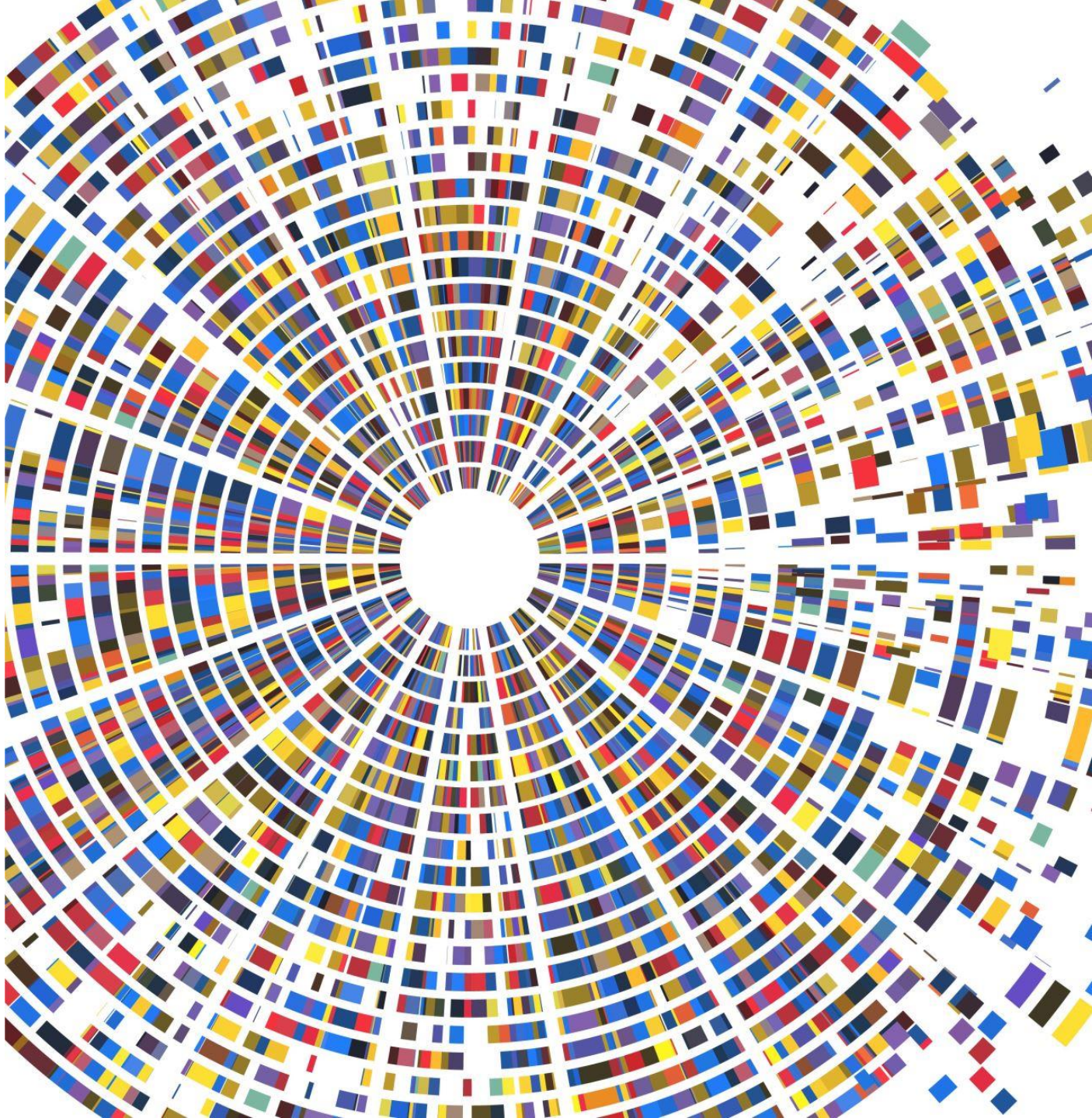
LOW PHOTON ADVANTAGES IN OPTICAL FIBER COMMUNICATION

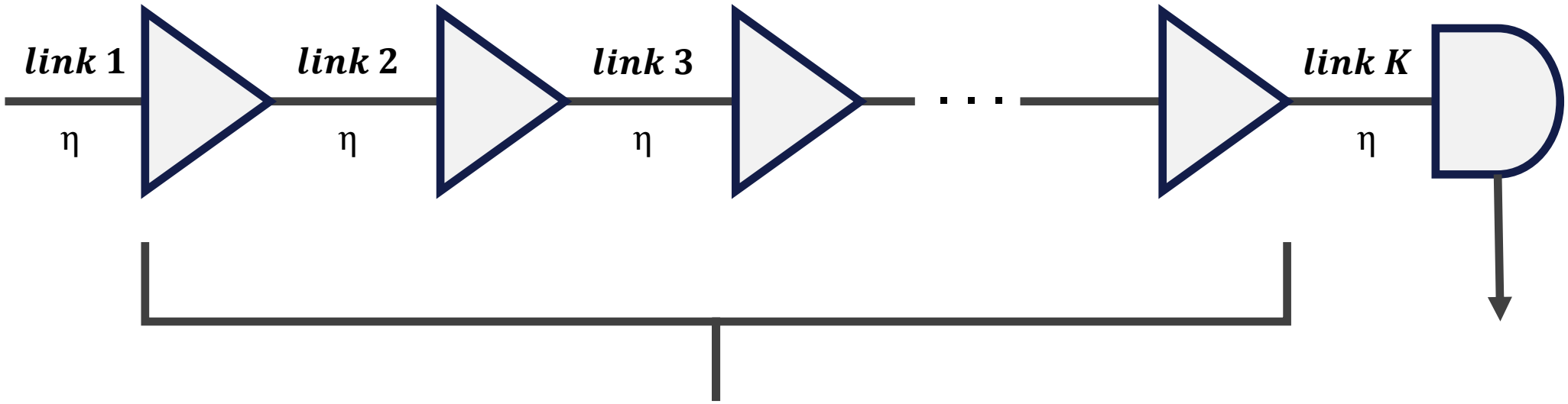
Presentation by Aakash Warke,

Peter van Loock's Group in Mainz

JOHANNES GUTENBERG UNIVERSITÄT MAINZ



Optical Fiber Channel



Phase-Insensitive Amplification (PIA)

(or)

Phase-Sensitive Amplification (PSA)

Shannon

(or)

Holevo Limits

$$\eta = e^{-0.05\,L/K}$$

Detection Methods

Heterodyne

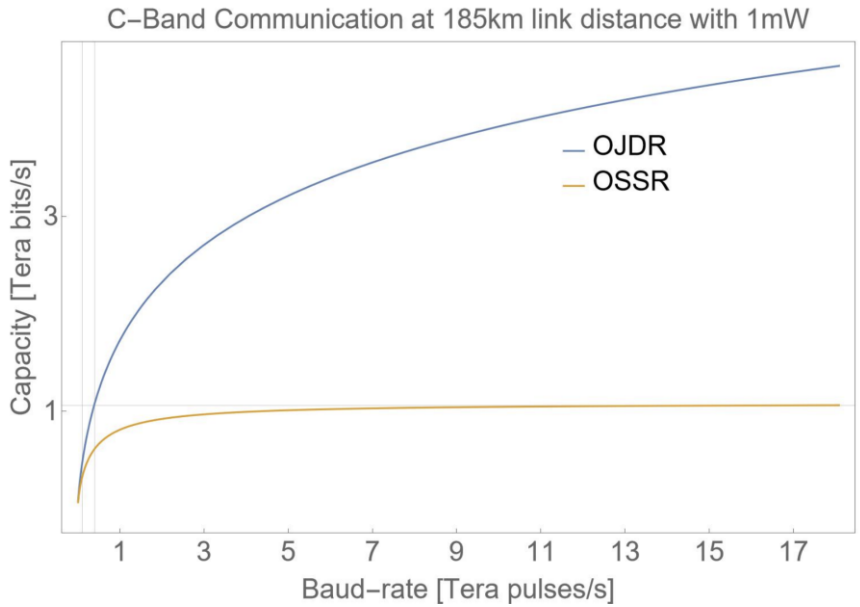
Homodyne

Shannon Limits

Optical Joint Detection Receivers

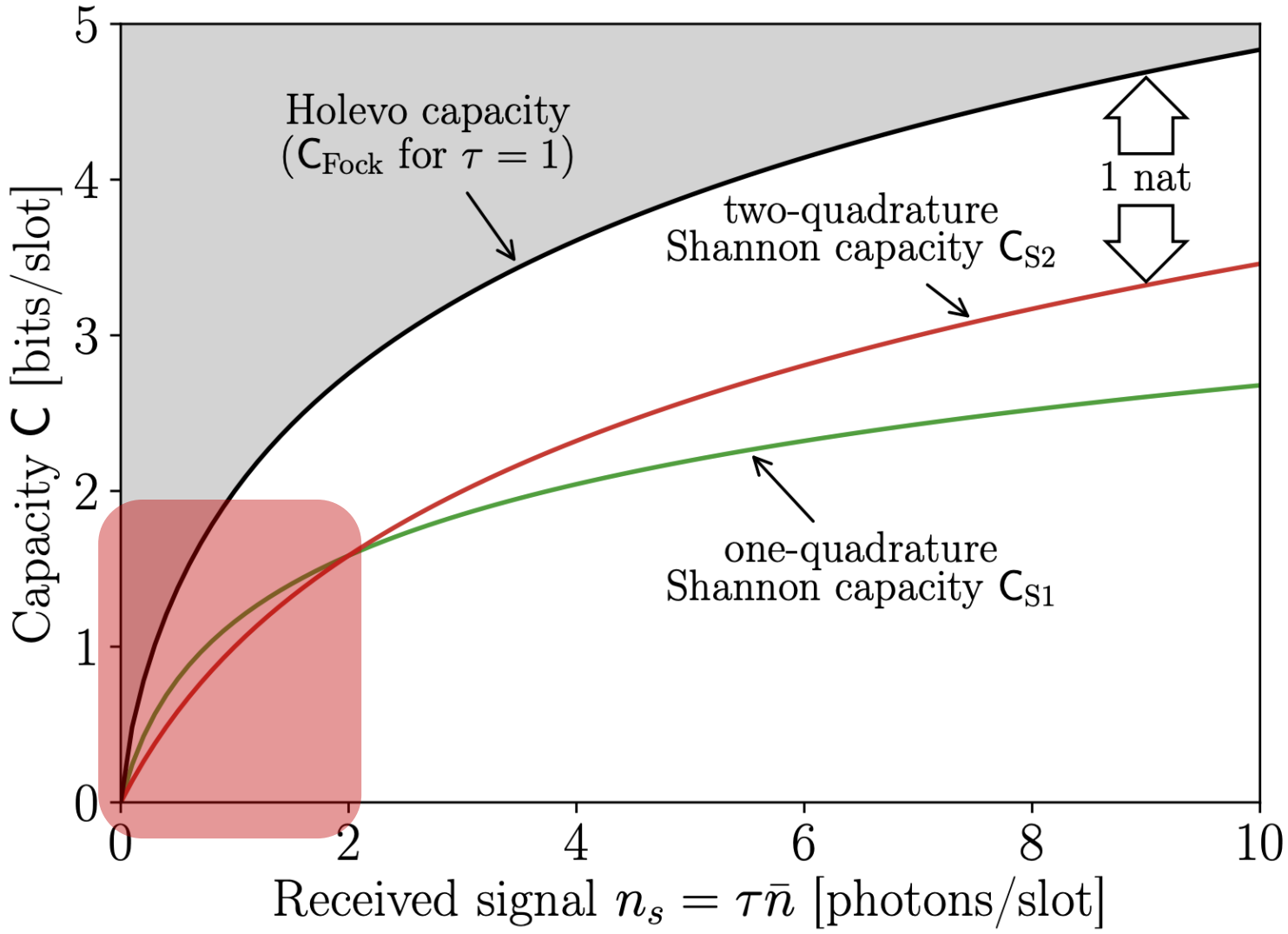
Holevo Limits

Collective Quantum Measurements



J. Nötzel and M. Rosati, "Operating Fiber Networks in the Quantum Limit," in Journal of Lightwave Technology (2023)

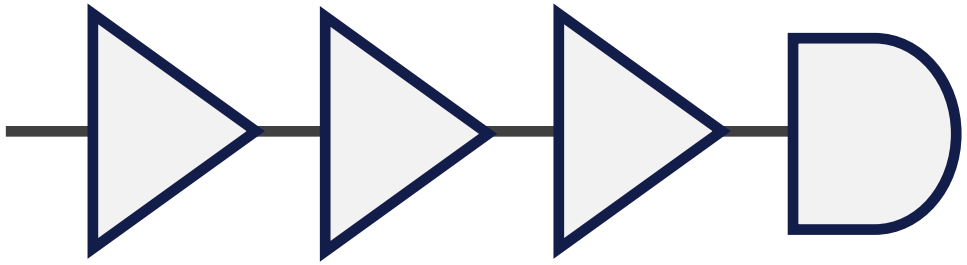
ARE THERE ANY REGIMES WITHIN WHICH PSA IS ADVANTAGEOUS?



K. Banaszek, L. Kunz, M. Jachura and M. Jarzyna, "Quantum Limits in Optical Communications," in Journal of Lightwave Technology, Vol. 38, No. 10 (2020)

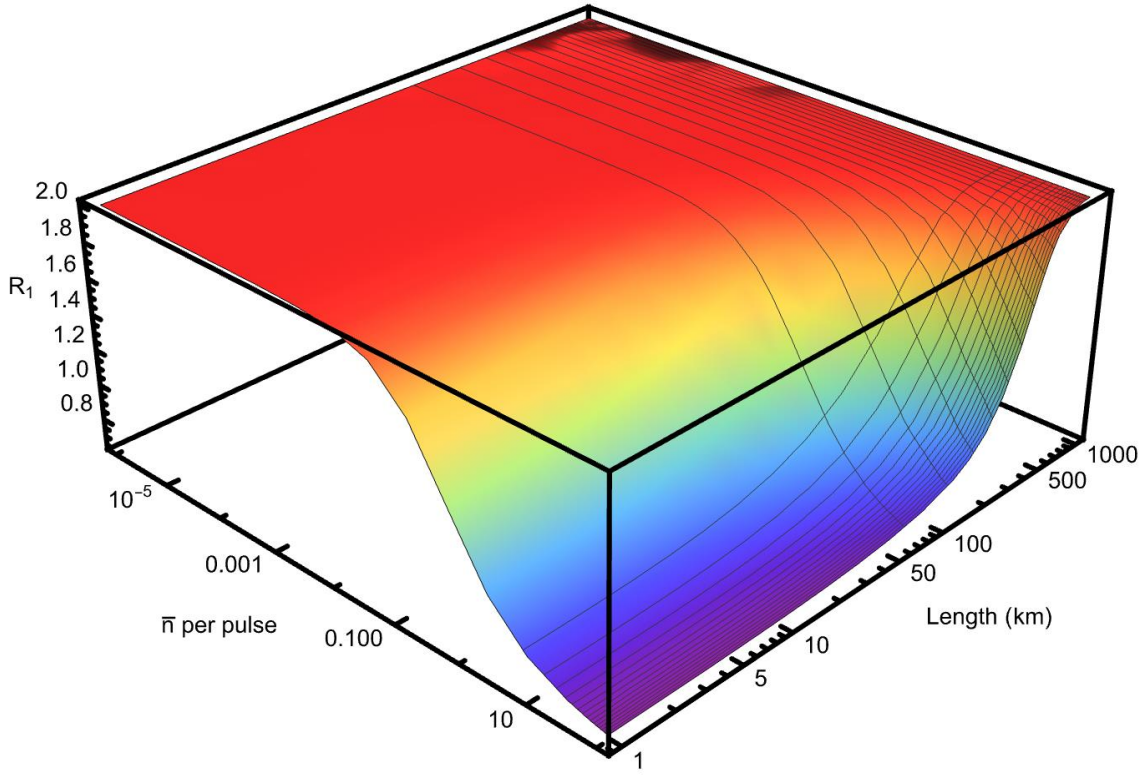
Shannon Limits

$$\frac{\eta n}{\eta + K(1-\eta)} \leq 2$$

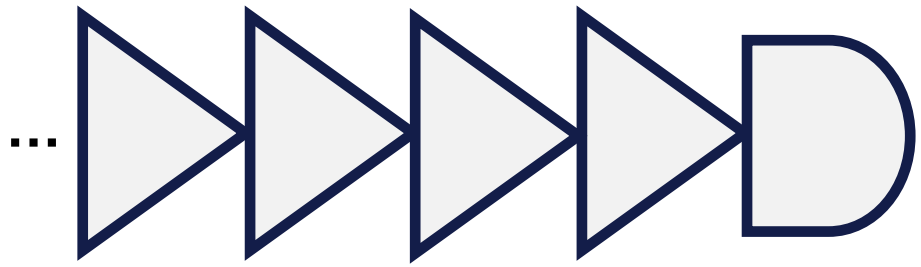


*example of a channel with 4 links

Ratio of the capacity of PSA channel to the capacity of PIA channel (4 links)

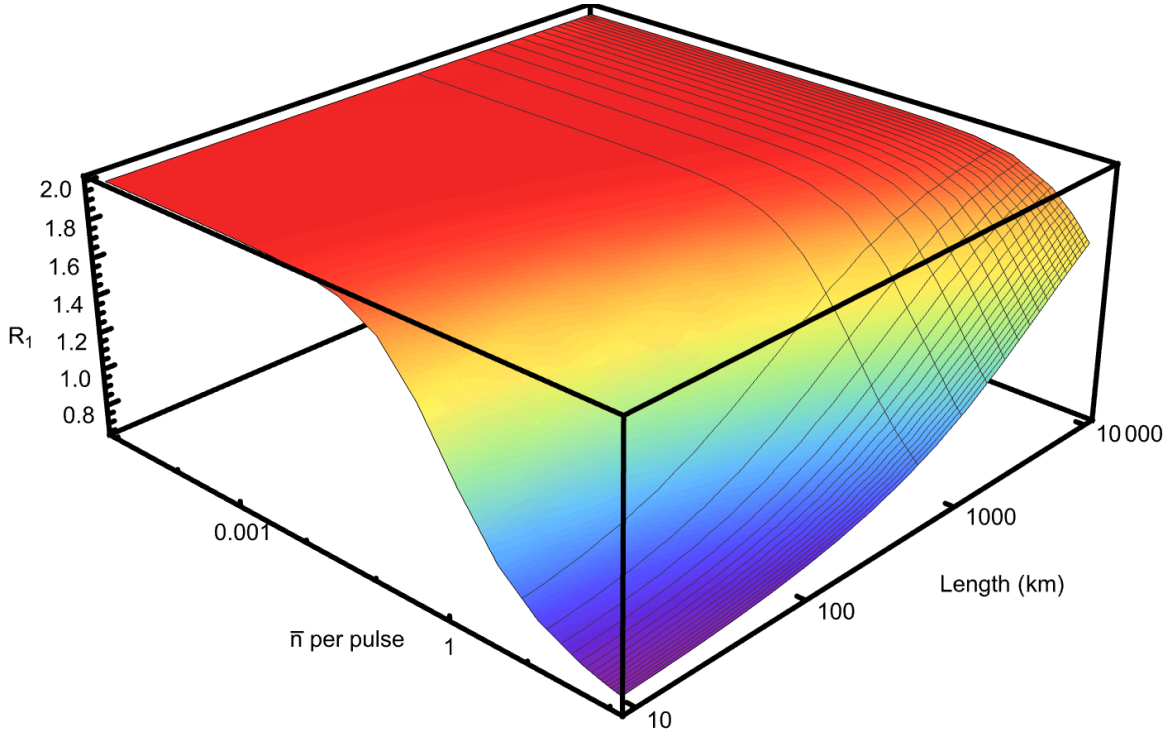


Shannon Limits

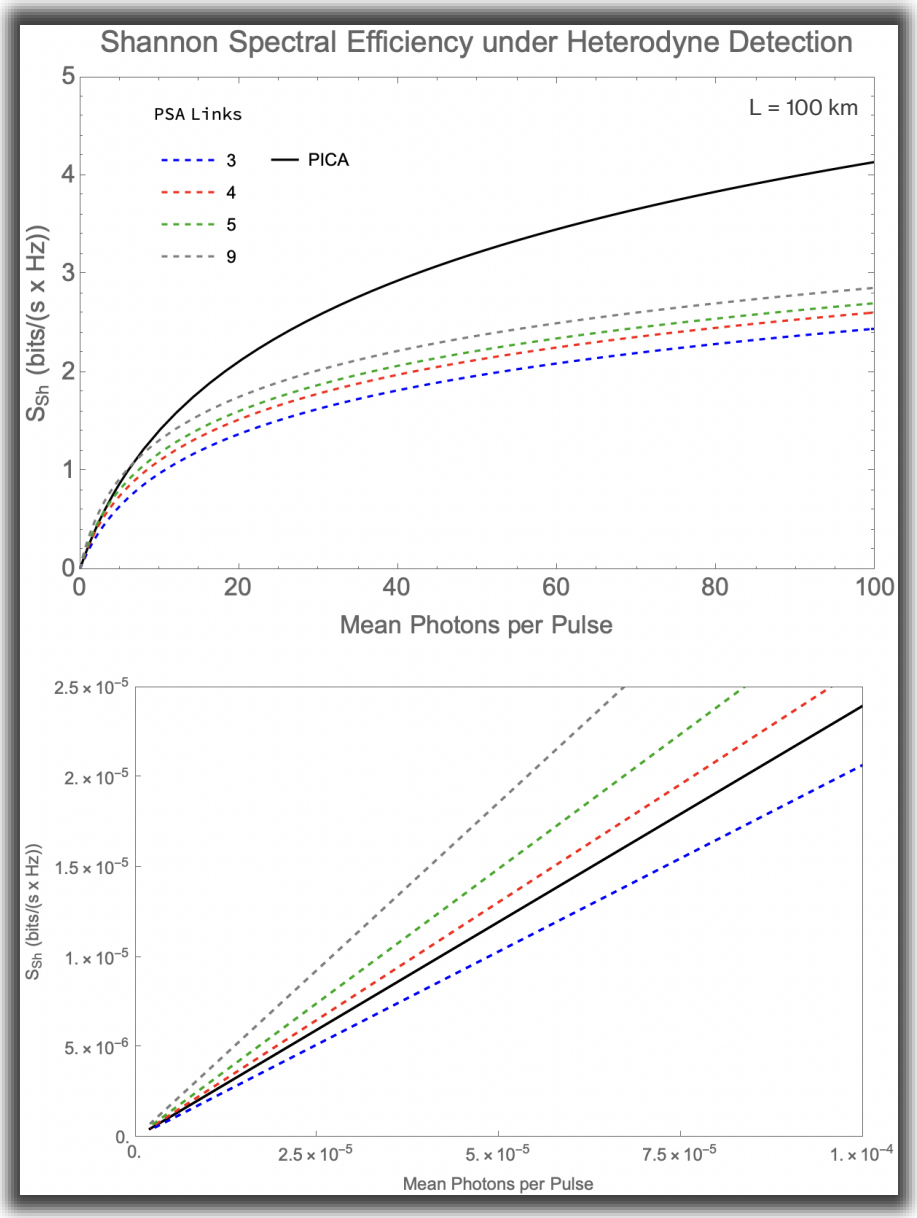


*continuous amplification

$$\frac{n}{1+\alpha L} \leq 2$$

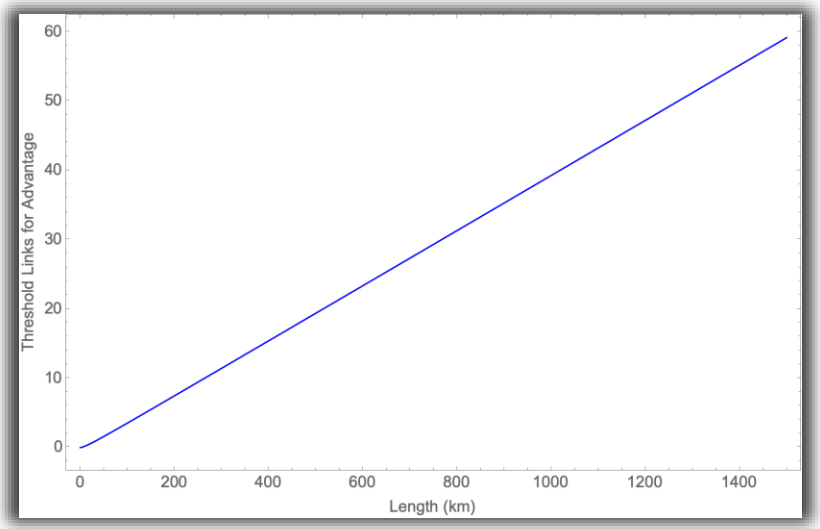


Ratio of the capacity of PSA channel to the capacity of PIA channel under continuous amplification



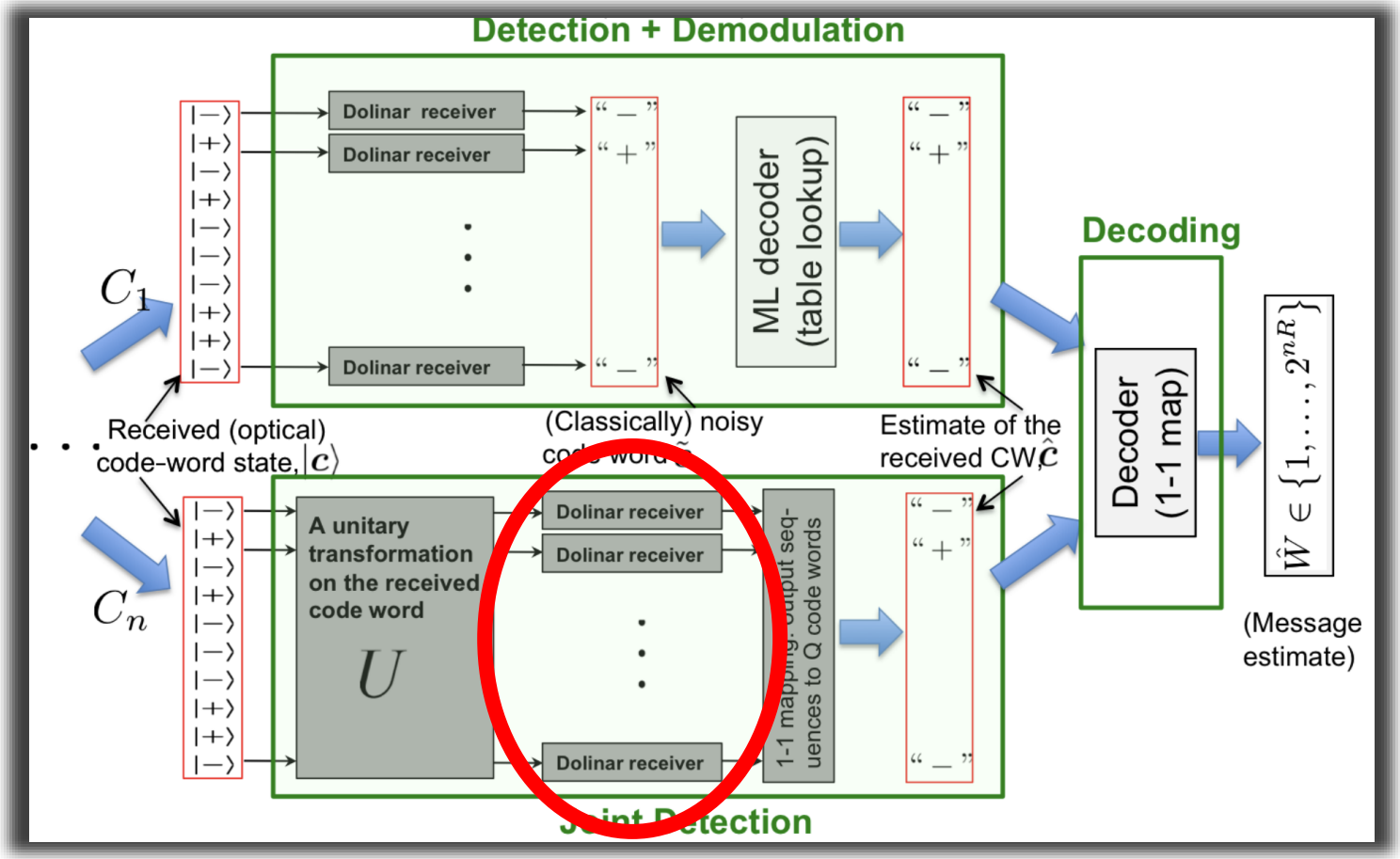
In the low photon regime, there exists a threshold value of the number of PSA links, after which phase-sensitive amplification obtains higher spectral efficiencies compared to phase-insensitive continuous amplification (PICA)

$$K_{thr} = \frac{-2\alpha^2 L^2 - \alpha L}{\alpha L + (2\alpha L + 1)\, W_{-1}\left(-\frac{\alpha L e^{-\frac{\alpha L}{2\alpha L+1}}}{2\alpha L + 1}\right)}$$

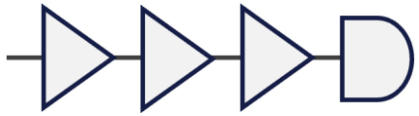


OPTICAL JOINT DETECTION RECEIVER

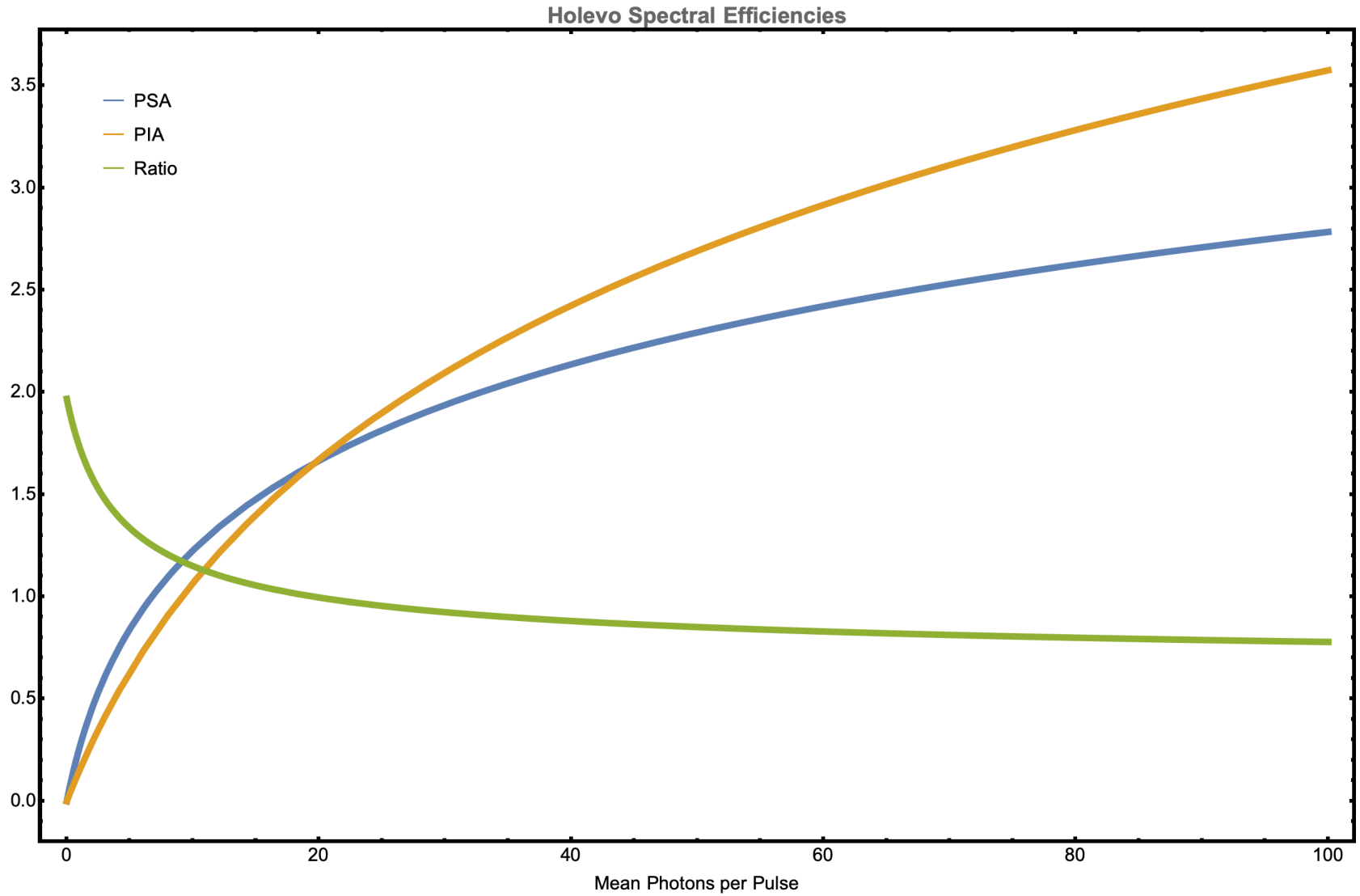
HOLEVO LIMITS

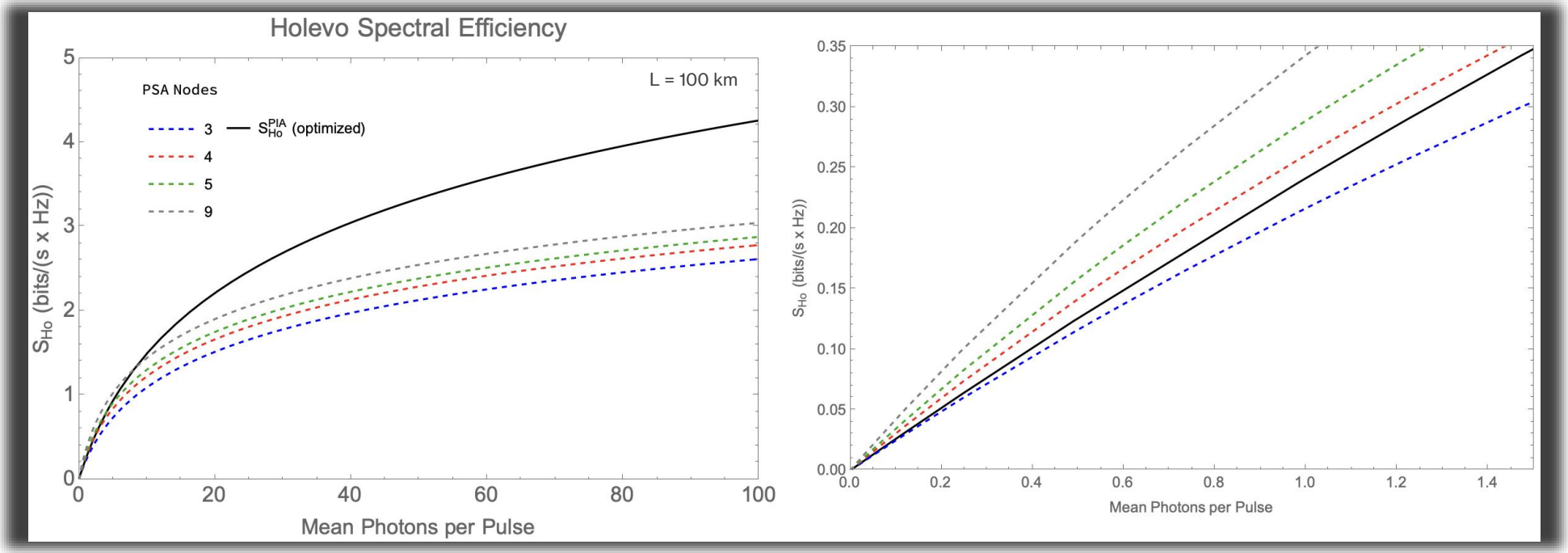


Saikat Guha, "Structured Optical Receivers to Attain Superadditive Capacity and the Holevo Limit", Phys. Rev. Lett. 106, 240502 (2011)



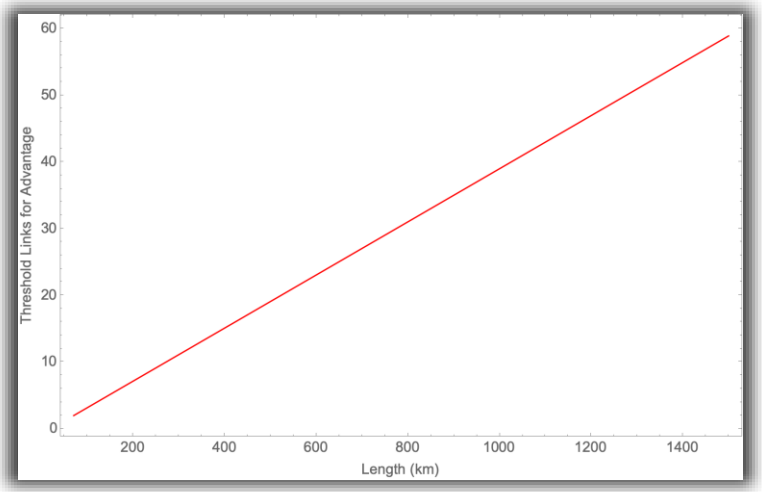
L = 100 km, 4 links





Minimum number of PSA links required to obtain advantage against PICA with Holevo detection in the low-photon regime

$$K_{thr} = 0.0398193\,L - 0.8091$$



Future Work

1. RECEIVER CONFIGURATIONS

2. EXPLORING ENTANGLEMENT ADVANTAGES