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THE FOUNDATION OF ‘SAINT VÉRAN–PAUL FELENBOK’ ASTRONOMICAL OBSERVATORY (1974)

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Abstract: This paper is dedicated to the memory of Dr. Paul Felenbok who was an astronomer at Paris-Meudon Observatory, and in 1974 founded a high-altitude observing station (2930 m), above Saint Véran village in the southern Alps (Queyras region of France). It was initially devoted to the study of the solar corona. After previous eclipses (1970, 1973) observed with the Lallemand electronic camera, the main goal was to investigate with this detector the structures of the far and hot corona in forbidden lines, using either narrow bandpass filters or spectroscopy. But everything had to be built prior to observations: a track to the observing station, a house to live in, a dome and a complex solar instrument. In this paper we summarize this adventure, which was partly successful in terms of scientific results but had to stop in 1982. However, activity at the station resumed after 1989 under the auspices of the ‘AstroQueyras’ association, which replaced the coronagraph with a 62-cm telescope on loan from Haute Provence observatory (OHP). The station was later extended with the installation of two 50-cm telescopes, and was rebuilt in 2015. It now receives visits from thousands of amateur astronomers every year.

Keywords: Sun; corona; prominences; instrumentation; coronagraph; coronameter; forbidden lines; Saint Véran–Paul Felenbok Observatory; electronic camera; amateur astronomers.

1 INTRODUCTION

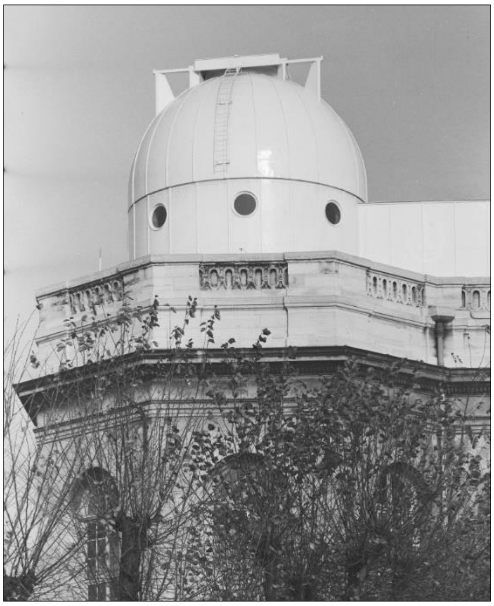
After the total solar eclipse of 30 June 1973 (Rösch, 1973, the famous eclipse of Mauritania chased during 74 minutes by the Concorde 001 prototype flying at 2200 km/h), the ‘Electronic Camera’ group of Paul Felenbok (1936–2020, Figure 1) at Paris-Meudon Observatory, planned to resume the observations of the solar corona with a Lallemand-type electronic (or electronographic) camera mounted on a mountain coronagraph. The solar corona is difficult to observe outside eclipses, which was why Lyot (1932) developed the coronagraph in order to eliminate as much as possible the parasitic light scattered by the lenses. In addition, high altitude stations are required to reduce the atmospheric atmospheric diffusion. Hence, Felenbok’s team had to find a suitable place and conceive an original instrument.

At that time Pic du Midi in the French Pyrénées (2870 m) was already considered as saturated—there was no free coronagraph, and there was no possibility of adding a heavy new instrument to an existing mount. While the construction of a new dedicated dome and mount would probably have been possible, the group preferred to look elsewhere. Indeed, preparations for the 1973 total eclipse took place in Auron, a ski resort in the southern Alps, at the top of the cable car, an easily accessible location. However, the National Institute of Astronomy and Geophysics (INAG) of the Centre National de la Recherche Scientifique (now INSU), reviewed possible new French observatory sites in 1970 and 1971 and identified ‘Pic de Château Renard’ (above Saint Véran) as the best option. In fact, INAG was looking for an excellent site for a 4-metre class telescope dedicated to astrophysics and, although this finally materialised as the Canada–France–Hawaii Telescope (CFHT) at the summit of Mauna Kea in Hawaii (Racine, 1981), in 1974 INAG recommended installing a coronagraph at Saint Véran. This marked the development of a new astronomical station in France for future small-to-medium-sized instruments, and the launch of a long-term program to monitor seeing.

2 THE 7-METRE DOME AT PARIS OBSERVATORY BEFORE ITS TRANSFER TO SAINT VÉRAN

Because this was not a national project, the budget for Saint Véran was rather limited and was only supported by Paris Observatory. A decision was made to dismount the unused

Figure 1*:* Paul Felenbok at the Sun’s house in Saint Véran village in 2016 (courtesy: Dominique Menel).



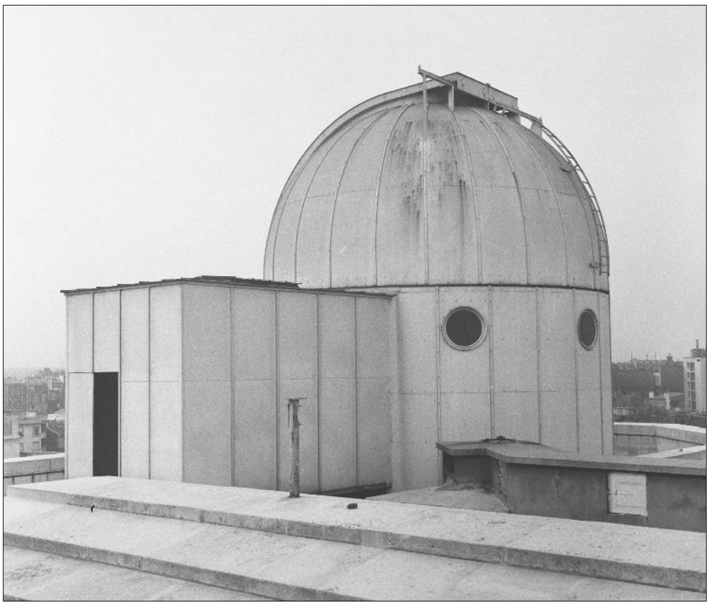


Figure 2 (left): The new metal 7-m dome of the West Tower at Paris Observatory in the 1950s (courtesy: Paris Observatory).

Figure 3 (right): The new dome in September 1961 (courtesy: Paris Observatory).

7-m dome located on the roof of the old 1667 'Perrault' building.

This dome has a long history (Véron, 2016), which began in 1857 when Urbain Le Verrier (1811–1877) decided to install an instrument on the west tower of Paris Observatory. A 7-m diameter wooden dome was ordered from Joseph Jean, a carpentry manufacturer, and delivered in 1858. Le Verrier equipped it with a 30-cm (f/17.5 refractor), which was built by Wilhelm Eichens (1818–1884), under the supervision of astronomer Antoine Yvon Villarceau (1813–1883). Although the telescope was completed in March 1858, 'first light' only occurred in October 1858. Villarceau considered that the objective was not of adequate quality, so it was corrected and the telescope finally was commissioned in November 1860. The mounting and drive were excellent, but the optics were not so good. A contract was then signed with the optician Adolphe Martin (1824–1896) for the supply of a new achromatic objective, and although it was delivered in 1878 it was not installed until 1884, when Paris Observatory astronomer Guillaume Bigourdan (1851–1932) noticed systematic errors induced by the original lens. During maintenance work, a fire started in July 1904, but it was quickly brought under control by the firefighters and repairs were undertaken. From 1933 to 1949, the medical doctor Paul Baize (1901–1995), a volunteer at the Observatory, carried out double star observations with the telescope. He later wrote:

> After the war, the dome, pierced in many places by flak, began to let the rain through. It was necessary to interrupt the observations, and, in January 1949, to dismantle the refractor. André Danjon (the director of Paris observatory) then offered me to go to the east tower, and to use the 38 cm equatorial. (Baize, 1987: 281; our English translation).

The wooden dome of 1858 was abandoned and in the 1950s was replaced by a new metal dome (Figures 2 and 3); this is the one that was transferred to Saint Véran in 1974. We have not been able to identify its manufacturer.

3 THE TRANSFER OF THE DOME FROM PARIS TO SAINT VÉRAN IN 1974

The selected place was 'Pic de Château Renard' (2930 m) above Saint Véran village (2040 m), near the city of Briançon. In June 1974 the 'Hautes Alpes' Administrative Department took arranged the construction of the access road (which was only usable in summer by 4-wheel drive). Paris Observatory provided the West tower dome, and INAG paid for a sheet metal house and the generators (because connection to the public electricity network was impossible at this altitude). Nice Observatory loaned an equatorial table. A 25-cm diameter 3-m focal length coronagraph (described below) was installed in October 1975.

The ex-Paris Observatory dome required the construction of a strong masonry foundation. Under the observation floor, there was a basement that was used as a workshop. A 5-m high metal annex, also with two levels, was attached to the dome. The opening in the cupola was 2.30-m wide and it rotated through 360°, both motions being manual. The dismantling, transport, and reassembly took almost two years: this operation started in summer 1974 and ended in autumn 1975. Gabriel Rousset (from Meudon) later wrote:

> We were in the presence of a rusty dome, having suffered from the dismantling and reassembly, with a rotating hard spot and a slight misalignment of the closing of the shutters; and zero impermeability to snow and condensation. To eliminate these defects, it was necessary to do many tasks, such as redo the painting, realign the rotation rollers to reduce the hard spot, eliminate snow infiltration with a system of skirts, deposit a water-proof coating on all joints and spray polyurethane on the inner wall of the dome to prevent water condensation. This work was spread over two summer campaigns (1975 - 1976), by which we had a more or less suitable dome, always having a defect in rotation and in closing the shutters. (Felenbok, n.d.; our English translation).

Successive stages in the construction are illustrated in Figures 4–7.

After 1977, the station included:

- The dome and its annex (Figures 8 and 9), plus the coronagraph (detailed below).
- A metal sheet house of 40 m² used as a living base, including kitchen, living room, bedroom, bathroom, which could accommodate four people. It was heated by gas (twelve bottles of 37 kg); water (non-drinkable) was delivered by tanks (14000 litres), and electricity was produced by fuel generators.
- A second metal hut of 15 m² for the liquid nitrogen liquefier (which in fact was never used).
- A technical hut containing 3 generators of 4, 6 and 10 KVA, as well as a small generator of 1 KVA for domestic use; the fuel tank (3000 litres) was installed underneath.
- An iron tunnel connecting the dome to the living base and a second one to the nitrogen liquefier hut.
- A radio-telephone line lent by the administration of the 'Hautes Alpes' Department.

The construction of the station and assembly of the dome and coronagraph required the active participation of many people, such as Remy Bellenger (optics, electronics), Yves Zéau (logistics), Jean-Pierre Dupin (electronics), Gabriel Rousset and Isidore Raulet (mechanics), Annick Fayet, Jean Guérin, Mireille Dantel and Jacques Baudrand (instrumentation), Christiane Jouan (administration). Many inhabitants of Saint Véran village (such as Joseph Brunet, Jacques Jouve, Pierre Prieur-Blanc) helped a lot, together with Jean-Eugène Chabaudie from Nice Observatory. Guérin was responsible for the instrument from 1975 to 1977 and Bellenger (Figure 10) from 1978 to 1982 (Bellenger, n.d.).

4 THE LALLEMAND ELECTRONIC CAMERA AND SOLAR OBSERVATIONS

In the early seventies, CCDs did not exist, so coronagraphs used photographic films. In order to observe faint coronal structures, some projects involving the André Lallemand electronographic camera were in progress. Its principle (Lallemand, 1937; Lallemand et al, 1960) is based on photo-electricity forming an electronic image on a specific emulsion, which made this camera much more sensitive than conventional photography. Fifty years of developments were summarized by Wlérick (1987) and recalled by Lequeux and Georgelin (2022). At Pic du Midi, imaging coronagraphs worked with argentic films, but the coronameters (dedicated to high precision photometry and polarimetry of coronal emission lines) used either photomultipliers or photodiodes (Arnaud, 1982; Charvin, 1965; Noens et al, 1984; Ratier, 1975); providing only single point measurements. This is why the Lallemand camera (native 2D field of view, photocathode as sensitive as photodiodes) was a major step to improve the observations. The first use of such a device on a coronagraph associated with a spectrograph was successfully experimented by Rozelot and Despiau (1972) at the Turret dome, Pic du Midi Observatory, which hosted a camera since 1960 for the one metre telescope. The first observations of a total eclipse with an electronic camera were made by Fort et al. (1972) in Mexico in 1970. Three years later, the Meudon camera group lined up two electronic cameras with electrostatic focusing at the 1973 eclipse in Mauritania (Picat et al., 1979), after having carried out tests at the top of the Auron cable car station in Alps; one camera was prepared for images and polarimetry in forbidden coronal lines, and the other one for spectroscopic studies; both experiments were conducted by Bernard Fort and Jean-Pierre Picat. It appeared natural to the group led by Paul Felenbok, to continue this strong technical and scientific investment with a mountain coronagraph at Saint Véran, a good site in perspective, but where the station had to be created from nothing.

Felenbok's team developed a new version of the Lallemand system, the electronic valve camera (Baudrand et al., 1972), a cross section of this camera is shown in Lequeux and George-

Figure 4: The house (left) and dome (right) under construction in the autumn of 1974 (courtesy: Paris Observatory).

Figure 5: The observatory (2930 m) under construction in autumn 1974. One sees the unfinished 7-m dome (1), the sheet metal house (2), a hut for temporary accommodation (3) and the yellow trailer that was used by INAG for site prospection (4) (photograph: Remy Bellenger).

Figure 6: Building the station in the summer of 1975. The heating of the house (left) was provided by gas, and electricity by fuel generators. The Mercedes Unimog U406 at left (a 4 × 4 truck) was owned by Joseph Brunet, an inhabitant of Saint Véran who helped a lot. The shelter (at right) was temporary (courtesy: Paris Observatory).

Figure 7: The completed station in 1977. One sees the two-storeyed 7-m dome and annex (1), the house (2), the double tunnel (3), the electric plant (4), the liquid nitrogen liquefier hut (5), the gas storage area (6), and the yellow trailer that was used by INAG for site testing (7) (courtesy: Paris Observatory).

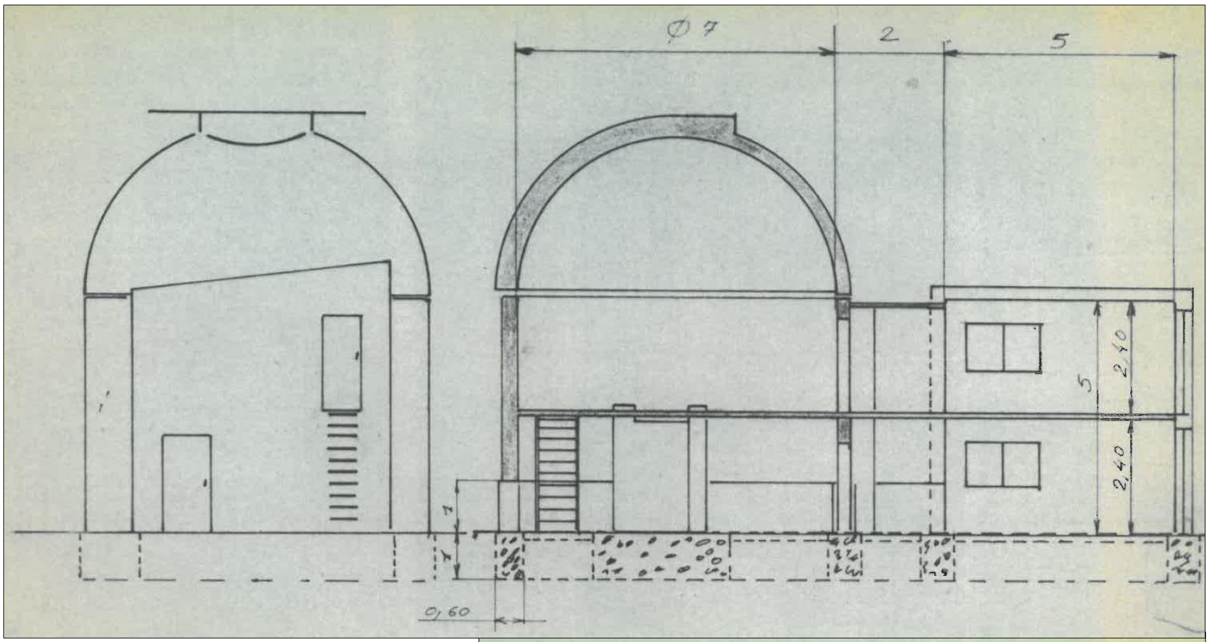


Figure 8 (top): The side elevation (left) and cross-section (right) of the dome and annex, both with two floors, including a workshop below the observing level. The height of the dome was 9 m, and its diameter 7 m. The technical annex was a square of 2 × 25 m^2 and 5 m high (courtesy: Paris Observatory).

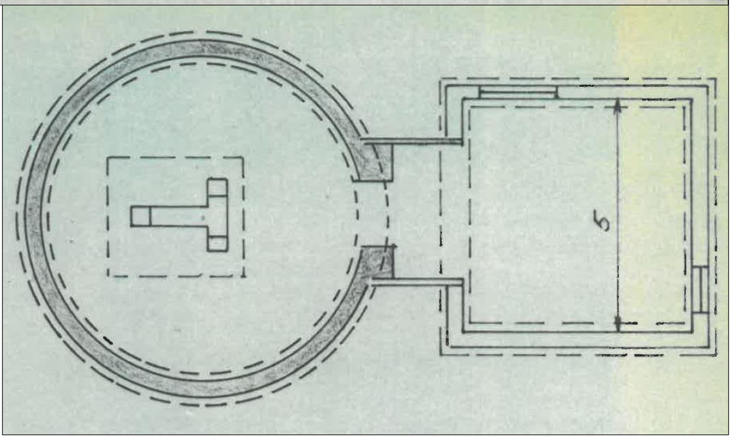


Figure 9 (right): A plan view of the 7-m dome and its annex (courtesy: Paris Observatory).

lin (2022). The valve avoided breaking the vacuum around the photo-cathode and electronic lenses during the change of nuclear plates (emulsions sensitive to the electrostatically focused electrons), and consequently prevented the discarding of the photocathode which had to be replaced each time the vacuum was broken. The issues of vacuum and cooling at low temperature (cryostat with liquid Nitrogen at 77 K to reduce degassing and thermal noise) were the major obstacles to the use of these delicate devices, especially in environments with reduced logistics. As solar structures may evolve rapidly (a minute for coronal mass ejections), it was also essential to have many plates on the same holder. Unfortunately, the Saint Véran prototype did not work properly due to unsolved problems of the vacuum, and the first successful valve camera of the group was the next one, but it was built for the CFHT (more than

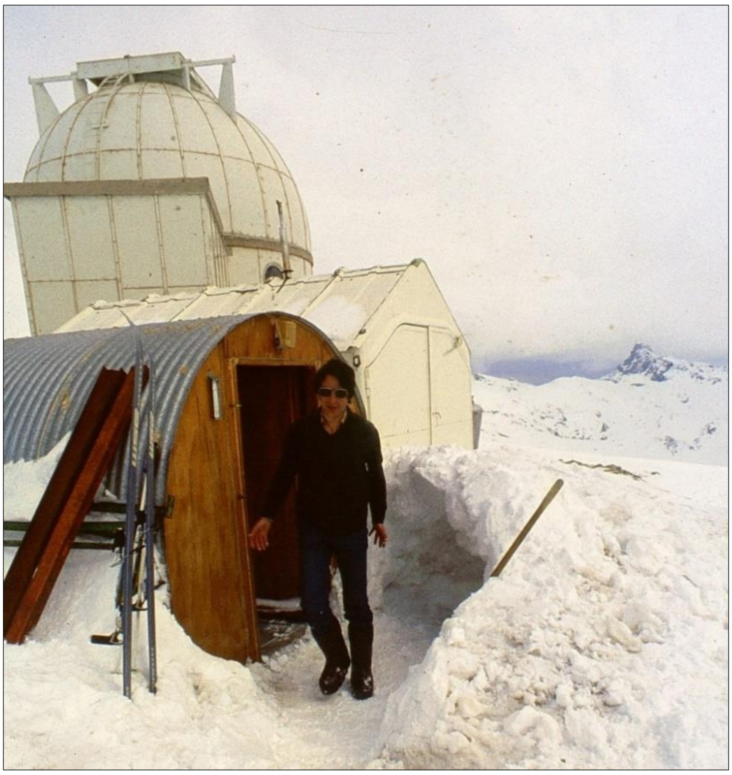


Figure 10 (right): Remy Bellenger in 1980, when he was responsible for the Saint Véran Observatory (courtesy: Mireille Dantel).

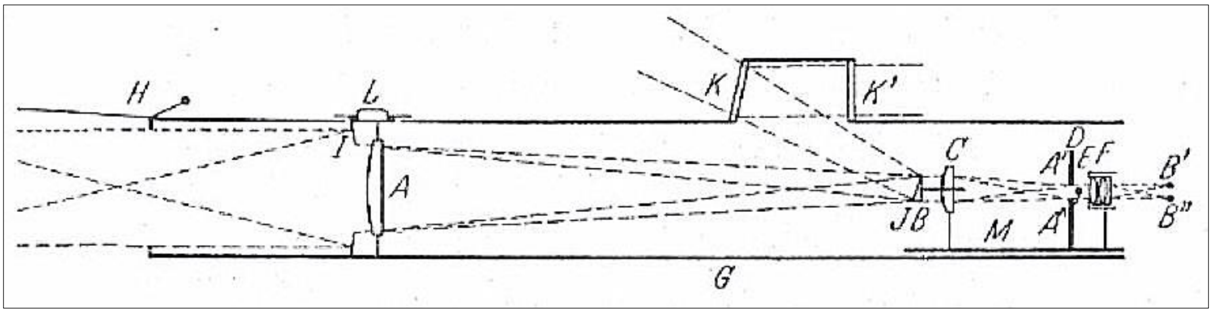


Figure 11: Diagram of the coronagraph (after Lyot, 1932). The occulting mask or cone B is at the primary focus of lens A, followed by the field lens C which forms a pupil image of lens A, cut by the diaphragm D to eliminate edge diffraction. There is a small circular mask E (the Lyot stop) to remove the secondary image formed by the internal reflections in lens A. F is an objective focusing the coronal image on the detector B’B”. K is the light of the disk.

one thousand images of galaxies were obtained at the CFHT prime focus with this valve camera, according to Wlérick, 1987).

5 THE CORONAGRAPH AT SAINT VÉRAN

Let us recall first the principles of the coronagraph (Dollfus, 1983). It was fully explained by Lyot (1932) but there exist more recent descriptions for non-specialists (Crifo, 1981; Detwiller and Noëns, 2008; Lequeux and Georgelin, 2022). It is a more subtle instrument (Figure 11) than a classical refractor. Indeed, the corona is 10^6 times less luminous than the solar disk, whose light produces parasitic light. First of all, there is the diffusion by the dust of the sky and the molecules; it will therefore be better to observe towards the red, because Rayleigh scattering dominates in the blue. At the primary focus, a reflecting cone obscures the solar disk; but there is a secondary focus, resulting from two internal parasitic reflections (with attenuation factor $R = 0.04^2$). This secondary focus has a short focal length, equal to f/7 (for the refractive index $n = 1.5$), if f is the focal length of the entrance lens (Dettwiller and Noens, 2008). Finally, the diffraction of light by the contours of the objective must be eliminated in the pupil plane. After removing these defects, an image of the corona forms on the detector; a photographic plate for the low corona is sufficient, but a more sensitive device is necessary for the outer corona in good sky conditions.

Paul Felenbok left us an optical diagram (Figure 12) of St Véran’s coronagraph built according to the Lyot design (this was a standard coronagraph, except the detectors based on Lallemand cameras). The objective is a single lens with a diameter of 25 cm and a focal length of 300 cm. The solar image at the primary focus has a diameter of 2.8 cm. On exit, the train of two lenses contains a narrowband interference filter (a few Angström wide) isolating a coronal emission line. It is an afocal system (0.5 magnification) of two converging lenses; the filter is crossed by a beam of parallel rays; the second lens forms an image of the corona at the image focus denoted F. The equivalent focal length of the coronagraph is 300 × 0.5 = 150 cm, which means that the masked solar disk has a diameter of 1.4 cm on exit. All lenses are made of borosilicate glass BSC 16-64.

At the exit focus F of Figure 12, an electronic camera of Lallemand-type could be installed, or a conventional 35 mm photographic film. A small spectrograph could also be inserted. It was first designed for the 1973 eclipse in Mauritania and was re-used. It had a magnification of 0.67, a grating of 10 × 10 cm², 600 grooves/mm, providing the dispersion of 12 Å/mm in the second order, and a spectral resolution of 0.3 Å. The useful spectral domain was the 3000 Å to 11000 Å range. The detector was in all cases either a standard or nuclear emulsion (for the electronic camera). The development of the plates was locally done; but the digitization was performed after the missions, with a micro densitometer (such as the Joyce at Meudon or the PDS-Perkin Elmer of Institut d’Optique at Orsay), allowing to measure the photographic densities and convert them into numerical values that could be processed by a computer (at that time, the IBM 360/65 of INAG was available in Meudon, together with a PDP 11/34 running the software of the Centre de Dépouillement des Clichés Astronomiques, the CDCA system developed at Nice by Albert Bijaoui). Figure 13 shows the coronagraph being assembled in Meudon, and the optical details are explained in Figure 14.

The coronagraph is shown in Figure 15 after being transported to Saint Véran in October 1975, while Figures 16 and 17 display some examples of observations. The scientific program was based on the outstanding sensitivity of the electronic valve camera. Felenbok (n.d.) wrote:

> … the preferred detectors are the electronic camera or the photomultiplier, whose photometric properties allow to

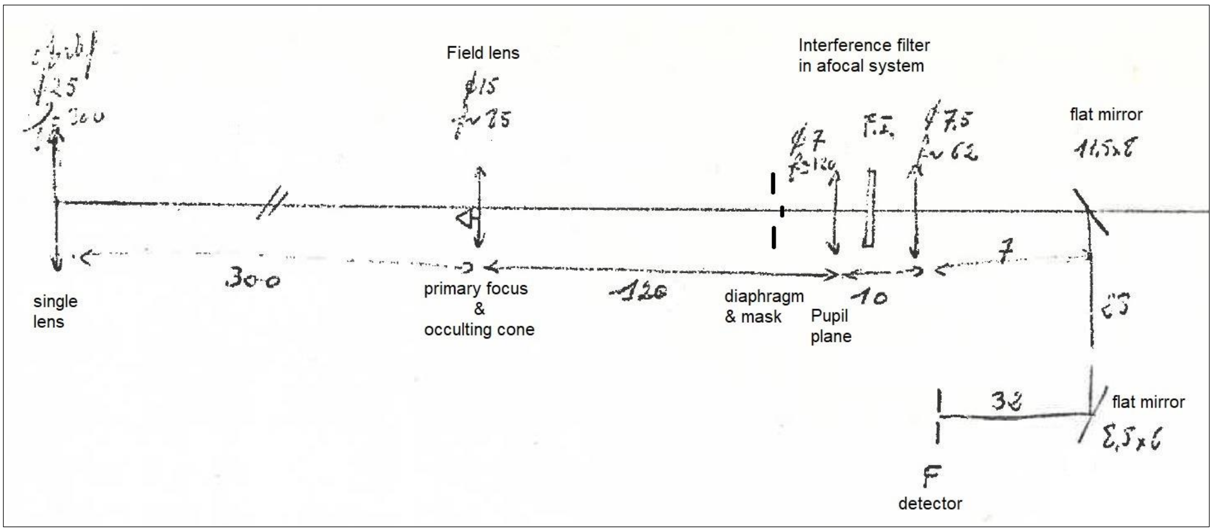


Figure 12: Diagram of the coronagraph of Saint Véran (after Paul Felenbok’s (n.d.) original drawing). The optical elements are located, along the z-optical axis, at the following positions:

z = 0 cm, entrance objective L1, single lens Ø 25 cm, f = 300 cm (plano-convex, R = 1558 mm)
43 cm, secondary focus (from two internal reflections), image Ø 0.4 cm
300 cm, primary focus, image Ø 2.8 cm, occulting cone, and field lens L2 (f = 85 cm, bi-convex, $R_1 = R_2$ = 878 mm, Ø 15 cm)
300 + 118 cm, pupil plane Ø 10 cm, Lyot diaphragm Ø 6.4 cm, Lyot stop Ø 0.2 cm (mask)
300 + 120 cm, L3, 1st lens of the afocal system, f = 120 cm (plano-convex, R = 612 mm, Ø 7 cm)
300 + 125 cm, narrow band interference filter (with oven for temperature control)
300 + 130 cm, L4, 2nd lens of the afocal system, f = 62 cm (plano-convex, R = 321.5 mm, Ø 7.5 cm)
300 + 130 + 62 cm, exit image, equivalent focal length = 150 cm, solar diameter Ø 1.4 cm

increase the observation height in the corona and the spectral field compared to conventional photometry.

Hence, the goal was to explore the hot corona at large distances from the Sun to improve our knowledge of hot magnetic loops and MHD instabilities driving coronal mass ejections (CMEs). For that purpose, it was necessary to acquire monochromatic images in the green and red forbidden lines (FeXIV 5303 Å, FeX 6374 Å, respectively at 1.8 10^6 K and 1.0 10^6 K) up to 0.4 solar radii from the limb, and even 0.8 radii using the IR lines of FeXIII (10747 Å and 10798 Å at 1.6 10^6 K). Such observations of neighbouring ions give access to the temperature (the ratio of the FeXIII to the FeXIV intensities) and electron density (the ratio of the FeXIII lines) using various diagnostics (Pasachoff et al., 1976; Srivastava et al., 2007). Meanwhile, the direction of the magnetic field can be found by measuring the linear polarization of the FeXIII 10747 Å and FeXIV 5303 Å lines (Picat et al., 1979).

Observations of cold prominences and their coronal interface were also made, in order to study the condensation process, plasma mo-

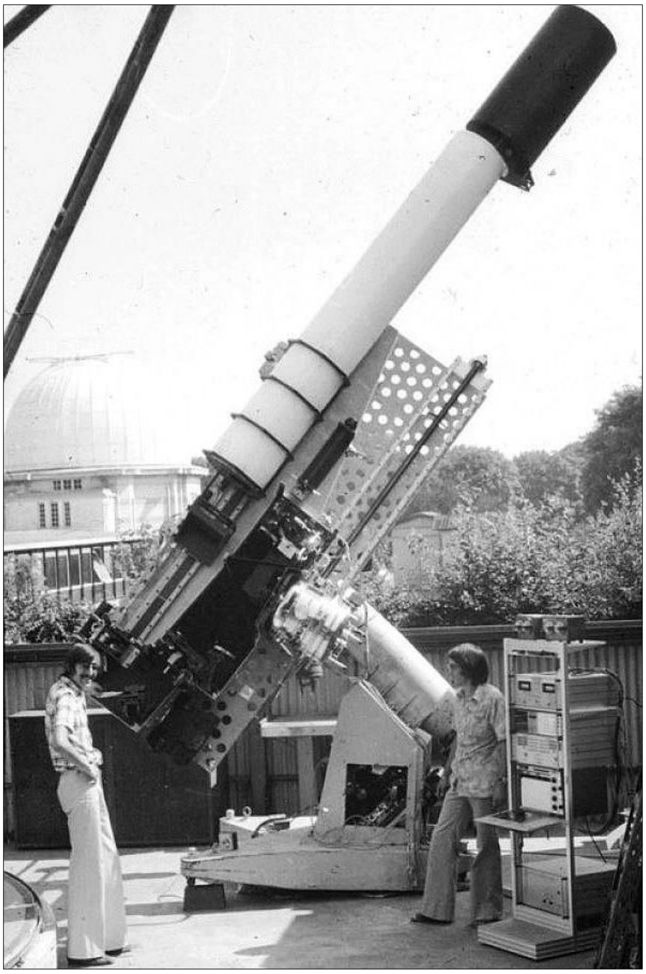


Figure 13 (left): The coronagraph with the electronic valve camera at the spectroscopic exit, assembled in Meudon, with Laporte (left) and Jean-Pierre Dupin (right) (courtesy: Paris Observatory).

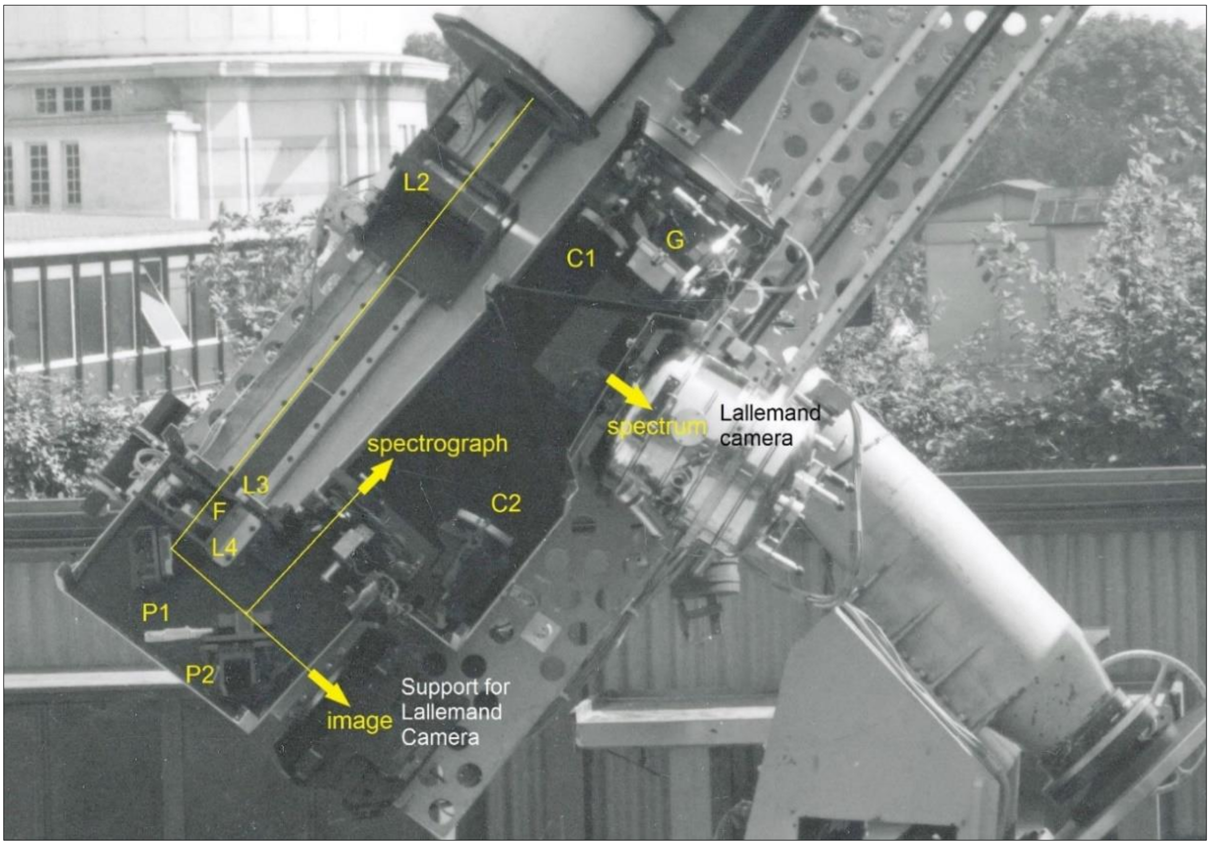


Figure 14: Detail of Figure 14. L2 = field lens (f = 85 cm); L3 (f = 120 cm), L4 (f = 62 cm) = afocal system with interference filter denoted F; P1, P2 = plane mirrors (P2 is shifted in imagery mode); C1, C2 = spectrograph collimator (f = 90 cm) and chamber (f = 60 cm); G = grating 600 grooves/mm. The electronic camera is mounted here at the spectrum focus but may also be used in imagery mode (courtesy: Paris Observatory).

tion, oscillations (and even magnetic fields through the Hanle Effect) with the Hα line (10^4 K) and the red line of FeX 6374 Å (10^6 K), as shown by the filtergrams (monochromatic images) in Figure 17.

6 WHY THE SAINT VÉRAN OPERATION WAS NOT A FULL SCIENTIFIC SUCCESS

Two young scientific researchers (retired today) of CNRS, from Meudon, worked with the coronagraph in collaboration with Paul Felenbok. They were Jean-Pierre Picat and Françoise Crifo. It was certainly a very difficult task for them, because we did not find, unfortunately, any scientific publications based on Saint Véran observations. The electronic valve camera never worked properly, because of vacuum issues, so it was necessary to return to a classic Canon 35 mm reflex camera with a motorized magazine of 250 frames to produce spectra and coronal images such as those reproduced in Figures 16 and 17, showing that the coronagraph worked perfectly. But obser-

Figure 15: Mireille Dantel making adjustments to the coronagraph at Saint Véran Observatory in 1980. The transparent screen at the top of the tube was removed before observations were made (courtesy: Remy Bellenger).

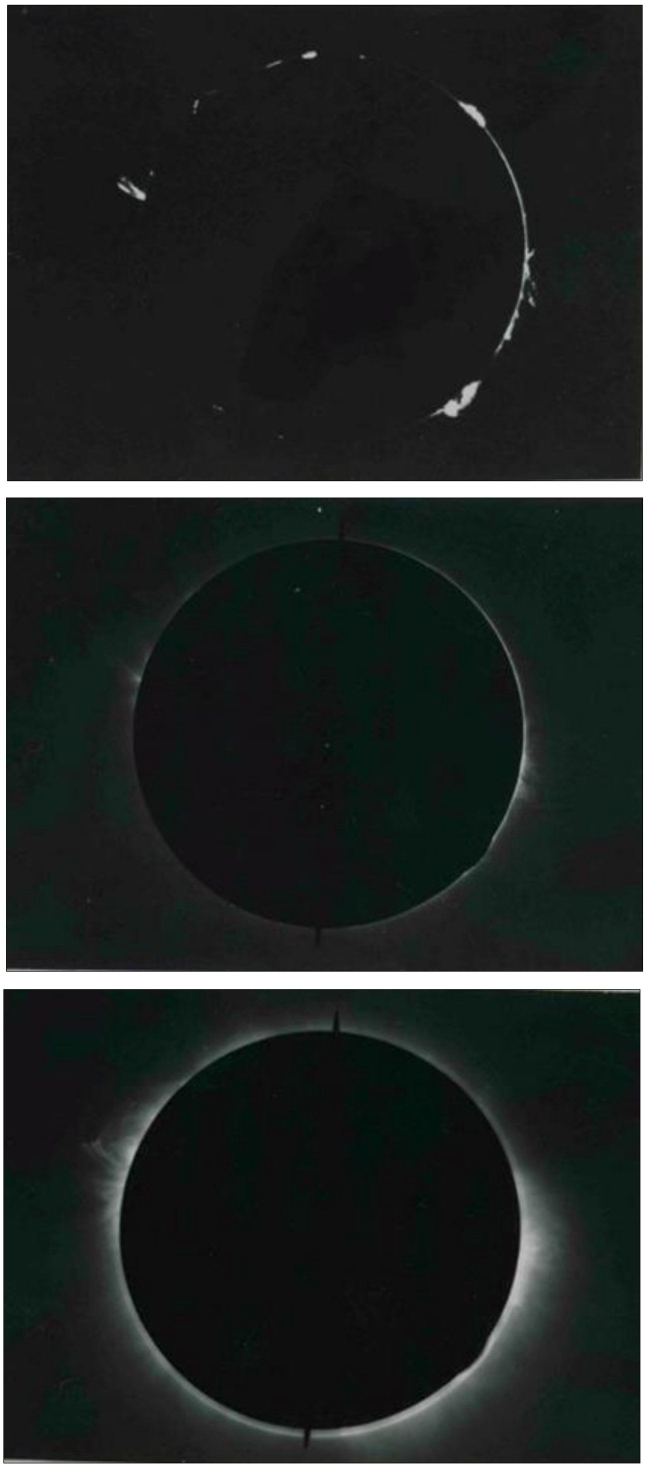


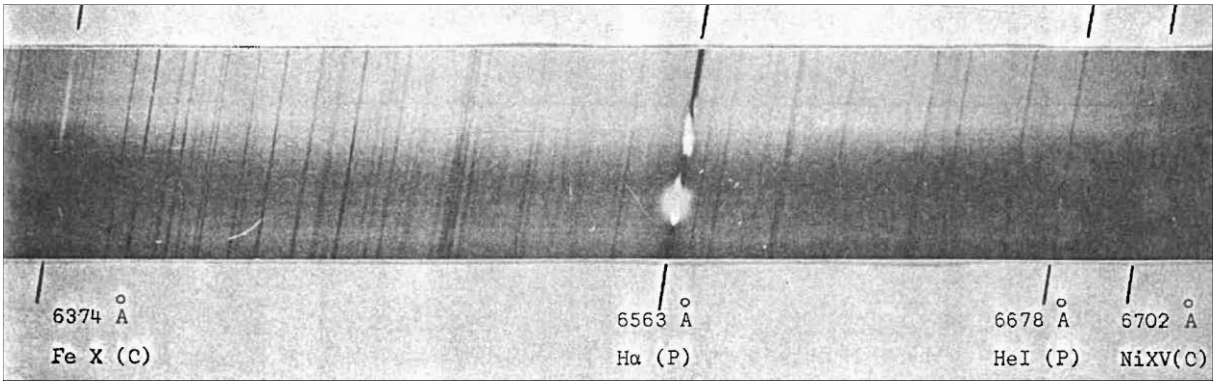
Figure 16 (left): Monochromatic images of the corona and prominences (30 October 1980, 9:00 UT) with narrow bandpass filters, obtained in usual photography with the Saint Véran coronagraph. (a) cold corona (prominences), Hα 6563 Å, 10^4 K; (b) hot corona, Fe X 6374 Å, 10^6 K (red line); (c) Fe XIV 5303 Å, 1.8 × 10^6 K (green line) (courtesy: Paris Observatory).

vations with such a detector, or with photoelectric coronameters, were common in other places (such as Pic du Midi).

We saw that the coronagraph project at Saint Véran was a continuation of the total eclipse missions of 1970 and 1973 with electronic cameras. During an eclipse, the sky is dark, and it is possible to observe the outer corona at several solar radii. This was the purpose of the Lallemand camera, which was invented for night time observations of faint deep-sky objects. Trying to detect coronal structures far from the Sun, in the forbidden lines of iron, with a device that was much more sensitive than photographic films, was a truly original and audacious goal. But we think that the choice of the electronic camera, a tool with severe constraints of vacuum and cooling, was probably too ambitious for Saint Véran, because of the lack of logistics, and human and financial resources. This was especially the case when one had to ensure the beginning from nothing of a new mountain station with complicated access and no permanent local staff. Rozelot already mentioned difficulties in 1972, even at Pic du Midi (where working conditions were much better). Classical photography, introduced in 1979, saved the project, but it was no longer as innovative compared to what was done elsewhere.

We should also notice the growing competition from space, at first with instruments using

Figure 17 (below): Spectrum of the hot corona (C) and prominences (P) obtained in usual photography at Saint Véran on 4 October 1977. The red line of Fe X corresponds to T = 10^6 K, that of Ni XV to 2.3 10^6 K. The prominences, visible in Hα or HeI, are 100 times cooler (10^4 K) and much brighter than the hot corona (courtesy: Paris Observatory).



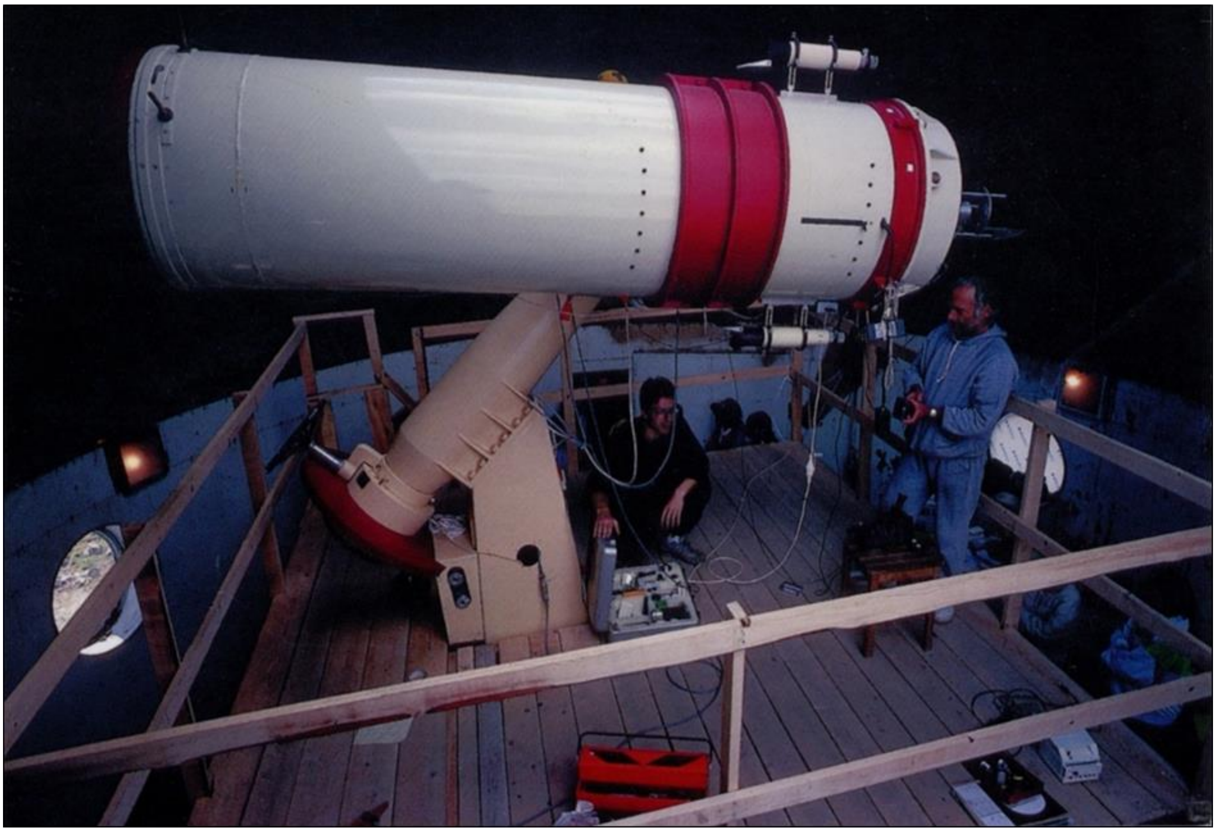


Figure 18: The 62-cm telescope that replaced the coronagraph in the 7-m dome at Saint Véran (courtesy: Paris Observatory).

35-mm film, such as the white-light coronagraph onboard SKYLAB/NASA (Apollo Telescope Mount—the ATM platform) from 1973 to 1979 (MacQueen et al., 1974), then those equipped with vidicon tubes, such as the Solar Maximum Mission (SMM) coronagraph after 1980, with on-board and real-time digitization (MacQueen et al., 1980).

The beginning of the CFHT in Hawaii in 1979 undoubtedly precipitated the rapid end of the Saint Véran project, as the team published its first CFHT scientific results and a revised model of the electronic valve camera as early as 1982 (Baudrand et al., 1982; Picat et al., 1982). The Saint Véran coronagraph lasted only a few years, due to the camera's failure and hostile local conditions in which to try and operate such a sophisticated instrument.

The future of the 7-m dome was then questioned, and in the 1981 expert report by Gabriel Rousset (Felenbok, n.d.; our English translation), we read:

> … a new dismantling and reassembly of this dome, if not impossible, presents great difficulties. Indeed, such an operation cannot be conceived without: (a) a complete review of the dome rotation and its driving system; (b) a complete overhaul of the slit opening and closing system; (c) redoing the polyurethane spray that would be completely destroyed by the dismantling, and repainting. Because of these major problems, I think that such a project cannot provide a serious, fast and economical means available to researchers.

As a consequence, the coronagraph was removed, but the dome and the house remained on the site, which was unoccupied for several years.

7 THE HERITAGE: TOWARDS A SECOND LIFE FOR THE OBSERVATORY

The second life of Saint Véran Observatory began after a visit by Paul Felenbok and Jacques Léorat in the summer of 1988: they were surprised to see the good condition of the facilities after six years of closure. Léorat then tried to interest amateur astronomers in arranging an agreement with Paris Observatory. The next step occurred in 1989 when the AstroQueyras association of amateur astronomers was created and took charge of the Saint Véran field station. In the 7-m dome they installed a 62-cm Cassegrain telescope (Figure 18), on loan from l'Observatoire de Haute Provence (OHP), which was available to amateurs from 1990 onwards (Menel, 2017).

Figure 19: Saint Véran Observatory after reconstruction in 2015 (courtesy: Dominique Menel).

The high-altitude observatory developed progressively with the addition of two further domes, both with 50cm telescopes. In 2015, the capacity of the station was extended from 6 to 18 visitors when the living area was totally rebuilt (Figure 19). Solar photovoltaic panels now provided electric energy.

In parallel, 'La Maison du Soleil' (The House of the Sun), was open in Saint Véran village in 2016, in collaboration with Paris Observatory. This is a modern public interpretation centre devoted to the nature of the Sun. It includes professional instruments, operated by the local staff: a 40-cm coelostat (previously used by Deslandres in Meudon before 1908, Malherbe, 2023); a 30-cm solar refractor that produces a large white-light image (the lens was built by Henry Brothers in Paris and used by Janssen at Mont Blanc before 1905: Malherbe, 2022); and a 7-m Czerny-Turner type spectrograph, the SHARMOR. It demonstrates the Doppler Effect using Sodium lines. This powerful tool formerly used for the analysis of laboratory experiments at Meudon is a high-resolution spectrograph (5 mm/Angström) that is now fed by a 50-cm concave mirror that was used by Raymond Michard at Pic du Midi before 1965 (Mein and Mein, 2020). Paul Felenbok was in charge of the scientific conception and construction of all of these experiments, which were provided by Paris Observatory. He also defined the contents of the displays about the Sun.

Other high-altitude stations were founded by French astronomers at other mountain sites, which operated for ten years within the framework of specific objectives, and then were made available to amateur astronomers who took advantage of the infrastructure thus created. This was the case, for example, of the Chiran station (1910 m, Haute Provence) where a 1-metre telescope was temporarily installed by OHP in 1976. The Chiran is now managed by a local association. In the same area, Mount Mounier station (2800 m) was created by Nice Observatory (with a 38-cm refractor) at the end of the nineteenth century, but was dismantled during WWI. The only altitude site where professional and amateur astronomers seem to coexist today is Pic du Midi.

The situation is more or less similar for Swiss mountain sites. The Gornergrat (3100 m) hosted two optical telescopes and a radio antenna that were replaced by small instruments for academic or public outreach; the Jungfraujoch Sphinx (3570 m) hosted a 76-cm telescope that is no longer operational.

Modern professional astronomy now focuses on observations made using space missions, or giant ground-based telescopes that are easily accessed, in dry climates with good seeing conditions. Remote observing is increasingly becoming the norm.

8 CONCLUDING REMARKS

The foundation of the high altitude (2930 m) astronomical station at Saint Véran was a difficult adventure that was led by Paul Felenbok. Everything had to be constructed (e.g. an access road, a house and a dome) or else brought to the site (e.g. electricity and heating generators). The task was complicated by the altitude and the lack of human and financial resources.

The coronagraph project was innovative and original, as it was based on the electronic valve camera in order to explore the outer corona using faint emission lines. Unfortunately, the camera failed. At the same time, the pressure to use the new CFHT Telescope with an improved electronic camera was increasing, so the Saint Véran observing station was closed prematurely in 1982.

It is clear, forty years later, that this innovative undertaking was hampered by a lack of logistics and resources. Later, professional astronomers proposed that the Saint Véran observing station should be used for night-time research projects, with a 3-m polar telescope (POST, 1990) or more recently a 1-m robotic telescope, but they were either not selected or else were not built there because of challenging working conditions. An automated solar telescope (MeteoSpace) was also proposed in 2015, but this was finally installed on the Calern plateau at the Côte d’Azur Observatory. The main issue with telescopes that operate remotely or automatically in environments similar to Saint Véran is the access and the lack of permanent staff in case of equipment failure.

That said, amateur astronomers succeeded in developing the Saint Véran facility after 1989, and they now have a 62-cm and two 50-cm telescopes there. The accommodation capacity increased in 2015, thanks to local and European grants, allowing members of the public to visit and observe for one night. Meanwhile, in 2016, the House of the Sun was opened in Saint Véran village, in close collaboration with Paris Observatory. The high-altitude station is now officially called ‘Saint Véran—Paul Felenbok’ Astronomical Observatory.

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