Title: Direct emission maps of cool gas in a star forming, low mass galaxy: connecting spatially resolved galactic processes to the CGM

Speakers: Chloe Neufeld

Collection/Series: Cosmic Ecosystems

Subject: Cosmology

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Abstract:

Observing the cycling of baryons in and out of galaxies, which largely takes places in the circumgalactic medium (CGM), is key to understanding how galaxies grow and evolve. This is especially true for dwarf galaxies, whose shallow potential wells produce even more effective feedback than more massive haloes, and whose cold virial temperatures imply the possibility of a CGM rich in cold accretion, in which gas efficiently inflows and settles, perhaps explaining the degree to which nearly all isolated dwarf galaxies are actively star forming. Understanding how baryons cycle in and out of dwarf galaxies is thus essential for understanding how these galaxies connect to their large scale environment, and is now tractable with recent and upcoming state-of-the-art instrumentation. I will present sub-kiloparsec scale resolution integral field spectroscopy of emission lines mapping cool ionized gas inside and close to the optical extent of a star forming, low mass (M*~10^8 Msun) galaxy out to 10 kpc. This high spatial and spectral resolution data will be combined with the large scale gas distribution of diffuse, ionized gas on scales up to 1 degree (~200 kpc) with the one thousand lens, narrowband upgrade of the Dragonfly telephoto array concept. I will show results of the spatial distribution, kinematics, and ionization properties of gas in the galaxy itself and its inner and outer CGM and additionally provide insight into the degree of cospatiality of neutral to ionized extragalactic hydrogen in the outskirts of this low mass galaxy, connecting galactic processes such as star formation and feedback to those occurring in the CGM.

BRIDGES: Baryon Recycling In Dwarf Galaxies Emission Survey

Direct emission maps of cool gas in a star forming, low mass galaxy

connecting spatially resolved galactic processes to the CGM

Chloe Neufeld | Yale University

Collaborators: Pieter van Dokkum and the Dragonfly Team

Cosmic Ecosystems 2025 | Perimeter Institute

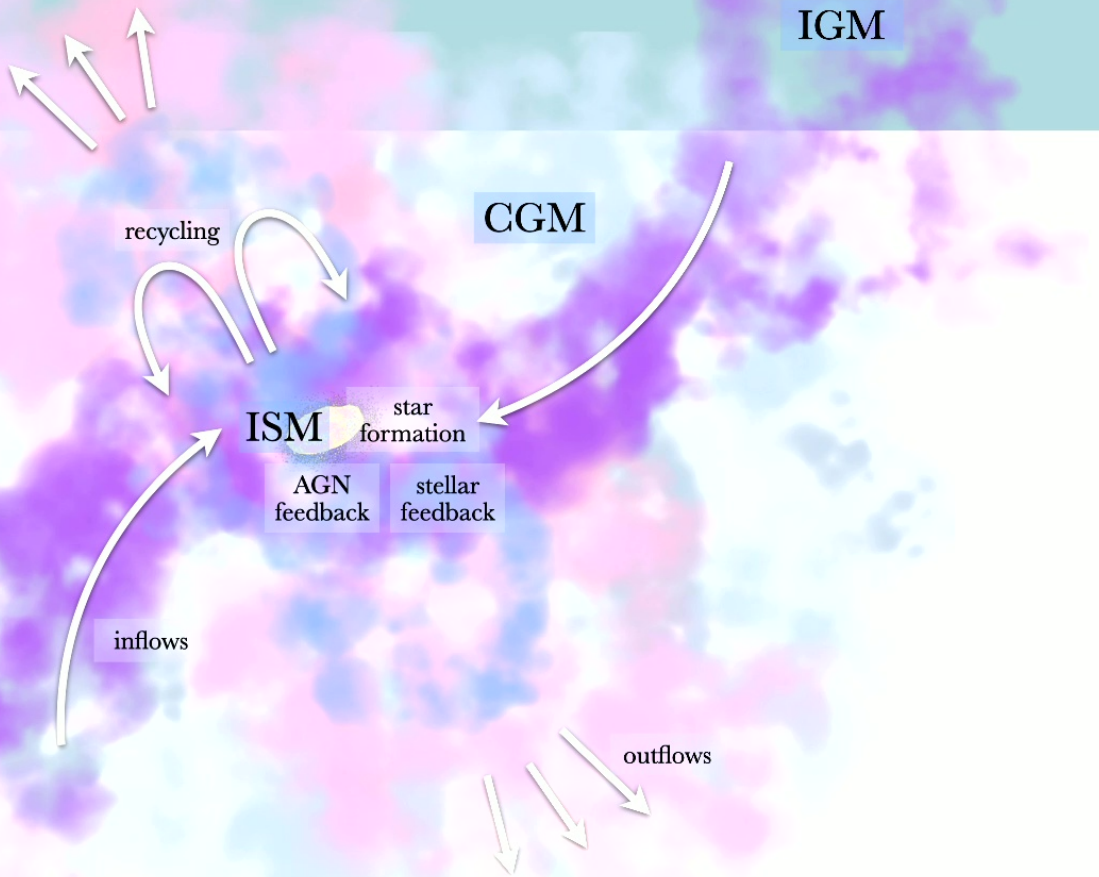
The baryon cycle

& the importance of the CGM

Star formation

Feedback

Chemical enrichment



The circumgalactic medium

Tumlinson, Peeples, & Werk 17; Crain & van de Voort 23; Faucher-Giguere & Oh 23

What is the role of the **CGM** in low mass galaxy evolution?

$10^7 M_\odot < M_* < 10^9 M_\odot$

Shallow potential wells: strong stellar feedback

McQuinn+ 15; Keller+ 16; Mina+ 21

Small systems: feasibly spatially map the entire baryon cycle

What is the role of the **CGM** in low mass galaxy evolution?

Low virial temperatures: cold accretion?

Geha+ 12; Fielding+ 17;Lokhorst+ 19; Lochhaas+ 20

Timescales: connect starburst events to signatures in the CGM?

Emami+ 19; Mintz+ 25

The circumgalactic medium

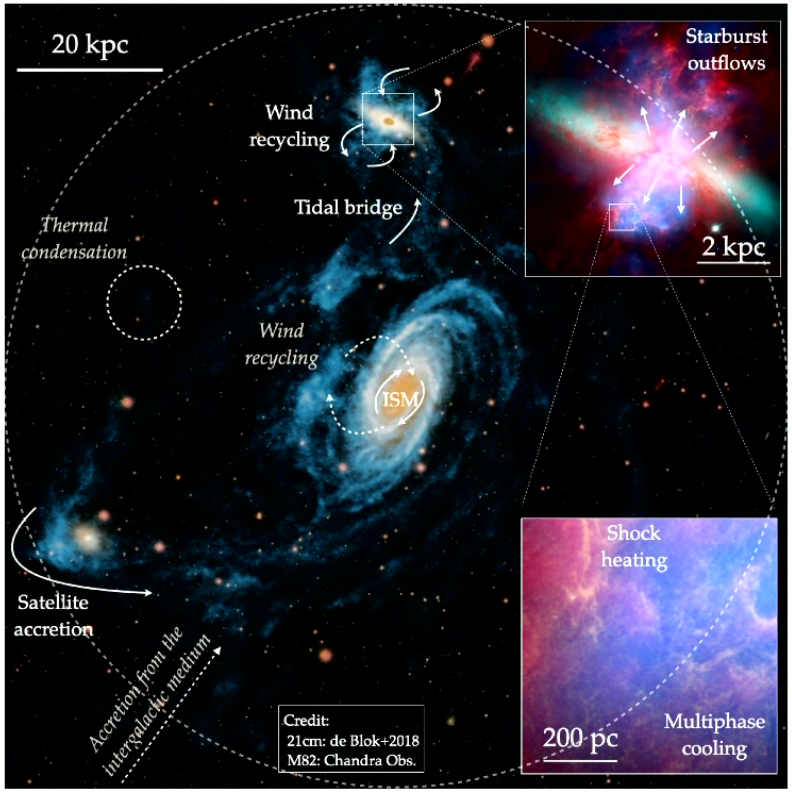
Observational challenges

Quasar sightlines: constrain mass and metal content

Diffuse

Multiphase

Clumpy



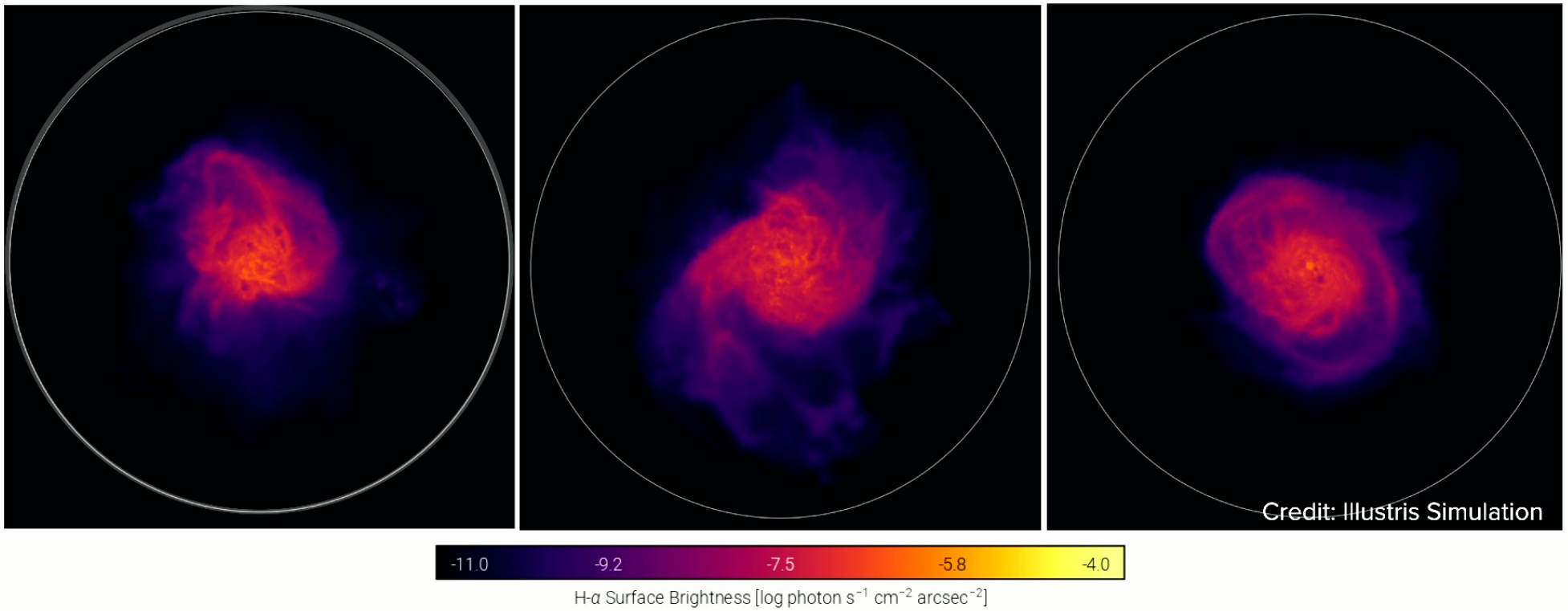
We also need spatial information in the CGM

Steidel+ 10; Lokhorst+ 19; Peng+ 25

Chen & Zahedy 24

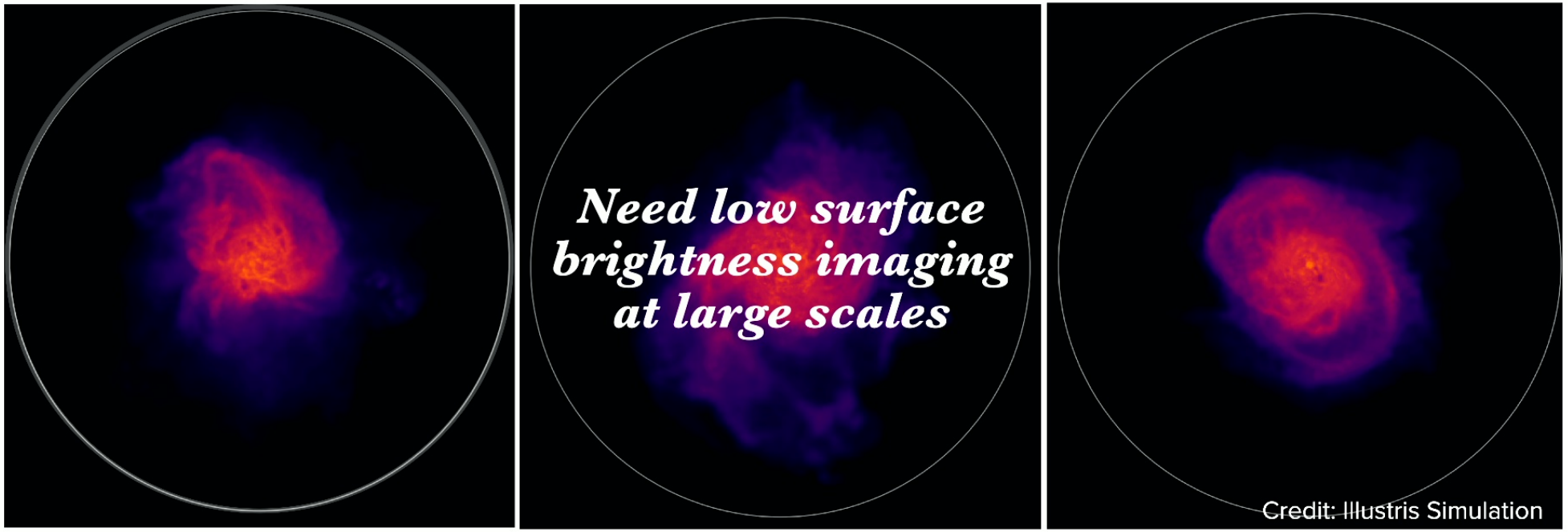
The circumgalactic medium

Direct emission mapping

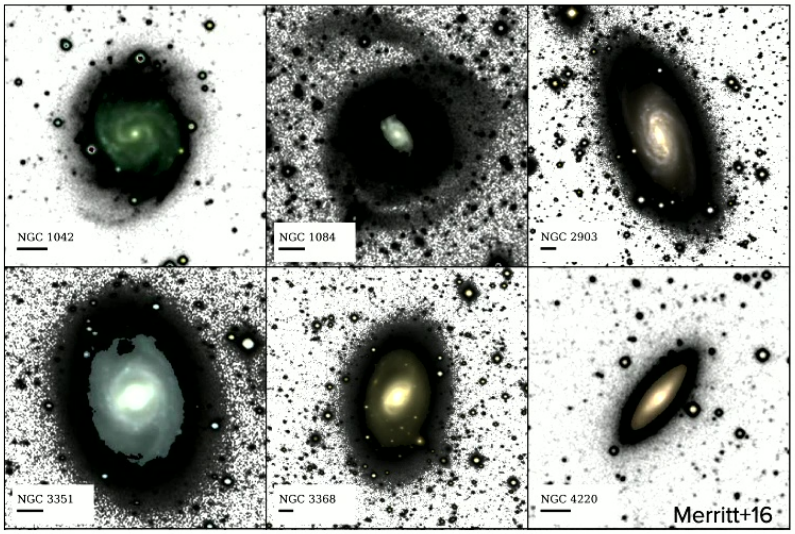


The circumgalactic medium

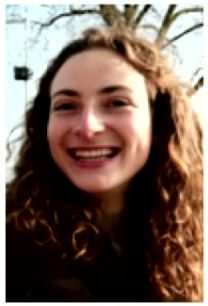
Direct emission mapping



Low surface brightness imaging with Dragonfly



Dragonfly Broadband: Low surface brightness stellar features



Talk to Juliette Hilhorst about the next steps for the Dragonfly Ultra Wide Survey!

Low surface brightness imaging with Dragonfly

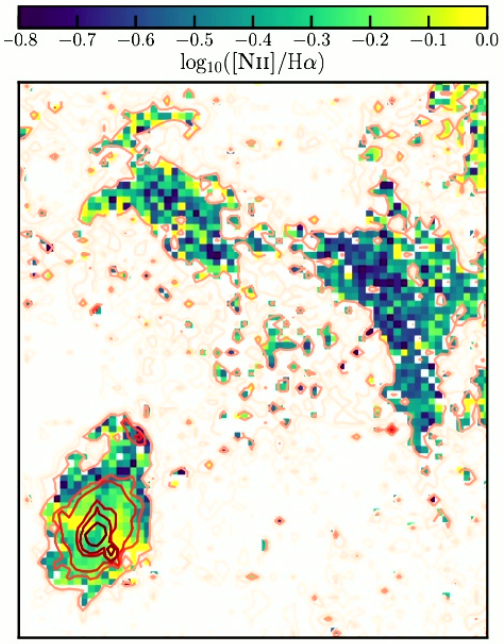
refractor telescope

+ many lenses

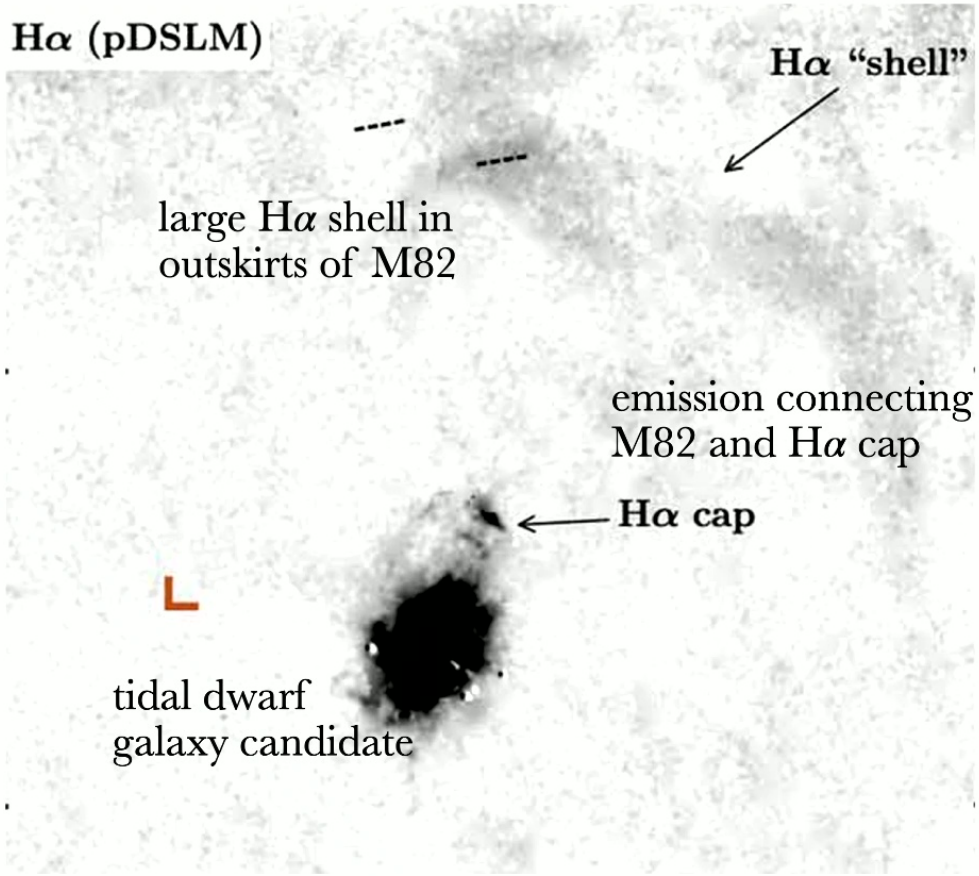
+ ultra-narrowband filters

→ Wide FOV detection of low surface brightness optical line emission from diffuse gas

Dragonfly Narrowband



Lokhorst+ 22

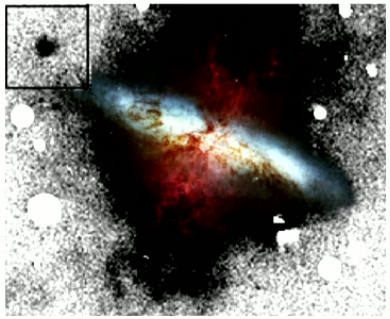


3 lens pathfinder observations of M82

~40 hours (Hα line) + ~15 hours ([NII] line)

Surface brightness depth: 5×10^{-19} erg s^{-1} cm^{-2} arcsec^{-2}

Pasha+ 21

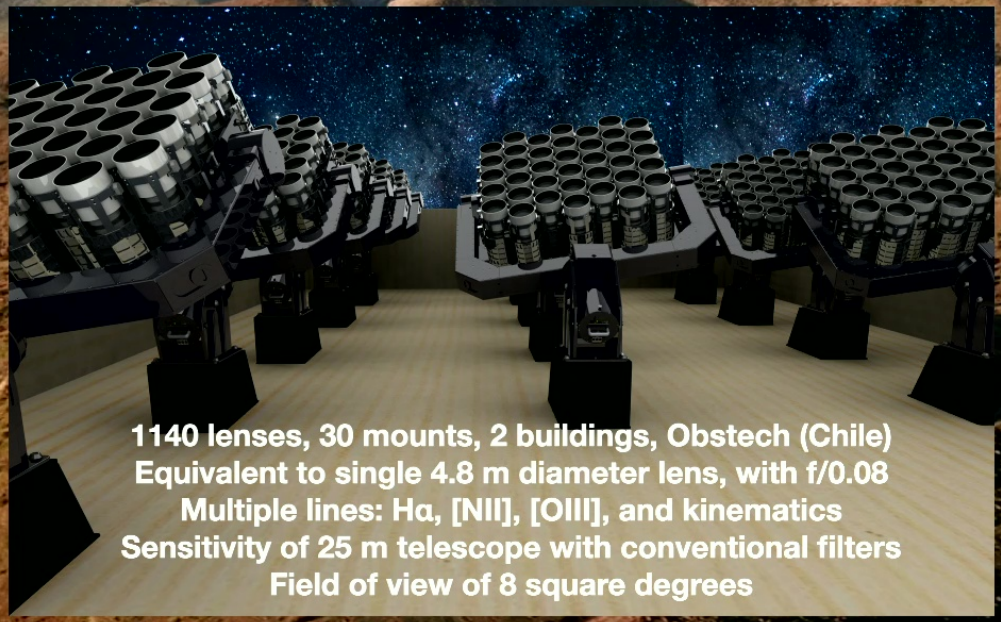


What's next for Dragonfly?

Mothra

A revolutionary upgrade to the Dragonfly Spectral Line Mapper

1000 lens array

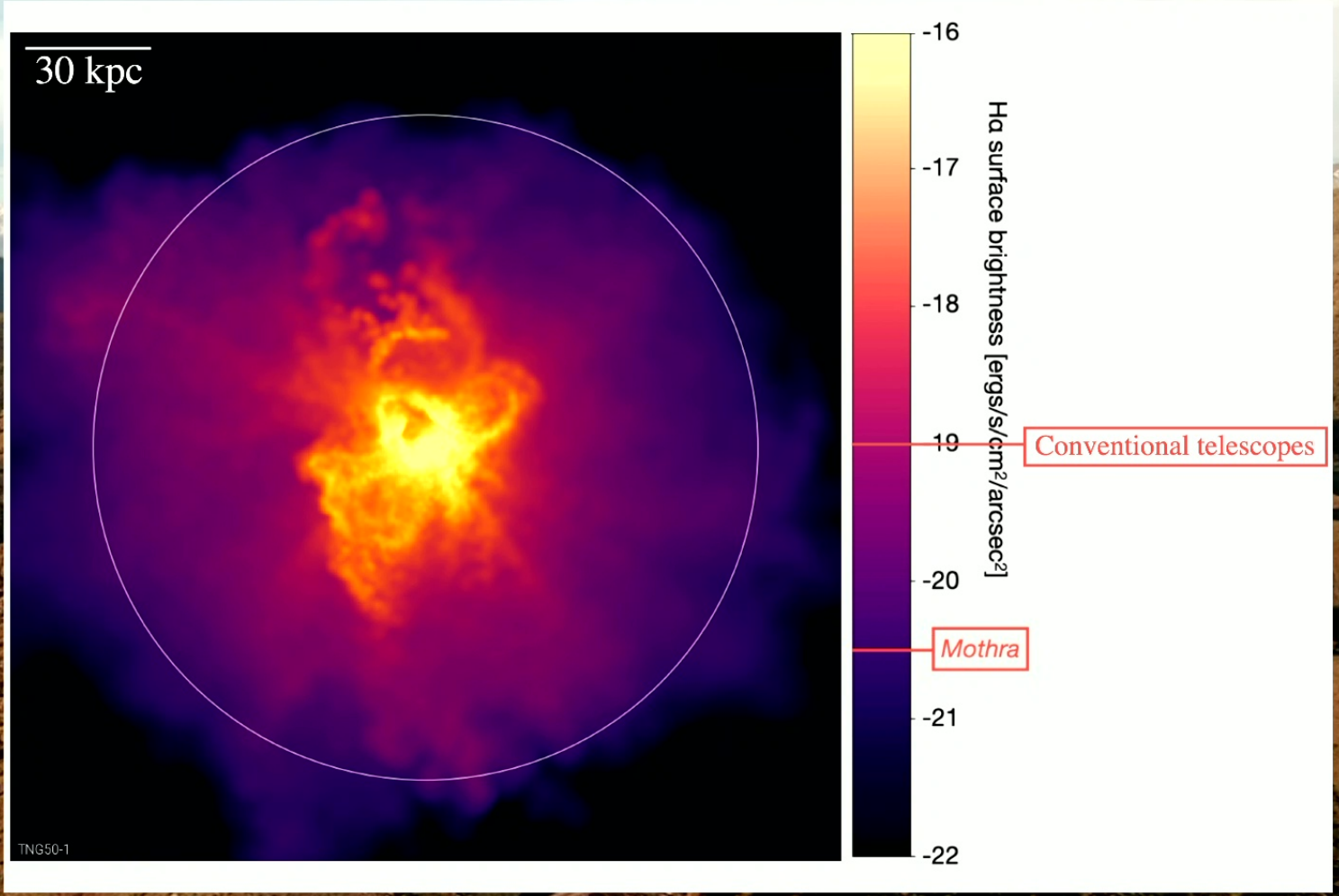


1140 lenses, 30 mounts, 2 buildings, Obstech (Chile)
Equivalent to single 4.8 m diameter lens, with f/0.08
Multiple lines: Hα, [NII], [OIII], and kinematics
Sensitivity of 25 m telescope with conventional filters
Field of view of 8 square degrees

Construction and operation by Dragonfly FRO, LLC

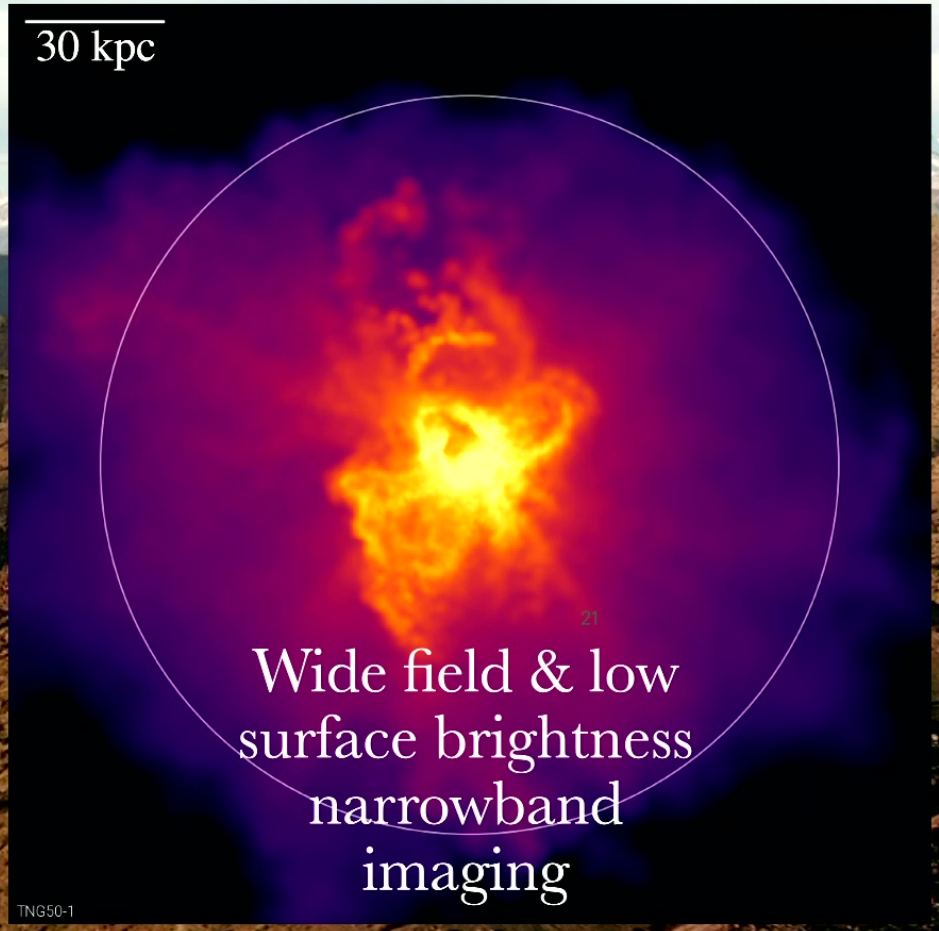
MOTHRA

Mothra



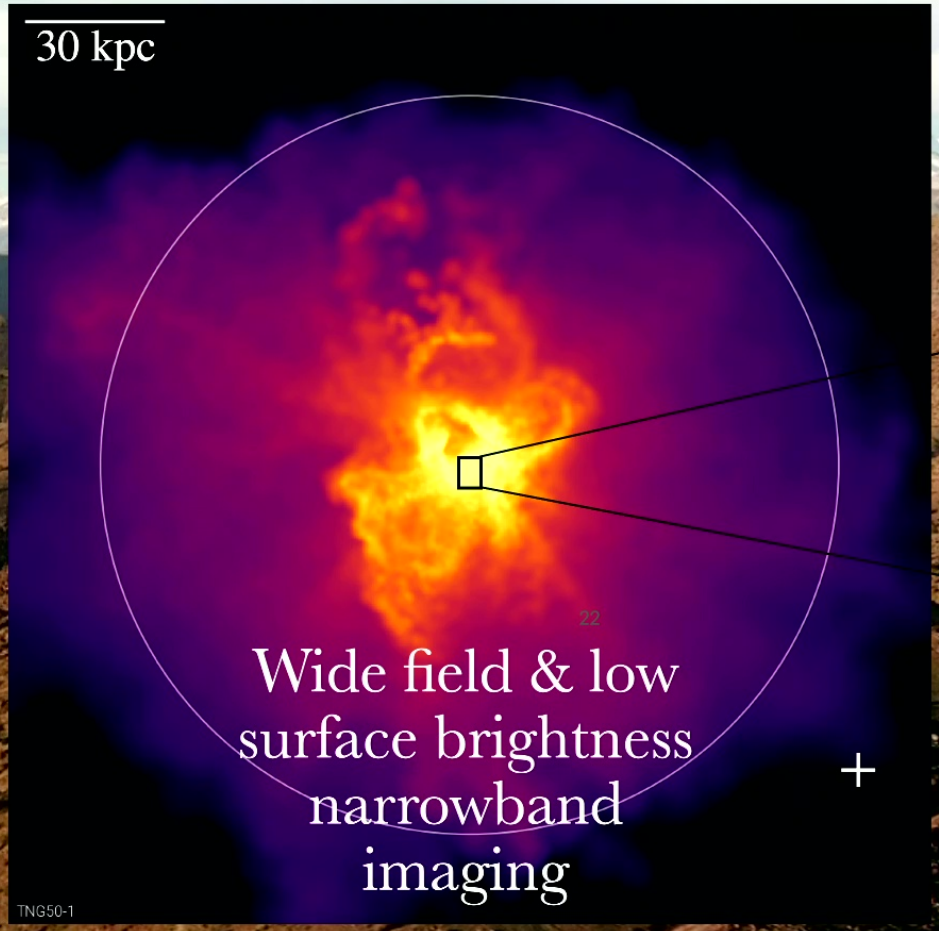
MOTHRA

Mothra



MOTHRA

Mothra



Wide field & low surface brightness narrowband imaging

+

IFU spectroscopy

MOTHRA

BRIDGES: Baryon Recycling In Dwarf Galaxies Emission Survey

KCWI

Smaller FOV, higher resolution

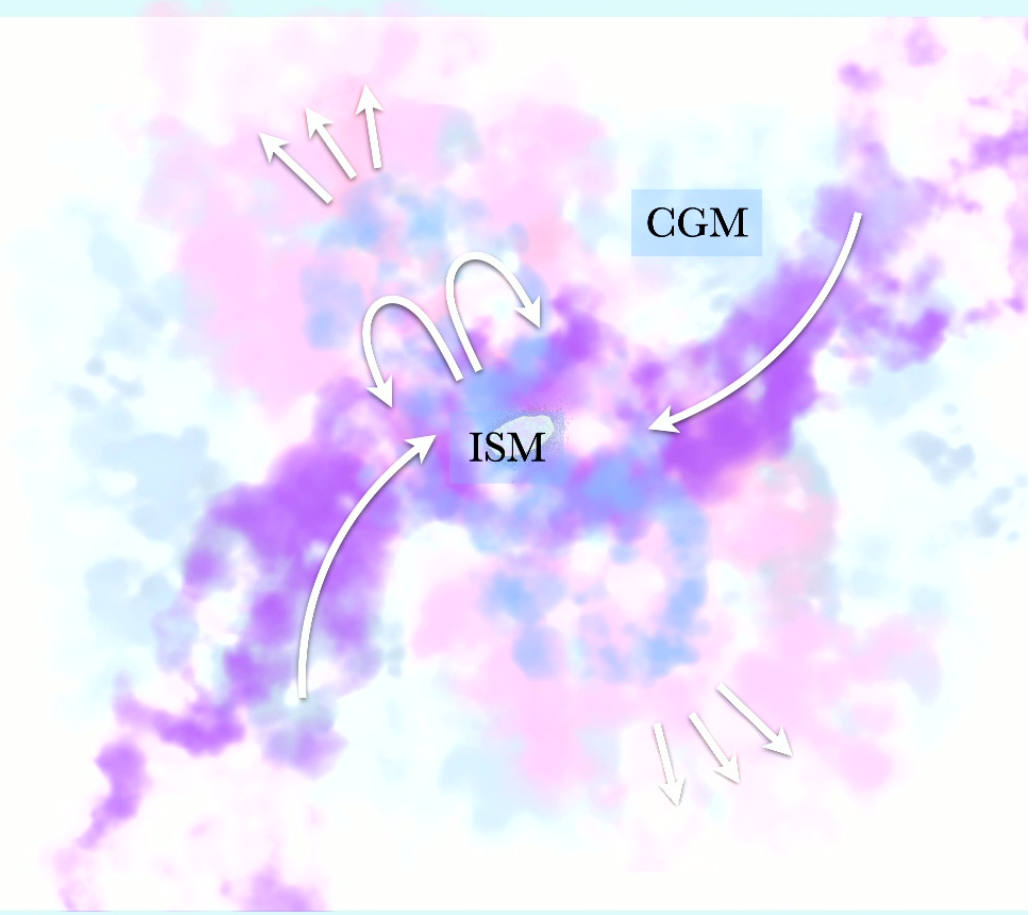
Central star formation

Inner CGM structure and ionization

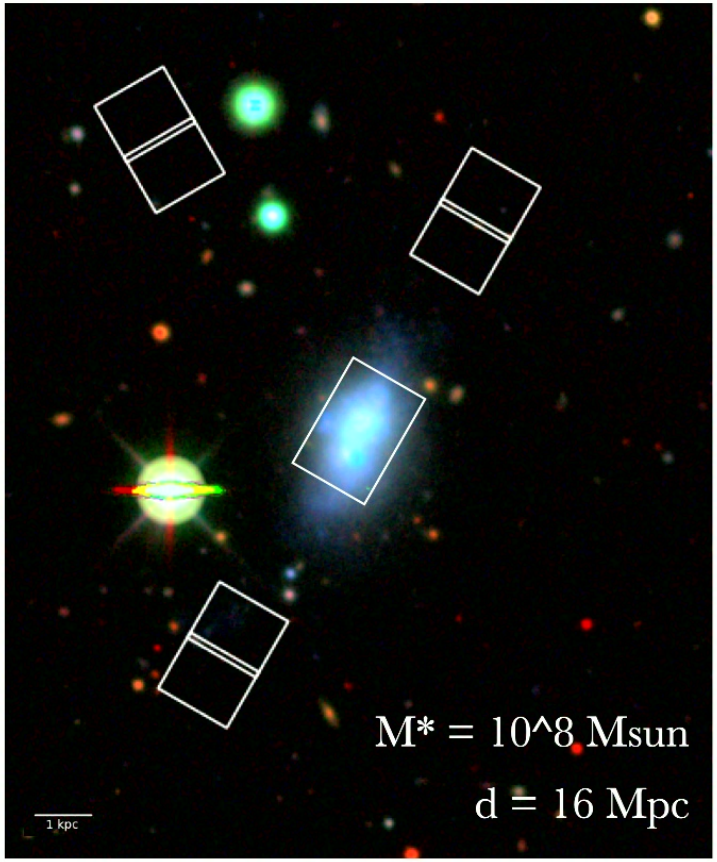
Mothra

Wide FOV, sensitive to diffuse CGM

Outer CGM morphology, extent, and ionization



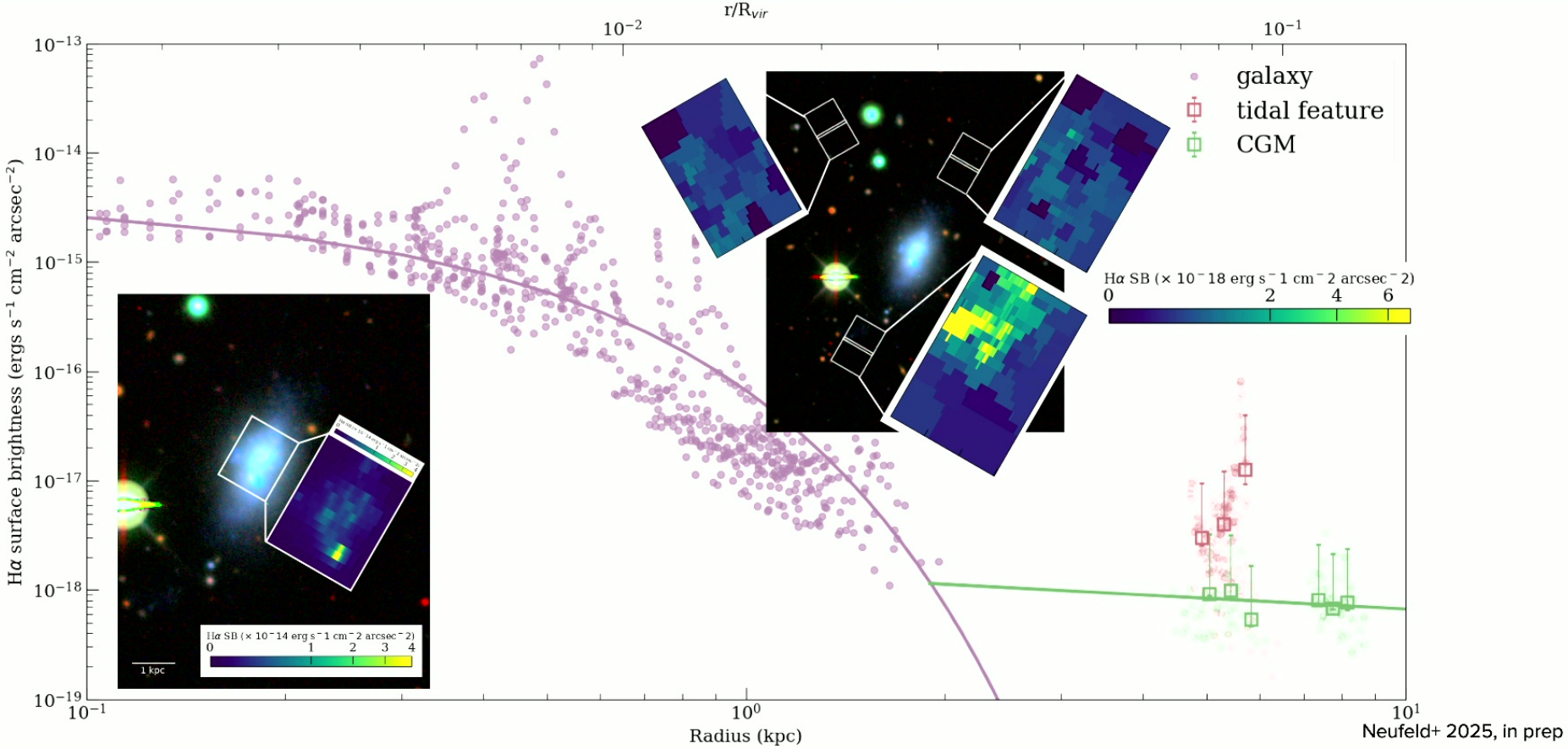
Pilot study: first results



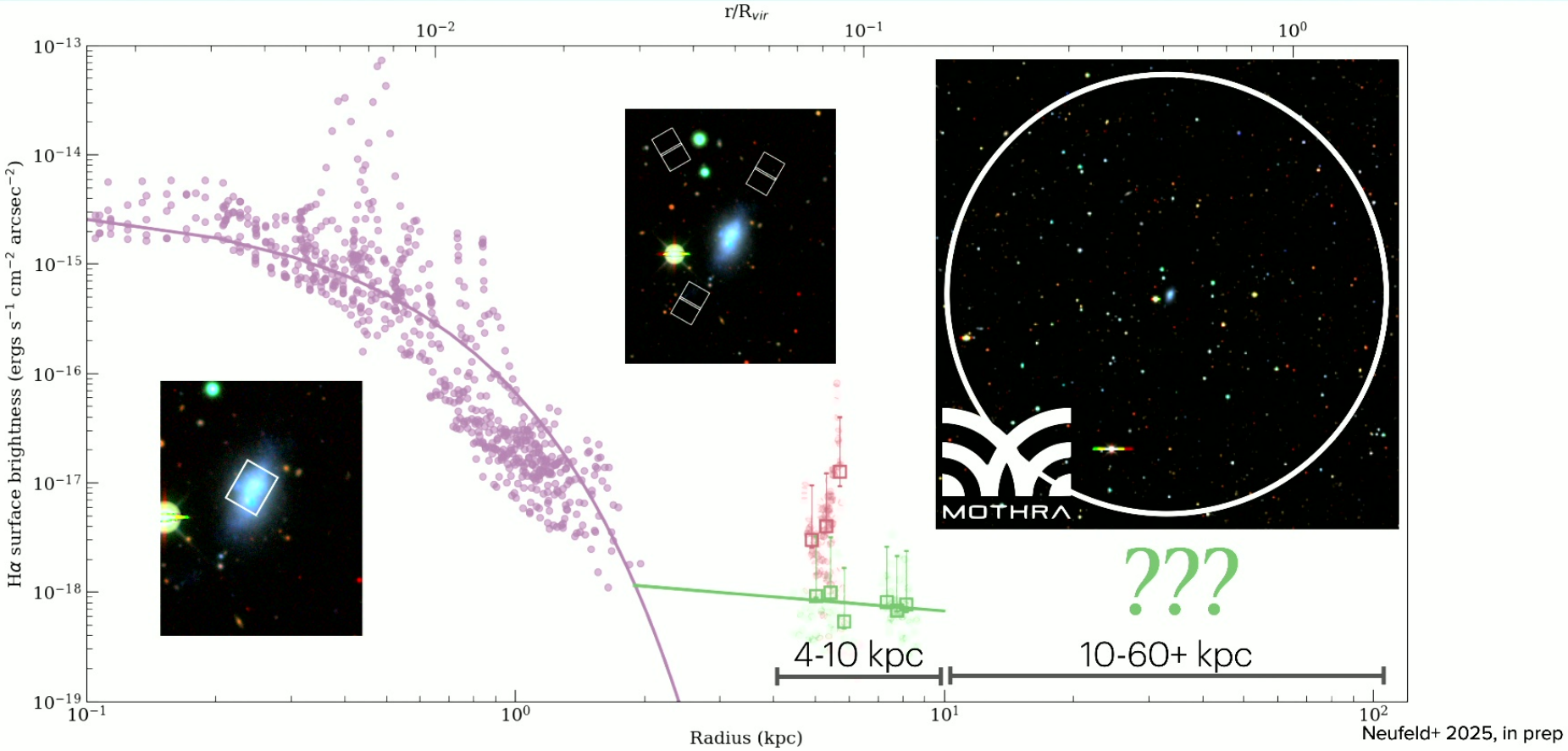
Pilot study with KCWI:

Several pointings on galaxy and inner CGM (out to ~8 kpc)

Pilot study: first results



Next steps: Mothra



BRIDGES: **B**aryon **R**ecycling **I**n **D**warf **G**alaxies **E**mission **S**urvey

KCWI

Smaller FOV, higher resolution

Central star formation

Inner CGM structure and ionization

Mothra

Wide FOV, sensitive to diffuse CGM

Outer CGM morphology, extent, and ionization

Future work (KCWI data)

Metallicity gradient

Outflow presence/characterization

Star formation history

Mothra first light coming soon!

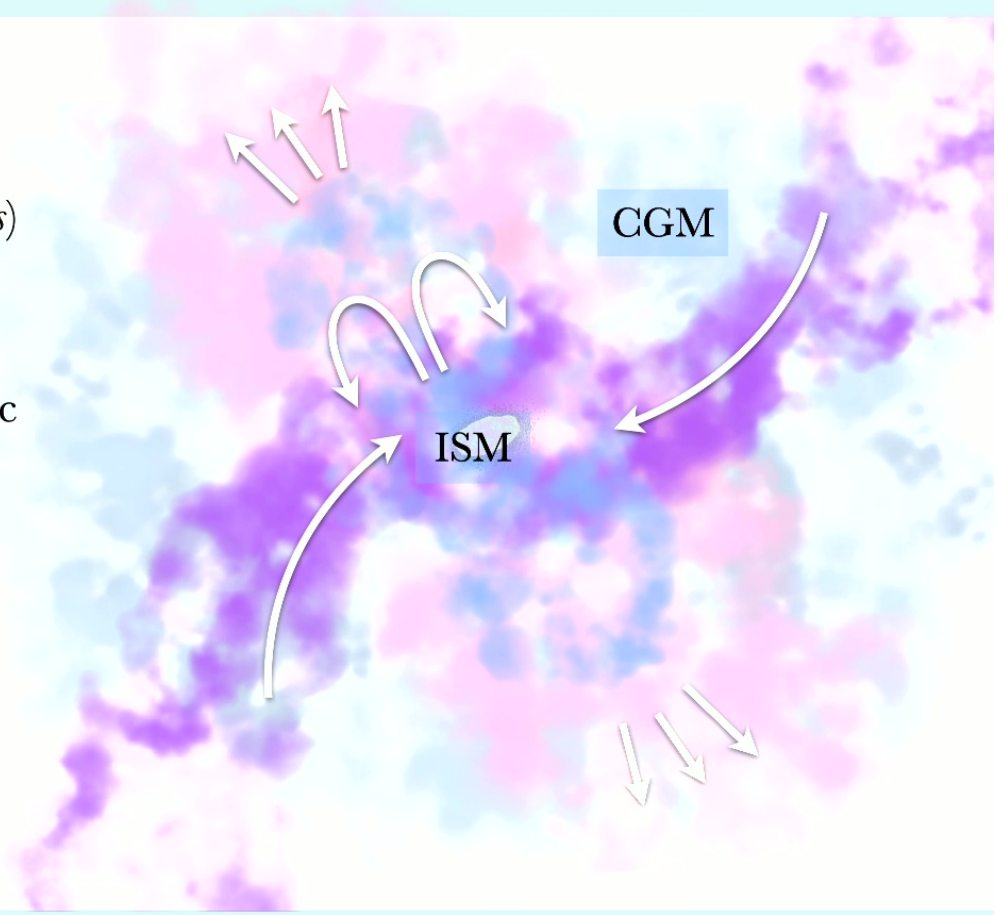
BRIDGES: Baryon Recycling In Dwarf Galaxies Emission Survey

Selection criteria:

1. **Stellar mass**: $10^7 M_\odot < M_* < 10^9 M_\odot$
2. **Redshift / radial velocity**: $z \lesssim 0.01$ (*filter tilter limits*)
3. **Gas rich**:

   Pseudo-isolated (not stripped of gas): nearest luminous ($M_* > 10^9 M_\odot$) neighbor is $D_{\rm host} > 1.5$ Mpc (Zhu+ 24)

   Archival data: spatially resolved HI emission



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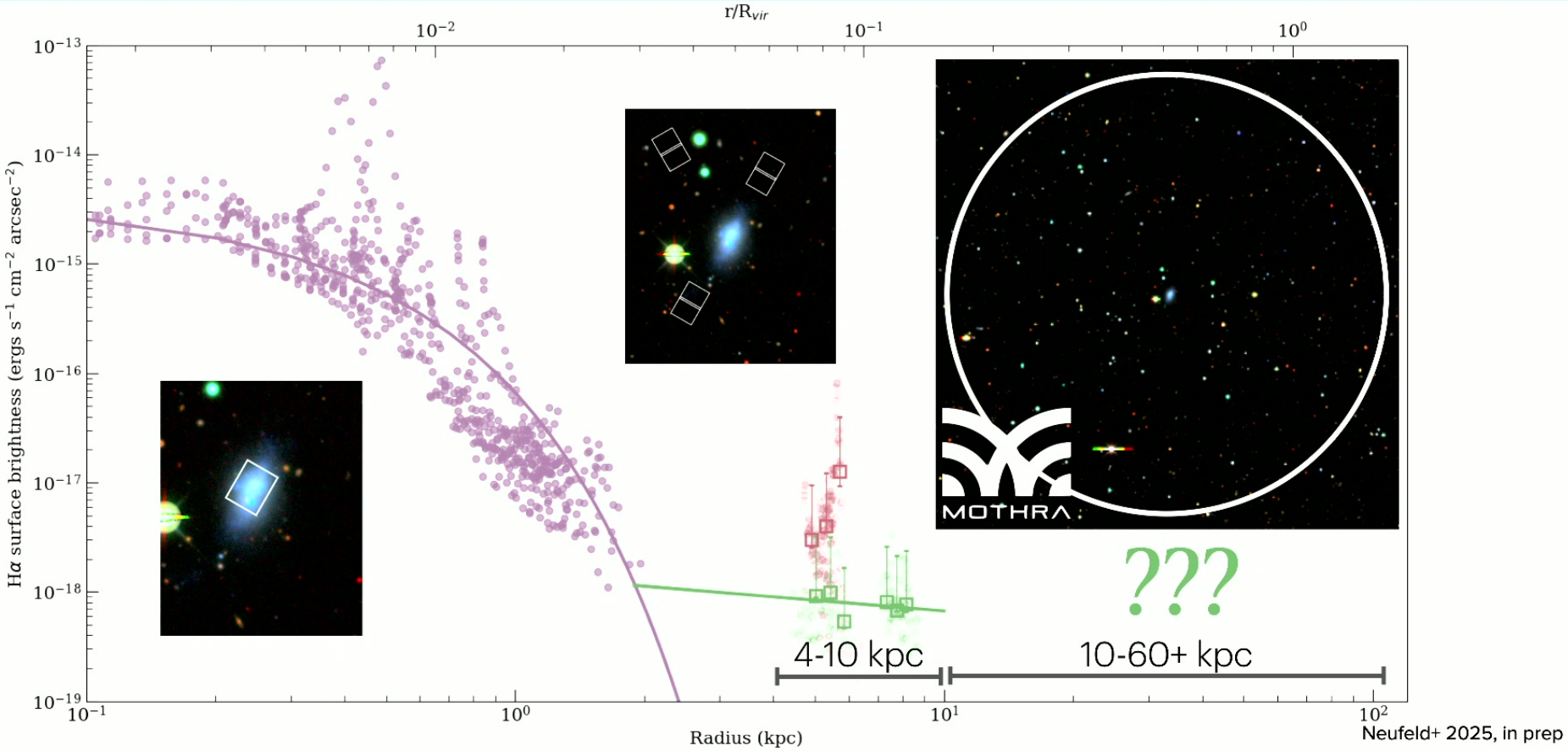

Extra slides

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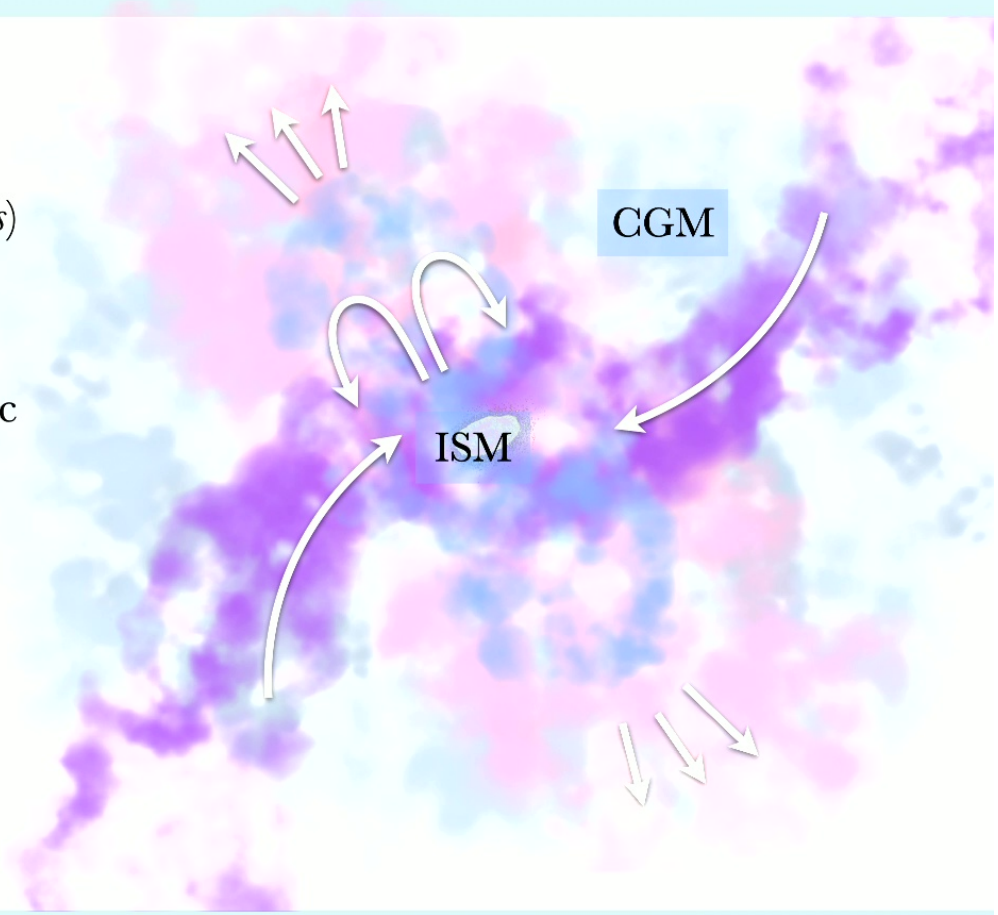
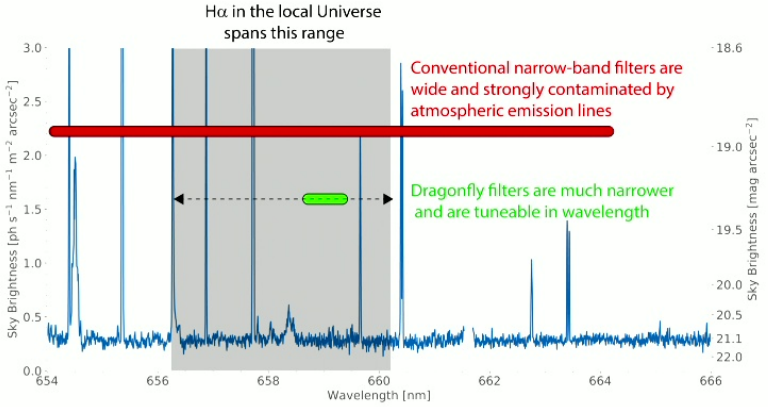
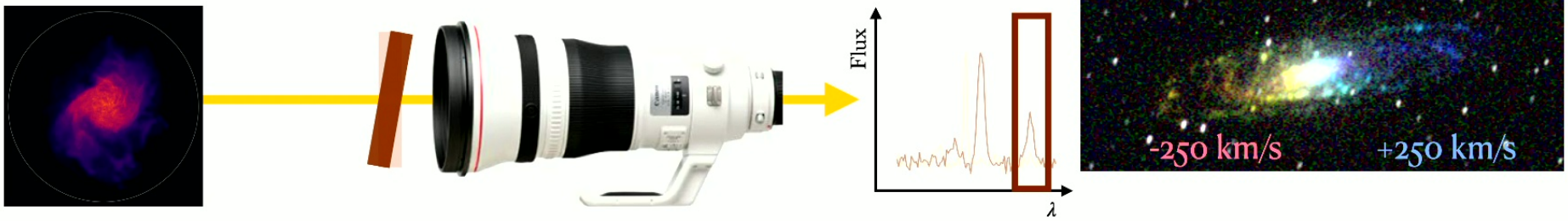


Dragonfly Narrowband

refractor telescope
+ narrowband filters
+ many lenses

Wide FOV detection of low surface brightness optical line emission from diffuse gas





Abramham+ 17; Lokhorst+ 19; Chen+ 22; Lokhorst+ 22,24