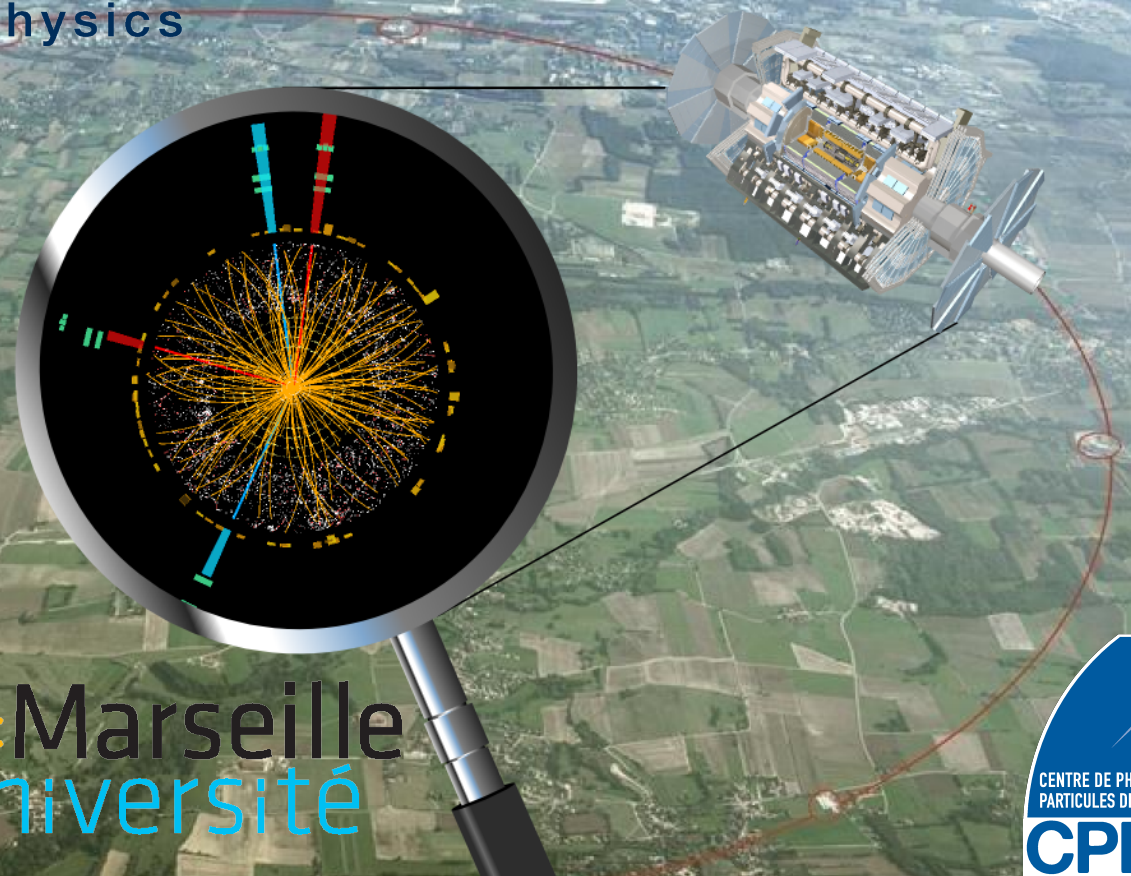


How to detect particles in ATLAS

INTERNATIONAL
MASTERCLASSES

hands on particle physics

Centre de physique des
particules de Marseille



Using Minerva to identify events

The image displays the Atlantis GUI interface, which is used for event analysis. The interface is divided into several panels:

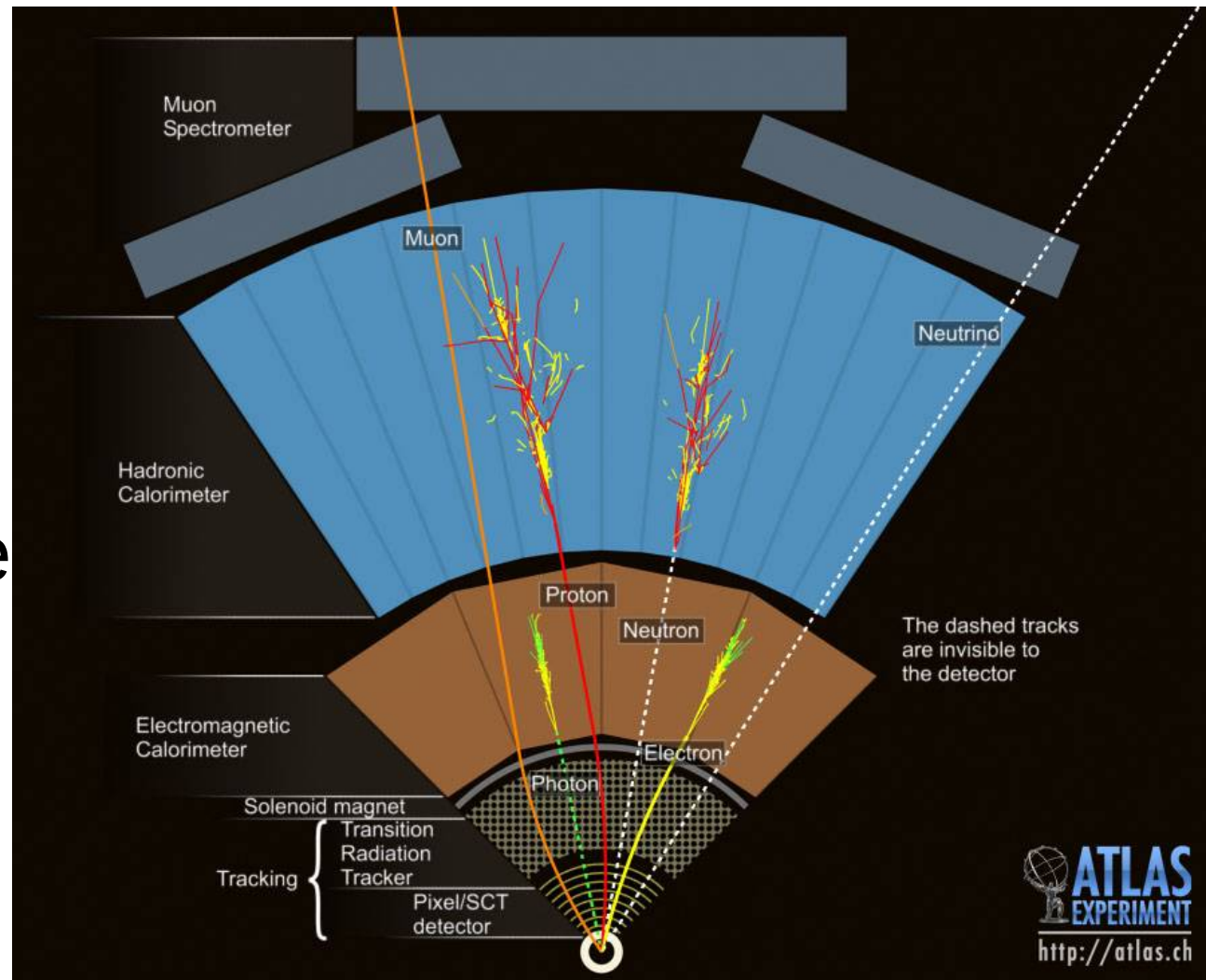
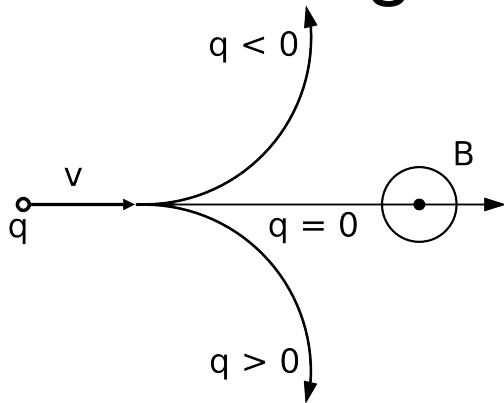
- Atlantis Canvas (Top Left):** Shows a 2D plot of the detector layout in the X-Y plane. The X and Y axes range from -10 to 10 meters. The plot shows concentric rings representing different detector components, with a central event vertex and tracks.
- 50 ET (GeV) Plot (Top Right):** A 3D plot showing the height of the tallest tower (ET) in GeV. The vertical axis ranges from 0 to 50 GeV. The horizontal axes are phi (0 to 360 degrees) and n (0 to 5). A red vertical bar indicates the current event's ET value, which is 44 GeV. A yellow bar indicates the user selection threshold of 50 GeV.
- Atlantis GUI (Right):** The main control panel. It includes a menu bar (File, Preferences, Lists), a toolbar, and a "Cuts" panel. The "Cuts" panel shows a table of cuts for the "InDet" detector. The table has columns for "Name" and "Value". A single cut is defined:

Name	Value
<input checked="" type="checkbox"/> Pt	> 1.0 GeV
- Atlantis Canvas (Bottom Left):** Shows a 2D plot of the detector layout in the rho-Z plane. The rho axis ranges from -20 to 20 meters, and the Z axis ranges from -10 to 10 meters. The plot shows the detector's longitudinal structure with tracks and event vertices.

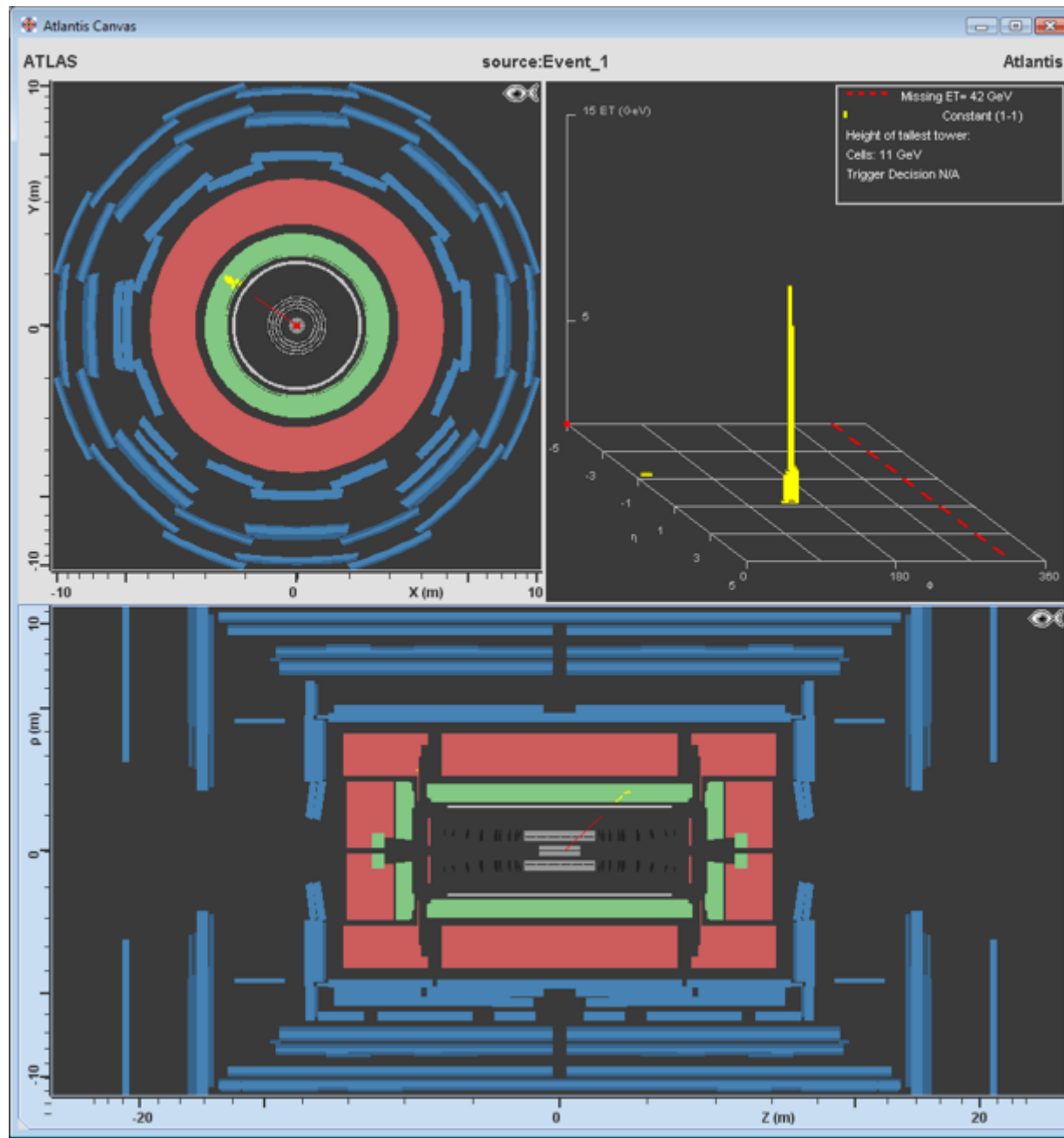
Additional information displayed in the GUI includes the event source: "ATLAS source:001_JiveXML_105200_190249 run:105200 ev:190249 lumiBlock:4294967295 Atlantis". The status bar at the bottom of the GUI shows: "Welcome to Atlantis !" and "001_JiveXML_105200_190249.xml (10520000190249)".

Electrons/positrons and photons identification

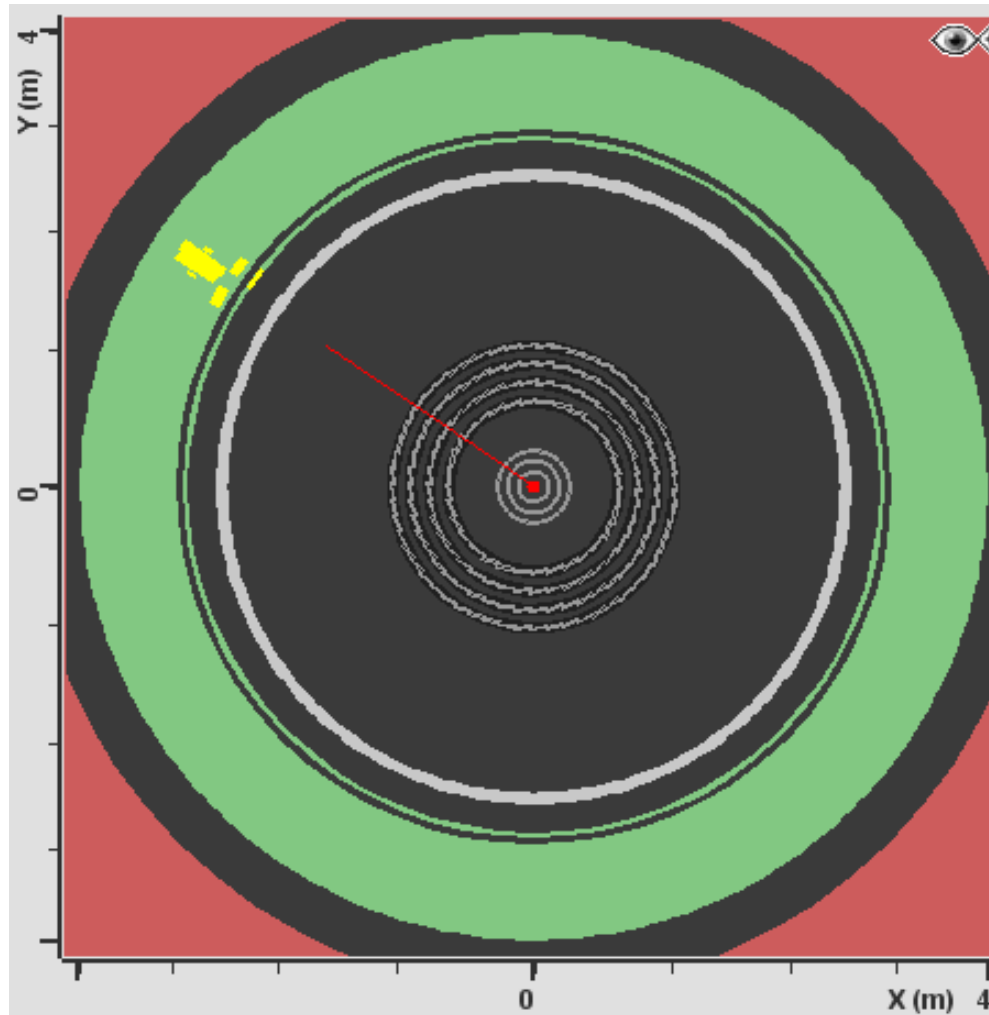
- Shower in the EM calorimeter
- e^+/e^- : charged particle, track in the tracker
- Curvature of the track \rightarrow sign of the electric charge



Electrons/positrons identification with Minerva

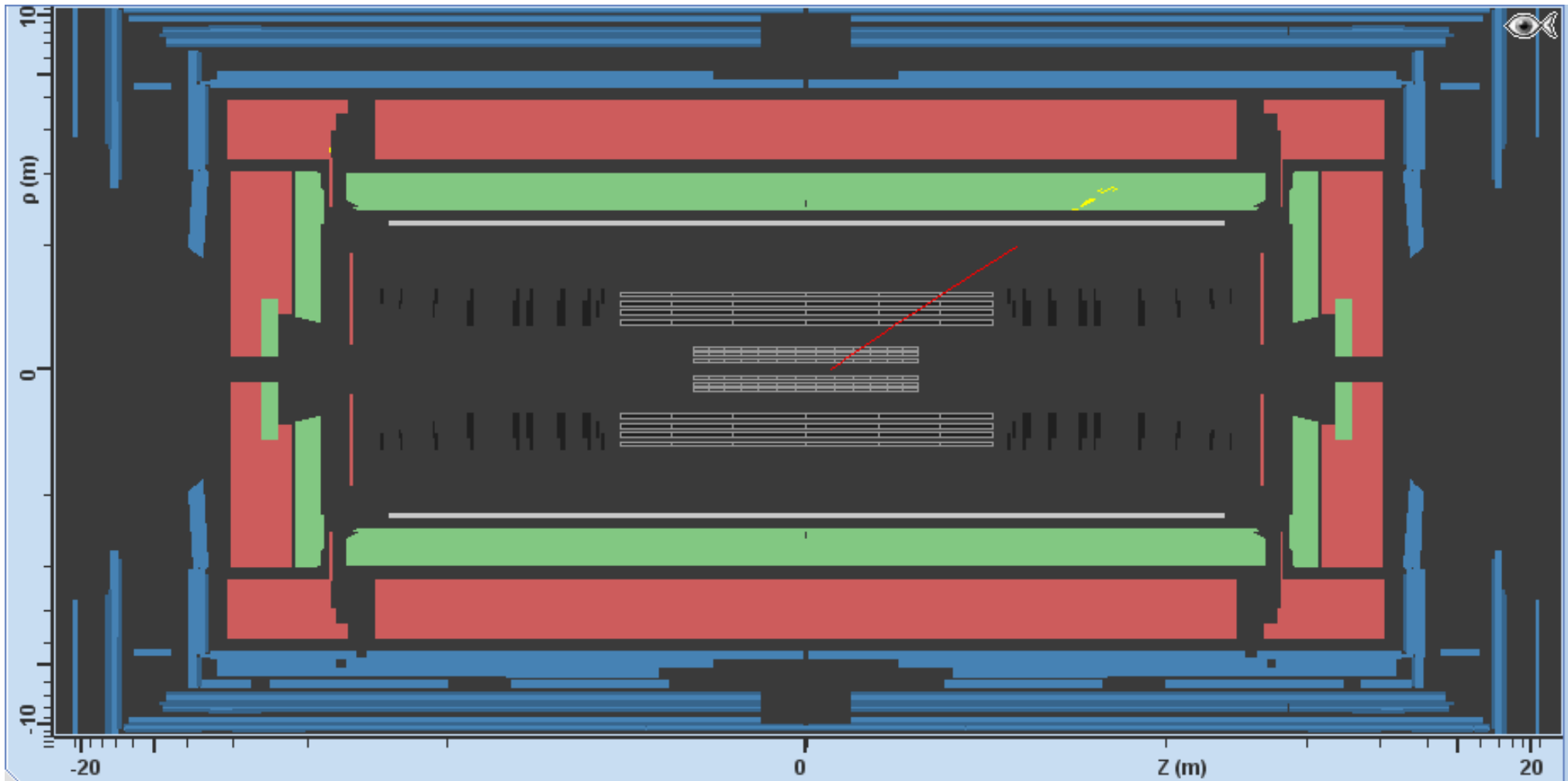


Electrons/positrons identification with Minerva



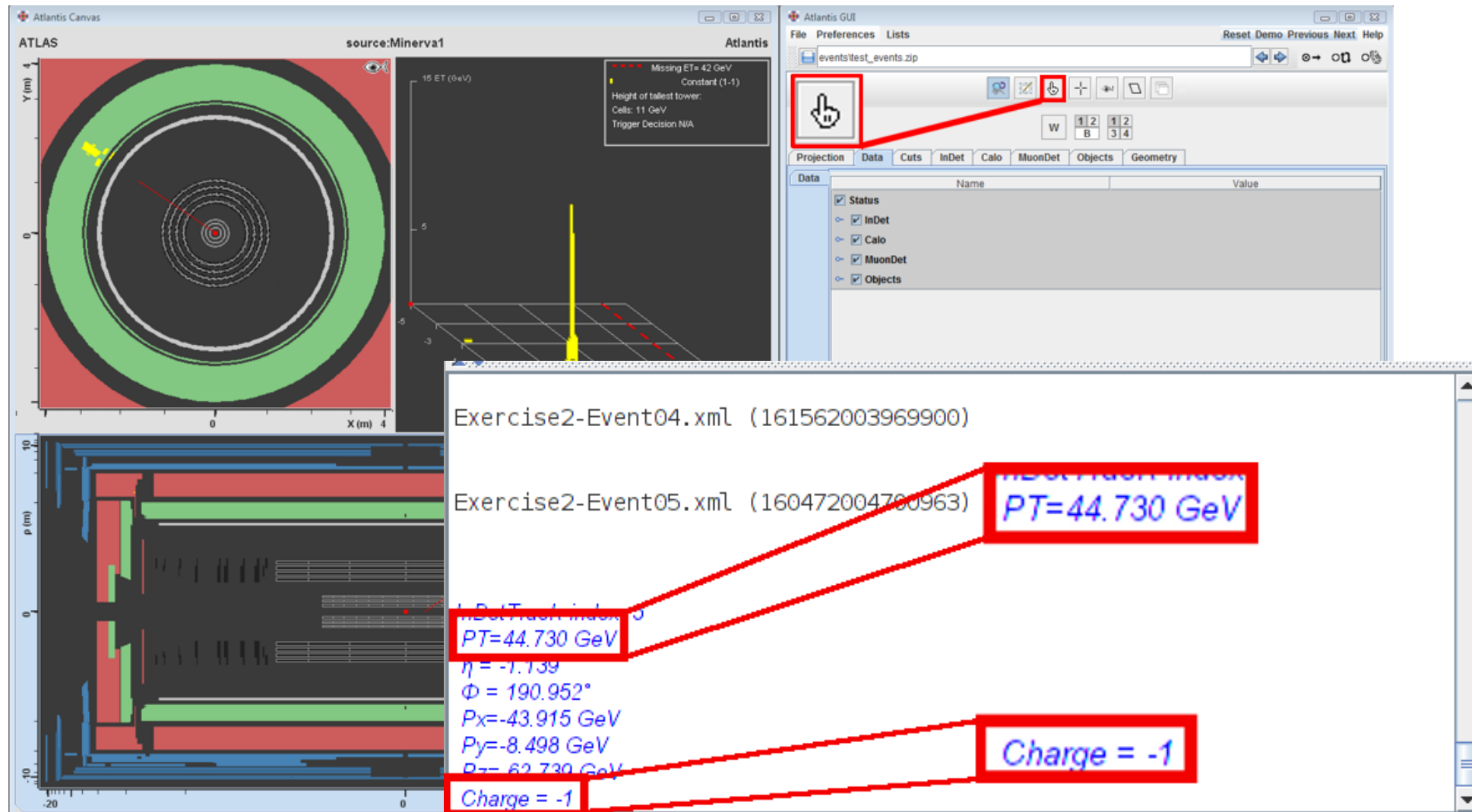
- Track in the tracker
- Energy in the calorimeter

Electrons/positrons identification with Minerva



- Track in the tracker
- Energy in the calorimeter

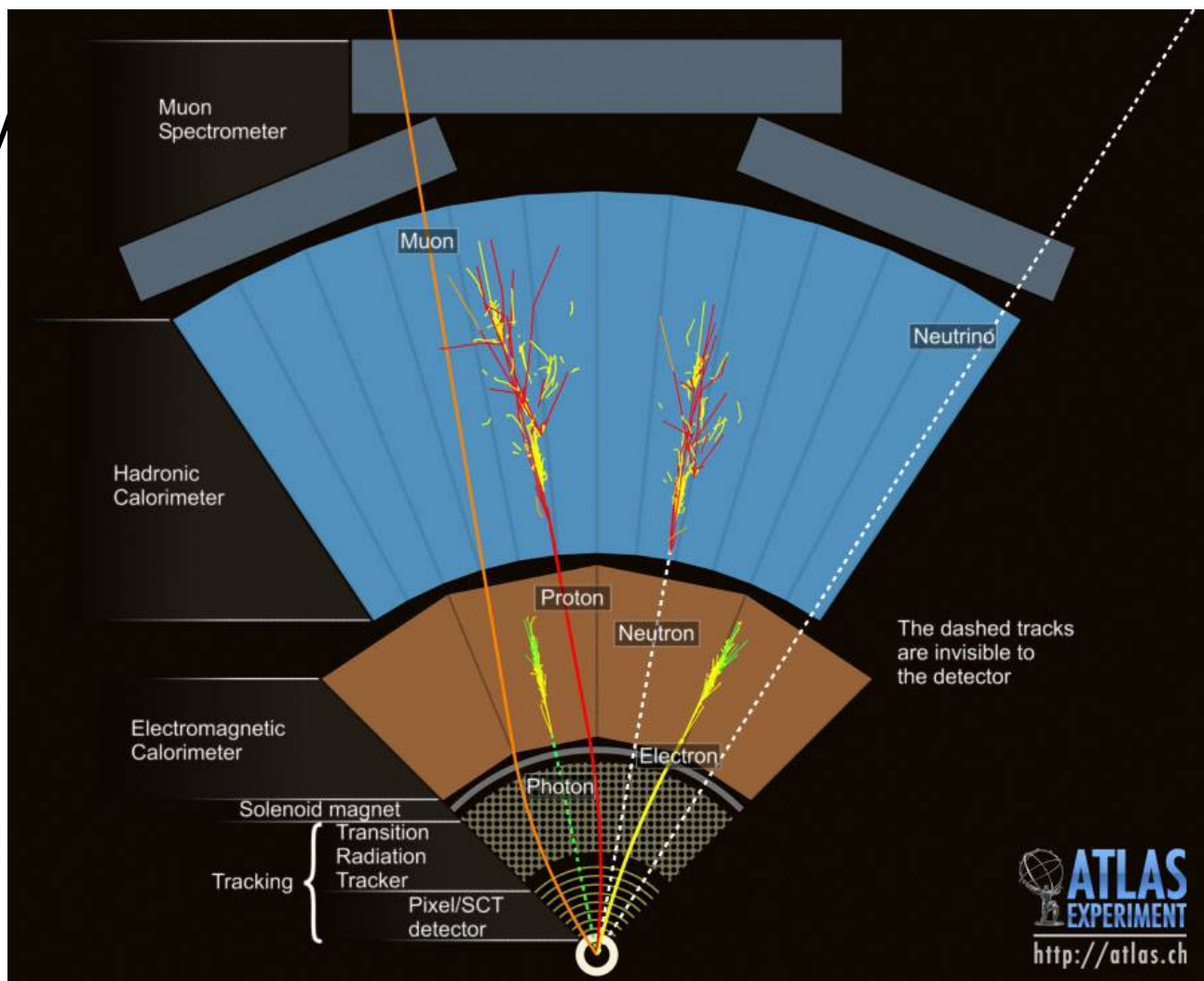
Electrons/positrons identification with Minerva



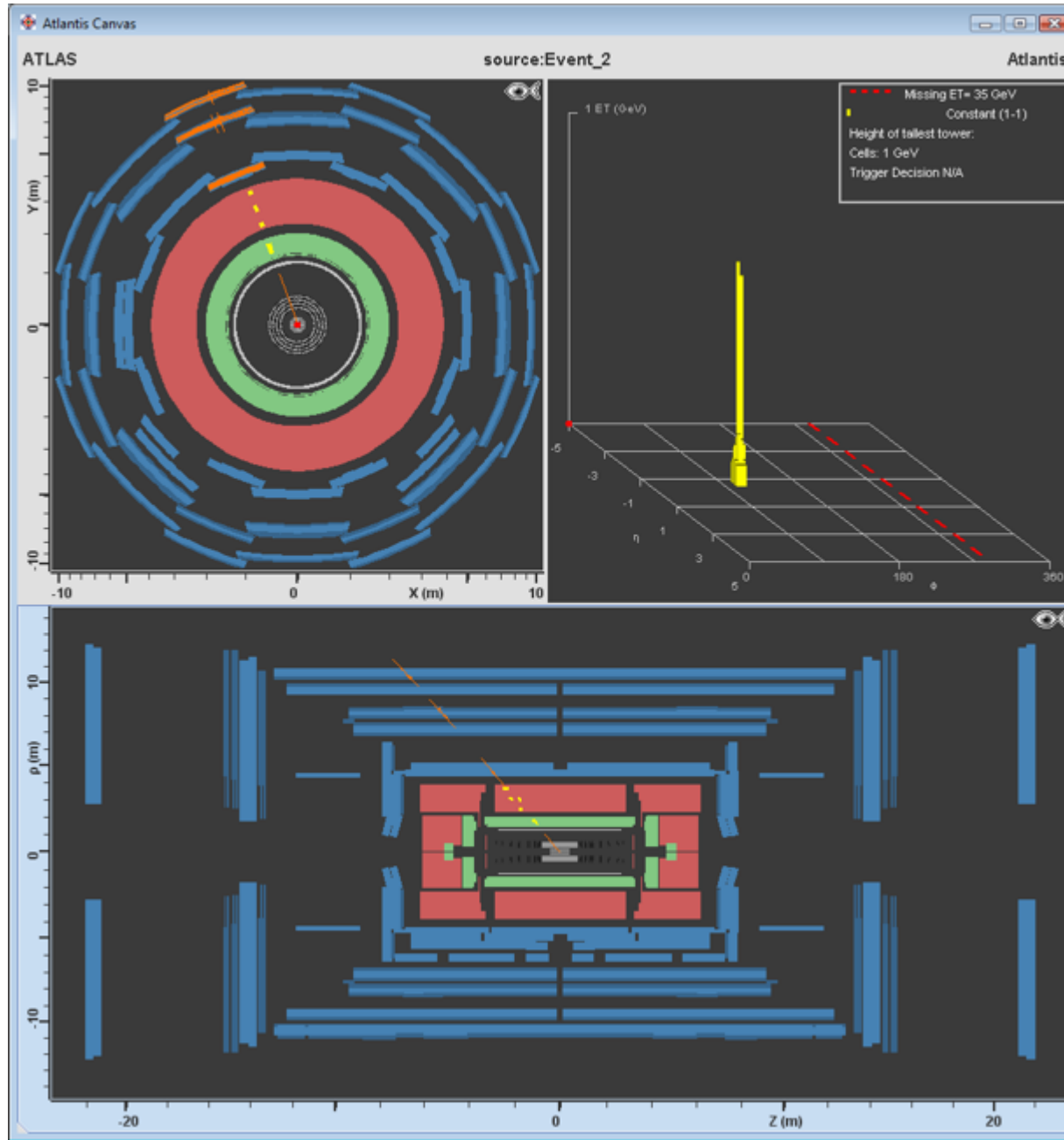
- P_T = transverse momentum
- Here, negative charge \rightarrow electron

Muons/antimuons identification

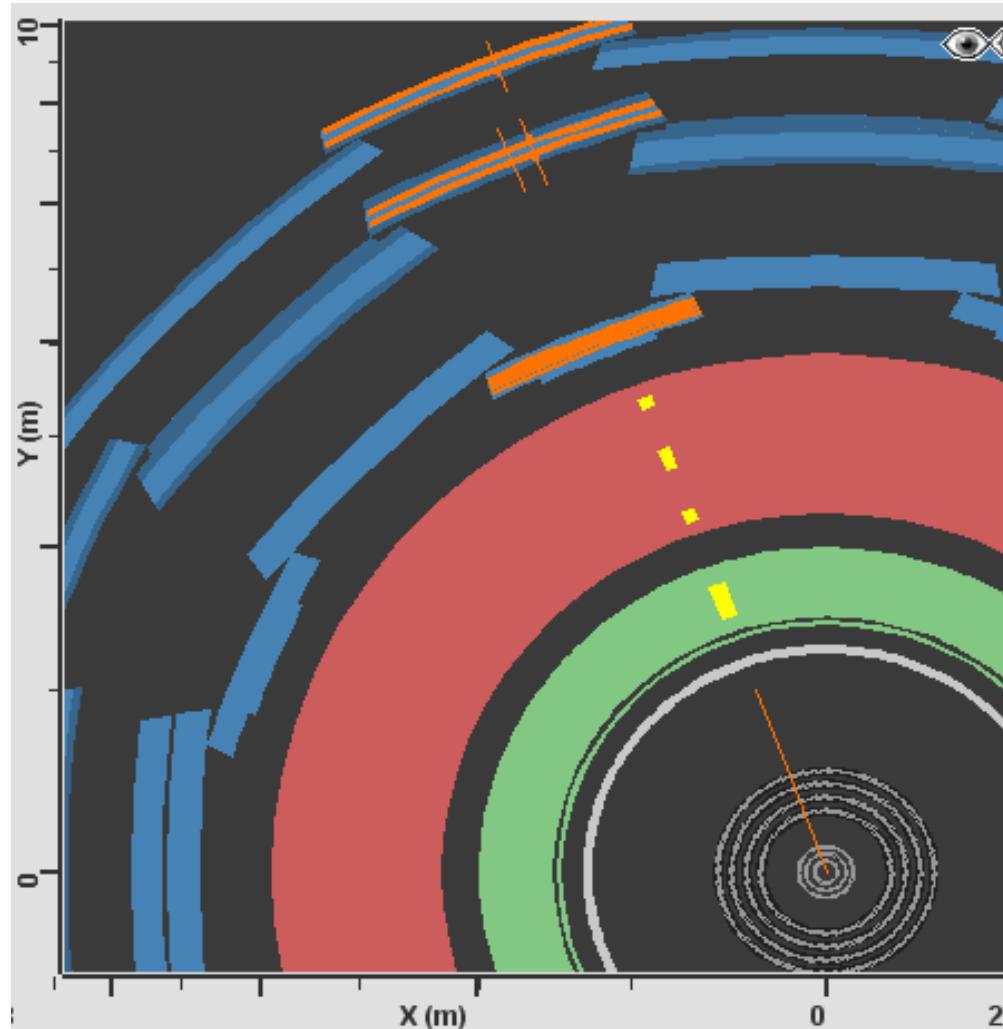
- Charged particle -> track in the tracker
- Few amount of energy in the calorimeter
- Track in the muon detector
- Curvature of the track → sign of the electric charge
- Not stopped by internal layers, travels through ATLAS



Identify muons/antimuons with Minerva

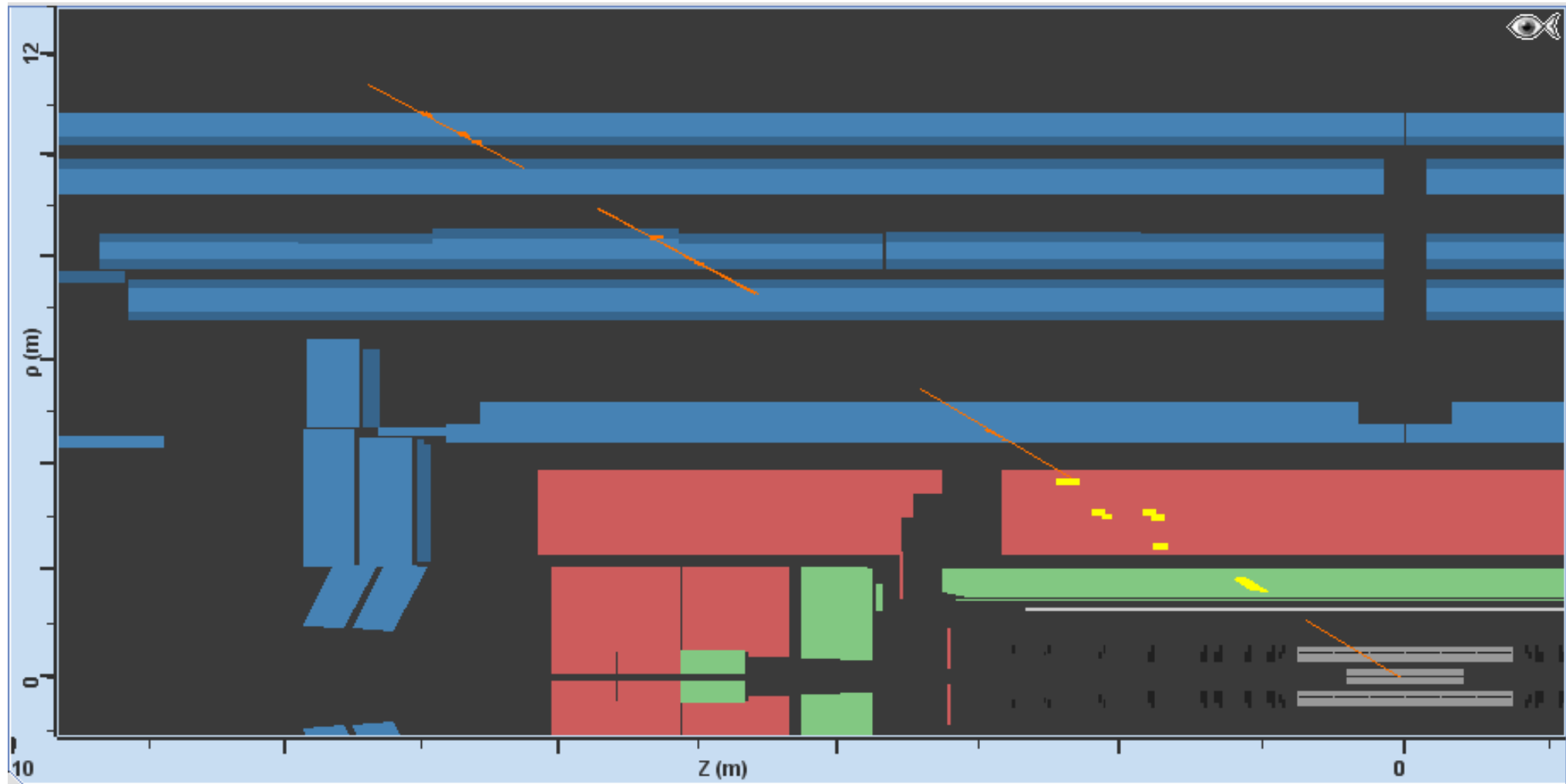


Identify muons/antimuons with Minerva



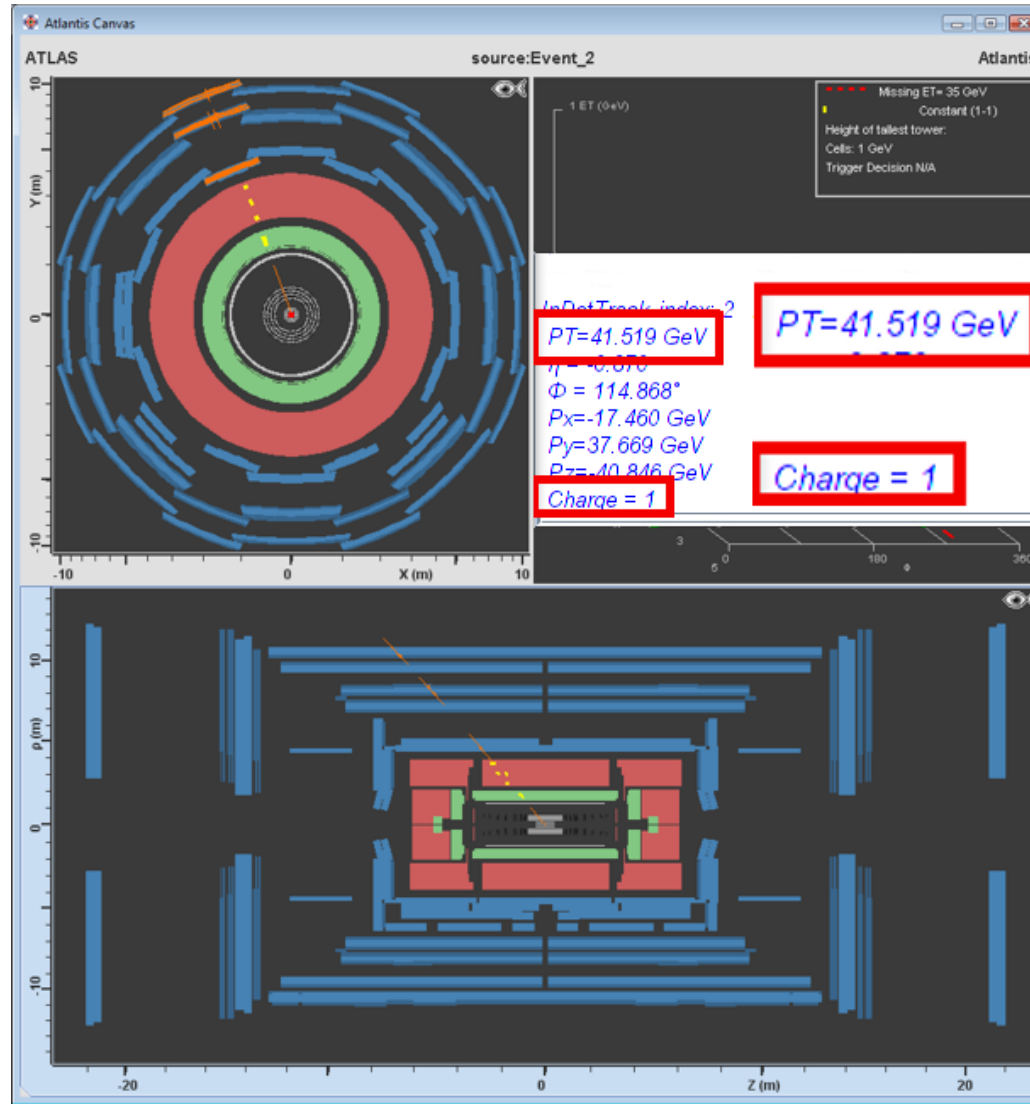
- Tracks in the tracker and muon detector (aligned)
- Some energy in the calorimeters

Identify muons/antimuons with Minerva



- Tracks in the tracker and muon detector (aligned)
- Some energy in the calorimeters

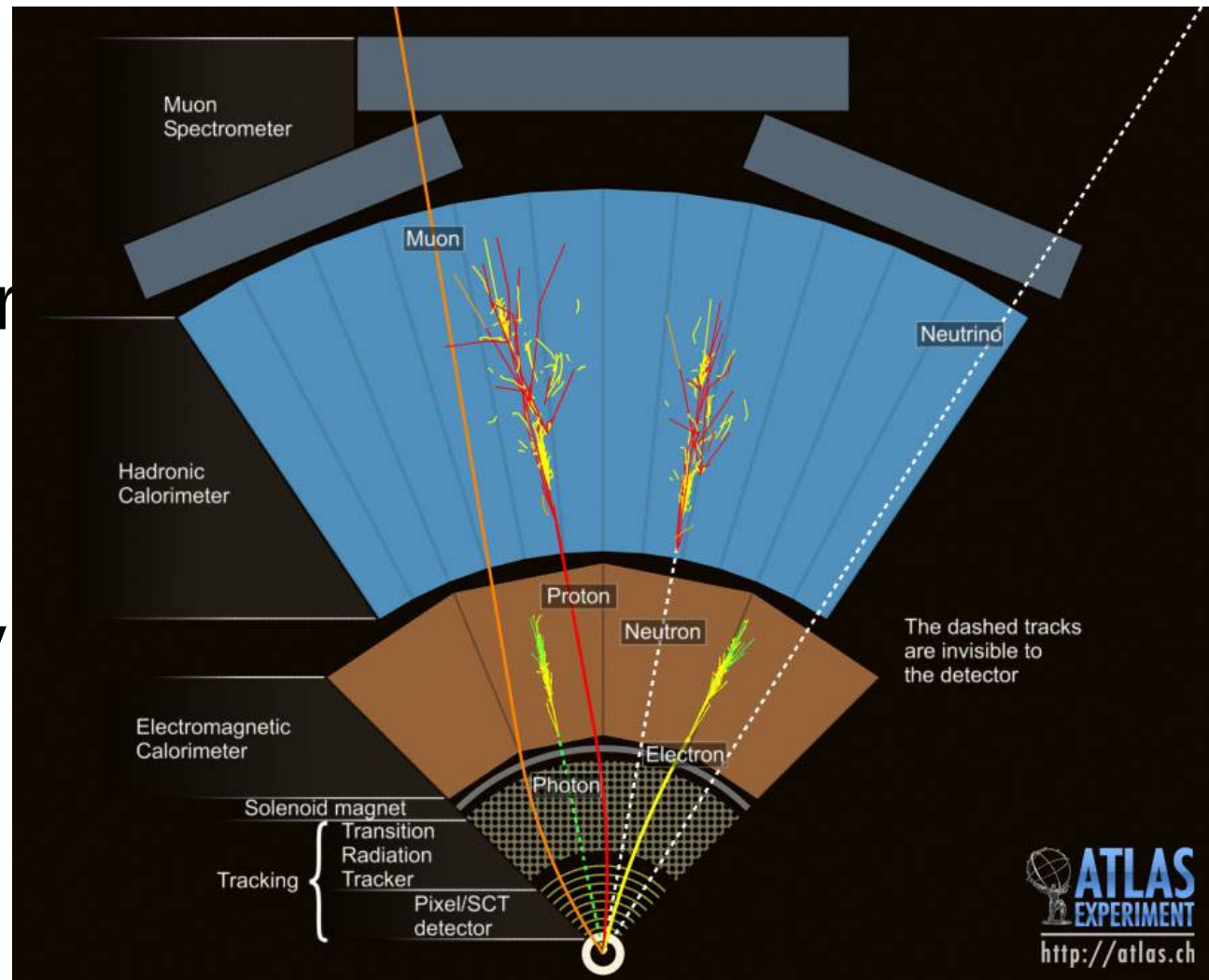
Identify muons/antimuons with Minerva



- Positive charge : antimuon

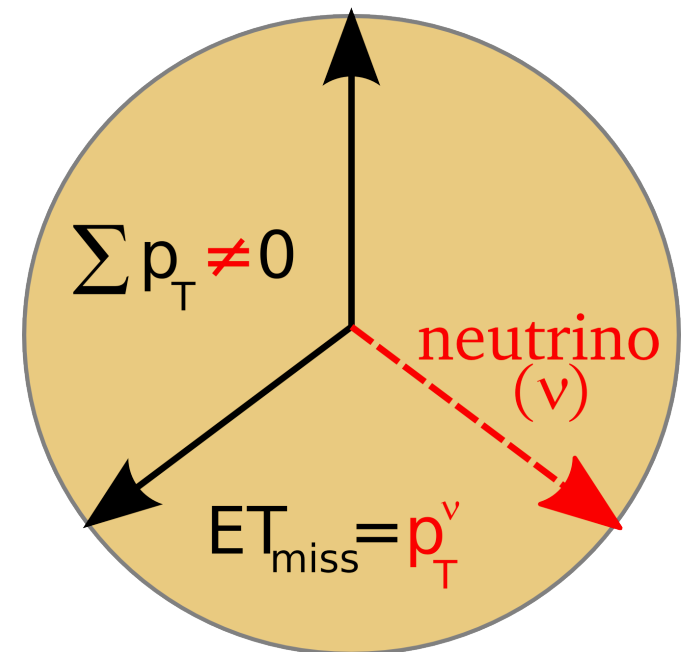
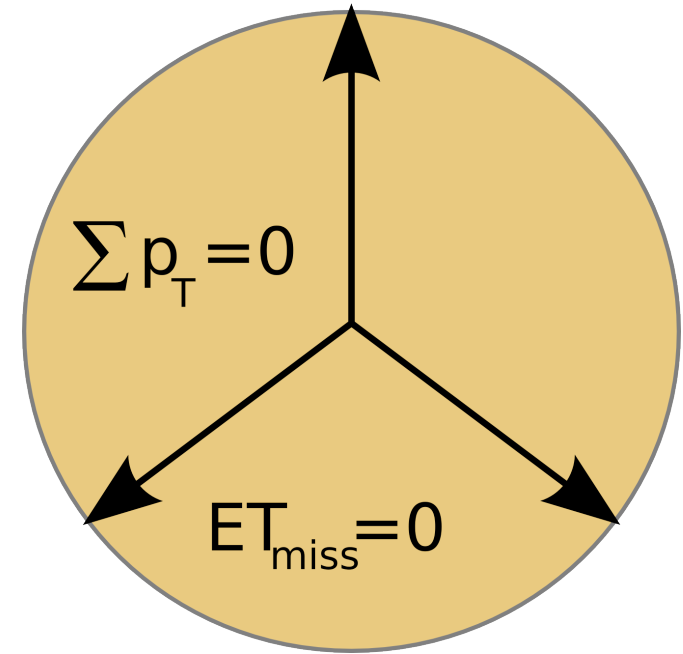
Neutrinos identification

- Neutral particle which does not interact with matter
- No traces in the detector
- Identified indirectly using momentum conservation

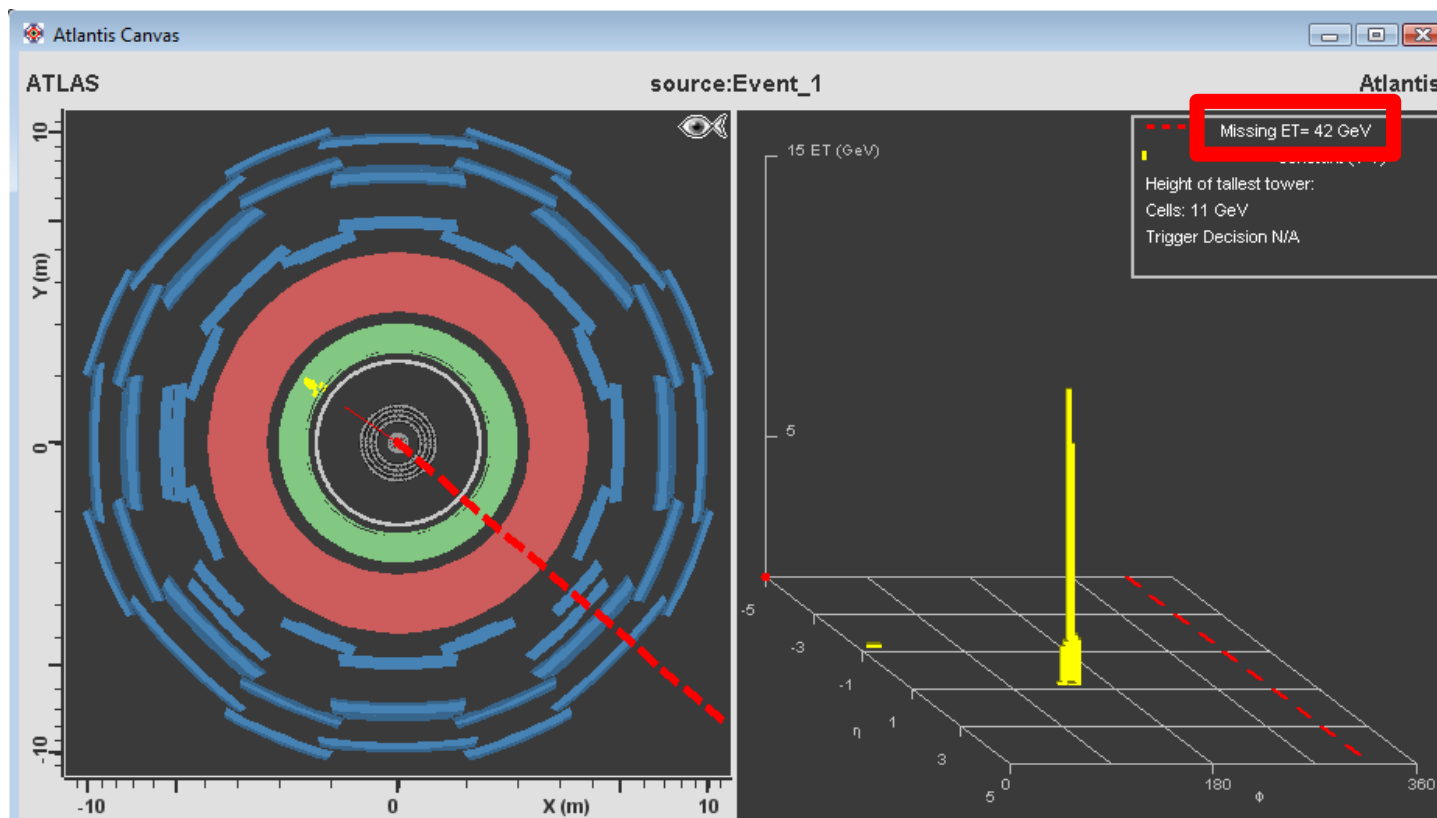


Missing transverse energy : E_T^{miss}

- Without neutrino
 - ▶ 3 reconstructed particles
 - ▶ In the transverse plane, sum of momenta : 0
 - ▶ So $E_T^{\text{miss}} = 0$
- With a neutrino
 - ▶ Part of the event is unseen
 - ▶ The sum of transverse momenta is non zero
 - ▶ The difference is E_T^{miss} , associated to the neutrino



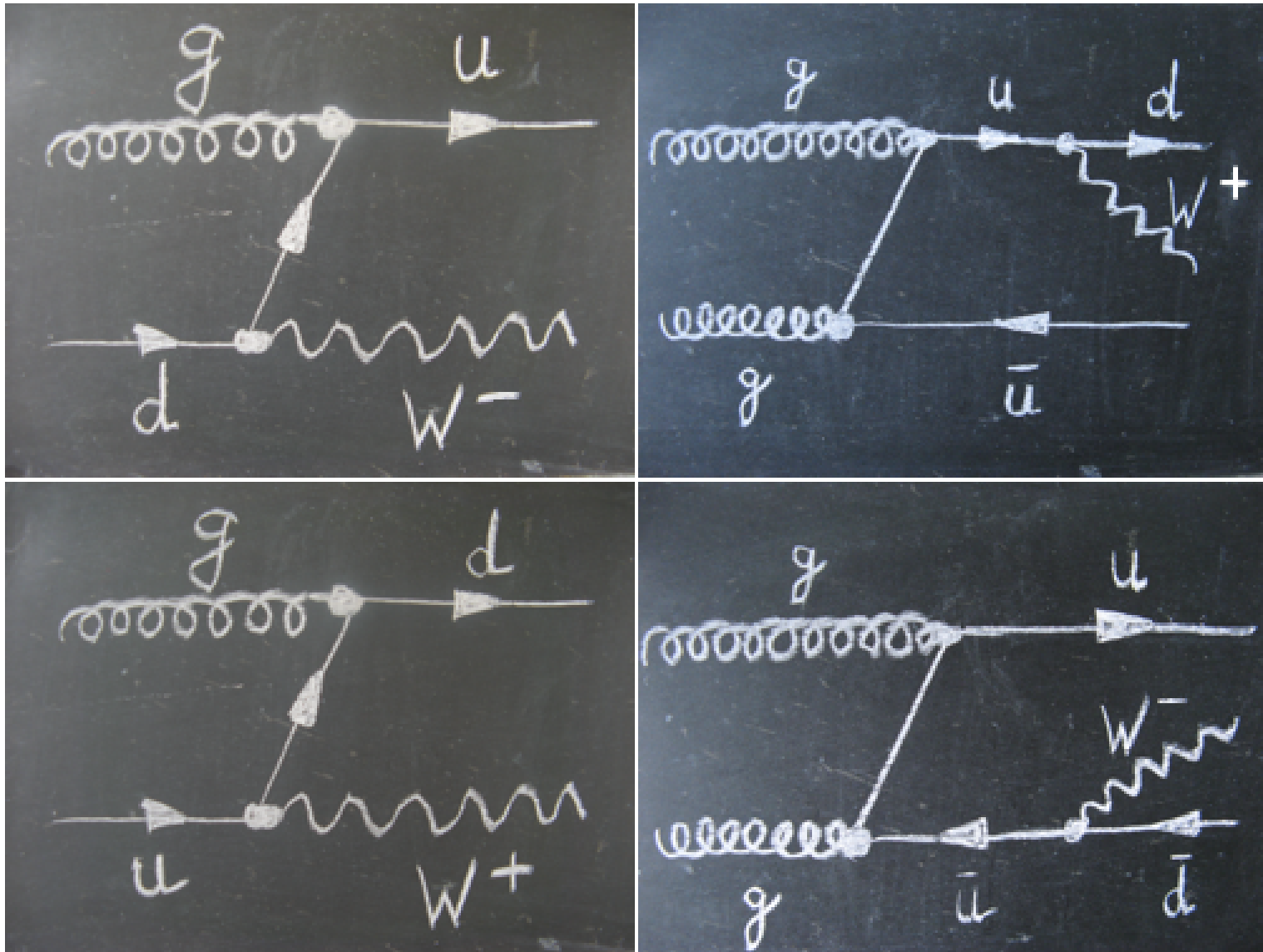
Neutrino identification with Minerva



- By conservation, the sum of momenta in the transverse plane is 0
- Else, Missing ET : unseen particles, or badly measured
- Representation with a dashed red line, value in the top right

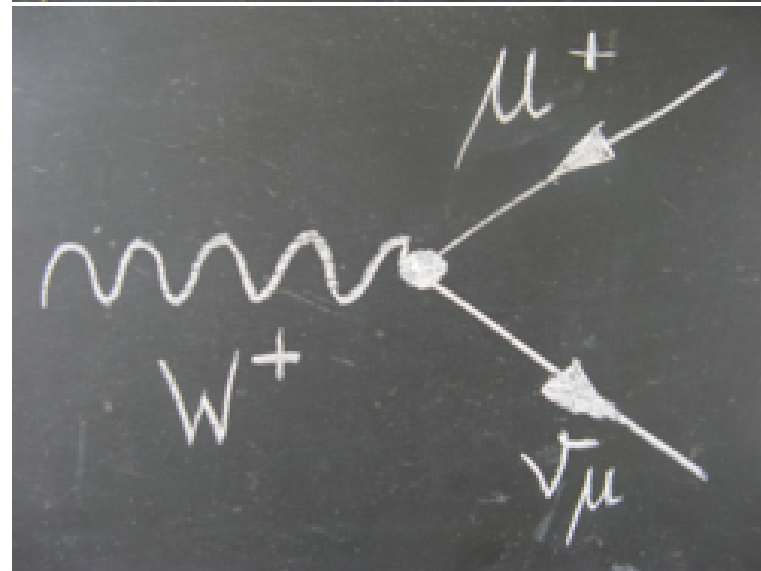
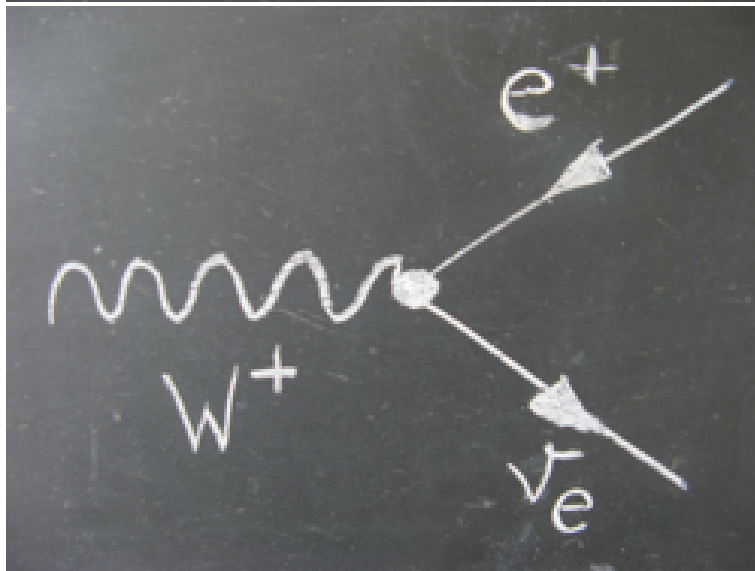
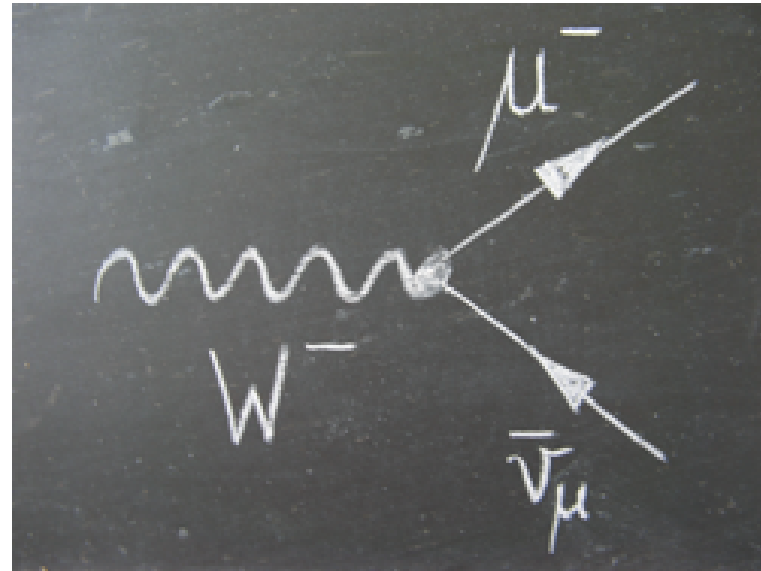
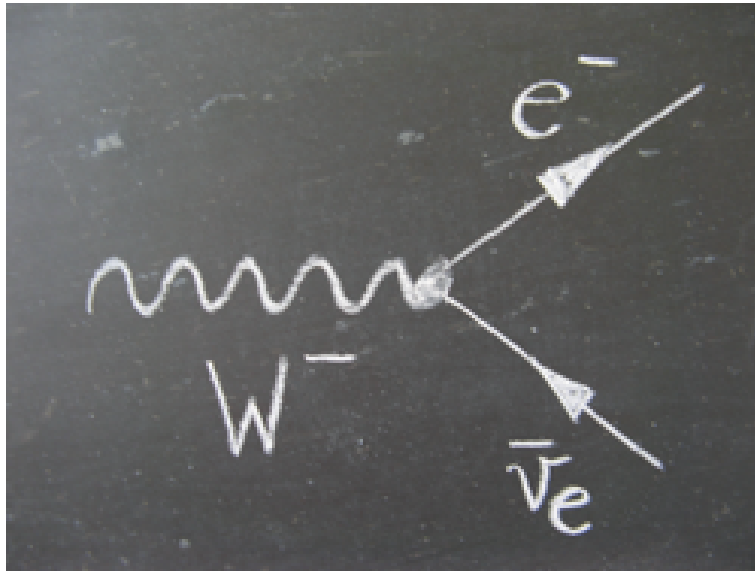
Analyse : W boson observation

Production



Analyse : W boson observation

Désintégration

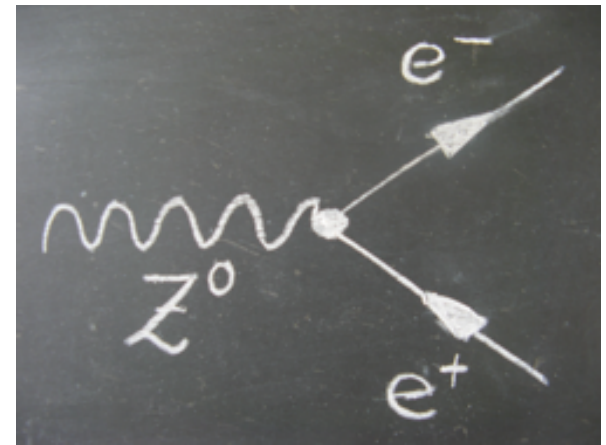
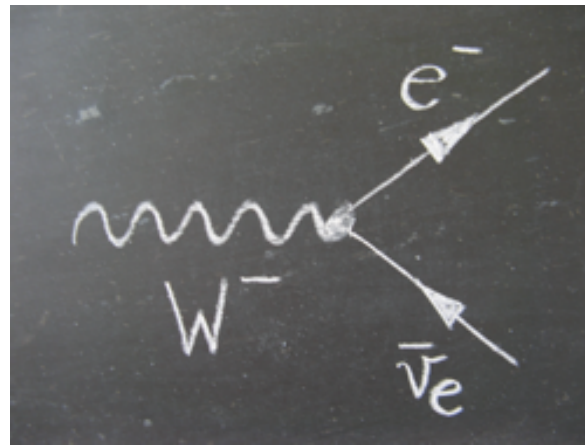
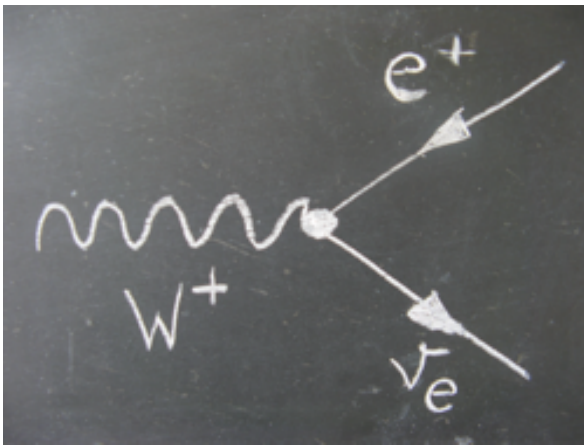


Difficulties : background

- Similar signature to what we look for, but coming from a different source
- Maybe a real process giving this final state
- ... or due to the fact that a particle was not observed
 - ▶ For example : escaping along the beam
- ... or due to a bad reconstruction
 - ▶ For example : there is a jet, but I think it's an electron
- ... or due to additional particles
 - ▶ Every event contains several collisions

Examples of signal and background

- Signal : W boson decay
 $W \rightarrow e\nu$
- Background : $Z \rightarrow ee$
- One electron is not reconstructed



- If we look for Z events, then W events can be a background !

And you ?

- Looking for W bosons
 - And measuring the structure of the proton
- Searching for the Higgs boson
 - $H \rightarrow W^+W^- \rightarrow$
 - $e^+ \nu \quad e^- \nu$
 - $e^+ \nu \quad \mu^- \nu$
 - $e^- \nu \quad \mu^+ \nu$
 - $\mu^+ \nu \quad \mu^- \nu$