VST Data Center
HW and Software facilities

Aniello Grado
Luca Limatola
Fedor Getman

INAF-Capodimonte Astronomical Observatory, Naples

First INAF ICT Workshop Pula, Cagliari, 16-19 September 2014

Overview

- The VST telescope and GTO
- VST Data Center HW
- VST Data Center SW tools
- Science supported by VST data Center

The VST project started with the following commitments and returns

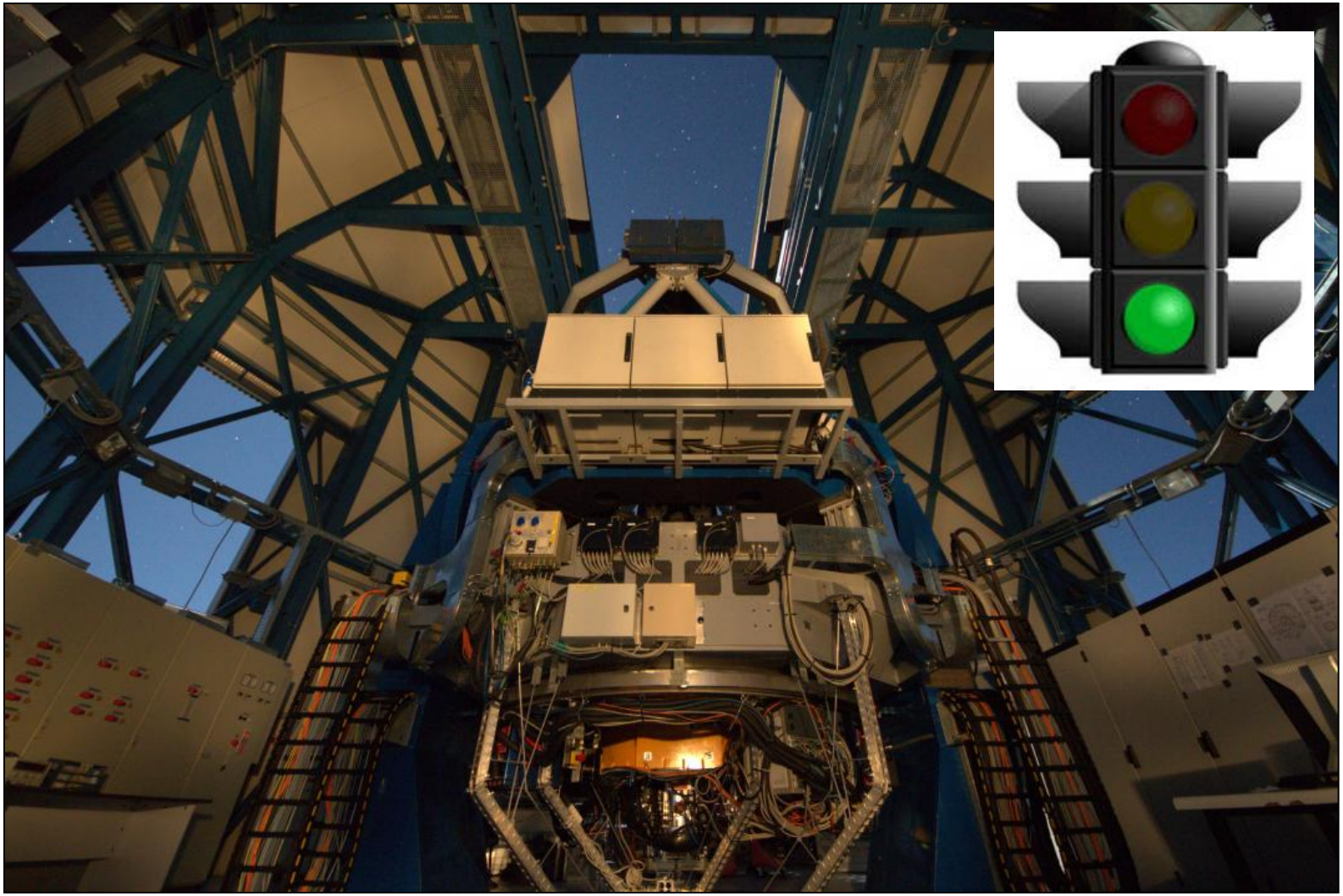
Naples Observatory (M. Capaccioli):

procurement of the telescope at Paranal
in exchange of some GTO @ VST & VLT

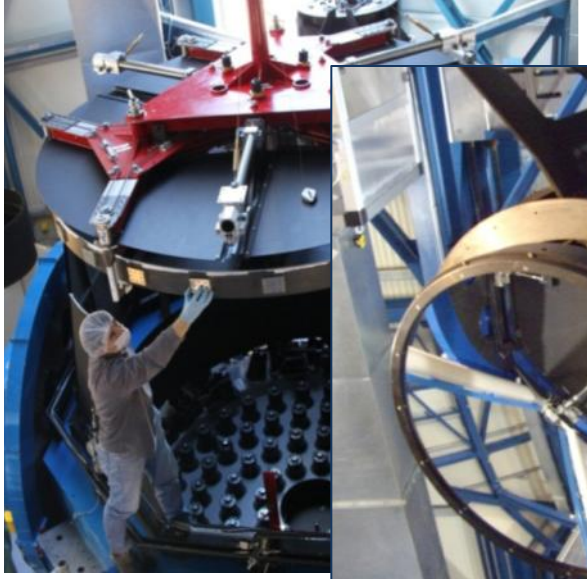
ESO: **civil work and operation of the facility for at least 10 years**;

OmegaCam: **procurement of the 16k×16k camera**
in exchange of some GTO @ VST.

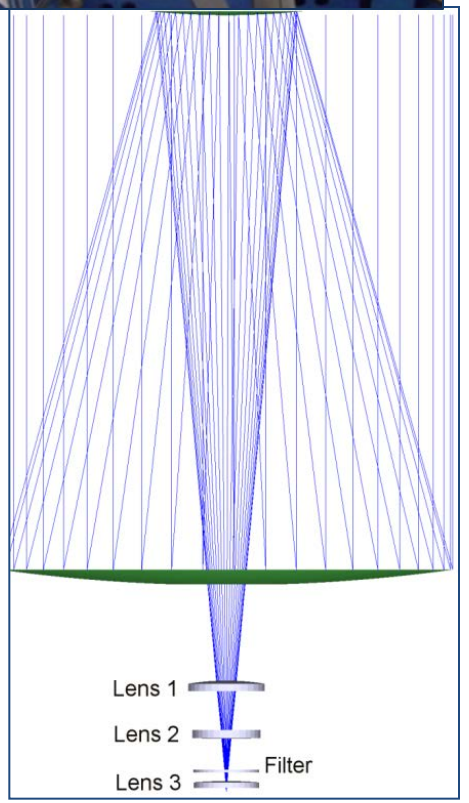
October 15nd, 2011: VST facility in service



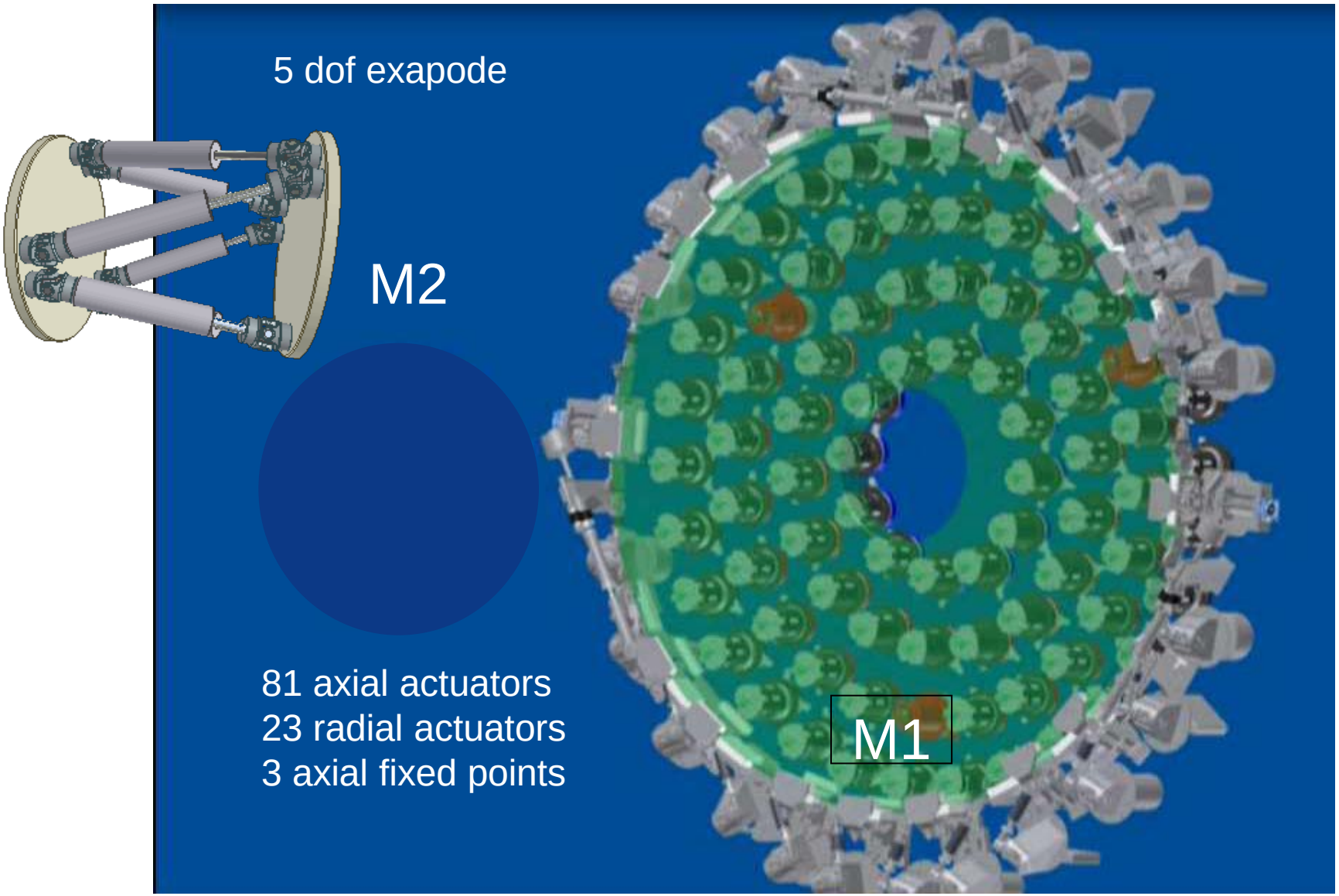
VST in a nutshell



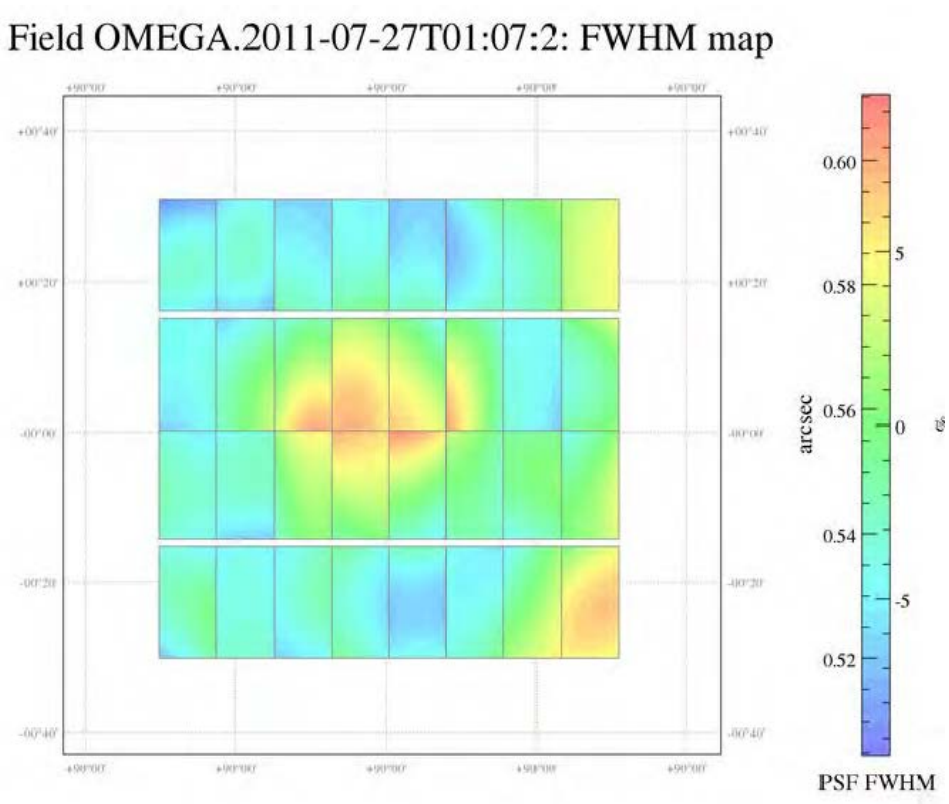
- Primary mirror: 2.6m
- Secondary mirror: 0.9m
- F# 5.5
- modified Ritchey-Chretien optical layout
- Field corrector with 3 lenses (2 in the telescope + 1 in the camera)
- ADC with counter-rotating doublet of prisms, exchangeable with 2 lens corrector
- 1.46 deg corrected FoV (∅)
- 80% EE in 0.4″
- Alt-Azimuth mount
- Active M1 shape control (81 active axial support + 3 axial fixed points)
- Active M2 positioning in 5 dof (hexapod)

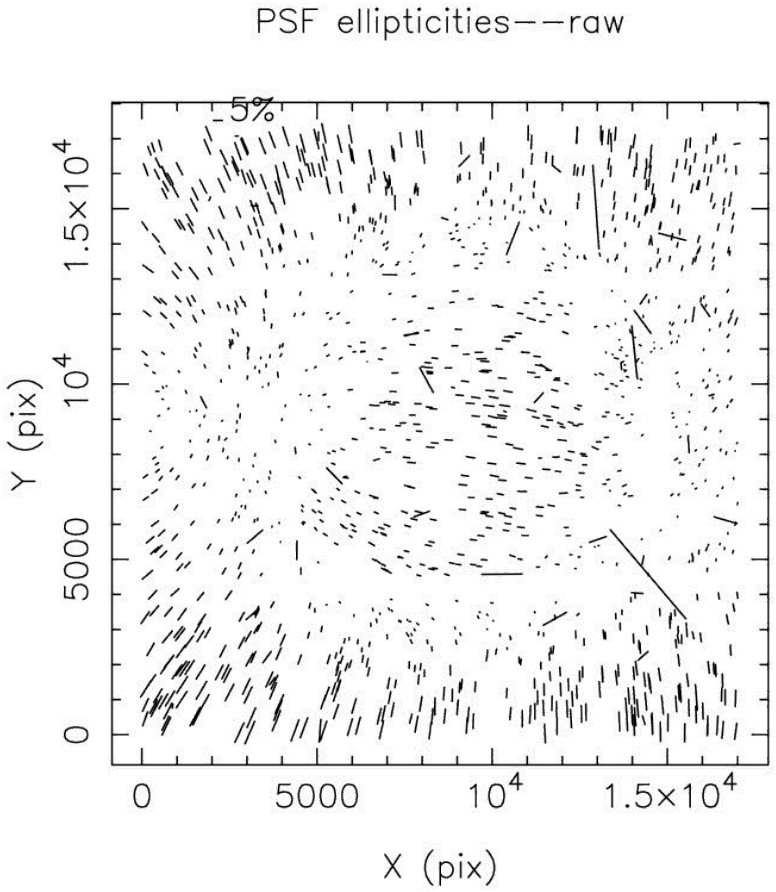


VST active optics



VST Image Quality performance

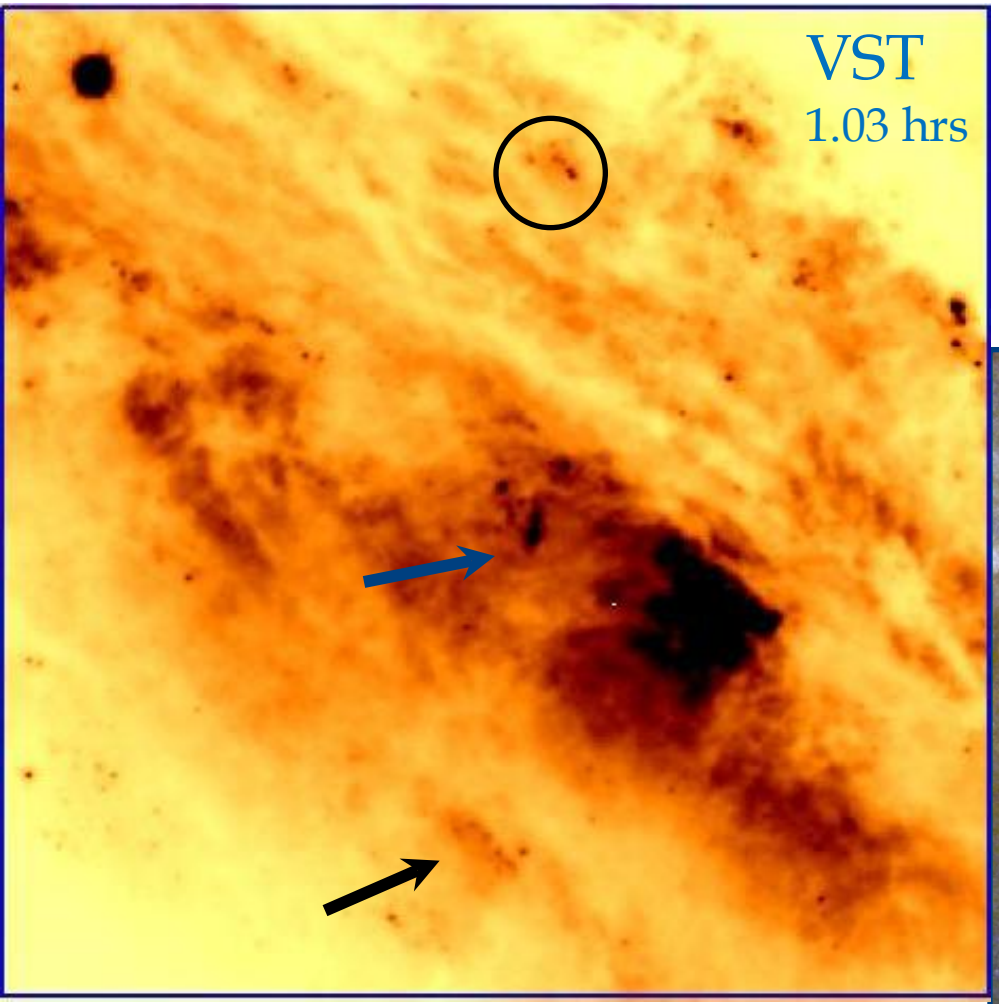


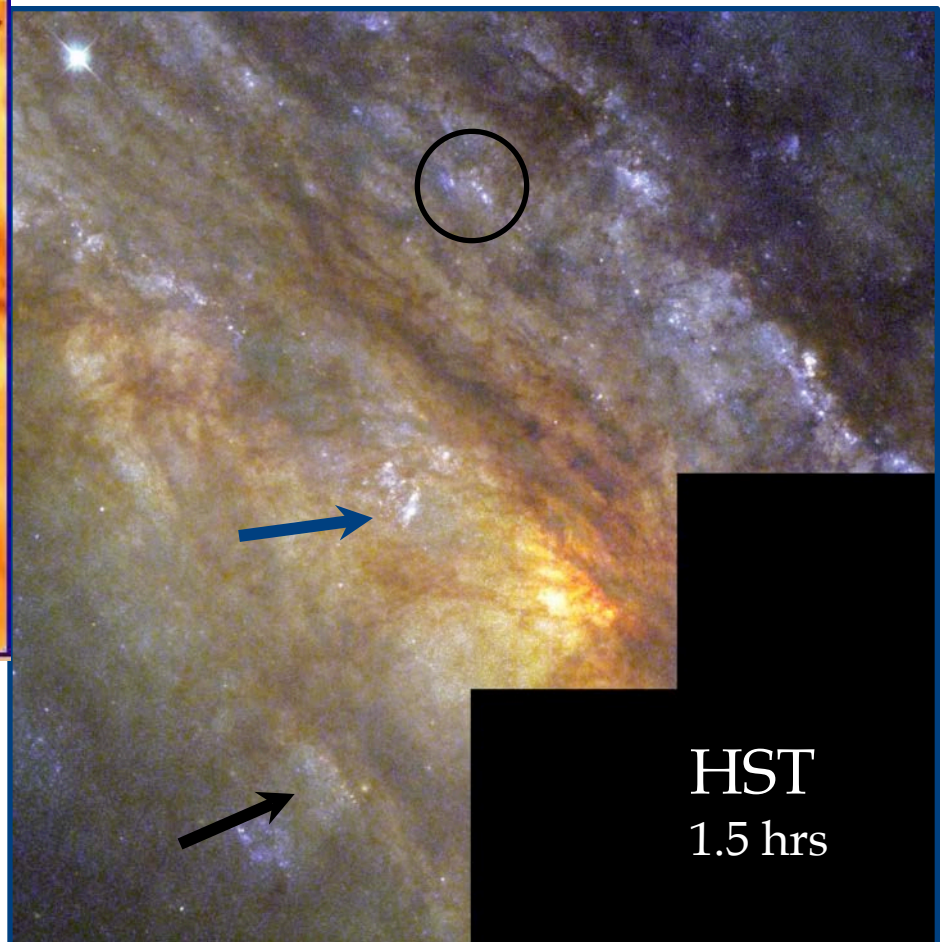


PSF FWHM = 0.5 arcsec, constant within <10% over the whole field

ellipticity ~ 10%

VST vs HST image of the NGC 253





VST camera OmegaCam

P.I. Konrad Kuijken
OmegaCAM Consortium:
the Netherlands, Germany,
Italy (Padova, E. Cappellaro),
ESO

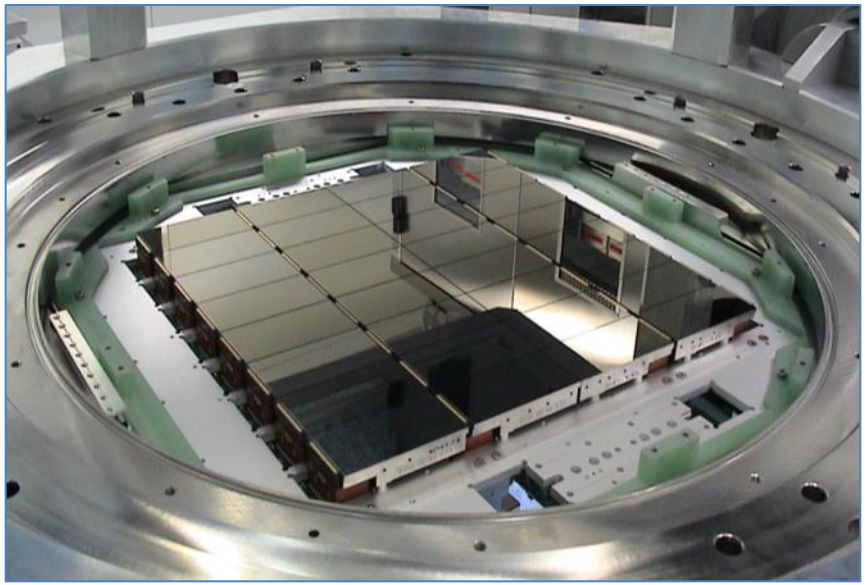
Format: 268 Mpixel mapping a 1°×1° field

Scale 0.21 arcsec/pixel

32 scientific CCDs + 4 outer CCDs

Autoguiding

Image analysis curvature sensor



VST Data Management

VST data flow/volume

VST can produce up to ~400 images/night

(220 GB single precision)

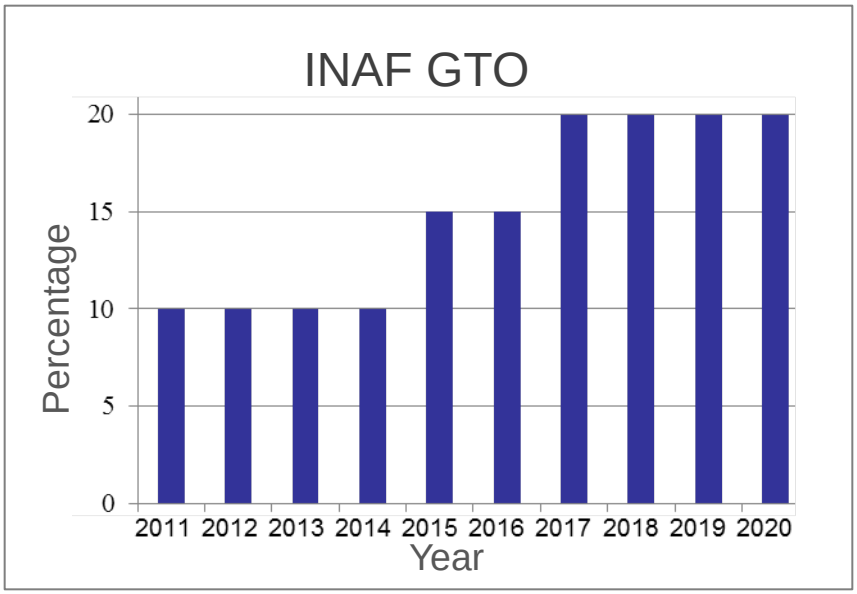
~ Real time data ingestion in ESO archive and replica in Munich archive

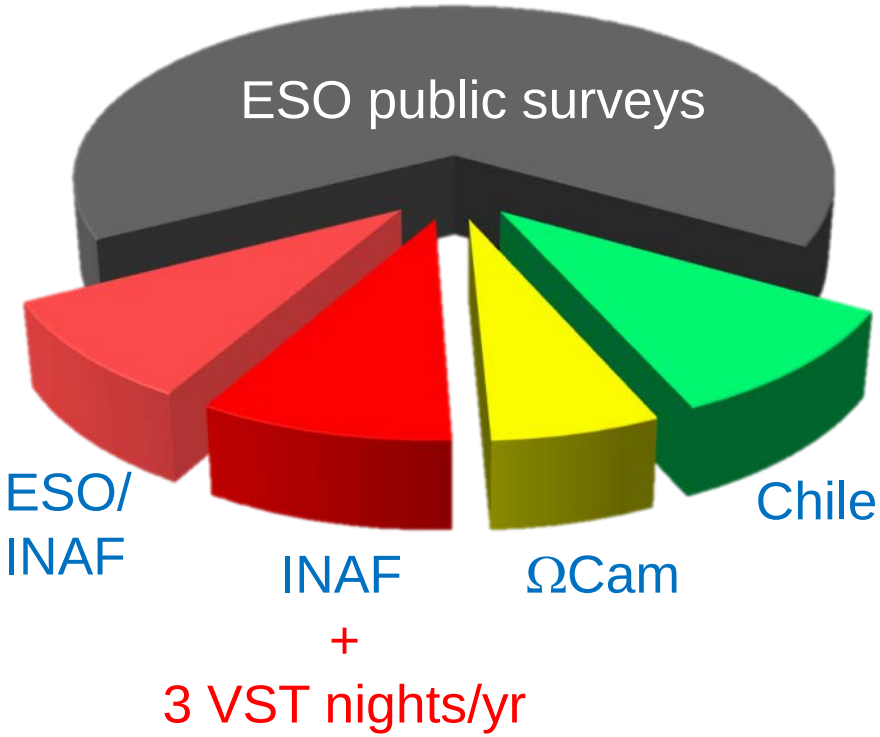
Download to the VST Data Center in Naples (GTO data)

VSTceN GoT: ~ 60 nights/year

Share of VST observing time

for the first 10 years of operation





VSTceN (PI M. Capaccioli): Science, Data Management, Telescope support

Presently ~ 100 astronomers are working on the VST data scientific exploitation

VST Data Center HW

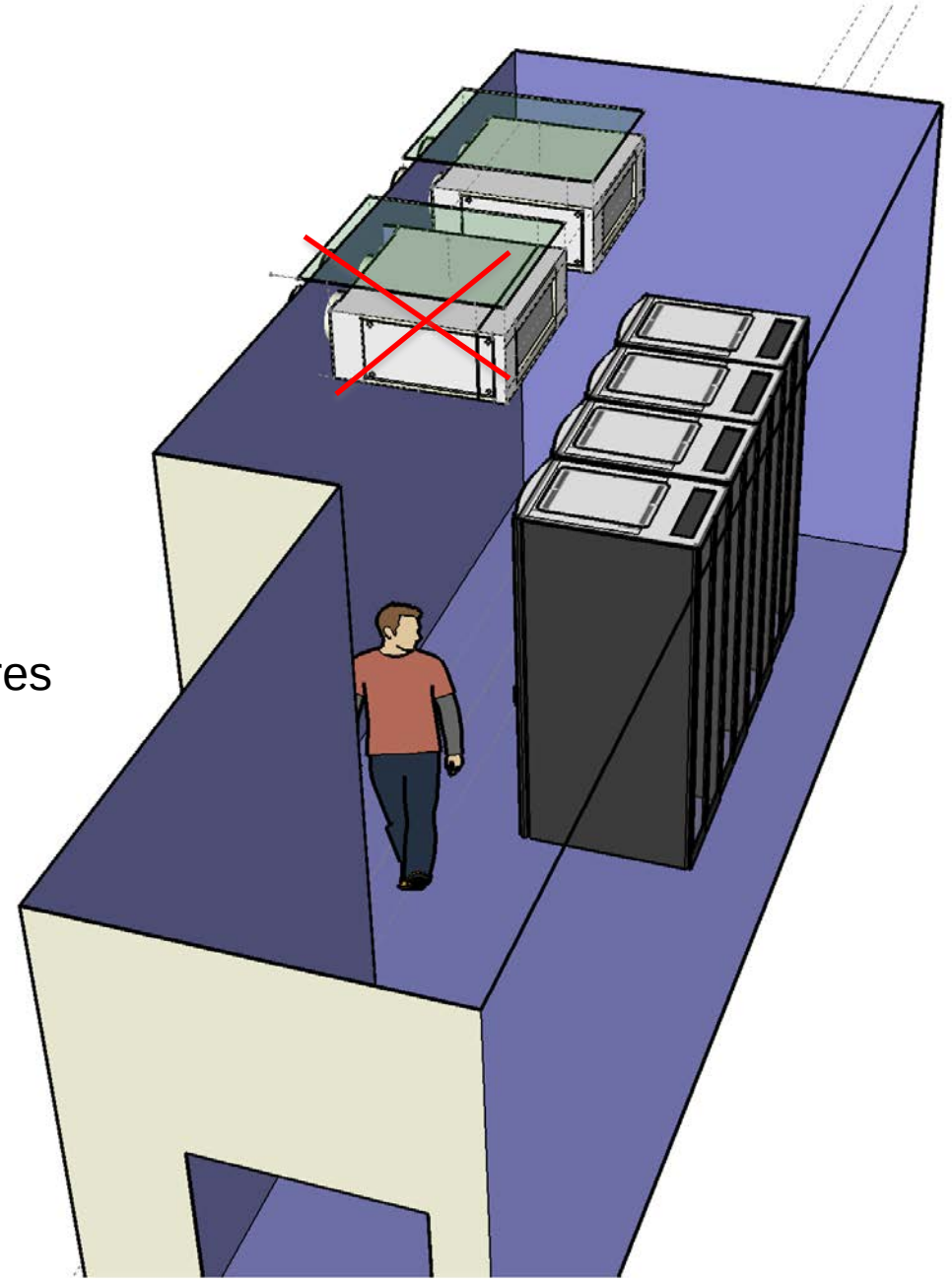
- Cluster 256 cores for data processing and analysis
- 10 Gb network
- ~ 300 TB effective storage

Hosting post-processing cluster 144 cores

Timing

Building works
Electric wirings
Network
Air conditioning
Racks
From call from tender to acceptance:

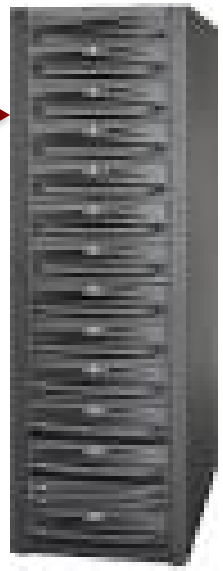
4 months!



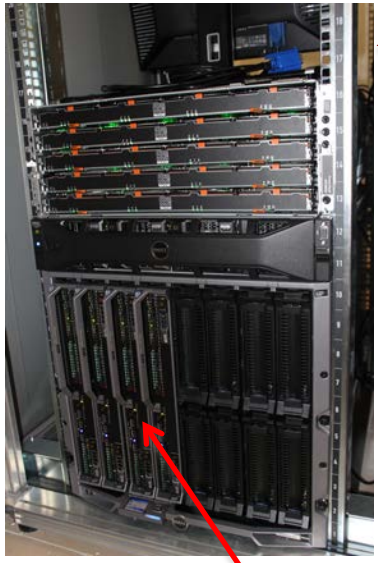
VST Data Center HW

SuperMicro 32C, Opt 6136,
64 GB, 96 TB, GPU TESLA M2075

4x1Gb



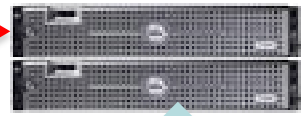
EMC NAS
NS704, 88
TB
FC/SATA



Dell MD3660i, iSCSI 10Gb, 240
TB, dual controller

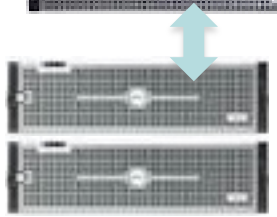
10 Gb

Dell R515, 16C Opt
4274, 32GB, 16 TB



2xDell PE2970, 8C,
Opt 2382, 16 GB

Dell M915 192C,
Opt. 6376/6320, 768
GB, 10Gb



2xDell MD3000, 15
TB

Cluster Blade high availability

Temperature safety systems

Sms+phone call alarm

GSM dialer

E-mail alarm + healthy check
from external servers

Ethernet

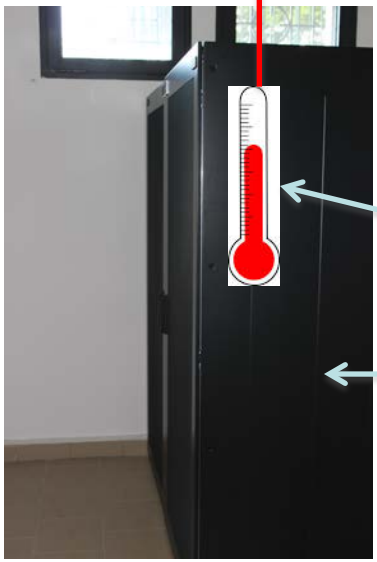
Monitoring system

Freecooling air
conditioning system
Fan under UPS

Alarm from the air
cond. system

Temp sensor in the
room

Independent electromechanical
temp sensor to switch off the
data center power supplies



Temp sensor in the rack

On each server a script
to poweroff in case of
high CPU temp

Power supplies protections

E-mail alarm

Ethernet

Sms+phone call alarm

GSM dialer

Monitoring system

Alarm from UPS

UPS line B

UPS line A

- Lightning arrestor
- Power supply analyzers on each phase
- Redundant UPSs
- Managed PDUs

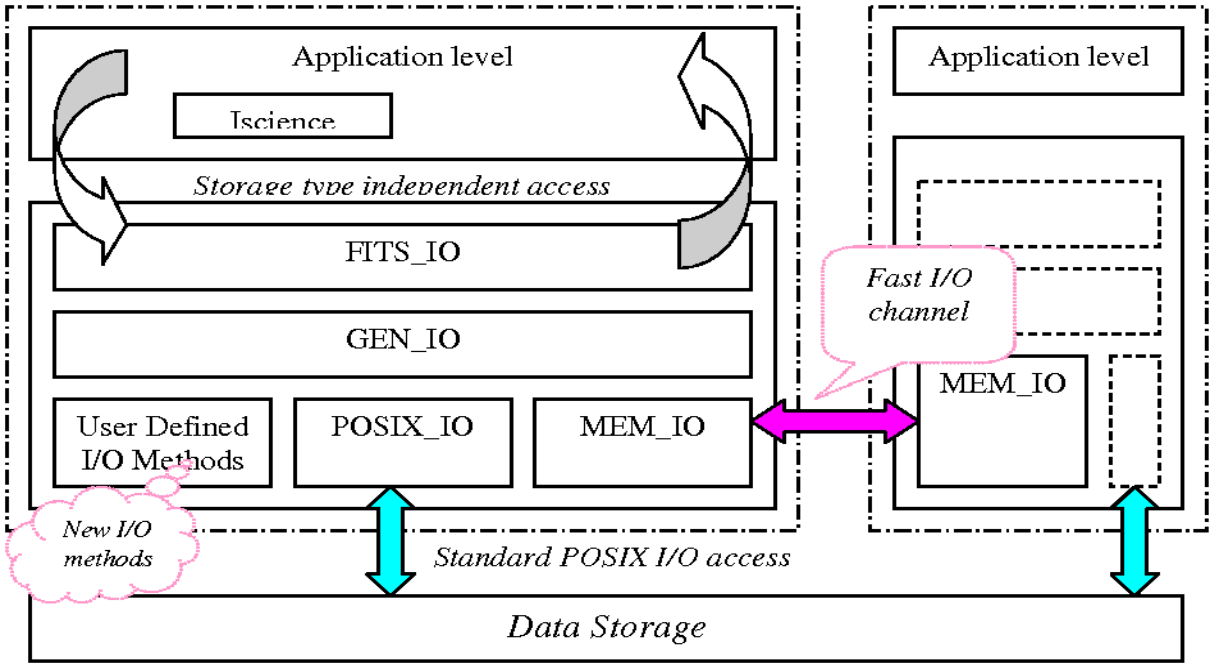
VST image processing dedicated software

- **Efits**: Completely new C library for FITS file processing
- **VST-Tube**: home made pipeline for images processing
- Fitshdr: tool to manipulate/edit FITS headers
- Astrobench: tool to benchmark HW for astronomical applications
- ..
- ..

VST image processing dedicated software
Efits

C-code library + set of tools to process Fits images

- usage of the shared memory to exchange data among independent processes (now less important with new HW performance)
- true noise map propagation mechanism.



VST image processing dedicated software EFits

Fits_io: includes set of functions for manipulations with FITS-key representation,FITS-header attributes, FITS-header manipulations, FITS-header history, FITS data manipulations

Gen_io: provides fixed, pre-defined, storage type independent interface. shared memory I/O and standard file system I/O operations are supported

Mem_io: a set of basic POSIX-like functions (open/read/write/seek/...) with the purpose of using the shared memory in the same way as a standard file-system file. The library uses special locking mechanism (semaphore based) to support multiple, parallel and concurrent access to the same data/ memory segment(s).

Iscience: statistics functions, pre-reduction methods, noise map generation and propagation functions

VST image processing dedicated software EFits

VSTcombine

Utility calculates FITS-files (scaled and/or de-biased) sum, average or median.
Options:

-h, --help	display this help and exit
--average	calculates average
--median	calculates median
--sum	calculates sum
--mul	two (or more) images multiplication
--clipped	calculates clipped average
--clipping=pedantic	
--clipping=relaxed	
--threshold=S.S	clipping threshold (in sigma)
--[no-]weighted	weighted (or not) operations
-V, --version	display version number and exit
-v, --verbose	explain what is being done
-s SS.SS, --bscale=SS.SS	SS.SS - scaling factor
-z ZZ.ZZ, --bzero=ZZ.ZZ	ZZ.ZZ - zero value
--weights=IWFILE	input weight-map file name: IWFILE
--readout-noise=NN.NN	input readout-noise: NN.NN
--bias=BFILE	master bias file name: BFILE
--bias-weights=BWFILE	master bias weights file name: BWFILE
--flat=FFILE	master flat file name: FFILE

VST image processing dedicated software

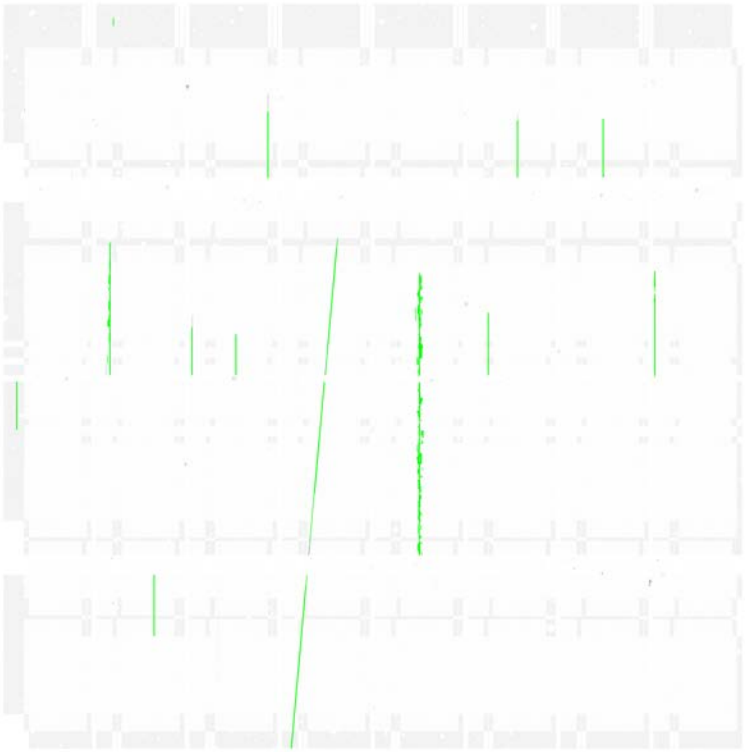
EFits

--flat-weights=FWFILE	master flat weights file name: FWFILE
--poisson	input Poisson noise distribution
-o OFILE, --output=OFILE	output file name: OFILE
--output-weights=OWFILE	output weight-map file name: OWFILE
--noclobber	does not overwrite existing files
--geometry=XSIZExYSIZE+X0+Y0	crop area size XSIZE x YSIZE, crop area offset X0,Y0
--ext-no=NNN	extension number for MEF files
--ext-id=EXTID	extension ID for MEF files
--byteorder=host	non-standard (arch dependent) byteorder in output
--byteorder=fits	standard byteorder in output file(s) [default]
--weightmaps-propagation	weightmaps direct propagation
--weightmaps-calculation	weightmaps (re)calculation

VST image processing dedicated software EFits

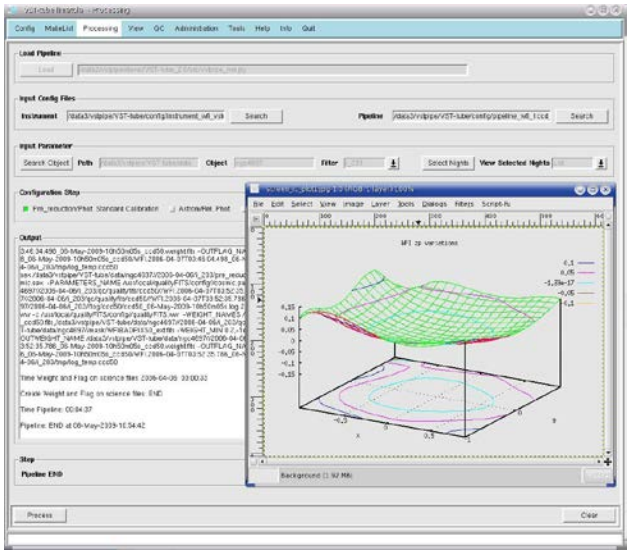
last option added to VSTcombine: creation of a flag mask of the clipped pixels for each input file

Why?
to create a mask for satellite tracks using the Hough transformation.



What is VST-Tube?

- an automated tool to go from raw astronomical images to fully calibrated co-added images
- an automated tool to extract catalogs with aperture (SExtractor) and PSF (Stetson tools based) photometry
- a set of tools to administrate data and check the quality of intermediate and final results
- a GUI to make configurations and actions easy and intuitive
- **tailored on surveys needs**
- not only VST …… (e.g. Subaru, VLT FORS, CFHT, WFI@2.2)



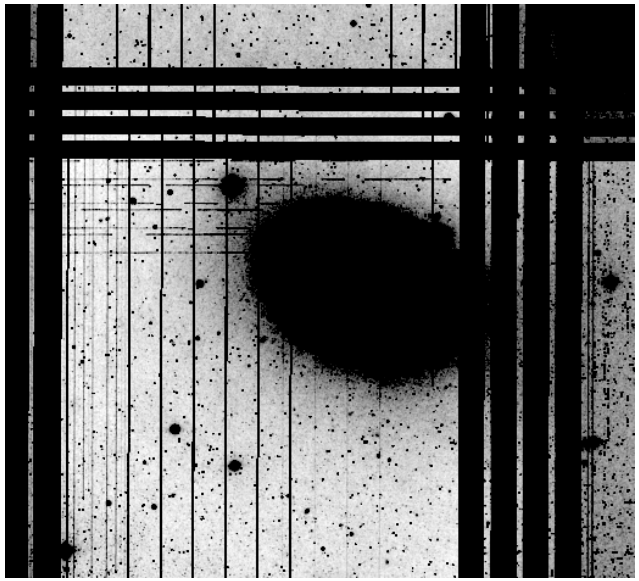
VST-Tube features

Written in Python, C, + external astronomical packages

~150 klines (C & Python codes)

Flexibility:

- Pipeline works without DB
  - – all the intermediate and final data are distributed in a intuitive directories tree
- Easy to adapt to peculiar data reduction model
- Easy to test new algorithms
- Full control on SW



NGC4697
Weight map section

In VST-Tube 2.0 the eclipse Fits library replaced with Efits

A. Grado, M. Pavlov and L. Limatola, 2007, "Efits: A New Efficient and Flexible FITS Library ", The 2007 ESO Instrument Calibration Workshop. Ed. Springer, p. 217

Unique characteristics: e.g. true noise map propagation

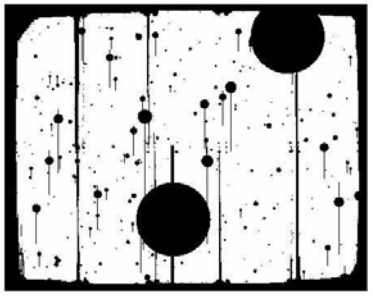
Tools

VST-Tube: a pipeline but also a growing collection of tools. Some examples:

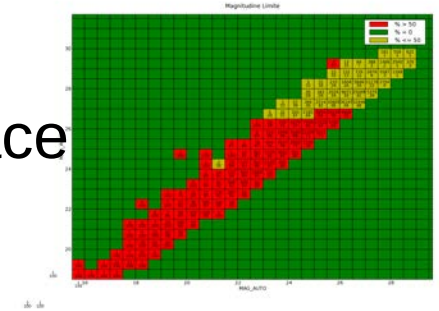
- ScanFits: report on raw fits files
- CopyFits: create file links
- ObjScan: object (or directory) processing resume'
- ObjLog: shows the differences in conf params among ID's of the same object
- Toolist: manually edit lists of files
- Photcal: absolute photometric calibration (M. Radovich)
- Catalogs: extract catalogs (Sex or Daophot) from images
- CheckPhotom: photometric diagnostic
- IC: creation of the illumination correction

Tools

- Sky2Fits: shows which CCDs contribute to a given RA and DEC in a mosaic
- Pointings: gives the list of images for each poir
- Report: write an automatic Latex report on the reduction



- Mask: automatic masks of bright stars and halos
- Bpmask: create cold/hot pixels mask
- Aperture and PSF (S. Zaggia) photometry
- MAgliM (completeness vs magnitude and surface brightness)



- VSTSim (images simulator)
- SBP Surface brightness profile tool

Running Surveys processed with VST-Tube

redshift

1) STREGA: STRucture and Evolution of the Galaxy (PI Marconi)

2) STEP: The Small Magellanic Cloud in time evolution … (PI Ripepi)

3) **VST-Omegacam Local Group Dwarf** survey (PI Held)

4) VEGAS: VST survey of Elliptical Galaxies in the South hemisphere (PI Capaccioli)

5) **WINGS** Wide field Imaging of Nearby Galaxy clusters Survey (PI Poggianti D'Onofrio)

6) VST-ACCESS**:** Complete CEnsus of Star-formation in Shapley (PI Merluzzi)

7) CHANGES:VST Halpha Imaging Survey of ``Transforming Galaxies'' in local (d{<}80,Mpc) Galaxy Groups (PI Campusano)

8) VOICE: The VST optical imaging of the CDFS and ES1 fields (PIs: Covone, Vaccari)

9) **SUDaRE**: SUpernova Diversity and Rate Evolution (PI Cappellaro)

10) COSMOS: SUpernova Diversity and Rate Evolution . Monitoring COSMOS field (PI Pignata)

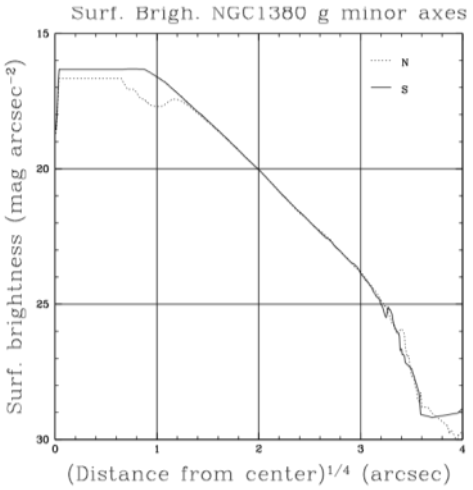
11) XXXL: Dark energy constraints from X-ray selected clusters in the XMM-XXL survey (PI. Poggianti)

Papers VST-Tube

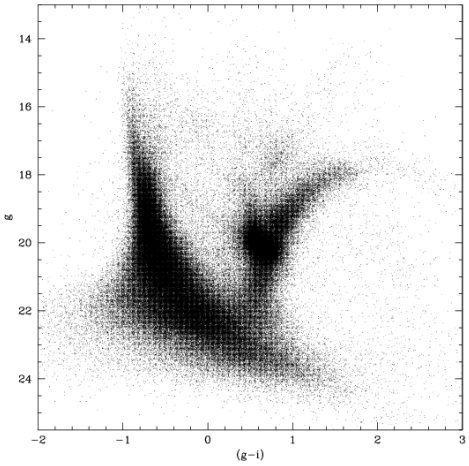
- Ripepi, V. ; Cignoni, M. ; Tosi, M. ; Marconi, M. ; Musella, I. ; Grado, A. ; Limatola, L. ; et al.” *STEP: the VST survey of the SMC and the Magellanic Bridge - I. Overview and first results*”; 2014, MNRAS, *442, Issue 3, p.1897-1921*
- Merluzzi, P.; Busarello, G.; Haines, et al., *Shapley Supercluster Survey (ShaSS): Galaxy Evolution from Filaments to Cluster Cores*, 2014arXiv1407.4628M
- Marconi, M.; Musella, I.; Di Criscienzo, et al, “STREGA: *STRucture and Evolution of the GAlaxy. I. Survey Overview and First Results*”, 2014arXiv1406.4375M
- Marconi, M.; Musella, I.; Criscienzo, et al. *Preliminary Results of the Structure and Evolution of the Galaxy Survey: Probing the Structure of the Milky Way Halo,* 2014ASPC..486..203M
- Omizzolo, A.; Fasano, G.; Reverte Paya, D.; De Santis, C.; Grado, A et al. “*U-band photometry of 17 WINGS clusters”*, 2014, A&A 561, id.A111, 9 pp
- Cantiello, M.; Grado, A.; Blakeslee, J. P.; Raimondo, G.; Di Rico, G.; Limatola, L.; Brocato, E.; Della Valle, M.; Gilmozzi, R.; “*The distance to NGC 1316 (Fornax A): yet another curious case”* Astronomy & Astrophysics, Volume 552, id.A106, 22 pp.
- Botticella, M. T.; Cappellaro, E.; Pignata, G.; “*SUDARE at the VST* “ 2014, The Messenger, vol. 151, p. 29-32

First VST image fully processed (Omega Centauri)

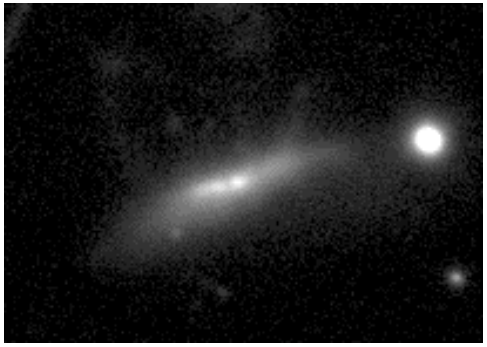
Science verification data (NGC253)



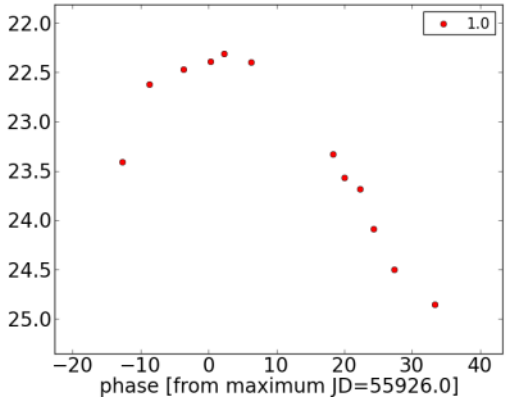
VEGAS:
faint surf. bright. profiles



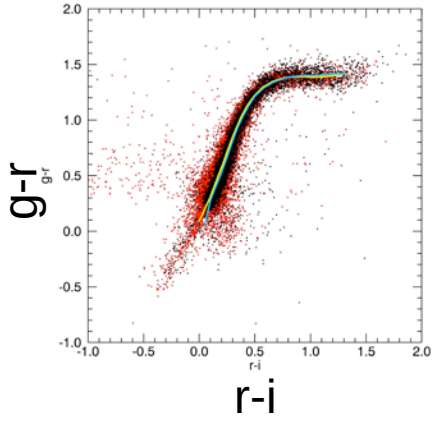
Vst Tube



ACCESS: identification of transforming galaxies by morphology



SUDARE: first VST SN detected.
< 24 hours between VST obs. and VLT spectr. confirmation



NGC253 - VLT Survey Telescope. *Credit: A. Grado & L. Limatola*