ADAPTIVE OPTICS TESTBED FOR PRE- AND POST-COMPENSATION OF EARTH-TO-GEO OPTICAL COMMUNICATION - DOWNLINK RESULTS

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taken from:
Atmospheric distortion and adaptive optics mitigation

- Atmosphere introduces phase distortions in the optical beam
  - Beam wander
  - Speckles
- Adaptive optics can reverse atmospheric distortions
- Other groups have shown: Correction of downlink beam, e.g. T-AOGS Earth-to-GEO and Earth-to-LEO communication
Post- and pre-compensation

- Post-compensation: correct after turbulence distortion
- Pre-compensation: distort beam before turbulence ➔ ideal profile after turbulence
- Point-ahead angle (PAA): uplink/dowlink propagate through different turbulence
- For efficient pre-compensation PAA should be smaller than isoplanatic angle
Idea of our testbed

- Down-sized baseline scenario
- Simultaneous post- and pre-compensation of turbulence

- Single phase screen turbulence
- Aperture stop, TT, DM & WFS are in conjugate planes
- Lateral shift of uplink source leads to point-ahead angle at aperture

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Setup

- Achromatic optical design
- High-power deformable mirror
- Custom wavefront sensor: high-speed InGaAs camera with micro lens array
- Rotating turbulence plate
- Real-time control loop
Results of uplink beam

- Without control: beam wanders with strong scintillation
- With control: more defined spot with some residual beam wander

\[ S = 0.04 \pm 0.04 \] (without control)
\[ S = 0.48 \pm 0.17 \] (at Earth-to-GEO PAA)

Results of downlink beam - Beam wander

- Cumulative distribution function (CDF)
- CDF(\(\beta\)): proportion of measurements with beam wander \(\leq \beta\)
Results of downlink beam - Strehl ratio

- Strehl ratio (including tip/tilt) ~ received light in a fiber
- w/o control: \(6,4 \pm 6,4\) %
- w control: \(60 \pm 19\) %.
Differences between uplink and downlink performance

- Controller reference strongly influences quality of uplink/downlink corr.
- Uplink beam shows more beam wander and overall lower Strehl ratio

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![Graphs showing uplink and downlink performance](image)

Conclusion and Outlook

- Adaptive optics testbed for pre- and post-compensation
- Investigation of point-ahead angle
- Differences in uplink and downlink performance

- Optimization of controller reference
- Upgrade to transportable system for free-space testing
  ➔ poster 231 by René Berlich

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Outlook transportable system