cailabs

Aerospace & Defense

Making laser satcom as routine as radio, even through the atmosphere

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TILBA Business Development Manager Europe

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cailabs | Shaping the Future of Light

Mastering & Shaping the Future of Light since 2013

3
Locations Worldwide
France & USA

7
OGS under contract

+110
Employees

+40
Engineers & PhDs

46 M€
Raised

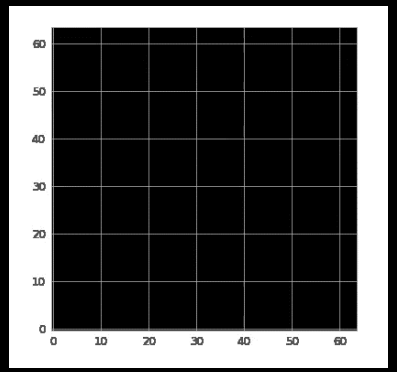
26
Patent Families

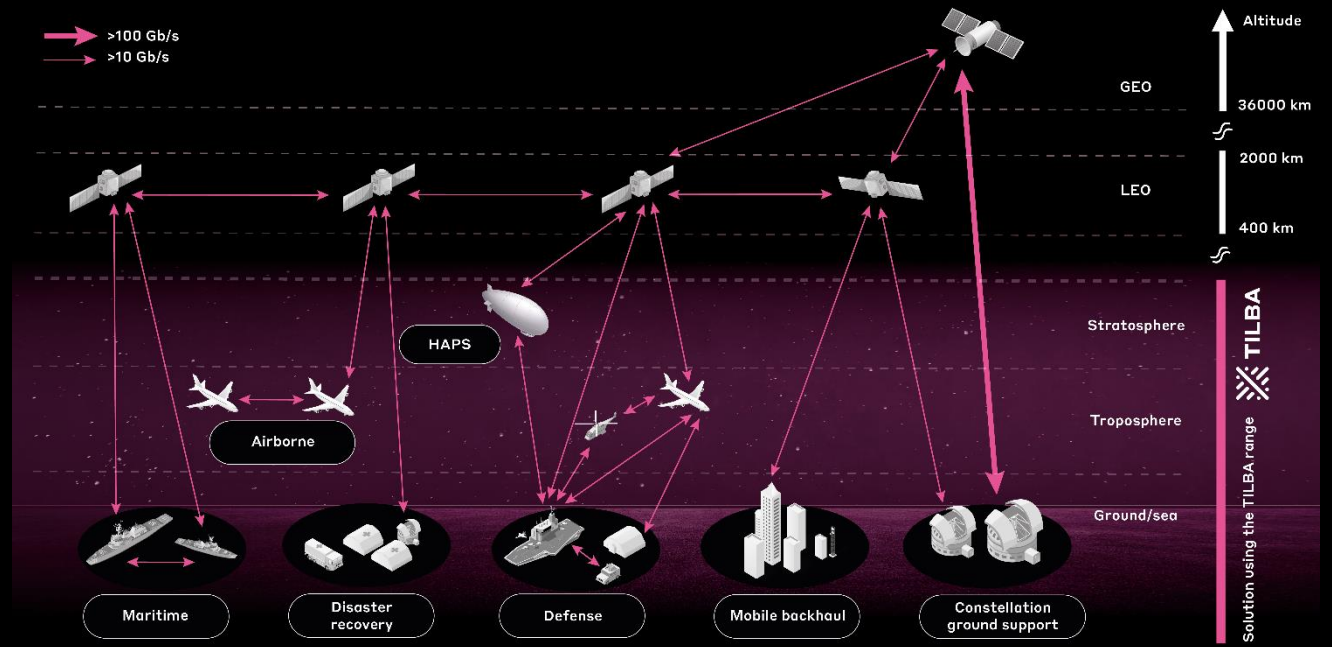
Laser communication holds three major promises
But requires atmospheric turbulence mitigation

FAST
100+ Gbps achievable

SECURE
Low probability of interception and detection

LICENSE-FREE
Unlicensed communication spectrum



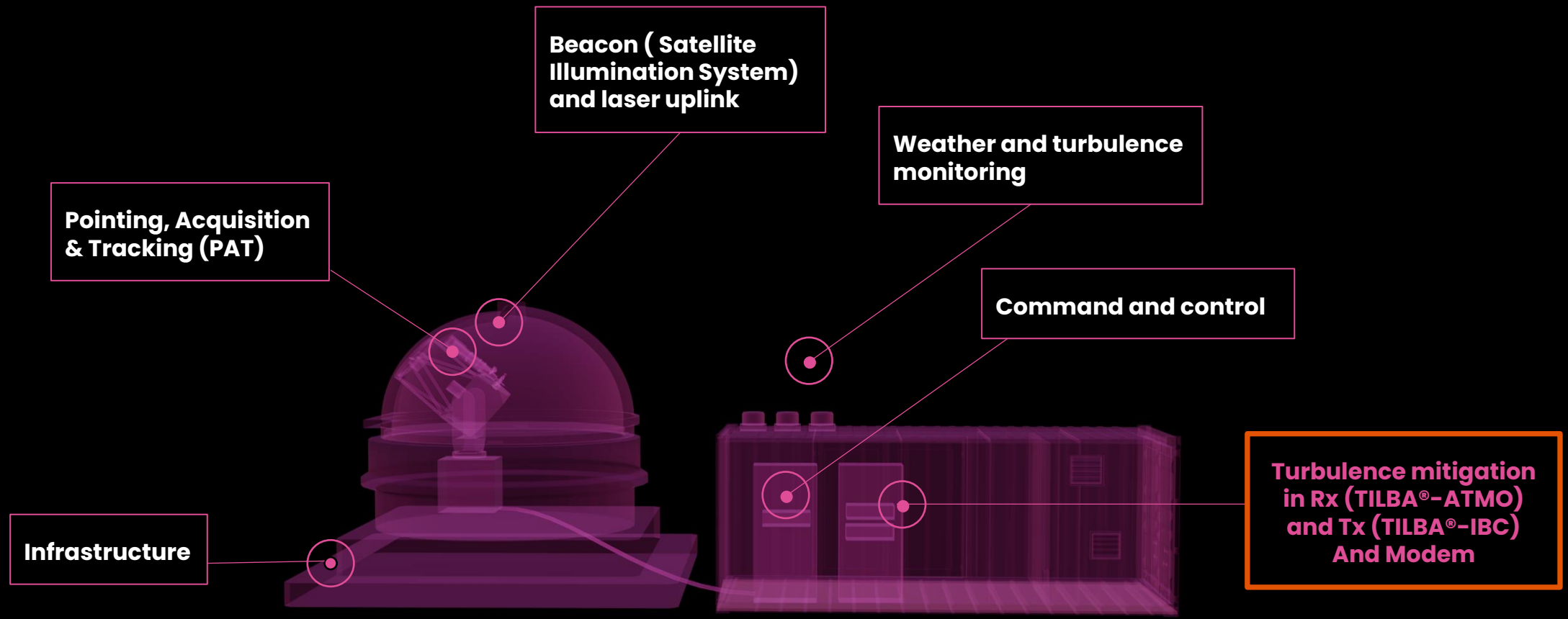


TILBA®-OGS

For space-to-ground satcom

- Turnkey Optical Ground Station
- Bidirectional 10+ Gbps links
- CCSDS and SDA compatible

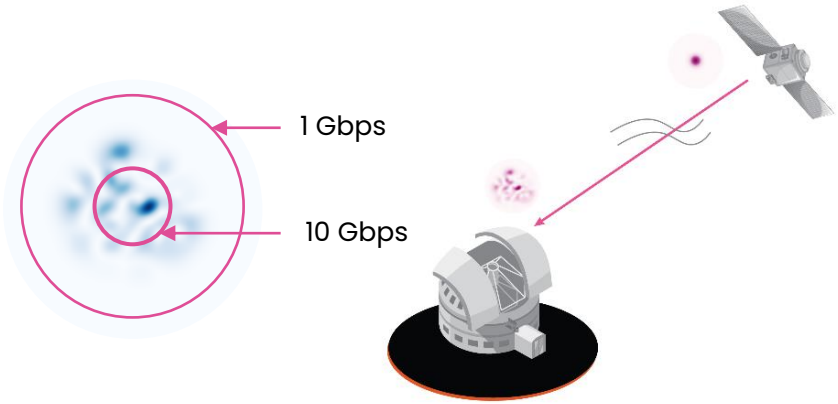
Architecture of an Optical Ground Station



Turbulent beams must be corrected to cancel the impact of the atmosphere

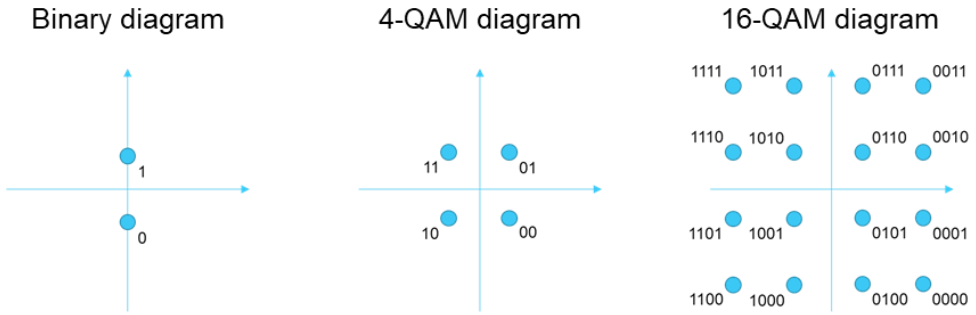
Lasercom is competitive with RF at high throughput (> 10 Gbps) where single mode fiber coupling is a must

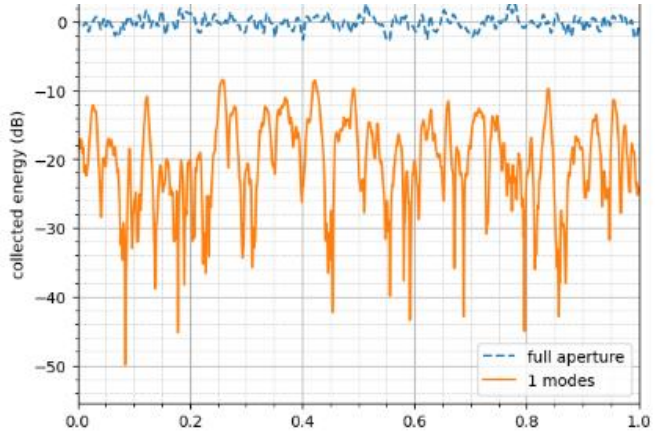
- To use small **high SNR detectors**
- To enable **coherent modulation**
- To unlock the use of **EDFAs** for signal amplification



Atmospheric turbulence has a strong impact on communication

- Uncorrected turbulence causes frequent **deep fading**
- Inefficient SMF coupling leads to **signal loss**





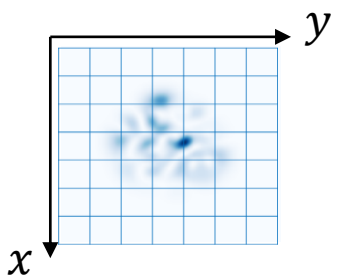
Two approaches coexist for Satcom
Astronomy values image quality; Satcom values correction speed

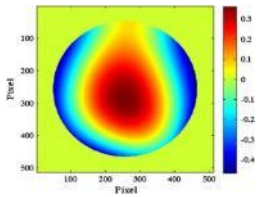
Typical Turbulence Mitigation Method

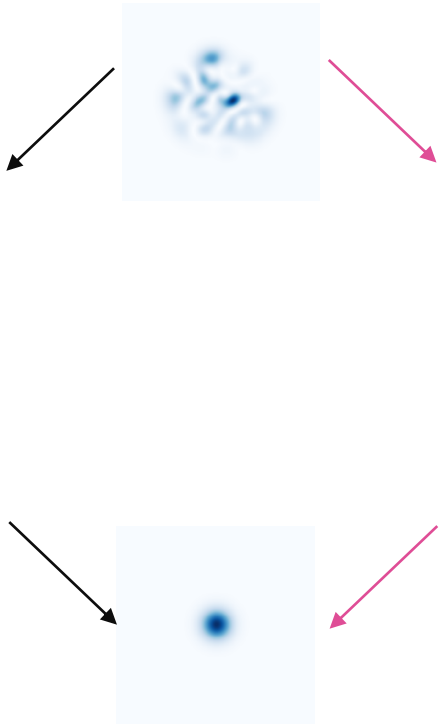
ADAPTIVE OPTICS

Zernike decomposition of the phase

Cartesian phase compensation







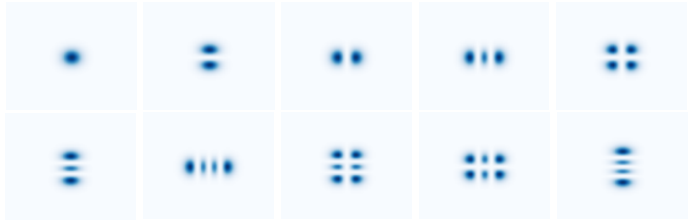
Cailabs Turbulence Mitigation Method

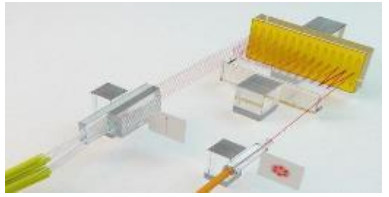
SPATIAL DEMUX

Spatial mode decomposition of the field

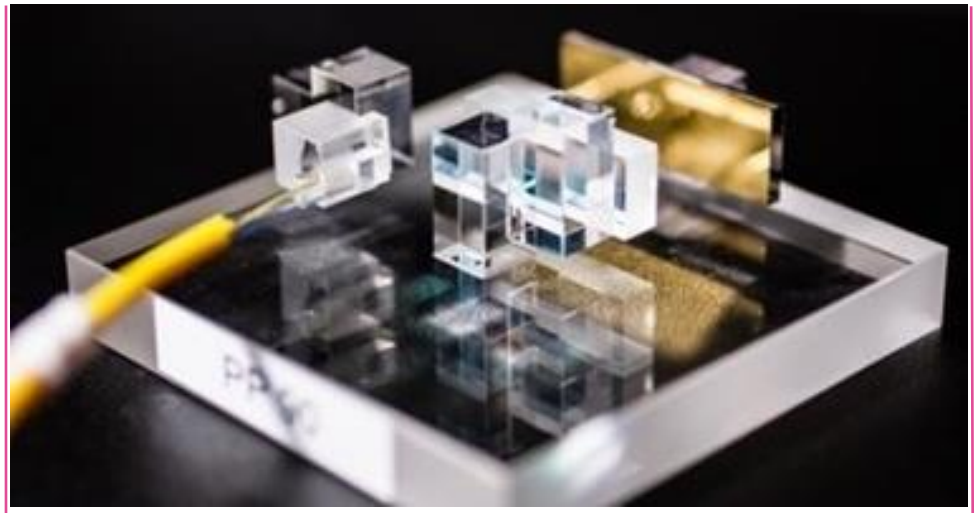
All-optical recombination

$$\sum \alpha_{n,m} \mathrm{HG}_{n,m} e^{i\psi_{n,m}}$$

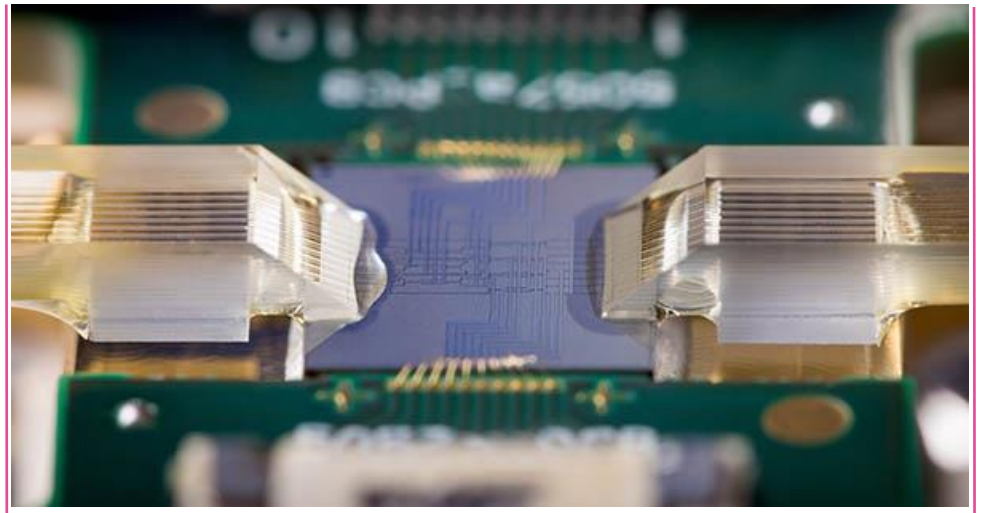




Space mode demux leverages 2 state-of-the-art technologies

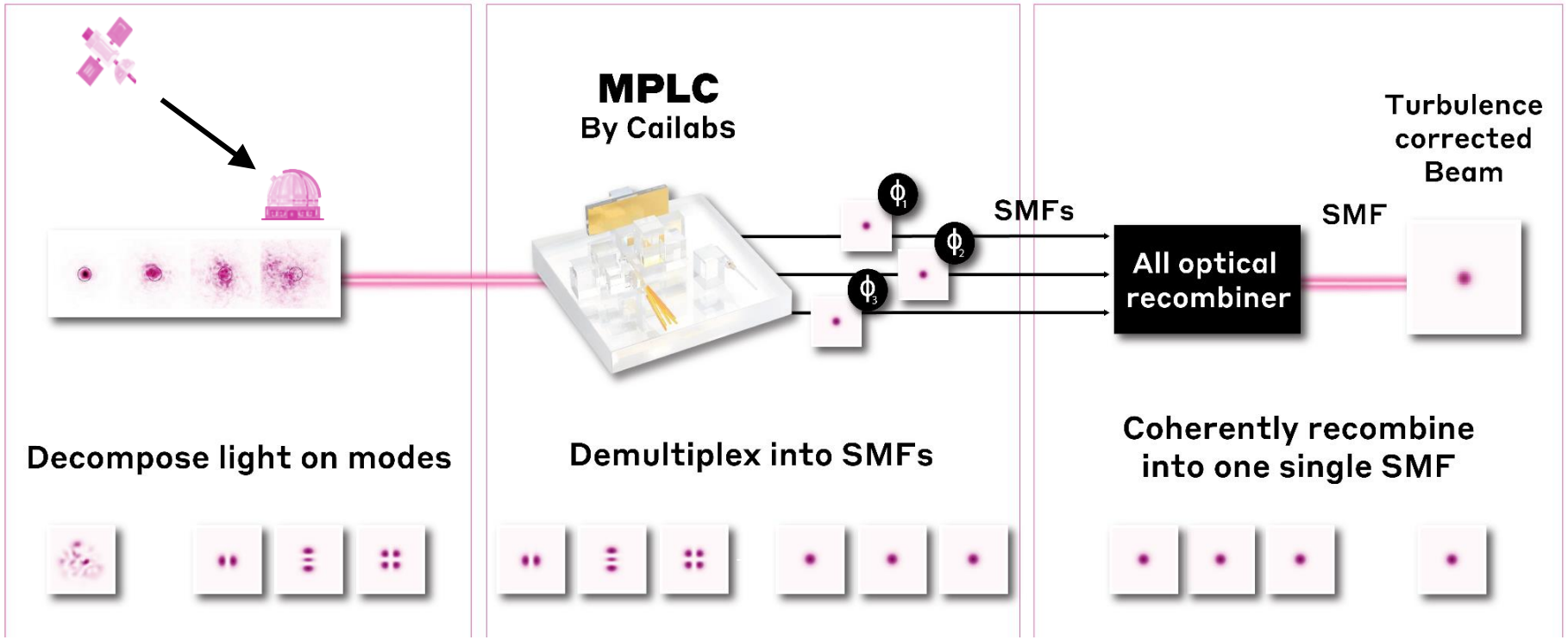


Multi-Plane Light Conversion (MPLC)

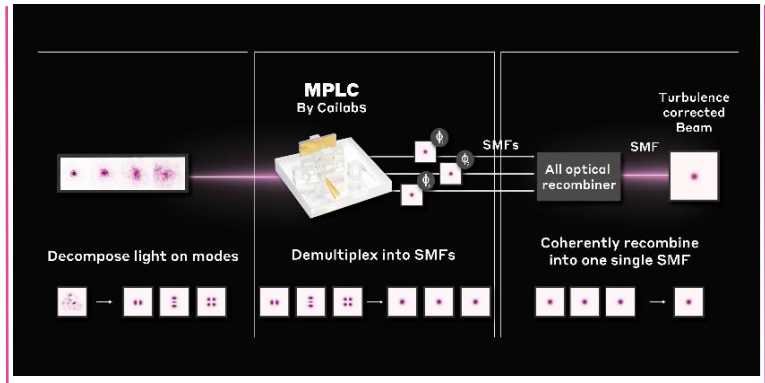


Photonics Integrated Chip

The synergy of the two enables turbulences mitigation



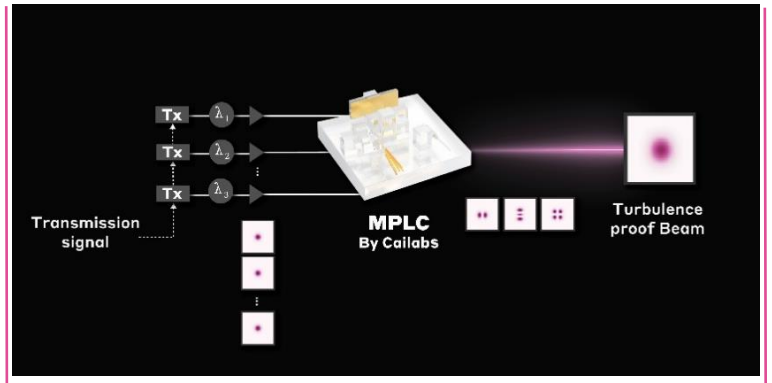
Building blocks
Leveraging Cailabs' patented MPLC core technology



TILBA®-ATMO

Rx turbulence mitigation without adaptive optics

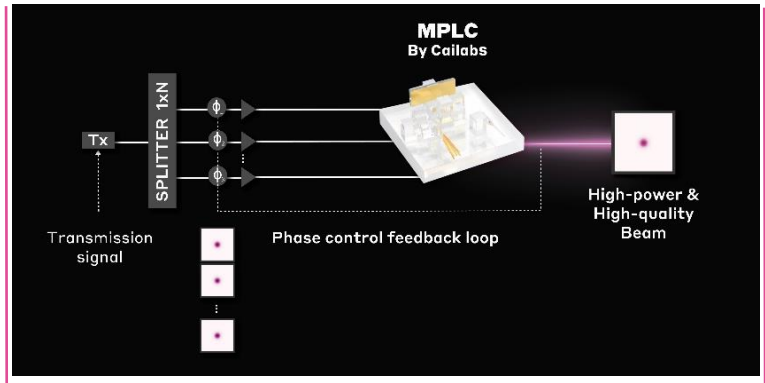
- 45-mode recombining
- 10+ kHz bandwidth for strong turbulence correction
- No moving parts



TILBA®-IBC

Incoherent Beam Combining for Tx turbulence mitigation

- Single-device spatial diversity
- Suited to OOK transmission
- Proven at high power

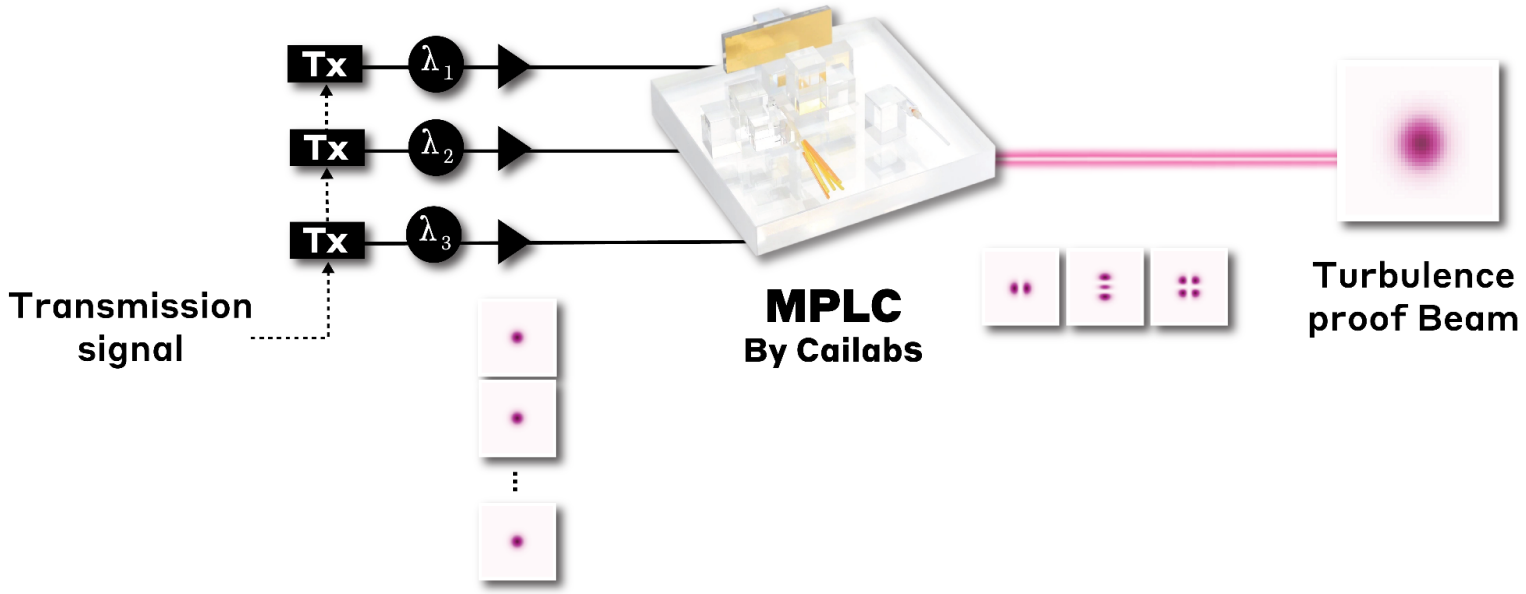


TILBA®-CBC

Coherent Beam Combining for high-power Tx

- >100W per channel
- >80% combination efficiency

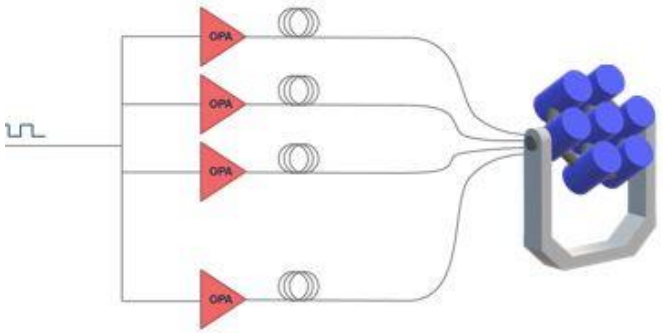
TILBA®-IBC architecture can be used for OOK transmission in LOS links and ground-to-sat optical feeder links



FSO beams can be made more robust to turbulence through spatial diversity

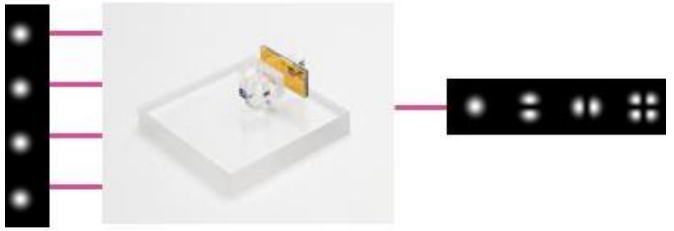
Spatial diversity: using multiple apertures generating uncorrelated turbulent channels to reduce fading probability

- Usually performed with multiple telescopes or multiple sub-pupils of a telescope
- Difficult to co-align a large number of emitters



TILBA-IBC: spatial diversity based on incoherent combination of spatial modes generated by MPLC

- Same outage probability decrease
- A single device to co-align the emitters
- A proven technology at high-power for non FSOC applications: multi-kW handling for laser material processing and directed energy weapons

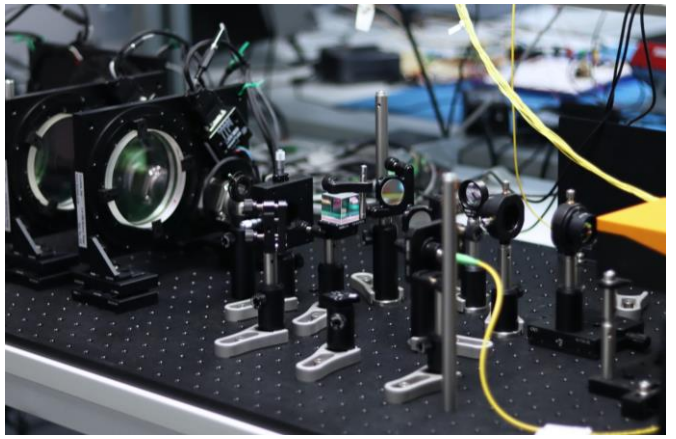


Results & Going forward

TILBA®-ATMO is validated experimentally

In the lab: Coherent and high data-rate links

- Validation on a turbulence emulation bench
- 100 Gbps DP-QPSK demonstration
- 50 Gbps NRZ demonstrated on recombining unit
- 10 Gbps DPSK



In the field: Ground-to-ground demonstration

- 200 m – 10 Gbps link in Cailabs
- 1 km – 10 Gbps link in Cailabs
- 10 km CW power link in partnership with the DLR
- 2.5 km – Lasercom Terminal to Cailabs OGS

Keraunos project

- Partnership with Unseenlabs
- Backed by French MoD
- Satellite launched end 2023
- First light Q3/24
- OGS is functional

Confirmed successes and industrialisation process

7 OGS sold

1st pilot OGS for French MoD-backed Keraunos LEO-ground demo

CCSDS compatible, SDA upgradeable OGS to be installed in Western Australia

SDA & QKD-compatible OGS to be installed in Korea

3 OGS for Greek Connectivity

2nd pilot OGS and associated CONOPS

3 structuring projects

Accelerate development of OGS, on-board terminals and laser LOS

Optical architecture proposal for the IRIS² constellation

Development of a coherent combiner for optical feeder links

What do we need from the EPIC & ESA community?

- Demonstrate Interoperability with LCTs and modem manufacturers
- Foster synergies between laser comms and QKD projects

- Ship-Ship is just starting (French DoD, major OEM)
- Aircraft / Drone, partnerships for airbone laser communications
- Others ? TBD

Thank you for your attention!

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