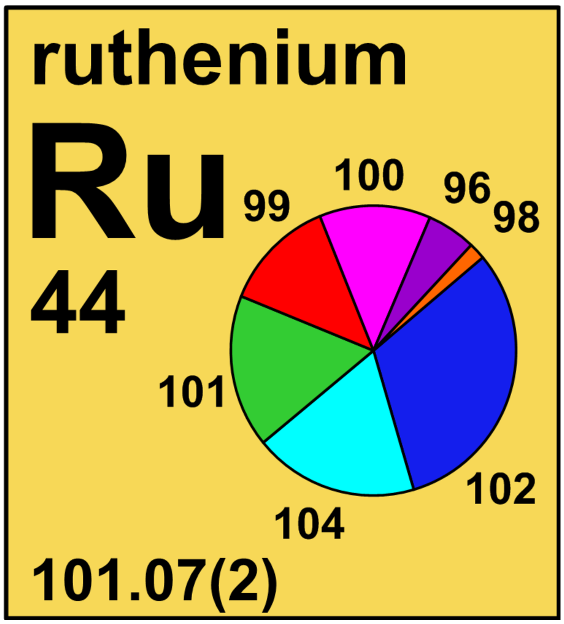
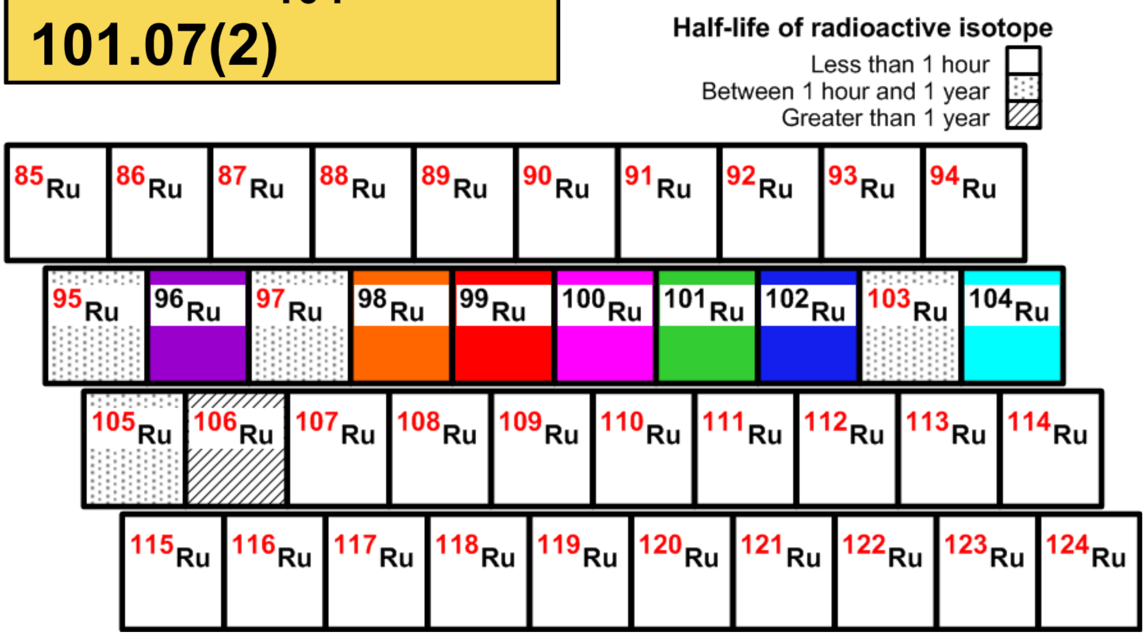
4.44 ruthenium



Stable isotope	Relative atomic mass	Mole fraction
^{96}Ru	95.907 590	0.0554
^{98}Ru	97.905 29	0.0187
^{99}Ru	98.905 934	0.1276
^{100}Ru	99.904 214	0.1260
^{101}Ru	100.905 577	0.1706
^{102}Ru	101.904 344	0.3155
^{104}Ru	103.905 43	0.1862



4.44.1 Ruthenium isotopes in Earth/planetary science

^{100}Ru is the product of a rare (and hence very long-lived) nuclear decay process from the **double beta decay** of ^{100}Mo. A careful measurement of the **half-life** for this decay, which is 7×10^{18} years, can be used to place an upper limit on the mass of the **electron neutrino**, which is a neutral and weakly interacting subatomic particle first postulated by Wolfgang Pauli in 1930 [323].

Ruthenium and molybdenum share many similarities. They both have seven **isotopes** (96, 98, 99, 100, 101, 102, and 104 for ruthenium and 92, 94, 95, 96, 97, 98, and 100 for molybdenum), and their isotopes are formed by the same nucleosynthesis **p-processes**, **r-processes**, and **s-processes**, namely, p, r, s and r, s only, s and r, s and r, and r, respectively. The molybdenum and ruthenium **isotopic composition** of most **meteorites** lie along a mixing line (Figure 4.44.1). The ruthenium and molybdenum of silicates in the Earth also lie on this line, which supports the hypothesis that the Earth **accreted** homogeneously. That is, the feeding zone of the Earth did not change substantially over time as both the bulk of the Earth and the late veneer accreted from material having the same ruthenium-molybdenum isotopic reservoir [324].

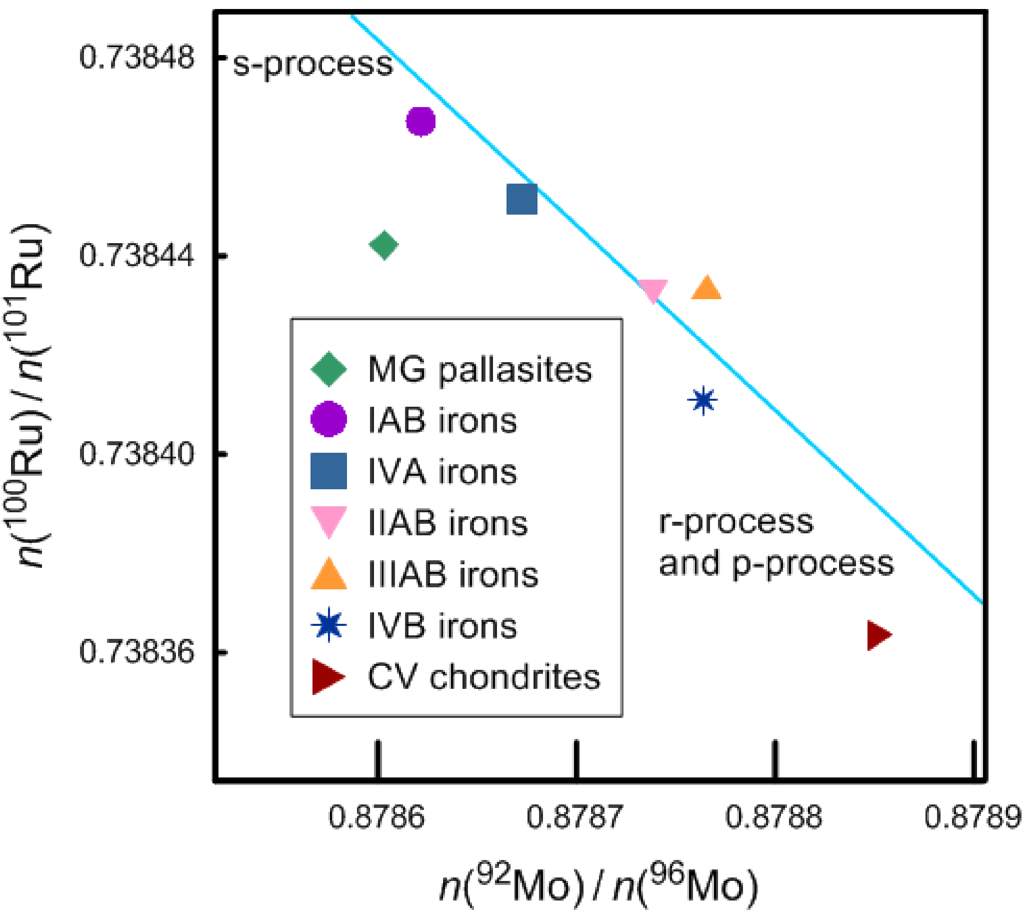


Fig. 4.44.1: Cross plot of $n(^{100}\text{Ru})/n(^{101}\text{Ru})$ **isotope-amount ratio** [325, 326] and $n(^{92}\text{Mo})/n(^{96}\text{Mo})$ isotope-amount ratio [327, 328] of selected **meteorite** groups (modified from [324], assuming a measured $n(^{100}\text{Ru})/n(^{101}\text{Ru})$ isotope-amount ratio of 0.738 48 [329] and a measured $n(^{92}\text{Mo})/n(^{96}\text{Mo})$ isotope-amount ratio of 0.878 61 [315].

4.44.2 Ruthenium isotopes in medicine

^{106}Ru plaque **brachytherapy** has been used for eye preservation and tumor control of uveal (the middle layer of the wall of the eye) melanoma [330]. The half-life of ^{106}Ru is 373 days.

4.44.3 Ruthenium isotopes used as a source of radioactive isotope(s)

^{96}Ru is used to produce **radioisotopes** ^{94}Ru (with a half-life of 52 minutes) and ^{95}Ru (with half-life of about 1.64 hours) via the reactions ^{96}Ru (n, 3n) ^{94}Ru and ^{96}Ru (n, 2n) ^{95}Ru, respectively (Figure 4.44.2) [331, 332]. ^{104}Ru is used to produce the radioisotope ^{105}Rh (with a half-life of about 35 hours) via the reaction ^{104}Ru (p, γ) ^{105}Rh. ^{105}Rh has been used in the treatment of bone pain [331].

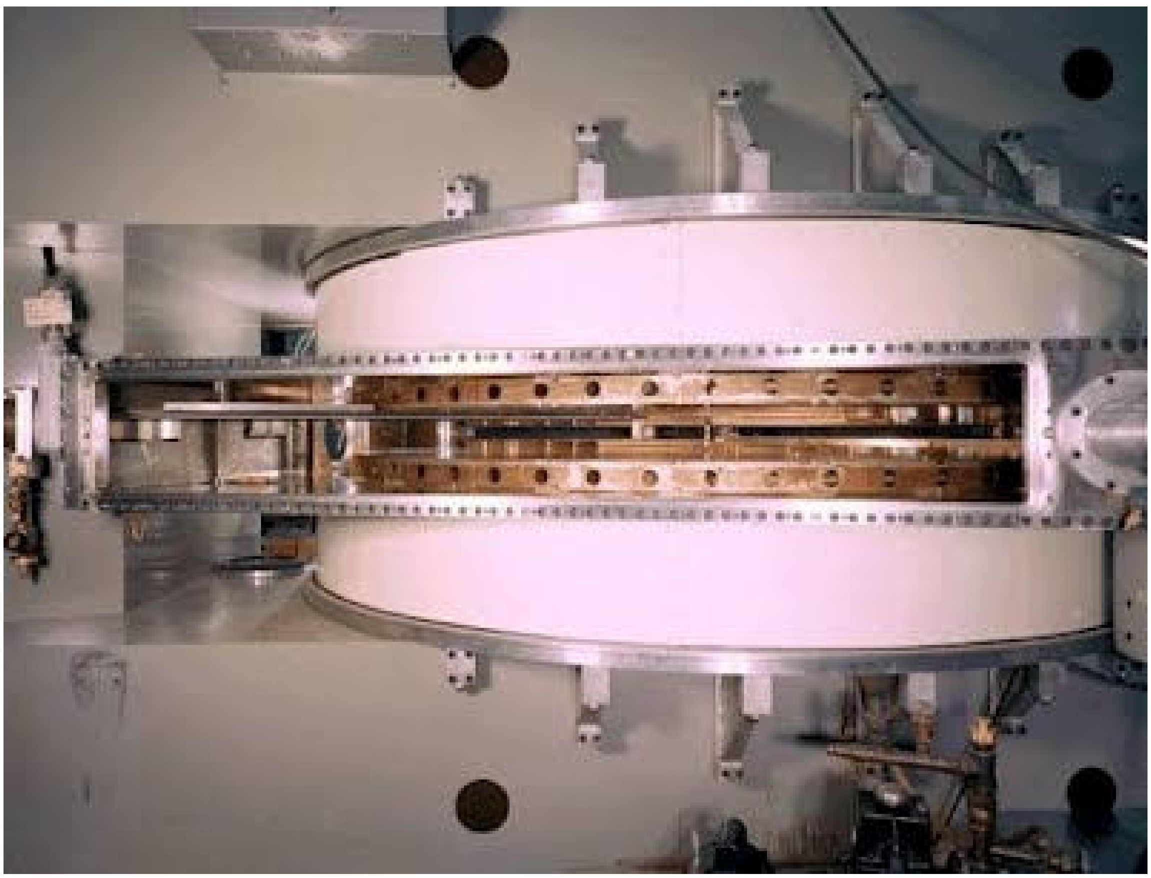


Fig. 4.44.2: The 88-Inch **cyclotron** was used to produce both light and heavy ions, including ^{94}Ru and ^{95}Ru. (Photo Source: Lawrence Berkeley National Laboratory) [333].