GBT Dynamic Scheduling System (DSS)

Dana Balser, Jim Braatz, Mark Clark, Jim Condon, Ray Creager, Mike McCarty, Ron Maddalena, Paul Marganian, Karen O’Neil, Eric Sessoms, Amy Shelton
Nomenclature

GBT
- Open Sessions
- Windowed Sessions
- Fixed Sessions

Butler
How does it work?

Data Collection Advance of Semester

- Sensitivity calculator
- Time availability prediction
- Proposal Submission Tool
- Science grades
- Phase II data collection

Provided by the DSS

Provided outside the DSS

Scheduling Algorithm 24-48 Hours in Advance

- Autoscheduler Run
- Scheduler modifies and approves
- Notification sent

Requirements

- Scheduling observers, not scripts
- Observers retain control
- Minimum of 24 hours advance notice for observers
- Wide array of hardware
- Cannot increase workload of staff or observers

Observing

- Monitor schedule
- Observing scripts
- Backup Project run

Post-Observation Reports

- Reports of schedule, logs, time lost, etc

Scheduling Probabilities

- Historical probabilities
- Weather forecasts
Atmospheric Effects

Condon & Balser (2011)
Weather Forecasts

Extragalactic H$_2$O Observations --- 20.82-22.38 GHz

Error Bars correspond to $\Delta \tau = 0.01$

Tippings at 45 GHz

Error Bars correspond to $\Delta \tau = 0.003$

Maddalena
Atmospheric Stability

Pyrgeometer: non-imaging device sensitive to 4.5-40 micron over 150 deg fov.

Maddalena; Balser (2011)
Wind Effects

\[ \sigma_1 \propto V^2 \]

Weather Forecasts: wind

Balser (2010); Maddalena
Solar Heating

Primary Surface
Day:  300 micron
Night: 250 micron

Offset Pointing
Day:  3.3 arcsec
Night: 2.7 arcsec

Surface
Wave front errors from OOF maps.
Grayscale: +/- 2 rad
Contour: ½ rad intervals

Nikolic et al. (2007)
Scoring Equation

\[ R = (\eta S P_\alpha^\beta P_\nu^\gamma) (l_{\text{eff}} l_{\text{HA}} l_z l_{\text{tr}} l_{\text{st}}) (f_{\text{oos}} f_{\text{com}} f_{\text{sg}} f_{\text{tp}}) (t_{\text{tn}} t_{\text{le}} t_{\text{tb}}) \]

Weather:
- Observing Efficiency
- Stringency

Pressure Factors:
- Right Ascension
- Frequency

Performance Limits:
- Observing Efficiency
- Hour Angle
- Zenith Angle
- Tracking Error
- Atmospheric Stability

Other Factors:
- Observers on Site
- Completion of Projects
- Science Grades
- Thesis Projects

Temporal Constraints:
- Transit
- Nighttime
- LST Exclusion
- Time Between
Scoring Equation

\[ R = (\eta S P_\alpha P_\beta P_\nu) \left( l_{\text{eff}} l_{HA} l_z l_{tr} l_{st} \right) \left( f_{oos} f_{com} f_{sg} f_{tp} \right) (t_{tn} t_{le} t_{tb}) \]
Observing Efficiency

\[ \eta = \eta_{\text{atm}} \eta_{\text{sur}} \eta_{\text{tr}} \]

\[ \eta_{\text{atm}} = \left[ \frac{T_{<\text{sys}} \exp(\tau_{<})}{T_{\text{sys}} \exp(\tau)} \right]^2 \]

\[ \eta_{\text{sur}} = \exp\left[ \frac{-32\pi^2}{\lambda^2} (\varepsilon_d^2 - \varepsilon_n^2) \right] \text{; where } \eta_a = \exp[-(4\pi\varepsilon)^2], \text{ and } \eta_{\text{sur}} \propto \eta_a^2 \]

\[ \eta_{\text{tr}} = \left[ \frac{1 + 4\ln(2)f_{<}^2}{1 + 4\ln(2)f^2} \right]^2 \text{; where } f \equiv (\sigma_{\text{tr}} / \theta), \text{ and } \left( \frac{\sigma_{\text{tr}}}{\text{arcsec}} \right)^2 = \sigma_0^2 + \left( \frac{|v|}{3.15 \text{ m s}^{-1}} \right)^4 \]
Observing Efficiency

![Observed Mean Observing Efficiency vs Frequency (VIE9)](image)
Stringency

\[ E_l = 60.0 \]

Graph showing the relationship between stringency and frequency (GHz) with various markers indicating different frequency bands such as K, Ka, Q, W, LS, and CX.
Scoring Equation

$$R = (\eta S P_{\alpha} P_{v}^{\gamma}) (l_{\text{eff}} l_{HA} l_{z} l_{tr} l_{st}) (f_{oos} f_{com} f_{sg} f_{tp})(t_{tn} t_{le} t_{tb})$$

Pressure Factors:

- Right Ascension
- Frequency
Pressure Factor

\[ P_\alpha = 1 + \ln \left( \frac{n_\alpha}{d_\alpha} \right) \]
Scoring Equation

\[ R = (\eta S P_\alpha^\beta P_\nu^\gamma) (l_{\text{eff}} l_{HA} l_z l_{tr} l_{st}) (f_{oos} f_{com} f_{sg} f_{tp})(t_{tn} t_{le} t_{tb}) \]

Performance Limits:

Observing Efficiency
Hour Angle
Zenith Angle
Tracking Error
Atmospheric Stability
Observing Efficiency Limit
Hour Angle Limit

Condon & Balser (2011)
Tracking Error Limit

\[ f = \sigma_{tr} / \theta = 0.20 \quad (10\% \text{ flux errors}) \]
Atmospheric Stability Limit

Balser (2011); Mason & Perera (2010)
Packing (Open Sessions)

Problem: a thief with a bag of capacity $N$, faced with a number ($M$) of possible goodies each having a different weight (cost) and value, how do you pack your bag to maximize your take?

Brute Force: order $(M!)$

Knapsack Algorithm: order $(M \times N)$

$N = $ number of quarter hours to schedule
$M = $ number of potential sessions
Overhead = 15 min.
Scheduler Page
## GBT Schedule

**Wednesday March 14 2012 08:19 EDT**

Start: 03/05/2012  
Days: 5  
Time Zone: ET  
View Schedule

**Historical Schedules | Printer Friendly Schedule**

**The project ID links in the below schedule will bring the user to the appropriate page in the DSS (login required)**

<table>
<thead>
<tr>
<th>2012-03-06 (ET)</th>
<th>Type</th>
<th>Project ID</th>
<th>Project Title</th>
<th>PI</th>
<th>Friend</th>
<th>Rcvrs</th>
<th>Frequency (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+00:00 - 06:00</td>
<td>A</td>
<td>GBT12A-388</td>
<td>Continuing the GBT All-Sky 350-MHz Pulsar Survey</td>
<td>Ransom</td>
<td>Denorest</td>
<td>342</td>
<td>0.29 - 0.40</td>
</tr>
<tr>
<td>08:00 - 16:30</td>
<td>M</td>
<td>Maintenance</td>
<td>Maintenance day: Add 800, Remove 342</td>
<td>Chestnut</td>
<td>Minter</td>
<td>800, L, S, C, X, Ka, MBA, KFP, W</td>
<td></td>
</tr>
<tr>
<td>16:30 - 23:00</td>
<td>A</td>
<td>GBT12A-114</td>
<td>Constraining Stellar and Galactic Chemical Evolution with 3-Helium Abundances</td>
<td>Barra</td>
<td>Balser</td>
<td>X</td>
<td>8.00 - 10.00</td>
</tr>
<tr>
<td>23:00 - 00:00+</td>
<td>A</td>
<td>GBT11B-001</td>
<td>MUSTANG Imaging of the CLASH Cluster Sample I. Completion of the Sample</td>
<td>Mroczkowski</td>
<td>Mason</td>
<td>MBA</td>
<td>800.00 - 1000.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2012-03-07 (ET)</th>
<th>Type</th>
<th>Project ID</th>
<th>Project Title</th>
<th>PI</th>
<th>Friend</th>
<th>Rcvrs</th>
<th>Frequency (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+00:00 - 03:30</td>
<td>A</td>
<td>GBT11B-001</td>
<td>MUSTANG Imaging of the CLASH Cluster Sample II. Completion of the Sample</td>
<td>Mroczkowski</td>
<td>Mason</td>
<td>MBA</td>
<td>800.00 - 1000.00</td>
</tr>
<tr>
<td>03:30 - 06:30</td>
<td>A</td>
<td>GBT11B-098</td>
<td>High resolution MUSTANG SZ Imaging of New Horizon Galaxy Clusters</td>
<td>Scalo</td>
<td>Mason</td>
<td>MBA</td>
<td>800.00 - 1000.00</td>
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<tr>
<td>06:30 - 11:30</td>
<td>A</td>
<td>GBT11B-010</td>
<td>Probing Metallicity Throughout the Milky Way Disk</td>
<td>Balser</td>
<td>Balser</td>
<td>X</td>
<td>8.00 - 10.00</td>
</tr>
<tr>
<td>11:30 - 15:30</td>
<td>A</td>
<td>GBT12A-114</td>
<td>Constraining Stellar and Galactic Chemical Evolution with 3-Helium Abundances</td>
<td>Barra</td>
<td>Balser</td>
<td>X</td>
<td>8.00 - 10.00</td>
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<tr>
<td>15:30 - 21:15</td>
<td>A</td>
<td>GBT11B-051</td>
<td>HI Mapping of the M31-M33 Stream</td>
<td>Wolfe</td>
<td>Lockman</td>
<td>L</td>
<td>1.15 - 1.73</td>
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<tr>
<td>21:15 - 23:19</td>
<td>T</td>
<td>TGB12A-500</td>
<td>Subreflector Circle point</td>
<td>Prestage</td>
<td>Prestage</td>
<td>Ka</td>
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<tr>
<td>23:15 - 00:00+</td>
<td>T</td>
<td>TGB11B-500</td>
<td>Receiver Checkout - 800</td>
<td>Minter</td>
<td>Minter</td>
<td>800</td>
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<table>
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<th>Project Title</th>
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<th>Friend</th>
<th>Rcvrs</th>
<th>Frequency (GHz)</th>
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<tbody>
<tr>
<td>+00:00 - 00:15</td>
<td>T</td>
<td>TGB11A-500</td>
<td>Receiver Checkout - 800</td>
<td>Minter</td>
<td>Minter</td>
<td>800</td>
<td></td>
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<tr>
<td>00:15 - 01:45</td>
<td>T</td>
<td>TGB11B-527</td>
<td>NFI Checkout - 800</td>
<td>Minter</td>
<td>Minter</td>
<td>800</td>
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<tr>
<td>01:45 - 01:00+</td>
<td>A</td>
<td>GBT 3A-032</td>
<td>Point source for source analysis in two globular clusters</td>
<td>Lomax</td>
<td>Propoer</td>
<td>600</td>
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</table>
User Home Page

Dana Balser

Active Projects

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>GBT11B-010</td>
<td>Probing Metallicity Throughout the Milky Way Disk</td>
</tr>
<tr>
<td>GBT12A-114</td>
<td>Constrainng Stellar and Galactic Chemical Evolution with 3-Helium Abundances</td>
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</table>

Assigned as Friend

<table>
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<tr>
<th>Project ID</th>
<th>Required</th>
<th>Title</th>
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<tbody>
<tr>
<td>GBT11B-010</td>
<td></td>
<td>Probing Metallicity Throughout the Milky Way Disk</td>
</tr>
<tr>
<td>GBT12A-114</td>
<td></td>
<td>Constrainng Stellar and Galactic Chemical Evolution with 3-Helium Abundances</td>
</tr>
</tbody>
</table>

Dynamic Contact Information

Home Phone: 434-589-6874

edit

Static Contact Information

To update, edit your profile at my.nrao.edu

Email(s)

dbaiser@nrao.edu (Other)

Phone(s)

134-325-024 (Work)

Upcoming Observations

- GBT12A-114
  - GBT12A-114-12:
    - Tue, Mar 07
    - 21:30 UTC for 6:30 hrs
- GBT12A-114-12:
  - Wed, Mar 07
  - 16:30 UTC for 4:00 hrs
- GBT11B-010
  - GBT11B-010-03:
    - Wed, Mar 07
    - 11:30 UTC for 5:00 hrs

Upcoming Reservations
User Project Page

GBT11B-010
Probing Metallicity Throughout the Milky Way Disk

Project Sessions

<table>
<thead>
<tr>
<th>Name</th>
<th>Coordinates</th>
<th>Freq</th>
<th>Recvr</th>
<th>Time billed</th>
<th>Min/Max Dur.</th>
<th>Type</th>
<th>Gr</th>
<th>Enabled</th>
<th>Other Parameters</th>
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<tbody>
<tr>
<td>GBT11B-010</td>
<td>RA: 18:22:12.0</td>
<td>9.0</td>
<td>X</td>
<td>14.0/14.0</td>
<td>1.25-5.0</td>
<td>continuum</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec: +23:50:24.0</td>
<td></td>
<td></td>
<td></td>
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<td>GBT11B-010</td>
<td>RA: 18:46:48.0</td>
<td>9.0</td>
<td>X</td>
<td>0.0/0.0</td>
<td>30-50</td>
<td>spectral line</td>
<td>A</td>
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<tr>
<td></td>
<td>Dec: +42:01:40.0</td>
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<tr>
<td>GBT11B-010</td>
<td>RA: 18:22:12.0</td>
<td>9.0</td>
<td>X</td>
<td>21.25/41.0</td>
<td>30-50</td>
<td>continuum</td>
<td>A</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Dec: +23:50:24.0</td>
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</tr>
</tbody>
</table>

Project Calendar (UTC)

** Any days shaded in ** in the calendar indicate that the project cannot be scheduled on that day (click on day for details). **

March 2012

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
</tr>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

5:00 Durs: Deliber.  Trav
8:00 Durs: Deliber.  Trav
5:00 Durs: Deliber.  TTC

3:30 Observing
8:00 Durs: Deliber.  Trav

5:00 Durs: Deliber.  TTC

11:30 Observing
5:00 Durs: Deliber.  Trav
8:00 Durs: Deliber.  TTC