my free week.

Aug 11, 2023

After flattering of my supervisor, I gave myself cheat day as a gift. So, I did not go to work, just hanged around the hotel and restaurant all day, chatting with people and playing table tennis with them.

Aug 12-13, 2023

These weekends I did not go anywhere, but I spent time with Chinese friend who was going to leave CERN next Wednesday. We had meals together, played table

tennis, watch movies, and finally we finished 1000 pieces Monalisa jigsaw.

Aug 14-15, 2023

As I said before, this week will be my last week of working, I have to clear everything. So, this week I spent almost of the time in my office or my supervisor office to finalize my project.

Aug 16, 2023

Before I went to work after lunch, I took opportunity to meet the Chinese friend for the last time and took a picture together for being the evident that we knew each other, in case one of us get Nobel prize. It was so sad to say bye to this friend, we are so close. Since the moment we met, we always have a meal together. We had many opportunities to discuss on many topics; from food, culture, politic, to physics and philosophy.

Aug 17-18, 2023

I still finalized my project with help from my supervisors. Finally, everything done on the noon of Friday 18, my supervisor so happy. When I was leaving the office, my supervisor walked me out and said something sweet to me. We also took a couple of picture together outside the building, such a beautiful smile of farewell.

Aug 19, 2023

I woke up at 8 am, then I pinged Antonin in WhatsApp. After packing, we bike to Carrefour, bought some drink and food, then headed to Jura by bike. This hike took around 7 hours including 1.5 hours of sleeping under huge rock. Among the hike, it was around 40 degrees Celsius, where the second half is just a lawn, no trees to hide. I could say that I can die with heatstroke in the hike, it was so hot, and I don't have any cap or sunglasses. Fortunately, I brought some extra water and an umbrella. This is the toughest hike I ever had.

Aug 20-22, 2023

The last week, my free week, I did nothing except writing the CERN report. Nevertheless, I didn't forget to meet people and say goodbye. This make my last week the week of sadness.

Aug 23, 2023

I decided to hike to Faulhorn again, but this time, I would take different path. Instead of start at First, Grindelwald, I started from Schynige Platte. This path is nicer, I would say; but of course, it is harder. This hike took me around 7 hours, longest and greatest hike I ever had. Hiking alone gives you different feeling, it makes you feel like you are the solo adventurer who is walking to the top of the world.

Aug 24, 2023

After the longest hike, I slept all day. Just at the lunch time and after the dinner that I went out my room to eat and meet people. Tonight, I finally submitted CERN report on CDS website, after edited as my supervisors suggested.

Aug 25, 2023

At the moment, I realized that the past 12 weeks are the best 12 weeks I ever had, and this might be the last time in my life being here. So, before the time comes, today, I wandered around Geneva, the same path I walked in the first day here. Walking along the lake under cloudy weather with airpods in my ears playing Interstellar soundtrack gives me the feeling of heart breaking, but not with some girls this time, with some places, instead.

Aug 26, 2023

The day before travelling, what do you expect? I packed all of my stuff of course!! After packing, only thing in my mind is my luggage definitely gonna be over 25 kg.

Aug 27, 2023

Time flight, finally, the time has come. After packed the stuff and checked out the hotel, I had lunch at CERN restaurant. During that time, I met some summer students there, we said goodbye to each other, it was a heart breaking moment. After that, I went to airport, meet other Thai students there, then we took the flight back, to Thailand.

Figure 4.24: Views from Faulhorn trip

Figure 4.25: View from Jura trip

Figure 4.26: Two of my supervisors

Chapter 5

Author's Biography

My name is Ek-ong Atthaphan. I was born and grew up in Hatyai, Thailand, until age 18. I was an ordinary child who just live for today, until when I was 17 and started question about the purpose of living. After this, after that, I decided to pursue Doctoral degree in physics and make researching as profession. Since then, I have taken study seriously. I moved to Nakhon Ratchasima to study at Suranaree University of Technology, and took DPST scholarship there. My performance when I was in the university is extraordinary. At the end of the degree, I chose theoretical particle physics as my final project. Here, I was just exposed to (almost) the entire industry of particle physics at CERN as summer student. Now, I am doing research assistant at Suranaree university of technology, preparing myself before Master's degree.