OUR CHANGING VIEW OF THE BLUE COMPACT DWARF NGC 2915

E. C. ELSON

UNIVERSITY OF CAPE TOWN

SUPERVISED BY:

PROF. W. J. G. DE BLOK

PROF. R. C. KRAAN-KORTEWEG

PANORAMIC RADIO ASTRONOMY

GRONINGEN 2009

SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

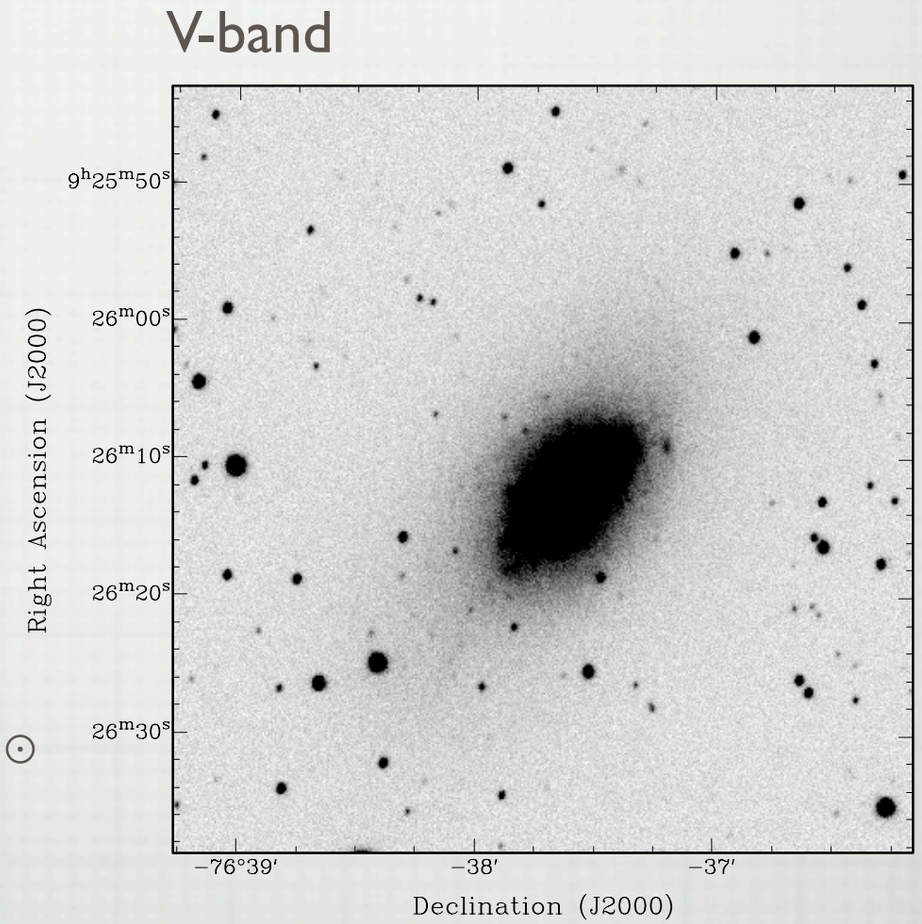
University of Cape Town

TALK OUTLINE

- ☐ An introduction to NGC 2915
- ☐ What is so strange about NGC 2915?
- ☐ Attempts at explaining the existing data
- ☐ New observations of NGC 2915
- ☐ A different outlook for NGC 2915
  - ☐ Modelling the central dynamics
  - ☐ Is NGC 2915 really so strange after all?
- ☐ Conclusions

INTRODUCTION TO NGC 2915

- Classified as a BCD.
- Distance: 3.78 Mpc (TRGB). 1″=18.3 pc
- 2 distinct stellar populations:
  - A lumpy blue core population
  - An diffuse red population
- Stellar component mass ~ 4.8×10^8 $M_\odot$
- HI morphology: late-type spiral

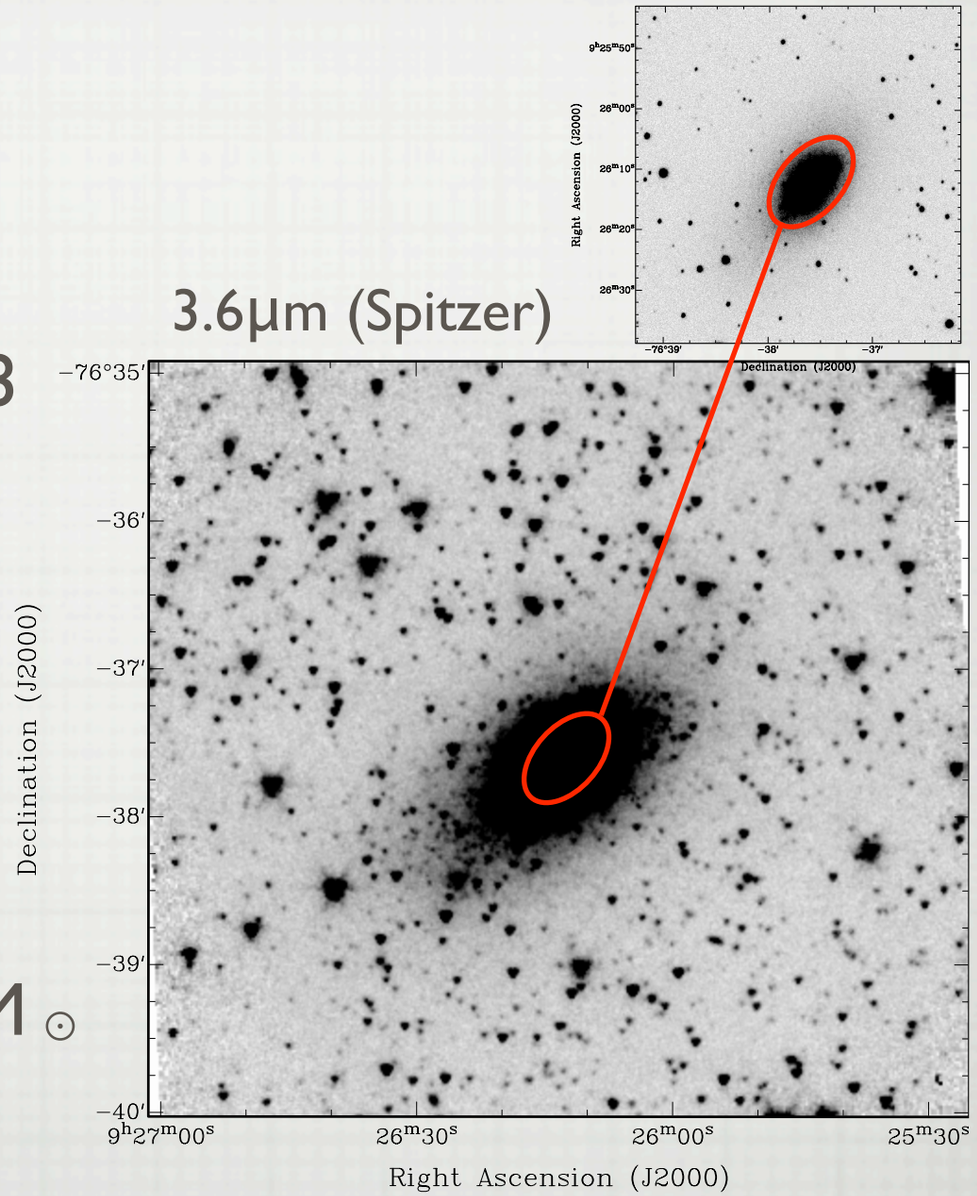


References: Meurer et al. 1994, 1996;

Karachentsev et al., 2004

INTRODUCTION TO NGC 2915

- Classified as a BCD.
- Distance: 3.78 Mpc (TRGB). 1″=18.3 pc
- 2 distinct stellar populations:
  - A lumpy blue core population
  - An diffuse red population
- Stellar component mass ~ 4.8×10^8 $M_\odot$
- HI morphology: late-type spiral

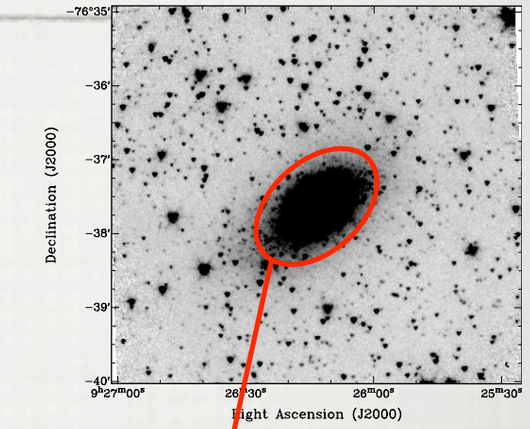


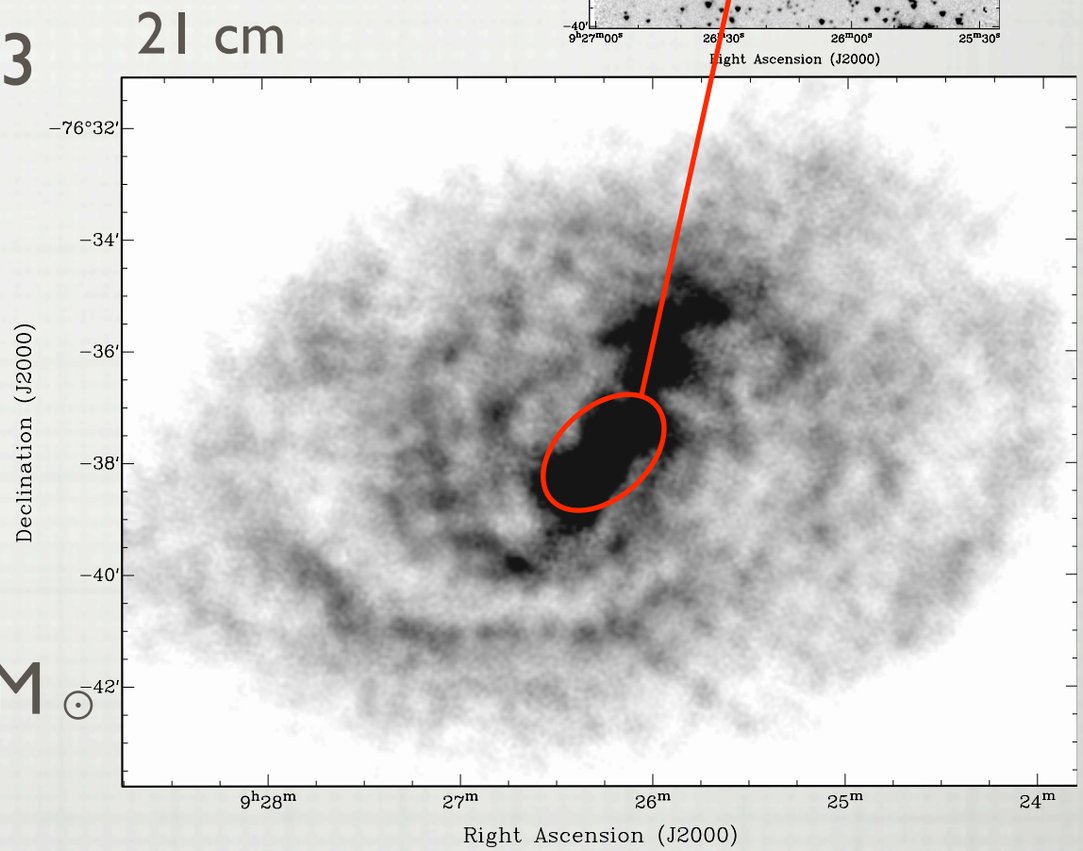
References: Meurer et al. 1994, 1996;

Karachentsev et al., 2004

INTRODUCTION TO NGC 2915

- Classified as a BCD.
- Distance: 3.78 Mpc (TRGB). 1″=18.3 pc
- 2 distinct stellar populations:
  - A lumpy blue core population
  - An diffuse red population
- Stellar component mass ~ 4.8×10^8 $M_\odot$
- HI morphology: late-type spiral





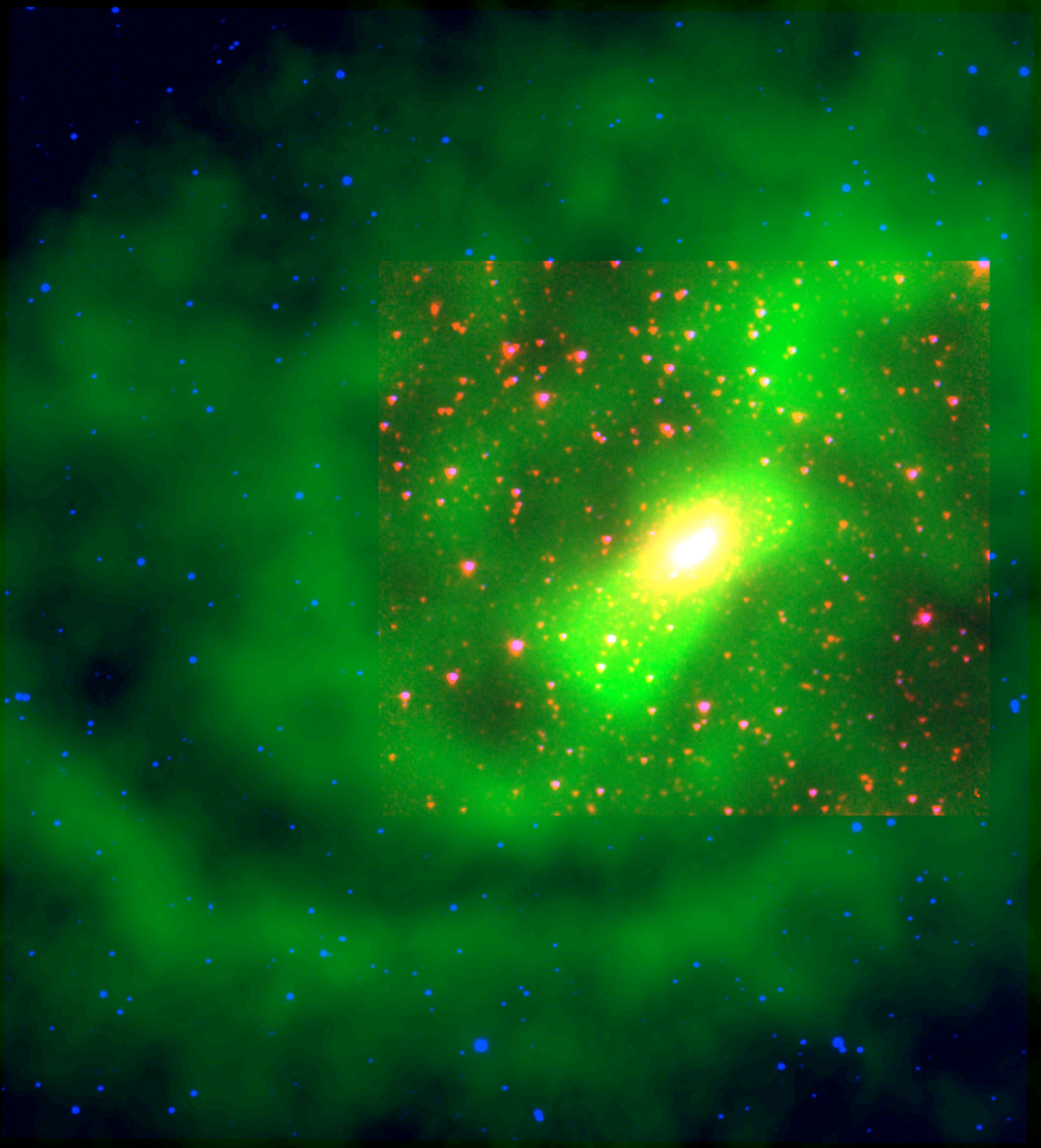
References: Meurer et al. 1994, 1996;

Karachentsev et al., 2004

Young stars

Old stars

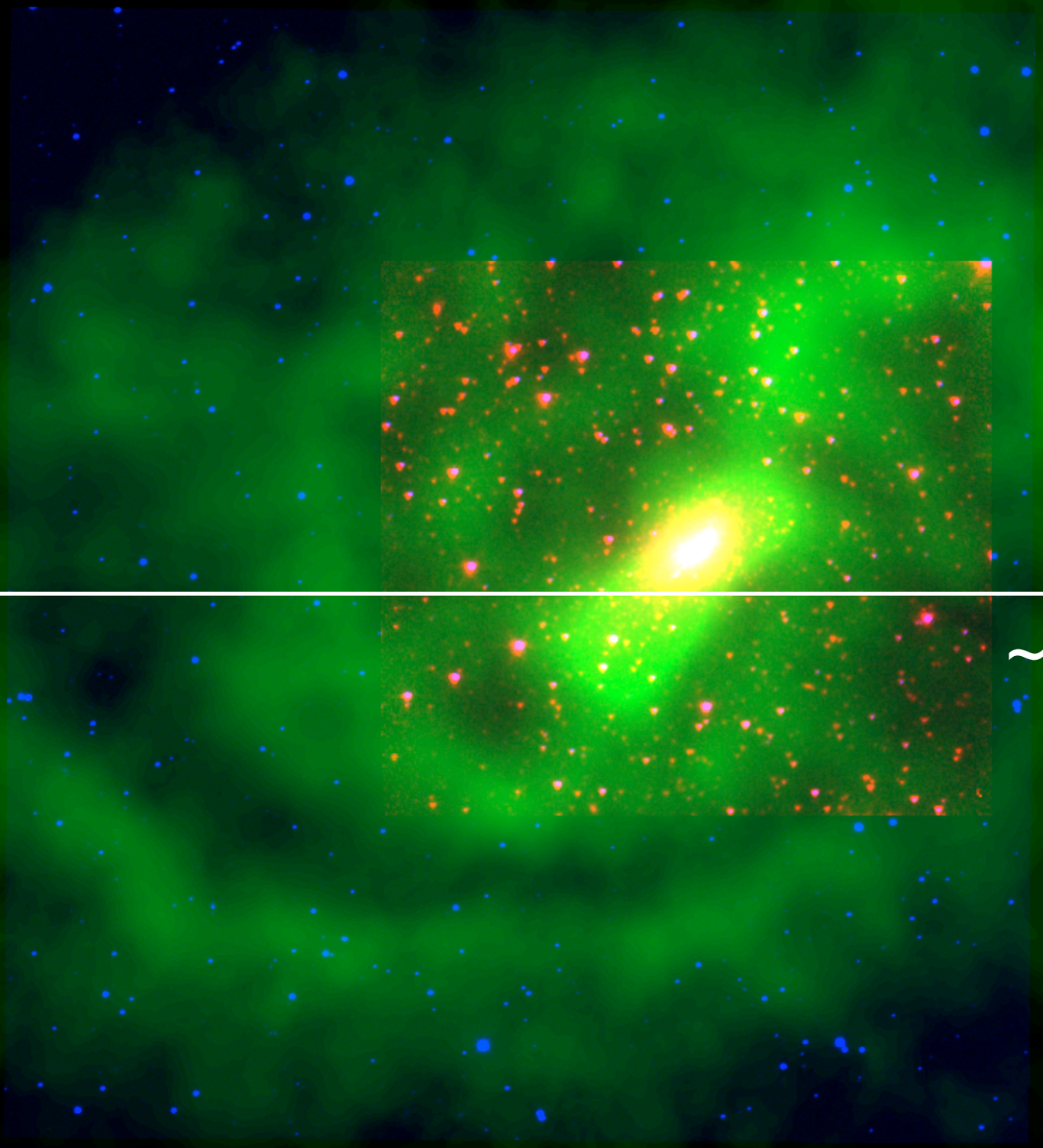
HI gas



Young stars

Old stars

HI gas



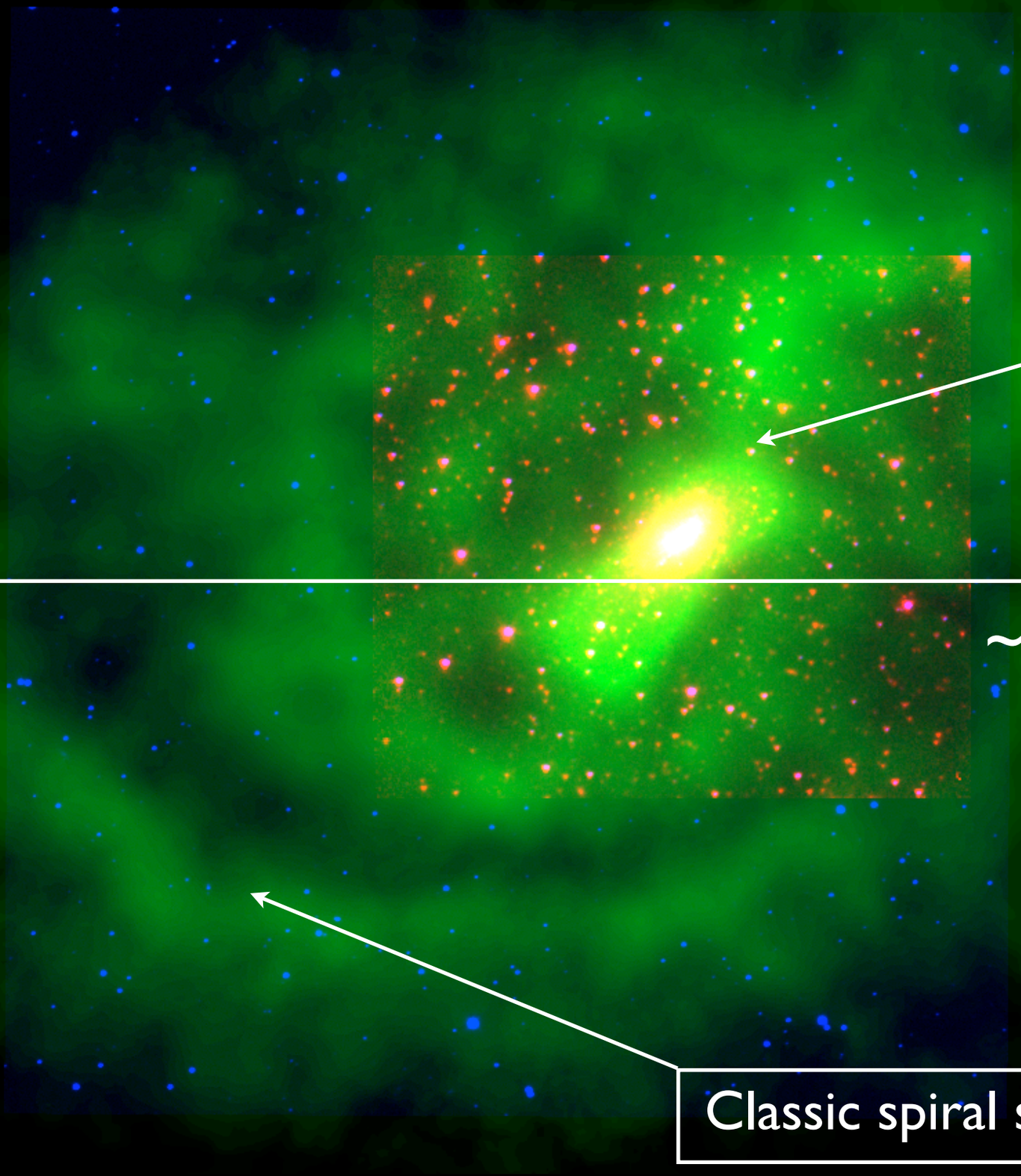
~ 20 kpc

Young stars

Old stars

HI gas

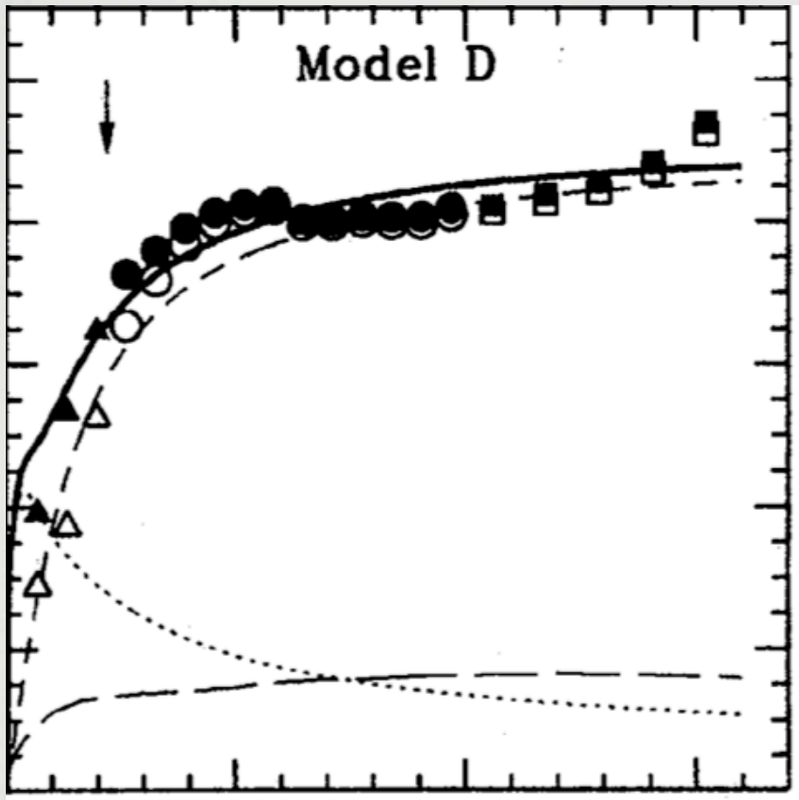
No stars in HI disk?



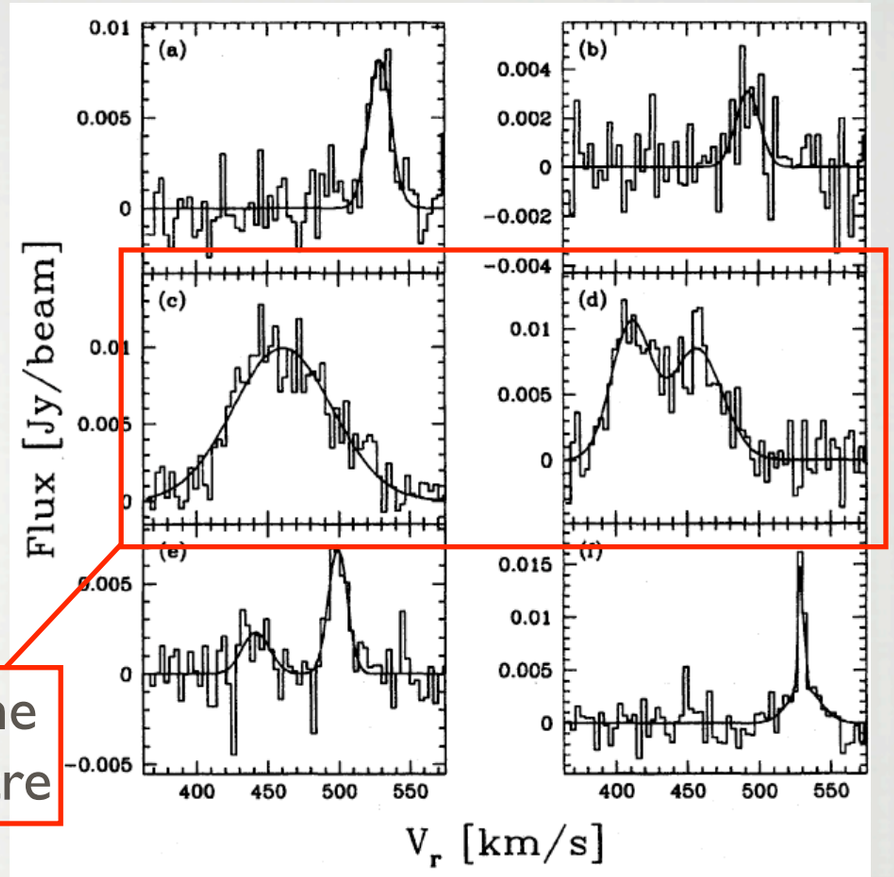
HI bar?

~ 20 kpc

Classic spiral structure?



$M_{tot}/L_B=76\ (M/L_B)_\odot$



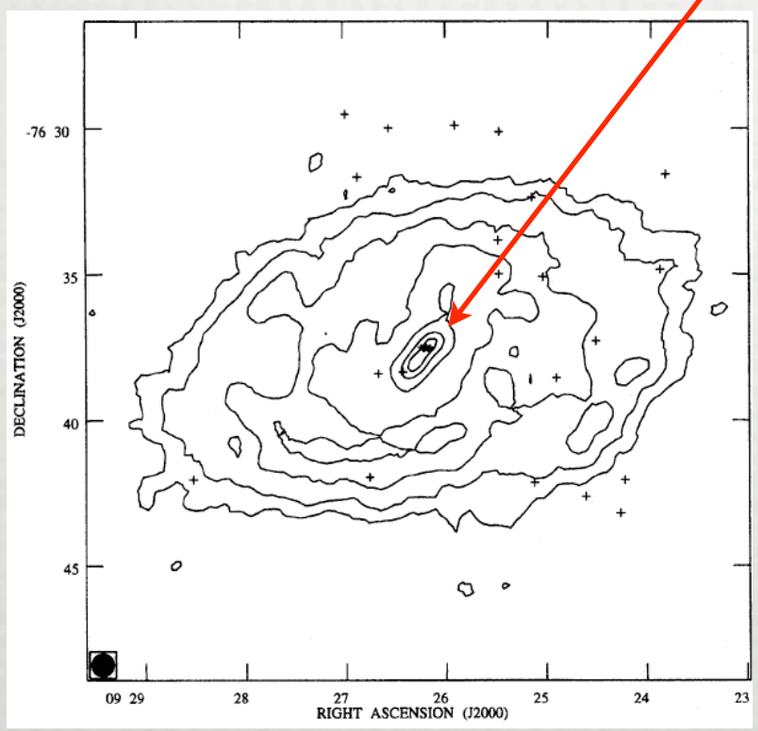
Broad and split line profiles near centre

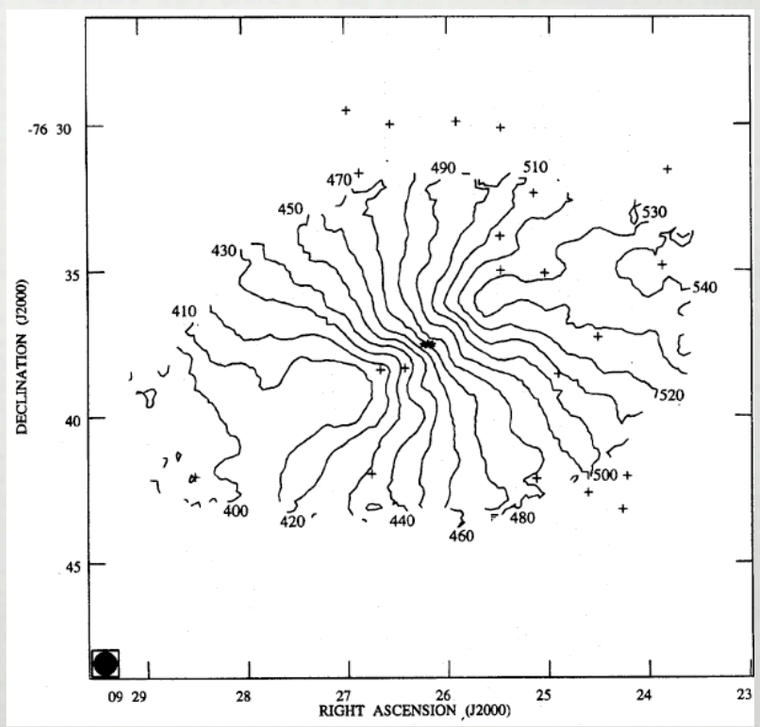
Meurer et al. 1996

Integrated column density map

Velocity field

HPBW=45″x45″





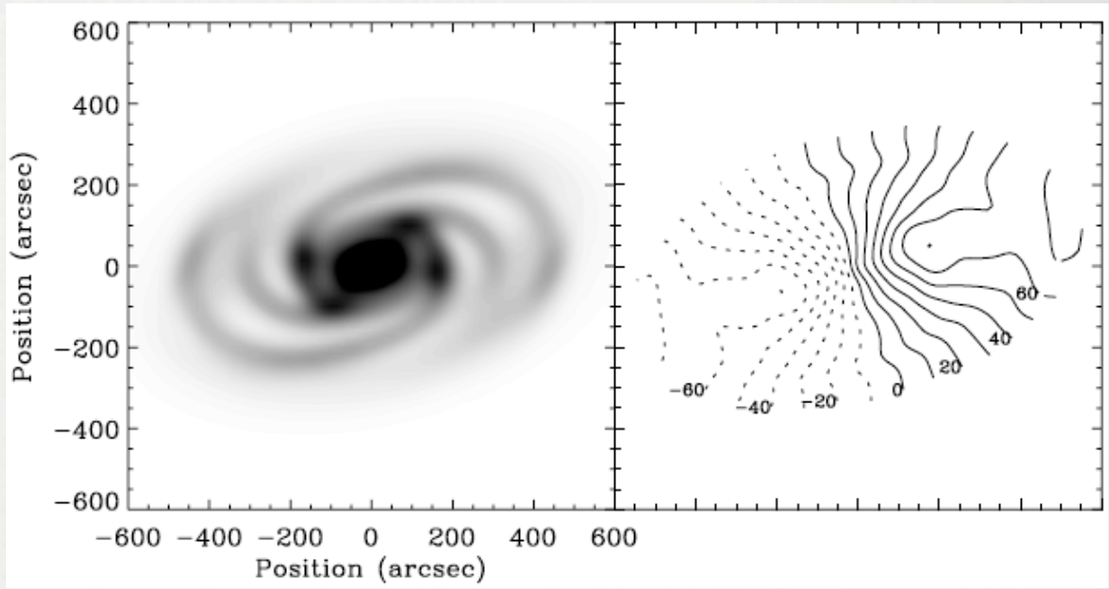
EXPLAINING THE OBSERVATIONS

- Commonly accepted mechanisms are unable explain the existence of the observed structure:
  - Gravitational interaction: NGC 2915 seems to be isolated.
  - Bar-driven spiral arms: required (unseen?) bar is far too massive ($\sim 5 \times 10^9 M_\odot$).
  - Swing amplification of spiral density waves: far too inefficient at all radii.

References: Bureau et al. (1999), Masset & Bureau (2003)

EXPLAINING THE OBSERVATIONS

- Alternative excitation mechanisms:
  - Rotating tri-axial DM halo: fast figure rotation required.
  - Heavy disk: Reproduces spiral structure BUT NOT the bar-like feature.



Best-fit heavy disk simulation from Masset & Bureau (2003).

References: Bureau et al. (1999), Masset & Bureau (2003)

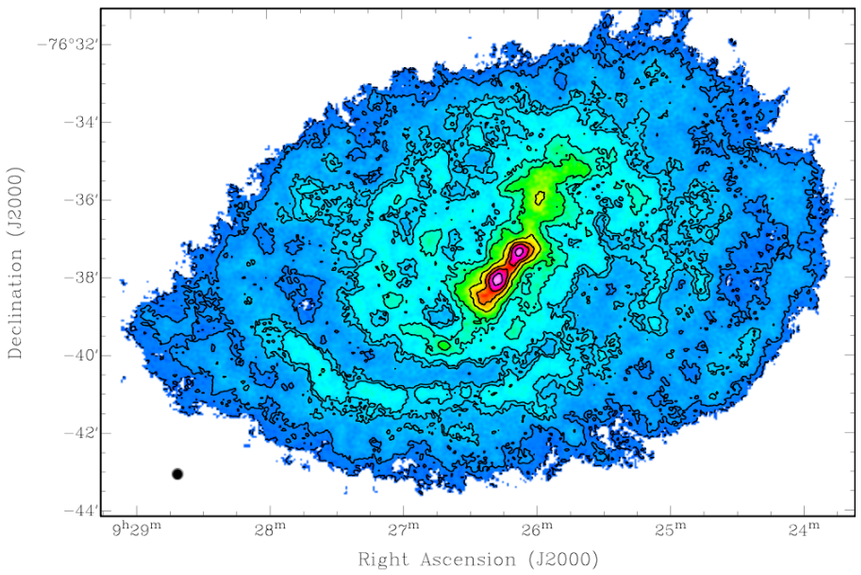
CURRENT STANDING OF NGC 2915

- ☐ Very different optical and HI morphologies
- ☐ Central HI bar → complex central gas dynamics
- ☐ Unaccounted-for spiral structure in outer disk
- ☐ No stars in outer disk
- ☐ Spiral structure excitation mechanism unknown

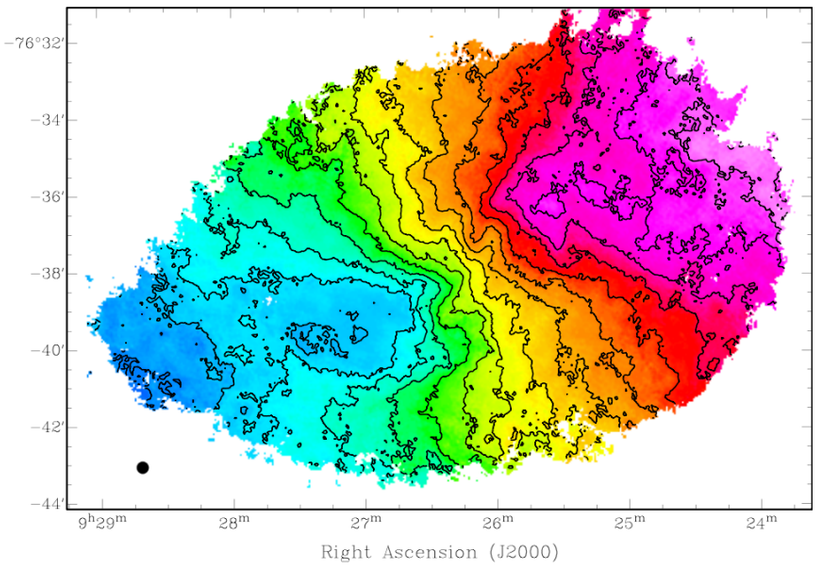
NEW OBSERVATIONS OF NGC 2915

- NGC 2915 observed with the ATCA as part of THINGS (South)
- ~101 hours of on-source time (including archival data)
- Spatial resolution: HPBW ~ 17″ = 0.31 kpc
- Velocity resolution = 3.2 km/s

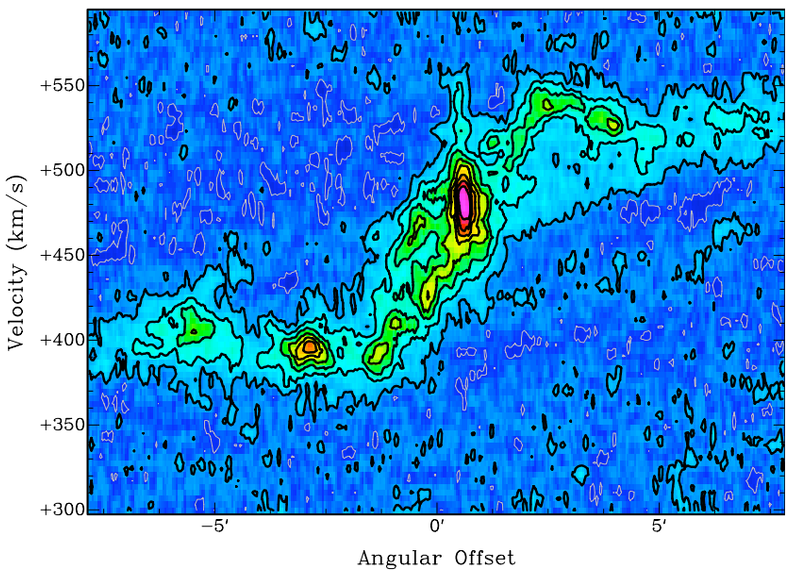
THINGS data (HPBW ~17″)



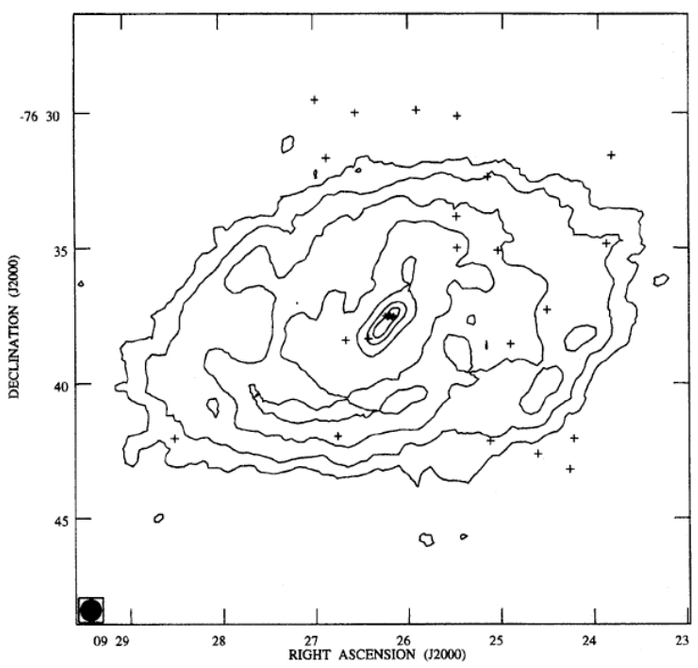
Total intensity map

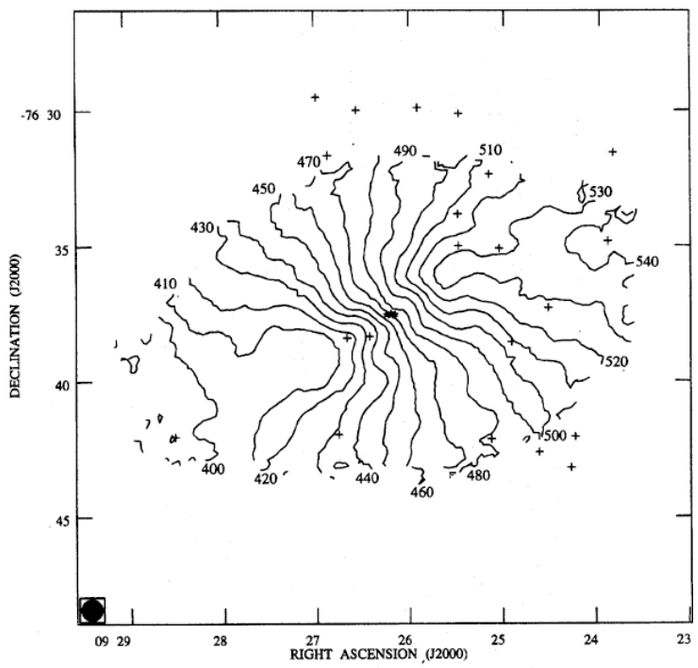


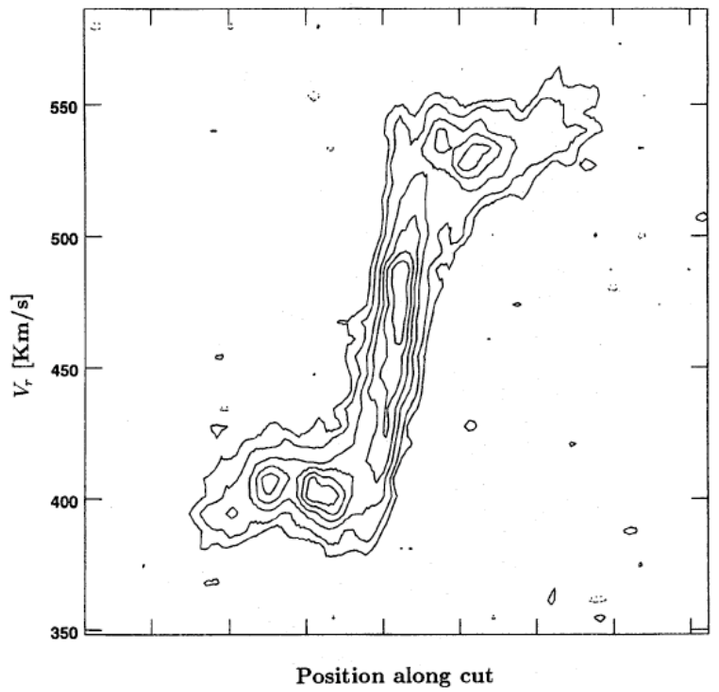
Velocity field



Position-velocity slice





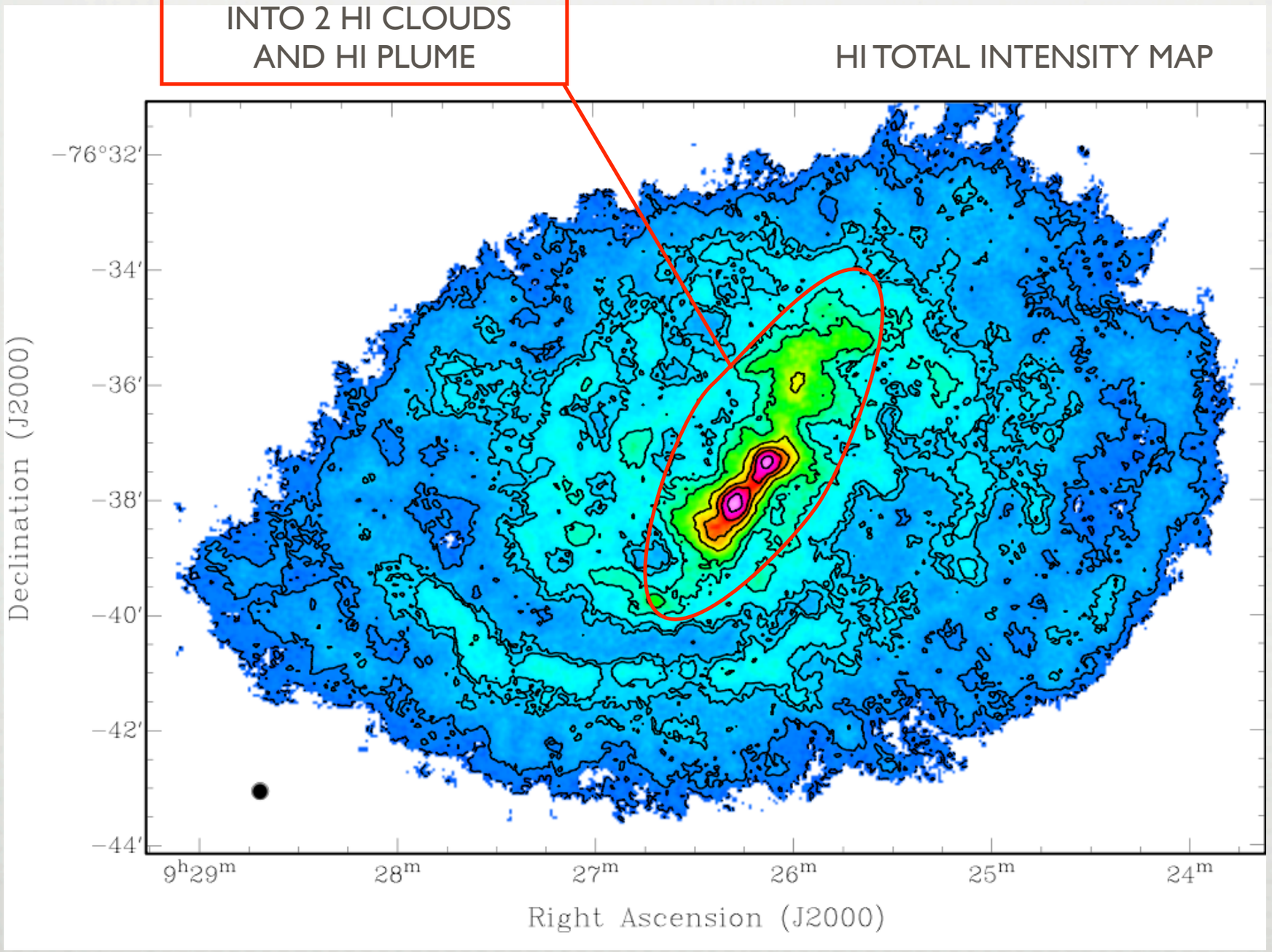


Meurer et al. (1996) data (HPBW ~45″)

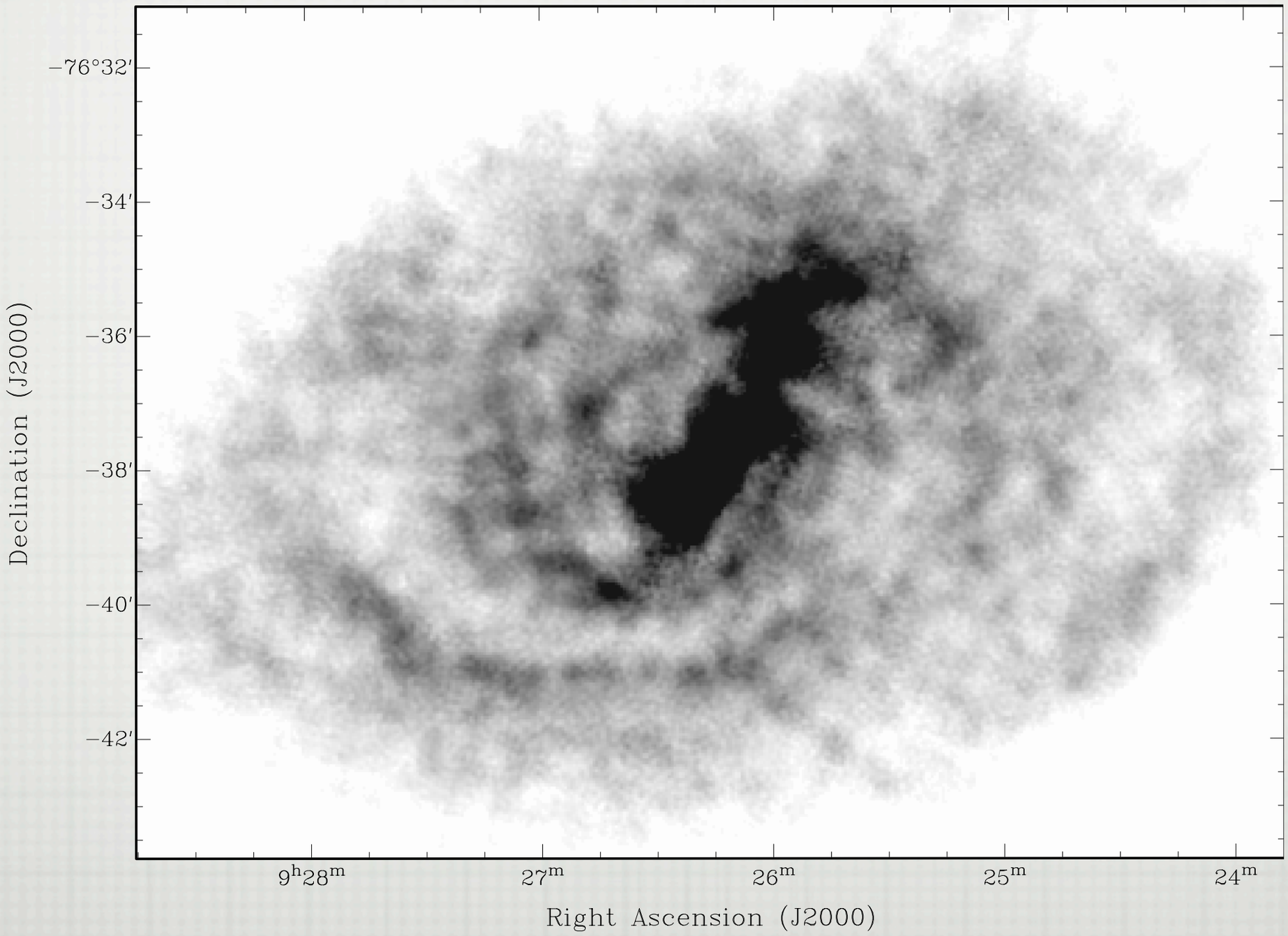
HI DISK MORPHOLOGY

CENTRAL BAR RESOLVES INTO 2 HI CLOUDS AND HI PLUME

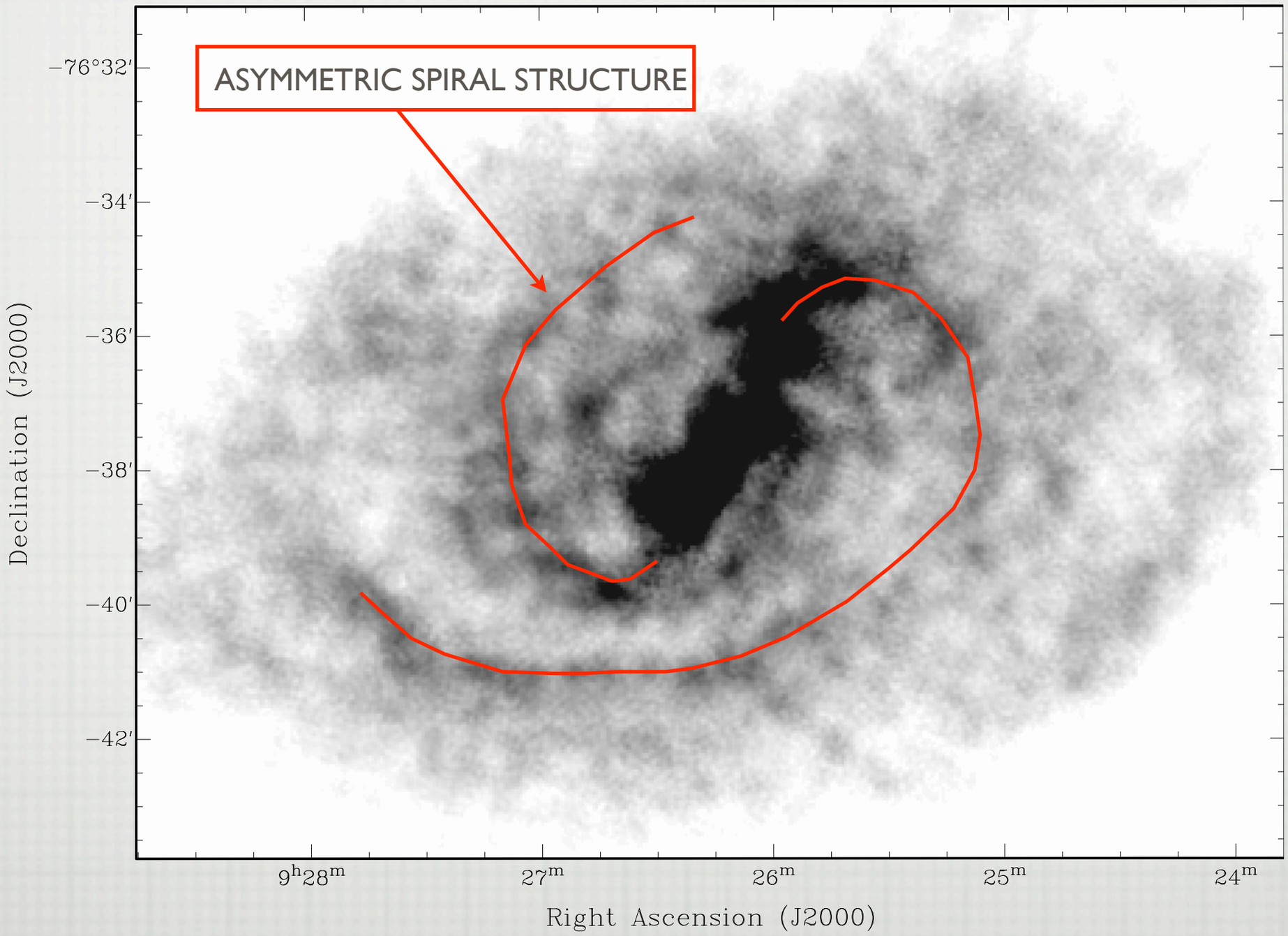
HI TOTAL INTENSITY MAP



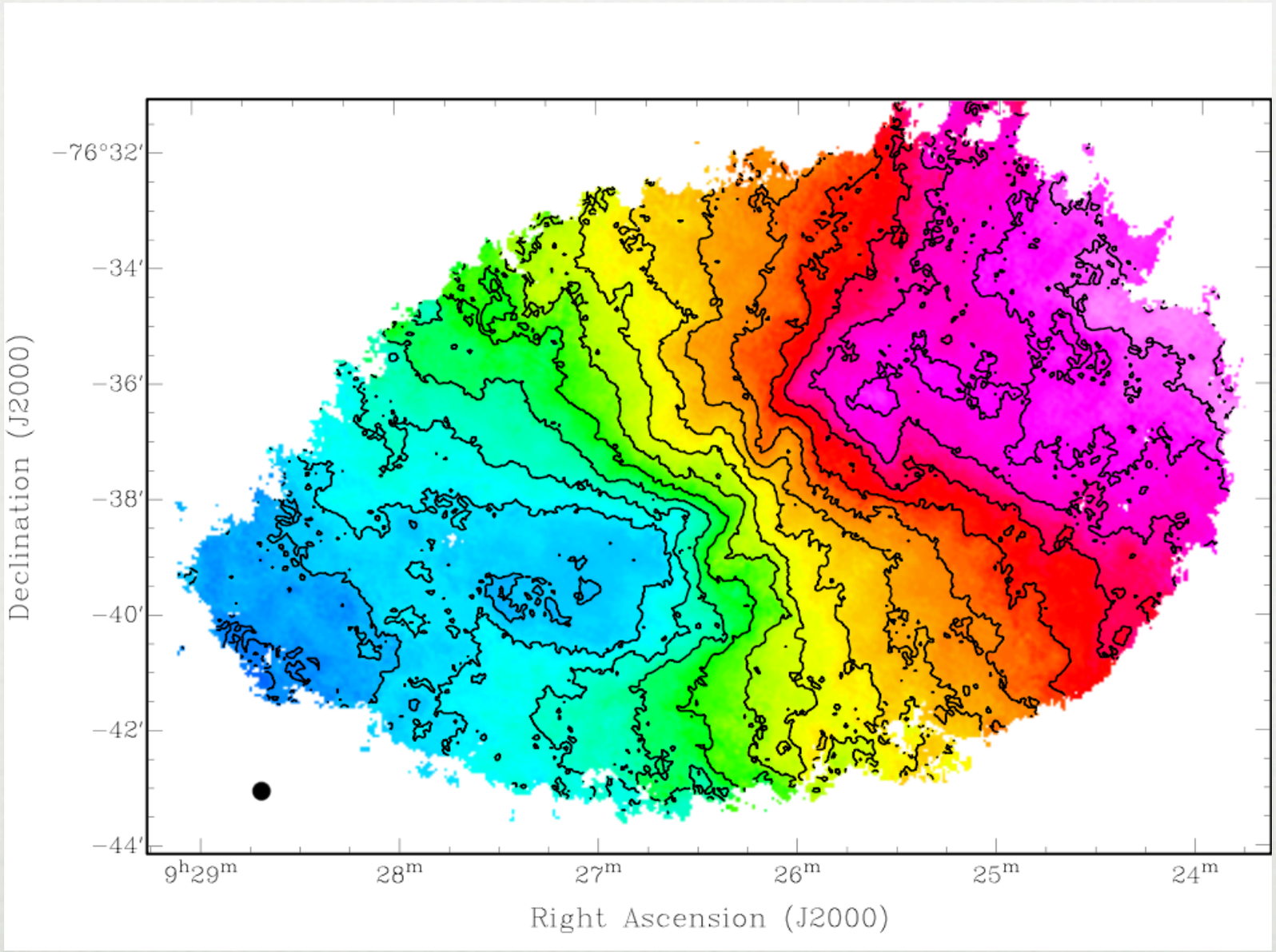
HI DISK MORPHOLOGY



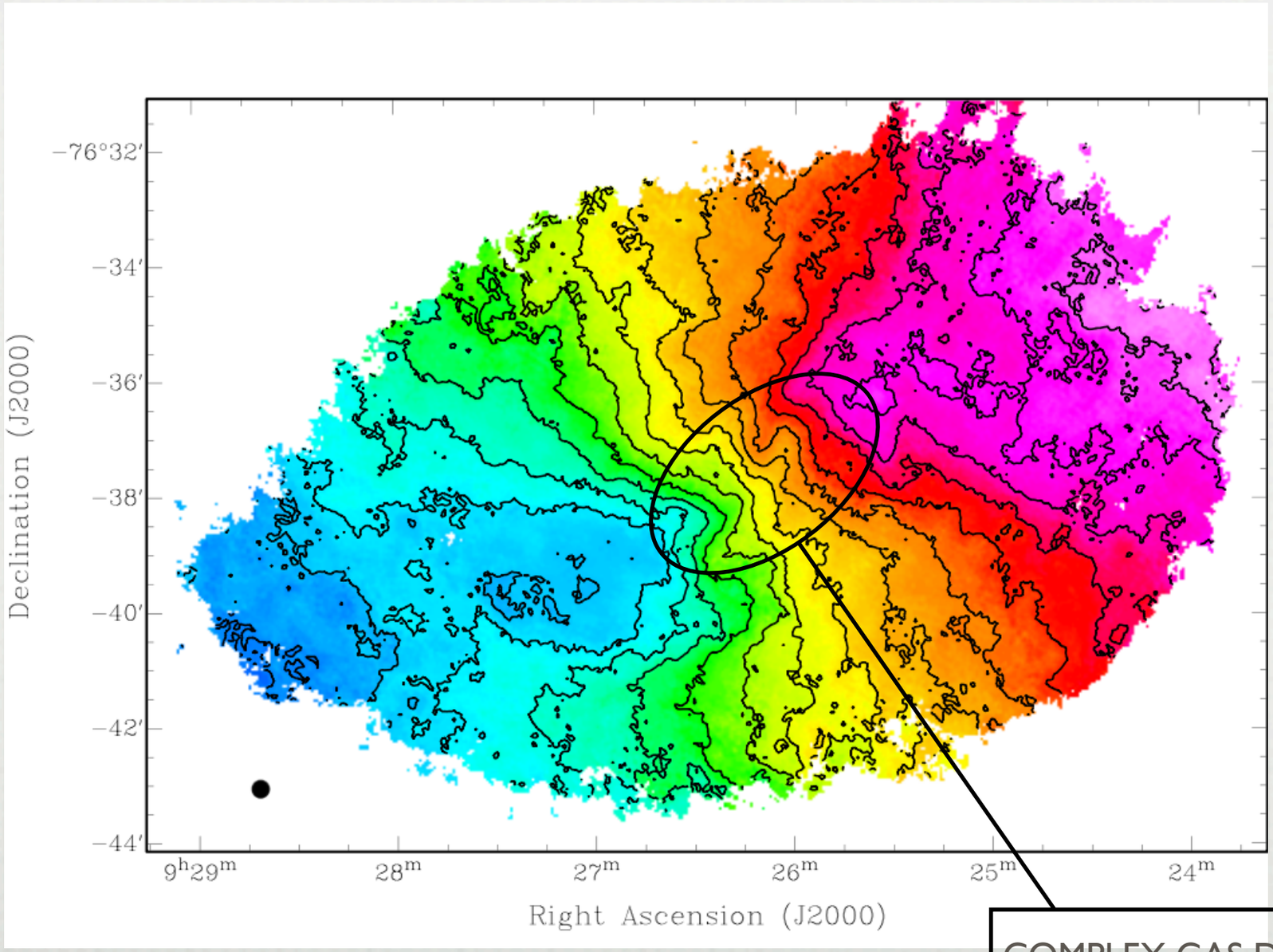
HI DISK MORPHOLOGY



HI VELOCITY FIELD



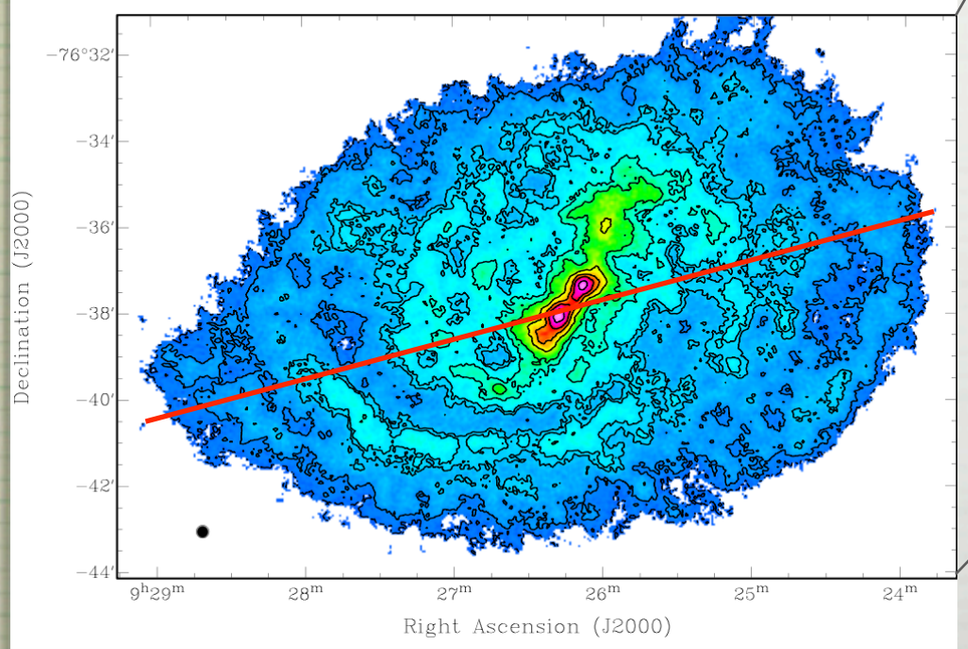
HI VELOCITY FIELD

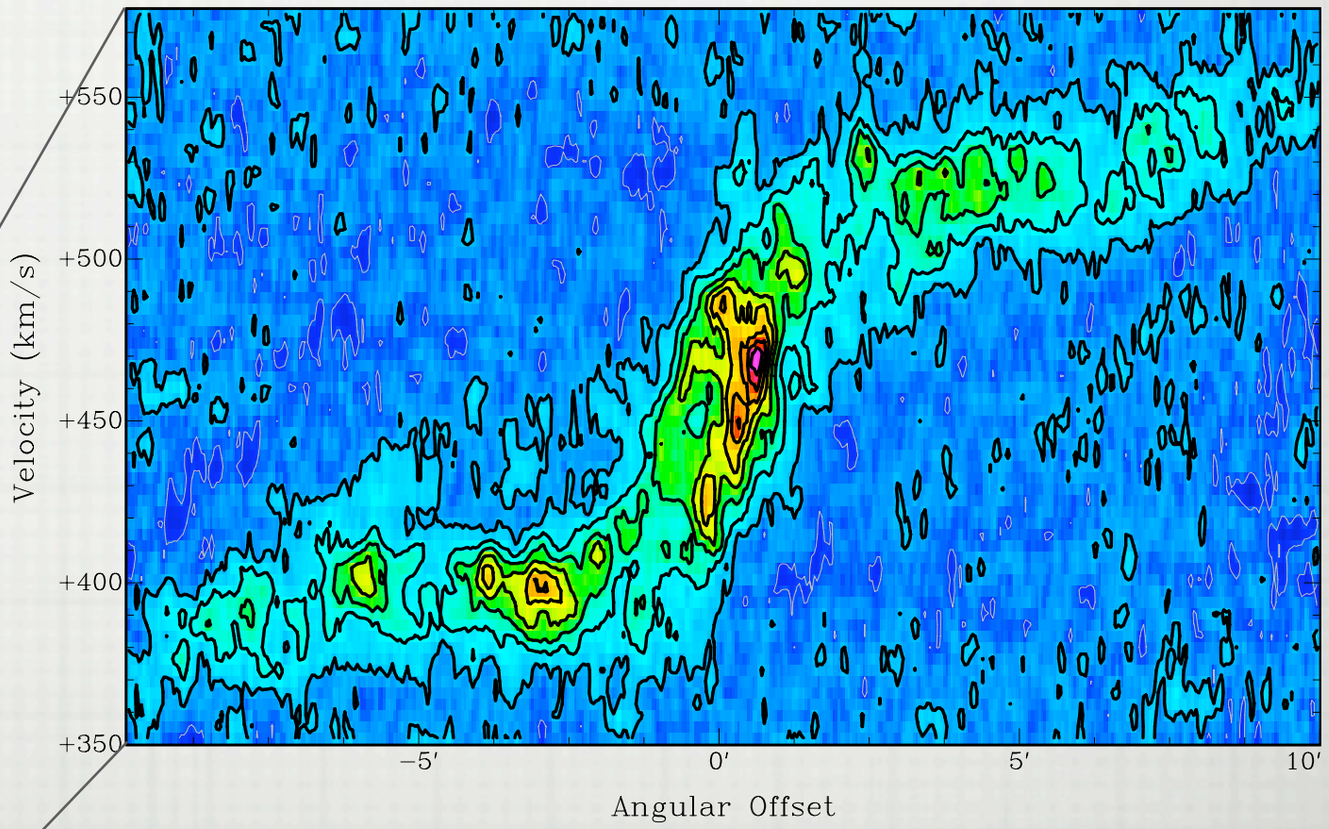


INSPECTING THE DATA

Outer disk exhibits regular kinematics

HI total intensity map

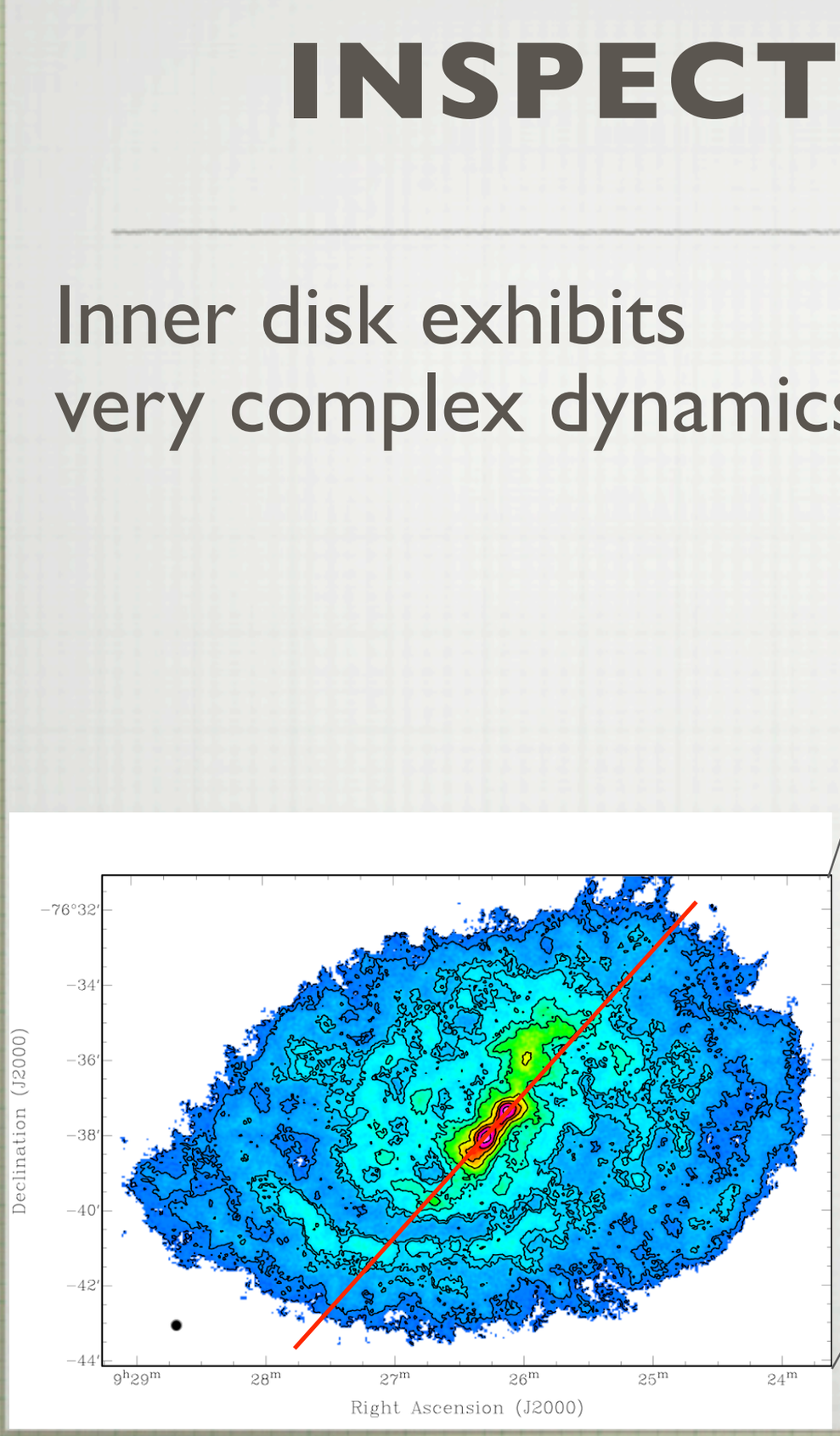


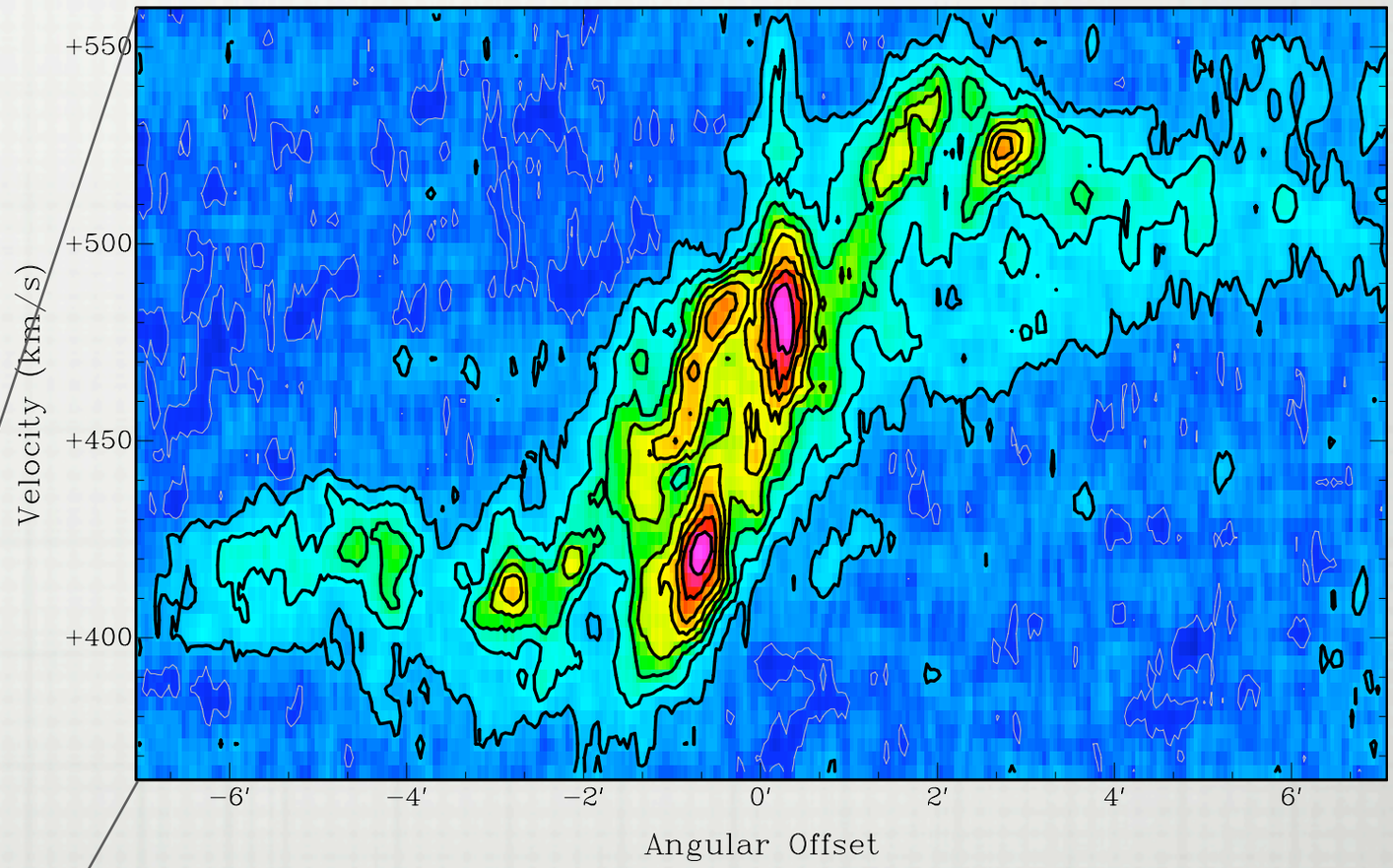


position-velocity slice

INSPECTING THE DATA

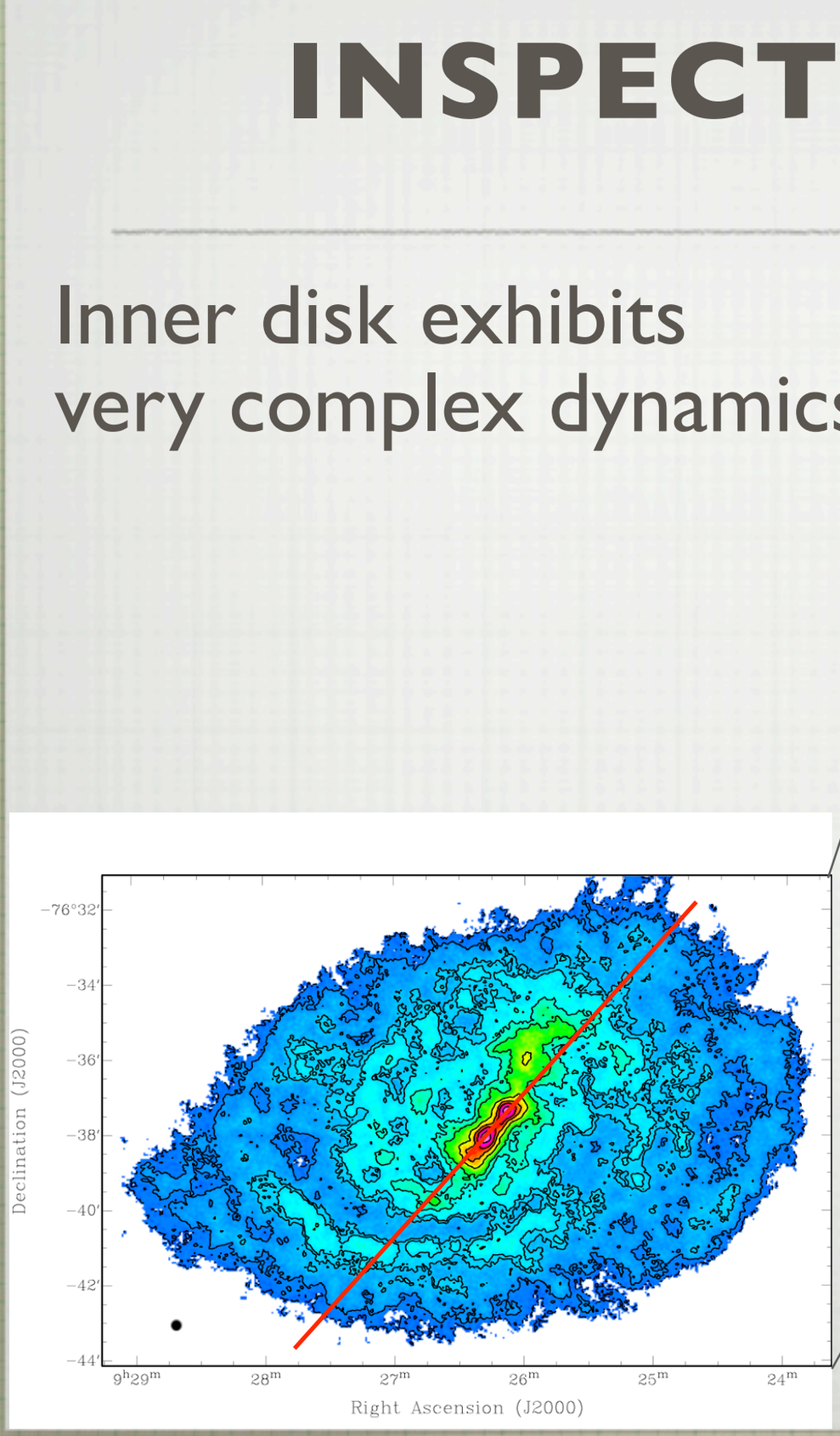
Inner disk exhibits
very complex dynamics

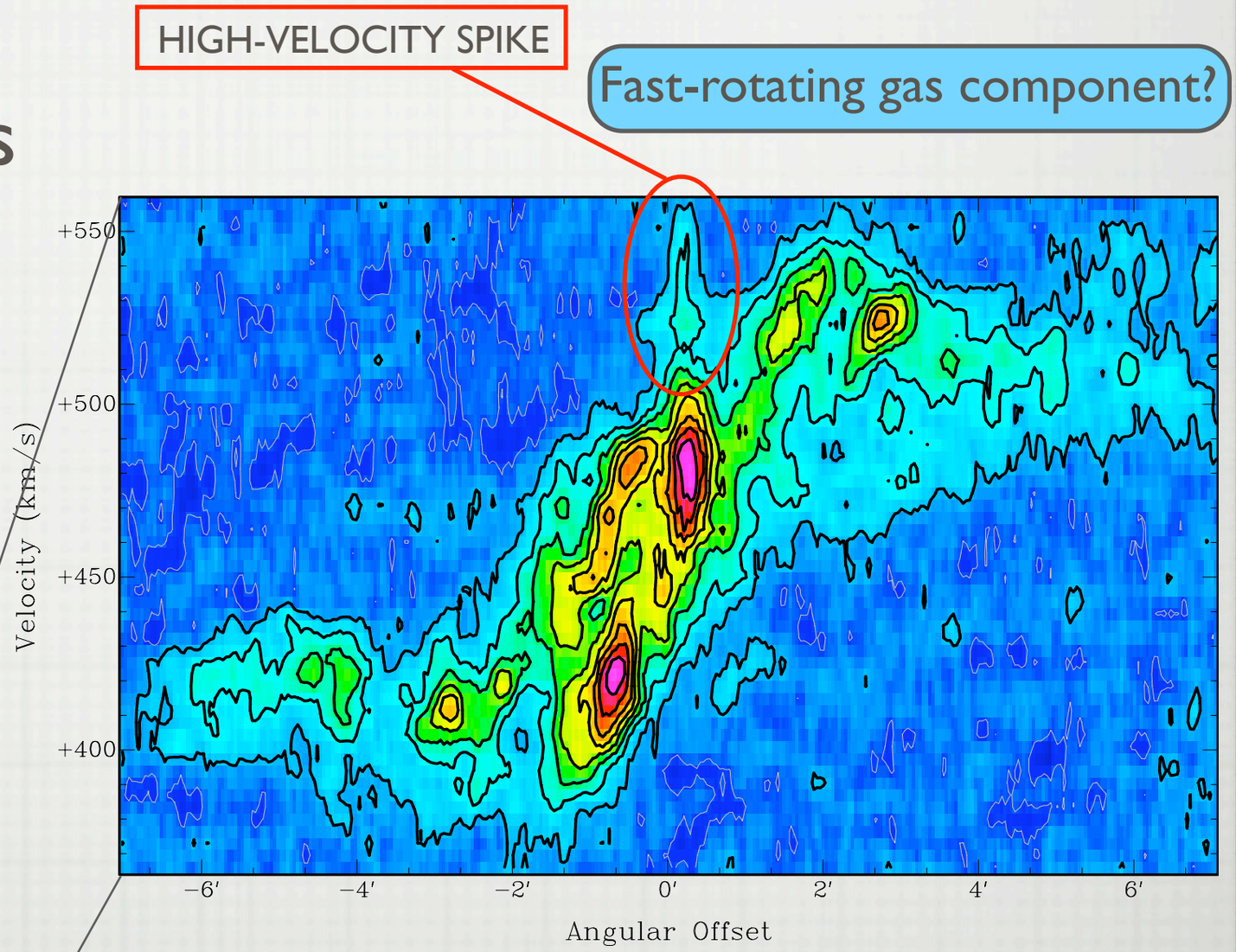




INSPECTING THE DATA

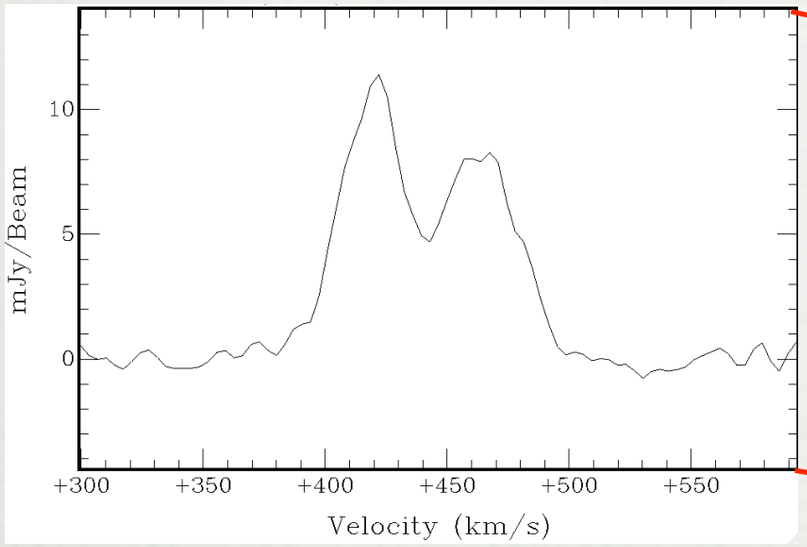
Inner disk exhibits
very complex dynamics





INSPECTING THE DATA

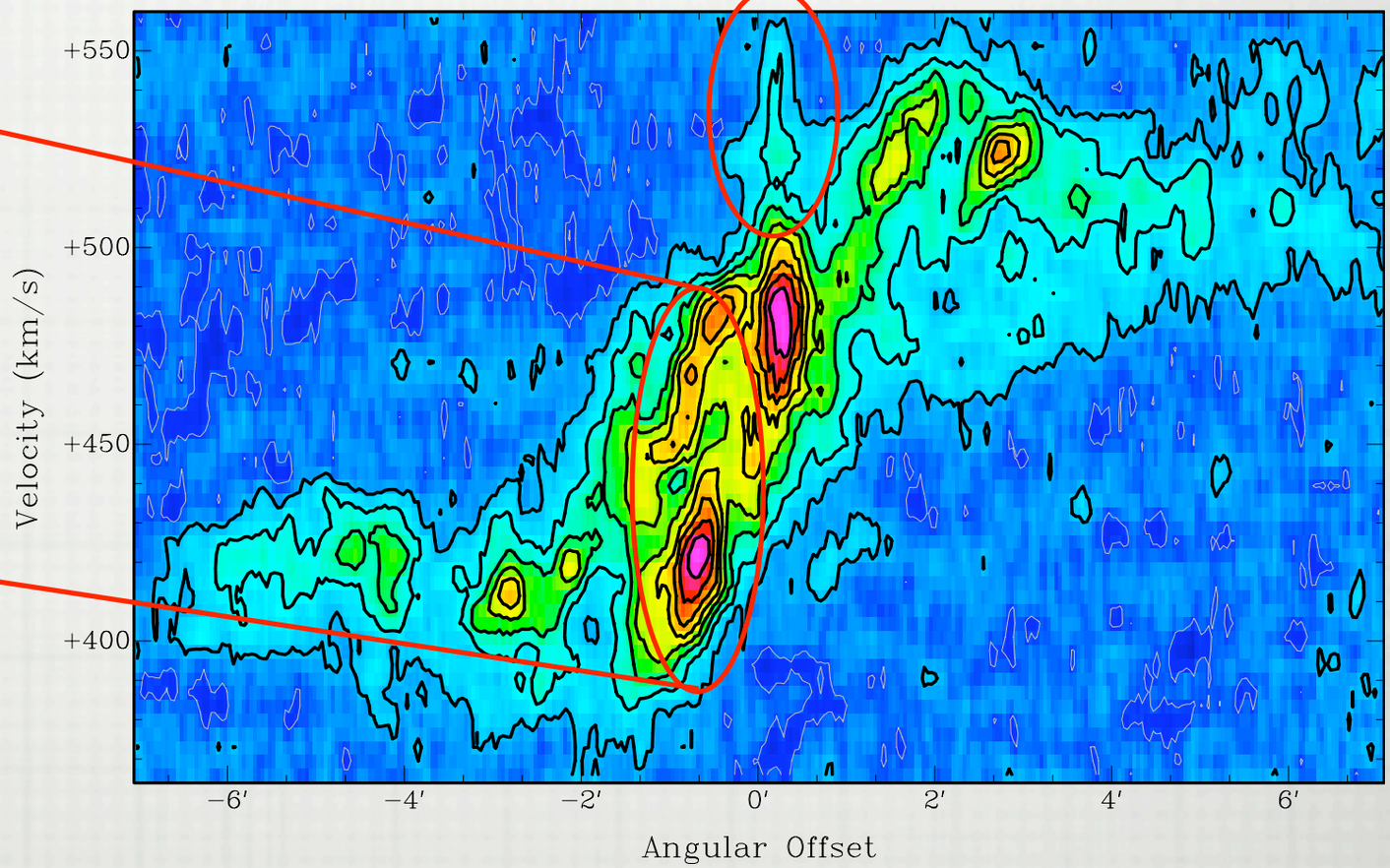
Inner disk exhibits
very complex dynamics



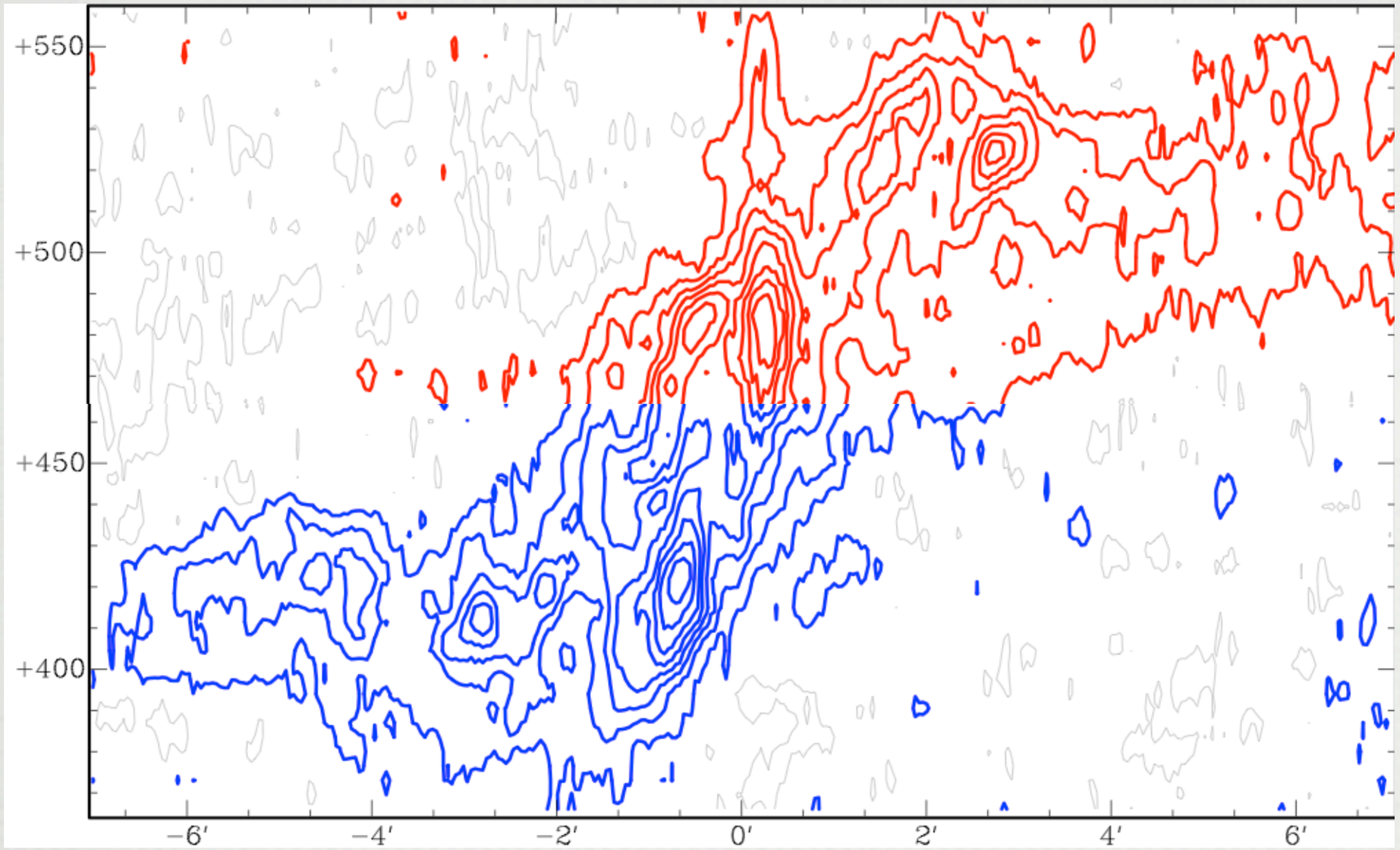
SPLIT LINE PROFILES

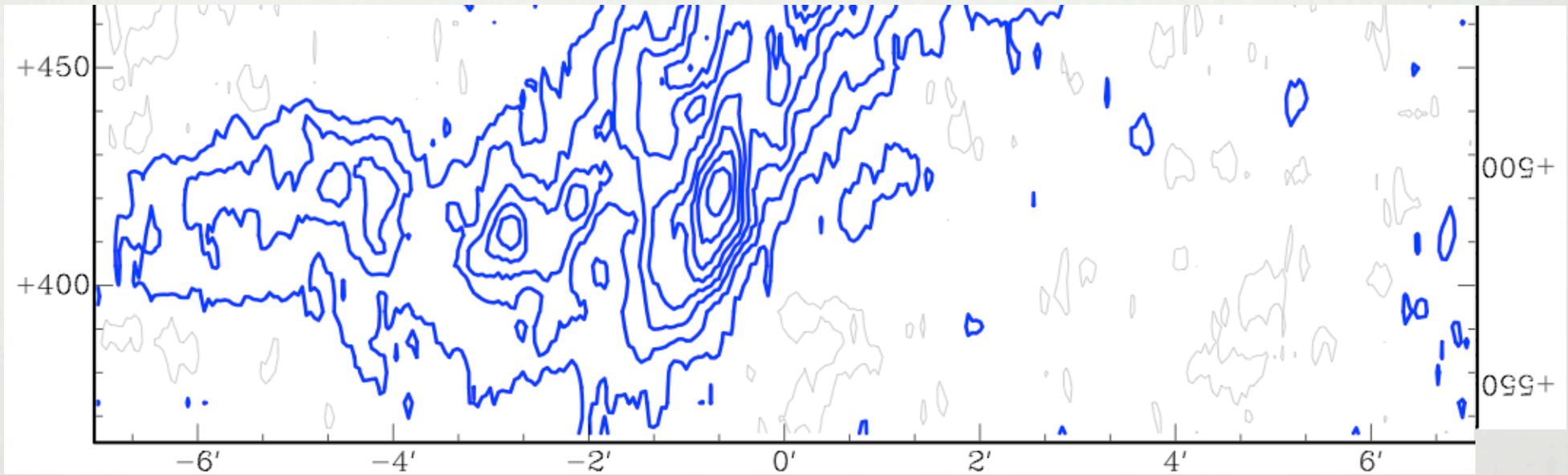
HIGH-VELOCITY SPIKE

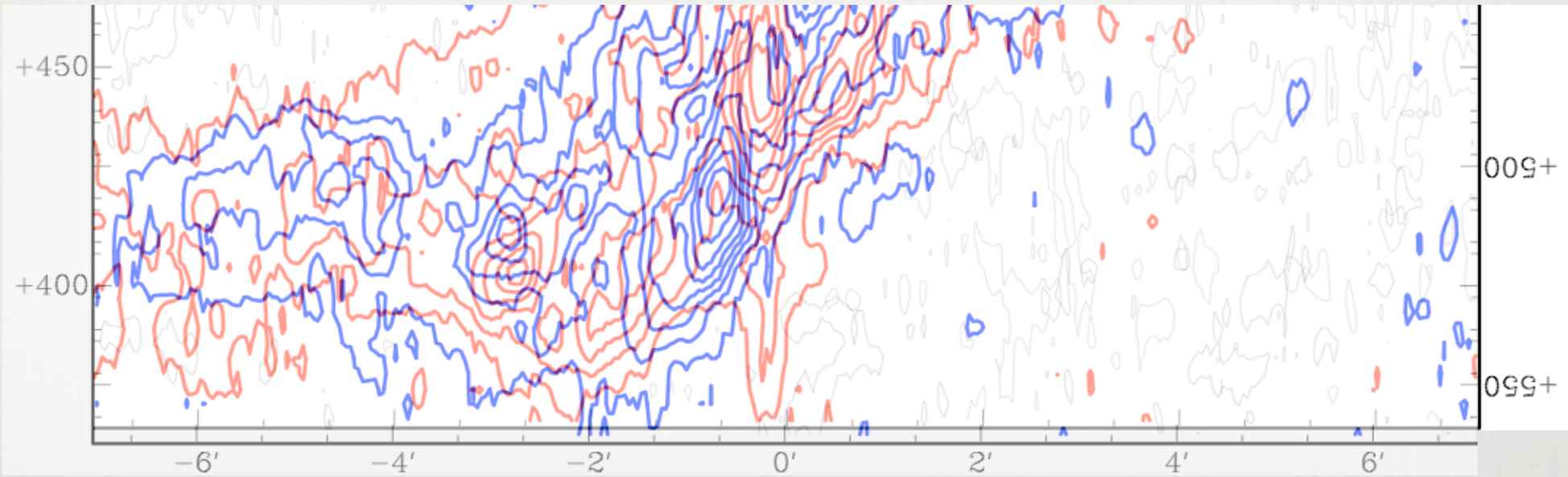
Fast-rotating gas component?

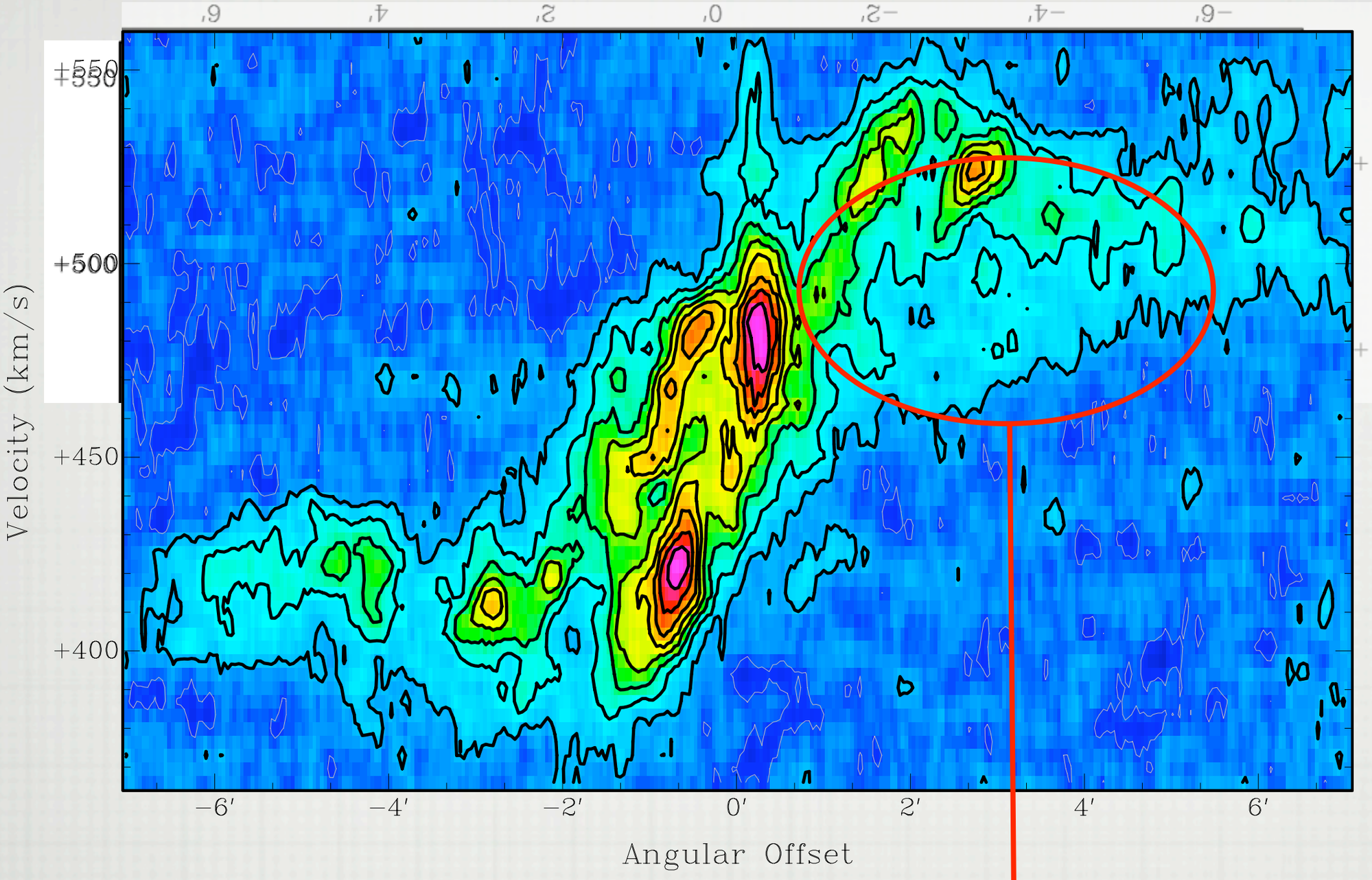


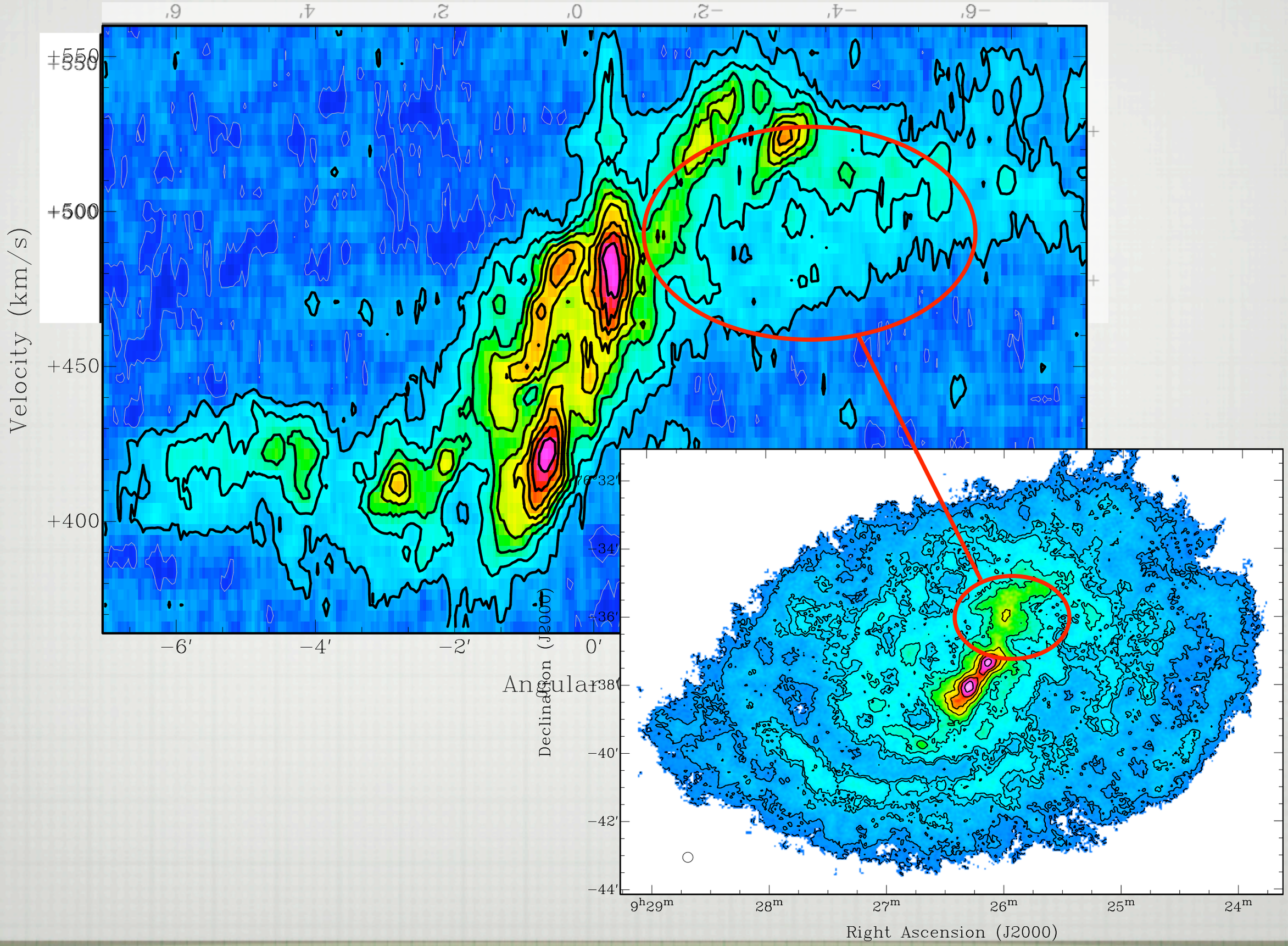
Evidence of expanding gas shells

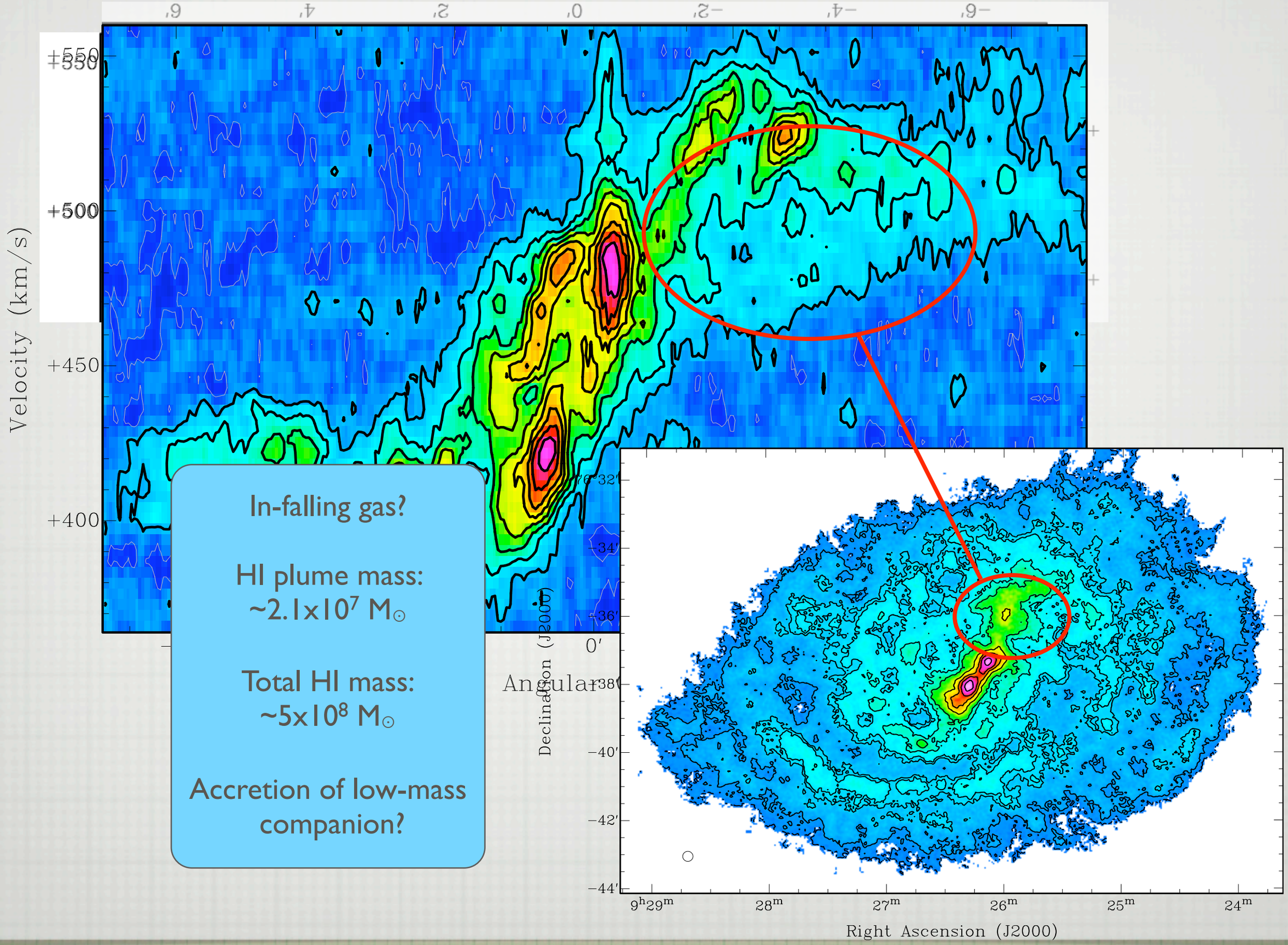

+550
+500
+450
+400
−6′
−4′
−2′
0′
2′
4′
6′


+450
+400
+500
+550
−6′
−4′
−2′
0′
2′
4′
6′


+450
+400
+500
+550
−6′
−4′
−2′
0′
2′
4′
6′


+550
+500
+450
+400
Velocity (km/s)
−6′
−4′
−2′
0′
2′
4′
6′
Angular Offset
Asymmetric, lagging HI


Velocity (km/s)
+550
+500
+450
+400
−6′
−4′
−2′
0′
Angular
Declination (J2000)
+38′
−34′
−36′
−40′
−42′
−44′
9h29m
28m
27m
26m
25m
24m
Right Ascension (J2000)



In-falling gas?

HI plume mass:
~2.1x10^7 M$_\odot$

Total HI mass:
~5x10^8 M$_\odot$

Accretion of low-mass companion?

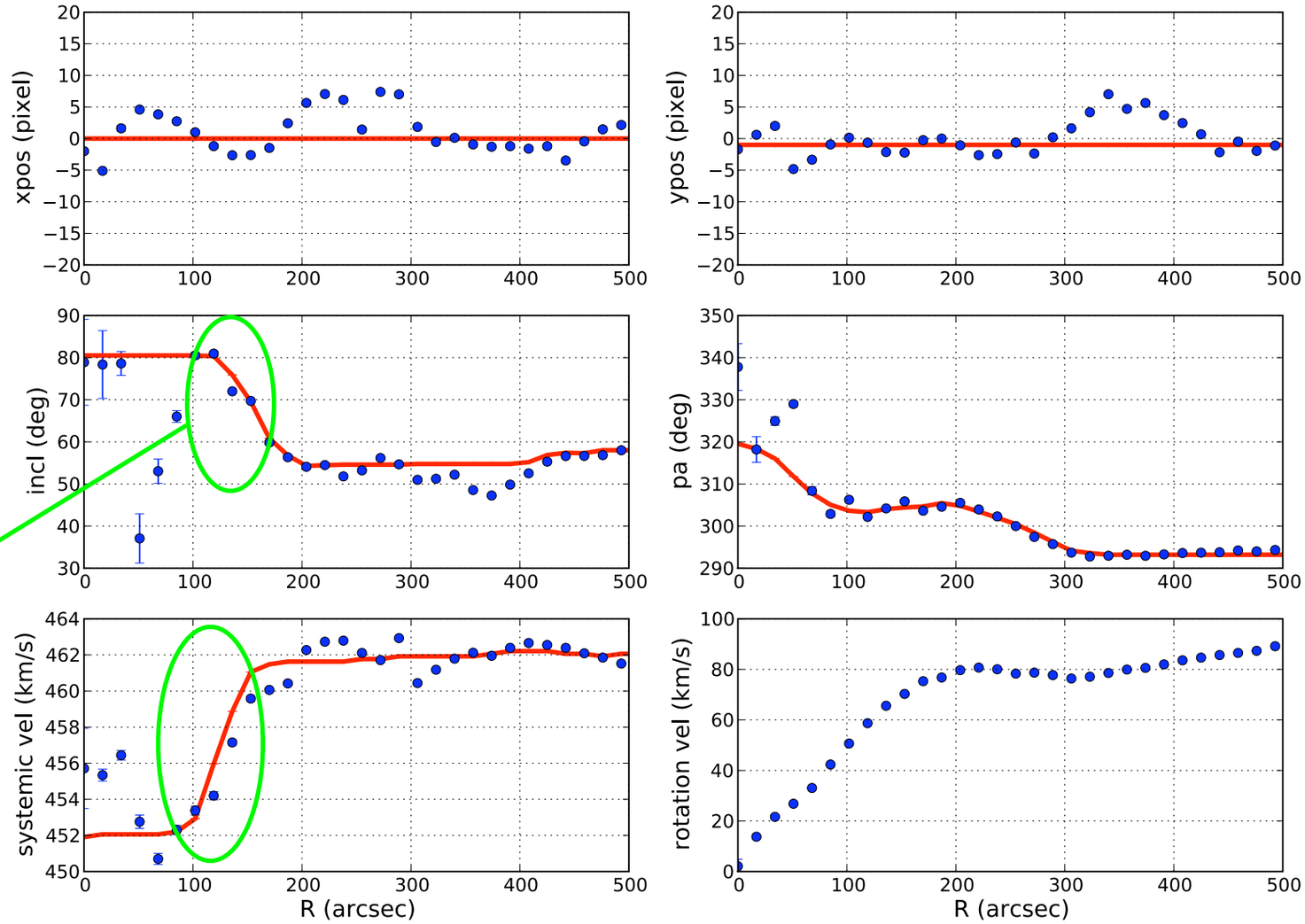
TILTED RING MODELLING

- ☐ Tilted ring model fit to HI velocity field.
- ☐ Inclined inner disk
- ☐ Kinematically separated core?

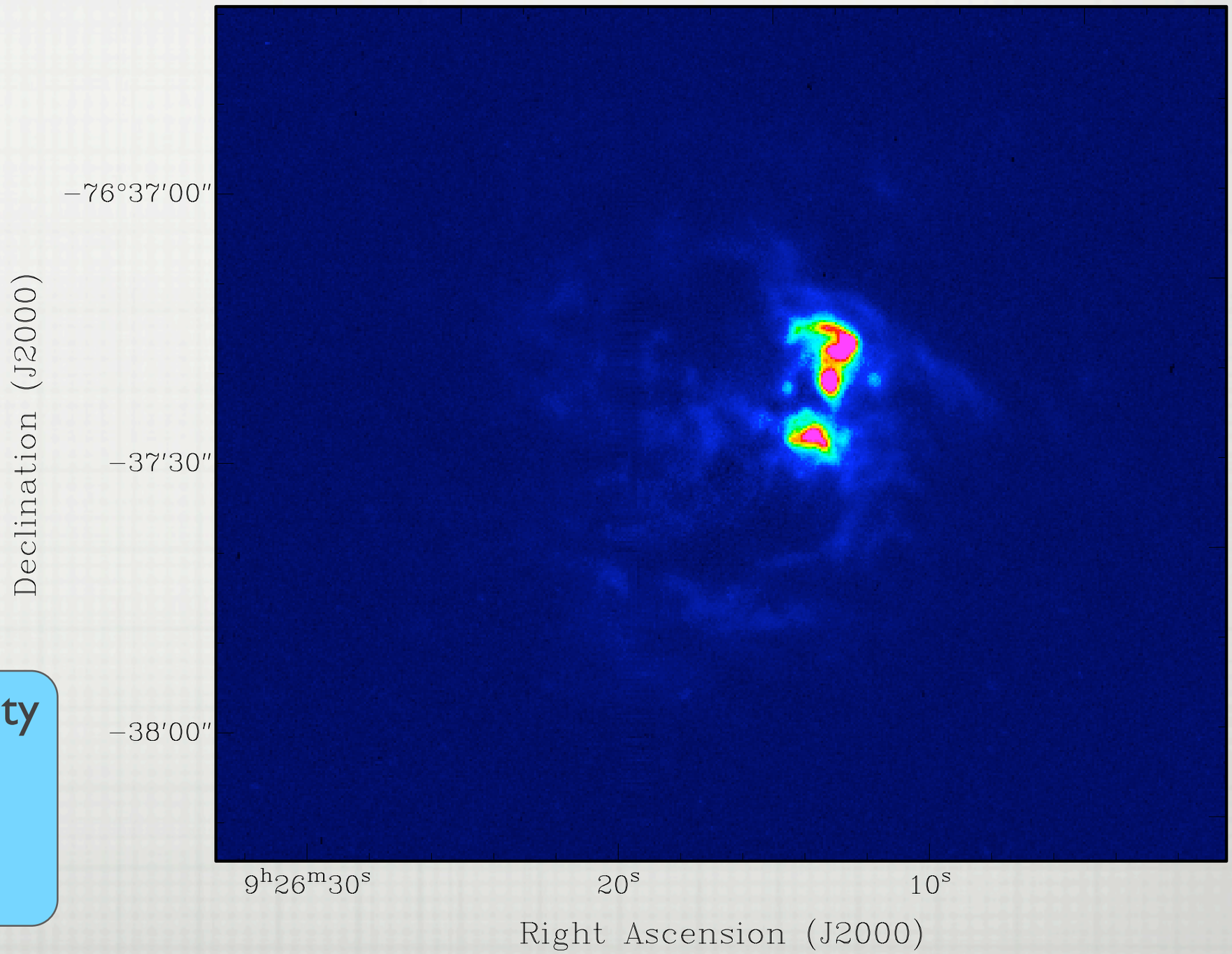
Reliable fits?

kinematic warp?

Gas in-fall?

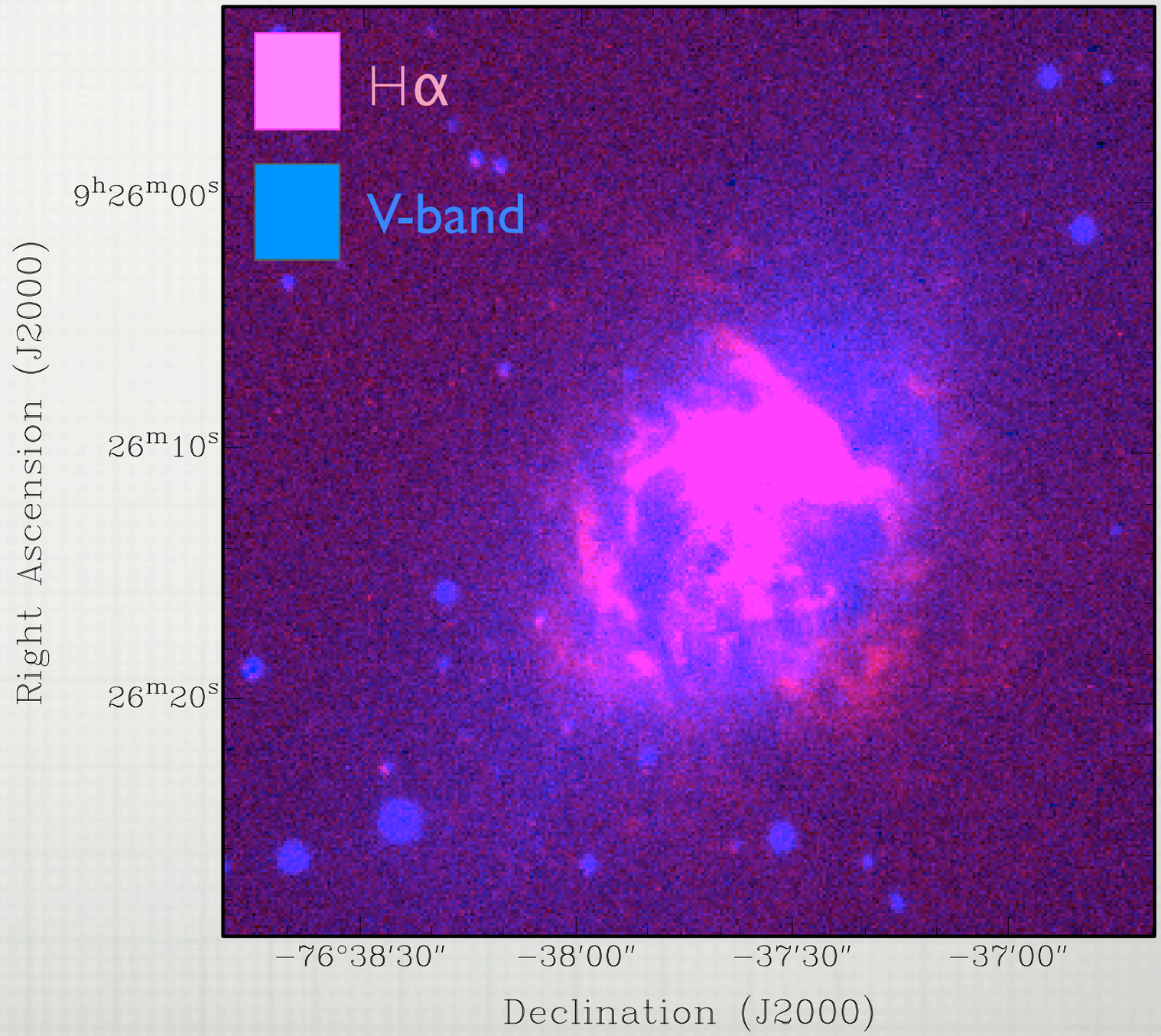


Hα EMISSION



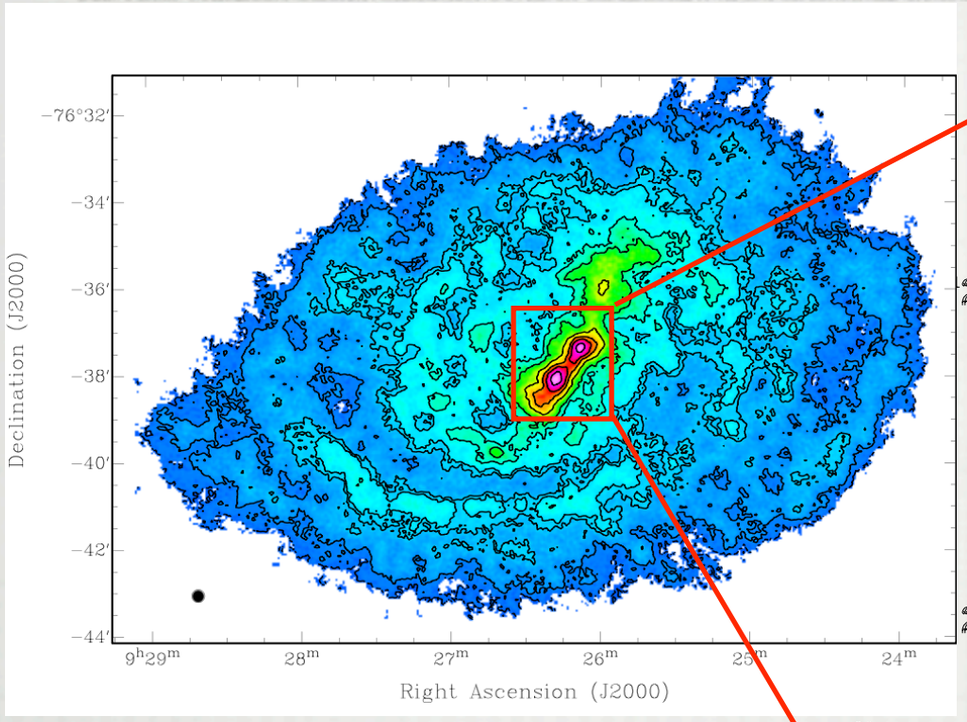
Total Hα luminosity ~ $10^{32.5}$ Joules/sec (Gil de Paz et al., 2003)

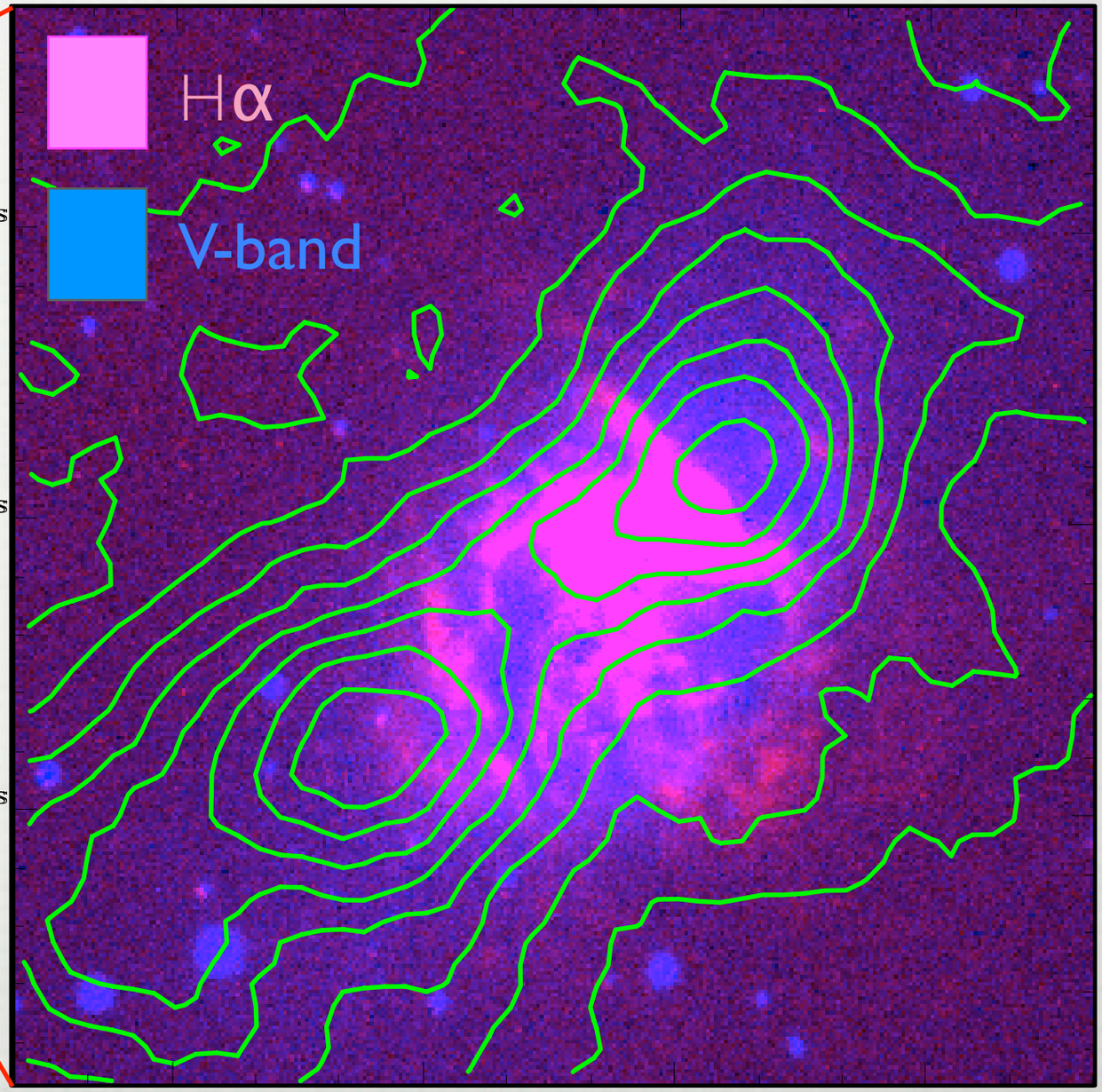
Hα EMISSION



Total Hα luminosity ~ $10^{32.5}$ Joules/sec (Gil de Paz et al., 2003)

Hα EMISSION





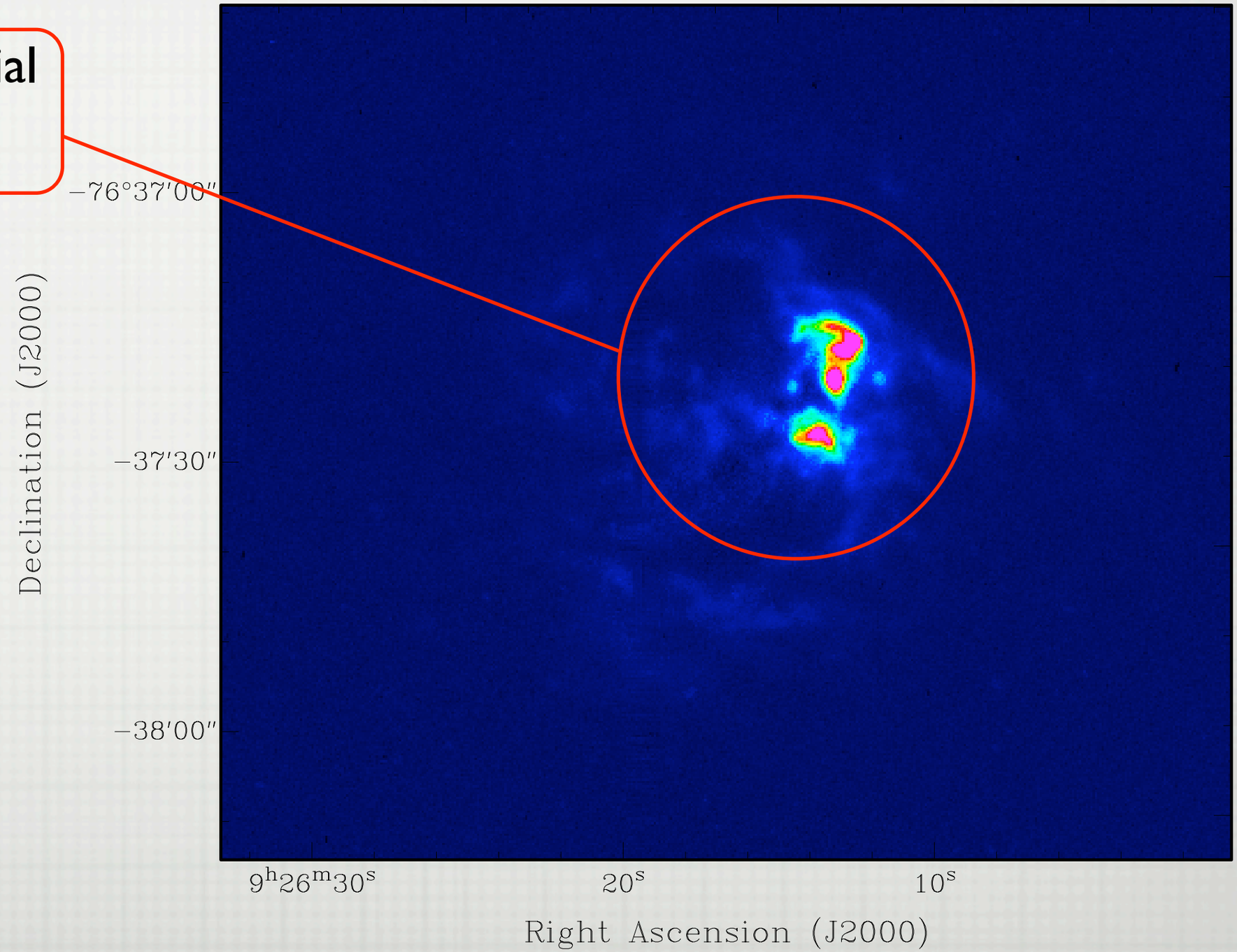
Total Hα luminosity ~ $10^{32.5}$ Joules/sec (Gil de Paz et al., 2003)

Hα EMISSION

Total Hα luminosity ~ $10^{32.5}$ Joules/sec (Gil de Paz et al., 2003)

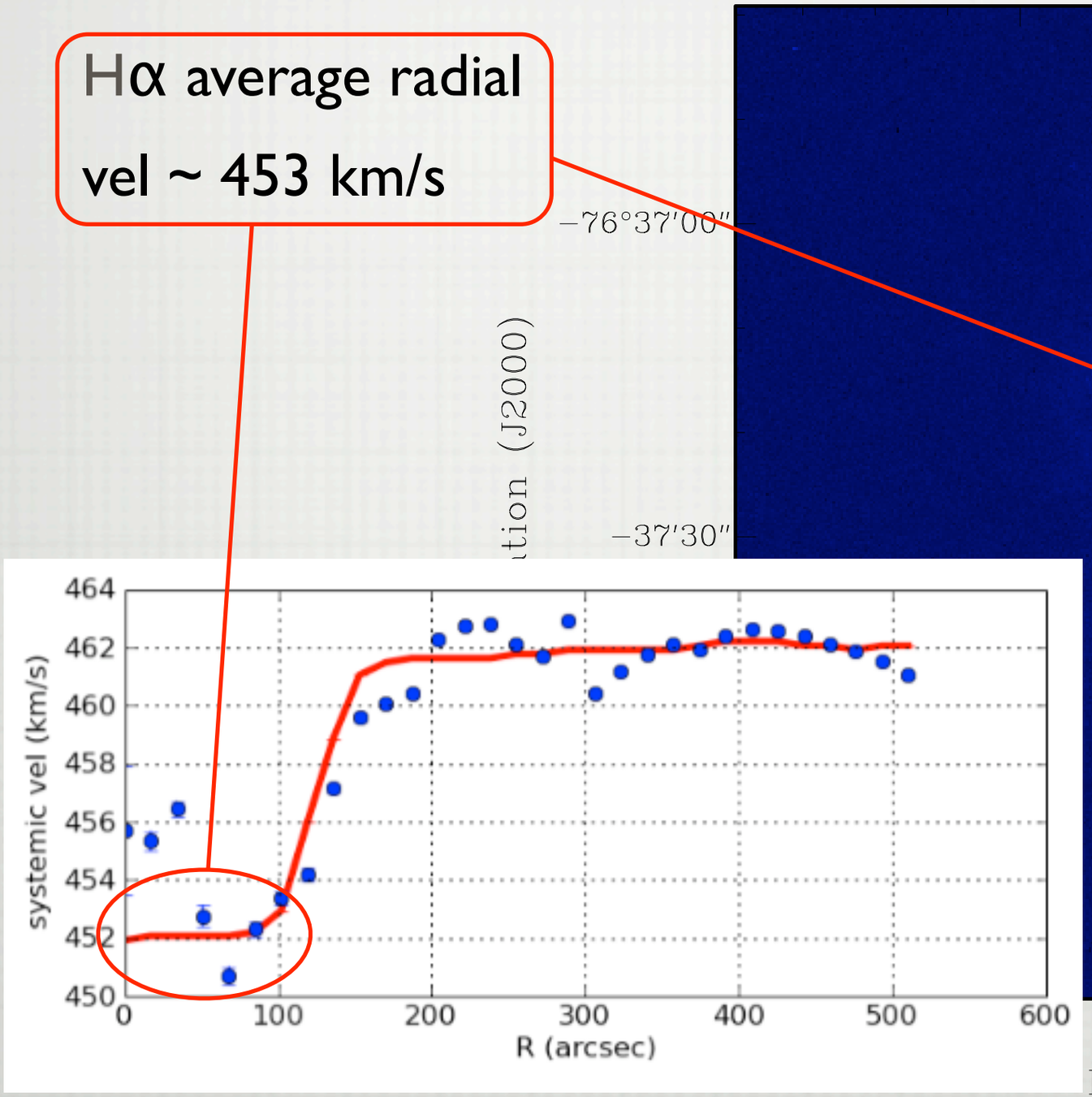
Hα EMISSION

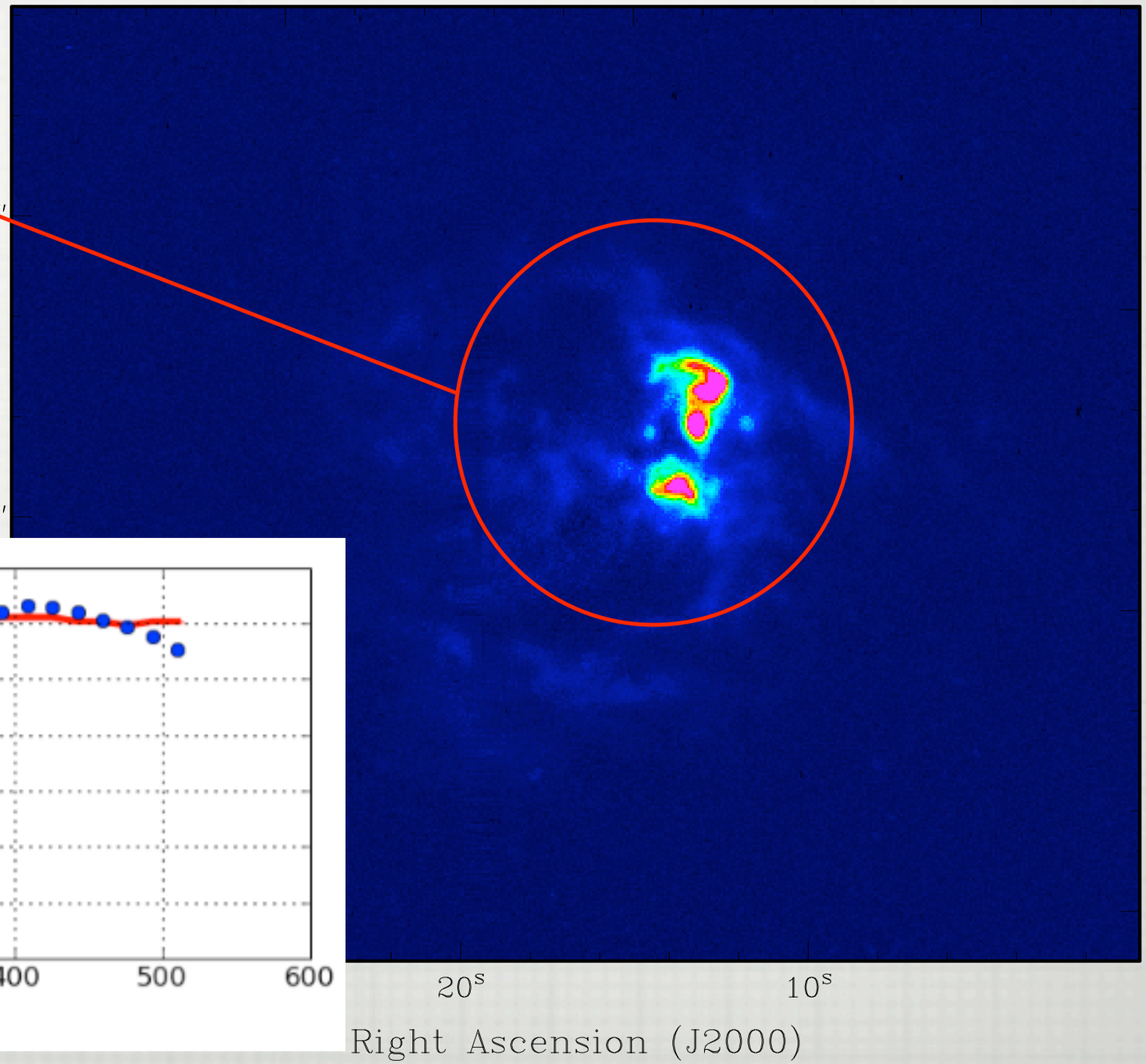
Hα average radial vel ~ 453 km/s



Hα EMISSION

Hα average radial vel ~ 453 km/s

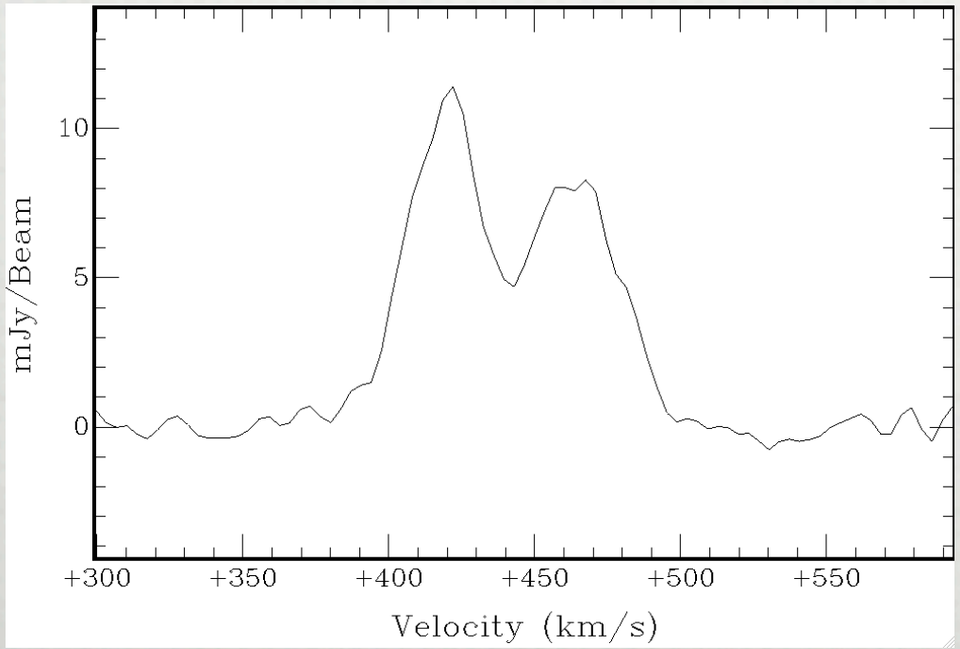




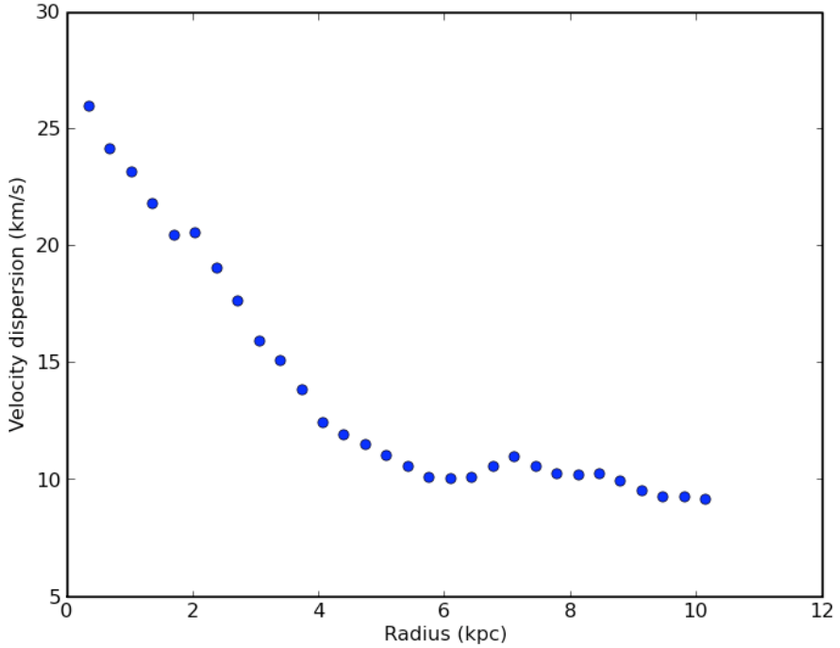
CENTRAL ENERGETICS

- Central region has:
  - ~ $1.3 \times 10^7 M_\odot$ of HI expanding at ~ 20 km/s.
  - ~ $2.2 \times 10^7 M_\odot$ of HI with a velocity dispersion ≳ 20 km/s

Typical split line profile from central region



Velocity dispersion radial profile

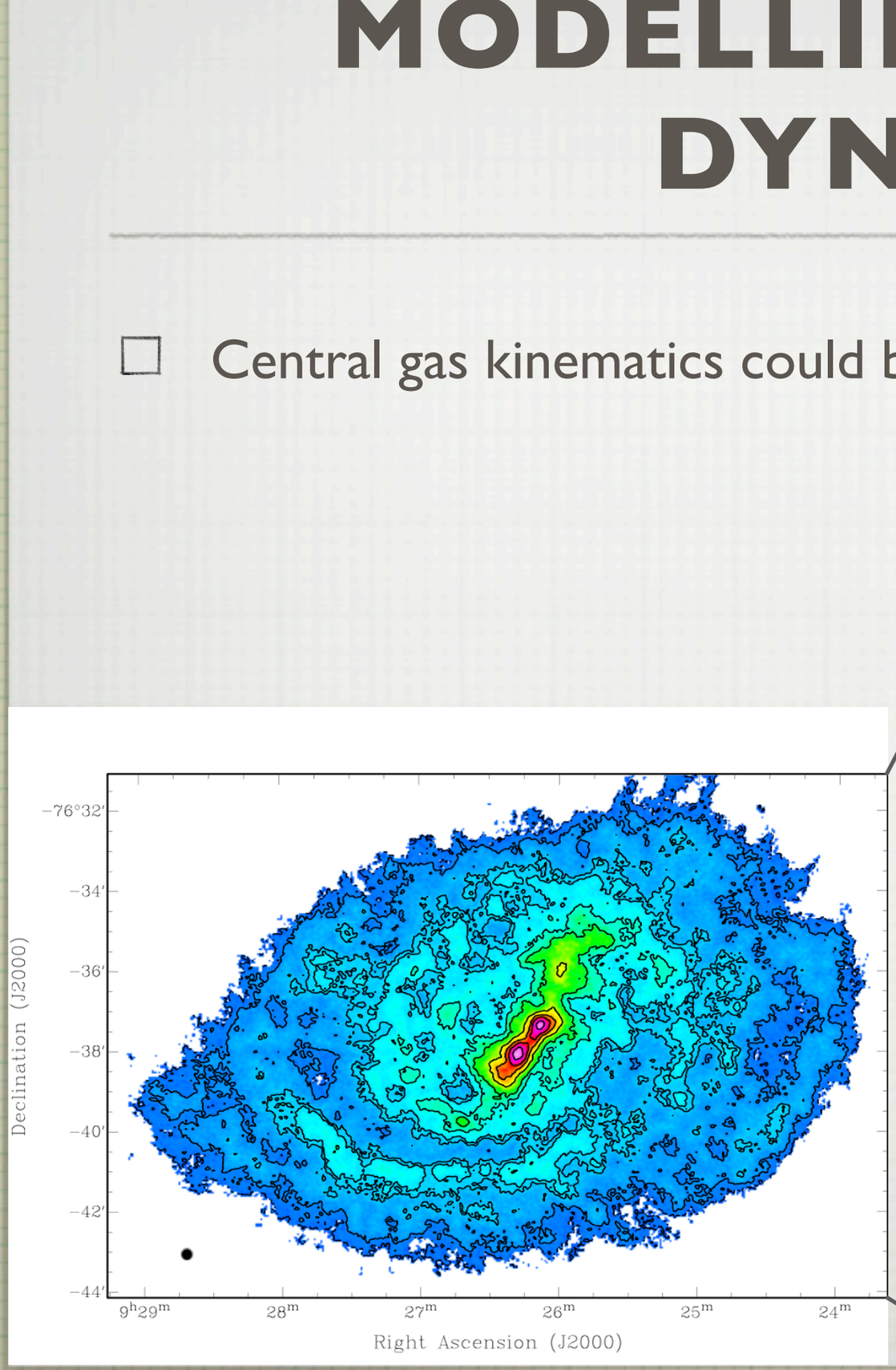


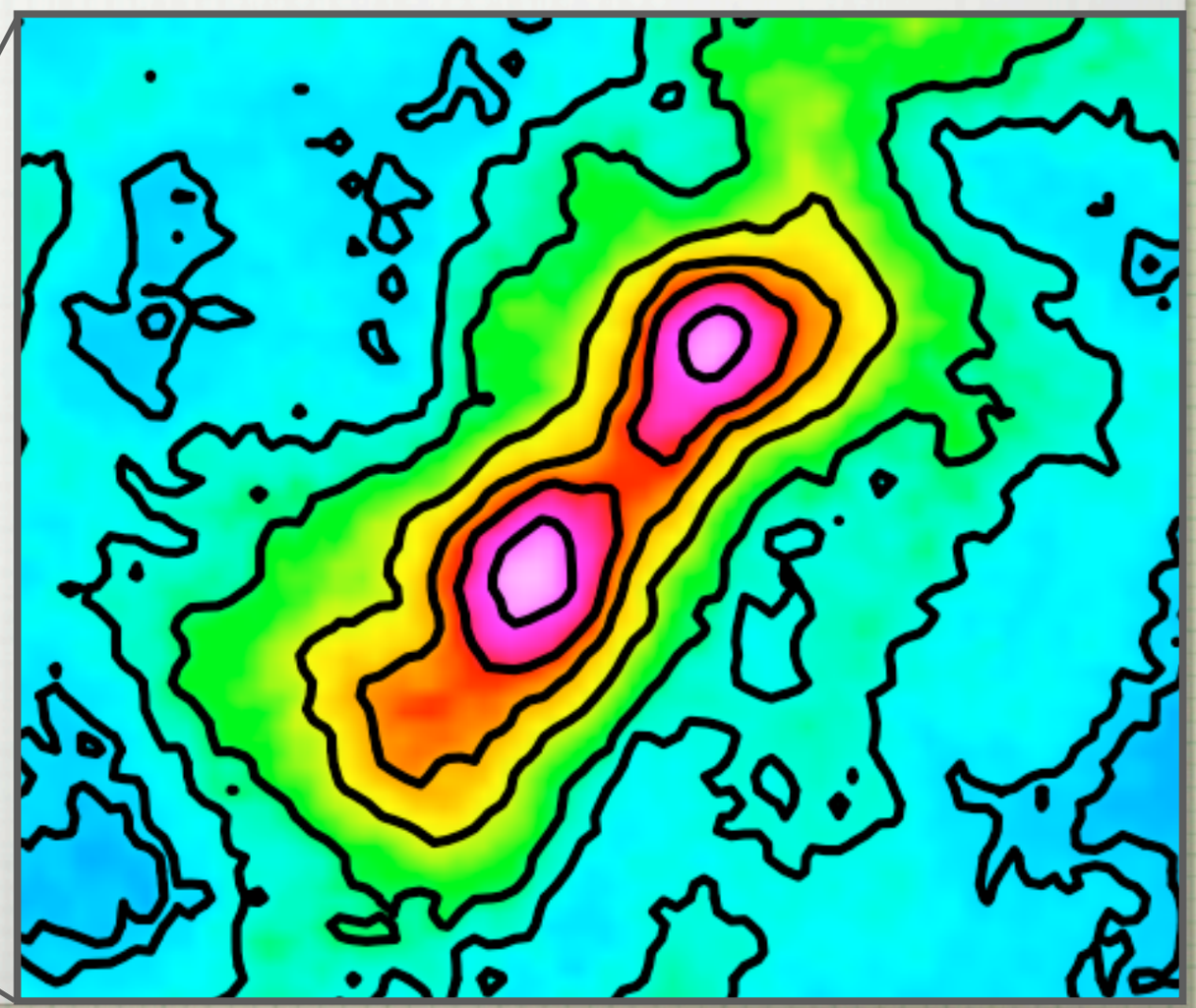
CENTRAL ENERGETICS

- Central region has:
  - ~ $1.3 \times 10^7 M_\odot$ of HI expanding at ~ 20 km/s.
  - ~ $2.2 \times 10^7 M_\odot$ of HI with a velocity dispersion ≳ 20 km/s
  - $E_k^{Total} \sim 5 \times 10^{46}$ Joules
  - Total Hα luminosity ~ $10^{32.5}$ Joules/sec (Gil de Paz et al., 2003)
  - Total central gas energetics accounted for within ~ 5 Myr.
  - Could stellar winds be dictating central gas dynamics? We test this...

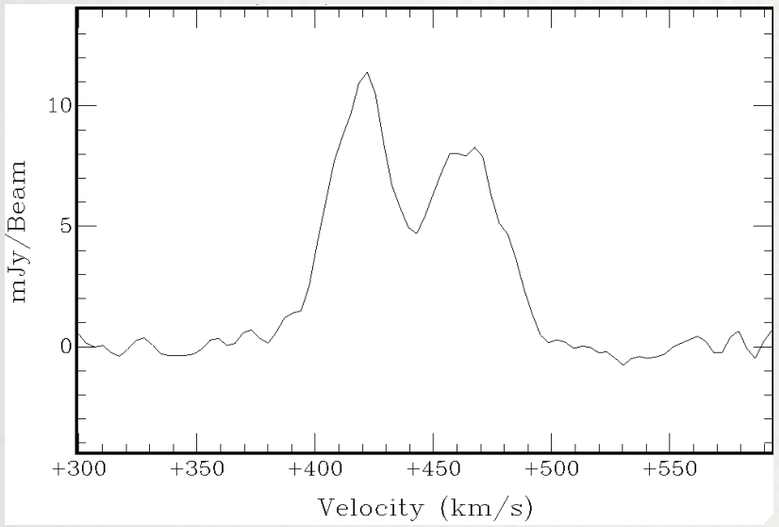
MODELLING THE GAS DYNAMICS

- ☐ Central gas kinematics could be those of an expanding gas torus.

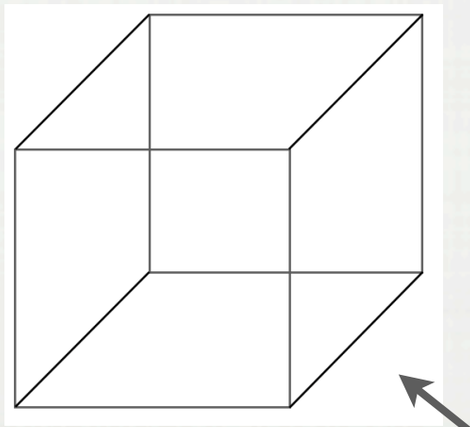




MODELLING THE GAS DYNAMICS



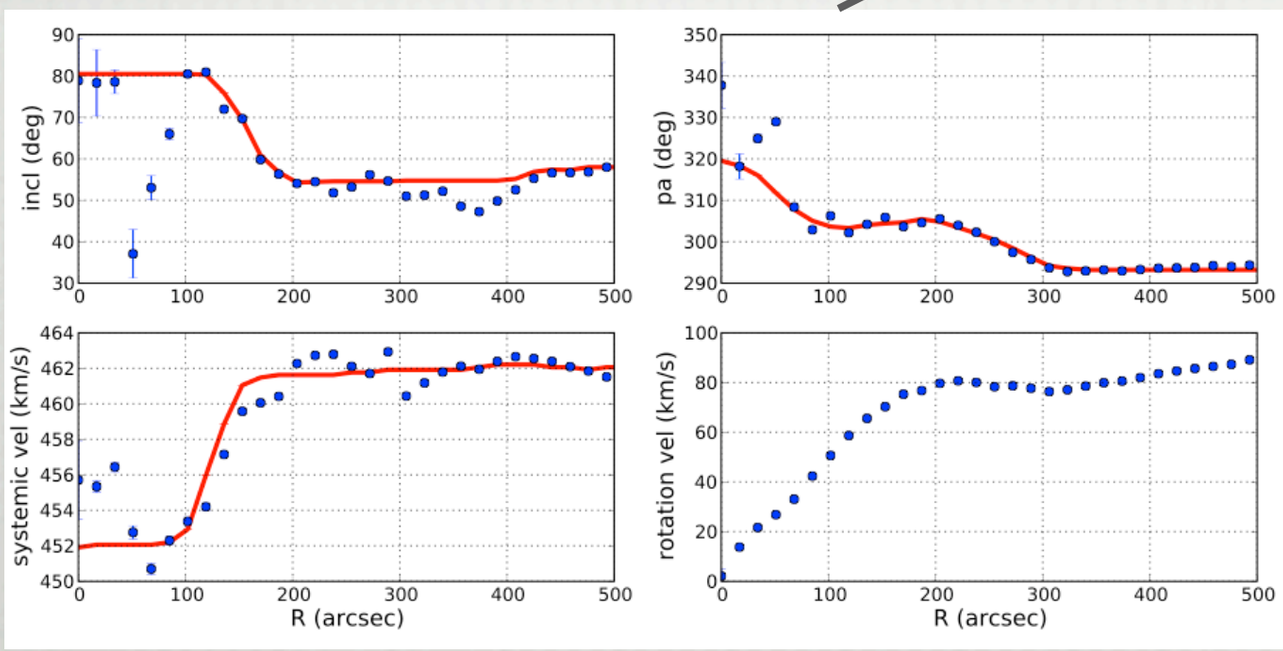
Expansion velocities

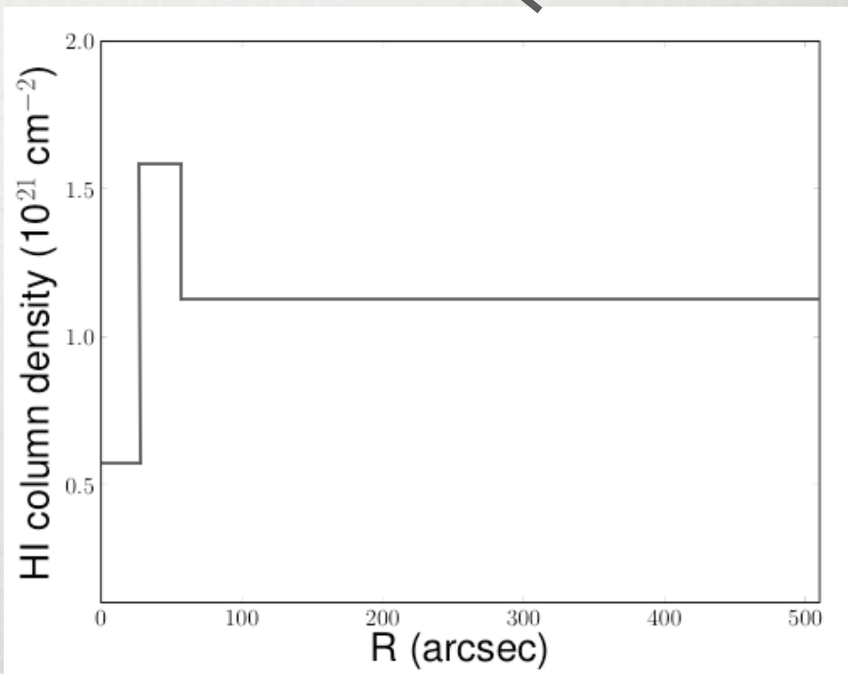


MODEL DATA CUBE

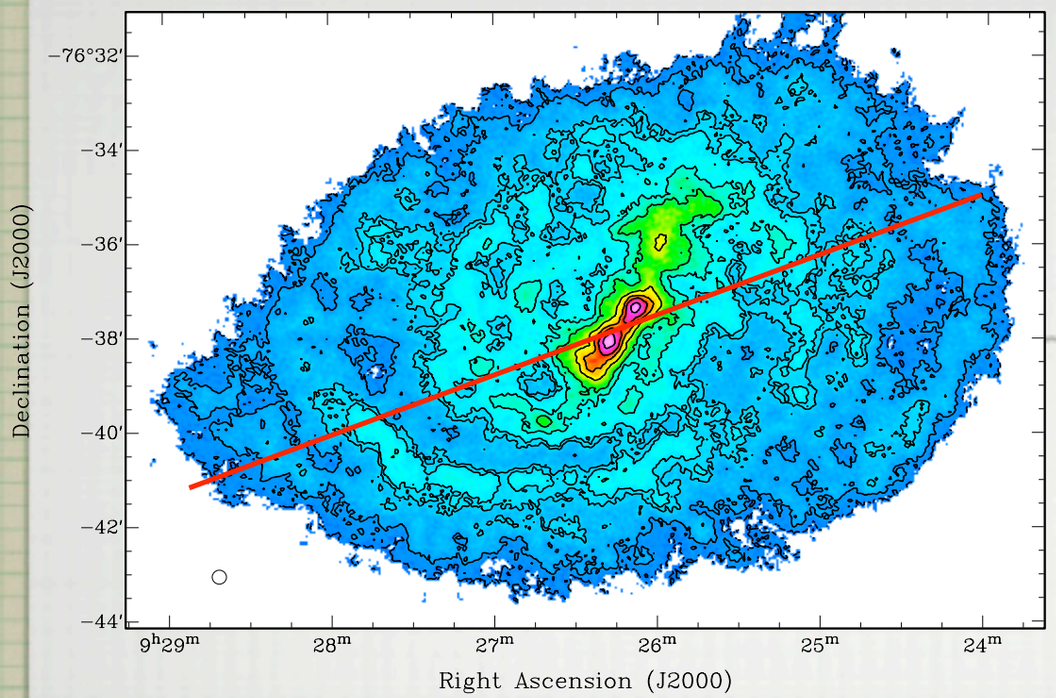
Kinematic parameters

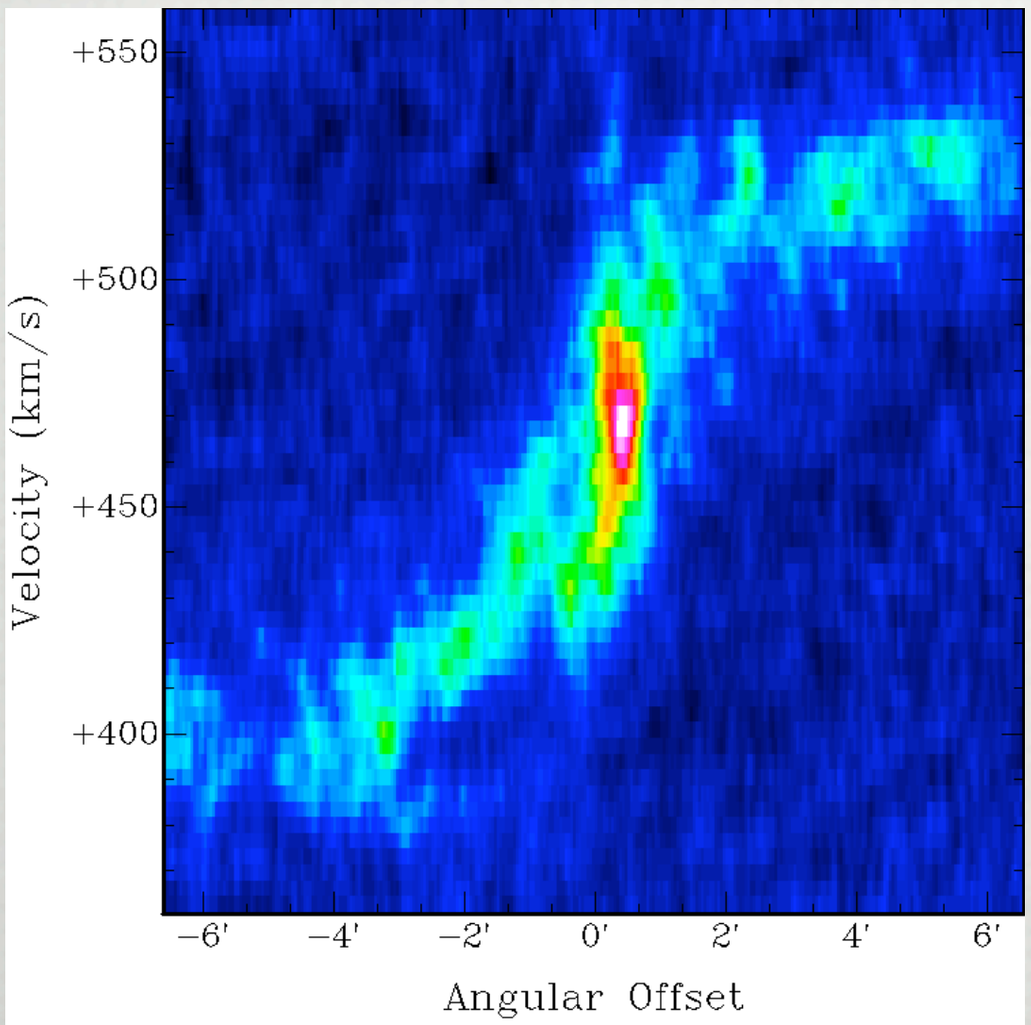
Gas distribution

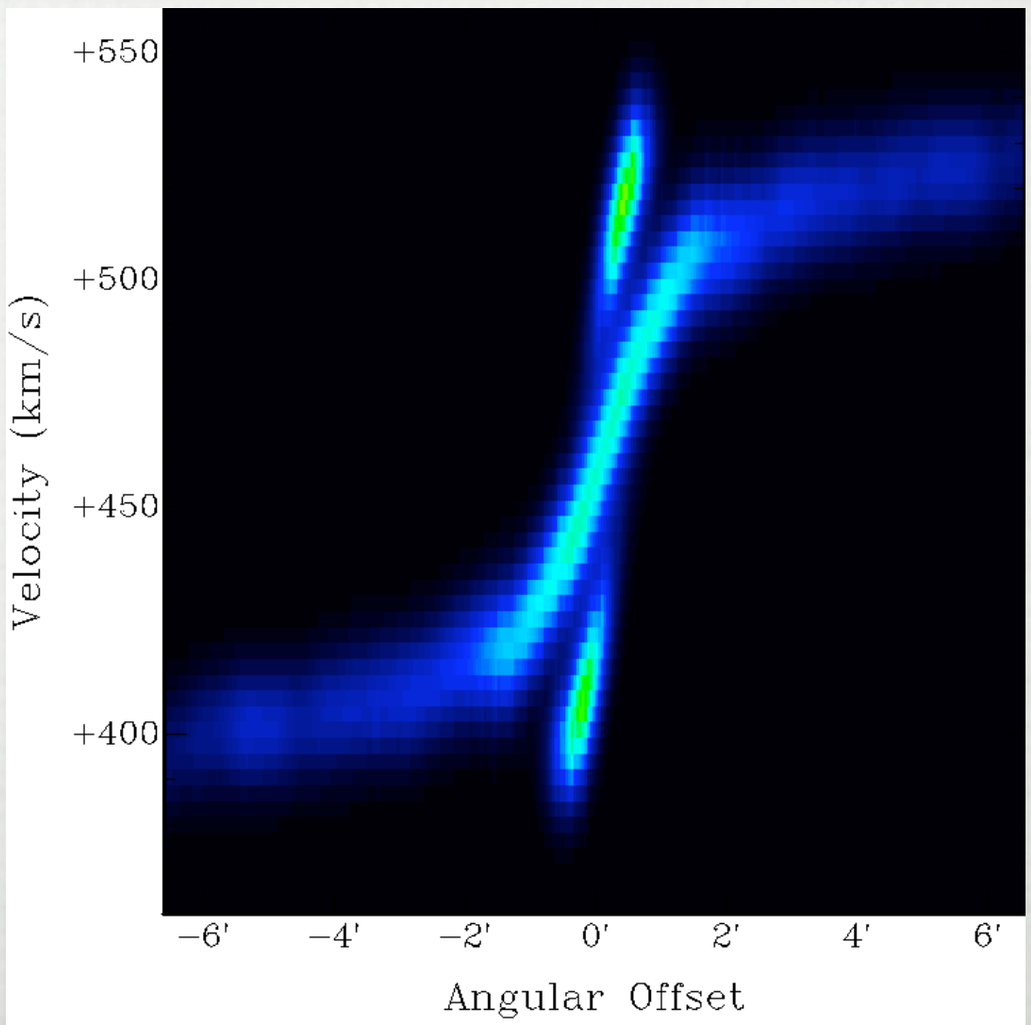




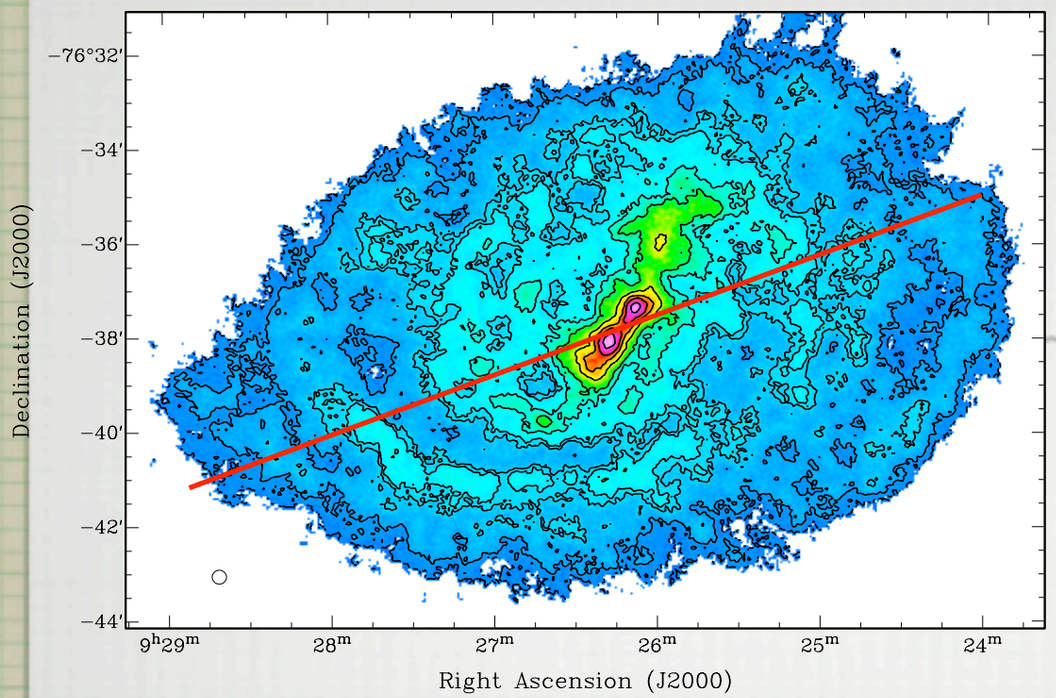
MODELLING RESULTS

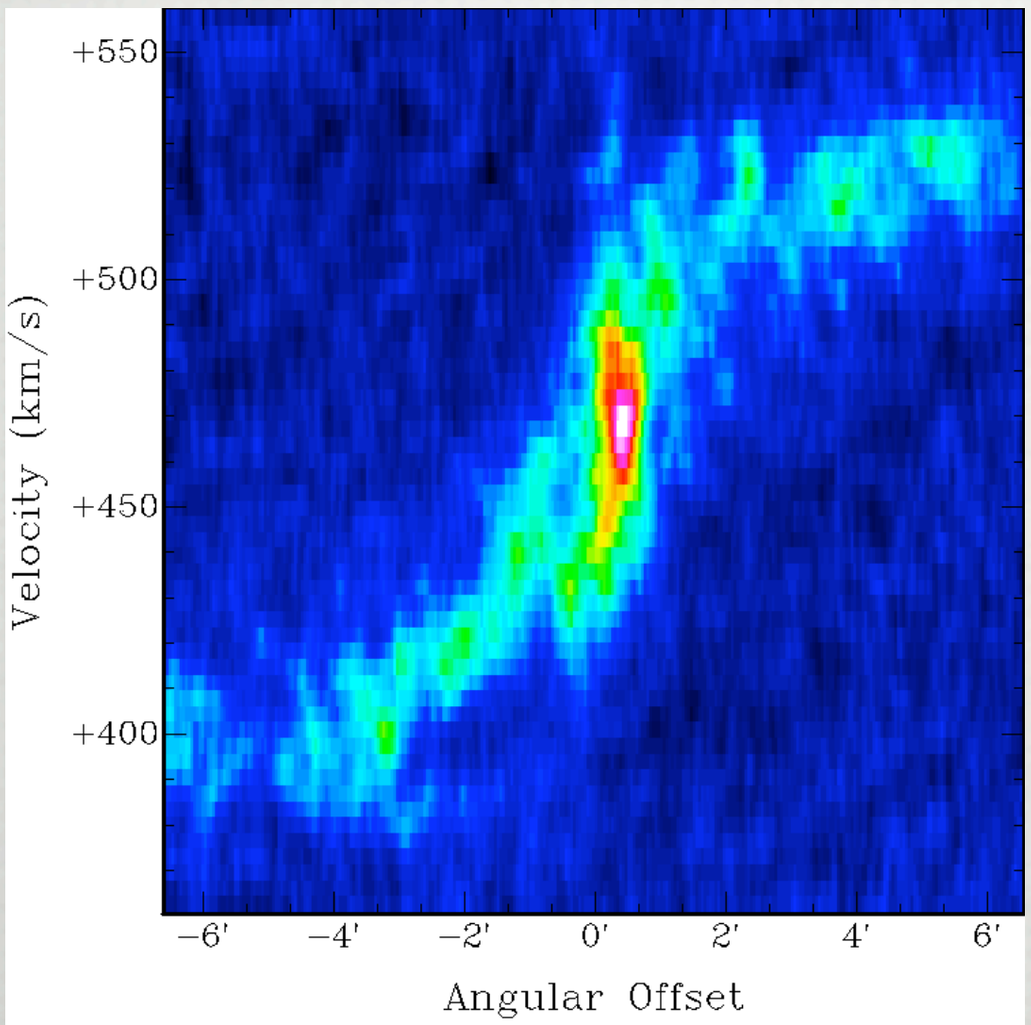


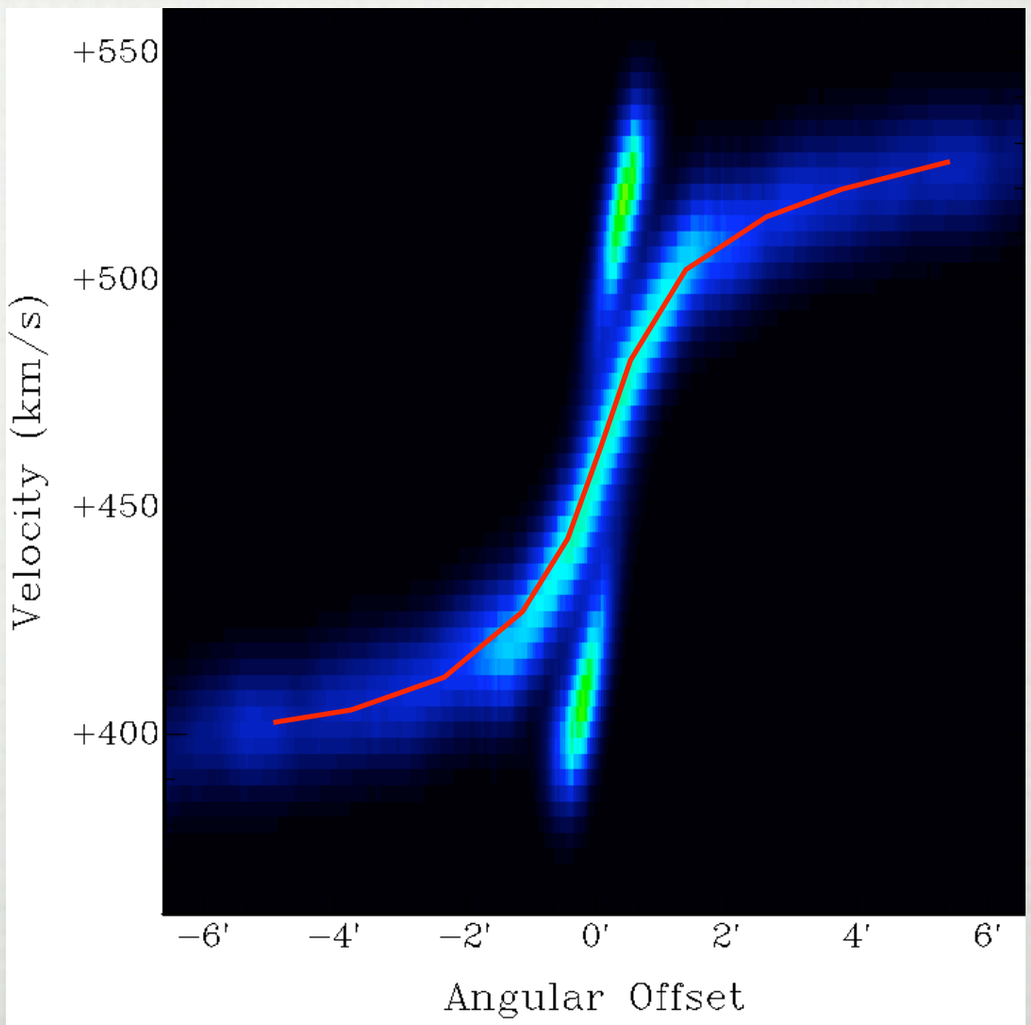




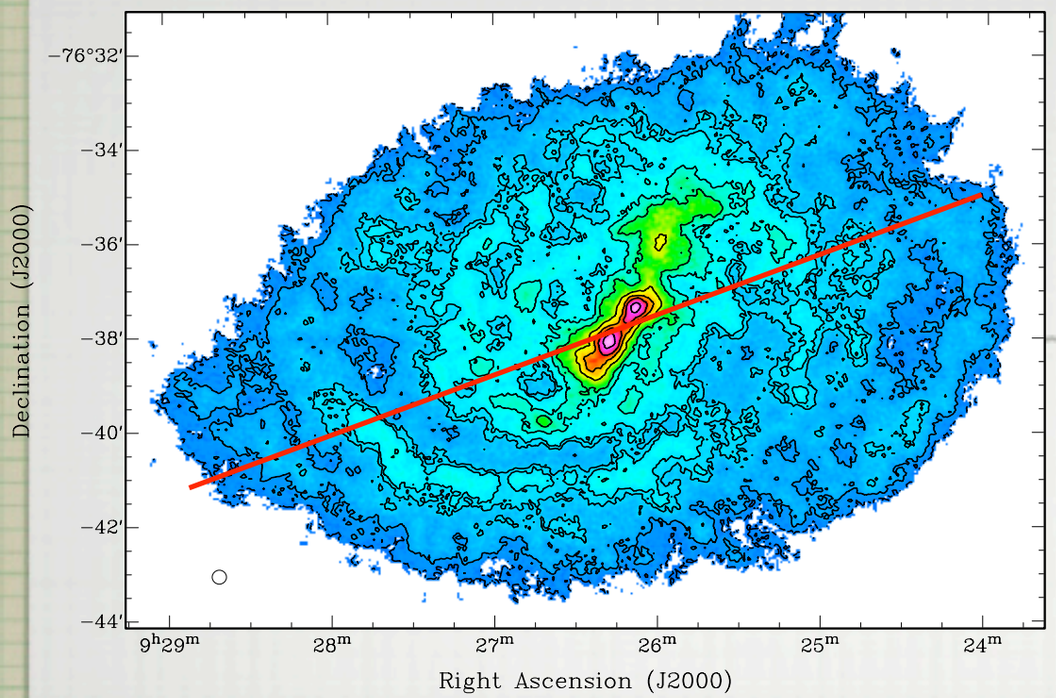
MODELLING RESULTS

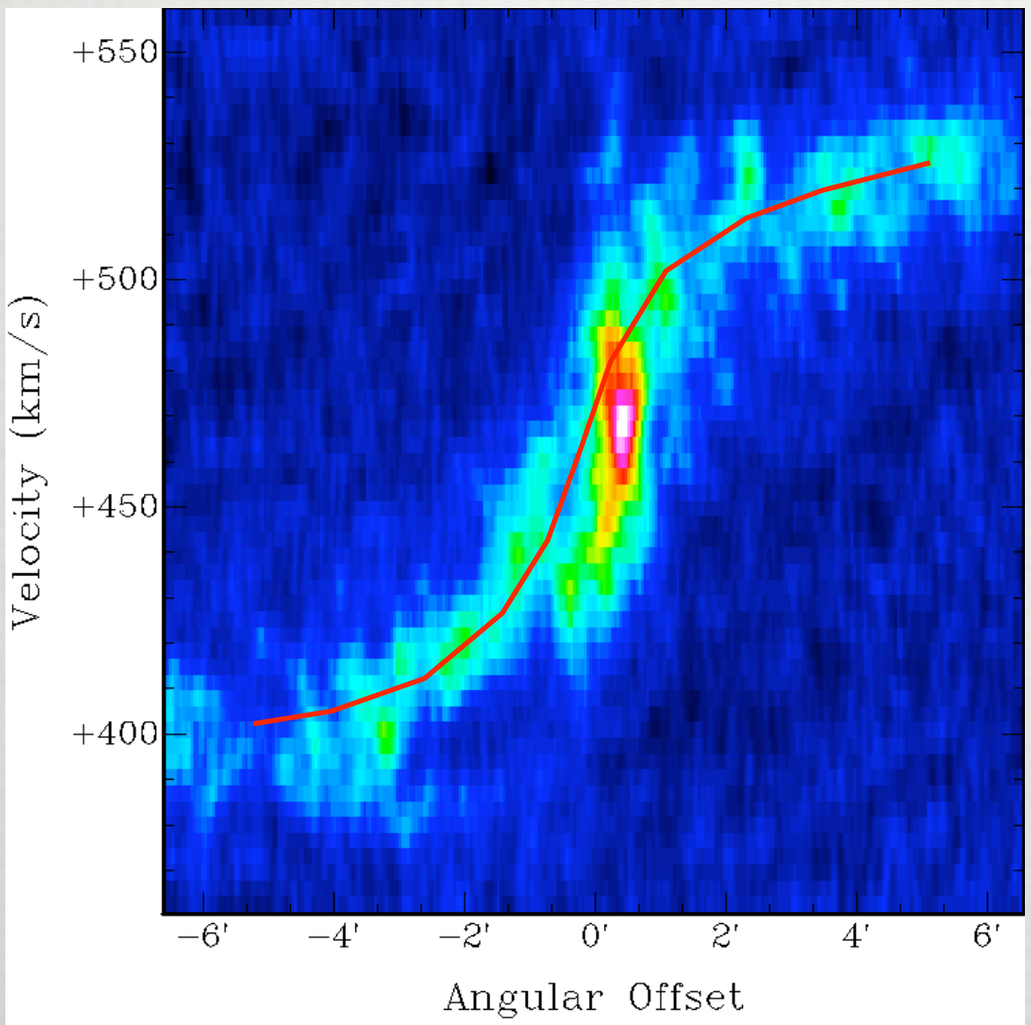


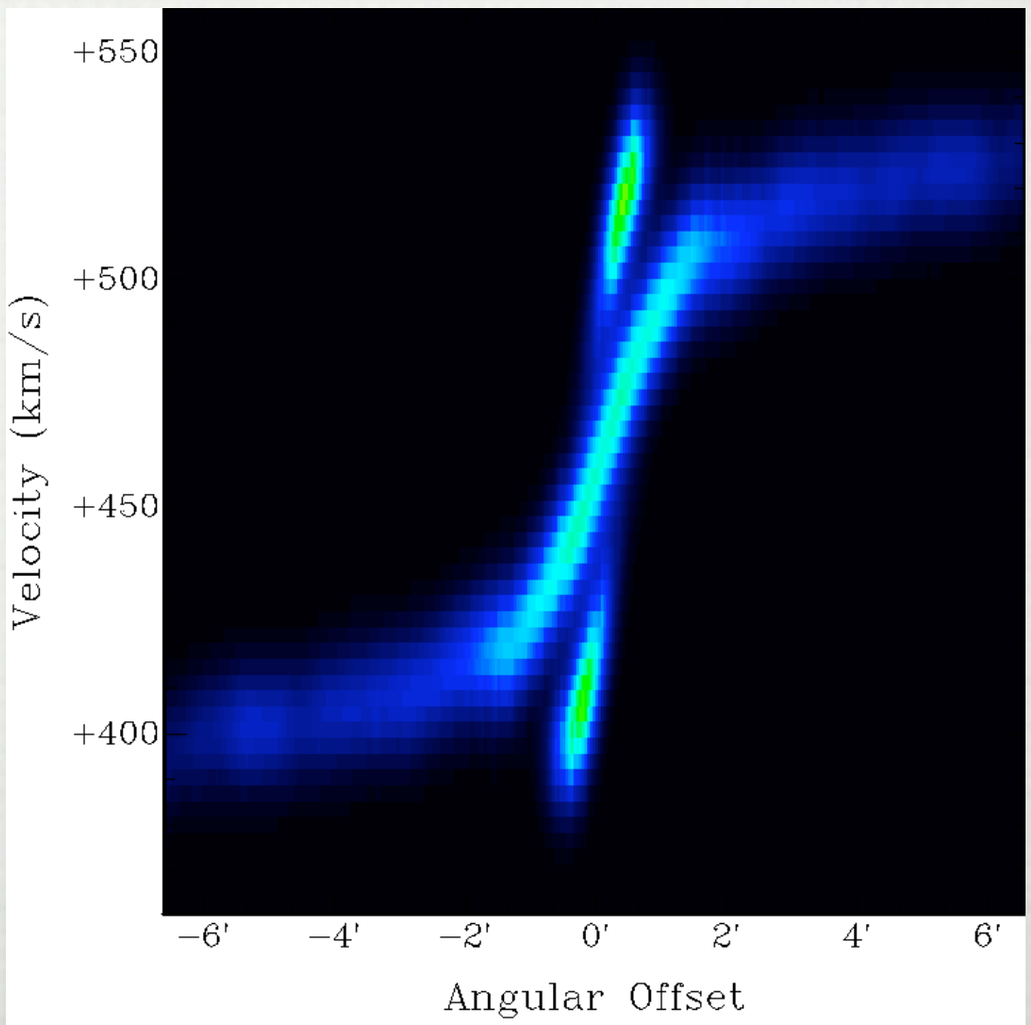




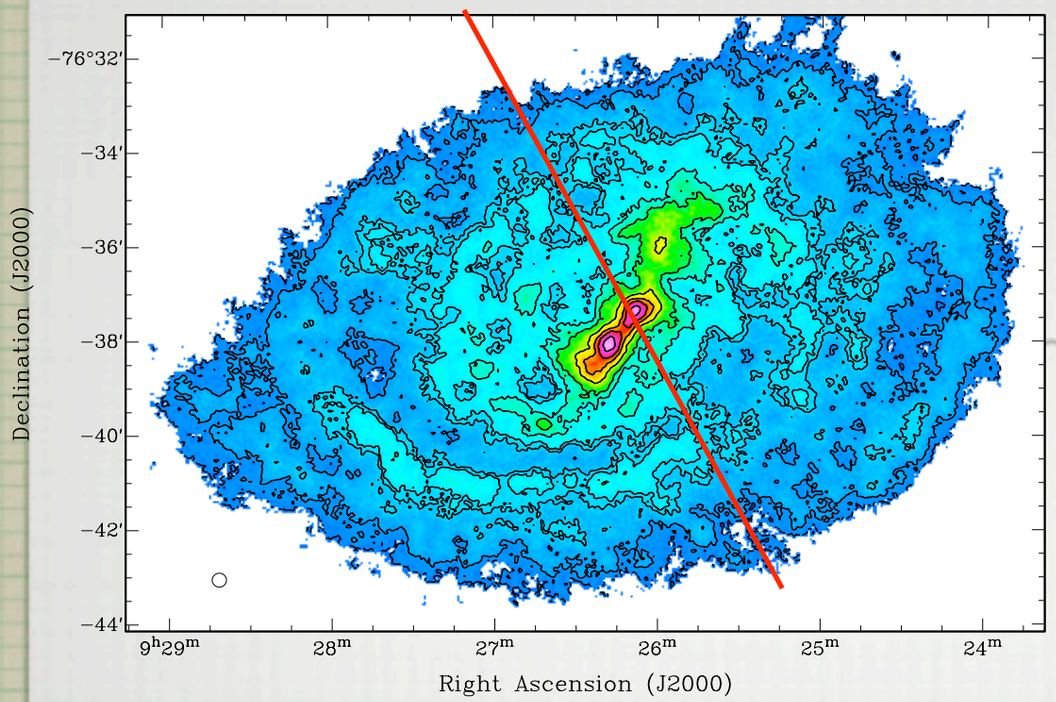
MODELLING RESULTS

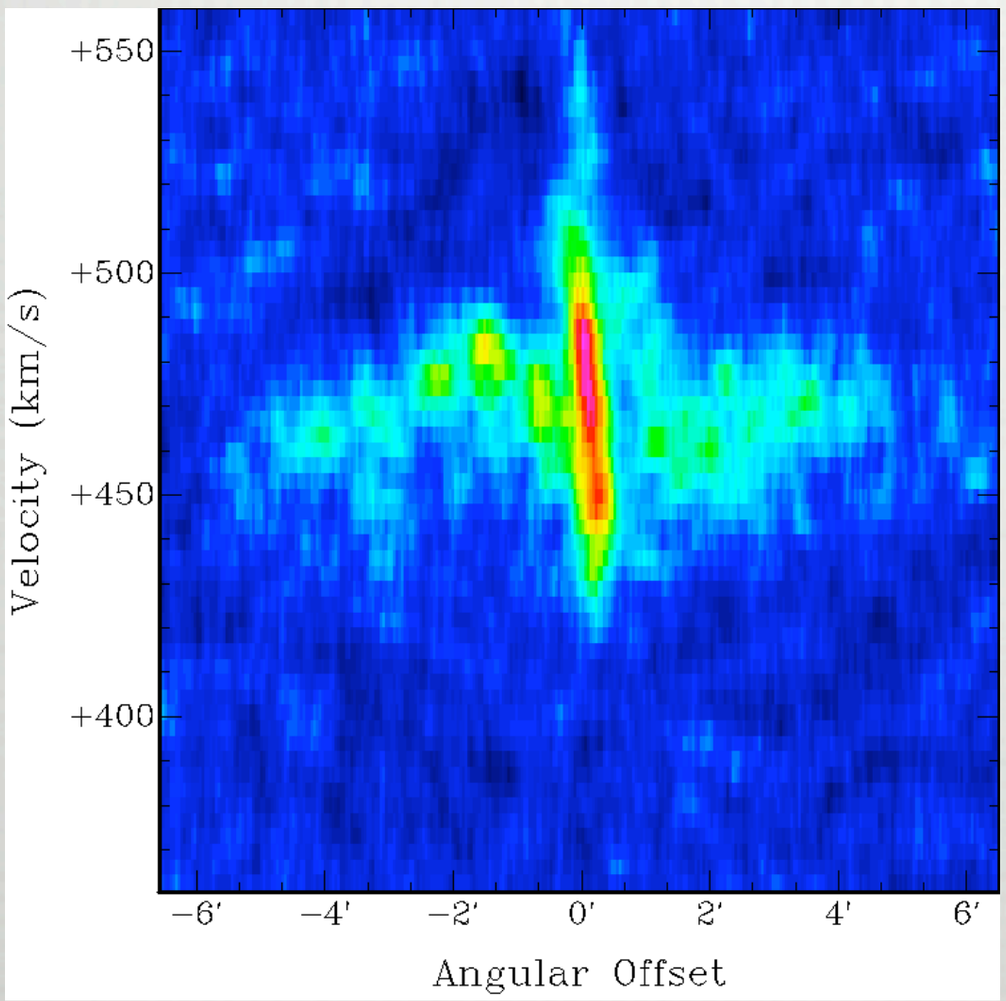


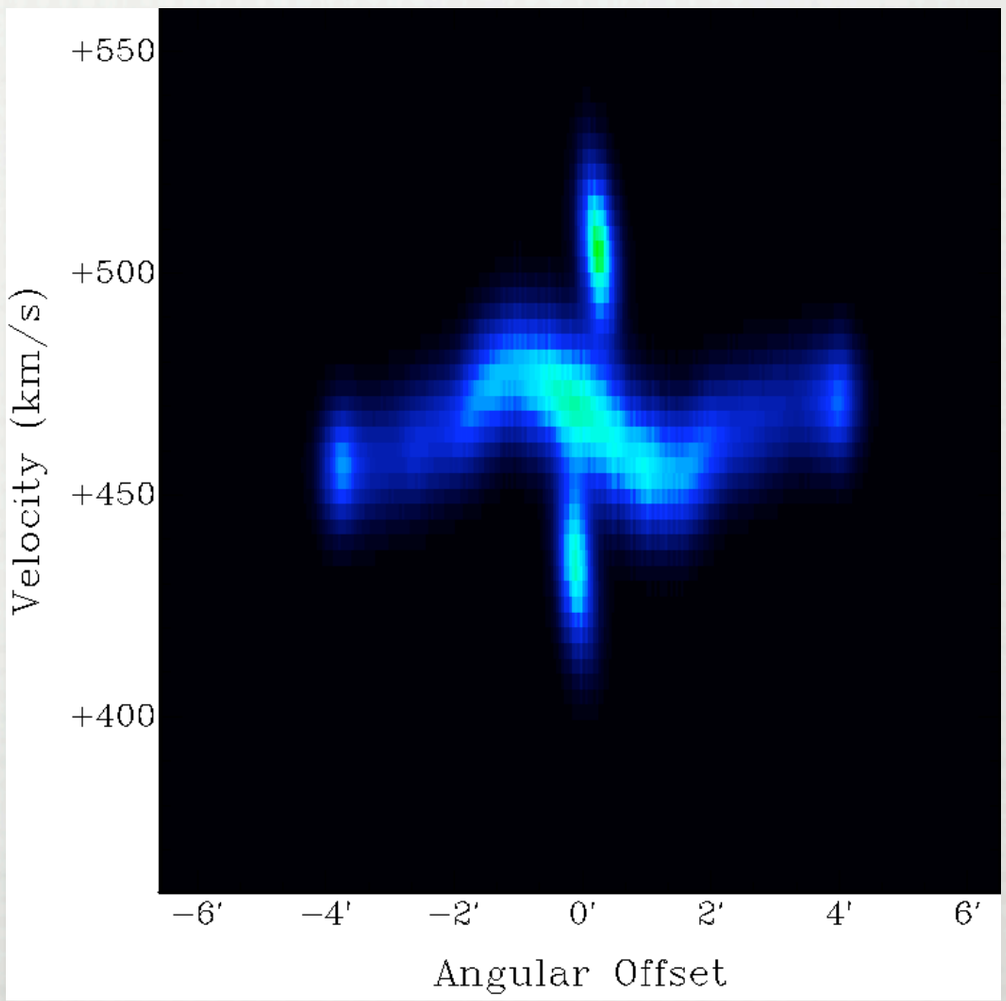




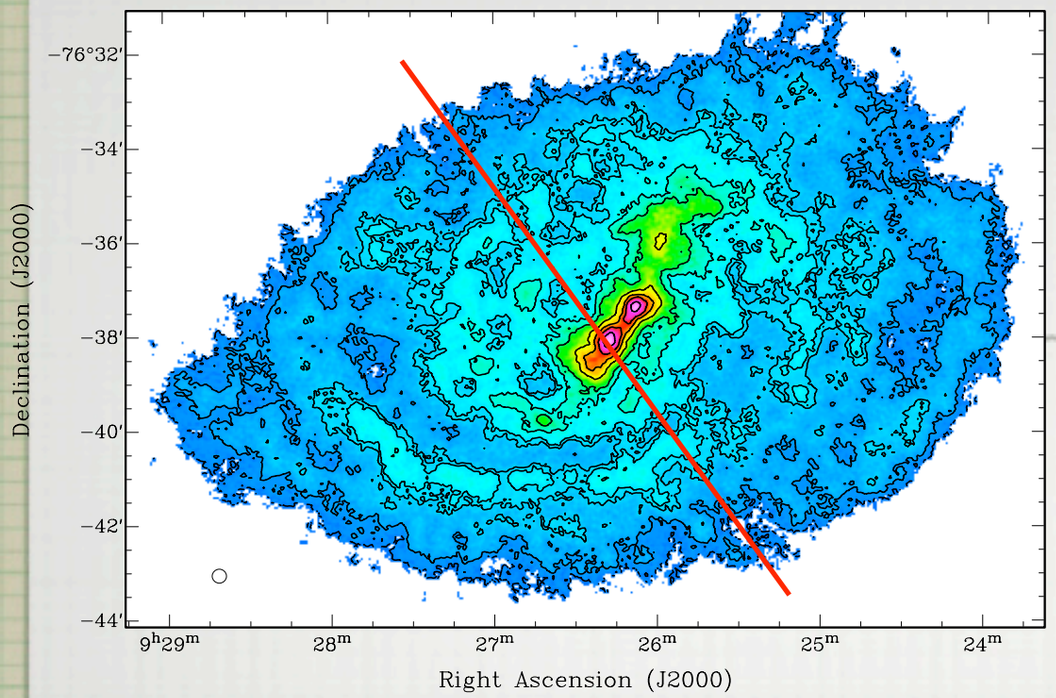
MODELLING RESULTS

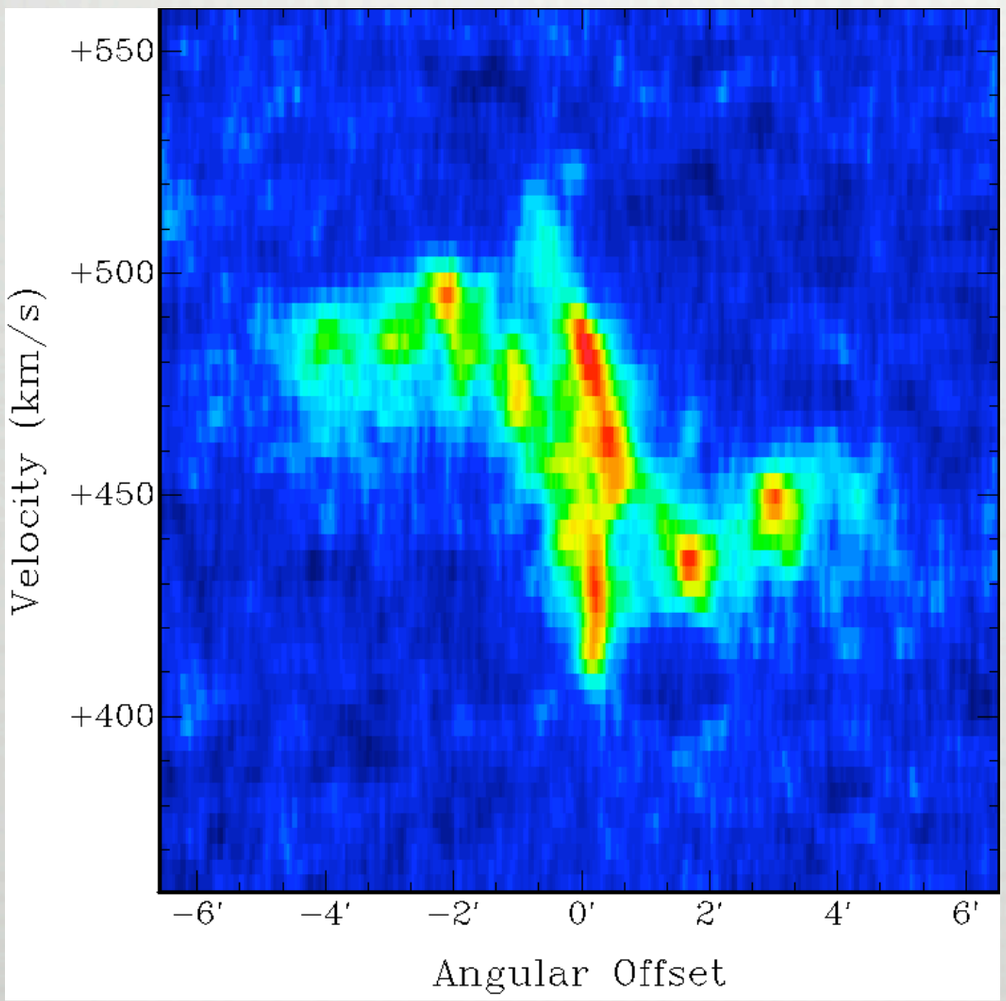


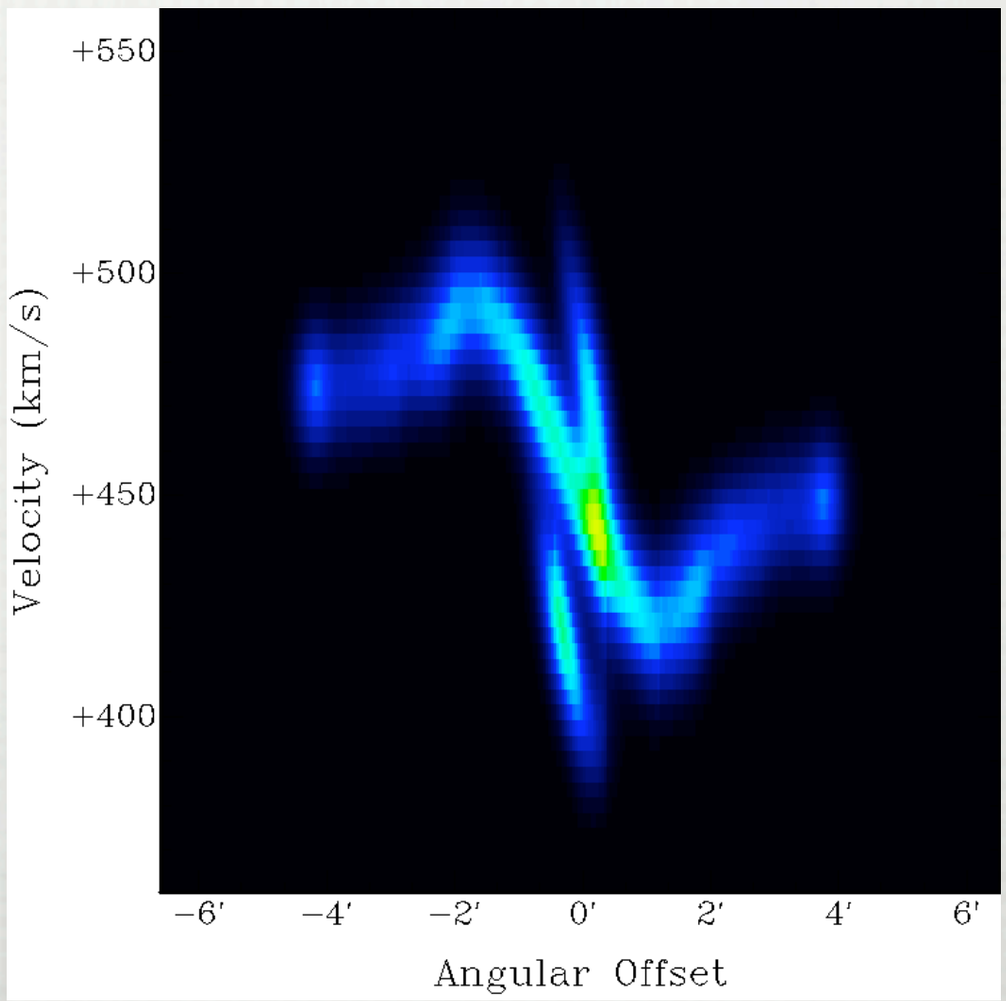




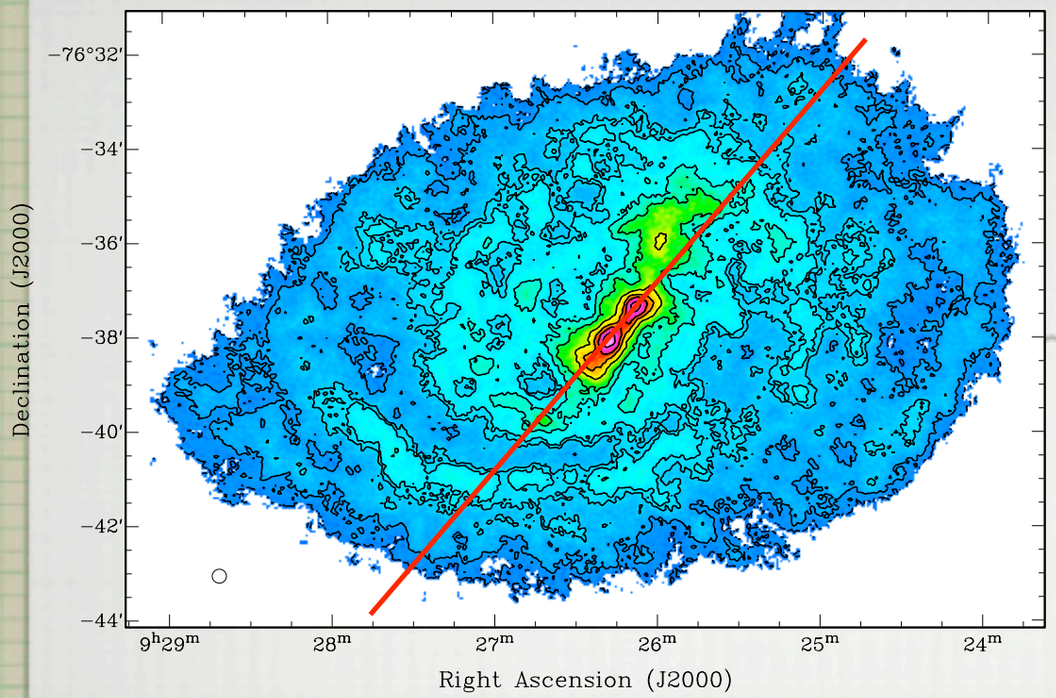
MODELLING RESULTS

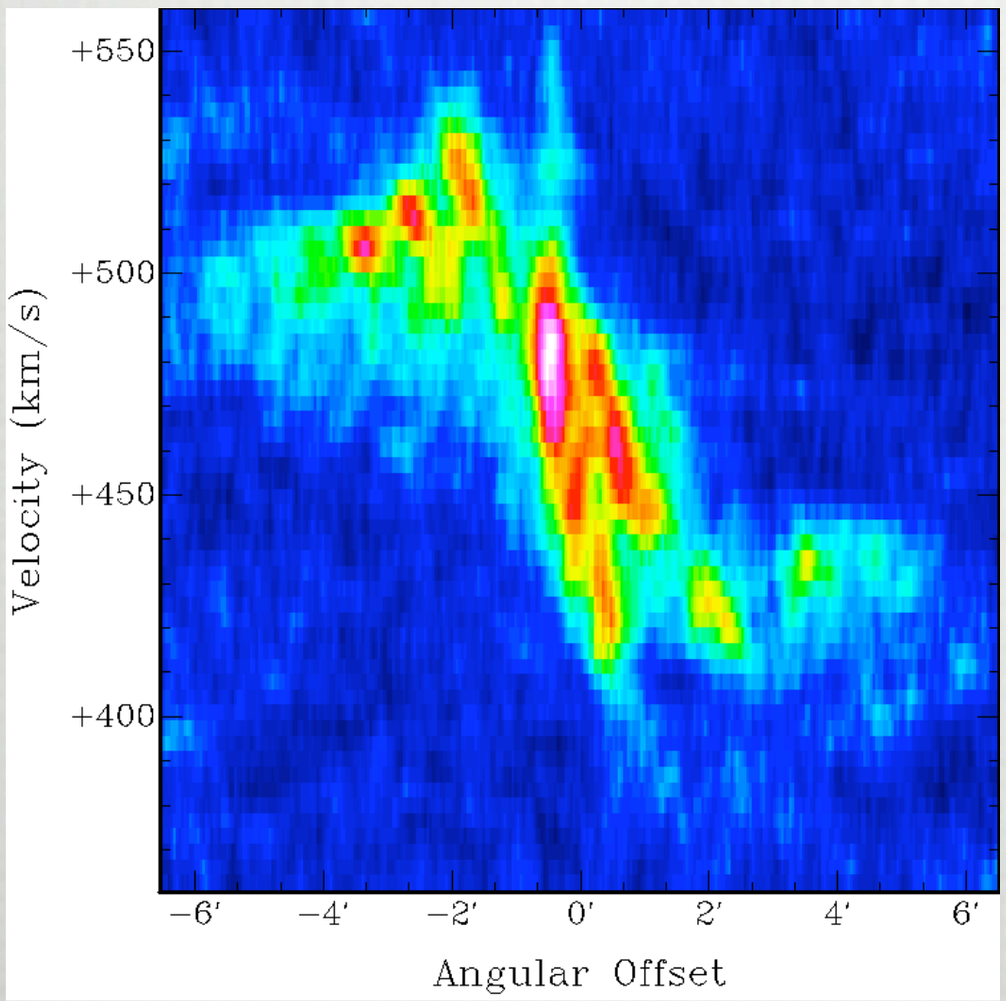


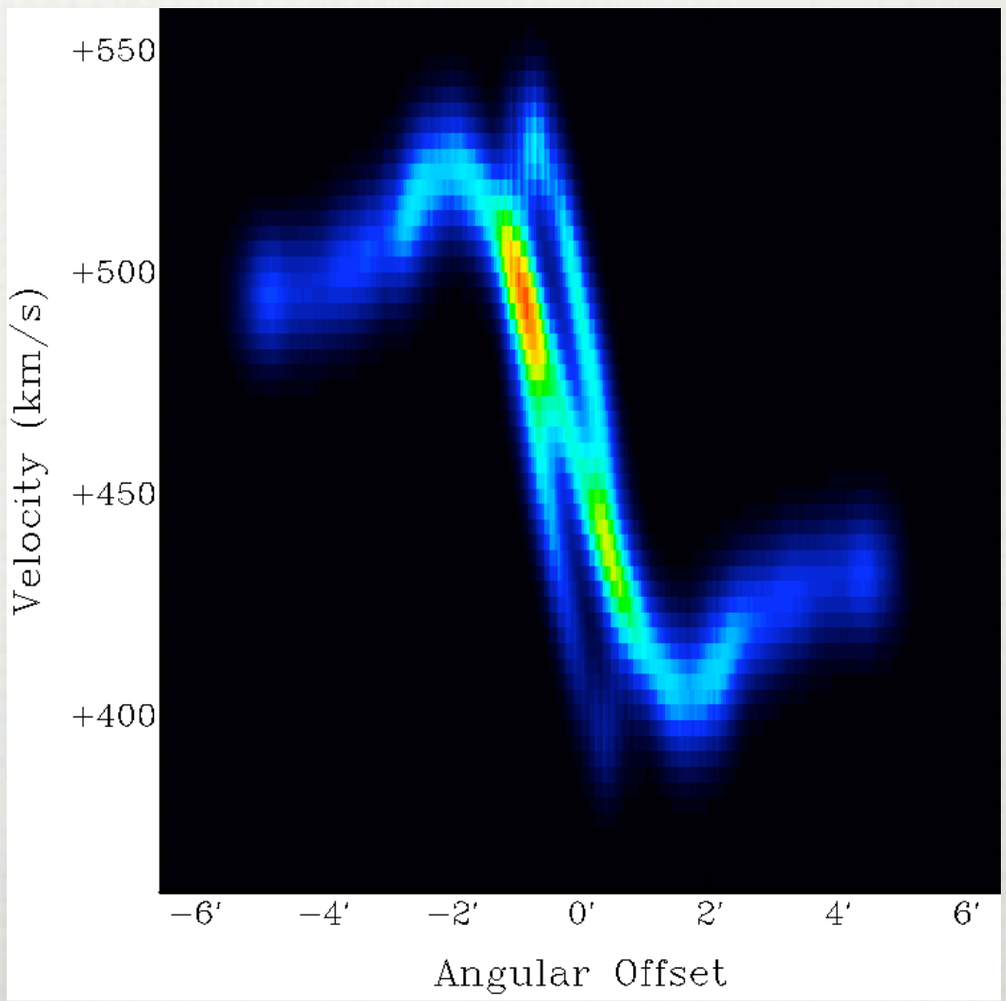




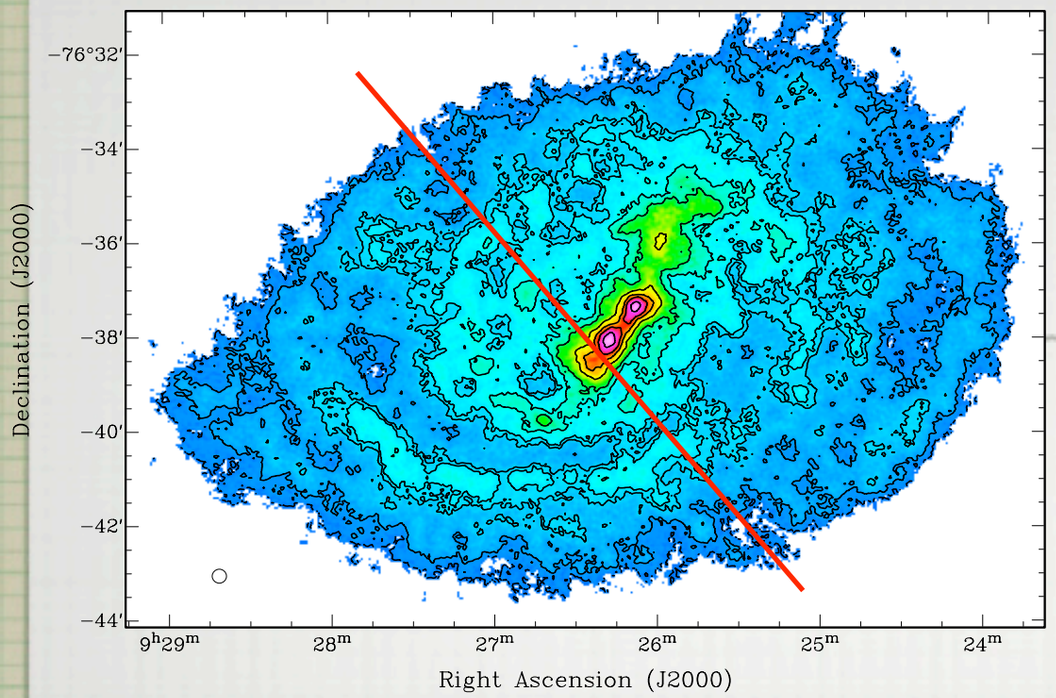
MODELLING RESULTS

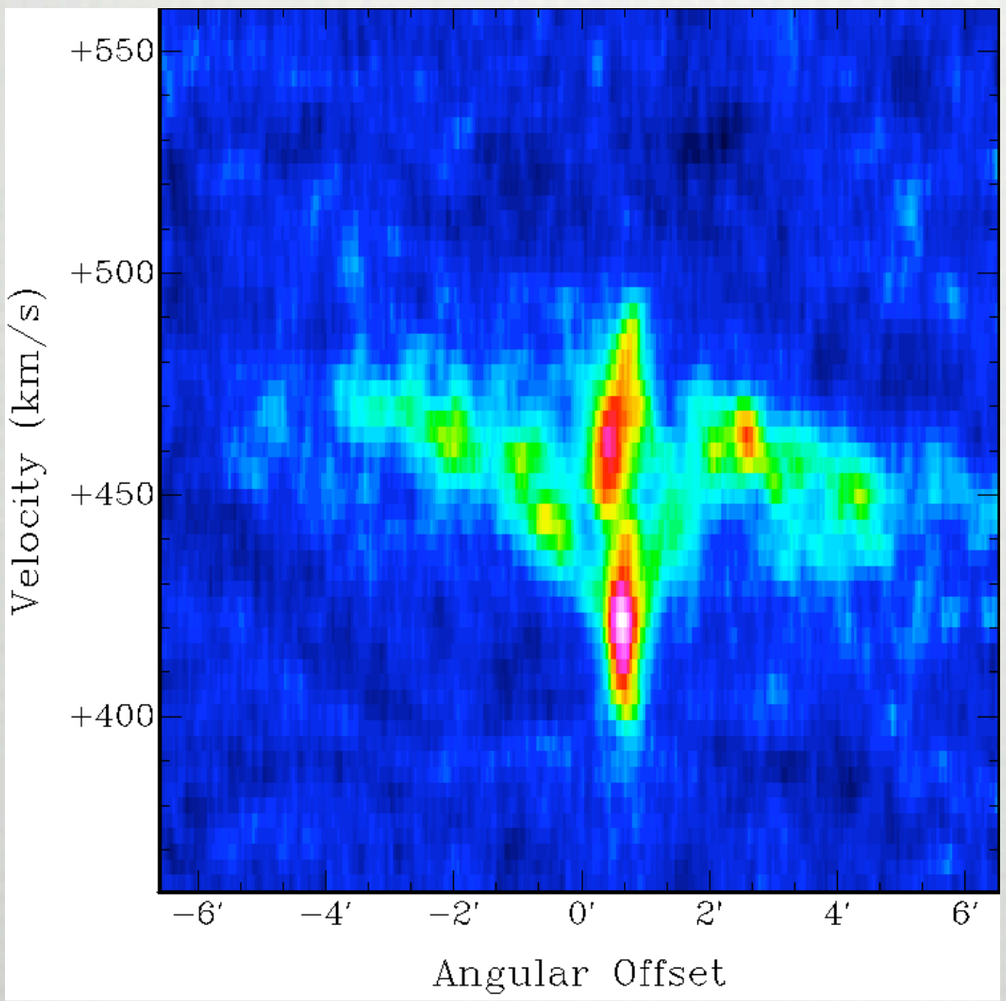


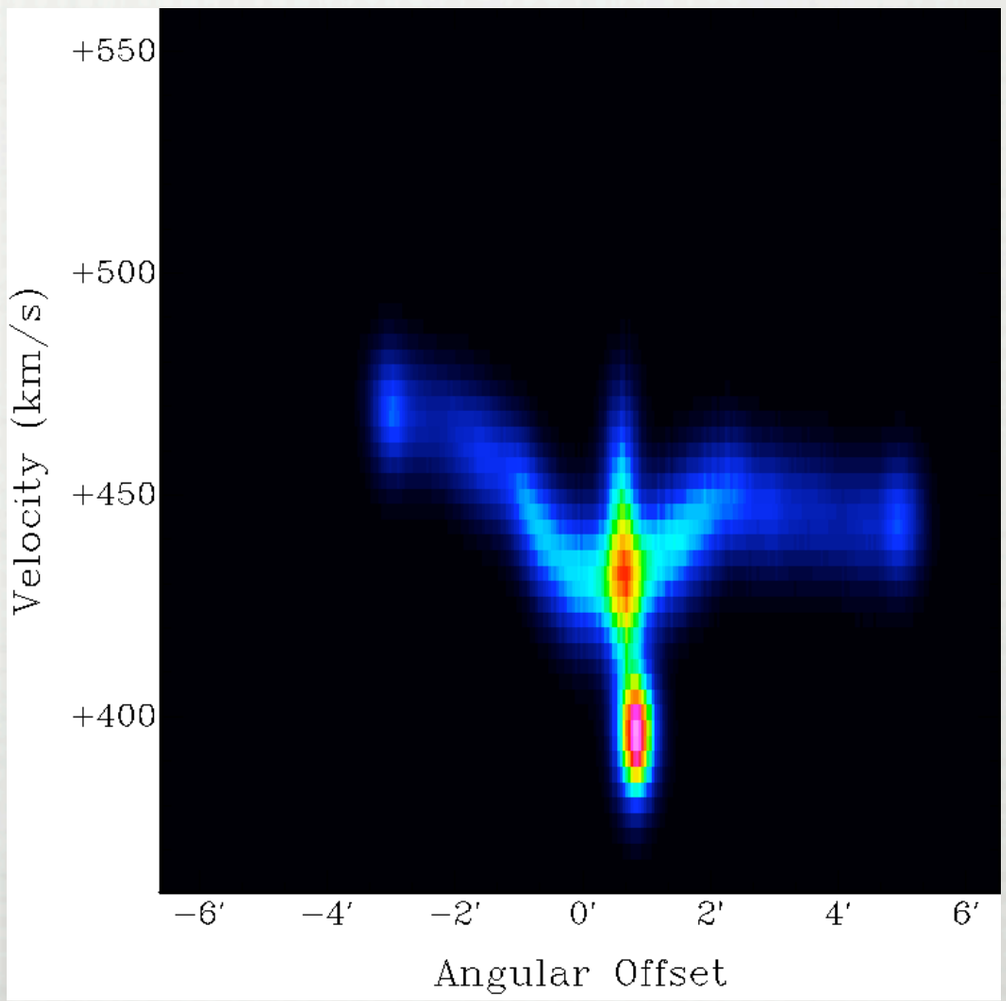




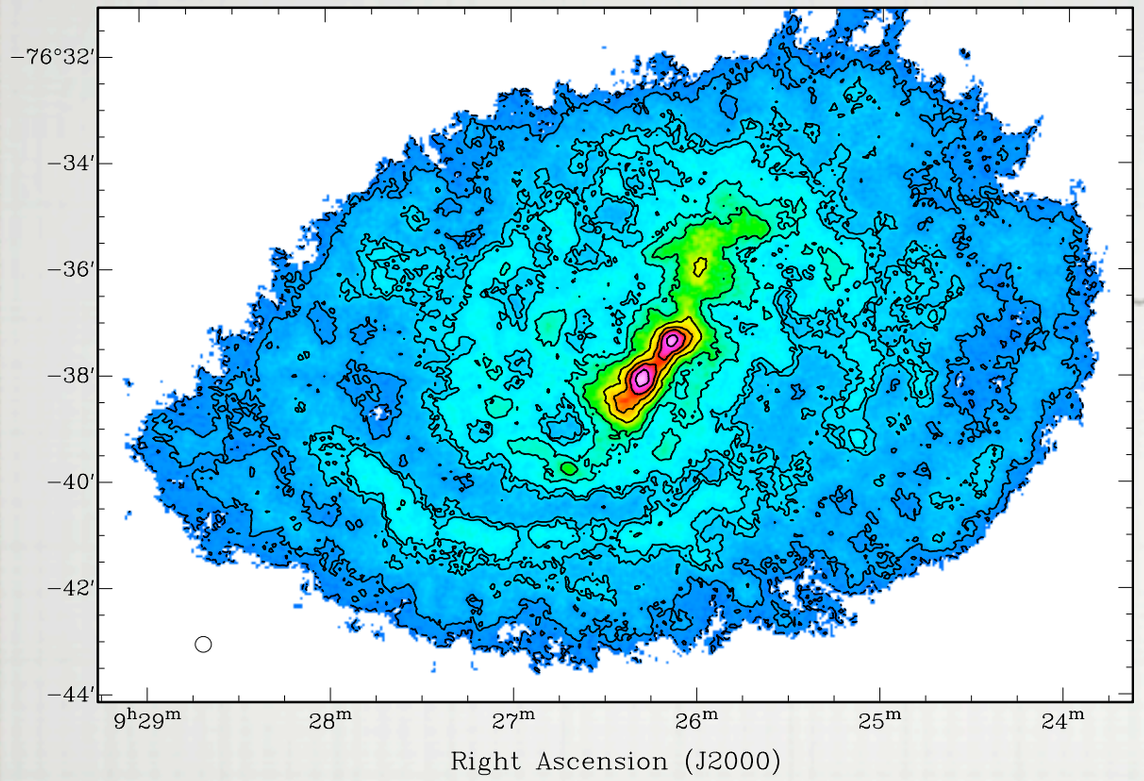
MODELLING RESULTS



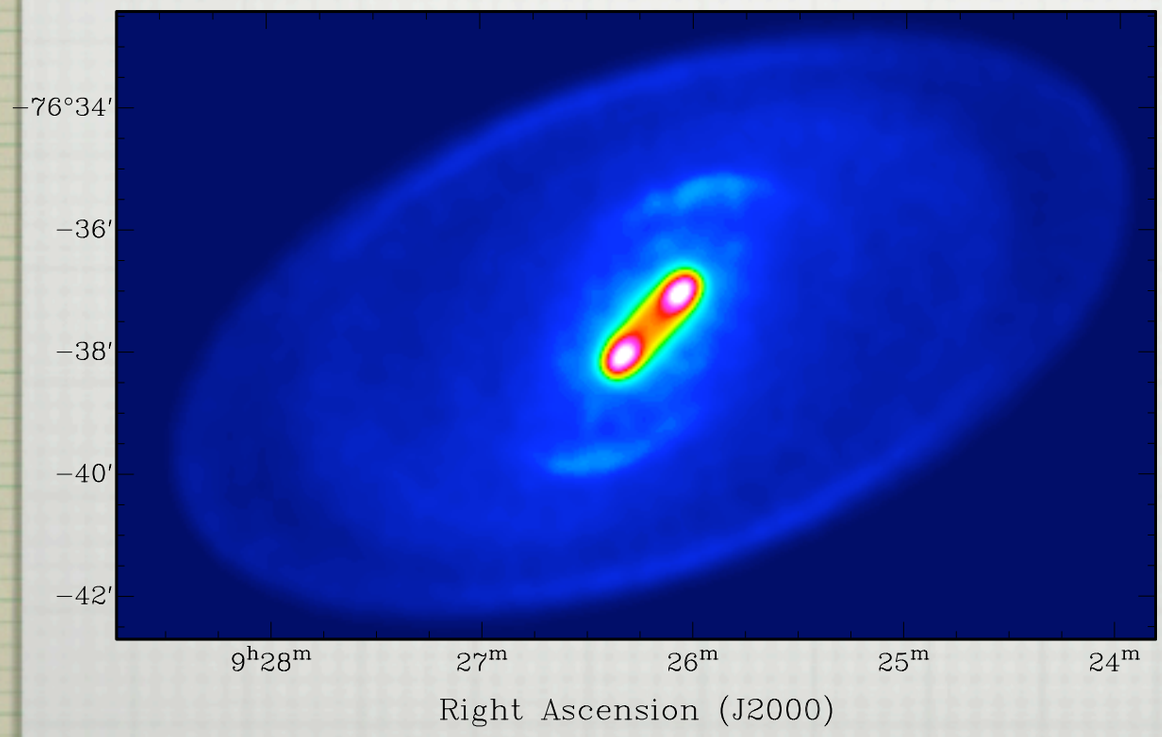




MODELLING RESULTS



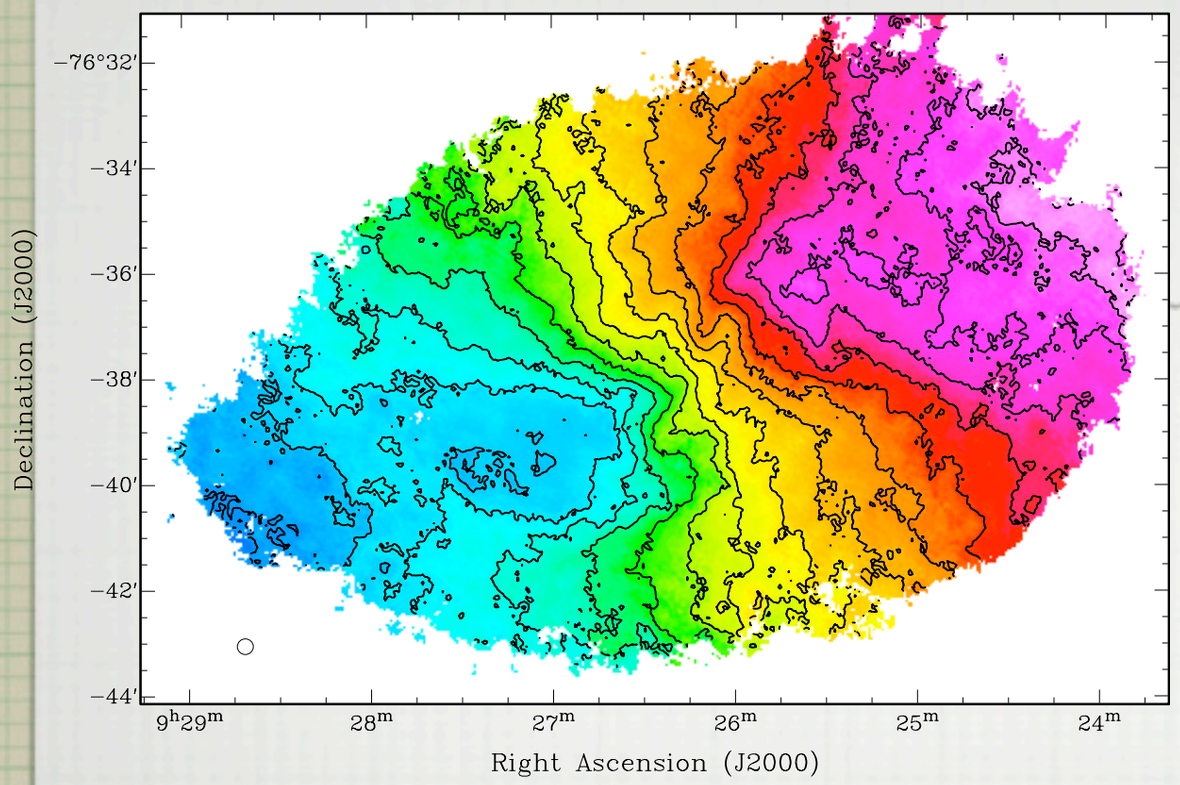
HI total intensity maps



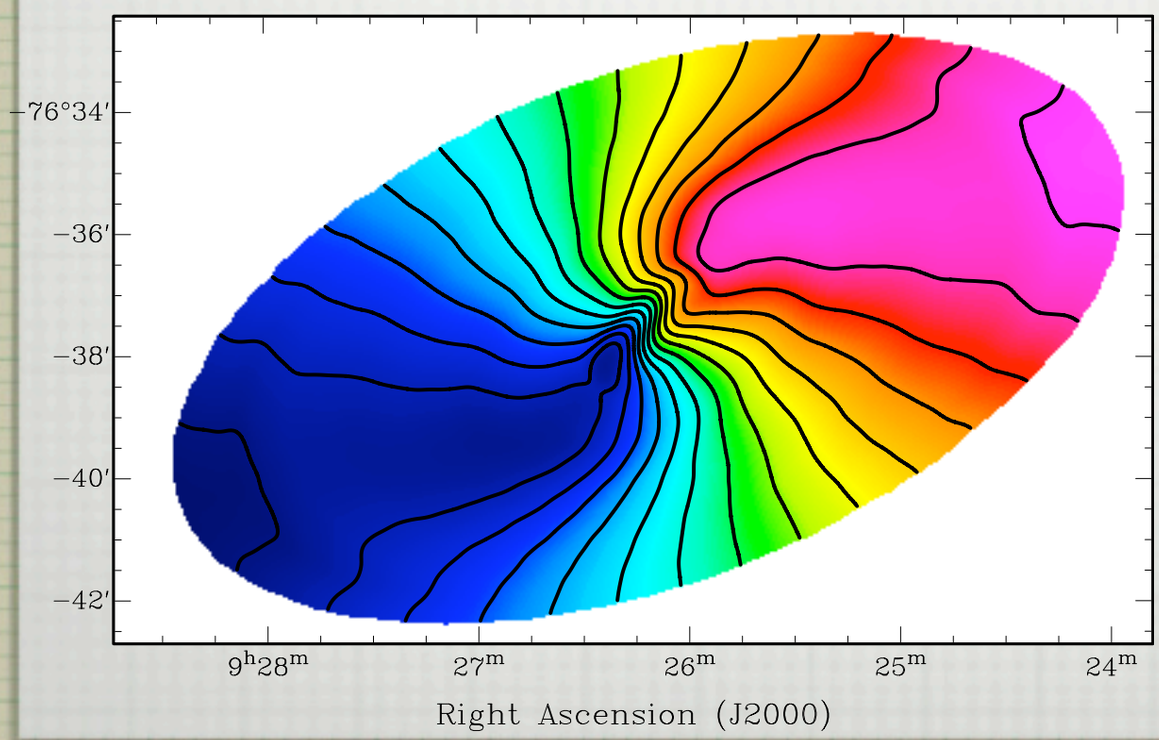
- Central HI clouds reproduced in total intensity map.
- Model cubes are radially symmetric →

  No spiral structure reproduced.

MODELLING RESULTS

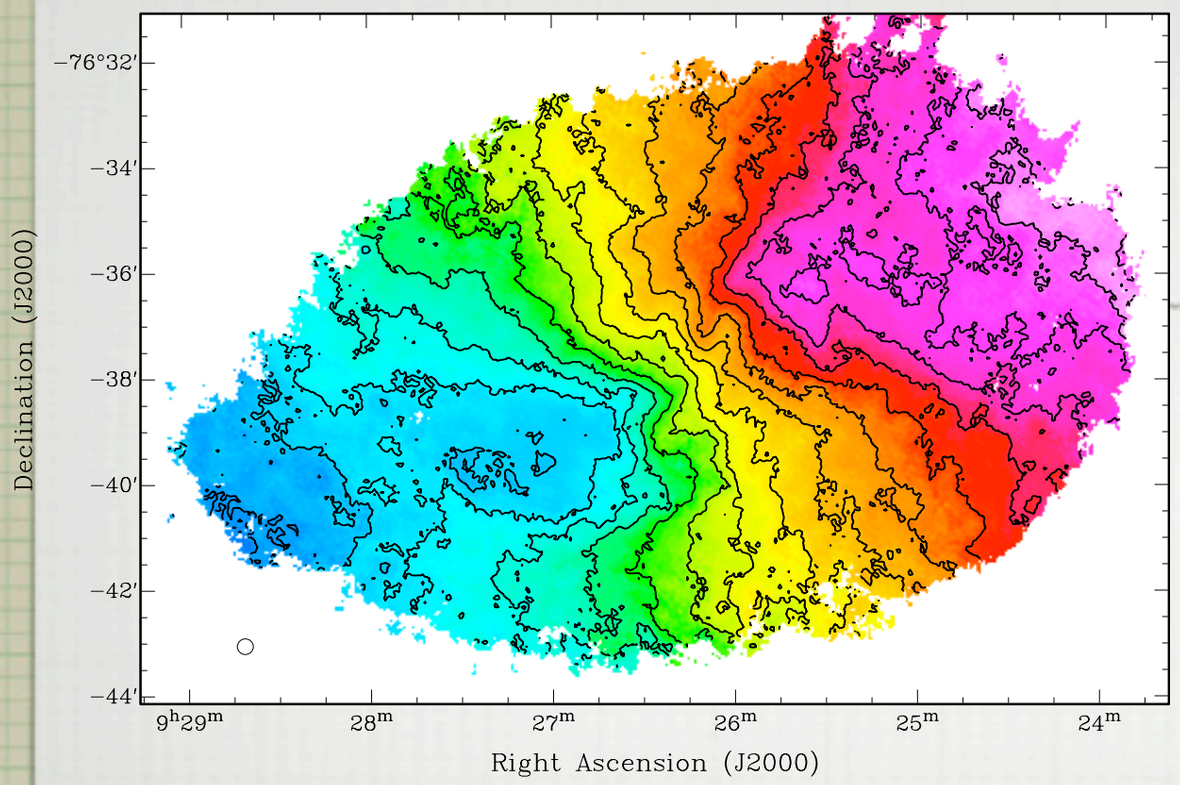


HI velocity fields

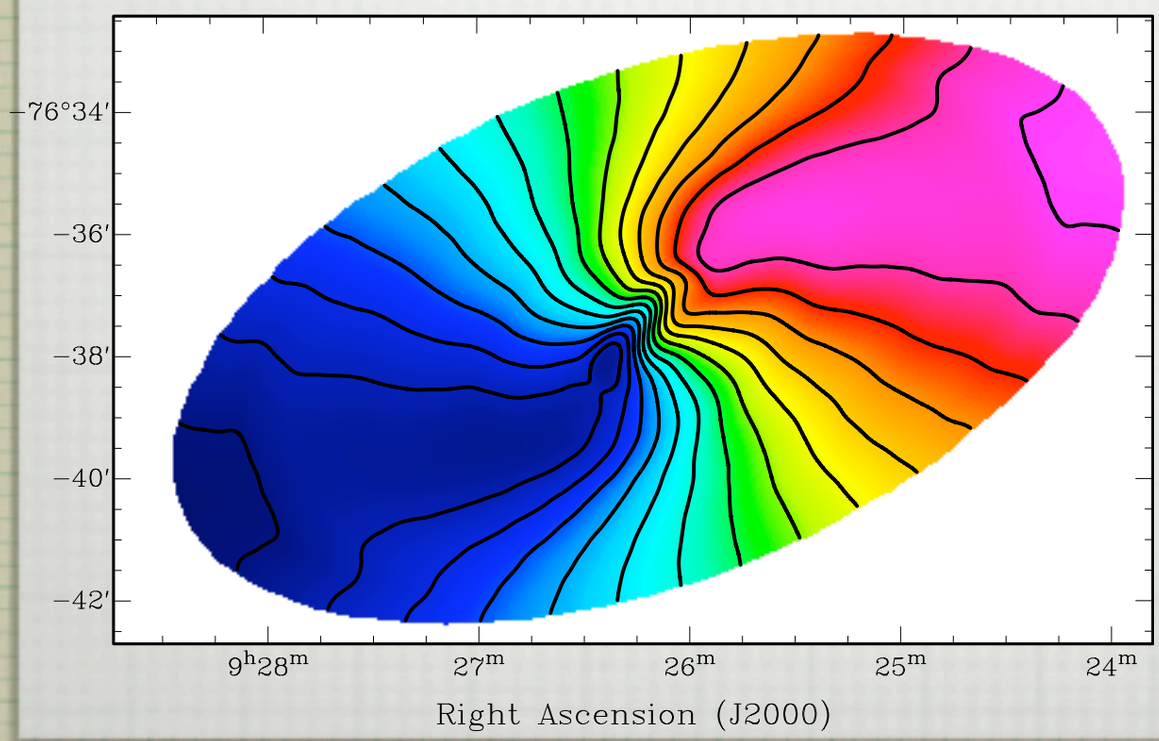


- ☐ Relatively poor agreement between data and model
- ☐ Further modelling required.

MODELLING RESULTS



HI velocity fields



- ☐ Relatively poor agreement between data and model
- ☐ Further modelling required.

Is NGC 2915 perhaps more BCD-like than we give it credit for?

CONCLUSIONS

- The nature of NGC 2915s HI content is perplexing.
  - Why is it there?
  - Why does it have a late-type spiral morphology?
- Evidence of gas in-fall and other anomalous gas components.
- Central dynamics are very complex. Why?
  - Energy output from high mass stars are consistent with central gas energetics.
  - Central dynamics seem consistent with a radially expanding HI torus.

ACKNOWLEDGMENTS

- Funding provided by SA SKA Project
- Supervisors (W. J. G. de Blok, R. C. Kraan-Korteweg)
- Prof. Renzo Sancisi
- Dr. Fillippo Fraternali