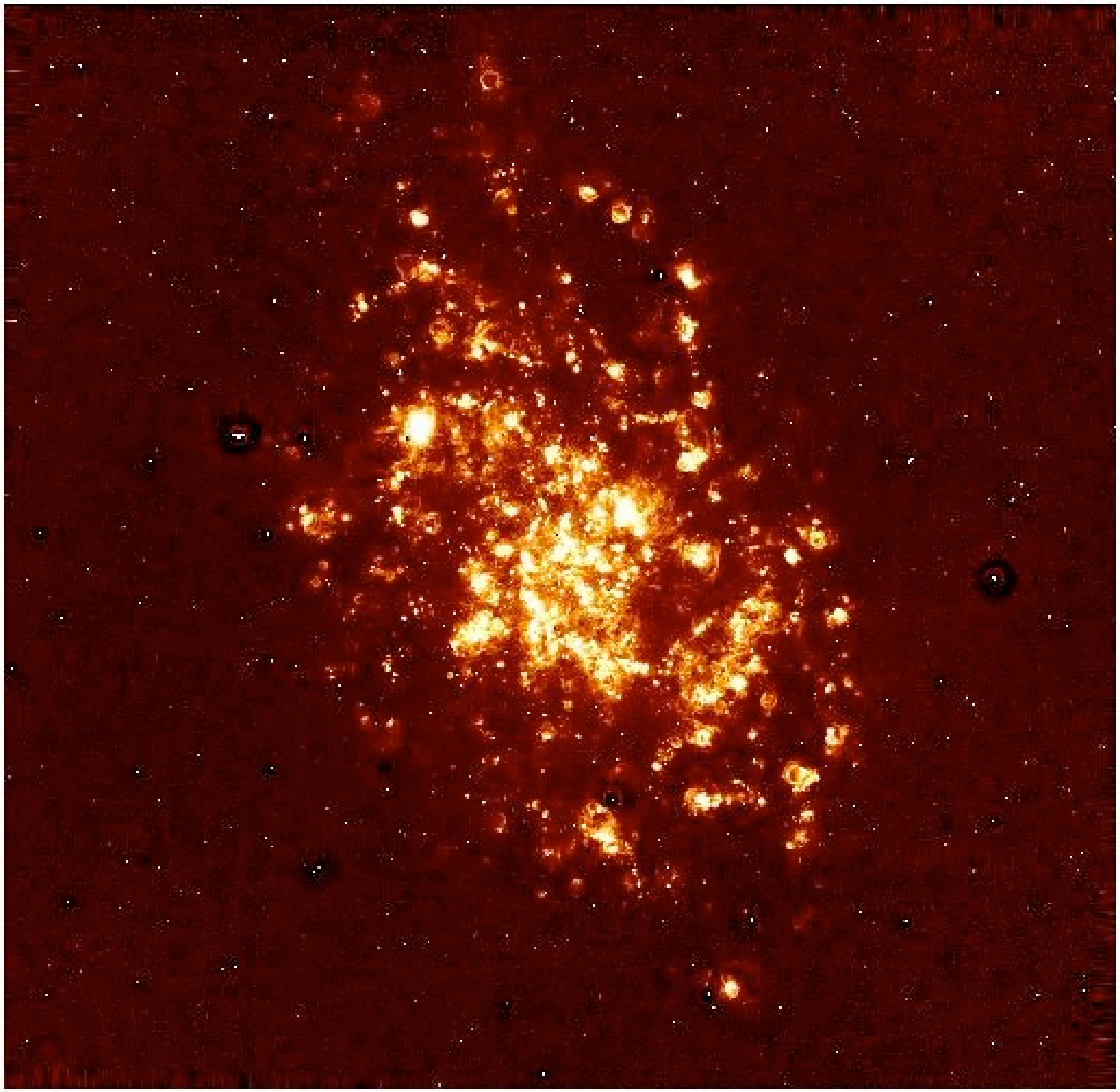
Ionized Gas in and Around the Bar



- Summary slide
- Evidence for bar
- HII distribution
- Diffuse ionized gas: shocks or photo ionization?
- Summary

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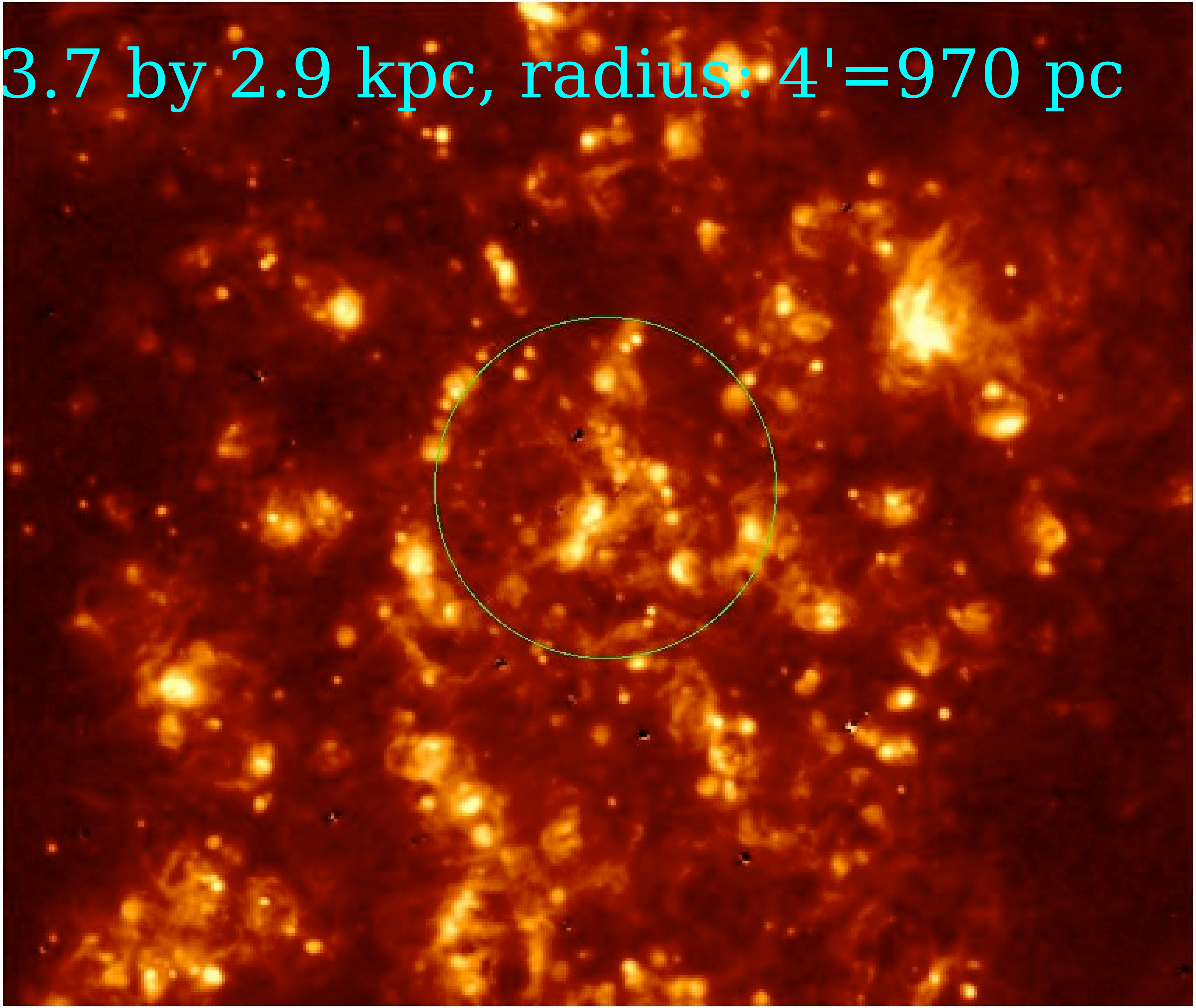
Ionized Gas, overview

- $L_{H\alpha} = 2.7\ 10^{40}$ erg/s
- Scalelength: 1.8 – 2.0 kpc
- Ionized gas mass and column density: dominated by DIG but unknown

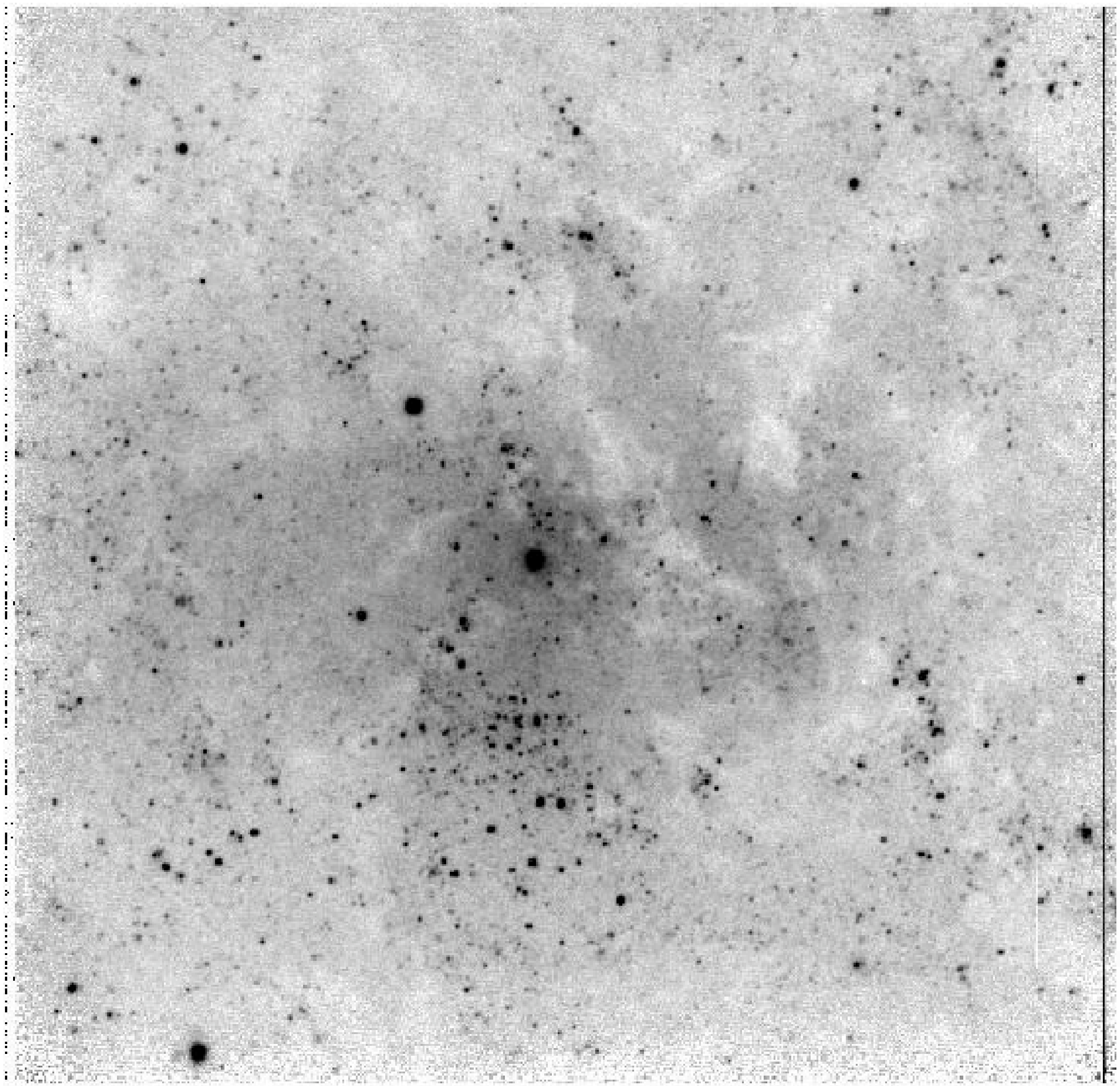
- DIG fraction: 43%
- DIG surface covering factor: 50 - 100%
- DIG ionization: 50/50 leakage/field stars


3.7 by 2.9 kpc, radius: 4'=970 pc

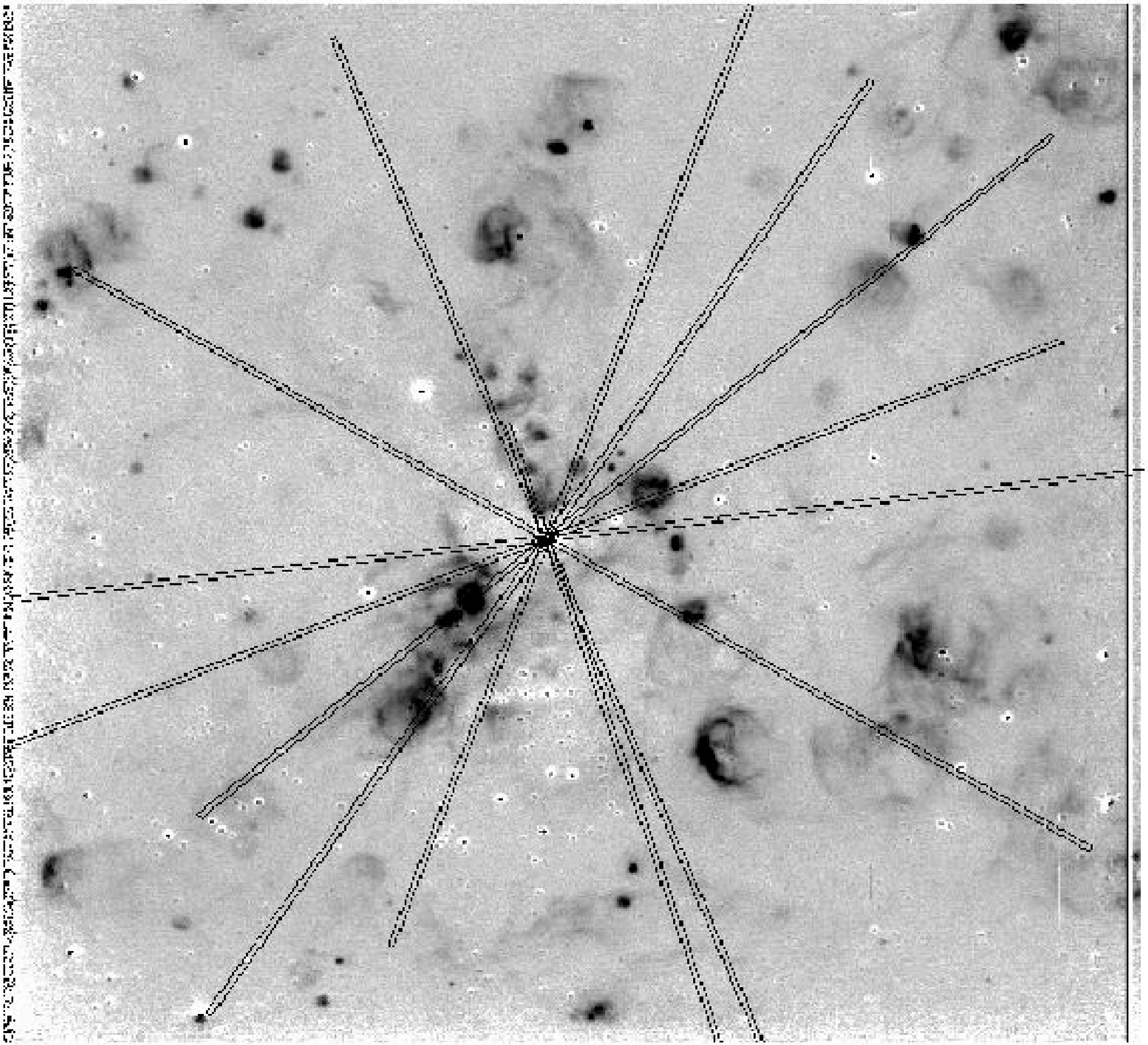
ARC 3.5-m telescope data

- Long slit spectroscopy of emission-line gas in various directions, 295” slit length, 1.5”w idth
- Gas, stellar kinematics and emission line ratios
- Spectral resolution from 2-4 Angstroms
- Images in various filters

Blue continuum, central 1 kpc



Central 1kpc, Hα



The case for a (weak) bar

- Bar causes streaming motions of gas (Roberts & Van Albada 79)
- Much of velocity patterns in gas in M33 consistent with bar aligned close to minor axis
- Example: velocity patterns observed in barred galaxies (e.g. Buta, NGC 6300)

and position angle of the ascending node 90° (see Burkhead and Burgess 1973). Techniques developed in our analysis make it possible to achieve a gas density distribution in these steady-state models with practically infinite resolution. Here the distribution of gas is displayed with a finite resolution of 50 pc on a grid of 480 × 480 cells. Most prominent is the sharp ridge of enhanced gas density which delineates the shock. The gas density increases somewhat before the flow

central component. Comparison of the two panels shows the important result that the gas is more strongly concentrated toward the offset shocks in model T + S than in model T. This enhanced sharpness of the gas density distribution in the bar region results from the larger difference between the actual and critical levels of forcing (see Fig. 9) due to the presence of the spheroidal component and the associated inner Lindblad resonance in model T + S. In the outer regions,

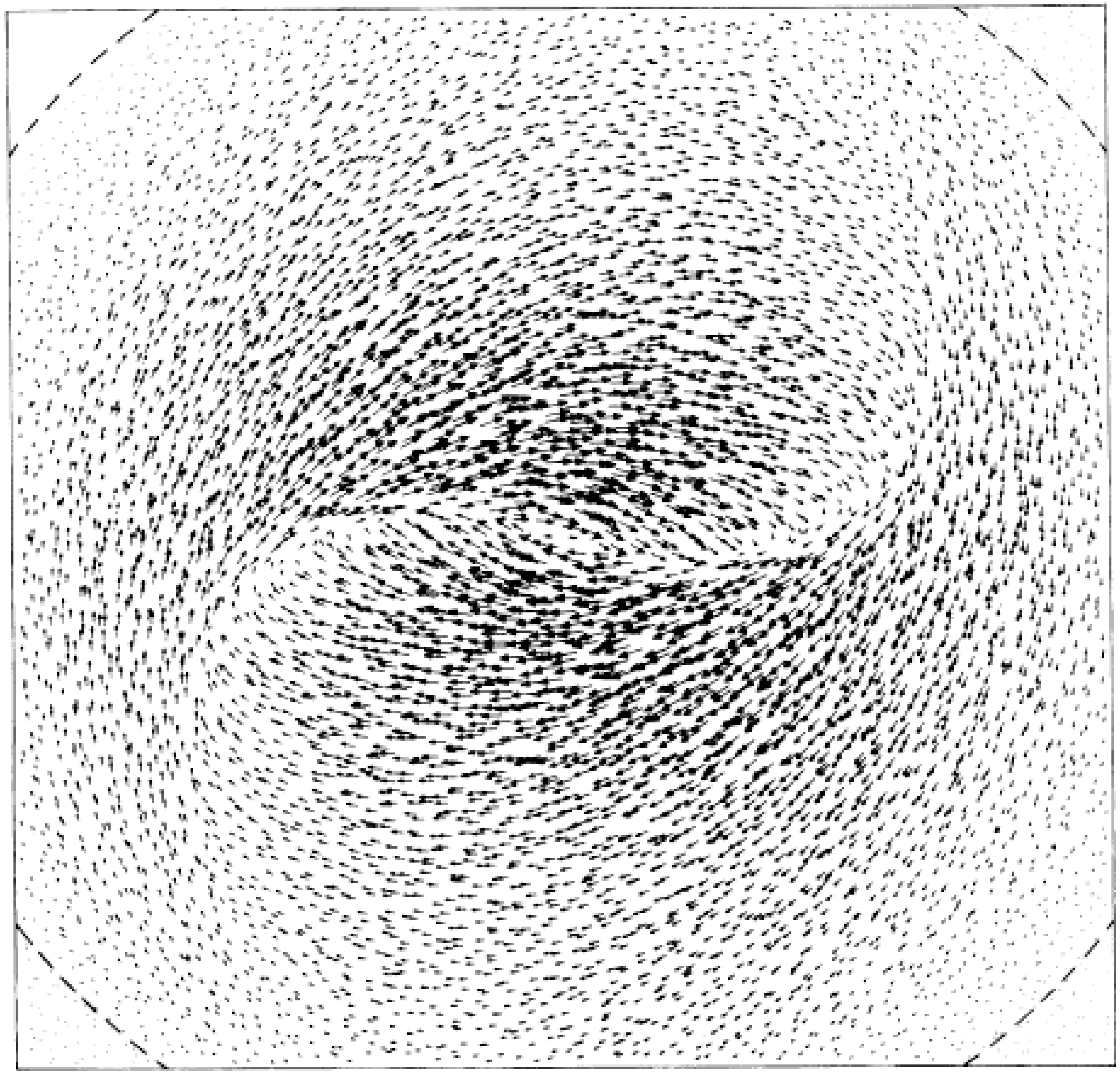
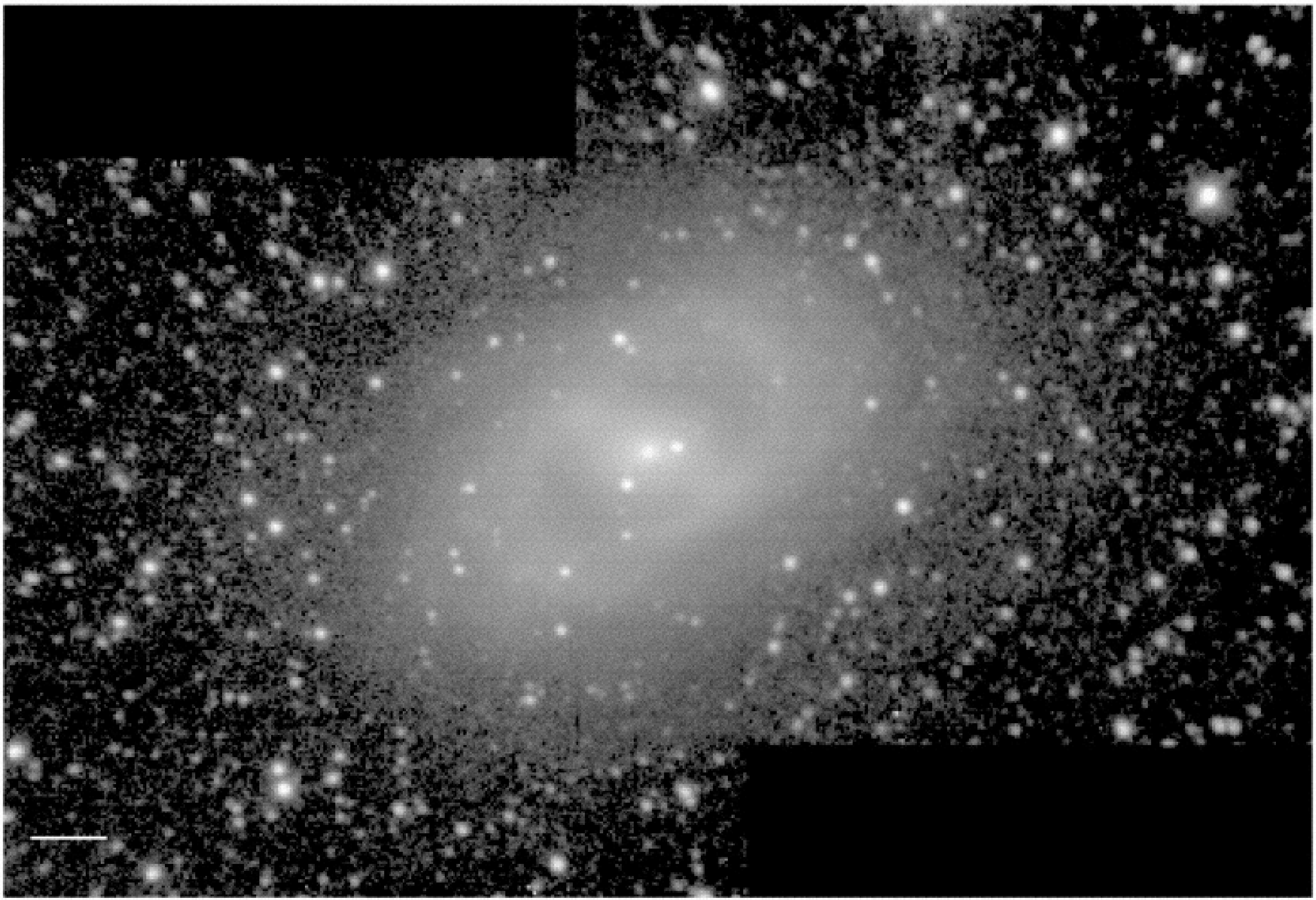
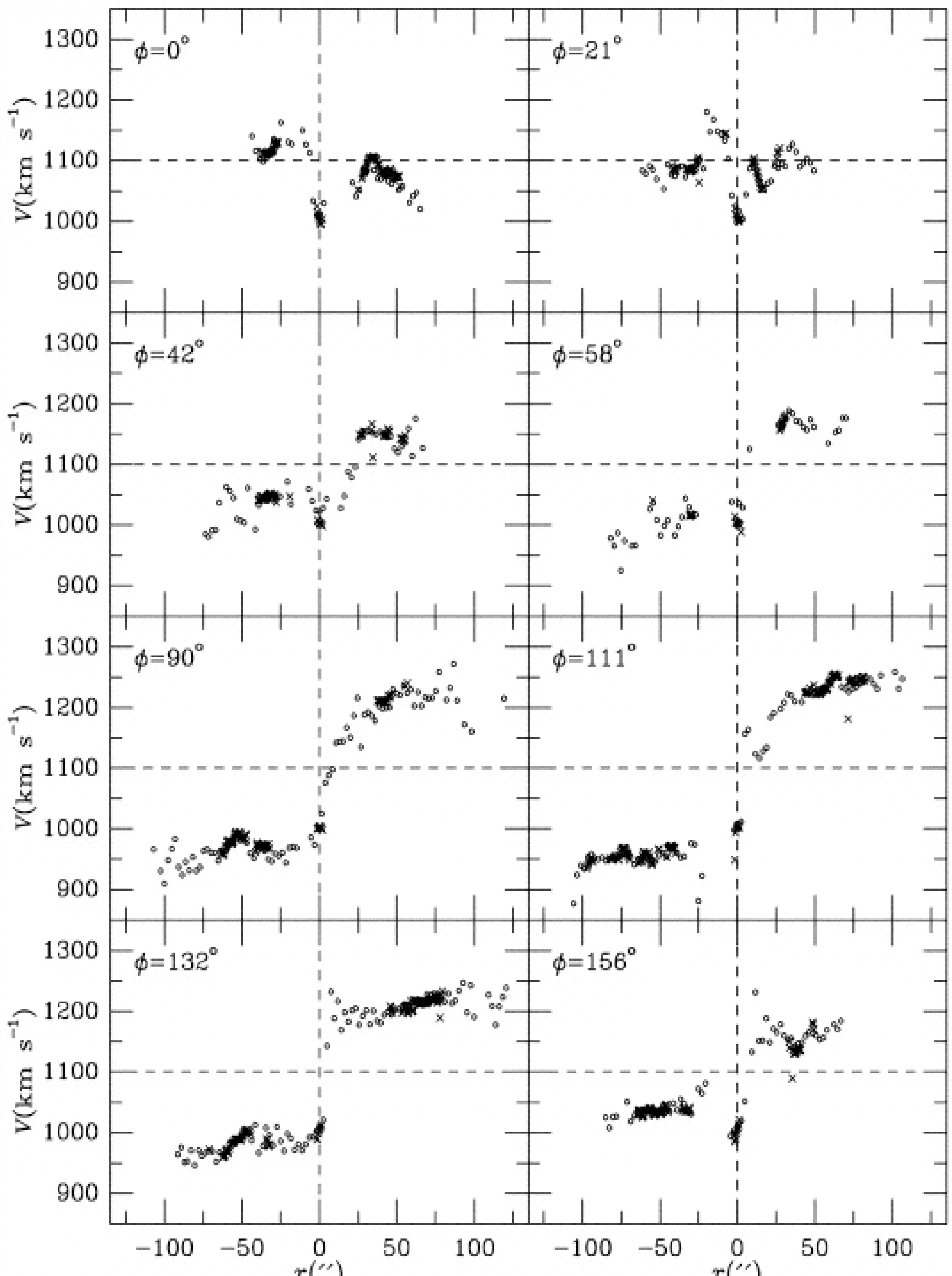


FIG. 12.—Map of the velocity field of the steady-state model T + S (corresponding to the gas streamlines in Fig. 6), delineated by some 6400 velocity vectors on a grid of 80 × 80 cells. To this degree of resolution the large-scale shocks along the bar are detectable.

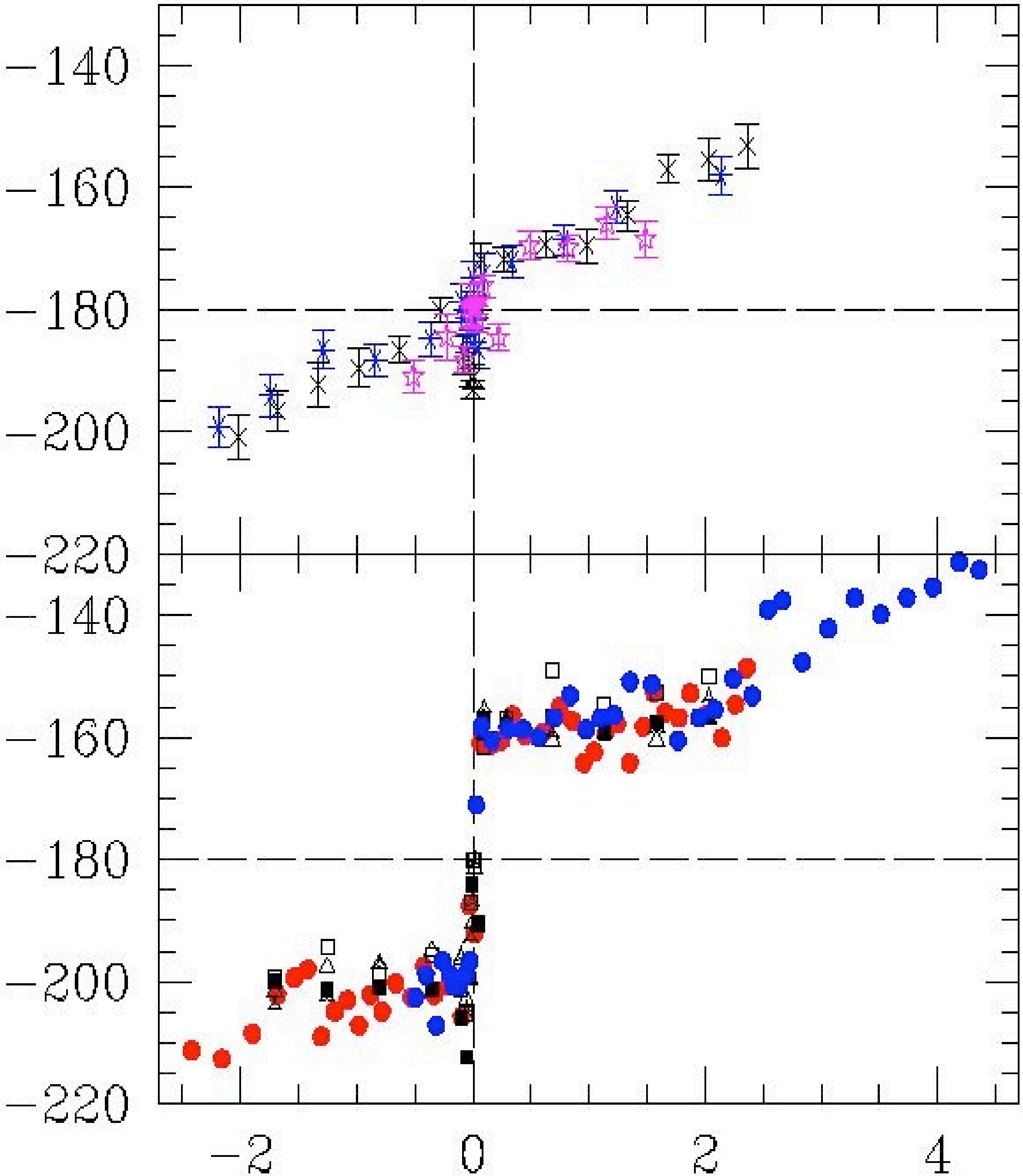
Barred spiral NGC6300 (Buta etal 2001)



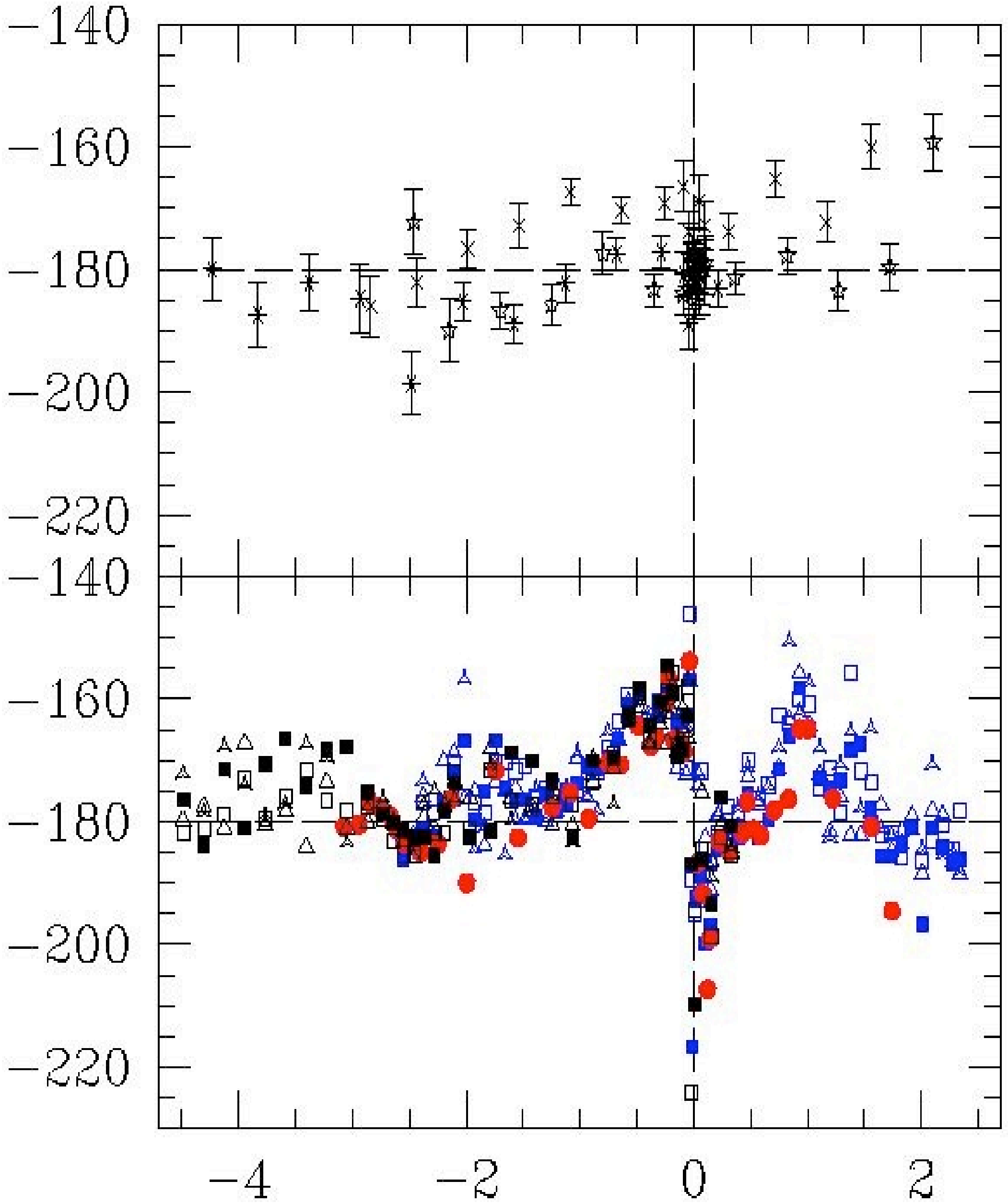


φ=0°
φ=21°
φ=42°
φ=58°
φ=90°
φ=111°
φ=132°
φ=156°
V(km s⁻¹)
r(″)

M33: Observed major axis velocities for stars and gas

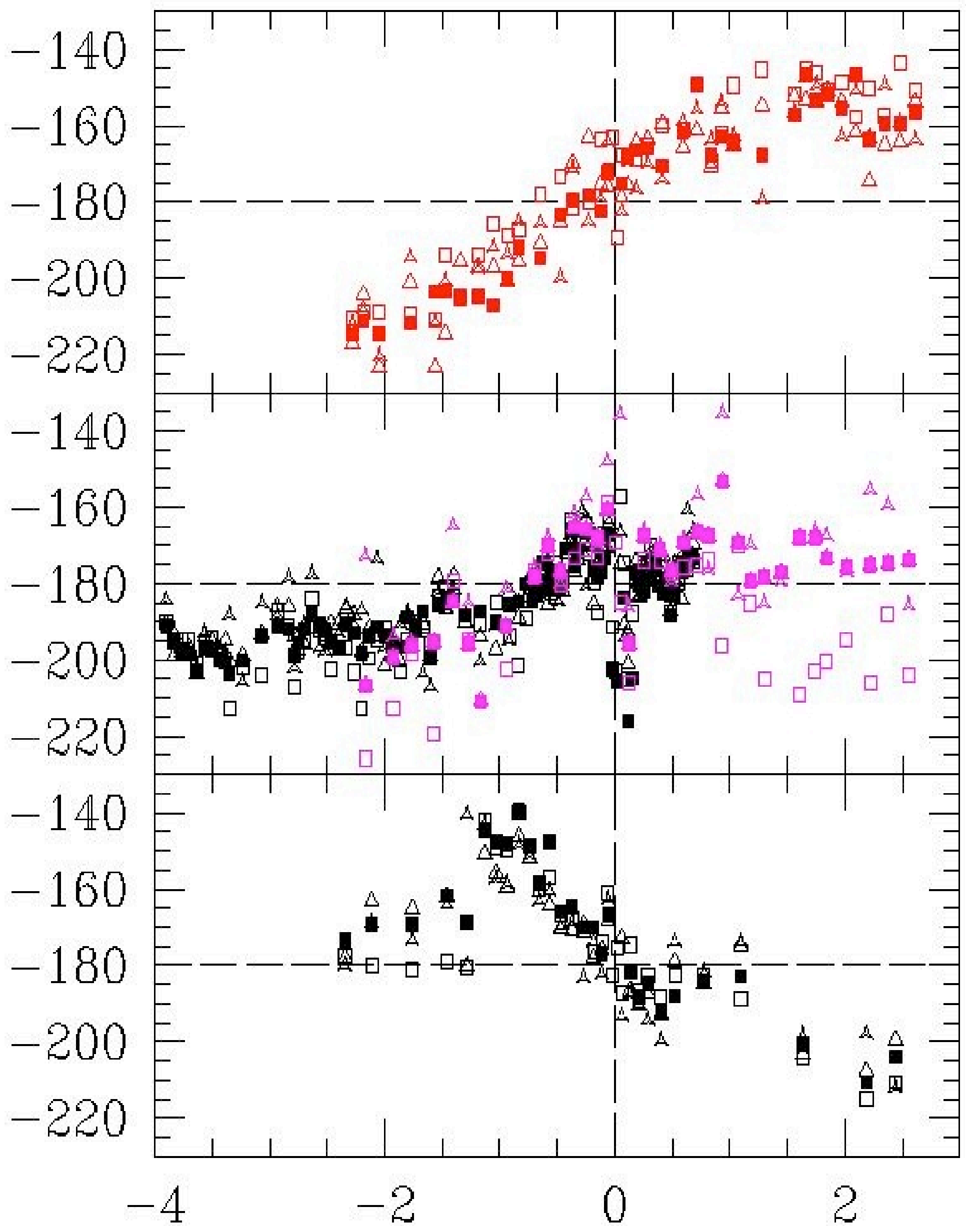


M33: Minor axis velocities



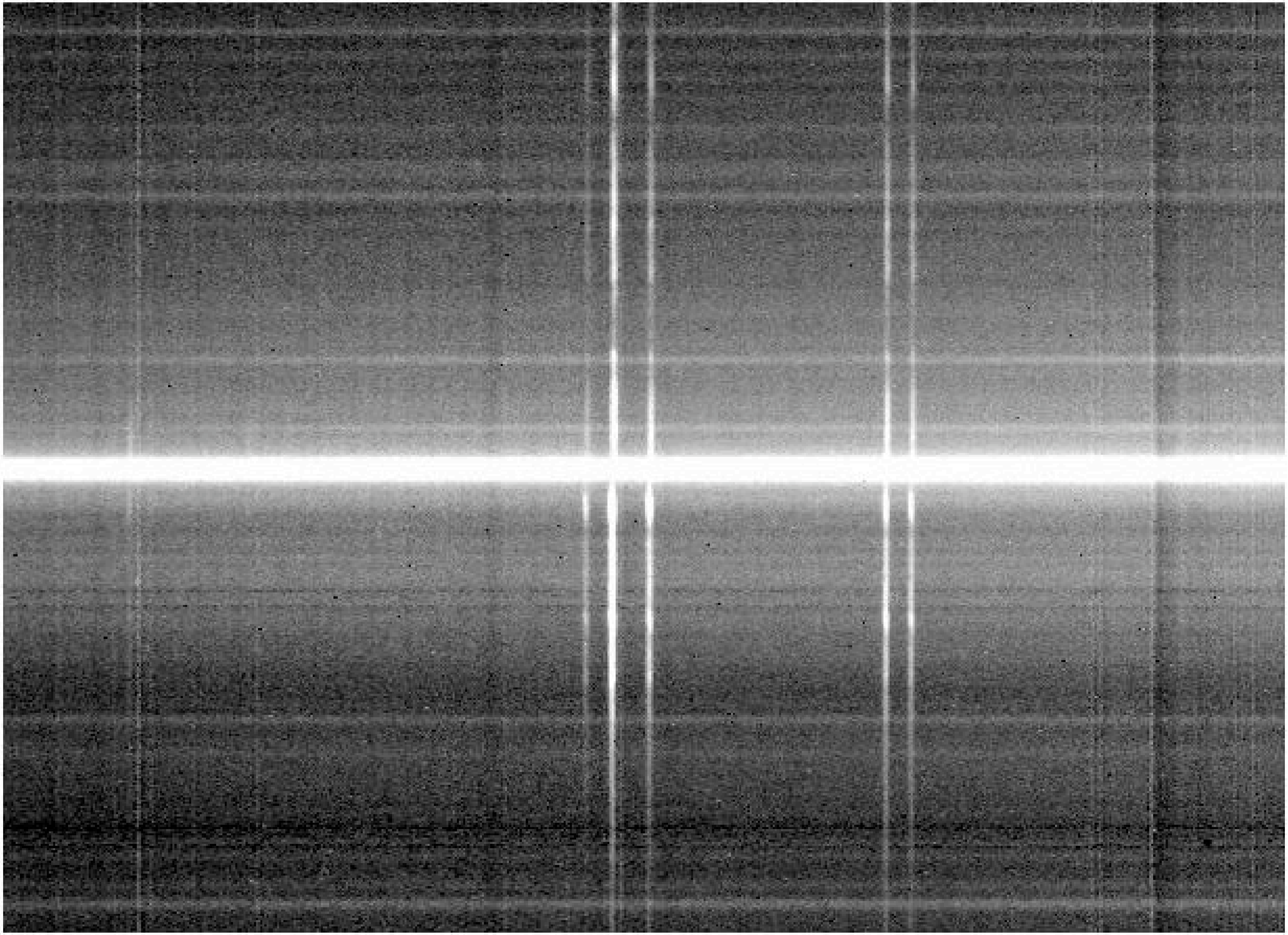
- Stars top, gas bottom
- Clearly non-circular motions
- Out to 1-1.5' (240-360 pc)

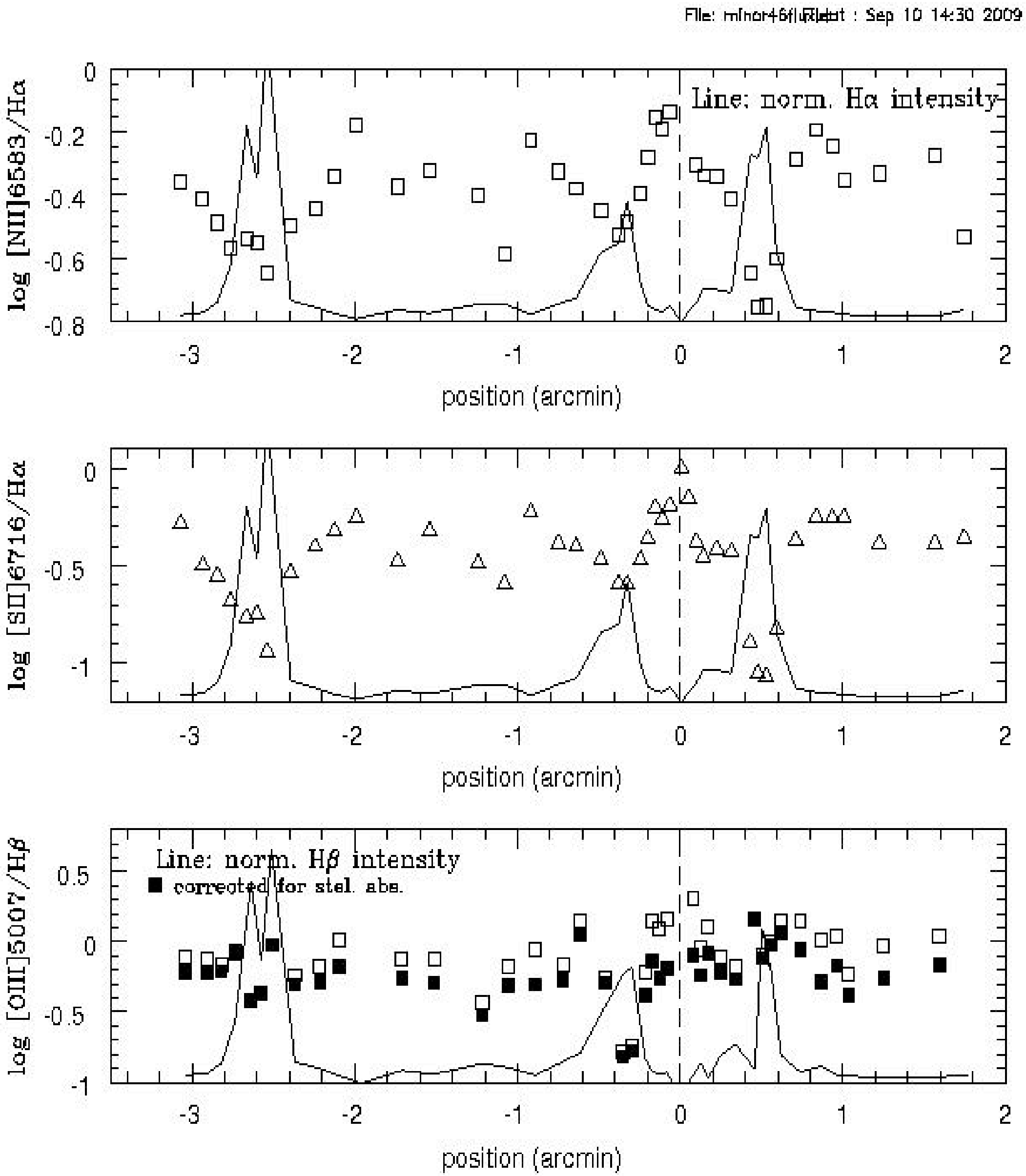
M33: velocities at PA=59, 96, 146



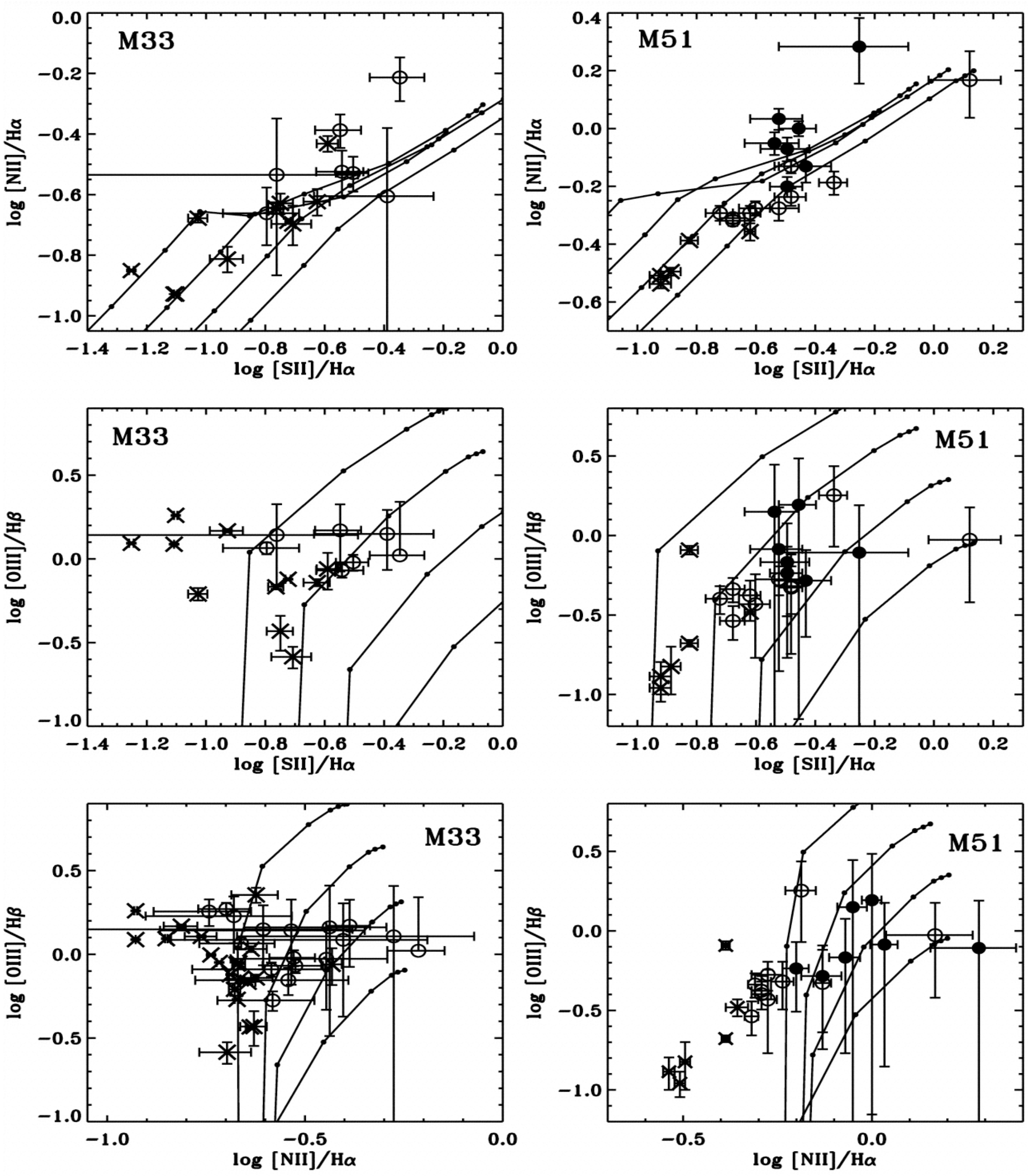
- PA=96 was suspected bar direction
- PA59 and PA146 should be each other's opposite
- Velocities reach equal amplitudes as on major axis, and are not constant
- Bar velocities similar to minor axis

Example red spectrum, major axis

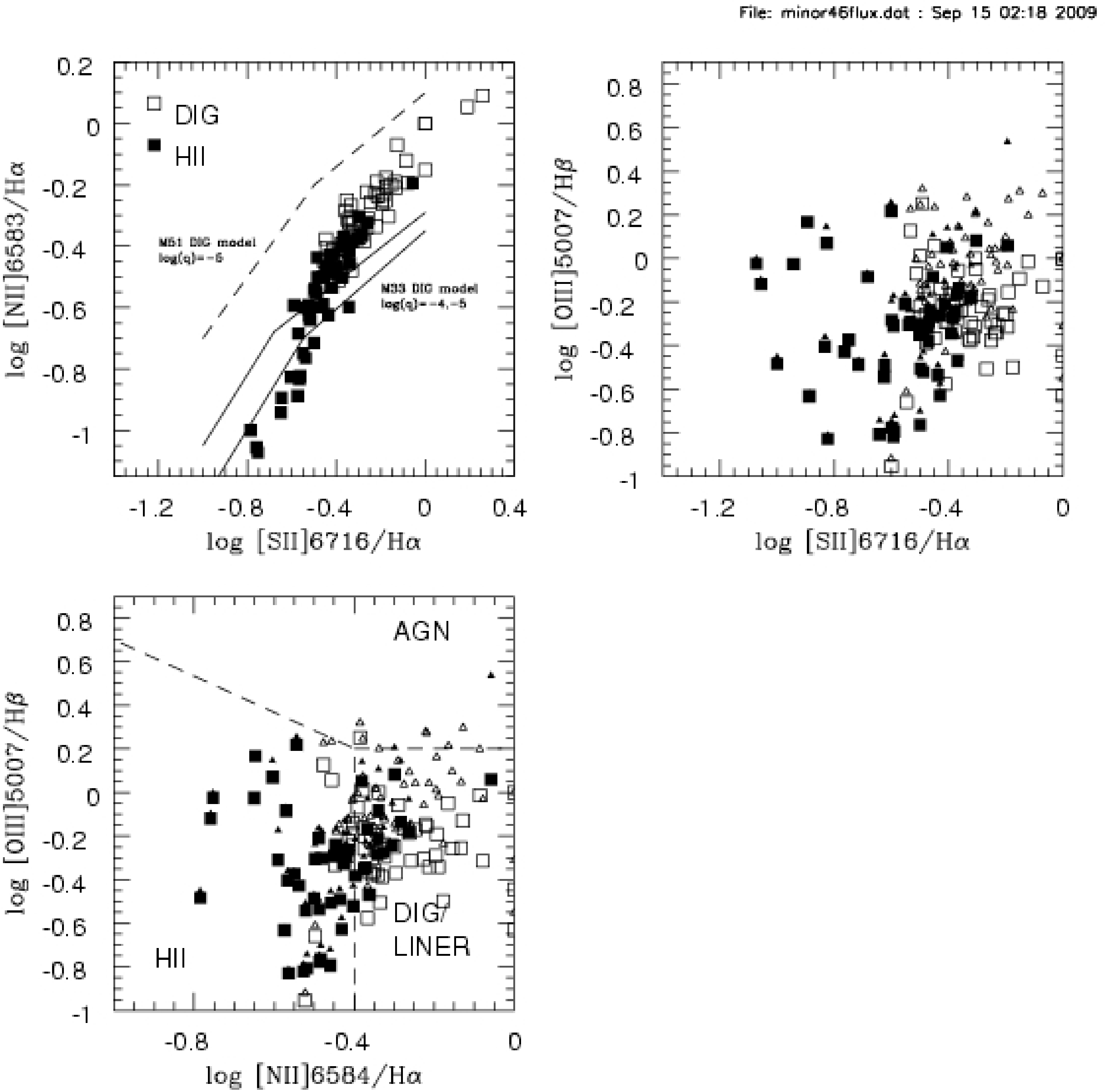




Minor axis, emission line ratios



M33 and M51 excitation diagram for disk HII and DIG, with “leaky HII region” ionization models (Hoopes & Walterbos 2003)



Central region: Line ratio (excitation) diagrams

Conclusions and future

- M33 gas kinematics point at weak oval or bar
- Emission line ratios in central DIG consistent with photo ionization, metallicity sub-solar
- Improvements in understanding of DIG requires: He lines, T_e, line widths
- Measuring bar parameters requires 2-D data for stellar and gas kinematics
- Bulge, bar, oval morphology? Need deeper IR images, better light decomposition