The Danish telescopes on La Silla

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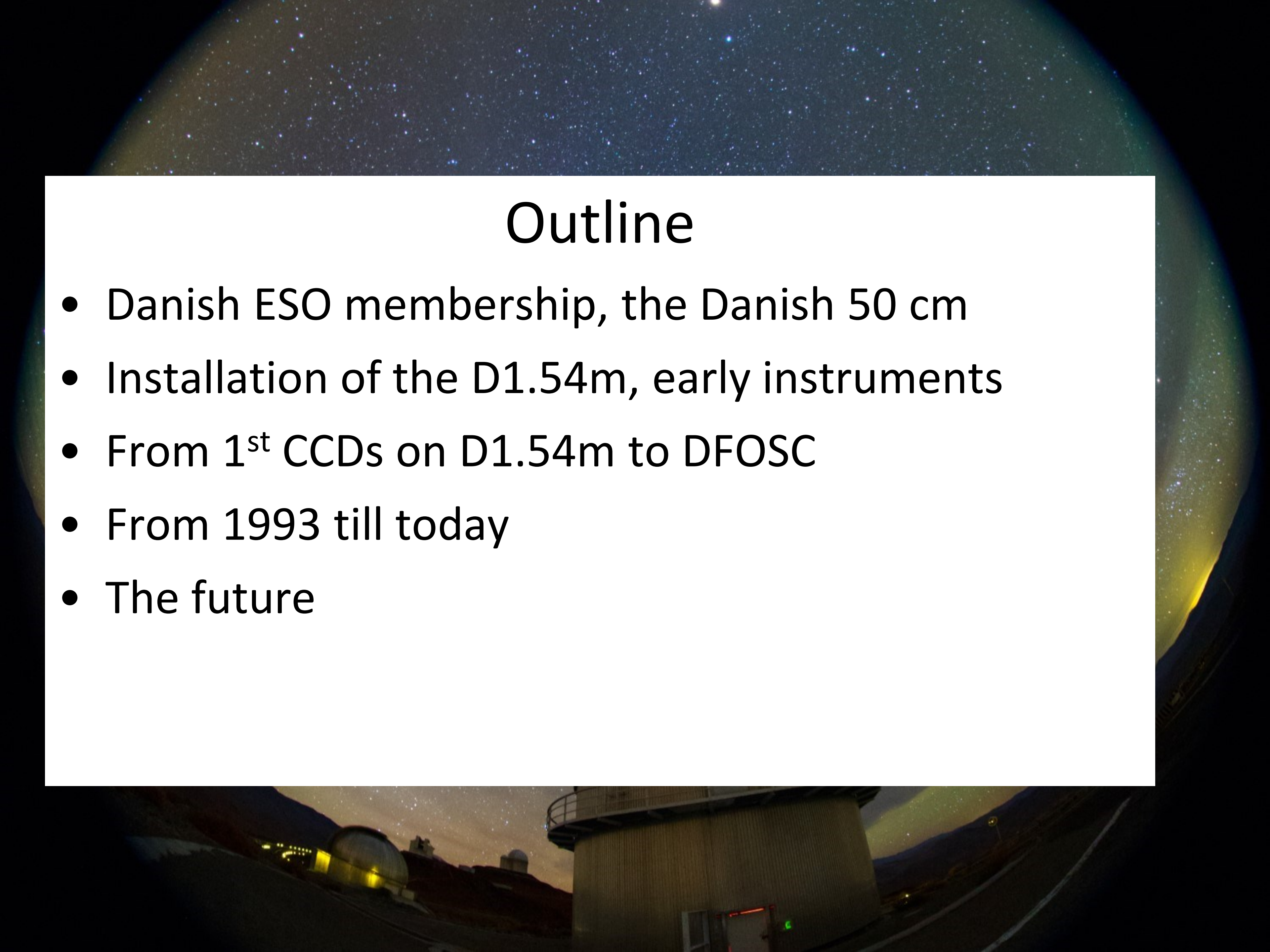

Outline

- Danish ESO membership, the Danish 50 cm
- Installation of the D1.54m, early instruments
- From 1st CCDs on D1.54m to DFOSC
- From 1993 till today
- The future

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Danish ESO membership

- Denmark had barely finished the Brorfelde Observatory in Denmark (plans initiated before WW2).
- Prof. Anders Reitz pushed strongly for ESO membership. Denmark joined in 1967.
  - The then minister of education called Reitz the biggest one-man army he had ever encountered.
- It was right from the beginning in the plans to erect a national telescope on La Silla.
  - This was to become the D1.54m

The Danish 50cm

- Installed in 1969
  - Was already in the making at the point of Danish entry into ESO.
  - Designed for Photoelectric photometry.
  - Several generations of instruments.

Major upgrades in the 80ies

- Fully digitally control system installed in 1986.
  - First telescope in the world to achieve this.
- Robotized by 1988
  - First robotic telescope (open dome manually).
  - Use V-slits to scan target, automatic centering.
- 6-Channel photometer integrated with the control system
  - u,v,b,y-Hβ photometer (Strömgren-photometry)
    - Yields spectral type, luminosity class and abundance.
  - Erik Heyn Olsen observed more than 10000 stars and set the standard in the field
- The ESO 50 cm is a copy of the Danish 50 cm

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The Danish 1.54m in the making

’Rasmus Klump bygger en båd’
in English, ‘Barnaby Bear builds a boat’

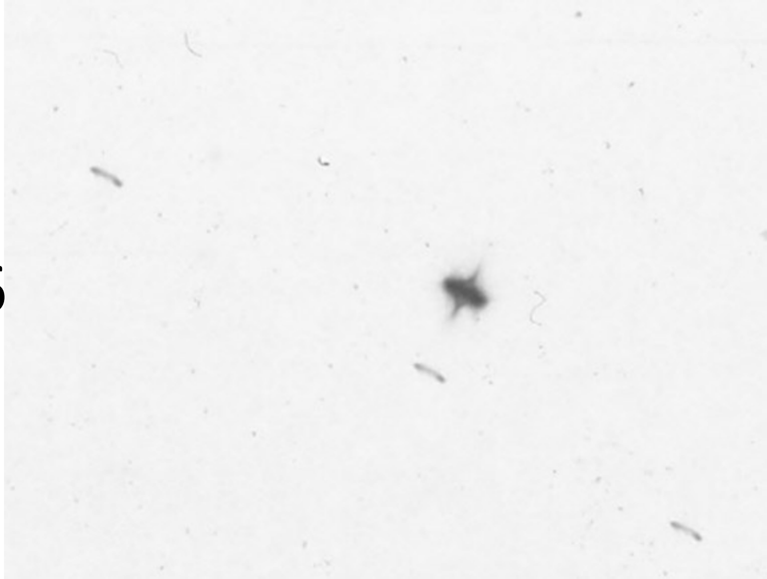
From the times before project management arrived to astronomy

- Barnaby Bear had the stering wheel
  - Thus, he had to build a boat
- Prof. Reitz ‘had’ a mirror
  - The one man army went to the ministry
  - And to the Carlsberg foundation
  - And the project came into the making
- Mirror polished by Malaise (Belgian)
- Telescope manufactured by Grubb Parsons

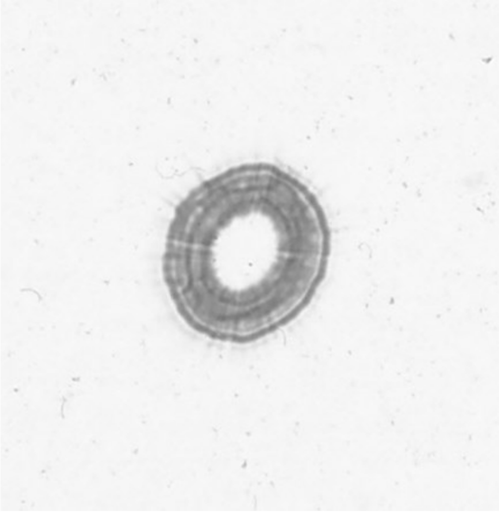
Danish 1.54 meter telescope

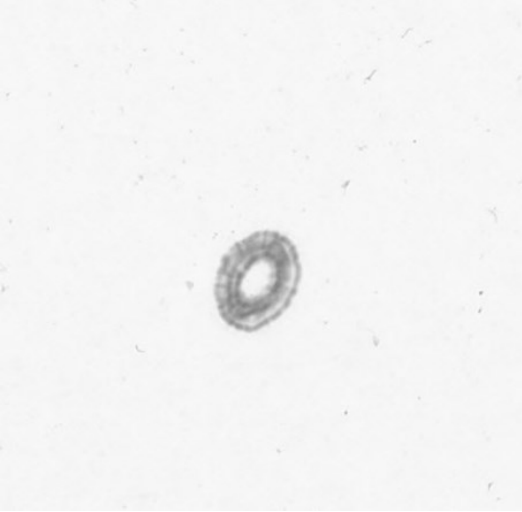
- Main mirror 1.54 meters
- Optical system classical Ritchey-Chrétien
- Zervit (Zerodur) mirrors
- focal length ~13meters
- Equatorial (German) mount

Installation of Danish 1.54m



- Building finished 1975
- Installation of telescope 1976
- Zero’th light late 1976
  - Astigmatism of almost 10”!
- Repolish at Grubb Parsons





First light, first instruments

- Reinstallation of mirror in 1978
  - First light in November 1978
    - Tests of telescope conducted by R. Wilson and J. Andersen (found original Hartmann exposures in our basement last week)
    - Direct images were ‘very good’, excellent for its time.
- First generation of instruments (not complete)
  - Four channel photometer (uvby Strömgren filters)
  - Single channel photometer (Johnson filters)
  - Wide field photographic camera

A couple of remarkable instruments

- The ‘McMullen’ electronographic cameras (after the Lallemand ‘camara electronique’)
  - In short, a photo-electron is accellerated towards a photographic film.
    - A single electron creates a trace in the emulsion
    - This detector is in principle linear
  - The problem: Resources to do the reduction were not available
    - Very limited science output
- Coravel: Build by Michel Major’s team
  - Exchange of instrument for observing time
  - Measured thousands of radial velocities

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First CCD’s on the Danish

- ESO developed first CCD cameras around 1980
- Plate scale better fit D1.54m than ESO 3.6m
  - Therefore a CCD was early on located at the D1.54m
  - 2nd ‘rediscovery’ of Halley’s comet Nov. 1992 (R. West) – Palomar beat ESO by 6 weeks
  - Search for distant supernovae (early Danish ‘Dark Eenergy’ experiment, Hansen, Jørgensen, Nørgaard-Nielsen)

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ASTRONOMY AND ASTROPHYSICS

Letter to the Editor

A supernova at $z = 0.28$ and the rate of distant supernovae*

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Inspiration from ESO

- D. Enard proposed EFOSC around 1980
  - Solving problem of plate scale matching
  - Spectroscopy capability on demand

  (the Swiss army knife of optical astronomy)
- P. K. Rasmussen became inspired during an observing run at the 3.6m
  - Funding from the Carlsberg Foundation, Dec 1988
    - Optical design by Delabre
    - FoV of 13.7’ x 13.3’, 2k x 2k CCD, 0.4”/sec
- The EFOSC concept is one of the main instrument legacies from La Silla

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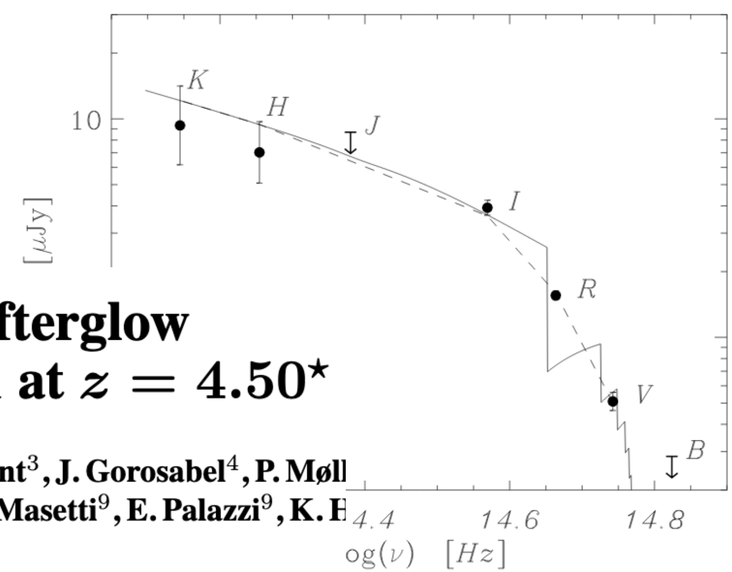
DFOSC

- DFOSC installed in Dec 1992
  - Initially using a 1k x 1k uv-enhanced front illiuminated Thomson CCD with ESO controller
  - In 1994 upgraded to a 2k x 2k Loral with excellent QE and a good deal of ‘CCD seeing’ (charge diffusion)
- At this point D1.54m + DFOSC was quite a powerful facility for the Danish community
- In 2003, descoped to ‘imaging only’ in order to reduce pointing restrictions
  - Has operated as focal reducer only since.
  - The ‘DFOSC Sister’ AlFOSC still most subscribed instrument on the Nordic Optical Telescope

GRB observations

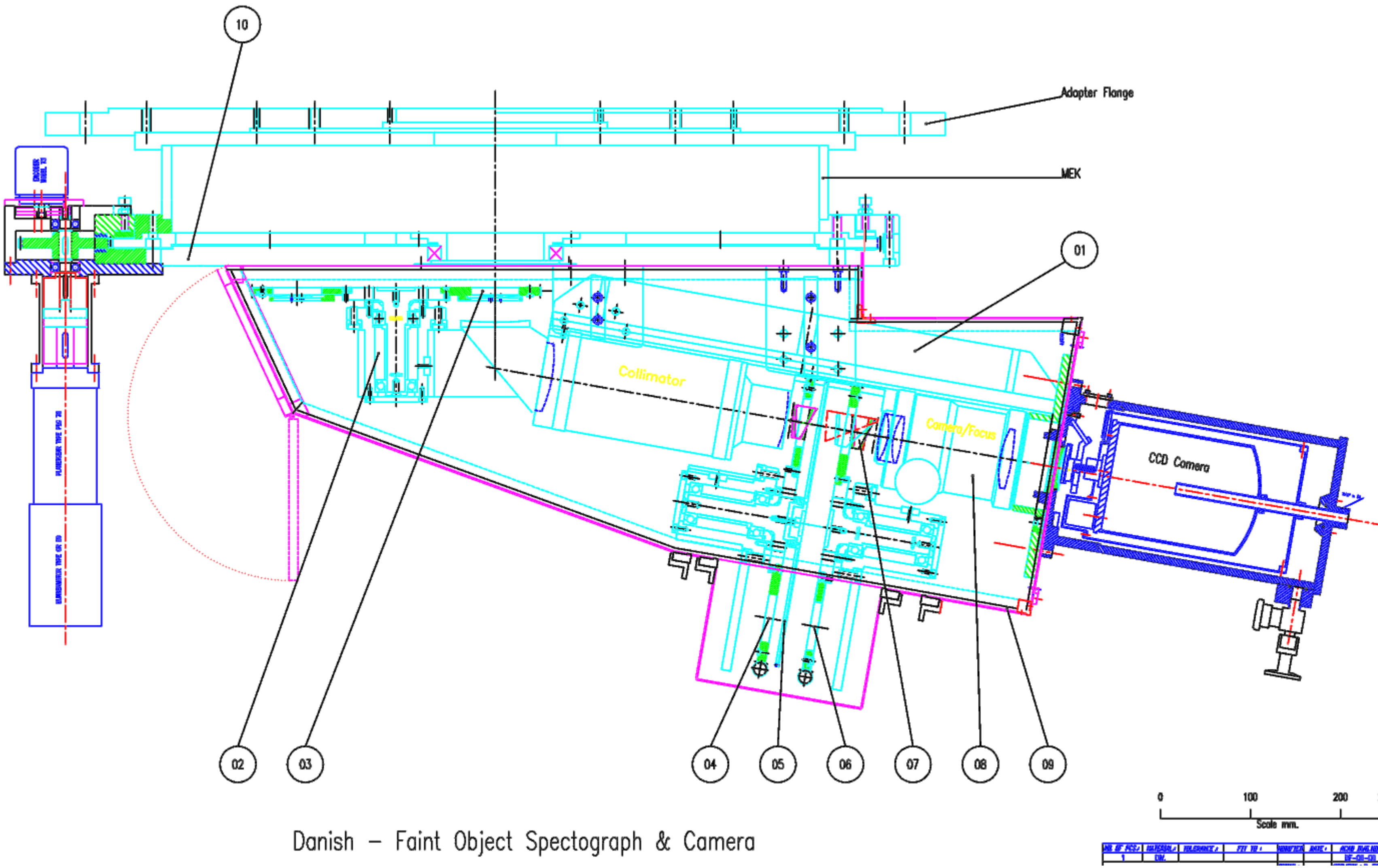
- Holger Pedersen ‘tricked me’ into this field in 1993 – did first follow-up with DFOSC then.
- One little highlight: GRB000131
  - One data point, the I-band photometry, became crusial for the interpretation of the VLT spectrum: Z=4.50 (which remained the record for 5 years)



VLT identification of the optical afterglow of the gamma-ray burst GRB 000131 at $z = 4.50^{\star}$

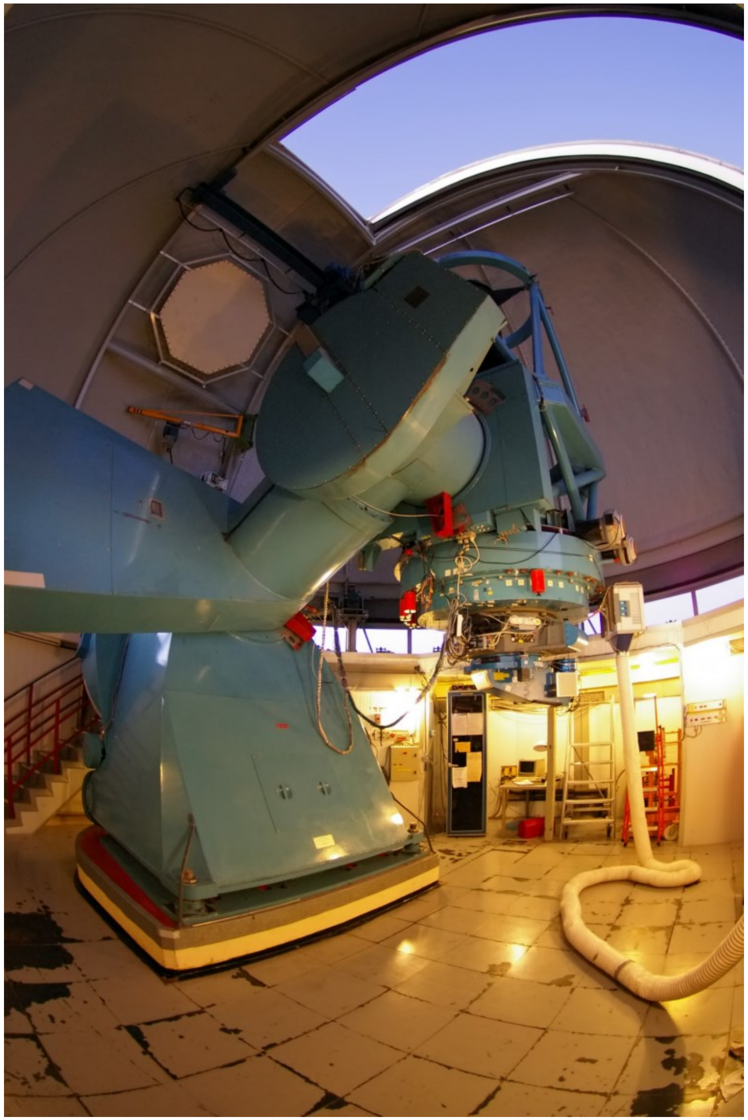
M.I. Andersen[1], J. Hjorth[2], H. Pedersen[2], B.L. Jensen[2], L.K. Hunt[3], J. Gorosabel[4], P. Møll
B. Thomsen[7], L.F. Olsen[2], L. Christensen[2], M. Vestergaard[8], N. Masetti[9], E. Palazzi[9], K. H
and A.O. Jaunsen[14]

DFOSC layout



Danish – Faint Object Spectograph & Camera

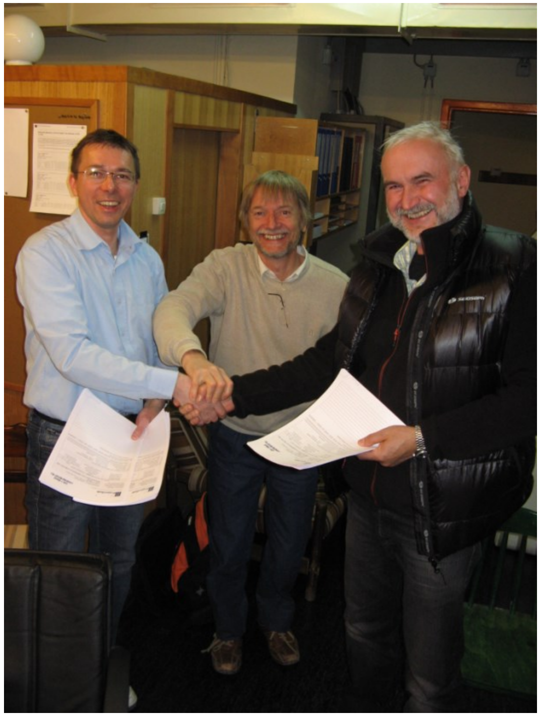
The Danish 1.54 telescope today



- A dedicated photometric telescope.
- Owner: University of Copenhagen (ESO owns the building)
- Operated jointly by NBI and research groups in Czech Republic, with support from ESO

The Danish 1.54 telescope now

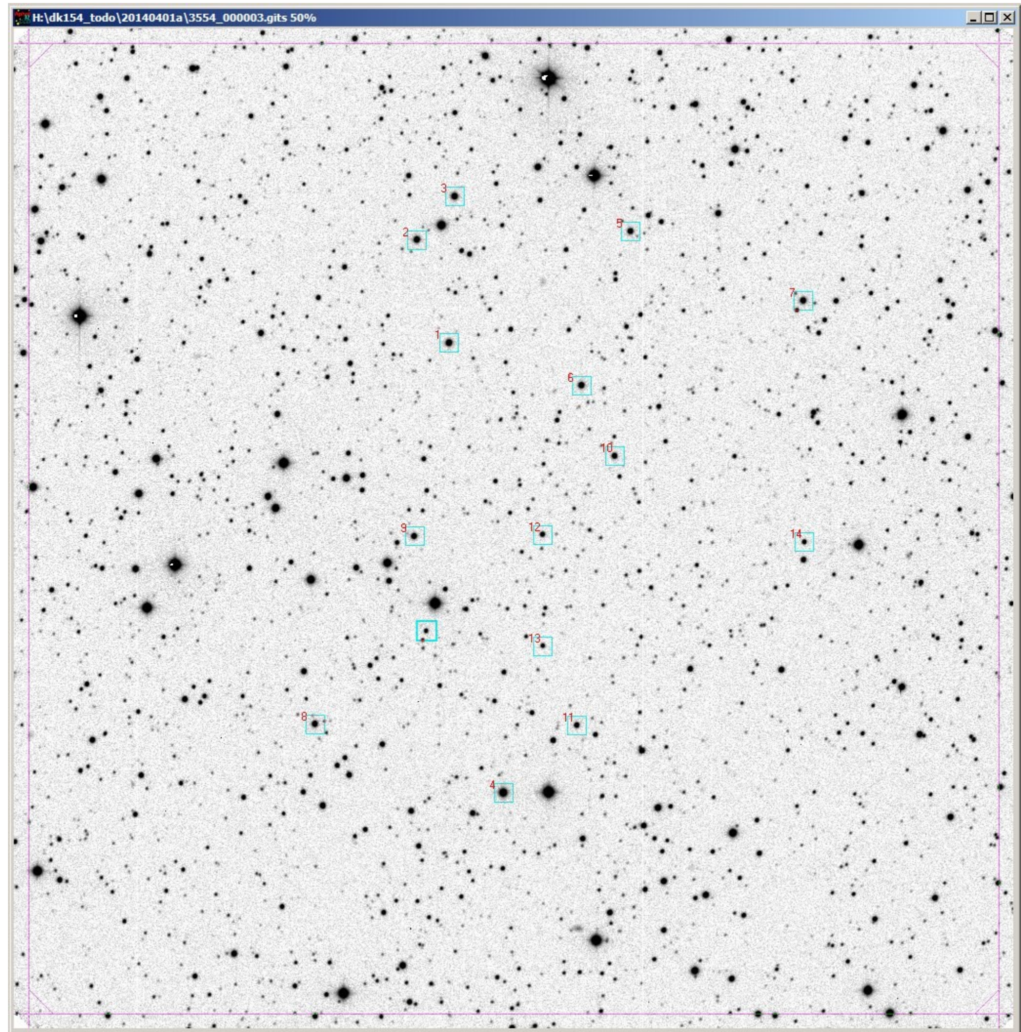
- In 2012 the telescope a new control system was installed
- ProjectSoft from Czech Republic delivered this system
- The upgrade was funded by the Academy of Sciences of the Czech Republic
- As payment, Czech astronomers got access to the telescope half of the year for 6 years (prolonged 3 years)



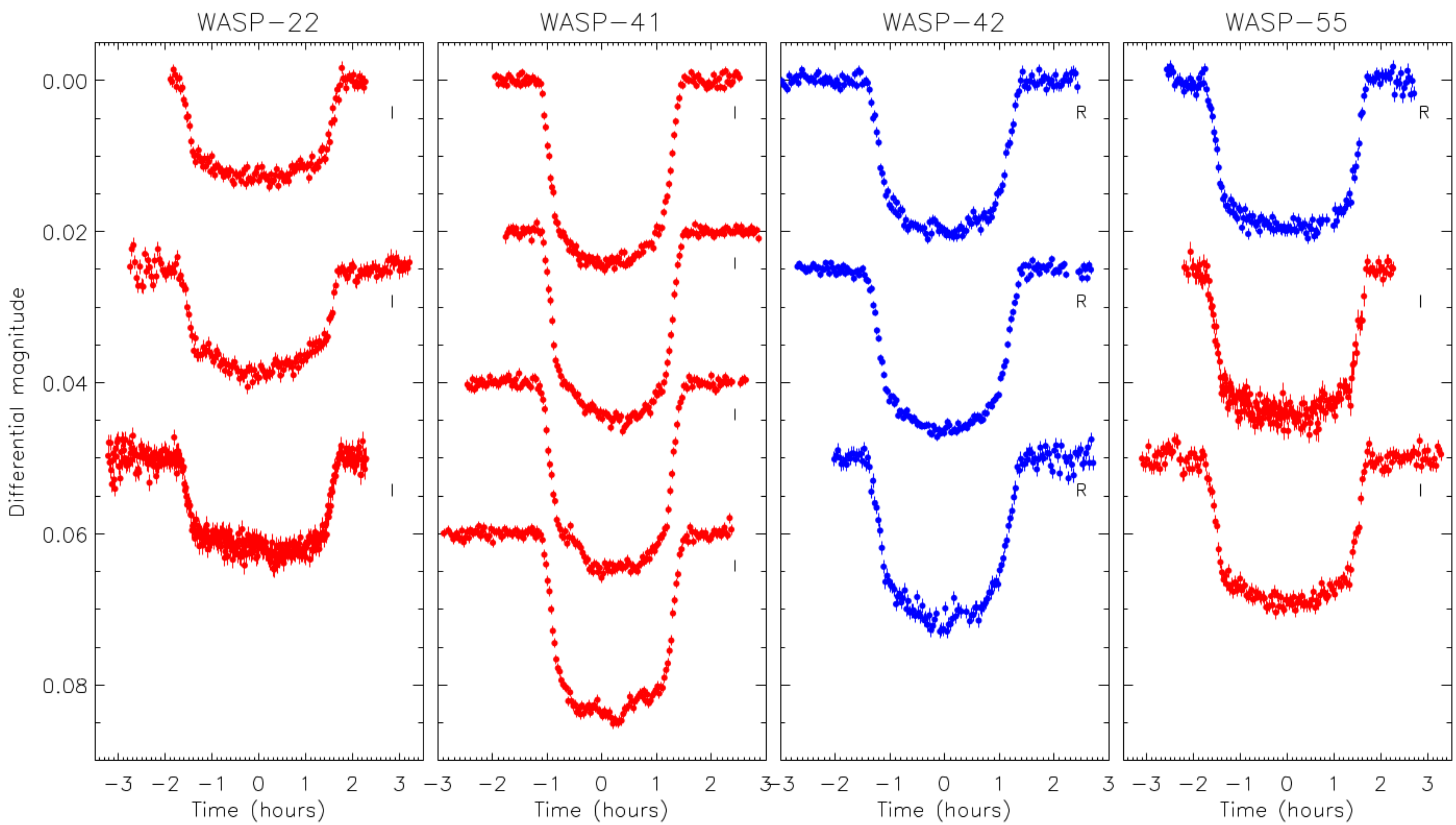
DFOSC imaging

2k deep depletion E2V CCD installed November 2018:

- Field-of-view: 13.7' x 13.7’
- Plate scale 0.39" / pixel
- Gain: 0.25 e^-/ADU
- Dynamical range 19.4 bit
- Linear to ~600,000 ADU
- Readout noise 3.5 e^-
- Full CCD readout time: 22 seconds



DFOSC science example



Southworth et al. 2016

The Danish 1.54 telescope control

- The telescope and instruments are controlled from a control room, just below the telescope itself
- The telescope can also be fully controlled remotely

Telescope Control System (TCS)

- Highly automated
- Safety systems which take care of the telescope and dome in case of:
  - Bad weather
  - Someone going into the dome during observations
  - Loss of remote connection
- The core is based on industrial components and solutions

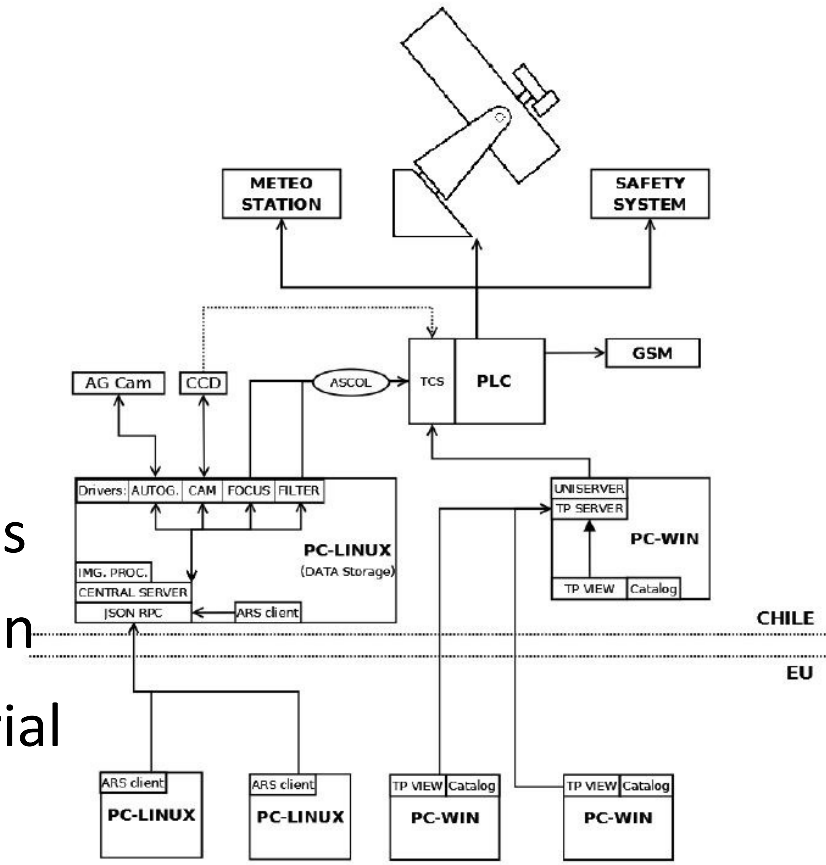
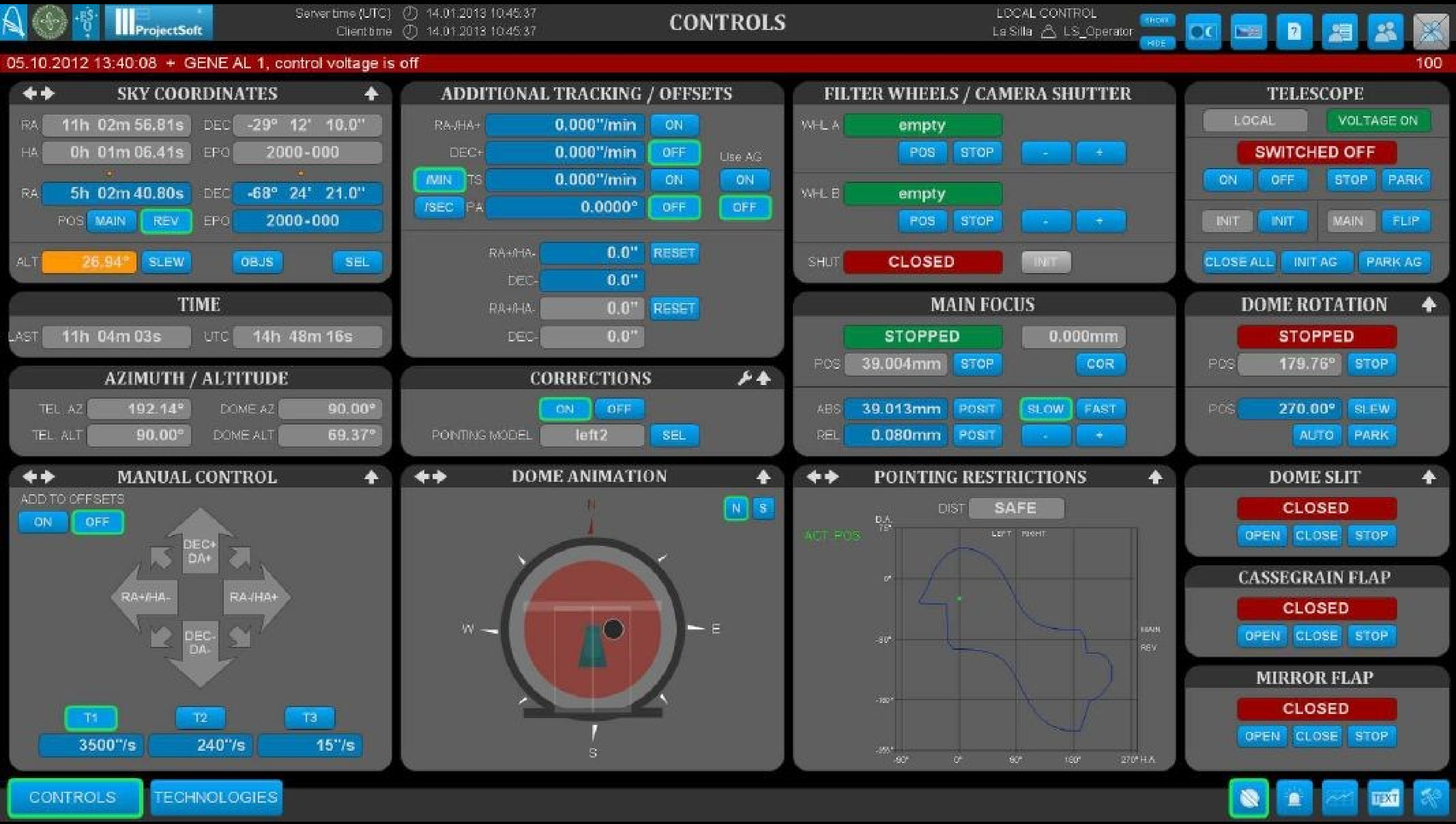
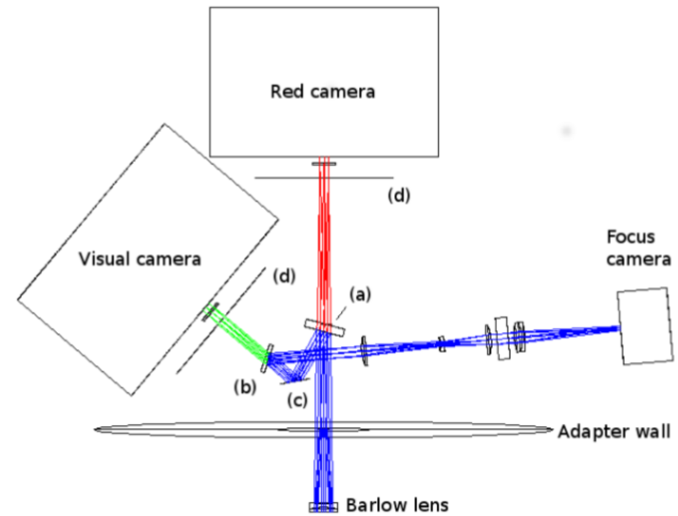


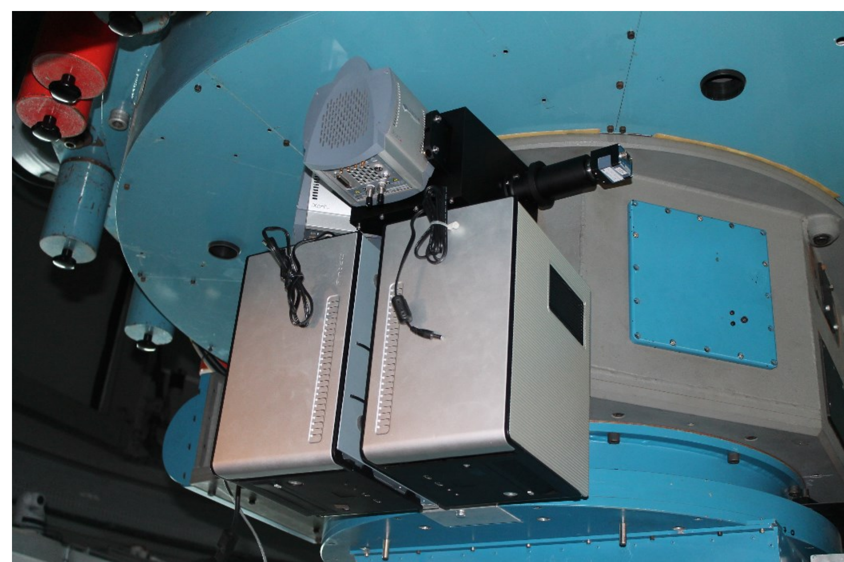
Fig.1: Structure of control and visualization system


ProjectSoft
Server time (UTC) 14.01.2013 10:45:37
Client time 14.01.2013 10:45:37
CONTROLS
LOCAL CONTROL
La Silla LS_Operator
05.10.2012 13:40:08 + GENE AL 1, control voltage is off
100
SKY COORDINATES
RA 11h 02m 56.81s DEC -29° 12' 10.0"
HA 0h 01m 06.41s EPO 2000-000
RA 5h 02m 40.80s DEC -68° 24' 21.0"
POS MAIN REV EPO 2000-000
ALT 26.94° SLEW OBJS SEL
ADDITIONAL TRACKING / OFFSETS
RA/HA+ 0.000"/min ON
DEC+ 0.000"/min OFF
Use AG
/MIN TS 0.000"/min ON ON
/SEC PA 0.0000° OFF OFF
RA+/HA- 0.0" RESET
DEC- 0.0"
RA+/HA- 0.0" RESET
DEC- 0.0"
FILTER WHEELS / CAMERA SHUTTER
WHL A empty
POS STOP - +
WHL B empty
POS STOP - +
SHUT CLOSED INIT
TELESCOPE
LOCAL VOLTAGE ON
SWITCHED OFF
ON OFF STOP PARK
INIT INIT MAIN FLIP
CLOSE ALL INIT AG PARK AG
TIME
LAST 11h 04m 03s UTC 14h 48m 16s
AZIMUTH / ALTITUDE
TEL. AZ 192.14° DOME AZ 90.00°
TEL. ALT 90.00° DOME ALT 69.37°
CORRECTIONS
ON OFF
POINTING MODEL left2 SEL
MAIN FOCUS
STOPPED 0.000mm
POS 39.004mm STOP COR
ABS 39.013mm POSIT SLOW FAST
REL 0.080mm POSIT - +
DOME ROTATION
STOPPED
POS 179.76° STOP
POS 270.00° SLEW
AUTO PARK
MANUAL CONTROL
ADD TO OFFSETS
ON OFF
DEC+ DA+
RA+/HA- RA-/HA+
DEC- DA-
T1 T2 T3
3500"/s 240"/s 15"/s
DOME ANIMATION
N S
N
W E
S
POINTING RESTRICTIONS
DIST SAFE
ACT. POS
D.A.
LEFT RIGHT
MAIN
REV
H.A.
DOME SLIT
CLOSED
OPEN CLOSE STOP
CASSEGRAIN FLAP
CLOSED
OPEN CLOSE STOP
MIRROR FLAP
CLOSED
OPEN CLOSE STOP
CONTROLS TECHNOLOGIES
TEXT

Danish 1.54 instruments: TCI

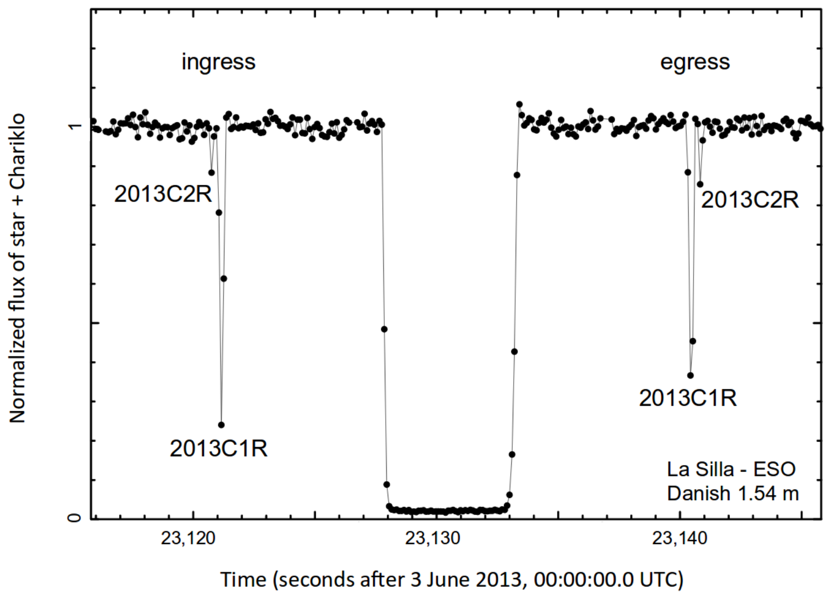
- Two colour imager (TCI): red and visual
- Electron multiplying CCDs (EMCCD)
- Uses Andor iXon +897 cameras
- 512 x 512 pixels
- Field of view 45" x 45"
- High frame-rate: 10Hz





Science with TCI

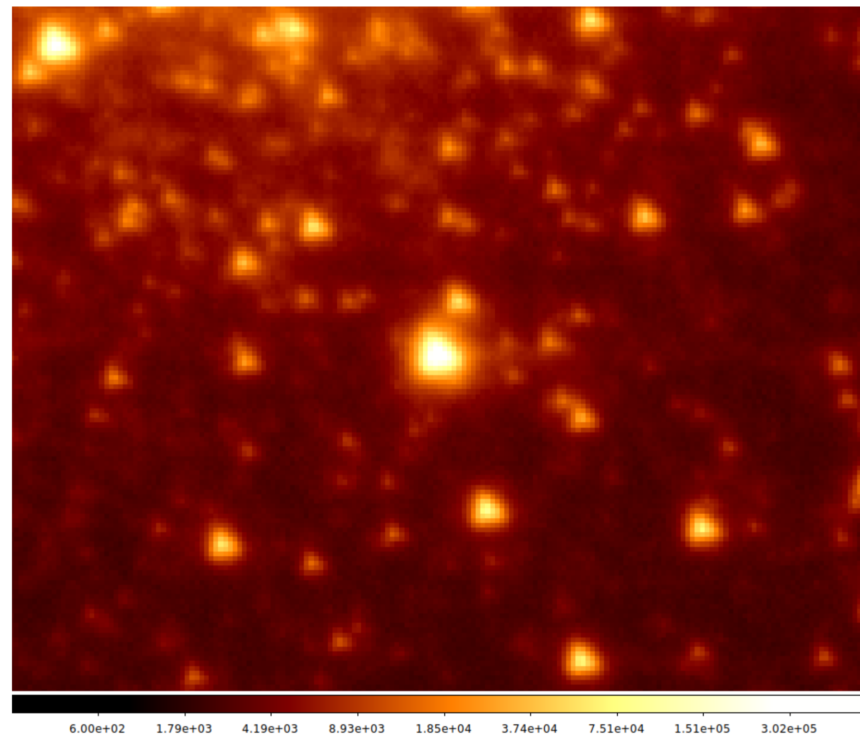
Braga-Ribas et al. 2014



- Asteroid occultations: Chariklo
- The stellar occultation was observed from eight sites in South America
- Observed dips before and after the stellar event: rings!
- Only the data from the TCI at Danish 1.54 show that the ring occultation is resolved into two sub-events, lasting only 0.1 and 0.3 seconds, with a 0.2 second gap.
- The best interpretation of the observations is that Chariklo has two rings: 7km and 3km wide

'Lucky imaging'

- Obtain short (T_exp < 100 msec) exposures
  - For conditions with $D/r_0 < 7$, some frames will be diffraction limited
  - Select best frames, stack
  - Challenge: Detector noise
    - Today: Use EM-CCD
    - Future: CMOS
- Capability to do 'poor mans HST'
  - Only works for moderate sized telescopes on good sites



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Status of D.154m today

- We have a stable telescope with a new control system
  - Dome lifted in 1998, sideports for flushing, very good seeing
- A number of shortcomings:
  - Triangular images, most likely ‘by design’ of M2 unit
  - Spherical aberration (matching error)
  - Declination drive hysteresis (roller wearing down sides of wheel)
    - These three issues will be investigated during our servicing mission this and next week
- Using DFOSC as a focal reducer is not optimal today
  - Lower throughput, coarse pixel scale
  - Thinking of replacement

The future

- Installing E2V CIS120 based CMOS camera in 2019 (mechanical/optical interface this week)
  - 2k x 2k detector, FoV – 2.7’ x 2.7’
  - Read noise: 4e– (not suited for faint objects)
  - Test bed for future camera, use for microlensing of bulge stars in Baade’s window
- Looking at fixing aberration problems
- Installing a large format CMOS camera
  - 12k x 12k back side illuminated sub-electron noise detectors appears to be realistic (E2V claim)
- This is the way to go when HST is no longer!