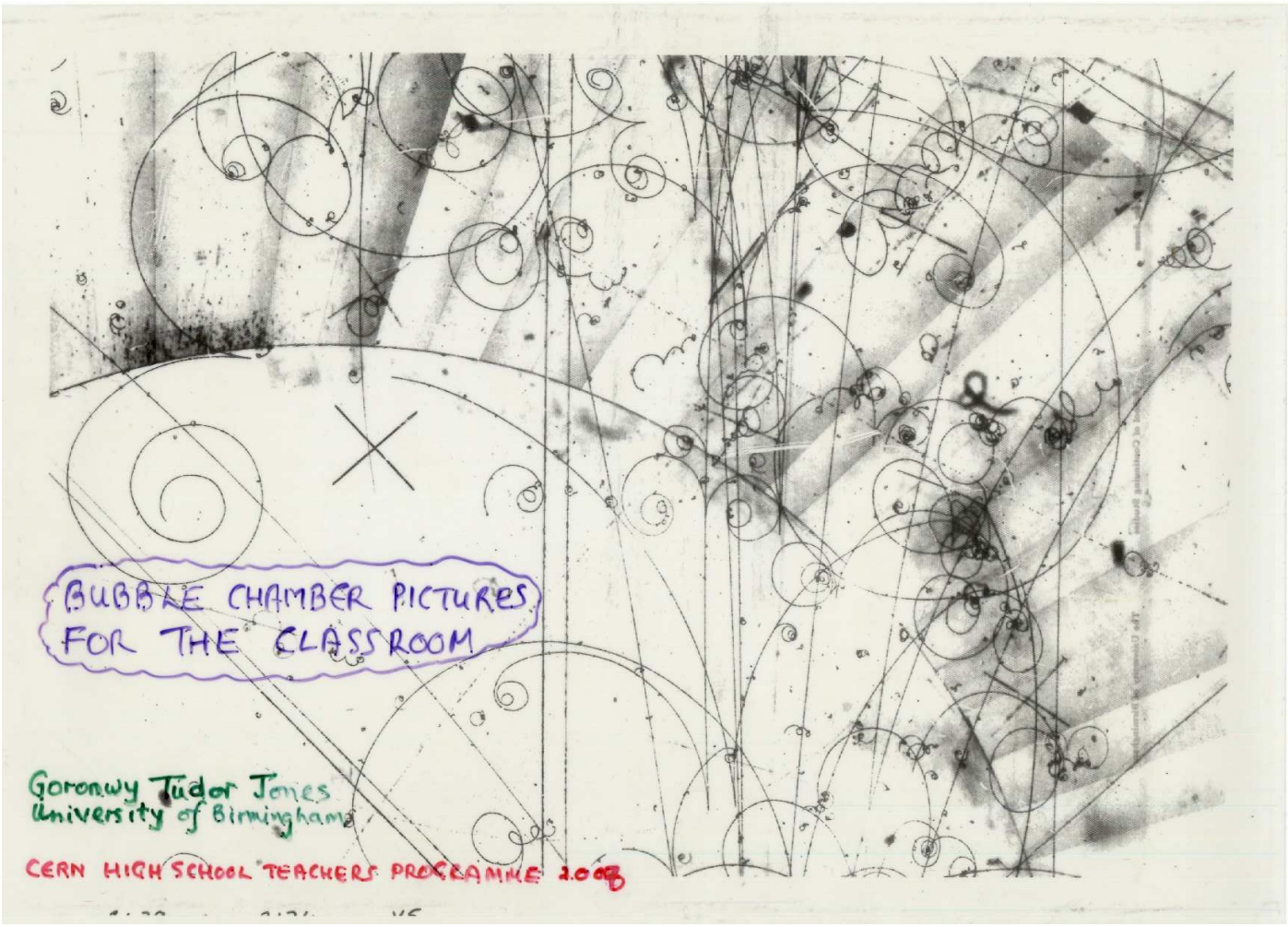

BUBBLE CHAMBER PICTURES
FOR THE CLASSROOM
Goronwy Tudor Jones
University of Birmingham
CERN HIGH SCHOOL TEACHERS PROGRAMME 2008

Introductory Remarks

Bubble chamber pictures popular

- beautiful (∴ 'cool'?)
- illustrate VISUALLY and QUALITATIVELY many phenomena/principles

  eg
  - $E = mc^2$
  - Momentum conservation
  - Statistical nature of quantum phenomena
  - Collisions
  - Decays
  - Accelerated charges radiate (mobile!)

Purpose of these lectures

- 'Comfort layer of knowledge' for teacher
- To invite you to think of contributing to the bubble chamber activity

PLAN

Lecture 1 Background information

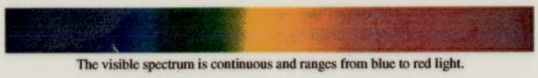
- How do we establish the existence of substructure?
  - discrete spectra
  - Rutherford type experiments
- The Spectrum of HADRONS
  ⇝ strongly interacting particles
  (or particles that feel the strong nuclear force)
  - dominated by the BUBBLE CHAMBER
- The Bubble Chamber
- Conservation laws

Lecture 2 The Bubble Chamber Web Site

- Teachers explore BC web site for ~1 hour
- Session for
  - questions
  - reactions
  - suggestions for improvements, activities ...

Visible and H atom Spectrum

Visible Spectrum



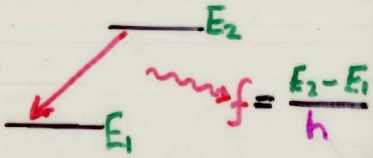
The visible spectrum is continuous and ranges from blue to red light.

Hydrogen Line Spectrum

The visible hydrogen spectrum is composed of discrete lines. Shown are the colors of the photons in the visible region that are emitted by excited hydrogen atoms.

Both pictures are from Zumdahl, Introductory Chemistry: A Foundation

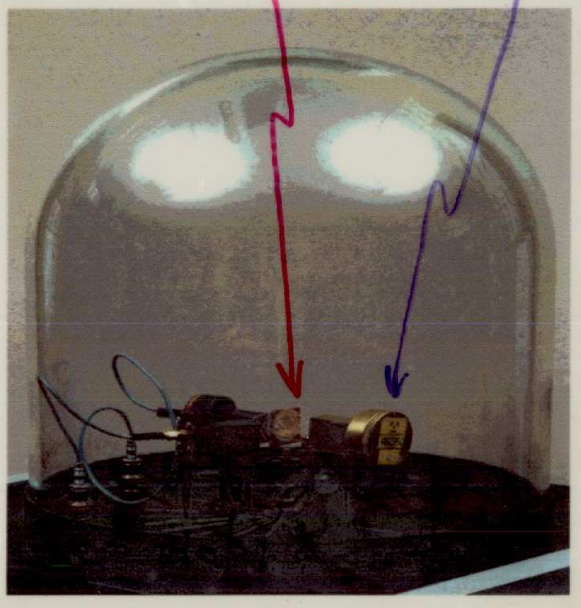
ATOMS ARE
CONFINED ELECTRON WAVES



Rutherford Scattering Apparatus

PPEP

Return



EVIDENCE FOR SUB-STRUCTURE OF PROTON AND OTHER SO-CALLED ELEMENTARY PARTICLES

- Discrete spectrum of "hadrons" (strongly interacting particles) ⇦
- Deep inelastic scattering

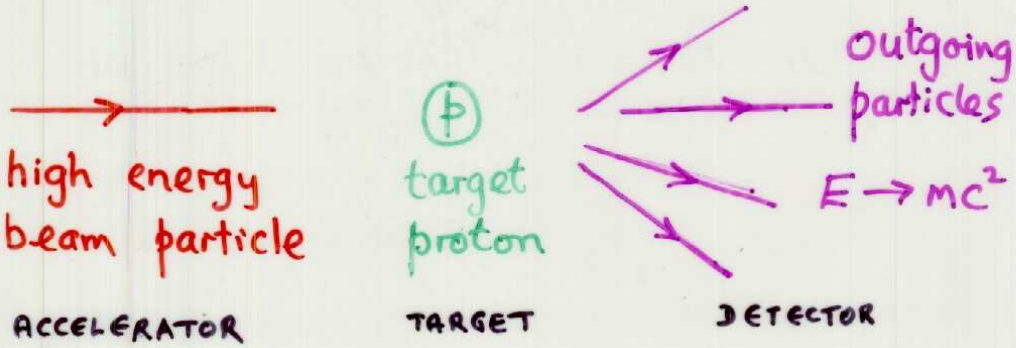
Here:

not analysis of spectrum to get at quark properties

but to introduce bubble chamber and its part in discovering the spectrum

FIXED TARGET

Typical particle physics experiment

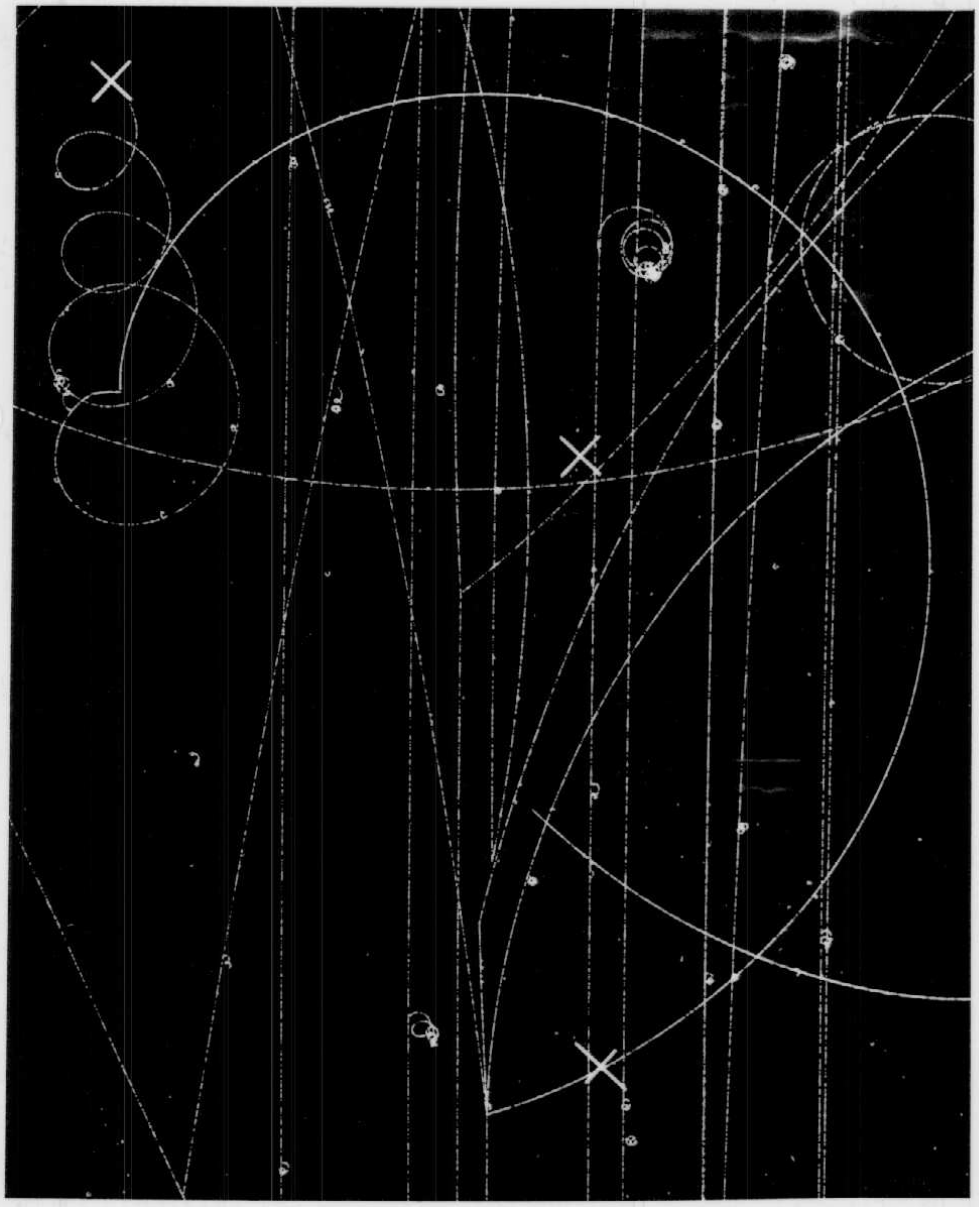


FOUND: discrete mass spectrum

i.e. not all masses are created in nature (even if the energy is available)

QM + Relativity → CONSTITUENTS

The story of the discovery of the discrete mass spectrum was dominated by the BUBBLE CHAMBER



HISTORICAL INTRODUCTION

~1950

ATOM - electrons held near nucleus by 'exchange of virtual photons'

NUCLEUS - neutrons and protons held together by 'exchange of virtual pions'

BUT: μ and 'strange particles' did not fit into this neat picture

For the next 15 years or so, with the bubble chamber as a major tool, many more particles† were found.

Examination of the properties of these particles led to the prediction of the existence of quarks.

† The 'stable' particles: $\pi, K, n, p, \Lambda, \Sigma^0, \Omega^-$ etc.
Unstable particles (lifetimes ~ 10^{-23} second) which are excited states of the stable particles