

THE ATLAS EXPERIMENT AT THE LARGE HADRON COLLIDER

DR. SAIME GÜRBÜZ

International Masterclasses "hands on particle physics" 2021: ATLAS-Masterclass

24 March 2021 - Bonn



NETZWERK
TEILCHENWELT



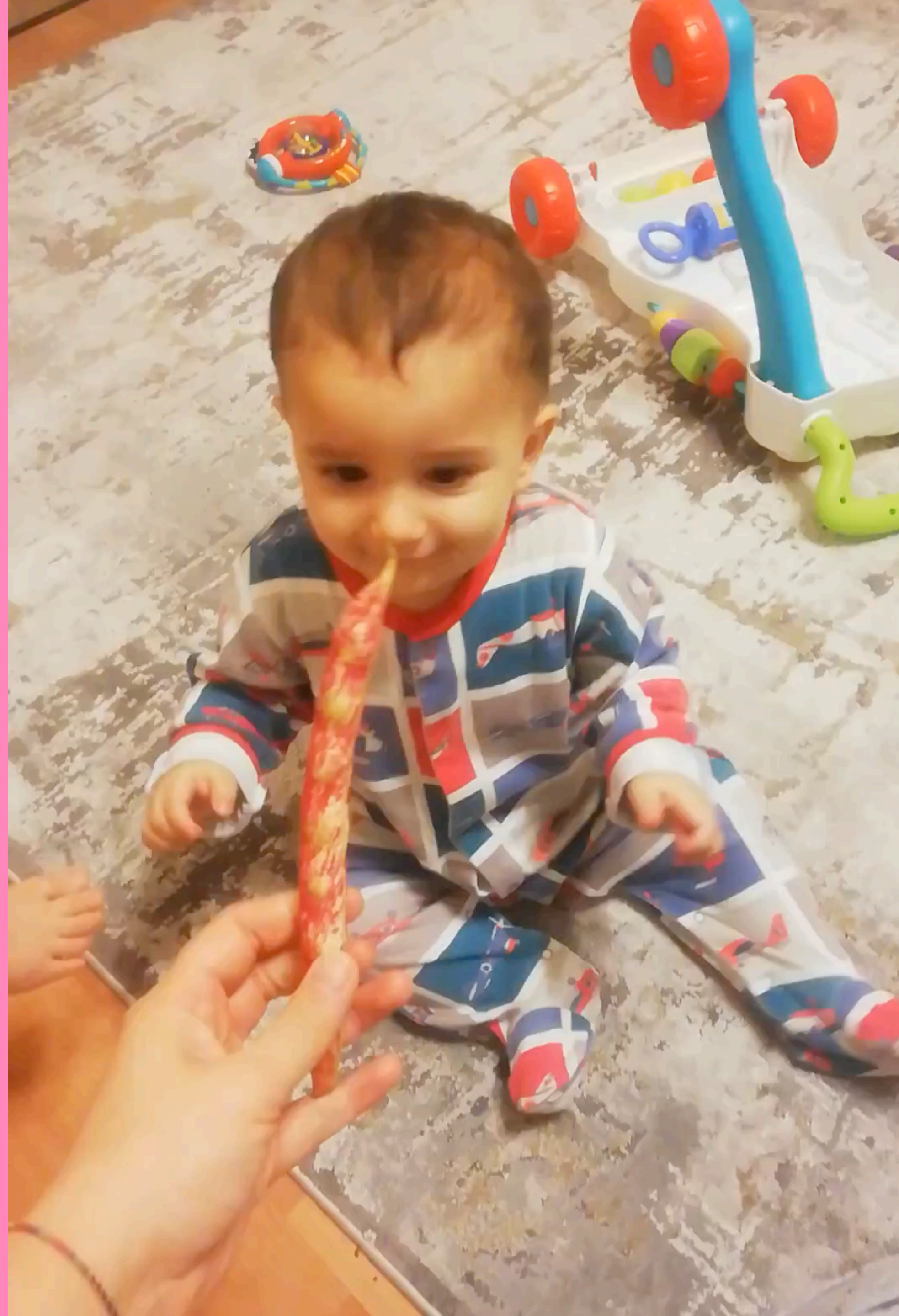
DR. SAIME GÜRBÜZ

- I am an experimental physicist at the University of Bonn.
- I work on particle physics detectors.
- I have been working in ATLAS experiment for 11 years.
 - Trigger Tracking
 - Physics Analysis
 - TRT Detector
- I am from Turkey (Boğaziçi University) and have been in Germany for 7 months.
- I like watching movies, cooking and scuba diving.



**KIDS ARE
LITTLE
SCIENTISTS**

**WHAT WILL HE DO
WITH
THE SHELL BEANS?**



**HE DOES NOT KNOW
WHAT IS INSIDE?
HOW TO OPEN IT?
WHAT WILL HAPPEN?**

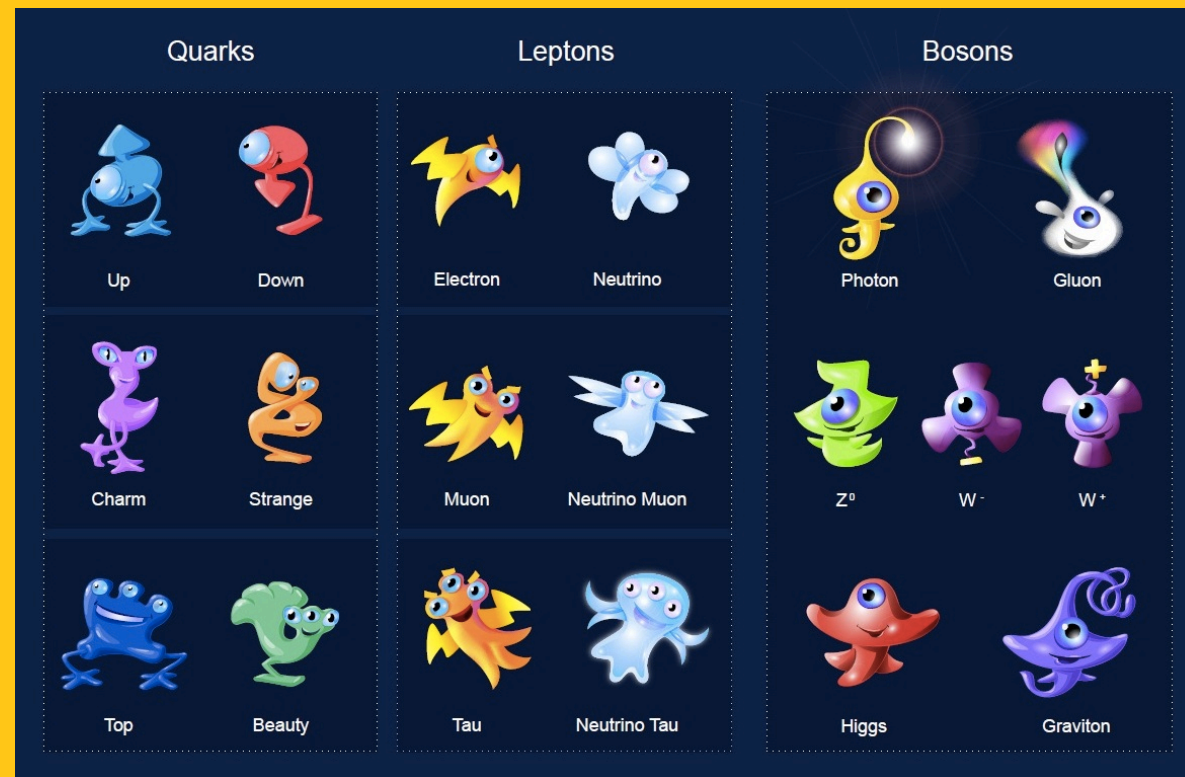
THROW IT!



Before the particle accelerator

WHAT WILL WE COVER?

Particles



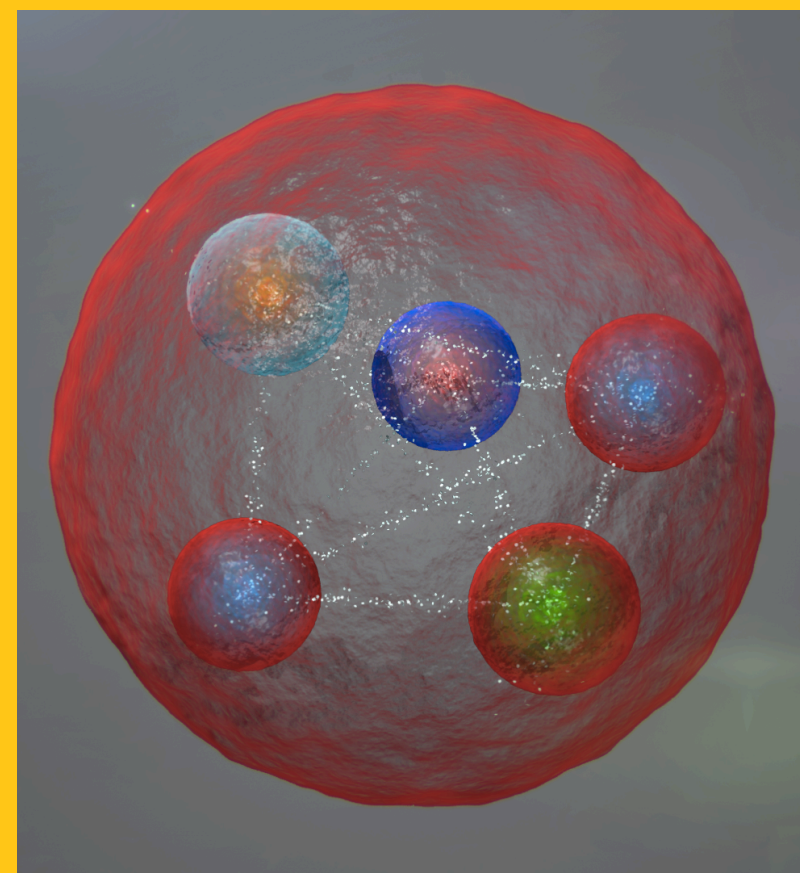
Accelerate Gains Kinetic Energy



Collide



New Particles



Record with our detector



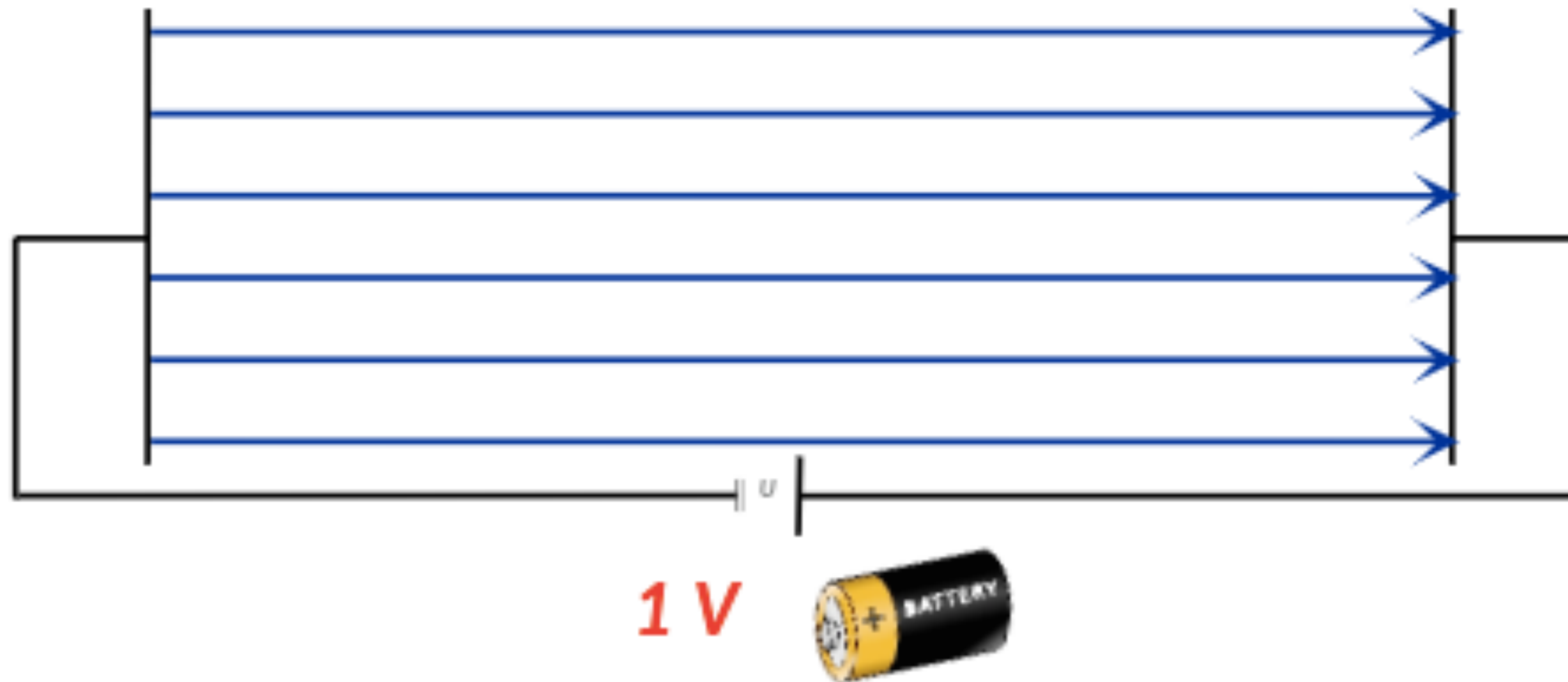
Analysis



HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

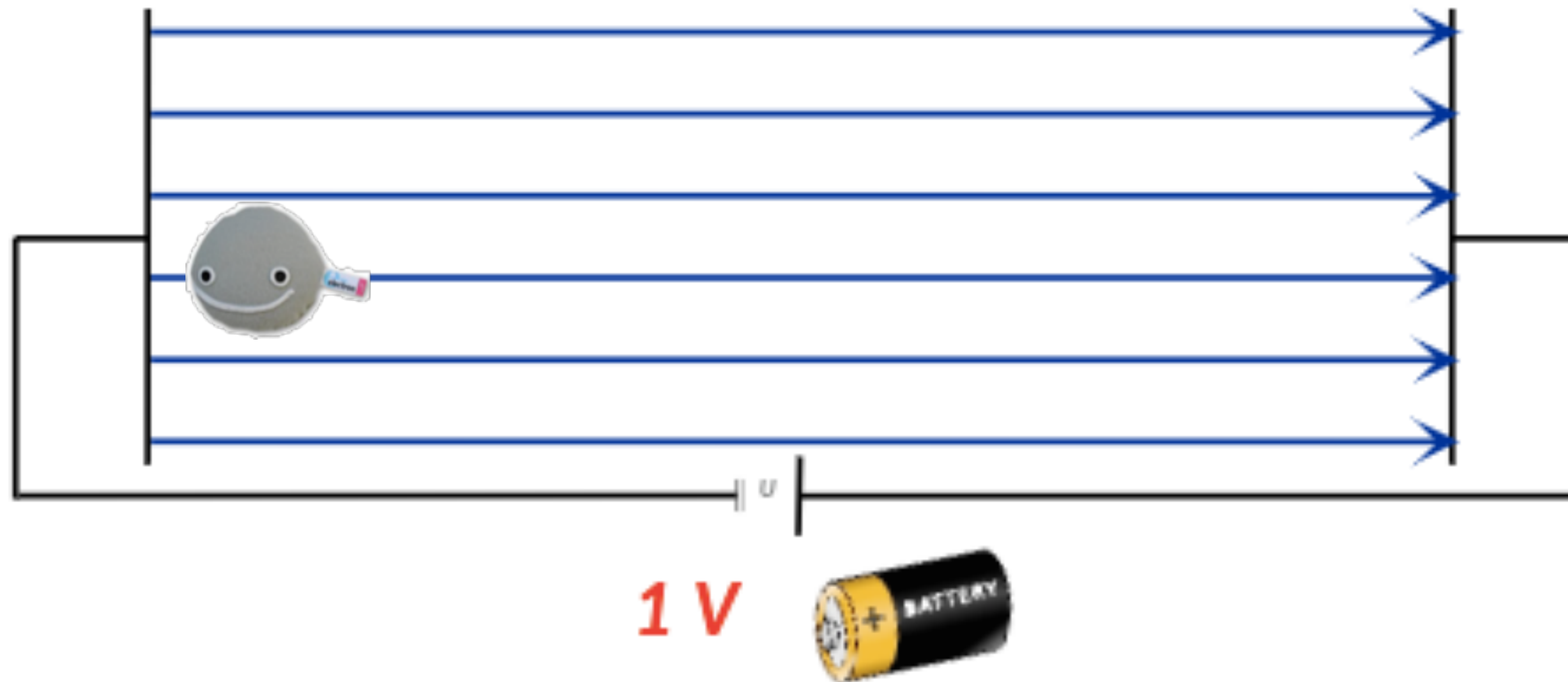


- They are all charged
- In an electric field they will be accelerated.



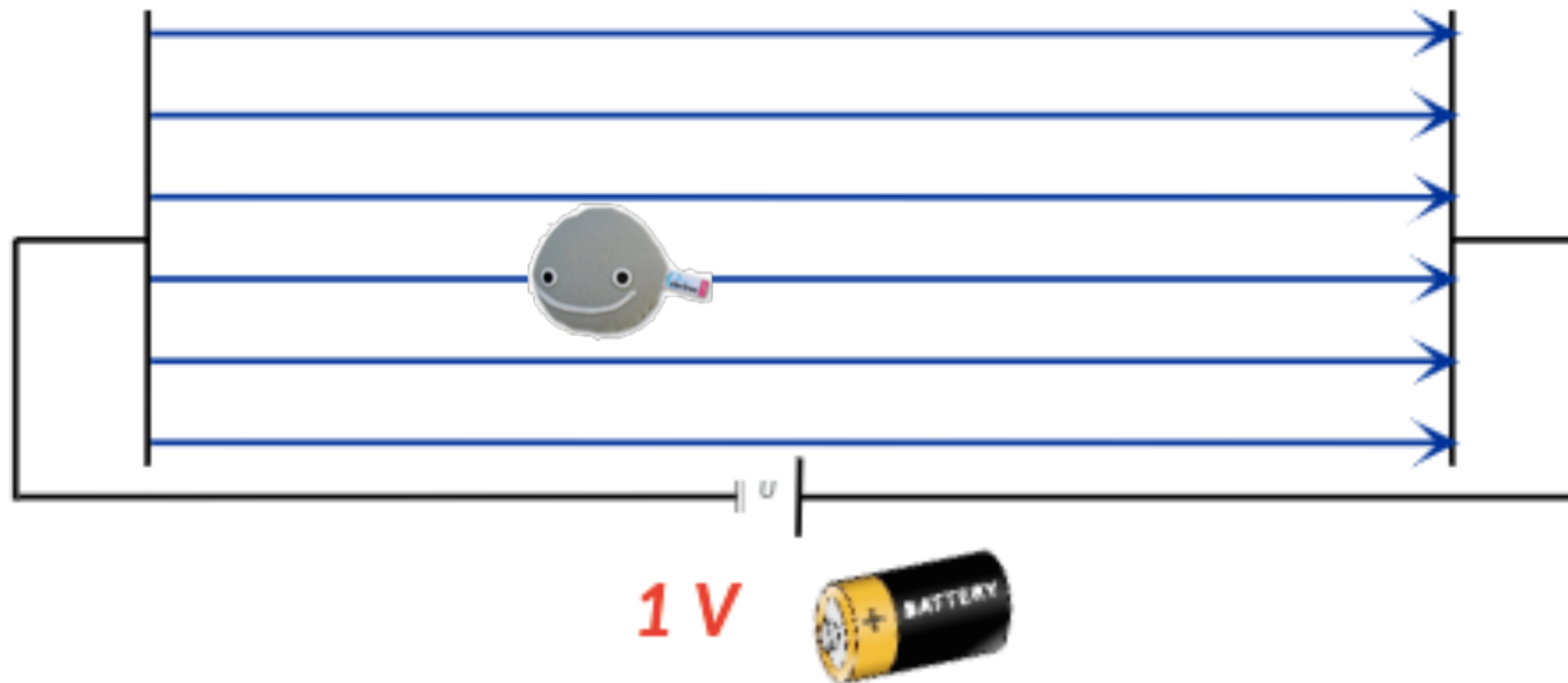
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- Let's put our little electron in an electric field!
- What will happen?



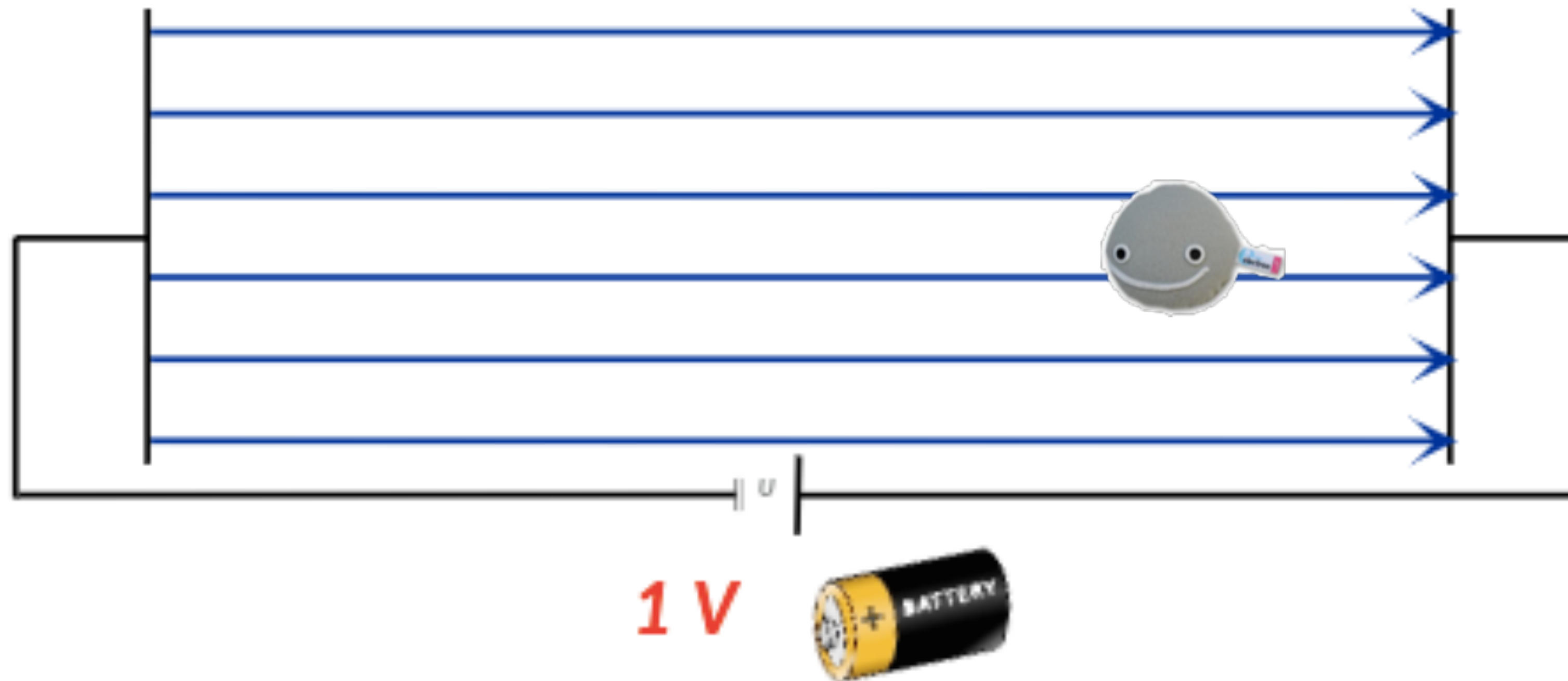
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- It moves! Yay!



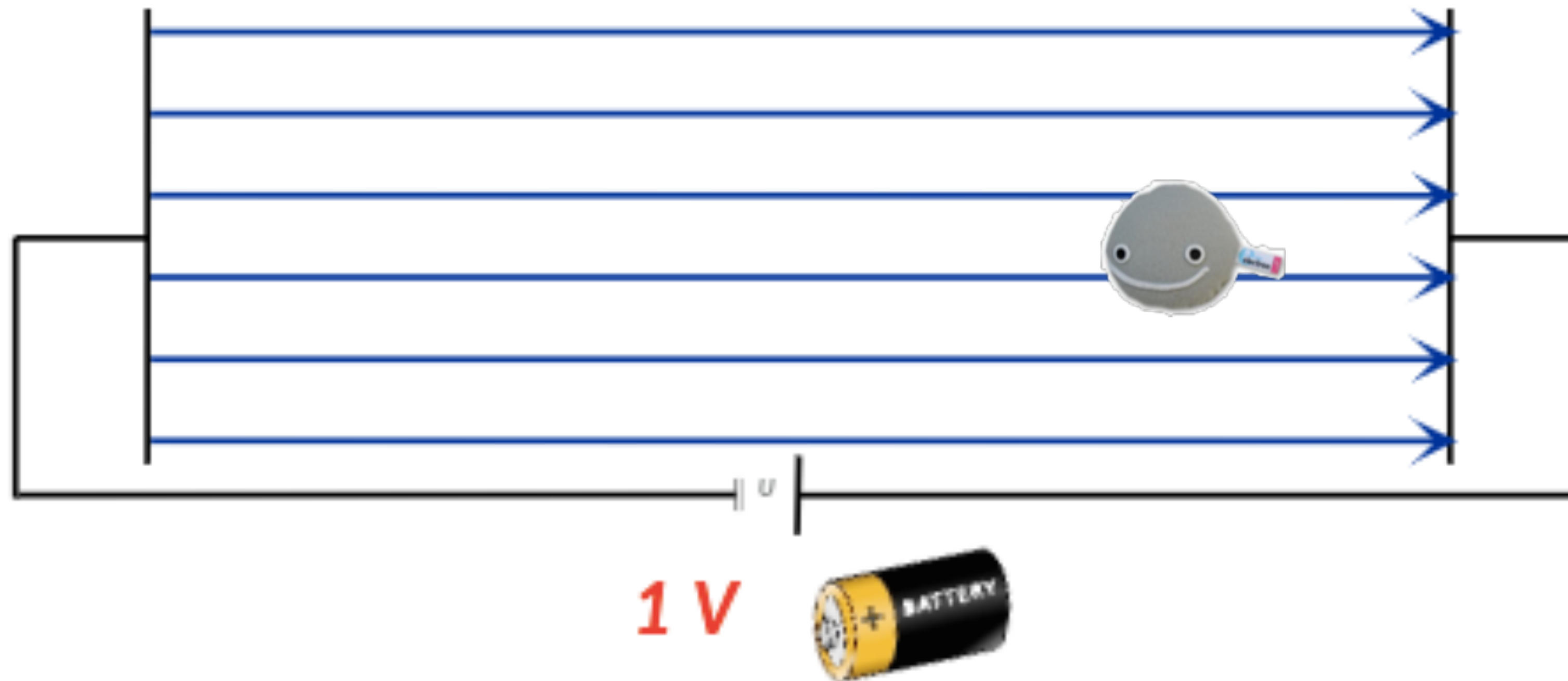
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- What is its energy?
- $E = q * U$



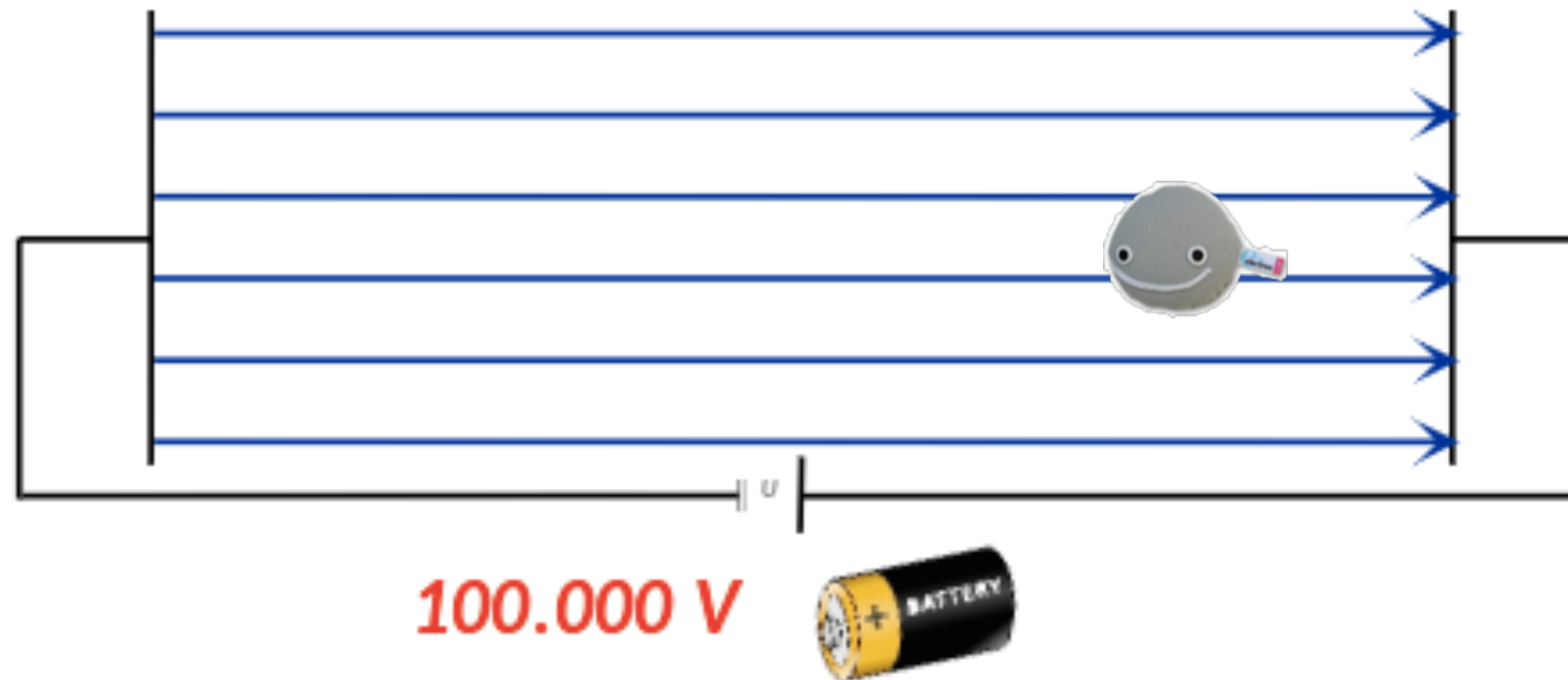
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- What is its energy?
- $E = q * U = 1\text{eV}$



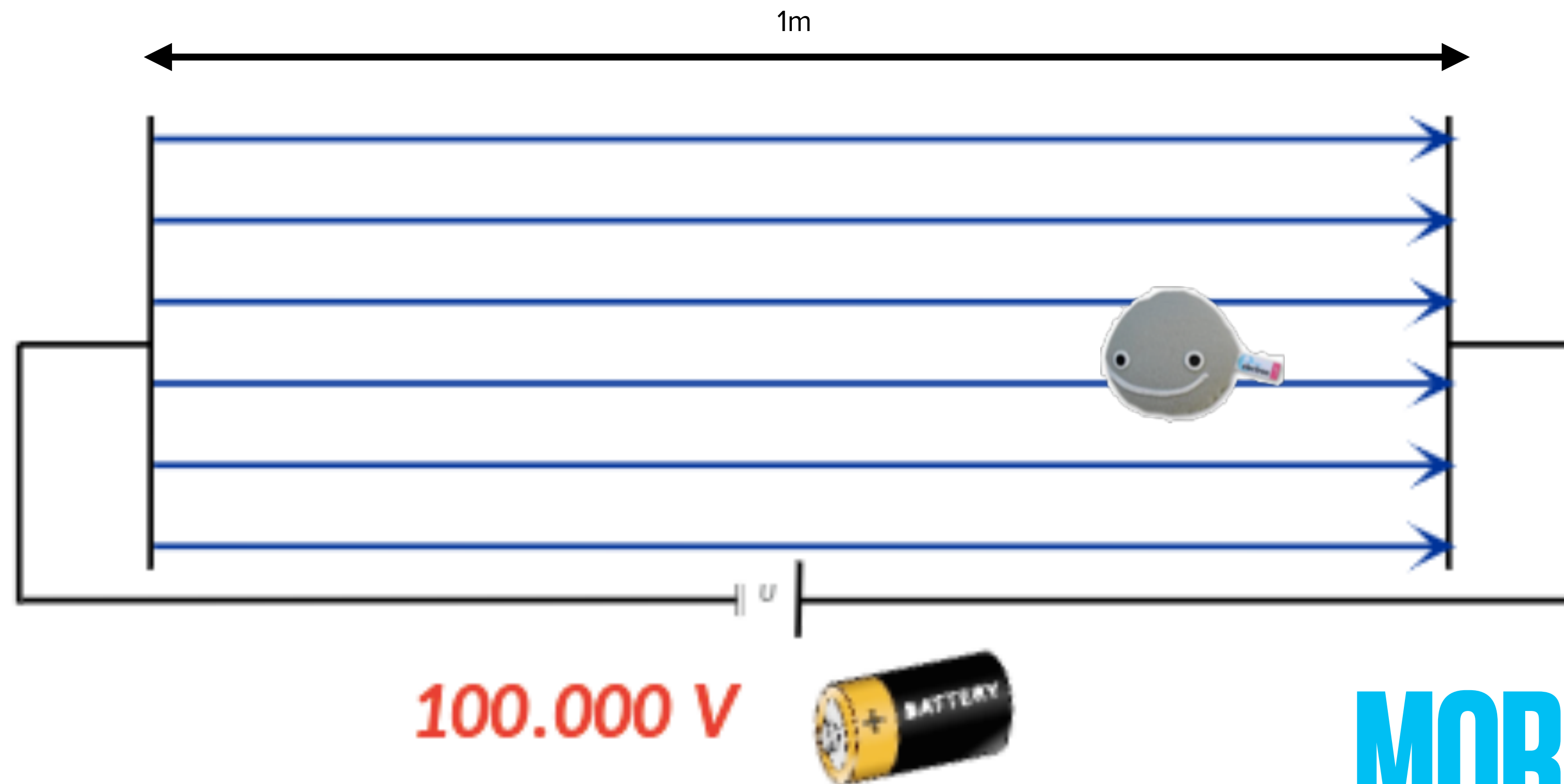
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- Increase to 100.000V?
-



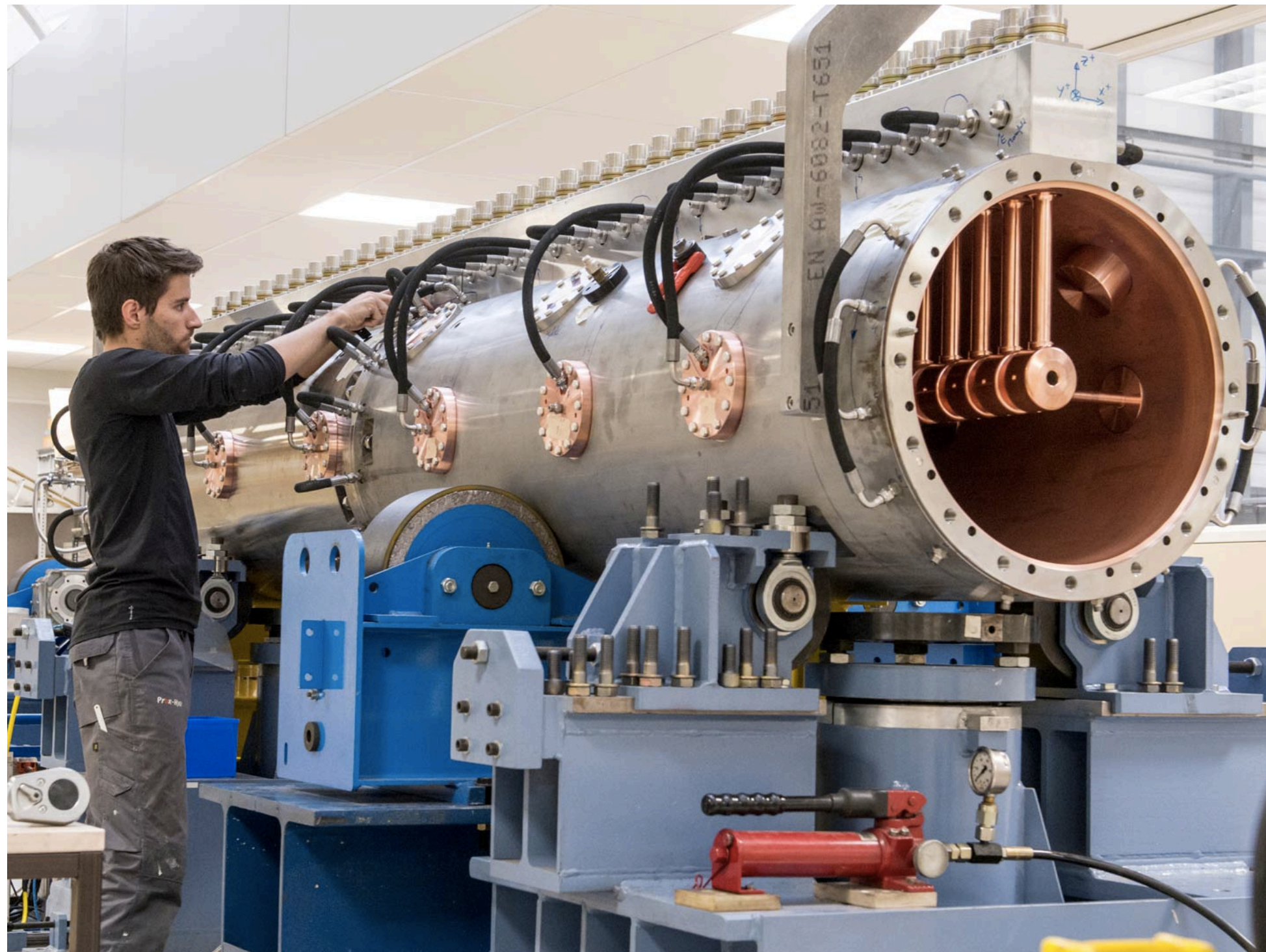
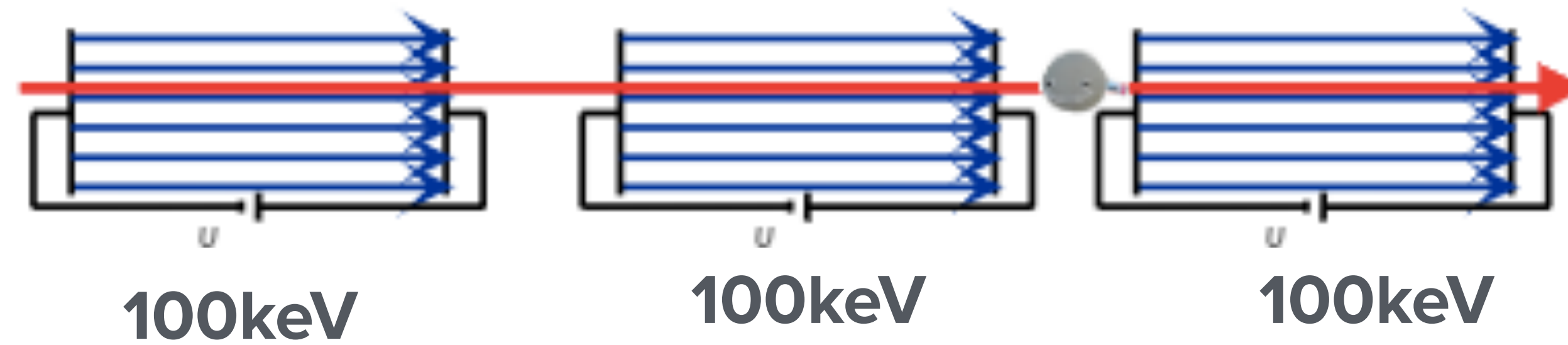
HOW CAN WE ACCELERATE PROTONS/ELECTRONS/IONS?

- Increase to 100.000V?
- $E = q * U = 100\text{keV}$



MORE ENERGY?

LINEAR ACCELERATORS

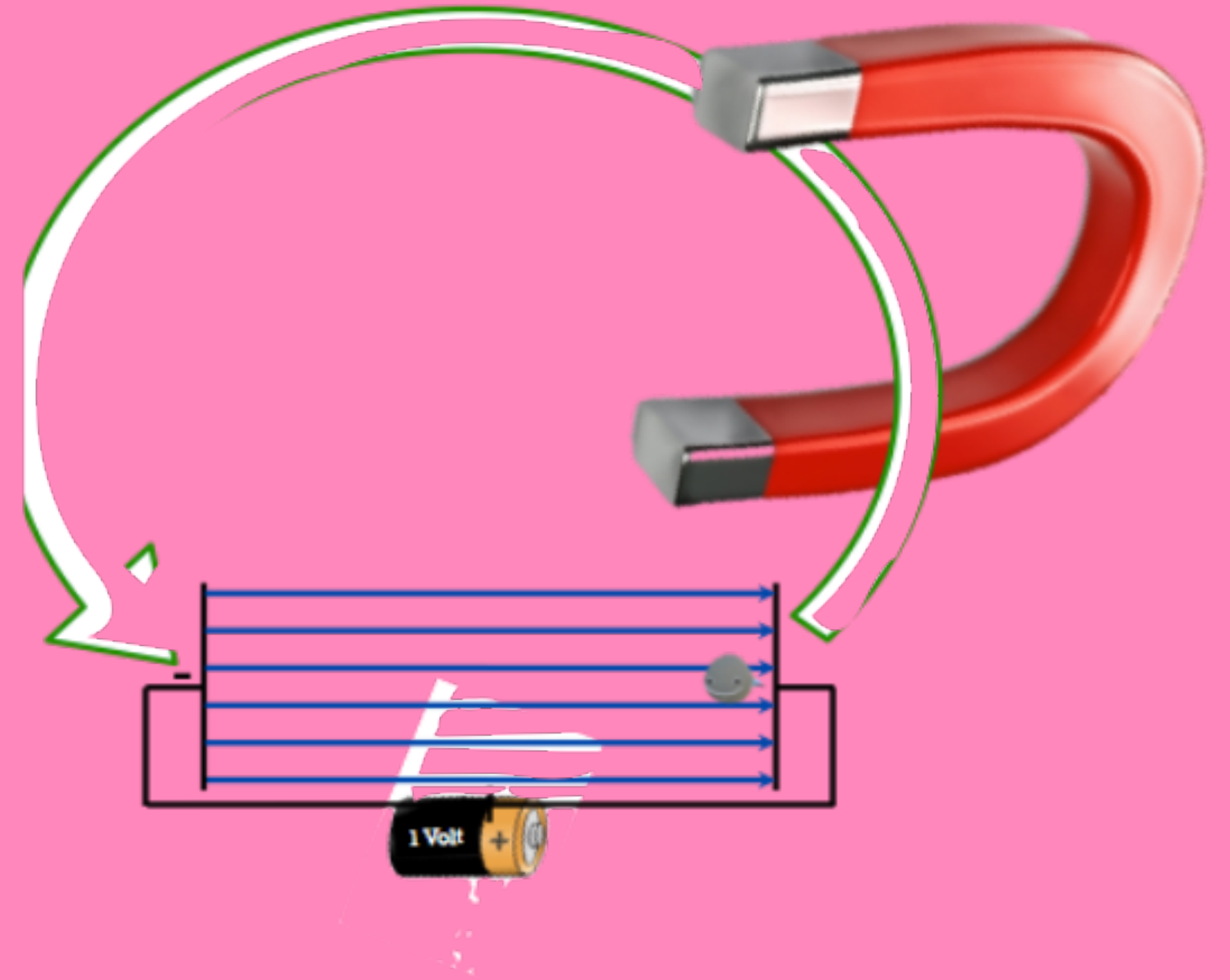
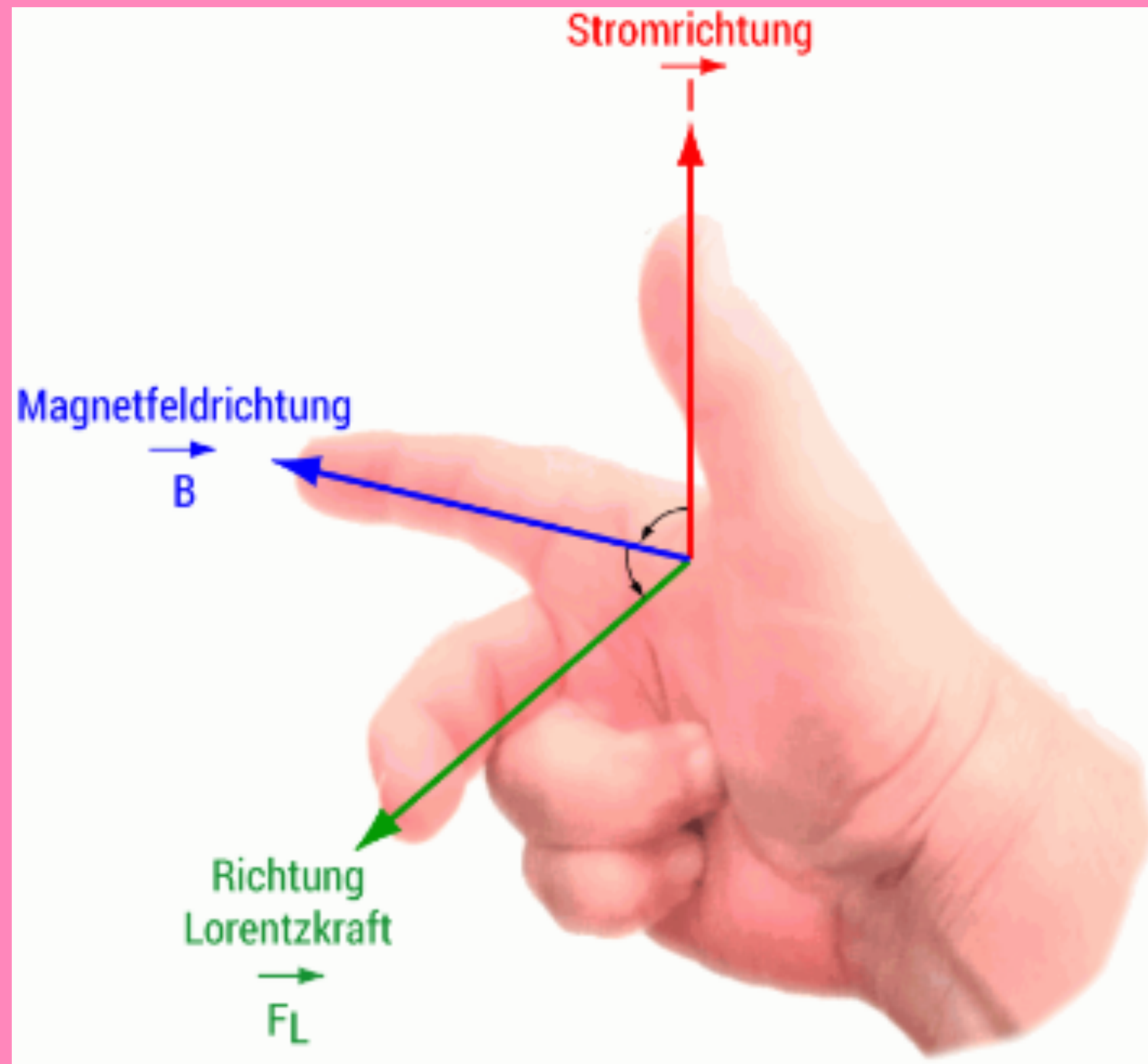


$$M_H = 125 \text{ GeV}/c^2 = 125.000.000 \text{ keV}/c^2$$

1250 KM
(HAMBURG - MUNICH 800KM)

WHAT ELSE CAN WE DO?

USE THE SAME ELECTRIC FIELD AGAIN! LORENTZ FORCE \rightarrow CIRCULAR PATH



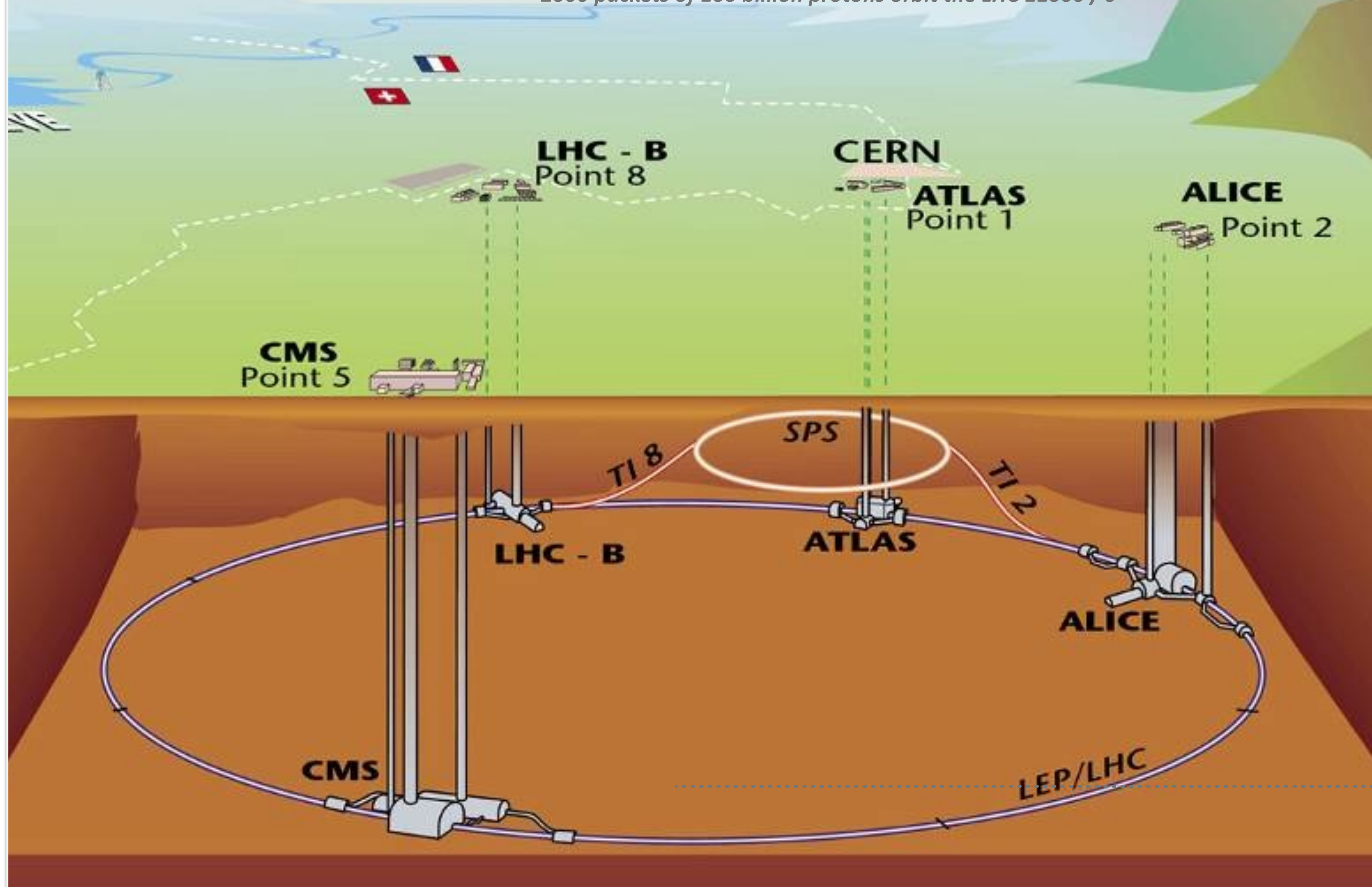
LETS CHECK WHAT CERN DOES!





THE LARGE HADRON COLLIDER

2000 packets of 100 billion protons orbit the LHC 11000 / s



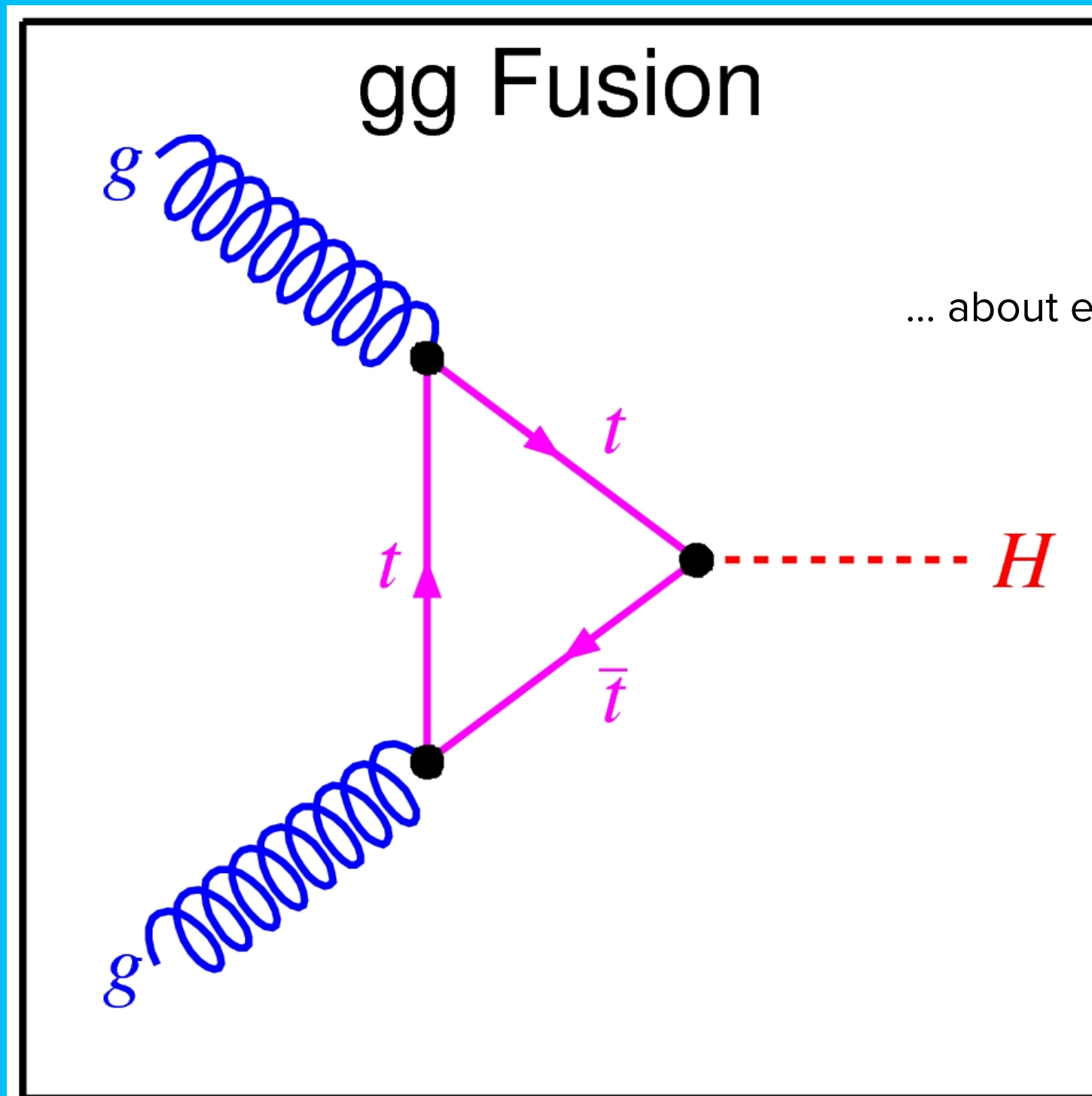
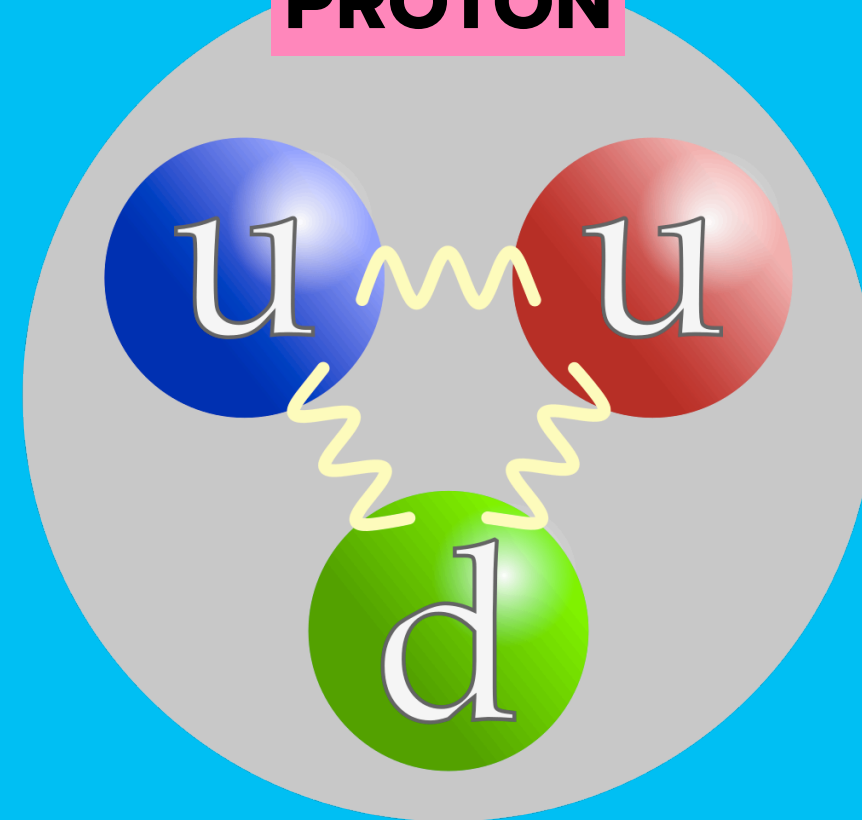


THE LARGE HADRON COLLIDER

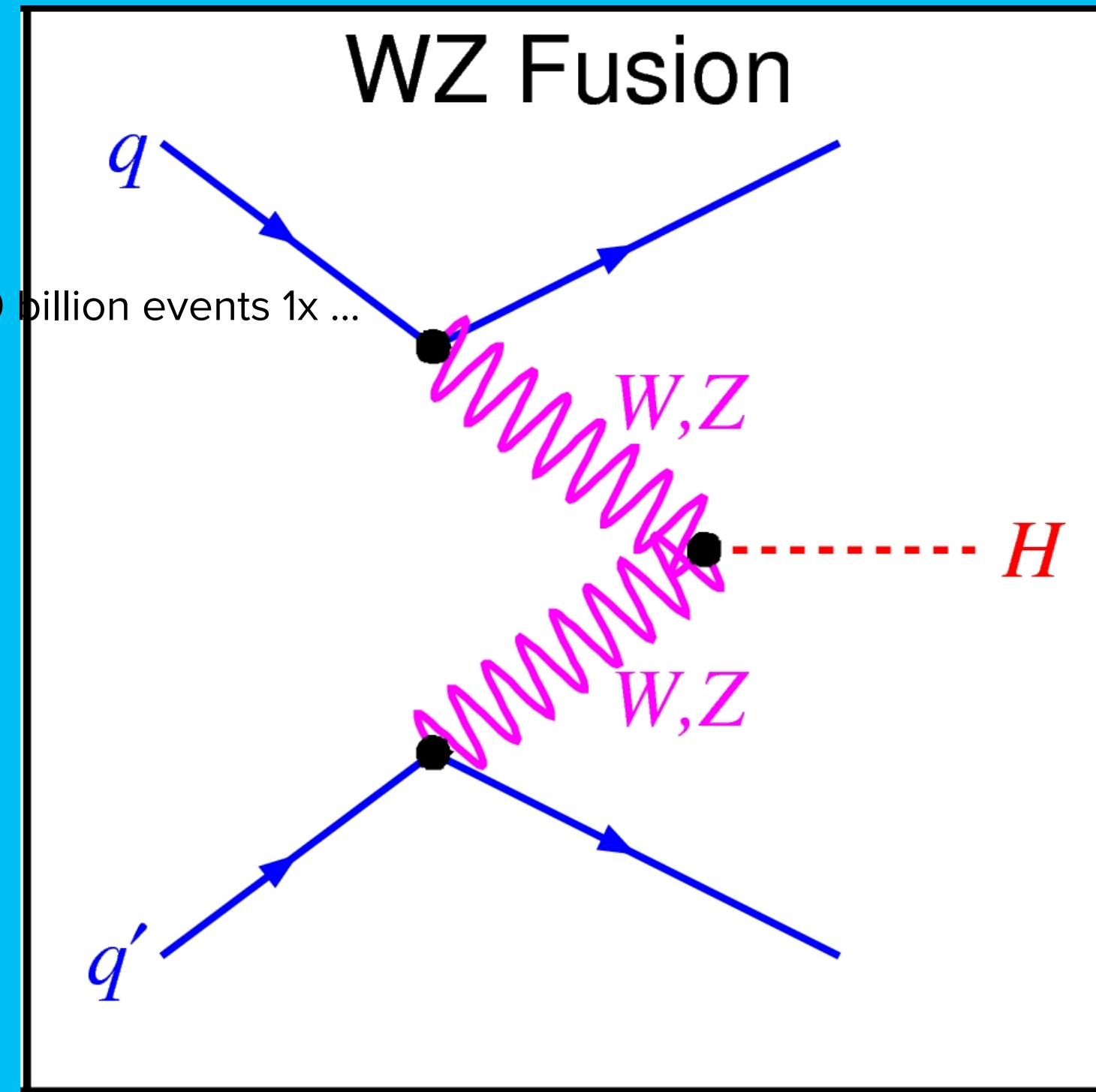
- 27 km circumference
- 100 m underground
- Protons reach energy of 6.5 TeV
- Magnets: superconducting at 1.9 K <(universe) = 2.7 K.
- Vacuum in the jet pipe 10 times emptier than on the moon

**HOW CAN WE CREATE NEW
PARTICLES FROM TWO PROTONS?**

PROTON



... about every 10 billion events 1x ...



+ MANY OTHER CHANNELS!

HOW OFTEN DO WE EXPECT TO OBSERVE HIGGS

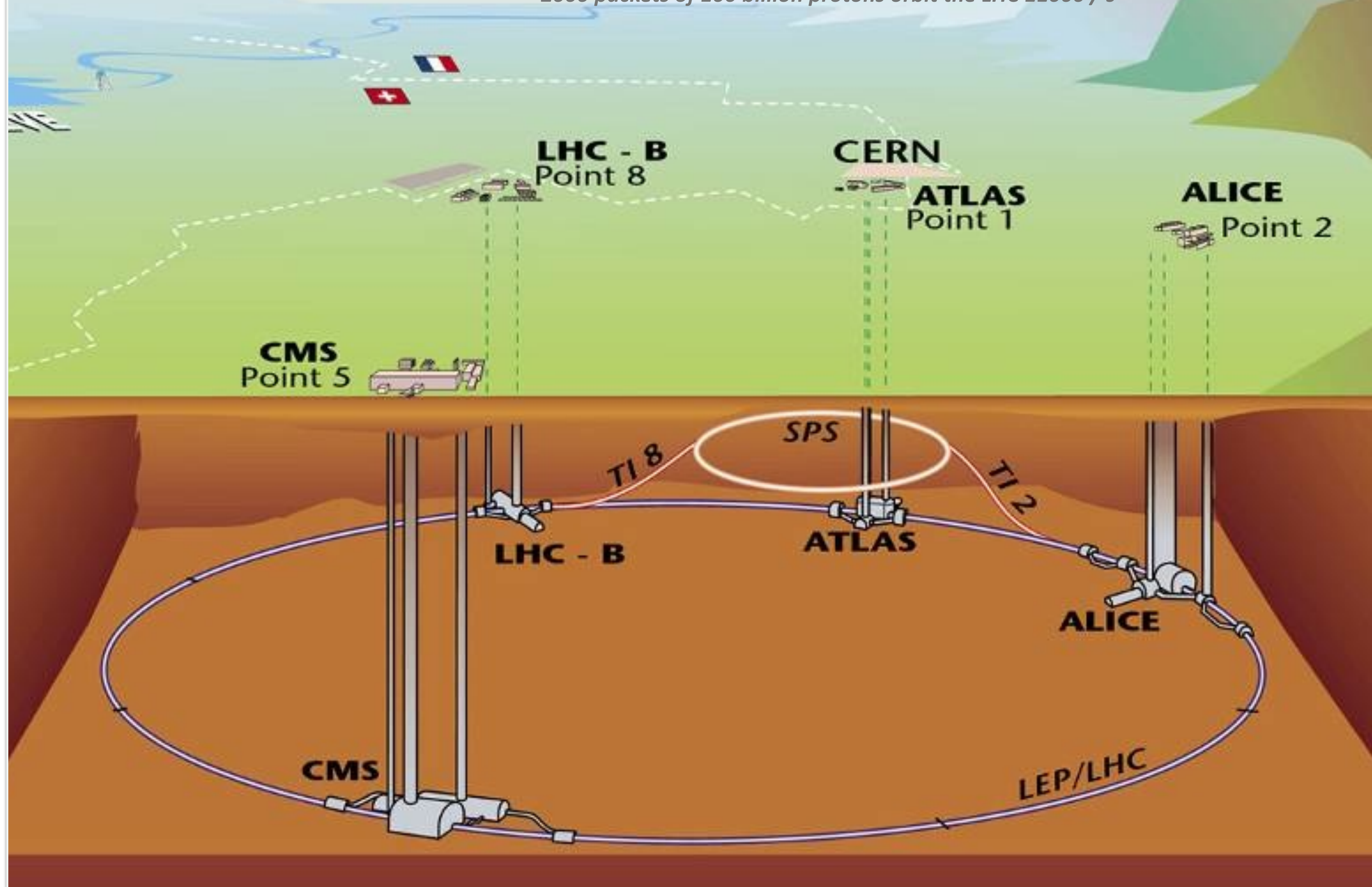


... about every 10 billion events 1x ...

WE NEED DETECTORS!

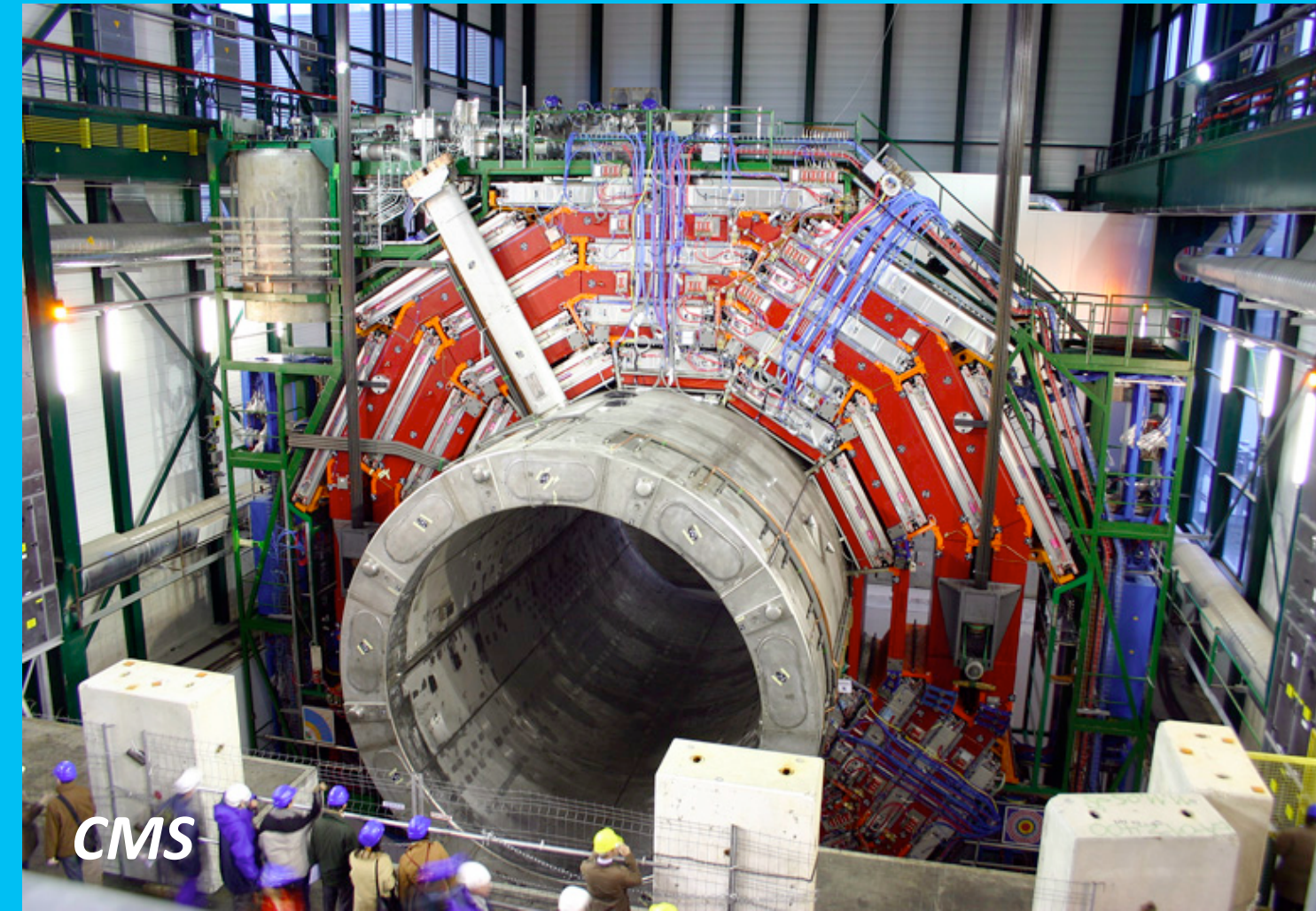
THE LARGE HADRON COLLIDER

2000 packets of 100 billion protons orbit the LHC 11000 / s

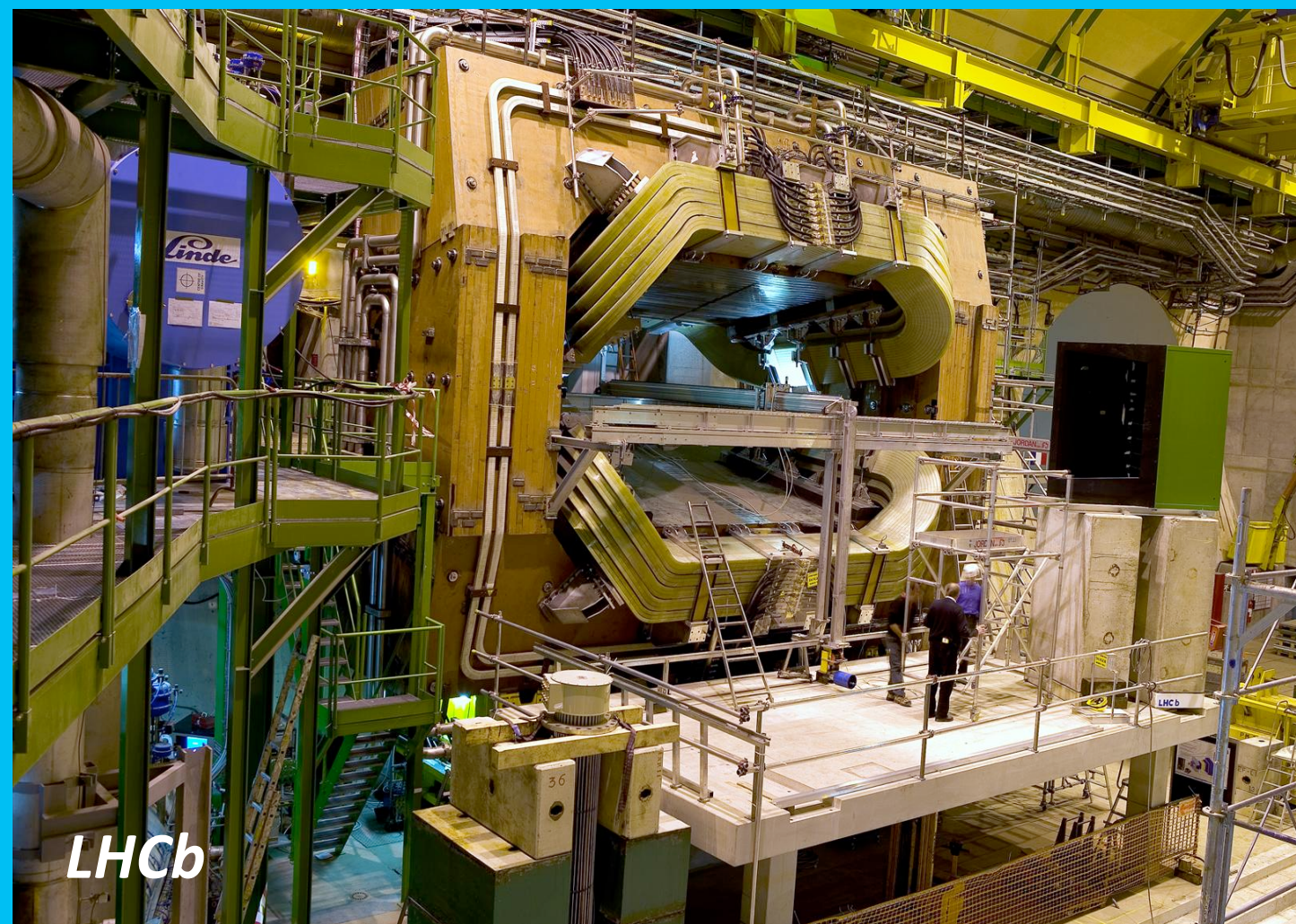




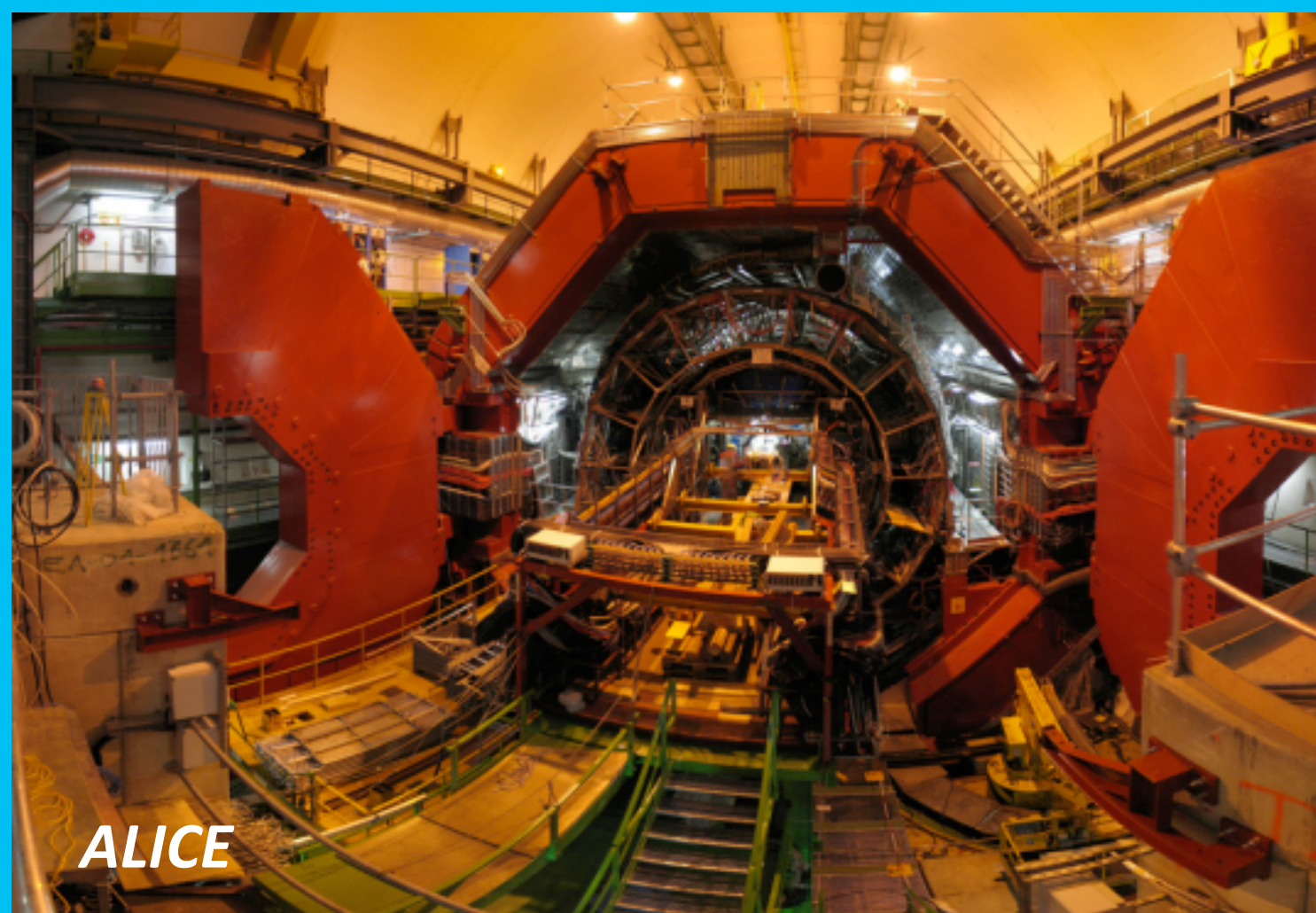
ATLAS



CMS



LHCb



ALICE

IF THE DETECTOR WERE A DIGITAL CAMERA

Resolution

100 mega-pixels

Data rate

2 MB / picture

Snapshots

100,000 frames / s in flash memory

Prints

200 frames / s in permanent memory

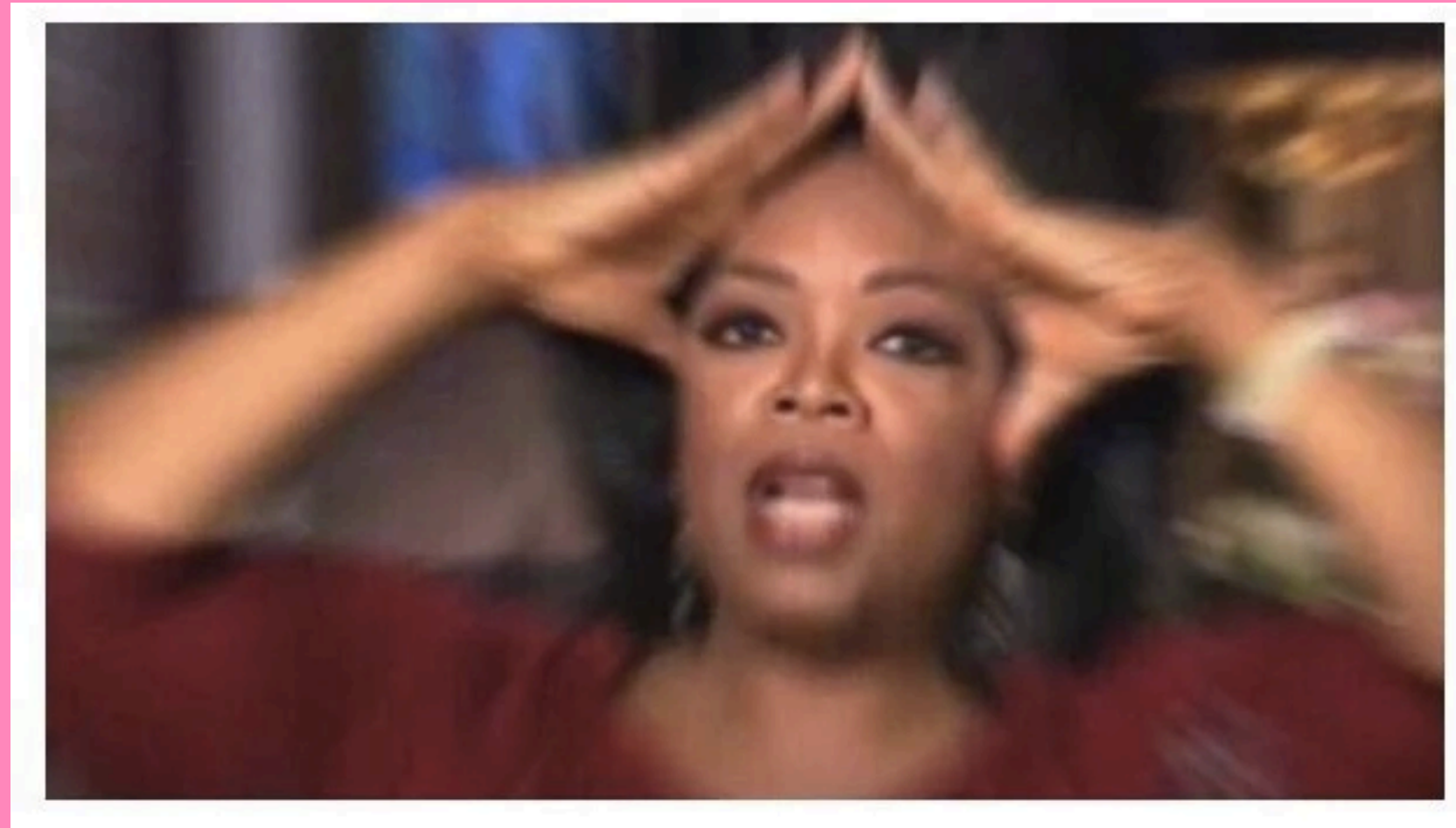
Data volume

90 PB / year



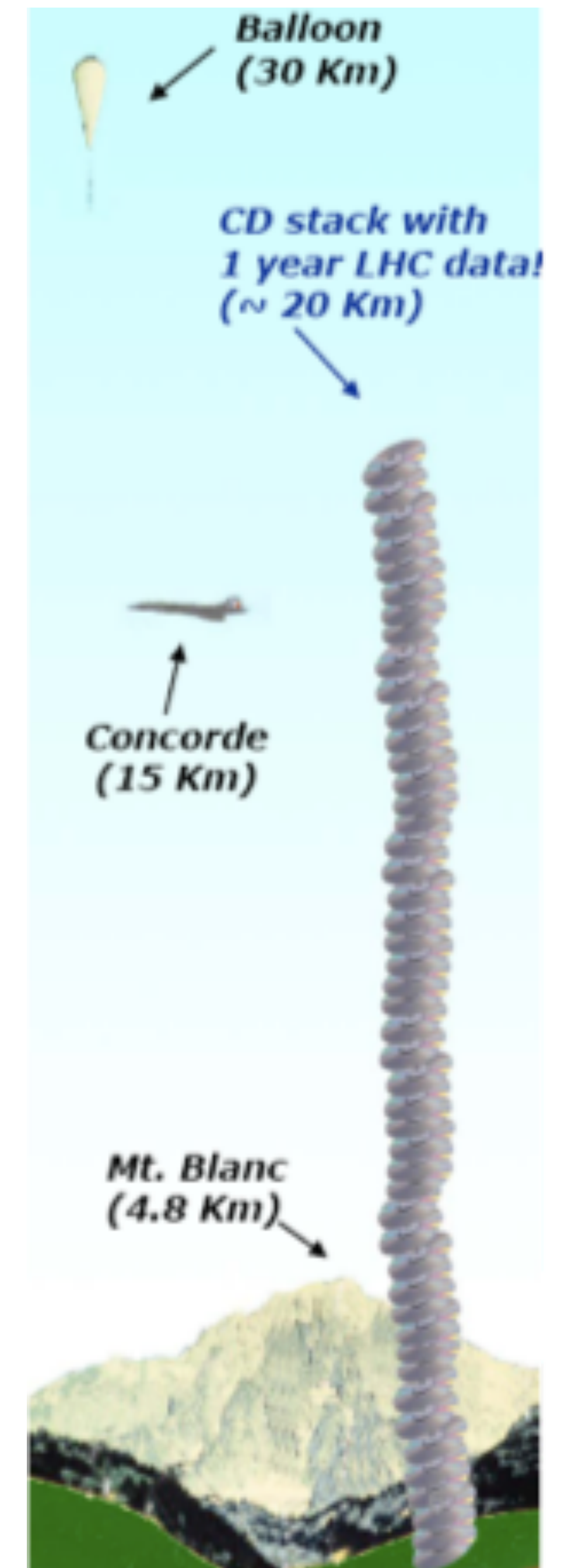
Before the particle accelerator

TOO MUCH DATA!



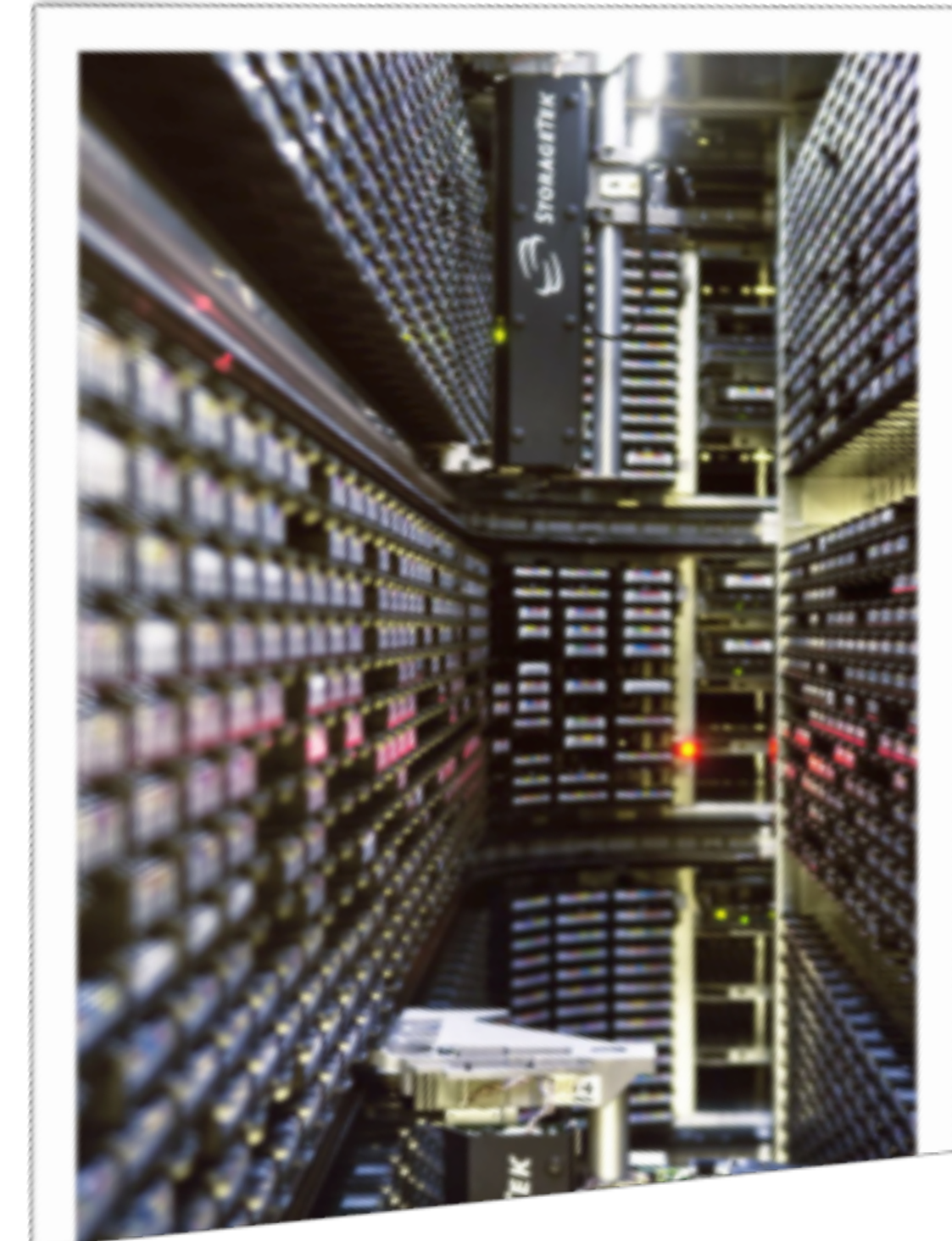
WE MUST FILTER!

- A total of 40 million collisions / s (80 TB / s)
 - We have to filter !!
- Interesting (e.g. Higgs-like) events trigger triggers
 - the photo is saved!
- Reduction to 200 "interesting" collisions / s

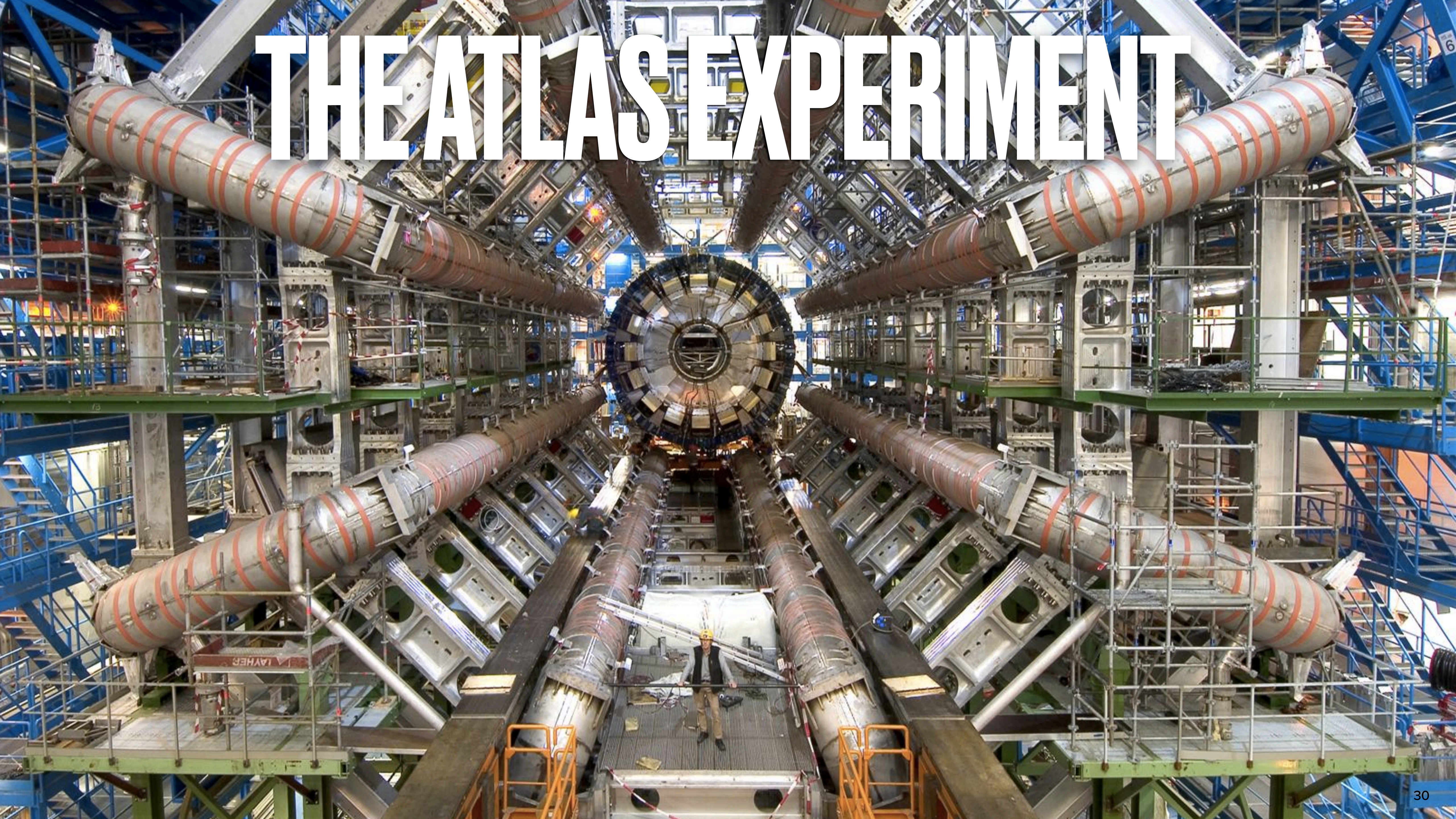


PROCESS, ANALYZE & STORE DATA

- A total of 40 million collisions / s (80 TB / s)
→ We have to filter !!
- 90 petabytes (90 million GB) of data per year
- Interesting (e.g. Higgs-like) events trigger triggers → the photo is saved!
- Cern has an extremely powerful computer grid
- Networks 200 computer centers around the world

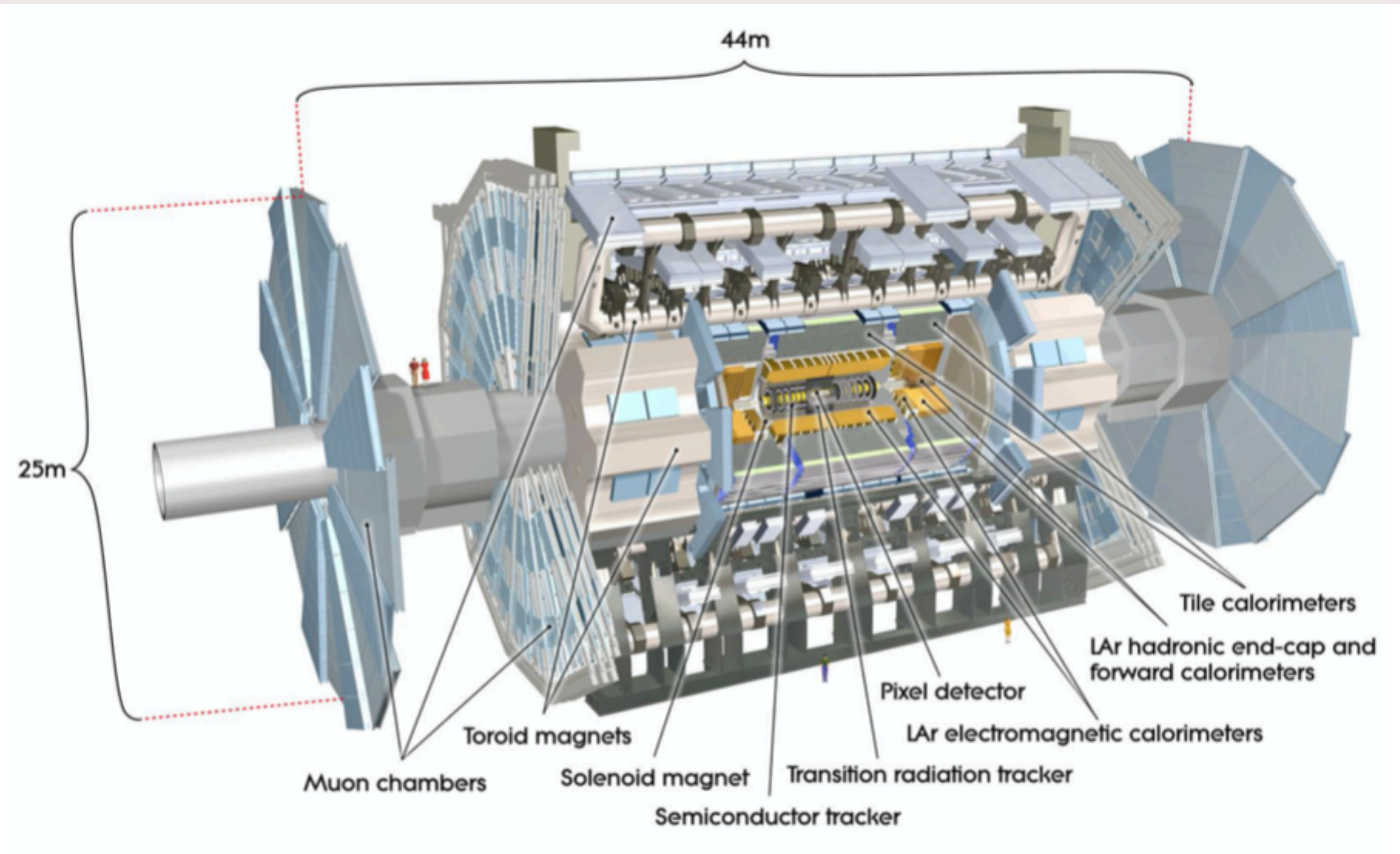


THE ATLAS EXPERIMENT



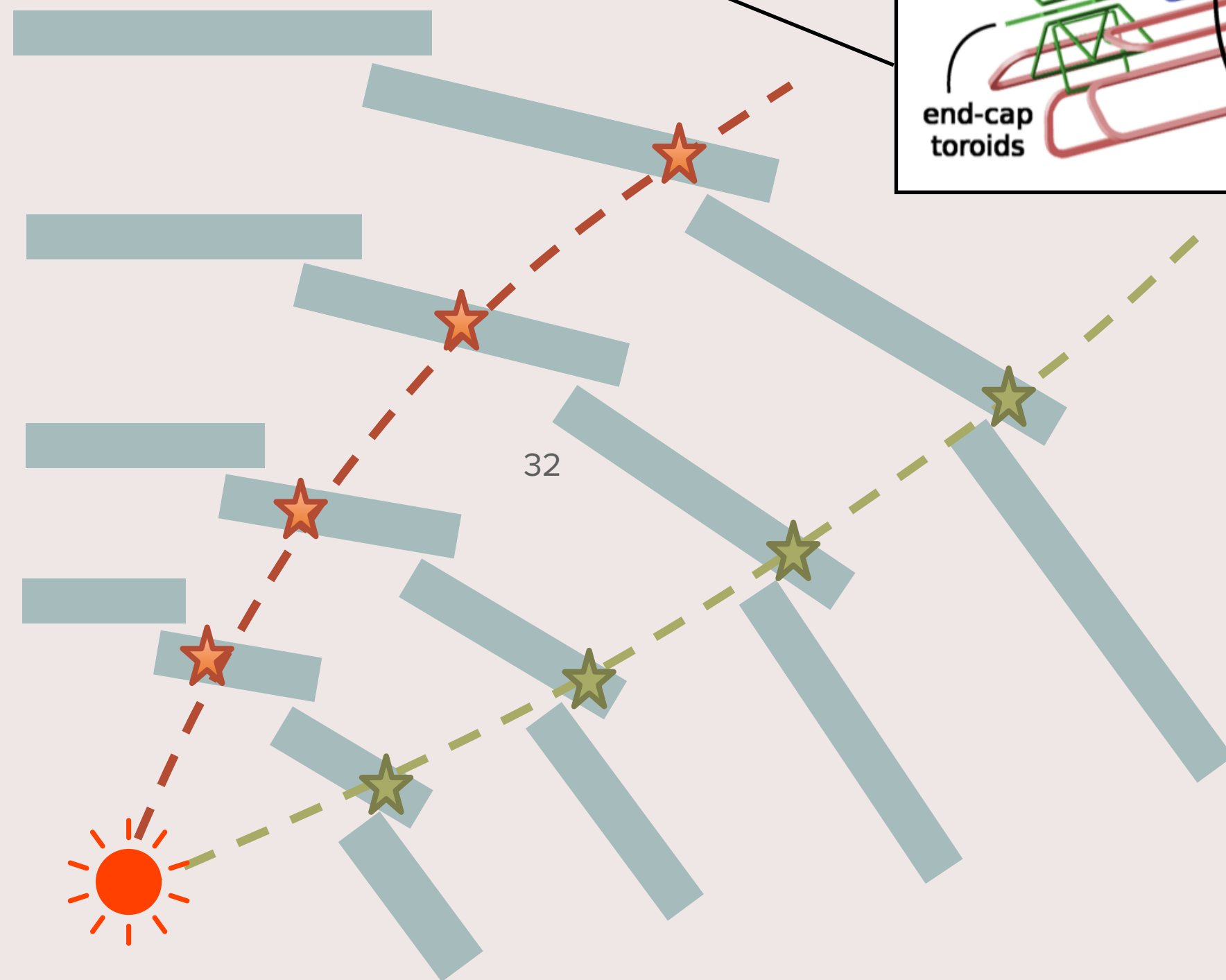
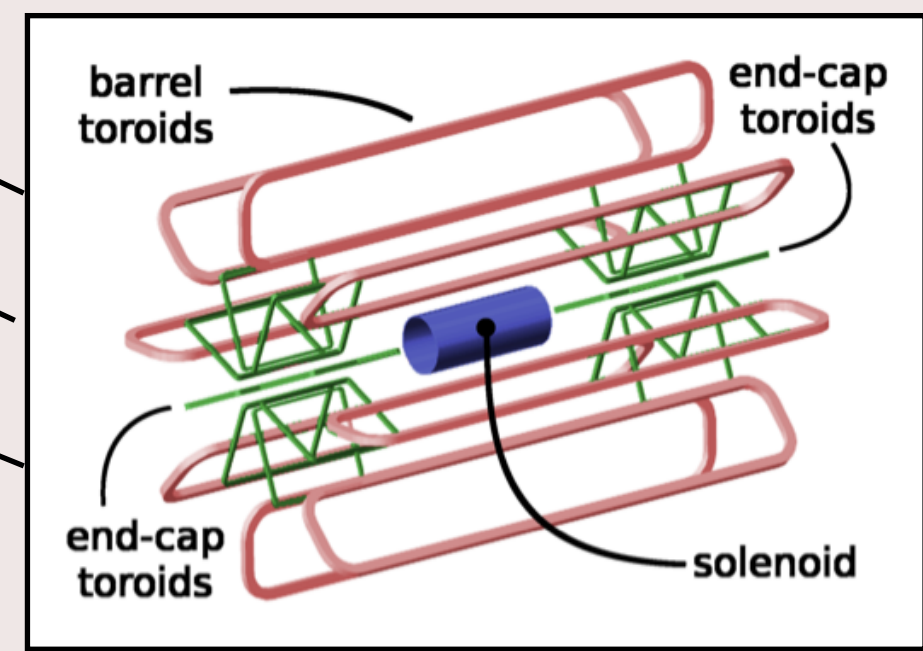
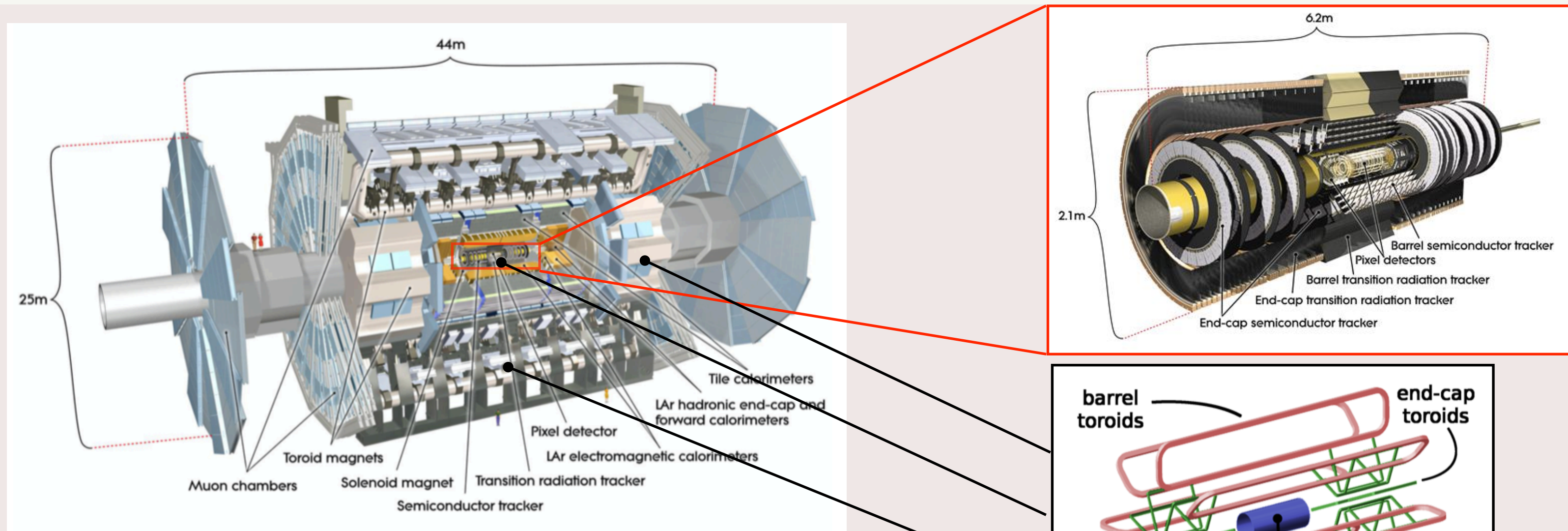
ATLAS Detector

A Toroidal LHC Apparatus

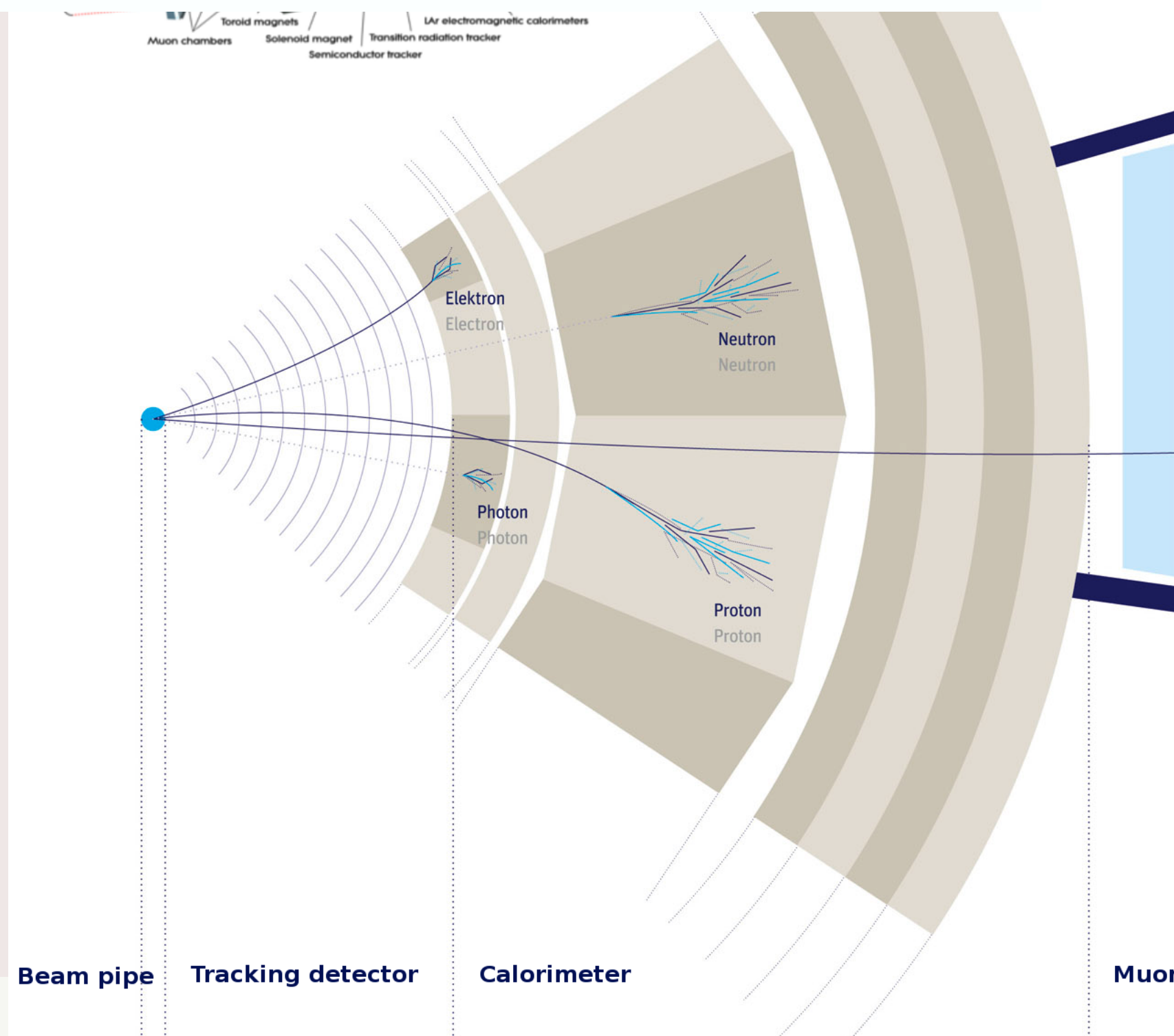
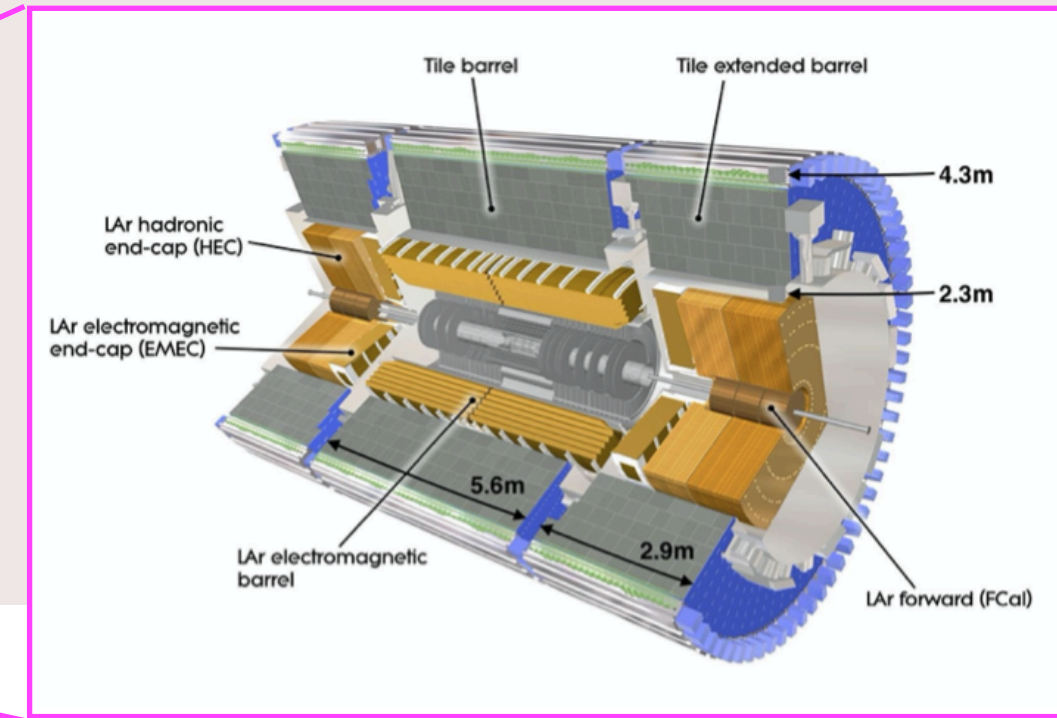
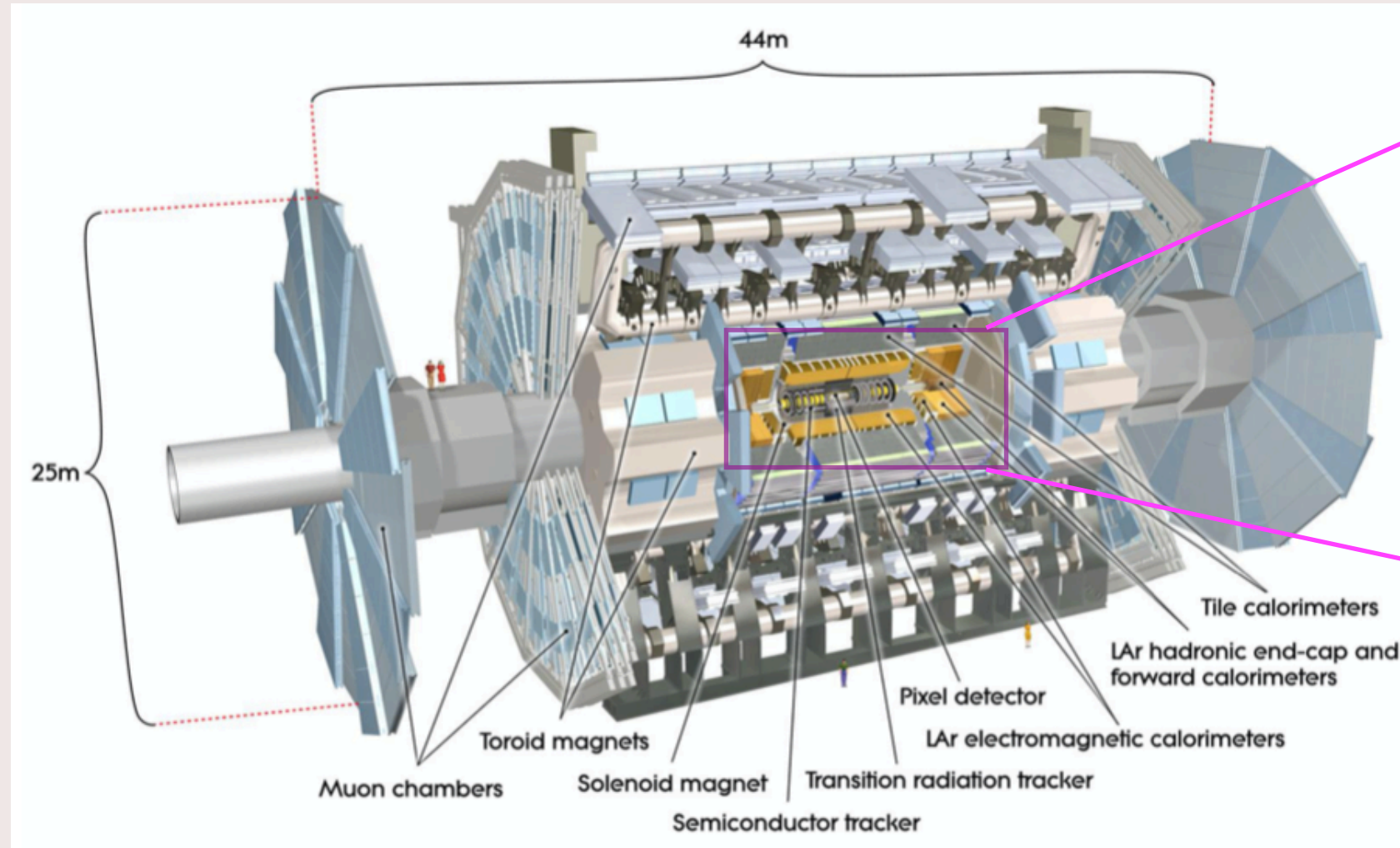


7000 ton

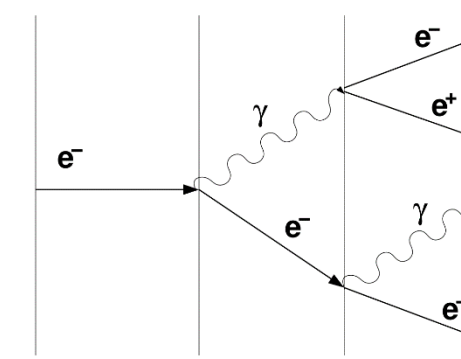
ATLAS Experiment - Inner Detector



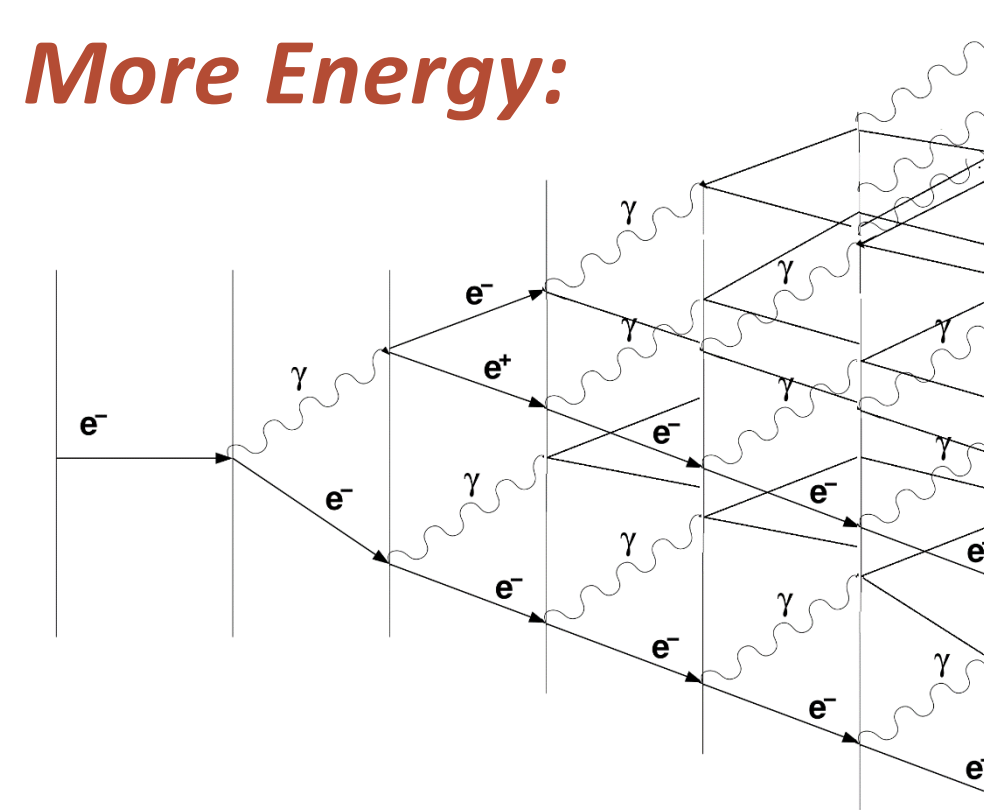
ATLAS Experiment - Calorimeters



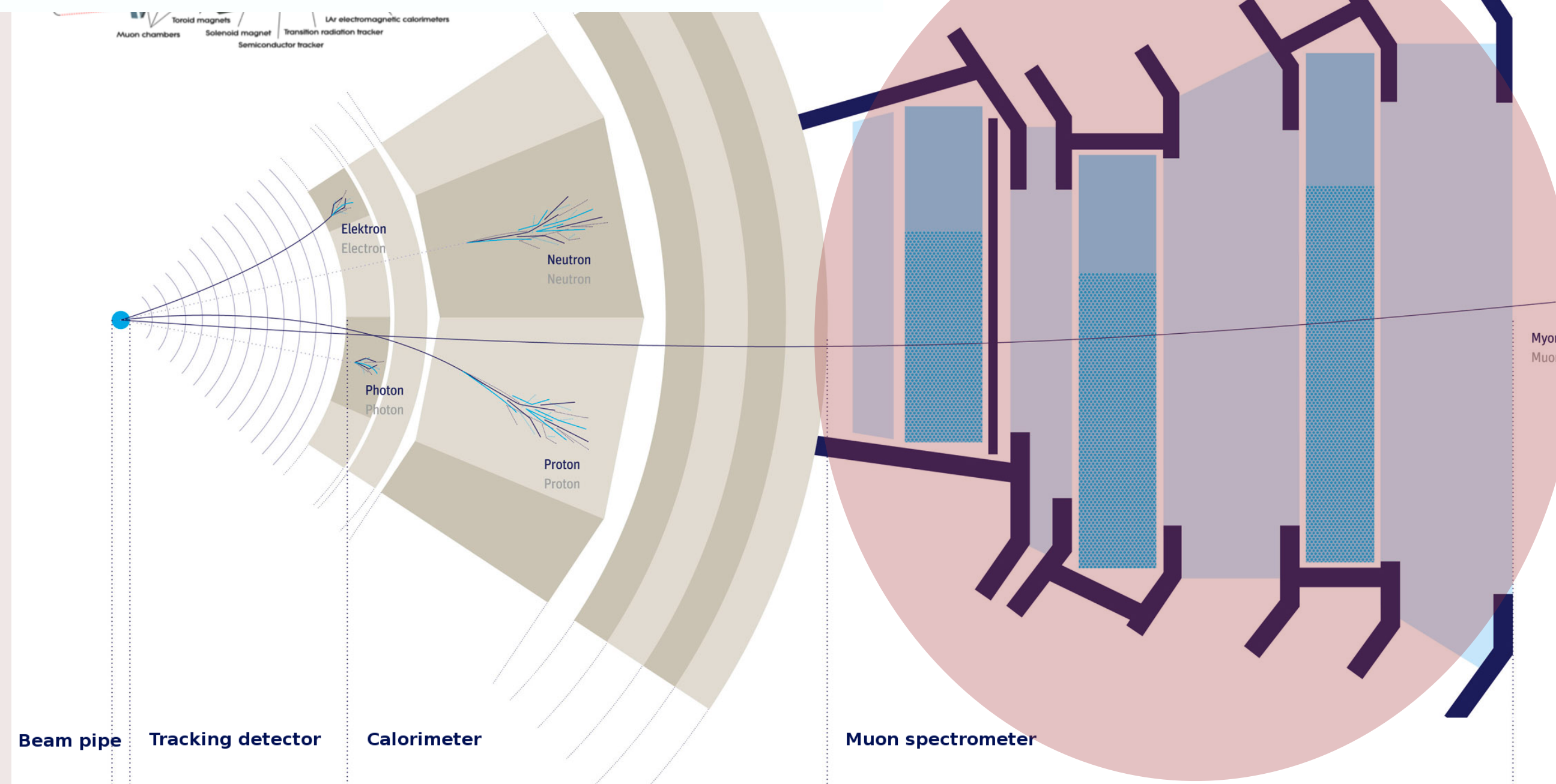
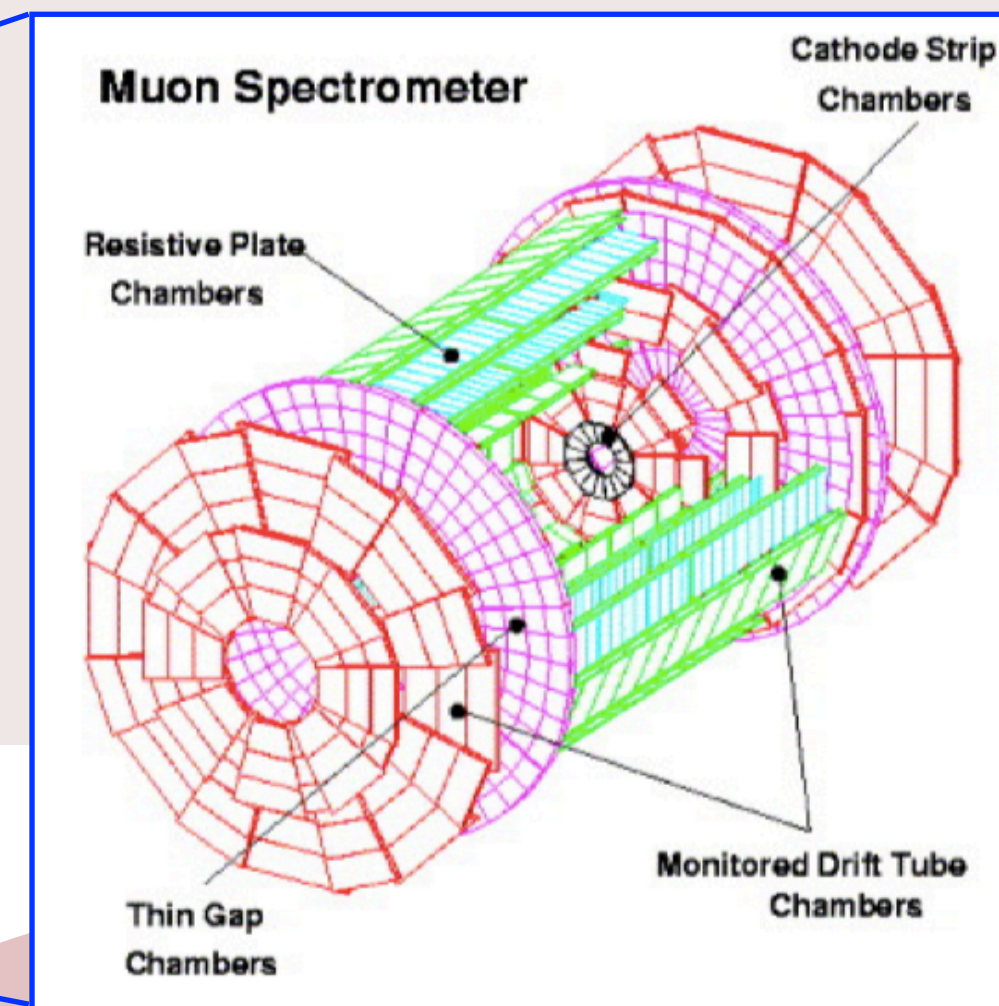
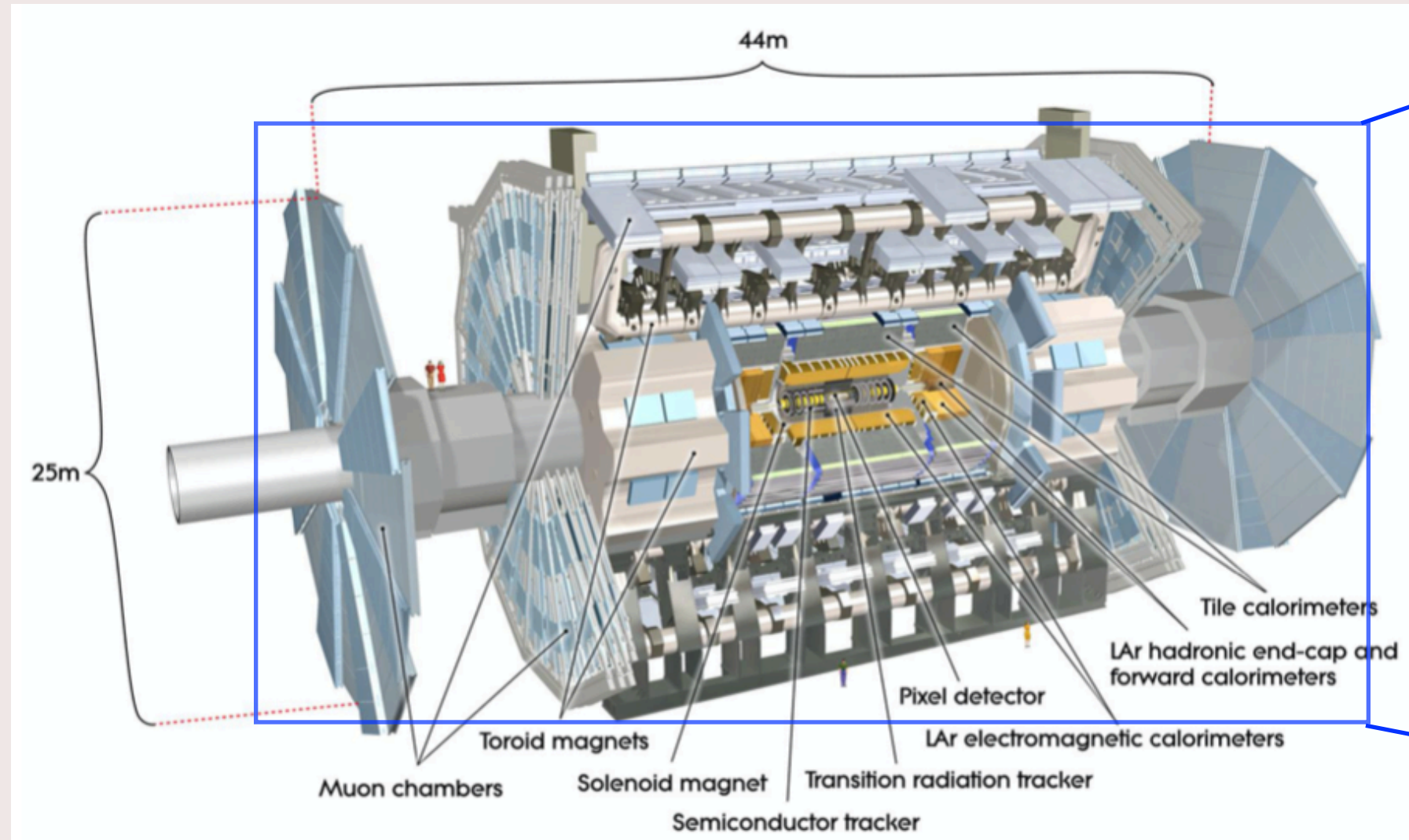
Less Energy:

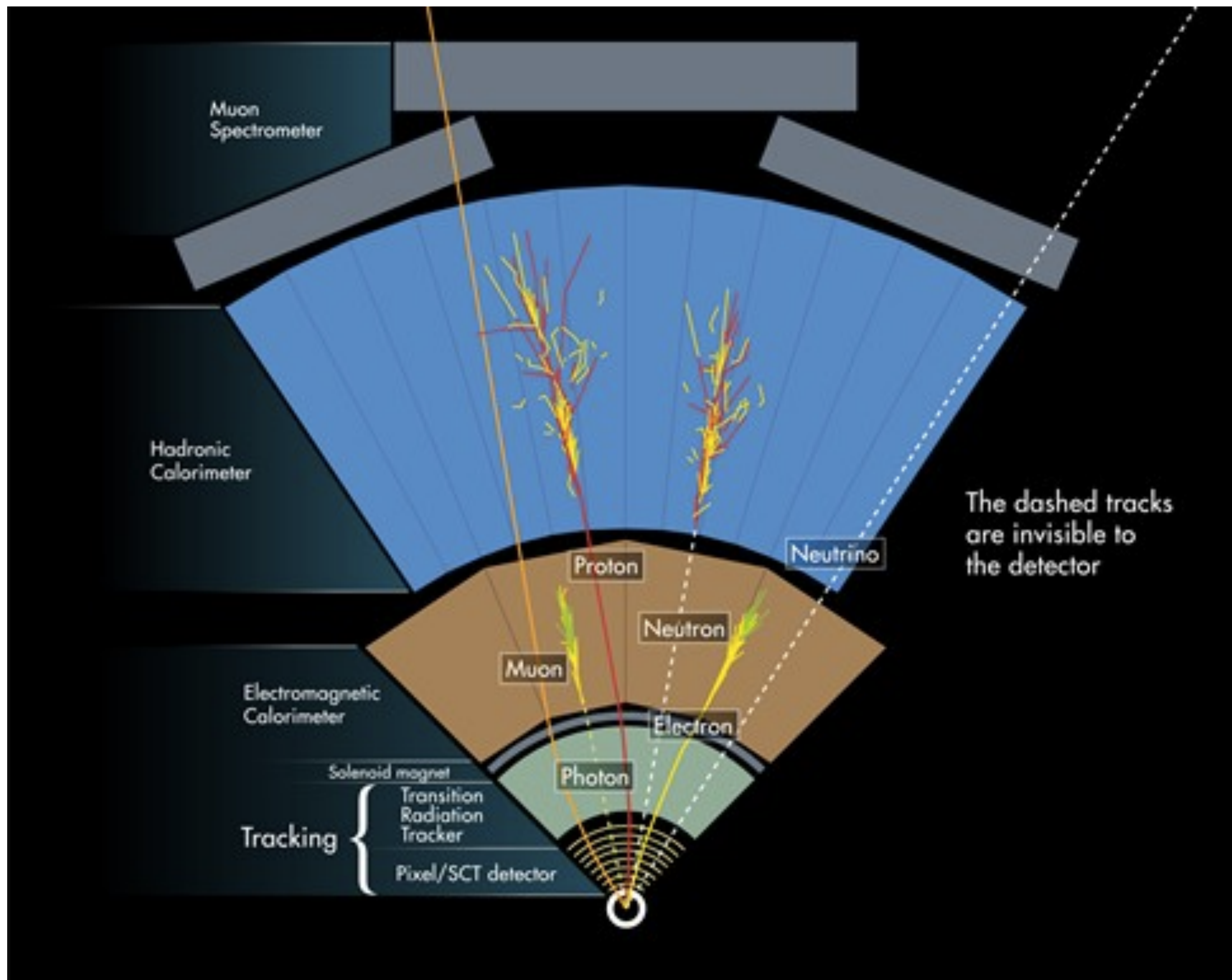


More Energy:



ATLAS Experiment - Muon System





THANKS FOR YOUR ATTENTION!

HAVE FUN WITH THE ANALYSIS!