



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

## NIRSpec status update

James Muzerolle Page (*STScI Branch manager*), and the NIRSpec team

JSTUC February 28, 2023



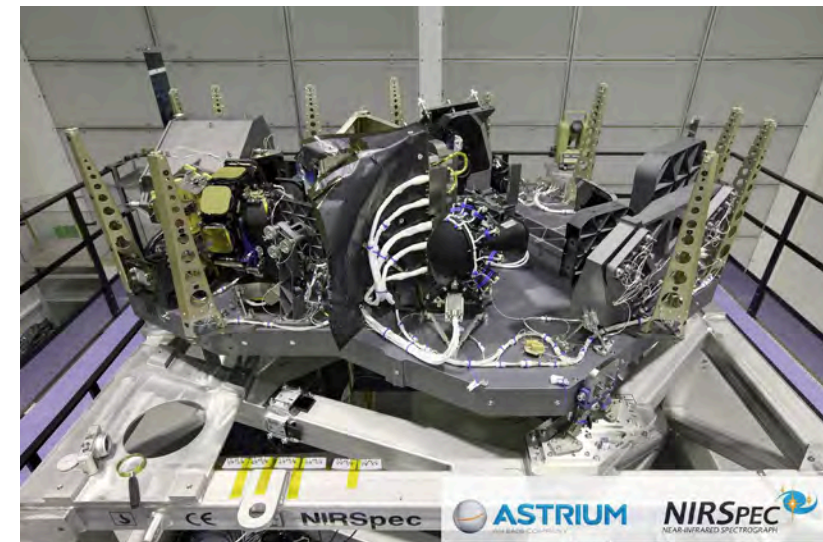


# NIRSpec overview

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

Mode	Target Type	Corresponding Aperture
Fixed slit spectroscopy	Single objects	0.2" x 3.2" slits (3) 0.4" x 3.65" slit
Bright Object Time Series	Exoplanet host stars	1.6" x 1.6" aperture
Integral-field spectroscopy	Moderately extended objects	3.0" x 3.0" IFU with 0.1" square spaxels
Multi-object spectroscopy (MOS)	Rich fields or extended objects	Selectable from $\sim 250,000$ 0.2" x 0.46" micro-shutters

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





# The Great NIRSpec Branch

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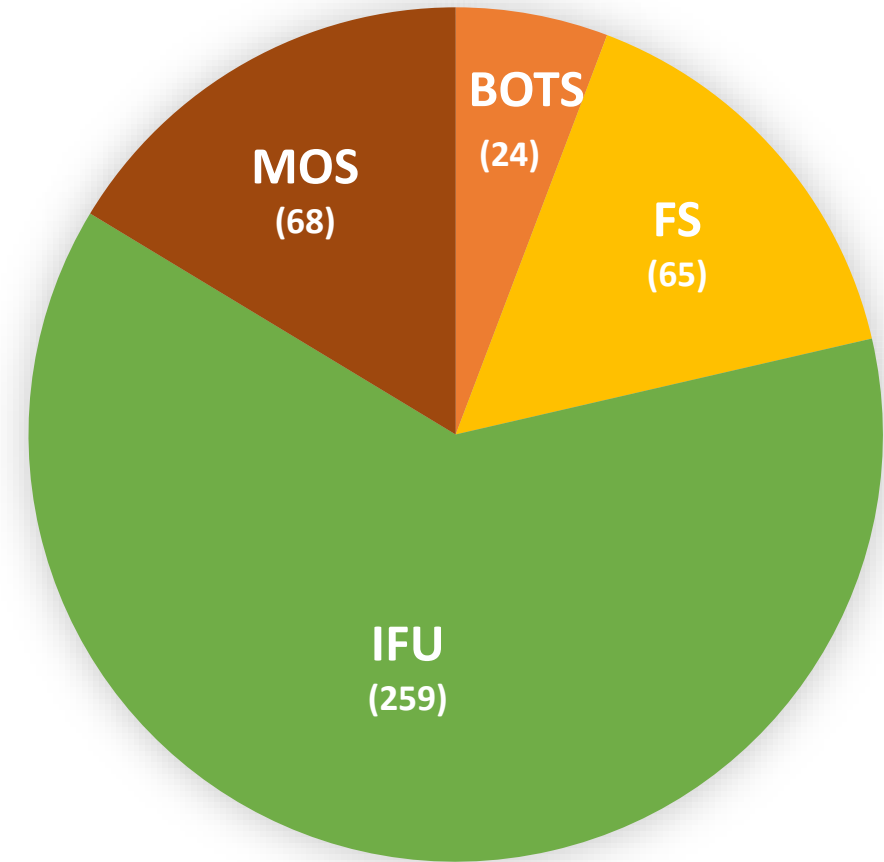
**operations**

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## 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

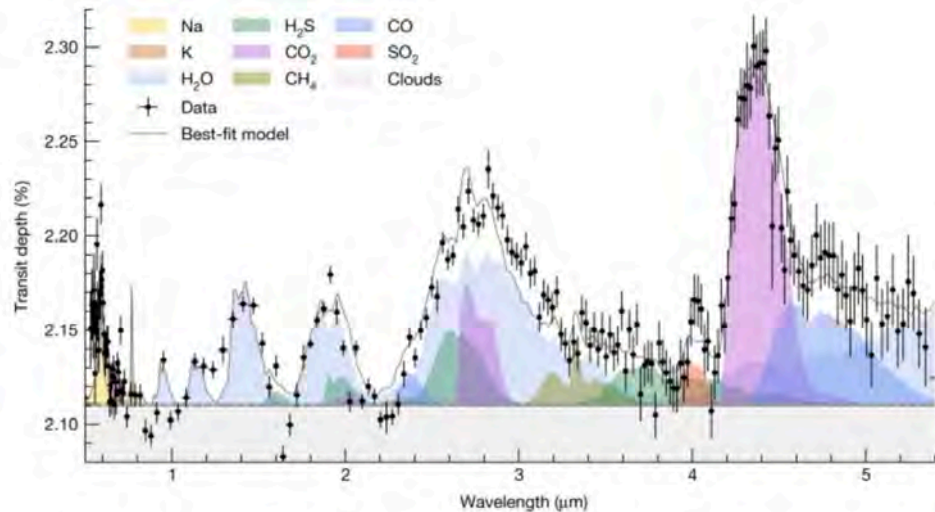
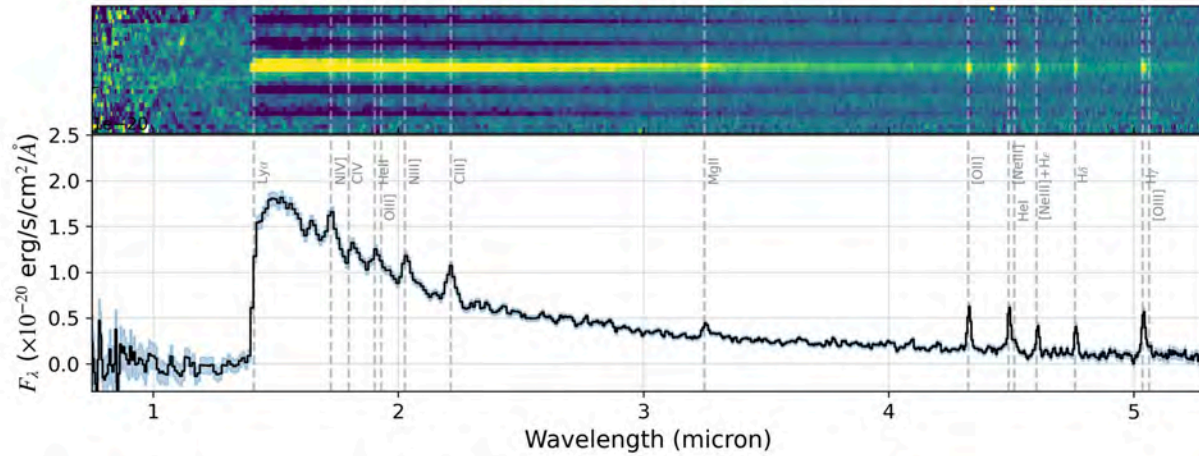


*successful cycle 1 visits by mode, as of Feb. 22*

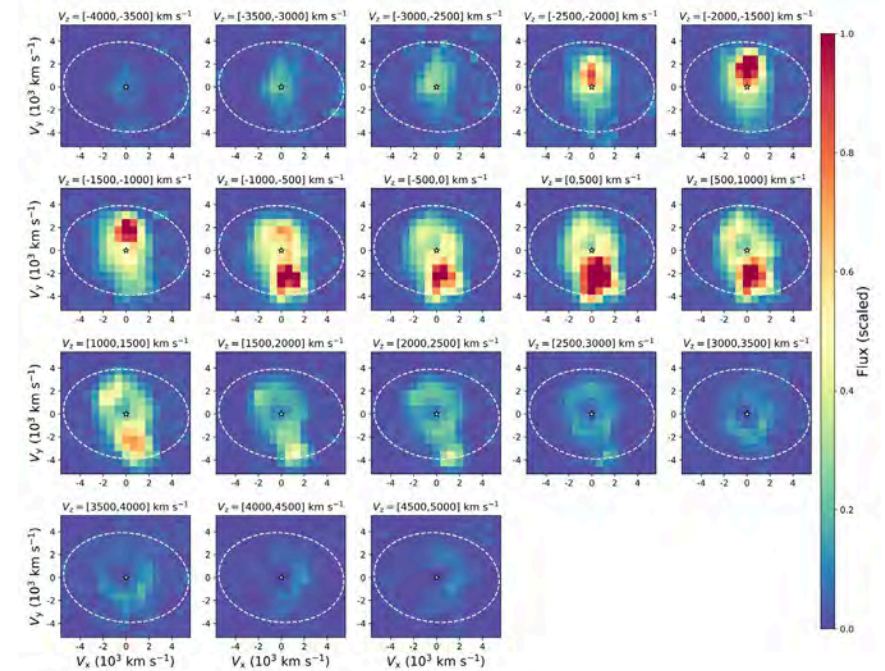


# Science with NIRSpec

MOS obs of  $z \sim 10.6$  galaxy (Bunker et al 2023)



WASP-39b BOTS transmission spectrum (Rustamkulov et al 2023)



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



# Status: Target Acquisition

## MSATA

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

only 7 failures (8%)

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

➤ exceptional performance since Commissioning

## WATA

	WATA All cases	WATA Commissioning	WATA Cycle 1
<b>N Total</b>	153	27	126
N Successful	139	27	112
N Failed	14	0	14

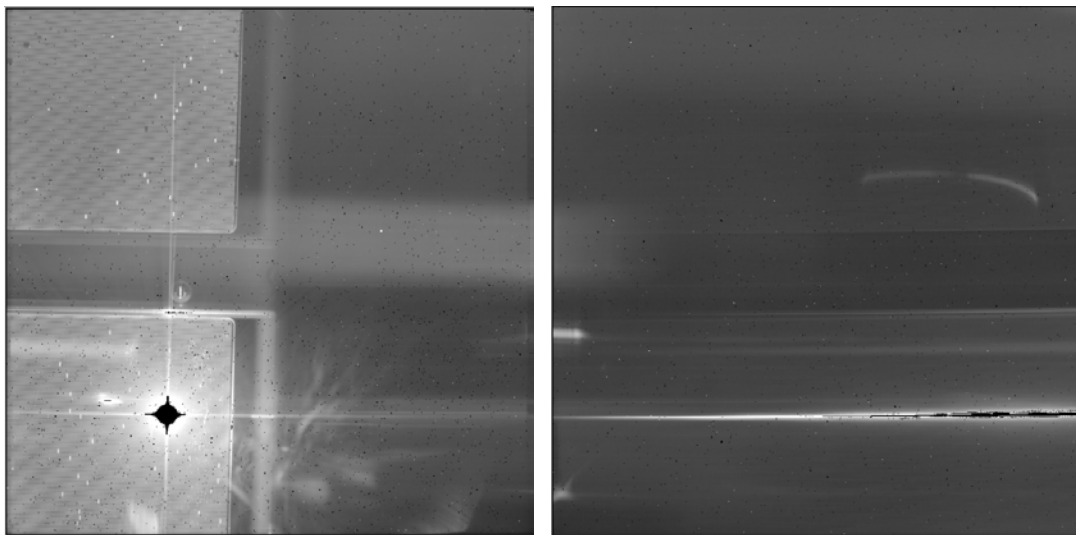
only 14 failures (9%)

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



## 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*



# MSA electrical shorts

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- 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

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- ~0.2" offset in the IFU reference point found in Commissioning
  - only impacts science programs requiring WATA centering
  - no programs effected 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

A deep blue and purple nebula with wispy, ethereal clouds of gas and dust. The background is a dense field of stars, many of which are bright blue and white, with some yellow and orange stars scattered throughout. The overall scene is a rich, multi-colored star field.

**calibration**

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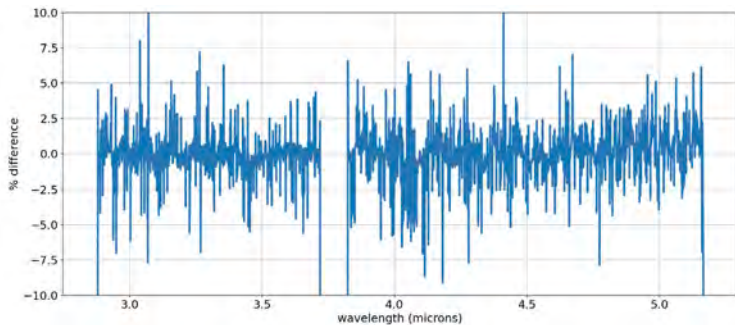
# Reference files

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- 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

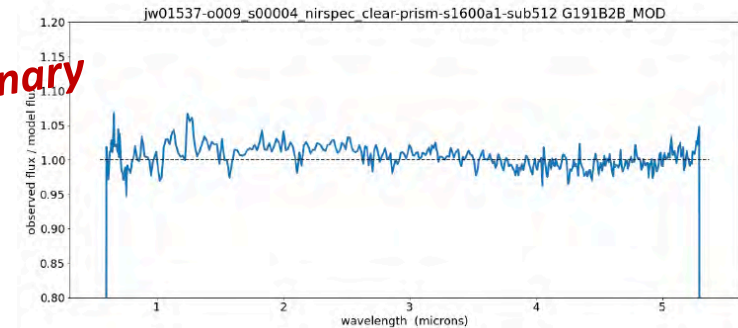
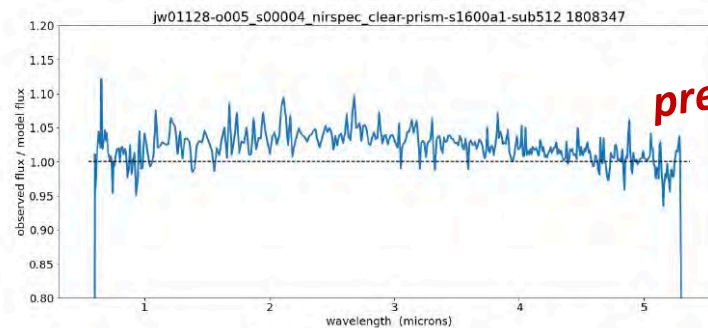


# Flux calibration



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

- 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

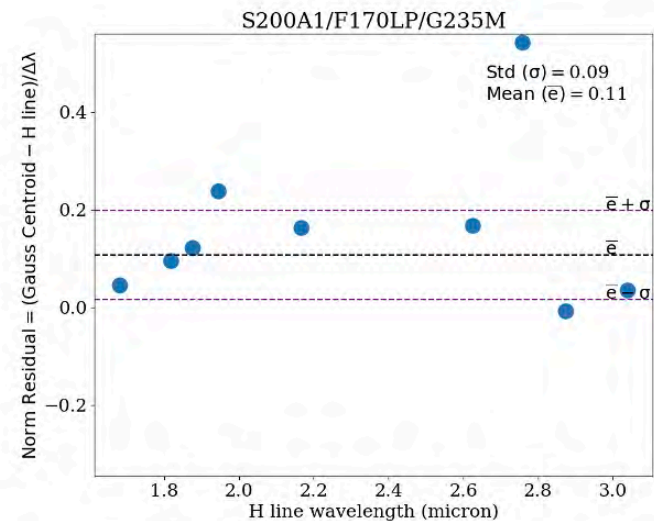


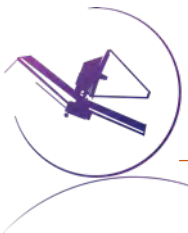
*ratio of pipeline extraction and calspec model for A- and G-star calibrators observed in cycle 1 with S1600A1, PRISM*



# 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  $\sim 1/10$  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)

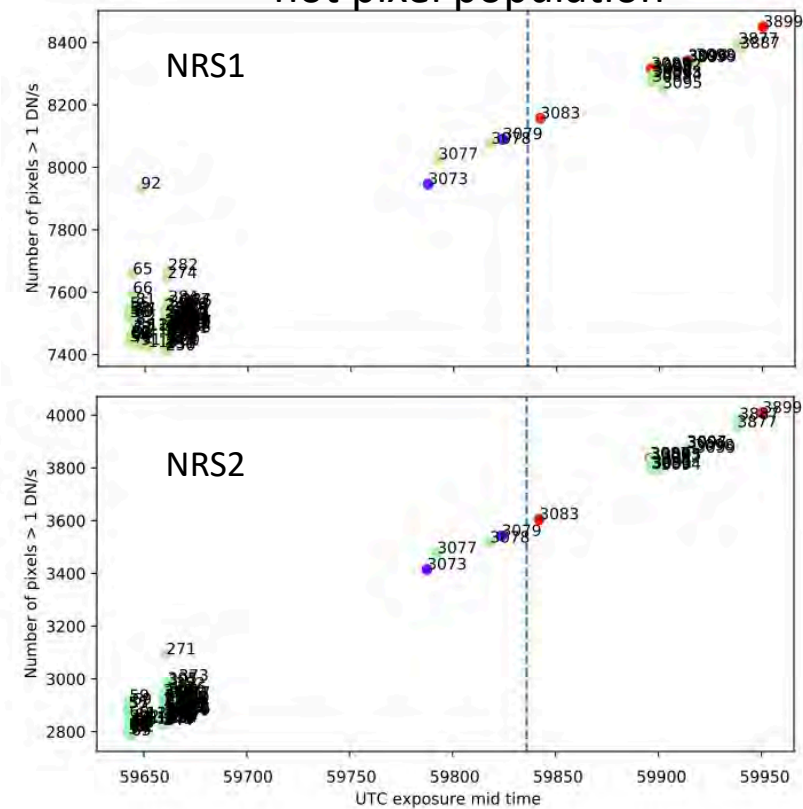




# Pipeline issues

- 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

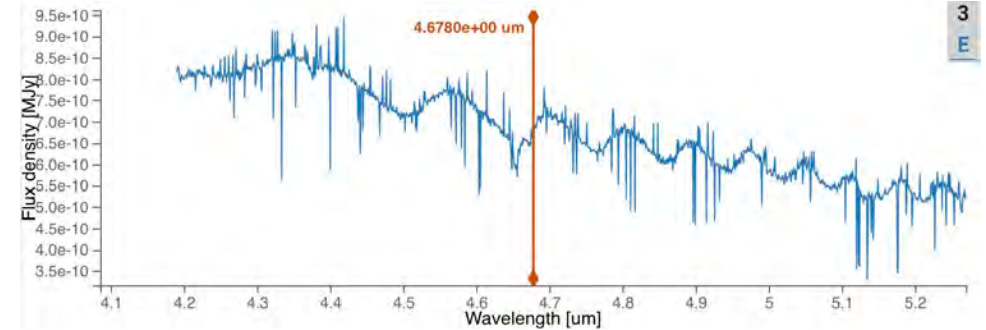
hot pixel population





# 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*

A deep blue and purple nebula with wispy, ethereal clouds of gas and dust. The background is a dense field of stars, many of which are bright blue, creating a sparkling effect. The text "onward to cycle 2..." is centered in a clean, white, sans-serif font. A thin, horizontal orange line runs across the width of the image, positioned just below the text.

**onward to cycle 2...**