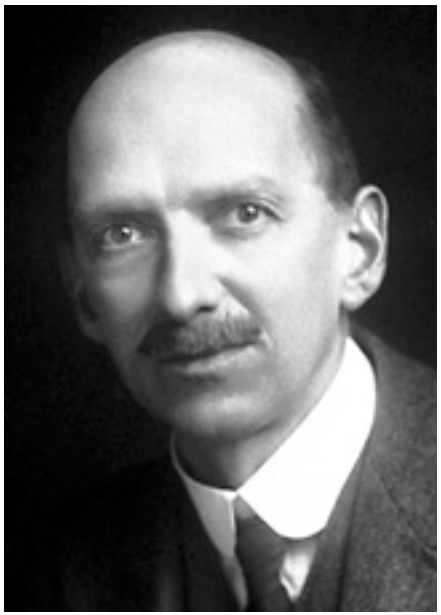
Invention of the Cloud Chamber by C.T.R. Wilson

Ryan Keisler, April 23, 2008

From a mountaintop...



- Charles Thomson Rees Wilson (C.T.R.), a Scotsman, born in 1869.

- Went to the mountains (Ben Nevis) on holiday in 1894 (25 years old). Working (for fun) as a meteorological observer.

- One morning he observed a "Broken Spectre". Returned to Cambridge intent on making clouds.

- Mountain hiking is good for you (and your career).

How a Cloud Chamber works, in the words of Wilson*:

- "The ionising rays are made to pass through moist air, or other gas, in which the water-vapour has been brought into the super-saturated state by sudden expansion of the gas.
- "Each ion liberated becomes at once the nucleus for the condensation of a visible droplet of water.
- "The clouds of drops thus formed are immediately photographed".

*Wilson 1923, Roy. Soc. Proc. A104

These were Busy Times

- Summer 1894 - Hiking on Ben Nevis
- Early 1895 - A working cloud chamber (!)
- Late 1895 - Rontgen discovers x-rays
- Mid 1895 - Dust filtering...
- Early 1896 - Exposes cloud chamber to xrays => dramatic increase in # of droplets.
- => Who cares about "Broken Spectre"; this is a new particle detector!

Original Design (1895-1912)

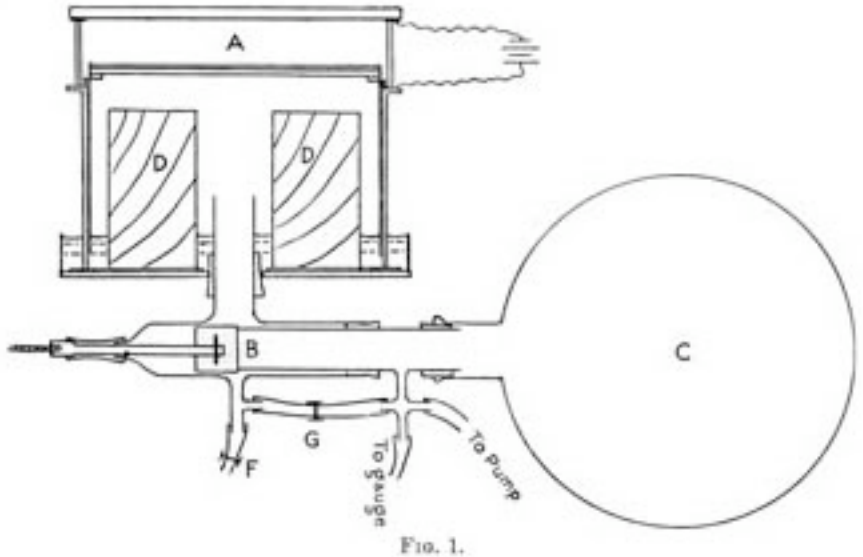
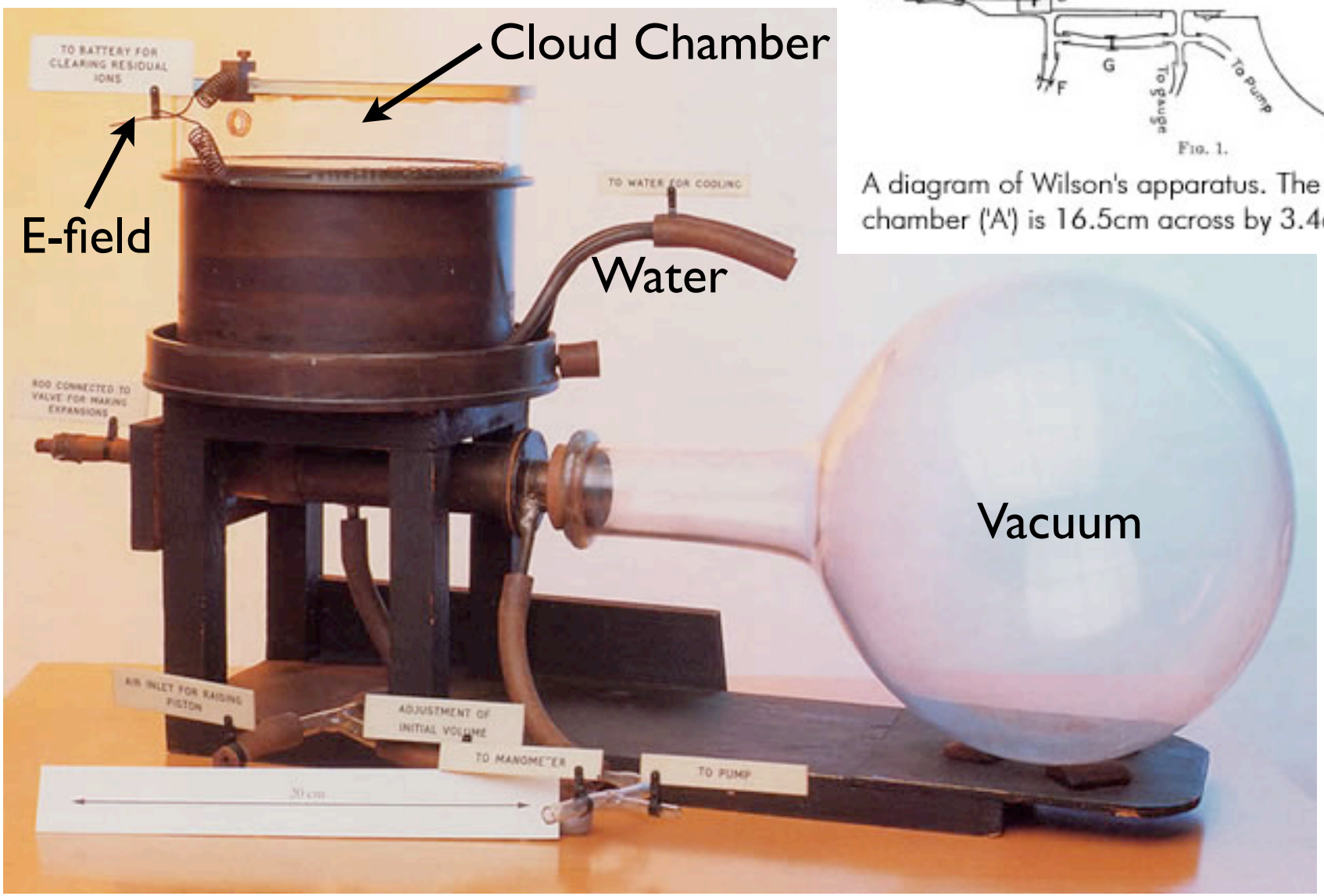


FIG. 1.

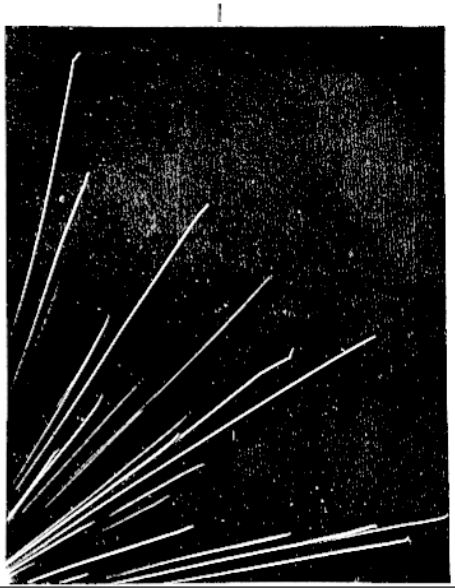
A diagram of Wilson's apparatus. The cylindrical cloud chamber ('A') is 16.5cm across by 3.4cm deep.



Many experimental challenges (turbulence, mobility, dew, *timing*...)

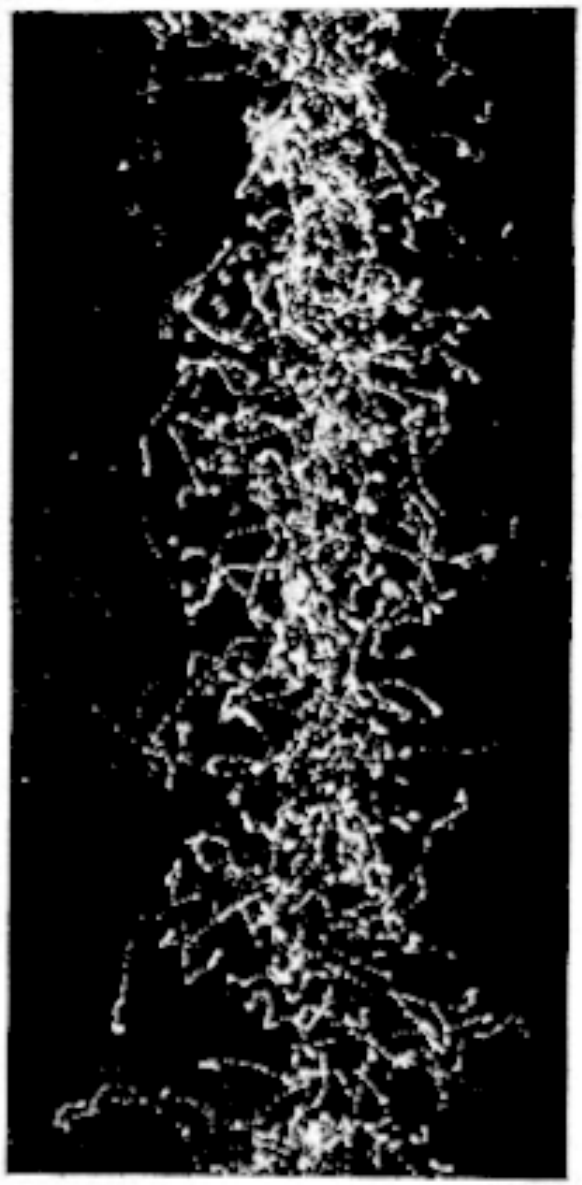
Seeing with (dE/dx)

Alphas



Betas

Gammas



Slow and Steady Progress

- 1895-1900, Original construction of cloud chamber and work on nucleation.
- 1900-1910, Other occupations (mainly tutorial) prevent him from developing cloud chamber further. Teaching strikes again.
- 1911, First person to see and photograph tracks of individual alpha and beta particles. => His first big paper (Wilson 1912, 21 pages)
- "A number of pictures...taken early in 1914, but the work was then interrupted by the War".
- 1921, improves cloud chamber, takes more photos. => Two huge papers (Wilson 1923, 68 pages).

Compton Electrons

- 1923, Arthur Compton reports* measurement of change in the frequency of x-rays scattered from electrons. Non-classical effect.
- "Compton recoil electron" is predicted. Should have low kinetic energy.
- In his 1923 papers, Wilson shows images of recoil electrons with low T, further supporting Compton's claim for a quantum interaction between light and electrons.
- Compton & Wilson share 1927 Nobel.

*Phys Rev 1923, 21, 5

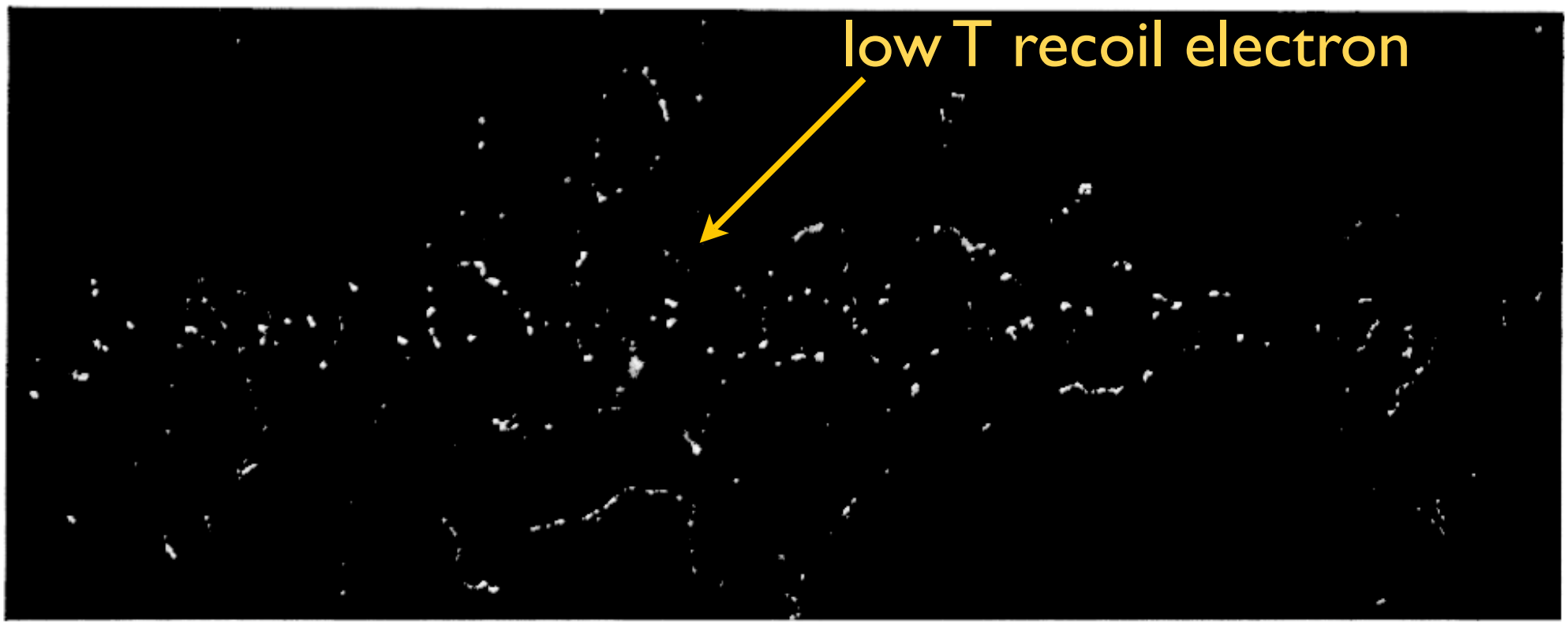


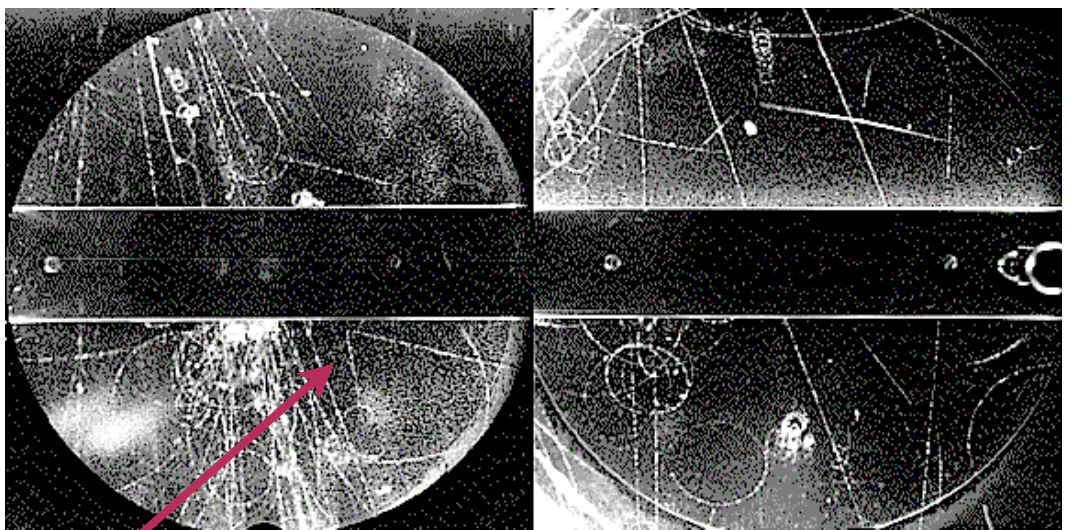
FIG. 4 (×3).

Different classes of β-ray tracks, "long," "fish," and "comma" tracks produced by hard X-rays. Initial forward component in long tracks. X-ray beam, about 3 mm. in diameter, had traversed 6×10^{-3} cm. lead. Final air pressure 50 cm.

Cloud Chamber was principle method for studying particle tracks for ~60 years, until invention of bubble chamber in 1950s.

Numerous important discoveries were made with it (to list a few):

- Compton Effect (1923)
- Discovery of positron (1933)
- Visualization of pair-production and annihilation (1933)
- Discovery of muon (1937)
- Discovery of first strange particles (Kaons) (1947)



"the most original and wonderful instrument in scientific history"
- Ernest Rutherford

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