

# National Aures Observatory: A new multimessenger facility

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**Abstract.** Algeria has taken upon itself to build a new astronomical observatory in the Ainess region in the Aures Mountains in Eastern Algeria to serve the aspirations of the Algerian astronomical community and also to open up for international projects. This Observatory will be mainly dedicated to multimessenger astronomy and the study of transient astronomical phenomena (optical counterparts of gravitational waves, GRBs, asteroid tracking, ...), but it will also have other secondary objectives such as the study of early phases of super novae, Space Situational Awareness like surveillance programs, variable stars, exoplanets ... In this paper, we describe the main scientific objectives of the National Aures Observatory as well as the rationale for the choice of the Ainess region as the main candidate site for setting up the observatory. We will also present statistical cloud coverage from the analysis of EUMETSAT cloud data and will conclude with the present statute of the Observatory and the different stages for its construction

## 1. Introduction

The idea of building a new Astronomical Observatory was born from the fact that there is currently only one Astronomical Observatory in Algeria, the Algiers Observatory. If that observatory built in 1890 and now located in the middle of the Algerian capital, had the quality of its site sufficient for the scientific objectives and the environmental conditions at that time, this is absolutely no more the case today. Indeed, the expansion of the city as well as the number of inhabitants has literally exploded since the last century, generating a huge light pollution and a micro climate inadequate for the requirements of modern astronomy which uses larger telescopes equipped with more sensitive instrumentation (CCD cameras ...) and stricter image quality requirement. All these factors has made the Algiers Observatory site unsuitable for modern astronomy. In addition, the Algerian astronomical community has increased in size, as evidenced by the various academic programs offered at Algerian universities set up in recent years (master programs at several universities, and few years ago a PhD program at Mentouri University within the so called "Ecole Doctorale d'Astrophysique") as well



as the various international conferences on Astronomy organized in Algeria since 2008. This Observatory project also aims at bringing together this Algerian astronomical community around major research axes and to provide future Algerian astronomers with new research perspectives [1].

Building a new astronomical observatory, or more precisely a first observatory in Algeria (it will indeed be the first post independence observatory) is not an easy task. Indeed the scientific objectives of this new observatory might be assimilated to an equation subjected to strong constraints: The main scientific objectives must fall within the current astronomical research problems, while being sufficiently varied to serve the entire Algerian (mainly) and the international scientific community through collaborations to be put in place. The Observatory must also have educational objectives and be within reach to students, not to mention also amateurs and the general public. Of course, this project has to be carried out within a limited budget provided by the DGRSDT (Direction Generale de la Recherche Scientifique et du Developpement Technologique). Given these constraints, and through close cooperation with the CNRS (ARTEMIS Laboratory), it was decided that the main project of the observatory will be dedicated to multimessenger astronomy and the study and observation of transient phenomena namely optical counterparts of Gravitational Waves (GW), GRBs, ... In this perspective, we opted for the implementation of the RAMSES (Robotic Advanced Multimessenger Space Environment Surveyor) project as proposed by one of the authors (M. Boer) [2]. In addition to the main objectives, the implementation of such a project will also address a set of secondary scientific objectives that is of interest to the scientific community: Space Situational Awareness , early supernova search, asteroids tracking, variable stars, exoplanets, etc. All these aspects will be presented in section 2.

The candidate site for the observatory is located on the Aliness plateau in the Khenchela Governorate. This plateau situated at some 1800m above sea level was first chosen following several criteria: altitude, distance from major cities, light pollution and accessibility. A statistical study on cloudiness and percentage of clear nights from satellite data (EUMETSAT) was also conducted and it shows that the site has a very good yearly percentage of clear nights (section 3). We still need to confirm the site quality on other important aspects such as the presence of aerosols and especially the level of atmospheric turbulence (seeing) that makes the stars dance at the focus plane of a telescope. A station with an automatic DIMM has been installed for this purpose and will be operational by the beginning of 2019. The status of the project is described in section 4.

## 2. Scientific Goals

Multi-messenger astronomy (MMA) is a field currently in full expansion. Indeed, the detection of the gravitational waves generated by the coalescence of binary black holes (BBH), GW 150914 [3] by the Advanced-LIGO experiment was the prelude to a revolution in the study of the Universe: up to now, the information was coming

mainly from one particle messenger namely the photon; nevertheless the commissioning of gravitational interferometers now allows access to processes that directly involves mass dynamics in the Universe at all scales. More recently, the detection of GW170817, corresponding to the coalescence of a binary neutron star system (BNS) [4] was even more significant since this detection was followed by the detection of GRB associated with it (GRB170817) [5] which was also observed in the visible band by terrestrial telescopes [6]. Moreover, it is known that neutrinos are produced during supernovae like SN 1987A [7] or in accelerated jets at speeds close to that of light as was detected by IceCube [8] and ANTARES [9]. On the other hand, the electromagnetic spectrum has not yet revealed all its secrets, especially with the recent discovery of the Fast Radio Bursts (FRBs) [10], whose origin are still unknown, although several hypotheses have been proposed [11]. Although the sources of these elusive messengers are not yet well identified, they are either related to star collapse for those with somewhat low energy, or to the enormous acceleration and interaction of matter in shocks for those of higher energies as in the Active Galactic Nuclei, or in compact sources such as for gamma-ray bursts. We are indeed at the dawn of a new era, that of multimessenger astronomy, where the joint detection of events in gravitational waves, electromagnetic waves and neutrinos will give us a fuller and probably a vastly different view of the Universe than the one we are holding today. This requires, for the visible and near-infrared domain, instruments with very large fields of view, and able to react quickly while adapting to the specific shape of the large areas on the celestial sphere where the source is assumed to be located. All this makes multimessenger astronomy one of the very exciting research areas today and the reason why it was chosen as the major research axis for the future Aures Observatory.

### *2.1. Gamma Ray Bursts*

Gamma Ray Bursts have been discovered in 1969 by military instruments, but the discovery was only published in 1973 [12]. However, it was only in the nineties that we have been able to understand their origin and the physical processes that cause them. We can define a Gamma Ray Burst as a sudden explosion of photons at all energies, lasting from milliseconds to minutes, followed by a rapid decay phase ( $t^{-1}$  or  $t^{-2}$ ) of the emission, which can be observed for a few hours to a few days depending on the size of the instrument Figure 1.

Nowadays, bursts are frequently detected events (400/year for Compton-GRO/BATSE, 80/year for Swift, 200/year for Fermi/GBM). We distinguish two classes of bursts by their temporal and spectral properties [14]. We call short bursts those whose duration is less than 2s and whose spectrum is rather harder than long bursts, which are therefore defined by longer duration and softer spectra on average as shown in Figure 2.

Short bursts are caused by the coalescence of a BNS, or, possibly, that of a neutron star - black hole binary system (NSBH). In the later stages, the two stars collapse,

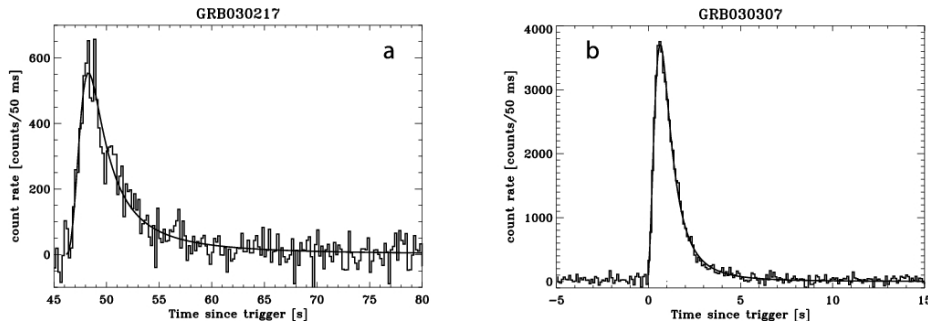


Figure 1: Examples of GRBs Light Curves [13]

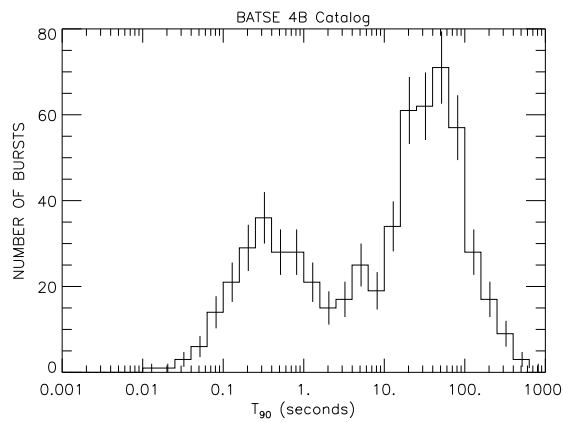


Figure 2: Histogram of GRBs durations showing statistical separation into two classes[14]

with the formation of a transient accretion disk around the newly created black hole (or possibly a transient magnetar) that rotates rapidly. This eventually result in the emission of a large fraction of the energy in the form of gravitational waves [15] followed by the short GRB. The long GRBs are caused by the collapse of a very massive star ( $20 - 50M_{\odot}$ ) that collapses directly into a black hole (or possibly a transient magnetar), before precipitation of the outer layers of the system on the central object with the emission of a collimated jet with an angle of the order of  $5^{\circ}$  to  $15^{\circ}$ . (For more information see [16] for example).

### *Localization of Gamma Ray Bursts*

Transient by nature, Gamma Ray Bursts are sources that are difficult to observe at wavelengths other than those detected by satellites. It requires a real chain of observation starting from the detection by a satellite carrying a gamma-Ray detector (Swift and Fermi at the moment), to the relay of this position on board towards an X and optical detector (case of Swift) and on the ground towards instrumental means in radio, visible and infrared (Figure 3). A central NASA server, the GCN/TAN, relays this information to the INTERNET in a fraction of a second [17].

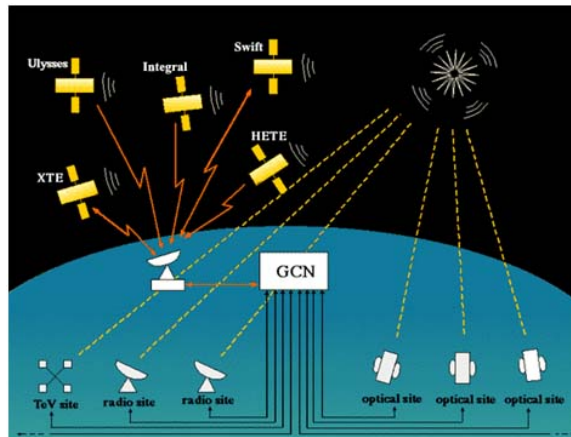


Figure 3: The physical GCN network[17]

The position obtained by the Swift BAT instrument is accurate to about fifteen minutes of arc, which makes it directly observable by large instruments. Shortly after, the position of the telescope XRT (X-ray Telescope) on the same platform, accurate to one or two minutes of arc, is transmitted [18]. Large telescopes can thus observe it and derive a distance (using spectroscopy techniques). However, even in this case, small telescopes like TAROT, RAPTOR, or ROTSE do a remarkable job (As testified by their numerous publications and quotations) by allowing an observation of the extremely fast source during the prompt part, or the beginning of the afterglow. The use of the GBM detector on the Fermi telescope (FGST) is more involved. In this case, the position is calculated by the flux difference measured on detectors of various orientations. The statistical error is of the order of the degree, to which must be added a systematic component of the order of  $10^\circ$ . The obtained position can represent an area of more than  $100^\circ^2$  on the sky, well beyond the field of most telescopes. Yet GBM has a sensitivity and especially a spectral range that allow it to record harsher bursts than those of Swift, especially short bursts. The challenge is therefore to be able to detect the source in near real time (a few seconds - minute), and to transmit a position with a few arcseconds accuracy for a spectroscopic analysis of the candidates while the source remains intense.

## 2.2. Gravitational Waves

Gravitational waves (GW) correspond to curvatures of space-time that propagate from the source like a wave carrying within it huge gravitational energy. They have been predicted as a consequence of the theory of general relativity [19] but were not thought to be detectable due to their weak effect on matter before the first attempts in the sixties. An indirect detection of such a GW have been made in the middle of 70's from the observation of binary pulsars [20]. A striking confirmation came from the first direct detection [3] of the coalescence of two massive black holes, which allowed to validate the production rates and the astrophysical consequences, thus opening this

new window in the sky [21]. Coalescence of compact binaries (binary neutron star systems, or neutron star - black holes) are powerful emitters of gravitational waves, as evidenced by the coalescence detection of two neutron stars GW170817, an event that was detected about 2 seconds after its occurrence by the Fermi and Integral satellites in the Gamma Ray frequencies. Its optical counterpart, AT2017gfo, was also observed by many ground-based facilities [6]. Other objects likely to emit gravitational waves are supernovae as much as their explosions are asymmetrical, the incorporation of an object by a super-massive black hole (in an active galaxy for example), and processes in the very early universe as imprints on the cosmological background. Cosmological Gravitational waves detection would allow us to see 'behind' the Cosmic Microwave Background radiation (CMB), thus to the very early stages of the Universe, providing us access to the masses and dynamics of systems before the recombination era at a time when the Universe was opaque to electromagnetic radiation. It is also a way to access relativistic physics in unknown regimes up to now. Current experiments, Virgo and LIGO measure the distance between 'free falling masses' through a laser interferometer. In practice, the masses are suspended so as to isolate them as much as possible from any unwanted vibration, and are separated by a distance of about  $3km$  in the case of VIRGO and  $4km$  for the two LIGO detectors (Hanford and Livingston). A wave that passes through the interferometer will deform the cavity and thus cause a displacement of the interference fringes. The displacements to be measured are less than  $10^{-18}/rmm$  along the length of the interferometer. The range of VIRGO and LIGO for the detection of BNS coalescence is  $120/rmMpc$  and  $190Mpc$  respectively at design sensitivity, to be reached around 2021. Currently the Japanese detector Kagra will complete this year this network with an estimated range of  $120Mpc$ . In a more distant future INDIGO, the Indian replica of LIGO should be built.

### *Localization of the gravitational waves sources*

In order to locate the origin or source of gravitational waves following an alert, the triangulation technique is used with the detectors LIGO (USA) and VIRGO (France - Italy) currently (Figure 4).

It can be seen from Figure 5 that the localization capability obtained by this method for events GW150914 and GW151226 for example are unfortunately poor. The localization error reaches or even exceeds one hundred square degrees.

We therefore need instruments with very large field of view, and able to react quickly while adapting to the specific forms of the large areas where the supposed source is located.

During the first run (O1) of LIGO-Virgo the LIGO-Virgo Consortium (LVC) had the property of the first gravitational waves detections. In order to optimize the scientific return of these observations, the LVC has launched an appeal to the scientific community in the form of a Memorandum of Understanding (MOU) in which the Aures Observatory team is already involved, through the TZAC collaboration (TAROT - Zadko - Aures -

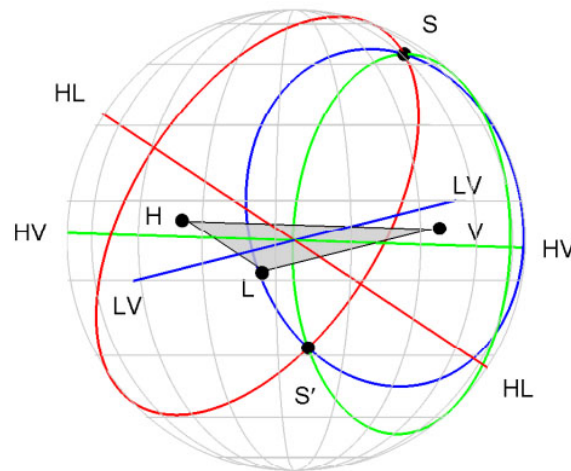


Figure 4: Principle of location with 3 gravitational detectors, VIRGO, LIGO at respectively Hanford and Livingston in the USA [22]

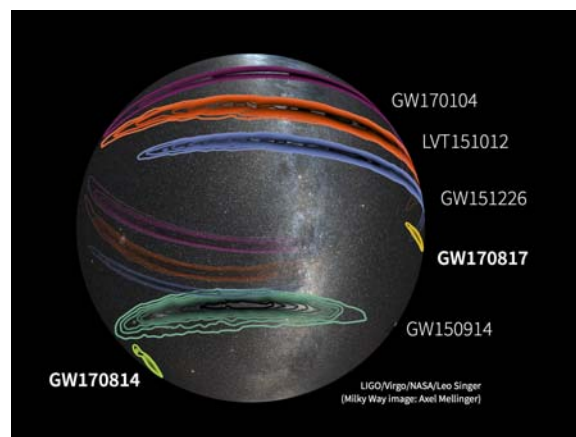


Figure 5: Sky map of gravitational wave detection patches. Credit: LIGO/Virgo/NASA/Leo Singer

C2PU). Indeed, in order to insure the success of the Aures project a collaboration has already been build with other facilities and institutions: TAROT (France, Chili and La Reunion Island), Zadko (Australia) and C2PU (France). The TZAC has participated to the observation of AT2017gfo [6]. Currently (runs O2 and O3), the alerts and the localization data is released freely to the community.

### 2.3. Neutrinos

Neutrinos are particles predicted by Pauli in 1930 to explain beta decay and detected for the first time in 1956. They are particles with zero electrical charge divided in 3 families according to the associated charged lepton, namely muonic, electronic and tauonic. Their cross section of interaction is extremely low, hence the great difficulty to detect them, and the large amount of detector material required.

In 1987 the first neutrinos from an astrophysical source other than the Sun were found, by the detection of neutrinos from the supernova 1987A [7]. Neutrinos are produced in numbers when protons and electrons interact to form a neutron with neutrino emission, as well as energy dissipation by neutrino-anti neutrino pair formation [23]. Because of their small interaction cross section, neutrinos are therefore the carriers of information on the internal processes going on during the neutron star collapse. These thermal neutrinos have energies of the order of a few tens of MeV.

High energy neutrinos (TeV) are produced during accelerated processes in the Universe, such as relativistic or ultra-relativistic jets in active galaxy nuclei, gamma-ray bursts, or supernova remnants. In these sources, it is the second-order Fermi acceleration in the relativistic shocks which is at work. The supernova remnants are considered to be the most efficient sites for the production of cosmic rays. Neutrinos come from the decay of charged pions produced by gamma and neutrino photo-production.

Few years ago IceCube and ANTARES collaborations have reported the detection of high energy neutrinos [8]. More recently searches for associated emission of gravitational waves and high energy neutrinos from astrophysical transients have been conducted [24] using data from AdLIGO first run and data from ANTARES and IceCube, but no significant coincident GW and neutrino candidate was identified. Nevertheless, next-generation of neutrino detectors will lead to significant improvement in sensitivity to high energy astrophysical neutrinos and thus possible multimessenger GW+neutrino sources are expected to be found in the near future.

The localization of neutrinos is done with an error of the order of the degree, but a greater delay than for the gravitational waves. Currently this process becomes quite efficient since IceCube has detected 37 extraterrestrial neutrinos in 3 years. As for Gravitational waves, it will be very interesting to localize and study the correlated sources of the extraterrestrial neutrinos. IceCube data is now accessible via the GCN/TAN. A collaboration has yet to be set up to access to ANTARES data.

#### *2.4. Secondary Science Objectives*

The main objectives described above will use at most 10% of the total telescope observation time. The remaining 90% of the time will be dedicated to many other topics. Although the science behind these topics is important, they are said to be 'secondary' because (i) they will not add additional constraints to the design of the observation instruments, and (ii) the main objectives will be given higher priority in the case of alerts (GWs, GRBs, astrophysical neutrinos). Among these 'secondary' objectives, we can mention the early detection and study of the shock breakout of collapsing supernovae, the long-term monitoring of exoplanets, as well as the study of the small bodies of the solar system. In addition, we can also consider topics of a more technological and economic nature such as the study of the artificial space environment and the observation of potentially dangerous asteroids for the Earth (NEOs).

Indeed, the observation of the near space objects and in particular the objects



presenting a potential danger, whether natural (near-Earth asteroids) or artificial (uncontrolled satellites, orbital debris, etc.) has become a major problem, and all the space agencies (ESA, NASA, CNES, DLR, etc.), as well as several private operators (Airbus, Thales - Alenia Space, EOS, Boeing), have now developing observation programs like the Space Surveillance Network for the USA and the Space Situational Awareness consortium for the European Community. Without going into details, we can note that the use of medium sized telescopes with a sufficiently large field is more effective than a large instrument with a small field [2, 25, 26, 27, 28]. The Aures Observatory will certainly have an important role to play in this area.

The study of collapsing supernovas is also very interesting in the context of the Aures Observatory. Indeed, in addition to the emission of neutrinos by inverse  $\beta$  processes, as observed for SN1987A, it is probable that a good quantity of gravitational emission is emitted notably in the case of an asymmetric collapse and/or in case of fast rotation [29]. In this process, the released energy is emitted in the form of an intense radiation, the 'shock breakout', with a spectrum close to a black body. The shock breakout, although difficult to detect because of its suddenness and its short duration, is however interesting in that this signal, which originates from the radiative phase of the shock, carries direct information on the properties of the progenitor and the explosion mechanism, which would be difficult to obtain otherwise. It is also directly correlated with the emission of neutrinos. In case of aspherical emission, the impact will also be visible on the shape of the light curve [30]. It is therefore important to be able to detect the shock breakout which signals the supernova explosion, as early as possible.

Gaia is a space observatory of the European Space Agency (ESA), launched in 2013 and expected to operate until 2022. The spacecraft is designed for astrometry, namely measuring the positions, distances and motions of stars in our galactic neighborhood with unprecedented precision. In addition to that, a Gaia Follow-Up Network for Solar System Objects (Gaia-FUN-SSO) has been set up. Its goal is to coordinate ground-based observations on alerts triggered by the data processing system during the mission for the confirmation of newly detected moving objects, or for the improvement of orbits of some critical targets. Gaia scans the sky following a pre-defined scanning law. Ground-based observations are required to avoid the loss of newly detected Solar System objects and to facilitate their subsequent identification by the probe [31]. The GAIA-FUN-SSO site [32] provides access to solar system object alerts, including the ephemerids to help locating the targets for the registered members of the Gaia Follow-up network. It is clear that the National Aures Observatory can efficiently contribute to this program.

In addition to these secondary objectives, many other topics can be supported by the NAO whether they are photometric or spectroscopic, such as variable stars, exoplanets, of course all this within the limits of the technical possibilities of the instruments (resolution, sensitivity, field, etc) whose specifications have been set by the main objectives defined above. The Observatory will be open to the Algerian and international scientific community through cooperation. Each project will have an observation time and researchers will be able to submit requests which will be

automatically taken in charge by a dedicated system. All of these queries will be scheduled through a dedicated software [33] which will establish a dynamic schedule of observation for each telescope and will archive the results. Of course, if an alert occurs (adLIGO / VIRGO, CGN, ANTARES...) the software is set to direct the instrument to the priority observation program, even if it means rescheduling observations that were taking place.

### 2.5. The RAMSES Project

The objectives mentioned above (Sections 2.2 to 2.3) outlined the contours the future Aures observatory as well as the constraints that it must meet. Indeed, we note that for gravitational waves and gamma ray bursts, the same constraints are faced: (i) First, it is important to locate the source of the event in an error box that can reach  $100^{\circ 2}$  in the sky. (ii) The chosen solution must also be flexible enough to adapt to the different geometries that can have this error box. (iii) And Finally , it is imperative to have a sufficiently sensitive system and to detect this source very quickly. Indeed, the optical counterparts of the GRBs generally decrease very quickly (in  $t^{-1}$  or  $t^{-2}$ ) and it is important to detect the first moments (merger, fireball) but also the kilonova. The selected instrument (s) must be sufficiently sensitive and fast enough in order to respond to alerts from LIGO/VIRGO, GCN, ICECUBE, ANTARES, and the like in few seconds, and flexible to adapt to large fields of view with different geometries. This last constraint forces us to work with a system with several telescopes. Each telescope should have a field of view (FOV) large enough to cover  $100^{\circ 2}$  in the sky, for example 16 telescopes with  $2.5^{\circ} \times 2.5^{\circ}$  FOV. The required sensitivity also implies the use of 400 to 500mm telescopes with highly sensitive CCD or sCMOS cameras. The telescopes will be mounted on very fast mounts able to point on a target in a few seconds with arcsec precision. Each telescope will be equipped with a filter wheel to observe a GRB (or other) in different wavelengths. A 1 or 2m telescope equipped with a spectrometer should be able to insure the follow up of the target after its localization. In addition, the whole system must be controlled by a computer system capable of processing images in less than 10 seconds, ensure the archiving of data as well as the dynamic scheduling of tasks. This is the solution proposed by the RAMSES (Robotic Advanced Multimessenger and Space Environment Surveyor)[2]. This solution will also allow a simultaneous observation of afterglows in different wavelengths using different filters. The instruments can be used for many other topics as well as described previously. An example of implementation of the project is presented in Figure 6.

## 3. Site selection and qualification

The choice of a site to host a new Astronomical Observatory has never been an easy task. Astronomers indeed want to capture the faint light of far away stars and they want to do so for a maximum number of nights during the year. There are however many obstacles

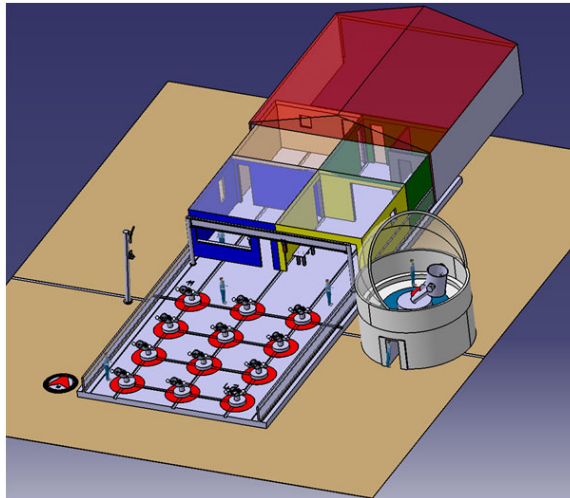


Figure 6: The RAMSES Project: A Metatelescope composed by 12 to 16 small fast telescopes with a 1m follow up instrument. Design: Mourad Merzougui, OCA [2]

in the way to achieving this goal. First the light of nearby cities will hide the dim light of stars, strong winds can damage instruments and reduce their pointing accuracy, aerosols can also damage instruments and scatter collected light, and clouds obstruct the path of light especially for instruments that operate in the visible part of the spectrum. On the other hand, even if one finds a seemingly clear location away from light pollution, one would still have to deal with the atmospheric seeing that makes the stars seem to dance at the focus plane of a telescope. Site selection often begin by choosing sites at elevated places, the latter often presenting the characteristics of the remoteness of cities and especially the fact of having smaller temperature gradients which is the main factor (Although not the only factor) of atmospheric turbulence. The site accessibility was also taken into account in this first phase. If we examine an elevation map of Algeria, we notice that the main elevated sites are located in the Hoggar region (Djebel Tahat, Assekrem) and in the Aures mountain range (Chelia, Aliness). For this project, we have dismissed the Hoggar region which is of great interest in itself but which is too far from the Northern Algeria and the location of the main Algerian universities, in addition to logistic considerations. Yet we mention that another astronomical project is being considered for Hoggar site but with no definite timetable.

We therefore focused our attention on the Aures region and selected two potential sites having a good geographical location and that can a priori host an Astronomical Observatory. The first one is located at the Djebel Chelia (Ras Kaltoum, 2328m), and the second one in the Chechar area (Aliness, 1800m). After a few visits on site, we unfortunately had to discard the Chelia site because of the important light pollution existing on the Northern side of the site, where quite few cities are in the line of sight and their light halos can be seen (Batna, Timgad, Arris ...) (Figure 7).

The second site is located North-West of the small city of Chechar, which has a much more subdued sky brightness and which lead us to choose this particular site. The

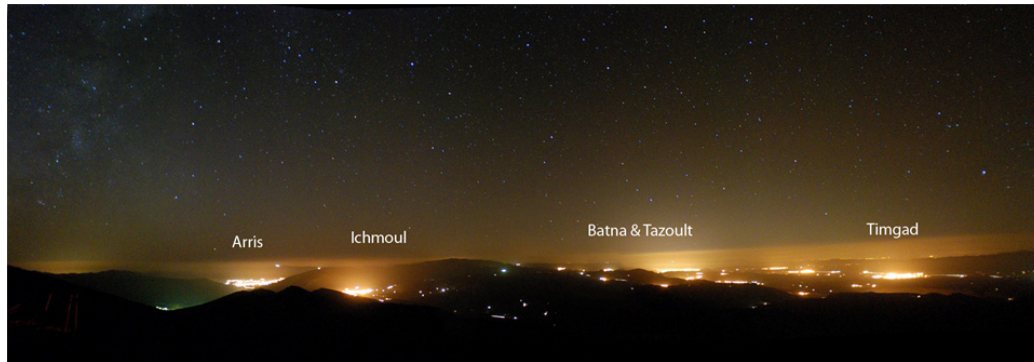


Figure 7: Light Pollution. Panoramic picture from Djebel Chelia. Credit: Nassim Seghouani



Figure 8: Candidate Site for the Aures Observatory (surrounded in red) in the Aliness area. Source: Google Earth

candidate site is located on a plateau at some 1900m elevation at about twenty km from Chechar and some 70km from the Wilayas main town of Khenchela. Figure 8 shows a map of the candidate site and surrounding area.

We then looked at the number of clear nights (cloudless nights). This task is nowadays facilitated by the availability of satellite weather data, and this method to characterize astronomical sites has come to use for many years now, especially that ground resolution are becoming more and more important in the site evaluation process. In fact, concerning the cloud data, the first generations of METEOSAT data offered images data every 3 hours in two infrared channels, with a ground resolution of 10km

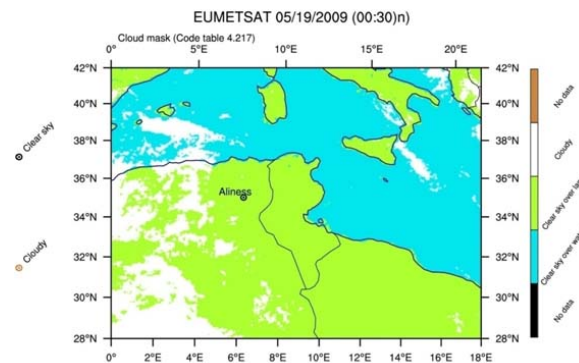


Figure 9: Typical EUMETSAT image around the Alings site.

[34]. The current generation of METEOSAT geostationary satellites (second generation MSG-SEVIRI) uses 12 channels with a horizontal resolution of  $3km$  at the sub-satellite point and an image repeat cycle of 15 minutes [35]. EUMETSAT cloud processing includes the cloud detection (called scene analysis (SCE)) and the cloud analysis (CLA). The scenes analysis derives a cloud mask (Cloud / No Cloud decision) on pixel basis, while the cloud analysis derives detailed information on the cloud type [35]. The present study uses the EUMETSAT cloud mask product in which each pixel is coded as clear over water / clear over land / cloudy as illustrated on Figure 9.

We therefore analyzed approximately 4 years of EUMETSAT cloud mask data from Jan 2007 to July 2010, for a total of 130, 238 images with a 15 min step corresponding to more than 1359 Nights (48 nights were rejected due to lack of data). The classical definition of a photometric night requires at least 6 hours of consecutive night time hours with no clouds at more than 5 degree above horizon. This definition is however related to observations with exposures of several hours necessary when using a medium size telescope. For large diameter telescopes, typical exposure times are much shorter. For transient objects applications, exposures times are even shorter. However it is very interesting to have statistics that are comparable to other astronomical sites. So we have estimated the number of photometric nights with 6 consecutive hours without clouds as well as the number of nights that have at least 4.5 consecutive hours without clouds. The results are presented in Figure 10, where we can see the distribution of photometric nights with 1.5 hour step. The results show that more than 985 nights have more than 6 hours of clearness which represents 72.5% total nights. We can see also that we have a total number of 1071 nights over 1359 with more than 4.5 hours of clearness, which represents a ratio of 78.8%.

These results shows very good ratio of photometric nights. Yet they need to be confirmed with in situ measurements, and other parameters need to be measured and analyzed such as wind velocity, aerosols concentration, humidity and of course the atmospheric turbulence.



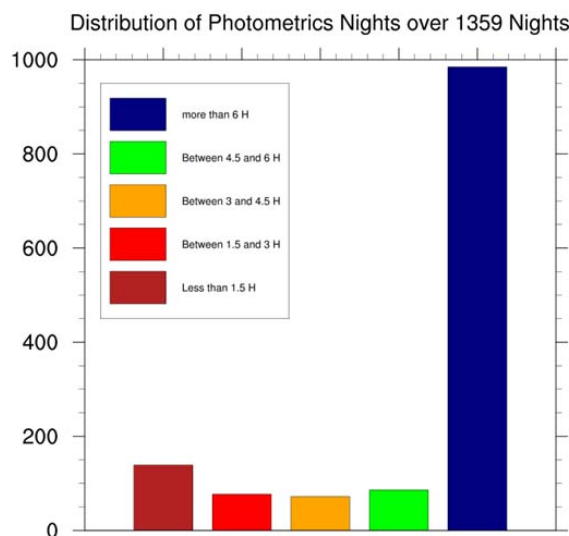


Figure 10: Statistical distribution of Photometric Nights.

#### 4. Present status and schedule

For the realization of this national project, several steps were necessary. After a preparatory work for the preliminary site selection phase described in the previous section, steps were taken with the local authorities to develop and extend the existing track into a mountain road capable of allowing trucks to reach up to the top. The first phase of the project consisted in implementing a first testing site station including:

- A robotic DIMM telescope (Differential Image Motion Monitor) to measure the seeing continuously over many months. The telescope is mounted on a metallic structure about 4m from the ground to avoid reverberation problems. It is housed under a clamshell type dome.
- A Vaisala AWS310 weather station with a WXT530 sensor located 10m above the ground to measure different atmospheric parameters: Wind speed and direction, humidity, precipitation, pressure and temperature. A sensor for measuring sunlight is also connected to the station, as well as a surface rain sensor to protect the dome.
- A Boltwood cloud sensor will also be installed.
- An All Sky camera providing a general overview of the sky will also be installed.
- The power supply of the various devices will be ensured by a solar station and a generator.
- A chalet was also built on the site to house the control computer, and host astronomers.

A general overview of the station under construction is given in Figure 11

At present, the instruments are in the installation phase, and the station will be operational current 2019. The next steps consist of:



Figure 11: An Overview of Aliness Site testing station.

- Developing a rapid mount prototype that will be used for the telescope farm as described in section 2.5.
- Preparing the site and the different structures of the Observatory
- Acquiring the necessary equipment for the Observatory

The next runs of AdLIGO/AdVIRGO are scheduled for the beginning of 2019, and it will be followed by one year of upgrade while the following run is scheduled for 2021. We hope that at least one or two telescopes will be operational for the 2021 run.

## 5. Conclusion

In conclusion, we have seen that the NAO has adopted a rich scientific program at the cutting edge of actual research, centered around the transient phenomena and particularly the detection and study of the optical counterpart of GW as well as GRBs. The scientific program includes also many other topics such as: the Space Situational Awareness space surveillance program, early super novae luminosity curves, small bodies of the solar system, exoplanets, variable stars. All these topics are of great interest for the Algerian and International astronomy community. A collaboration TZAC program has been set up including TAROT (France, Chili and La Reunion Island), Zadko (Australia), Aures Observatory (Algeria) and C2PU (France). We have also seen that the Aliness site in Khenchela Governorate in the Aures mountain range has an interesting potential to be home to a major astronomical observatory. It is situated in a region of the globe without any observational observatory to monitor transient phenomena like GW. Light pollution from surrounding towns is much circumscribed comparing to the Chelia site which is situated at a bit higher altitude. A satellite weather study was carried out using METEOSAT data with the EUMETSAT cloud processing program which has shown that the number of cloudless nights is very satisfactory with 72.5% of total nights with more than 6 hours of clearness and 78.8% with more than 4.5 hours

of clearness. It remains to assess the seeing by a thorough on site studies and for that purpose, a DIMM robotic telescope has been put in place to confirm what looks like a great astronomical site.

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