DAG telescope site studies and infrastructure for possible international co-operations

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ABSTRACT

The selected site for the 4 m DAG (Eastern Anatolian Observatory in Turkish) telescope is at "*Karakaya Ridge*", at 3170 m altitude (3150 m after summit management). The telescope's optical design is performed by the DAG technical team to allow infrared observation at high angular resolution, with its adaptive optics system to be built in Turkey. In this paper; a brief introduction about DAG telescope design; planned instrumentation; the meteorological data collected from 2008, clear night counts, short-term DIMM observations; current infrastructure to hold auxiliary telescopes; auxiliary buildings to assist operations; the observatory design; and coating unit plans will be presented along with possible collaboration possibilities in terms of instrumentation and science programs.

Keywords: Observatory: DAG; Site and facility operations,

1. INTRODUCTION TO DAG

Picking the DAG project from the current position on the time line just shows "a moderate sized **telescope** with an **enclosure** on a relatively **high altitude** mountain top with service and coating plant **buildings**" (see [1] for a general view). If a country has already begun to explore night sky it means that astronomers, as well as scientists demand more and more advanced technology from engineers in answering questions about universe for every aspects of observations: high optical quality, high mechanical stability, durable and hassle-free civil work, wide diversity in the wavelength. After decades of struggle, Turkey could now be counted as one with DAG.

In coming to a stage like DAG, with a state-of art mechanical and optical telescope and a smooth and hassle-free site, many things had to happen on the time line. They will be given here as a short history dating back to pre-DAG era.

1.1 Pre-DAG era

The previous attempt to have a *large* telescope in Turkey started in 1960s. To find the best place for this important telescope a government funded project was initiated in 1978 and the project team have examined 17 candidate sites throughout the country. They reduced the number to 4 for on-site testing (1982-1986). They finalized the site to be "Bakirlitepe, Antalya" by adding more weight of having an airport and harbor in close proximity to the site (see [2] for this very important site selection work).

The funds for a dedicated telescope designed from the scratch was never foreseen at the times of this site testing. Therefore, an already manufactured Russian made (by LOMO) telescope with a mirror diameter of 1.5 m was brought to the site as part of a collaboration between three parties (Scientific & Tech. Res. Council of Turkey - TUBITAK; Kazan State University - KSU; Space Res. Inst. of Russian Academy of Sci. – IKI) and the telescope was named as RTT150. The site was established in 1998 (i.e. TUG – TUBITAK National Observatory in Turkish); the first light of RTT150 was gathered in 2001. The site now occupies more telescopes however all are smaller than RTT150.

One of the important goal of RTT150 was/is its spectroscopic capabilities particularly TFOSC (Turkish Faint Object Spectrometer and Camera) and Coude spectrograph. However, observations with these instruments are limited with mirror size which heavily effects the science case of observation runs. In addition to these facts, in imaging which is

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relatively easier and more effective than spectroscopy, a 4k x 4k array on T100 telescope (1m diameter, third largest in Turkey; located in Bakirlitepe too) continues to be very productive since the first light in 2009.

Even though we had very limited funding to telescopes and focal plane instruments, Turkish astronomers with their wide spread connections and abilities, they have collaborated with many scientific groups and they have involved into many international projects in all parts of the spectrum. Many Turkish students graduated and will be graduated from well-known international universities. Number of young astronomy staff members in Turkish universities on the increase as well. Therefore, this was/is the driving force to pass to "**DAG era**" in around 2010s.

1.2 DAG-era

It all started when the PI of the DAG project (C. Yeşilyaprak) had established in 2008 the very first and primitive weather station on one of the accessible place of "Karakaya Ridge", namely "Palandöken Mountain" at an altitude of 3175 m which has a similar elevation as the DAG site (see Figure 1 for an aerial view of the DAG site before the summit management in summer 2015).

Figure 1. Aerial view of the DAG site; west of the Karakaya Ridge.

Establishing the largest astronomical project of Turkey using rough weather data, of course cannot be done. However, in analyzing this data set with support from other means of astronomical and meteorological data (data from both ground based stations, and meteorological balloons and satellites) several points were always remaining the same among all the data sets at the summit altitude: (1) way above the inversion layer – **many clear nights**, (2) calm atmosphere – **not windy**, (3) dry air – **not humid**, (4) short snow season with shallow snow coverage – **less irradiation** during nights (see [5] for some of the current values).

Unfortunately, going through the well-known but both expensive and time consuming procedure of erecting a telescope couldn't be applied to Turkish astronomy while ground-based large-scale observatories are racing with new space-based experiments. Keeping this fact as the key point in our science case, initial core team members kept explaining to government and funding bodies why Turkish astronomy needs a kick with a brand new telescope which could then compete with the rest of the world by the trending keyword of "follow-up" in mind.

DAG's site quality, however, is later confirmed by another ongoing project which relied on GIS data sets [3]. They have established an overall view of several astronomically important layers combined either to pick the best geographic locations or to compare existing sites. DAG site came out as the best site together with TUG's Bakirlitepe, reserving better sites in remote inaccessible locations of South-East Anatolia region and along Taurus Ridge.

1.3 Funding

As is explained earlier, the DAG project has been crafted with a very different organizational establishment than TUG. The project's main goal is to catch current astronomical trend using a moderate sized telescope **but** with state-of art optics and instruments combined with both working in NIR waveband and using Adaptive Optics from the start (note that many large-scale *aged* telescopes acquire this technology in very late stages of their life time). Details of the optical performance are given in [4].

The first phase of the project (telescope, enclosure, building and infrastructure) is fully funded in January 2012 (see [5] for all the details of project) by the State Planning Organization of Turkey (which is now merged into Ministry of Development).

The second phase is funded in May 2016 where it's aim is to populate both Nasymth platforms with the most advanced focal plane instruments covering both Visible and NIR, for both imaging and spectroscopy. This second project is organized so that three stages of astronomical instrumentation (a) nation-wide classical instruments, (b) DAG platform instruments, and (c) new technology future instrumentation; could be handled without international requirements by established appropriate four labs around the nation (see [6] for the whole project details).

The third and the final phase of the project will secure the quality of the optics through the years: Mirror Coating Plant. Since coating a mirror in 4-meter size can only be achieved with a suitable chamber *next to* the telescope, therefore when it is established it could very well be used for any other optical systems. Thus, geographically making the facility the largest in this size within Europe.

Figure 2. Artist's impression of the final design of the DAG buildings; telescope and enclosure are embedded into the picture.

Since funding body (Ministry of Development) has already secured this huge investment by making all the facility available to whole community of Turkish astronomers, therefore it has to be operated with high performance in mind (queue mode observation, continuous monitoring of atmosphere, w/ and w/o AO options, choosing different platform instruments by means of M4 mirror, cutting-edge technology in both pointing and tracking). This, of course, won't limit the international collaborations. On the contrary, platforms could easily be exploited with a variety of scientific goals; thanks to the default instruments that will be commissioned during the second phase of the project (see later sections and [6]).

2. DAG TELESCOPE

Having the advantage of examining aged-telescopes with respect to their performance both optically and mechanically, DAG team had a radical decision of removing Cassegrain focus altogether. As is explained earlier to catch up with the trending astronomical questions, telescopes have to outperform the average which includes (a) pointing-tracking accuracy, (b) stability of focal plane correlated with platform layout, and (c) image corrections AO (adaptive optics) coupled with aO (active optics). Optics of DAG telescope is designed, in house, all these parameters in mind (see [4] for full details of the optics). Since we have already passed the FDR stage of the telescope, by design, no-Cass w/ 2-Nasmyth is much more stable than any configuration which includes Cassegrain focus. Note that, no-Cass configuration leads to a small tube size which also increases stability of fork structure (see Figure 3 for a general view of the DAG telescope optics).

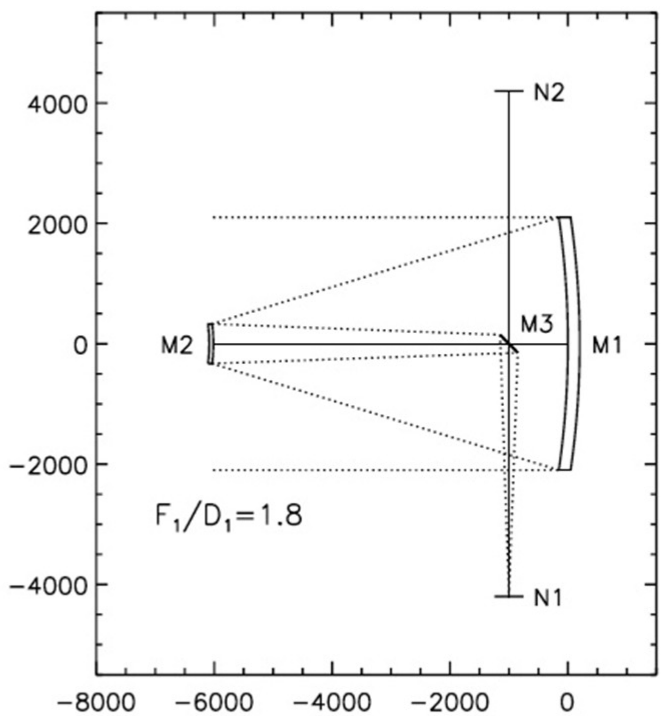

Figure 3. A general view of DAG telescope optics with fundamental sizes of the M1; axes are in mm.

Starting with small tube size but relatively long focal length (see both [4], [6] for other dimensional values) creates a potentially wide focal plane size (vignetted). DAG telescope's optics is tailored-down so that both AO and general purpose, "follow-up telescope" could be achieved.

Experience we gained through the optical design of DAG telescope, proved once again that first, optical requirements of scientific goals have to be studied for any future telescopes rather than customization of classical designs by going through copy-modify-produce cycle.

3. DAG INFRASTRUCTURE

Another very important decision that DAG team has taken was the motto established at the very early stage of the development: In the current technological age, "*telescopes should be taken as experimental tools that continuously produce high quality data in large amounts*". Therefore, whole establishment designed with "**remote observation**" from the start: (a) 48 core, 100 Gbit fiber cabling from the summit to the campus control room (26 km); (b) therefore minimal human activity is gained at the summit which creates less dust motion from the surface at the summit; (c) a meteorological measurement system that gathers scintillation measurements from almost all important layers of the atmosphere and distributes simultaneously to the site network; (d) which is the main rule of using queue mode observation: point the telescope where atmosphere quality is maximum; (e) HPC computing power in hand both for a quick-look and to post-process the data acquisition; (f) intelligent building design to prevent heat leak to line of sight of the telescope.

4. DAG FOCAL PLANE INSTRUMENTATION

Having excluded Cassegrain focus and distributed the focal plane into two Nasmyth using M3, platforms of DAG telescope became an optical laboratory. Furthermore, using well-designed modes of a motorized M4 mirror before the focal plane, each platform could occupy many instrument (see Figure 4). In applying for the second phase of the project, DAG team have allocated 6 potential slots for the whole telescope (see Table 1).

Table 1. DAG Focal Plane Instrumentation (DAG-FPI) – version 2016.

	N1 (w/ AO)		**N2 (seeing limited)**
Beam correction	Derotator		Derotator
Beam distribution	M4-a		M4-b
Main waveband	NIR (< 3 um)		Visible
AO	ON	OFF	N/A
@ Direct Beam	New Generation FPI		MOS
@ Beam to Right	Imaging FPI @ NIR		Both Imaging + Spectroscopy @ Visible
@ Beam to Left	SPARE SLOT		SPARE SLOT

Some of the priorities in Table 1 have to be mentioned: (a) Spare slots are for further instrument development; (b) A slot is going to be reserved for new generation of instrumentation (see [7] for DAG's current intention of these kinds); (c) Classical imaging and spectroscopy (like TFOSC in TUG) will be a permanent instrument of the platform; (d) A "**MOS Instrument**" and state-of the art "**imaging @ NIR**" will be the main engine and driver of the DAG in the world of observatories.

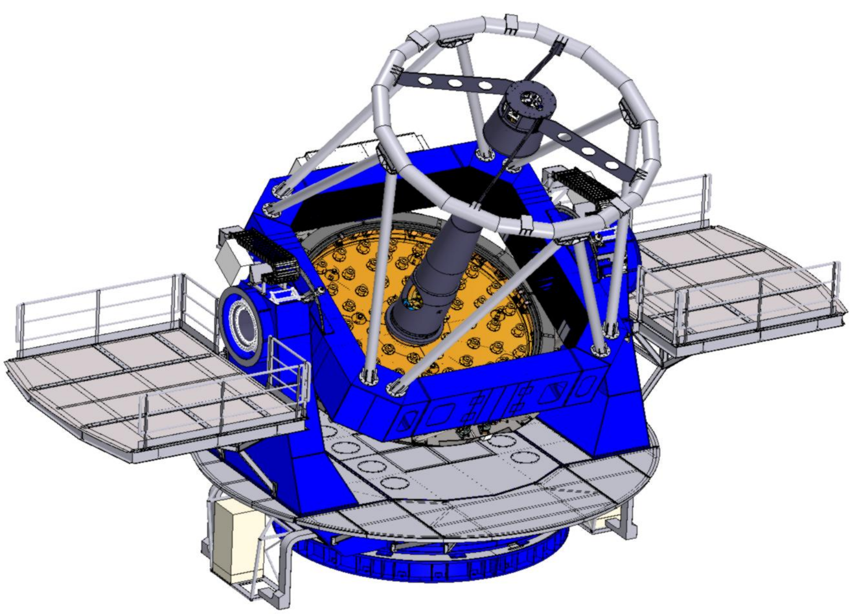

Figure 4. Final look of DAG telescope with two Nasymth platforms.

5. BENEFITS OF COLLABORATING WITH DAG

- High optical performance @ 4m class telescope.
- High pointing and tracking accuracy coupled with AO.
- Remote observing with computing power.
- Geographically fills longitude gap.
- An important potential partner in between North-South hemisphere projects.
- Potential spare site locations (with full infrastructure support) at 3170 m altitude.
- Exceptional weather conditions on a mainland geology which is comparable to other well-known crowded sites.

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