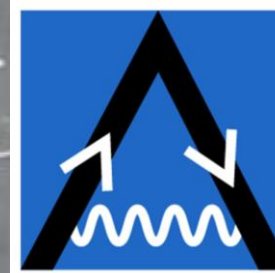




**Co-funded by
the European Union**



**International Master
Advanced Methods
in Particle Physics**

Erasmus Mundus Joint Master of Advanced Methods in Particle Physics (IMAPP)

Kevin Kröninger, Department of Physics, TU Dortmund University

www.imapp.eu

International character

[wikipedia.de]

Universities:

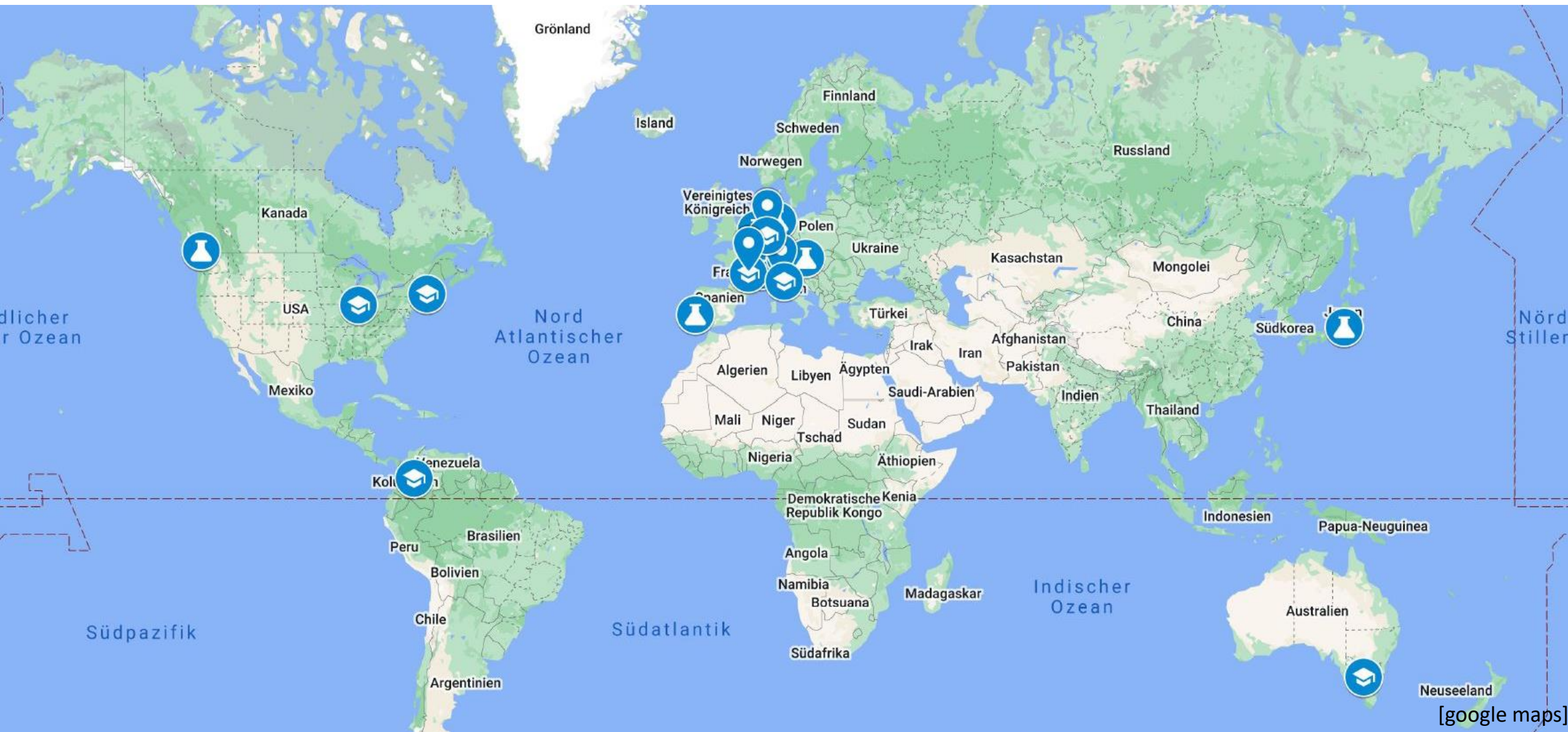
- TU Dortmund University
- University of Bologna
- University of Clermont Auvergne

Associated partners:

- International research laboratories
- Research networks
- Universities around the world
- Companies



International character



[google maps]

Master program

Education:

- Physics: Experimental and theoretical particle physics — Scientific case
 - Methods:
 - Instrumentation and detector physics
 - Large-scale scientific computing and programming
 - Statistical data analysis and machine learning
- } Technical aspects,
relevant for employability

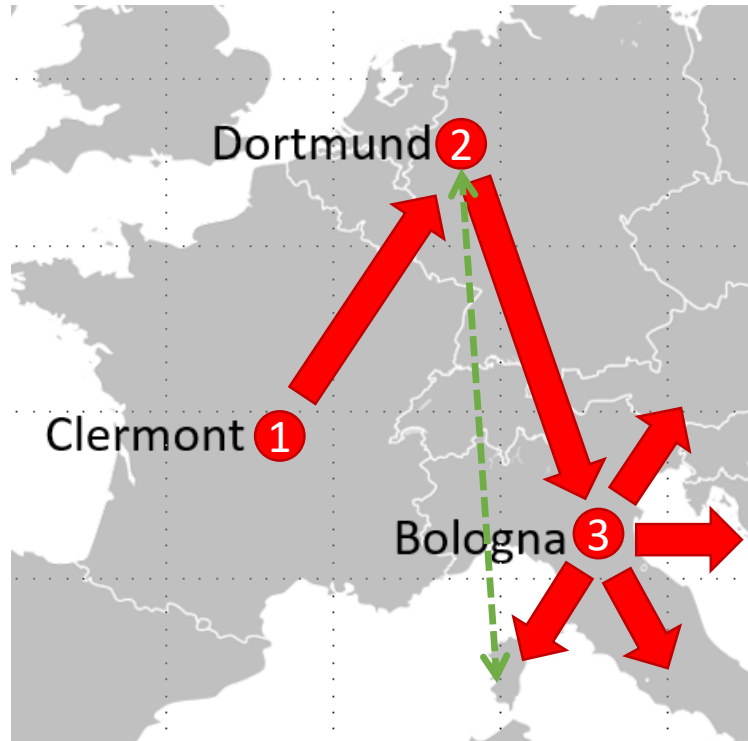
Courses:

- Mandatory courses from the realm of theoretical and experimental particle physics
- Mandatory courses on the technical aspects
- Specialization possible by choosing compulsory courses
- Extracurricular (free) language courses

Issued degree:

- Joint degree signed by all three universities
- Acknowledged as Master degree in physics (with/without specialization) in each country

Mobility



Schedule:

Sem.	Location	Academic focus	Events
1 (Winter)	Clermont	Particle physics and statistics	Orientation week
2 (Summer)	Dortmund	Particle physics and detectors	Spring school
3 (Winter)	Bologna	Particle physics and computing, introduction Master thesis	Trade fair for Master theses
4 (Summer)	Any	Master thesis	Virtual industry day

Prerequisites and organization

Prerequisites:

- First cycle degree qualification or equivalent in physics (**Bachelor degree**)
- Qualifying degree has to be passed with a grade higher or equal to “B” (“good”) (corresponds to best 35% of students) → **thresholds: 2.8 (German system), 84/110 (Italian system), 14 (French system)**
- Command of the English language, i.e. either native speaker or at least level B2 (**certificate**)
- If applicable, **visa/residence permit**

Costs and services:

- There are tuition fees about 950 Euro / semester
- Full access to all university facilities in Bologna, Clermont and Dortmund
- Use the services of the universities as much as possible, e.g. support of the international offices, computing infrastructures, etc.
- Have to provide some additional services, e.g. help in finding accommodation, visa support, etc.

Organization

Application, admission and enrollment

- Application to admission via TU Dortmund University
- Admission for all three universities only checked once
- Enrollment at TU Dortmund University, registration with the University of Bologna and the University of Clermont Auvergne

Organization

- Joint examination regulations, committees, ...
- Welcome and summer school organization in Clermont
- Organizational center of the Master program in Dortmund
 - Collection and distribution of fees
 - Collection of grades
 - Preparation of intermediate and final documents
 - ...
- Dissemination, quality assurance and preparation of Master projects in Bologna

Financial support

Erasmus Mundus

- Large EU project that aims at getting the best students from all over the world
- 18 full stipends per intake: 1.400 Euro/month, no tuition fees, insurance coverage
- National quota: about 1.8 students from one country per intake

French German University

- Program with a focus on French-German relationship and cultural exchange
- Mobility support for all interested students: up to 350 Euro/month for up to 10 month a year when abroad (note details)

Further funding

- Local stipends from Clermont and Bologna
- Franco-Italian University

Status

Status

- Fully accredited in France, Germany and Italy.
Procedure followed the European approach
- Program was installed in the academic year 21/22 –
Late/small time window for application
- Composition of intakes:
 - First intake: 7 students (6 IT/1 FR)
 - Second intake: 10 students (4 IT/3 FR/2 DE/1 ES)
 - Third intake: 34 students (from 6 continents)
- First intake has graduated end of September 2023
- Program is running smoothly so far, initial hickups
have been solved



Design suggestions

General

- Survey: are there compatible Master programs around?
- Survey: is there need for such a Master program (in particular outside academia)?
- For EM: connection to industry and/or society necessary

Mobility

- Several options:
 - Fixed path (here): one cohort that moves together (except Master phase)
 - Flexible path: split at some point, e.g. according to topics, detector components, etc. → can be more than three universities
 - For EM: need at least two mobility phases outside of country of origin

Program and organization

- Perform sanity checks, e.g. are the semester times compatible?
- Do courses appear in the right order? Do you cover everything the students need?
- Familiarize with the legal constraints of your country/state/university

Design suggestions

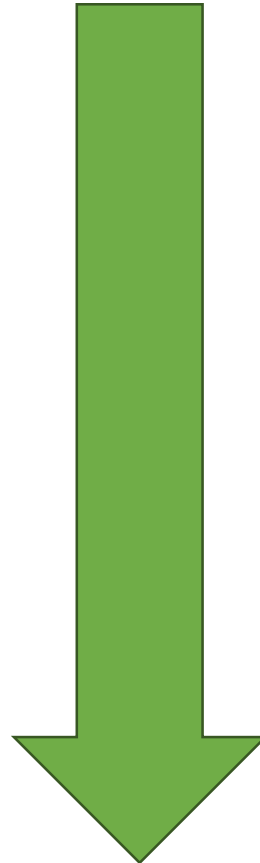
Issues and problems

- Avoid pandemics when setting up a Master program with a lot of mobility!
- During preparation:
 - Setting up the initial contract (lot's of laws, regulations and opinions by the administrations)
 - Collection of fees (German problem)
 - Accreditation
- During the program:
 - Housing
 - Visa

Schedule



Since 2015: common teaching activities



03/2019: Initial preparation

12/2020: Collaboration contract signed

09/2021: Start of first cohort

03/2022: Accreditation completed

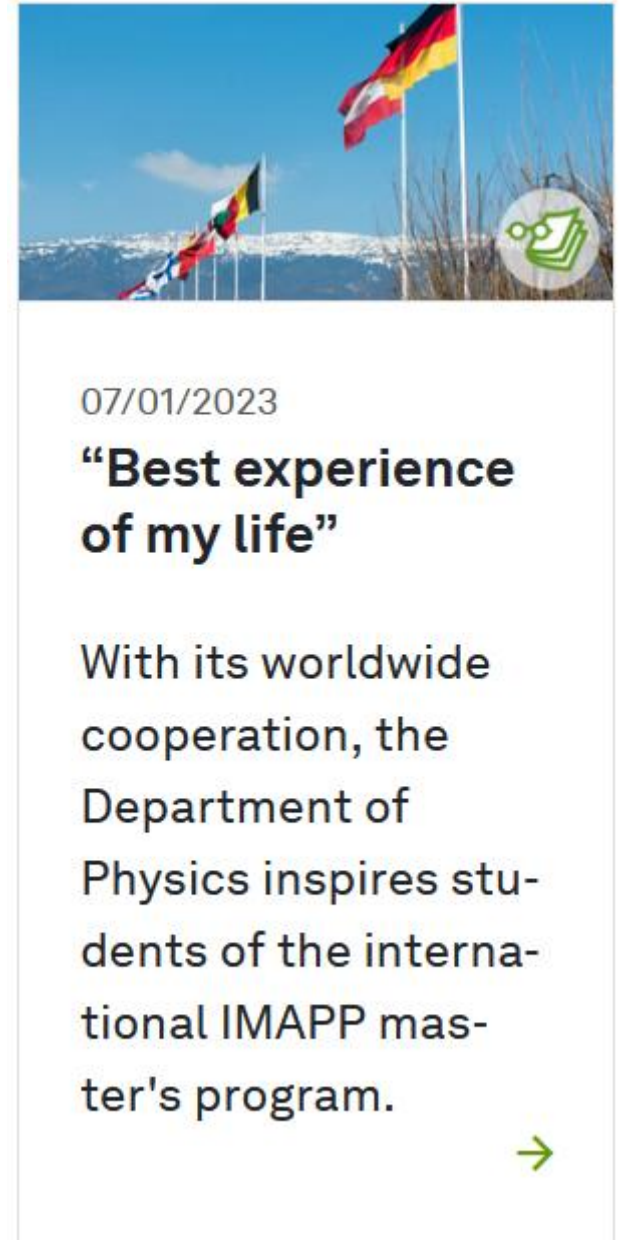
04/2022: Funding by DFH

08/2022: Funding by Erasmus Mundus

Design suggestions

Personal remarks

- It is a lot of work! Only do it if you are really behind the project!
- Find a good and well motivated team which you trust
- Bring your Department and/or rectorate to support your project.
- Think about the necessary resources (in particular if there is no external funding)
- Prepare for frustration during the development
 - Local (legal) constraints
 - Details, details, details
 - Long time scale
 - ...
- **Despite the trouble: it is definitely worth it!**



Backup

International character

Universities:

- Massachusetts Institute of Technology, Cambridge, USA
- Monash University, Clayton, Australia
- Purdue University, West Lafayette, USA
- TU Dortmund University
- Universidad Nacional de Colombia, Bogota, Colombia
- University of Bologna
- University of Clermont Auvergne

Companies:

- Aegetis, Aubière, France
- E4 Computer Engineering. SpA, Scandiano, Italy
- Point-8 GmbH, Dortmund, Germany

Research laboratories:

- Brookhaven National Lab, Brookhaven, USA
- CERN, Geneva, Switzerland
- DESY, Hamburg, Deutschland
- HEPHY / TU Wien, Vienna, Austria
- INFN, Italy
- IN2P3, France
- NIKHEF, Amsterdam, Netherlands
- Laboratory of Instrumentation and Experimental Particle Physics (LIP), Portugal
- MPI for Physics, Munich, Germany
- TRIUMF, Vancouver, Canada
- High Energy Accelerator Research Organization (KEK), Tsukuba, Japan

Study plan

Semester 1: Clermont

Module	ECTS	Comments
Compulsory modules		
Introduction to quantum field theory and gauge theories	6	Graded
Introduction to particle physics and the experimental foundations of the Standard Model	9	Graded
Programming and data analysis	6	Graded
Statistics and artificial intelligence	6	Graded
Elective modules		
Guest lecture on various topics	3	e.g. on cosmology, graded
UCA seminar on particle physics	3	Not graded

Study plan

Semester 2: Dortmund

Module	ECTS	Comments
Compulsory modules		
Model building in particle physics	6	Graded
Practical aspects of particle physics measurements	6	Graded
Detector systems in particle and medical physics	9	Graded
Spring/summer school	3	Summer school in Cargese / Corsika; not graded
Elective modules		
Electronics lab course	6	Graded
Modern particle physics	6	Graded
Astroparticle physics	6	Graded
Guest lecture on instrumentation	3	Graded
TUDO seminar on particle physics	3	Not graded

Study plan

Semester 3: Bologna

Module	ECTS	Comments
Compulsory modules		
Advanced Standard Model	6	Graded
Phenomenology and experimental flavor physics	6	Graded
Computer science for High Energy Physcs	12	Graded
Preparation for scientific research and internship orientation	6	Preparation of Master thesis, graded

Study plan

Semester 4: Any of the three universities or a partner institution

Module	ECTS	Comments
Compulsory modules		
Master's thesis	18	Written during an internship
Final examination	12	Presentation of internship and oral examination

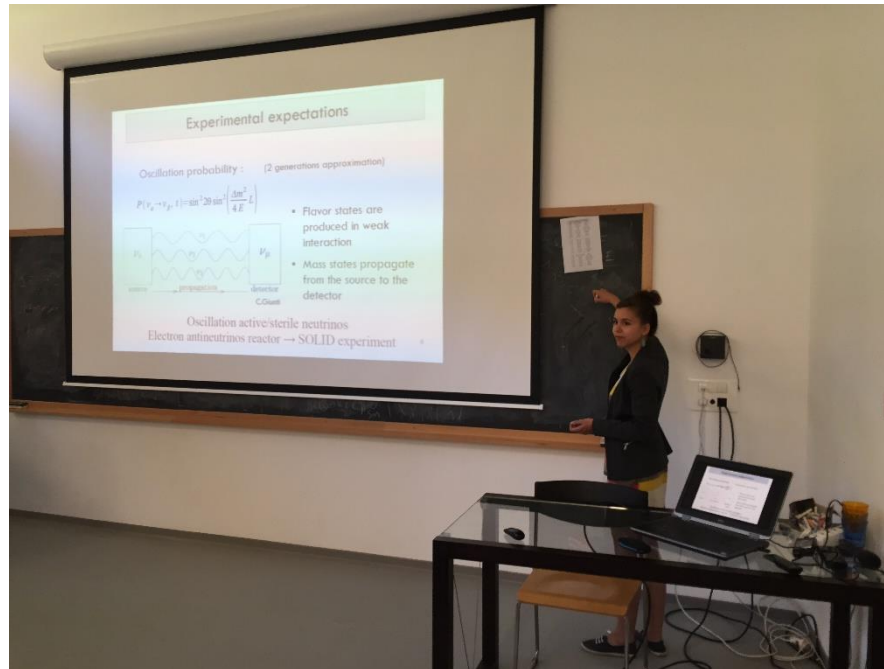
Notes on the Master's thesis:

- The internship for the Master's thesis can be conducted at any of the three universities, any of the associated partners (in academia or industry), or any other institution.
- There is a 6 CP course for the preparation of the Master thesis during the third semester. This course will help to identify a topic for the thesis.
- The final examination is basically a presentation of the results of the Master thesis and will take place at one of the partner institutions at the end of September.

Special events

Spring / summer school (second semester)

- Since 2015 in Cargese, Corsika (France)
- One week school on advanced particle physics
- Lectures on current topics in particle physics, presentations by students, discussion and exercise sessions



Special events

Preparation for scientific research and internship orientation (third semester)

- Presentations by associated partners on particle-physics topics
- Introduction of the universities, institutes and companies
- If applicable, presentation of possible Master thesis projects

Virtual industry day (fourth semester)

- Motivation: get in touch with relevant branches in industry close to finishing the Master program
- Virtual meeting with industry partners and guests
- Presentations on the field that the company is active in, what their company does, how everyday life in the company looks like, how they recruit employees, etc.
- Time for discussion with the partners and guests