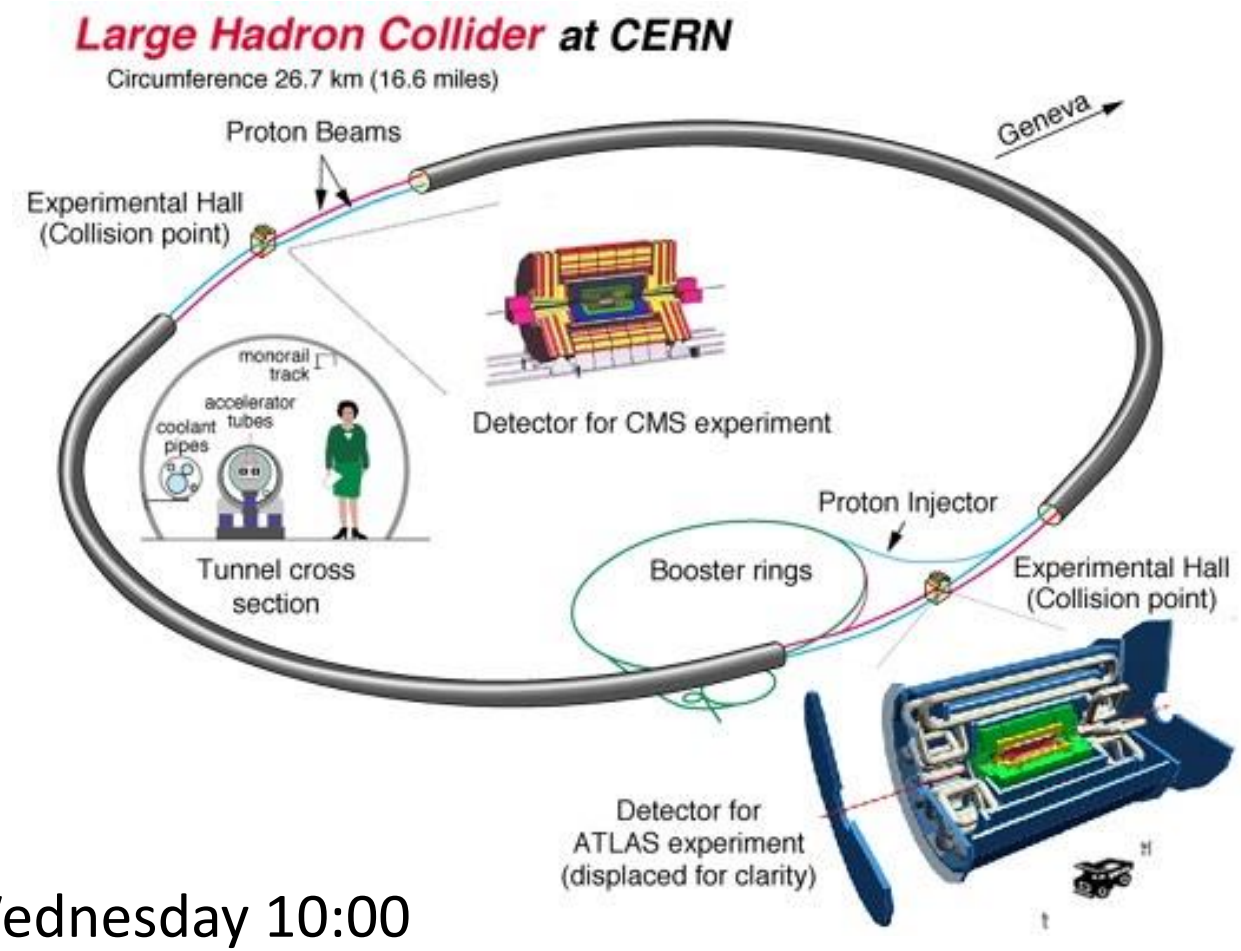
PHY2405
Experimental High Energy Physics



Monday & Wednesday 10:00
MP408

R.S. Orr
Office: Room 818A

Course Overview:

.Magnets, RF Cavities, Beams, Accelerators;

.Interaction of charged particles with matter;

.Charged particle tracking detectors;

.Calorimeters;

.Particle Identification;

.Electronics, Triggering, and data acquisition;

.Experiment Design;

I concentrate on detector technology to enable one to:

- Build Detectors
- Operate Detectors
- Write Reconstruction Software

Analysis, statistics …. Needs another course

Texts:

No set text. There are many books that I have used. I'll refer to them as we go along.

Grades:

3 assignments worth 25% each of final mark

In the past I have tended to wait until most of the material of the problem set has been covered – this proved to be a mistake. This time I'll try to distribute problems every week or two.

I have in mind to reduce the amount of stuff on accelerators. I need your feedback on this.

- Accelerators – Jan/Feb
- Particle Detectors – Feb/Mar
- A simple Monte Carlo simulation –due mid April
  - I think this is really worthwhile – it lets you understand how detector resolutions really work. But often falls off the end!

The remaining 25% based on a report

On an existing, planned, or influential past accelerator, experiment or. detector system. Discuss with me before starting.

The Report

It should cover:

- System design and physics reasons for technical design choices.
- Compromises between desired performance, and what could be realistically achieved. This is usually an interplay between desired resolution and available $$$$.
- New technology, or any innovation, which made a new area of physics accessible.
- Performance achieved, and how it affected the physics.
- I'd be really pleased if you discuss it with me while you are working on it.
- It should be around 20 pages – with figures.
- If you prefer, you can do a 30 minute presentation, followed by 15 minutes of questions from me and the rest of the class.

Sources for Ideas on Report

For Current & planned Experiments

Web Sites at (e.g.):

- Cern
  - LEP Experiments
  - Neutrino
  - LHC - ATLAS, CMS, LHC-b
- SLAC
  - BaBar, SLD
- Desy
  - ZEUS, H1, HERMES, HERA-b
- Fermilab
  - D0, KTeV, BTeV, MINOS, CDF
- Cornel
  - CESR-III
- KEK
  - BELLE, T2K, KAMLAND
- SNO, SuperKamiokande, etc....

What is High Energy Physics?

High Energy - because looking at

- small distances

- fundamental constituents
- basic interactions

A theorist would be tempted to say

- fundamental symmetries

But we infer these from constituents and interactions seen experimentally

Subatomic Physics & Engineering

- **Civil Engineering**
  - 30 km long tunnels
  - Superconducting magnets and RF - mass production
- **Mechanical Engineering**
  - Detectors 6 stories high
  - Precision alignment to microns
- **Electronic Engineering**
  - VLSI on 1000 mm^2 die - S, GaAs, etc
  - Digital and Analog @ > 50 MHz
- **Materials Science**
  - Exotic Detector materials
  - Chemical Vapour Deposited Diamond
- **Computer Science**
  - Embedded Processing
  - Software tools - OO
  - Pbytes of data 10^{15}
  - 1000 processor parallel farms
  - Web developed by HEP - international data sharing
  - GRID computing & Data sharing

Subatomic Physics & Engineering

- **Aerospace Engineering**
  - Orbiting Anti-matter detector - test flown on shuttle
  - Final Detector on Space Station

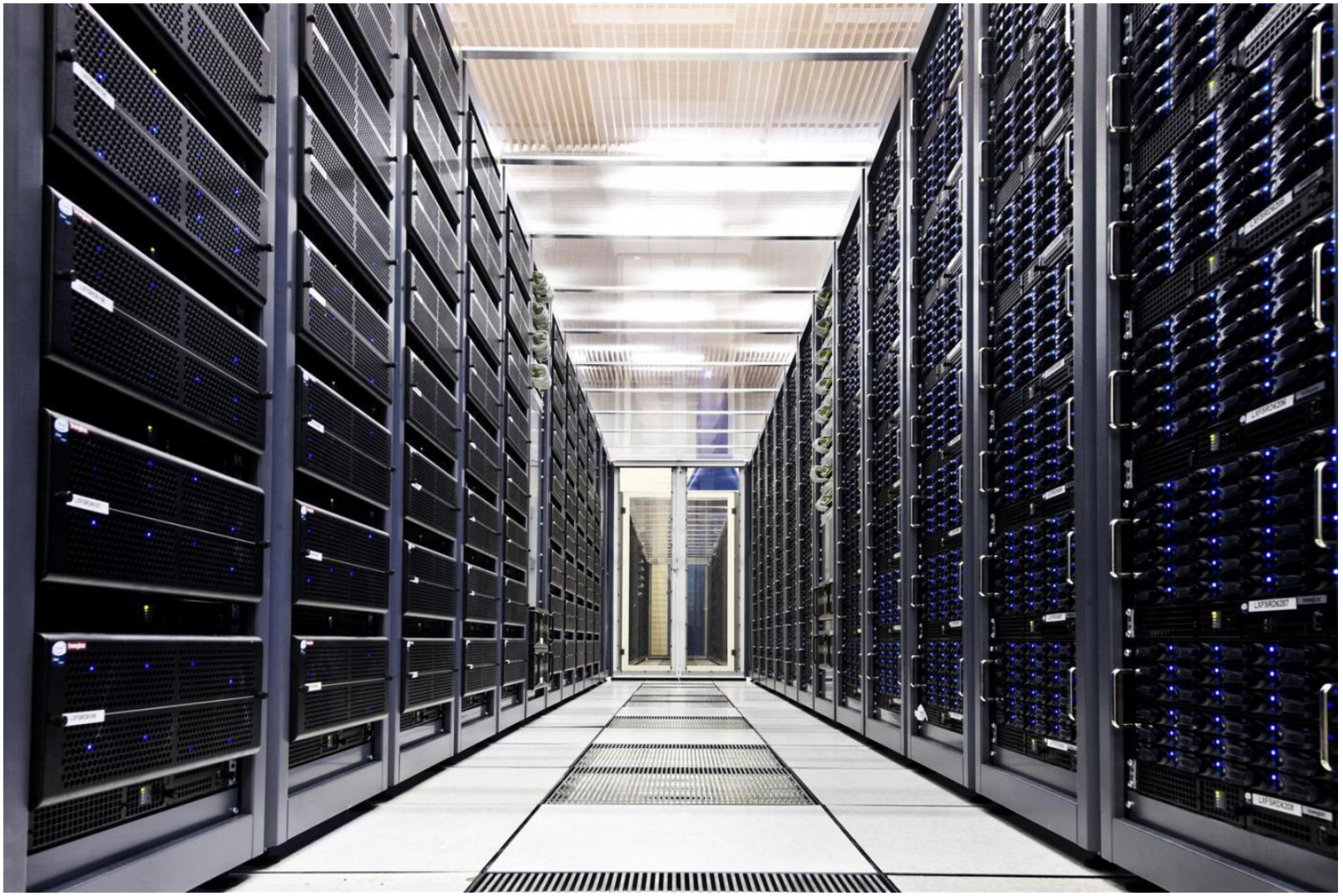
- **Biomedical Engineering**
  - New Detectors to minimize dose
  - Positron emission imaging
  - New radiotherapy isotopes
  - New forms of therapy - hadrotherapy

Goodbye - SciNet

- General Purpose Cluster consists of 3,780 IBM System x iDataPlex dx360 M3 nodes, each with 2 quad-core Intel Nehalem (Xeon 5540) processor running at 2.53 GHz, totaling 30,240 cores in 45 racks
- All nodes are connected with Gigabit Ethernet, and DDR InfiniBand is used additionally in 864 nodes to provide high-speed and low-latency communication for message passing applications.[4]

Lxplus.cern.ch

The Meyrin site currently provides some 45 petabytes of data storage on disk, and includes the majority of the 100,000 processing cores in the CERN DC.



- The WLCG is the world's largest computing grid.
- European Grid Infrastructure (link is external) in Europe
- Open Science Grid (link is external) in the US –
- Has many associated regional and national grids (such as TWGrid in Taiwan and EU-IndiaGrid and SciNet

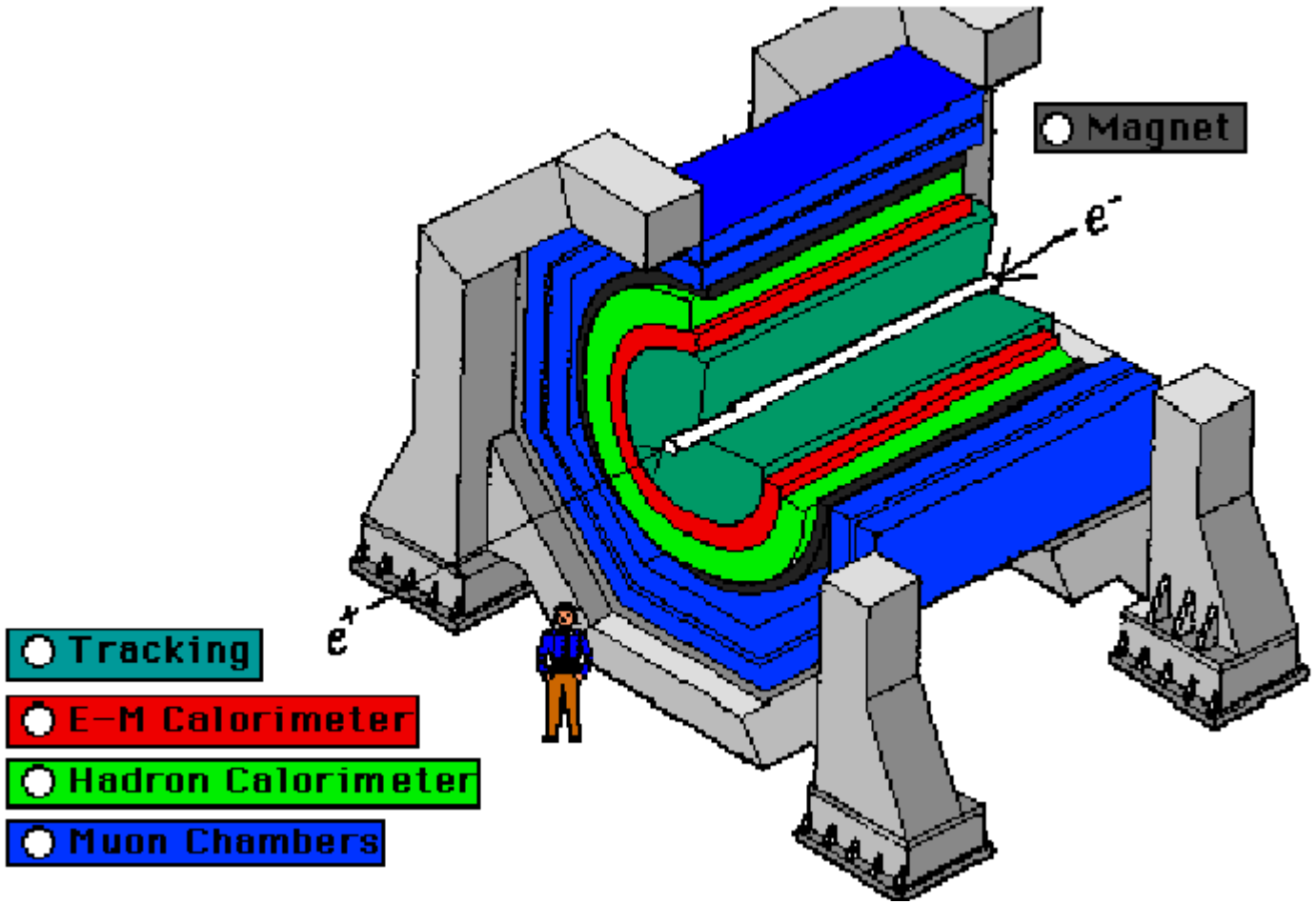
High Energy Physics Experiments?

1. Collide Particles

2. Detect Final State

3. Understand connection of 1. And 2.

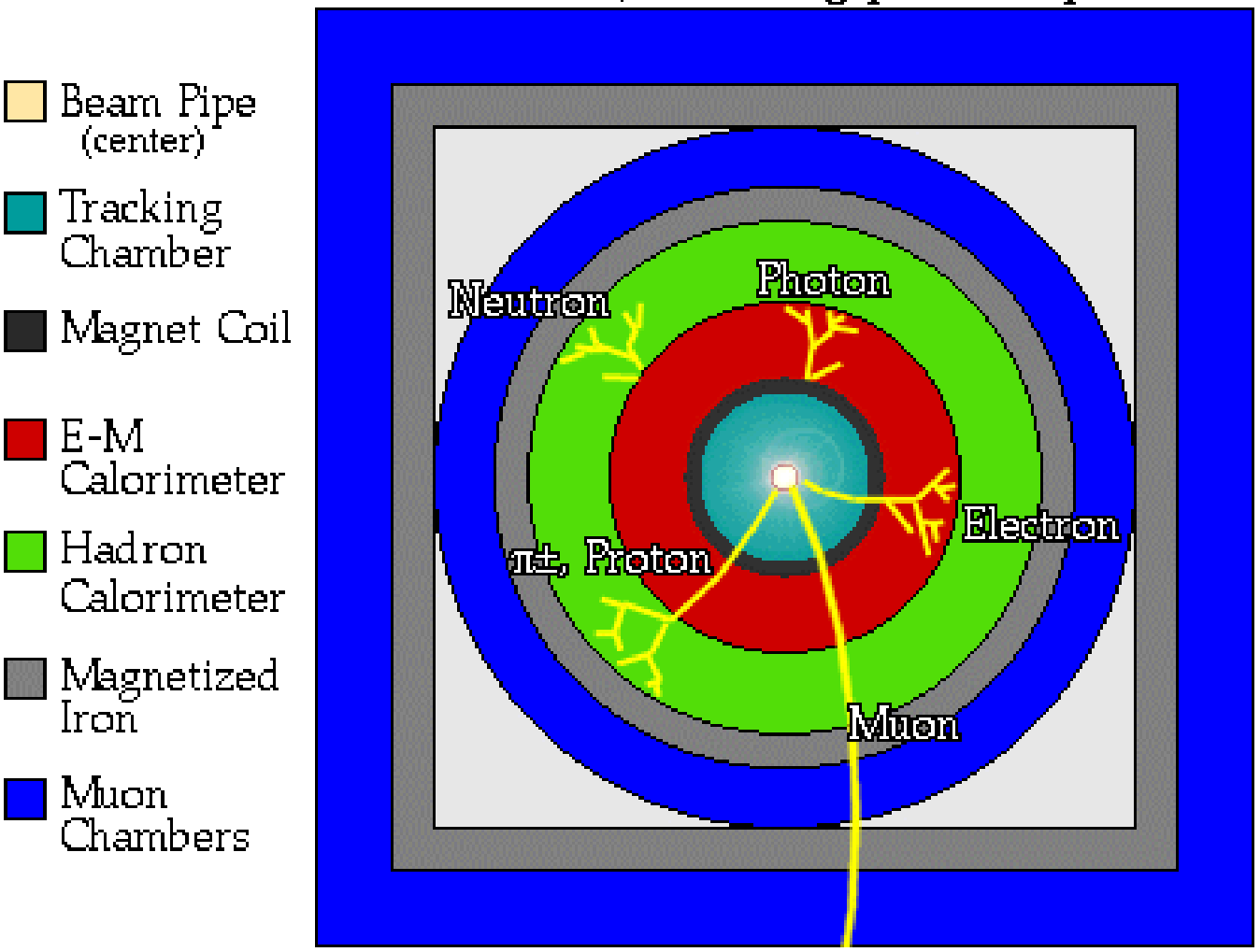
Generic Collider Experiment



Layers of detector systems around collision point

Generic Collider Experiment

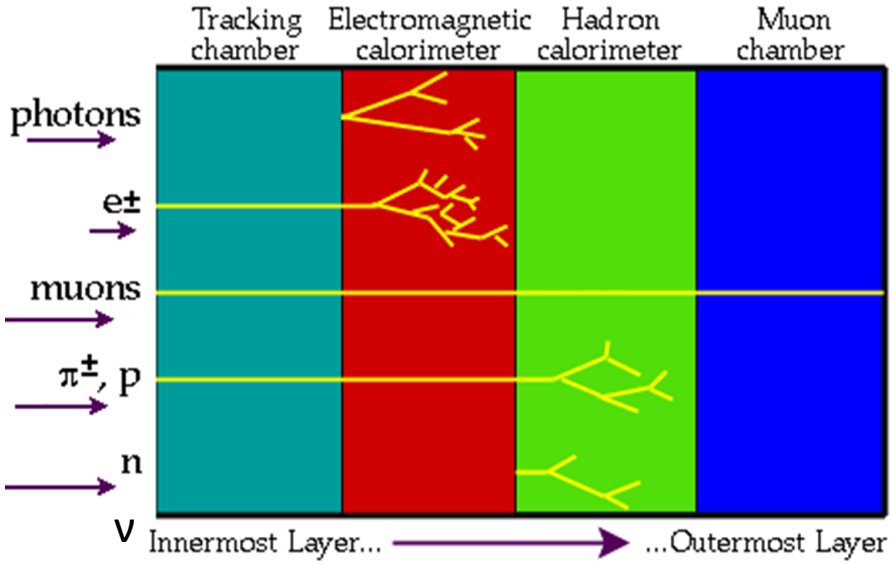
A detector cross-section, showing particle paths



Generic Fixed Target Experiment

Extracted Beam

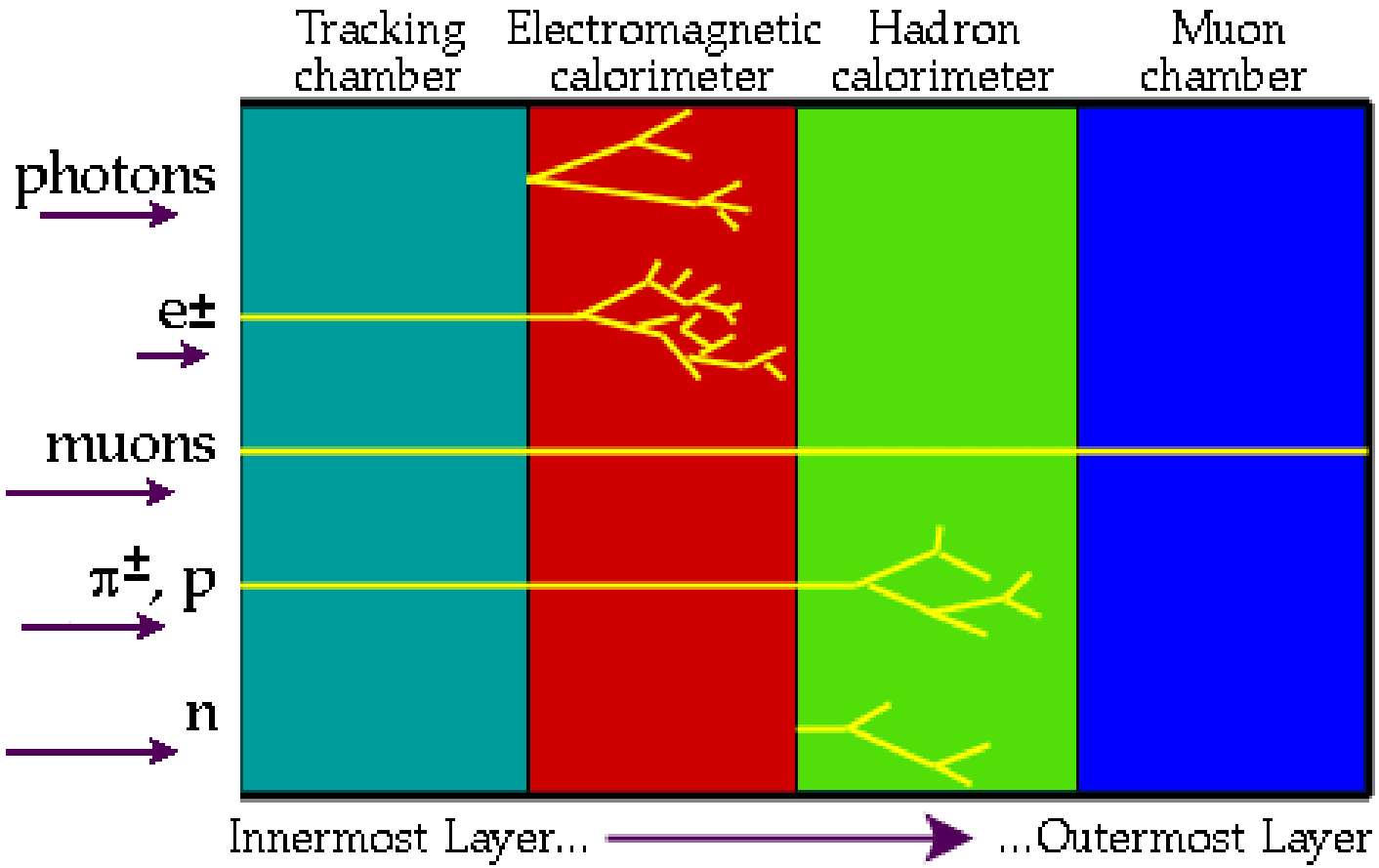
Target



Accelerator

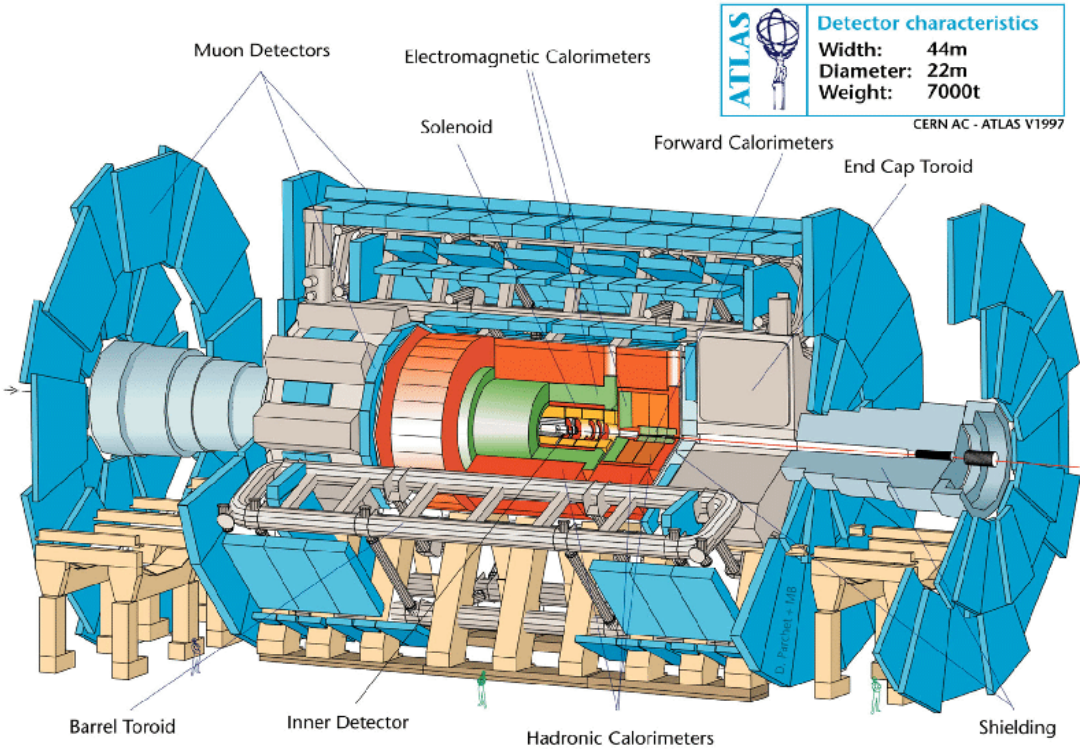
Detector

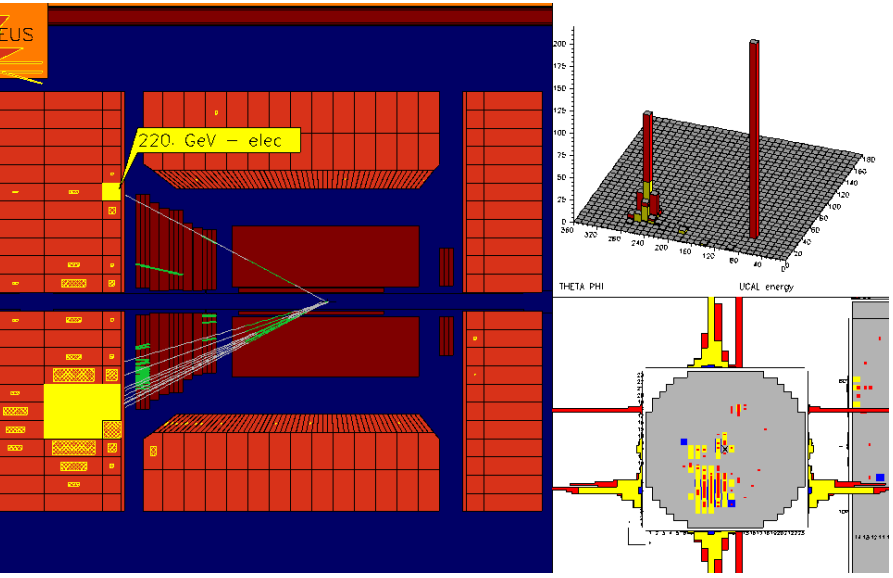
Particle Detection and Identification



- Different particles detected by different techniques.

- Calorimeter detects ionisation from a shower of secondaries produced by primary particle.


Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding
ATLAS
Detector characteristics
Width: 44m
Diameter: 22m
Weight: 7000t
CERN AC - ATLAS V1997


220. GeV – elec
THETA PHI
UCAL energy