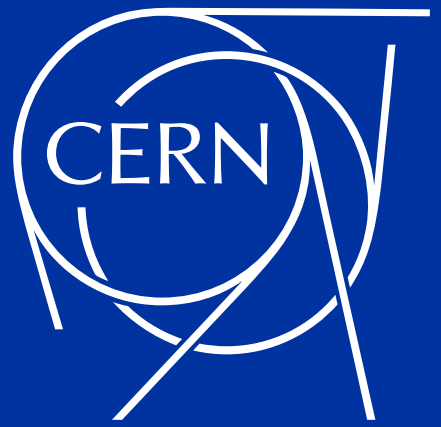
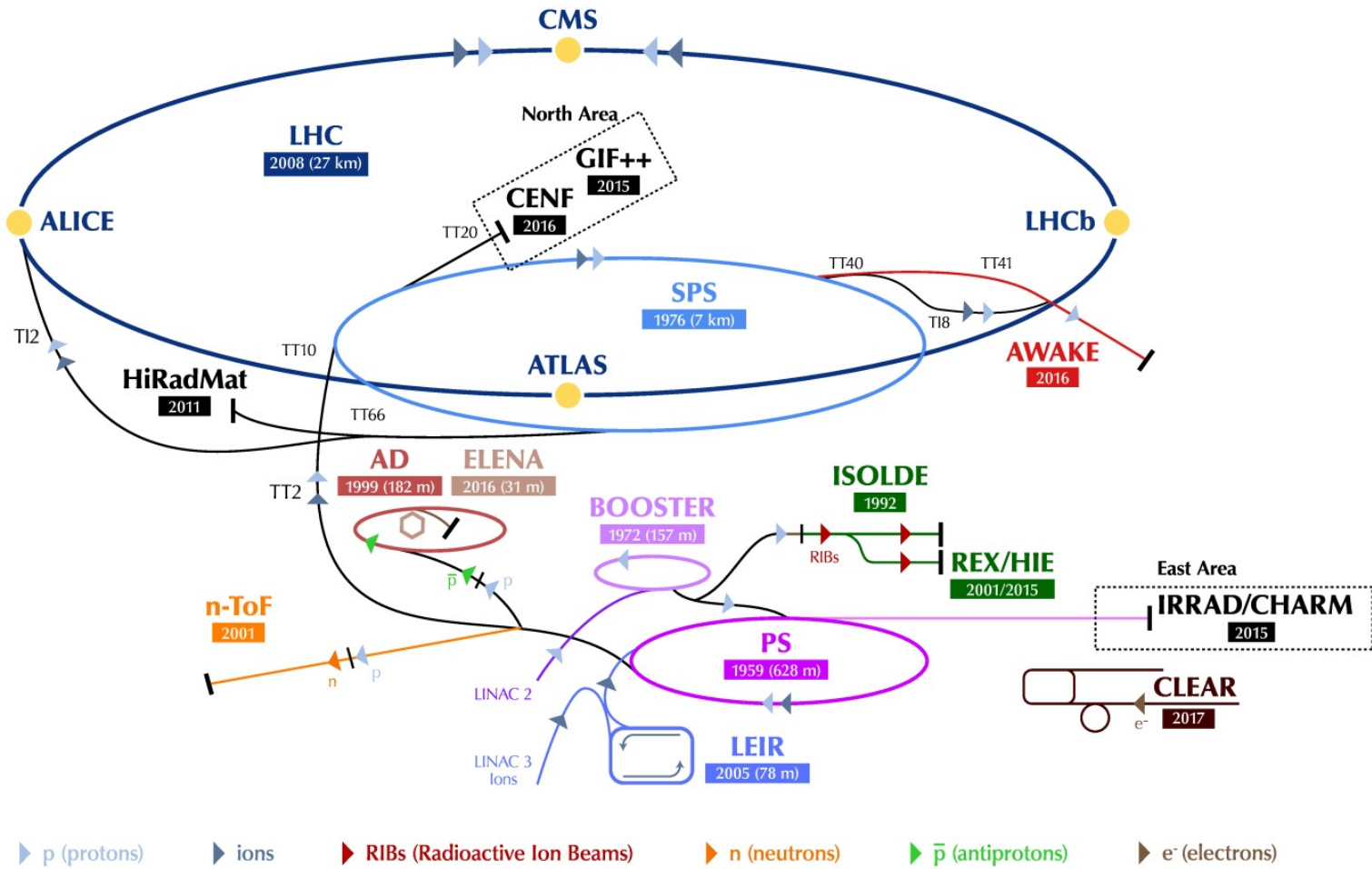


A virtual tour of the Large Hadron Collider sources

Speaker: *Sonia Natale*
Guide: *Mario Campanelli*

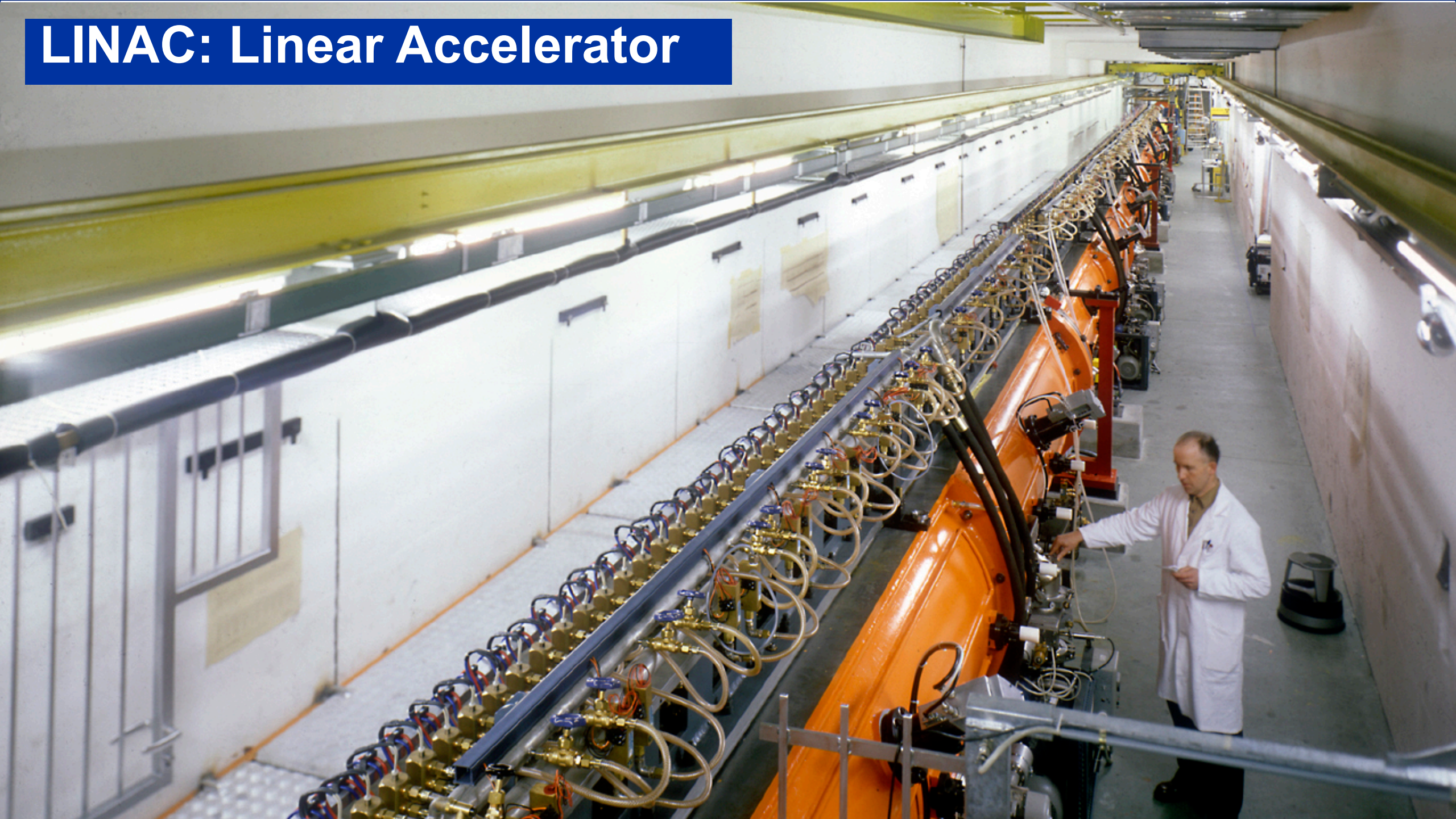
Sep 16th 2021

The CERN accelerator complex
Complexe des accélérateurs du CERN

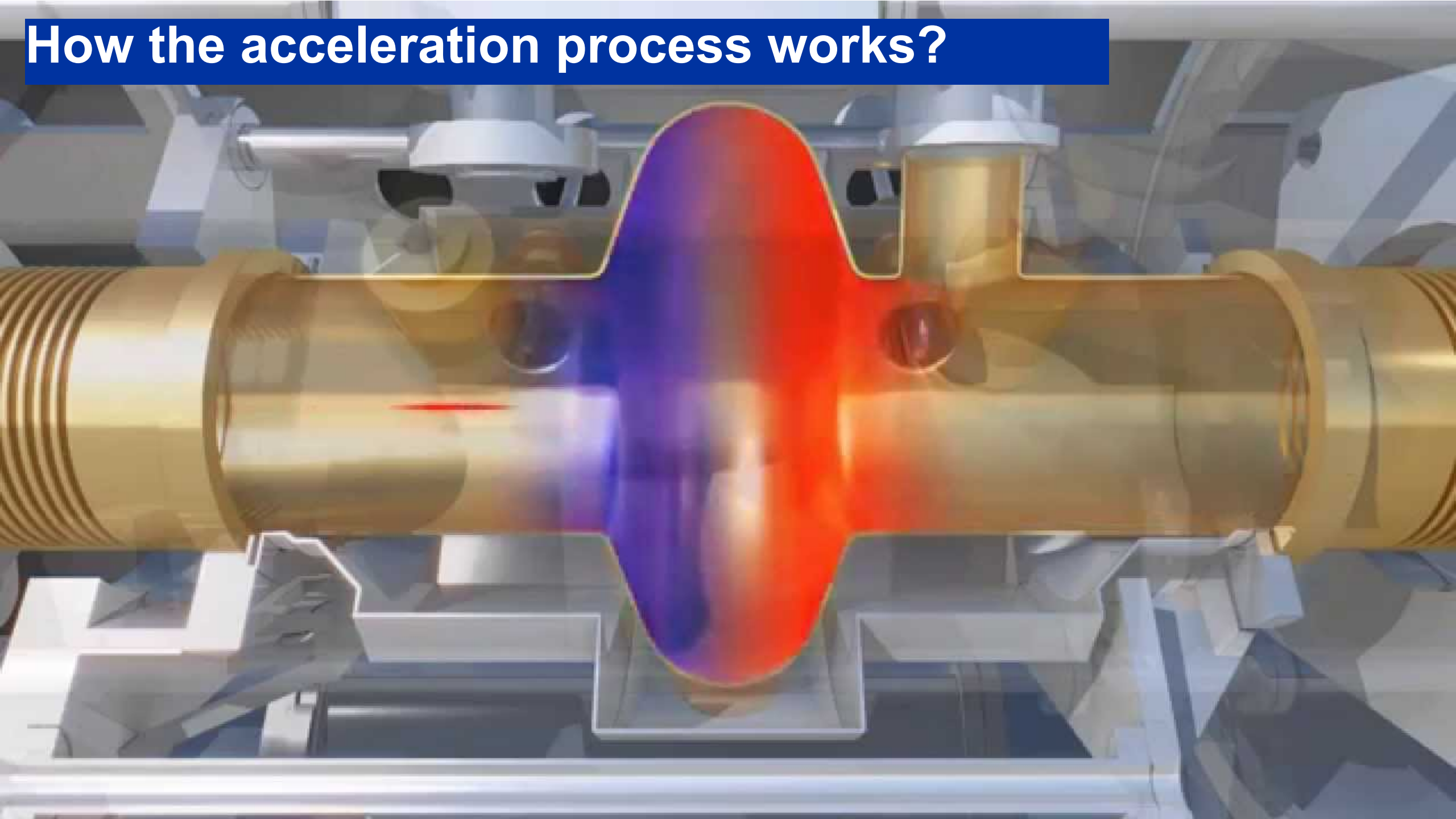


LHC - Large Hadron Collider // **SPS** - Super Proton Synchrotron // **PS** - Proton Synchrotron // **AD** - Antiproton Decelerator // **CLEAR** - CERN Linear Electron Accelerator for Research // **AWAKE** - Advanced WAKefield Experiment // **ISOLDE** - Isotope Separator OnLine // **REX/HIE** - Radioactive EXperiment/High Intensity and Energy ISOLDE // **LEIR** - Low Energy Ion Ring // **LINAC** - LINear ACcelerator // **n-ToF** - Neutrons Time Of Flight // **HiRadMat** - High-Radiation to Materials // **CHARM** - Cern High energy AcceleRator Mixed field facility // **IRRAD** - proton IRRADiation facility // **GIF++** - Gamma Irradiation Facility // **CENF** - CErn Neutrino platForm

LINAC: Linear Accelerator



How the acceleration process works?

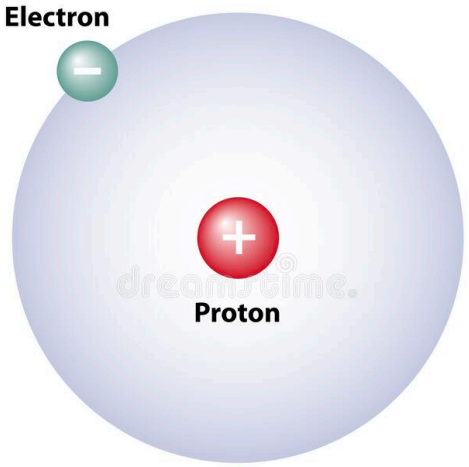


Protons source

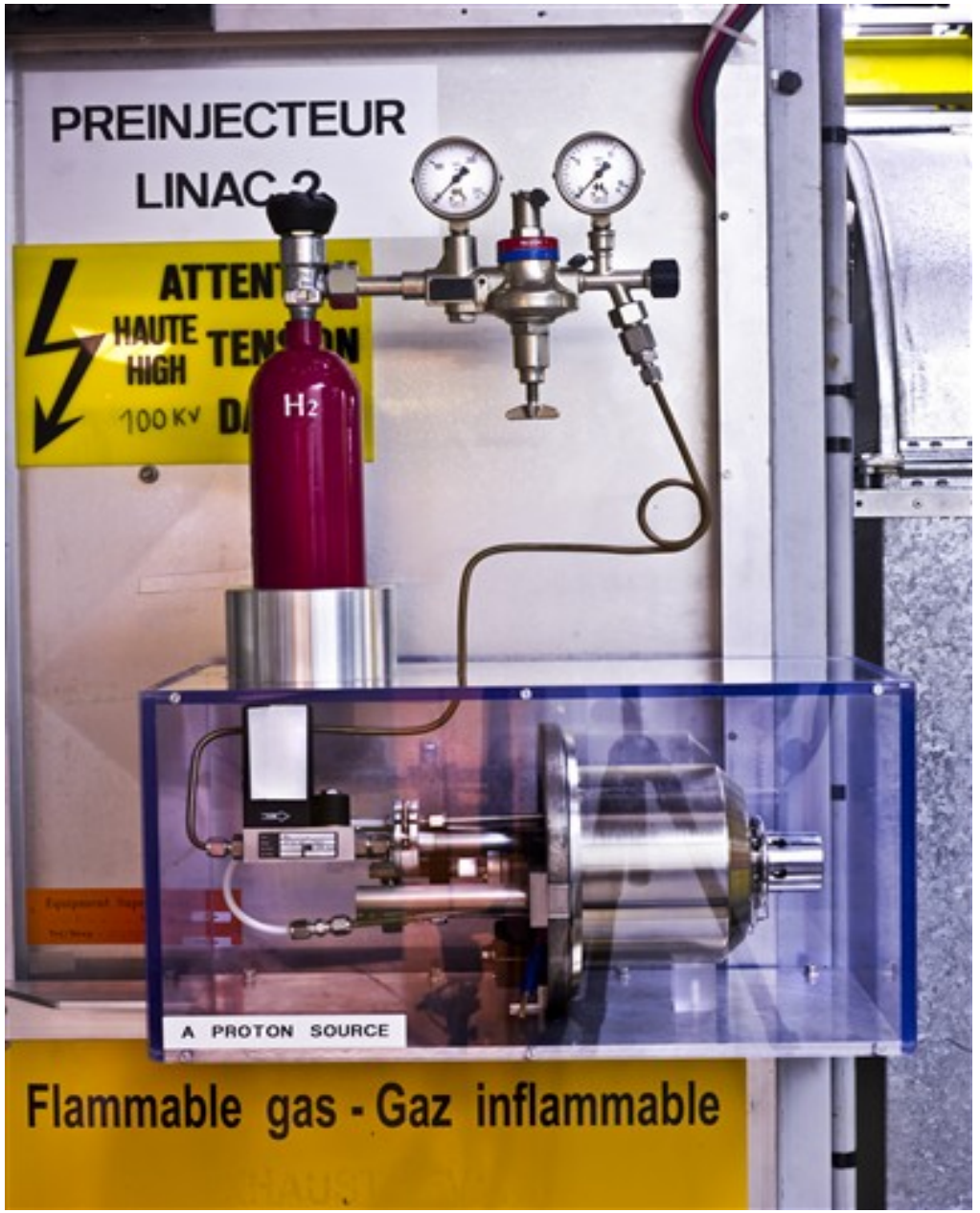
1

H

Hydrogen
1 proton
0 neutron



Hydrogen Atom

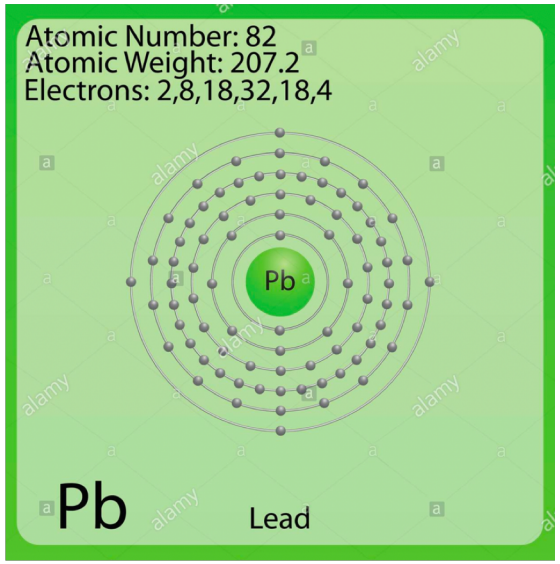


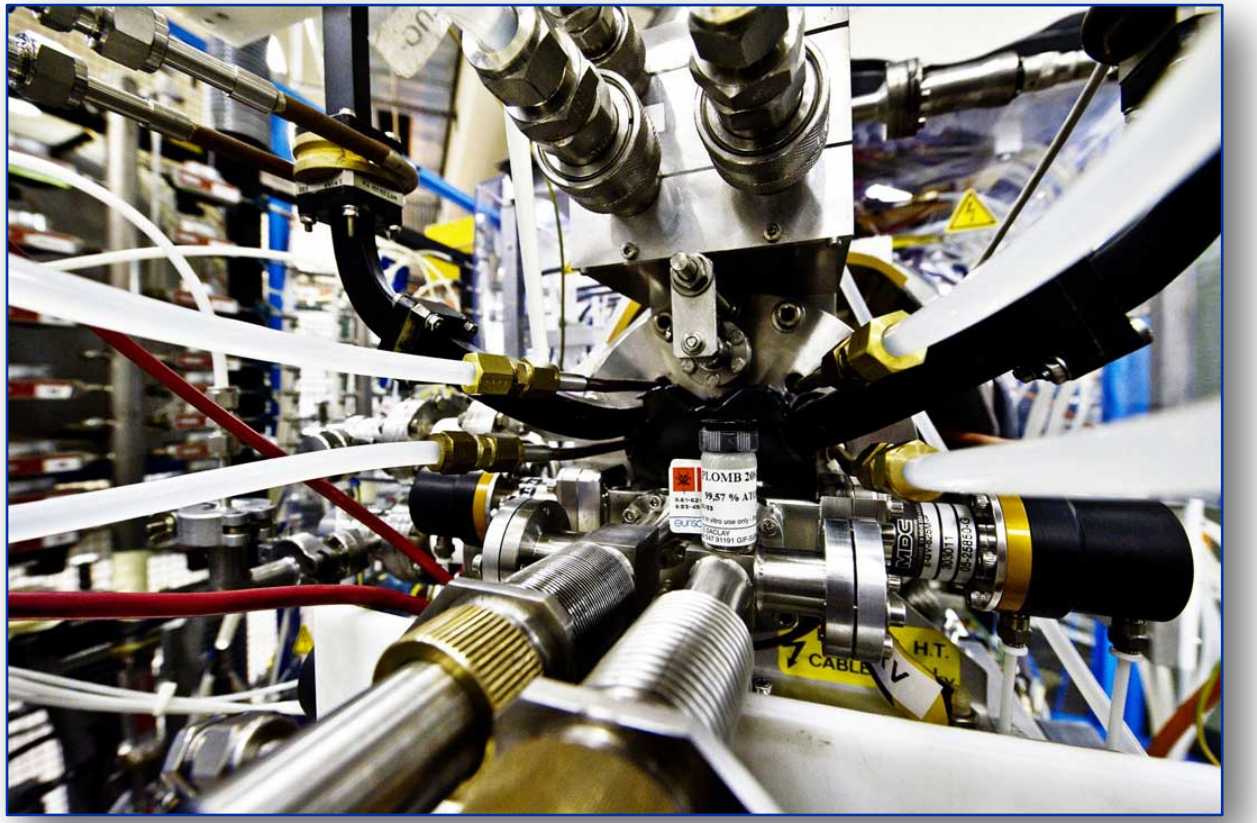
Lead Ions source

208 *(stable)*

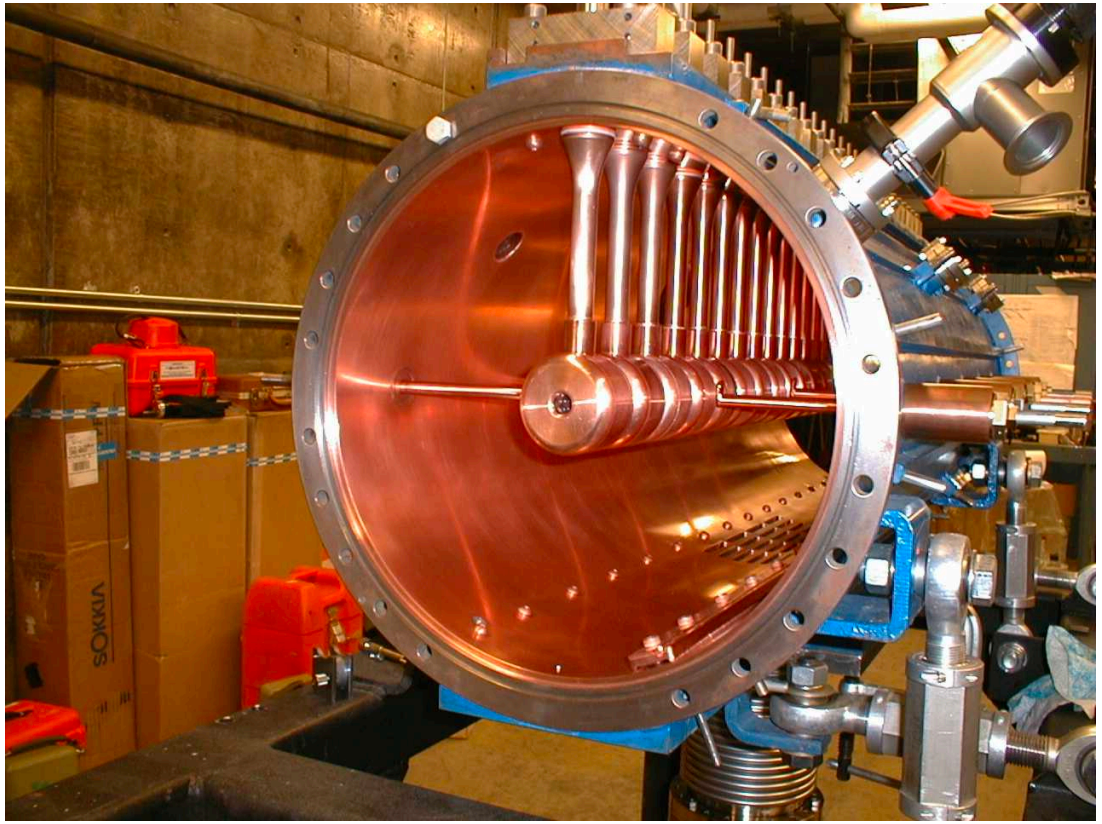
Pb

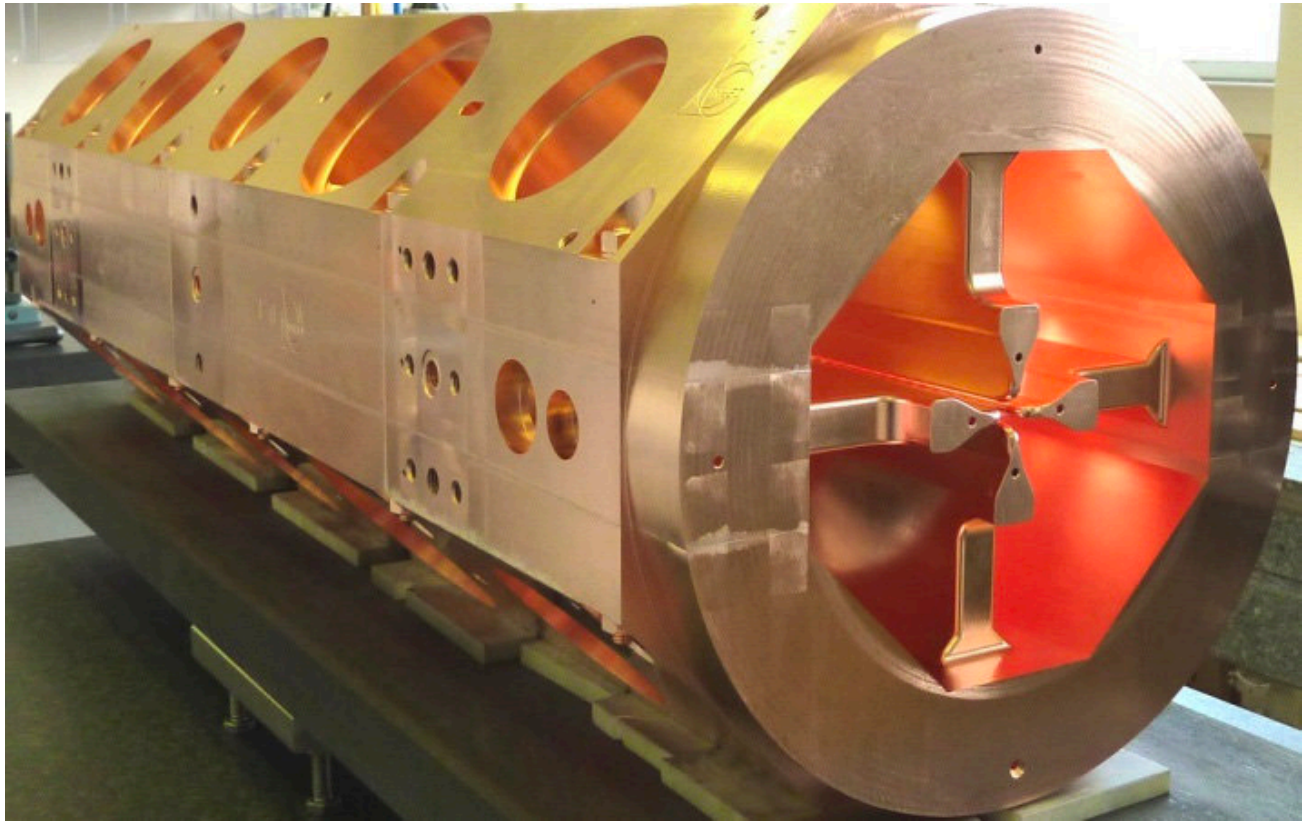
Lead
82 protons
126 neutrons



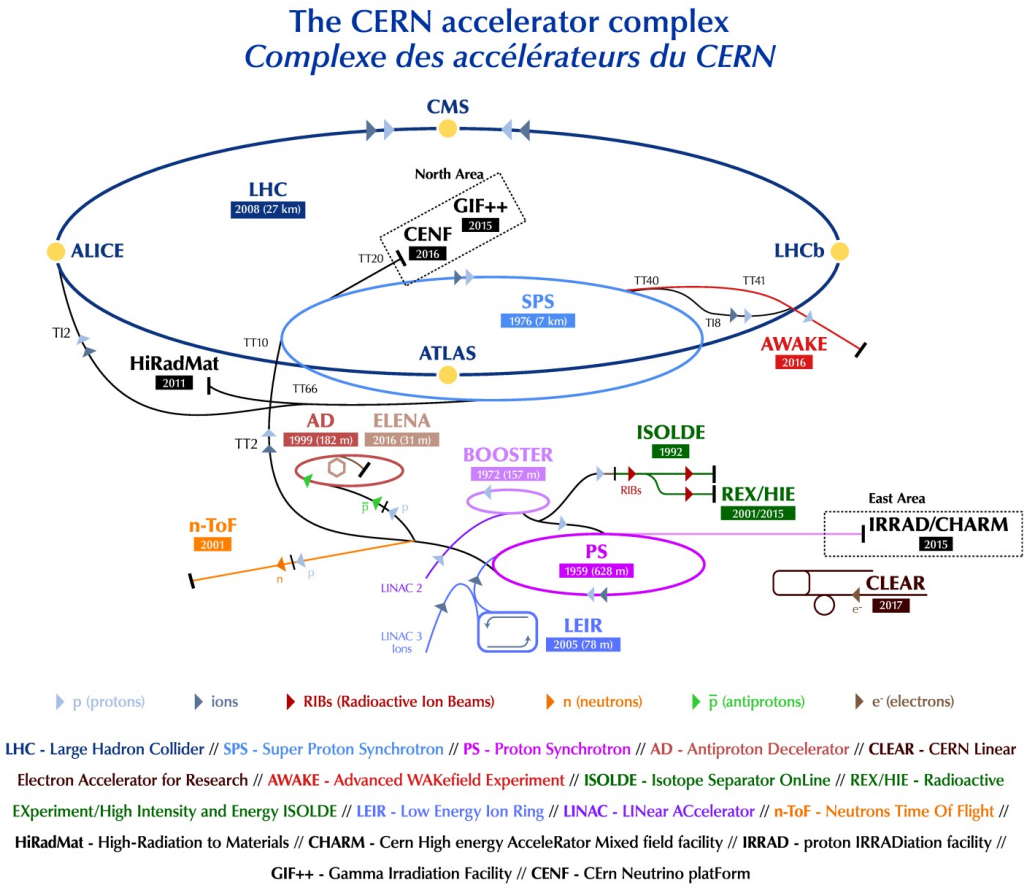


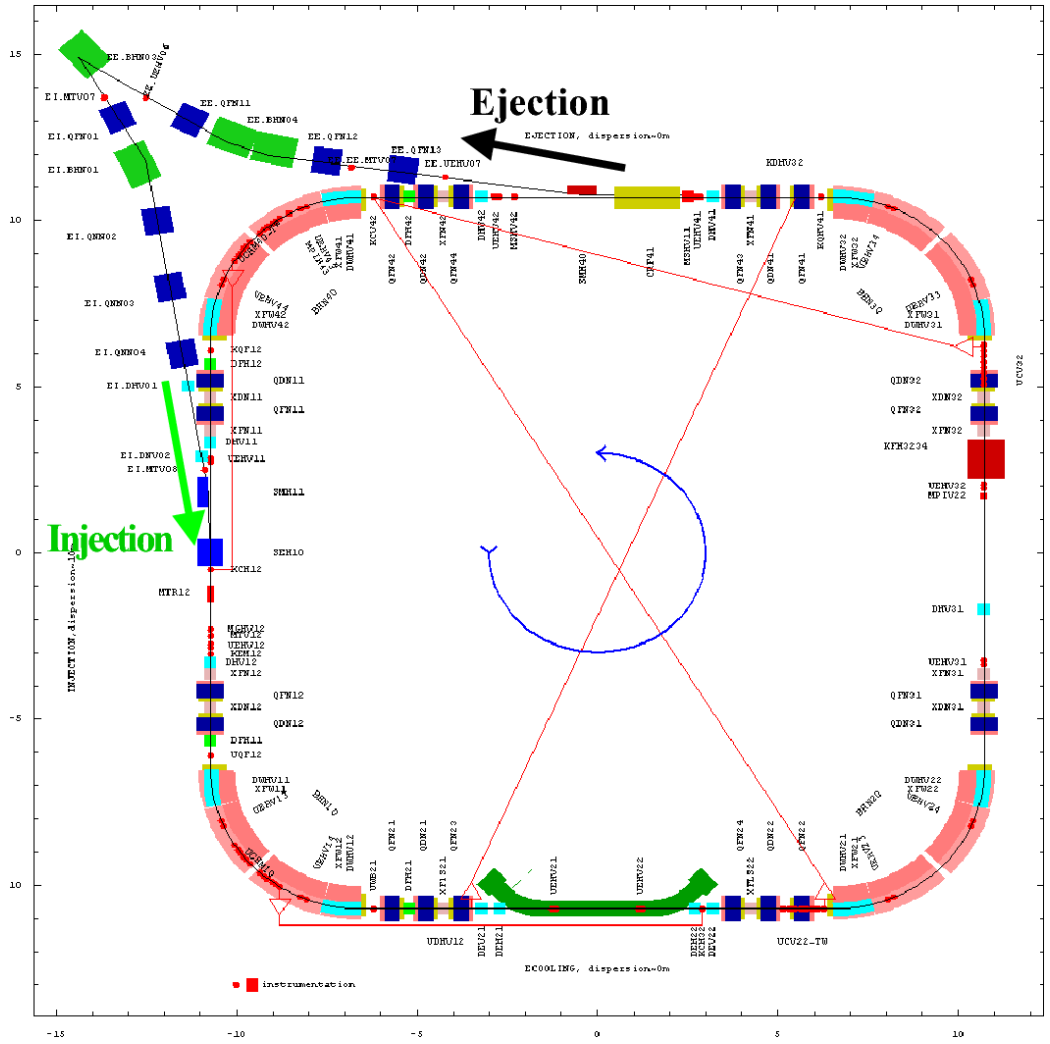
Acceleration and tuning



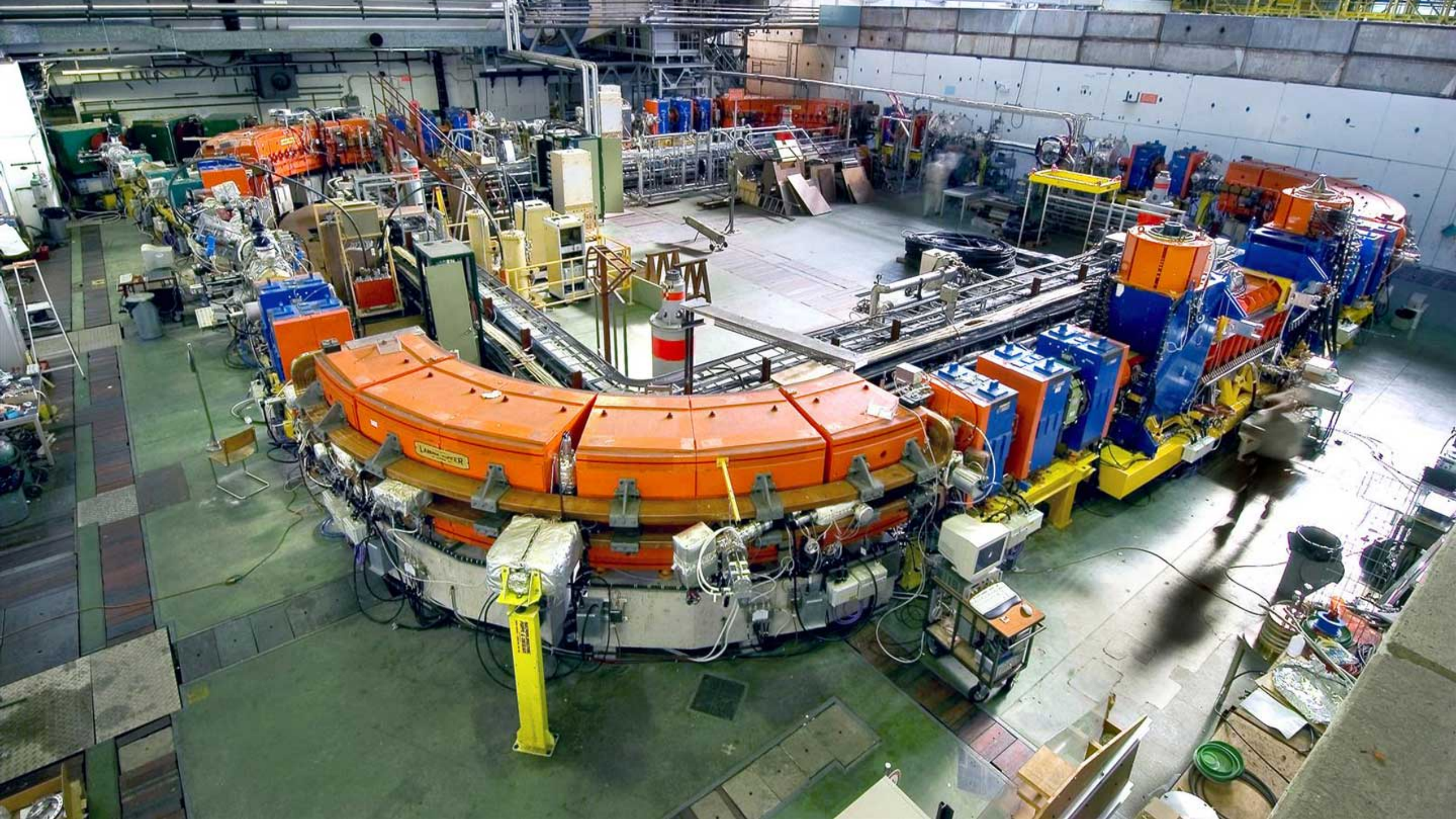


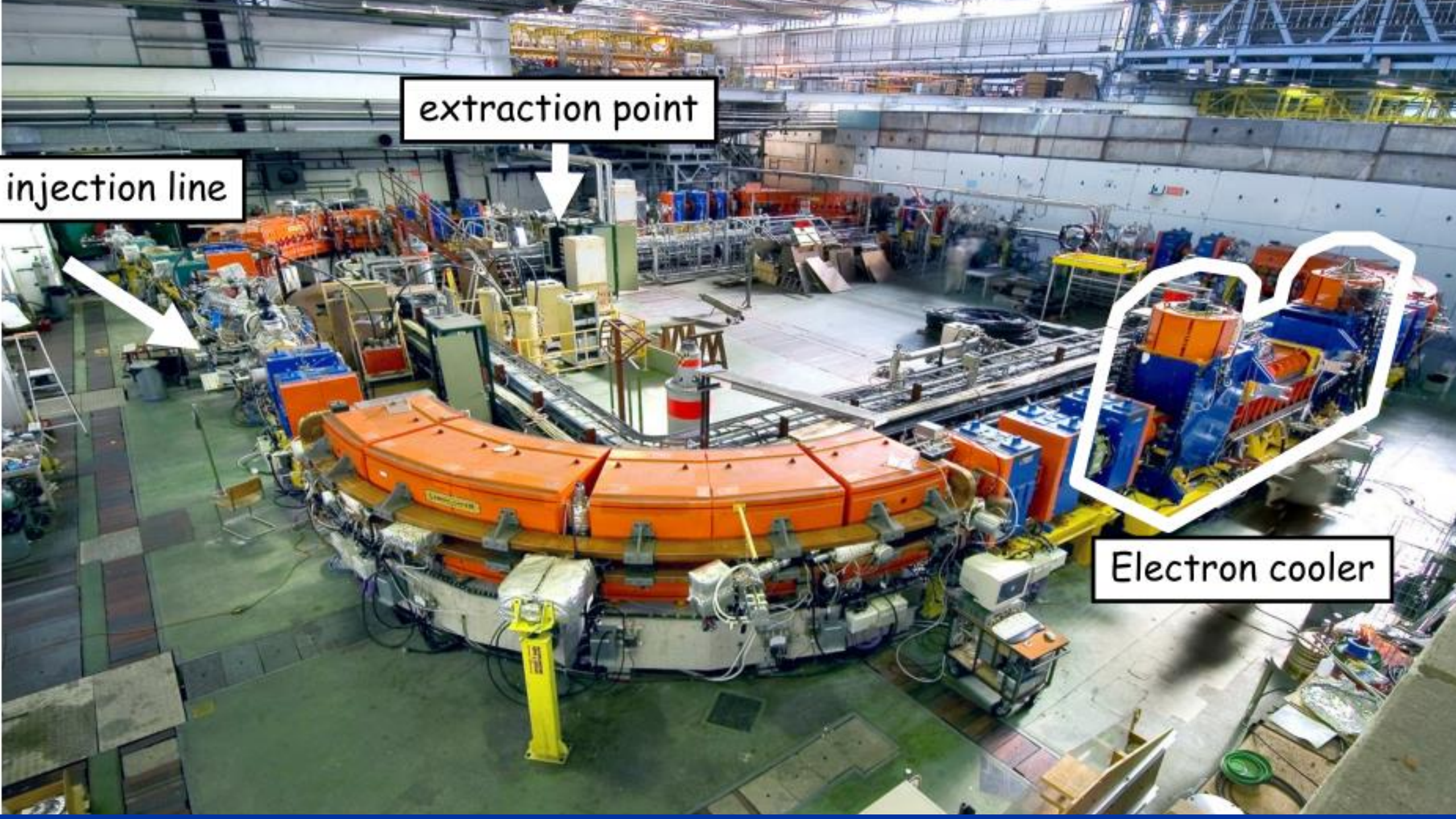
Where is LEIR located at CERN?



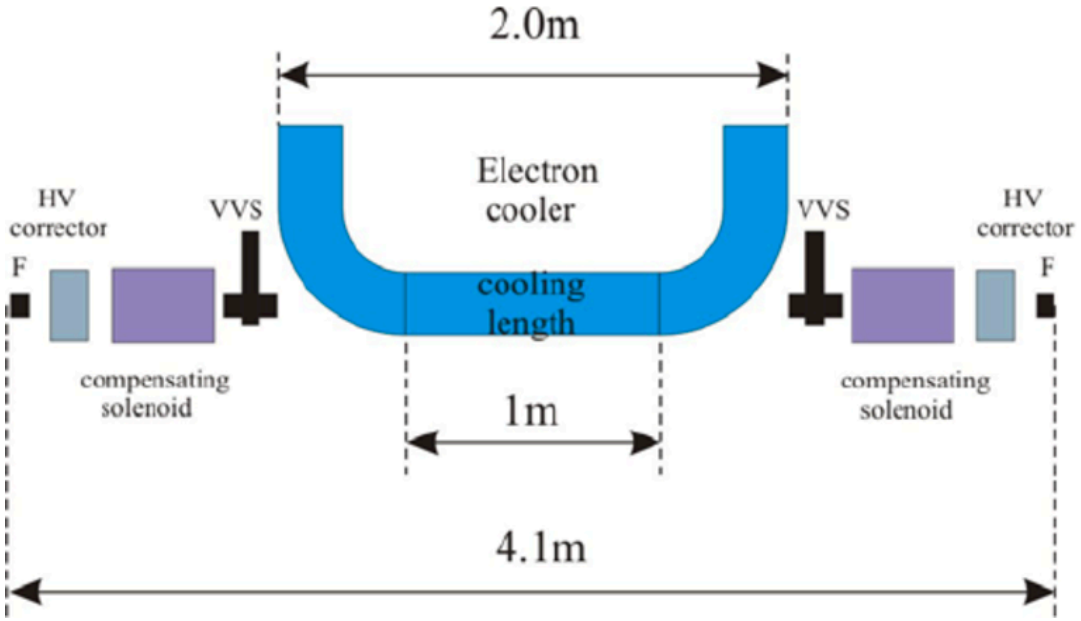


LEIR : Low Energy Ion Ring

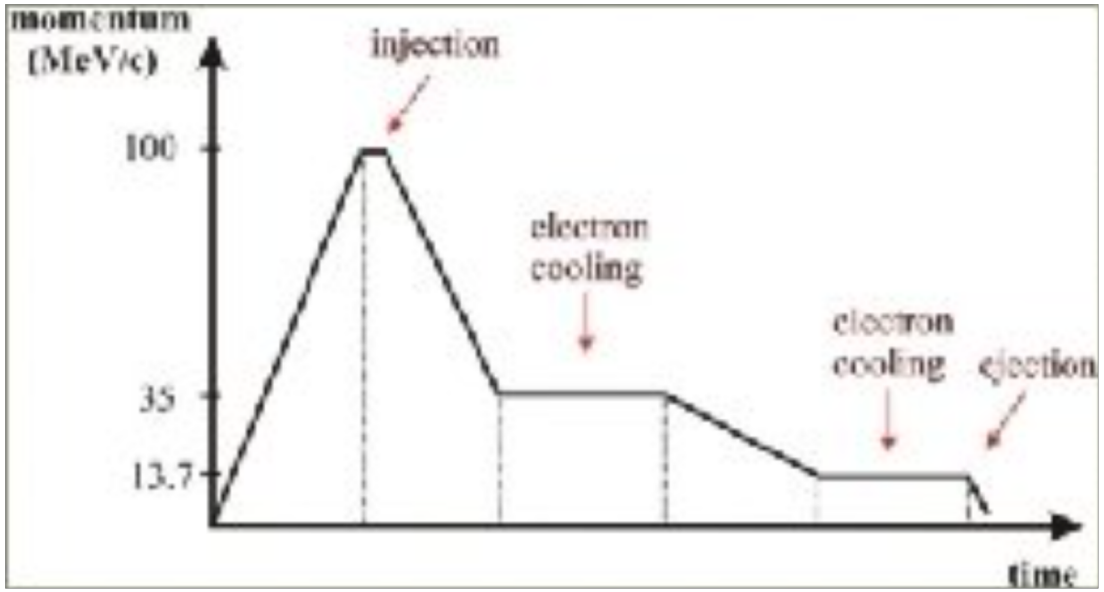



extraction point
injection line
Electron cooler

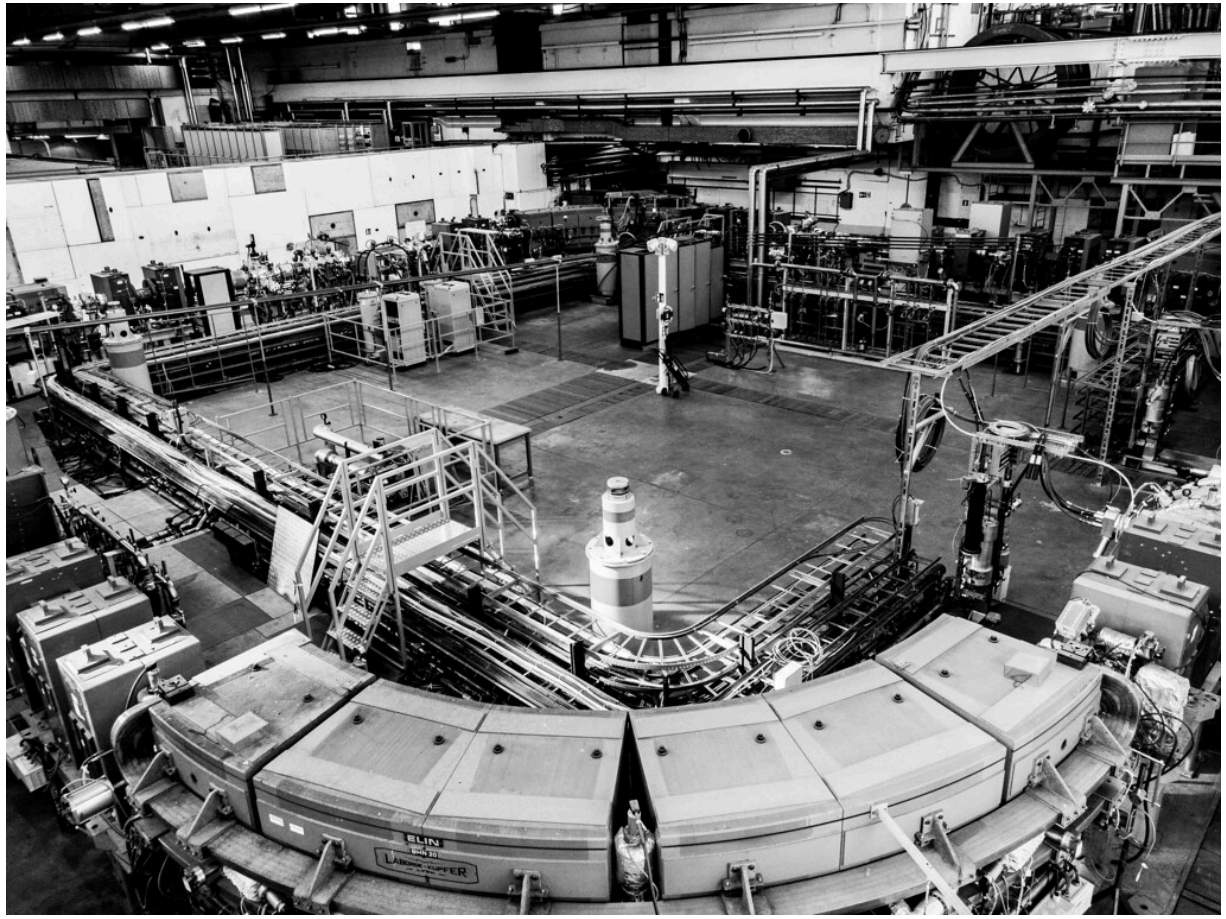
What does cooling particles means?

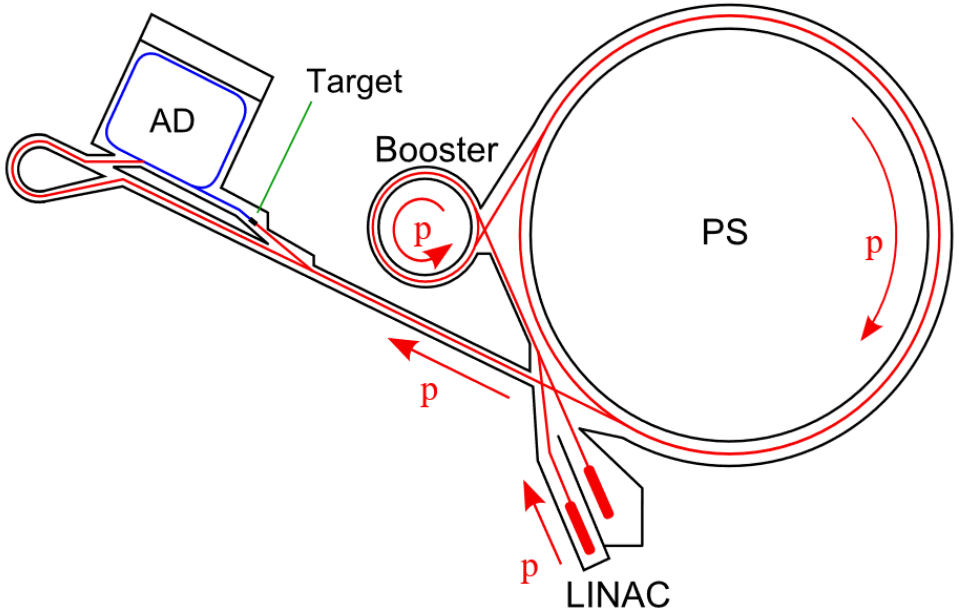


BM

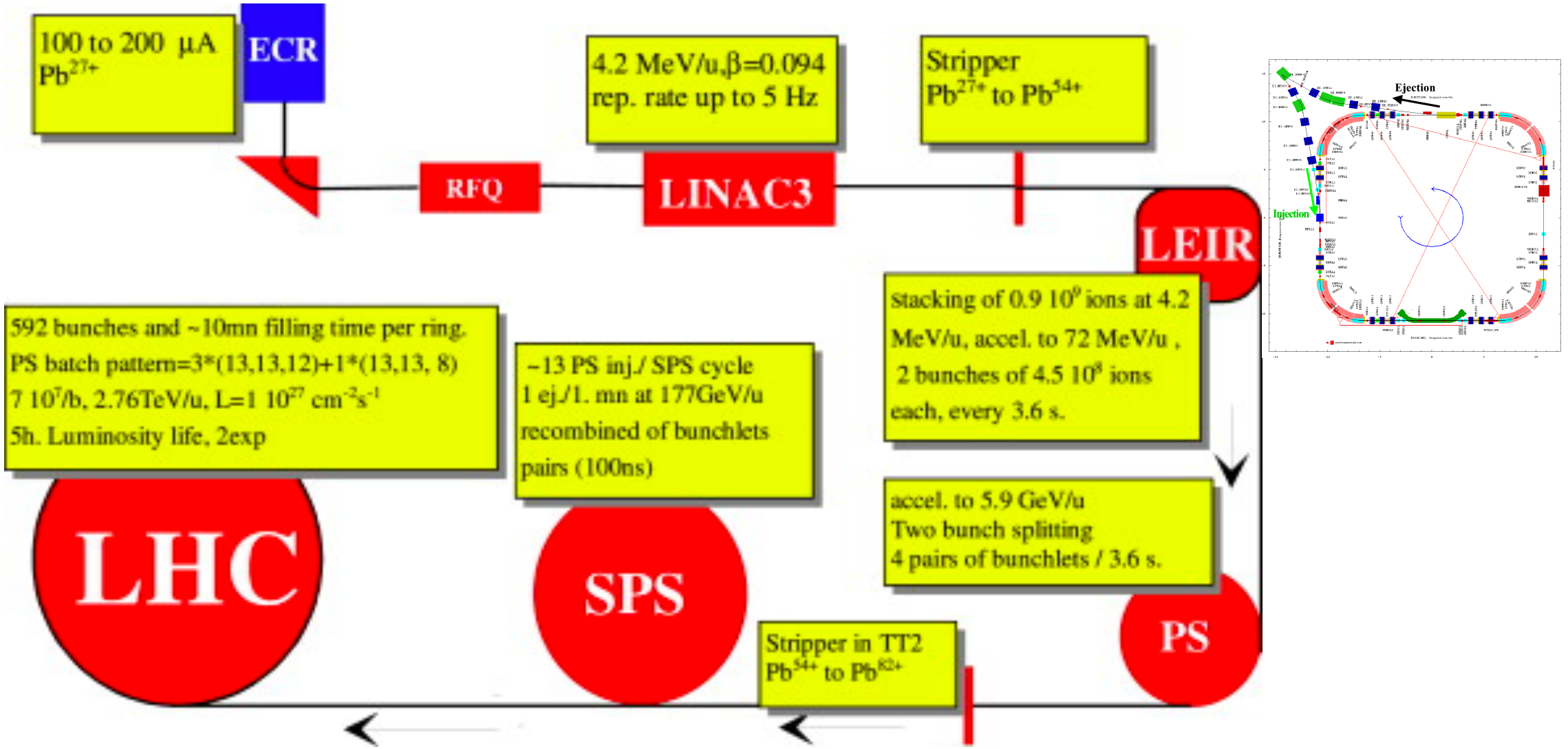


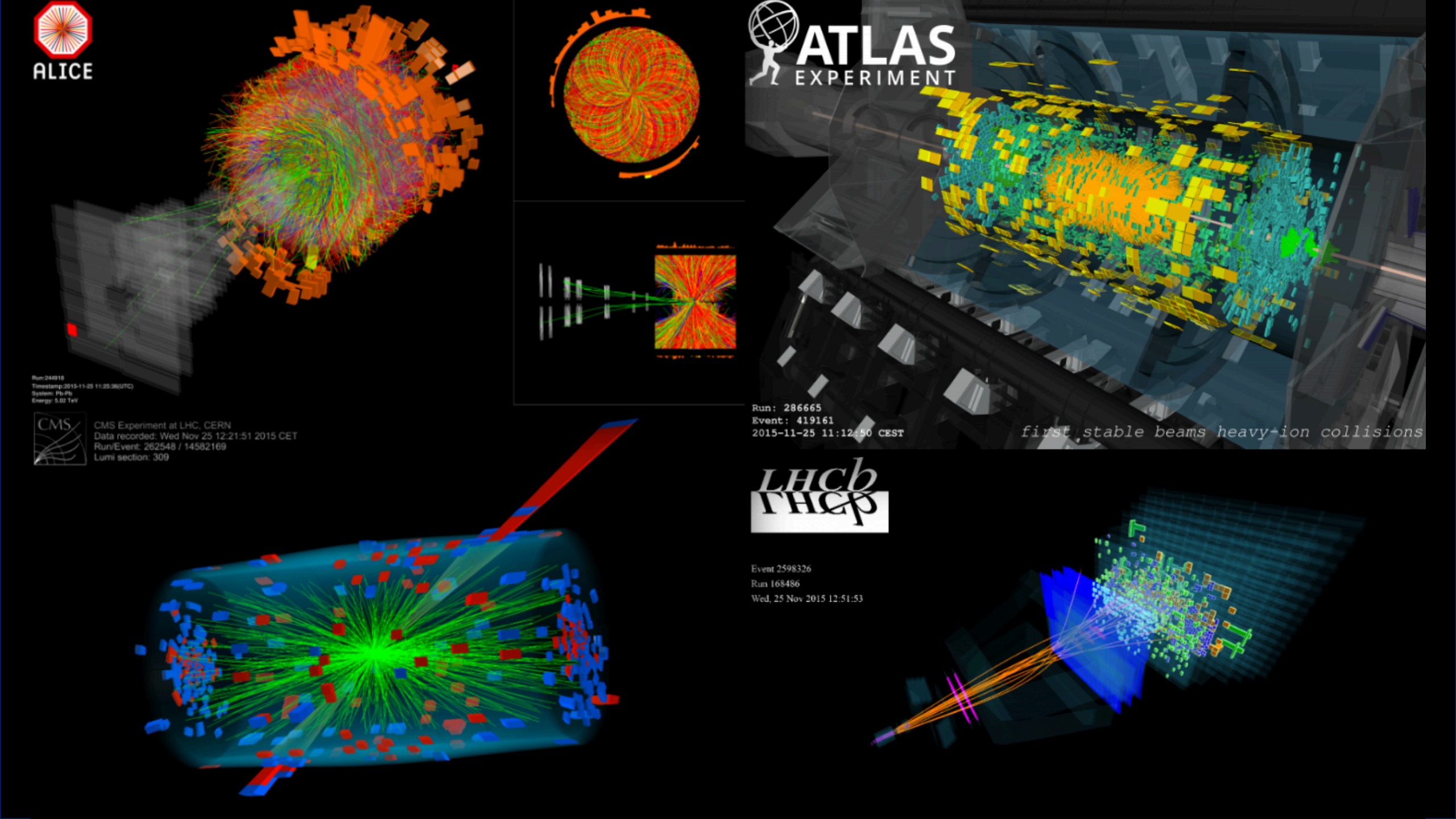
When LEIR was LEAR





LEAR : **L**ow **E**nergy **A**ntiproton **R**ing


100 to 200 µA
Pb27+
ECR
RFQ
4.2 MeV/u,β=0.094
rep. rate up to 5 Hz
LINAC3
Stripper
Pb27+ to Pb54+
LEIR
Ejection
Injection
Stacking of 0.9 10^9 ions at 4.2 MeV/u, accel. to 72 MeV/u , 2 bunches of 4.5 10^8 ions each, every 3.6 s.
accel. to 5.9 GeV/u
Two bunch splitting
4 pairs of bunchlets / 3.6 s.
PS
592 bunches and ~10mn filling time per ring.
PS batch pattern=3*(13,13,12)+1*(13,13, 8)
7 10^7/b, 2.76TeV/u, L=1 10^27 cm^-2s^-1
5h. Luminosity life, 2exp
LHC
~13 PS inj./ SPS cycle
1 ej./1. mn at 177GeV/u
recombined of bunchlets pairs (100ns)
SPS
Stripper in TT2
Pb54+ to Pb82+


ALICE
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System: Pb-Pb
Energy: 5.02 TeV
CMS
CMS Experiment at LHC, CERN
Data recorded: Wed Nov 25 12:21:51 2015 CET
Run/Event: 262548 / 14582169
Lumi section: 309
ATLAS
EXPERIMENT
Run: 286665
Event: 419161
2015-11-25 11:12:50 CEST
first stable beams heavy-ion collisions
LHCb
Event 2598326
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Wed, 25 Nov 2015 12:51:53

CERN Bulletin

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PROTON-ION COLLISIONS: BEHIND THE SCENES OF AN EXOTIC INTERACTION

Protons to the right, ions to the left: the basic principle of proton-ion collisions at the LHC might seem straightforward. However, this is an almost unprecedented mode of collider operation, certainly unique at the energy provided by the LHC. In addition to being a remarkable technical achievement, this interaction between a proton and an ion can potentially contribute a lot to the understanding of the properties of matter in its primordial state.

Prior to last week, the LHC had only collided protons with protons and lead ions with lead ions. These were indeed the two operational schemes the LHC was designed for. However, since science can often evolve in directions that were not necessarily expected at the beginning of a project, over the years the scientific community has become more and more interested in the hybrid type of interaction – that between protons and ions. Last week's collisions were only a test for the teams involved in the operation of the LHC, in preparation for the four week run in 2013. But why are these collisions so interesting to physicists?

"The relevance of studying this type of interaction is twofold," replies Urs Wiedemann from CERN's Theory Unit. "In addition to being a benchmark for ion-ion collisions, proton-ion collisions could provide valuable insights into a so-far unexplored region of QCD, the model that describes the behaviour of, among other things, nuclei, protons and quarks, in which novel phenomena are expected to occur."

From observations at the LHC and in other colliders we already know that when two ion beams are collided, a new state of matter is formed: the quark-gluon plasma (QGP). This is the hot and dense matter that existed in the initial moments of the Universe. At the LHC, the properties of this state can be probed by studying how