

In collaboration with Felix Marti & Wolfgang Mittig

See “The Stripper foil lifetime utility” part 1 (v.8.3.6) at:
http://groups.nsl.mscl.msu.edu/lise/8_3/foil_lifetime_v8_3_6.pdf

Stripper Lifetime utility (version 8.3.13)

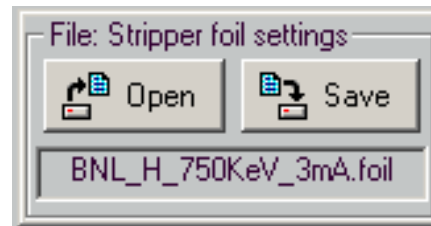
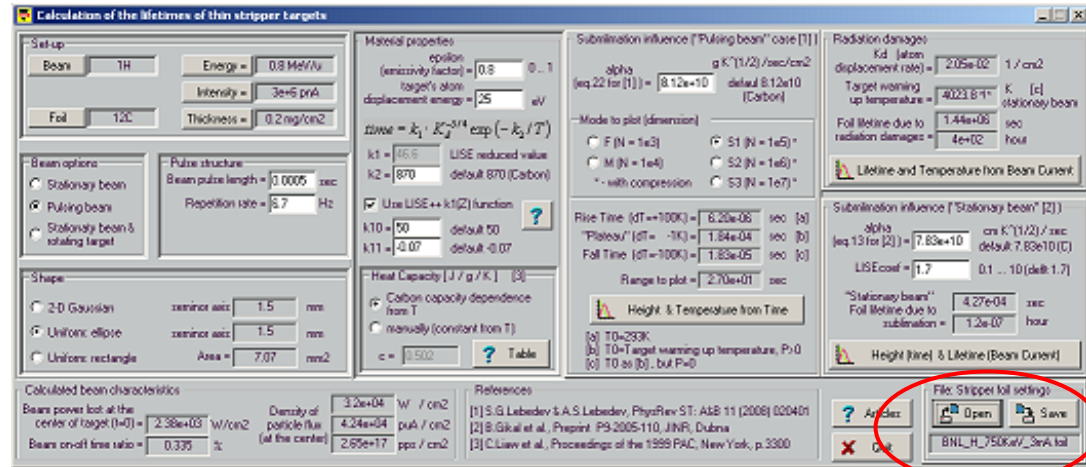
- ❖ I/O file for the Striper lifetime dialog
- ❖ Baron’s parameterization
- ❖ LISE++ k1-dependence from Z
- ❖ Comparison with experimental data
 - ^{40}Ar @ Dubna : Radiation damage
 - ^{20}Ne @ Dubna : Radiation damage
 - ^{112}Sn @ MSU : Radiation damage
 - ^{238}U @ MSU : Radiation damage
- ❖ Analysis of some parameters
 - Interaction area (Current)
 - Foil thickness
 - Beam energy
 - Emissivity factor
 - Heat capacity (pulsing beam)
 - k2 coefficient
 - rotation target frequency

The code operates under MS Windows environment and provides a highly user-friendly interface.
 It can be freely downloaded from the following internet addresses:

<http://www.nsl.mscl.msu.edu/lise>

Default : “ Lise / files ” directory

File extension: “ *.foil “



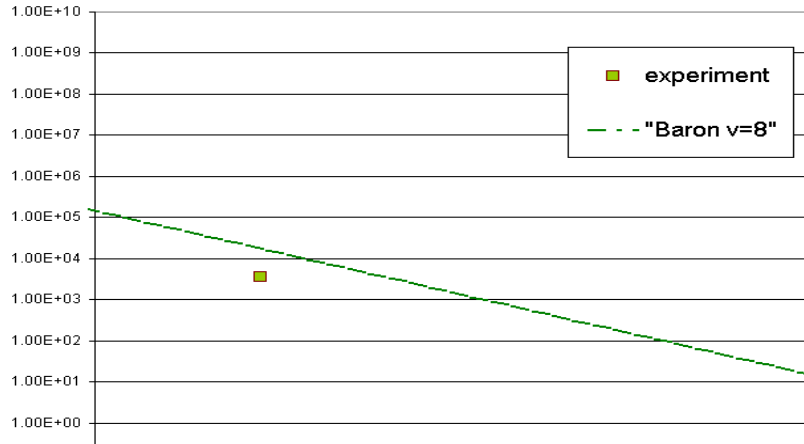
Durée de vie des cibles de stripping (carbone)

Eric Baron, en réponse à une question de W. Mittag, 17/04/08

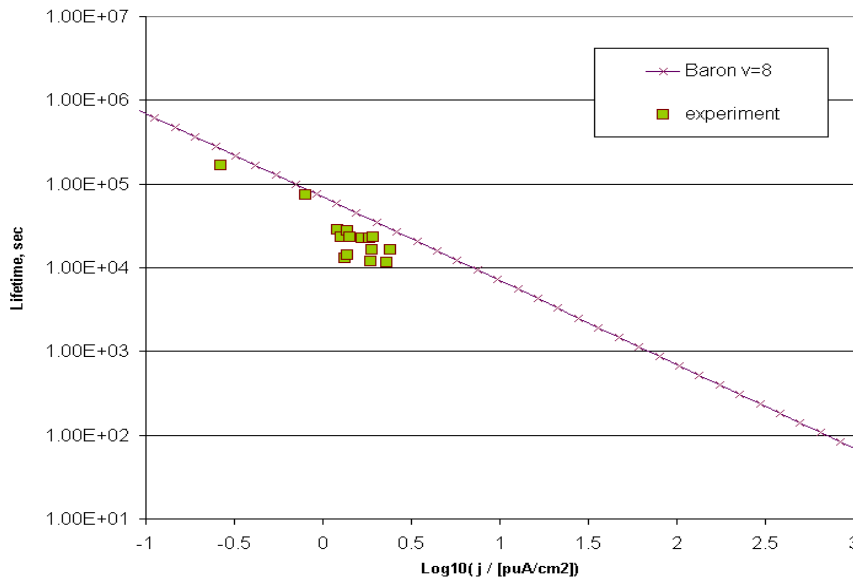
$$T(\text{heures}) = 3.6 \cdot 10^4 \frac{W(\text{MeV}/n)}{Z^2 v J (\mu\text{A}/\text{cm}^2)}$$

W = l'énergie du projectile de numéro atomique Z, J la densité de courant à l'endroit de l'impact du faisceau sur la cible en $\mu\text{ampères-particule}$, et v un nombre qui varie entre 5 et 8 (ce n'est donc pas très important, en première approximation) ; c'est le nombre moyen d'atomes de carbone déplacés par un atome de carbone issu d'une collision avec un ion.

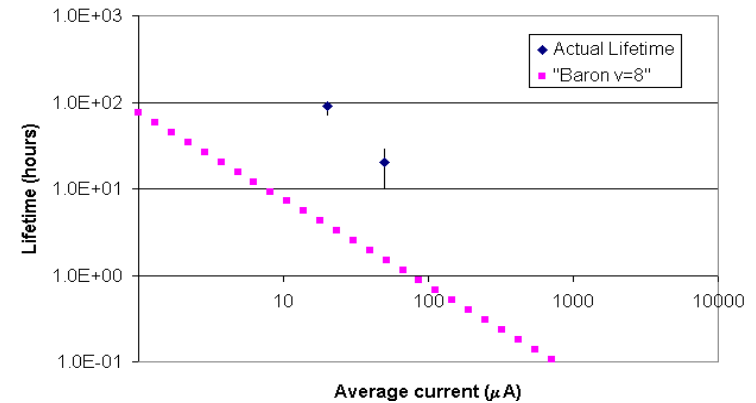
^{238}U 30+ 7.68 MeV/u 1 μA
C-thick 600 $\mu\text{g}/\text{cm}^2$



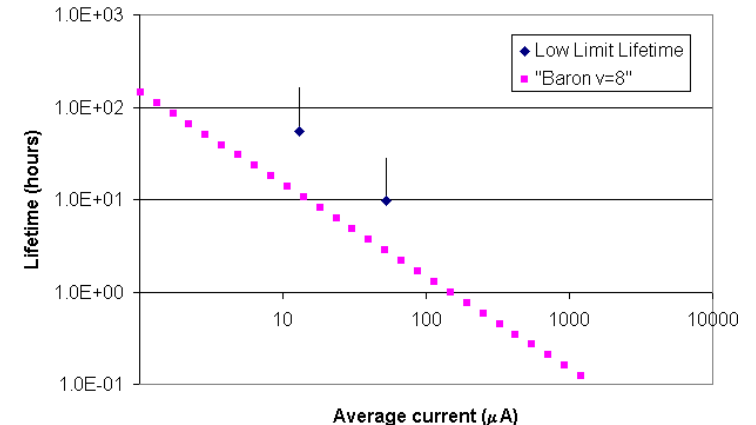
^{112}Sn 10.86 MeV/u
Beam size = 4 mm^2 (rectangle) C-thick 600 $\mu\text{g}/\text{cm}^2$



40Ar5+ 5 MeV/u Emiss. = 0.8
Beam size = 0.5 cm^2 thick=50 $\mu\text{g}/\text{cm}^2$



20Ne (5 MeV/u) Emiss. = 0.8
Beam size = 0.5 cm^2 thick=50 $\mu\text{g}/\text{cm}^2$



Material properties

epsilon (emissivity factor) = 0.8 0..1

target's atom displacement energy = 25 eV

$$time = k_1 \cdot K_d^{-5/4} \exp(-k_2/T)$$

k1 = 11.8 LISE reduced value

k2 = 870 default 870 (Carbon)

Use LISE++ k1(Z) function ?

k10 = 50 default 50

k11 = -0.08 default -0.07

Calculation of the lifetimes of thin stripper targets

Material properties: epsilon = 0.8, target's atom displacement energy = 25 eV

Substitution influence ["Pulsing beam" case [1]]

alpha (eq 22 for [1]) = 0.12e+10 default 8.12e10 (Carbon)

Mode to plot (dimension): F (N = 1e3), S1 (N = 1e5), S2 (N = 1e6), S3 (N = 1e7)

Use LISE++ k1(Z) function ?

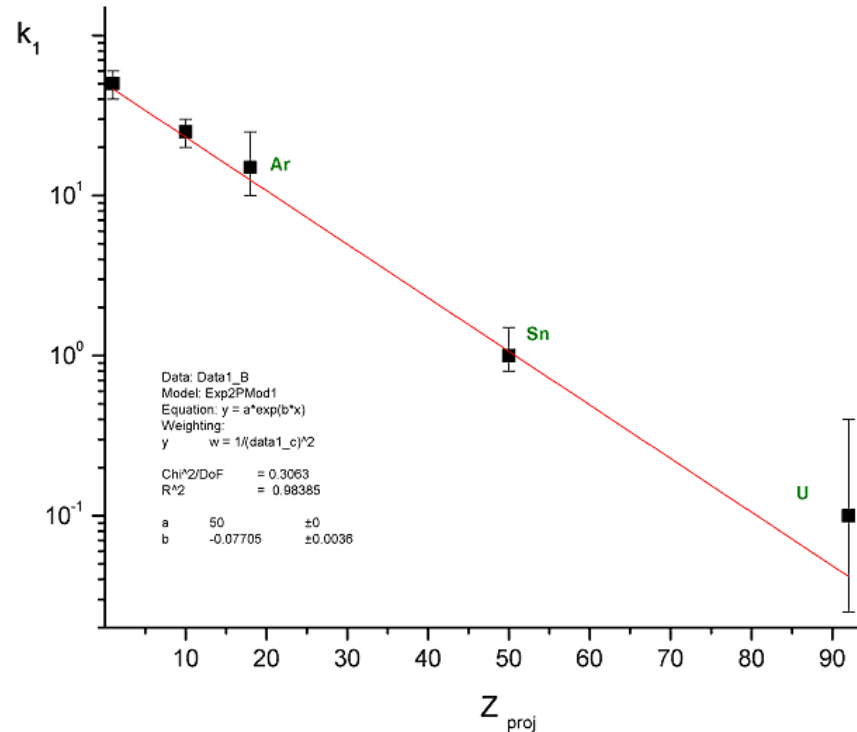
k1 = 11.8 LISE reduced value

k2 = 870 default 870 (Carbon)

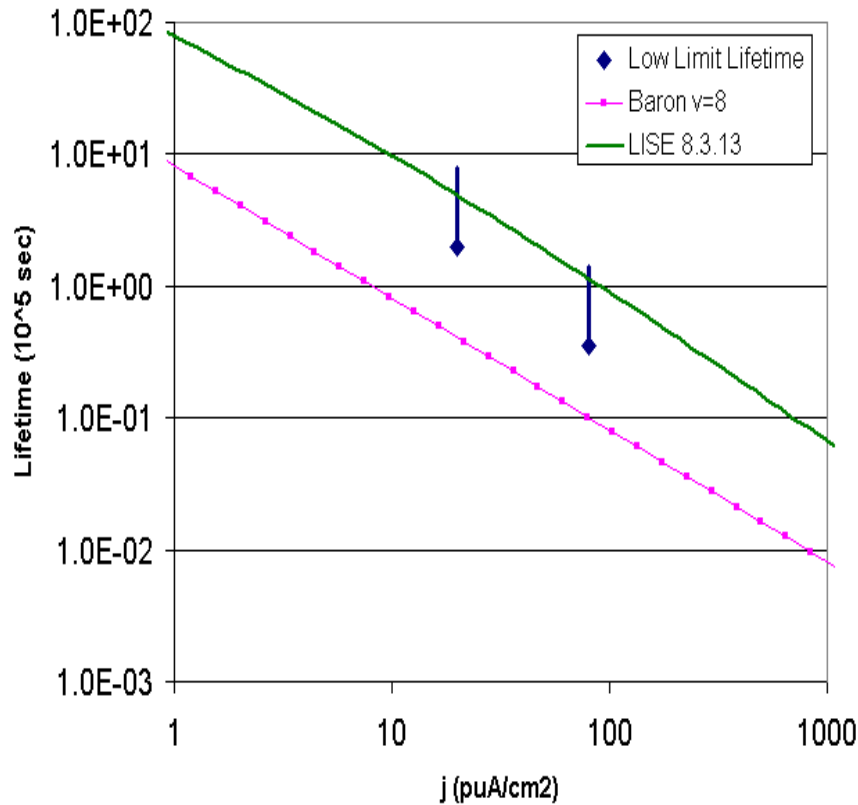
Calculated beam characteristics: Beams power, Density of particle flux, Beams on-off time ratio

References: [1] S.G. Lebedev & A.S. Lebedev, PhysRev ST: Acc 11 (2008) 020401, [2] B. Sikul et al., Preprint P9.2005-110, JINR, Dubna, [3] C. Liaw et al., Proceedings of the 1999 PAC, New York, p.3300

$$k_1 = k_{10} \cdot \exp(-k_{11} \cdot Z_{proj})$$

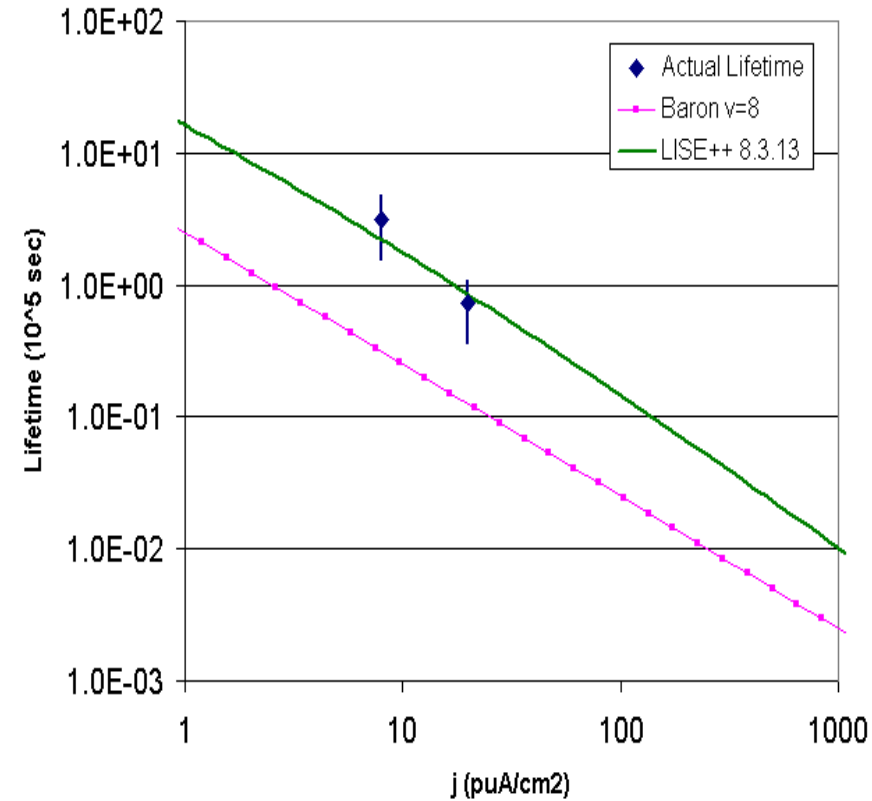


^{20}Ne (5 MeV/u) Emiss. = 0.8
 Beam size = 0.5 cm² thick=50 μg/cm²



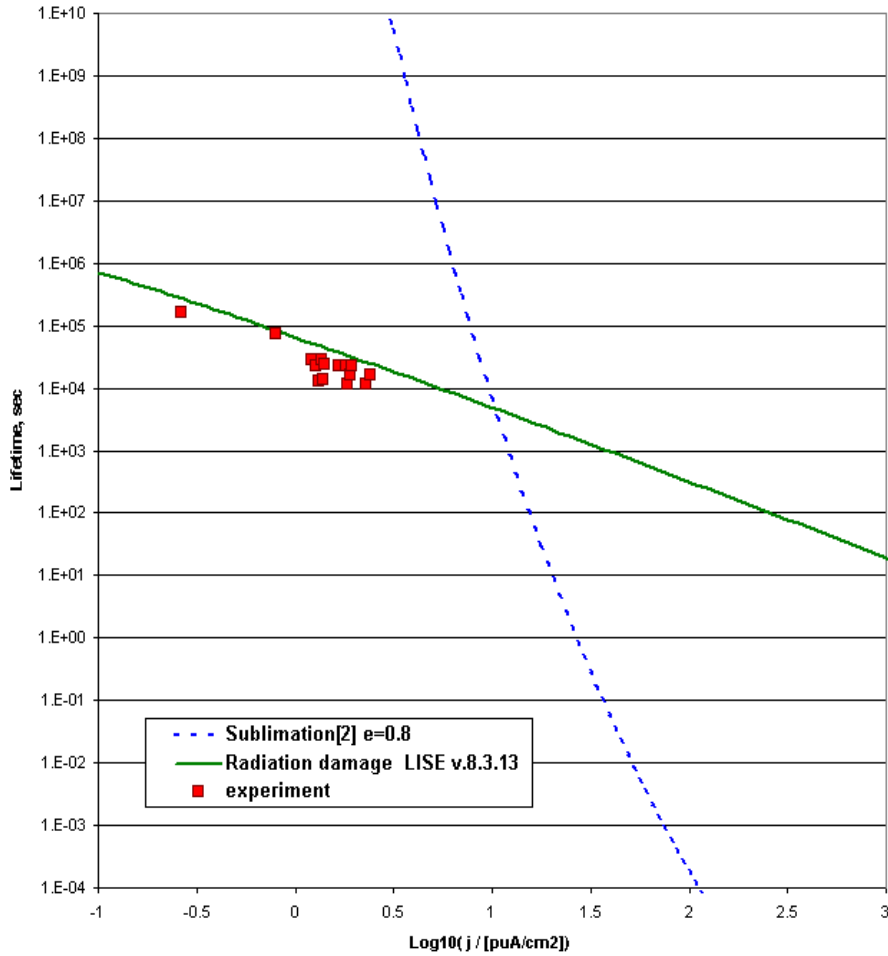
v.8.3.13 http://groups.nsl.msu.edu/lise/8_3/Dubna_20Ne.foil

$^{40}\text{Ar}^{5+}$ 5 MeV/u Emiss. = 0.8
 Beam size = 0.5 cm² thick=50 μg/cm²

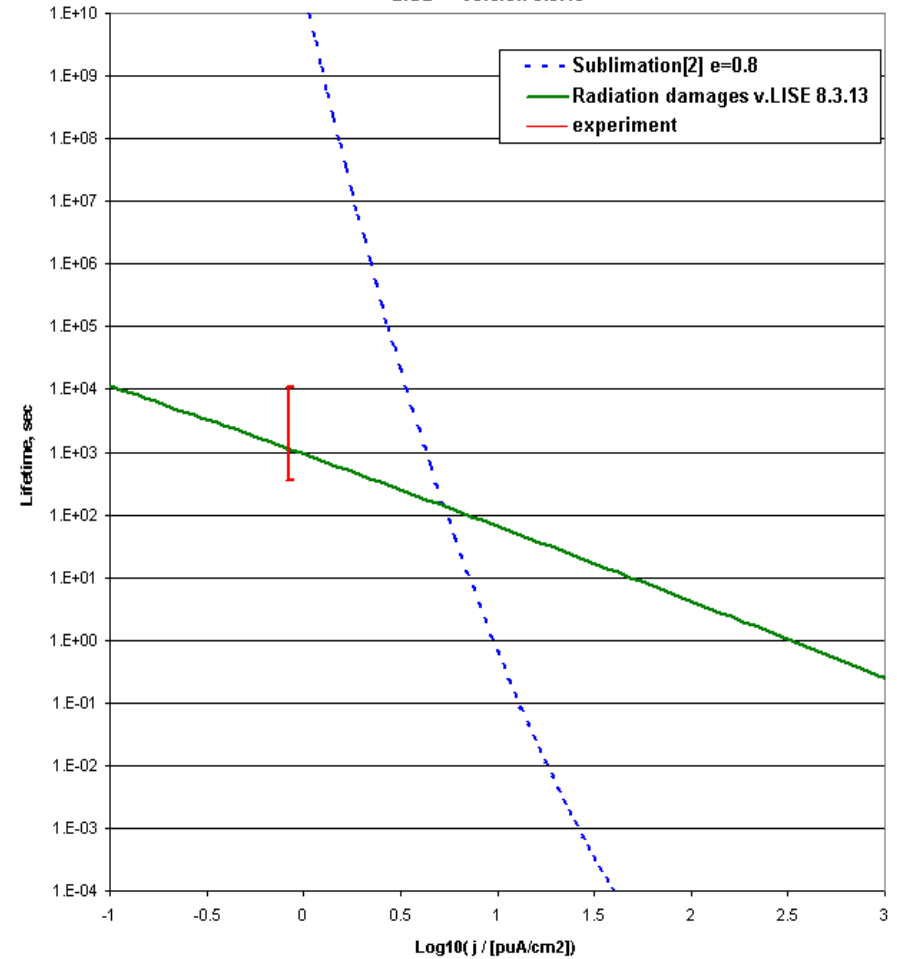


v.8.3.13 http://groups.nsl.msu.edu/lise/8_3/Dubna_40Ar.foil

112Sn 10.86 MeV/u
 Beam size = 4 mm2 (rectangle) C-thick 600 ug/cm2
 LISE++ version 8.3.13



238 U 30+ 7.68 MeV/u 1euA
 C-thick 600 ug/cm2
 LISE++ version 8.3.13



v.8.3.13 http://groups.nsl.msu.edu/lise/8_3/MSU_112Sn.foil

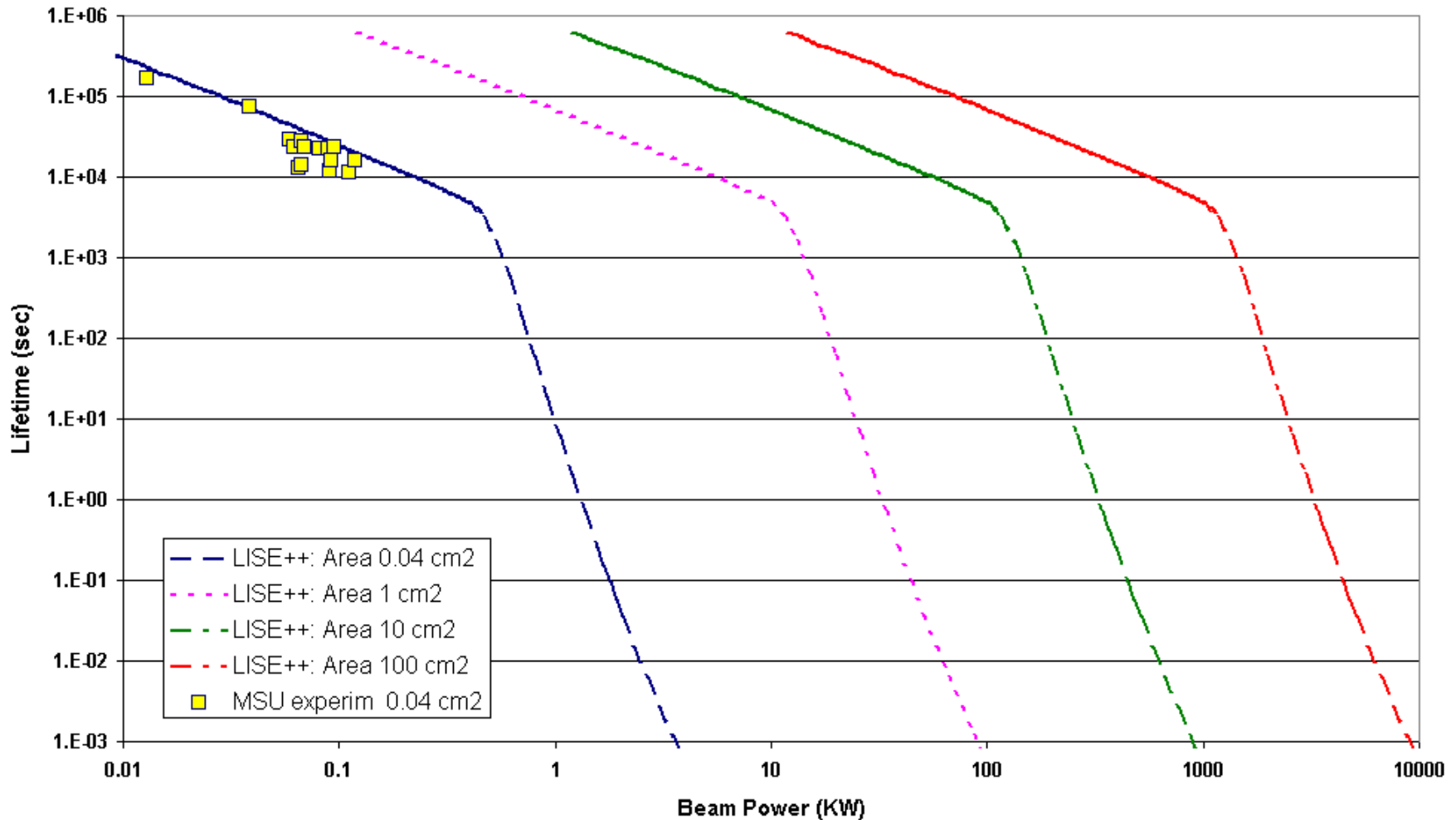
v.8.3.13. http://groups.nsl.msu.edu/lise/8_3/MSU_238U.foil

Lifetime = f (j),

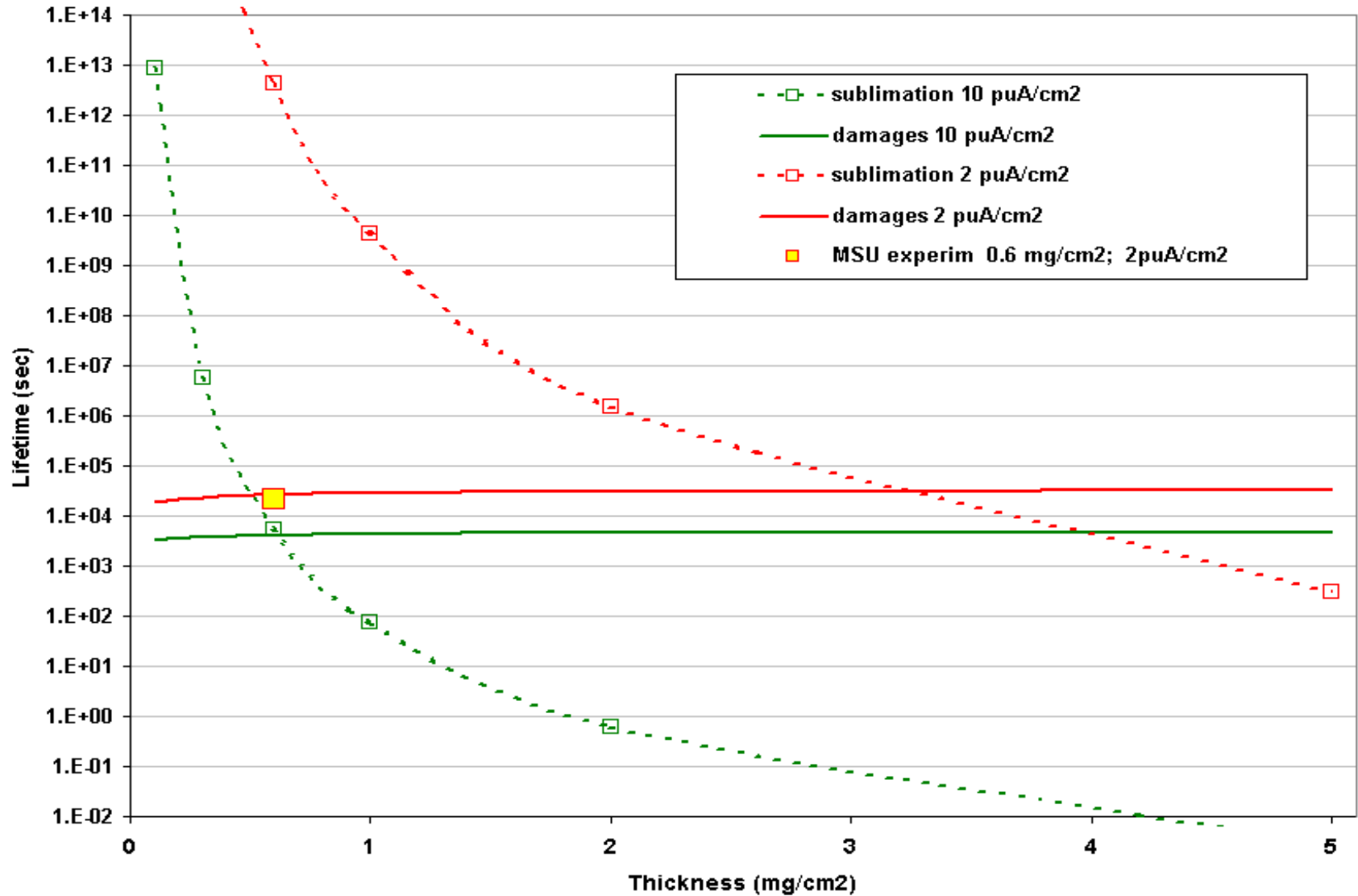
where j is the density of particle flux [$\mu\text{A}/\text{cm}^2$], and equal to
 Decrease an interaction area to increase lifetime.

$$\frac{\text{Current}}{\text{Interaction Area}}$$

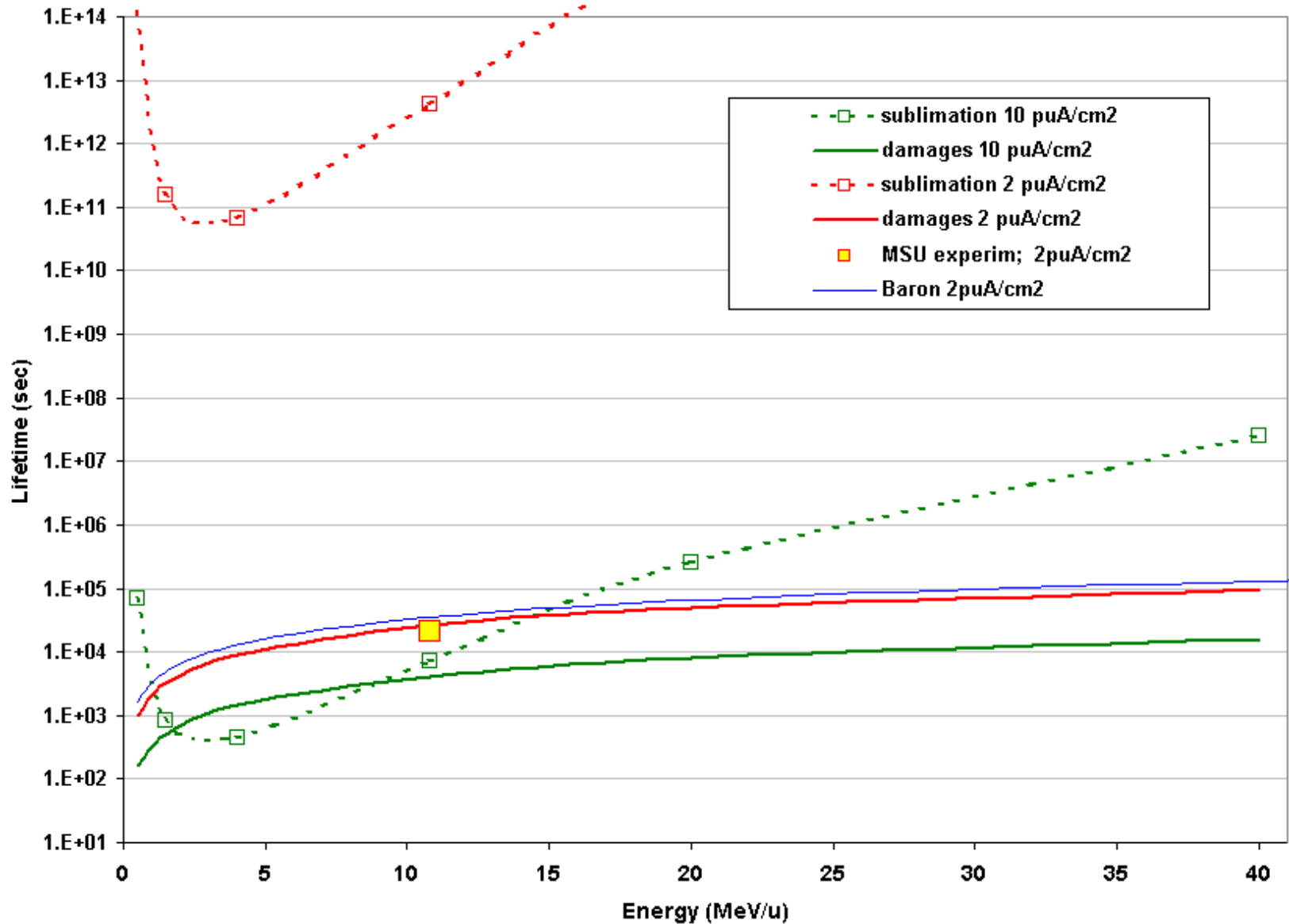
112Sn 10.86 MeV/u
 Carbon 0.6 mg/cm²



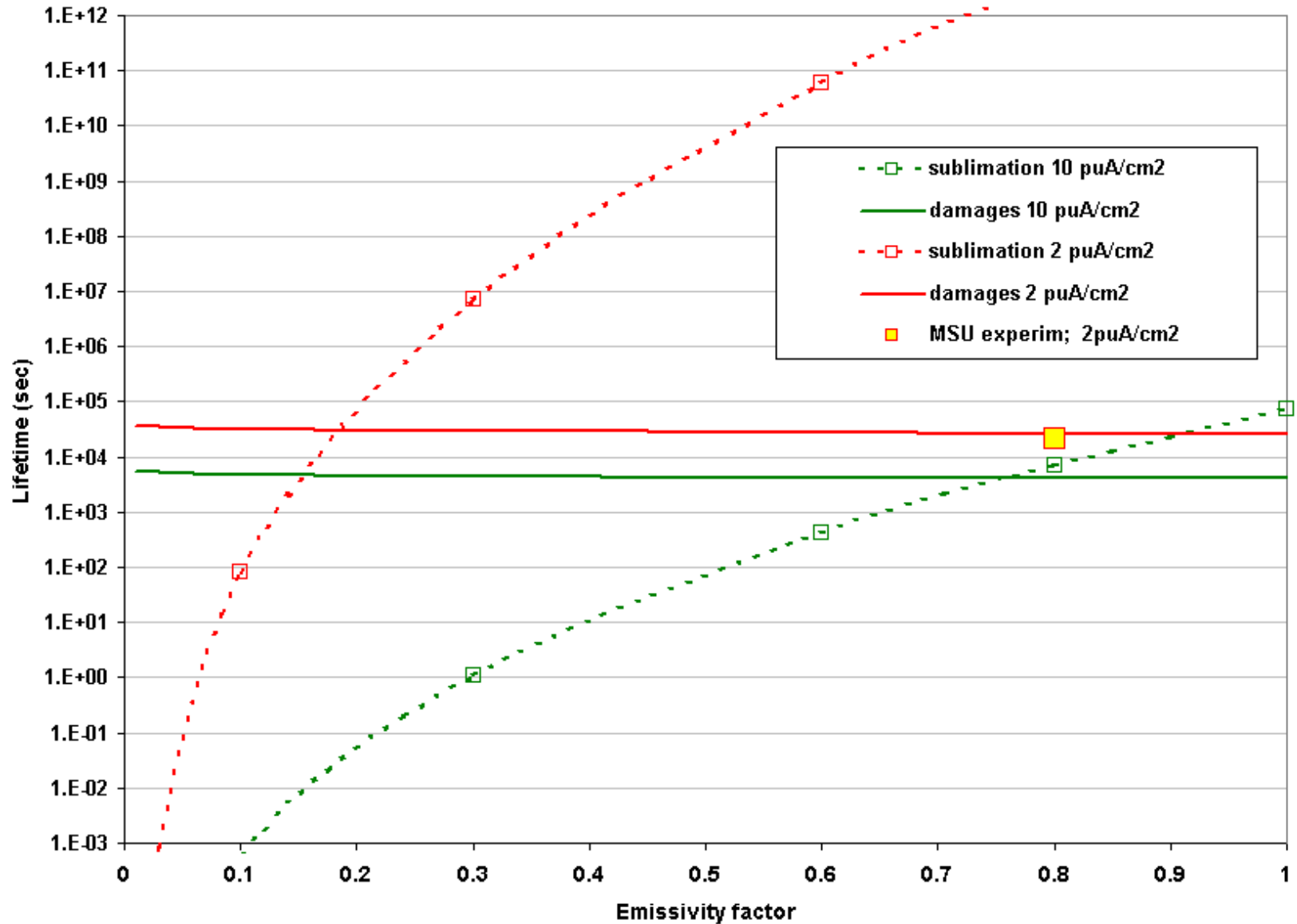
112Sn 10.86 MeV/u
Range in Carbon = 20 mg/cm²



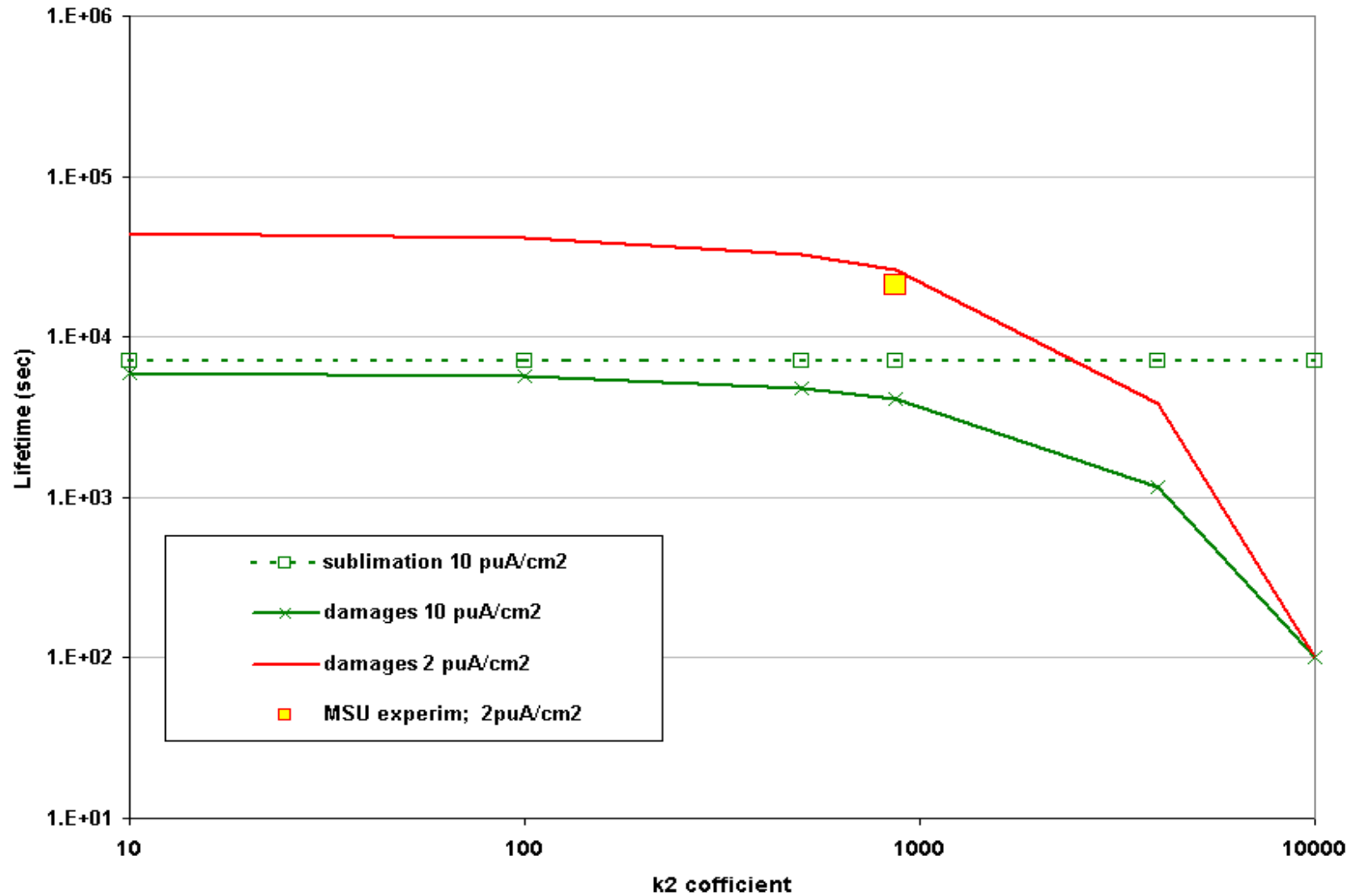
¹¹²Sn
Carbon 0.6mg/cm² (Range Energy is 0.06 MeV/u)



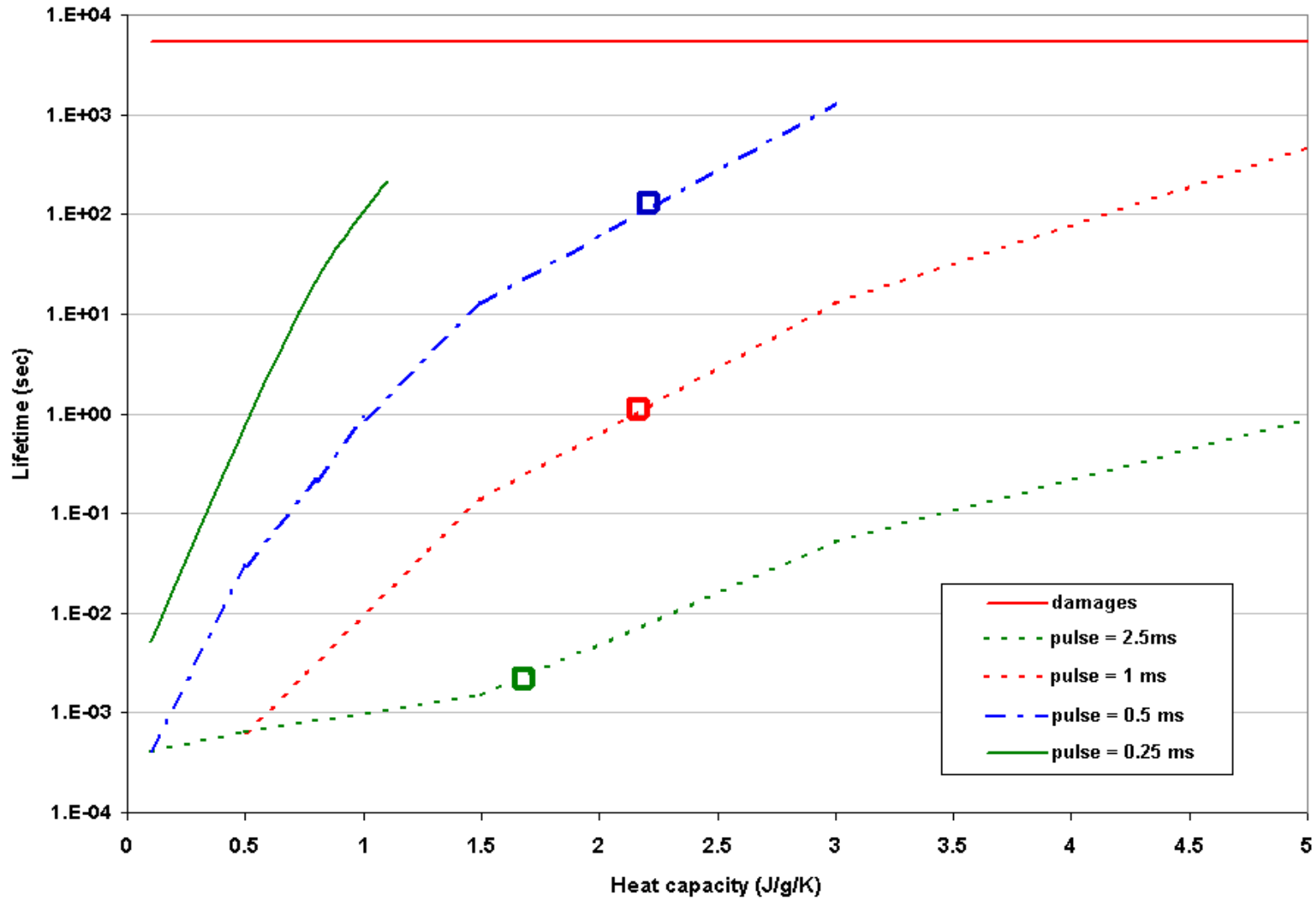
112Sn 10.8 MeV/u
Carbon 0.6mg/cm²



112Sn 10.8 MeV/u
Carbon 0.6mg/cm2



112Sn 10.8 MeV/u & Carbon 0.6mg/cm²
 j=100 pA/cm²
 Beam on-off time ratio = 5%



- corresponds to the Carbon capacity dependence of [3] C.Liaw et al.

- ❖ The “Stripper foil lifetime” dialog has possibility to load/save dialog settings to/from file
- ❖ Lebedev’s method of radiation damage calculation overestimates foil lifetimes in the case of heavy projectiles (Sn, U)
- ❖ Baron’s parameterization underestimates foil lifetimes in the case of light projectiles (Ne, Ar)
- ❖ LISE⁺⁺’s k_1 -dependence from the atomic number of projectile for the Lebedev’s method of radiation damage helps well to reproduce experimental data for projectiles in wide region (from Neon up to Uranium).
- ❖ Analysis of contribution of some parameters in the models has been done