ALFALFA Harvest: 3D Modeling of HI-Rich Candidate Local Group Dwarf Galaxies

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AGC 198606: We impose a systemic velocity V_{sys} = 53 km s^{-1} (Janesh *et al.* 2019) and a position angle PA = 140º, adapted from Adams *et al.* (2013). The primary SNR cut is set to 3σ, the growth cut to 2σ, and the minimum channels for detection to 3.

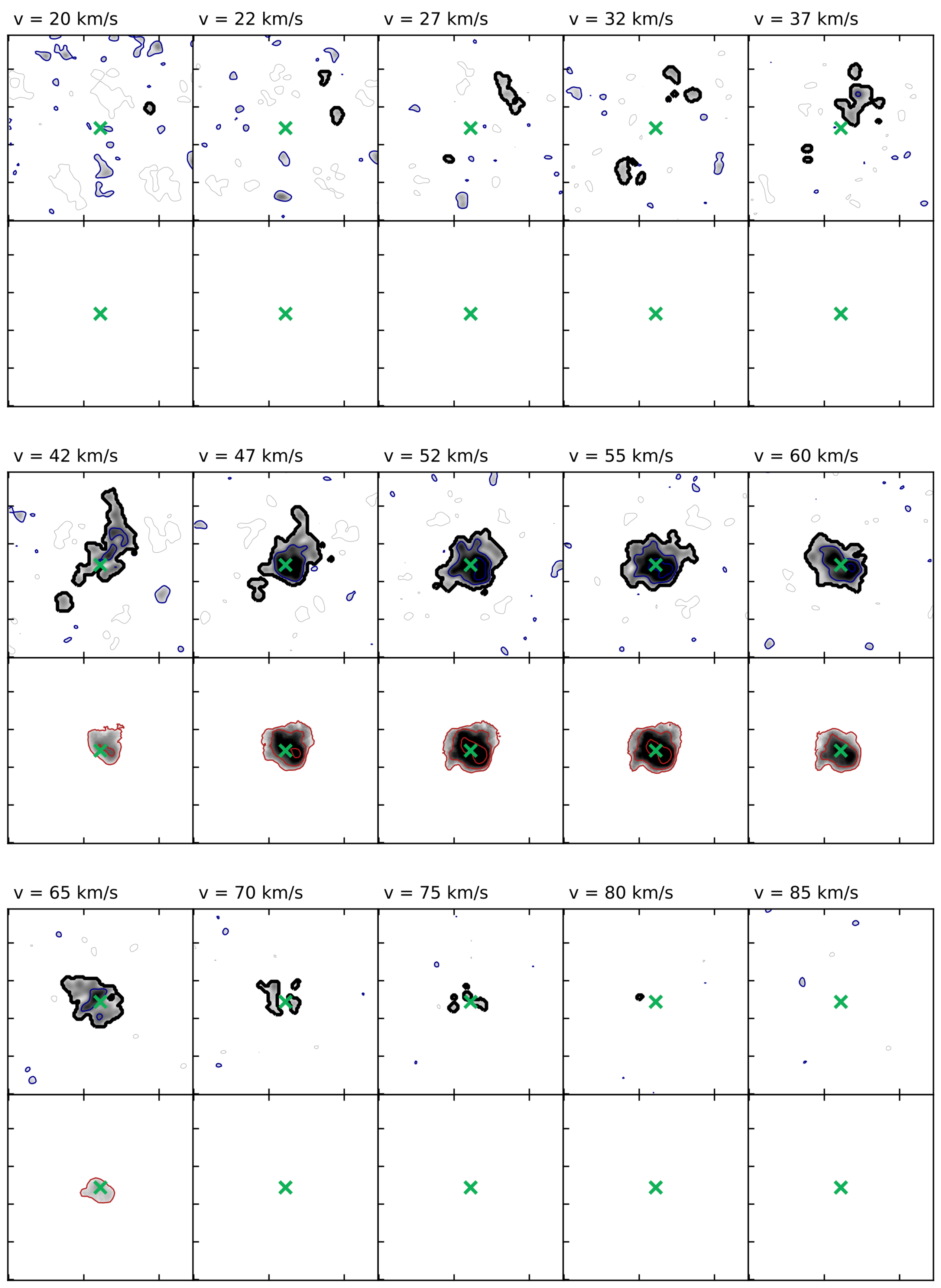

Figure 1: Channel maps for AGC 198606. The top and bottom frames at each velocity correspond to the data and the model, respectively. The thick black contour shows the outline of the mask imposed by 3D-Barolo. Thinner contours appear at levels $2^n\ c_{min}$, where c_{min} = 0.0039 Jy beam^{-1} and n = 0, 1, …, 8.

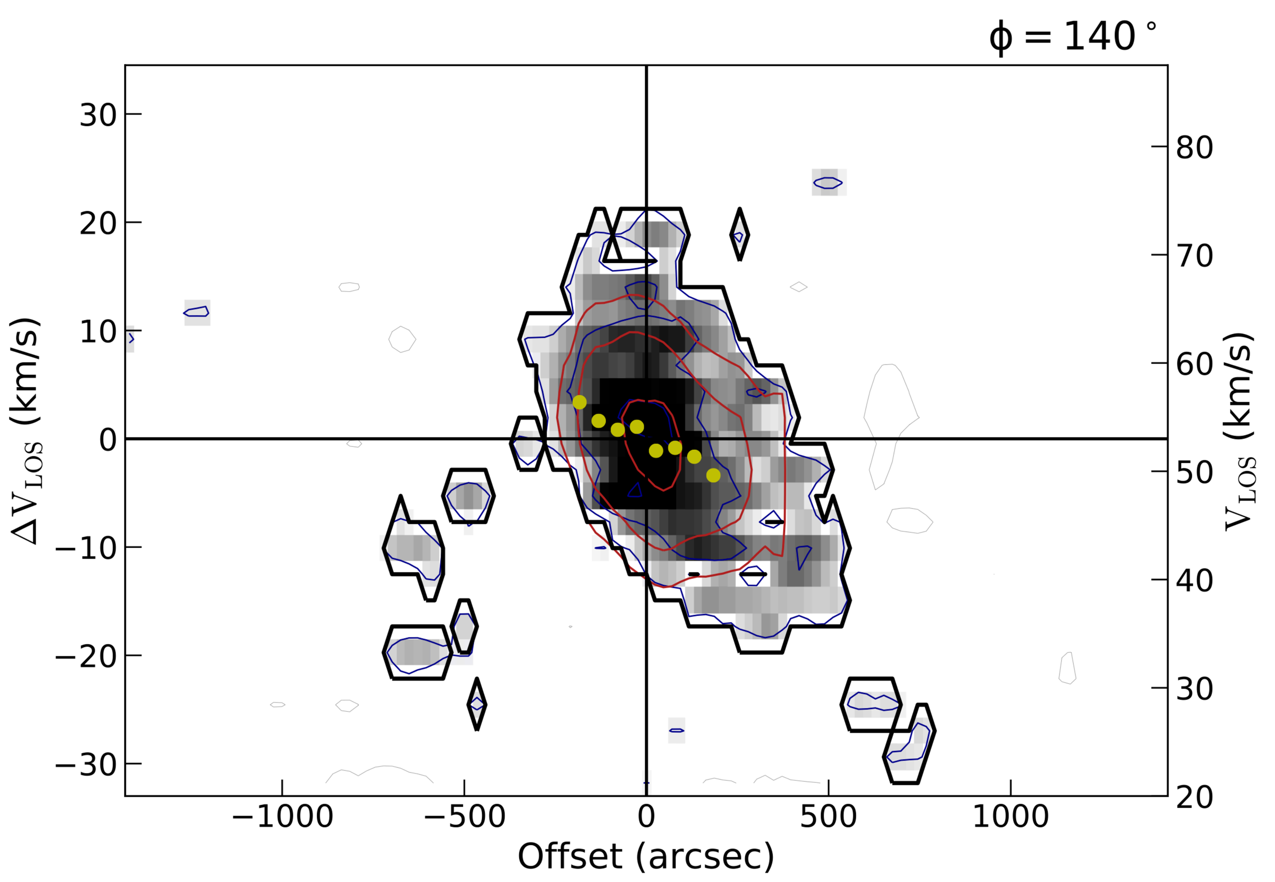

Figure 2: A major-axis position-velocity (PV) slice for AGC 198606. The thick black contour shows the outline of the mask imposed by 3D-Barolo. Thinner counters for the data (blue) and model (red) appear at the same levels as those in Figure 1. Green points show rotational velocity calculated in each ring R built by 3D-Barolo. While the true inclination of this source is uncertain, the magnitude of the projected velocity gradient in this PV slice is approximately 30 km s^{-1} over 13', which, if interpreted as rotation, corresponds to a rotation velocity of order 15 km s^{-1}.

Abstract

The ALFALFA blind extragalactic survey has populated the faint end of the neutral hydrogen (HI) mass function with statistical confidence for the first time. Of particular interest is a subset of the ALFALFA detections, termed "ultra-compact high-velocity clouds" (UCHVCs). These systems, if located within ~1 Mpc, would populate the lowest-mass end of the HI mass function. Subsequent optical imaging has revealed that some of these UCHVCs harbor associated (though sparse) stellar populations, revealing that they may be some of the most extreme galaxies known in the Local Volume, with optical properties akin to ultra-faint dwarf galaxies but with significant neutral gas reservoirs. In this campaign, we investigate the neutral hydrogen properties of six UCHVC candidate galaxies using deep VLA HI spectral line imaging. A companion poster (Paine *et al.*) presents details on the data reduction, imaging, and resulting products. Here, we examine the morphological and kinematic properties of selected sources. We apply the modeling software 3D-Barolo to our deep HI images in order to derive the rotation curve and constrain the inclination angle for each source. Successful modeling allows us to determine the dynamical masses of these objects and thus to consider them in the context of various fundamental scaling relations defined by more massive galaxies.

Methodology: The code 3D-Barolo (3D-Based Analysis of Rotating Objects from Line Observations), presented in Di Teodoro & Fraternali (2015, MNRAS, 451, 3021) fits 3D tilted-ring models of sources to user-provided spectroscopic data cubes. Here, we use reduced and cleaned VLA HI data cubes, smoothed to a consistent circular beam of 105''. Instead of threshold blanking by hand, we take advantage of 3D-Barolo's built-in source finder, imposing signal-to-noise ratio (SNR) and spatial and spectral adjacency cuts in order to isolate the primary cloud in each object.

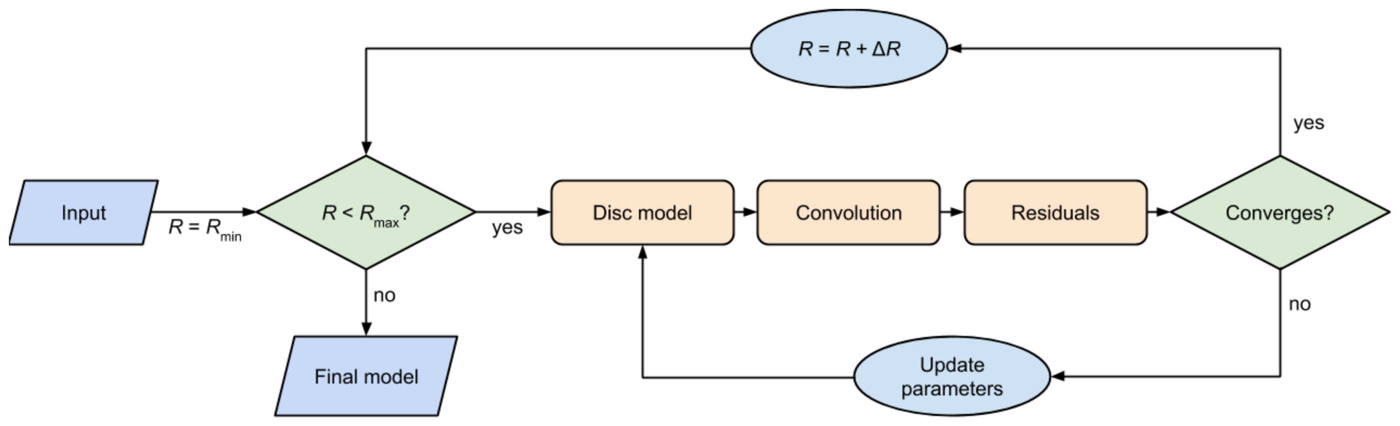

Figure 3: A flowchart depicting the main algorithm run by 3D-Barolo. For each ring R at a defined radius, the algorithm builds a model and convolves it with the observational beam, then compares it to the data pixel-by-pixel. Convergence is achieved through proper minimization of the sum of the residuals between the model and the provided data cube.

Imaging Parameters: In these preliminary models, we impose an inclination i = 35º on all sources; in the future, this will be allowed to vary for optimization. The separation between rings is chosen to be half of the smoothed beam width, or ΔR = 52.5''.

Conclusions: Although we have not yet constrained the inclination for each source using 3D-Barolo, these preliminary models allow us to foresee which objects will be useful to examine further. AGC 215417 and AGC 258237 are as of yet inconclusive in models, given their unusual gas kinematics and lack of spatially and spectrally contiguous emission. However, AGC 198606 and AGC 249525 show promise, as their gas morphology and kinematics are already suggestive of galaxy-like behavior.

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AGC 249525: We impose a systemic velocity V_{sys} = 48 km s^{-1} (Janesh *et al.* 2019) and a position angle PA = 165º, adapted from Adams *et al.* (2013). The primary SNR cut is set to 5σ, the growth cut to 4σ, and the minimum channels for detection to 3.

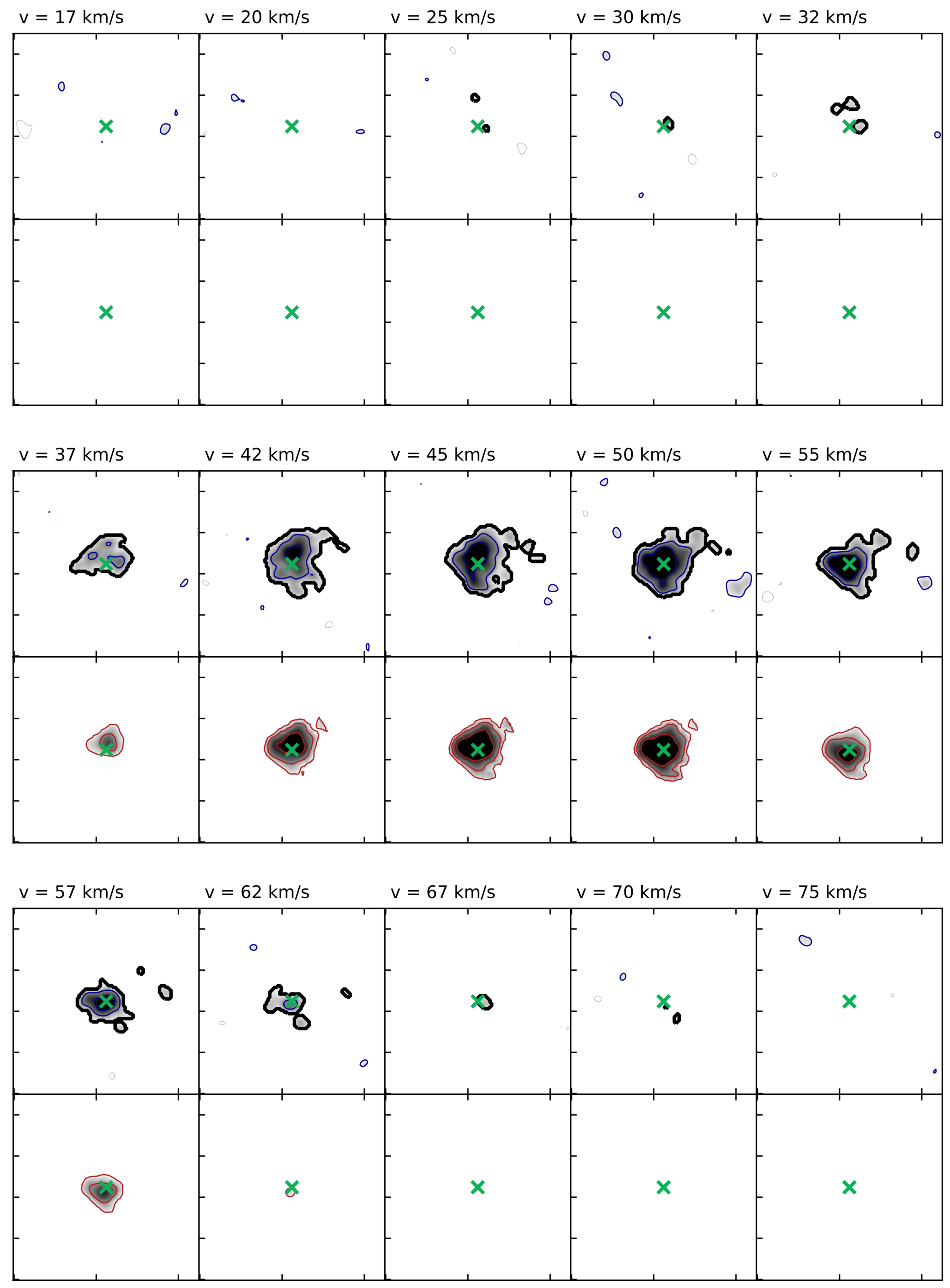

Figure 4: Channel maps for AGC 249525. The top and bottom frames at each velocity correspond to the data and the model, respectively. The thick black contour shows the outline of the mask imposed by 3D-Barolo. Thinner contours appear at levels $2^n\ c_{min}$, where c_{min} = 0.0036 Jy beam^{-1} and n = 0, 1, …, 8.

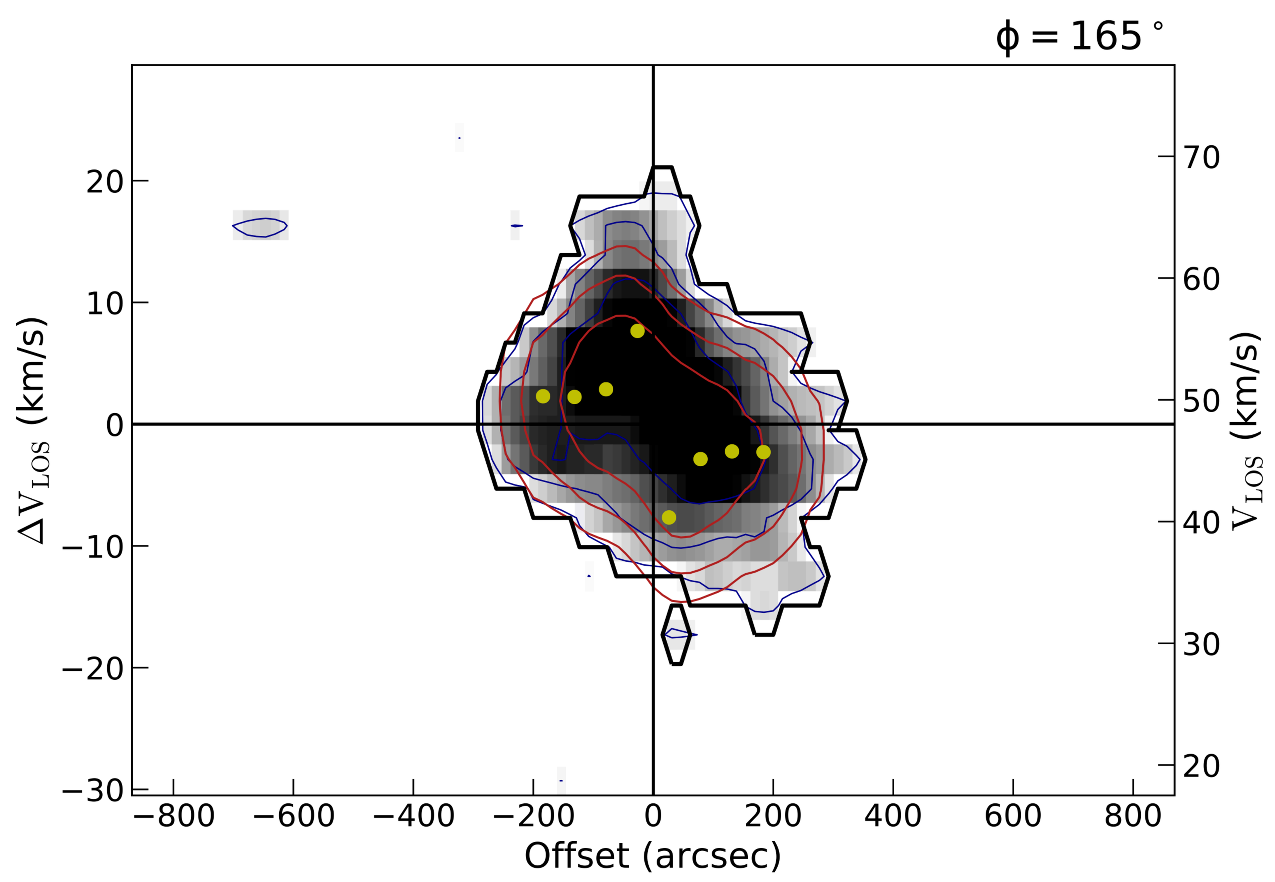

Figure 5: A major-axis position-velocity (PV) slice for AGC 249525. The thick black contour shows the outline of the mask imposed by 3D-Barolo. Thinner counters for the data (blue) and model (red) appear at the same levels as those in Figure 4. Green points show rotational velocity calculated in each ring R built by 3D-Barolo. While the true inclination of this source is uncertain, the magnitude of the projected velocity gradient in this PV slice is approximately 30 km s^{-1} over 10', which, if interpreted as rotation, corresponds to a rotation velocity of order 15 km s^{-1}.