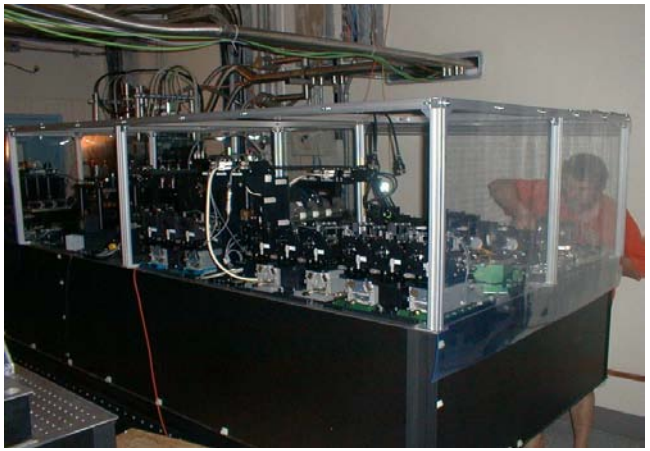
Using the VLT Interferometer
AMBER data reduction



Tools session

ESO Workshop “10 years of VLTI”

ESO Headquarters Garching

27 October 2011

Markus Wittkowski

User Support Department (USD), ESO Garching

Resources

- Description of AMBER:
  http://www.eso.org/instruments/amber/index.html
  Petrov et al. 2007, A&A, 464, 1: “AMBER, the near-infrared spectro-interferometric three-telescope VLTI instrument”

- Data reduction description:
  Tatulli et al. 2007, A&A, 464, 29: “Interferometric data reduction with AMBER/VLTI. Principle, estimators, and illustration”
  Chelli et al. 2009, A&A, 502, 705: “Optimised data reduction for the AMBER/VLTI instrument”

- Software:
  Distributed and maintained by the JMMC:
  http://www.mariotti.fr/data_processing_amber.htm

AMBER principle

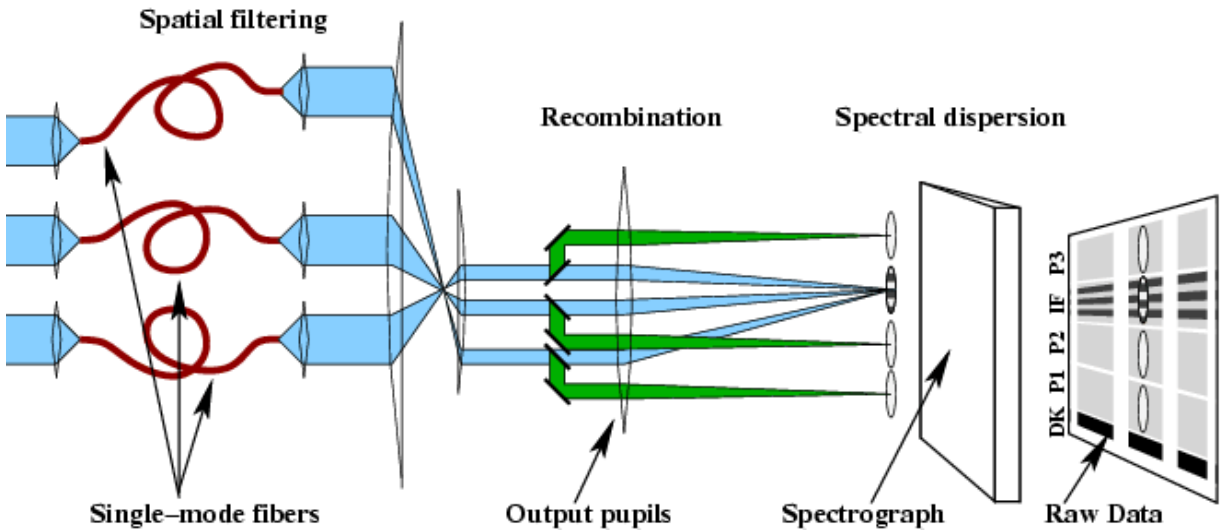
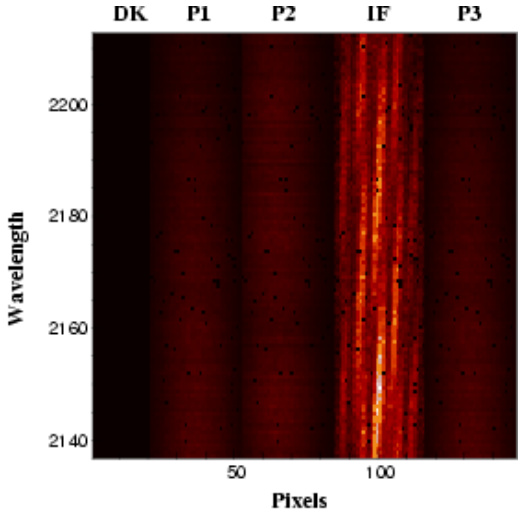


Fig. from Tatulli et al. 2007



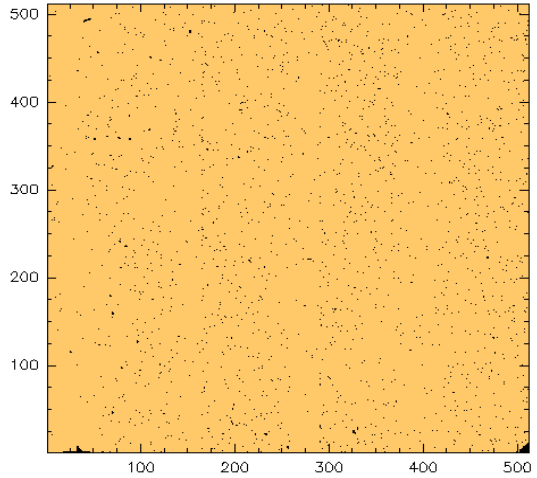
- Warm optics: Dichroic plates separate the *J,H,K* bands, light is injected into single mode fibers for spatial filtering, and the *J,H,K* light is again combined so that the airy disks for each band have the same size. Photometric channels are separated.
- The three collimated beams form a non-redundant set up, and are focused into a common Airy pattern that contains the fringes (beam combination in image plane).
- In addition: Cylindrical optics to reduce noise, neutral density filters, polarisers.
- Spectrograph: Dispersion by a standard long-slit spectrograph (3 different spectral resolutions of R = 30, 1500, 12000). Includes an image plane cold stop and a cold pupil masks.
- Detector: One quadrant of a 1024x1024 pixel Hawaii detector.

AMBER DATA REDUCTION OVERVIEW

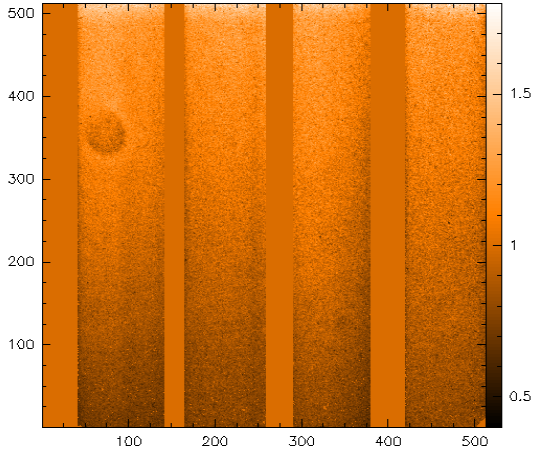
- Cosmetic corrections in the raw data
  - Bad pixel map
  - Flatfield map
  - Spatial distortions, Wavelength calibration
  - Detector fringes
- The Pixel-to-Visibility Matrix (P2VM)
  - Calibration of the “carrying waves”
- Computing visibility values
  - Fitting of amplitude and phase of the complex coherent fluxes
  - Correction for biases
  - Computation of unbiased V^2 values
  - Computation of phase closures
  - Calculation of piston values using cross spectra
- Frame selection
  - Definition of criteria to select the “best” frames (piston, fringe S/N, flux ratio)
- Visibility calibration

AMBER DETECTOR ISSUES

- Classical issues of IR-detector:
  - flat-field map
  - bad pixel map



Bad pixels map



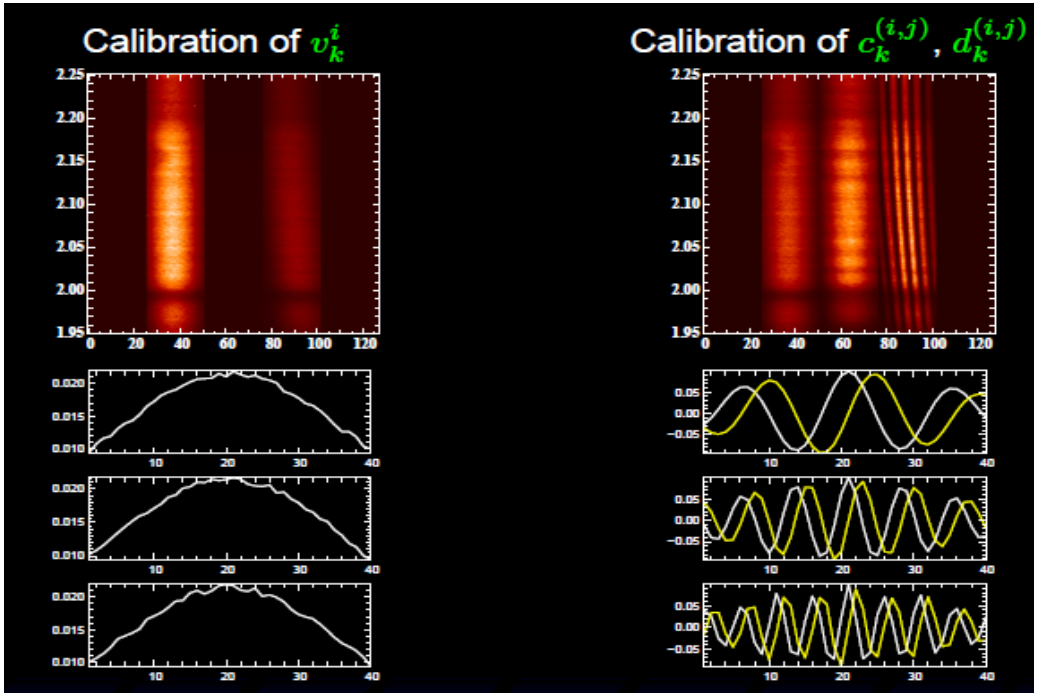
Flat field map

INTERNAL CALIBRATION (P2VM)

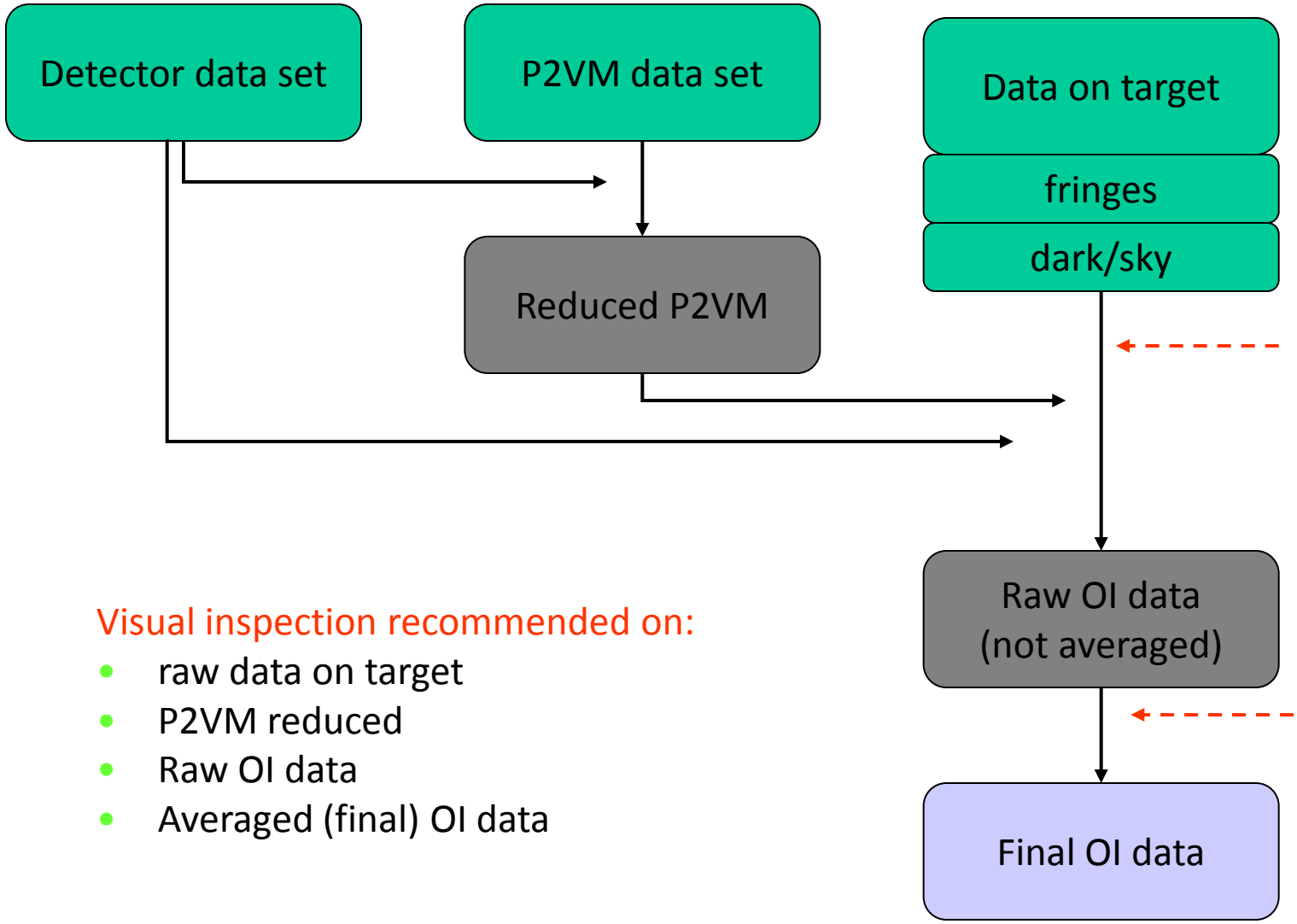
The fringe systems for each pair of beams, normalize to the unit energy, are called “carrying waves”. The complex coherent fluxes are related to the raw data by a relatively simple linear relationship, which can be addressed by a matrix (P2VM matrix).

- Need for a internal calibration:
  - relative flux in the photometric and interferometric beams
  - relative transmission in λ
  - wavelength table
  - disentangle the 3 fringe patterns by a fringe fitting technique
- Internal calibration depends
  - on setup (LR, MR…)
  - on time (unstable)
- Calibration sequence:
  - wavelength calibration
  - one beam at a time (1)
  - one pair at a time (2)

(1) (2)



AMBER DATA REDUCTION FLOW



Visual inspection recommended on:

- raw data on target
- P2VM reduced
- Raw OI data
- Averaged (final) OI data

DATA REDUCTION SOFTWARE PACKAGE

Library *amdlib*, latest released version is version 3.0.3, provided by the Jean-Marie Mariotti Center at http://www.mariotti.fr/data_processing_amber.htm

Consisting of

- C routines (basic routines used for all AMBER data reduction packages)
- A *yorick* package to call the routines and to visualize the data and the results, and to provide further functions (calibration)
- A description of the data reduction and a “cookbook”
- A helpdesk

Absolute wavelength calibration

- MR & HR: Using telluric features.
- LR : More uncertain, telluric features, or H band position (colpos data)
- Now included in amdlib calibration script