Beamline for Schools

A physics competition for high-school students

Welcome to CERN and DESY!

What is BL4S?

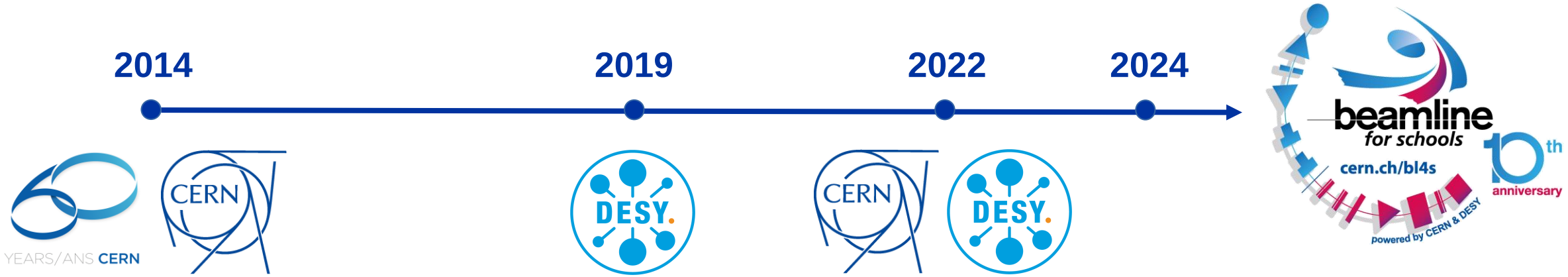
Perform your own experiment at a real particle accelerator!

You can be a scientist

Teams of high school students from all around the world can propose an experiment that they want to perform at a particle accelerator.

What is BL4S?

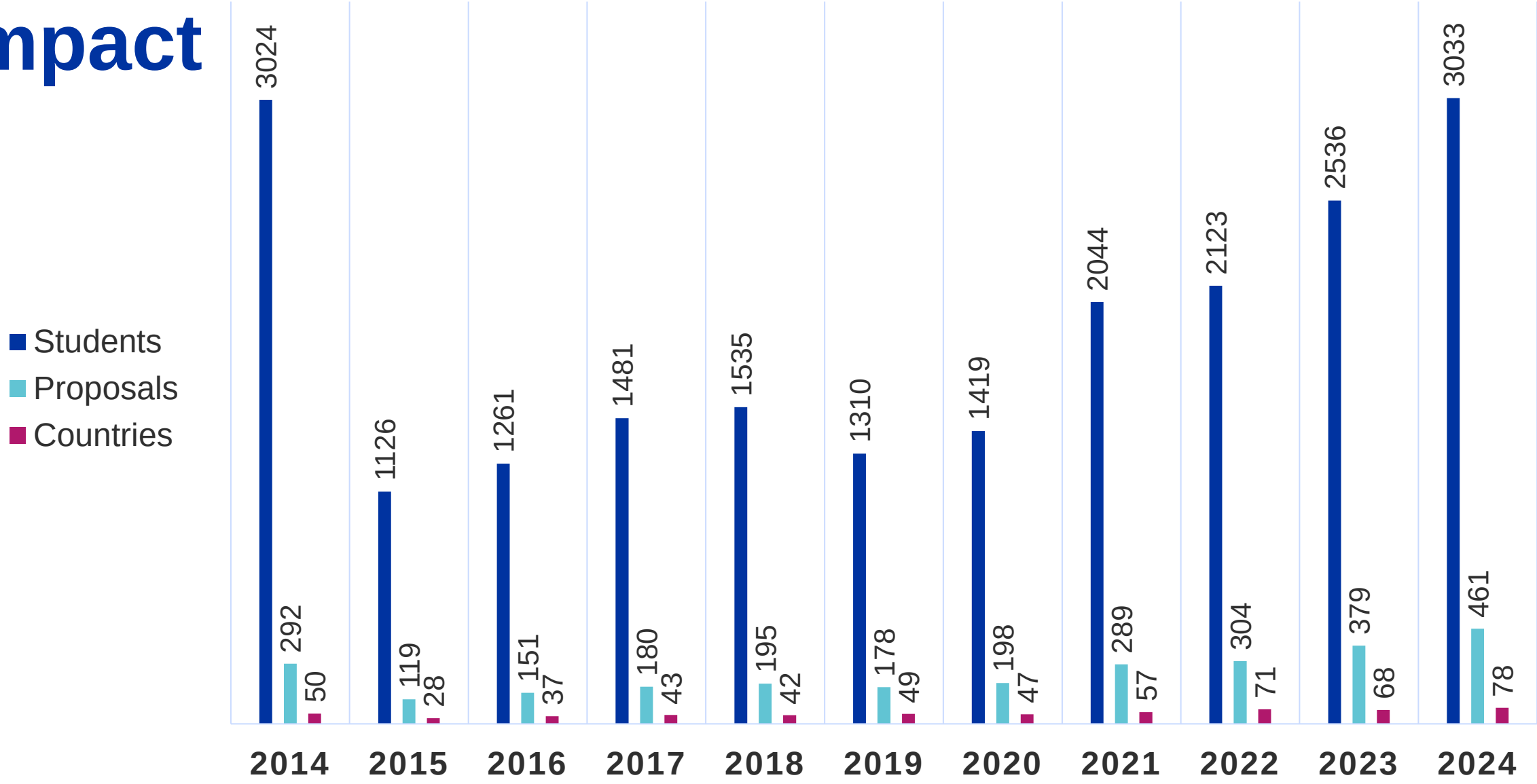
The 2024 edition is the 10th anniversary of the competition!



Who can participate in BL4S?

- **Teams:** min. 5, max. 9 people, ≥ 16 years old (when submitting your proposal)
- Enrolled in **high-school** in the school year 2023/2024 or gap between school and university
- Each team has to be led by an adult “**team coach**” (max. 2 per team)

Impact


Students
Proposals
Countries
3024
292
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1310
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2014
2015
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2021
2022
2023
2024

Special prizes 2024

Award for the best video proposal: BL4S t-shirts and DIY cloud chamber – **1 team**

Award for the best outreach proposals: BL4S t-shirts and telescopes (sponsored by the Belgian project “Stars Shine For Everyone”) – **10 teams**

Shortlisted teams: BL4S t-shirts and DIY cloud chamber and pixel detector – **30 teams**

Winning teams 2024

Two winning teams will be invited to **CERN** in Geneva, Switzerland, to conduct their proposed experiments (~2 weeks).

One winning team will be invited to **DESY** in Hamburg, Germany.

Experiment proposal

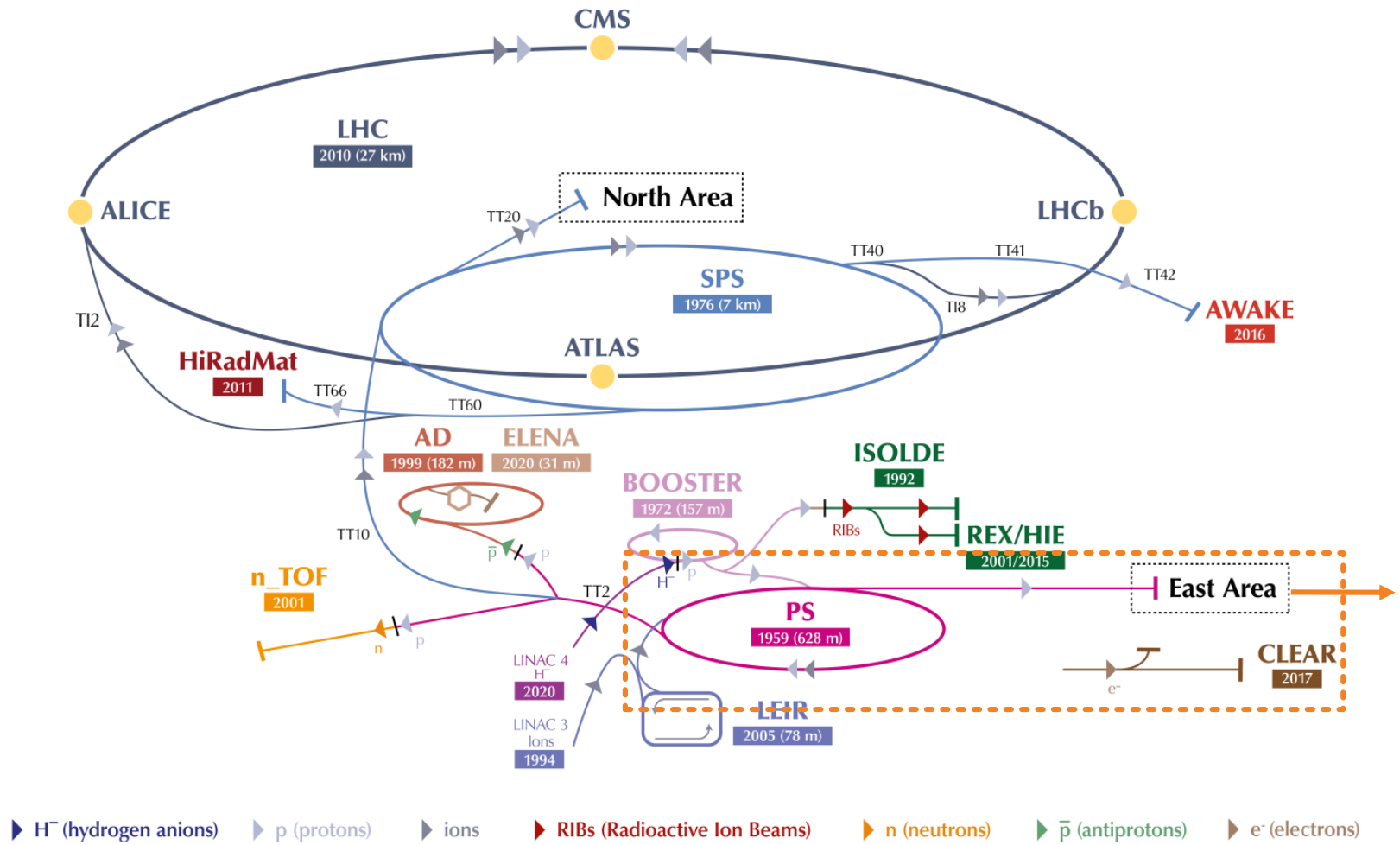
Written proposal (~1000 words)

- Motivation (~ 100 words)
- Proposed experiment (~800 words)
- What you hope to take away from this experience (~100 words)

Video proposal

(~1 min, optional)

The CERN accelerator complex
Complexe des accélérateurs du CERN

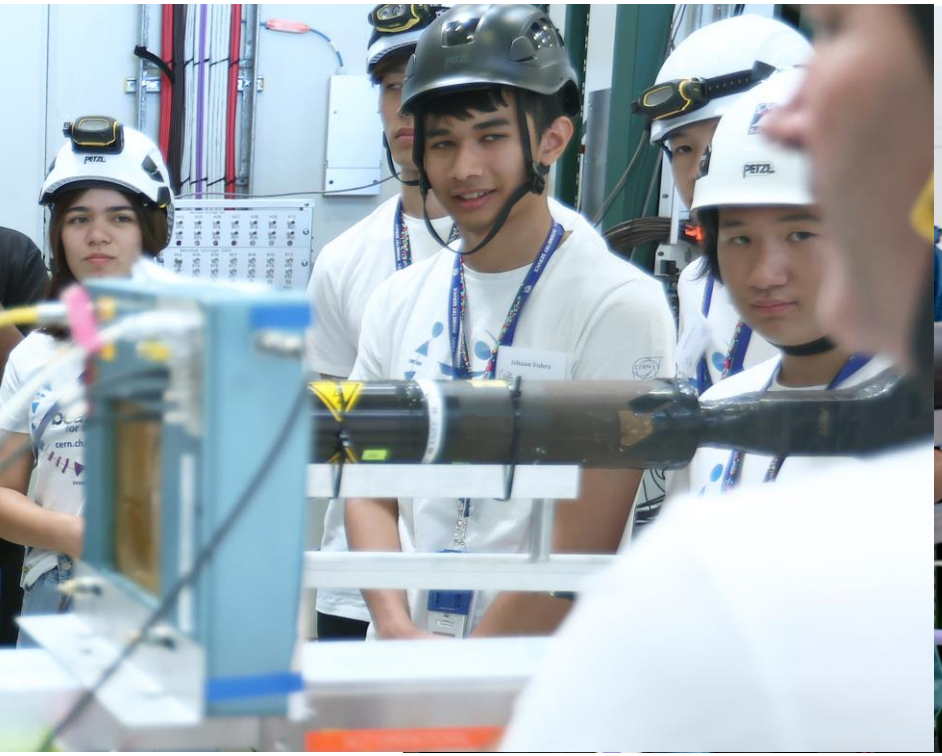


East area

- Experimental areas ‘T’
- Control rooms ‘Hut’

Thank you for your attention!

Questions?

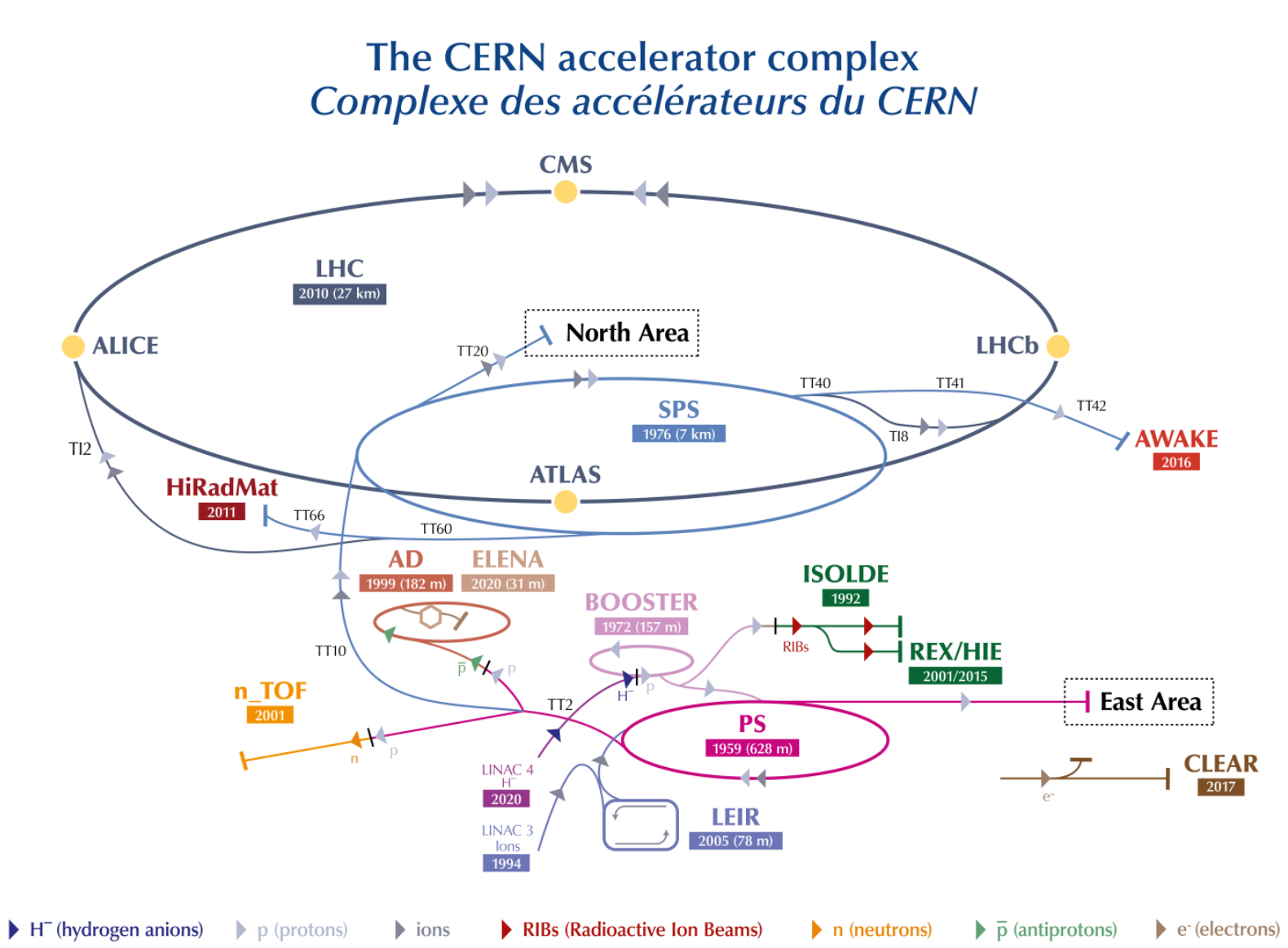


Experiment proposal

The proposals will be evaluated by a committee of scientists.

Evaluation Criteria:

- Feasibility of the experiment
- Motivation of your experiment idea and your participation
- Creativity of the experiment
- Following a scientific method



- **Different types of particles** are available for permanent experiments (ATLAS, CMS, ALICE, LHCb, etc..) and for temporary users
- BL4S winners are **temporary users of CERN's beams**

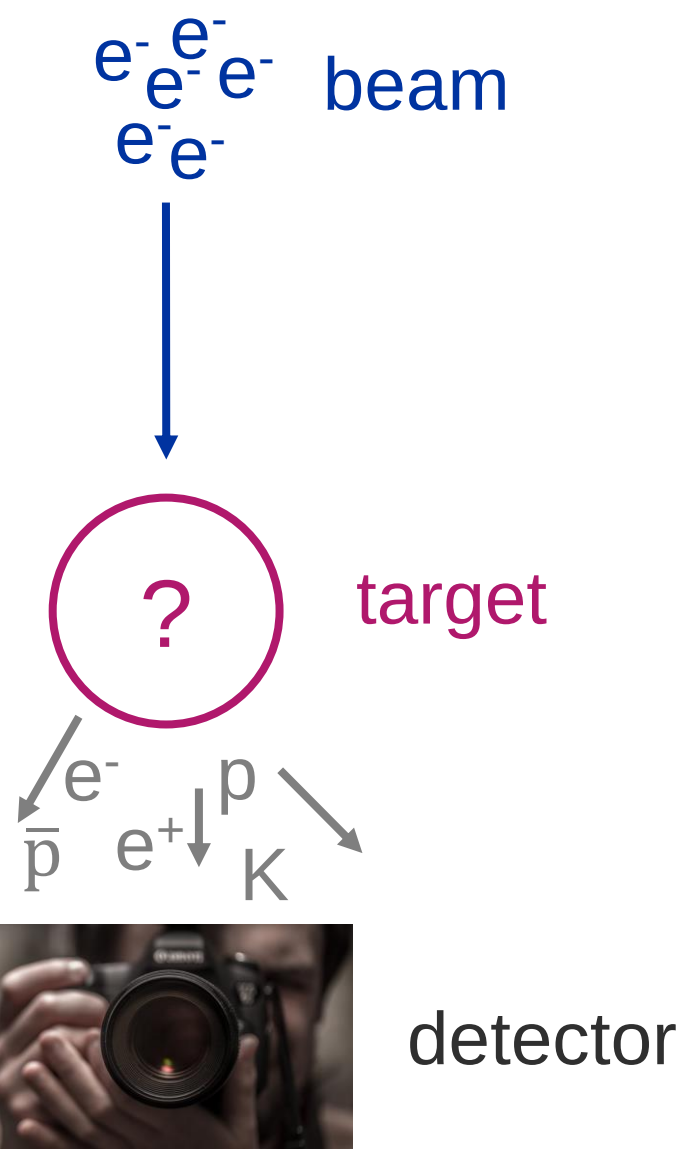
- **Electron accelerator complex**
- DESY II provides a pure electron or positron beam
- BL4S winners are temporary users of the **DESY II beamlines**

A beamline

… is a straight section of a particle accelerator leading the particles to an experimental area.

This experimental area might look empty ⇨ You can fill it with your experiments! :)

Experiment requirements



The proposed experiment must be designed in a fixed target configuration.

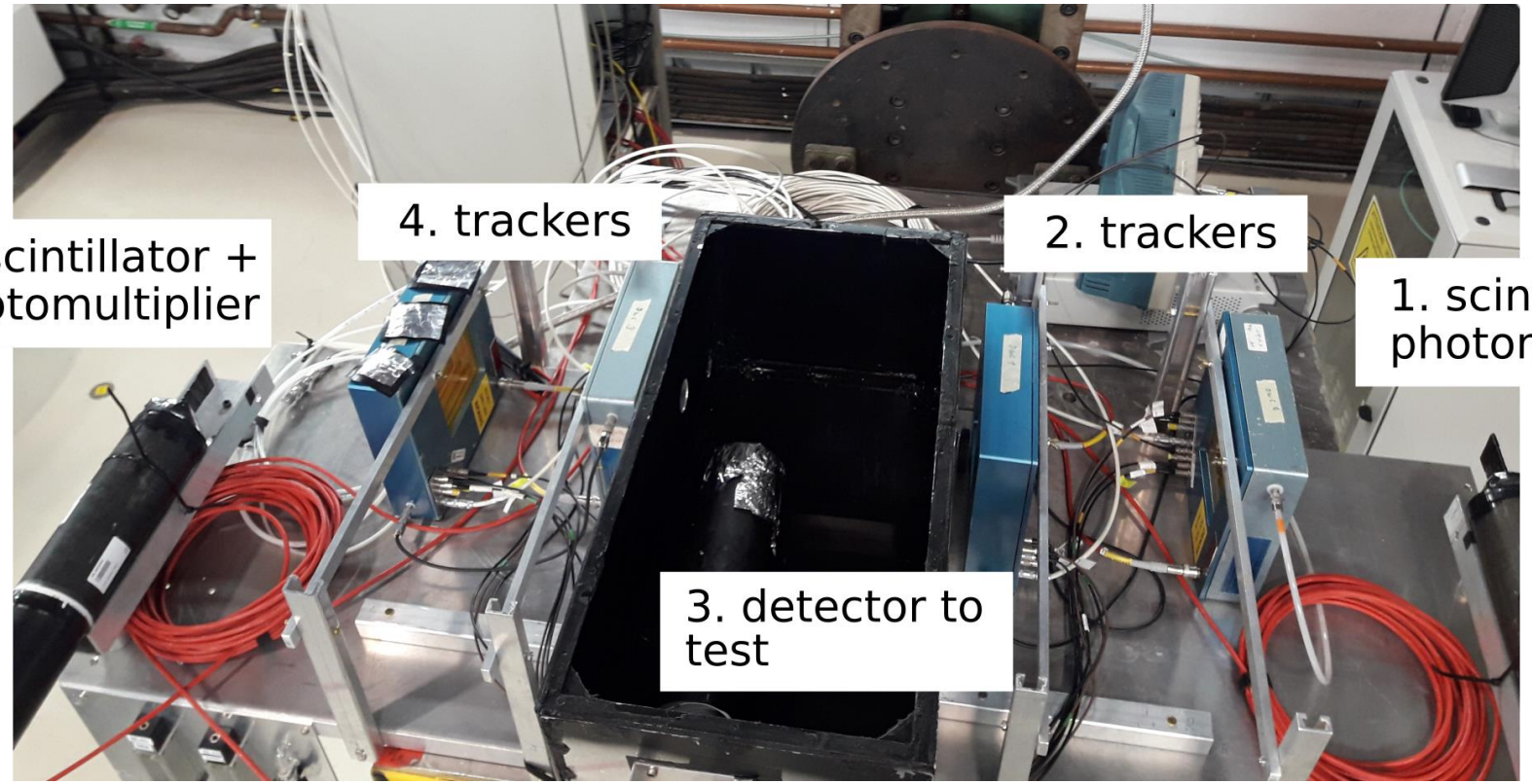
- **Fixed target configuration:** beam crossing or passing close to a target (solid, liquid, gas)
- **Experiment design:** beam, target, detectors, and trigger/readout

(new) particles moving in many different directions

detector

Note that we cannot perform collider-type experiments in BL4S

An experimental setup



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Some useful questions

- How do high-energy particles interact with matter?
- How can we detect high-energy particles?
- What can we learn from interactions of particles with matter?
- How can we use these phenomena (e.g. applications in medicine or industry)?

Find a phenomenon that triggers your curiosity and start to draft your experiment!

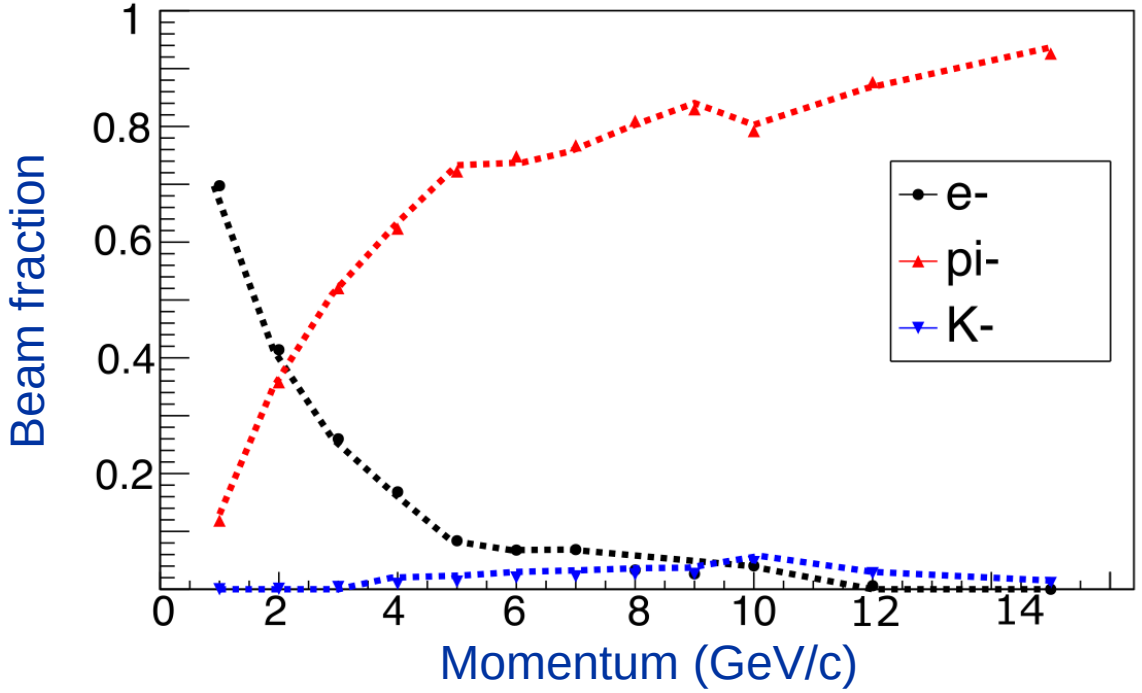
Example experiments: https://beamline-for-schools.web.cern.ch/sites/default/files/Experiment_examples_2024.pdf

Beam properties at CERN

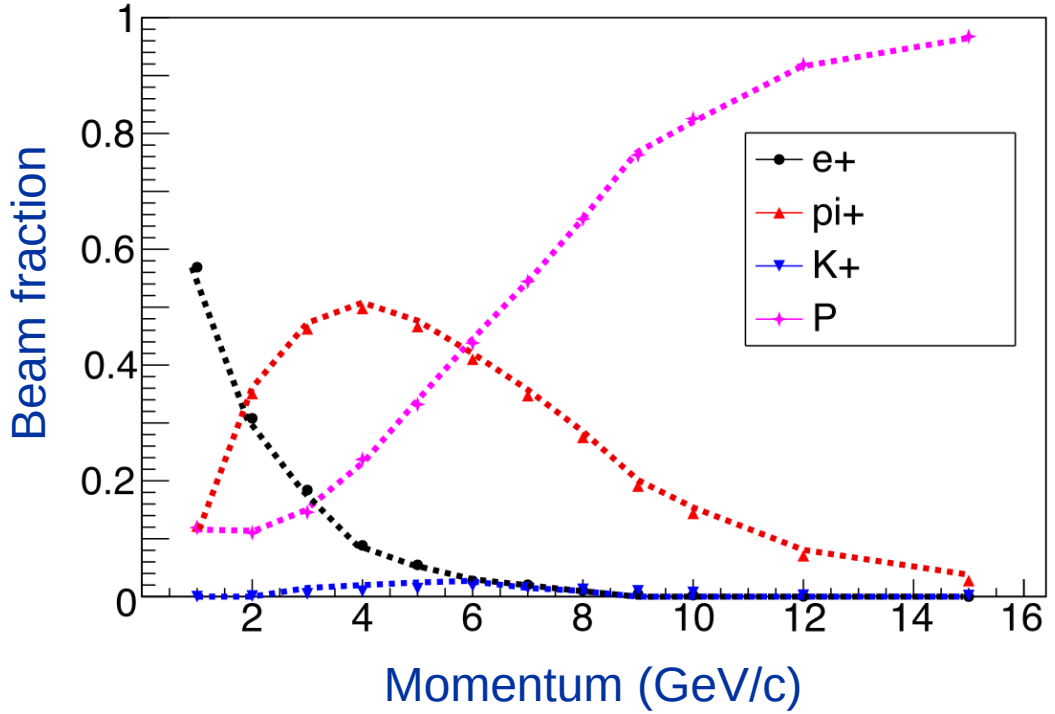
- Protons accelerated by the Proton Synchrotron (up to 26 GeV; ‘primary beam’) are smashed into a target.
- The energy of the protons transforms into the energy of new particles. These new particles ('secondary beam’) are available for the users.
- Users can select the particles’ electric charge (positive or negative), their energies, and the opening of collimator (i.e. the beam diameter).
- **Beam diameter:** ~ 2 cm

Beam properties at CERN

Negative beam

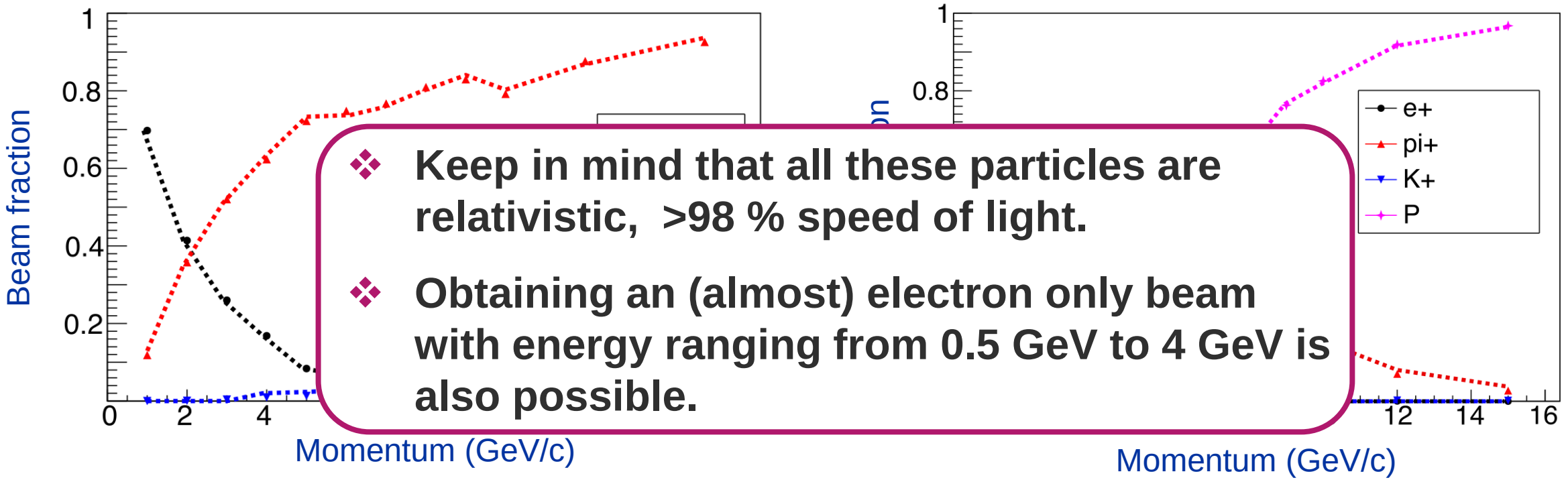


Positive beam



Protons or pions, respectively, make up the highest fraction of particles.
Energy range: 0.2-15 GeV

Beam properties at CERN

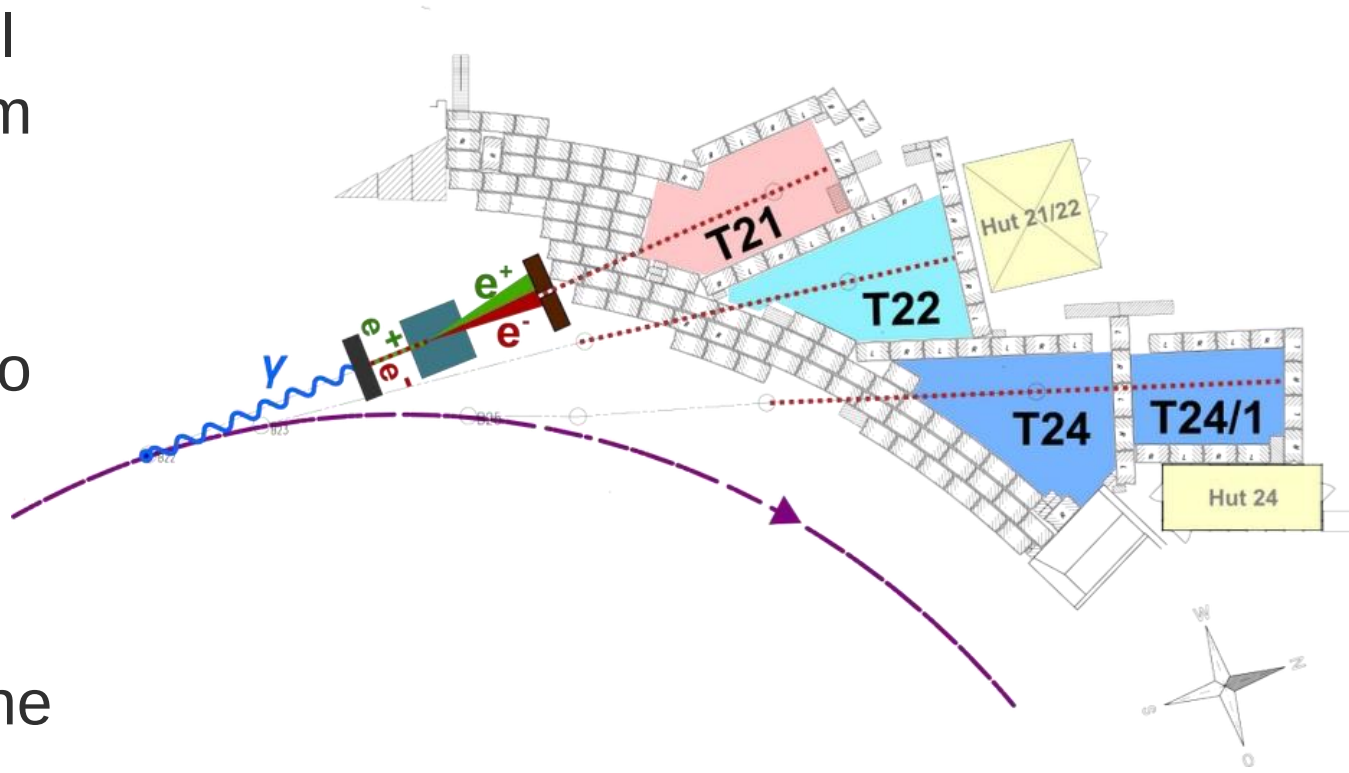


- **Keep in mind that all these particles are relativistic, >98 % speed of light.**
- **Obtaining an (almost) electron only beam with energy ranging from 0.5 GeV to 4 GeV is also possible.**

Protons and pions make up the highest fraction of particles.
Energy range: 0.2-15 GeV

Beam properties at DESY

- Electrons accelerated by the DESY II (synchrotron) send out energy in form of photons with up to 10 GeV. These photons are smashed into a target.
- Energy of the photons transforms into the energy of electron-positron-pairs at different energies.
- The user can select the particle type (positive or negative), their energy, the opening of collimator (i.e. the beam diameter).
- **Beam diameter:** ~ 2 cm



Beams and detectors: https://beamline-for-schools.web.cern.ch/sites/default/files/Beams_Detectors_BL4S2024.pdf

?

You don’t need to express a preference.
Build your experiment according to your scientific needs.
The evaluation committee will assign you to the laboratory that fits your experiment’s requirements best.

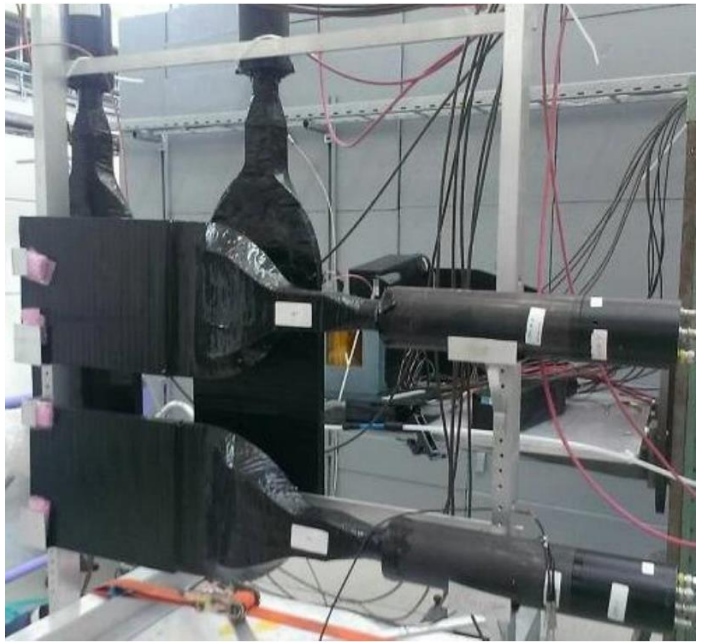
Detectors

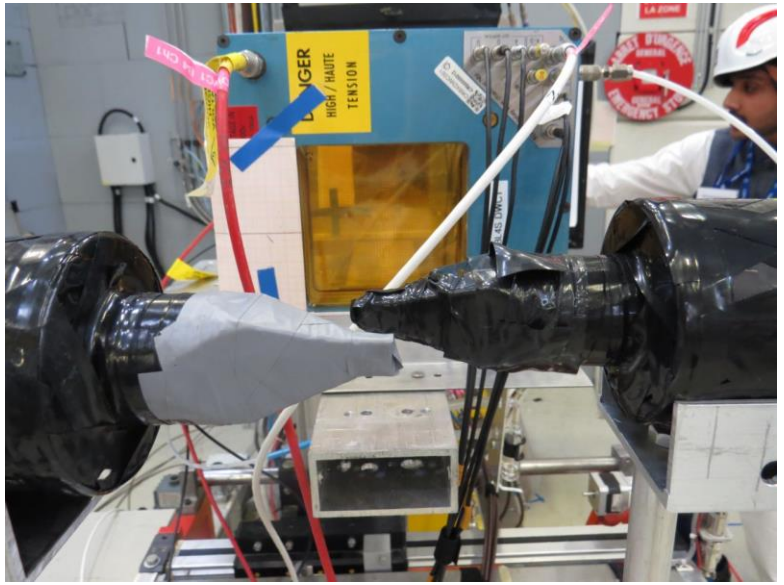
- Different detectors are available for BL4S
- The choice depends on the purpose of your experiment
- Each detector has its own readout system
- The data-acquisition systems controls all the detectors and the experiment (you don’t need to worry about that)

Beams and detectors: https://beamline-for-schools.web.cern.ch/sites/default/files/Beams_Detectors_BL4S2024.pdf

Detectors

- Scintillators + photomultipliers – particle counting, trigger, time-of-flight measurements ⇨ How many? When?
- Delay Wire Chamber – 2D tracker with an area of 10x10cm and a resolution of 200−300μm ⇨ Where?
- MicroMegas detectors – 1D tracker with an area of 40x40cm, resolution 200μm ⇨ Where?
- Silicon pixel detectors – 2D tracker with an area of 2x2 cm, contact us if interested ⇨ Where?





Detectors

- Muti-gap resistive plate chambers (MRPC) – trackers with an area of 30x30 cm and a time resolution 100 ps (10^{-10} s), time-of-flight measurements ⇨ How many? When?
- Cherenkov detectors – gas detectors ⇨ What type of particle?
- Lead crystal calorimeter (scintillator) + photomultipliers – energy of particles, with a volume of 10x10x37 cm

You are free to design and test your own detector!

Beam properties

- Protons: uud
- When they interact with a target they can produce different particles, both elementary and not.
- Given the energy provided by the PS, one can have **electrons, muons and particles composed of u,d, and s quarks (pions and kaons)**.