UNSW CANBERRA

Never Stand Still

COAT Workshop, ONERA, Paris, France 2-3 December 2019

Experiments in Free Space Laser Communications

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space UNSW CANBERRA

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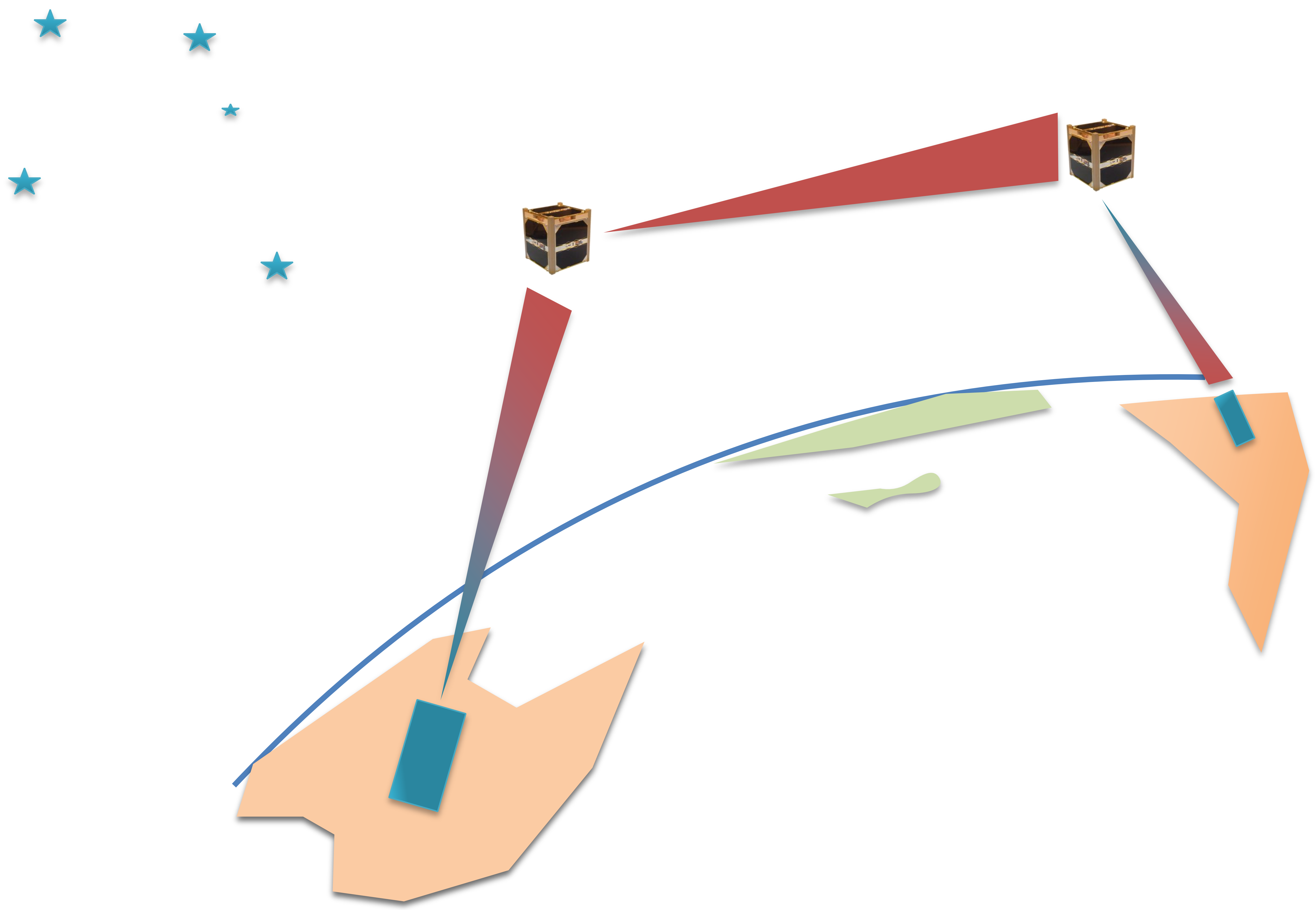
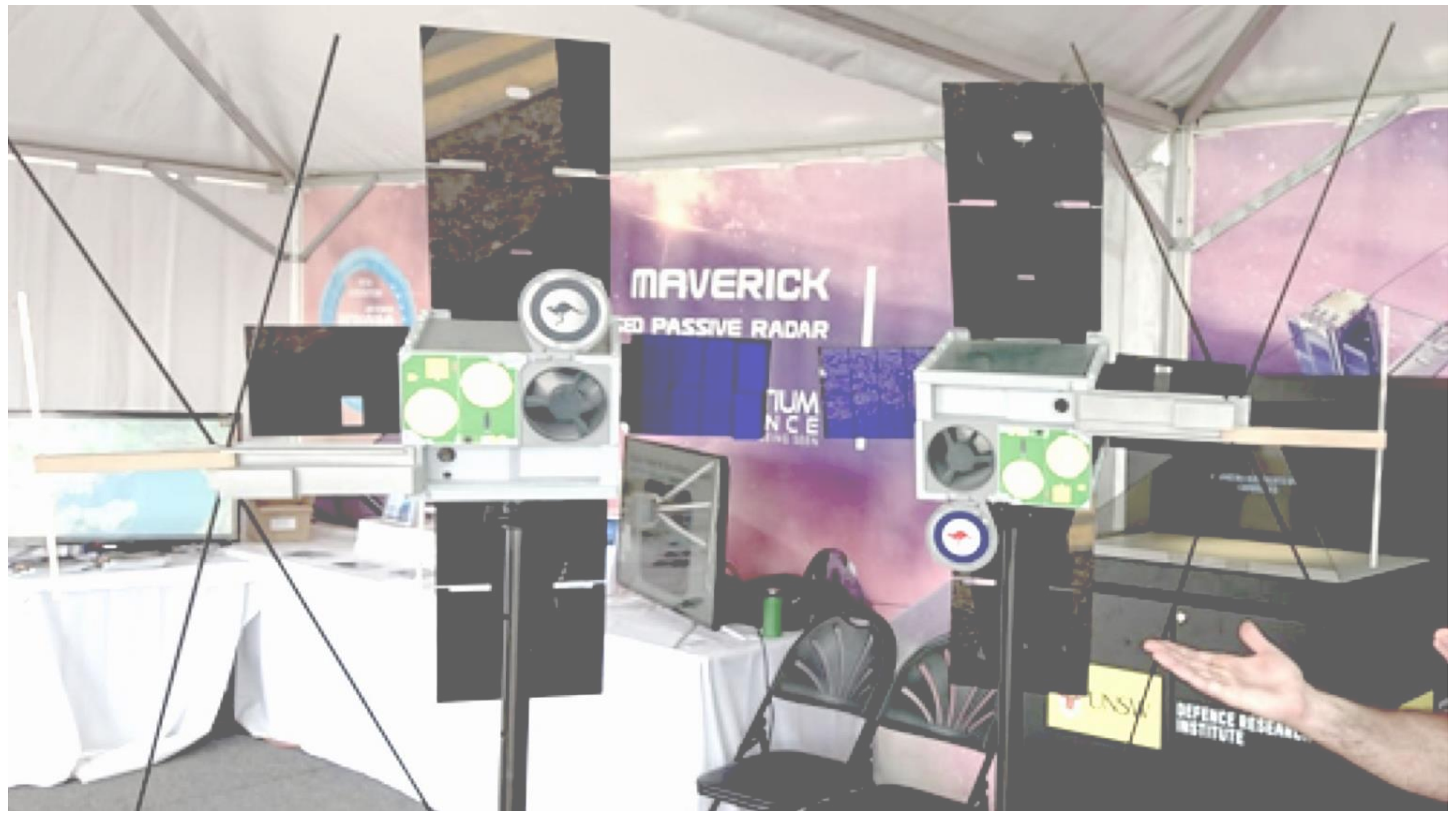
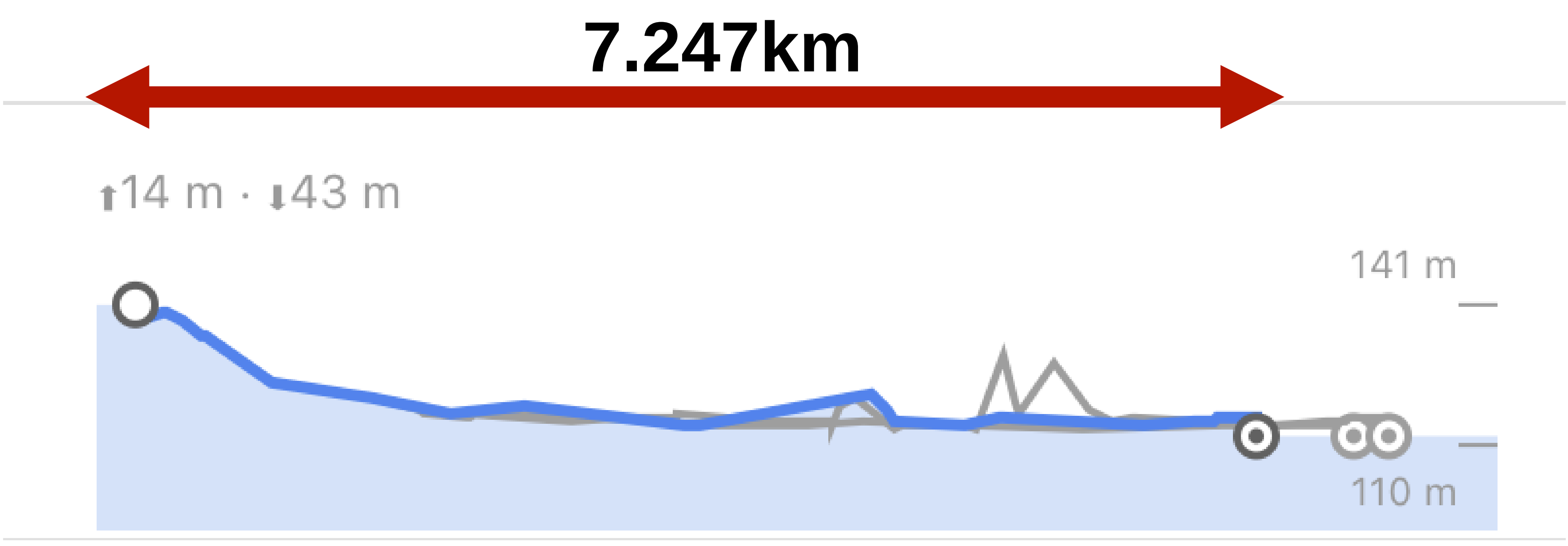
Jointly interested in terrestrial free-space laser communications and ground to space space to space, and space to ground quantum laser communications, with turbulence mitigation

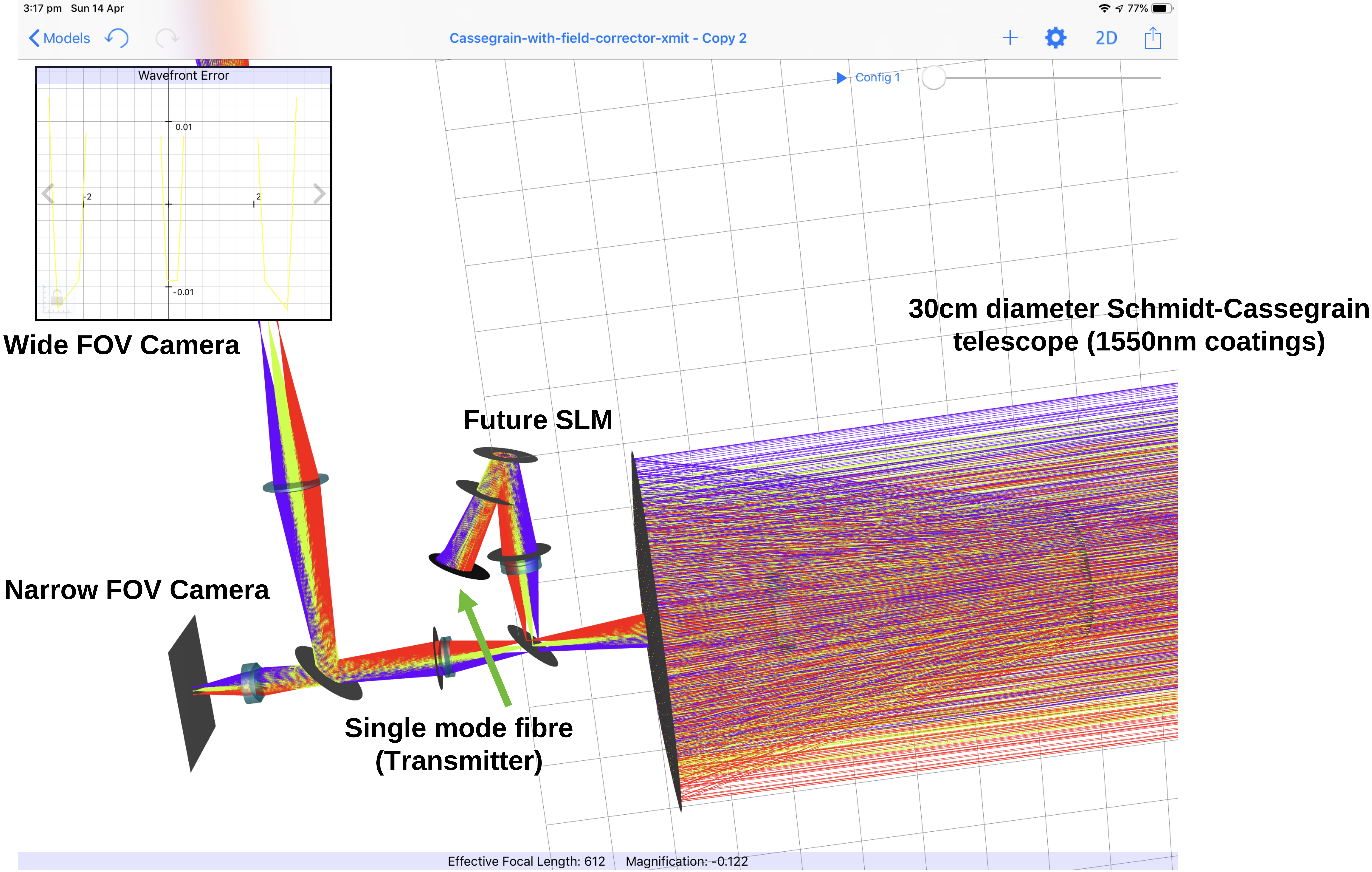


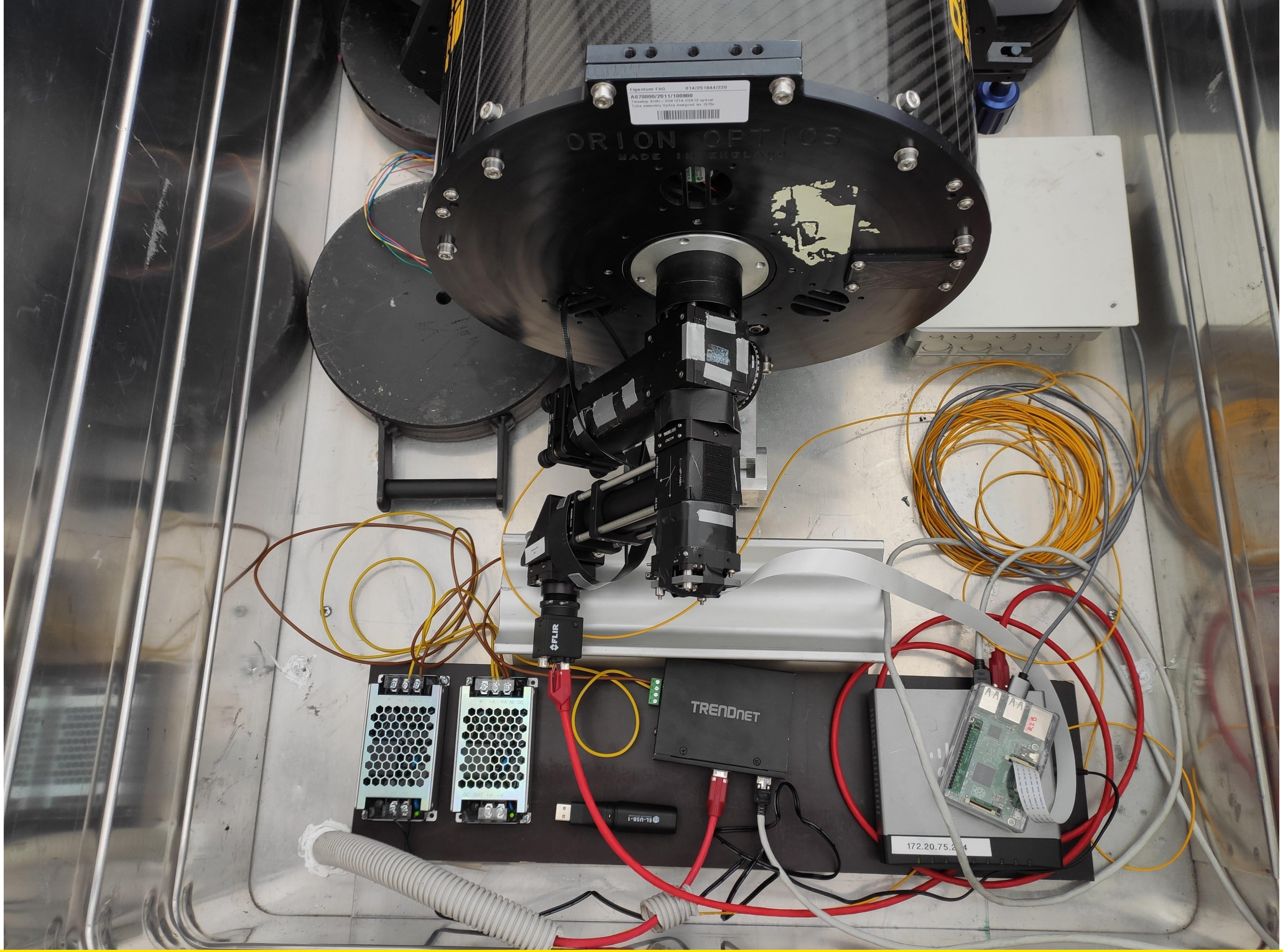


Terrestrial free-space laser communications

- All weather capable, sealed box.
- Schmidt-Cassegrain with option for Off-axis replacement
- 0.3m telescope
- f=2m
- Transmitter λ = 1550nm
- Visible wide and narrow field cameras
- IMU for building motion
- Local temperature modelling




3:17 pm Sun 14 Apr
77%
Models
Cassegrain-with-field-corrector-xmit - Copy 2
2D
Config 1
Wavefront Error
0.01
-2
2
-0.01
Wide FOV Camera
30cm diameter Schmidt-Cassegrain
telescope (1550nm coatings)
Future SLM
Narrow FOV Camera
Single mode fibre
(Transmitter)
Effective Focal Length: 612
Magnification: -0.122


ORION OPTICS
MADE IN ENGLAND
FLIR
TRENDnet
172.20.75.2

Receiver telescope

- Also 0.3m diameter Schmidt-Cassegrain with 1550nm coatings
- (Same design as used in the shorter path)
- Mounted on optical bench
- With light path via periscope to a range of adaptive optics systems
- We hope first light on this Thursday!

Wide FOV Camera

Luther Kirche Tower ~7km

Morning 11.7.2019 - Cloudy

Afternoon 11.7.2019 – Moderate Rain

Shorter range laser link

- Schmidt-Cassegrain 0.3m telescope
- Tip and tilt periscope system
- IMU monitoring of lab motion
- Cailabs OAM systems
- 1550nm and 632nm operation
- Hamamatsu IR camera/WFS

Rui Barros, Sarah Keary, Lydia Yatcheva, Italo Toselli, Szymon Gladysz, "Experimental setup for investigation of laser beam propagation along horizontal urban path," Proc. SPIE 9242, Remote Sensing of Clouds and the Atmosphere XIX; and Optics in Atmospheric Propagation and Adaptive Systems XVII, 92421L (21 October 2014)

- range 411m
- Hollow retroflectors

Two retroflectors at range 411m from transceiver.
- one to simulate a point source return, and the other for collimated and focused structured beams.
- 1550nm coating

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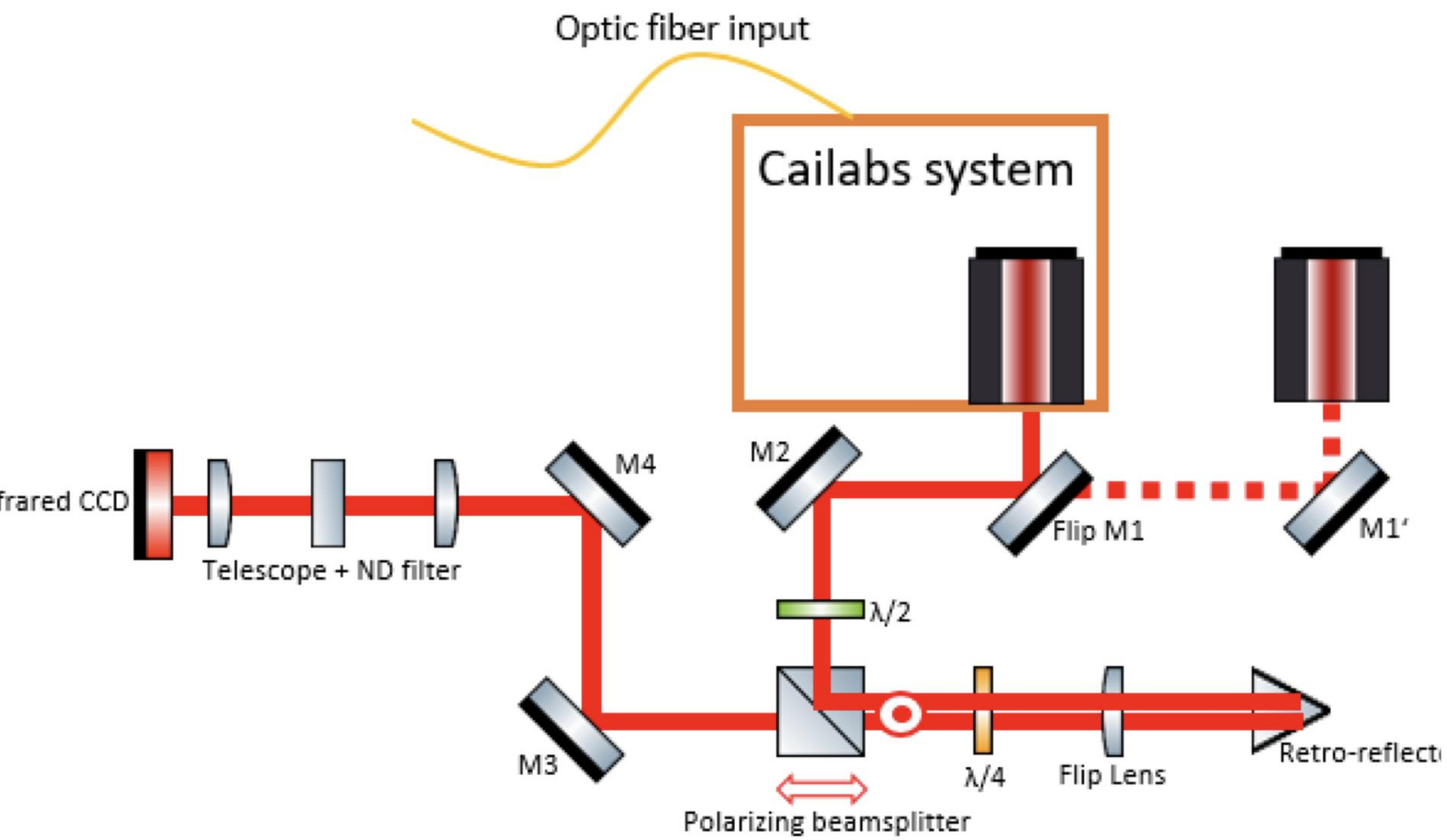
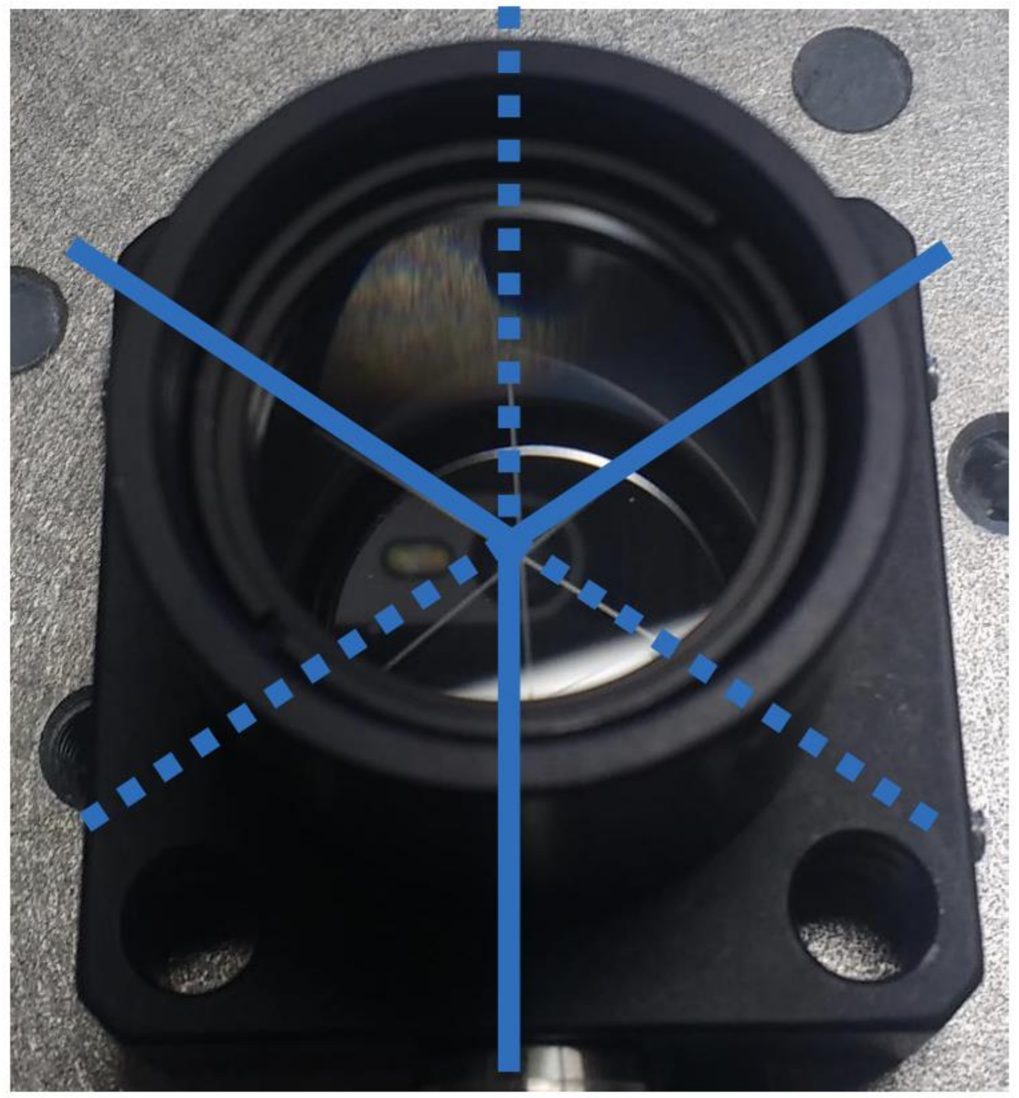
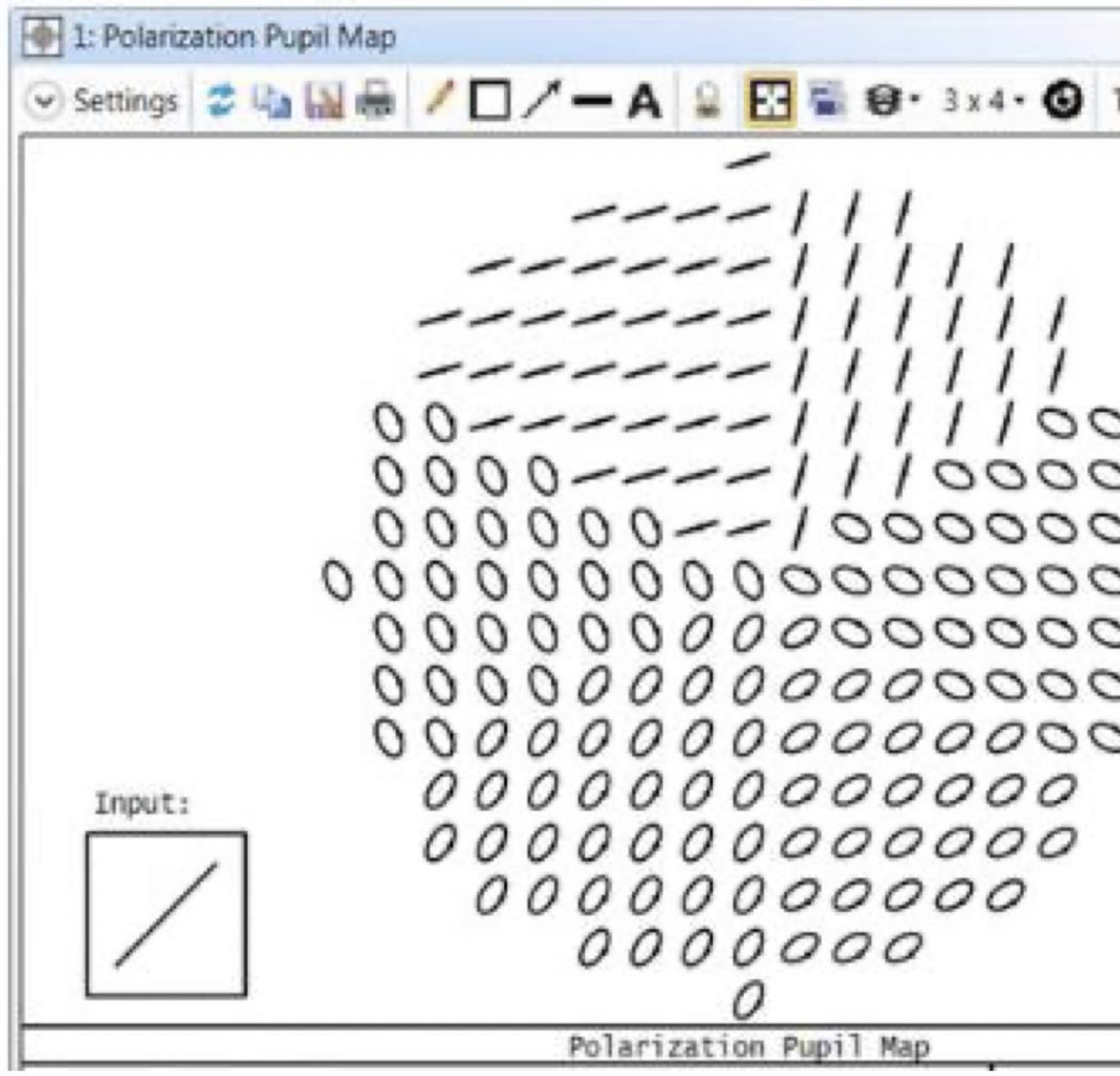
OAM transmission and retro-reflection - in laboratory (very short path)



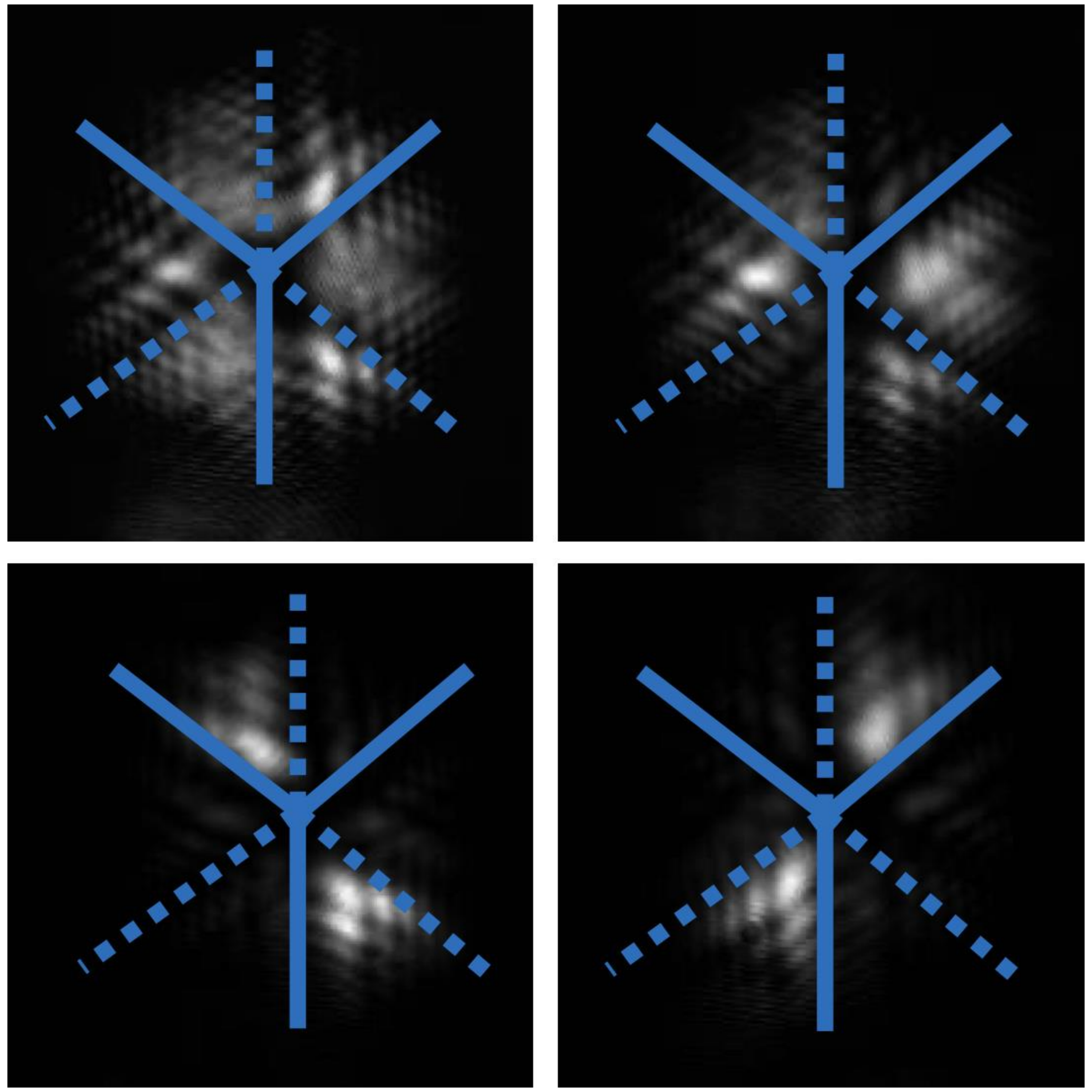




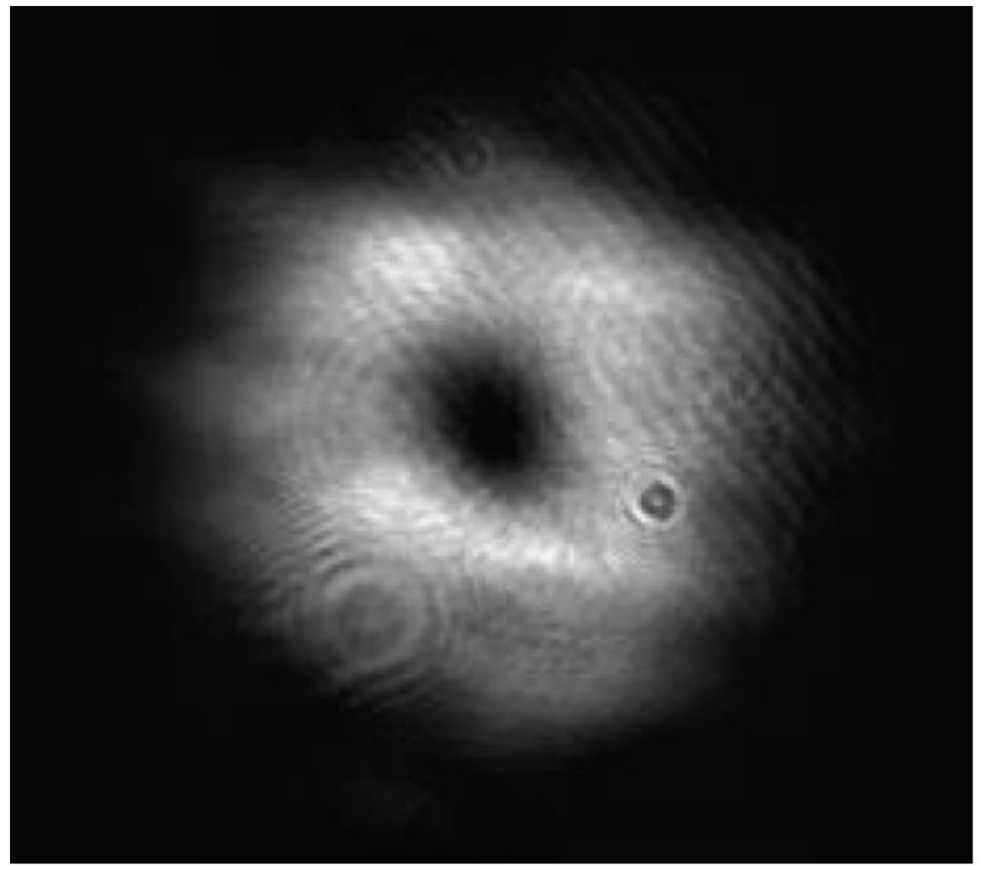
Credit: How to Model Corner-Cube Retroreflectors,

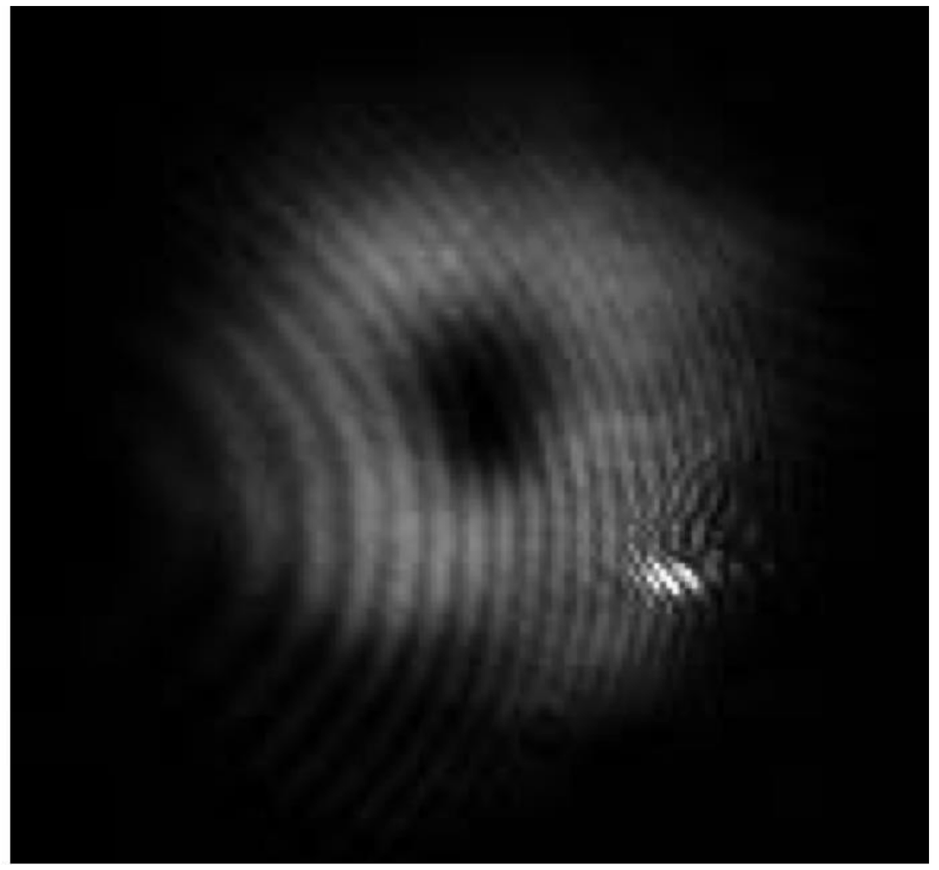
In-laboratory calibration

- Retroreflector - open front-“silvered” mirrors
- Gaussian collimated beam with linear polarisation
- analysed on return by linear polariser at different angles

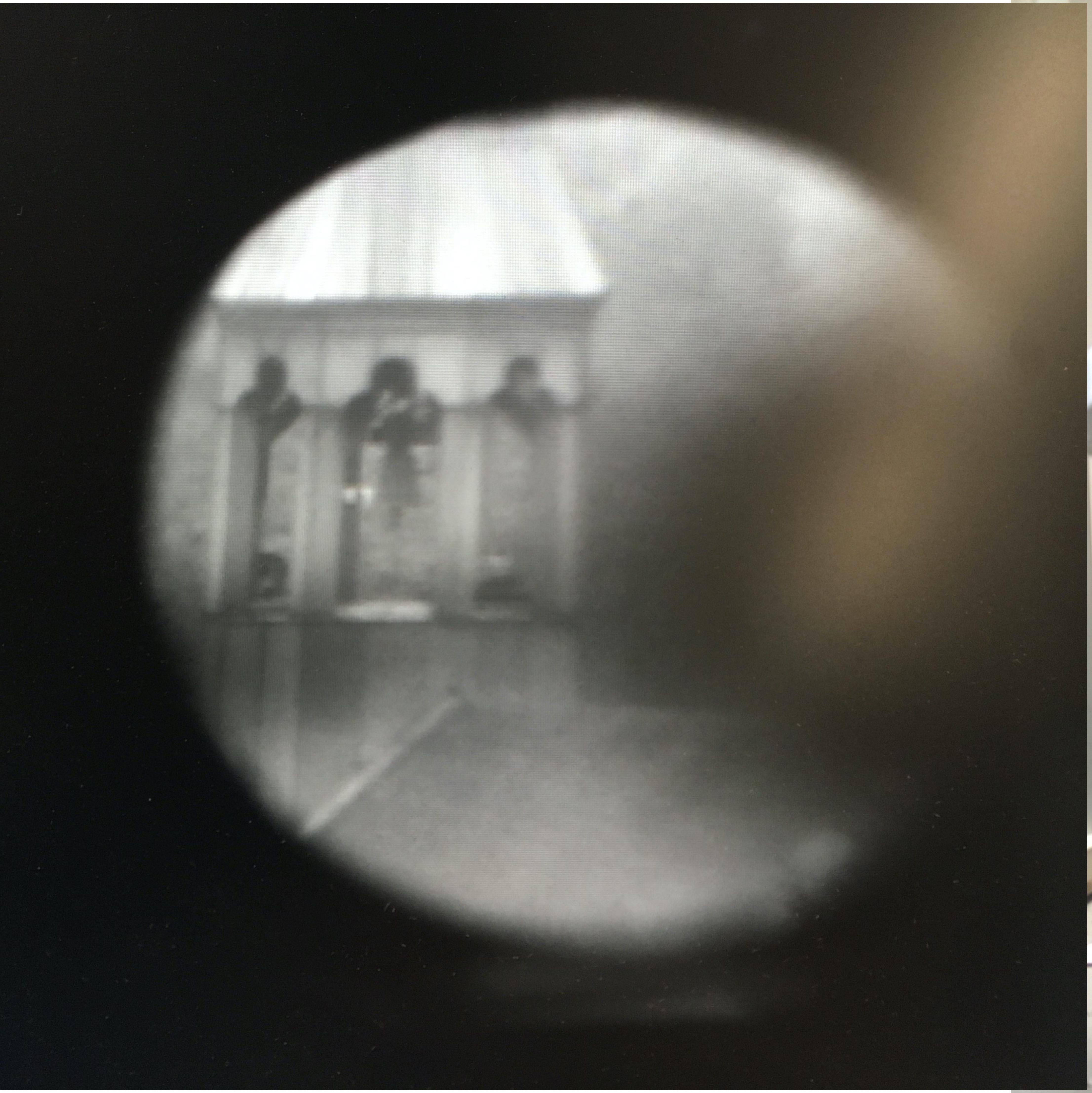


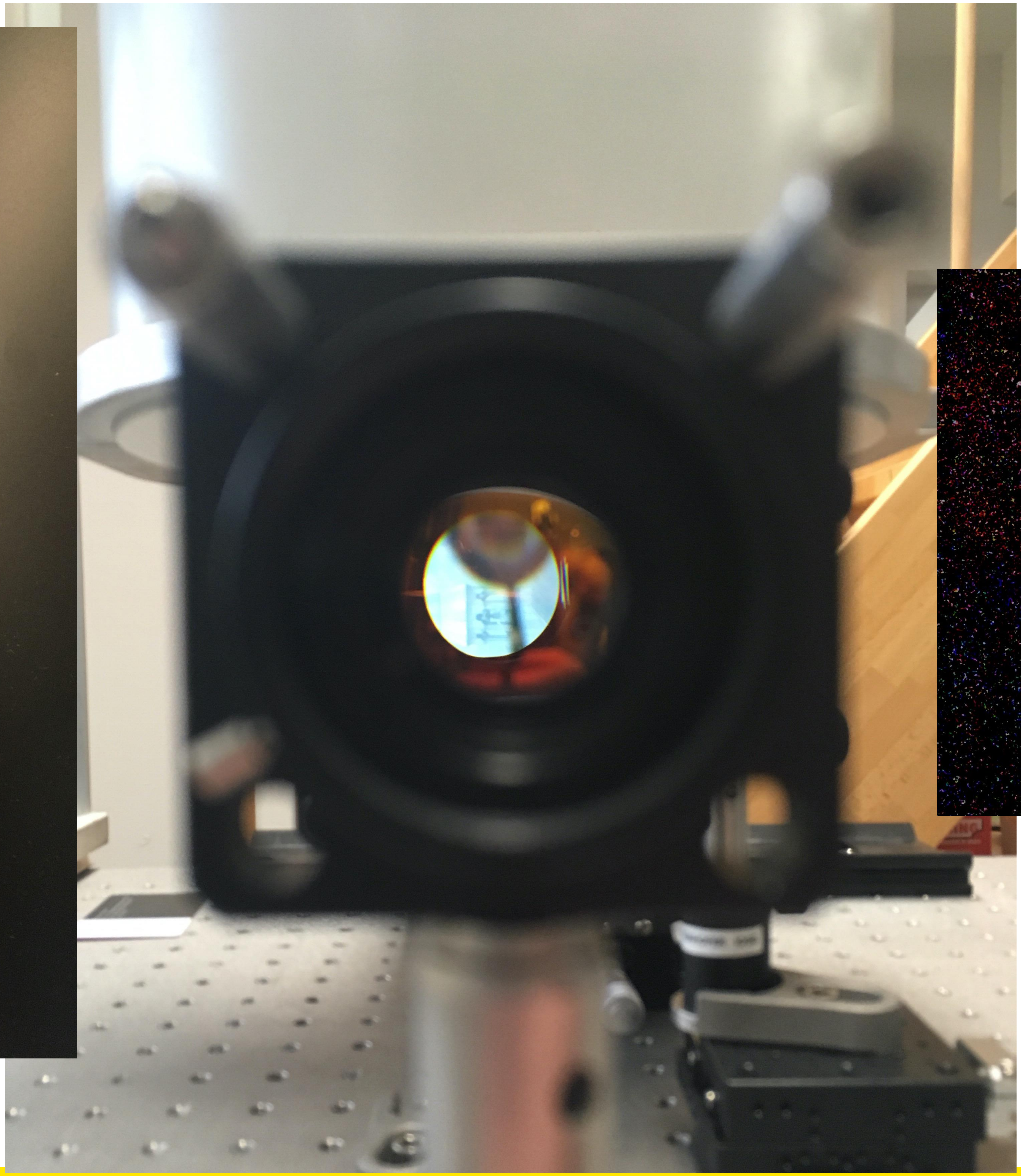
First Order OAM beam



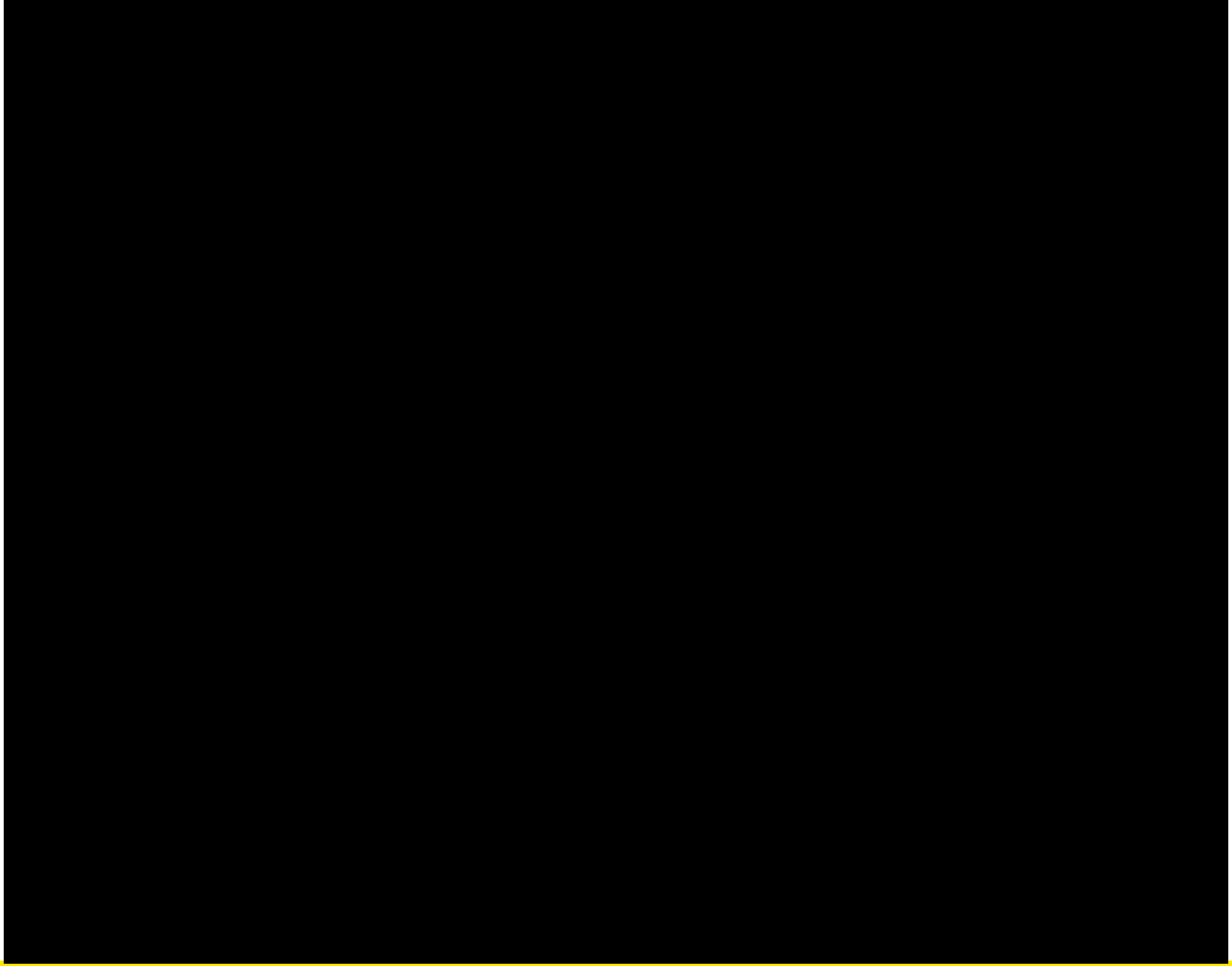


Modulated beam after return from retro-reflector

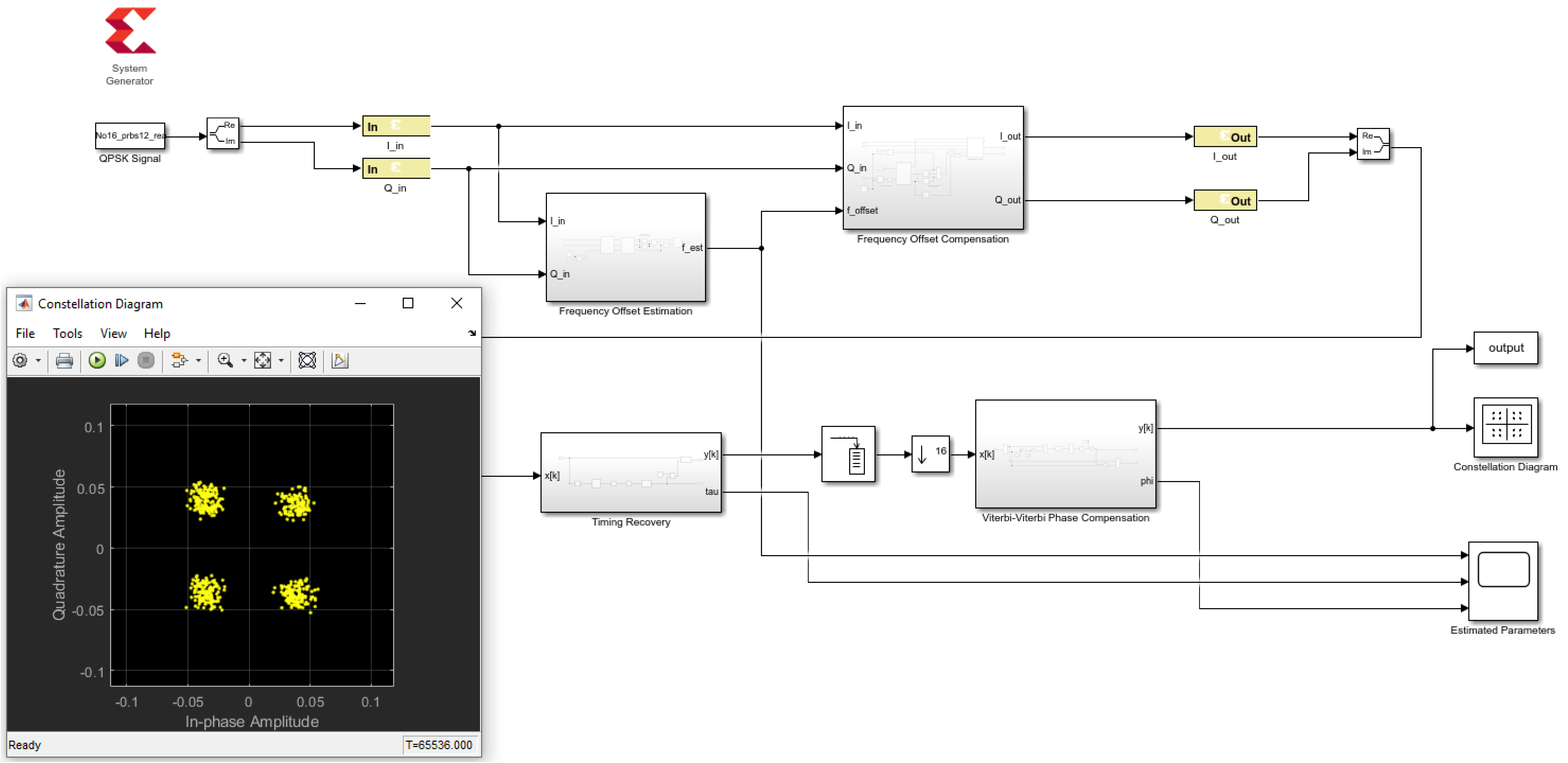


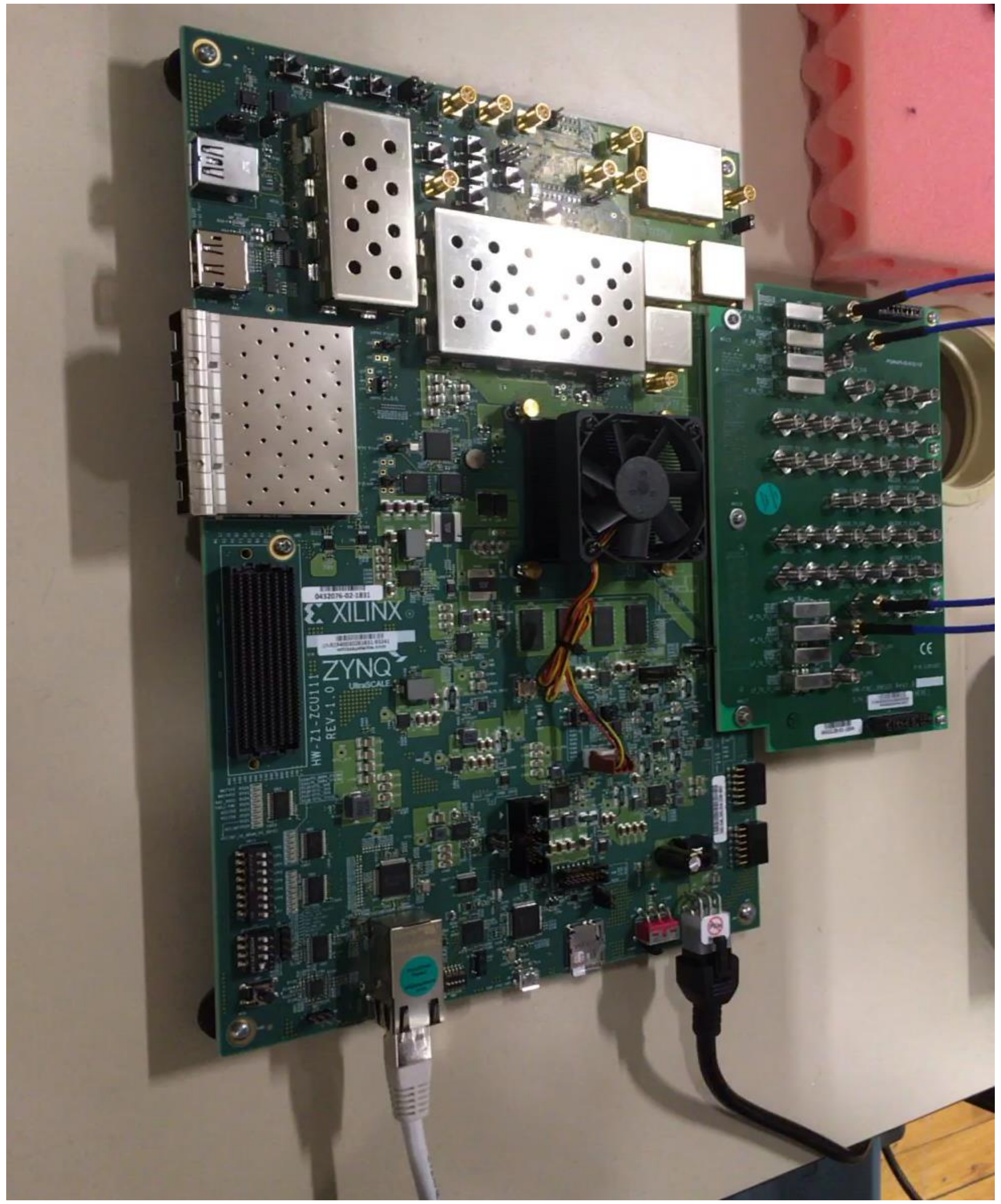


- Focused beam
- Single facet
- Scintillation in pupil



Data Communications at 6.25 Gbaud



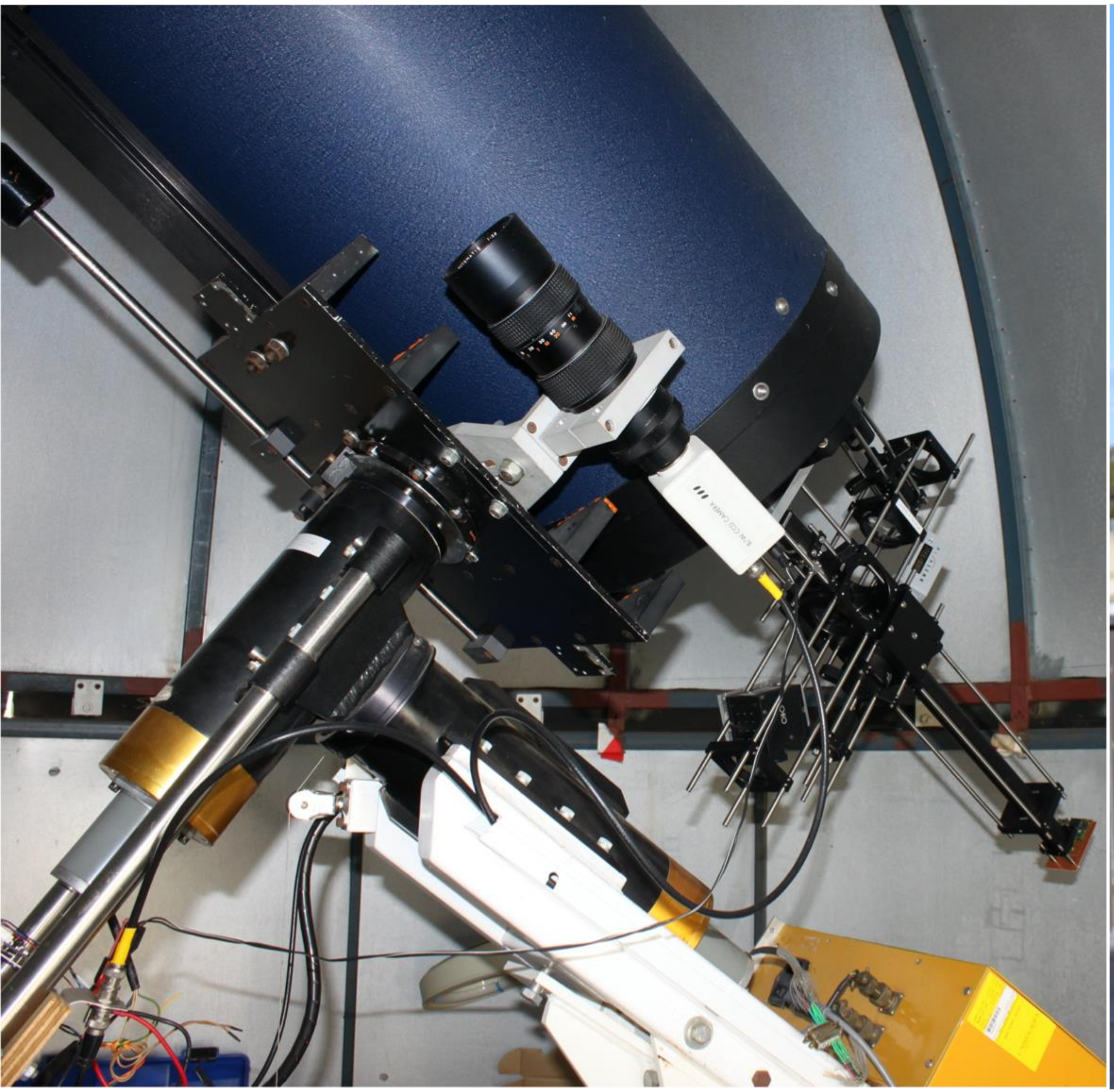


- Simulink simulations for OOK/PSK
- Implemented with FPGA with RF Zync from Xilinx

Max Segel, Szymon Gladysz, and Karin Stein "Optimal modal compensation in gradient-based wavefront sensorless adaptive optics", Proc. SPIE 11133, Laser Communication and Propagation through the Atmosphere and Oceans VIII, 111330V (6 September 2019); https://doi.org/10.1117/12.2531121

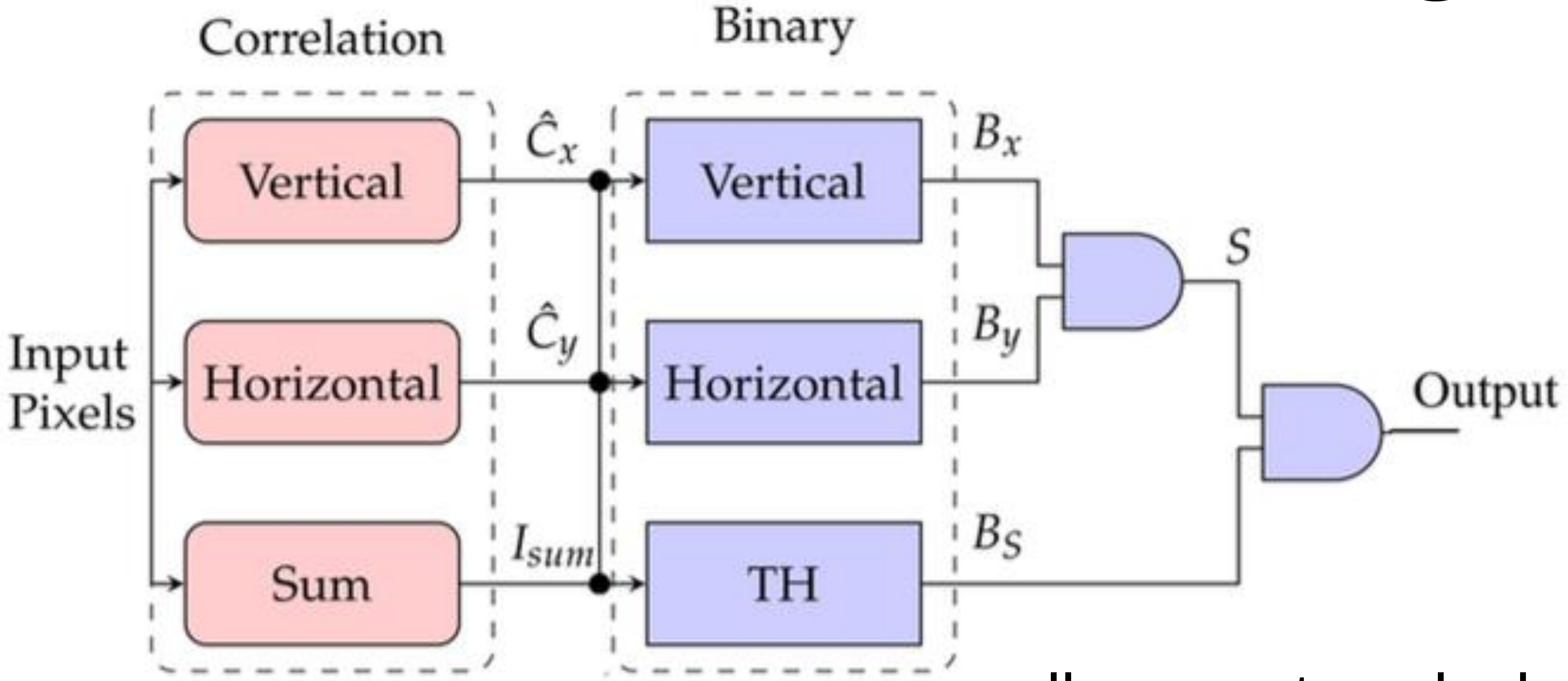
Ground to Space and Space to Ground Laser Communications

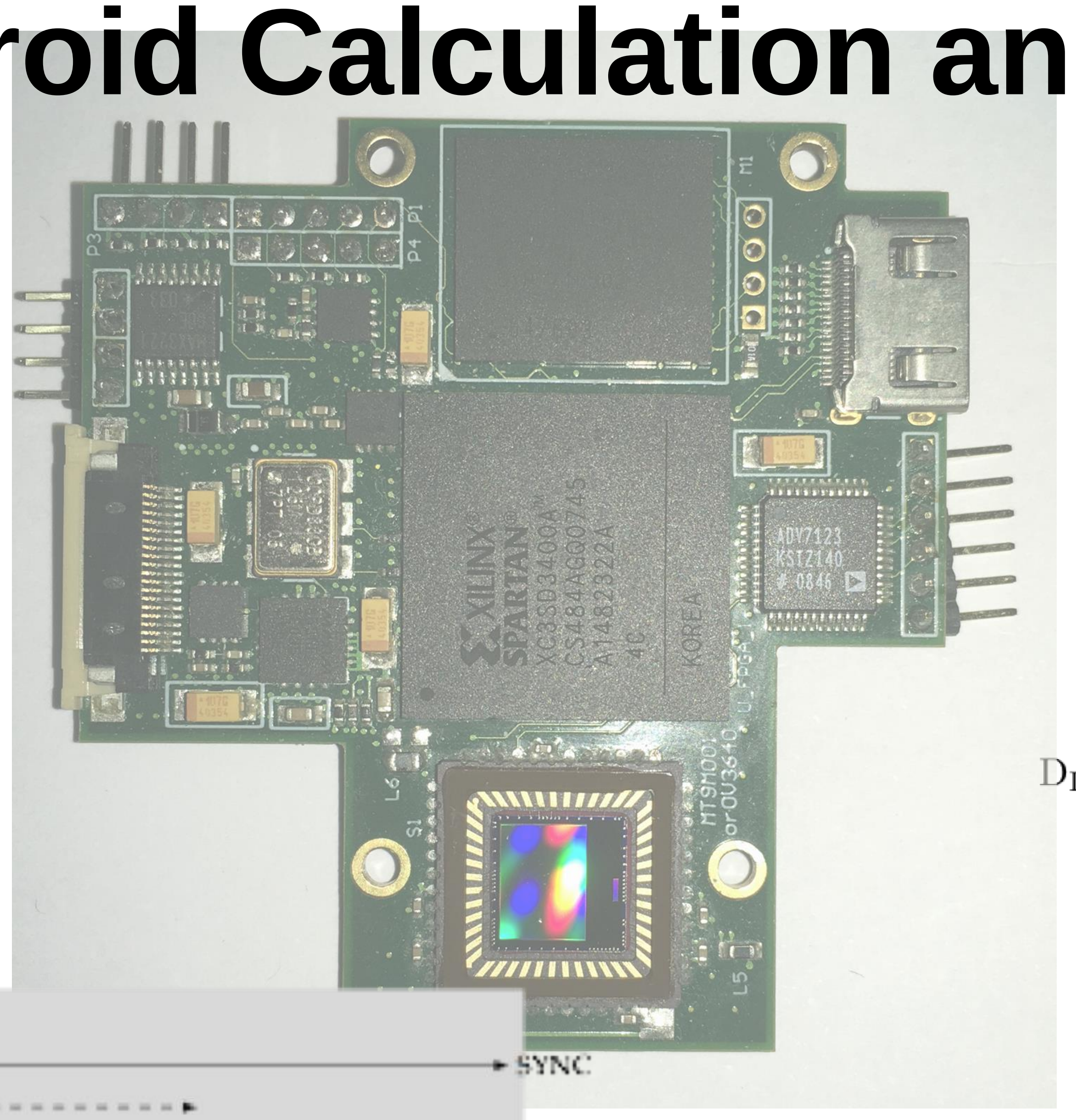
- Size, Weight and Power (Form-factor)
- Location, Location!
- Sensing "Opportunities"
- Adaptive and Active Optics



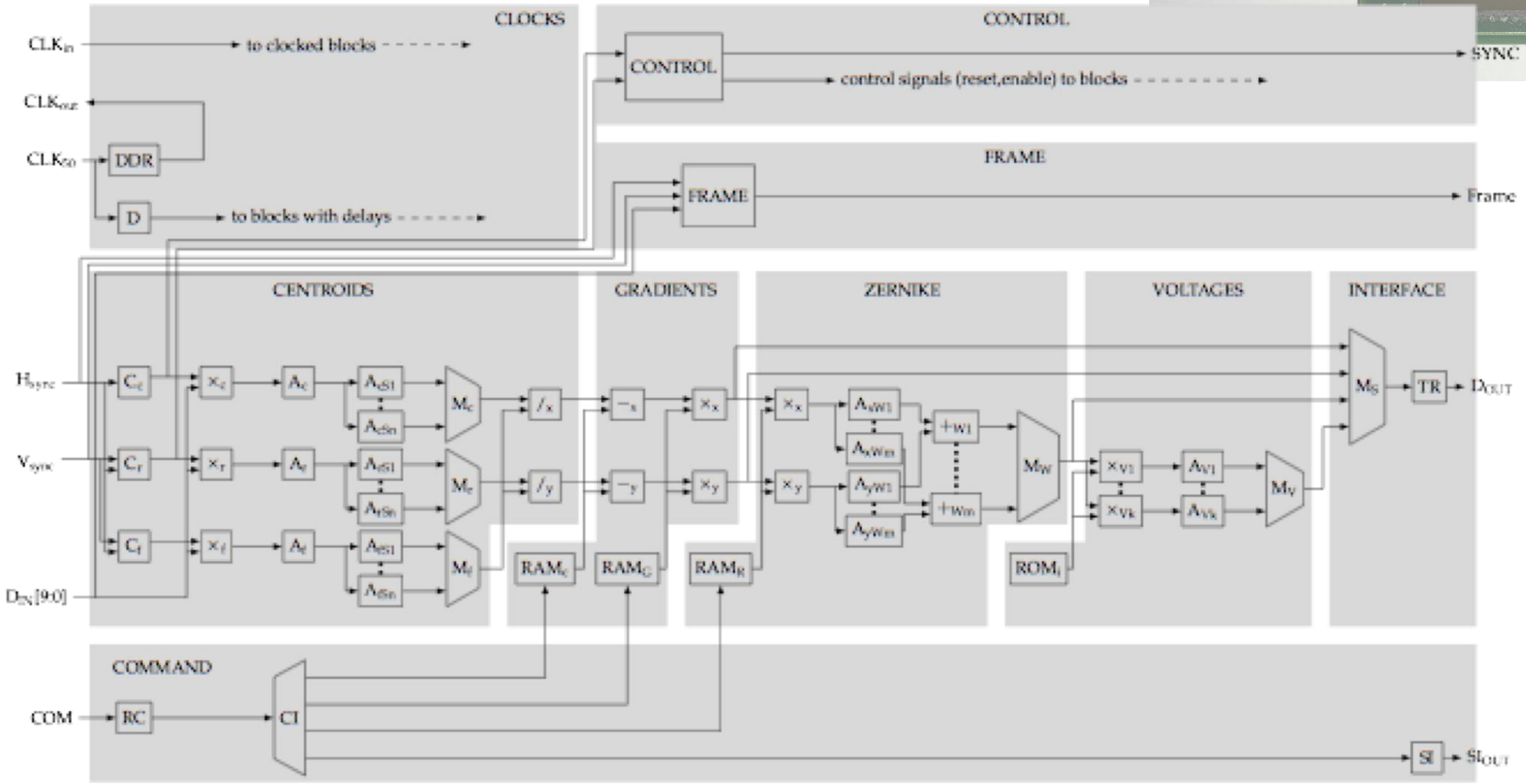
Towards a Network of Small Aperture Telescopes with Adaptive Optics Correction Capability. M.Cegarra Polo and A.Lambert. AMOS2016 Hawaii(US), 20-23 Sep 2016

Advanced Streaming Centroid Calculation and Hardware Loop





.... allows us to calculate around every pixel, and reduce the size of the "filter"....



C: Counter ×: Multiplier A: Accumulator M: Multiplexer /: Divider −: Subtraction +: Addition TR: Transmitter RAM$_C$: RAM centroids RAM$_G$: RAM gradients RAM$_R$: RAM zernike ROM$_I$: ROM influence functions RC: Receiver CI: Command Interface SI: Serial Interface TR: Transmitter DDR: Double Data Rate module D: Delays

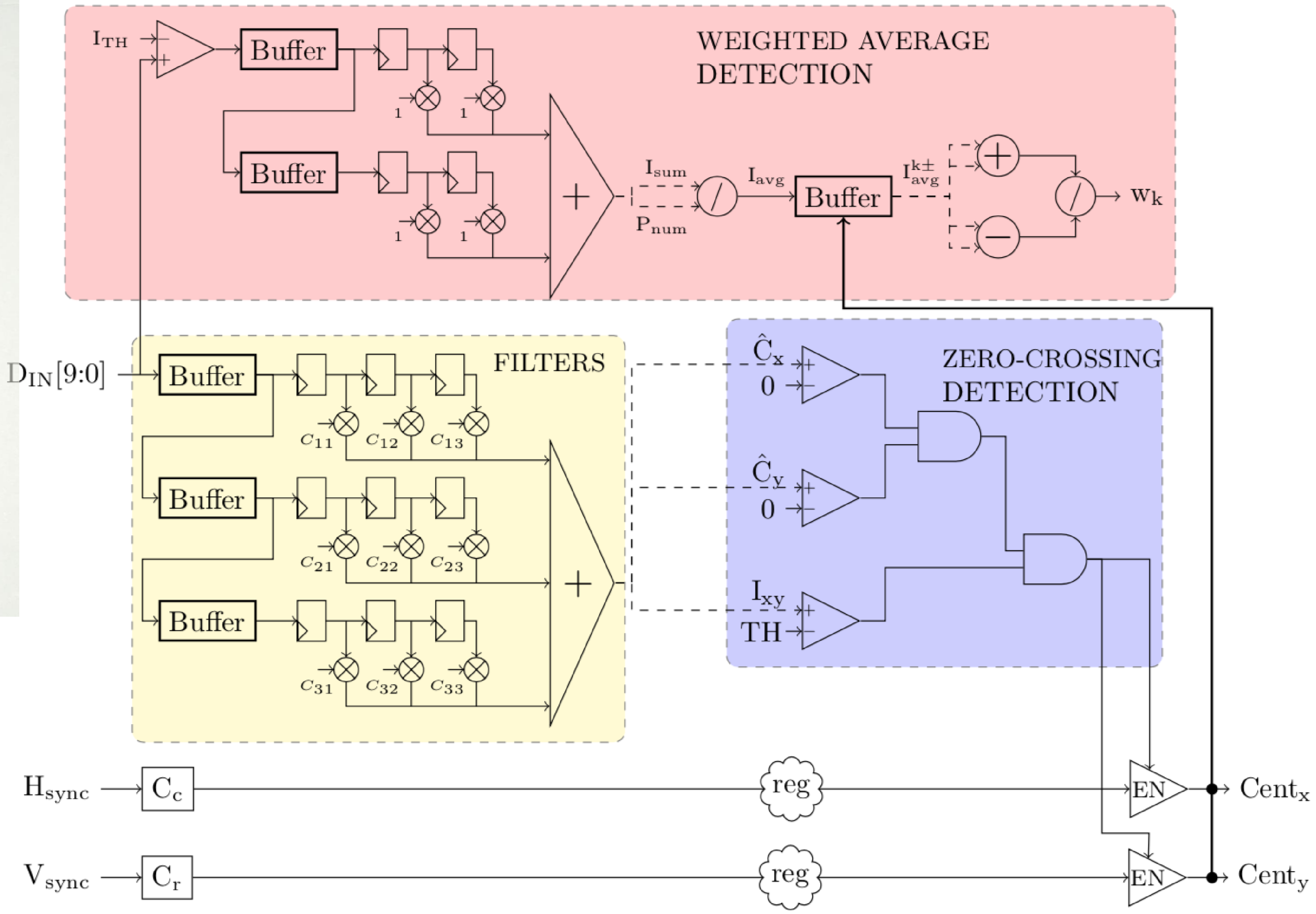


Figure 6.1: Block diagram of a generalised stream-based image processing system. The dashed lines mean the results are from similar logic implementations with different parameters or from the same logic but at different time. For instance, $\hat{C}_x, \hat{C}_y$ and I_{xy} are results from the FILTER logic within the yellow block with different filter values. $I^{k\pm}_{avg}$ are values from the same buffer but at different pixel(spot) locations.

.....to get the centroid with LOW LATENCY, and MINIMISING NOISE bias, and CAPTURING all objects in the field.

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WTD 91

Thank you for your attention.

[1] Max Segel, Szymon Gladysz, and Karin Stein "Optimal modal compensation in gradient-based wavefront sensorless adaptive optics", Proc. SPIE 11133, Laser Communication and Propagation through the Atmosphere and Oceans VIII, 111330V (6 September 2019); https://doi.org/10.1117/12.2531121

[2] Raphael Bellossi, Andrew Lambert, and Szymon Gladysz, "Experimental verification of the effects of atmospheric turbulence and retro-reflection on laser beams with orbital angular momentum", Proc. SPIE 11153, (2019).

[3] Rui Barros, Sarah Keary, Lydia Yatcheva, Italo Toselli, Szymon Gladysz, "Experimental setup for investigation of laser beam propagation along horizontal urban path," Proc. SPIE 9242, Remote Sensing of Clouds and the Atmosphere XIX; and Optics in Atmospheric Propagation and Adaptive Systems XVII, 92421L (21 October 2014)