

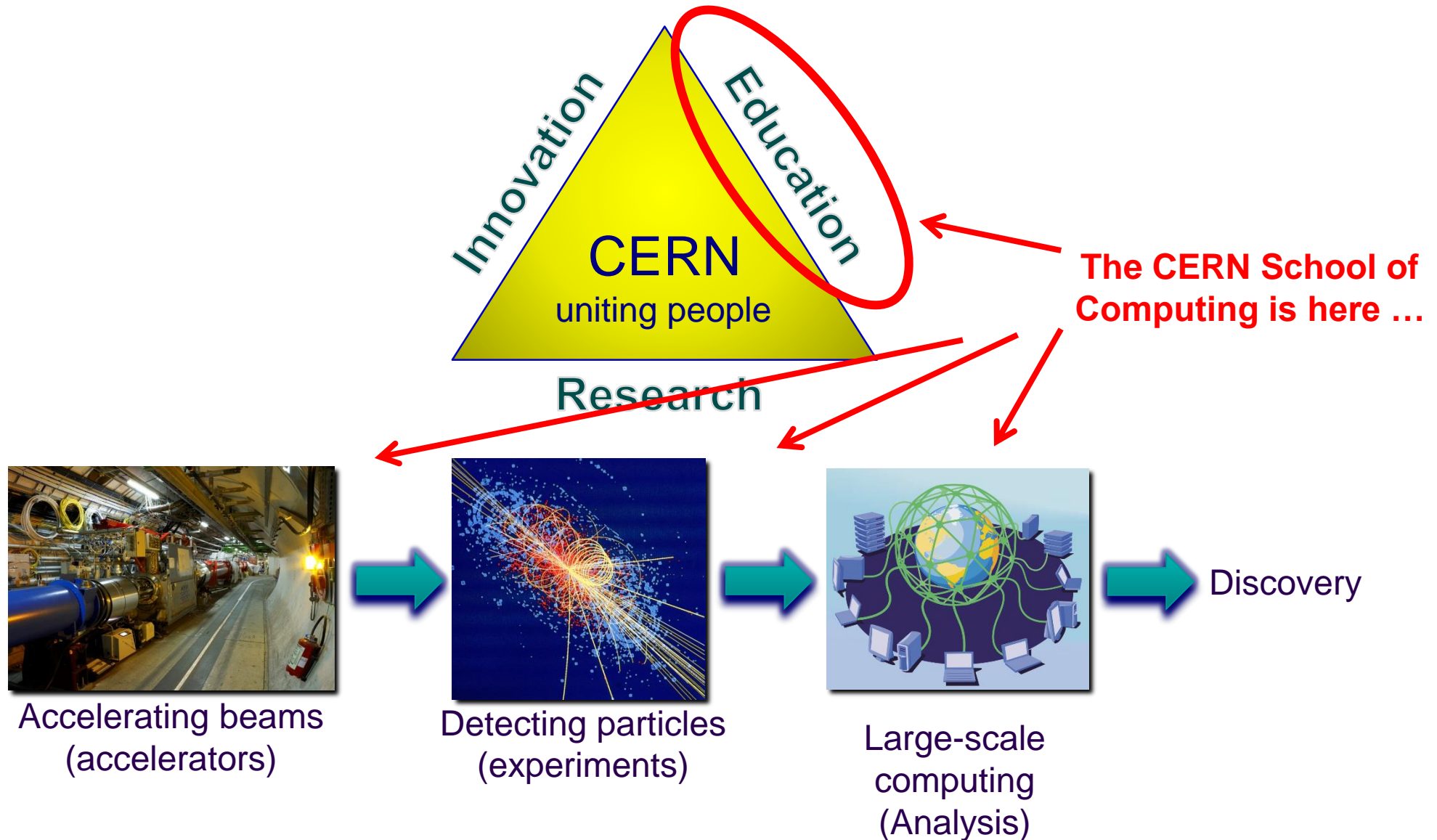




# Welcome to the 15<sup>th</sup> **thematic** CERN School of Computing (and the 1<sup>st</sup> School on Machine Learning)

Alberto Pace, school director

# CERN's mission



# A statement from Ivica ...

- ◆ <https://www.facebook.com/1334424117/posts/10232249117833997/?mibextid=rS40aB7S9Ucbxw6v>
- ◆ “Another reason for your optimism is the fact that you go to school every day to learn something new. I know you are usually not exactly thrilled about going and being in school, but consider the following arguments. For thousands of years, millions of people have tried to understand various things about nature and society. Some of them spent their entire lives trying to understand the basic laws of nature, what our planet looks like, how the universe looks like, how stars, planets, people etc were created. You learn most of these things in a few hours of teaching and working at school or at home. **From that perspective you know more after a few years of school than some of the greatest scientists in human history. And you find out more and more every day.**”

# A school with a long history

- ◆ The school was created in 1970, 2023 will be the 44th edition
- ◆ This is the 15<sup>th</sup> edition of the **Thematic** School
- ◆ The school has visited 22 countries
  - ◆ all member states (except Bulgaria, Slovak Republic)  
+ Croatia, Cyprus, India
- ◆ 88 different nationalities
- ◆ 3294 students have followed the school

# Mandate and mission

- ◆ Create a *common culture in scientific computing* among young scientists and engineers involved *in particle physics or other sciences*, as a strategic direction to *promote mobility* and to facilitate the development of large computing-oriented *transnational projects*.
  - ◆ <http://cern.ch/csc>
- ◆ Participants come from worldwide laboratories and universities with typically 20 to 30 different nationalities (61 different nationalities in the past 10 years).
  - ◆ <http://cern.ch/csc/alumni>

# Bridging science and computing

- ◆ The unprecedented technological evolution in computing has profited directly to several scientific research projects, in particular in high energy physics
  - ◆ Computing is today **the main strategy** for many sciences to boost their research productivity
- ◆ It is nowadays essential that:
  - ◆ Scientists master computing technologies as the main tool for their research
  - ◆ Computer scientists understand the scientific domain of the investigation to deliver computing services that meet the needs of the research project

# An additional side effect ...

- ◆ ... knowledge transfer of (CERN) skills and (CERN) know-how in computing to academic, national laboratories, research institutes, institutional and industrial circles in Member States and other countries
  - ◆ With direct or potential applications up to all spheres of the society (as exemplified with the Web, and the Grid).



# The CERN Schools of computing

- ◆ The **Main** School
  - ◆ Two weeks, ~ 60 participants (*64 this year*)
  - ◆ Multiple topics on scientific computing
- ◆ The **Thematic** schools
  - ◆ Goes more in depth on a particular topic
  - ◆ Smaller participation, shorter duration (one week), clear goals
  - ◆ Last year, two schools 23 + 30 participants
  - ◆ This school: 33 participants, 24 institutes, 21 nationalities
- ◆ The **Inverted** school
  - ◆ It is frequent to find among students real experts on specific topics, and the cumulated knowledge of the students exceeds the one of lecturers.
  - ◆ At the end of each school, we invite students to propose some lectures, and we organize an “inverted” school. *“Where students turn into teachers”*
  - ◆ In 2024, the 15<sup>th</sup> edition had 12 lecturers and more than hundred participants



# An outreach opportunity

- ◆ For the local organizers



# An outreach opportunity

## ◆ For CERN



# The school governance

- ◆ ... is discussed at the School Advisory Committee
  - ◆ <http://csc.web.cern.ch/advisory-committe>
  - ◆ Includes several fulltime university professors from different countries
  - ◆ Two meetings per year

# The School Advisory Committee



**Arnulf Quadt**

Advisory Committee Chair, Programme Committee  
Universität Göttingen



**Andrzej Nowicki**

School Technical Manager, Advisory Committee  
CERN



**Toni Šćulac**

Advisory Committee  
University of Split, Faculty of Science



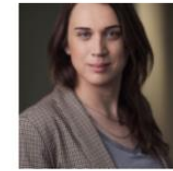
**Alberto Pace**

School Director, Advisory Committee, Programme Committee  
CERN



**Sebastian Łopieński**

Advisory Committee  
CERN



**Veronika Zadin**

Advisory Committee  
University of Tartu Institute of Technology



**Enrica Porcari**

Advisory Committee, CERN IT Department Head  
CERN



**Verena Kain**

Advisory Committee, Programme Committee  
CERN



**Judith Katzy**

CSC 2024 Local Organising Committee  
Deutsches Elektronen-Synchrotron DESY



**Kristina Gunne**

School Administrative Manager, Advisory Committee  
CERN



**Danilo Piparo**

Advisory Committee, Programme Committee  
CERN





# Thematic CSC 2024 on Machine Learning

# CSC Organizers



**Kristina Gunne**  
Administrator



**Andrzej Nowicki**  
Technical Manager



**Alberto Pace**  
Director

... and the MEDILS staff !

# The school learning process

- ◆ Learning process
  - ◆ Lectures
  - ◆ Exercises
  - ◆ Exam
- ◆ Meet special persons,  
Build trusts with colleagues across the world
  - ◆ Lunches, dinners, coffee breaks, evenings
  - ◆ Excursions
  - ◆ Music events
  - ◆ Sport programme

Mandatory



Optional



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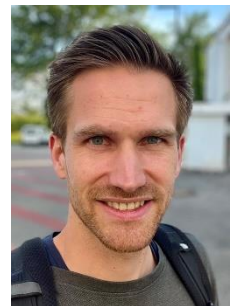
Mandatory



Optional

# Academic Programme

- ◆ Theme: “Machine Learning”
  - ◆ Track 1: A summary of Machine Learning Methods
    - ◆ Introduction to data analysis, Classical Machine Learning, Introduction to deep learning, Advanced deep learning
    - ◆ Toni Šćulac, Francesco Vaselli
  - ◆ Track 2: Machine Learning in Accelerator Technologies
    - ◆ Machine Learning for particle accelerators, Bayesian Optimisation, Reinforcement Learning
    - ◆ Verena Kein, Michael Schenk
  - ◆ Track 3: Machine Learning in Data Analysis
    - ◆ Introduction to Machine Learning for HEP, Anomaly detection and real time applications, data reconstruction, generative Models, Systematics in ML
    - ◆ Sofia Vallecorsa, Ilaria Louise



# The School site is on indico

- ◆ <https://indico.cern.ch/event/1407896/>
- ◆ Check it regularly for updates

## Thematic CERN School of Computing on Machine Learning 2024

### Overview

Scientific Programme

Timetable

**Application**

Privacy Information

School guide

Lecturers

Organisers

Participants

Practical Information

└ Terms and Conditions

└ Fees and Payment

└ Sport/spare time

└ Laptop configuration/CERN services activation

Visit Split

CERN School of ComputingContact

✉ [Computing.School@cer...](mailto:Computing.School@cern.ch)

The 15th **Thematic** CERN School of Computing (tCSC **Machine Learning** 2024) will take place on **October 13-19, 2024**.

The school will focus on the theme of **Machine Learning** and **Artificial Intelligence** applied to **Data Analysis** and **Accelerator Technology**. The programme will offer 22 hours of lectures and hands-on exercises, and student presentation sessions.

This school is organized by **CERN** in collaboration with **the Faculty of Science, University of Split**. **The school will take place in Split, Croatia**, and be hosted at the Mediterranean Institute For Life Sciences (**MEDILS**) Conference Centre. The Centre is a historical renovated building situated in a wooded and landscaped park located on the Adriatic Sea coast, a few kilometers from the centre of Split.

### Important dates 2024

- 8 May application opens
- 19 June application close
- 3 July invitations sent to selected students
- 4 September participation fee deadline

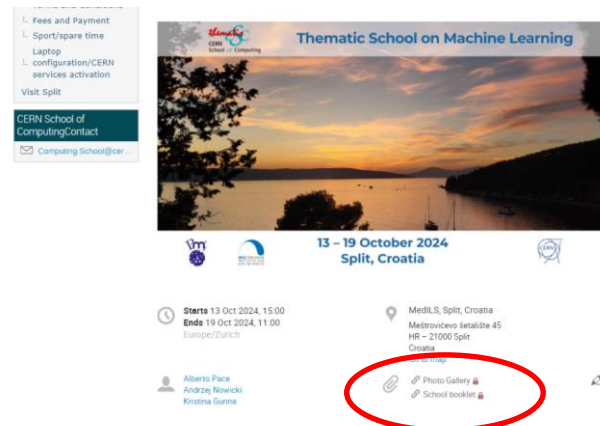


**13 – 19 October 2024**  
**Split, Croatia**



# School booklet

- ◆ Printed version for those who asked for it
- ◆ Electronic version (PDF) Linked from school main page on Indico
  - ◆ <https://indico.cern.ch/event/1407896/>
- ◆ Contains pictures and short biographies of all participants



## Machine Learning

A summary of Machine Learning Methods  
Machine Learning in Accelerator Technologies  
Machine Learning in Data Analysis

<https://indico.cern.ch/e/mlCSC-2024>



# The tuition programme

Sunday 13 October 2024	Monday 14 October 2024	Tuesday 15 October 2024	Wednesday 16 October 2024	Thursday 17 October 2024	Friday 18 October 2024
	08:45 opening session - Alberto Pace (CERN)	08:45 Machine Learning in Accelerator Technologies: Machine Learning for particle accelerators - Verena Kain (CERN)	08:45 Machine Learning in Accelerators: Introduction to Reinforcement Learning - Michael Schenk (CERN)	08:45 Machine learning in Data Analysis: Introduction to Machine Learning for HEP, Anomaly detection and real time applica...	08:45 Lightning talks Departures from MedILS 08:00 - 11:00
	09:45 Machine learning methods: L1 Introduction to Statistics	09:45 Machine Learning in Accelerator Technologies: Bayesian Optimisation - Verena Kain (CERN)	09:45 Machine Learning in Accelerators: Advanced concepts for Reinforcement Learning - Verena Kain (CERN)	09:45 Machine learning in Data Analysis: The data reconstruction step - a pattern recognition problem - Sofia Vallecorsa (CERN)	09:45 Machine Learning in Accelerators: Systematics in ML - Sofia Vallecorsa (CERN)
	10:45 Announcements	10:45 Announcements	10:45 Announcements	10:45 Announcements	10:45 Announcements
	11:00 Coffee	11:00 Coffee	11:00 Coffee	11:00 Group photo	11:00 Coffee
	11:30 Machine learning methods: L2 Statistics and Machine Learning	11:30 Machine Learning Methods: L4 Introduction to Deep Learning	11:15 Machine Learning methods: exercise 3	11:30 Machine learning in Data Analysis: Generative Models for HEP	11:30 Machine learning in Data Analysis: Exercise 3
	12:30 Lunch	12:30 Lunch	12:15 Lunch	12:30 Lunch	12:30 Lunch
	13:30 Study time or daily sports	13:30 Study time or daily sports	13:00 River rafting excursion	13:30 Study time or daily sports	13:30 Exam
15:00 Registration at MedILS	15:15 Coffee	15:15 Coffee		15:15 Coffee	14:30 Break
16:00 Welcome and self presentation session - Andrzej Nowicki (CERN) Alberto Pace (CERN) Kristina Gunne (CERN)	15:45 Machine learning methods: L3 Classical Machine Learning	15:45 Machine Learning Methods: L5 Advanced Deep Learning		15:45 Machine learning in accelerators: Exercise 3 - Verena Kain (CERN)	15:00 Closing ceremony - Alberto Pace (CERN)
	16:45 Break	16:45 Break		16:45 Break	16:00 Sports and leisure time
	17:00 Machine Learning methods: exercise 1	17:00 Machine learning in accelerators: Exercise 1 - Michael Schenk (CERN) Verena Kain (CERN)		17:00 Machine learning in Data Analysis: Exercise 1	
17:30 Transport to Split	18:00 Machine Learning methods: exercise 2	18:00 Machine learning in accelerators: Exercise 2 - Michael Schenk (CERN) Verena Kain (CERN)		18:00 Machine learning in Data Analysis: Exercise 2	
18:00 Guided tour of Split			18:30 Dinner at Kastel Stanica Omis		
19:30 Welcome dinner at Restoran Para di šoto	19:30 Dinner at MedILS	19:30 Dinner at MedILS		19:30 Dinner	19:30 Closing dinner
			21:00 Transport back to medILS		

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  - ◆ Sport programme

Mandatory



Optional

# The School culture in “exercises”

- ◆ The school has an entire computing infrastructure for exercises. Remotely accessible to the students
  - ◆ The quality of the computing infrastructure is a shop window for CERN
- ◆ Students works in pair (2-student teams). If possible:
  - ◆ 1 student with physics background
  - ◆ 1 student with computing background



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Mandatory



Optional



# An exam part of the learning process

- ◆ The test statistic is usually a single number whose value ...
  - ◆ ... reflects an agreement between the data and the hypothesis.
  - ◆ ... is equivalent to the mean value of the data sample.
  - ◆ ... must be equal to the most probable value of the distribution in question.
  - ◆ ... is never larger than the difference between values of variances of two competing hypotheses.

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- ◆ In the process of hypotheses testing, we often define the null and the alternative hypotheses. The most robust final results are obtained for ...
  - ◆ ... the acceptance of the alternative hypothesis.
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Mandatory



Optional

# Lunch and Dinners

- ◆ Mix of Students + lecturers
- ◆ Tables of 8 - 12 persons



# (Optional) Social programme

- ◆ Excursions
  - ◆ Culture
  - ◆ History
  - ◆ Nature



- ◆ Social games



# (Optional) Music events

- ◆ Many students have hidden talents
- ◆ Music values are universal across all cultures







## Optional Sports ....



# This school

## ◆ Basket



# This school

## ◆ Badminton



# This school

## ◆ Table tennis



# This school

## ◆ Music



# This school

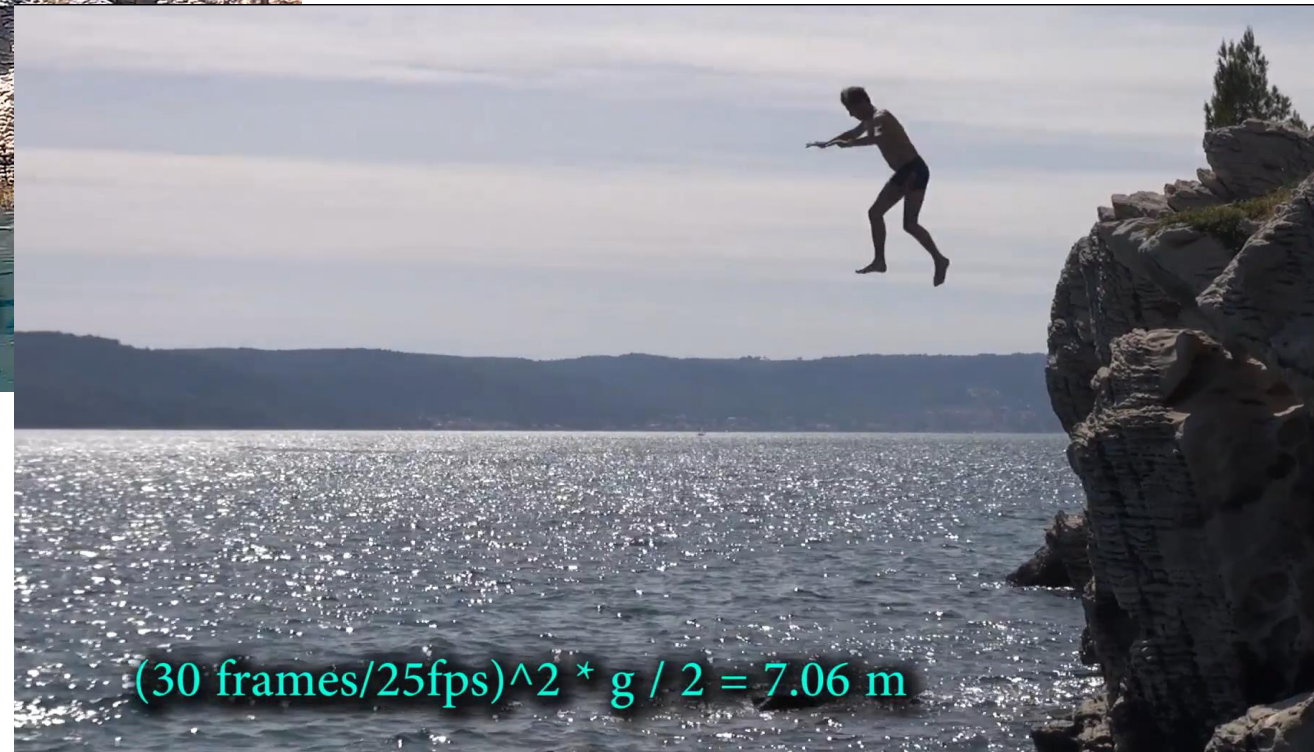
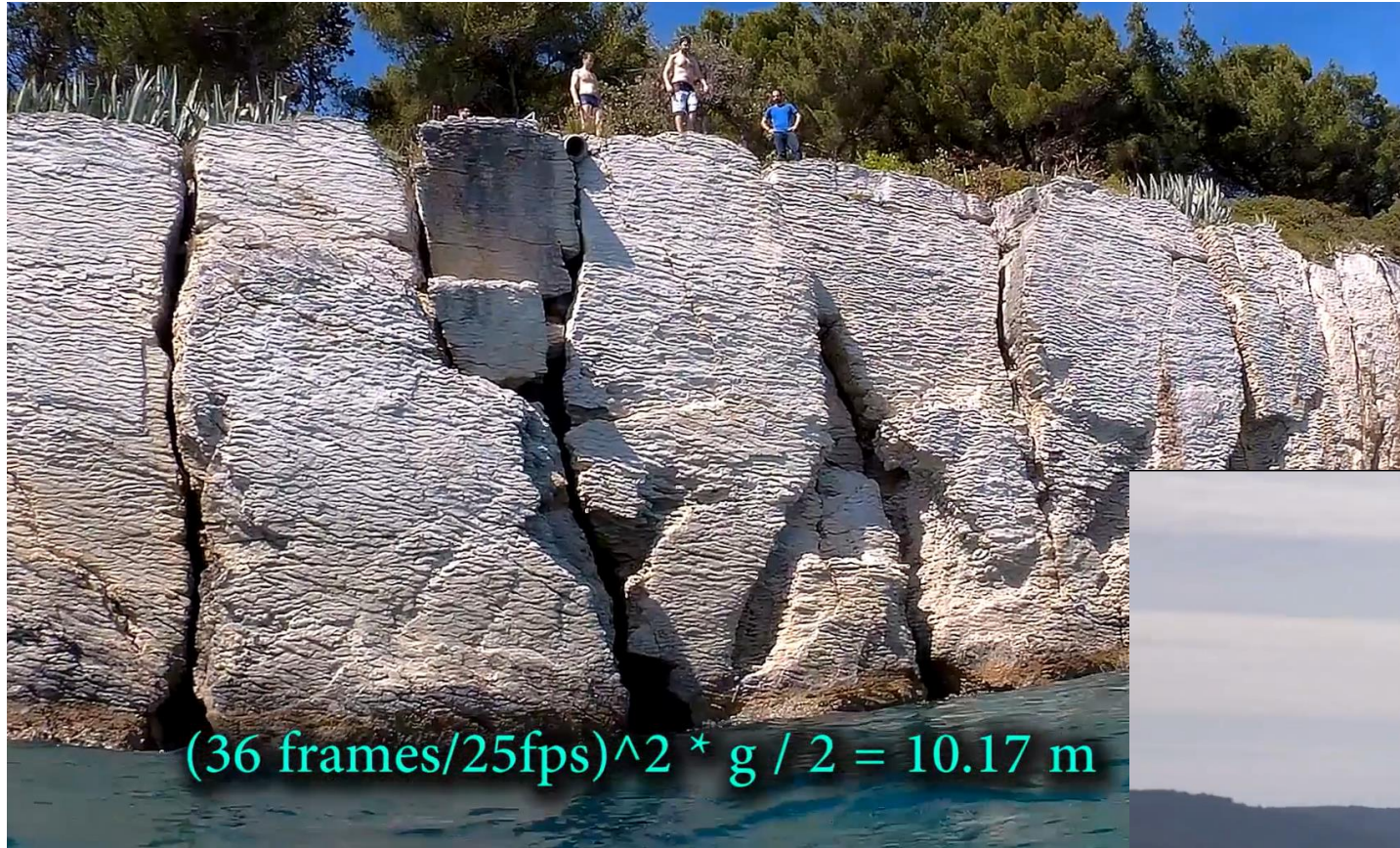
## ◆ Farniente



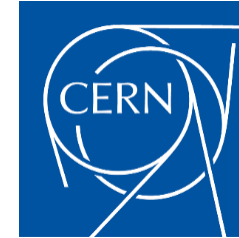
# This school

- ◆ Swimming and sun bathing
- ◆ Careful when you jump from the cliff in the sea
  - ◆ Then you will have to swim ~ 100 meters to come out
- ◆ The rocks to walk on to get in and out of the water are extremely sharp
  - ◆ Wear shoes is possible









## School rules ...

# School rule #1

## ◆ **Participate**

- ◆ Attendance at all lectures and exercises is mandatory
- ◆ You should attend all meals and coffee breaks
- ◆ Taking part in social and sports events is optional
  - ◆ You must let us know whether you participate or not

# School rule #2

- ◆ **Be on time**
- ◆ Check what the schedule says:
  - ◆ “Lecture starts at 9:00” => You must be in the room before 9:00
  - ◆ Sign the presence sheet beforehand – it will be removed at 9:00
  - ◆ “The bus leaves at 18:00” => It will leave at 18:00
- ◆ If you're late, we won't wait

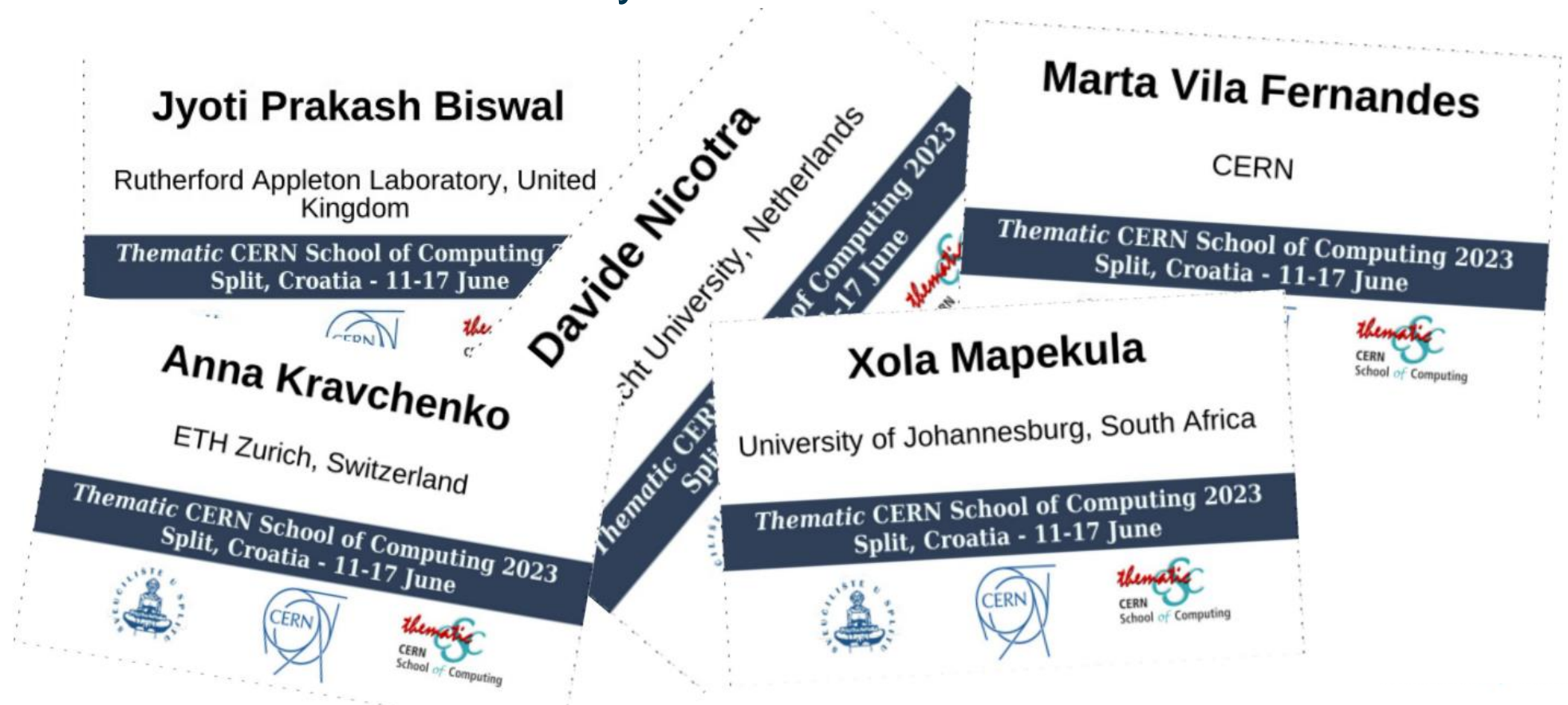
<https://www.youtube.com/watch?v=1dZveoBfiww>

Spaceballs, Mel Brooks, 1987



# School rule #3

- ◆ **Wear your badge**
  - ◆ At least until I have learnt all your names !



# WhatsApp group

- ◆ Unofficial communication channel
- ◆ We recommend you to join the group
- ◆ Autojoin link:



# Drinking yellow liquid in Split





the participants give the most value to the school !

Why ?

# For example, this school

- ◆ 58 applicants, 28 nationalities
  - ◆ Austria, Azerbaijan, Cameroon, China, Colombia, Croatia, Czechia, Denmark, France, Germany, Hong Kong, India, Italy, Lithuania, Mexico, Norway, Pakistan, Palestina, Poland, Romania, Russia, Serbia, Sweden, Taiwan, Tunisia, Türkiye, Ukraine, United Kingdom.
- ◆ Selected 33, 21 nationalities
  - ◆ Austria, Azerbaijan, China, China, Croatia, Croatia, Czechia, Denmark, Germany, Hong Kong, India, Italy, Lithuania, Norway, Romania, Serbia, Sweden, Taiwan, Tunisia, Ukraine, United Kingdom.



# The 40 applying institutes

- ◆ University of London, Higher School of Economics, University of Bucharest, Academia Sinica, Taiwan, AGH University of Cracow, CERN, Helmut-Schmidt-University, Deutsches Elektronen-Synchrotron (DESY), University of Zagreb, Humboldt University of Berlin, INFN- Sezione di Bari, Information Technology School (ITS), Institute of High Energy Physics (HEPHY) Vienna, Instituto de Fisica Corpuscular (IFIC), Univ. de Valencia (UV), Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Napoli, Karlsruhe Institute of Technology, Middle East Technical University, Physikalisches Institut, Heidelberg University, Qaid\_e\_Azam university , islamabad , pakistan, TATA Consultancy Services, Technical University of Vienna, Theoretical and Computational lab at Universiti Sains Malaysia, TRANSMUTEX SA, UNAM, Universidad Iberoamericana, Università Degli Studi di Firenze, University of Bologna, Department of Physics and Astronomy, University of Bonn, Physical Institute, University of Bucharest, Bucharest Romania | Horia Hulubei National Institute of Physics and Nuclear Engineering, University of California San Diego, University of Cambridge, University of Glasgow, University of Hamburg, University of Manchester, University of Milano-Bicocca, University of Novi Sad, University of Science and Technology of China, University of Yaounde, Vega IT, Vrije Universiteit Brussel (Free University of Brussels),



So ...

We have quite some diversity

But where is the value?

# Excerpts from reference letters

- ◆ I consider ... to be among the top 20% of PhD students I have encountered throughout my career.
- ◆ Compared to other students at comparable stages of their studies, ... is one of the top 10% of my students.
- ◆ ... clearly ranks among the top 5-10% of students in the HEP community, both compared to students I have supervised and compared to students I worked with
- ◆ ... belongs to the best 5% of our students.
- ◆ Compared to other students at comparable stages of their studies, ... is one of the top 5% of my students.

# Who are the CSC participants ?

- ◆ You are young, diverse, come from many countries, from different institutes ...
- ◆ You have all an outstanding potential and a passion for both computing and science.
- ◆ You will work together one weeks to widen your skills but also establish **lifetime links** with other participants and **research institutes across the world** that will be useful throughout your future career.
- ◆ This is what gives the highest value to the school

# It is a small world ...

- ◆ All top scientists knows each other very well



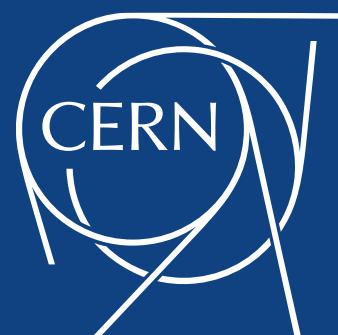
# CSC 2024, Hamburg, Germany



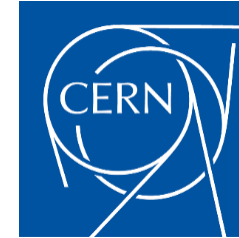
# tCSC 2024 on Machine Learning, Split, Croatia

- ◆ Are you ready to write history ?









# Announcements

Monday 14







# Announcements

Tuesday 15







# Announcements

Wednesday 16





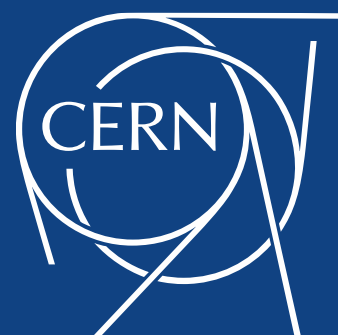




# Announcements

Thursday 17







# Announcements

Friday 18



