The FLAKE instrument, a speckle camera for the ELT

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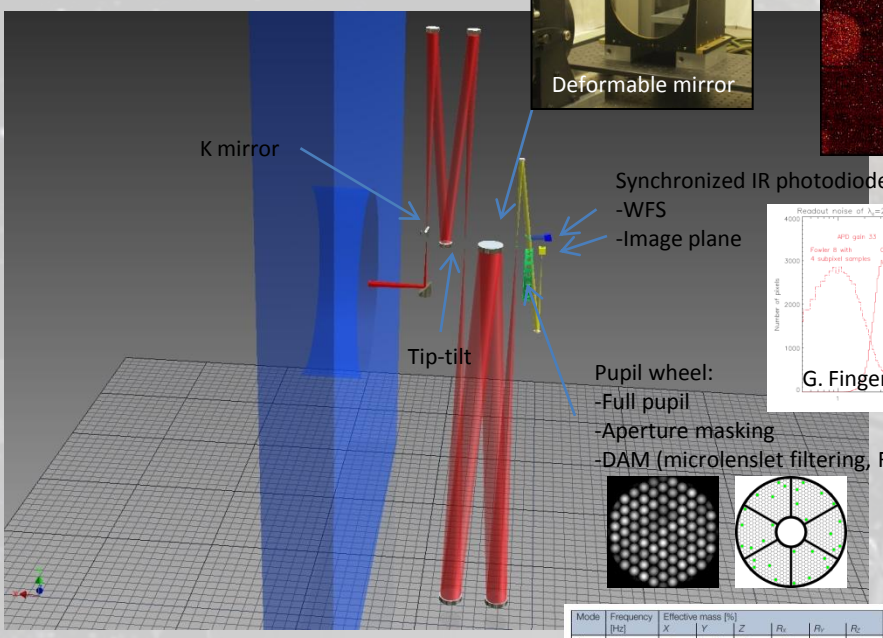
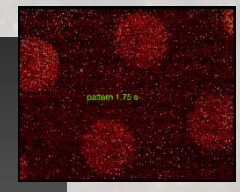
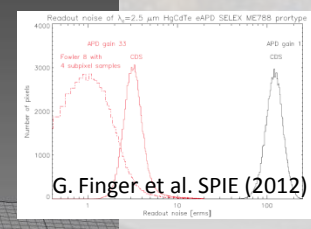
The use of a fast camera combined with the appropriate deconvolution algorithms would allow safe and reliable diffraction limited imaging in the 0.9-2.5µm range for a whole range of science cases including high contrast with a resolution down to ~5 mas (i.e, circumstellar environments) and precision astrometry (i.e galactic center) on a ~1'' FoV. That would apply even with any defective -or missing - segments (or segment clusters) on the 39-m primary mirror. This instrument would permit early science at high angular resolution, within the scientific topics of YSO, late type stars, and AGNs. We propose to build the "**Fast and Light Aperture masking and specKle imager for the E-ELT**" (**FLAKE**) instrument. We will present a design which consists of a low order AO, a pupil wheel, and two avalanche gain HgCdTe detectors: one in the pupil plane and one in the focal plane. The idea is to realize the simplest possible instrument based on the most advanced deconvolution algorithms: Holographic imaging (R. Schoedel et al., 2012), Kernel-phase deconvolution (F. Martinache, 2010) and Aperture masking (S. Lacour et al., 2011).

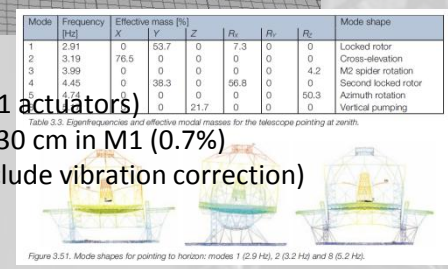
FLAKE

Optical concept









Mode	Frequency [Hz]	Effective mass [%] X	Y	Z	R_x	R_y	R_z	Mode shape
1	2.91	0	53.7	0	7.3	0	0	Locked rotor
2	3.19	76.5	0	0	0	0	0	Cross-elevation
3	3.99	0	0	0	0	0	4.2	M2 spider rotation
4	4.45	0	38.3	0	56.8	0	0	Second locked rotor
5	4.74	0	0	0	0	0	50.3	Azimuth rotation
6	5.19	0	0	21.7	0	0	0	Vertical pumping

Table 3.3. Eigenfrequencies and effective modal masses for the telescope pointing at zenith.

Figure 3.51. Mode shapes for pointing to horizon: modes 1 (2.9 Hz), 2 (3.2 Hz) and 8 (5.2 Hz).

Technical Requirements :

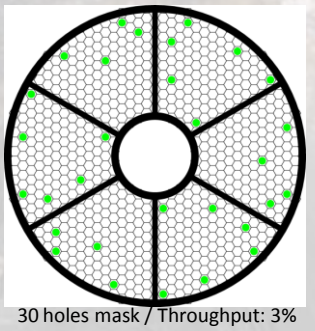
-Coherencing with a low order but fast AO (eg, 41x41 actuators)

-Pupil tracking (lateral and rotational) equivalent to 30 cm in M1 (0.7%)

-Fast readout camera: 512x512 pixels ≥ 10 Hz (to include vibration correction)

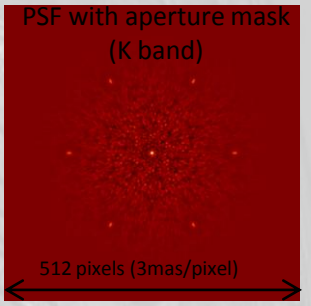
-Low noise camera: eg SELEX detectors

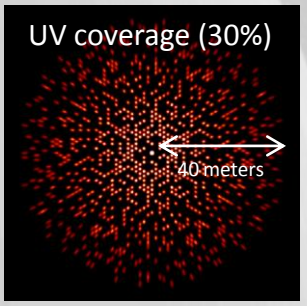
A gigantic interferometer



30 holes mask / Throughput: 3%

Aperture masking: for bright targets, a non-redundant mask will be place in the pupil. The 30 green segments will be used. The advantage is to further stabilized the OTF.





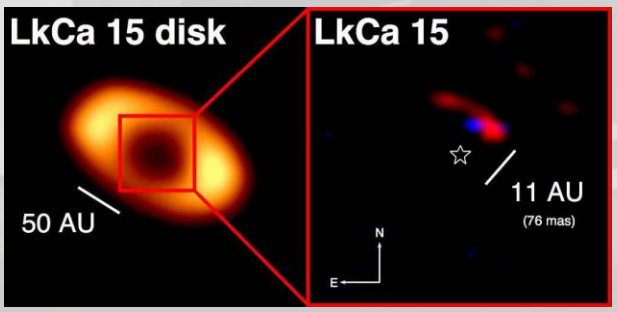
This mode is under study for the MICADO instrument

Technical advantages:

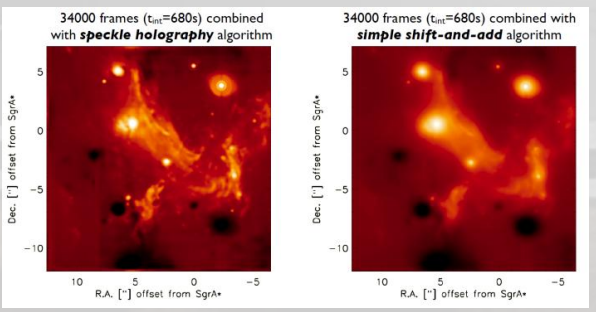
- Diffraction limited imaging on bright targets (resilient to vibrations, non-common path aberrations)
- High contrast levels at lambda/D (7 magnitudes with the aperture mask)
- Open to many options for post-processing image reconstruction (PSF reconstruction, Kernel phase, etc..)

Science cases (high contrast and high angular resolution)

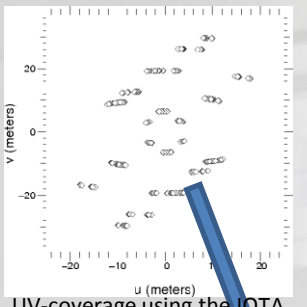
- Protoplanetary disks and planet formation
- High angular resolution imaging of crowed field (eg Sgr A*)
- Evolved stars and stellar surfaces imaging



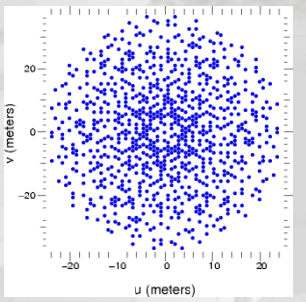
IR detection from Krauss & Ireland (2011) of a planet under formation next to the young T Tauri star LkCa 15



Deconvolution of the Sgr A* field using speckle holography (R. Schoedel et al. 2012)



UV-coverage using the IOTA optical interferometer



UV-coverage using FLAKE

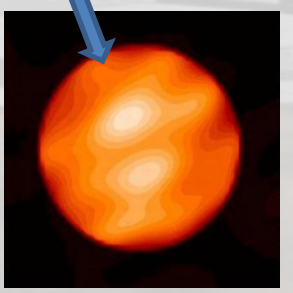


Image of Betelgeuse spotty surface (Haubois et al. 2009)