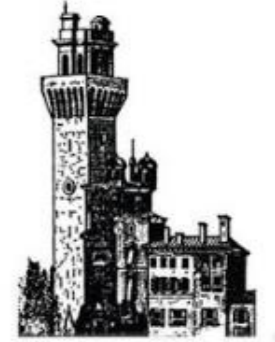




ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

OSSERVATORIO ASTRONOMIC DI PADOVA



Robotic Schmidt & RoboCop

low-cost robotisation projects for the Schmidt 67/92 and Copernico 1.82m telescopes
Asiago, Mount Ekar

L. Tomasella, E. Cappellaro, S. Benetti, D. Fantinel
(INAF OAPd)

T. Forte, A. Frigo, L. Lessio, M. Mosele, D. Selvestrel, L. Traverso
(technical Staff, INAF Asiago-Ekar/Padova)

M. Fiaschi - MFC Elettronica
(external company)



Lina Tomasella 28.02.2024

Mount Ekar, Asiago

Long: 11° 34' 08.397" E - Lat: 45° 50' 54.894" N - Altitude: 1376.2m



Mount Ekar, Asiago

Long: 11° 34' 08.397" E - Lat: 45° 50' 54.894" N - Altitude: 1376.2m

Copernico 1.82m (1973):

photometry and spectroscopy

Afosc (FoV=8.8 x 8.8 arcmin, uBVgriz and narrow-band filters; grisms R=200-5000);

Echelle (R~20,000);

Proprietary instruments.

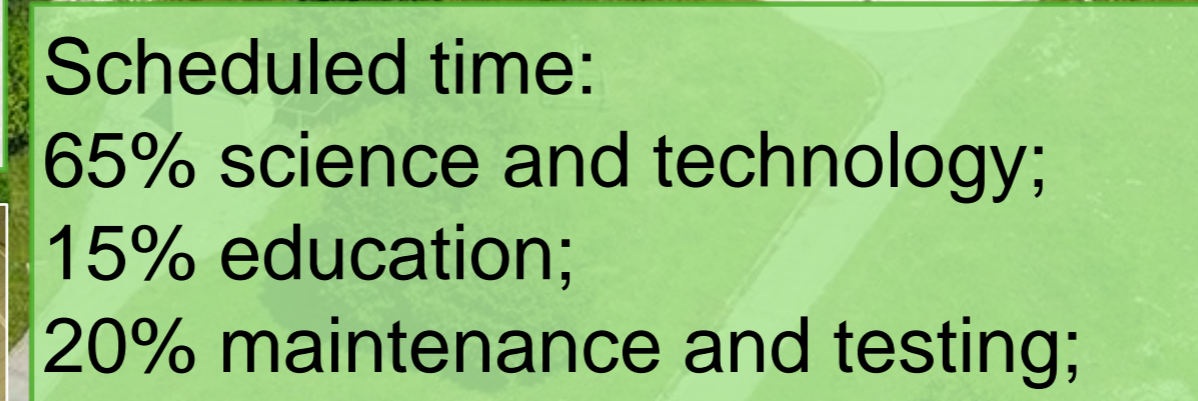
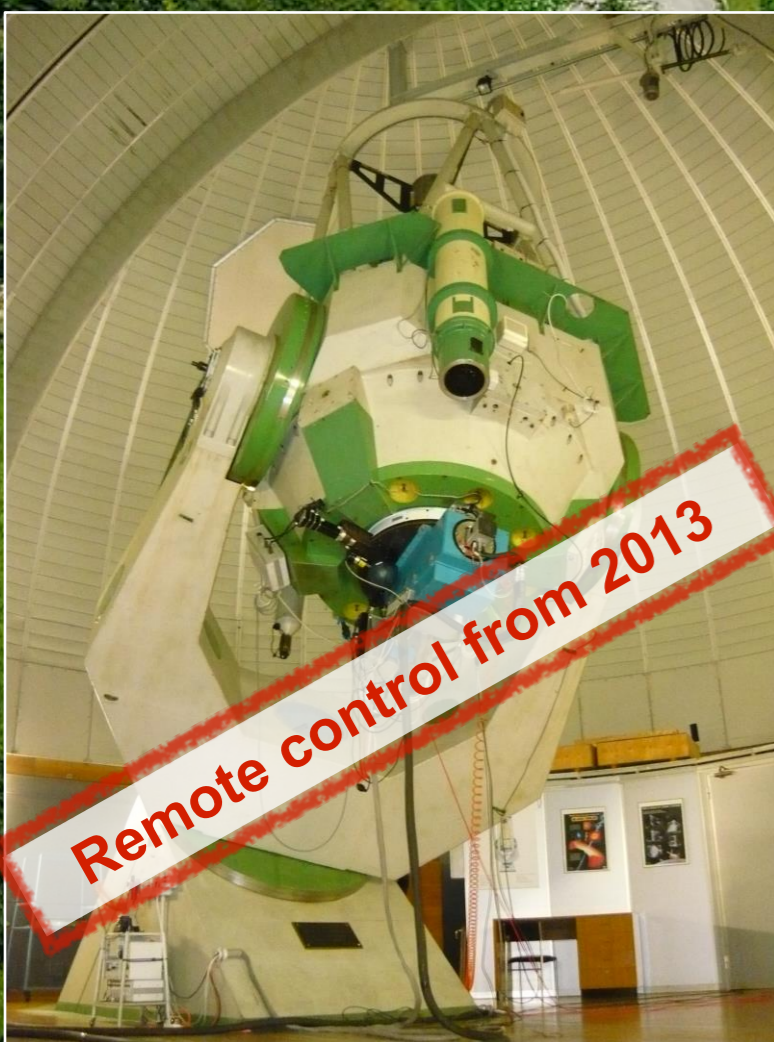
Remote control from 2013; now upgrading to robotic.

Schmidt 67/92 (1967):

uBVgri photometry, FOV~1 deg².

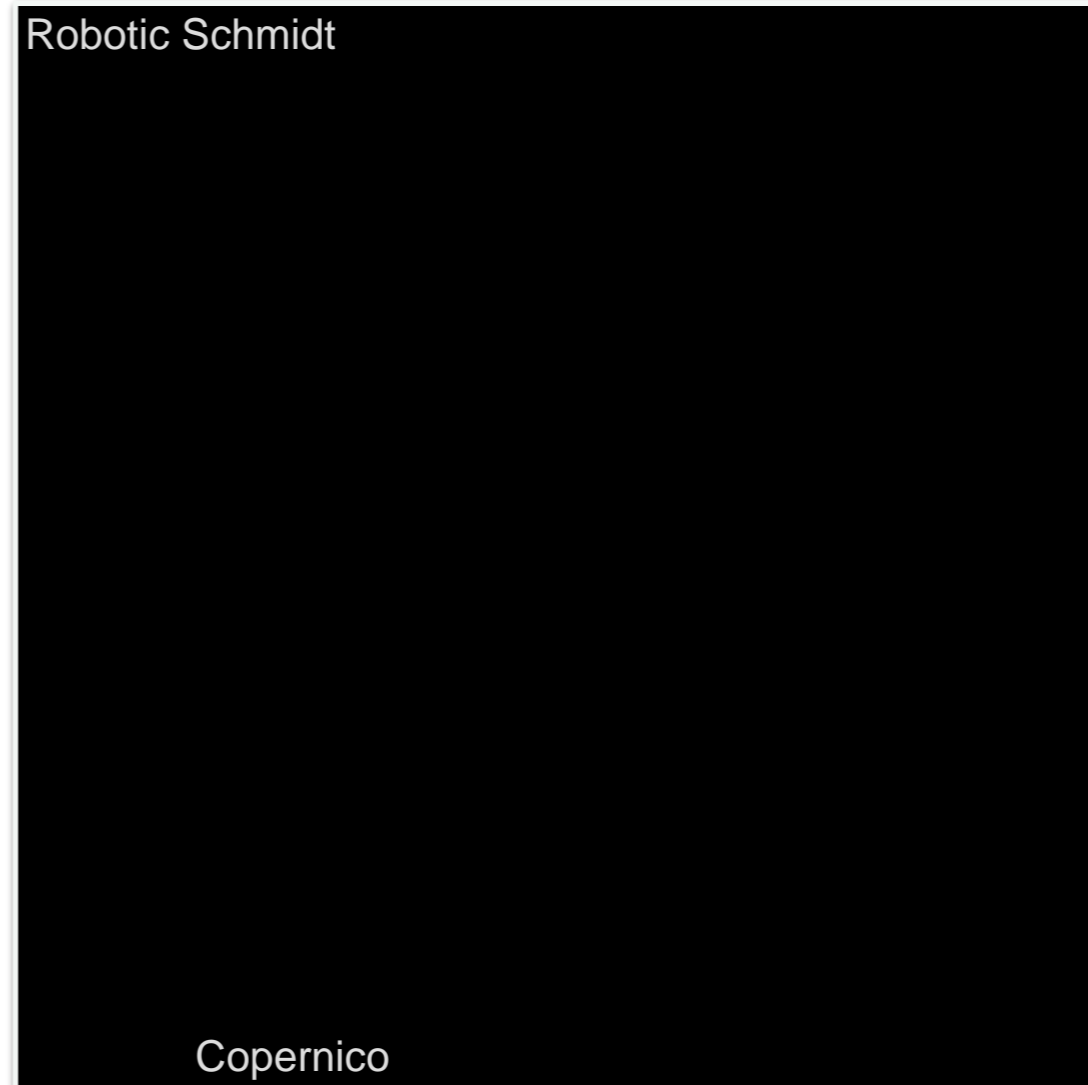
No human presence during night-time: robotic control.

Scheduled time:
65% science and technology;
15% education;
20% maintenance and testing;



Brief history of Schmidt 67/92


- Built in 1965, inaugurated in 1967
- Photographic plates and films till 1998 (FoV=5.1 × 5.1deg)
- Dec. 2000 - Mar. 2002: ADAS Asiago-DLR Asteroid Survey project, using a front illuminated Loral chip (FoV=49' × 49')
- [... close ...]
- 2009: the telescope is refurbished, mainly for outreach, and equipped with SBIG STL-11000MC2 (FoV=58' × 38')
- 2017: remote control achieved; purchase of a Moravian CCD camera with a KAF-16803 detector (FoV=59' × 59')
- **2020: Robotic Schmidt achieved!**



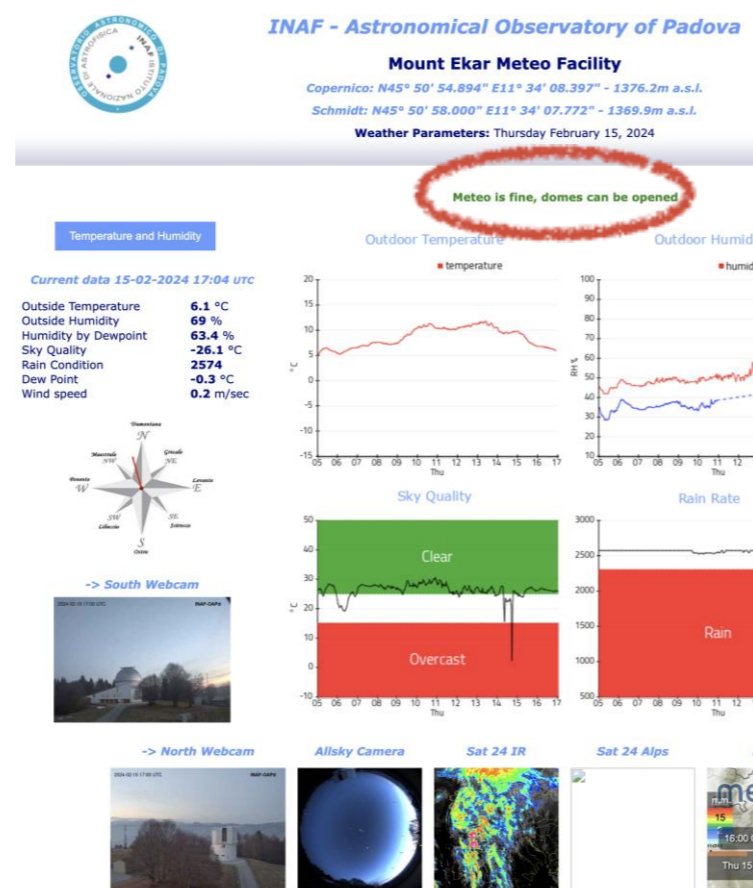
The Schmidt 67/92 Robotic Telescope
RoboSchmidt - User Manual
ver. 2.0 (Feb 2023)
L. Tomasella, E. Cappellaro, S. Benetti

NB: It is mandatory that publications based on Ekar-Asiago proprietary or archive observations include a footnote on the first page of the article or in the Acknowledgments section the following citation:

“Based on observations collected at the Copernico 1.82m telescope [or/and Schmidt 67/9 telescope] (Asiago, Italy) - INAF Osservatorio Astronomico di Padova.”



M51@RoboSchmidt, by Giovanni Benetti



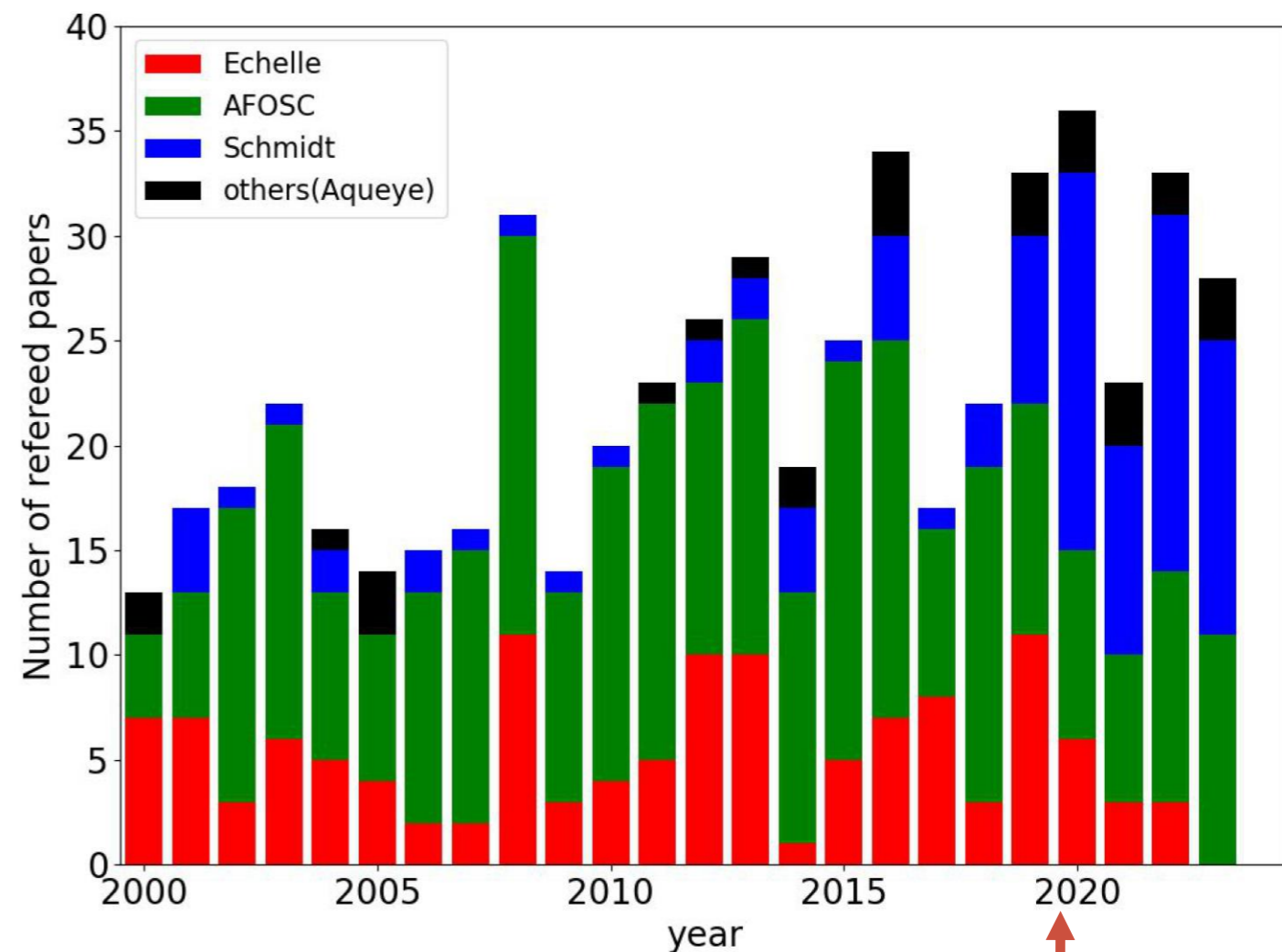
Observing night 13 Feb 2024: the dome of the Schmidt telescope is opened/closed under the robotic control of the weather stations.

Robotic Schmidt: the efficiency leap

Last 4 years: **30-37 refereed papers per year** using data from Asiago-Ekar (several dozens of non refereed communications, AstroNote, Atel, GCN, etc per year); around **16-18 papers using Schmidt data**.

year	number of fits files in archive
2023	32150
2022	56271
2021	46612
2020	29984
2019	9274
2018	12353
2017	12732

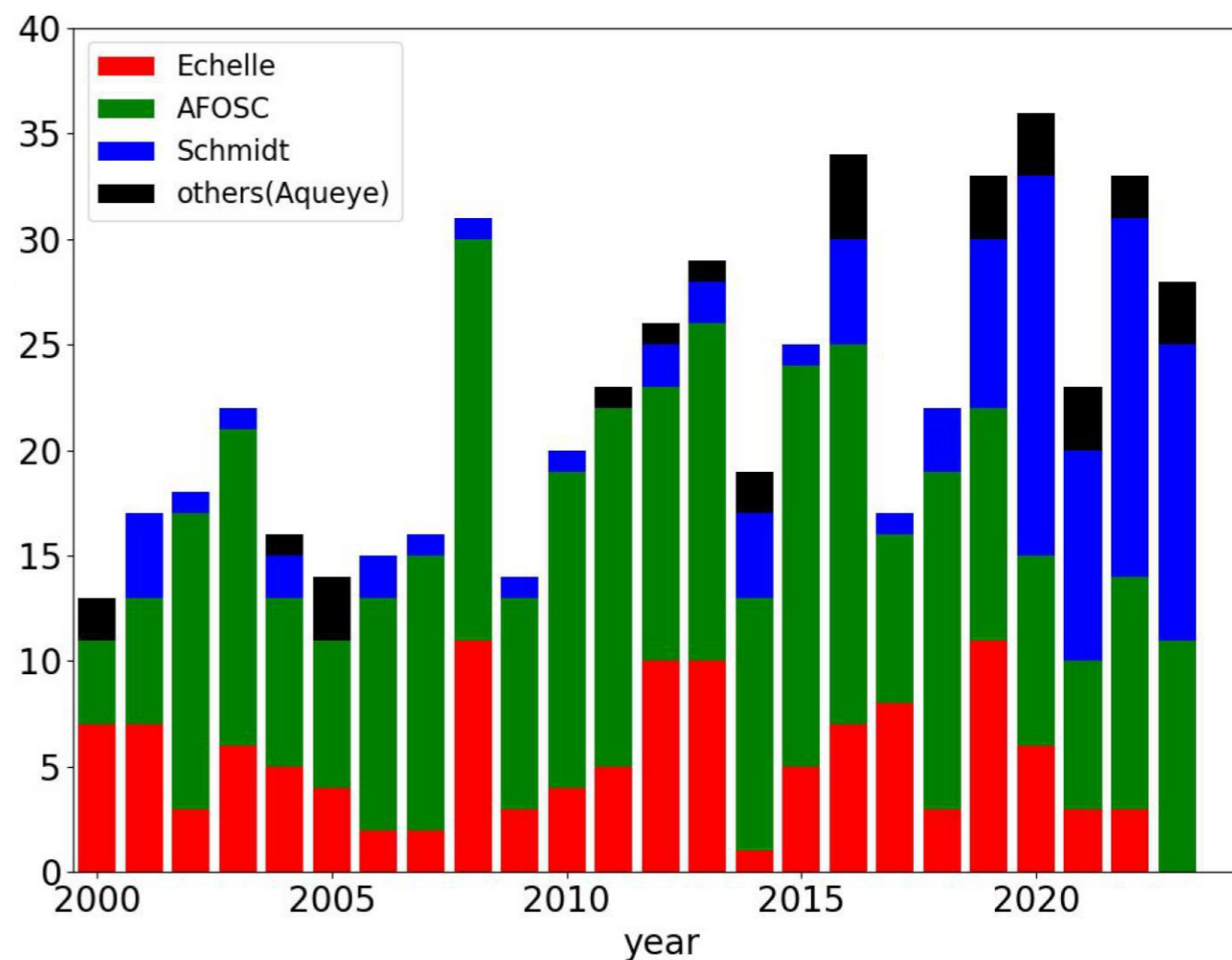
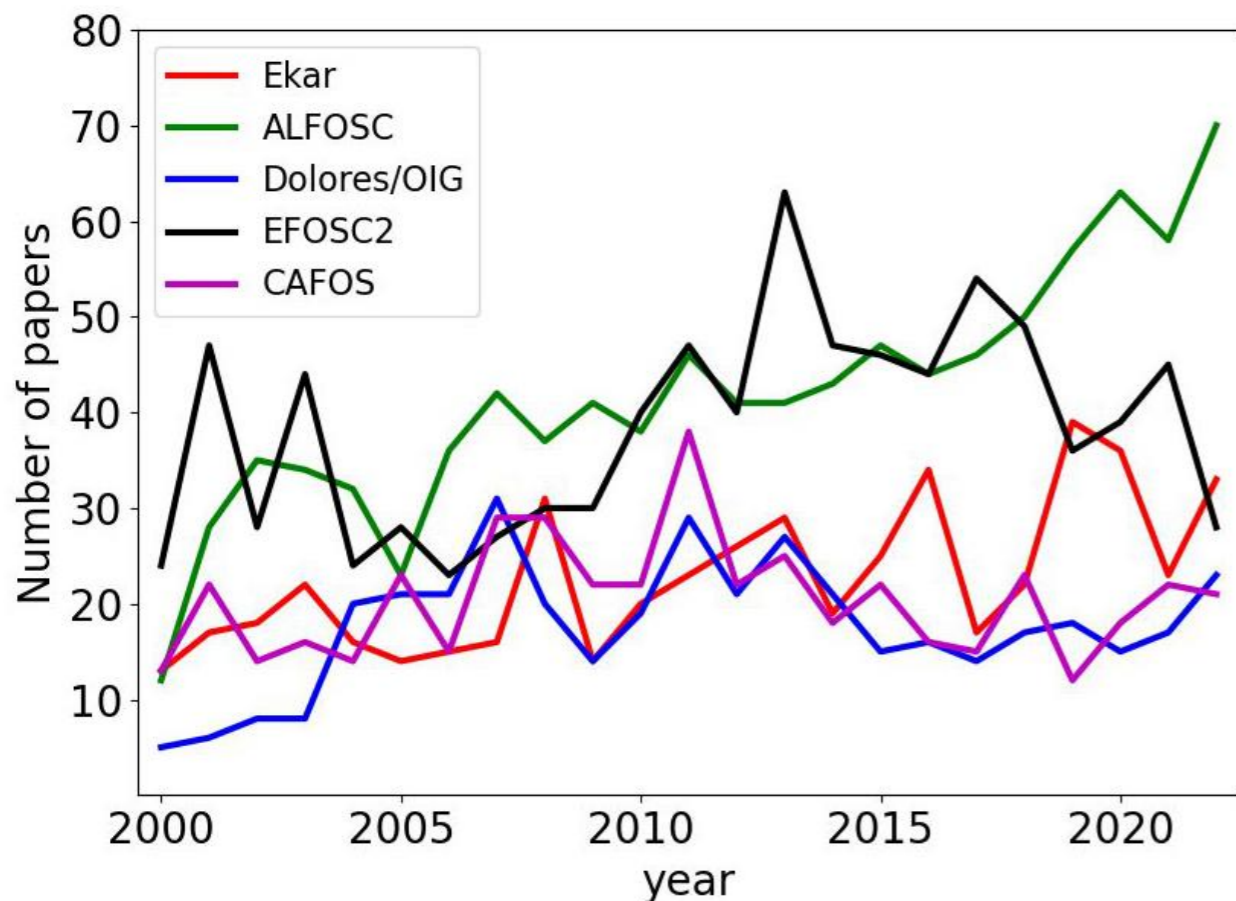
Robotic Schmidt



The efficiency has increased **at least by a factor of three** in the volume of collected data, even more considering their scientific use.

Robotic Schmidt: the efficiency leap

Last 4 years: **30-37 refereed papers per year** using data from Asiago-Ekar (several dozens of non refereed communications, AstroNote, Atel, GCN, etc per year); around **16-18 papers using Schmidt data**.



Robotic Schmidt vs Remote Copernico

statistics for February 2023

Open-dome (nautical twilight-dawn):

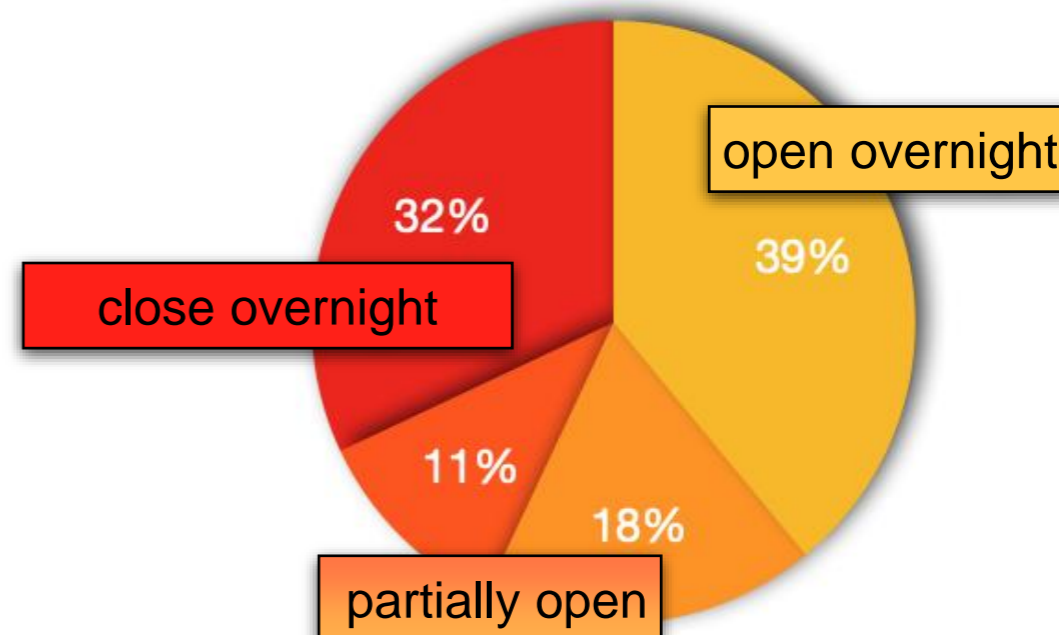
- Robotic Schmidt: **182 h**
 - Remote Copernico: **165 h**
- RSch/RemoteCop ratio = 1.1

Open-shutter (Σ exptime fits from archive):

- Robotic Schmidt: **114 h**
 - Remote Copernico: **89 h**
- RSch/RemoteCop ratio = 1.3

Copernico telescope % open-close dome for meteo:

● totally open dome
 ● partially (50-89%)
 ● partially (10-49%)
 ● close dome



Why Robotic Schmidt is successful:

- better use of (even small) fraction of clear sky;
- reduction of telescope overheads.

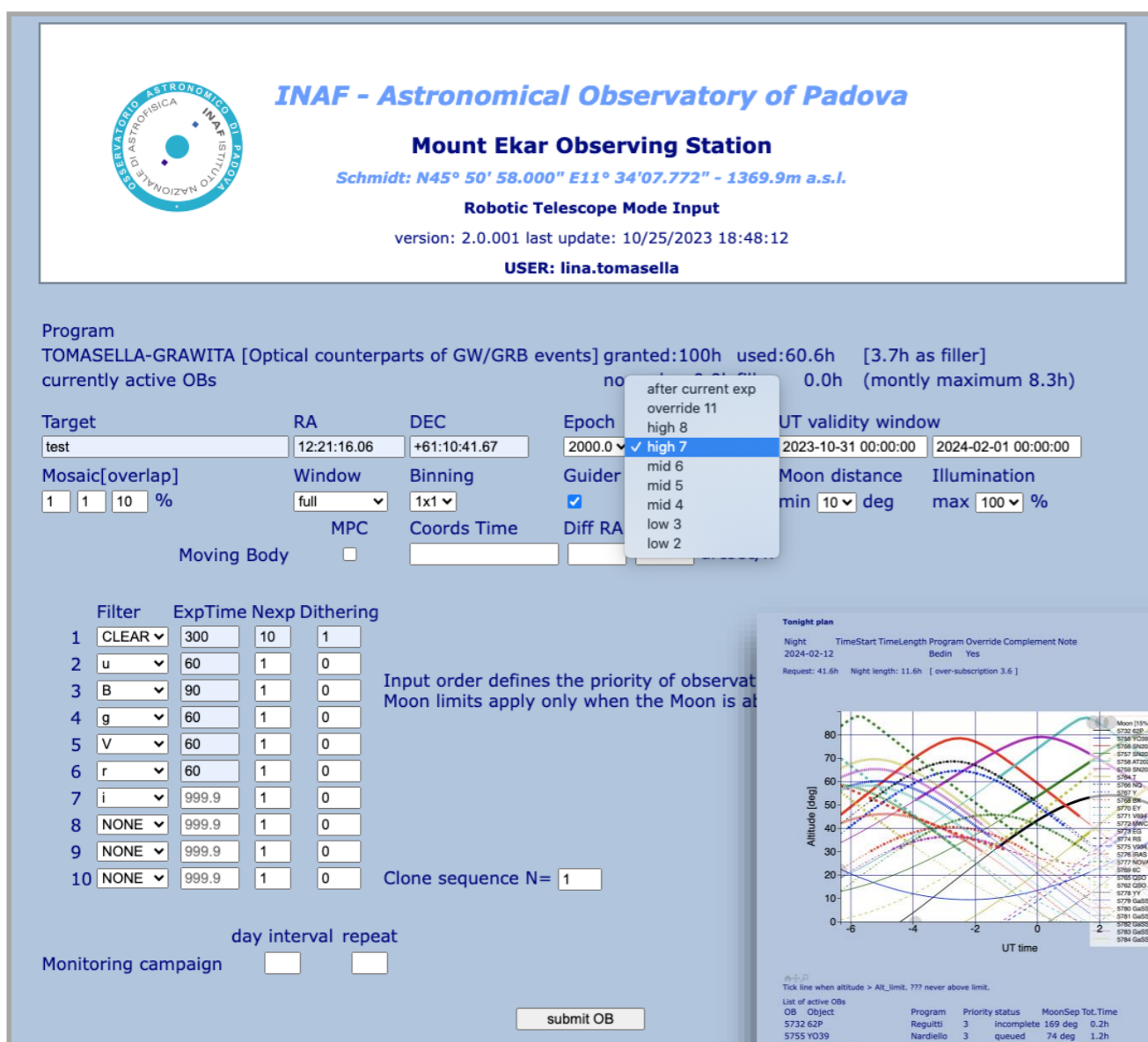
Robotisation in a nutshell

web pages for users (by E. Cappellaro):

telescope control (by MFC - M. Fiaschi):

- authorised users can insert the Observing Block **OB**.
- the OB are stored in a **Data Base DB**.
- the executed OB is deactivated (an email is sent to the program's PI and telescope managers).
- the incomplete/not executed OB remains in a queue.

- check of weather stations for dome open/close.
- check the **DB** once per minute.
- choice of the OB with higher priority; check the temporal observability of the OB (**scheduler**).
- focusing, choice of the guiding star, start observation.



INAF - Astronomical Observatory of Padova

Mount Ekar Observing Station
 Schmidt: N45° 50' 58.000" E11° 34' 07.772" - 1369.9m a.s.l.

Robotic Telescope Mode Input
 version: 2.0.001 last update: 10/25/2023 18:48:12
 USER: lina.tomasella

Program
 TOMASELLA-GRAWITA [Optical counterparts of GW/GRB events] granted:100h used:60.6h [3.7h as filler]
 currently active OBs no 0.0h (monthly maximum 8.3h)

Target test RA 12:21:16.06 DEC +61:10:41.67 Epoch 2000.0 UT validity window 2023-10-31 00:00:00 2024-02-01 00:00:00

Mosaic[overlap] 1 1 10 % Window full Binning 1x1 Guider [checked] Moon distance min 10 deg Illumination max 100 %

Moving Body [unchecked]

Filter	ExpTime	Nexp	Dithering
1 CLEAR	300	10	1
2 u	60	1	0
3 B	90	1	0
4 g	60	1	0
5 V	60	1	0
6 r	60	1	0
7 i	999.9	1	0
8 NONE	999.9	1	0
9 NONE	999.9	1	0
10 NONE	999.9	1	0

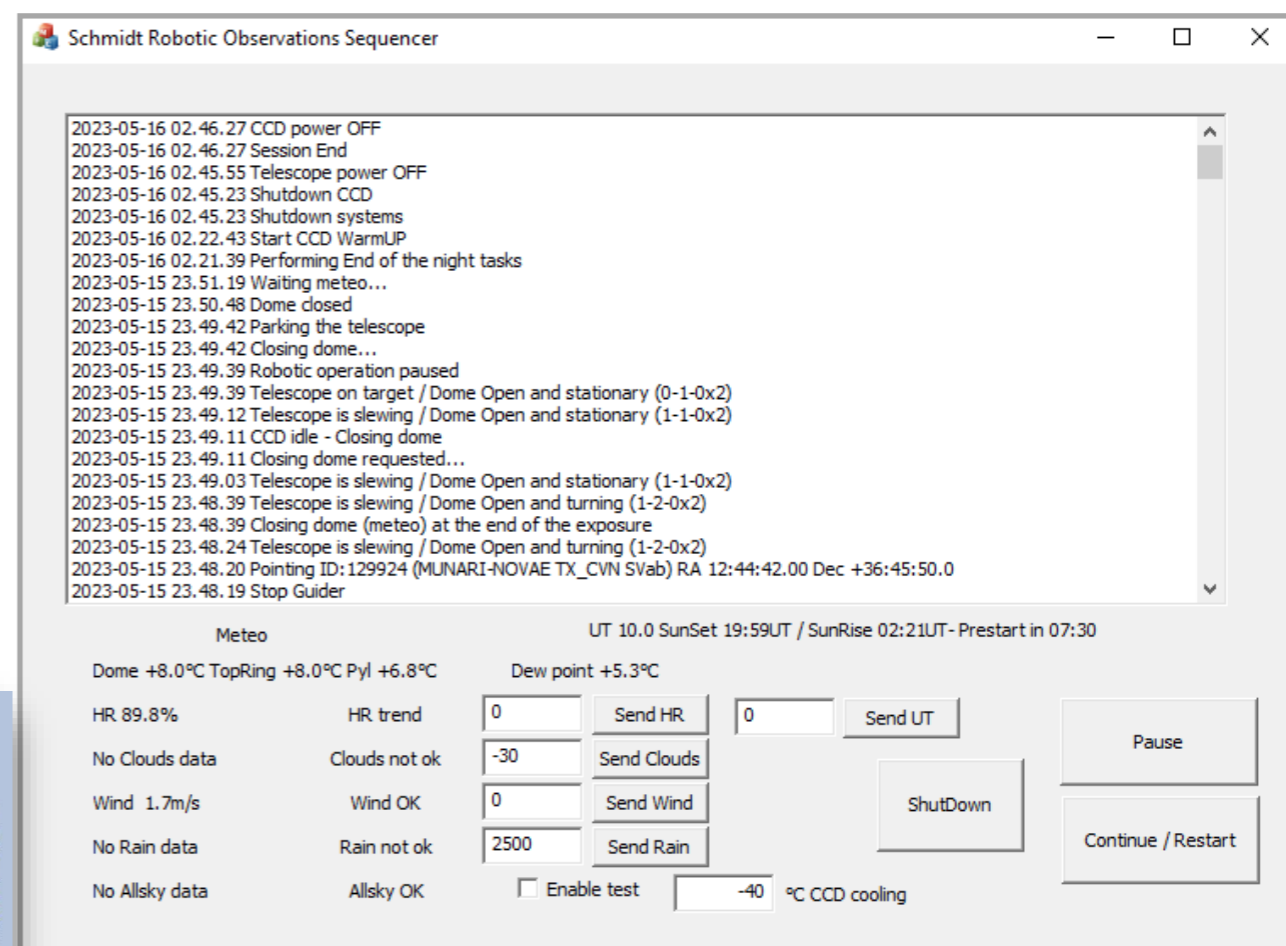
Input order defines the priority of observations
 Moon limits apply only when the Moon is at []

Clone sequence N= 1

day interval repeat [] []

Monitoring campaign [] []

submit OB



Schmidt Robotic Observations Sequencer

2023-05-16 02:46:27 CCD power OFF
 2023-05-16 02:46:27 Session End
 2023-05-16 02:45:55 Telescope power OFF
 2023-05-16 02:45:23 Shutdown CCD
 2023-05-16 02:45:23 Shutdown systems
 2023-05-16 02:22:43 Start CCD WarmUP
 2023-05-16 02:21:39 Performing End of the night tasks
 2023-05-15 23:51:19 Waiting meteo...
 2023-05-15 23:50:48 Dome closed
 2023-05-15 23:49:42 Parking the telescope
 2023-05-15 23:49:42 Closing dome...
 2023-05-15 23:49:39 Robotic operation paused
 2023-05-15 23:49:39 Telescope on target / Dome Open and stationary (0-1-0x2)
 2023-05-15 23:49:12 Telescope is slewing / Dome Open and stationary (1-1-0x2)
 2023-05-15 23:49:11 CCD idle - Closing dome
 2023-05-15 23:49:11 Closing dome requested...
 2023-05-15 23:49:03 Telescope is slewing / Dome Open and stationary (1-1-0x2)
 2023-05-15 23:48:39 Telescope is slewing / Dome Open and turning (1-2-0x2)
 2023-05-15 23:48:39 Closing dome (meteo) at the end of the exposure
 2023-05-15 23:48:24 Telescope is slewing / Dome Open and turning (1-2-0x2)
 2023-05-15 23:48:20 Pointing ID: 129924 (MUNARI-NOVAE TX_CVN SVab) RA 12:44:42.00 Dec +36:45:50.0
 2023-05-15 23:48:19 Stop Guider

Meteo
 Dome +8.0°C TopRing +8.0°C Pyl +6.8°C Dew point +5.3°C
 HR 89.8% HR trend 0 Send HR 0 Send UT
 No Clouds data Clouds not ok -30 Send Clouds
 Wind 1.7m/s Wind OK 0 Send Wind
 No Rain data Rain not ok 2500 Send Rain
 No Allsky data Allsky OK [] Enable test -40 °C CCD cooling

UT 10.0 SunSet 19:59UT / SunRise 02:21UT - Prestart in 07:30

Pause
 ShutDown
 Continue / Restart

Robotisation in a nutshell

Mosaic 3 x 4 deg by Rolly Bedin

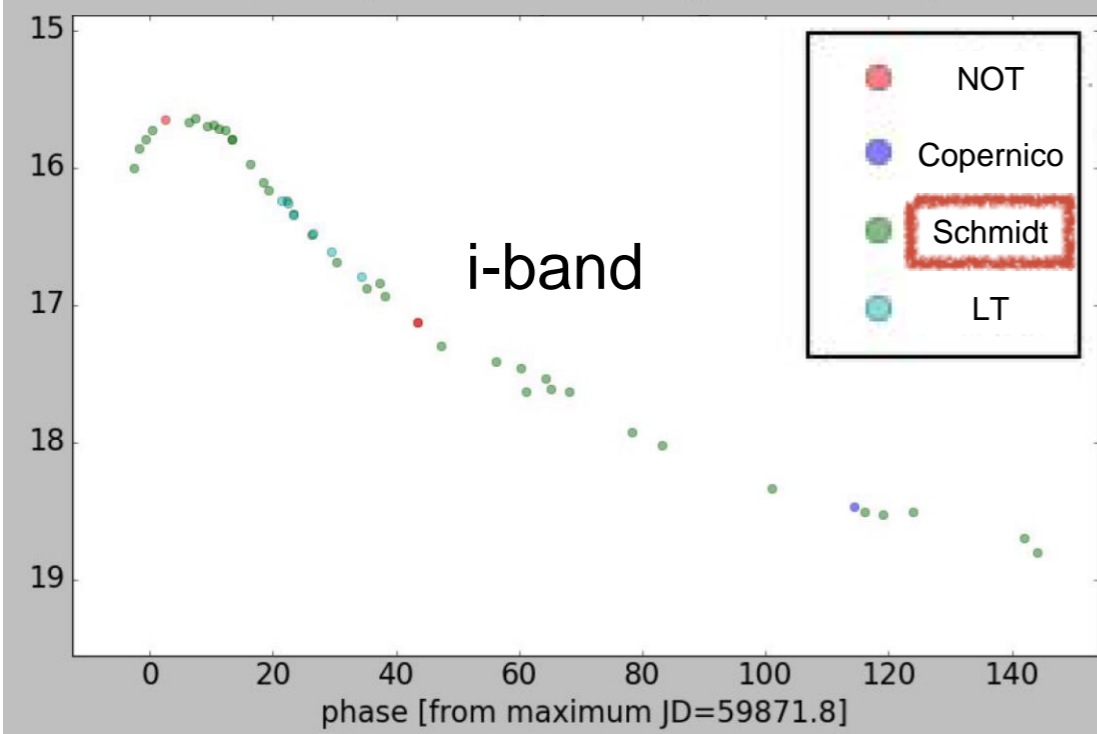
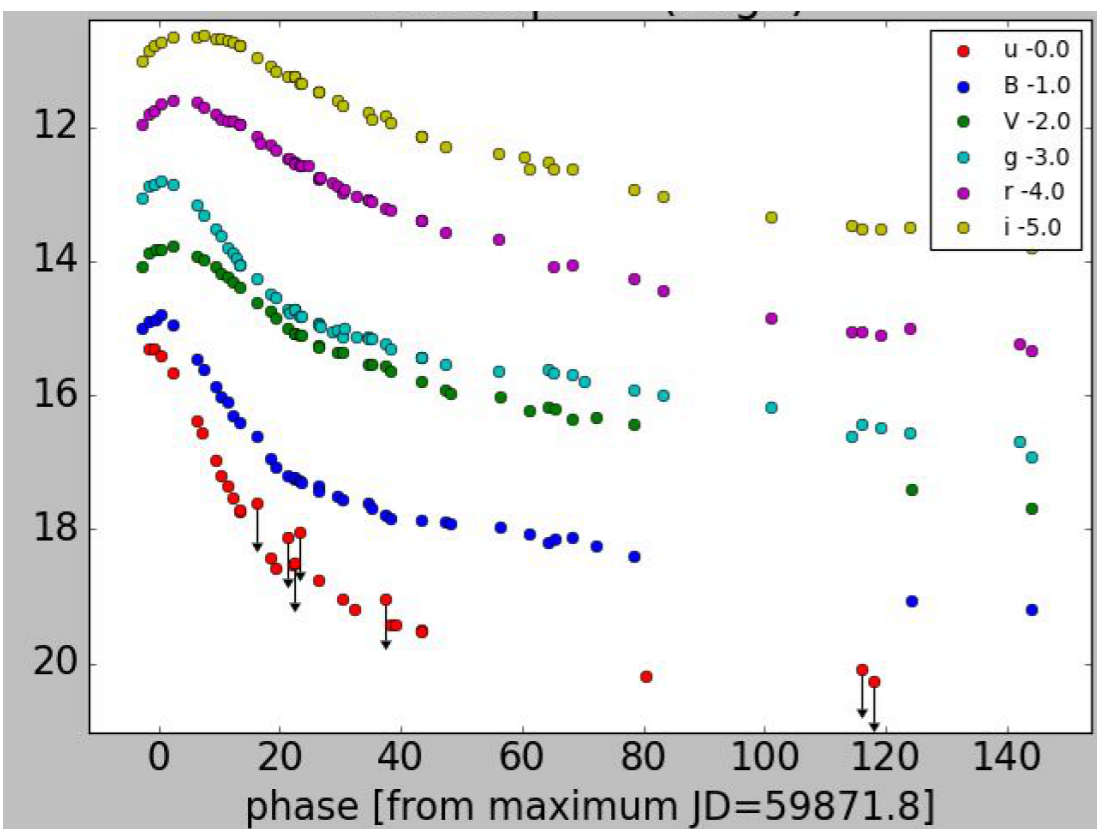


BVr trichrome by Giovanni Benetti



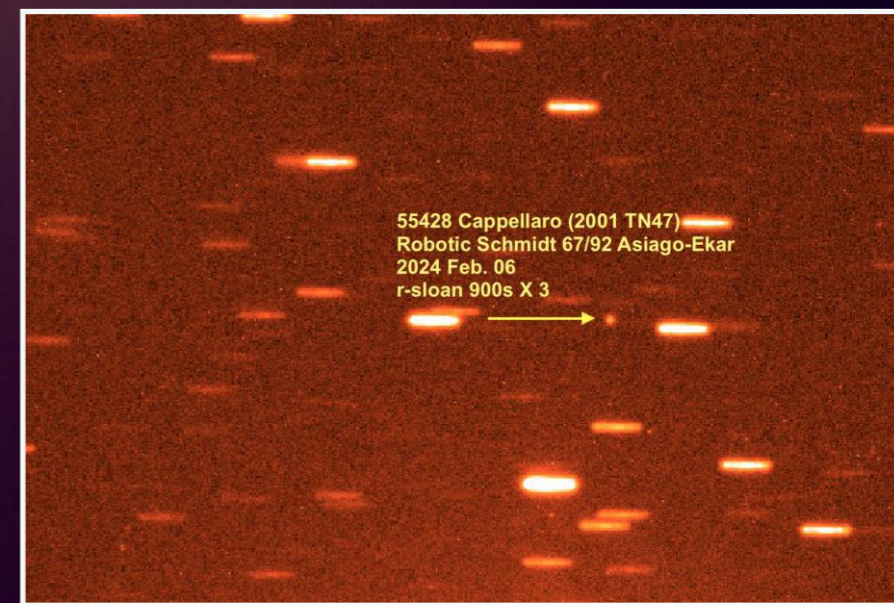
Robotisation in a nutshell

differential tracking on moving objects



SN 2022xlp light curves in a monitoring campaign

comet NeoWise by Giovanni Benetti



Wikipedia list of Robotic Telescopes

List of Robotic Telescopes [edit]

See below for further information on these professional robotic telescopes:

- [TRAPPIST](#), 60 cm, [La Silla](#), Chile.
- [T80S](#), 80 cm, [Tololo](#), Chile.
- [Super-LOTIS](#), 60 cm, [Steward Observatory](#) on [Kitt Peak](#), Arizona, USA.
- [Liverpool Telescope](#) (robotic telescope), 2.0 m, on [La Palma](#), [Canary Islands](#)
 - [Faulkes Telescope North](#), 2.0 m, [Haleakala Observatory](#), Hawaii
 - [Faulkes Telescope South](#), [Siding Spring Observatory](#), New South Wales, Australia
 - [RoboNet](#), multiple locations
- [Lick Observatory](#) on [Mount Hamilton](#), California, USA.
 - [Automated Planet Finder](#), 2.4 m,
 - [Katzman Automatic Imaging Telescope](#), 76 cm
- [Slooh](#) telescopes, various sizes & locations.
- [Rapid Eye Mount telescope](#), 60 cm, [La Silla](#), Chile
- [TAROT-South robotic observatory](#), 25 cm, [La Silla](#), Chile
- [Bradford Robotic Telescope](#), 35.5 cm, [Teide Observatory](#), Canary Islands
- [Warner and Swasey Observatory#Nassau Station Robotic Observatory](#), 91 cm, Warner and Swasey Observatory, Ohio, USA
- [Observatorio Astronómico de La Sagra](#), 3x 45 cm, Granada, Spain
- [ROTSE-IIIb](#), 45 cm, [McDonald Observatory](#), Texas, USA
- [GROWTH](#), 70 cm,
- [Indian Astronomical Observatory](#), Ladakh, India
- [MASTER](#) network of small rapid-response robotic telescopes
- [Thailand NARIT Thai Robotic Telescope](#), National Astronomical Research Institute of Thailand (Public Organization) Thailand.
- [RAPTOR \(telescope\)](#), Fenton Hill
- [Milutin Milanković](#), 140 cm, [Belgrade Observatory](#), Astronomical Station of Vidojevica, Mount Vidojevica, Serbia.



Liverpool Telescope Logo

The RCS has a rapid-response capability where it will often automatically interrupt regular observations to slew (shift) to observe short-lived events with higher priority, such as [gamma-ray bursts](#).

The LT is one of the largest robotic telescopes in the world^[3] and was built by a subsidiary^[6] set up by [Liverpool John Moores University](#) who own and masterminded it. It is operated (maintained) by the [Astrophysics Research Institute](#), partly funded by the UK's [STFC](#). It is at the [Roque de los Muchachos Observatory](#) on [La Palma](#).

Faulkes Telescope North

[Article](#) [Talk](#)

From Wikipedia, the free encyclopedia

The **Faulkes Telescope North** is a clone of the [Liverpool Telescope](#), and is located at [Haleakala Observatory](#) in the U.S. state of [Hawaii](#). It is a 2 m (79 in) f/10 [Ritchey-Chrétien](#) telescope.

The telescope is owned and operated by [LCOGT](#). This telescope and its sister telescope [Faulkes Telescope South](#) are used by research and education groups around the globe. The [Faulkes Telescope Project](#) is one such group which provides observing time (awarded by LCOGT) for education projects for UK schools and amateur astronomers.

Faulkes Telescope South

[Article](#) [Talk](#)

From Wikipedia, the free encyclopedia

The **Faulkes Telescope South** is a clone of the [Liverpool Telescope](#) and is located at [Siding Spring Observatory](#) in New South Wales, Australia. It is a 2 m (79 in) [Ritchey-Chrétien](#) telescope. It was

2-m class (~like Copernico...)

What about Robotic 1.82m Copernico? (imaging and spectroscopy with Afosc ...)

imaging with Afosc > astrometry > **target to-slit** > spectroscopy
(with pointing and tracking precision)



to be sufficiently precise we needed several HW improvements!

(i.e. the resolution of the new encoders is 0.275 arcsec vs 4.36 arcsec of the previous ones)

RoboCop project and INAF Techno Grant 2022

Short Abstract

RoboCop is a low-cost project, aimed at the robotisation of the Copernico 1.82m telescope (Asiago, Mt. Ekar), for obtaining both photometry and spectroscopy (up to mag ~19-21) in fully automatic mode, i.e. without a night-time operator, with the aid of a robotic scheduler. The project is based on the experience we have acquired in the successful robotisation of the Schmidt 67/92 telescope. In the 2 year project, we foresee a number of limited HW and SW upgrades to the Copernico telescope, which is already regularly used remotely, to be implemented while the telescope continue operation. RoboCop can be a valuable experience for the robotisation of other small-to-medium size telescopes still operated manually.

Analytic budget description (numbers in Euro)

Item	Year 2022	Year 2023
N. 2 optical encoders Renishaw (for HA and Dec)	2500	0
Optical strips (2,85m for HA; 0,5m for Dec)	2200	0
N. 3 Brushless engines (400W 60V; for HA and Dec)	1100	0
N. 3 controller iPos4808BX	1900	0
N. 3 power supplies 1kW 48V	1200	0
N. 2 Inverters	800	0
Control interface (for M1, primary mirror)	1800	0
Electronic board for M1 (implementation, installation and configuration)	0	6000
Electronic board for M2 (secondary mirror)	0	6500
Purchase of MTX humidity/temperature sensors	1000	0
TOTAL BUDGET = 25000 Euro		

25k€

#	PI	Titolo	Importo	Punteggio
1	Saracco P.	SHARP - A near-IR multi-mode spectrograph for MAORY@ELT	98000	54,6
2	Sacco G.	Machine Learning for Spectroscopy	89144	53,5
3	Campana R.	Beyond HERMES: toward a multipurpose interplanetary X and gamma-ray spectrometer instrument	100000	53,0
4	Speziali R.	SAMM Versione 2	99180	52,2
5	Basso S.	Nested Optics With Chemical Bonding	100000	52,1
6*	Tomasella L.	RoboCop: a low-cost robotisation project for Copernico 1.82m telescope	13676	49,9

*Proposta finanziata parzialmente a completamento delle risorse allocate

~13,7k€

(not enough ...)

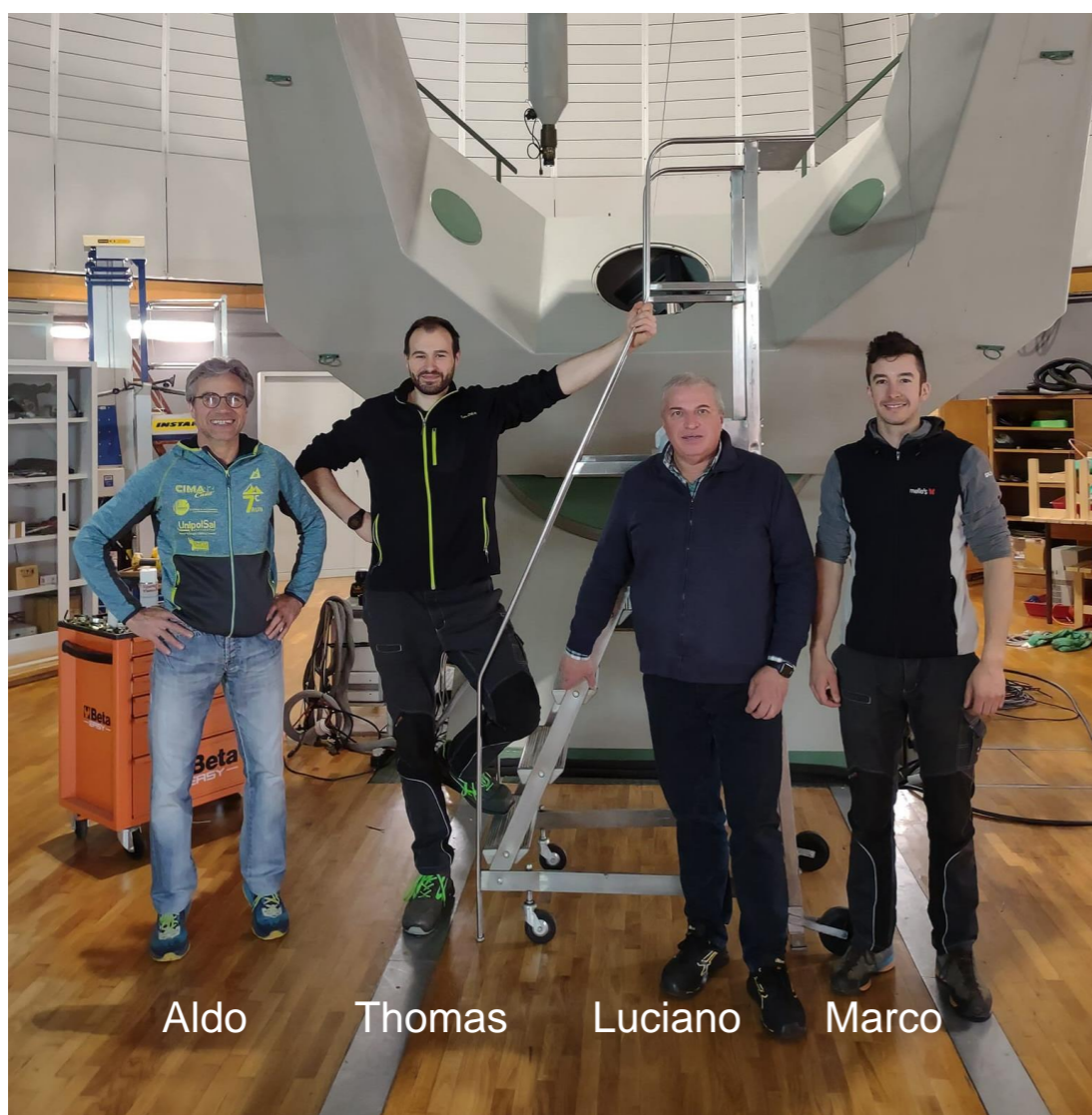
- **co-financed** by INAF OAPd;
- cooperation with **IA2 TS** for the **archive**;
- HW installation by the **technical staff** Asiago-Ekar & Padova;
- Home-made **Robotic SW for the users** by Enrico Cappellaro;
- telescope SW and control by MFC of Marco Fiaschi.

low-cost project thanks to the work of technical and scientific staff!

(... and to the previous home-made experience with the Schmidt ...)

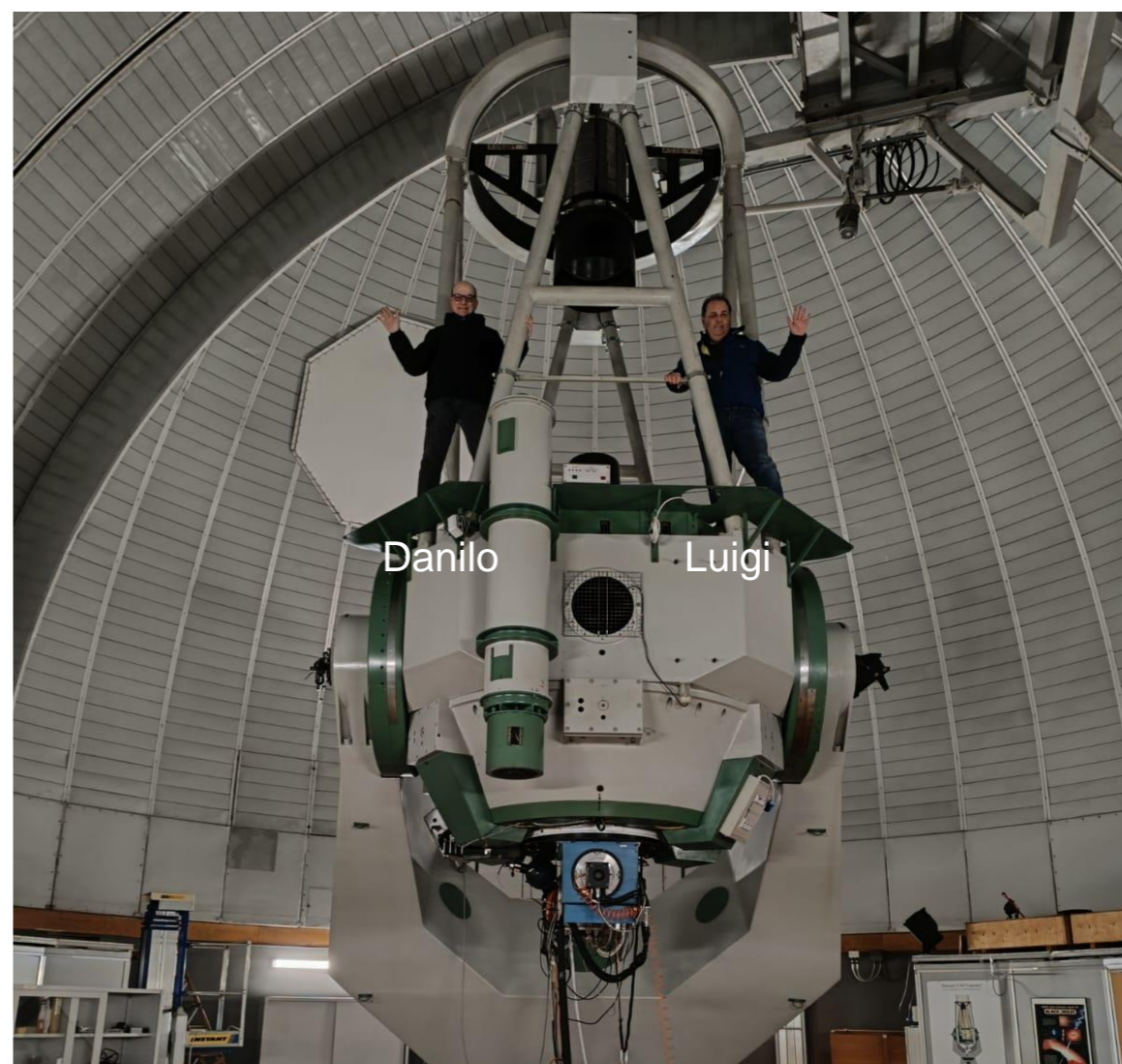
RoboCop project

May - Sept. 2023: the technical staff, in collaboration with MFC, has changed about 80% of telescope&dome HW systems (encoders HA&Dec and in M2 for focusing; brushless motors; CanBus cables; electronics, (redundant) weather stations; webcams ...), in order to reach the required precision for pointing (target to-slit) and tracking and for a robust meteo parameters control.



Aldo Thomas Luciano Marco

technical staff in Asiago-Ekar and from Padova



Danilo Luigi

RoboCop project

Nov 2023 - ongoing: development of the users web interface for OB data entry and scheduler; integration with the telescope control; debugging and overnight testing (commissioning phase).



Mount Ekar Observing Station
Copernico Robotic Input Form
version: 0.0.1 last update: 17/08/23 10:00:00
user: lina.tomasella

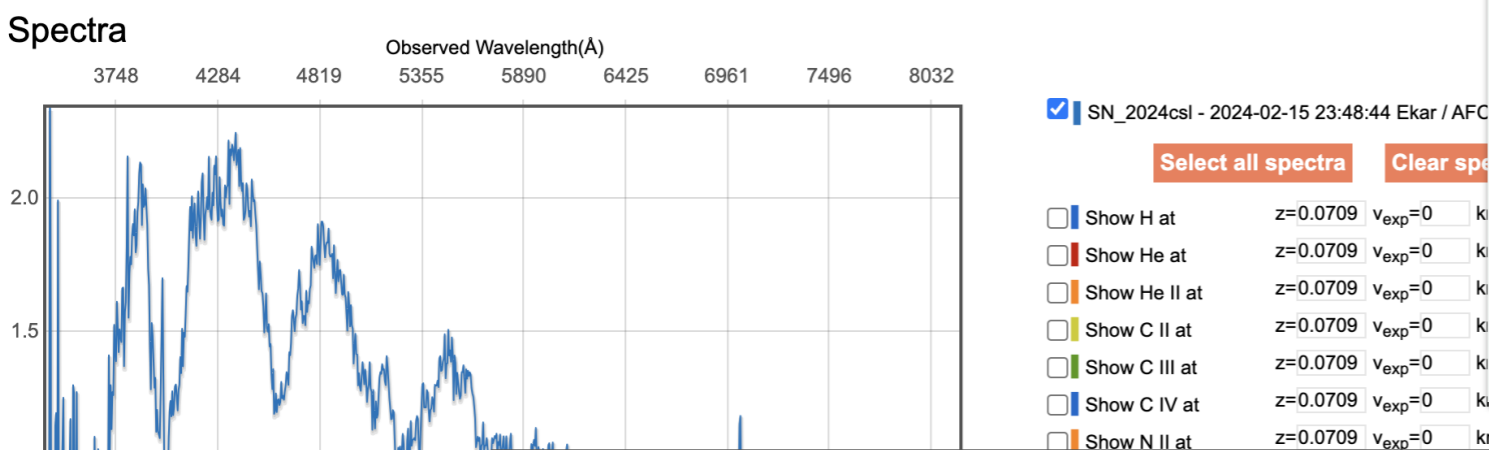
Program: Technical ACTIVE
Obs Time: 2024-02-14 17:00 UT ST 3:24 Sunset 17:43 Sunrise 05:11

Target	RA	DEC	PosA	Alt	ParA		
AT2024cpo	15:08:03.696	27:15:42.84	0	-17	-3	edit	delete

ExpType	Filter	Aperture	Grism	ExpTime	Repeats	Offset	sStatus
Object	NONE	1.69	GR04	2400.0	1	Center	active
Object	u-Sloan	NONE	NONE	90.0	3	NONE	active
Object	g-Sloan	NONE	NONE	60.0	3	NONE	active
Object	r-Sloan	NONE	NONE	60.0	3	NONE	active
Object	i-Sloan	NONE	NONE	60.0	3	NONE	active
Object	z-Sloan	NONE	NONE	90.0	3	NONE	active

NGC891	2:22:33	42:20:48.12	0	79	select	edit	delete	+
Test	2:00:00	45:00:00	0	76	select	edit	delete	+
AT2024bch	10:21:50.208	56:55:36.12	0	30	select	edit	delete	+
test	0:00:00	0:00:00	0	26	select	edit	delete	+

Back to main



The following new AstroNotes were released:

[#2024-55](#)

Released: 2024-02-16 10:24:36
Type: Object/s-Discovery/Classification
Keywords: Supernova, Spectroscopy, Optical

Title: Asiago spectroscopic classification of optical transient with RoboCop (Robotic Copernico Telescope)

Authors: L. Tomasella, E. Cappellaro, S. Benetti (INAF OAPd), T. Forte, A. Frigo, M. Mosele, L. Traverso (technical staff at INAF OAPd, Cima Ekar) and M. Fiaschi (MFC Elettronica)

Abstract: The Asiago Transient Classification Program (Tomasella et al. 2014, AN, 335, 841) reports the spectroscopic observations of AT2024csl as a Type Ia-91T like SN obtained with the Asiago 1.82m Copernico Telescope (+ AFOSC; range 340-820 nm; resolution 1.4 nm). The observations were secured exploiting the new fully robotic telescope operation mode (RoboCop project supported by Techno Grant INAF 2022) currently in phase of commissioning.

[Click here to see the full text](#)

Related Objects: [2024csl](#) [[ZTF24aaejfw](#)]

Select	ID	Obs-date (UT)	Tel / Inst	Exp-Time	Observer/s	Reducer/s	Group	Spectrum ascii file	Spectrum fits file
<input checked="" type="checkbox"/>	16672	2024-02-15 23:48:44	Ekar / AFOSC	2400	RoboCop	Tomasella	Padova-Asiago	tns_2024csl_2024-02-15_23-48-44_Ekar_AFOSC_Padova-Asiago.dat	tns_2024csl_2024-02-15_23-48-44_Ekar_AFOSC_Padova-Asiago.fits

Objectives

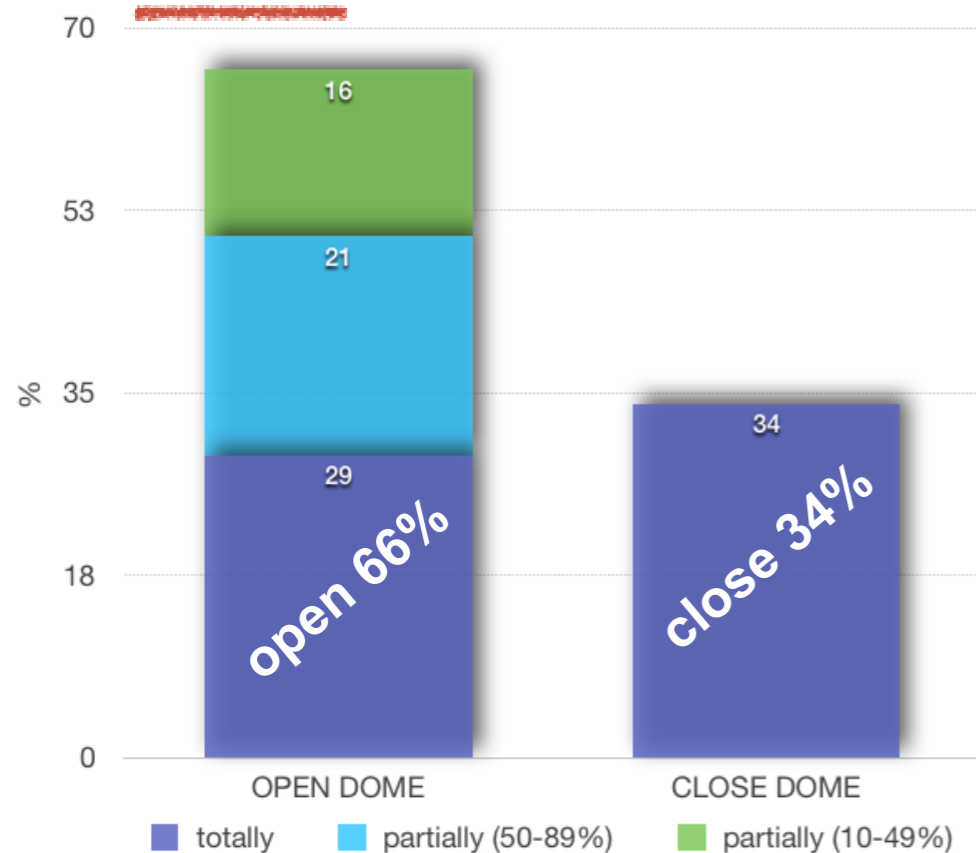
- **simplification** and **optimisation** of the use of the telescopes (no need of specific training and of human presence overnight).
- improving the **ability to quickly respond** to the astronomical multi-messenger triggers (immediate OB submission/execution).
- **maximise the data collection capability** of the telescopes and the scientific productivity (weather monitoring overnight).
- **pilot experience** for low-cost robotisation of small-to-middle size telescopes (know-how acquisition).



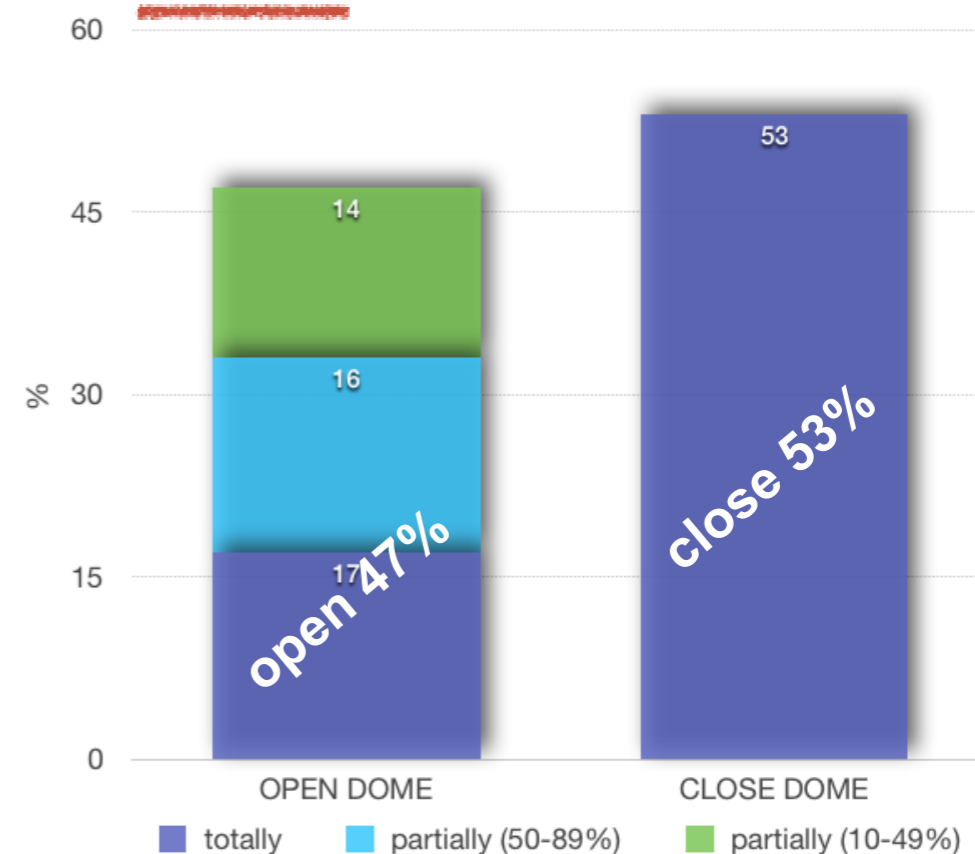
Thanks!

Meteo Ekar

Year 2017 (Jan-Dec from 229 night reports)



Year 2018 (Jan-Dec from 222 night reports)



INAF - Astronomical Observatory of Padova
10:36:55 AM UTC

Mount Ekar Observing Station
Copernico: N45° 50' 54.894" E11° 34' 08.397" - 1376.2m a.s.l.
Schmidt: N45° 50' 58.000" E11° 34' 07.772" - 1369.9m a.s.l.
Weather and Telescope Parameters: Tuesday May 23, 2023

182cm Telescope	Schmidt Telescope	Outdoor: 182cm Balcony	Outdoor: Pylon
Humidity: Dome: 38%	Humidity: Dome: 61%	Measured Humidity: 61%	Measured Humidity: 62%
Temperatures: Dome: 20 °C	Temperatures: Dome: 14.8 °C	Temperature: 18.2 °C	Temperature: 15.2 °C
M1-East: 18 °C	M1: 12.4 °C	Solar Radiation: 871 W/m²	Solar Radiation: 890 W/m²
M1-West: 18.7 °C	Spider: 14.6 °C	Pressure: 863.925 hPa	Pressure: 863.925 hPa
		Wind Direction: 214 °	Wind Direction: 46 °
		Wind Speed: 1.2 m/sec	Wind Speed: 1.6 m/sec
		Dew point: 9.5 °C	Dew point: 7.1 °C

Meteo is fine, domes can be opened

INAF - Astronomical Observatory of Padova
02:02:37 PM UTC

Mount Ekar Observing Station
Copernico: N45° 50' 54.894" E11° 34' 08.397" - 1376.2m a.s.l.
Schmidt: N45° 50' 58.000" E11° 34' 07.772" - 1369.9m a.s.l.
Weather and Telescope Parameters: Tuesday May 23, 2023

182cm Telescope	Schmidt Telescope	Outdoor: 182cm Balcony	Outdoor: Pylon
Humidity: Dome: 33%	Humidity: Dome: 62%	Measured Humidity: 56%	Measured Humidity: 59%
Temperatures: Dome: 20.5 °C	Temperatures: Dome: 15.5 °C	Temperature: 15.9 °C	Temperature: 15.2 °C
M1-East: 18.7 °C	M1: 12.8 °C	Solar Radiation: 105 W/m²	Solar Radiation: 106 W/m²
M1-West: 18.8 °C	Spider: 15.9 °C	Pressure: 863.925 hPa	Pressure: 863.925 hPa
		Wind Direction: 214 °	Wind Direction: 46 °
		Wind Speed: 1.2 m/sec	Wind Speed: 1.6 m/sec
		Dew point: 7.1 °C	Dew point: 7.1 °C


Domes closed for adverse weather conditions

Meteo is fine, domes can be opened



Archive Analyze Plots Sky video Technical notes

Domes closed for adverse weather conditions

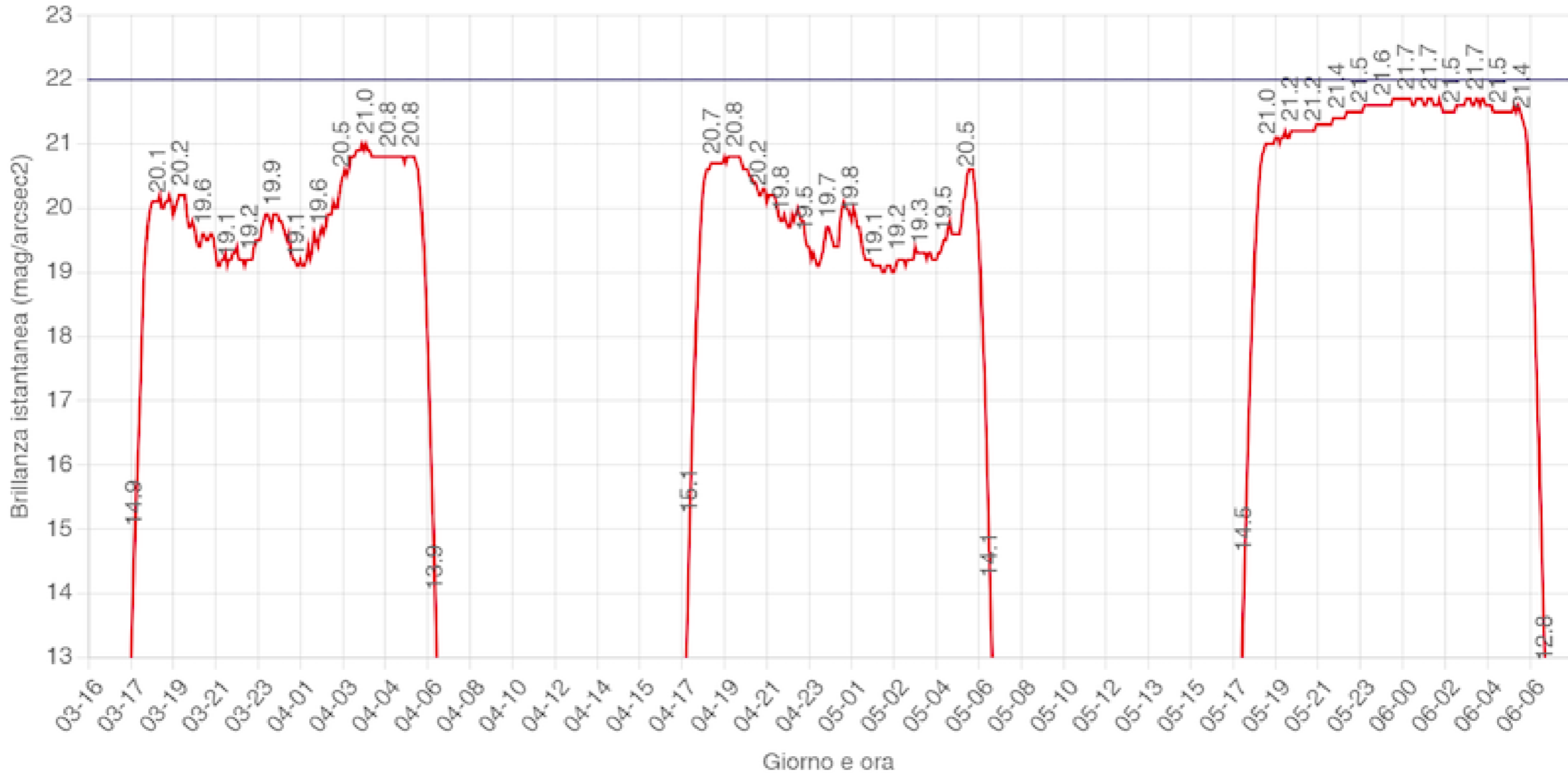


Archive Analyze Plots Sky video Technical notes

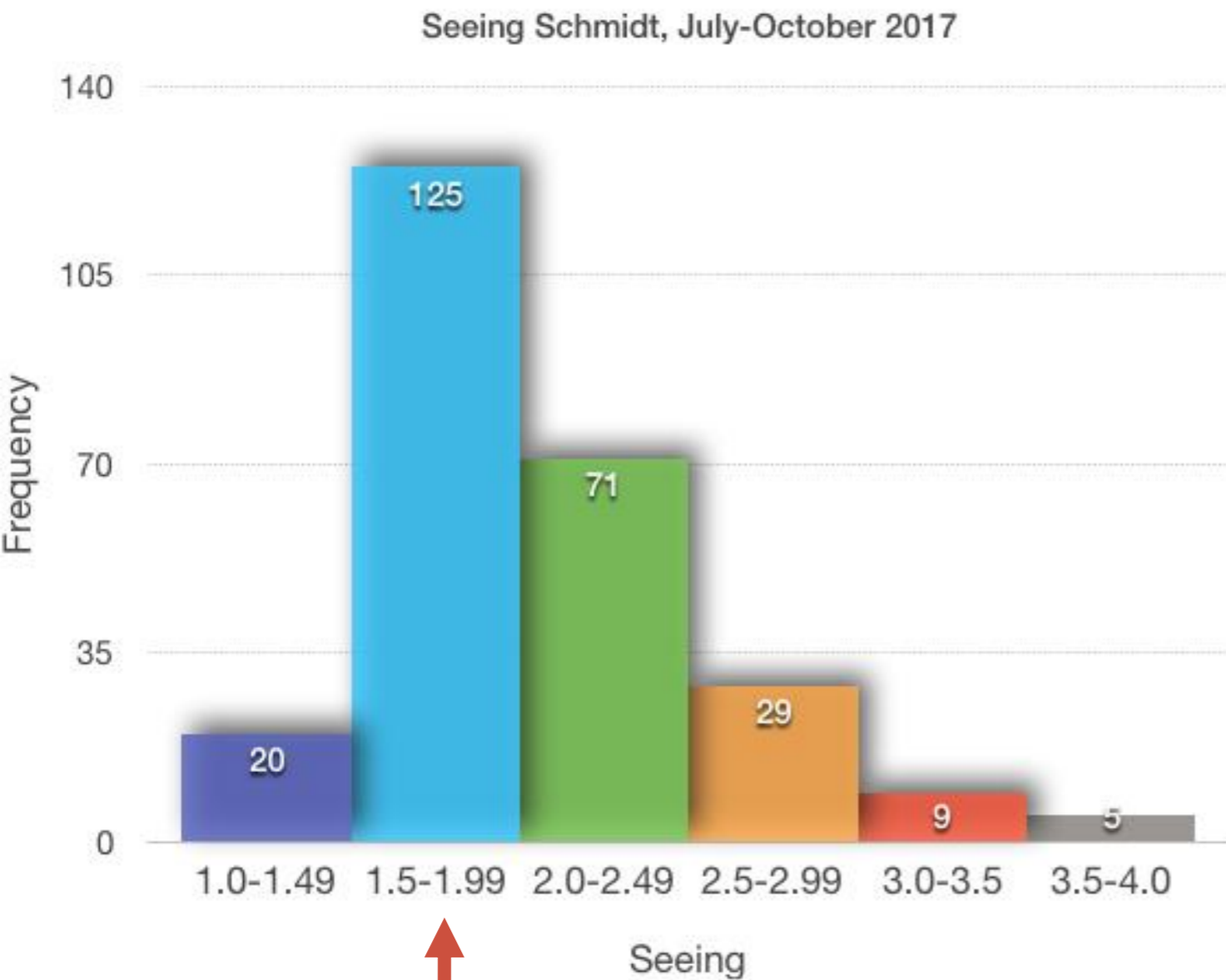
ARPAV SQM - SKY QUALITY

21.7 mag during a foggy night in Asiago and on the Pianura Padana (usually between 20.1 and 20.8)

Brillanza istantanea



Seeing from Schmidt images



1.5 - 2.0 arcsec

