Threshold calculator and its application to REACTION SF3 checking

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We often need to list all contributing target and channels to get a particular product nuclide for comparison of measured production cross sections (*e.g*, activation cross sections) with model prediction etc. One of us (RS) developed a threshold calculator (C++) to show all contributing target nuclides and channels with AME2020 mass evaluation as the mass table. Below are screenshots of an input and output on a web interface of this calculator (https://www.jcprg.org/tcalc/).

Example of input

Target and projectile are mandatory. Ejectile or product is mandatory.

Target	Fe	(e.g., 100Mo, Mo)
Projectile	a	(e.g., g, n, p, d, t, h, a, 27Al)
Ejectile		(e.g., 2p+3d)
Product	51Cr	(e.g., 99Tc)
Upper energy (MeV)	30	

submit   reset

Example of output

Your request

Target	Projectile	Ejectile	Product	Emax (MeV)
^{nat}Fe	α	(Unspecified)	^{51}Cr	30

Possible channels

| Reaction	Q (MeV)	E_{thr} (MeV)
$^{56}Fe(\alpha,n+2\alpha)^{51}Cr$	-19.652682	21.062699
$^{54}Fe(\alpha,h+\alpha)^{51}Cr$	-19.735119	21.203445
$^{54}Fe(\alpha,p+d+\alpha)^{51}Cr$	-25.228594	27.107022
$^{57}Fe(\alpha,2n+2\alpha)^{51}Cr$	-27.298854	29.225011
$^{54}Fe(\alpha,n+2p+\alpha)^{51}Cr$	-27.453160	29.497829

Such a tool is useful to check whether REACTION SF3 follow the following EXFOR compilation rules:

1. SF3 should not be X when only one process is possible.

2. SF3 should be X when several processes are possible.

Examples

- `(79-AU-197(D,`**`P`**`)79-AU-198,,SIG)`
  rather than
  `(79-AU-197(D,`**`X`**`)79-AU-198,,SIG)`
  below the ^{197}Au(d,nπ^+)^{198}Au threshold (~140 MeV).

- `(39-Y-89(D,`**`X`**`)38-SR-87,,SIG)`
  rather than
  `(39-Y-89(D,`**`A`**`)38-SR-87,,SIG)`
  above the ^{89}Y(d,pt)^{87}Sr threshold (~13 MeV).

It is not always trivial to follow these rules for compilers since there exists variety in expressions adopted in the source articles. We implemented checking against **the first rule** by using the newly developed threshold calculator, and it is added to the JCPRG EXFOR compilation tool (https://www.jcprg.org/exfor/tool/) which now gives an additional output **SF3 check output**:
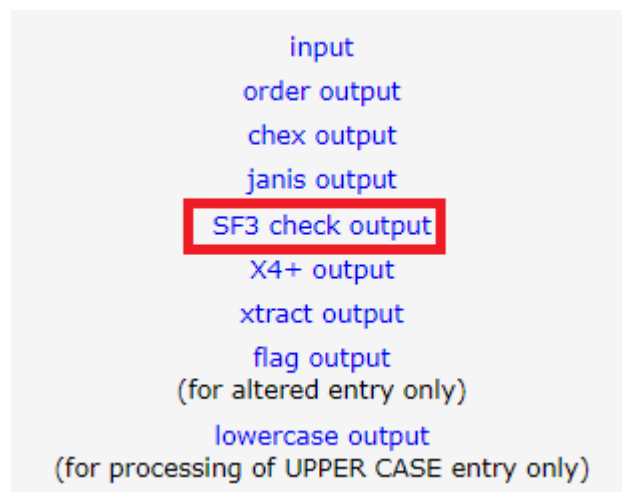
By clicking this link, you can see an output like

```
SF3=X Checker for ACTIV run on 2022-5-8
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 Input file: ../exfor/tool/./work/trans-584a.txt

 F1456.002: X -> 6N        63-EU-151(A,X)65-TB-149-G,,SIG
 F1458.002: X -> N         6-C-12(D,X)7-N-13,,SIG

 Program terminated normally
```

The program currently does not check the energy range, and the message should be utilized with caution *when the incident energy is beyond the pion production threshold*. We wish this new function is useful for preparation of your future preliminary tapes.