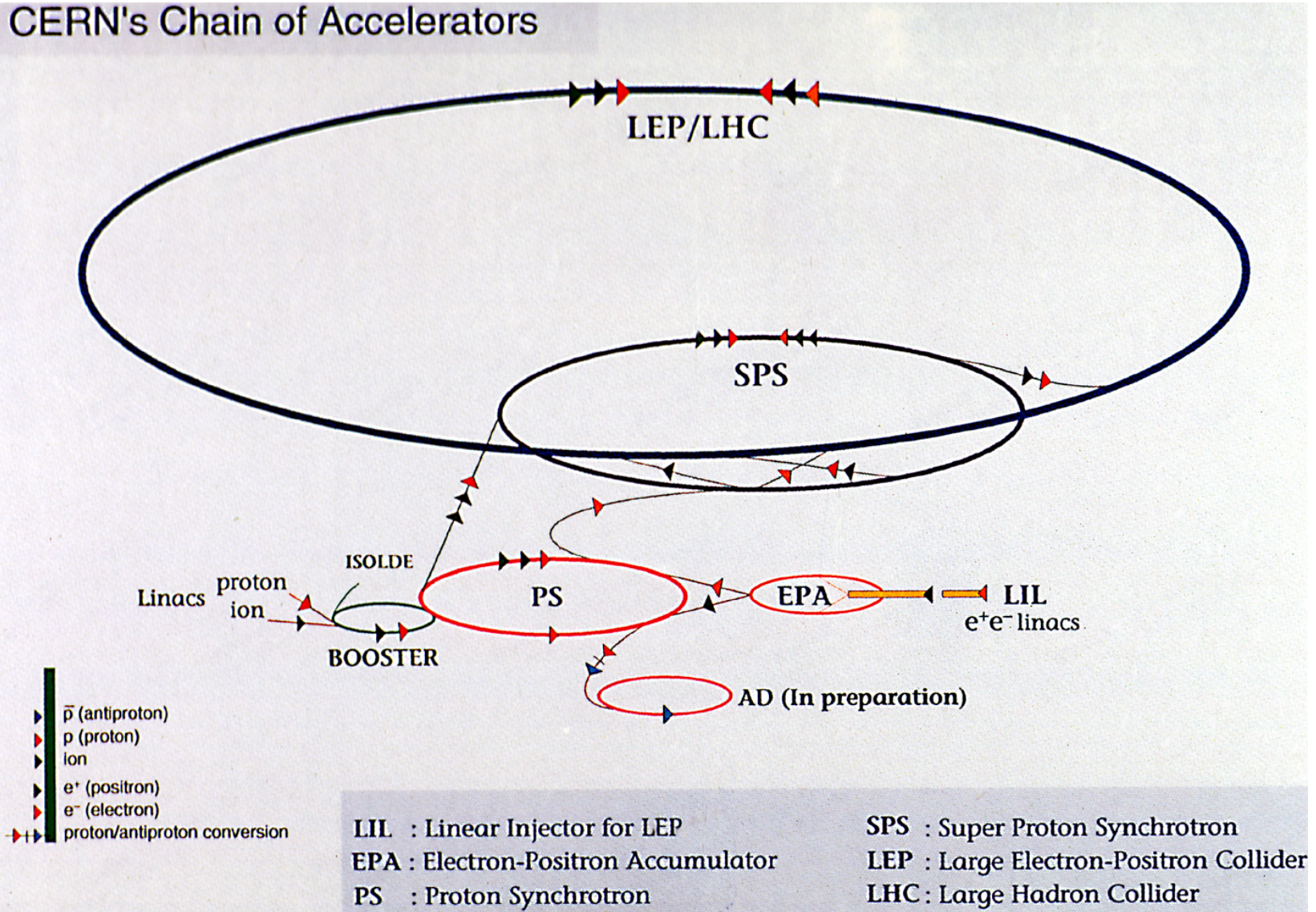# Lecture 2, 3: An Introduction to LEP
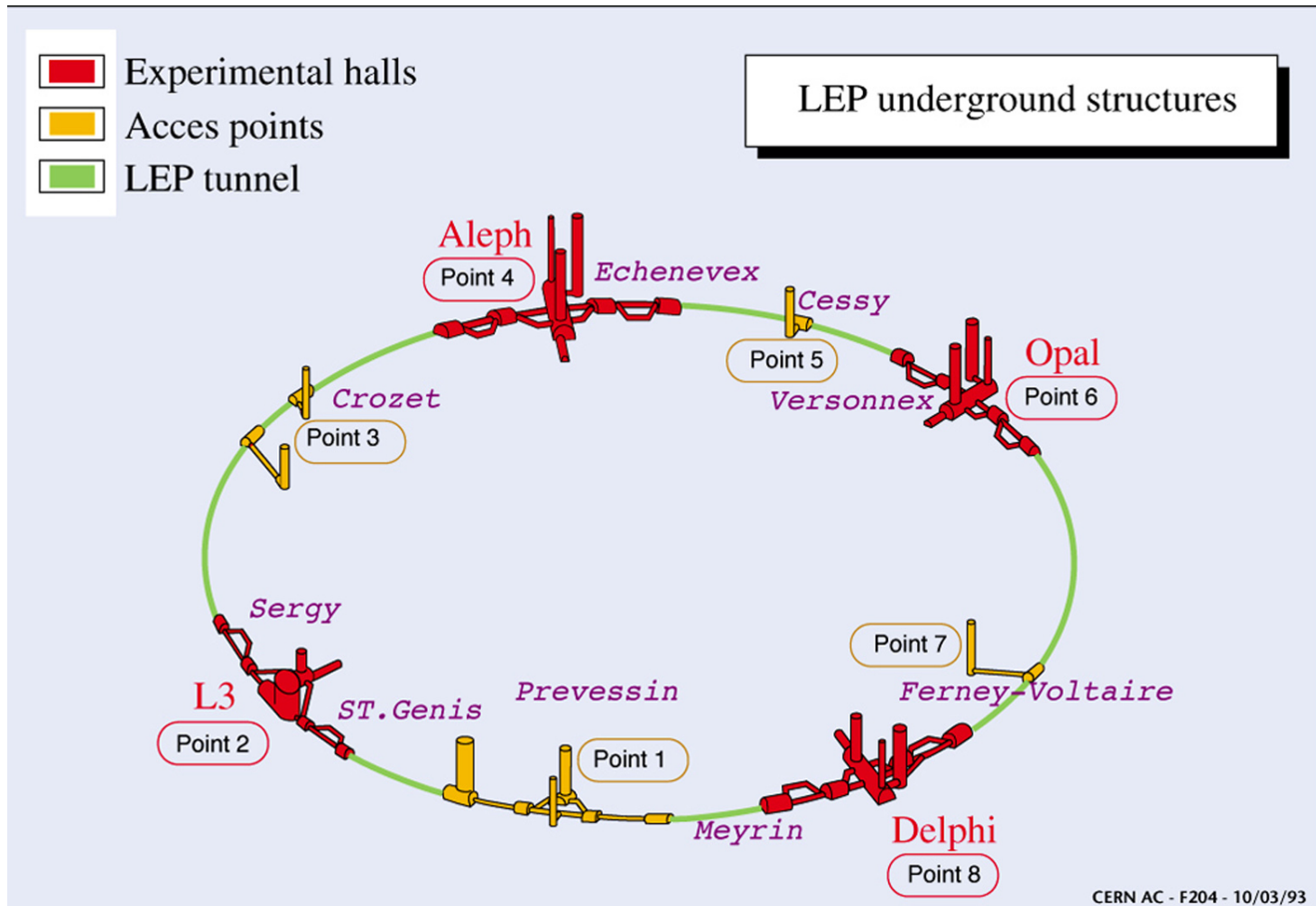
CERN Accelerators (an old picture)

A LEP Superconducting Cavity

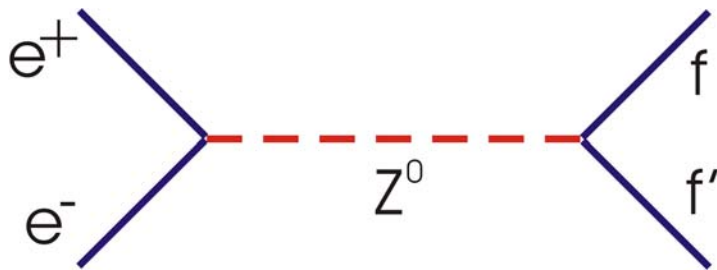Serious bending magnet! More on how accelerators work later!

LEP Layout

4 Multi-purpose detectors, ALEPH, DELPHI, L3, OPAL

Basics of LEP-I Physics

- LEP-I (1989-1995) beam energy 45.6 GeV
- CMS energy 91.2 GeV
- Many millions of Z bosons per experiment

f = quark (u,d,s,c,b)
        lepton (e, μ, τ)
        neutrino (ν_e, ν_μ, ν_τ)

- None of the discoveries hoped for ☹
- Amazing, unprecedented precision in testing the Standard Model ☺
- Indirect constraints on Higgs boson and many exotics

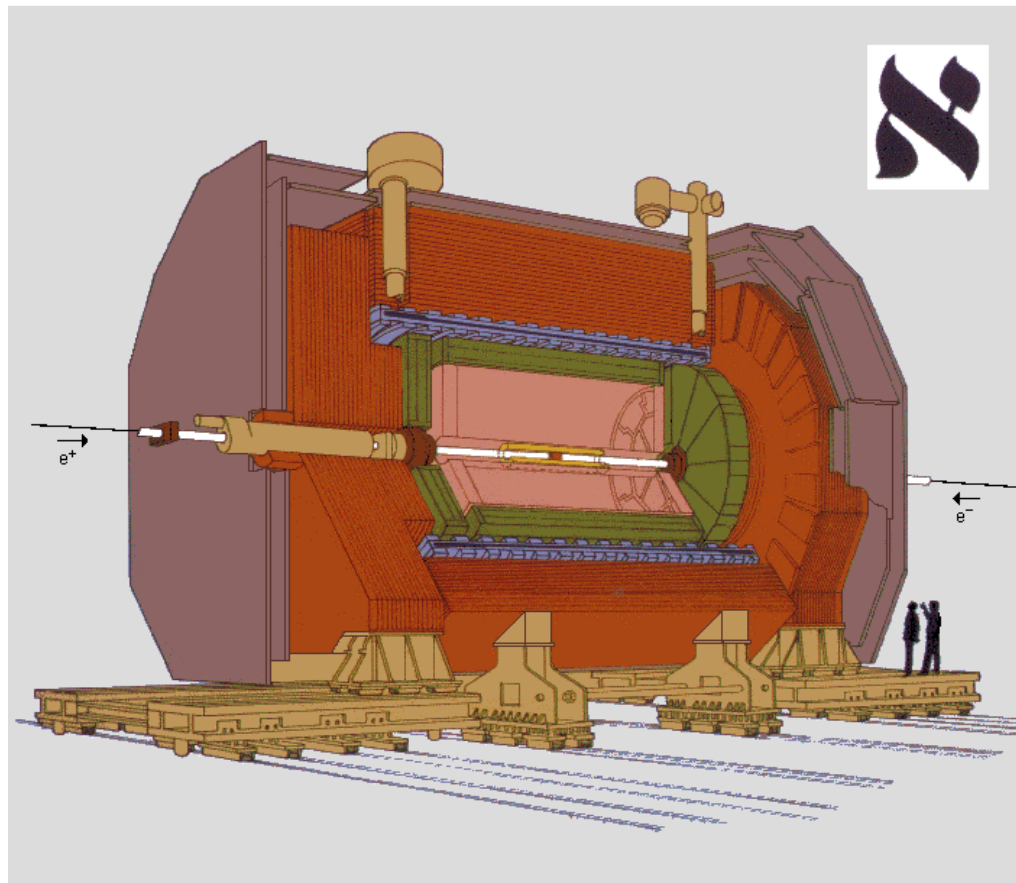# LEP Detector Requirements

An ideal LEP detector should have …..

- As full a solid angle coverage as possible
- Good particle identification to distinguish different fermions
- Good measurements of momentum and / or energy
- Fast response to avoid deadtime (more of an issue at hadron colliders
- Non-infinite cost!

In practice, this means …..

- The usual `onion' type multi-layered cylindrical design
- Low density (tracking) detectors on the inside
- High density (calorimeter) detectors next
- Solenoid to give high magnetic field (about 1T at LEP)
- Muon detectors on the outside
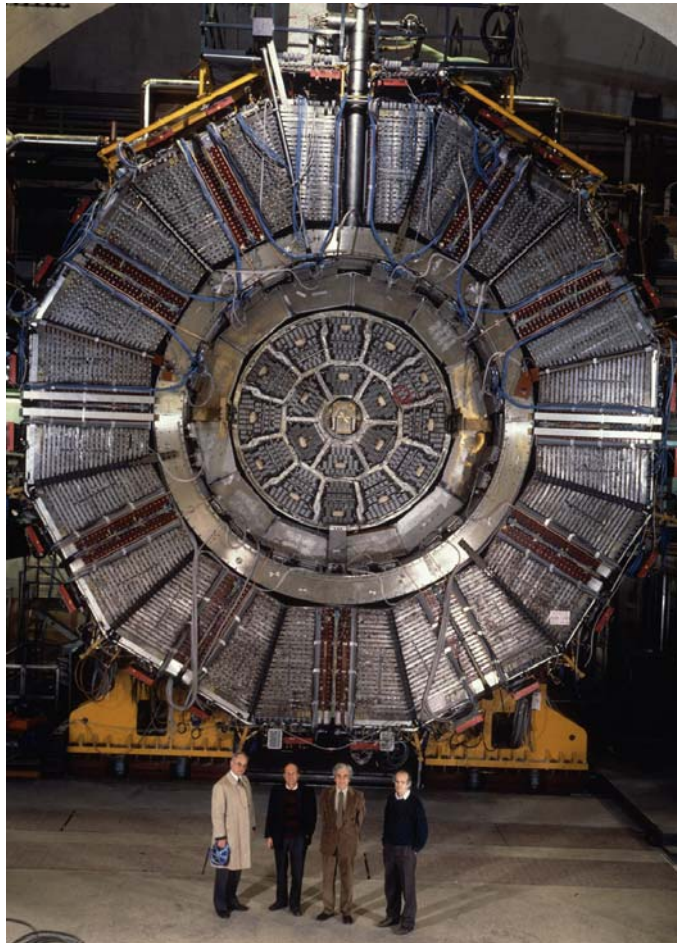- Overall as large as possible within budget constraints

A LEP Detector

The ALEPH Detector

Legend:
- Vertex Detector
- Inner Tracking Chamber
- Time Projection Chamber
- Electromagnetic Calorimeter
- Superconducting Magnet Coil
- Hadron Calorimeter
- Muon Chambers
- Luminosity Monitors

e^+ e^-

Roughly cylindrical ….. Note the order of components

Just in Case you were in any doubt …


Particle Physics Detectors are Big!

Basics of Particle Identification

- **Electrons** leave tracks & stop in EM calorimeter
- **Photons** don't leave tracks & stop in EM calo
- **Hadrons** leave tracks if charged & usually stop in hadronic calo
- **Muons** leave tracks & small calo deposits & are seen in muon detectors
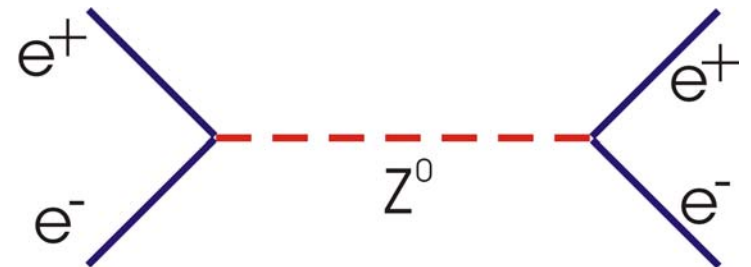- **Neutrinos** are completely unobserved
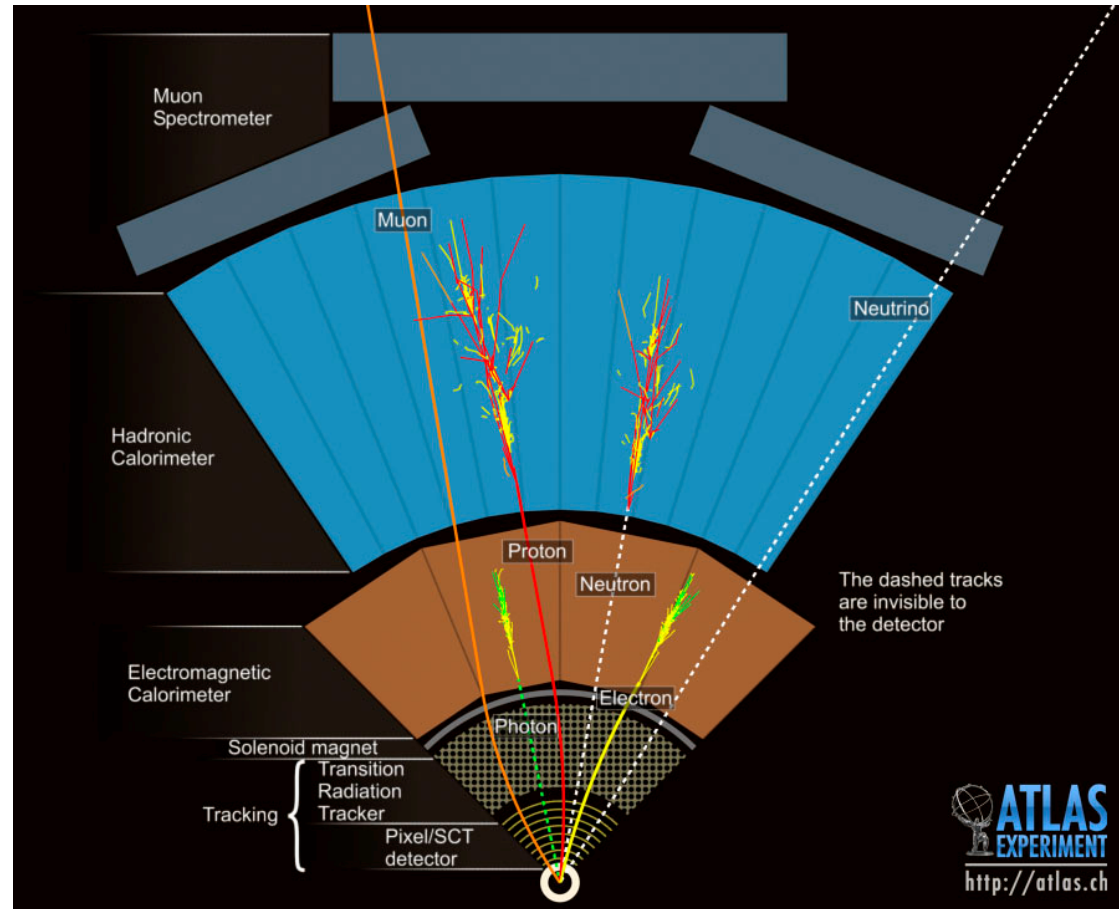
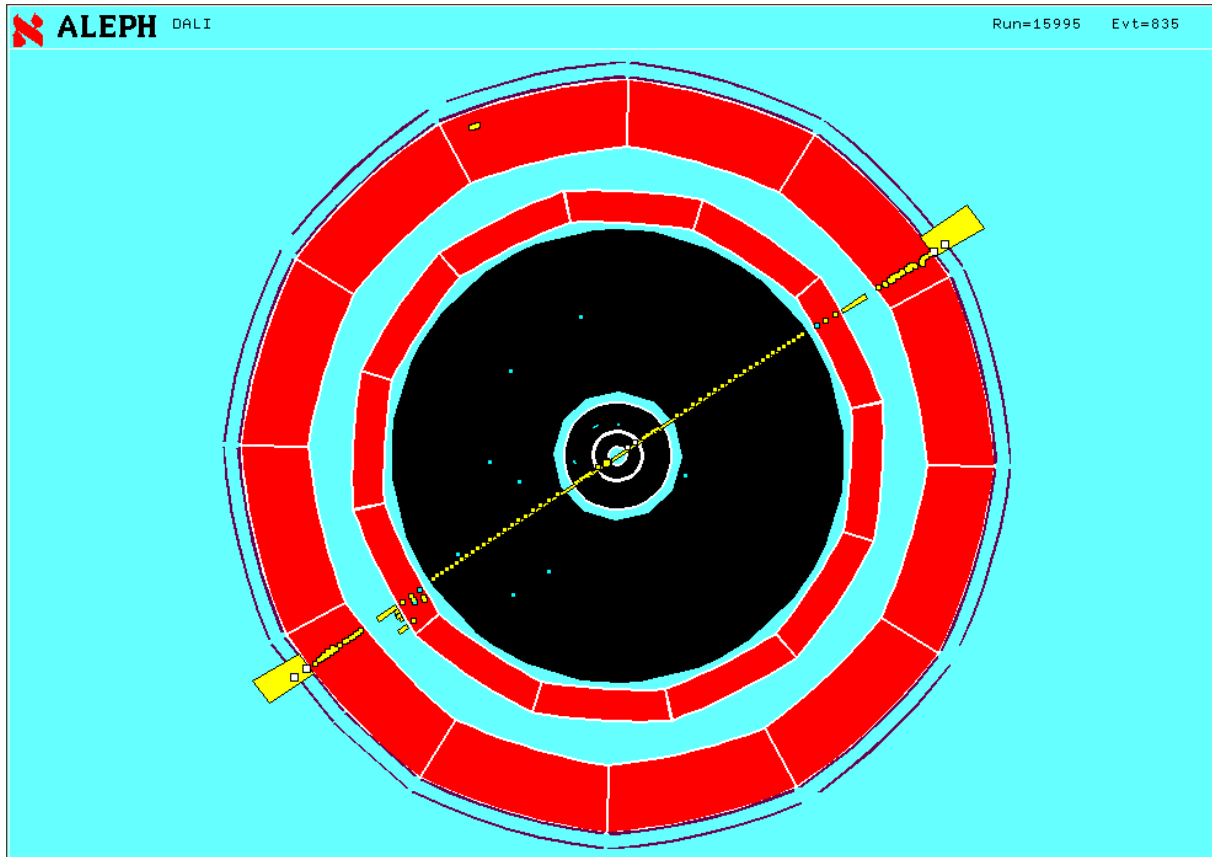Much more on detector design in future lectures ...

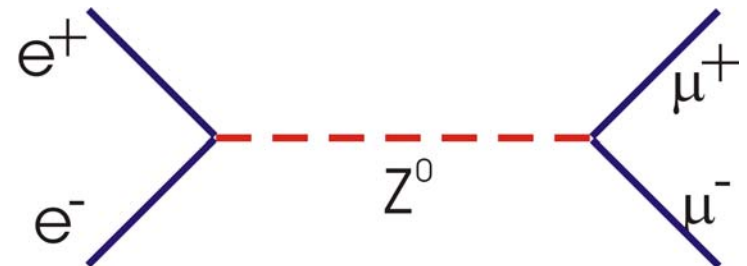# A LEP Event (ALEPH)
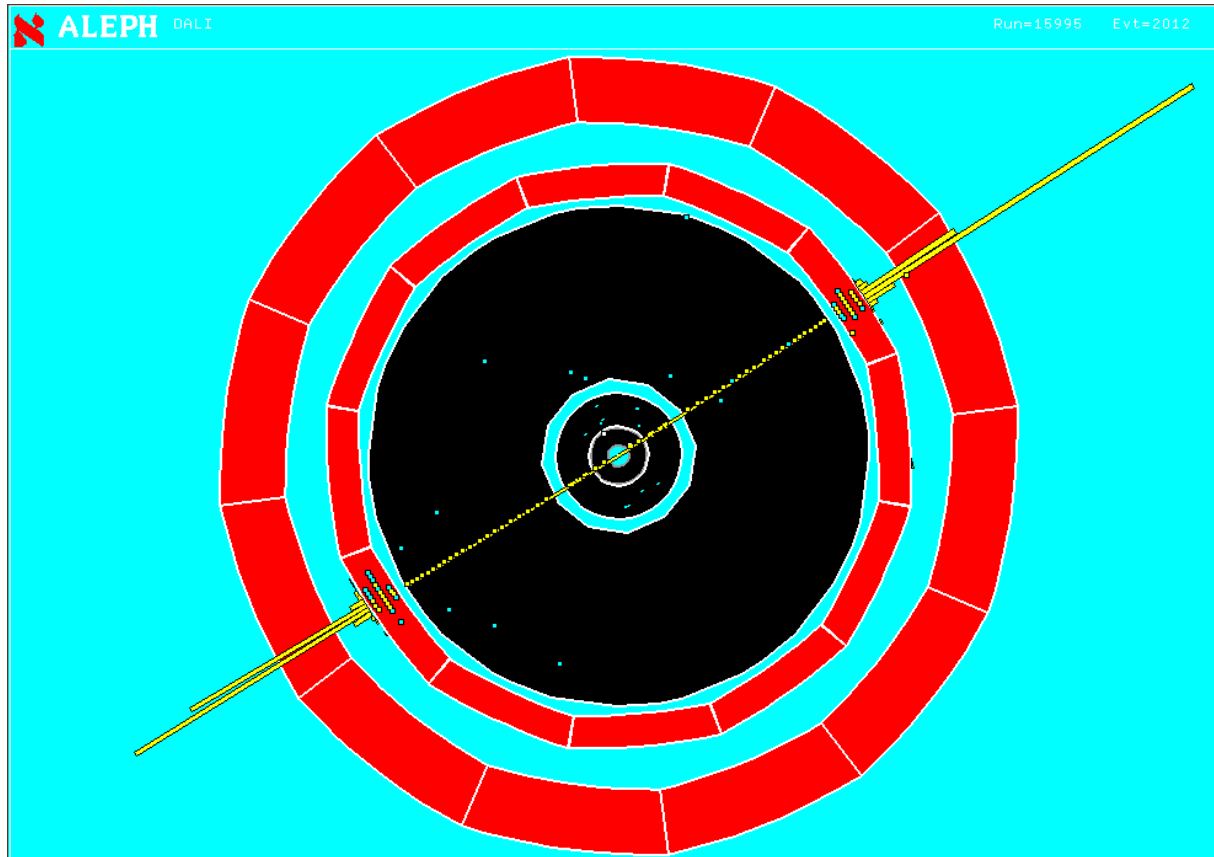
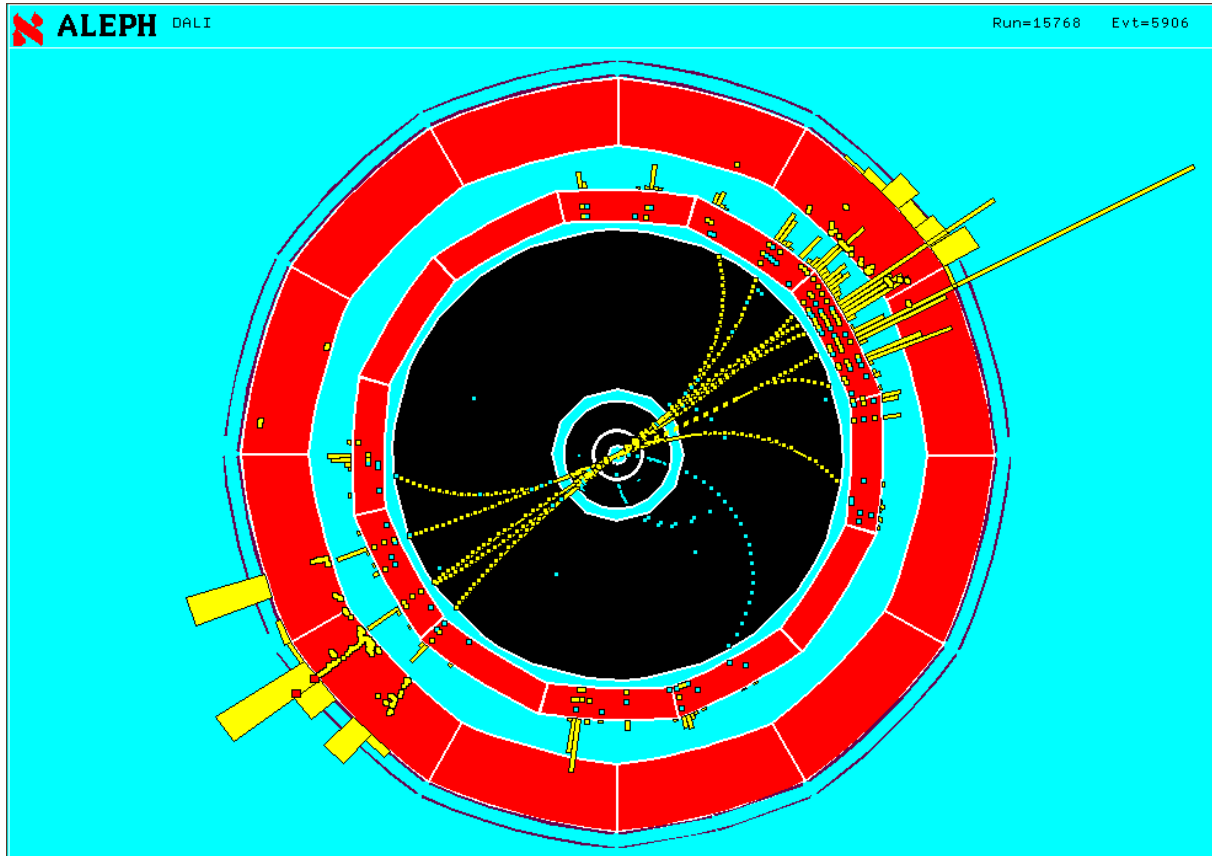Can you interpret this event?
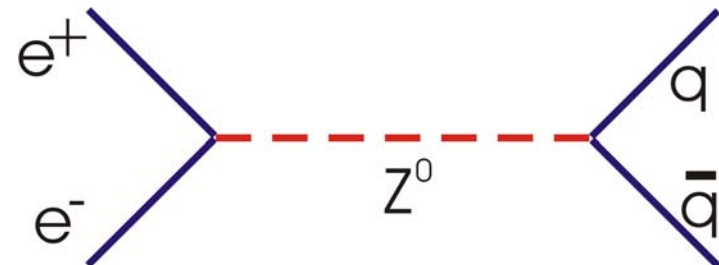
Another LEP Event (ALEPH)

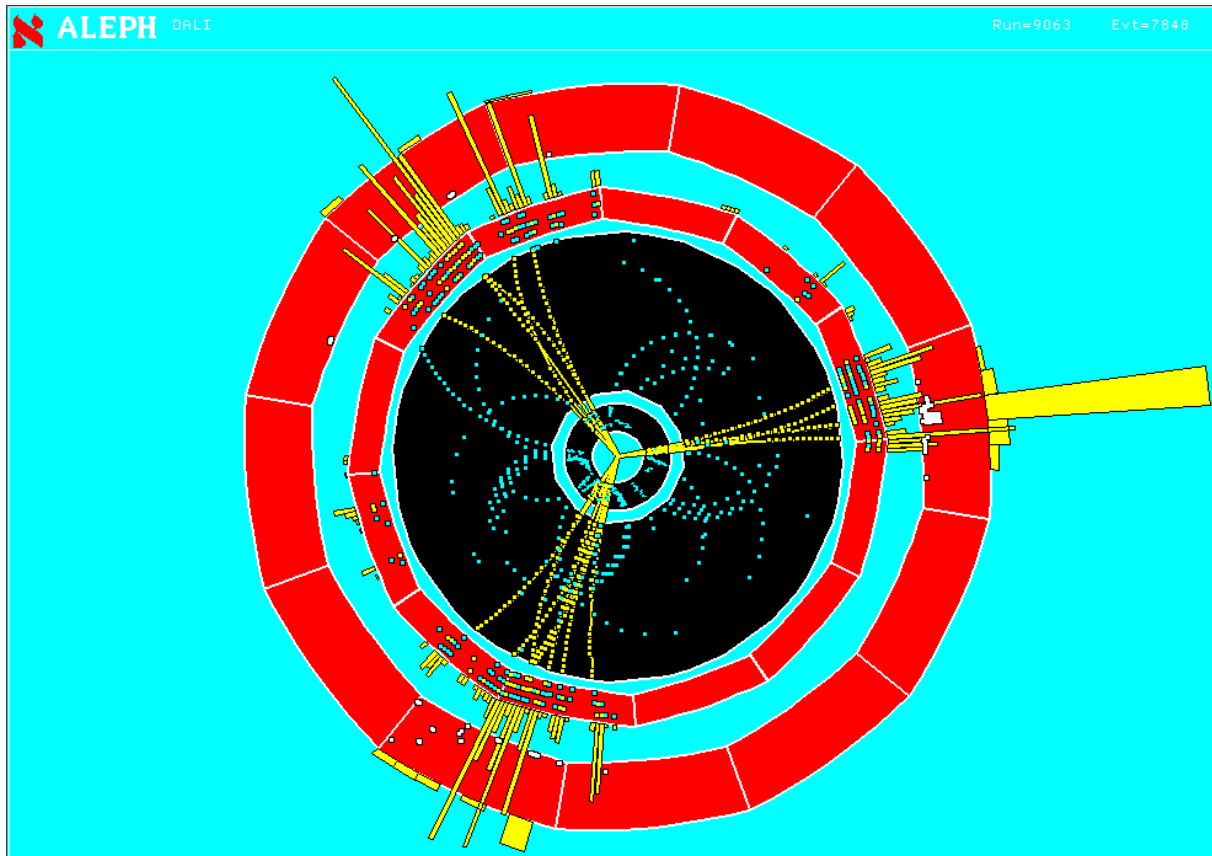Can you interpret this event?

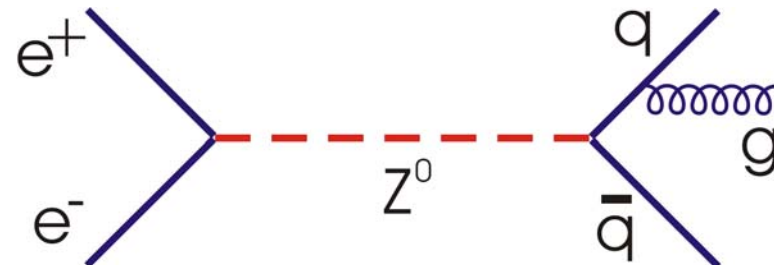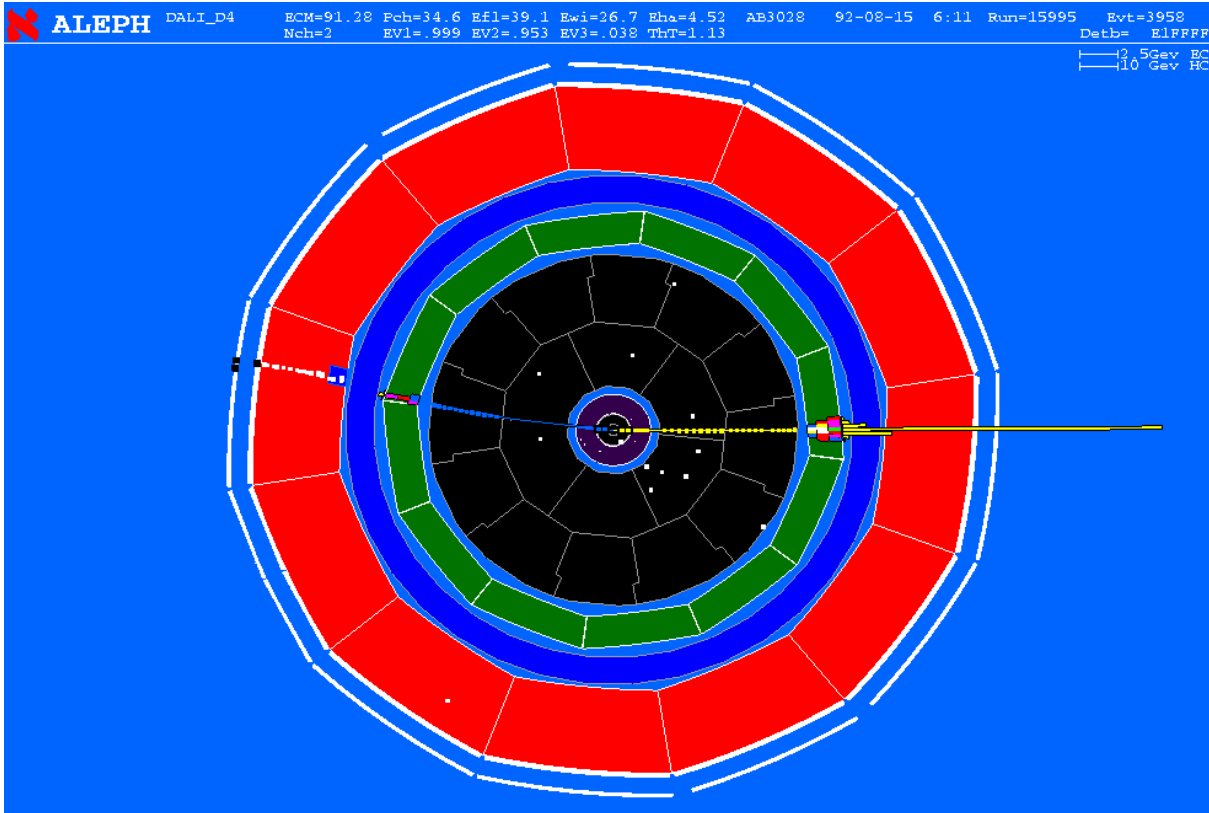# Yet Another LEP Event (ALEPH)

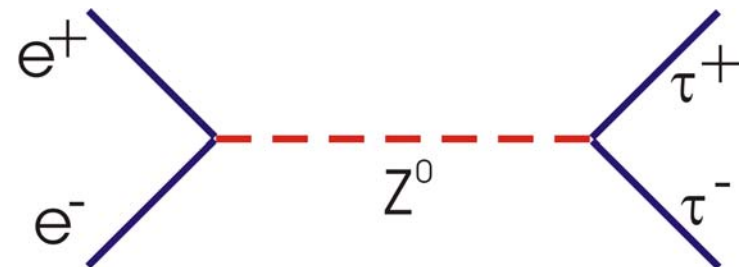Can you interpret this event?

Guess what … A LEP Event (ALEPH)

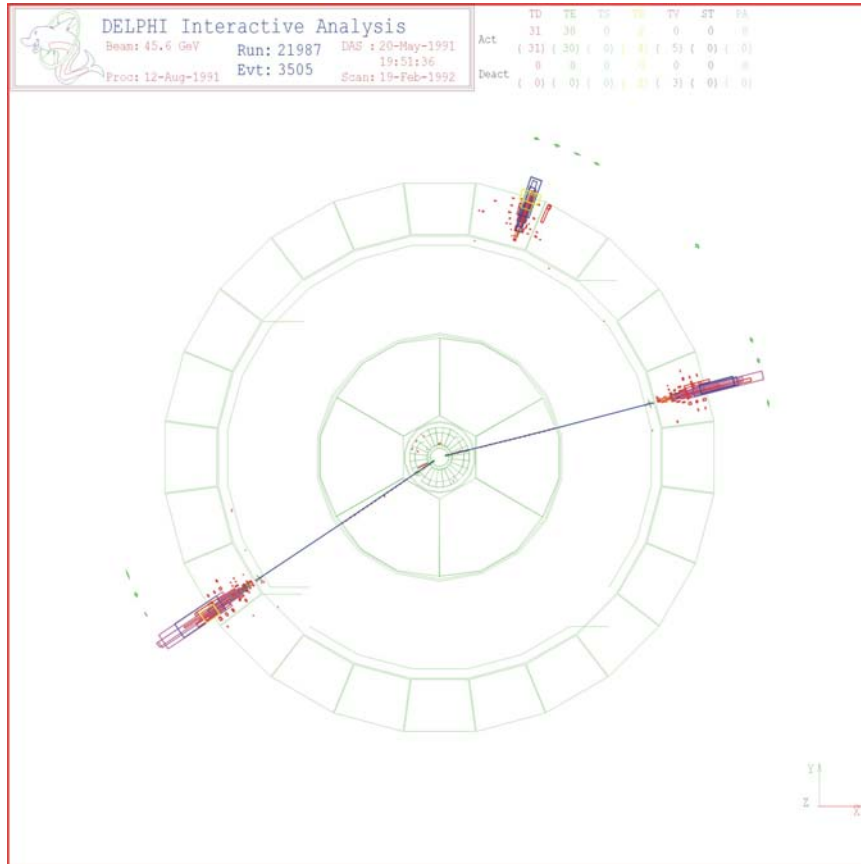Can you interpret this event?

One More LEP Event (ALEPH)
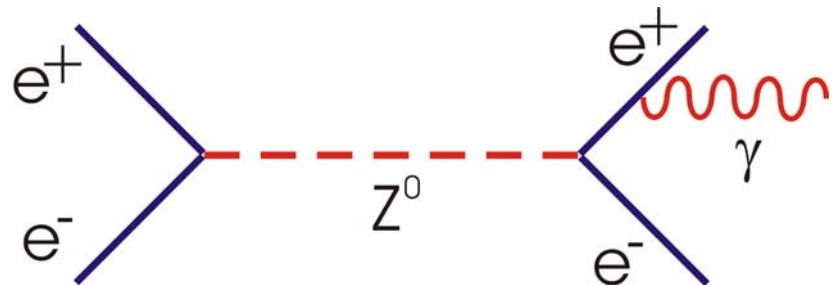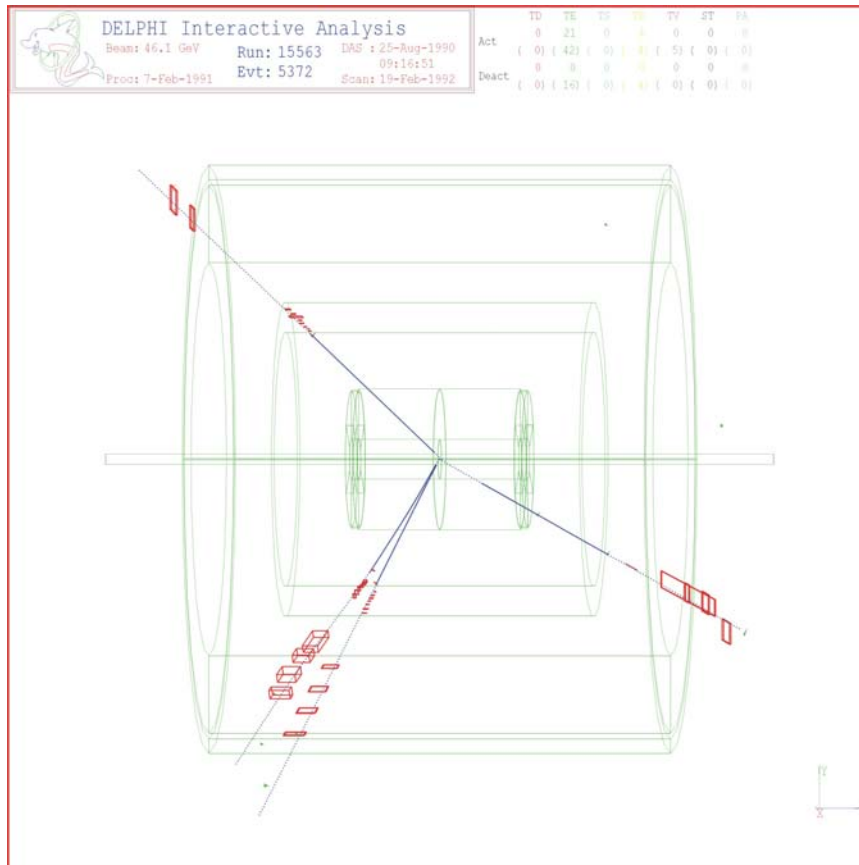

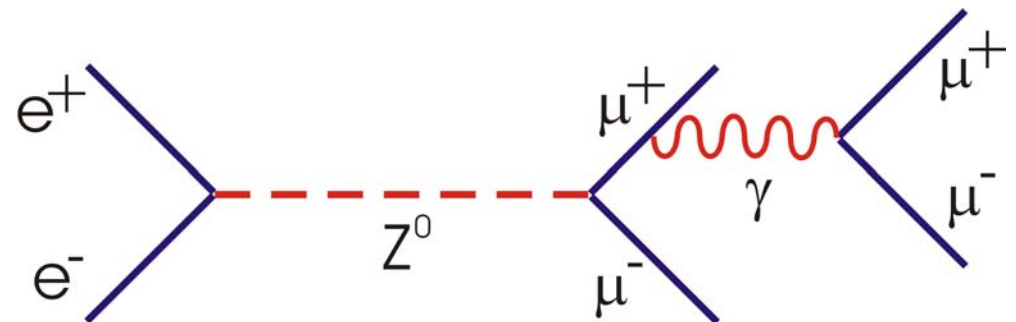Can you interpret this event?

A LEP Event (DELPHI)

Can you interpret this event?
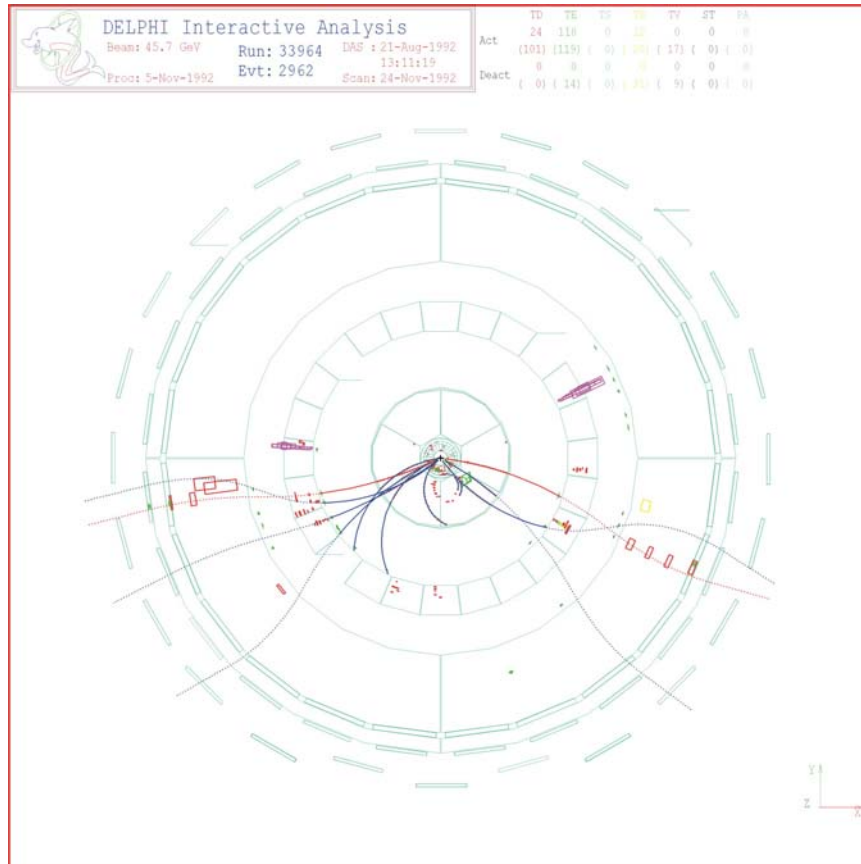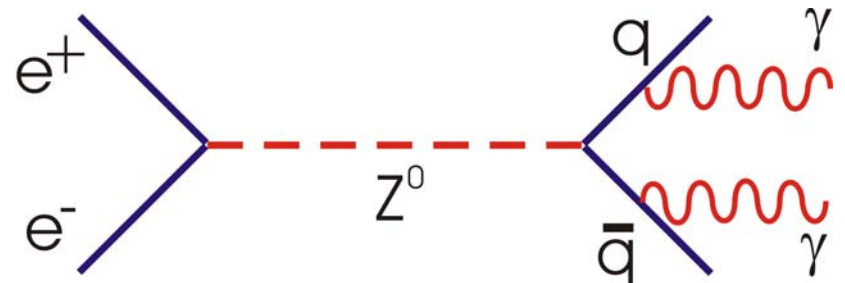
Another LEP Event (DELPHI)

Can you interpret this event?
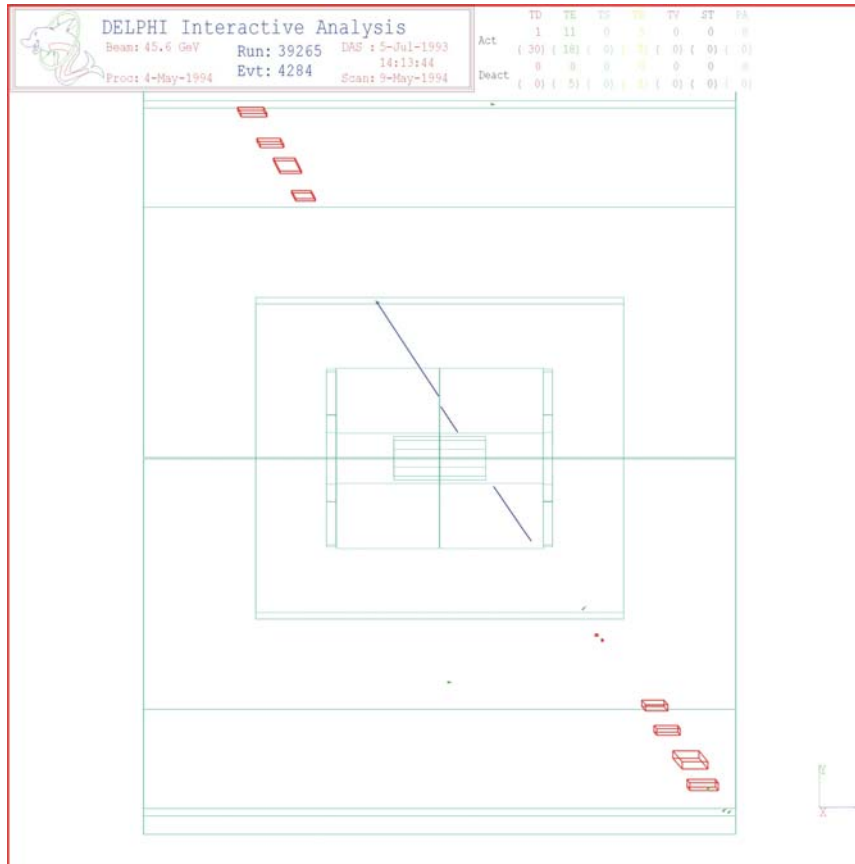
Yet Another LEP Event (DELPHI)

DELPHI Interactive Analysis
Beam: 45.7 GeV   Run: 33964   DAS : 21-Aug-1992
                                      13:11:19
Proc: 5-Nov-1992   Evt: 2962   Scan: 24-Nov-1992

Can you interpret this event?

e^+ e^- Z^0 q $\bar{q}$ γ γ

One More LEP Event (DELPHI)

DELPHI Interactive Analysis
Beam: 45.6 GeV Run: 39265 DAS : 5-Jul-1993
Proc: 4-May-1994 Evt: 4284 14:13:44
Scan: 9-May-1994

Can you interpret this event?

Cosmic Ray Muon!