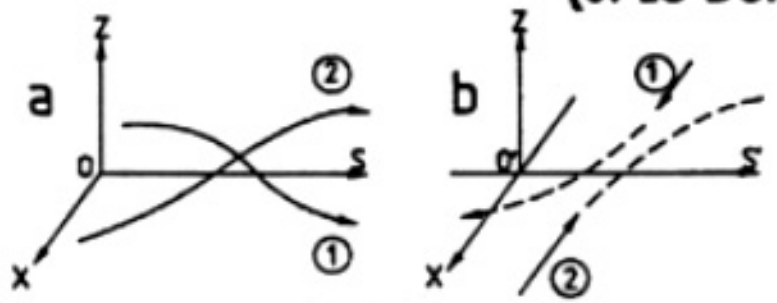
Wienands

Touschek Effect

- Single intra-beam Coulomb scattering events in the horizontal plane leading to particle loss mostly due to ∂E/E aperture.

(J. Le Duff)



Coulomb scattering of two particles inside the bunch.
(a) Laboratory system, (b) Centre-of-mass system.

- The scattering rate is given by

$$\frac{dN}{dt} = \int_V \frac{\sigma_T}{\gamma^2} v n^2 dV$$

V=bunch volume, σ_T=total cross section

n=density

Touschek Effect (cont'd)

- The particle loss rate then is after substantial manipulation:

$$\frac{1}{N}\frac{dN}{dt} = \frac{1}{\tau} = \frac{Nr_0^2 c}{8\pi\sigma_x\sigma_y\sigma_s}\frac{\lambda^3}{\gamma^2}D(\xi)$$

where

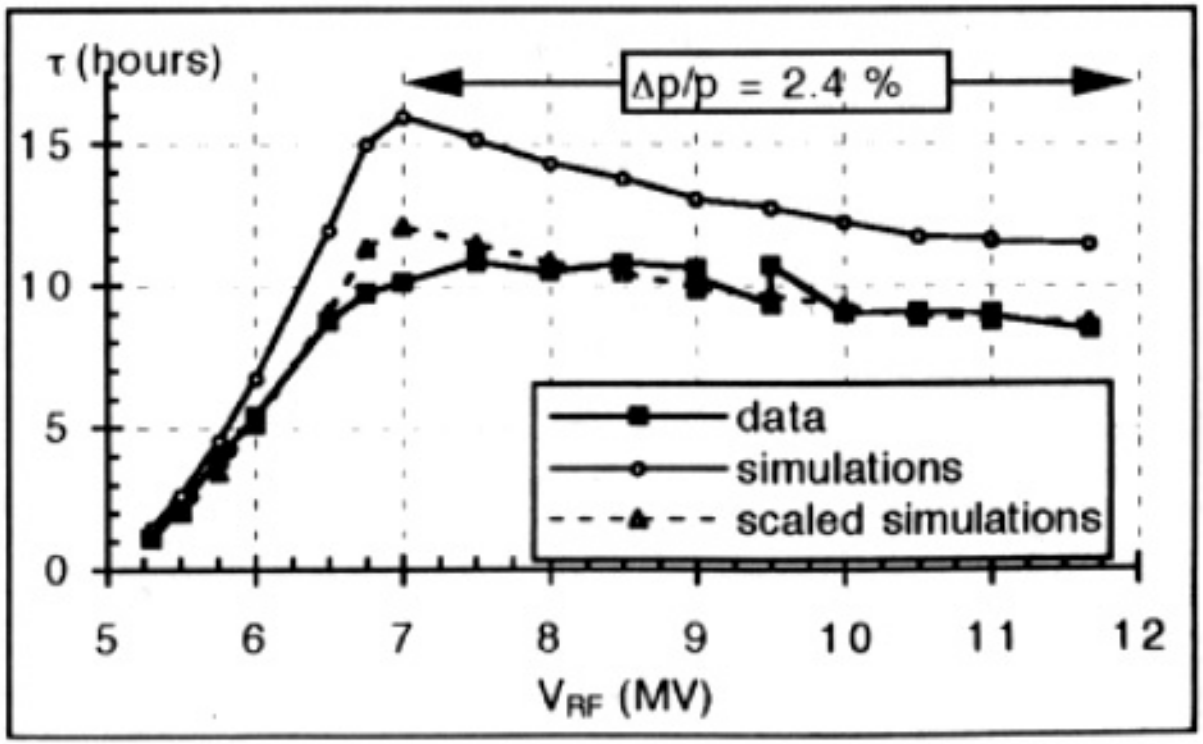
$$\xi = \left(\frac{\Delta E / E}{\gamma}\right)^2 \frac{\beta_x}{\varepsilon_x}$$

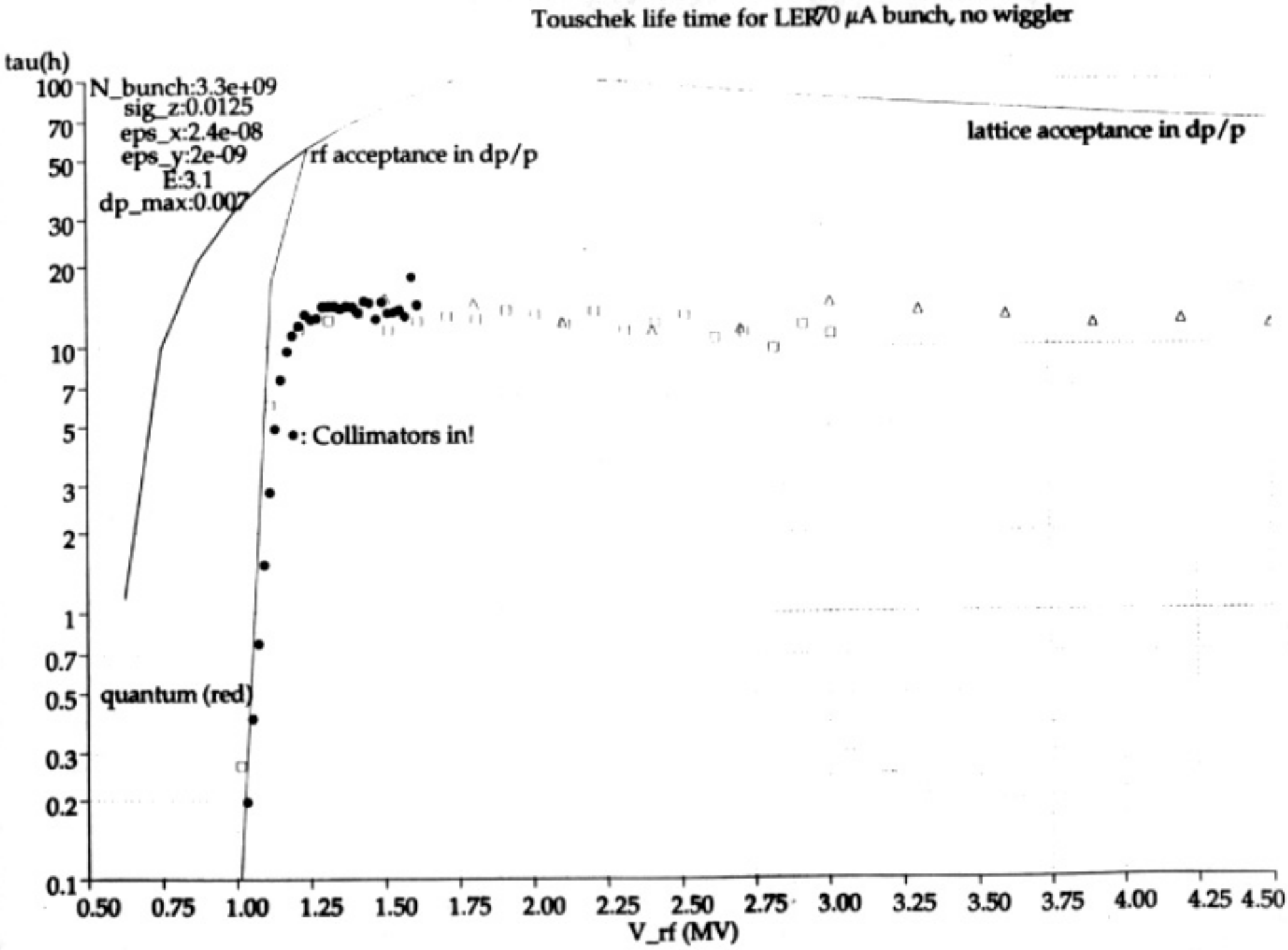
and

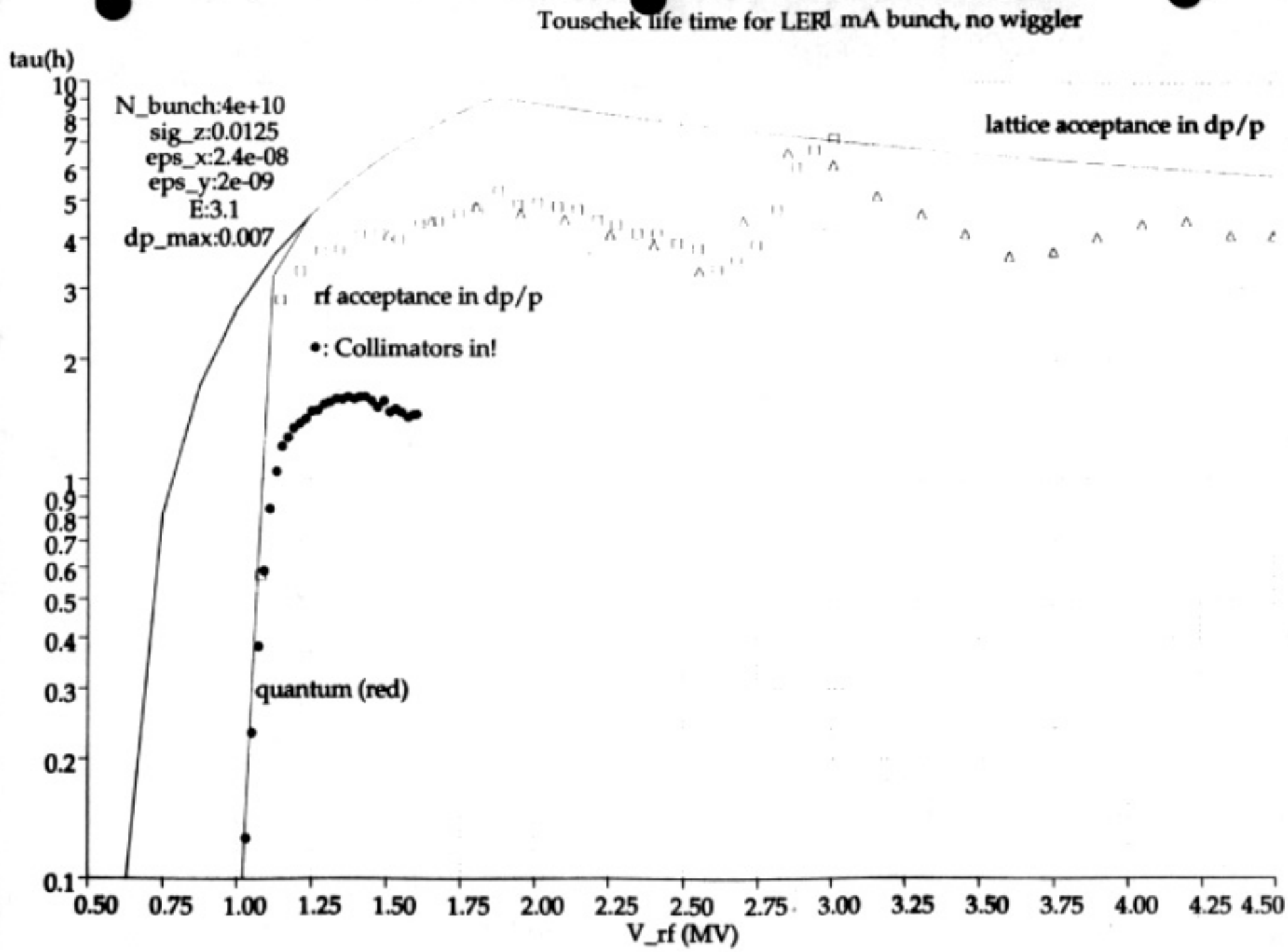
$$D(\xi) = \sqrt{\xi}\left(\ln\left(\frac{1}{1.78\varepsilon_x}\right) - \frac{3}{2}\right)$$

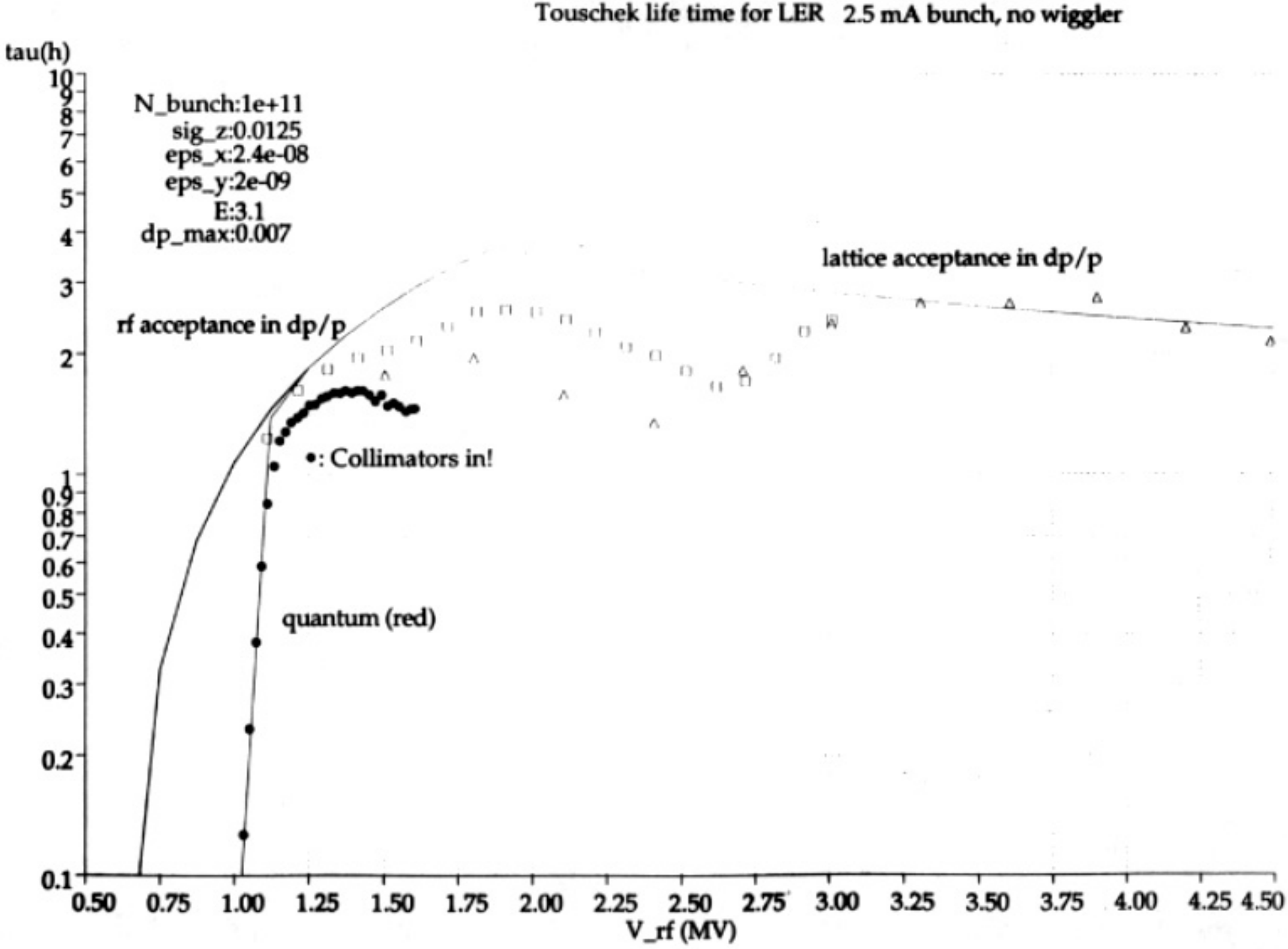
(H. Bruck's approximation for $\xi \leq 0.01$)

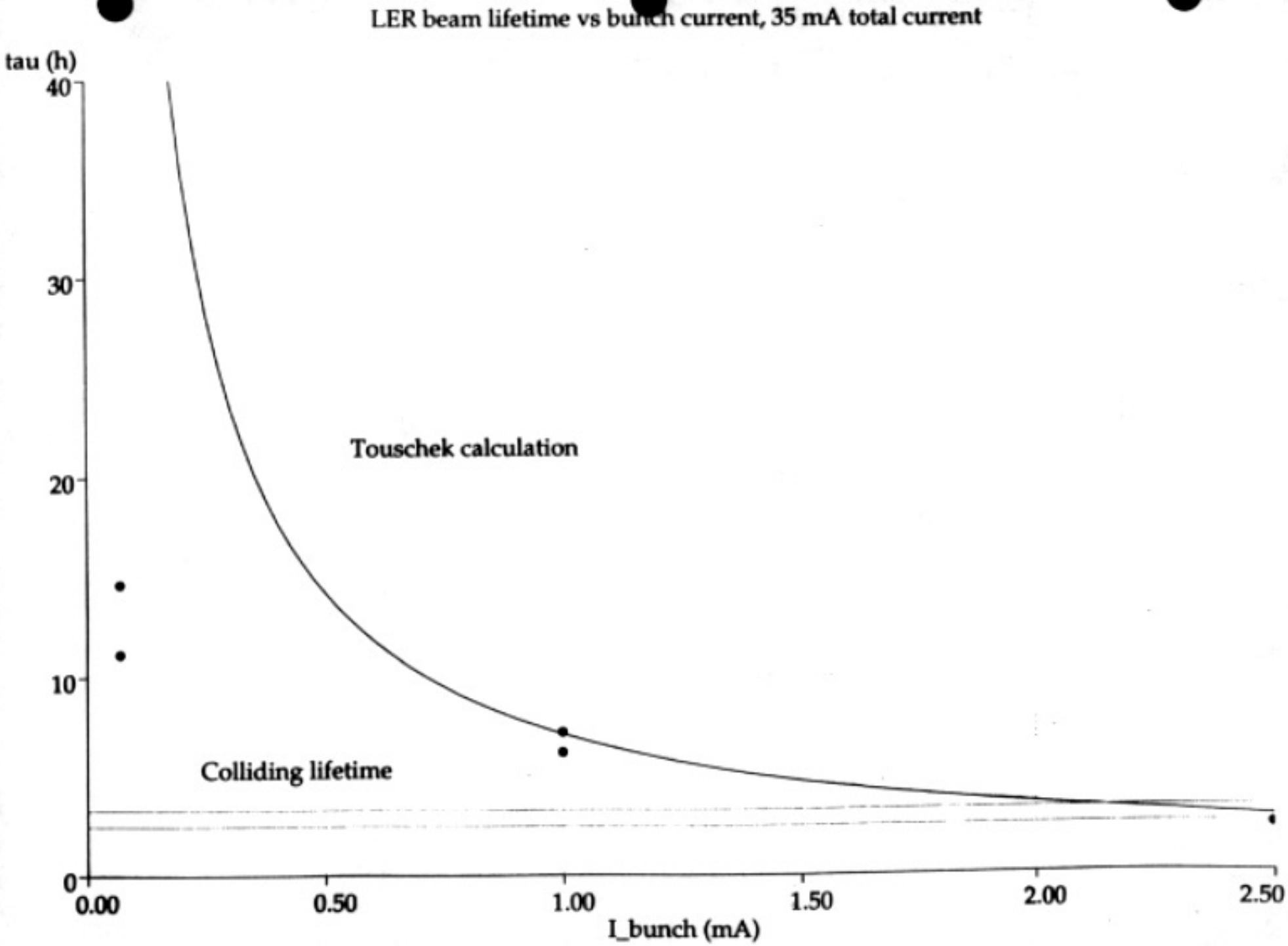
A. Ropert, PAC 99




Touschek life time for LER70 μA bunch, no wiggler
tau(h)
100
70
50
30
20
10
7
5
3
2
1
0.7
0.5
0.3
0.2
0.1
N_bunch:3.3e+09
sig_z:0.0125
eps_x:2.4e-08
eps_y:2e-09
E:3.1
dp_max:0.007
rf acceptance in dp/p
lattice acceptance in dp/p
•: Collimators in!
quantum (red)
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
V_rf (MV)


Touschek life time for LER1 mA bunch, no wiggler
tau(h)
N_bunch:4e+10
sig_z:0.0125
eps_x:2.4e-08
eps_y:2e-09
E:3.1
dp_max:0.007
lattice acceptance in dp/p
rf acceptance in dp/p
•: Collimators in!
quantum (red)
10
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
V_rf (MV)


Touschek life time for LER 2.5 mA bunch, no wiggler
tau(h)
N_bunch:1e+11
sig_z:0.0125
eps_x:2.4e-08
eps_y:2e-09
E:3.1
dp_max:0.007
lattice acceptance in dp/p
rf acceptance in dp/p
•: Collimators in!
quantum (red)
10
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 4.25 4.50
V_rf (MV)


LER beam lifetime vs bunch current, 35 mA total current
tau (h)
40
30
20
10
0
Touschek calculation
Colliding lifetime
0.00
0.50
1.00
1.50
2.00
2.50
I_bunch (mA)