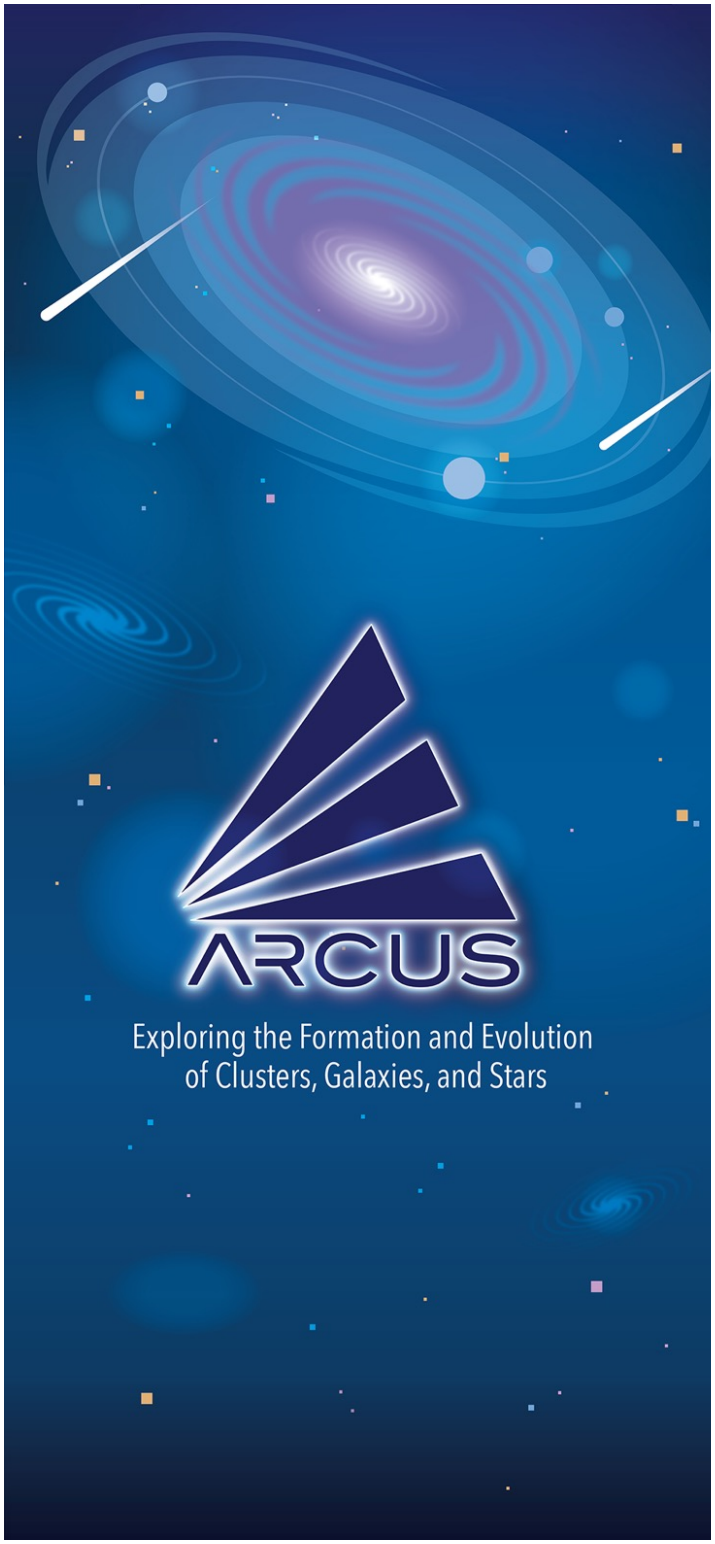


The Arcus Probe Mission

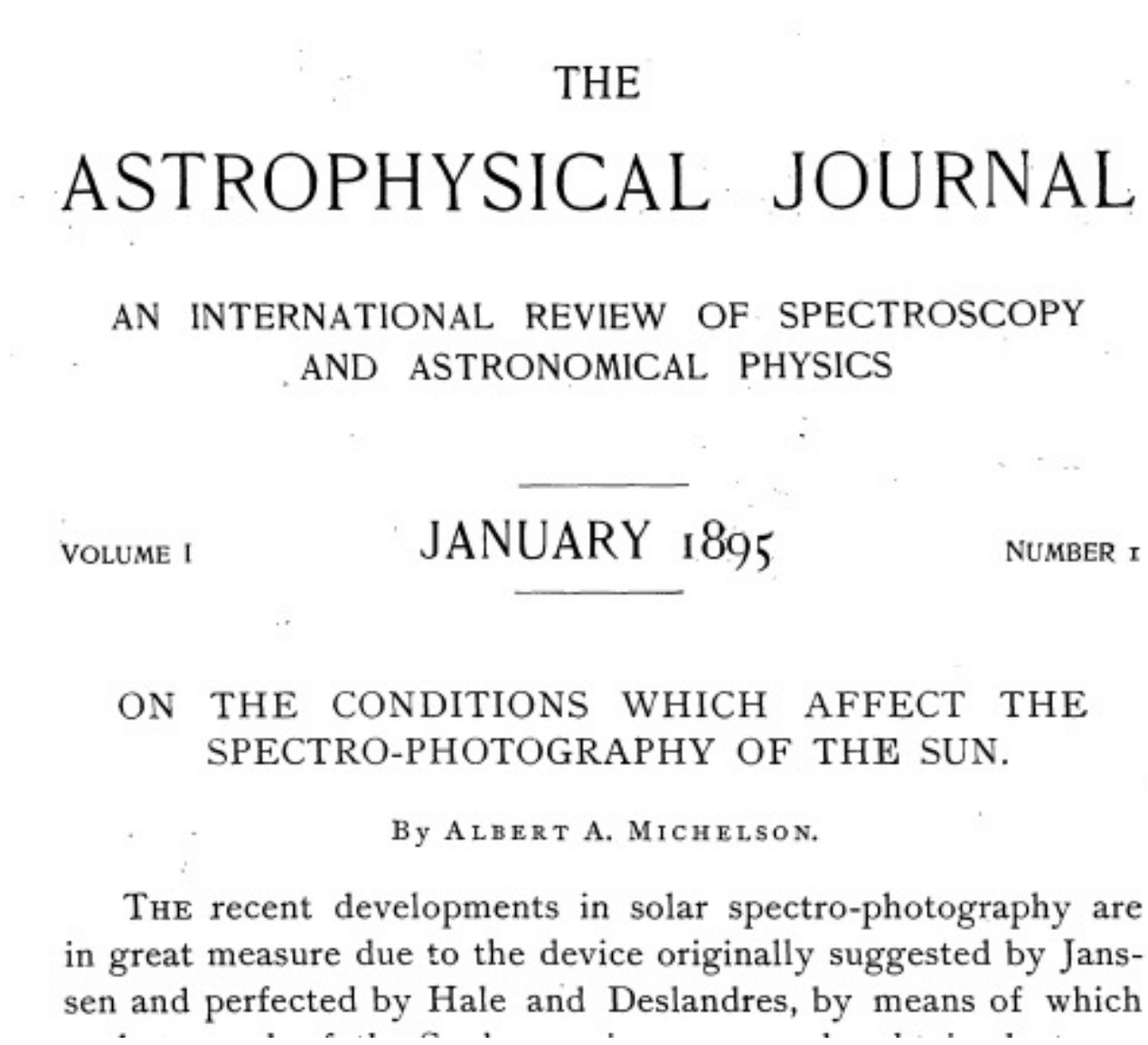
High-resolution FUV and X-ray Spectroscopy

Randall Smith

for the Arcus Team

www.arcusxray.org

Astro2020 and UV/X-ray Spectroscopy



THE

ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

VOLUME I JANUARY 1895 NUMBER 1

ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

By Albert A. Michelson.

The recent developments in solar spectro-photography are in great measure due to the device originally suggested by Janssen and perfected by Hale and Deslandres, by means of which

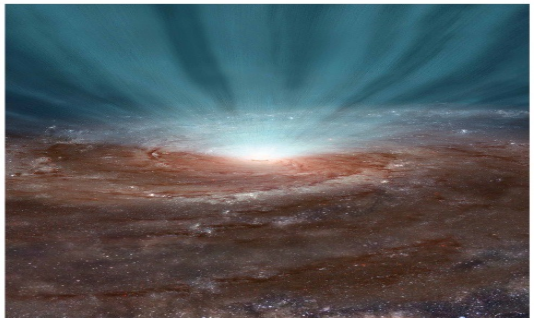
"Astronomy became astrophysics with the first spectrum. Spectroscopy determines compositions, magnetic field strength, space motion, rotation… and other important physical traits. ***In the next decade, spectroscopy will be the dominant discovery tool for astronomy****."*

–Astro2020 Decadal

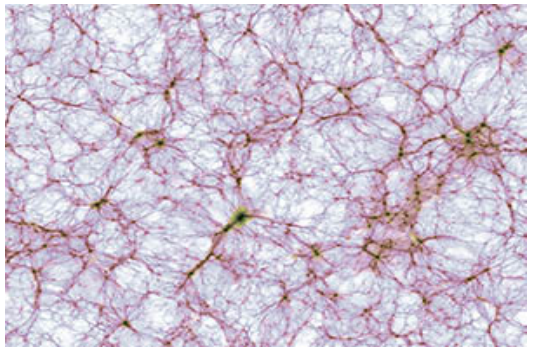
The Arcus Probe Mission – PI Randall Smith

Simultaneous, high-resolution FUV and X-ray spectroscopy

Reveal how black holes impact their surroundings



Find the Universe's missing baryons and metals



Trace the birth, life, and death of stars and stellar systems

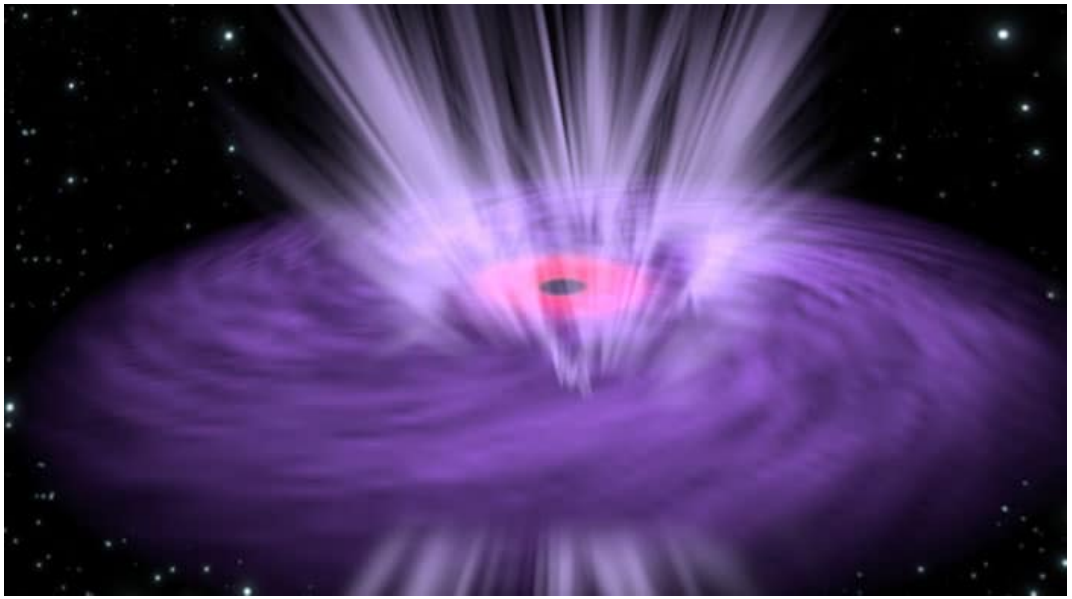
Arcus addresses a broad range of key astrophysics challenges prioritized by Astro2020.

Basic Capabilities of Arcus Probe

- X-ray Spectrometer (XRT)
  - 10-50Å Bandpass
  - Resolution 2500 across the entire bandpass
  - Average Effective area: > 300 cm^2
    - Compare to Chandra HETG @ O VII of < 10 cm^2
- FUV Spectrometer (TAUS)
  - 1020-1560Å Bandpass (O VI through C IV)
  - Resolution 17,000 at 1020Å (O VI)
  - Sensitivity of S/N = 10 in 100 ks w/ $2x10^{-15}$ erg/s/cm^2/Å
    - Compared to FUSE, 10x more sensitive
- Mission
  - All observations simultaneous and co-aligned
  - ToOs with 4 hour response time
  - 7 day Lunar Resonant Orbit, similar to TESS (which is 14 day)

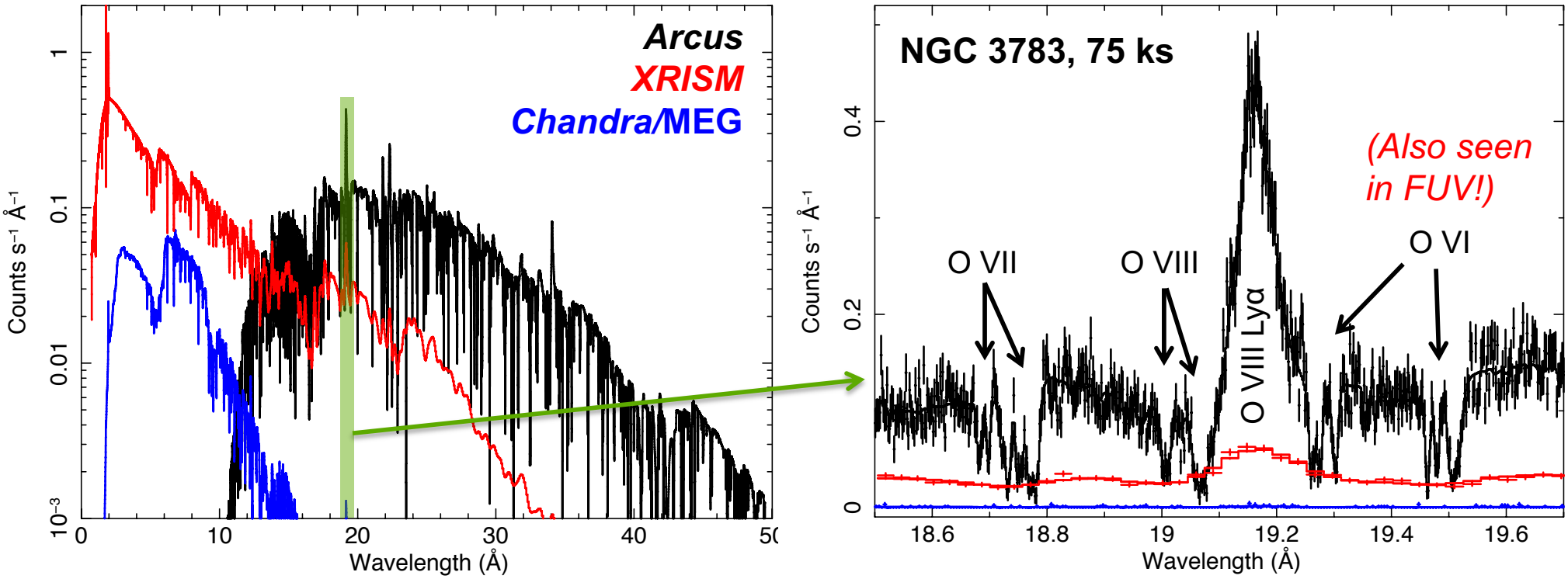
Supermassive Black Hole Outflows

"[T]he understanding of how AGN spectra… and winds vary with luminosity, black hole mass, black hole spin, and perhaps other properties is rudimentary. This currently is a major bottleneck in understanding the evolution of galaxies. **Higher sensitivity and spectral resolution optical-UV and X-ray spectroscopy** of broad emission and absorption line outflows from AGN are needed…."



Astro2020 Decadal

Example X-ray/FUV Synergistic Science: Active Galactic Nuclei (AGN)

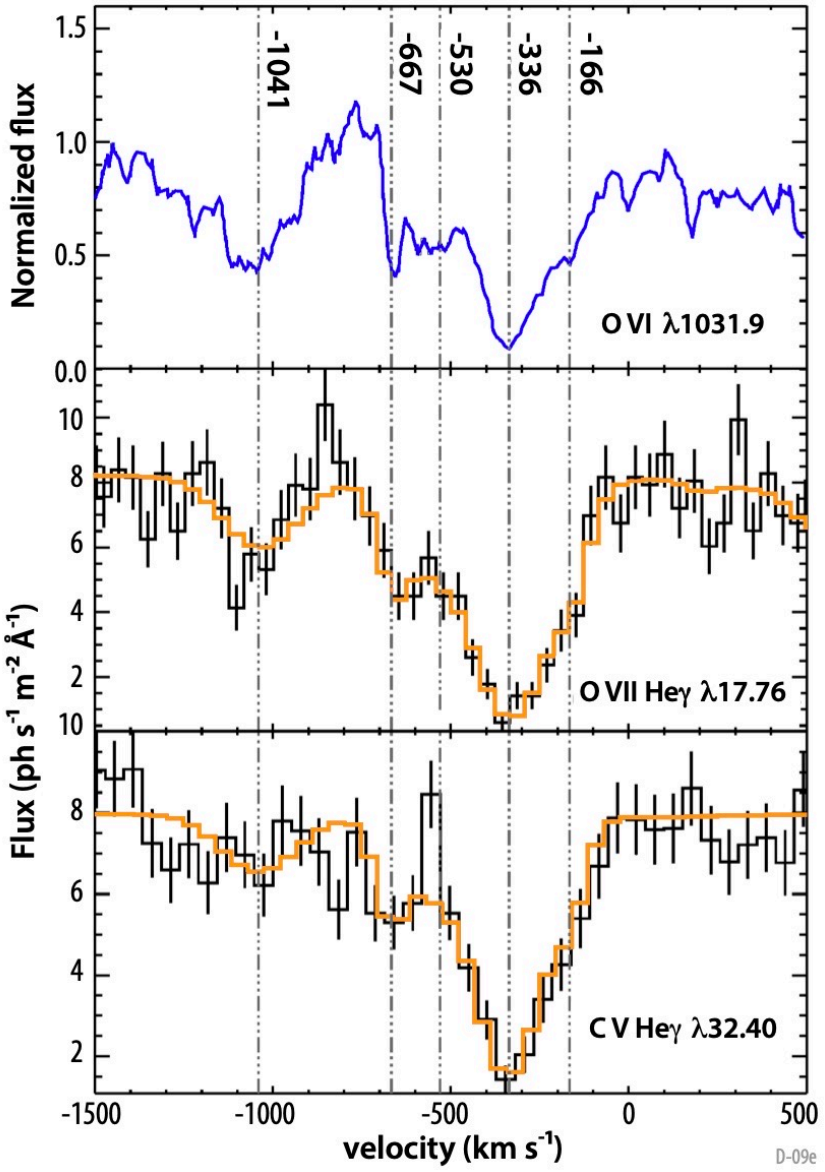


Arcus provides 100x improvement in sensitivity across the 10-50 Å bandpass; even better than μCalorimeters at these wavelengths. The AGN Broad Survey will observe 100+ AGN deeper than the best existing data; other surveys will go far deeper.

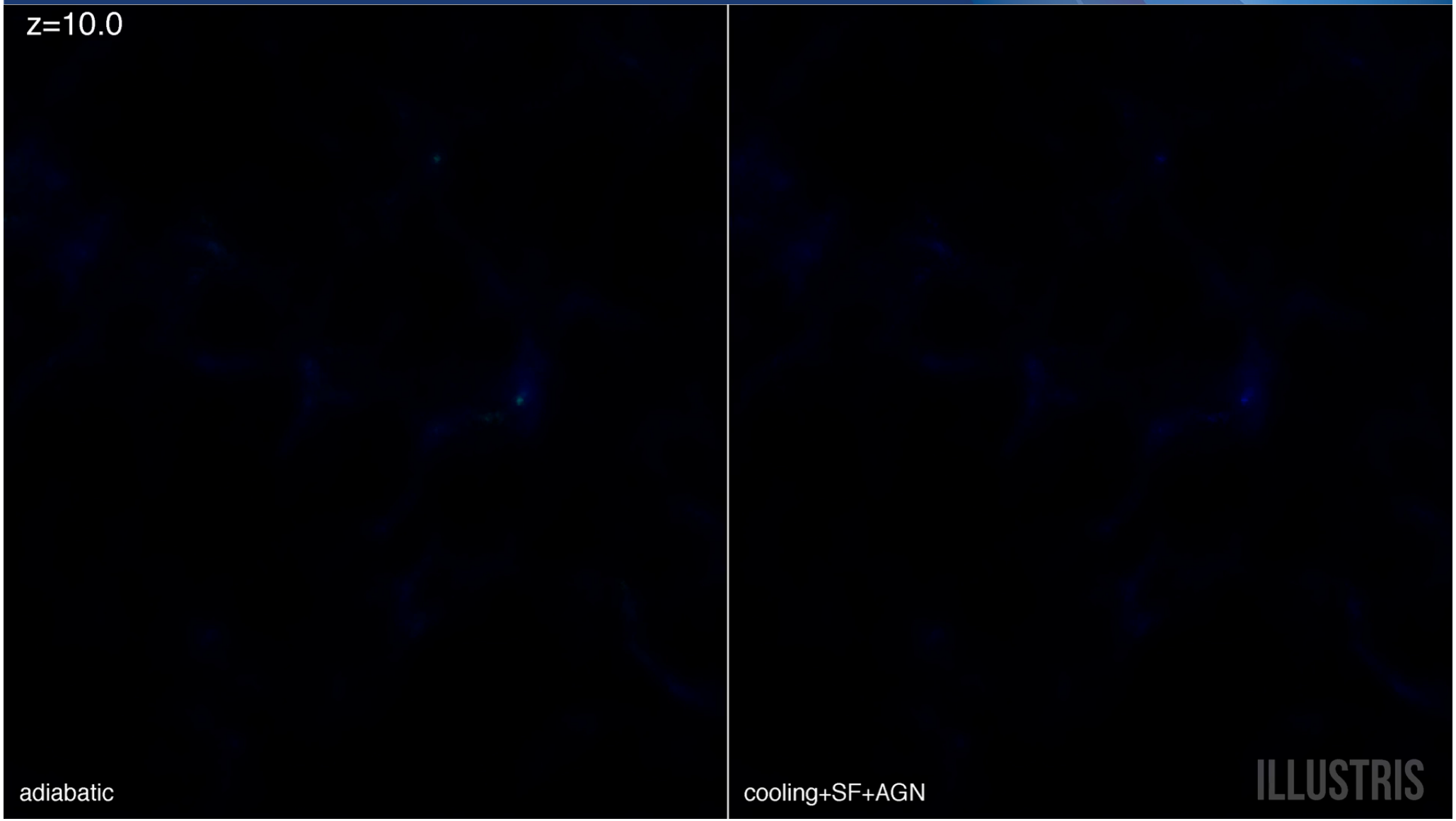
Arcus is the only mission capable of providing revolutionary spectral diagnostics simultaneously in the 10-50 Å and FUV bandpasses.

Example X-ray/FUV Synergistic Science: Active Galactic Nuclei (AGN)

- *Chandra* and *XMM-Newton* gratings observations have made important progress toward understanding the mass and energy carried into the ISM/IGM by AGN outflows.
- However, these data lack the sensitivity and resolution to accurately constrain launch radii and reveal mass outflow rates and kinetic power.
- *Arcus's* leap in sensitivity and resolution will transform our understanding of wind feedback from AGN. Arcus will provide a set of unparalleled soft X-ray and FUV spectra that can be directly compared with new IR and sub-mm spectra, test unified models of AGN appearance, and connect AGN feedback from 0.01 pc to kpc scales.

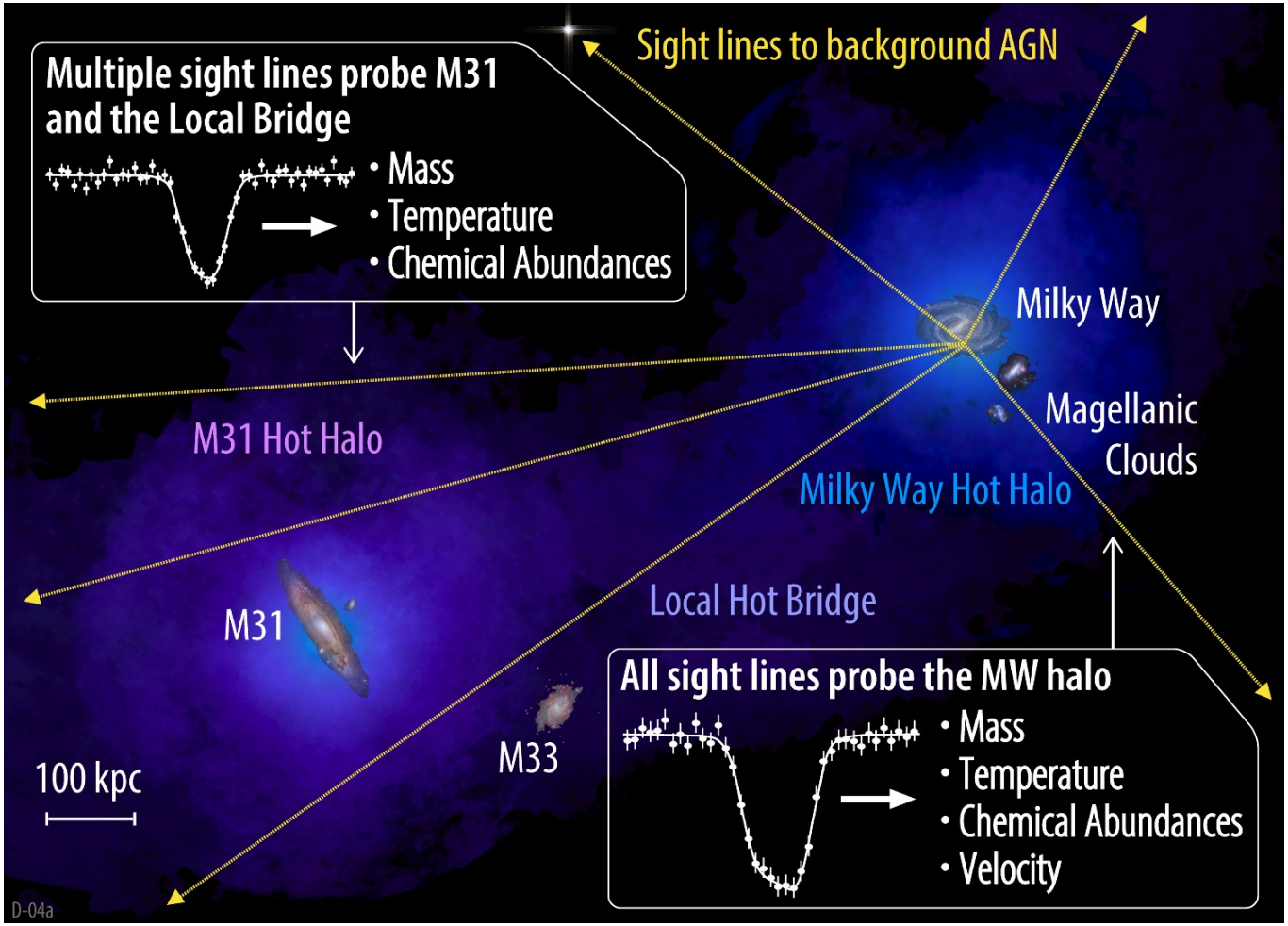


How does multi-scale feedback shape the evolution of structure in the Universe?



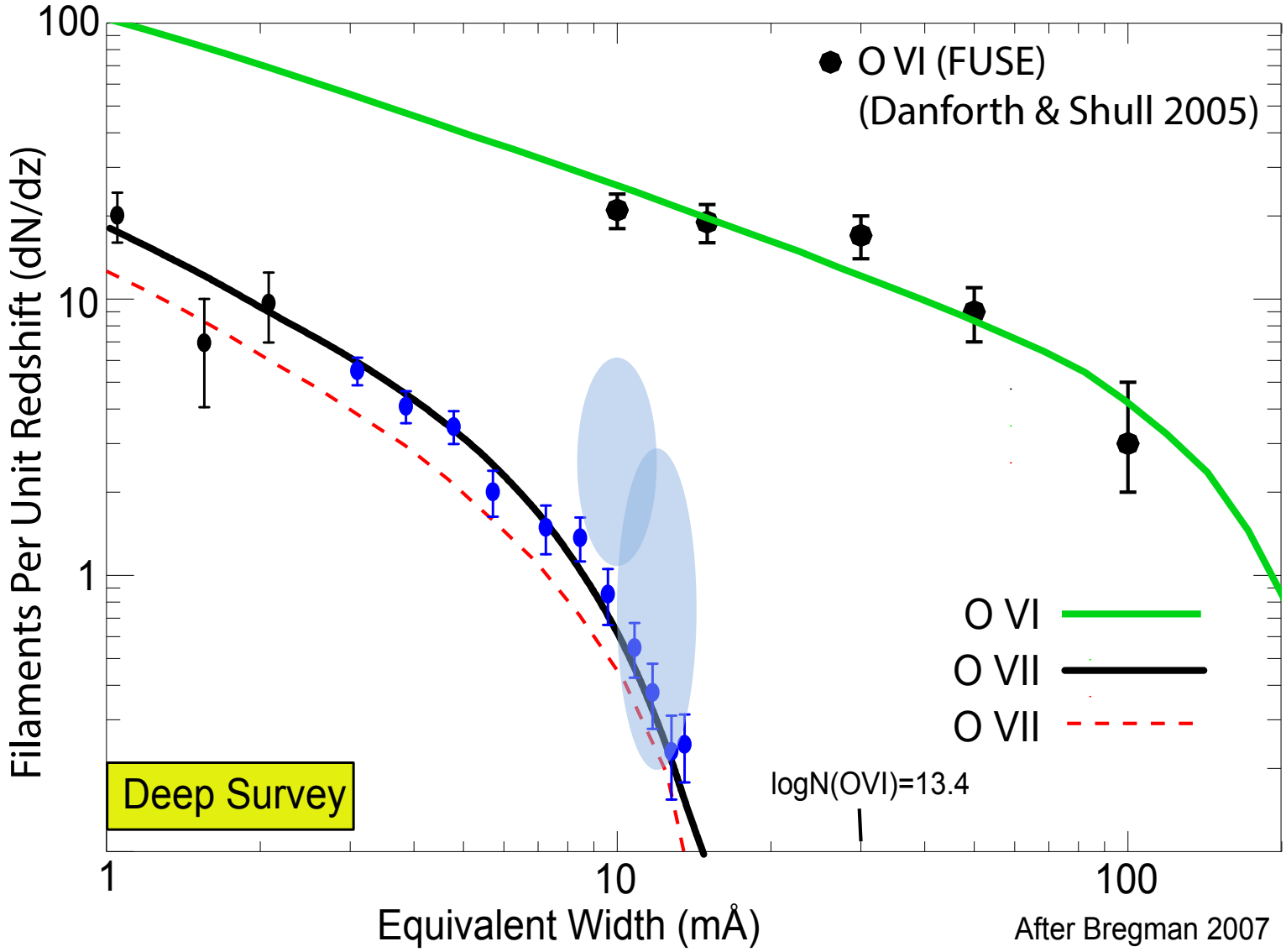
Arcus surveys hot gas in the Universe

- Arcus will observe 100+ lines of sight towards bright AGN, using them as backlights to detect hot and warm gas in the foreground IGM and galactic halos.
- Observations of halos in lines of H Lyβ w/ O VI, O VII, and O VIII (& C, N ions) will reveal the temperature, density, metallicity and dynamics of the tenuous cosmic web.



Arcus data will provide the first true census of baryons and metals in the Universe.

Example X-ray/FUV Synergistic Science: Warm-Hot Intergalactic Medium (WHIM)

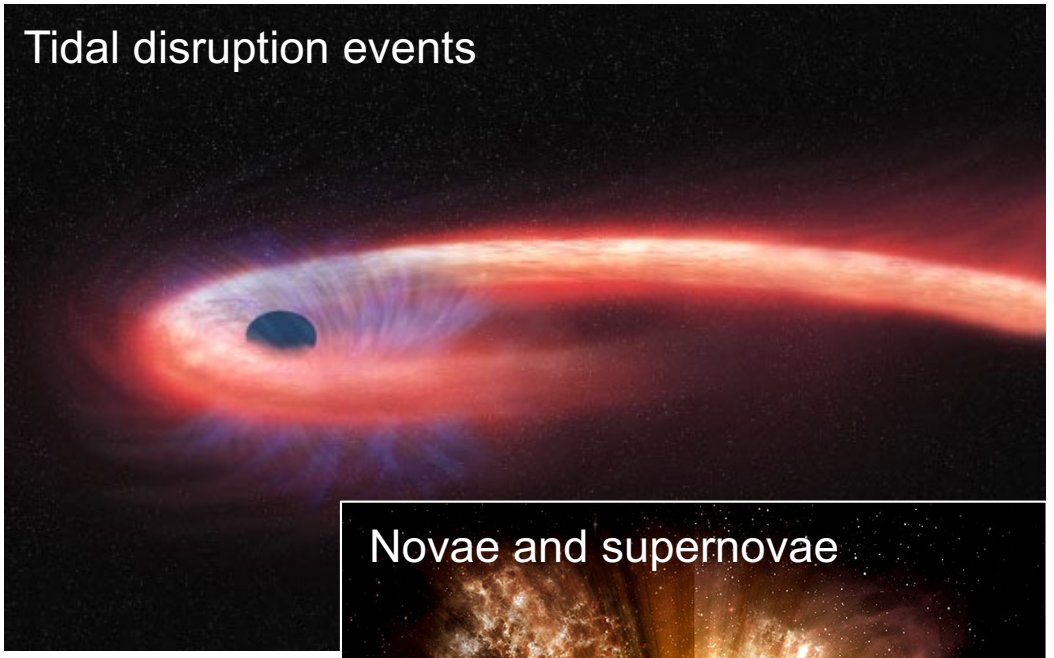


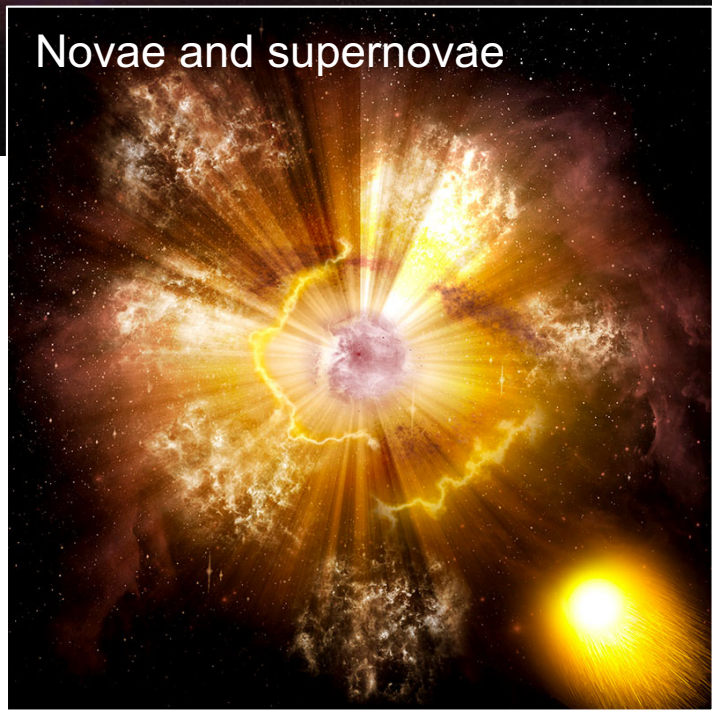
Time Domain Science with Arcus Probe

Astro2020 New Messengers and New Physics Priority Area:

New Windows on the Dynamic Universe

"[T]he study of neutron stars, white dwarfs, collisions of black holes, and stellar explosions using the complementary perspectives provided by the wide range of messengers from light in all its forms from radio to gamma rays, gravitational waves, neutrinos, and high-energy particles." This requires "A suite of small and medium-scale ground and space-based observational facilities across the electromagnetic spectrum to discover and characterize the brightness and spectra of transient sources as they appear and fade away."





Transient Science with UV/X-ray Spectroscopy

- Supernovae – Type II SNe shocks reveal the late-phase stellar wind in a way no other observation can, if we can get on w/in 12-24 hours.
- Stellar flares / Exoplanet atmospheres – Especially in the FUV, may have huge impact on evolution of exoplanets.
- Gamma-Ray Bursts – Will expand halo gas background source population, need response w/in ~2 hours.
- Galactic Sources: Novae, Black hole outbursts, XRB Type 1 & 2 bursts
- Gravitational wave sources (LIGO *and* LISA) – Timelines TBD
- Longer timelines: Tidal Disruption Events, Changing-look quasars, Solar-system planets & comets seen in sunlight & solar wind charge exchange

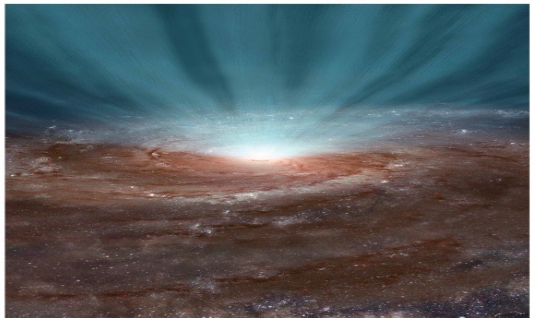
Arcus will follow up detections of transient sources in any waveband, providing unparalleled FUV/X-ray spectroscopy for a huge range of source types from the solar system to the early Universe.

The Arcus Probe Mission – PI Randall Smith

Simultaneous, high-resolution FUV and X-ray spectroscopy

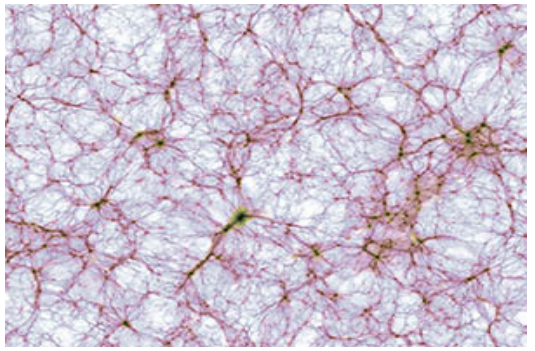
Reveal how black holes impact their surroundings

Measure the mass, energy, and composition of outflowing winds driving feedback from the inner regions of supermassive black holes.



Find the Universe's missing baryons and metals

Measure the spatial and temperature distribution of hot gas at and beyond the virial radii of galaxies and clusters, and the distribution and metal abundance of all phases of gas in our Galaxy's disk.



Trace the birth, life, and death of stars and stellar systems

Measure the thermodynamic properties of hot gas in stellar magnetic structures and shocks; measure outer radial density profiles of exoplanet atmospheres.

Arcus addresses a broad range of key astrophysics challenges prioritized by Astro2020.