Experimental characterization of transitions between locking regimes in a semiconductor laser with optical feedback and small amplitude current modulation

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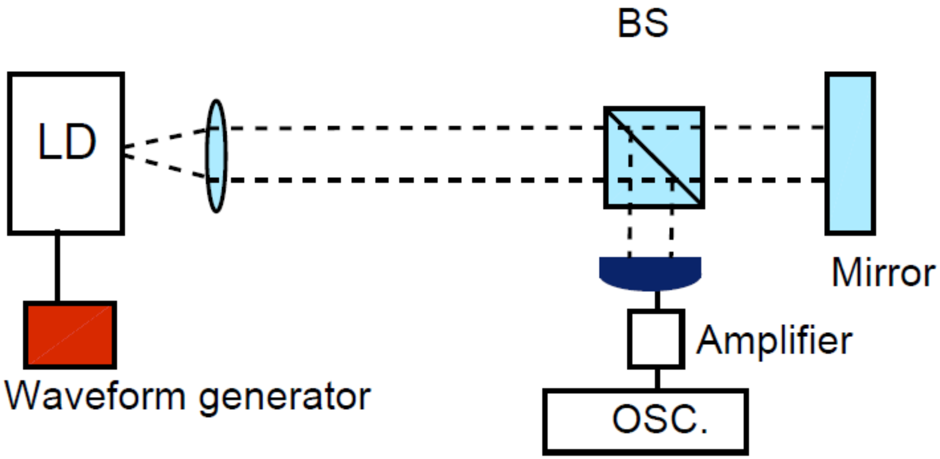
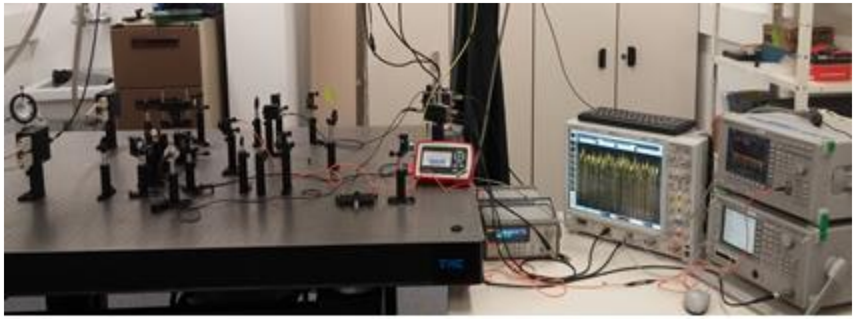
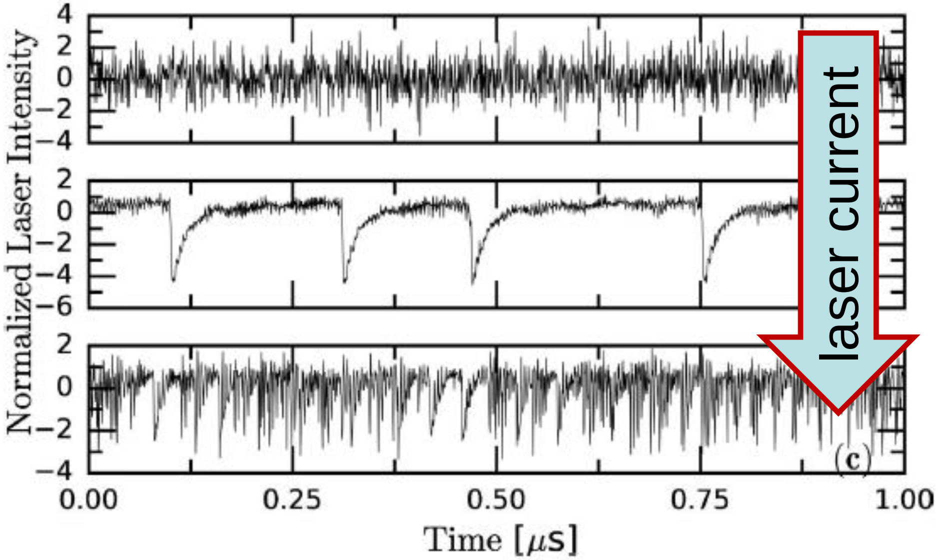
ESLW 2018, Bari, Italy

Dynamics of a semiconductor laser with optical feedback







Video: [how complex signals emerge from optical noise]

Different dynamical regimes are difficult to distinguish.

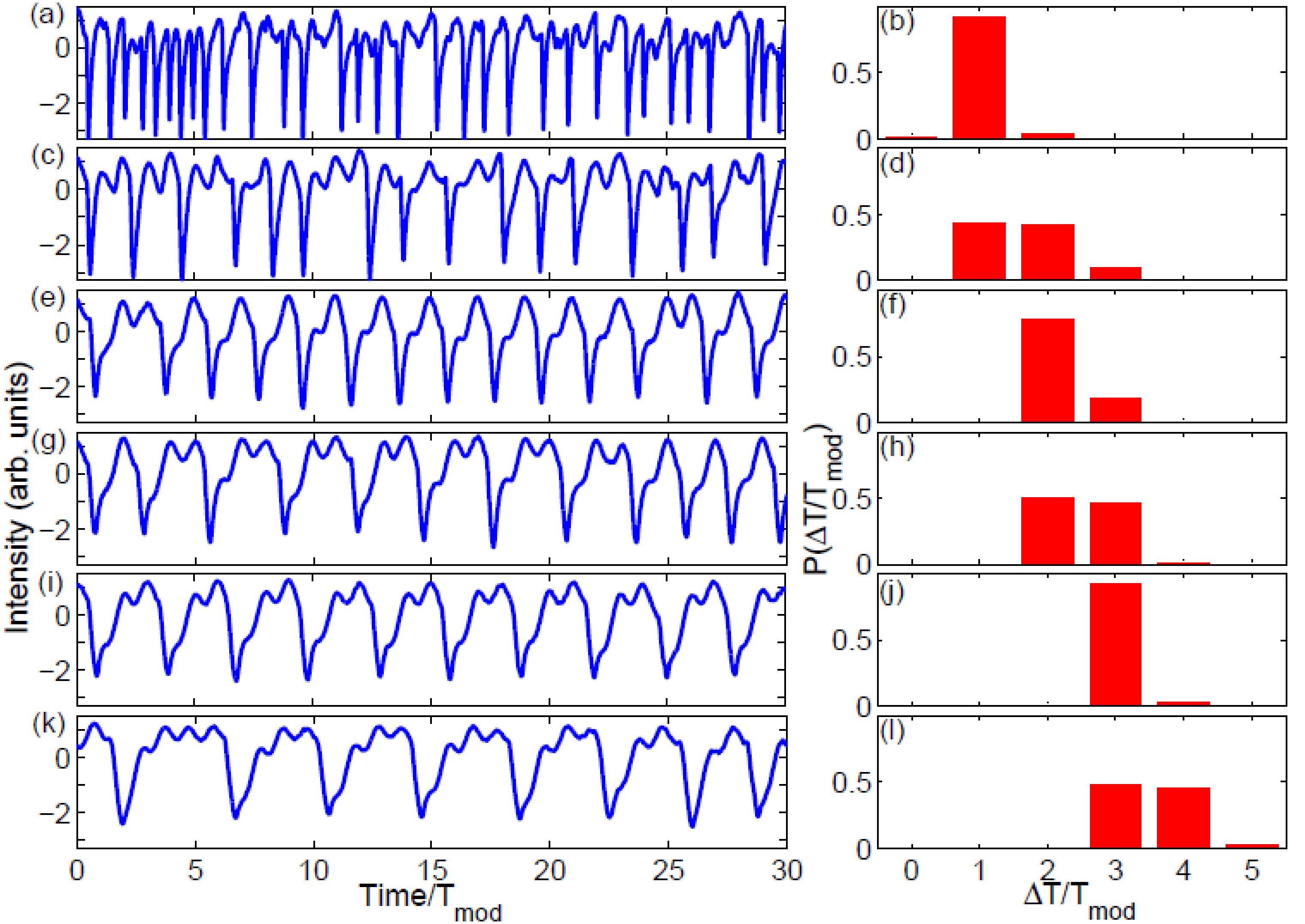
Under small-amplitude sinusoidal current modulation: noisy locking

Mod. Freq.

Mod. Amplitude =1.2 % I_{DC}

7 MHz

49 MHz



How to *control* the laser spikes?
How to *quantify* the degree of entrainment?

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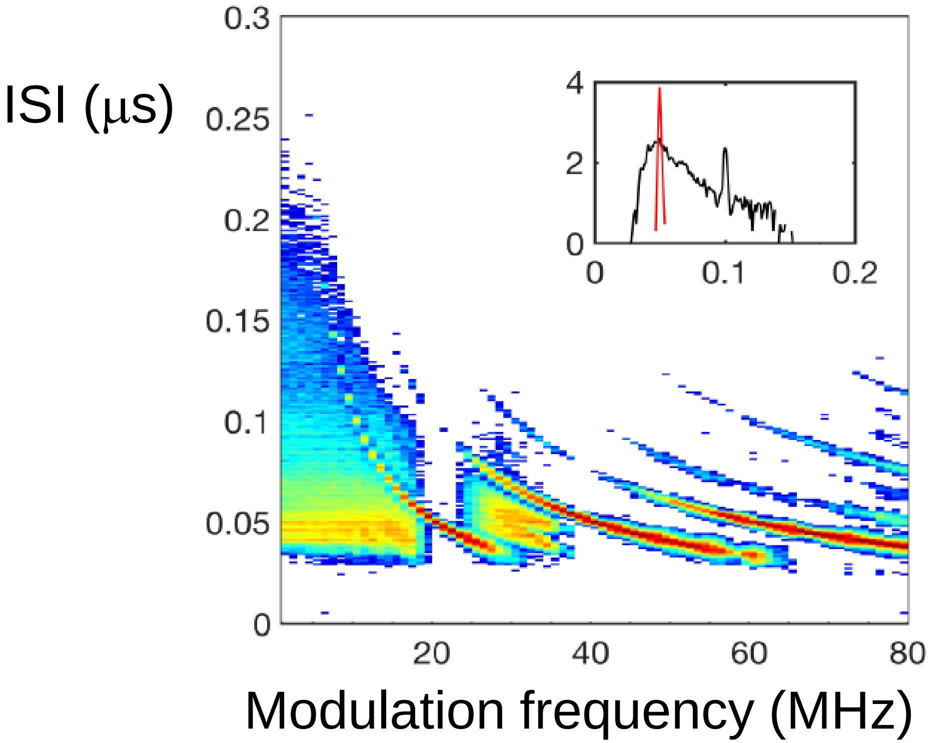
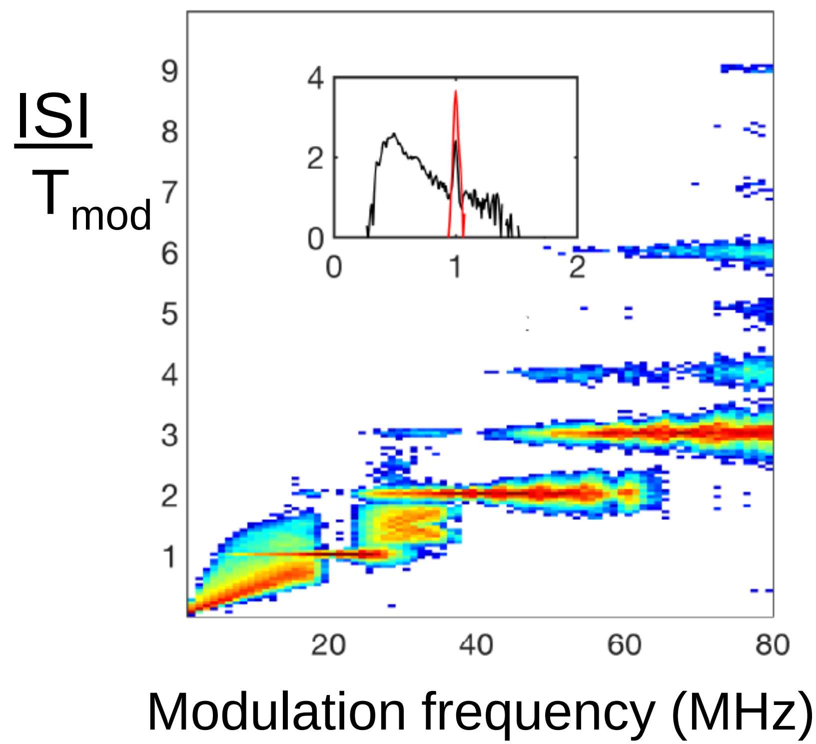
Inter-spike time interval distribution as a function of the frequency of the current modulation

$I_{th,sol} = 26.62$ mA

$I_{th} = 24.70$ mA

I_{dc}= 27 mA (f_0=15 MHz), A_{mod} = 2.3% of I_{dc}

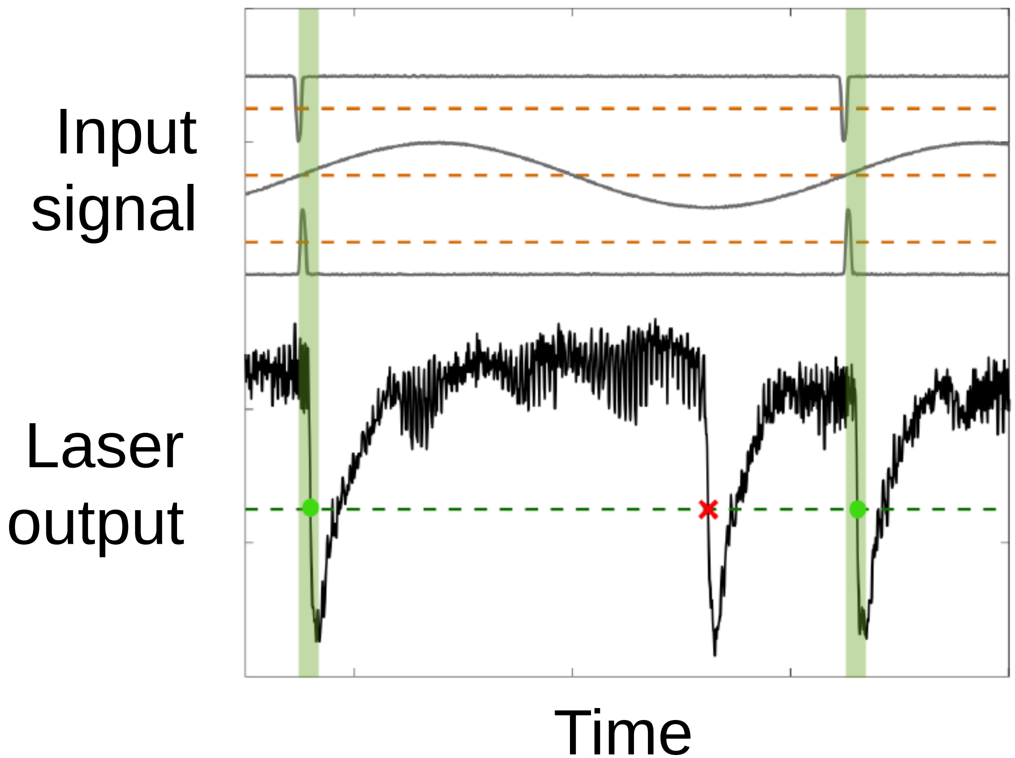




⇒ “refractory time” clear

⇒ “locking” horizontal

We test three modulation waveforms and quantify locking with the <u>success rate</u> and the <u>false positive rate</u>

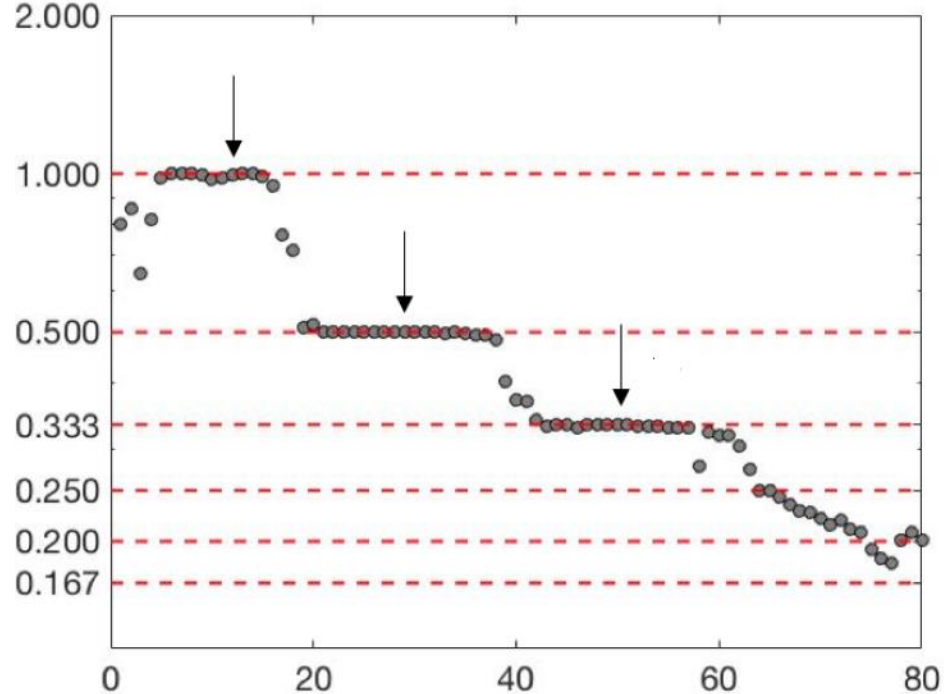


$$SR(\tau) = \frac{\text{\# of spikes emitted in the interval } \tau}{\text{\# of modulation cycles}}$$

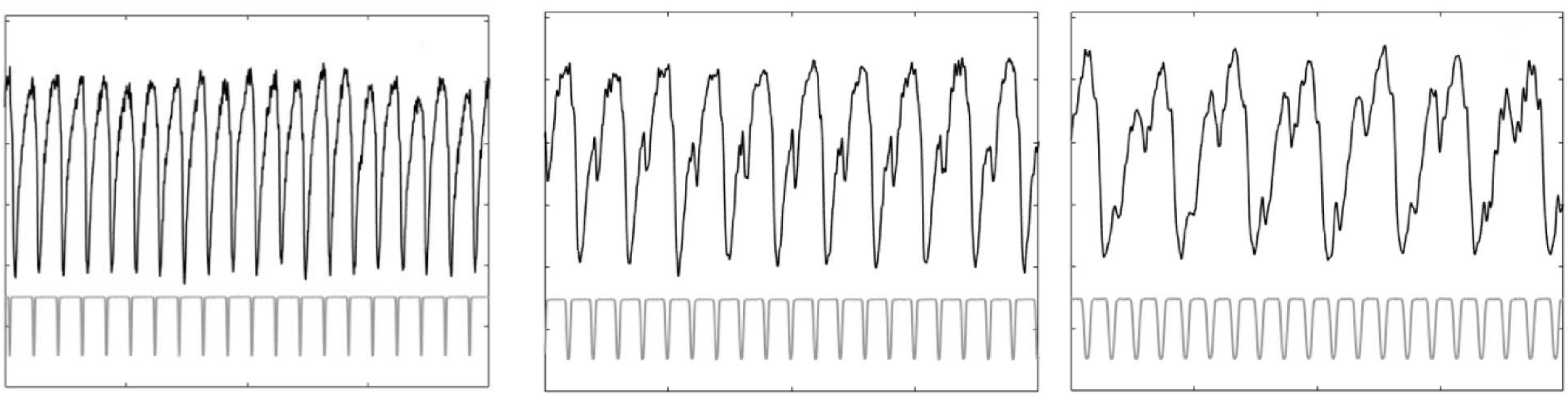
$$FPR(\tau) = \frac{\text{\# spikes that are not emitted in the time interval } \tau}{\text{Total \# of spikes}}$$

Quantification

Success rate

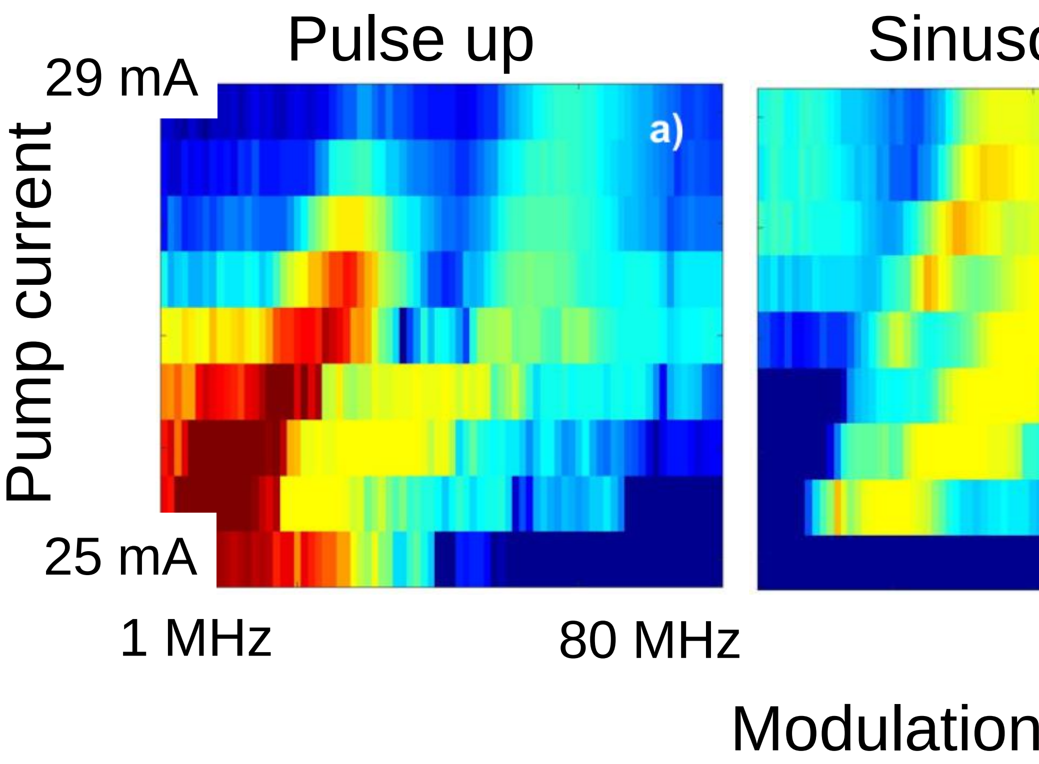


Modulation frequency (MHz)



Time/T_{mod}

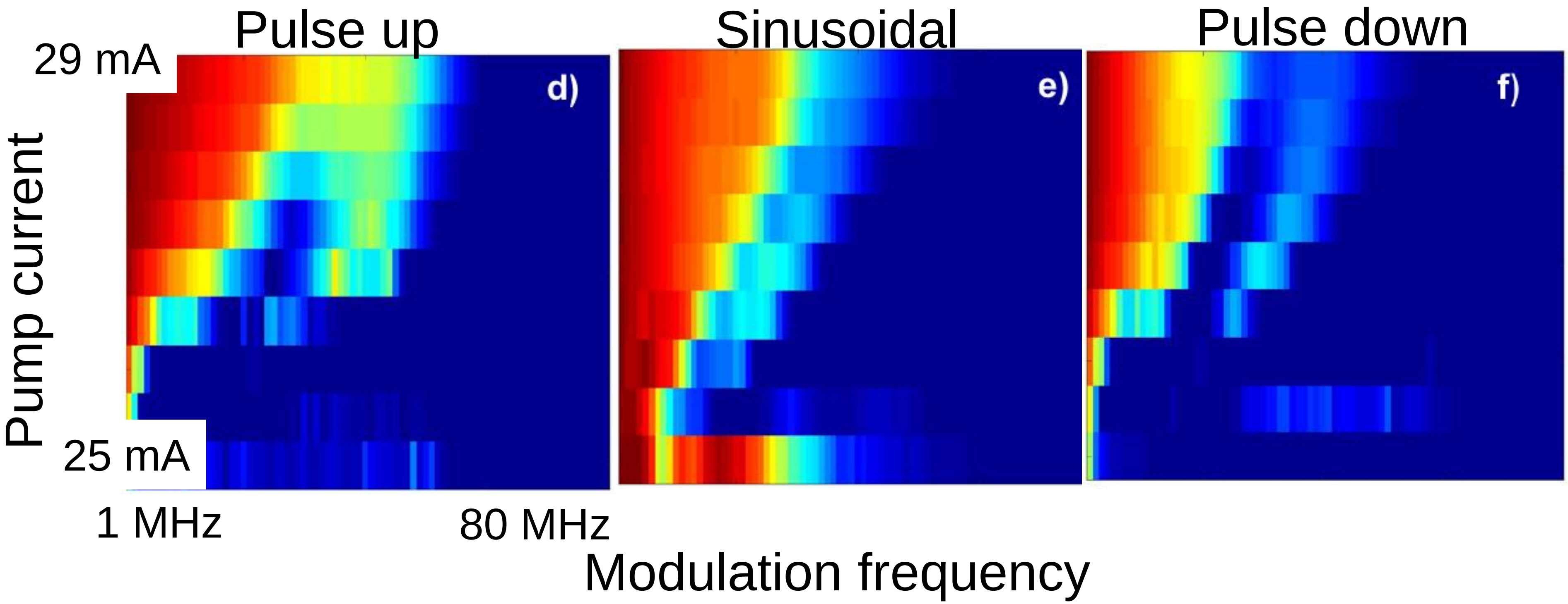
Waveform comparison: in color code the success rate (red SR=1)



⇒ pulse-down waveform produces a wider locking region

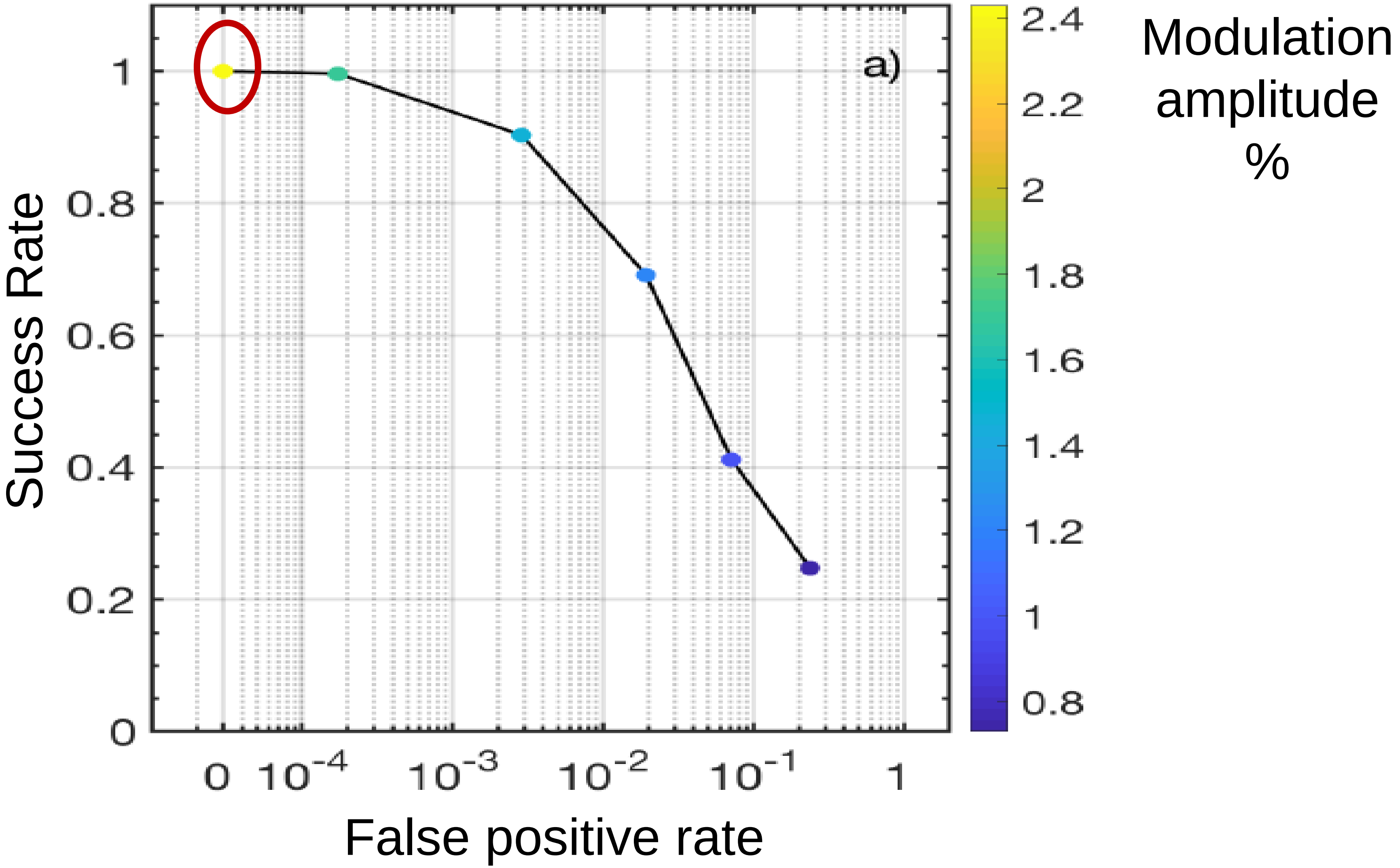
J. Tiana et al., Opt. Express 26 9298 (2018)

And the false positives? (the natural, uncontrolled spikes)



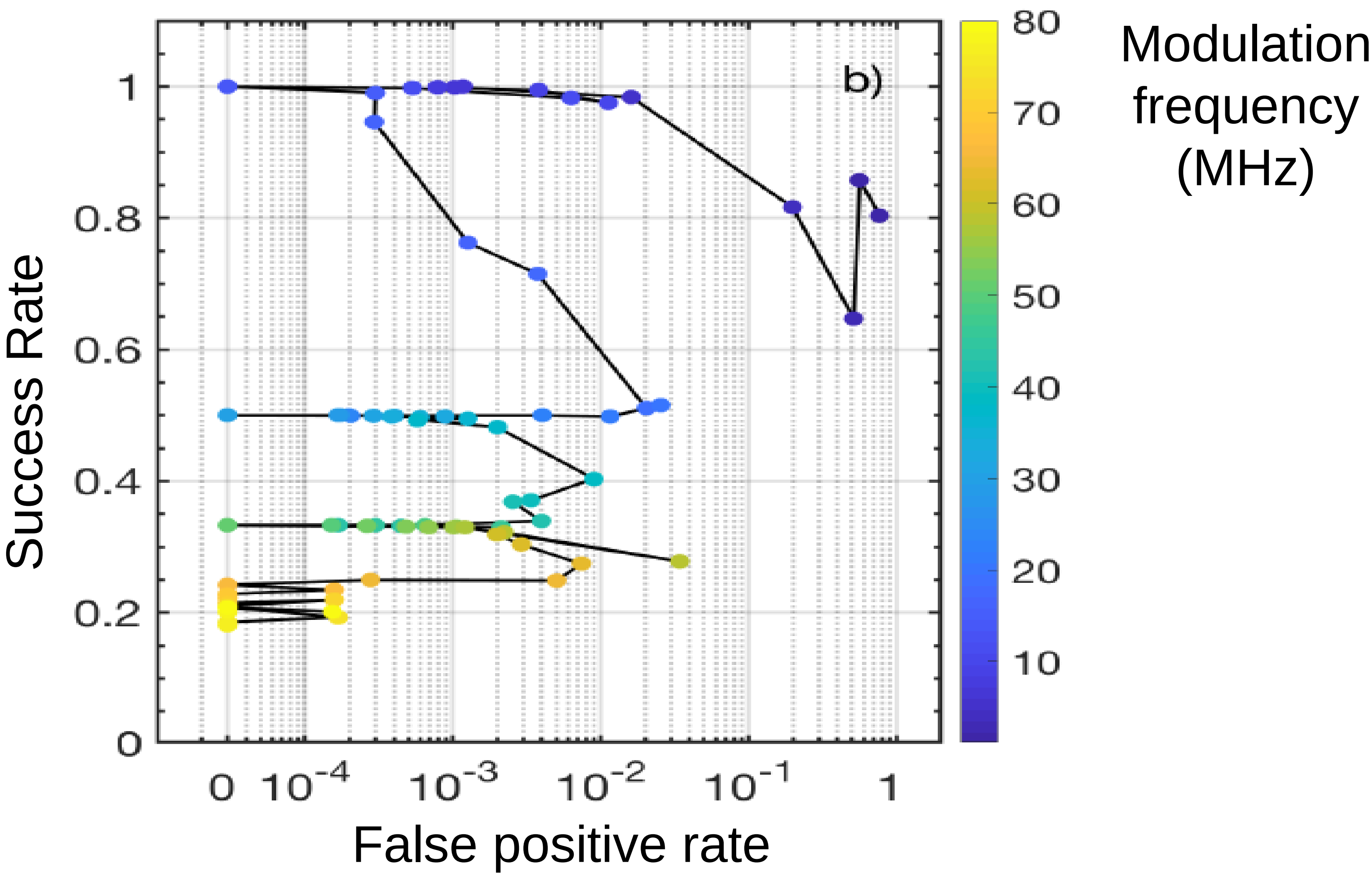
J. Tiana et al., Opt. Express 26, 9298 (2018)

Receiver operating characteristic (ROC) curves



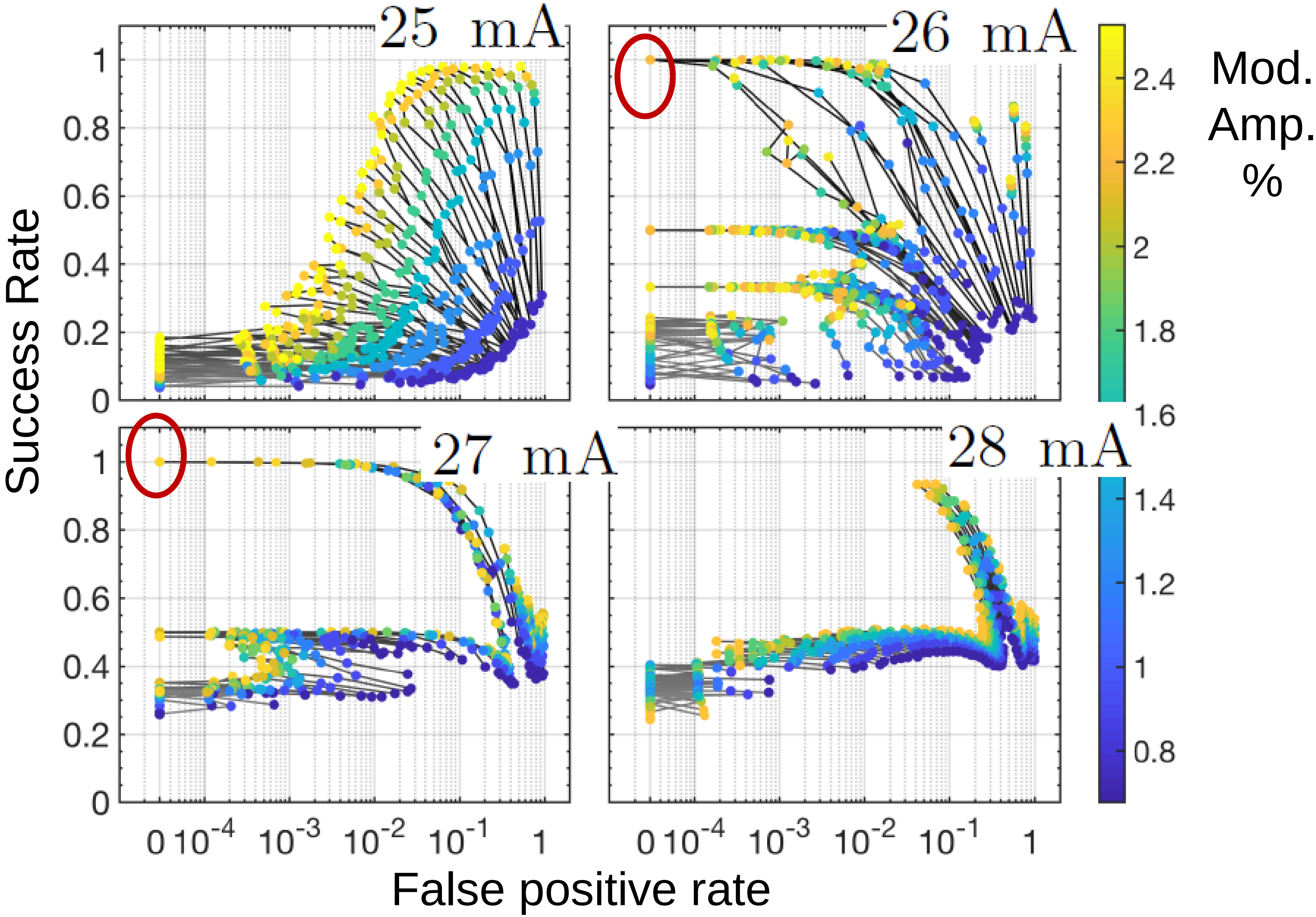
J. Tiana et al., arXiv:1806.08950v1 (2018)

Locked-unlocked transitions when the modulation frequency increases



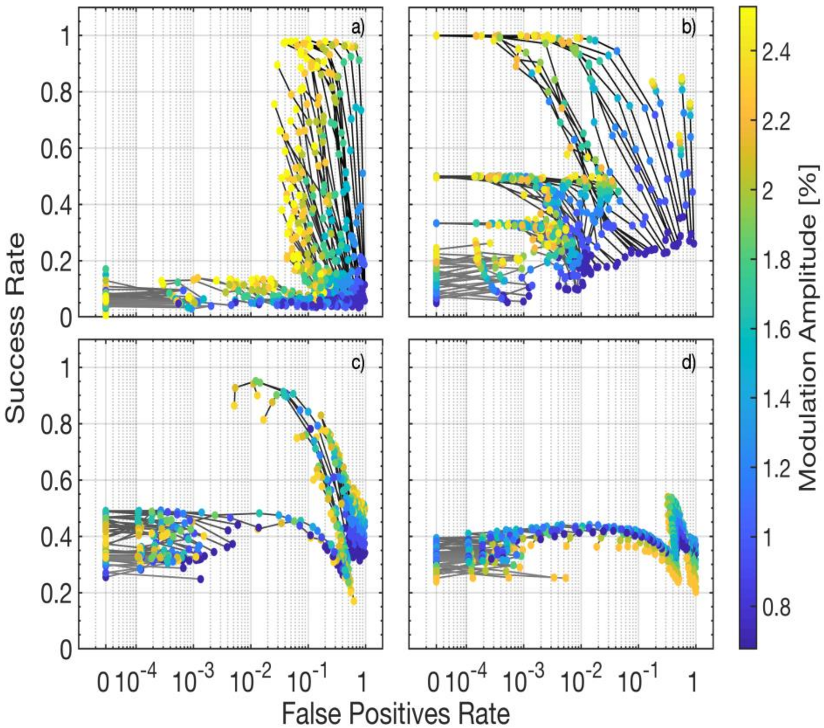
J. Tiana et al., arXiv:1806.08950v1 (2018)

Role of the laser current (controls the natural spike rate)

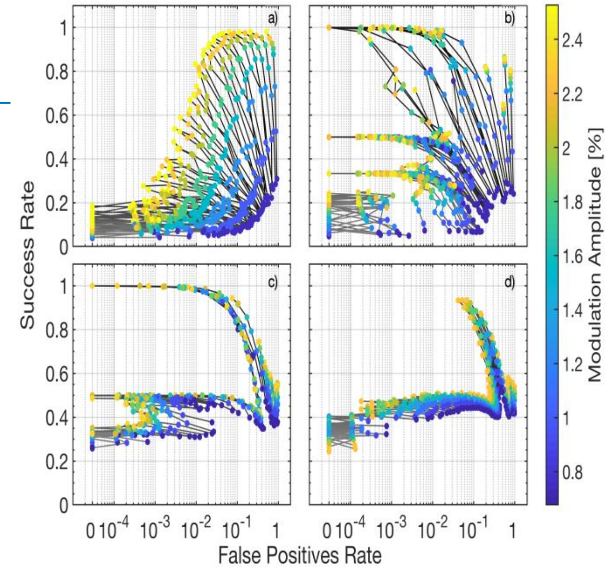


Influence of the modulation waveform

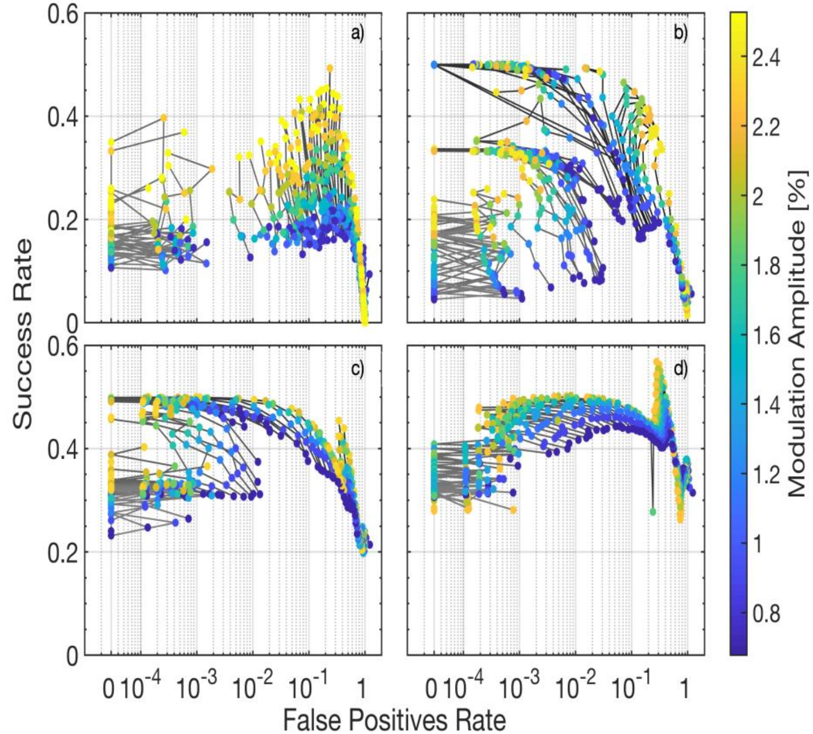
Pulsed-up



Pulsed-down



Sinusoidal



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What did we learn?

- ROC curves allow to quantify the degree of entrainment of the optical spikes to a small-amplitude electrical signal.
- Pulse-down waveform produces a wider locking region
- Perfect 1:1 locking identified.

Ongoing work: potential for sensing applications?

Thank you for your attention

J. Tiana et al., Opt. Express 26, 9298 (2018)

J. Tiana et al., arXiv:1806.08950v1 (2018)

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