Particle Accelerators

and how to introduce them in the classroom…

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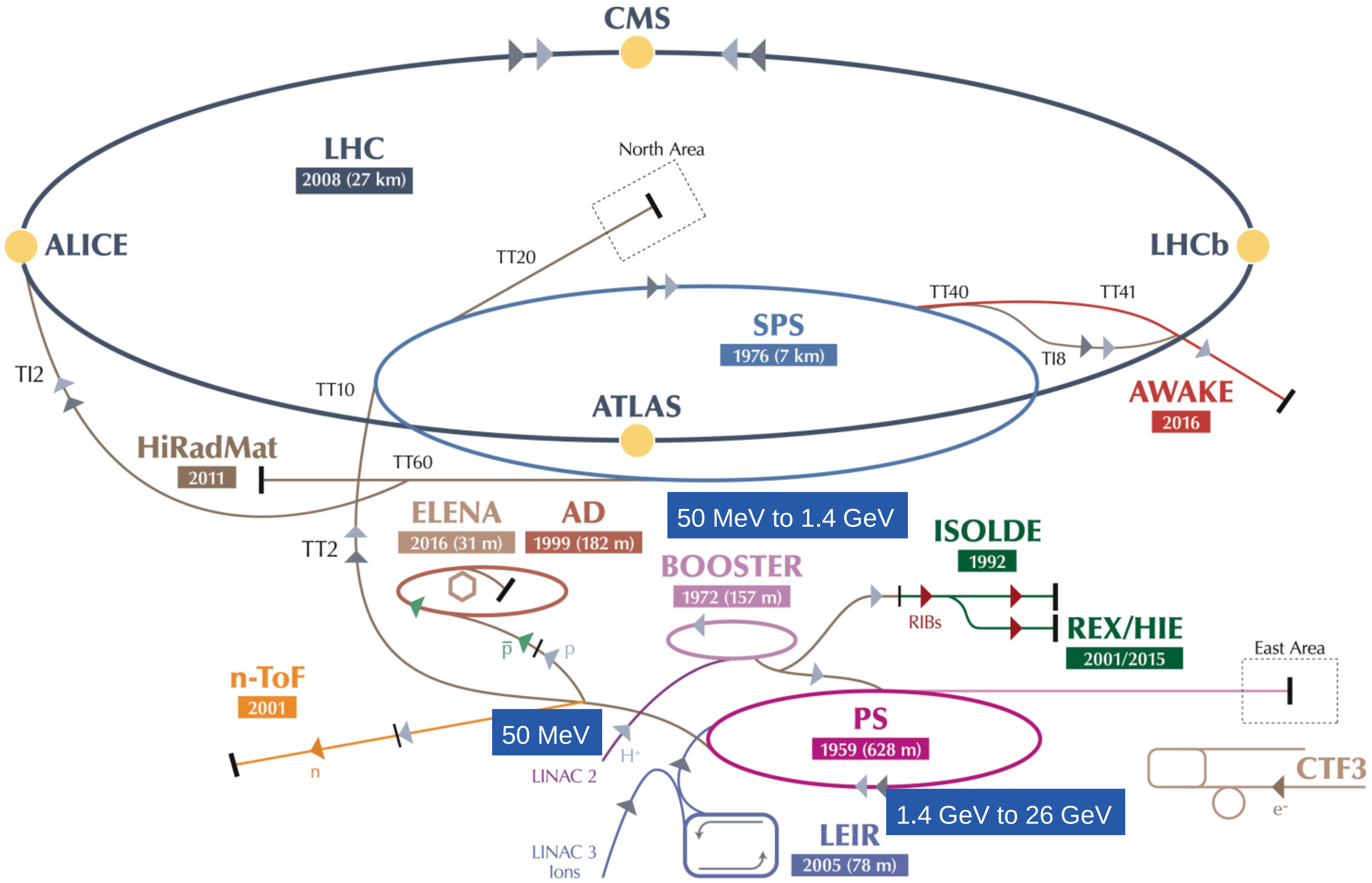
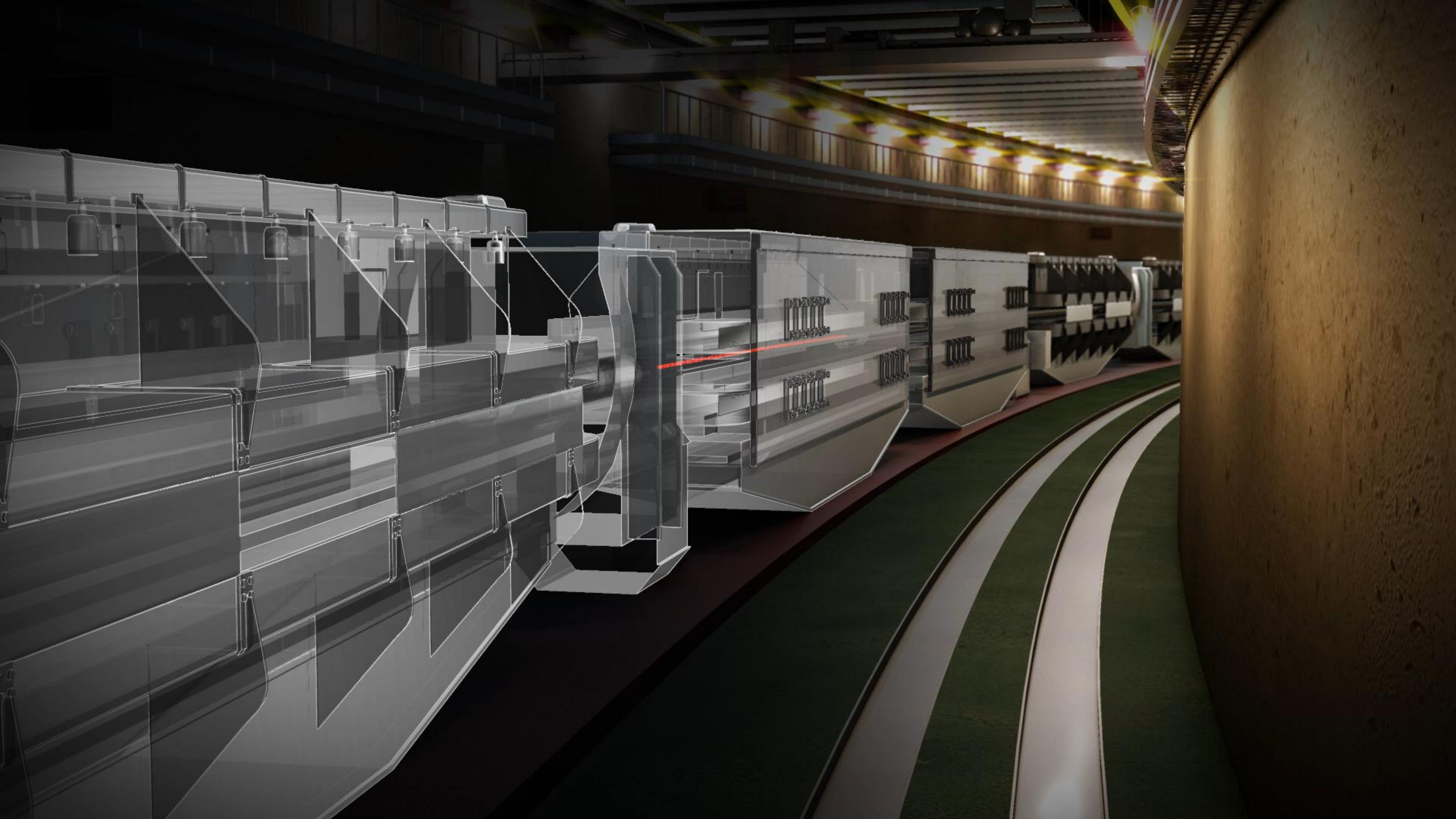
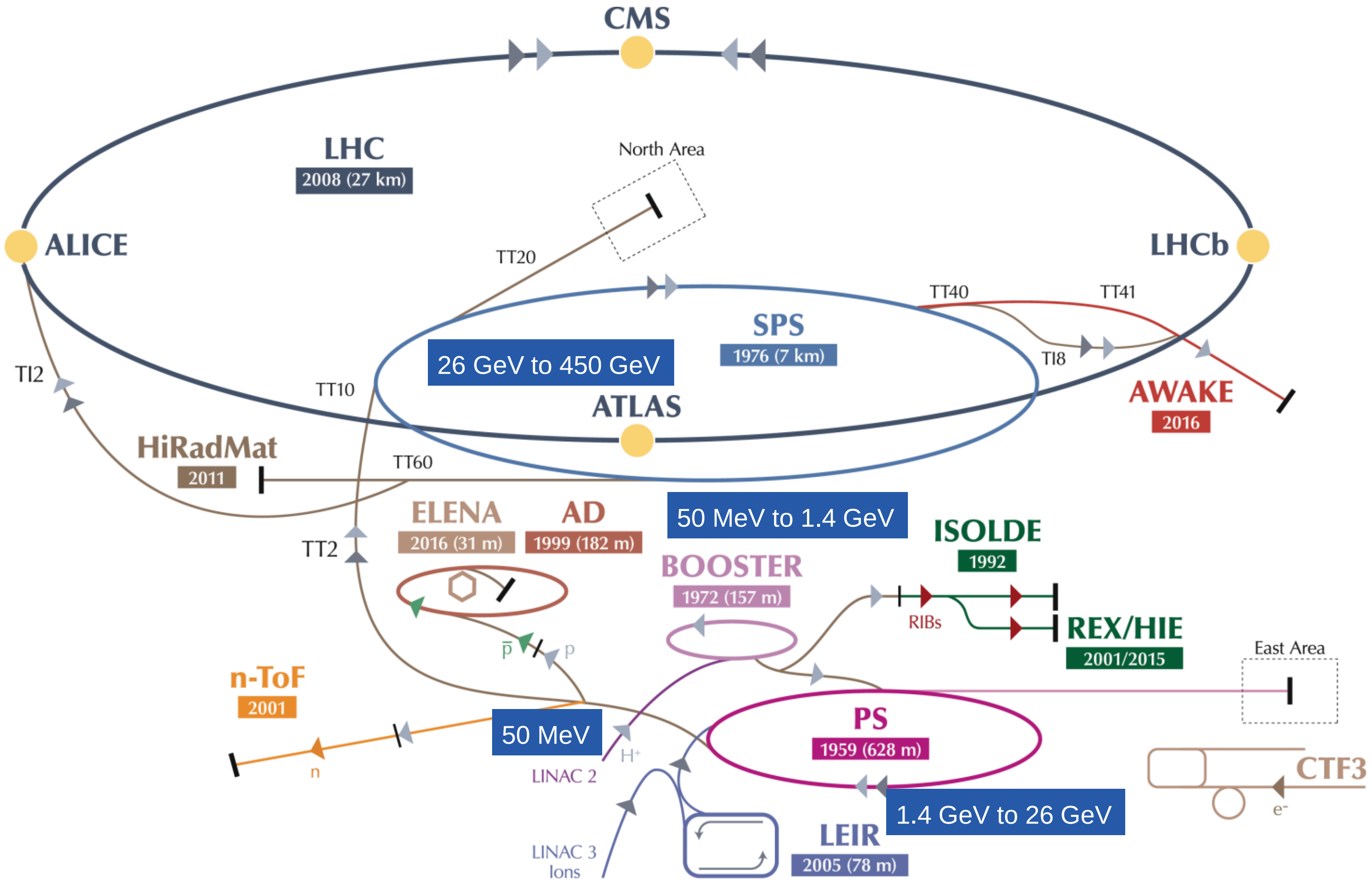

CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT20
TT40
TT41
SPS
1976 (7 km)
TI8
TI2
TT10
ATLAS
AWAKE
2016
HiRadMat
2011
TT60
ELENA
2016 (31 m)
AD
1999 (182 m)
50 MeV to 1.4 GeV
ISOLDE
1992
TT2
BOOSTER
1972 (157 m)
RIBs
REX/HIE
2001/2015
p̄
p
East Area
n-ToF
2001
50 MeV
PS
1959 (628 m)
n
H⁺
LINAC 2
CTF3
e⁻
1.4 GeV to 26 GeV
LEIR
2005 (78 m)
LINAC 3
Ions

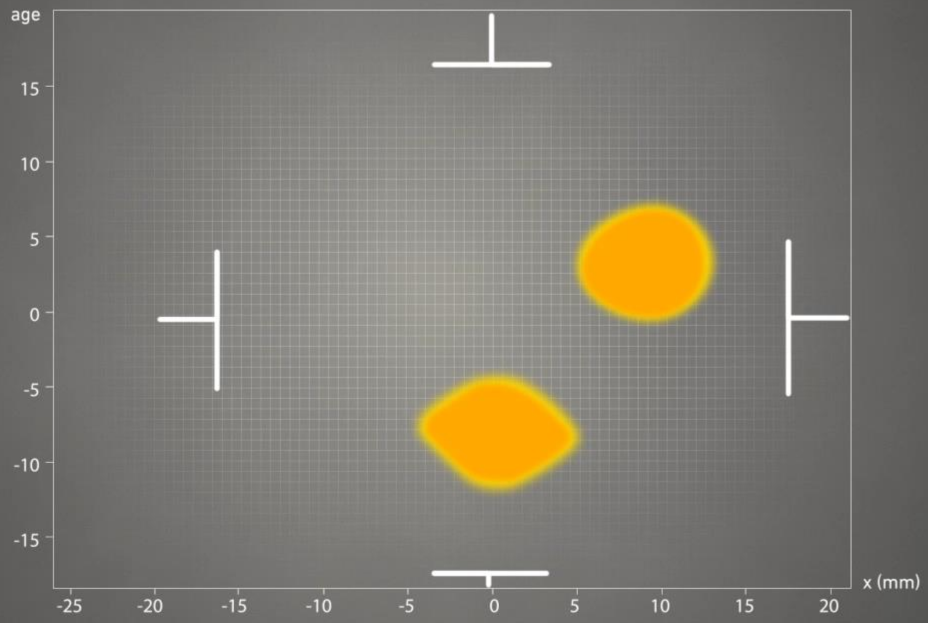
CERN

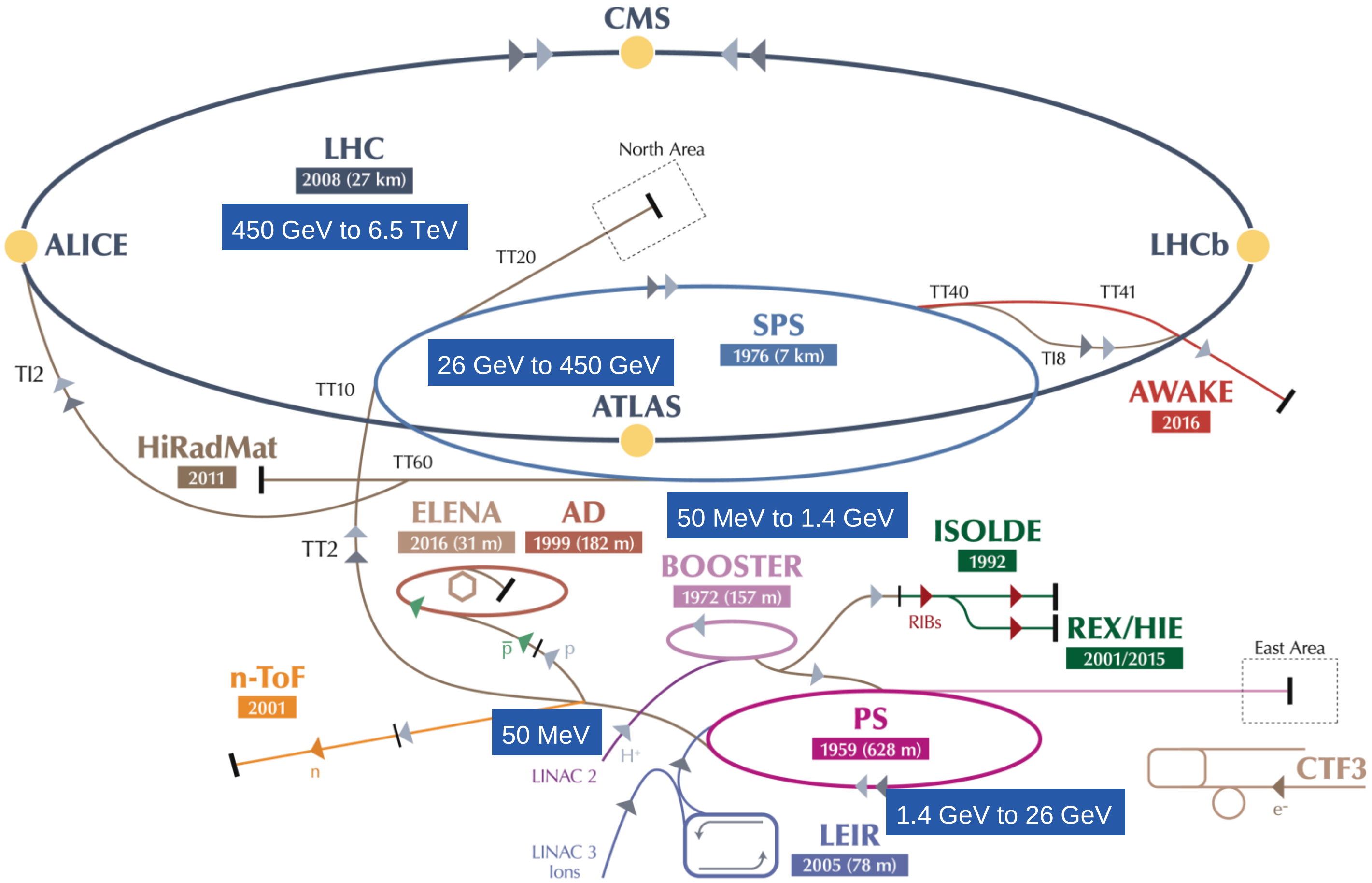


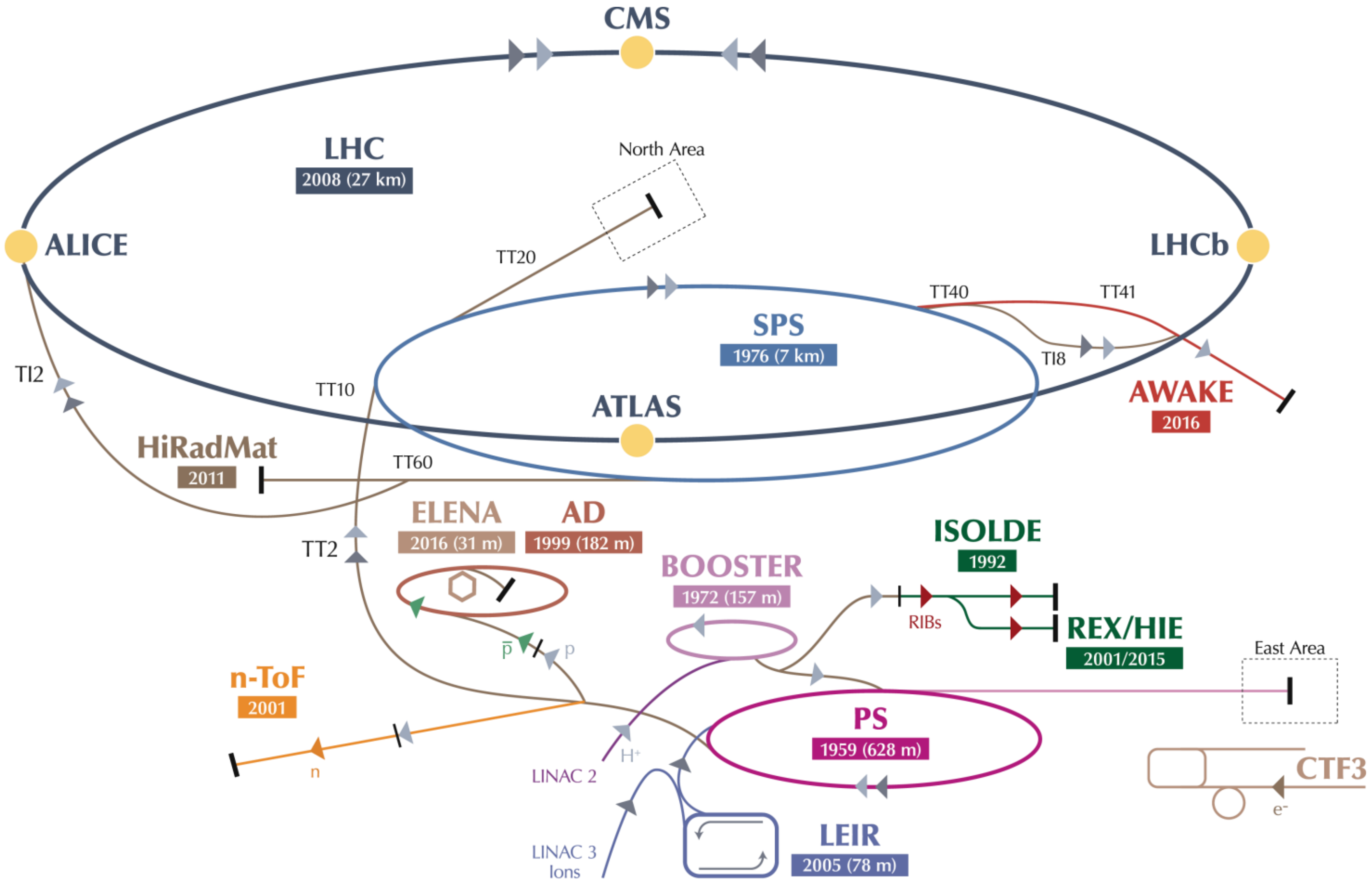


CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT20
TT40
TT41
SPS
1976 (7 km)
26 GeV to 450 GeV
TI8
AWAKE
2016
TI2
TT10
ATLAS
HiRadMat
2011
TT60
ELENA
2016 (31 m)
AD
1999 (182 m)
50 MeV to 1.4 GeV
ISOLDE
1992
TT2
BOOSTER
1972 (157 m)
RIBs
REX/HIE
2001/2015
p̄
p
East Area
n-ToF
2001
50 MeV
PS
1959 (628 m)
H+
n
LINAC 2
CTF3
e−
1.4 GeV to 26 GeV
LEIR
2005 (78 m)
LINAC 3
Ions

Beam image
Image du faisceau



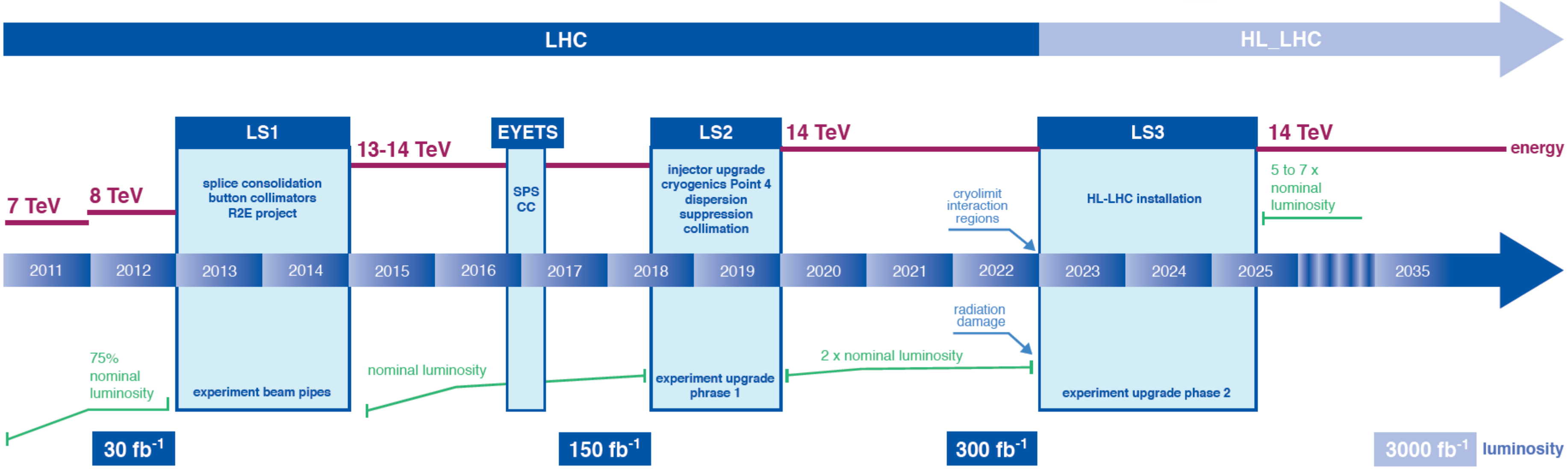

CMS
LHC
2008 (27 km)
450 GeV to 6.5 TeV
ALICE
LHCb
North Area
TT20
TT40
TT41
SPS
1976 (7 km)
26 GeV to 450 GeV
TI8
TI2
TT10
ATLAS
AWAKE
2016
HiRadMat
2011
TT60
ELENA
2016 (31 m)
AD
1999 (182 m)
50 MeV to 1.4 GeV
ISOLDE
1992
TT2
BOOSTER
1972 (157 m)
RIBs
REX/HIE
2001/2015
p̄
p
East Area
n-ToF
2001
PS
1959 (628 m)
50 MeV
n
H⁺
LINAC 2
CTF3
e⁻
1.4 GeV to 26 GeV
LEIR
2005 (78 m)
LINAC 3
Ions


CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT20
TT40
TT41
SPS
1976 (7 km)
TI8
TI2
TT10
ATLAS
AWAKE
2016
HiRadMat
2011
TT60
ELENA
2016 (31 m)
AD
1999 (182 m)
ISOLDE
1992
TT2
BOOSTER
1972 (157 m)
RIBs
REX/HIE
2001/2015
East Area
p̄
p
n-ToF
2001
PS
1959 (628 m)
H+
n
LINAC 2
CTF3
e-
LINAC 3
Ions
LEIR
2005 (78 m)

HL-LHC

High Luminosity

LHC / HL-LHC Plan

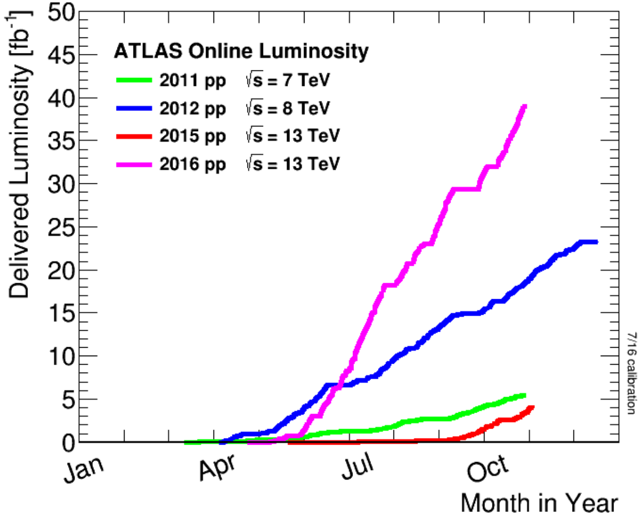


$$L = \frac{1}{4\pi e^2 f_0 \ n_b} \times \frac{I_{p1} I_{p2}}{\sigma_x \sigma_y}$$

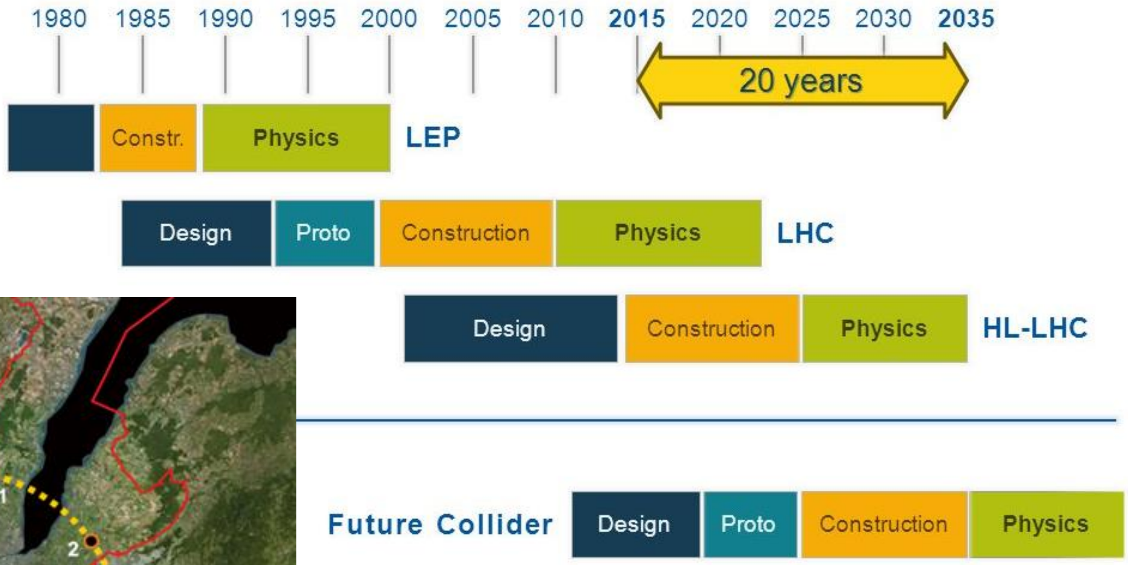
For example at the LHC:

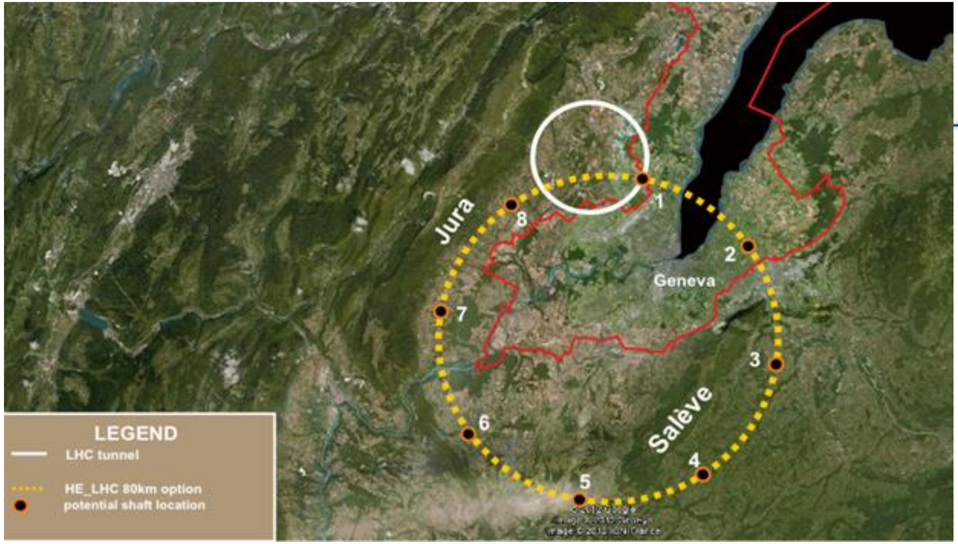
f_0 = 11.245 **kHz**
n_b = 2808 bunches
I_p = 584 **mA**
σ = 16 **μm**

L = 1.0 × 10^{34} cm^{-2}s^{-1}

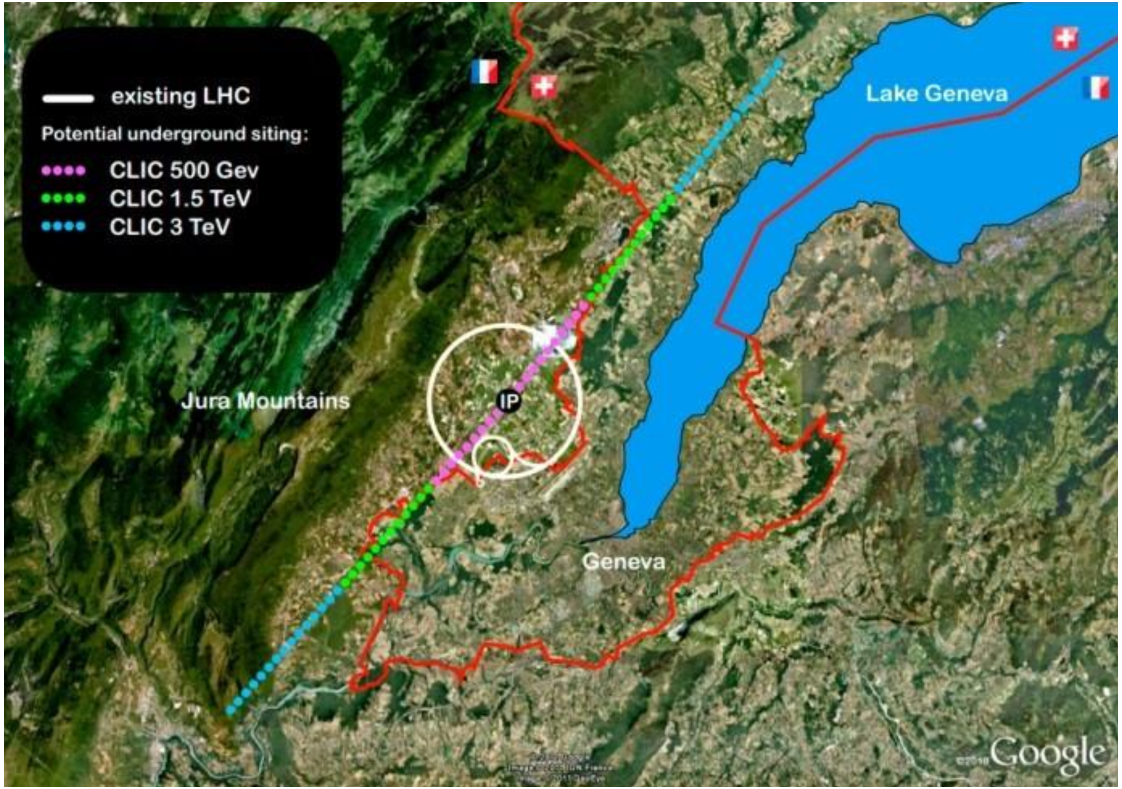


Is the LHC the final step?


1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
20 years
Constr.
Physics
LEP
Design
Proto
Construction
Physics
LHC
Design
Construction
Physics
HL-LHC
Future Collider
Design
Proto
Construction
Physics


Jura
Geneva
Salève
1
2
3
4
5
6
7
8
LEGEND
LHC tunnel
HE_LHC 80km option
potential shaft location

Or maybe it will just “click”…


existing LHC
Potential underground siting:
CLIC 500 Gev
CLIC 1.5 TeV
CLIC 3 TeV
Jura Mountains
Lake Geneva
IP
Geneva
Google

The LHC in the classroom…

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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

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

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