

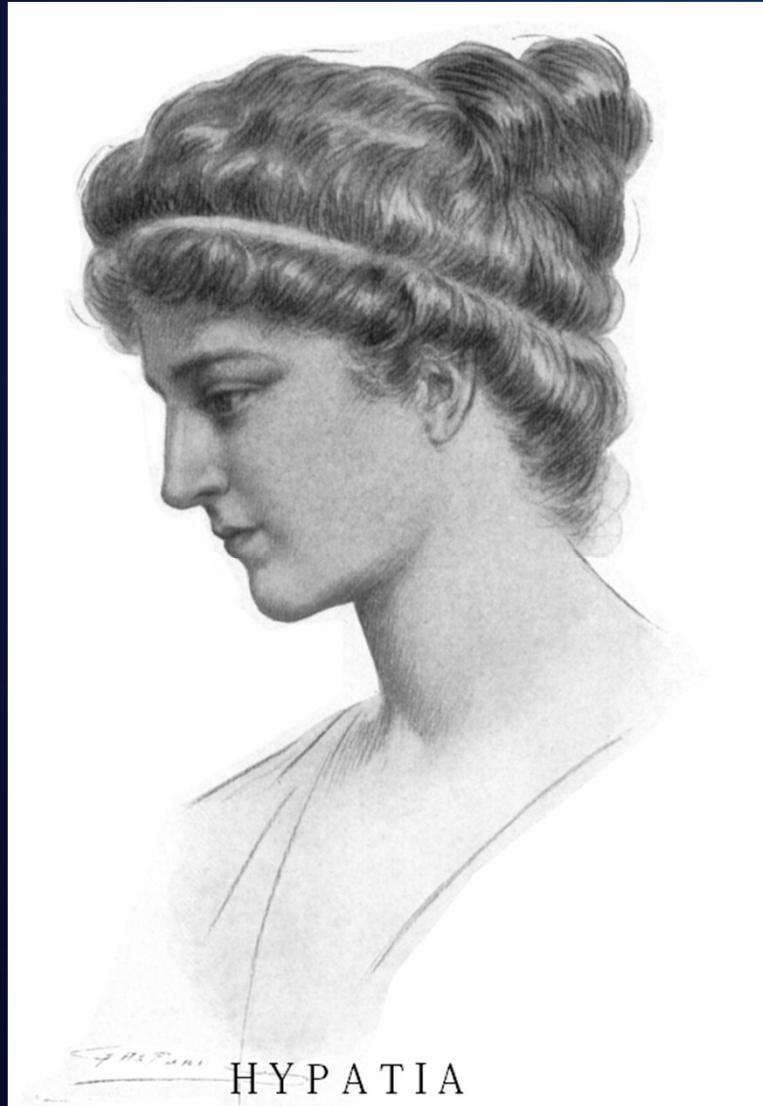
Search for the Z and Higgs Bosons

Christine Kourkoumelis

Stelios Vourakis

University of Athens

Hypatia of Alexandria

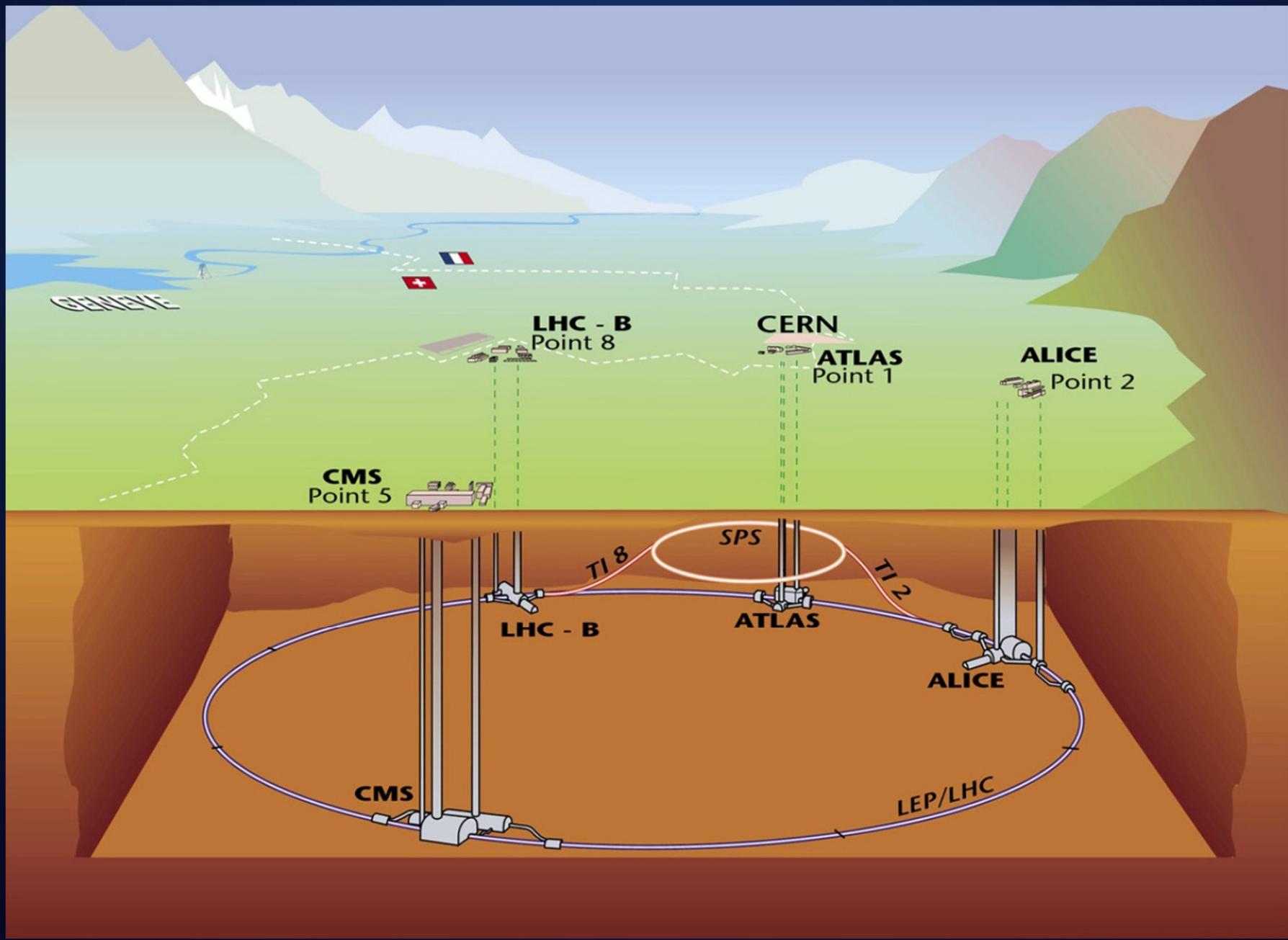


- First Woman Mathematician
- Alexandria, Egypt
(370 - 418 B.C.)

HY.P.A.T.I.A.

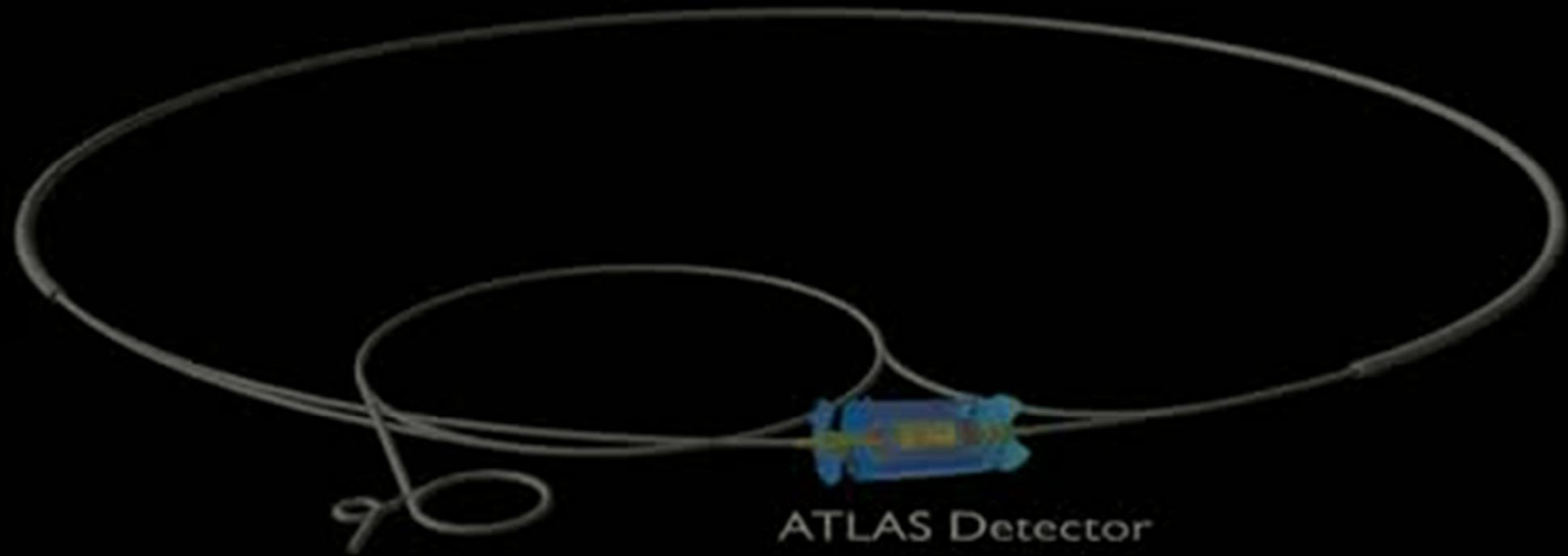
- Event Display for **real events** from the ATLAS experiment
- Developed by the **University of Athens**
- Part of several E.U. projects **Learning with ATLAS@CERN**, **The Pathway to Inquiry Based Science Teaching**, **Discover the Cosmos**, **GoLab**, **ISE**, **Creations**, **Frontiers**, **Reinforce**.
- Allows high school students and teachers to study fundamental particles and their interactions
- For **scientific** and **educational** use

LHC and ATLAS

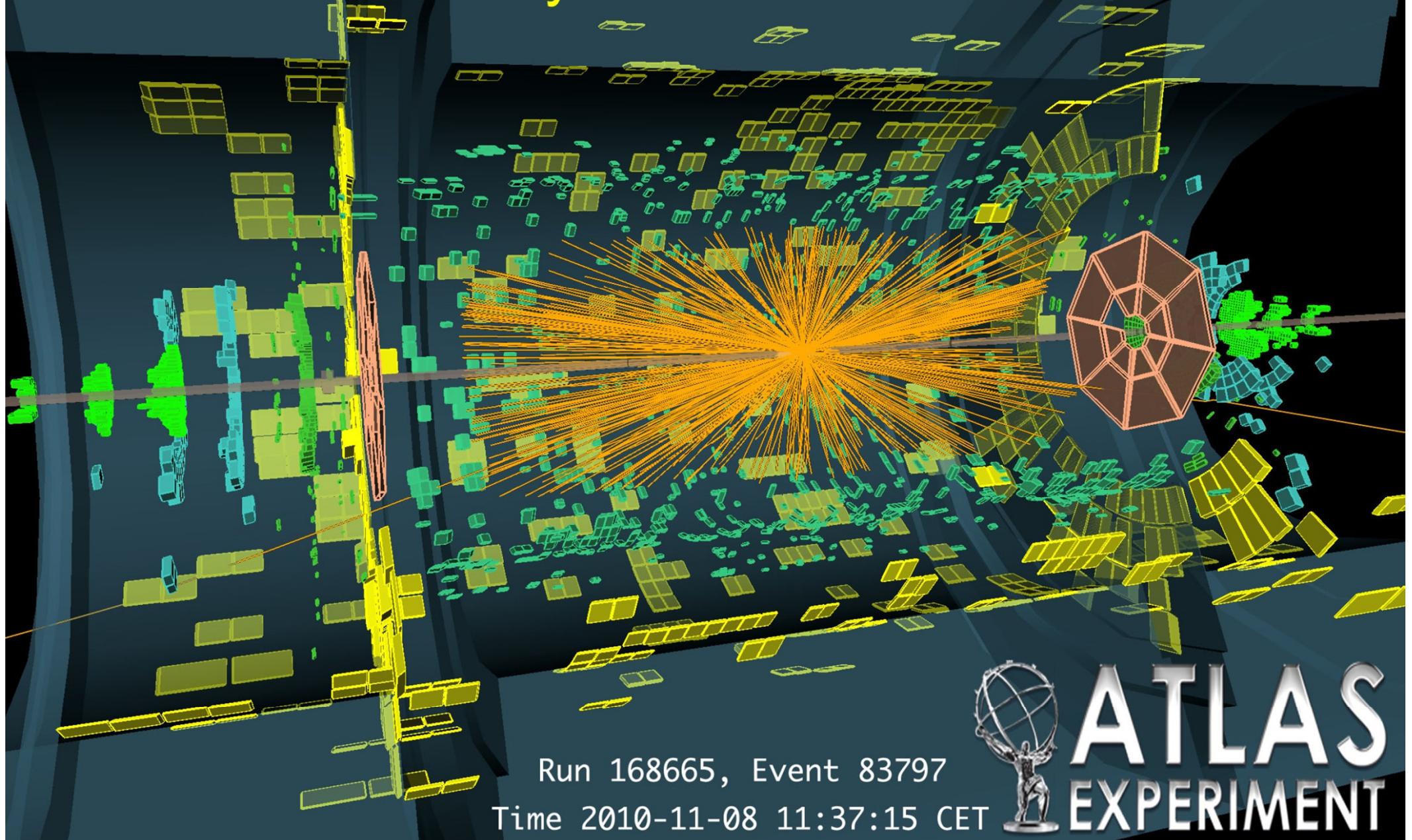


PLAY▶

Large Hadron Collider



Heavy Ion Collision Event



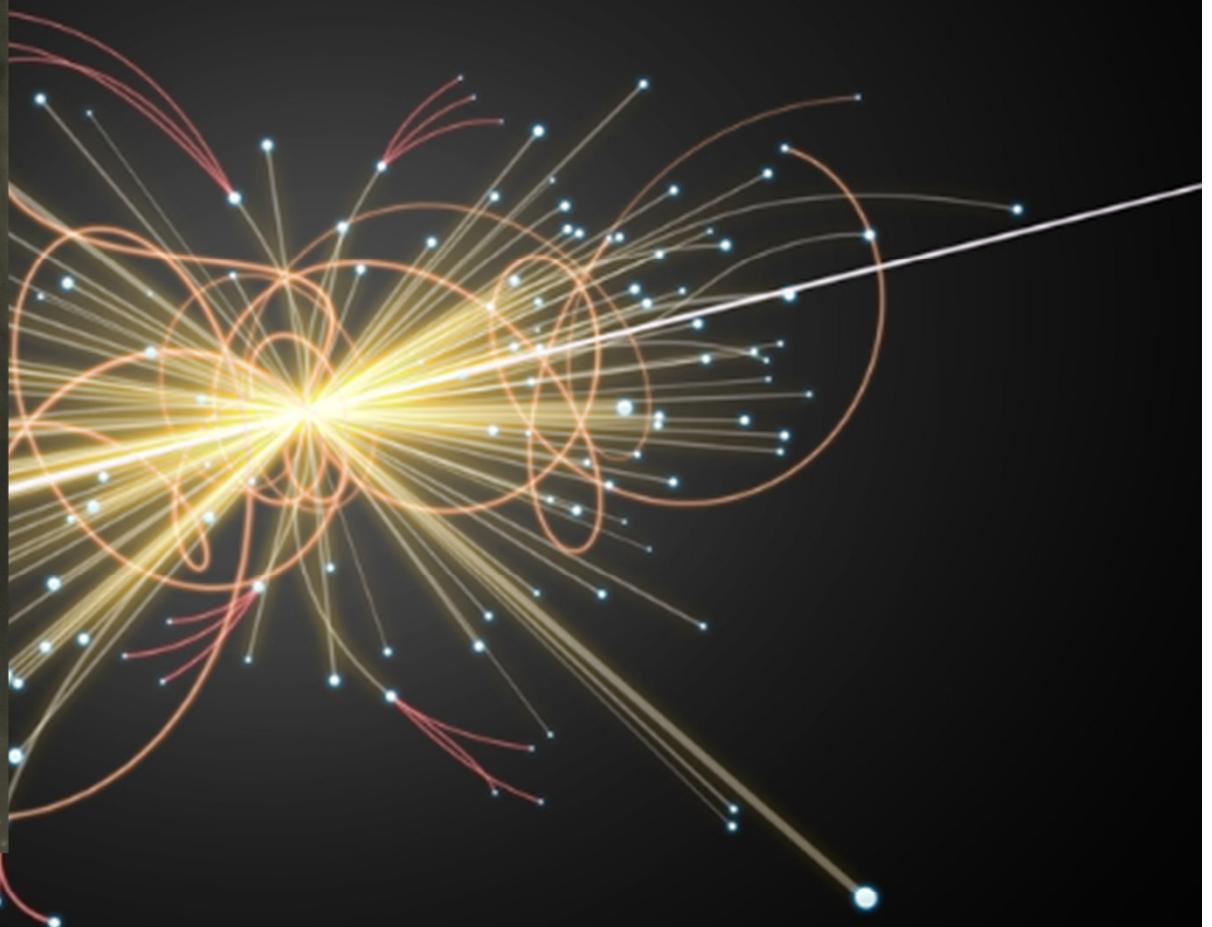
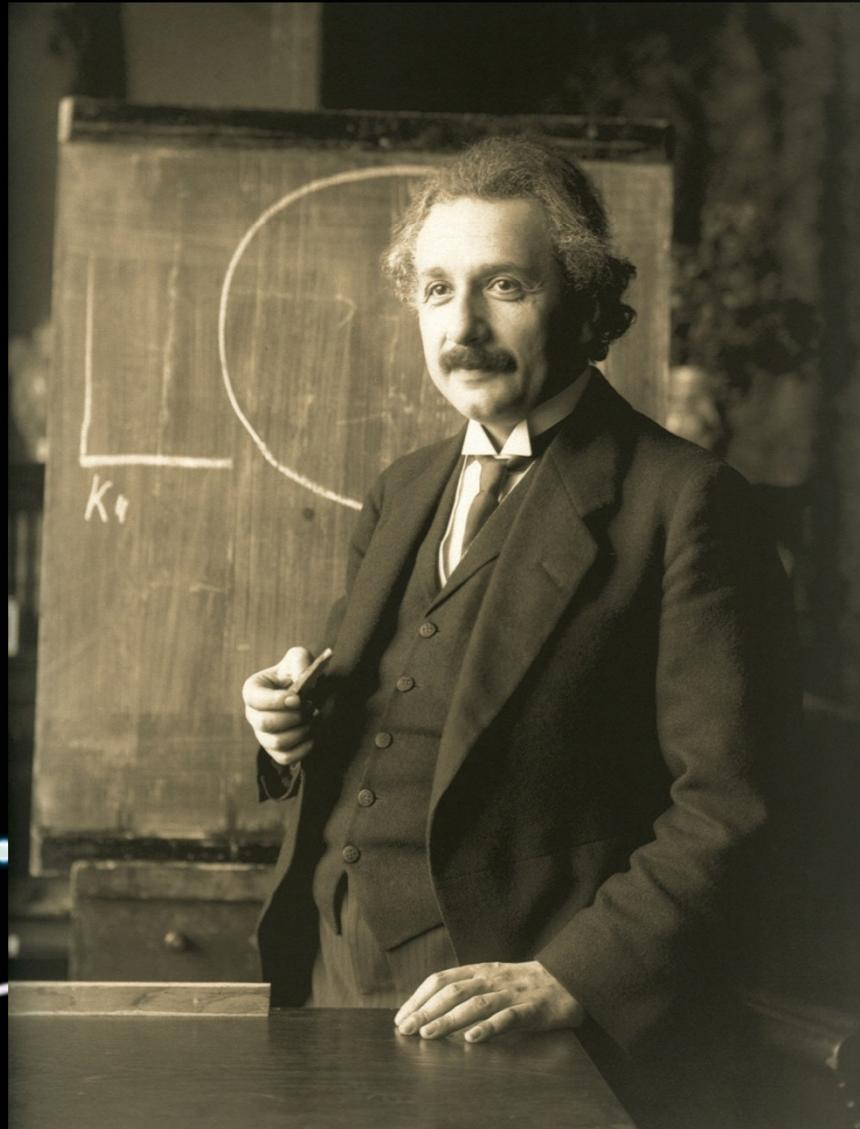
Run 168665, Event 83797
Time 2010-11-08 11:37:15 CET



ATLAS
EXPERIMENT

$$E=mc^2$$

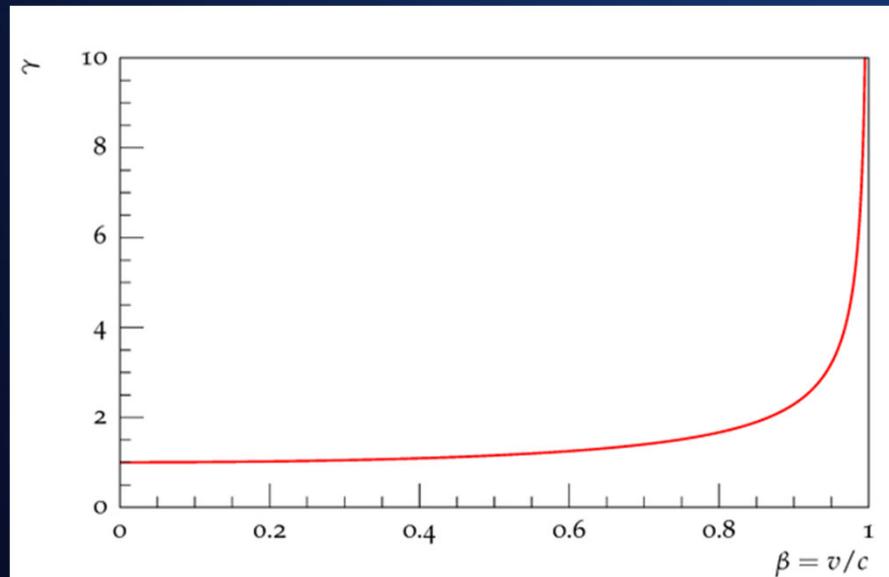
Does the Inertia of a Body Depend Upon Its Energy Content? – Sep. 1905



Proton Energy

Proton rest mass ≈ 1 GeV

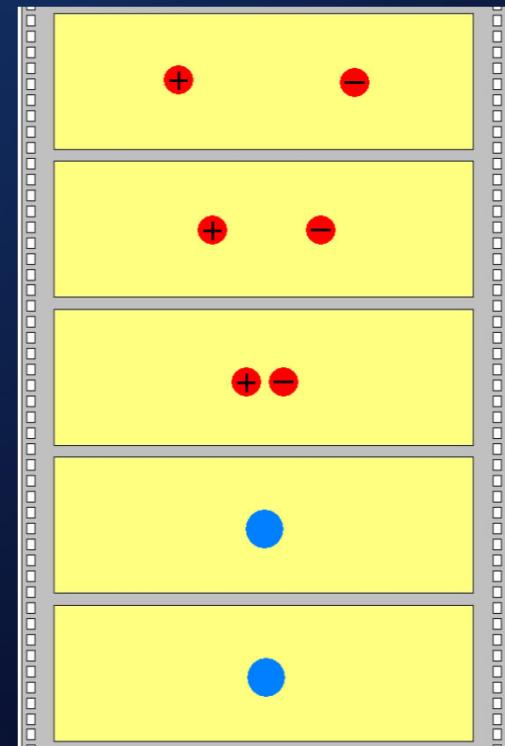
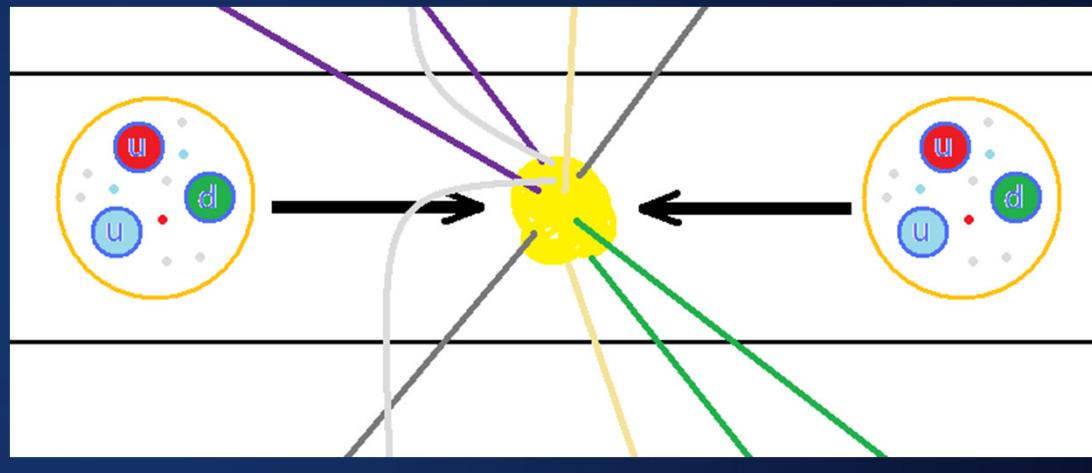
Moving particle mass $E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$



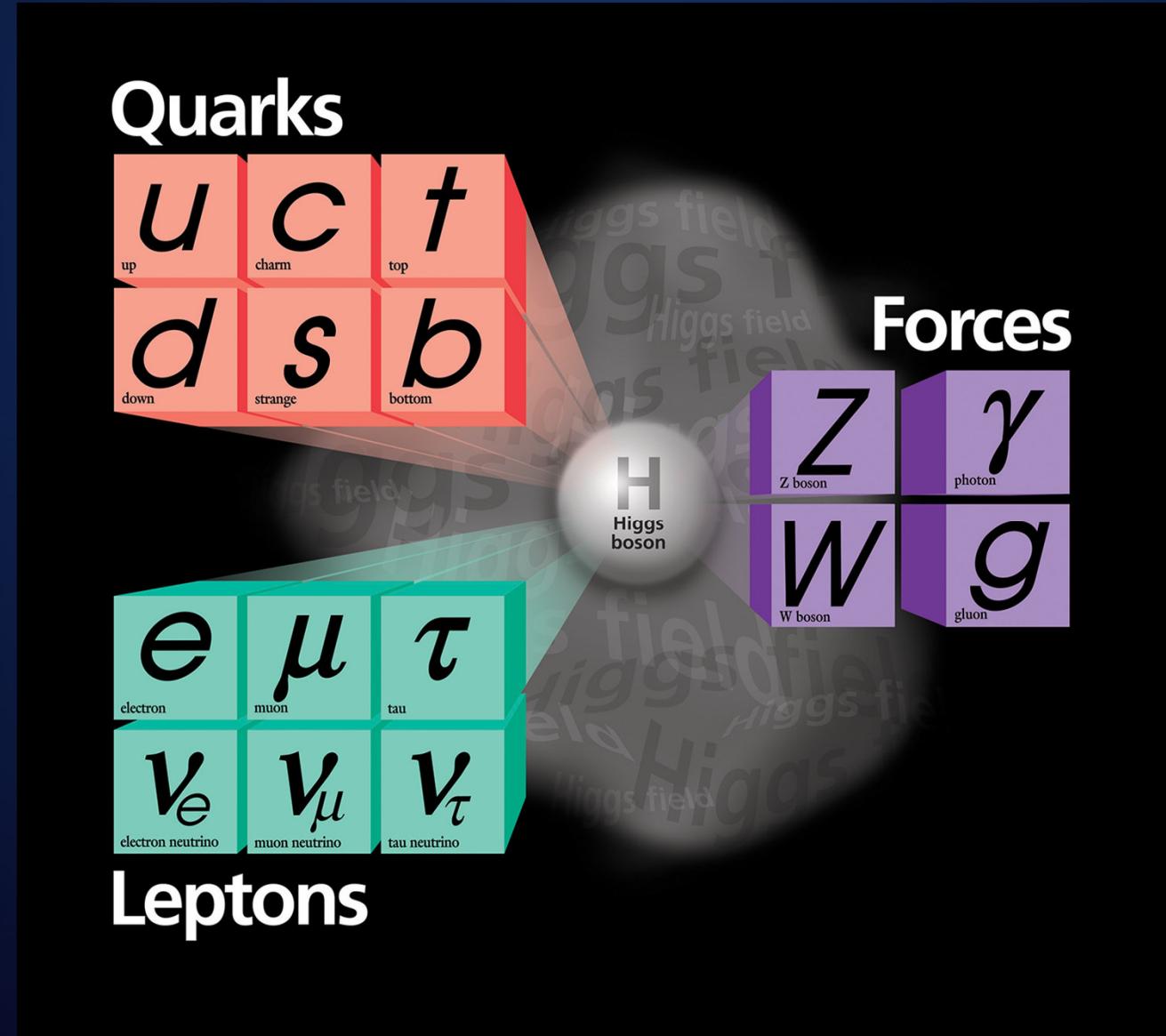
Proton mass at $0,999999991c = 7000$ GeV

Συγκρούσεις

- Each proton has 7 TeV energy (*14 TeV total*)
- Some of the particles produced are unstable and decay immediately



Exercise



Exercise

Z^0 boson

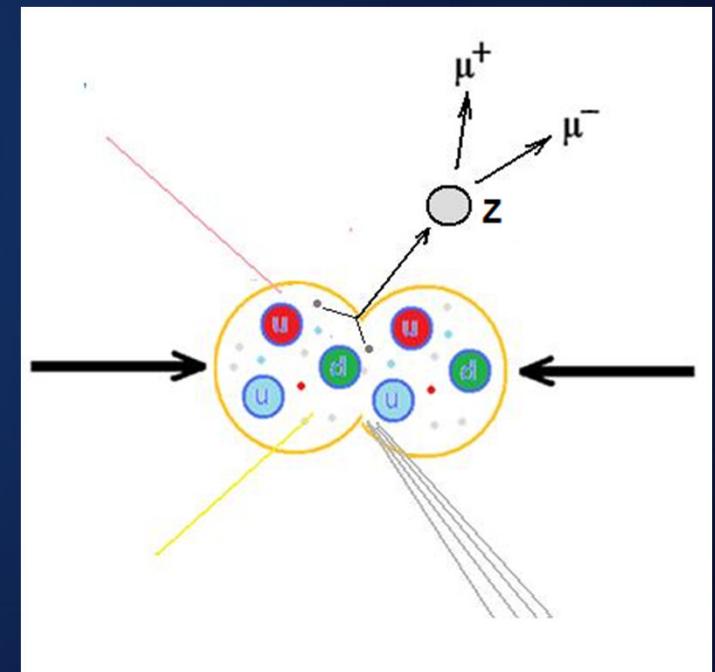
- Carrier of the weak nuclear force (along with W^+ , W^-)
- Discovered in 1974 at CERN
- 1979 Nobel Prize in Physics, Glashow, Weinberg και Salam
- Neutral
- Mass 91.1876 ± 0.0021 GeV
- Decays immediately (3×10^{-25} sec)

Exercise

Discovery and calculation of the mass of Z^0

Real Events

- $Z^0 \rightarrow e^- + e^+$ $Z^0 \rightarrow \mu^- + \mu^+$
- 2 Tracks, Opposite sign, Isolated
- Invariant mass 91,2 GeV
- Low missing energy (E_{miss})



- **Background events**
- Usually contain only one lepton ($W \rightarrow \text{lepton} + \nu$)
- Cosmic rays: opposing tracks on both projections
- High ETMiss (Neutrinos)

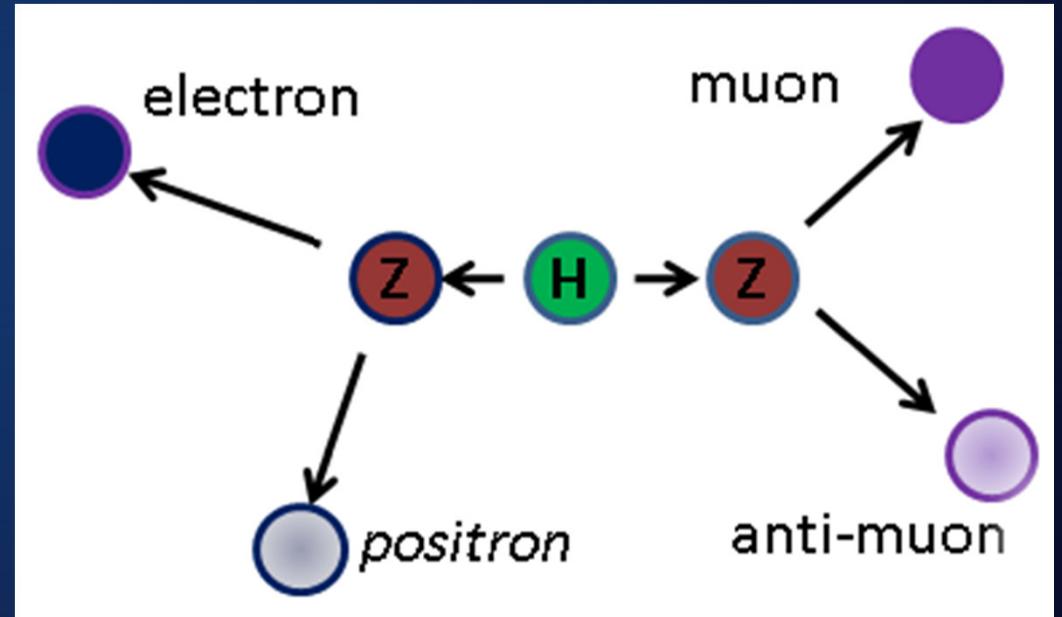
Exercise

Discover the Higgs

$$H \rightarrow 2 Z \rightarrow 4l$$

$$Z \rightarrow e^- + e^+ \text{ or } Z \rightarrow \mu^- + \mu^+$$

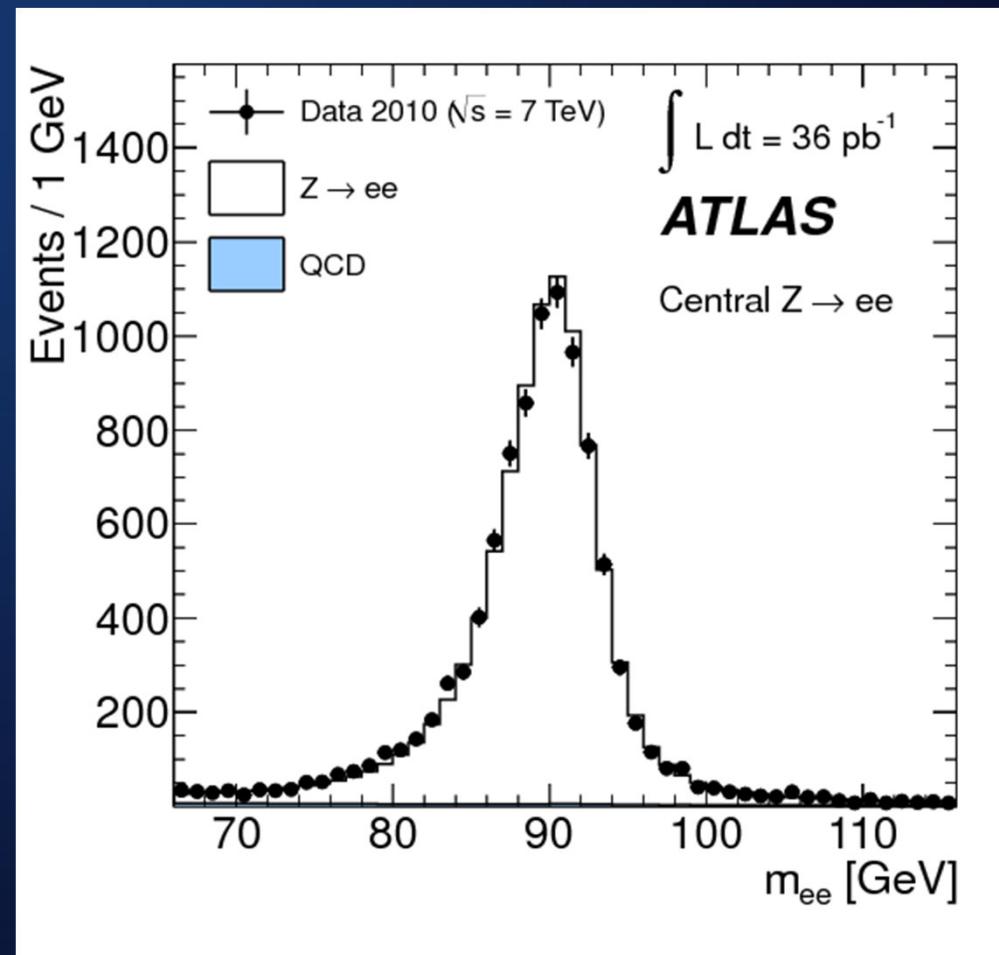
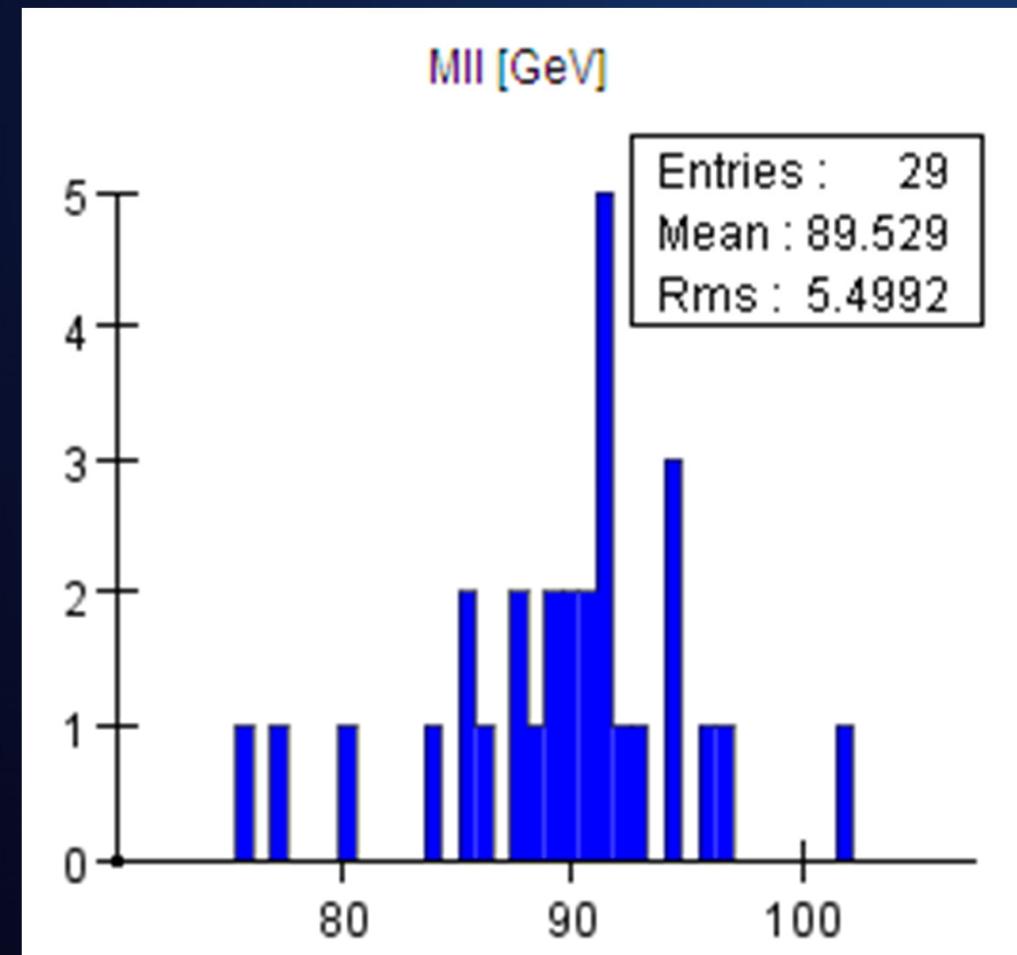
- $H \rightarrow 2 e^- + 2 e^+$
- $H \rightarrow 2 \mu^- + 2 \mu^+$
- $H \rightarrow e^- + e^+ + \mu^- + \mu^+$



- Isolated Tracks
- 6 GeV Cut
- 4 track invariant mass
- Simulated Higgs, mass 180 GeV

Exercise

Mass Histograms

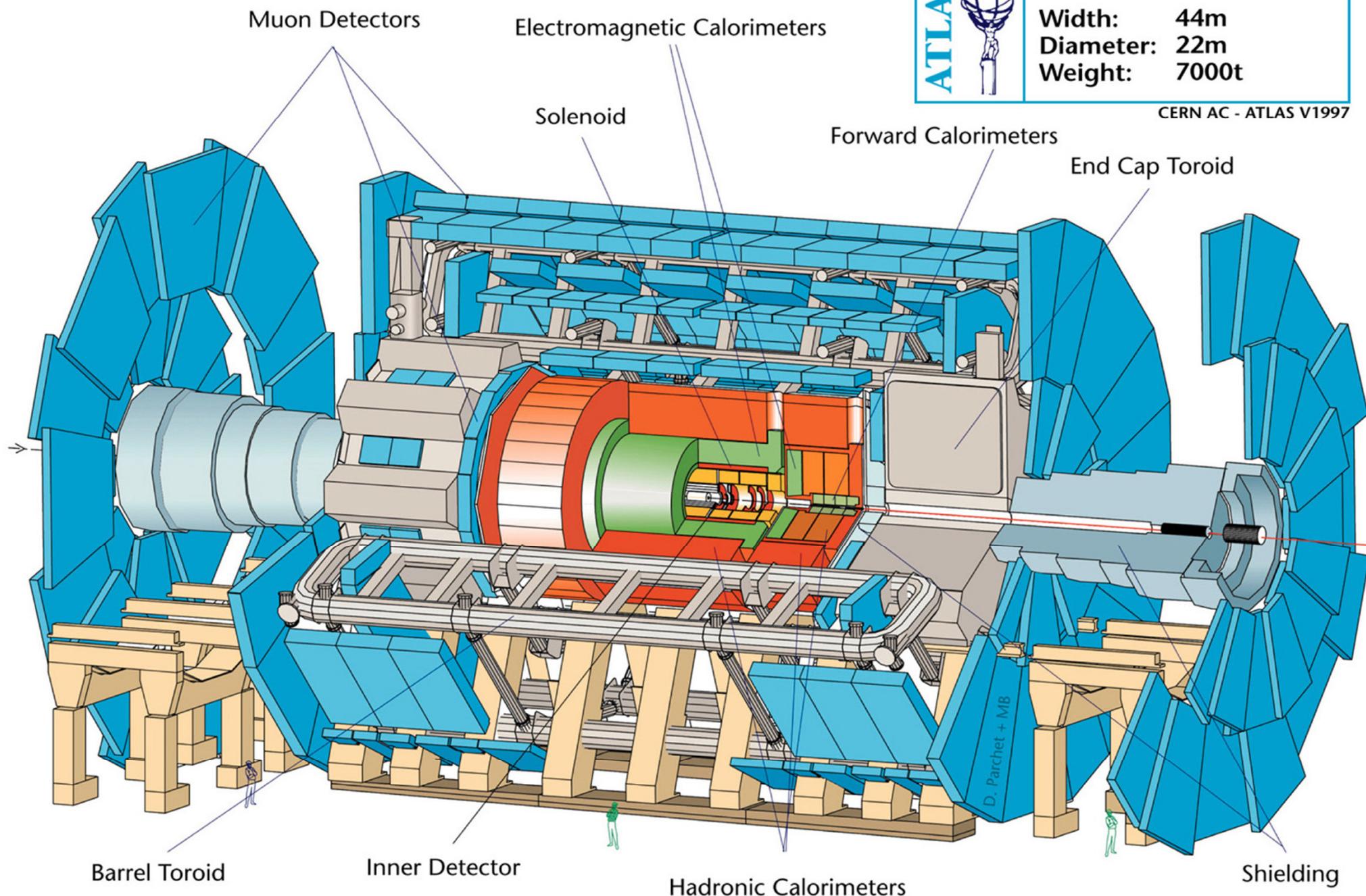




Detector characteristics

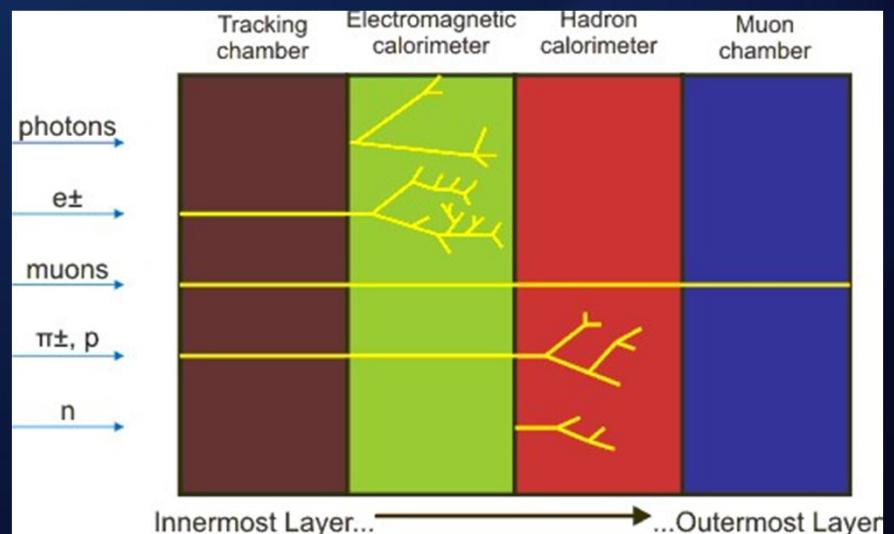
Width:	44m
Diameter:	22m
Weight:	7000t

CERN AC - ATLAS V1997



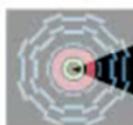
ATLAS

- Particle **tracks** appear as lines in the various parts of the detector
- The **length** of each track depends on the particle **type**
- Each particle leaves a **trace** only on certain parts of the detector depending on its type



ATLAS

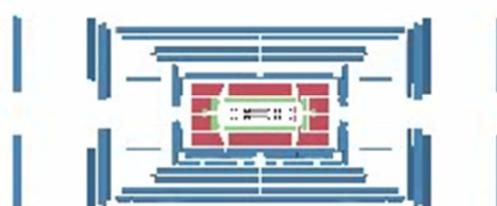
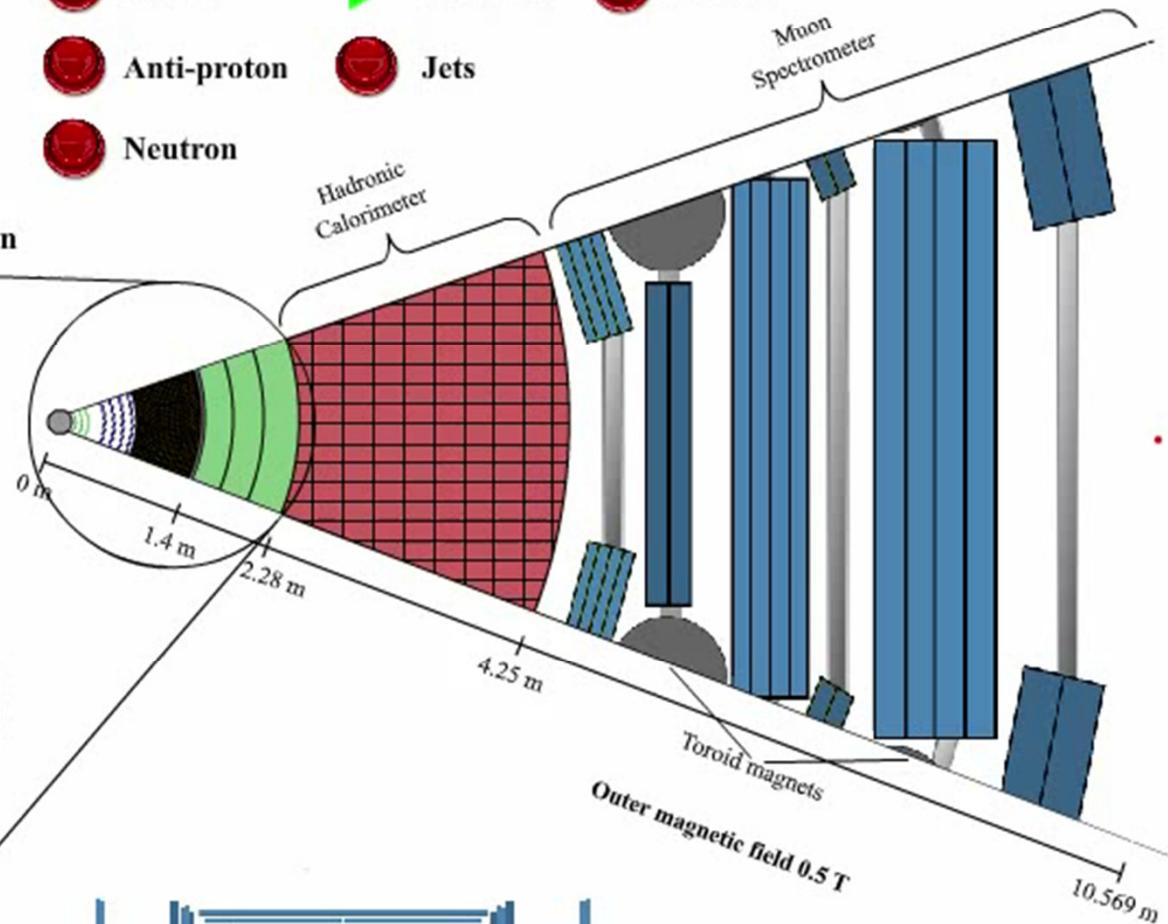
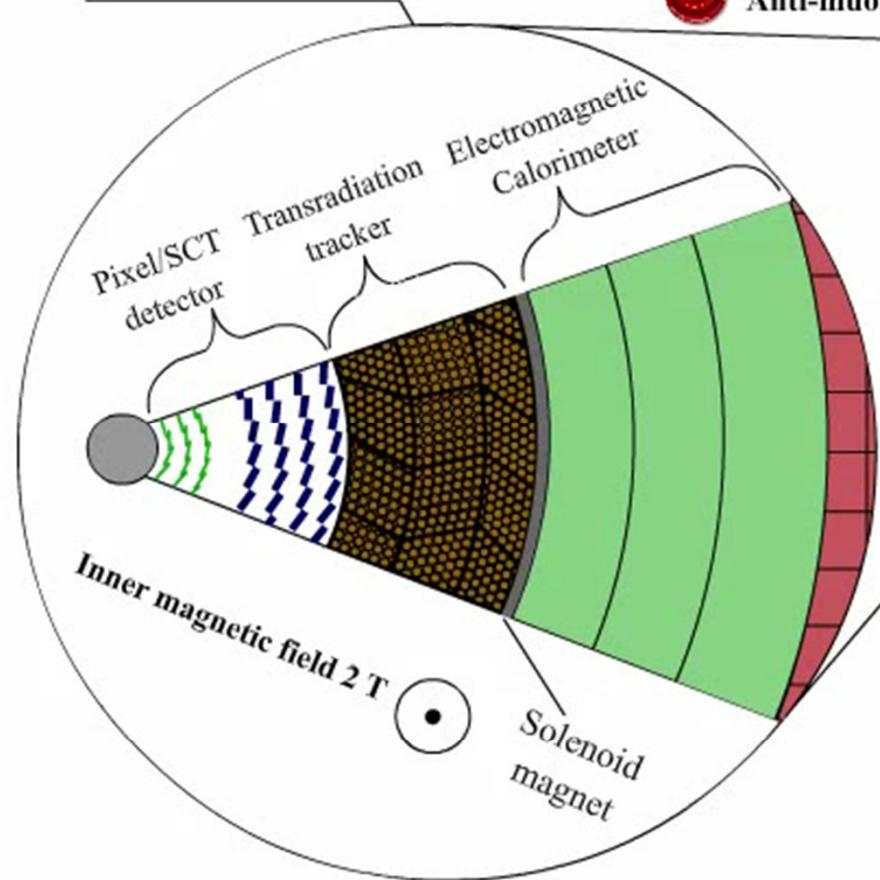
animation



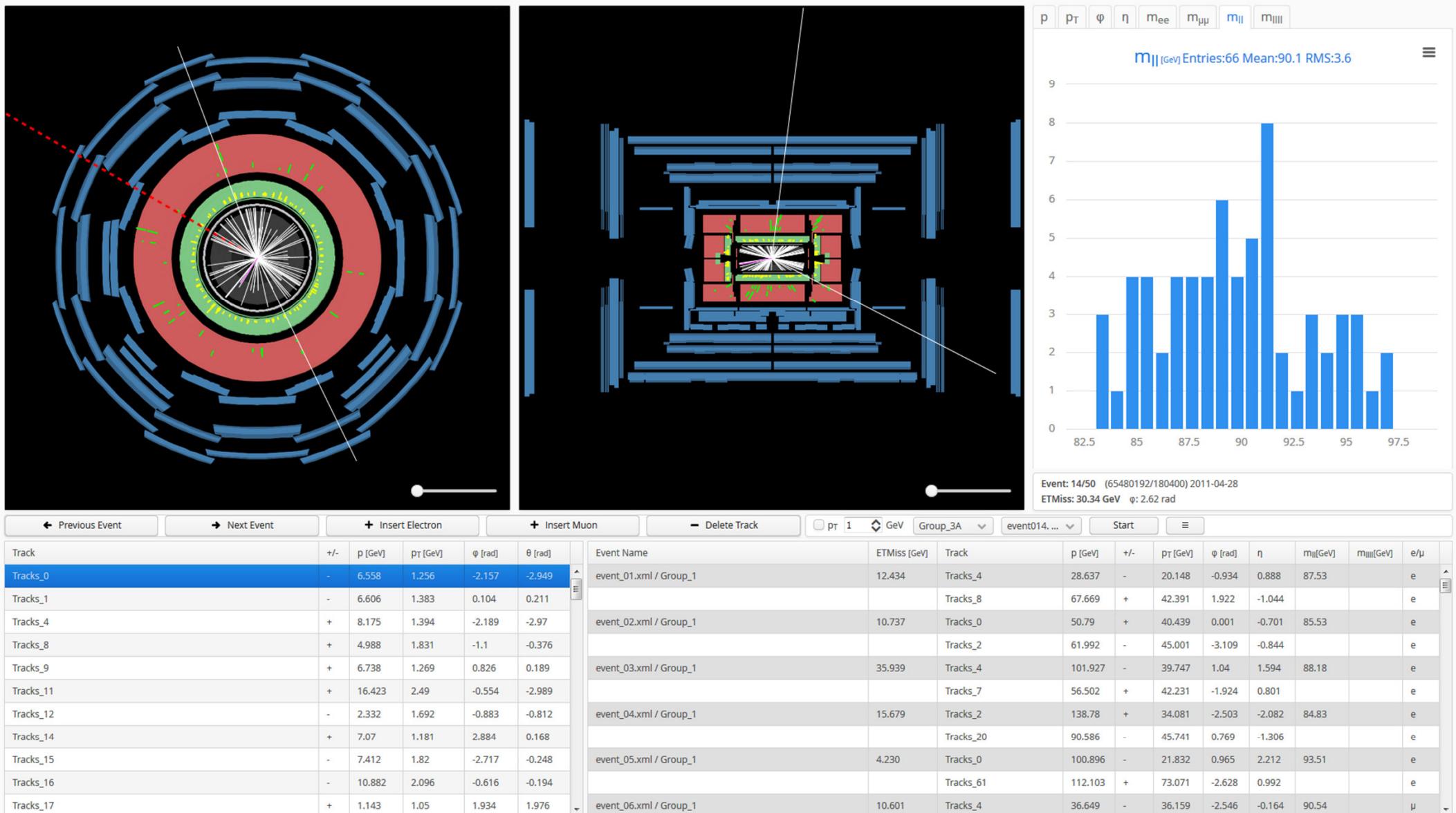
display instantly

-  Electron
-  Proton
-  Positron
-  Anti-proton
-  Muon
-  Neutron
-  Anti-muon
-  Neutrino
-  Photon
-  Jets

Magnification 3x



Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobe



<http://hypatia.iasa.gr/>

- General **information** about CERN, LHC, ATLAS
- Physics knowledge about the ATLAS experiment
- **Instructions** for the HYPATIA web application
- **Links** for more information

Demonstrator Name	English	French	Greek	Portuguese
Discover the Z and Higgs	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=270c02e179f742a7a19c0dfef74d52b0&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=3fd1bd592781492e9a69560ee7bb2de8&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=b0f97383107b49c79b47349ea1d42cee&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=d43ffc704e344bbc801edc2aadd784d8&t=p
Magnetic Field	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=1e0e531b7ab348f98288b0b6ef9c565a&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=dd87d43232d341dd9f3431623fad5b0d&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=24386dfc91c8495bad879a99c36a98dd&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=95eedcc7e6f04687ac5f93fb85397709&t=p
How to Accelerate particles	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=4ca172fdfc1b4609b2a637f35ede83a6&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=6e94c45a99844335a01fc7fecb3a2c5&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=619de75b03e6422c8a95736c7cb92ddc&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=a77a7d5126aa4fde99af418f592fc386&t=p
Study data from the LHC	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=9dbc01856adb4f50b84a5fa864502507&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=1e69c0f397ad4420a0cb6b89afb68231&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=01ee9eb8c6ce4ca3bbb2090d95bc40a&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=04304cf1c53d4a30bf998d851b69b4e8&t=p
Cosmic Rays	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=228690c20d7141fc9ecfe69221302584&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=a9d890ef9fef4dc6a1d8dea8a28d369a&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=c6df6077e8e44c64b24a9c35c898a7dd&t=p	http://inspiringscience.rde.a.gr/delivery/view/index.html?id=eff4ce0a9bcb4da7a00bf482a14fc63&t=p

<https://bit.ly/2Dz2dQw>