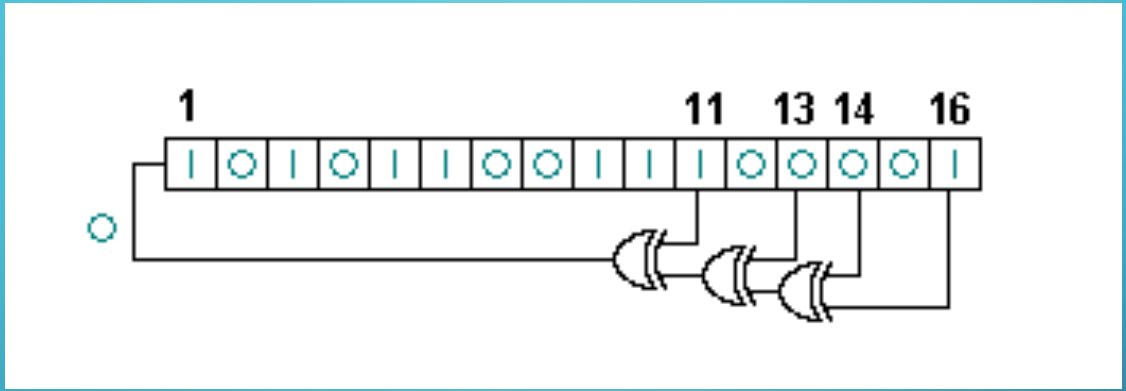
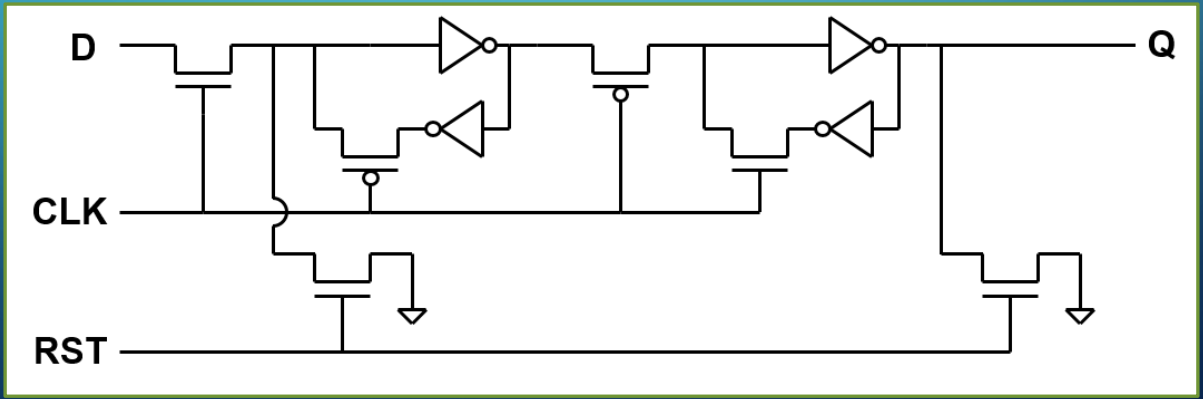
INVESTIGATING INTEGRATED SINGLE-PHOTON OPTICS FOR POWER-EFFICIENT QUANTUM RANDOMNESS

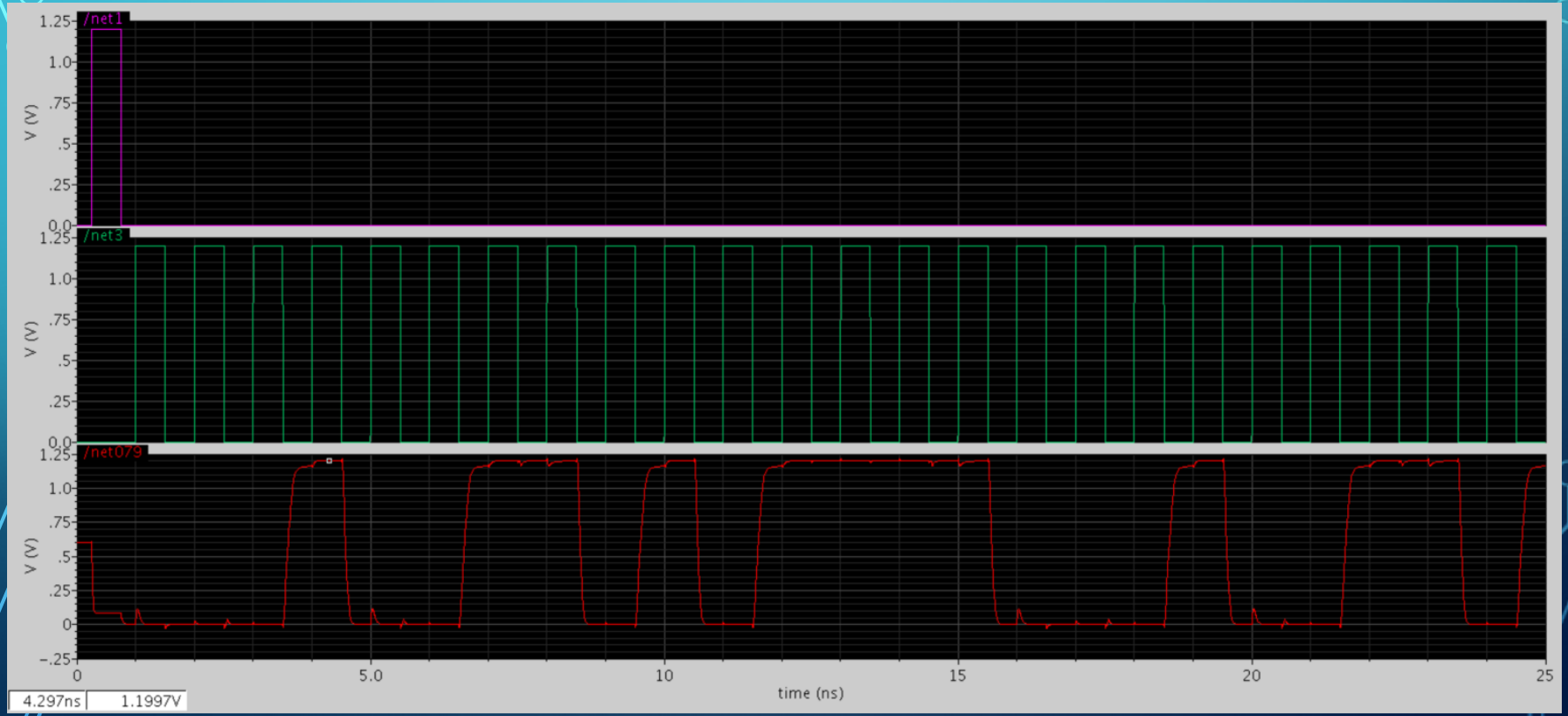
ETHAN GORDON, DANIEL STANLEY

PSEUDO-RANDOMNESS IN CIRCUITY: LFSR

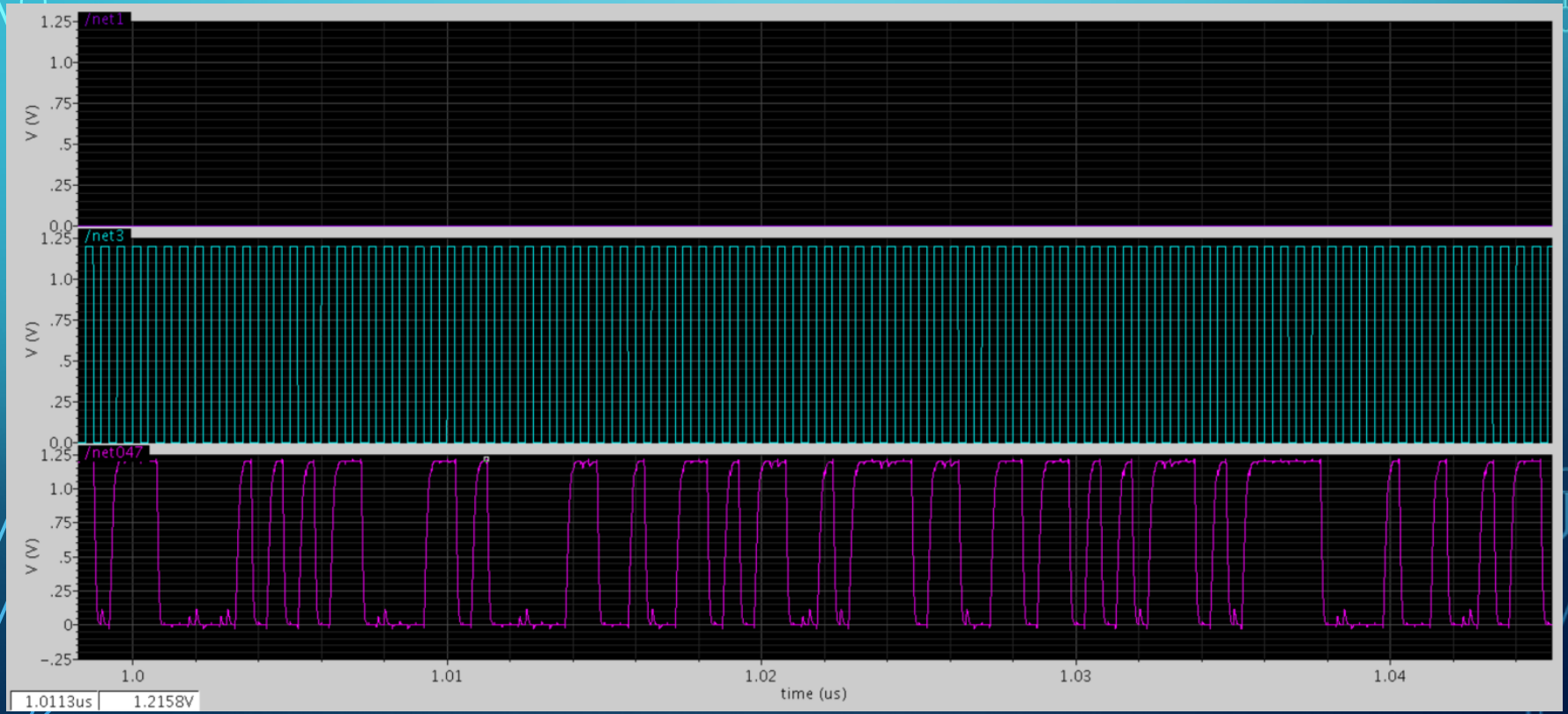




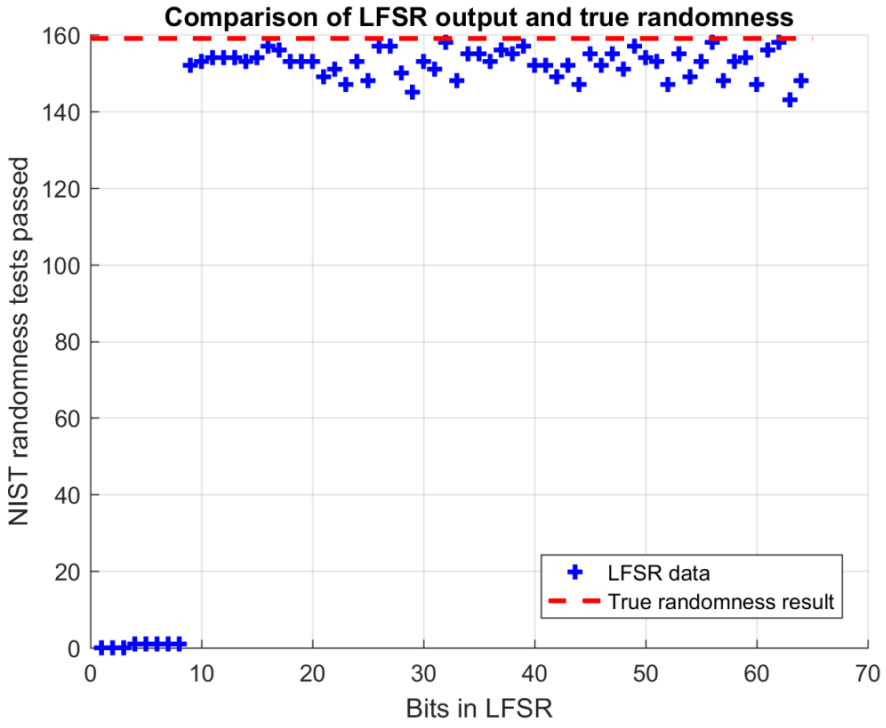
4-BIT LFSR IN CADENCE

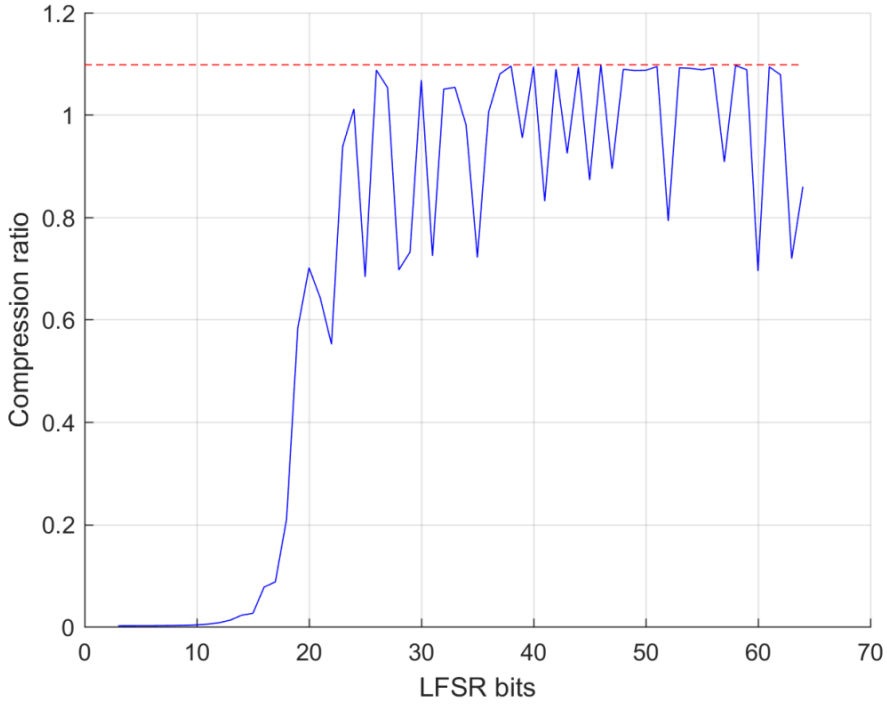


17-BIT LFSR IN CADENCE

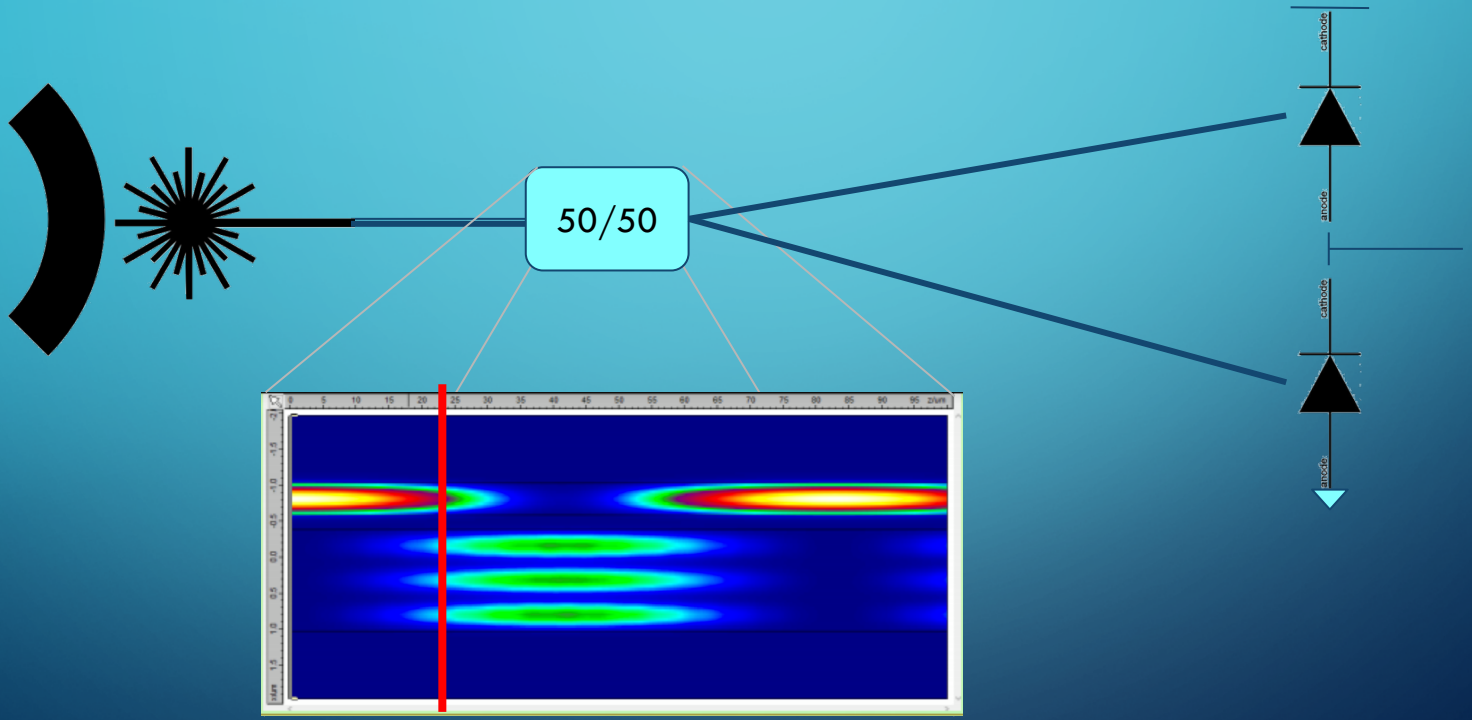


LFSR LIMITATIONS

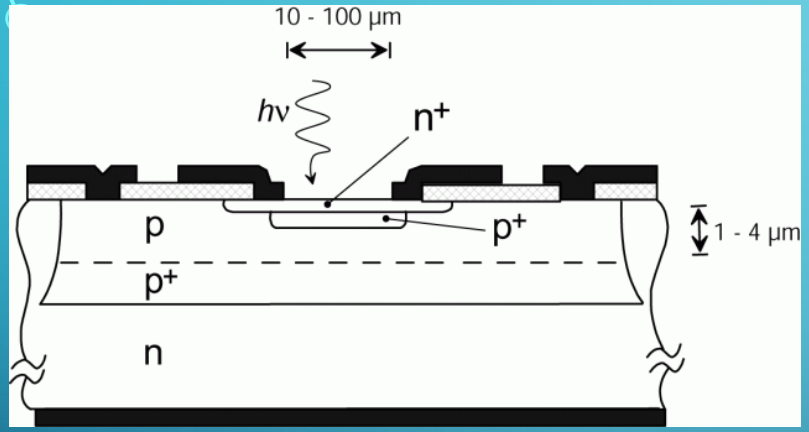


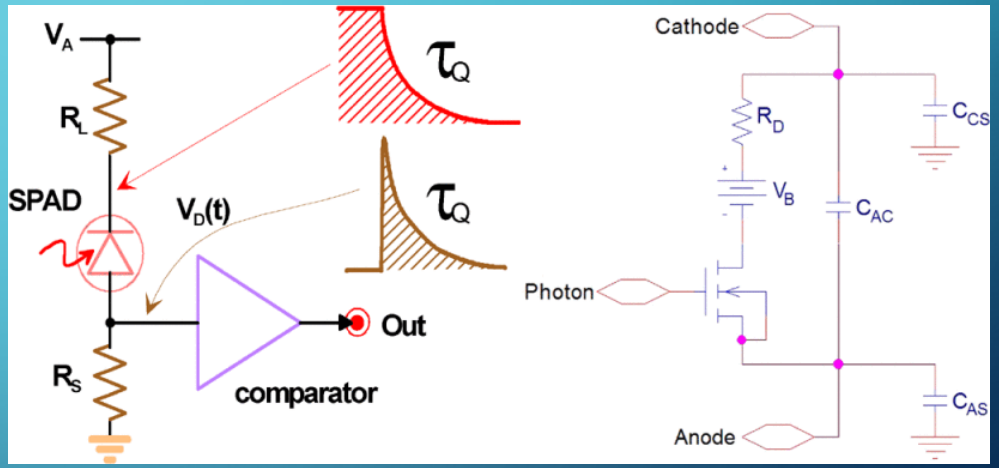


QUANTUM RANDOMNESS IN SINGLE-PHOTON OPTICS

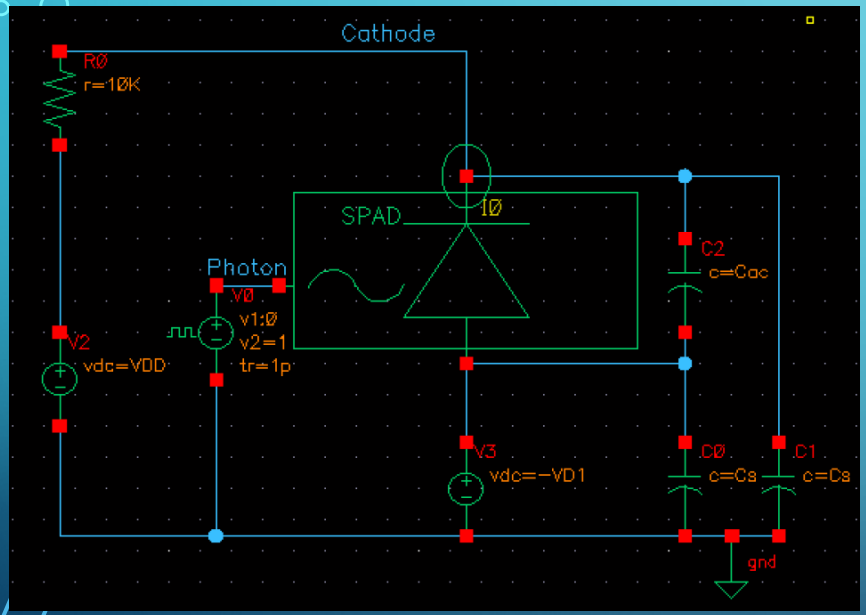


SINGLE-PHOTON AVALANCHE DIODE

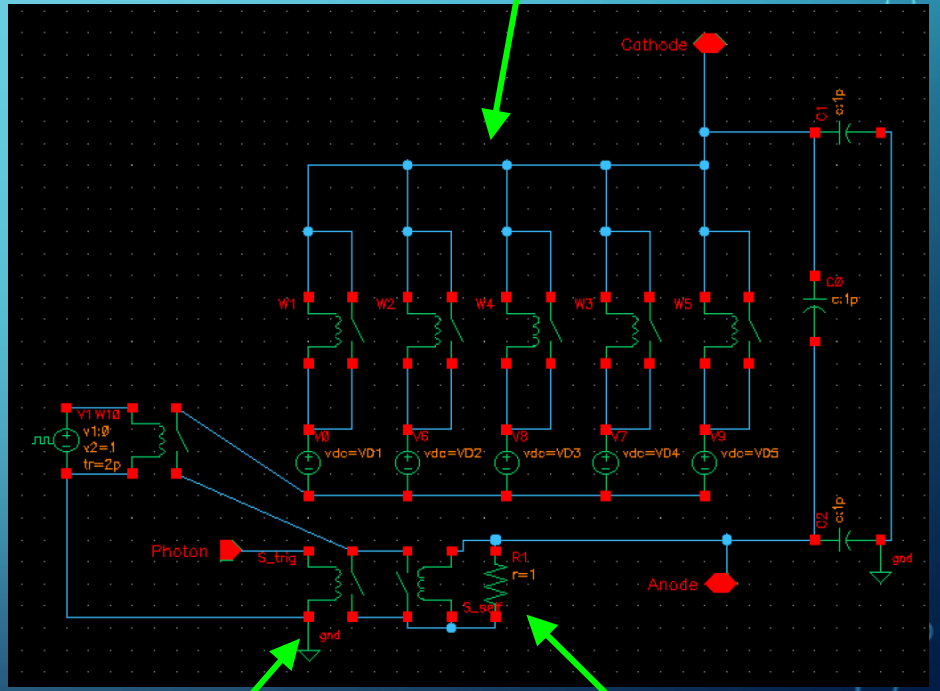




SPAD IN CADENCE: PASSIVE QUENCHING



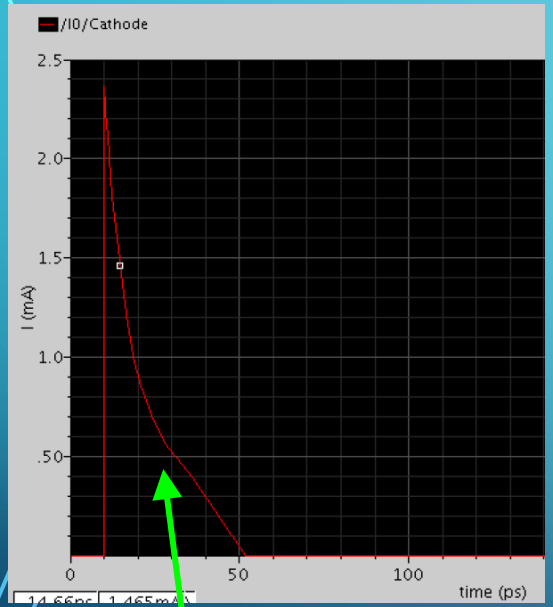
Variable Resistor



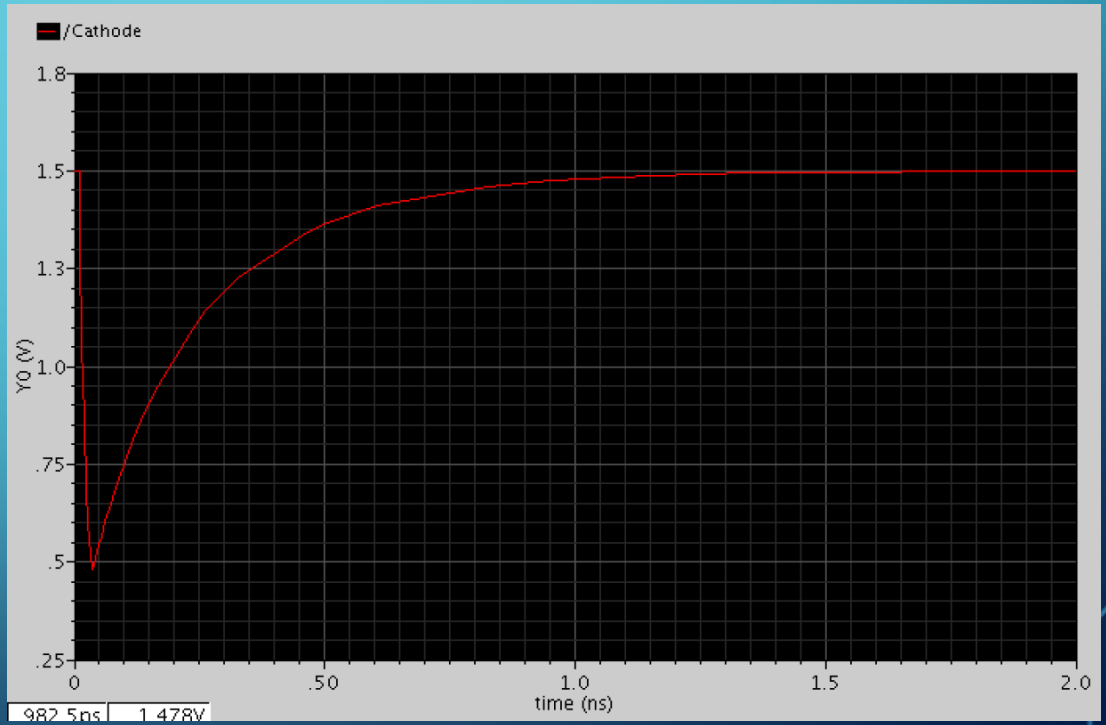
Photon Trigger

Self-Sustain

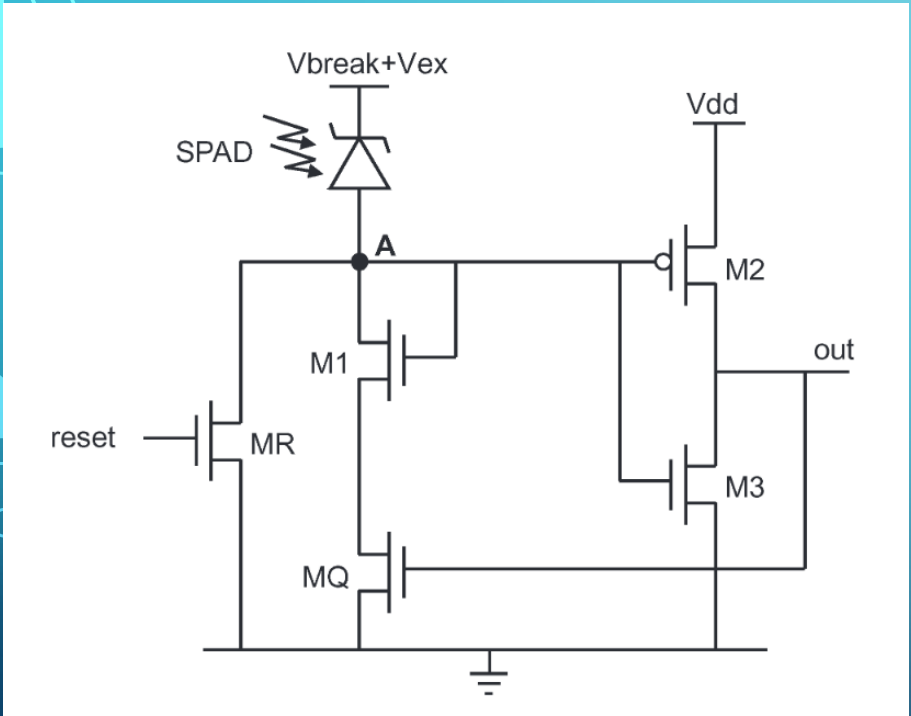
SPAD IN CADENCE: PASSIVE QUENCHING

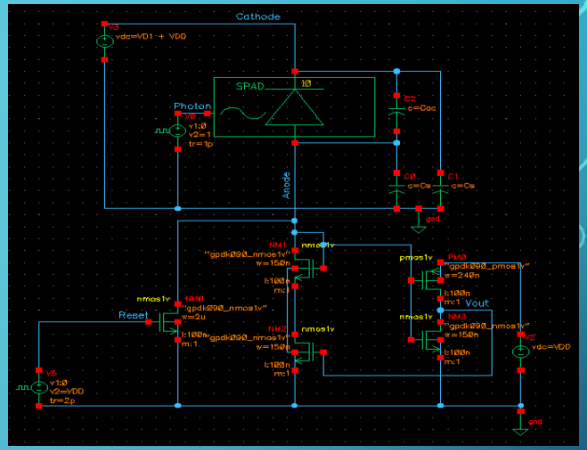


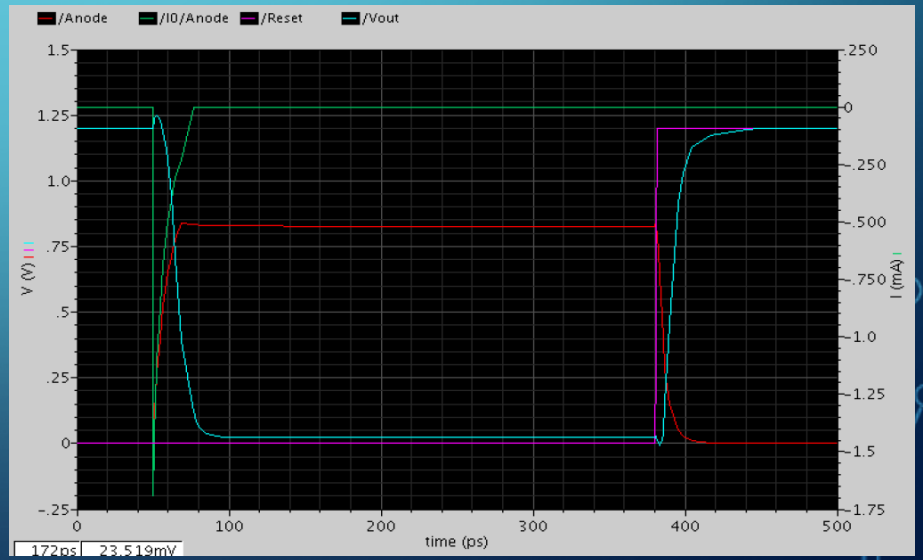
Self-Quench



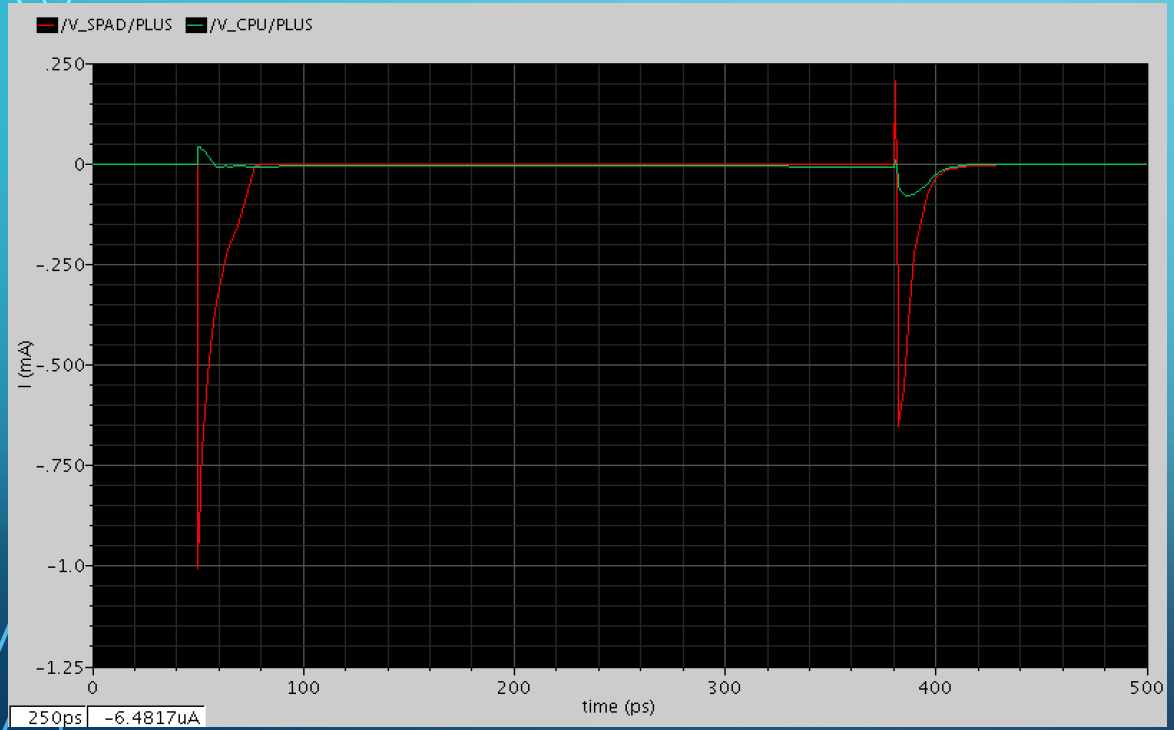
SPAD IN CADENCE: ACTIVE QUENCHING







SPAD IN CADENCE: POWER CONSUMPTION



Computation (Green):
8.88μW

SPAD Recharge (Red):
592.1μW

Optical Power Estimate:
~10μW

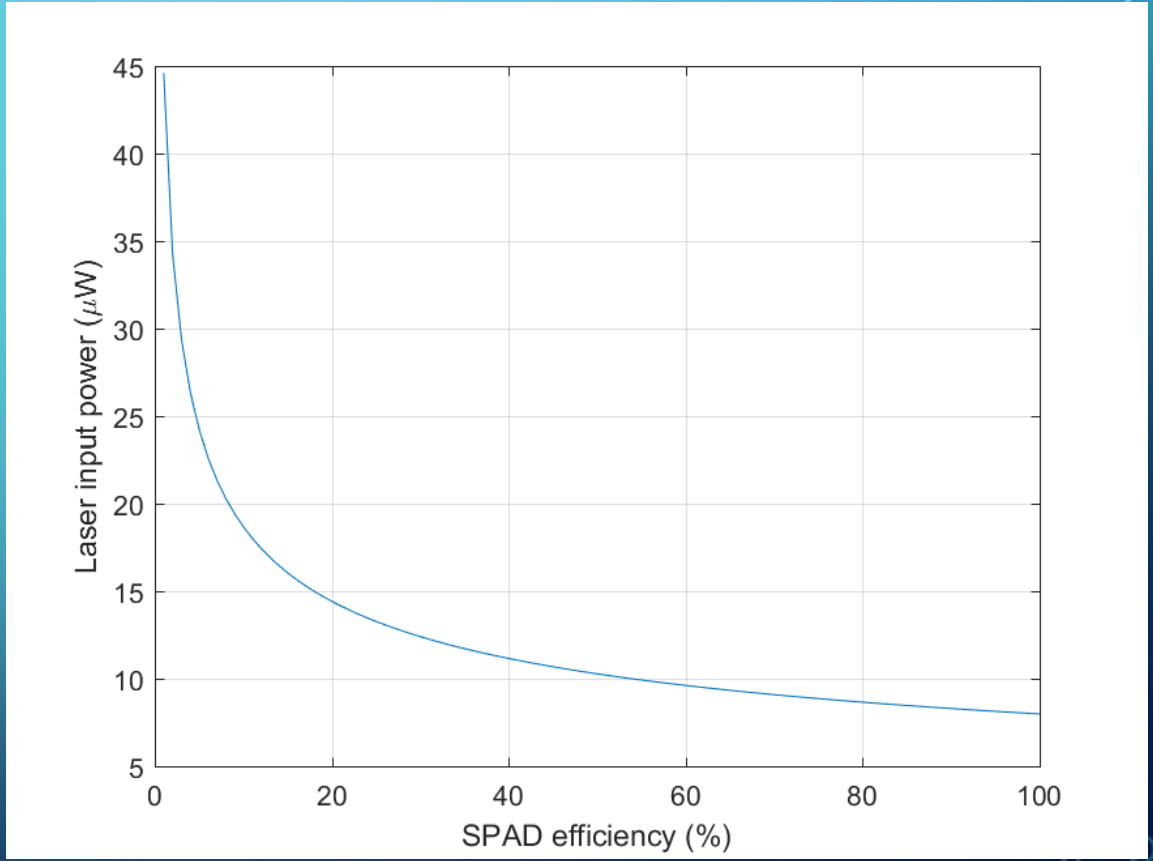
OPTICAL POWER ESTIMATION

$$p_{generate} = 2(1 - \frac{p}{2})^n - 2(1-p)^n$$

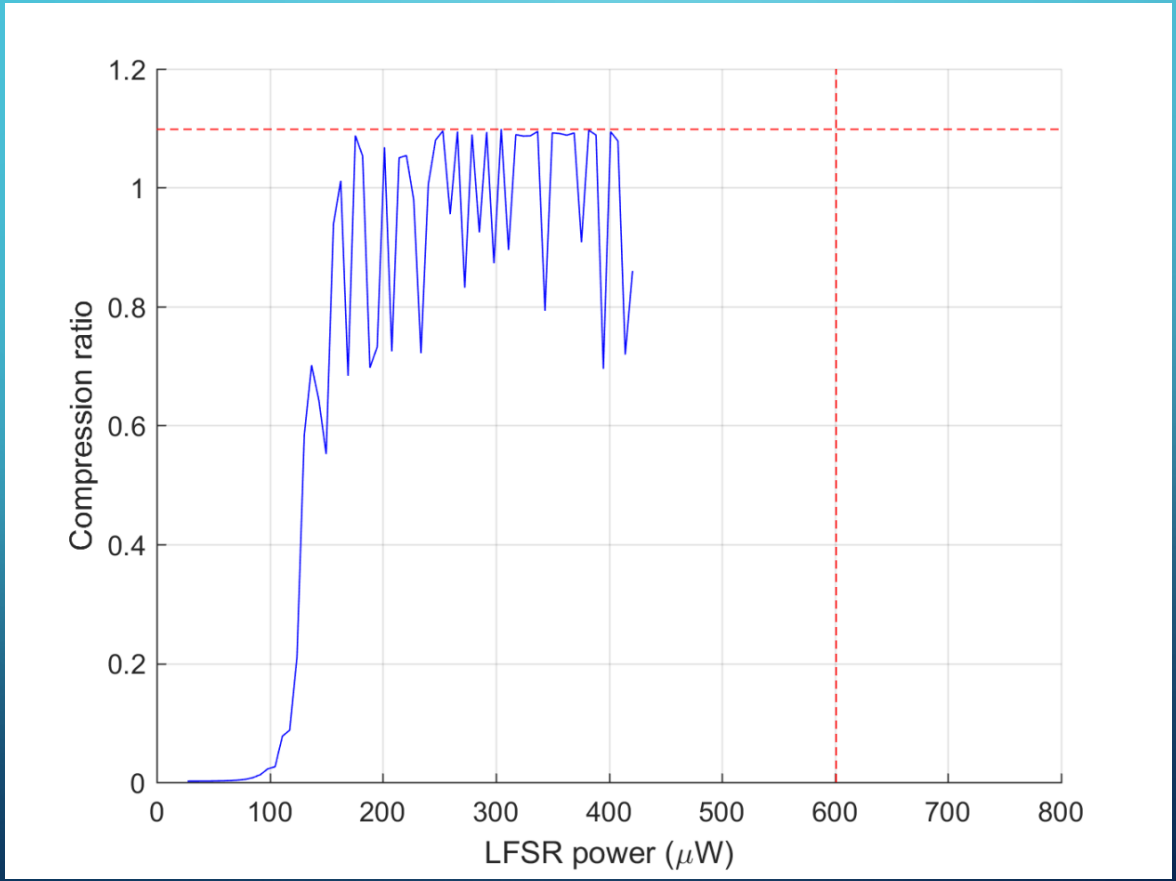
$$p_{generate} = 2e^{-\lambda p}\left(e^{\frac{\lambda p}{2}} - 1\right)$$

$$\lambda_{opt} = \frac{2\log(2)}{p}$$

$$p_{opt} = \frac{1}{2}$$



COMPARISON


1.2
1
0.8
0.6
0.4
0.2
0
Compression ratio
0
100
200
300
400
500
600
700
800
LFSR power (μW)


TIRED OF GRAPHS?
HERE'S A GIRAFFE!
HE'S HERE TO ANSWER QUESTIONS...