HAWK-I CALIBRATIONS

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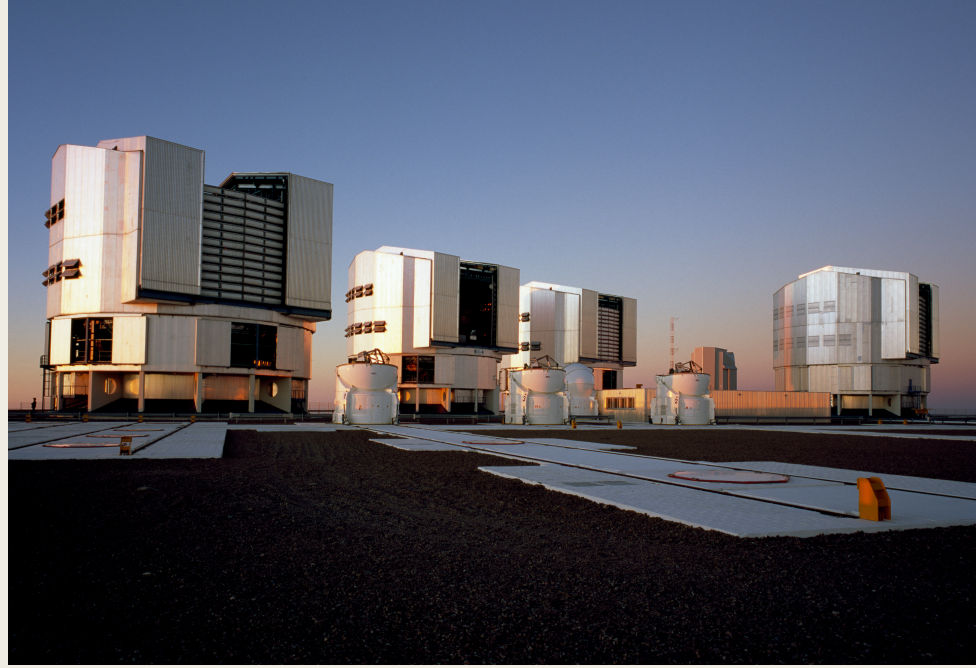
HAWK-I Instrument Operation Team

Outline

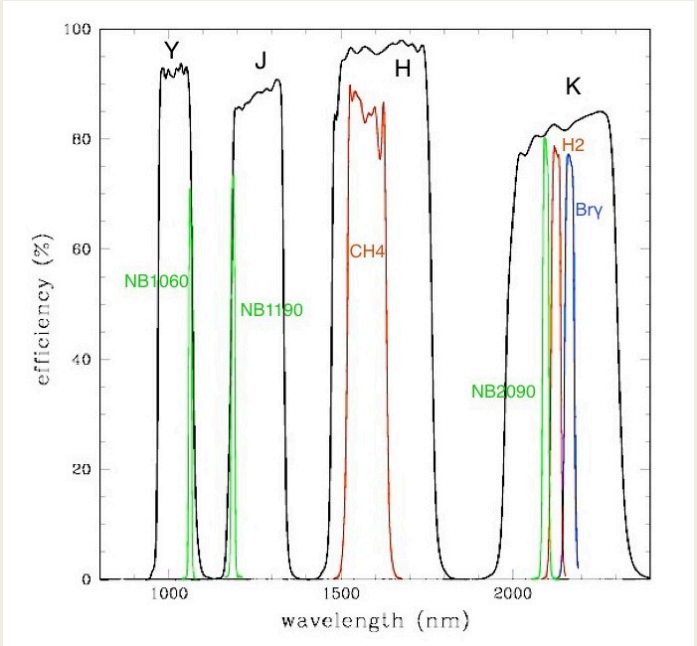
- Presentation of HAWK-I
- Description of the calibration plan
- Presentation of GRAAL
- How GRAAL affects the Calibration Plan ?

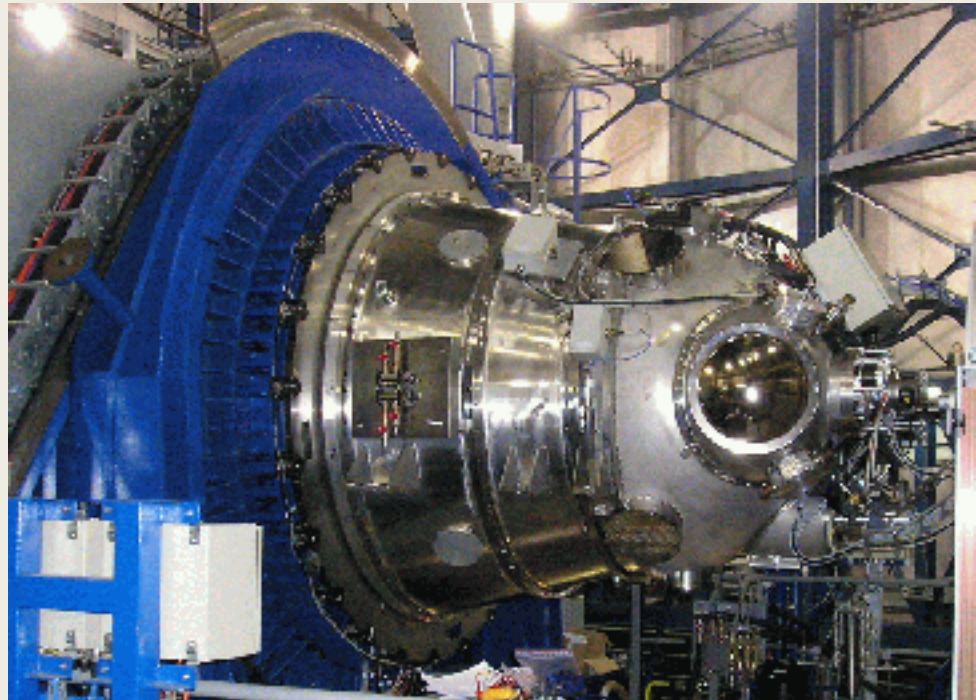
HAWK-I

High Acuity Wide field K-band Imager



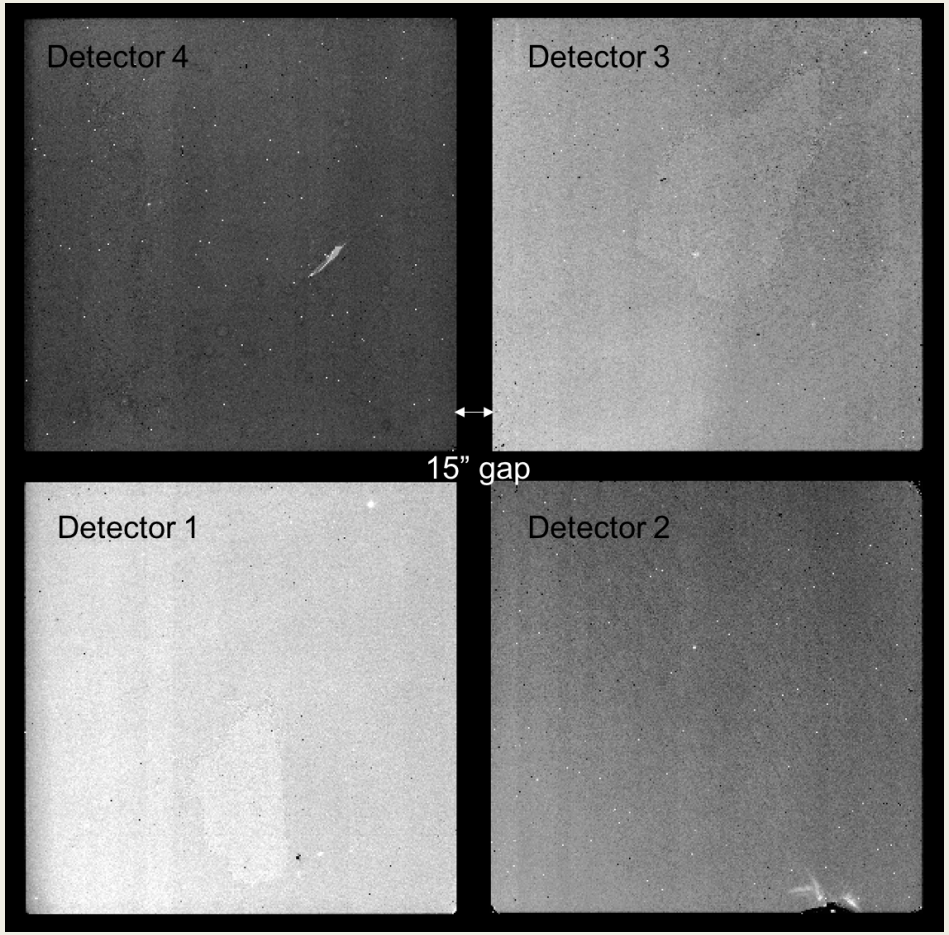
- NIR Imager 0.9-2.5 microns
- 7.5 x 7.5 sq. arcmin
- 0.106”/pixel
- YJHK + 6NB filters
- Mostly used for extragalactic studies + non-sidereal objects.





HAWK-I Detectors

- Four HAWAII 2RG 2048x2048 pixels detectors
- Status and Health continuously monitored : www.eso.org/qc
- Series of daytime and nighttime calibrations
- Linearity calibration data taken once a month

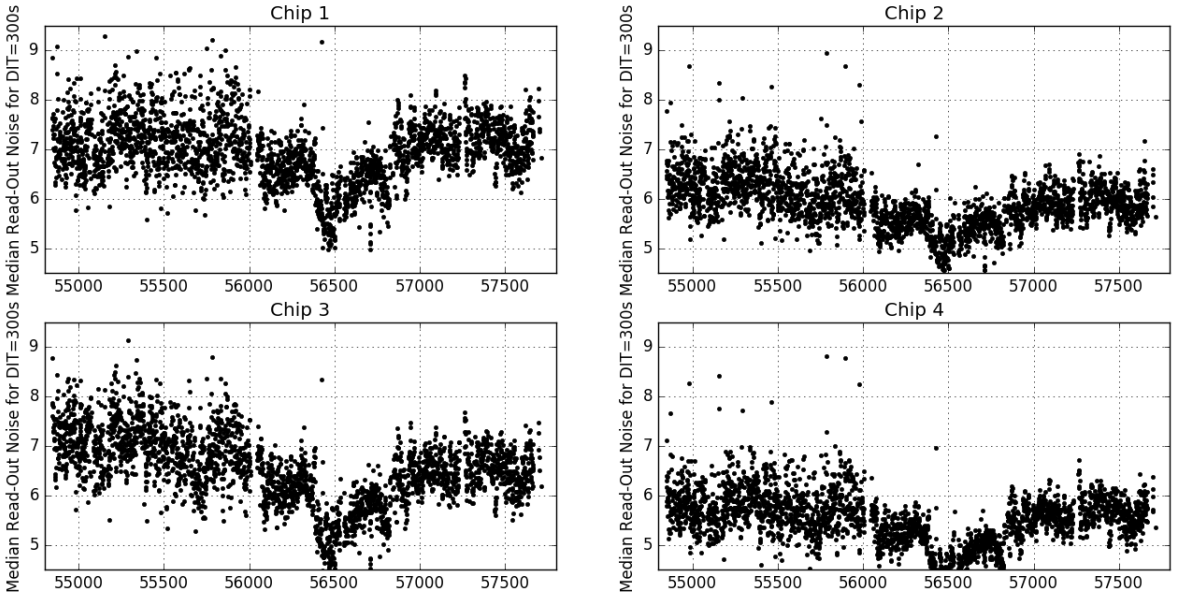


Very good stability over time.

Gain (e- /ADU)	Between 1.7 and 2.1
Dark Current (e-/s) at 75K	Between 0.10 and 0.15
Linear Range (1%)	~30 000 ADUs
Saturation level	Between 40 000 & 50 000 ADUs.

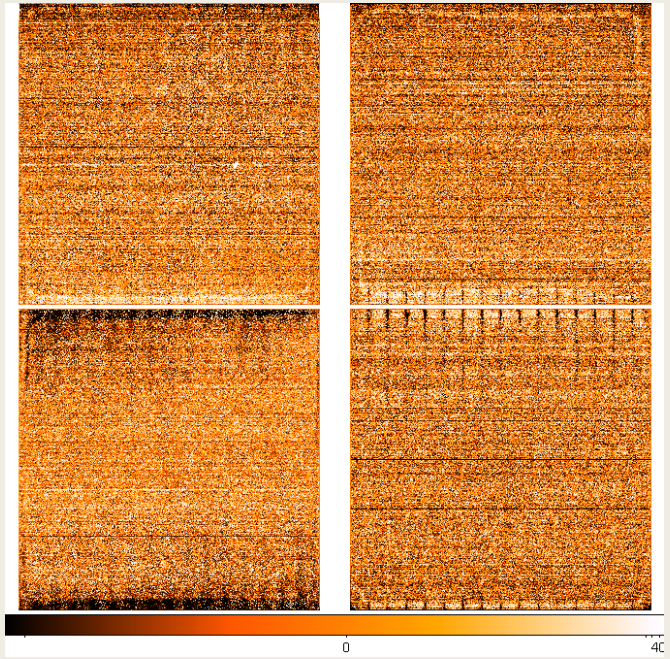
Maintenance Data Calibrations Detector Characterization and Monitoring

- Via the following parameters:
  - RON as a function of read-out mode Dark current
  - Conversion factor
  - Bad pixel/columns map
  - Linearity
  - Gain
  - Fixed Pattern Noise
  - Inter-pixel capacitance correction
- Procedure: Take a series of flats, darks for the standard detector modes
- Monthly executed during Daytime

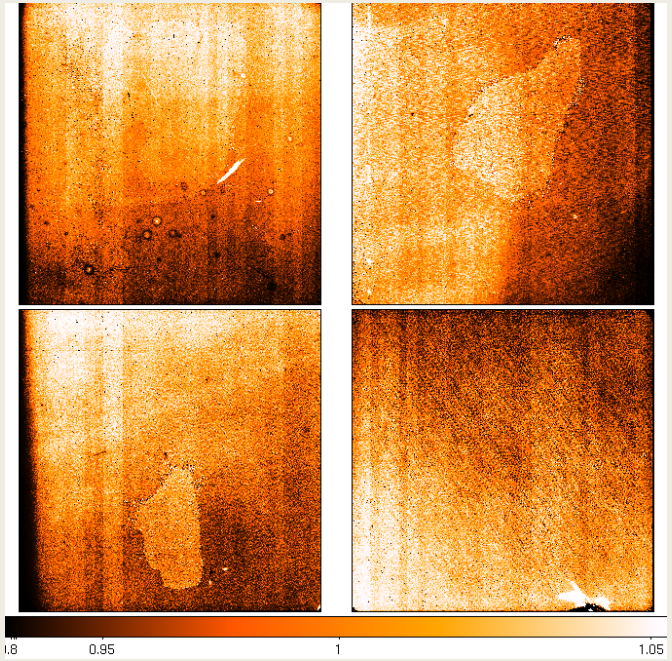


Scientific Data Calibrations DARKS + FLATS

- Daily darks
- Several standard settings : every DIT/NDIT combination used during the previous night.
- Outputs: pipeline products:
  - Master dark frame
  - Hot pixel map
  - Readout Noise: mean/median/rms

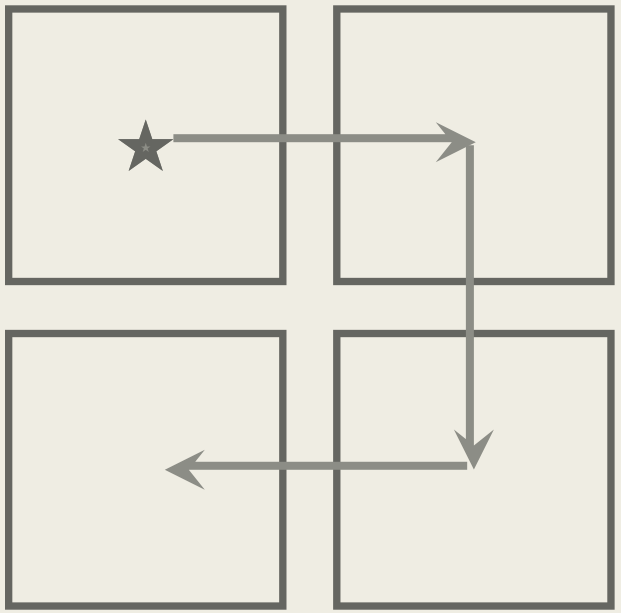


- Rely on **twilight** flat-fields : sufficient to correct (up the ~ 3% level) for any pixel-to-pixel and small scale variations.
- Outputs:
  - Master flat-field frames
  - Cold pixel map

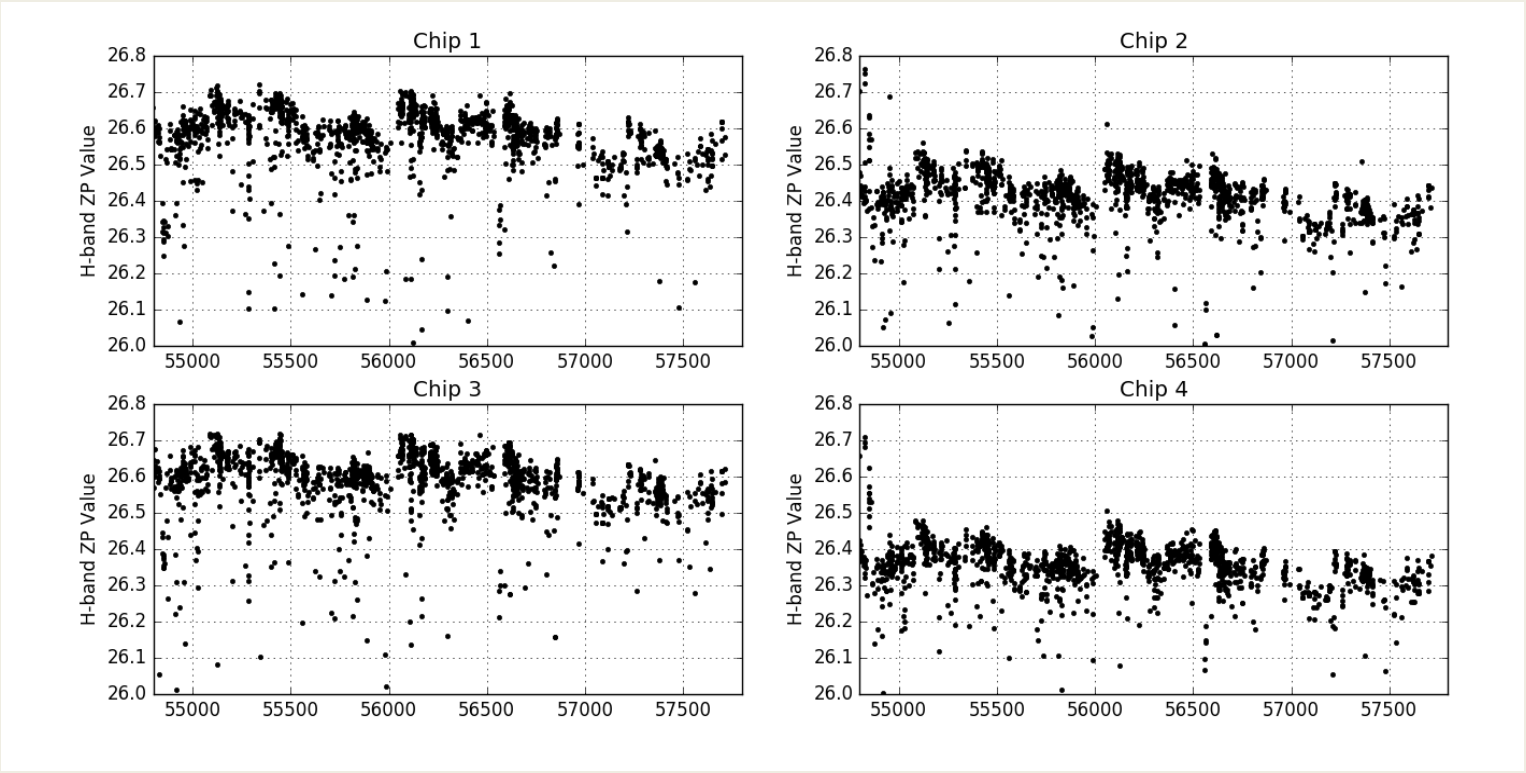


Scientific Data Calibrations Photometric Standards

- Measurement of the zero-point and comparison with previous nights
- Once per month, color terms and extinction coefficients are monitored.



- Very inefficient!!

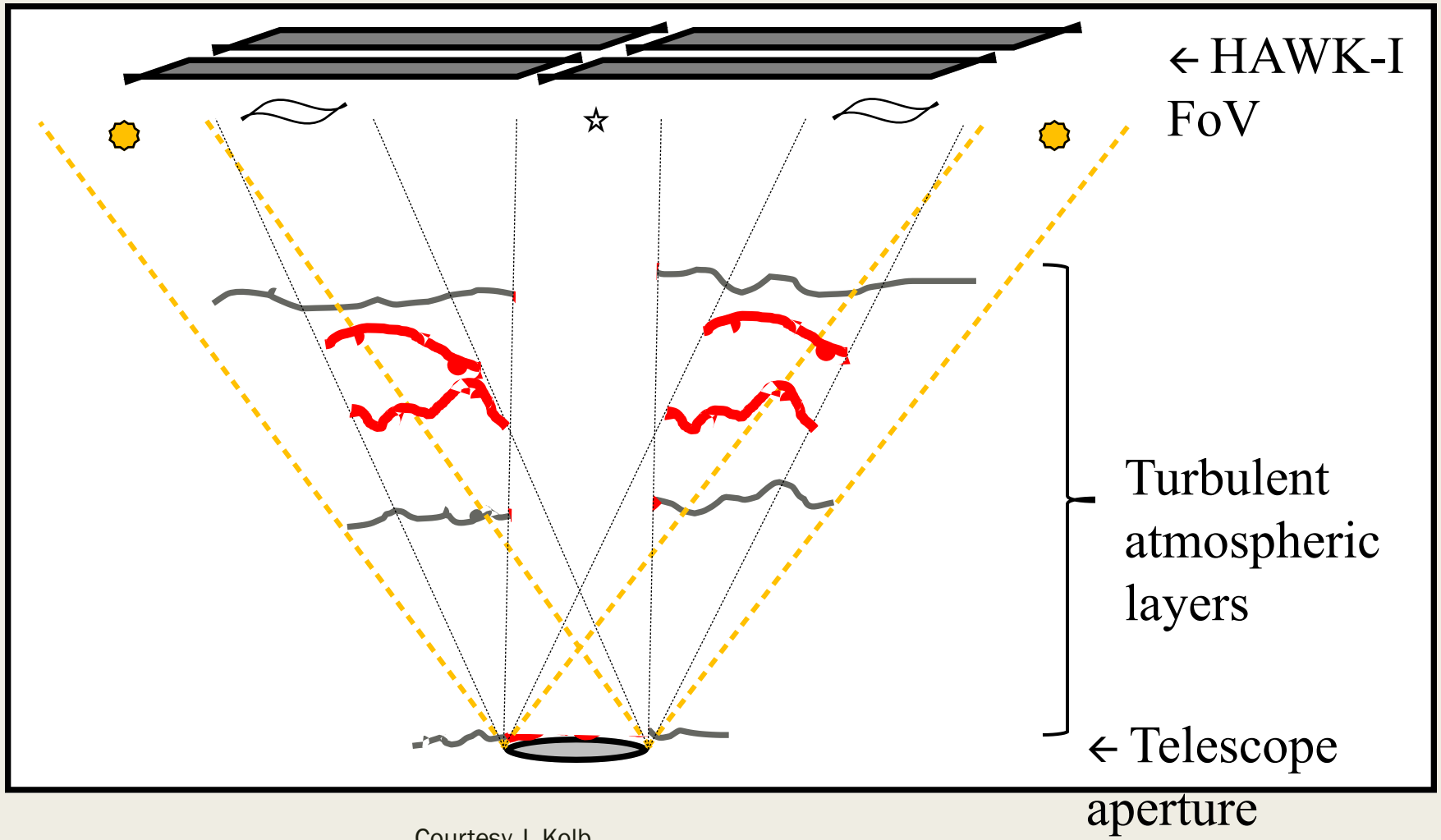


Fast Photometric mode : New Calibration

- Fast Phot mode : intended for observations of extremely bright objects
  short DITs to avoid saturation, small overheads, increase of the efficiency
- Windowing down the detectors to speed up the observations and to decrease the overheads for data transfer.
  For a ~6×6 arcsec window, MINDIT = 0.1022 sec.
  + detector readout mode = ReadRstRead
- As per users and USD request : new windowed sky flat template
- Same template than the actual HAWKI sky flat template, with the specifications for the windowing parameters and fast photometry readout mode.
- Necessary for better data reduction,.

Ground Layer Adaptive Optics

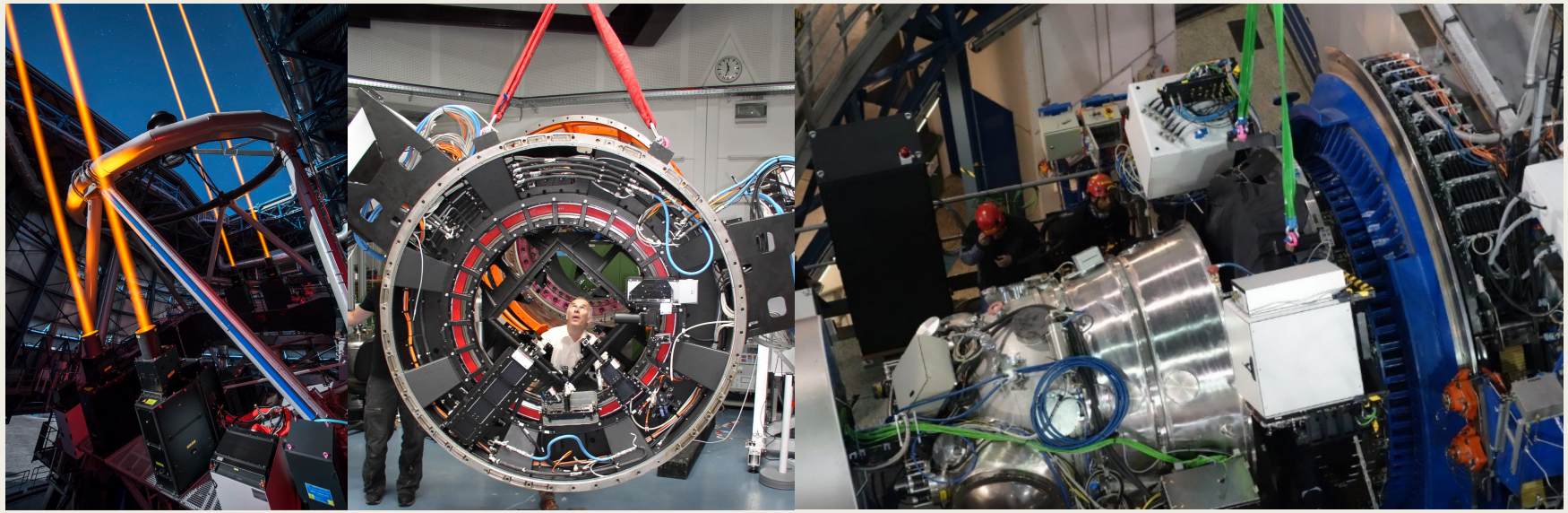
- For Wide-Field Instruments
- Improve the seeing in the whole FOV by correcting the Ground Layer of turbulence

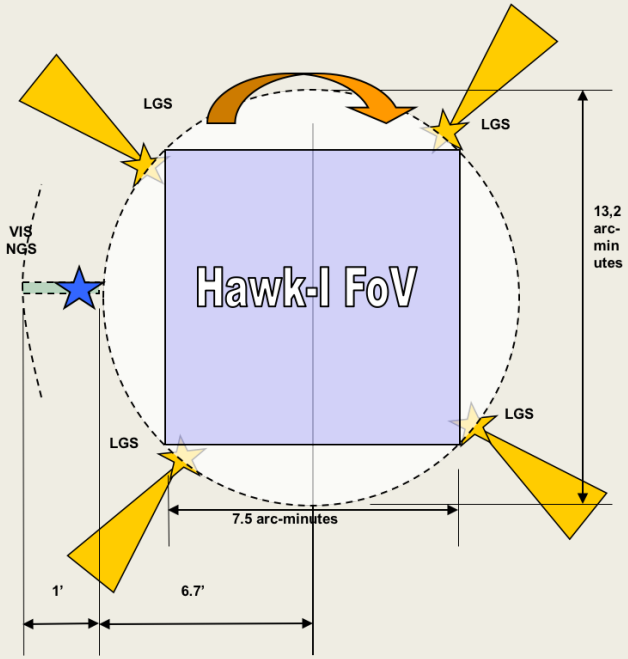


Courtesy J. Kolb

GRAAL : Adaptive Optics System for HAWK-I

- Ground Layer Adaptive Optic Module based on the 4LGSF + DSM.
- Seeing Enhancer : improve the quality of images by compensating for turbulence in the lower layers of the atmosphere, up to an altitude of 1 km.
- Transparent to the system
- Performance : Expected gain in integration time or limiting source flux : factor 1.5 to 2

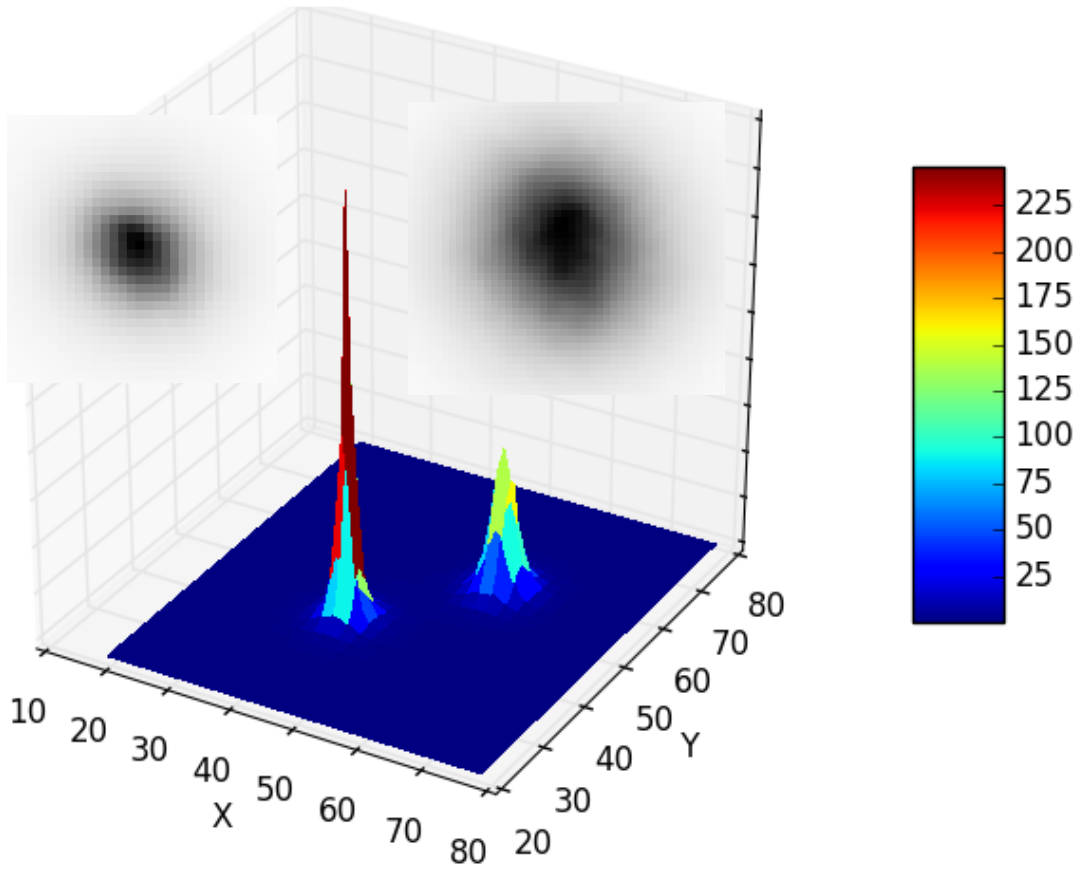


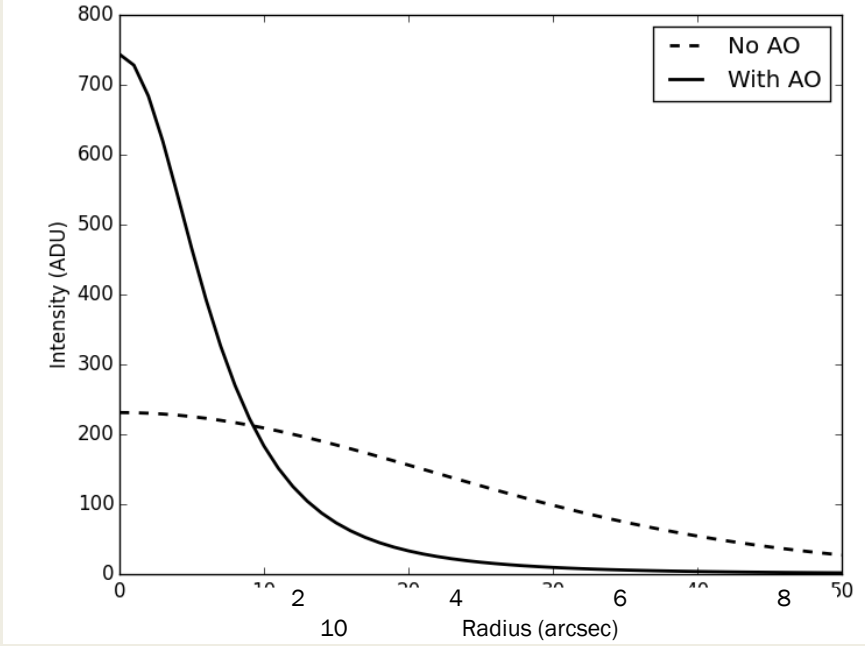


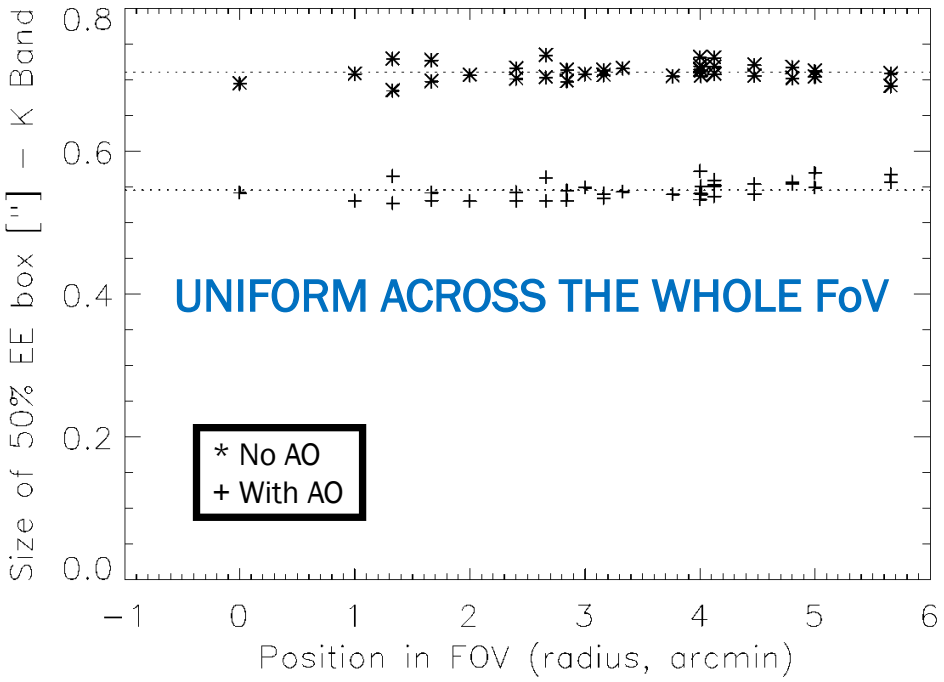
GRAAL + HAWK-I : Operations

- Installed since 2015.
- GRAAL corrects efficiently atmospheric layers below 300 m altitude.
  60% of the time, more than 60% of the turbulence is located in this effective correction domain.
  -> GRAAL providing a seeing improved by about 20% the vast majority of the time.
- overhead time < 5min, when using the AOF.
  -> optimization and automatization of the AOF acquisition.
- HAWK-I uses the adapter/rotator of the Nasmyth focus to derotate its field of view. GRAAL LGS-WFS must derotate the pupil -> a derotator carrying the LGS-WFS counteracting the adapter's.
- WARNING! Will need to be very cautious as stars will more easily get saturated...)

GRAAL + HAWK-I Performance







Schedule

Milestones	Date
GRAAL module installed on UT4	June 2015
GRAAL-LGS Unit 1 combined tests	October 2015
4LGSF Commissioning in Stand-Alone	Completed in July 2016
DSM installation on UT4 and UT4 recommissioning	Dec. 2016
GRAAL Maintenance and Commissioning Mode comm. with the validation DSM in AO mode	March 2017
GRAAL GLAO comm.	Early 2018
AOF Provisional Acceptance in Chile	Towards mid-2018

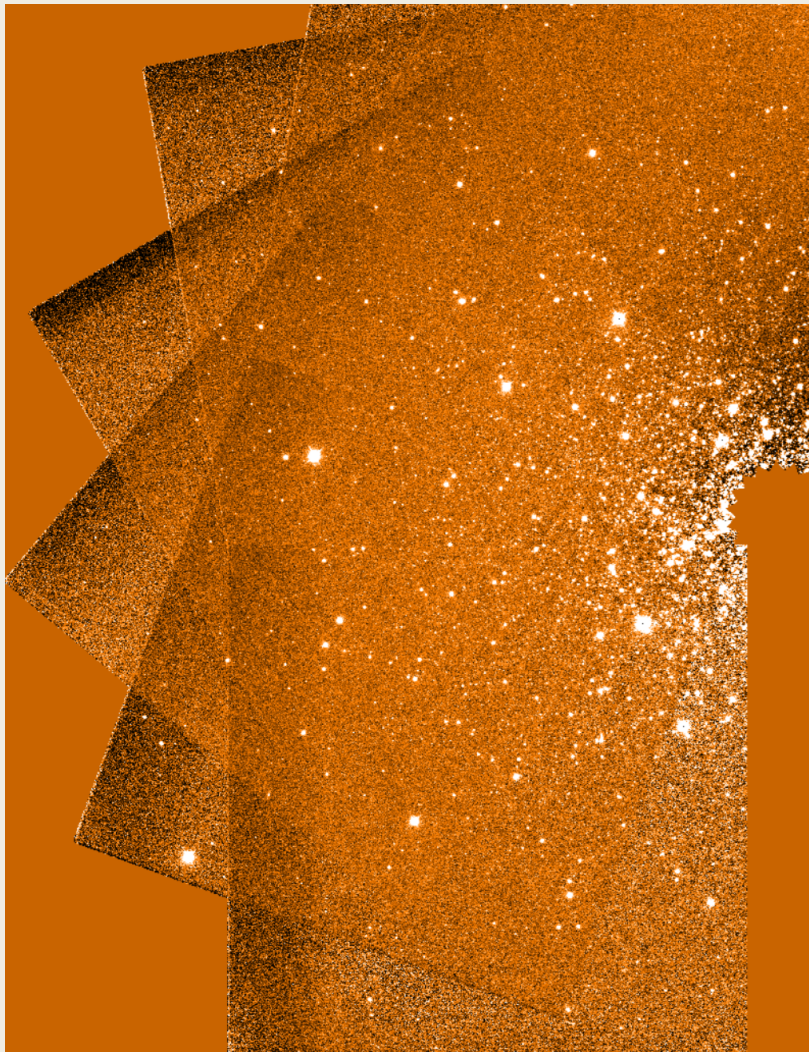
GRAAL+HAWK-I Science

- **Stellar Evolution** : provide K-band data with HST resolution + wavelength range unavailable with HST.
- **Star Formation – Planetary systems** : unique capability : very large and homogeneous AO corrected FOV.
- **Galaxy & AGNs : 2<z<3** : well improved angular resolution over very wide FOV
- **Cosmology** : essential role for high-z galaxies search with enhanced point source sensitivity + combination of BB & NB filters.

Maintenance Data Calibrations Distortion & Flexure

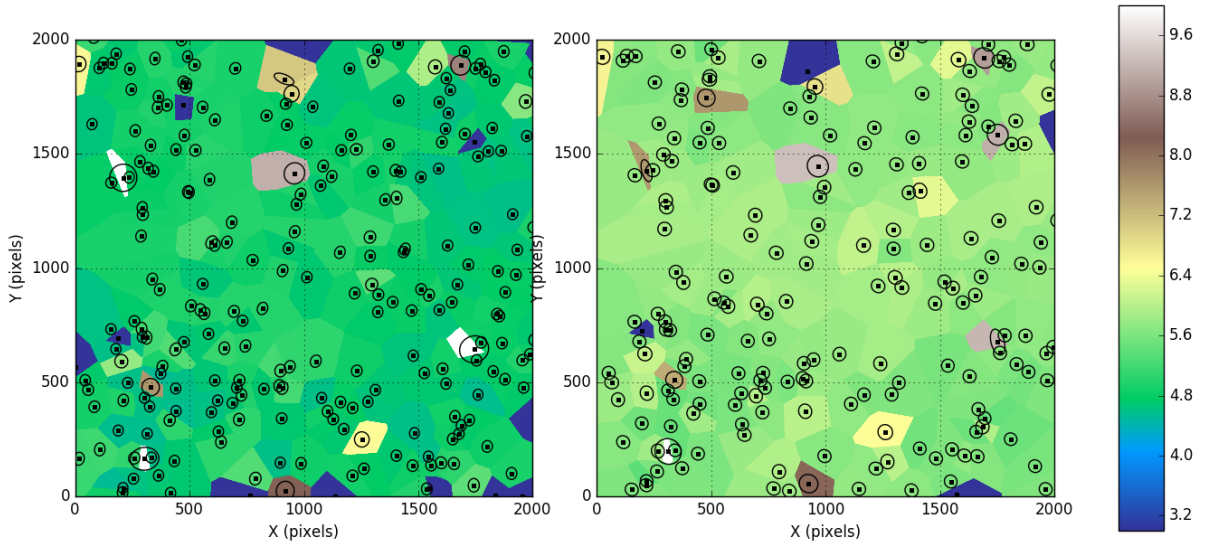
- Distortion : to monitor scale and spatial distortions in the 4 HAWKI detectors.
  The template goes to the object, then immediately makes a BIG offset to sky, jitter a while, and then the move back to the object and in the end makes another BIG offset to sky.
  Using globular cluster with excellent astrometry

- Flexure : Important to check how and if flexure has changed especially for future GRAAL + HAWK-I operations. Template for the 4 BB filters and take an image of the same globular cluster than the Distortion template but modifying for each exposure the position angle.



Scientific Data Calibrations
Photometric Standards – the new way

- 2MASS fields so that we can cross-calibrate the HAWK-I photometry. These fields are adapted - in terms of field coverage and magnitude - from the 2MASS touchstone fields.
  More well known Globular Clusters can be added to the list of fields we can use.
- Used for Astrometric Calibration.
- Used for FWHM monitoring across the large FOV.
- Reduced using the new CASU pipeline.
- *Project* : Live FWHM/EE estimation on the RTD to have a quality control on each images.



New pipeline

- vast improvement over what we currently have.
- full astrometric and photometric correction based on field sources,
- sophisticated background correction,
- can combine frames into tiles.
- The new pipeline does away with the very inefficient HAWK-I standard star calibration by using the 2MASS touchstone fields.
- No distorsion recipe : astrometric correction of the science images done using all objects in the frame matched to catalogues -> most of the low-order distortions are intrinsically removed.
  No distortion map is made by the new pipeline
- adequate for the vast majority of science cases, but we may have to consider developing something else if we want corrections to better than a tenth of a pixel.

Conclusions

- HAWK-I : reliable and robust instrument over the years.
  remains very popular
- GRAAL : Seeing Enhancer for HAWK-I
- GRAAL enables HAWK-I to conduct its most demanding science programs, that would normally require the best seeing conditions, during most nights.
- More efficient surveys, better detailed studies of crowded fields and a more precise astrometry and photometry
- Importance of good, reliable astro-photometric calibrations and their procedure.
- With AOF, and GRAAL : importance of monitoring distortion, flexure and FWHM homogeneity across the FOV.
- Observations can be done much faster, saving a significant amount of observing time - **Gain of factor 1.5 to 2 !**