The role of star formation-driven outflows in the baryon cycle

Bron Reichardt Chu

Postdoc at Durham University

And the DUVET team:

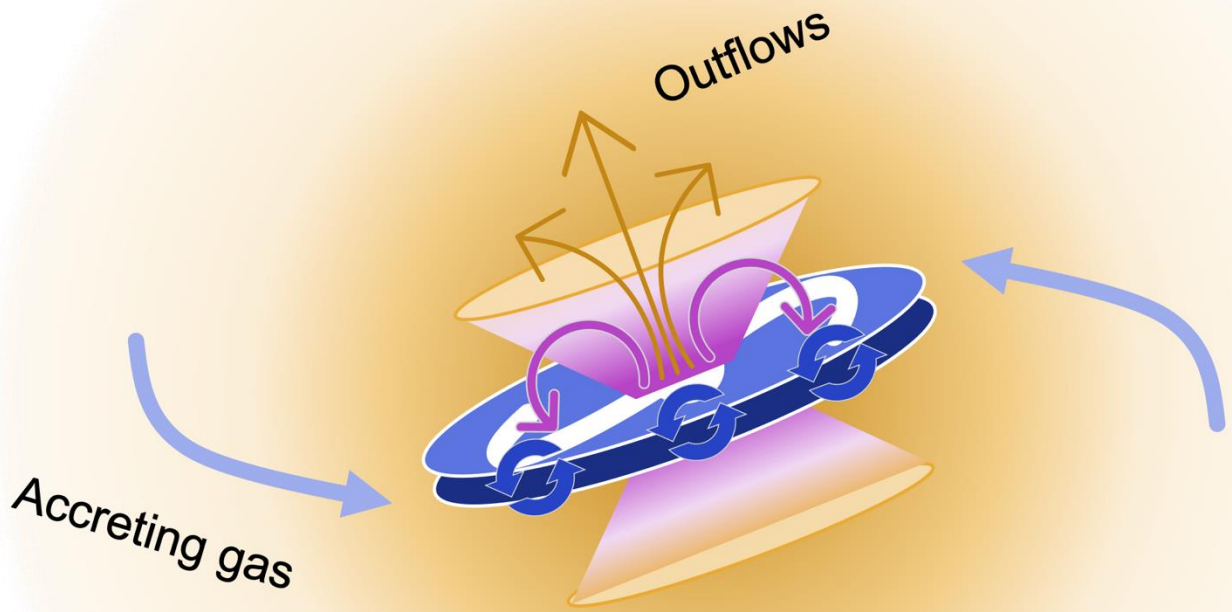
Deanne Fisher, John Chisholm, Glenn Kacprzak, Nikki Nielsen, Daniel McPherson, Magdalena Hamel Bravo, Alberto Bolatto, Danielle Berg, Alex Cameron, Karin Sandstrom, Anna McLeod, and others

SWINBURNE Centre for Astrophysics and Supercomputing

Durham University

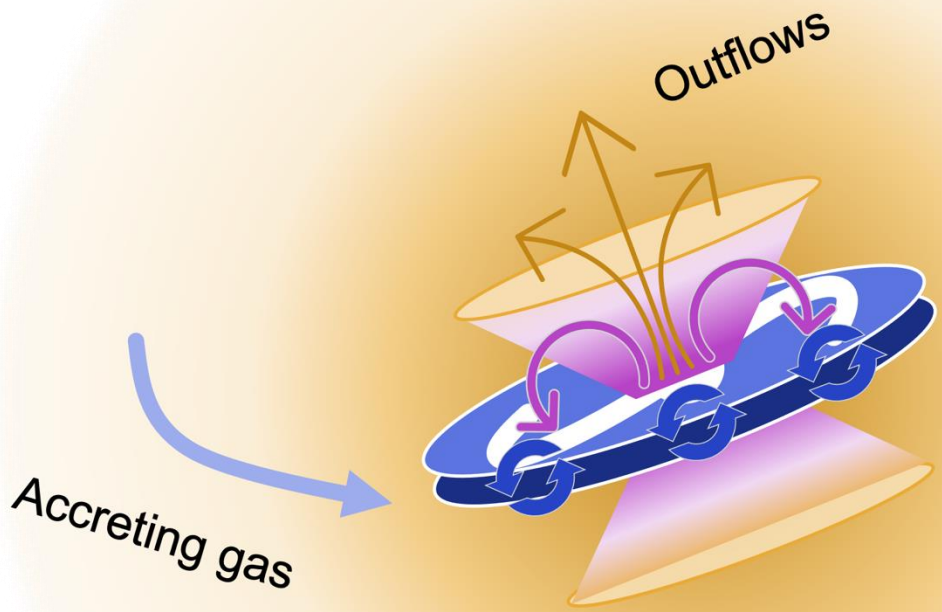
ASTRO 3D

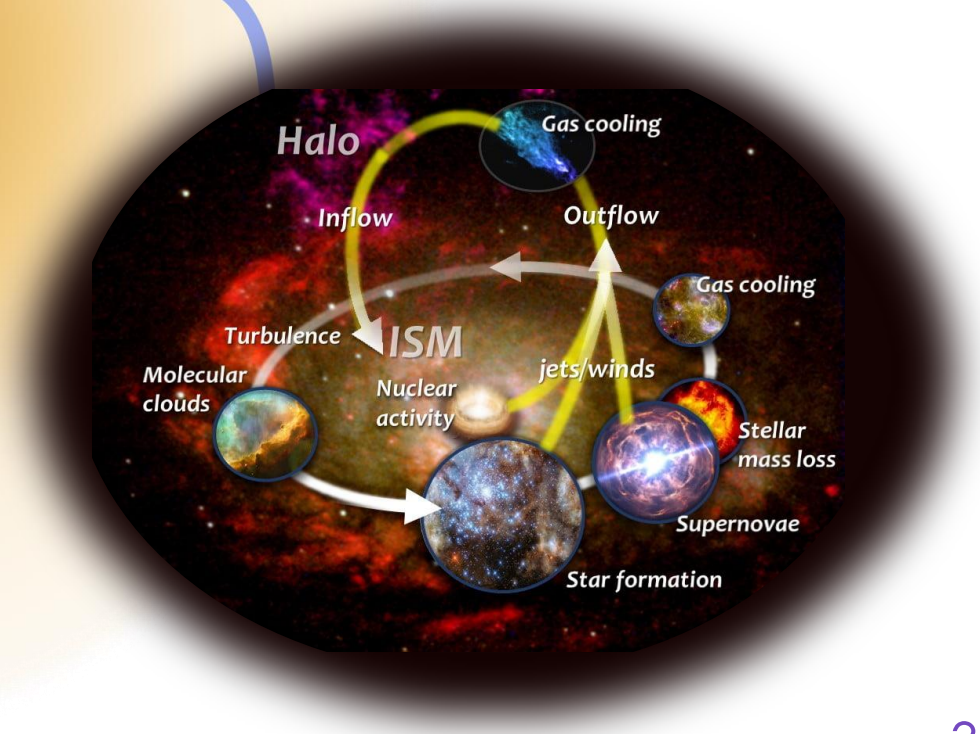
DUVET


Outflows
Accreting gas


DUVET
Face-on

DUVET
Face-on





M82

Image Credit: X-ray: NASA/CXC/JHU/D. Strickland;
Optical: NASA/ESA/STScI/AURA/The Hubble Heritage Team;
Infrared: NASA/JPL-Caltech/Univ. of Arizona/C. Engelbracht

We need more resolved observations of local star formation-driven outflows

M82

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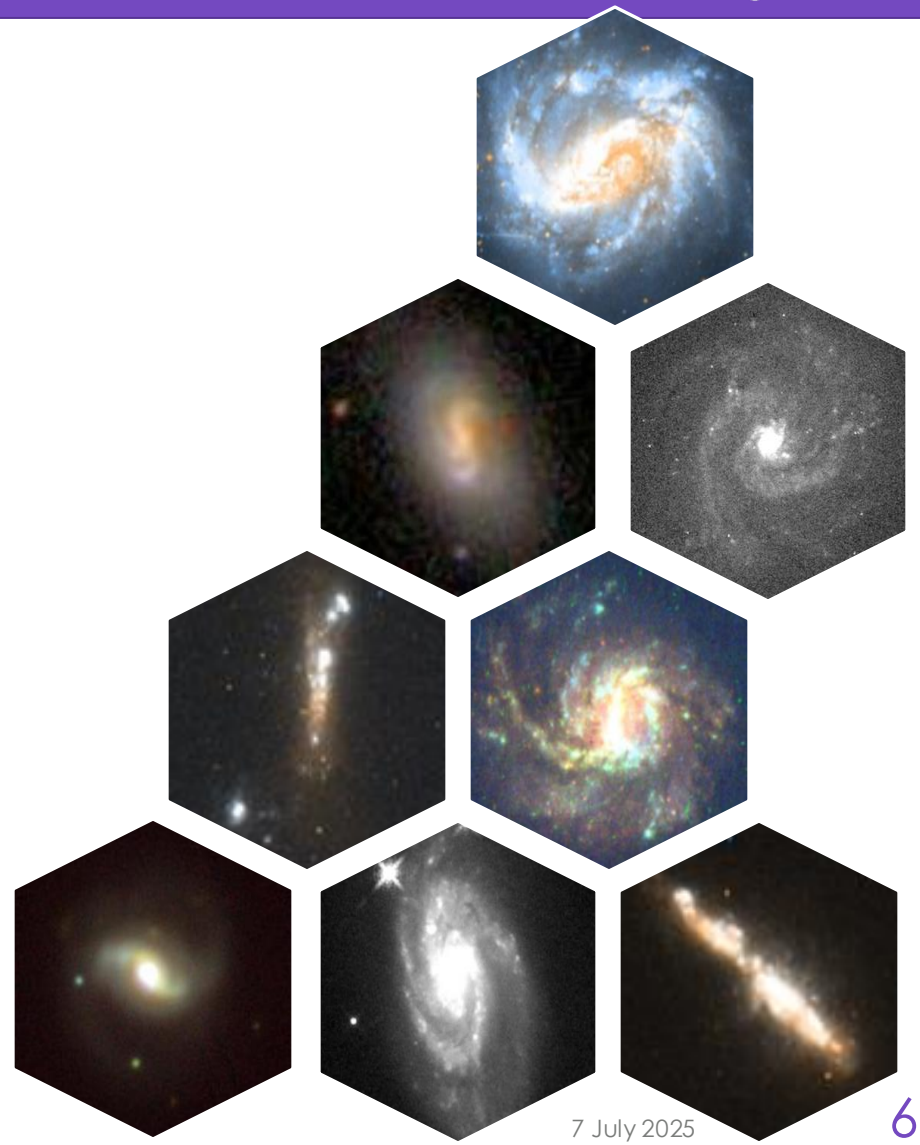
DUVET: We've got you covered!

PI : Deanne Fisher (Swinburne)

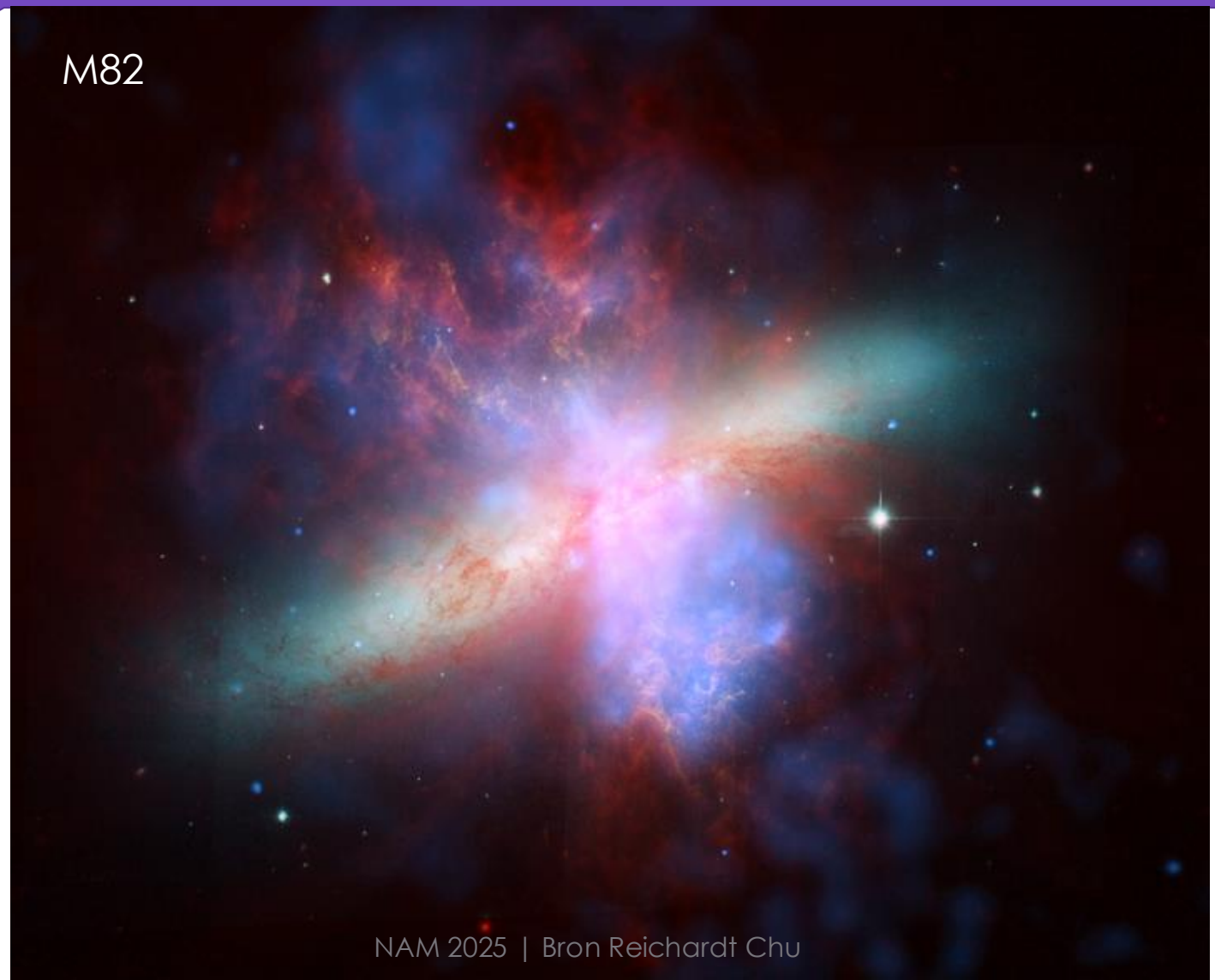
- Disks
- Starbursting: $SFR = 5{-}15 \times MS$
- Stellar Mass: $\log M_* = 9{-}11\ \mathrm{M}_\odot$
- Compact: $r_e = 1{-}3$ kpc
- Nearby: $z = 0.015{-}0.03$
- Metallicity: $0.01{-}1\ Z_\odot$

27 galaxies observed with KCWI/Keck II

Some overlap with HST observations



Observations of outflows using edge-on galaxies



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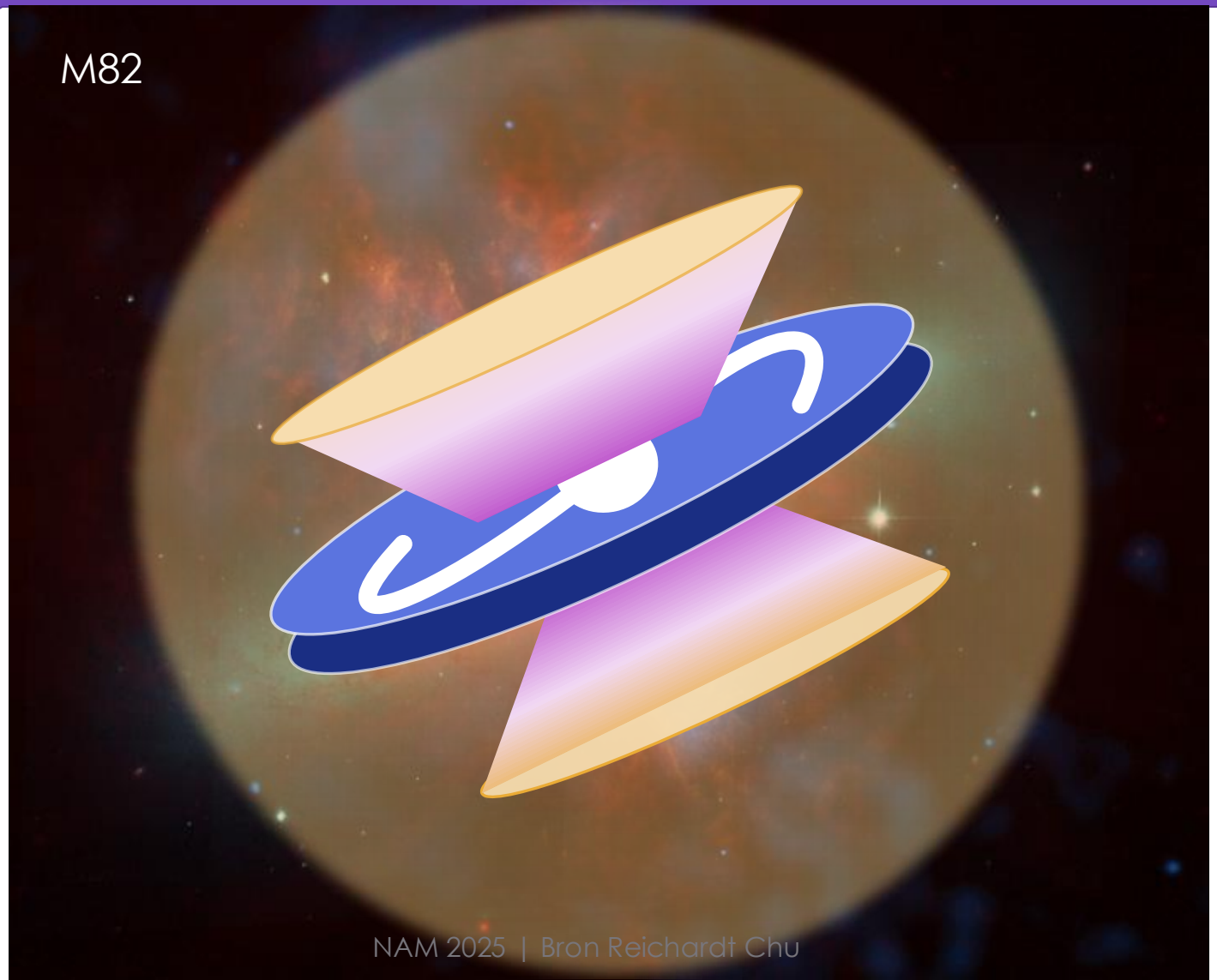
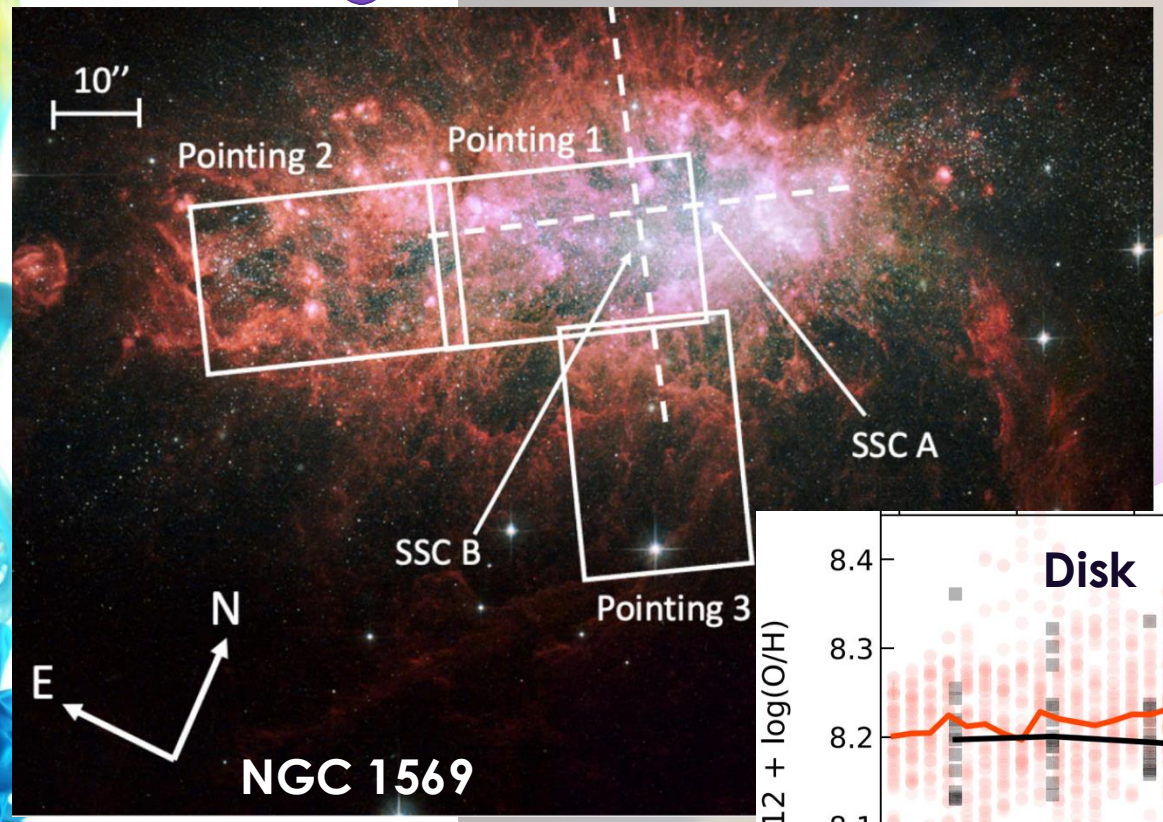
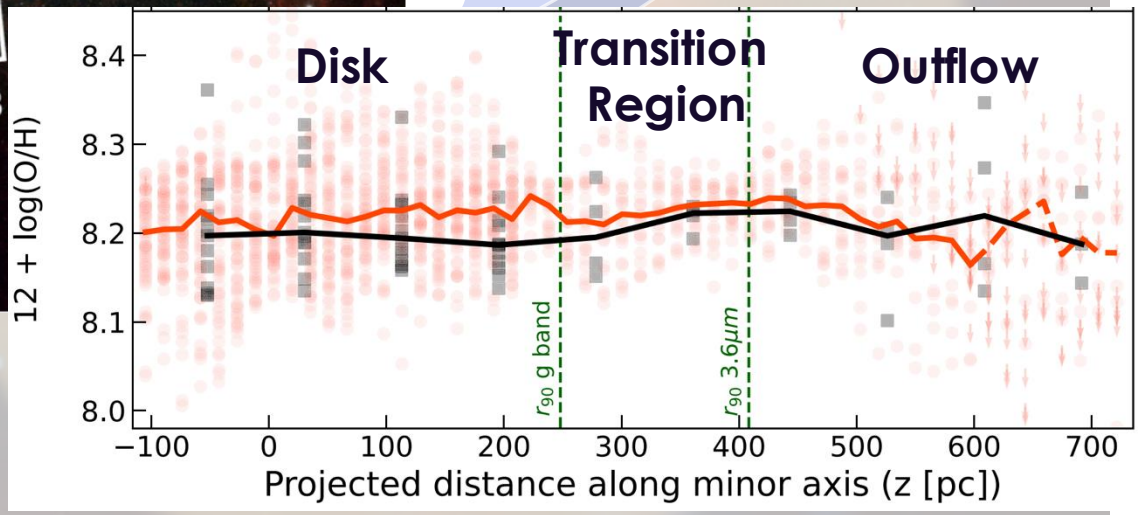


Observations of outflows using edge-on galaxies gives us metal loading

DUVET
Edge-on





See also Cameron+2021 for measurements in Mrk 1486

Magdalena Hamel-Bravo
Hamel-Bravo+2024,
MNRAS 530, 3855

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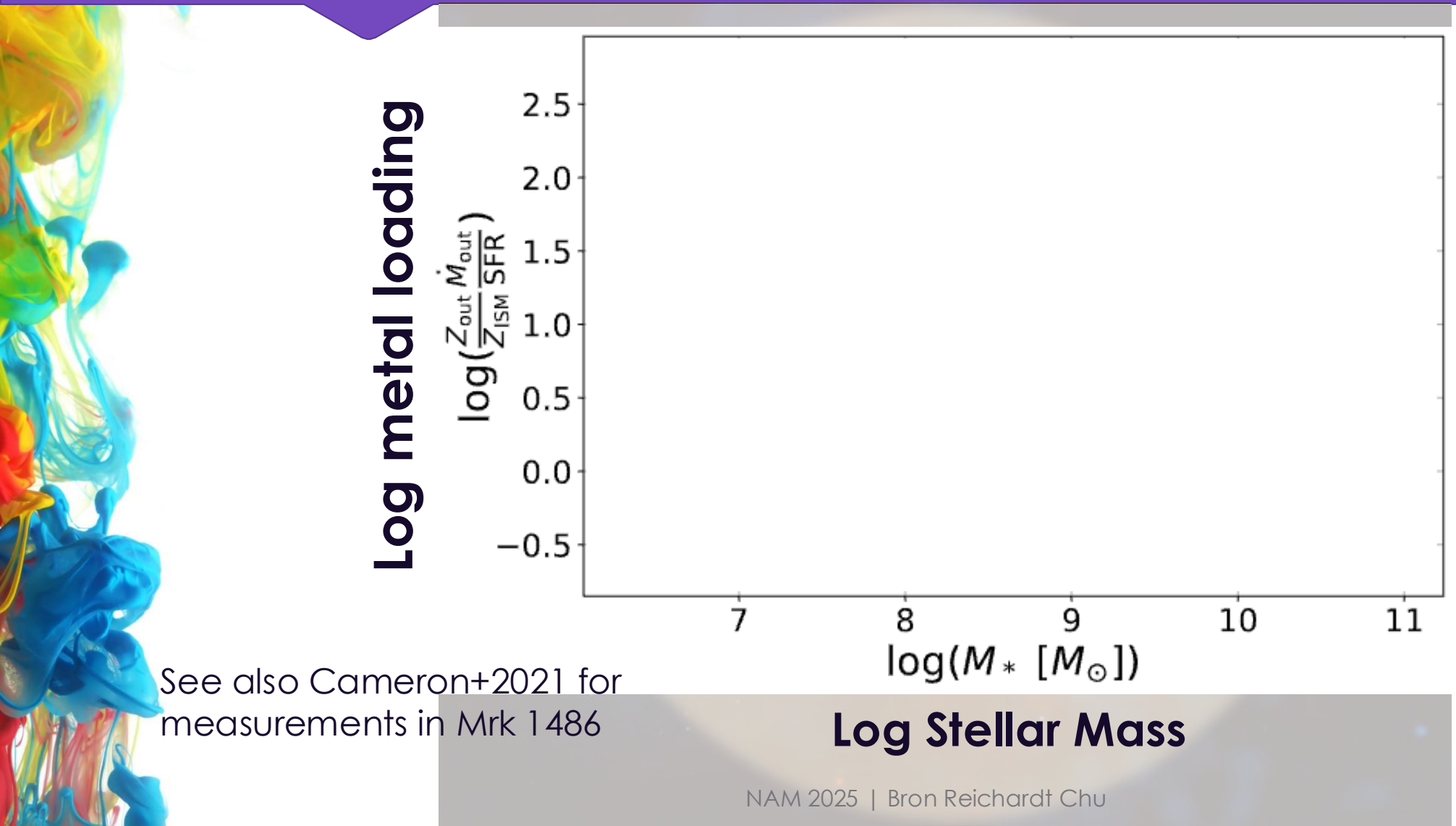

Magdalena Hamel-Bravo
Hamel-Bravo+2024,
MNRAS 530, 3855

Hamel-Bravo et al.
(in prep)

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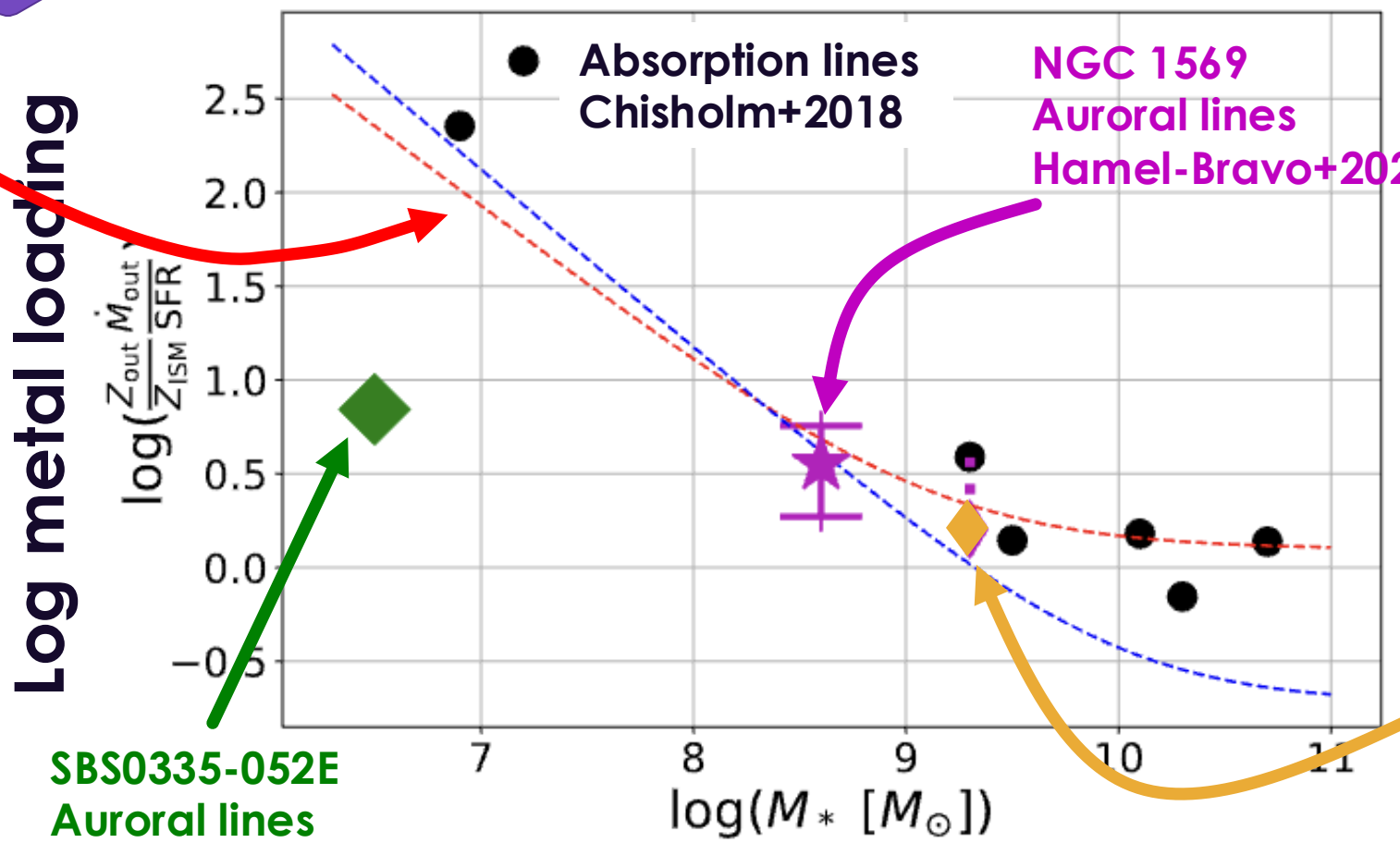
DUVET
Edge-on

Theory necessary to reproduce the MZR



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Hamel-Bravo+2024,
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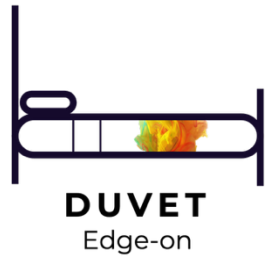
Observations of outflows using edge-on galaxies

Measuring geometry
McPherson+2023, MNRAS 525, 6170

Measuring metallicities and ionisation
Hamel-Bravo+2024, MNRAS 530, 3855

Cameron+2021, ApJL 918, L16

Observations of outflows using face-on galaxies



Outflow scaling relations

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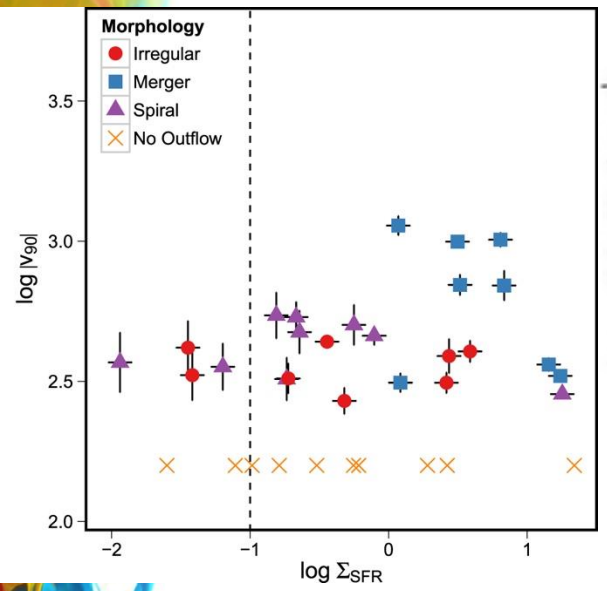
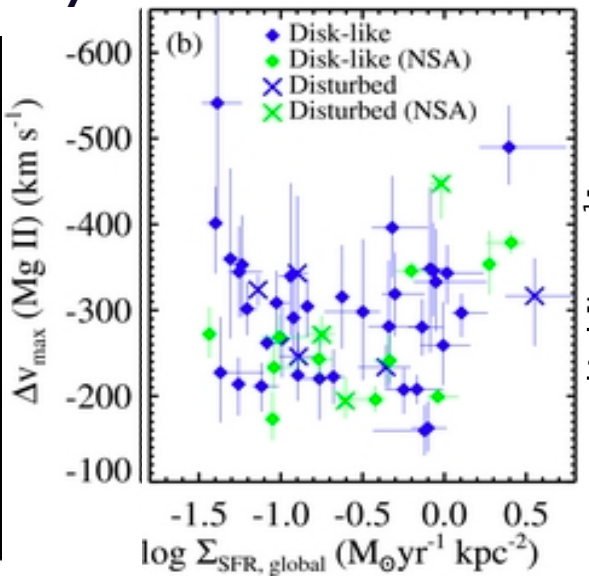
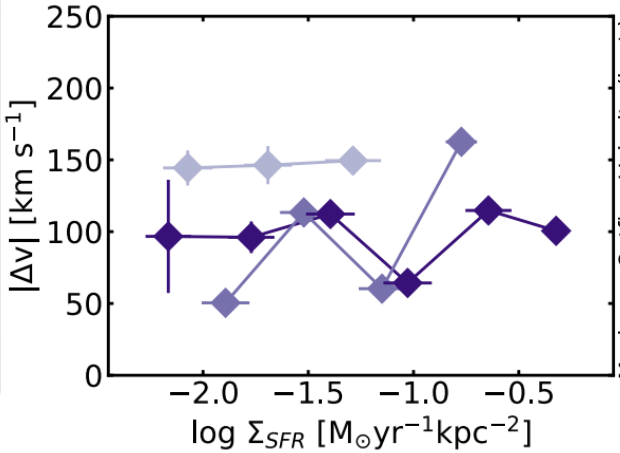
Edge-on

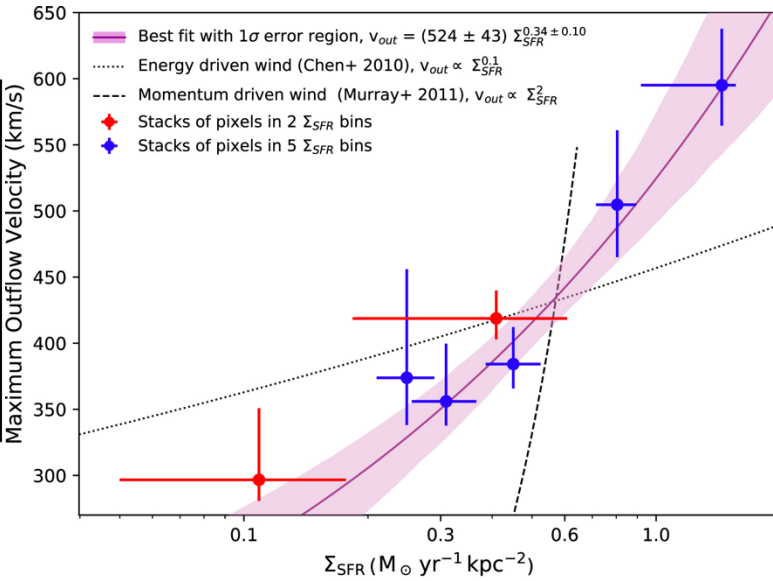
Global galaxy measurements





Stacked galaxy measurements





Chisholm et al. 2015
48 galaxies
$z \sim 0$
Si II absorption

Rubin et al. 2014
105 galaxies
$0.3 < z < 1.4$
Mg II absorption

Roberts-Borsani et al. 2020
405 galaxies
$z \sim 0$
NaD absorption

Davies et al. 2019
28 galaxies
$2 < z < 2.6$
Hα emission

Testing sub-grid physical models

SNe-driven:

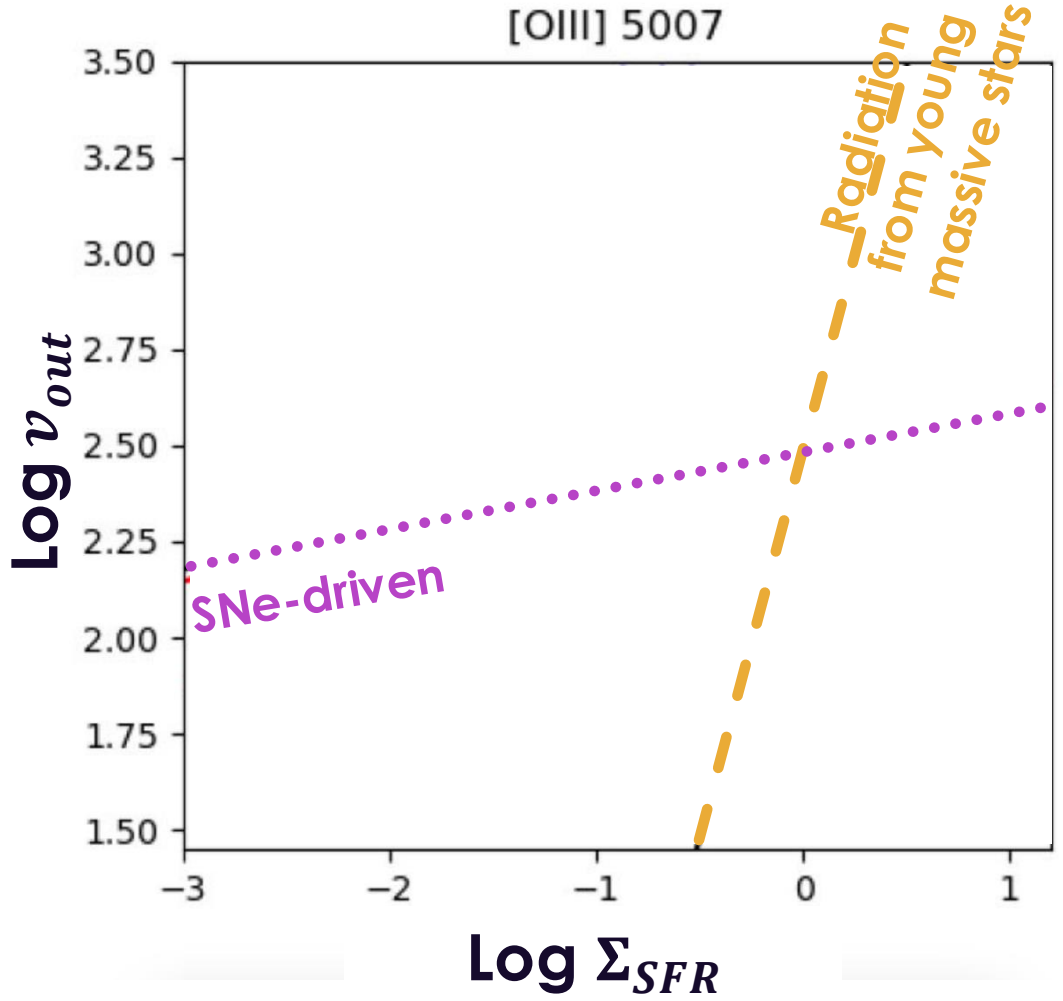
$v_{out} \propto \Sigma_{SFR}^{0.1}$

Chen et al. 2010, Li et al. 2017, Kim et al. 2020

Radiation from young massive stars:

$v_{out} \propto \Sigma_{SFR}^{2}$

Murray et al. 2011



Reichardt Chu et al. (2025)

Supernovae are primarily driving the outflows in DUVET face-on galaxies

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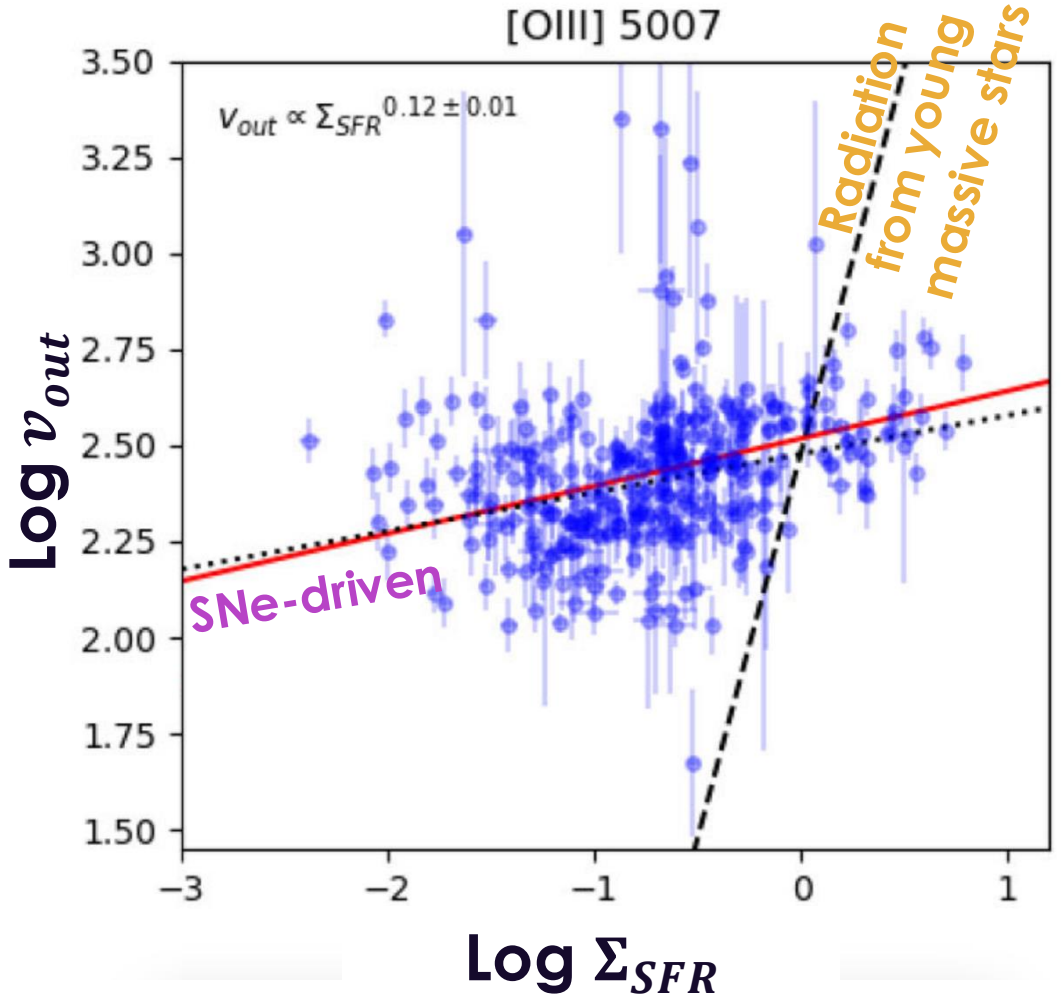

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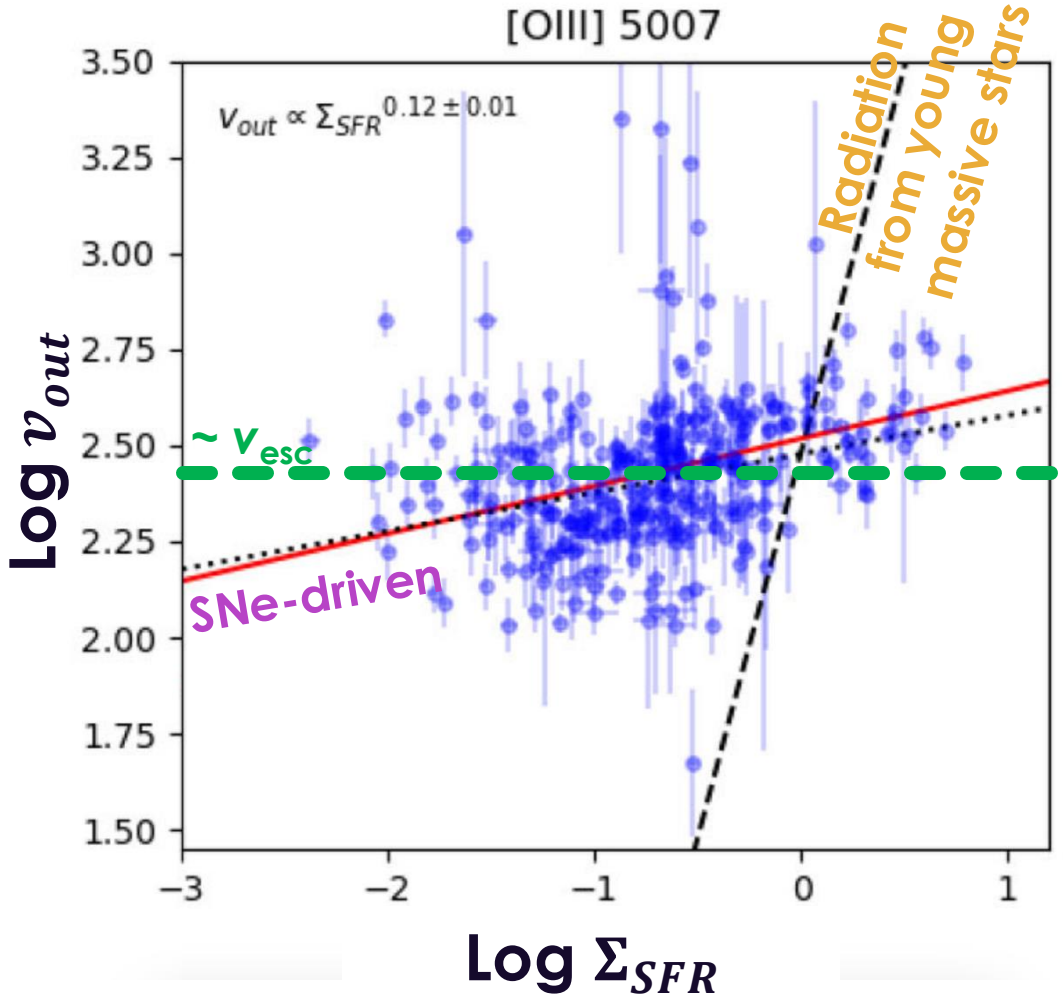


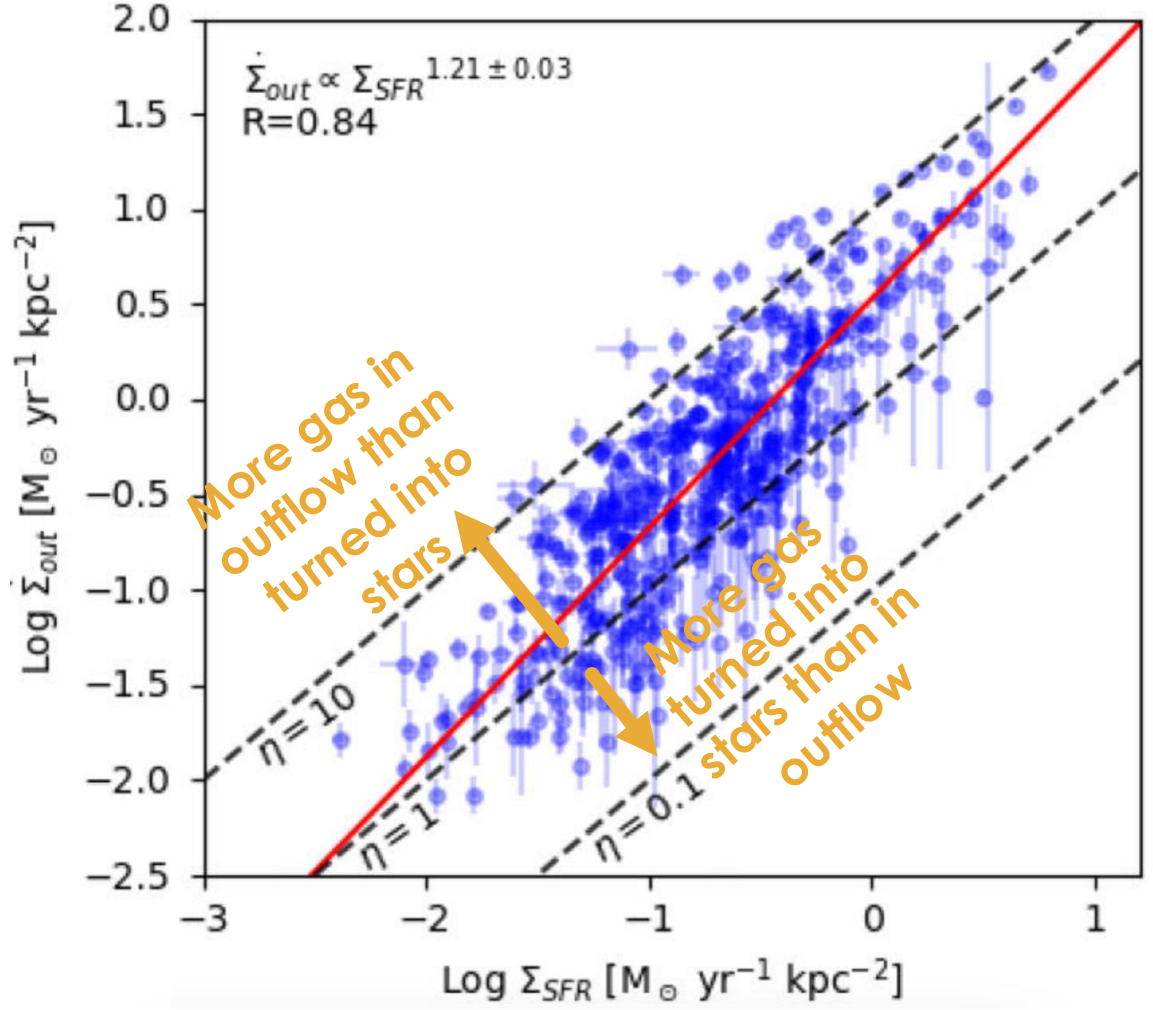
Reichardt Chu et al. (2025)

High Σ_{SFR} regions drive stronger outflows

DUVET
Face-on

$\dot{\Sigma}_{out}$
mass outflow rate per area

Assumptions:
R_{out} ~ 500 pc
n_e ~100 cm^{-3}



For a full table of our results, see the Supplementary Files for the paper:

SCAN ME

Reichardt Chu et al. (2025)

How do outflows affect the star formation?

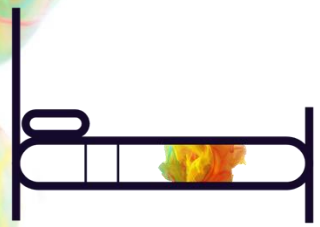
How do outflows affect the star formation?

Come to my talk tomorrow to find out!

Star formation across environments: From individual molecular clouds to entire galaxies

2:15pm – 3:45pm

TLC 113



Edge-on

Face-on

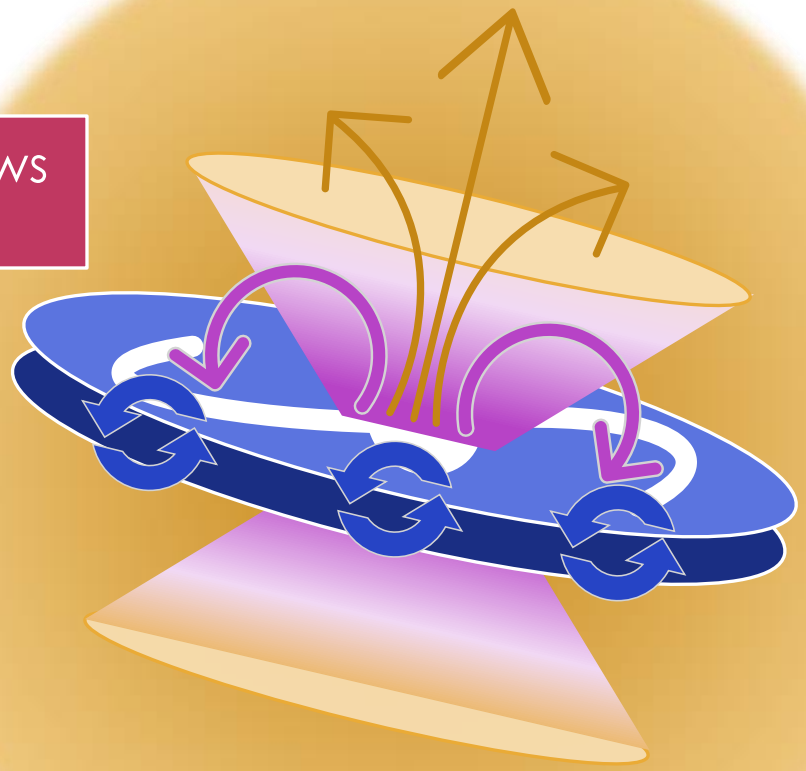
How are outflows distributed?

Outflows are integral to the metallicity cycle in galaxies

Hamel-Bravo+2024, MNRAS 530, 3855

Cameron+2021, ApJL 918, L16

Outflows in low-mass low-metallicity galaxies may not expel enough metals to follow MZR



What mechanism is driving the outflow?

Outflow velocities consistent with SNe-driven models

Higher SFR surface density drives more gas out

Reichardt Chu et al. (2025) MNRAS, 536, 1799

For a full table of our results, see the Supplementary Files for the paper

How do outflows regulate star formation?

See my talk tomorrow!