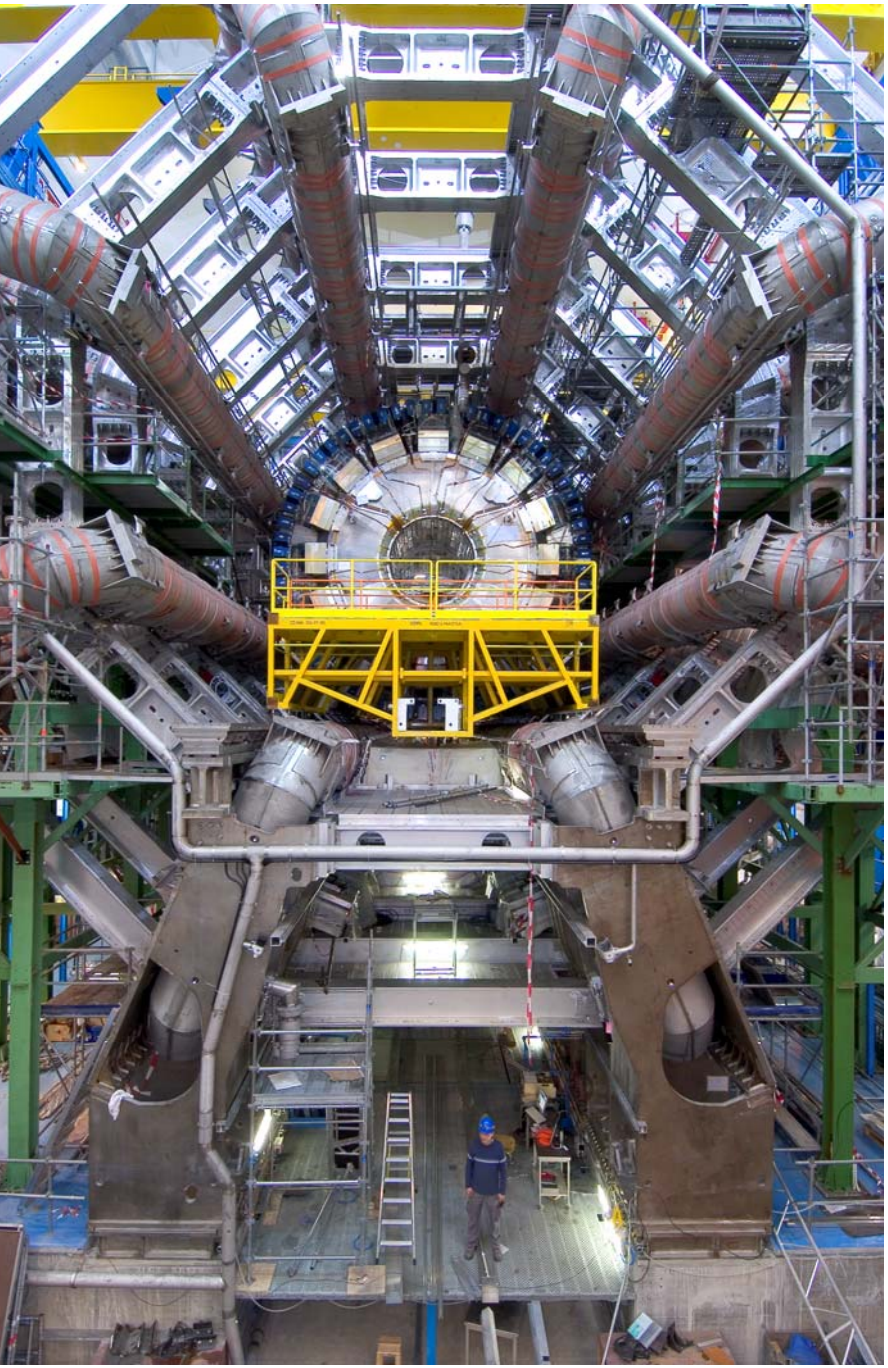

Advanced Particle Physics Techniques

… or …

Advances in Particle Physics Technology

… or …

Particle Physics Experimentation and Interpretation

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Course Aims

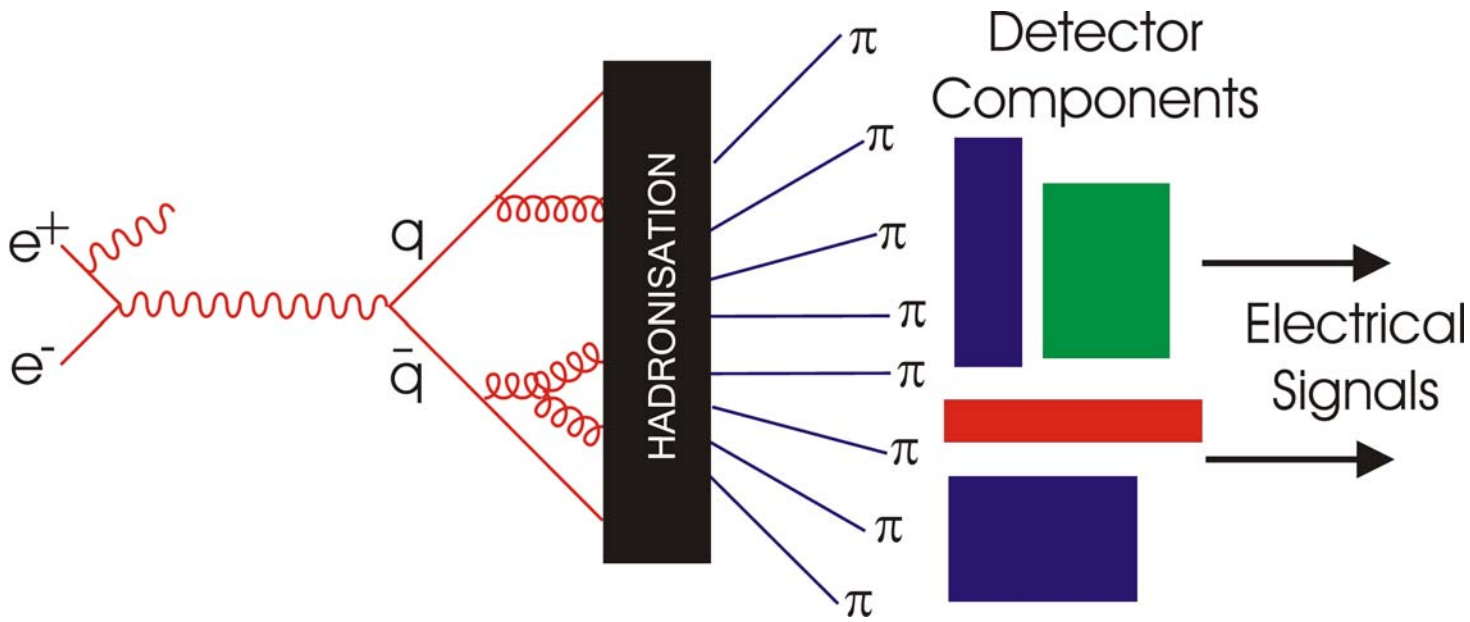
• Other particle physics courses are concerned with 'what we know' … i.e. our modern theory and understanding of the microscopic World.

• This course is concerned with `how we know it' … i.e. `how to really be an experimental physicist'

- Overview of Particle Physics Experimental Facilities
- Detectors and their use to reconstruct events
- How to make an experimental measurement
- Statistical analysis of Data

An Example … Real life is Tough!

- Consider a 'simple' process such as $e^+ e^- \rightarrow q\ \bar{q}$.
- 'Easy' to calculate in QED



… but electrons may radiate photons (QED)
… quarks radiate gluons / fragment (partly QCD calculable)
… quarks and gluons hadronise (not calculable)
… we don't even see the hadrons, just electrical signals
… and no detector exists that doesn't have holes!!!

Course Overview

• 20 lectures / lecture-discussions + 2 revision lectures. Assessment via exam (60%), two sets of assessed problems (15% each) and one `case study' (10%).

• Aimed at C4 Physics with Particle Physics and Cosmology students

• Open to other C4 students who do `Current Topics in Particle Physics'

Open to first year particle physics Ph.D. students (optional)

• Lecture times …

- Monday 12.00 in West 115
- Friday 10.00 in West 115

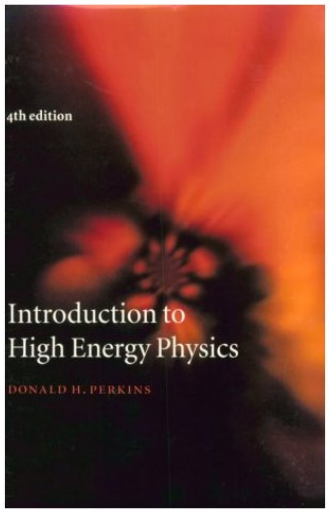
Lecture Synopsis

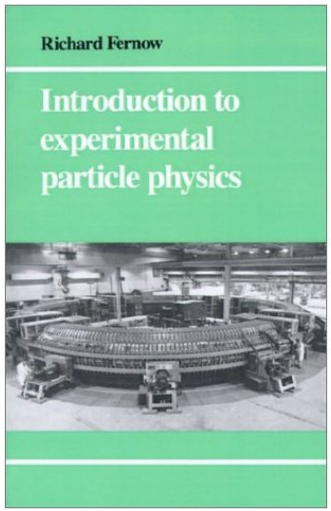
1) Introduction to Colliders
2) LEP
3) More e^+e^- Facilities
4) ep Facilities
5) pp Facilities
6) The LHC
7) Neutrino & Ion Facilities
8) Tracking Detectors
9) Track Reconstruction
10) Calorimetry
11) Triggering and Data Acquisition
12) Monte Carlos and Cross Section Measurement
13) Systematic effects. Differential cross sections.
14) Probability and Statistical Errors
15) Probability Distributions
16) Likelihood, Chi2 and Fitting Data
17) Hypothesis Testing and Signal assessment
18) Case Study I
19) Case Study II
20) Case Study III

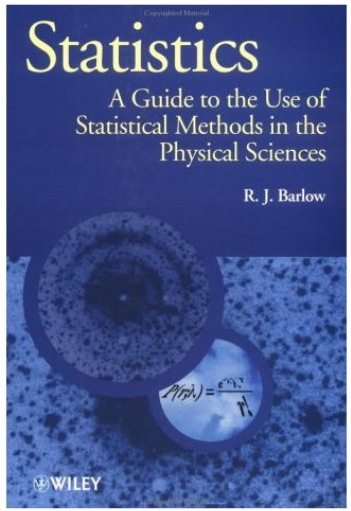
(All subject to change)

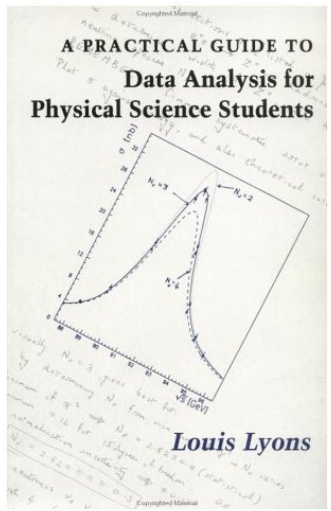
Course Resources

- This is not a 'normal' course! – You will not find everything you need to know in any text book, though some are useful!









- Many of the best resources are on-line (and also some of the worst!) Particle physics invented the web, so use it!!!
- Use the course web-page and links therein …
  http://www.ep.ph.bham.ac.uk/user/newman/appt08/appt.html
…and last year's version …
  http://www.ep.ph.bham.ac.uk/user/newman/appt07/appt.html

Types of Particle Physics Accelerator Facility

1) Fixed Target

- Rutherford's experiment! … accelerate charged particles, fire them (or things they produce) at a fixed target …
- pp, ep, μp, γp, πp, ppbar where the 'p' target is often really a heavy atom, *A*.
- Still used e.g. for neutrino experiments νp, but also for Many experiments which do not require the highest energy.

2) Colliding beam facilities

- Much higher energies achievable by colliding two moving particles …
- … storage ring circular colliders since 1970s (e^+e^-, ppbar, *AA*, ep, maybe μp)

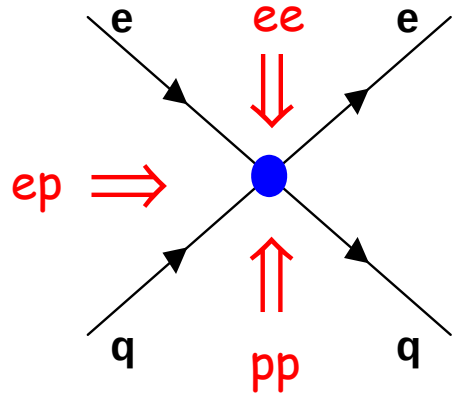
… linear colliding beam facilities planned (e^+e^-)

… linac x ring (ep?)

Beams / targets are often polarised in both cases

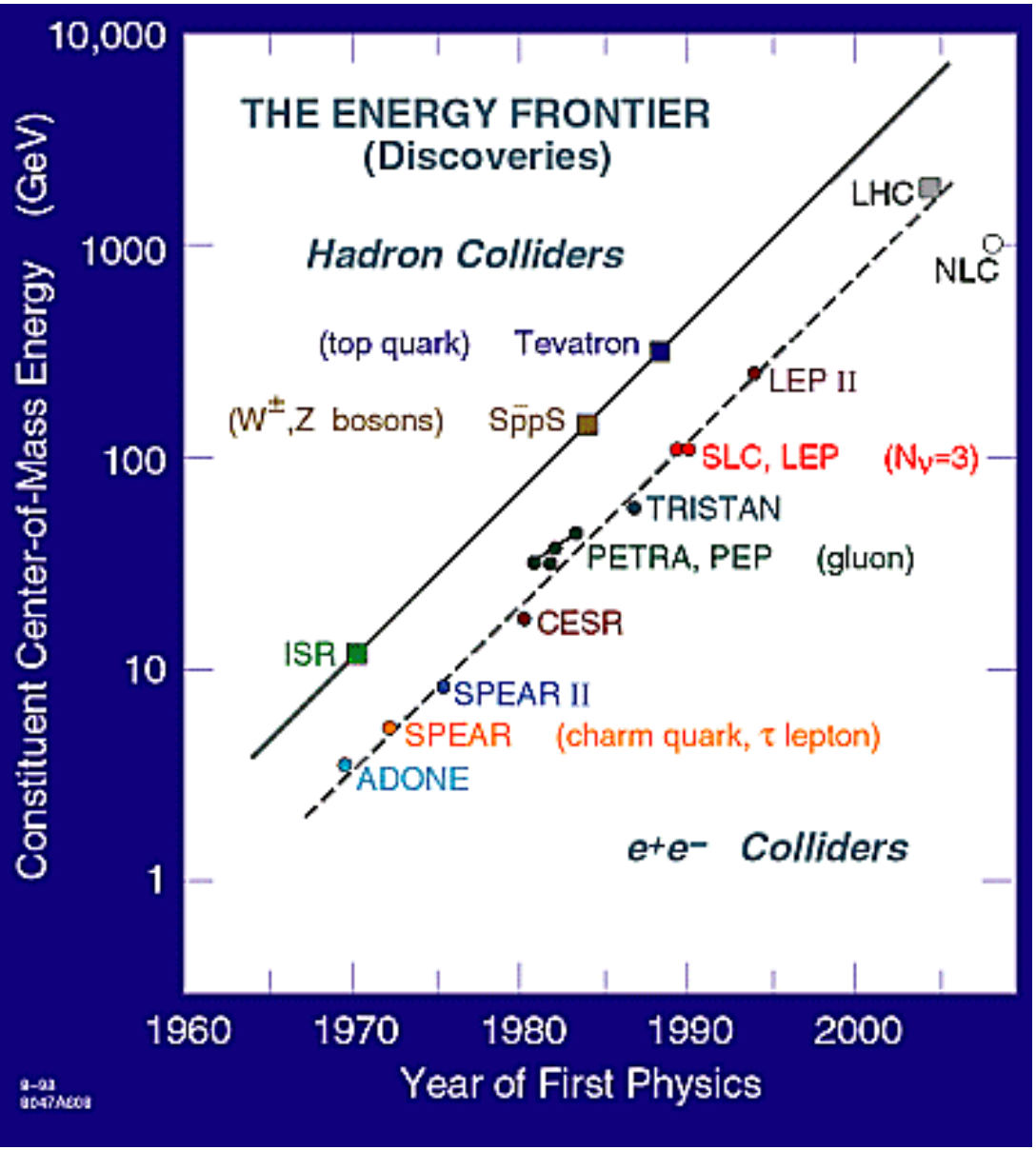
Exploring Physics in new energy Regimes requires beams with both Quarks and Leptons

Historical Development of Particle Physics through studies of qq, e^+e^- , eq



	1970		2000	2015
DIS	Bjorken scaling – QPM neutral currents asymptotic freedom		(high) parton densities low x and diffraction .... QCD	
e^+e^-	J/Ψ gluons		3 neutrinos ..... electroweak theory	... ILC
pp	charm,	W,Z, bottom top		LHC ...

The 'Livingstone' Plot



Energy of man-made machines has grown exponentially since 1950s.

Current state of the art:

e^+e^-: E_{cms}=209 GeV
(LEP, CERN)

pp: E_{cms}=2 TeV
(Tevatron, FNAL)
E_{cms}=14 TeV
(LHC, CERN 2008)

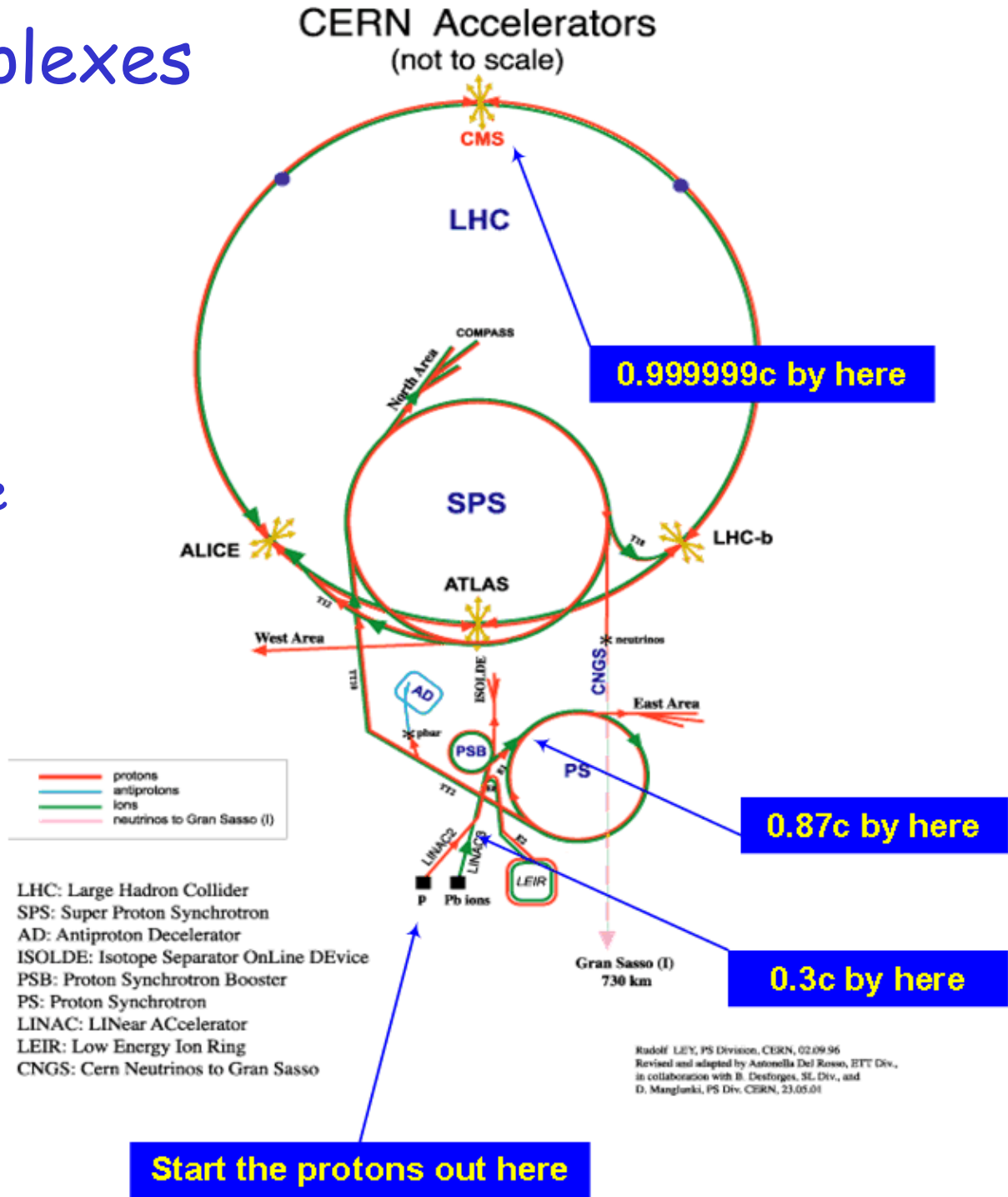
ep: E_{cms}=318 GeV
(HERA, DESY)

AA: E_{cms}=200 GeV for **nucleons** in Au-Au
(RHIC, BNL)

Accelerator Complexes

Little wastage!...
Accelerators recycled and re-used often as injectors, but also to run other experiments simultaneously with the big one.

In parallel detection techniques have developed!
... bubble / spark / cloud chambers → complex multi-layer detectors with many sub-components



Next 2 Lectures: e^+e^- Facilities

Please prepare a little by looking on-line, eg at course web-site (some links supplied):

- What are LEP, PEP-II, Future Linear Collider?
- What experiments exist at these colliders?
- What do the detectors look like?
- What are their main physics aims / results?