Rutherford backscattering spectrometry (RBS) analytical technique used in materials science

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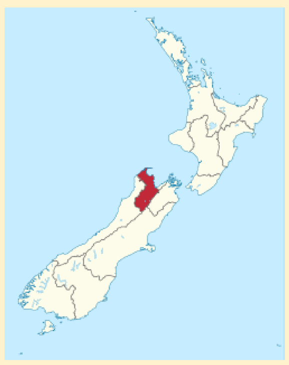
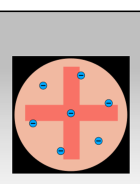
The discovery of the nucleus of the atom made possible a very important moment in the study of materials science

A few interesting facts about the young Ernest Rutherford.



He was born at Brightwater, near Nelson, New Zealand, and he studied at Havelock School and then Nelson College and he won scholarship to study at Canterbury College, **In 1895 Rutherford was awarded an Research Fellowship from the Royal Commission for the Exhibition of 1851, to travel to England for postgraduate study at the Cavendish Laboratory, University of Cambridge, under the leadership of J. J. Thomson.**

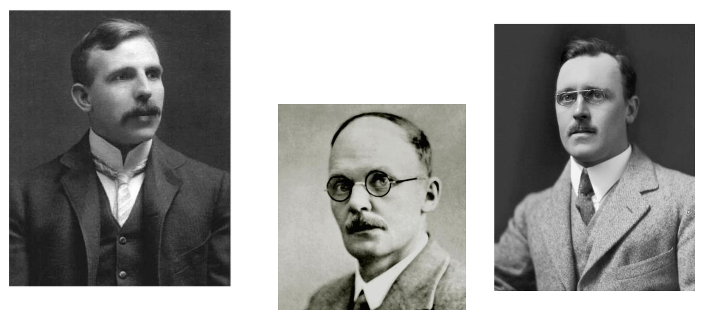


The plum pudding model of the atom, as envisioned by Thomson.

The theory of atomic structure was the "plum pudding model". This model was proposed and developed by Lord Kelvin and further developed by J. J. Thomson. Electron was discovered as a component of every atom by Thomson. He proposed the model in which the atom is a sphere with a positive charge. This model was based entirely on classical physics. The electrons are in this ball just like the raisins in the Christmas pudding. In the proposed model, protons and neutrons were not considered as they had not yet been discovered.

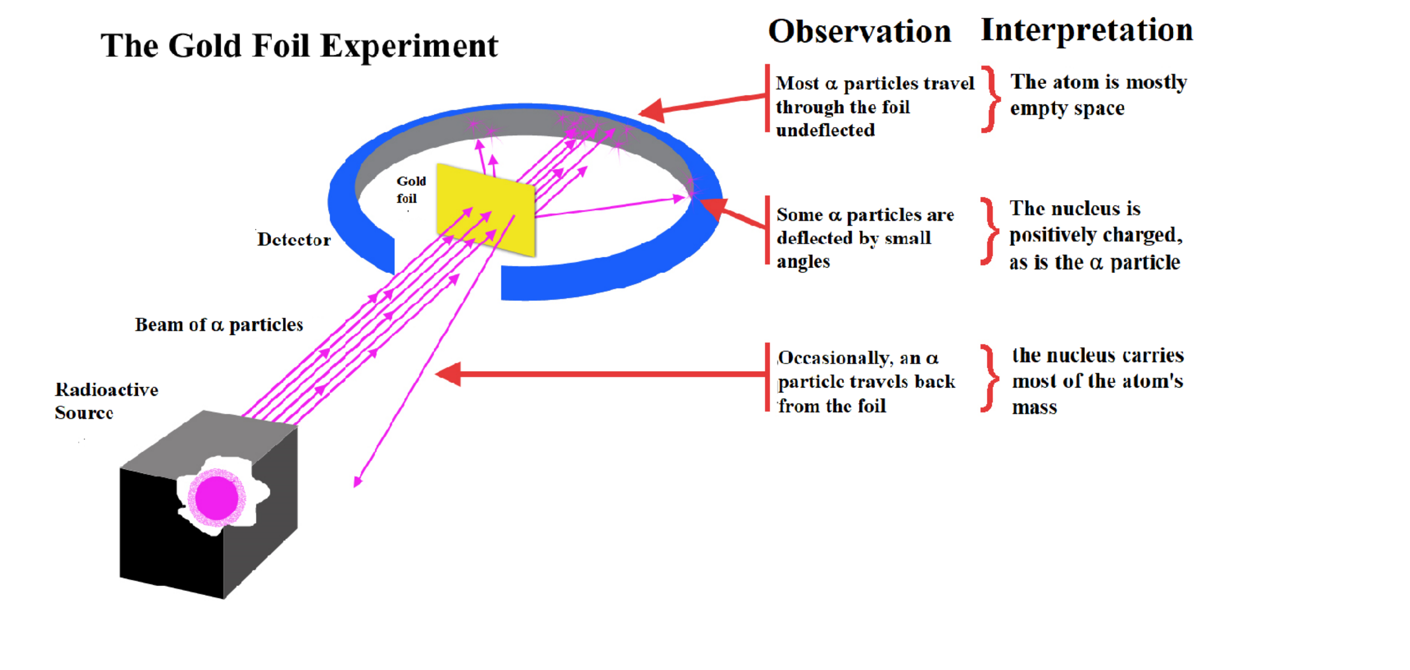
"Random" meeting and joint work of three gentlemen

Ernest Rutherford was Professor of Physics at the Victoria University of Manchester. In 1906, he received a visit from a German physicist Hans Geiger, and was so impressed that he asked Geiger to stay and help him with his research. Ernest Marsden (from New Zealand) was a physics undergraduate student studying under Geiger.

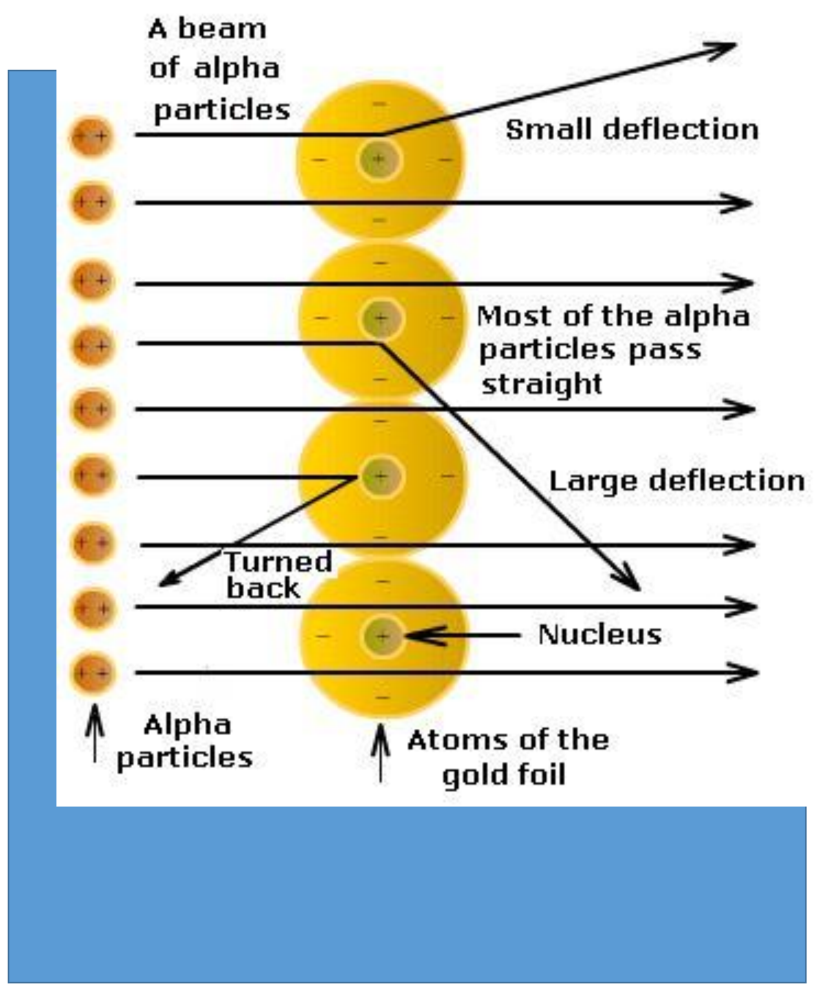


Ernest Ruterford Ernest Marsden

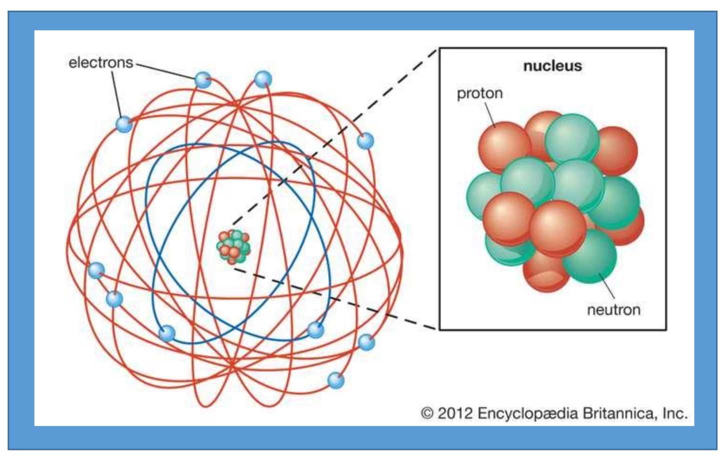
Johannes Wilhelm "Hans" Geiger

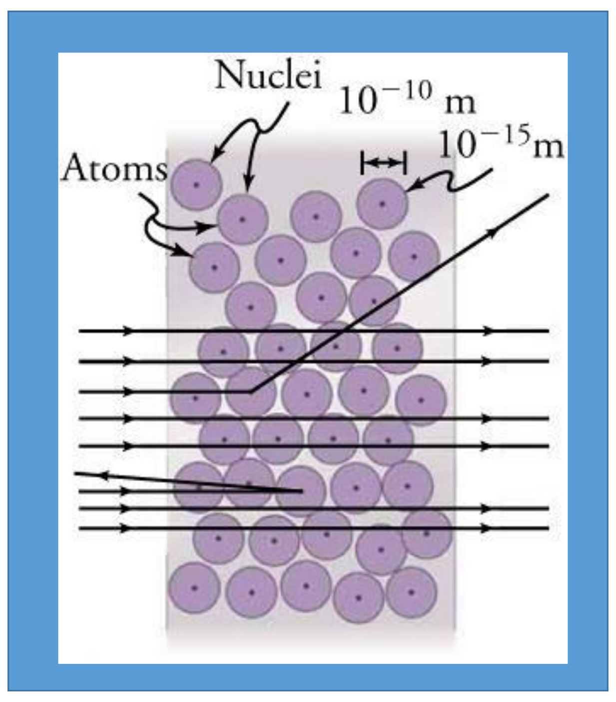


(A) The experimental setup for Rutherford's gold foil experiment: A radioactive element that emitted alpha particles was directed toward a thin sheet of gold foil that was surrounded by a screen which would allow detection of the deflected particles.
(B) According to the plum pudding model (top) all of the alpha particles should have passed through the gold foil with little or no deflection. Rutherford found that a small percentage of alpha particles were deflected at large angles, which could be explained by an atom with a very small, dense, positively-charged nucleus at its center.

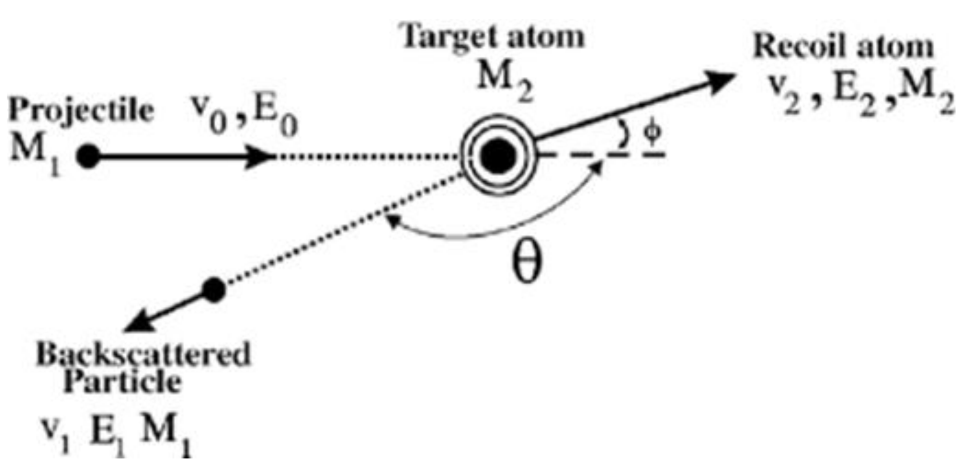


Rutherford atomic model
Physicist Ernest Rutherford envisioned the atom as a miniature solar system, with electrons orbiting around a massive nucleus, and as mostly empty space, with the nucleus occupying only a very small part of the atom. The neutron had not been discovered when Rutherford proposed his model, which had a nucleus consisting only of protons.





physical basis of RBS research



In Rutherford backscattering spectrometry, monoenergetic particles in the incident beam collide with target atoms and are scattered backwards into the detector-analysis system, which measures the energies of the particles.
In the collision, energy is transferred from the moving particle to the stationary target atom; the reduction in energy of the scattered particle depends on the masses of incident and target atoms and provides the signature of the target atoms.

$$\frac{1}{2}M_1v^2 = \frac{1}{2}M_1v_1^2 + \frac{1}{2}M_2v_2^2,$$
$$M_1v = M_1v_1\cos\theta + M_2v_2\cos\phi,$$
$$0 = M_1v_1\sin\theta - M_2v_2\sin\phi.$$

Conservation of energy and conservation of momentum parallel and perpendicular to the direction of incidence are expressed by the equations

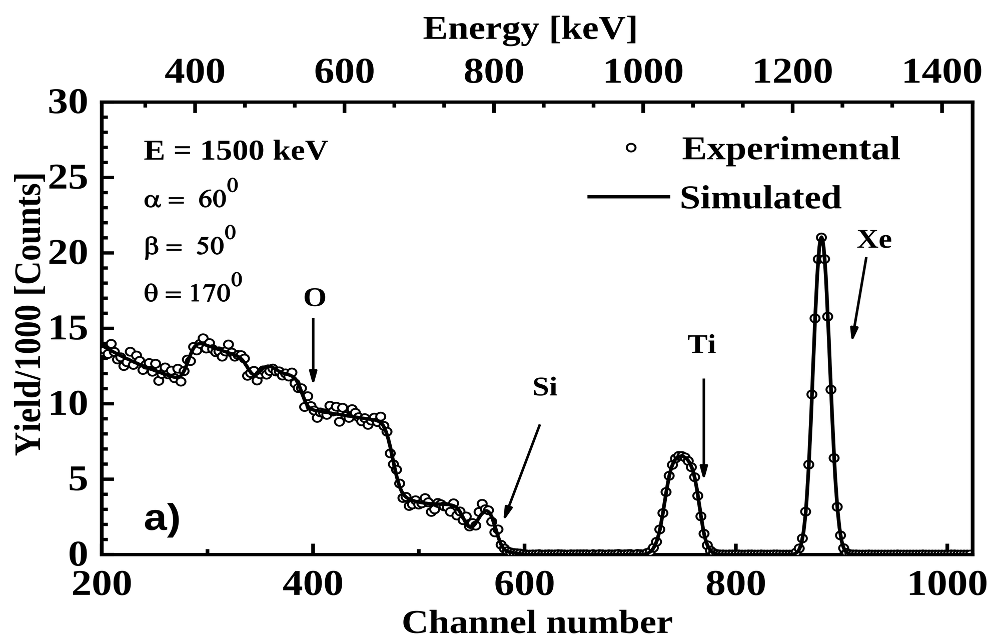
Result solutions of equations

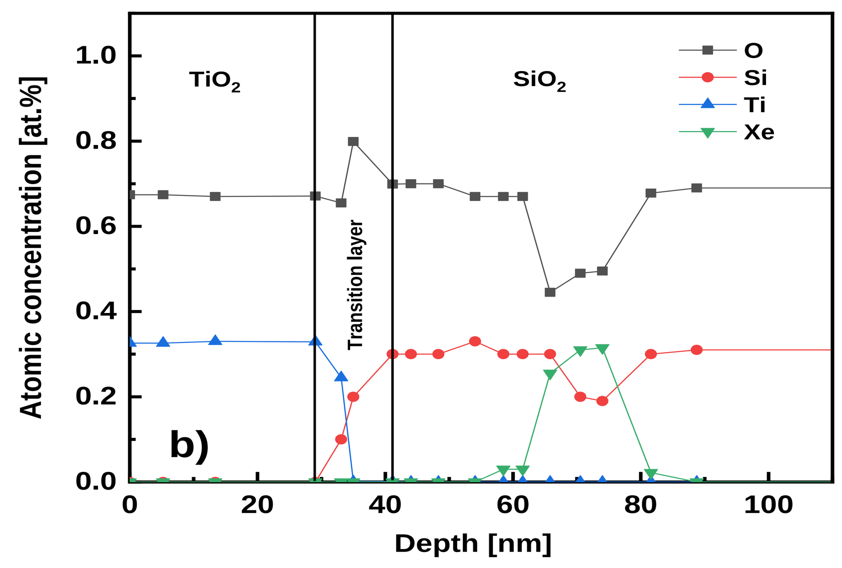
$$\frac{V_1}{V_0} = \frac{\left[\pm\left(M_2^2 - M_1^2\sin^2(\theta)\right)^{1/2} + M_1\cos(\theta)\right]}{M_1 + M_2}$$

$M_1 < M_2$ attention

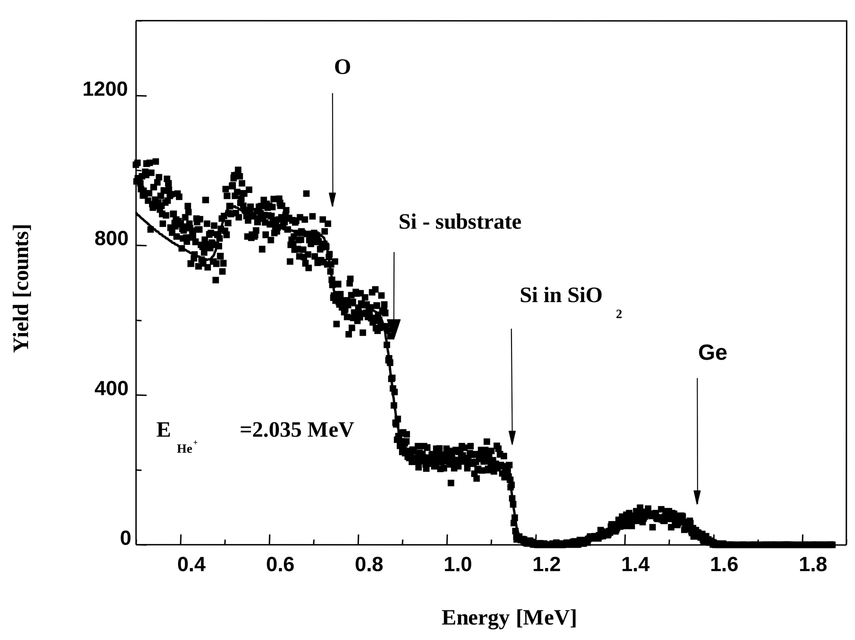
$$K = \left[\frac{M_1\cos(\theta) + \left(M_2^2 - M_1^2\sin^2(\theta)\right)^{1/2}}{M_1 + M_2}\right]^2$$

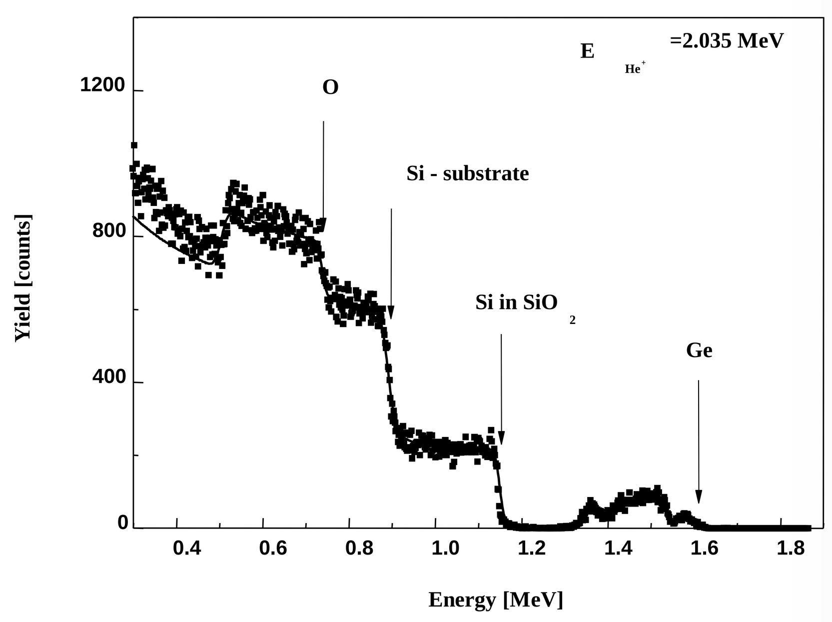
$E_o K = E_1$ ⟵ ***Energy particles after impact***



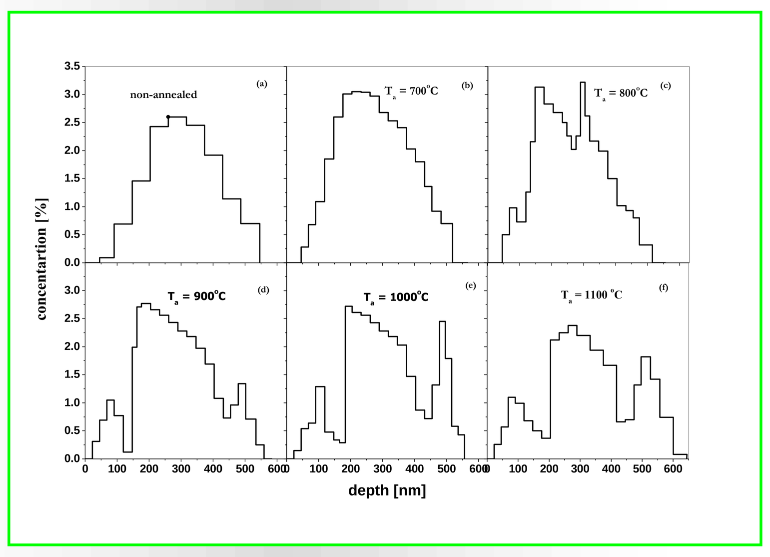


The RBS spectra (a) and depth profile of elements (b) for the TiO2/SiO2/Si structure after implanted by 250-keV Xe ion.





RBS spectra of Ge+-implanted SiO_2/Si layer Ge+-implanted SiO_2/Si layer non-annealed (left) and annealed at 1100°C (right). The fit is given by a solid line.



Sequence of germanium concentration/depth profiles obtained from RBS.V. Bohac, D.M. Shirokov, Nucl. Instrum. Meth **B.84,** (1993) 497

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[1] W.K. Chu, J.W. Mayer and M.A. Nicolet, 1978. *Backscattering Spectrometry*, Academic Press, New York.
[2] M. Mayer, 1997. *SIMNRA User's Guide*, Report IPP 9/113, Max-Planck-Institut für Plasmaphysik, Garching, Germany.