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)









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 "<u>Stars Shine For Everyone</u>") – 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)

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Hey, what is up guys, I'm the electron all right

Video proposal (~1 min, optional)

DESY.



SIGN







East area







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

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Hey, what is up guys, I'm the electron all right





- 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

Note that we cannot perform collider-type experiments in BL4S



detector



An experimental setup





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



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



Beam properties at CERN



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).





