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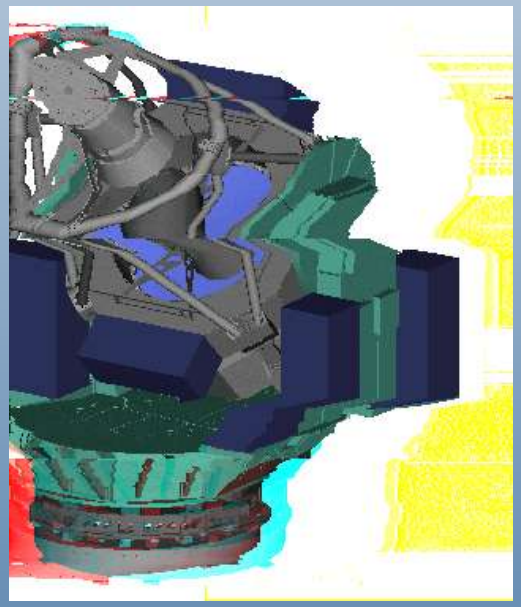
ESO Calibration Workshop 2007



Wide Field Imaging (Surveys?)

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Plan of talk

- WFI
  - Science
  - Description of instrument
  - Description of operations
  - Calibration plan
  - What we did right
  - What we could have done better
  - What we just did not do (and should have)
- VST

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The Wide Field Imager at the 2.2-m MPG/ESO Telescope: First Views with a 67-Million-Facette Eye

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[3]ESO, La Silla; [4]Osservatorio Astronomico di Capodimonte, Napoli

1. Introduction

The basic capabilities of the Wide Field Imager (WFI) were described in a previous *Messenger* article (No. 93, p. 13; see also Table 1) which also includes a brief account of the contributions by the three participating institutes, namely ESO (Garching and La Silla), the Max-Planck-Institut für Astronomie in Heidelberg, and the Osservatorio Astronomico di Capodimonte in Napoli. Table 1 summarises the most important characteristics. A first fairly complete version of the user manual is now offered via the WFI home page on the Web (URL: http://www.ls.eso.org/lasilla/Telescopes/2p2T/E2p2M/WFI/WFI.html). The same page also provides access to some examples of pictures obtained with the instrument. An exposure time calculator is available under the URL: http://www.eso.org/observing/etc/

Following the completion of the 2.2-m Telescope Upgrade Plan (cf. *The Messenger*, No. 93, p. 19 and No. 94, p. 12), the WFI was installed on La Silla as the only instrument offered at the 2.2-m MPG/ESO Telescope. Since January 18, it is used by ESO Visiting Astronomers and MPI-A observers. Every night, the WFI's 67 million pixels produce an amount of data comparable to that generated by all other ESO telescopes on La Silla plus the VLT UT1!

2. Installation

A team of engineers from Heidelberg and Garching arrived on La Silla on December 8. Nine boxes with a total weight of almost one ton, in which the partly disassembled instrument, a handling cart, tools, spare parts, etc. had been packed after the system integration tests during the second half of November in Garching, were already waiting for them. Because of its sensitivity to mechanical shocks, the dewar head with the fully assembled science mosaic and the tracker CCD was transported as hand luggage by one of the Commissioning Team members. The weight (33 kg) and dimensions (80 cm × 80 cm × 25 cm) of the aluminium container made this travel a small adventure of its own.

Figure 1: The Wide Field Imager mounted in the Cassegrain focus of the 2.2-m MPG/ESO telescope on La Silla. The authors apologise for the obscuration by foreground objects (from left to right: H. Böhnhardt, J. Alonso, J. Brewer, E. Robledo, N. Haddad, J. Reyes, O. Iwert, A. Böhm, R. Donaldson, K. Meisenheimer, R. Klein, T. Augusteijn, D. Baade). However, although being excellent at taking images, the WFI does not render itself very suitable for being imaged because the instrument housing is deep black.

Table 1: The Wide Field Imager in a Nutshell

Field of view:	(34 × 33) arcmin^2
Pixel scale:	0.24 arcsec/pixel
Detector:	mosaic of eight 2k × 4k CCD's
Filling factor:	96.2%
Read-out time:	27 seconds
Read-out noise:	4.5 ± 0.1 e$^-$/pixel
(Inverse) gain:	2.0 ± 0.1 e$^-$/ADU
Dynamical range:	16 bit
Full-well capacity:	> 200.000 e$^-$
Telescope aperture:	2.2 m
Telescope focus:	Cassegrain (f/8)
Instrument F ratio:	5.9
Useful wavelength range:	atmospheric cut-off through 1 μm
Limiting magnitude (*B* band):	23 mag (5-σ detection in 2 min. at 1″ seeing)
Overall intrinsic image quality:	0.4 arcsec
Overall geometrical distortions:	≤ 0.1%
No. of simult. mountable filters:	50
Slitless spectroscopy:	4.5 (5.7) nm resolution at 400–640 (650–850) nm
Raw data format:	FITS (with extensions), 142 Mbyte/file

WFI Science 1999-2006

WFI Science 1999-2006

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Refereed papers

50% of work together with other instruments
H-index = 30

2006	37
2005	28
2004	36
2003	18
2002	20
2001	15
2000	0
1999	7
	161

Clusters and Cosmology	48
Galaxies outside LG	22
Local Group	22
Galactic structure	4
Star formation	21
Stellar	41
Extra solar planets	1
GRISM	1
Mini surveys	32
	192

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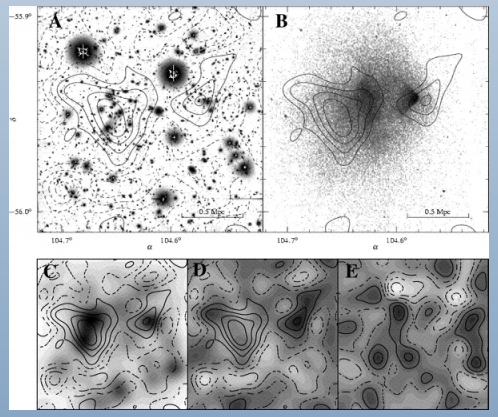
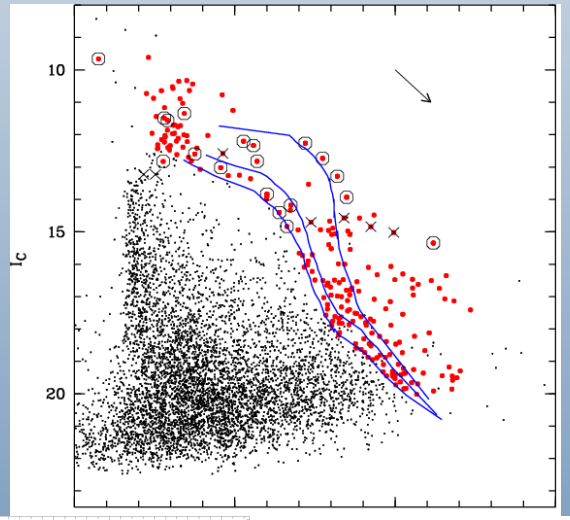
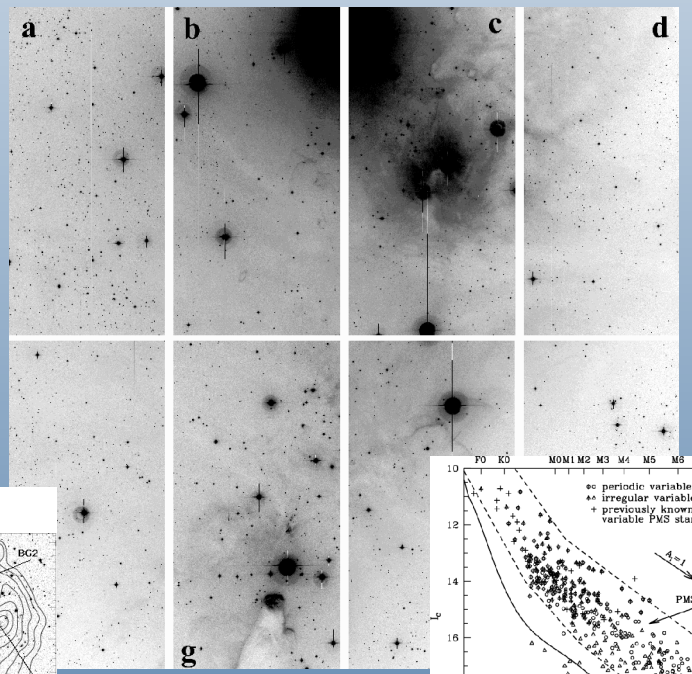
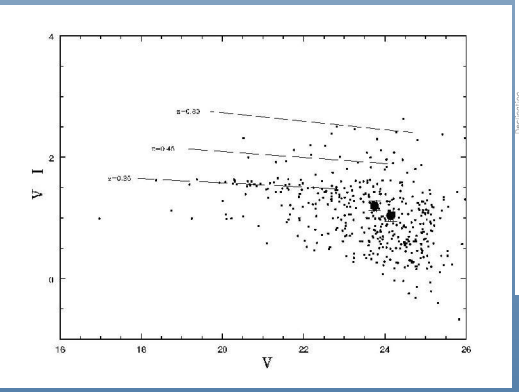
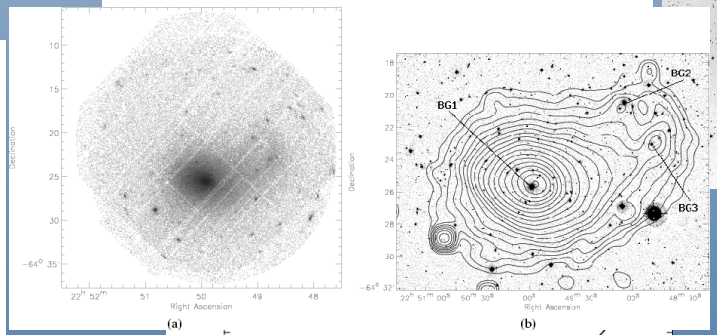
WFI Science 1999-2006

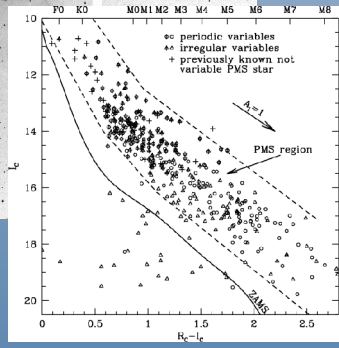


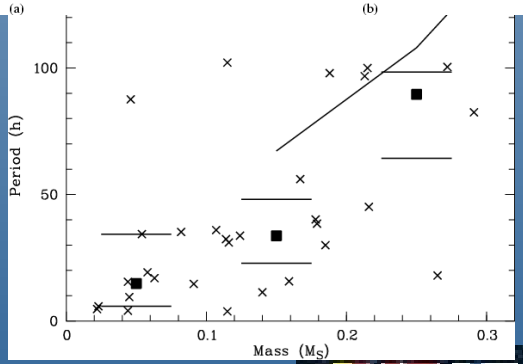


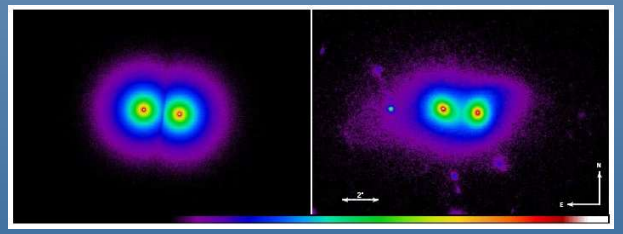












Wide Field Imager

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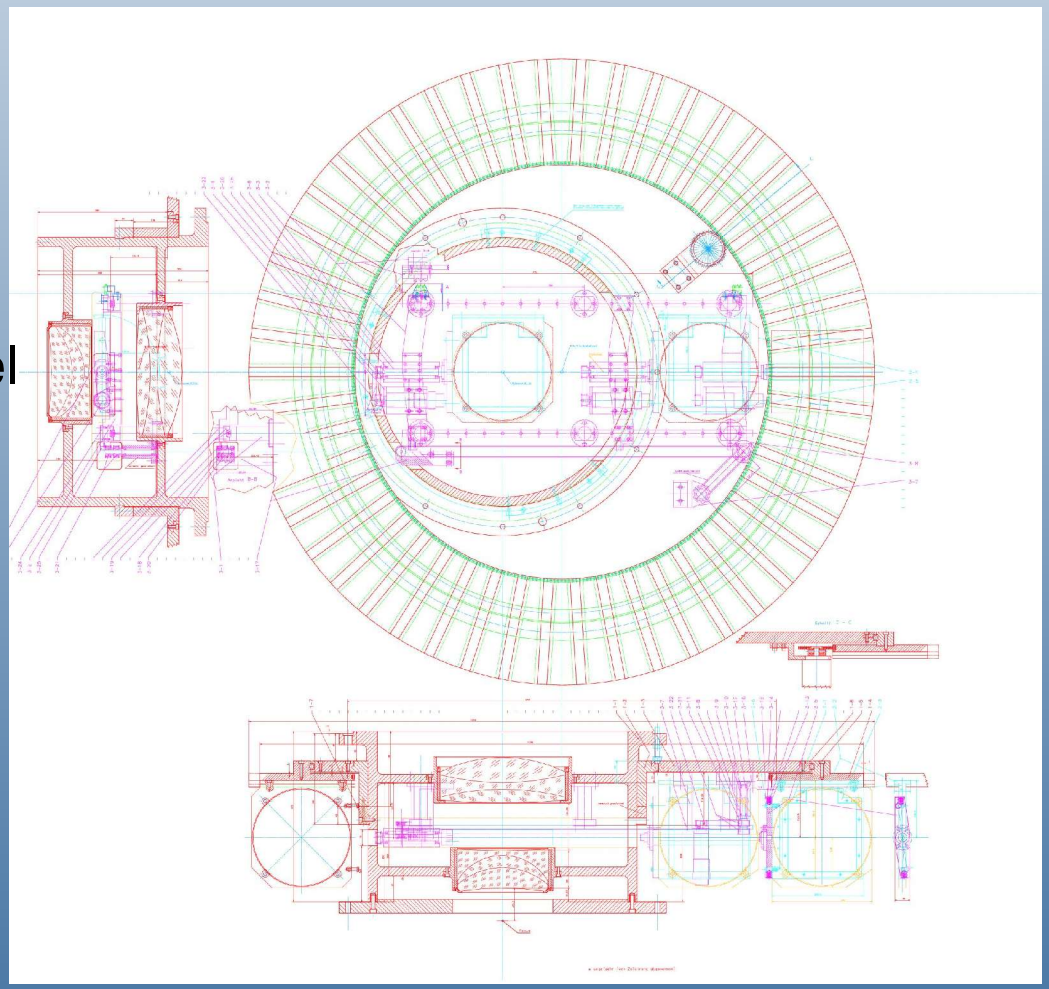
- 4x2 mosaic of 2048x4096 EEV CCD
- Fov: 34x32 arcmin
- Plate scale: 0.238 arcsec/pixel (15μm pixels)
- 45 filters (average ~80% efficiency) Includes “White” filter much in demand!
- Read-out time: 27s (binning 1x1)



Wide Field Imager

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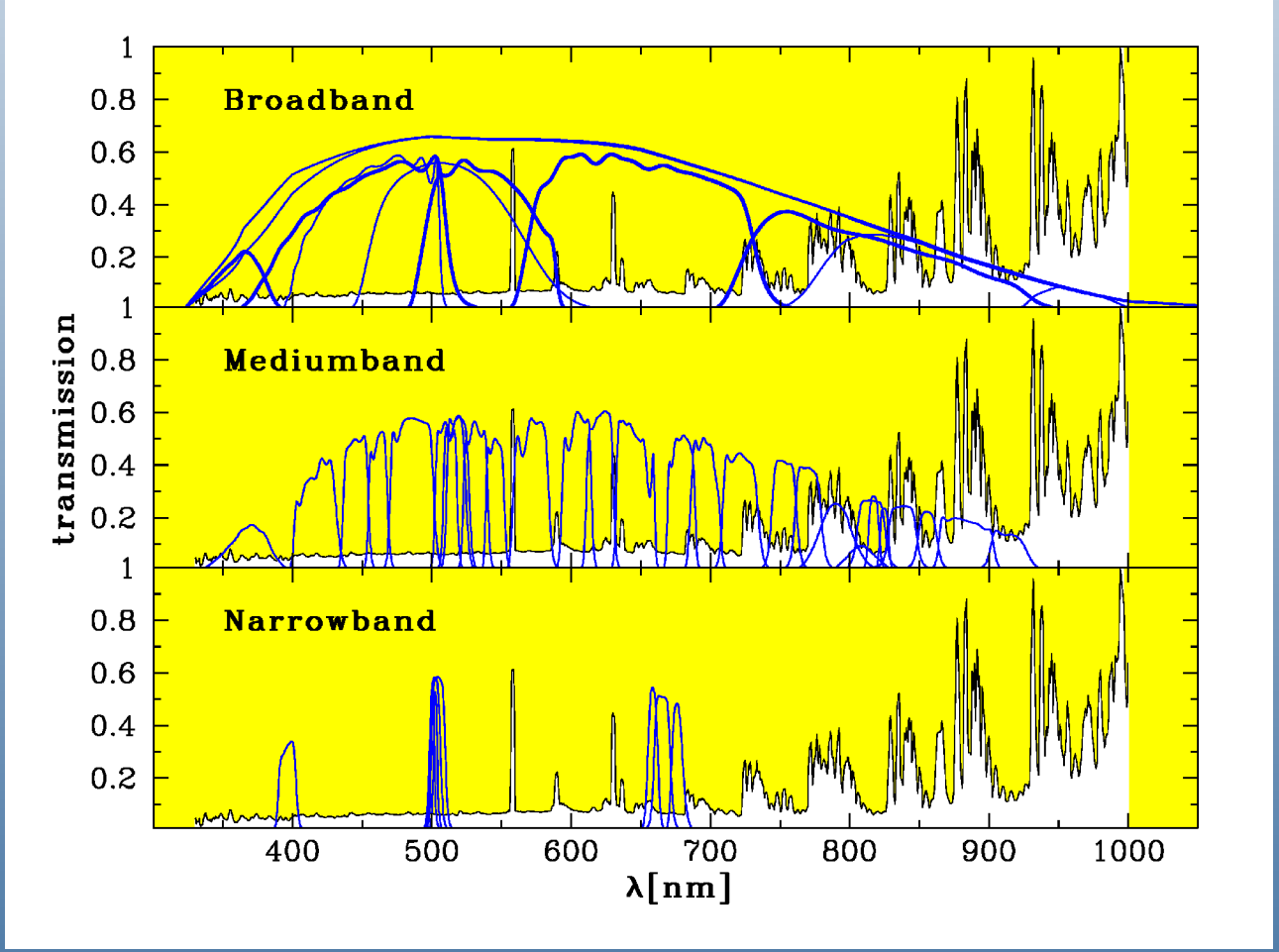

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WFI in Context

Instr.	FoV	Scale	FOM
WFI	34x33	0.238	1.2
SUSI	5.5x5.5	0.161	0.08
FORS	6.8x6.8	0.25	0.67
VIMOS	4x7x8	0.205	3.3
VST	1x1	0.22	6.7
SUPRIME	34x27	0.202	13
Megaprime	1x1	0.187	9
LSST	10 d2		300

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Quick overview of operations

- Fully flexible queue observing during the period 2002-2005
- Calibration plan to satisfy the need of most users.
- We only provide raw data
- ESO does not provide data reduction programs.
- All data is archived

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Queue observing with WFI

- Priority of programmes and observing condition constraints.
- Constraints:
  - Transparency: PHO, CLR, THN,THK
  - Seeing: better than 0.8, 0.8-1.2, > than 1.2”
  - Moon
  - Air-mass
- Observations carried out by astronomer with the help of a Telescope Instrument Operator.

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WFI Calibration Plan

- Instrument monitoring.
  - Daily health check (m)
  - Weekly health checks (m)
  - Screen and sky flat fields (m)
  - Bad pixel map (o)
  - Zero point map (o)
- Instrument calibration
  - 10 biases daily (o)
  - 5 screen flat field (on demand per filter)
- Scientific calibration
  - Shutter error
  - Sky flat field (on demand per filter)
  - Photometric standard fields
  - Darks

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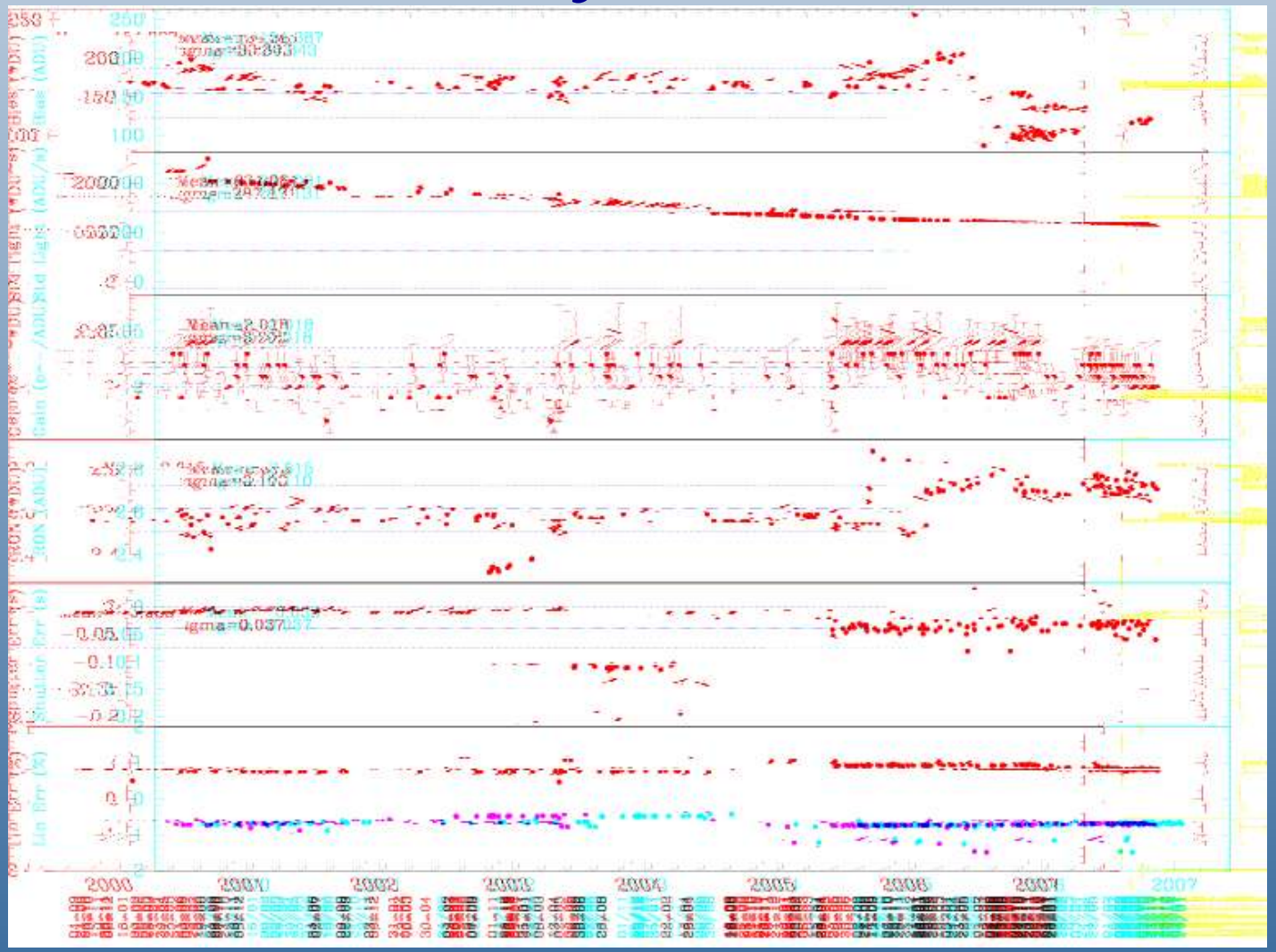
What we did right: Weekly Health Checks



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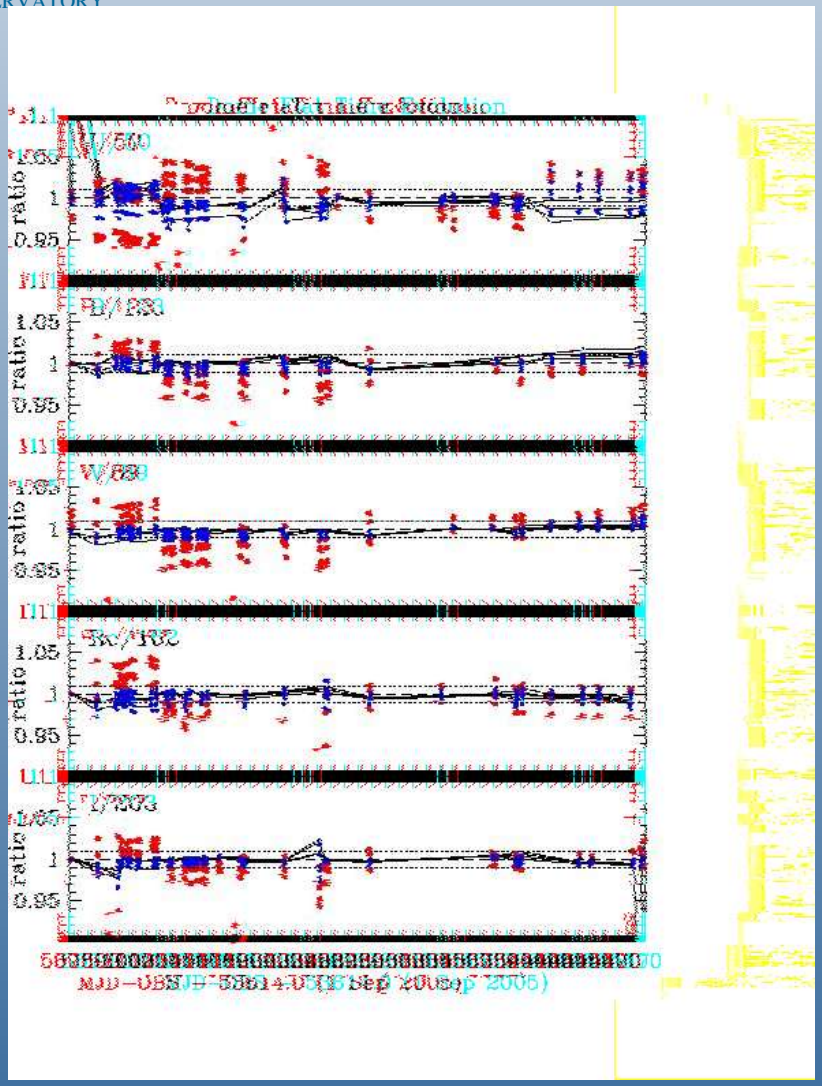
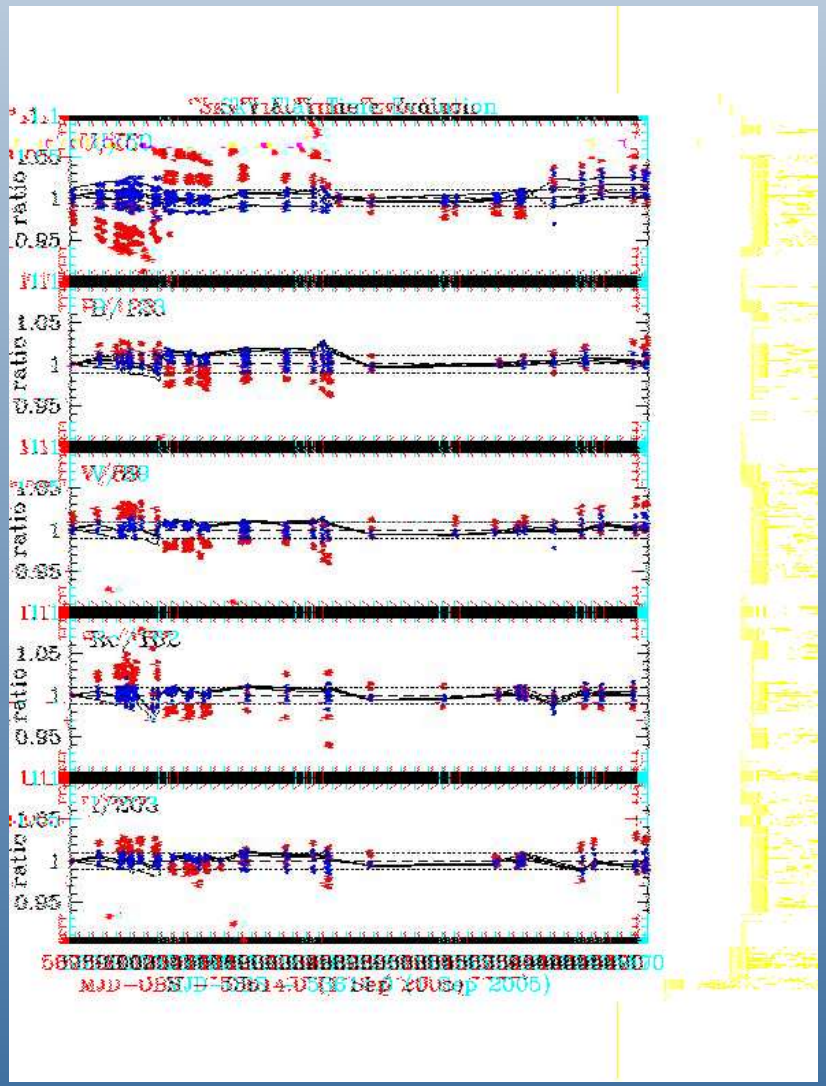
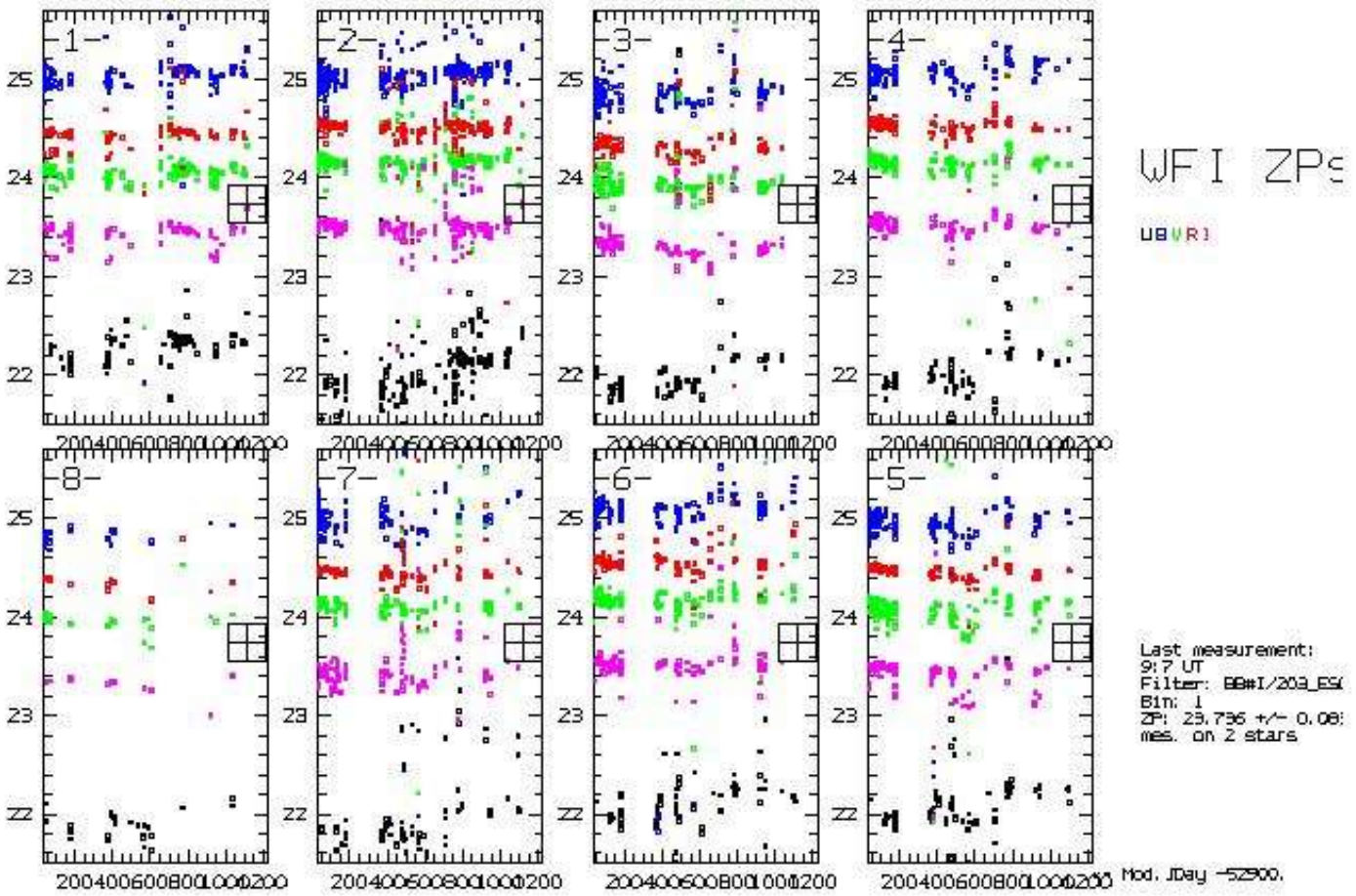
Sky Flats in Std Filter Set





Standard stars in Std Filter Set



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What we did right: optical distortions

A&A 440, 453-471 (2005)
DOI: 10.1051/0004-6361:20041523

Weak lensing study of dark matter filaments and application to the binary cluster A 222 and A 223[★,★★]

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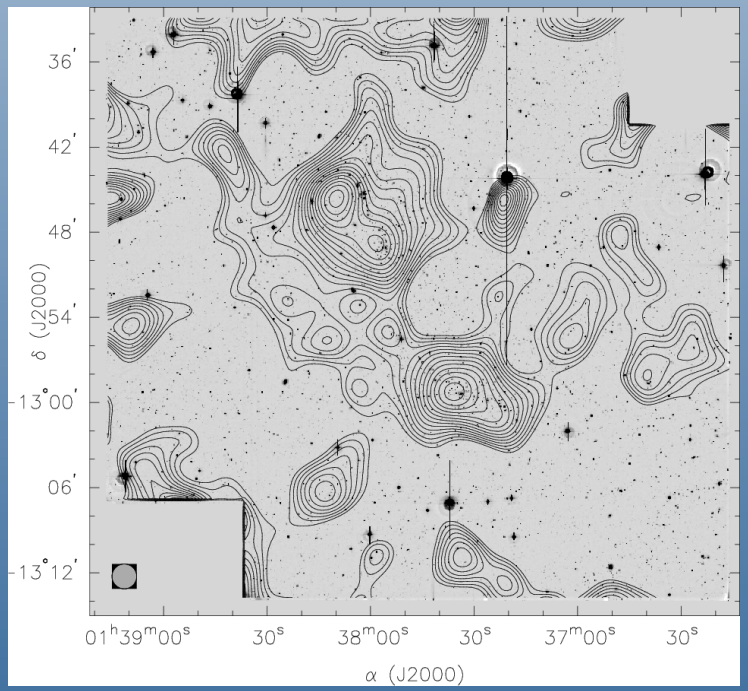
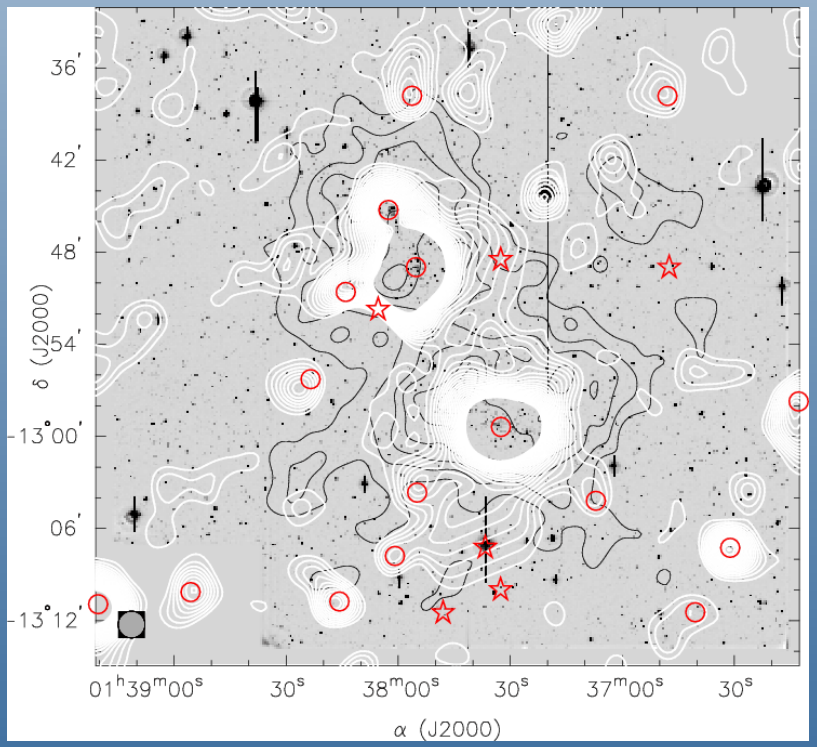
Received 24 June 2004 / Accepted 19 May 2005





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What we did right: accept Jacoby's proposal!

IRAF/MSCRED/ESOWFI

The Astronomical Journal, 123:269-278, 2002 January

A SURVEY FOR VERY FAINT PLANETARY NEBULAE IN THE SMC. I. IDENTIFICATION, CONFIRMATION, AND PRELIMINARY ANALYSIS[1]

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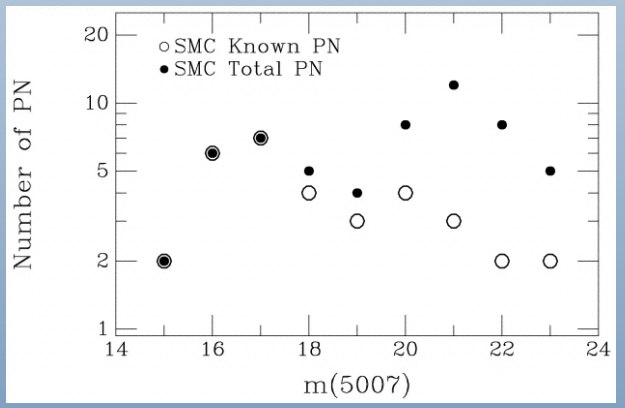
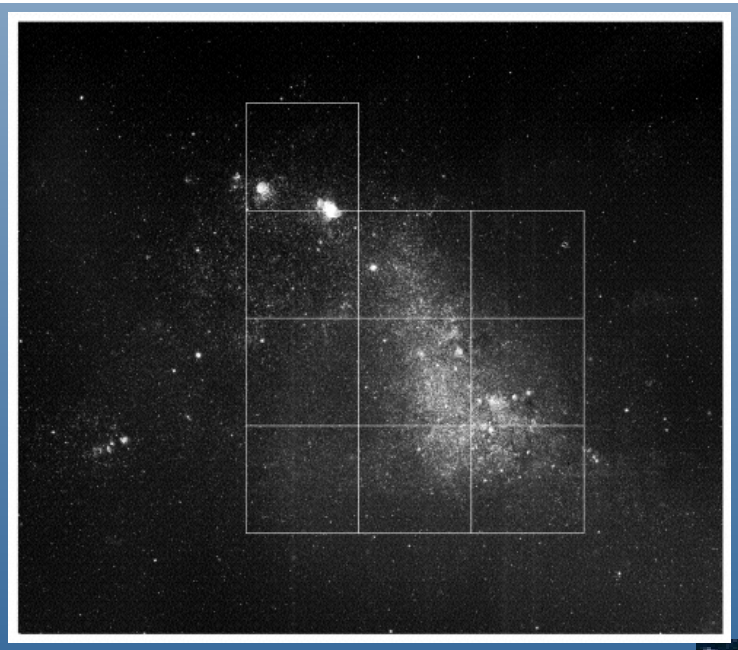
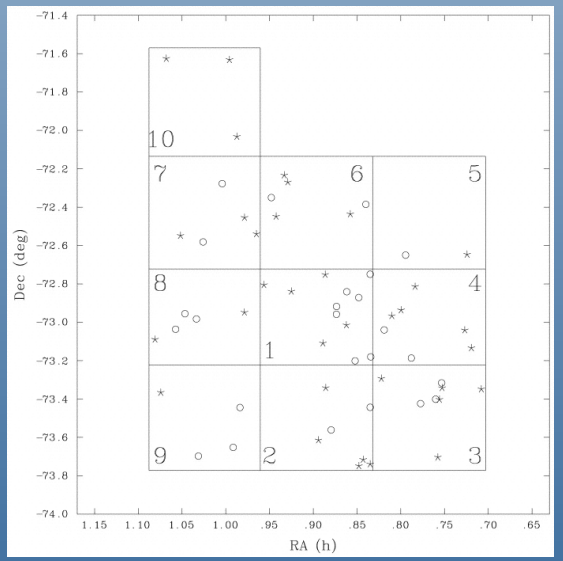
Received 2001 August 9; accepted 2001 October 1







…but in better shape now.

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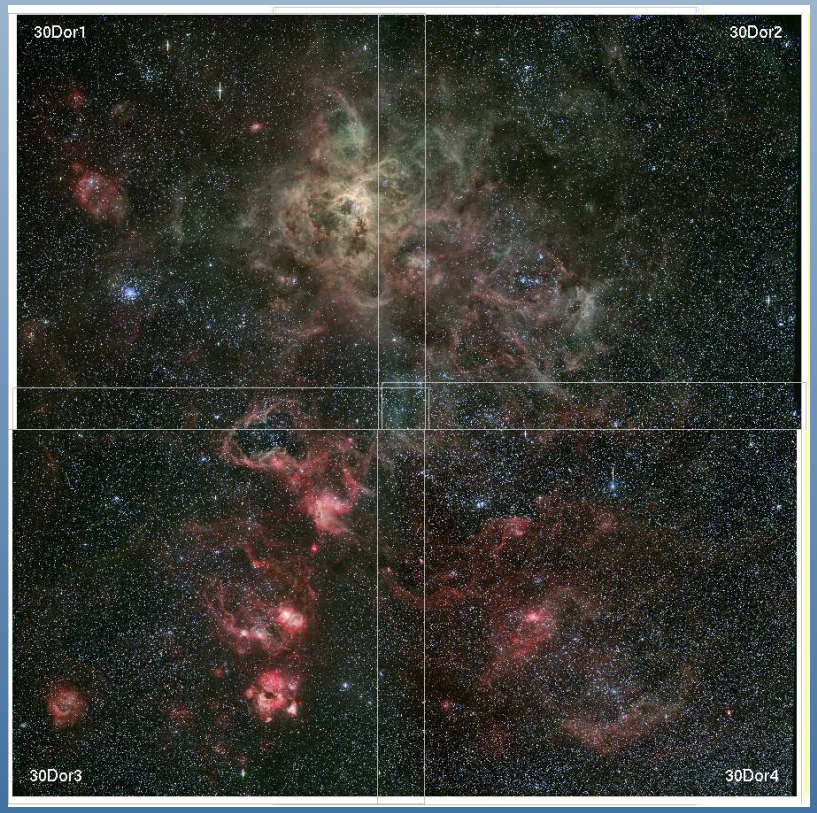
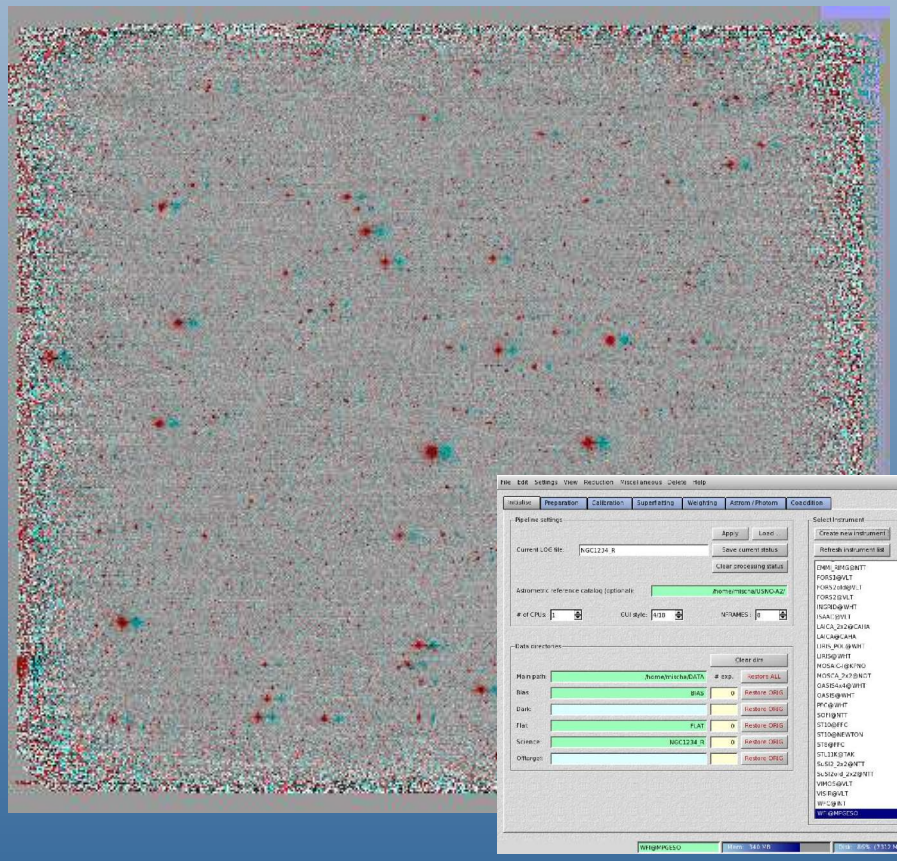
ESO EIS - ADP
MVM image processing pipeline (v1.3.5)
Vandame



GaBoDS
THELI processing pipeline
Schirmer Poster: ?



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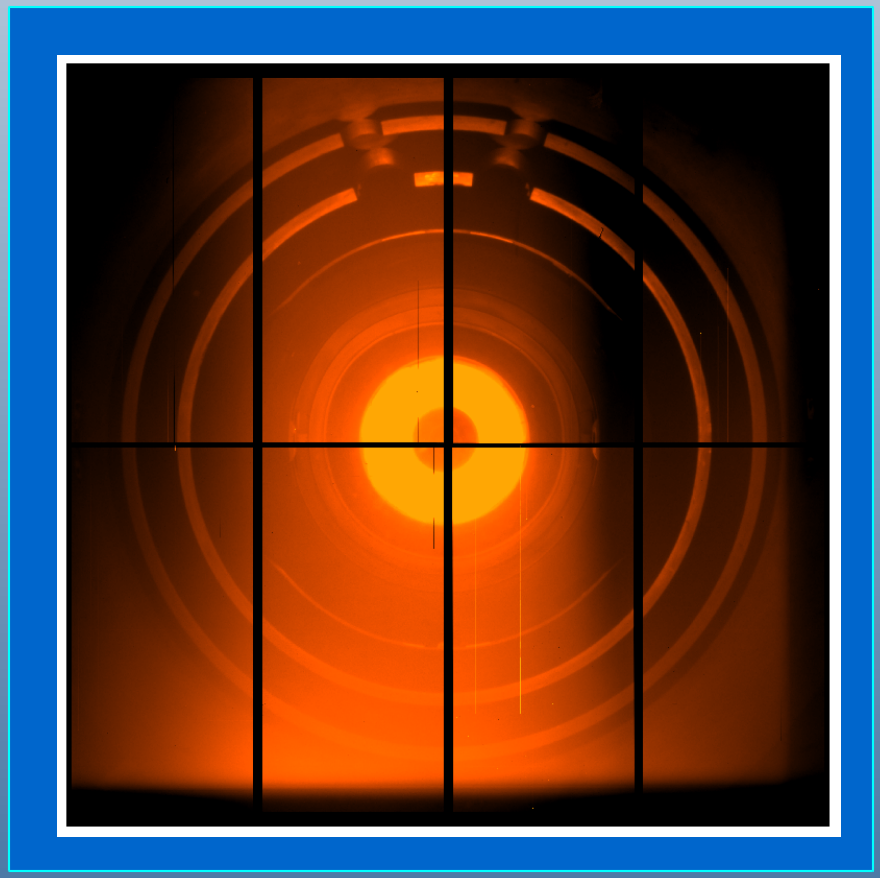
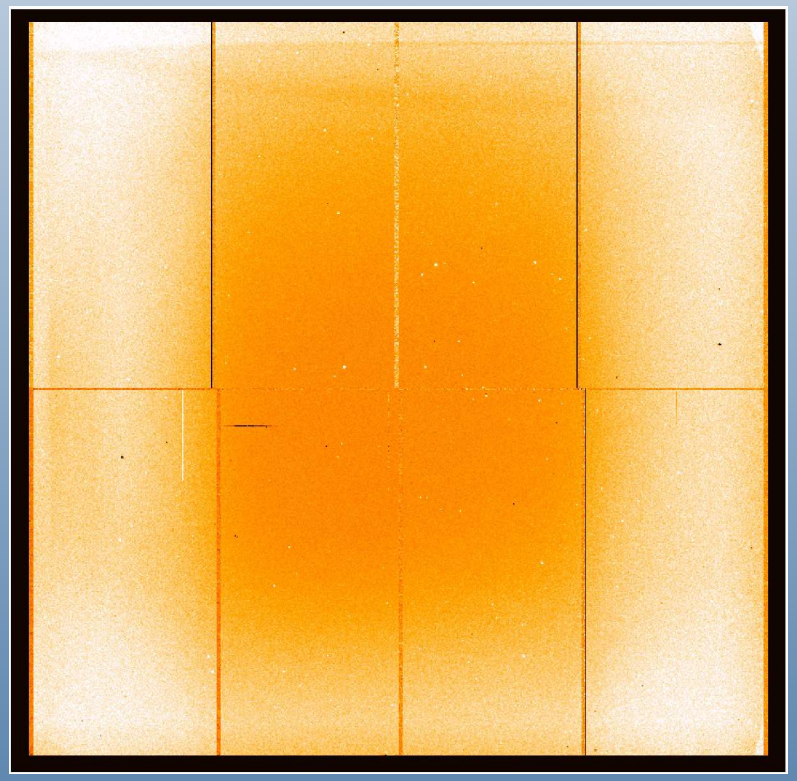
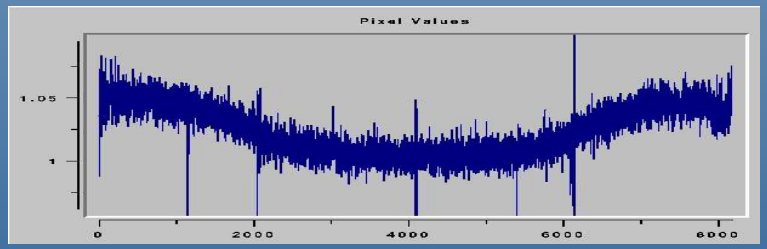
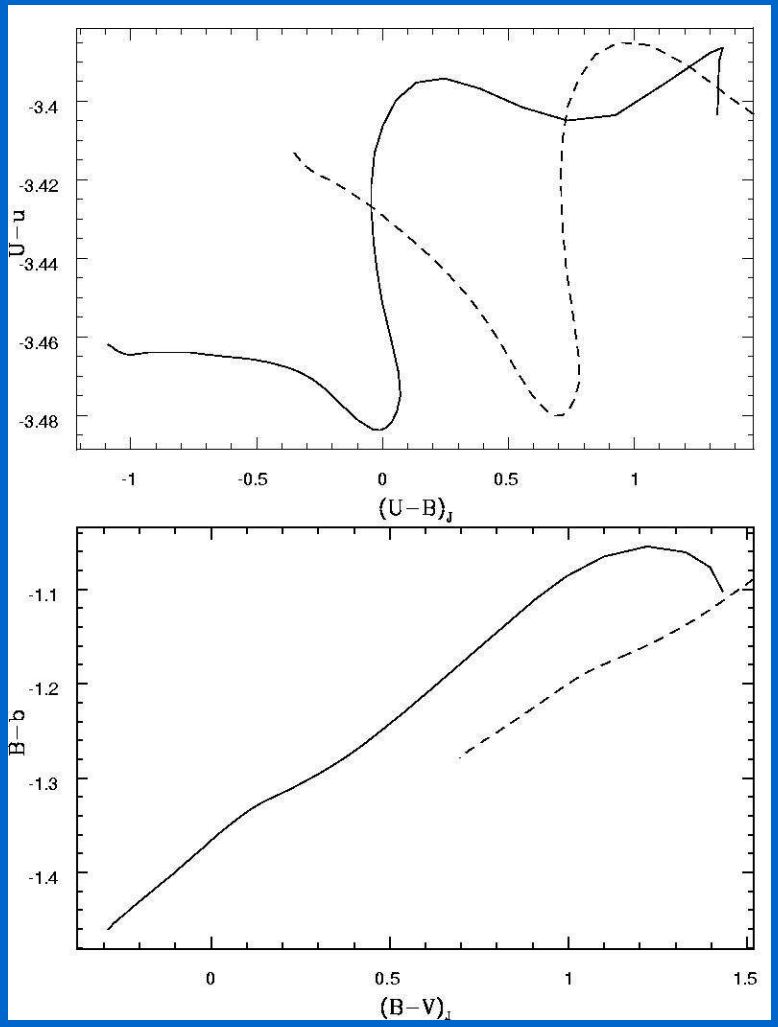
What we could have done better: Earlier baffle improvement

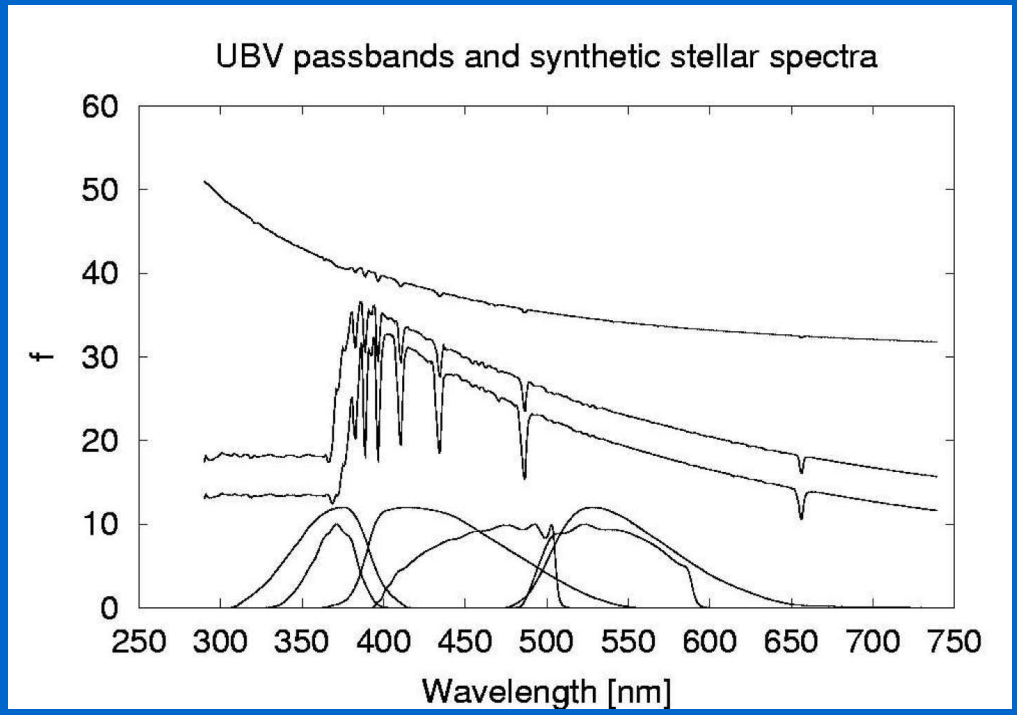




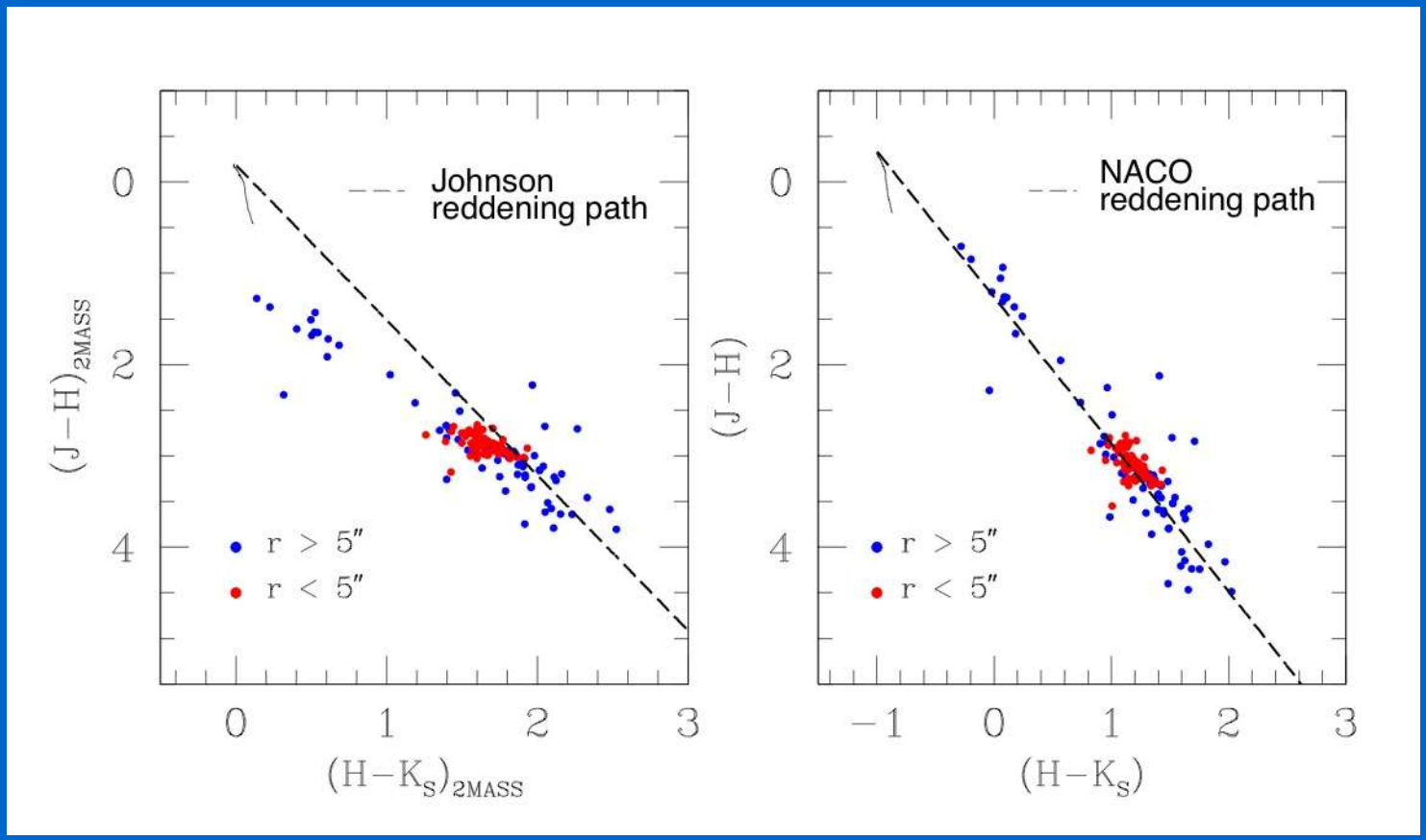


What we could have done better: Standard photometric system



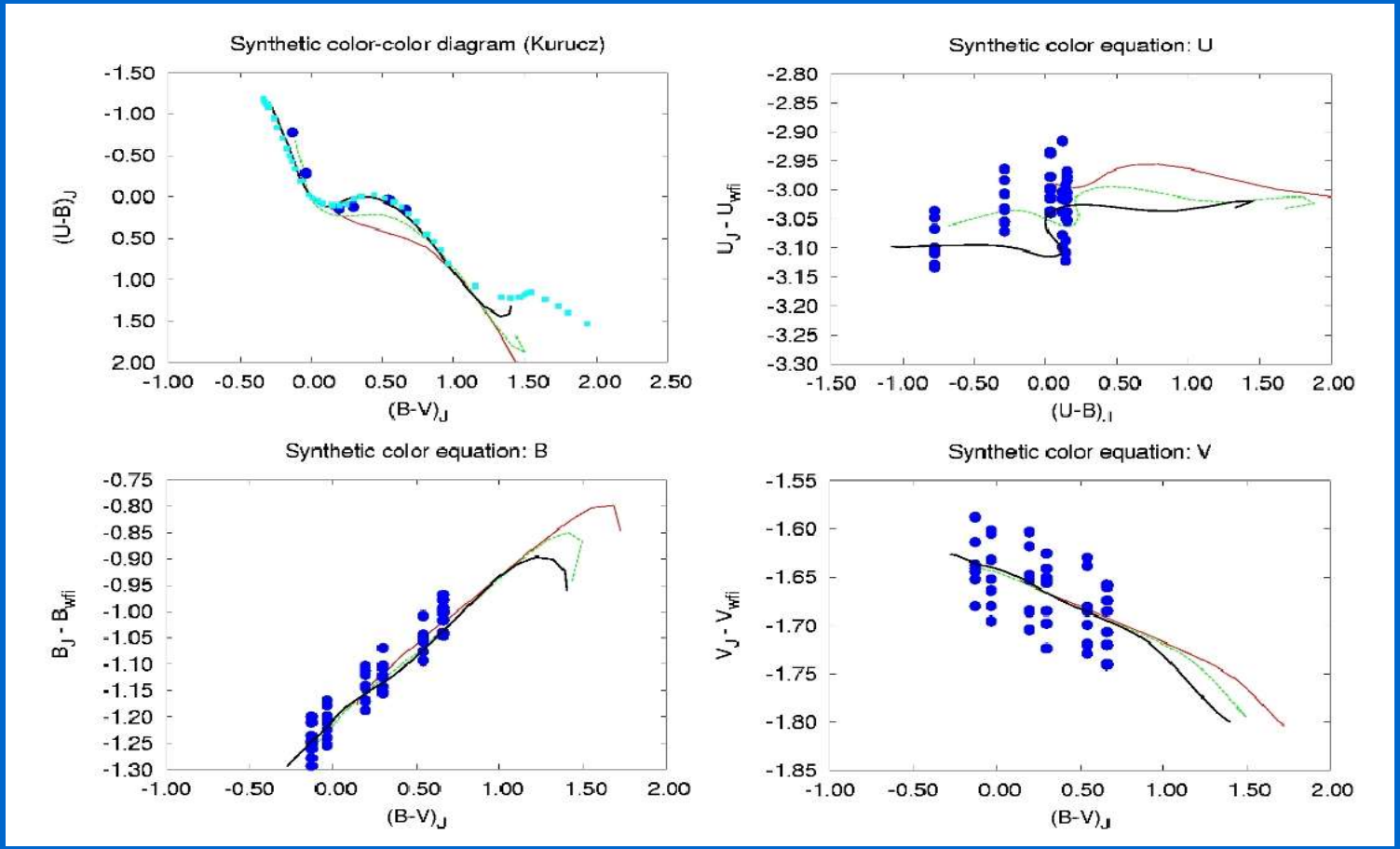


What we could have done better: Standard photometric system

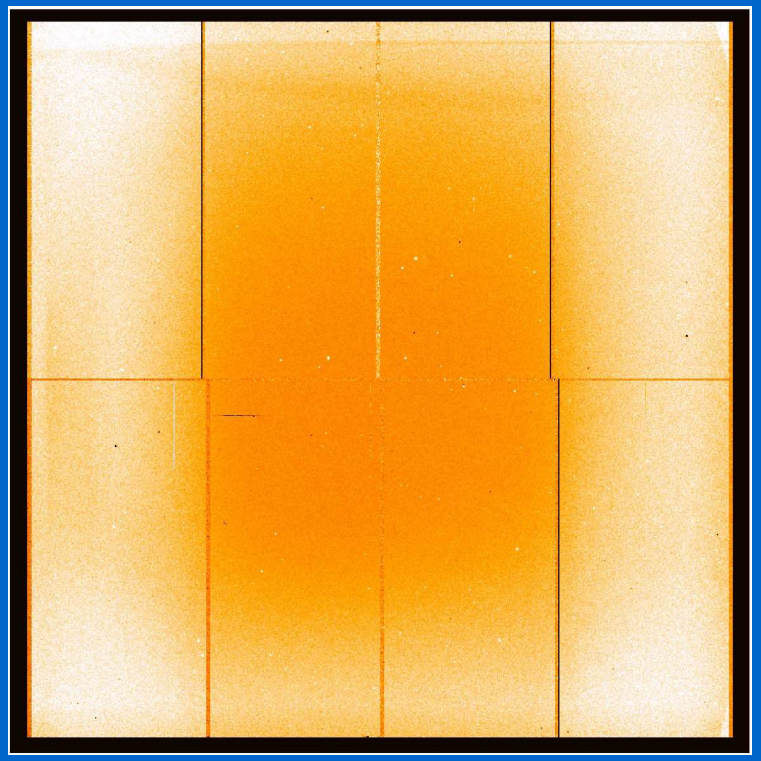


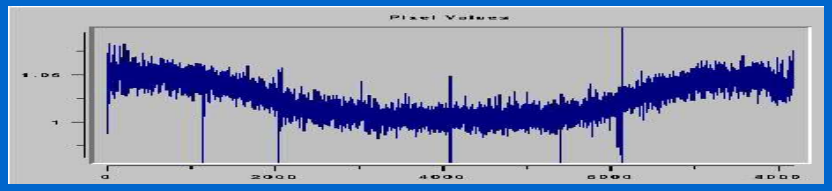
What we could have done better: Light concentration

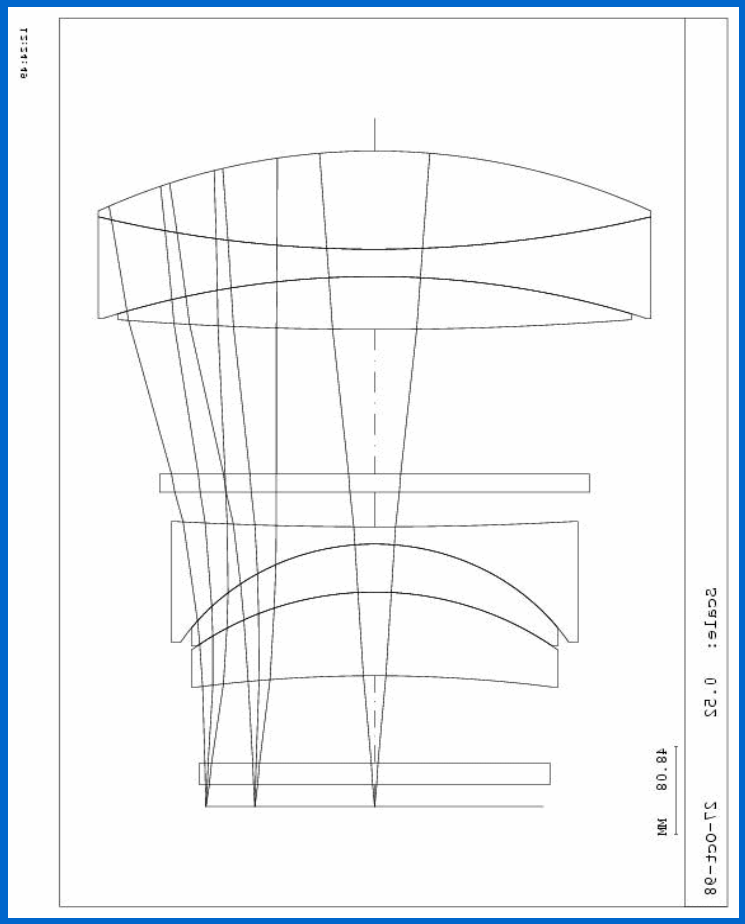
Scatter: dV = 0.034, dB = 0.029, dU = 0.040



What we could have done better: Light concentration







…but we did something …

Photometric flats method

(Andersen, Freyhammer, and Storm 1995
Manfroid, Selman, and Jones 2001;
Koch et al. 2004;
Selman and Melnick 2004;)

- $\{m(x_i, y_i), m(x_i + h_x, y_i), m(x_i, y_i + h_y)\}_{i=1}^{n}$.
- $zp = zp(x, y) = \sum_{j=1}^{l} b_j f_j(x, y)$
- $$\begin{aligned} \delta m_i &= m(\mathbf{x}_i + \delta\mathbf{x}_i) - m(\mathbf{x}_i) \\ &= \sum_{j=1}^{n} b_j((f_j(\mathbf{x}_i + \delta\mathbf{x}_i) - f_j(\mathbf{x}_i)) \\ &= \sum_{j=1}^{n} \delta f_{ij} b_j, \end{aligned}$$
- $$\begin{pmatrix} \delta m_1 \\ \vdots \\ \delta m_n \end{pmatrix} = \begin{pmatrix} \delta f_{11} & \cdots & \delta f_{1l} \\ \vdots & \ddots & \vdots \\ \delta f_{n1} & \cdots & \delta f_{nl} \end{pmatrix} \times \begin{pmatrix} b_1 \\ \vdots \\ b_l \end{pmatrix}$$
- $\Delta\mathbf{M} = \mathcal{A} \times \mathbf{b}$

1

…which after some work…

Photometric flats method (cont.)

- $\tilde{b} = (\tilde{b}_1, \ldots, \tilde{b}_l)^T$
- $\Delta\tilde{\mathbf{M}} = (\delta\tilde{m}_1, \ldots, \delta\tilde{m}_n)^T = \mathcal{A} \times \tilde{\mathbf{b}}$
- $\tilde{e} = (e_1, \ldots, e_n)^T = \Delta\mathbf{M} - \mathcal{A} \times \tilde{\mathbf{b}}$
- *Residual sum-of-squares* $E = \sum_{i=1}^{n} e_i^2$
- $E = \sum_{i=1}^{n} (\delta m_i - \delta f_{i1}\tilde{b}_1 - \ldots - \delta f_{il}\tilde{b}_l)^2$
- $$\frac{\partial E}{\partial \tilde{b}_k} = 2\sum_{i=1}^{n}(-\delta f_{ik})(\delta m_i - \delta f_{i1}\tilde{b}_1 - \ldots - \delta f_{il}\tilde{b}_l) = 0$$
- $\mathcal{A}^T\Delta\mathbf{M} = (\mathcal{A}^T\mathcal{A})\tilde{\mathbf{b}}$

2

… a lot of work, really…

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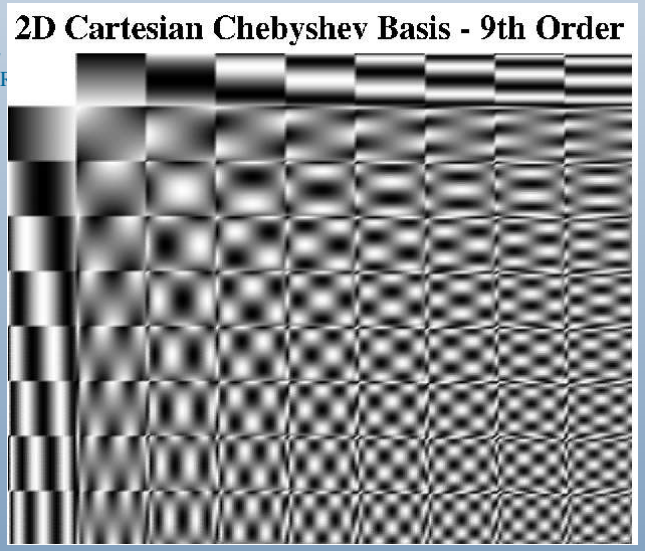
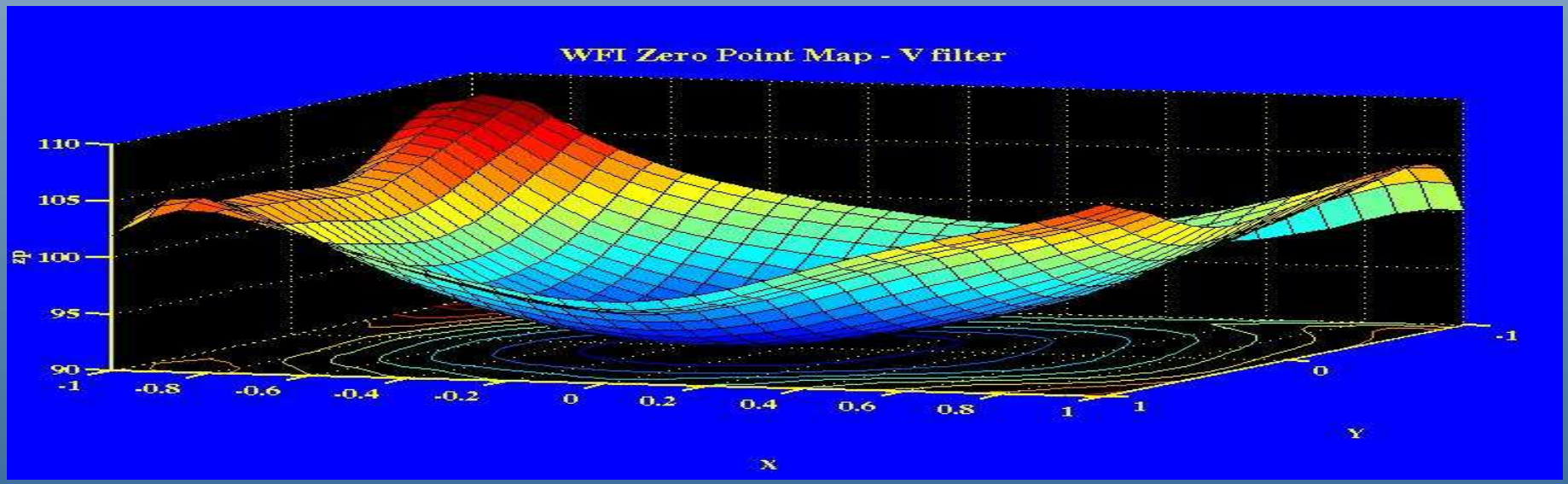


+

3 properly dithered frames obtained in photometric conditions



…we can do a little bit better.

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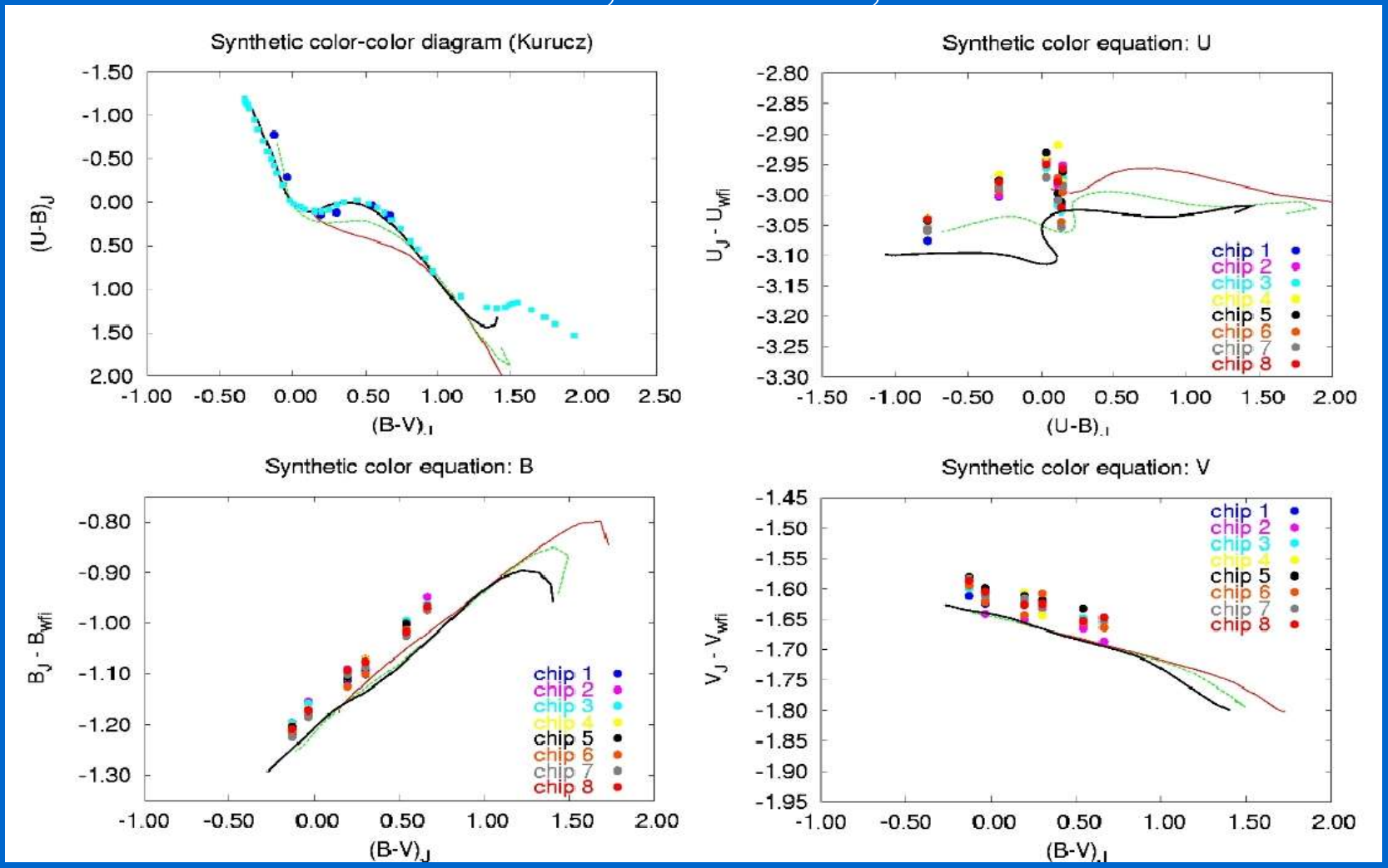
Scatter: dV = 0.009, dB = 0.010, dU = 0.014



…but to go further:

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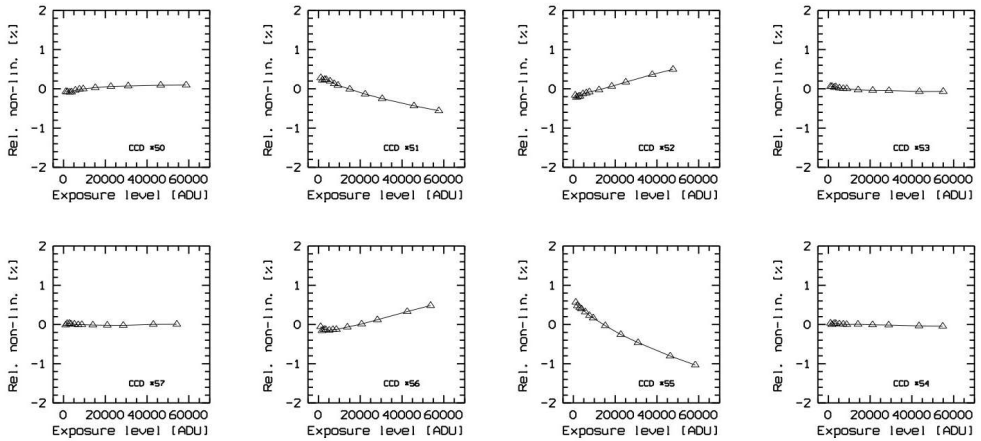
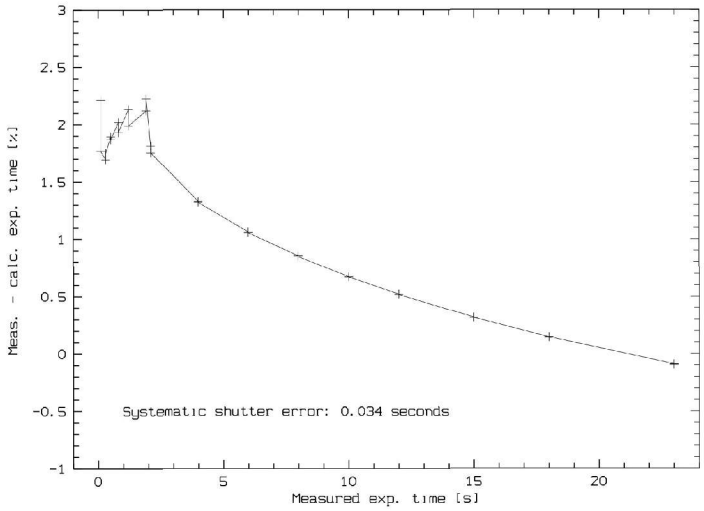


WFI_tec_ShutterError



We need to disentangle non-linearity
And shutter error.

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What we just did not do

- Astrometry
- Data reduction pipeline.
  - Automatic IQ monitoring
  - Automatic photometric monitoring
  - Automatic telescope pointing monitoring
- Keep a constant configuration (first FEROS, now GROND).
- Improve thermal environment of dome/telescope
- Improve Tserrurier measurements

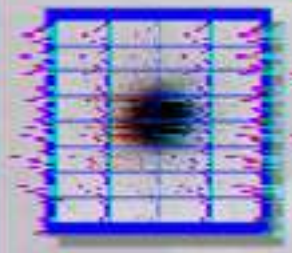
What about the VST

VST: inventory

VST: VLT Survey Telescope

- built by the Capodimonte Astronomical Observatory
- 2.6 m primary mirror
- 1.46 deg corrected FoV (Ø)
- 80% EE in 0.4"

OmegaCAM



- built by a Dutch/German/Italian consortium + ESO
- 16k×16k CCD mosaic
- 1 deg FoV (□)
- 0.21"/pixel scale

location, civil work & operations

- located at Cerro Paranal, Chile
- dome built by ESO
- operation carried out by ESO

What about the VST?

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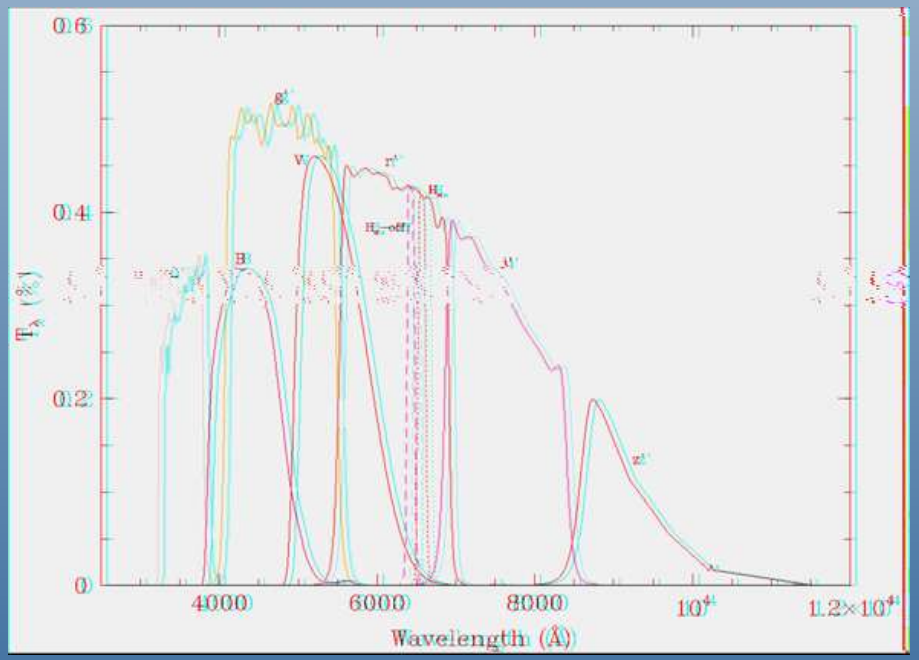
- Designed to avoid pupil ghosts
- ADC for all filters (but U!)
- Active optics (constant refocusing)
- Pipeline data reduction including light concentration recipes.
- Better matched pass-bands
-.Single instrument telescope



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The will is infinite,
The execution confin'd;
Desired is boundless,
The act a slave to limit.

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Fin

WFI scientific performance - 2

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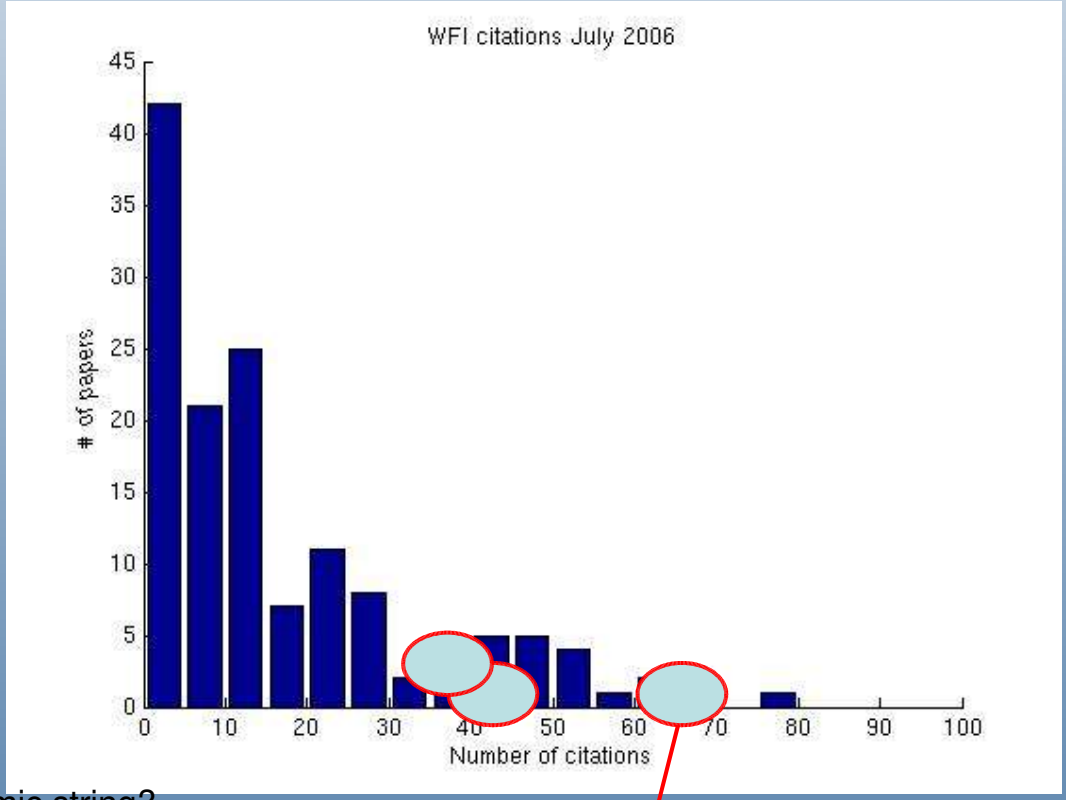

- 50% work in collaboration with other instruments: EMMI, SofI, FORS1-2
- h-index: 30

CSL-1: chance projection effect or serendipitous discovery of a gravitational lens induced by a cosmic string?
Sazhin, M.; Longo, G.; Capaccioli, M.; Alcalá, J. M.; Silvotti, R.; Covone, G.; Khovanskaya, O.; Pavlov, M.; Pannella, M.; Radovich, M.; Testa, V.

EIS: Deep public survey: Multi-color optical data for the Chandra Deep Field South[*] S. Arnouts, B. Vandame, C. Benoist , M.Groenewegen - L. da Costa, M. Schirmer, R. Mignani, R. Slijkhuis , E. Hatziminaoglou, R. Hook, R. Madejsky, C. Rité - A. Wicenec.

Intracluster Planetary Nebulae in Virgo: Photometric Selection, Spectroscopic Validation, and Cluster Depth. Arnaboldi, Magda; Aguerri, J. Alfonso L.; Napolitano, Nicola R.; Gerhard, Ortwin; Freeman, Kenneth C.; Feldmeier, John; Capaccioli, Massimo; Kudritzki, Rolf P.; Méndez, Roberto H.

Scientific performance - 3

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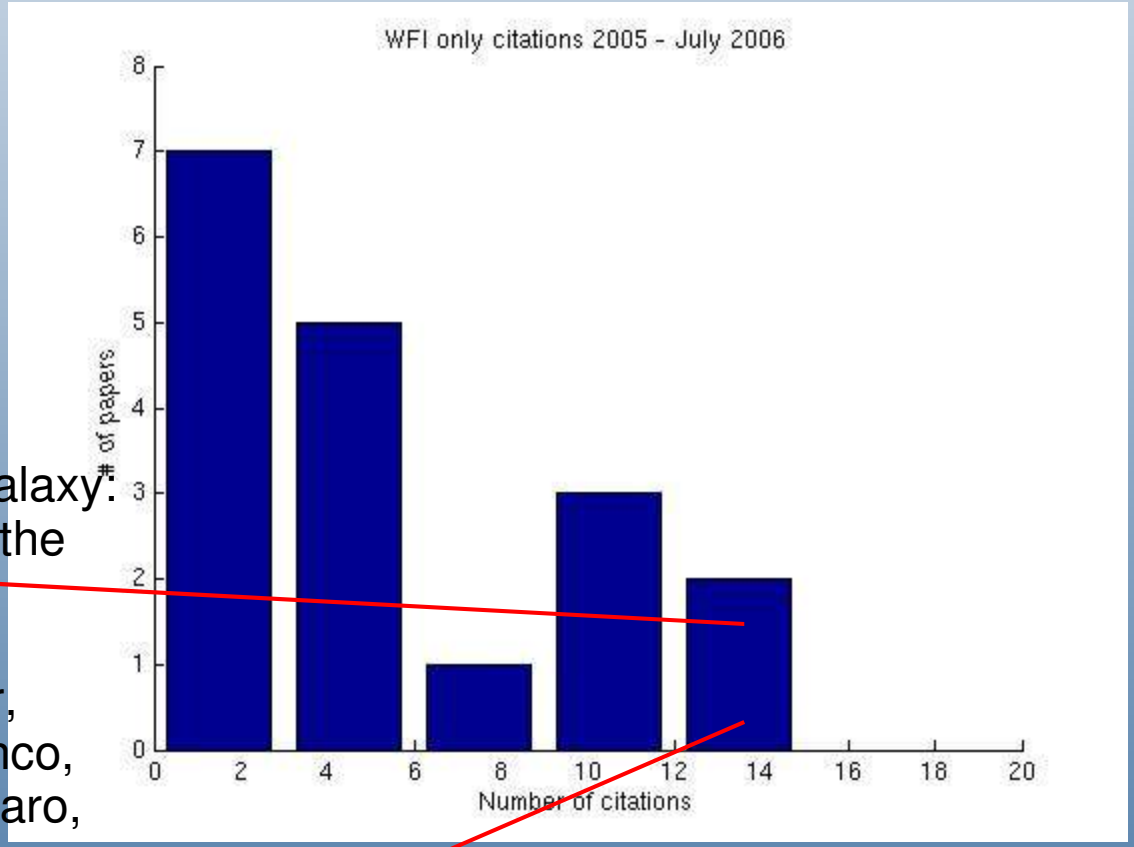
WFI only 2005-2006:

- 18 refereed papers
- h-index: 6



The Closest View of a Dwarf Galaxy: New Evidence on the Nature of the Canis Major Overdensity

Martínez-Delgado, David; Butler, David J.; Rix, Hans-Walter; Franco, Y. Isabel; Peñarrubia, Jorge; Alfaro, Emilio J.; Dinescu, Dana I.

The Garching-Bonn Deep Survey. IV. Methods for the image
of multi-chip cameras demonstrated on data from the ESO Wide-Field Imager
Schirmer, M.;

A&A 446, L1-L4 (2006)
DOI: 10.1051/0004-6361:200500223

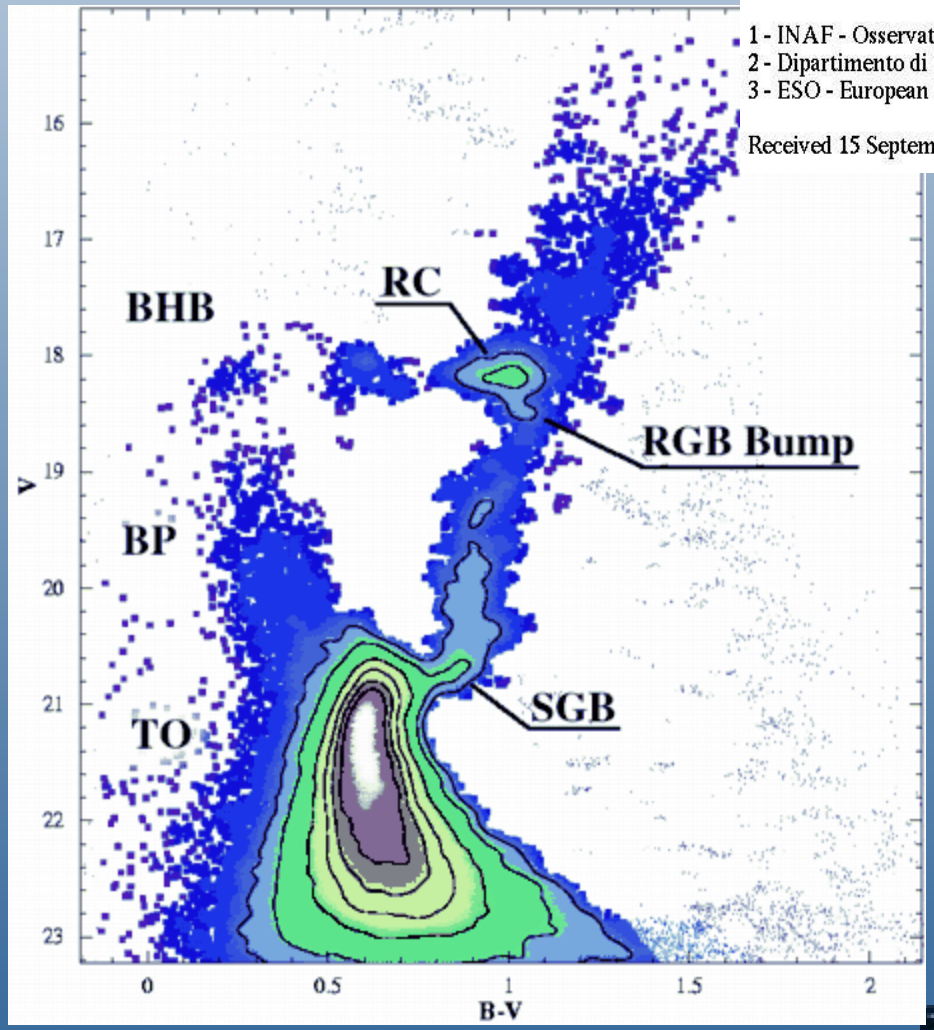
The age of the main population of the Sagittarius dwarf spheroidal galaxy

Solving the ``M giant conundrum''

M. Bellazzini[1] - M. Correnti[2] - F. R. Ferraro[2] - L. Monaco[3] - P. Montegriffo[1]

1 - INAF - Osservatorio Astronomico di Bologna, Via Ranzani 1, 20127 Bologna, Italy
2 - Dipartimento di Astronomia, Università di Bologna, Via Ranzani 1, 20127 Bologna, Italy
3 - ESO - European Southern Observatory, Alonso de Cordova 3107, Santiago 19, Chile

Received 15 September 2005 / Accepted 3 December 2005



WFI 1 square degree BVI

7 citations

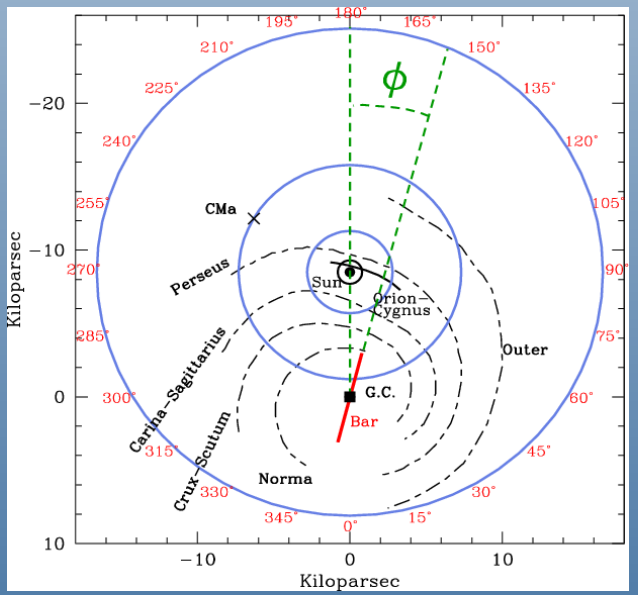
The Astrophysical Journal, 633:205-209, 2005 November 1

The Closest View of a Dwarf Galaxy: New Evidence on the Nature of the Canis Major Overdensity

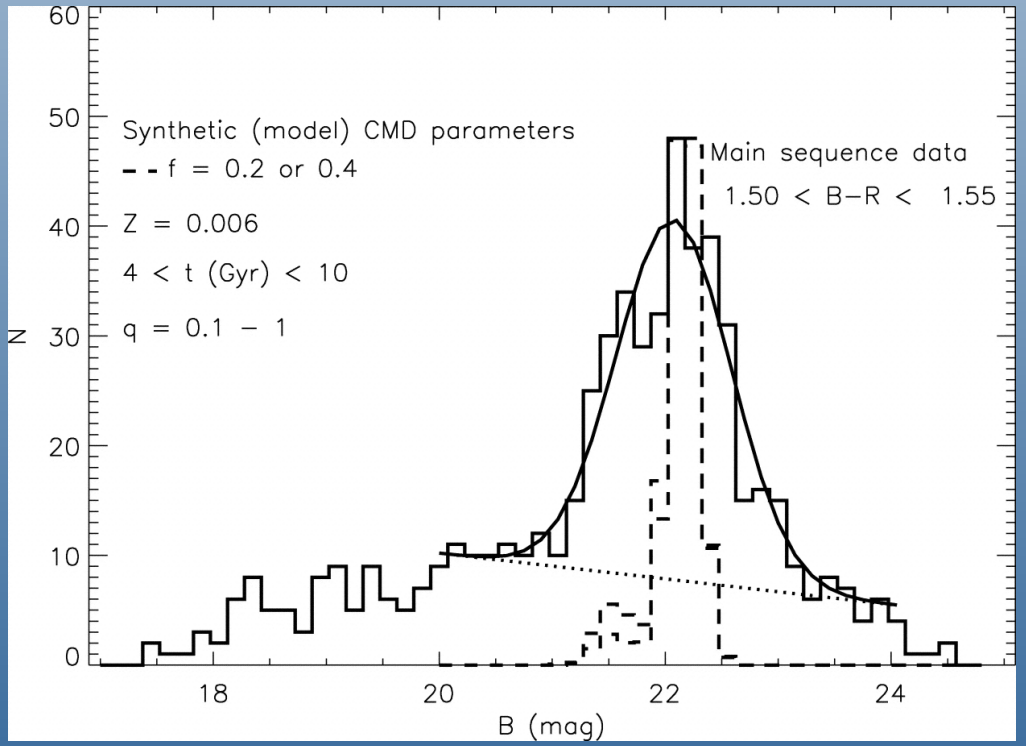
David Martínez-Delgado,[1,2] David J. Butler,[1] Hans-Walter Rix,[1] Y. Isabel Franco,[1] Jorge Peñarrubia,[1] Emilio J. Alfaro,[2] and Dana I. Dinescu[3]

Received 2004 October 25; accepted 2005 June 3

13 citations



From Momany et al.



Controversy: Momany et al. Bellazini et al., etc.

La Silla Paranal Observatory

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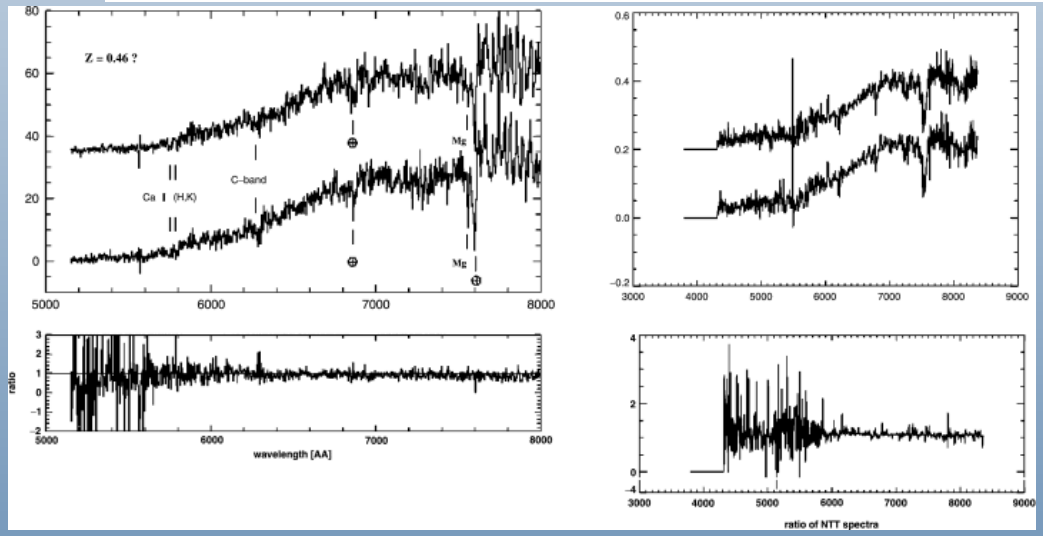
Volume 343 Page 353 - August 2003
doi:10.1046/j.1365-8711.2003.06568.x

Volume 343 Issue 2

CSL-1: chance projection effect or serendipitous discovery of a gravitational lens induced by a cosmic string?

M. Sazhin[1,2], G. Longo[3,4]★, M. Capaccioli[1,3], J. M. Alcalá[1], R. Silvotti[1], G. Covone[4], O. Khovanskaya[2], M. Pavlov[1], M. Pannella[1], M. Radovich[1] and V. Testa[5]



Lensing by cosmic string?...

42 citations