
NICER
Neutron star Interior Composition ExploreR
Maximizing NICER Science — Observation planning, ToOs, and the GO Program
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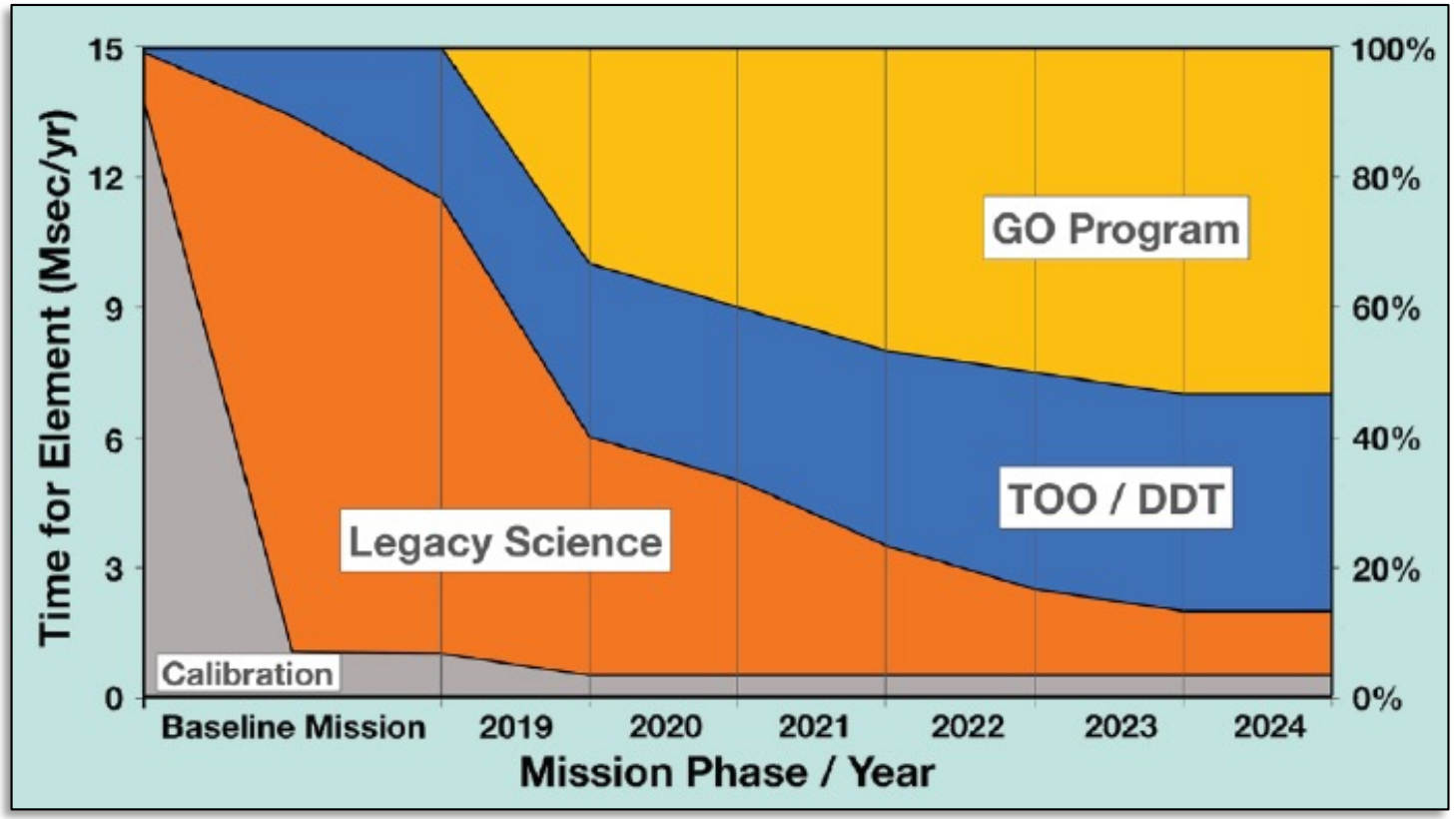
NICER Science Inputs

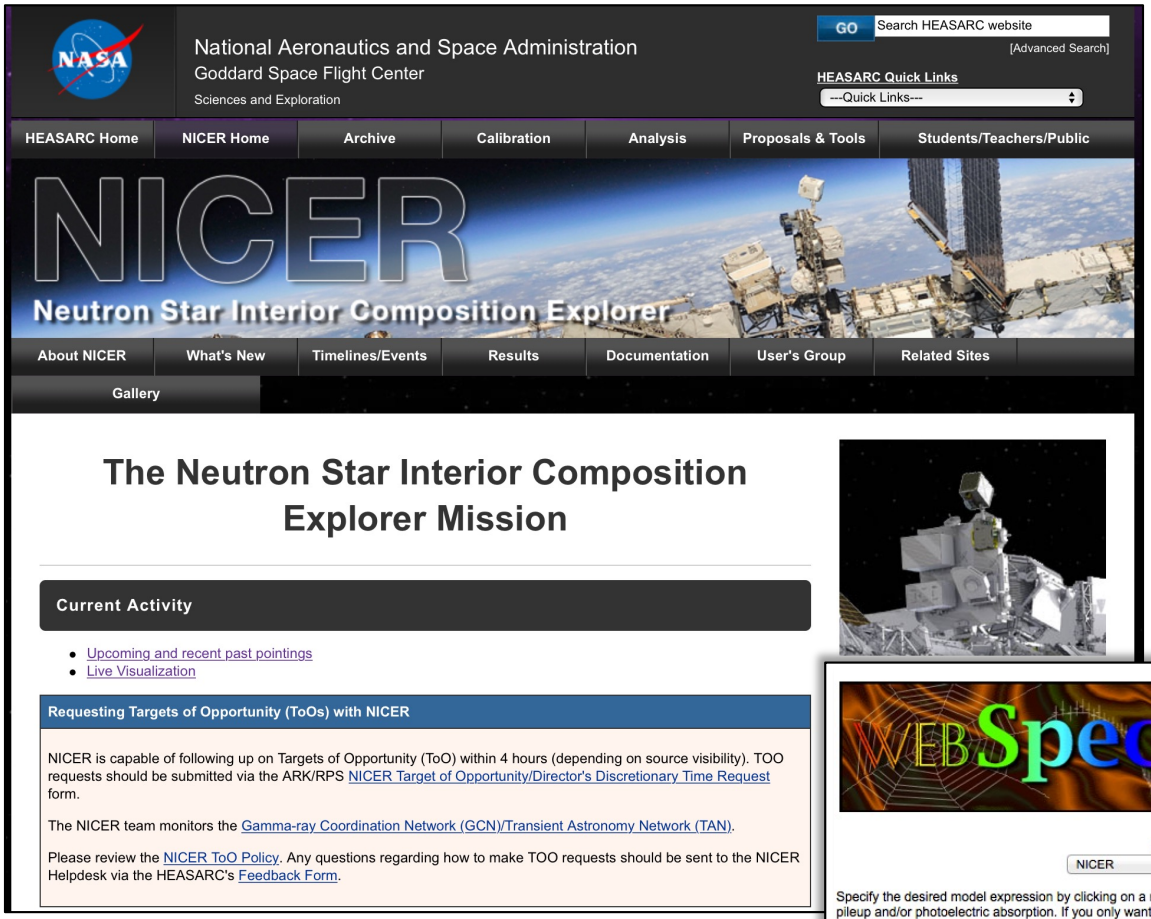
NICER science priorities are guided by input from

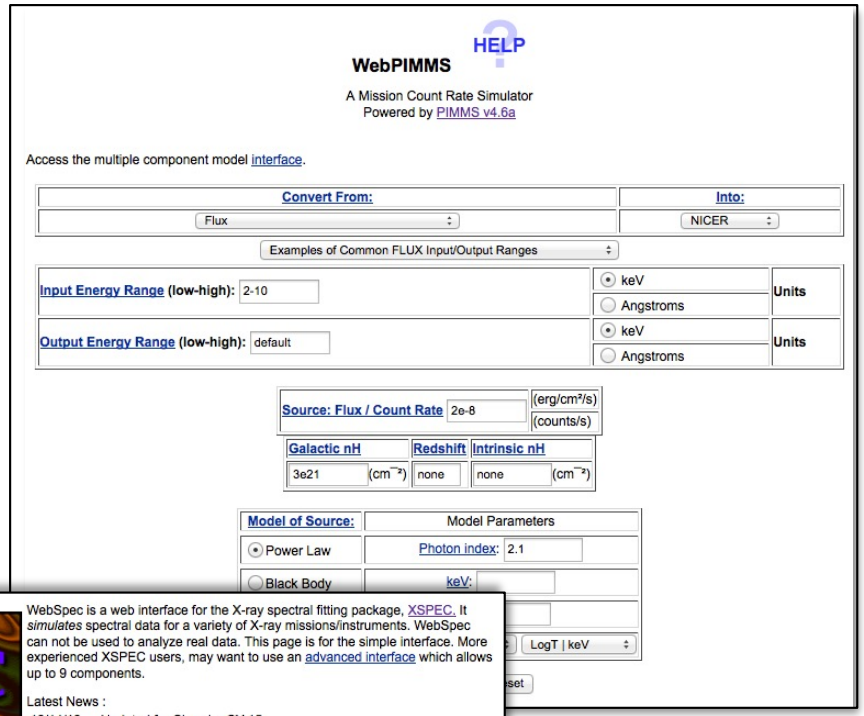
- peer-reviewed Guest Observer (GO) proposals
- the NICER Science Team
- requests for Discretionary Time, including Targets of Opportunity (DT/ToOs).

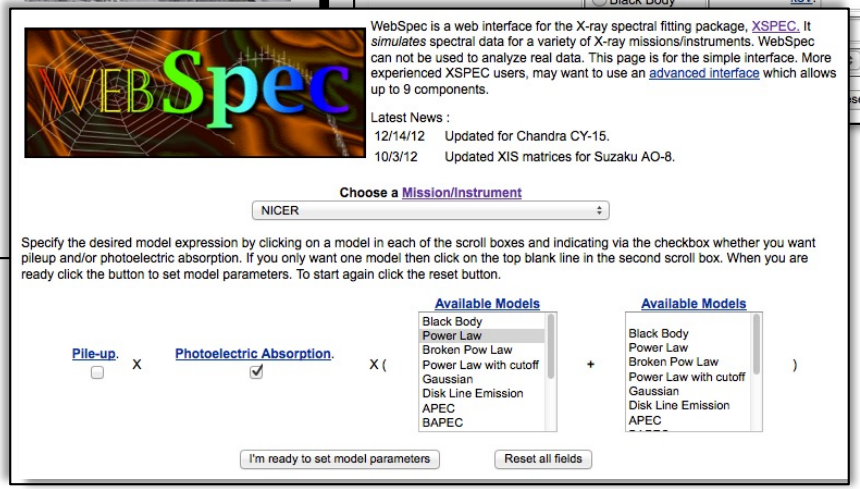


Guest Observer Program

NICER tools at HEASARC available to anticipate observations of your favorite targets







GO Program — Cycle 3 (for example)

GOF Lead Scientist: Elizabeth Ferrara

Overview

- **7 Ms** planned allocation
  - **1 Ms** carryover from Cycle 2: multi-cycle and uncompleted investigations
- Up to **400 ks** of joint NuSTAR time
- Up to **$1.5M** to help support US scientists using NICER for investigations through the GO program.

Timeline

March 2020 : ROSES announcement
17-Aug-2020 : AO amendment released
17-Nov-2020 : Proposal deadline
23-Jan-2021 : Proposal review completed
01-Mar-2021 : Start of GO Cycle 3 observations
28-Feb-2022 : End of GO Cycle 3

GO Program — Cycle 3 Response

NICER Cycle 3 GO opportunity resulted in

- submission of **112** proposals (+21 over Cycle 2)
- by **370** unique proposers (+8)
- from **27** countries (-1)

Time requested

- NICER: **12.7** Ms = **2.1x** oversubscription
- Joint NuSTAR: **1.3** Ms = **3.3x** oversubscription

Global interest in NICER

- **40** proposals were submitted by principal investigators affiliated with non-US institutions (35%)

GO Program — Cycle 3 Response (cont.)

Submissions by topic

- Rotation-powered pulsars & magnetars: 17 proposals
- X-ray binaries: 58 proposals
- White dwarfs: 5 proposals
- Active galaxies & quasars: 23 proposals
- Other: 9 proposals

Subsets of proposals requesting:

- ToO: 57 (50.8%)
- Exclusive-use period: 33 (29.4%)
- Joint NuSTAR: 18 (16%)
- Coordinated with other facilities: 49 (43.7%)
- Multi-cycle observations: 6 (5.4%)

Peer review

- Dual anonymous
- Five panels of 6–7 reviewers each
- Top-ranked proposals from each panel recommended to HQ for selection.

GO Program — Cycle 3 Outcomes

Number of accepted proposals: **81**
Total time granted: **7.1 Ms + 1 Ms carryover**
Joint NuSTAR time granted: **393 ks**
Number of unique targets in program: 122 known, up to 82 unknown

Accepted proposals by topic

- Magnetars & rotation-powered pulsars: 12 proposals
- X-ray binaries: 40 proposals
- White dwarfs: 3 proposals
- Active galaxies & quasars: 18 proposals
- Other: 8 proposals (ULXs, FRBs, comets, transients, etc.)

Percentage of recommended proposals with these attributes:

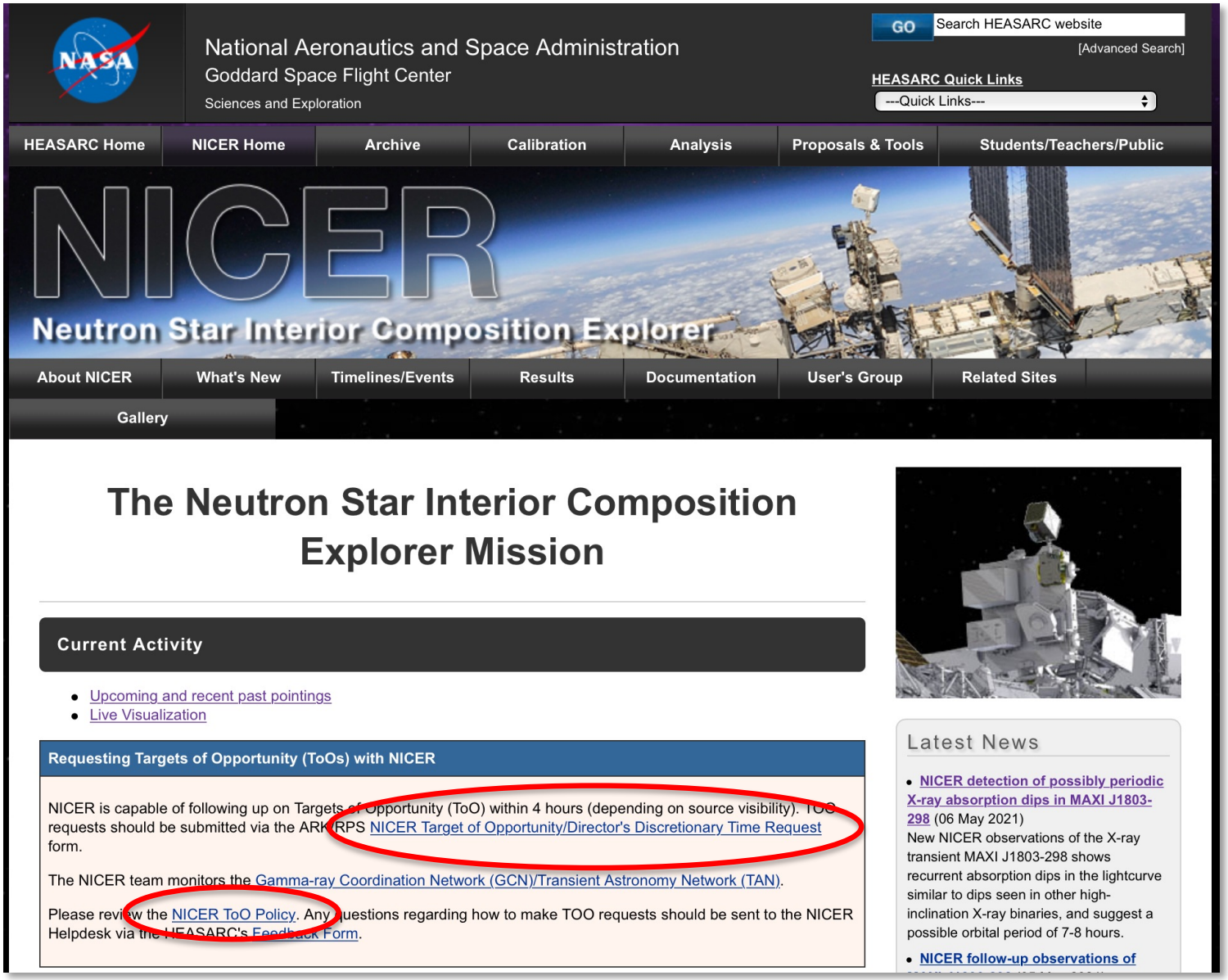
- ToO: 45 (55%)
- Exclusive-use period: 21 (26%)
- Joint NuSTAR observations: 7 (9%), 6 are ToOs
- Coordinated with other facilities: 28 (34%), 18 are ToOs
- Multi-cycle investigations: 4
  - Carrying over 570 ksec into Cycle 4

NICER Science Team

- Organized into six Working Groups (most meet weekly)
  - Lightcurve Modeling
  - Searches & Multiwavelength Coordination
  - Bursts & Accretion Physics
  - High-Precision Timing
  - Magnetars & Magnetospheres
  - Observatory Science
- Comprises ~75 members, plus students
  - Instrument Team
  - Original mission proposal science Co-Is and Collaborators
  - Affiliated Scientists (post-doc & higher seniority)
  - Under- and post-graduate students
- Many Team investigations involve external collaborators

ToOs and Discretionary Time

- Link to submit requests is on the NICER HEASARC homepage
- Urgency can be next day, within a week, or within a month
- Definition of “opportunity” is broad!



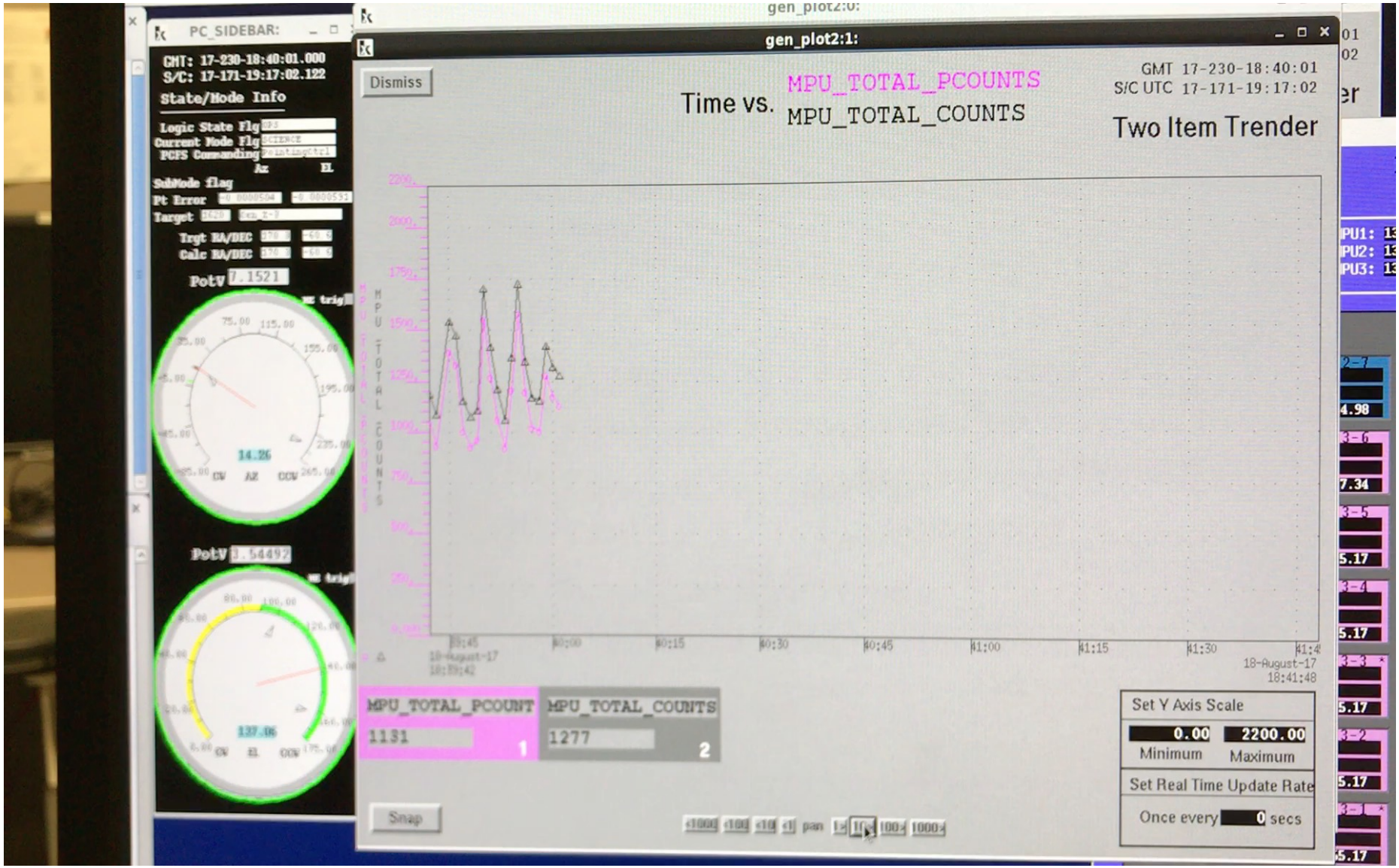
ToO Policy

Please read details linked from NICER home page. Briefly,

- NICER is committed to maximizing science yield
- To avoid missed opportunities, we aim to react promptly to all time-sensitive requests, whatever their origin (Science Team, approved GO ToO, or broader community)
- We also try to provide quick-look data to all ToO requesters; all non-GO data enter public archive within two weeks
- For GO ToOs, it is the PI's responsibility to notify NICER to trigger scheduling of observations. *It is possible that an independent request (e.g., coordination) for the same target will have already been received and acted upon*; in such cases, implementation of GO trigger will take place at next reasonable scheduling opportunity. Earlier data will be public within two weeks
- Occasionally, we will reach out to both GO and independent ToO requesters to suggest collaboration where data and interests overlap.

Live ISS contact ~85% of the time

Cen X-3 pulsations in real time



Quick turnaround

ToO request to Telegram in 6 hours!

NICER detection of a 83 s periodicity in the super-soft source emission from V3890 Sgr

ATel #13086; ***A. P. Beardmore, K. L. Page (U. Leicester), C. B. Markwardt, K. C. Gendreau, Z. Arzoumanian (NASA/GSFC), J. S. Pope (KBRwyle/NASA/GSFC)***
on 7 Sep 2019; 01:24 UT
Credential Certification: Andy Beardmore (apb@star.le.ac.uk)

Subjects: X-ray, Nova

Referred to by ATel #: 13099, 13104, 13124

Tweet

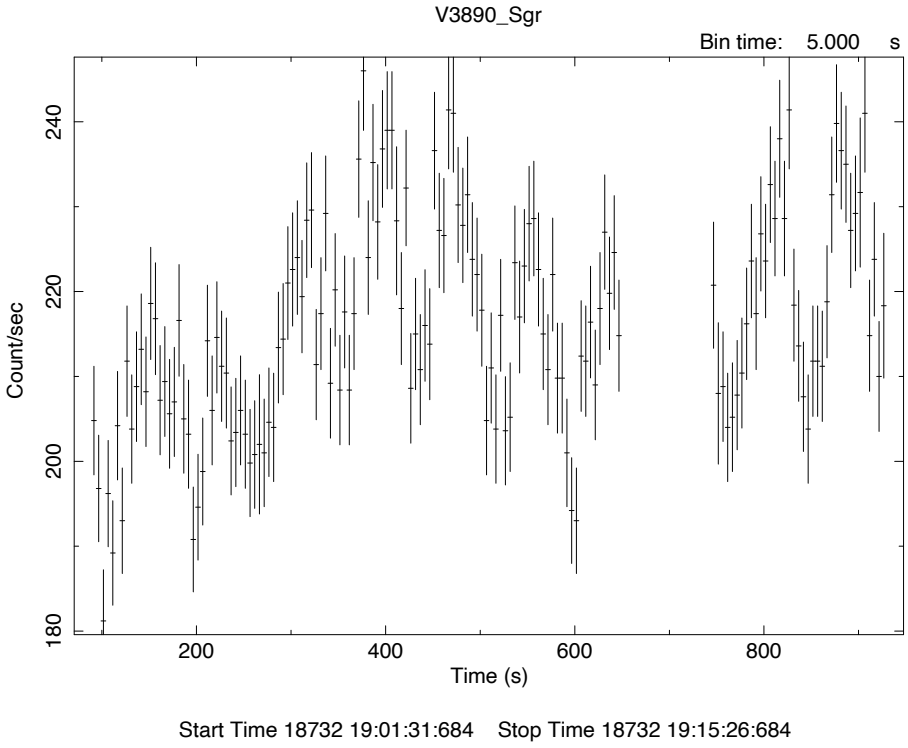
Following the detection of super-soft source (SSS) emission from the recurrent nova V3890 Sgr by the Swift-XRT (Page et al., ATel#13084), we initiated a real-time target of opportunity observation of the source with NICER. 737 s of data were obtained on 2019-Sep-06 from 19:00 to 19:14 UTC (i.e., starting 9.923 days after the optical discovery of the nova outburst). NICER measures a counting rate of 215 count/s over 0.3-10 keV and confirms the SSS emission. The observed rate is over a factor of three times higher than that estimated from the Swift-XRT data taken 19 hours earlier.

Closer examination of the data reveal a clear oscillation in the NICER light curve, on a timescale of 83 s. The modulation, confined to the SSS spectral component (i.e., below 0.7 keV), has a sinusoidal profile when folded, with an amplitude of 6 per cent.

Prior to this observation, five other nova undergoing SSS emission have revealed short period oscillations in their soft X-ray light curves (i.e., below 1 keV), with timescales ranging from 33 to 70 s. These include RS Oph (35 s: ATel#770, Osborne et al. 2011, ApJ, 727, 124, Ness et al. 2007, ApJ 665, 1334), KT Eri (35 s: Beardmore et al. ATel#2423), V339 Del (54 s: Beardmore et al. ATel#5573, Ness et al. ATel#5626) and Nova LMC 2009a (33 s: Ness et al ATel#6147). A similar timescale modulation was also seen in the persistent SSS Cal 83 (67 s: Odendaal et al. 2014, MNRAS, 437, 2948). The origin of these short-period modulations is not certain and is possibly related to either the spin of the white dwarf, or nonradial g-mode pulsations driven by an instability in the nuclear burning rate of the hot white dwarf.

Further observations with NICER are planned.

NICER is a 0.2-12 keV X-ray telescope operating on the International Space Station. The NICER mission and portions of the NICER science team activities are funded by NASA.



Observation planning & scheduling

Link to upcoming and recent-past observations is on the NICER HEASARC homepage

National Aeronautics and Space Administration
Goddard Space Flight Center
Sciences and Exploration

GO | Search HEASARC website | [Advanced Search]

HEASARC Quick Links
---Quick Links---

HEASARC Home | NICER Home | Archive | Calibration | Analysis | Proposals & Tools | Students/Teachers/Public

NICER
Neutron Star Interior Composition Explorer

About NICER | What's New | Timelines/Events | Results | Documentation | User's Group | Related Sites | Gallery

The Neutron Star Interior Composition Explorer Mission

Current Activity

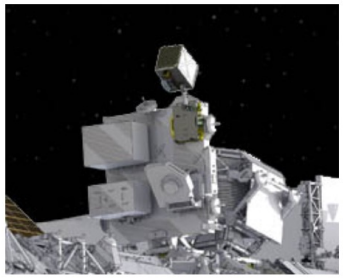
- Upcoming and recent past pointings
- Live Visualization

Requesting Targets of Opportunity (ToOs) with NICER

NICER is capable of following up on Targets of Opportunity (ToO) within 4 hours (depending on source visibility). TOO requests should be submitted via the ARK/RPS NICER Target of Opportunity/Director's Discretionary Time Request form.

The NICER team monitors the Gamma-ray Coordination Network (GCN)/Transient Astronomy Network (TAN).

Please review the NICER ToO Policy. Any questions regarding how to make TOO requests should be sent to the NICER Helpdesk via the HEASARC's Feedback Form.

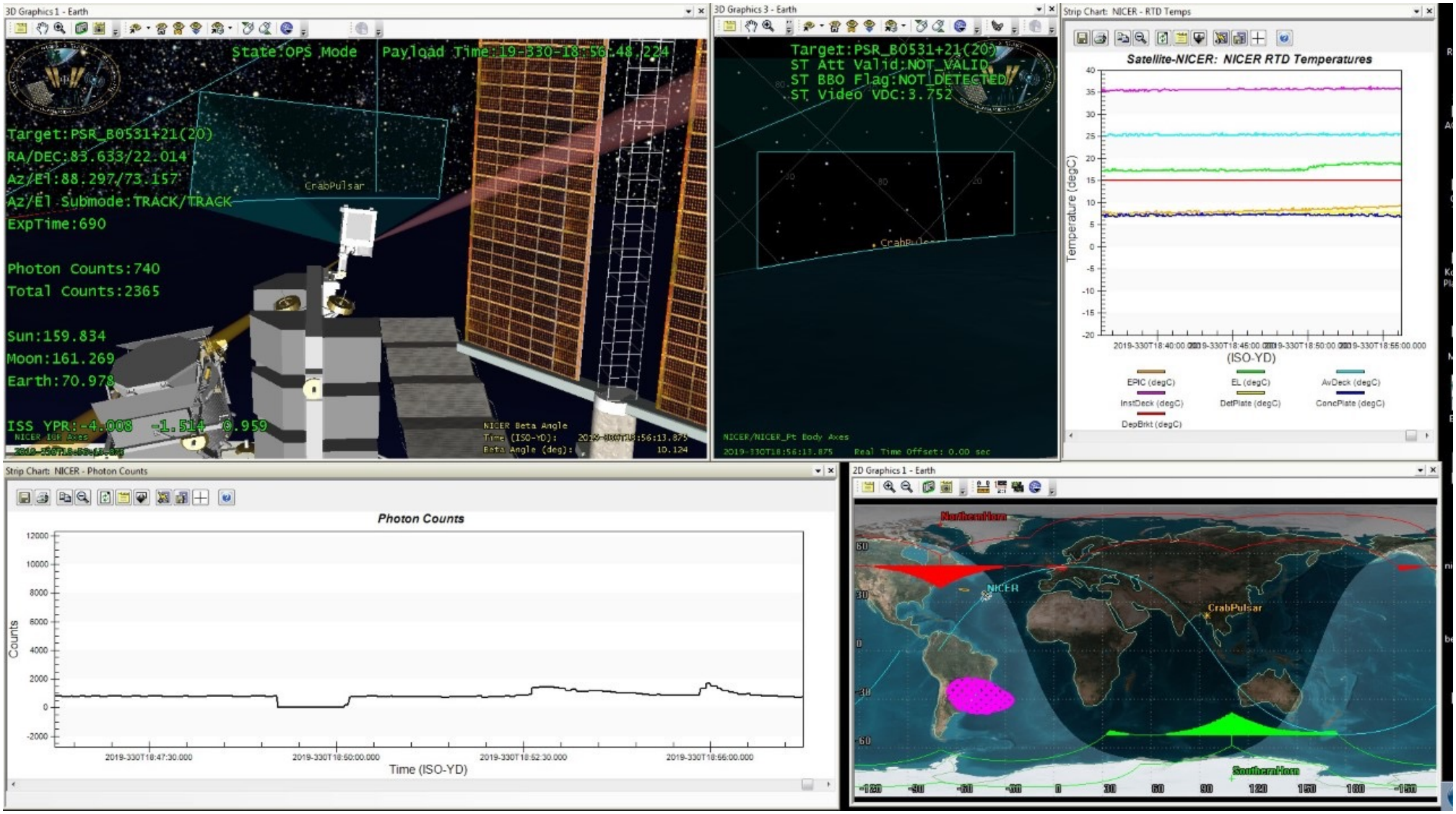


Latest News

- **NICER detection of possibly periodic X-ray absorption dips in MAXI J1803-298** (06 May 2021)
  New NICER observations of the X-ray transient MAXI J1803-298 shows recurrent absorption dips in the lightcurve similar to dips seen in other high-inclination X-ray binaries, and suggest a possible orbital period of 7-8 hours.
- **NICER follow-up observations of**

Live Visualization

https://heasarc.gsfc.nasa.gov/docs/nicer/ql/nicer_ql1.html



Caveats: *Photon counts* is subject to optical loading; target name may be incorrect.

Schedule online

NICER Recent and Planned Schedule

The schedule is updated from both planning and operator console information, typically at UTC midnight. It contains recently observed targets, planned target timelines, as well as any recent operator-commanded targets such as Targets of Opportunity (TOOs).

Currently Scheduled Target:

RE_J1034+396 (from 2021-05-09T18:23:02 to 2021-05-09T18:43:02 UTC)

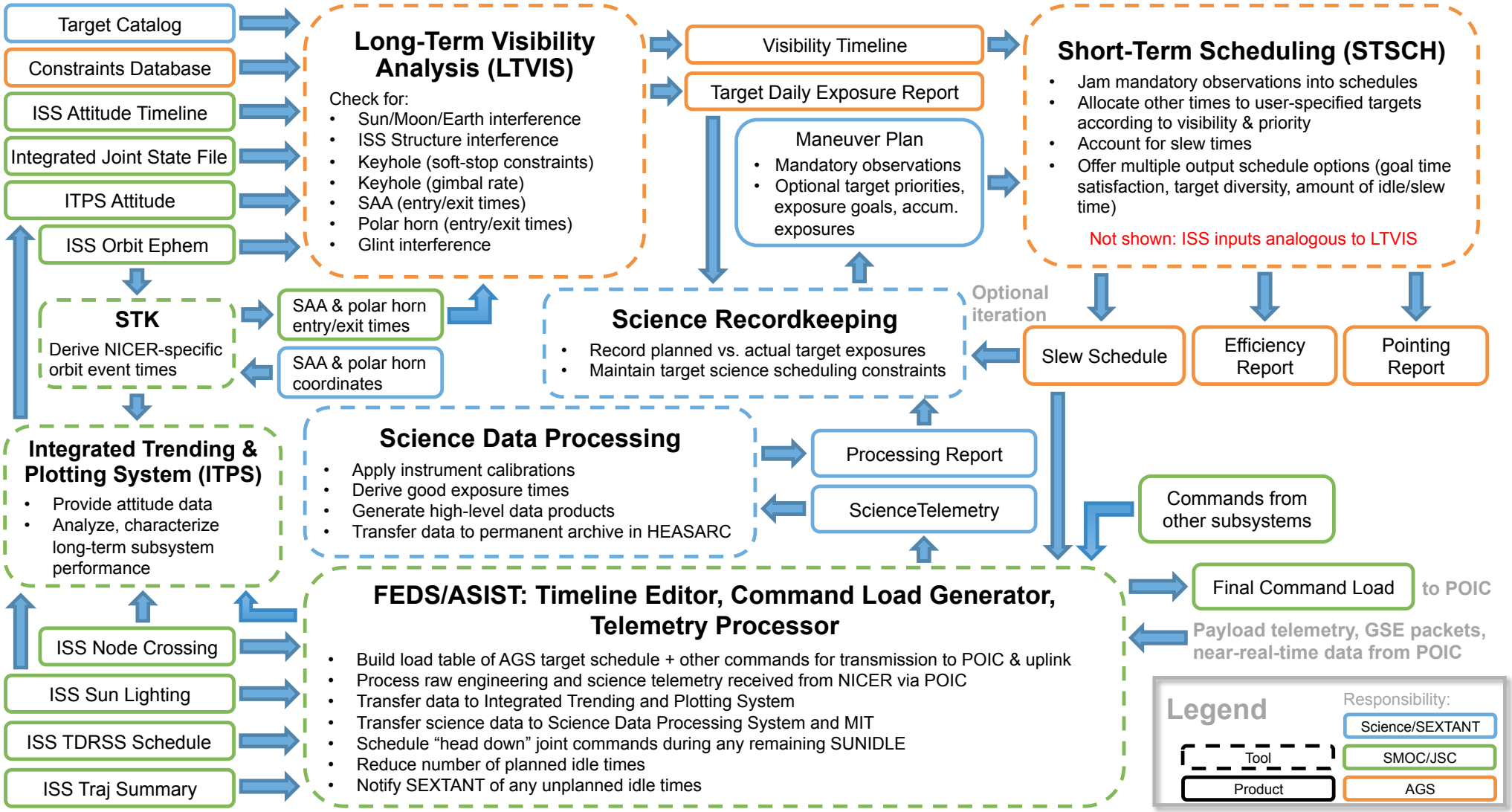
This page has "recently observed and scheduled" targets. For definitively observed past targets, use the HEASARC Mission Timeline Tool.

Please Note: The NICER schedule is usually made to include times extending beyond the next planned schedule update. Treat these as a "weather forecast:" subject to change. The uploaded planning timeline can be altered and ToOs can be uploaded to interrupt the current timeline.

Click to
Scroll to NOW

ObservationID	Target Name	TargetID	Start Time UTC	Stop Time UTC	Duration [s]	R.A. [deg] J2000	Dec. [deg] J2000	Mode
4020050112	PSR_J0205+6449	1110	2021-05-03T00:04:22	2021-05-03T00:18:51	869.0	31.408	64.829	Ingested
4300150111	Chi1_Ori	1277	2021-05-03T00:18:51	2021-05-03T00:25:20	389.0	88.596	20.276	Ingested
4662013804	ESO253-G003	6523	2021-05-03T00:25:20	2021-05-03T00:43:02	1062.0	81.325	-46.006	Ingested
3010250176	Vela_X-1	519	2021-05-03T00:43:02	2021-05-03T00:53:18	616.0	135.528	-40.555	Ingested
4518011701	Swift_J1357.2-0933	6652	2021-05-03T00:53:18	2021-05-03T01:08:06	888.0	209.320	-9.544	Ingested
4202110105	PG_1553+113	5208	2021-05-03T01:08:06	2021-05-03T01:16:58	532.0	238.929	11.190	Ingested
4202130102	MAXI_J1803-298	5210	2021-05-03T01:16:58	2021-05-03T01:27:22	624.0	270.762	-29.830	Ingested
4202110105	PG_1553+113	5208	2021-05-03T01:27:22	2021-05-03T01:37:22	600.0	238.929	11.190	Ingested
4020050112	PSR_J0205+6449	1110	2021-05-03T01:37:22	2021-05-03T01:51:51	869.0	31.408	64.829	Ingested
4300150111	Chi1_Ori	1277	2021-05-03T01:51:51	2021-05-03T01:58:12	381.0	88.596	20.276	Ingested
4662013804	ESO253-G003	6523	2021-05-03T01:58:12	2021-05-03T02:16:02	1070.0	81.325	-46.006	Ingested
3010250176	Vela_X-1	519	2021-05-03T02:16:02	2021-05-03T02:27:10	668.0	135.528	-40.555	Ingested
4202070140	Swift_J1626.6-5156	5204	2021-05-03T02:27:10	2021-05-03T02:33:10	360.0	246.652	-51.942	Ingested
4549031302	1E_1048.1-5937	6549	2021-05-03T02:33:10	2021-05-03T02:44:02	652.0	162.530	-59.889	Ingested
4202110105	PG_1553+113	5208	2021-05-03T02:44:02	2021-05-03T02:51:02	420.0	238.929	11.190	Ingested
4680010102	4U_1820-30	6615	2021-05-03T02:51:02	2021-05-03T02:59:22	500.0	275.919	-30.361	Ingested

NICER Operations Workflow



NICER Operations

- Ground System: John Pope (lead) & Maxine Saylor;
  Pipeline Processing: Kristin Rutkowski… Unsung heroes!
- Three weekly (MWF) tag-ups of ops team
  - Scheduling & ToOs
  - ISS inputs
  - Hot issues (e.g., payload health & safety, ISS operations)
  - Pipeline processing status
  - GO status
  - Science updates
- Two regular command loads a week
  - Scheduling (a.k.a. “planning”) Monday & Thursday afternoons for loads Tuesday and Friday mornings
  - Additional planning & commanding as needed for ToOs

Ability to command from home and prompt after-hours ToO response possibility is a CoVID silver lining…

Target visibility — celestial constraints

- Avoidance cone for the Sun is 45º (but for soft sources we prefer > 60º)
- Avoidance cone for the Moon is 15º
- Sun and Moon constraints are captured by HEASARC *Viewing* tool
- Bright and dark Earth limb avoidance are typically 30º and 20º, respectively.

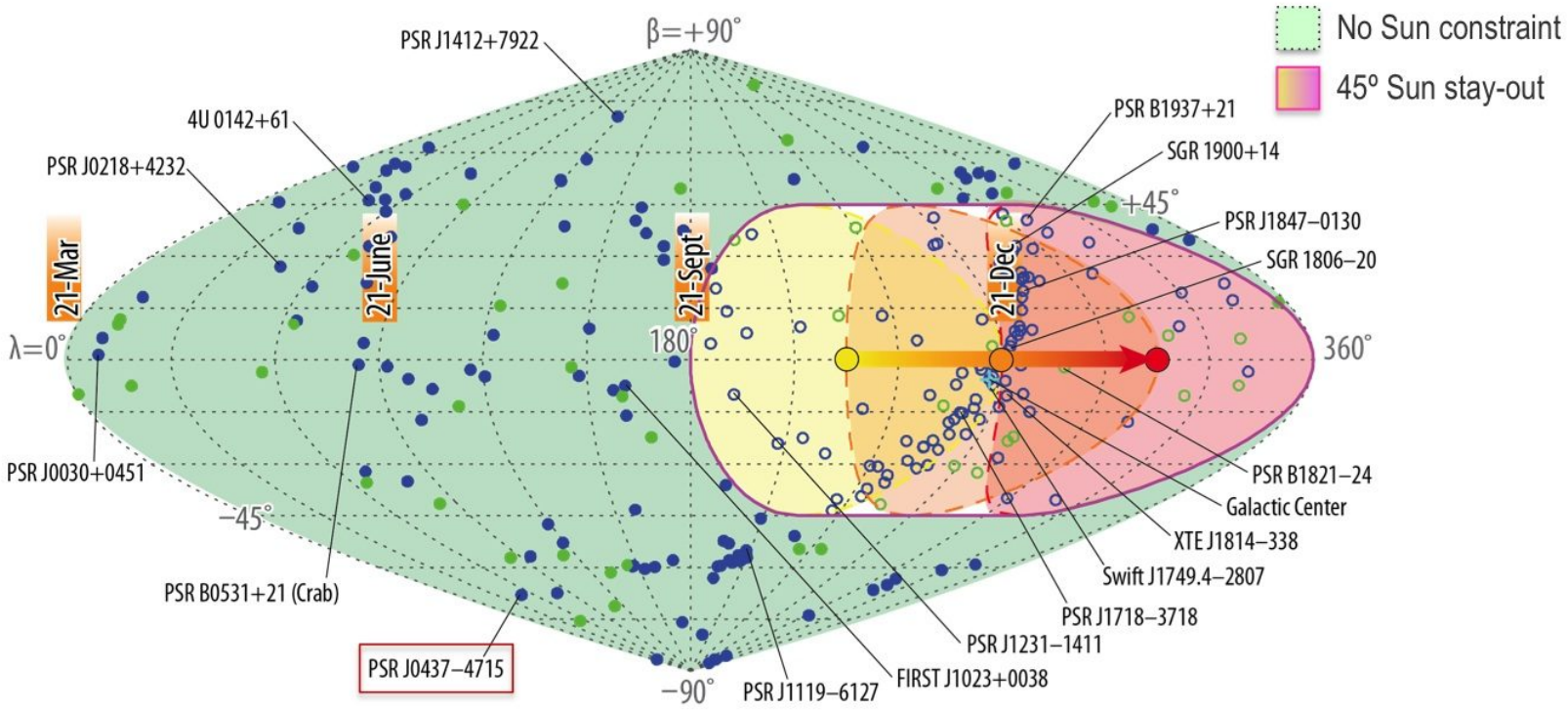


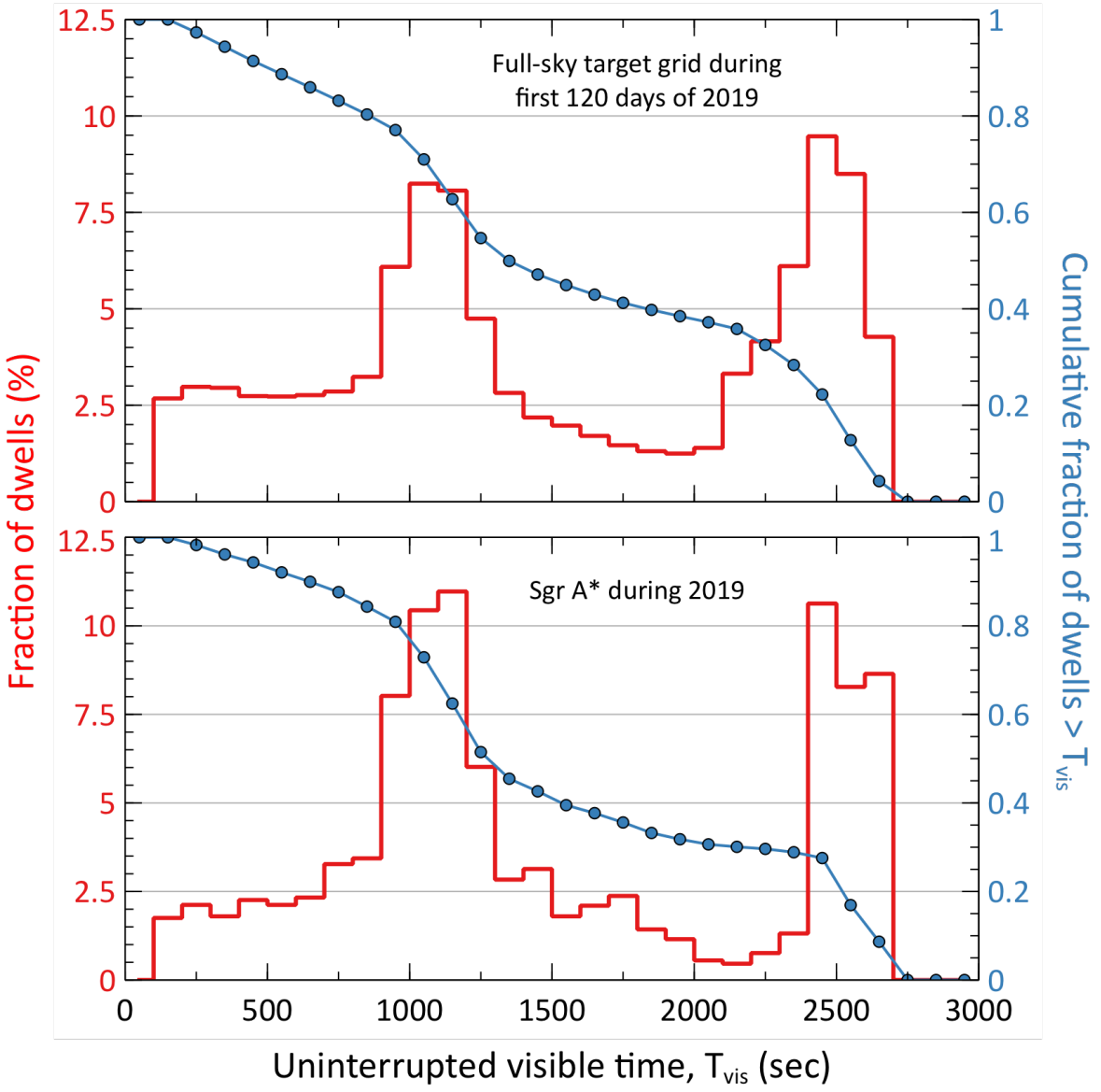
Figure 4. NICER targets are widely distributed across the sky. Plotted in ecliptic coordinates, blue symbols represent 200 known astrophysical targets of interest, including calibration targets, and green symbols simulate 50 randomly distributed targets of opportunity. The path of the Sun over a 3-month period centered on the winter solstice (Dec. 21) is shown by the broad arrow. For a Sun avoidance angle of 45°, exclusion zones at the beginning (yellow), middle (orange), and end (red) of the period are shown by the long dashed borders, while the heavy purple outline encloses the entire region affected by Sun avoidance during these 3 months. Unaffected targets, remaining visible throughout, are shown as filled circles; open circles are targets with restricted visibility. The location of the Galactic Center is shown by a light-blue cross—because of the concentration of targets along the plane of the inner Galaxy, Sun avoidance during the interval depicted here represents the worst-case impact on visibility of the collection of NICER targets.

Visibility implications of ISS orbit

- ISS is in 90-min low-Earth orbit →16 potential snapshots per day
- There are no “continuous viewing zones” → maximum uninterrupted observation is one-half orbit, or 2.7 ks; most observations are significantly shorter
- Orbit inclination is 51.5º → reaches high northern and southern latitudes
  - Generally, can observe northern sky while over the northern hemisphere, southern sky while over southern hemisphere
  - Passage through northern and southern auroral zones, or “polar horns,” with low geomagnetic cut-off rigidities and thus high (sometimes extremely high) particle background
  - Passage through South Atlantic Anomaly
- Orbit plane precesses 5º per day → solar-panel obstructions recur with ~ monthly cadence; NICER’s position near starboard ISS solar panels disfavors southern-sky target observations
- Targets transiting directly overhead interrupted by Az-El “keyhole”
- Coming soon: online visibility calculator that takes ISS-specific constraints into account.

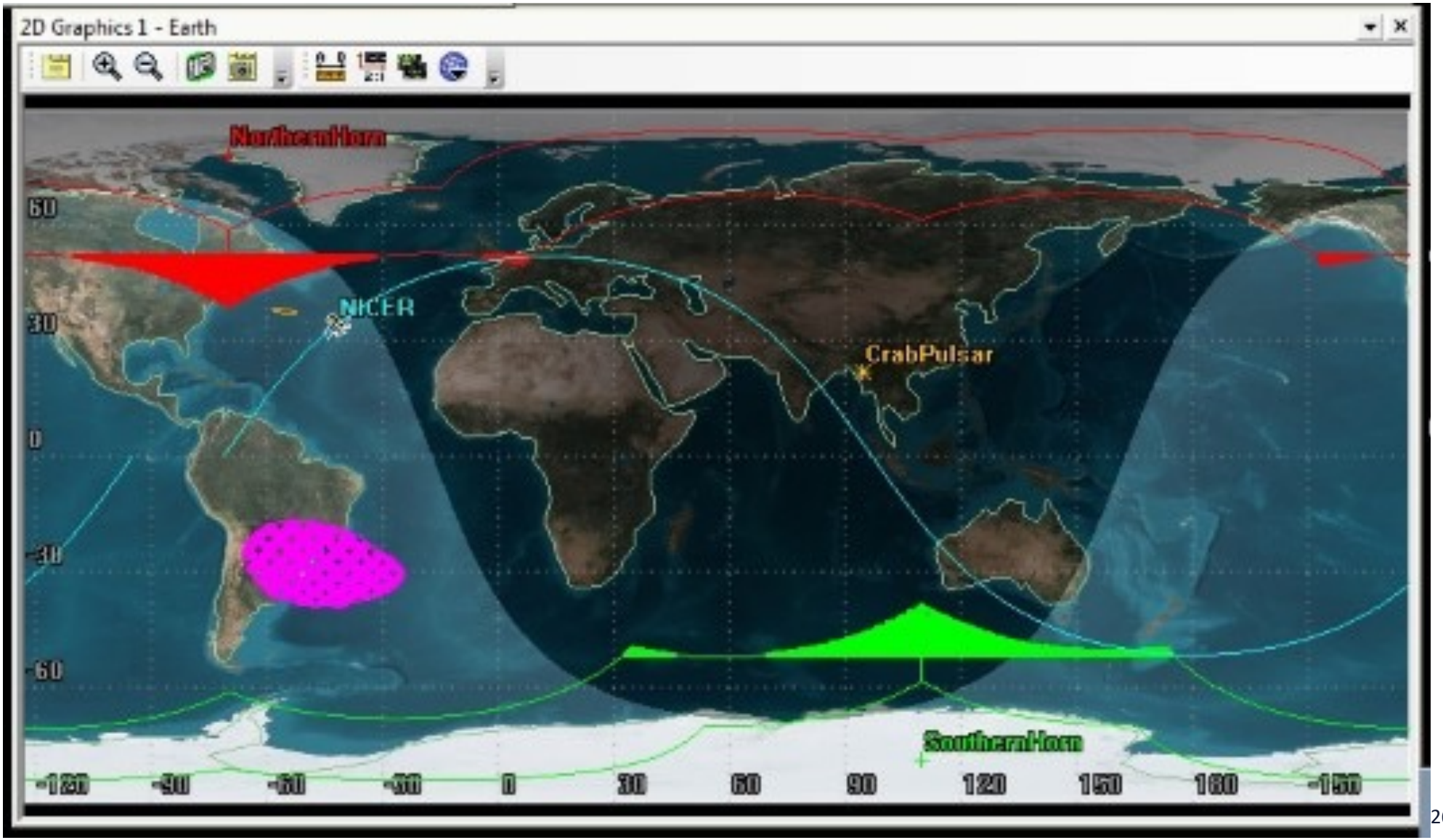
Uninterrupted "snapshot" durations

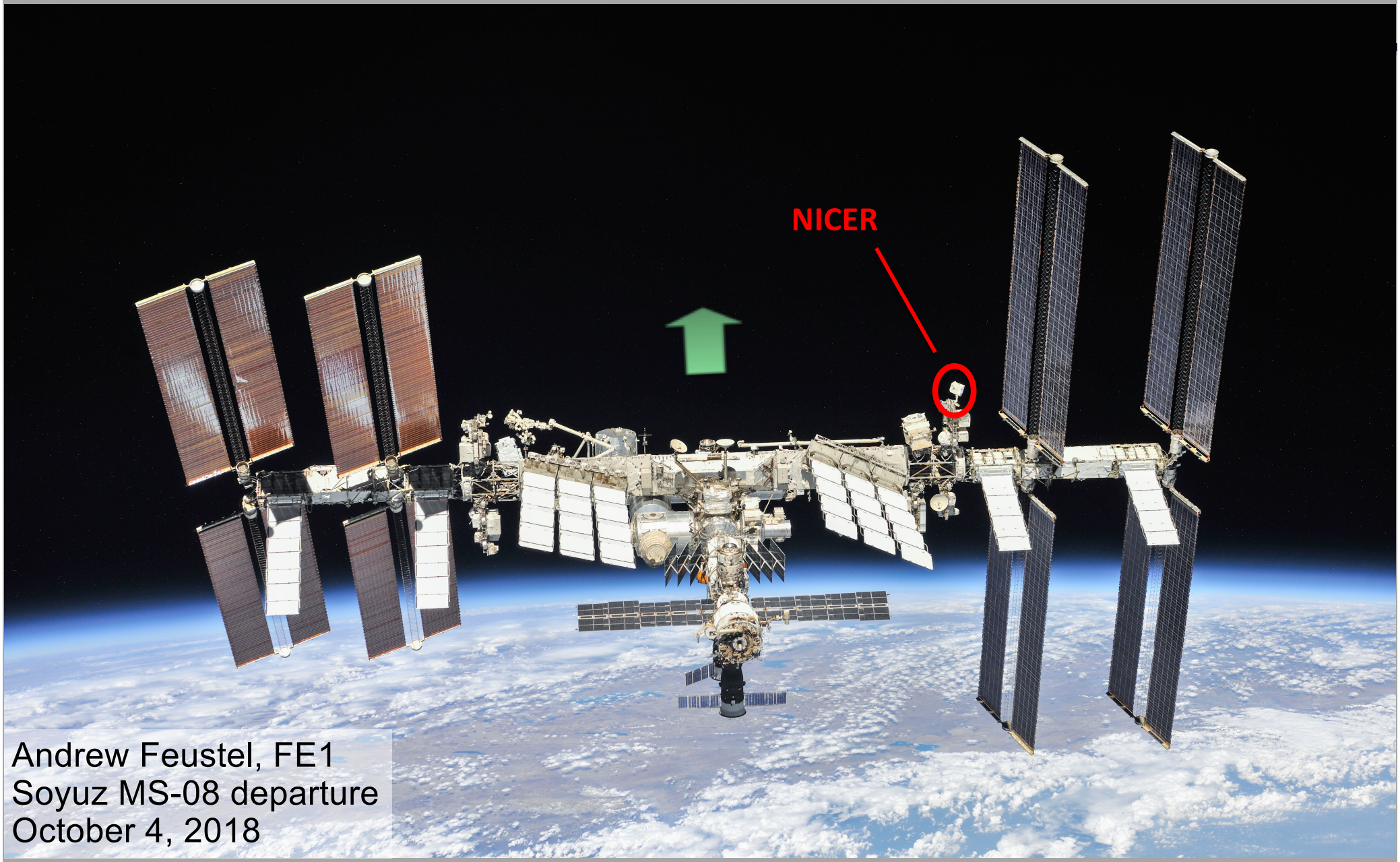
- Distribution of uninterrupted dwell times for (*top*) a sample of targets all over the sky, and (*bottom*) a typical southern-sky target
- Averaged over the full sky, nearly 40% of valid pointings span ≥ 2 ks, dropping to 30% in the south; for ≥ 1 ks, the fractions are comparable at ~75%
- Note that these percentages exclude times of zero visibility!



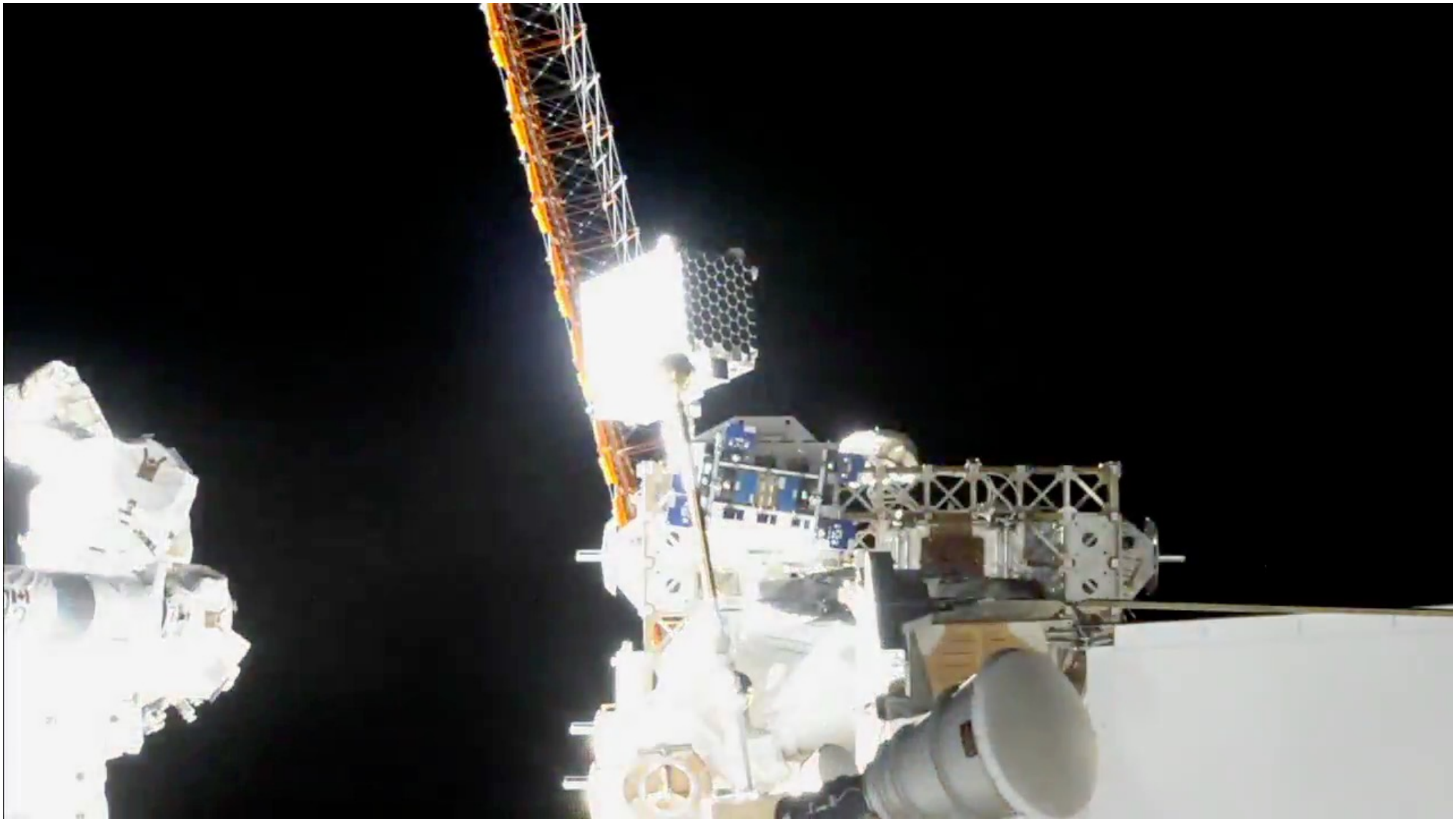
Radiation zones

South Atlantic Anomaly (pink), Northern (red) and Southern (green) ”polar horns”



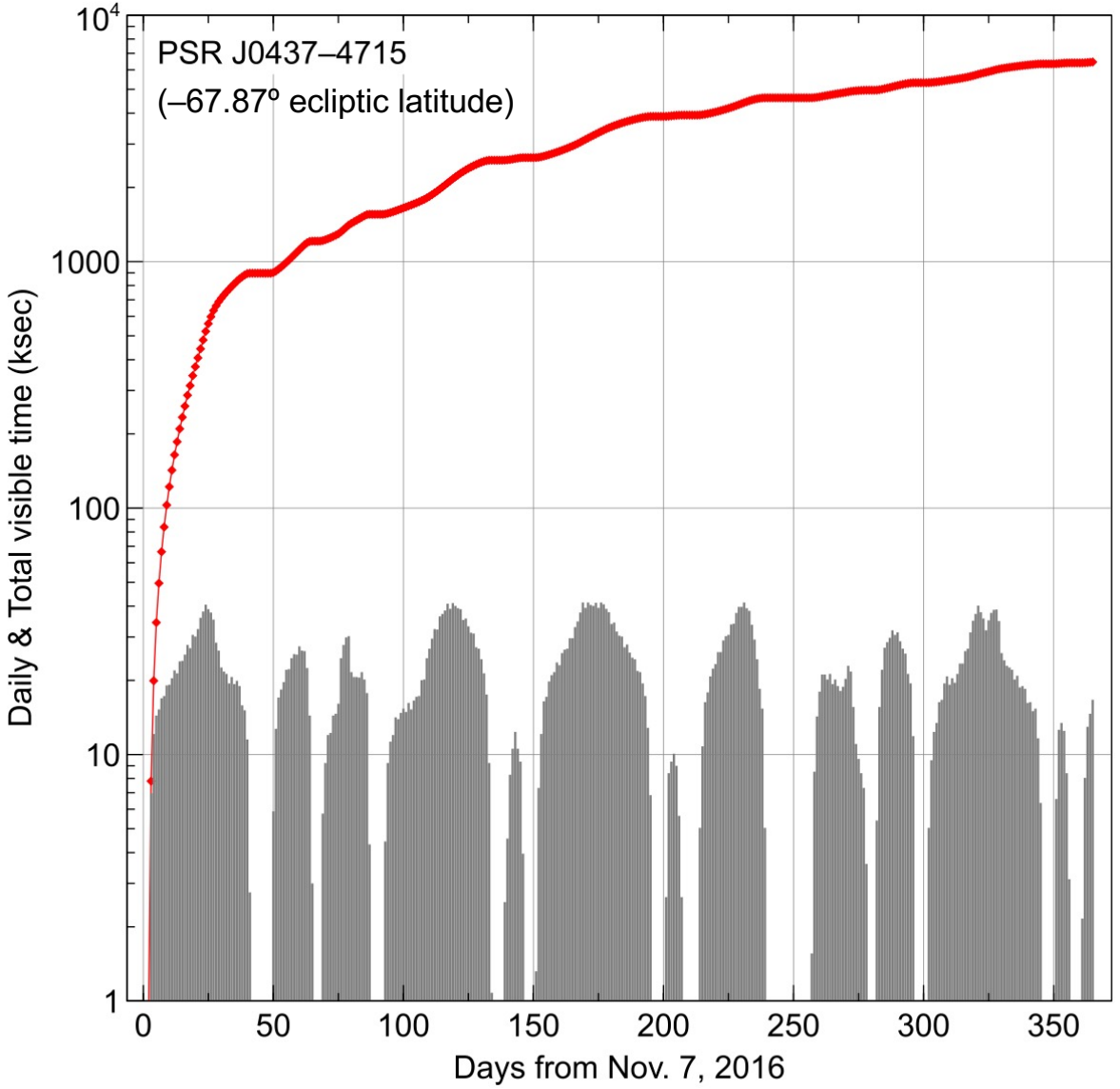

NICER
Andrew Feustel, FE1
Soyuz MS-08 departure
October 4, 2018

Dancing with the SAs

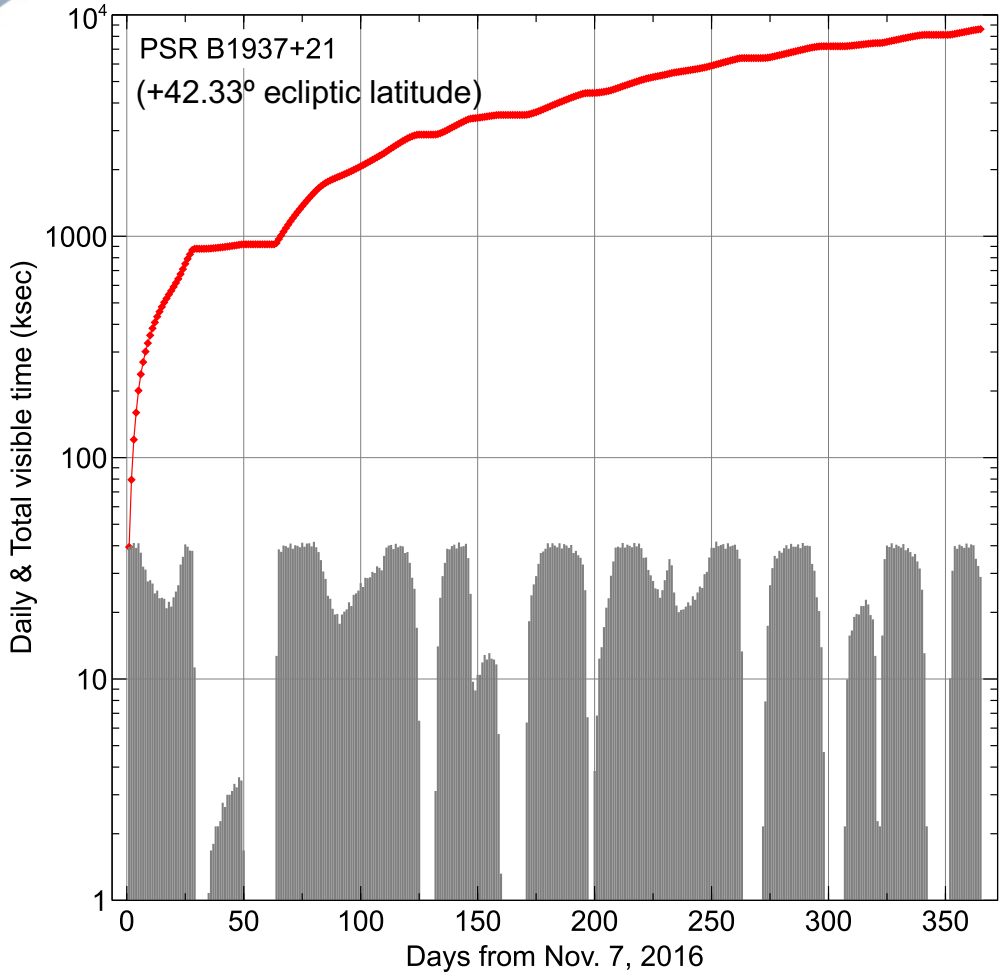


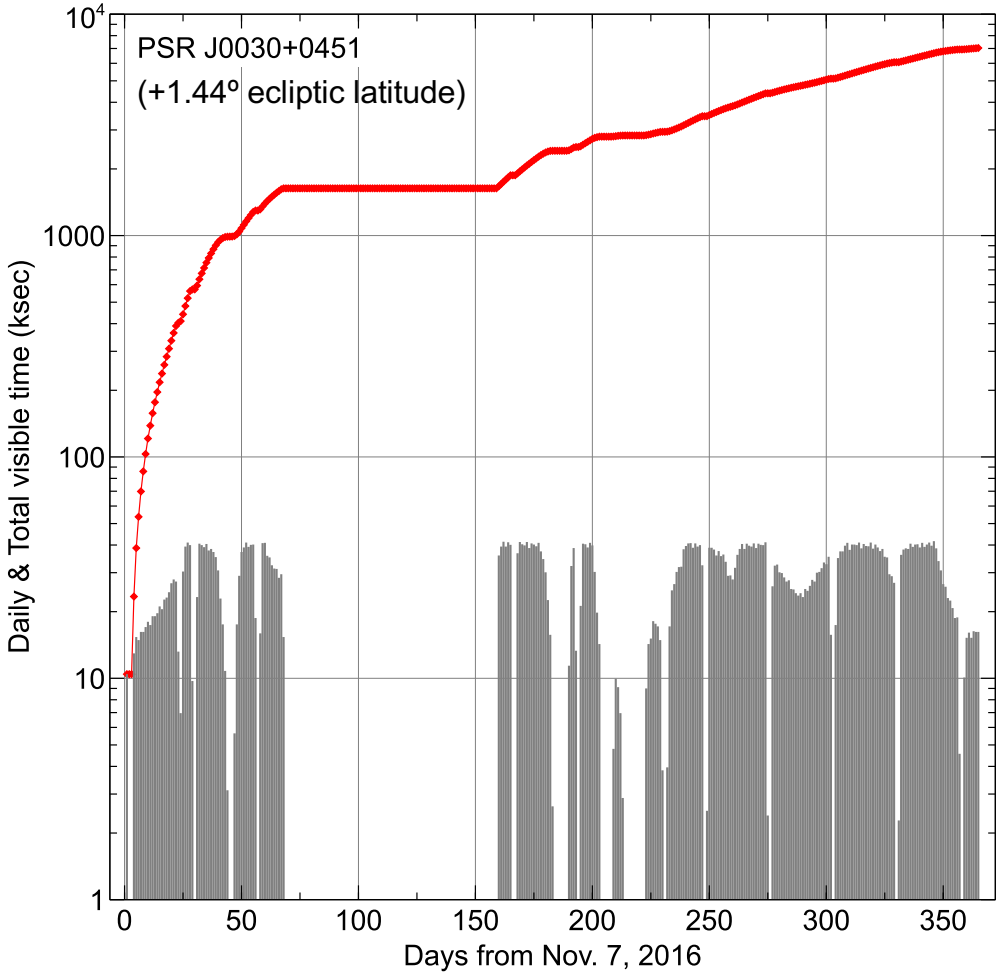
Long-term visibility examples

- Daily (grey bars) and cumulative (red connected points) available exposure time for PSR J0437–4715 — NICER's "poster child" target for lightcurve modeling — over a nominal year of operations
- PSR J0437 is always outside Sun avoidance
- Gaps every ~40 days are due to solar-array obstruction
- Intervals of good visibility are very "peaky" — daily maxima of ~40 ks (16 x 2.5 ks) are short-lived.



Long-term visibility examples (cont.)

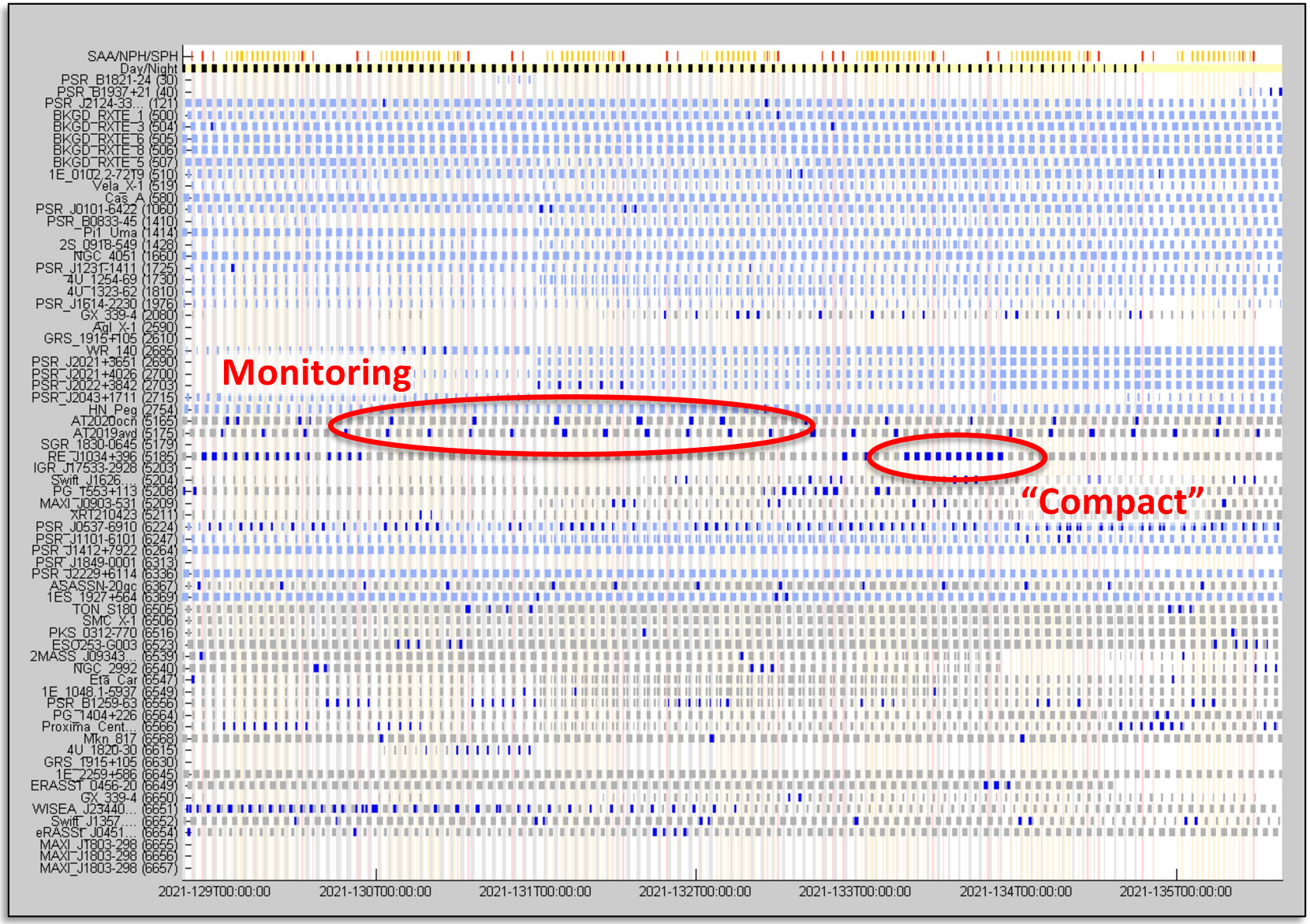




- PSR B1937, further north, has flat-top visible intervals near 40 ks max
- PSR J0030, at low ecliptic latitude, has a 3-month gap due to Sun avoidance.

Putting it all together…

- Scheduling can be labor-intensive for time-constrained requests.



Summary

- We aim to blend GO, Team/legacy science, and ToO/discretionary observing needs to maximize scientific productivity
- We encourage scientifically well-motivated requests of all kinds, and welcome coordination requests
- NICER offers scheduling “agility” but not necessarily “flexibility” — we have little control over when a given target is visible, but we can visit frequently when conditions permit
- Expect to see high-fidelity visibility calculator online soon!