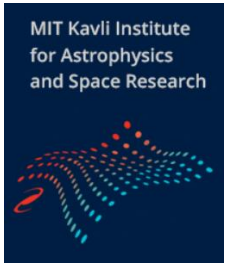
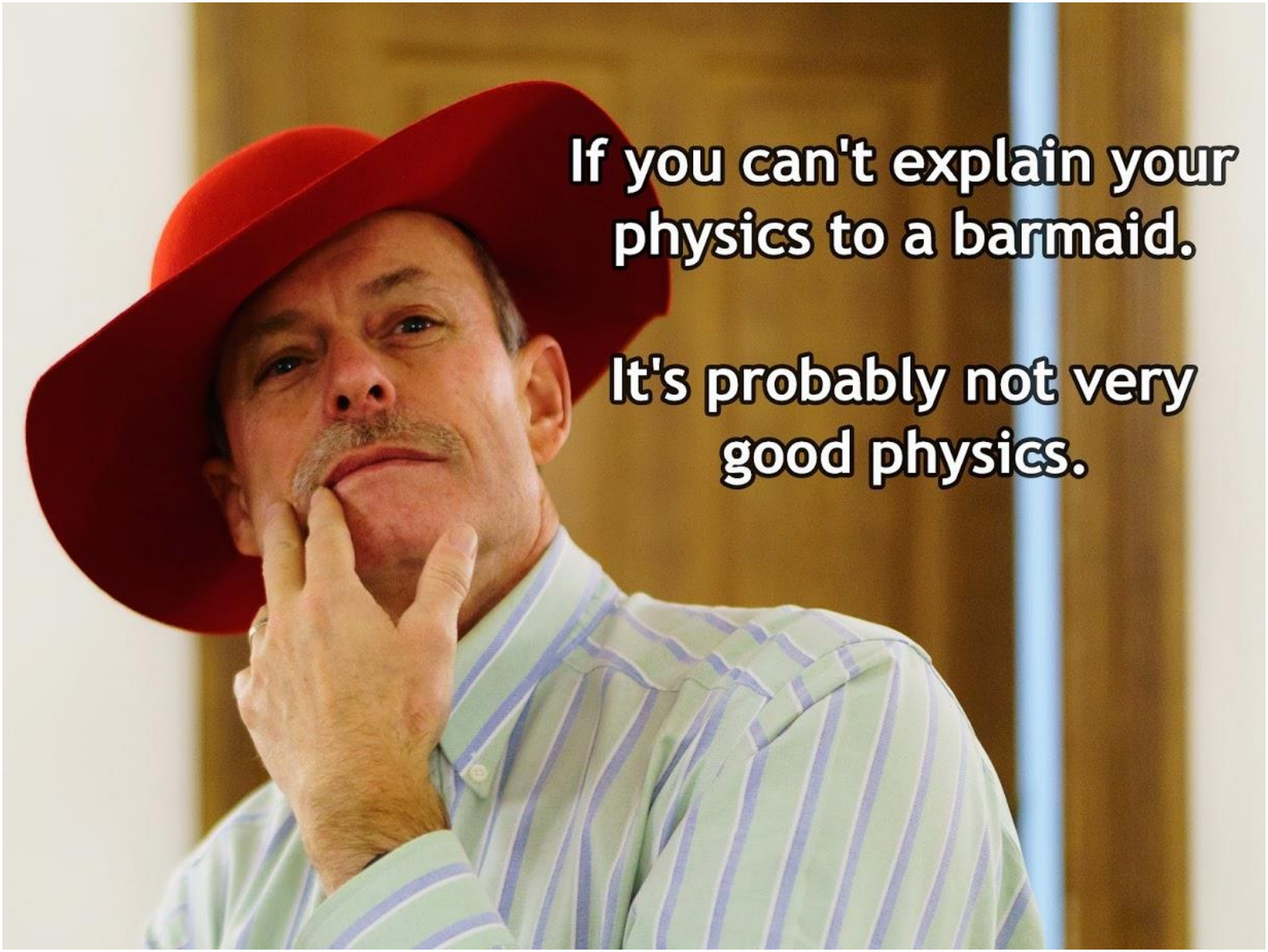
Advancing Soft X-ray Polarimetry with REDSoX

ALAN GARNER

AXRO 2019.12.06

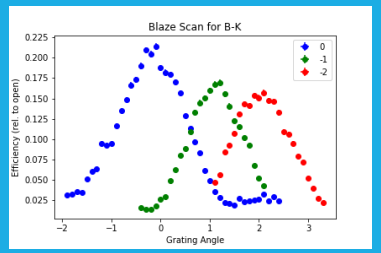



If you can't explain your physics to a barmaid.
It's probably not very good physics.

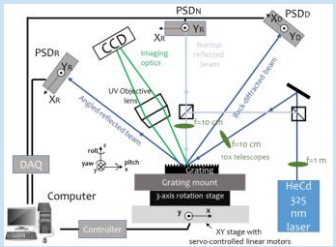
Outline

The REDSoX Polarimeter

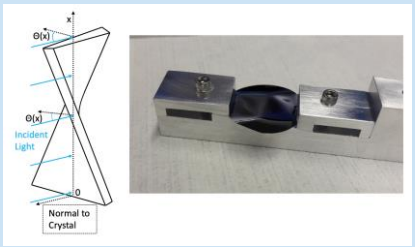
CAT Grating Tests



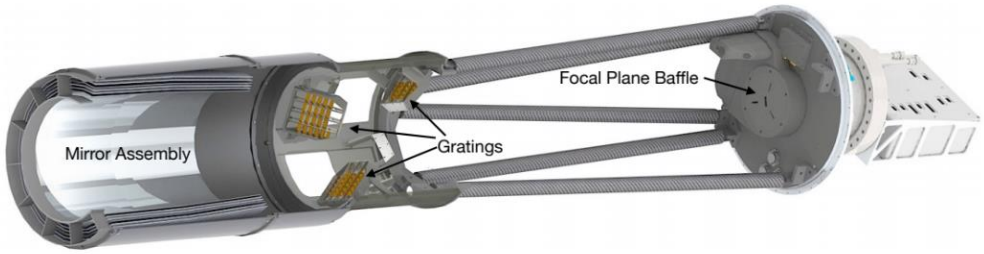
REDSoX Grating Alignment Tests

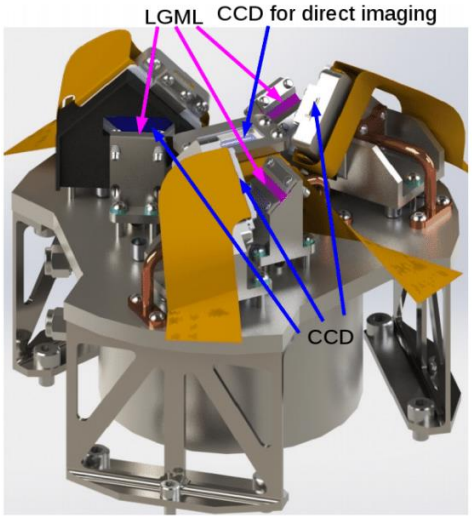


Twisted Crystals



REDSoX Polarimeter



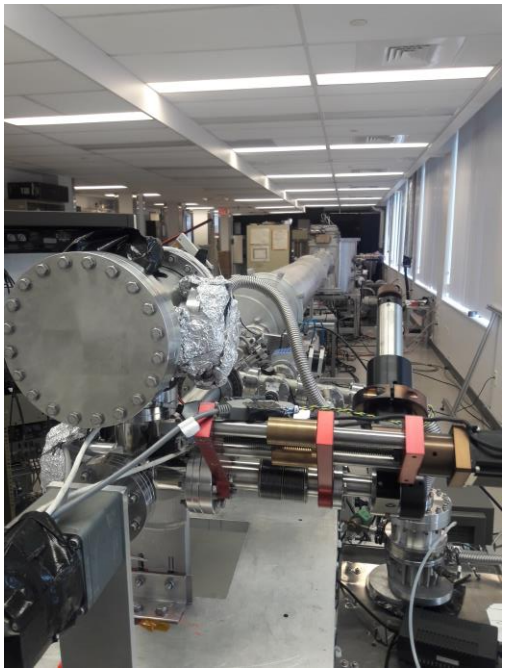


Grazing incidence optics focus the x-rays to a point.

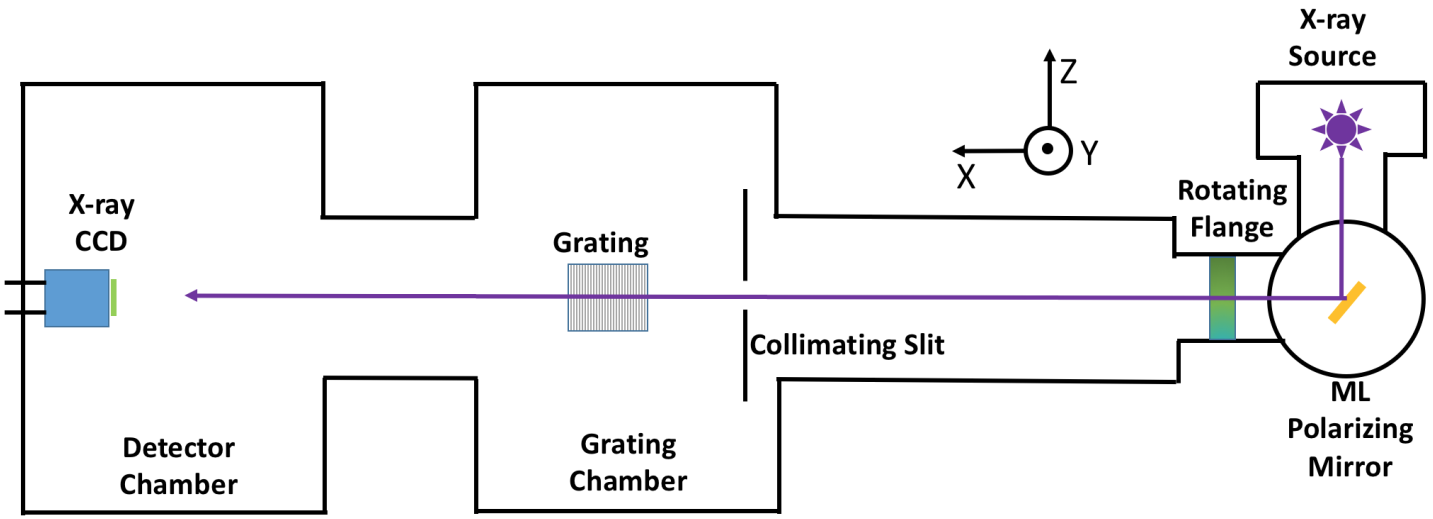
Gratings disperse this light onto a trio of laterally graded multilayer mirrors at an angle of incidence of 45^{o} to measure the polarization.

In other words, **the gratings see a converging beam, and must disperse this light appropriately onto a multilayer mirror.**

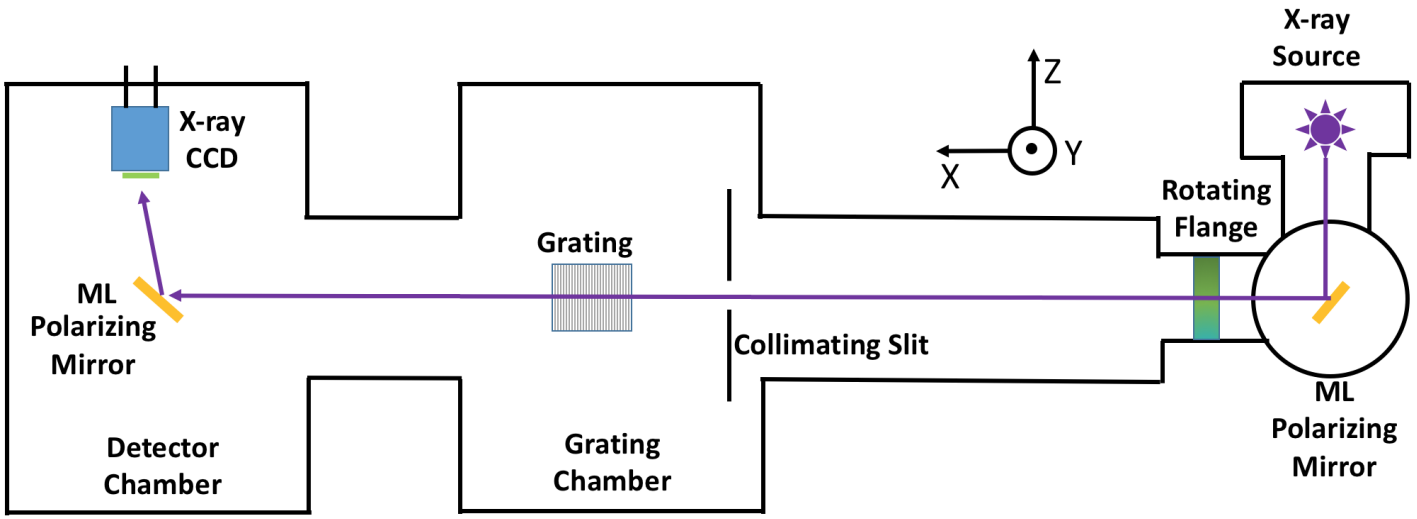
MIT X-ray Polarimetry Beamline



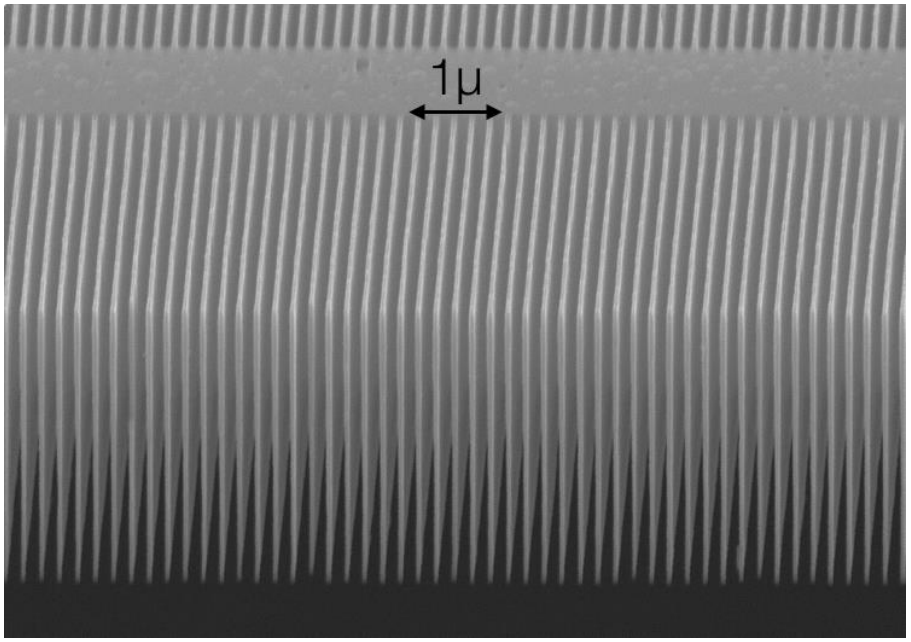
Current Configuration

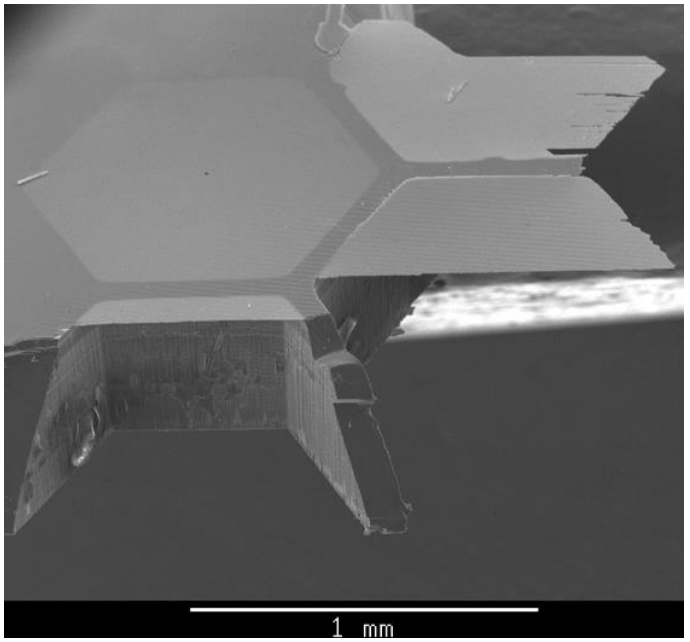


Polarimetry Configuration

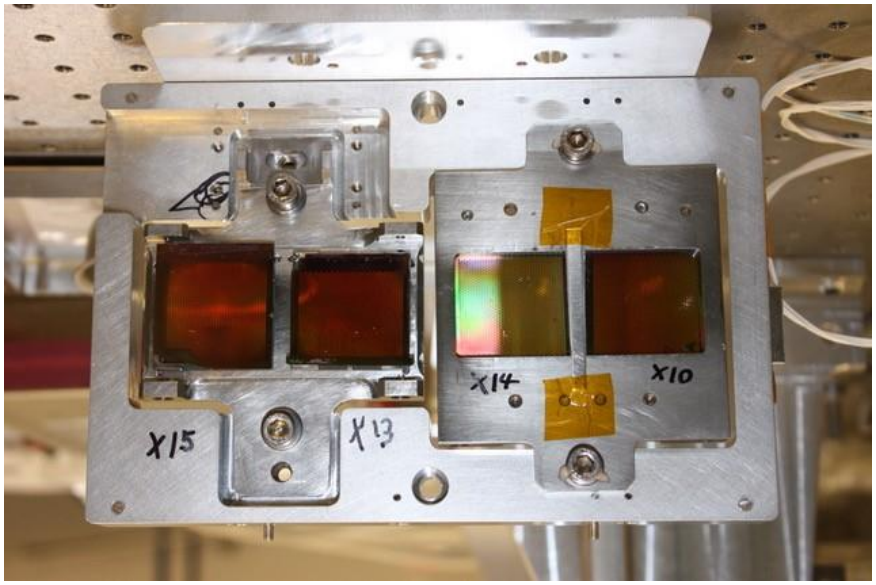


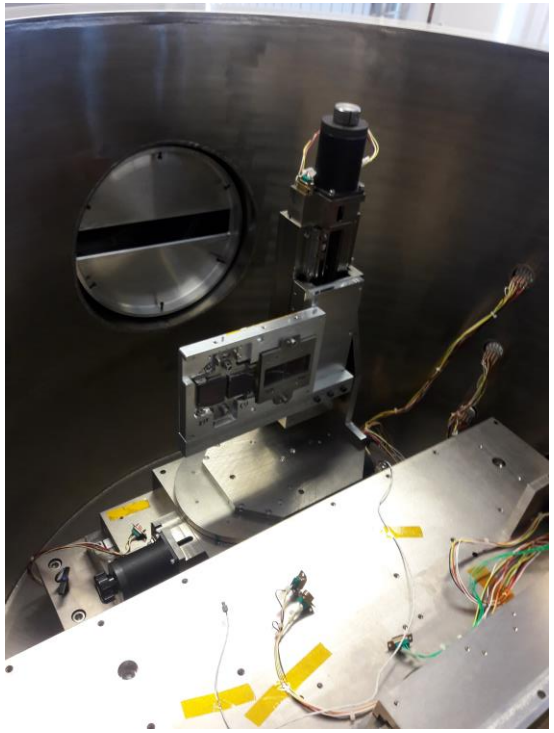
CAT Gratings



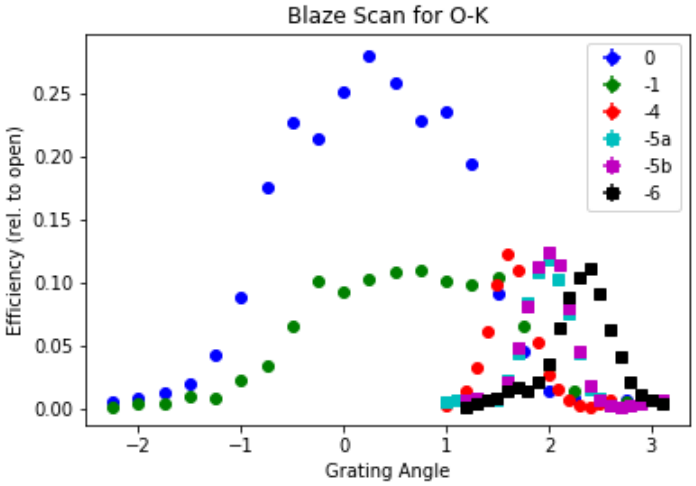


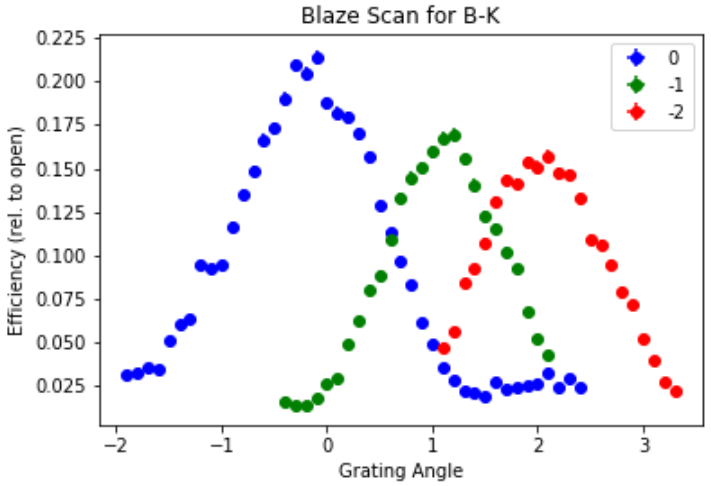
CAT Gratings



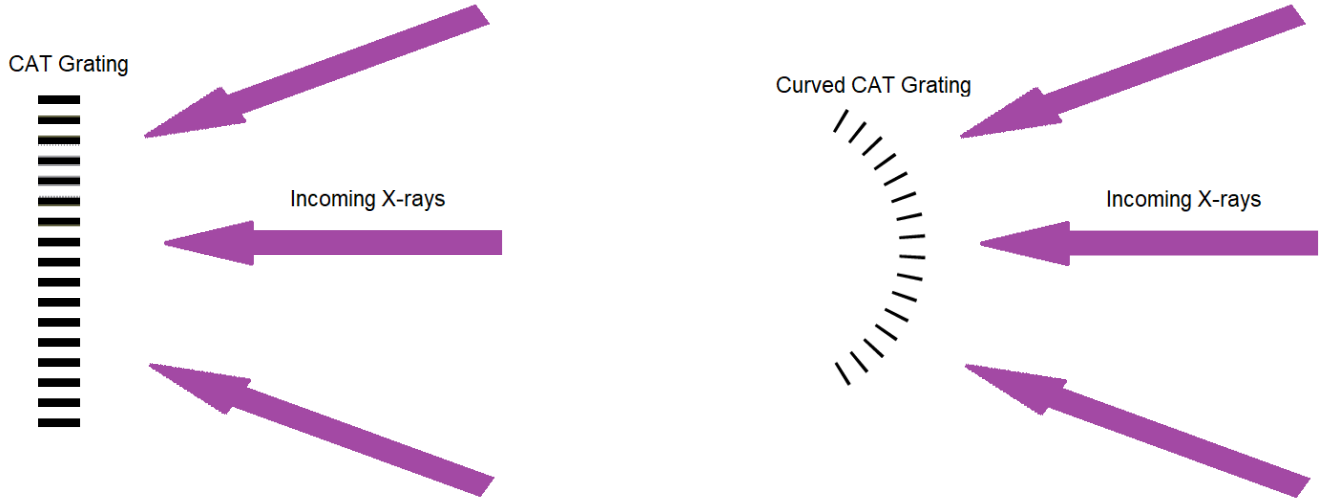


CAT Gratings

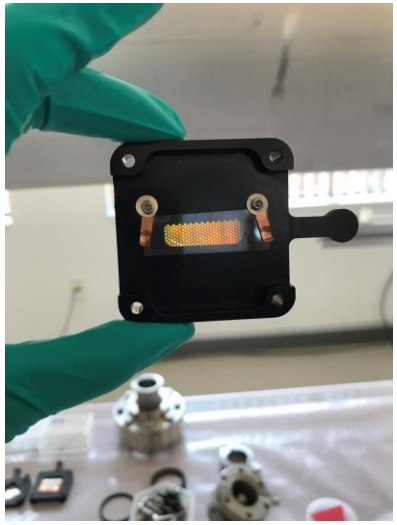


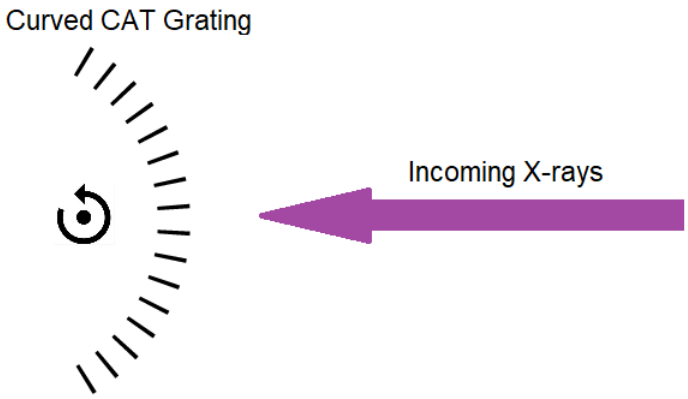


Curved CAT Gratings

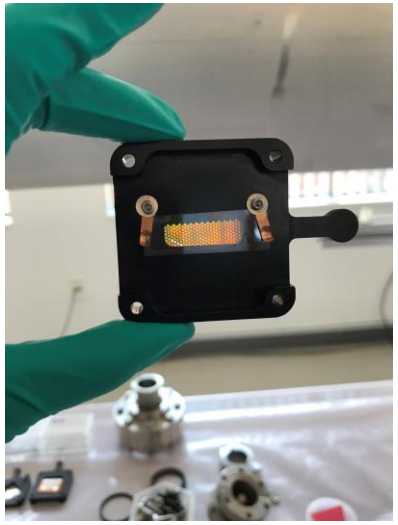


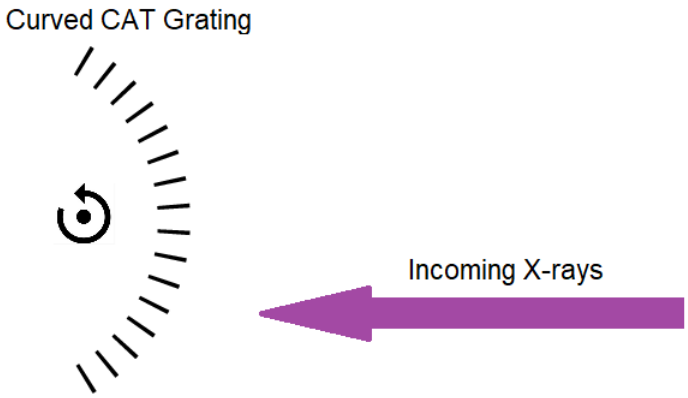
Curved CAT Gratings



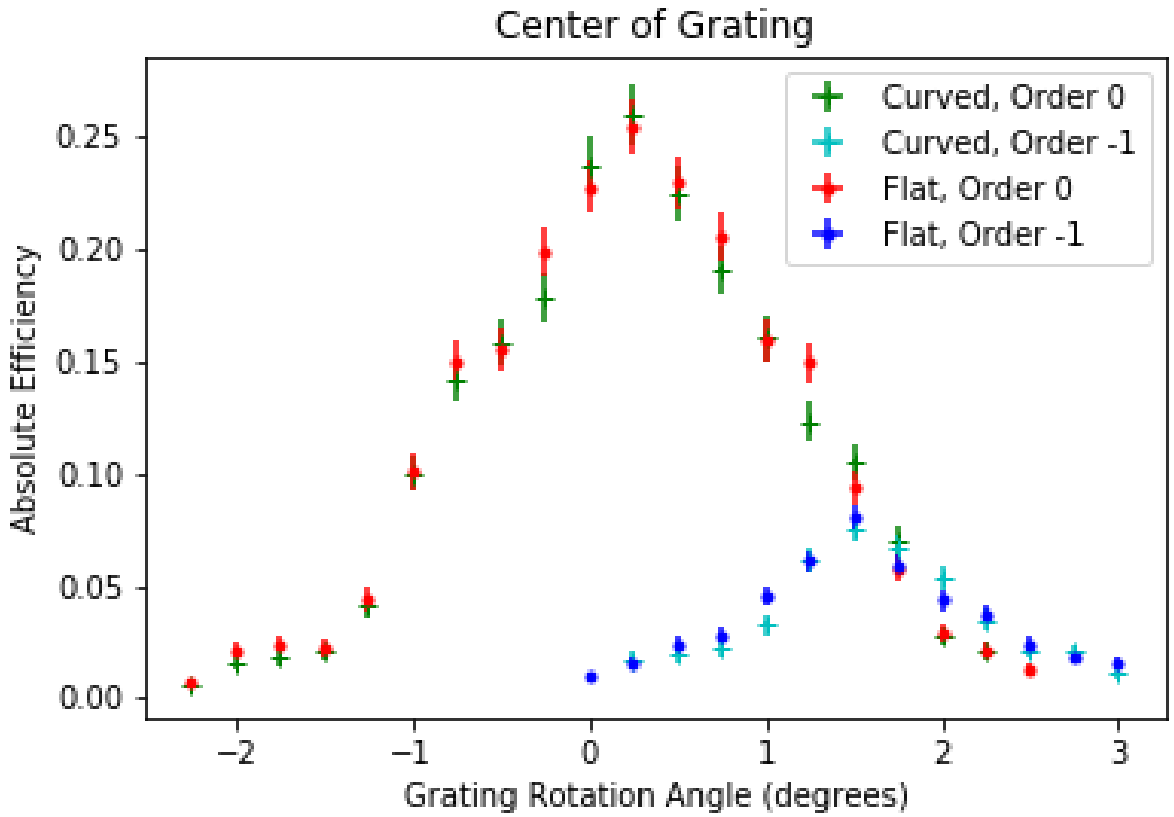


Curved CAT Gratings

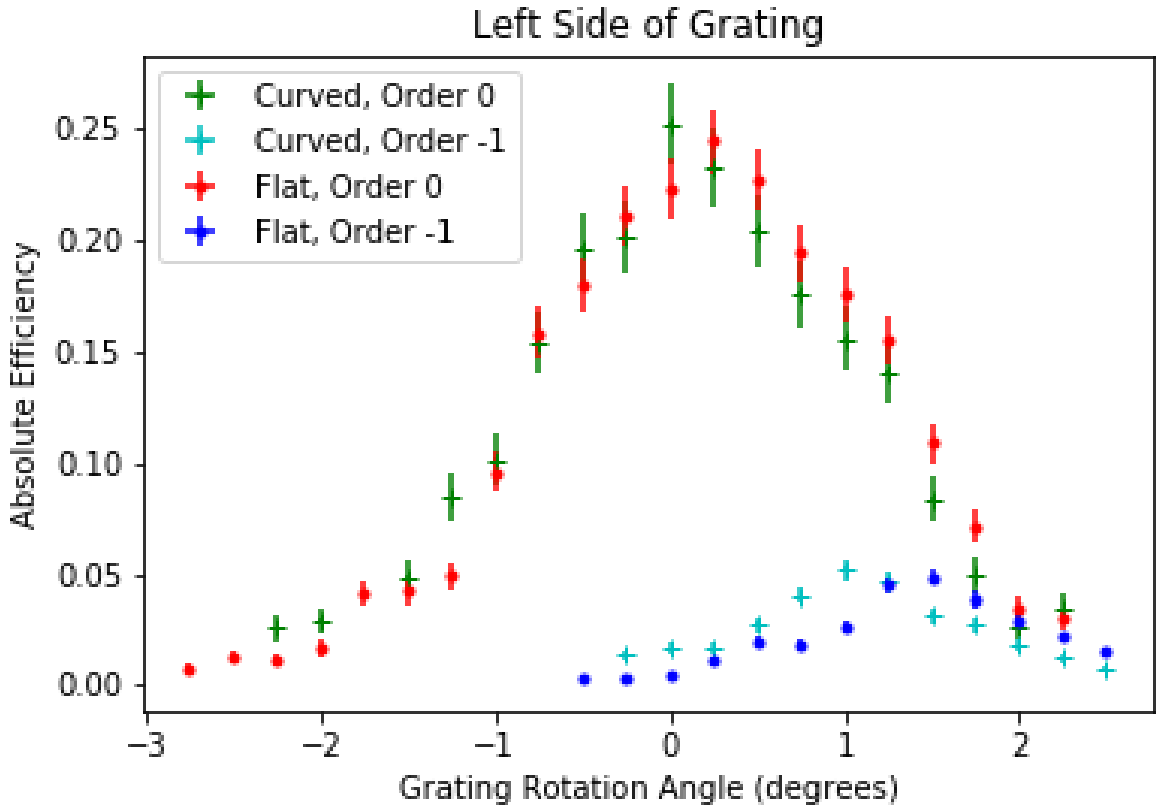




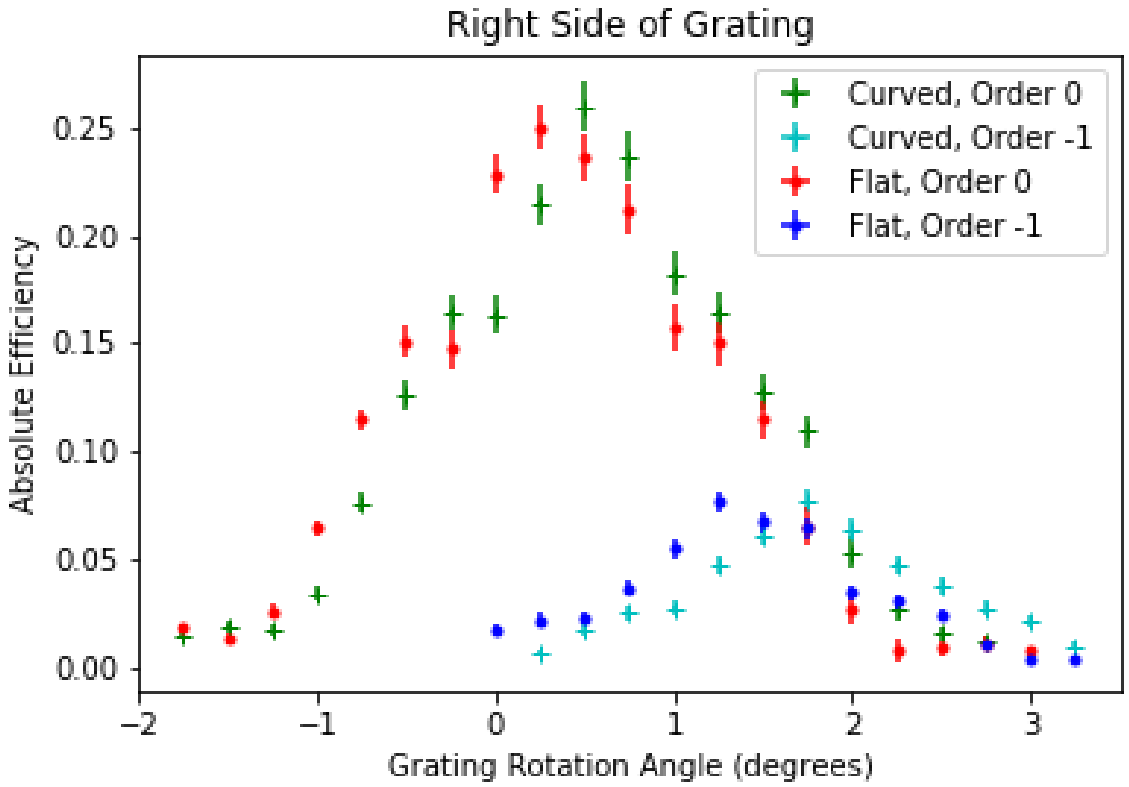
Curved CAT Grating Results



Curved CAT Grating Results



Curved CAT Grating Results



CAT Grating Alignment

Being able to align the gratings within tolerances will be critical to the success of the REDSoX polarimeter.

Table 2: System tolerances

	Positional			Angular		
	x	y	z	x	y	z
Subsystem	mm	mm	mm	$'$	$'$	$'$
Optics	2.0	2.0	2.0	60	60	–
Grating petal to structure	1.0	1.0	1.0	6.0	6.0	60
CAT grating to petal	0.5	0.5	0.5	6.0	6.0	60
ML mirror	0.1	2.	1.0	15.0	15.0	60.0
CCDs	2.0	2.0	2.0	120	120	120

CAT Grating Alignment

Being able to align the gratings within tolerances will be critical to the success of the REDSoX polarimeter.

Table 2: System tolerances

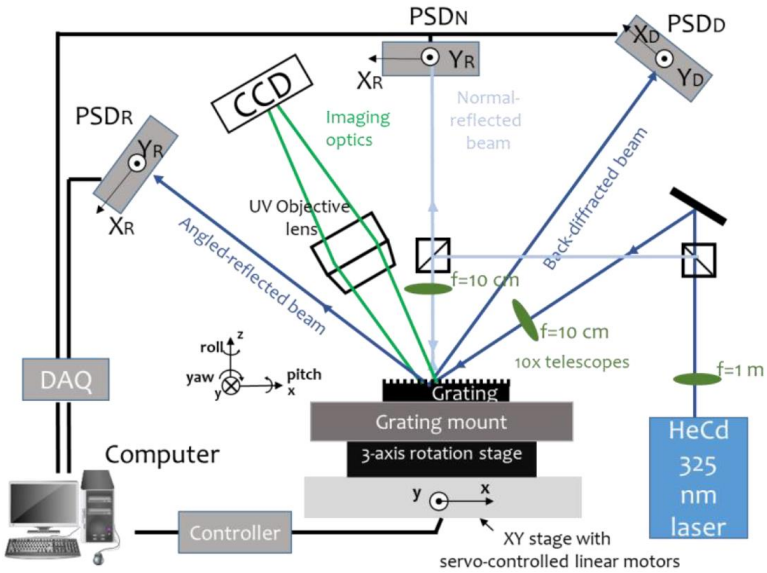
	Positional			Angular		
	x	y	z	x	y	z
Subsystem	mm	mm	mm	$'$	$'$	$'$
Optics	2.0	2.0	2.0	60	60	–
Grating petal to structure	1.0	1.0	1.0	6.0	6.0	60
CAT grating to petal	0.5	0.5	0.5	6.0	6.0	60
ML mirror	0.1	2.	1.0	15.0	15.0	60.0
CCDs	2.0	2.0	2.0	120	120	120

CAT Grating Alignment

Requirement: Align every CAT grating in a cluster to within 6 arcmin of one another in both tip and tilt.

This has already been done by Jung Ki et al., 2018 who were able to align the Arcus prototype CAT gratings within 4 arcmin (typically <2 arcmin).

We are reproducing their scanning laser reflection tool (right) to measure the alignment of the REDSoX prototype gratings.



Jung Ki et al., 2018 (SPIE)

Grating Mounts

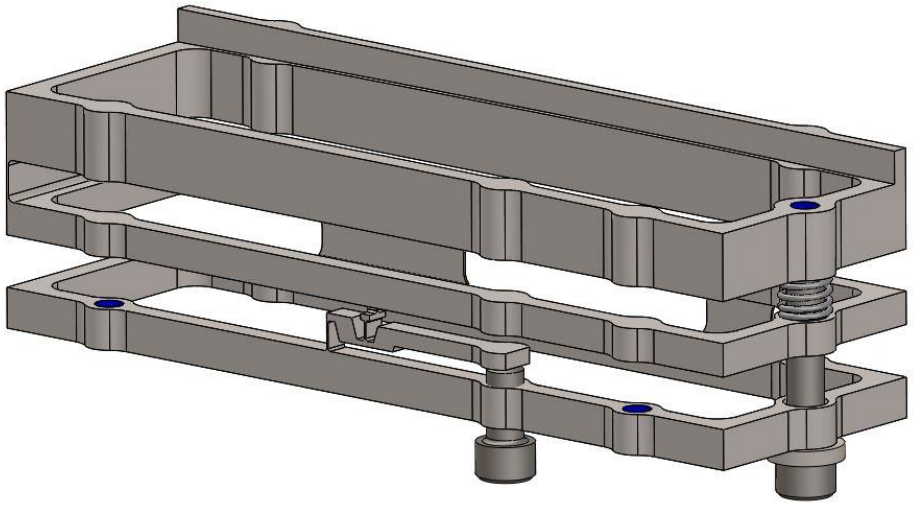
Each mount made from a single piece of titanium

Top surface is curved to match desired curve of the grating

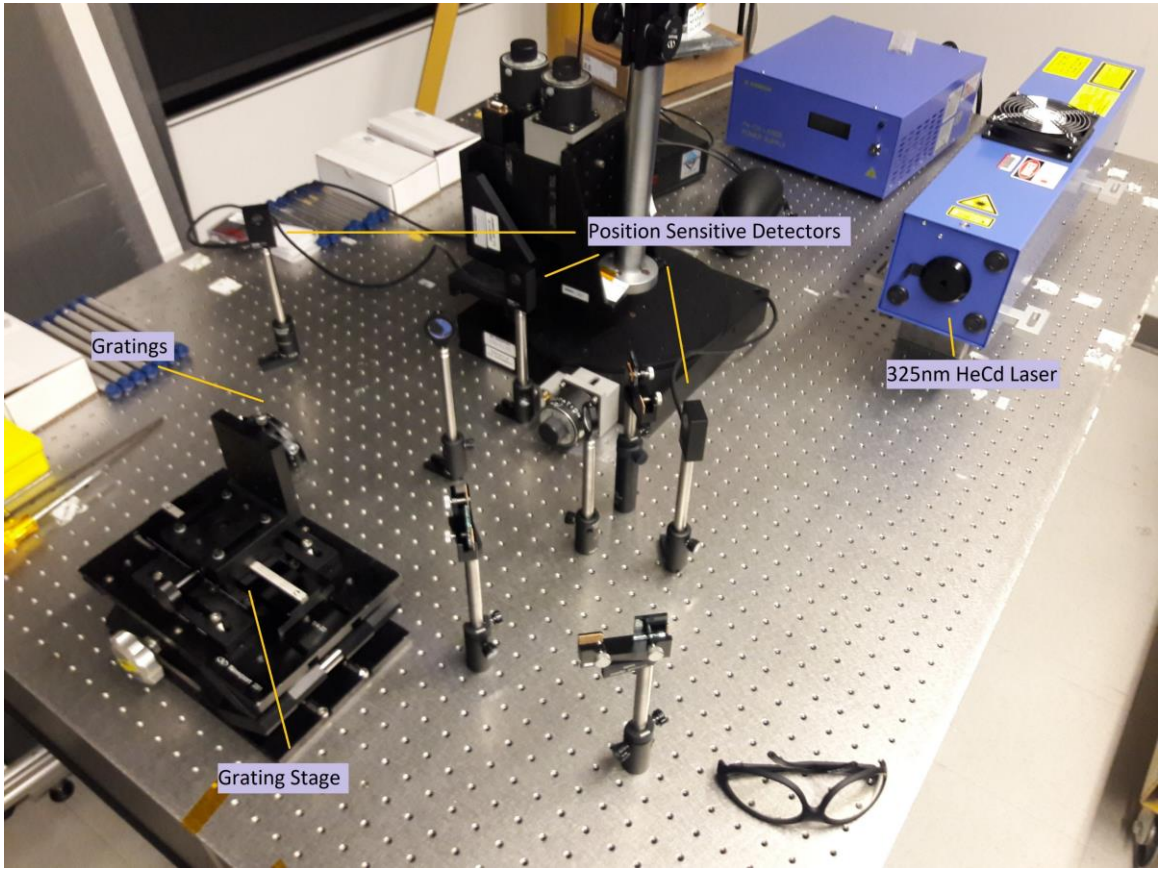
Flexures are built into the part itself using wire EDM

Adjustable in both tip and tilt

Angular resolution of 2 arcmin (corresponds to 90^{o} turn of screw)

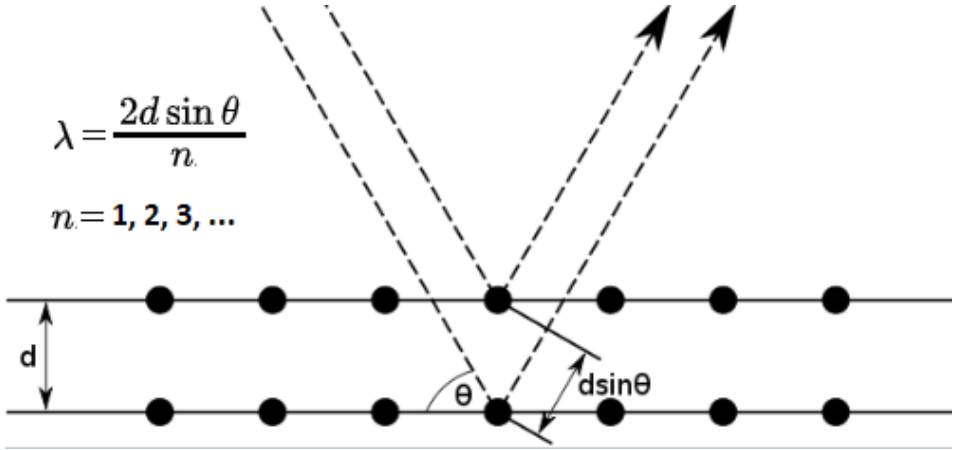


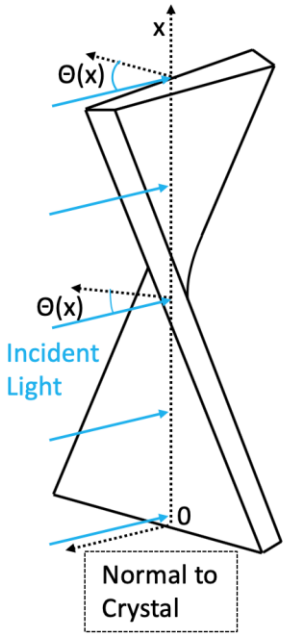
CAT Grating Alignment



TWISTED CRYSTALS

An alternative to laterally graded multilayer mirrors?

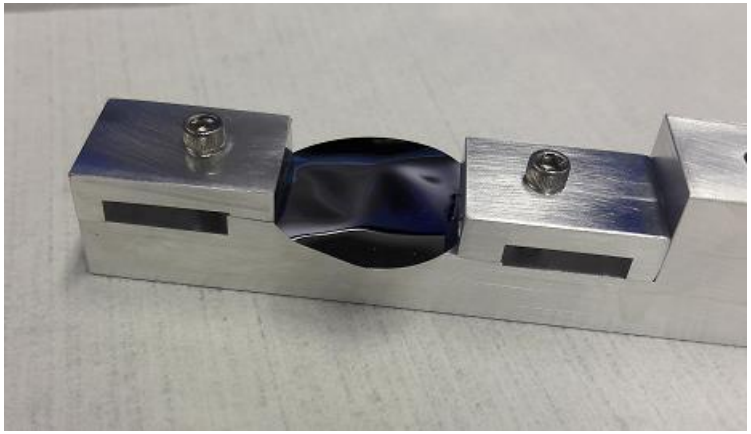


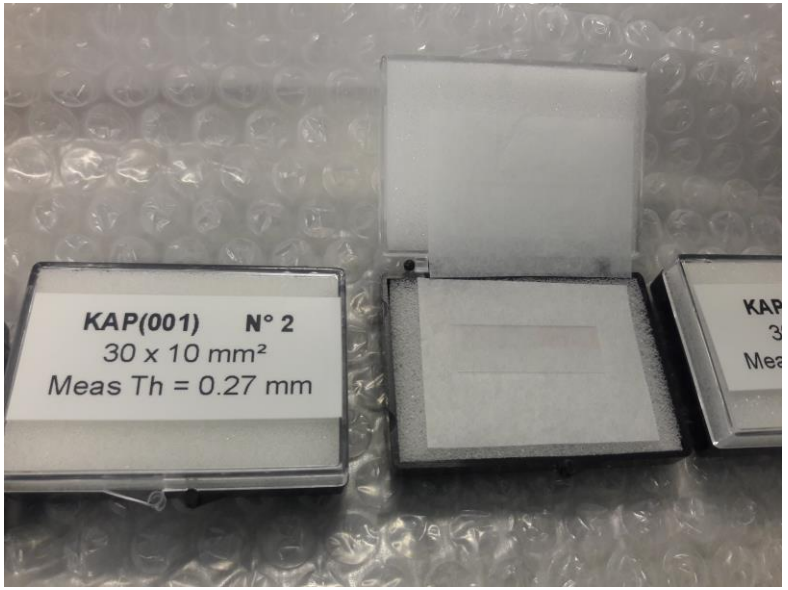


Instead of changing “d” with a constant “θ,” change “θ” with a constant “d”!

TWISTED CRYSTALS

An alternative to laterally graded multilayer mirrors?



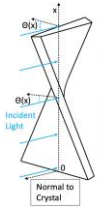


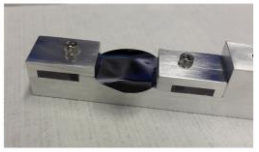
Summary

Our facility is capable of producing monochromatic soft x-rays to test CAT gratings with plenty of room for larger optics or even small missions. We are open to collaboration with anyone who needs a large beamline for testing.

Using the beamline we have demonstrated that curved CAT gratings for the REDSoX polarimeter are feasible, and we are able to align the gratings to the required specification.

In parallel we are pursuing new ideas for soft x-ray optics in the form of twisted crystals.





MIT Kavli Institute for Astrophysics and Space Research