Target of Opportunity and Time Critical Queue Observations at Gemini Observatory

Katherine Roth, Rodrigo Carrasco, Bryan Miller, Andrew Stephens, Andy Adamson, Inger Jorgensen, Bernadette Rodgers
(Gemini Observatory)
Outline

• Background
• ToO Categories
• Queue Priorities
• Queue Filling
• Software enhancements
  (not what we are doing but what we want to be doing in the future)
  • Duplications
  • Trigger Notifications
  • Timing Windows
  • Observing Constraints
  • Adaptive Queue Planning
Background

• ToO refers to Target of Opportunity programs awarded time by the TAC and allowed to trigger new observations during the semester which meet the pre-defined criteria

• Refers to either a specific class of object that will be discovered or a known object which will undergo a specific type of event sometime during the semester - the scientific merit behind the observations is detailed in the proposal

• Does not refer to Directors Discretionary programs which may also be proposed for anytime during the semester

• Targets historically are transient in nature but not a requirement
• ToOs have been supported in queue mode since the early days of science operations
• ToOs constitute about 20-25% of allocated time in the highest ranking band 1
• Fraction of time awarded to ToOs has been fairly constant through the years
• Number of ToOs expected to increase with the advent of large dedicated survey telescopes (eg. Pan-STARRS and LSST)
• Gemini well suited to ToO observations with fast switching between multiple active instruments, flexible queue operations, staff queue observers
**Background - cont.**

*comments motivated by Tuesday/Wednesday afternoon discussion*

- at Gemini ToO triggers are PI driven; *not* Observatory policy driven
- transient ToOs are special case of time critical queue observations (one short timing window)
- static queue schedule made in advance is not flexible; Gemini runs multiple adaptive queues (software advances needed to automate and streamline these queues)
- any observatory that executes ToOs is already operating in adaptive queue mode
- queue observing ensures higher ranked programs are executed in required conditions (or better); enables time critical observing programs and flexibility without duplication
ToO Categories

- Two flavors of ToOs: Standard and Rapid
- Standard ToOs *do not* interrupt the current queue operations (no pop-up or audible alert, e-mail alert only), but are scheduled by the queue coordinator at a convenient time during the next appropriate queue night; software advances will allow for automatic same night inclusion of standard ToOs into the adaptive queue
- Rapid ToOs *are* allowed to interrupt the on-going queue and also interrupt classical observing (time is returned to the classical PI in the queue under the same conditions, observations executed by Gemini staff astronomer/observer)
ToO Categories - cont.

- Rapid ToOs in support of GRB follow-up have been discussed in Roth et al. *Proc. SPIE, Vol. 7016, 70161Z (2008)*

- PI triggered observations generate real-time alerts to the queue observer (via the observing tool) and e-mail alerts

- Observers interrupt on-going science observations and slew to the ToO within 2 min, taking spectral data within 15 min

- Data (including acquisition images) available to the PI via the Gemini archive within minutes

- Often PIs “eavesdrop” via e-mail and archive to advise on target identification, proceeding with spectroscopy, sequence refinement, etc.
Rapid ToO Observing Tool Alert

Pop-up provides information about the target (visibilities, observing conditions) and a direct link to the observation.

Accompanied by audible alerts: beep and repeating voice: “Attention – Target of Opportunity”
ToO Categories - cont.

- **Rapid ToOs** come in several flavors:
  - **Slew Immediately**
    - reserved for newly discovered, rapidly fading GRBs
  - **Slew Tonight when Convenient (Transient)**
    - mainly utilized for older follow-up observations of less quickly fading afterglows
  - **Slew Tonight when Convenient (non-Transient)**
    - typically GRB host galaxy follow-up (eg. redshift determination), source is not fading, time sensitive nature driven purely by competition
  - **Observe within 24-48 hrs**
    - intermediate between standard and rapid classes, used (eg.) for coordinated observations with other telescopes
• **Standard ToOs** have two distinct types:
  
  o **Transients**
    - the traditional ToO, eg supernova or nova follow-up. The target is fading but not very quickly. Observation normally has observing conditions and will expire in about a week.
  
  o **non-Transients**
    - class becoming increasingly popular in the Gemini queue; handled as a ToO as a matter of convenience. Targets are not fading, have no time critical nature. Coordinates were not known when the observing proposal was submitted but the target list was expected to be compiled during the semester (eg. as candidates discovered during the course of an on-going survey, or as the result of a previously scheduled but not yet executed observing run.)
Queue Priorities

- Rapid ToOs: Band 1 only (higher priority has a lower number, ranking bands 1-3)
  - Slew Immediately: Priority 0
    - Cannot be interrupted, the only queue observations with comparable priority are tightly constrained (24 hr) Band 1
  - Slew when Convenient (transient): Priority 0.25
    - Same priority as Band 1 with only a few remaining observing opportunities
  - Slew within 24-48 hrs: Priority 0.25
    - Same priority as Band 1 with only a few remaining observing opportunities
  - Slew when Convenient (non-transient): Priority 0.50
Queue Priorities - cont.

• Standard ToOs:
  o Transients: Priority = "Band - 0.50".
    - Have higher priority than normal observations in the same ranking band, but should not displace observations in a higher ranking band. If the timing windows are about to expire the priority dynamically improves until the target is observed or the timing period expires. Gemini may wish to consider disallowing transient Standard ToOs in Band 3.
  o non-Transients: Priority = “Band”
    - same priority any normal observation in the same ranking band. Non-transient Standard ToOs can be scheduled in Band 3.
Queue Filling

• Cannot predict Gemini demand for ToOs in Pan-STARRS and LSST era but expect it to increase

• Current queue filling ~20-25% in highest ranking band, ~10-15% across all bands

• Cannot operate a queue with no defined targets so must limit the total fraction of ToOs in the queue for practical reasons

• Propose to have fewest possible restrictions on ToO queue fraction if NTACs rank science important
  
  o no limit on Band 1 fraction: any ToO status
  o no rapid ToOs in any Band other than Band 1
  o no limit on Band 2 fraction: Standard ToOs
  o no transient ToOs in Band 3
  o < 50% Band 3 fraction: non-transient standard ToOs
Software: Duplication Checks

• Requires instantaneous feedback (not days)
• Minimize instances of targets observed multiple times with similar instrument configurations
  ○ Across sites and instruments (eg. GMOS-N/GMOS-S, NIRI/NIFS/GNIRS/F2, Michelle/T-ReCS, NIRI-AO/NICI/GSAOI)
• Currently only one GRB rapid ToO program per site, approved individual programs merged
  ○ No plans to implement the same structure for standard ToOs
• Higher ranked programs override lower ranked previously triggered (but still unobserved) ToOs
• Duplications warnings can be overruled by Gemini Staff (eg. PIs may relinquish target rights to allow monitoring by other groups)
• OT warnings visible to PIs as well as Gemini Staff
Software: Trigger Notifications

• **GOAL:** more efficient ToO operations
  - Faster rapid ToO slew immediately response
  - Minimize unnecessary interruptions of queue operations
  - More efficient inclusion of high ranked standard ToOs into queue (both transients and non-transients)

• Expanded ToO categories specified in software

• Visual and audible alerts modified according to
  - ToO category
  - Visibility, airmass constraints and timing windows
  - Observing Constraints (CC, BG, IQ, WV)

• Standard ToOs and “when convenient” rapid ToOs generate modified queue plan; must inform the observer when the queue adapts
Software: Timing Windows

• Apply to transient ToOs and time constrained queue observations
  - ToOs treated the same as any other queue target with timing windows, typically have higher priority since they have fewer timing windows (one) and potentially shorter visibility windows

• Improve scheduling of targets with timing windows (minimize lost observations)
  - Visual flagging of time constrained observations
  - Dynamic adjustment of scheduling priorities to boost priority as the time remaining in a window diminishes

• Improve communications with PIs
  - Automatically notify queue coordinators and contact scientists when timing windows
  - Feedback for potentially extending timing windows
Software: Observing Constraints

• OT Phase II checking to flag incompatible observing constraints (BG) and timing windows
  o Automatic error generation when a timing window does not include enough time when the sky brightness constraint is satisfied for observation execution

• Extend to other observing conditions when automatic weather monitoring enabled
  o Feedback for potentially relaxing observing constraints when alternative is missed timing window

• Observing constraints needed for rapid ToO programs with several types of observations
  o Slew immediately rapid ToOs take Any conditions
  o **New for 2011B**: follow-up observations in good conditions require separate ToO proposal
Software: Adaptive Queue Planning

- Currently Gemini queue plans are generated manually by a daytime queue coordinator

- Automatic adaptive queue planning advantages:
  - Save operations cost
  - Efficient queue planning (inclusion of new ToOs, adapt to weather or fault time loss)
  - Let the queue coordinator sleep!

- Software improvements have provided valuable visualization tools, but still a manual process
  - Current queue plan is static webpage that does not automatically update during the course of the night
  - Queue observer calls queue coordinator to request a new set of queue plans as needed
Example Queue Plan: 2010 June 30

Queue plans for various observing conditions (IQ, CC, WV)

### Good Seeing, Photometric
SB = unconstrained / CC = 50 / IQ = 70 / WV = unconstrained

#### Observation Schedule

<table>
<thead>
<tr>
<th>Start</th>
<th>Dur</th>
<th>BG</th>
<th>Observation</th>
<th>Steps</th>
<th>Inst</th>
<th>Config</th>
<th>WFS</th>
<th>Target</th>
<th>IQ</th>
<th>CC</th>
<th>WV</th>
<th>BG</th>
<th>Rise</th>
<th>Trans</th>
</tr>
</thead>
<tbody>
<tr>
<td>19:14</td>
<td></td>
<td></td>
<td>N10A-Q-20</td>
<td>00:23</td>
<td>100%</td>
<td>N10A-Q-20 [141]</td>
<td>GMOS-N</td>
<td>1.0arcsec, B600, none</td>
<td>OIWFS</td>
<td>PTF10mwt</td>
<td>85</td>
<td>70</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>19:48</td>
<td></td>
<td></td>
<td>N10A-Q-20</td>
<td>00:23</td>
<td>100%</td>
<td>N10A-Q-20 [143]</td>
<td>GMOS-N</td>
<td>1.0arcsec, R400, OG515</td>
<td>OIWFS</td>
<td>PTF10mwt</td>
<td>85</td>
<td>70</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

- Rapid ToOs (slew immediately) interrupt the queue
  - Interruptions also happen during the course of normal operations, eg. observations fail or faults occur
  - Queue coordinator generates a new plan or
  - Observer executes a plan for worse observing conditions
- Rapid ToOs (slew when convenient) enter the queue
  - Queue coordinator generates a new plan or
  - Observer decides which queue observations to drop in order to accommodate the ToO
- Standard ToOs often can enter the queue right away, replacing lower ranked observations
  - “On demand” queue plan generation
  - Adaptive software would monitor the database and automatically produce new plans as needed
Concluding Remarks

• ToOs are already well supported at Gemini and integrated into adaptive queue operations

• OT triggering and archive distribution of data handled well by software, other aspects still need work (e.g., automatic queue scheduling for ToOs or any time critical program including time domain astronomy and coordinated observations with other observatories)

• Improvements would allow Gemini to support a significantly higher fraction of queue programs having ToO status as requested by the science community

• Does not require a physical presence at the telescope; fully consistent with remote operation and automated queue generation