The Observatory of the University of Innsbruck

System Overview

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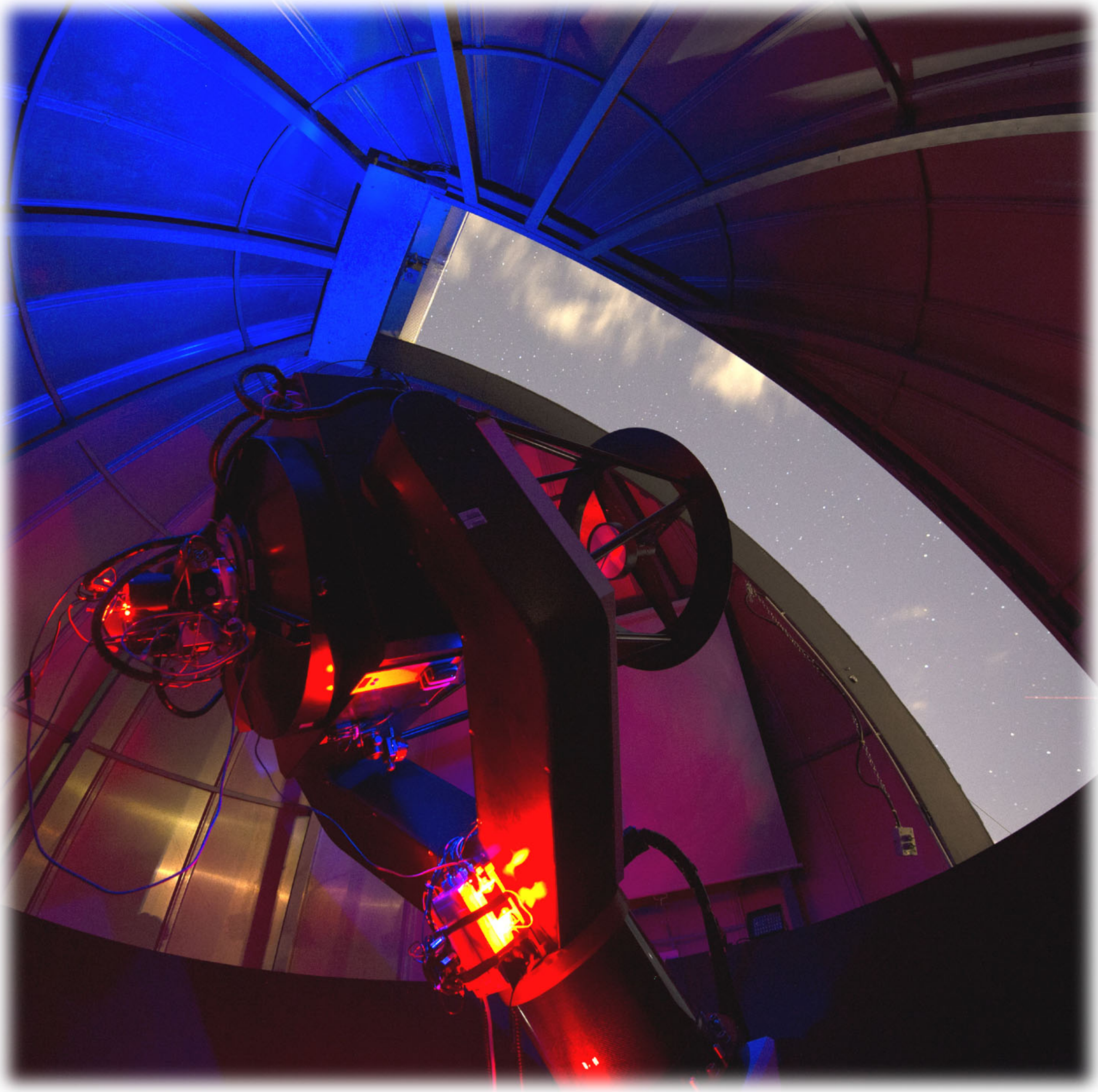

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Contents

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1 Scope of this document

This document is intended to be a technical overview of the 60cm Observatory of the University of Innsbruck and its capabilities. A detailed operational manual will be provided at a later stage.

2 Introduction

The Innsbruck 60cm Observatory belongs to the University of Innsbruck. It is located in the valley close to the local airport[1] and is operated by the Institute for Astro- and Particle Physics and mainly dedicated for student's education and small science projects.

3 History

The 60 cm Cassegrain telescope of the Institute of Astro- and Particle Physics of the Universität Innsbruck was taken into test operation in October 1995. The planning of the telescope and the building of the telescope mounting was carried out by the engineers from the workshop of the Institute for Astronomy of the University Vienna under the guidance of Mr. Pressberger. The blanks for the two mirrors made of ZERODUR come from SCHOTT in Mainz. The mirrors were dragged by Mr E. Aeppli (company Astro Optik, Adlicon, Switzerland). *More historical hot air to follow....*

After some technical breakdowns of the motor control and huge difficulties to obtain spare parts, the entire telescope was refurbished and the mount was replaced with a modified ASA DDM160 fork mount. The whole refurbishment started in 2015 and included also a new recoating of the main mirror. However, severe problems encountered when removing the old coating at the Sternwarte Hamburg, requiring a new dragging of the mirror at ASA. We took the opportunity to also slightly change the shape of the main mirror to increase the back focus of the optical system, which was necessary since the telescope is now equipped with a 4-port selection switch (Perseus), which enables the use of four instruments without mounting/dismounting individual devices.

4 Dome

The dome was manufactured by by a local company without interacting with the Universtity then (Vienna central Bautenministerium). The company that carried out the work went bankrupt already in the 1980s. After a series of problems and failures the local company Elektro Berchtold installed in October 2000 new motor drivers (on top of the old undocumented system by error an trial investigation) and a IACODE Wegmesssystem (from DETO electronic systems) based on bar-codes to read with a computer interface the positions and switch the motors via an RS422 industrial interface. However no drivers or software was available for that. In a BSc thesis of an informatics student designed, after an extensive study of the behaviour of the dome with accelerator detectors, in 2012 an RTAI (realtime LiNUX) based control. This is able to handle commands via a network TCP/IP connection over a socket. It is not (yet) connected to the telescope software. Thus up to now we can rotate the dome only via manually switches. Their controls are located in the dome (see Fig. 1).

5 Telescope and focuser

The telescope is a Ritchey-Chretien type with a main mirror size of 60cm (598 mm exact). After the recoating and slight reshaping of the mirror in 2016 the focal length is ∼5180 mm leading to an f-ratio of ~ 8.6. The secondary mirror is of size 196 mm in a cell holder with 221 mm leading to a linear central obstruction of $\epsilon = 0.37$[2] and an areal shadowing of 13.7%. It also incorporates the focuser of the telescope, which can be controlled with the `ASCOM`[3] based software `ACC` ([ASA19b]), which is installed on the Main Telescope Control PC (see Section 9). In the Cassegrain focus there is the Optec Perseus 4-port switch, which allows to remotely select the attached instruments, currently two spectrographs and an imaging system (see Section 7).

[1] Lon: 11.342538E, Lat: 47.26428N, 590 m.a.s.l.

[2] https://en.wikipedia.org/wiki/Airy_disk#Obscured_Airy_pattern

[3] https://ascom-standards.org/

Figure 1: Switches for the rotation of the dome.

6 Mount

The new mount is an equatorial fork mount built and installed in 2015 by Astrosysteme Austria (ASA[4]). It is a modified DDM160 type equipped with direct drives, absolute encoders and a fork designed and manufactured for the Innsbruck observatory. It is connected via a serial-Port/USB converter to the Main Telescope Control PC and can be controlled by means of the `ASCOM` based control software `Autoslew` ([ASA19a]) and a dedicated joystick (see Fig. 10).

7 Instruments + CCDs

The current suite of three instruments is mounted in the Cassegrain focus and can be selected via the Optec Perseus 4-Port Gen 3 selector (see Section 8.1). As of now there are the following instruments mounted:

- Port #1: Shelyak LHIRES long slit low-resolution spectrograph + ZWO ASI 1600MM-Pro CMOS
- Port #2: Shelyak eShel echelle high-resolution spectrograph + QSI660 CMOS
- Port #3: Imaging system (12-slot Filter wheel + QHY600 CMOS)
- Port #4: Baches high-resolution echelle spectrograph + ASI294MM Pro CMOS

7.1 Long Slit Spectrograph LHIRES III

This section is an overview on the Shelyak LHIRES III spectrograph as installed at the observatory of the University of Innsbruck. A comprehensive technical description is given in [Ins06] and at the web pages[5].
The long-slit spectrograph LHIRES III covers a nominal wavelength range between 400nm and 700nm. The spectral resolving power R depends on the inserted grating. At the Innsbruck observatory the gratings with 2400, 600, 300 and 150 lines/mm are available leading to $R \sim 700...17,000$ (see Table 2). We also have several different slits available (long slits with widths W=19, 50 75,

[4] https://www.astrosysteme.com/
[5] https://www.shelyak.com/categorie-produit/pour-les-inities-en/lhires-iii-en/?lang=en

		Grating – Lhires III (lines/mm)				
		2400	**1200**	**600**	**300**	**150**
Dispersion (Hα)	*nm/pix*	0.012	0.035	0.074	0.149	0.300
Resolving power		17000	5900	2800	1400	700
Radial Velocity	*Km/s*	5	17	35	75	150
Field of view	*nm*	8.5	25	55	110	230
All visual domain in #	*images*	45	15	7	4	2
Limiting magnitude		5.0	6.8	7.5	8.4	9.2

Table: parameters based on grating used
(ETCL simulation: 200mm f/10 telescope, 30µm slit,
KAF0400 camera, 1h exposure, Signal/Noise of 100)

Figure 2: Table with technical data of the gratings (taken from [Ins06]). Note that the limiting magnitudes are calculated not for the Innsbruck 60cm telescope system.

100 µm and the photometric shorter slit set consisting of [Width×Length]=23×200 μm, 27×250 μm, 31×300 μm and 35×350 μm). The standard configuration is the 150 lines/mm grating with the 23 μm slit. Note that a change of the slit/grism/wavelength range cannot be selected remotely from the control room, but is only possible manually and requires new calibration frames for each setup.
The spectrograph is equipped with a ZWO ASI 1600MM-Pro CCD camera, incorporating a 4/3 CMOS chip[6], a Peltier cooling and a USB3.0 connection.
The internal calibration unit can be remotely controlled with the SPOX module[7] (see [Ins18]) and the corresponding ASCOM software, which enables Ne-Ar wavelength calibration sources and a tungsten flatfield lamp. As the internal Ar-Ne sources turned out ot be insufficient, especially in the blue end, we have developed a generic wavelength calibration system based on penray lamps (see Section 7.4 for more details). We highly recommend to use this device.
To place the object in the slit there's a WATCOM 120N$^+$ videocamera installed in the spectrograph. Its signal can be viewed in the control room with a small dedicated monitor (above the main monitor, see Fig. 10).
The LHIRES spectrograph (i.e. CCD and SPOX) can be controlled via the Telescope Control PC in the control room.

7.2 Echelle Spectrograph eShel

The Shelyak eShel[8] is an echelle-type spectrograph in the optical range ($\sim$ 400....700nm) (for technical details see [Ins09]). It is equipped with the upgraded collimator module[9] to enhance the wavelength range towards the blue end. It incorporates a fiber head unit, which was pimped with a small foreoptics lens (80 mm planeconcave) to reduce the focal length, i.e. to concentrate the infalling signal. The fiber head is mounted at the Perseus port #2 and feeds two 10m-fibers, one 50µm feeding the eShel spectrograph, and a second 200µm-fiber which provides the light from the calibration unit located at the control room (see Fig. 3). Both fibers were replaced with blue-enhanced types.
The spectrograph is equipped with a cooled QSI-660 CCD camera (Sony IXC694 CMOS[10]), which is connected via USB2.0 to a dedicated control PC located directly aside. This PC, the spectrograph and the corresponding calibration unit can be controlled from the main control room (cf. Section 9 and Fig. 10). Connected to the fiber head is a WATCAM 120N$^+$ videocamera, which records the entrance hole of the fiber and enables a placement of the object to maximise the S/N. In the control room there's a dedicated small monitor for that purpose.

[6] Panasonic MN34230, 4656 × 3520 pixels, 3.8 µm
[7] https://www.shelyak.com/categorie-produit/accessories/spox-en-2/?lang=en
[8] https://www.shelyak.com/categorie-produit/for-pros-and-experts/eshel-en/?lang=en
[9] https://www.shelyak.com/produit/se0220-upgrade-kit-collimator-module/?lang=en
[10] 2758 × 2208 pixels, 4.54µm

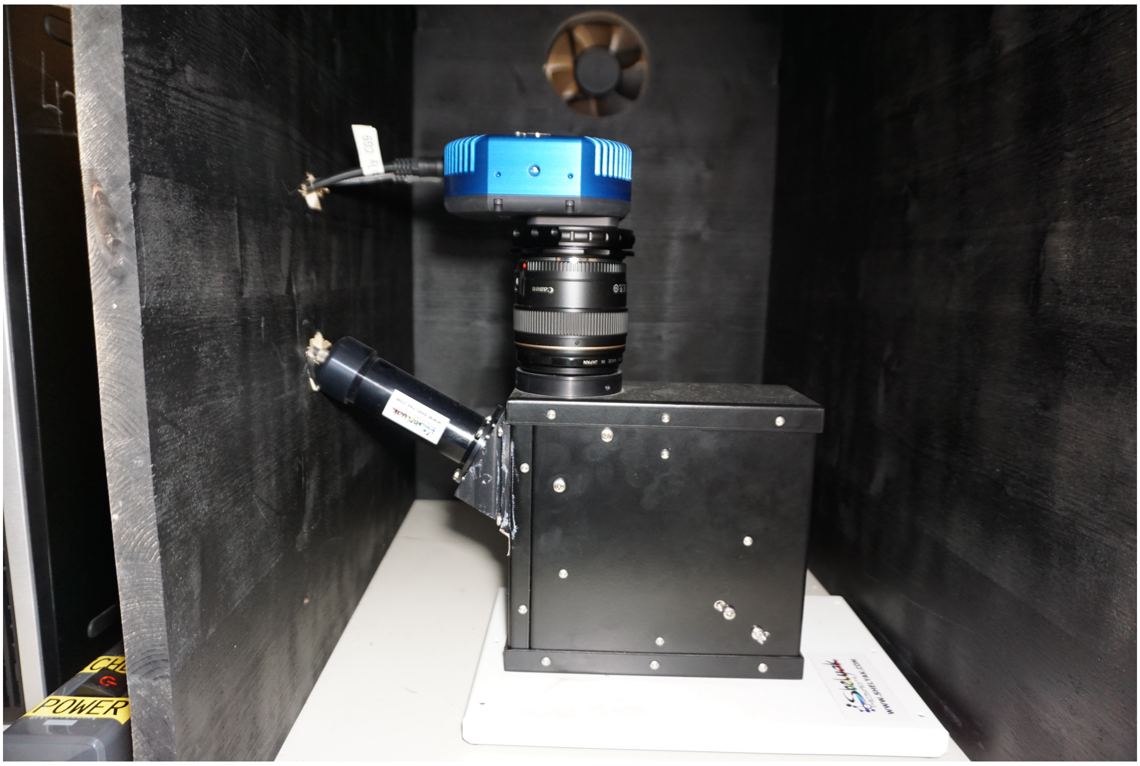

Figure 3: eShel spectrograph with the QSI660 CCD located under the stairs in the room below the dome.

7.3 BACHES Echelle Spectrograph

The BACHES spectrograph[11] is built by Baader Planetarium and is also an echelle type instrument covering the optical wavelength range (392-800 nm) with a spectral resolving power of $R \sim 18,000$. It is equipped with two slits (widths 25 and 50 µm, length 125 µm). The Remote Calibration Unit is located in the control room and incorporates a ThAr wavelength calibration and a Halogene lamp for the flatfielding connected to the spectrograph via a fiber. The instrumentis equipped with an ASI294MM Pro CMOS CCD as the Sony IMX492 sensor allows to cover the entire wavelength range with a reasonable pixel resolution.

7.4 Wavelength calibration system

As the LHIRES III internal wavelength calib unit turned out to be insufficient we have installed a dedicated unit consisting of four penray lamps filled with Ar, Ne, Kr, and Hg. In principle, this enables to calibrated the entire wavelength range of all spectrographs available at the Innsbruck Observatory, but is necessary only for the LHIRES III device. The lamps are located in the dome at the north-western side (in direction towards the Hechenberg). In order to use them the lamp holder can manually be moved up (see Fig. 4) so the telescope can directly point into the lamps. The lamps can then be switched on/off individually via the control room PC. This is necessary as the exposure time is different to avoid overexposure After the calibration, the holder MUST be moved down again.
CAVEAT: Some of the penray lamps have strong UV emission. It is therefore strictly forbidden to enter the dome without the protection glasses when the lamps are in operation!

7.5 Imaging system

The imaging system consists of a cooled QHY600-L backside-illuminated CMOS CCD[12] and a 12-slot CFW3-12 filter wheel from FLI 2-inch filters. The following filters, manufactured by Astrodon, are installed:

[11] https://www.baader-planetarium.com/de/baches-echelle-spektrograf.html
[12] Sony IMC455, 9.576×6.388 pixels, 3.75µm, USB3.0

Figure 4: Penray lamp array. Left: Penray lamps at the movable holder; Right: Power supply for the lamps (individually remotely controllable). Note that some of the lamps have strong UV emission. Use the shown protection glasses!

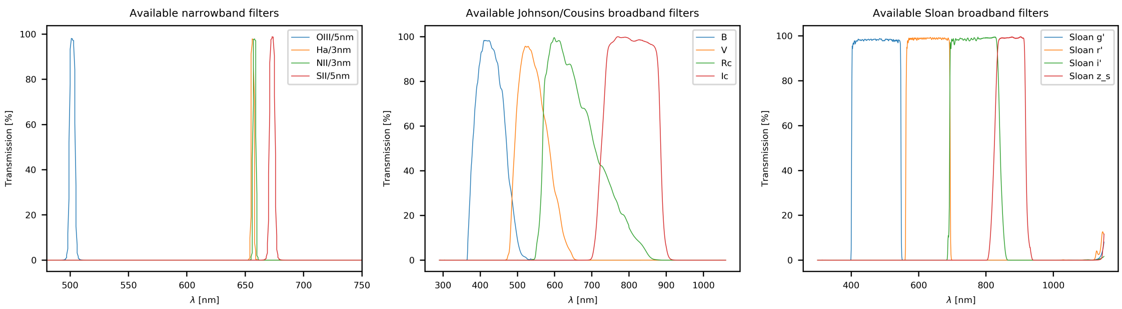

Figure 5: Filter curves of the imaging system.

Slot position	Filter
0	SII 5nm
1	Johnson-B
2	Johnson-V
3	Johnson-R
4	Johnson-I_c
5	Sloan g′
6	Sloan r′
7	Sloan i′
8	Sloan z_s
9	Hα (3 nm)
10	NII (3 nm)
11	OIII (5 nm)

The camera and the filter wheel are connected via USB to a dedicated control PC located in the dome and can be remotely controlled from the main control room via the corresponding ASCOM based software.

8 Supplementary Subsystems

8.1 Optec Perseus 4-port switch

The Optec Perseus[13] 4-port switch comprises one 3-inch port (Port #1, male OPTEC-3600 type dovetail) and three 2-inch ports (Ports #2-4, male OPTEC type 2400 dovetail), the latter being

[13] https://optecinc.com/astronomy/catalog/perseus/default.htm

also equipped with a parfocal receiver adapter and lock which can be used to set them into parfocal distance with Port #1 (not yet done at this telescope!). The Perseus is connected via USB to the Main Telescope Control PC (LAN would be also available) and can be controlled vie the `Perseus Commander` software.

8.2 Weather station

The installed Davies Vantage Pro 2 weather station is located at the observatory's south-east edge of the roof (see Fig. 6). The sensor device measures temperature, pressure, and humidity inside and outside the dome, and in addition wind speed and direction, and amount of rain. The actual weather station control is located inside the dome at the southern part of the ceiling. The data are transferred via the USB logger to the Weather and AllSky-Camera Control PC at the upper board in the control room (see Fig. 10). The corresponding software `Weatherlink` displays the current and historic values in addition to some values calculated from them, e.g. the dew point within the dome. Especially important is the wind speed due to the fairly frequent Foehn situations in Innsbruck, which often lead to wind gusts $> 8\,\mathrm{m/s}$, which is the limit to close the dome to avoid damage on the observatory.

Figure 6: Located at the south-west edge of the building roof is the Davies Vantage Pro weather station (right) and the All Sky Camera (left). Also the Navilock GPS receiver is mounted here (not visible).

8.3 All Sky Imager

The All Sky Imager is an Interactive Astronomy SkyEye device, which incorporates a Sony ICX205AL SuperHAD CCD[14] with a f=2.6mm (f/2) foreoptics enabling a field-of-view of $161° \times 112°$ (see Fig. 7). The All Sky Imager is automatically active from evening to morning twilight[15] and takes continuously sky images[16]. The exposure time -hence also the frequency of the taken images- is automatically adjusted depending on the sky brightness (usually updated between 1 and 60 seconds).

8.4 GPS module

The observatory is equipped with a Navilock NL-602U GPS receiver. The observatory position is read by the mount control software `Autoslew` to automatically set the correct position. The receiver is connected via USB to the Telescope Control PC and is located outside the dome directly aside the weather station and the All Sky imager.

8.5 DomeCam / SlitCam / IR floods

For monitoring activities within the dome there are two small ASI120MM cameras and IR floods installed (see Fig. 8). One is dedicated as DomeCam and equipped with a wide-angle lens capturing the majority of the dome interior. It is located above the ceiling directly aside the weather station control. It is connected via USB2.0 to the PC which also controls the weather station and the All Sky Imager in the main control room (upper board, see Fig. 10). From there it can be accessed via the software `Firecapture`.
The second ASI120MM camera is mounted at the telescope tube parallel to it to enable a view on the dome slit. This is a necessary monitoring because the dome and the mount are not connected and require continuous manual re-adjustment of the slit position. The SlitCam is connected (via USB2.0) to the Telescope Control PC[17] and can also be accessed with `Firecapture`.
Within the dome there are three LED IR floods mounted, one at the ceiling and two aside the

[14] 1392 x 1040 pixel, 4,65 µm
[15] https://astro-staff.uibk.ac.at/~teleskopmeteo/skyeye.jpg
[16] These images are also stored at the data RAID array in the directory `/TBD/`
[17] A connection of two ASI120MM cameras at one PC is not possible due to USB issues.

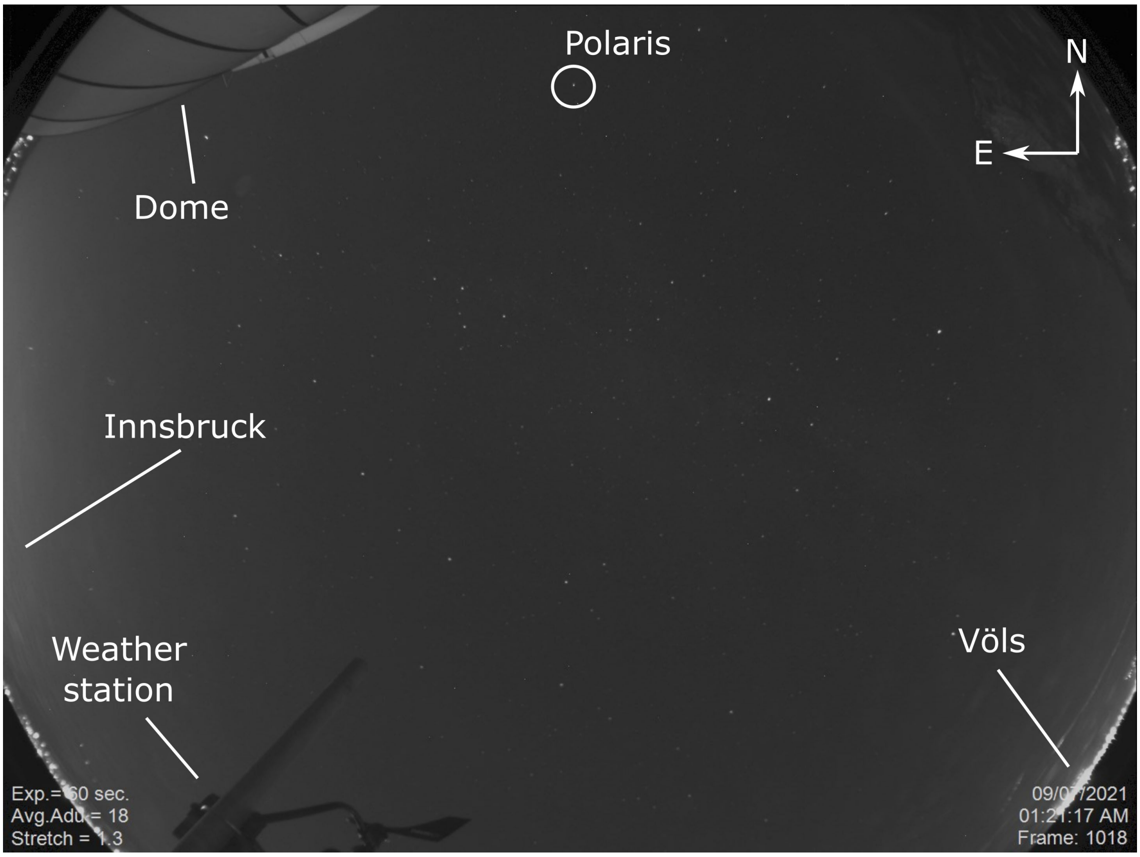

Figure 7: Field-of-view of the All Sky Imager.

mount pedestal. These floods are equipped with 940 nm LEDS and are intended to illuminate the dome interior at a wavelength range outside the scientific interesting range of our instruments (optical regime). As the ASI120MM is still a bit sensitive in that range, we expected to be able to operate these floods in parallel to the science observations. This was necessary since we encountered severe mount problems in the past leading to unexpected behaviour. Unfortunately, it turned out that these floods have blue leaks impairing the red end of our observations. As the mount problems seem to be solved we recommend to switch on the floods only if really necessary.

8.6 Power supplies

The telescope and the instruments are powered by three individual power supplies (see Fig. 9) to avoid short voltage peak problems e.g. induced by the switching of the CCD Peltier cooling. The supplies are labelled "Power West" (a Basetech BT-305 device) feeding the QHY-600-L imager CCD only, "Power Middle" (same device) powering the ASI camera, filter wheels, the video cameras etc. and "Power East" (QJE QJ3010S) powering the mount and the focuser.

8.7 Main control room

The main control room is located in the 9th floor of the building, right below the dome. In incorporates the central control facilities to operate the observatory, i.e. access to all PCs and the supplementary systems (see Fig. 10) except the dome rotation and the dome slit.

9 IT Infrastructure

References

[ASA19a] ASA. Autoslew software manual for mounts with absolute encoders. *ASA Dcoumentation*, 2019.

[ASA19b] ASA. Getting started with acc focusing software. *ASA Dcoumentation*, 2019.

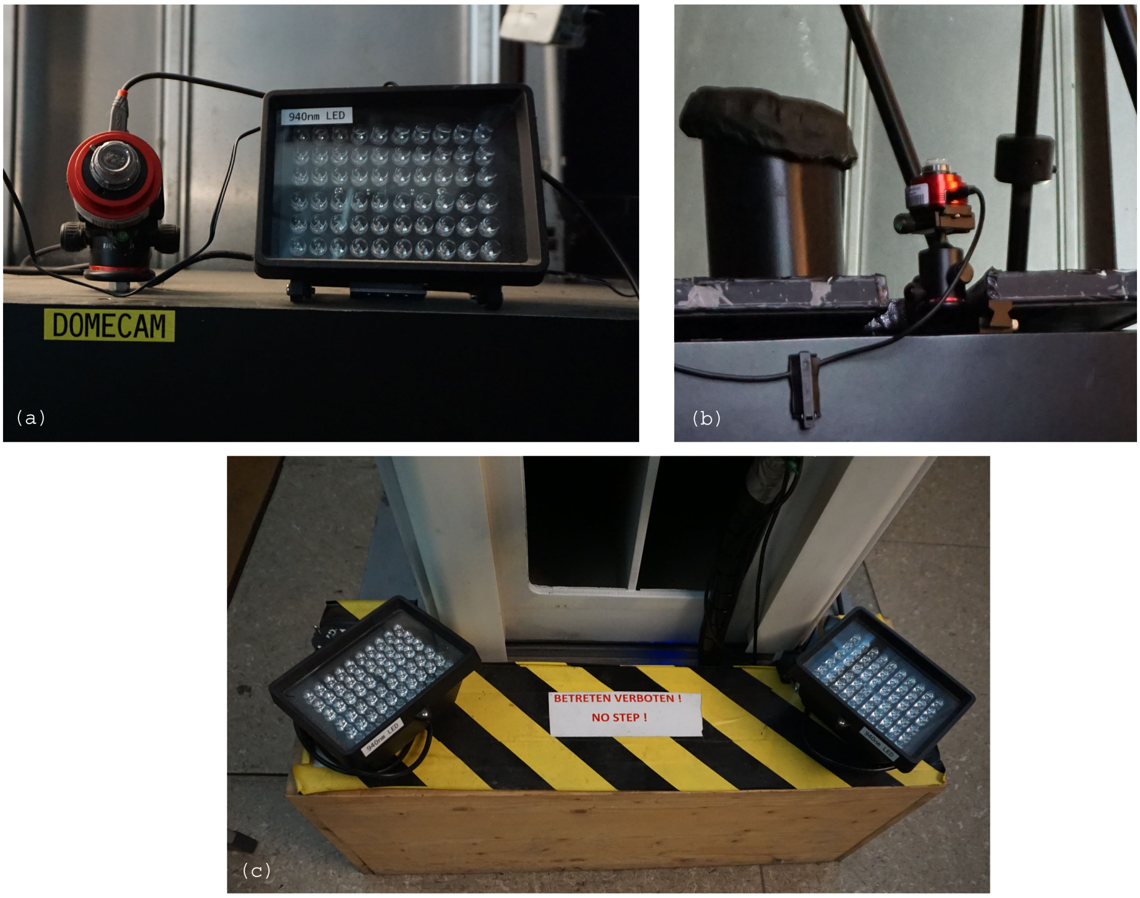

Figure 8: a) DomeCam within the Dome at the southern ceiling with a corresponding IR flood; b) SlitCam mounted at the telescope tube looking towards the slit; c) IR floods at the mount pedestal.

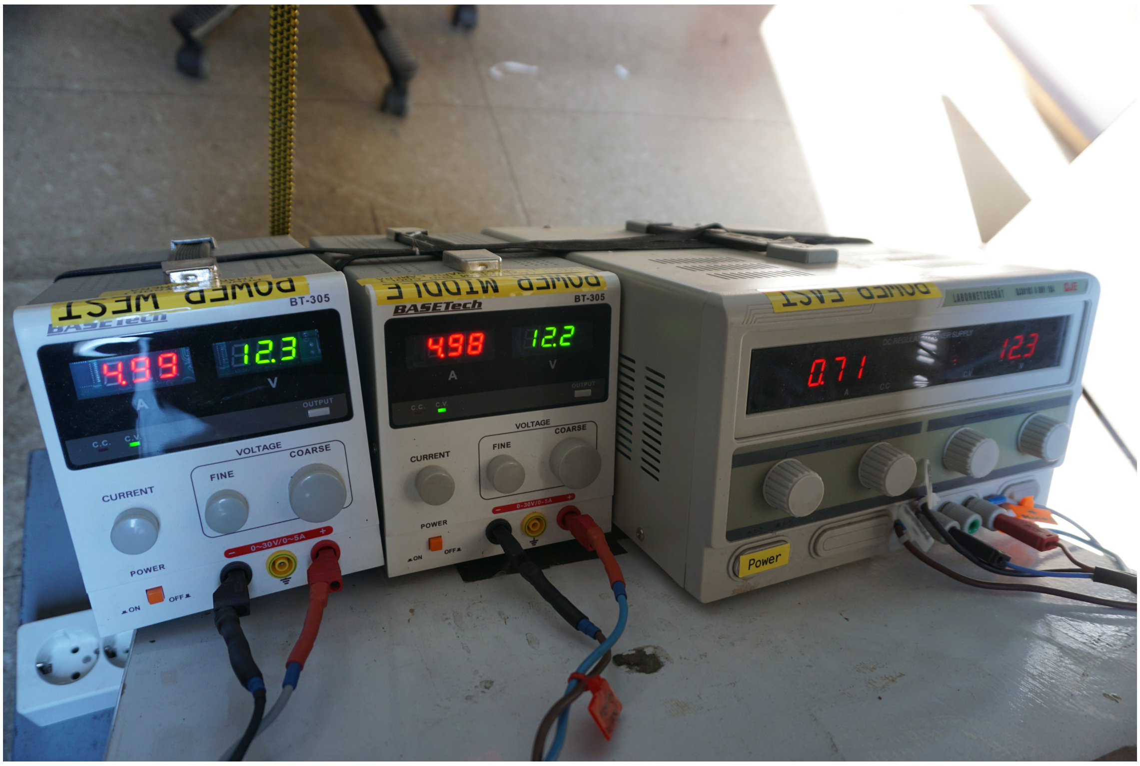

Figure 9: Power supplies of the mount, focuser and instruments within the dome.

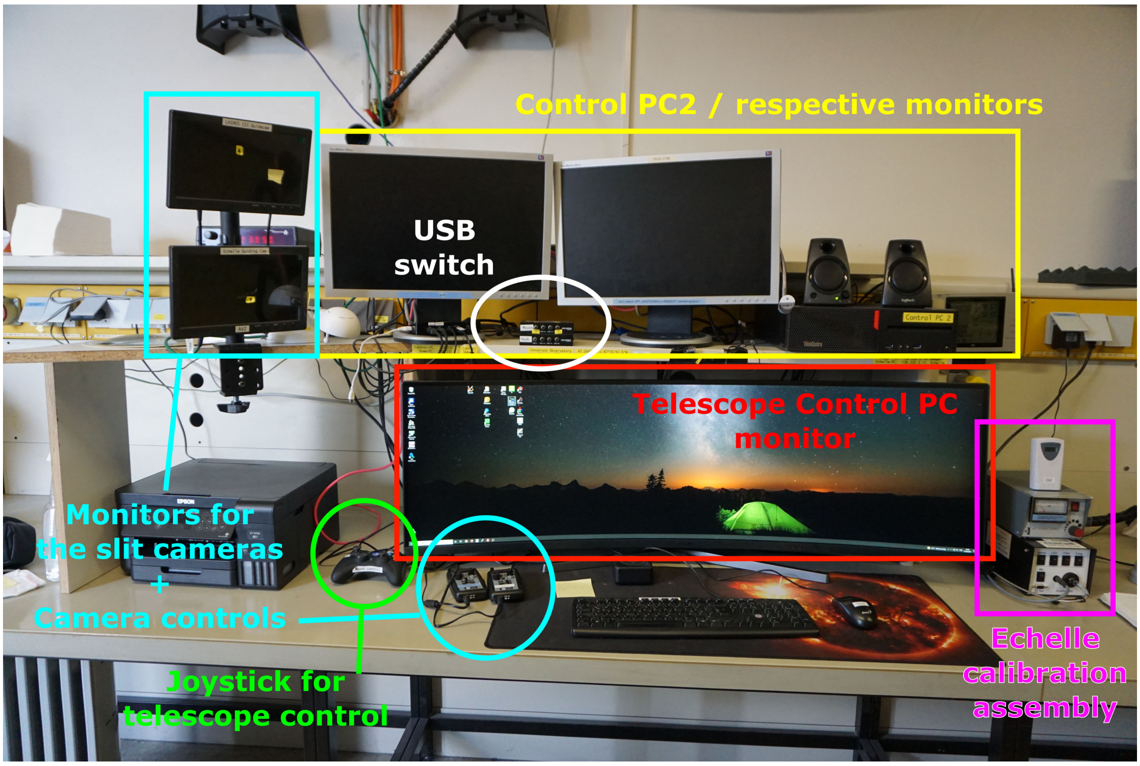

Figure 10: Main control room of the Innsbruck Observatory.

[Ins06] Shelyak Instruments. Lhires iii user guide. *Shelyak Eigenverlag*, 2006.

[Ins09] Shelyak Instruments. eshel user guide. *Shelyak Eigenverlag*, 2009.

[Ins18] Shelyak Instruments. Spox user guide. *Shelyak Eigenverlag*, 2018.