# Science Frontier Panel on "The Local Galactic Neighborhood"

Michael Shull, University of Colorado

Dec. 12, 2015 - NAS (Irvine) Mid-Decade Workshop

*"Connecting galaxies to extended gaseous systems"*

*"Laboratory to constrain physics that governs the assembly and evolution of galaxies and their components"*

- Evolution of stars (and ISM, CGM, IGM)
- Structure of dark matter
- Formation of Supermassive Black Holes
- Flows of gas in and out of galaxies

# Our Panel's Four Key Questions

GAN-1 *What are the flows of matter and energy in the Circumgalactic Medium?*

GAN-2 *What controls the mass-energy-chemical cycles within galaxies?*

GAN-3 *What is the fossil record of galaxy assembly?*

GAN-4 *What are the connections between dark and luminous matter?*

Frontier Areas: Time-Domain & Astrometry

LSST GAIA

# Good News: NSF started LSST

GAN Panel Frontier Area

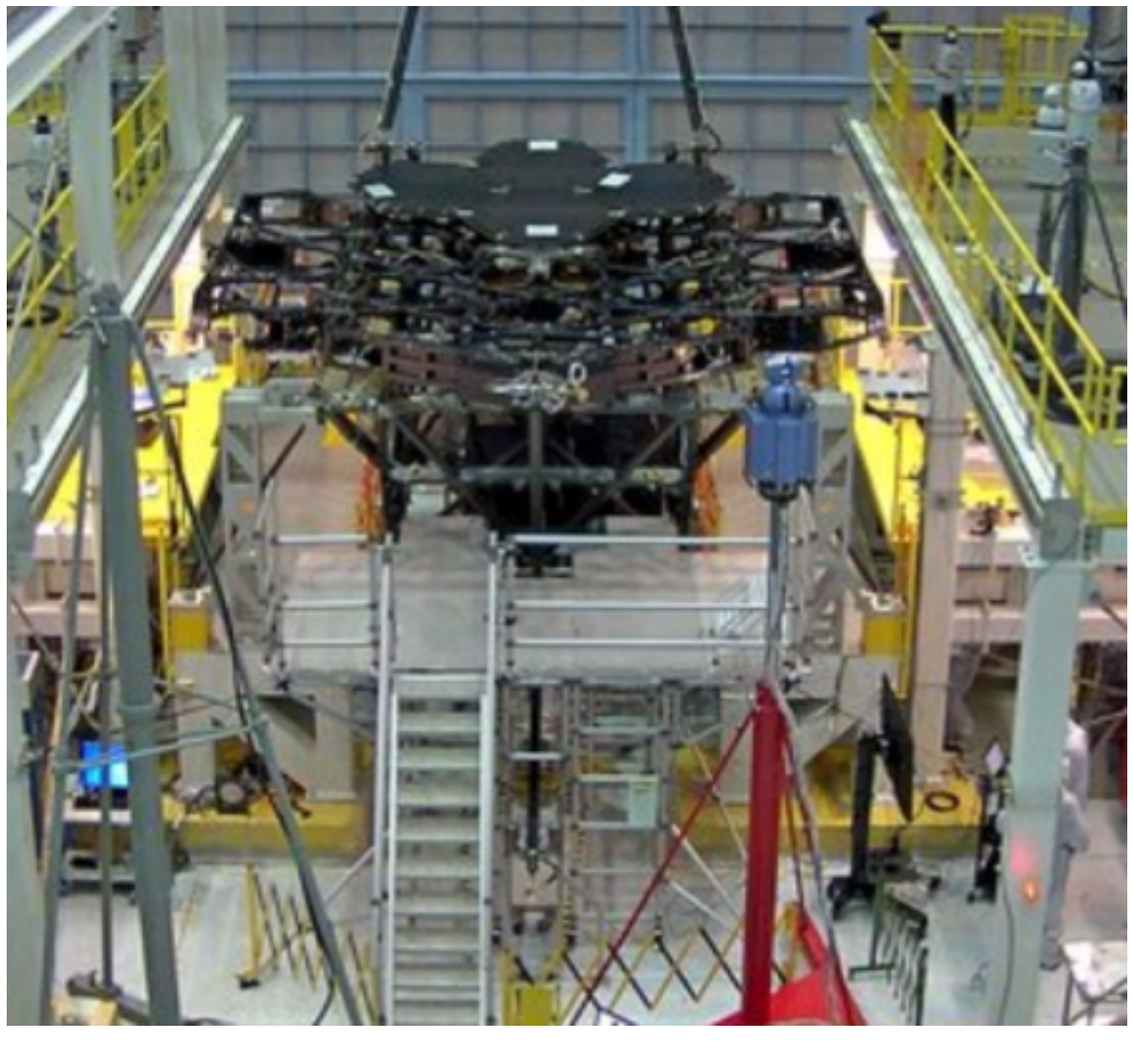
Jim Ulvestad's presentation to SSB (Oct 8, 2015)

## *NWNH* Large Ground Projects-1

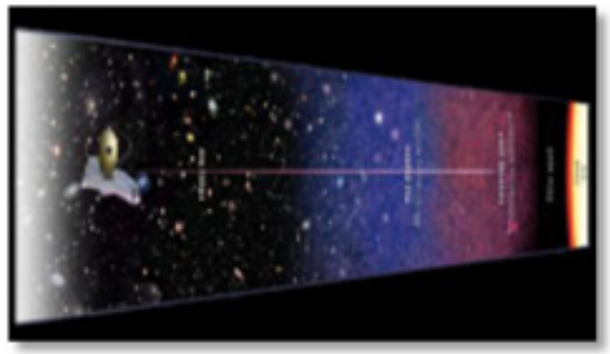
- 1. Large Synoptic Survey Telescope (LSST)
  - NSF construction award in August 2014
  - Strong NSF/DOE partnership in construction and operations
  - NRC committee studied OIR system in LSST era (later slides)

# Good News: NASA remains on schedule for JWST (Oct 2018 launch)

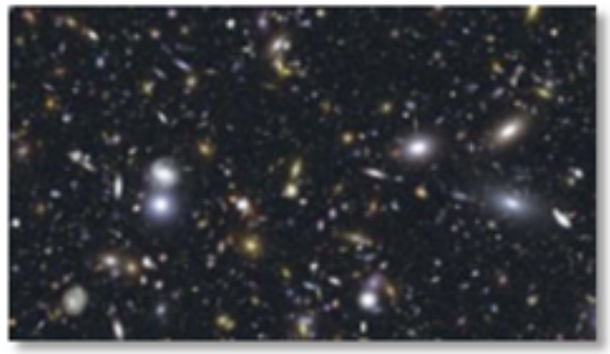
Installation of JWST
1.3$^{m}$ hexagonal mirrors



## JWST Science Goals



The End of the Dark Ages:
First Light and Reionization

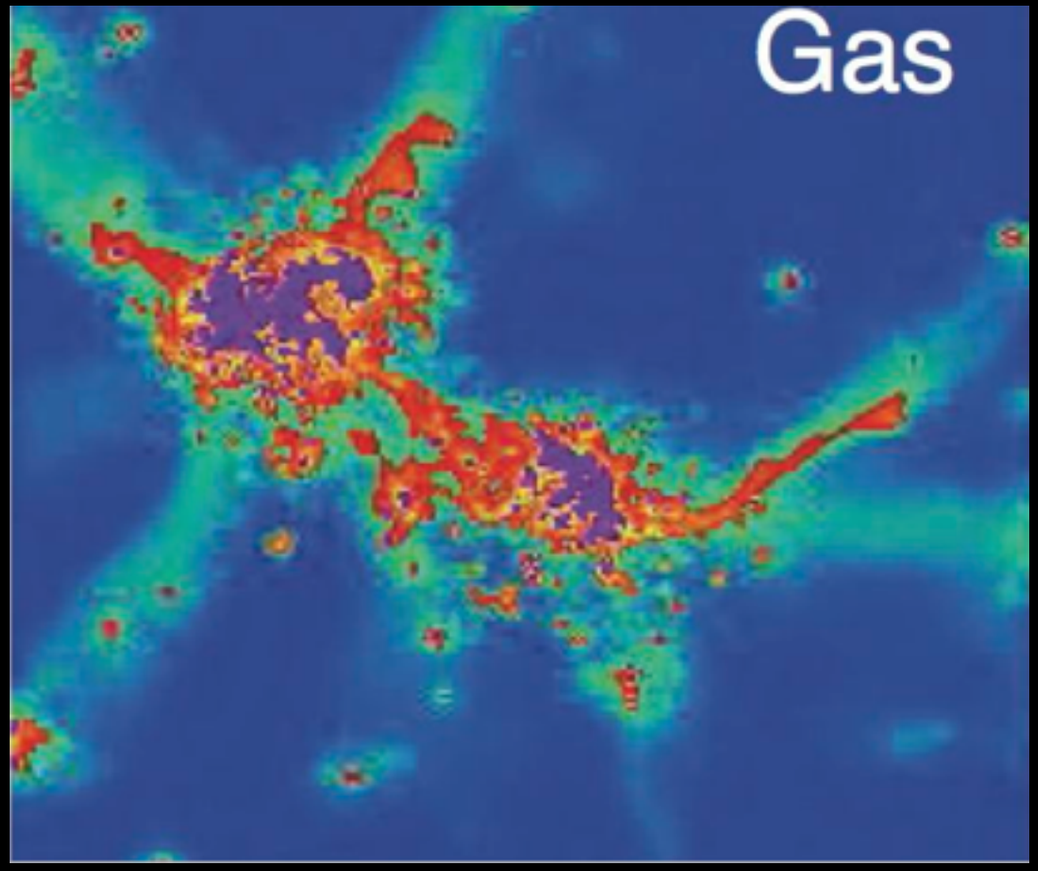


The Assembly
of Galaxies

GAN-3

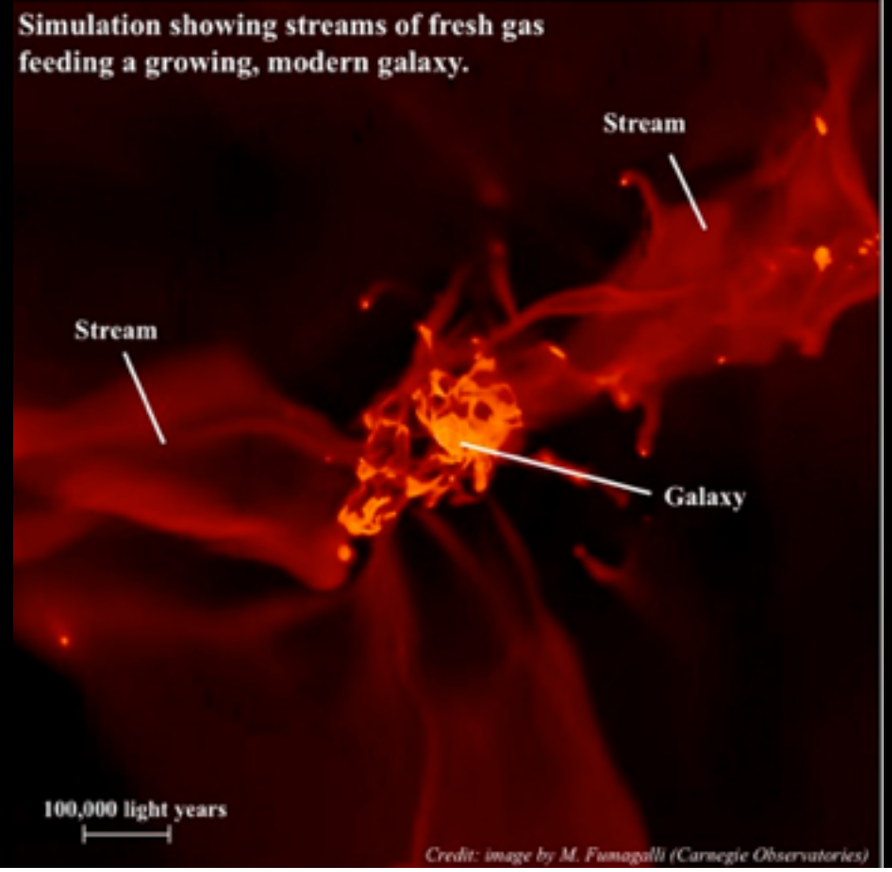
The Birth of Stars and
Protoplanetary Systems

Planetary Systems
and the Origins of Life



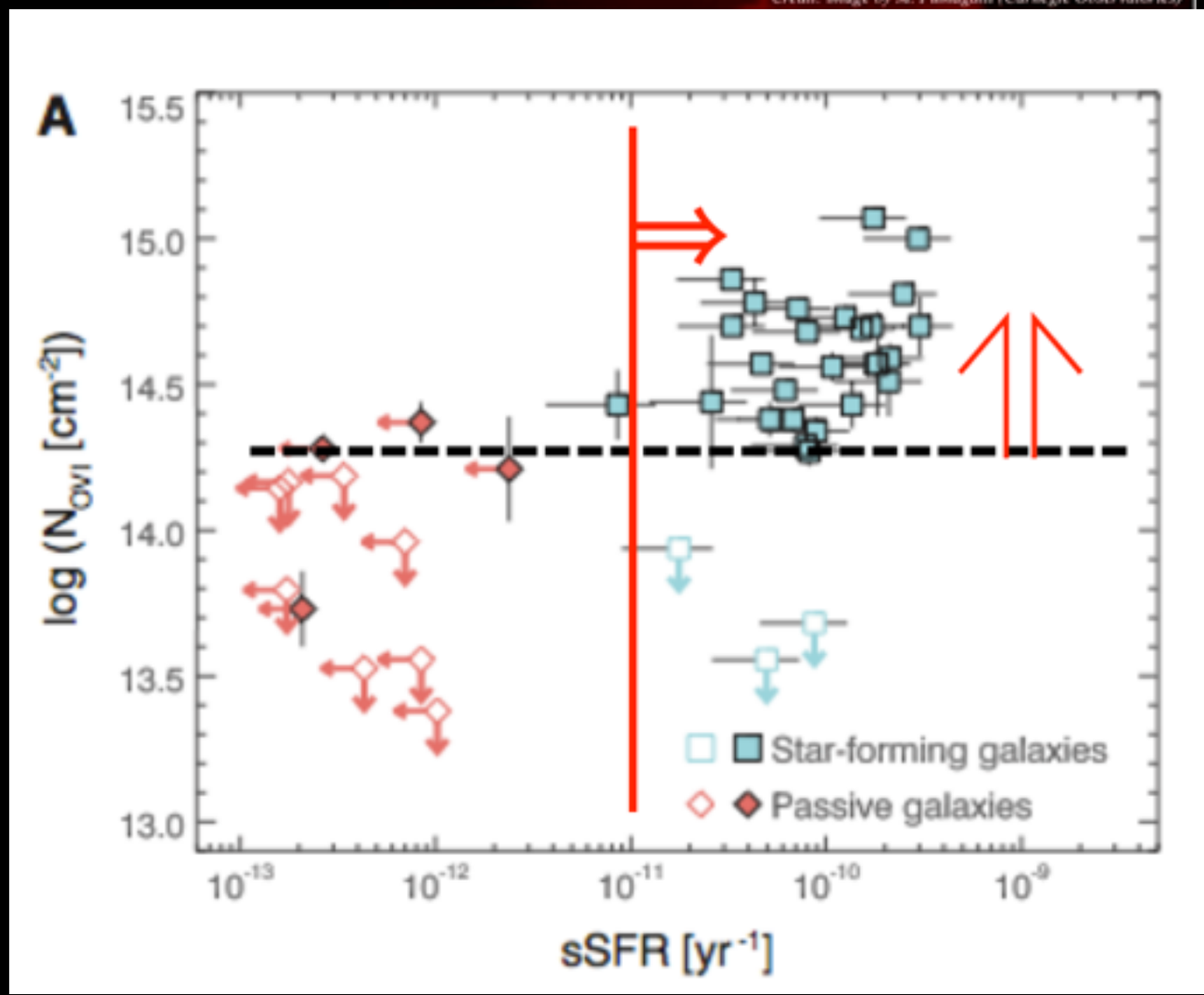

# Detecting gas flows

GAN-1
GAN-2




COS-O VI Halos (UV absorption in halos around star-forming galaxies) Tumlinson et al (2011, 2013) ➡

Cold-Flow vs Hot-Flow Accretion processes can be probed by (UV and X-ray) absorption (HST/COS) spectra of extended gaseous halos, sometimes called the CGM (Circum-Galactic Medium)

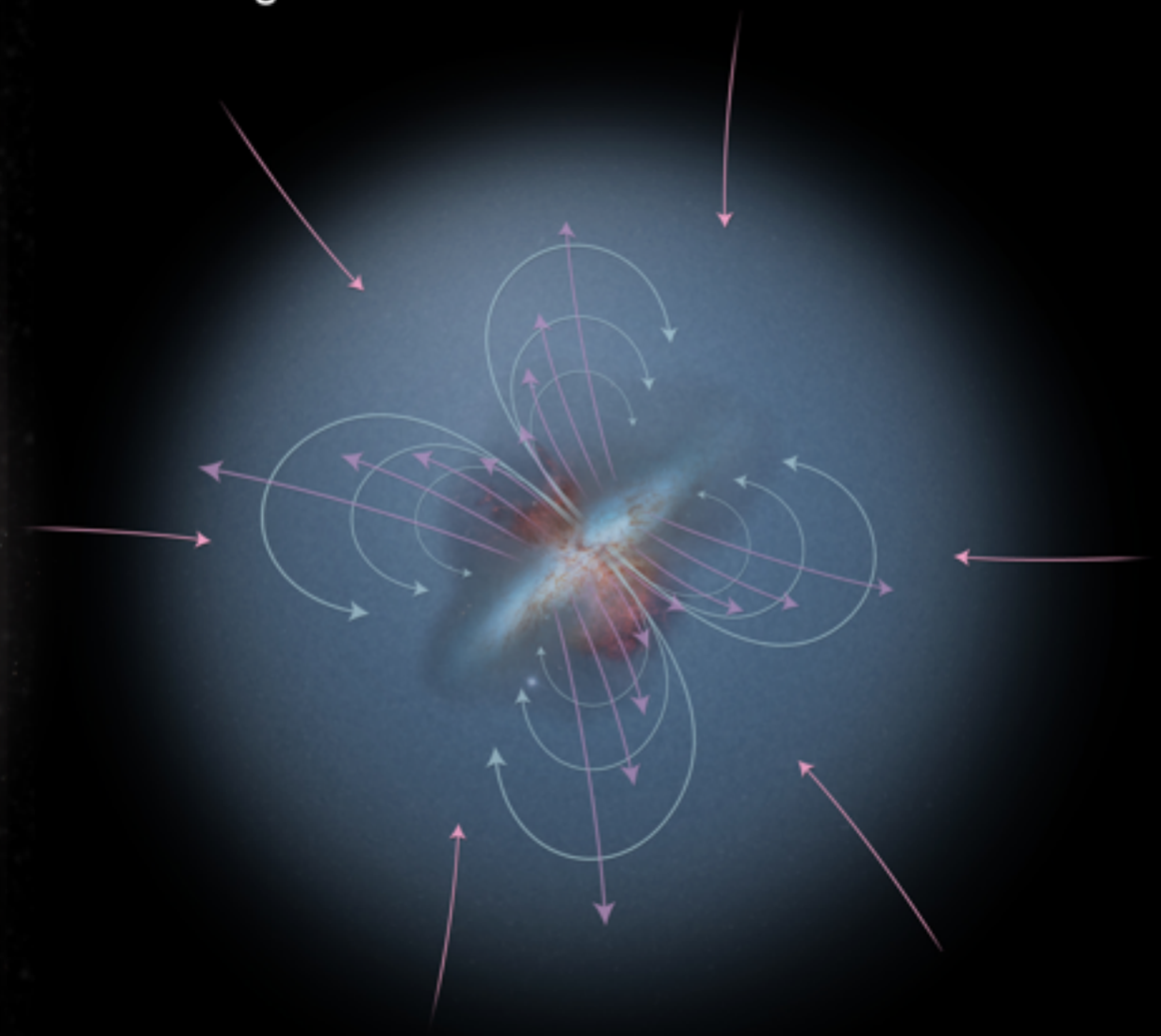


# It matters whether outflows escape their halos

A galaxy with vigorous star formation can drive gas out of its own halo and cease to form stars.

Outflow of 100 km/s over 300 Myr ⇒ 30 kpc

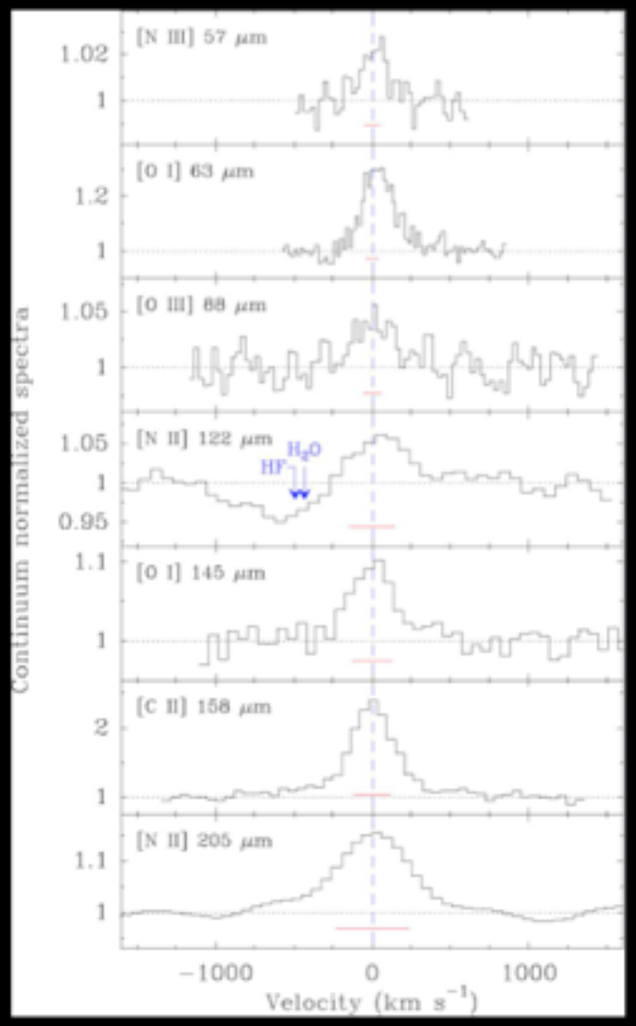
A spiral galaxy like our Milky Way acquires gas for star formation and recycles it through a massive gaseous halo.



Recycled (returning) gas for gas with $V < V_{esc}$

# FIR line emission and quasar outflows

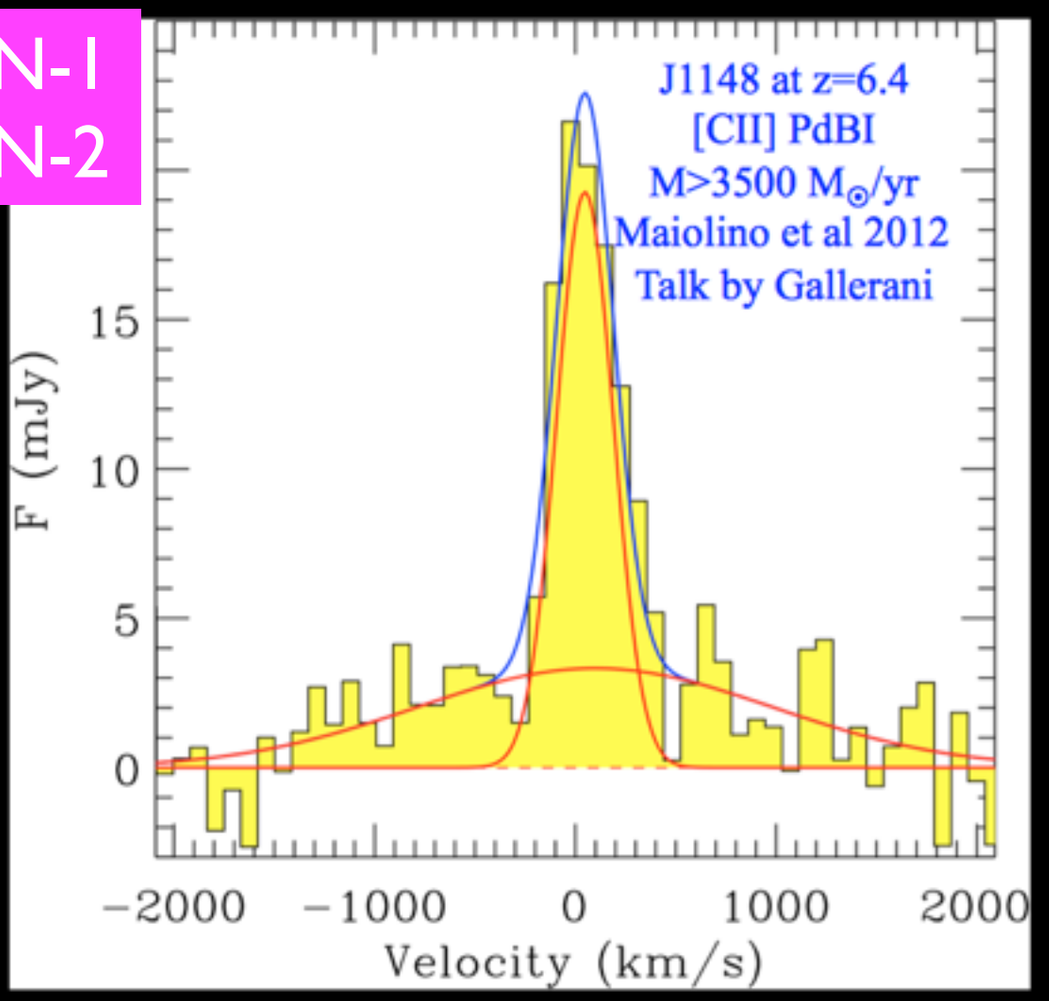
GAN-1
GAN-2

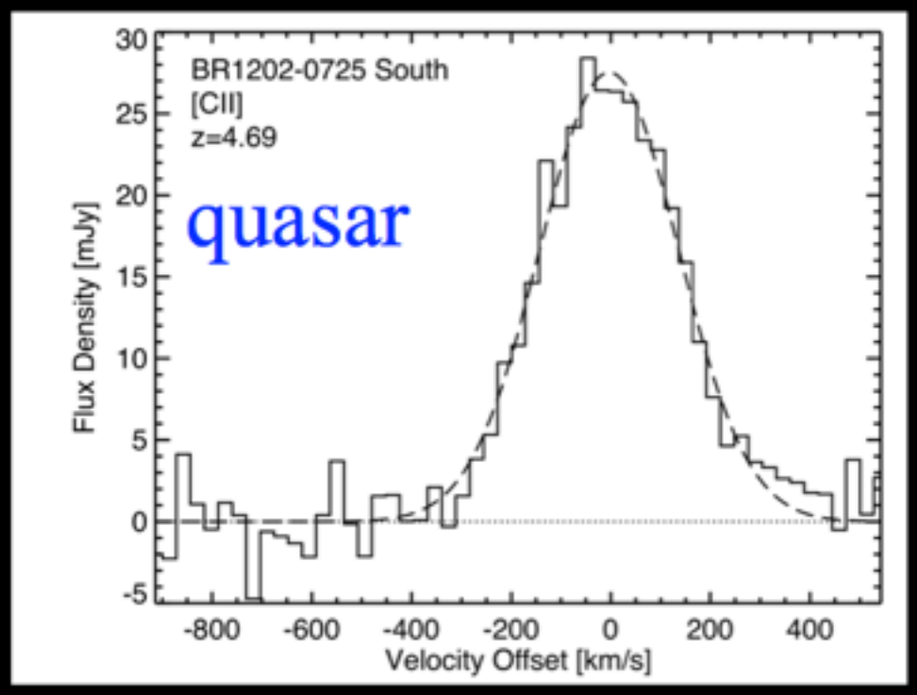



**Local ULIRGS:**
- P-Cygni profiles in OH
- extended wings in CO, OH and FIR line profiles

**High-z quasars:**
- extended wings in [CII] line profiles

Mk231: BAL quasar
*Herschel*/PACS
Fischer et al 2010



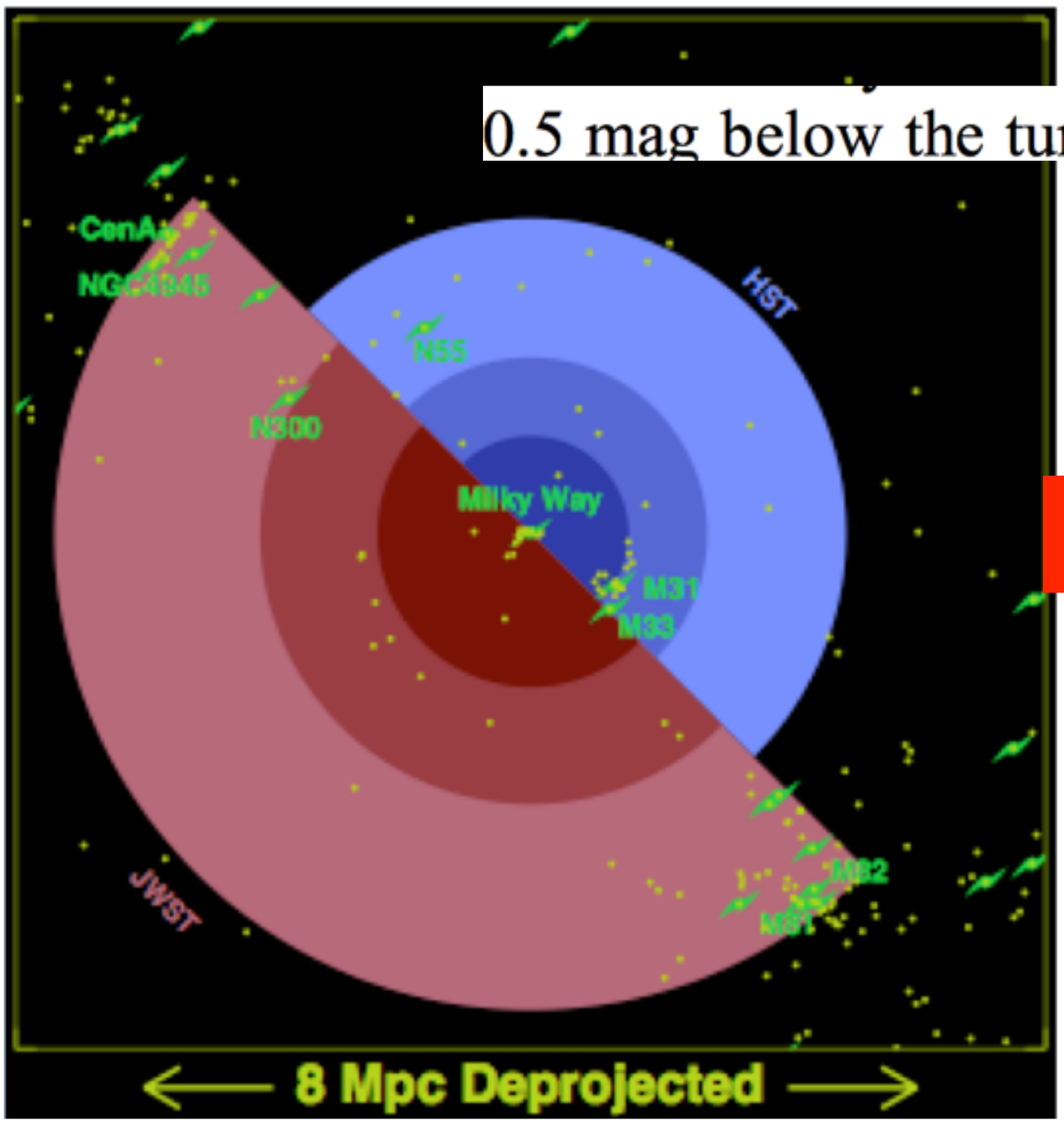

BR1202-0725 at z=4.7

# Studying Resolved Stellar Populations with the James Webb Space Telescope

GAN-3

T. Brown[1], H. Ferguson[1], J. Gardner[2], L.Greggio[3], H. B. Hammel[4], A. Renzini[3], M. Rich[5], H. Richer[6], M. Stiavelli[1,7] (editor), R. Wyse[7]

0.5 mag below the turnoff in a 12 Gyr population.




Concentric circles show distances to which HST or JWST can observe in 10 hrs, 100 hrs, 1000 hrs

# Suggested advances in these areas

- High-resolution Spectroscopy (UV and X-ray) GAN-1&2

  No new missions, but HST/COS, Chandra, XMM continue

  COS discovers large halos, metal reservoirs, 100-kpc outflows

  Next large UVOIR mission - not until 2035?

- FIR and Sub-mm Imaging (ground & space) GAN-2

  CARMA & CSO gone; CCAT still in limbo

  Herschel completed; ALMA, EVLA, SOFIA making discoveries

- UV/Optical/IR Imaging & Spectra (ground and space) GAN-3

  Waiting for giant telescopes (20-30$^{m}$ ground) and 8-16$^{m}$ (space)

  Spectroscopy of resolved stellar populations

  Local-group dwarfs (LSST and GAIA)

# Disappointments from 2010 Survey

(1) Lack of grant funding to use the new facilities (ALMA, later LSST) and to interpret the observational results

(2) Slow progress in implementing NWNH recommendations, plus the large costs of building JWST and WFIRST

(3) Mid-scale programs (both NSF and NASA) have not fulfilled the expectations that many of us had in the Science-Panel recommendations