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# Upgradation of MOT and its Relevance to WET Campaigns

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**Abstract.** The Maidanak One-meter Telescope (MOT) is a Ritchey-Chretien telescope by Carl Zeiss, located atop Maidanak in Uzbekistan, where site parameters indicate excellent atmospheric seeing conditions. An effort to computerize the MOT, jointly made by an Uzbek, Taiwanese and Baltic consortium, is expected to complete in 2005. Monitoring the variability of star clusters will be among the first scientific projects to be carried out. Equipped with sensitive CCD cameras, the MOT, with its middle-Asia geographic location, will be a desirable addition to the Whole Earth Telescope (WET) network. We describe the upgrade engineering and instrumentation of the telescope and how the system can be used in future campaigns.

*Key words.* Telescopes—method: observational—stars: oscillation.

## 1. Introduction

Asteroseismology belongs to one of the main subjects of the Whole Earth Telescope (WET) activity. The principal aim of WET's Extended Coverage (XCov) is uninterrupted observations of the targets. For this purpose the observing sites ideally should be widely distributed in longitude. In the earlier years of the project such a longitudinal coverage was lacking. In an attempt to fill these gaps in the Eastern Hemisphere, Prof. Jan-Erik Solheim and Dr. Edmundas Meištas arranged a special exploration for potential sites in Central Asia in 1992, including possibility of Tien-Shan (Kazakhstan), Assy-Turgen (Kazakhstan), Sanglok (Tadjikistan) and Maidanak (Uzbekistan) observatories (Meištas 1993; Meištas *et al.* 1999). The first WET run was successfully carried out at Mt. Maidanak in May 1992 and again in September 1992 (Meištas 1993; Meištas & Solheim 1993). At the end of the last millennium two Asian observatories – in Kavalur (India) and Beijing (China) – were ready to join the WET (Meištas *et al.* 1999) and Odessa National University Observatory (Ukraine) has arranged expeditions to Mt. Dushag-Eregdag Observatory (Turkmenistan) for possible participation of the WET campaigns (Dorokhova & Doroknov 2003). Recently, Lulin Observatory (Taiwan) has started to join the WET activities and participated in the latest two campaign observations, XCov 23 and XCov 24. However, up to now a considerable incompleteness in the longitudinal coverage still exists, in particular in middle Asia (AKA 'Asian gaps'), which leads to imperfection in light curves (see e.g., Solheim 2003) and therefore to difficulties in time series analysis.

## 2. About the site

### 2.1 *Location*

Mount Maidanak Observatory (Uzbekistan) is located in Central-Middle Asia atop one of the isolated peaks of Pamir and Alay mountain ranges. It has a longitude of $4^h27^m35^s$E, latitude of $38°41'18''$N and an elevation of 2540 m. The nearest town is Kitab (40 km northwards) while the nearest larger cities, Samarkand and Karshi, are 100 km and 150 km away, respectively. In Fig. 1, the location of the observatory is shown with the main world observatories and is zoomed in the separate window.

### 2.2 *Seeing conditions*

The site seeing and other atmospheric conditions in respect of observational astronomy (AKA 'astroclimate') have been investigated for more than thirty years. Site explorations indicated good astroclimatic parameters which were confirmed later on by modern evaluations using ESO's Differential Image Motion Monitor (DIMM, Sarazin & Roddier 1990) started in 1996 and Generalized Seeing Monitor (GSM, Martin *et al.* 1994). As an example, the seeing distribution obtained by DIMM during a 3-year duration is shown in Fig. 2 (top panel) with a median seeing of 0.69 arcsec. The bottom panel of Fig. 2 shows the cumulative seeing (solid line) in comparison with those

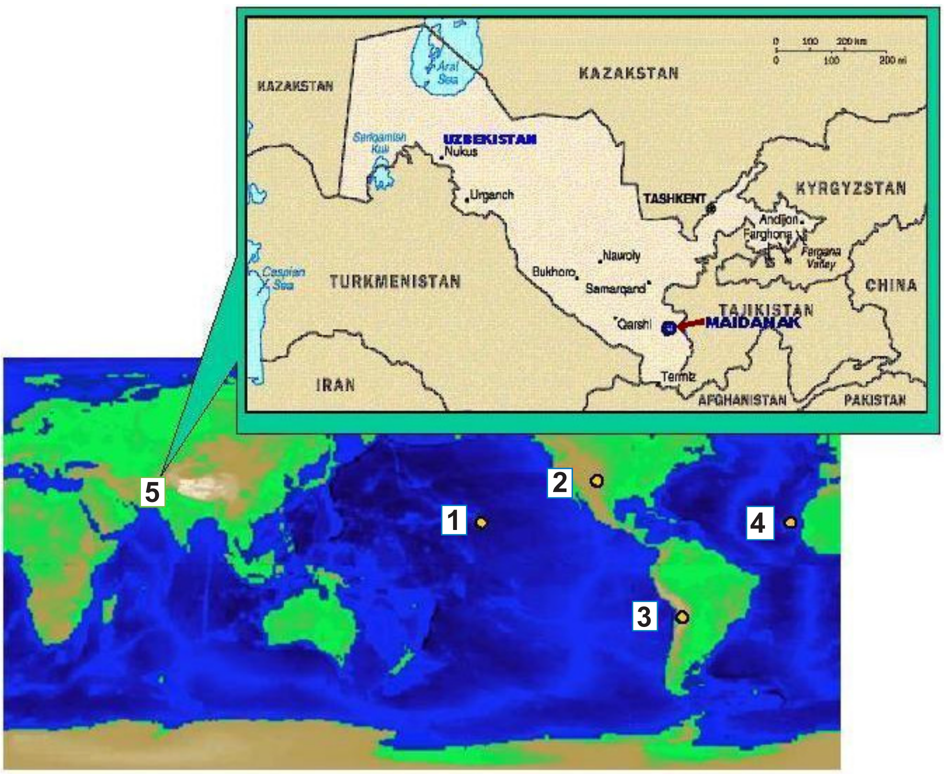
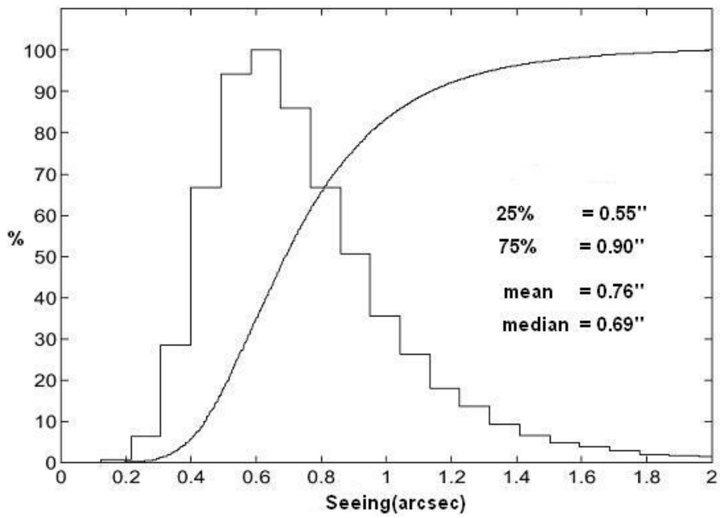



**Figure 1.** Global distribution of main good seeing optical observatories: (1) Hawaii, (2) NOAO, (3) Chile, (4) Canaries and (5) Maidanak.



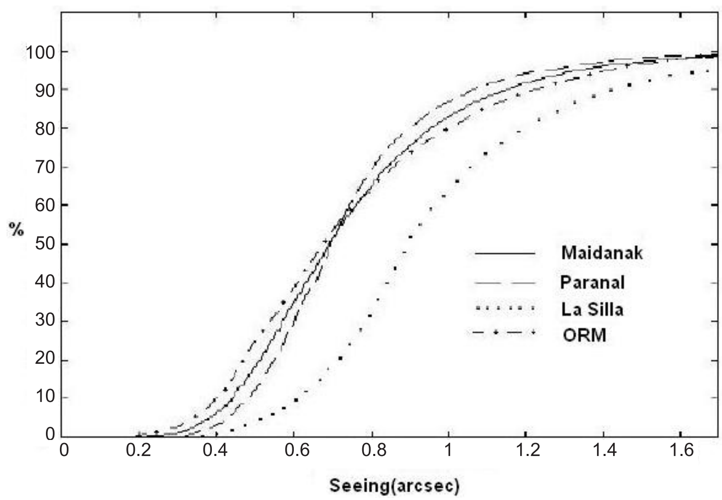




**Figure 2.** Mt. Maidanak seeing distribution (top panel) and its comparison with the sites in Chile and Canary islands.

**Table 1.** Some seeing parameters obtained by GSM (median values).

| | |
|---|---|
| Outer scale (m) | $25.9 \pm 19.0$ |
| Seeing angle (arcsec) | $0.67 \pm 0.25$ |
| Isoplanatic patch (arcsec) | $2.48 \pm 0.70$ |

of Chilean sites – La Silla (dotted line) and Paranal (dashed line) in 1989–1995 and Canarian site – Roque de los Muchachos Observatory (ORM) in 1996–1999 (dash-dot line) (Ehgamberdiev *et al.* 2000; Frogel 2002). The main seeing parameters obtained by GSM are given in Table 1.

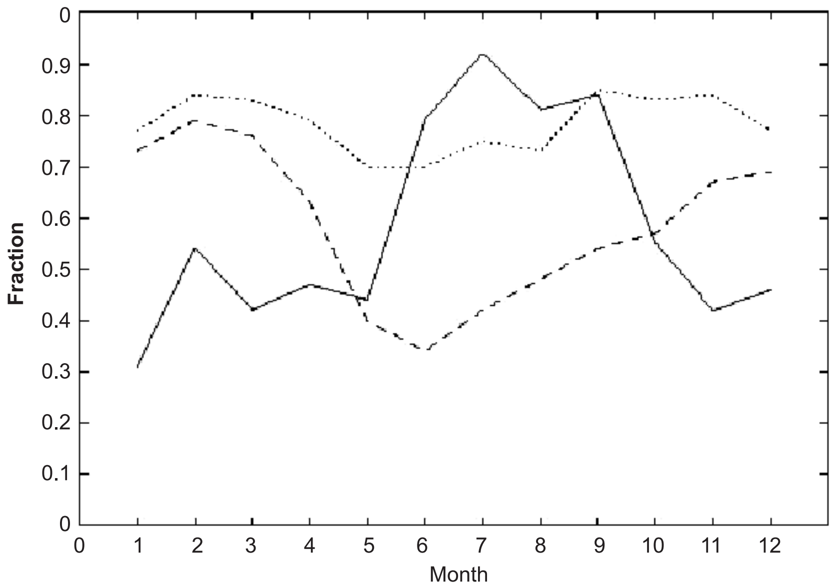



**Figure 3.** Clear nights distribution at Mt. Maidanak (solid line), La Silla (dashed line) and Paranal (dotted line).

In Fig. 3, we present monthly average fraction of clear nights at Maidanak in 1979–1985 (solid line) compared to the statistics of photometric nights at La Silla (dashed line) and Paranal (dotted line) in 1983–1997. Yearly fractions of clear nights are 58 per cent for Mt. Maidanak, 59 per cent for La Silla, and 78 per cent for Paranal, respectively. The total clear night sky is about 1900 hours per year. For more details on astroclimate atop Maidanak we refer readers to Sarazin (1999) and Ehgamberdiev *et al.* (2000).

### 2.3 *Facilities*

The observing facilities include 10 small-aperture telescopes. The main are 1.5 m and 48 cm telescopes made in St. Petersburg (Russia), one 1 m and three 60 cm Carl Zeiss telescopes (Germany), and one 50 cm telescope made in Kharkov (Ukraine). The Maidanak One-meter Telescope (MOT) had already been used in previous WET campaigns in combination with a special portable double-channel PMT photometer (Meištas 1993; Meištas & Solheim 1993). The 1.5 m telescope is equipped with an LN cooled back-illuminated CCD camera BroCam SITe005 with 2000 × 800 pixels. There are also a few old, hand-made single-channel PMT photometers. The currently operating DIMM instrument mounted on a standard Celestron-11 telescope (Sarazin & Roddier 1990) provides continuous and homogeneous seeing estimation coming in real time.

## 3. MOT upgrade and its possible use for WET

The MOT is a Cassegrain–Ritchey–Chretien–Coude system telescope, with a 1016 mm f/13 primary mirror. A recent photograph of the MOT is shown in Fig. 4. It was built in 1978 by Carl Zeiss in Jena (East Germany – former GDR) and has been operational

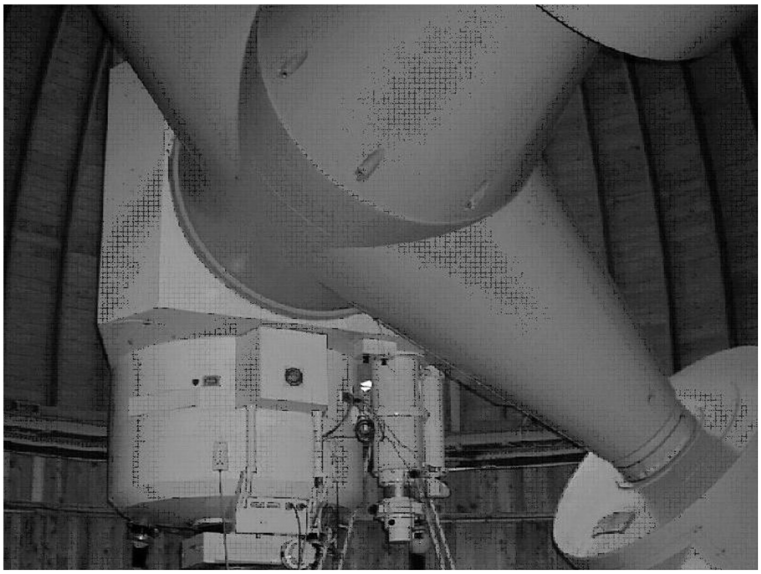


**Figure 4.** General view of the MOT.

since it first saw the light in 1981. In the summer and autumn (June–November) stellar photometry, mainly in the medium-band Vilnius photometric system, is conducted and in the winter some spectroscopy and radial velocity measurements are made (Meištas 1993). Naturally, the telescope electronics became old and outdated during this time thus making observing inefficient.

The idea to modernize and automate the MOT was initiated in 2001 when a team of devoted scientists from Institute of Astronomy of National Central University (Taiwan) observed at Maidanak (Hojaev *et al.* 2003). The financial resources were found later on when a group of astronomers from Taiwan, Lithuania, Latvia and Uzbekistan was funded by the Taiwan–Baltic Foundation to study open clusters. Simultaneously with conducting a joint research, the collaboration prepared and discussed possible renovation plans. The Yunnan Observatory group, which created a new computer control system (Zhou *et al.* 2001) and successfully upgraded their very similar telescope (the elder brother of the MOT – analogous 1 m RCC Zeiss telescope with the serial number differing from that of MOT by just 1 !), agreed to join the collaboration and offered to fabricate the new computer control electronic components. A multilateral agreement has thus been signed. The installation of the new electronic system is planned for early 2005.

After the upgrade, the MOT should have computer control of pointing, tracking and focus, with display and analysis of telescope, instrument, and site status parameters. The observer can select a particular target from a graphical interface of allsky catalogs (e.g., GSC, DSS and USNO A or B) and the telescope will then slew (point) towards it. The new system also implements synchronization of the dome, *i.e.*, the dome slit follows where the telescope is pointing.

The CCD camera AP-10 (Apogee Instruments Inc., USA) is considered as the shakedown instrument for photometry and imaging of open clusters and star forming regions, and we plan to use it for the WET campaign. AP-10 has a front-illuminated Thompson Atmel THX7899 chip with specifications as presented in Table 2.

**Table 2.** Atmel THX7899 chip parameters.

| | |
|---|---|
| Array size (pixels) | 2048 × 2048 |
| Pixel size | 14 × 14 microns |
| Imaging area | 28.7 mm × 28.7 mm |
| Pixel well capacity | 270,000 e- |
| Dynamic range | > 79 dB |
| CTE | 0.99997 |
| Peak QE | 38 per cent (@ 720 nm) |

**Table 3.** AP-10 camera system parameters.

| | |
|---|---|
| PC interface | PCI controller card (proprietary) |
| Digital resolution | 14 bits @ 1.3 MHz |
| Download time (typical) | 5 seconds |
| System noise (typical) | 13–25 e-RMS |
| Pixel binning | 1 × 1 to 8 × 64 on-chip |
| Exposure time | 30 milliseconds to 17 minutes (10 millisecond increments) |
| Frame sizes | Full frame, sub-frame, focus mode |
| Cooling | Thermoelectric cooler with forced air. Maximum cooling 35–38°C below ambient temperature |
| Dark current (nom.) | 4 e-/pixel/sec (−10°C) |
| Temperature stability | ±0.1°C |
| System gain | 10–13 e-/ADU (14-bit) |
| Camera | Head Aluminum, hard black anodized. 7 inch × 7 inch × 2.5 inch |
| Weight | 4 lb. 5.125 inch bolt circle for mounting. Optional Nikon, Canon or Thread mount |
| Operating environment temperature | −30° to 80°F |
| Relative humidity | 10 to 90 per cent non-condensing |
| Power | Supplied by host PC. 25W max. power with shutter open and cooling maximum |
| Shutter | Melles Griot 63 mm iris |
| Remote triggering | TTL input to PC controller allows exposure start within 100 ns of trigger for applications requiring precise synchronization of exposures to external events |

The AP-10 camera system performance is presented in Table 3. As one can see from Tables 2 and 3, in spite of a relatively low QE of the camera especially in the blue range, it is quite large and at the same time fast (read-out time is 5 sec only). It should have possibilities for sub-framing and binning. The common shortcoming of the Apogee camera is the problem with its bias. For AP-8E, for instance, the bias drift is smooth and slow within a night. In case of AP-10 we met with a sporadic jumping of the bias level. However the rest of the data are reliable and we simply excluded the 'jumped' (high-biased) frames from consideration.

One of the most important requirements of the WET observations is proper time-setting, *i.e.*, the correct fixing of the time of each measurement and synchronizing it with other observers and head-quarters. For this purpose we plan to use portable GPS station. It may be included as part of the new control system, as Yunnan Observatory has implemented for their 1 m (Zhou *et al.* 2001). Alternatively, voice time synchronization via a telephone will be used. The second item is operative link with WET head-quarters. Unfortunately, Maidanak has no internet link or reliable phone communication yet. But there were a few examples of successful use of the satellite communication systems. Bruvold (1993) describes the possibilities to use the micro-satellite communication with remote sites. During the WET runs in 1992 the TUBSAT-A (a student satellite of Technical University of Berlin launched as secondary payload of European Remote Sensing satellite ERS-1) was used which allowed sending and receiving short messages. However, it was not possible to transfer large volumes of data. Another successful usage of the satellite phone at Maidanak was by American amateur astronomers in 2003 during their visit to observe the Mars opposition when they had a voice communication with their partners in Tashkent and in the USA. Therefore the use of satellite communication systems for future WET campaigns is feasible.

One of the possibilities is a participation of Taiwan partners in the WET runs at Maidanak with such a device. Their immediate participation will be very desirable because they already have a good experience with WET activity at Lulin Observatory in Taiwan (XCov 23, XCov 24). We are also considering the use of a mobile phone for this purpose. The cellular communication systems as well as the internet are intensively developing also in Uzbekistan and becoming more spread. Obviously the signal will be weak in mountains far from settlements but hopefully we will be able to use the cellular phone with some signal amplifier to link with the internet and could use it at least for emailing. For instance, the cellular phones are in use in another mountain area north from Maidanak where the new large radio astronomy telescope should be installed soon.

## 4. Discussion and conclusions

The data presented in section 2.2 show that Maidanak has sky conditions rivaling those of the best sites worldwide. Its advantageous location can contribute to fill in the longitudinal gap in a global, continuous observing campaign. It can improve the WET coverage especially in cases of the monsoon season in India or be complementary to other network sites nearby. The recent distribution of observing sites which are involved in the WET activity is presented in Fig. 5. The WET community observatories as well as the Taiwan and Korea observatories that participated in the last campaigns are shown by filled circles while the Vainu Bappu Observatory in India is represented by the open circle. The Maidanak position is marked by a cross.

As mentioned earlier, the MOT has participated in previous WET observations (Solheim 2003; Meištas *et al.* 1999 and references therein). A total of 4 successful WET campaigns have been carried out with the MOT (Meištas *et al.* 1999). Figure 6

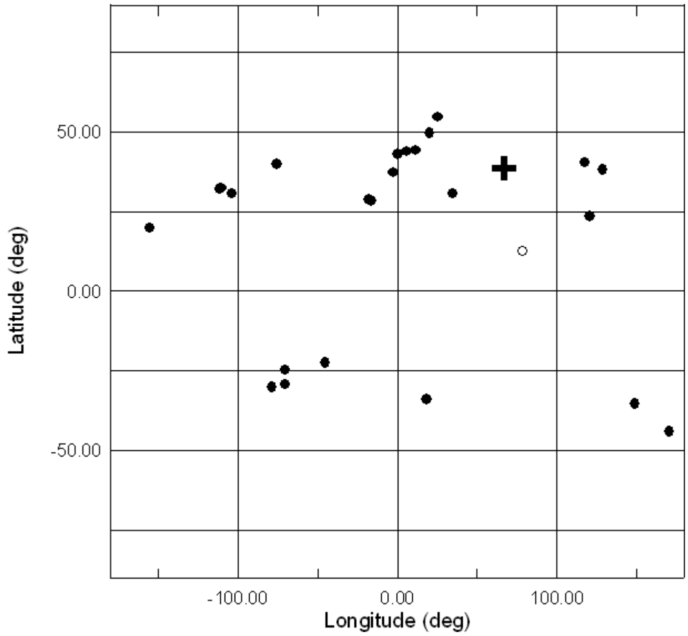



**Figure 5.** Distribution of the WET sites (filled circles); the open circle corresponds to the Vainu Bappu Observatory locus; the plus sign shows the location of the Maidanak Observatory.

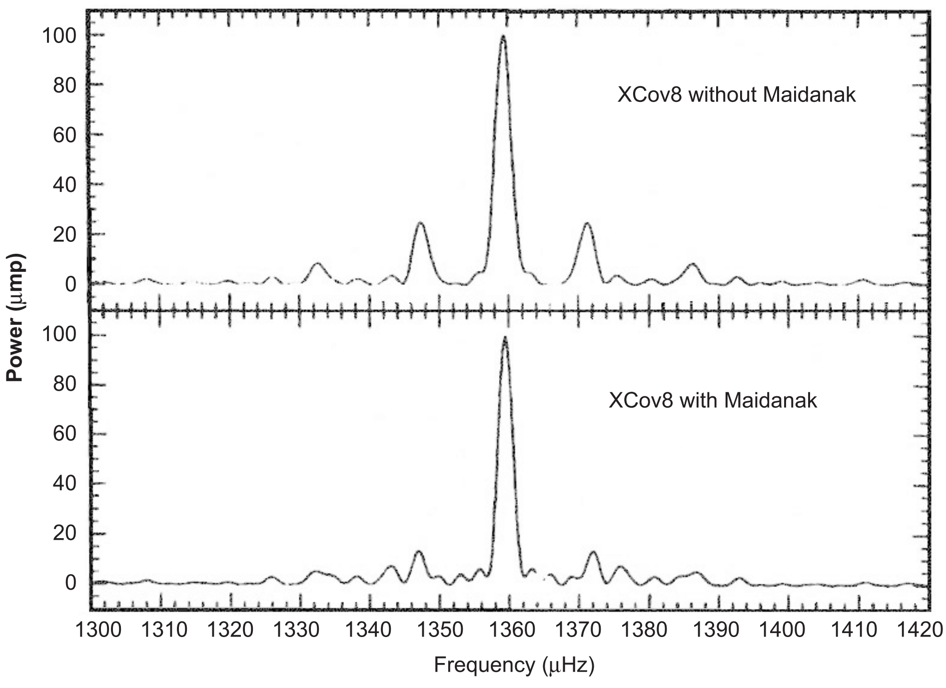



**Figure 6.** PG 2131+066: window function of XCov 8 campaign in September 1992 with and without the Mt. Maidanak data.

shows the window functions without and with inclusion of the Maidanak data for PG 2131+066 reported by Solheim (1993). A more complete longitudinal coverage makes a cleaner power spectrum (Solheim 1993).

After the upgrade is completed the MOT should have a much higher observing efficiency and be more user friendly. With CCD cameras the photometry will be deeper and more precise than using, for example, the one-channel PMT photometer. Together with the favored geographical and sky conditions of the site, we expect Maidanak to become a useful part of the WET network.

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