



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Update on MIRI Long-Wavelength Count Rates

Update to the JSTUC

18 March 2024

S. Kendrew (MIRI Team Lead)



Recap (September 2023)

- In April 2023, MRS team identified a drop in count rates at long wavelengths for flux standards, as well as in backgrounds counts.
 - Increasing with wavelength; most severe in Channel 4C (~50% count rate loss)
 - Asymptotic decline, appears to be stabilising
- In July 2023, new imager data revealed that a similar issue is visible in our long-wave imager filters
 - Effect is measurable in from F1280W onwards & increases with wavelength; F2550W shows a reduction of 18% in count rate
 - Temporal trend not very well constrained; additional observations are planned to address this.
- The MIRI team + Mission Office produced several public statements, shared via JWST Observer News, and engaged with affected PIs to ensure their science goals can be met.



Summary of Actions

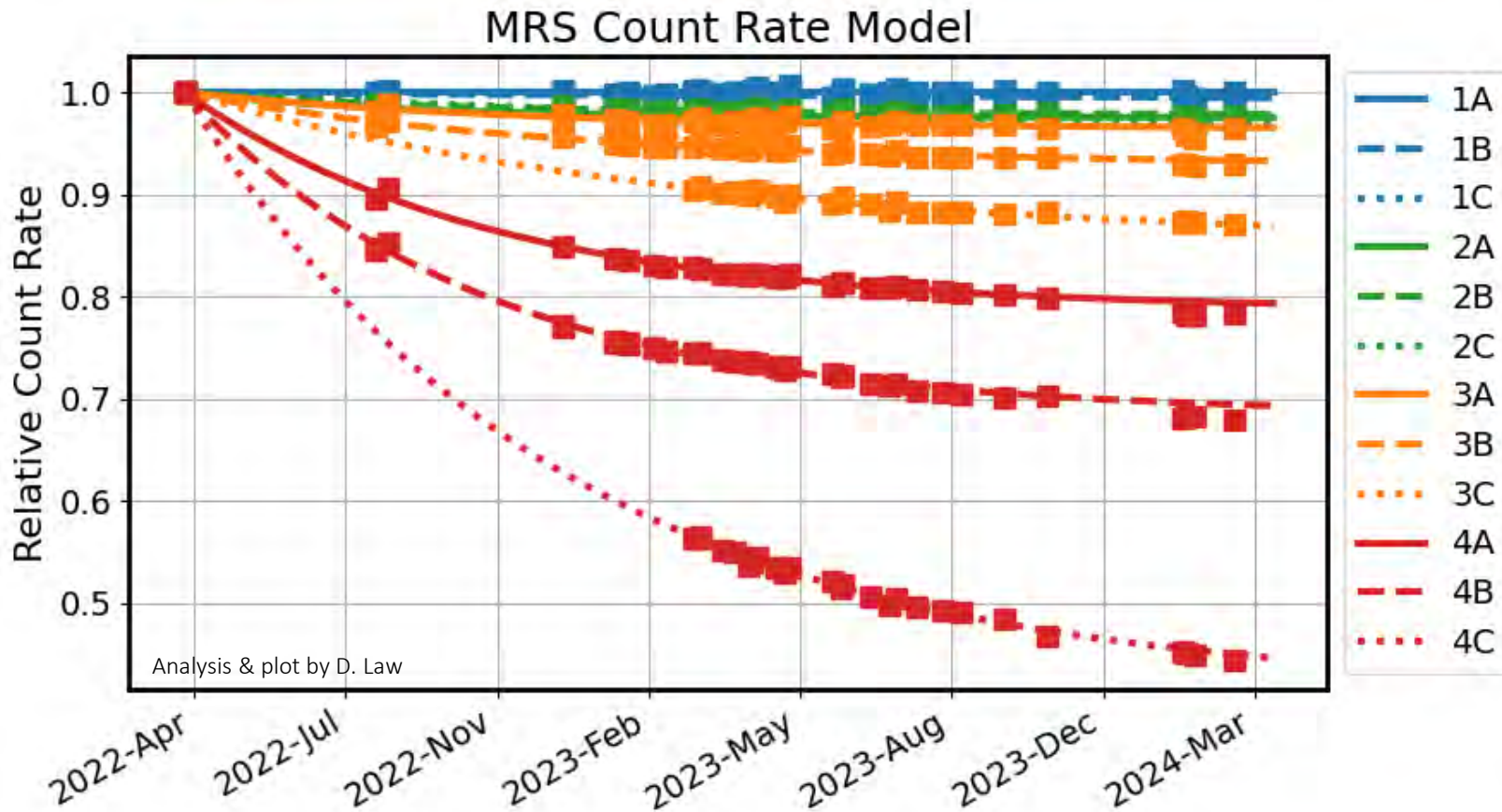
- Monitoring & characterizing the trend
- Keeping MIRI calibrations accurate
- Accuracy of JWST ETC
- Supporting the user community
- Continuing with the root cause investigations via the ARB process



Monitoring

Very soon after the initial findings, we enhanced our abs flux calibration program to perform monthly trending observations in all imager filters + MRS

As of March 2024, the overall trend shows a settling behaviour in all channels/bands except 4C, which shows the steepest decline



MRS: observations of flux calibrator HD 163466

Dec/Jan opportunities were missed due to observatory issues

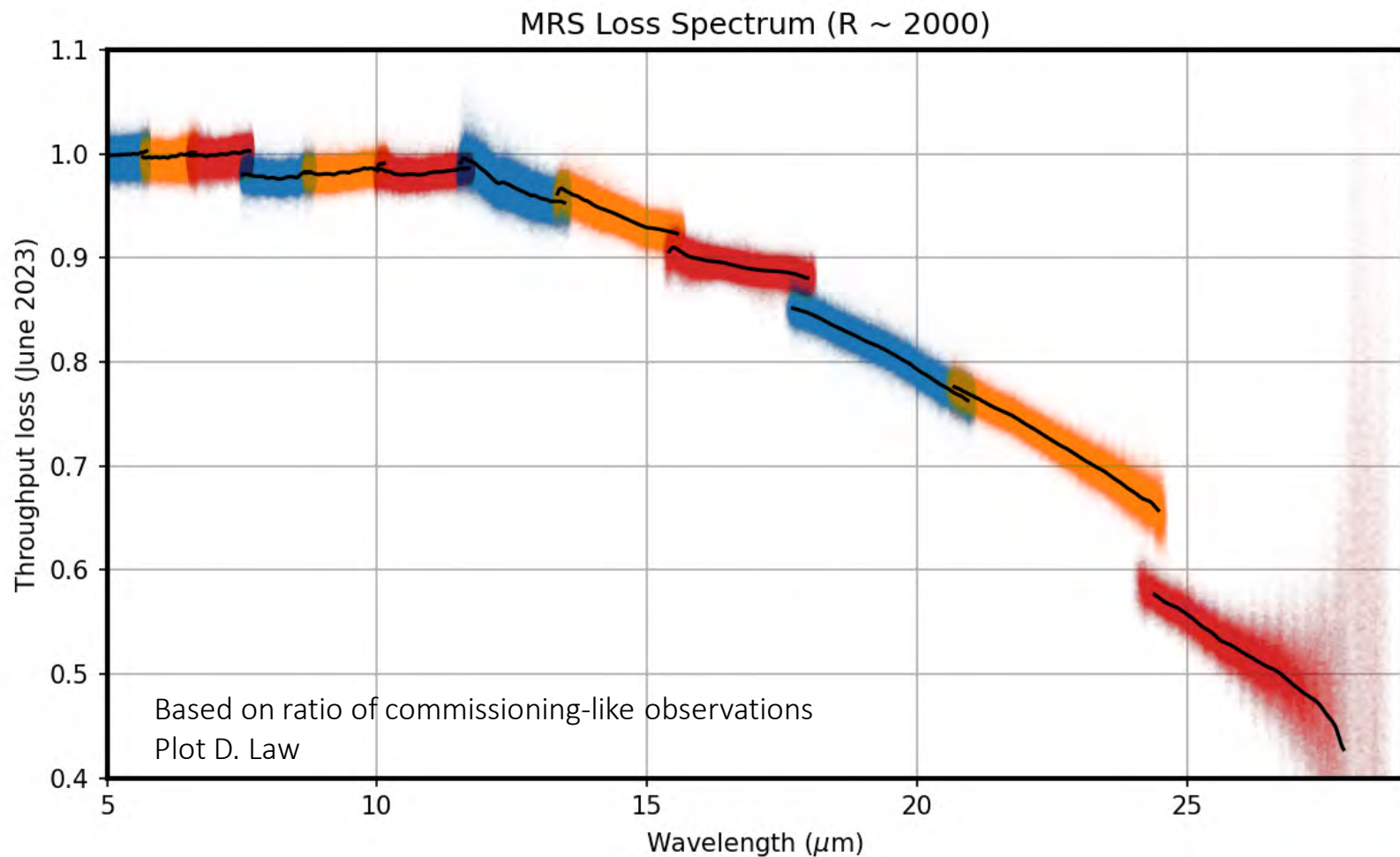
Most recent data shown: March 3rd, 2024

Model was updated with a further delivery in Nov 2023 (affecting mostly Ch 4C) and will be maintained as needed



Profile of MRS count rate loss

Smooth with some discontinuities

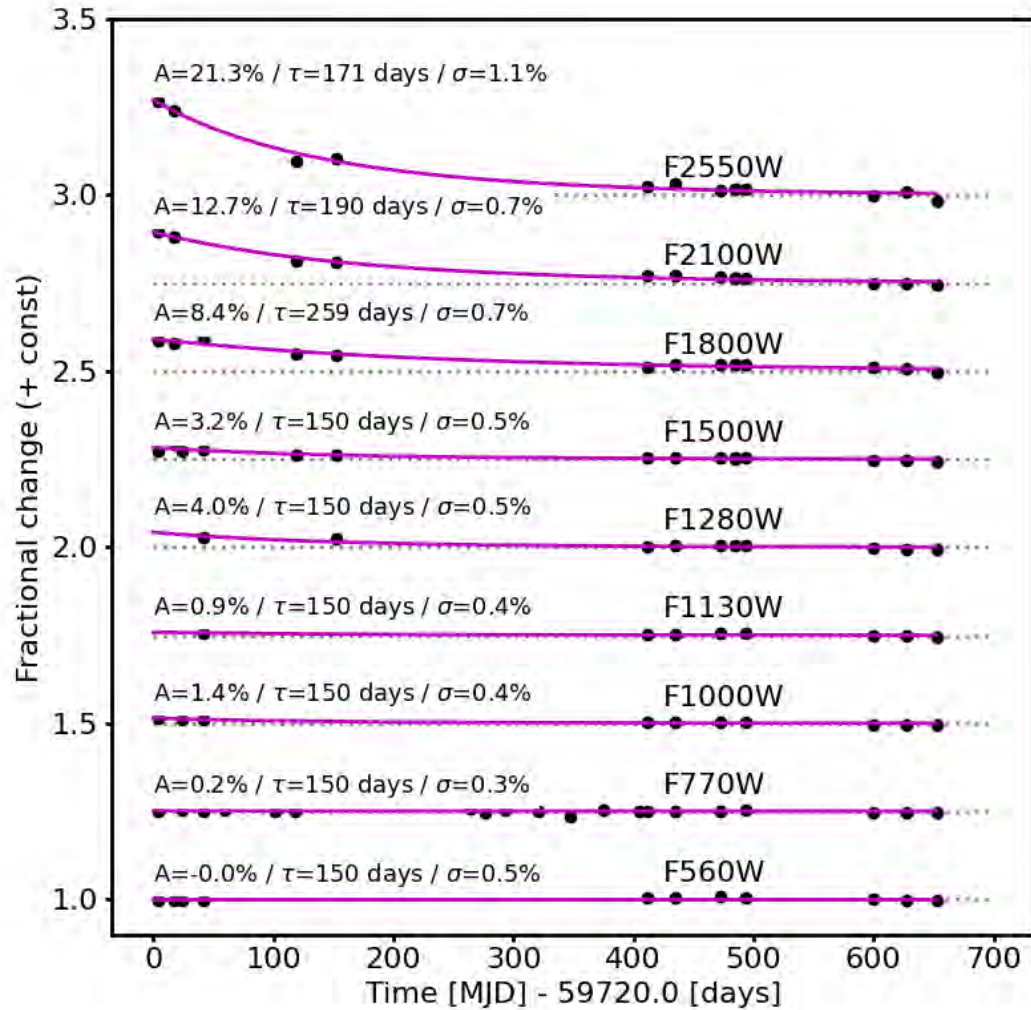


- See differences in loss % between channels & bands, even at common wavelengths
- Suggestion of spatial variations on the detectors has been eliminated following improved understanding of detector noise features



Monitoring

Imager



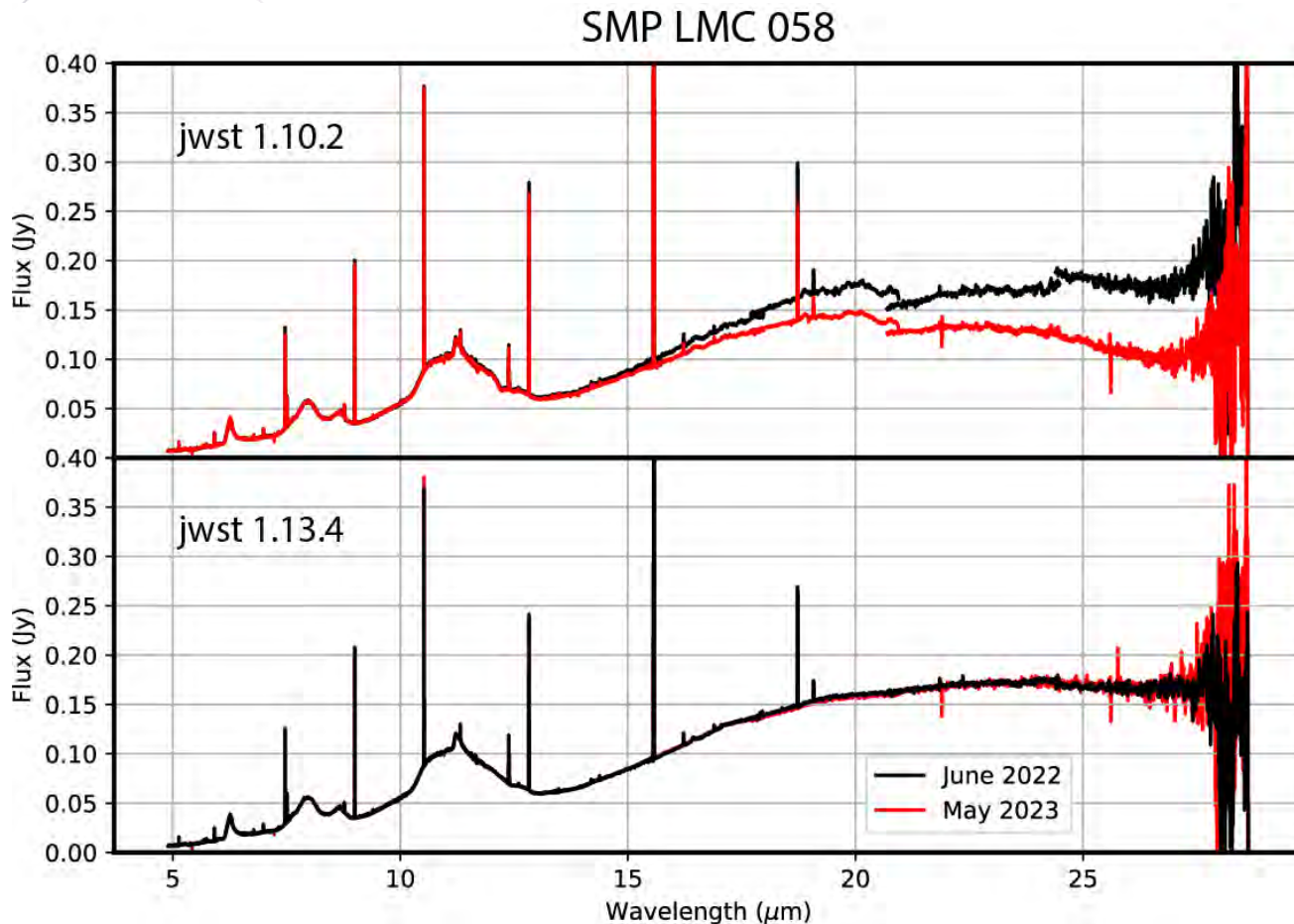
Latest data shown: March 3rd 2024

Time-dependent correction in place since Sep 2023

| Filter | Loss as of March 2024 (Sep 2023) |
|------------------------------|----------------------------------|
| F2550W | 21% (18%) |
| F2100W | 13% (12%) |
| F1800W | 8% (8%) |
| F1500W | 3% (3%) |
| F1280W | 4% (3%) |
| F560W, F770W, F1000W, F1130W | <u>< 1.5%</u> |



Calibration updates: MRS



Upper panel: Observations of 06/2022, 05/2023 before corrections
Lower panel: Same observations, processed with pipeline v1.13.4 (B10.1) + latest calibration updates (Analysis + plot by D. Law)

- Time dependent correction to the MRS flux calibration was implemented in July 2023 ([public statement](#)); this update became operational in September.
- Further update to MRS spectrophotometric calibration was delivered in Nov 2023, specifically targeting $\lambda \geq 24 \mu\text{m}$.
 - Included an incremental update to the correction model
 - Used red source to derive calibration (asteroid) instead of standard star
- Spectrophotometric accuracy now \leq 0.5% for Ch 1-3, rising to ~5% for Ch 4C (statistical uncertainty; not accounting for systematics)



Calibration Updates: Imager

- Time-dependent correction was first implemented in September 2023 ([public statement](#))
 - due to timeline difficulties between MIRI's analysis work and the pipeline build schedule, this made use of a list of 22 photom reference files, each with different USEAFTER dates, to apply the appropriate corrections to the data.
 - Included further improvements to the calibrations due to improved analysis methods
- Full model-based correction implemented in B10.1, which became operational in late Feb.
 - Some changes anticipated for data taken early in commissioning/cycle 1 due to correction method
 - Public statement issued in early March
- Calibration accuracies < 3% for all filters



JWST Exposure Time Calculator

MRS

- ETC v3.0 contained an adjustment to MRS calculations, baselining the MRS performance to the end of Cycle 3 based on the degradation model (i.e. a conservative estimate)
- This projection will be updated for Cycle 4

Imager

- Chosen not to update for Cycle 3 given that the model was less constrained at that time + the degradation is at much lower level than for MRS (assuming $\text{SNR} \propto \sqrt{DN/s}$)
- Provided guidance in the [Call for Proposals](#) the [public statement](#) released in Sep 2023.
- Currently investigating the accuracy of the ETC for MIRI Imager, with a view to updating the ETC for v4.0 (June 2024)



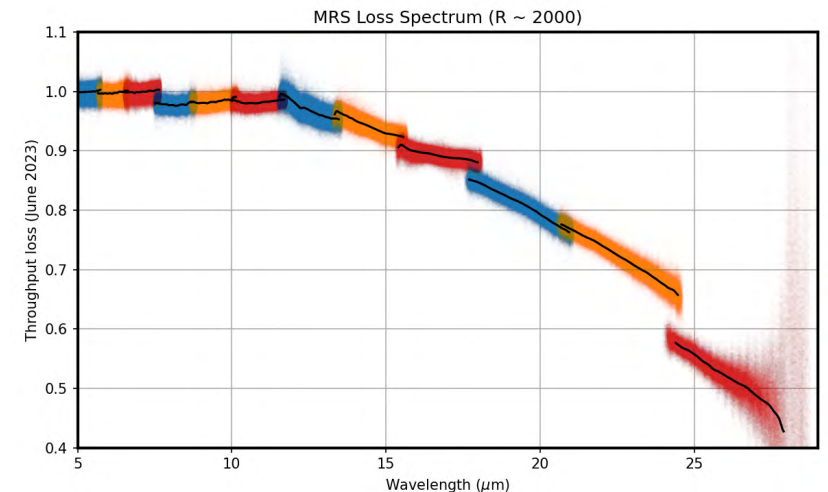
Support to the community

- Have issued public statements at important junctures in the ARB process and key milestones:
 - Initial findings (April 2023, May 2023, Aug 2023)
 - Pipeline updates (July 2023, Sep 2023, March 2024)
 - Status updates around proposal deadlines (Sep 2023)
- The count rate loss issue is documented in Jdox, in multiple locations. Includes plots of degradation.
 - In the process of reviewing & updating information
- 14 proposals have requested additional time via the TTRB process to reach their science goals at long wavelengths
 - Average additional time request was ~12% of the original time
 - Total extra time granted across all requests = **44 hours**
- Support to individual users via the Helpdesk



Updates on Investigations

- Monthly trending continues as part of the absolute flux calibration program (enhanced for MIRI to include all imager filters, since mid-2023)
- In Oct 2023, we investigated the hypothesis that radiation damage had led to the decrease in width of depletion region of the detectors, via dedicated testing.
 - **Tests were valuable, but inconclusive:** the effect may contribute to the observed trend, but does not fully explain the loss profile.
- Performed further testing using the Dichroic & Grating Wheels in the MRS in crossed settings, to isolate potential contribution from the optics
 - Specifically addressing the observed discontinuities in the loss curve, pointing to different % loss between channels/bands at the same wavelength
 - Test also performed during commissioning
 - **This test suggests that dichroics are at least partially implicated in the observed loss**
 - Further analysis & investigations are required as the root cause remains unknown.



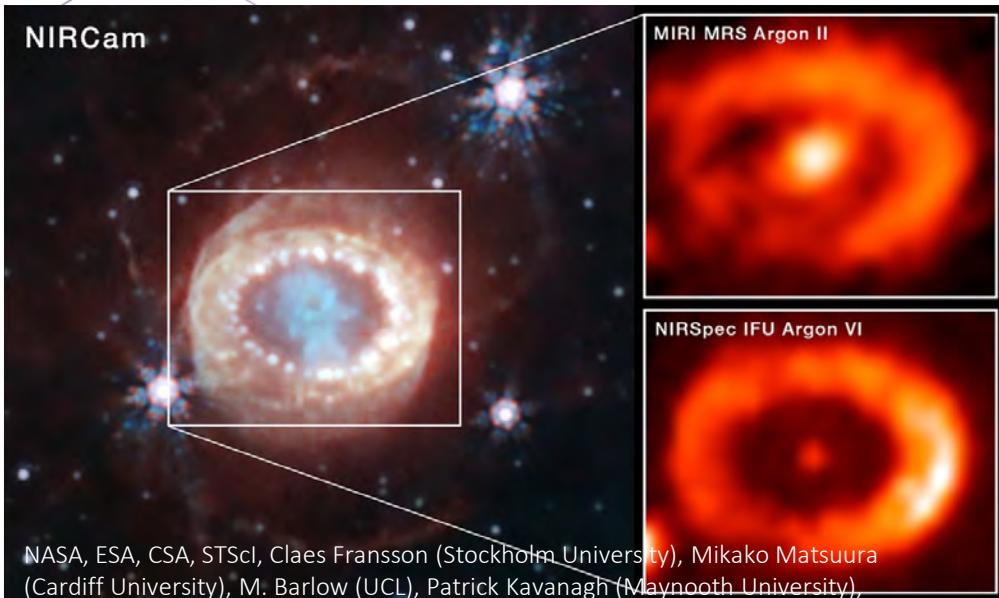


Next steps

- Monitoring observations continue monthly for MRS and Imager, all filters
 - No further algorithmic updates envisioned for the pipeline flux calibration; correction model will be updated as needed.
- ETC will be updated for Cycle 4:
 - For MRS in line with the updated for Cycle 3 (i.e projecting the best-fit model to the end of the cycle)
 - For Imager this will be the first update to the ETC since cycle 1; investigation into accuracy currently ongoing.
- Root cause investigations ongoing.
 - Detector tests proved inconclusive
 - Further testing is being performed to understand the discontinuities seen in the loss curve
- **We will continue to inform the community of significant changes or findings**

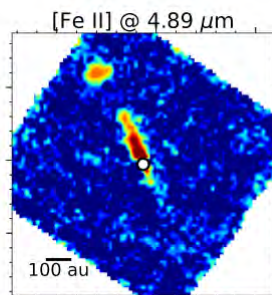


MRS is producing beautiful science

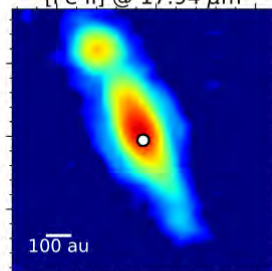


NASA, ESA, CSA, STScI, Claes Fransson (Stockholm University), Mikako Matsuura (Cardiff University), M. Barlow (UCL), Patrick Kavanagh (Maynooth University),

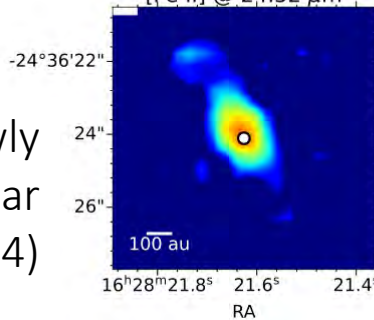
Discovery of neutron star in SN1987A (Fransson et al 2024)



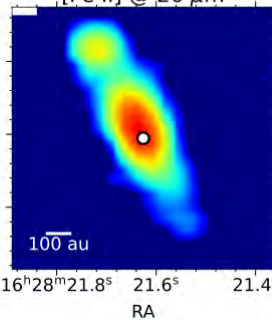
[Fe II] @ 17.94 micrometers



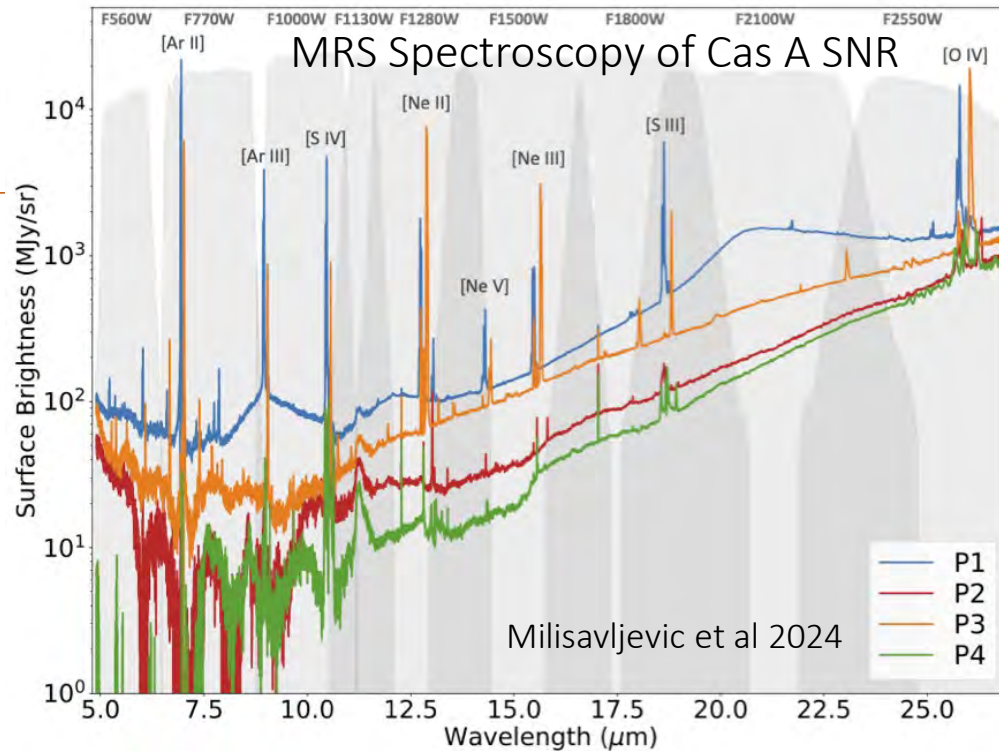
[Fe II] @ 24.52 micrometers



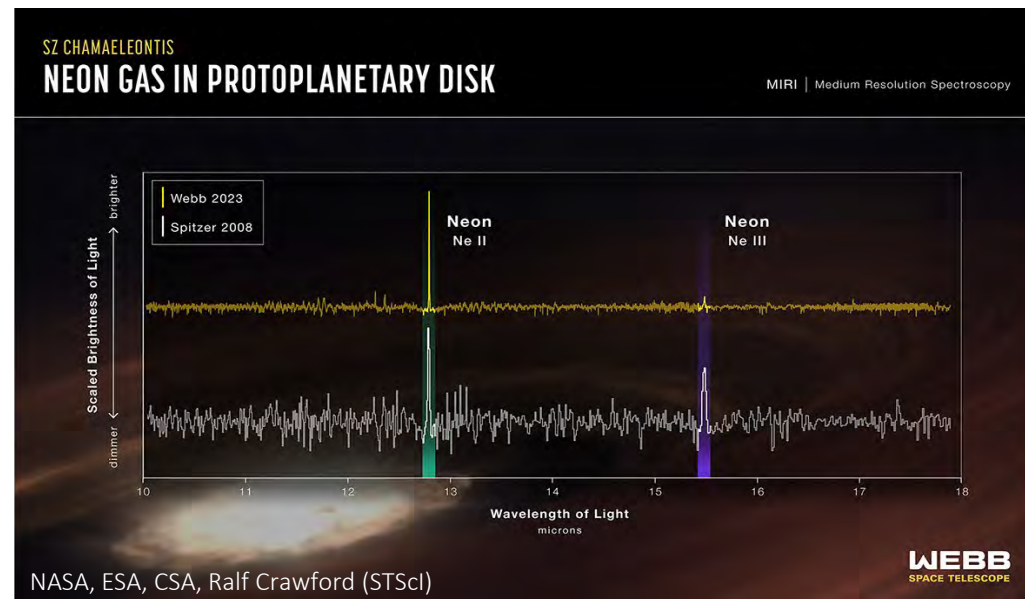
[Fe II] @ 26 micrometers



Spectral images of newly discovered collimated protostellar jet (Narang et al 2024)



Milisavljevic et al 2024



NASA, ESA, CSA, Ralf Crawford (STScI)

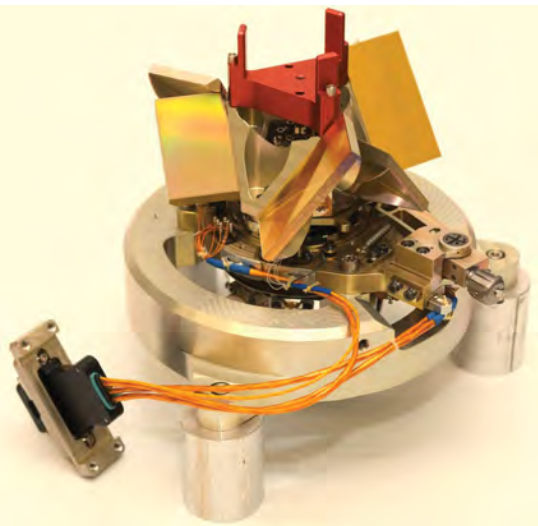
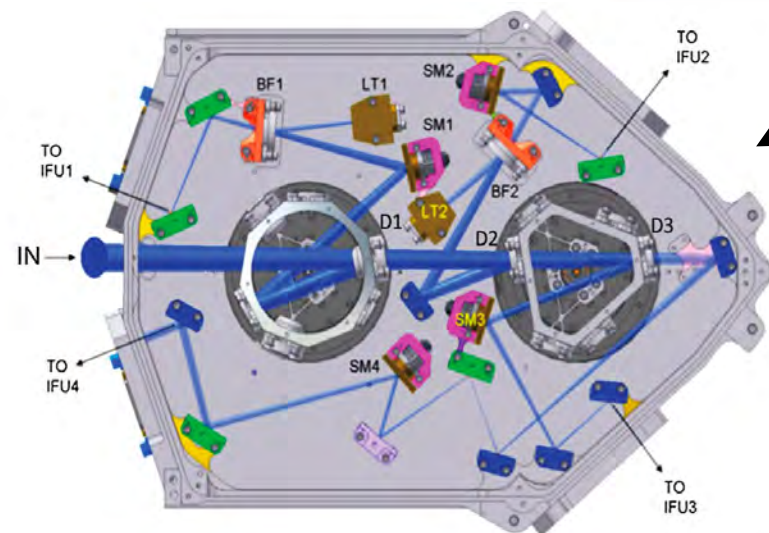
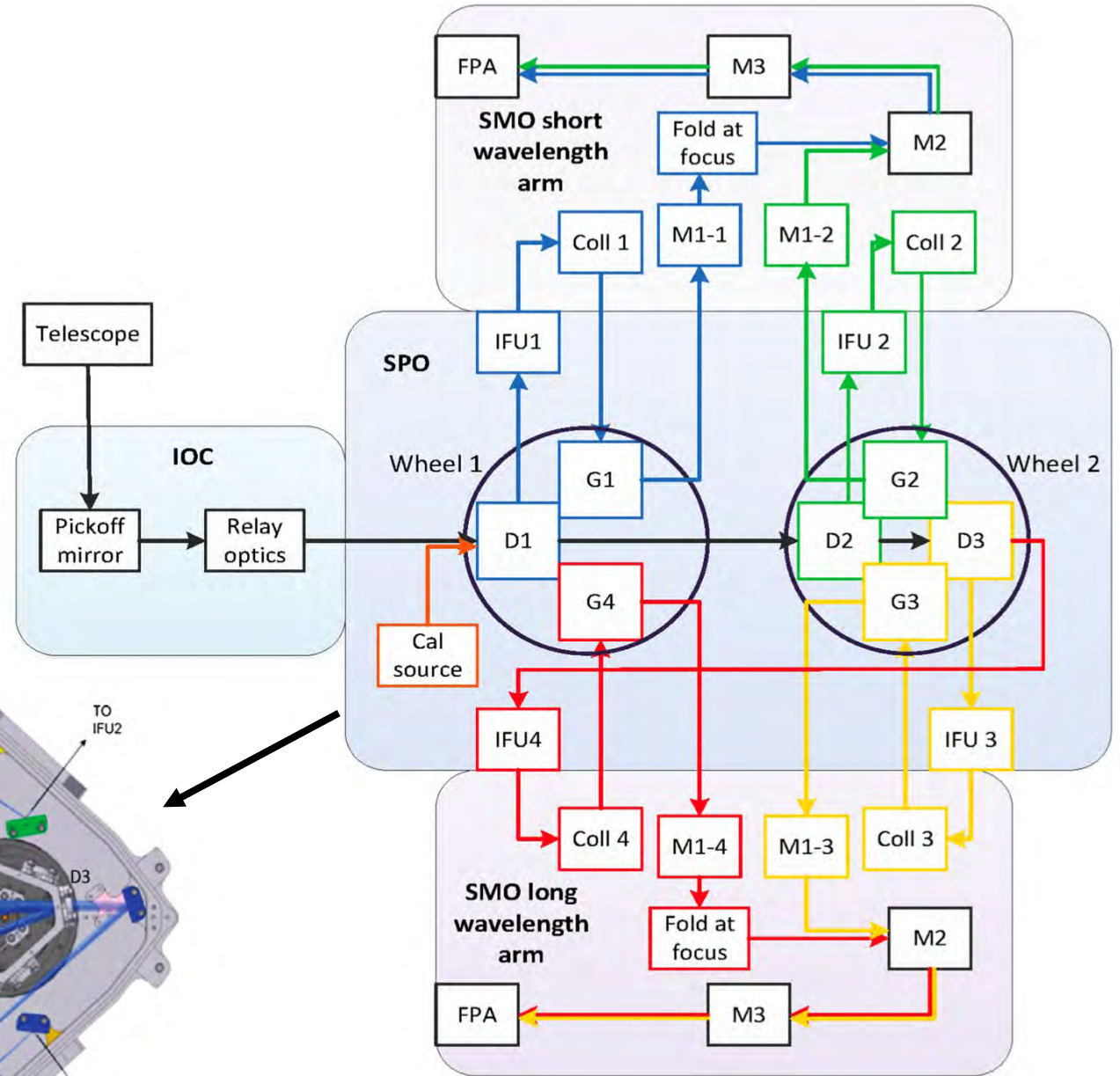


Backup Slides



MRS optical train

- IOC = input optics & Calibration
- SPO = spectrometer pre-optics
- SMO = spectrometer main optics
- 9 dichroics (D*)
- 2 Blocking filters (BF*)
- 12 Gratings (G*)



Wells et al 2015