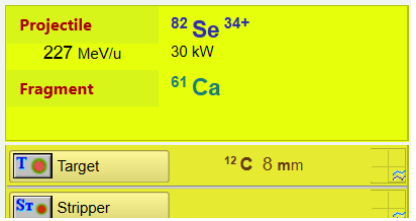
Light Particle Production in LISE^{++}

- **Goal:**
  understand why radiation benchmarks need “Light-Z yield factor = 10” vs EPAX3 + Oleg factors.
- Test: simple projectile-fragmentation case in LISE^{++} (screenshot at right; comparison below).
- Light-particle production through the breakup-channel of highly excited fragments above the limiting temperature—assumed to undergo multifragmentation—is not included in LISE^{++}.
- Multistep reactions in target are not included; they need dedicated study.
- The laboratory-frame kinematics of evaporated light particles must also be analyzed and compared with the current projectile-fragmentation treatment.



	Cross sections in mb				
	EPAX3 + Oleg's factors	EPAX3 original	AA	evaporated particles (AA)	Ratio AA light particles vs EPAX3+factors
n				5.60E+03	
p	160	0.4	2.3E-02	1.12E+03	7.0
d	310	0.7		2.48E+02	0.8
t	150	0.35	1.1E-06	1.35E+02	0.9
3He	28	0.43	6.5E-08	3.70E+01	1.3
4He	52	0.8	1.2E-04	3.79E+02	7.3

Evaporation alone gives ≳7× higher p and ^{4}He yields than EPAX3 + Oleg factors.
Factor 10 is plausible for radiation benchmarks, but remains empirical until breakup and multi-step reactions are modeled.

LISE^{++} update: v.18.5.13

Based on the analysis presented here, which indicates that additional enhancement is required only for proton and alpha-particle yields, while the calculated yields of other light charged particles appear to be consistent with the model, an additional multiplicative factor of 7 was applied to the proton and alpha-particle production cross sections in LISE^{++} version 18.5.13.

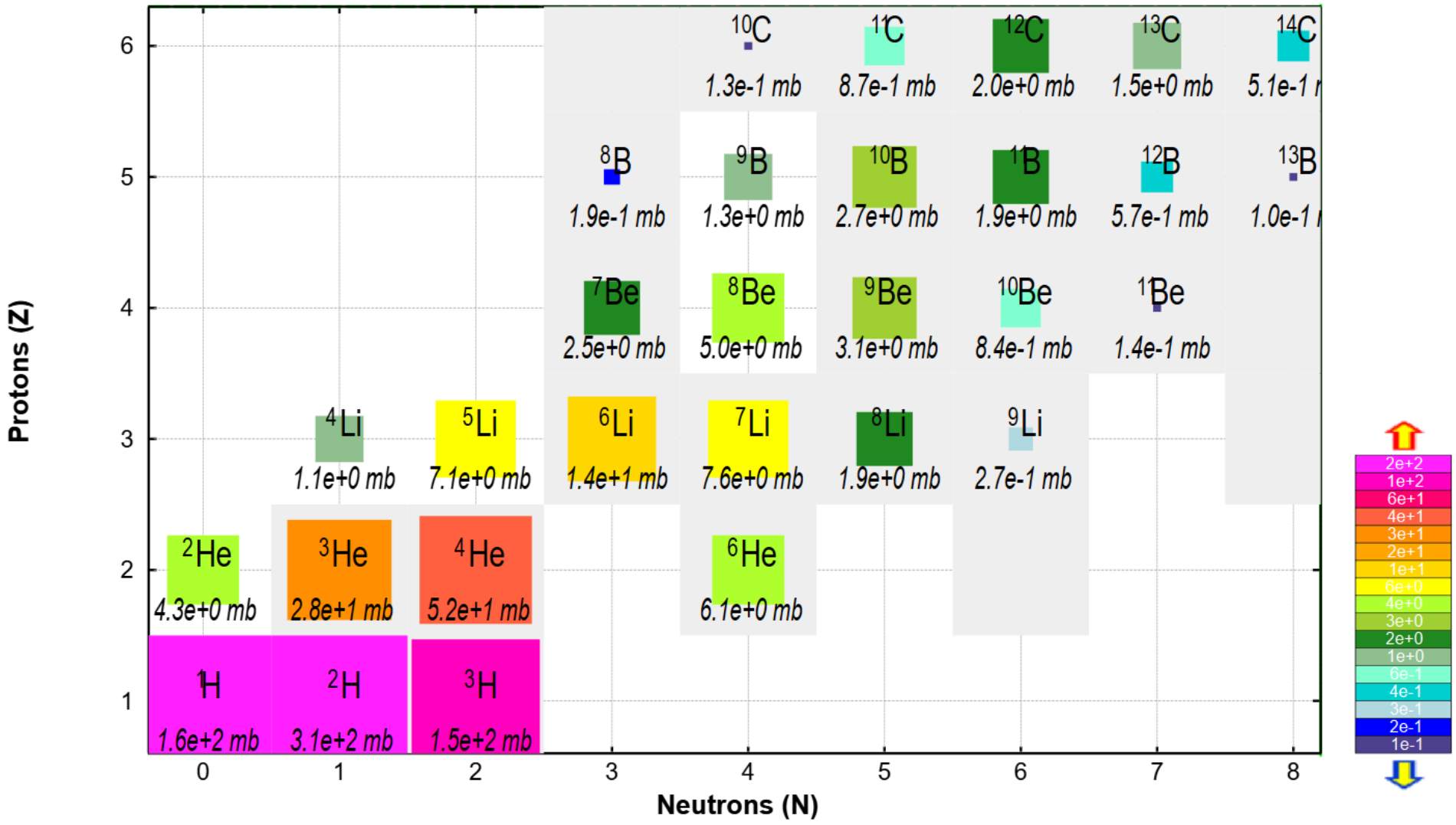
This provides *consistency* between standard LISE^{++} production-rate calculations, including power-deposition estimates, and the Prompt Radiation Calculator using a Light-Z yield *factor of 1*.

EPAX3 with Oleg's factors

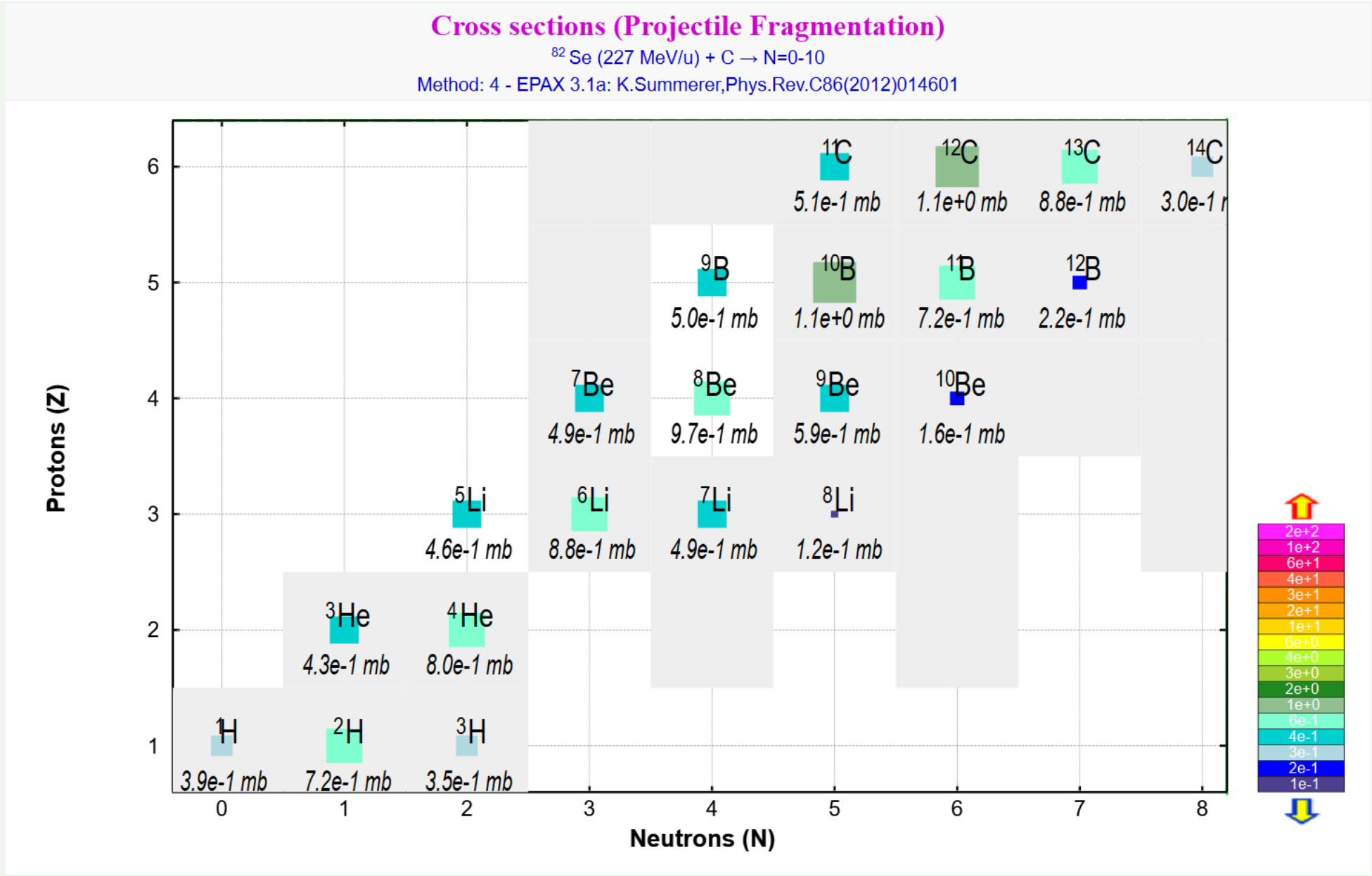
Cross sections (Projectile Fragmentation)

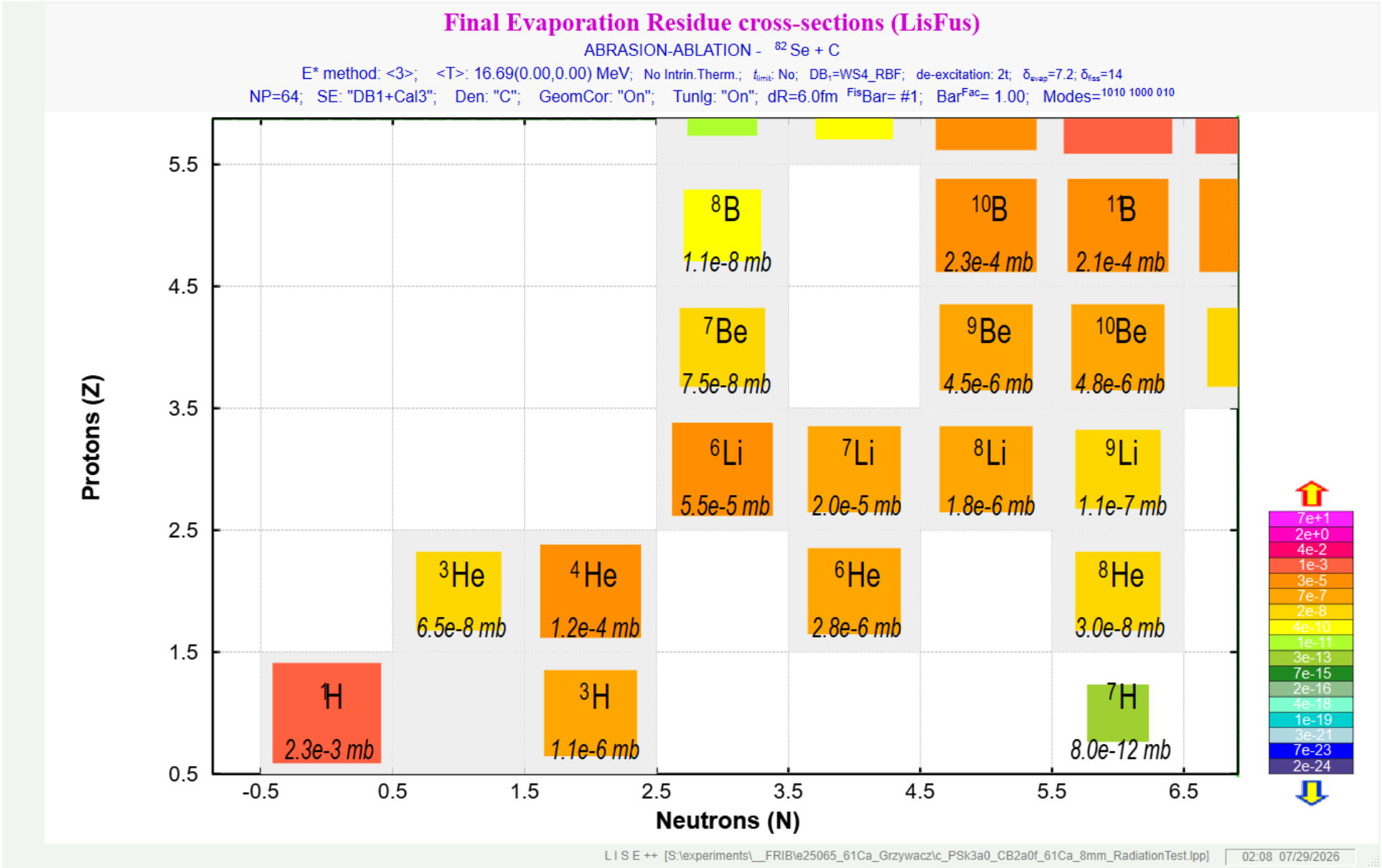
^{82}Se (227 MeV/u) + C → N=0-10

Method: 4 - EPAX 3.1a: K.Summerer,Phys.Rev.C86(2012)014601



EPAX3 without Oleg's factors




Final Evaporation Residue cross-sections (LisFus)
ABRASION-ABLATION - 82 Se + C
E* method: <3>; <T>: 16.69(0.00,0.00) MeV; No Intrin.Therm.; t_limit: No; DB1=WS4_RBF; de-excitation: 2t; δevap=7.2; δfiss=14
NP=64; SE: "DB1+Cal3"; Den: "C"; GeomCor: "On"; Tunlg: "On"; dR=6.0fm FisBar= #1; BarFac= 1.00; Modes=1010 1000 010
Protons (Z)
Neutrons (N)
8B 1.1e-8 mb
10B 2.3e-4 mb
11B 2.1e-4 mb
7Be 7.5e-8 mb
9Be 4.5e-6 mb
10Be 4.8e-6 mb
6Li 5.5e-5 mb
7Li 2.0e-5 mb
8Li 1.8e-6 mb
9Li 1.1e-7 mb
3He 6.5e-8 mb
4He 1.2e-4 mb
6He 2.8e-6 mb
8He 3.0e-8 mb
1H 2.3e-3 mb
3H 1.1e-6 mb
7H 8.0e-12 mb
7e+1
2e+0
4e-2
1e-3
3e-5
7e-7
2e-8
4e-10
1e-11
3e-13
7e-15
2e-16
4e-18
1e-19
3e-21
7e-23
2e-24
L I S E ++ [S:\experiments__FRIB\e25065_61Ca_Grzywacz\c_PSk3a0_CB2a0f_61Ca_8mm_RadiationTest.lpp]
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LISE^{++} Evaporation Calculator