BREAKING THE BARYONIC–DARK MATTER DEGENERACY USING HYDRODYNAMIC SIMULATIONS

THE CASE OF NGC 1291

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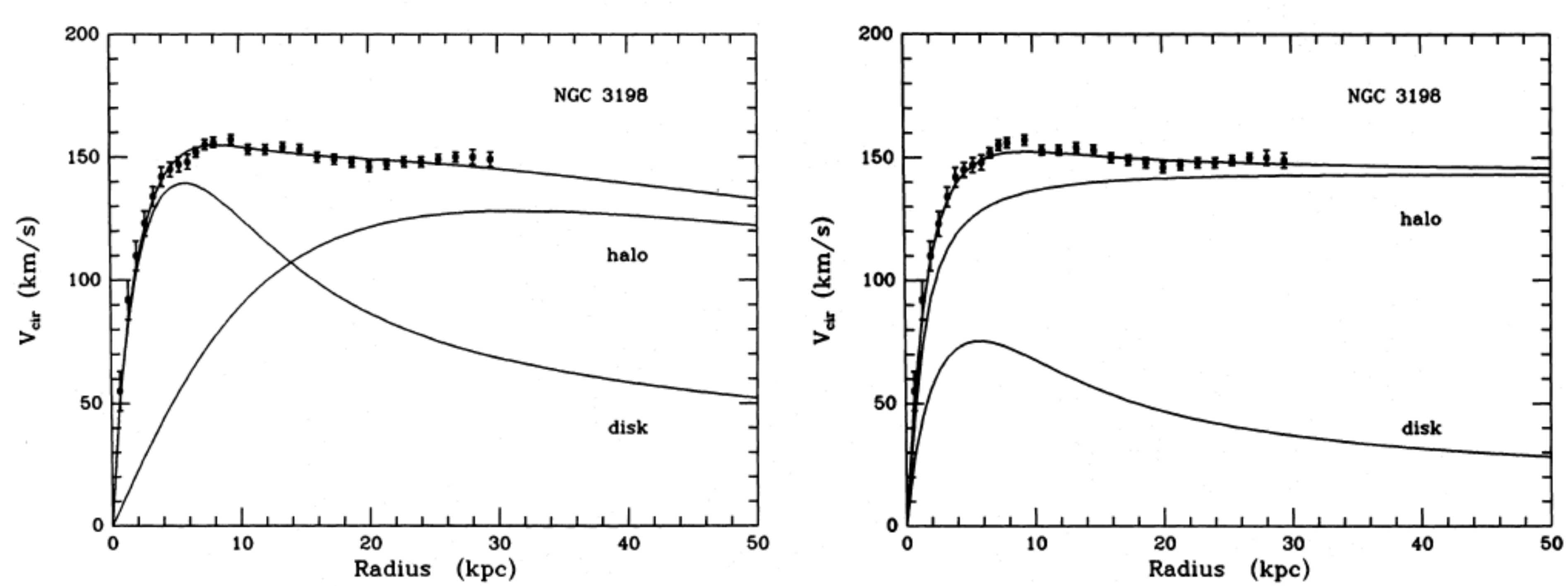
DISC-HALO DEGENERACY

Disc-halo degeneracy when decomposing rotation curves

M/L of the disc is uncertain (IMF, late phases of stellar evolution, etc.)

Roadblock for testing galaxy formation models



van Albada+1985

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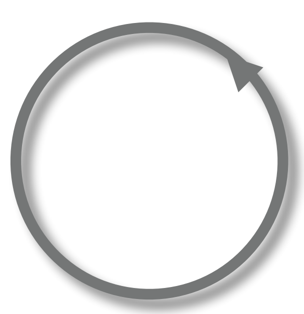
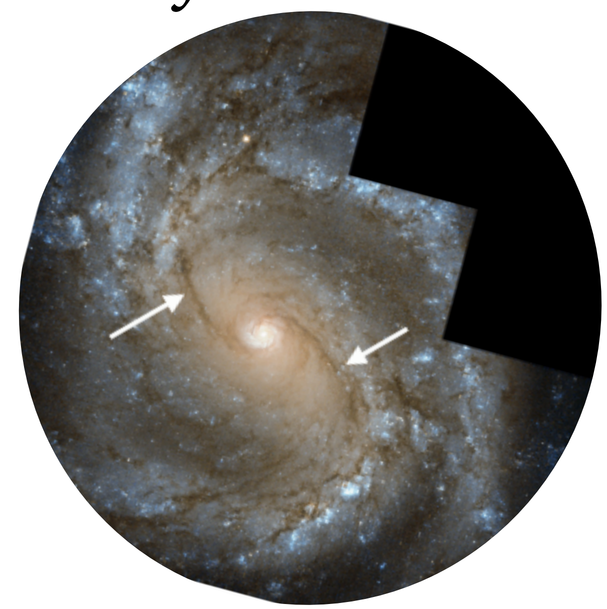
USING NON-AXISYMMETRIES

Gas in axisymmetric potential



USING NON-AXISYMMETRIES

Baryonic matter



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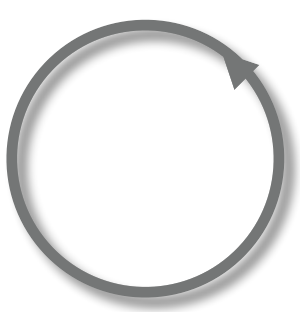

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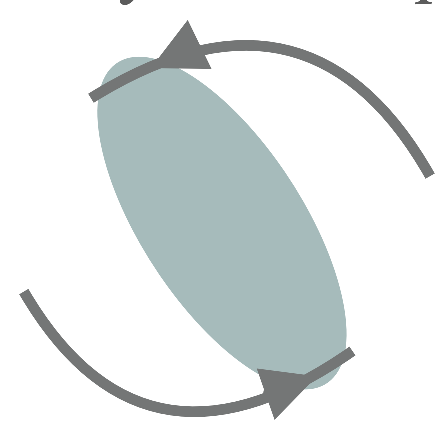

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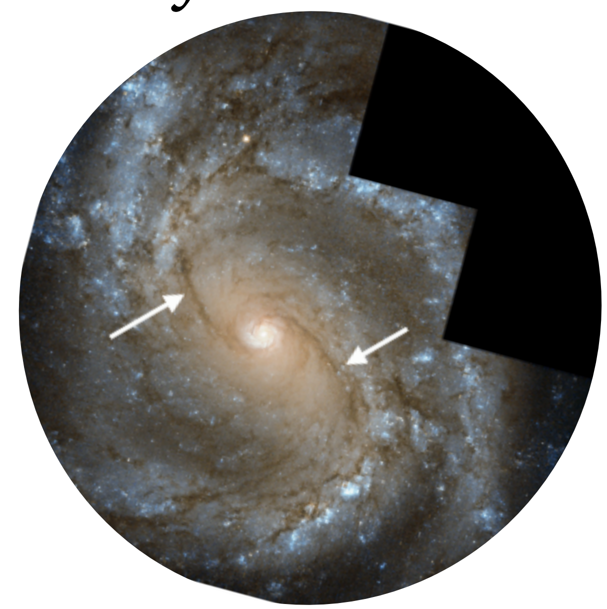

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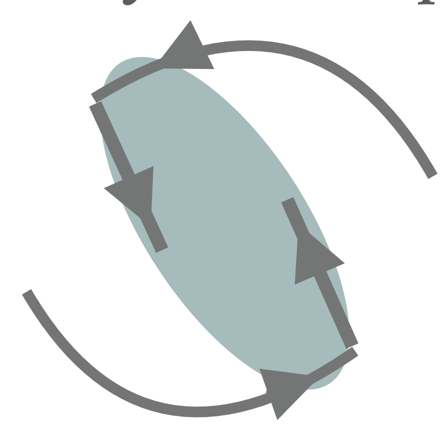

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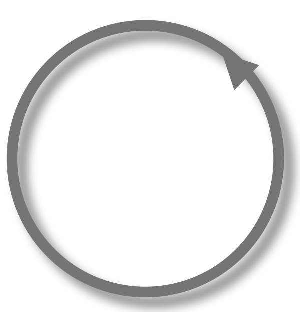
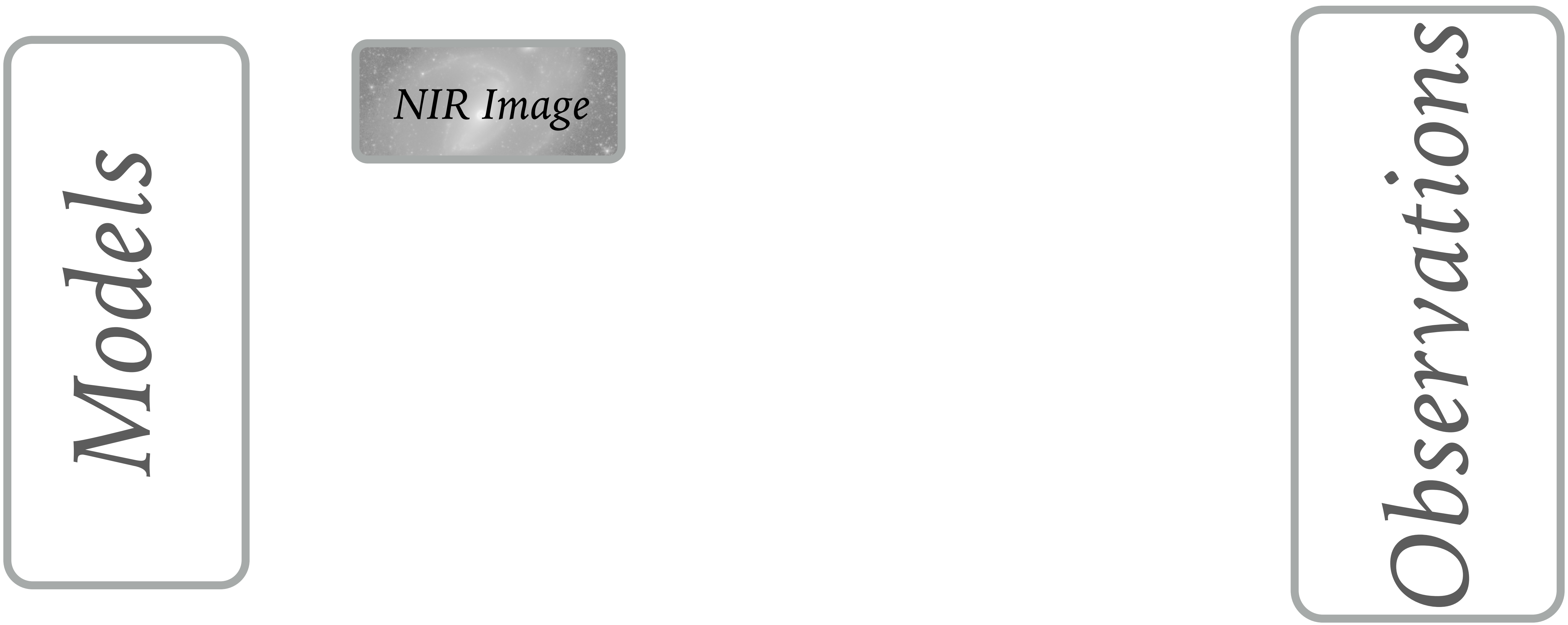


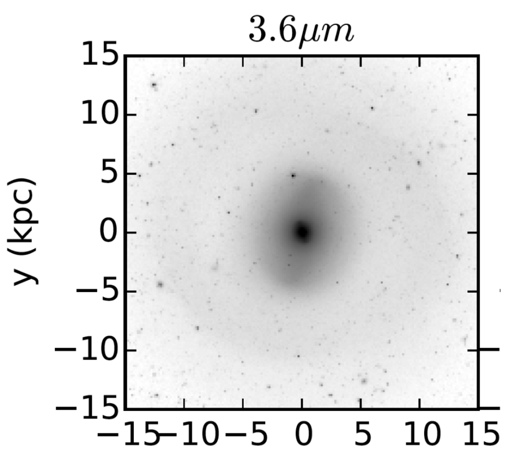
HOW THE MODELLING WORKS



HOW THE MODELLING WORKS

Models

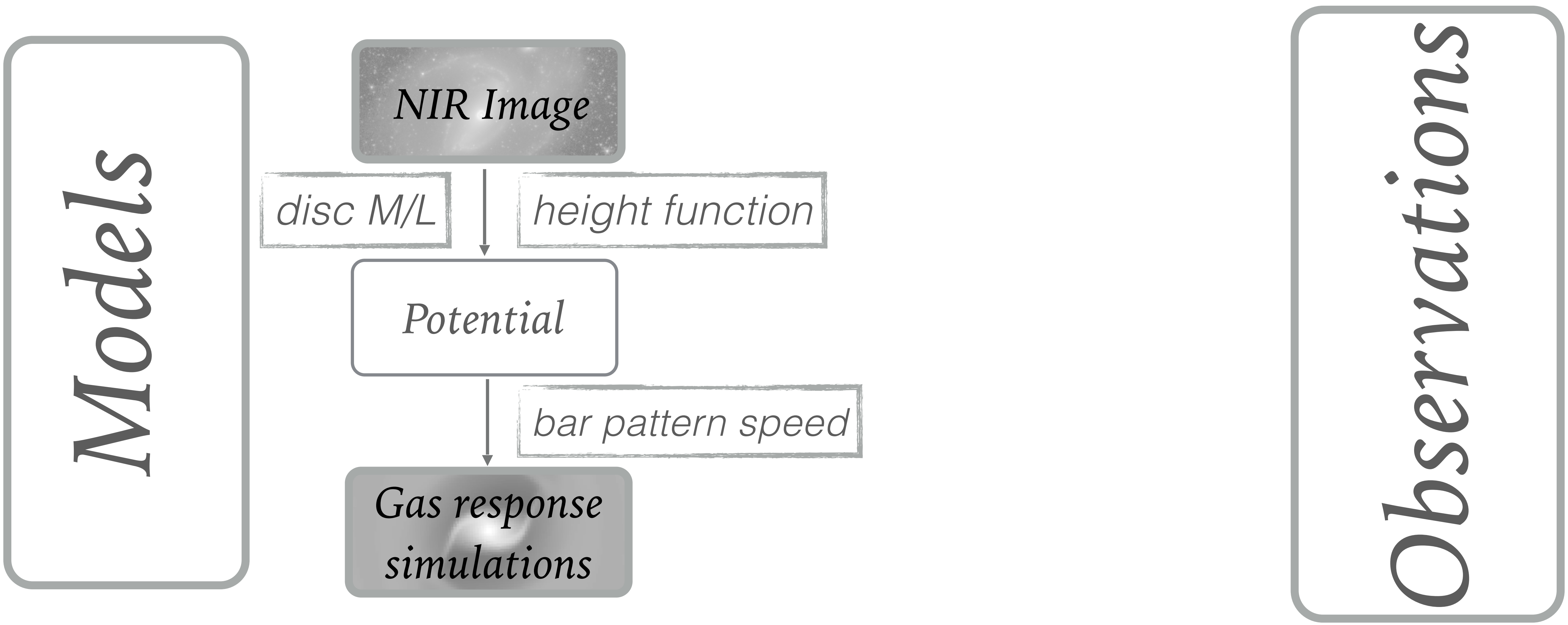
NIR Image



S^4G
(Sheth+10)

Observations

HOW THE MODELLING WORKS



HOW THE MODELLING WORKS

Models

1. *disc M/L*
2. *height function*
3. *bar pattern speed*

Gas response simulations

Observations

GAS RESPONSE SIMULATIONS

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- Fixed gravitational potential from image of galaxy which rotates at given pattern speed (patch of gravana.f90)
- Slowly introduce the non-axisymmetric potential to avoid transients in the gas (patch of update_time.f90)
- Refinement strategy: density discontinuity. Quasi-Lagrangian strategy requires many more refined cells to capture the shocks.

GAS RESPONSE SIMULATIONS

HOW THE MODELLING WORKS

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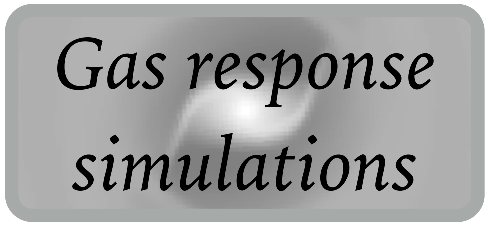

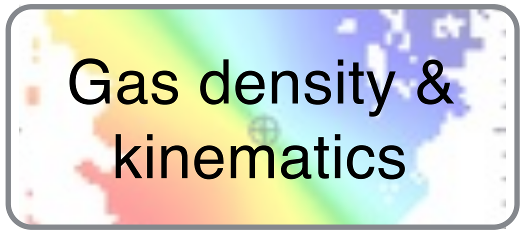

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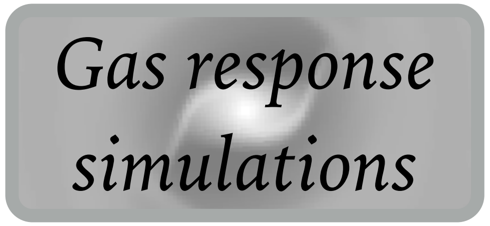
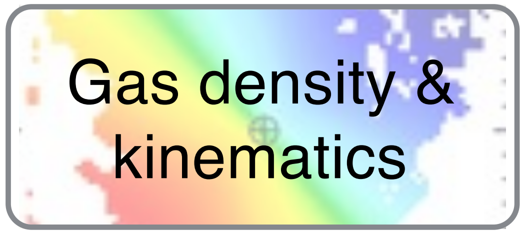
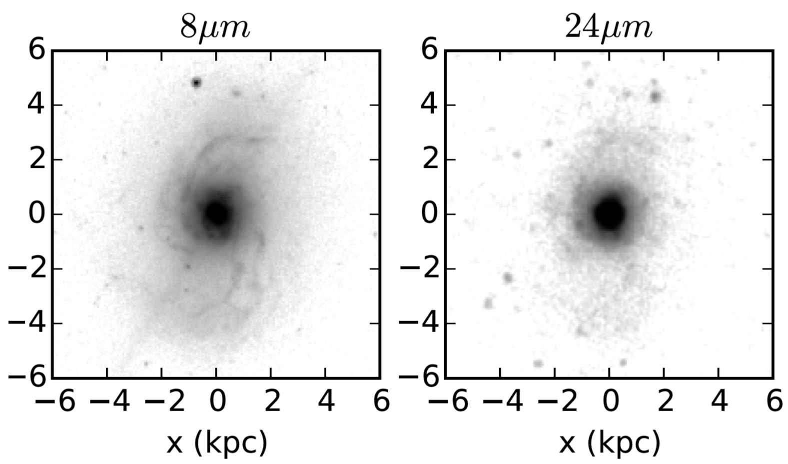




Dust lanes



SINGS survey (Kennicutt+03)

Observations

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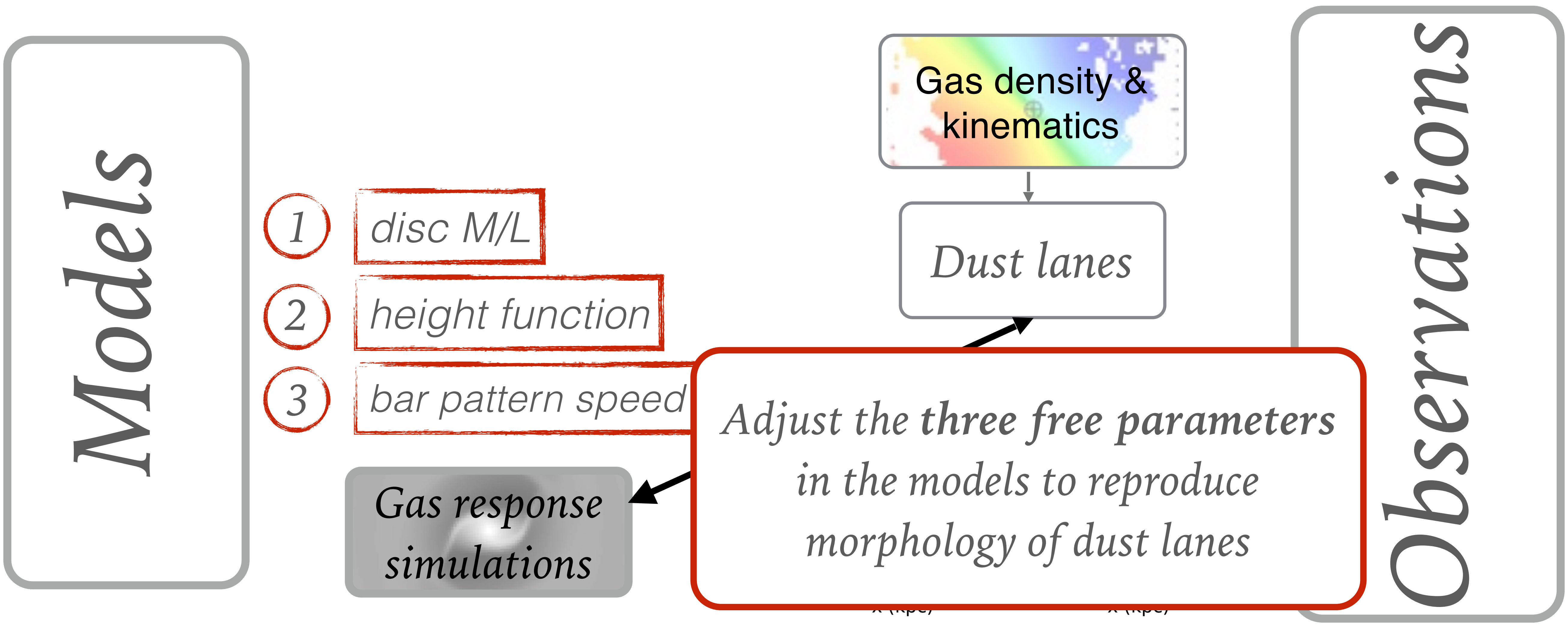

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EXPLORING THE PARAMETER SPACE

1 disc M/L — $\Upsilon = f_d \Upsilon_{3.6}$

2 height function — z_0, h_z

variable z_0 (B/P)

3 bar pattern speed — $r_L = \mathcal{R}\, r_B$

EXPLORING THE PARAMETER SPACE

1 disc M/L

$$\Upsilon = f_d \Upsilon_{3.6}$$

Fiducial M/L=0.6 from Meidt+14, Roeck+15, Querejeta+15

EXPLORING THE PARAMETER SPACE

1 disc M/L

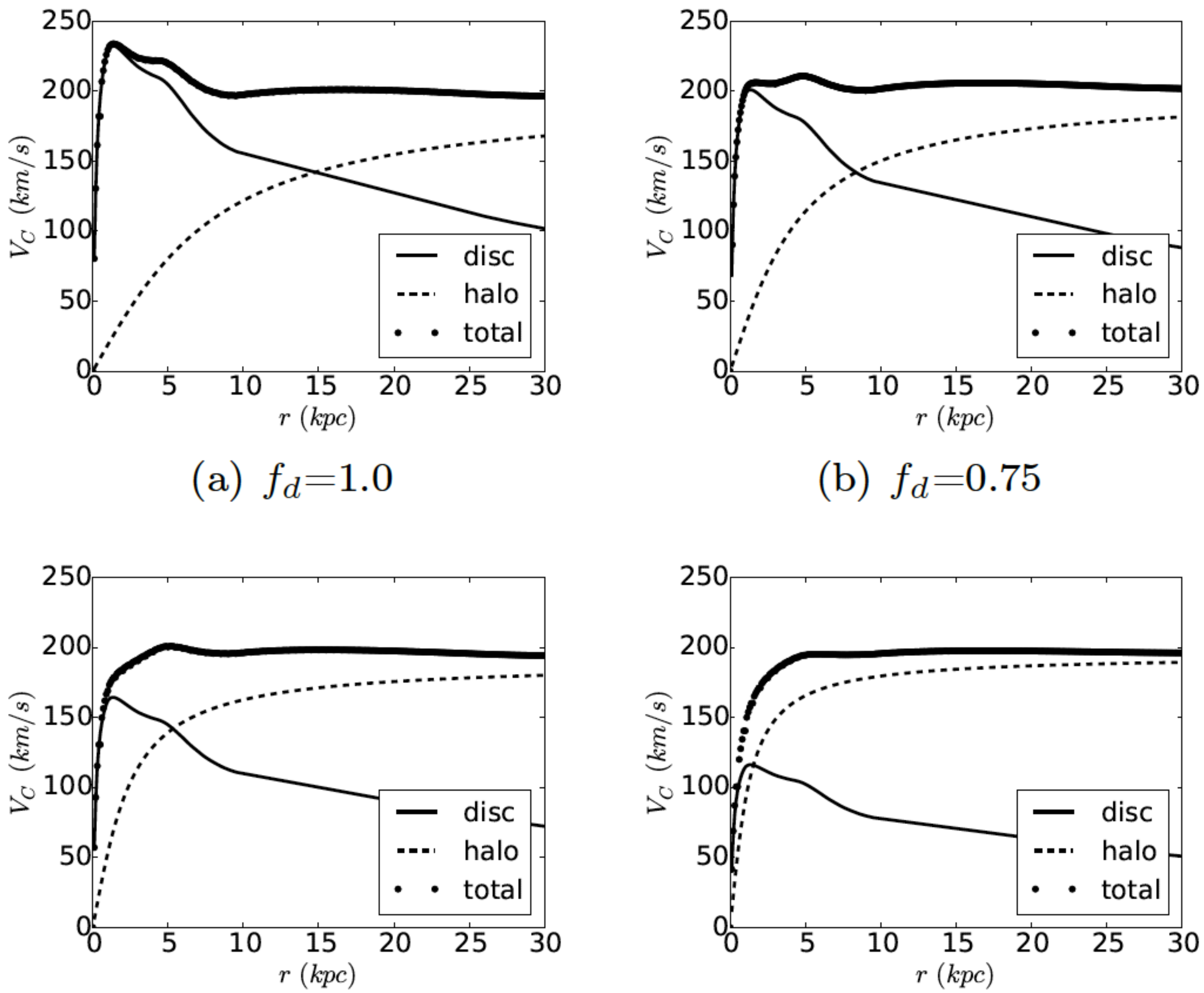
$$\Upsilon = f_d \Upsilon_{3.6}$$

fd = 1

fd = 0.75

fd = 0.5

fd = 0.25



(a) f_d=1.0

(b) f_d=0.75

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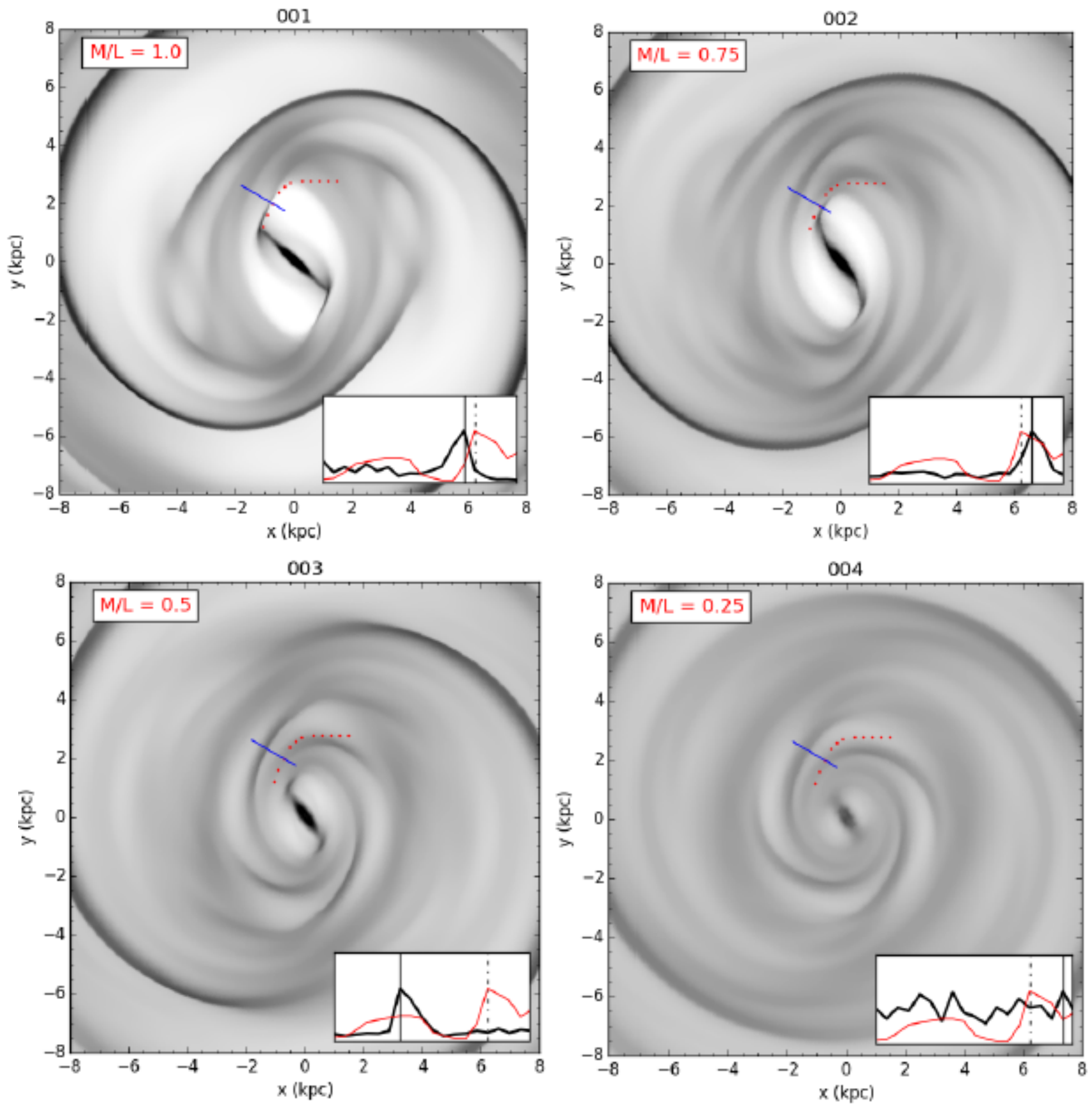


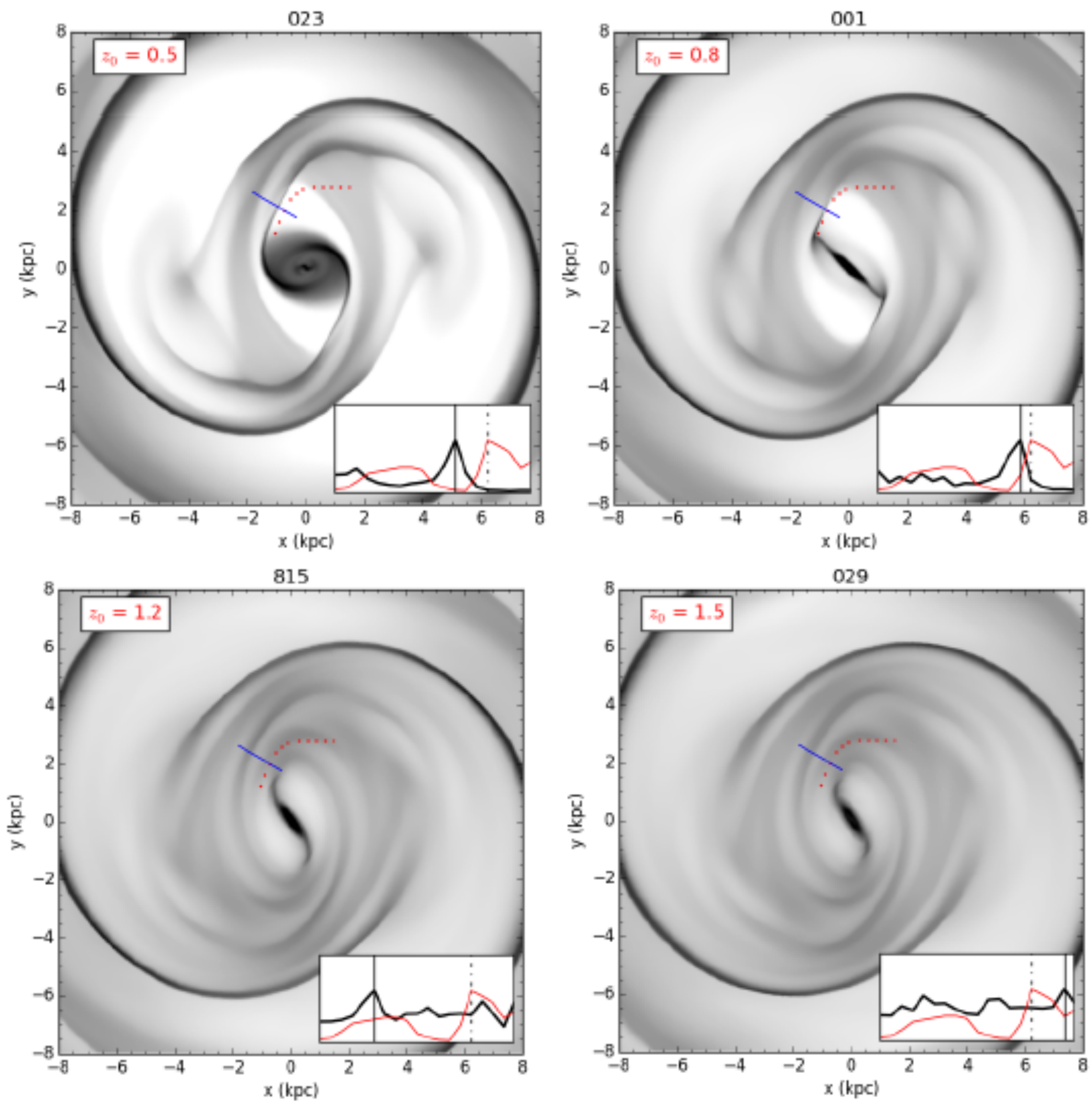
EXPLORING THE PARAMETER SPACE

z_0, h_z

variable z_0 (B/P)

2 height function

thin disc



thick disc

EXPLORING THE PARAMETER SPACE

3 bar pattern speed

corotation radius $r_L = \mathcal{R}\, r_B$ bar semi-major axis

EXPLORING THE PARAMETER SPACE

(3) *bar pattern speed*

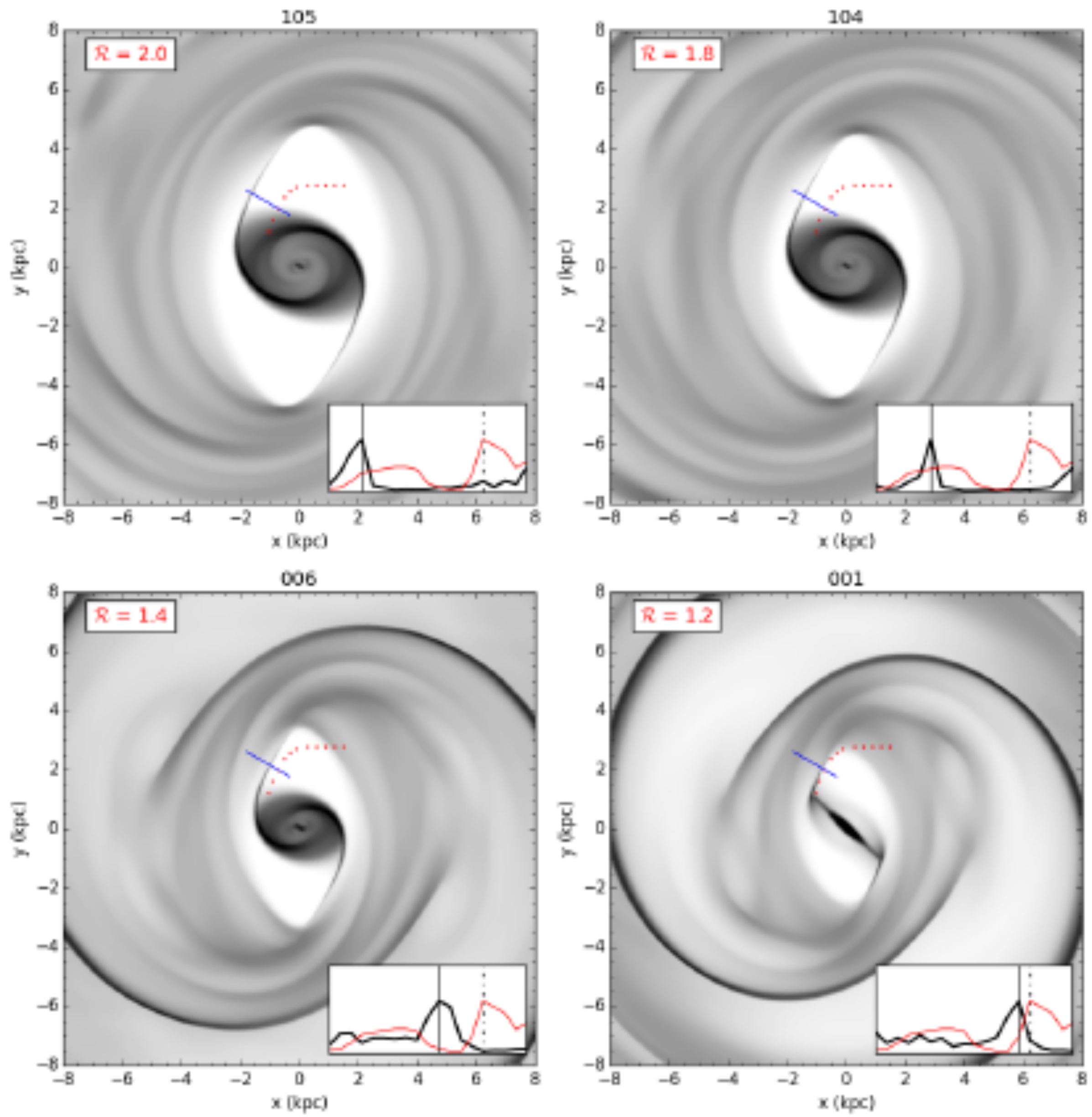
$$r_L = \mathcal{R}\, r_B$$

$\mathcal{R} < 1.4$ vs $\mathcal{R} > 1.4$

fast bars | slow bars

EXPLORING THE PARAMETER SPACE

slow bar



fast bar

3 *bar pattern speed*

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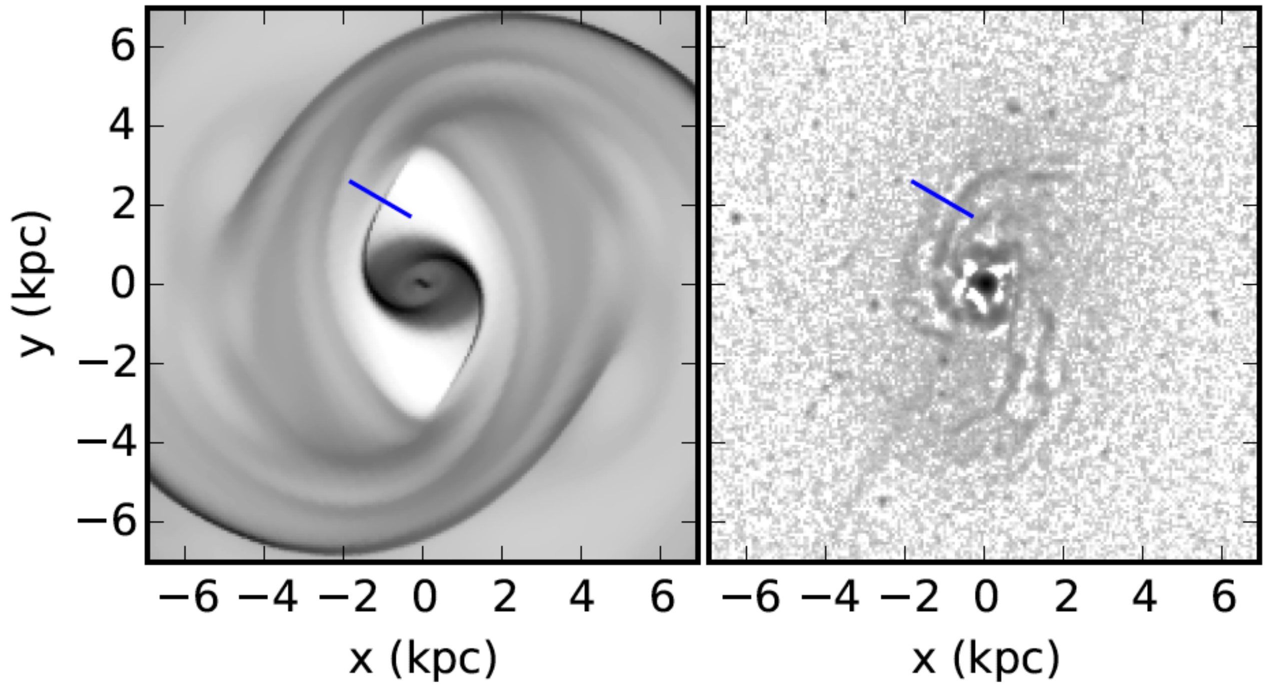
fast bars — slow bars

COMPARING MODELS AND OBSERVATIONS



Place pseudo-slits perpendicular to the shocks in the model and observations

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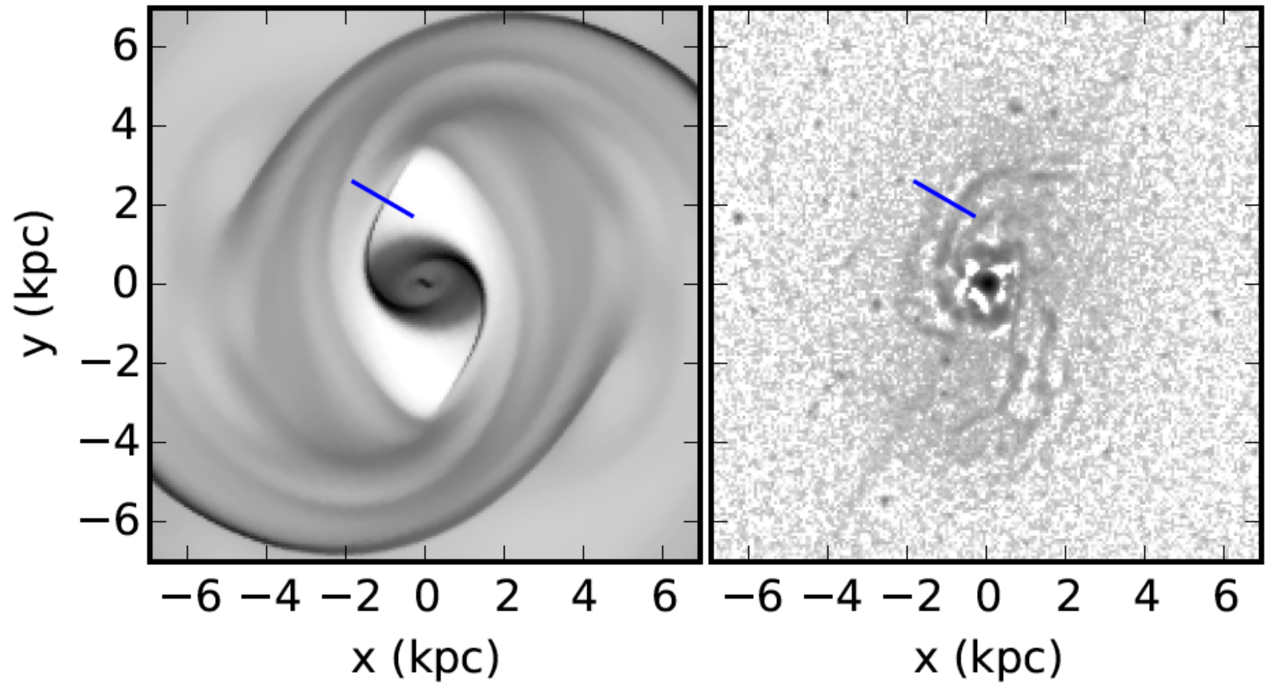

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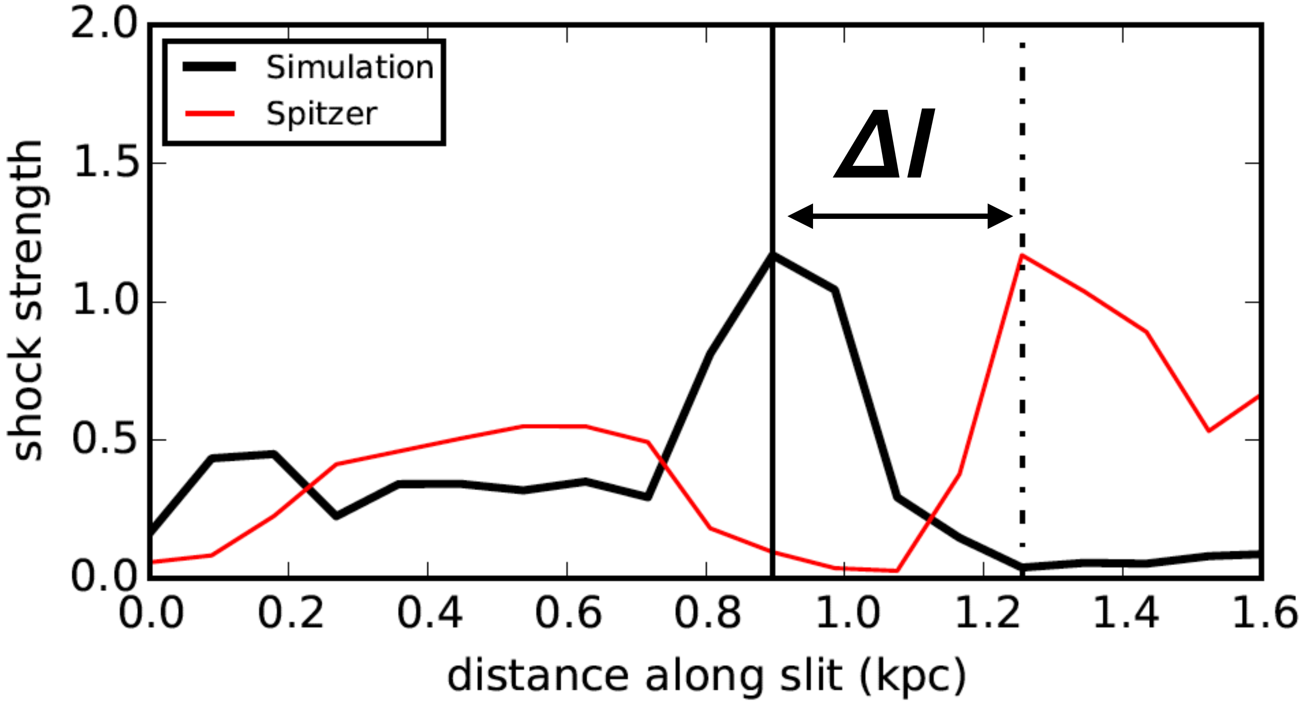

Distance between shocks (*Δl*) is used to measure the goodness of fit

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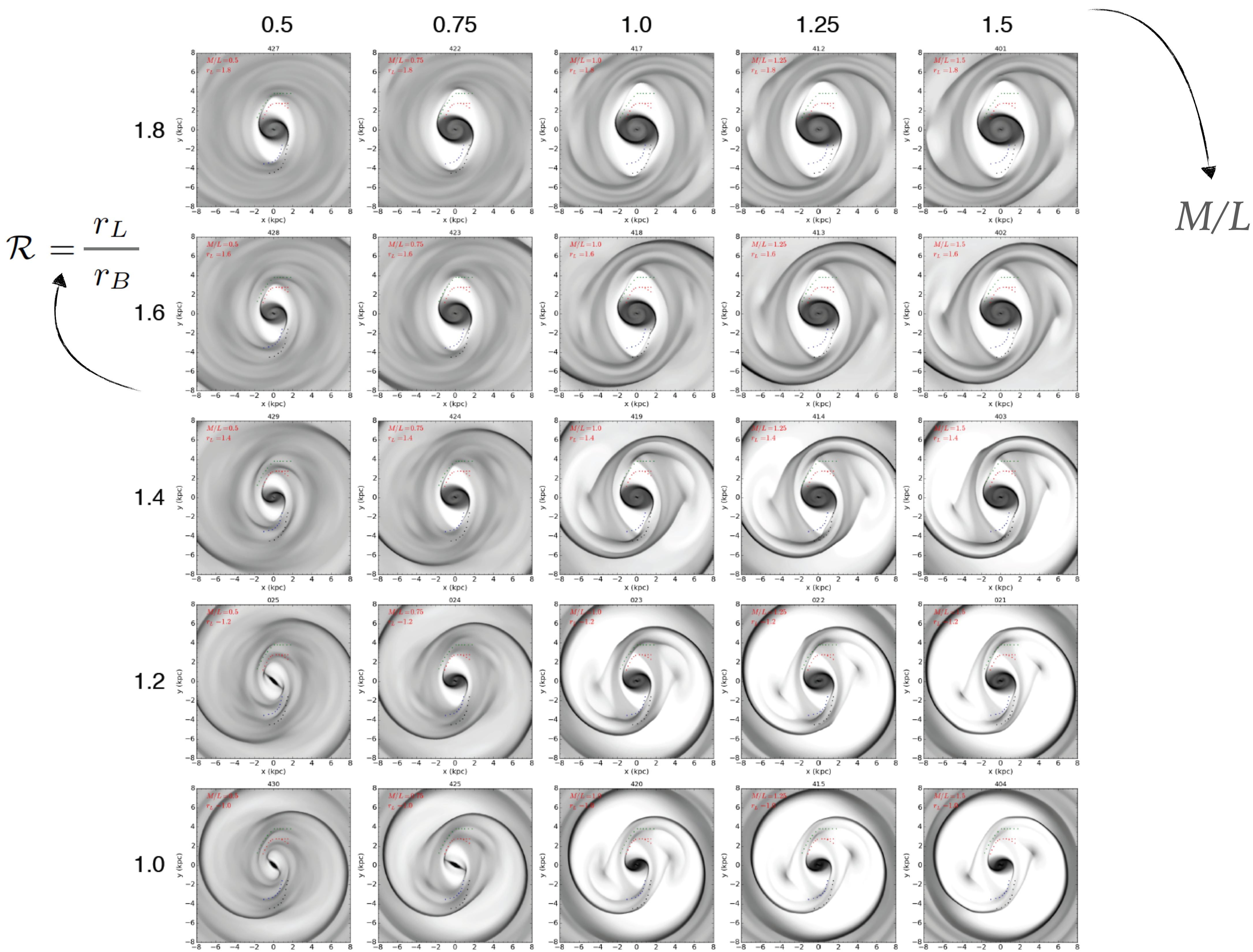

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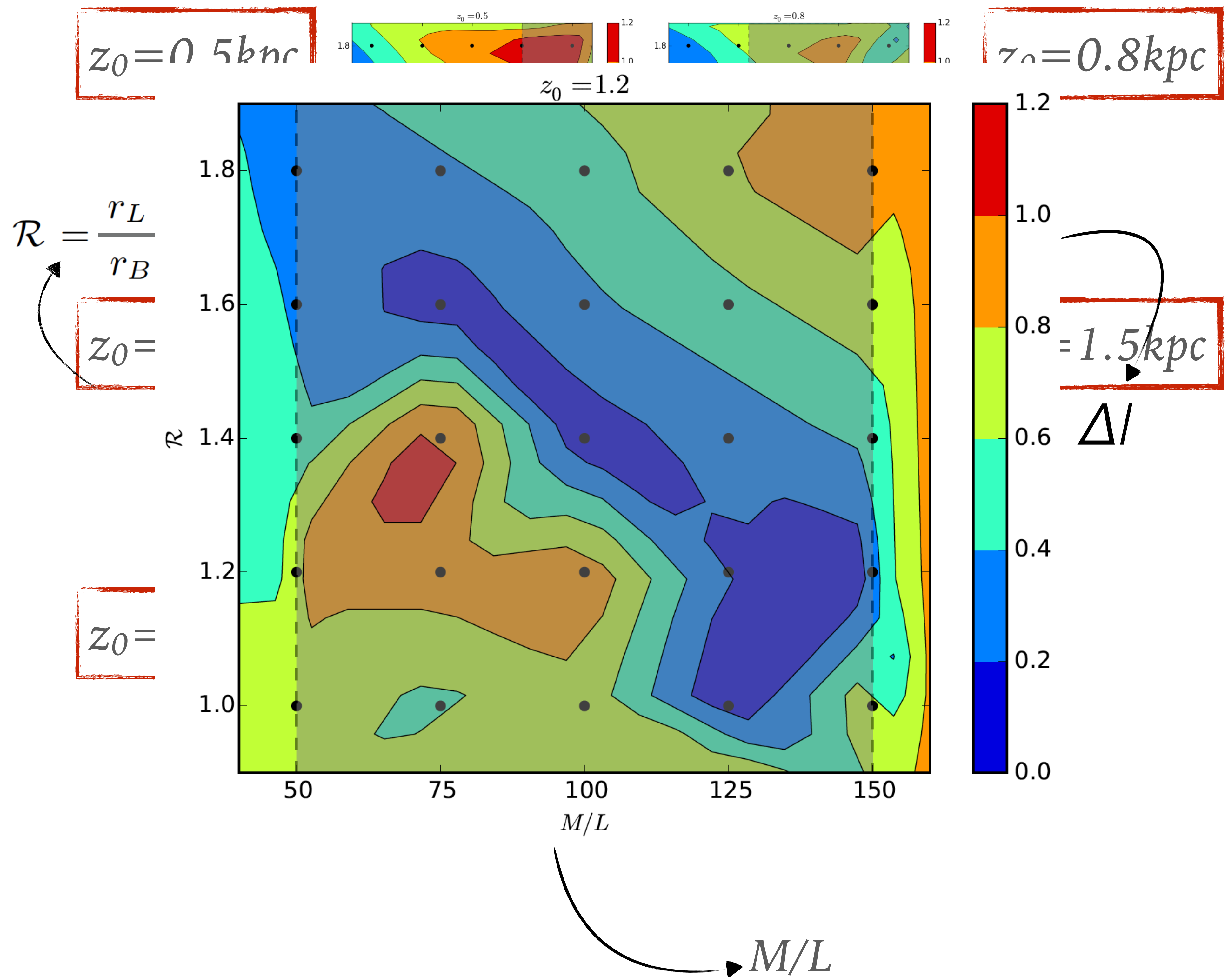


EXPLORING THE PARAMETER SPACE

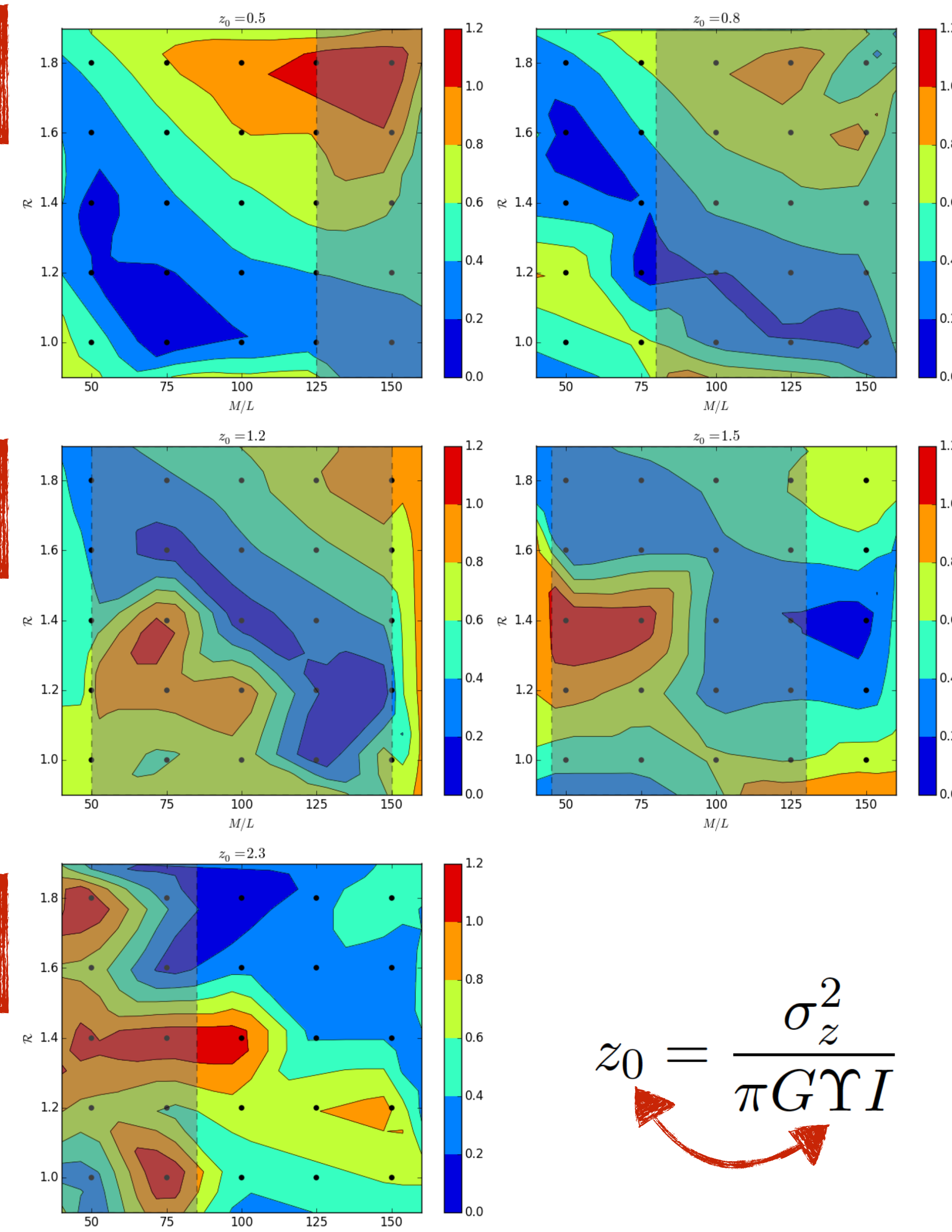
z_0=0.5kpc

z_0=0.8kpc

z_0=1.2kpc

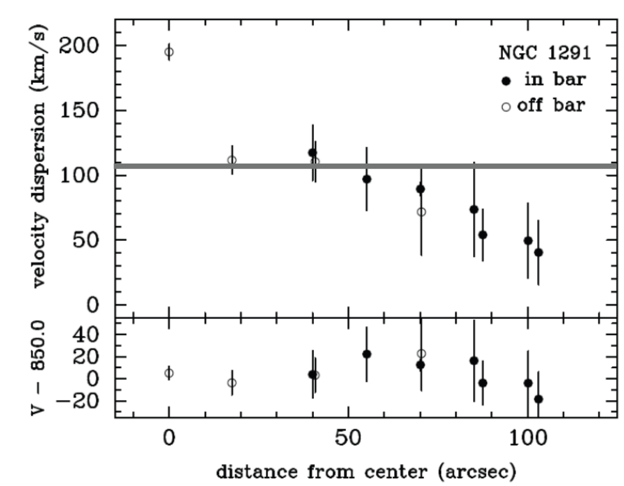
z_0=1.5kpc

z_0=2.3kpc

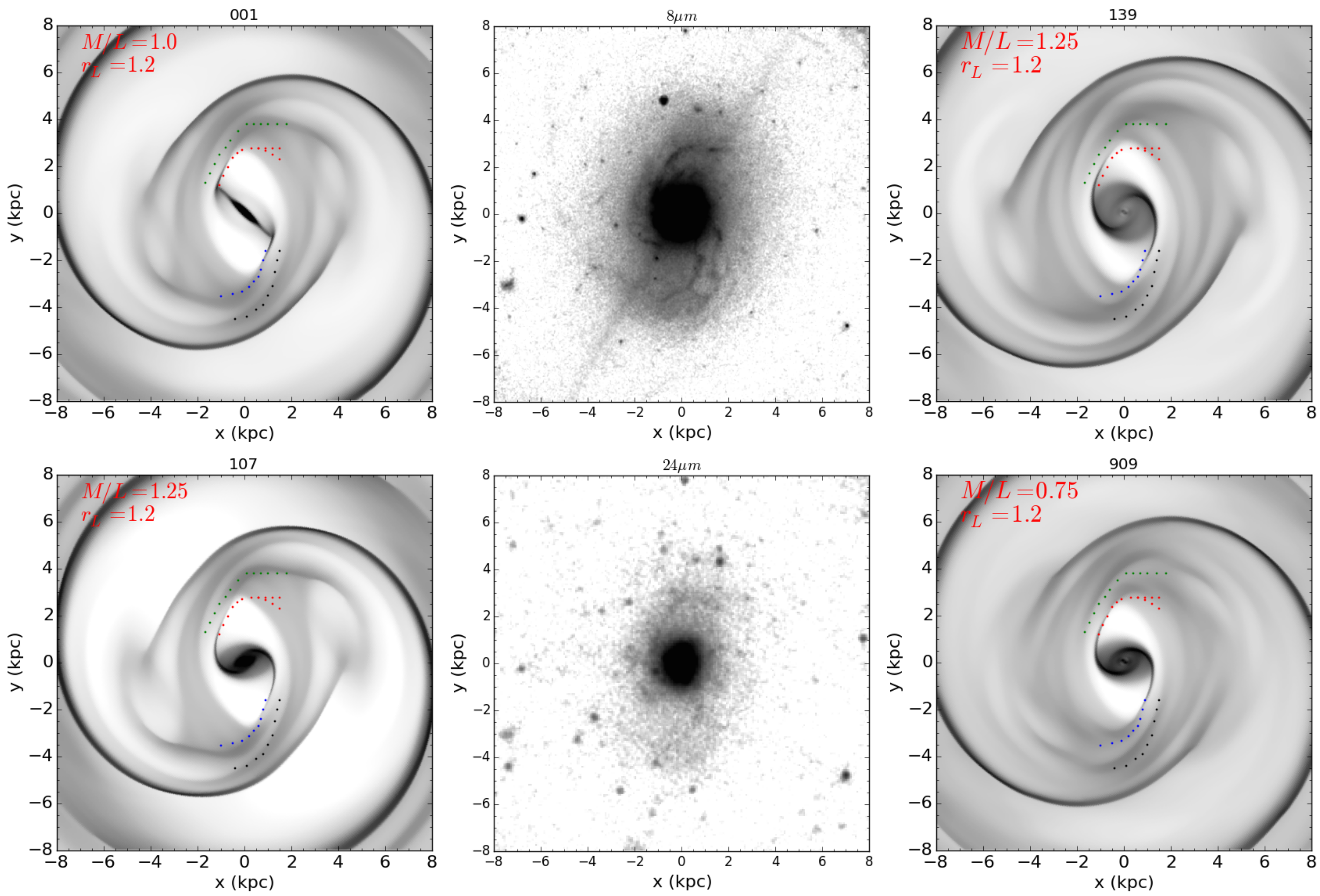


$$z_0 = \frac{\sigma_z^2}{\pi G \Upsilon I}$$

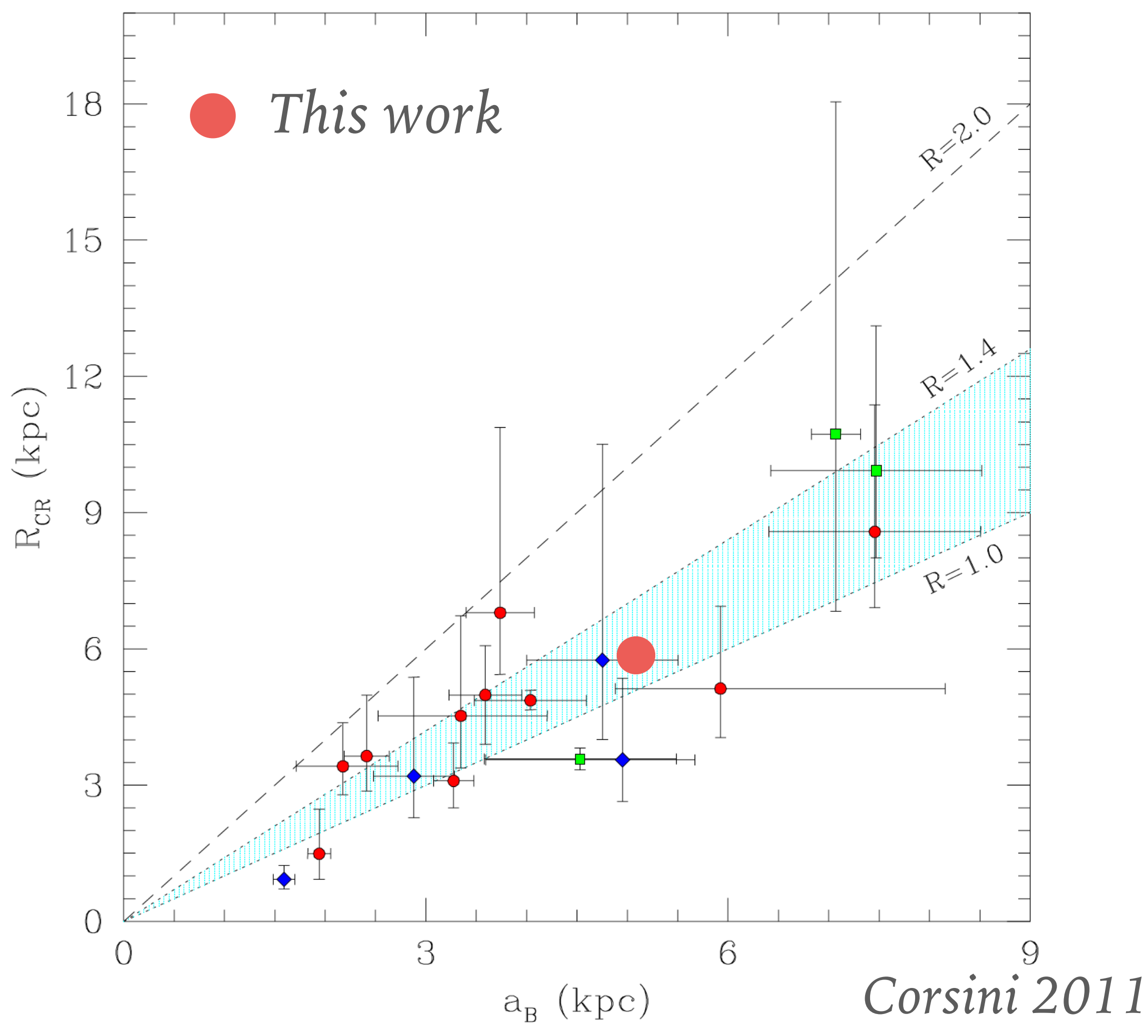
Bosma+10



BEST FIT MODELS



NGC 1291 HAS A FAST-ROTATING BAR



In accordance with:

- Measurements of bar pattern speeds using the stellar Tremaine-Weinberg method.
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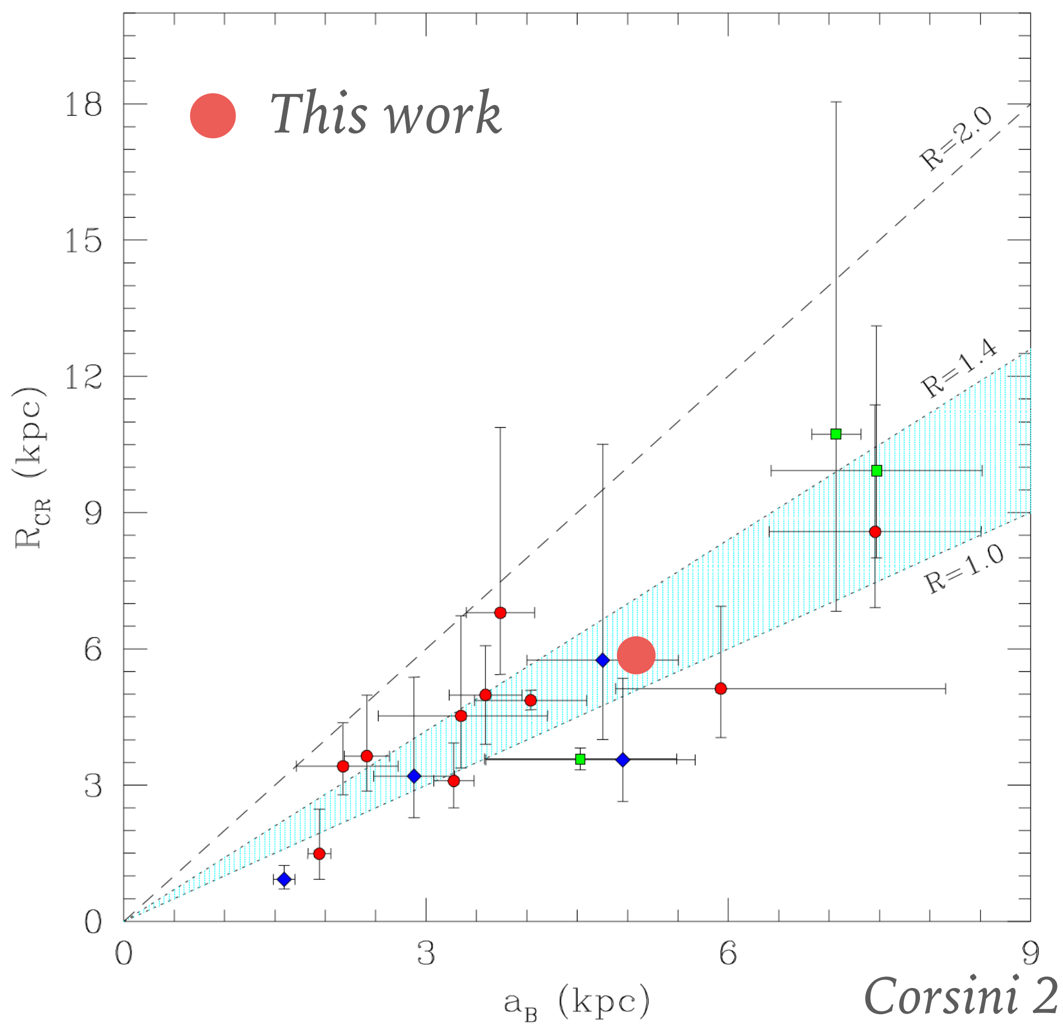
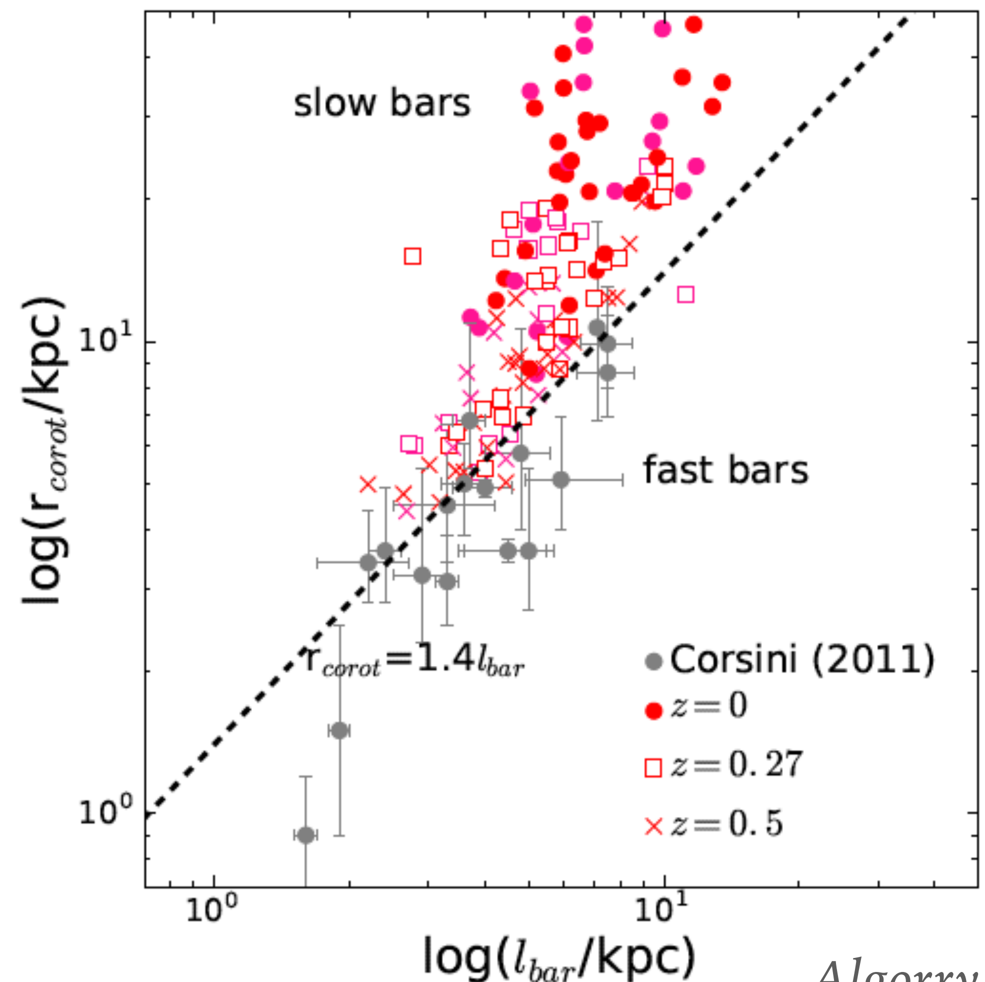


Corsini 2011



Algorry+16

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However see Algorry+16 (slow bars in EAGLE simulation)

NGC 1291'S MAXIMAL DISC

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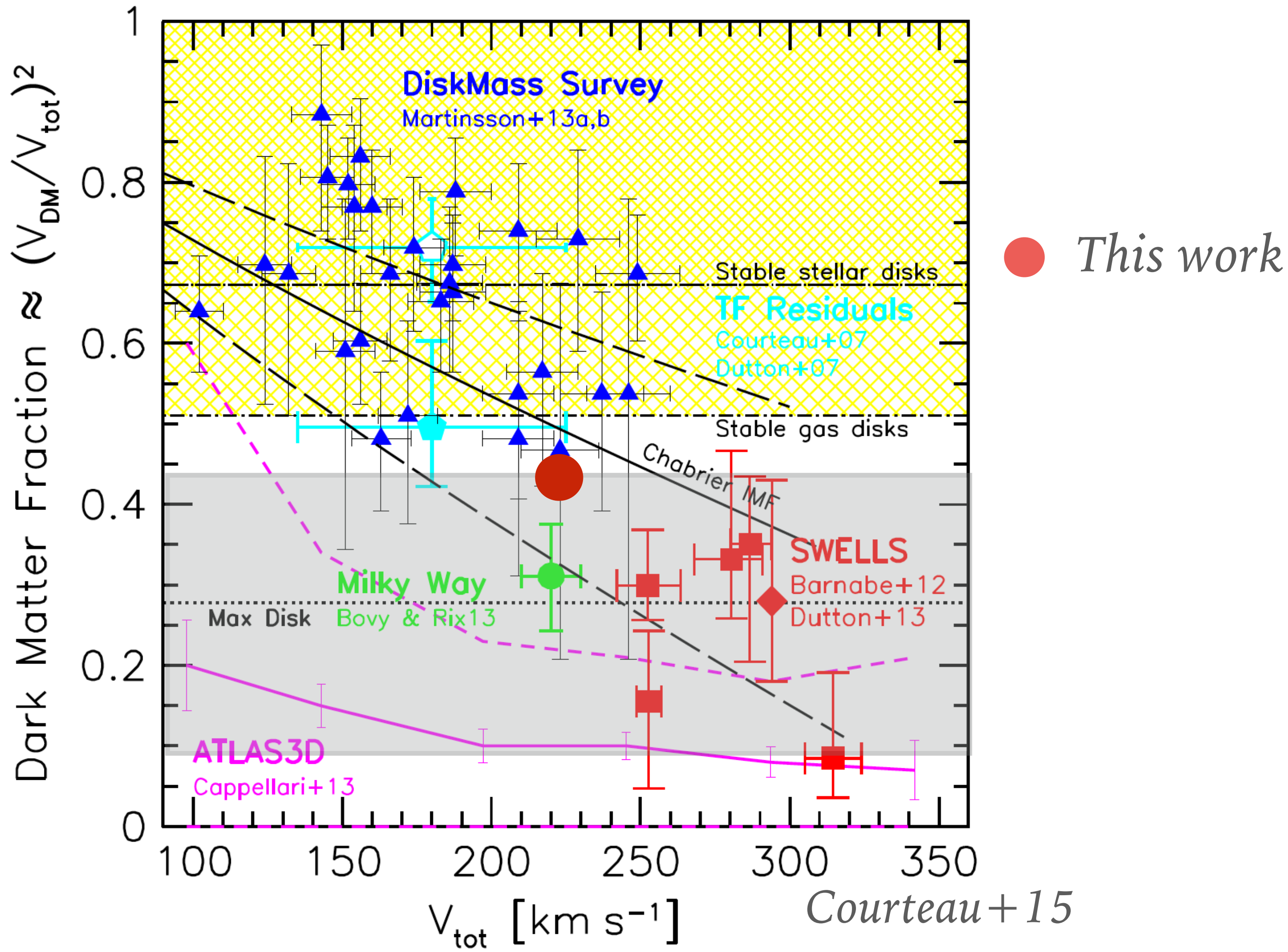

Courteau+15

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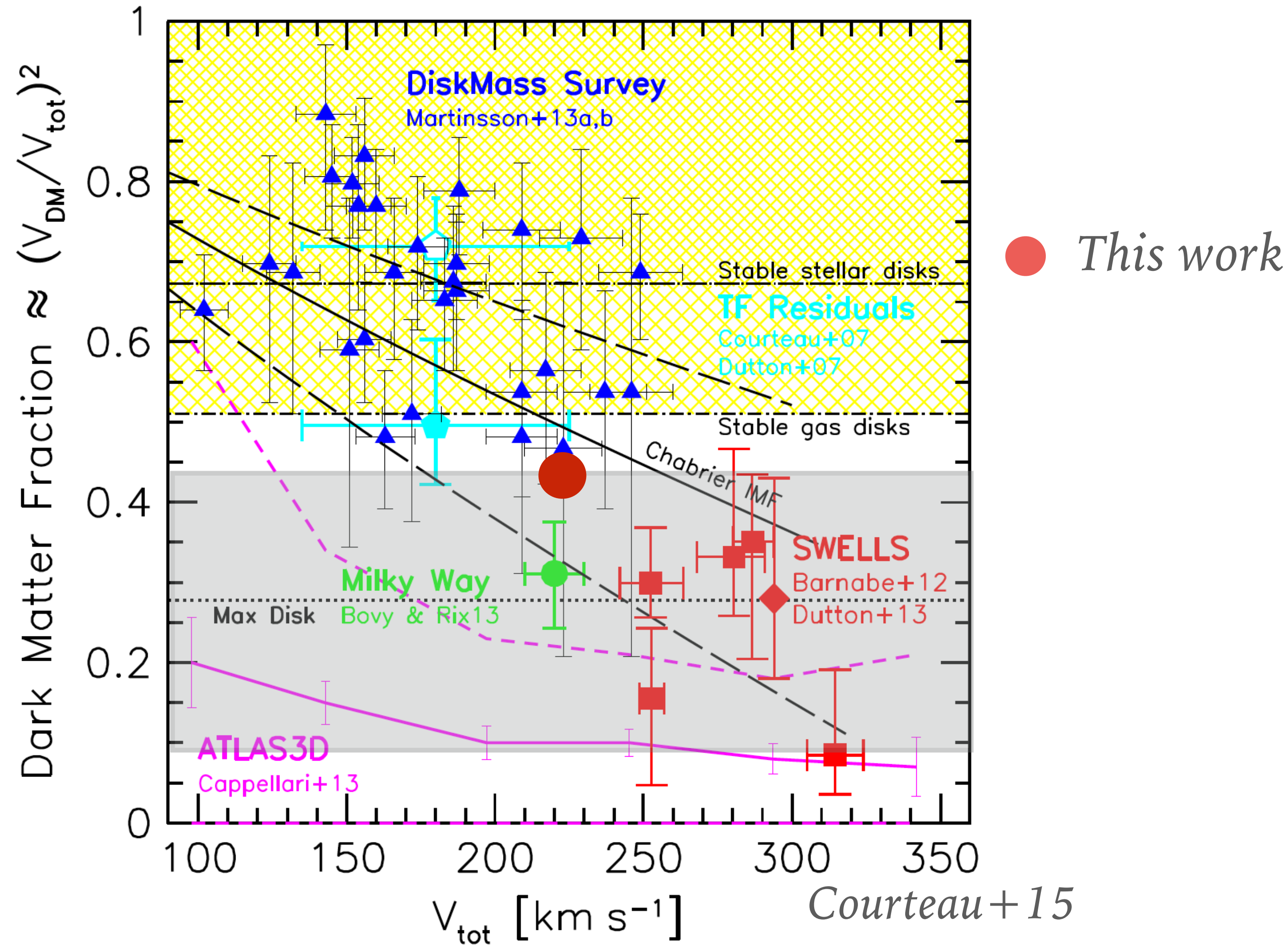

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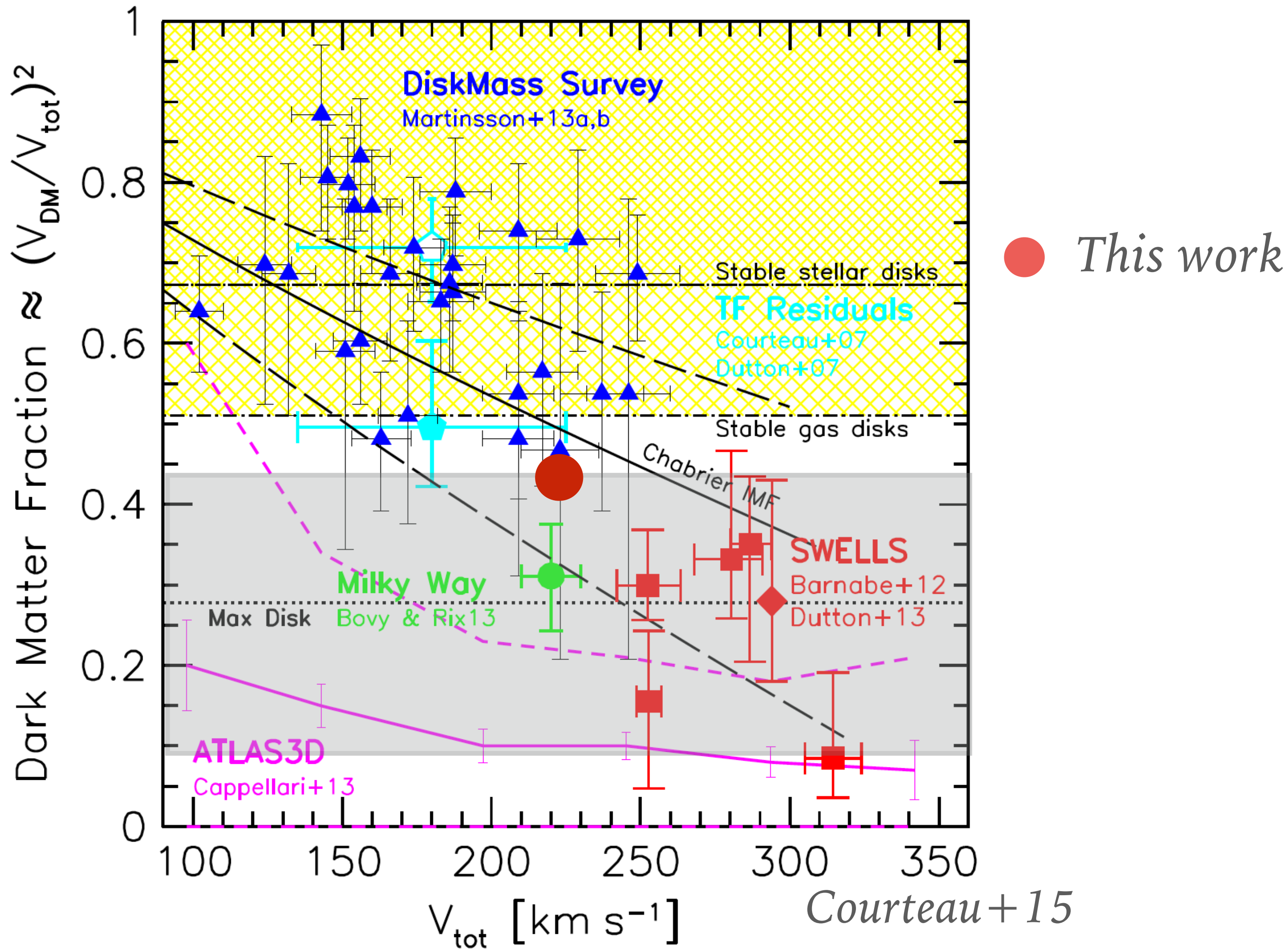

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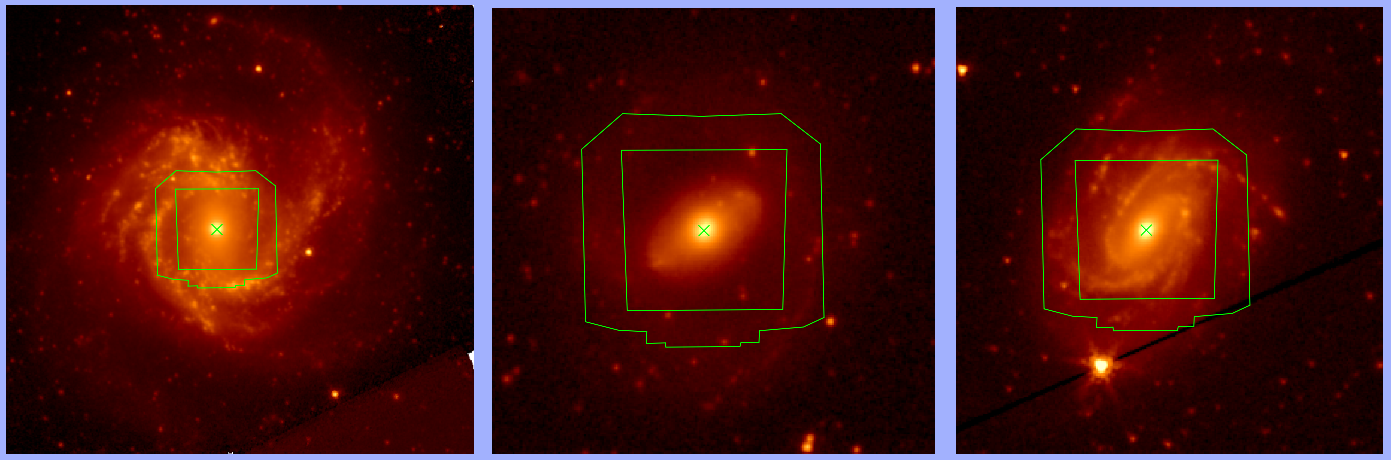
The best fit models have 0.45-0.75 $M_\odot/L_\odot$, which is compatible with that found by SPS modelling (Meidt+14, Roeck+15)

COMBINING METHODS TO DETERMINE THE M/L

TIMER

PI: Gadotti

- *Sample of galaxies with MUSE data*
- *Can combine different methods (SPS and velocity dispersion method) to constrain M/L*



www.muse-timer.org

SUMMARY

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- The galaxy has a bordeline **maximum disc**
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Fragkoudi et al., (2016) arXiv:1605.05754

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