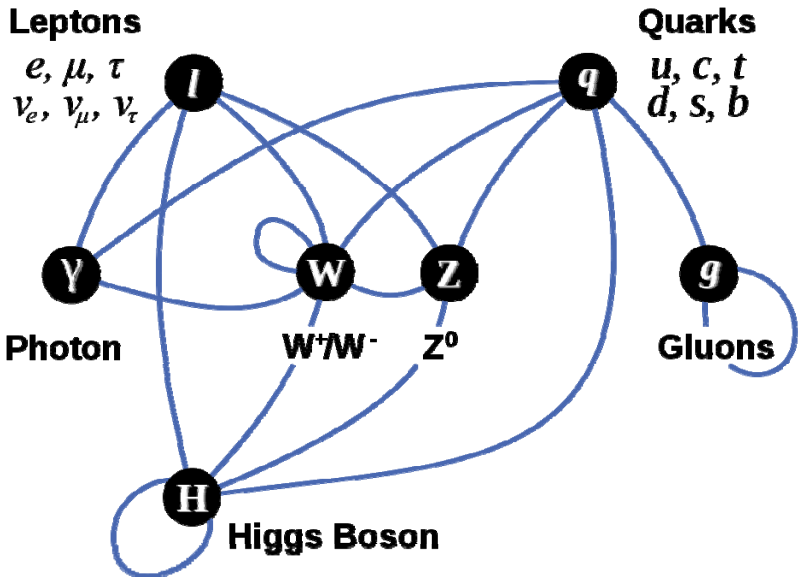
Outline

- 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.

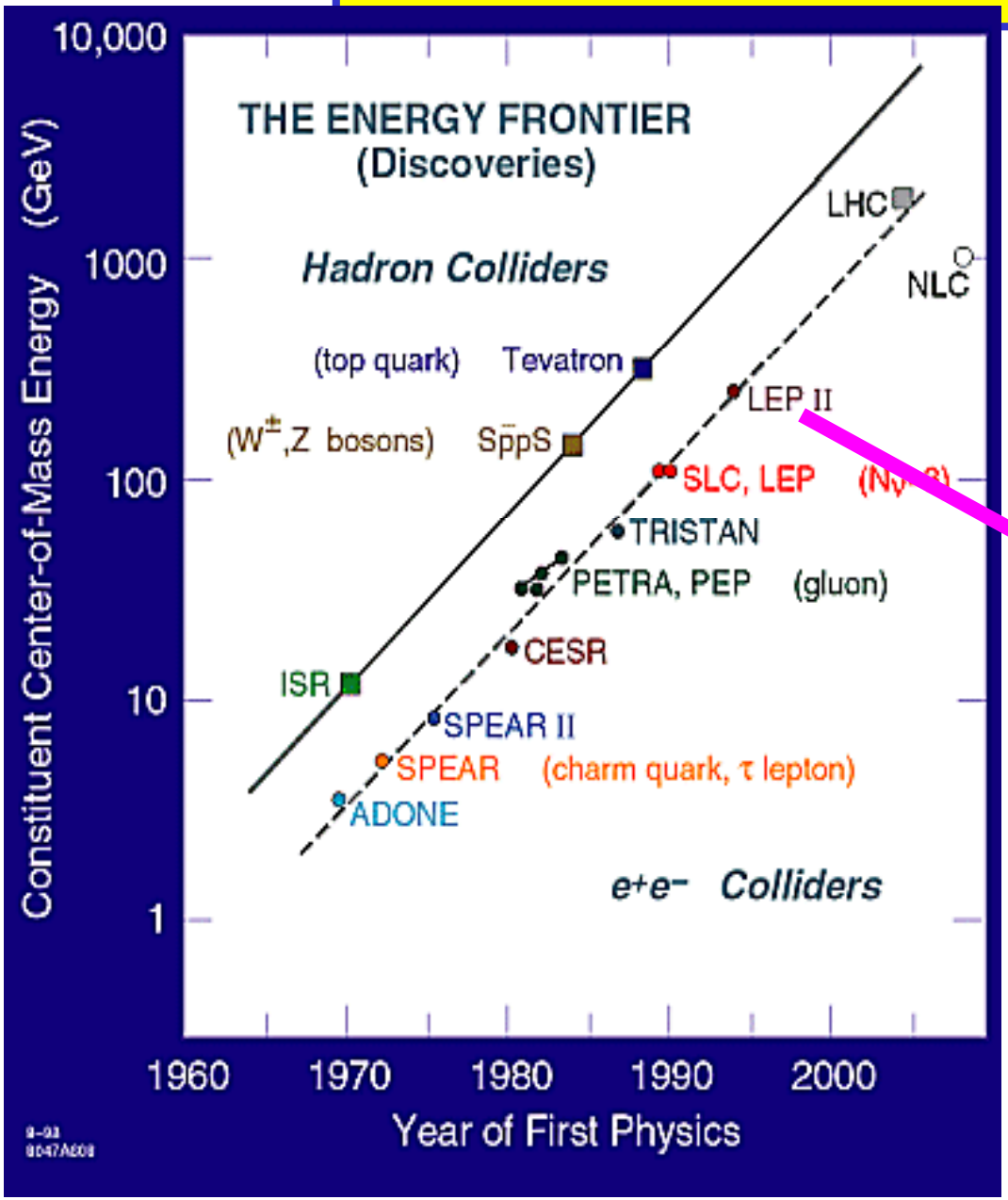
Health warning



- 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

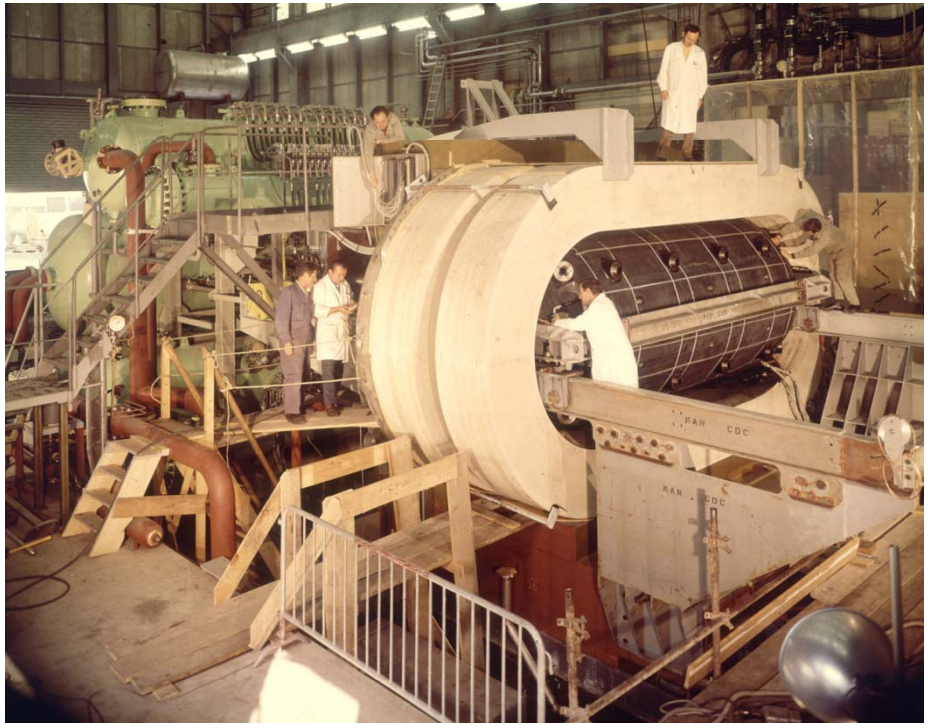
"Energy Frontier" Accelerators



LEPII at CERN
E_{cm} ~ 209 GeV
P_{RF} ~ 30 MW

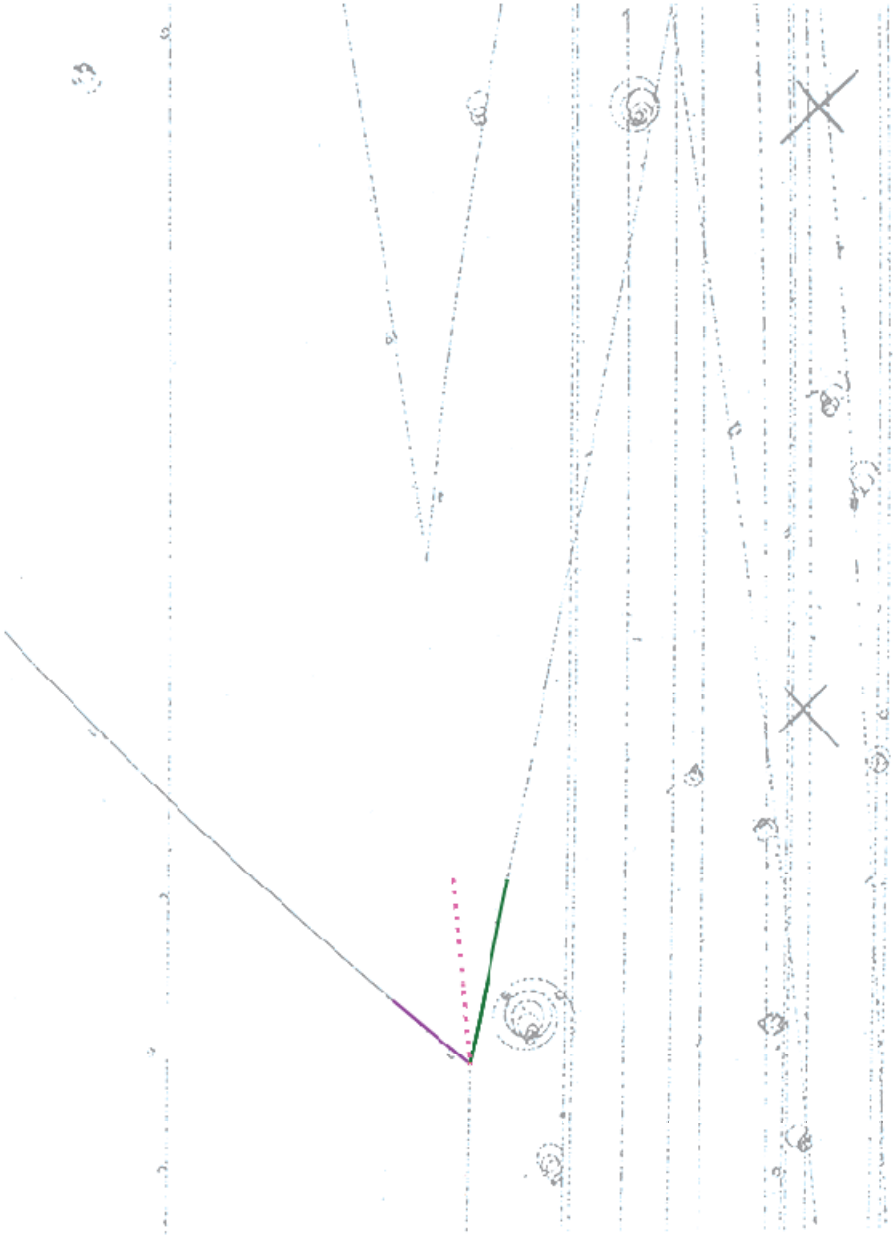
[c/o/ N.Walker]

Bubble chambers



- Liquid (e.g. H_2) at high pressure, ~several atm.
- Pressure reduced as beam arrives (superheated)
- Ionisation along charged particles' trajectories causes boiling
- Bubbles form for ~ms
- Flash photgraphs, 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^-

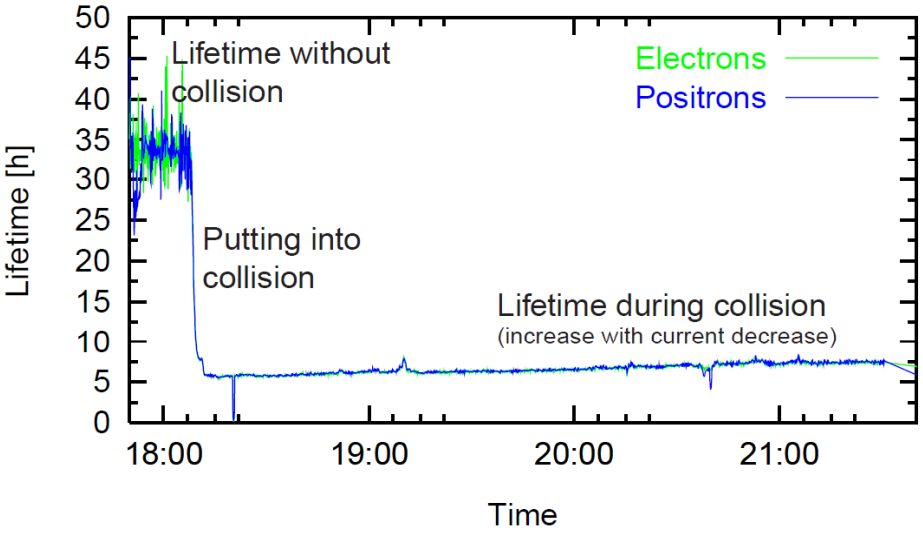


Figure 1: Evolution of beam lifetime in LEP.

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

Luminosity vs. time (energy)

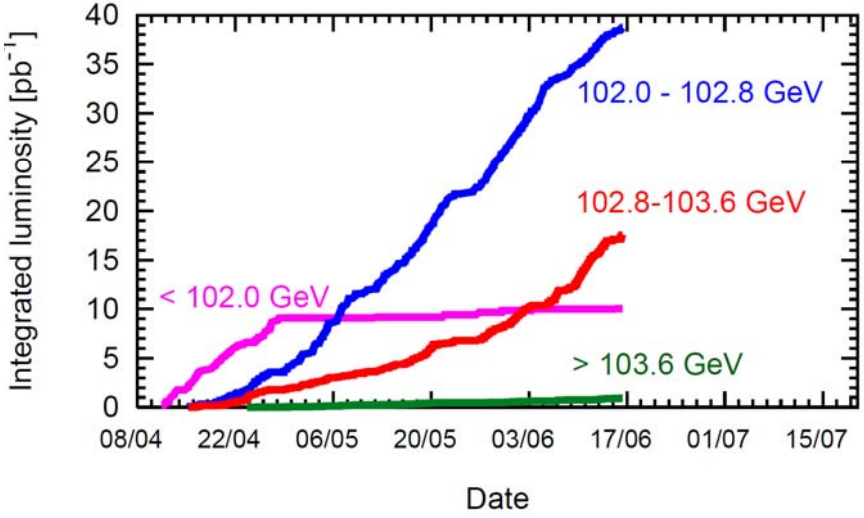


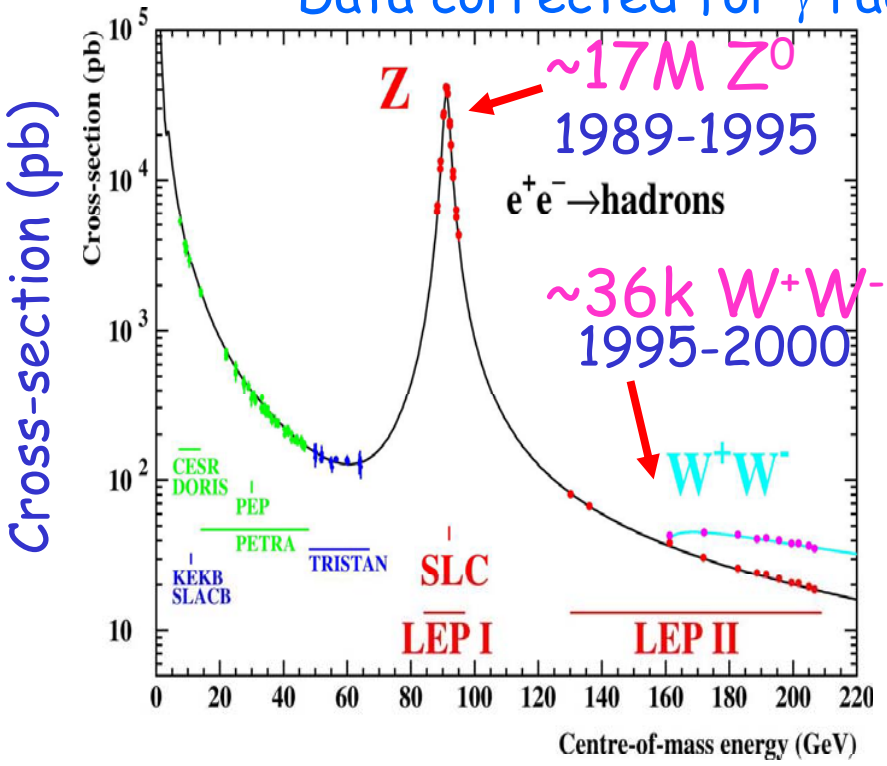
Figure 2: Luminosity production in 2000. The three ranges correspond to 2, 1 and 0 klystrons overhead (right hand numbers, from top to bottom).

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

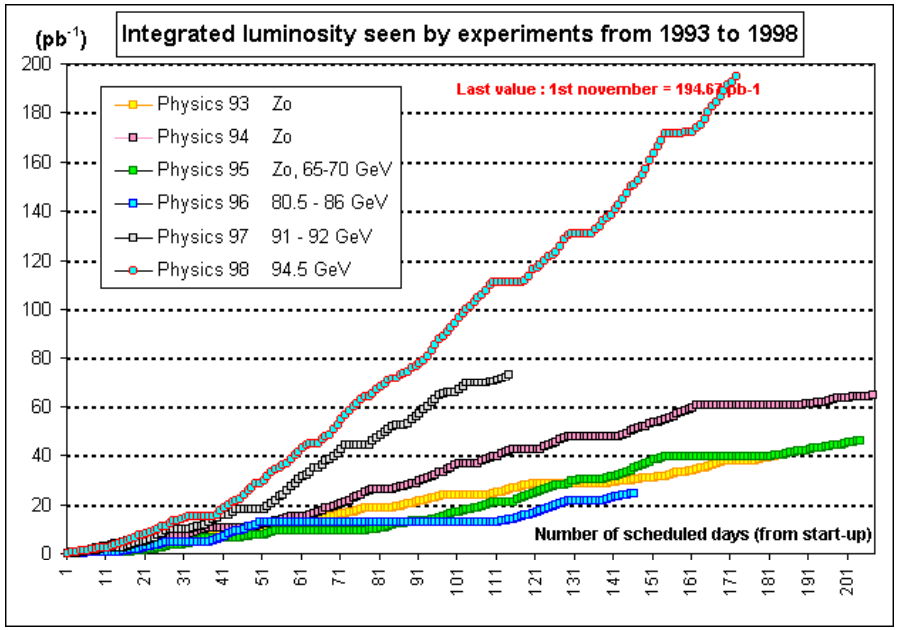
Example: data rates

Physics cross-sections

Data corrected for γ radiation



Integrated collider lumi.



Integrated lumi. (1/pb)

Days since start up

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.
  - ttbar
  - separation of WW/ZZ