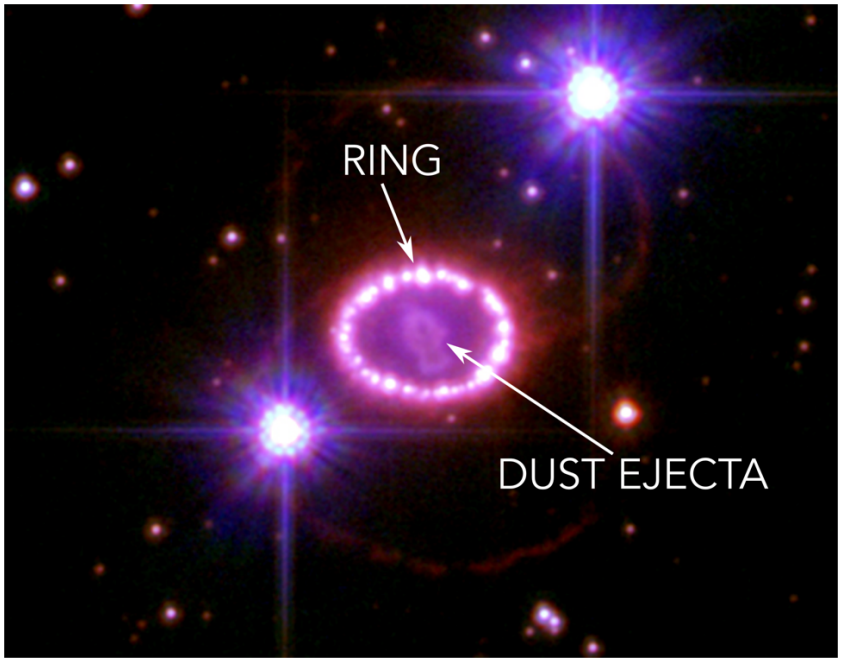
MIRI MRS Observations of SN1987A

1. Background

SN1987A is one of the best studied SN. It consists of a bright ring, enclosing the dust ejecta from the SNa. One challenge is to detect the ejecta without saturating the ring.

- Ring diameter ~ 1.1 arcsec, with thickness ~0.2 arcsec
- Total emitting area ~ 1.3 arcsec^2.
- With a MIRI pixel scale of 0.11 arcsec/pix → 107 pixels
- Ejecta occupy approx. 4 pixels, i.e. just-resolved.



2. ETC (20min)

GOAL: Create an ETC workbook that estimates the exposure time needed to observe the SN ejecta and ring using the MIRI Medium Resolution Spectrometer (MRS) with simultaneous imaging.

Scenes and Sources:

In the "Scene and Sources" you can create different sources and combine them to make an astronomical scene. Because the SN will completely fall into the MRS FOV, we will simulate a couple of stars to estimate the exposure time in the imager.

Source 1: The provided Spitzer integrated spectrum (5-30+ micron, *sn1987a_spitzer_kendrew.txt* with format: first column wavelength in microns, second flux in mJy), represents the combined ring + ejecta. Use it to create a source with the following options:

- No renormalization
- Extended source with flat shape (i.e. assumed uniform). Semi-minor and semi-major axes both 0.638".
- Source centred in the middle of the scene.

Source 2: Create a point source using a stellar A0V 9500 K template. Renormalize it at 15 Abmag, Bessel K-band. This represents a star for the imaging FOV.

Source 3: Create a point source using a stellar A1V 9500 K template. Renormalize it at 13 Abmag, Bessel K-band. This represents a star for the imaging FOV.

Scenes: Create three different scenes:

- Scene 1: Contains source 1 only, representing SN1987A ring+ejecta in the MRS FOV.
- Scene 2: Contains source 2 only.
- Scene 3: Contains source 3 only.
- Scenes 2 and 3 represent stars in the imager FOV.

Calculations:

MIRI MRS: Use Scene 1, and target the [NeV] line at 24.3 μm with Ch 4 - Medium (FOV 7.2x7.9" in size).

- Use FAST mode (Hint: default readout mode for all MIRI observations as prime).
- In the strategy tab pick the 24.3 microns and Nod Off scene to correct for the background and thermal emission and choose aperture radius (MRS slice width). Do you think the Nod In scene would work in this case?
- Aim for SNR of about 60 in the spectral region of interest. Use 4 exposures to simulate a 4pt dither pattern.

Hint: With MIRI, favour long single integrations over short multiple integrations. Having a low percentage of slightly saturated pixels should not be an issue; the calibration pipeline will use the unsaturated portion of the ramps to estimate a count rate value.

Simultaneous MIRI Imaging: Use F770W, F1000W and F2550W filters in scenes 2 and 3. Use a low background. In the strategies tab use "Imaging aperture photometry" and define an aperture radius and annulus suitable to perform photometry and background subtraction.

Hints:

- Watch for significant saturation and consider using imaging subarrays if you run into issues.
- If feasible, with MIRI, favour long single integrations over short multiple integrations. Default readout mode for the imager is FAST.

3. APT (20 min)

Create New JWST Proposal

- File → New → New JWST Proposal
- Investigate the Proposal Information Tab (you can leave this for the end and focus on the more technical part of the proposal first)
- Under the Targets Tab add a "fixed target" and search for SN1987A. Fill in the information about the target. Pay attention to the "Extended" target field.
- Then specify a background target [1]:
  - RA: 05 35 28.3900
  - DEC: -69 16 15.6025

  Go back to the SN1987A target. Click on the box "Observation Requires companion background obs." Select the background Target.

Define Target Observations

- Under the Observations tab: Create a New Observation Folder. This will always be needed for each set of instruments/observing modes/configurations.
- When submitting your proposal, the observation summary should be filled. For the sake of this exercise, that step is not needed.
- Click on the Observation and fill in all the information. You will need one observation folder and three sets of exposures to be able to use the three MRS gratings (and thus cover the entire spectral range) with three imager filters. Go to your observation and specify:
  - Instrument, template to use (MIRI Medium Resolution Spectroscopy), target.
  - Go to edit observation:

[1] Feel free to specify your own background region by investigating with the Aladin visualization or ESASky. Also, make sure to check background recommendations on this JDox page: https://jwst-docs.stsci.edu/mid-infrared-instrument/miri-observing-strategies/miri-cross-mode-recommended-strategies

        - TA method: Given he expected blink pointing accuracy we choose No TA. This option should be carefully considered for your particular science case.
        - MIRI imager Subarray (same one as used in the ETC).
    - Primary channel: ALL (equivalent to Channel 1).
    - Wavelength: Short/Medium/Long gratings should be split off into three separate sets of exposures to be able to use multiple filters for the simultaneous imaging.
    - Dither points, filters, readout mode and exposure times should be consistent with those defined in the ETC exercise.
- Use the Aladin visualization tool with the MIRI footprint.

Define Background Observations

- The Background observation folder can be created by duplicating the science target observation folder, and changing the target. Click on the Observation and fill in all the information.
- Consider your background strategy. Do you need to dither in the background?
- Go to the Special Requirements tab and add a Time Constrain Explicit Requirement. Link the SN1987A observations and SN1987A background observations to be executed in a non-interruptible sequence **(if you get an error on this you probably have not selected "sequence").** This is a requirement to ensure data are taking under the exact same conditions.

Observation Schedulability

Visit planner: Highlight the Observation folders and run the Visit Planner. Verify the schedulability of the program. Go to the visit planner menu and run smart accounting to remove potential unnecessary overheads.

Review the program: Do you have errors or warnings? If yes, are they expected? Can you "fix" any?