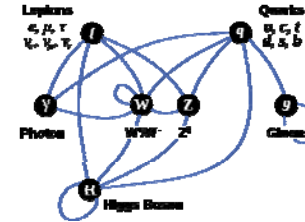


Outline

- Relativistic Kinematics
 - ▶ (4-momentum)² invariance, invariant mass
 - ▶ Hypothesis testing, production thresholds
 - ▶ Cross-sections, flux and luminosity
 - ▶ Particle lifetime, decay length, width
- Classification of particles
 - ▶ Fermions and bosons
 - ▶ Leptons, hadrons, quarks
 - ▶ Mesons, baryons
- Quark Model
 - ▶ Meson and baryon multiplets
 - ▶ Isospin, strangeness, c, b, t quarks
- Particle Interactions
 - ▶ Virtual particles and range of forces
 - ▶ Strong and weak decays, conservation rules
 - ▶ Parity, charge conjugation, CP
 - ▶ Weak decays of quarks
 - ▶ Colour charge, QCD, gluons
 - ▶ Charmonium and upsilon systems
- Electroweak Interactions
 - ▶ Charged and neutral currents
 - ▶ W, Z, LEP experiments
 - ▶ Higgs and the future
- LHC Experiments
- Future - introduction to accelerator physics

Note: no lecture on Monday 30 Jan.
To be re-arranged later in term as required.

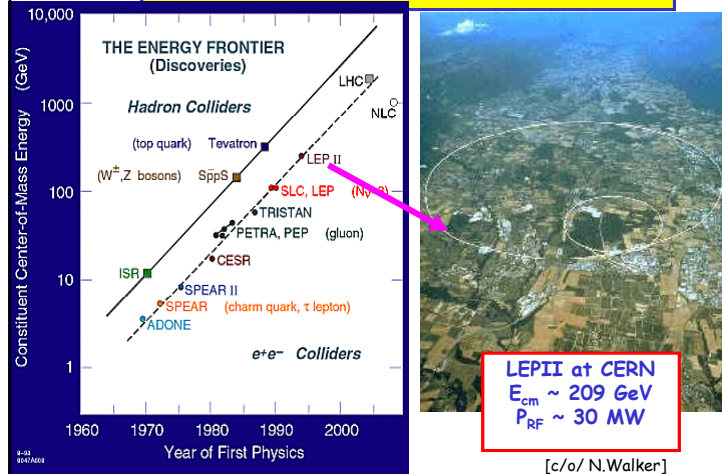
Health warning



- Comments in Allday's book about leptons being subject to the other three forces (not strong)
- Only charged leptons subject to e.m., γ couples to charge
- Similarly for Wikipedia

http://en.wikipedia.org/wiki/Standard_Model

"Energy Frontier" Accelerators

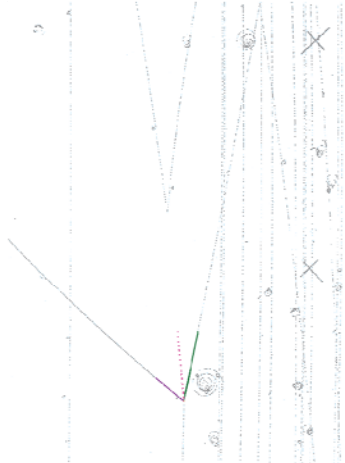


Bubble chambers



- Liquid (e.g. H_2) at high pressure, \sim several atm.
- Pressure reduced as beam arrives (superheated)
- Ionisation along charged particles' trajectories causes boiling
- Bubbles form for \sim ms
- Flash photographs, multiple angles, 3d-reconstruction
- Increase pressure and repeat
- Slow to accumulate data
- Iconic, full angular coverage for detection

Decays in bubble chamber



- Reconstruction of neutrals by charged decay products
- Many detailed examples from course web page, incl. interactive demos.
- Worth a visit.

LEP Collider close to max. energy

Beam "lifetime" in e^+e^-

Luminosity vs. time (energy)

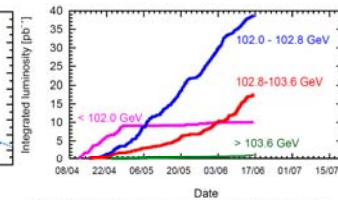
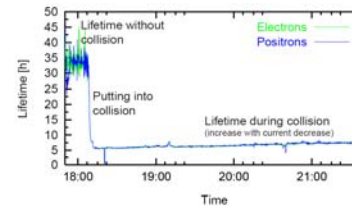


Figure 1: Evolution of beam lifetime in LEP.

Figure 2: Luminosity production in 2000. The three angles correspond to 2, 1 and 0 klystrons overhead (right hand numbers, from top to bottom).

R. Assmann et al, "Luminosity and Beam Measurements Used for Performance Optimisation in the LEP Collider", EPAC, Vienna, p. 265 (2000).

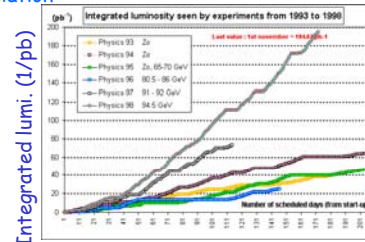
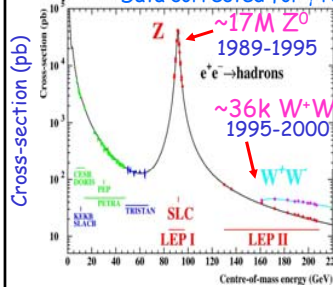
G. Arduini et al, "LEP Operation and Performance with 100 GeV Colliding Beams," EPAC, Vienna, p. 265 (2000).

Example: data rates

Physics cross-sections

Integrated collider lumi.

Data corrected for γ radiation



Days since start up

Centre-of-mass energy (GeV)

Higher energy e^+e^- colliders

- In planning/R&D phase
- Physics motivations many
- Cross-sections small!
- Luminosity the issue!
- b/c-tagging with high purity/efficiency
 - ▶ e.g. Higgs branching ratios
- Precision Tracking
- Recoil mass measurements
- Jet energy resolution
- Multi jet final states, e.g.
 - ▶ $t\bar{t}$
 - ▶ separation of WW/ZZ

