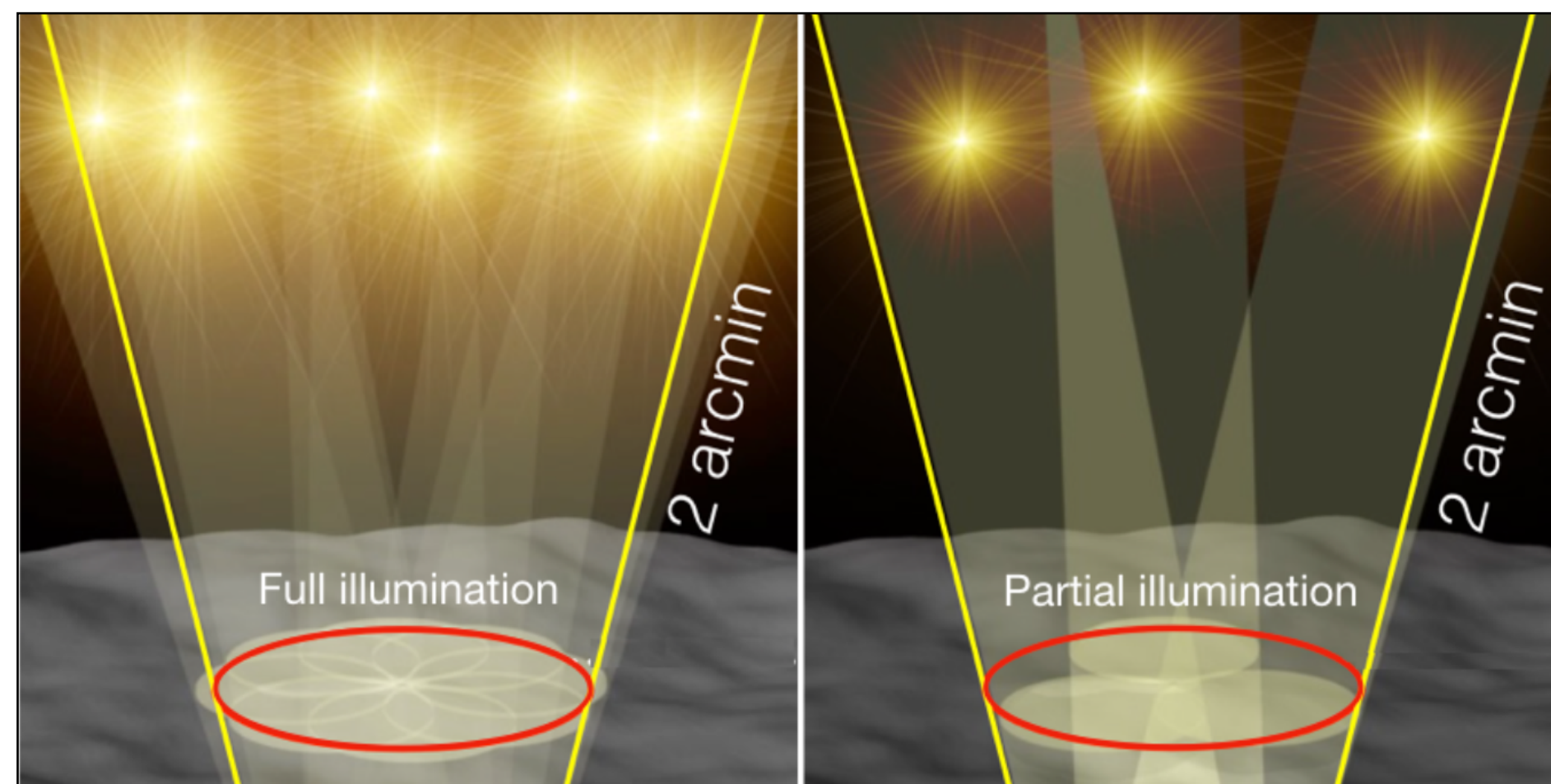


AO Telemetry as a Remedy for the Metapupil Partial Illumination Issue

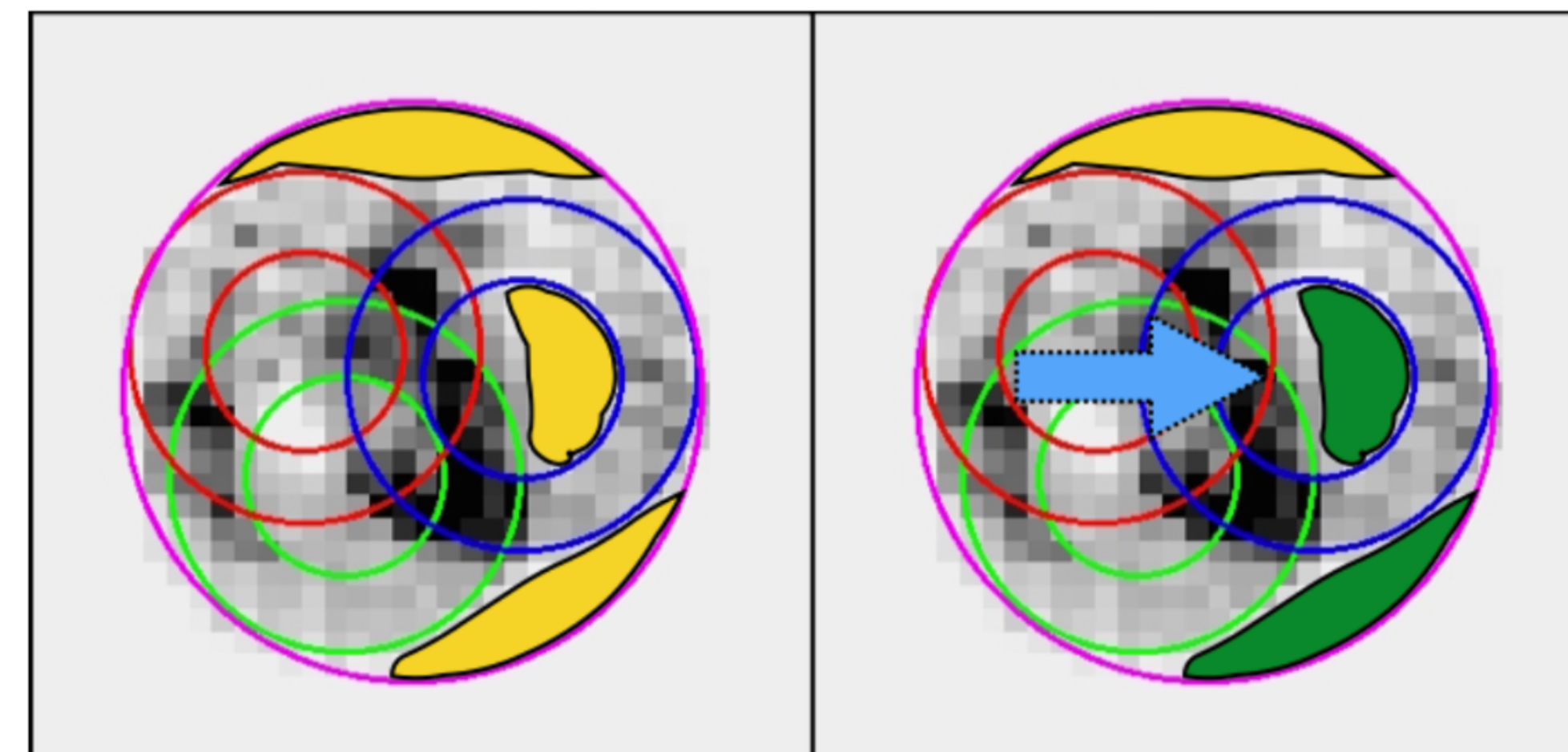
Allocated Budget: 19000 Euro (Funding received on 17 January 2023)

People: Kalyan Radhakrishnan (INAF-OAPD), Saavidra Perera (UCSD), Florian Briegel (MPIA), Tom Herbst (MPIA), Carmelo Arcidiacono (INAF-OAPD), Roberto Ragazzoni (INAF-OAPD)

Goal of the project: Multi-Conjugate Adaptive Optics (MCAO) systems suffer from the partial illumination of the metapupil at the high conjugated layer. This indeed affect the AO performance and stability. The star-oriented MCAO systems tackle this at the level of tomographic reconstruction. For the layer-oriented MCAO systems, the reconstructor need to be modified according to the illumination pattern. The aim of this project is to use the AO telemetry to extract the wind vector of the specific layer and alleviate the issue by using proper weighing criterion and algorithm to virtually illuminate the non-illuminated sub-apertures, thereby stabilizing and improving the AO performance.



Left - Full illumination of the metapupil (red circle) using eight stars.
Right - Partial illumination scenario when only three stars are available.



Left - The partially illuminated metapupil.
Right - A favorable wind direction virtually fills in some of the non-illuminated sub-apertures.

Extraction of wind vector from LINC-NIRVANA (LN) high-layer WFS AO Telemetry (using calibration sources as stars)

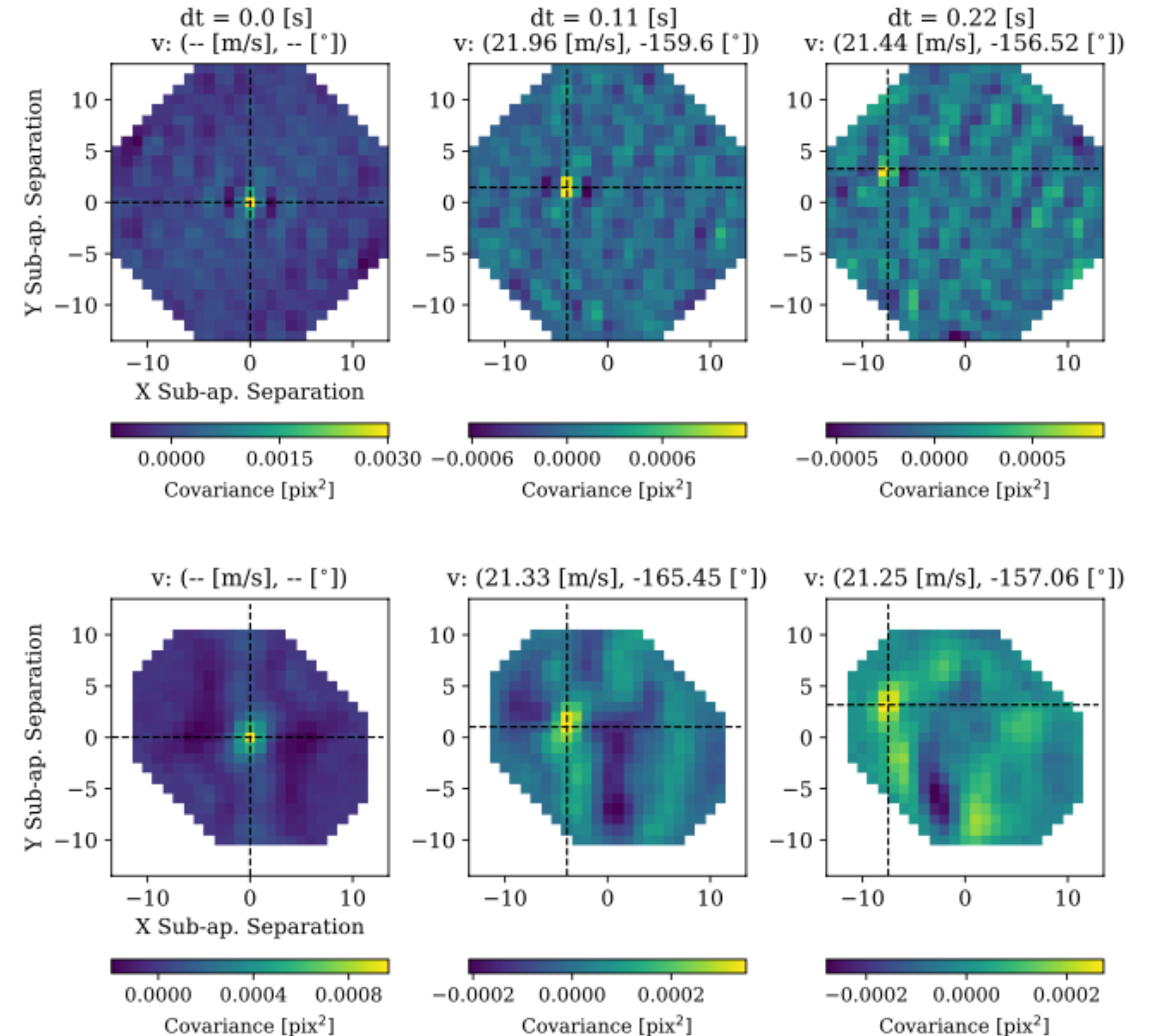
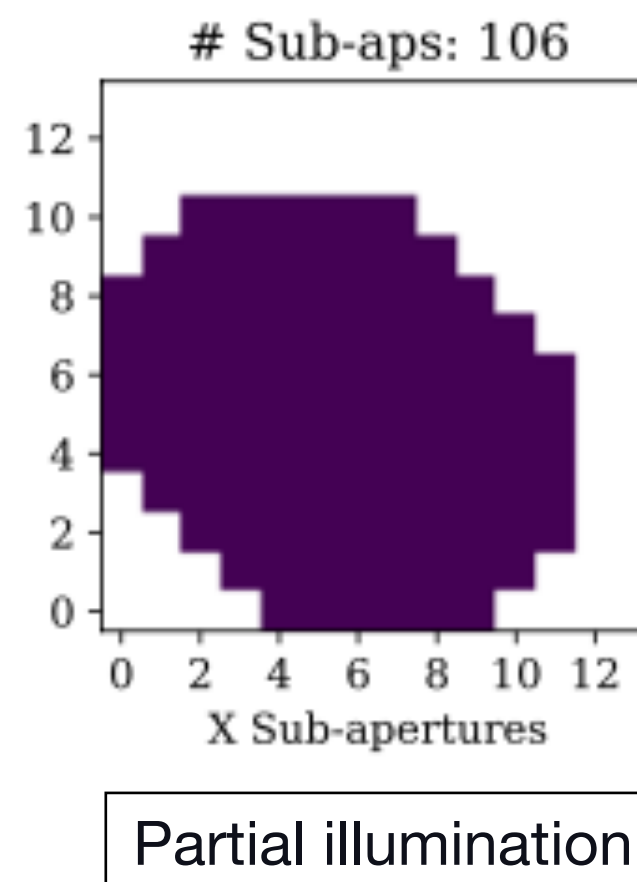
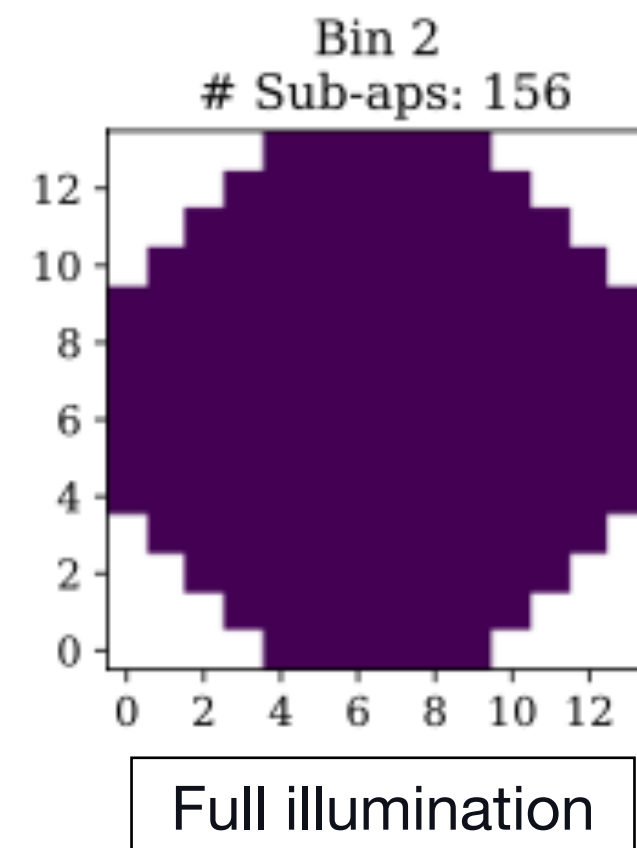
Turbulence was introduced at the Xinetics DM on board LN with the parameters tabulated below.

Parameter	Value
Fried's Parameter	0.92 m
Num. layers	1
Altitude	7 km
Wind speed	20 m/s
Wind direction	0 °

We performed the testing for WFS CCD Binnig of 1x1, 2x2, and 4x4. Here we show the results for the binning 2x2.

For an input wind speed of 20 m/s, the estimated average output wind speed for open loop and pseudo-open loop (from closed loop data) are 22 m/s and 21 m/s respectively.

The input simulated wind direction is 0deg. The output is close to -159deg. This is because, there are flips and rotations of the plane between the DM and the WFS CCD for a given k-mirror angle. This results in the value we estimate here.



Covariance maps of closed-loop fully illuminated (top row) and partially illuminated (bottom row) metapupil of binning 2 for increasing temporal offsets.

Progress on the 'Deliverables and Milestones'

1. A python code to extract the wind vector from the LN AO telemetry - **completed**
2. The stand-alone algorithm/python code which is verified by laboratory testing - **almost completed**
3. Implementation of the algorithm into LN AO software and daytime testing - **on going**
4. Communicating the first peer-reviewed paper on the concept of the project supported with daytime laboratory tests - **submitting an abstract in SPIE 2024**
5. Atmospheric profiling above the LBT during nighttime testing - **for later (and depends on the time allotment from LBT for LN)**
6. A fully working algorithm tested on-sky - **for later**
7. Communicating the second peer-reviewed paper on the project results with on-sky data and performances - **for later**

Summary and Critical Issue

1. Interaction and some progress made during the AO4ELT7 conference in Avignon in the month of June 2023.
2. Colleagues from MPIA (METIS team) has interest in using LINC-NIRVANA and high layer wavefront sensor as a testbed for simulating some of the features they might encounter in ELT. This work may become part of this project, if it fits in.
3. A visit to MPIA-Heidelberg to work on the 3rd deliverable and collaborating with the METIS team is anticipated in the year of 2024.
4. Kalyan has applied to renew the US visa to go to LBT. However, there are road blocks. The solution is not very trivial. This might affect the project timeline.