The meteoroid environment encountered by the James Webb Space Telescope

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Asteroids, Comets, Meteors
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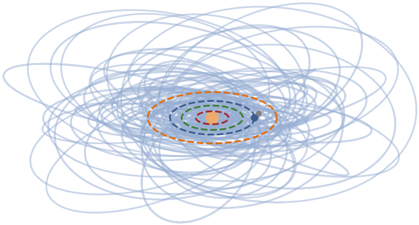
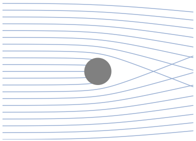
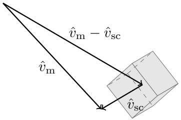
JWST has endured numerous meteoroid impacts since launch.

- Impacts were expected, but JWST experienced a particularly large hit last June. Image available here.
- JWST's NIRCam can detect/count impacts in the form of wavefront errors (WFEs).
- JWST detected 6 WFE impacts in the first 6 months and ~ 39 to date.

NASA's Meteoroid Engineering Model (MEM) describes the meteoroid environment encountered by a spacecraft.







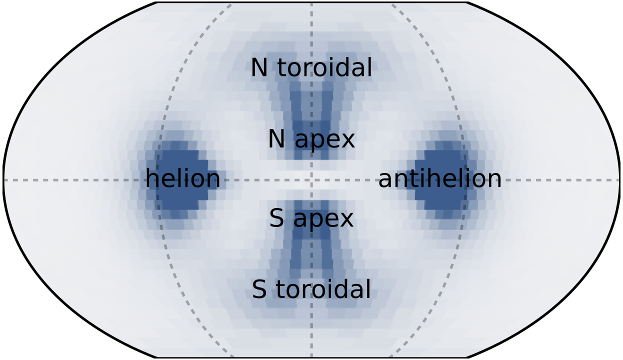
It contains a dynamical model of the sporadic meteoroid complex.

The gravity and size of the Earth and Moon affect the local environment.

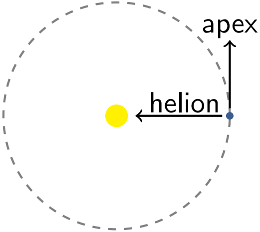
The spacecraft's motion factors in to the apparent velocity/direction of the meteoroids it encounters.

No special population of meteoroids is known to orbit Sun-Earth L2.

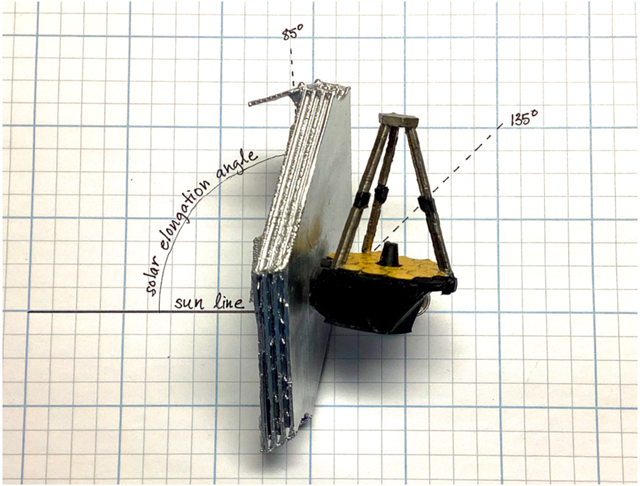
Meteoroid directionality is not isotropic.



The three orbit populations appear as six concentrations (three pairs) of meteors in this directional map.

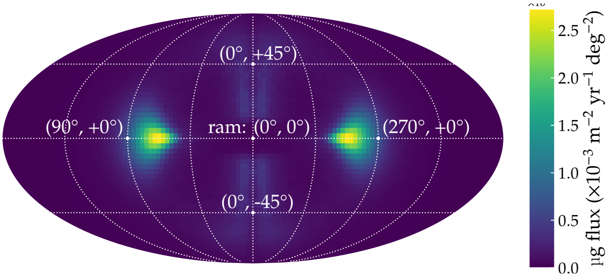


JWST's observatory coordinate system is similar to MEM's.

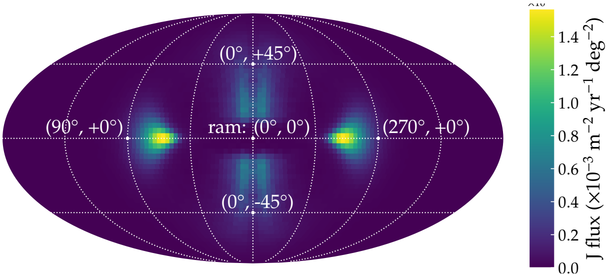


JWST's sensitivity threshold is thought to be determined by impact KE.

flux of meteoroids $> 1\ \mu g$
encountered by JWST

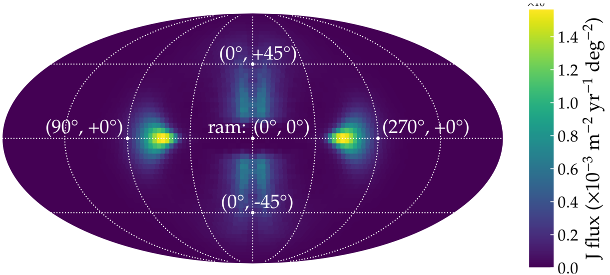


flux of meteoroids > 1 J
encountered by JWST

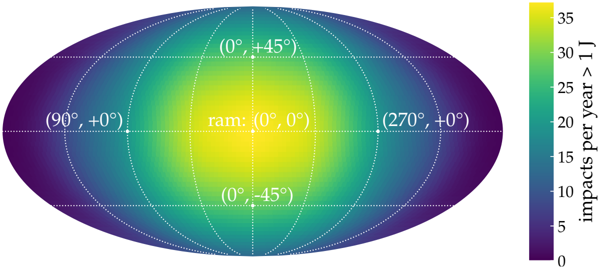


The mirror is exposed to half the sky at any point.

flux of meteoroids > 1 J,
mapped by meteoroid radiant

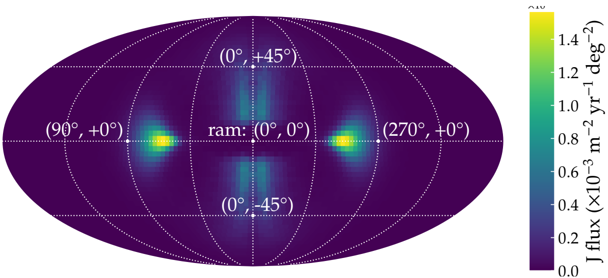


meteoroid impact rate,
mapped by mirror pointing angle

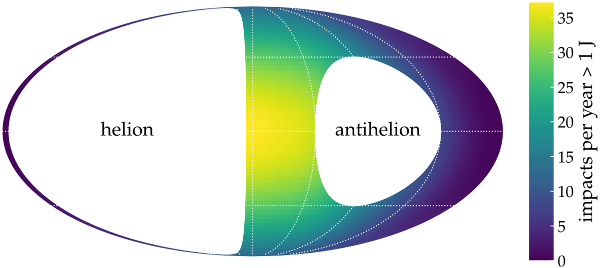


The sunshield must remain between the Sun and the spacecraft.

flux of meteoroids > 1 J, mapped by meteoroid radiant

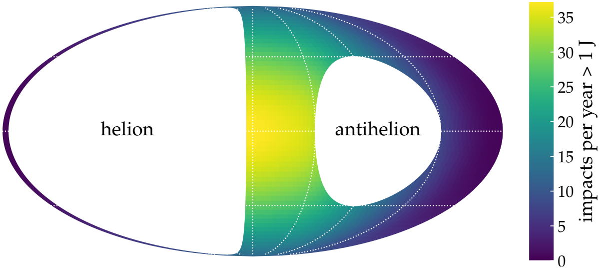


meteoroid impact rate, mapped by mirror pointing angle

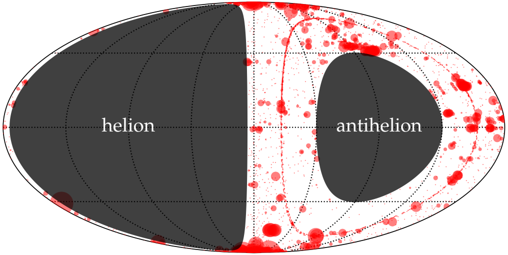


At first, JWST often pointed towards the ecliptic poles.

meteoroid impact rate

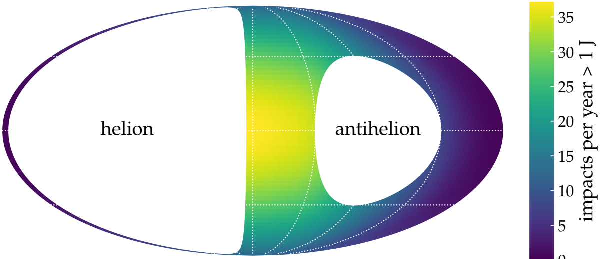


pointing angle distribution
prior to start of Cycle 1

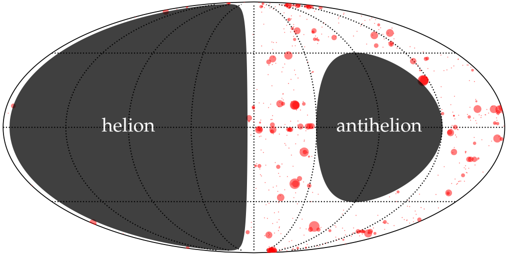


Once Cycle 1 began, the pointing pattern was more isotropic.

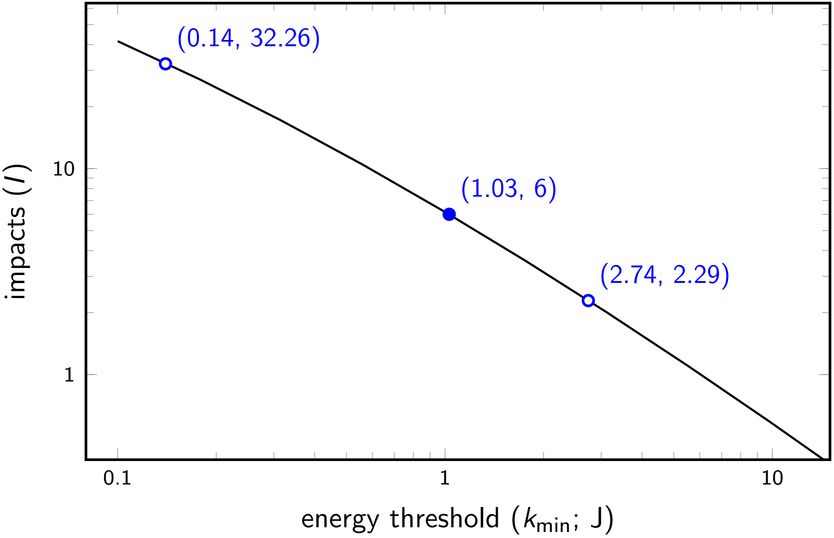
meteoroid impact rate



pointing angle distribution in
July 2022

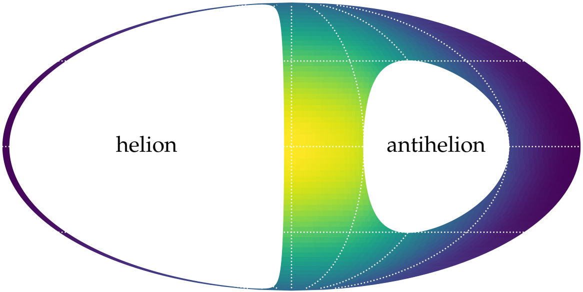


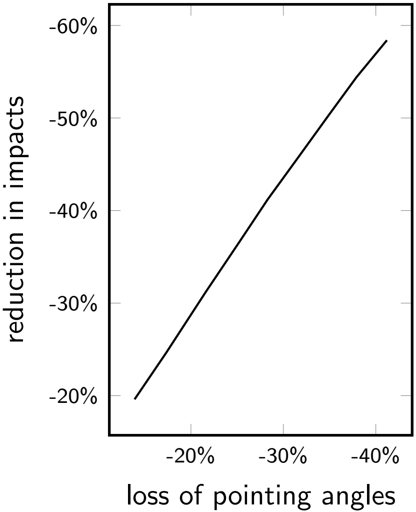
We used the number of impacts (6) during the first 6 months of exposure to estimate JWST's impact threshold



Risk can be reduced by avoiding certain orientations.

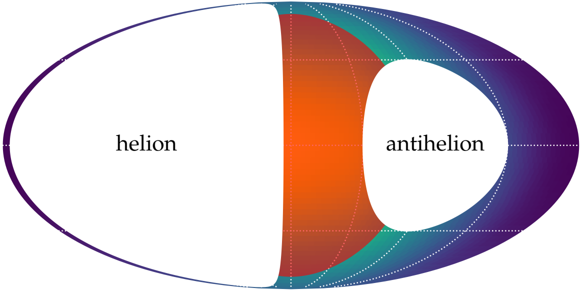
Because the impact rate is higher when JWST points toward ram, the risk of future impacts can be reduced by minimizing the amount of time spent facing ram.

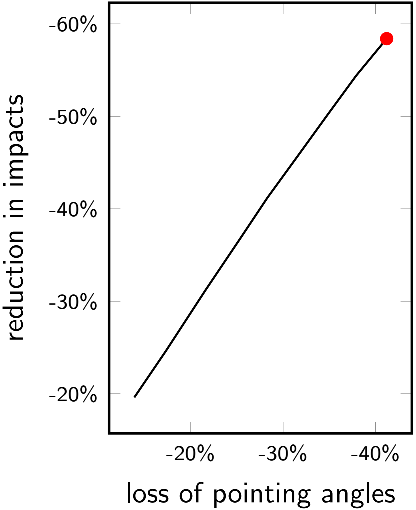




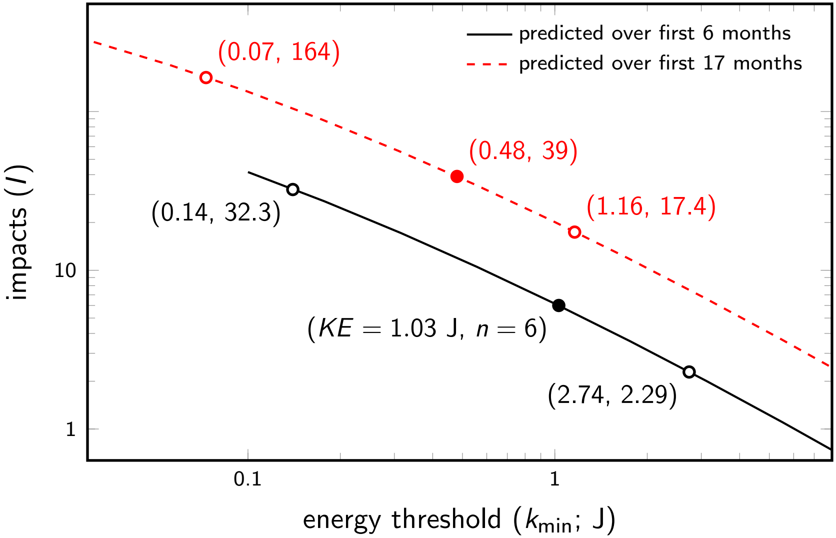
JWST has implemented a meteoroid avoidance zone (MAZ) that can reduce risk by over 50%.

Cycle 2 proposers were encouraged to avoid pointing angles within 75° of ram.

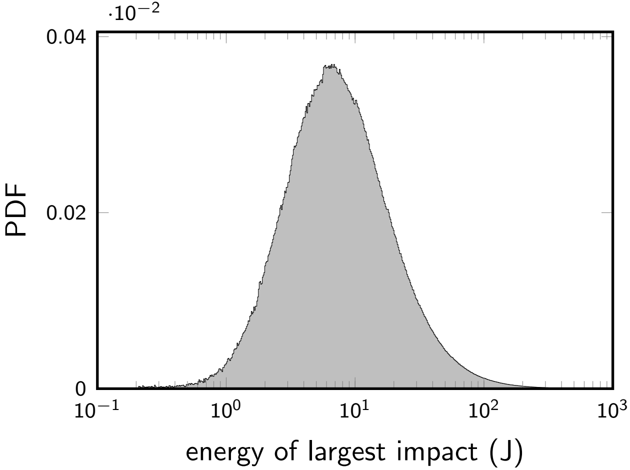




Now: JWST has now experienced ∼ 39 impacts in 17 months.
This corresponds to a factor of 2 revision in KE threshold.



What about that big June 2022 impact?



The energy of the largest of 39 impacts is not tightly constrained at all.

We estimate it at 20 J but the 95% confidence interval ranges from 3 J to 340 J.

Hydrocode simulations of the impact suggest an energy around 7 J.

Can we use JWST as a meteoroid detector?

Overall flux: We don't have a way to measure impact energy *currently*, but the JWST team is:

- performing hydrocode simulations to map impactor energy to mirror distortion, and
- conducting new impact tests to better establish the mirror's impact threshold.

Meteoroid dynamics: JWST appears to have experienced more impacts over the winter than it did in the first 6 months. Variations could occur due to:

- changes in orientation pattern,
- seasonal variations in the sporadic complex, or
- changes in JWST's distance from the ecliptic plane.

It may not be possible to disentangle these effects.

What about meteor showers?

On average, meteor showers are not a significant source of flux, but we do forecast shower activity for JWST: