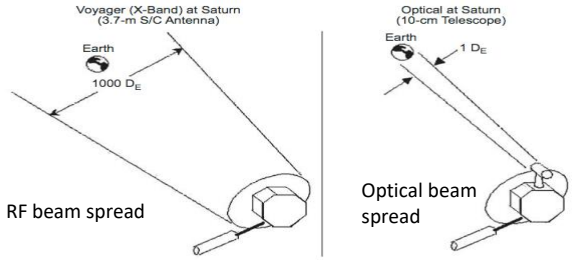
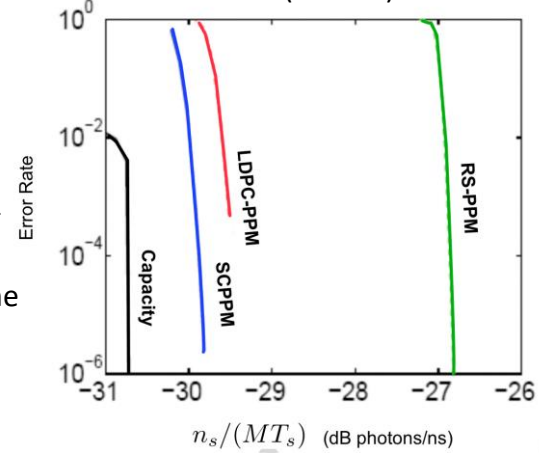
Deep Space Optical Communications at NASA and JPL

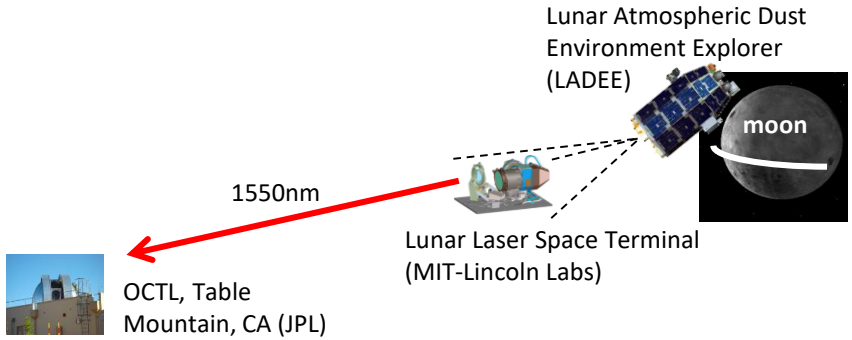
- Optical transmission features a much smaller beam spread compared to conventional Radio Frequency (RF) transmissions and therefore is a more power efficient option for high data rate deep space communications.
- Direct photon detection with a high-alphabet pulse position modulation (PPM) makes multiple-bit-per-photon optical communications possible.
- Efficient forward error correction codes are required.



- Bruce Moision (CMRR '99) and Jon Hamkins used PPM as an inner code in serial concatenation with a short constraint length outer code to create the Serially Concatenated Pulse Position Modulation (SCPPM) scheme.
- Simpler to implement,
- Outperforms both Reed-Solomon and Low-Density Parity-Check PPM, and
- Within one dB of the channel capacity



- Kevin Quirk (ECE '00) and Michael Cheng (CMRR '04) implemented the SCPPM receiver and decoder system.
- NASA's Lunar Laser Communication Demonstration (2013) downlinked data from the moon to California at a throughput of 78Mbps using the SCPPM coded modulation.
- CMRR's reach has extended to the moon.



- The spacecraft for JPL's Psyche mission (launch 2022, arrival 2026) plans to carry an optical communications system that would use SCPPM to uplink and downlink data.
- Psyche is an asteroid that orbits the Sun between Mars and Jupiter.
- CMRR's footprint does not stop at the moon.