

# FIRST-PL : Halpha differential imaging of protoplanets with a visible photonic lantern

Elsa Huby

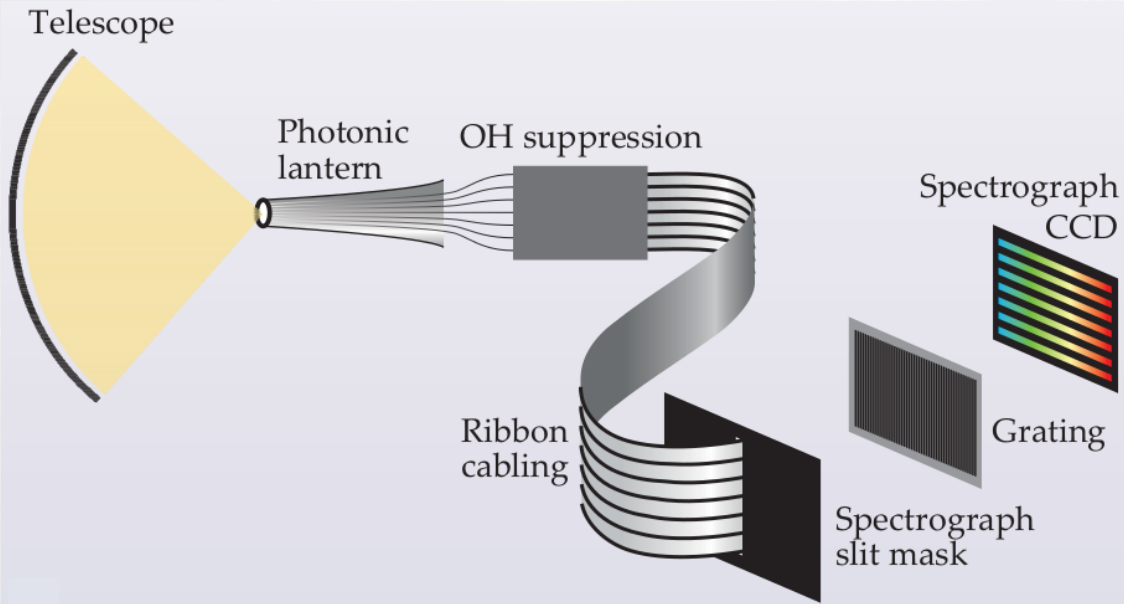
## FIRST team

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M. Lallement, J. Sarrazin, G. Martin, M. Nowak,  
A. Walk, H.-D. Kenchington Goldsmith, T. Kotani, G. Perrin  
C. Betters, S. Leon-Saval, Y.J. Kim, M. Fitzgerald, V. Deo,  
C. Hamner, N. Jovanovic, J. Lozi, T. Currie, M. Lucas, B. Norris,  
S. E. Sallum, M. Tamura, M. El Morsy

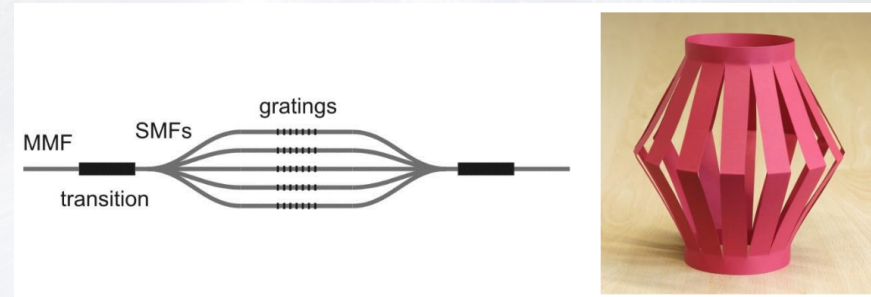


# What is a photonic lantern?

“The photonic lantern is a low-loss optical waveguide device that connects one **multimode** core to several cores that each support **fewer modes**”  
(Birks et al., *The photonic lantern*, Adv. Opt. Photon. 2015)

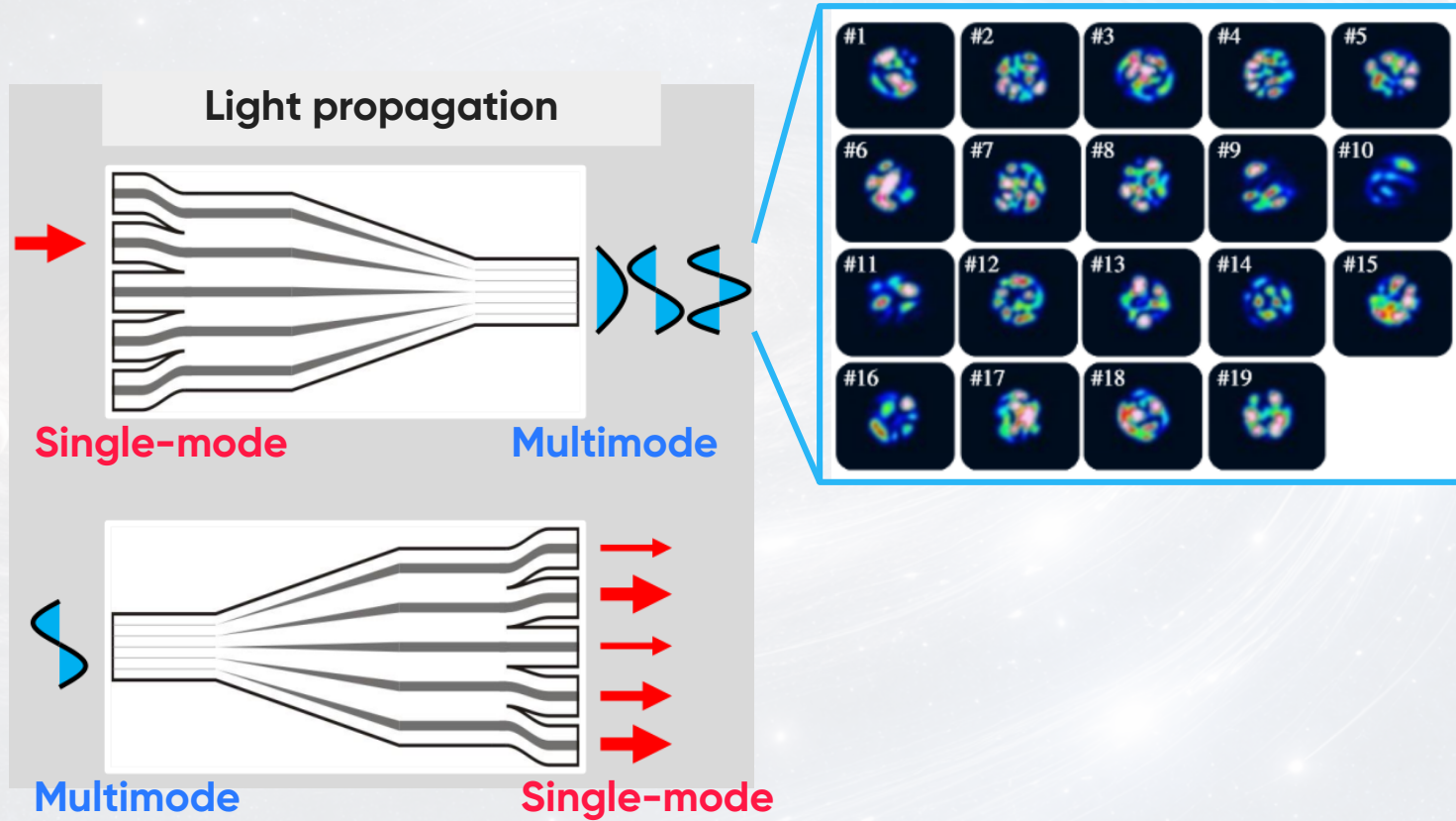


The original application: compact spectrograph  
(Bland-Hawthorn et al., 2010, 2012)

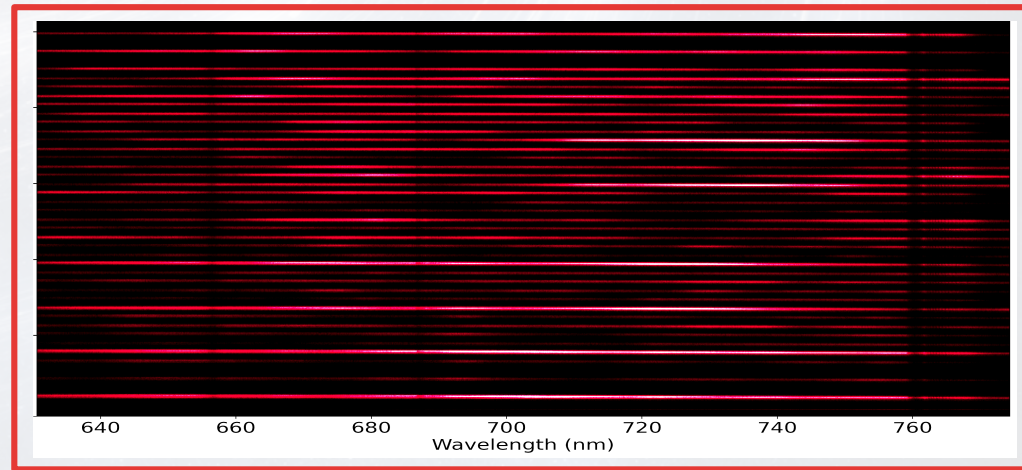
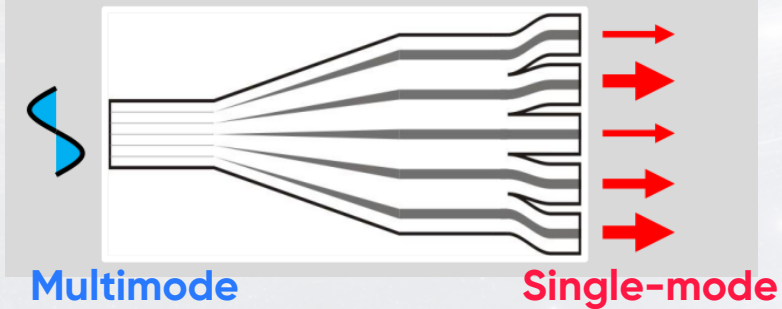
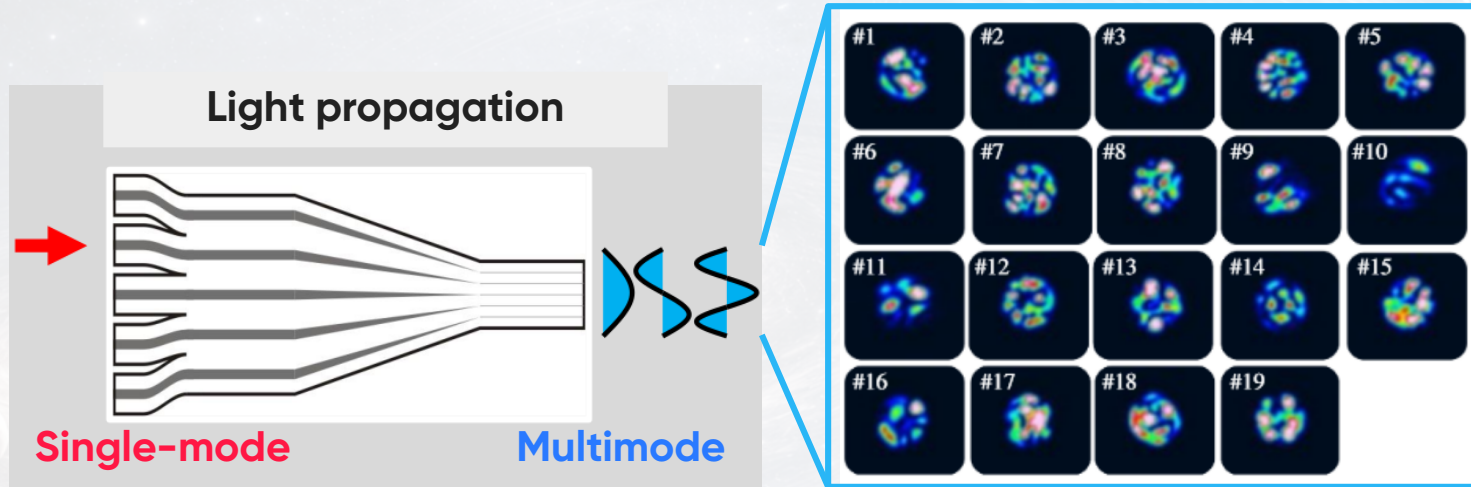


Original schematic of an MM-SM-MM lantern pair  
(Leon-Saval et al. 2005, Birks et al. 2015)

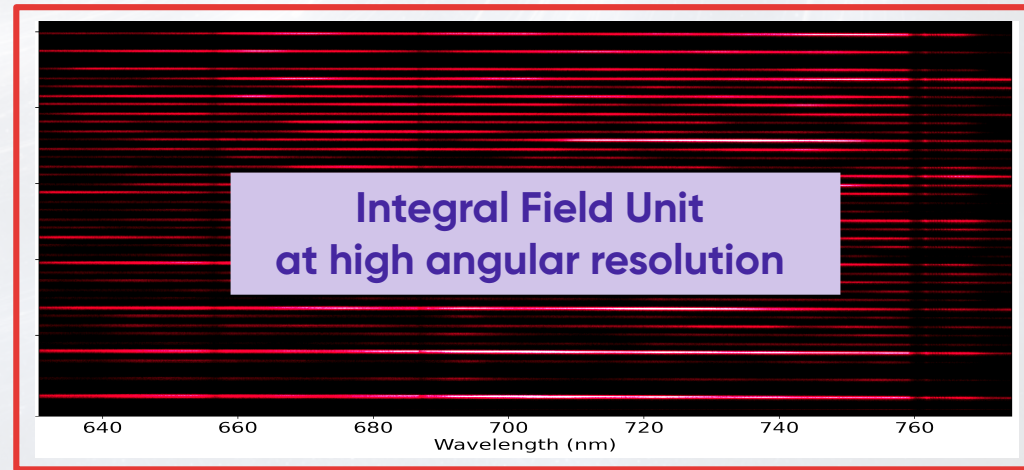
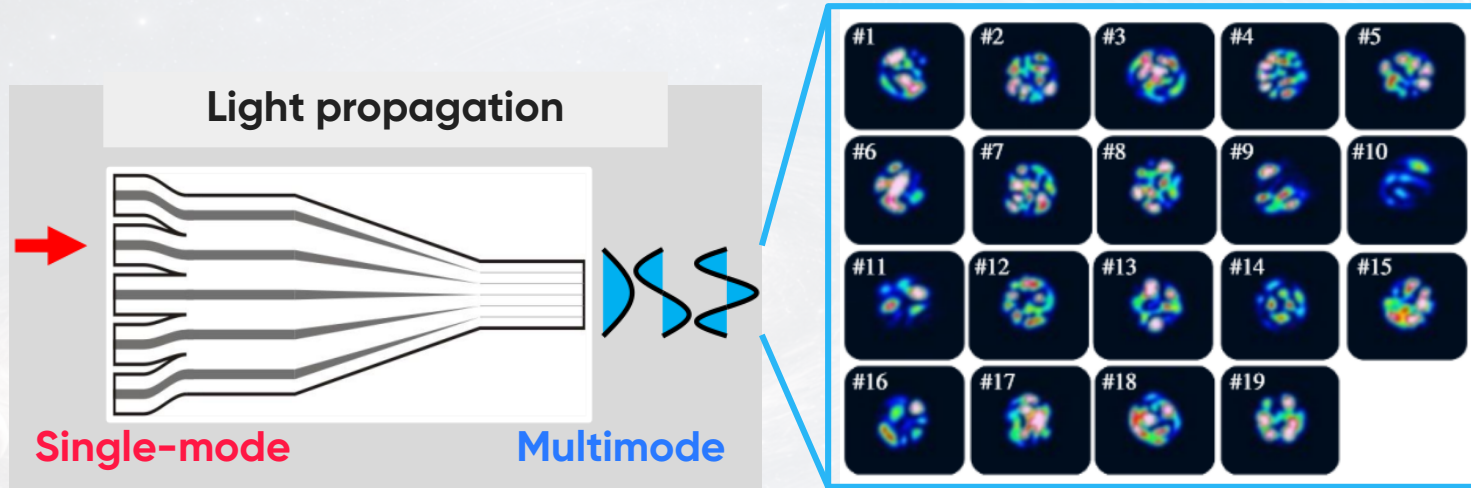
# What is a photonic lantern?



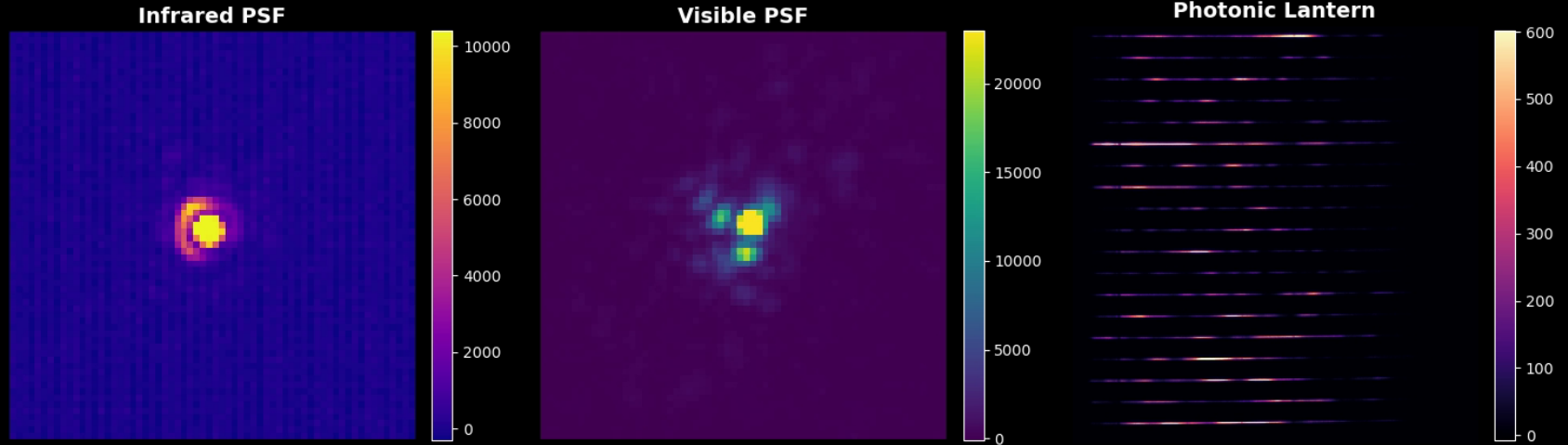
# What is a photonic lantern?



# What is a photonic lantern?



# The photonic lantern in action



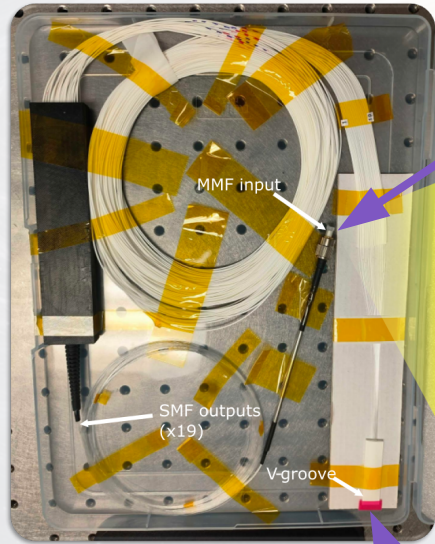
## Applications:

- Spectroscopy
- Imaging
- Spectro-astrometry
- Wavefront sensing

# FIRST-PL on SCExAO

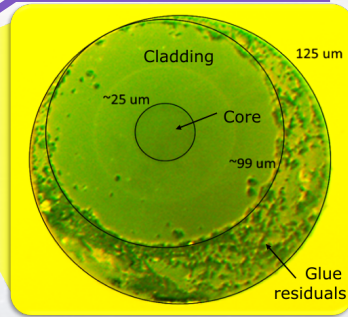


Photonic lantern device

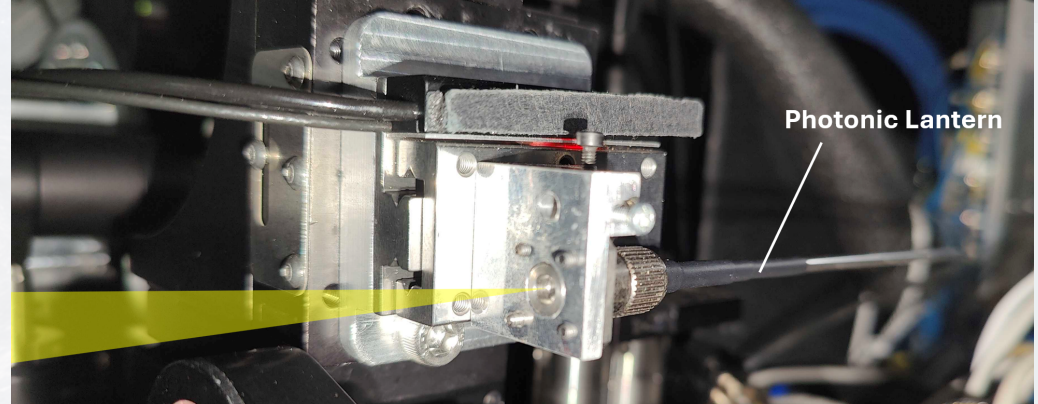


Vievard et al. 2024

Multi-mode fiber



19 Single-mode fibers



Photonic Lantern

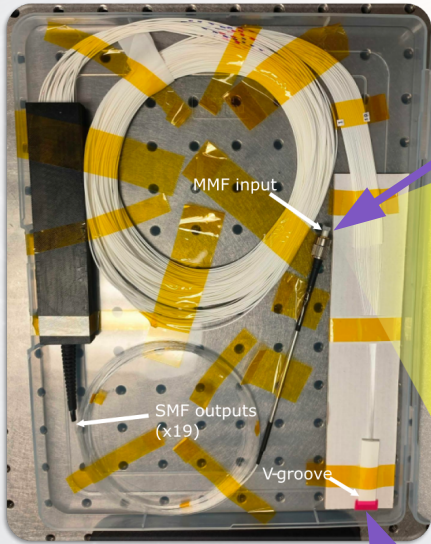
Injection into the photonic lantern MM end

Credits: S. Vievard

# FIRST-PL on SCExAO

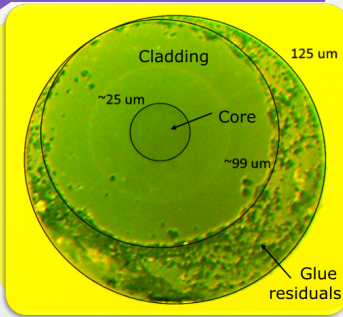


Photonic lantern device

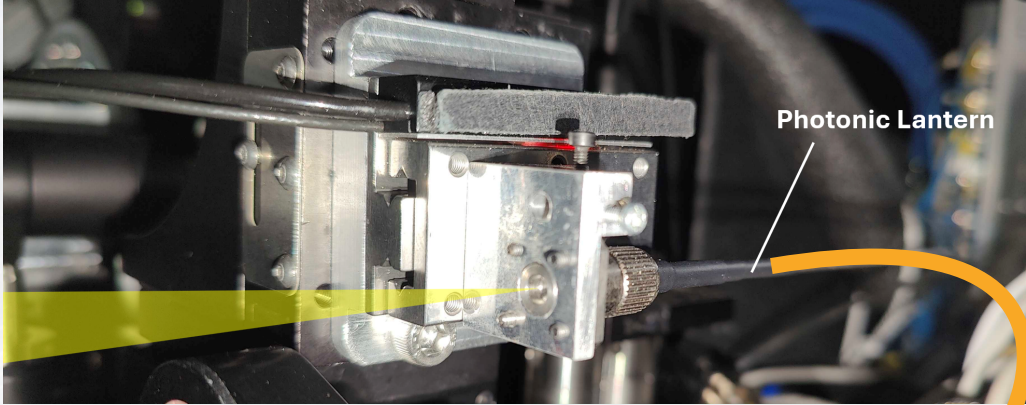


Vievard et al. 2024

Multi-mode fiber

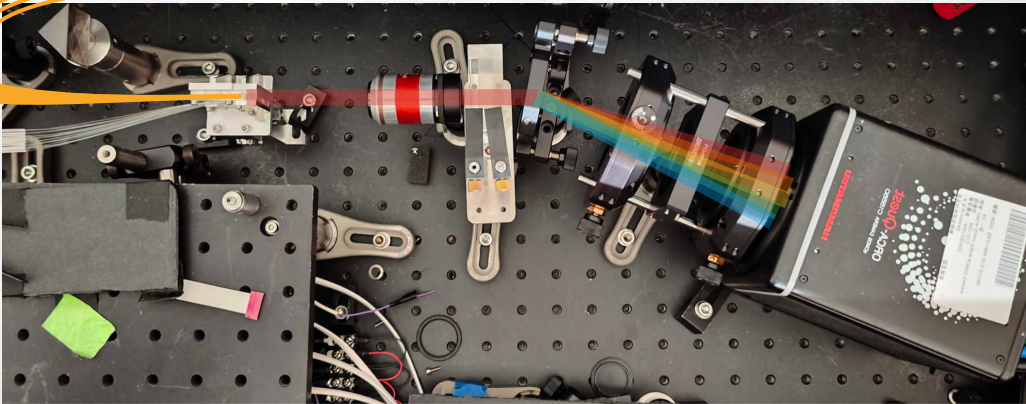


19 Single-mode fibers



Photonic Lantern

Injection into the photonic lantern MM end



Spectrograph 600-800nm (RS 3000)

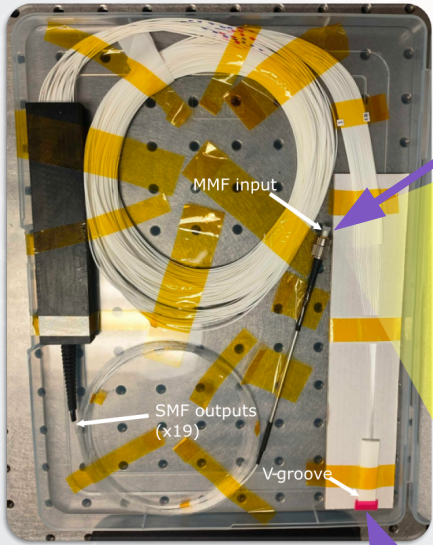
Credits: S. Vievard

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# FIRST-PL on SCExAO

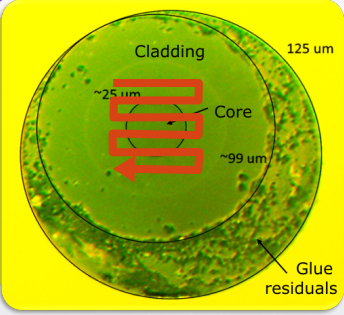


Photonic lantern device



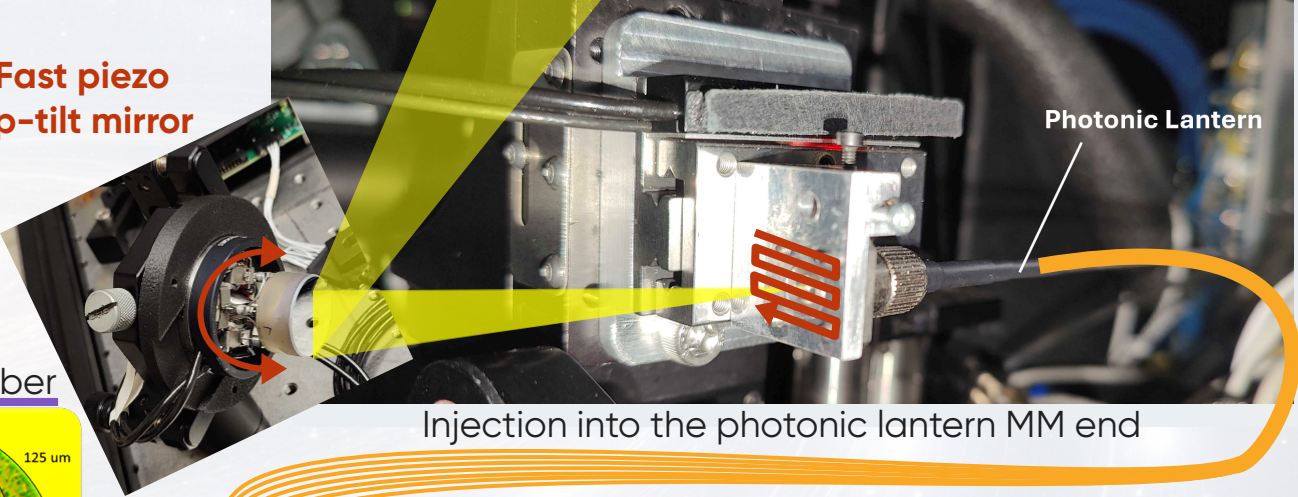
Vievard et al. 2024

Multi-mode fiber



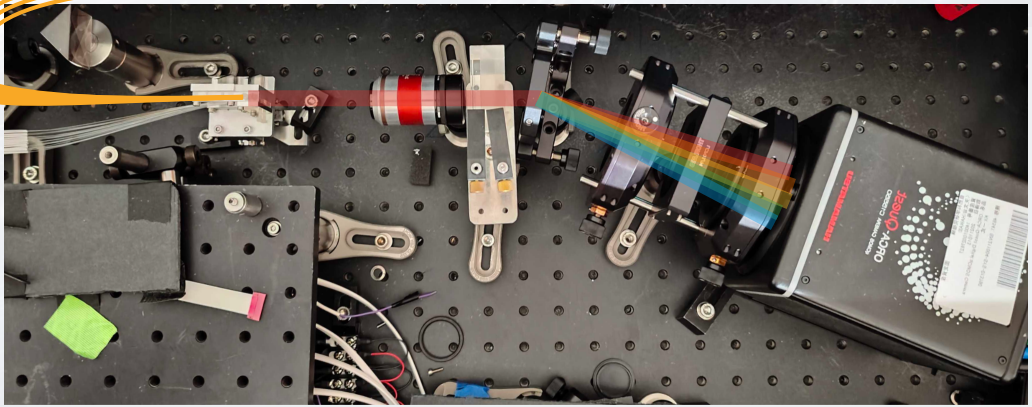
19 Single-mode fibers

Fast piezo tip-tilt mirror



Photonic Lantern

Injection into the photonic lantern MM end



Spectrograph 600-800nm (RS 3000)

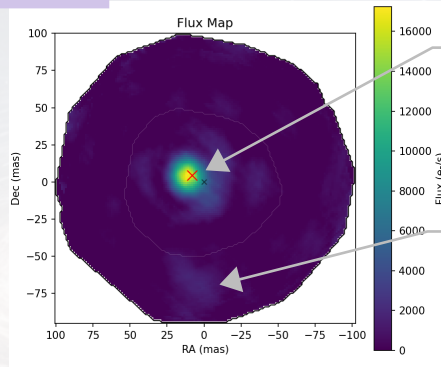
Credits: S. Vievard

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# Observing modes

## Imaging: on-axis & off-axis

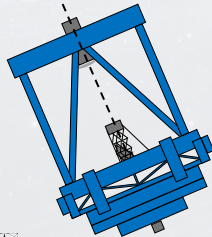
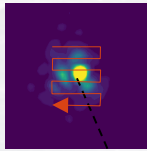
On-axis imaging:  
contrast  $< \sim 100$



HIP 81126 A

HIP 81126 B

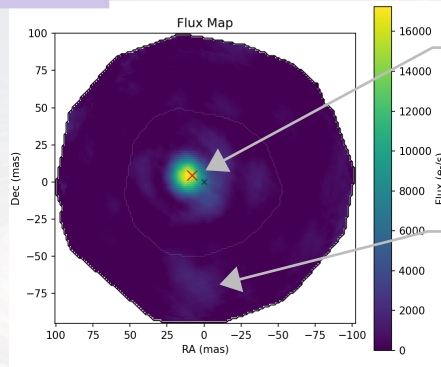
Observations of  
**HIP 81126**  
(Rmag 6,  
sep  $\sim 70$  mas,  
flux ratio  $\sim 0.1$ )



# Observing modes

## Imaging: on-axis & off-axis

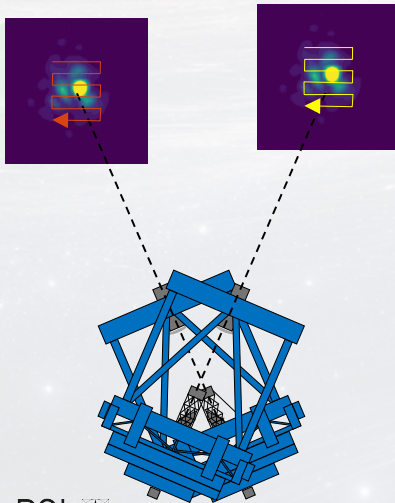
On-axis imaging:  
contrast  $< \sim 100$



HIP 81126 A

HIP 81126 B

Observations of  
**HIP 81126**  
(Rmag 6,  
sep  $\sim 70$  mas,  
flux ratio  $\sim 0.1$ )



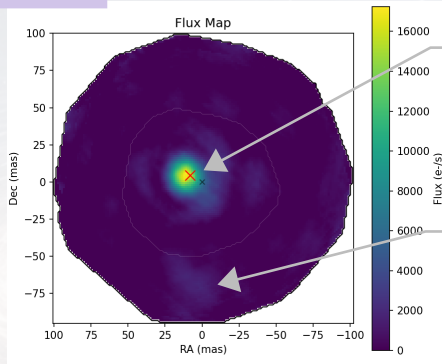
# Observing modes

## Imaging: on-axis & off-axis

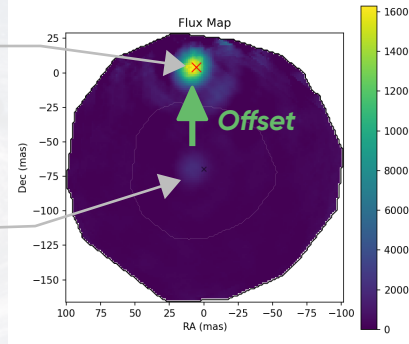
On-axis imaging:  
contrast  $\lesssim 100$

Off-axis imaging:  
contrast  $\lesssim 1000$

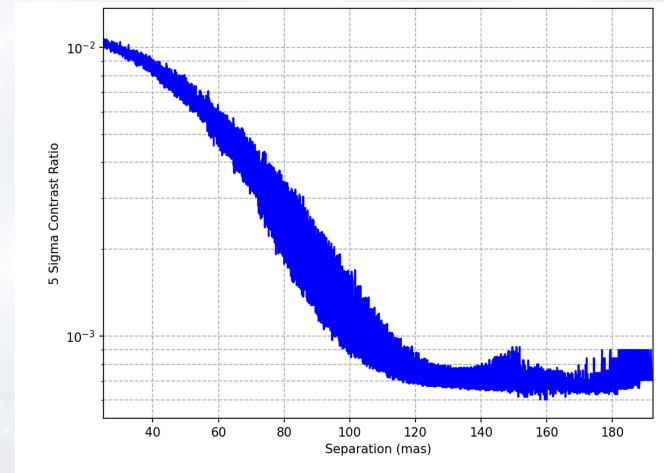
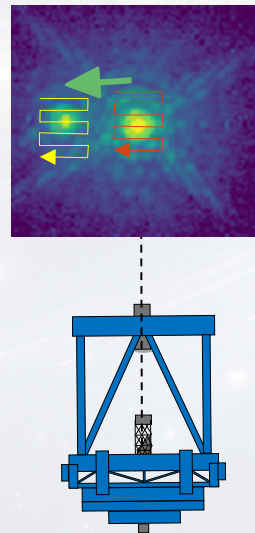
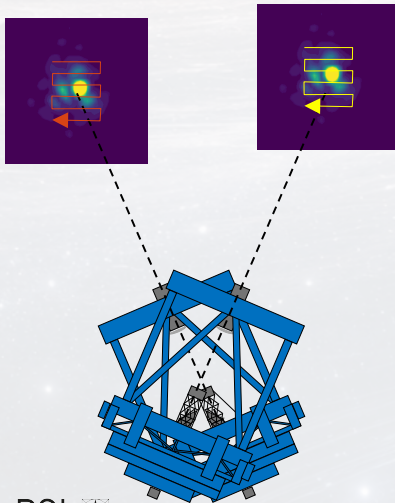
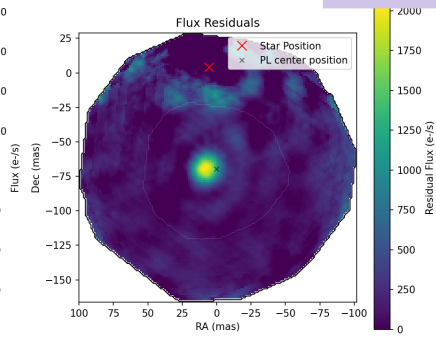
Observations of  
**HIP 81126**  
(Rmag 6,  
sep~70mas,  
flux ratio~0.1)



HIP 81126 A



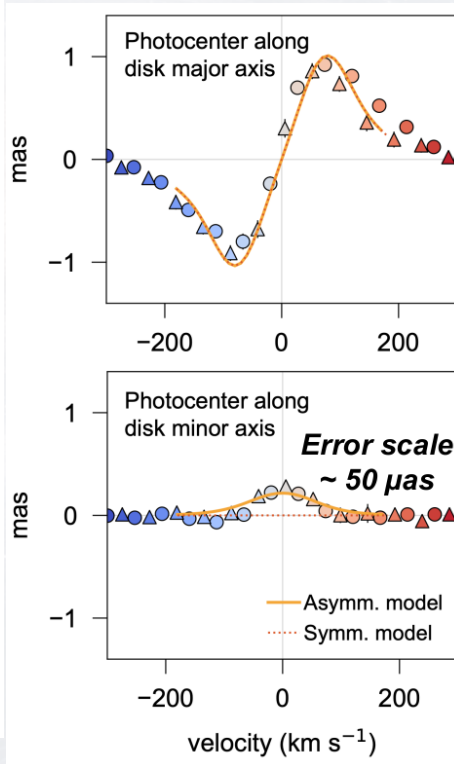
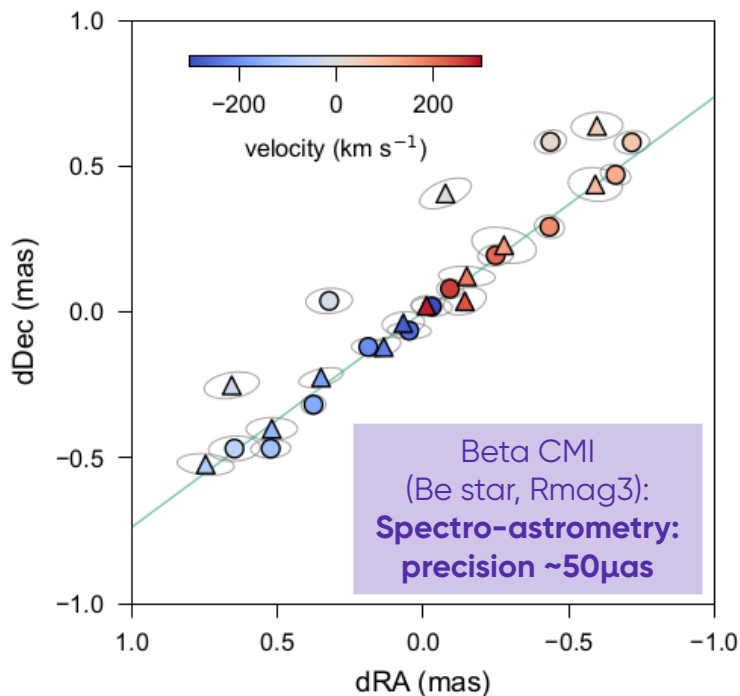
HIP 81126 B



# Observing modes

## H $\alpha$ spectro-astrometry

**a** Two-dimensional centroid map

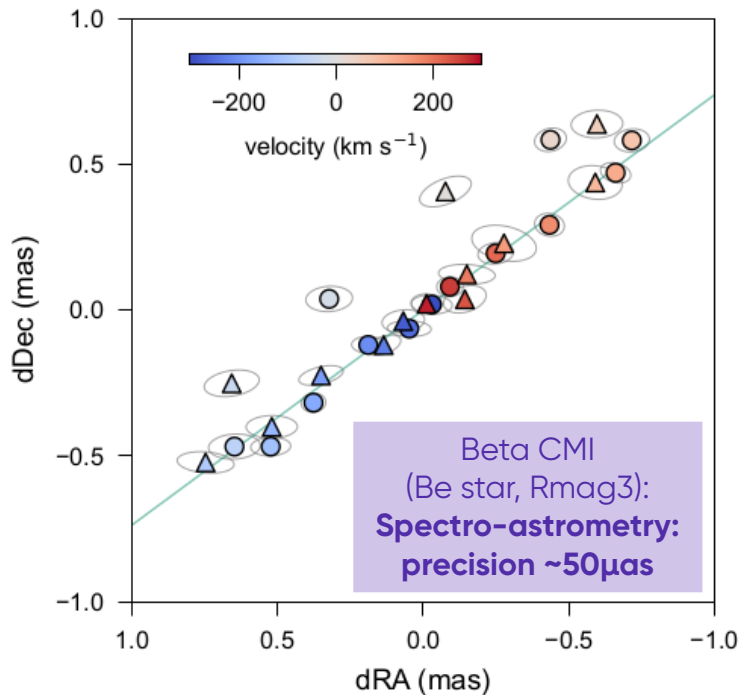


Kim et al. 2025

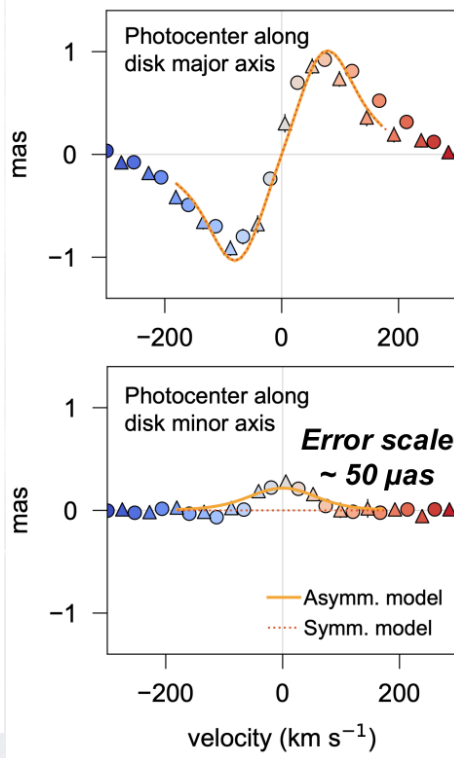
# Observing modes

## H $\alpha$ spectro-astrometry

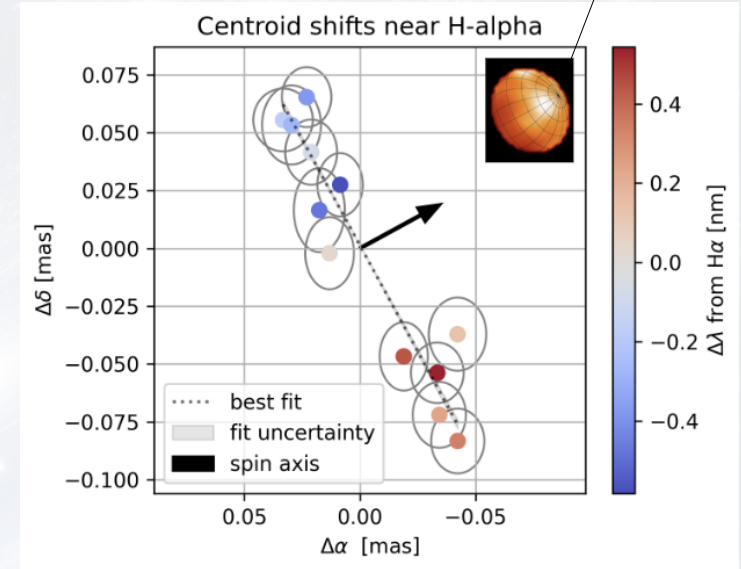
**a** Two-dimensional centroid map



Kim et al. 2025



Monnier et al. 2007  
(using the CHARA array)

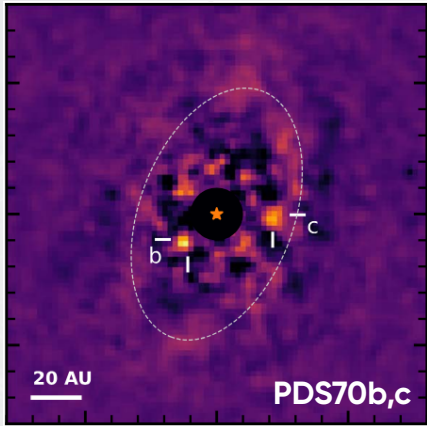


Walk, Vievard et al. in prep

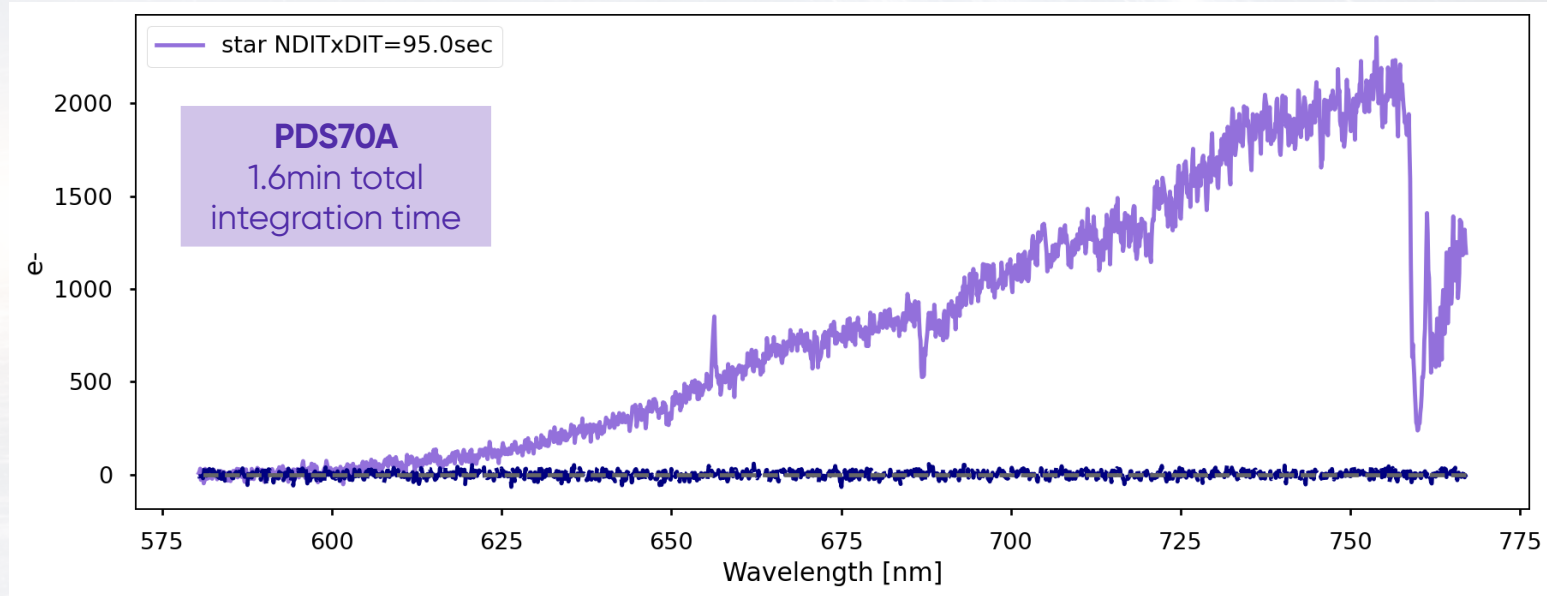
Altair: spectro-astrometric signal revealing the rotation of the stellar surface  
→ measurement of the spin axis

# Observing modes

## H $\alpha$ emission of protoplanets

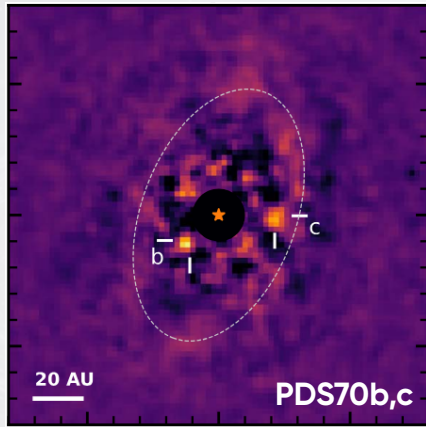


Zhou et al. 2025

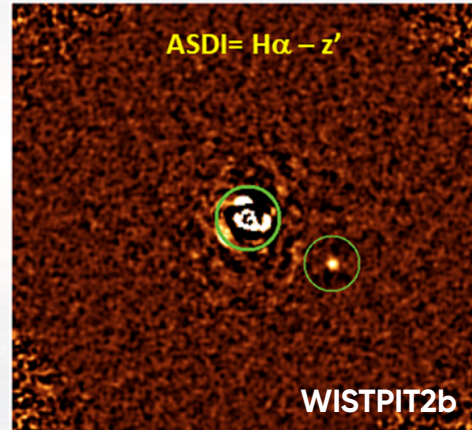


# Observing modes

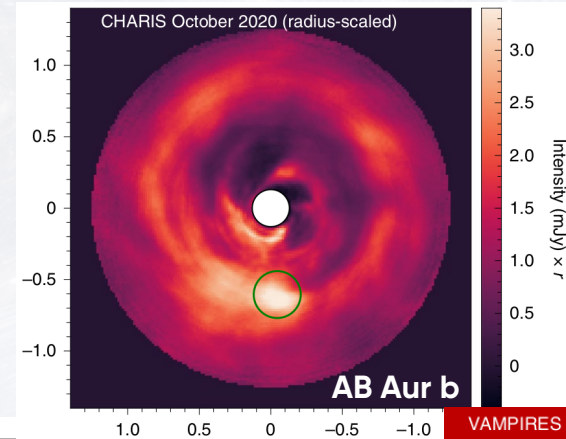
## H $\alpha$ emission of protoplanets



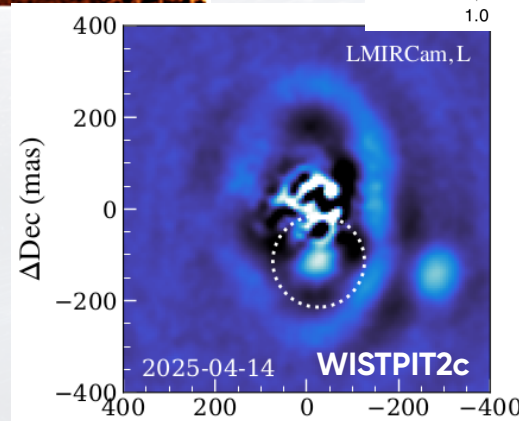
Zhou et al. 2025



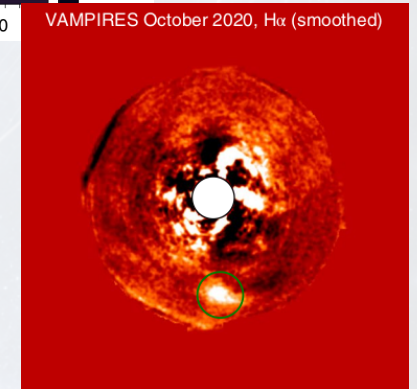
Close et al. 2025



Currie et al. 2022



Lawlor et al. 2026

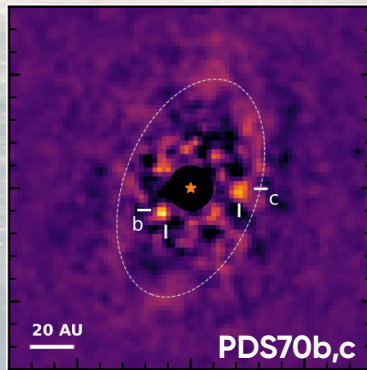


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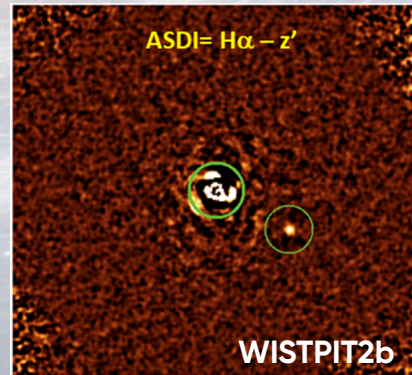
# Conclusions

SCEXAO/FIRST-PL has been commissioned →  
open for Science observations

- A **photonic lantern** is an **IFU (SR3000)** with high angular resolution in a small **FoV (100mas)**
- **Off-axis mode** for **characterization of known companions.**
- Spectro-astrometric precision of **50 $\mu$ as** (on bright targets)



Zhou et al. 2025



Close et al. 2025

