Quasar Feedback Survey:
The drivers and properties of multiphase outflows

- **Aishwarya Girdhar**
Aishwarya.Girdhar@eso.org
European Southern Observatory

Supervisors:
Dr. Chris Harrison | Newcastle University, UK
Dr. Vincenzo Mainieri | ESO, Germany

Supermassive black holes reside inside all massive galaxies

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Active Galactic Nuclei (AGN) - growing supermassive BH

AGN required by galaxy evolution models to explain wide range of properties of massive galaxies and their central SMBH

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Quasars – most powerful AGN

- Do the winds from quasar/ radiation couple with ISM?
- Do they affect the global SF in galaxy positively or negatively?
- **What are the properties and drivers of multi-phase outflows?**

their role still controversial

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Quasar Feedback Survey

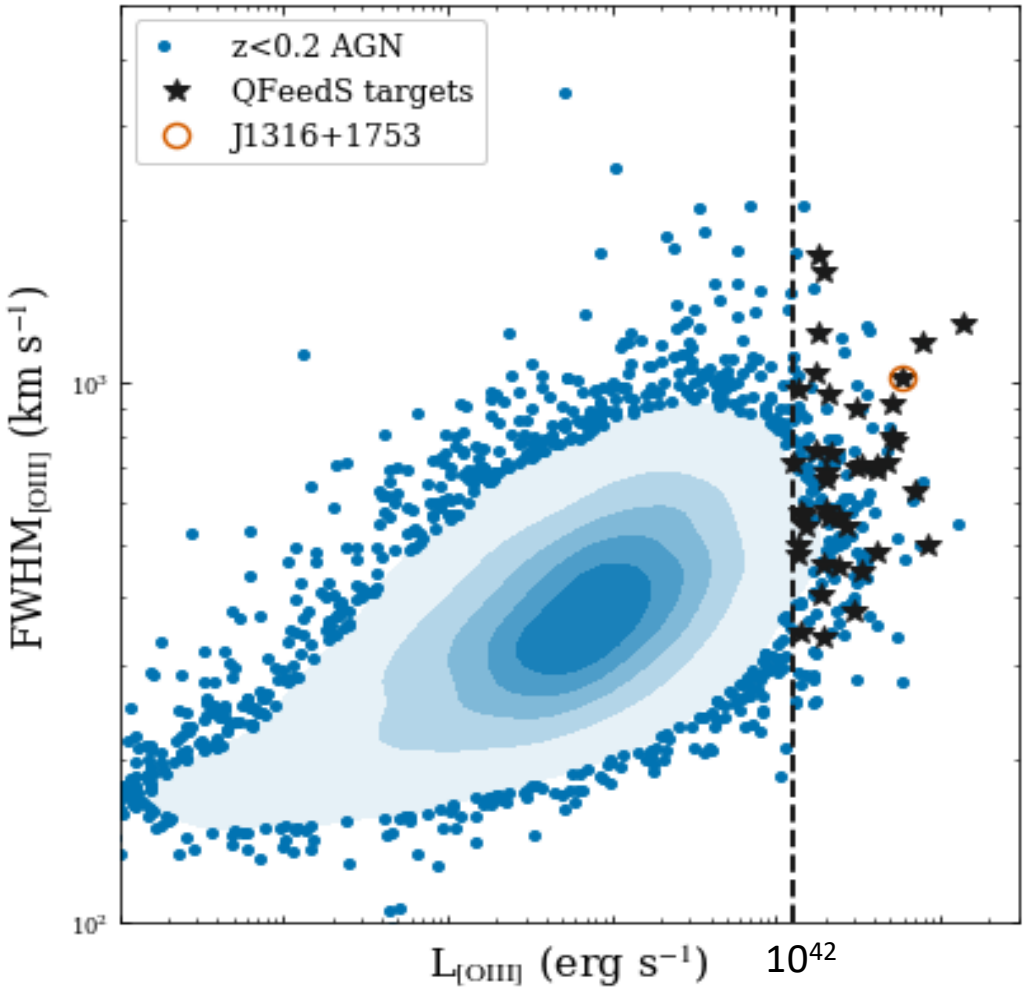
Quasar Feedback Survey

https://blogs.ncl.ac.uk/quasarfeedbacksurvey/

Jarvis, Harrison +21

- Sample of 42 powerful quasars, $L_{bol}>10^{45}$ erg/s
- Mostly-radio quiet, $L_{1.4Ghz}<10^{23}$
- Multi-wavelength data:
  - Radio imaging
  - Sub-mm interferometry
  - Integral field spectroscopy

Pilot Sample



Gives sub-kpc spatial resolution for IFS observations

High L-regime, equivalent to L*-values at z~1-2, where outflows are prevalent

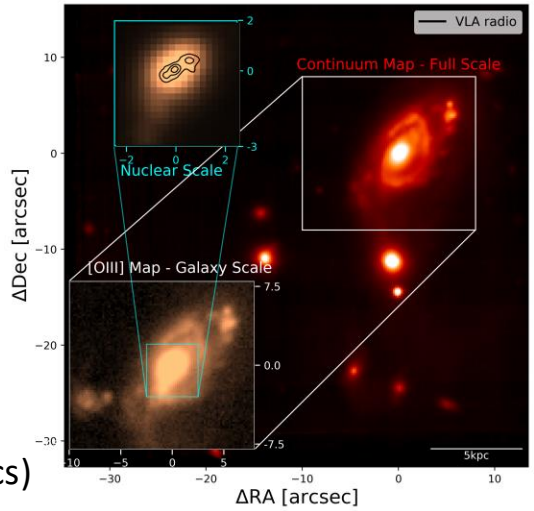
Aishwarya.Girdhar@eso.org

Textbook Case: J1316+1753

Main Question: What are the properties and drivers of the multiphase outflow?

Data:

- VLA radio images;
- MUSE-AO spectroscopy (ionised gas and stellar kinematics);
- ALMA (molecular gas kinematics)

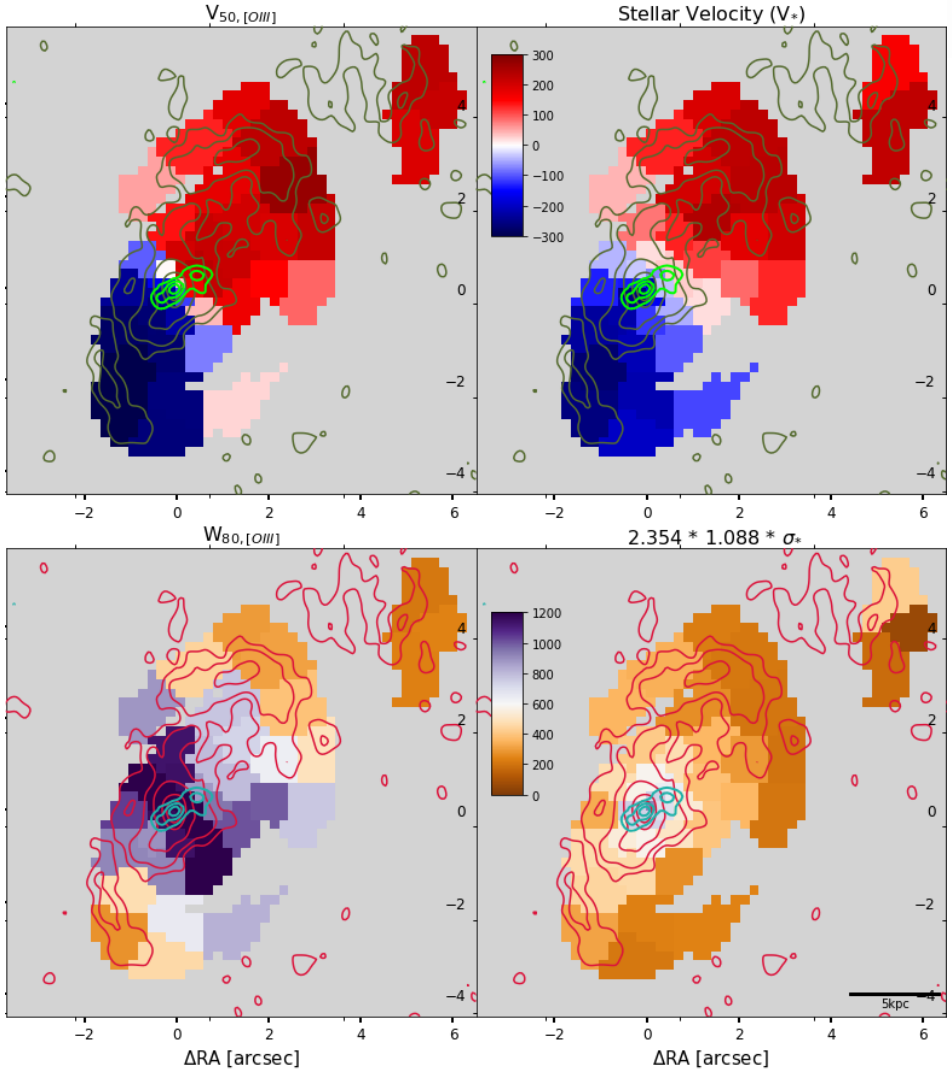


Galaxy on global scale:

- **Large scale**: molecular and ionised gas follow galaxy dynamics
- **Central regions:** high velocity residuals and high velocity dispersions close to jet
- **Enhanced velocity dispersion for ionised gas in regions perpendicular to the jet**

MUSE - [OIII] - Ionised Gas

Stellar Kinematics (GIST*

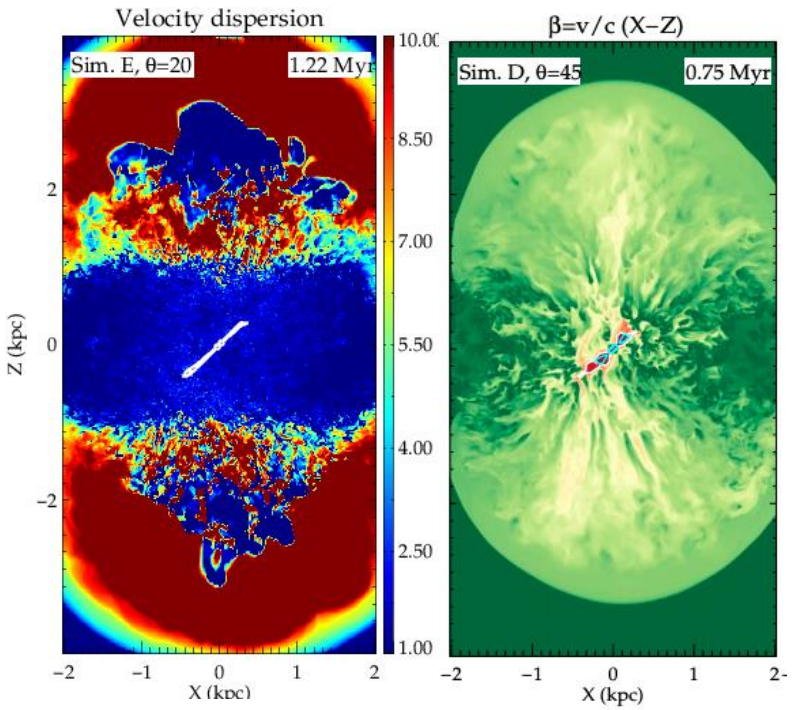


Girdhar+ in prep.

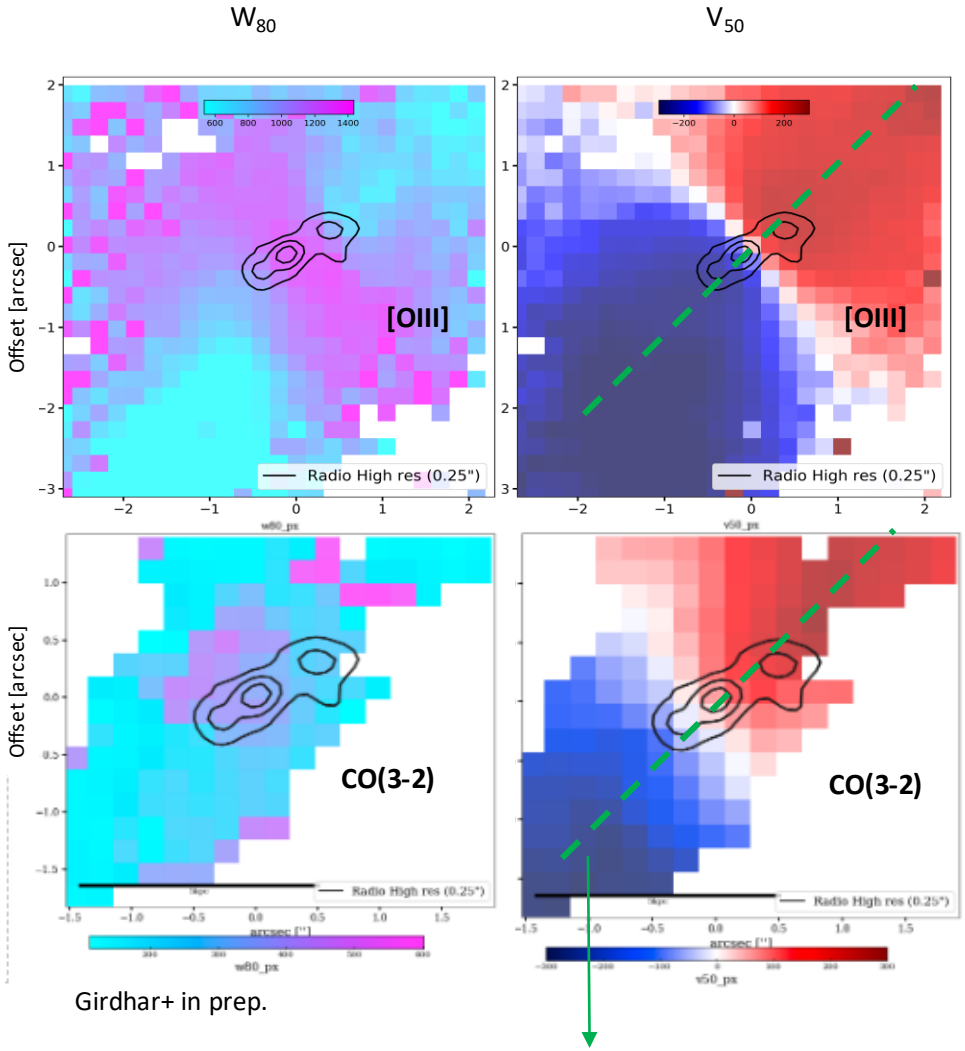
*GIST: Bittner+2019

Aishwarya.Girdhar@eso.org

Zooming in on Nuclear scale:



Mukherjee(pvt. comm.) Mukherjee+2018



Girdhar+ in prep.

Conclusions

- Ionised gas seen to be more disturbed than molecular gas, due to low density
- An enhanced velocity dispersion seen perpendicular to the jets in ionised gas
- Outflow component seen above the jet in molecular gas
- In agreement to simulations for inclined jets (~ 45°), which predicts, while jet is inside the disc, it increases dispersion

References: read more about our survey!
- Harrison+17, Harriosn+18
- Jarvis,Harrison +19
- Jarvis,Harrison +20
- Jarvis,Harrison +21
- Molyneux, Harrison, Jarvis +19

Aishwarya.Girdhar@eso.org