We present the scientific motivation and performance for Arcus, an X-ray grating spectrometer mission to be proposed to NASA as a MIDEX in 2016. This mission will observe structure formation at and beyond the edges of clusters and galaxies, feedback from supermassive black holes, the structure of the interstellar medium and the formation and evolution of stars. Key mission design parameters are $R = \lambda / \Delta \lambda > 3000$ with $>500 \text{ cm}^2$ of effective area at the crucial O VII and O VIII lines, with the full bandpass going from ~10-50\AA. Arcus will use the silicon pore optics developed for ESA’s Athena mission, paired with off-plane gratings being developed at Pennsylvania State University and combined with MIT/Lincoln Labs CSDs. With essentially no consumables, Arcus should achieve its mission goals in under 2 years, after which we anticipate a substantial period of operation as a general observatory.

Arcus will address all of the scientific recommendations of the 2010 Decadal Survey for soft X-ray grating science in a MIDEX mission.

### Optical Design

- Arcus optical design uses 4 identical ‘petals’, each of which has 38 SPO mirror modules mounted in one ‘petal’ with 32 Off-Plane Grating (OPG) grating modules mounted in a second ‘petal’, as shown at right.
- The photons are dispersed into an arc at the focal plane, with the channels aligned so that one CCD detector array can read out photons from two channels.
- CCDs will be built by MIT/Lincoln Labs with requirements similar to the Suzaku mission.
- Uses high-throughput silicon-mesh filters similar to those used for Hitomi SXS detector.
- Overall design achieves a figure of merit for primary science requirement to detect weak absorption features from O VII, O VIII, and CVI that is nearly an order of magnitude larger than currently available with Chandra or XMM-Newton observations.

### Silicon Pore Optics (SPO)

- Arcus’ design leverages ESA’s substantial and ongoing investment in advancing SPO technology by using the same focal length and radii of curvature mirrors as Athena.
- Optical design aligns the highly asymmetric SPO PSF in order to disperse the “transverse” PSF into a spectrum, achieving the equivalent of a 1” mirror in one dimension, all that is required for a non-imaging spectroscopy mission like Arcus.
- Test data from PANTER runs shown here at right find a 1” HEW in the transverse PSF, meeting Arcus requirement.
- Further PANTER tests planned for September to test latest generation of 12m SPO mirror module from Cosine Research with a flight-like grating module.

### Off-Plane Gratings (OPGs)

- Arcus leverages NASA’s long-term investment in OPGs for Con-X, I XO, and now X-ray Surveyor.
- Flight-like gratings meeting Arcus size, efficiency, flatness, and resolution requirements have been fabricated (picture at right) with preliminary testing at NASA/MSFC’s stray light facility (see talk by R. McEntaffer at this meeting).
- Tests at NASA/MSFC stray light facility show that R=3000 can be obtained for a single grating plate.

### Arcus Spacecraft & Instrument

- Arcus uses power, telemetry, and pointing systems with high heritage. Launch into a high altitude 4.1 lunar resonant orbit will be by a Falcon 9 or similar.
- The 12m focal length is achieved with an extendable optical bench. Spacecraft will be provided by Orbital ATK based on their high heritage LEOStar platform.

### Feedback from Supermassive Black Holes

- Exploring how physics behaves at the extremes of space and time near a black hole and learning how supermassive black holes have formed and evolved requires disperse high resolution X-ray spectra of density-dependent lines. Arcus will allow us to identify features in hot gas outflow that match cooler gas detected by HST, and use their density sensitivity to measure the total mass outflow from the SMBH.

### The Birth and Evolution of Stars

- Arcus simulations (5 ksec)

### Line Detection FoM (cm)

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Arcus: Exploring the Formation and Evolution of Clusters, Galaxies, and Stars