

The **Experiment** for **Cryogenic Large-** **Aperture Intensity Mapping** (EXCLAIM):

A sub-mm experiment using micro-spectrometers to unveil star formation history via intensity mapping.

NASA Goddard

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CITA: Simulation and interpretation

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The EXCLAIM Team





EXCLAIM in numbers...

Band: 420 – 540 GHz

Resolution: R \sim 512, 6 pixels

Survey size: \sim 300 deg² area (wide)

Scan: \sim 7° in azimuth at fixed elevation 45°

Beam size: 76 cm projected aperture provides \sim 4' FWHM.

Redshifts: CO $0 < z < 0.6+$, CII $2.5 < z < 3.5$, CI $z \sim 0$

Cross correlation: BOSS quasars

Spectrometer: MKID on-chip u-Spec

Detectors: Antenna-coupled MKID

Flight duration: conventional (e.g. 1-day) flight

Flight location: NM, USA

Cryogenics: 3500 l LHe Bucket dewar

Balloon class: \sim 2400 kg dry mass, 34 MCF balloon

Holding time: \sim 2000 l LHe fill gives 18 hr of 1.7K operation at float

Cold optics: superfluid fountain-effect pumps cool the optics to 1.7 K (Kogut+ 2021)

Heritage: ARCADE/PIPER

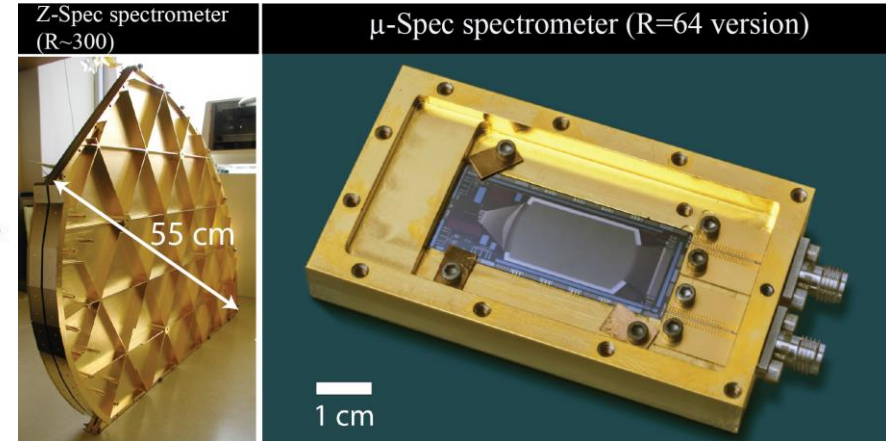
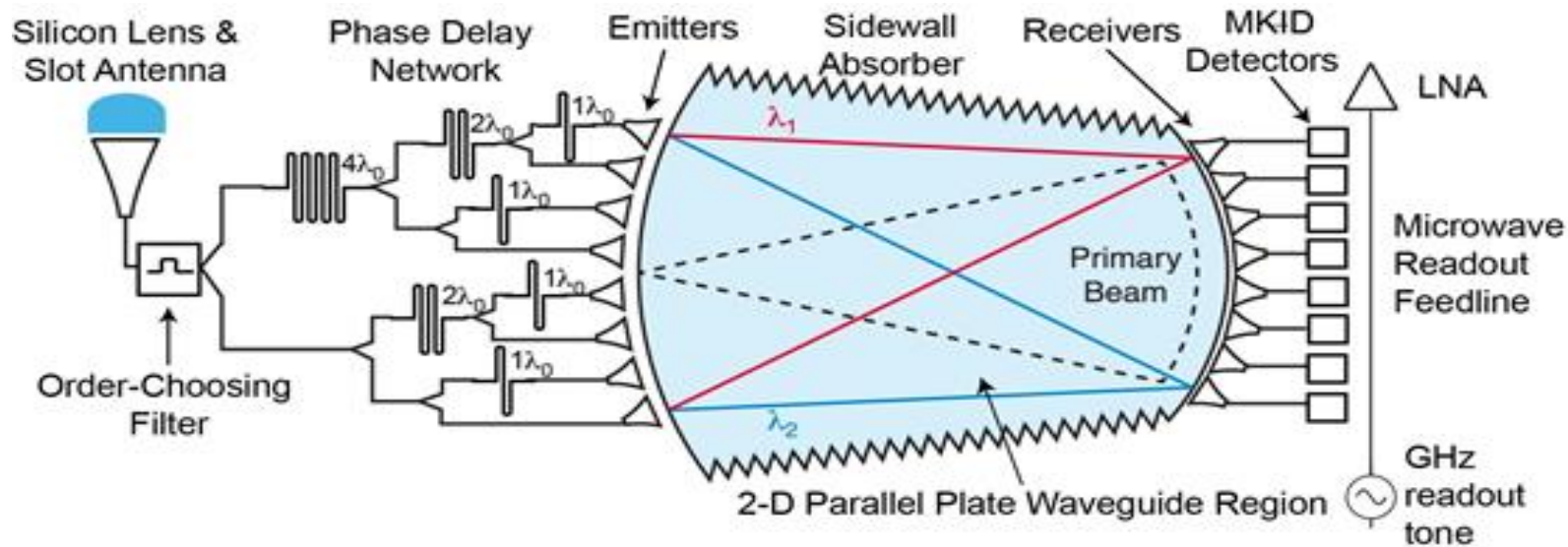
The **EX**periment for **Cryogenic Large Aperture Intensity Mapping**



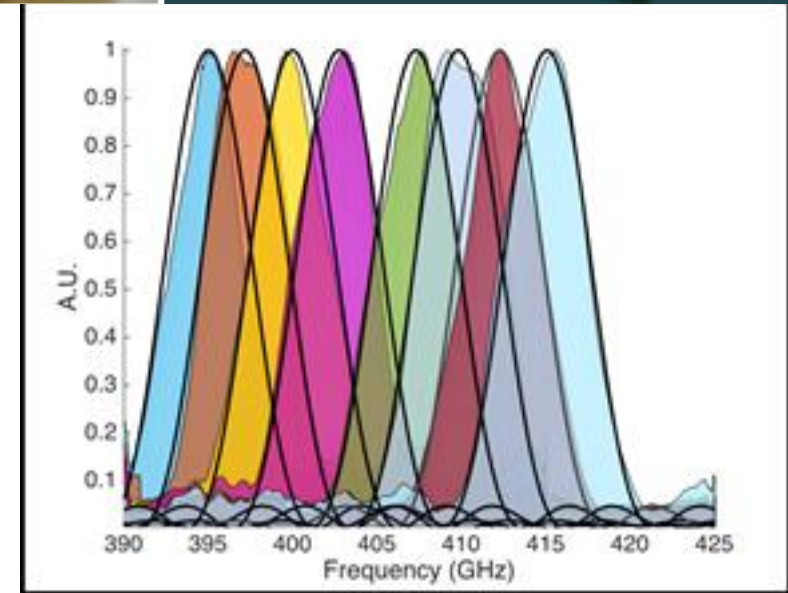
EXCLAIM's innovating technology

- Designed for **line-intensity mapping** with **cross-correlation**
- Employs **micro-spectrometers** (reduced-size spectrometer on a chip technology)
- Pushes existing micro-spectrometer design to **higher resolutions**
- Incorporates **high Q_i aluminum MKID** detectors
- Covers the difficult-to-observe **420-540 GHz** range
- Maps **[CII]** and **CO**, at higher *z*, and provides rare **Galactic [CI]** data

μ -Spec: An Integrated Grating-Analog Spectrometer



- μ -Spec integrates all the elements of a grating spectrometer on a single silicon chip, **providing order of magnitude reduction in size.**
- Instead of a classical grating, a phase delay is introduced by a tree of meandered superconducting niobium microstrip transmission lines on a single-crystal silicon substrate
- The high index of refraction of silicon allows us to introduce the required phase delay in a compact space.
- The low-loss of single-crystal silicon and the superconducting transmission lines provides high efficiency and resolution.
- We use Microwave Kinetic Inductance Detectors (KIDs) due to their intrinsic multiplexing capability and capability to reach ultra-low sensitivity.



Heritage: ROSES APRA R=64 development & demo (PI: S. Harvey Moseley)

Answering the Decadal

“Unveiling the Drivers of Galaxy Growth”

Astro2020: “[The] development of intensity mapping from concept to a robust cosmological tool will take several decades of steady support.” (C-13)

EXCLAIM: is a pathfinder for line intensity mapping, and employs cross-correlation for robust detection.

Astro2020: “[We] have essentially no detailed information about progenitors of typical disk galaxies like the Milky Way at the peak of cosmic star formation rate density ($z \sim 2$) or earlier...” (D-14)

EXCLAIM: Will make observations of the abundance and excitation of the cumulative populations of star-forming CO and CII gas at redshifts of 0 - 0.6+ for CO, and 2.5 - 3.5 for CII.

Astro2020: “How do molecular clouds form and interact with their environments?” (F-4)

EXCLAIM: Will directly study the typical abundance and excitation of the molecular gas in which stars form integrated over all galaxies.

Astro2020: “Wide-field... high-sensitivity mapping of velocity-resolved... far-IR lines... in the MW and nearby galaxies is needed to study the “CO-dark” gas...” (F-6)

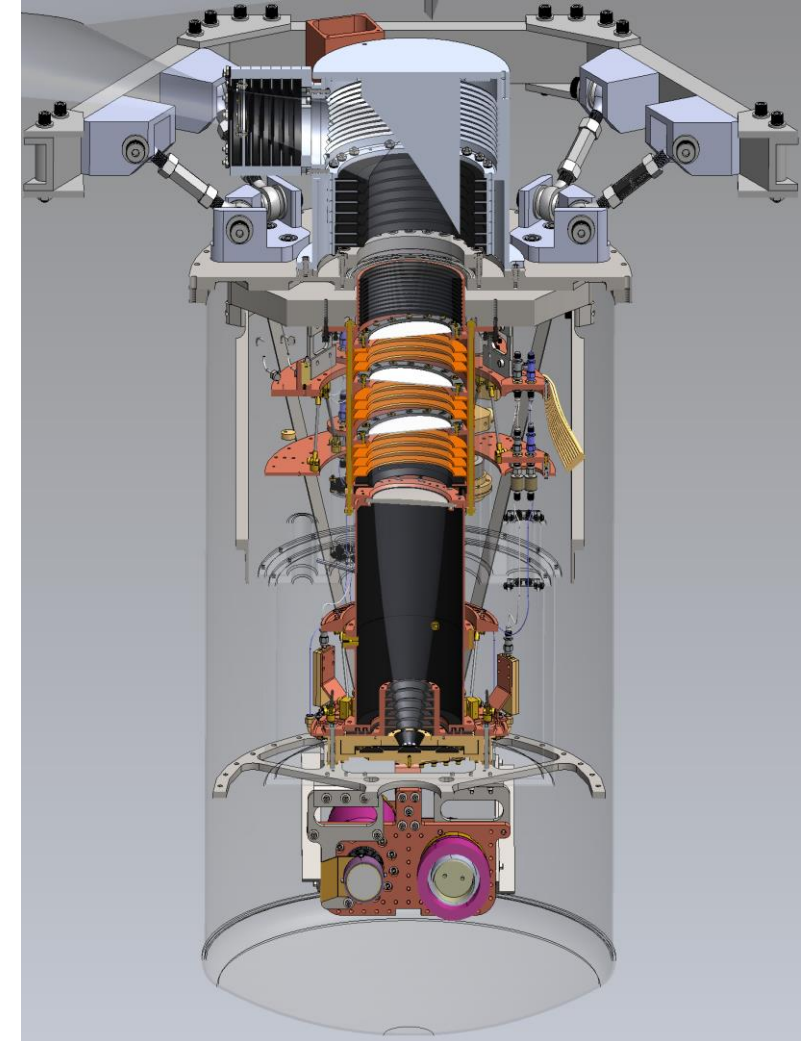
EXCLAIM: Will directly map the abundance of [CI] across the Milky Way environment, probing the viability of the assumed CO/[CI] ratio in different environments.

Current Status:

In the *implementation phase*:
we are cutting metal!

*EXCLAIM flight spectrometer fabrication is proceeding
(a spring 2022 yield is expected)*

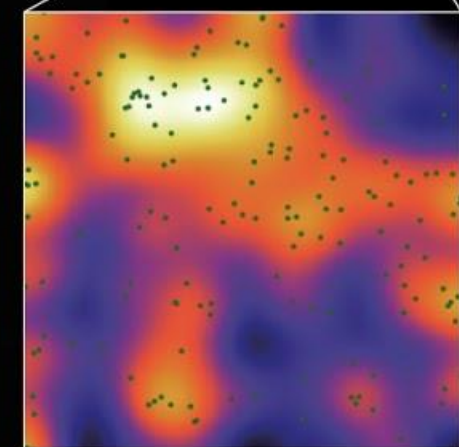
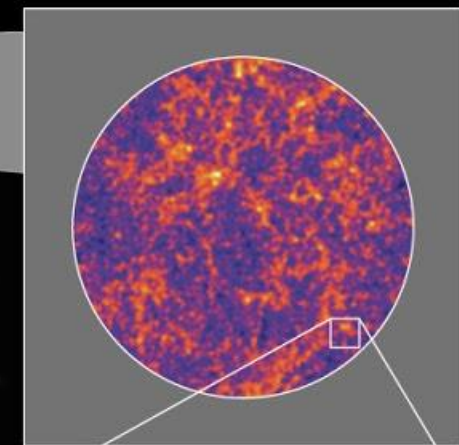
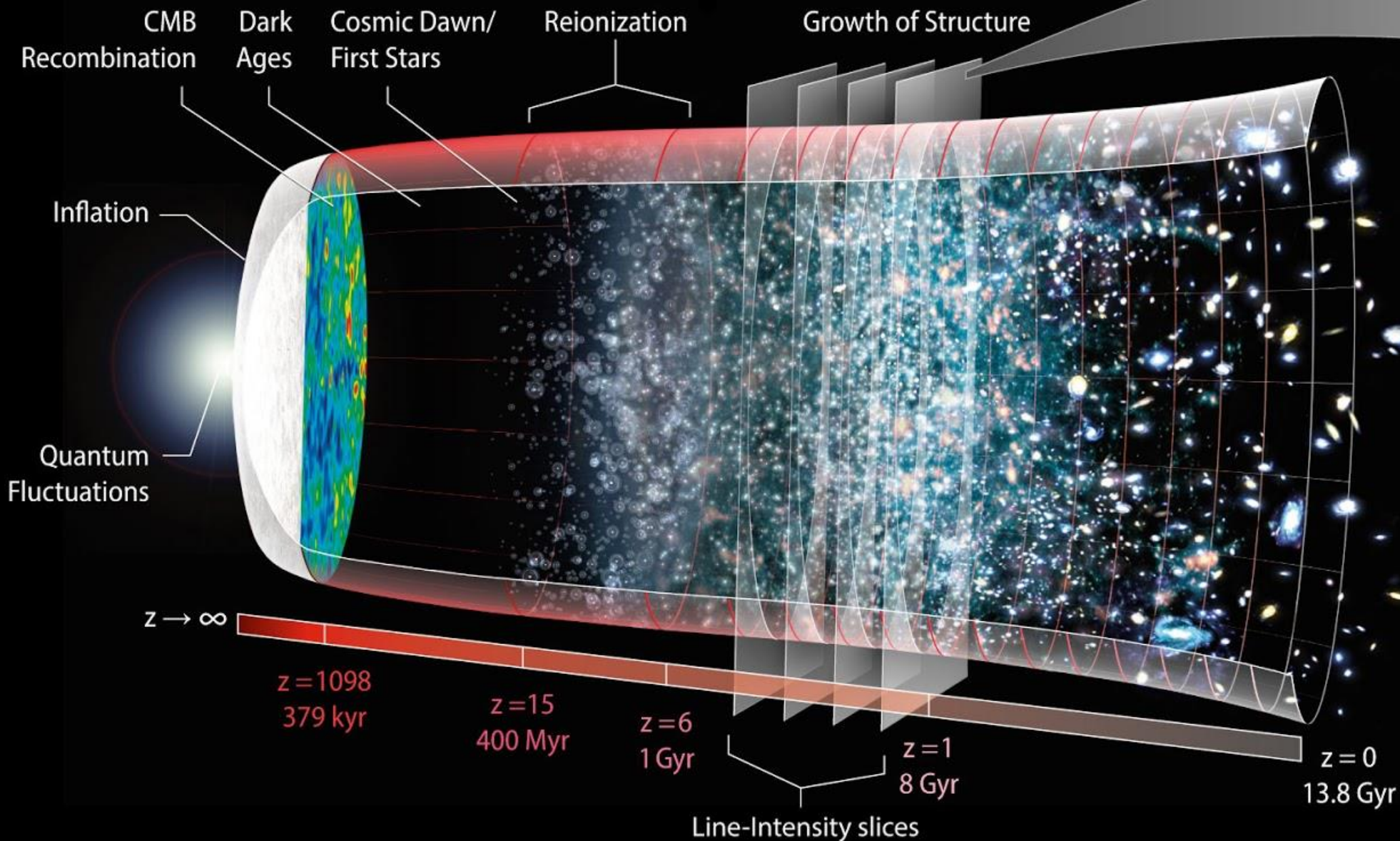
First Engineering Flight:
Preparing for Fall 2023
Ft. Sumner, NM flight opportunity



Thank you for your time

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Line Intensity Mapping (LIM)



Line-Intensity Mapping simulation with galaxy distributions