

DIGITIZATION OF SONNEBERG PLATE ARCHIVE - CURRENT STATE AND ACTIVITIES

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Sonneberg Observatory houses a plate collection with about 275,000 photographic plates taken between 1923 and 2010. About 85% of the plates of sizes from $6\times6\text{cm}^2$ up to $30\times30\text{cm}^2$ have been scanned since 2004 yielding approximately 15 TB of raw data. The database of image and log-book data and the processing pipeline is currently under construction.

1 Sonneberg Observatory

Cuno Hoffmeister, founder of Sonneberg Observatory in 1925, aimed at covering the whole sky by photographic means as frequently as possible in order to detect and to classify variable stars. Over the years, several different instruments and batteries of small telescopes have been used. From the late 1950ies on, a homogeneous system of 14 Tessar objectives, assembled at two mountings, were applied for the so-called *Sky Patrol* (Fig. 3), which covered the whole sky from the North Pole to about -30° declination (Fig. 6) in two color bands, while deeper exposures of about 80 selected fields (Fig. 7), mostly along the galactic equator, were taken with two 40-cm astrographs and a 50/70/172-cm Schmidt telescope (Fig. 2), which formed the so-called *Field Patrol*.



Figure 1. Sonneberg Observatory (spring, 2016).

The photographic observations have stopped in 2010 as chemical emulsions suitable for astronomical exposures became more and more difficult to procure. Furthermore, CCD and CMOS detectors with their much higher quantum efficiency and immediate access to the data became available. Since 2010, Sonneberg Observatory runs a digital patrol of about 20 selected fields and since beginning of 2015 an fish-eye all-sky camera.

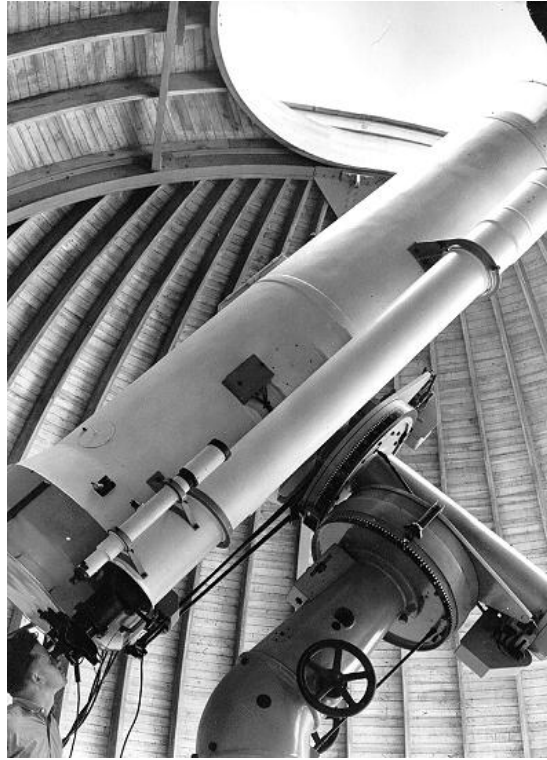


Figure 2. Schmidt Camera 500/700/1720 mm.



Figure 3. Sky Patrol cameras (55/250 mm) on two mountings.

2 Plate archive

Every plate exposed at Sonneberg has been developed, fixed, labeled. They are stored at the plate archive, consisting of two rooms. Furthermore, there are plates taken on the southern hemisphere during the four expeditions of Hoffmeister to the Carribean Sea and Namibia. There are plates from Landessternwarte Heidelberg (Bruce astrograph) and Lohrmann Observatorium Dresden, too.



Figure 4. Collection of sky patrol plates.

Among the direct image plates there are also several hundreds of spectral plates taken with objective prism of the Schmidt camera in Sonneberg and with another camera at Bolivia.

Up to 20 plates are stored in cardboard boxes, which are piled up in steel shelves ordered by coordinates. Each box is labeled with the field coordinates and the date of exposures.

The plates are of different sizes from 60 mm×60 mm up to 300 mm×300 mm.



Figure 5. Labelling of cardboard boxes of astrograph plates.

Table 1 gives an overview about the principal plate series listed by instrument classes.

3 Sky coverage

The following two figures give a rough overview about the sky coverage of the sky patrol (Fig. 6) and the field patrol (Fig. 7). The color encodes the number of plates available for this region.

4 Digitization

Digitization started at 1991 with a simple line scanner with projection objective. Within three years 5000 plates were scanned.

Bulk scanning started in 2004 with a set of four scanners HP Scanjet 7400 C (Fig. 8) with illumination unit. By the way, within two years nearly all of the equal-sized sky patrol plates have been digitized. For the larger astrograph plates, a Microtek ScanMaker 9800 XL (Fig. 9) was used.



Figure 8. HP Scanjet 7400 C with illumination unit.

By today, there are 211,751 sky patrol plates and 25,697 bigger astrograph field patrol plates scanned. This gives a total of 237,430 digital images representing about 85% of the whole plate collection.

The two scanner types were operated by VueScan 62. software to achieve 16 bit output. The spatial resolution is 20 μm (1200 dpi).

The output data are stored as 16-bit TIFF files, which were lossless gzip-compressed (gain of 5% to 20%). The file size of the raw data are 72 MB for sky patrol plates and 450 MB for the big astrograph plates.



Figure 9. Microtek ScanMaker 9800 XL.

5 Database

During the 1980ies the log-books have been manually key-punched to fill a dBase type database. This database is going to be transferred to MySQL database which will also contain the information about the digitization data. The digital data themselves are stored on DVD and on hard disk drives. Currently the data are copied to a RAID based storage system of 24 TB capacity.

6 Reduction pipeline

A reduction pipeline to achieve an inventory of astronomical objects of the plates and to get astrometric and photometric data of them is currently under construction.

6.1 Astrometric solution

Owing to difficulties to find a reliable astrometric solution for very-wide-field plates, we are working on a generalization of this problem to handle not only plates but also digital fish-eye exposures.

Wide-field exposures are usually handled by different celestial coordinate projections. It is our aim to continuously connect these different projection, which can be achieved by one parametric representation as depicted in Fig. 10. The center of projection is given by the parameter Z .

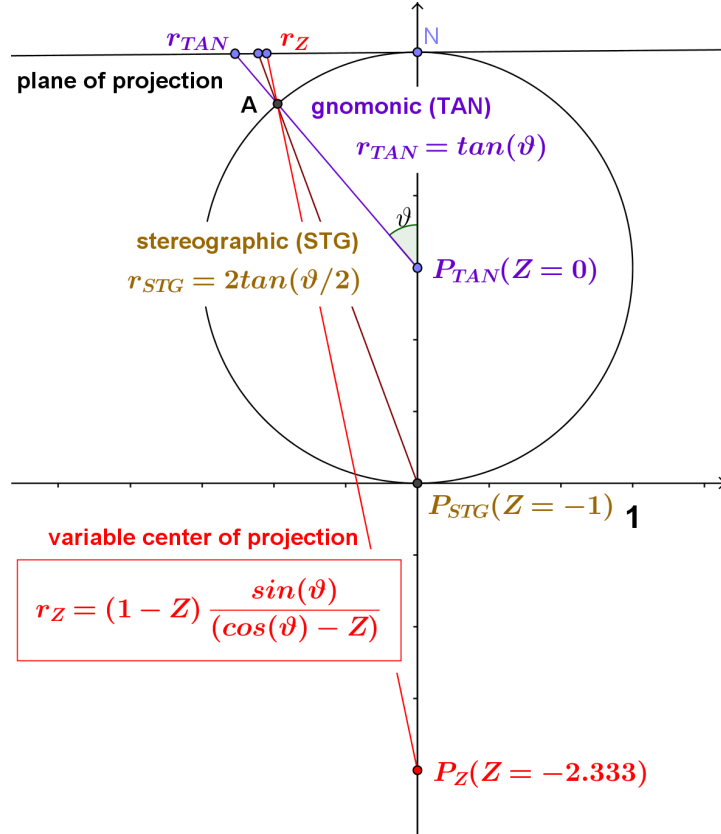


Figure 10. Parametric projection.

Fig. 11 displays the resulting functions of $r(\theta)$ for the gnomonic (TAN), stereographic (STG), equidistant (ARC), orthographic (SIN), and equal-area (ZEA) projections. This method can still be generalized by moving the projection point P_Z aside from the Z -axis in order to – by breaking the polar symmetry – describe the case where the plate is not perpendicular to the optical axis or similar problems.

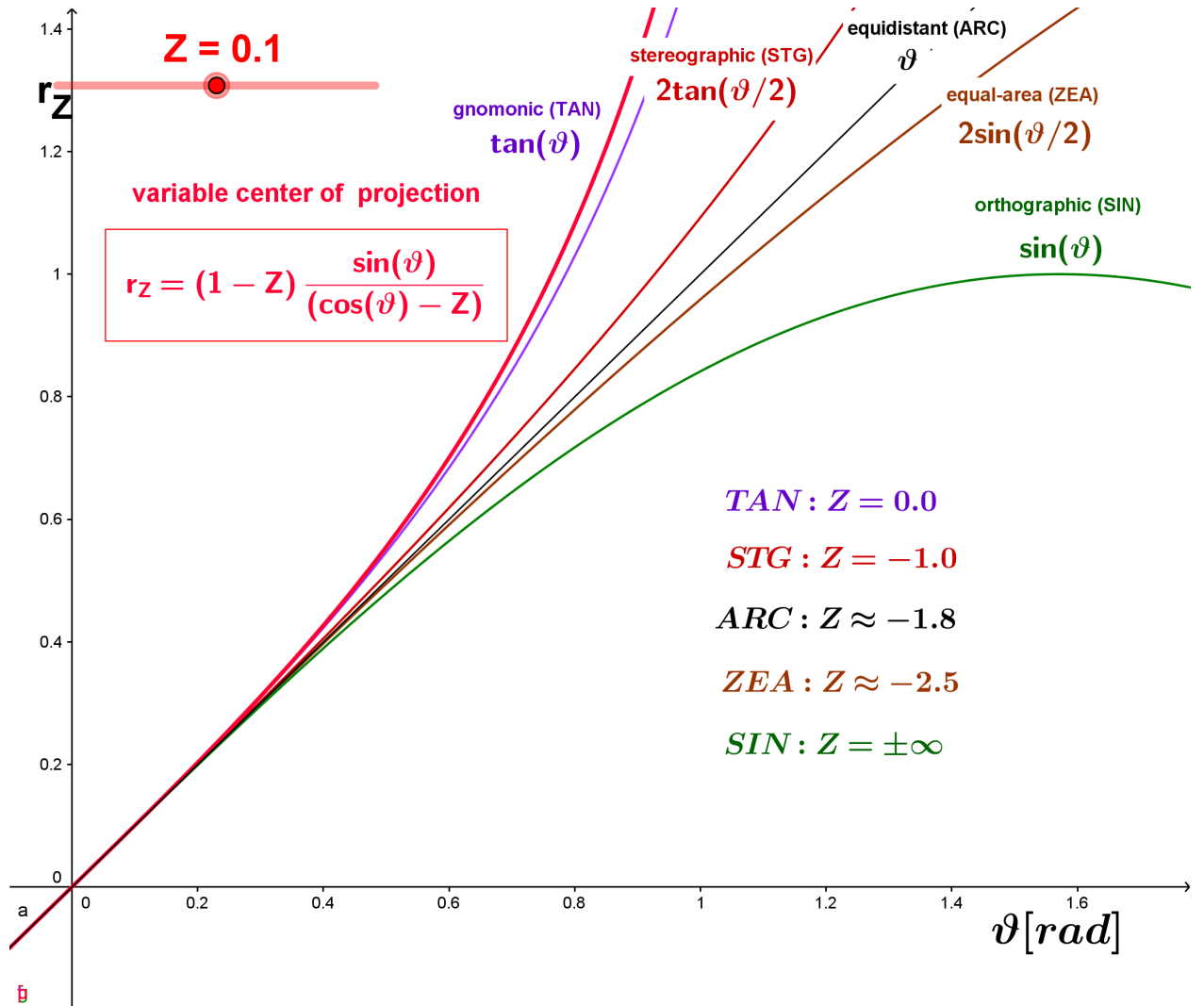


Figure 11. Gnomonic (TAN), stereographic (STG), equidistant (ARC), orthographic (SIN), and equal-area (ZEA) projections (screen shot from GeoGebra).

Fig. 12 shows an example of the Sky Patrol field centered at $RA=0^h$, $DEC=+40^\circ$ for gnomonic (TAN) and stereographic (STG) projections.

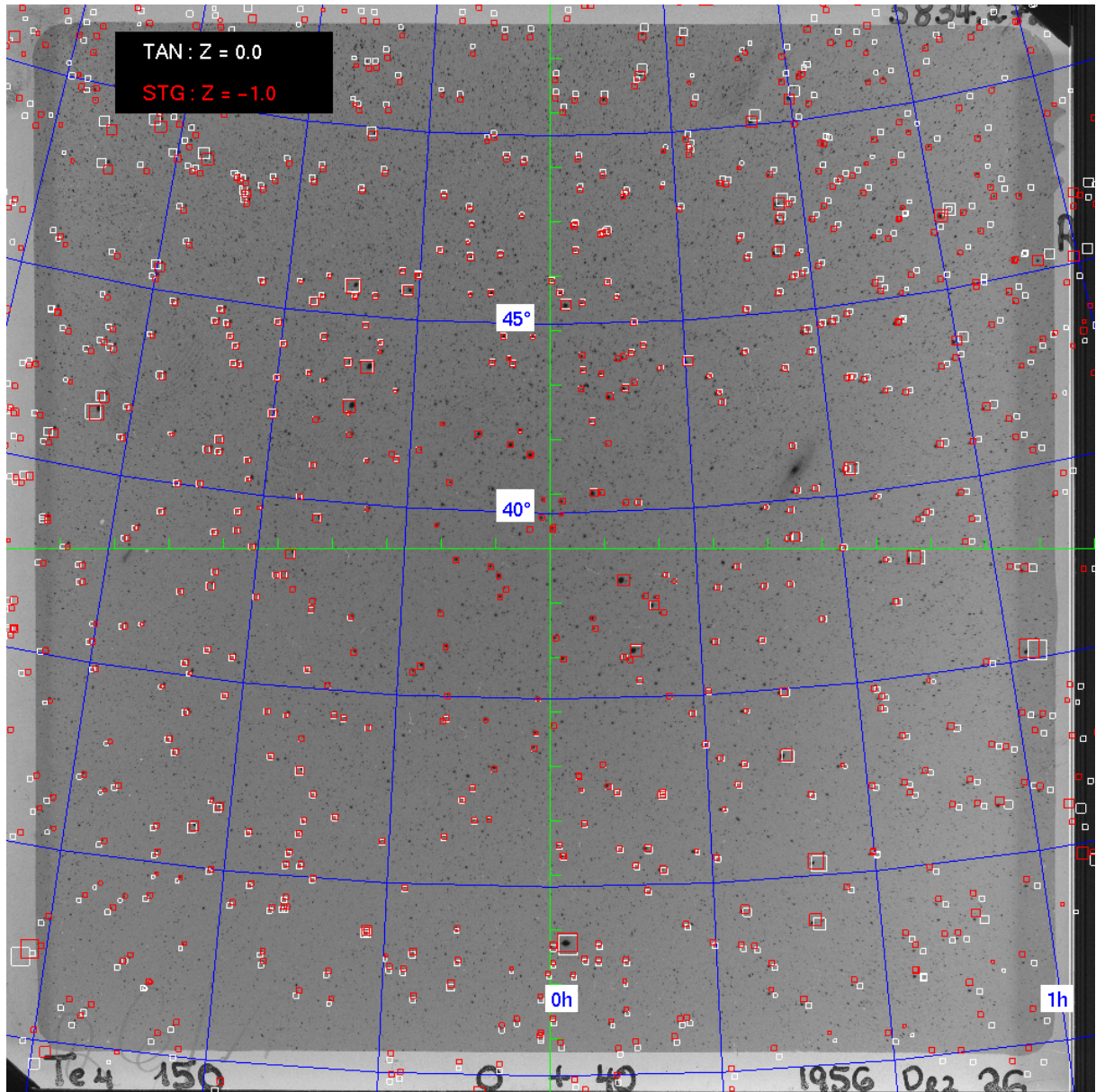


Figure 12. Example of two projection functions (gnomonic (TAN) and stereographic (STG)) for the Andromeda field.

7 Access to the data

Data are available on request to the authors (pk@4pisysteme.de, famatthai@t-online.de).

Images of the fields of sky patrol plates are available as a digital atlas at
http://4pisysteme.de/observatory/observatory_4.2.html

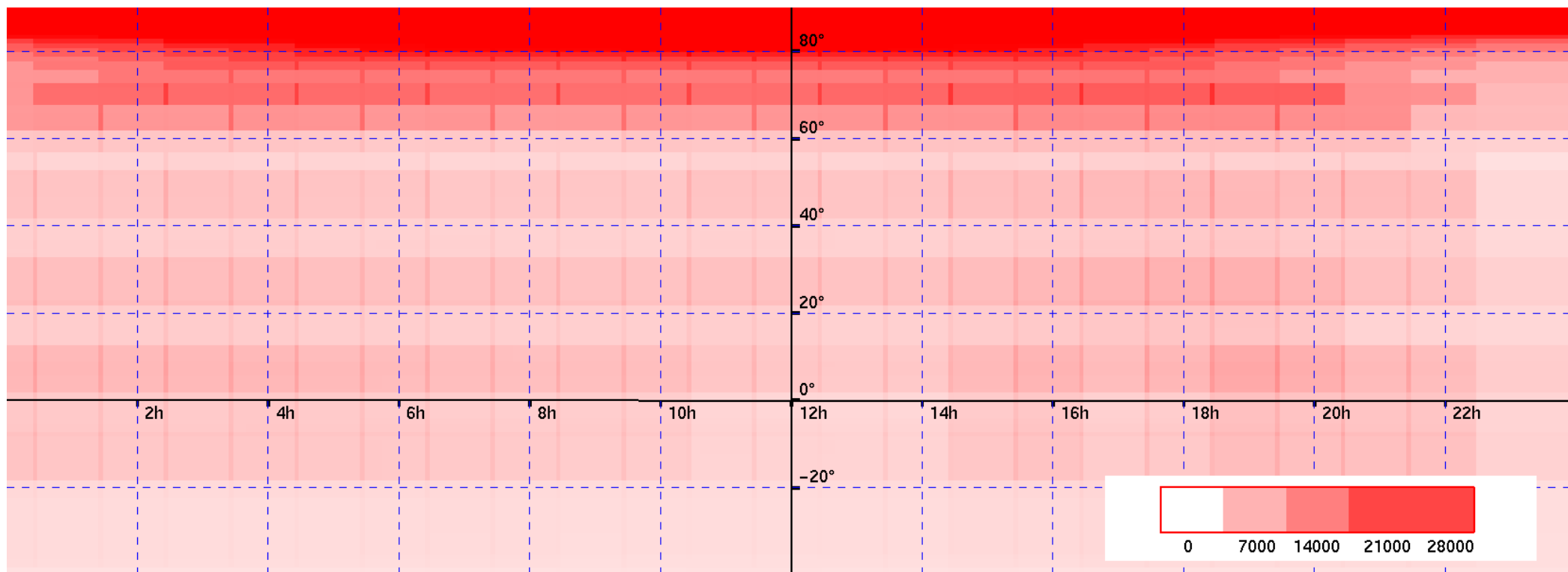


Figure 6. Sky coverage of Sky Patrol plates, reaching 15^m in blue(B) and 14^m in red(V) bands.

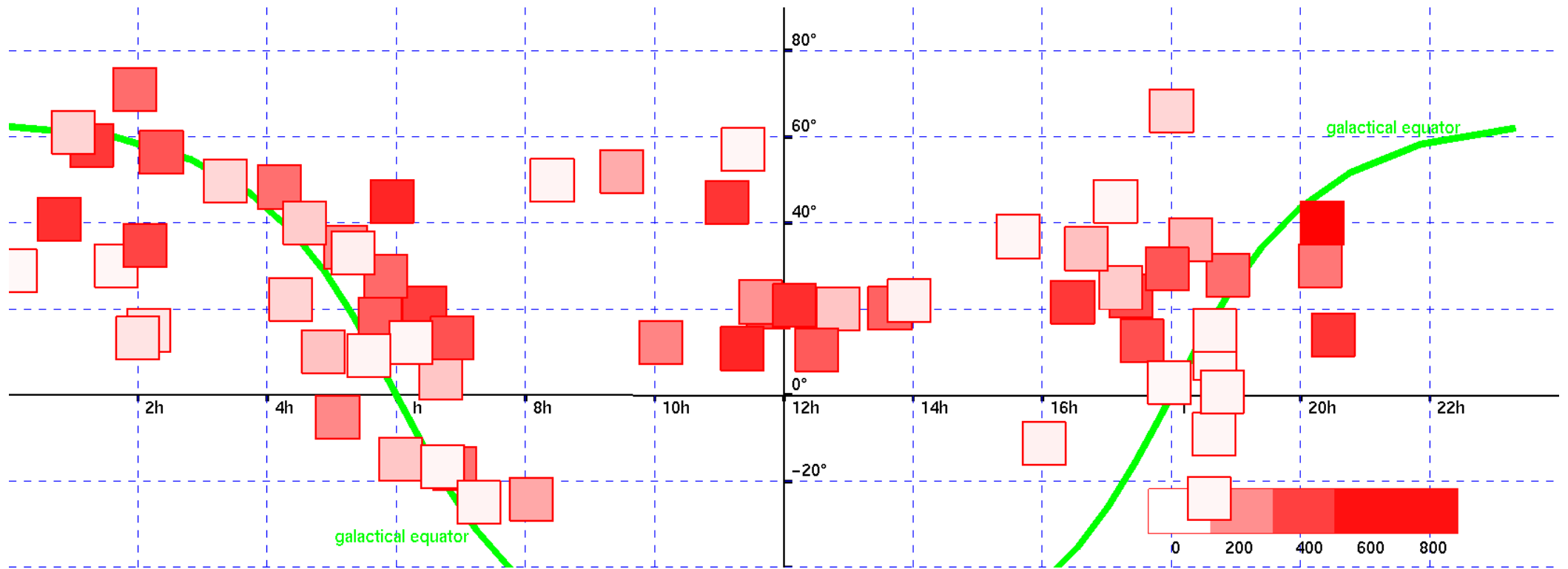


Figure 7. Sky coverage of Field Patrol plates, reaching 16^m to 18^m in blue (B) band.

Camera type	Camera name	Aperature [mm]	Focal length [mm]	Plate size [mm × mm]	Scale ["/mm]	Plate limit [^m]		Years	Number of plates		Comments
Zeiss triplet	A	170	1200	200 × 200	170	16.5	pg	1923-1971	7970	FP	
Zeiss triplet	F	140	700	100 × 150	300	16	pv	1928-1969	6241	FP	
Zeiss quadruplet	GA,GB,GC	400	1600,2000	300 × 300	100,130	17.5	pg	1938-1998	≈21000	FP	Astrograph
Schmidt telescope	Sc	500/700	1720	130 × 130	120	18	pg	1952-1993	8733	FP	Partly objective prism
Double Schmidt tel.	DS	200/300	300	60 × 60	690	16	pg	1960-1976	5310		Circular field
Ernemann Ernostar	E,E2,E3	135	240	130 × 180	860	14-13.5	pg	1926-1957	22766	SP	
Tachar	T, Ta	100	250	90 × 120	830	12.5	pg	1934-1956	7035	SP	
Zeiss Triotar	L, Tr	60	210	90 × 120	980	12.5	pg	1941-1953	3655	SP	
Zeiss Tessar	Te1-Te10	47-71	250	130 × 130	830	14.5	pg	1950-2010	≈120000	SP	
	Te19-Te23										
Zeiss Tessar	Te13-Te18	55	250	130 × 130	830	13.5	pv	1950-2010	≈65000	SP	
Steinheil objective	TA	400	5500	120 × 120	38	10	pg	1917-1938	1436		Toepfer astrograph Berlin Babelsberg
				16 × 16							
Petzval objective	B	400	1950	240 × 300	110	17.5	pg	1957-1959	1184	FP	Bruce astrograph (Heidelberg-Königsstuhl)
Zeiss quadruplet											
plates of the southern sky											
Zeiss triplet		300	1500	90 × 120				1926-1929	915		Kapteyn selected areas
				300 × 300							Objective prism
Zeiss Ernostar	UE, WE	133	240	130 × 180	860	13.5	pg	1934-1938	1975	SP	Windhoek Station
Zeiss Tessar		50	165	90 × 120	1250	13	pg	1952-1953	1912	SP	Southwest Africa
Metcalf telescope		250	1250	200 × 200	170	16.5	pg	1959	490		South Africa
Bache camera		200	1000	200 × 200	210	16.5	pg	1959	314		South Africa
Ross Tessar		75	300	200 × 200	690	14.5	pg	1959	95		South Africa

Table 1: The Principal Sonneberg Plate Series. (FP = Field Patrol, SP = Sky Patrol, pg = photographic (B), pv = photo-visual (V))