NIRSpec status update

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NIRSpec overview

near-infrared spectroscopy with wavelength coverage 0.6 – 5.3 microns, resolving powers ~100, 1000, 2700, available in 4 modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Target Type</th>
<th>Corresponding Aperture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed slit spectroscopy</td>
<td>Single objects</td>
<td>0.2” x 3.2” slits (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4” x 3.65” slit</td>
</tr>
<tr>
<td>Bright Object Time Series</td>
<td>Exoplanet host stars</td>
<td>1.6” x 1.6” aperture</td>
</tr>
<tr>
<td>Integral-field spectroscopy</td>
<td>Moderately extended objects</td>
<td>3.0” x 3.0” IFU</td>
</tr>
<tr>
<td>(MOS)</td>
<td></td>
<td>with 0.1” square spaxels</td>
</tr>
<tr>
<td>Multi-object spectroscopy</td>
<td>Rich fields or extended</td>
<td>Selectable from ~250,000</td>
</tr>
<tr>
<td>(MOS)</td>
<td>objects</td>
<td>0.2” x 0.46” micro-shutters</td>
</tr>
</tbody>
</table>

built for ESA by Airbus Defense and Space, with microshutter assembly (MSA) and detector subsystem provided by NASA/GSFC
operations
Performance status overview

- the instrument is performing extremely well, with no significant anomalies

- data taken with all modes, IFU being the most popular to date in terms of visits

*successful cycle 1 visits by mode, as of Feb. 22*
Science with NIRSpec

MOS obs of z~10.6 galaxy (Bunker et al 2023)

[Fe I] channel map from IFU obs of SN 1987A (Larsson et al 2023)

WASP-39b BOTS transmission spectrum (Rustamkulov et al 2023)
## Status: Target Acquisition

### MSATA

<table>
<thead>
<tr>
<th></th>
<th>MSATA All cases</th>
<th>MSATA Commissioning</th>
<th>MSATA Cycle 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N Total</strong></td>
<td>83</td>
<td>16</td>
<td>67</td>
</tr>
<tr>
<td><strong>N Successful</strong></td>
<td>76</td>
<td>13</td>
<td>63</td>
</tr>
<tr>
<td><strong>N Failed</strong></td>
<td>7</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>1-try cases</strong></td>
<td>78</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td><strong>N Successful</strong></td>
<td>72</td>
<td>11</td>
<td>61</td>
</tr>
<tr>
<td><strong>N Failed</strong></td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>2-try cases</strong></td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>N Successful</strong></td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>N Failed</strong></td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

only 7 failures (8%)

2 due to user error, 4 due to ground system issues, 2 due to FGS issues

### WATA

<table>
<thead>
<tr>
<th></th>
<th>WATA All cases</th>
<th>WATA Commissioning</th>
<th>WATA Cycle 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N Total</strong></td>
<td>153</td>
<td>27</td>
<td>126</td>
</tr>
<tr>
<td><strong>N Successful</strong></td>
<td>139</td>
<td>27</td>
<td>112</td>
</tr>
<tr>
<td><strong>N Failed</strong></td>
<td>14</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

only 14 failures (9%)

8 due to user coordinate errors, 2 due to user overestimate of target brightness, 2 due to GS tracking or catalog issues, 2 due to algorithm limitation

☑️ exceptional performance since Commissioning
MSA electrical shorts

- electrical shorts between rows or columns in an MSA quadrant
- occur randomly, thought to be due to metallic particulate contamination
- revealed by elevated currents and/or thermal glow on the detectors
  - regular telemetry monitoring by FOT, but often not above the detection threshold
- primary impact is contamination of science data from the thermal glow
  - possible long-term impact on multiplexing

![count rate image of IFU exposure with one of the gratings, showing saturated zeroth-order image, spectrum, and scattered light from the glow of an MSA electrical short](image)
MSA electrical shorts

- Visits with WOPRs for data contaminated by short glow, as of Feb. 9:
  - 8/64 (12.5%) MOS
  - 12/241 (5.0%) IFU

- Process in place to find and mask the shorts as they occur
  - Requires manual intervention
  - Impacts on scheduling, some MOS/IFU visits have had to be pulled until new mask is uploaded
  - Several improvements (OSS & PPS) are being worked that will significantly reduce the impact on observatory efficiency

- Many shorts appear to be transitory
  - Plan to eventually reevaluate previously-masked shorts to see if some have recovered
IFU position offset

• ~0.2" offset in the IFU reference point found in Commissioning
  - only impacts science programs requiring WATA centering
  - no programs affected up to now, users opted to go forward using blind pointing

• solution using astrometric calibration observations
  - requires a simple change to SIAF
  - analysis nearly complete, expect update in the next few weeks
Reference files

• 95% of all files are now in-flight versions
  - all based on Commissioning data
  - remaining cases have required further analysis and/or better data
    • MOS S-flat (2D correction of spectrograph throughput), some limitations on field-dependent flux calibration accuracy
    • FS pathloss Commissioning data compromised (source mis-centered?), more data coming later in cycle 1

• cycle 1 expected updates coming this spring
  - detector-level files (darks, biases, bad pixels)
  - FS & MOS pathloss
  - improved flux calibration (ensemble of standards)
  - MSA operability
Flux calibration

• current flight calibration for each mode & disperser is based on a single star
  - estimated absolute accuracy ~5% for FS, 10% for MOS and IFU, based on verification testing, some limited cross-checks from Commissioning observations of a second star

• cycle 1 calibration observations of a larger set of spectrophotometric standards, multiple positions over the MOS FOV – analysis underway

difference between pipeline extraction and calspec model of A-star calibrator used for F-flat ref file for S1600A1, G395H

ratio of pipeline extraction and calspec model for A- and G-star calibrators observed in cycle 1 with S1600A1, PRISM
Wavelength calibration

• wavelength calibration done as part of the instrument model calibration
  − Commissioning observations of internal lamps
  − will be checked once in cycle 1 (data taken this past week)
  − critical piece is GWA tilt calibration, monitored at a higher cadence (analysis pending)

• accuracy based on internal verification generally ~1/10 pixel for all dispersers
  − additional checks using Commissioning FS observations of A-star shows similar results
  − Commissioning & cycle 1 observations of unresolved PN will provide further checks for all modes, improve the correction for offset point sources, and characterize LSF (analysis ongoing)
Pipeline issues

• bad pixel masking
  - still optimizing step masks
  - evolution of hot pixels will require increased cadence of reference file updates

• outlier detection
  - stage 3 step generally not working correctly (too many false positives)
  - requires extra-pipeline manipulation to identify outliers

hot pixel population

NRS1

NRS2
Pipeline issues

• resampling artifacts
  - several bugs in IFU cube_build step fixed
  - resampling noise in point source data from pixel aliasing (curved spectra + undersampled PSF)
    ➢ can be mitigated by summing over multiple spaxels, or averaging over multiple dithers

• 1D extraction aperture centering
  - automated centering based on source coordinates, typically offset from true center of trace (affects all modes)
  - user can manually adjust, but process is painful for MOS data
  - tracked down one possible source, testing underway
  - need to investigate other possible algorithms

1D spectrum from a single spaxel on a point source, single dither exposure
onward to cycle 2...