

X-ray grating spectroscopy as a mission enhancement

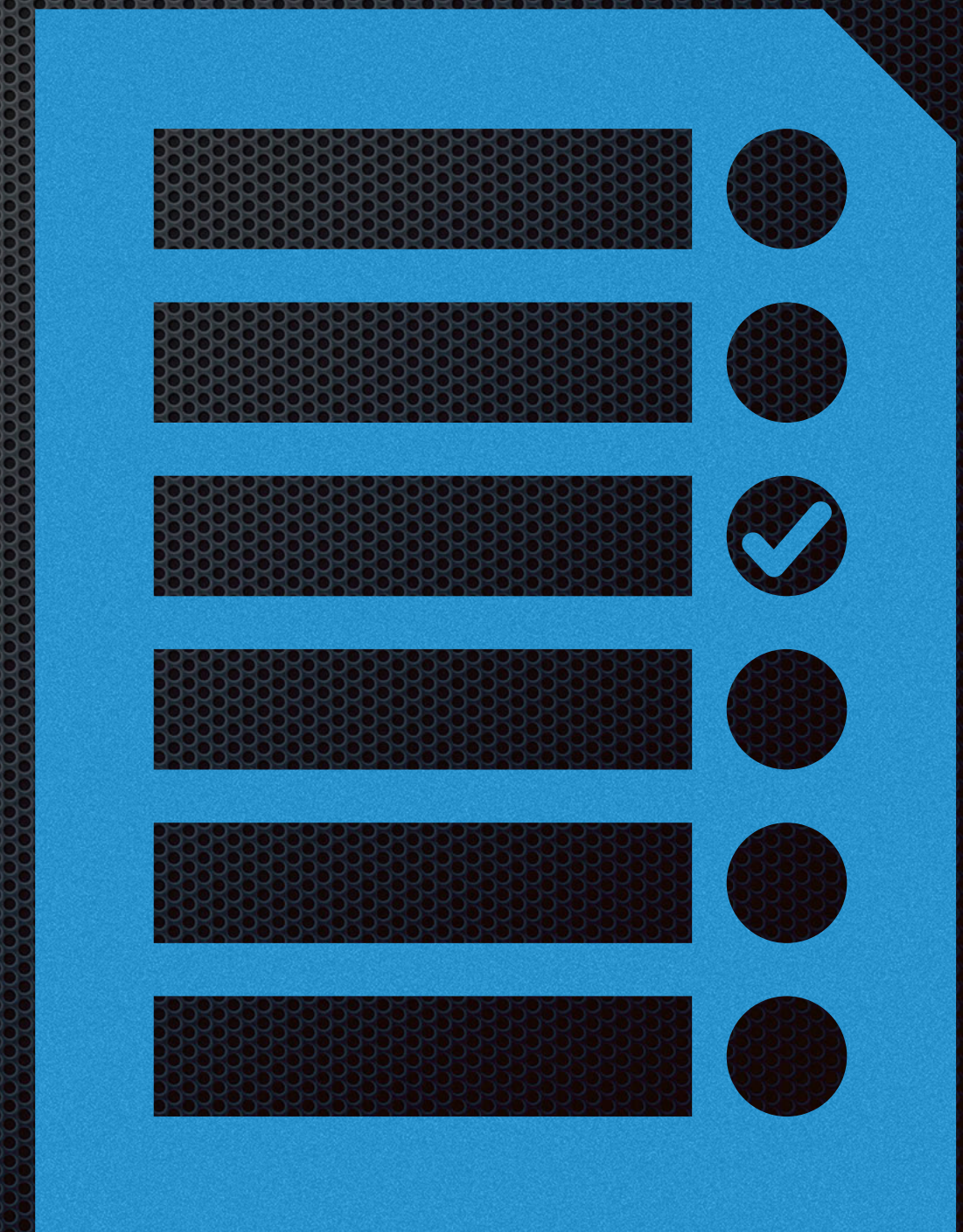
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Mission enhancement

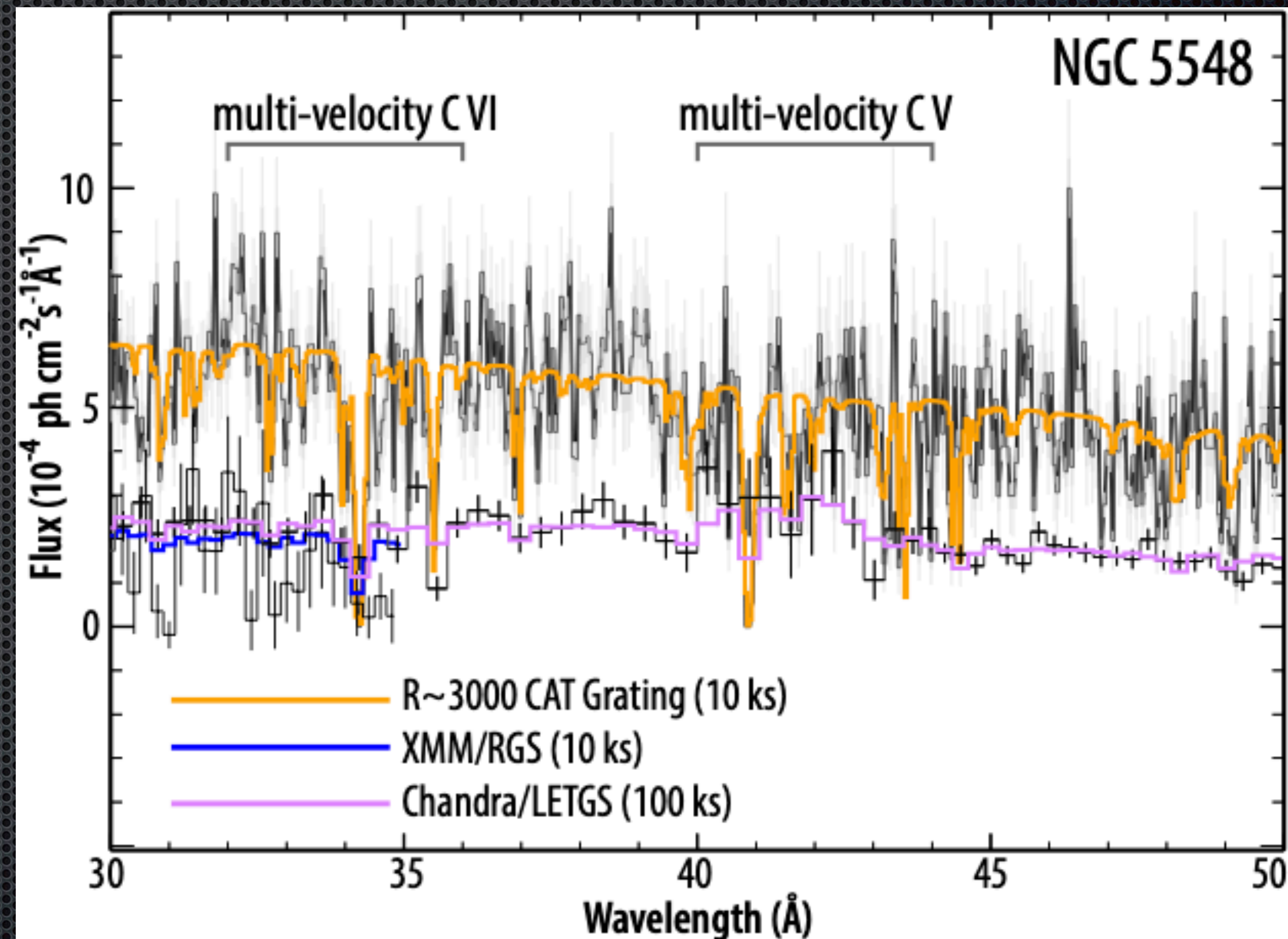
Add instruments to (almost) any X-ray imager

- Soft (10 - 40 Å = 0.2-1 keV) X-ray grating spectrometer ($R > 3000$)
- UV grating spectrometer
(e.g. 1200-2500 Å; $R=10,000-100,000$)
- UV imager



Science: Drivers of galaxy growth

- ✦ AGN wind feedback
- ✦ Missing baryons ($K\alpha$ absorption of C, N, O: The elements of life)
- ✦ Galaxy halos (O VII and O VIII absorption line profiles)
- ✦ Resolve absorption lines:
X-ray: $R > 3000$, UV: $R > 10000$
- ✦ Collect signal in one dynamic time:
Effective area $>$ a few Chandra



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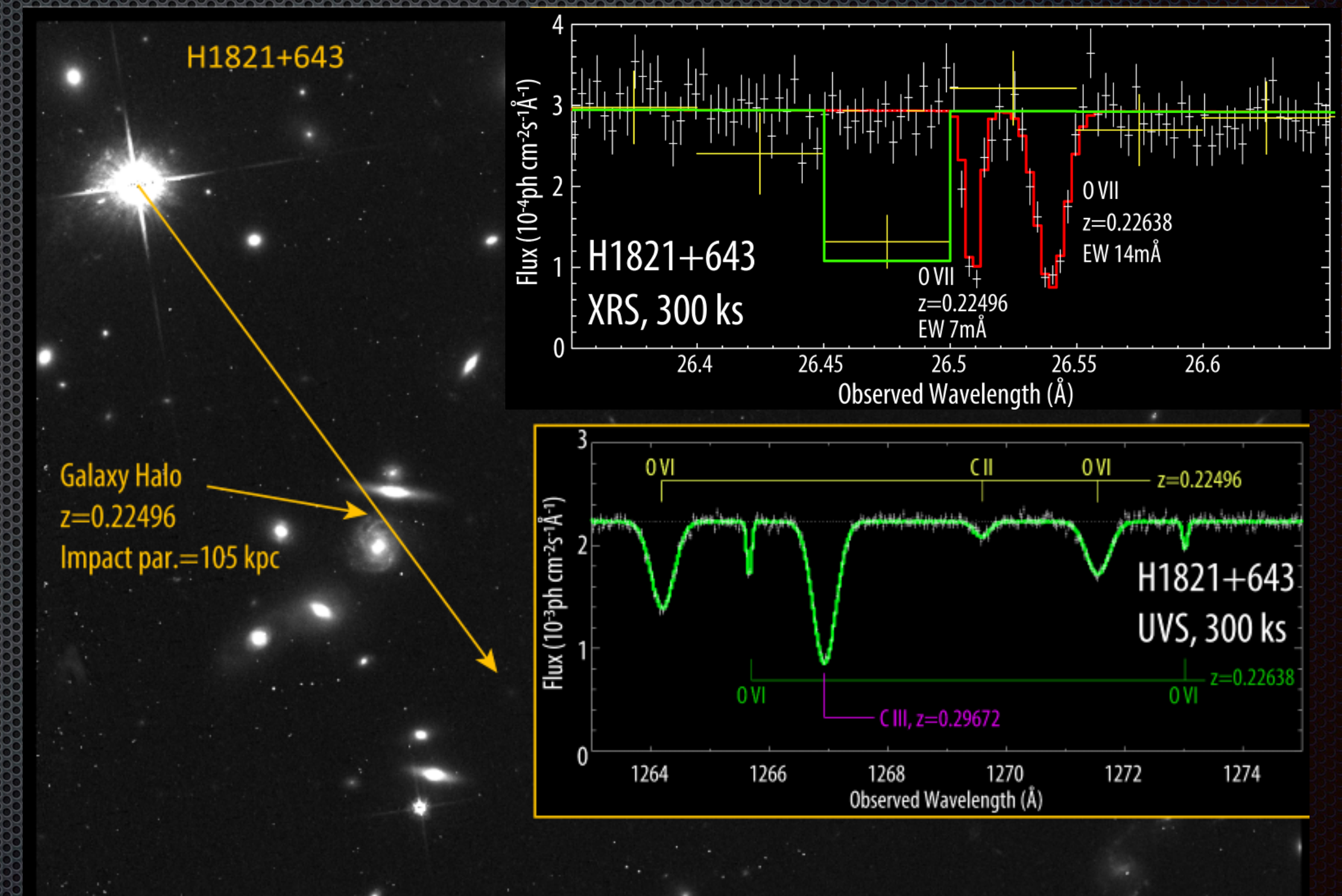
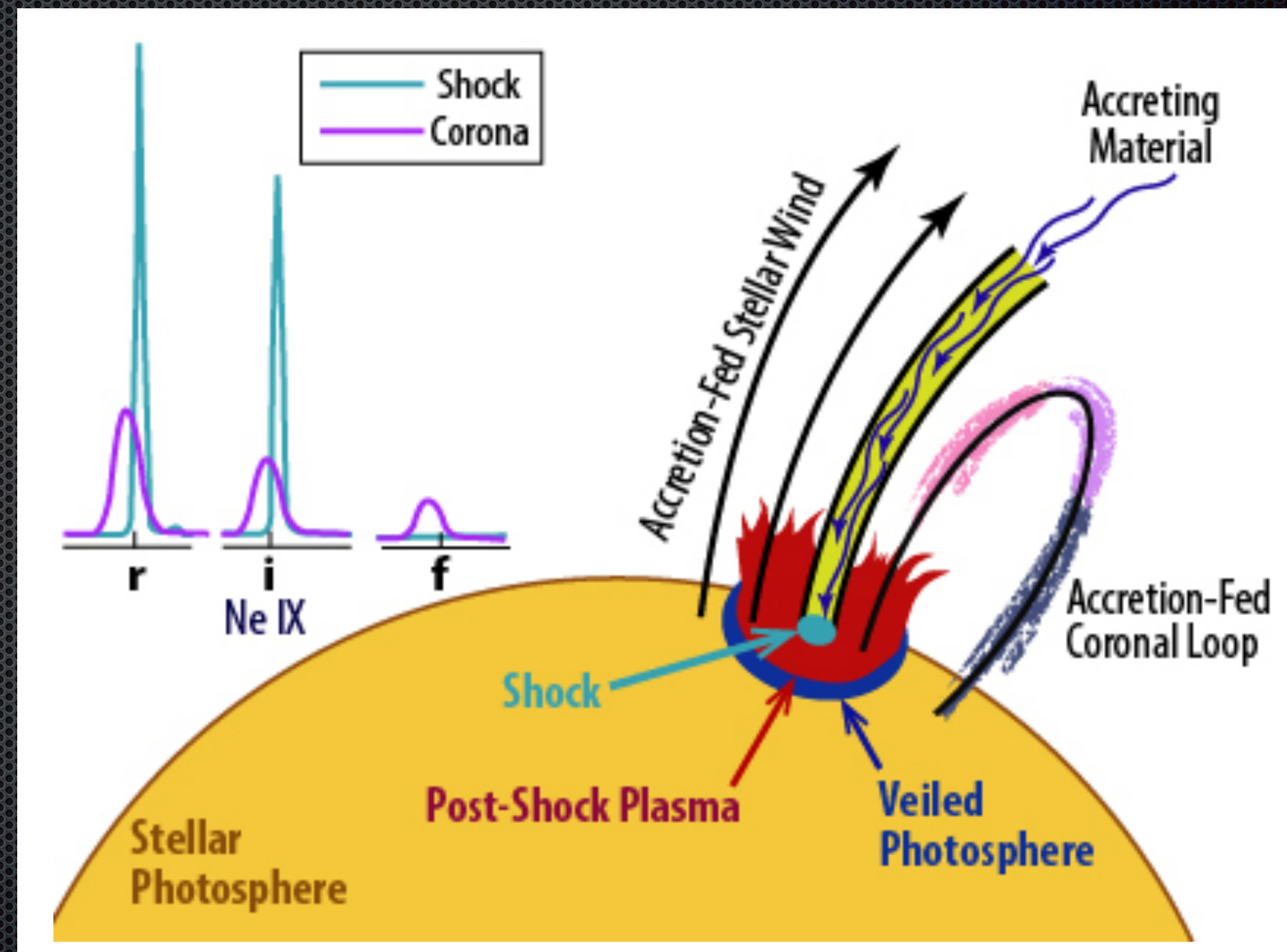


Figure from Todd Tripp. Simulations based on Todd et al (2008) data.
Top: Yellow data point are observed Chandra /LETGS data.

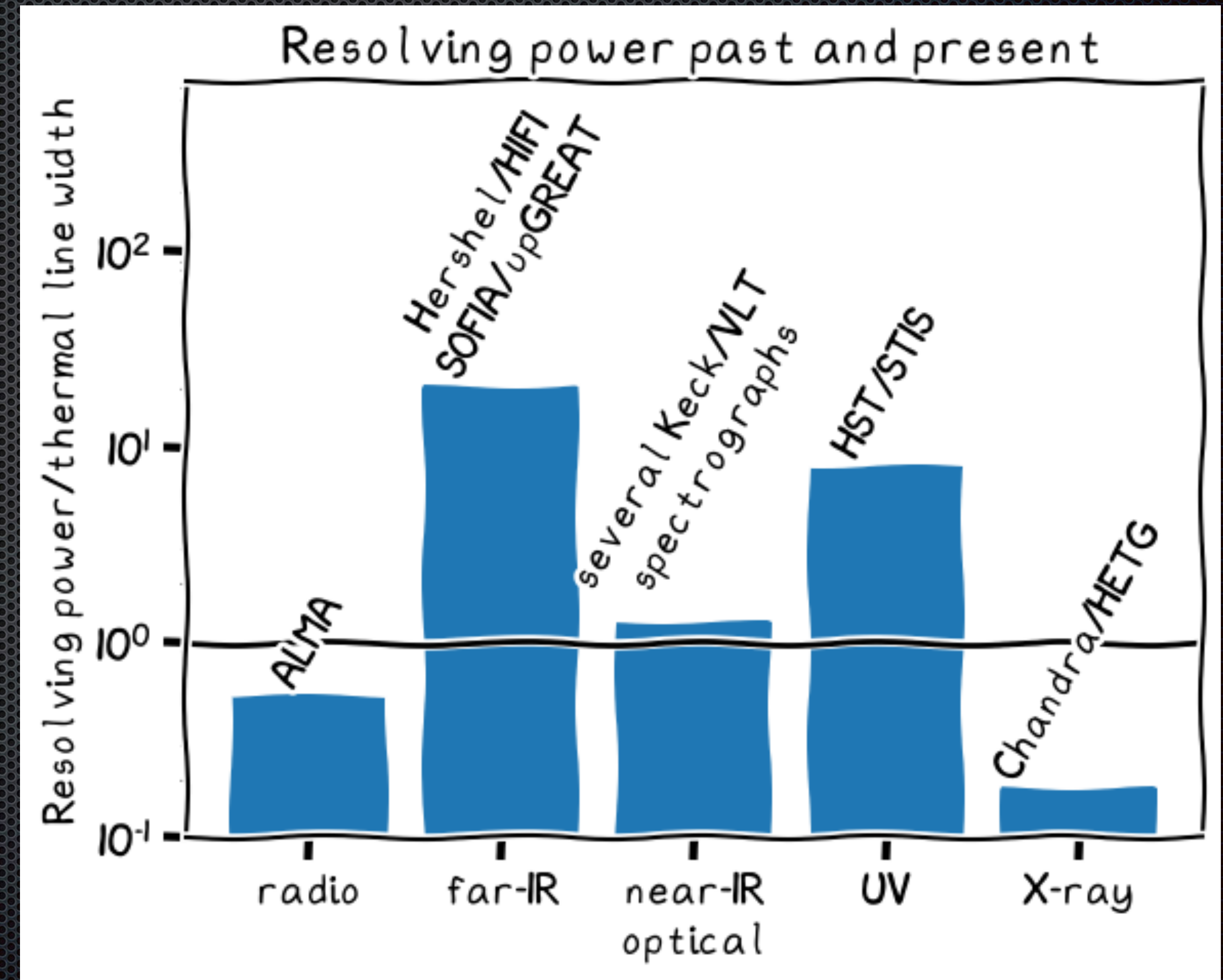
Science: Worlds and Suns in context

- ✦ ISM dust and missing oxygen (talk on day 1)
- ✦ Star formation (He-like triplets for density and kinematics)
- ✦ Winds and feedback from massive stars and outbursts
- ✦ Resolve absorption lines and edges:
X-ray: $R > 3000$, UV: $R > 10000$
- ✦ Resolve emission line profiles:
X-ray: $R > 3000$, UV: $R > 10000$
- ✦ Collect signal in one dynamic time:
Effective area $>$ a few Chandra



A gap in capability

- ✧ Need to resolve line profiles.
- ✧ Need to measure line shifts.
- ✧ Need to distinguish blended lines.



UV instruments

- ✦ More UV photons than X-ray photons!
- ✦ Basically just bolt on the side (but avoid stray light). (Cheimets et al (2024) JATIS)
- ✦ UV imager (like OM on XMM, GALEX). Easy. Small. Cheap.
- ✦ UV spectrograph (like COS or STIS, but smaller)
 - ✦ ~0.5 m diameter (France et al (2025) JATIS)
 - ✦ $R > 10,000$
 - ✦ 1200 - 2500 Å region

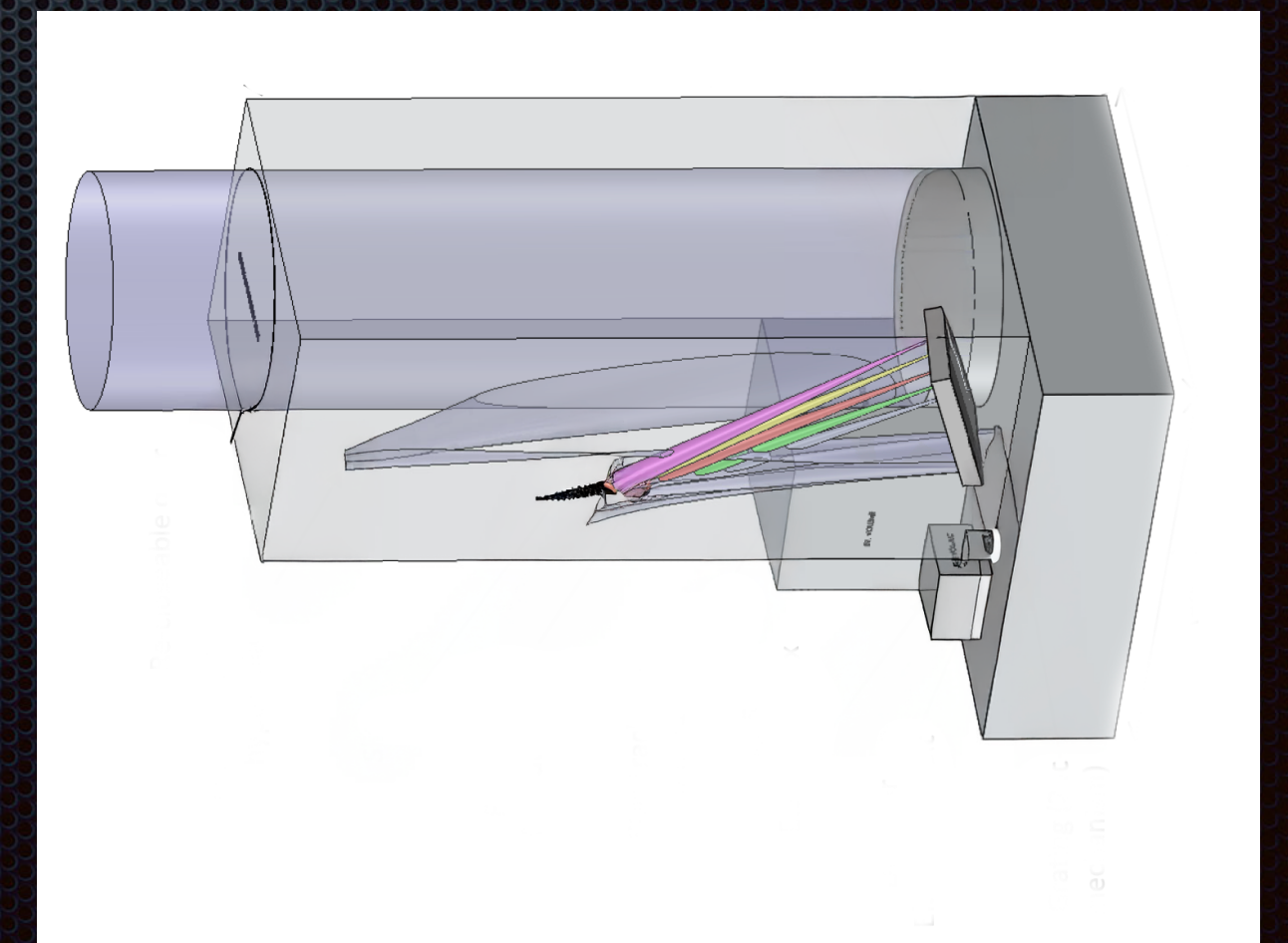
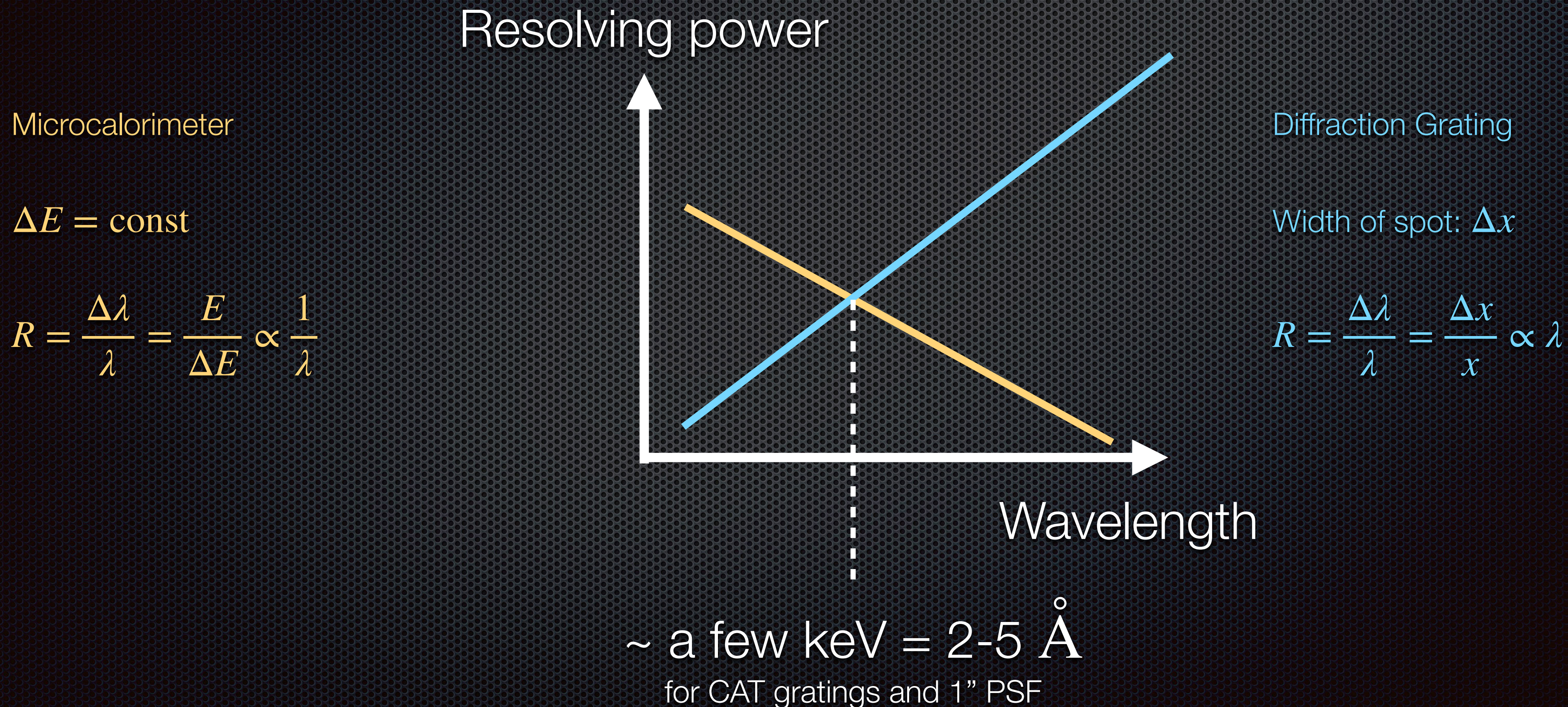


Figure from TAUS community workshop presentation by K. France

At long wavelengths (=low energy) gratings outperform microcalorimeters



How does this look?

Host mission

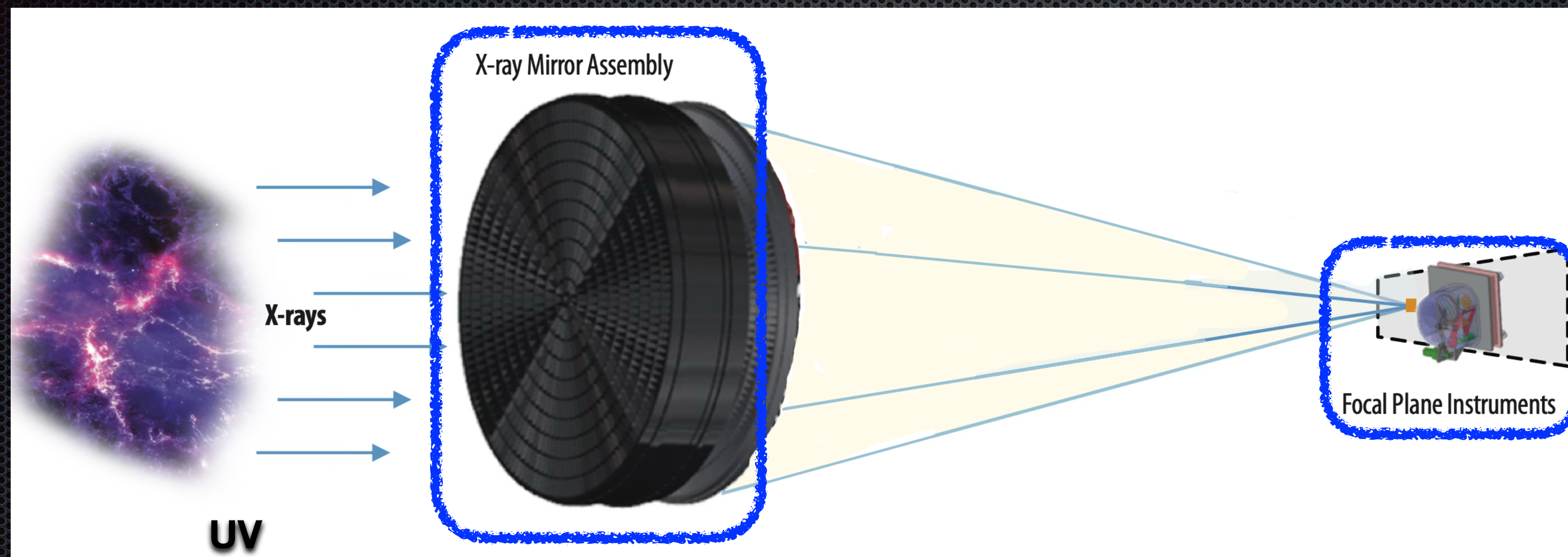


Figure modified from Lynx 2020 report

How does this look?

Host mission

Mission enhancement

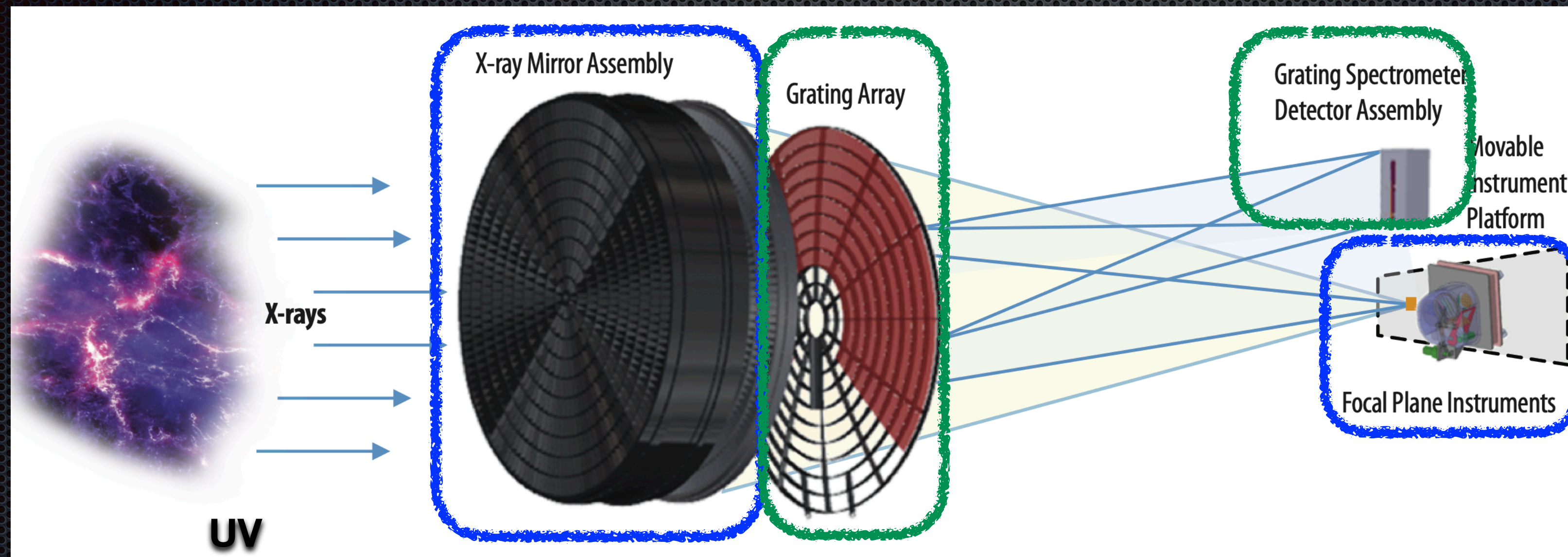


Figure from Lynx 2020 report

How does this look?

Host mission

Mission enhancement

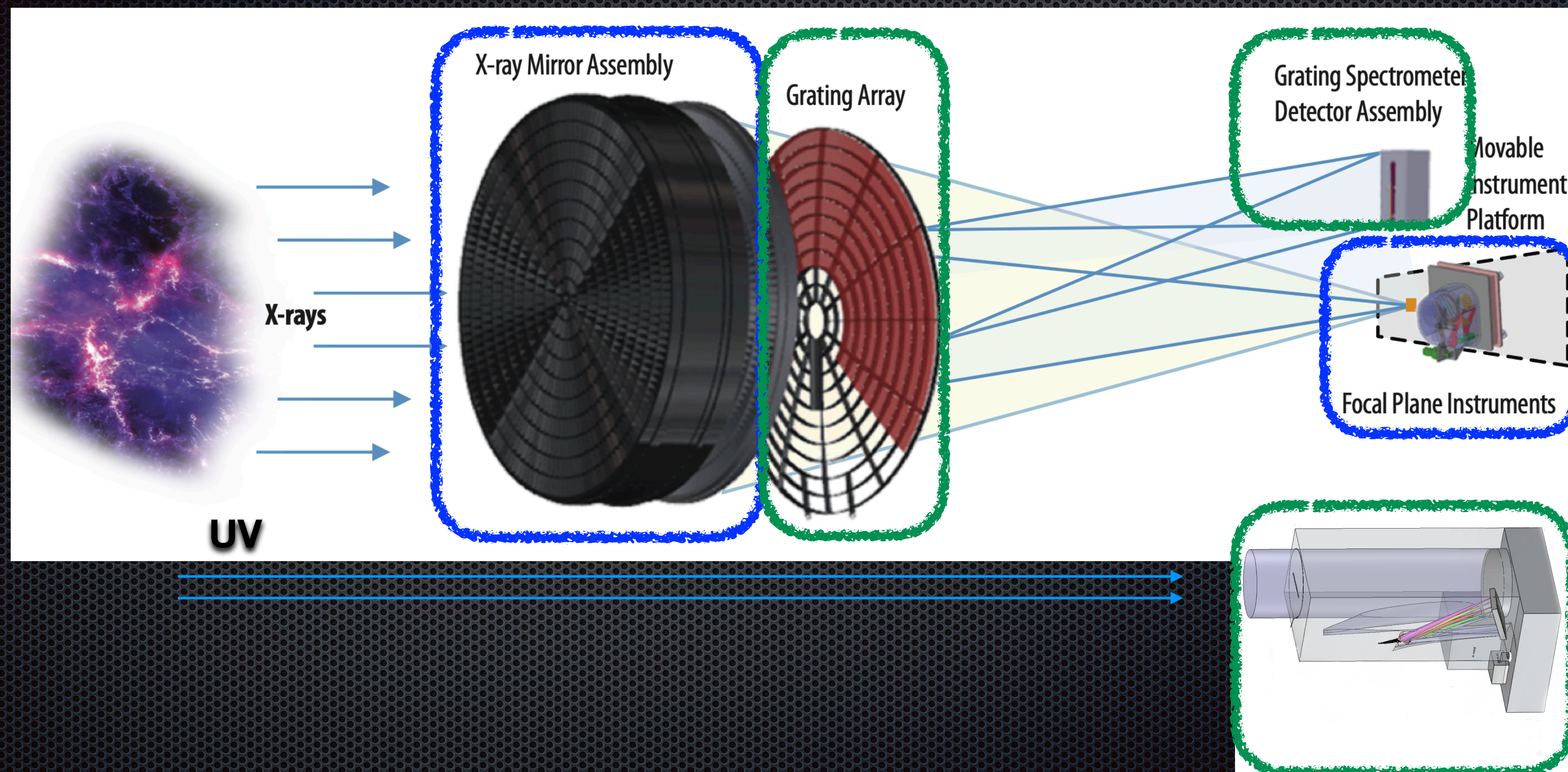
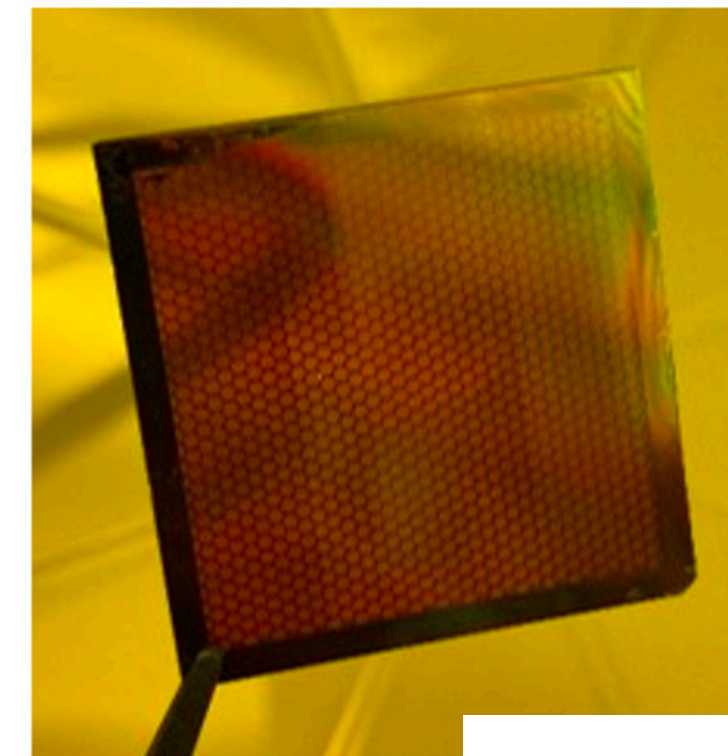
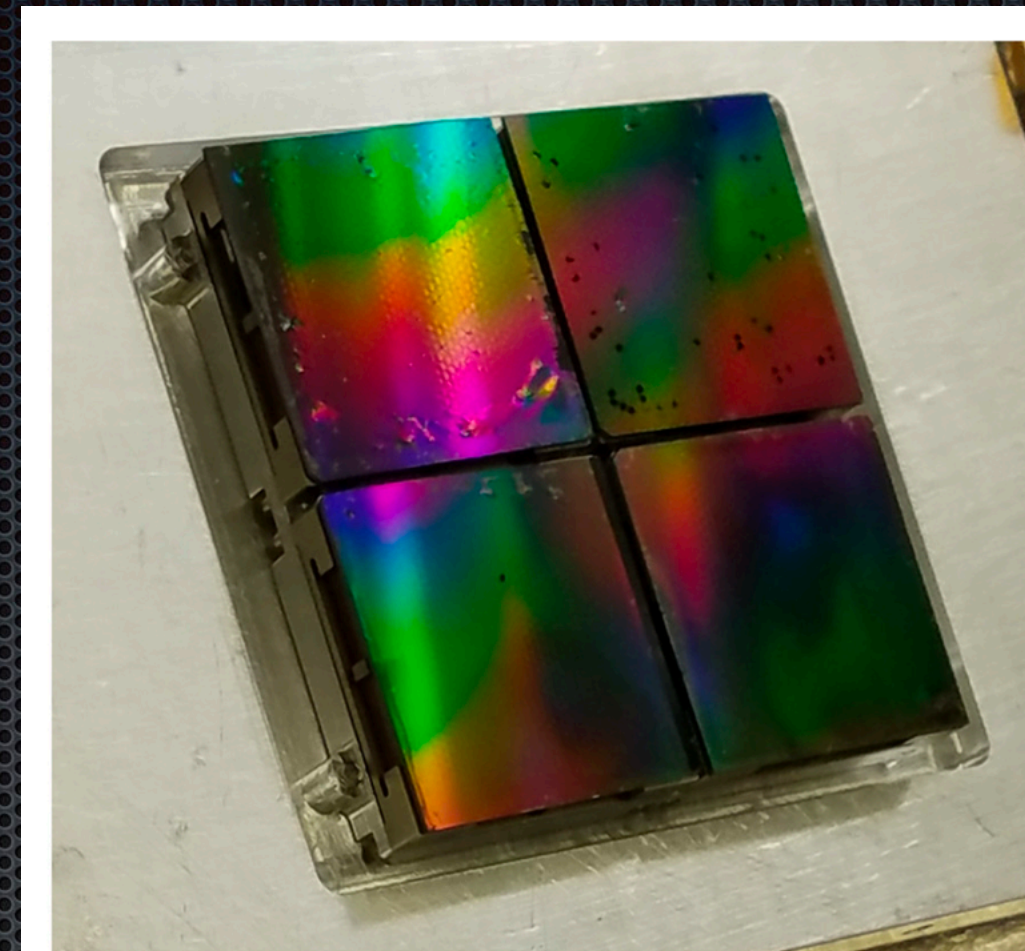
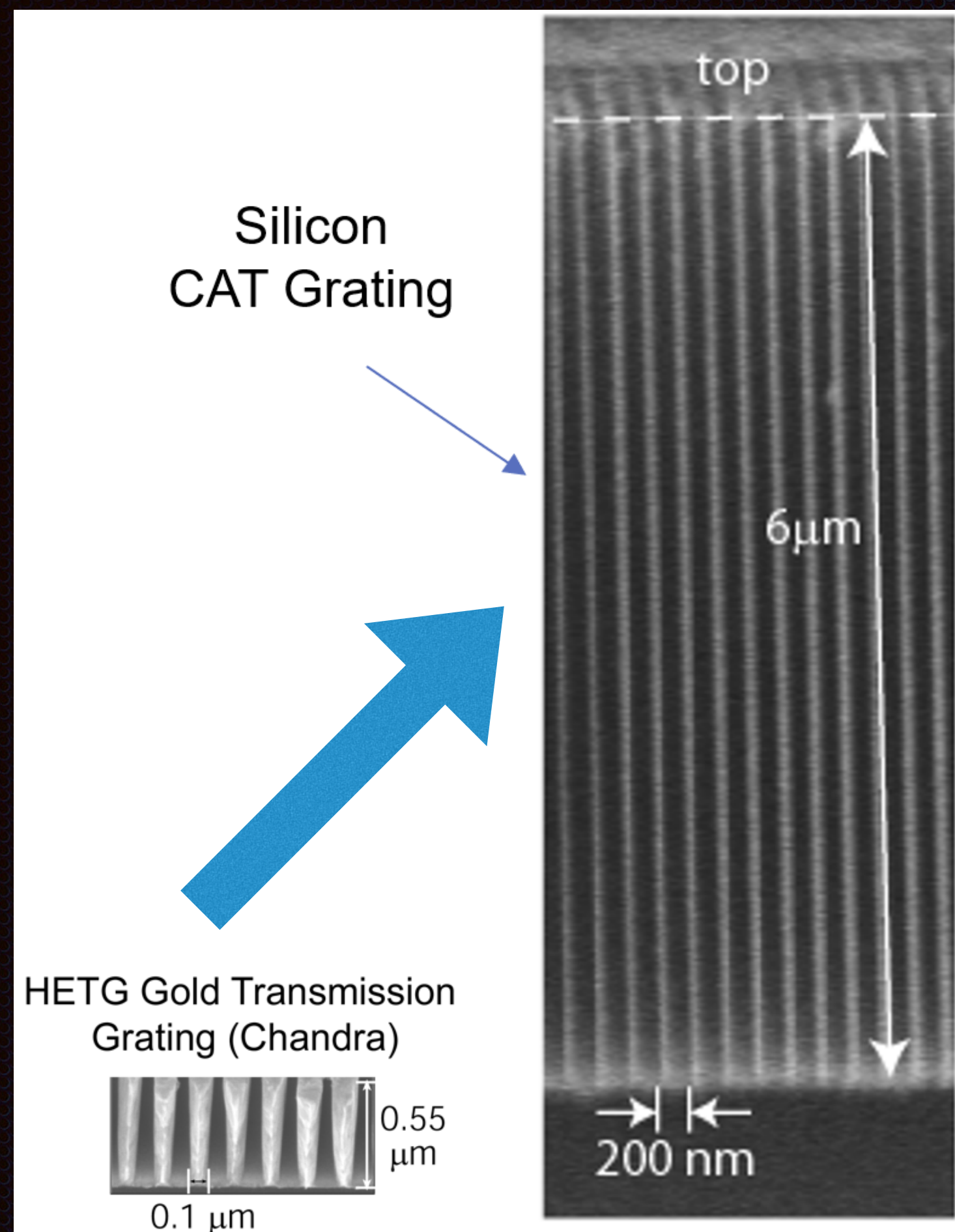


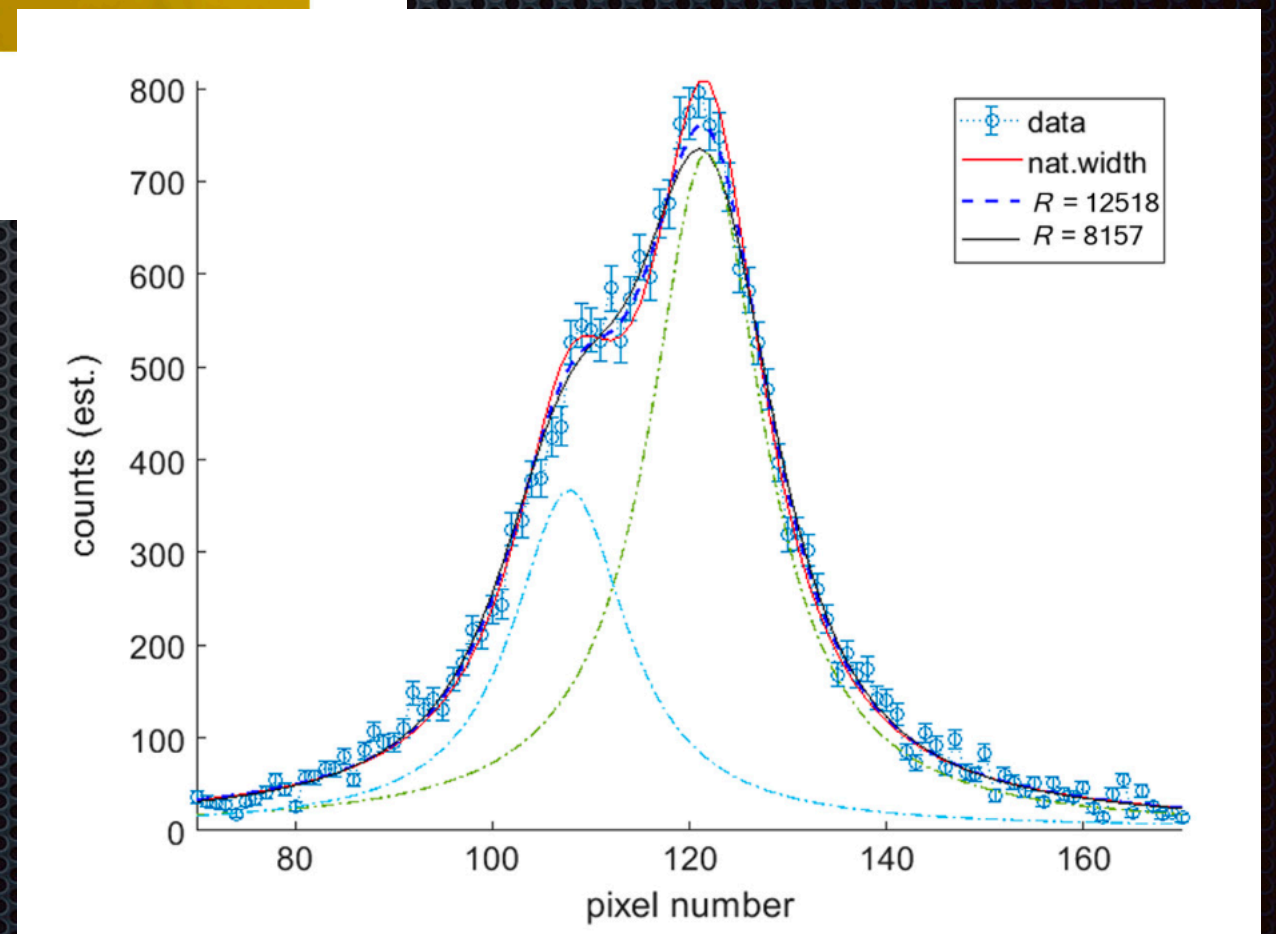
Figure from Lynx 2020 report

Figure from TAUS community workshop presentation by K. France



CAT gratings
Top: one or more mounted and co-aligned gratings.
Right: Beamline test of two co-aligned gratings.

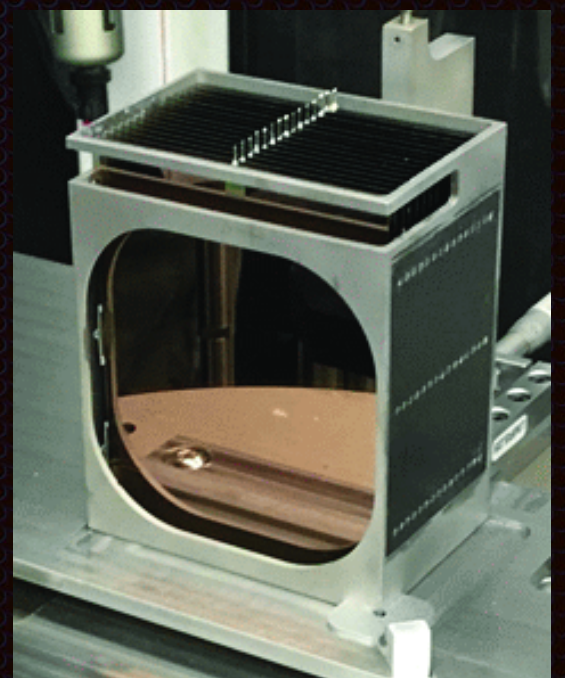
Poster 149, Heilmann et al. (2025) JATIS



Enabling technology

Critical angle transmission (CAT) gratings.

Off-Plane gratings, too, but pick CAT here as example.



Subaperturing

Cover only part of aperture to get narrow line-spread-function

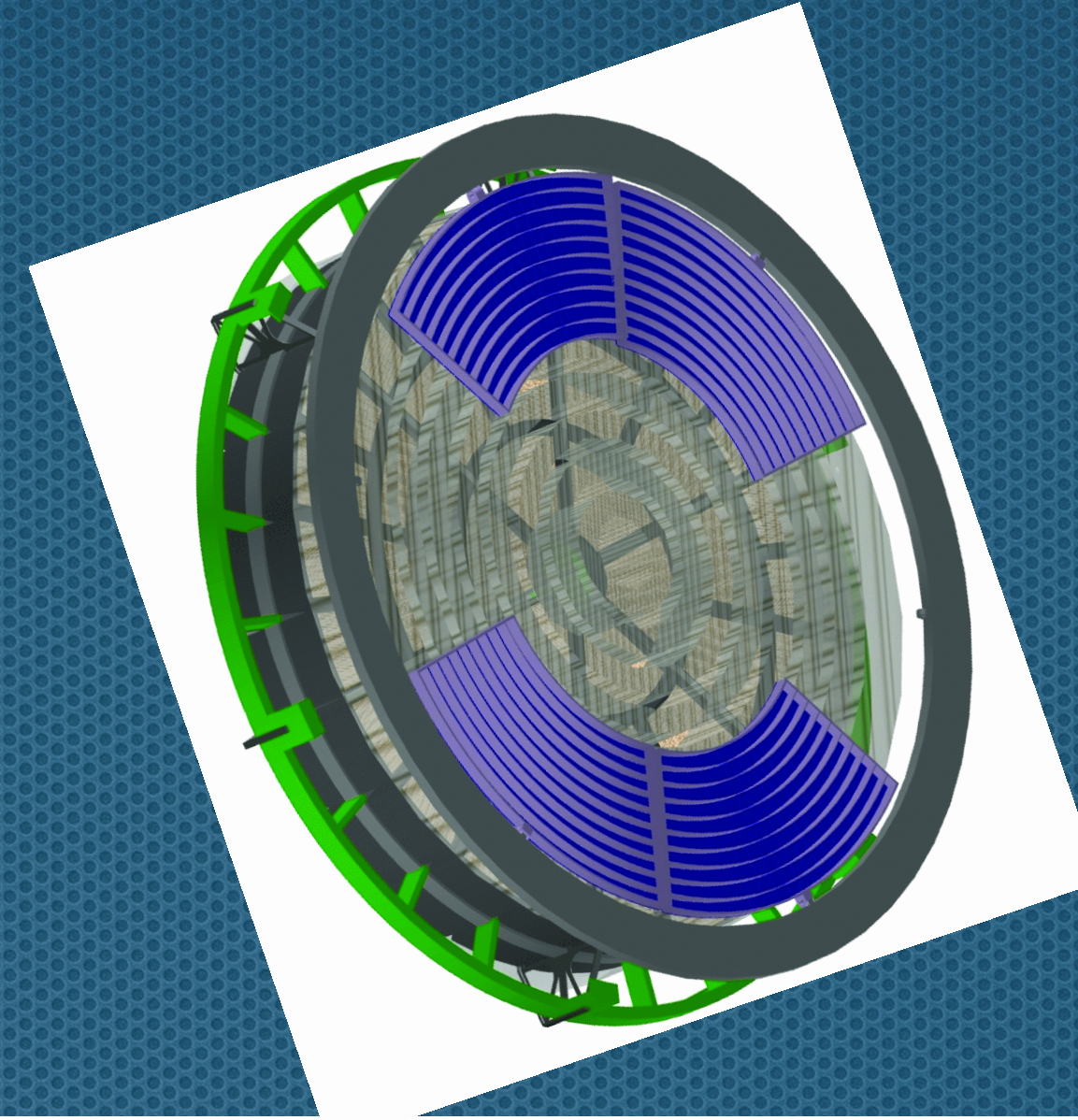
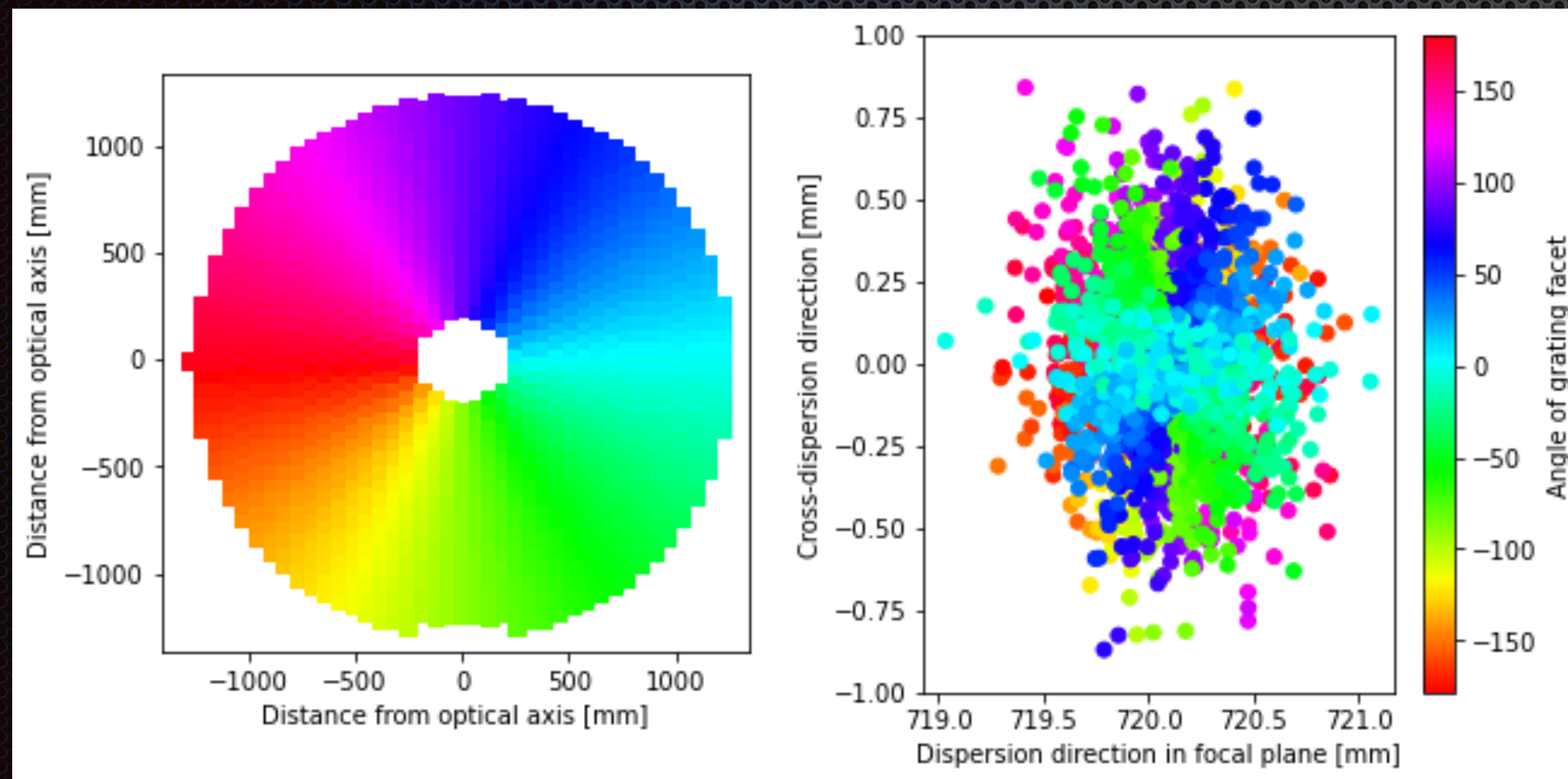
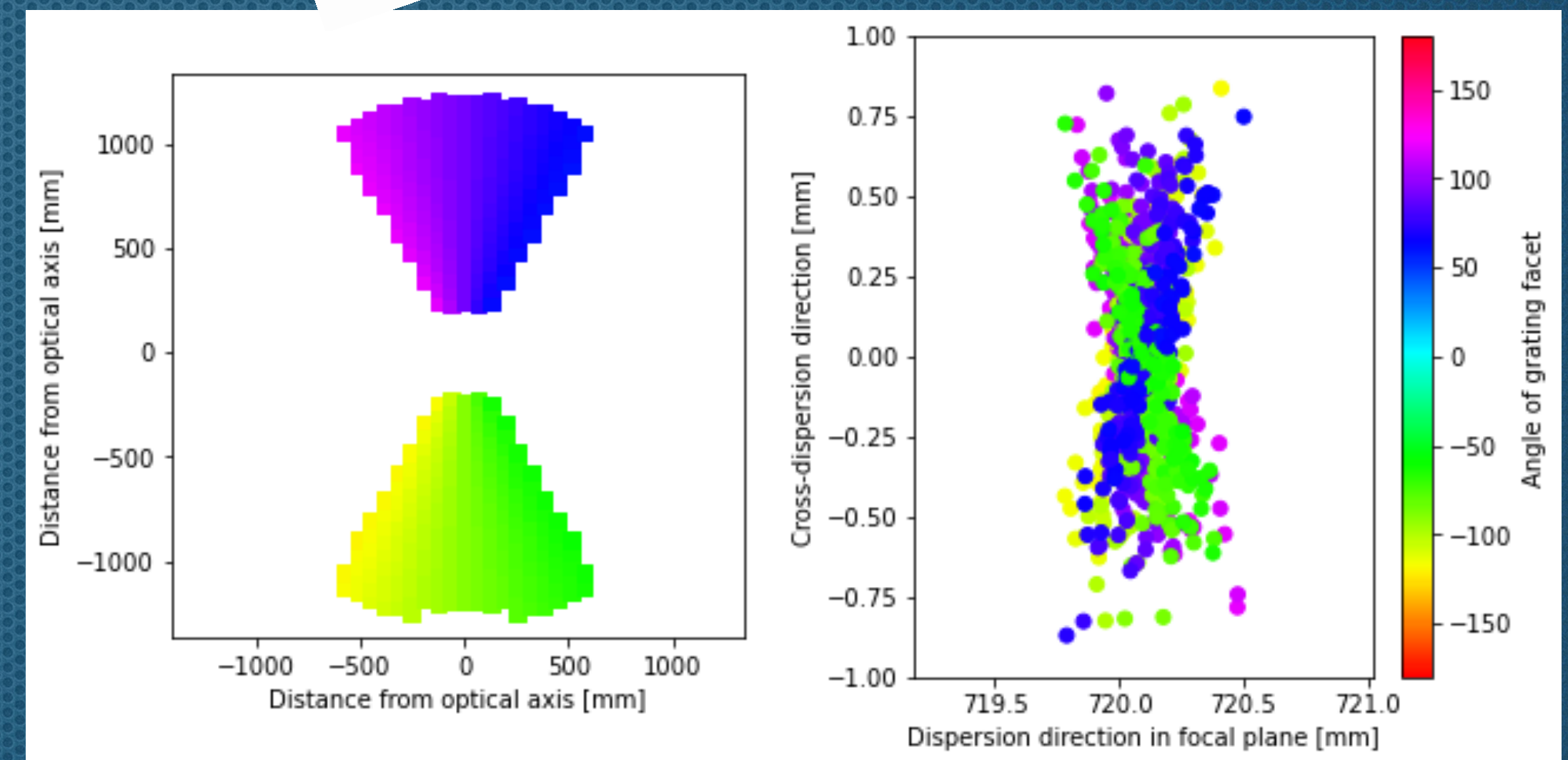


Figure from Lynx 2020 report



→
Dispersion (wavelength)

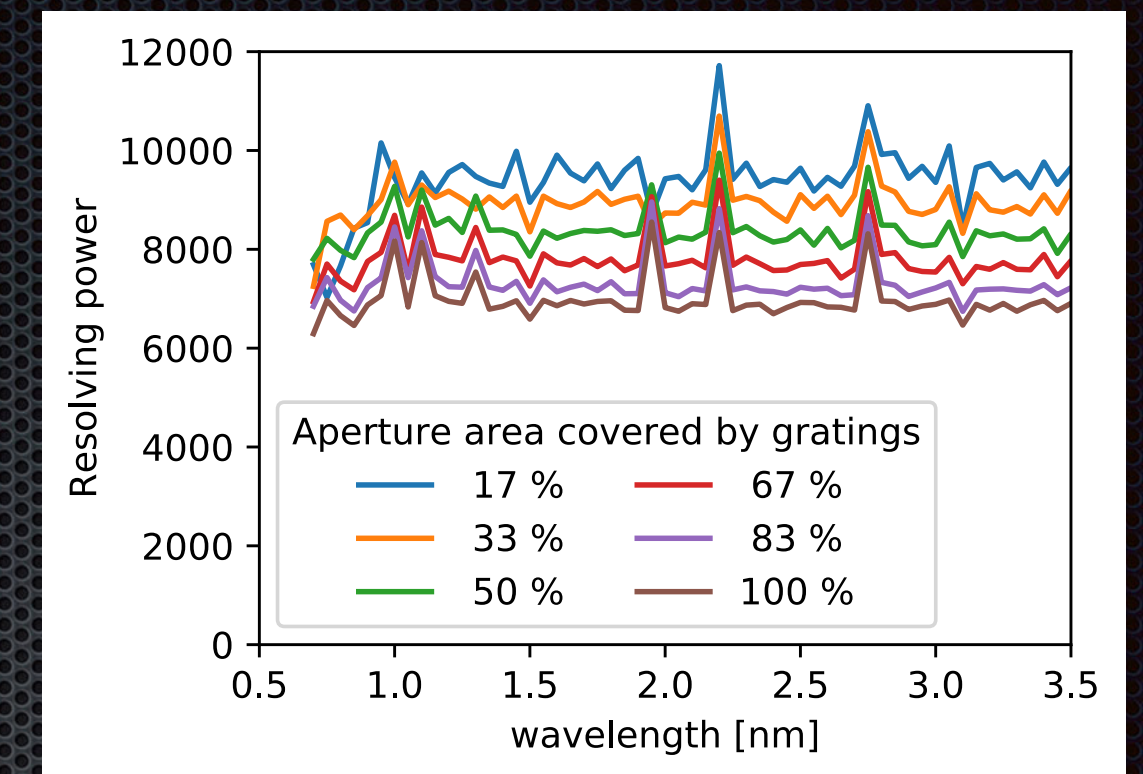
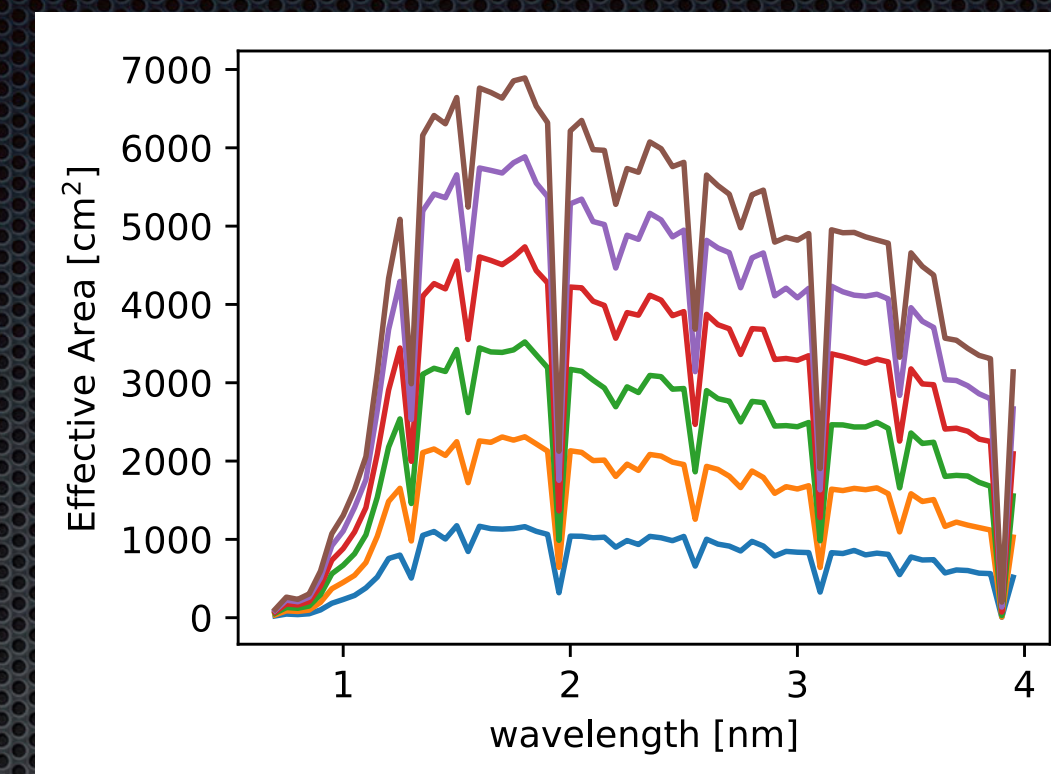


→
Dispersion (wavelength)

Works for
almost any
focussing mirror

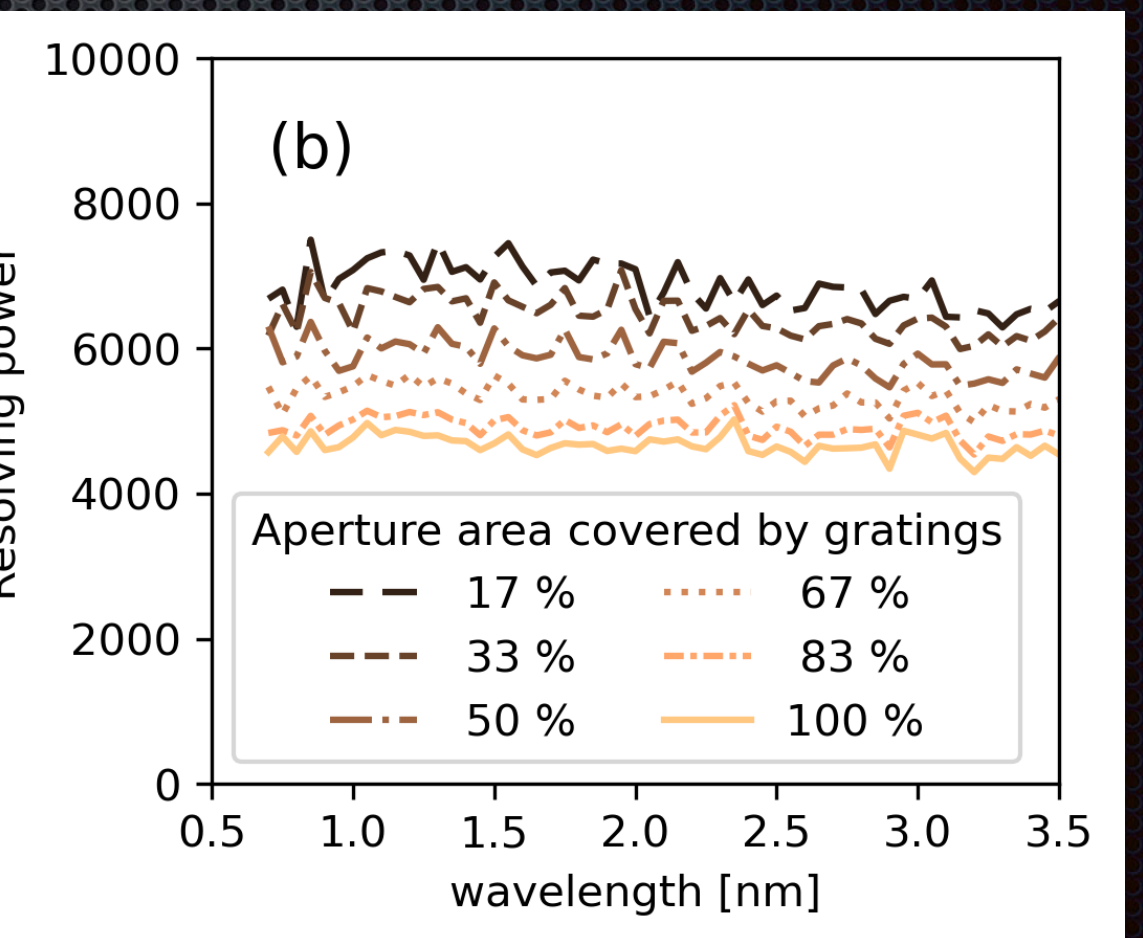
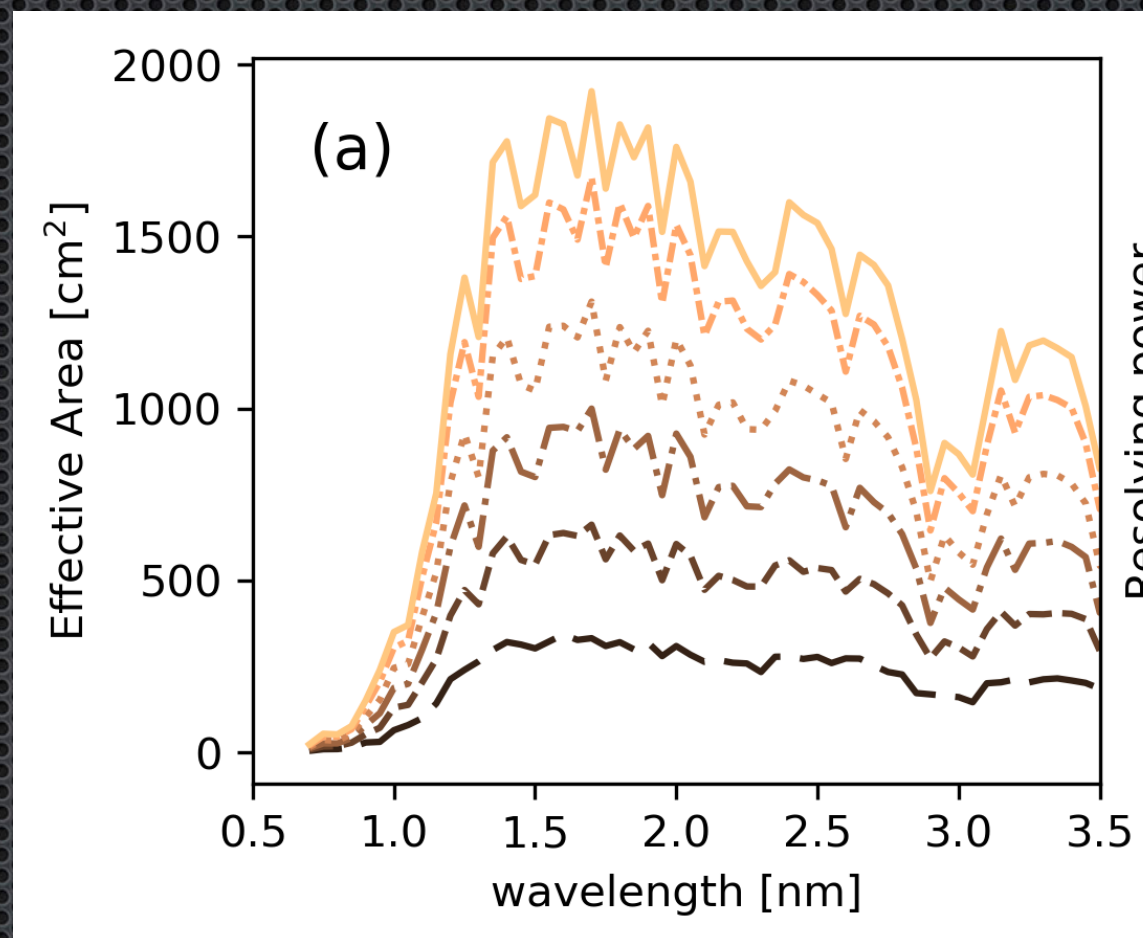
Lynx
(0.5" PSF)

Günther et al (2019), JATIS



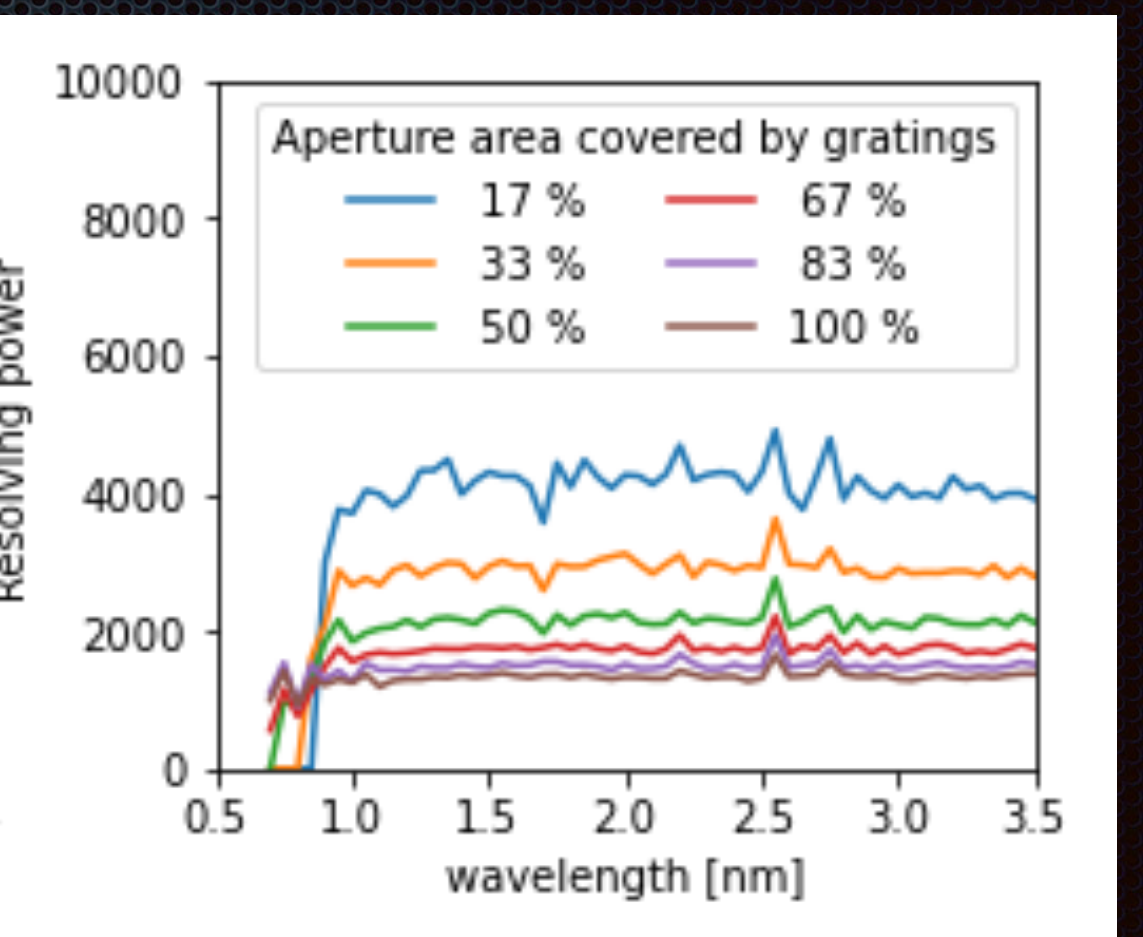
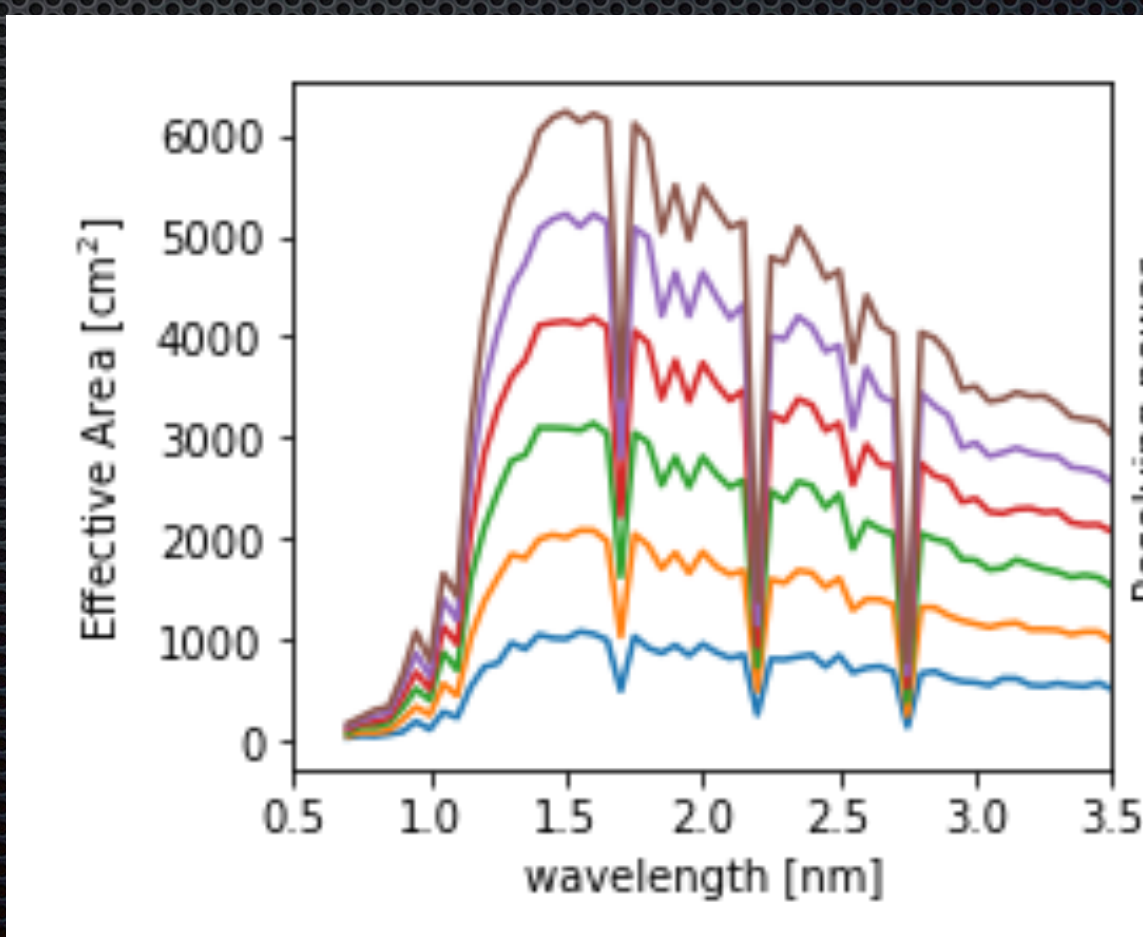
AXIS
(1.5" PSF)

Günther et al (2023), JATIS



Athena
(5" PSF)

Unpublished



Great impact @ low cost, low risk, short time-to-science

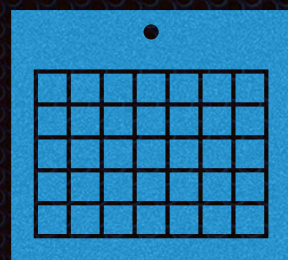
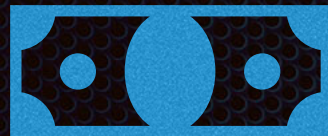
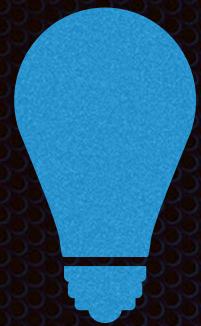
- ✦ Low risk

- ✦ Detectors same as host mission or off-the-shelf
- ✦ Gratings already produced for flight mission with Lincoln Labs and industry
- ✦ Algorithms and software very similar to Chandra.

- ✦ Modest cost (\$ 100-200 million = a few % of mission cost)

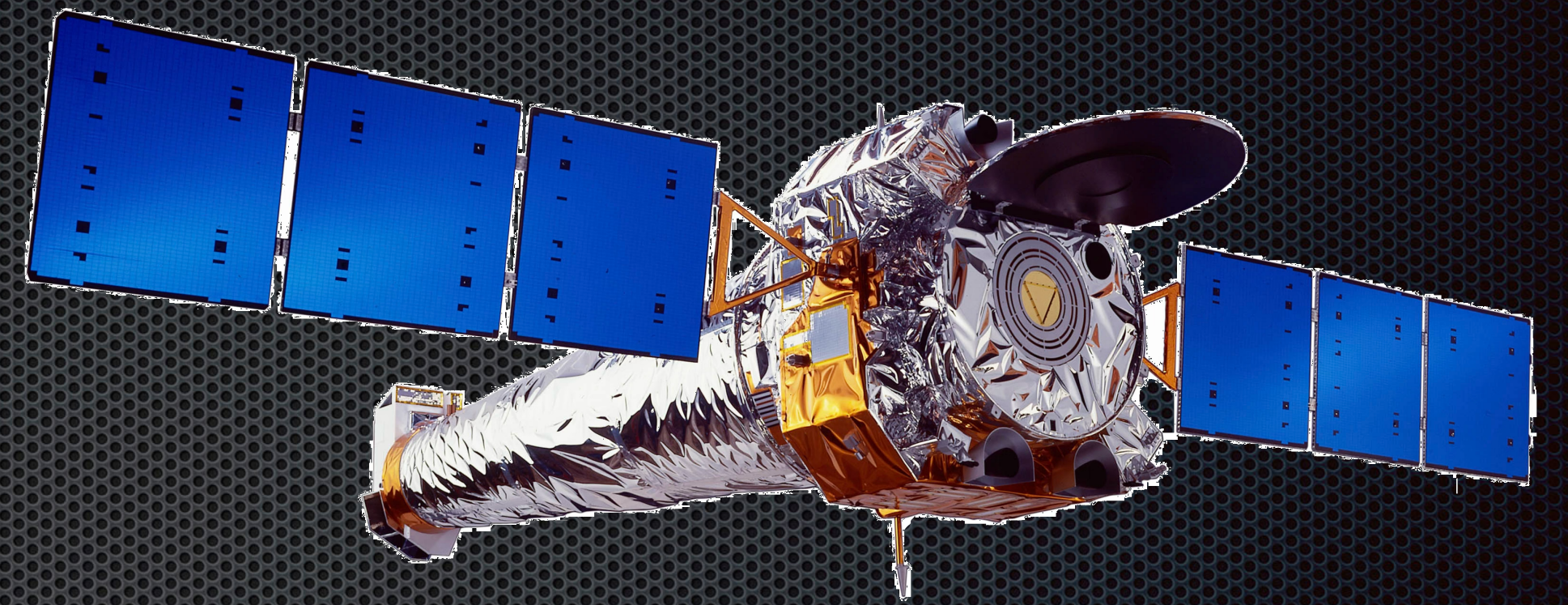
- ✦ Short time-to-science

- ✦ Mission Ops with host mission.



Adding X-ray gratings
/ UV to a mission is a
proven idea!

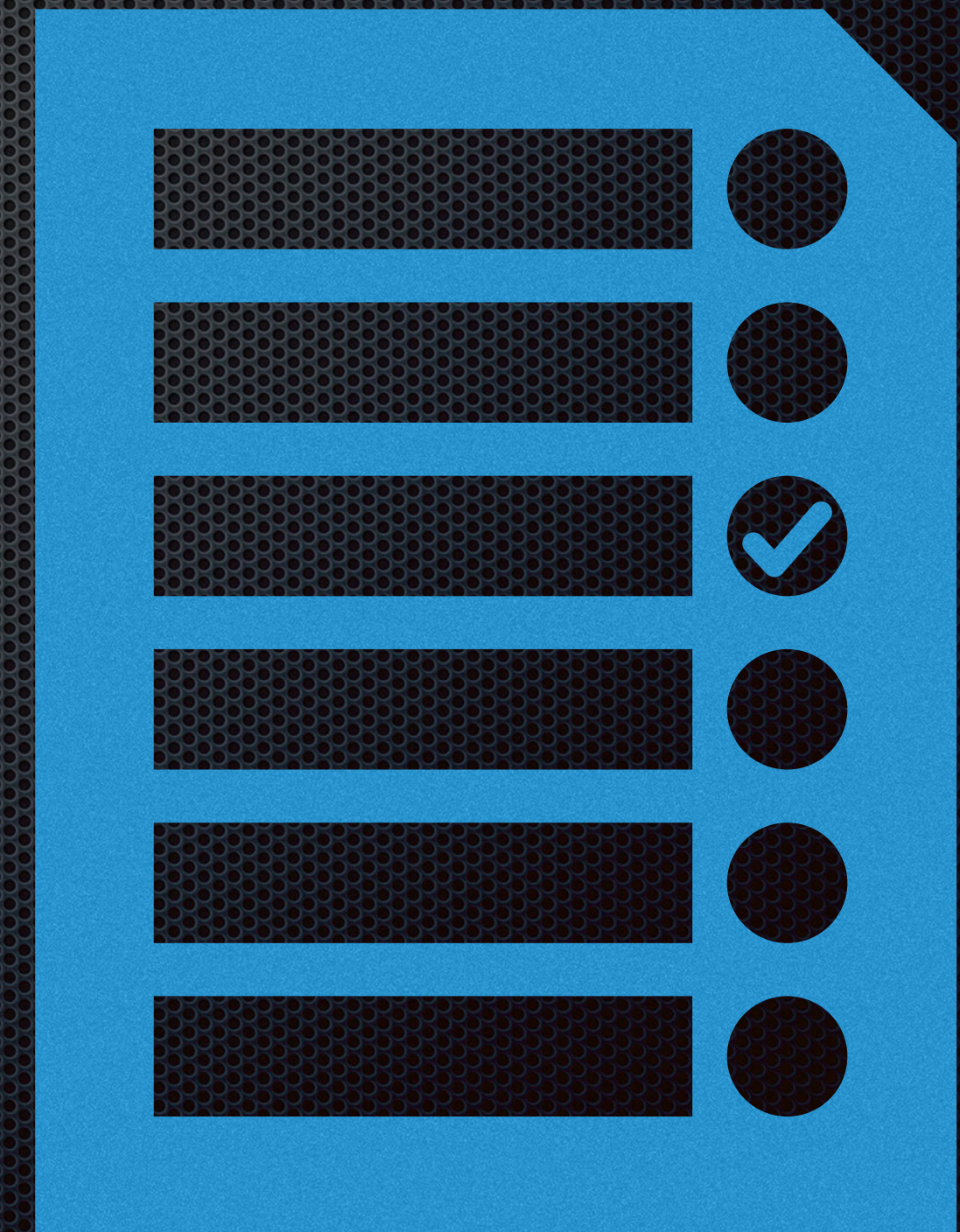
Chandra and XMM-Newton
show how operations work
with imaging AND gratings.



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(e.g. 1200-2500 Å; R 10,000-100,000)
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Options for balancing effective area vs resolving power

