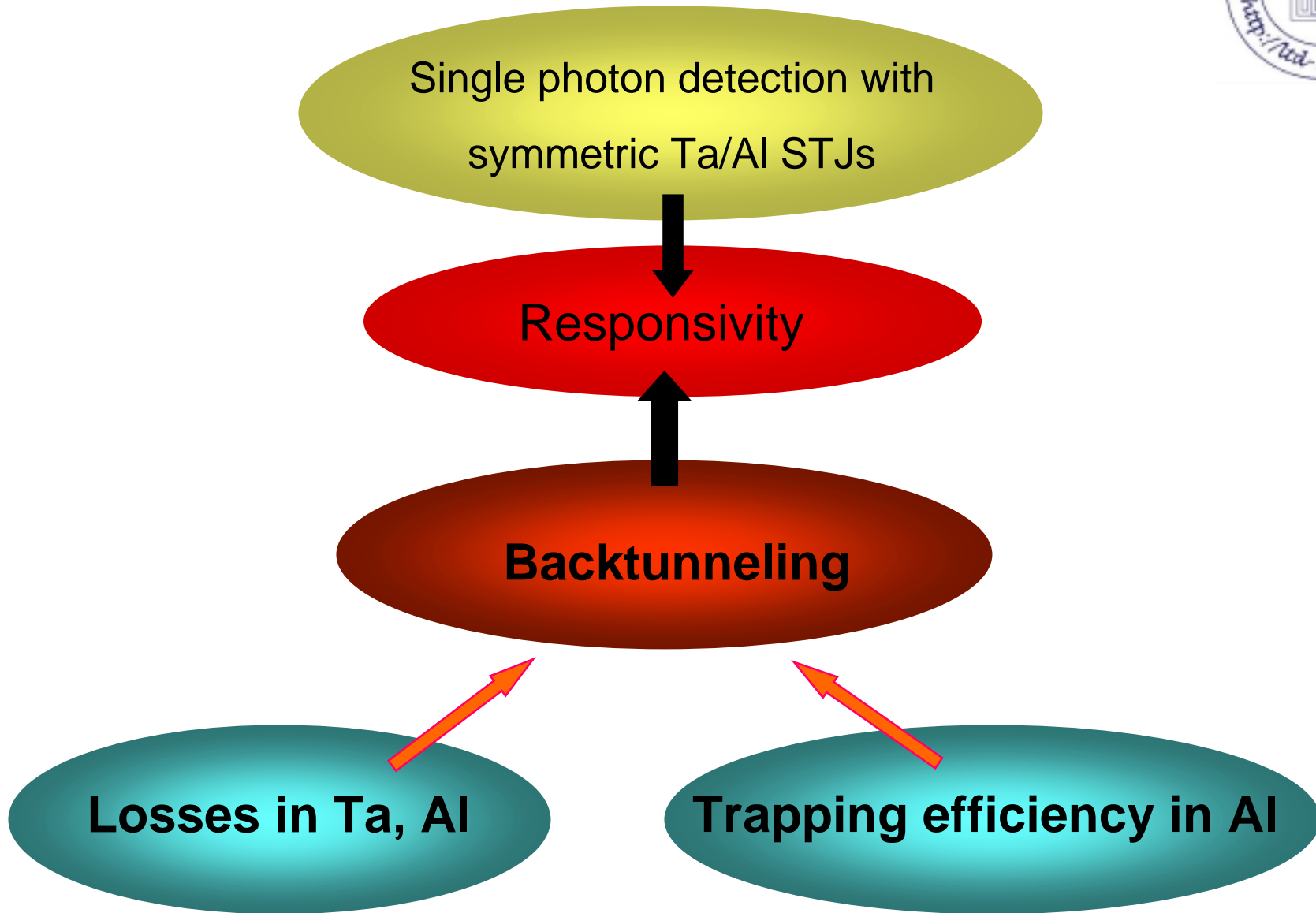


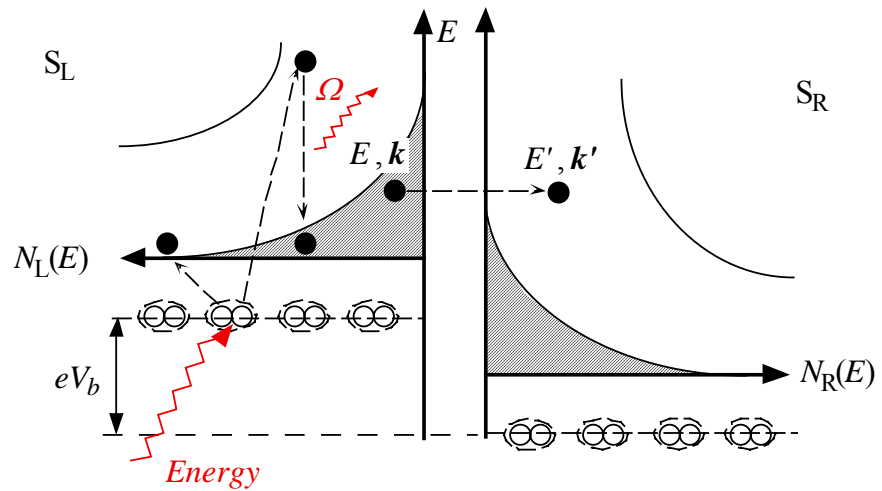
Responsivity of Ta-based STJs to visible light as a function of Al trapping layer thickness

I. Jerjen

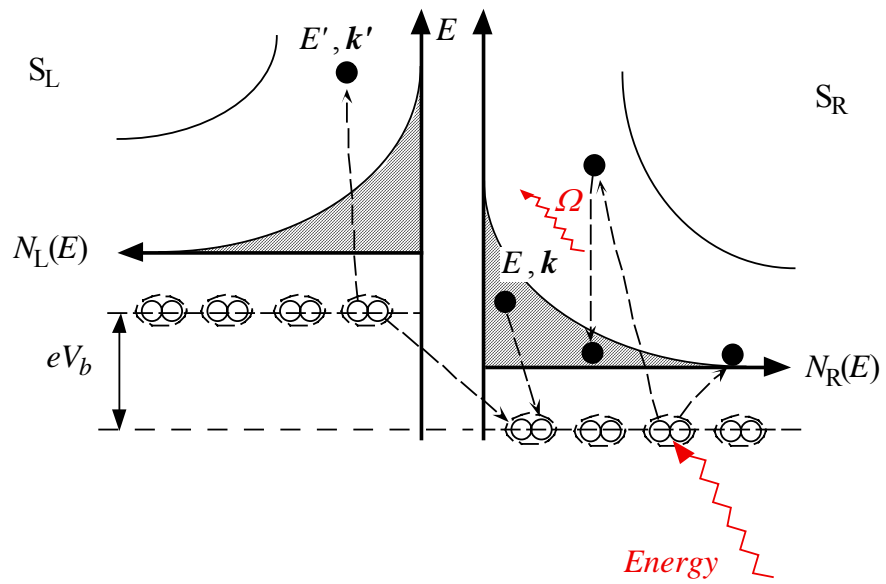
E.C. Kirk, Ph. Lerch, A. Zehnder, M. Furlan,
D. Twerenbold, A. Mchedlishvili, H.R. Ott



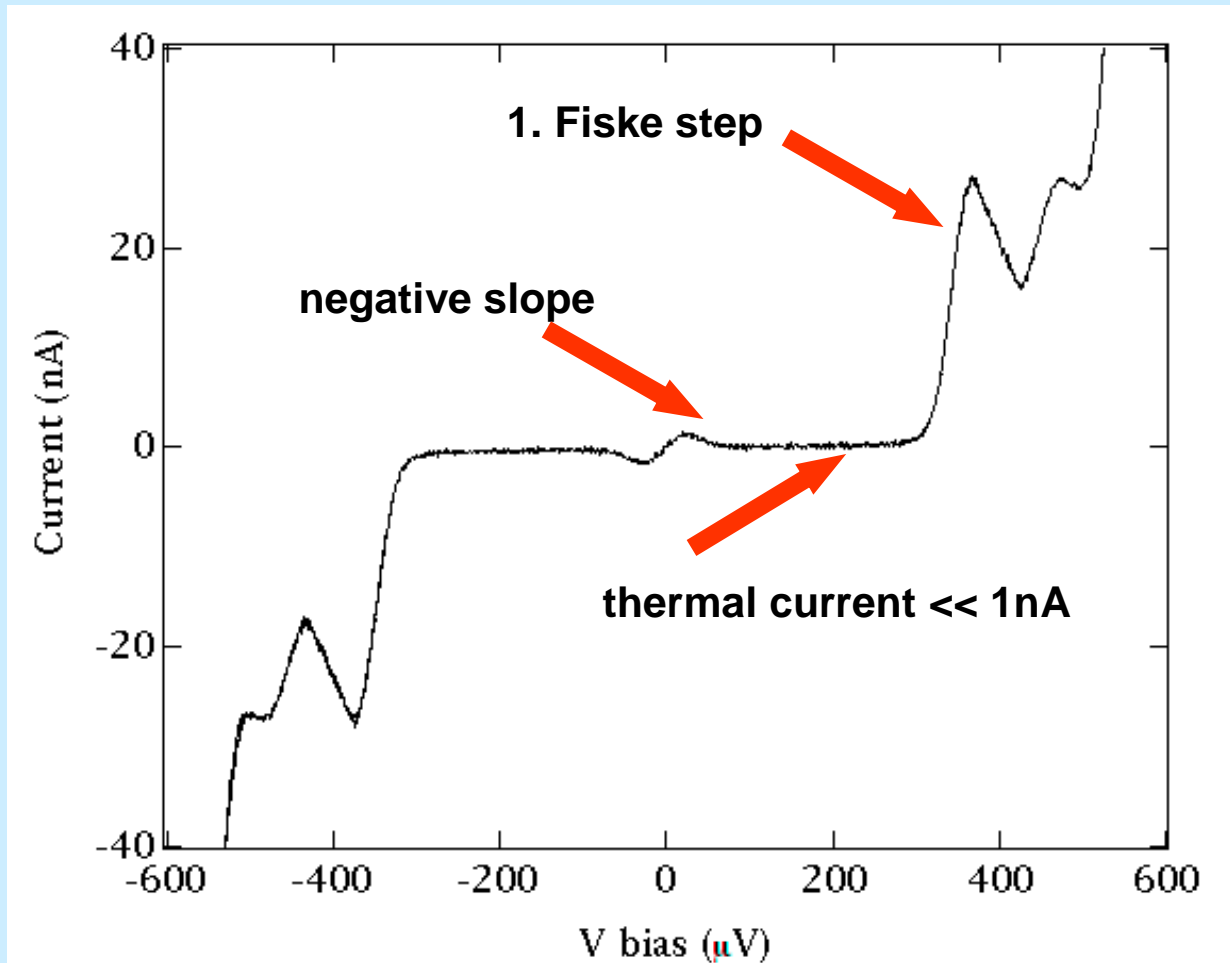
Tunneling



Backtunneling



IV characteristic of one of our STJs

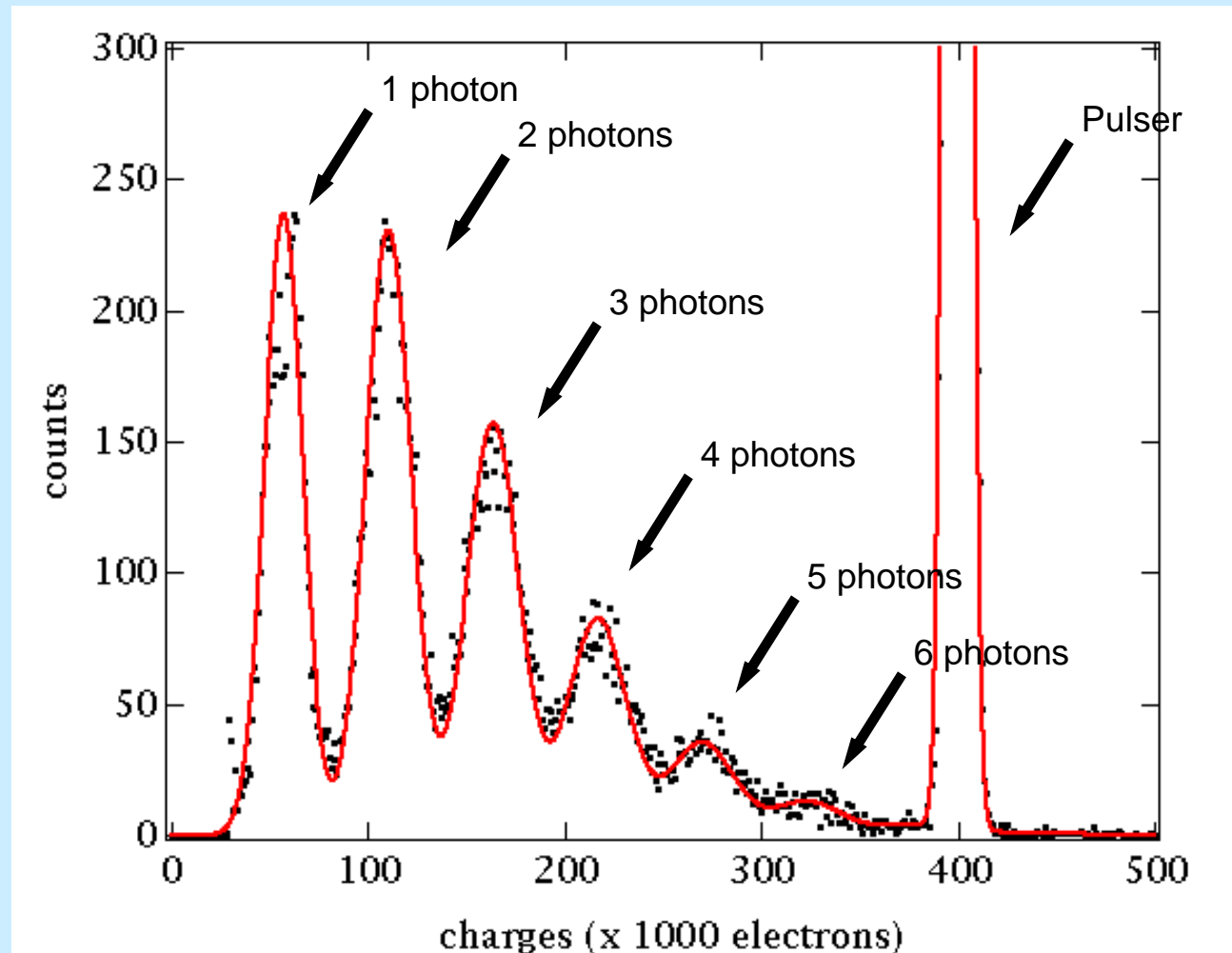


Voltage bias

$T = 315 \text{ mK}$

100 nm Ta; 10 nm Al

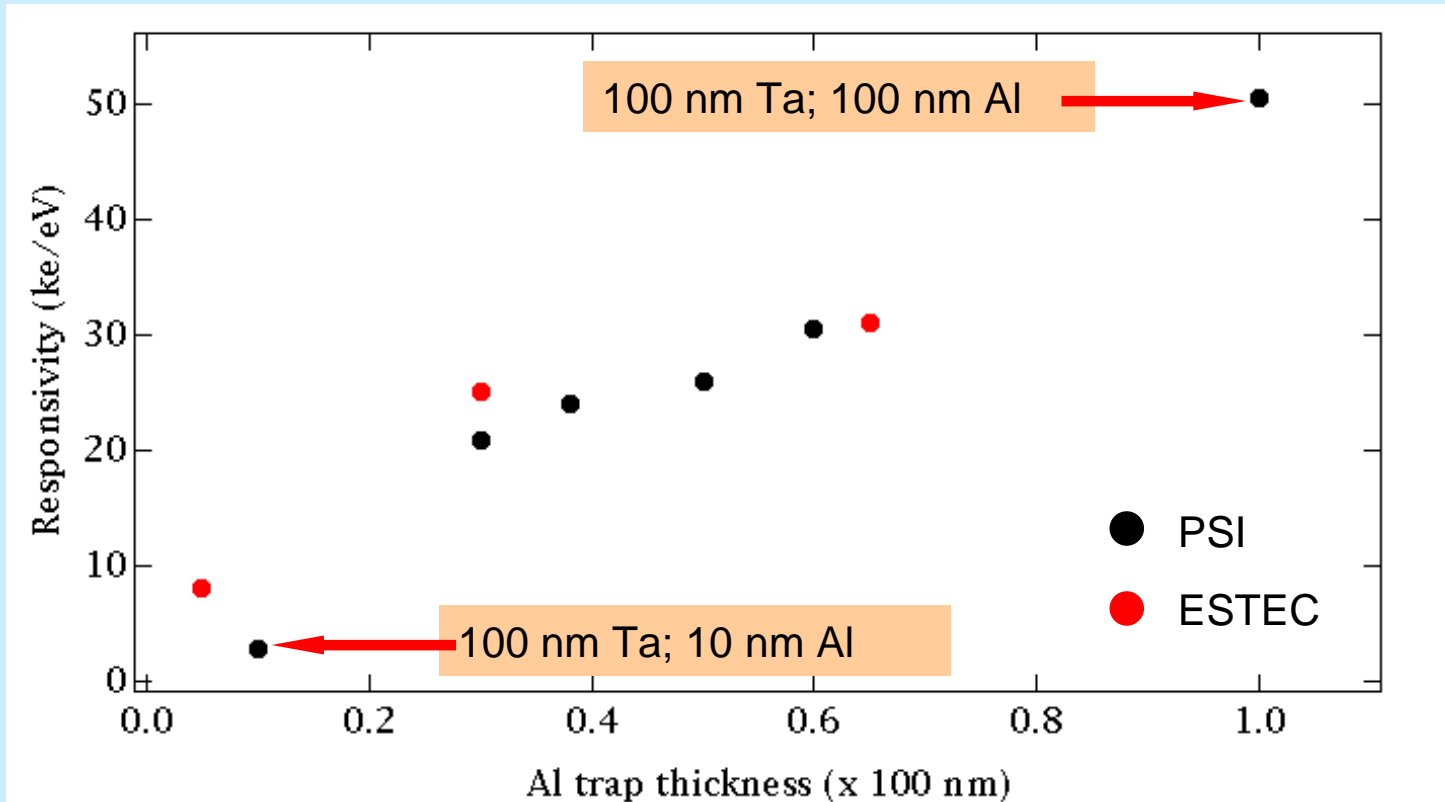
Measurement of the responsivity



Pulsed light source
LED 500 nm
T = 340 mK
R = 21'500 charges/eV

**Poisson
distribution**

Responsivity as a function of the Al trap thickness

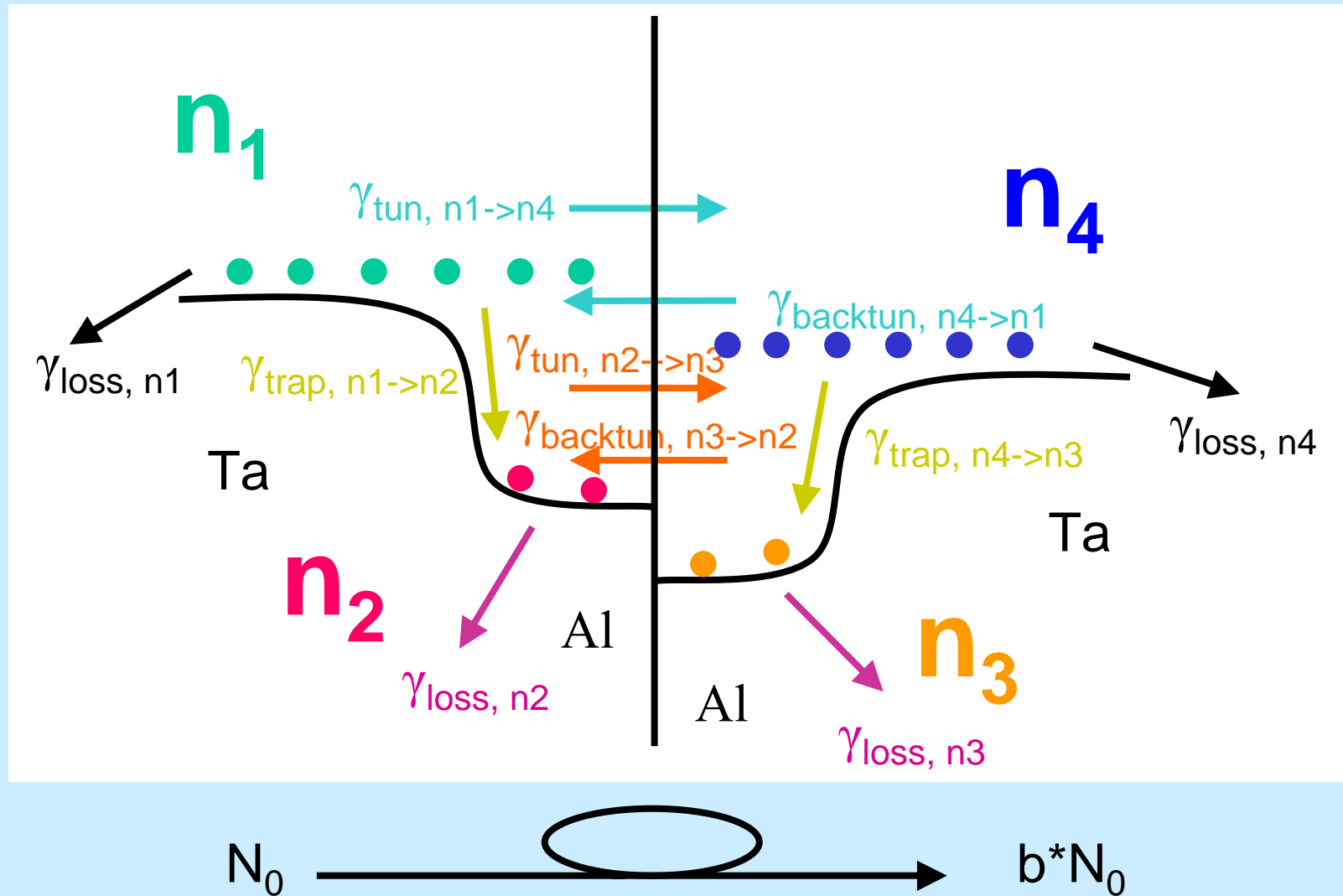


Tunnel rate

Trapping efficiency

Loss rate Ta \gg Loss rate Al

Model of SS'IS'S junction: 4 quasiparticle populations



The rate equations

$$\frac{dn_1(t)}{dt} = -(\gamma_{tr,n_1 \rightarrow n_2} + \gamma_{loss,n_1} + \gamma_{tun,n_1 \rightarrow n_4})n_1(t) + \gamma_{tun,n_4 \rightarrow n_1}n_4(t)$$

$$\frac{dn_2(t)}{dt} = \gamma_{tr,n_1 \rightarrow n_2}n_1(t) - (\gamma_{loss,n_2} + \gamma_{tun,n_2 \rightarrow n_3})n_2(t) + \gamma_{tun,n_3 \rightarrow n_2}n_3(t)$$

$$\frac{dn_3(t)}{dt} = \gamma_{tr,n_4 \rightarrow n_3}n_4(t) - (\gamma_{loss,n_3} + \gamma_{tun,n_3 \rightarrow n_2})n_3(t) + \gamma_{tun,n_2 \rightarrow n_3}n_2(t)$$

$$\frac{dn_4(t)}{dt} = -(\gamma_{tr,n_4 \rightarrow n_3} + \gamma_{loss,n_4} + \gamma_{tun,n_4 \rightarrow n_1})n_4(t) + \gamma_{tun,n_1 \rightarrow n_4}n_1(t)$$

$$\gamma_{tr,n_1 \rightarrow n_2} = \gamma_{tr,n_4 \rightarrow n_3} = \frac{1}{\tau_s \left(\frac{\Delta_{Ta}}{\Delta_{Al}}, \tau_{0,Al} \right)} \frac{d_{Al}}{d_{Al} + d_{Ta}}$$

proximitised

$$\frac{dn_1(t)}{dt} = -(\gamma_{tr,n_1 \rightarrow n_2} + \gamma_{loss,n_1} + \gamma_{tun,n_1 \rightarrow n_4})n_1(t) + \gamma_{tun,n_4 \rightarrow n_1}n_4(t)$$

$$\frac{dn_2(t)}{dt} = \gamma_{tr,n_1 \rightarrow n_2}n_1(t) - (\gamma_{loss,n_2} + \gamma_{tun,n_2 \rightarrow n_3})n_2(t) + \gamma_{tun,n_3 \rightarrow n_2}n_3(t)$$

$$\frac{dn_3(t)}{dt} = \gamma_{tr,n_4 \rightarrow n_3}n_4(t) - (\gamma_{loss,n_3} + \gamma_{tun,n_3 \rightarrow n_2})n_3(t) + \gamma_{tun,n_2 \rightarrow n_3}n_2(t)$$

$$\frac{dn_4(t)}{dt} = -(\gamma_{tr,n_4 \rightarrow n_3} + \gamma_{loss,n_4} + \gamma_{tun,n_4 \rightarrow n_1})n_4(t) + \gamma_{tun,n_1 \rightarrow n_4}n_1(t)$$

$$\gamma_{loss,n_1} = \gamma_{loss,n_4} = \frac{\gamma_{loss,Ta} \cdot d_{Ta} + \gamma_{loss,Al} \cdot d_{Al}}{d_{Ta} + d_{Al}}$$

Fitting parameter

$$\gamma_{loss,Ta} = \frac{1}{a\tau_{0,Ta}}$$

$$\gamma_{loss,n_2} = \gamma_{loss,n_3} = \gamma_{loss,Al} = \frac{1}{a\tau_{0,Al}}$$

$$\frac{dn_1(t)}{dt} = -\left(\gamma_{tr,n_1 \rightarrow n_2} + \gamma_{loss,n_1} + \gamma_{tun,n_1 \rightarrow n_4}\right)n_1(t) + \gamma_{tun,n_4 \rightarrow n_1}n_4(t)$$

$$\frac{dn_2(t)}{dt} = \gamma_{tr,n_1 \rightarrow n_2}n_1(t) - \left(\gamma_{loss,n_2} + \gamma_{tun,n_2 \rightarrow n_3}\right)n_2(t) + \gamma_{tun,n_3 \rightarrow n_2}n_3(t)$$

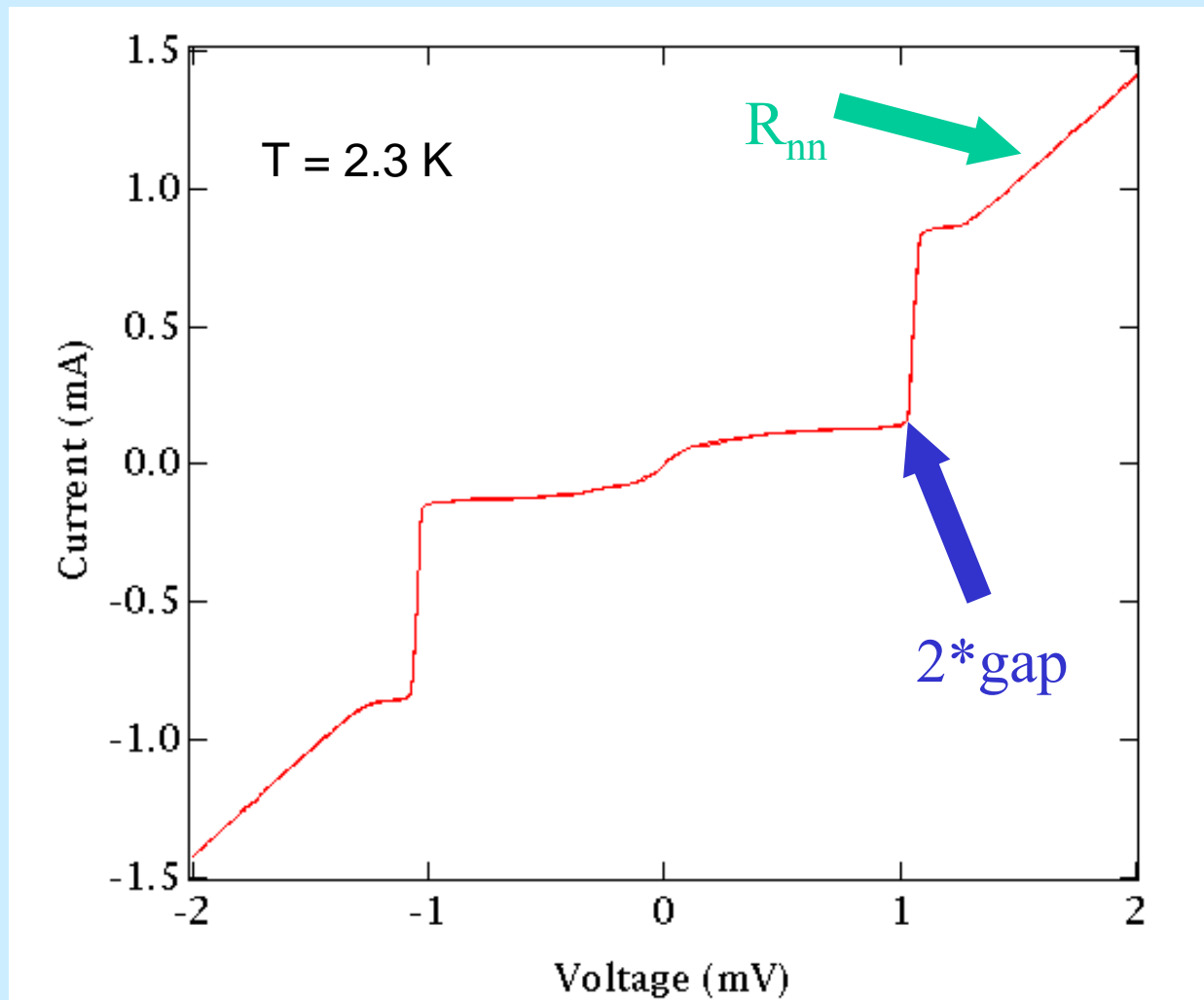
$$\frac{dn_3(t)}{dt} = \gamma_{tr,n_4 \rightarrow n_3}n_4(t) - \left(\gamma_{loss,n_3} + \gamma_{tun,n_3 \rightarrow n_2}\right)n_3(t) + \gamma_{tun,n_2 \rightarrow n_3}n_2(t)$$

$$\frac{dn_4(t)}{dt} = -\left(\gamma_{tr,n_4 \rightarrow n_3} + \gamma_{loss,n_4} + \gamma_{tun,n_4 \rightarrow n_1}\right)n_4(t) + \gamma_{tun,n_1 \rightarrow n_4}n_1(t)$$

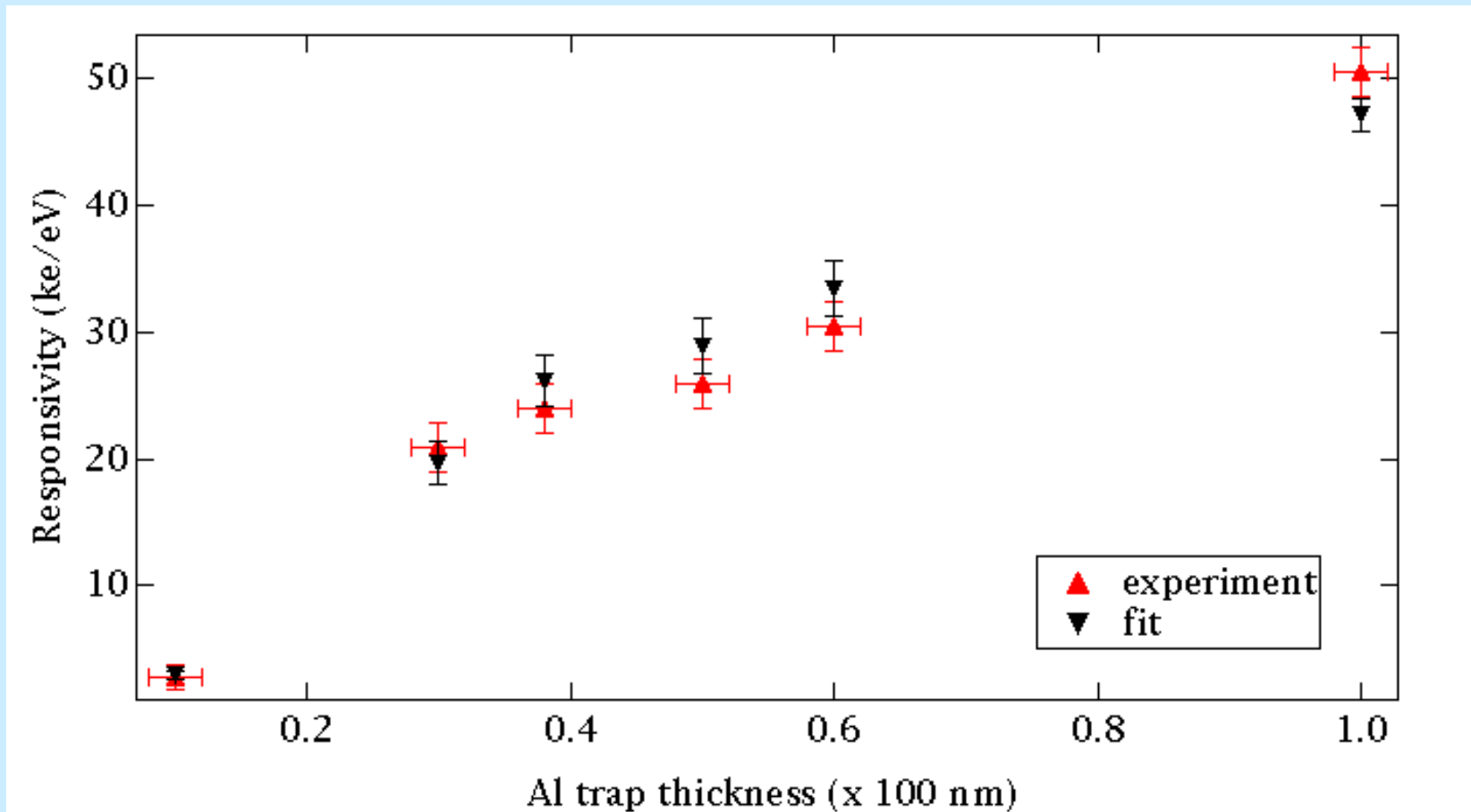
$$\gamma_{tun,n_1 \rightarrow n_4} = \gamma_{tun,n_4 \rightarrow n_1} = \frac{1}{4e^2 N(0) R_{nn} Ad_{Ta+Al}} \cdot \frac{\Delta_{Ta} + eV_b}{\sqrt{(\Delta_{Ta} + eV_b)^2 - \Delta_{Ta}}}$$

$$\gamma_{tun,n_2 \rightarrow n_3} = \gamma_{tun,n_3 \rightarrow n_2} = \frac{1}{4e^2 N(0) R_{nn} Ad_{Al}} \cdot \frac{\Delta_{Al} + eV_b}{\sqrt{(\Delta_{Al} + eV_b)^2 - \Delta_{Al}}}$$

Measurement of R_{nn} and the gap



Comparison of the experiment with the model



Conclusion

Fitting parameter $a = 79$



$$\tau_{\text{loss,A1}} = 35 \pm 2 \mu\text{s}$$

$$\tau_{\text{loss,Ta}} = 0.14 \pm 0.01 \mu\text{s}$$

$$0.09 \pm 0.01 \mu\text{s} < \tau_{\text{trap}} < 43 \pm 6 \mu\text{s}$$

Outlook:

Consolidate the model: Varying d_{Al} and d_{Ta} ; Measuring $R(T)$

Understand the high losses in Ta
(impurity trapping, border effects,...?)