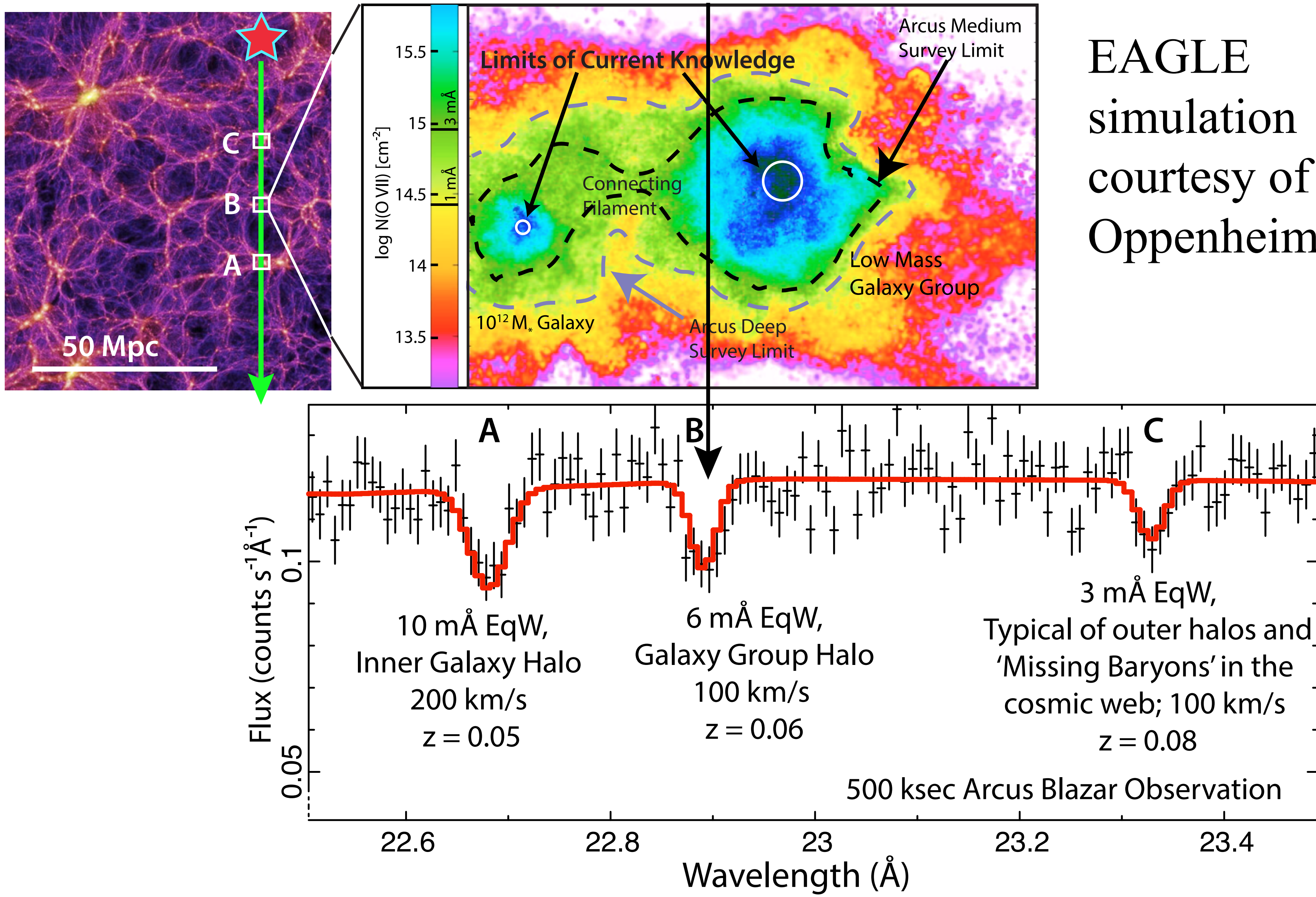
ARCUS

EXPLORING THE FORMATION AND EVOLUTION
OF CLUSTERS, GALAXIES, AND STARS

Overview

- Soft X-ray grating spectroscopy MIDEX mission
- **Science**
  - Understanding the formation and evolution of clusters of galaxies, black holes, and stars.
- **Key Parameters**
  - Effective Bandpass ~12-50Å (~0.25-1 keV)
  - $\lambda/\Delta\lambda$ (= R) > 2500 between 22-25Å (design is >3500).
  - Area = 200-400 cm^2; 300 cm^2 at O VII (21.6-28Å)
    - In the O VII band, *Chandra* HETG had <10 cm^2 at launch, <1 cm^2 today
    - (and R~1000)

Science Goal #1: Structure Formation



EAGLE simulation courtesy of Ben Oppenheimer

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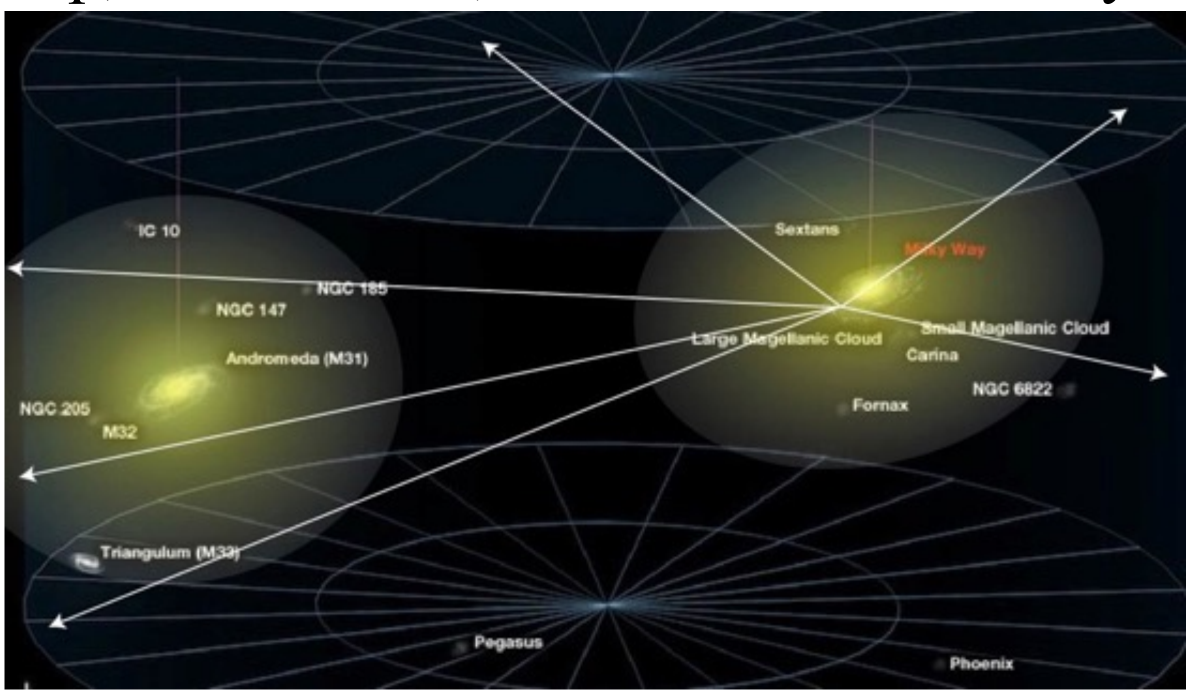
Science Goal #1: Structure Formation

X-Ray Absorption in the Milky Way, M31, and "Local Group"

- Every extragalactic sight line probes our Galaxy's hot halo
  - Arcus will obtain density, temperature, mass distribution, and shape
- M31 (6 sight lines within 200 kpc; 2 near M33)
  - Differentiated by velocity from the MW
- Local Group, if detectable, has a different velocity than MW



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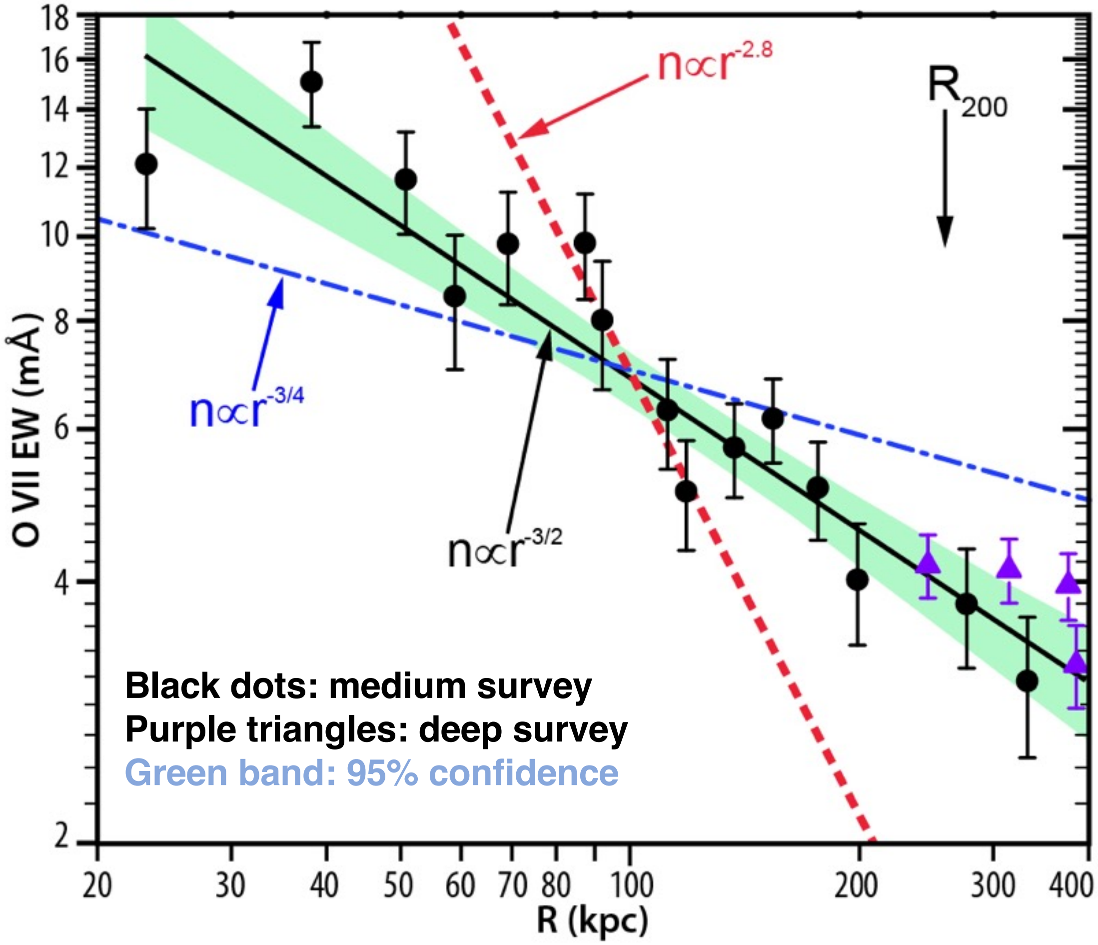
Science Goal #1: Galaxy Halos



Arcus will measure the slope of average radial density distribution to beyond R_{200}.

- Galaxy halos contain most of the "normal" material in the Universe
- Arcus will determine shape, size of galaxy halos not possible to measure any other way
- Halo gas could follow dark matter distribution ($n \sim r^{-2.8}$); or distribution inferred from r<50 kpc of galaxy ($n \sim r^{-3/2}$); or distribution where baryons are within R_{200} ($n \sim r^{-3/4}$)

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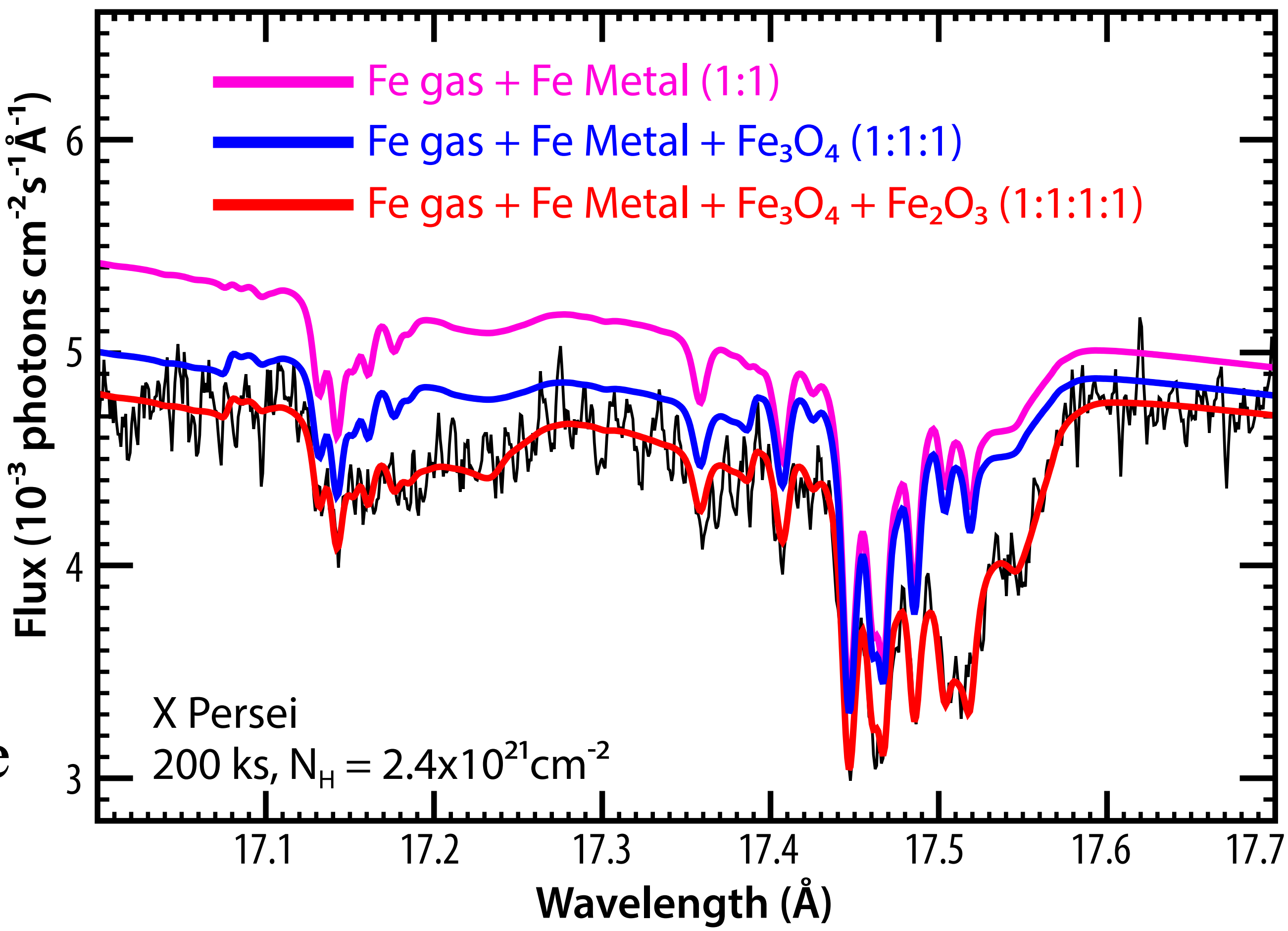
X-rays and CMB polarization…

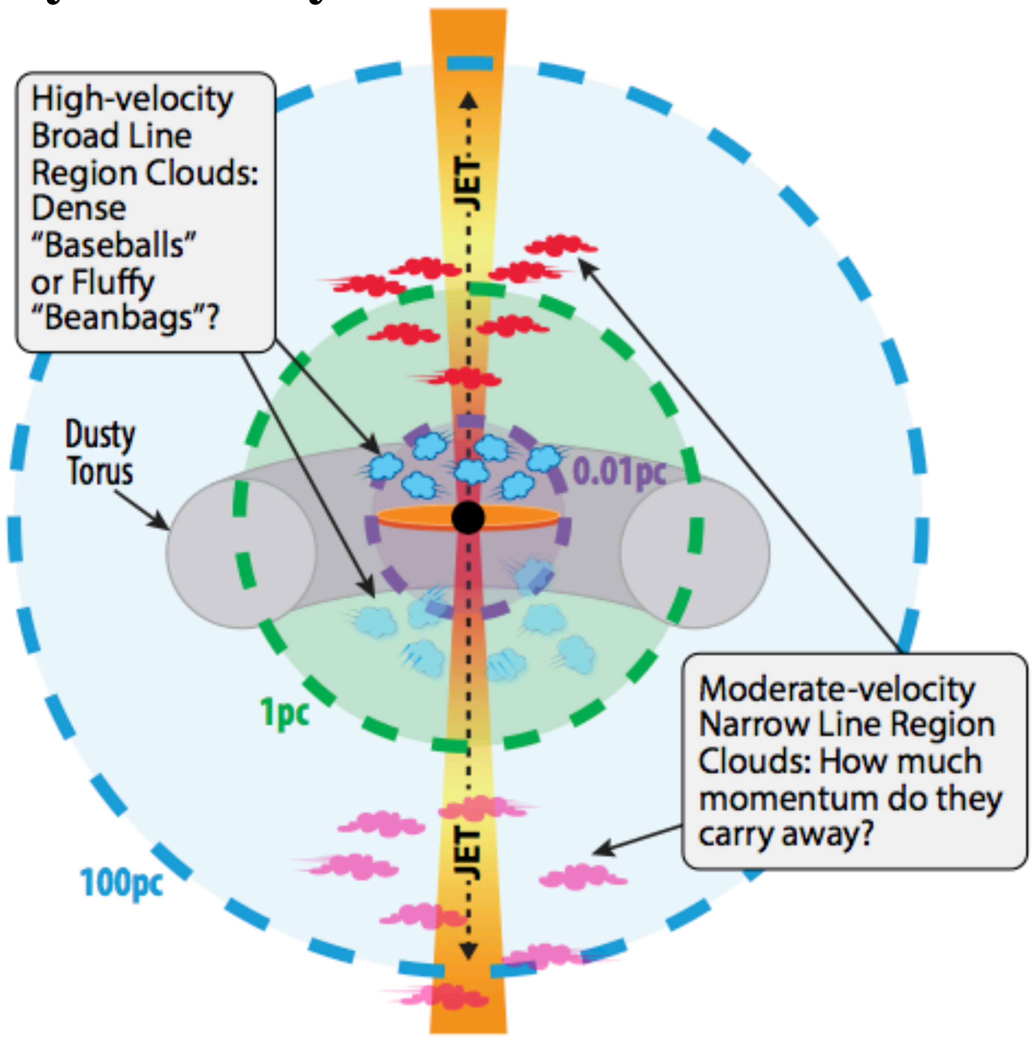
The Cosmic Microwave Background has a dusty 'foreground,' that depends on the presence of magnetic inclusions. The expected polarized dust emission can increase by 4 × in the microwave band depending on whether the magnetic inclusions are Fe_2O_3, Fe_3O_4, or metallic Fe – which *Arcus* can measure easily.



Science Goal #2: SMBH Feedback

The bulk of outflowing material in AGN winds is highly ionized and accessible only in X-rays.

- *Arcus* will measure wind momentum by tracking the response time of the wind properties to changes in the continuum on timescales from 10 ks to 10 Ms.
- Breaks degeneracy between the density of the outflowing wind and its launching radius.
- Important implications for the role of AGN feedback in shaping host galaxies.



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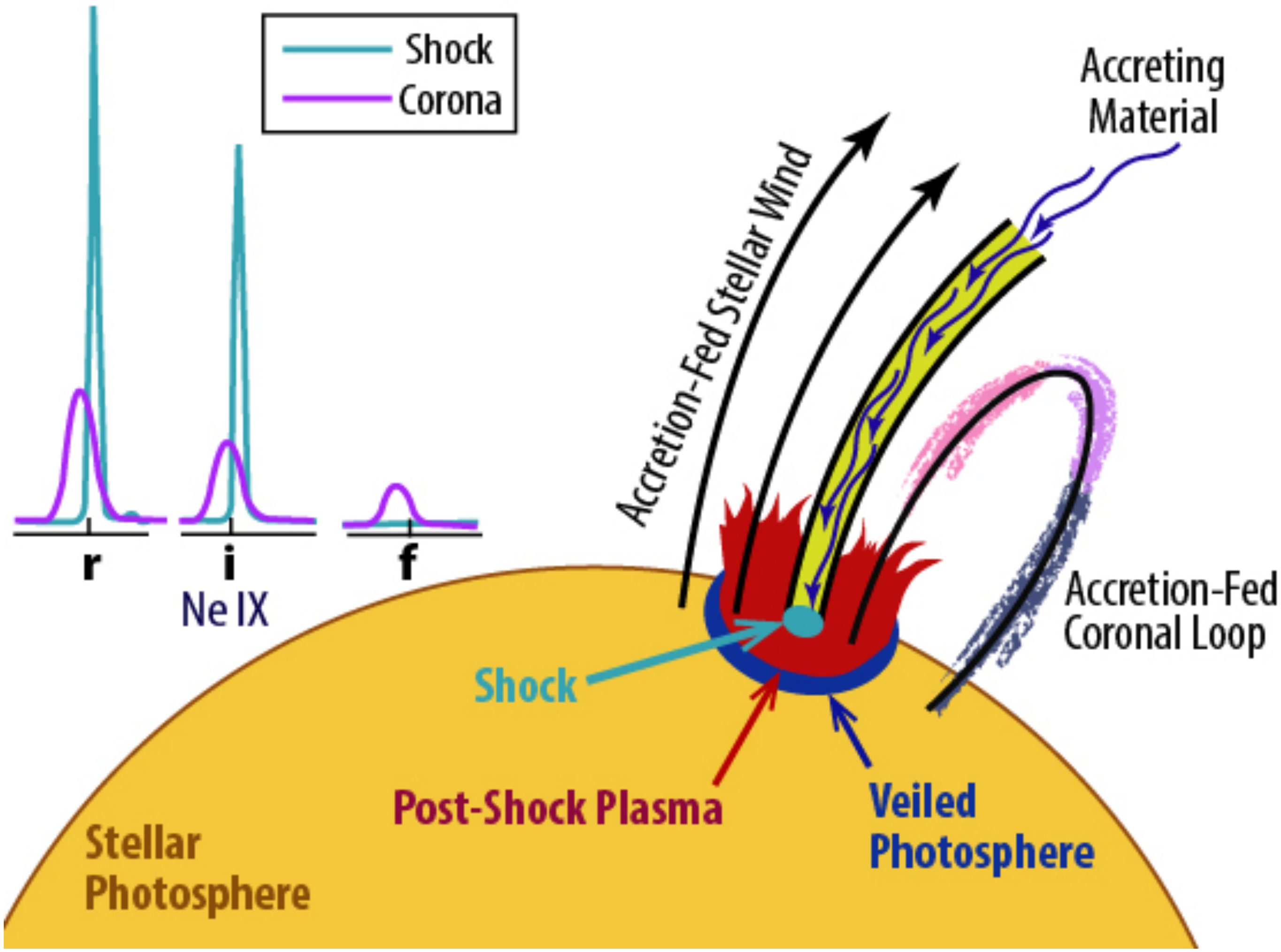
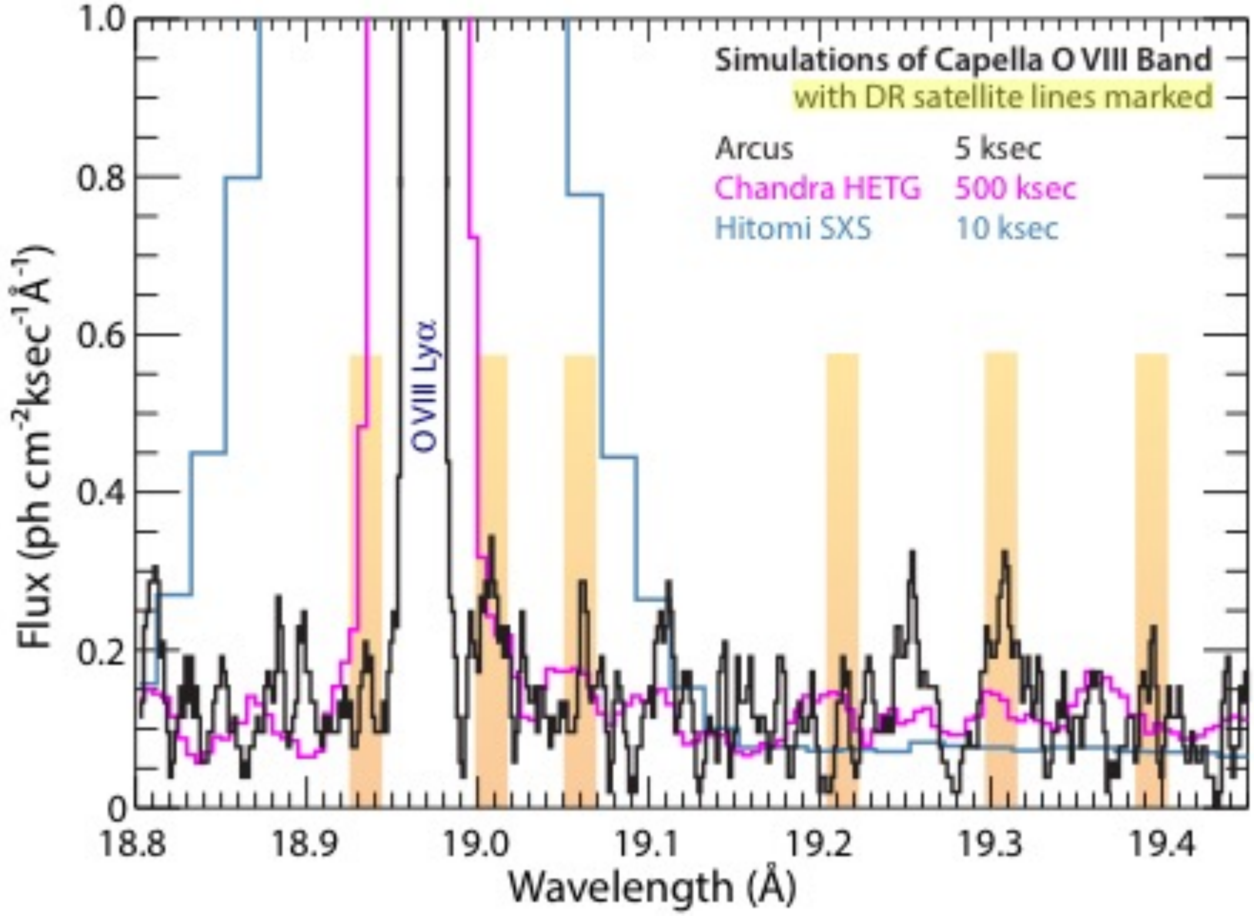
Science Goal #3: Stars & Stellar Formation

Arcus differentiates between the distinct line signatures produced by accretion shocks near the surface vs. those from coronal emission, revealing the origin of the accretion flow. We will map the density, absorbing column, shock velocity and turbulence using the He-like ion line diagnostics.



Science Goal #3: Stars & Stellar Formation

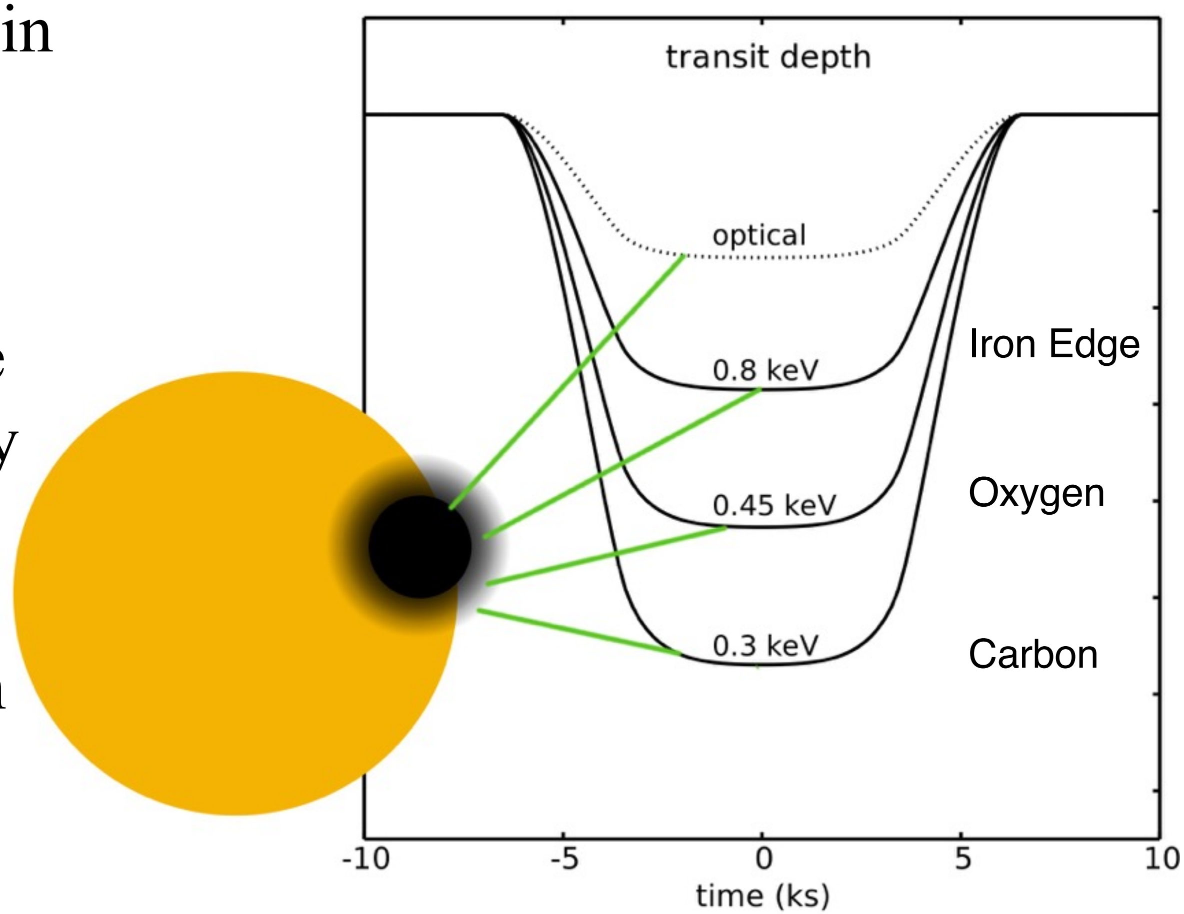
Testing coronal heating models using temperature-sensitive dielectronic recombination (DR) lines. A 5ks *Arcus* observation will identify these lines; longer observations capture the changes in the dynamic coronal environment.



Chandra's HETG is limited by both resolution and throughput, and a microcalorimeter like Hitomi or XARM cannot resolve the features.

Arcus & Exoplanets

- Low-altitude exoplanet atmospheres are accessible in the Opt/IR
- *Arcus* will directly measure the thermal profile and can infer the composition of the high-altitude outer layers by exploiting the energy-dependent transmission of different elemental edges in soft X-rays.
- The upper atmosphere and exosphere of one such exoplanet, HD 189733b, have been detected with *Chandra*.



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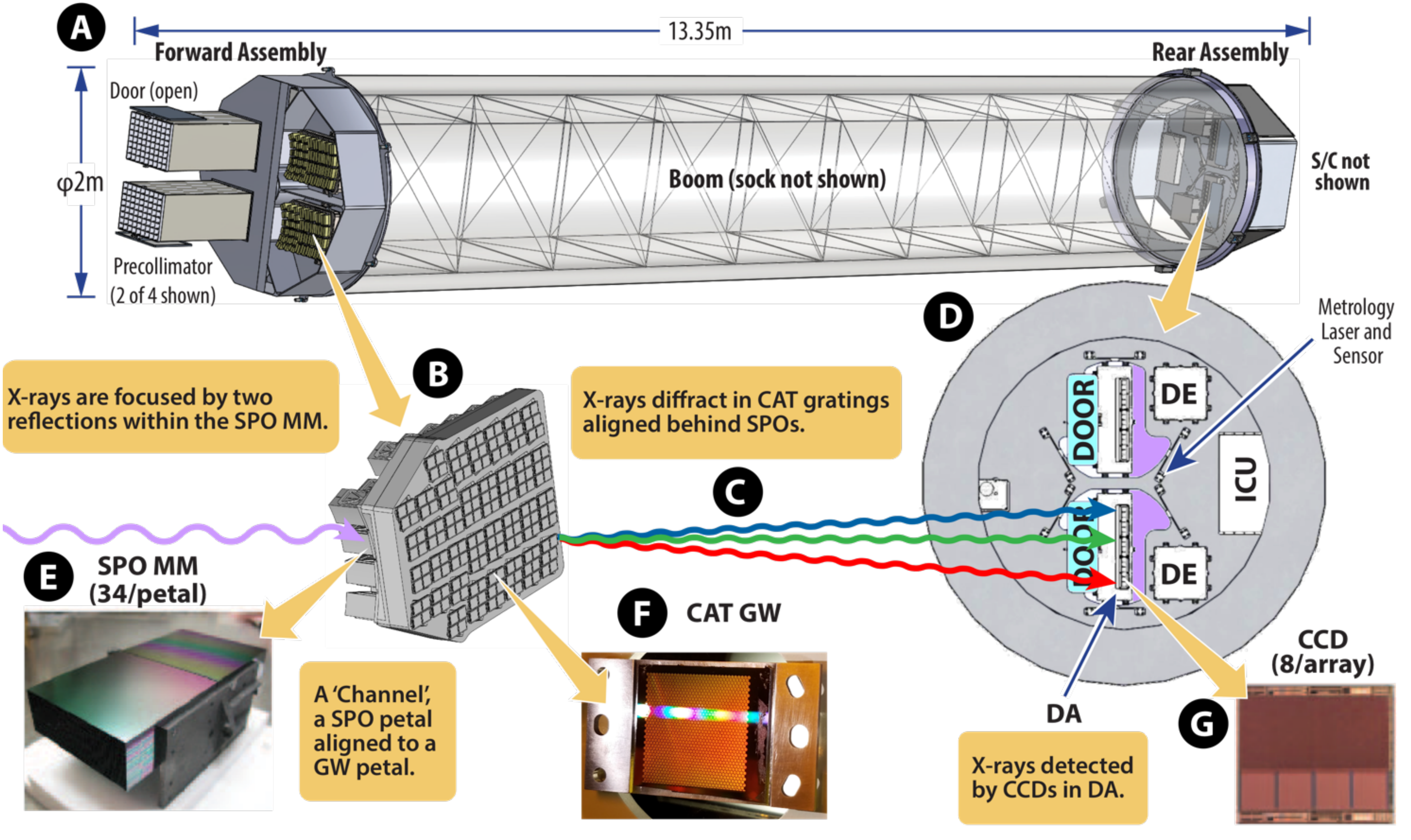
Schematic Overview



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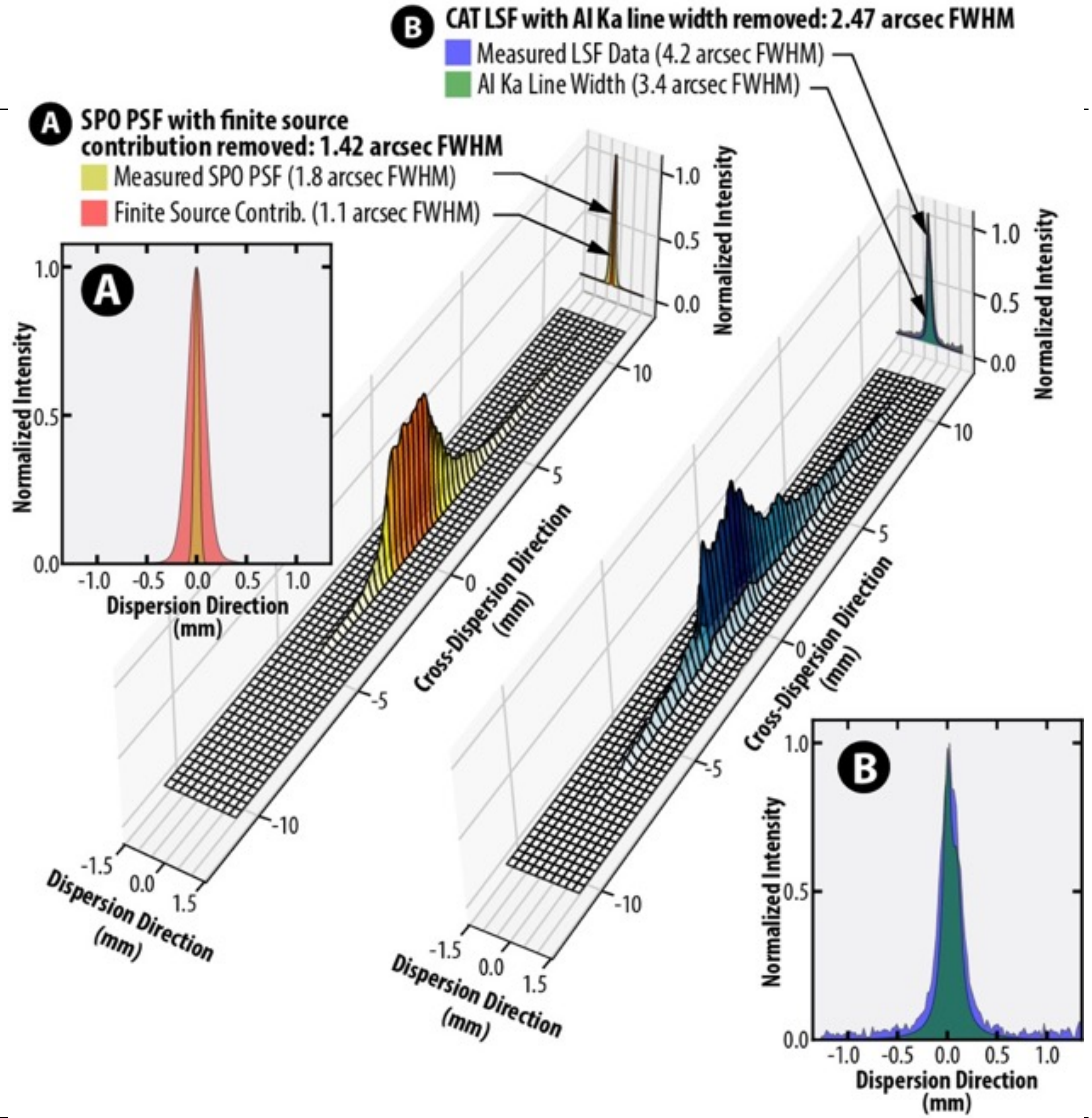
Measurements

Same focal length and optics tech as ESA's Athena mission

X-ray tests of silicon pore optics (SPOs) and Critical-Angle Transmission (CAT) gratings show they already meet *Arcus* requirements



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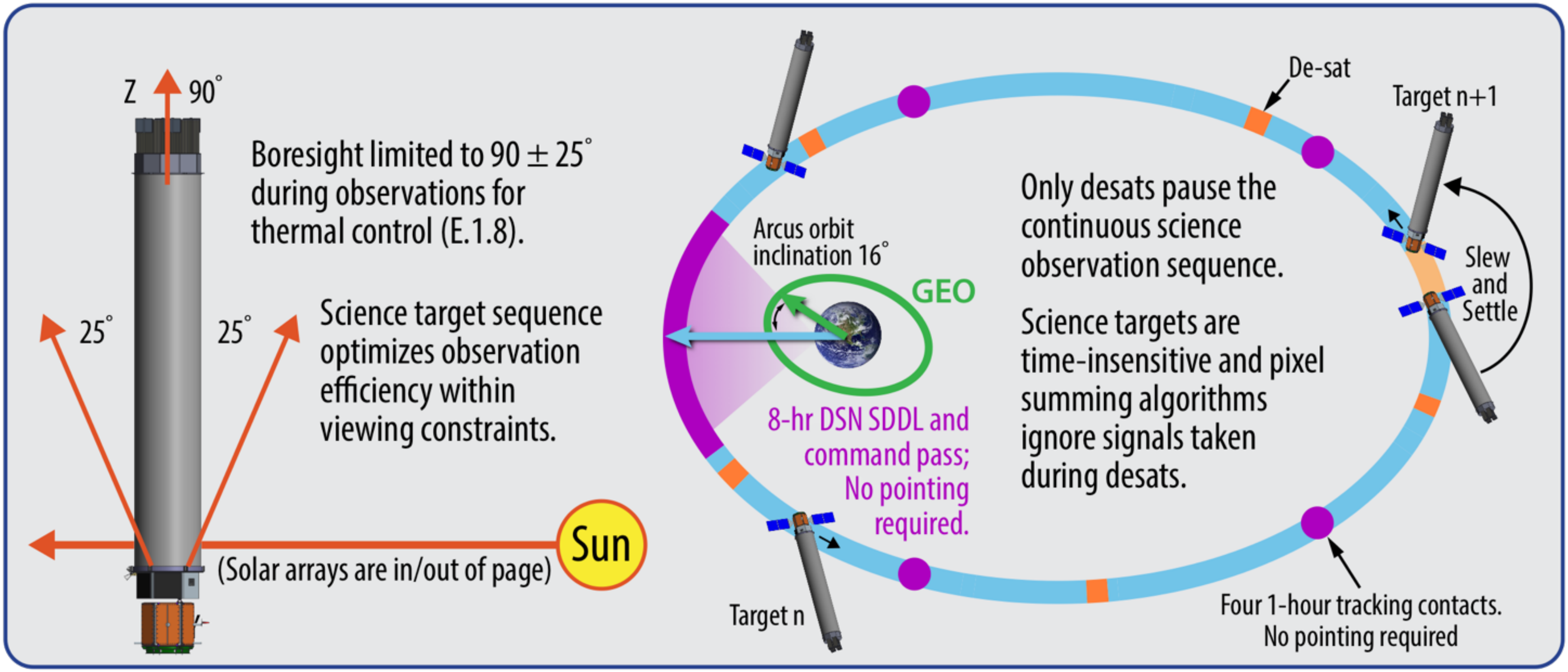
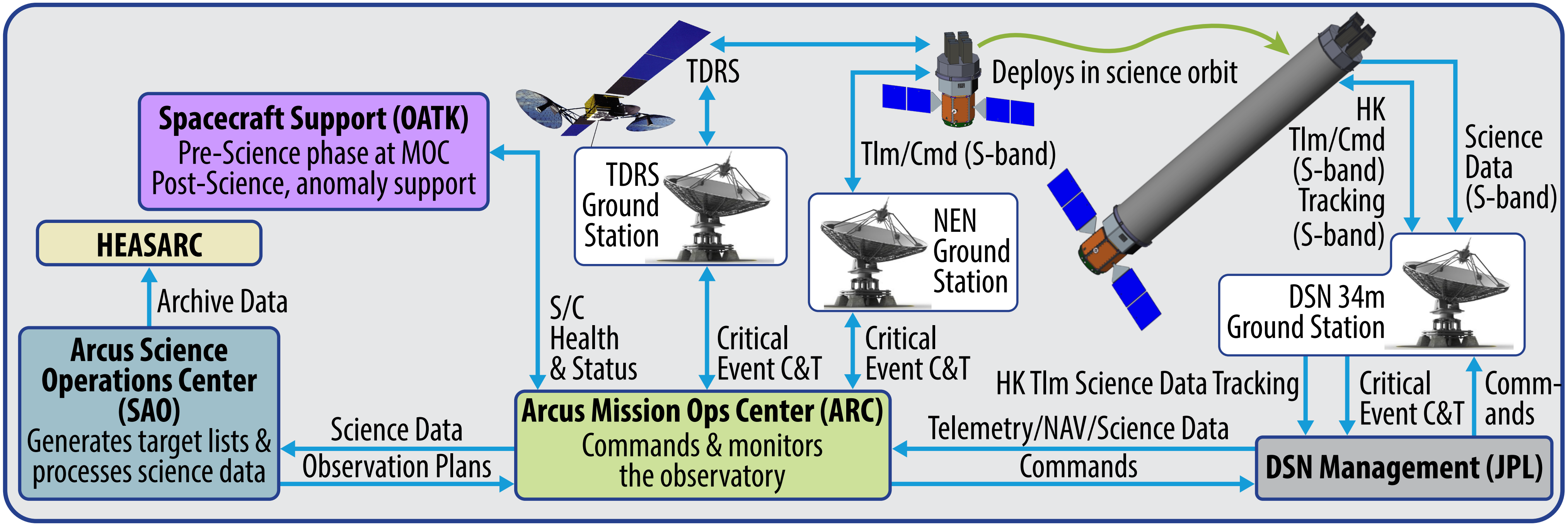
Mission - Orbit



Lunar resonant orbit offers infrequent eclipses, a stable thermal environment, and long-term orbit stability that enables simple operations.

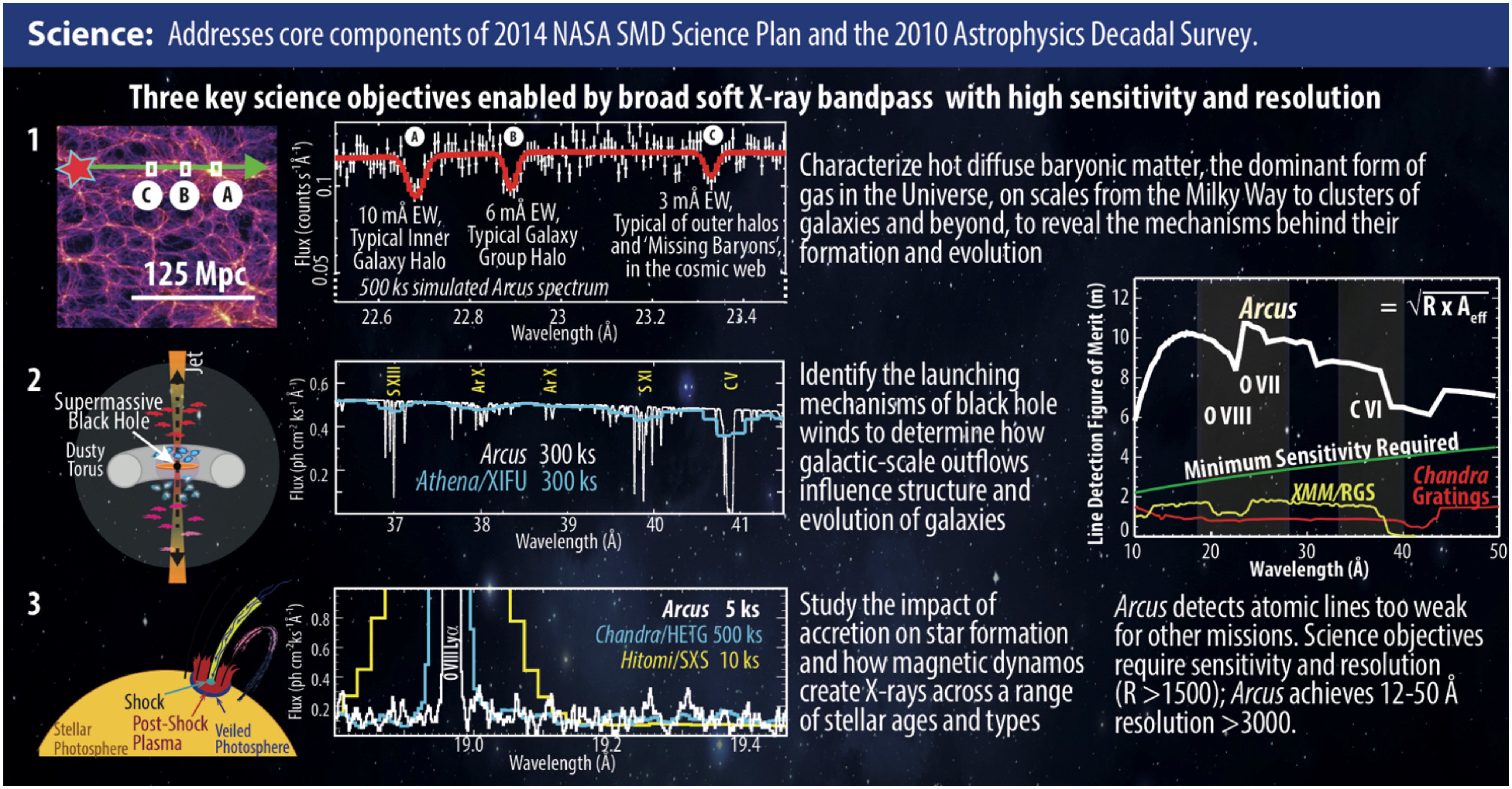
Science Orbit Parameters	Value
Perigee Altitude	11 Re
Apogee Altitude	35 Re
Inclination	16 degrees
Orbital Period	6.85 days (0.59 Msec)
Maximum Eclipse	4.5 hours

Operations



- Arcus uses a mission operation architecture with substantial heritage throughout all mission phases.
- Data will be processed at Smithsonian Astrophysical Observatory and put into an archive (HEASARC) available to anyone.
- All observations will be available within 3 months of completion.

Arcus in Summary (arcusxray.org)



Arcus Team Members

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