Beamline for Schools (BL4S)
Particle Accelerators and Beams

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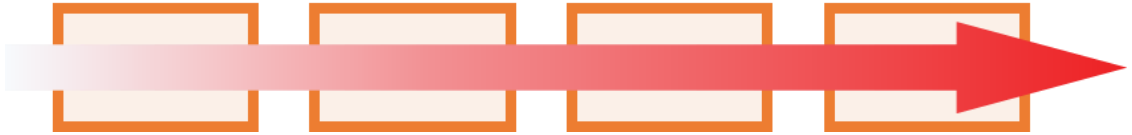
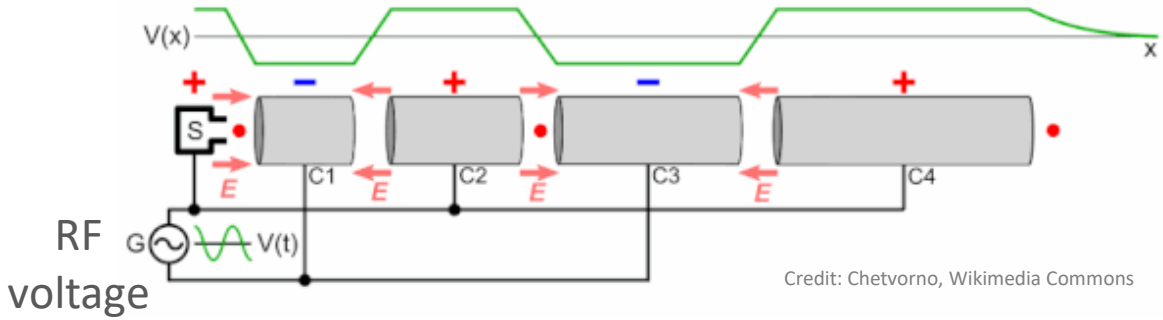
Linear Accelerator or Linac



Particle's energy is higher along the accelerator.

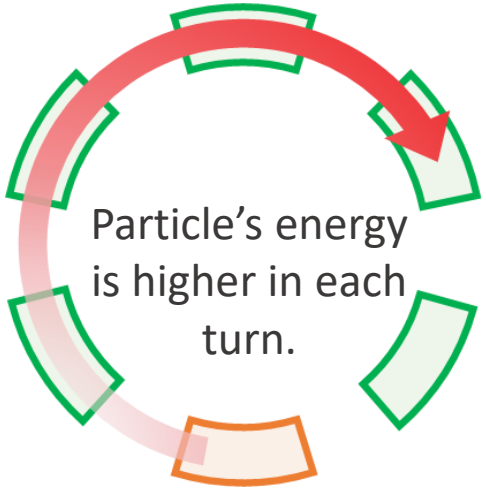


Credit: Chetvorno, Wikimedia Commons

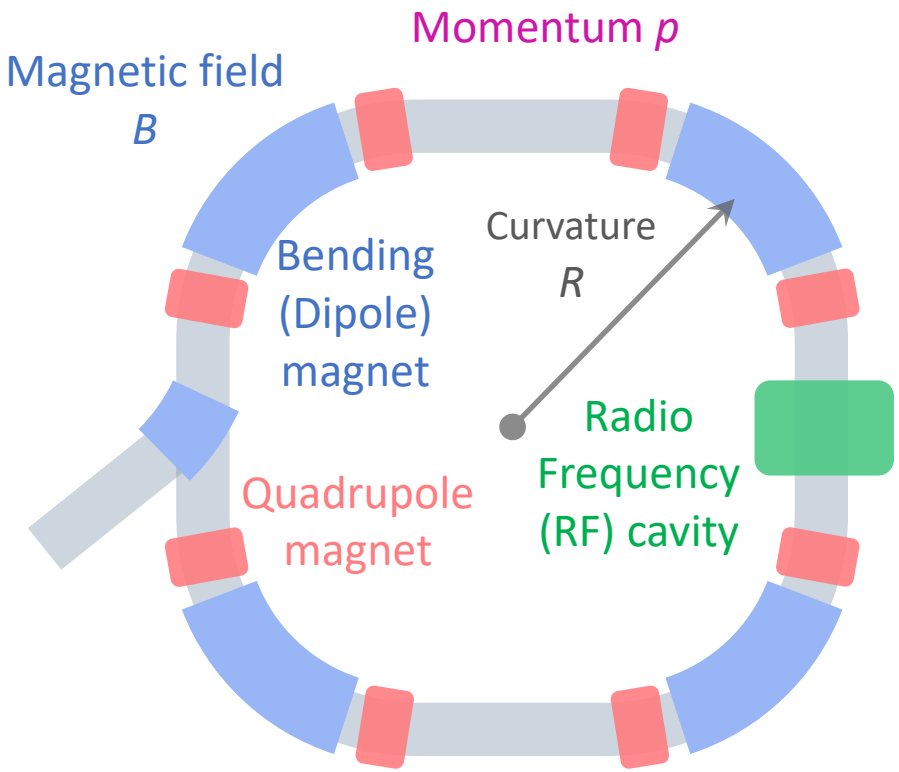
LINAC 4 at CERN

Linac at SLRI

Circular Accelerator or Synchrotron



Particles travel in
a circular path
like a racetrack.



As particle's **energy** and **momentum** are higher, **Magnetic field** must be stronger to maintain constant **curvature**.

$$BR = \frac{p}{q}$$

Synchronization between
- Particle energy/momentum
- Magnetic field
- RF frequency

Also known as

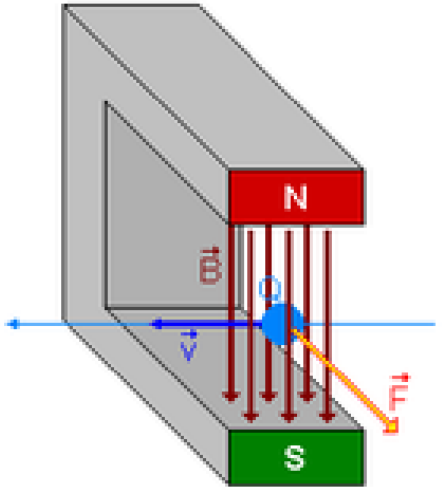
Booster synchrotron for raising beam energy

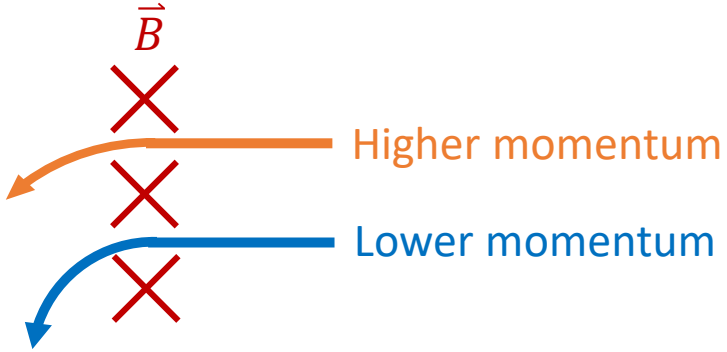
Storage ring for maintain constant beam energy

Bending/Dipole Magnet

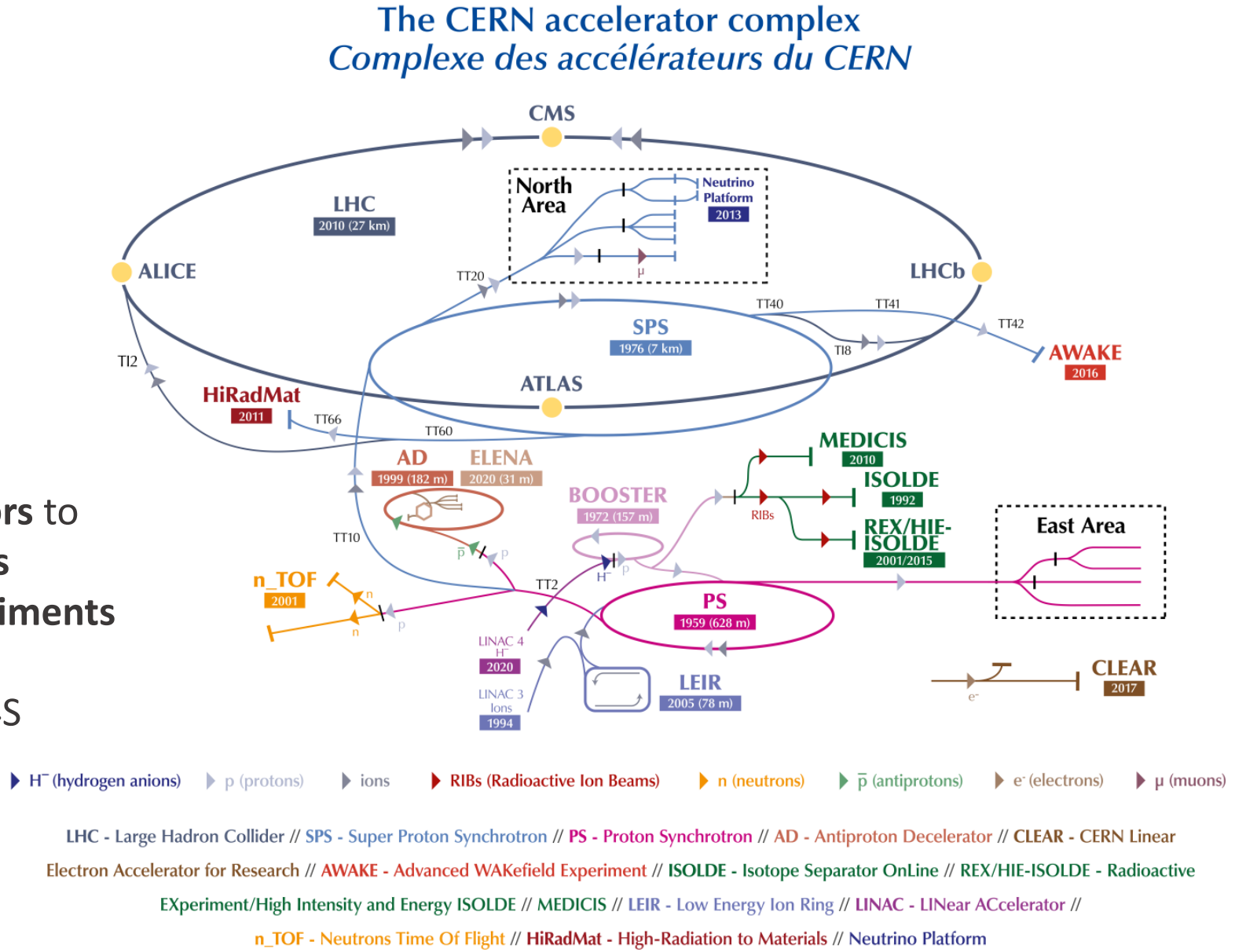
- It is a device (typically electromagnets) used to **change the direction** of charged particles by applying the **Lorentz force.**
- The strength of the magnetic field can be adjusted by varying the current in the magnet coils.
- The **deflecting angle** of the particles is determined by their **momentum**.
- Bending magnets are used as **energy/momentum analyzers** to select particles based on their energy/momentum.

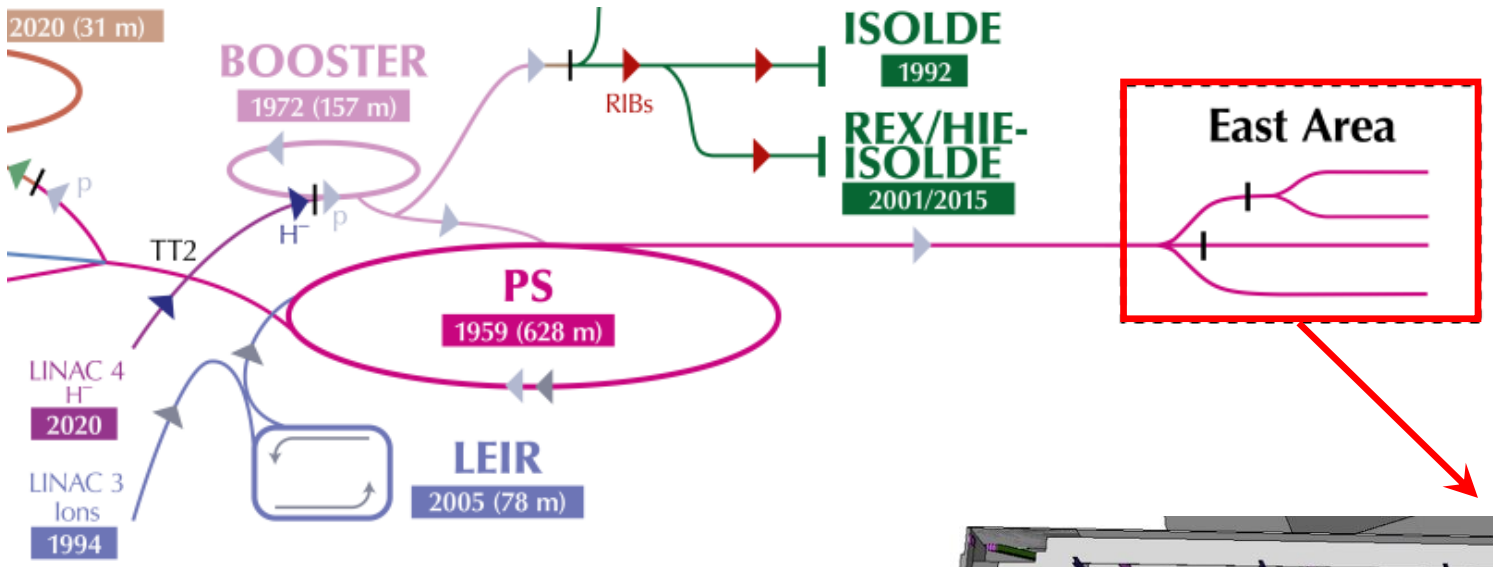
$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$



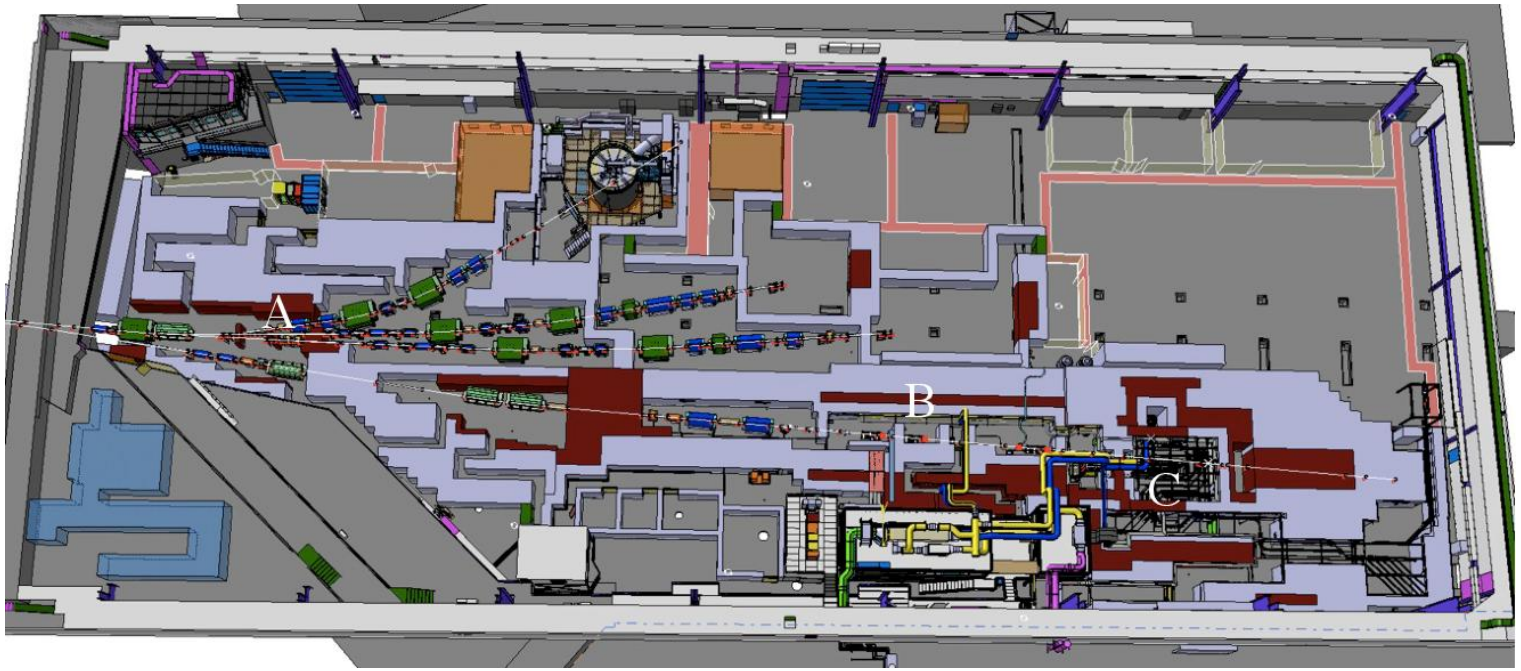


- **CERN** operates **different accelerators** to produce **different types of particles** (p, e⁻, ions, etc.) for **different experiments** (CMS, ATLAS, ALICE, LHCb, etc.).
- **Beams from PS** will be used for BL4S experiments at CERN.





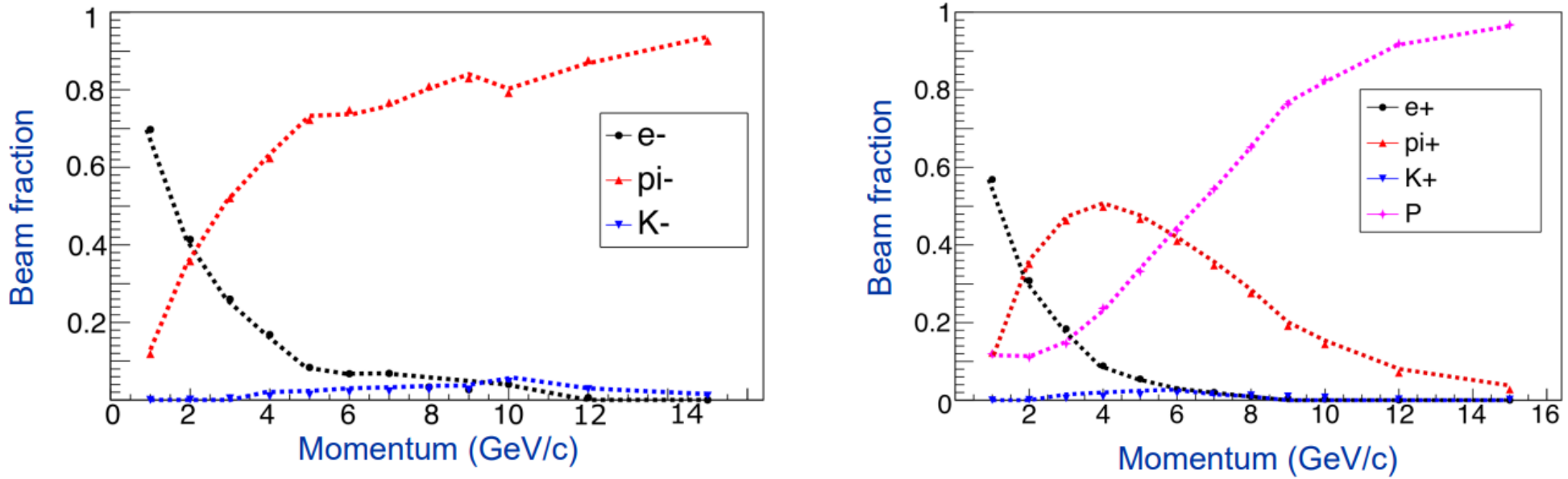
The BL4S experiments at CERN take place at the **PS Test Beam Facility**.



Beam Properties at CERN

- **Protons** (energy ≤26 GeV as **primary beam**) are directed into a target.
- The energy of the protons is converted into the energy of new particles (**secondary beam**).
- **Only the secondary beam** is made available for users' experiments.
- Users can select the secondary beam's properties—such as particle charge, energy, and beam diameter—using the available equipment and instruments.

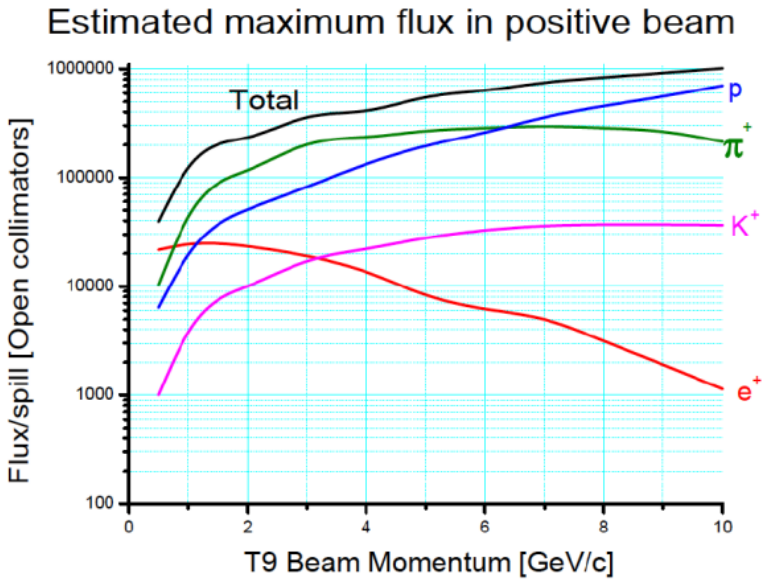
Negative beam **0.5 - 15 GeV/c** Positive beam



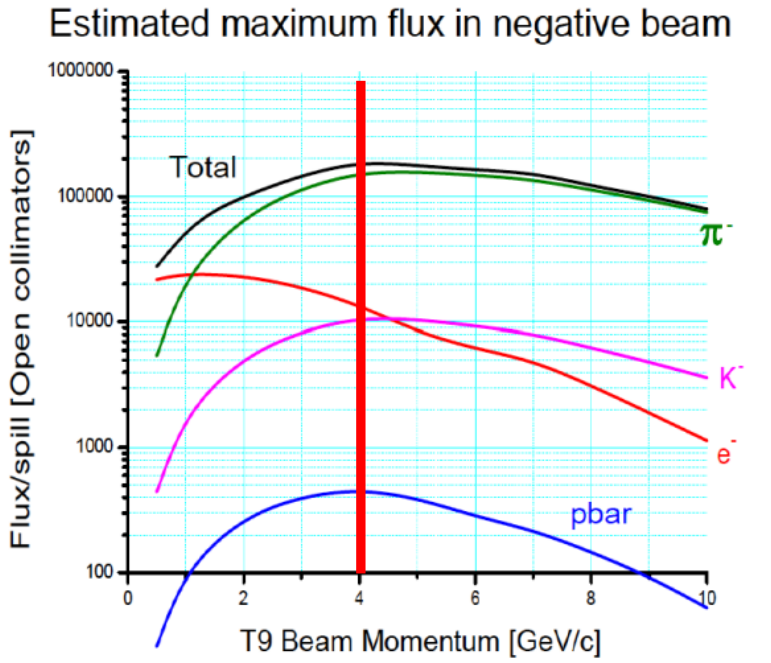
Muons are available through the decay of pions and kaons!

Beam Properties at CERN

- **Flux** = the number of particles per unit of time and area



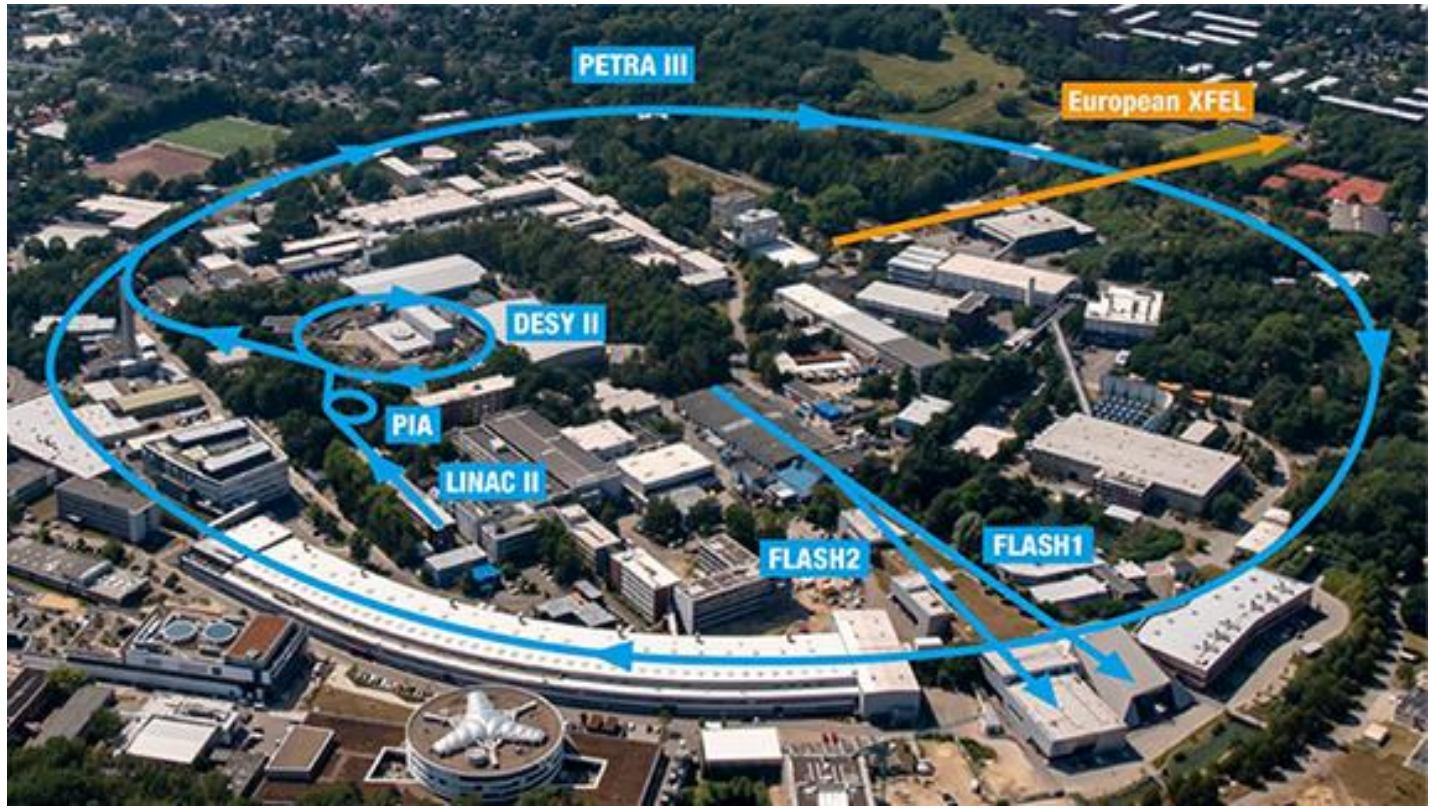
(a) The flux of positive particles present in the beam as a function of their momentum.



(b) The flux of negative particles present in the beam as a function of their momentum.

Flux over 400 ms

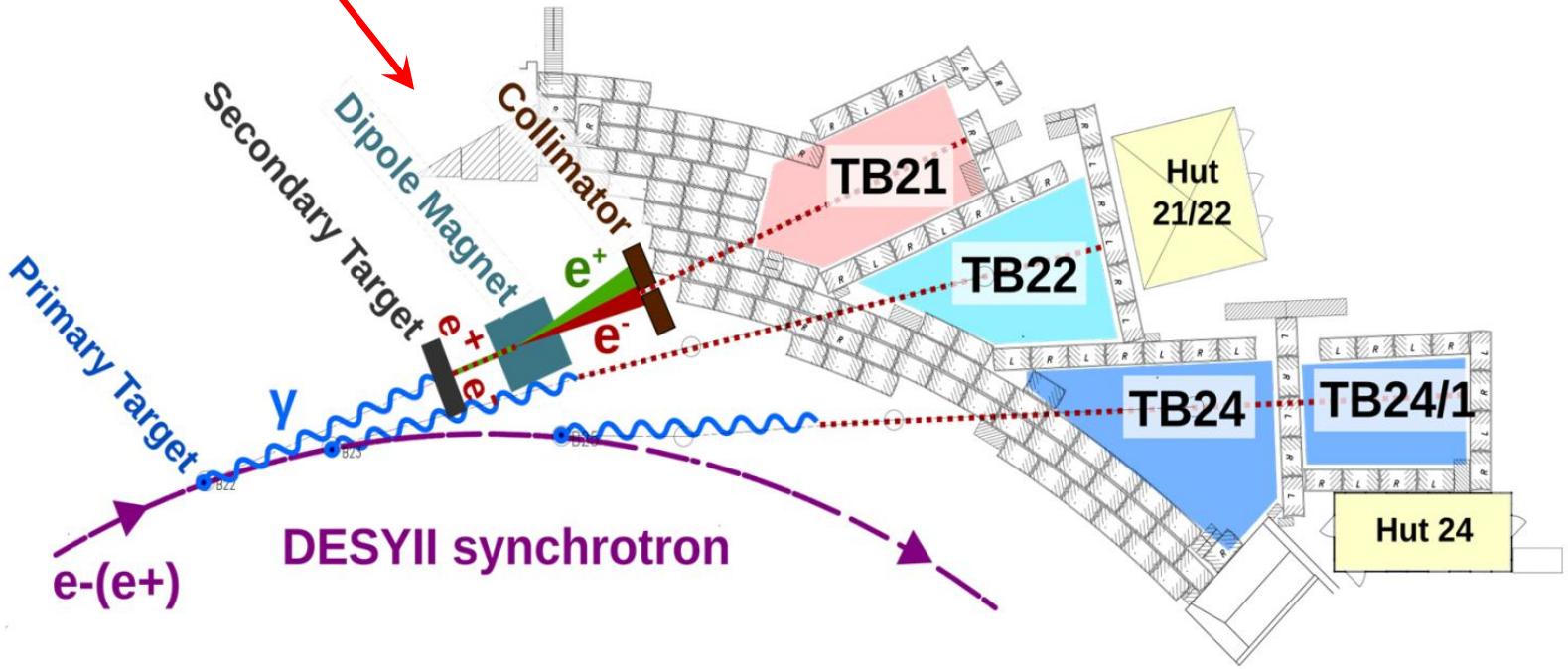
DESY Accelerator Complex



- **DESY** specializes in electron accelerators to produce **photons** for a wide range of experiments and applications (material sciences, medicine, chemistry, etc.).
- **Beams from DESY II** will be used for the experiment of one BL4S winning team.

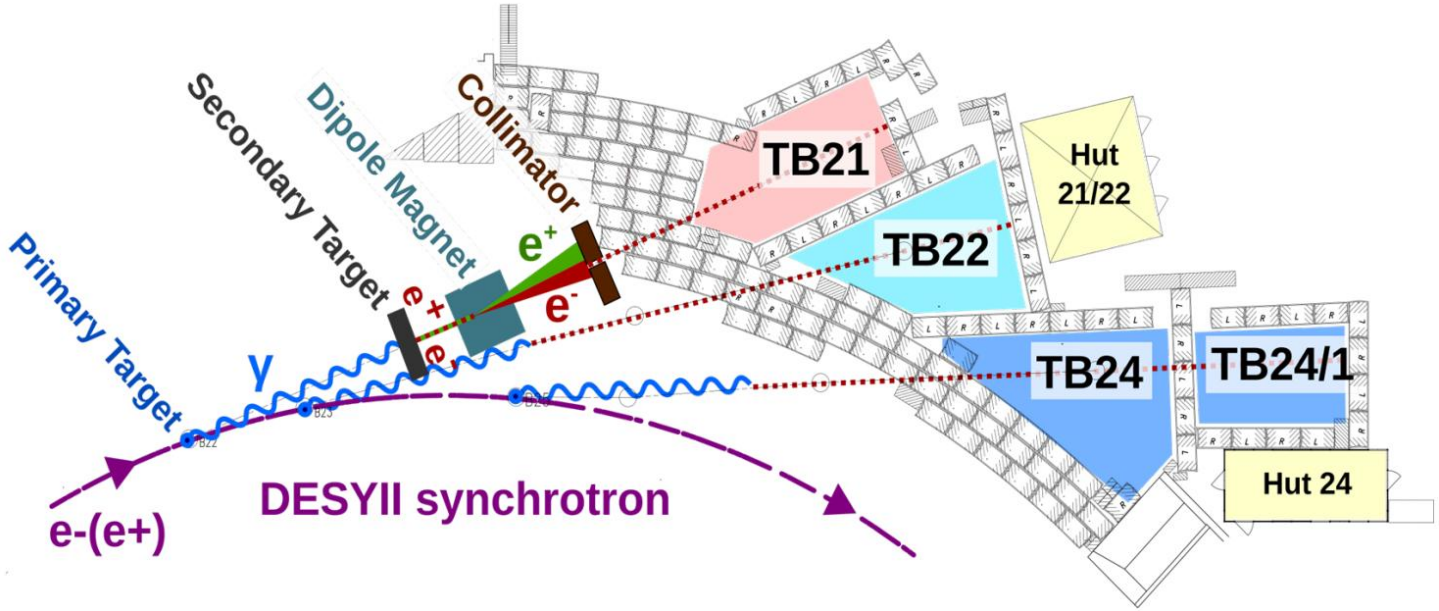

DESY II
PIA
LINAC II


Hut 24
T24/1
T24
T22
T21
Hut 21/22
Hut 23


Secondary Target
Dipole Magnet
Collimator
Primary Target
TB21
TB22
TB24
TB24/1
Hut 21/22
Hut 24
e+
e-
γ
e-(e+)
DESYII synchrotron

Beam Properties at DESY

- **Electrons** (energy ≤6.3 GeV) are accelerated by the DESY II synchrotron and directed into a primary target (carbon fibre).
- Photons are generated as the electrons lose energy while passing through the primary target. These photons then interact with a secondary target (metal plates) to produce electron-positron pairs.
- The photons move towards a secondary target (metal plates) to generate electron/positron pairs
- A **pure electron beam** or a **pure positron beam** (1 - 6 GeV/c) is available for the BL4S experiments. Photons are not available for user experiments!



Beam Properties at DESY

- **The beamline at DESY usually provides one particle at a time.**

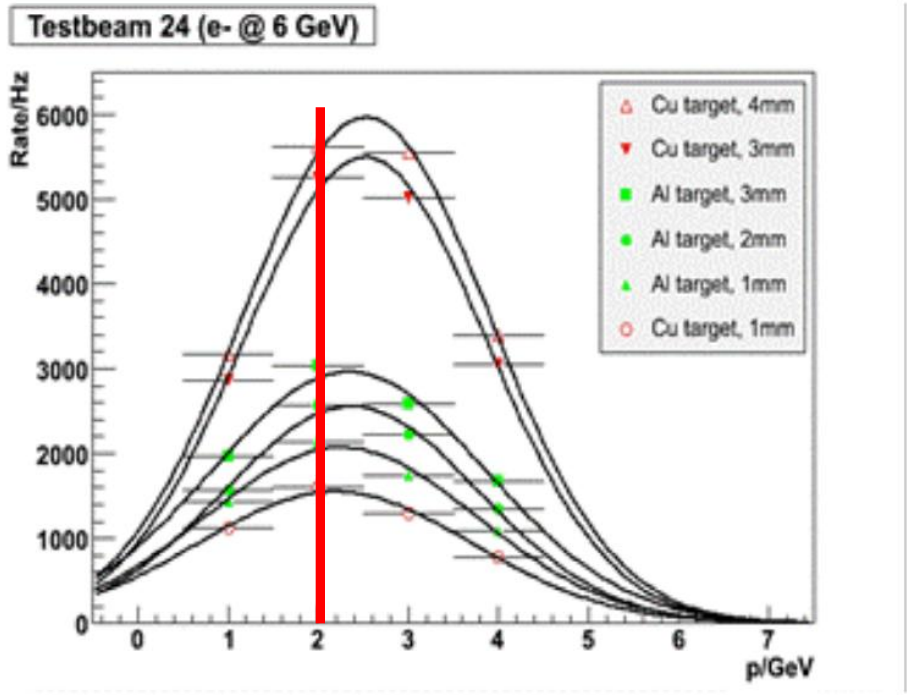


Figure 3: Typical **rate of the single electron beam in the experimental area at DESY** depending on the particle momentum. Rates are shown for different types and thicknesses of the secondary target.

BL4S Beams

Property	CERN	DESY
Particle type	Either + or - charge $p/\bar{p}$, e^+/e^-, K^+/K^-, π^+/π^- and μ^+/μ^-	pure e^- or e^+
Momentum	0.5 - 15 GeV/c	1 - 6 GeV/c
Beam cross section	Round	Round
Beam diameter	2 cm	2 cm