Course for ASP2026: Particle accelerators

Laury Batista: laury.batista@universite-paris-saclay.fr

July 2026

Install the "Kahoot!" app (or go to kahoot.it on your browser) before class begins so that you're ready to participate.

Particle accelerators are currently used at several Kenyan hospitals in cities like Mobassa [1] and Nairobi [2, 3, 4].

1 Particle accelerators are already in Kenya

According to [5], Kenya recorded around 44,700 new cancer cases in 2026 and 32,000 deaths so far. In Kenya, there are linear accelerators installed in hospitals to treat cancer patients. Particle accelerators use high-energy particle beams to destroy cancer cells with precision, while sparing healthy tissue around the tumor.

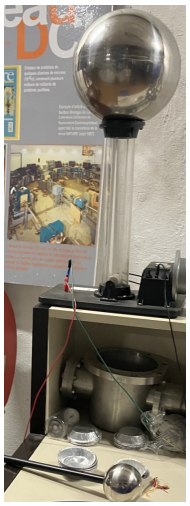
2 How do particle accelerators work?

The Lorentz force is the force experienced by a particle of charge q moving at a velocity v in an electromagnetic field. It is expressed in SI units as

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{1}$$

2.1 Experiment: The Van de Graaff Generator

Mini contest: draw a graph of how the Van der Graaff generator works and send it to laury.batista@universite-paris-saclay.fr within 3 days. The winner will be included in the course handout for future years.



$$\mathbf{F} = q\mathbf{E} \tag{2}$$

This expression shows on one hand that in an electric field, the particle experiences a force that is directly proportional to its charge and the strength of the electric field. The direction of this force depends on the sign of the charge. For a positive charge, the force is in the direction of the electric field, and for a negative charge, it is in the opposite direction.

In a particle accelerator, the electric field is used to accelerate particles

2.2 The Thomson Experiment

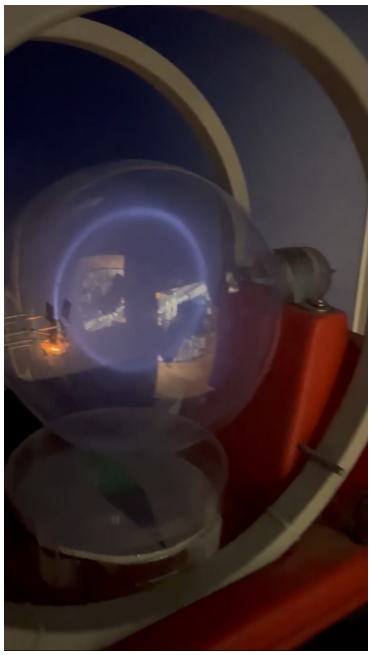


Figure 1: Thomson experiment

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B} \tag{3}$$

The interaction of the particle with a magnetic field requires the particle to be moving. The magnitude of the force is proportional to the charge, the velocity of the particle, the magnetic field amplitude, and depends on the sine of the angle between the velocity and the magnetic field direction.

In a particle accelerator, the magnetic field is used to bend the particles trajectory

3 Interactive visualization: SILMARIL

To finish, we will use a simulation tool created by the SILMARIL team, to see directly how electromagnetic elements (dipoles, quadrupoles) act on a particle beam.

Guided questions for the 2D plot

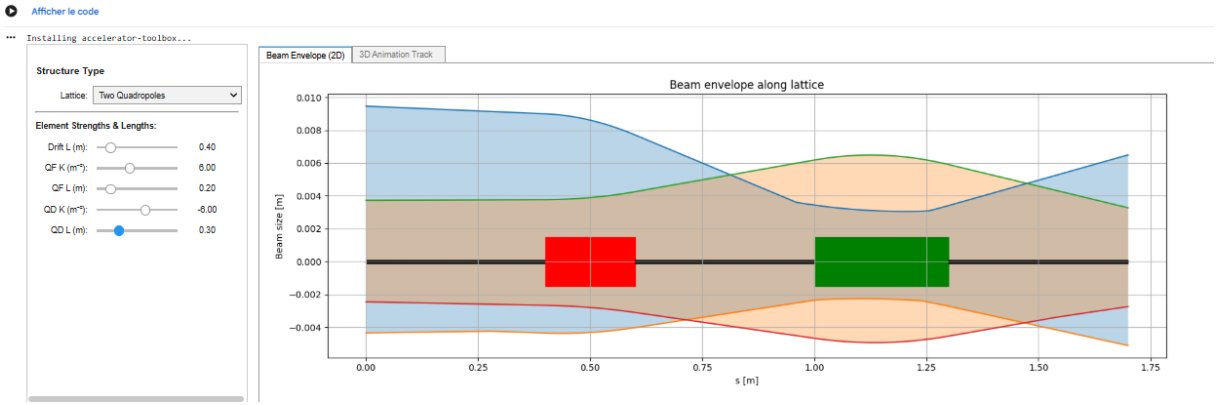


Figure 2: Evolution of the transverse size of the beam as it travels along the accelerator (SILMARIL tool)

- "What is the x-axis?"
- "What is the y-axis?"
- "What does this plot represents?"

Guided questions for the 3D visualization

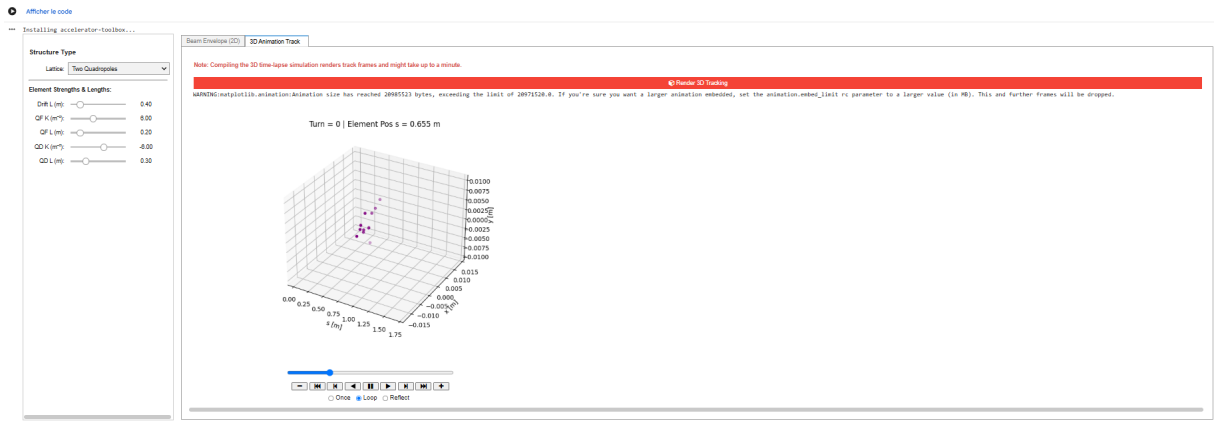


Figure 3: 3D view of a particle bunch (SILMARIL tool)

- "What is the x-axis?"
- "What is the y-axis?"
- "What does this plot represents?"

Impact of dipoles and quadrupoles

- **Dipoles**: they bend the beam's path
- **Quadrupoles**: they focus the beam horizontally while defocusing vertically (and vice versa)

The people that helped to prepare this course

The introduction on the applications was prepared together with Naomi Chege, a Kenyan student currently doing a PhD in stem cell biology in Canada. The first part of the course was prepared at Science ACO, a particle accelerator museum at the Paris-Saclay university in France and the second part of the course was prepared with the SILMARIL team.

References

[1] International Atomic Energy Agency / HealthCare Middle East & Africa, *Kenya partners with IAEA to launch Advanced Mombasa Radiotherapy Centre*, 2026. https://www.healthcaremea.com/2026/05/12/kenya-partners-with-iaea-to-launch-advanced-mombasa-radiotherapy-centre-to-expand-cancer-care-access/

[2] Daily Nation, *Lifeline for cancer patients at Kenyatta Hospital with new radiotherapy machine*, 2026. https://nation.africa/kenya/health/lifeline-for-cancer-patients-at-kenyatta-hospital-with-new-radiotherapy-machine-5474018

[3] Accuray, *Pioneering Advanced Radiotherapy in Kenya*, 2024. https://www.accuray.com/blog/pioneering-advanced-radiotherapy-in-kenya/

[4] Nairobi Radiotherapy & Cancer Centre, *About Us*. https://nairobiradiotherapy.com/about.php

[5] Nation Africa. Cervical cancer now Kenya's deadliest cancer, WHO report shows. https://nation.africa/kenya/health/cervical-cancer-now-kenya-s-deadliest-cancer-who-report-shows--5521304. Consulté le 10 juillet 2026.