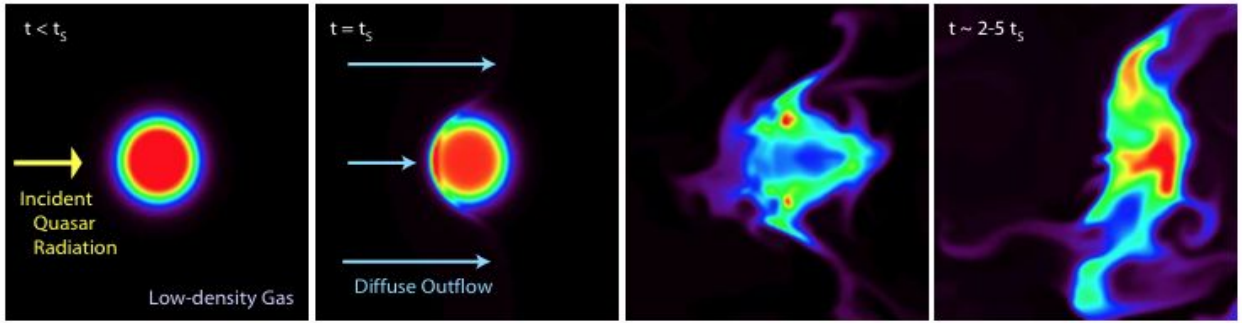
Moderate Luminosity AGN Outflows as Probes of Feedback

"Supermassive Black Holes Explained", PhD. Comics

Rebecca Nevin, NSF GRFP, CU Boulder
Julie Comerford
Francisco Müller-Sánchez
Robert Barrows

Two standing questions in AGN feedback:

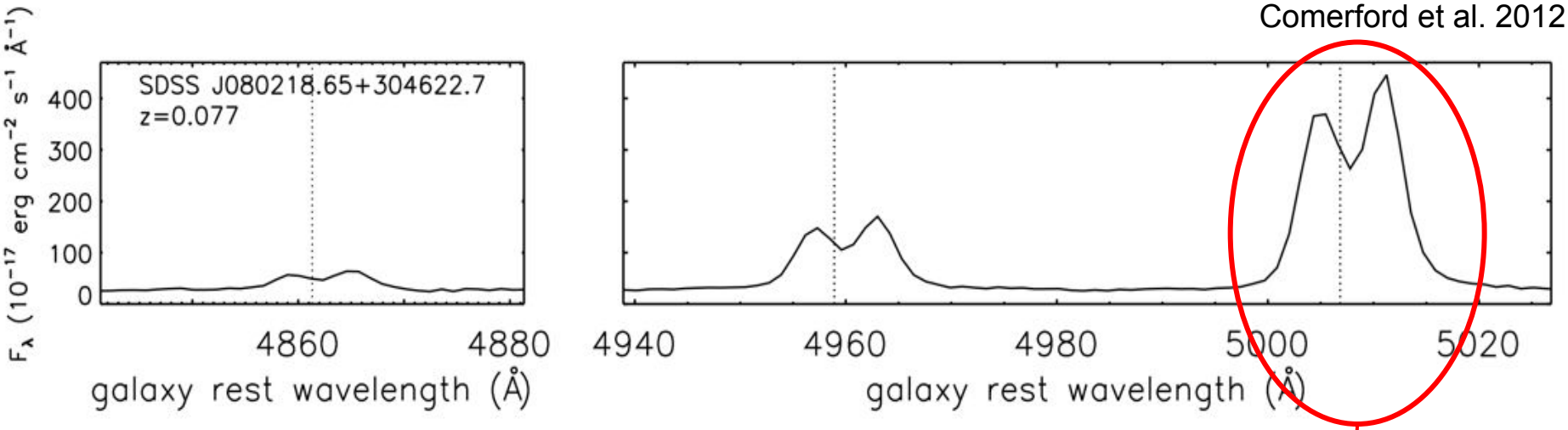
1. What is the energy at different scales?
   a. X-ray/ UV Absorption lines [BALQSOs] (pc-scales)
   b. NLR winds and outflows (100 pc to kpc-scales)
   c. Radio jets (> kpc-scales)
2. What is the effect on the host galaxy (quenching SF)?



$$L_{KE}/L_{bol} > 0.5\%$$

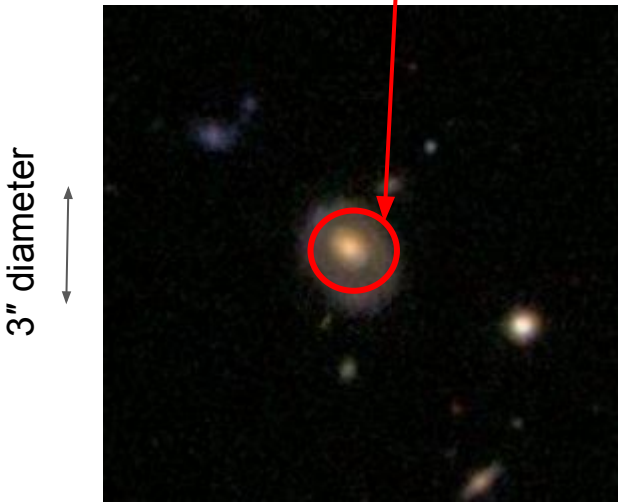
Hopkins & Elvis 2010

Comerford et al. 2012



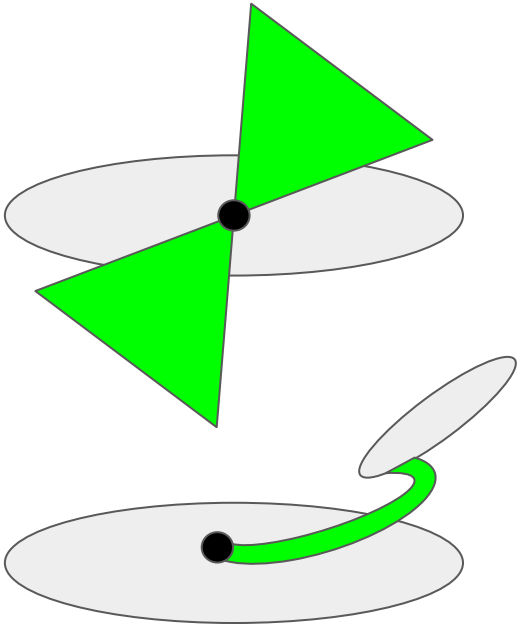
Sample:

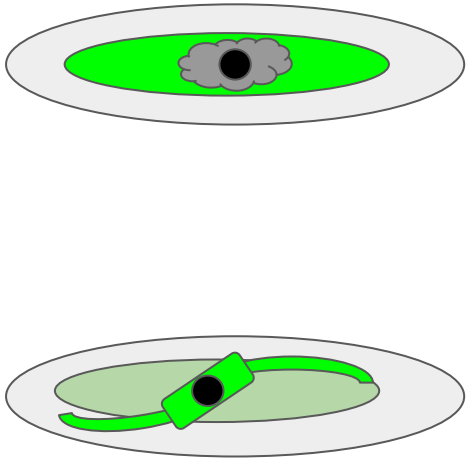
- $z < 0.1$
- Moderate luminosity ($40 < \log L_{[OIII]}$ (erg s^{-1}) < 42)
- Sample = 71 galaxies (VLA + optical longslit)



The Origin of Double-Peaked Narrow Lines in Active Galactic Nuclei II: Conclusions

- Determined kinematic origin of double peaks
  - Rotation-dominated
  - Ambiguous
  - Outflow-dominated
- **58 have outflow-dominated kinematics (Nevin et al. 2016)**

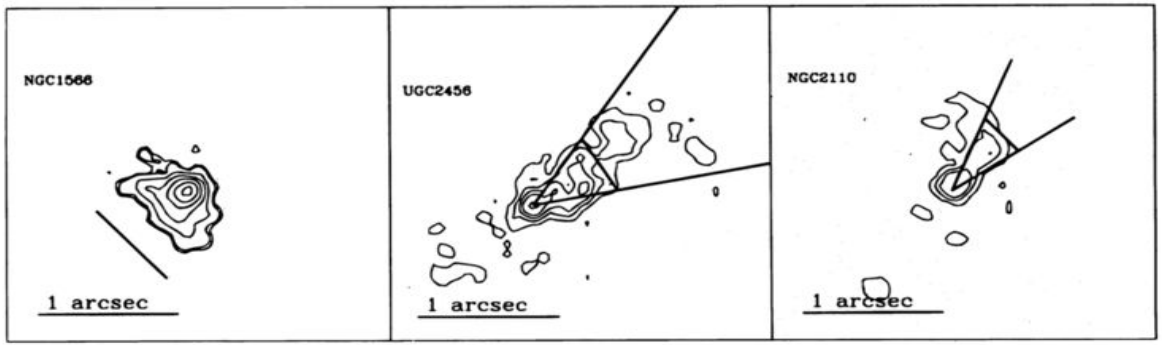




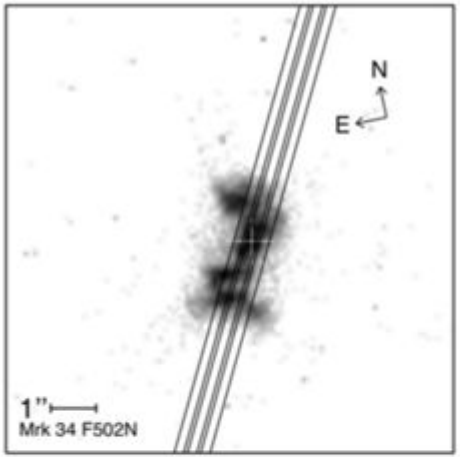
Science Goals

1. Energy output of the ionized outflows
2. Tracing the ISM-outflow interaction

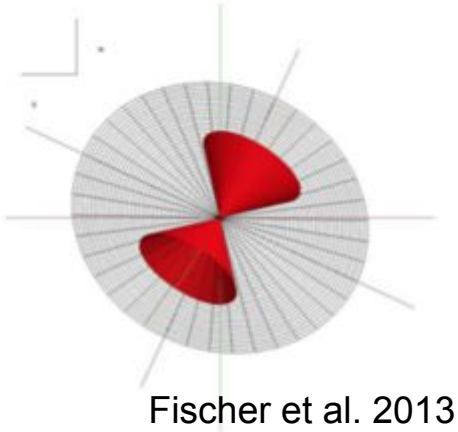
Motivation for conical outflows: Observations



Schmitt & Kinney 1996



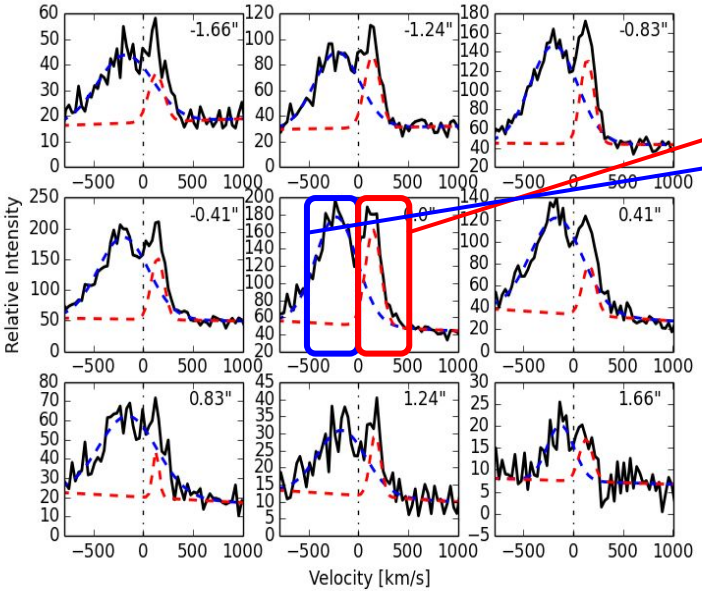
Conical outflows motivated by and modeled in previous work: Schmitt & Kinney 1996, Das et al. 2006, Muller-Sanchez et al. 2011, Fischer et al. 2013, Crenshaw et al. 2014

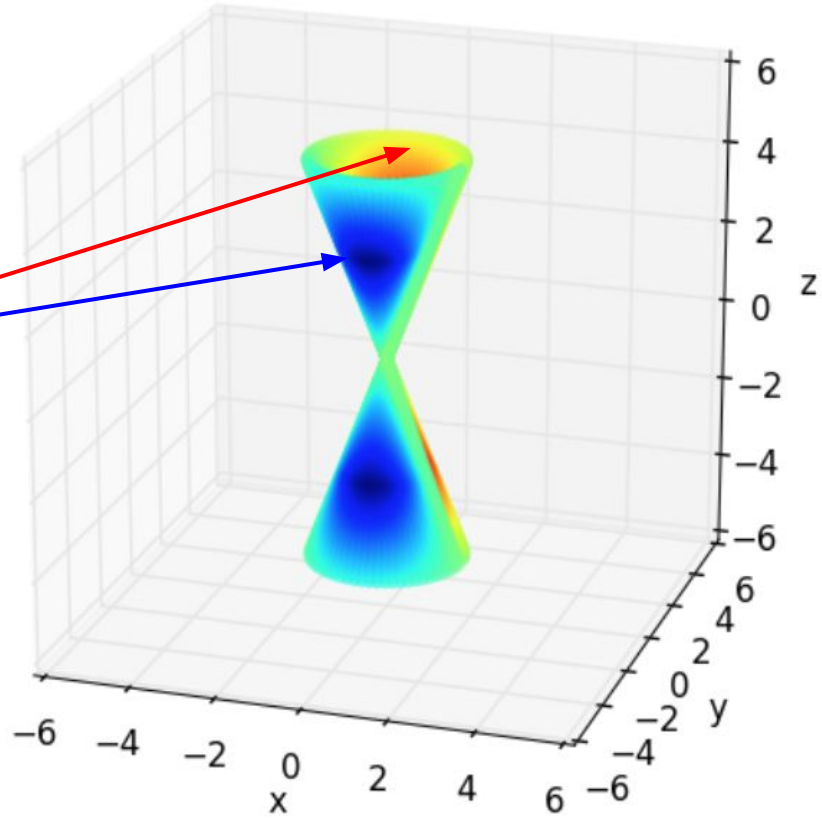


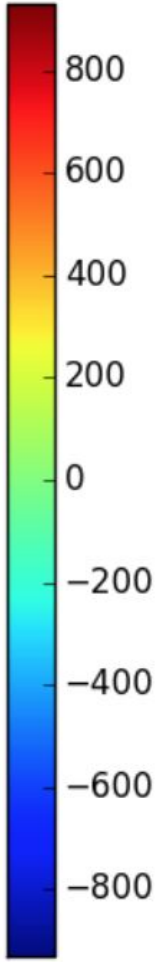
Fischer et al. 2013

Science Goal 1: Energy output

Motivation for analytic model

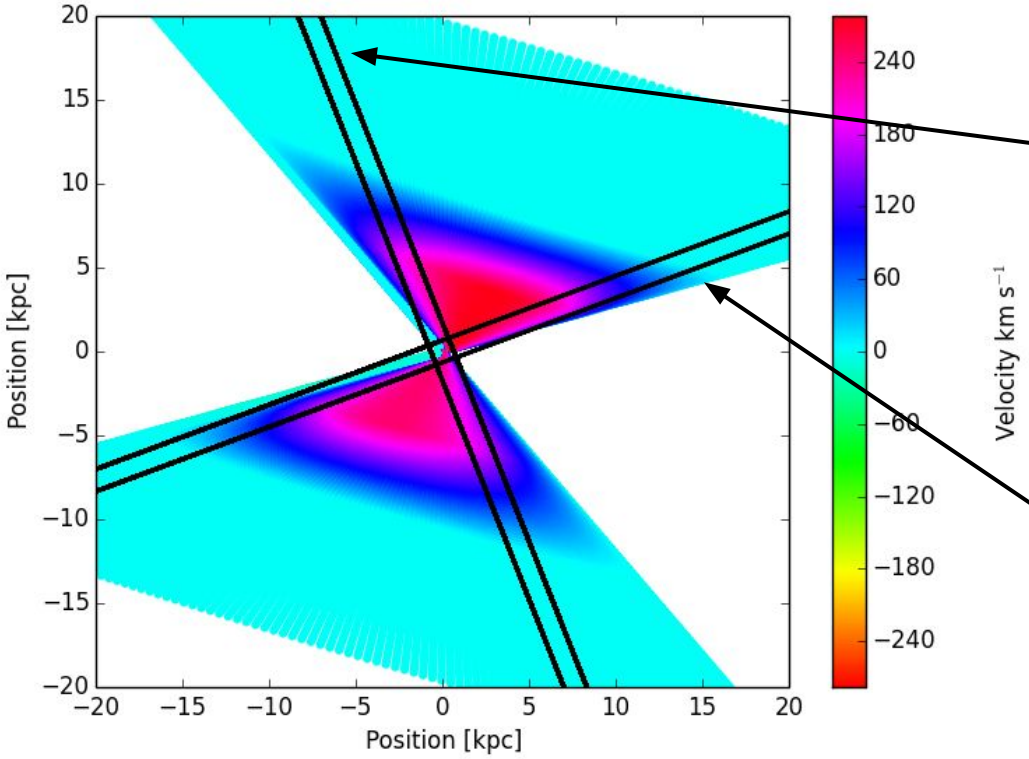


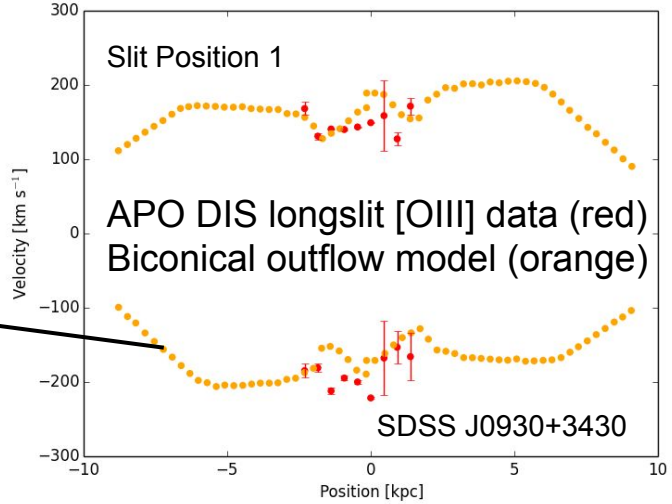


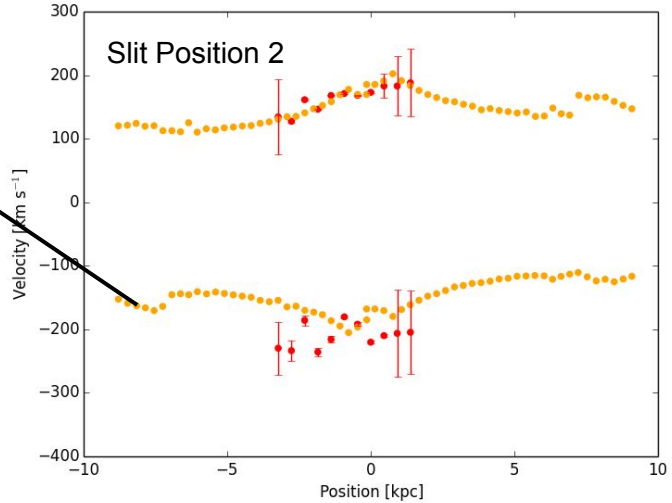


Science Goal 1: Energy output

Result: Modeled 8/58 outflow-dominated galaxies







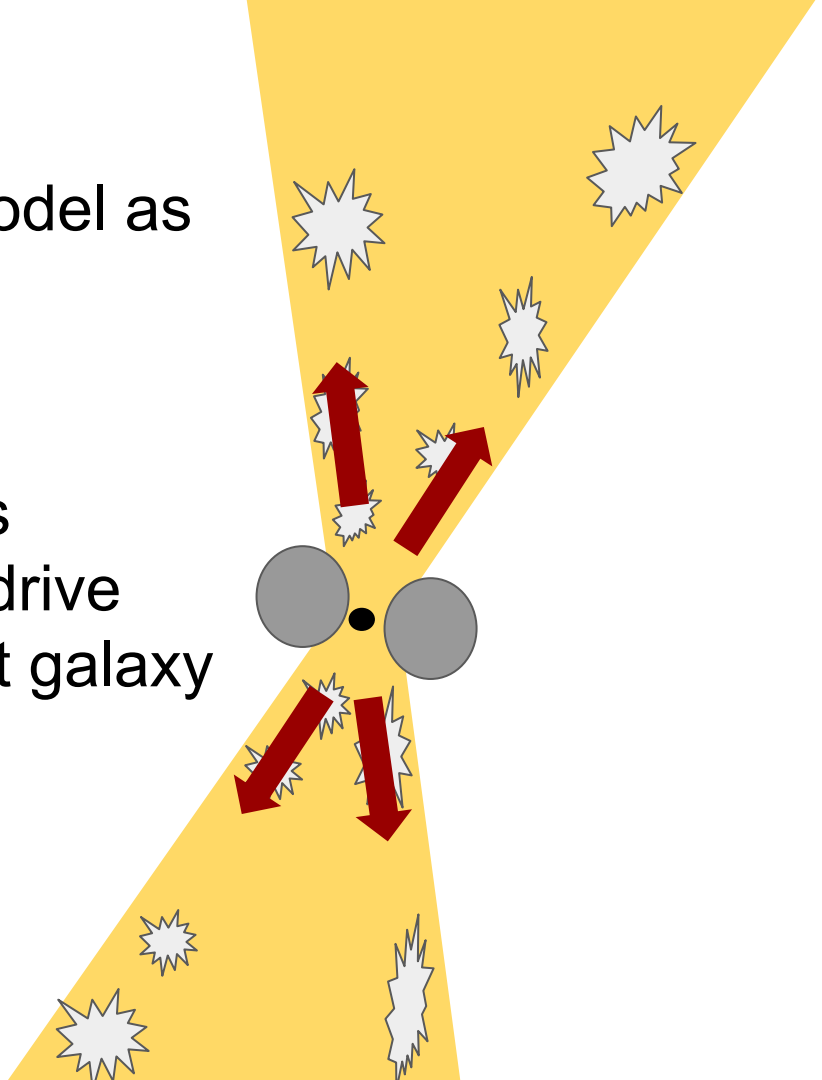
Science Goal 1: Energy output

Kinetic energy of the outflows

- 25% of the galaxies (2/8) we model as conical AGN outflows have:

$$L_{KE}/L_{bol} > 0.5\%$$

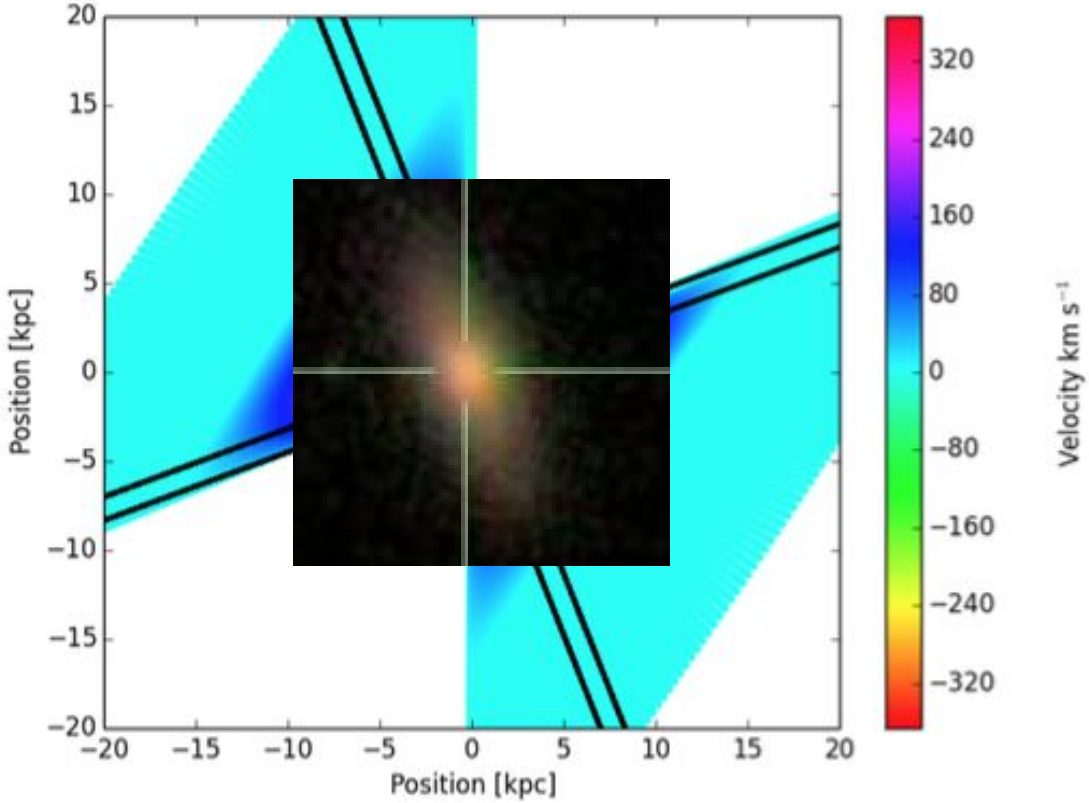
- Outflows with energy above this threshold have the potential to drive two-stage feedback in their host galaxy (Hopkins & Elvis 2010)



Science Goal 2: ISM-outflow interaction

Outflow alignment

75% (6/8) of all outflow-dominated galaxies **that were modeled** have outflows that intersect their disks.

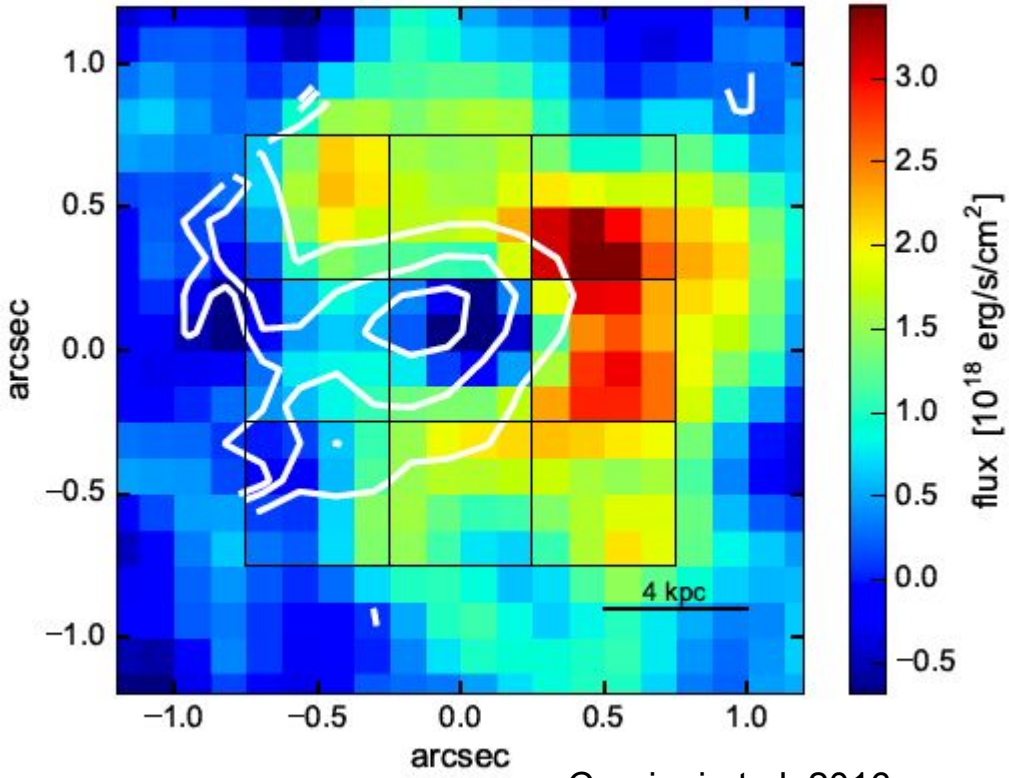


(e) J0930+3430 Bicone

Science Goal 2: ISM-outflow interaction

Implications of alignment for feedback

- Opportunity for negative feedback in the disk
- There have been some implications of positive feedback associated with outflows
- Future work: IFU star formation maps and ALMA molecular data



Carniani et al. 2016

Science Goal 2: ISM-outflow interaction

Conclusions

- Of the eight galaxies we model as outflows, 25% have ratios:

$$L_{KE}/L_{bol} > 0.5\%$$

- 75% of modeled galaxies have an outflow axis that intersects the disk of the galaxy, implying a possible quenching of star formation in the disk
- Moderate-luminosity outflows may be important for star formation regulation