

## Improving Low-Spatial Frequency Figure Errors in Full-shell X-Ray Optics

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The project aims to reduce low-spatial frequency figure errors in electroformed x-ray mirror shells to improve their optical performance for x-ray telescopes.

### What are full-shell x-ray optics?

Because of the high energy of x-ray photons, **x-ray telescopes** using special grazing-incidence mirrors to focus radiation from **astrophysical** sources.

Each full shell mirror can individually focus x-rays, but mirrors are nested to increase collecting area.

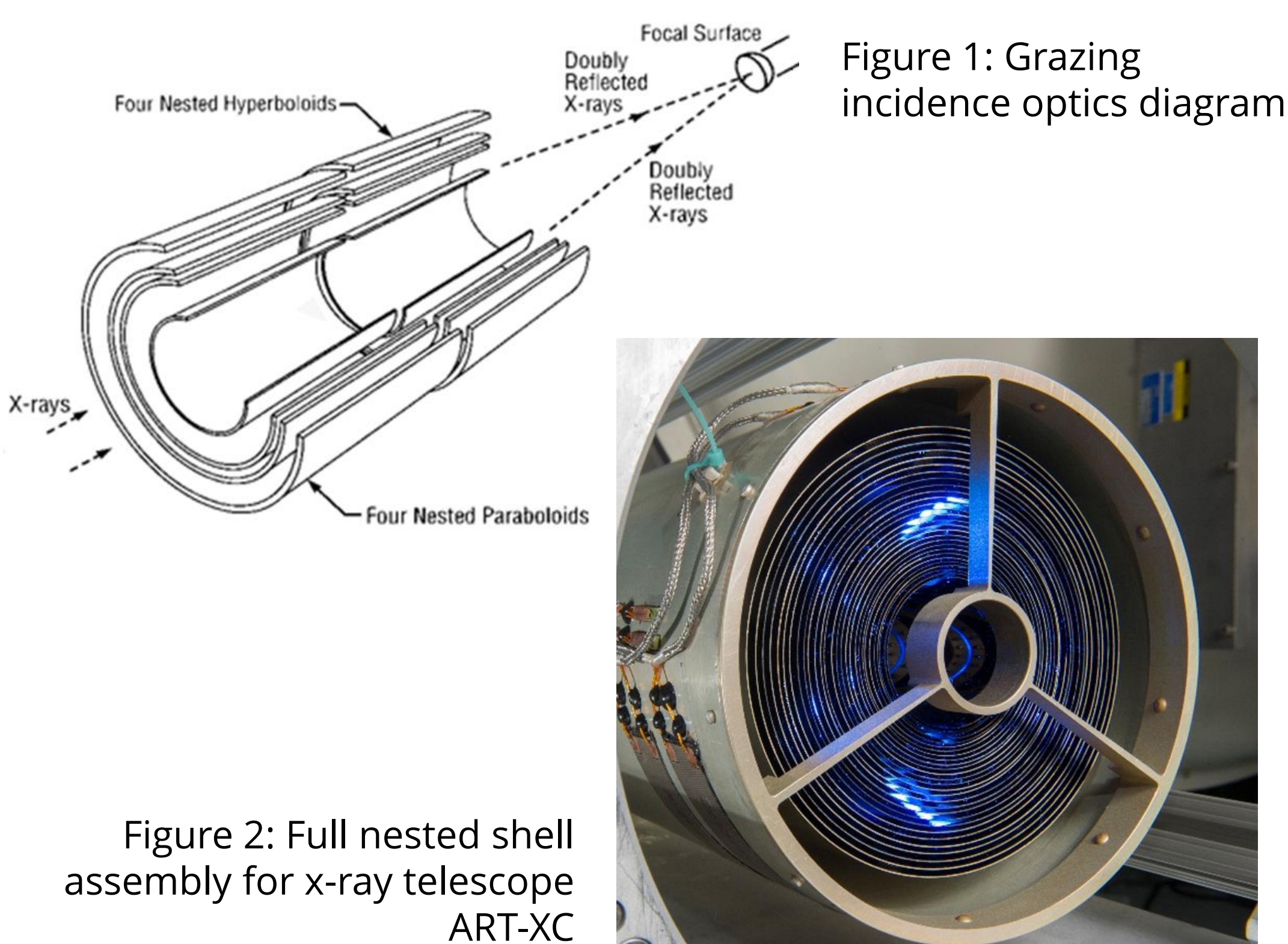


Figure 1: Grazing incidence optics diagram

Figure 2: Full nested shell assembly for x-ray telescope ART-XC

### X-ray Mirror Fabrication

At NASA MSFC, x-ray mirror shells are replicated from a figured mandrel through **electroforming**.

**Problem:** Newly made shells have surface profiles that deviate from the mandrel, however. These **figure errors** may arise from the manufacturing process.



Figure 3: X-ray mirror shell fabrication process

### Acknowledgements

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### Testing Manufacturing Parameters

Five sets of shells were fabricated with production parameters:

- Typical shells (control)
- Thicker shells
- Low plating stress
- High plating stress
- Slowly cooled



Figure 4: Example of replicated x-ray mirror shells

### Results

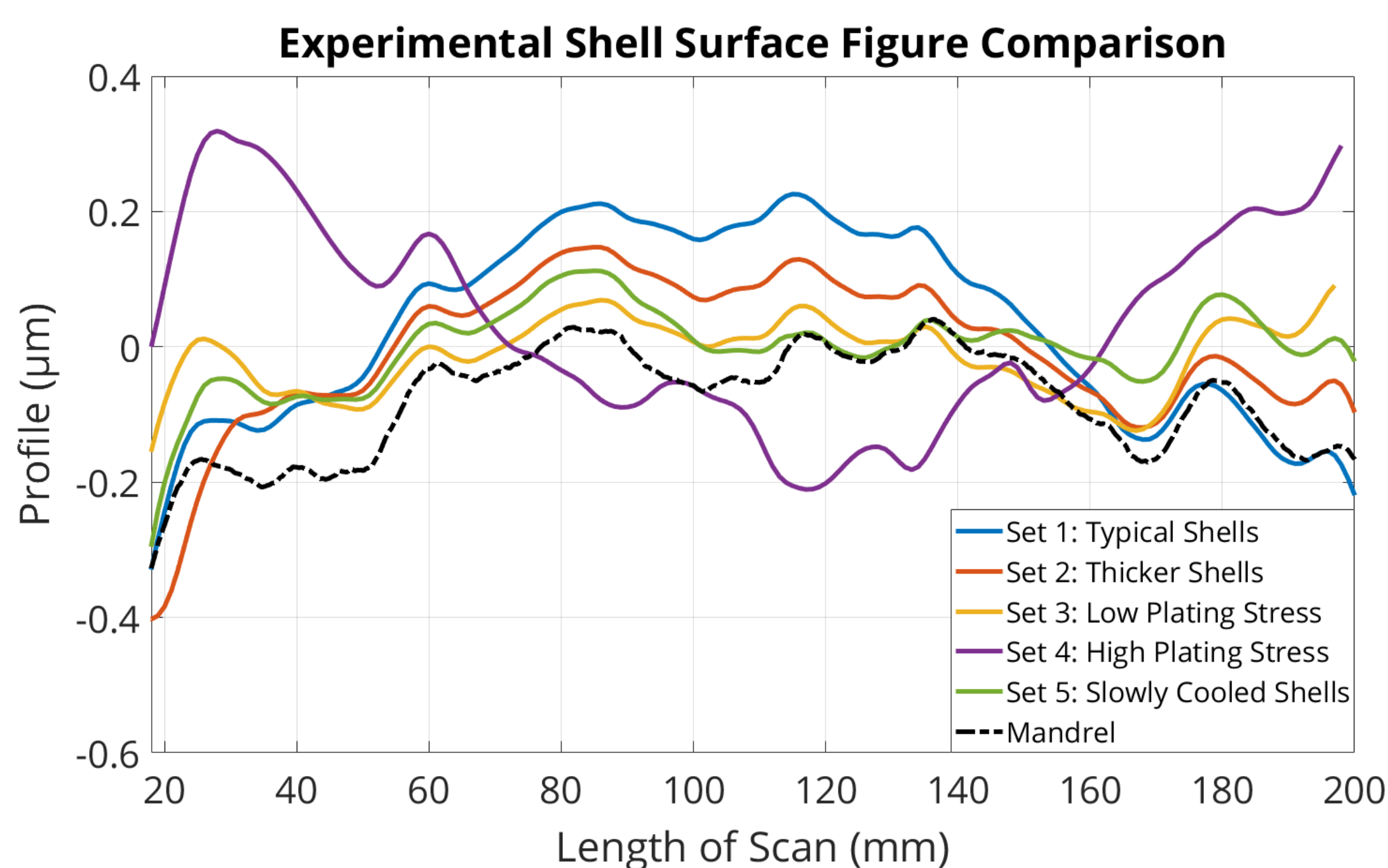


Figure 5: Measured figures of test shells and mandrel

*Optical performance* is determined by angular resolution, calculated using HPD. A smaller angular resolution means **more precise, resolved astronomical images**.

Shell Type	HPD (arcseconds)
1: Typical	15.85
2: Thicker	14.96
3: Low plating stress	14.34
4: High plating stress	17.58
5: Slowly cooled	14.08
Mandrel	8.78

Table 1: Experimental results for shell performance

### Conclusions

Electroplating **stress** highly influences replication results. **Slow cooling** during shell separation and **low plating stress** can reduce surface figure error and **improve optical performance**.

