Adaptive Compensation of Atmospheric Turbulence in Strong Scintillation Conditions with Hybrid RF Optical Communication System

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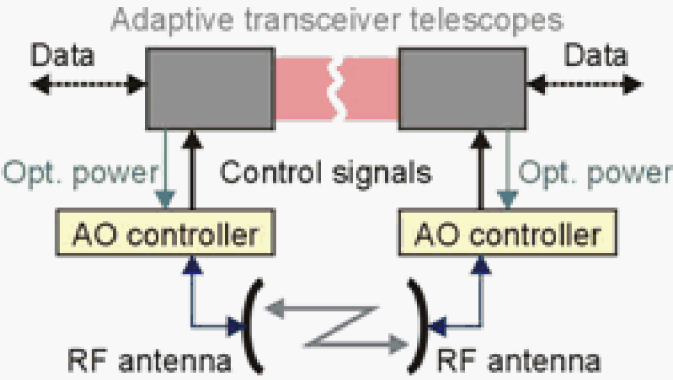
Sub-contractors:

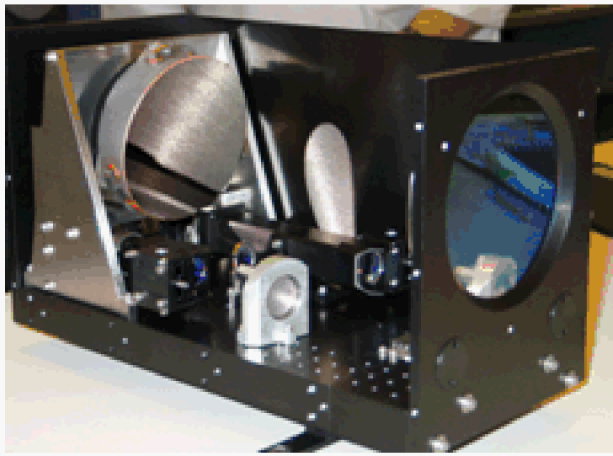
- University of Maryland

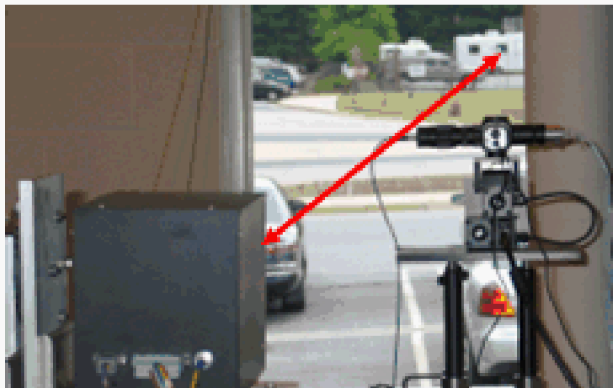
- NU-TEK Precision Optical Corporation

ORCLE: ARL Team Accomplishments

- Developed novel adaptive optics approach for mitigation of atmospheric turbulence effects in FSO links based on:
  - Model-free stochastic parallel gradient descent (SPGD) optimization technique. SPGD approac works under strong scintillation conditions
  - Cooperative control of two adaptive transceiver antennas using RF link
- Developed compact, light-weight optical transceiver telescope with integrated adaptive optics elements:
  - Fiber-tip positioning actuators for tip/tilt control (2kHz bandwidth)
  - Low-resolution (6-13 control channels) adaptive tertiary mirror (10kHz bandwidth)
- Demonstrated significant improvement of FSO link in short-range outdoor experiment

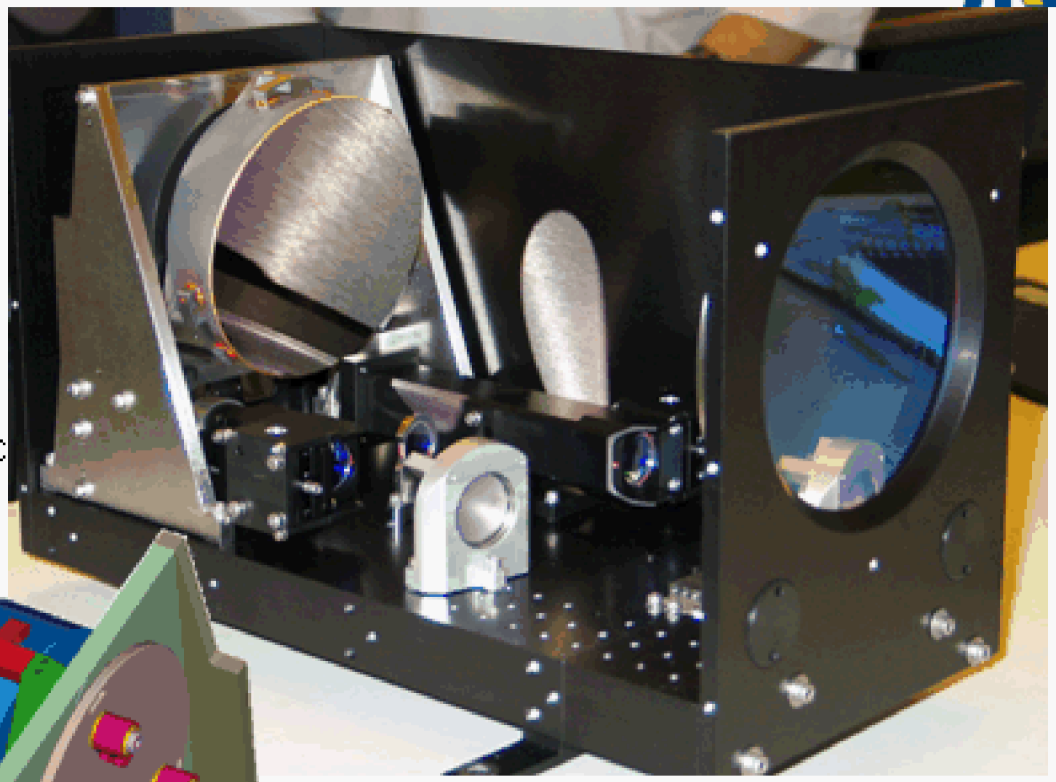


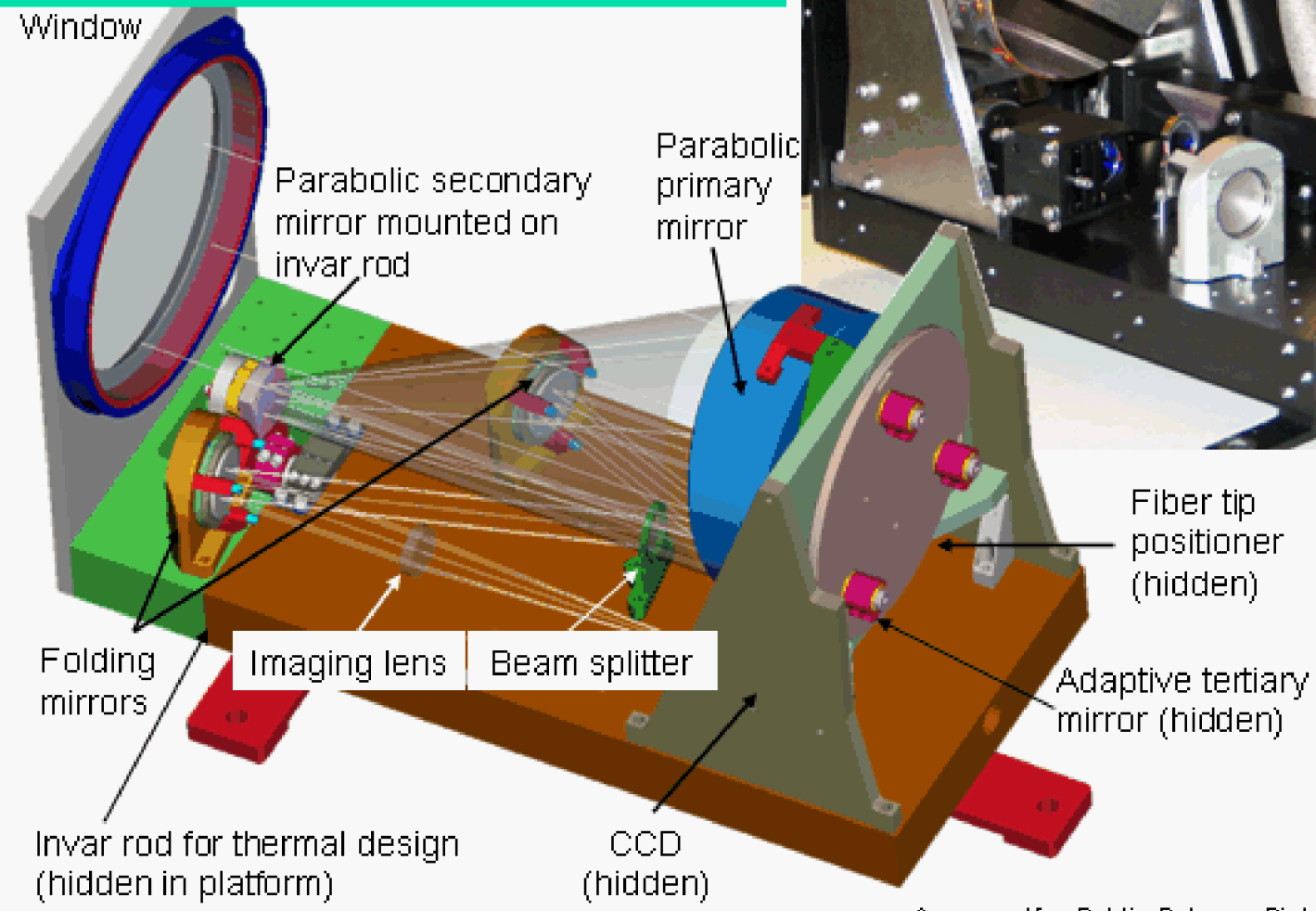




Cooperative Adaptive Transceiver (CAT)

Compact (100 mm aperture) adaptive laser com transceiver telescope with capabilities for target imaging and adaptive compensation of turbulence Induced phase aberrations.

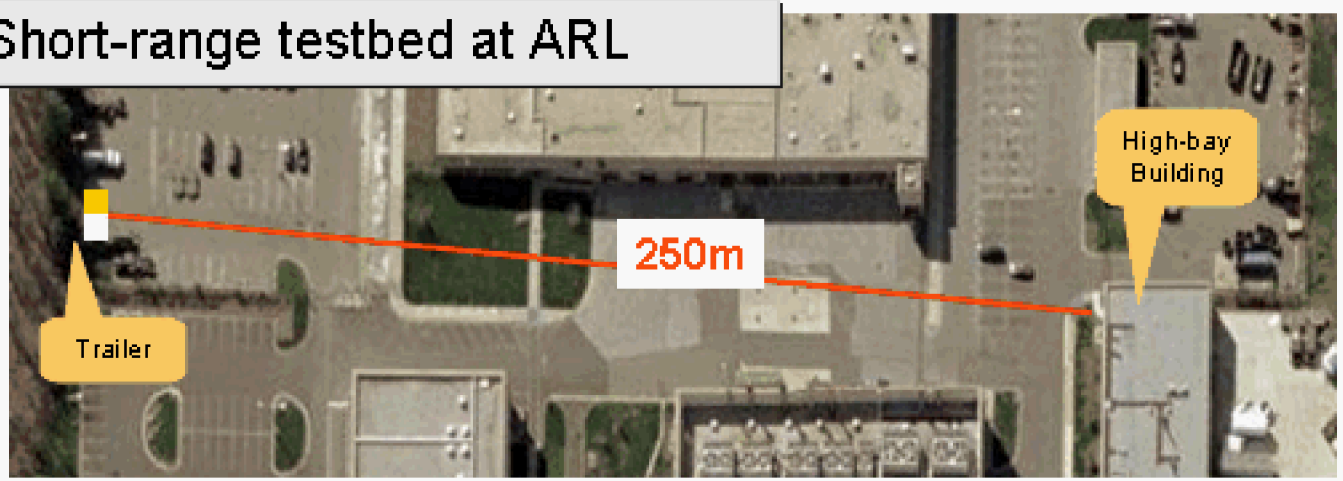


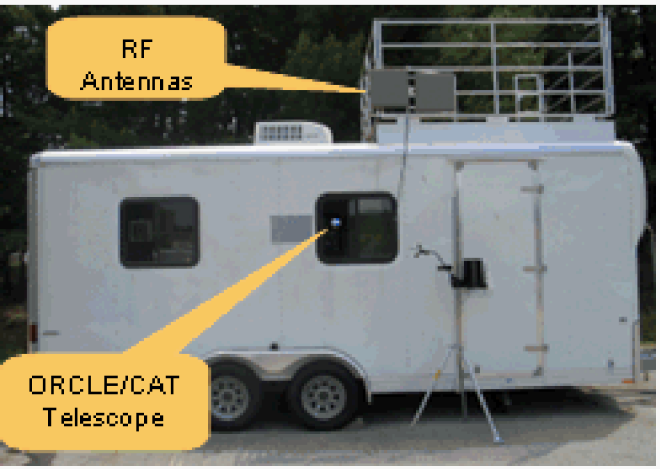


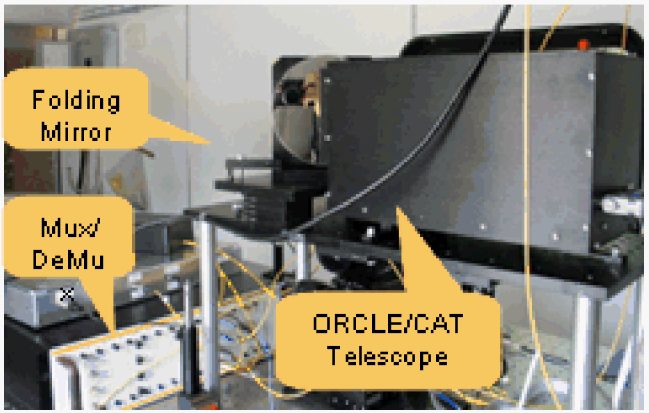
Atmospheric Evaluation

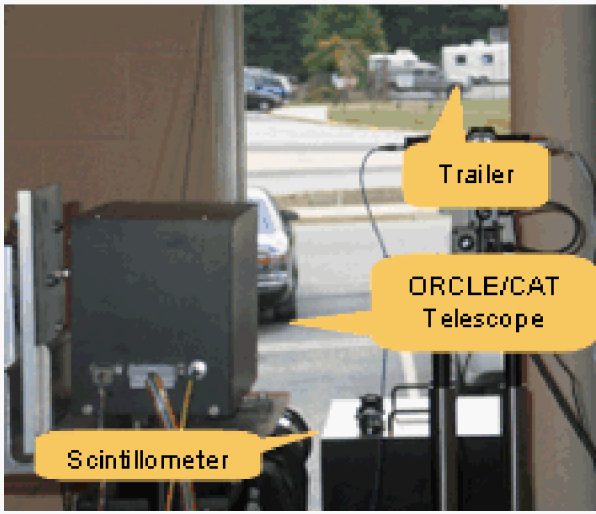
- WDM (2×2.488 Gb/s) free space link over 250 m & 500m optical paths (2 m above the parking lot)
- Typical $C_n^2 \sim 10^{-13}$ $m^{-2/3}$, Intensity scintillation index >1.0

Short-range testbed at ARL

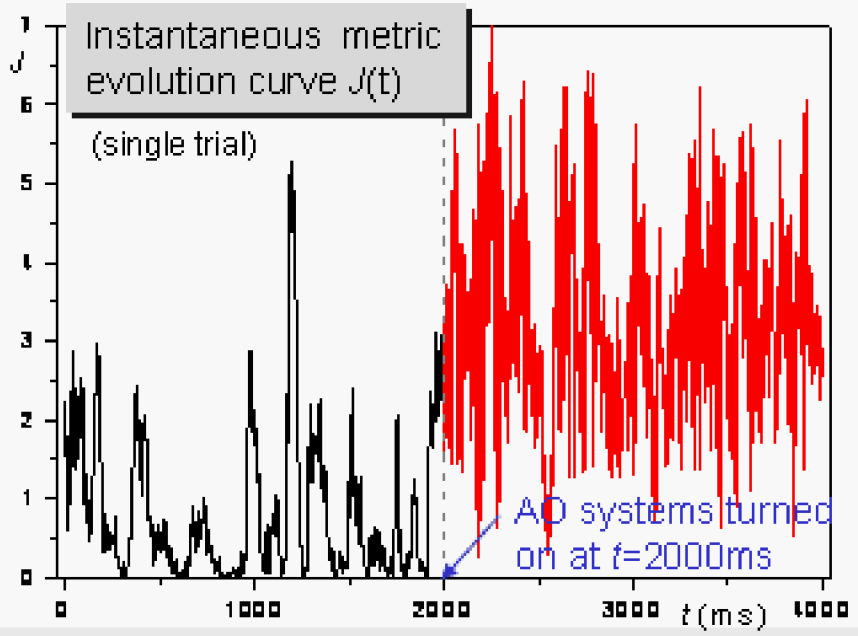


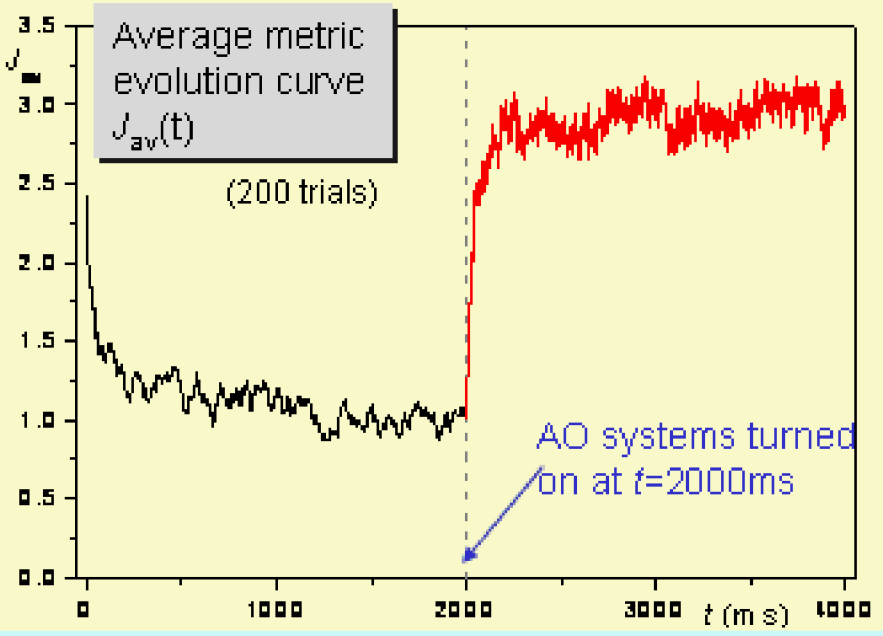


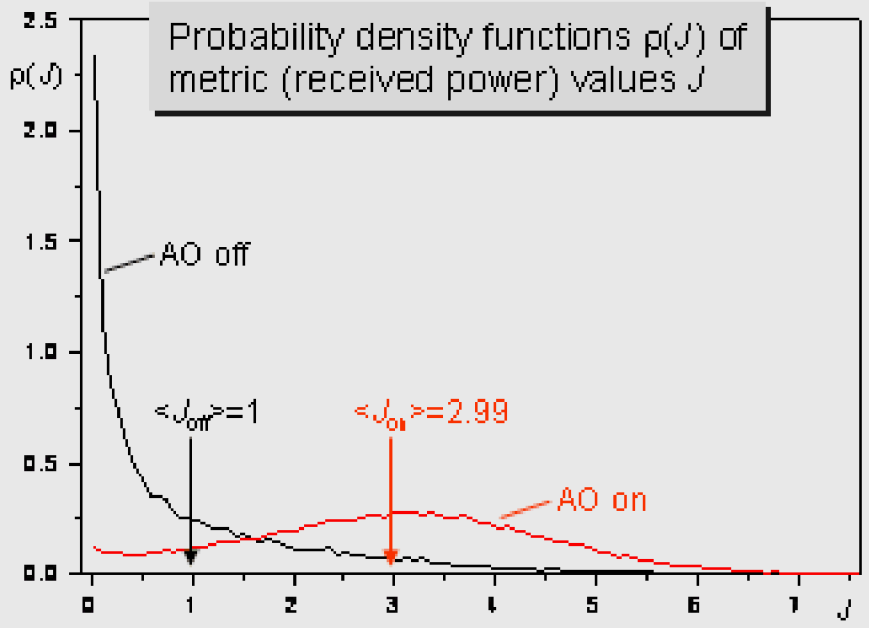


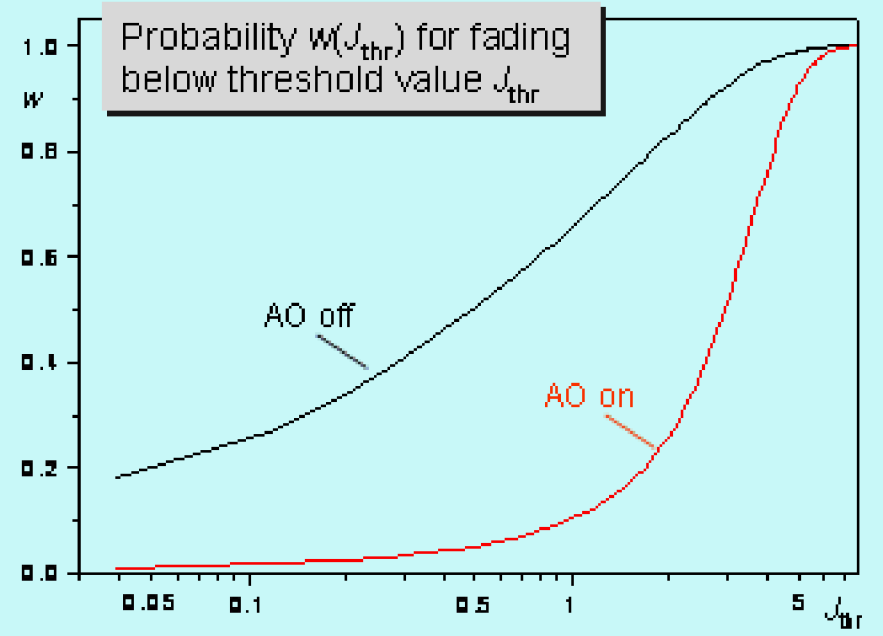


Atmospheric Compensation with CATs



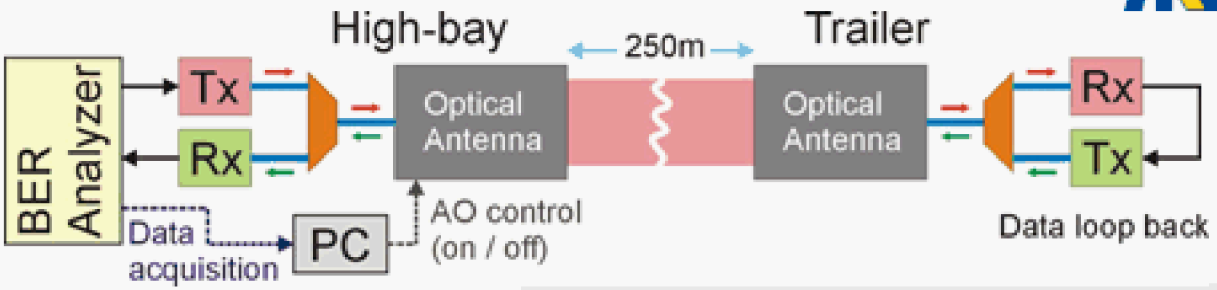


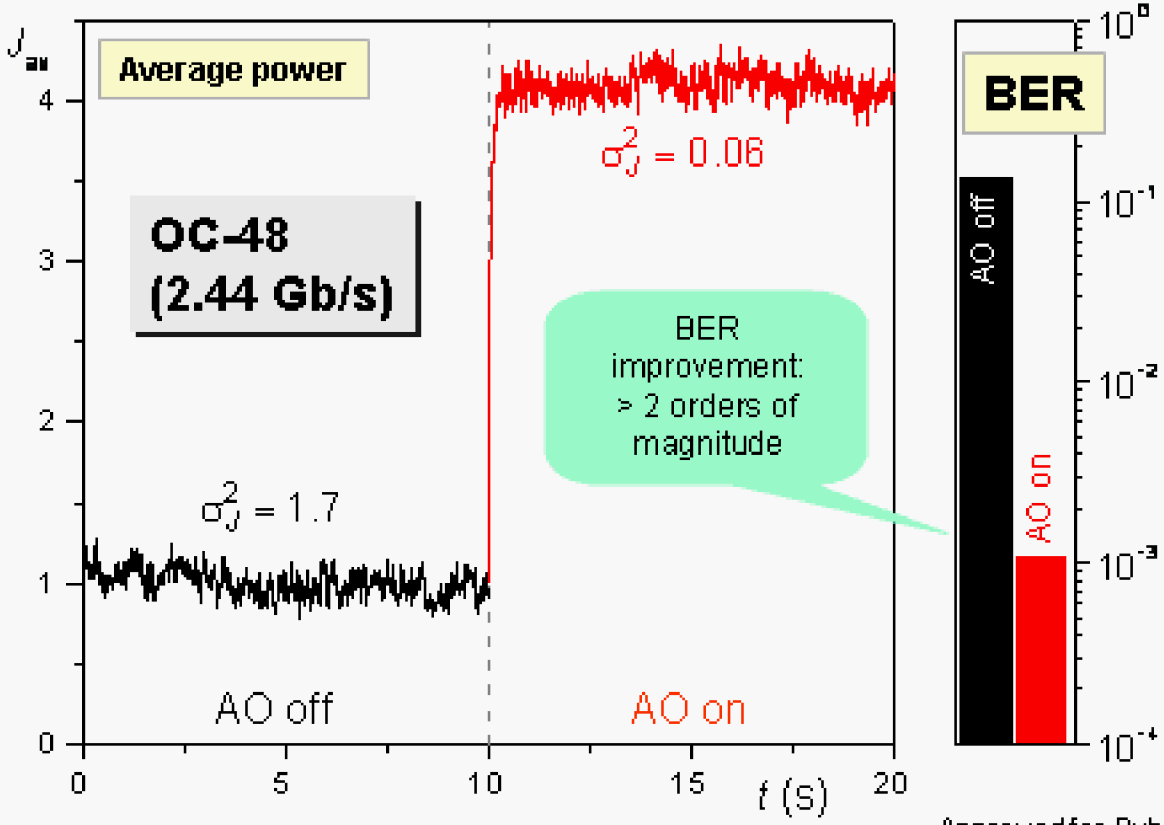




Bit-error-rate (BER) Analysis

- Loop-back data transmission between two transceiver modules (high bay ↔ trailer)
- AO of high-bay transceiver is turned on and off
  - Bit-error rate is measured for both cases





- Transmitted power level ~50μW
  - lowered to achieve reasonable bit error numbers within acceptable time frame
- Average $C_n^2 \sim 5\times10^{-14}$ $m^{-2/3}$
- Wind speed ~ 1 m/s
- Metric scintillation index

$$\sigma_J^2 = \frac{\langle J^2 \rangle}{\langle J \rangle^2} - 1 = 1.7$$

for uncompensated case