A Real-time Automatic Validation System for Optical Transients Detected by GWAC

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Outline

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1 Introduction

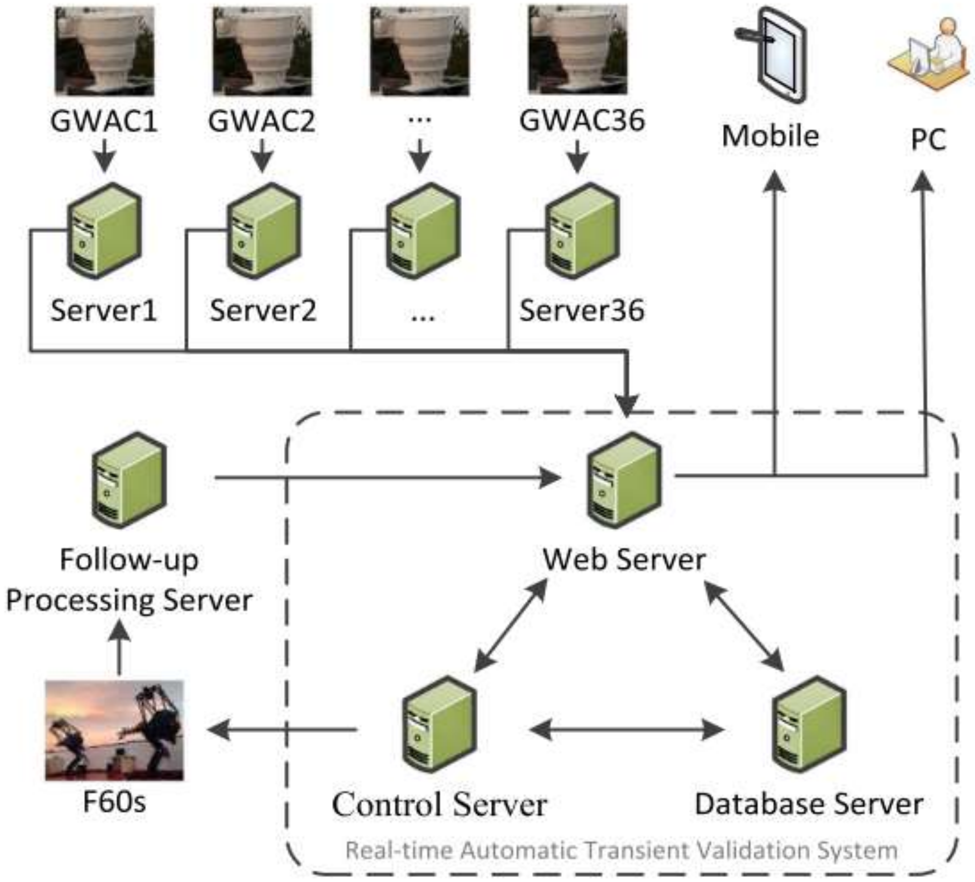
- The ground-based wide-angle camera array (GWAC) is a set of ground-based instruments under the framework of the SVOM mission. SVOM, is a Chinese–French space mission dedicated to detecting gamma-ray bursts(GRBs), besides catching GRBs, GWAC is also an optical transient factory in discovering diverse optical transients, including supernovae.

- One key issue in GWAC is how to pick up real transients from millions of alerts in one night by auto filtering and by subsequent follow-up observations.

- In order to shorten the delay of follow-ups and to follow-up multiple events by an optimal strategy, an auto follow-up system must be established to avoid overloading of a duty scientist and to guarantee the scientific return, and inform the follow-up result to duty scientist by multiple ways in real-time.

2 System Overview

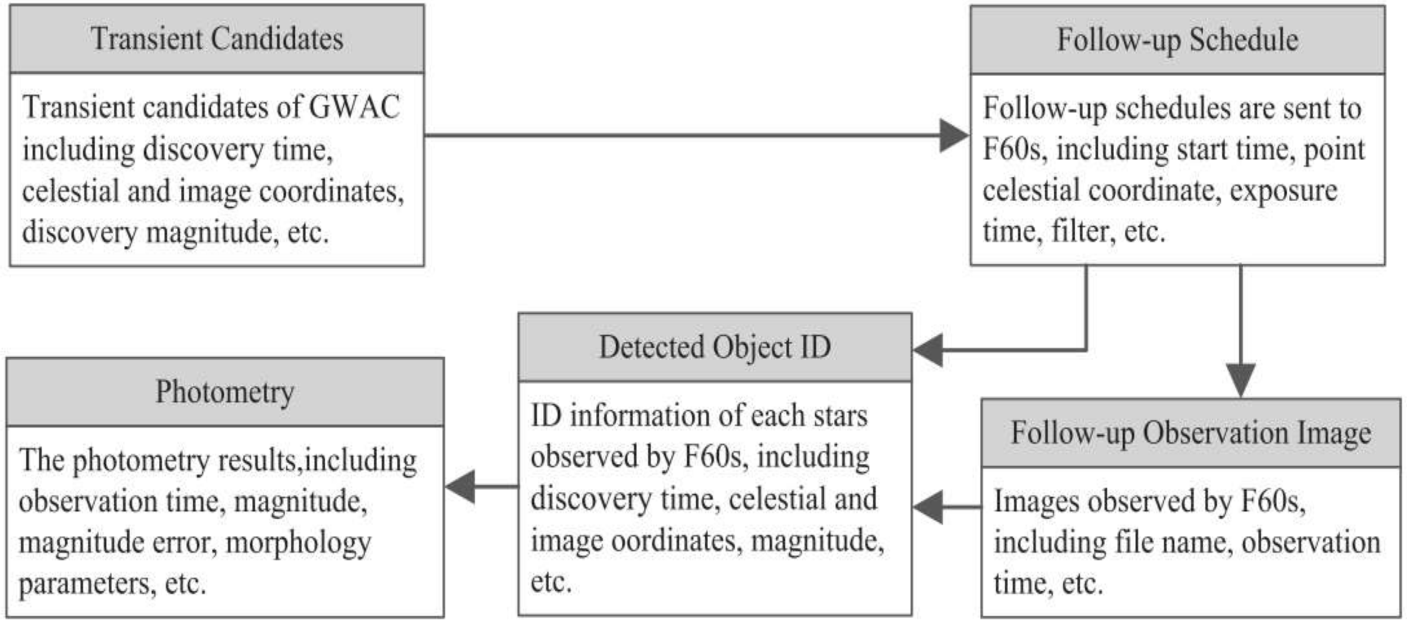
RAVS is a fully automatic follow-up observation control system that automatically confirms transient candidates detected by GWAC by rapid follow-up observation. And all of these operations are performed without human intervention.



System Architecture and data processing stream. The RAVS is in the dashed-line box. The data flow is shown by the arrows.

2 System Overview

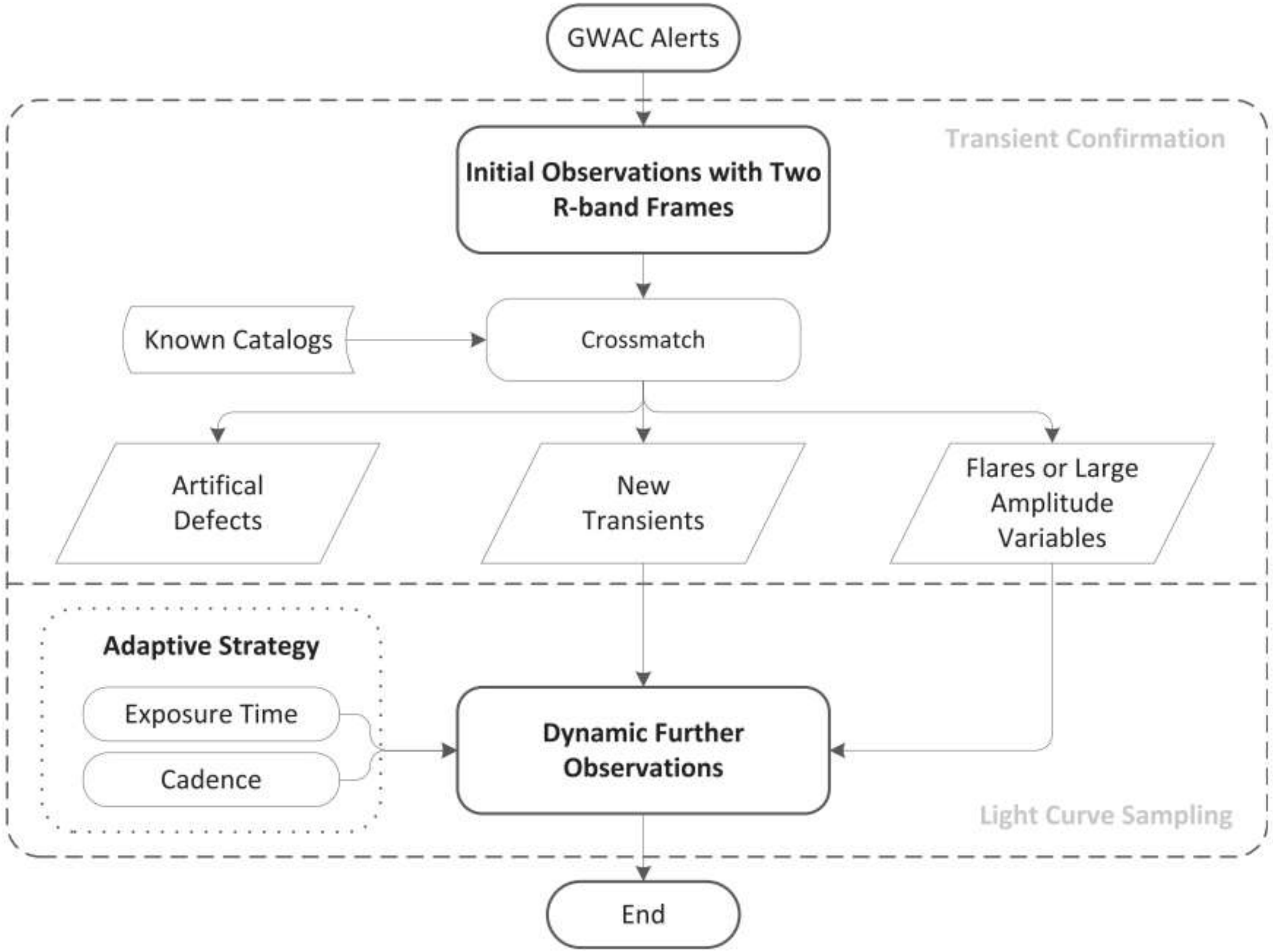
In order to support the data processing of RAVS, we create five tables: transient candidates table, follow-up schedule table, follow-up observation image table, detected object ID table and detected object record table. These five tables are briefly described as follows and the related structures are shown in blow.



Simplified key schema of RAVS database.

3 Adaptive Strategy of RAVS

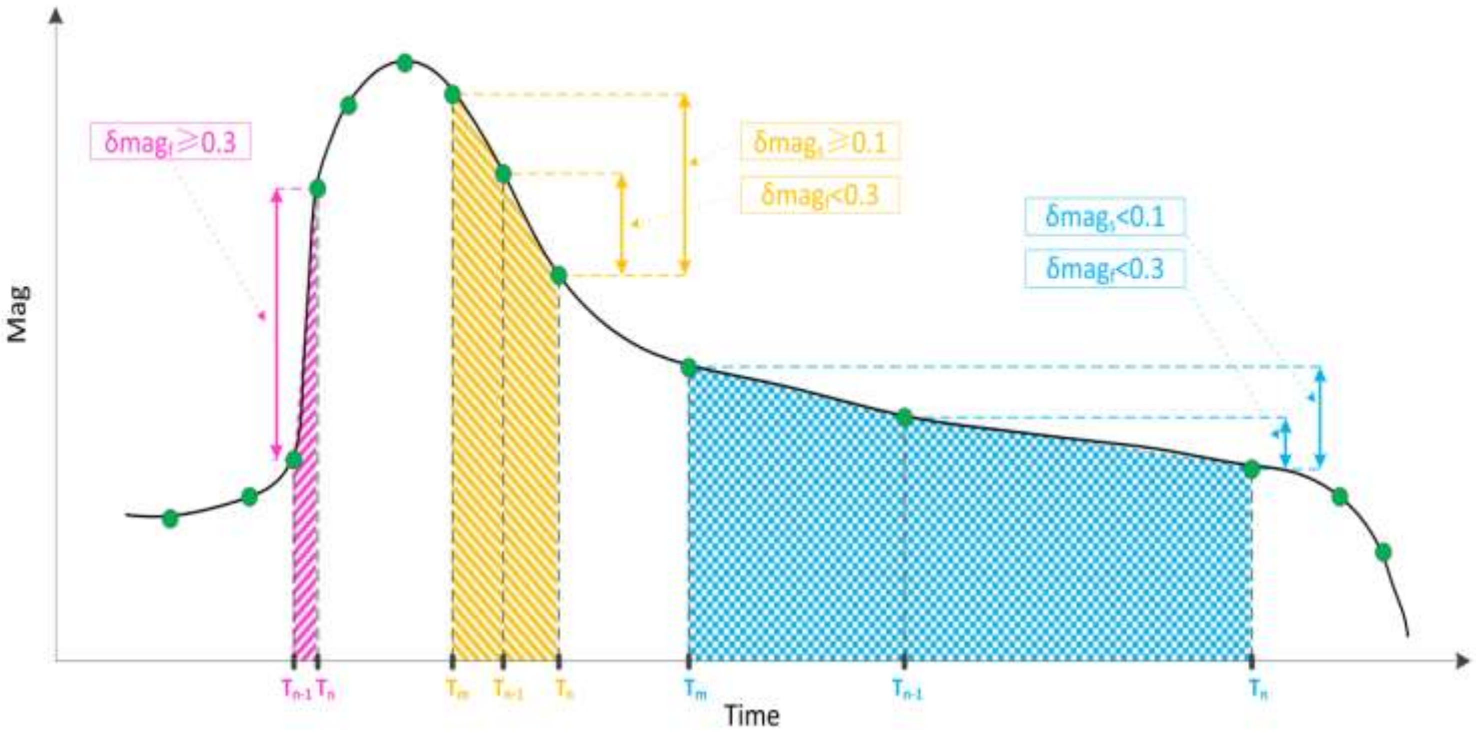
The automatic flow chart of RAVS is briefly shown in blow. The follow-up observation of a transient candidate can be divided into two steps.



RAVSs control pipeline including the confirmation stage and the light curve sampling stage.

3.2. The Light Curve Sampling

The adaptive exposure strategy described above is schematically illustrated by a cartoon in blow.



For a target, the formula for calculating the exposure time of the $(n+1)$th observation is:

$$t_{n+1} = t_n \times 10^{0.4\Delta m_n},\ n \geqslant 3,\ t_n \geqslant 3\ \mathrm{s} \tag{1}$$

where $\Delta m_n = m_n - m_{n-1}$. The maximum exposure time of 200 s is setup considering the tracking stability of F60s.

3.2.2. Observation Time

The $(n+1)$th observation time T_{n+1} is determined from

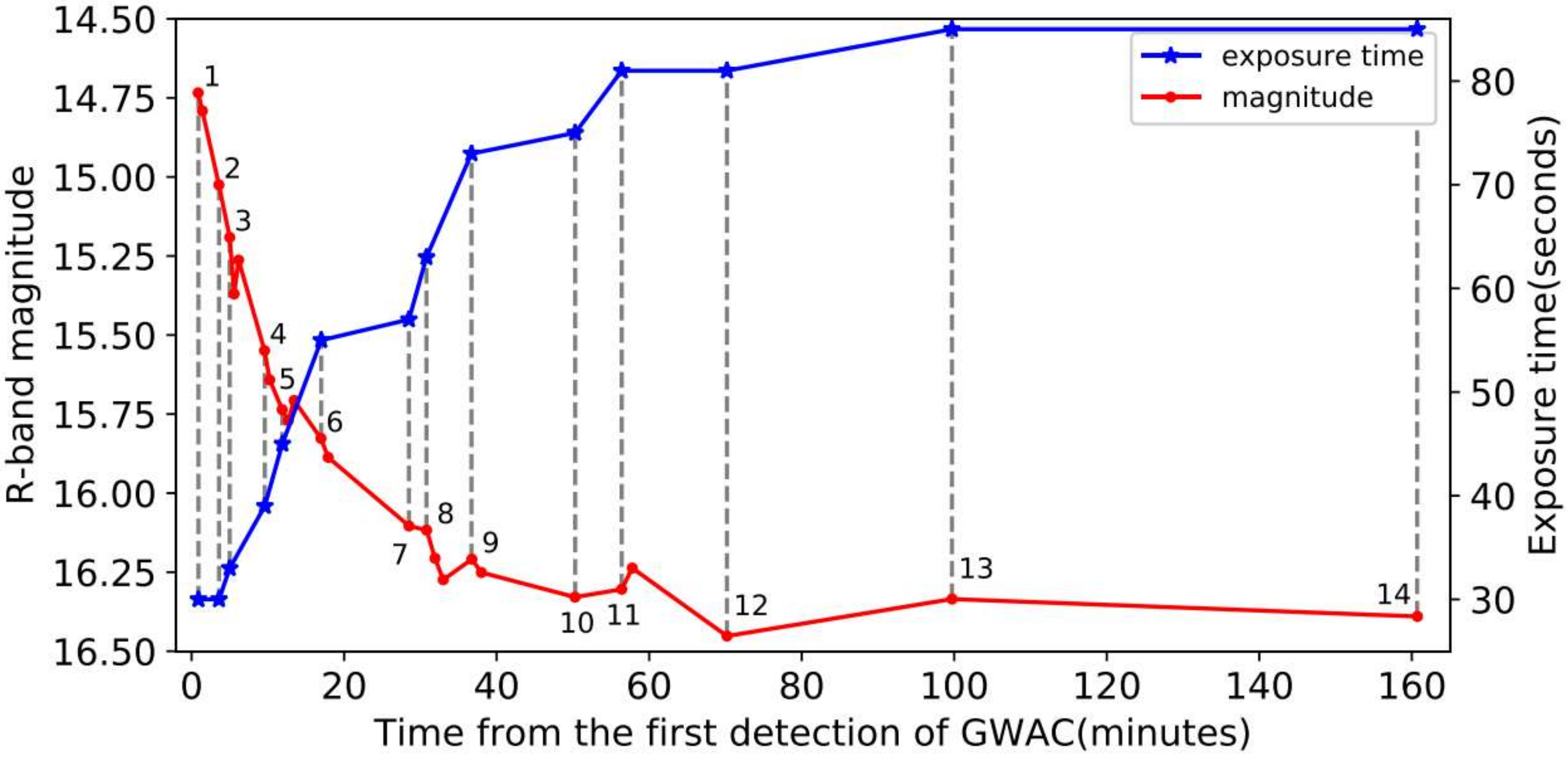
$$T_{n+1} = T_n + \delta T_{n+1} \tag{2}$$

where T_n is the nth observation time. δT_{n+1} is the delay time between two exposures which is determined by the following formula:

$$\delta T_{n+1} = \begin{cases} 0, & \Delta m_f \geqslant 0.3 \\ 3\ \text{minutes}, & \Delta m_f < 0.3,\ \Delta m_s \geqslant 0.1 \\ (1+f)(T_n - T_m), & n \geqslant 3,\ m < n,\ \Delta m_f < 0.3,\ \Delta m_s < 0.1,\ f = 0.3 \end{cases}$$

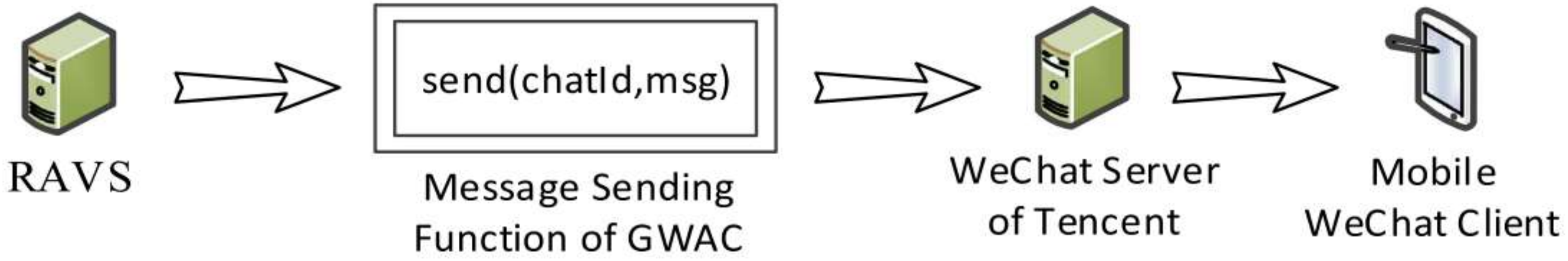
3 Adaptive Strategy of RAVS

The Figure shows an example of the follow-up results of fast transient GWAC 190101A sampled by RAVS, which is finally identified as a large-amplitude flare of an M-dwarf.



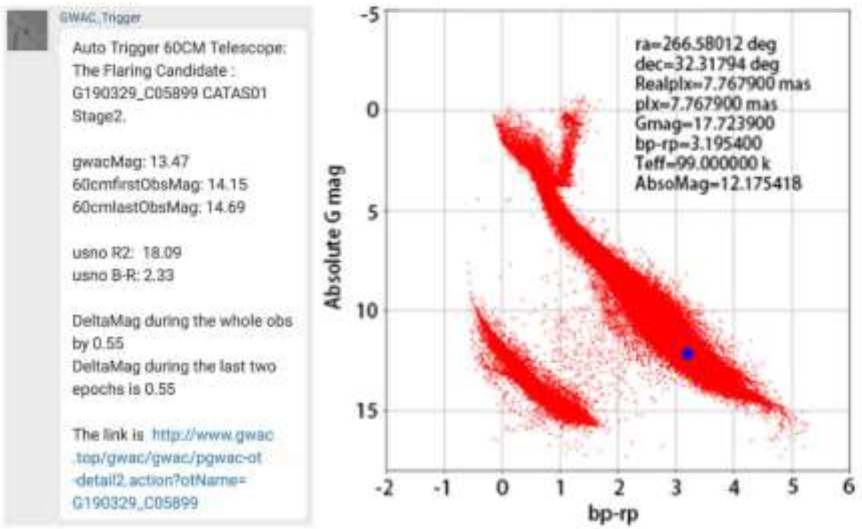
4. Mobile Notification

RAVS uses enterprise WeChat6 as a solution of the real-time mobile notification for pushing follow-up results of each alert and ancillary data. and only needs to focus on the processing and analysis of astronomical data, regardless of the differences of different mobile operating systems and the re-development requirements caused by the upgrade of mobile phone.



Sample pipeline of sending message to Enterprise WeChat client.

The Figure is a snapshot of Wechat for one transient identified as a flare of an M-dwarf.



5. Project Status and Future Work, Summary

- The control pipeline of RAVS is written in Python and uses Postgresql as the archive database. The followed and re-followed observation commands are sent to the global scheduler of GWAC system. The scheduling algorithm is mainly based on the priority of the target.

- RAVS can be conveniently ported to other telescopes, especially the follow-up system of SVOM, since the control logic of RAVS isdesigned to be independent on the telescope hardware.

- With RAVS, one transient candidate detected by GWAC can be automatically validated in real-time by adaptive follow-up strategy without human involvement.

Thanks