BLACKOUT Meeting

A project funded by
PRIN MIUR contract
2017PH3WAT
blackholewinds.inaf.it

BLACKOUT @ OATs personnel

Fabrizio FIORE

Chiara FERUGLIO

Fabio FONTANOT

Manuela BISCHETTI, AR 100% on PRIN

Andrea TRAVASCIO, AR 50% on PRIN (starting october 2020)

Maria Vittoria ZANCHETTIN, master student, SISSA PhD starting October 2020

Roberta TRIPODI, new PhD student UniTs, 50% funded on PRIN from October 2020

Resume of 2020 activities

- **WP1**- **WISSH** QSO project: 1 paper submitted, referee report received (Bischetti)
- **WP3**- **IBISCO** survey:
  1. 1 master thesis on Mrk509 to be submitted September 10, 2020; 1 paper draft on Mrk509 ALMA data to be ciurculated soon (Zanchettin)
  2. 1 paper on scaling relations in prep (Feruglio)
  3. Analysis of ALMA data ongoing, paper on atlas of disks and outflows (Bischetti)
  4. paper on ESO428-G30 ALMA+Chandra data, Feruglio+2020 ApJ
  5. ESO428-G30 MUSE data, draft paper planned (Feruglio, Travascio)
- **WP1**- 3 **z~6 QSO**s, ALMA CO observations (Feruglio)
- **WP3**- **SUBWAYS** with NOEMA
- **WP4**- Paper ***Disk-wind dynamical systems*** in advanced state (Fiore)
- **WP4**- Paper ***The Rise of Active Galactic Nuclei in the GAlaxy Evolution and Assembly semi-analytic model***, 2020 MNRAS in press (Fontanot)

WP1- WISSH

- Manuela's paper is on arxiv
- Referee report received in August
- Circulate revised version within September

The WISSH QSOs project

IX. Cold gas content and environment of luminous QSOs at Cosmic noon

M. Bischetti[1,2] ⋆, C. Feruglio[1], E. Piconcelli[2], F. Duras[3,2], M. Pérez-Torres[4,5], R. Herrero[6,7], G. Venturi[8], S. Carniani[9], G. Bruni[10], I. Gavignaud[11], V. Testa[2], A. Bongiorno[2], M. Brusa[12,13], C. Circosta[14], G. Cresci[15], V. D'Odorico[1,9], R. Maiolino[16,17], A. Marconi[18,15], M. Mingozzi[19], C. Pappalardo[20], M. Perna[21,15], E. Traianou[22], A. Travascio[2], G. Vietri[23], L. Zappacosta[2], and F. Fiore[1]

(Affiliations can be found after the references)

3 Sep 2020

ABSTRACT

Context. Sources at the brightest end of the QSO luminosity function ($L_{\rm Bol} > 10^{47}$ erg s^{-1}) during the peak epoch in the history of star formation and black hole accretion ($z \sim 2-4$, often referred to as "Cosmic noon") are privileged sites to study the *feeding & feedback* cycle of massive galaxies.

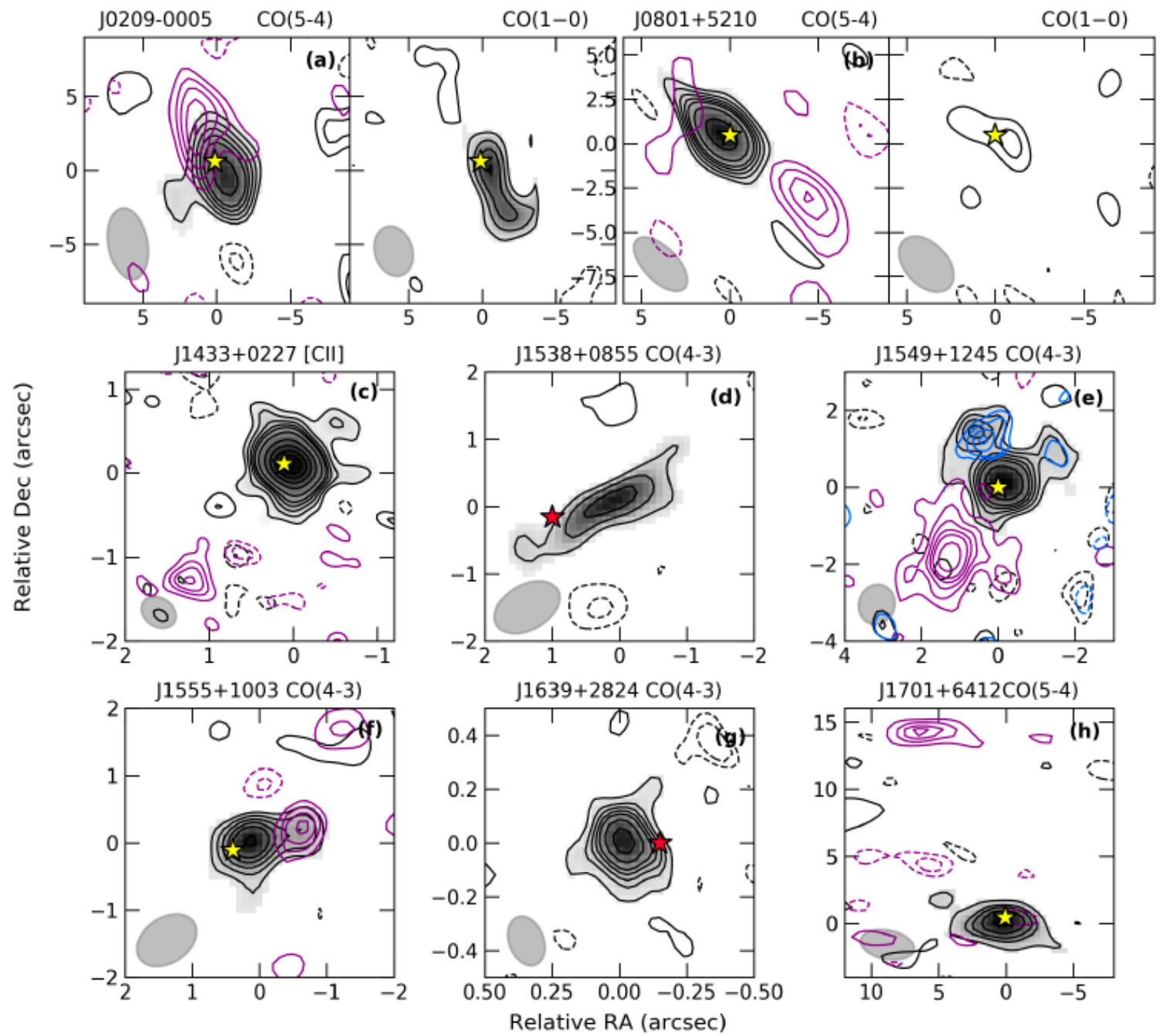
Aims. We aim to perform the first systematic study of cold gas properties in the most luminous QSOs, by characterising their host-galaxies and environment. These targets exhibit indeed widespread evidence of outflows at nuclear and galactic scales.

Methods. We analyse ALMA, NOEMA and JVLA observations of the far-infrared continuum, CO and [CII] emission lines in eight QSOs (bolometric luminosity $L_{\rm Bol} \gtrsim 3 \times 10^{47}$ erg s^{-1}) from the WISSH sample at $z \sim 2.4-4.7$.

WP1- WISSH

Bischetti+2020
Remarkable results based on ALMA, NOEMA, JVLA data of 8 QSOs (CO, CII)

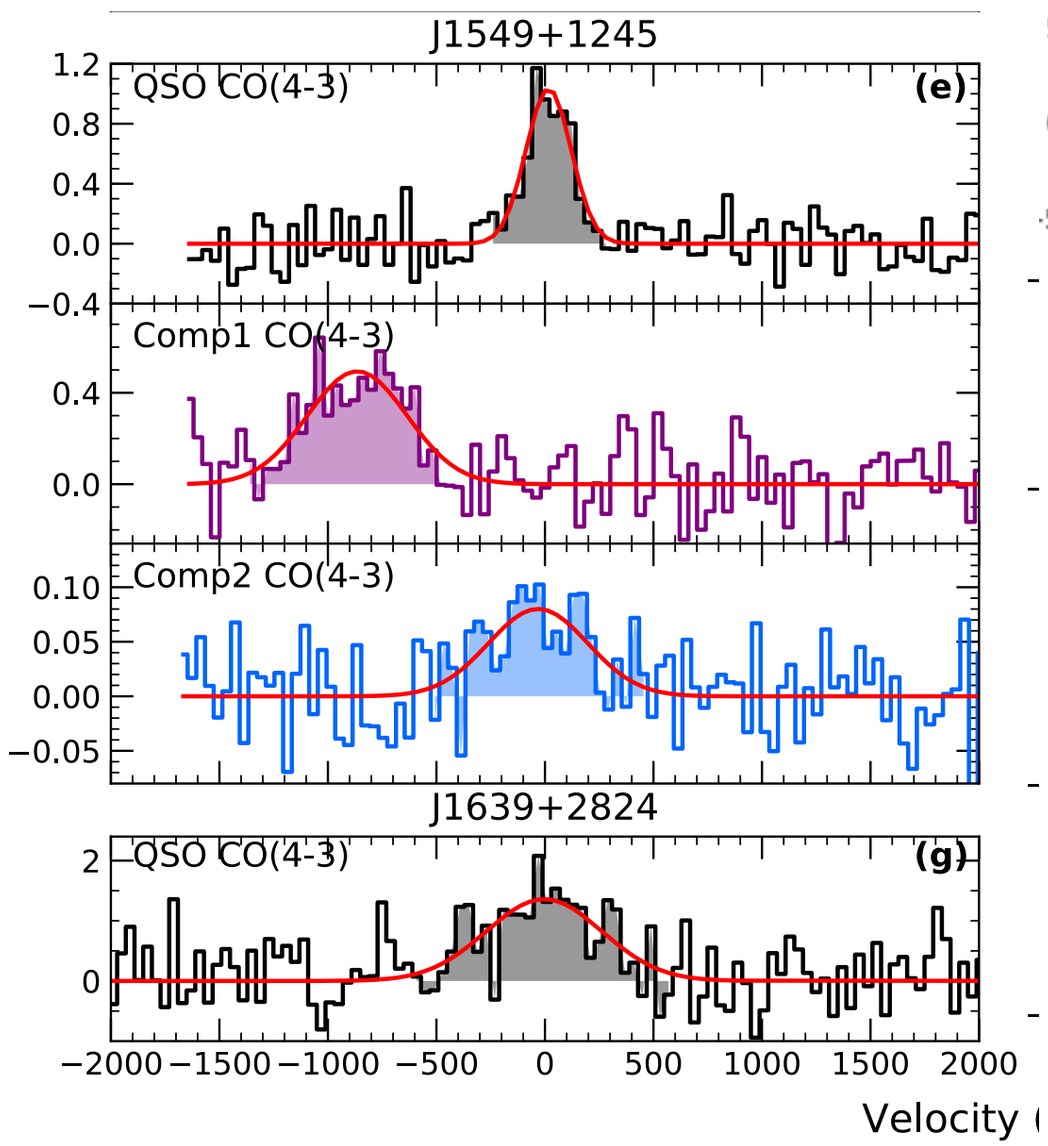
- **Widespread presence of one or more line emitters physically associated to the QSO —> overdense environments —> mergers —> build up of M* of giant galaxies in these sites (see also similar case in Bischetti+2018)**

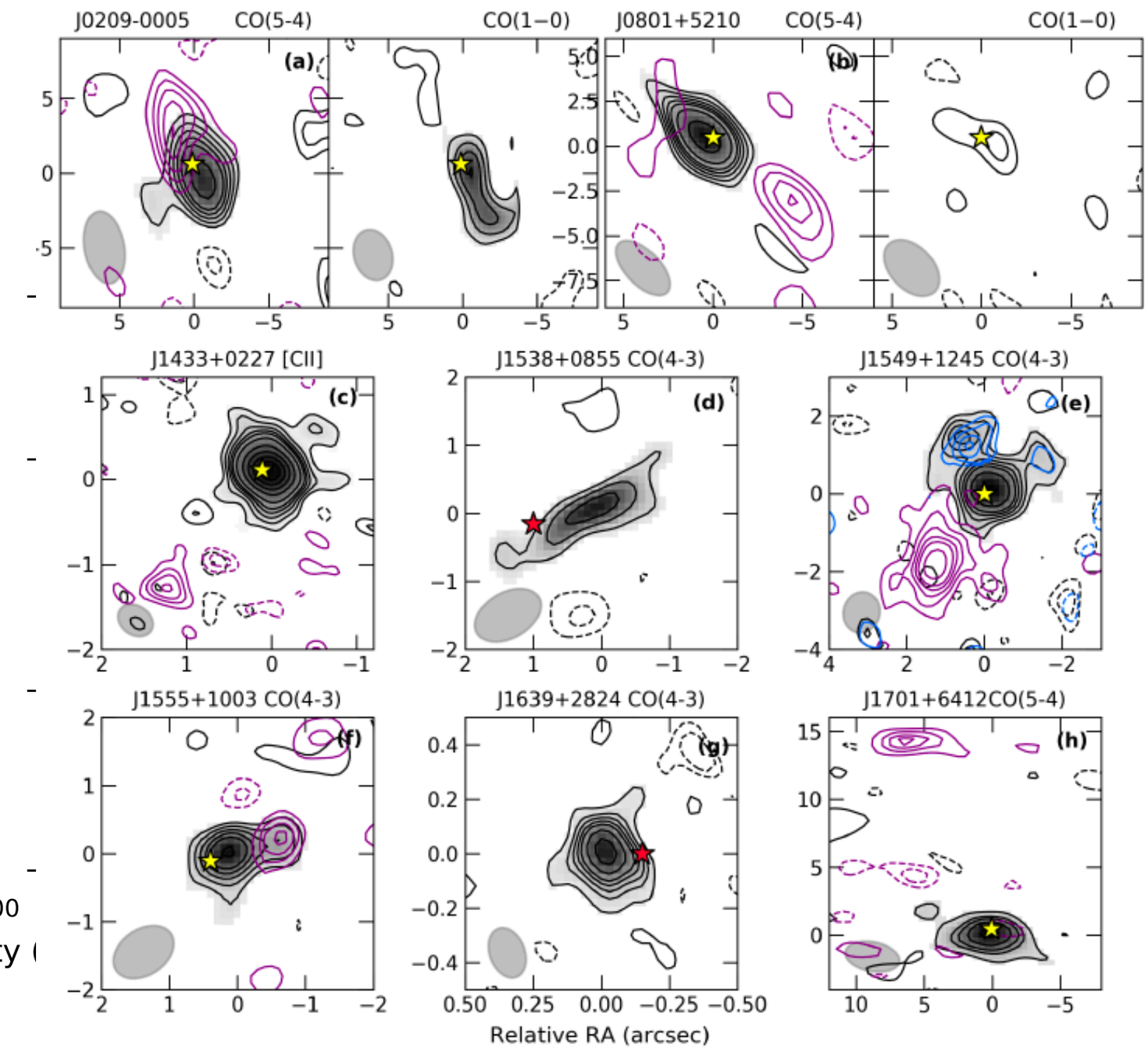


WP1- WISSH

Bischetti+2020

Remarkable results based on ALMA, NOEMA, JVLA data of 8 QSOs (CO, CII)





WP1- WISSH

Bischetti+2020
For some we detect velocity gradient

- **dynamical modeling**
- **derive Mdyn and M***

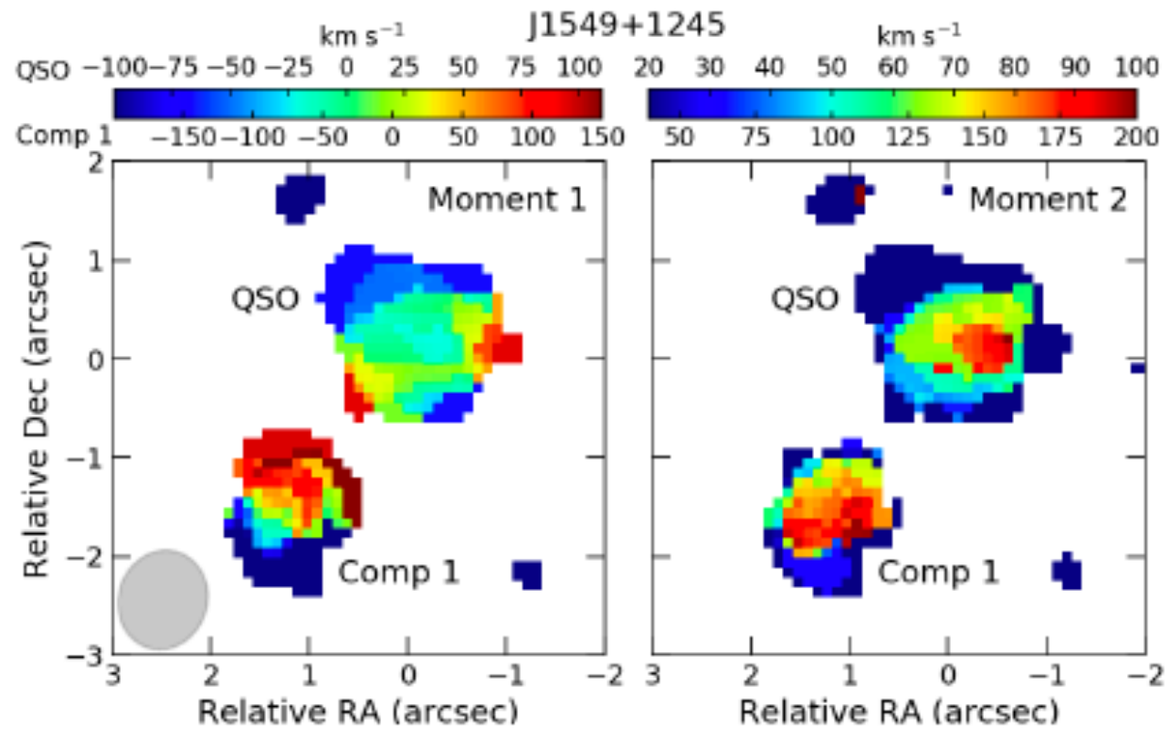


Fig. 8. Velocity (left) and velocity dispersion (right) maps of J1549+1245 and its bright companion, associated with CO(4–3) emission detected at > 3σ significance. In both panels, top(bottom) colorbar labels indicate values observed in the QSO(companion). The ALMA beam is also shown by the grey ellipse.

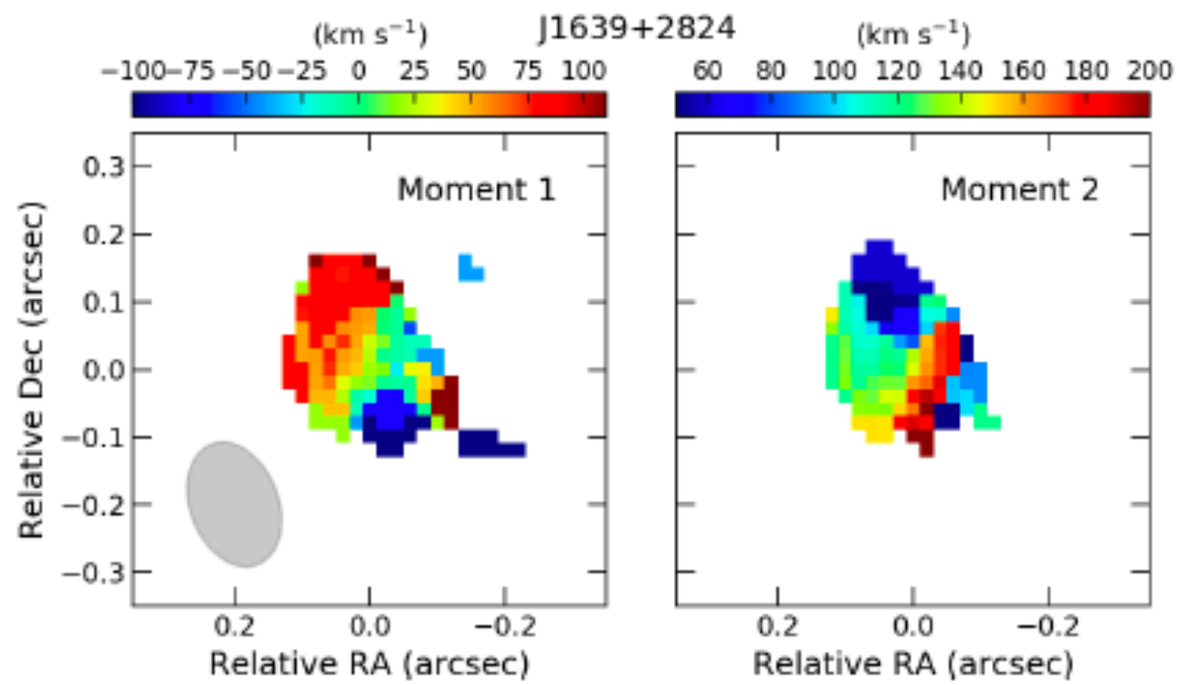
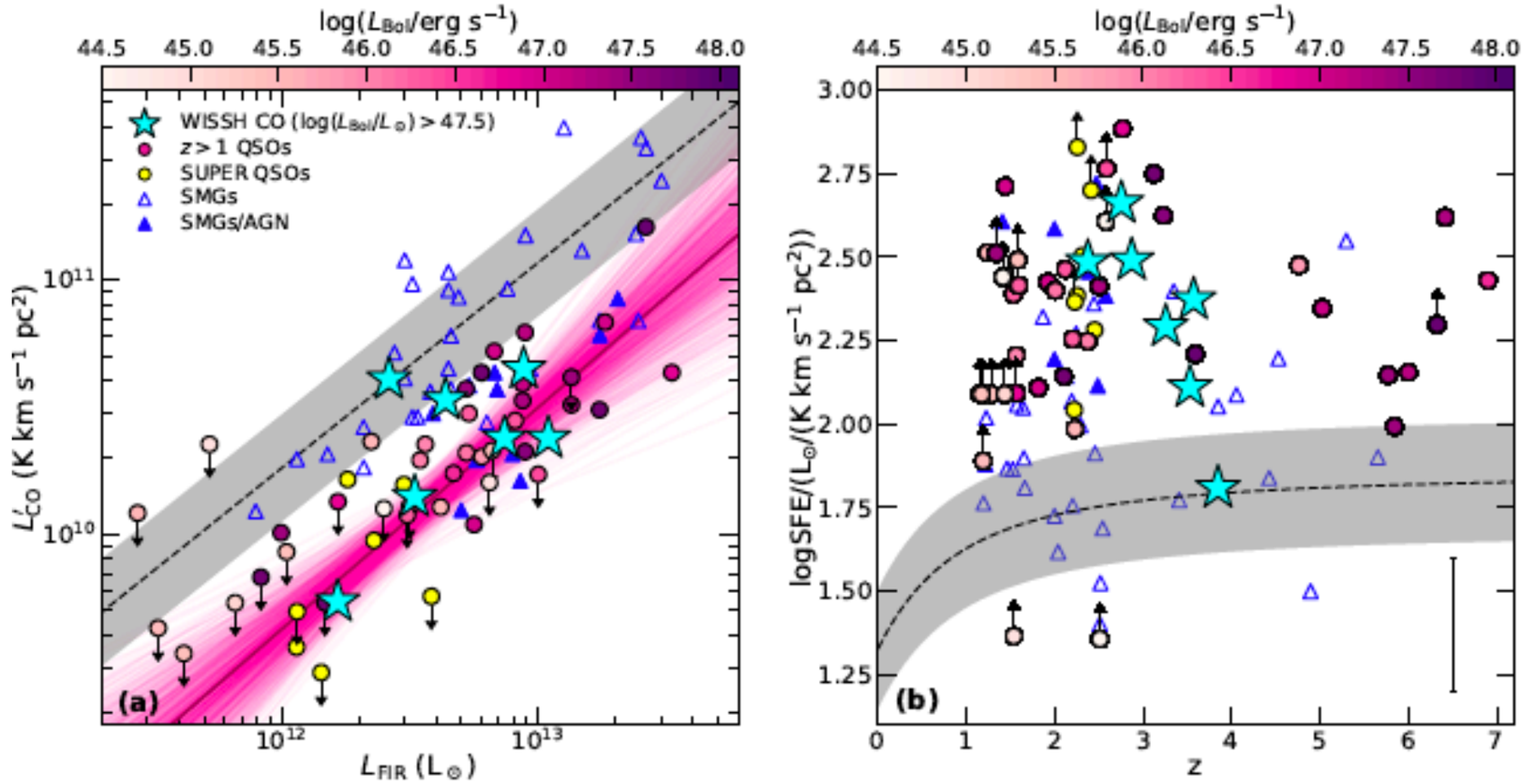


Fig. 9. Velocity (left) and velocity dispersion (right) maps of J1639+2824, associated with CO(4–3) emission detected at > 3σ significance. The ALMA beam is also shown by the grey ellipse.

WP1 - WISSH

Bischetti+2020

- **x4 below L'CO-LFIR correlation**
- **High SFE**



WP1 - WISSH

Bischetti+2020

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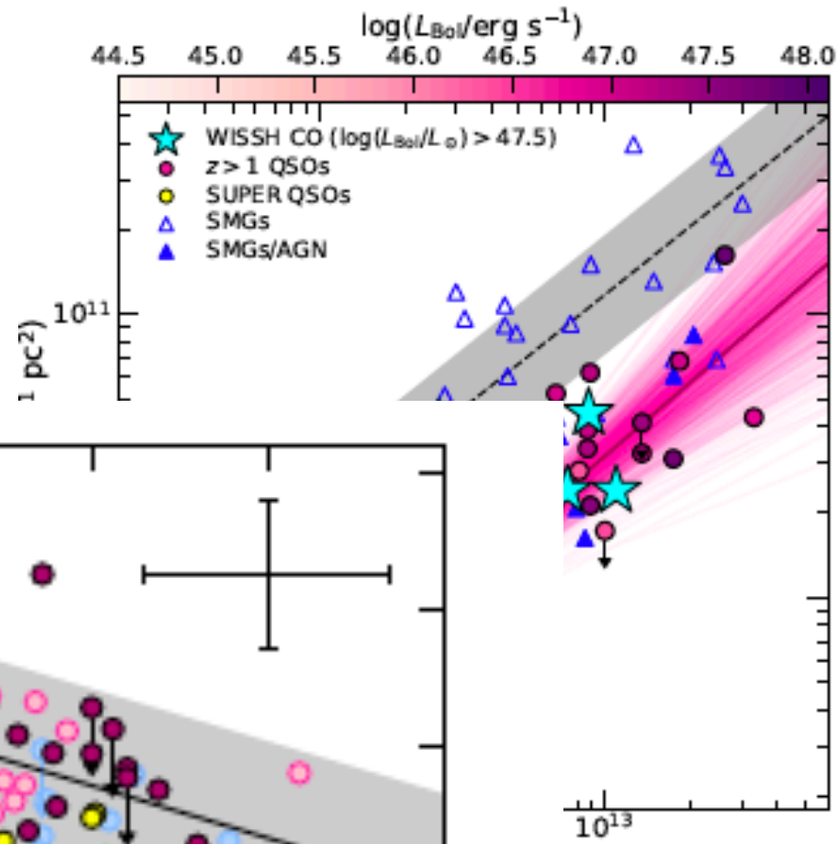
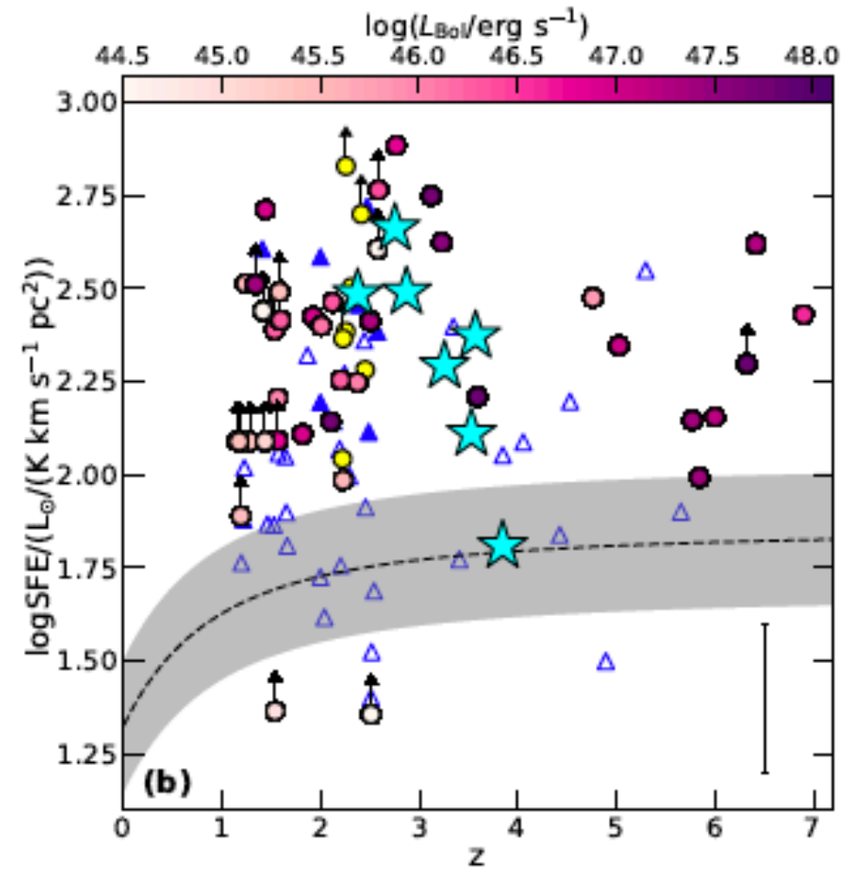
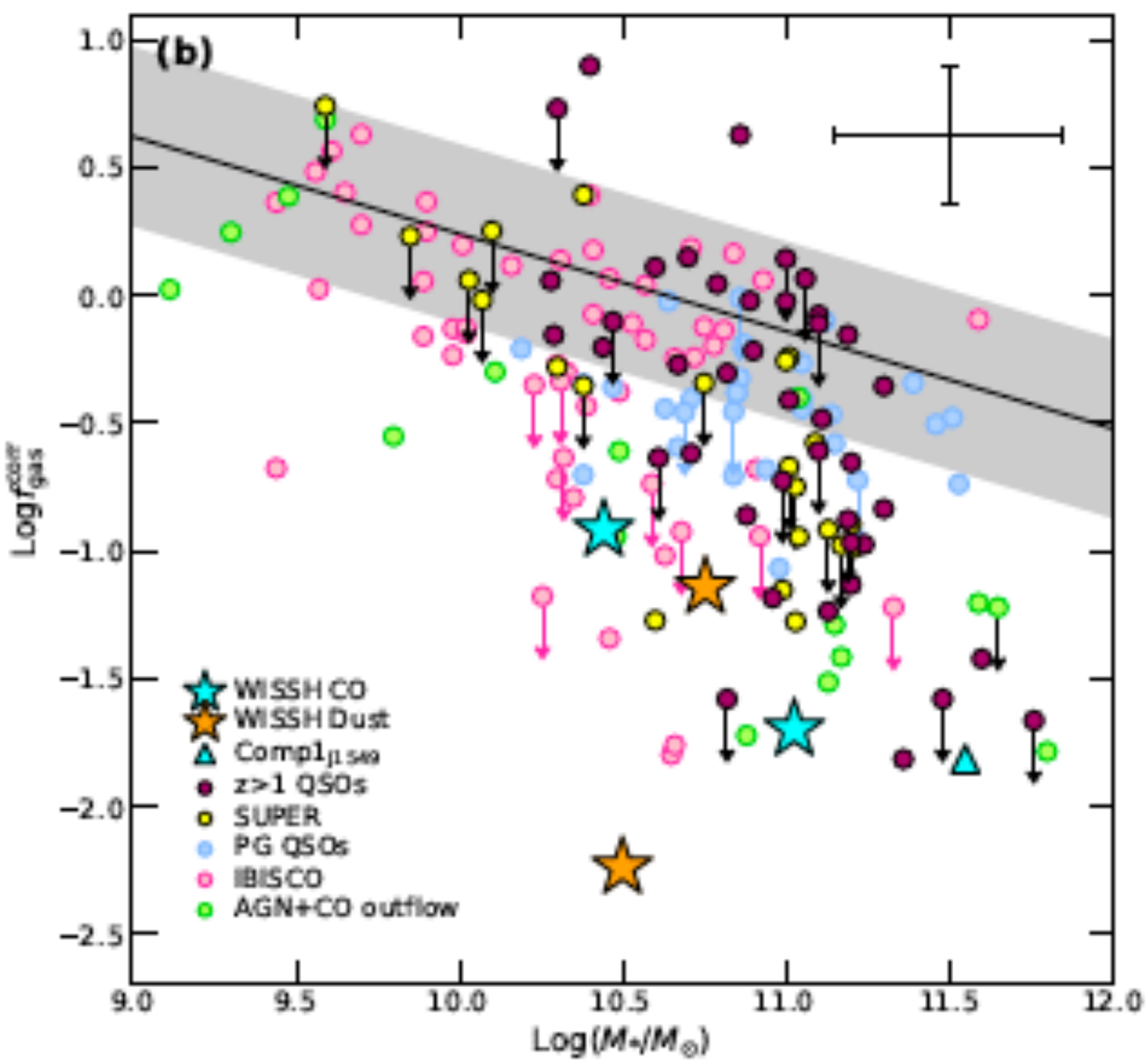






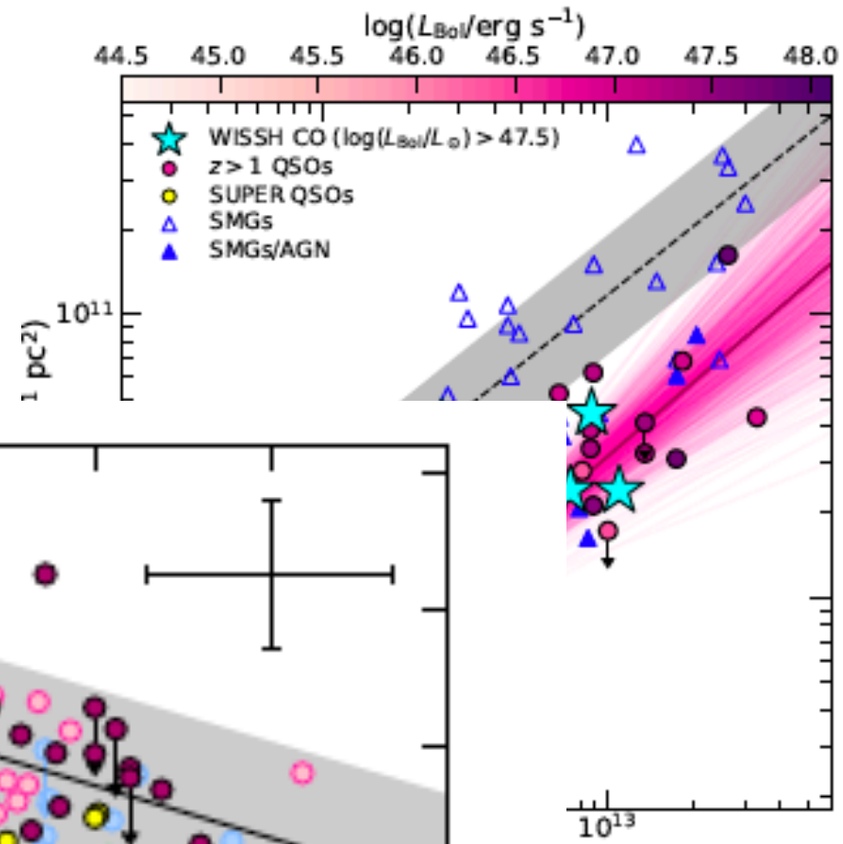
Low Gas fraction (corrected)

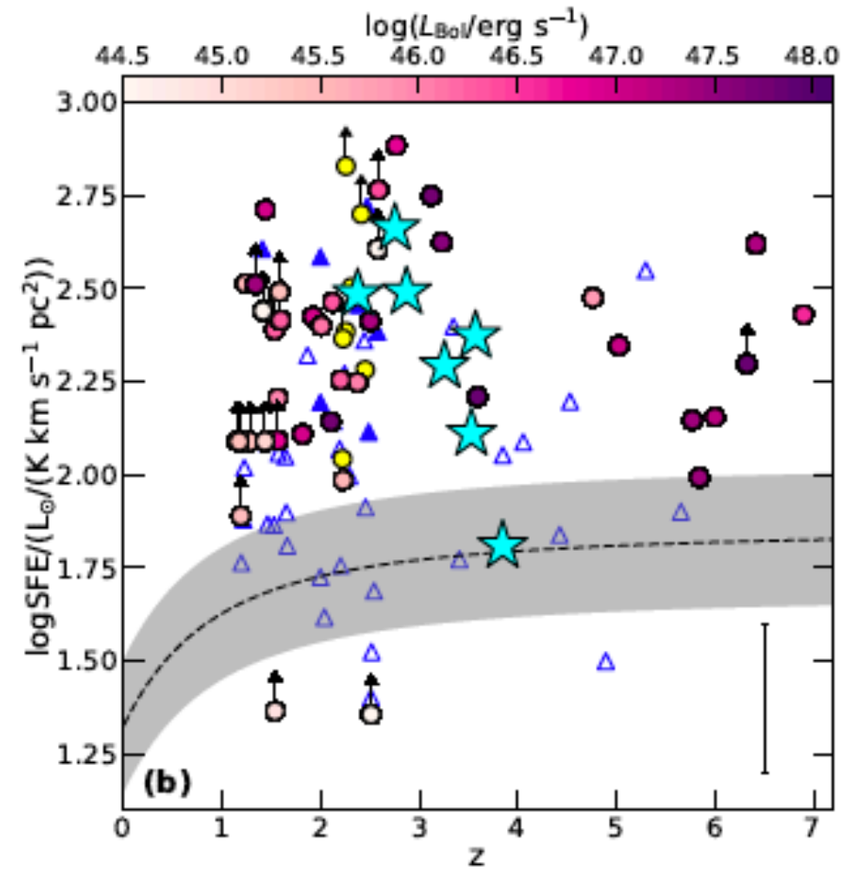
- **WISSH QSO host are gas-poor**

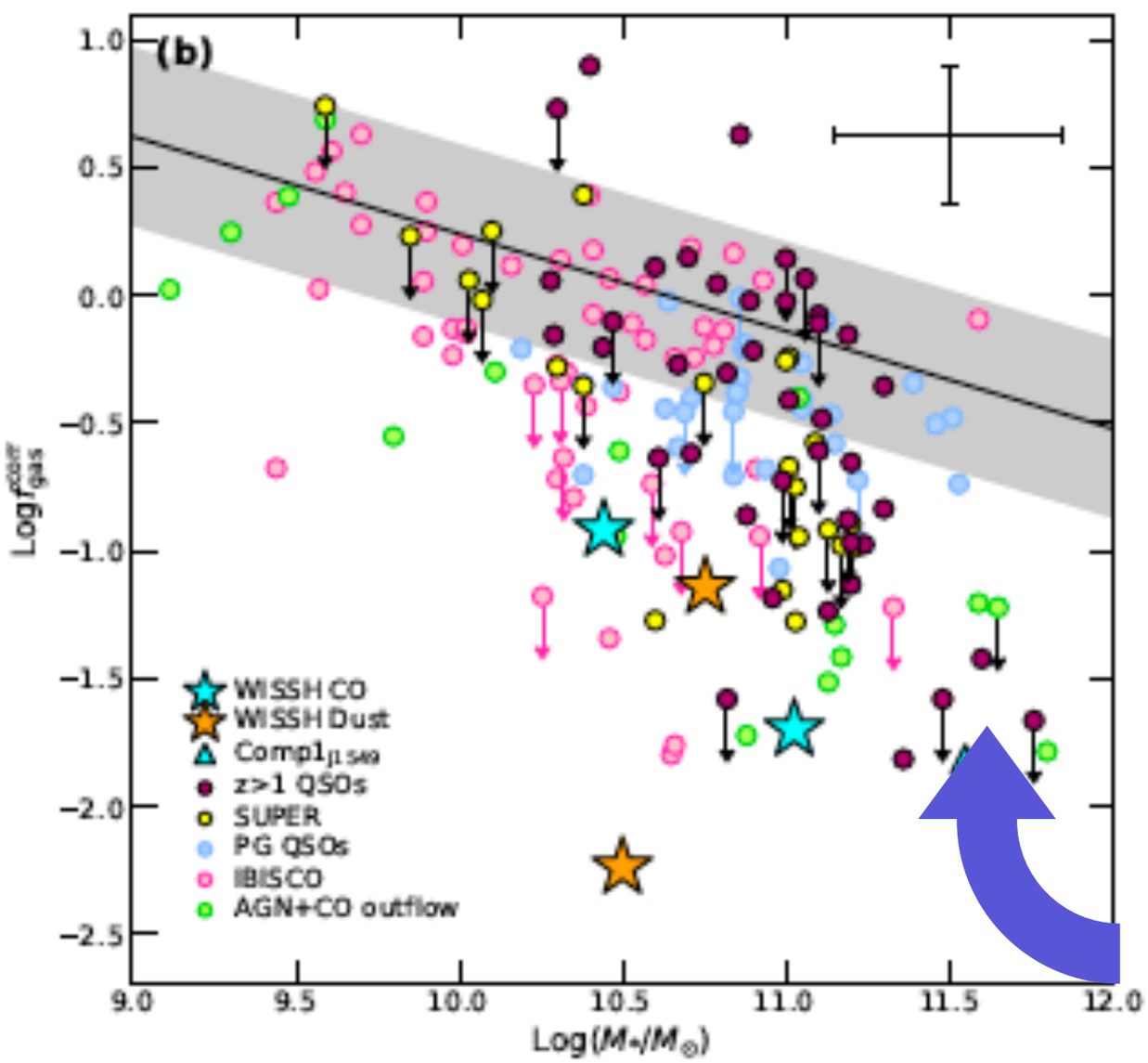
WP1 - WISSH

Bischetti+2020

- **x4 below L'CO-LFIR correlation**
- **High SFE**







Low Gas fraction (corrected)

- **WISSH QSO host are gas-poor**
- **SUPER CO-based gas fractions included (based on Circosta+2020, to be subm.)**
- **IBISCO gas fractions included**

WP3- Mrk509 (IBISCO) ALMA

UNIVERSITÀ DEGLI STUDI DI TRIESTE

Dipartimento di Fisica

Laurea Magistrale in Fisica

Multiwavelength high resolution study of AGN host galaxies.

Settembre, 2020

Laureando
Maria Vittoria Zanchettin

Relatore
Prof. Fabrizio Fiore

Master thesis by Maria Vittoria to be discussed on September 18, 2020

Also a paper draft ready to be circulated soon to the collaboration

- **Analysis of CO(2-1) ALMA data of Mrk 509**
- **BBAROLO**
- **dynamical modeling**
- **Outflow parameters**

Zanchettin+ in prep.

WP3- Mrk509 (IBISCO) ALMA

Astronomy & Astrophysics manuscript no. output
September 8, 2020

MKN509: ALMA observations and dynamical modelling I.

M.V. Zanchettin[1], F. Feruglio[2], M. Bischetti[2], F. Fiore[2], E. Piconcelli[3], A. Bongiorno[3], C. Ceccarelli[4], M. Molina[5], A. Malizia[5], and F. Tombesi[6,7]

[1] Dipartimento di Fisica, Sezione di Astronomia, Universita' degli Studi di Trieste, Via Tiepolo 11, I-34143 Trieste, Italy e-mail: mariavittoria.zanchettin@studenti.units.it
[2] INAF Osservatorio Astronomico di Trieste, via G.B. Tiepolo 11, 34143 Trieste, Italy
[3] INAF - Osservatorio Astronomico di Roma, Via di Frascati 33, 00040, Monteporzio Catone, Rome, Italy
[4] Univ. Grenoble Alpes, CNRS, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), 38000 Grenoble, France
[5] INAF-OAS Bologna, via Gobetti 101, I-40129 Bologna, Italy
[6] Dept. of Physics, University of Rome 'Tor Vergata', via della Ricerca Scientifica 1, 00133, Rome, Italy
[7] Dept. of Astronomy, University of Maryland, College Park, MD, 20742, USA

Received September ; accepted

ABSTRACT

Context. We present ALMA observation of the CO(2-1) emission line and the underlying 1.2 mm continuum (rest frame frequency ~ 230 GHz) of the Seyfert galaxy Markarian 509, with angular resolution 0.3 arcsec (~ 200 pc).
Aims. High resolution mapping with ALMA is ideal to perform a detailed study and modeling of the cold gas kinematics in active galaxies in order to resolve AGN driven outflows and modifications to the ISM through outflows.
Methods. The main velocity gradient seen in CO(2-1) data-cube is well modeled by a disk with $M_{dyn} = 2 \times 10^{10}\ M_{\odot}$ up to ~ 2.4 kpc and inclined 44 deg with respect to the line of sight. The residual perturbations are distributed in a rotating inner tilted disk up to ~ 760 pc, plus a radial velocity component.
Results. We found two main positive perturbations located west-ward the AGN position that we identified as molecular outflows. They present a total mass between 4.2 and 11 $M_{\odot}$ and a total outflow rate in the range 2.1 - 5.7 $M_{\odot}/yr$; for optically thin and thick case. Comparing the ratio between the outflow momentum rate P_{of} and the radiation momentum rate P_{rad} with UFOs and [OIII] winds, we found that the molecular and the ionized outflow rate from GEMINI IFU [OIII] data are quite similar unlikely what found for other active sources, that show higher values of molecular outflow rate.
Conclusions. We found that Mrk 509 presents a molecular gas mass fraction on average higher that the one of similar galaxies from the COLD GASS survey with same stellar mass. Comparing HST narrow band image in FQ508N filter with ALMA observations we found that neither the jut nor the linear tail are visible in ALMA data-cubes. This led us to conclude that this features have not significant molecular gas content.

Master thesis
by Maria Vittoria
to be discussed on
September 18, 2020

Also a paper draft ready
to be circulated soon
to the collaboration

Analysis of CO(2-1) ALMA
data of Mrk 509
BBAROLO
dynamical modeling
Outflow parameters

Zanchettin+ in prep.

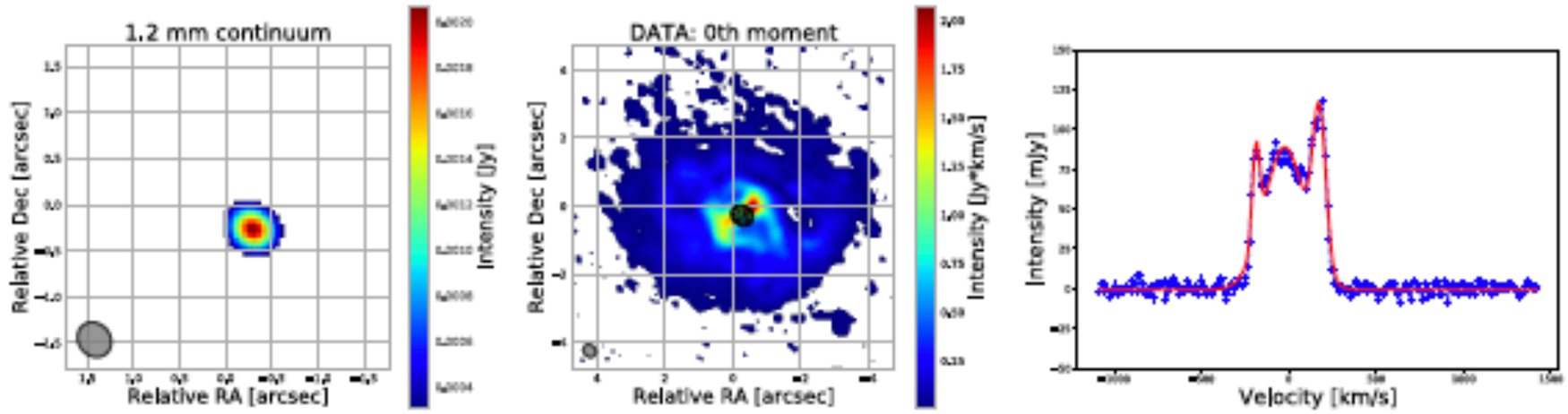


Fig. 1. Left panel: The 1.2 mm continuum map of Mrk509. Regions with emission below σ have been blanked ($\sigma = 0.3$ mJy/beam). The synthesized beam is 0.396× 0.343 $arcsec^2$ at a PA = 51 and it is shown by the grey filled ellipse. Center panel: The CO(2-1) mean-flux (moment 0) map, where a threshold of 3σ has been applied ($\sigma = 0.3\ mJy/beam$ for 10.6 $km\,s^{-1}$). Black contours show the 1.2 mm continuum emission at (1,2,4,6)σ where $\sigma = 0.3$ mJy/beam. The synthesized beam is 0.412× 0.353 $arcsec^2$ at a PA = 48 and it is reported in figure. Right panel: CO(2-1) line extracted from the continuum-subtracted clean data-cube from the regions where emission is above 2σ. The red line shows the multi-gaussian fit of the CO(2-1) line. The parameters of the fit are reported in Table 1.

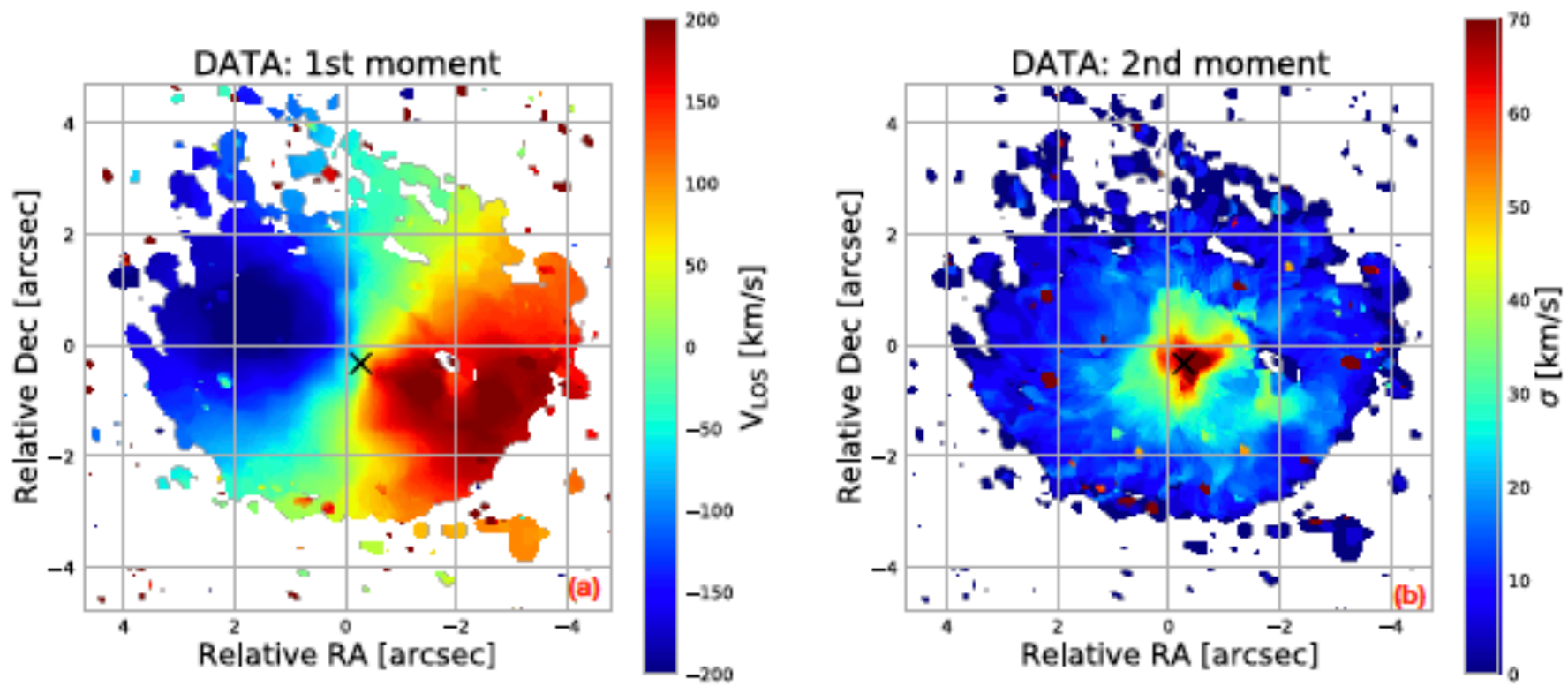


Fig. 2. (a): The CO(2-1) mean-velocity and (b) the velocity dispersion maps. A threshold of 3σ has been applied to derive these maps ($\sigma = 0.3$ $mJy/beam$ for 10.6 $km\,s^{-1}$) The black cross marks the AGN position.

Zanchettin+ in prep.

WP3 -Mrk509 (IBISCO) ALMA

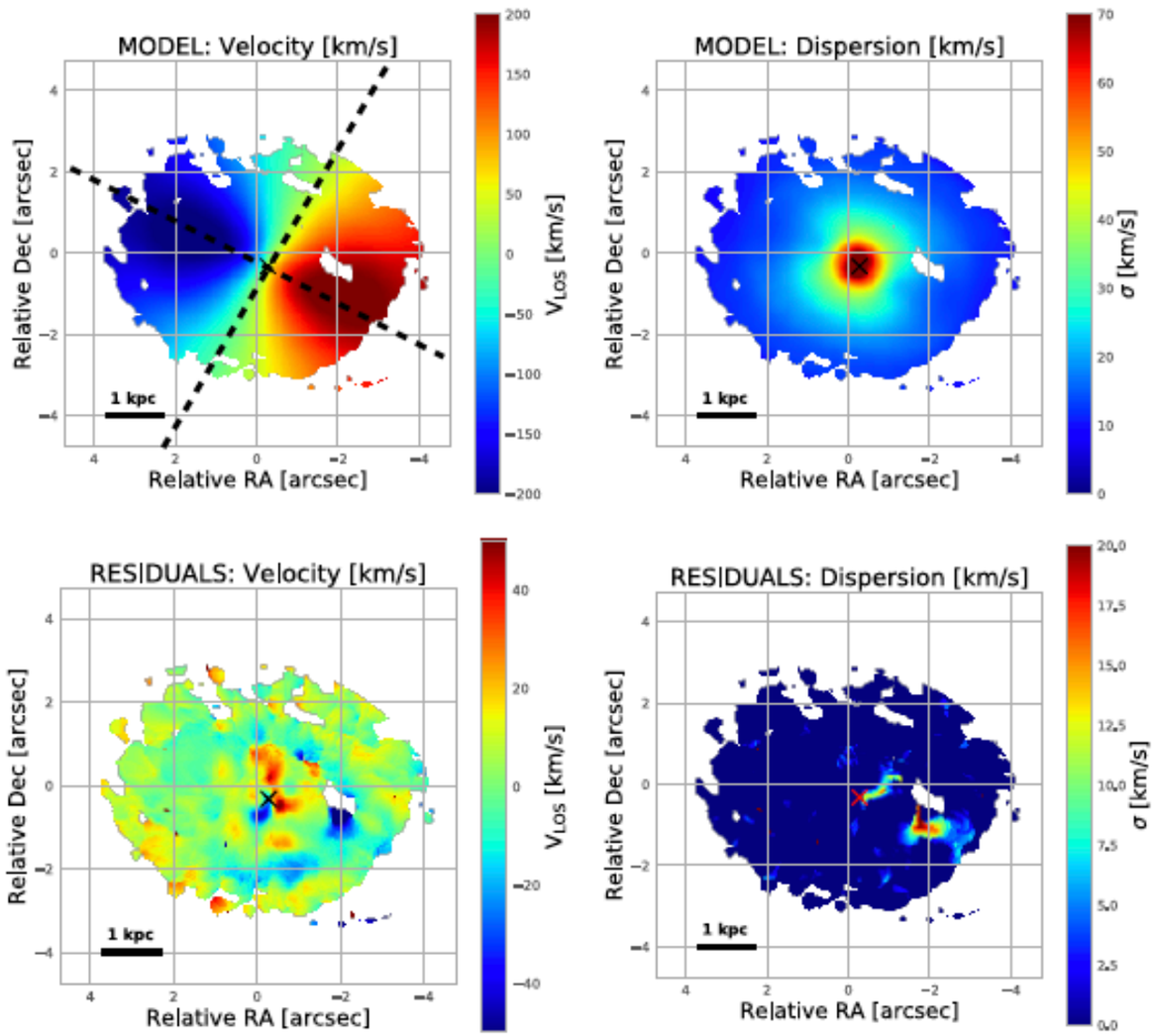
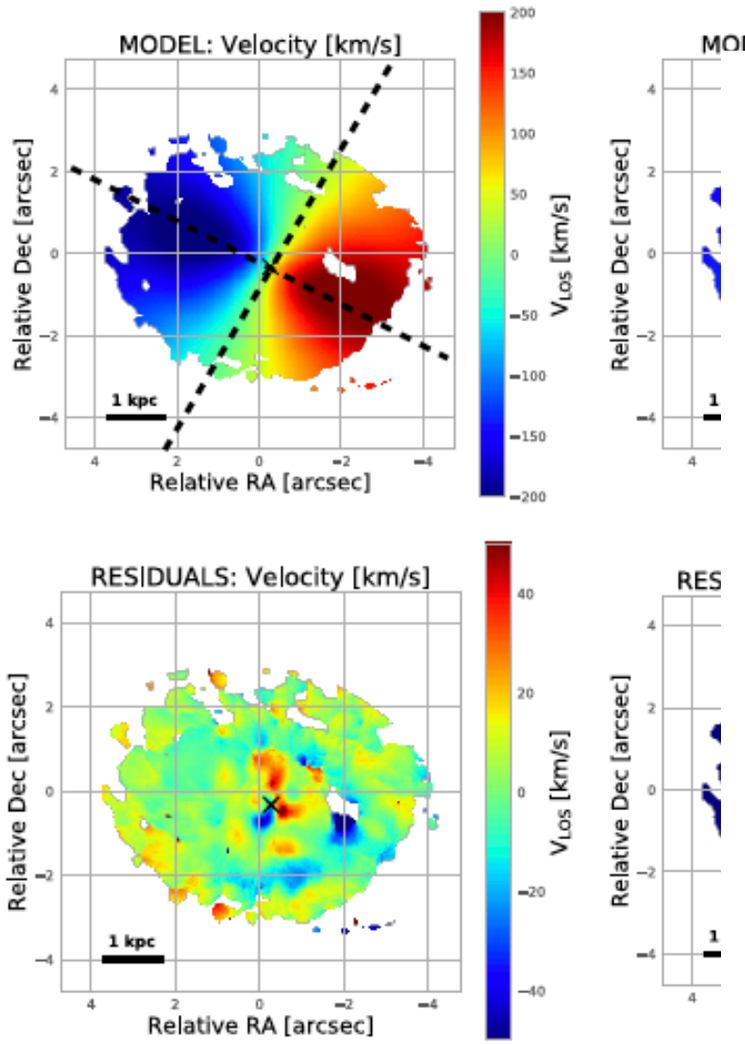


Fig. 3. The mean-velocity (top-left) and velocity dispersion (top-right) maps of the ^{3D}*BAROLO* disk model. The black dashed lines mark the orientation of the major (248 deg) and minor (338 deg) kinematic axis. Bottom panels: the mean-velocity (bottom-left) and velocity dispersion (bottom-right) map of the residuals obtained subtracting the disk model from the map of the cleaned data-cube. The cross indicates the position of the AGN position.

Zanchettin+ in prep.

WP3 -Mrk509 (IBISCO) ALMA



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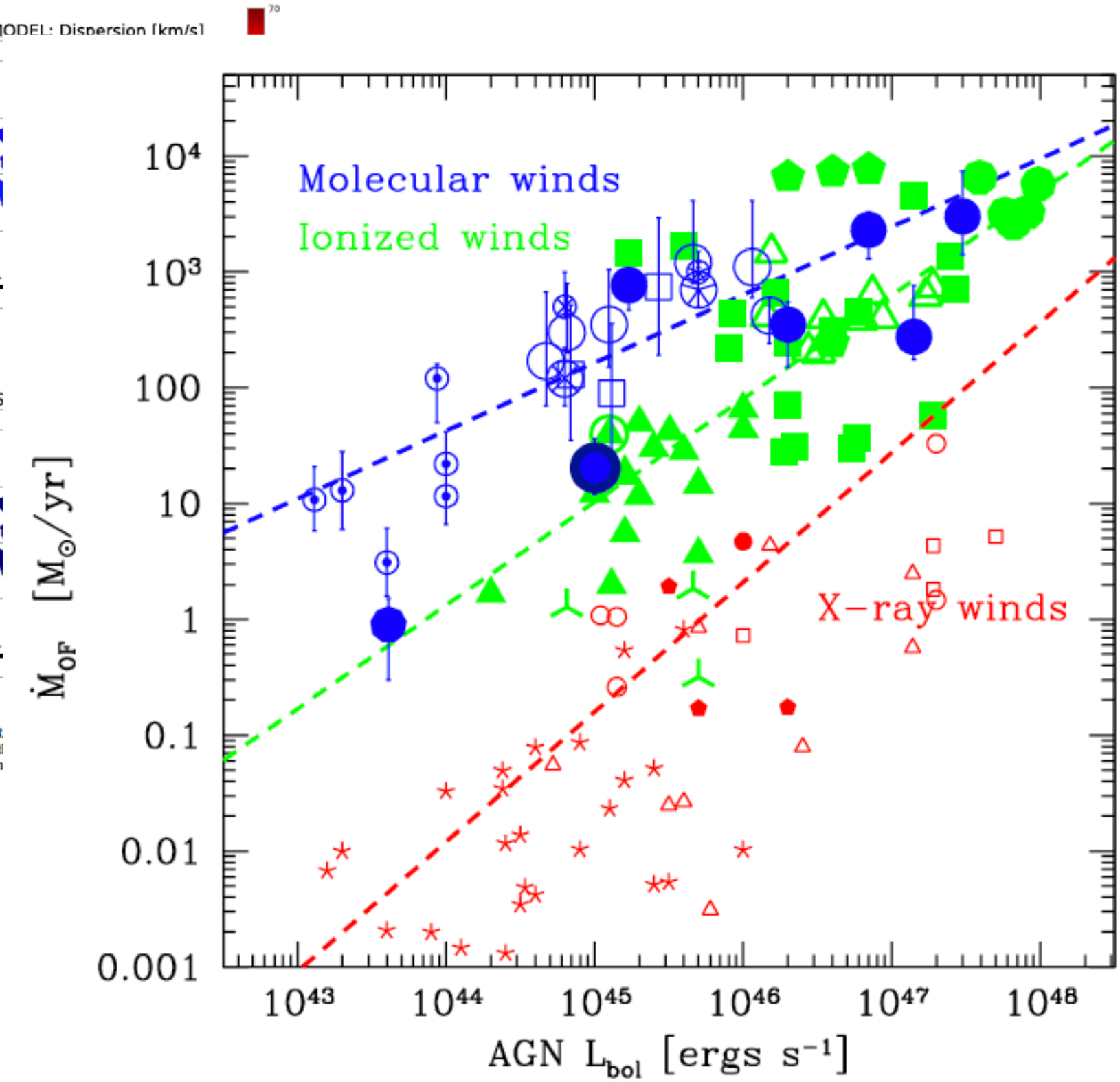
(bottom-right) map of the residuals obtained subtracting the disk model from the map of th
the AGN position.



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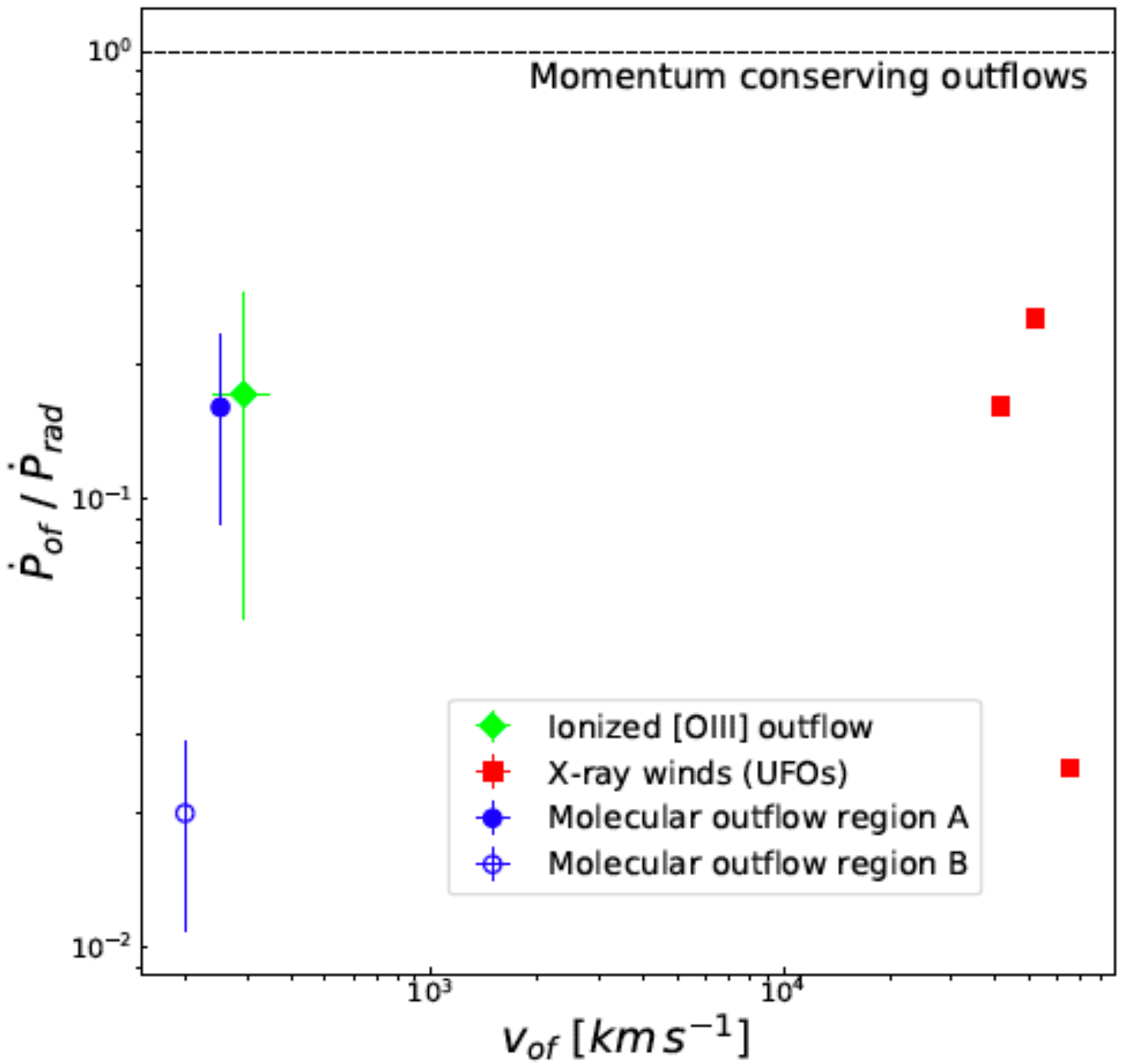
Momentum conserving outflows
10^0
10^{-1}
10^{-2}
$\dot{P}_{of} / \dot{P}_{rad}$
10^3
10^4
v_{of} [$km\,s^{-1}$]
Ionized [OIII] outflow
X-ray winds (UFOs)
Molecular outflow region A
Molecular outflow region B

WP3 - IBISCO ALMA

A paper is planned "*Atlas of disks and outflows*", including out PI data and archival data (Bischetti+).
Imaging completed - CO(2-1) + continuum - resolution range 50 -150 pc
Dynamical modeling ongoing (BBAROLO, Kinemetry). Examples below.

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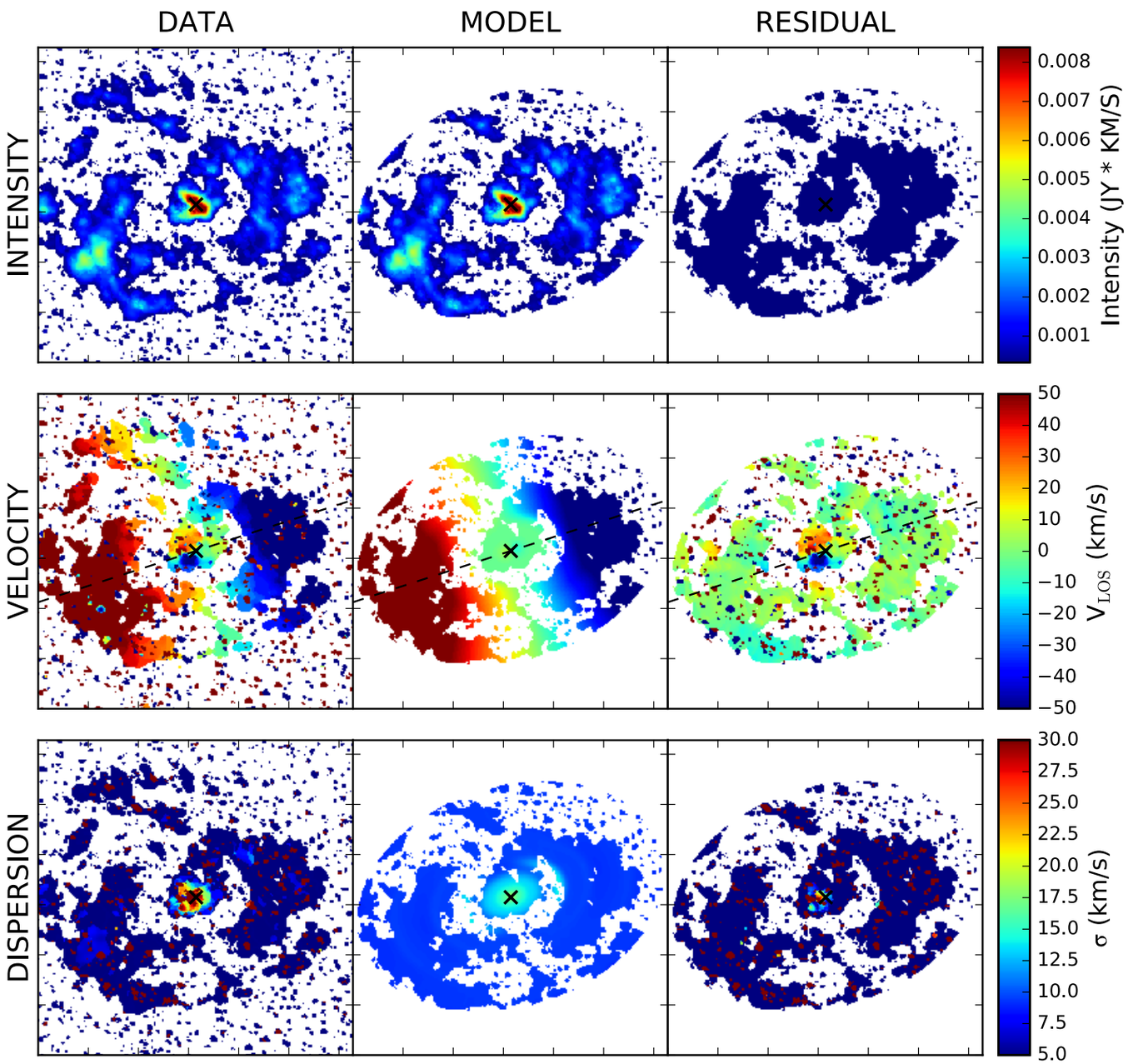

IGRJ19378
resolution 140 pc

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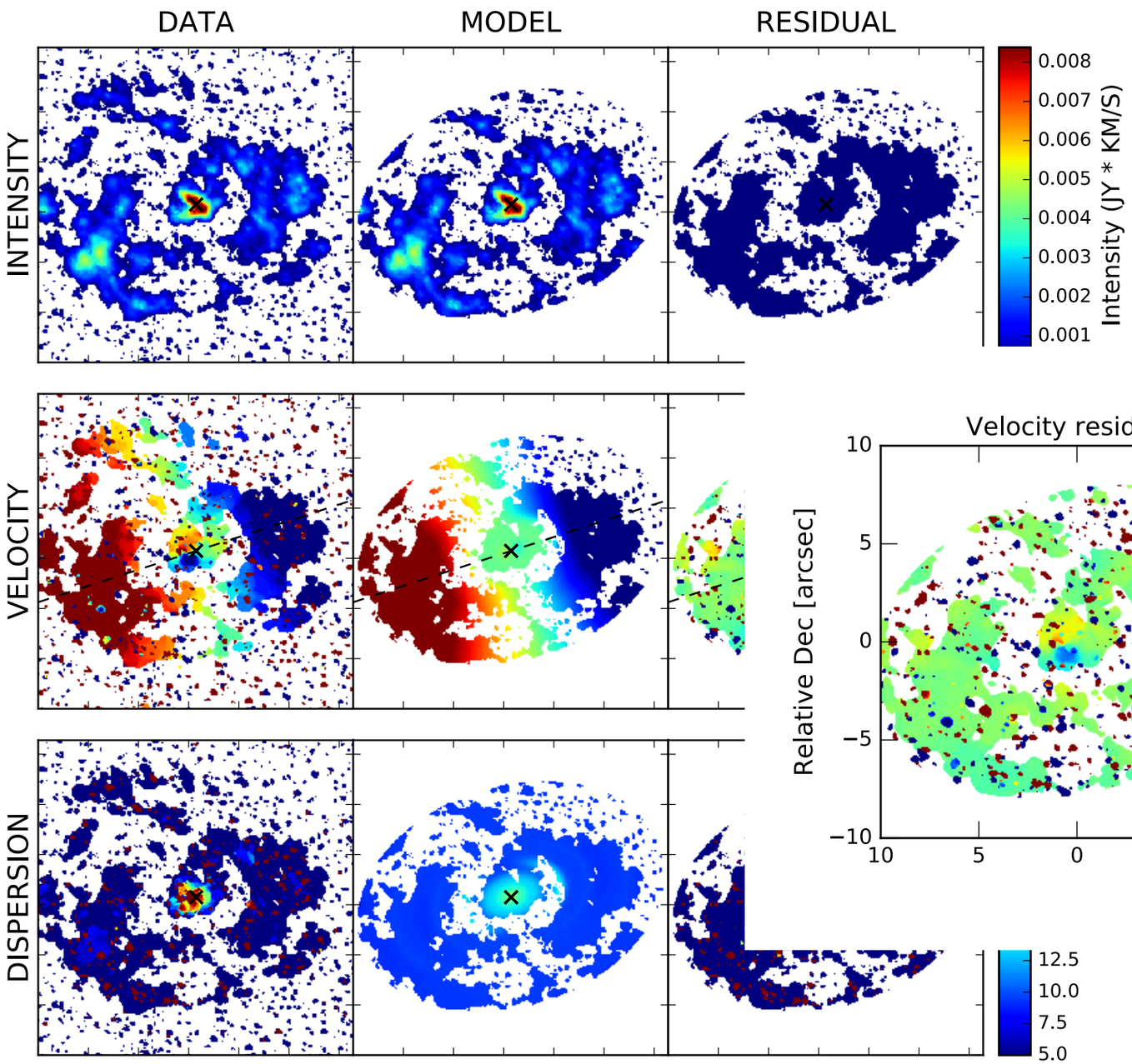
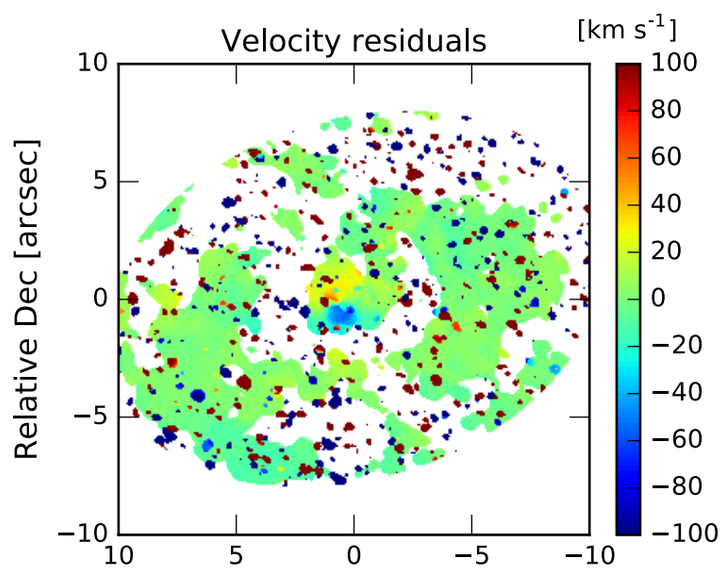
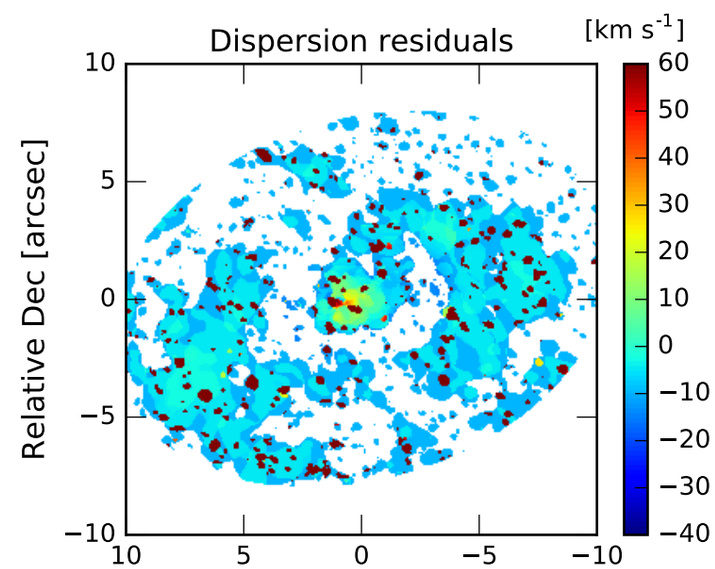


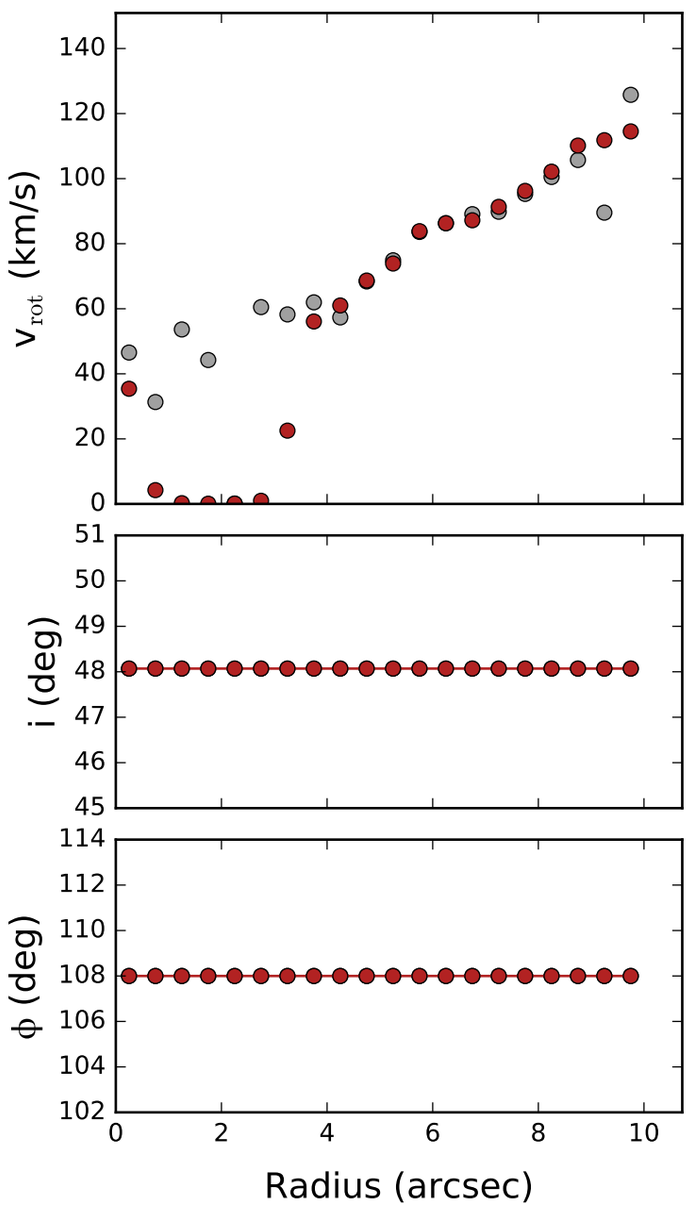
IGRJ19378
resolution 140 pc

Data - model





disk rotation + evident perturbations
probably outflow
or inner warped disk
as usual



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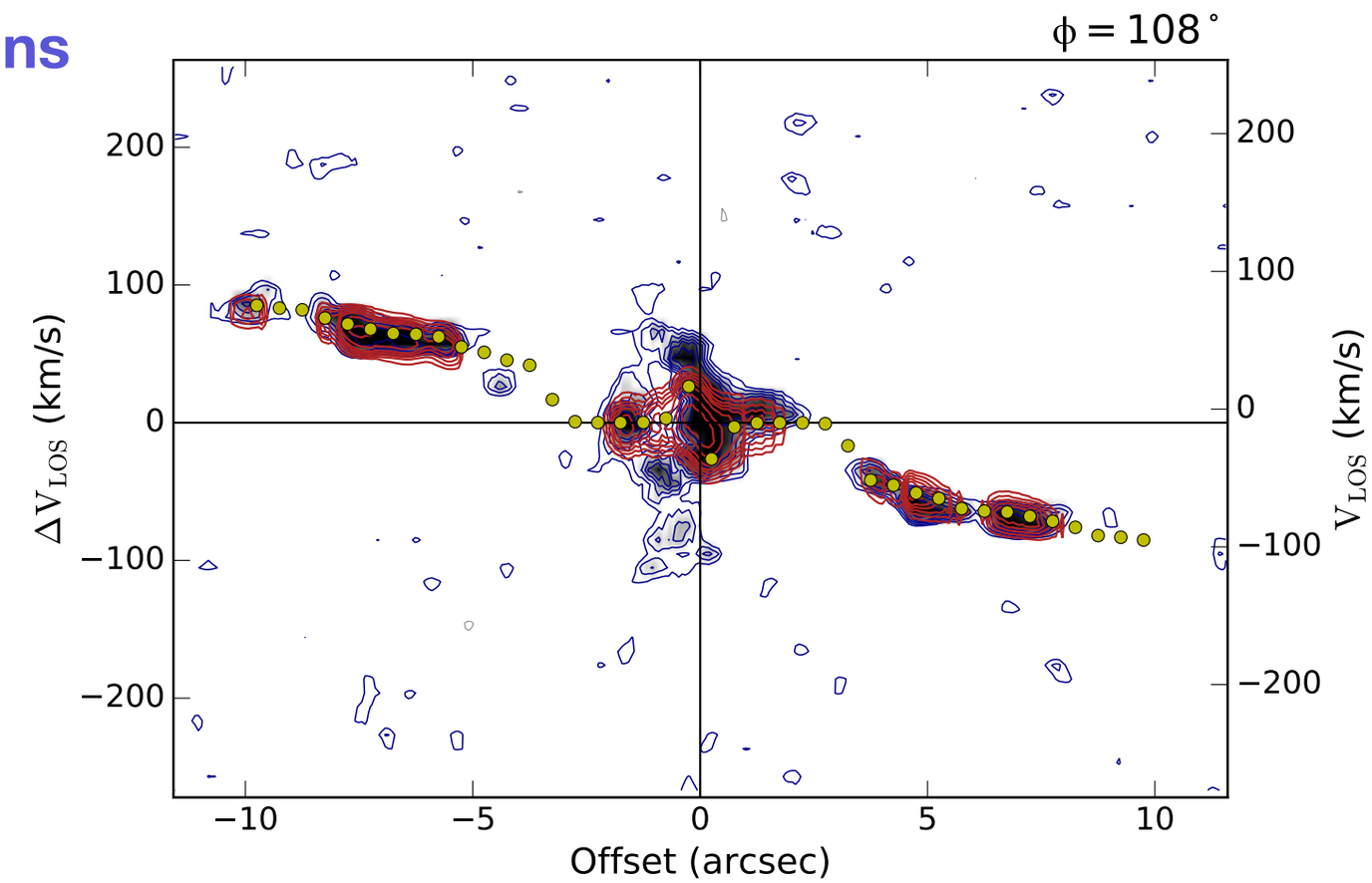
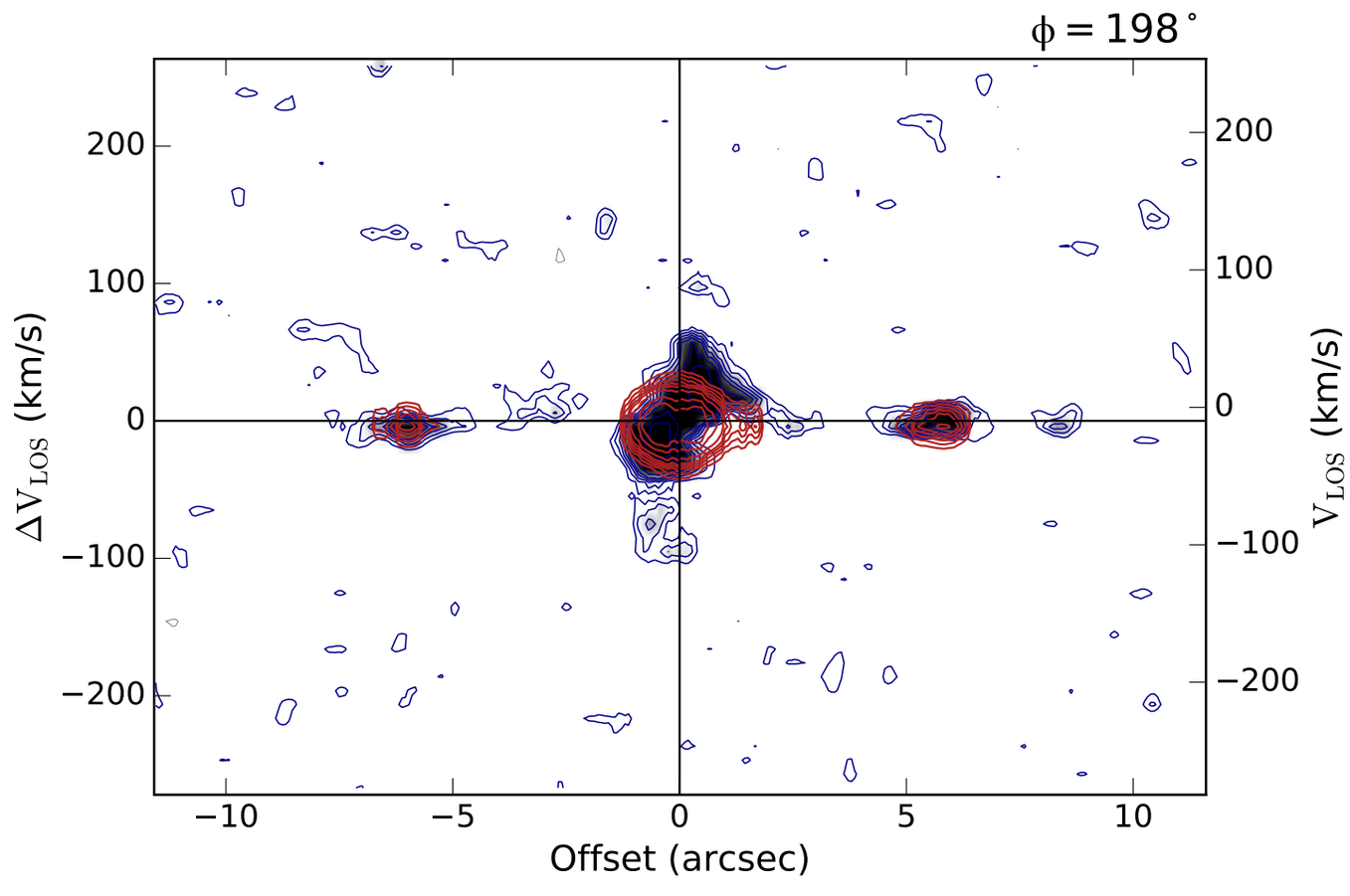
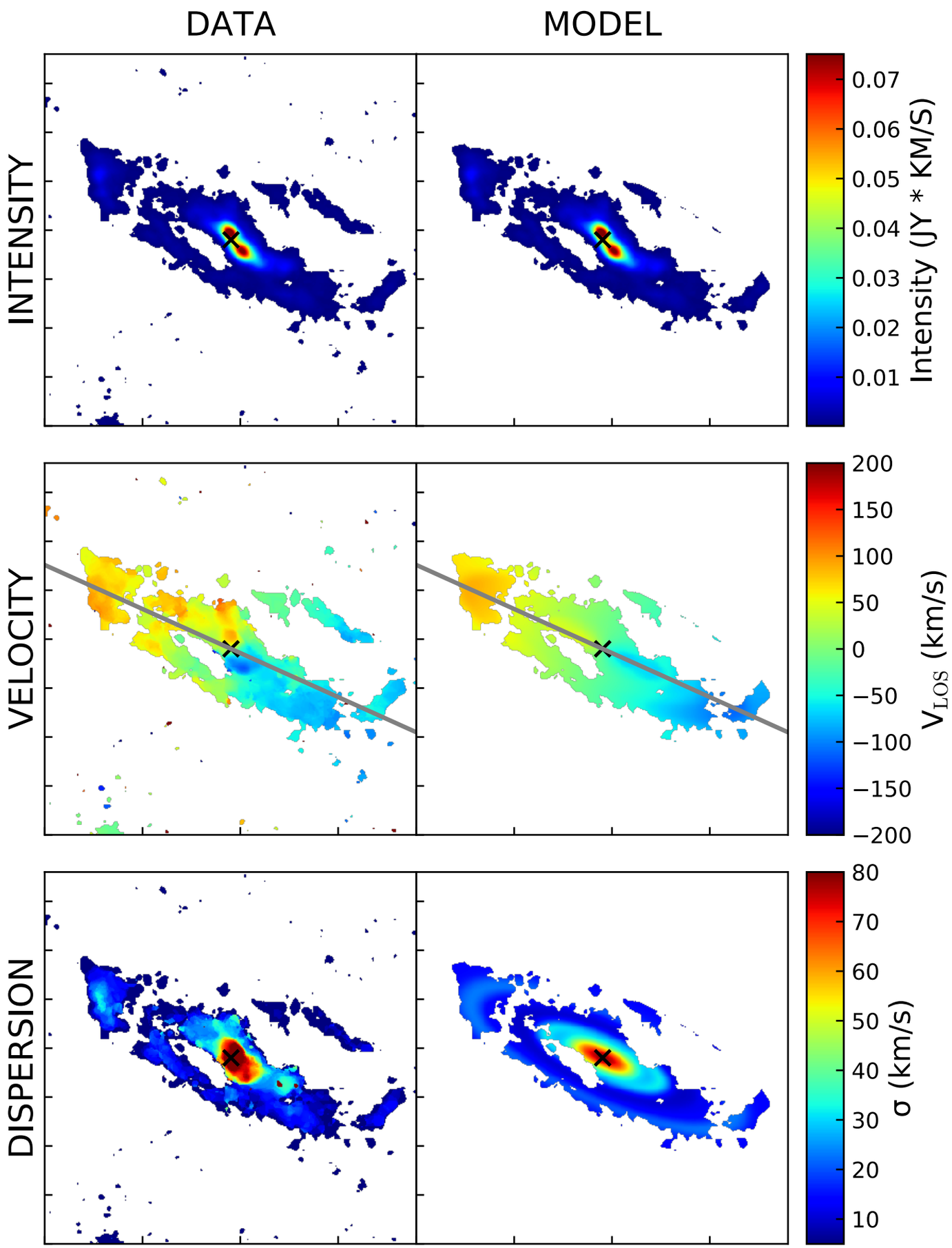
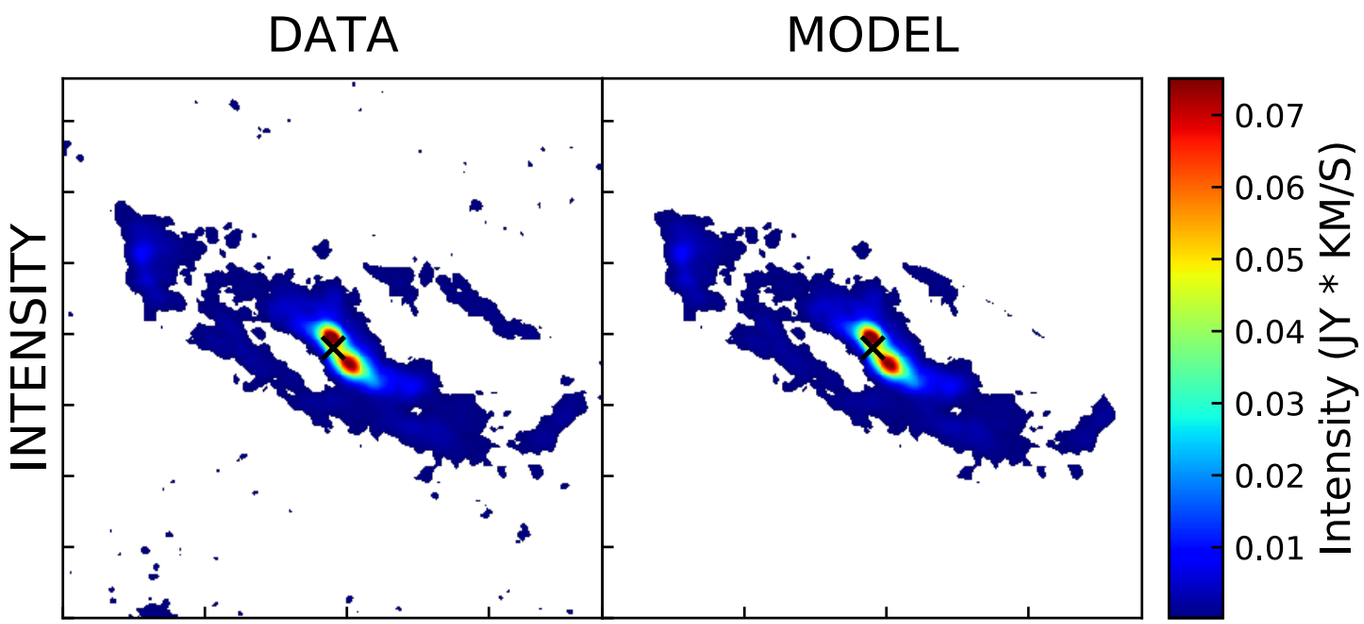




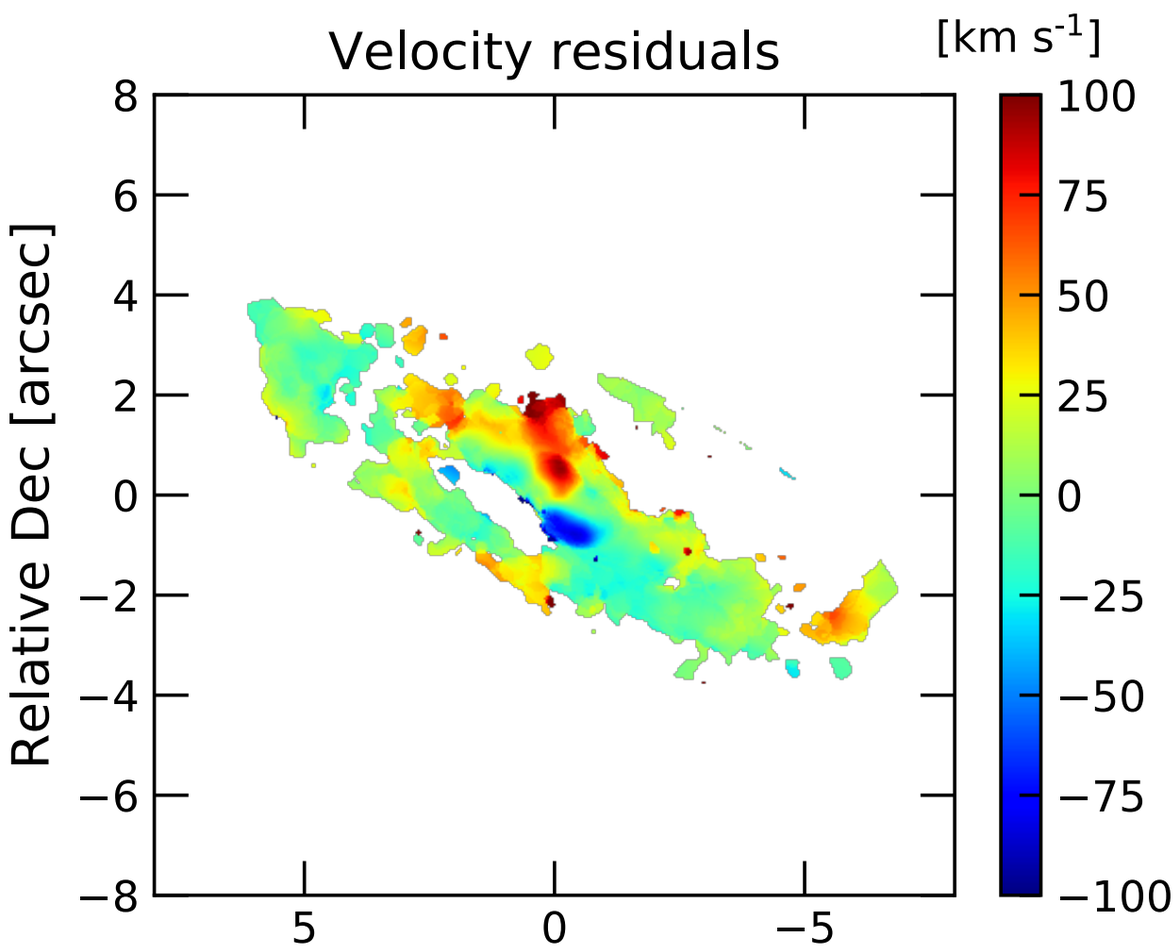


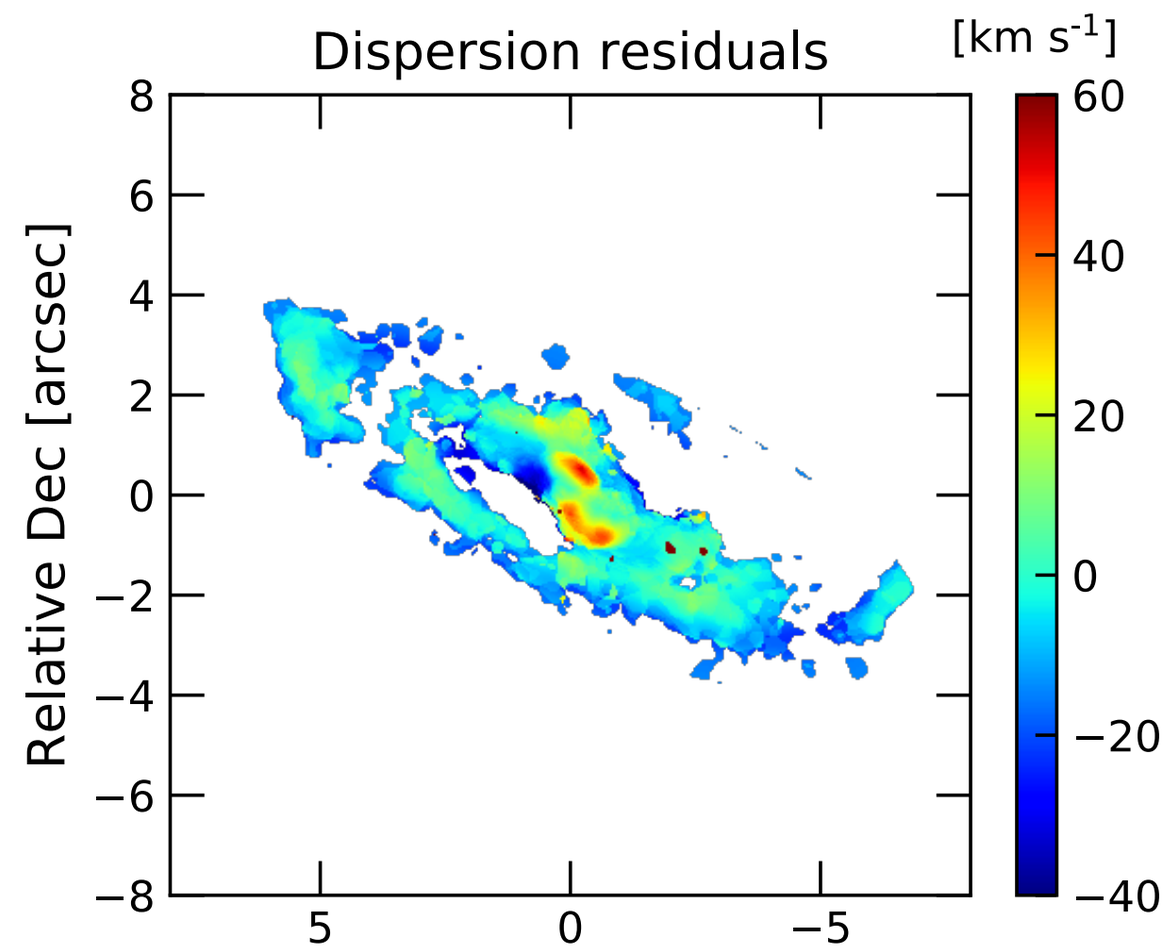
MCG-01-40
resolution 150 pc

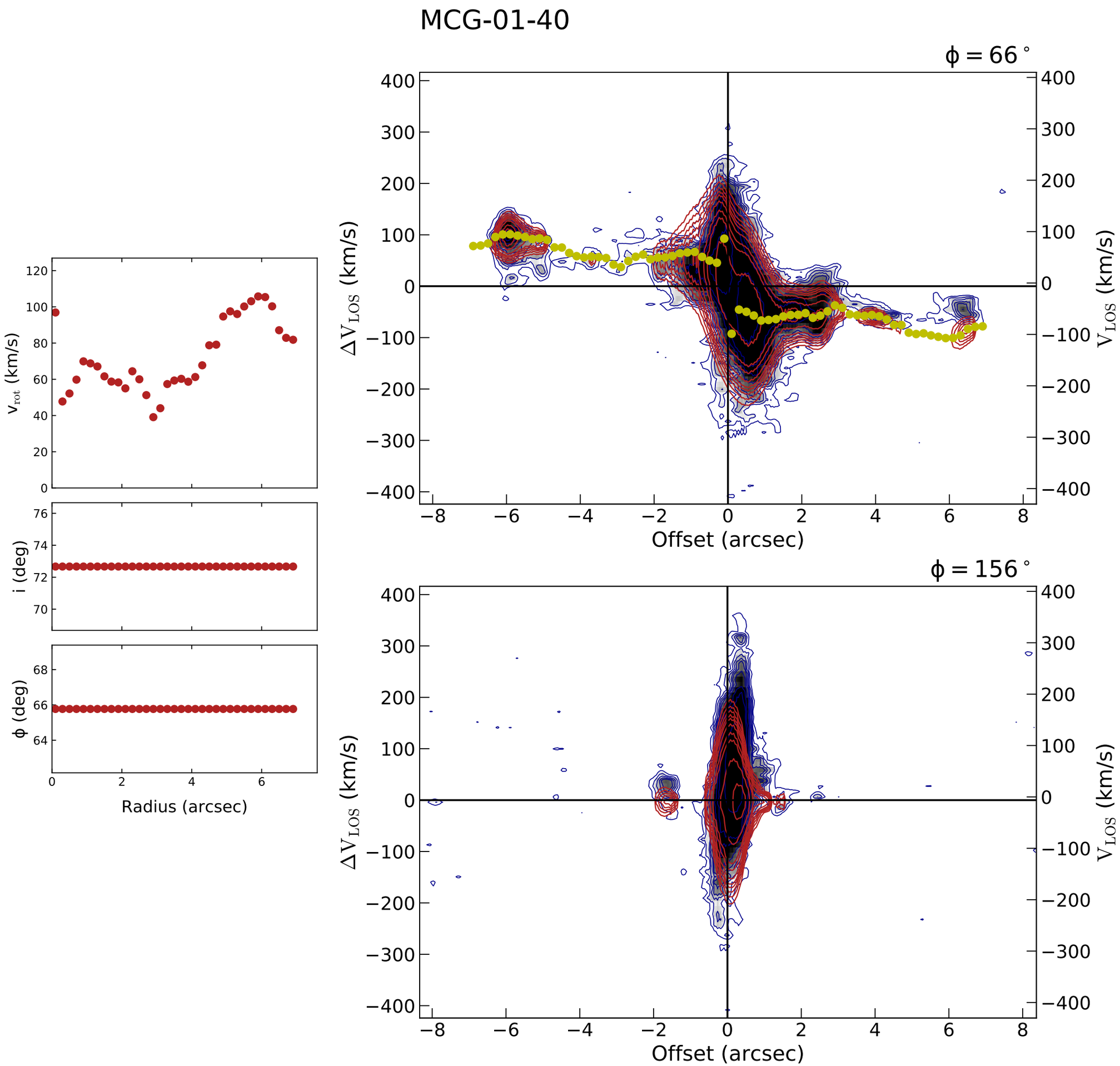


MCG-01-40
resolution 150 pc

data-model

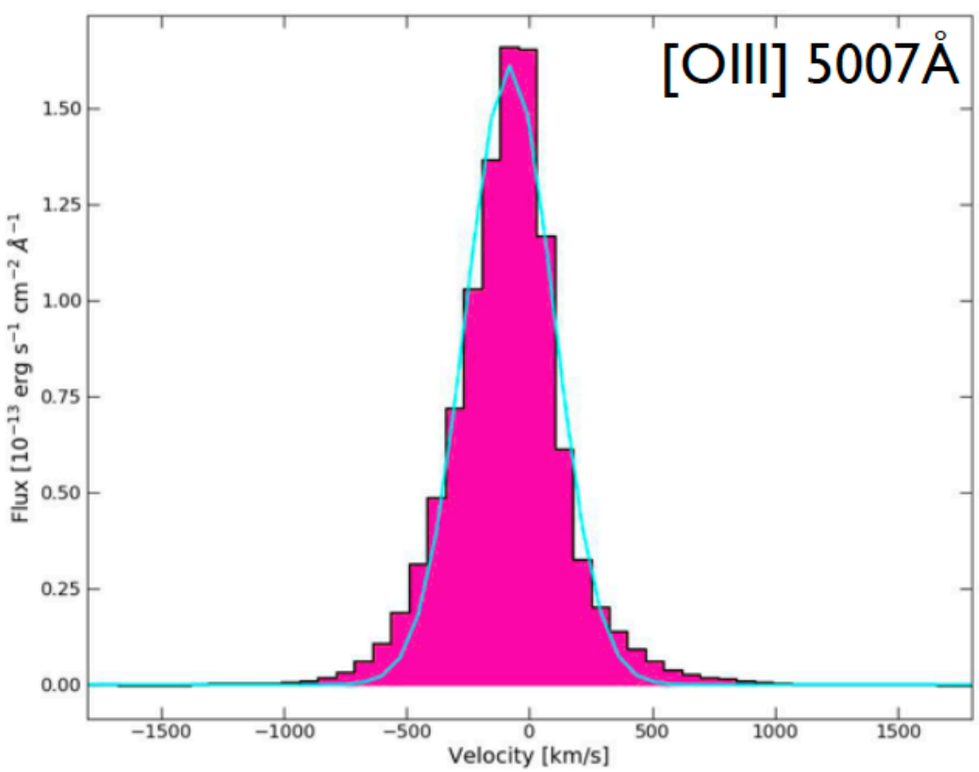


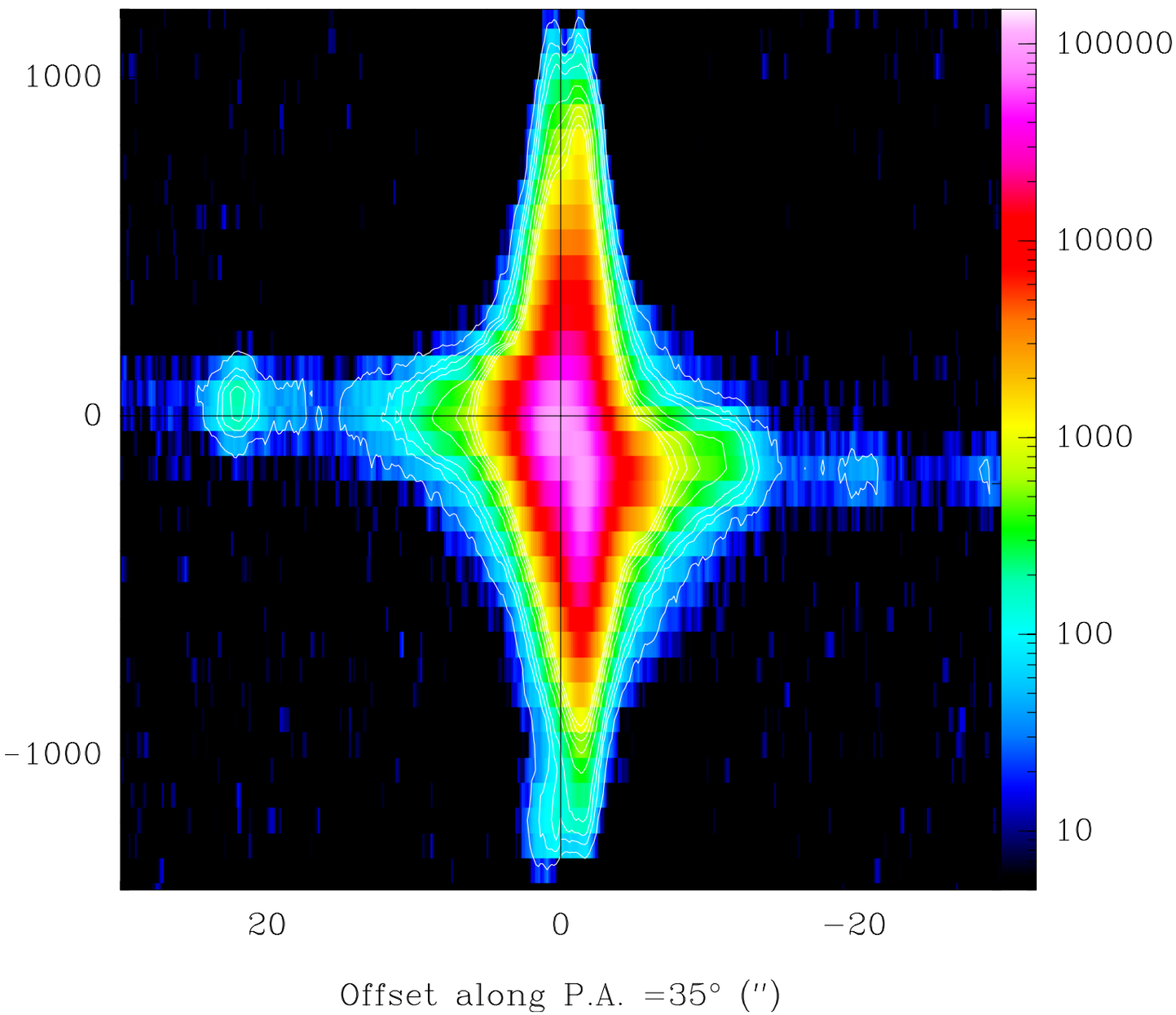



MCG-01-40
ϕ = 66 °
ϕ = 156 °
v_{rot} (km/s)
i (deg)
ϕ (deg)
Radius (arcsec)
ΔV_{LOS} (km/s)
V_{LOS} (km/s)
Offset (arcsec)

WP3 -ESO428-G14 - she was part of MAGNUM

- **Paper with ALMA+ Chandra+ SINFONI data published in 2020 , collaboration Pepi Fabbiano** *Multiphase gas flows in the nearby Seyfert galaxy ESO428-G14, 2020ApJ…890…29F*
- **We also analysed MUSE data: super-[OIII] outflow there!**
- More Chandra+ALMA+MUSE analysis planned for additional sources with A. Travascio





WP3 -ESO428-G14 - she was part of MAGNUM

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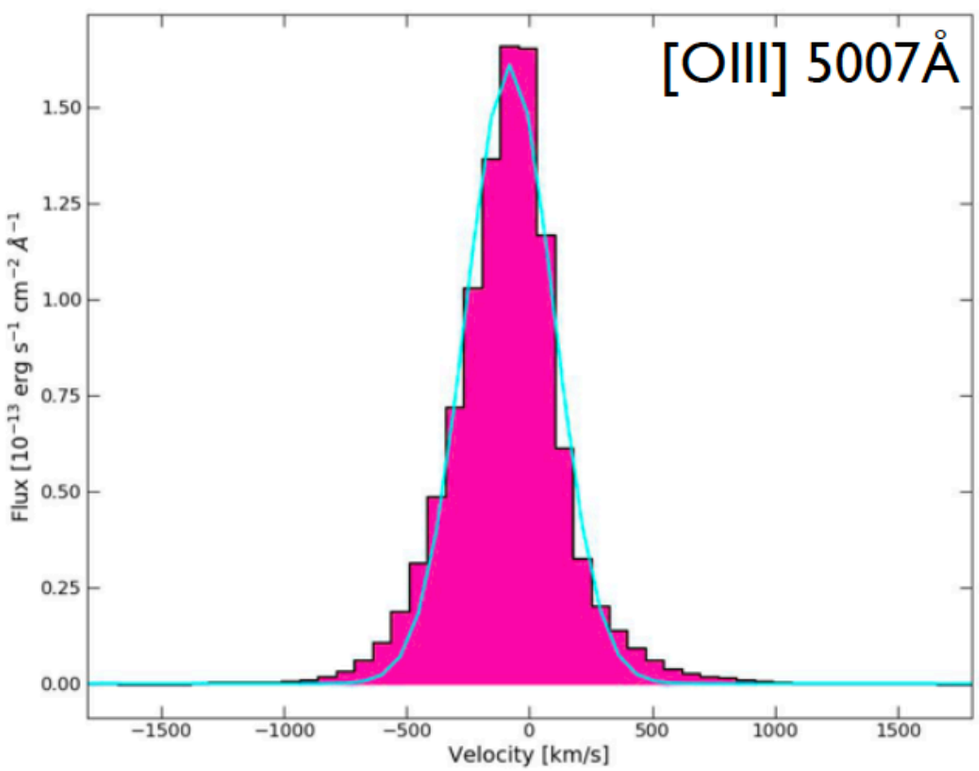
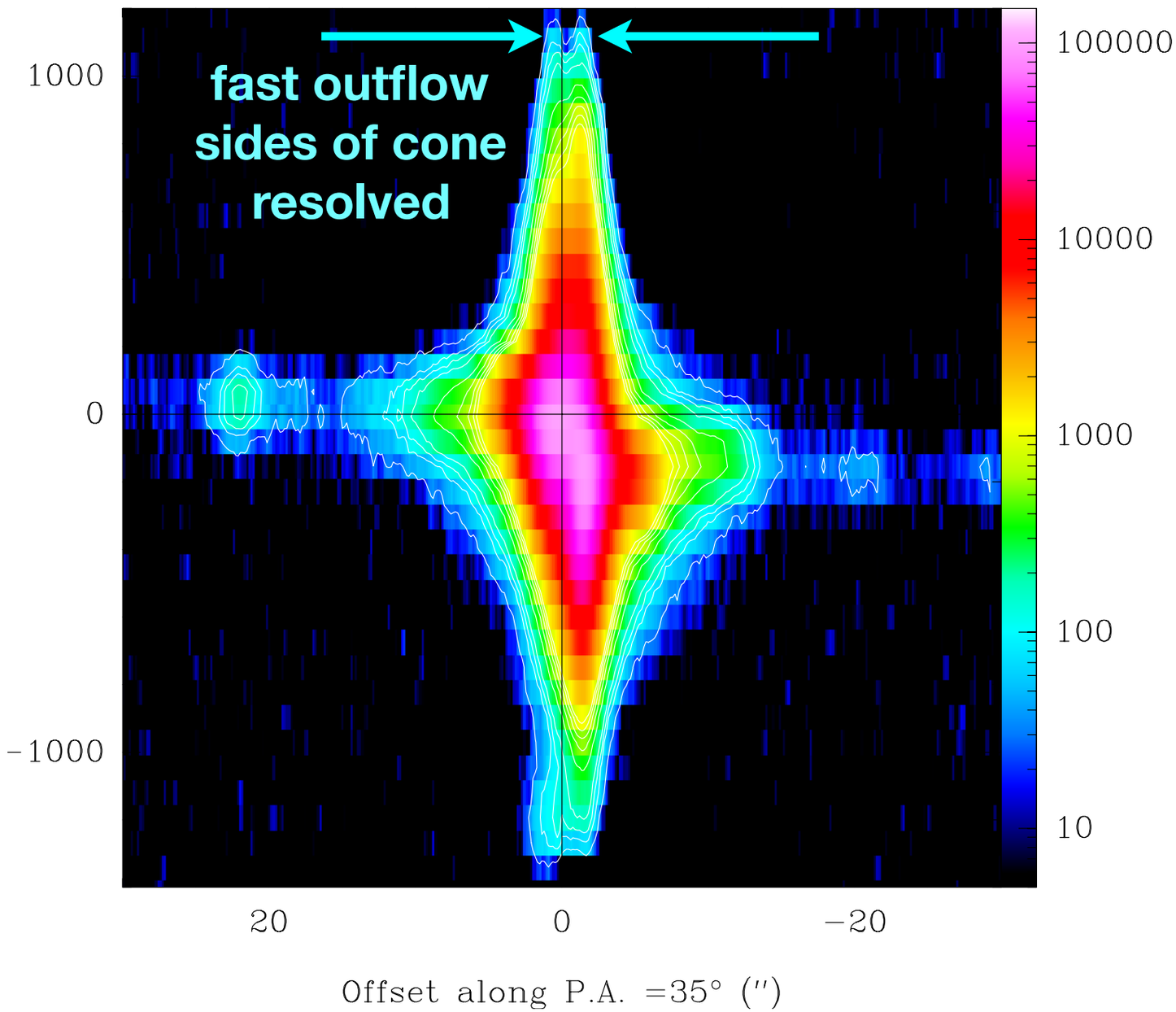
- More Chandra+ALMA+MUSE analysis planned for additional sources with A. Travascio

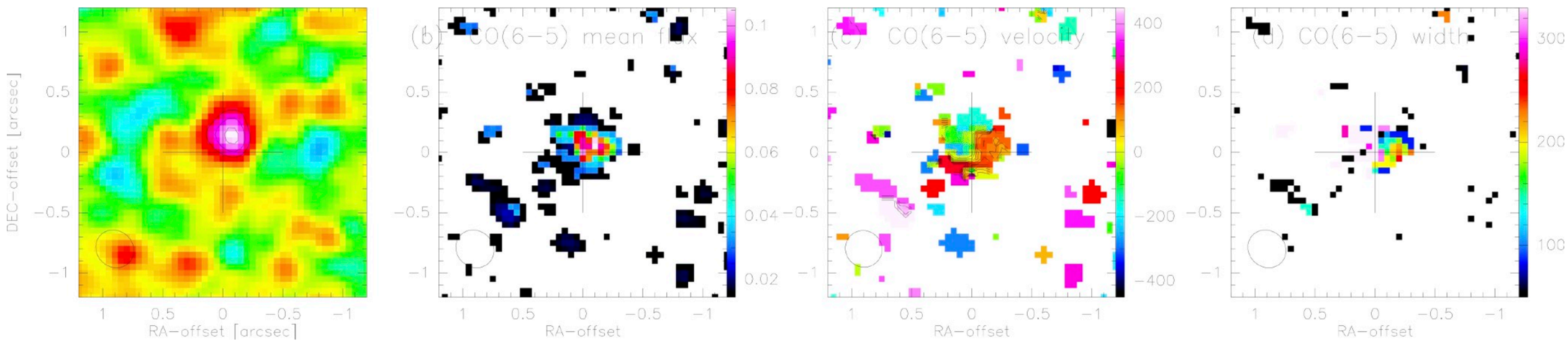


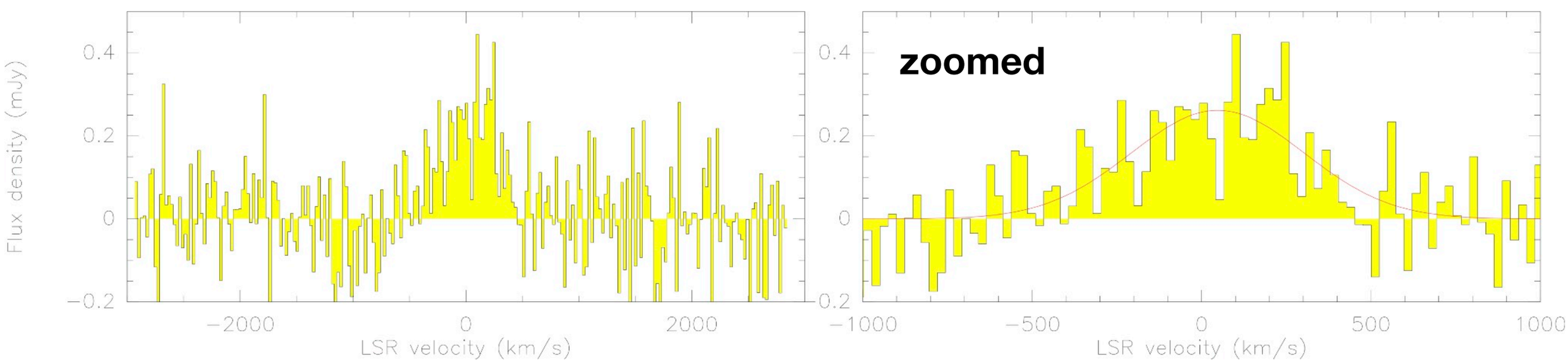


WP1 - z~6 QSOs with ALMA

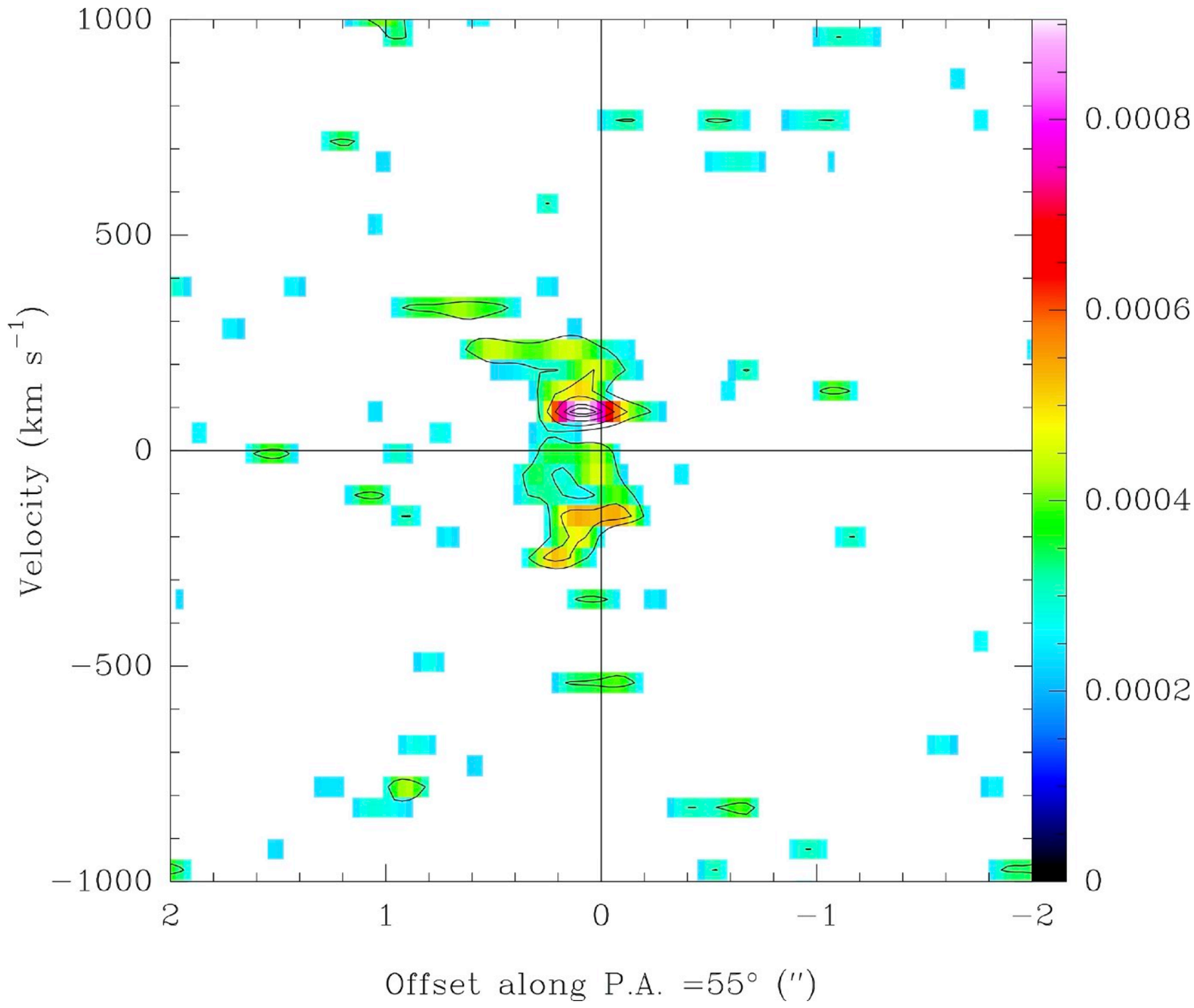
SDSS J205406-000514
SDSS J012958-003539
ULAS J131911+095051
completed in cycle 6

CO(6-5) ULAS J1319 **VELO** **V DISPERSION**





ULAS J1319



- **The other two QSO have similar data quality, marginally resolved**
- **Probably worth a dedicated publication**

WP3- SUBWAYS with NOEMA

NOEMA observations completed

- strong continua (S/N~50)
- NO CO line detected from QSOs

	Sensitivity 1sigma rms, /beam	CO(1-0) sky freq [GHz]	Line detection	Continuum detection
PG1626+554	0.39mJy per 16.3MHz	101.74		✓
PG0953+414	0.44mJy per 15.8MHz	93.412		✓
PG0947+396	0.34mJy per	95.661	✓ nearby galaxy	✓
PG1114+445	0.46 per 16.3MHz	101.115		✓

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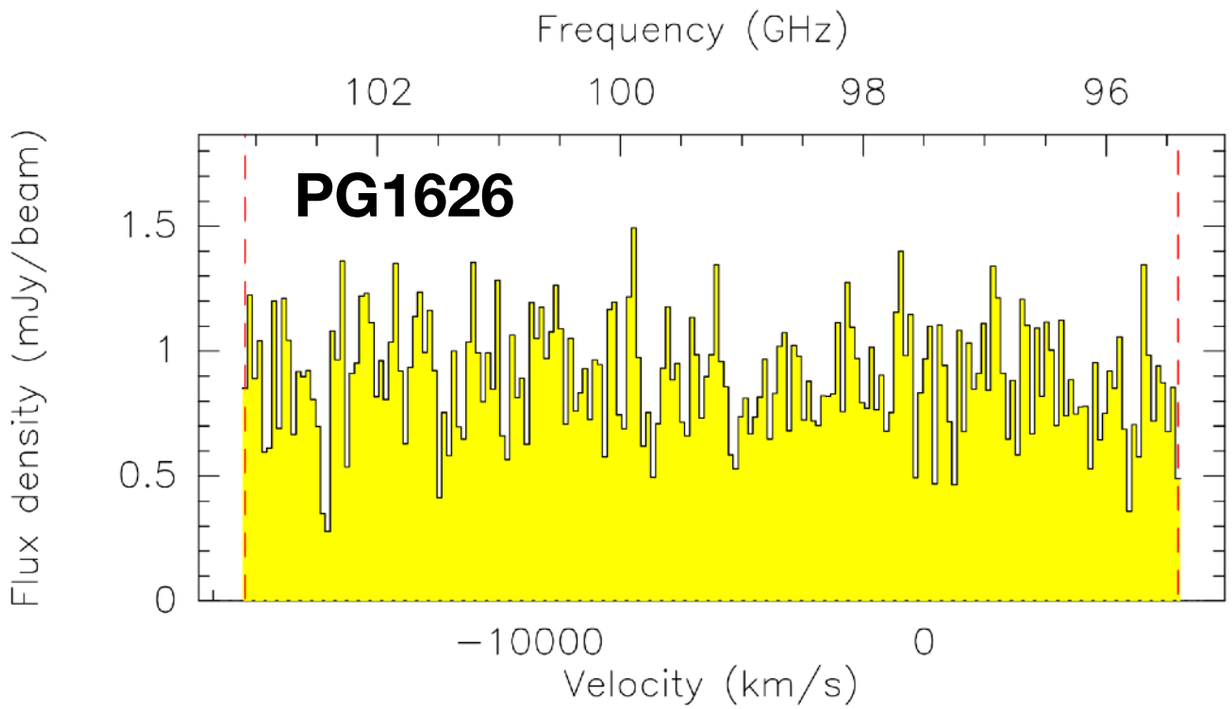

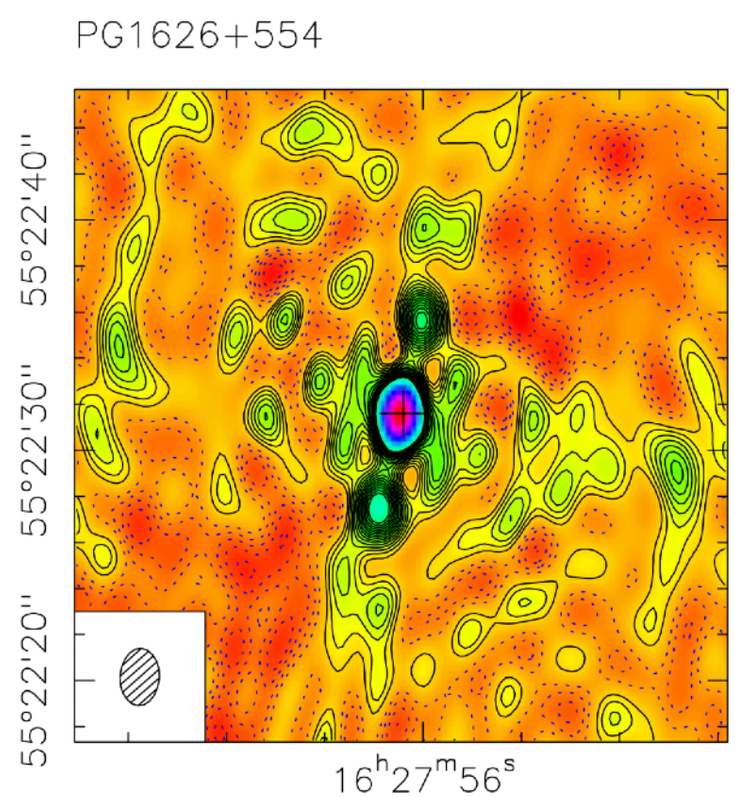

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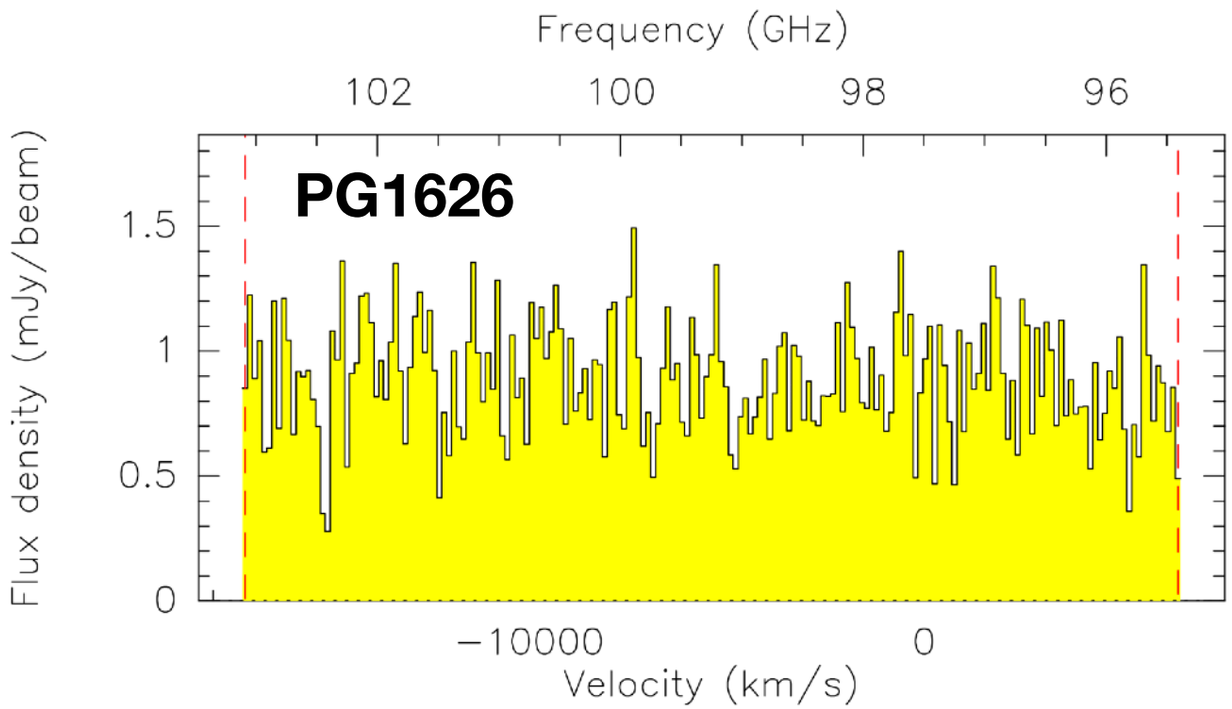
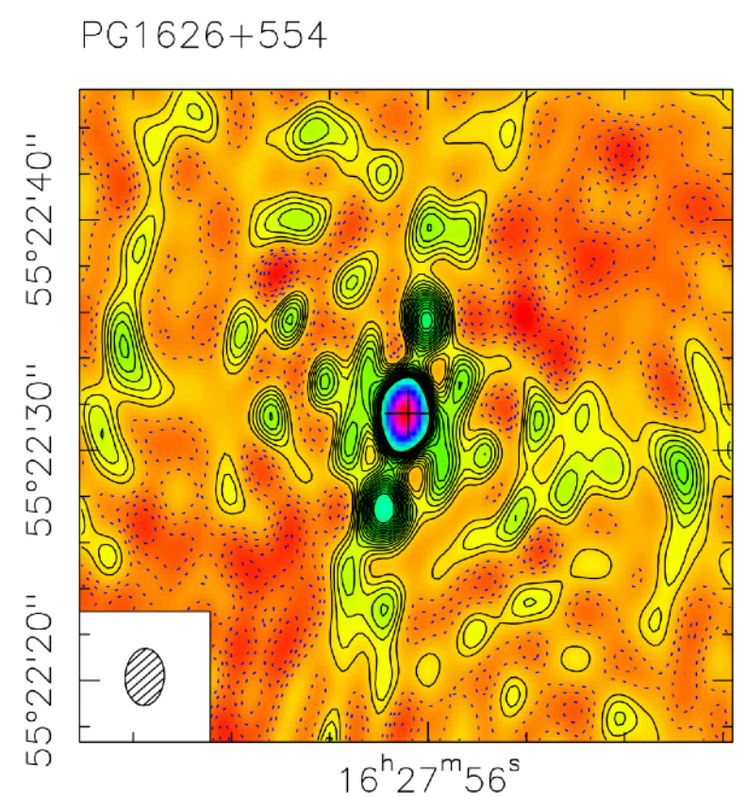
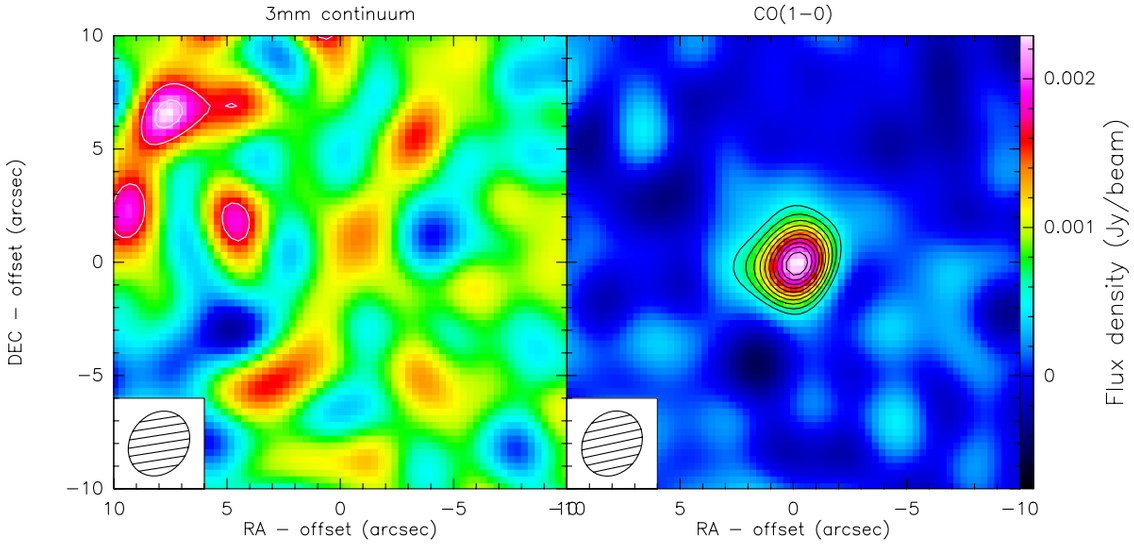


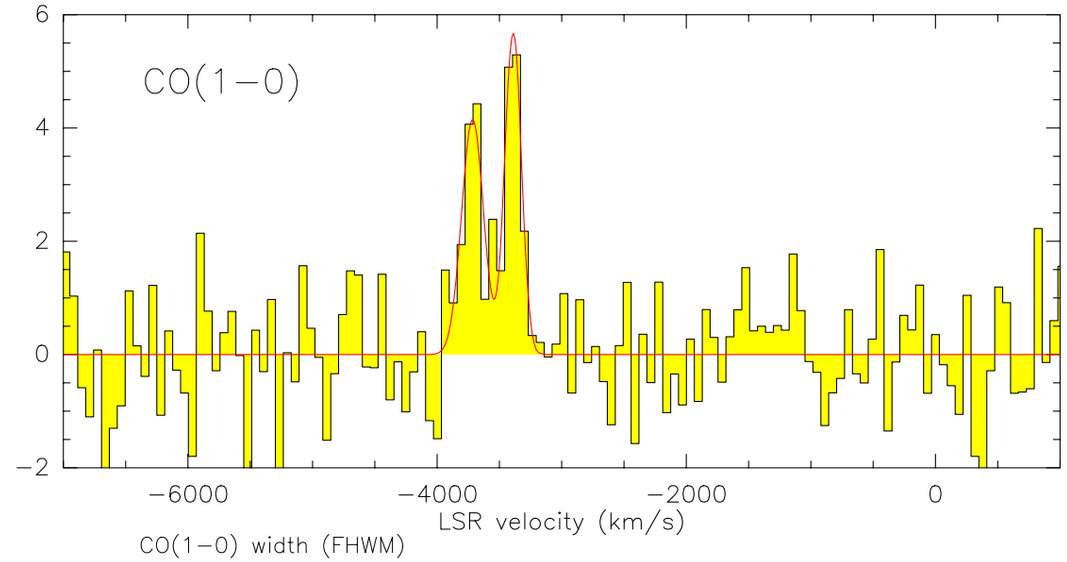


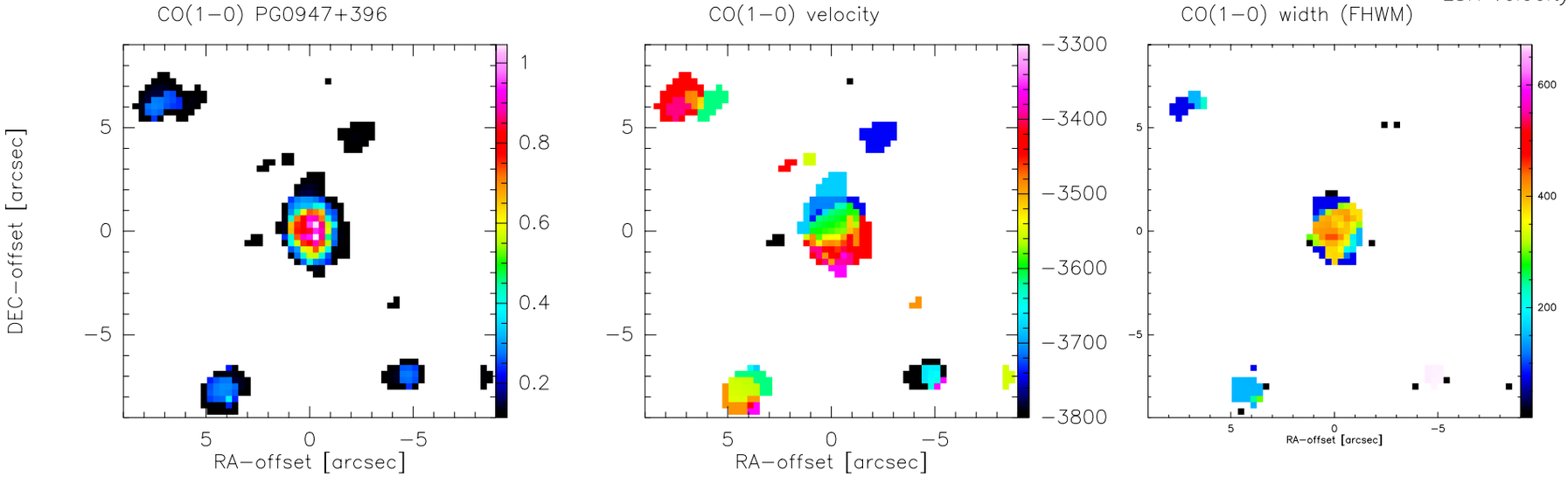
L'CO<10^8 K km/s pc^-2

x10 lower than typical L'CO in other PG (Shangguan +2020)

Disk galaxy nearby
PG0947+396
same z







WP4

- Paper published ***The Rise of Active Galactic Nuclei in the GAlaxy Evolution and Assembly semi-analytic model***, 2020 MNRAS
- New model of AGN winds implemented
- Data available for any use, please contact Fabio Fontanot

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The rise of active galactic nuclei in the galaxy evolution and assembly semi-analytic model

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