The François-Xavier Bagnoud Observatory

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Abstract The François-Xavier Bagnoud Observatory (FXBO), inaugurated in 1995, stands at an altitude of 2,195 meters (7,200 feet). Located on a site renowned for the purity and stillness of the air, it is easily accessible via a funicular. Equipped with numerous instruments (a 60-cm reflecting telescope, a 20-cm refracting telescope, a 16-cm coronograph, a coelostat, and four smaller instruments), it can be used day and night by schools and amateurs wishing to accomplish high quality work and can be of interest, as well, for general public demonstrations. The aims of the present paper are: 1) to present the background of how this observatory came into existence, 2) to describe the main characteristics of the equipment (presently available and foreseen in the future), 3) to propose pedagogical activities which can be performed with the present installations, and finally 4) to discuss some future developments.

1. A short history of the observatory

1.1. The observatory: a comet's present

The astronomical events at St-Luc began with the most recent return of Halley's Comet in our evening sky. On this occasion a small group of friends organized a conference at Tignousa above St-Luc, followed by small-instrument observations of the comet and other Solar System objects. On the night of 3 January 1986, 250 persons braved the freezing cold to attend the first astronomical evening organized there. The comet was not so spectacular, but it nevertheless brought the participants a marvelous present: the encouragement to pursue the organization of several astronomical evenings. Soon after, these conferences followed by observations made St-Luc a village known for its astronomical events, and this holiday resort became the village of the (real) stars!

1.2. Planets among the cows

In August 1989, the St-Luc planetary trail was inaugurated. This six-kilometer walk through alpine pastureland offers the opportunity to visit the nine planets of our Solar System. Two scales are used: the first one, for the distance between the planets, is 1 meter = 1 million km, and the second one, for the diameters of the planets, is 1 cm = 1000 km. On this scale, the earth is represented by a 12-cm diameter sphere, Jupiter by a 1.4-meter sphere, while the Sun is a 14-meter diameter horizontal sundial. The starting point of this planetary trail is located about 200 m from the arrival station of the St-Luc-Tignousa funicular.

A special feature of this installation is the attention given in designing the supports of the planets. Each station is unique and the artist in charge of the design (Jacques Zufferey) brought fantasy and originality to this pedagogical and touristic project. At the same time, another astronomical attraction opened in the village. An old wooden chalet was transformed into a "stellarium," which is a 3-meter diameter hemisphere inside which the northern (and part of the southern) constellations have been painted. Phosphorescent paint was used so that, in the dark, visitors see the sky almost as if it were a very clear night without moonlight!

1.3. The opening of the François-Xavier Bagnoud Observatory

The François-Xavier Bagnoud Observatory was inaugurated in August 1995. This crowning achievement of many years of astronomical activities in St-Luc would have been impossible without the support of the François-Xavier Bagnoud Association. The FXBO opening was celebrated during three days of festivities attended by 10,000 people.

2. The site, the instruments, and the facilities

2.1. The site: 46° 10' N, 7° 35' E

The Observatory is located at an altitude of 2,195 meters (7,200 feet) in a place called Tignousa. It may be reached quite easily from St-Luc via a three-minute funicular ride. The observatory offers a wide view of the horizon. In the northern direction the sight is limited: due to the mountains, the first nineteen degrees above the horizon are lost. Consequently, the celestial bodies which can be observed during the whole night all year long have a declination between +65 and +90 degrees. In the eastern direction, the first ten to fourteen degrees are occulted by the Alps, while to the south and the west the viewpath is completely clear.

From an astronomical point of view, the site ranks among the very best in Central Europe. Protected from the wet weather coming from the south and the north by the barrier of the Alps, it benefits from generally dry and sunny weather. It is estimated that yearly, on average, 55% of the nights are at least partly clear enough to allow for astronomical observations, and 140 nights per year are of good astronomical quality. The best periods for observing are the beginning of autumn and winter. In addition to good meteorological conditions, the site is far away from any big city, thus avoiding intense light pollution.

2.2. Instruments for night and day observations

Table 1 summarizes the characteristics of the four most important instruments at FXBO. In addition, three small Zeiss Telemator (6-cm refractors) and one Celestron 8 are available. A more detailed description of the instruments listed in Table 1 follows.

2.3. The T60 telescope

This 1.2-ton instrument on an equatorial mount is driven electrically (see Figure 1). The automatic tracking has been improved in order to permit exposures more than 10 minutes. Two cogwheels (480 teeth) on the right ascension and declination axes with optical encoders allow computer-controlled pointing (with an accuracy of a few tenths of an arcsec).

The accuracy of the optics lies between $\lambda/15$ and $\lambda/20$. The secondary is made of Zerodur, the primary of E6-glass. Mirrors were aluminized and coated with a silicon oxide layer. An ingenious system allows the user to switch from the Cassegrain to the Newton configuration within a minute. A small 9 × 60 mm Meade refractor and a Telrad are used as finders.

2.4. The Schaer and the coronograph

These two instruments are set up in parallel on an electronically-driven equatorial mount (see Figure 2). The rate of accuracy of the automatic tracking is better than 3" in one minute. A filter limiting sunlight penetration to 1/100,000 transforms the Schaer refractor into a very interesting instrument complementary to the coronograph. This last instrument is equipped with an interference filter centered on Hα (4Å width). Different eyepieces (a binocular 1" 1/4, Plössl 40 26 mm, Nagler 20 mm 2", Panoptic 35 mm 2", Clavé 65 mm 2", Barlow 2 × 2") can be used with these two instruments and with the T60.

2.5. The coelostat

Fixed onto an electrically-driven equatorial mount, this coelostat displays a 1.1-m diameter image of the Sun on a screen in the auditorium. A mild vacuum can be produced along the light path in order to stabilize the image. It is possible to switch from the image of the solar photosphere to the spectrum of the sunlight. The main solar absorption lines can be seen on a 4-foot long, 2-inch wide band.

2.6. Other facilities

A photo laboratory is available for developing black and white film. The observatory owns a small multi-media library with books, atlases, maps, slide collections, videos, and computer simulations. The small auditorium, which accommodates thirty-five visitors, is equipped with a slide projector and a viewgraph projector, as well as a video projector. This last device allows not only the projection of video films but also the projection of computer simulation programs. It is also possible to present color images obtained with the CCD camera on the T60 in the auditorium.

Currently, the observatory uses three interlinked computers. One is used only for automatic pointing and tracking of the T60. The second one will be used for remote control of the telescope and for data acquisition. Finally, the third is a graphic station (DEC Pentium 90 Mhz) which will serve to process the images of the CCD camera (IRAF is the software presently used for that purpose). A modem (28,800 bps) links these computers with the rest of the world via the Internet. A color printer (HP 1200C/PS) has also been installed. Data are archived on optical disks (CD-R, 650 Mb). A workshop, a small kitchen, and 6 sleeping berths complete the accommodations.

3. A visit to the FXBO: a pedagogical experience

The main aim of the FXBO is to offer a first exposure to astronomy. The observatory is particularly well-equipped for receiving young pupils who can be entertained by intelligent observations of the night sky and the manipulation of small instruments. In the near future, the FXBO will also be dedicated to high-quality observations by experienced amateurs and professionals using up-to-date detectors (see section 4 below).

In order to describe some of the possibilities offered by the various installations, let us imagine that we are following a school visiting the FXBO. The tour begins with a look at the stellarium where the students learn what the celestial equator and the ecliptic are, how celestial coordinates are defined, the shape of the constellations, how to recognize the most brilliant stars, and where the Milky Way is. Then they will be told that, in contradiction to this two-dimensional representation of the sky where all the stars appear to be at the same distance from the center of the sphere, there is a third dimension, and that the exploration of this third dimension is a very long story beginning with the most ancient civilizations and pursued today with the Hubble Space Telescope, the HIPPARCOS satellite....

In Tignousa, the pupils discover that the building hosting the observatory is itself an astronomical instrument (the building was designed by a young talented architect, Claire Mollet). The large triangle (see Figure 3) located at the North is oriented along the North-South direction. Its hypotenuse is parallel to the earth's rotational axis. The projected shadow falls onto a big sundial where it is possible to read the real solar time at a rate of precision on the order of one minute. Analemmas enable conversion from real solar time to mean solar time. At night it can serve as a pointer to the North Star. The children thus learn that for a long time the sky was the only clock and compass available to human beings.

The pupils then have a look at the Sun in three different ways:

1) They first have a look at the photosphere on a screen in the auditorium where, thanks to the coelostat, a 1.1-m diameter image of the Sun is projected. Observations of sunspots, and of the progressive darkening from the center to the limb can be immediately performed. One can, of course, imagine more sophisticated observations being performed during astronomical camps lasting for a few days—for instance, observing the differential rotation of the Sun.

2) Then a very simple manipulation permits projecting on the same screen an image of the solar spectrum. The numerous dark lines superposed on the rainbow require some explanation and provide an opportunity to explain the basics of spectroscopy. It is interesting to measure the temperature when a sensitive thermometer is moved along the different colors of the spectrum. Amazingly, the highest temperatures are observed in a place where no colors are perceived by the human eye. This is the way William Herschel discovered what is known today as infrared radiation.

3) Our group then goes up on the roof of the auditorium where it can discover a third aspect of our Sun. The coronograph will give them a direct look at the prominences and flares occurring on the surface of the Sun, demonstrating that despite its apparent calmness, our Sun hosts cataclysmic processes. A comparison between the extensions of these prominences with the known diameter of the Sun allows direct evaluation of their heights. In tandem with the coronograph, the Schaer refractor equipped with its Sun filter offers a new opportunity to look at the photosphere.

After these observations of the Sun, our group begins its journey into the solar system, walking along the planetary trail. By measuring the walking time from one planet to the next one, pupils can try to check Kepler's third law, which states that the square of the orbital period (which is indicated on the pillar for each planet) is proportional to the third power of the mean distance to the Sun (which is proportional to the walking time). It is also certainly of interest to figure out where the asteroid belt, Halley's comet, or the star nearest to the Sun are at the scale of this model solar system. In addition to these astronomical aspects, the beauty of the landscape is an invitation to take a close look at our environment.

In the evening, pupils come back to the observatory. They learn in small groups how to set up an instrument on an equatorial mount. On the terrace of the observatory, three pillars equipped with electrical power may be used for that purpose. Comparisons of the images of solar system bodies given by the small 6-cm refractors, the 20-cm Celestron, and the 20-cm Schaer refractor enable them to discuss the respective qualities of these instruments.

The use of ephemerides, celestial maps, atlases, and computer programs (such as The Sky) can help the pupils organize their observations made with the T60 telescope. This part of their visit is dedicated to the observation of nebulae, globular clusters, and galaxies.

In case of bad weather, other types of activities can be organized (developing photographs, slides, video projections, computer simulations, preparing observational programs, and image processing).

4. Past and future activities

During its first two years the observatory has received tourists, schools, and other groups. It is open every Saturday and Sunday from mid-December until the end of April and from mid-May until the end of October. Moreover, during the holiday periods, Christmas, Easter, and so forth, it is open every day. A well-informed guide is in charge of assisting the observers and narrating the visits.

The FXBO received about 7,000 visitors in the last two years, 70% of them during the daytime. About one-third visited the observatory as members of a group. The weather statistics for this period corresponded well to what was expected (see section 2.1).

In the future, we would like the FXBO to become a place where one can learn the fundamentals of practical astronomy. This means that astronomical lectures focused on various subjects like astrophotography, CCD astronomy, and elementary spectroscopy/photometry must be organized. Moreover, we would like to open the observatory to amateurs or even to professionals, who would perform their own observations.

4.1. The CCD camera

The CCD camera is of interest not only to advanced observers but also to the public. The possibility of seeing the changing aspects of the image as monocolor views are superposed on the screen in the auditorium certainly represents quite a spectacular and instructive perspective. For that purpose (and other ones of more scientific interest), the camera is equipped with *BVRI* filters.

Presently the observatory has a Hi-SIS 44 CCD camera (16 bits ADC, electronic noise less than 15 electrons, double-stage Peltier cooling system, and a proprietary high-speed parallel bus). The chip is a Kodak KAF-1600, with 1552 × 1032 pixels. The pixel size is 9 × 9 μm, thus the responsive surface is 14 × 9.3 mm. The field of view at the Newton Focus of the T60 is 23' × 15' (0.87" / pixel); 5' × 3.5' (0.2" / pixel) at the Cassegrain focus.

4.2. The low-resolution spectrograph

This instrument is the property of the University of Lausanne Astronomical Institute and of the Geneva Observatory, currently on loan to the St-Luc Observatory. Conceived initially by J.-F. Bopp from Geneva Observatory, it has been recently updated by M. Grenon and F. Taugwalder in view of its future use at St-Luc. It will be connected to the T60 by optical fibers and provide spectra with a resolution of $\lambda / \Delta\lambda \sim 1{,}200$ in the wavelength range of 470–850 nm.

This instrument will be of particular interest for the study of cool stars with large absorption molecular bands. It will also provide measurements of the quantity of water vapor above FXBO, an interesting bit of information on the photometric quality of the site!

5. Conclusion

Astronomy is a wonderful discipline through which to be introduced to science, and in this respect the FXBO offers myriad possibilities adapted for a varied public. In 1996, the Observatory had the luck of receiving Swiss astronaut Claude Nicollier as a visitor. He participated in the famous Hubble Space Telescope repair mission and was certainly thinking about this memorable experience when he wrote in the Observatory's "Golden Book" [guest book], "The means are different, but we follow the same dream."

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Table 1. Characteristics of FXBO instruments.

Instrument	*Type*	*Diameter*	*Focal Length*	*Construction*
Telescope	Newton-Cassegrain	60 cm	Cass. 9.6 m	S. Déconihout[a]
			Newt. 2.3 m	J. Mulherin[b]
				E. Ischi, B. Tartarat[c]
Schaer	Refractor	20 cm	4 m	Lichtenecker
Coronograph	Refractor	16 cm	2.4 m	S. Déconihout
Coelostat		11 cm	4.5 m	AOK[d]

[a]*Mechanics, Valmeca s.a.r.l., Lantelme, F-04700 Puimichel, France.*
[b]*Optics, Torus Precision Optics Inc., 67 Bon-Air, Iowa City, Iowa 52240 U.S.A.*
[c]*Electronics, Geneva Observatory, CH-1290 Sauverny, Switzerland.*
[d]*Astrooptik Kohler, Bahnhofstr. 63, CH-8620 Wetzikon, Switzerland.*

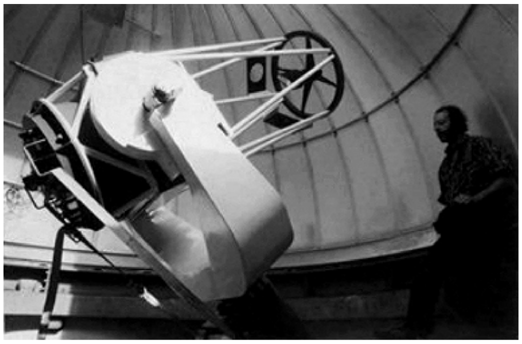

Figure 1. *above* The 60-cm reflecting telescope and its constructor Serge Déconihout.

Figure 2. The coronograph (instrument on the right) is a refracting telescope which can produce an artificial total solar eclipse through the insertion into the instrument of a small disc whose diameter matches the one of the image of the Sun produced by the coronograph. This instrument is mounted in parallel with the 20-cm Schaer-refracting telescope (on the left). In the back, Claude Nicollier, the Swiss astronaut, listens to the explanations of Michel Grenon.

Figure 3. The *François-Xavier Bagnoud* Observatory. The building itself is a summary of the history of astronomy, with the oldest astronomical instrument at the North (the large triangle aligned with the meridian serves as gnomon for a big sundial), and the most recent ones at the South (the dome houses a 60-cm telescope equipped with a CCD camera).