

See

“The Stripper foil lifetime utility” part 1 (v.8.3.6) at:

http://groups.nsl.msu.edu/lise/8_3/foil_lifetime_v8_3_6.pdf

“Update of the Stripper foil lifetime utility” part 2 (v.8.3.13) at:

http://groups.nsl.msu.edu/lise/8_3/foil_lifetime_v8_3_13.pdf

Stripper Lifetime utility (version 9.2.38)

- ❖ Target initial temperature
- ❖ Modification for “stationary beam” models in the case of pulsing beams
- ❖ Rotation target: modifications for a reduced beam pulse length
- ❖ New flux structure: Pulsing beam & rotating target

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.msu.edu/lise>

Initial temperature

Calculation of the lifetimes of thin stripper targets.

Set-up: Beam: ^{40}Ar , Energy: 140.0 MeV/u, Intensity: 10 pnk, Fol: ^{90}Zr , Thickness: 500 micron

Material properties: Initial temperature = 293 K (circled in red), epsilon (emission factor) = 0.1, target's atom displacement energy = 25 eV

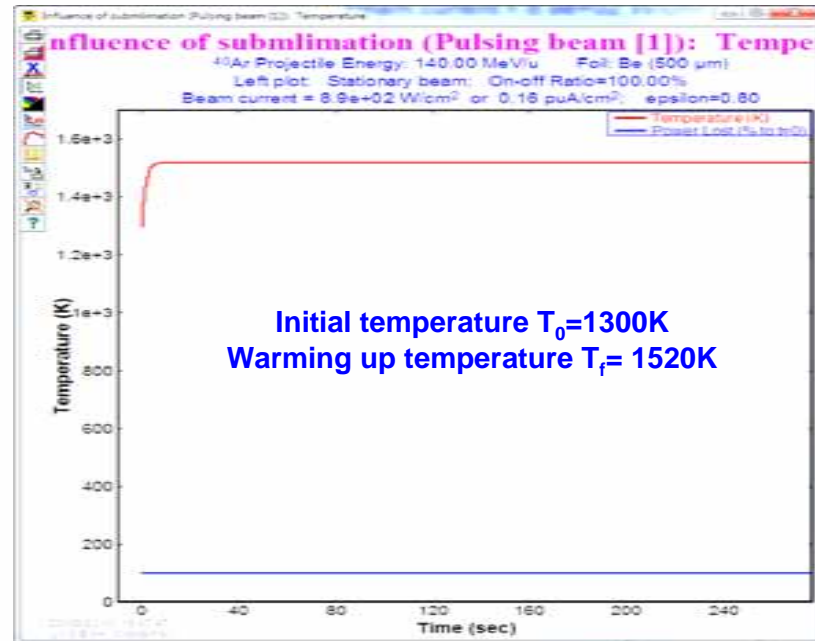
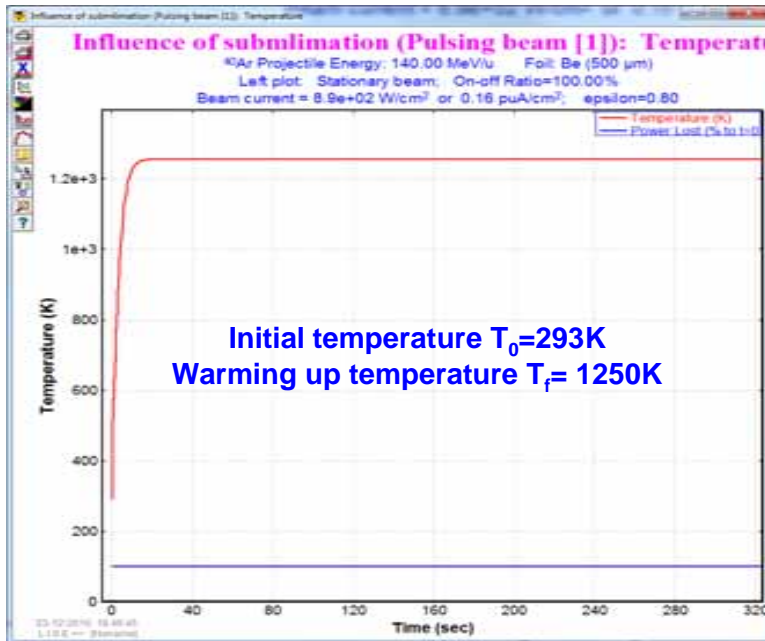
Sublimation influence ("Pulsing beam" case [1]): alpha (eq.22 for [1]) = $8.12\text{e}+10$ g K^{1/2}/sec/cm² (Carbon)

Radiation damages: k.d (atom displacement rate) = $1.2\text{e}-07$ 1/cm², target warming up temperature = 1255.0 K (stationary beam)

Flux structure: Stationary beam, Pulsing beam, Stationary beam & rotating target, Pulsing beam & rotating target

Shape: 2-D Gaussian, Uniform: ellipse, Uniform: rectangle

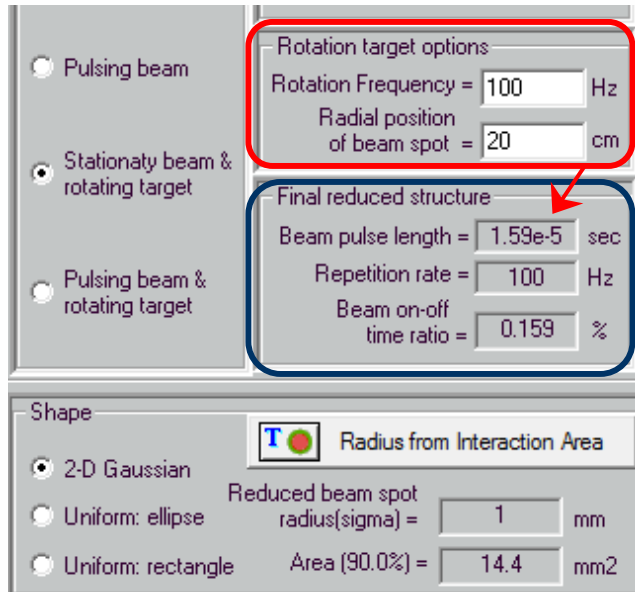
References: [1] S.G. Lebedev & A.S. Lebedev, PhysRev ST: A&B 11 (2008) 020401; [2] B. Gikal et al., Preprint P9-2005-110, JINR, Dubna; [3] C. Liaw et al., Proceedings of the 1999 PAC, New York, p.3300



In version 9.2.38 LISE++ takes the reduced value

$$\text{Flux}_{\text{reduced}} = \text{Flux}_{\text{during the pulse}} * \text{Ratio}_{\text{beam on-off_time}}$$

for calculations in “Stationary beam” models



Pulse = Reduced beam pulse length [sec]
R = Rotation target radius [mm]
v = Rotation target frequency [Hz]
W = Beam spot horizontal size [mm]
v = Linear velocity [mm/sec]

$$v = 2 \pi R v$$

$$\text{Pulse} = W / v$$

Where W is

2D-gaussian: $x_{\text{spot}} = 2 \sigma_x$
Uniform Ellipse: $x_{\text{spot}} = 2 * \text{seminor axis "x"}$
Uniform Rectangle: $x_{\text{spot}} = \text{Width}$

$$\text{Ratio}_{\text{beam on-off_time}} = \text{Pulse} * \text{Rotation target frequency}$$

Calculation of the lifetimes of thin stripper targets

Set-up
 Beam: 238U Energy: 1000.0 MeV/u Intensity: 3.2e+7 pA
 Foil: 12C Thickness: 3 g/cm2

Flux structure
 Stationary beam
 Pulsing beam
 Stationary beam & rotating target
 Pulsing beam & rotating target

Pulse structure
 Beam pulse length = 5e-8 sec
 Repetition rate = 1 Hz

Rotation target options
 Rotation Frequency = 1 Hz
 Radial position of beam spot = 25 cm

Final reduced structure
 Beam pulse length = 5e-8 sec
 Repetition rate = 0.00127 Hz
 Beam on-off time ratio = 6.37e-9 %

Material properties
 Initial temperature = 293 K
 epsilon (emissivity factor) = 0.8
 target's atom displacement energy = 25 eV
 $time = k_1 \cdot K_d^{-5/4} \exp(-k_2/T)$
 k1 = 0.0798 LISE reduced value
 k2 = 870 default 870 (Carbon)
 Use LISE++ k1(Z) function
 k10 = 50 default 50
 k11 = -0.07 default -0.07

Sublimation influence ("Pulsing beam" case [1])
 alpha (eq.22 for [1]) = 8.12e+10 g K^(1/2) / sec/cm2 default 8.12e10 (Carbon)
 Mode to plot (dimension):
 F (N = 1e3) S1 (N = 1e5) *
 M (N = 1e4) S2 (N = 1e6) *
 S3 (N = 1e7) *
 * - with compression pay attention for "compression" results in the case of very short pulses. Might be curious.
 Rise Time (dT= +1K) = 4.67e-10 sec [a]
 "Plateau" (dT= -1K) = 6.58e-10 sec [b]
 Fall Time (dT= -1K) = 1.03e+01 sec [c]
 Range to plot = 3.93e+03 sec
 Height & Temperature from Time
 [a] T0 = 293.0K
 [b] T0 = 448.9 K, P>0
 [c] T0 = 448.9 K, P=0

Radiation damages
 Kd (atom displacement rate) = 2.63e-11 1 / cm2
 Target warming up temperature = 448.9 K [c] stationary beam
 Foil lifetime due to radiation damages = 1.93e+11 sec = 5.4e+07 hour
 Lifetime and Temperature from Beam Current

Sublimation influence ("Stationary beam" [2])
 alpha (eq.13 for [2]) = 7.83e+10 cm K^(1/2) / sec default 7.83e10 (C)
 LISEcoef = 1.7 0.1 ... 10 (deflt 1.7)
 "Stationary beam" Foil lifetime due to sublimation = INF sec = INF hour
 Height (time) & Lifetime (Beam Current)

Shape
 2-D Gaussian Radius from Interaction Area
 Uniform: ellipse Reduced beam spot radius(sigma) = 2.45 mm
 Uniform: rectangle Area (68.0%) = 42.71 mm2

Calculated beam characteristics (during the pulse)
 Beam power lost (W/cm2) at the center of target (t=0) = 4.73e+09
 Density of particle flux (at the center) = 2e+10 W / cm2 = 8.49e+04 pA / cm2 = 5.30e+17 pps / cm2

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

Parameters have been taken from “Calculations of high-power production target and beam dump for the GSI future Super-FRS for a fast extraction scheme at the FAIR Facility”, N.A.Tahir et al., J. Phys. D: Appl. Phys. 38 (2005) 1828–1837.

Beam current was set to 2e17 pps in order correspond to 1e10 particle per 50 ns pulse

Use the LISE++ foil file: http://groups.nsci.msu.edu/lise/9_2/9_2_38/GSI.foil

Pulsing beam

Rotating target

Pulsing beam + Rotating target

Probability with rotating target is defined as
 $X\text{-spot size} / \text{Target Length} = 0.127\%$,

where the target length is $2\pi R$,

Therefore distance between reduced "pulses" is 787 seconds,
 with the pulse length equal to 50 ns

N.A.Tahir et al., J. Phys. D: Appl. Phys. 38 (2005) 1828–1837.

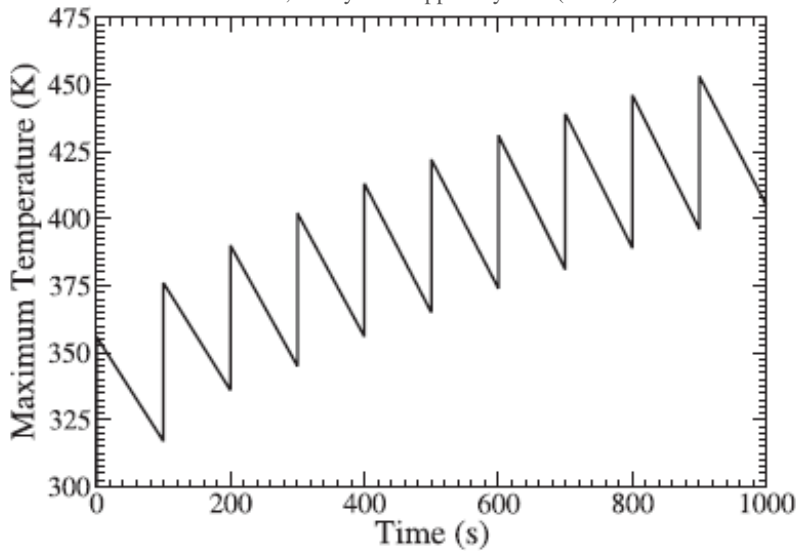


Figure 5. (a) Temperature versus time in the target during 1000 irradiations by a 1 GeV u^{-1} U bunch with $N = 10^{10}$ and $\tau = 50$ ns, $\sigma_x = 1$ mm and $\sigma_y = 6$ mm.

LISE++

