



Alert Chain and Observation Planning for Ground Wide Angle Camera Network

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Abstract

The Ground Wide Angle Camera Network (GWAC-N) is a robotic telescope network. It consists of ten wide-field core telescopes (GWAC-A) and two 60 cm narrow-field rapid follow-up telescopes (GWAC-F60A/B). The primary scientific goal of GWAC-N is to detect optical counterparts of gamma-ray bursts (GRBs) discovered by the Space-based multi-band Variable Objects Monitor (SVOM) satellite. This is achieved through synchronized monitoring with the GWAC-A array. Upon receiving a GRB trigger alert, the network conducts rapid, multi-band follow-up observations using the GWAC-F60A/B telescopes. The two-stage observation process involves many telescopes, making manual control impractical. Automated operations are therefore essential. They are realized through an integrated alert processing chain and an automated observation scheduling and dispatching mechanism. To enable this, we employ the SVOM Follow-up Observation Coordinating Service (FOCS) and GWAC-N's Automatic Observation Management (AOM) system. This paper presents the integrated alert processing workflow. It also describes the formulation of observation strategies, and the scheduling and execution of observations enabled by FOCS and AOM.

Key words: telescopes – gamma rays: general – methods: observational

1. Introduction

Identifying and characterizing the optical counterparts of gamma-ray bursts (GRBs) is crucial for understanding the physics of relativistic jets and circumburst environments. Optical synchrotron emission from GRBs provides essential diagnostics for shock physics and particle acceleration mechanisms within these jets. Early-time optical afterglow emission offers critical information unavailable at other wavelengths and enables precise astrometric localization, which is necessary for host galaxy identification and redshift determination. The rapid temporal evolution of optical transients—often decaying on timescales of minutes to hours—demands rapid, automated follow-up systems. Such systems are indispensable for capturing the initial brightness rise and early decay phase, which are essential for discriminating between theoretical afterglow models and constraining jet parameters.

In recent years, several robotic telescope networks and wide-field survey projects have developed advanced observation scheduling systems to enable automated transient follow-up. For instance, the Las Cumbres Observatory Global Telescope (LCOGT) network employs a network of globally distributed robotic telescopes with a dynamic scheduler that

allocates observations (Brown et al. 2013; Saunders et al. 2014). The Zwicky Transient Facility (ZTF) uses a real-time alert system and automated follow-up observation planning (Bellm et al. 2019). The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) has developed sophisticated scheduling algorithms to optimize survey efficiency (Naghib et al. 2019). In polar regions, the AST3 telescope array also implements automated observation strategies (Liu et al. 2018). Looking forward, projects like the Sitian array (also known as the GOTTA project) aim to further advance multi-telescope coordination and automated response to transients. Its pathfinder, the Mini-SiTian Array, has already demonstrated key technologies in its first two years of operation, including a dedicated master control system for automated observation management (He et al. 2025; Huang et al. 2025; Wang et al. 2025). These efforts highlight the critical role of automated scheduling in time-domain astronomy.

The Ground Wide Angle Camera Network (GWAC-N) (Wei et al. 2016; Xin et al. 2026) is a robotic telescope network. Its primary scientific goal is to capture and perform multi-band observations of the optical counterparts of GRBs detected by the Space-based multi-band Variable Objects Monitor (SVOM) satellite (Atteia et al. 2022; Cordier et al. 2026). The core of GWAC-N is the Ground Wide Angle Cameras Array (GWAC-A). It comprises 10 mounts and

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covers approximately 3,600 square degrees. Through optimized field planning, GWAC-A coordinates its observations with the SVOM/Eclairs instrument (Godet et al. 2026). This strategy allows it to monitor a large portion of the Eclairs field (approximately 8,000 square degrees). Consequently, it significantly increases the probability of detecting prompt optical emission. Upon receiving a GRB alert from Eclairs, the two 60 cm narrow-field telescopes (GWAC-F60A/B) autonomously initiate follow-up observations. This ensures continuous data collection from the prompt emission phase into the early afterglow.

The scale of GWAC-N makes manual control impractical. Efficient automation is therefore essential and is realized through an integrated alert chain and an automated scheduling mechanism. Specifically, we integrate the SVOM Follow-up Observation Coordinating Service (FOCS, Han et al. 2026) with GWAC-N’s Automatic Observation Management system (AOM, Han et al. 2021). This synergy allows users to design sophisticated strategies via FOCS, while AOM intelligently allocates telescopes and executes observations autonomously.

In the following sections, we detail the integrated workflow of the FOCS and AOM systems, including alert processing, the formulation of observation strategies, and the scheduling and execution of observation plans.

2. System Architecture

The coordinated observations between GWAC-N and SVOM are built upon a two-stage, automated pipeline. This integrated system, centered on the FOCS and AOM services, handles the entire workflow from external alert ingestion to final telescope execution, enabling end-to-end automation without manual intervention.

The observational sequence begins with plans from the SVOM satellite. The SVOM Chinese/French Science Centers (CSC/FSC) and the Mission Center formulate the SVOM General Program (GP) and Target of Opportunity (ToO) observation plans. The FOCS server processes the satellite’s GP/ToO observation plans and generates a matching list of GWAC-A sky fields for synchronized observation with the SVOM/Eclairs instrument. This list is ingested by the AOM system, where it is merged with other observational targets of GWAC-N. AOM then performs unified scheduling and dynamically assigns the fields to available GWAC-A telescopes for monitoring.

The system responds to transient events through two parallel, automated alert chains. The primary chain is triggered by a GRB detection from SVOM/Eclairs. The resulting alert is processed by FOCS, which formulates a follow-up observation request for the narrow-field F60A/B telescopes. Concurrently, an internal triggering mechanism exists: if the GWAC-A array itself detects a promising optical transient during its monitoring, it automatically generates a follow-up request for the

F60A/B telescopes to obtain confirmation and multi-band light curves (Xu et al. 2020).

All follow-up requests—whether originating from external SVOM alerts or internal GWAC-A detections—converge at the AOM system. AOM evaluates their priority, integrates them into the overall observation plan, and dynamically dispatches them to the F60A/B telescopes for execution.

In this architecture, FOCS and AOM play distinct, complementary roles. FOCS acts as the gateway and translator, processing all external inputs (GRB alerts, GP, and ToO plans) into standardized observation requests. AOM acts as the central executive and scheduler for GWAC-N. It oversees all observation requests, performs global observation planning, and dynamically schedules and dispatches tasks to every telescope in the network. The complete workflow is illustrated in Figure 1.

2.1. SVOM Follow-up Observation Coordination Service

The SVOM FOCS is built on a Client-Server (C/S) architecture to coordinate multi-telescope observations. The server, hosted at the CSC, serves as the central hub. The FOCS server performs three primary functions. First, it ingests and distributes GRB alerts in real time through a subscription model. Second, it provides observation planning capabilities. After processing external inputs—such as GRB alerts, satellite’s GP/ToO observation plans—it generates standardized observation requests. These requests are tailored to the scientific needs of users and the technical specifications of their instruments. Third, it runs a message notification service. This service pushes GRB alerts in real time to platforms like MATTERMOST⁽⁴⁾, ENTERPRISE WECHAT⁽⁵⁾, DINGTALK⁽⁶⁾, and FEISHU⁽⁷⁾. This assists astronomers and telescope operators in rapid event validation and observation coordination.

Standardized FOCS clients enable individual telescopes or networks to connect to the server. These clients facilitate the exchange of alerts, requests, and plans while maintaining bidirectional links for real-time feedback. Crucially, the clients also possess observation planning capabilities, allowing telescope team to flexibly design customized strategies tailored to their specific instruments. A web-based interface provided by the client allows users to monitor the entire workflow in real time, from the arrival of an alert or request through observation planning, execution, and feedback.

As a core ground-based system for the SVOM mission, GWAC-N operates a customized FOCS client at its site. This client manages observation tasks received from the central FOCS server. Following a custom interface protocol, it generates specific observation requests for the GWAC-A and

⁴ <https://mattermost.com>

⁵ <https://work.weixin.qq.com>

⁶ <https://www.dingtalk.com>

⁷ <https://www.feishu.cn>

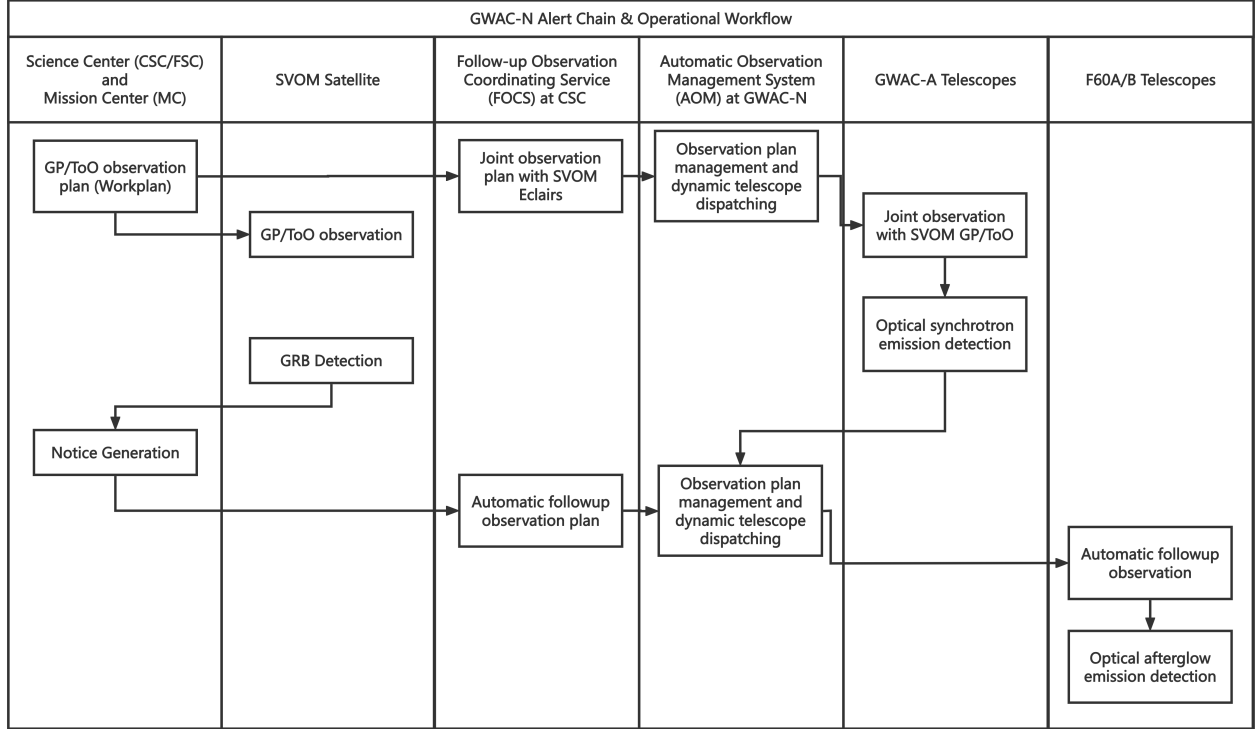


Figure 1. The end-to-end operational workflow of GWAC-N, depicting the integrated alert chain and observation process. Two parallel paths are shown: (1) The processing of *SVOM* General Program/Target of Opportunity (GP/ToO) observation plans into joint GWAC-A observation plans; and (2) The automated response chain triggered by *SVOM* GRB alerts and internal GWAC-A transient detections, leading to follow-up observations by the F60A/B telescopes. The FOCS and AOM systems coordinate these processes, handling external alerts, planning observations, and dynamically scheduling tasks across the telescope network.

F60A/B telescopes and forwards them to the local AOM system for execution. This setup supports GWAC-N’s coordinated planning with *SVOM* and enables its fully automatic GRB follow-up operations.

The FOCS server, hosted at the *SVOM* CSC, actively pushes alerts and observation plans to all registered clients, including the dedicated FOCS client deployed at the GWAC-N site. To ensure reliable delivery, the server maintains a queue for each client. In the event that a client becomes unavailable (e.g., due to network interruption or system crash), the server retains all pending messages. Once the client reconnects, it automatically receives the queued messages and sends an acknowledgment to the server, guaranteeing zero data loss during transient failures.

At the GWAC-N site, the FOCS client forwards received observation requests to the local AOM system for execution. The communication between the FOCS client and AOM follows a handshake protocol: after sending a request, the client waits for an acknowledgment from AOM. If AOM is unavailable (e.g., due to a system crash), the client does not queue messages for later automatic retransmission. Instead, the client’s web interface displays the offline status of AOM, prompting human operators to manually restart the AOM system. This design avoids overloading AOM with a burst of

pending requests upon recovery, which could otherwise cause processing delays or miss critical observation windows. It also prevents the execution of outdated observation plans that could pose risks to telescope safety.

The basic architecture of the FOCS system, including its server-client relationship with GWAC-N, is illustrated in Figure 2.

2.2. Automatic Observation Management System (AOM) of GWAC-N

The architecture and workflow of the AOM system are illustrated in Figure 3. The AOM coordinates all observational activities within GWAC-N, managing input targets, distributing them to appropriate telescopes, and executing observations. Its complete architecture comprises several core modules: a ToO follow-up module, a target management module, a dynamic scheduler, an automatic dispatcher, and a communication center.

In the current implementation of AOM for GWAC-N, the ToO follow-up module—designed to process and standardize external GRB alerts before passing them to the target management module—is temporarily bypassed. This is because the FOCS system already handles the coordination, planning, and alert response for follow-up observations.

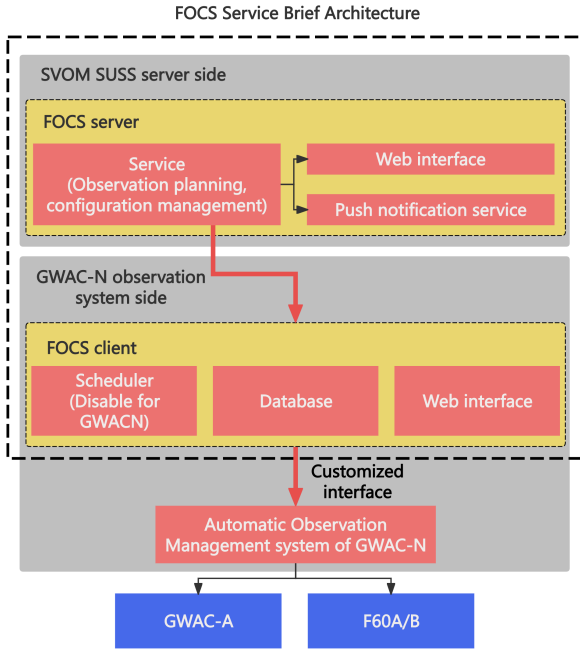


Figure 2. Architecture of the FOCS system. The server is hosted at the SVOM CSC, while a dedicated client operates at the GWAC-N site. FOCS coordinates observation planning between SVOM and GWAC-N, enabling automated follow-up observations through the GWAC-A and F60A/B telescopes.

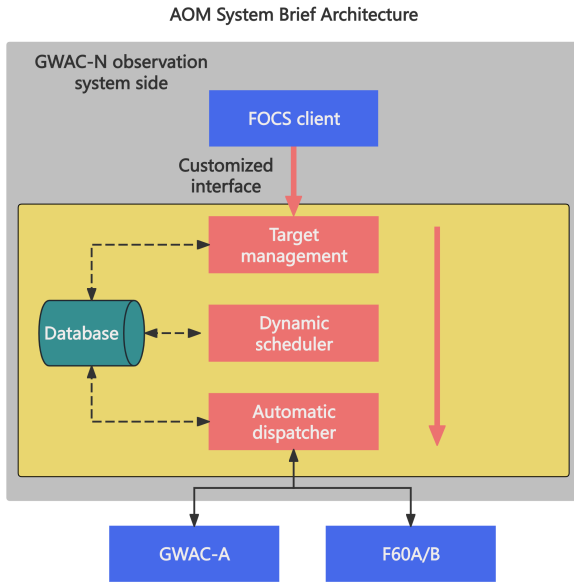


Figure 3. Schematic architecture of the Automatic Observation Management (AOM) system for the GWAC-N observation system.

Instead, observation requests sent from FOCS are directly ingested by the target management module in the form of observation targets. All targets, including those from various scientific programs of GWAC-N, are processed, classified, and inserted into the database by the target management

module. The rationale for this design will be further discussed in Section 5.

Following target ingestion, the dynamic scheduler initiates observation planning. It aims to generate observation plans for all telescopes based on target prioritization and visibility. The highest-priority visible targets are scheduled as extensively as possible within the available telescope resources. Higher-priority targets may also interrupt ongoing lower-priority observations.

GRB alerts received from FOCS are assigned the highest priority and can preempt both GWAC-A and F60A/B observations. Preemption is implemented as an immediate abort of the current lower-priority observation, allowing the telescope to slew to the GRB position without delay. This ensures the earliest possible capture of the optical afterglow. After the high-priority observation is completed, the system may resume the interrupted observation if feasible.

The dispatcher retrieves an observation plan from the scheduler. It then checks the availability of the assigned telescope and verifies the target’s observability. Once confirmed, it sends an observation command to the telescope controller and continuously monitors the observation status. All actions are driven by real-time information. A centralized communication center manages the complex interactions among external interfaces, internal modules, and the telescopes. It also provides message sequencing control to ensure that all modules and actions proceed in a predetermined order. This guarantees that the scheduling and dispatching operate in a fully dynamic manner.

2.3. Interface between FOCS and AOM

A customized interface, developed by modifying value fields in the standard FOCS communication protocol, facilitates the transmission of observation requests between the FOCS client and the AOM system. Each request contains comprehensive metadata, including:

1. GRB trigger designations and trigger timestamps;
2. Detection instruments and trigger coordinates with astrometric errors;
3. Alert classification types, signal-to-noise ratios, and confidence levels;
4. Designated telescope groups and observation strategies (e.g., single pointing or mosaic coverage);
5. Observation modes (photometry or spectroscopy) and configurations (filters/gratings, slit widths, exposure times, frame counts, readout speeds, observation cycles, priorities, and scheduled start/end times).

This structured dataset provides all necessary information for photometric and spectroscopic follow-up observations. It supports real-time candidate matching (i.e., the search and identification of optical counterparts) and facilitates retrospective data analysis.

3. Observation Strategy and Planning

3.1. Joint Observation between GWAC-A and SVOM/Eclairs

The wide-field GWAC-A telescope array operates in continuous synchronization with the SVOM/Eclairs instrument, monitoring the same sky region. This spatiotemporal coordination enables GWAC-A to search for prompt optical emission simultaneously with Eclairs' gamma-ray detections. Real-time monitoring ensures that any optical counterpart appearing during the initial seconds of a GRB can be promptly identified and recorded.

Observation planning is carried out on the FOCS server. The server processes SVOM ToO and GP observation plans—collectively referred to as ToO/GP workplans. For each workplan, FOCS performs several steps: it matches GWAC sky regions based on positional and field-of-view overlap; assigns observation priorities according to the hierarchy SVOM ToO > SVOM GP > GWAC routine observations; calculates observable time windows for the matched regions during the same night; and finally generates a list of regions as observation requests for GWAC-A.

During execution, the AOM system refines these requests by recalculating observable time windows, taking into account telescope pointing constraints such as hour angle, altitude limit, and lunar distance. Regions with valid observing windows are then sorted. The primary sorting criterion is the assigned priority. For regions with equal priority, a dedicated optimization algorithm determines the sequence based on a weighted score that evaluates three factors: proximity to the center of the Eclairs field of view (FoV), elevation, and galactic latitude. The weighting decreases in the order of distance, altitude, and galactic latitude, ensuring that closer regions are strongly preferred, while altitude and galactic latitude act as secondary tie-breakers.

The resulting sorted list is integrated into a dynamically maintained nightly observation schedule. This schedule is automatically re-sorted whenever the list content or the status of observations changes. This structured approach ensures that GWAC-A coordinates optimally with Eclairs, dynamically prioritizing the most scientifically critical targets while managing telescope resources and observational constraints efficiently.

The final observation sequence for equal-priority targets is determined by a composite `ranking_score`. This score is a weighted sum of four observational parameters, each representing a distinct priority level designed to optimize field selection. The detailed formulation for each candidate GWAC field is as follows:

Level 1: Distance Score. This is the primary score, based on the angular separation (d) between the field center and the center of the SVOM/Eclairs FoV. The score increases as the

distance decreases and is normalized by the matching radius R :

$$S_{\text{dist}} = \text{round}\left(1 - \frac{d}{R}, 1\right), \quad S_{\text{dist}} \in [0, 1].$$

Level 2: Altitude Score and Hour Angle Score. The Altitude Score depends on the field's altitude angle (Alt) at the observation time. A higher altitude yields a higher score:

$$S_{\text{alt}} = \text{round}\left(\frac{\text{Alt}}{90} \times 0.1, 2\right), \quad S_{\text{alt}} \in [0.00, 0.09].$$

The Hour Angle Score is calculated from the absolute hour angle (|HA|) of the field. It encourages observation near the meridian ($\text{HA} \approx 0$):

$$S_{\text{ha}} = \text{round}(\max(0, (5 - |\text{HA}|) \times 0.01), 2), \quad S_{\text{ha}} \in [0.00, 0.05]$$

Level 3: Galactic Latitude Score. This score acts as a final micro-adjustment based on the absolute galactic latitude ($|b|$):

$$S_{\text{gal}} = \begin{cases} 0.001, & \text{if } |b| > 20^\circ \\ 0.000, & \text{otherwise} \end{cases}$$

The final composite score is the sum of these four components:

$$\text{ranking_score} = S_{\text{dist}} + S_{\text{alt}} + S_{\text{ha}} + S_{\text{gal}}$$

Algorithm Design and Rationale

The scoring function is hierarchically designed to enforce the strict observational priorities between GWAC and SVOM/Eclairs. The weights are calibrated across distinct orders of magnitude to create an unambiguous ranking order: distance > (altitude + hour angle) > galactic latitude.

The distance score (S_{dist}), on the order of 10^0 (range [0, 1]), is the primary and decisive factor. Its dominance ensures that fields closest to the Eclairs pointing are selected first, directly maximizing the spatial coverage and scientific yield of the joint observations.

The altitude (S_{alt}) and hour angle (S_{ha}) scores form a secondary tier, both contributing on the order of 10^{-2} . Within this tier, altitude (range [0.00, 0.09]) typically has a slightly stronger influence than hour angle (range [0.00, 0.05]). Together, they fine-tune the ranking by favoring targets under better observational conditions: higher altitude minimizes atmospheric extinction, while a smaller hour angle favors tracking near the meridian.

The galactic latitude score (S_{gal}) serves as a final micro-adjustment, with a value on the order of 10^{-3} . It applies a subtle, systematic bias toward higher galactic latitudes ($|b| > 20^\circ$), helping to avoid crowded star fields and reduce background confusion.

This structured approach deliberately scales the contribution of each successive level by an order of magnitude. It efficiently encodes a complex multi-criterion decision into a single,

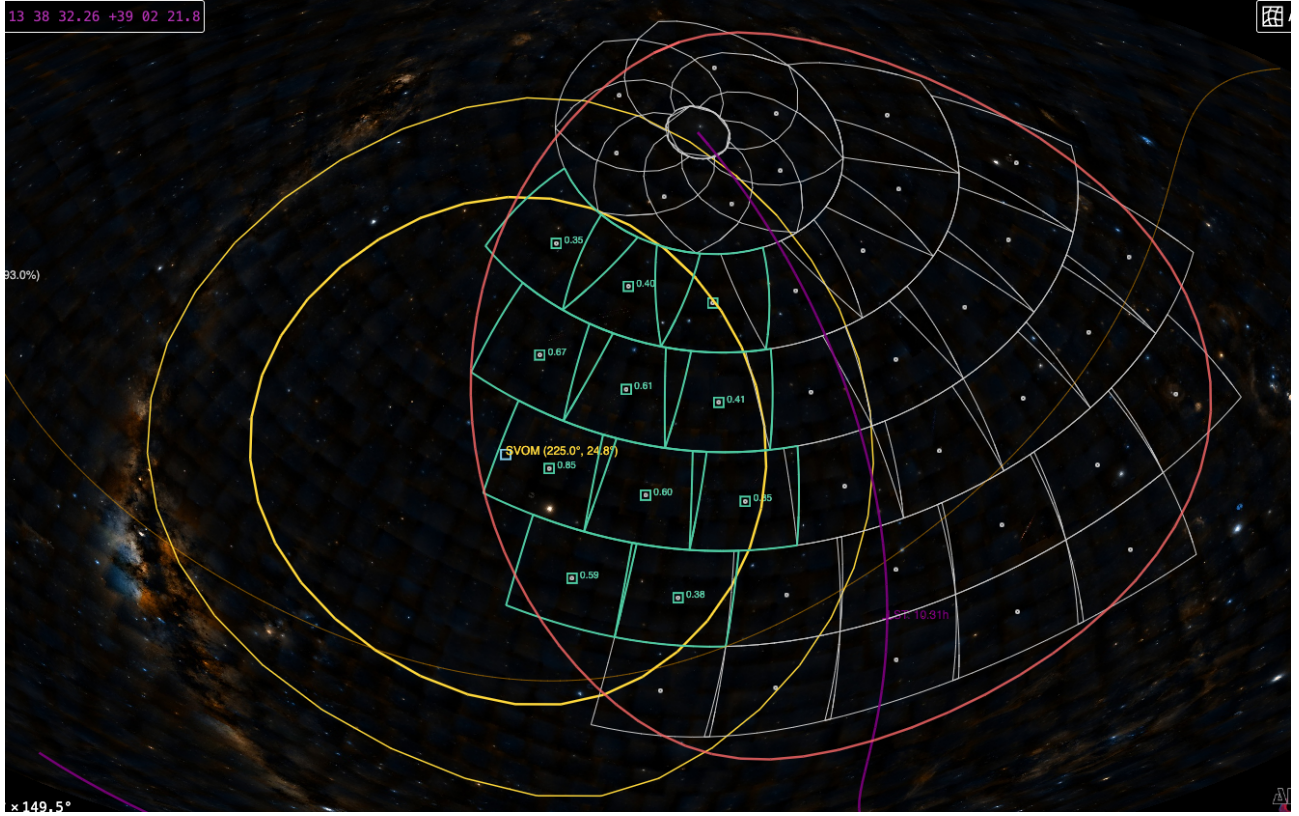


Figure 4. Web interface of the automatic co-observation planning tool. The interface displays: the current SVOM pointing (small blue square) and the Eclairs FoV (thick yellow circle for central region, thin yellow circle for periphery); the GWAC-A visible sky (gray box); the 25° altitude limit (red circle); the local sidereal time (purple curve); and all automatically suggested fields as blue boxes, with the ten highest-scoring fields labeled by their scores. The example shown corresponds to a SVOM pointing at the source NGC 4328.

sortable metric. The resulting `ranking_score` enables the automated scheduler to make choices that are both scientifically targeted and observationally efficient. This system has been validated through the daily operation of GWAC-N, optimizing telescope time allocation to increase scientific throughput.

The observation planning for GWAC-N is supported by two complementary tools operating at different levels. An automatic co-observation planning tool, integrated as a dedicated plugin within the FOCS server, implements the scoring algorithm described above. It provides observers with a real-time web interface (Figure 4) that visualizes the current SVOM pointing, the Eclairs FoV (with a thick yellow circle for the central region and a thin yellow circle for the periphery, reflecting the uncertainty in satellite platform rotation), the GWAC-A visible sky, and all automatically suggested fields as blue boxes, with the ten highest-scoring fields labeled by their scores. All automatically suggested fields satisfy both temporal (visibility window overlapping the SVOM observation) and spatial (overlap with the Eclairs FoV) constraints.

A manual planning tool, integrated as a plugin in the GWAC-N observation control system, allows observers to adjust the field selection to address specific scientific goals or to avoid technically challenging conditions. Figure 5 shows an example of this interface. The main canvas displays the same sky context as the automatic tool, including the SVOM pointing, the Eclairs FoV, the altitude limit, and the automatically suggested fields (shown in white with field numbers). Observers can drag a field to a new position (the adjusted field appears in red) or modify its parameters via the control panel on the right. The panel provides detailed information for the selected field: its number, the associated SVOM target (e.g., NGC 4328) and coordinates, the visibility window, and a list of available GWAC-A telescopes that can be assigned to the observation. After adjustments, the updated plan is submitted to the AOM system for execution.

Figure 6 presents an example of the resulting field placement for a specific SVOM observation plan (source NGC 4328, R.A. 185.8335, decl. +15.8204), demonstrating the combined

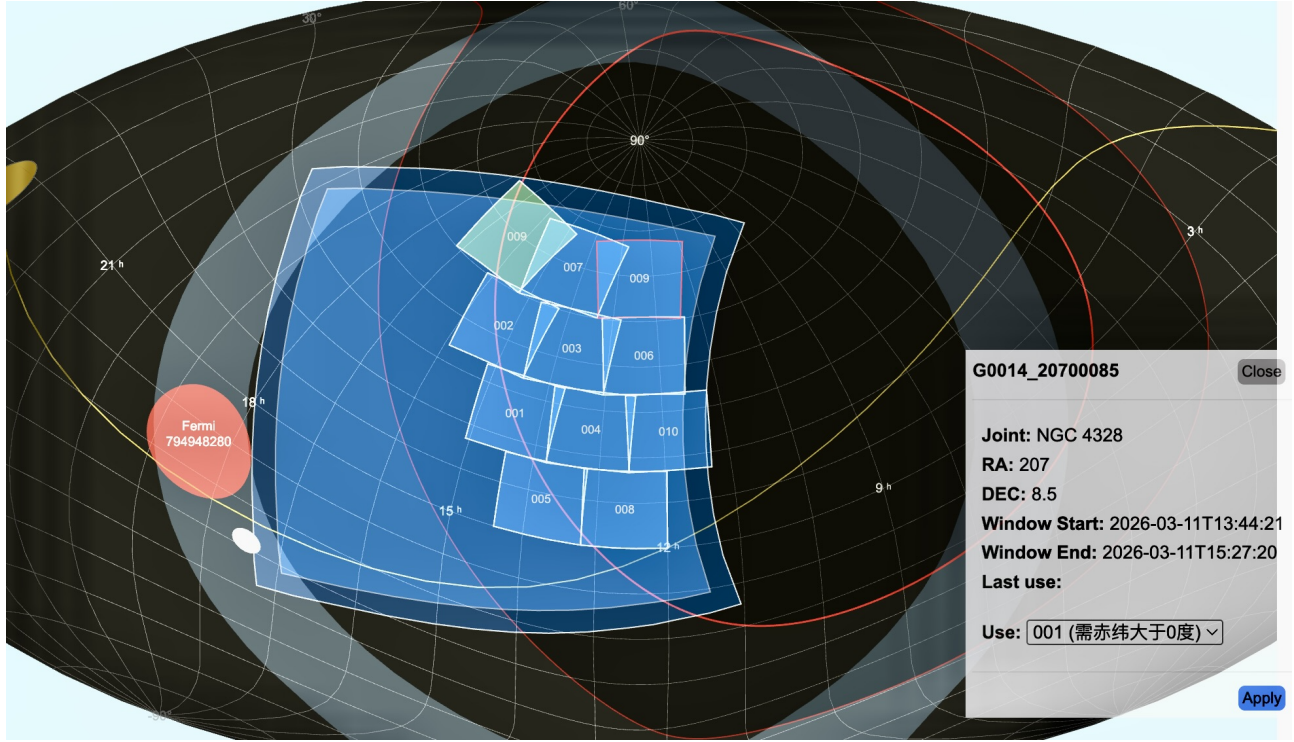


Figure 5. Interface of the manual planning tool. The main canvas shows the same sky context as Figure 4, with automatically suggested fields displayed in light green (e.g., field 009). The observer has dragged field 009 to a new position (shown in red) to avoid pointing too low. The right panel provides detailed information for the selected field: field number, associated SVOM target (NGC 4328) and coordinates, visibility window, and a list of available telescopes for assignment.

outcome of the automatic and manual planning tools. The figure illustrates how the system achieves coordinated sky coverage while accommodating operational considerations.

3.2. GRB Automatic Follow-up with F60A/B

The automated follow-up observations with the F60A/B telescopes are orchestrated by the FOCS service. The workflow is fully automated and includes several key steps. First, incoming GRB alerts from instruments such as SVOM/Eclairs, Swift/BAT, and EP/WXT are filtered based on predefined criteria, primarily alert classification types and the signal-to-noise ratio. Next, visibility windows are calculated, accounting for all telescope constraints. Then, coordinate deviations are assessed. Finally, the event is matched to a predefined observation strategy to generate a detailed, executable plan.

The core of this automation is an adaptive, time-sequenced observation strategy. A fundamental principle is that the exposure sequence is not fixed but is dynamically chosen based on the time elapsed since the GRB trigger when observations begin (t_{start}). This design adapts to the expected rapid decay and dimming of the optical afterglow. The strategy is divided into three primary scenarios, each aiming for a total on-source integration time of approximately one hour:

1. *Observation commencing within 3 minutes post-trigger.* Observations beginning in this prompt/early phase use an increasing exposure sequence: 20 s, 60 s, 100 s, and finally 200 s. This progression prioritizes high temporal resolution at the start to capture rapid early variations (e.g., flares or plateaus), then gradually transitions to longer exposures to maintain a high signal-to-noise ratio as the source fades.
2. *Observation commencing between 3 and 30 minutes post-trigger.* For observations starting in this early afterglow phase, the strategy begins with a medium 50 s exposure to achieve adequate initial depth, then switches to a series of 200 s exposures. This balances the need for good sensitivity with efficient monitoring of the more gradual decay.
3. *Observation commencing beyond 30 minutes post-trigger.* During the late-time afterglow phase, the source is faint and evolves slowly. The strategy employs 200 s exposures exclusively to maximize detection depth and photometric precision for accurate light curve measurement and counterpart identification.

This adaptive strategy is grounded in the typical power-law decay ($F_{\nu} \propto t^{-\alpha}$) of GRB afterglows. The detailed exposure

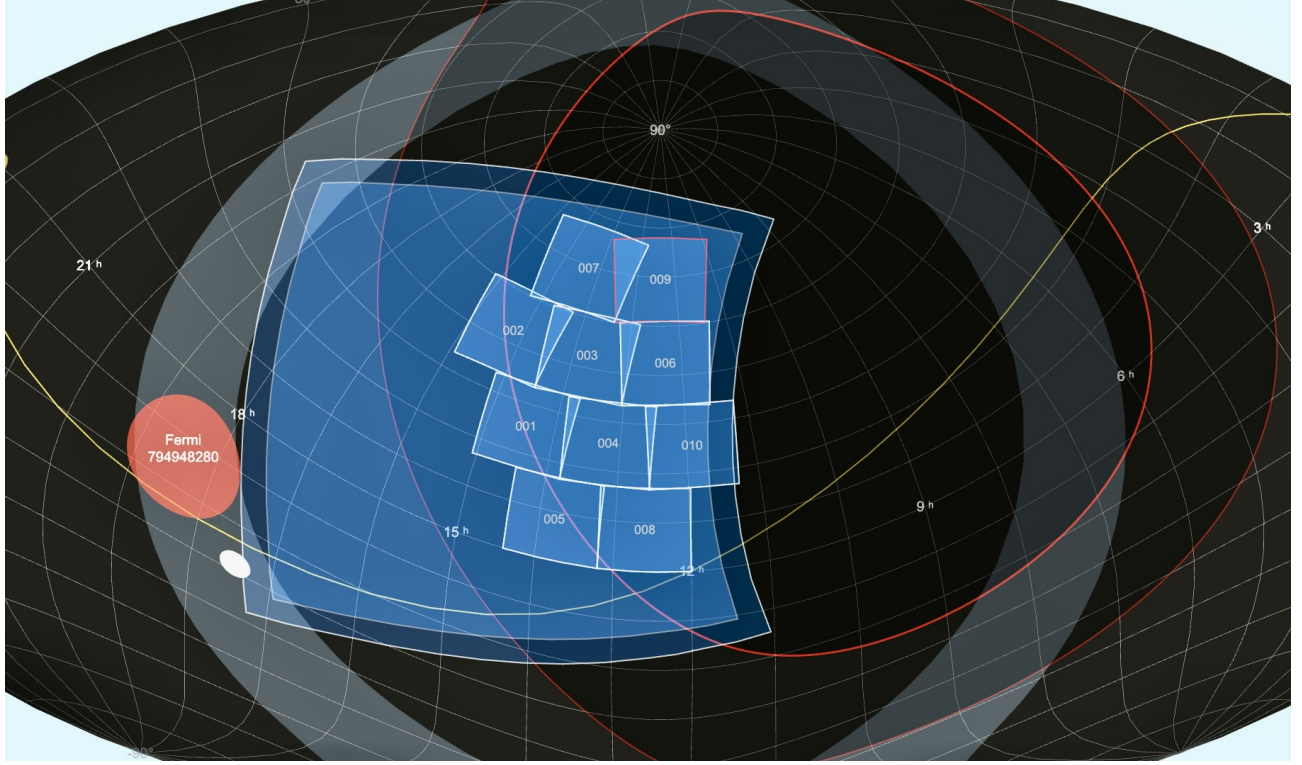


Figure 6. Visualization of the coordinated observation strategy between GWAC-A and SVOM/Eclairs. The smaller fields indicate the pointings of the GWAC-A array: white boxes represent automatically planned fields, while red boxes represent manually adjusted fields (field numbers are labeled). The larger blue field represents the sky coverage of the SVOM/Eclairs instrument for source NGC 4328. The Fermi alert position and its error range are also indicated. The solid red curve marks the 25° altitude limit from the GWAC observing site. The shaded gray region highlights the area of low galactic latitude ($|b| \leq 20^\circ$), which is strategically avoided to minimize stellar crowding and background confusion. The plot demonstrates the algorithm’s effectiveness in maximizing coverage of the Eclairs fields within observable sky regions while adhering to observational constraints.

Table 1
Adaptive Exposure Strategy for F60A/B Telescopes Based on Observation Start Time (t_{start})

Start Time	Exposure Sequence	Frames	Total Time	Scientific Rationale
$t_{\text{start}} \leq 3 \text{ min}$	20 s, 60 s, 100 s, 200 s	20, 10, 10, 10	4000 s	Maximize temporal resolution for early fast variability; adapt to rapid initial decay.
$3 < t_{\text{start}} \leq 30 \text{ min}$	50 s, then 200 s	10, 15	3500 s	Balance depth and efficiency for a moderately bright, smoothly decaying afterglow.
$t_{\text{start}} > 30 \text{ min}$	200 s	15	3000 s	Maximize sensitivity and precision for a faint, slowly evolving afterglow.

strategy for the F60A/B telescopes is summarized in Table 1. It offers significant advantages over a static, fixed-exposure approach. A single fixed exposure would be suboptimal: too long during the bright early phase, it would smear out fast variations; too short during the faint late phase, it would fail to detect the afterglow. The F60 strategy functions as a rule-based, dynamic sampling system. It automatically prioritizes high-cadence observations early on to capture dynamic behavior, then shifts to deep, sensitive exposures later to

secure precise measurements. This ensures maximum scientific yield across the afterglow’s entire evolutionary timeline.

4. Performance

We have evaluated the performance of the FOCSS system between 2025 January 15 and 2025 December 25. During this period, the system processed 323 GRB events. It issued 2,975 observation requests to the telescope network and generated 21,936 individual observation tasks for coordinated observations

between GWAC-A and SVOM/Eclairs. Despite experiencing unstable network conditions at the Xinglong Observatory site, the system maintained an average end-to-end alert transmission delay of only 1.8 s, with a maximum delay of 5.0 s. It is noteworthy that the system achieved zero message loss throughout the entire operational period.

The observation of GRB 201223A demonstrates the operational readiness and scientific value of the integrated GWAC system (Xin et al. 2023). Historically, for this event, GWAC-A monitored the target field continuously with a 15 s cadence. Its coverage spanned from 70 minutes before the trigger to 25 minutes after, successfully capturing a fast optical transient synchronous with the prompt gamma-ray emission. The system now operates with an increased cadence of 3 s (Xin et al. 2026). This enhanced temporal resolution allows GWAC-A to not only study GRB afterglows in greater detail but also to significantly improve its sensitivity for detecting other classes of fast optical transients. Upon receiving the alert, the F60A telescope autonomously began follow-up observations within 45 s, validating the robustness of the automated FOCS-AOM pipeline.

Scientifically, this event underscores GWAC’s unique ability to detect prompt optical emission concurrent with GRB high-energy activity. The resulting optical light curve shows distinct phases: an initial brightening ($\alpha_1 \approx 0.66$), a peak at approximately 52 seconds, followed by a decay ($\alpha_2 \approx -1.07$). The observed optical flux was significantly in excess of the extrapolation from high-energy data. This characteristic, reminiscent of the physical mechanism in GRB 080319B, suggests that bright prompt optical emission may not be confined to the most luminous GRBs but could occur across a broader range of burst luminosities.

To quantitatively assess the effectiveness of the joint observation strategy, we plan to evaluate the detection rate through numerical simulations. We will develop a simulation framework that models the joint observation geometry, telescope visibility, and realistic operational constraints to estimate the theoretical detection rate. This simulated metric will provide a direct measure of the system’s intrinsic capability to capture prompt optical emission and will serve as a quantitative benchmark for further optimization of the field selection algorithm.

5. Discussion and Future Plans

The GWAC-N system employs a distinct operational model within the SVOM follow-up network. While observation plans for other telescopes are typically generated locally by their FOCS clients, planning for GWAC-N is performed centrally on the FOCS server. This server-side approach provides significant advantages. The server integrates comprehensive, real-time information that is challenging to disseminate to individual clients, including detailed SVOM pointing plans,

satellite eclipse schedules, South Atlantic Anomaly (SAA) entries, and the status of ongoing observational tasks. By leveraging this global information, the server can perform more sophisticated and optimized planning for the complex joint observations between GWAC-A and the SVOM Eclairs instrument. Furthermore, this centralized architecture provides a robust foundation for future coordinated operations across a geographically distributed, multi-site GWAC-N.

A key ongoing objective is to further improve and quantitatively assess the efficiency of the joint GWAC-A and Eclairs observations. The primary challenge lies in maximizing the combined spatiotemporal coverage of the Eclairs fields within the operational constraints of the GWAC telescopes. To address this, developing well-defined, quantifiable efficiency metrics is crucial for refining the field-planning algorithms. Parameters such as target altitude, galactic latitude, and lunar distance must be intelligently weighted within the scheduling logic. Additionally, the timing of field transitions requires careful optimization. Together, these factors critically determine overall observational effectiveness and warrant systematic investigation.

Therefore, enhancing the efficiency of the GWAC-A and Eclairs joint observations remains a top development priority. This will be pursued by leveraging and enhancing a future multi-site GWAC-N architecture, with the goal of achieving a coordinated and significant increase in scientific data yield.

In addition to optimizing field selection, future work will integrate real-time weather data and observing conditions (e.g., cloud cover, seeing, lunar phase) into the scheduling logic. This will enable more robust and adaptive decision-making, improving the overall efficiency and reliability of the GWAC-N system.

The open-source simplified client software is available for download.⁸ To promote transparency and enable broader community use, we plan to release key components of the FOCS and AOM software as open-source packages in the near future.

6. Conclusion

This paper presents the integrated workflow and observational strategy of the GWAC-N system. We have demonstrated its capability to perform fully automated, two-stage coordinated observations in tandem with the SVOM mission. The synergy between the FOCS and AOM systems enables efficient alert processing, dynamic observation planning, and rapid telescope response. Together, they form a complete, automated pipeline from initial GRB detection to detailed multi-band follow-up.

The system’s operational readiness has been validated by observations such as GRB 201223A, which captured prompt

⁸ <http://www.svom-gwacn.cn/doc/focs-client.zip>

optical emission and produced a well-sampled light curve revealing distinct physical phases. The observed optical excess suggests that bright prompt optical emission may occur across a broader range of GRB luminosities. This highlights GWAC-N's potential to uncover new aspects of GRB physics through its unique high-cadence monitoring capability.

Looking forward, the continued optimization of the field-planning algorithm remains a priority, and we plan to establish a quantitative benchmark by evaluating the theoretical detection rate through numerical simulations. Incorporating factors such as target altitude, galactic latitude, and lunar distance into a quantifiable efficiency metric will further enhance the spatiotemporal coverage of SVOM Eclairs fields. Furthermore, the planned expansion to a geographically distributed, multi-site GWAC-N will significantly increase the system's sky coverage and observational flexibility.

With its automated, responsive architecture, the GWAC-N system stands as a powerful automated facility for time-domain astrophysics. It is well-positioned to contribute substantially to the study of GRBs and other optical transients in the multi-messenger era.

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