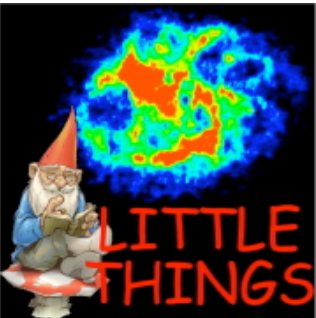


The Stellar and Gas Kinematics of LITTLE THINGS dIm galaxies NGC 1569, DDO 168, and DDO 46

Megan Johnson
NRAO, Green Bank

Star Formation in Dwarf Galaxies, June 2012

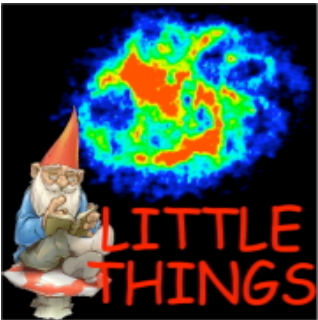


LITTLE THINGS Team

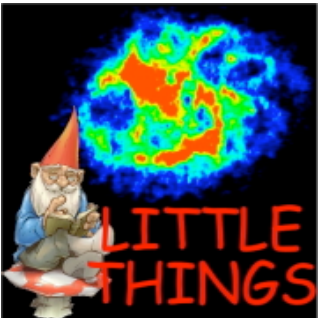


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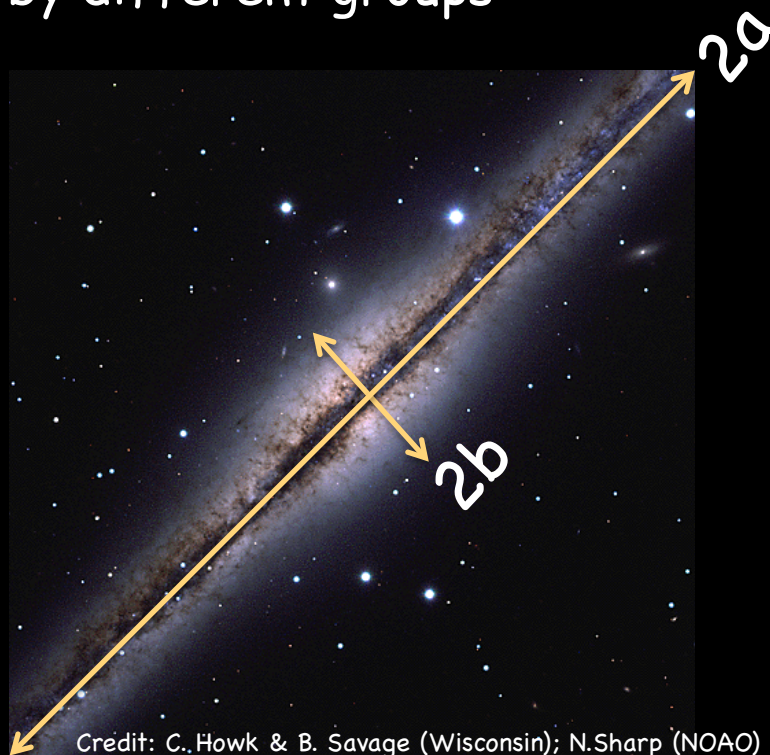


What is the shape of a
dIm galaxy?



Previous Works

- Determining the shape of dIm galaxies is controversial
 - Distributions of projected b/a ratios lead to different interpretations by different groups

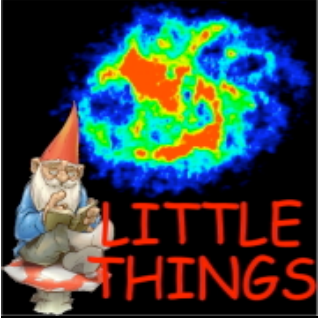


Credit: C. Howk & B. Savage (Wisconsin); N. Sharp (NOAO)

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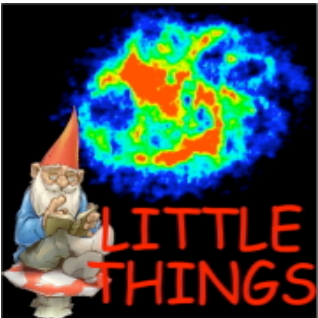
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Previous Works

- Determining the shape of dIm galaxies is controversial
 - Distributions of projected b/a ratios lead to different interpretations by different group
 - Thick disks → Hodge & Hitchcock 1966; van den Berg 1988; Staveley-Smith et al. 1992
 - Triaxial → Binggeli & Popescu 1995

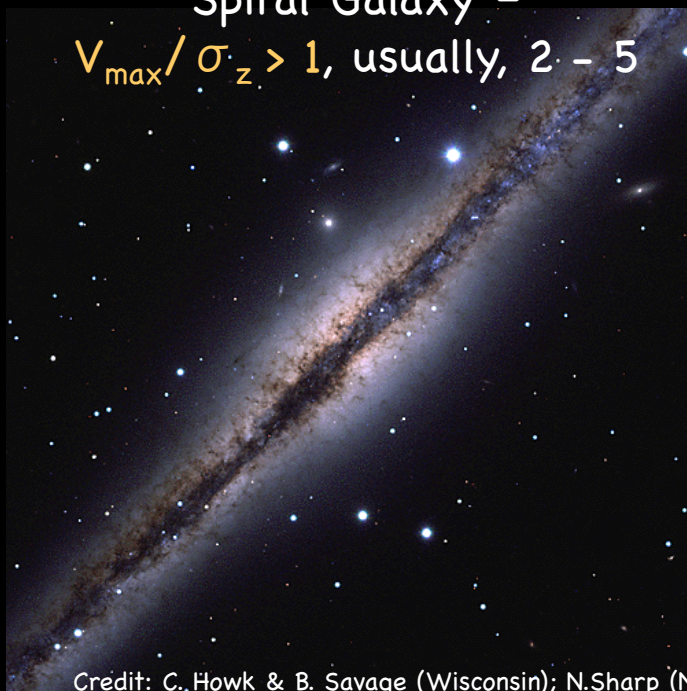


Kinematics to Determine Shape

- *Stellar* kinematics, combined with maximum rotation, provide a kinematic measure, V_{\max}/σ_z , of the shape of dIm systems.

Spiral Galaxy -

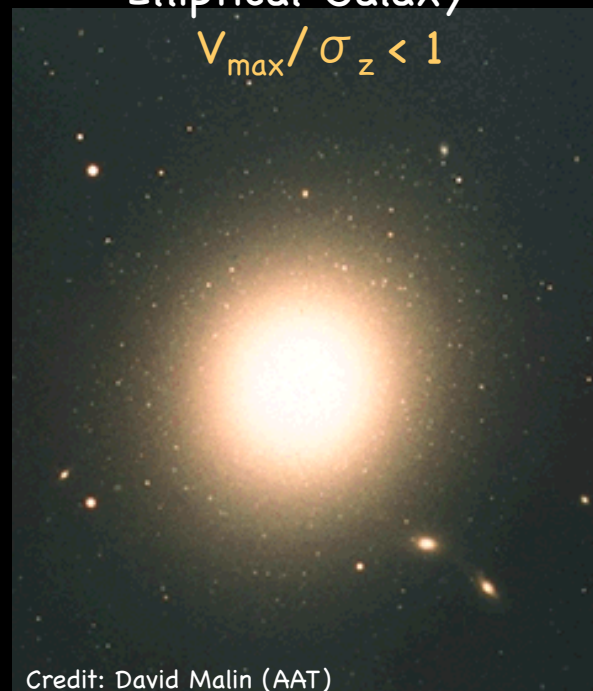
$$V_{\max}/\sigma_z > 1, \text{ usually, } 2 - 5$$



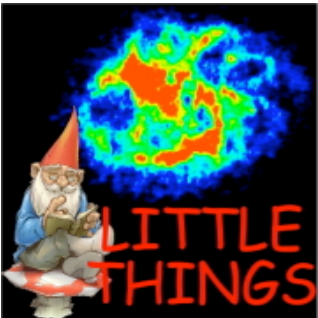
Credit: C. Howk & B. Savage (Wisconsin); N. Sharp (NOAO)

Elliptical Galaxy -

$$V_{\max}/\sigma_z < 1$$

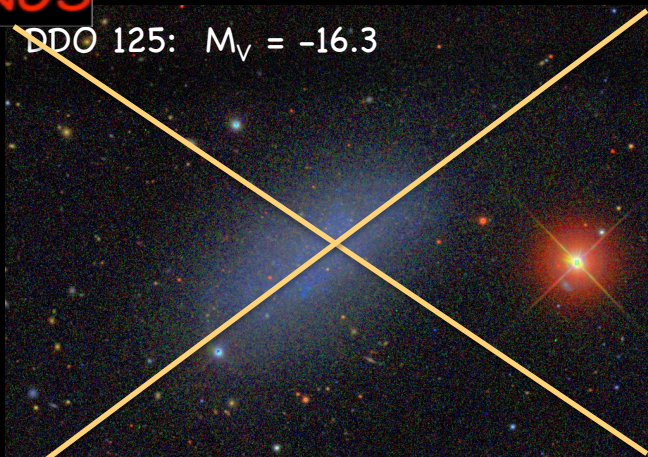


Credit: David Malin (AAT)



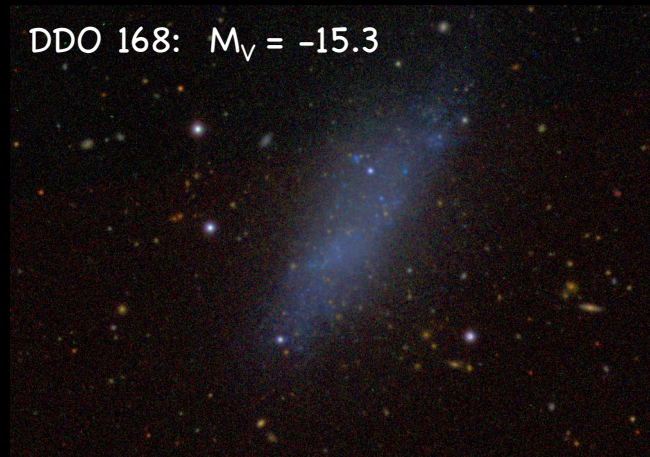
Sample of 4 dIm galaxies

DDO 125: $M_V = -16.3$



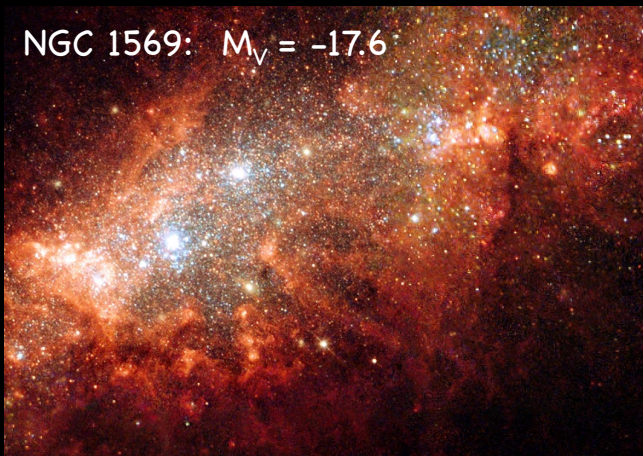
http://cosmo.nyu.edu/hogg/rc3/A_1225+43_UGC_7577_DDO_125_irg_hard.jpg

DDO 168: $M_V = -15.3$



http://cosmo.nyu.edu/hogg/rc3/A_1312+46_UGC_8320_DDO_168_irg_hard.jpg

NGC 1569: $M_V = -17.6$

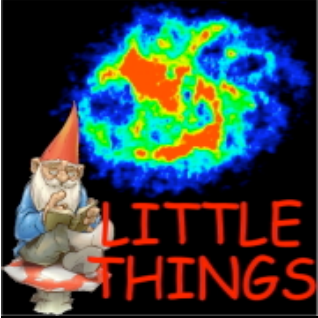


http://www.nasa.gov/images/content/55530main_mm_hubble_020304_4.jpg

DDO 46 U H $M_V = -14.4$



<http://www.lowell.edu/users/dah/littlethings/d46.html>

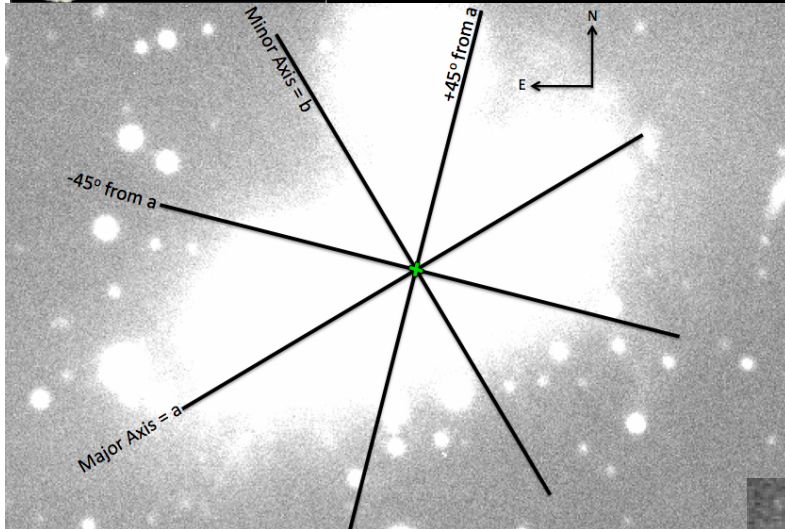
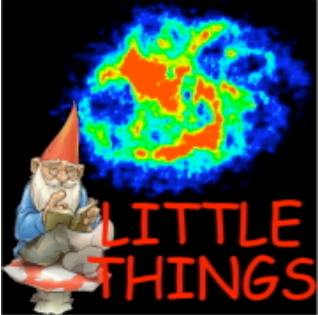


Stellar Kinematics

- KPNO 4-meter + Echelle Spectrograph
- 3' Long-slit
- Observed 4 PAs per galaxy
- Used CCF to determine stellar velocities and velocity dispersions
- Compared stars and gas



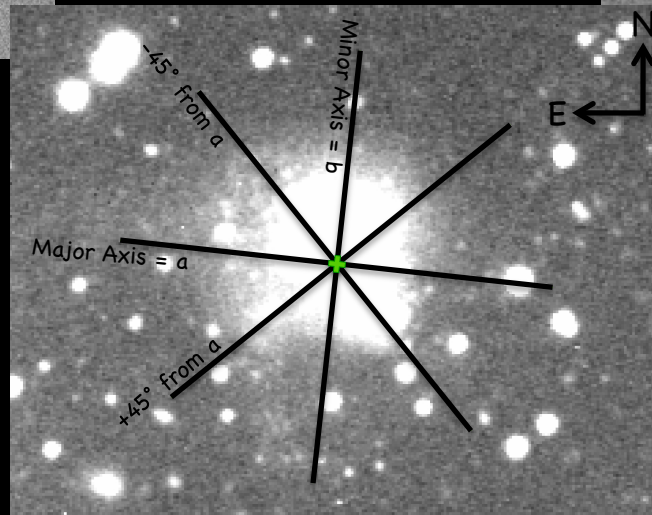
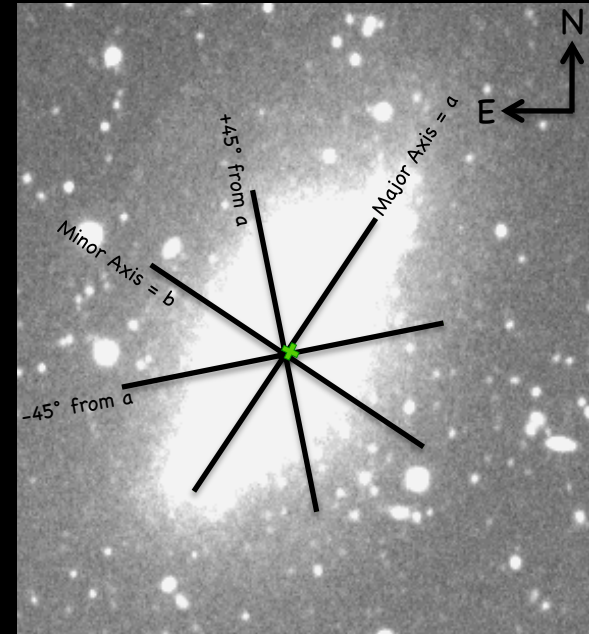
Stellar Kinematics



NGC 1569:

- Stellar Mass = $2.8 \times 10^8 M_{\odot}$
- HI Mass = $2.3 \times 10^8 M_{\odot}$
- $M_V = -17.6$
- D = 3.36 Mpc (Grocholski et al. 2008)

- ## DDO 168:
- Stellar Mass = $5.9 \times 10^7 M_{\odot}$
 - HI Mass = $2.6 \times 10^8 M_{\odot}$
 - $M_V = -15.3$
 - D = 4.3 Mpc

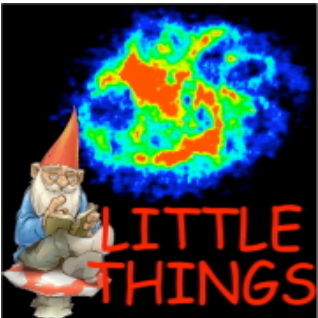


DDO 46:

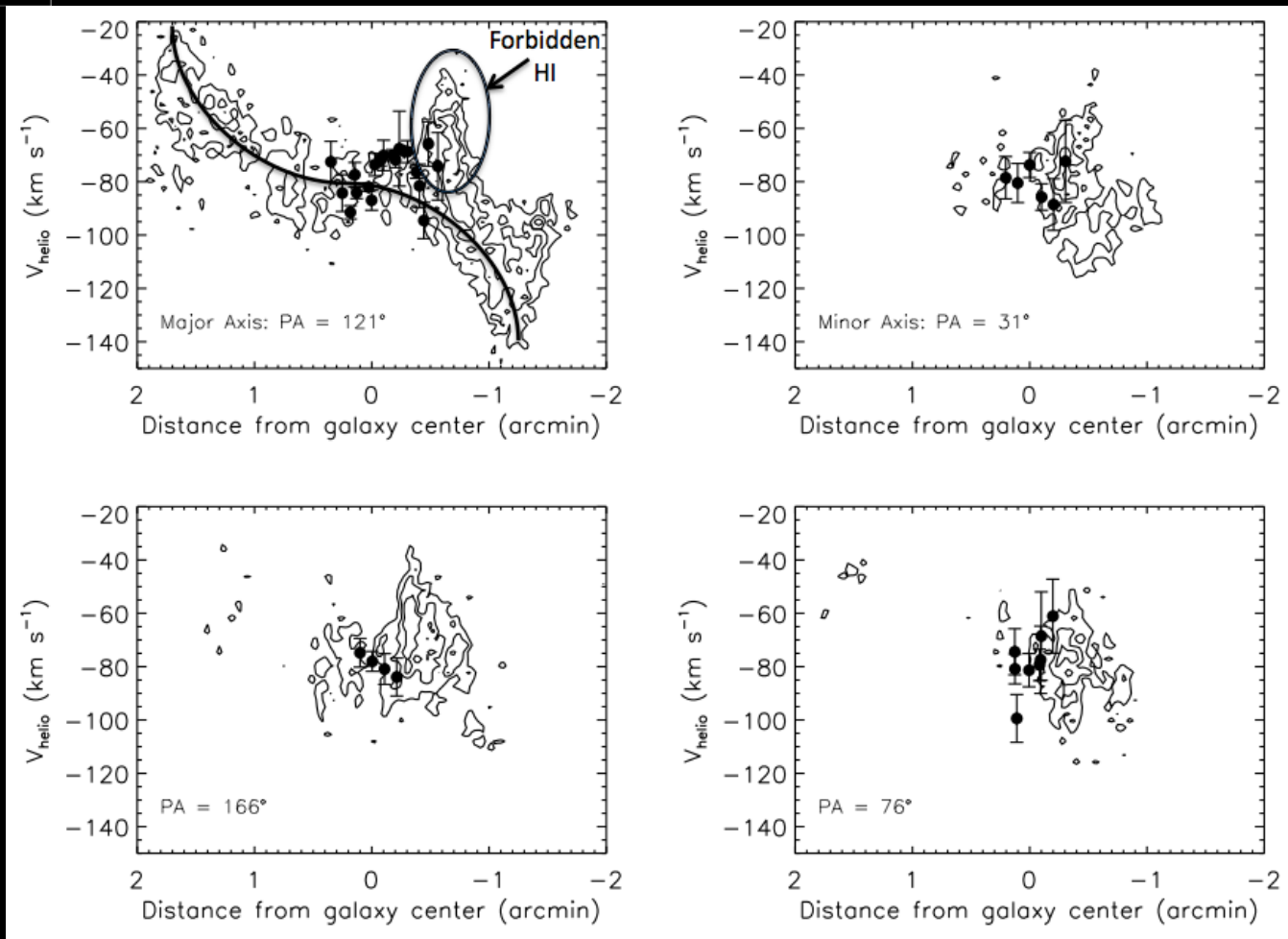
- HI Mass = $1.7 \times 10^8 M_{\odot}$
- $M_V = -14.4$
- D = 6.1 Mpc

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Position-Velocity Diagrams - NGC 1569

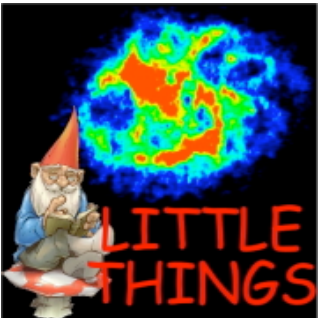


Johnson et al. 2012, submitted

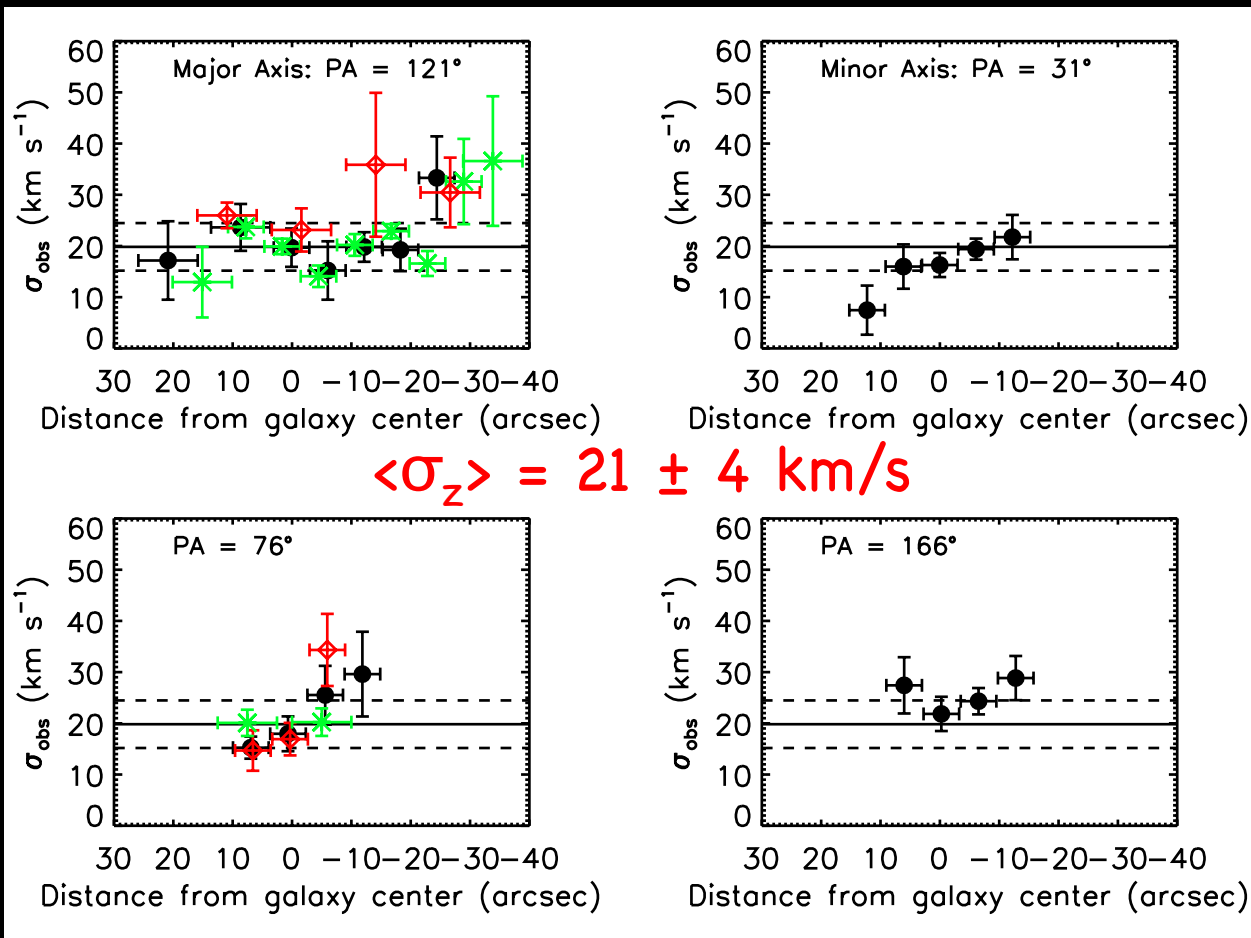
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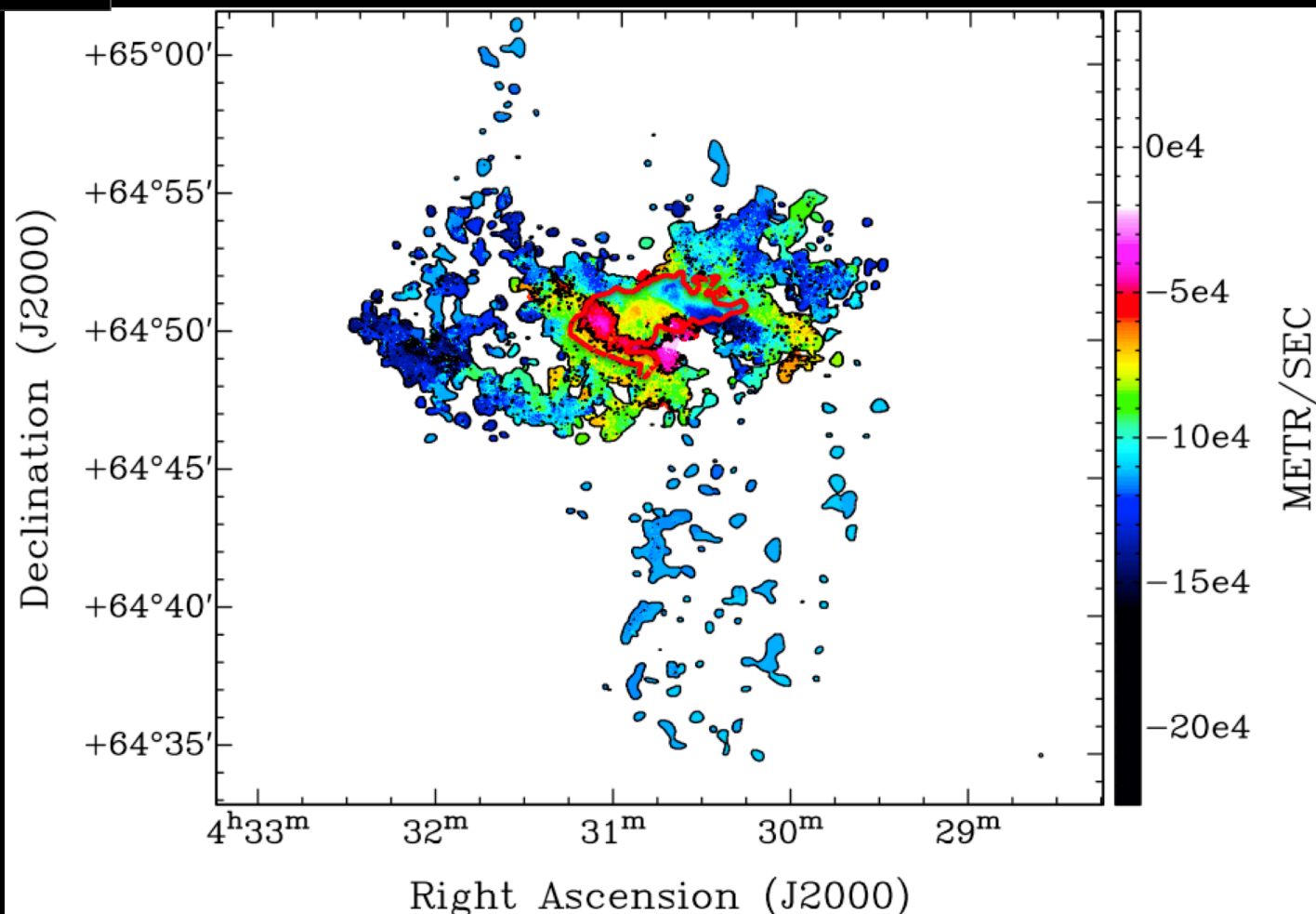
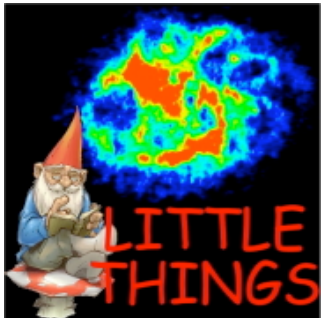


Stellar Velocity Dispersions - NGC 1569



Johnson et al. 2012, submitted

Gas Kinematics - NGC 1569



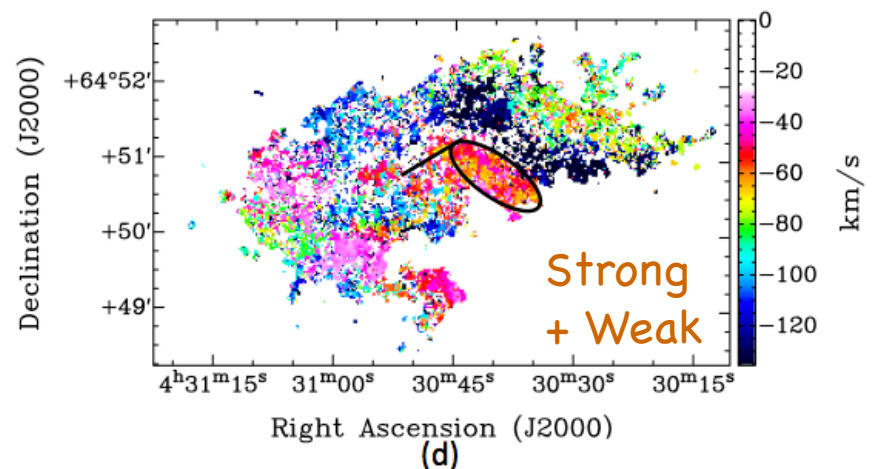
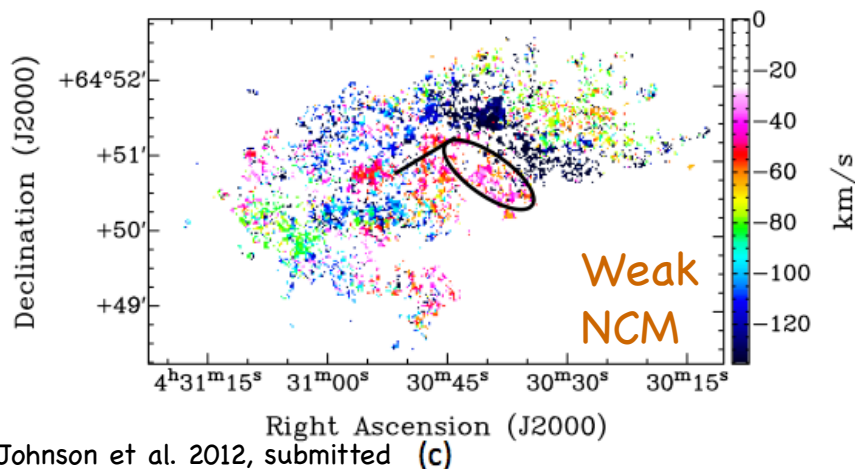
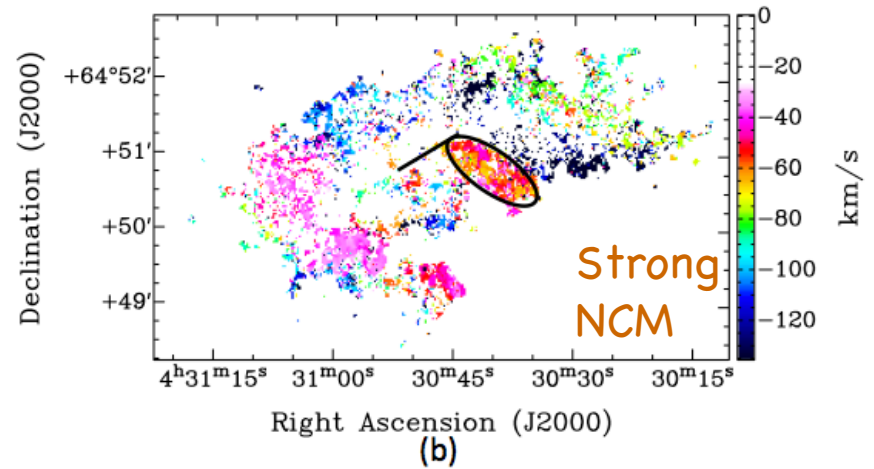
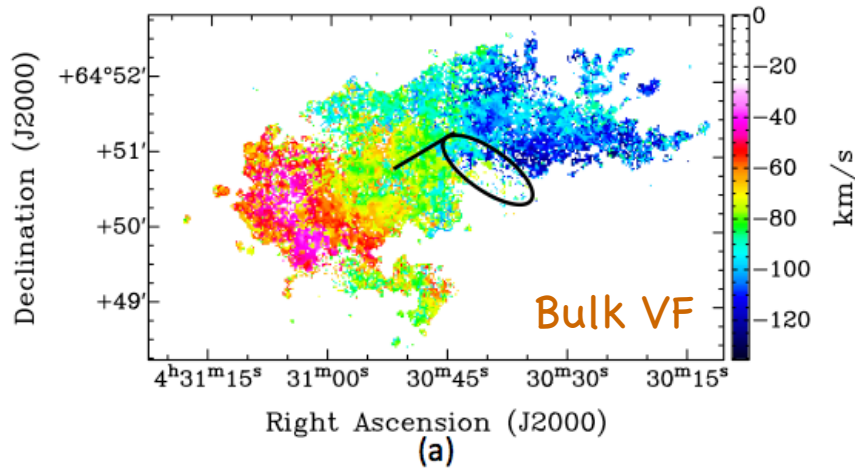
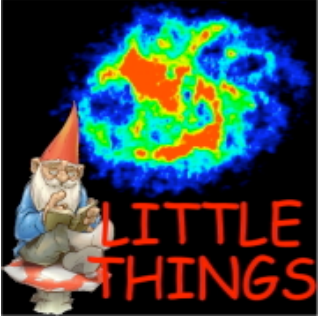
Johnson et al. 2012,
submitted

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Gas Kinematics



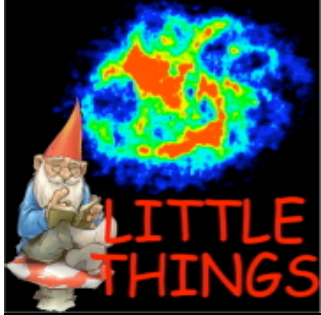
Johnson et al. 2012, submitted

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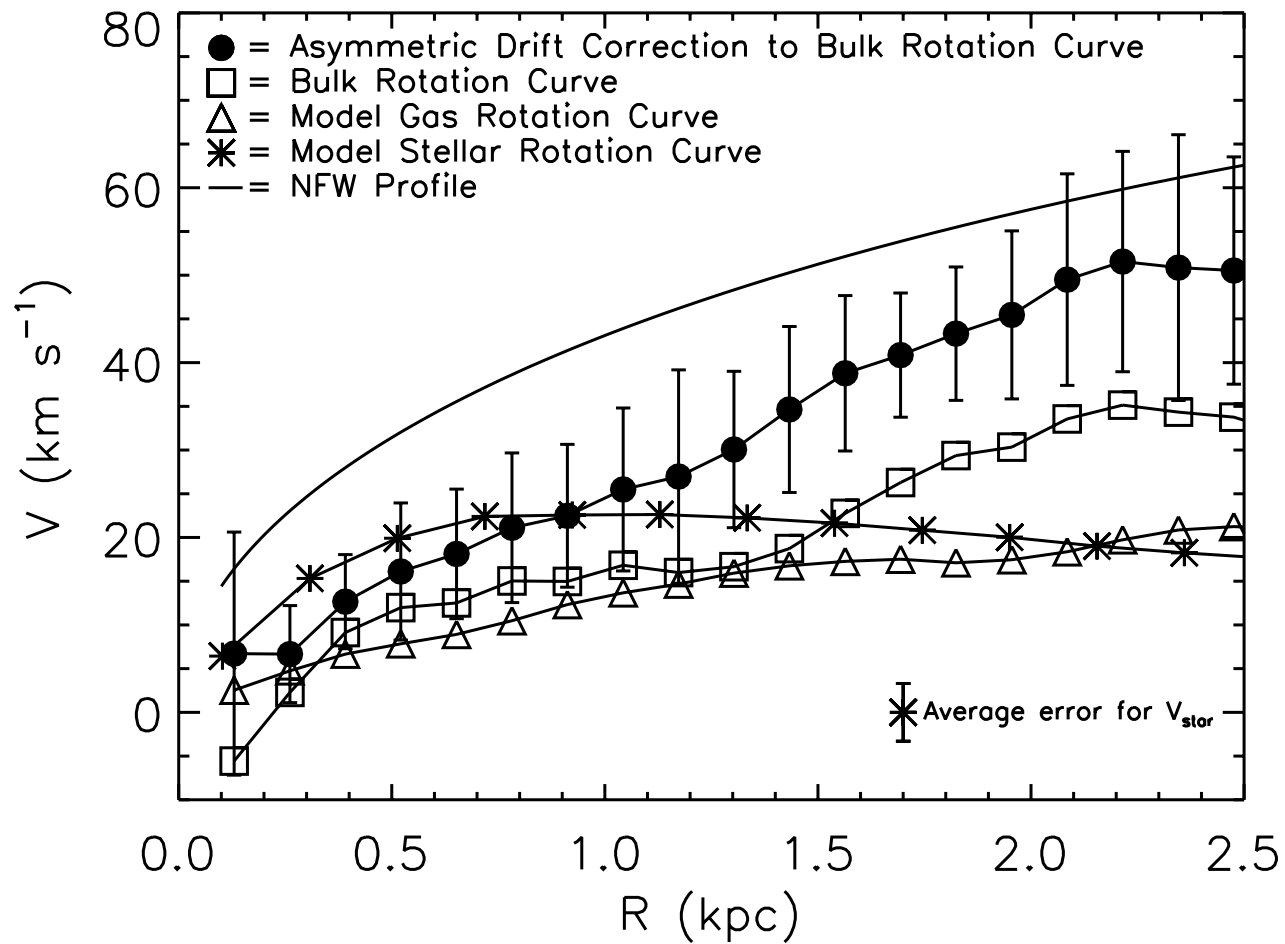
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Gas Kinematics



$$V_{\max} = 50 \pm 10 \text{ km/s}$$

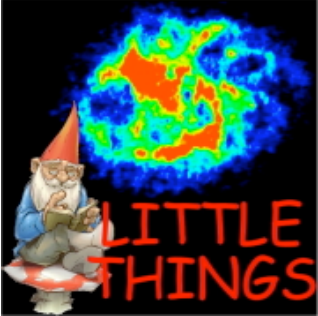


Johnson et al. 2012,
submitted

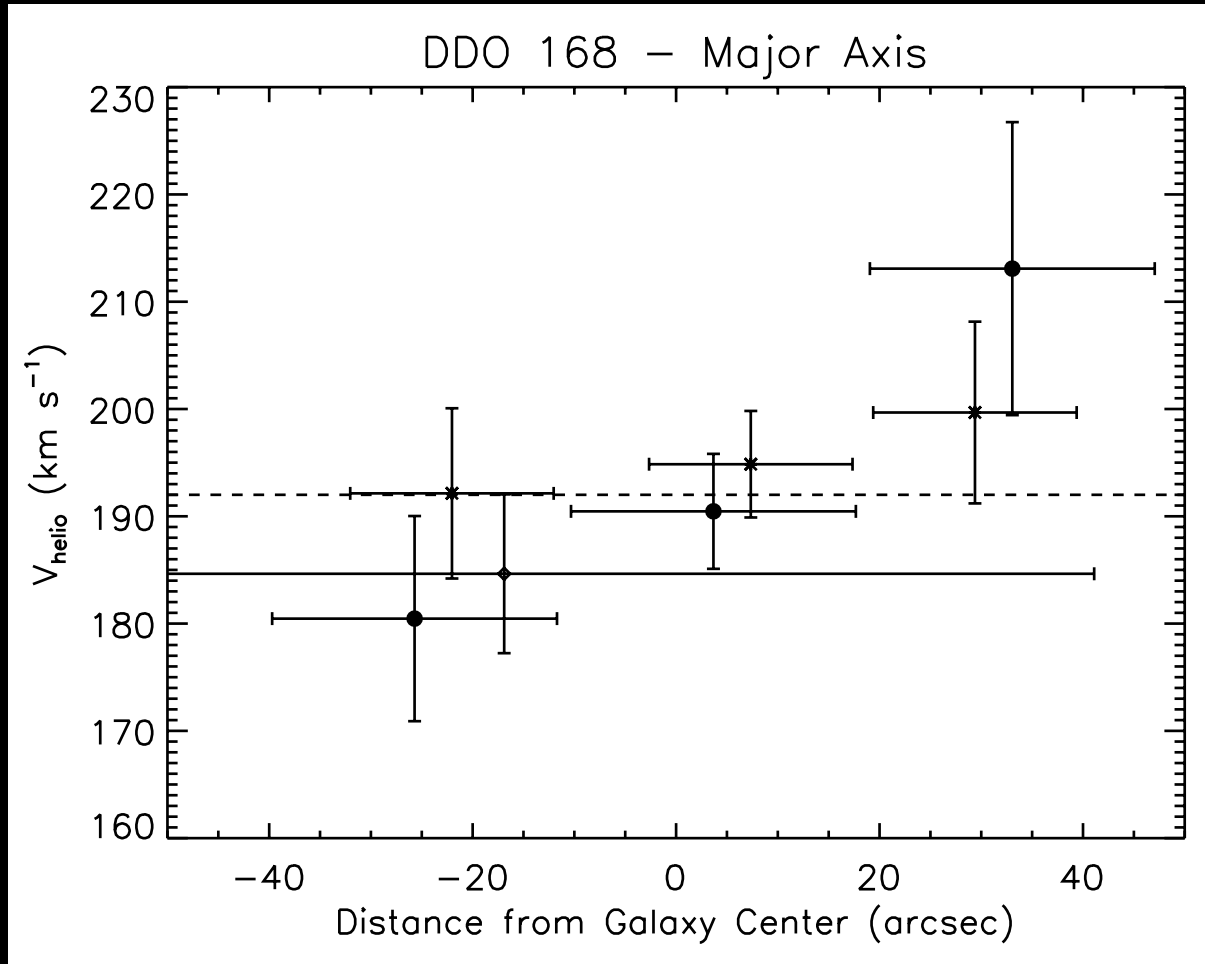
June 24, 2012

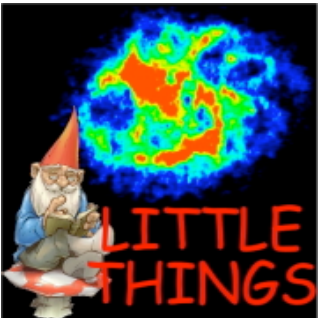
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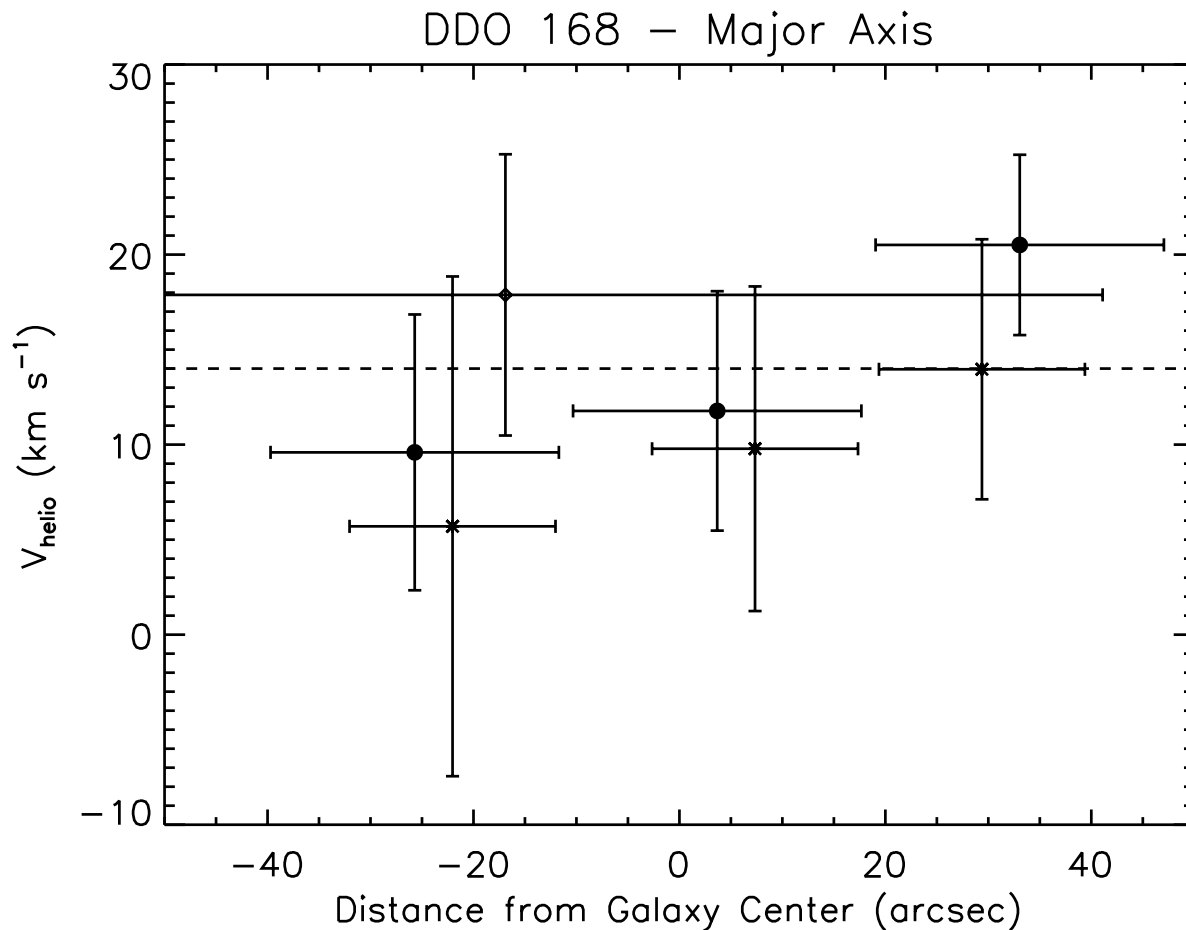
Stellar Velocities - DDO 168

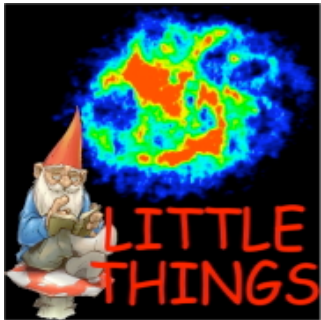




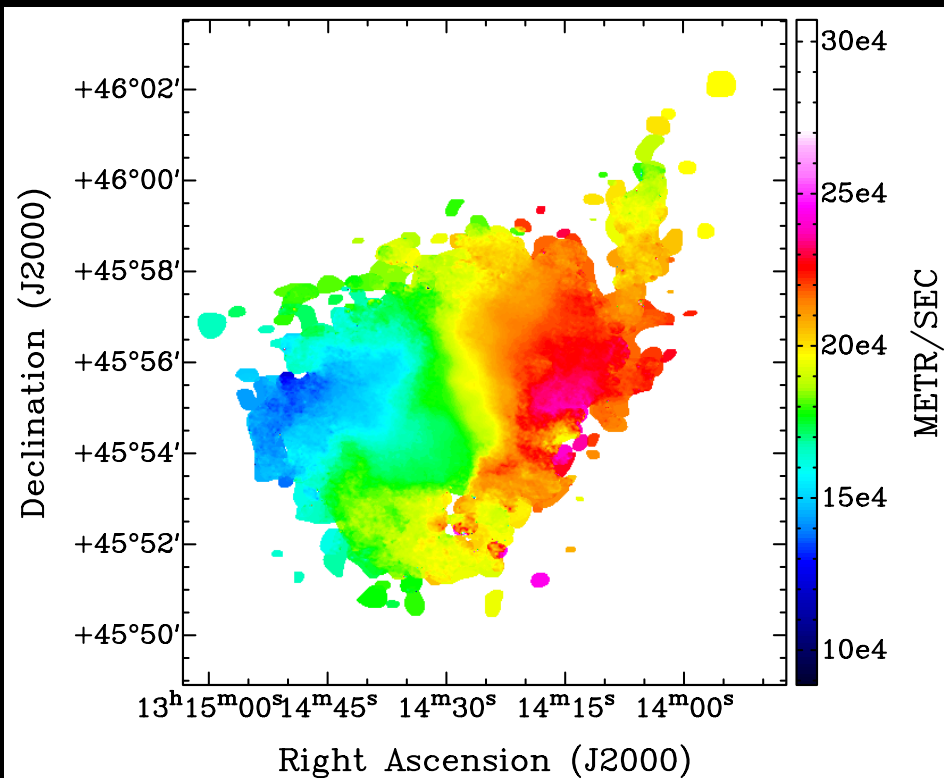
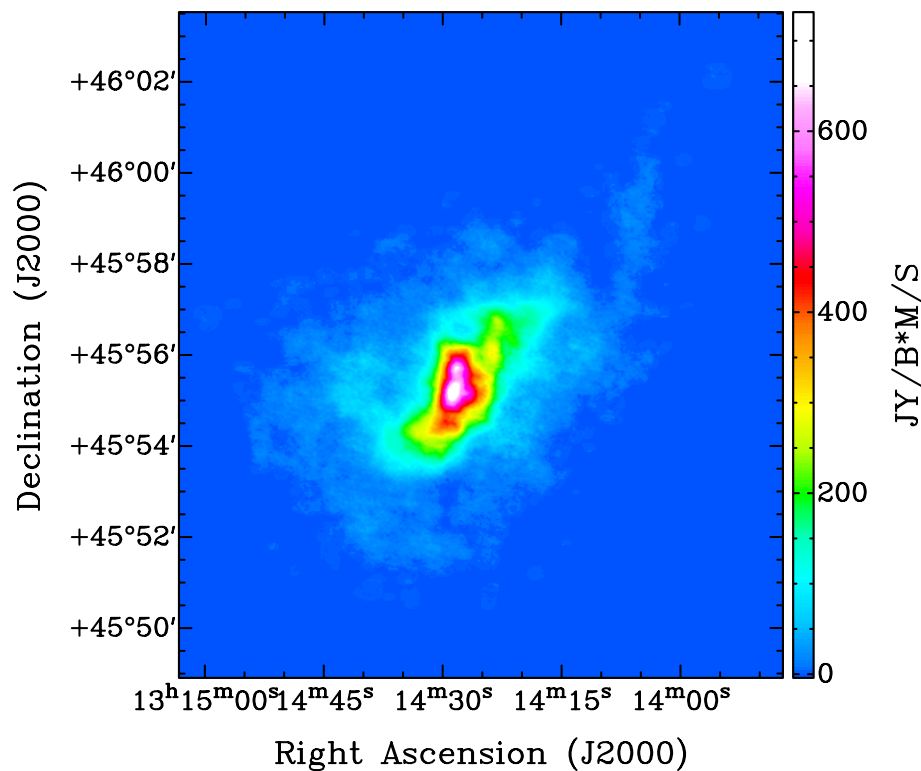
Stellar Velocity Dispersion - DDO 168

- Major Axis:
 - Mean Stellar Velocity Dispersion = 14 ± 7 km/s



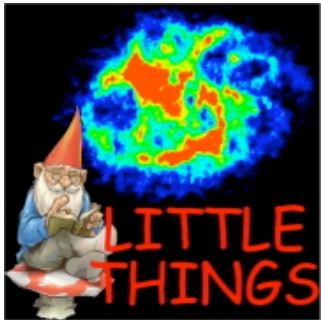


Gas Kinematics - DDO 168

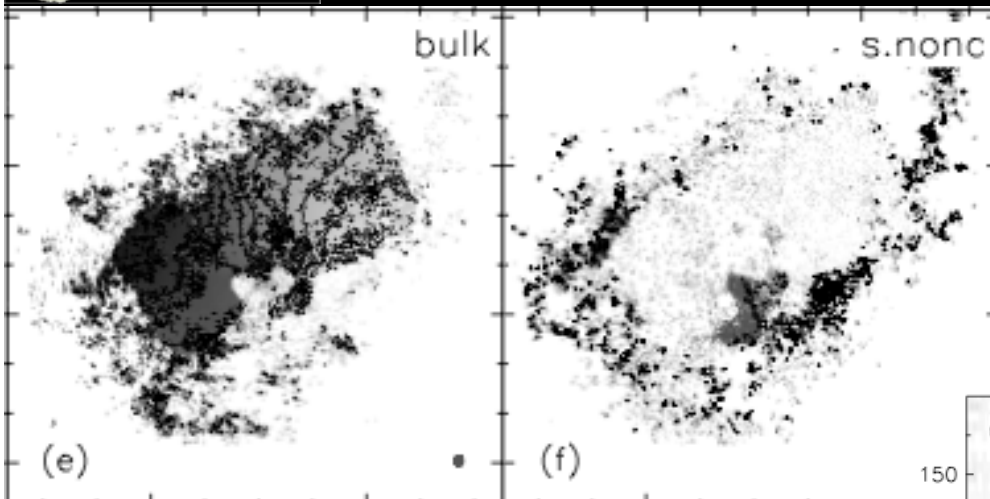


Integrated Intensity

Intensity-weighted Velocity Field

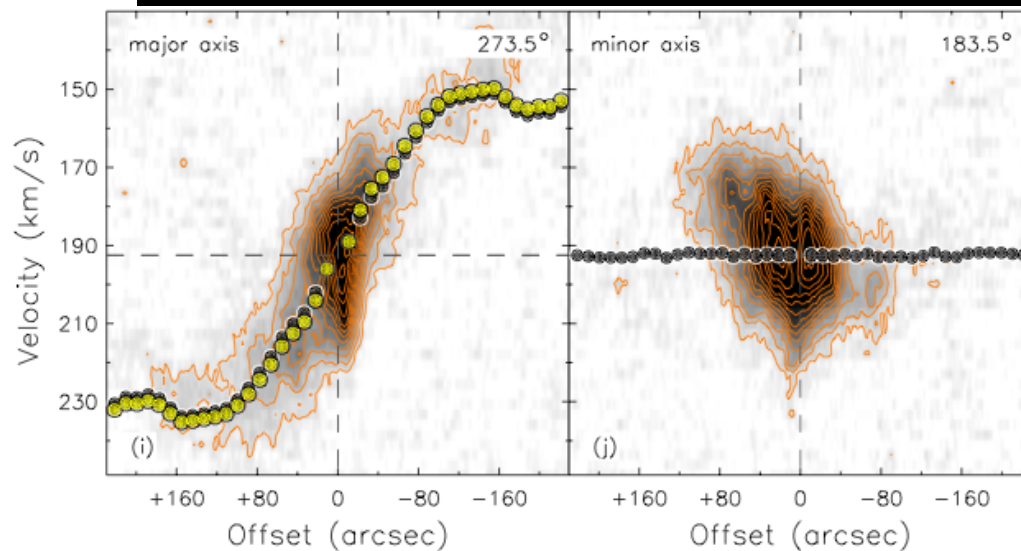


Gas Kinematics - DDO 168

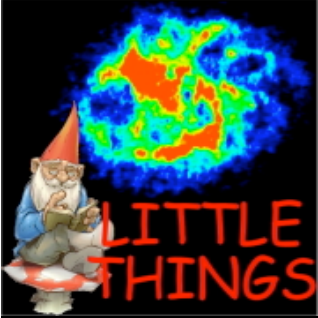


$$V_{\max} = 52 \text{ km/s}$$

Bulk and Strong Non-circular Motion Maps

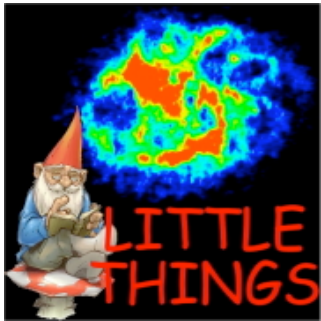


Rotation Curve

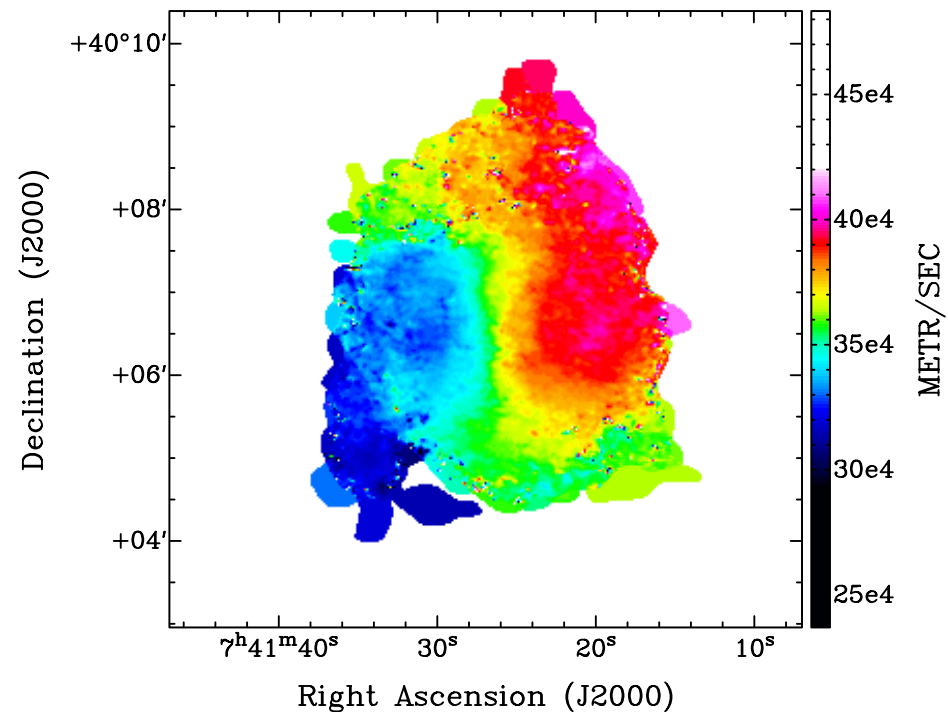
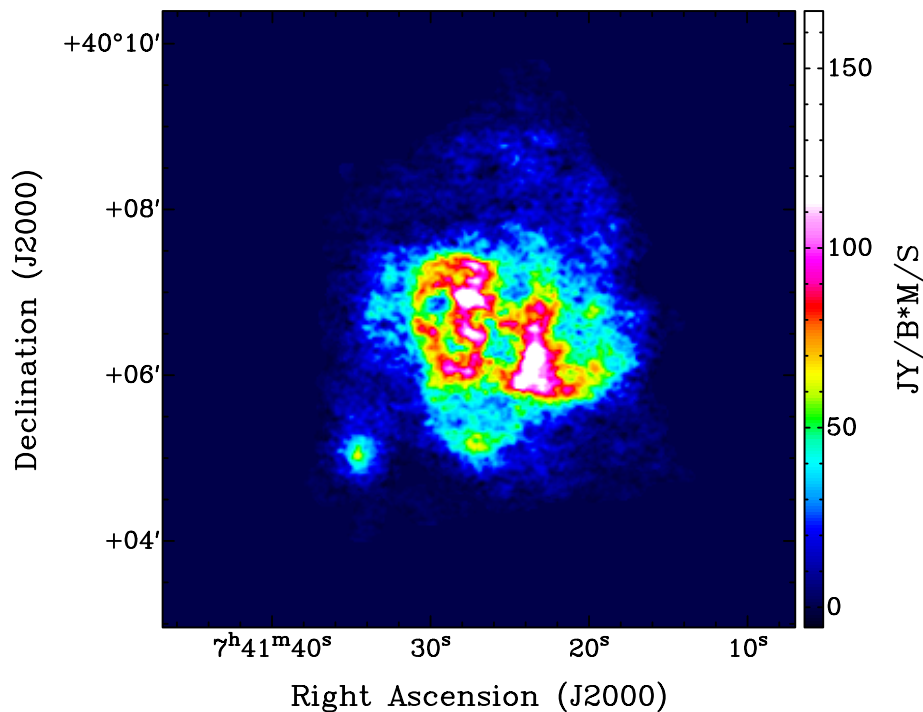


Stellar Kinematics - DDO 46

- Major Axis
 - Summed over $\sim 1'$ of slit to extract 1 spectrum
 - Mean Stellar Heliocentric Velocity = 378 ± 13 km/s
 - Mean Stellar Velocity Dispersion = 15 ± 3 km/s

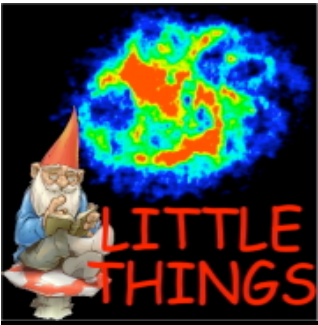


Gas Kinematics - DDO 46

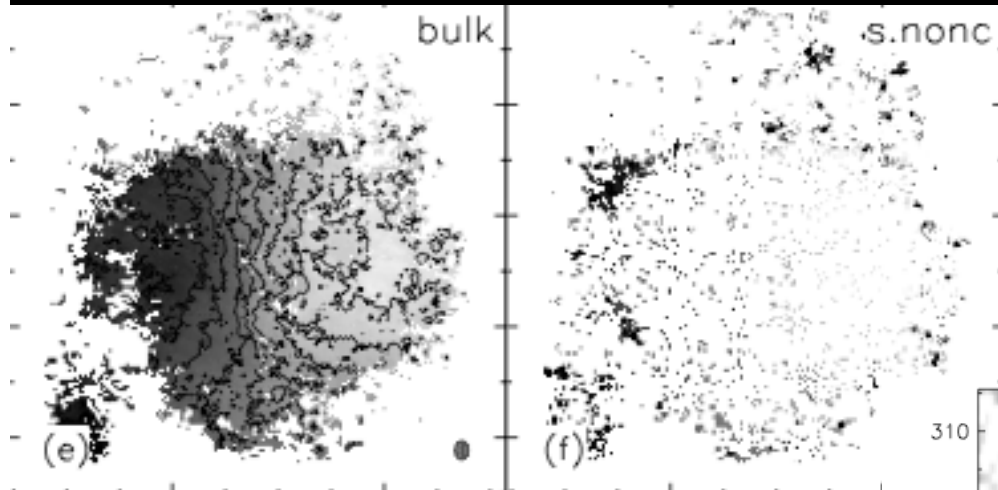


Integrated Intensity

Intensity-weighted Velocity Field

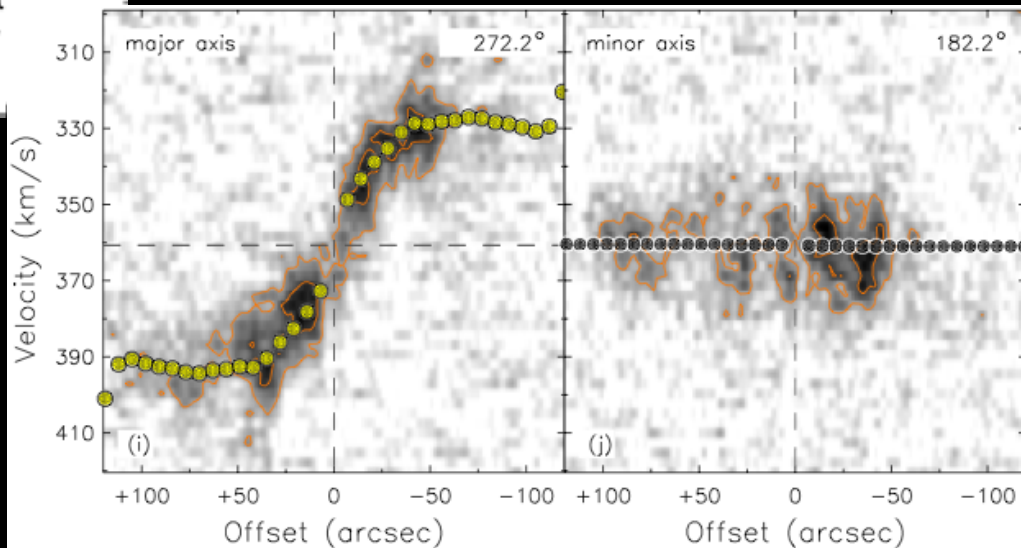


Gas Kinematics - DDO 46

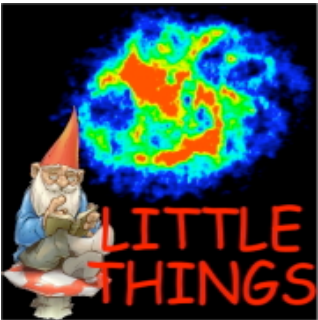


$$V_{\max} = 65 \text{ km/s}$$

Bulk and Strong Non-circular Motion Maps

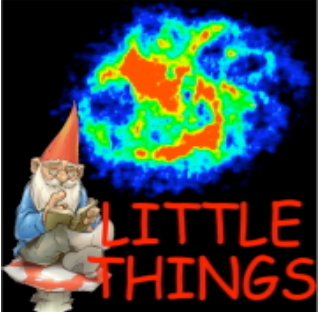


Rotation Curve

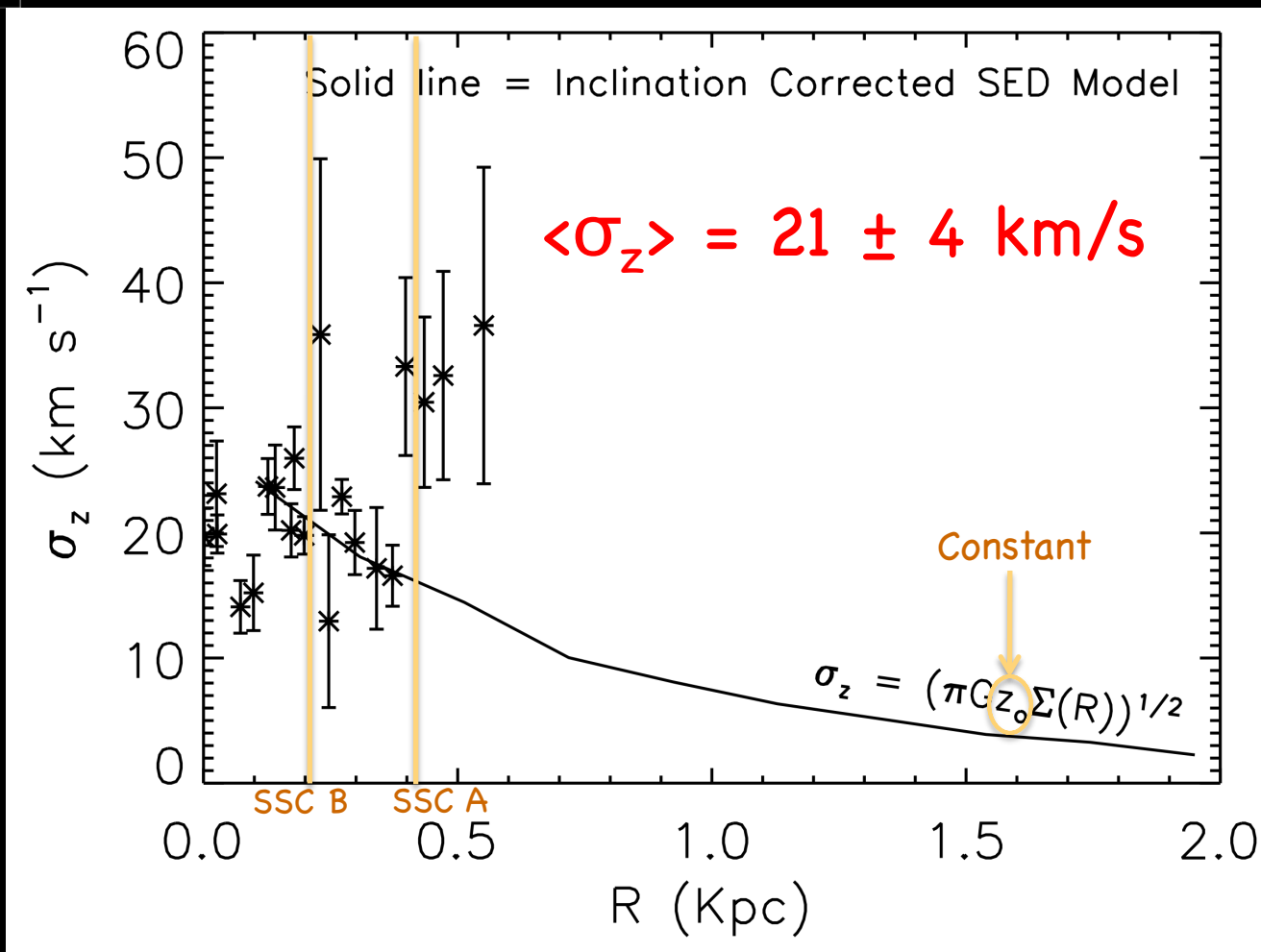


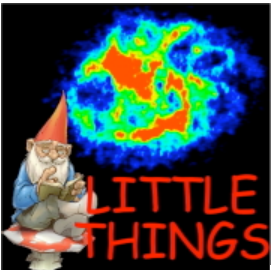
Summary

- NGC 1569
 - $V_{\max}/\sigma_z = 2.4 \pm 0.7 \rightarrow$ Thick Disk
 - Stars and gas kinematically follow each other
- DDO 168
 - $V_{\max}/\sigma_z = 3.7 \rightarrow$ Thin-ish Disk?
- DDO 46
 - $V_{\max}/\sigma_z = 4.3 \rightarrow$ Thin-ish Disk?
- This small sample shows that dIm galaxies are *disks*, perhaps thicker than spirals.
- HI morphology suggests that dIm galaxies are "unsettled"?
- HI kinematics suggests that dIm galaxies have bars?

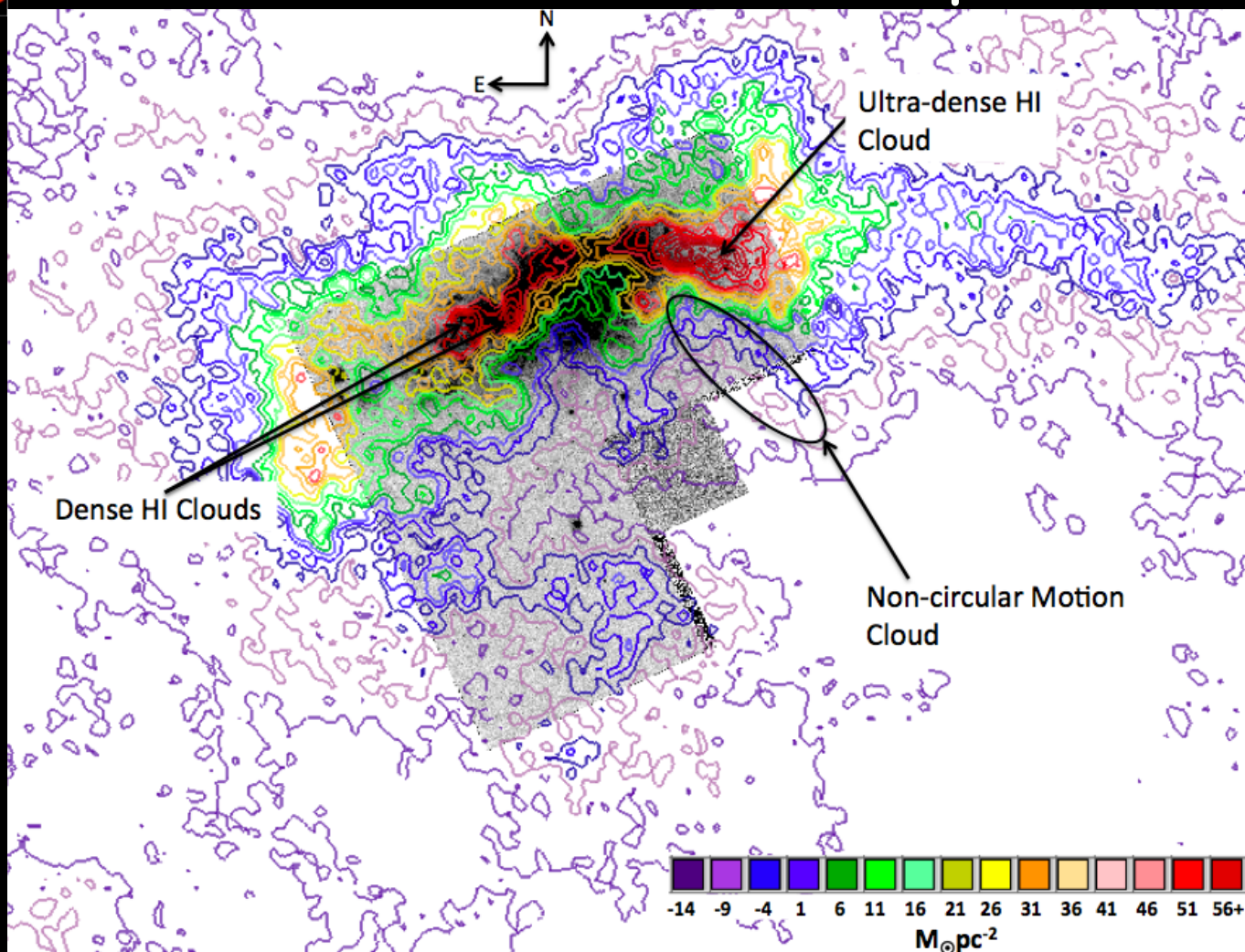


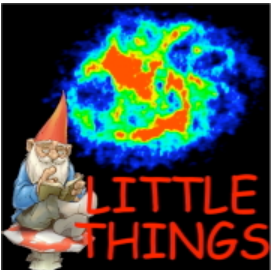
NGC 1569: Stellar Velocity Dispersions





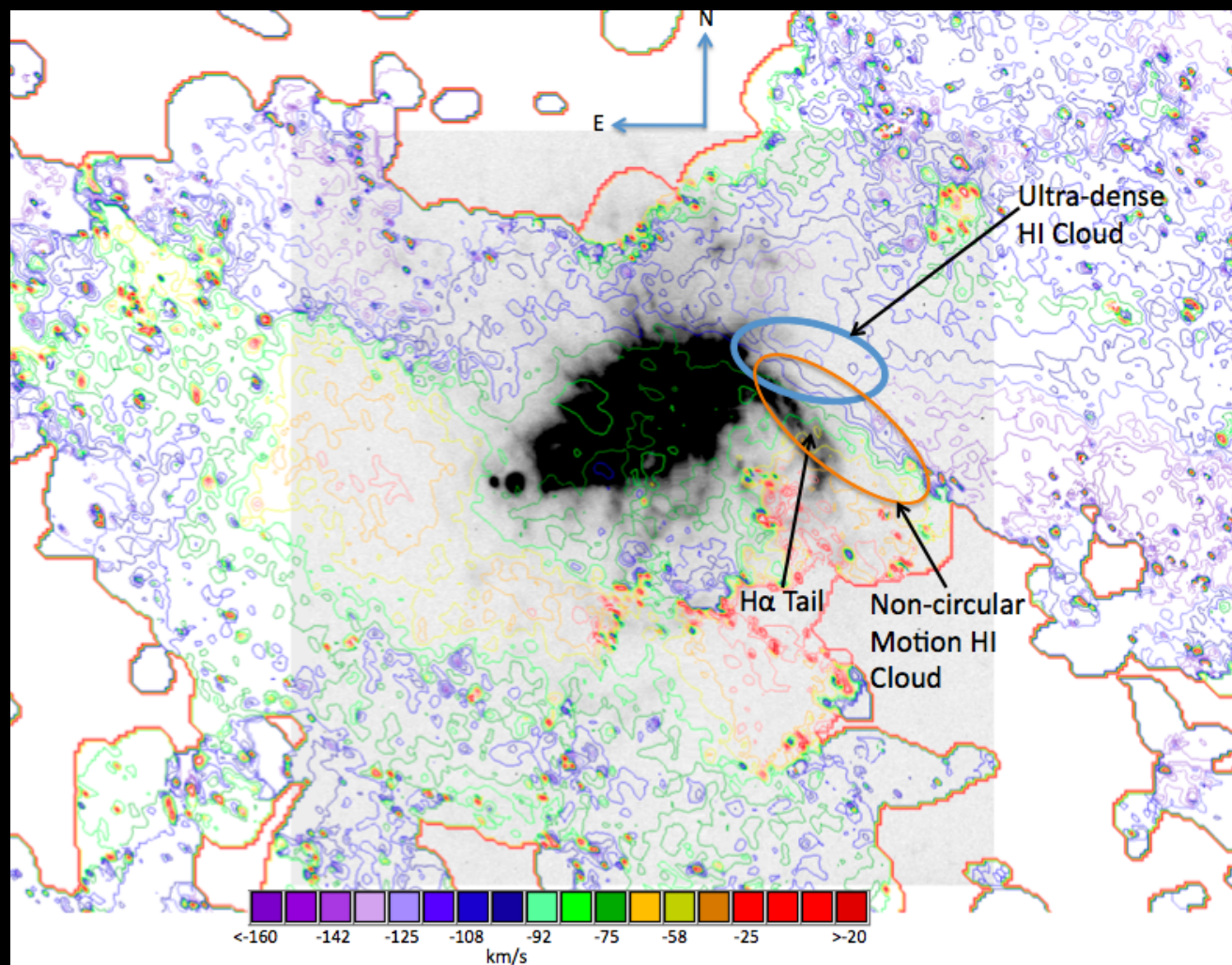
NGC 1569: Integrated HI Intensity Contour Map

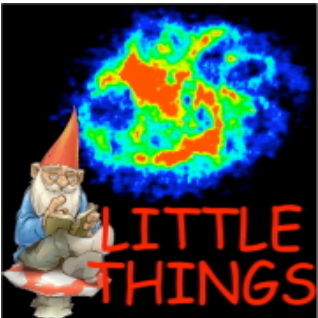




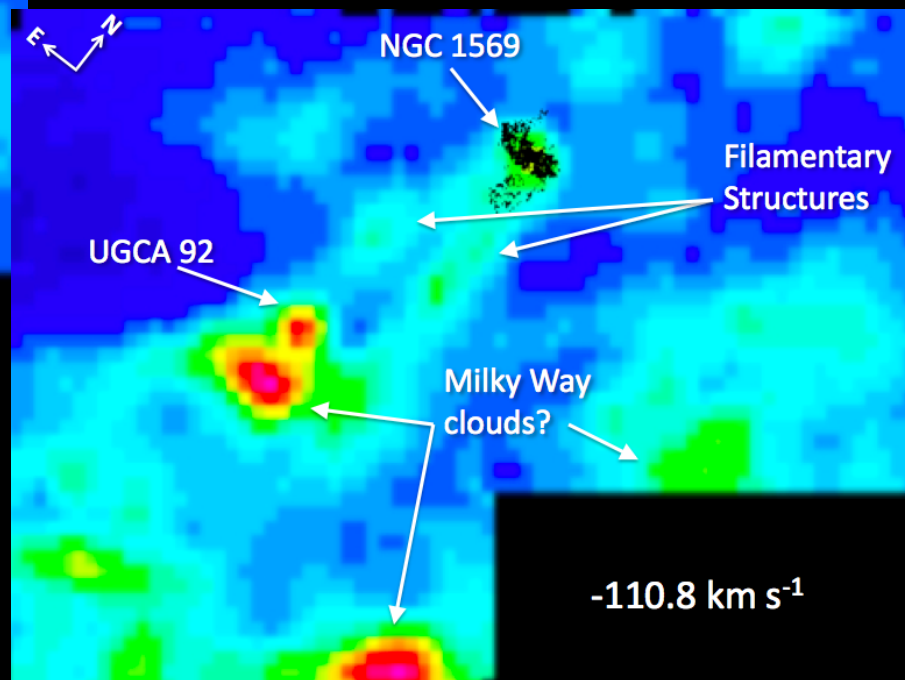
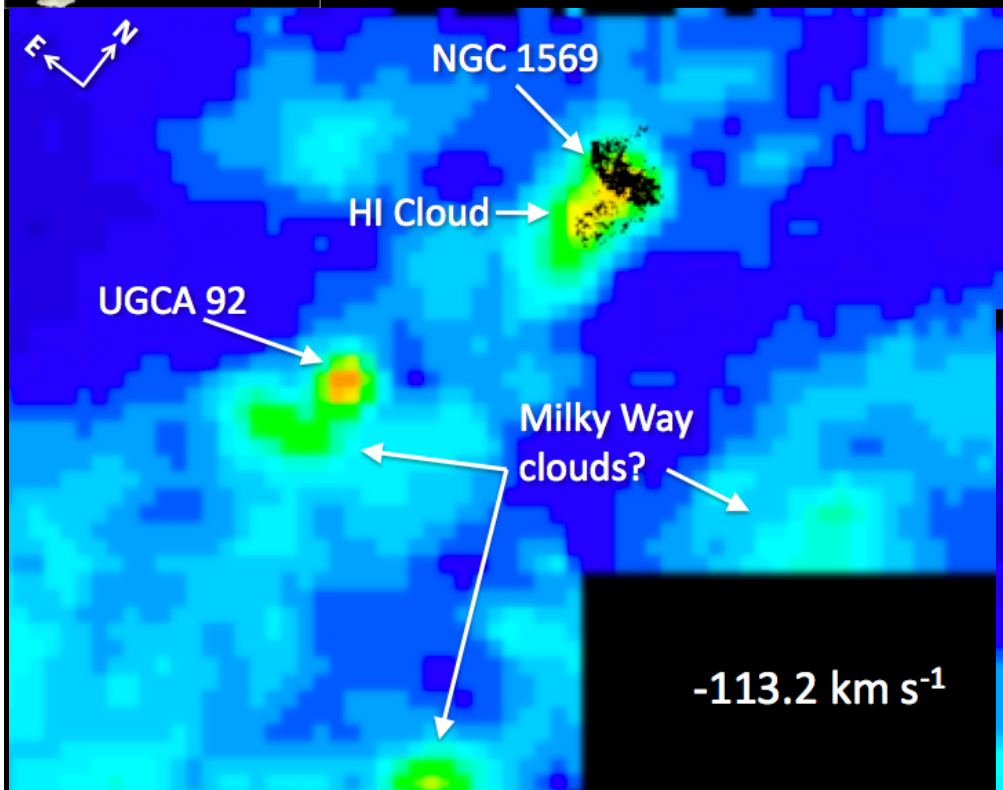
NGC 1569: Ultra-dense HI Cloud

H α tail -
Velocity \sim
-90 km/s
(Tomita et al.
1994)





GBT Map around NGC 1569



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