Dynamic Shack-Hartmann System "RAPID"

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UNAM
PAPIIT IN104910

Telescopes OAN

OAN-SPM

- 2.1m telescope
- 1.5m telescope
- 0.84m telescope

- OAN-Tonanzintla
  - 1m telescope

2.1m telescope

Astronomical site SPM

Observing statistics

1982-2002 (Tapia+ 2007)

- "Photometric" nights: 64.1%
- "Spectroscopic" nights: 80.2%
- "Bad weather" nights: 21.2%

- Sky Transparency

Extinction coefficients:

- Visible: ky = 0.14
- Red: KR = 0.05

SPM confirmed have largest fraction of clear nights of any site in the Northern Hemisphere

0.84m telescope

Sky Brightness in SPM

Brightness magnitudes

- $m_U = 21.7$
- $m_B = 22.4$
- $m_V = 21.5$
- $m_R = 20.7$
- $m_I = 19.2$

Astronomical site SPM

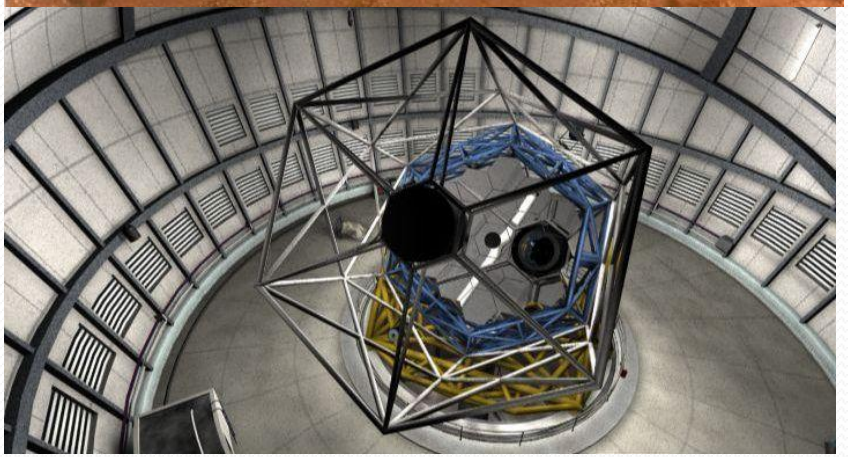
San Pedro Martir

- Good sky transparency
- Big number of clear nights
- Excellent image quality
- Photometric stability
- SPM is one of the darkest sites in the Northern Hemisphere
- SPM is good for IR observing
- So, we are looking for big telescopes

1.5m telescope

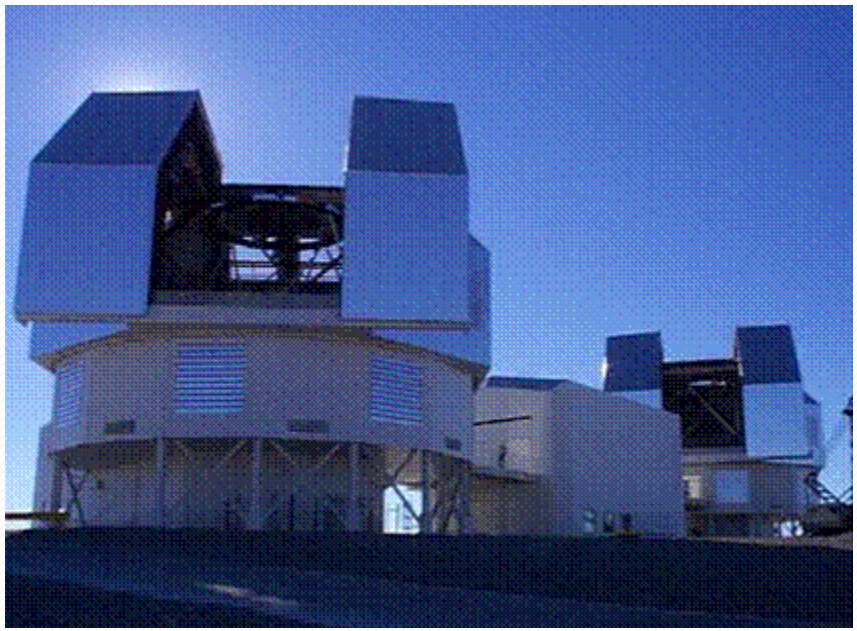
Telescopio Optico-Infrarrojo Mexicano (TIM)

- **alt-azimuth** mount
- Segmented mirror
- 6.5m > BTA
- *(1996-2004)*



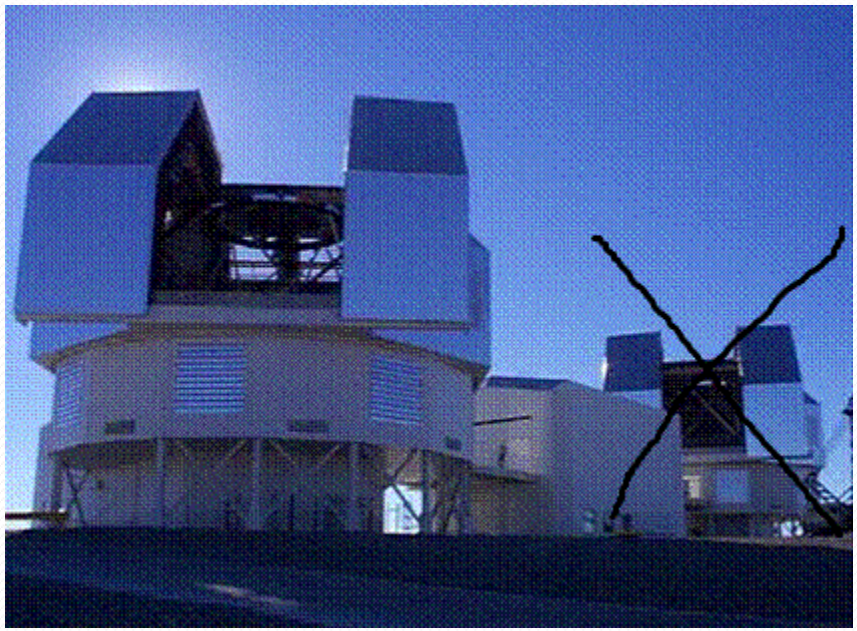
SPM-Twin

- Copy of Magellan
- 2 x 6.5m telescopes f/4.5 :
  - WF-Spectroscopic Telescope
  - WF AO telescope
- *(2005-2008)*



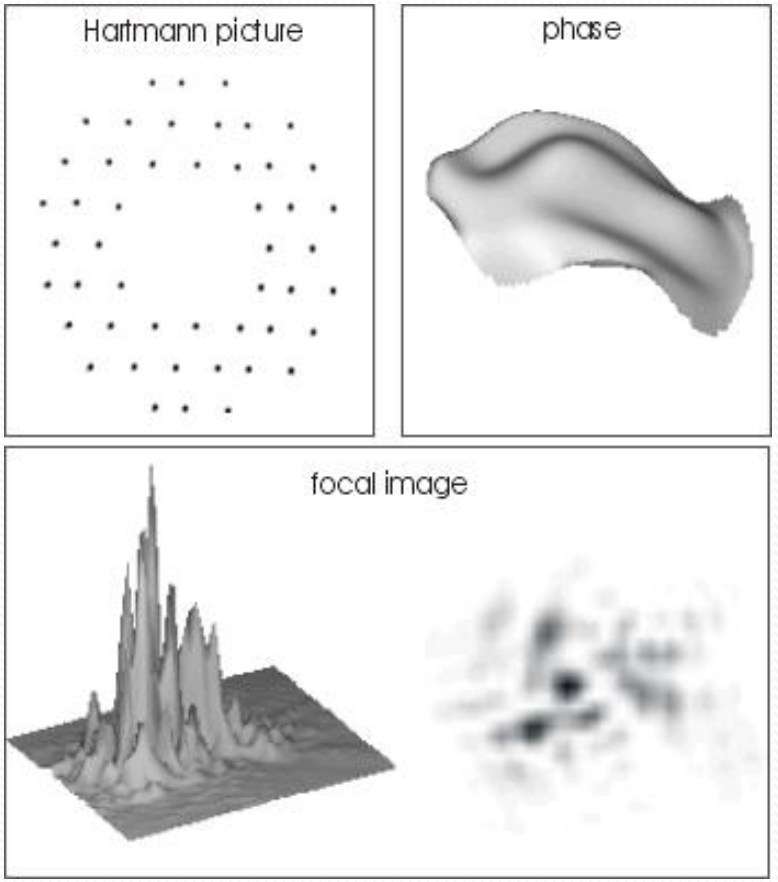
Synoptic All-Sky Infrared Survey (SASIR)

- Magellan-inspired
- 6.5m mirror
- At least we have the mirror.
- *(2008-...)*



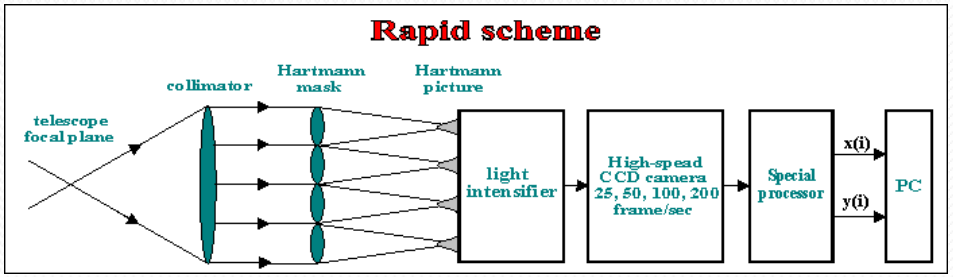
Rapid **-** Dynamic Shack-Hartmann

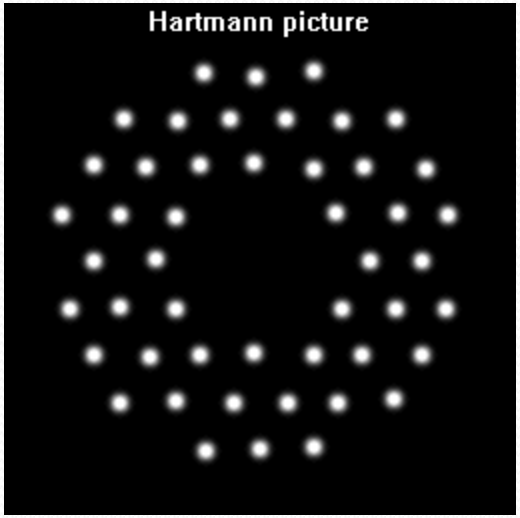
- All modern telescopes demand installation of adaptive system.
- So, we have to study of spatial and temporal characteristics of the wavefront distortions.
- We have chosen a Shack-Hartmann wavefront sensor :
  - It is simply
  - Compact data



Rapid **-** Dynamic Shack-Hartmann

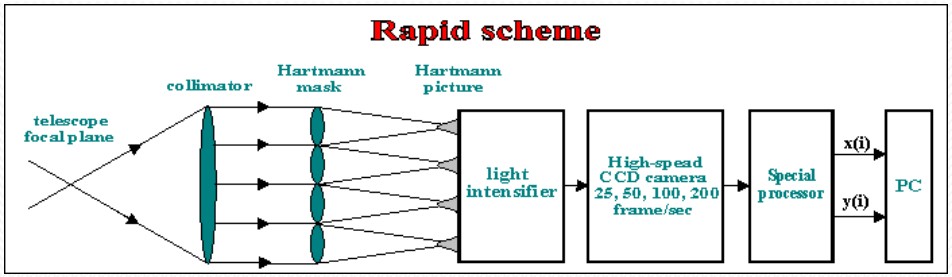
1. Collimator:
   - Focal distance 200mm
2. Lenslet-Array. Shack–Hartmann diaphragm:
   - Consists of 48 lenses with a focal distance of 150 mm
   - Hexagonal arrangement to minimize the wavefront measurement errors





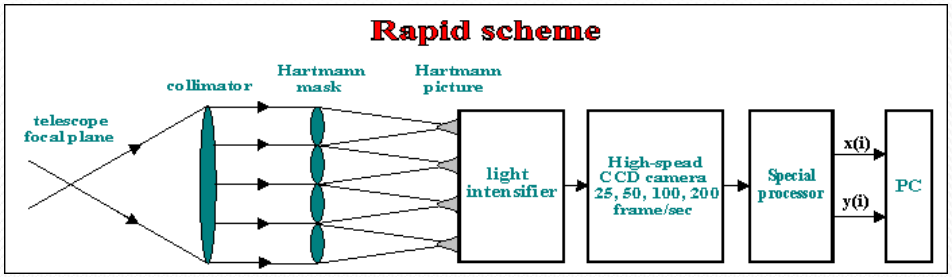
Rapid **-** Dynamic Shack-Hartmann

- Image Intensifier Tube
- Generation 2 (ЭП-10)
- Photocathode diameter, mm 24.5
- Resolution, lp/mm 33,8
- Photocathode sensitivity, μA/lm 280
- Light gain, 30,000
- Dark background brightness, max, cd/m2 2.5x10-3
- Signal-to-noise ratio 4
- Consumption, max, mA 35
- Mean time before failure, hours 2,000



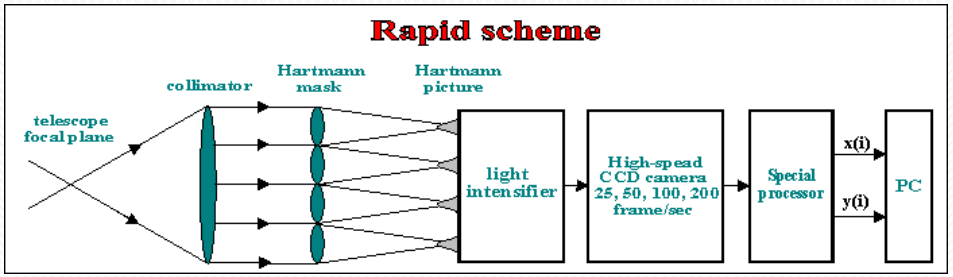
Rapid **-** Dynamic Shack-Hartmann

- Light intensifier
  - Generation 2 (ЭП-10) 3
  - Photocathode operating diameter, mm 24.5 18
  - Resolution, lp/mm 33,8 58
  - Photocathode sensitivity, μA/lm 280 1500
  - Light gain, 30,000 42,000
  - Dark background brightness, max, cd/m2 2.5x10-3 0.4
  - Signal-to-noise ratio 4 21
  - Consumption, max, mA 35 20
  - Mean time before failure, hours 2,000 10,000



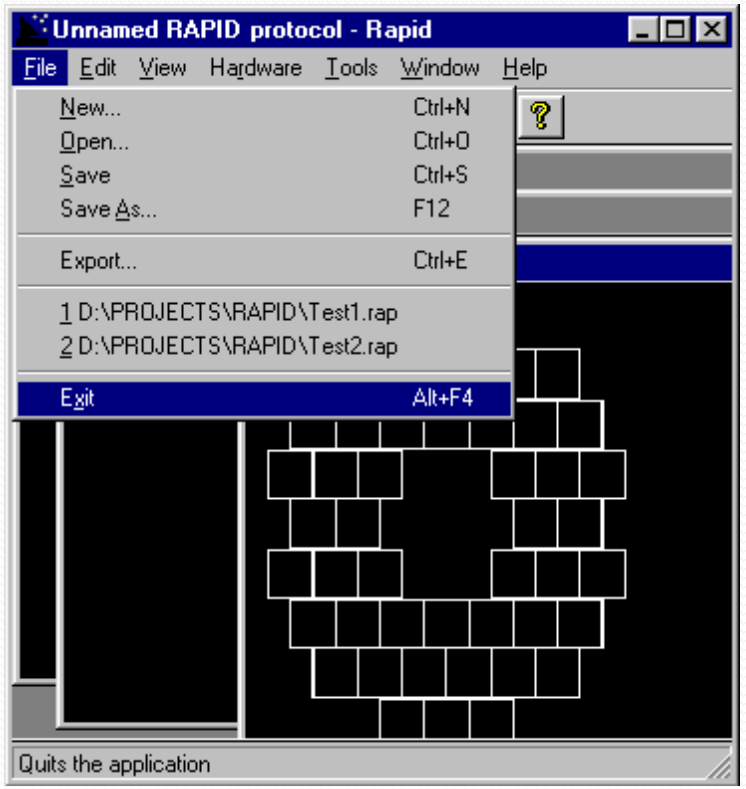
Rapid **-** Dynamic Shack-Hartmann

- High-speed CCD
  - Based on SONY ICX055AL 1/3-inch CCD Image Sensor for CCIR B/W Camera
  - 25,50,100,200 fr./sec.
  - 200 is possible only for 256*288
  - Electronic shutter
- Special processor
  - Calculate coordinates of the center of mass for each spot.



Rapid **-** Dynamic Shack-Hartmann

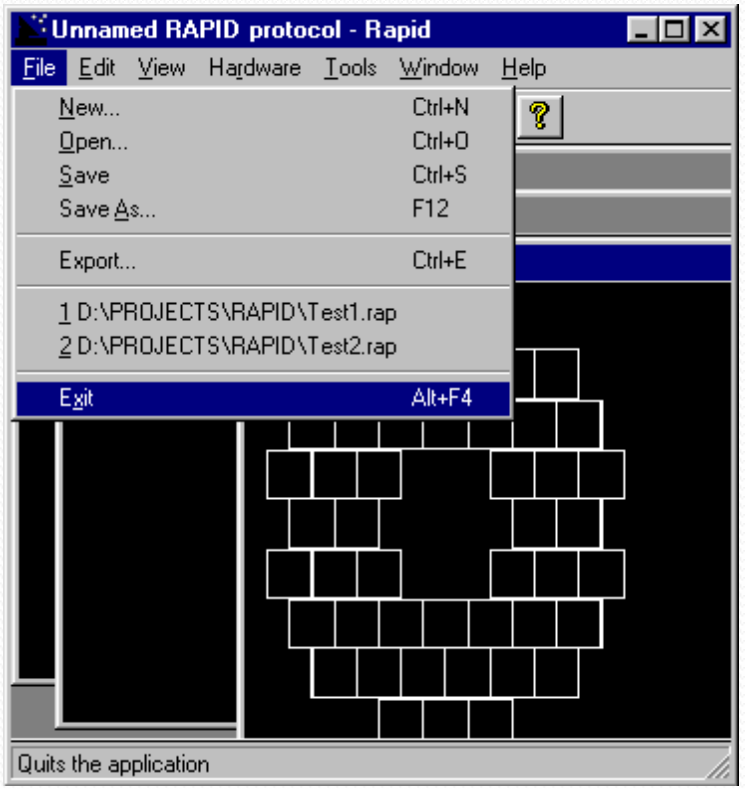
- Rapid Software:
  - Creation, saving or loading of RAPID protocols
  - Viewing and addition copies of the camera image, with tuning and textual comments saving
  - Execution of operation of data accumulation in "Master" (Wizard) mode .



steps

First step:

- choose of parameters of the camera
- assignment of the dark current.
- choose a video mode for reading data
- amount of frames, used for a dark level calculation.
- Shutter on/off
- amplification



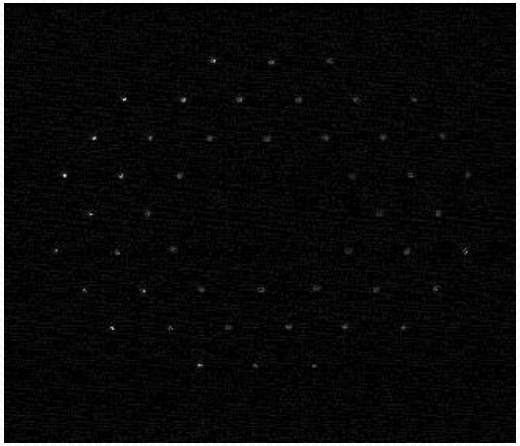
steps

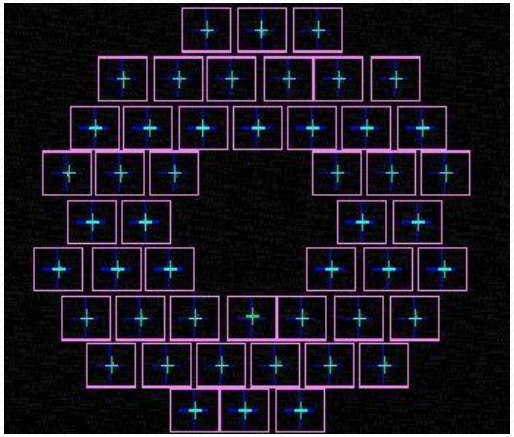
Second step:

- Parameters for Hartmann picture place calculation :

  frequencies
  - 200/100/50 (for 256*288)
  - 100/50/25 (for 512*288) Hertz are available,

  amount of averaged frames: from 2 up to 1024
- Amplification of the camera
- Amplification of the II
- "Preview" for previewing the image.

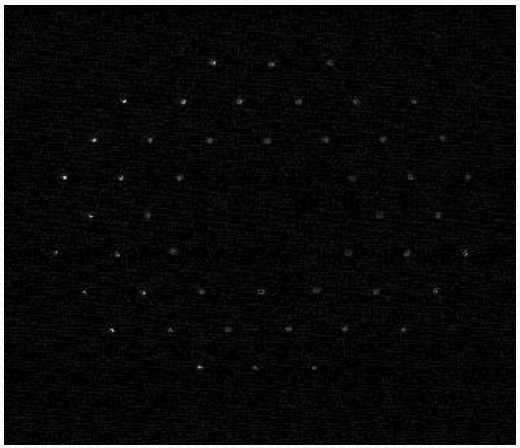




steps

Third step:

Choice of threshold meanings for Hartmann picture calculation. appropriate buttons

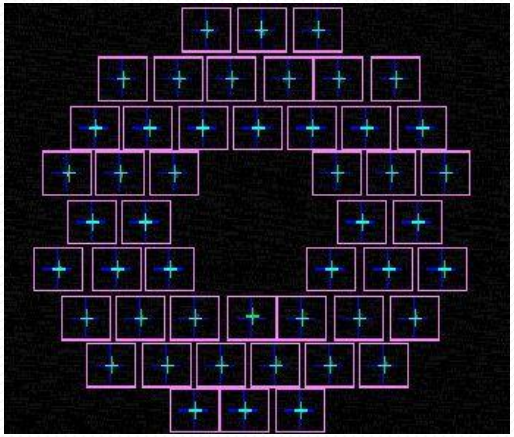


Fourth step:

Save data on the memory

Fifth step:

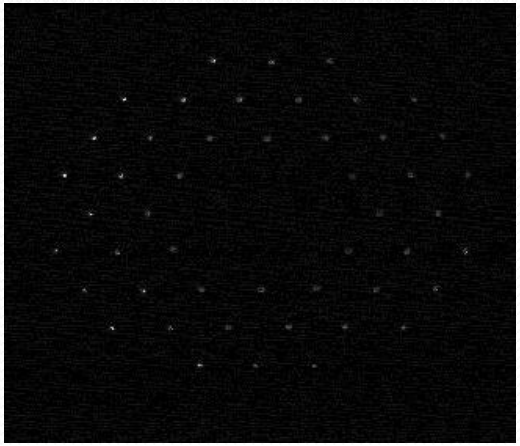
Save on the hard disk

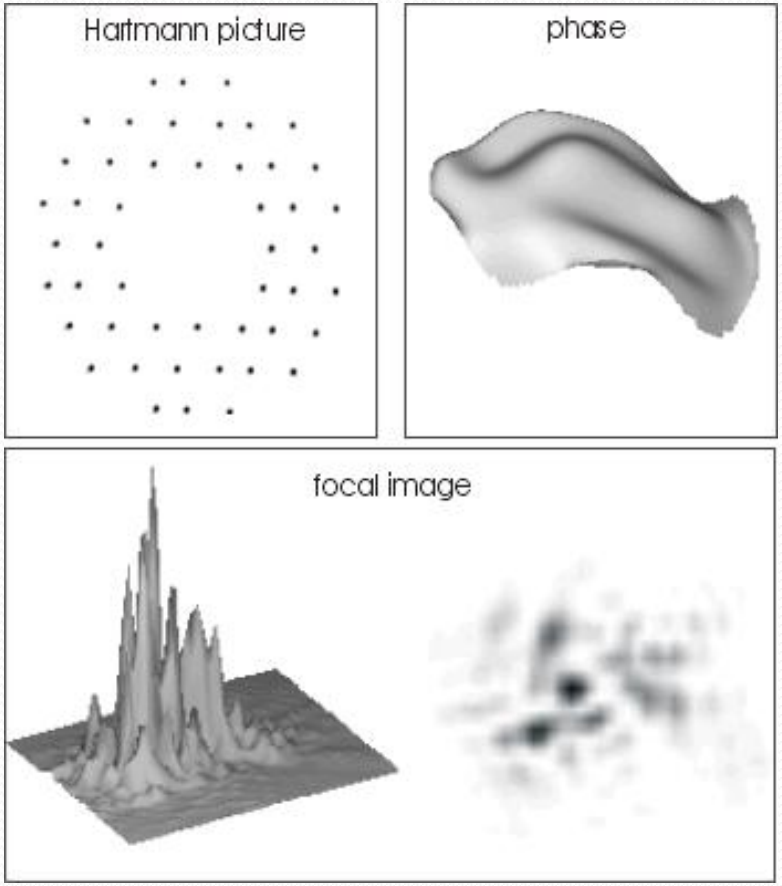


Rapid Software

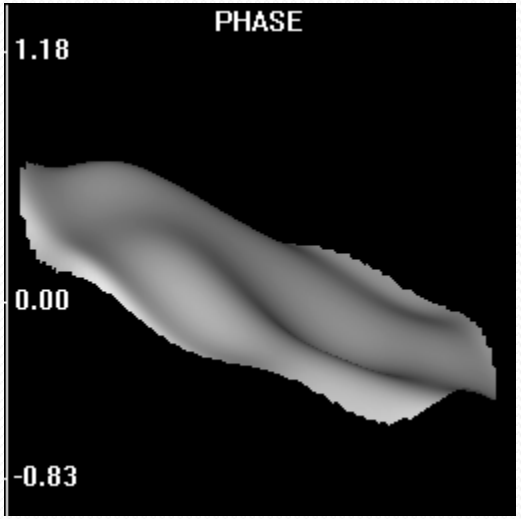
In the same protocol also it is possible:

- write text of the comment
- save up to 50 mages directly from ccd.

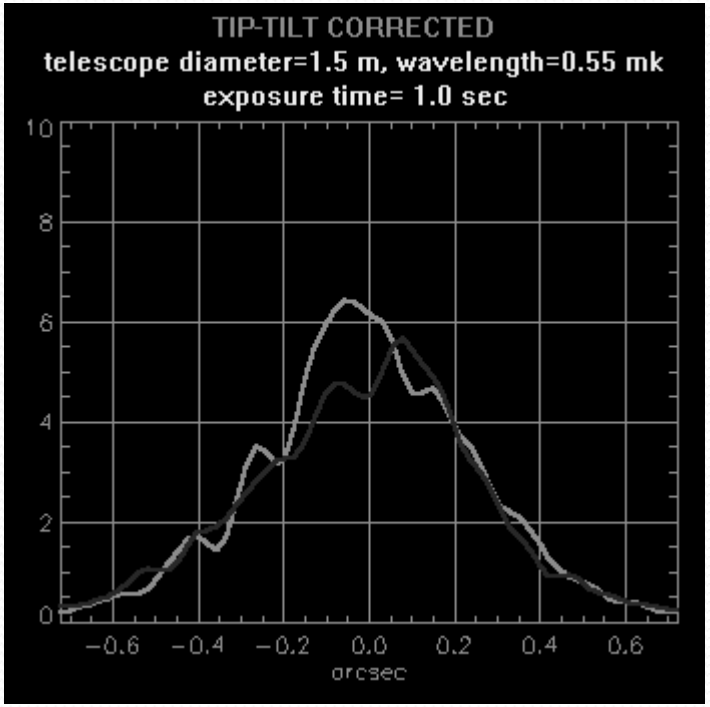


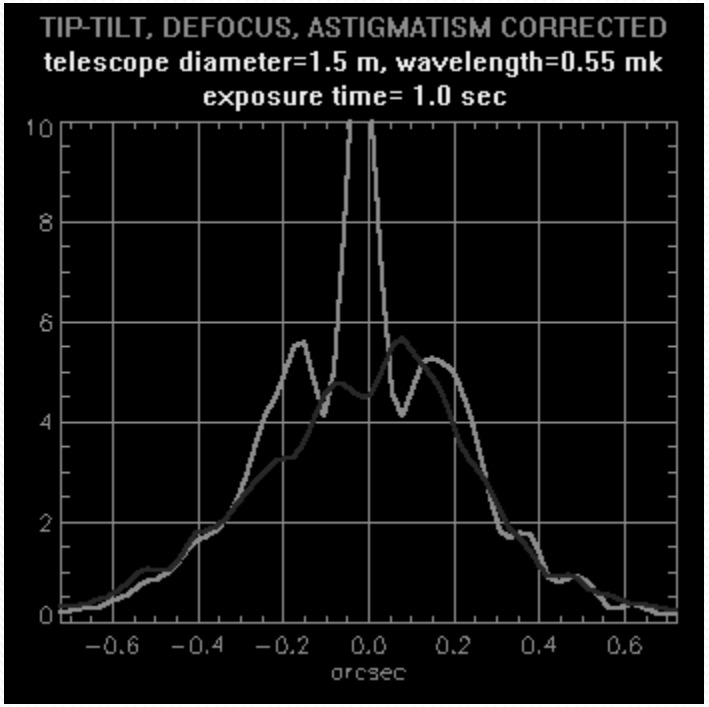

Hartmann picture
phase
focal image

- The phase reconstruction is very fast and simple.



Hartmann method




TIP-TILT, DEFOCUS, ASTIGMATISM CORRECTED
telescope diameter=1.5 m, wavelength=0.55 mk
exposure time= 1.0 sec
10
8
6
4
2
0
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
arcsec