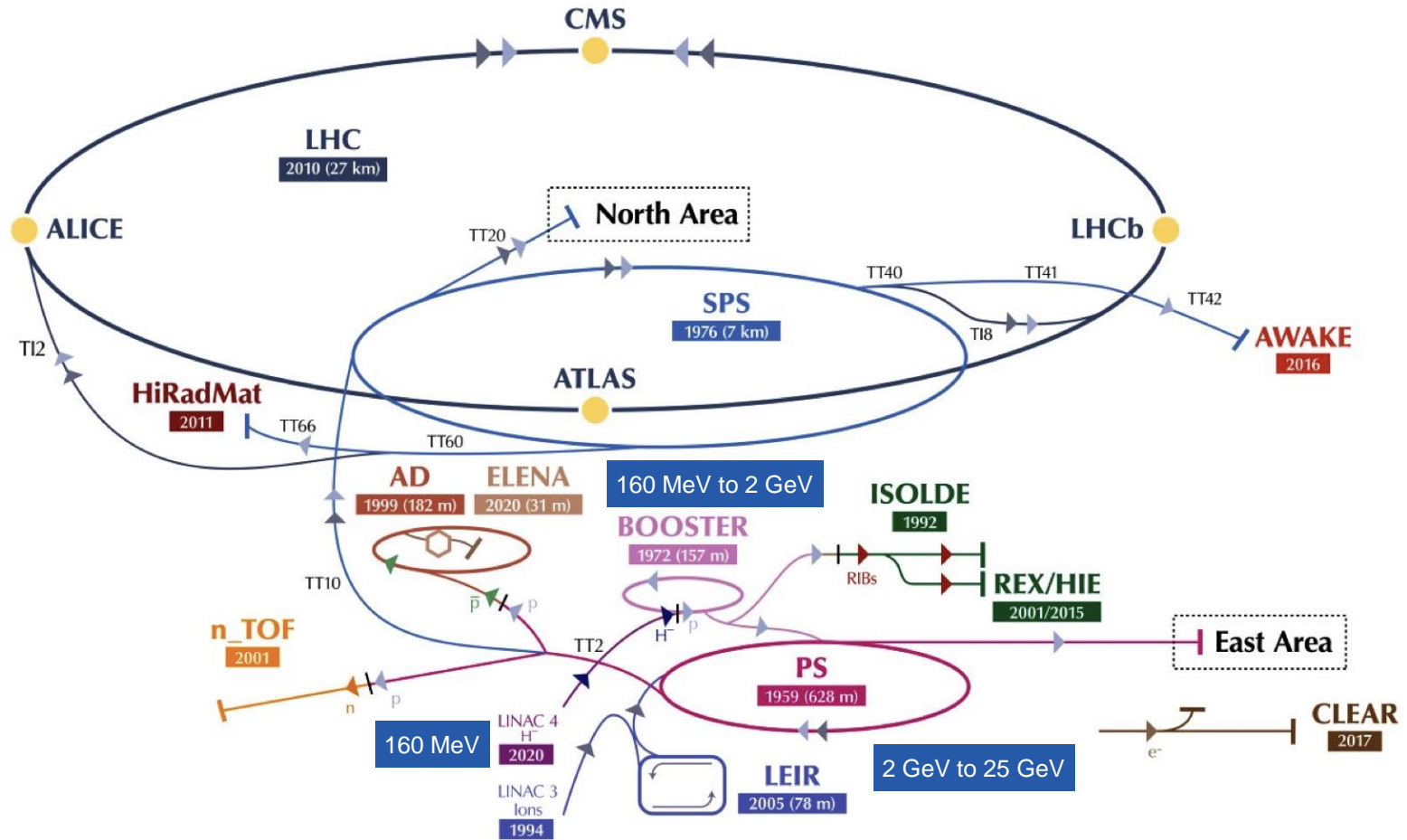
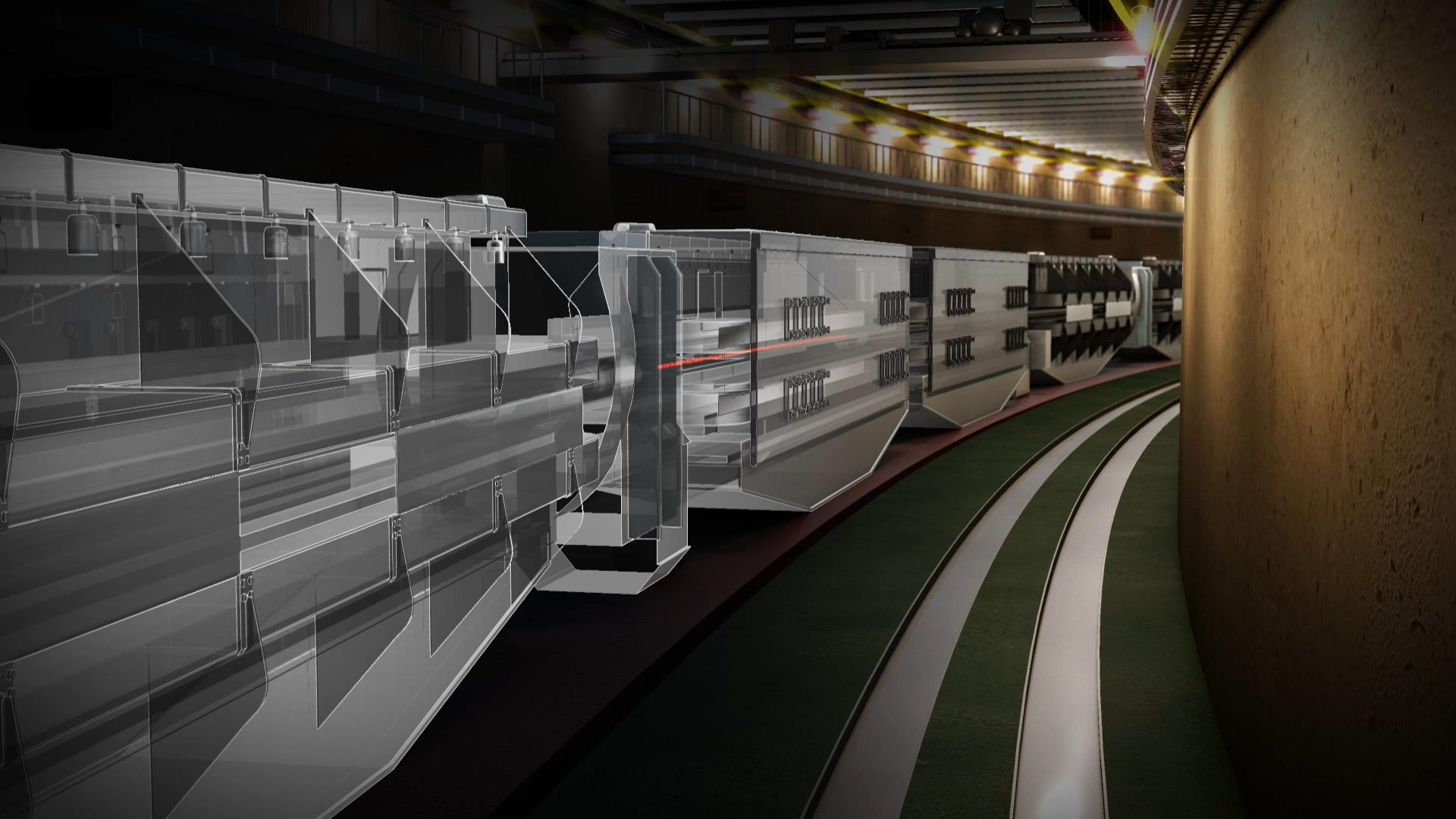


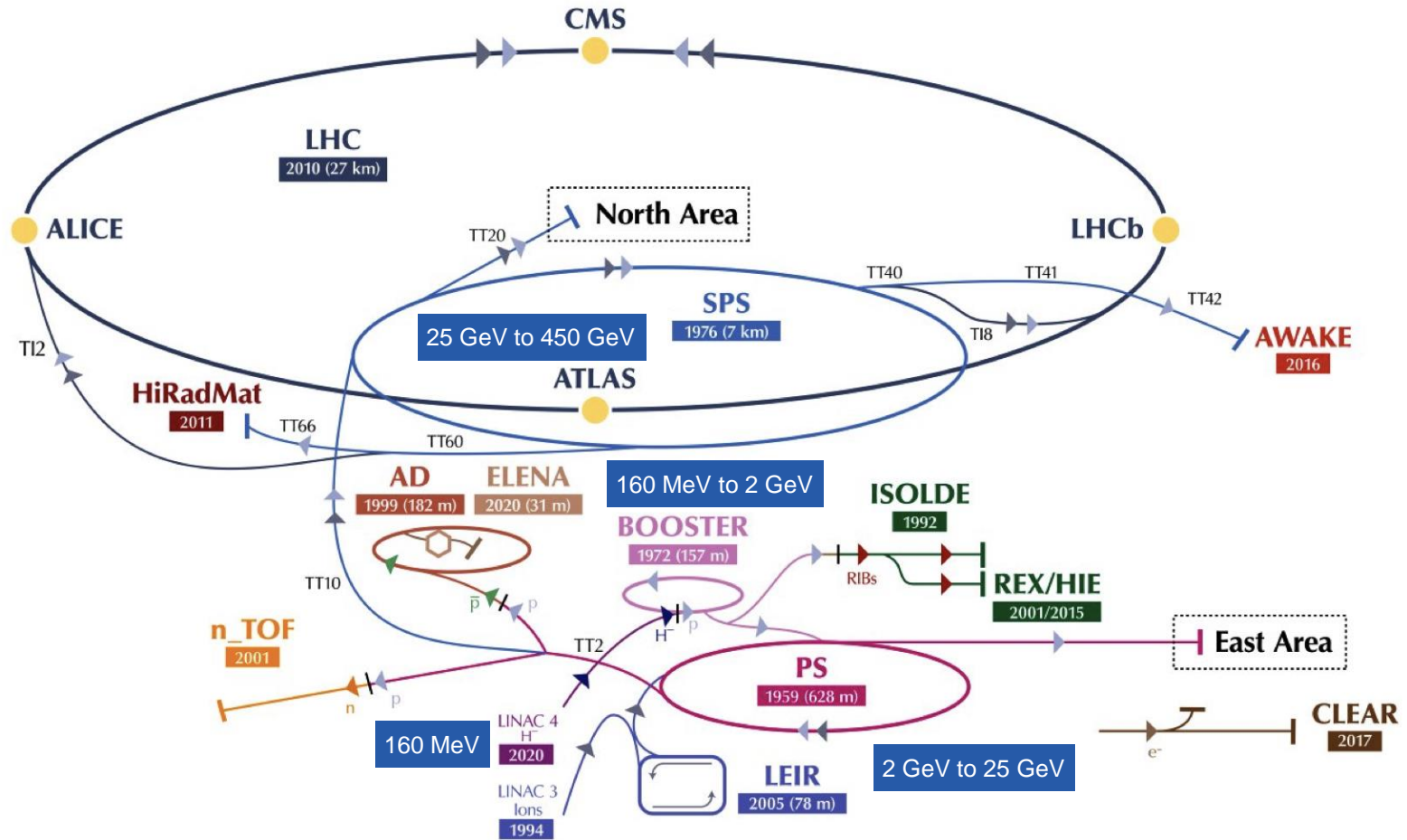
# Particle Accelerators

and how to introduce them in the classroom...



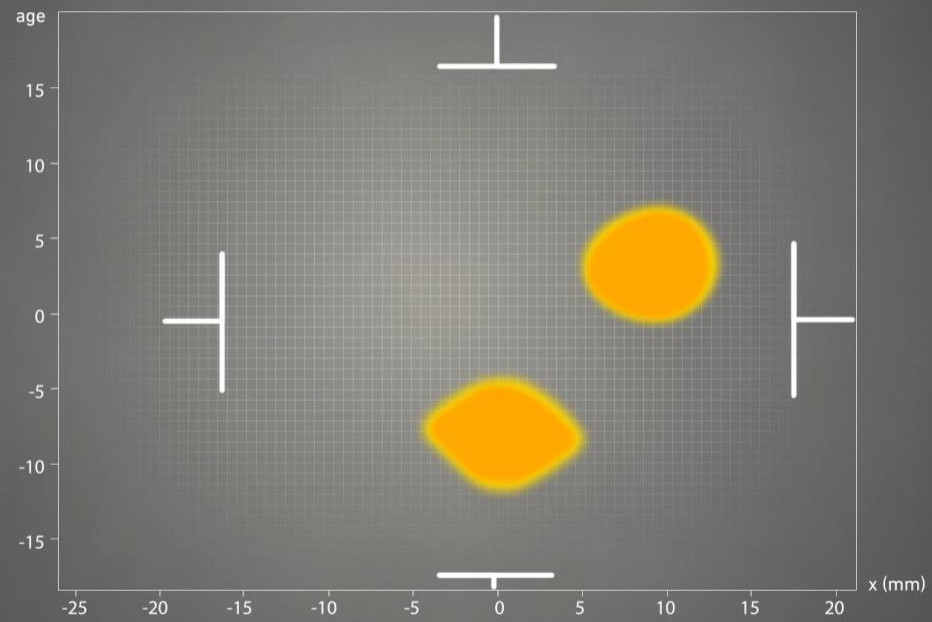


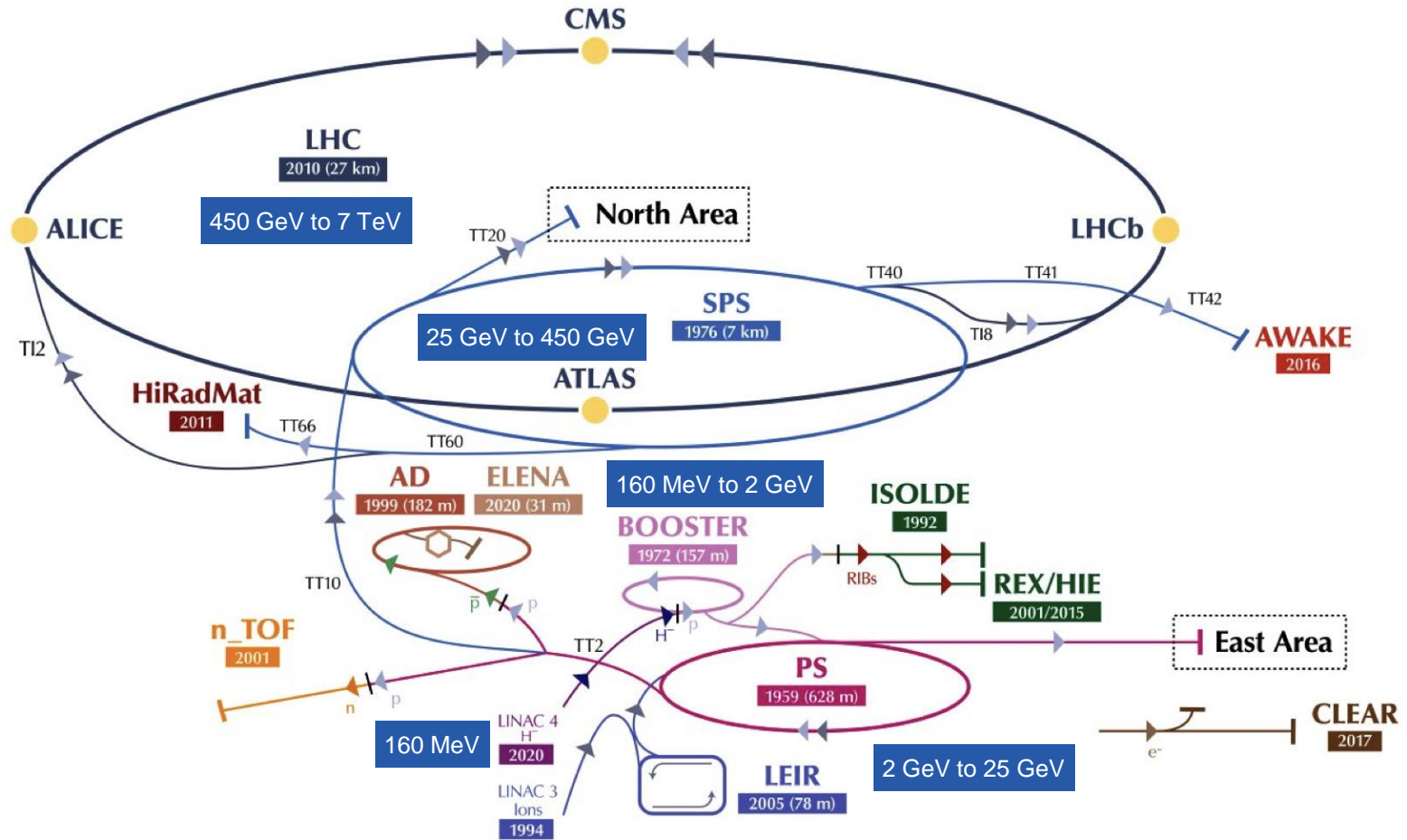




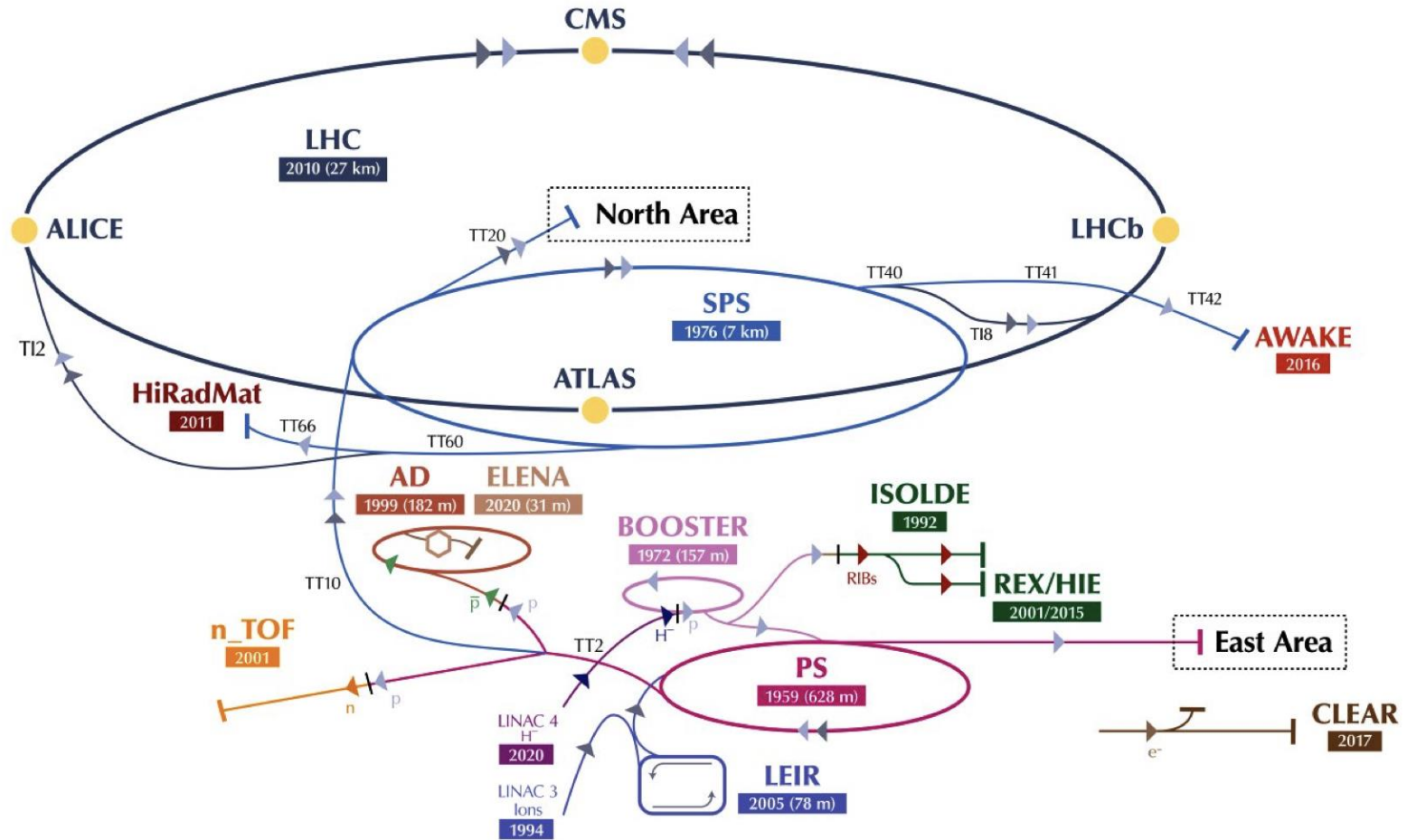
## Beam image

Image du faisceau









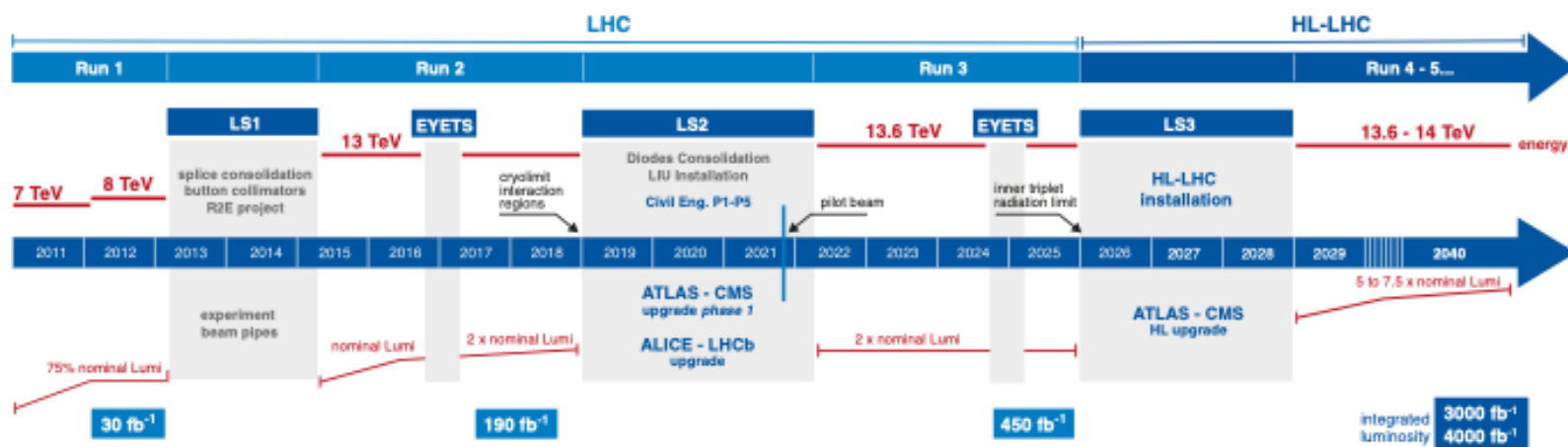


# HL-LHC

High Luminosity



# LHC / HL-LHC Plan



## HL-LHC TECHNICAL EQUIPMENT:



## HL-LHC CIVIL ENGINEERING:



$$L = \frac{1}{4\pi e^2 f_0 n_b} \times \frac{I_{p1} I_{p2}}{\sigma_x \sigma_y}$$

For example at the LHC:

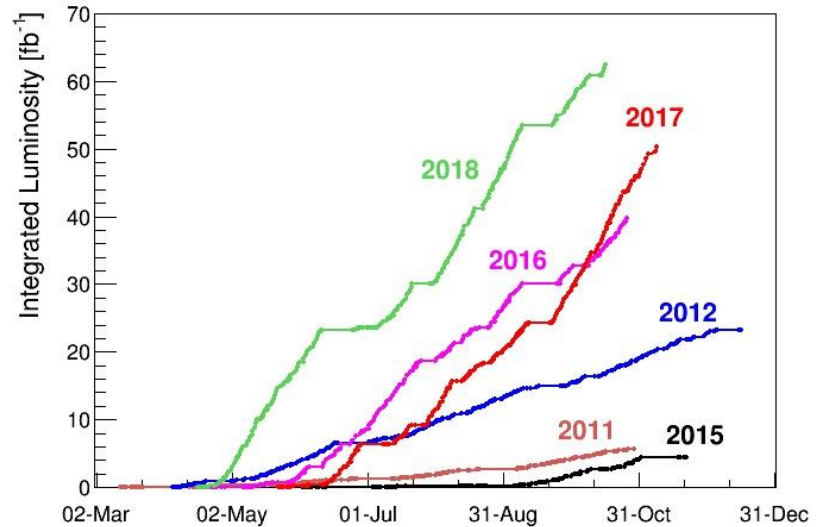
$f_0 = 11.245 \text{ kHz}$

$n_b = 2808 \text{ bunches}$

$I_p = 584 \text{ mA}$

$\sigma = 16 \text{ }\mu\text{m}$

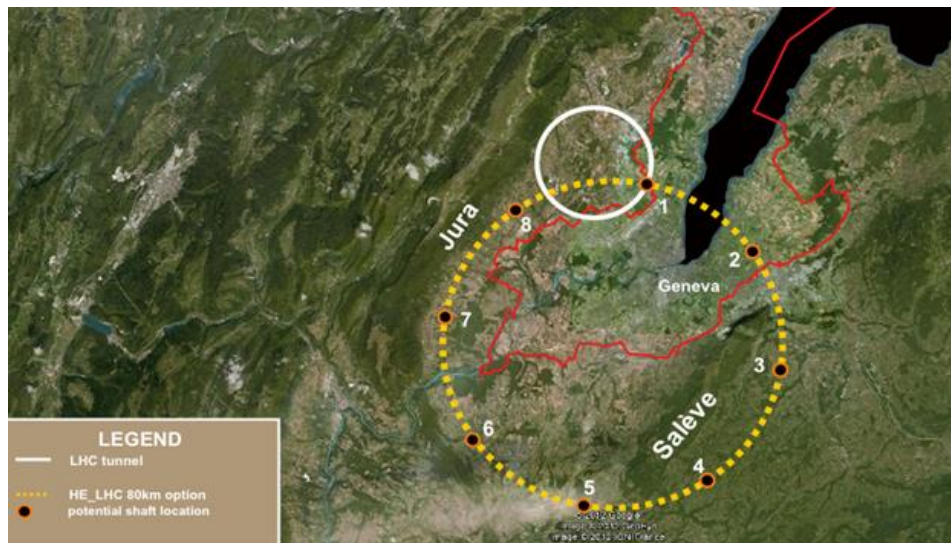
$L = 1.0 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$





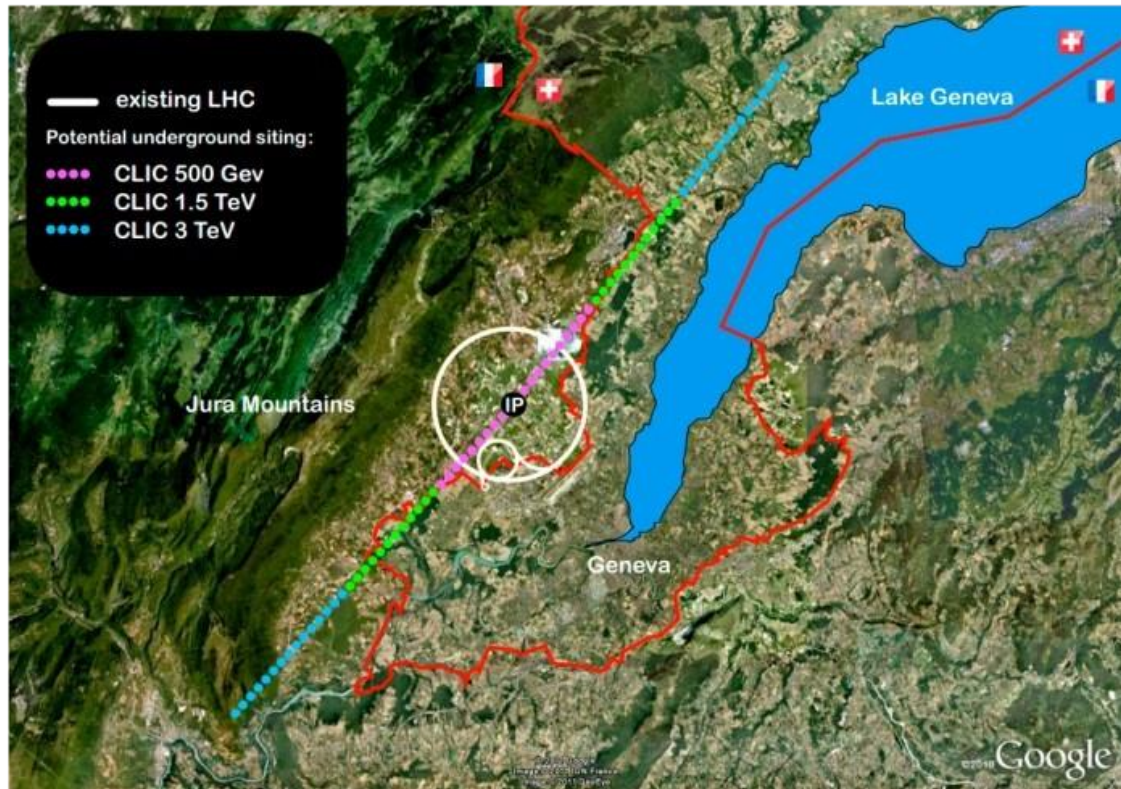
Is the LHC the final step?





Or maybe it will just “click”...





The LHC in the classroom...

# Introducing the LHC in the classroom: an overview of education resources available

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## Abstract

In the context of the recent re-start of CERN's Large Hadron Collider (LHC) and the challenge presented by unidentified falling objects (UFOs), we seek to facilitate the introduction of high energy physics in the classroom. Therefore, this paper provides an overview of the LHC and its operation, highlighting existing education resources, and linking principal components of the LHC to topics in physics curricula.

## Introduction

Early in 2015, CERN's Large Hadron Collider (LHC) was awoken from its first long shutdown to be re-ramped for Run 2 at unprecedented beam energy and intensity. Intense scrutiny was required to verify the full and proper functioning of all systems. This included a special run of the machine to ensure a well-scrubbed LHC [1]. However, due to the increased beam currents, a critical but familiar issue reared its head during the run. Interactions between the beams and unidentified falling objects—so called UFOs—led to several premature protective beam dumps (see figure 1). These infamous UFOs are presumed to be micrometre-sized

dust particles and can cause fast, localised beam losses with a duration on the order of 10 turns of the beam. This is a known issue of the LHC which has been observed before. Indeed, between 2010 and 2011, about a dozen beam dumps occurred due to UFOs and more than 10000 candidate UFO events below the dump threshold were detected [2]. Thus, UFOs presented more of an annoyance than a danger to the LHC, by reducing the operational efficiency of the machine. However, as beam currents increase, so does the likelihood of UFO-induced magnet quenches at high energy, creating a possible hazard to the machine. Therefore, particular care is taken to keep an eye on the timing and frequency of UFO occurrences. As the number of UFOs during Run 1 decreased over time, it is hoped that this will be the same in Run 2.

The recent re-start of the LHC at higher collision energies and rates presents high school

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<http://iopscience.iop.org/article/10.1088/0031-9120/51/3/035001>



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