“Vibration Analysis of Mo-100 Targets for Accelerator-Based Mo-99 production”

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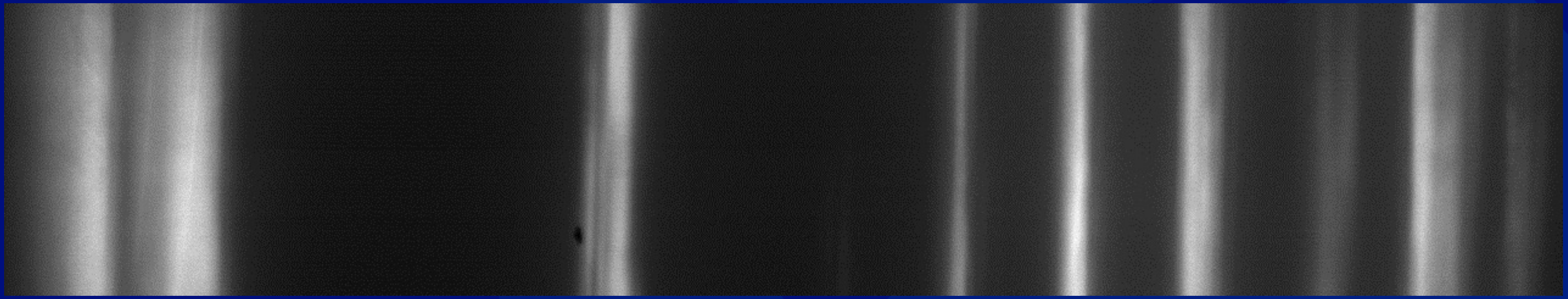

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LA-UR-23-32114

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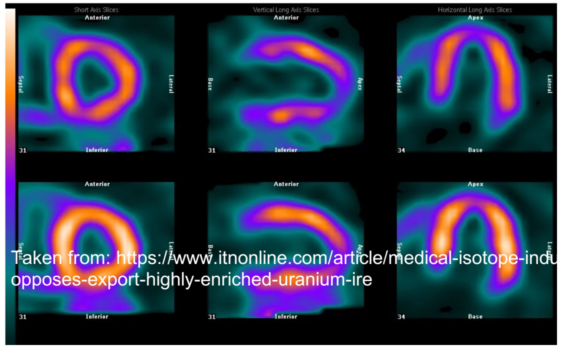
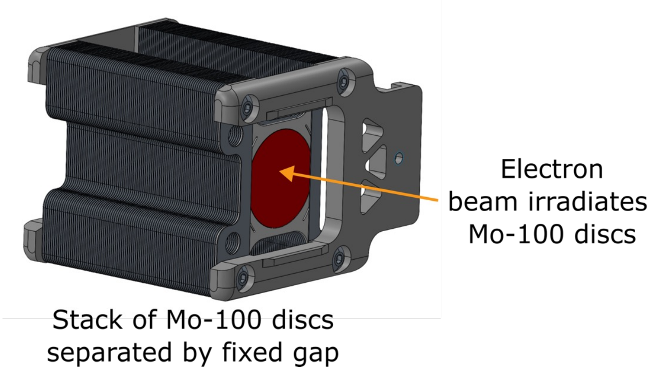
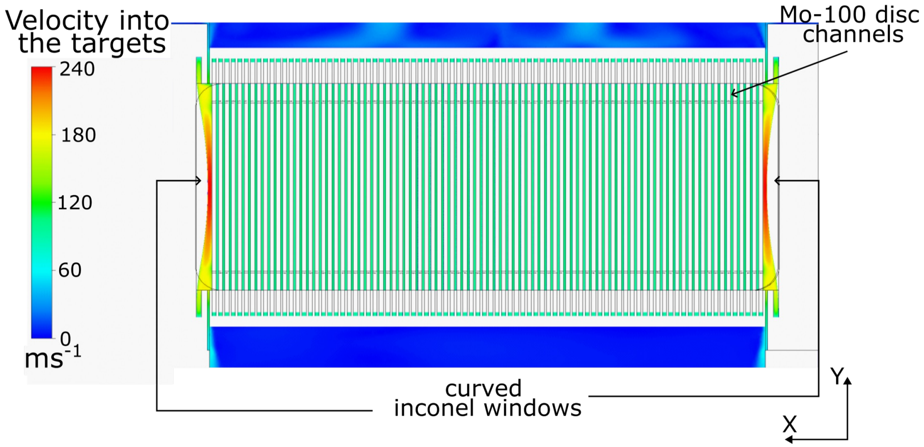
Electron irradiation of Mo-100 targets to produce Mo-99

Heart scan using Mo-99 based imaging isotope Tc-99m



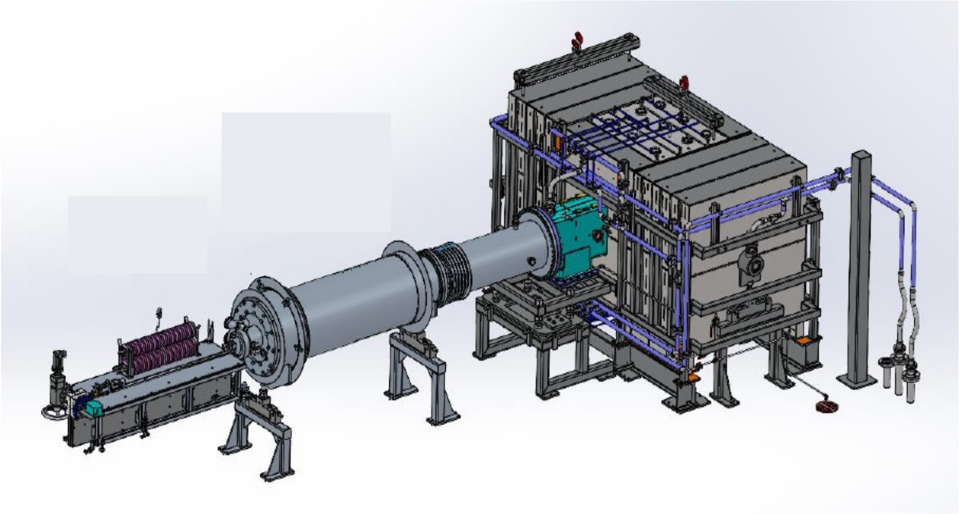
Accelerator-based Mo-99 Production





Pressurized helium gas flows through disk gaps to cool them.

Producer accelerator facility



Broken Mo-100 disk

- 20% disk breakage during cold flow testing
- Possibility of radioactive contamination
- Mo-100 disks expensive to produce
- Cause of disk failure needs to be investigated

Hypothesis: Increased flow induced vibrations coupled with disk rotation is leading to disk failure.

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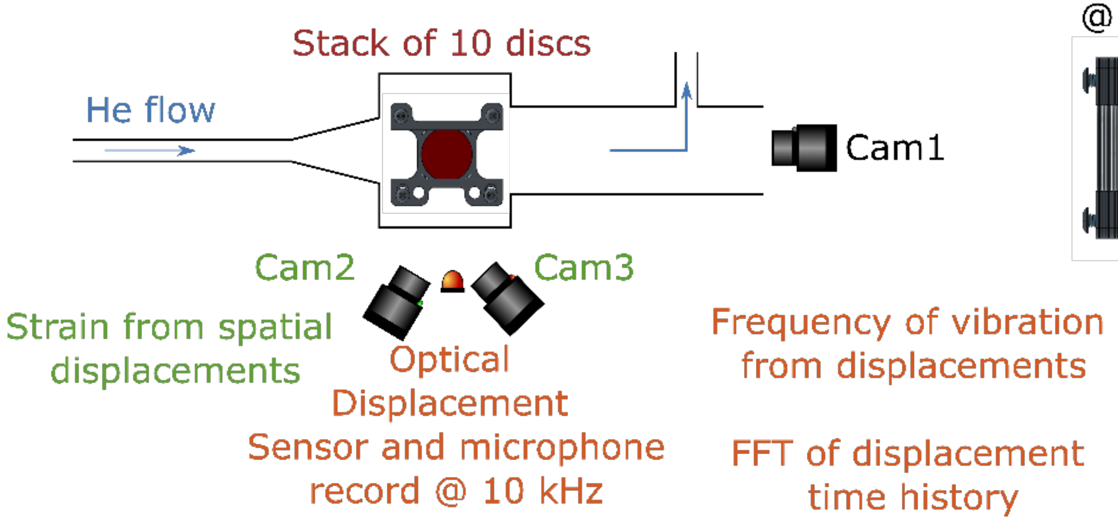
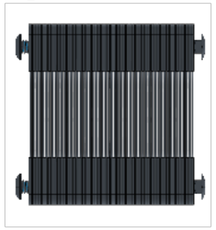
Target design and reduced order experiments

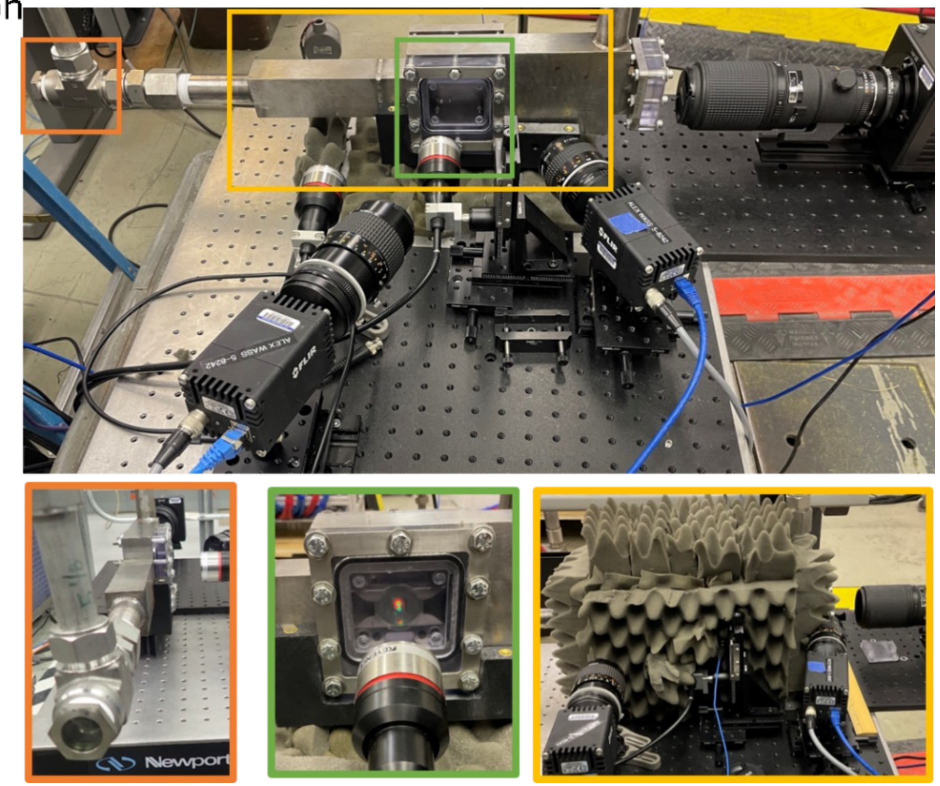
Measurement diagnostics



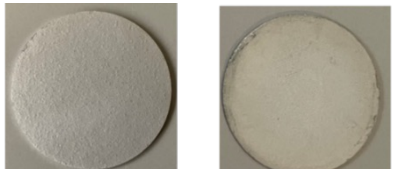
Cam 1 records disc motion @ ~ 10 kHz



Laboratory set-up



Disk and lamination thickness



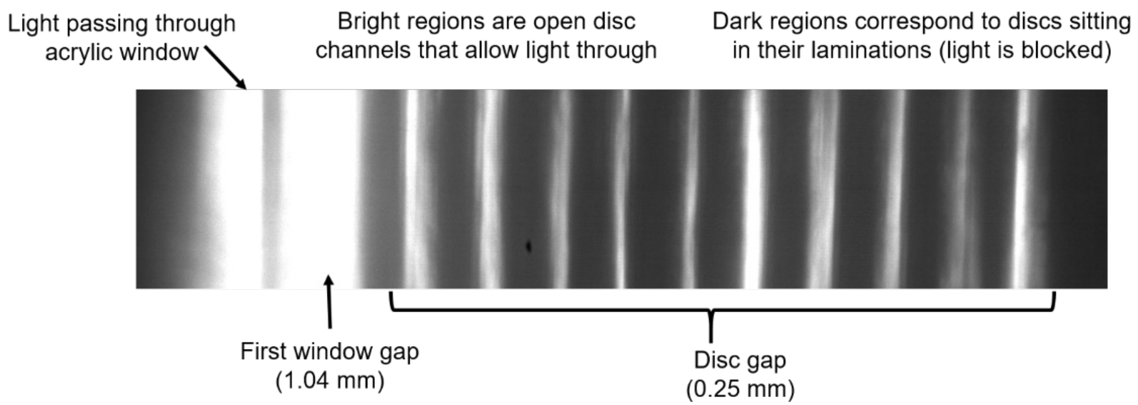
a-Mo (0.74 mm) n-Mo (0.74 mm)

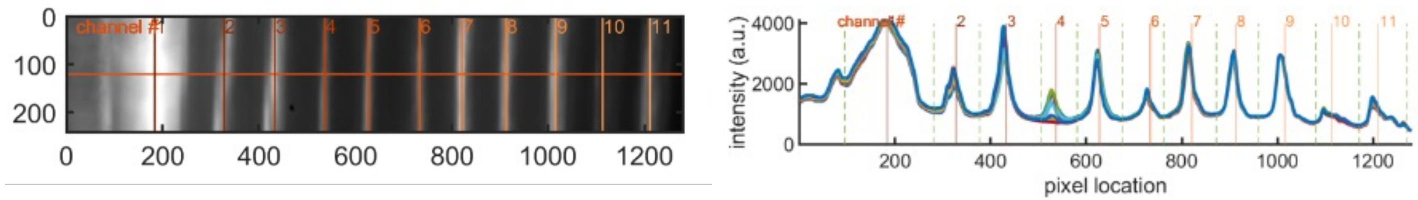
holder (0.79 mm) spacers (0.38 & 0.25 mm)

Test section mass flow (g/s)	Effective total mass flow (g/s)	Reynolds number (disk channels)
60	326	11200
75	402	13800

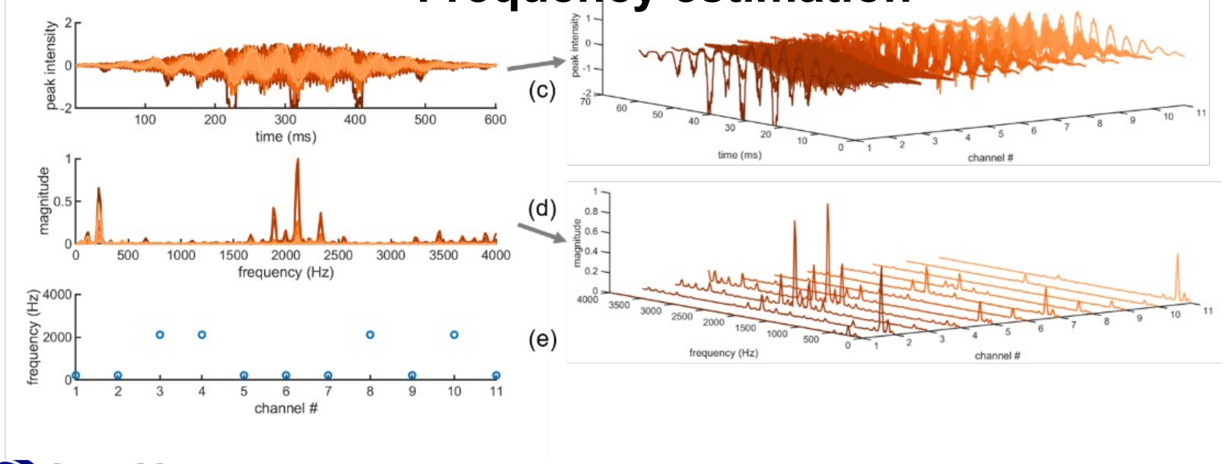
Image and signal processing for vibration frequency

High speed image processing

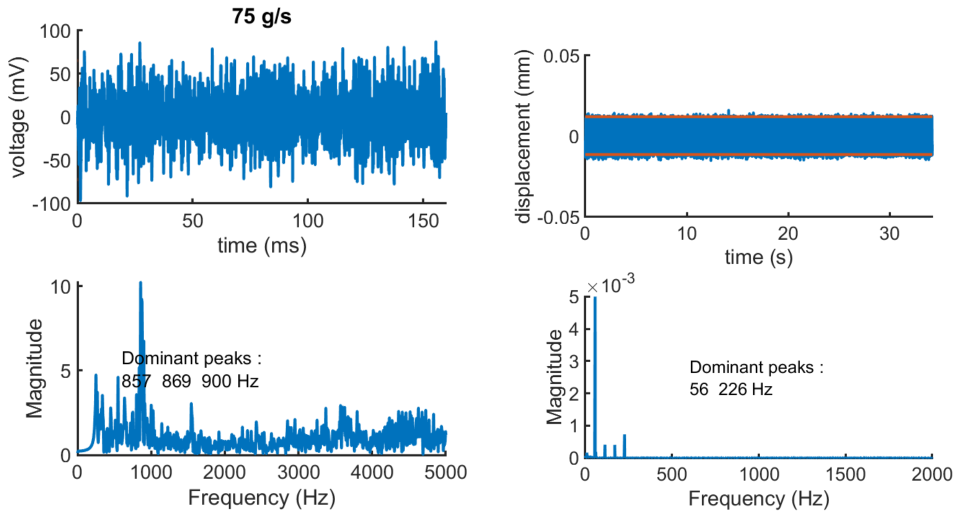




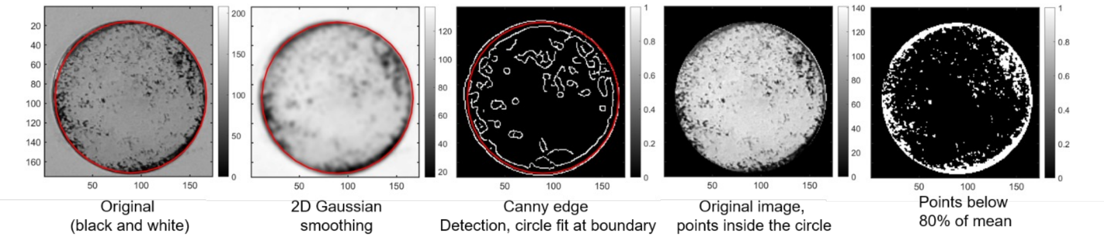
Frequency estimation



Microphone and displacement sensor signal processing



Quantify damage to disks



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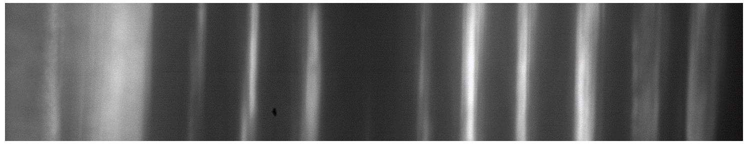
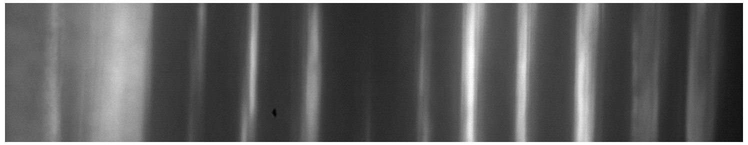
High flow rate, small window gap and enriched Mo disks result in higher mass loss

1.04 mm window gap

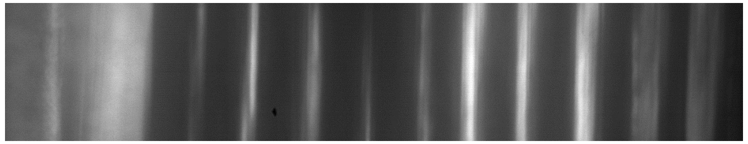
40 g/s



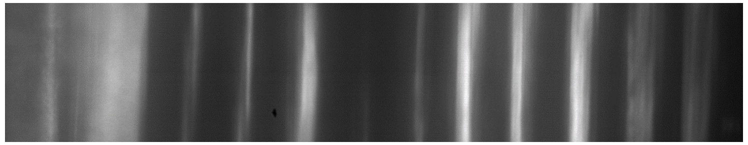
50 g/s



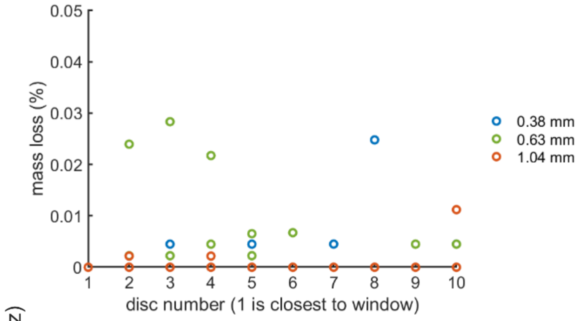
60 g/s

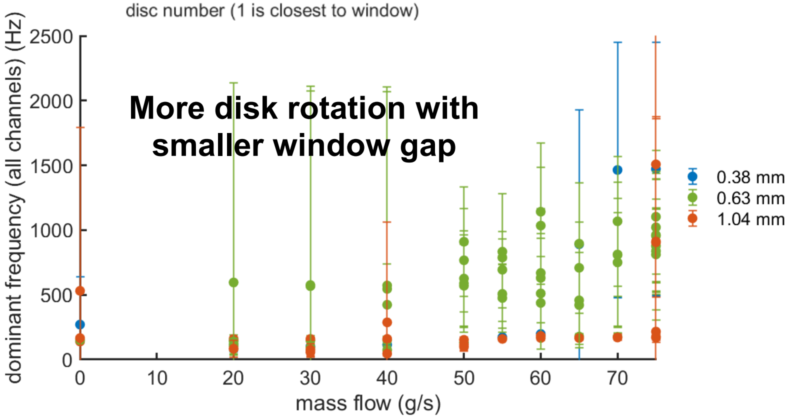


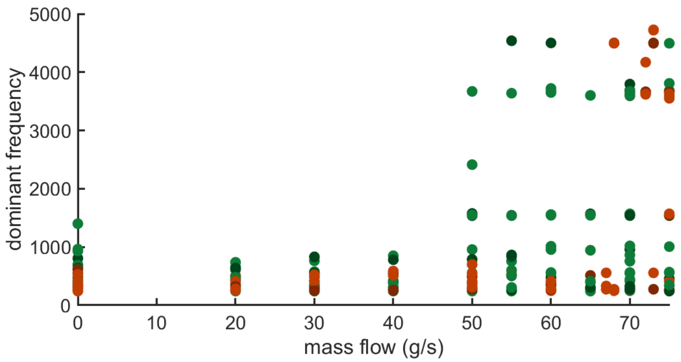
75 g/s



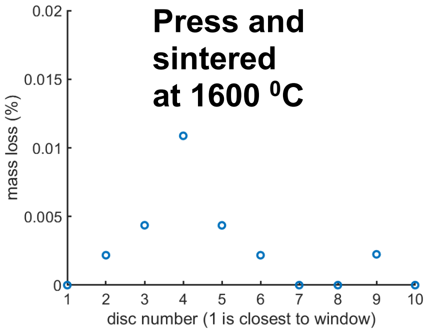
Window gap and flow rate

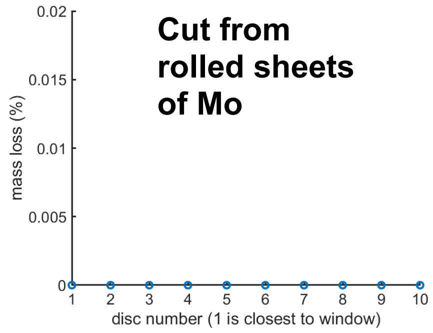




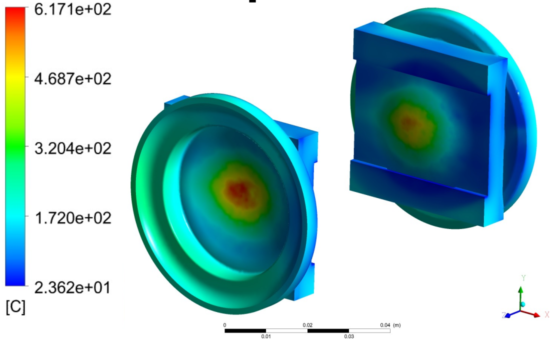


Enriched and natural Mo disks





Simulations: window gaps > 1.04 mm can lead to excessive window heating making it susceptible to yield and rupture



Simulations by Eric Olivas

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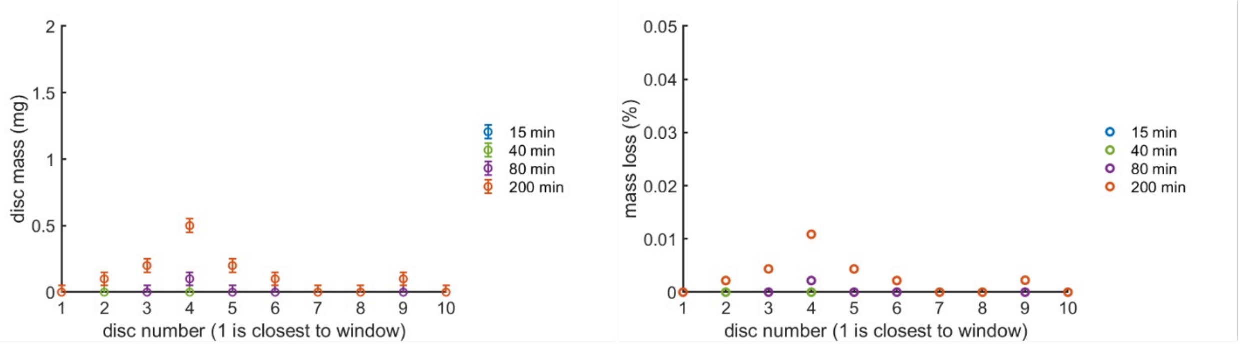
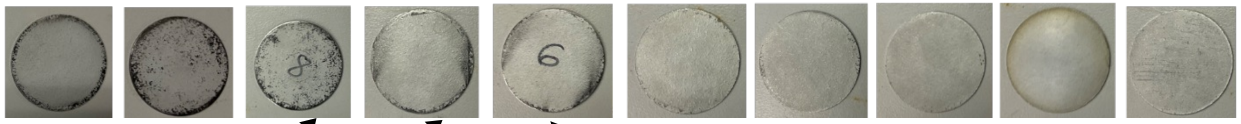
Longer duration testing approximates up to 5% (25 g) mass loss over 6 days of irradiation

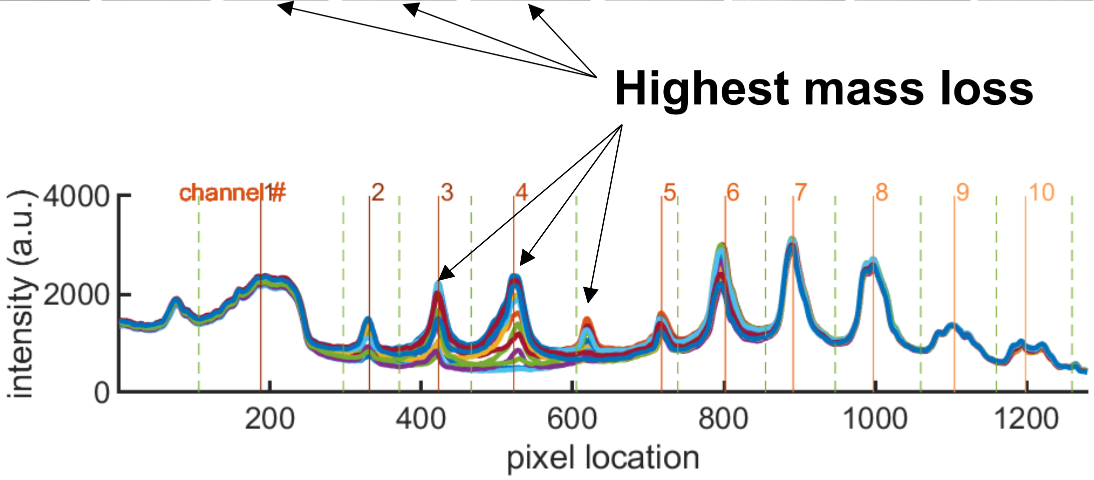
Mass loss trend across disks



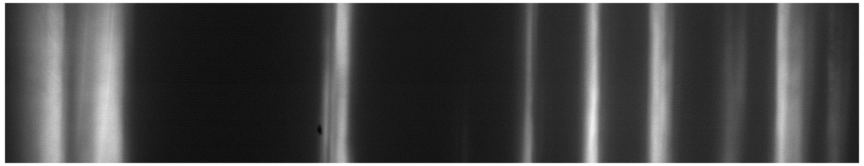
Disc 1 | Disc 2 | Disc 3 | Disc 4 | Disc 5 | Disc 6 | Disc 7 | Disc 8 | Disc 9 | Disc 10

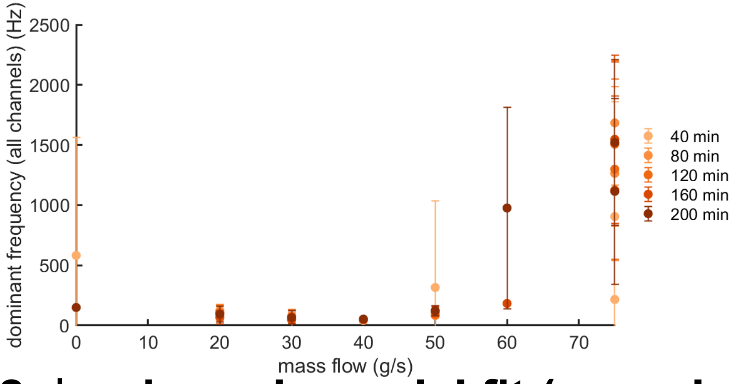


Highest mass loss

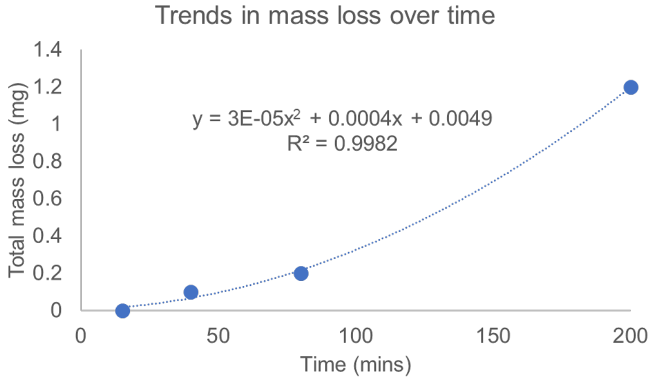


More vibration after > 3 hours of testing





2nd order polynomial fit (mass loss trend with time)



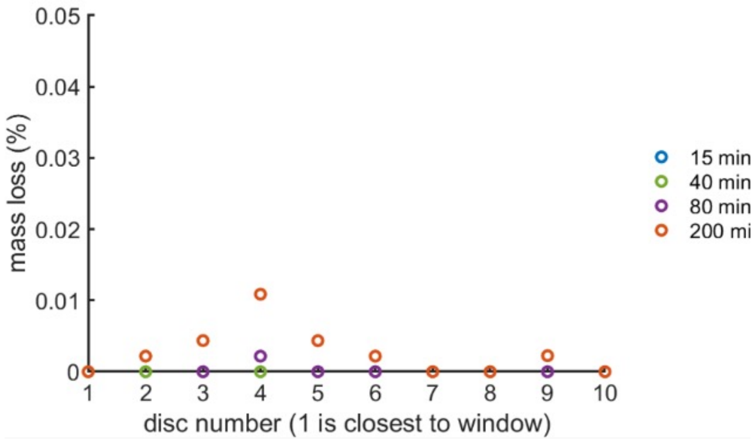
10 disks, 200 minutes : 1.4 mg

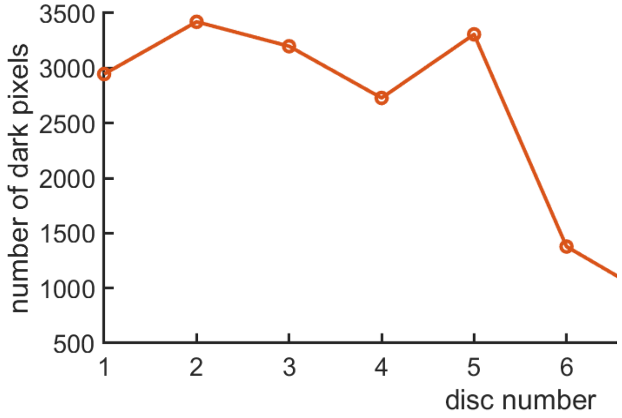
10 disks, 6 days: 2.2 g

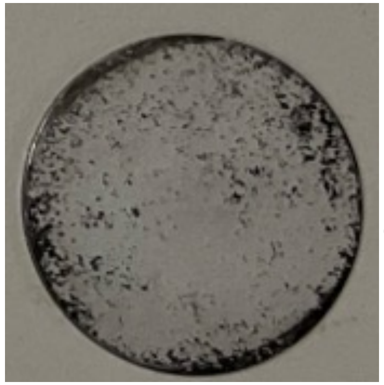
65 disks, 6 days: 24.5 g

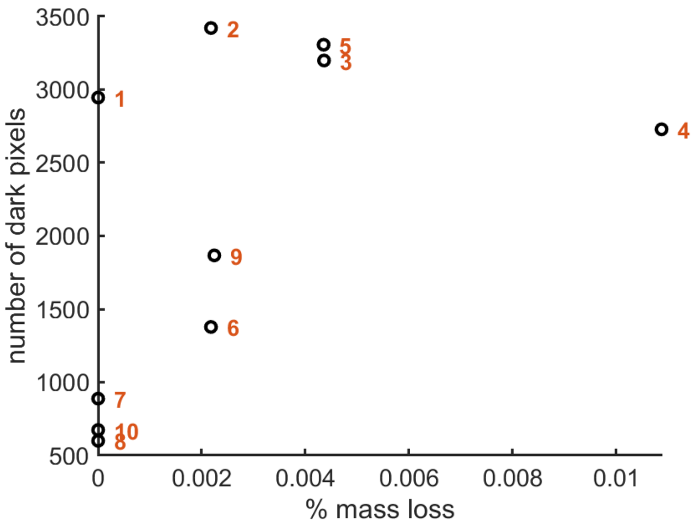
Correlations for mass loss and microphone measurements

Correlation between disk wear and mass loss

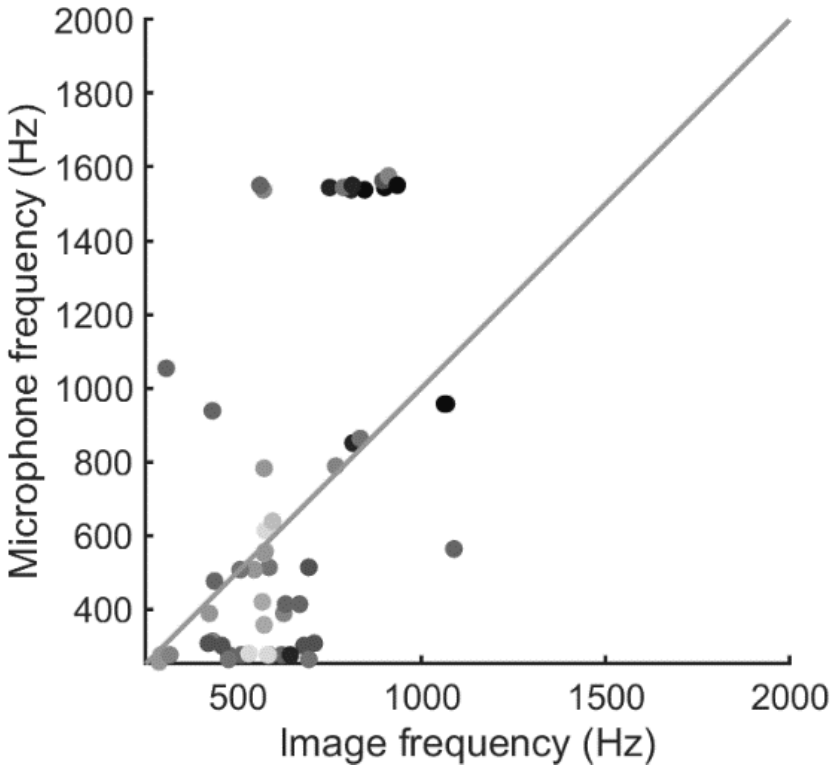








Correlation between microphone and high-speed camera



More data will be collected to establish correlations

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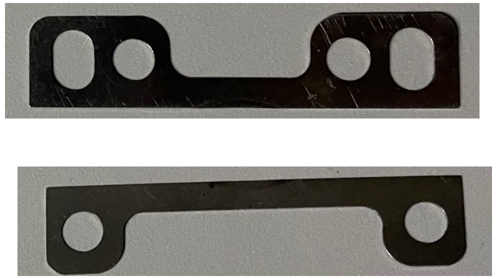
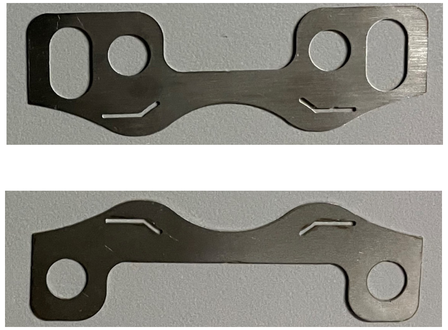
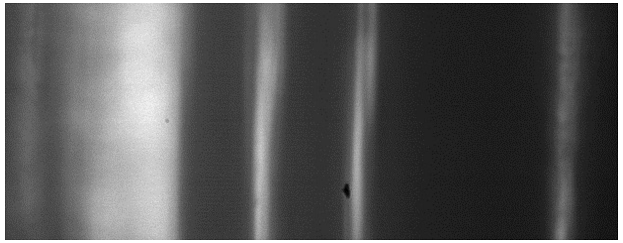
Updated target design, preliminary tests & future work

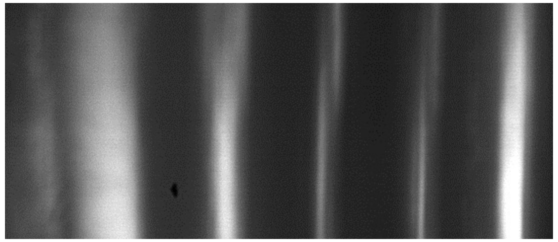
Original spacer lamination

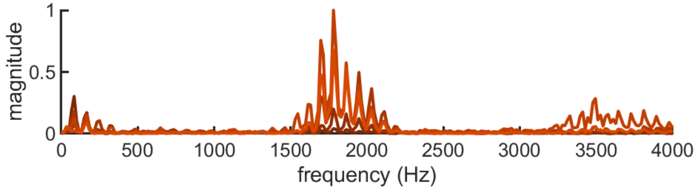


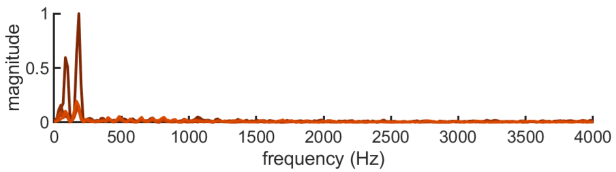
Updated spacer lamination design











Less vibrations and negligible mass loss with updated spacer lamination design

Future work:

- Run more long duration tests with new and old laminations
    - Assess correlations between microphone and imaging data
    - Provide recommendations on installation and use of microphone
    - Correlate disc wear to mass loss
    - Improve projected mass loss over long duration tests

Findings:
Diagnostics provided quantitative evidence of factors leading to mass loss.

A larger window gap and adding contact area between spacer laminations and discs significantly reduced mass loss.

This work was supported by:
USDOE NNSA Office of Material Management and Minimization (NA-23)

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