Particle detectors

Overview

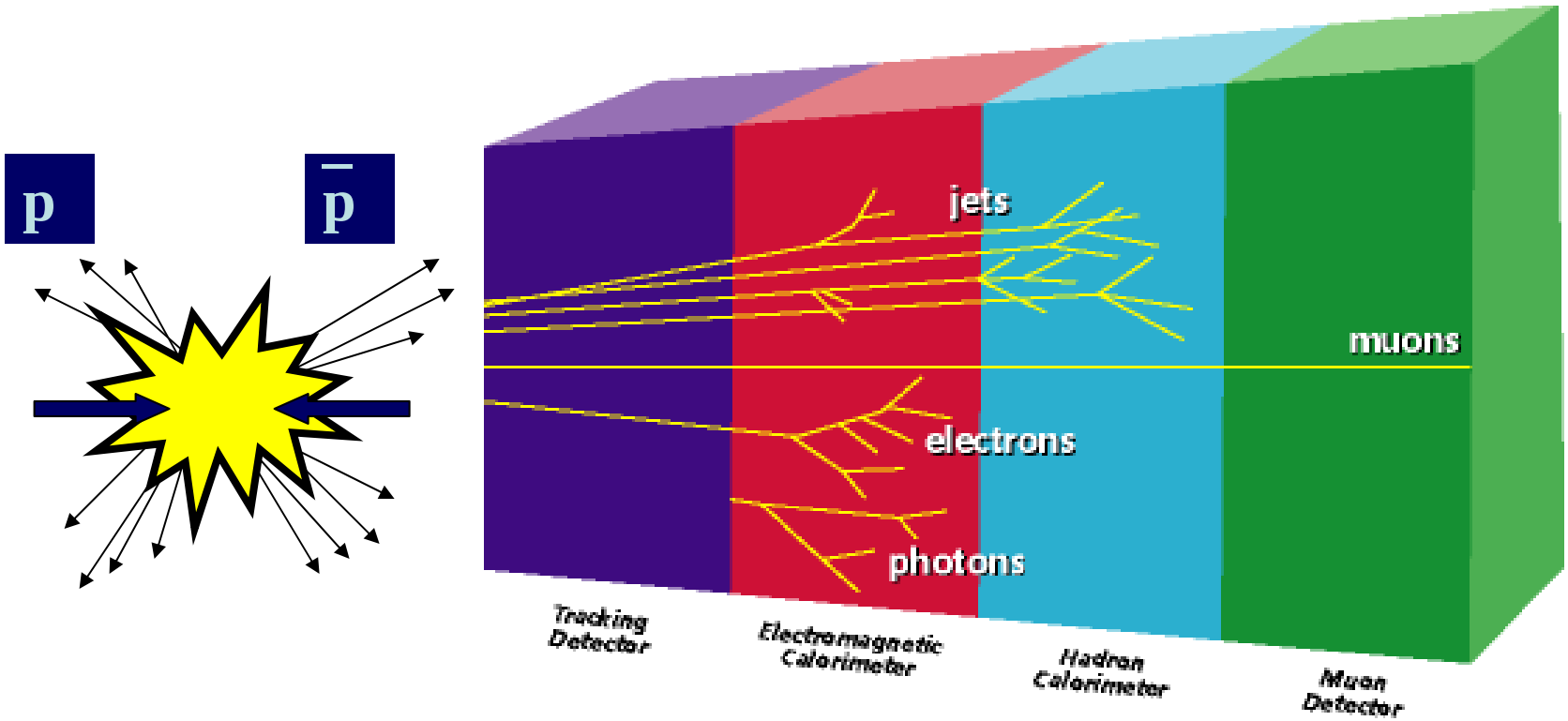
How to detect particles:

- **Concept of particle physics experiments**

- **Constituents of detectors**
  - Tracking chambers
  - Calorimeters
  - Muon chambers

- **Example of how we visualise interactions**

Particle detectors

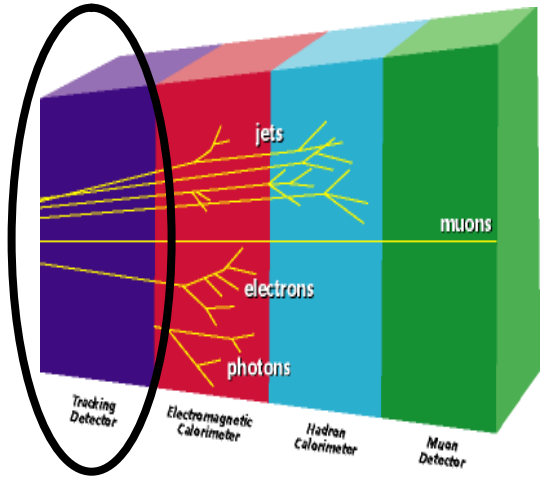


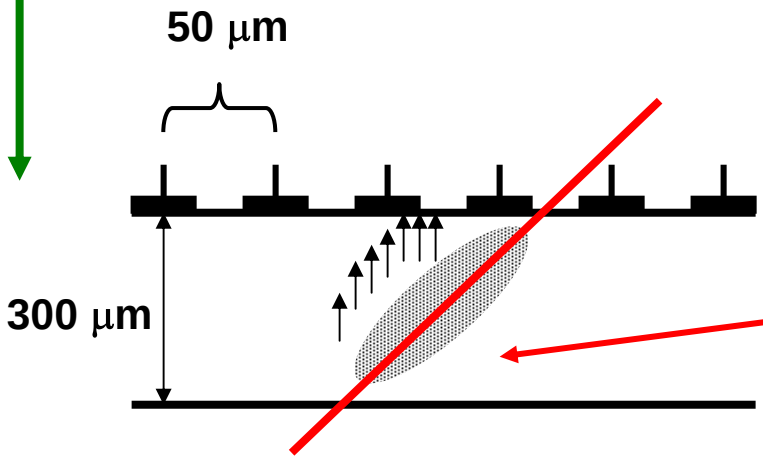
Tracking detectors

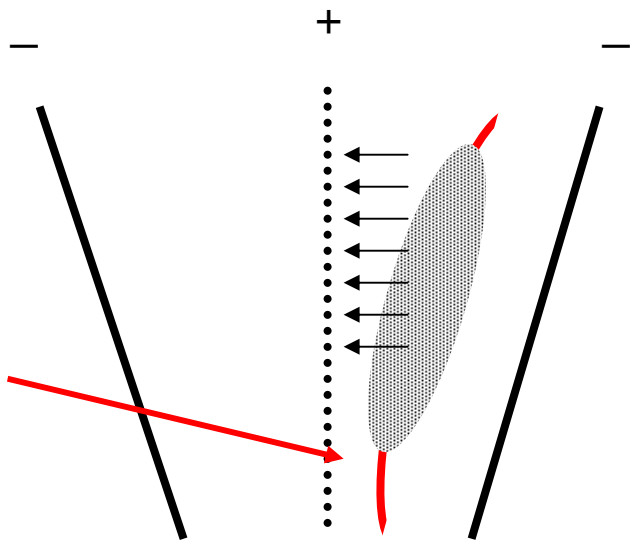
Measure position of charged particles to high precision. (→ p with B)

Drift chambers:

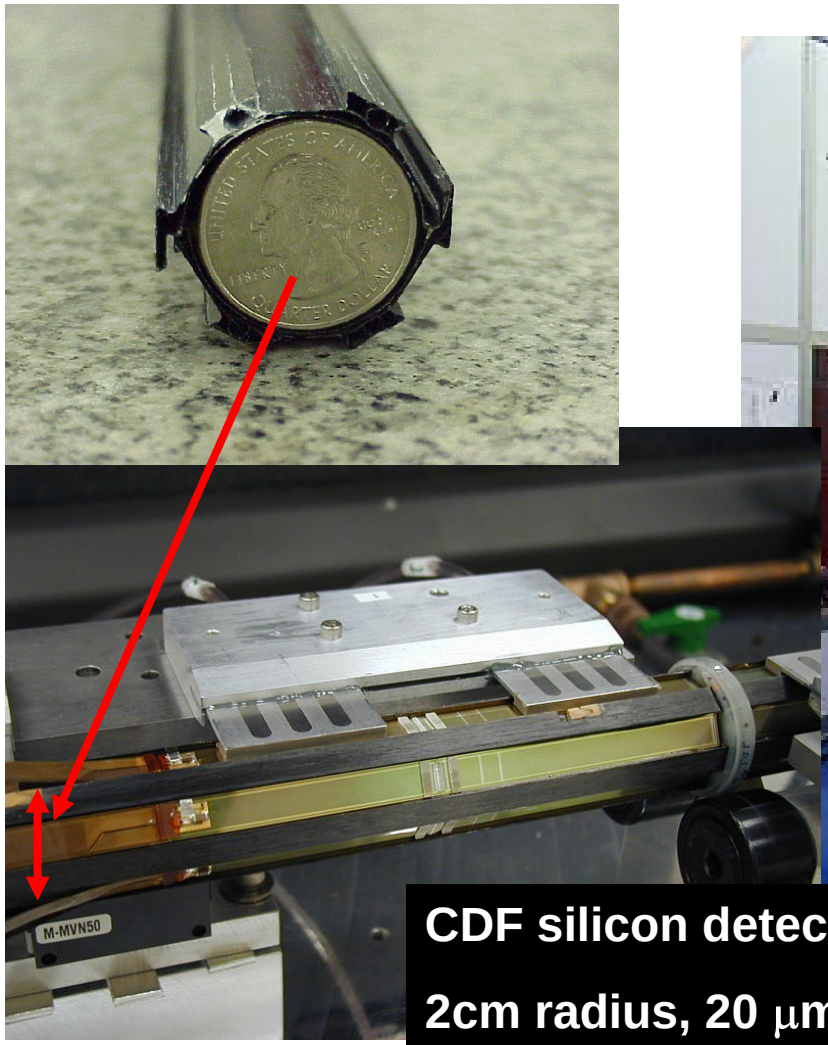
Silicon detectors:







CDF (Tevatron) tracking detectors



CDF silicon detector

2cm radius, 20 μm precision

CDF drift chamber
1.4 m radius

100 μm precision

Bubble chambers

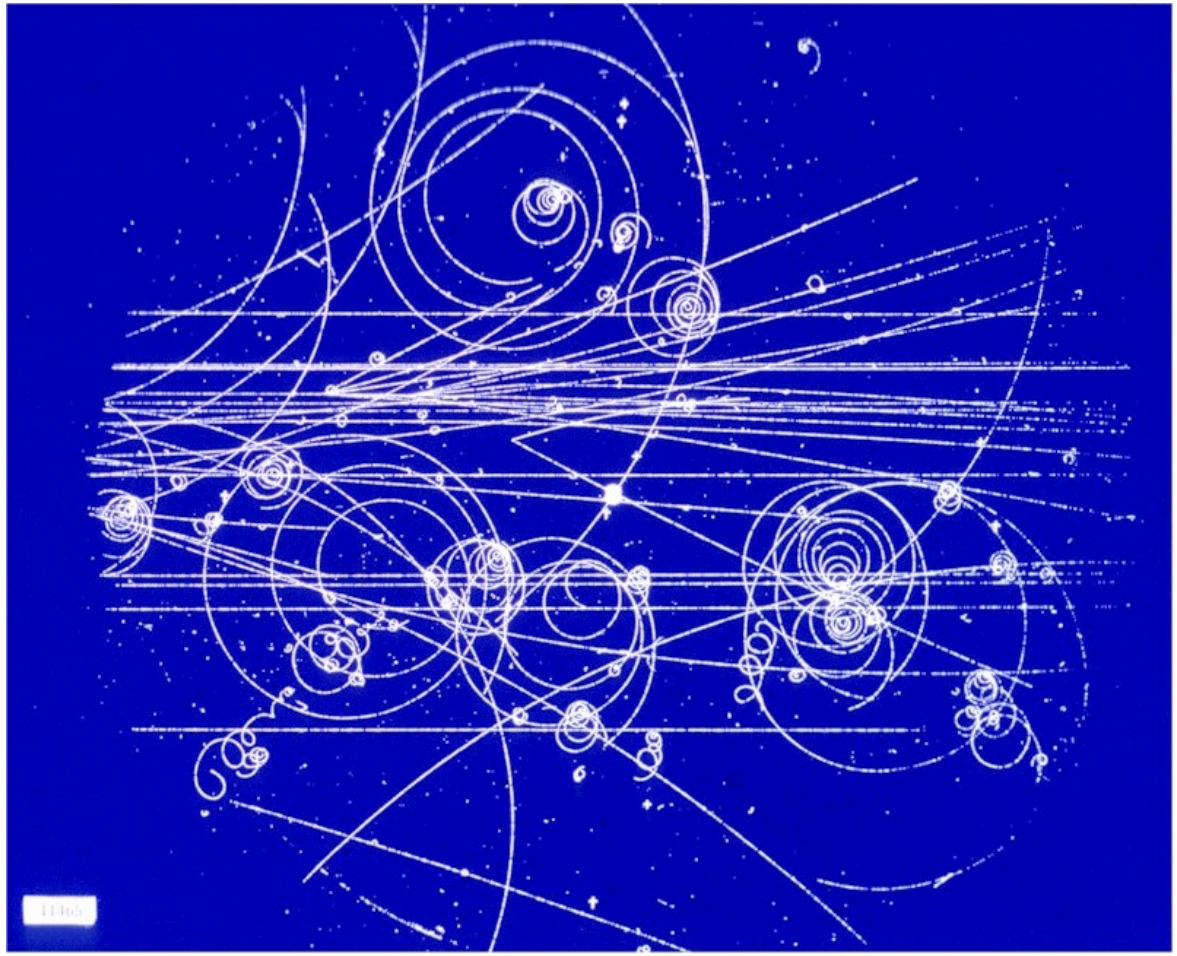
Used 1950 – 1980s

Chamber contains superheated liquid (eg. Hydrogen) – proton target

Bubbles appear along track of charged particle

Spatial resolution 100-200 μm

Cons: slow repetition rate (bubbles must dissolve), slow to analyse photographic film



Pion beams interacting with proton targets

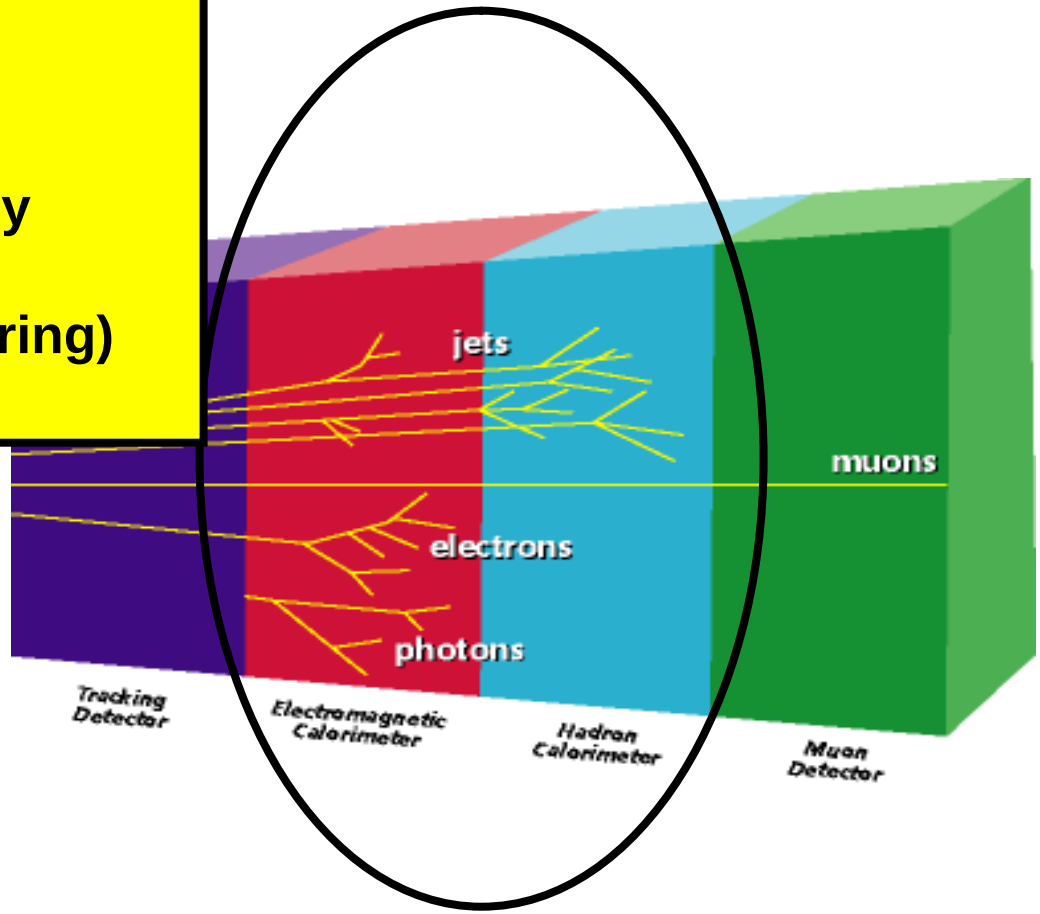
Calorimeters

Two types of calorimeter:

Electromagnetic

Hadronic

Both detect particles by provoking "shower", absorbing (and measuring) energy

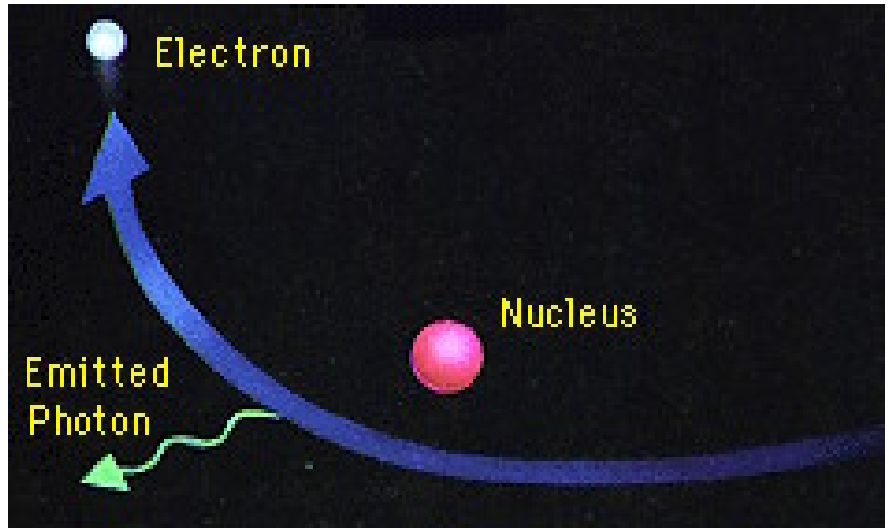


Bremsstrahlung

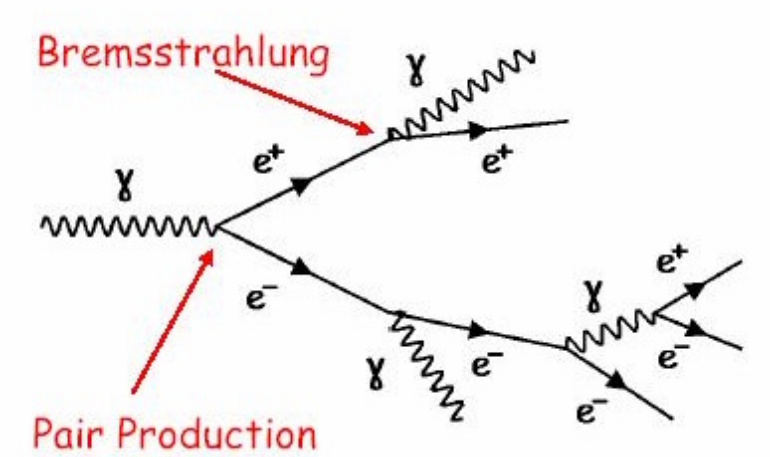
(For EM calorimetry)

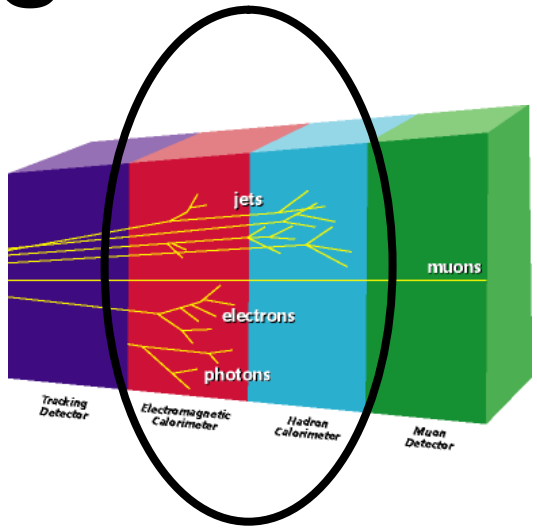
“Braking radiation”

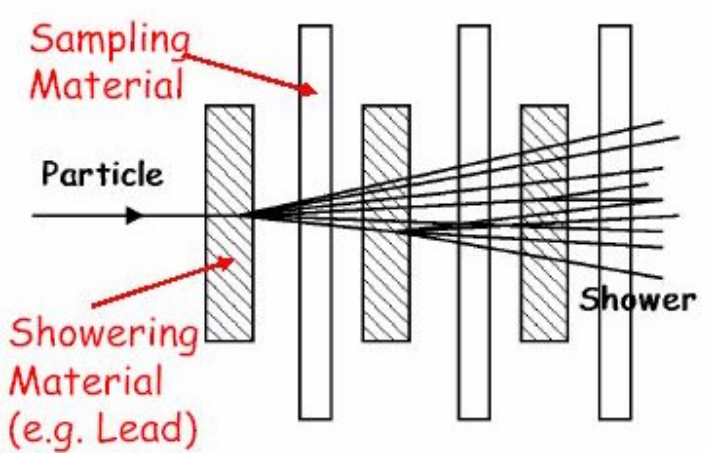
Photon emitted after charged particle interacts with other charged body



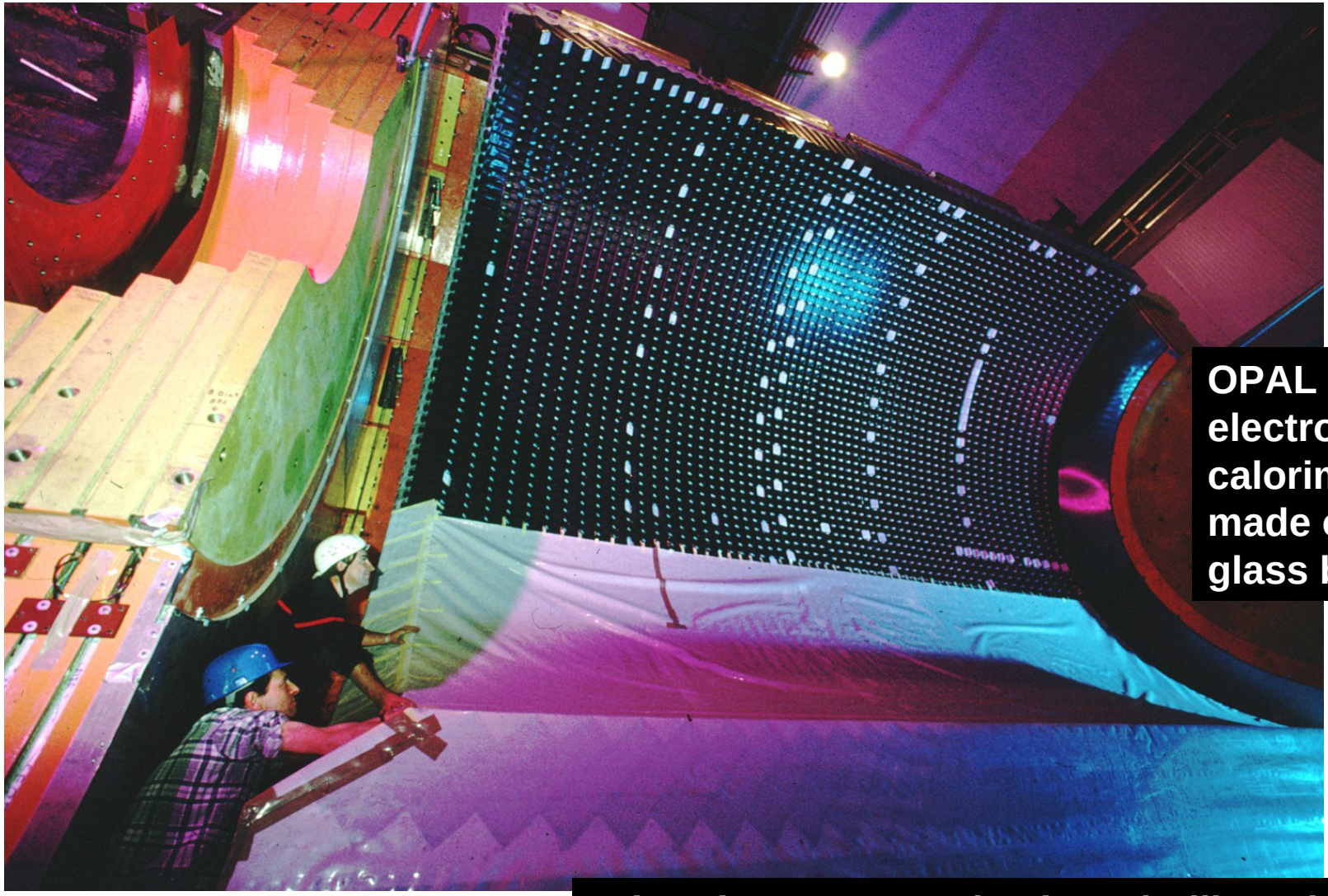
Calorimeters







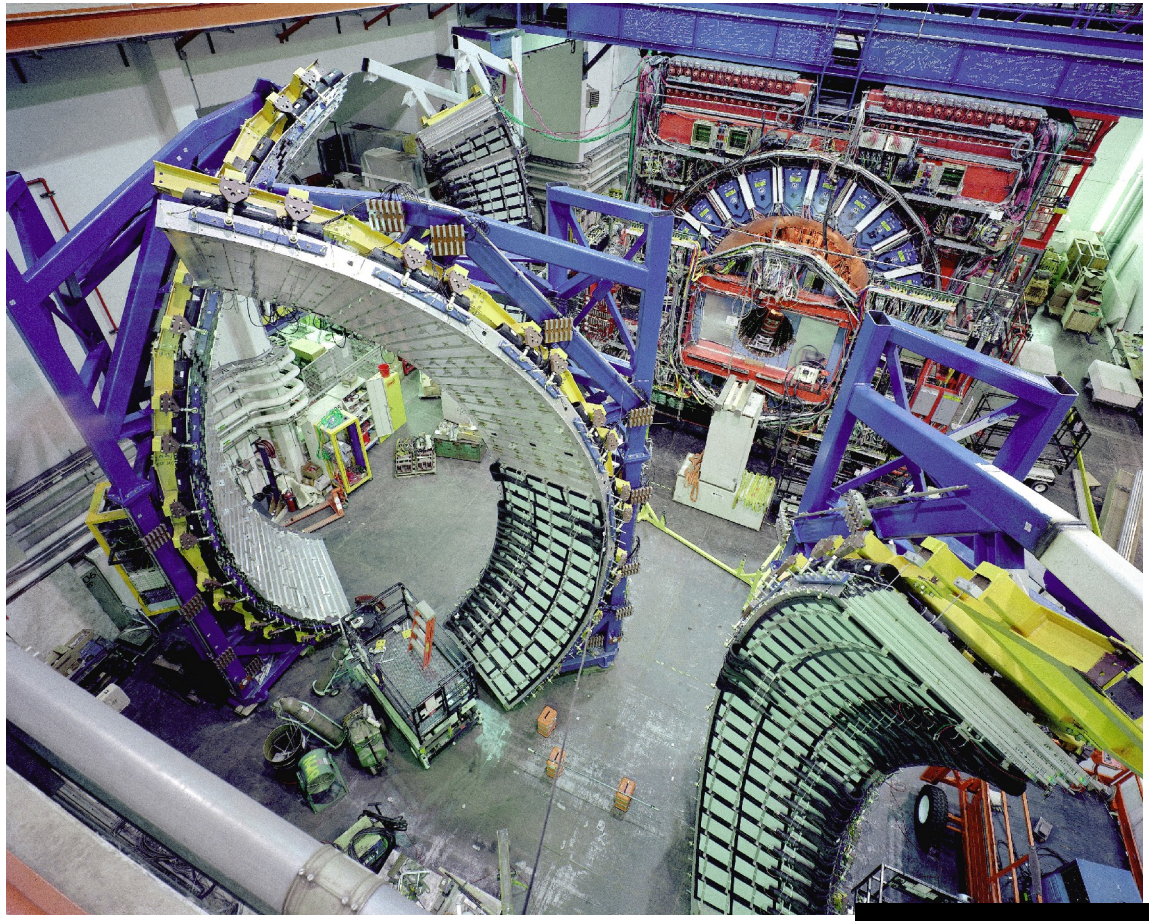
Calorimeters



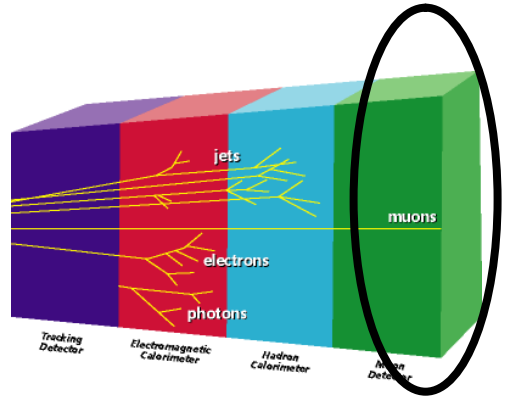
OPAL (LEP) electromagnetic calorimeter; made of lead glass blocks

Other detectors use lead + scintillator in layers

Muon chambers



CDF muon chambers prior to installation



Muons are weakly interacting and pass through calorimetry

Add chambers to detect particle path at large radii

Detection summary

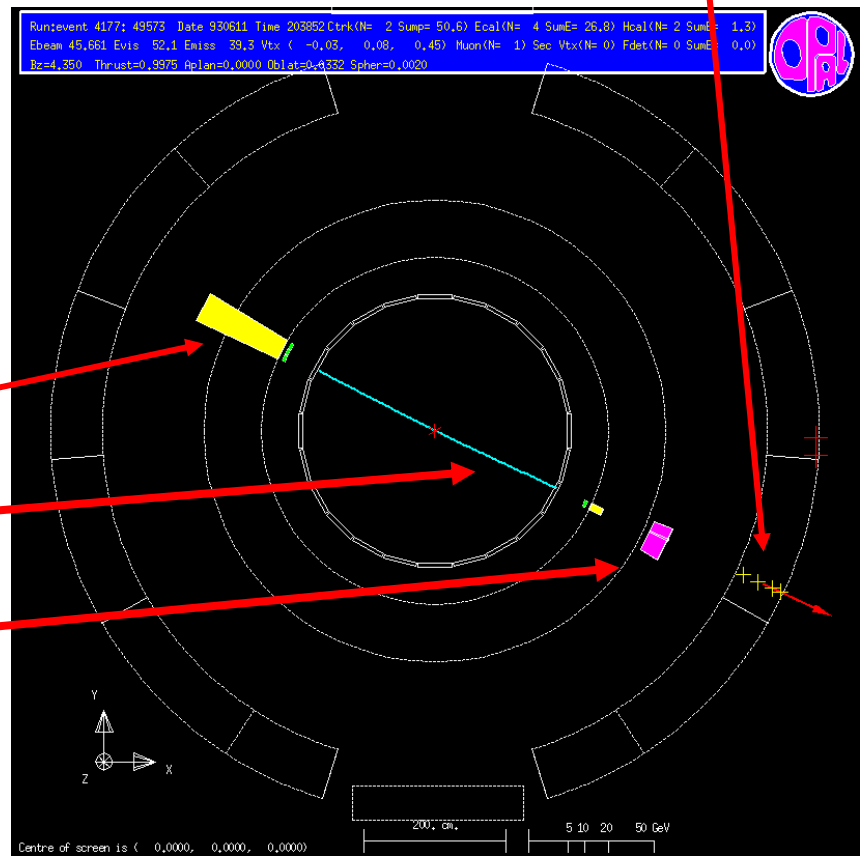
particle	Tracking chambers hit	Electromagnetic calorimeter hit	Hadronic calorimeter hit	Muon detector hit
Photon, π^0	no	**yes**	no	no
electron	**yes**	**yes**	no	no
π^+,K^+,p	**yes**	no	**yes**	no
n,K^0	no	no	**yes**	no
μ	**yes**	no	no	**yes**
ν	no	no	no	no

Hit = major deposit of energy

Event displays

- Detector information digitised in readout.
- Reconstructed using computer programs
- Enables us to visualise interactions

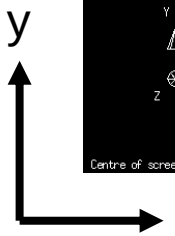
Hits in muon chamber



Yellow: electromagnetic energy

Tracks (from tracking info)

Pink: hadronic energy



$Z^0 \rightarrow \tau^+\tau^-$, $\tau^+ \rightarrow \mu^+\nu_\mu$, $\tau^- \rightarrow e^-\nu_e$

Summary

Detecting fundamental particles:

- High precision trackers reconstruct charged particle tracks (and thus momentum)
- Electromagnetic calorimeters distinguish electrons, photons, π^0s
- Hadronic calorimeters distinguish π^+, kaons, protons
- Muon chambers distinguish muons
- We never see neutrinos