A hundred years of science at the Pic du Midi Observatory

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Abstract. The Pic du Midi Observatory, situated at an altitude of 2890 meters, was always very hard to reach, and living there was difficult. Its history is a lesson in courage. It is also a lesson in creativity, because astronomers took advantage of the remarkable quality of the site in many ways, to study planets and, later, to prepare for the Apollo missions. They also invited geophysicists, botanists, and cosmic ray physicists to conduct experiments there, and the Observatory became a successful center for multidisciplinary studies. The heroic period, which ended in 1952, is reviewed through the accomplishments of four directors, Célestin Vaussenat, Emile Marchand, Camille Dauzère and Jules Baillaud.

1. Introduction

The Pic du Midi Observatory is located at an altitude of 2890 meters (9470 feet) on an isolated summit of the Pyrénées range which separates France from Spain. Its largest instrument is the 2-meter Bernard Lyot telescope, which is mainly used for CCD imaging and spectroscopy; it is also equipped with a Nicmos infrared camera. Next is a 1-meter telescope, also equipped with CCD cameras, mainly used for planetary research. Several other domes house coronographs and other instruments for solar research; the site is one of the best in the world for solar observations, with long periods of stable and excellent (down to 0.3 arcsec) seeing in the morning and early afternoon. This Observatory is also open to amateur astronomers, and a 60-cm reflector is exclusively reserved for their projects. The summit also houses an important communication, radio and TV transmission center with a tall antenna.

The Pic du Midi Observatory has acquired its world wide fame from its remarkable astronomical achievements: the mapping of planetary surfaces, the determination of the period of rotation of Venus, the preparation of the Apollo Moon landings. Astronomy is presently the most important field of research conducted at this Observatory, but it was initially a meteorological station and, over the years, it has hosted research in many other scientific domains, such as Earth magnetism, atmospheric physics, seismology, natural radioactivity, glaciology, cosmic ray physics, botany, and, to a lesser extent, artificial radioactivity, physiology and medical research.

A review of the scientific results obtained at the Pic du Midi Observatory would certainly be very interesting, but, in this historical account, I will emphasize the scientists rather than the science. Living permanently and conducting
research at the Pic du Midi Observatory was undoubtedly difficult in view of the isolation and the altitude of the site. In the 1930’s, one of the staff members used to say that he lived a six hour walk away from France. Until the cable car was built in 1952, it took a lot of dedication to live permanently up there, at the expense of family life, as one could not go home every day or even every week-end, and of health. Poor heating and inadequate ventilation of the living quarters caused chronic bronchitis, and the poor diet, mainly composed of preserves, salted pork and the like, often caused digestive problems.

The history of the Pic du Midi Observatory actually started about 1000 feet below the summit, at the Sencours pass, where a temporary meteorological station was established in 1873. The two leading figures of the project were Charles Champion du Bois de Nansouty, a retired army general, and Célestin-Xavier Vaussenat, a construction engineer by trade. While Nansouty spent about eight years at the Sencours pass conducting daily routine meteorological observations, Vaussenat criss-crossed the country giving public conferences to raise money and find sponsors for their project, which was an entirely private initiative.

Construction of the Observatory at the summit started in 1878 and lasted 4 years, because it could only be conducted during the 4 months or so (mid-July to early or mid-October) that the summit was free of snow and easily accessible. The main concern of the founders was to protect the workers from lightning which frequently hit this isolated peak. Several lightning rods were installed, and linked to the nearby lake of Oncet by a metallic cable about a mile long.

The Observatory was inaugurated in August of 1882. At that point, the founders of the Observatory realized that they would never have enough funds to maintain their establishment. They thus offered to donate the Observatory to the State, on the condition that it would pay their debts and provide a yearly allowance of 30 000 francs, a large sum at the time, for the salary of the director and the maintenance of the site and its activities. Under the pressure of prominent politicians and scientists lobbied by Nansouty, the State accepted the donation; the establishment became a National Observatory supervised by the Central Bureau of Meteorology in Paris and Vaussenat became its first director. Nansouty retired to the city of Dax and never went back to the Pic du Midi.

2. Célestin Vaussenat (1882 - 1891)

Being an engineer and not a scientist, Vaussenat devoted most of his time and effort to expanding the Observatory. He razed most of the summit to make place for several terraces, built a storage house (later called the Vaussenat building) and the so-called “blockhaus” on top of which all the meteorological instruments were housed. Since the terraces were covered with several meters of snow during most of the winter season, a tunnel had to be constructed in the rock to facilitate the access to the blockhaus.

Vaussenat invited scientists to conduct experiments at the Observatory. In November 1882, two astronomers from Paris came to observe the transit of Venus over the Sun. Because of bad weather, they did not manage to bring their heavy equipment to the summit and had to settle at Sencours pass. On December 6, the day of the transit, the weather was clear at the summit, but overcast at
Sencours pass. At that time occurred the only major tragedy in the history of the Observatory, when the porters were caught in an avalanche which caused the death of three of them. After that, the porters were extremely cautious and would not climb to the summit when the risk of avalanche was high, usually leaving from the valley well before sunrise.

Other visitors of that period included physicists who measured the carbon monoxide and ozone content of the air in 1881 and the next two summers, two astronomers from Paris in 1883, who tested the site and found it exceptionally good, army geodetists in 1884 who were making a new map of France, Jules Janssen from Meudon Observatory who observed the Sun in 1887, a medical doctor who studied the effects of altitude on various animals (dogs, chickens, cats, rabbits, etc.) in 1890, and two astronomers from Lyons Observatory, also in 1890.

At the request of the Central Bureau of Meteorology, Vaussenat conducted an expensive and elaborate project between 1883 and 1885. The purpose of this “Lemström experiment” was to produce artificial aurorae. Selim Lemström was a Finnish physicist who successfully carried out such an experiment in the North of Finland, and reported his results to the French scientific community (Lemström 1884). Vaussenat purchased 200 long wooden sticks treated against weathering, planted them evenly over 530 m$^2$ on the summit and joined them with a mesh of metal wire studded with 10800 metal points. The instrumental setup did not produce the expected result; on the other hand, it efficiently attracted bolts of lightning which forced Vaussenat to buy himself a new suit and watch.

3. Emile Marchand (1882 - 1914)

Vaussenat had a heart problem at the summit in November of 1891, was carried down to the valley by two porters and died in Bagnères a week later. After a fierce tug of war between the Central Bureau of Meteorology, Paris Observatory and other institutes, Emile Marchand, a seasoned astronomer and geophysicist from Lyons Observatory, who had visited the Pic du Midi Observatory two summers before, became the second director of the Pic du Midi Observatory.

He immediately took on the task of improving and expanding the scientific observations and measurements conducted at the Observatory. During the 22 years of his directorship, he collected and partly analyzed a remarkable set of routine daily observations made by his staff at the summit, of astronomy, meteorology (including a map of the cloud cover), static electricity, the horizontal and vertical components of the Earth’s magnetic field, seismology. During that period, he published 35 papers on meteorology, 22 on geophysics, 20 on astronomy, 6 on solar-terrestrial relations, and 9 on botany. Unfortunately, he published most of his papers in the journal of a local scientific society and in obscure conference proceedings, so his work is still waiting for its readers.

The astronomical observations, a daily map of sunspots, a study of the aspect of Venus (to determine its period of rotation), the search for an atmosphere on the Moon, occultation events of the satellites of Jupiter, were all made by his assistant Sylvain Latreille, using an 8 inch refractor of mediocre quality donated by Paris Observatory. Marchand acquired a spectroheliograph, but the instru-
ment was defective and he never managed to make it function properly. He made detailed plans for installing a polar siderostat, an instrument well suited for a permanently snowed in site, but his expensive project never materialized, for lack of support from Paris.

Marchand resided in the town of Bagnères, 20 km away, where he conducted the same kinds of observations as at the top of the mountain. Since he would also conduct these measurements on his way up to the summit, this would give him detailed information on the variations with altitude of all the physical parameters. He was in daily contact with the Observatory through a private phone line, but the connection was so bad that they often communicated by Morse signals. The line was also cut off altogether several times a year by snow, falling branches, avalanches, or grazing sheep, and Marchand had to send someone to find and repair the damage. Since the line was made of copper, part of it was stolen on two occasions.

Marchand spent a lot of time on administrative duties and on practical tasks linked to the maintenance and supply of the Observatory in food, fuel and other indispensable items. During the brief period of summer, when there was no snow, a permanent train of mules (carrying a load of up to 100 kg each) would carry to the summit 10 to 15 metric tons of coal, 2 tons of potatoes, 50 12-gallon barrels of wine, as well as wood, tiles, drinking water, preserves, etc. The rest of the year, the Observatory would be supplied with fresh meat, bread, cheese and vegetables by 2 or 3 porters, who, weather permitting, made the 5 to 8 hour climb on Sunday morning, the day after market day in Bagnères. These expensive means of transport would double the cost of all the material used at the summit. Furthermore, since the transport would often be delayed or even cancelled when snow fell (because of the increased risk of avalanches), the food would go bad and be lost.

At the turn of the century, the Central Bureau of Meteorology asked Marchand to build a botanical garden at the summit, in order to study the behavior of plants at high altitude. Joseph Bouget, a modest gardener from Bagnères, took charge of the project, and over the years he and others published over 30 papers on the botanical experiments conducted at that garden; he became an expert who was consulted by the most renowned botanists of France. In the mid- and late-1930's he managed to produce potatoes from seeds (Bouget 1935), which is apparently quite a feat. But the ministry consistently refused to give him a permanent position at the Observatory, and he was always paid by expedients.

Also at the beginning of the century, Benjamin Baillaud, then director of Toulouse Observatory, decided to build an astronomical telescope at the Pic du Midi Observatory. Baillaud was often on the inspection team mandated by the Central Bureau of Meteorology to inspect the Observatory every summer, so he was familiar with the site and well aware of its advantages. But first he wanted to establish for himself the high quality of the site. He had a temporary dome installed on the summit, and he and members of his staff spent several summers doing test astronomical observations with several small telescopes. They concluded that the images were indeed often remarkable (Baillaud & Bourget 1903). Baillaud obtained funds for the construction of a 50-cm reflector and a house for the visiting astronomers, and construction began in 1904. In the summer of 1906, the dome was ready and the telescope built in Paris by Gautier
was shipped to the foot of the mountain. The 22 crates, weighing between 600 and 1600 pounds, were then transported by oxen to the Tourmalet pass, and from there to the summit with great difficulty by a dozen soldiers belonging to a nearby artillery regiment. In fact, they only managed to reach the Sencours pass before the first snowfall, and the telescope parts only reached the Observatory the next summer.

It took another summer to install the telescope properly, and it was only in 1909 that it became fully operational. It was first used by Count Aymar de la Baume Pluvinel, a private astronomer from Paris, and his assistant Fernand Baldet, to observe Mars in the fall of 1909. The excellent images that they obtained allowed them to claim that the canals of Mars were not visible (de la Baume Pluvinel & Baldet 1909). The next year was that of Halley’s comet. Unfortunately, it was visible in May, the worst time of the year for observing at the Pic du Midi Observatory. Henri Godard from Bordeaux Observatory and Gaston Millochau from Meudon Observatory spent over three weeks without opening the dome. One of the rare forms of entertainment was a record player with half a dozen records, and, by the end of their stay, they knew pretty well all of them by heart. The same year, de la Baume and Baldet returned to the Pic du Midi for observing Saturn, and ran into the same bad weather as their colleagues in the spring, so the Observatory immediately acquired the ill-founded reputation of being permanently clouded over, and was very seldom used by French astronomers. The only one who persistently observed at the 50-cm telescope was Jules Baillaud, the son of Benjamin Baillaud, and his thesis is based on these observations (Baillaud 1924).

The new telescope, managed by Toulouse Observatory, was a thorn in Marchand’s side from the very start. He felt it as an intrusion on his turf; so did his staff at the summit, and friction between them and the workers and visitors from Toulouse continuously erupted.

Emile Marchand died in March of 1914, and, before a new director was appointed, war broke out. The anxiety felt in these difficult moments is discernable in a letter of the caretaker director: “I have to discontinue my work at the Observatory because I have been mobilized. The office will be closed as of today. (...) The two assistants, also mobilized, left the Observatory yesterday. Mr. Labayle, observer, must leave in two weeks. At the summit there will be Mr. Latreille, all alone.” And alone at the summit he remained for 14 months without interruption, until someone was found to replace him temporarily, because he would not allow any gap in the daily meteorological observations.

This was the occasion to put all the instruments and staff at the summit under a single authority (that of Toulouse Observatory) and Pic du Midi Observatory merged with Toulouse Observatory in 1915. Joseph Rey, a Navy officer, was nominated vice-director of Pic du Midi Observatory in 1915, but only took office in late 1917.

4. Camille Dauzère (1920 - 1937)

For several reasons, Rey soon resigned from his position and was replaced by Camille Dauzère, a physicist, in 1920. The latter immediately started renovating the buildings which had considerably suffered from lack of maintenance during
the war. But it was already a bit late, as part of the northern terrace collapsed in July, 1922. This was paradoxically a lucky event, as it helped Dauzère emphasize the impending catastrophe if nothing was done about the poor state of affairs, and politicians on all sides mobilized to save the Observatory. This mobilization actually happened again in the early 1990’s when the Ministry decided to close the Observatory. As a result, Dauzère received adequate funding for over ten years to renovate the buildings and build new ones.

French astronomers did not show the same eagerness to renovate astronomy at the summit. Henri Deslandres, director of Meudon Observatory, was mandated in 1922 to inspect all French Observatories. After visiting the Pic du Midi Observatory he recommended closing it. So Dauzère resolutely set his course toward geophysics to save the establishment, and for the next 15 years this was the main field of research conducted at the Pic du Midi, together with botany. Joseph Devaux did his thesis on the thermal behavior of snowfields and glaciers (Devaux 1933), and participated in several expeditions to Greenland with Charcot. Hubert Garrigue did his thesis on natural radioactivity in the mountains (Garrigue 1936). Dauzère himself became interested in thunderstorms and hail, using the remarkable database on the location of lightning impacts in the region, collected by Joseph Bouget over twenty years, and expanding it by sending out forms to be filled out by witnesses of lightning and hail storms. He thus became a nationally famous expert on the subject.

A gradual shift toward astronomy occurred in the 1930’s, when Bernard Lyot invented the coronograph and experimented it at the Pic du Midi between 1930 and 34 (Lyot 1939). This revolutionary instrument allowed the solar corona to be observed outside eclipses. But it took the talent of Lyot to produce a diffusion-free instrument and the quality of the atmospheric conditions at Pic du Midi to make the experiment successful. In 1935, Jules Baillaud, a strong advocate of astronomy at the Pic du Midi, became president of the society “Les amis de l’Observatoire du Pic du Midi”. In this quality, he proposed a project for improving the existing 50-cm telescope built by his father and for building a new one. Finally, in 1936, the ministry appointed an astronomer rather than a geophysicist to replace Joseph Devaux who disappeared with Charcot off the coast of Iceland. This was Henri Camichel, resolutely decided to observe even in winter, and one of the members of the team that conducted very successful planetary observations at the Pic du Midi in the 1940’s and 1950’s.

5. Jules Baillaud (1937 - 1947)

When Camille Dauzère retired in 1937, nobody volunteered to take his position. The ministry then decided that, if no candidate for the position of vice-director was found, the Observatory would be shut down. At that point one man stepped forward, because he could not bear the idea that this Observatory whose development his father had so much contributed to would be closed. This man was Jules Baillaud. At the time, he was 63 years old, thus soon to retire, and head of La Carte du Ciel, the sky survey of the time, at Paris Observatory. Furthermore, as everybody knows, Paris is the center of the world, so why go and live in some small town in south-western France? He nevertheless reluctantly accepted the position, on the condition that he would share his time between Paris and
Bagnères, and that a responsible person in Bagnères would be in charge and do all the paper work in his absence. That person was Charles Taule, a former meteorologist at the summit and primary school teacher, who would contribute a lot to the survival of the Observatory during the war years.

Jules Baillaud soon embarked upon an ambitious project of renovating astronomy at the Observatory, and of improving living conditions by installing a cable car and replacing the batteries, an unreliable and weak source of electric current, by an electric line from the valley. But he had hardly time to do much before war broke out and all the staff of the Observatory was again mobilized and sent to the front.

One would think that an old man, who didn’t really want to be there, alone in this empty Observatory, in a period when the whole country was in great turmoil, would just give up. Well, he did just the contrary. This is perhaps a typical case of Gallic pride; in the face of defeat and humiliation, France has to stand up and show that, in Baillaud’s own words, “its genius and influence are not extinct”. This is very similar to what happened after 1870 and the defeat of the French by the Prussian army: in the ten following years, French astronomers built six provincial observatories with funds from the State, as well as two private ones.

Baillaud first sought to renovate the existing 50-cm refractor, whose mirror was of poor quality. He negotiated with René Jarry-Desloges, a wealthy amateur astronomer and owner of a good 50-cm objective, but the latter was not very eager to lend his precious lenses; furthermore, he did not believe one could do good photographic work with it. The imminence of the 1941 opposition of Mars forced the astronomers to find a solution rapidly. They borrowed the 38-cm objective of Toulouse Observatory, and they made excellent observations of Mars which convinced them that a permanent solution had to be found.

Lyot then thought of the 60-cm objective of the coudé telescope of Paris Observatory. But its focal length was 18 meters, three times that of the 50-cm telescope, which required that the light rays be folded twice, with two flat mirrors. The telescope would then in effect become a refracto-reflector, a system already successfully tested by the Swiss astronomer Emil Schaar in the beginning of the century. This was quite feasible, since the existing Pic du Midi telescope was composed of two tubes, one for the 50-cm reflector and one for the 23-cm refractor used for guiding. The partition between the two tubes was knocked out and three bearings for the objective and two flat 50- and 30-cm diameter mirrors ordered from an instrument factory near Vichy. The pieces were manufactured and shipped amidst incredible difficulties of production, communication and transport. This was in the fall of 1942, when the Allied forces landed in North Africa and the Germans occupied the Southern part of France to prevent any landing there.

The refracto-reflector, later called “lunette Baillaud” was very successfully used until the early 1960’s, to measure very accurately the diameter of planets, to map the surface of Mercury, to study the spots on the surface of Jupiter’s satellites (Dollfus 1961). One had to wait for observations from space to get better results.

Baillaud then turned to his other project, the construction of two new telescopes, a 85-cm Schmidt telescope for wide-field photography, and a 150-cm
long-focus reflector for high-resolution studies. The design of the latter, mainly
due to Lyot, was very bold and revolutionary, well ahead of its time. It was to
be a domeless telescope, with a closed tube filled with helium and refrigerated
from the outside. The absence of a dome would eliminate any local turbulence
due to such a structure. Completely retractable domes are becoming a standard
for new generation telescopes such as the VLT. But the telescope had to be very
rigid, in order to operate with high winds, of up to 20 m/s; the frost and snow
presented another serious difficulty for the design. The helium in the tube and
the external refrigeration would improve the temperature stability and thus the
seeing. Several new techniques for maintaining the shape of the mirror during
pointing were considered.

The mirror would not be made of glass, but of steel. There was a very simple
practical reason for that, namely that the Saint-Gobain factory’s ovens had been
destroyed by the Germans and could not produce blanks of the required size.
The advantage of steel is its rigidity and thermal stability. The disadvantage
of steel is its low power of reflectivity, less than 65%. Baillaud made thorough
investigations for improving the reflectivity, by a layer of chrome or of various
alloys. Another problem was that nobody knew how to polish steel to the
required shape.

The feasibility studies started in January of 1943, and were done by Messier,
an aircraft landing gear manufacturer, out of work because the Germans forbade
any sensitive R&D in occupied France. The advantage of this company over tra-
ditional telescope makers was its lack of preconceived ideas on how to build a
telescope, and thus its openness to new ideas. It met considerable material dif-
ficulties, especially in June of 1944, when the country was completely disrupted
by the Allied landing in Normandy. No material of any kind was available for
building models, no wood, screws, nails, glue or soldering material. Mail would
take weeks to arrive, and many higher ranking civil servants were put in prison
by the new government, in effect paralyzing the country.

It is paradoxically the end of the war that put an end to the project. Messier
returned to its more profitable work on aircraft R&D, Baillaud soon retired, Lyot
died prematurely in 1952, but the main reason why this project never material-
ized was the stubborn opposition of André Danjon, director of Paris Observatory
and de facto boss of French astronomy. He had decided once and for all that no
good images could be obtained at high altitude, and he wanted to develop the
competing site of Haute-Provence and provide it with a large telescope. The
large telescope project at Pic du Midi only went ahead in the sixties, after Dan-
jon retired, and, by that time, the design was completely reconsidered by the
entirely new team of astronomers.

6. The present and the future

The end of the war nevertheless saw the completion of Baillaud’s other projects
for improving conditions at Pic du Midi Observatory. A high voltage power
line soon reached the summit, allowing expensive cosmic ray experiments to be
conducted, and a cable car was inaugurated in 1952, in effect creating a tight
border between “before” and “after”, between those who had known the heroic
period, when it took many hours of difficult climbing to reach the summit, and
those who arrived up there in a suit and tie and with a briefcase, as if they had just stepped out of the subway.

With these essential improvements, research at the summit expanded spectacularly, with up to 10 or 20 people at the Observatory at a time, several research teams simultaneously at the various telescopes and instruments, doing exceptional planetary observations and solar research, monitoring the solar corona every day, visitors from Manchester (England) for the study of cosmic rays and later for the preparation of the Apollo Moon landings.

As for the future, it is not as bright as one might expect. In the present context of economic crisis, the ministry again threatened to close the Observatory, and the only way out was to lend two thirds of its surface to private enterprise, which in turn will open it to the public, with a science museum, astronomy shows, a restaurant, shops, etc. The site will be accessible all year round and 150000 visitors are expected annually, starting in 1998. My hope is that, while this showcase of astronomy will be a drawback for astronomers at the Pic du Midi, it will entice the taxpayers to contribute more funds for French astronomy in the future.

Acknowledgments. The 14 photographs illustrating this paper are available in gif format at [http://www.obs-mip.fr/omp/umr5572/patrimoine/asp.html](http://www.obs-mip.fr/omp/umr5572/patrimoine/asp.html). This is an invited lecture at the History session (Astronomy from difficult places) of the 109th Meeting of the Astronomical Society of the Pacific jointly with the Astrophysics From Antarctica Symposium. It will appear in Astrophysics From Antarctica - Scientific Symposium Conference Proceedings (ASP Conference Series).

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