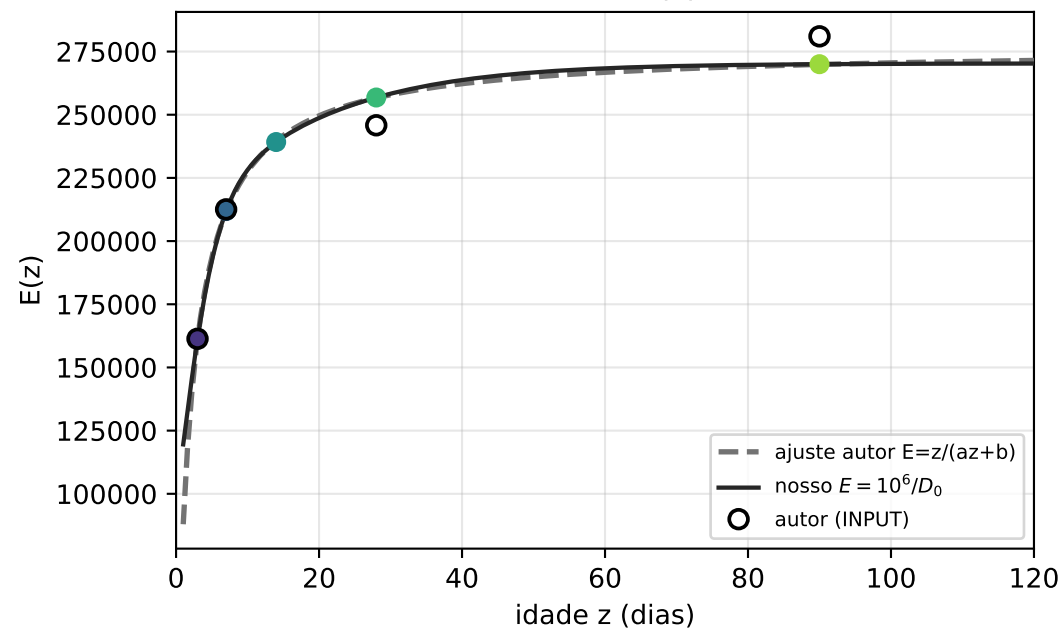


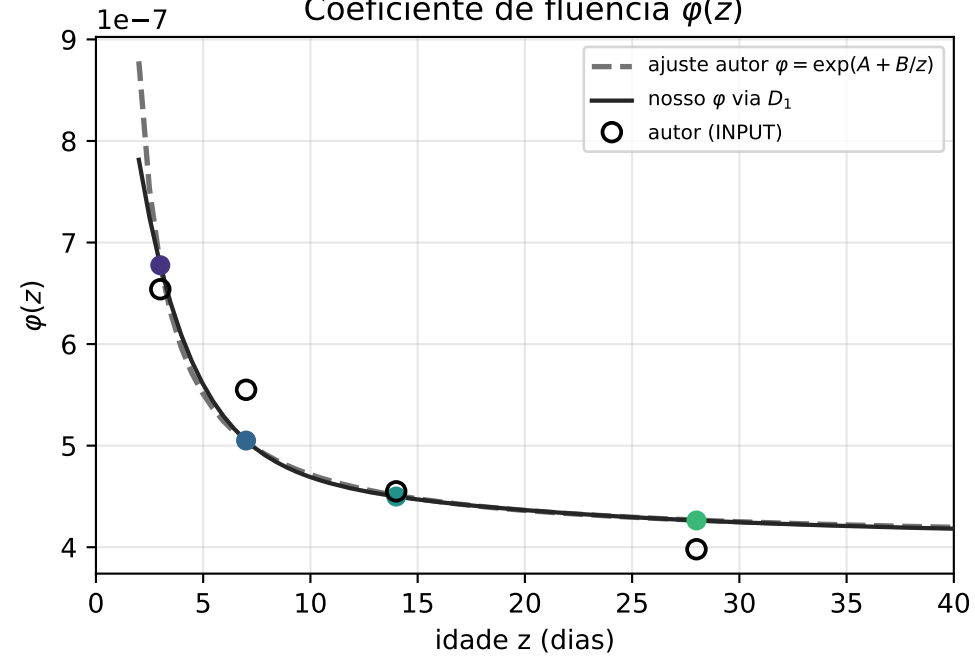
Itumbiara — E , φ , fluência e relaxação

— $z=3$ — $z=7$ — $z=14$ — $z=28$ — $z=90$ ○ INPUT (vazado) ● nosso D_0/D_1 (cheio)

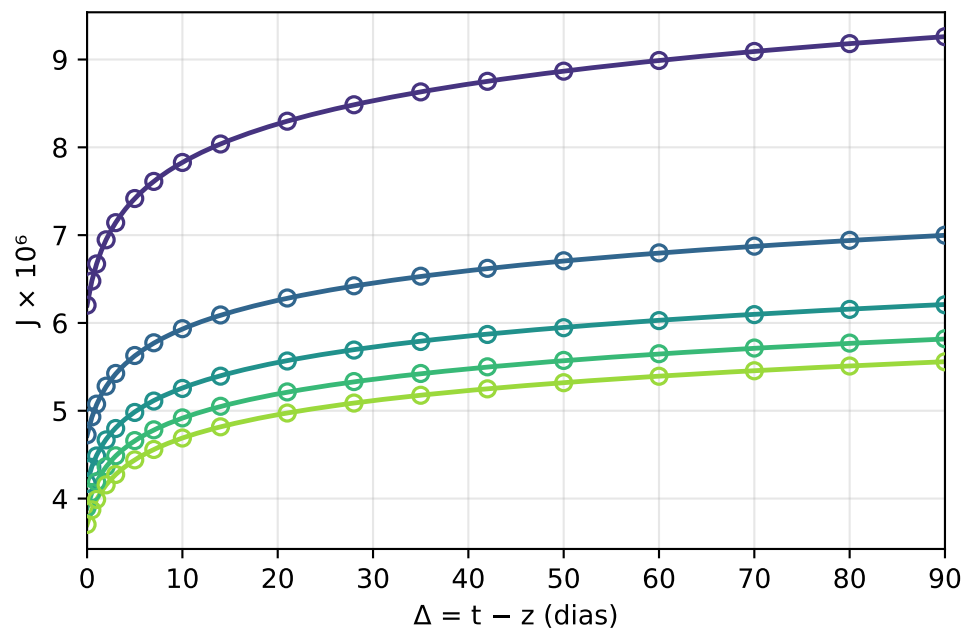
Módulo $E(z)$



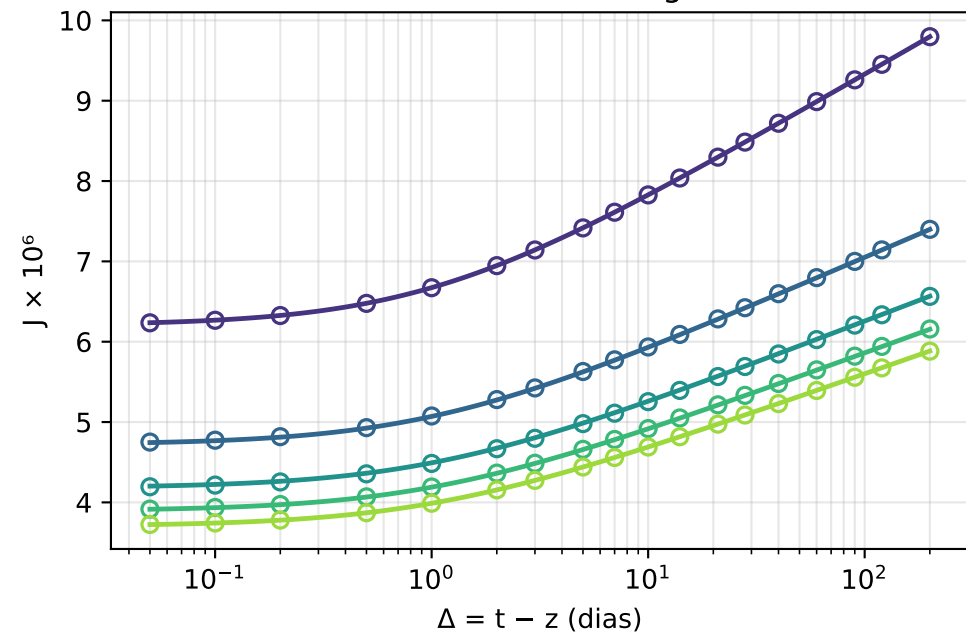
Coeficiente de fluência $\varphi(z)$



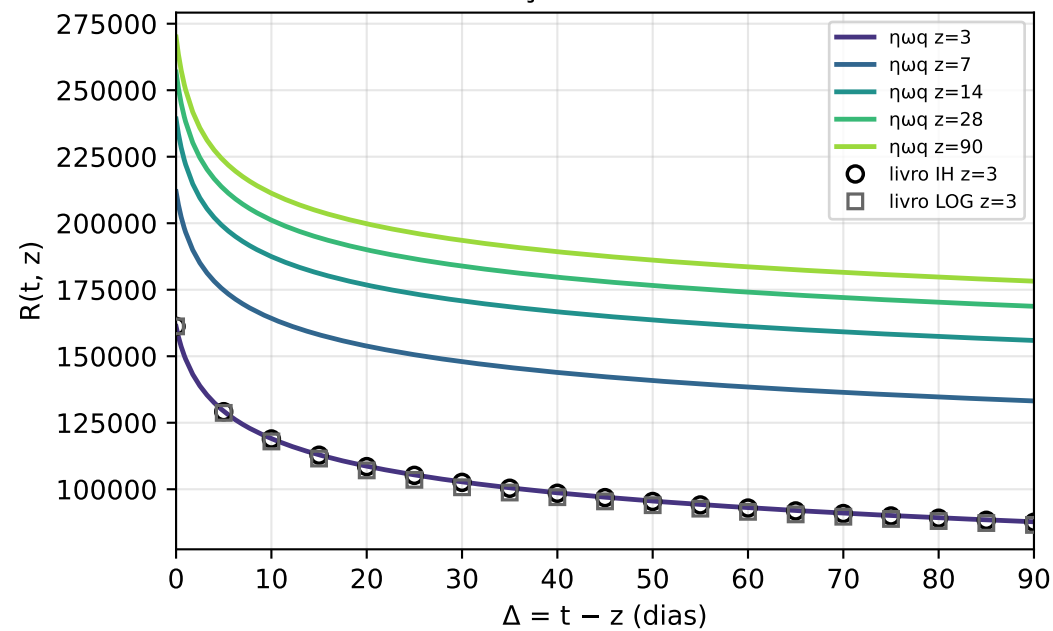
Fluência — eixo linear



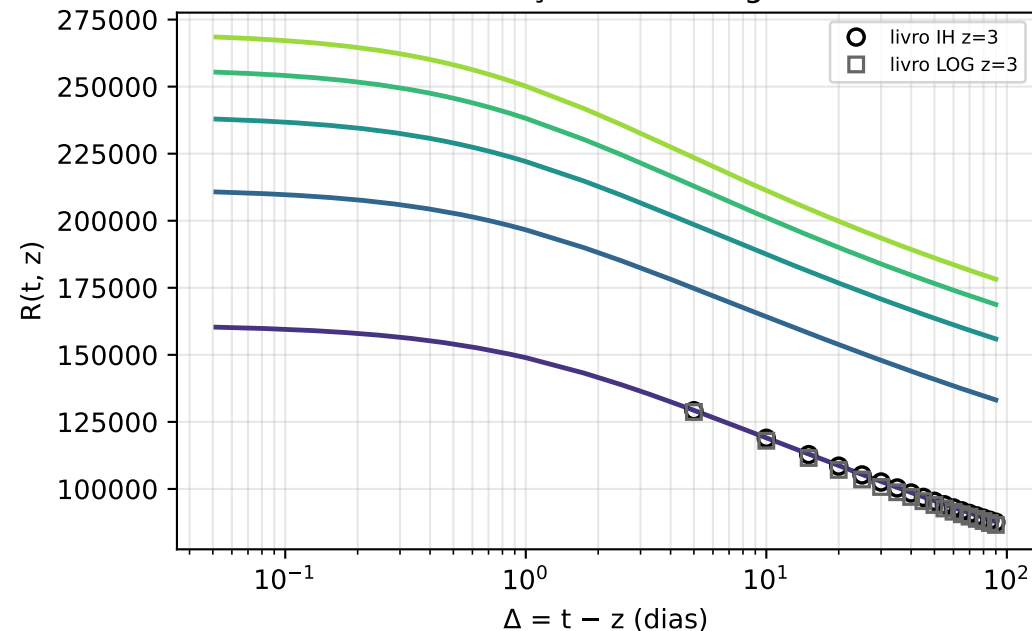
Fluência — eixo $\log_{10}$



Relaxação — eixo linear



Relaxação — eixo $\log_{10}$



Itumbiara — equações do autor e modelo reológico generalizado

Obra: ITUMBIARA. Tempos em dias. Idade de carregamento z ; duração $\Delta = t - z$.

1) Equações do autor (livro)

Módulo: $E(z) = z/(a \cdot z + b)$, $a = 3,618904 \times 10^{-6}$, $b = 7,750205 \times 10^{-6}$ ($R = 0,9934$).

Coeficiente de fluência: $\phi(z) = \exp(A + B/z)$, $A = -1,472291 \times 10^1$, $B = 1,555529$ ($R = 0,9447$).

Fluência nas páginas numéricas: $J(t,z) = 1/E(z) + \phi(z) \cdot \ln(\Delta + 1)$.

Nota: USBR clássico usa $\log_{10}$; neste livro a interconversão bate com $\ln$. Equivalente:

$\phi_{\log_{10}}(z) = \phi \cdot \ln(10) \Leftrightarrow \exp(A' + B/z)$ com $A' = A + \ln(\ln 10) = -1.388888E+01$.

2) Modelo reológico generalizado (Kelvin com envelhecimento — $D_0 + D_1 + \text{Núcleo}$)

$J(t,z) \cdot 10^6 = D_0(z) + D_1(z) \cdot \sum_i \phi_i [1 - \exp(-\Delta/\tau_i)]$.

$E_{\text{fit}}(z) = 10^6/D_0(z)$. Amplitudes das unidades: $D_i(z) = \phi_i \cdot D_1(z)$.

Relaxação $R(t,z)$: formulação operacional η , ω , q ($\epsilon=1$, $\Delta\epsilon=0$), app lajefundacaoHcS.

O espectro (ϕ_i , τ_i) é único para todas as idades; o envelhecimento entra em D_0 e D_1 .

3) Amplitudes — forma exp2: $f(z) = a + b \cdot e^{(-z/c)} + d \cdot e^{(-z/c_2)}$

$L = \log_{10}(t_f + 1) = 3.000434$ ($t_f = 1000$ d). $N=12$. Resíduo mediano do núcleo $\approx 9.69E-06$. $r^2(J) \approx 0.999995$.

Amplitude	a	b	c (d)	d	c ₂ (d)
D ₀	3.69964E+00	5.47895E+00	2.41598E+00	1.11011E+00	1.60629E+01
D ₁	2.83836E+00	4.62376E+00	2.41598E+00	6.11673E-01	1.60629E+01

Itumbiara — núcleo de fluência (válido para todas as idades z)

Núcleo normalizado: $f(\Delta) = \log_{10}(\Delta+1)/L \approx \sum_i \varphi_i [1 - \exp(-\Delta/\tau_i)]$.

Montagem da fluência: $J \cdot 10^6 = D_0(z) + D_1(z) \cdot f(\Delta)$.

Montagem da relaxação: mesmas τ_i e $D_i(z) = \varphi_i \cdot D_1(z)$ na formulação $\eta/\omega/q$.

i	φ_i	τ_i (dias)
1	5.298934E-03	3.099349E-01
2	3.488260E-02	7.618876E-01
3	7.646413E-02	1.872886E+00
4	1.046609E-01	4.603962E+00
5	1.192762E-01	1.131754E+01
6	1.254699E-01	2.782100E+01
7	1.285886E-01	6.839008E+01
8	1.279857E-01	1.681177E+02
9	1.401115E-01	4.132701E+02
10	6.710361E-02	1.015908E+03
11	3.274102E-01	2.497324E+03
12	0.000000E+00	6.138968E+03

Itumbiara — dados discretos do autor (INPUT E e ϕ)

Valores da foto EquacoesFluenciaModulo. ϕ na base ln (1/unidade de E).

Módulo de elasticidade

z (d)	E INPUT	E ajuste	erro %
3	161346	161230.4	-0.07
7	212550	211592.0	-0.45
28	245823	256693.5	+4.42
90	281018	269904.3	-3.95

Coefficiente de fluência ϕ

z (d)	ϕ INPUT	ϕ ajuste	erro %
3	6.540E-07	6.778E-07	+3.64
7	5.550E-07	5.040E-07	-9.19
14	4.550E-07	4.510E-07	-0.88
28	3.980E-07	4.266E-07	+7.19

Itumbiara — relaxação discreta do livro, z = 3 d (1/2)

Fonte: z3inspec1-3. Demais idades (7, 14, ...) serão inseridas quando digitalizadas.

NO	TEMPO	Δ	INT.HERED.	CARLSON E	CARLSON M	LOG MEDIO
0	3.00	0	1.61230E+05	1.61230E+05	1.61230E+05	1.61230E+05
1	4.00	1	1.48642E+05	1.48552E+05	1.48718E+05	1.48625E+05
2	5.00	2	1.41357E+05	1.41011E+05	1.41235E+05	1.41253E+05
3	6.00	3	1.36248E+05	1.35597E+05	1.35846E+05	1.36029E+05
4	7.00	4	1.32329E+05	1.31368E+05	1.31629E+05	1.31990E+05
5	8.00	5	1.29161E+05	1.27903E+05	1.28170E+05	1.28706E+05
6	9.00	6	1.26508E+05	1.24972E+05	1.25240E+05	1.25944E+05
7	10.00	7	1.24232E+05	1.22435E+05	1.22705E+05	1.23567E+05
8	11.00	8	1.22242E+05	1.20203E+05	1.20472E+05	1.21482E+05
9	12.00	9	1.20476E+05	1.18213E+05	1.18481E+05	1.19631E+05
10	13.00	10	1.18893E+05	1.16419E+05	1.16686E+05	1.17966E+05
11	14.00	11	1.17458E+05	1.14788E+05	1.15053E+05	1.16457E+05
12	15.00	12	1.16148E+05	1.13295E+05	1.13558E+05	1.15077E+05
13	16.00	13	1.14943E+05	1.11918E+05	1.12179E+05	1.13807E+05
14	17.00	14	1.13830E+05	1.10642E+05	1.10902E+05	1.12632E+05
15	18.00	15	1.12794E+05	1.09454E+05	1.09712E+05	1.11539E+05
16	19.00	16	1.11828E+05	1.08344E+05	1.08600E+05	1.10519E+05
17	20.00	17	1.10922E+05	1.07302E+05	1.07556E+05	1.09562E+05
18	21.00	18	1.10071E+05	1.06321E+05	1.06573E+05	1.08662E+05
19	22.00	19	1.09267E+05	1.05395E+05	1.05645E+05	1.07813E+05
20	23.00	20	1.08507E+05	1.04518E+05	1.04766E+05	1.07099E+05
21	24.00	21	1.07786E+05	1.03685E+05	1.03932E+05	1.06246E+05
22	25.00	22	1.07100E+05	1.02893E+05	1.03138E+05	1.05521E+05
23	26.00	23	1.06447E+05	1.02138E+05	1.02382E+05	1.04830E+05
24	27.00	24	1.05824E+05	1.01417E+05	1.01660E+05	1.04171E+05
25	28.00	25	1.05227E+05	1.00727E+05	1.00968E+05	1.03540E+05
26	29.00	26	1.04656E+05	1.00067E+05	1.00306E+05	1.02935E+05
27	30.00	27	1.04108E+05	9.94323E+04	9.96706E+04	1.02355E+05
28	31.00	28	1.03581E+05	9.88228E+04	9.90598E+04	1.01798E+05
29	32.00	29	1.03074E+05	9.82363E+04	9.84721E+04	1.01262E+05
30	33.00	30	1.02586E+05	9.76714E+04	9.79059E+04	1.00745E+05
31	34.00	31	1.02110E+05	9.71259E+04	9.73594E+04	1.00321E+05
32	35.00	32	1.01653E+05	9.65994E+04	9.68317E+04	9.99202E+04
33	36.00	33	1.01212E+05	9.60904E+04	9.63217E+04	9.95295E+04
34	37.00	34	1.00786E+05	9.55980E+04	9.58283E+04	9.91474E+04
35	38.00	35	1.00374E+05	9.51212E+04	9.53506E+04	9.87735E+04
36	39.00	36	9.99742E+04	9.46592E+04	9.48875E+04	9.84077E+04
37	40.00	37	9.95866E+04	9.42111E+04	9.44384E+04	9.80498E+04
38	41.00	38	9.92103E+04	9.37761E+04	9.40024E+04	9.76993E+04
39	42.00	39	9.88450E+04	9.33535E+04	9.35790E+04	9.73564E+04
40	43.00	40	9.84898E+04	9.29428E+04	9.31674E+04	9.70208E+04
41	44.00	41	9.81441E+04	9.25422E+04	9.27670E+04	9.66920E+04

Itumbiara — relaxação discreta do livro, z = 3 d (2/2)

Fonte: z3inspec1-3. Demais idades (7, 14, ...) serão inseridas quando digitalizadas.

NO	TEMPO	Δ	INT.HERED.	CARLSON E	CARLSON M	LOG MEDIO
46	49.00	46	9.65451E+04	9.06959E+04	9.09155E+04	9.51457E+04
47	50.00	47	9.62482E+04	9.03534E+04	9.05722E+04	9.48546E+04
48	51.00	48	9.59584E+04	9.00188E+04	9.02369E+04	9.45689E+04
49	52.00	49	9.56752E+04	8.96919E+04	8.99093E+04	9.42888E+04
50	53.00	50	9.53983E+04	8.93725E+04	8.95891E+04	9.40138E+04
51	54.00	51	9.51274E+04	8.90601E+04	8.92761E+04	9.37439E+04
52	55.00	52	9.48624E+04	8.87546E+04	8.89698E+04	9.34789E+04
53	56.00	53	9.46031E+04	8.84556E+04	8.86701E+04	9.32187E+04
54	57.00	54	9.43491E+04	8.81628E+04	8.83767E+04	9.29631E+04
55	58.00	55	9.41002E+04	8.78761E+04	8.80893E+04	9.27119E+04
56	59.00	56	9.38562E+04	8.75952E+04	8.78078E+04	9.24650E+04
57	60.00	57	9.36171E+04	8.73199E+04	8.75319E+04	9.22223E+04
58	61.00	58	9.33826E+04	8.70500E+04	8.72613E+04	9.19838E+04
59	62.00	59	9.31525E+04	8.67853E+04	8.69960E+04	9.17492E+04
60	63.00	60	9.29266E+04	8.65257E+04	8.67358E+04	9.15184E+04
61	64.00	61	9.27009E+04	8.62707E+04	8.64802E+04	9.12951E+04
62	65.00	62	9.24801E+04	8.60204E+04	8.62293E+04	9.11180E+04
63	66.00	63	9.22648E+04	8.57746E+04	8.59830E+04	9.09256E+04
64	67.00	64	9.20539E+04	8.55326E+04	8.57411E+04	9.07424E+04
65	68.00	65	9.18468E+04	8.52961E+04	8.55034E+04	9.05584E+04
66	69.00	66	9.16434E+04	8.50631E+04	8.52698E+04	9.03778E+04
67	70.00	67	9.14436E+04	8.48341E+04	8.50402E+04	9.01988E+04
68	71.00	68	9.12471E+04	8.46089E+04	8.48146E+04	9.00221E+04
69	72.00	69	9.10538E+04	8.43874E+04	8.45926E+04	8.98473E+04
70	73.00	70	9.08636E+04	8.41696E+04	8.43743E+04	8.96746E+04
71	74.00	71	9.06764E+04	8.39553E+04	8.41595E+04	8.95038E+04
72	75.00	72	9.04933E+04	8.37444E+04	8.39481E+04	8.93349E+04
73	76.00	73	9.03110E+04	8.35369E+04	8.37401E+04	8.91681E+04
74	77.00	74	9.01327E+04	8.33325E+04	8.35352E+04	8.90030E+04
75	78.00	75	8.99567E+04	8.31312E+04	8.33336E+04	8.88398E+04
76	79.00	76	8.97835E+04	8.29331E+04	8.31349E+04	8.86784E+04
77	80.00	77	8.96128E+04	8.27378E+04	8.29392E+04	8.85188E+04
78	81.00	78	8.94448E+04	8.25454E+04	8.27464E+04	8.83609E+04
79	82.00	79	8.92789E+04	8.23559E+04	8.25564E+04	8.82048E+04
80	83.00	80	8.91152E+04	8.21691E+04	8.23692E+04	8.80503E+04
81	84.00	81	8.89542E+04	8.19849E+04	8.21846E+04	8.78975E+04
82	85.00	82	8.87953E+04	8.18033E+04	8.20026E+04	8.77464E+04
83	86.00	83	8.86384E+04	8.16242E+04	8.18231E+04	8.75968E+04
84	87.00	84	8.84836E+04	8.14476E+04	8.16461E+04	8.74489E+04
85	88.00	85	8.83311E+04	8.12734E+04	8.14715E+04	8.73024E+04
86	89.00	86	8.81805E+04	8.11016E+04	8.12992E+04	8.71576E+04
87	90.00	87	8.80318E+04	8.09325E+04	8.11282E+04	8.70141E+04