The Ultraviolet Hardware Path to HWO

Sarah Tuttle, University of Washington, Seattle
on behalf of the Cosmic Origins Program Analysis Group

Who are we?

- A combination of UV technologists and astronomers who are excited about the potential of HWO
- A cross-section of career stages - from graduate students to retired experts
- A broad multi-institution collection - contributors from Universities, NASA centers, and industry

Ultraviolet Technology To Prepare For The Habitable Worlds Observatory

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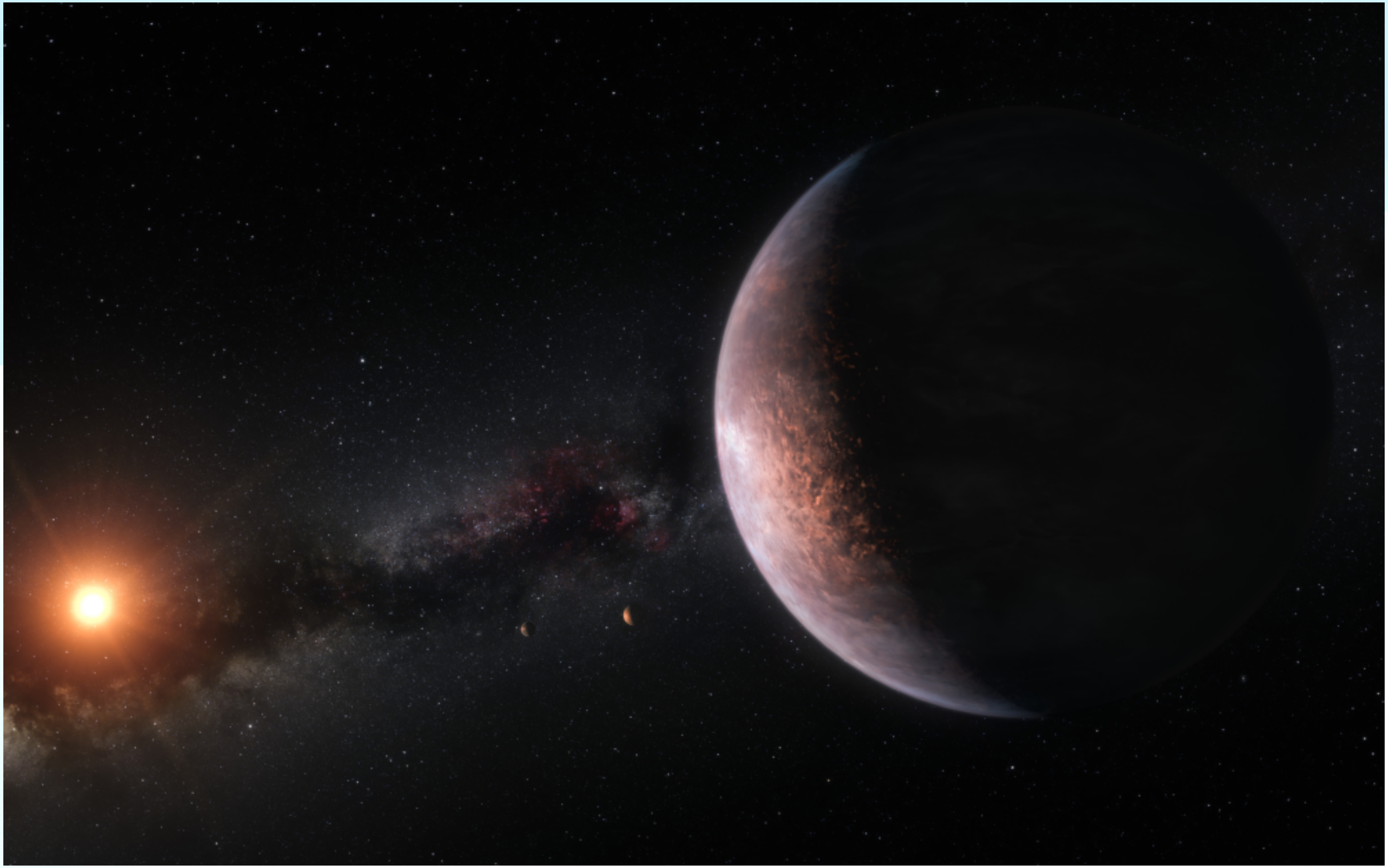
Why this working group?

- The road to HWO is both really long (work wise) and surprisingly short (time wise)
- Crucial to capture the current state of UV technology
- Want to document and address some past concerns & experiences
- Demonstrate current state of the art – and exciting development paths!
- Instrumentalists are surprisingly (not that surprisingly) mediocre at publishing things. Building things? Great. Documenting that? A… little less great.

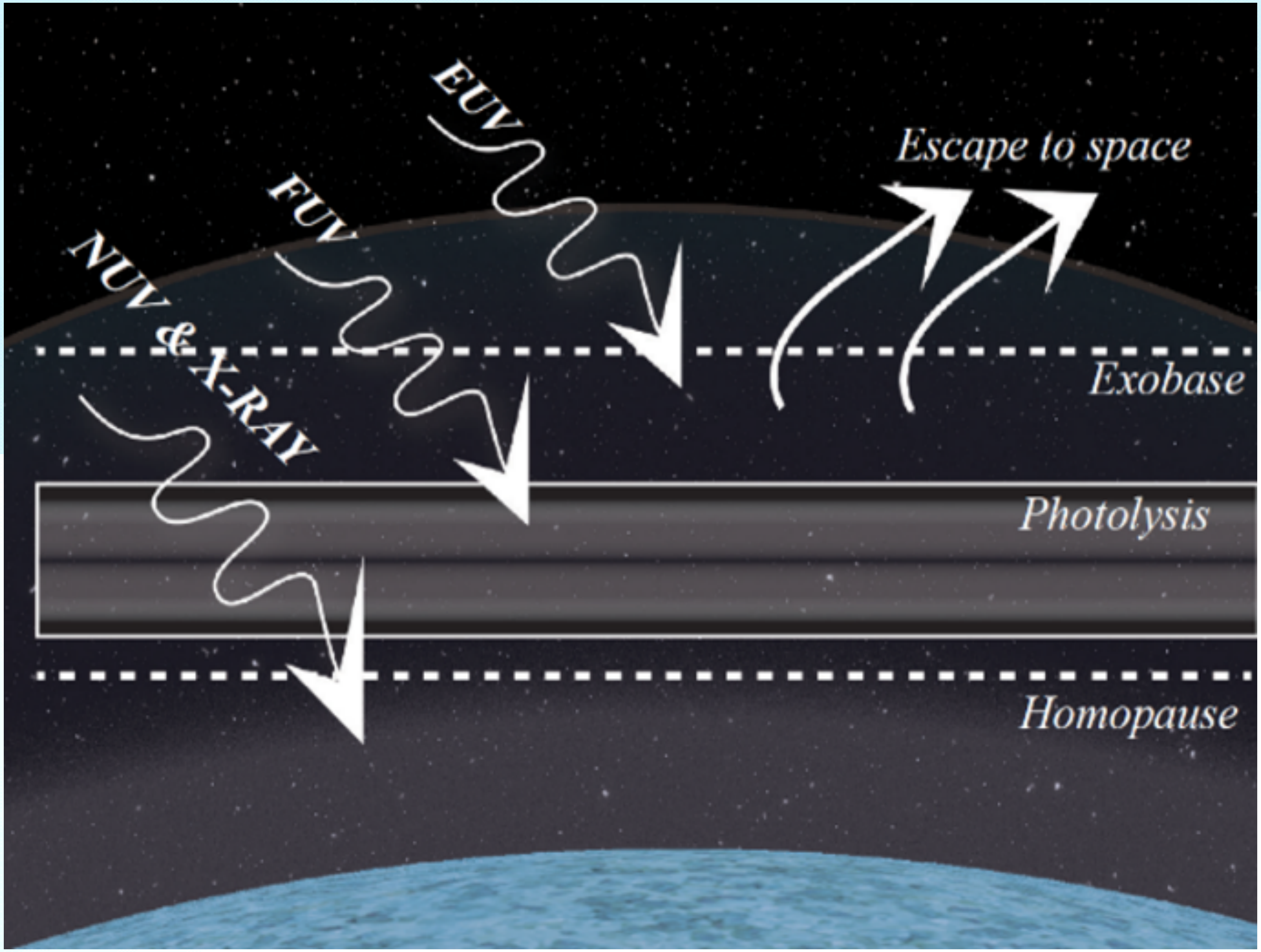
Worlds & Suns in Context



ESO/M. Kornmesser

UV drives exoplanet photochemistry

100 - 320nm



100 - 115nm provide temperature and abundance diagnostics

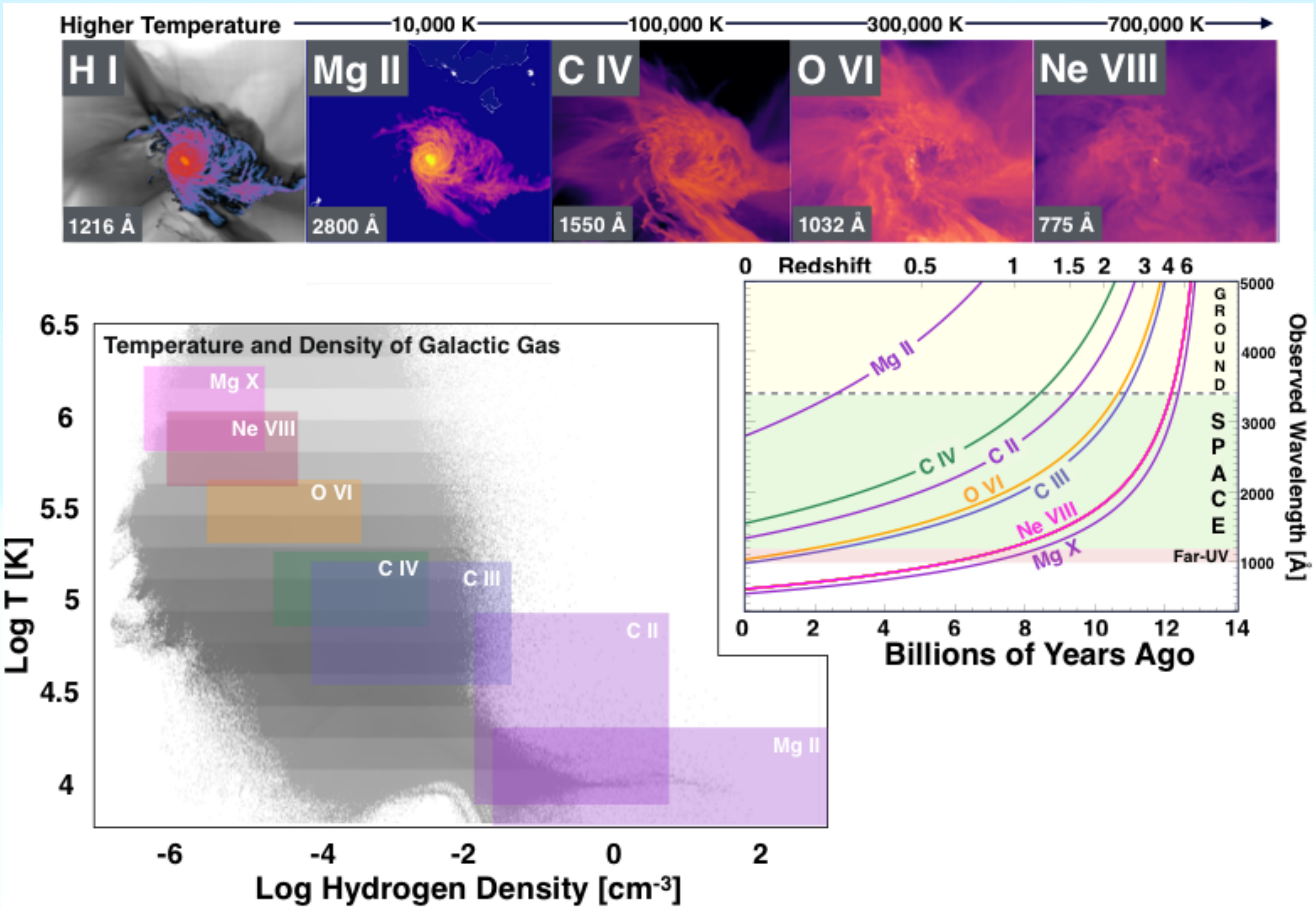
Tsai et al 2023

Cosmic Ecosystems

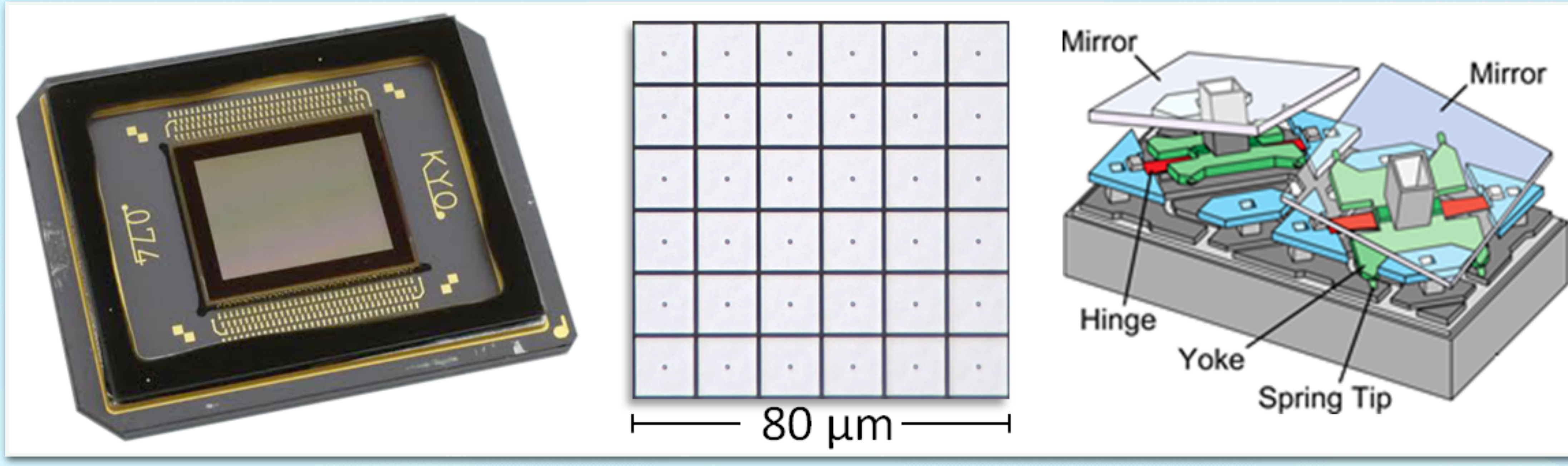
E. Bacarra

Key Science

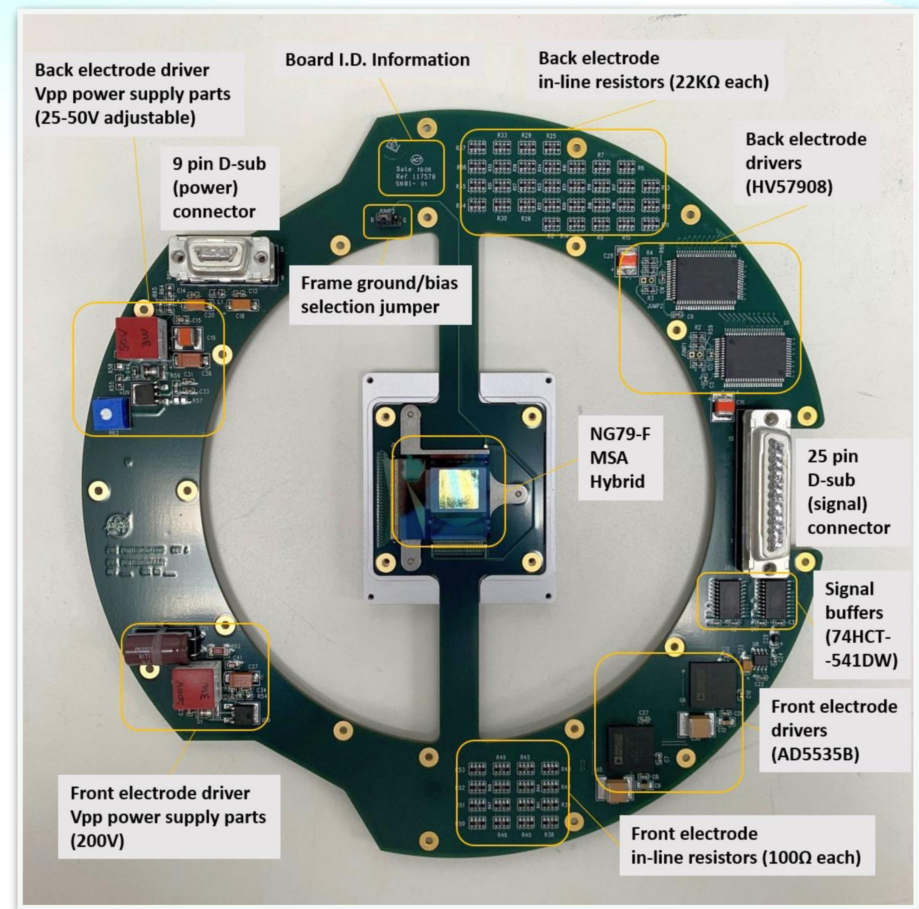
Observing the Circumgalactic Medium (CGM)



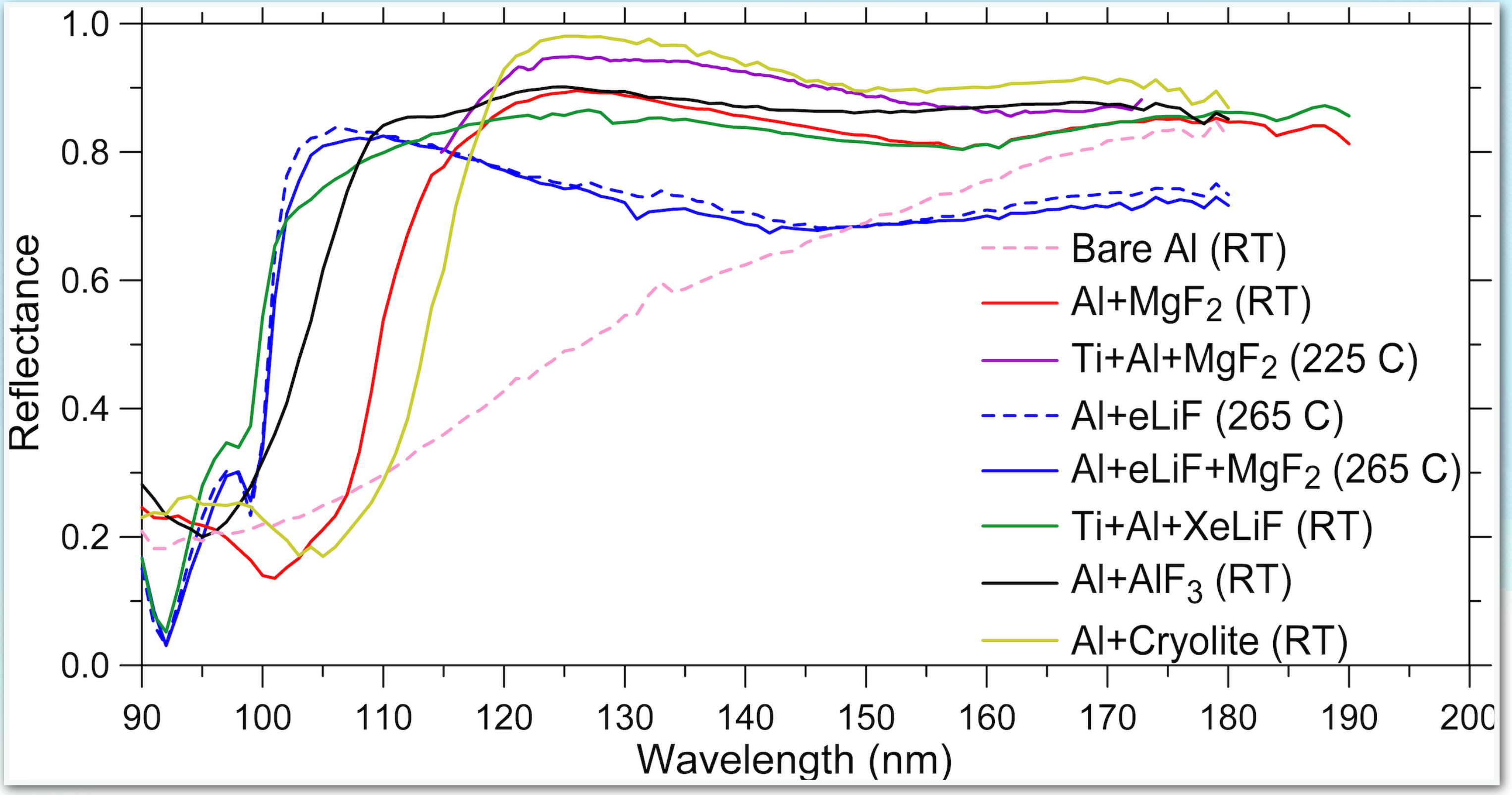
100 - 120 nm captures OVI (103.2nm) at z > 0.1 and Ne VIII and Mg X at z > 0.5

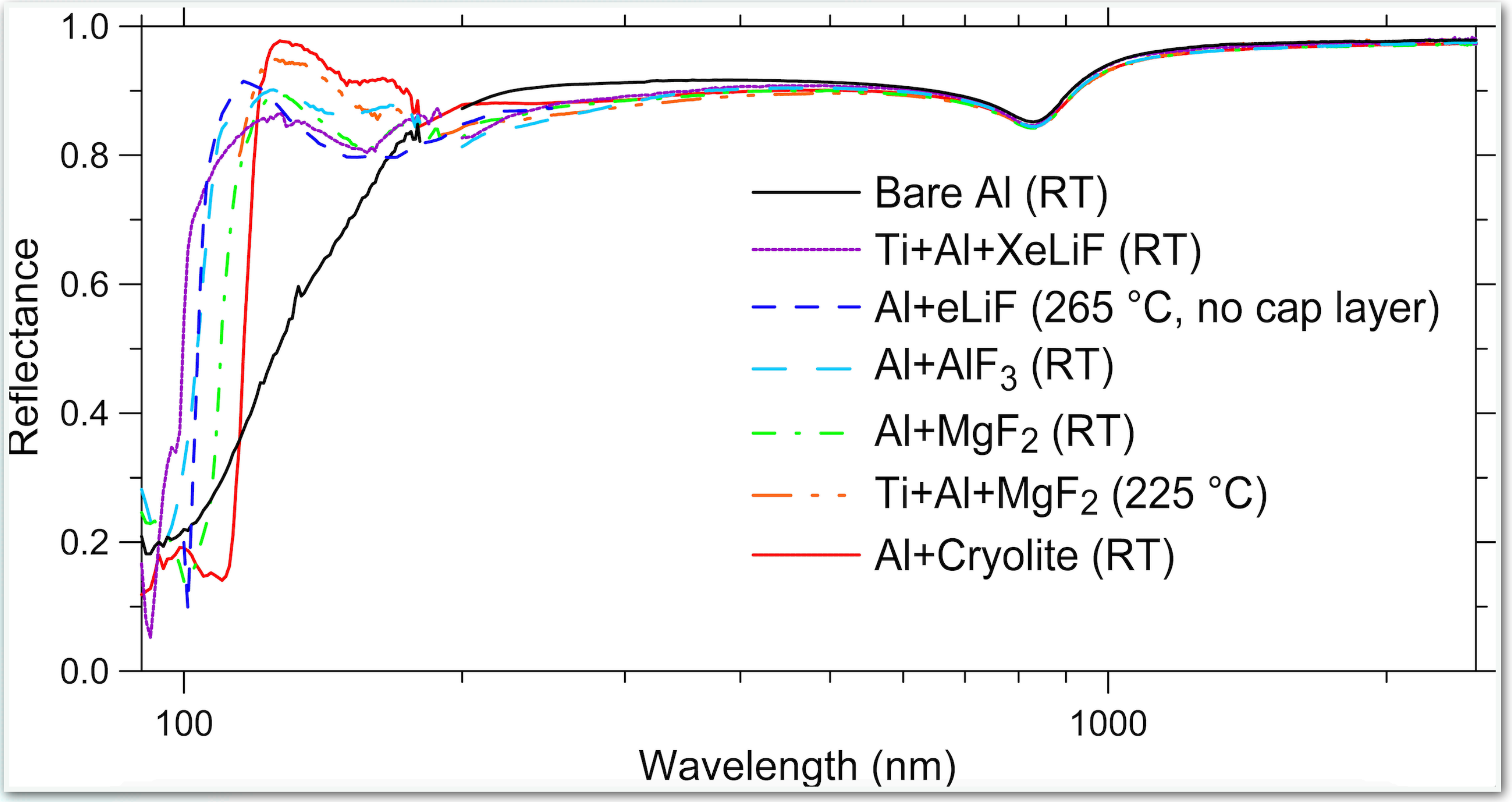


Hardware
& Processes

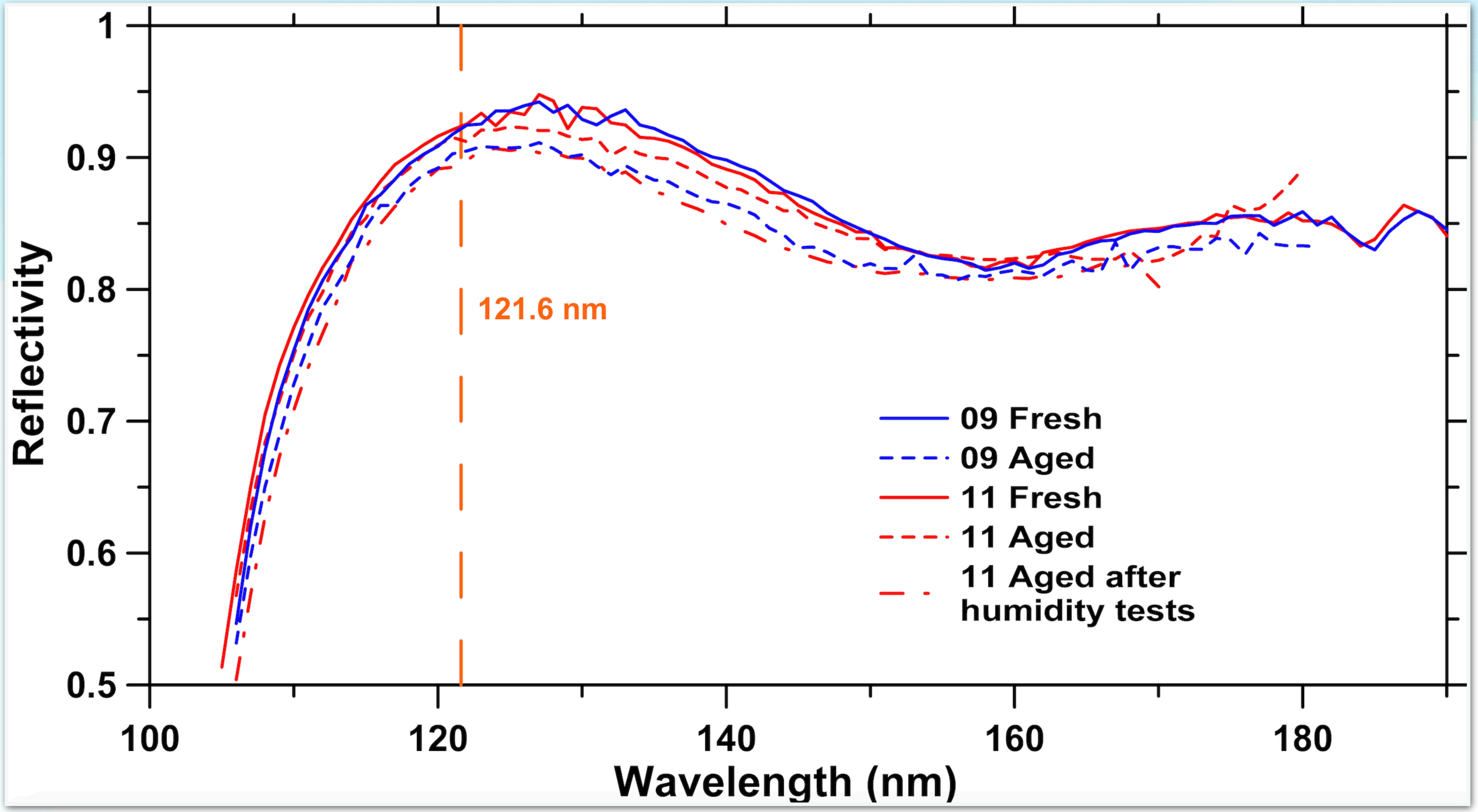


UV & Optical Coating Performance





Reflective Coatings - XeLiF

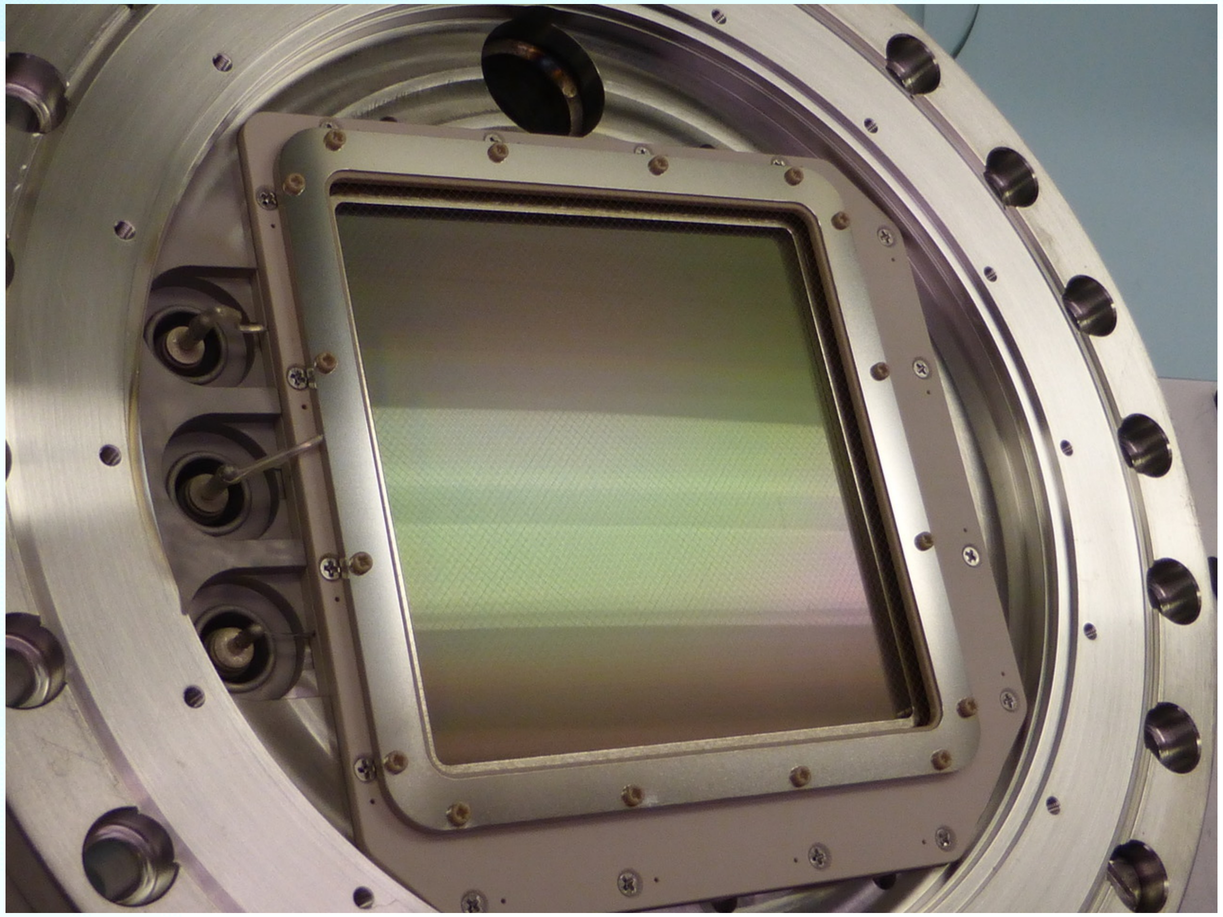


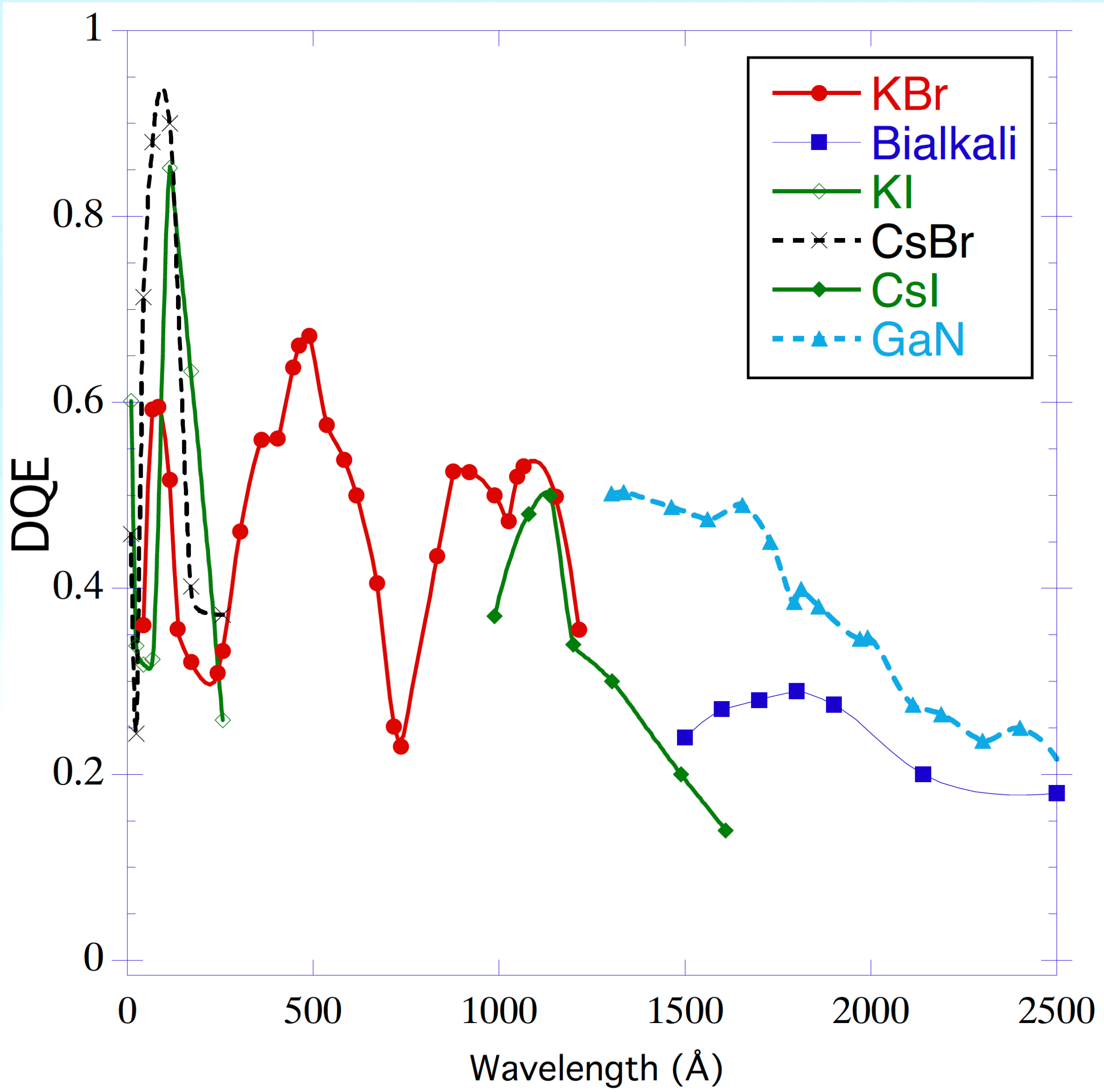
Reflective Coatings

Coating Technology	Coating Properties						
	λ Value @ R>60%	TRL	Largest Optics Coated	Elevated Substrate Temperatures Required?	Max. Relative Humidity for Coating Stability	Dielectric Layer Deposition Process	μ-roughness
Bare Al	>150 nm	6	> 1 meter	No	~70-100%	-	~0.78 nm
Al+MgF_2	>111 nm	6	> 1 meter	No	~70%	PVD	~1.84 nm
Al+LiF	>101 nm	6	~0.5 meter	No	< 30%	PVD	Fresh 1.5-2.5 nm Aged >3 nm
Al+eLiF+MgF_2	>102 nm	~5-6	~ 0.3 meter	Yes	~60 %	eLiF (PVD) MgF_2 (ALD)	1.5-2.5 nm
Al+XeLiF	>103 nm	~3	5x5 cm^2	No	~60%	Reactive PVD	~1-1.5 nm
Al+AlF_3 (e-beam)	>105 nm	~4	5x5 cm^2	No	~60%	E-beam Plasma	~0.81 nm

Next push - scaling optics upward

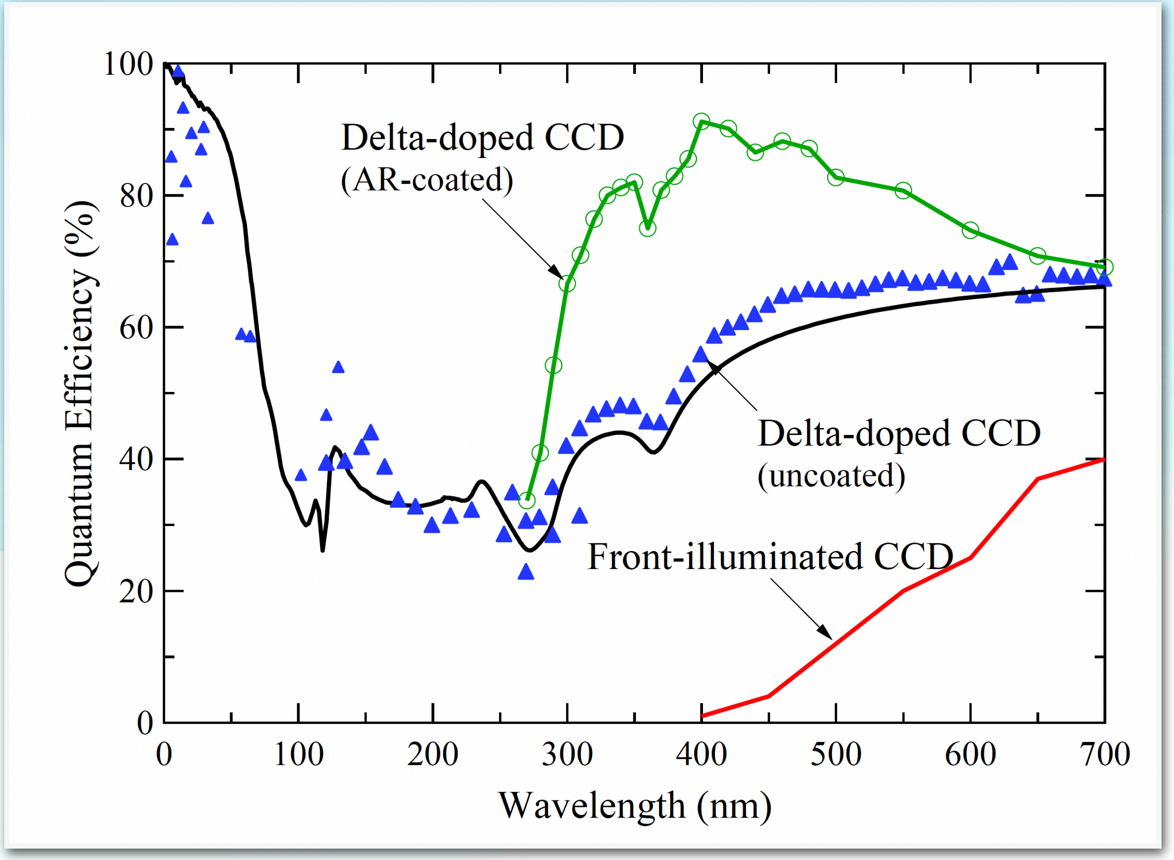
Detectors - Microchannel Plates

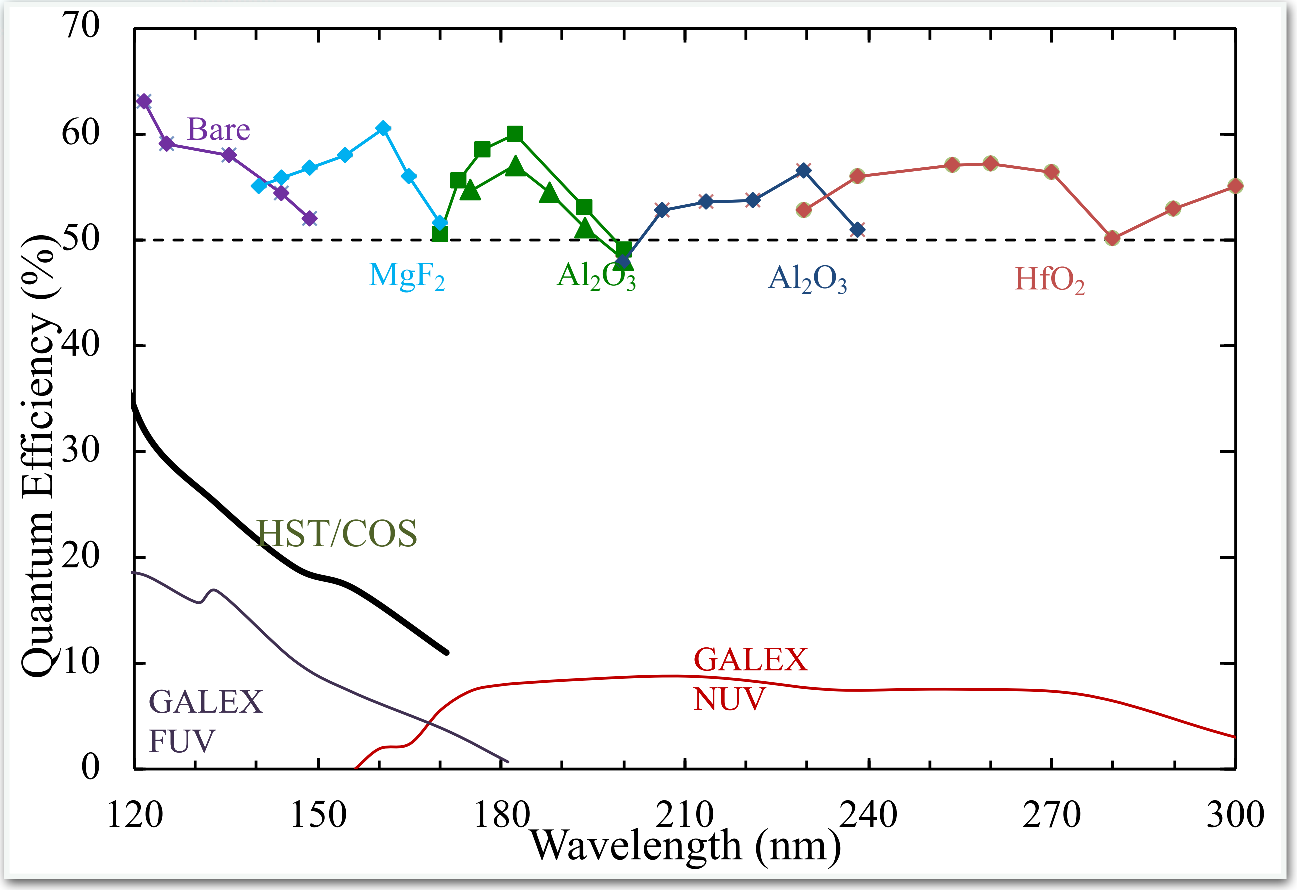




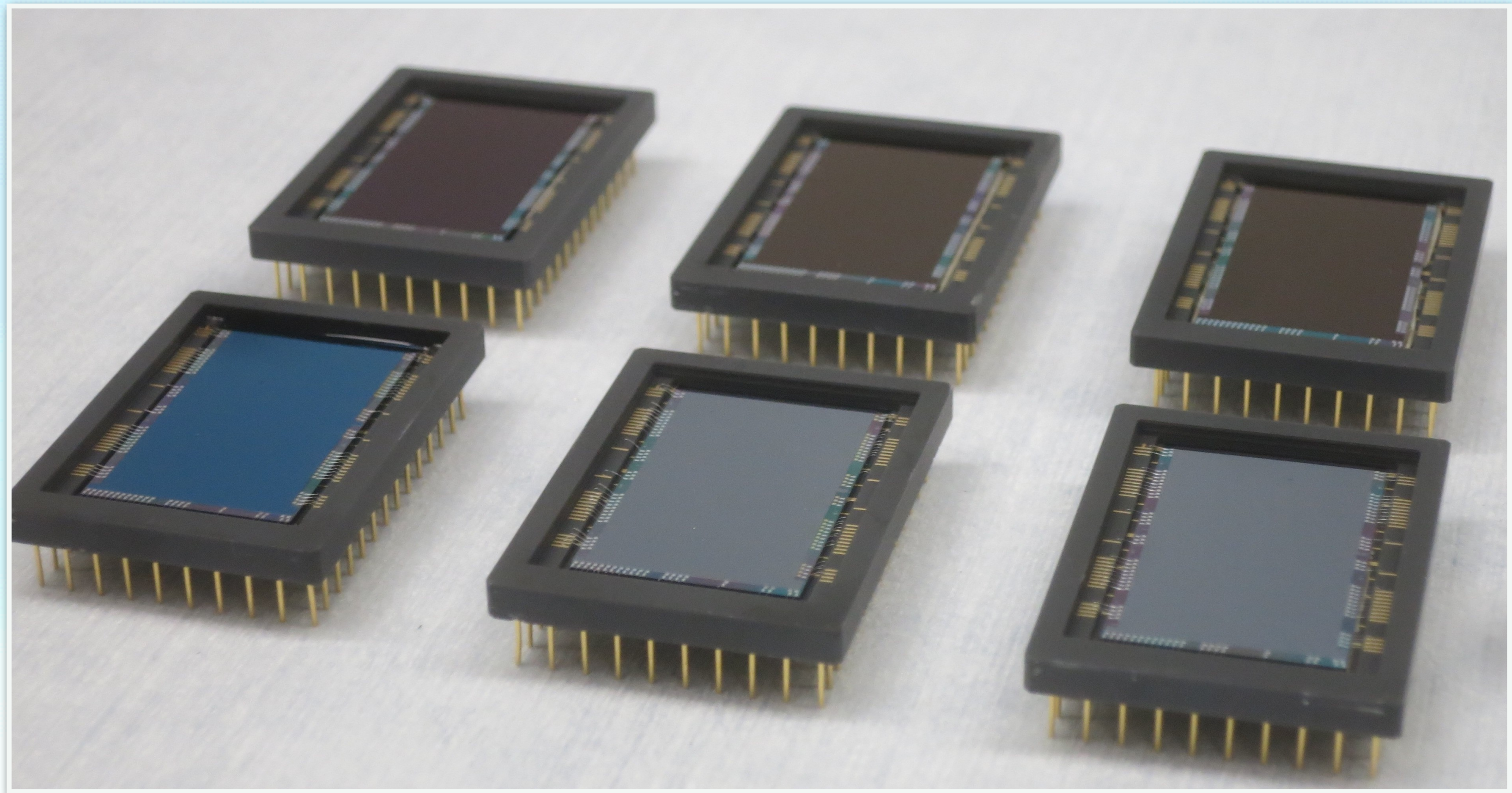
Detectors - Solid State Detectors

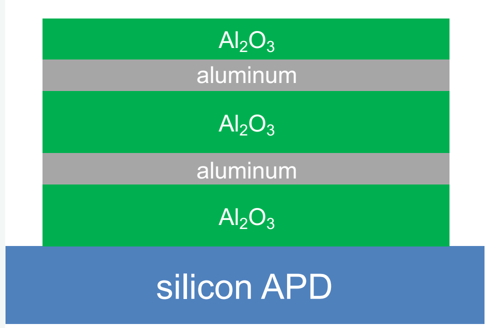
Delta Doped CCDs

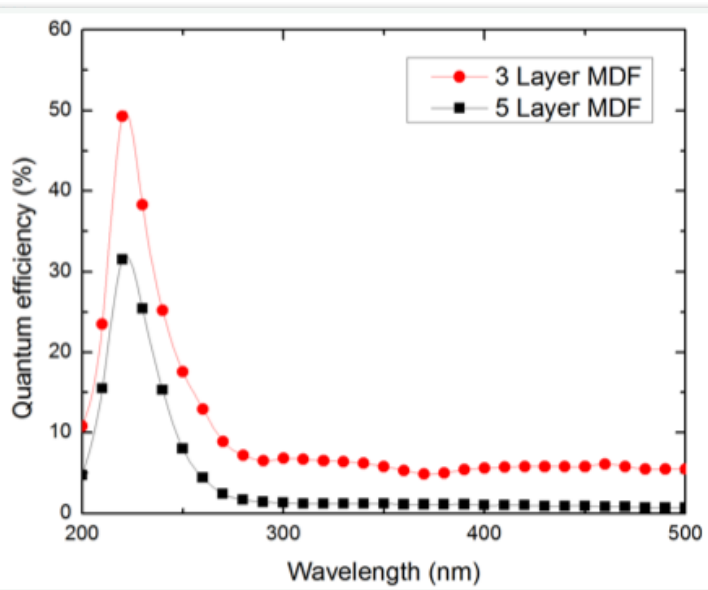


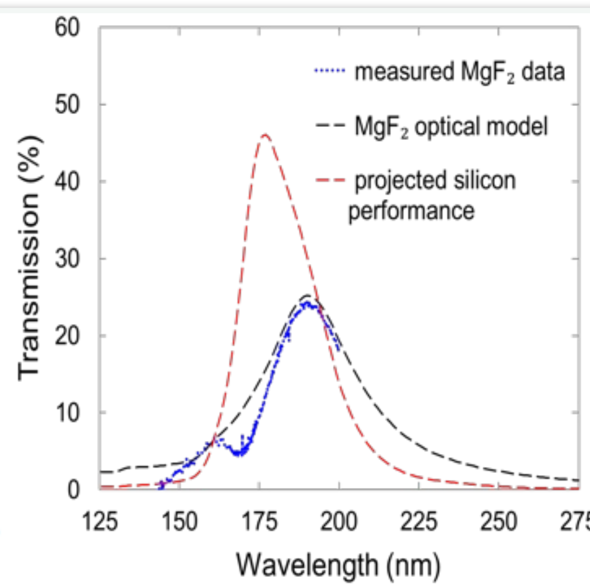


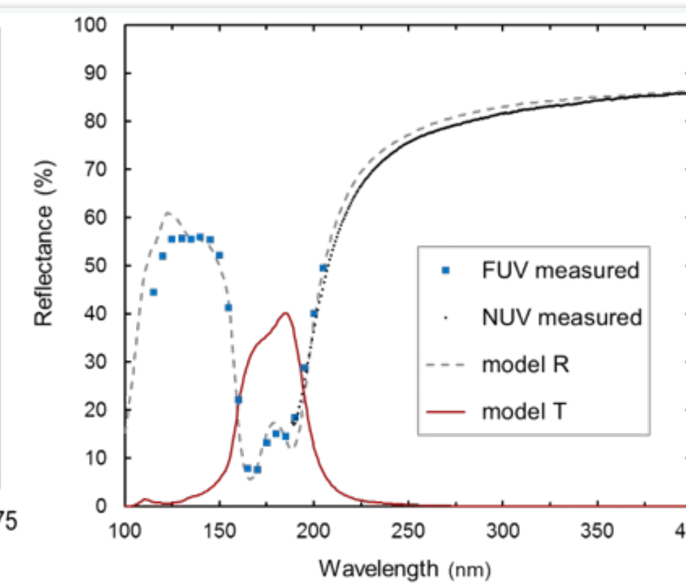
Detectors - Solid State Detectors



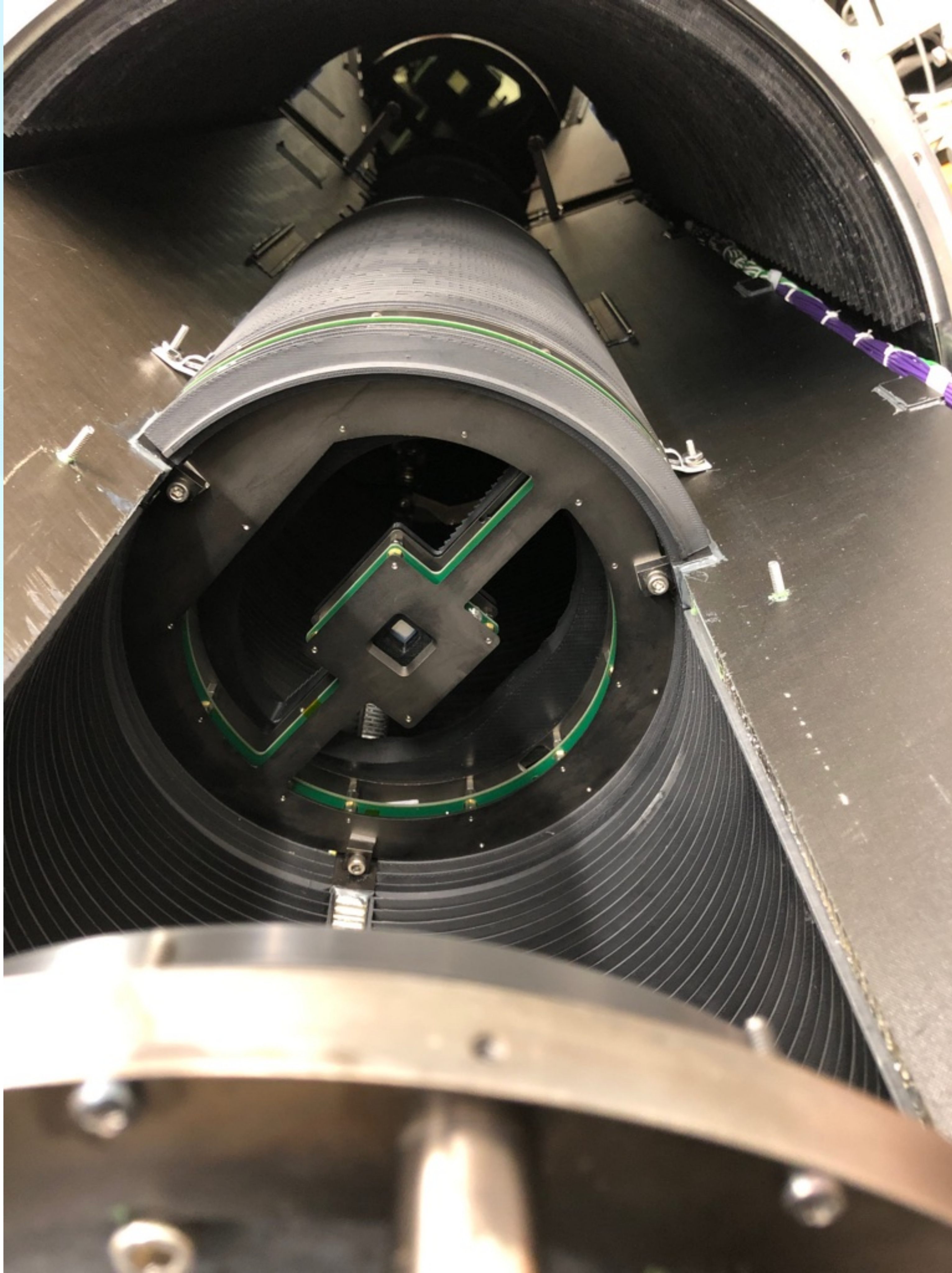








Developing Systems



Take aways

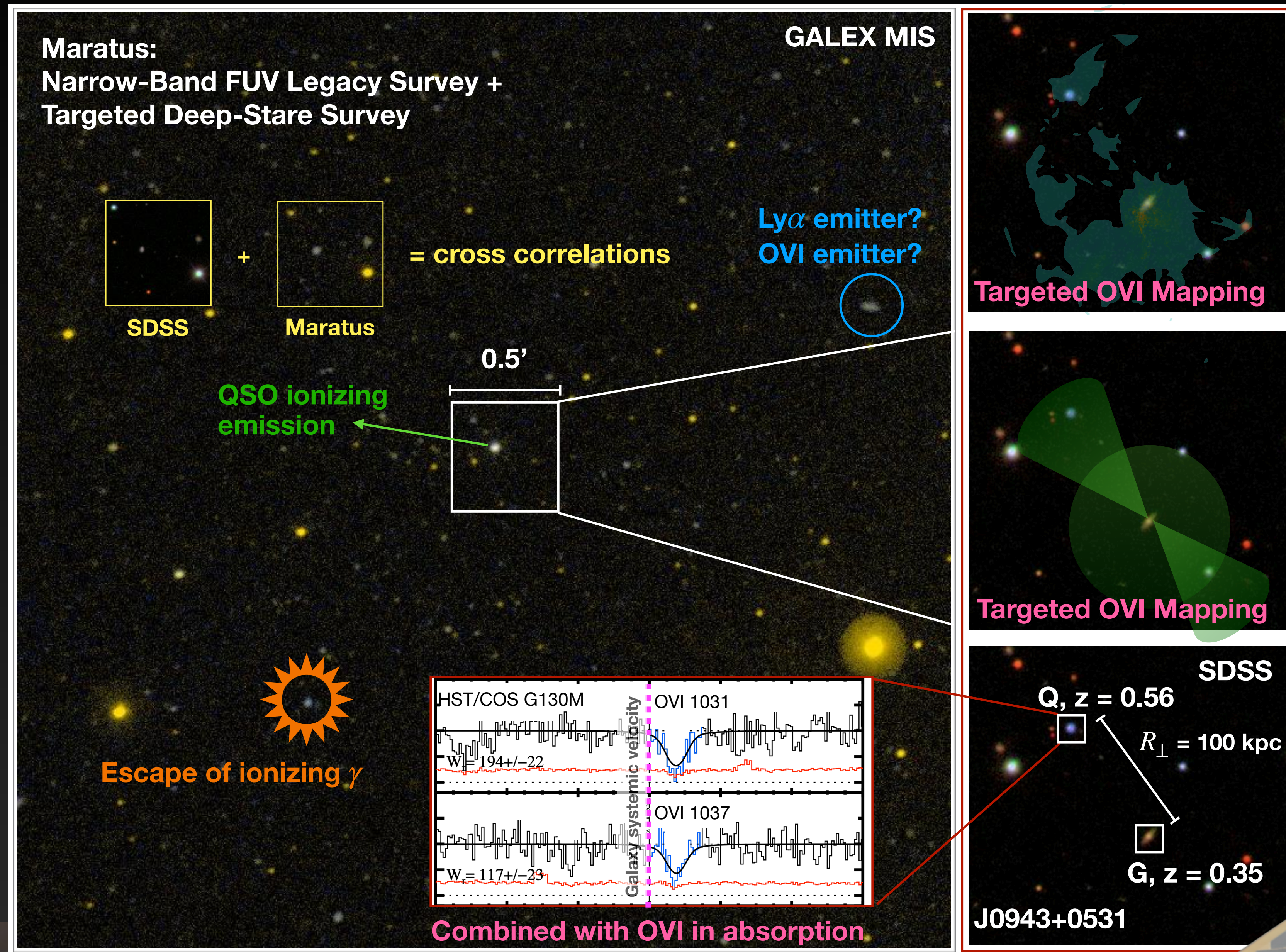
- Both planetary characterization and the circumgalactic medium (key science drivers) require pushing down to the 100nm cutoff.
- Current coatings reach nominal desired values in the UV.
- Electron-beam lithography is our most promising UV grating technology and has been tested sub-orbitally.
- Several mature UV detector technologies are available and flight qualified (with several more in the wings). There is room for performance improvement - this will especially benefit the transformational astrophysics goal of HWO.
- Contamination must be controlled at the systems level and the component level. We capture the wealth of knowledge on this topic to provide a strong start for HWO.
- Several multiplexing technologies have been space qualified. When combined with UV coating development, there is a very exciting path to a multiplexed UV instrument.

What comes next?

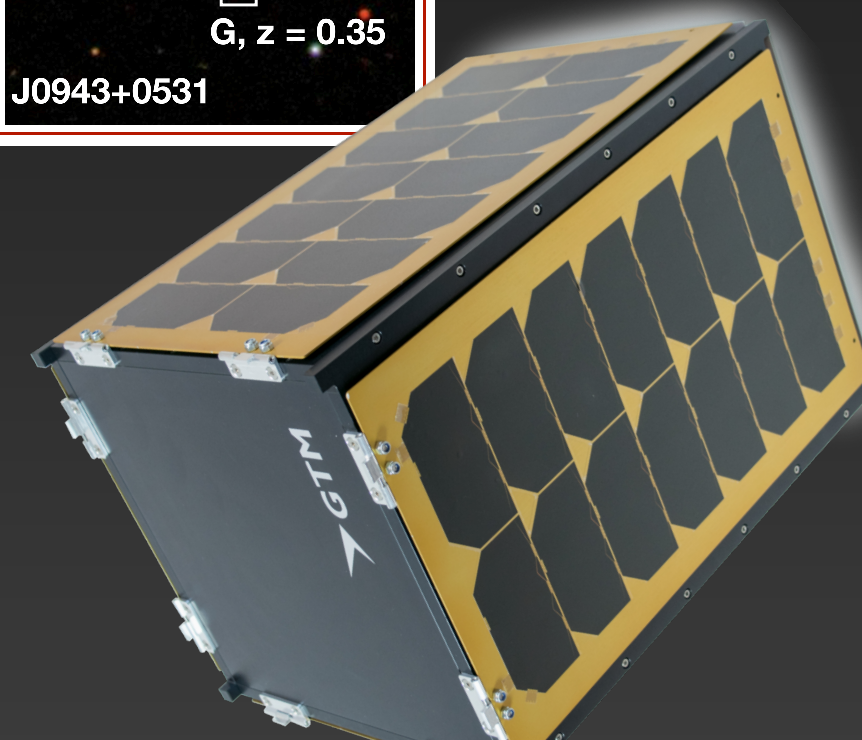
We suggest…..

- Process level (material physics) development (polarimetry performance of coatings, for example)
- Technologies need to scale up in aperture. We need to support facility to begin testing these larger scale components.
- Shifting modes from proving components to developing production lines and systems development and testing.
- Development of laboratory prototype testbed instruments
- Investment beyond APRA (sub-orbital) missions
- Technology Demonstration Missions (smallsats/pathfinders) to do systems level testing and provide early-career mission training

Maratus: Mapping the CGM in the FUV

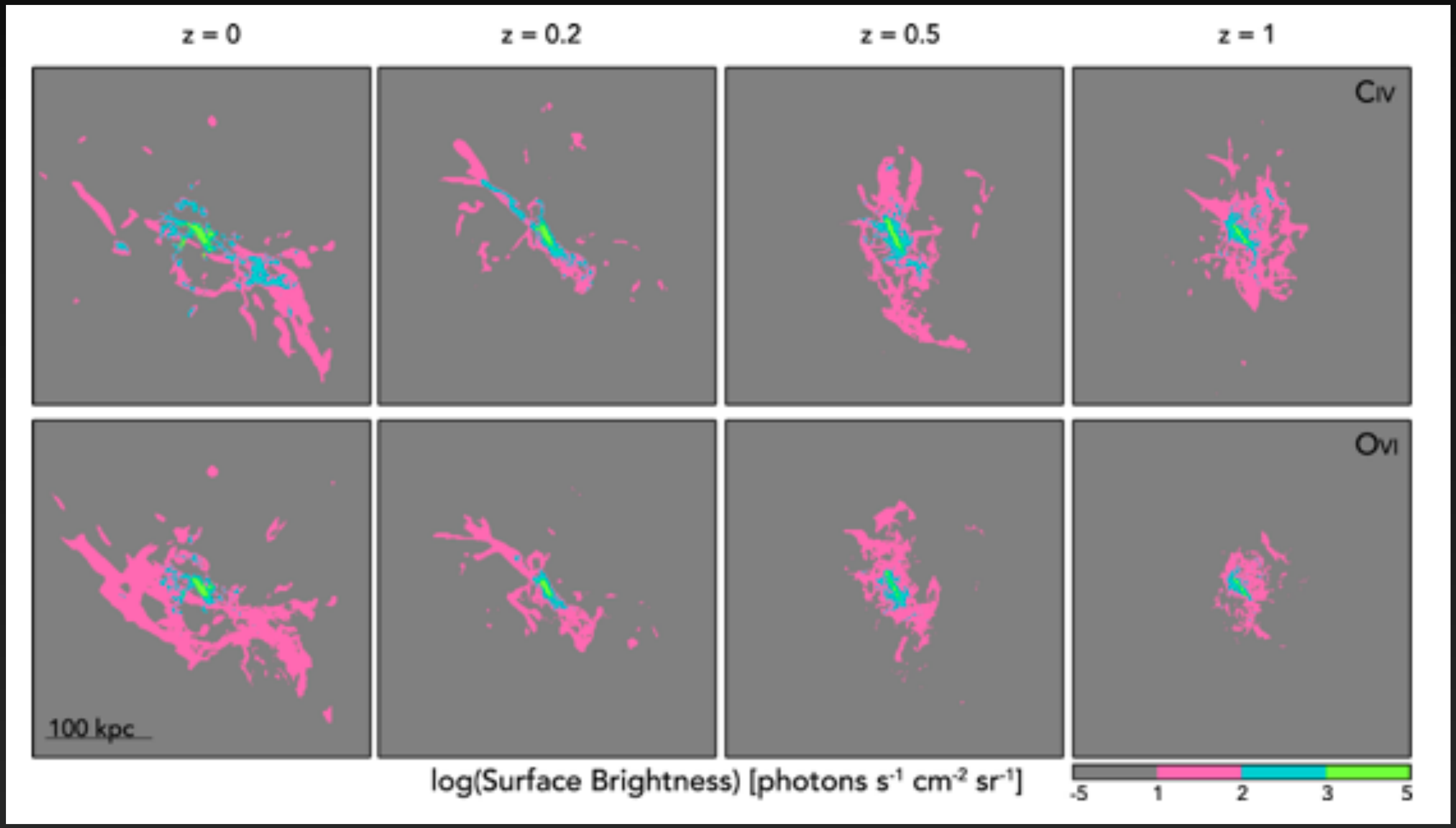


Jessica Werk (UW), Matt McQuinn(UW), Tom Quinn(UW), Lauren Corelis (VRO), Paul Scowen (GSFC), Brian Fleming (CU), Jason McPhate (UCB)

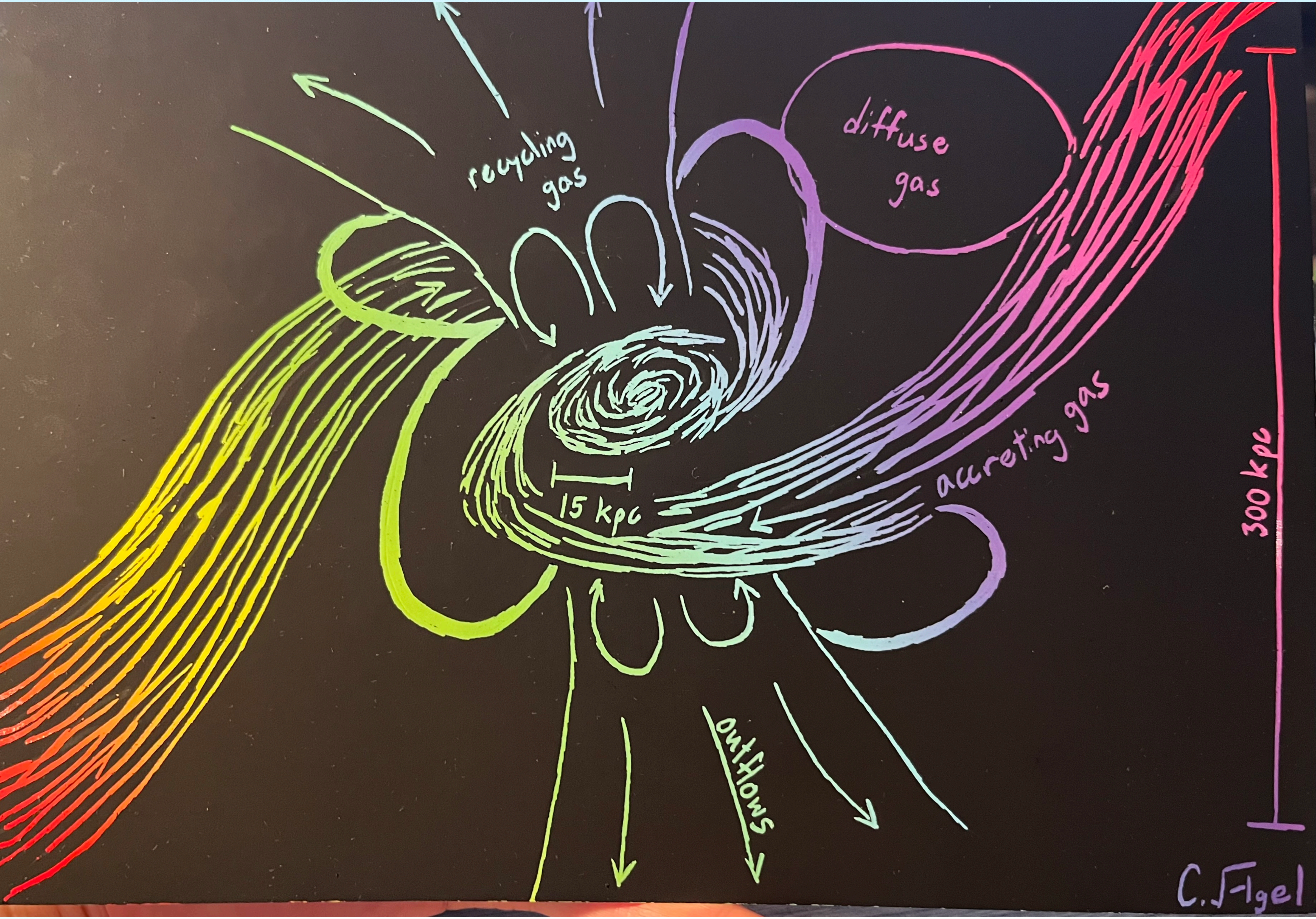


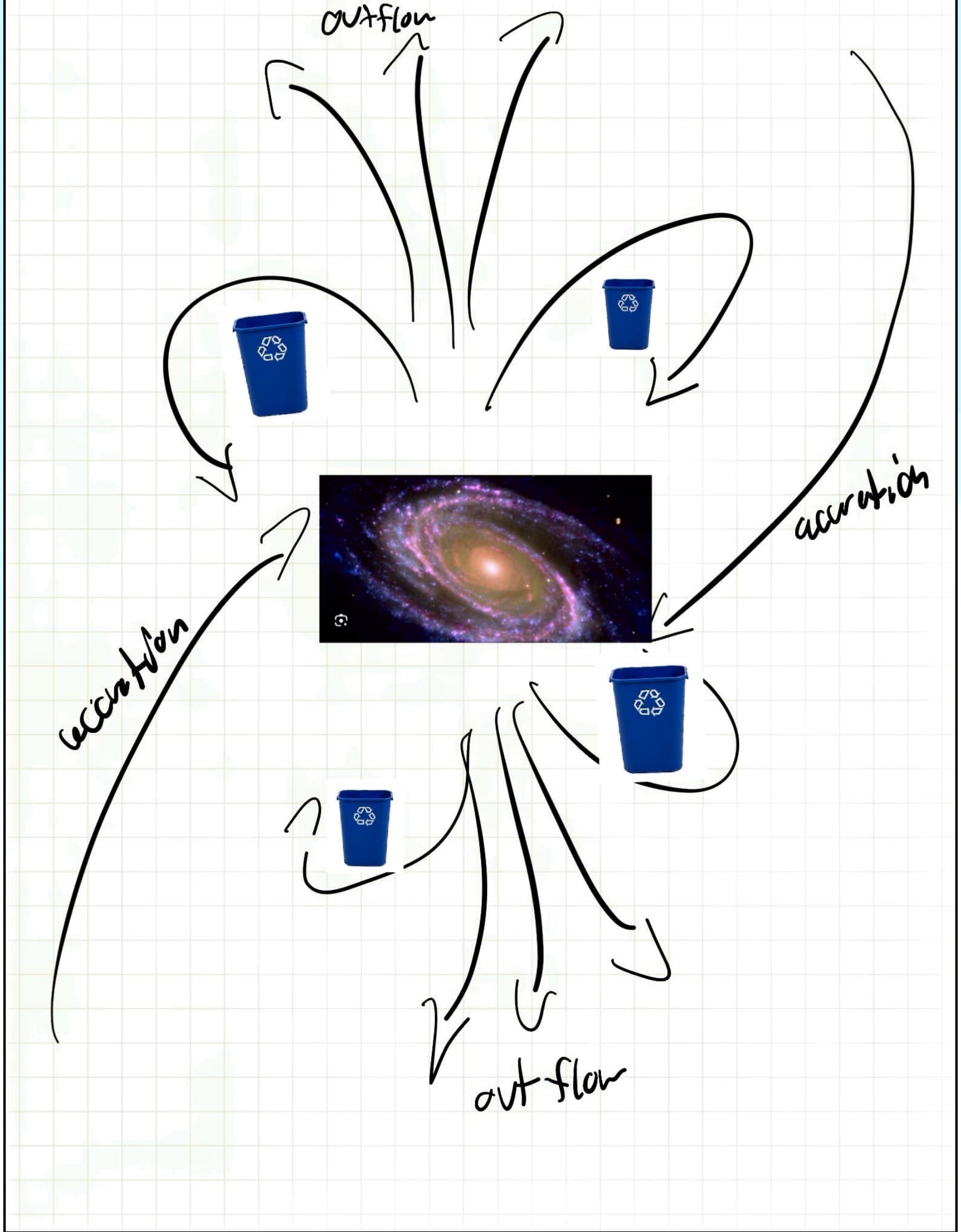
Mapping the Circumgalactic Medium

OVI at z ~ 0.3



- Predictions (from multiple simulations)
- Constraints from past projects (FIREBall1 & 2)
- Absorption measurements (COS-HALOs etc.)


recycling gas
diffuse gas
accreting gas
15 kpc
300 kpc
outflows
C. √-1gel


outflow
accretion
accretion
out flow