Off-Plane X-ray Grating Spectrometer Concept

Author: Randall L. McEntaffer

Presenter: Webster Cash

On behalf of the OPXGS team:

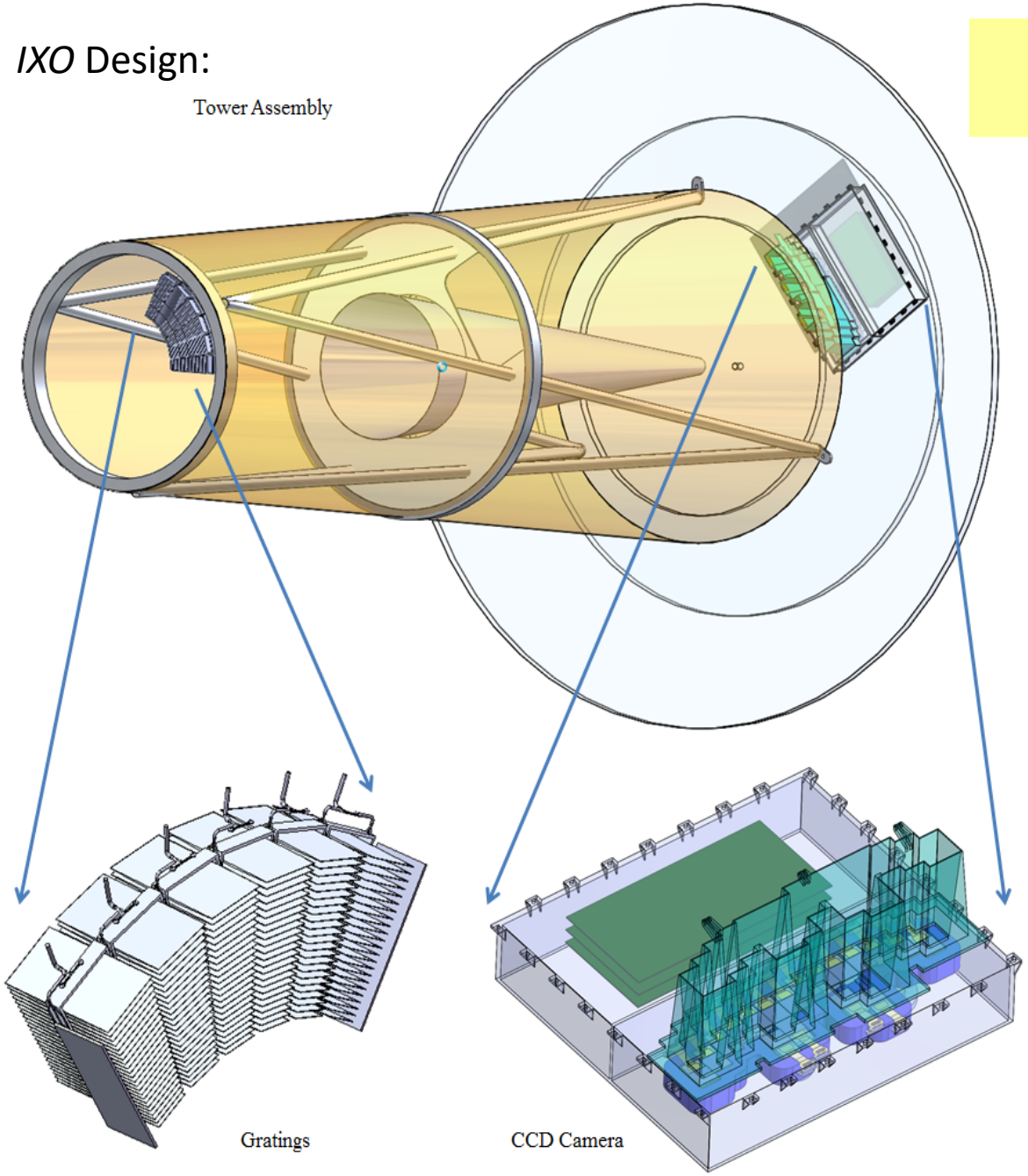
Randall McEntaffer	University of Iowa
Webster Cash	University of Colorado
Chuck Lillie	Northrop Grumman
Suzanne Casement	Northrop Grumman
Andrew Holland	Open University
Neil Murray	Open University
Mat Page	MSSL
Dave Walton	MSSL
Dick Willingale	University of Leicester

Enabling a Key IXO Science Goal

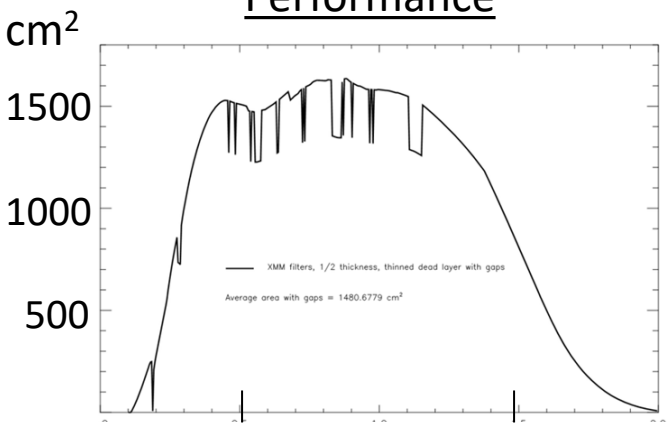
- "How does large scale structure in the universe evolve?"
  - Absorption lines due to filaments along line of sight to bright AGN
    - Requires high spectral resolving power – R > 3000 ($\lambda/\Delta\lambda$) and high throughput over the 0.3-1.0 keV band
  - Filaments enriched via AGN outflows
    - Determine kinematics of these flows with high velocity resolution
  - Most detectable lines at energies < 1 keV
    - Highly ionized C, N, O, Ne, etc.
    - Necessitates dispersive spectrometers

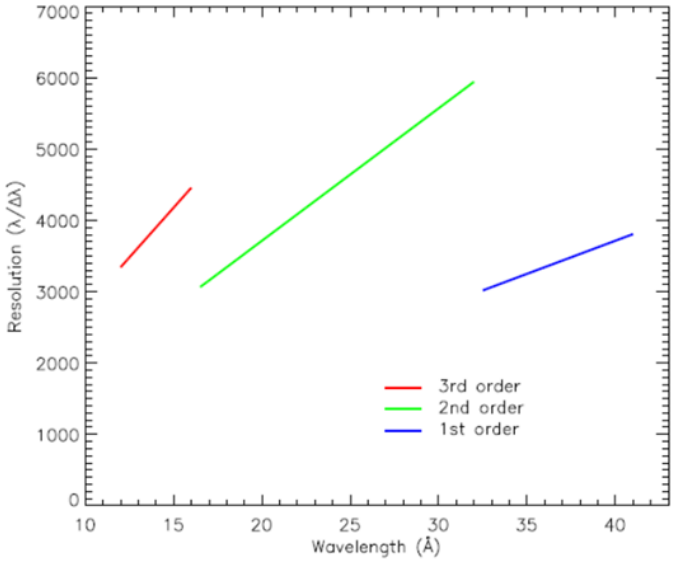
Instrument Overview

IXO Design:



Performance





TRL Assessment

TRL	Definition	Hardware Description	Exit Criteria
3	Analytical and experimental critical function and/or characteristic proof of concept.	Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.	Documented analytical/experimental results validating predictions of key parameters.
	Off-Plane Reflection Grating Technology Assessment		
3	**Gratings** • Theoretical calculations give dispersion efficiency >50% sum of orders (including Au reflection). 40% sum of orders has been obtained empirically for a radial, blazed, high density grating. • Theoretical resolution at 1 keV in 3rd order is ~9000. We have obtained an empirical resolution of > 200 at 1keV with a 3' telescope. Projection to a 5" telescope gives a extrapolated resolution of 7200. The spectral resolution requirement is >3000 over the bandpass.	• A combination of analytical predictions and laboratory demonstrations shows that Off-plane gratings are capable of obtaining the performance requirements for IXO. • Tests were performed in a relevant environment in terms of temperature and vacuum with X-rays, but vibration tests have not been performed. • A prototype grating (low fidelity component) has been fabricated but not tested.	Experimental results verify analytical predictions and validate the concept for the key IXO XGS performance requirements. Demonstration of resolution required to advance technology to TRL 4.
3	**CCDs** Theoretical CCD throughput based on thin 13 nm MgF_2 23 nm Al optical blocking filter (required for low energy efficiency)	Optical blocking filters of 26 nm MgF_2 and 45 nm Al currently exist on XMM CCDs.	Filter deposition technique has been demonstrated. Extrapolation of throughput achieves requirements.

Technology Development Plan

Demonstrate high spectral resolving power

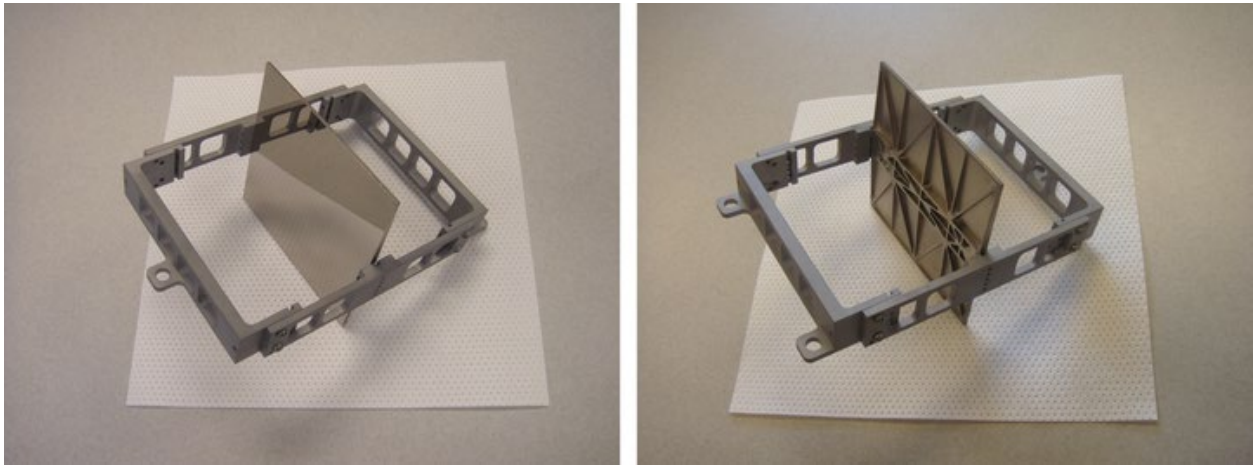
- Obtain high density, radial profile master
- Performance testing at MSFC
- Align gratings in a module
  - Verify replication procedure
  - Verify alignment procedure
  - Environmental testing
  - Performance test with appropriate optics and CCDs

Demonstrate ability to create pinhole free thin optical blocking filters deposited directly on CCDs

- Obtain filtered CCDs from e2v
- Test at room temperature – TRL 4
- Cryogenic testing – TRL 5
- Tested flight prototype CCDs – TRL 6

Ongoing Work

- Grating development plan to be furthered through an upcoming Strategic Astrophysics Technology grant
  - New master, Resolution testing at MSFC in 2012
  - Alignment studies have been ongoing
    - Populate and test a grating module in 2013



- CCD filter development planned for the next year in the UK at Open University (Andrew Holland).