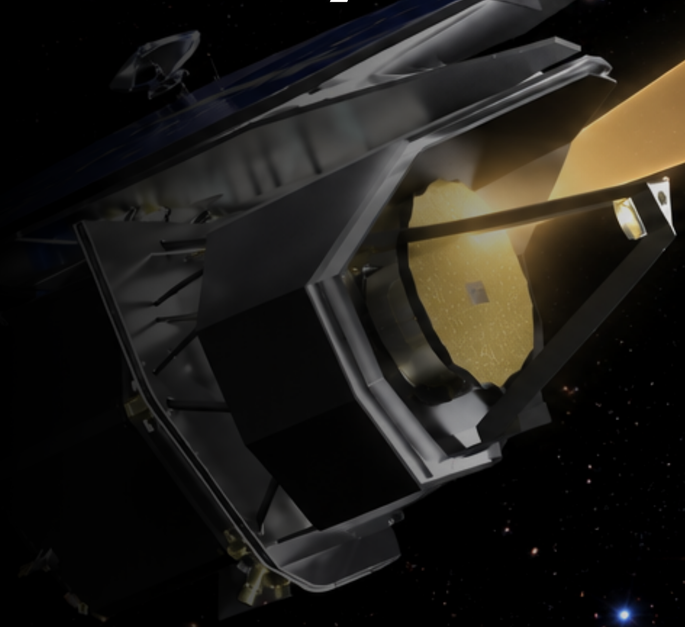
Caltech ipac

CHROMOS:

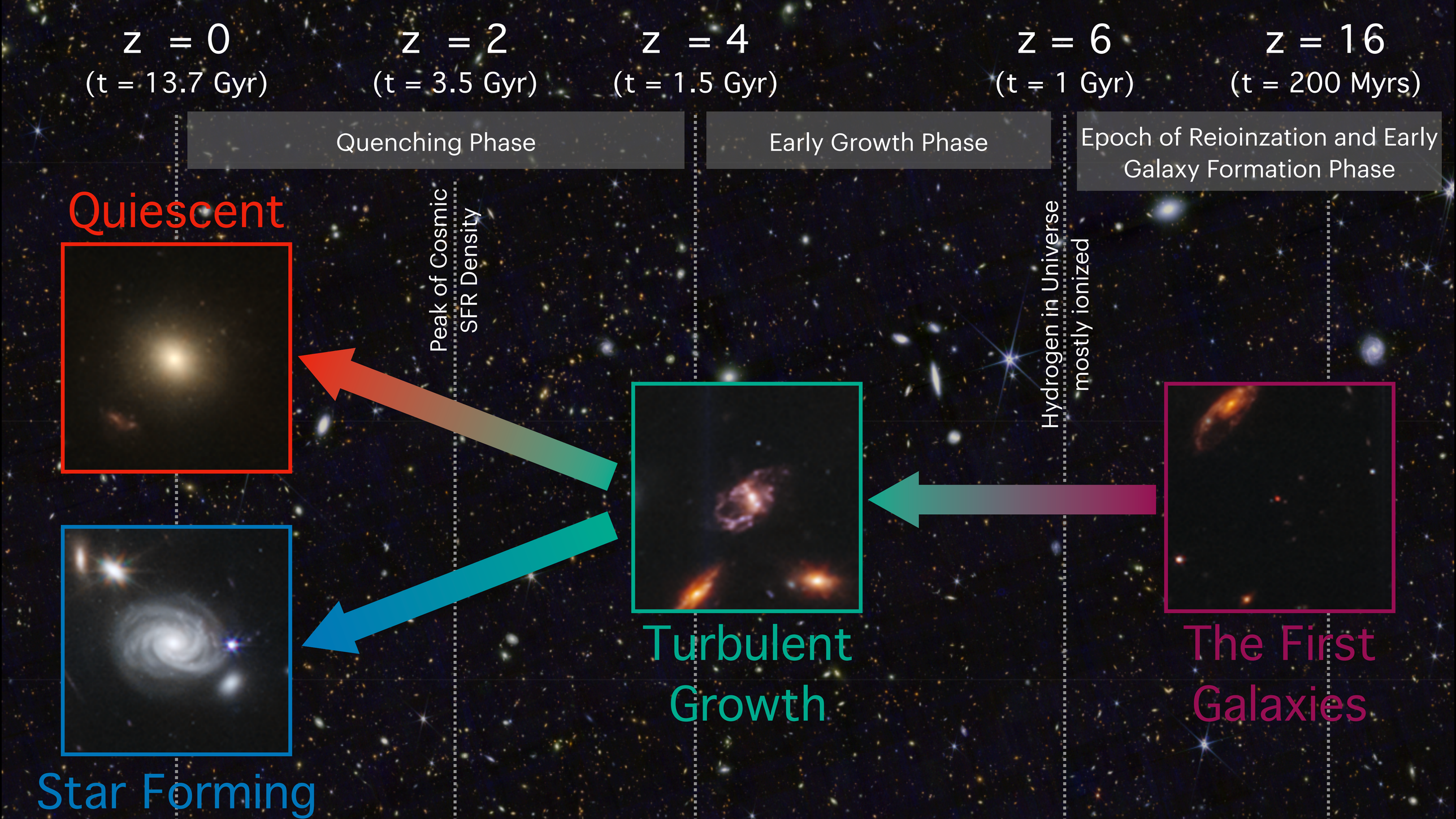
Explore the Drivers of Large Scale Structure, Galaxy, and Black Hole Evolution



Andreas Faisst
Caltech/IPAC
(afaisst@caltech.edu)

for the CHROMOS team

AdAstra, Caltech, September 1, 2026


z = 0
(t = 13.7 Gyr)
z = 2
(t = 3.5 Gyr)
z = 4
(t = 1.5 Gyr)
z = 6
(t = 1 Gyr)
z = 16
(t = 200 Myrs)
Quenching Phase
Early Growth Phase
Epoch of Reioinzation and Early Galaxy Formation Phase
Peak of Cosmic SFR Density
Hydrogen in Universe mostly ionized
Quiescent
Star Forming
Turbulent Growth
The First Galaxies

Current Landscape

Substantial progress in understanding galaxy formation and evolution.

- JWST observations measured detailed physical properties of galaxies on small scales
- Euclid/Roman provide wide-area coverage on sky
- Ground-based narrow-band imaging surveys trace galaxy overdensities
- Ground-based spectroscopy (e.g., Subaru/PFS) offers spectroscopic follow-up

Galaxies do not live in isolation!

Dark Matter structure informs cosmological models of ΛCDM

Galaxy density affects reionization topology (patch vs. smooth)

Formation of the most massive structures affect galaxy growth

Overdense structures lead to ram pressure stripping and gas heating, thus quenching

Dark Matter Filaments lead gas inflows and star formation

What is Currently Missing

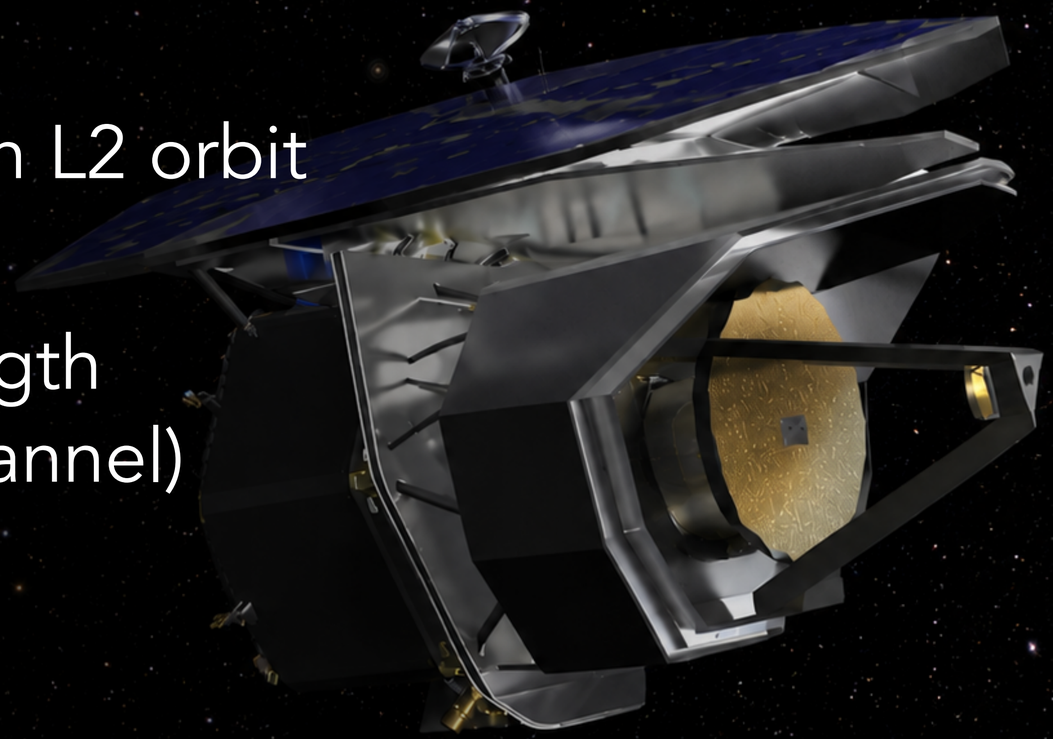
A wide-area, space-based, medium-resolution spectroscopic survey in the near-IR.

- **Wide-area:** put the detailed measurements into context of the large-scale structure
- **Medium-Resolution Spectroscopy:** robust measurements of line properties (e.g., broadening, doublets)
- **Near-IR:** cover broad range of optical lines at high redshifts
- **Space-Based:** not limited by atmospheric transmission; enables continuous wavelength / redshift coverage

CHROMOS: Cosmic Higher Resolution Origins Multi-Object Spectroscopy

See Mission implementation talk: Greg Wirth (BAE)
September 2, 1:42pm, "UV Optical IR" session

CHROMOS will fill in the gap.



- 2-meter near-IR space telescope in L2 orbit with ~0.7 deg^2 FoV
- Simultaneous 1.25 - 5μm wavelength coverage (split in blue and red channel)
- R = 1000 spectroscopic resolution
- ~24,000 spectra at once!
- Sensitivity (5σ): $3 - 8 \times 10^{-18}$ erg/s/cm^2 for 5 hour integration
- Digital Micro Mirror (DMD) with 0.75" x 0.75" slit size @ 0.375"/px

CHROMOS ASTRA Team

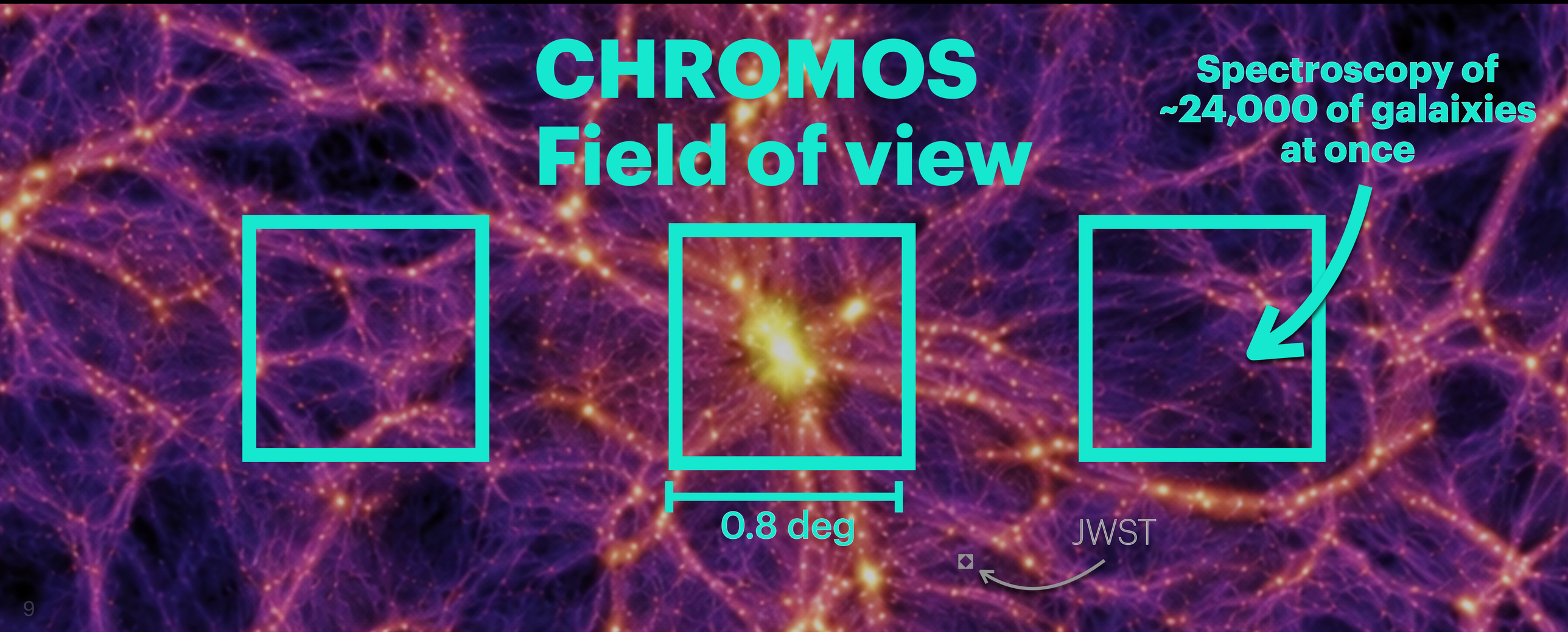
- **PI**: Yun Wang (Caltech/IPAC) → **Talk (September 1, 11:45am)**
- **Instrument Scientist**: Massimo Robberto (JHU/STScI)
- **Industry Lead**: Gregory Wirth (BAE) → **Talk (September 2, 1.42pm)**
- **Scientific Advisory Committee**: Mark Dickinson (Noirlab), Thomas Greene (Caltech/IPAC), Jeffrey Kruk (GSFC), Will Percival (Canada), Joshua Schlieder (GSFC)
- **Cosmology Science Leads**: Nikhil Padmanabhan (Yale), Lado Samushia (Kansas State)
- **Exoplanet Science Lead**: Thomas Greene (Caltech/IPAC) → **Talk (September 1, 11:15am)**
- **Galaxy Evolution Science Leads**: Andreas Faisst (Caltech/IPAC), Jeyhan Kartaltepe (RIT) → **Talk (now!)**
- **Milky Way Science Lead:** Lynne Hillenbrand (Caltech) → **Poster**
- **Instrument Working Group:** Robert Content (AAO), Jon Lawrence (AAO), Gregory Mosby (GSFC), Zoran Ninkov (RIT), Jack Piotrowski (JHU), Steve Smee (JHU)
- **Cosmology Science Work Group:** Florian Beutler, Samuel Brieden (UK), Kyle Finner (Caltech/IPAC), Andrew Hearin (ANL), Cullan Howlett (Australia), Alvise Raccanelli (Italy), Jason Rhodes (JPL), Shun Saito (Missouri S & T), Hee-Jong Seo (Ohio Univ), Zachary Slepian (Univ of Florida), Francesco Spezzati (Caltech/IPAC)
- **Galaxy Evolution Science Working Group:** Lee Armus (Caltech/IPAC), Andrew Benson (Carnegie), Micol Bolzonella (Italy), Jarle Brinchmann (Portugal), Emanuele Daddi (France), Ken Osato (Japan), Casey Papovich (Texas A&M), Lucia Pozzetti (Italy)

CHROMOS Comparison

Wide Survey Mode	*CHROMOS*	*Roman*	*SPHEREx*	*Euclid*	*JWST**	*HST*
Slit spectroscopy	**Yes**	No	No	No	Yes	No
Spectral resolution	**1000**	461	41, 35, 110, 130	380	1000, 2700	130
Wavelength (μm)	**1.25-5**	1-1.91	0.75-5	1.25-1.85	1-5	0.8-1.7
Redshift range Δz	**1-9 Hα/[OIII]**	1-2.85 Hα/[OIII]	z < 2 (6.2″ pixels)	0.9-1.8 Hα	0.5-9 Hα/[OIII]	0.2-1.6 Hα
Redshift error σ_z	**0.0002**	0.001	0.1	0.001	0.0002	0.002
Magnitude cut	**H<24.5**	H<24.5	H<20	H<24	N/A	N/A
Survey depth (erg/s/cm^2)	**3.5 - 8×10^{-18} (5σ)**	1.5× 10^{-16} (5σ)	5×10^{-15}, 1×10^{-15} @1, 4 μm (5σ)	3×10^{-16} (5σ)	2×10^{-19} (5σ)	5×10^{-17} (5σ)
Survey area (deg^2)	**~14,000**	~2,400	~28,000	~14,000	< 1	< 0.2
Survey Volume (Gpc^3)	**1,000**	44	111@z=1, 426@z=2	121	0.084/deg^2	0.0058/deg^2
FOV (deg^2)	**0.7**	0.28	39.6	0.55	0.0034	0.00147
Telescope aperture (m)	**2**	2.4	0.2	1.2	6.6	2.4

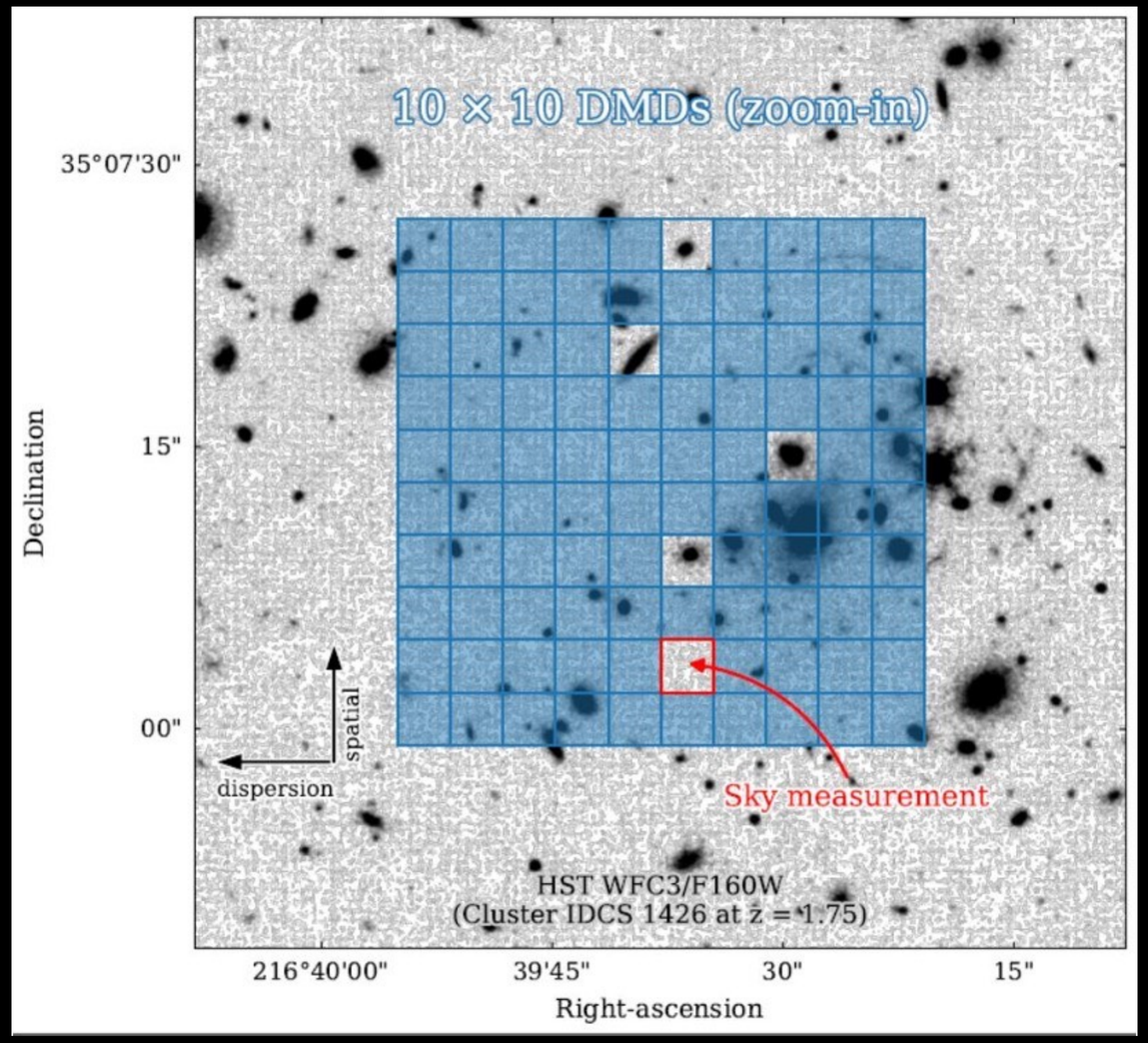
Why a Large FoV is Important

Probing dense structures, filaments, and voids at the same time.



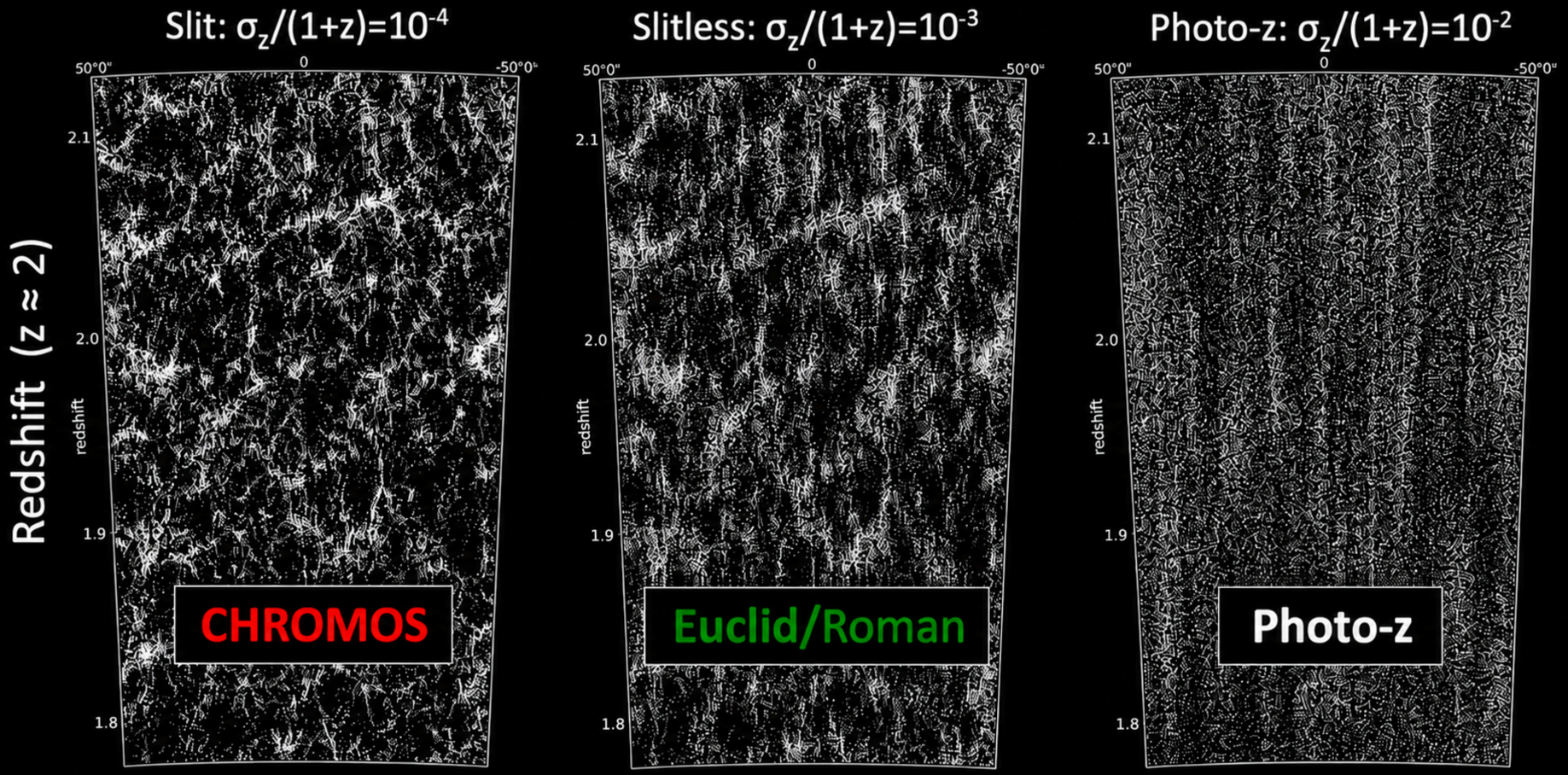
Why a Large FoV is Important

Probing dense structures, filaments, and voids at the same time.



Why R = 1000 Is Important

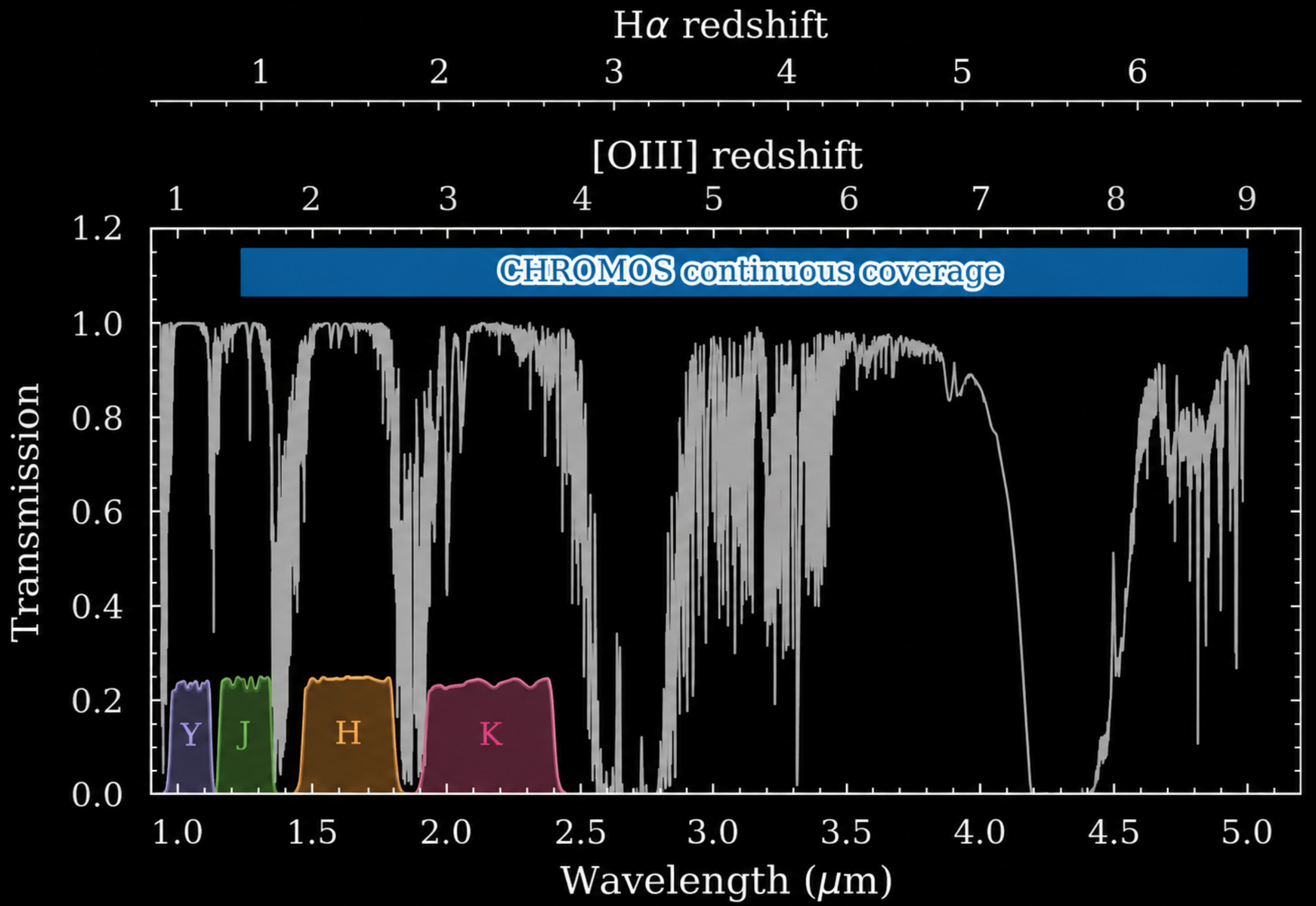
Robust tracking of large scale structures and galaxies within them.



(Figures by Alvaro Orsi)

Why Space-Based is Important

Continuous coverage of large scale structure and galaxy properties across cosmic time.



Questions CHROMOS will Answer

1. Does Reionization Progress Patchy or Smooth?

- **Map the spatial distribution of [OIII] and Hα emitters at z > 6, cornerstones of reioinzation**
- Combine with measurements of Lyα emission from optical telescopes
- Constrain ionized bubble sizes: tracer of reionization process and topology

Questions CHROMOS will Answer

2. What are the Drivers of Large Scale Structure Evolution?

- **Spectroscopic confirmation and characterization of galaxy clusters from Cosmic Noon to today**
- Constrain cosmological structure formation
- Kinematic properties (merging clusters)
- Enable weak lensing follow up with Roman/Euclid (identify background/foreground galaxies)

Questions CHROMOS will Answer

3. How does Large Scale Structure Impact Galaxy Formation and Evolution?

- **Characterize galaxy properties in dense structures (cluster and protoclusters) across cosmic time**
- Complement narrow-band (Lyα) observation with optical line detections from CHROMOS to trace complementary galaxy populations
- Understand cold vs. hot accretion modes in clusters (quenching of galaxies in overdensitites)

Adapted from Umehata et al. (2019)

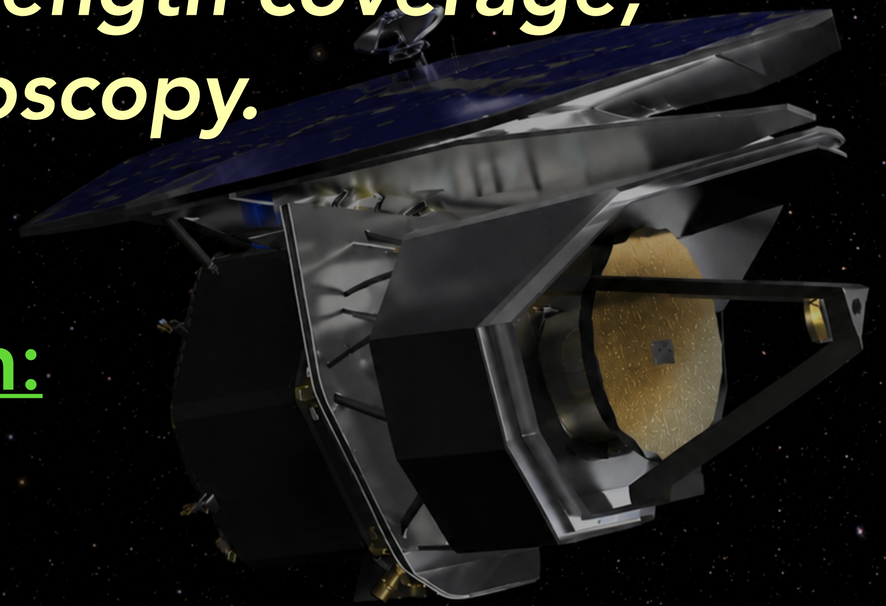
Questions CHROMOS will Answer

4. How is Super Massive Black Hole Growth Coupled to Host Galaxies?

- **First statistical study of AGN in different environments and galaxy populations**
- Efficient AGN surveys for large galaxy samples in different environments
- R=1000 spectroscopy identifies broad optical lines
- Repeated observations and stability: time domain studies (changing look AGN, SNe, etc.)

Summary

CHROMOS fills a current gap in wavelength coverage, high resolution, and wide-area spectroscopy.



CHROMOS will address and solve the following questions in **Galaxy Evolution:**

- What is the topology of reionization?
- What are the drivers of large scale structure evolution?
- How does the large scale structure impact galaxy evolution?
- How is super massive black hole growth related to galaxy evolution and environment?

Andreas Faisst | afaisst@**caltech**.edu

CHROMOS ASTRA Team

- **PI**: Yun Wang (Caltech/IPAC) → **Talk (September 1, 11:45am)**
- **Instrument Scientist**: Massimo Robberto (JHU/STScI)
- **Industry Lead**: Gregory Wirth (BAE) → **Talk (September 2, 1.42pm)**
- **Scientific Advisory Committee**: Mark Dickinson (Noirlab), Thomas Greene (Caltech/IPAC), Jeffrey Kruk (GSFC), Will Percival (Canada), Joshua Schlieder (GSFC)
- **Cosmology Science Leads**: Nikhil Padmanabhan (Yale), Lado Samushia (Kansas State)
- **Exoplanet Science Lead**: Thomas Greene (Caltech/IPAC) → **Talk (September 1, 11:15am)**
- **Galaxy Evolution Science Leads**: Andreas Faisst (Caltech/IPAC), Jeyhan Kartaltepe (RIT) → **Talk (now!)**
- **Milky Way Science Lead:** Lynne Hillenbrand (Caltech) → **Poster**
- **Instrument Working Group:** Robert Content (AAO), Jon Lawrence (AAO), Gregory Mosby (GSFC), Zoran Ninkov (RIT), Jack Piotrowski (JHU), Steve Smee (JHU)
- **Cosmology Science Work Group:** Florian Beutler, Samuel Brieden (UK), Kyle Finner (Caltech/IPAC), Andrew Hearin (ANL), Cullan Howlett (Australia), Alvise Raccanelli (Italy), Jason Rhodes (JPL), Shun Saito (Missouri S & T), Hee-Jong Seo (Ohio Univ), Zachary Slepian (Univ of Florida), Francesco Spezzati (Caltech/IPAC)
- **Galaxy Evolution Science Working Group:** Lee Armus (Caltech/IPAC), Andrew Benson (Carnegie), Micol Bolzonella (Italy), Jarle Brinchmann (Portugal), Emanuele Daddi (France), Ken Osato (Japan), Casey Papovich (Texas A&M), Lucia Pozzetti (Italy)