

LEXFOR “Multiplicity”

(N. Otsuka, 2021-05-03, Memo CP-D/1046)

This paper seeks an approval to define the multiplicity (MLT) and product yield (PY) without TT in SF8 as the number of products per reaction and to introduce some new unit families to ensure an appropriate combination between the quantity code and unit code.

LEXFOR “Multiplicity” starts from the following paragraph:

Multiplicity

(See also **Fission Yields, Neutron Yield, Thick- and Thin-Target Yields**)

Definition

Yield per event (per one incident particle, per the reaction), except for yield of reaction product (Product yield) and yield from fission (Fission yield).

REACTION Coding: MLT in SF6.

Examples:

(... (P, A) ..., , MLT, G)	γ yield from (p, $\alpha\gamma$) reaction
(... (N, G) ..., , MLT)	γ yield from capture gamma

I propose the following revisions:

Multiplicity and Product Yield

(See also **Fission Yields, Neutron Yield, Thick- and Thin-Target Yields**)

Definition

Number of particles or nuclei (~~per one incident particle~~, per the reaction), except for yield of reaction product (Product yield) and yield from fission (Fission yield). The quantity is referred to **multiplicity** when the particle considered is in REACTION SF3 or SF7, and **product yield** when the particle considered is in REACTION SF4.

REACTION Coding: , MLT (for multiplicities) or , PY (for product yields).

Units: a code from Dictionary 25 with the dimension MLT. The unit code PRT/REAC and its derivative for multiplicities and PRD/REAC and its derivative for product yields.

Examples:

(... (P, A) ..., , MLT, G)	γ yield from a (p, $\alpha\gamma$) reaction
(... (N, G) ..., , MLT)	γ yield from a neutron capture gamma
(... (P, X) 0-G-0..., , PY)	γ yield from a proton induced reaction

...

See LEXFOR **Thick target yields** for the number of particles or nuclei per incident particle.

Definition

The current description defines the multiplicity as the “yield per event” but we know the term “yield” is used in various meanings in the literature, and it is better to be more specific.

The current description distinguishes the product yield (P_Y) from the multiplicity (M_{LT}), but it is more important for compilers to distinguish

- (1) the multiplicity (M_{LT}) and yield (P_Y) from
- (2) the thick target multiplicity ($M_{LT,TT}$) and product yield (P_Y,TT).

The first group of the quantities is free from the concept of the target thickness while the second group of the quantities requires the target thickness information (usually assuming a target thicker than the range without a specific number under THICKNESS),

Units

The current dictionary does *not* distinguish the unit family of the unit family of the multiplicity/product yield (e.g., $P_{RT}/REAC$, $P_{RD}/REAC$) from the thick target multiplicity/product yield (e.g., P_{RT}/INC , $P_{RT}/MUCOUL$, P_{RD}/INC , $P_{RD}/MUCOUL$), and it does not allow checking programs to check the right combination between the REACTION SF5-SF8 and unit code.

I propose introduction of new unit families (M_{LT} , M_{DA} , M_{DE} and M_{AE}) for the multiplicity and product yield:

Dictionary 26 (Unit families)

MLT	products/reaction
MDA	products/angle/reaction
MDE	products/energy/reaction
MAE	products/angle/energy/reaction

Code	Expansion	Family	Family (new)
NUC/PART	nuclei per incident projectile	YLD	
P/IN/MEVSR	particl./inc.proj. per Sr per MeV	YAE	
P/MEVMUCSR	particles/(MeV muC sr)	YAEC	
P/RC/MEVSR	particles/reaction/MeV/sr	YAE	MAE
PC/DECAY	particles per 100 decays	YLD	?
PC/INC	particles/100 incid.projectiles	YLD	
PC/INC/SR	particles/100 incid.projectiles/sr	YDA	
PC/REAC	particles/100 reactions	YLD	MLT
PRD/IN/MEV	products per inc. proj. per MeV	YDE	
PRD/INC	products/incident projectile	YLD	
PRD/INC/SR	products/inc.projectile/steradian	YDA	
PRD/MUAHR	products/micro-Ampere-hour	YLDC	
PRD/MUC/SR	products/micro-Coulomb/sr	YDAC	
PRD/MUCOUL	products/micro-Coulomb	YLDC	
PRD/REAC	products/reaction	YLD	MLT
PRT/DECAY	particles per decay	YLD	?
PRT/IN/MEV	particles per inc. proj. per MeV	YDE	
PRT/INC	particles per incident projectile	YLD	
PRT/INC/SR	partcles/inc.projectile/steradian	YDA	

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PRT/MAMIN	particles/milli-Ampere-minute	YLDC	
PRT/MUAHR	particles/micro-Ampere-hour	YLDC	
PRT/MUC/SR	particles/micro-Coulomb/steradian	YDAC	
PRT/MUCOUL	particles/micro-Coulomb	YLDC	
PRT/RCT/SR	particles per reaction per sterad	YDA	MDA
PRT/REAC	particles/reaction	YLD	MLT
PT/RCT/MEV	particles per reaction per MeV	YDE	MDE

Example

Quantity	REACTION	Unit
$^{235}\text{U}(n, \gamma)^{236}\text{U}$ γ multiplicity	(92-U-235 (N, G) 92-U-236, , MLT)	PRT/REAC
$^{235}\text{U}(n, \gamma+x)$ γ product yield	(92-U-235 (N, X) 0-G-0, , PY)	PRD/REAC
$^{235}\text{U}(n, f)$ prompt γ yield	(92-U-235 (N, F) 0-G-0, PR, FY)	PRD/FIS