The physical conditions of gas flows observed with MUSE and ALMA

Celine Peroux

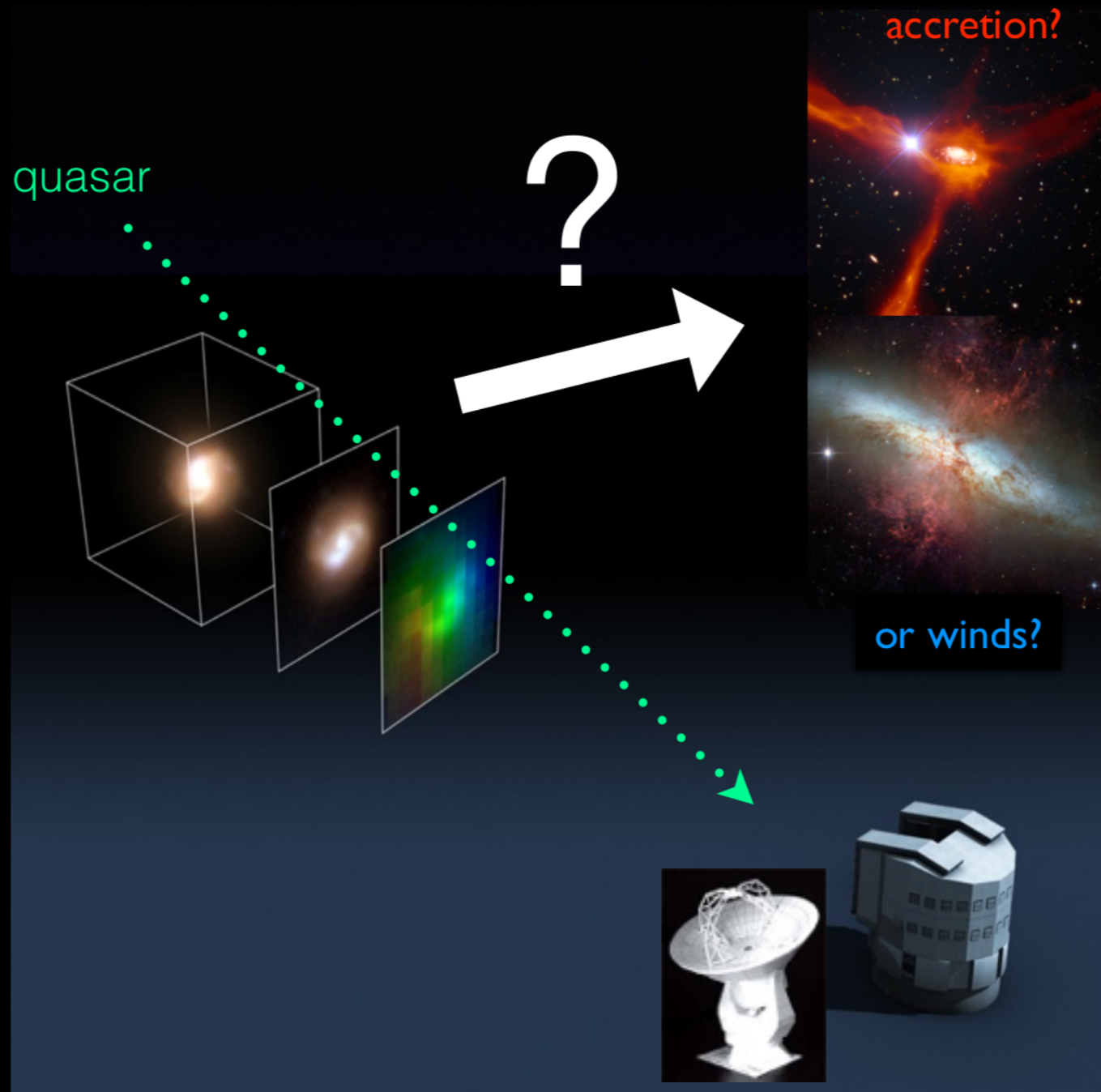Martin Zwaan, Anne Klitsch, Ramona Augustin, Aleksandra Hamanowicz, Hadi Rahmani, Max Pettini, Varsha Kulkarni, Lorrie Straka, Andy Biggs, Don York & Bruno Milliard
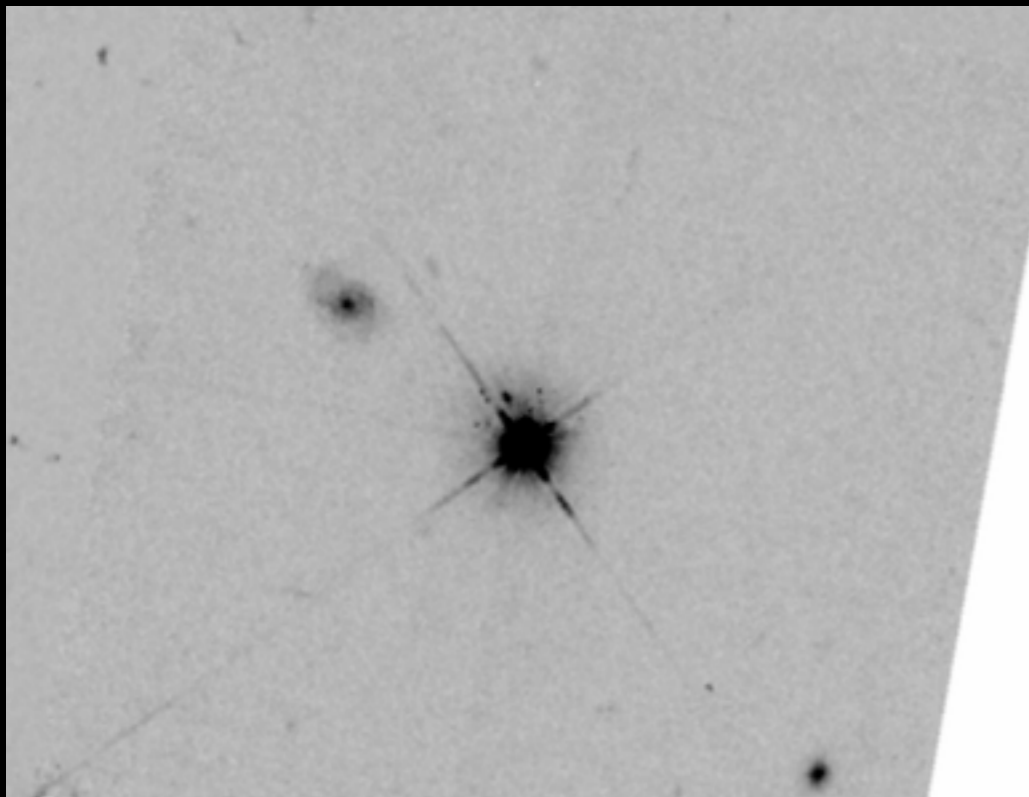
Questions to Address

1- How to probe galactic gas flows?

2- How to characterise the multi-phase CGM?

3- On which scales are metals mixed?
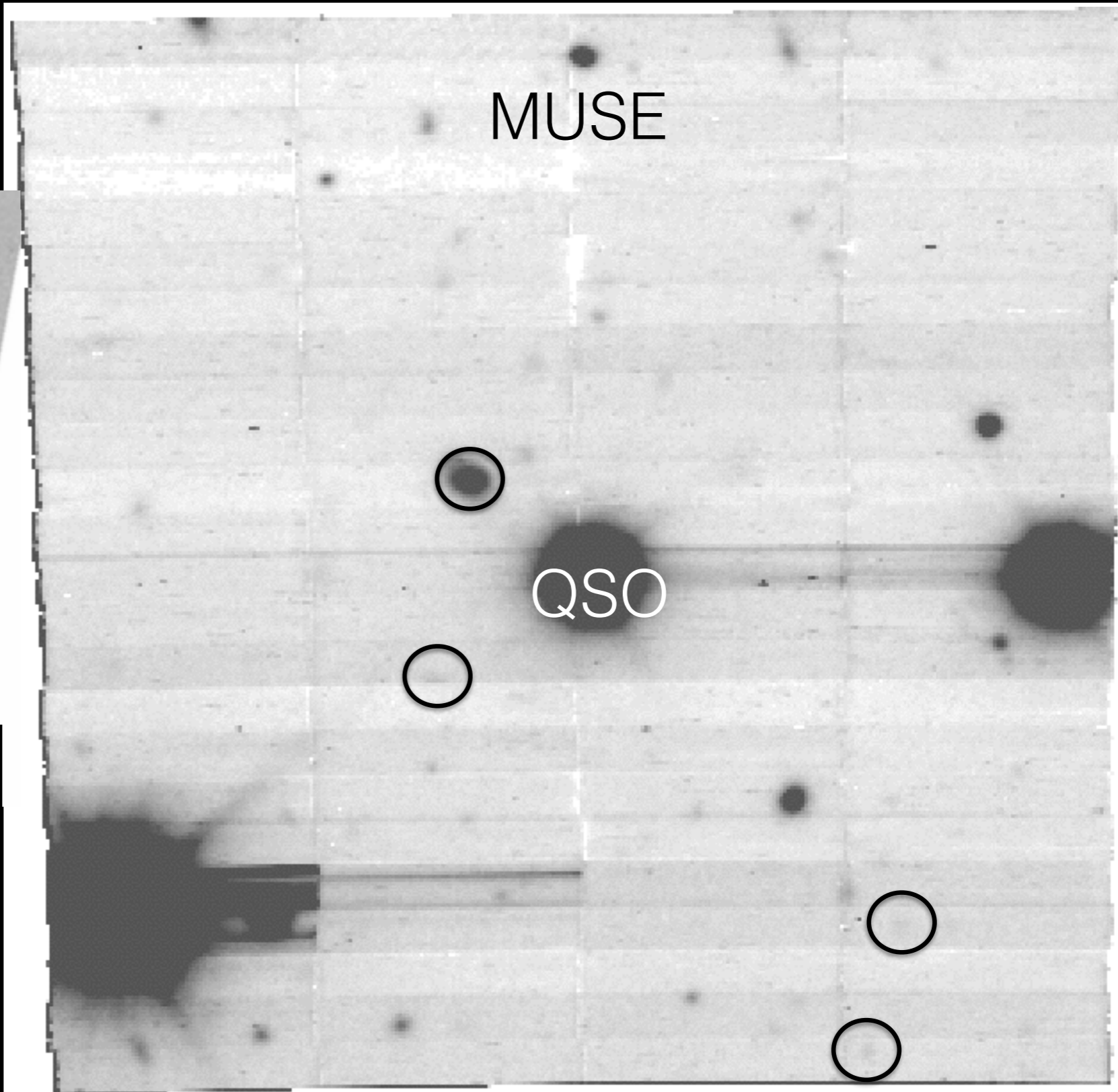
3D cubes:
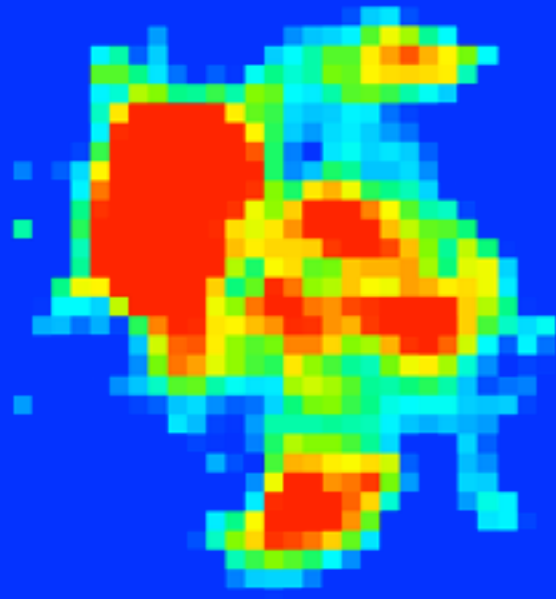# a powerful tool to connect gas & stars

quasar

?

accretion?

or winds?

Gas Flows probe by Kinematics
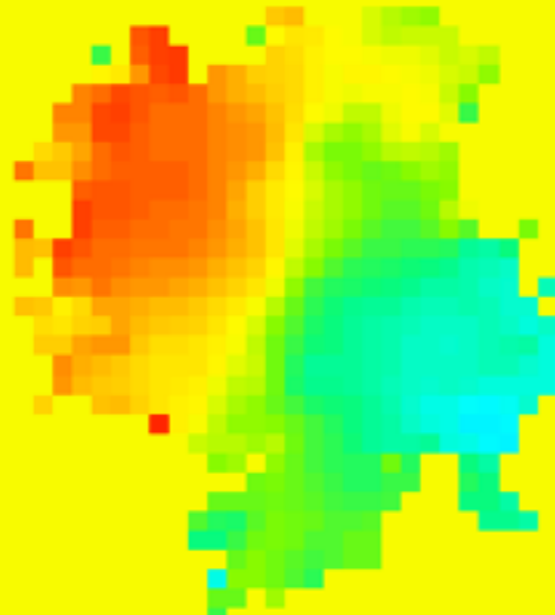

HST

MUSE

QSO

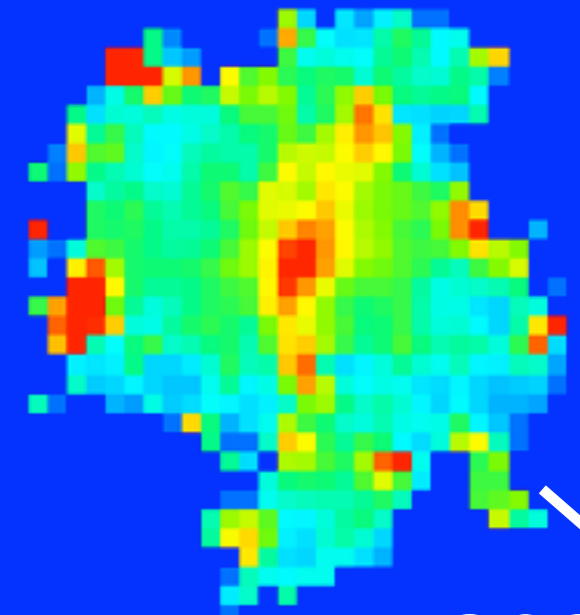log N(HI)=19.5

[OIII] 5008 Obs Flux

2.5

1.5

1.0x10⁻¹⁹

Obs Velocity

150

-150
km/s

Vel Dispersion

90

60

40
km/s

QSO

• $M_{dyn} = 7 \times 10^{10} M_{sun}$, $M_{halo} = 3 \times 10^{12} M_{sun}$

2

Galaxy "a"

N

E

Model Velocity

150
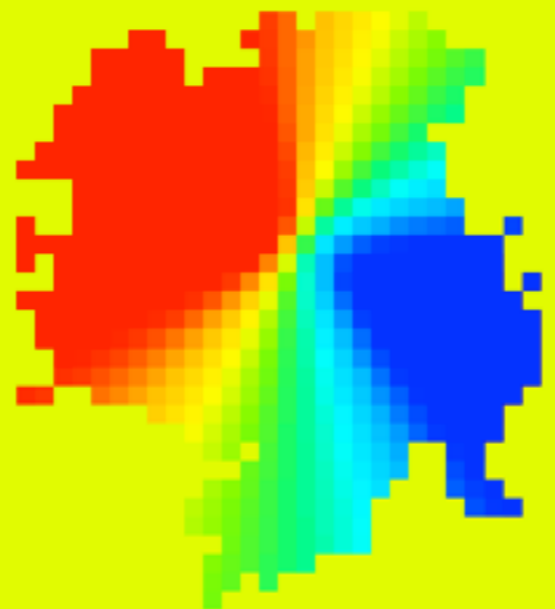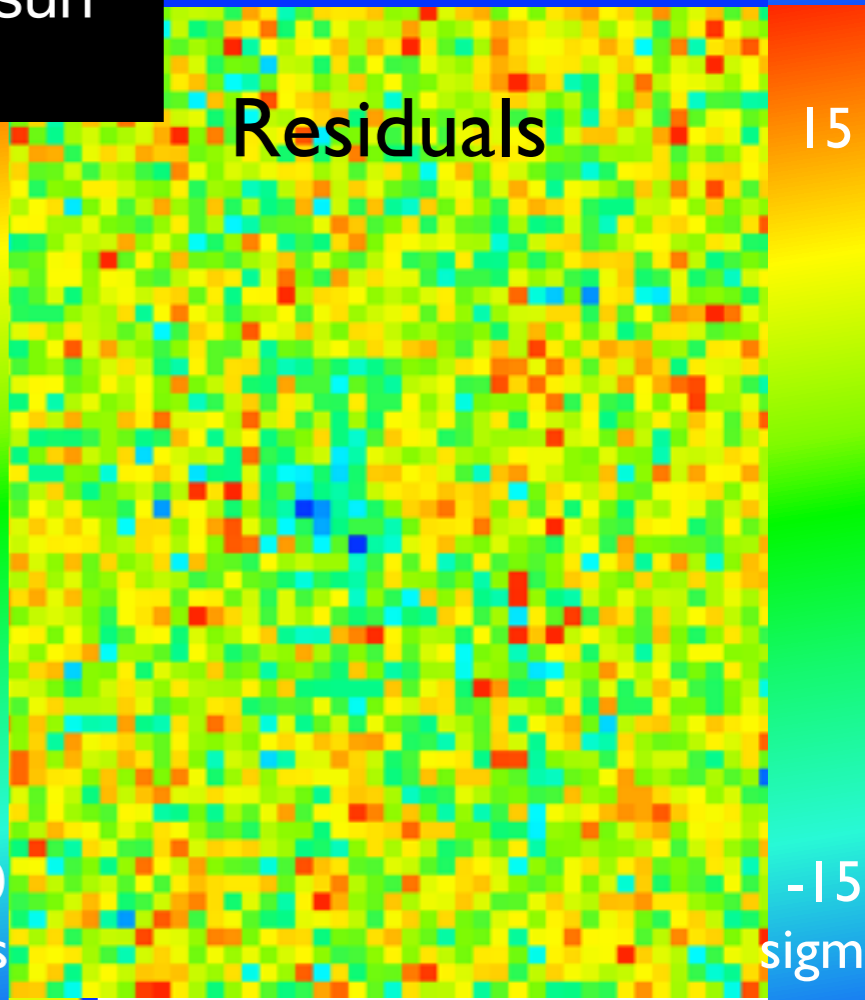
-150
km/s

Residuals

15

-15
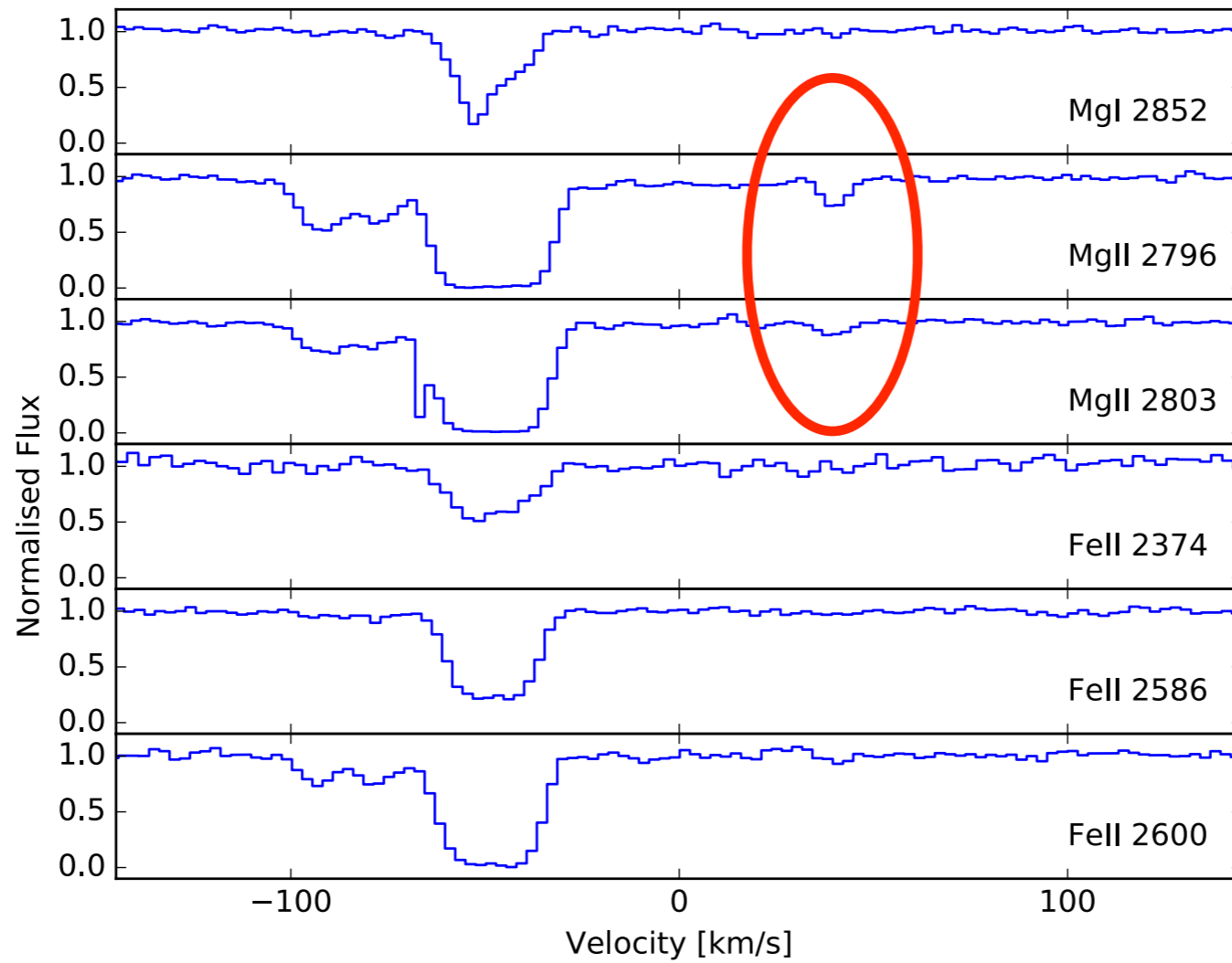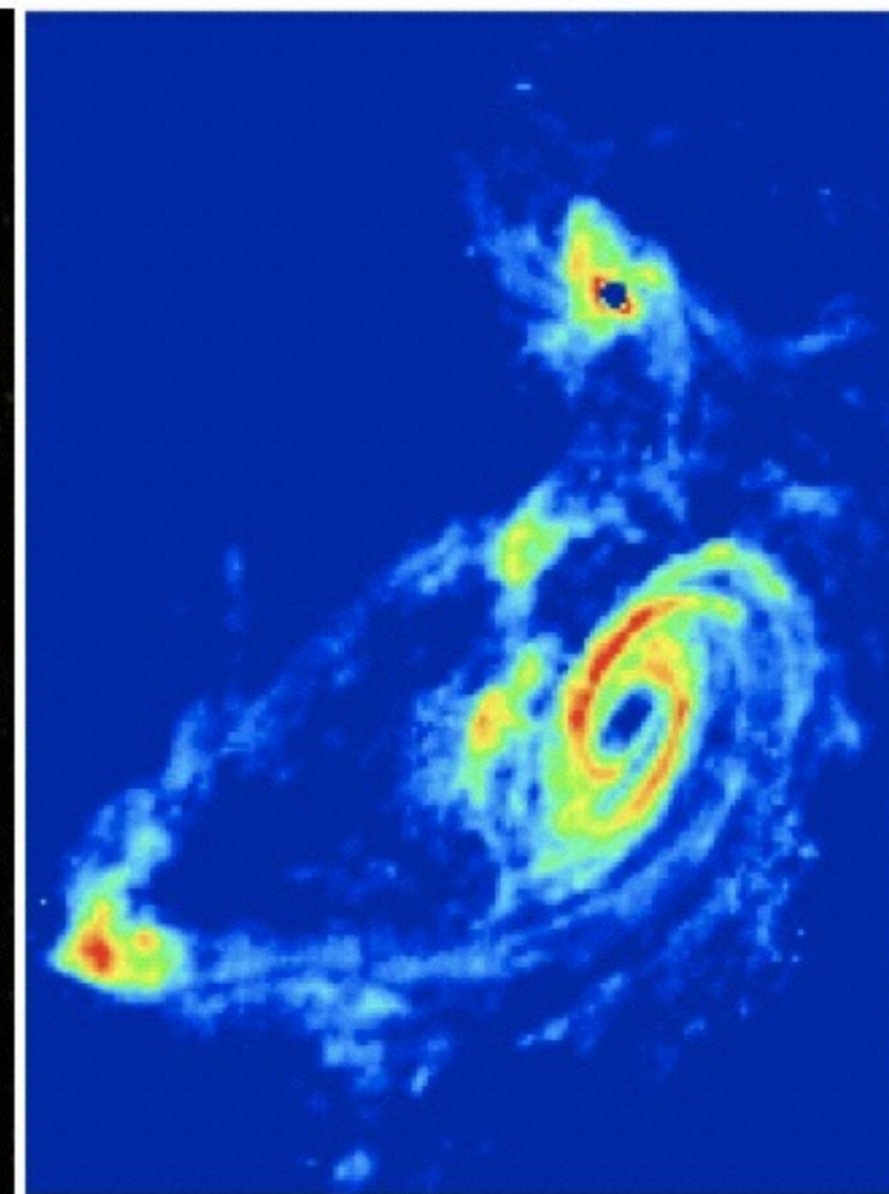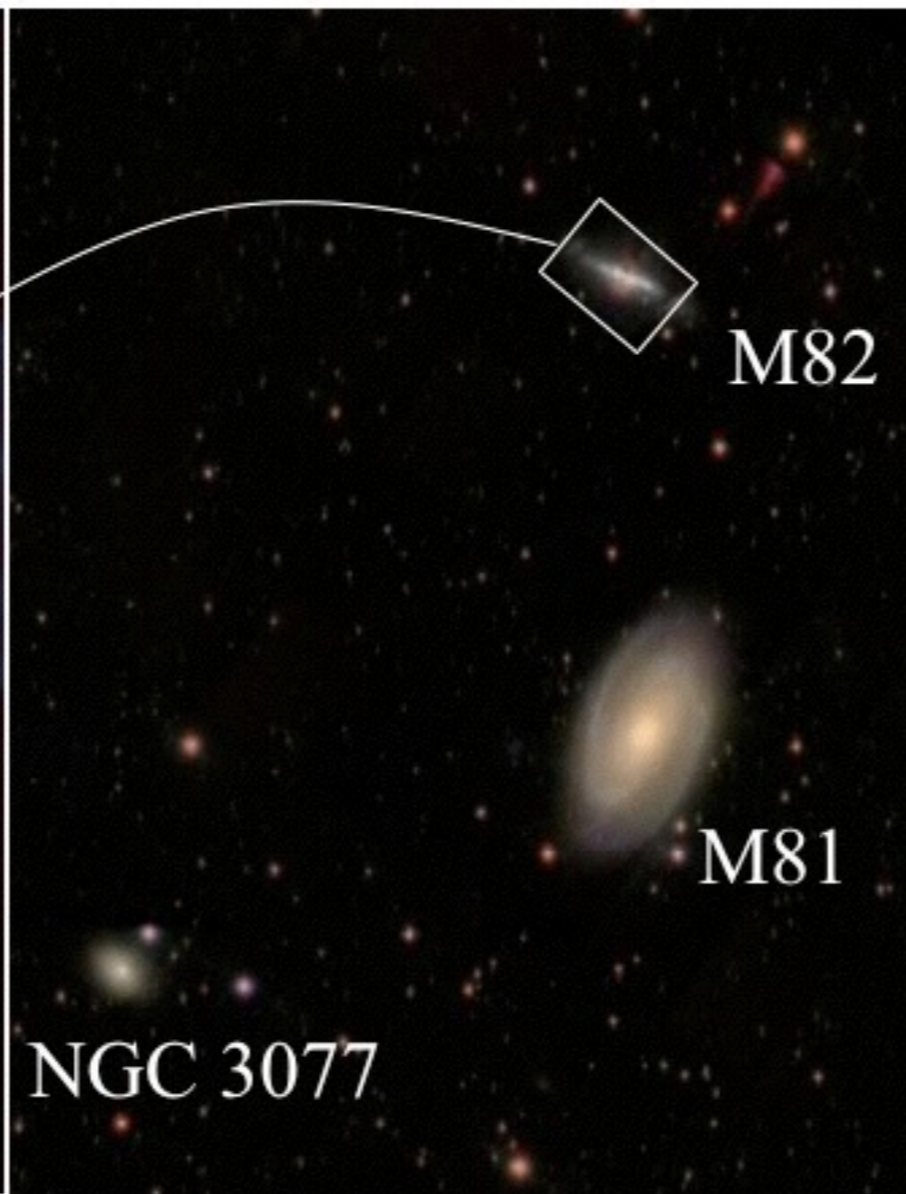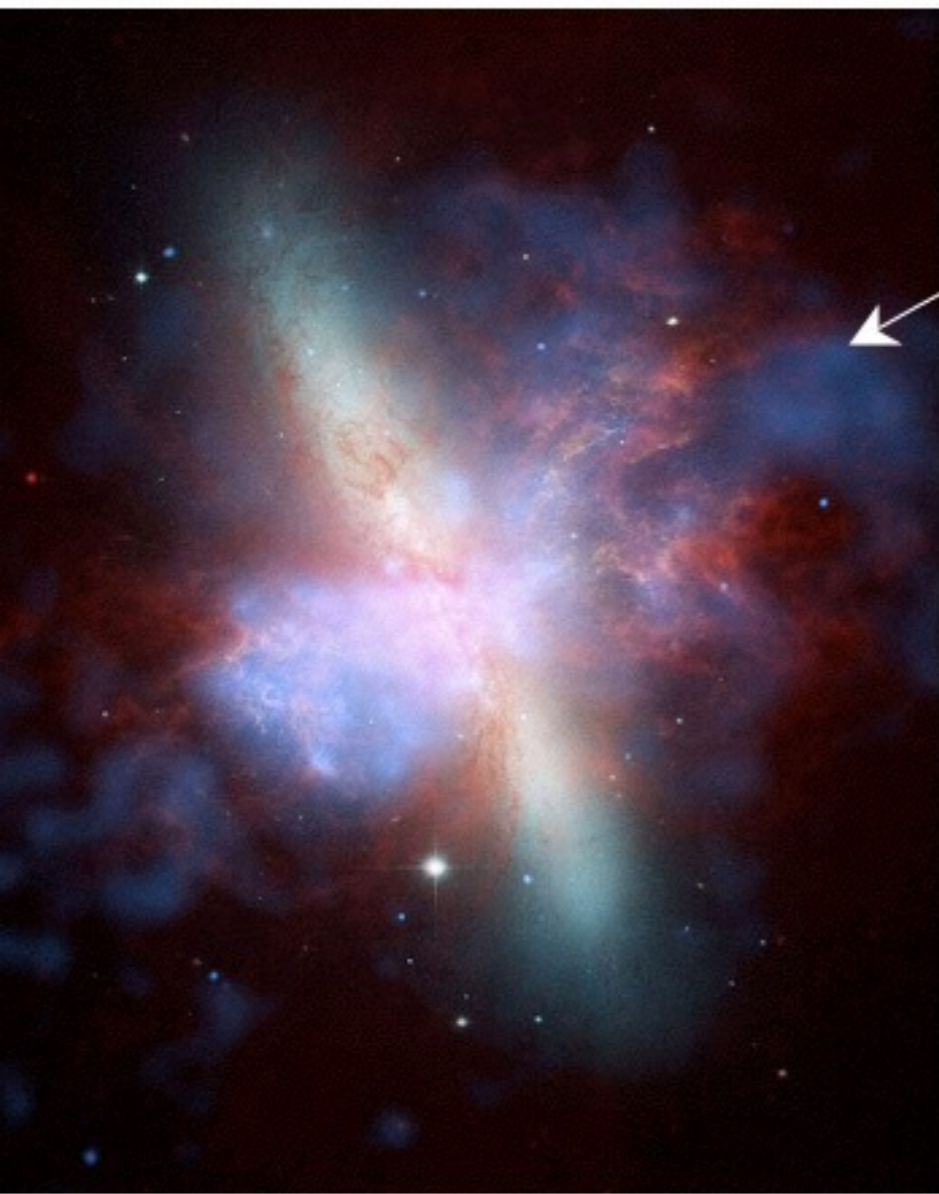sigma
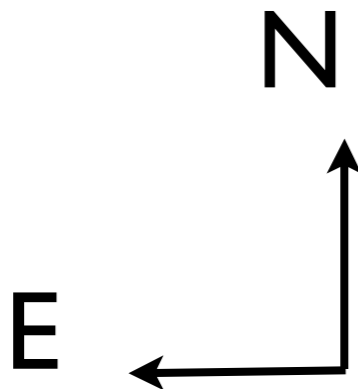
What is this Gas?

CP+17

Low-redshift Analog

Galactic Wind
(M82)

Starlight
(optical)

HI Gas
(radio)

Questions to Address

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Multi-Phase CGM

HST

MUSE

log N(HI)=21.7

Kacprzak+10, Christensen+14

Absorber related to Small Group

[OIII]5007 - MUSE

G19

G4

G22

G21

G2   G18

G17

G6   G0   G1

G16

100 kpc

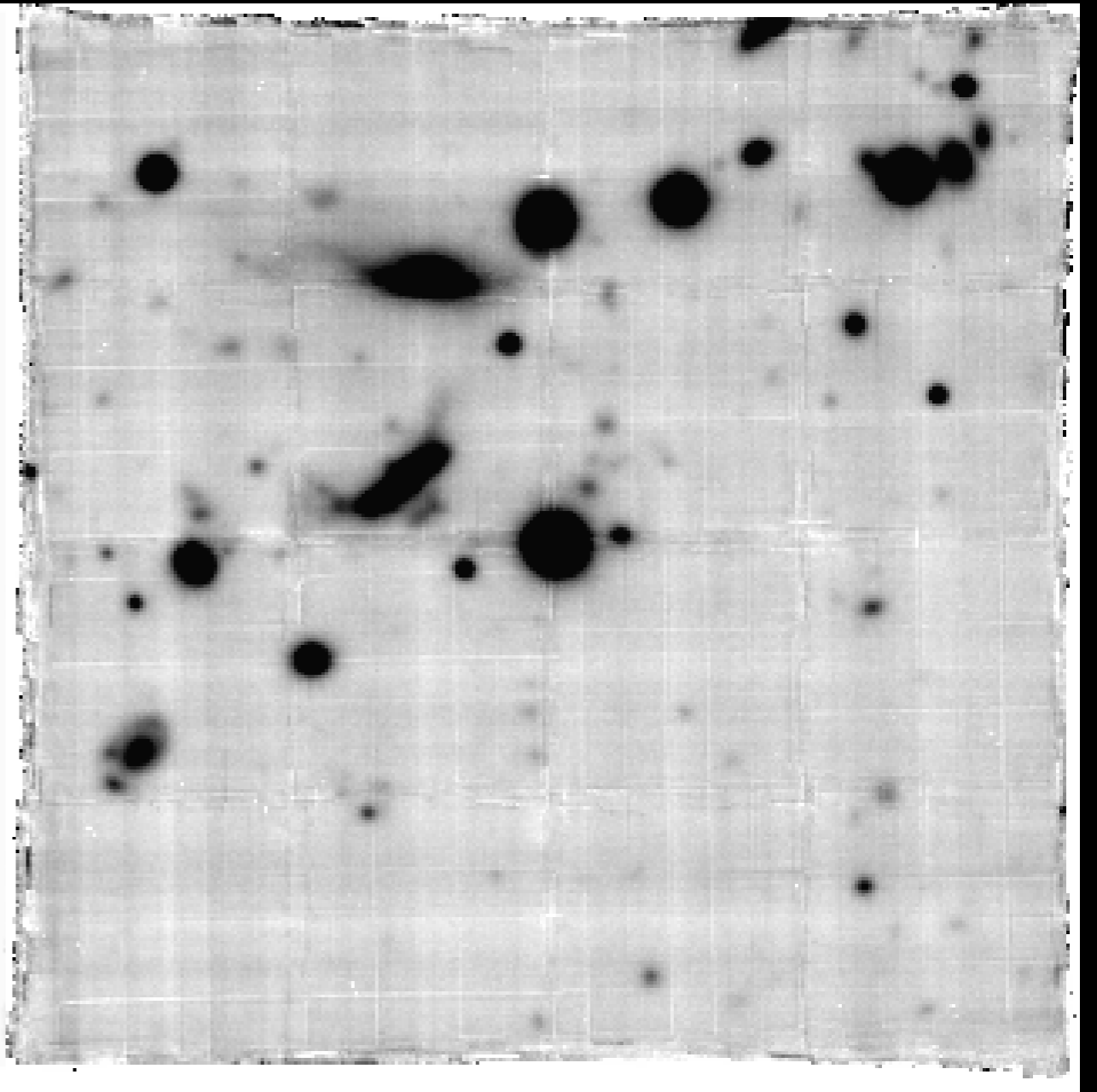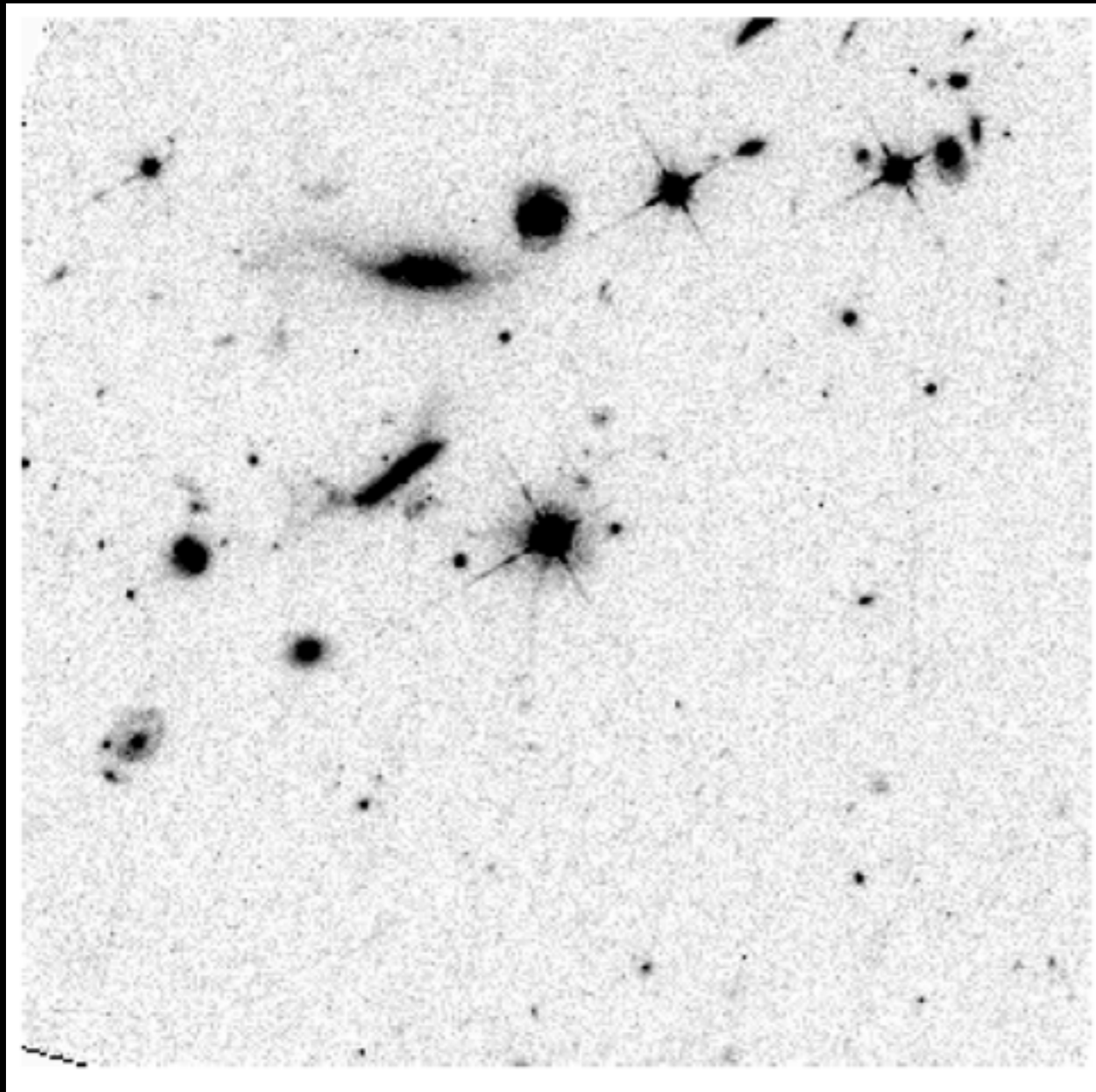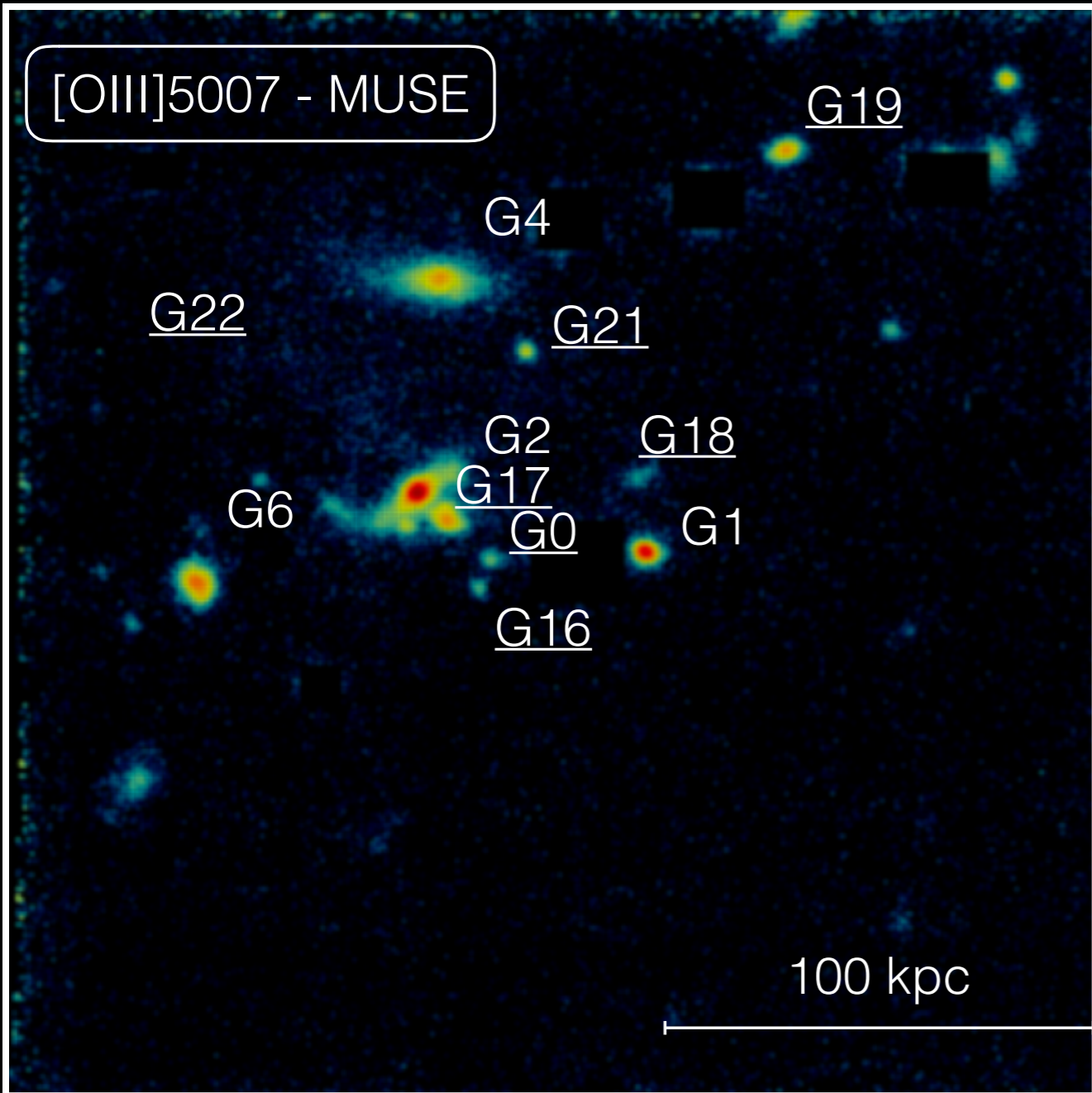# Large Molecular Gas Reservoirs
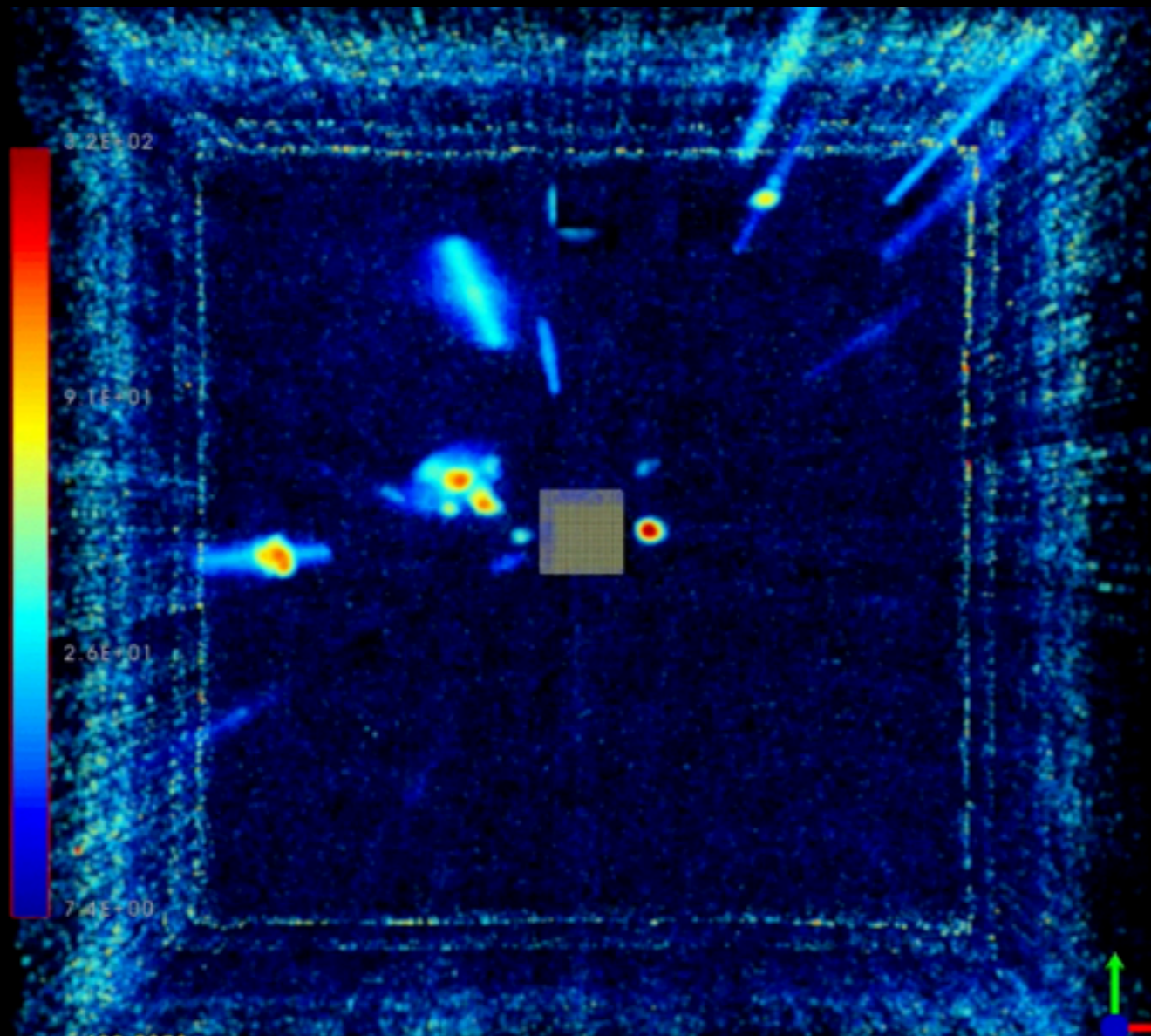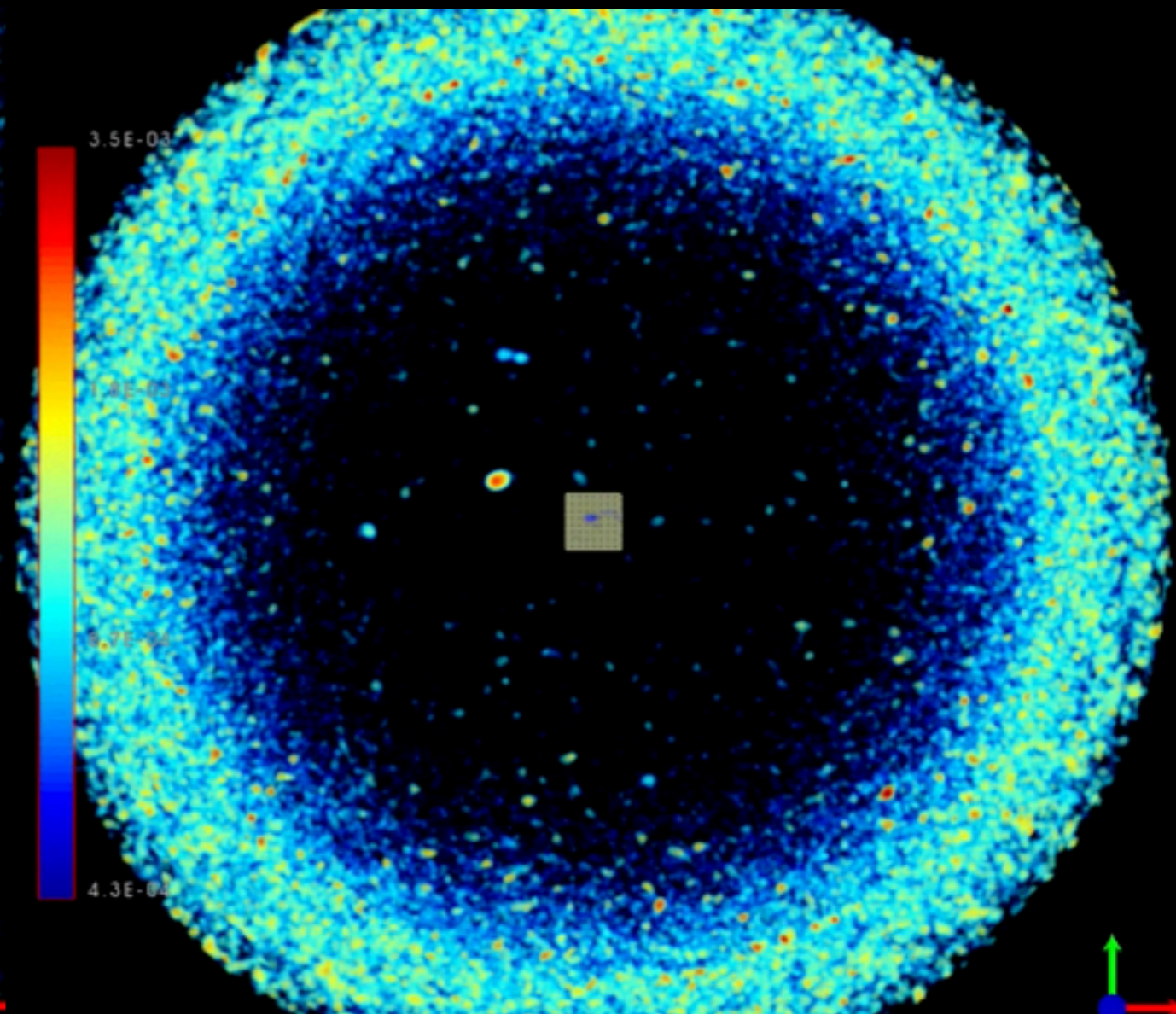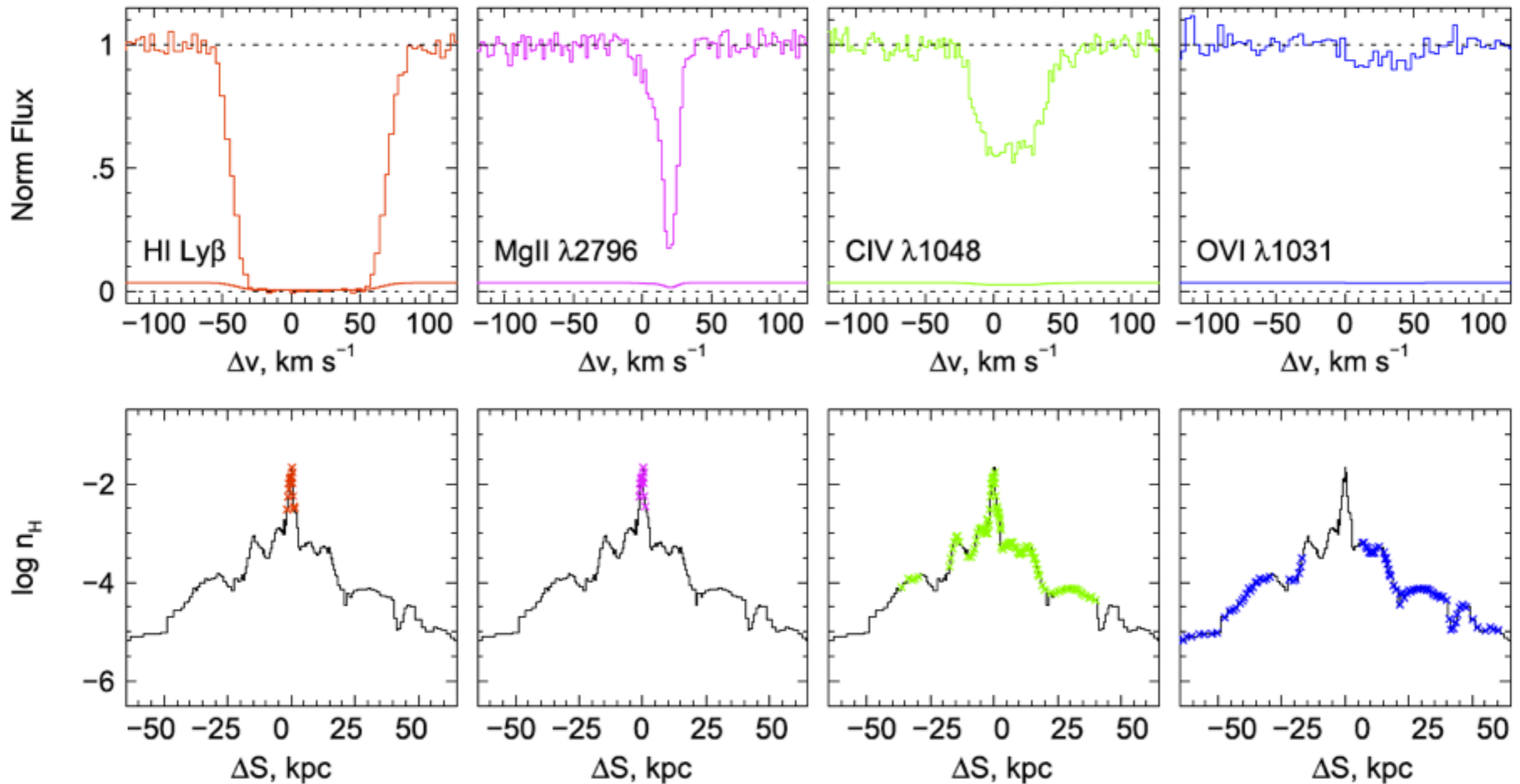
Ionised Gas   molecular gas

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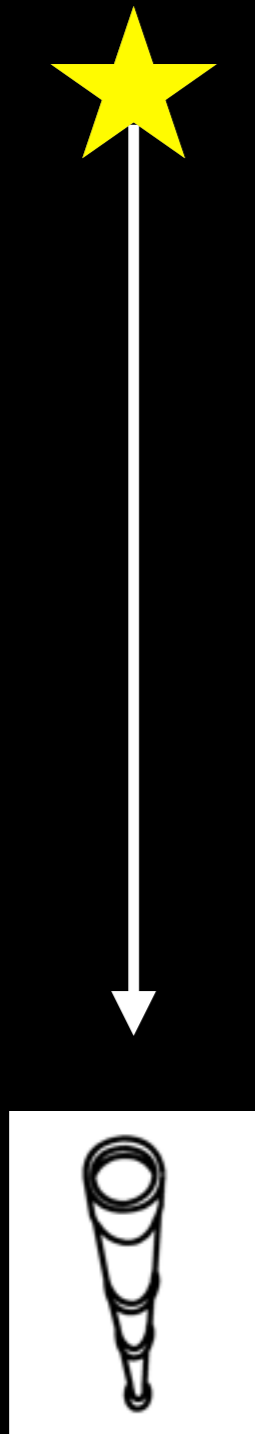
3- On which scales are metals mixed?

Cold Gas Mixing

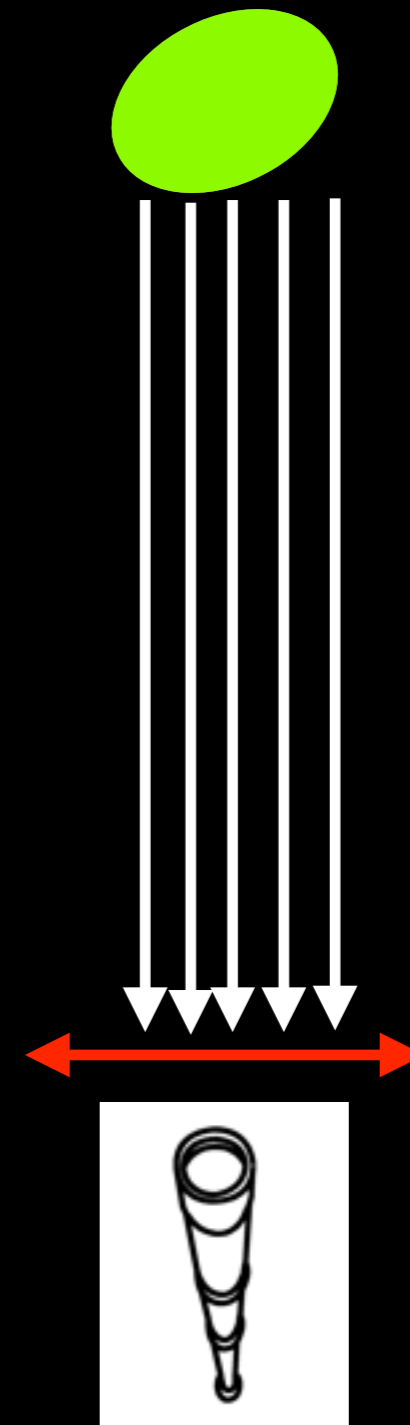

Churchill+15

Schaye+05,07; Gronke+17

Beyond 1D along the Line-of-Sight

quasar (pt-like)

extended source
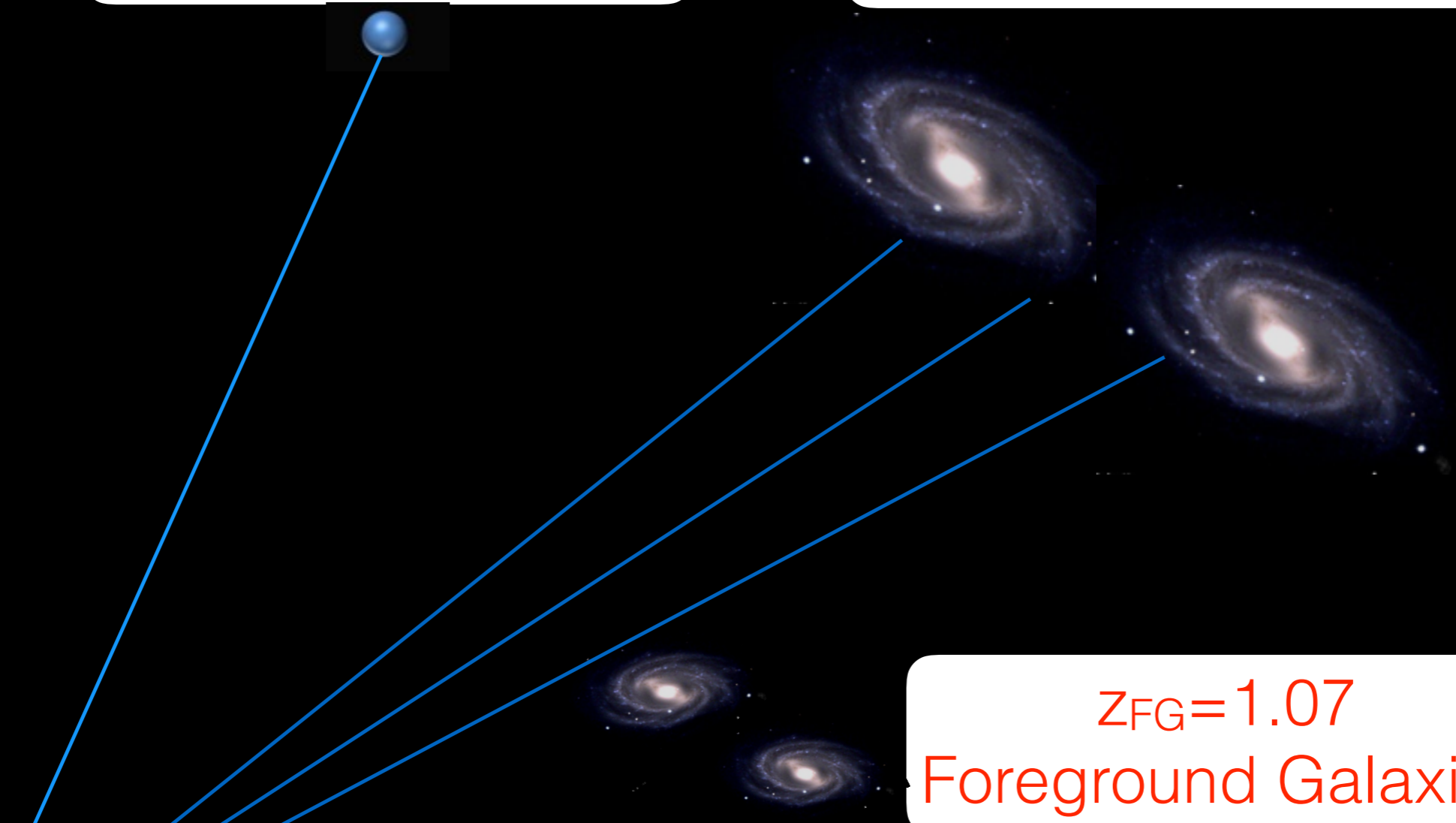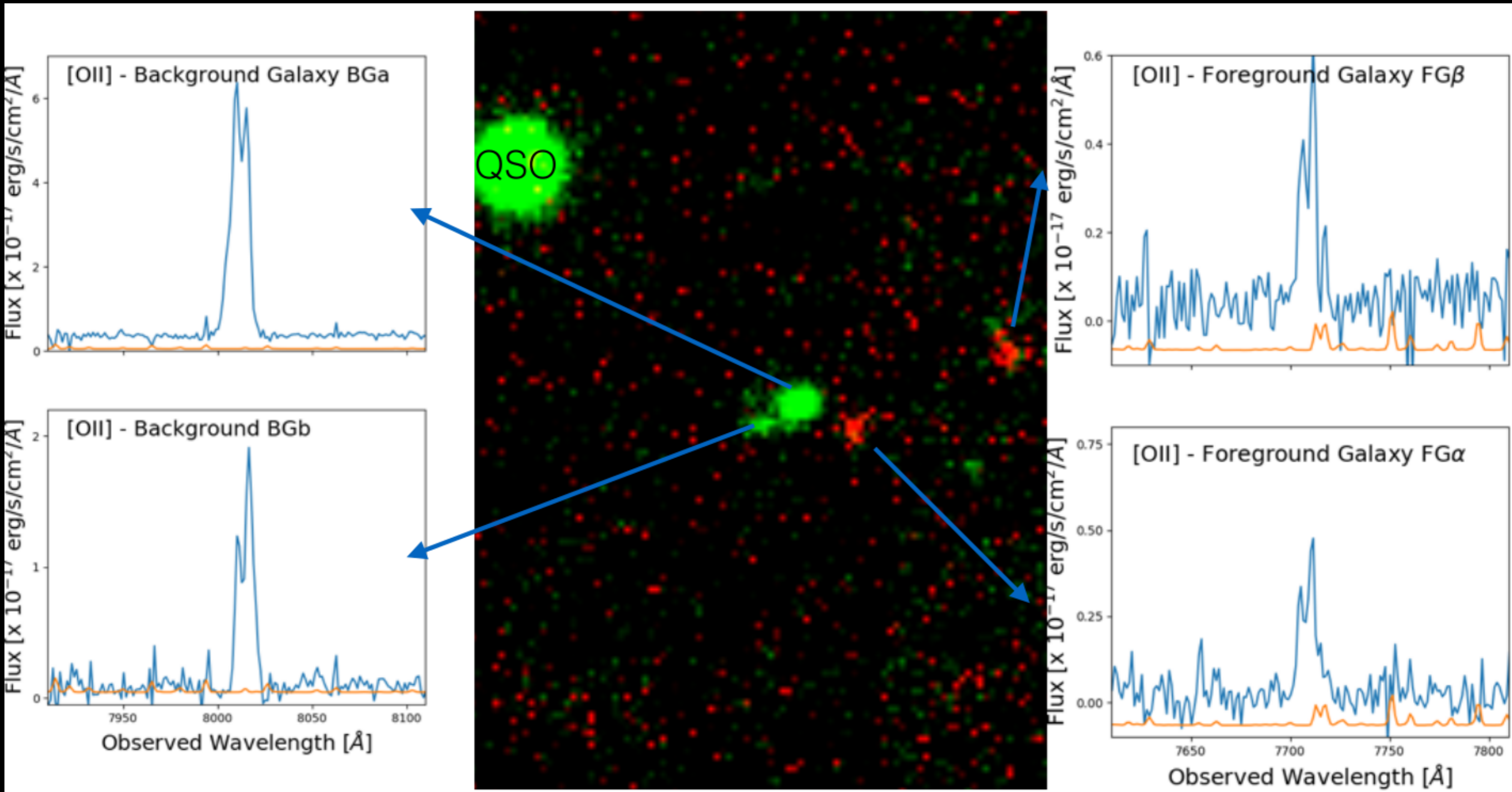
kpc-scale
in transverse
direction

Hennawi+06, Lopez+07, +18, Lan+17

z_QSO=3.33 Background Quasar

z_BG=1.15 Background Galaxies

z_FG=1.07 Foreground Galaxies

z_abs=1.07 absorbers in Background Galaxy spectra

[OII] - Background Galaxy BGa

[OII] - Background BGb

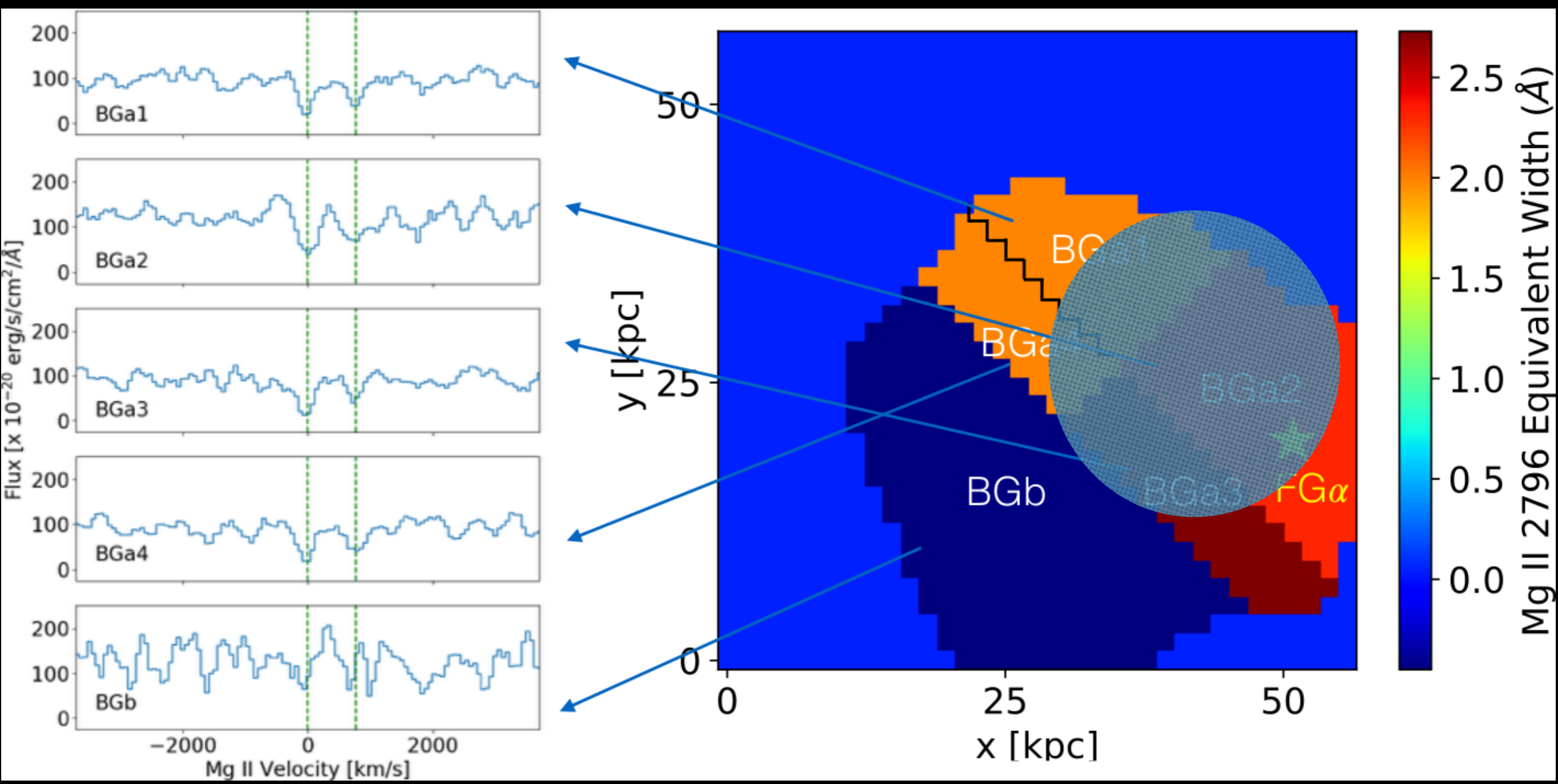[OII] - Foreground Galaxy FGβ

[OII] - Foreground Galaxy FGα

QSO

total area = 30kpc²

Spatially Resolved Metal Clouds

Cloud Gas Mass < 2×10^9 M$_{sun}$

Take Home Messages

extended source

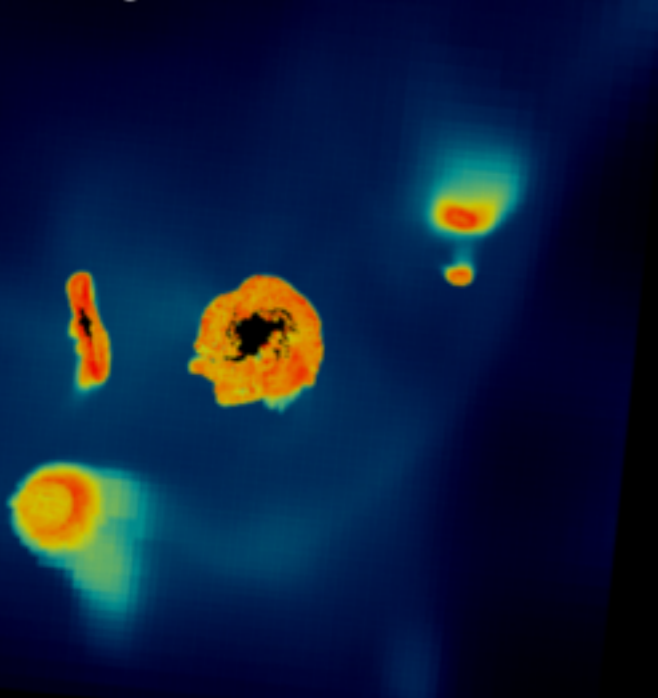Ha Cosmological Zoom-in Simulations

8.2E-18

1.2E-19

1.9E-21

2.9E-23

Absorbers best tool to date to characterise low-surface brightness tidal gas

kpc-scale in transverse direction

Absorbers inefficiently convert gas into stars

Ionised Gas

molecular gas
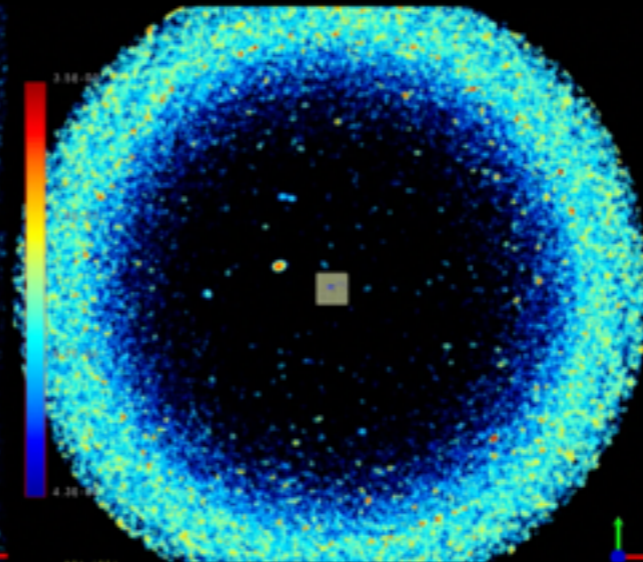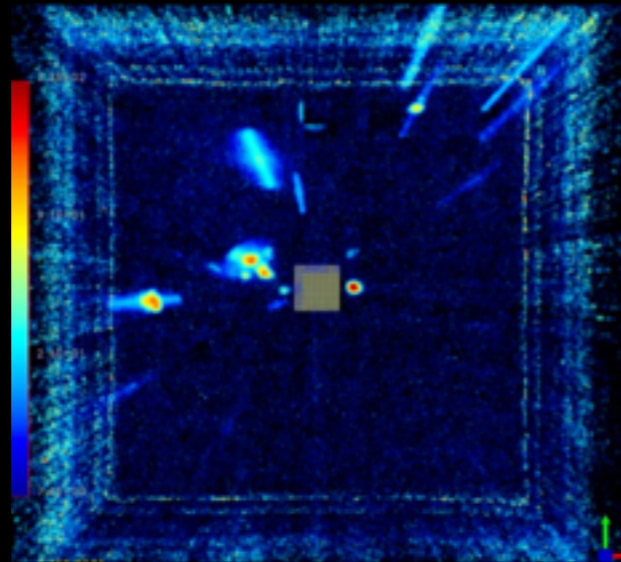
Good efficiency of the metal mixing as traced by cold gas