Irradiation Time for Production Thick Target Yield

(N. Otsuka, 2013-04-19, CP-D/784)

The physical thick target yield α_{phys} is time independent, while the production thick target yield (*i.e.*, unsaturated thick target yield) a_{prod} depends on irradiation time t:

$$a_{prod}(t) = \alpha_{phys}(1-e^{-\lambda t}) / \lambda ,$$

where λ is the decay constant of the reaction product. Addition of irradiation time in free text was proposed in Memo CP-D/631. Following discussion with Otto Schwerer on coding of thick target yields from BNL [1] (EXFOR C1954 transmitted in `TRANS.C123`), however, we concluded that irradiation time must be treated as coded information when we compile $a_{prod.}$ It is an essential variable for this quantity, and I would like to propose the following new heading code to implement this idea:

Dictionary 24 (Data Headings)

`TIME-IRRD` Irradiation time

Reference

[1] D.G. Medvedev *et al*, Radiochim. Acta **99** (2011) 755 (EXFOR C1954).

Appendix: Determination of quantity code for EXFOR C1954

Articles reporting thick target yield (activity) often do not provide enough information for determination of EXFOR quantity code as discussed in Memo CP-D/696. It would be worthwhile to share my experience in determination of the quantity code for the ^{86}Y ($T_{1/2}$=15 hrs) yield compiled in EXFOR C1954 from Tables 2 and 3 of [1].

Table 2. Irradiation conditions and target parameters.

Energy, MeV	$SrCl_2$ mass, g	Target dimensions, $d \times \Delta x$, inch (cm)	Beam current through the pellet, μA	Irradiation time, h
45.5 → 37.2	6.61	1.250 × 0.131 (3.18 × 0.33)	35.1	1
66.4 → 44.6	74.49	2.375 × 0.466 (6.03 × 1.18)	39.5	0.5
45.1 → 38.9[a]	5.02	1.250 × 0.120 (3.18 × 0.30)	24.5	0.5

a: $^{88}SrCl_2$ target.

Table 3. Production yield of ^{86}Y and its isotopic impurity at EOB in % of ^{86}Y.

Energy, MeV	^{87m}Y	^{87}Y	^{86m}Y	^{86}Y yield, mCi/μA h (MBq/μA h)
45.5 → 37.2	34.8	4.3	403.7	13.9 (514.3)
66.4 → 44.6	35.7	7.3	901.9	10.2 (377.4)
45.1 → 38.9[a]	56.0	5.1	489.0	11.0 (407.0)

a: $^{88}SrCl_2$ target.

Among three thick target yields (activity) defined in EXFOR – (1) physical, (2) production (= unsaturated) and (3) saturated thick target yield, only physical one can be given in MBq/μAh (others must be in MBq/μA etc.). But the physical yield is time independent, and I was confused by "at EOB" (at the end of bombardment) in the caption of Table 3 of the article. Fortunately the corresponding author kindly explained me that the activity at EOB was divided by the accumulated charge to obtain the yield. The total activity after irradiation time t with current I can be expressed as $I \times a_{prod}(t)$ while the total accumulated charge is expressed by $I \times t$. Therefore the yield derived by the authors can be expressed as:

$$[I \times a_{prod}(t)] / (I \times t) = a_{prod}(t) / t = \alpha_{phys} (1-e^{-\lambda t}) / \lambda t \sim \alpha_{phys}.$$

The last approximation (~) is the "short irradiation approximation" (*i.e.,* $\lambda t << 1$). The longer irradiation time in Table 2 (1 hr) and the half-life of ^{86}Y (15 hrs) give

$$\lambda t = \ln 2 / T_{1/2} / t \sim 0.04.$$

Therefore the irradiation condition given in Table 2 probably satisfies the short irradiation approximation condition. But this logic is not described in the article, and I proposed Otto Schwerer to apply

`,TTY,,(PHY)` Thick target yield, uncertain if it is physical yield

to be on the safe side.

For this specific article case, fortunately I could receive key information from the corresponding author. But I would believe that the experimentalists should provide more clear derivation and definition of their thick target yields in general. A short article describing our problem is under preparation for submission to Radiochimica Acta.