EPFL

Laboratoire de Physique des Hautes Energies

LPHE for future Master students

Fred Blanc

Guido Haefeli

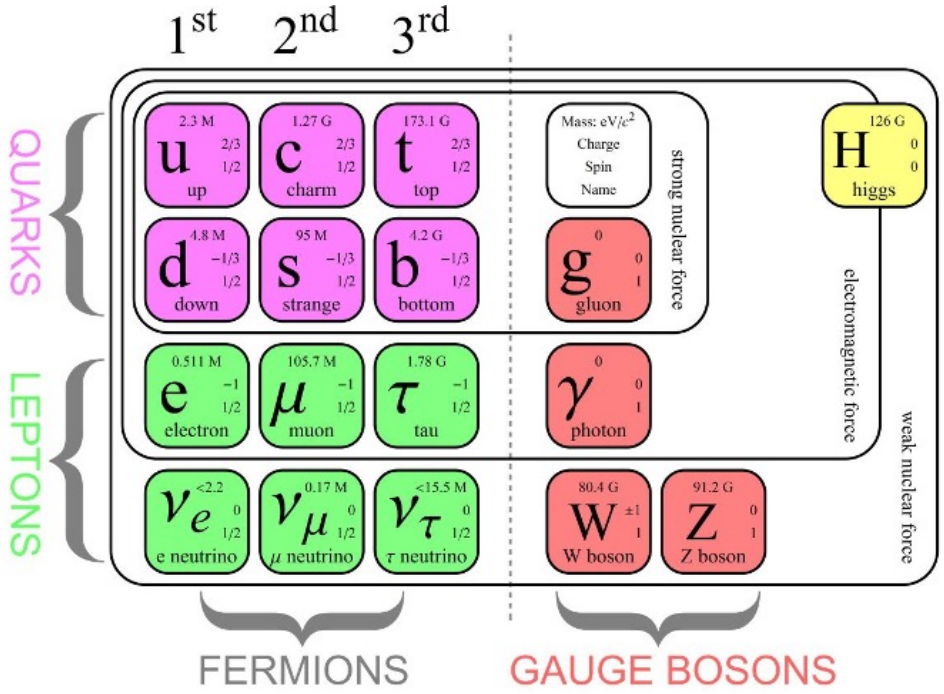
Radoslav Marchevski

Olivier Schneider

Lesya Shchutska

February 29, 2024

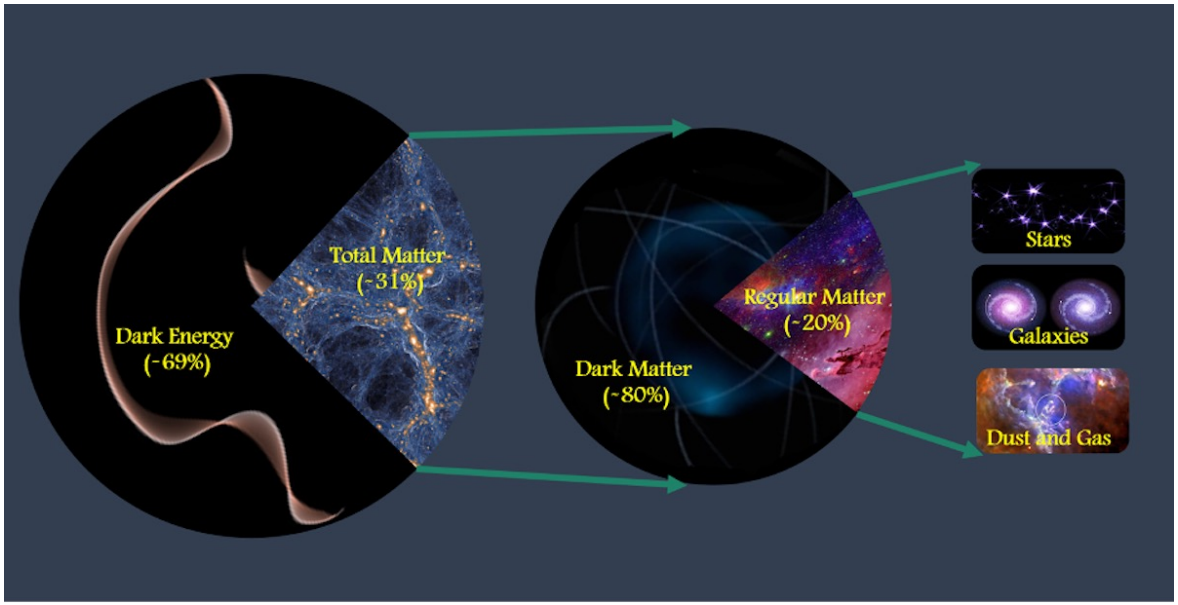
Standard model of particle physics



- is complete since 2012:
  - 3 generations of matter particles, identical apart from their mass
  - carriers for 3 forces
  - Higgs mechanism for masses
- works very well for all phenomena observed ***in the lab***
  - several tensions here and there exist

Lesya Shchutska, Fred Blanc

Why particle physicists do not stop?



- standard model accounts for about 5% of the content of the universe
- dark matter was "discovered" more than 90 years ago – and still no explanation for its nature
- + there are many more arguments of why standard model of particle physics is not an ultimate theory

All these motivate numerous "new physics" searches

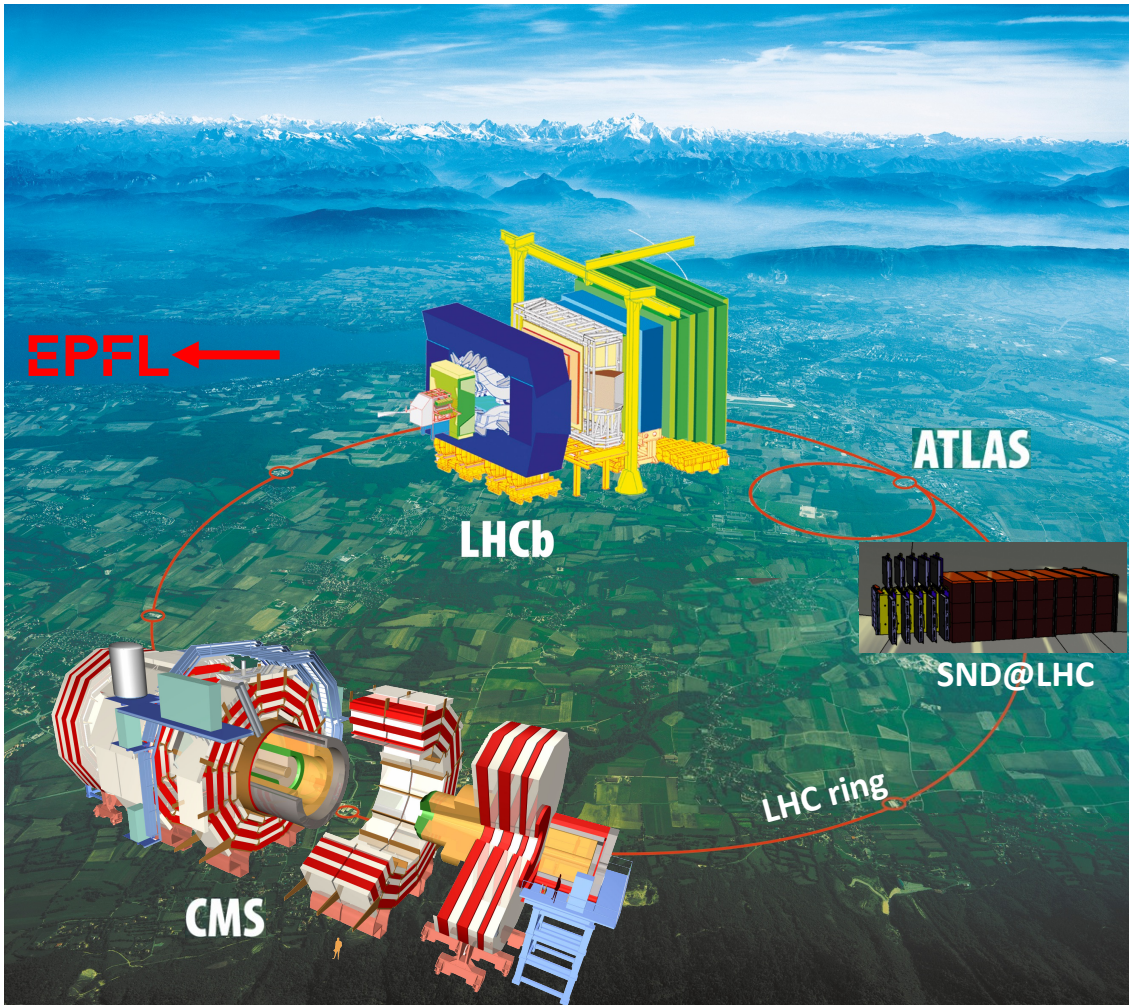
LHC and detectors – our main tool

First idea of the LHC in 1976

Approved for construction in 1994

Started stable operation in 2009

Planned to run till ~2040



Some numbers:

- pp collisions at 7, 8, and 13.6TeV, with 25ns bunch crossing (40MHz)
- ~10^{13} b hadrons produced
- Power consumption of the LHC and experiments: 750 GWh/year

Master thesis: LHCb

Thesis	
Report number	CERN-THESIS-2022-122
Title	**Study of $B^0 \to K^{*0}\gamma$ with conversions and $B^0 \to K^{*0}e+e-$ at very low q^2**
Author(s)	Lemettais, Clotilde (LPHE, Lausanne)
Publication	77 p.
Thesis note	Master of Science MSc in Physics : EPF Lausanne : 2022
Thesis supervisor(s)	Quagliani, Renato ; Schneider, Olivier
Note	Presented 12-07-2022
Subject category	Particle Physics - Experiment
Accelerator/Facility, Experiment	CERN LHC ; LHCb

- measured $B^0 \to K^{*0}e^+e^-$ rate for low $q^2 \equiv m^2(e^+e^-)$
- proved that we calibrated our electrons well in this regime!
- thesis is cited in a high-profile LHCb paper (arXiv:2212.09153)
- Clotilde is doing a PhD on Belle II (exp. in Japan)

https://cds.cern.ch/record/2826428

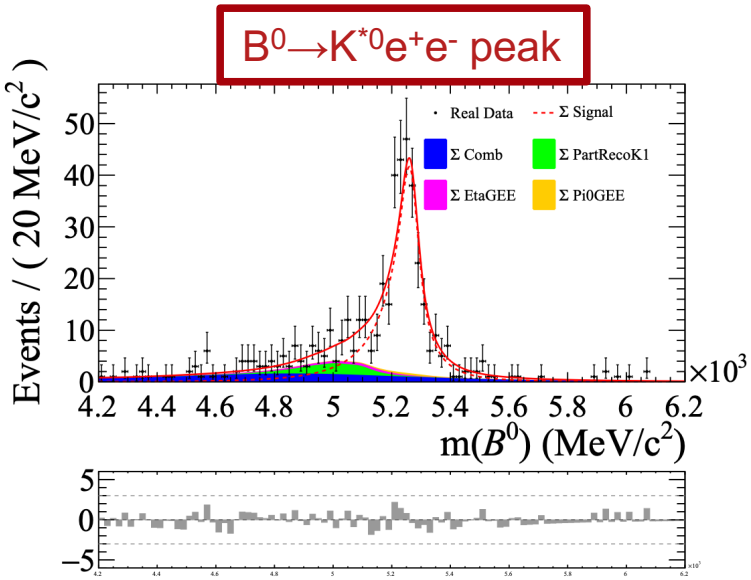


FIGURE 9.1: Total data fit of $B^0 \to K^{*0}e^+e^-$ candidates in the very low q^2 for all run periods and trigger categories merged

	$\mathcal{B}(B^0 \to K^{*0}e^+e^-, vl)$
Nominal setup	$(1.57 \pm 0.12) \cdot 10^{-7}$
Nominal, noPRMVA setup	$(1.54 \pm 0.12) \cdot 10^{-7}$
Tight setup	$(1.53 \pm 0.12) \cdot 10^{-7}$
Tight, noPRMVA setup	$(1.54 \pm 0.12) \cdot 10^{-7}$
Predicted value (PDG)	$(1.58 \pm 0.10) \cdot 10^{-7}$
Predicted value (Belle)	$(1.50 \pm 0.08) \cdot 10^{-7}$

measurement

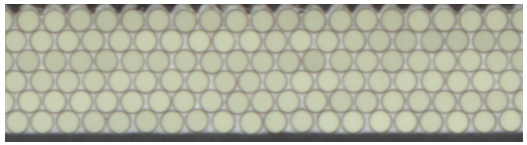
Master thesis: external (on IceCube, 2022)

- physics projects at LPHE
- Master thesis external
- After his Master, Marc spent one year at the South Pole doing a "winterover": running the IceCube detector
- more reading in LPHE news:
  - https://www.epfl.ch/labs/lphe/en/fulfilling-his-dream-marc-is-going-to-antartica-for-the-icecube-experiment/

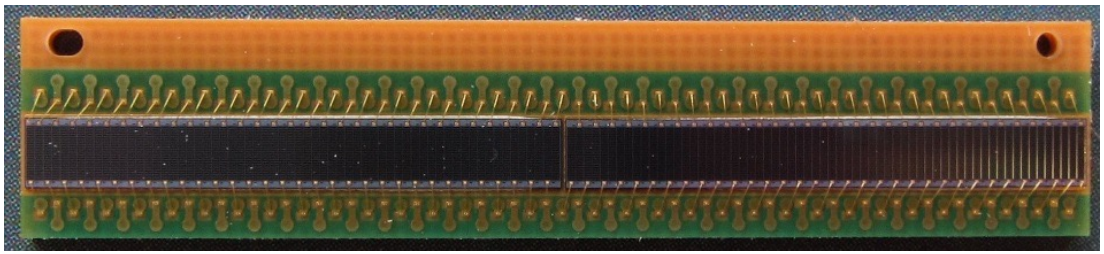
Instrumentation projects: SciFi

SciFi: charged particle tracking detector

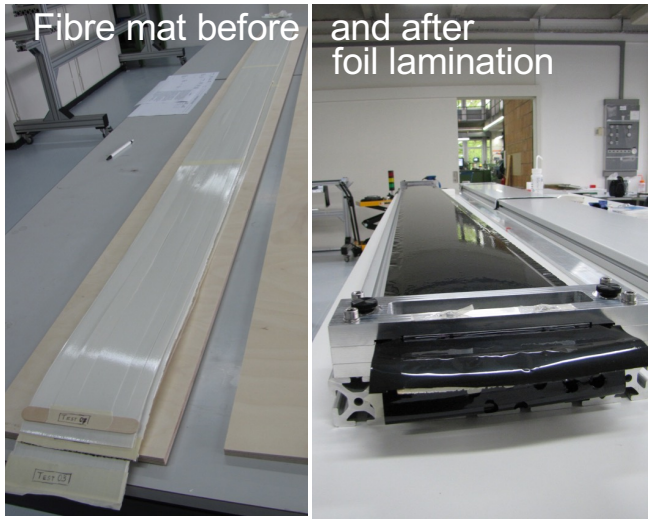
- Scintillating fibres
  - ø250 microns
  - 6 layers



- Light read out by photodetectors:

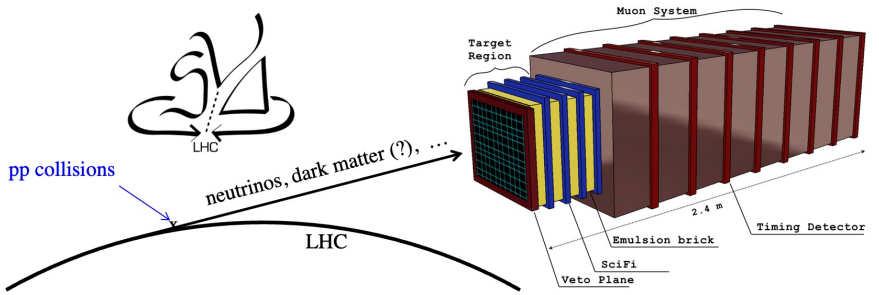


- Fast data acquisition: at 40 MHz



SciFi for the SND@LHC: Scattering and Neutrino Detector at the LHC

- more compact SciFi stations:
  - 39×39 cm^2
- active R&D of new features:
  - particle time arrival measurement (300 ps precision)
  - electron shower imaging and energy measurement
- data-taking since 2022



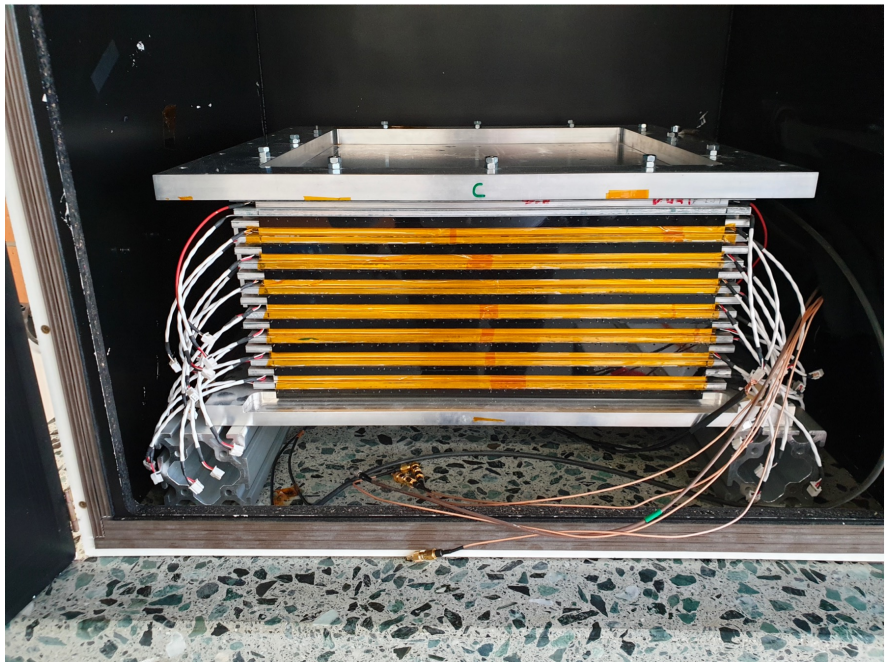
SND in the LHC tunnel

Full experiment as a start: Physics Project I

- design, construction and operation of a small complete particle physics experiment
- work in a group of 2-3 people
- final written report by each group

Cosmic ray detection with a ECAL

- this one is a new experiment
- students are developing new features each semester:
  - develop and refine simulation
  - decide how to take data
  - develop reconstruction algorithms
  - come up with new analysis ideas
- achieved muon lifetime measurement in fall'22 for the first time!

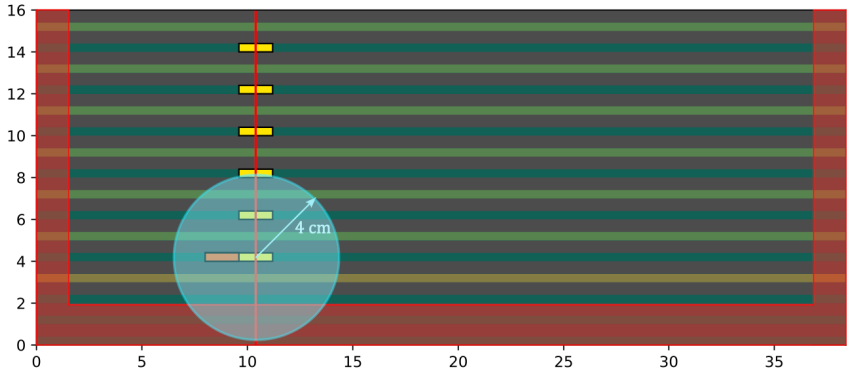


Lesya Shchutska, Fred Blanc

Cosmic ray detection with a ECAL

Example event of a decaying muon

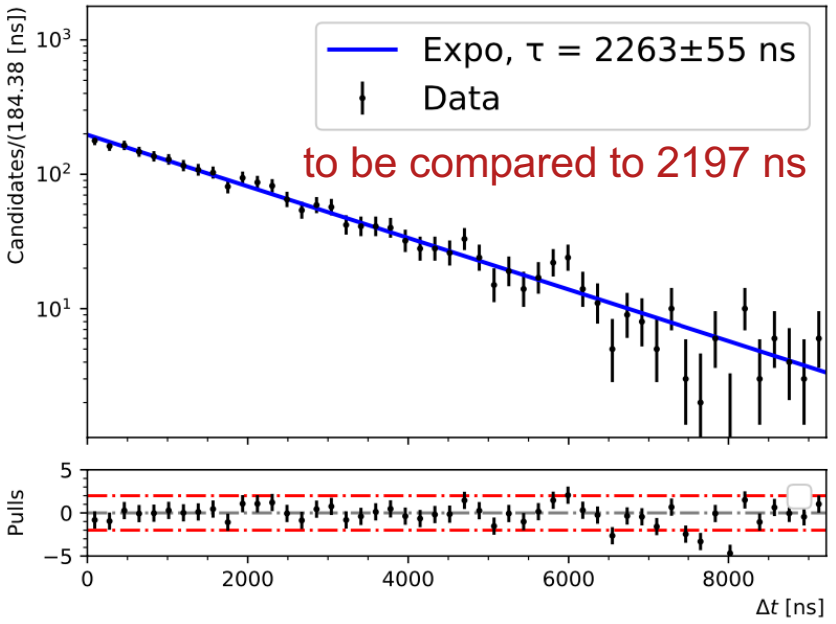
yellow hits: incoming muon



orange hits: electron from $\mu \rightarrow e\nu\nu$ decay

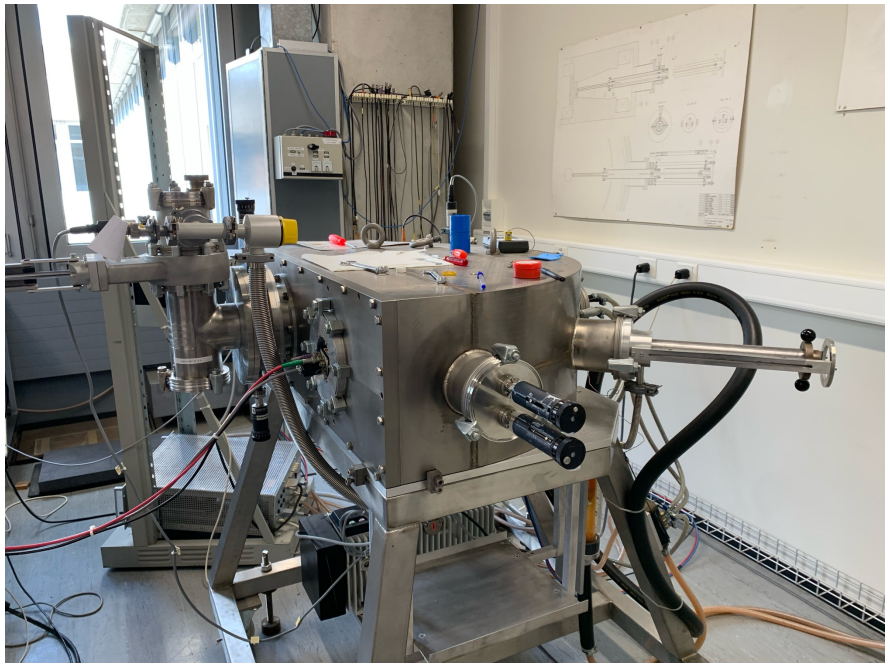
Time interval between the arrival of the muon and production of the electron is Δt = 3299 ns

Result by the students (fall'22)



Physics Project I: two other experiments

β-spectrometer: "measure" ν mass



μ lifetime measurement

Further projects: individual, you choose

Physics Project II
spring'24 edition

- LPHE for future Master students

LPHE Physics Project II (=TP4b) kick-off meeting

Monday 19 Feb 2024, 08:15 → 15:25 Europe/Zurich
BSP 626 (EPFL)

Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH)),
Guido Haefeli (EPFL - Ecole Polytechnique Federale Lausanne (CH)),
Lesya Shchutska (EPFL - Ecole Polytechnique Federale Lausanne (CH)),
Olivier Schneider (EPFL - Ecole Polytechnique Fédérale de Lausanne (CH)),
Radoslav Marchevski (EPFL - Ecole Polytechnique Fédérale de Lausanne (CH))

08:15 → 08:25 Physics Project (TP4) kick-off: Introduction
Convener: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))

- 08:15 **Welcome and general information** 10m
  Speaker: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  TP4b_kick-off_intro... TP4b_kick-off_intro...

08:25 → 10:15 Physics Project (TP4) kick-off: Presentation of the proposed projects by the supervisors
Convener: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))

- 08:25 **Photodetection efficiency and gain measurements in silicon photomultiplier detectors** 7m
  Supervisor: Esteban Curras Rivera
  Responsible teacher: Guido Haefeli
  Speaker: Esteban Curras Rivera (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  TP4b_project_Esteb...
- 08:32 **Improving the simulation of $B^+ \to K^+\tau^+\tau^-$ decays with real $B^+ \to D^+D^-K^+$ data** 7m
  Supervisor: Maria Faria
  Responsible teacher: Fred Blanc
  Speaker: Maria Carolina Feliciano Faria (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  TP4b_project.pdf
- 08:39 **Detection of gamma-rays with the DAMPE space mission** 7m
  Supervisor: Jennifer Frieden
  Responsible teacher: Chiara Perrina
  Speaker: Jennifer Maria Frieden (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  DAMPE_TP4b_Welc...
- 08:46 **Towards neutrino reconstruction with machine learning at the SND@LHC experiment** 7m
  Supervisor: Jan Steggemann
  Responsible teacher: Lesya Shchutska
  Speaker: Jan Steggemann (EPFL and ETH Zurich (CH))
  2024_02_19_special...
- 08:53 **R&D of Scintillating Fibre mats for the LHCb Upgrade II** 7m
  Supervisor: Gianluca Zunica
  Responsible teacher: Giudo Haefeli
  Speaker: Gianluca Zunica (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  tp4b_project.pdf

- 09:00 **SiPM Cross-Talk measurement and microlens characterisation** 7m
  Supervisor: Federico Ronchetti
  Responsible teacher: Guido Haefeli
  Speaker: Federico Ronchetti (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  TP4b2024.pdf
- 09:07 **Selection Design for the Semileptonic Hyperon Decay $\Xi^- \to \Lambda\mu^-\bar{\nu}_\mu$** 7m
  Supervisor: Alexandre Brea Rodriguez
  Responsible teacher: Olivier Schneider
  Speaker: Alexandre Brea Rodriguez (Universidade de Santiago de Compostela (USC), IGFAE)
  Xi- -> Lambda mu n...

09:15 **Break** 20m

- 09:35 **Distribution of projects to the students (discussion and decision)** 25m
  Speaker: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))

11:15 Physics Project (TP4) kick-off: Introduction to CERN, detectors, [NA62/CMS/LHCb/SND@LHC], ...
Convener: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))

- 10:15 **Introduction to CERN** 10m
  Speaker: Gianluca Zunica (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  cern_intro_V5.pdf
- 10:25 **Introduction to analysis** 30m
  Speaker: Maria Carolina Feliciano Faria (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  AnalysisIntro.pdf
- 10:55 **Introduction to detectors** 20m
  Speaker: Anna Mascellani (EPFL and ETH Zurich (CH))
  TP4b_detectors.pdf

15:00 Physics Project (TP4) kick-off: Cluster tutorial [ssh connection, queues, interactive nodes, ...]
Convener: Fred Blanc (EPFL - Ecole Polytechnique Federale Lausanne (CH))

- 14:00 **LPHE computing cluster: intro and setup** 45m
  Speaker: Dr Luis Miguel Garcia Martin (EPFL - Ecole Polytechnique Federale Lausanne (CH))
  OldCluster.pdf OldCluster.pptx

More information and application

- more information on Master level courses and Physics Project I:
  - https://www.epfl.ch/labs/lphe/enseignement/
- if interested, please fill in the form by June 9 for full consideration:
  - https://forms.gle/Rkyh2okmP9rzaYta9
    sign in with your EPFL account

Application for Physics project, Specialisation or Master project at LPHE (experimental high energy physics)

Please fill in the form by June 11 for full consideration.
More information: https://www.epfl.ch/labs/lphe/enseignement/

lesya.shchutska@epfl.ch Switch accounts

The name, email address and photo associated with your Google Account will be recorded when you upload files and submit this form

*Required

Name *

Your answer

Which type of project would you like to do in fall'23 at LPHE: *

- (•) Physics Project I
- ( ) Physics Project II
- ( ) Specialisation semester
- ( ) Master project

Please provide your motivation to join LPHE for physics projects: *

Your answer