The origin of stellar breaks as probed by S^{4}G

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Kartik Sheth, Armando Gil de Paz, Sharon Meidt
+ the S^{4}G team

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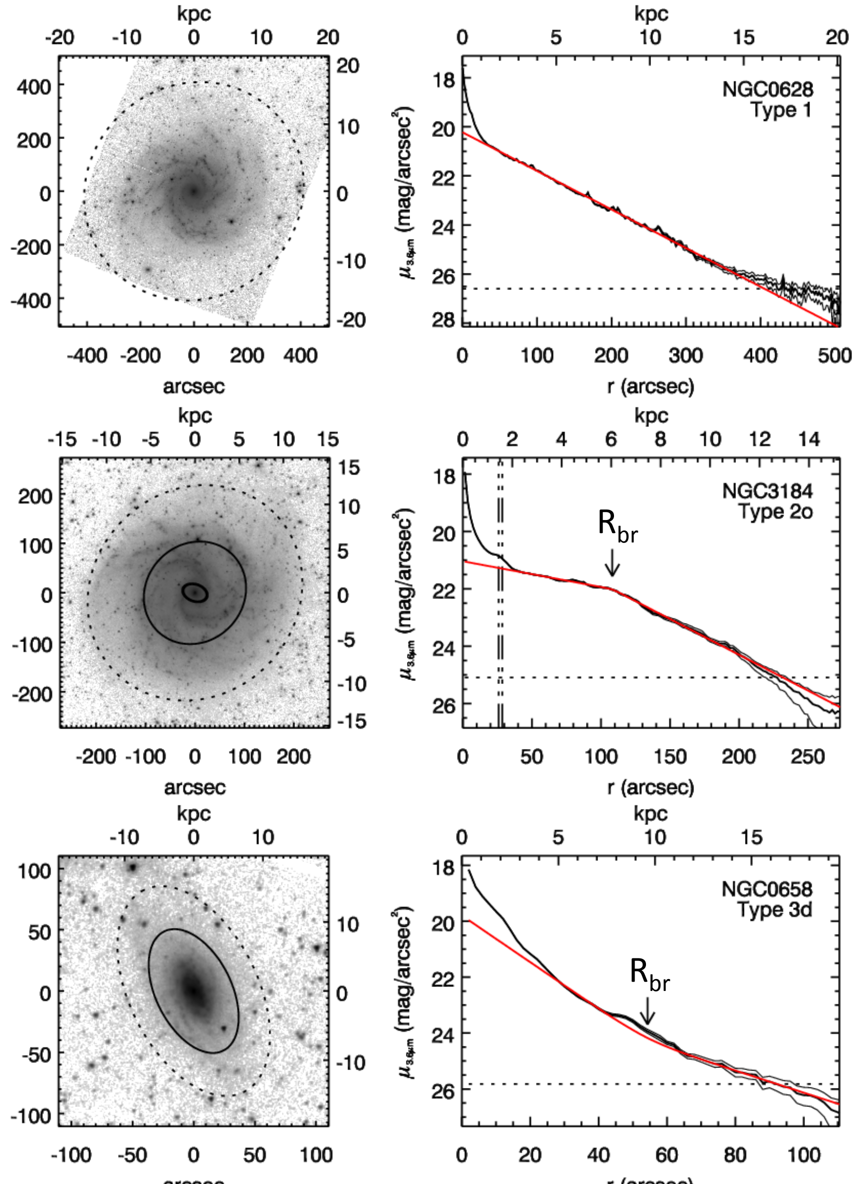
Tenerife

Disks come in three flavors

- Type I (10%)
  Single exponential
- Type II (60%)
  Downbending exponential
- Type III (30%)
  Upbending exponential

Work by Freeman, van der Kruit, Erwin, Pohlen, Trujillo…



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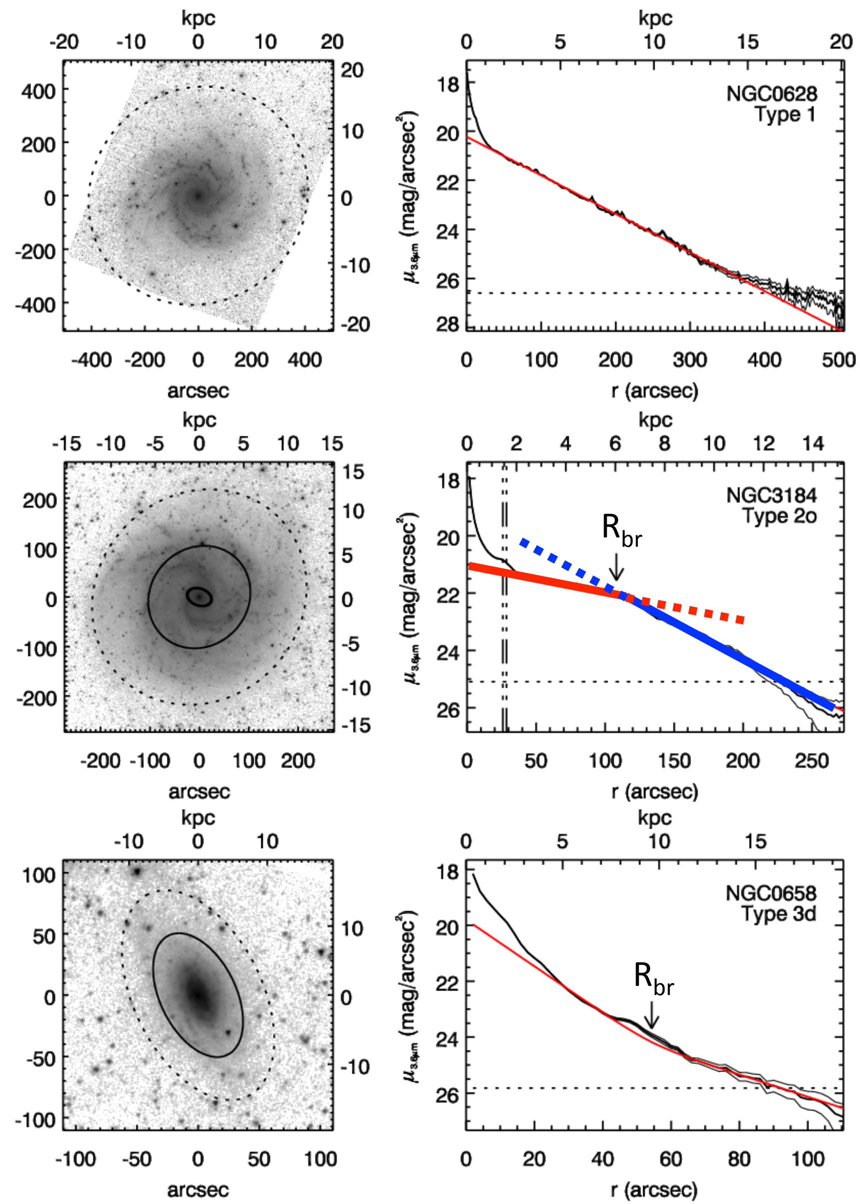

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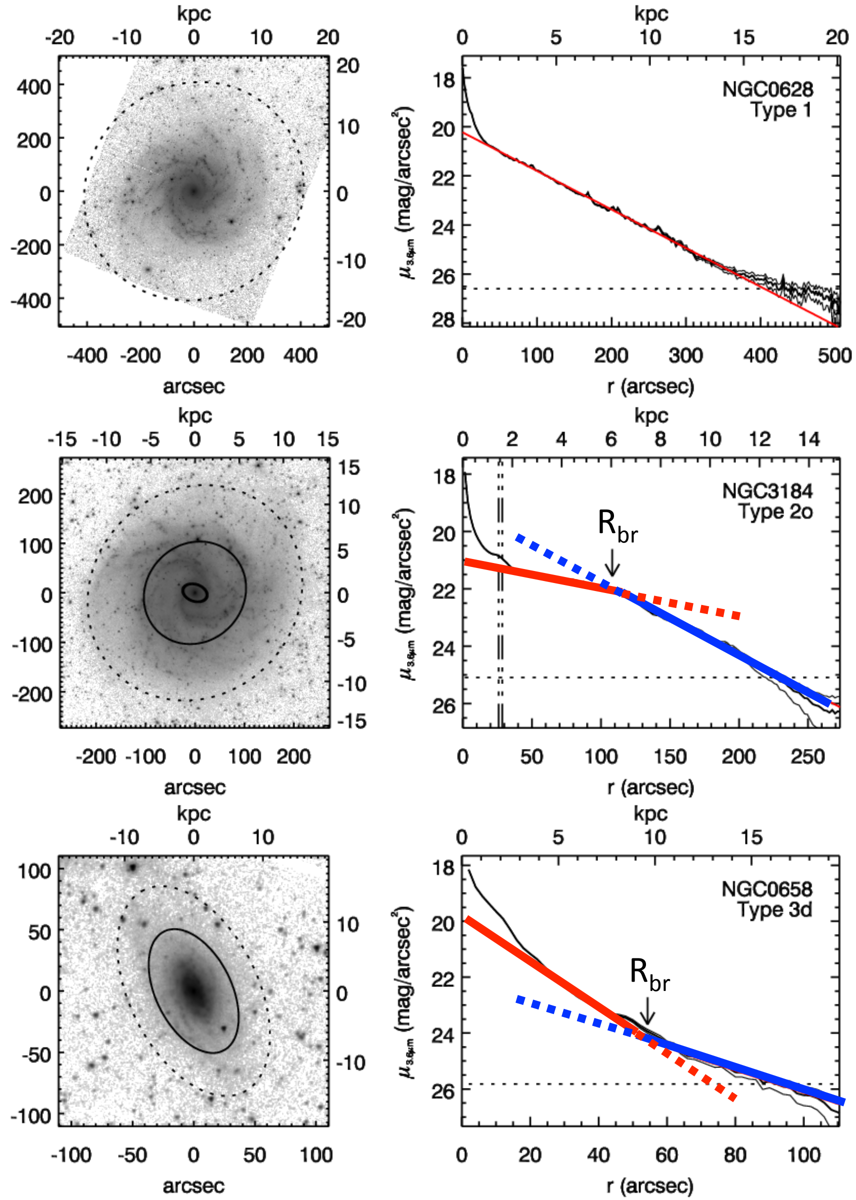

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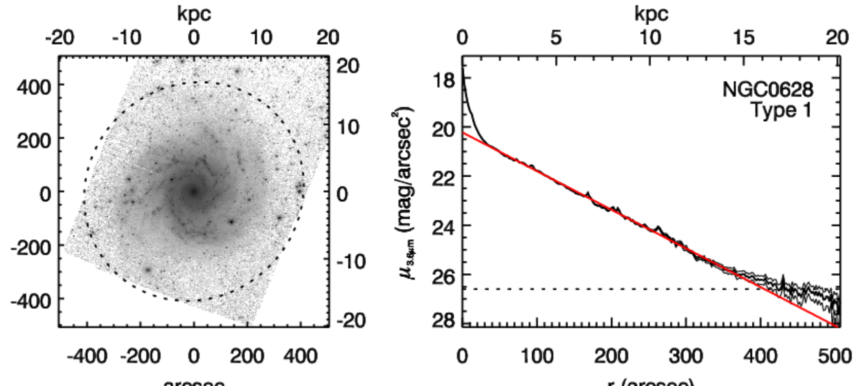

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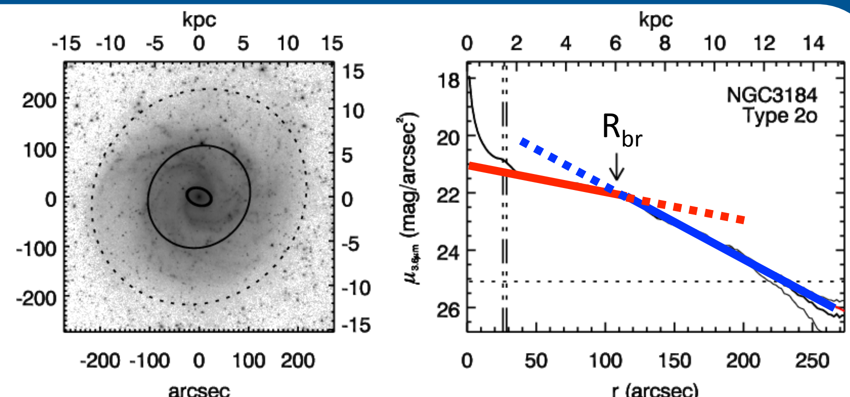

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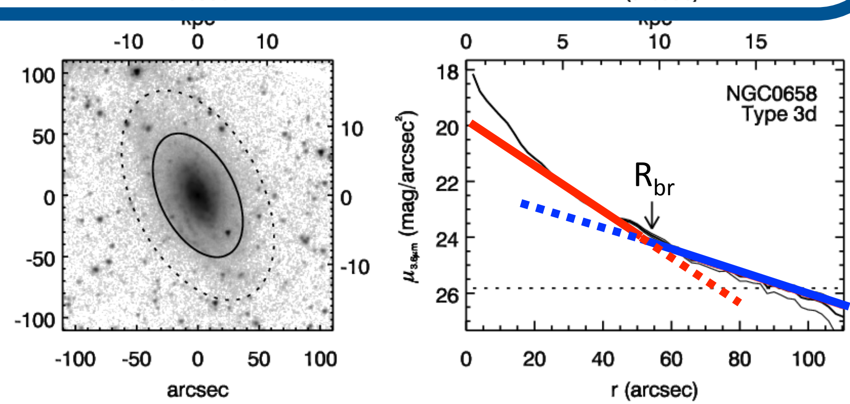

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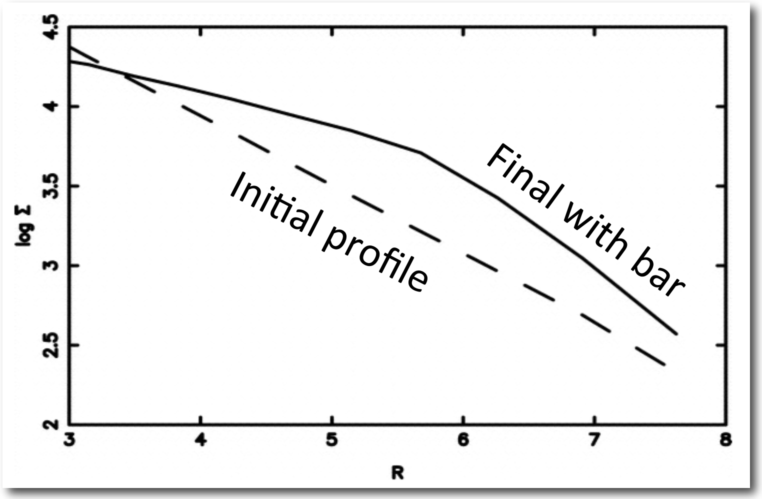
Two scenarios for break formation

- Redistribution of angular momentum by bars and/or spirals.



Debattista et al. (2006)

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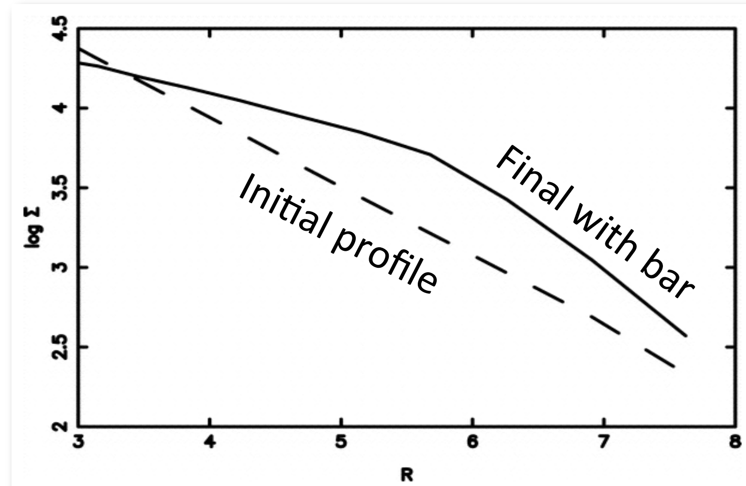
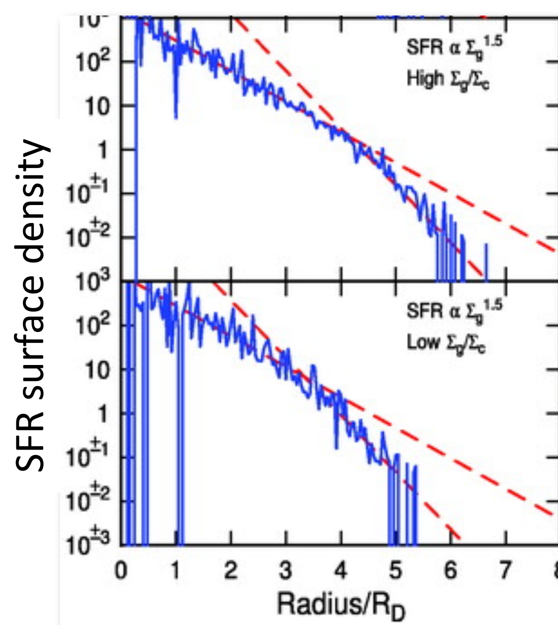


Debattista et al. (2006)

- ❖ Radial changes in the star formation efficiency.



Elmegreen & Hunter (2006)

The Spitzer Survey of Stellar Structure in Galaxies (Sheth+2010)

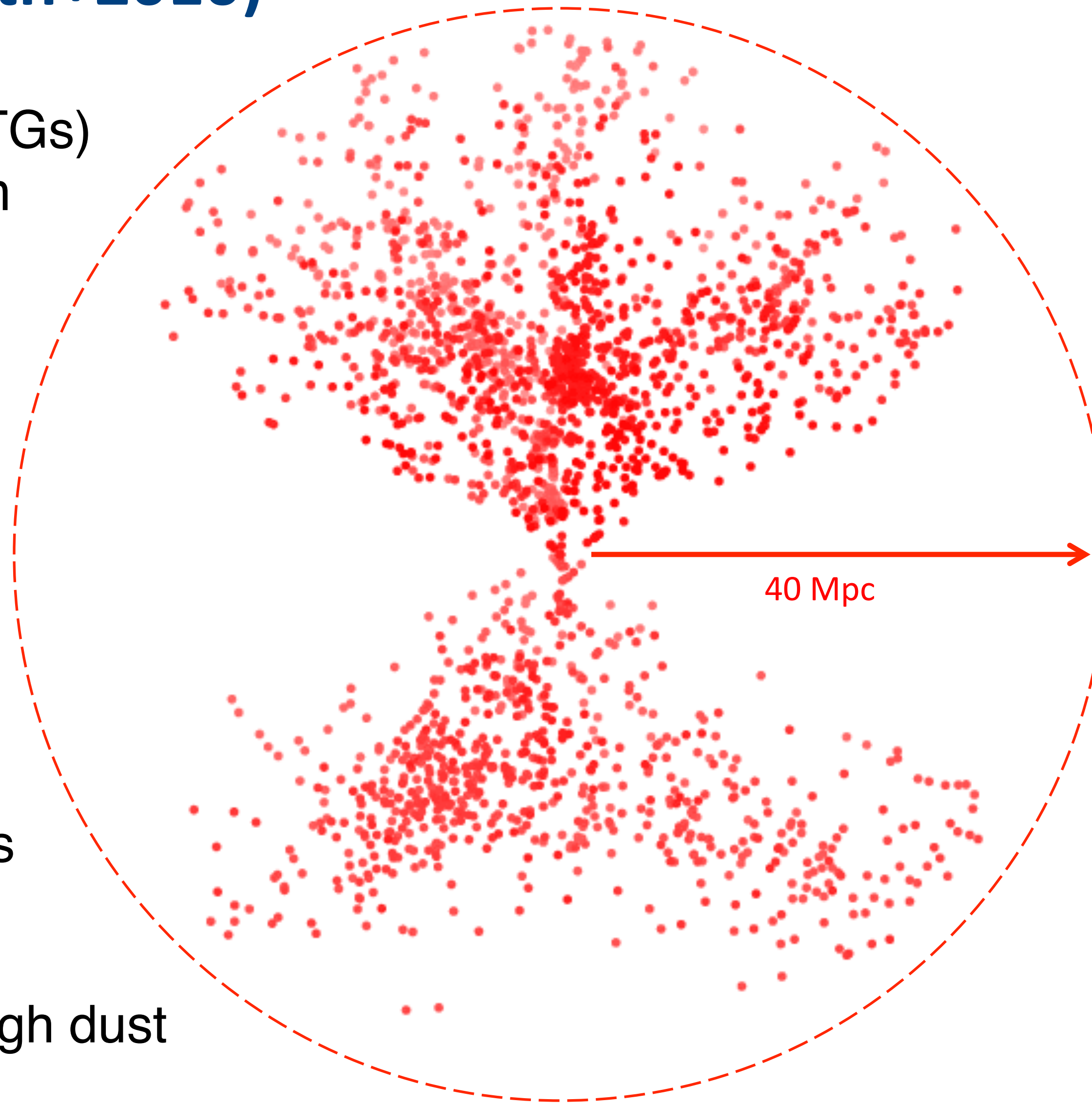
2352 galaxies (+ 465 ETGs) observed at 3.6 & 4.5μm

Dist < 40 Mpc, |b| > 30°
m_{Bcorr} < 15.5, D_{25} > 1'

Very deep IR images
$\mu_{3.6\mu m}$ ~ 27 ABmags/arcsec^2
(~1 $M_\odot$/pc^2)

Directly probing old stars

We can easily see through dust



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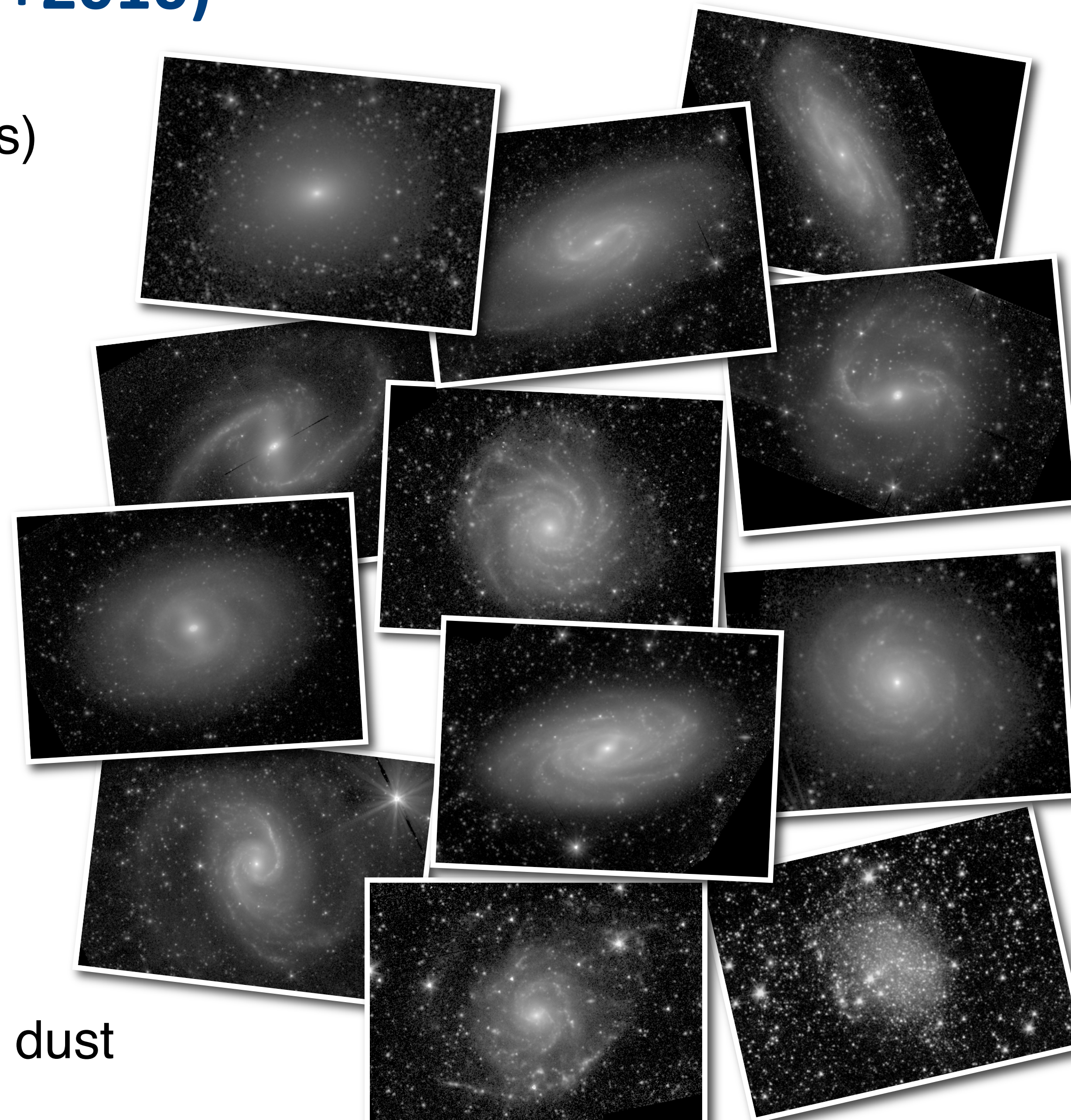
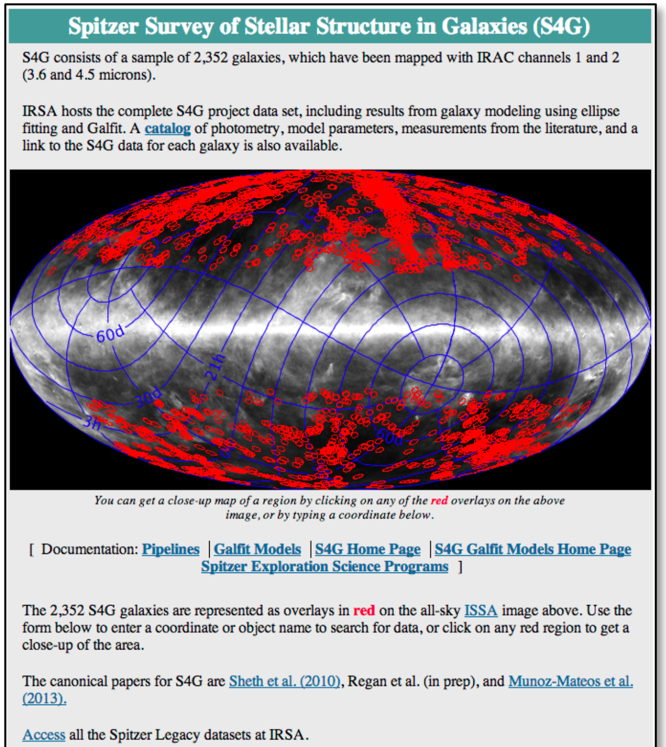
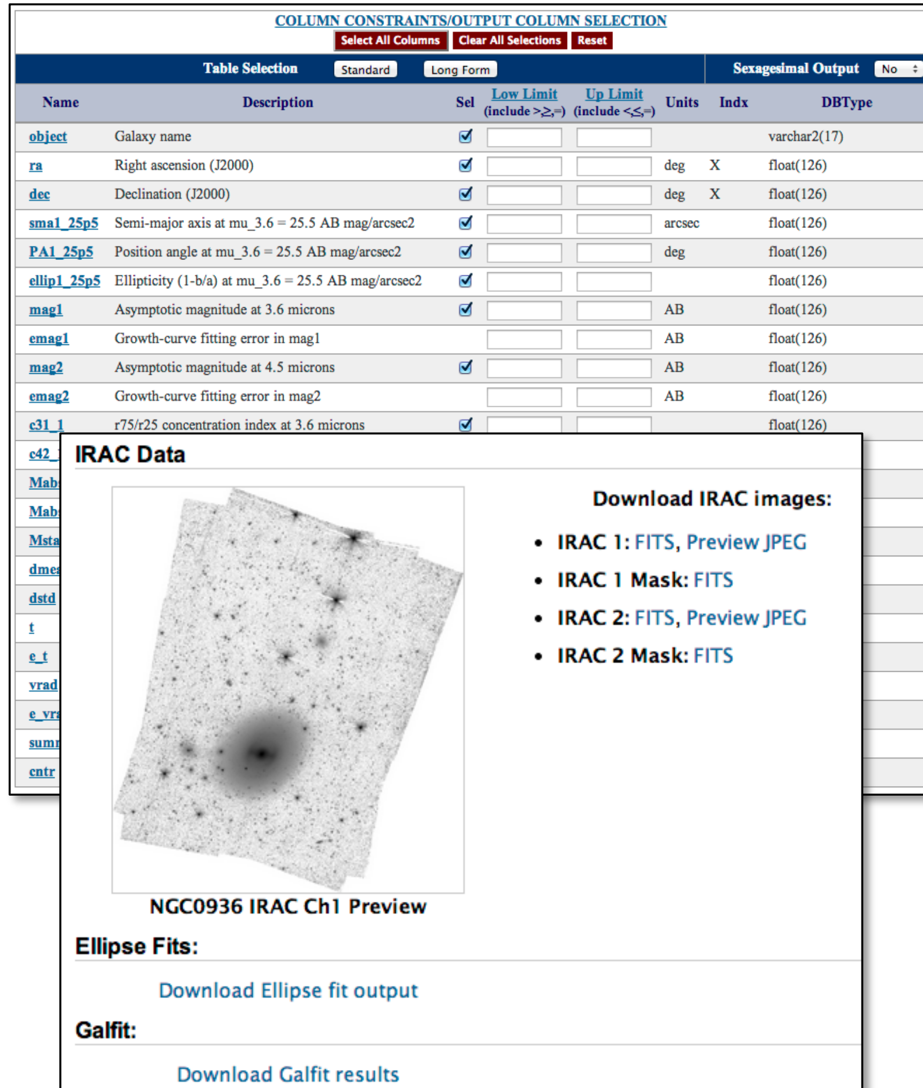


Data access at IRSA

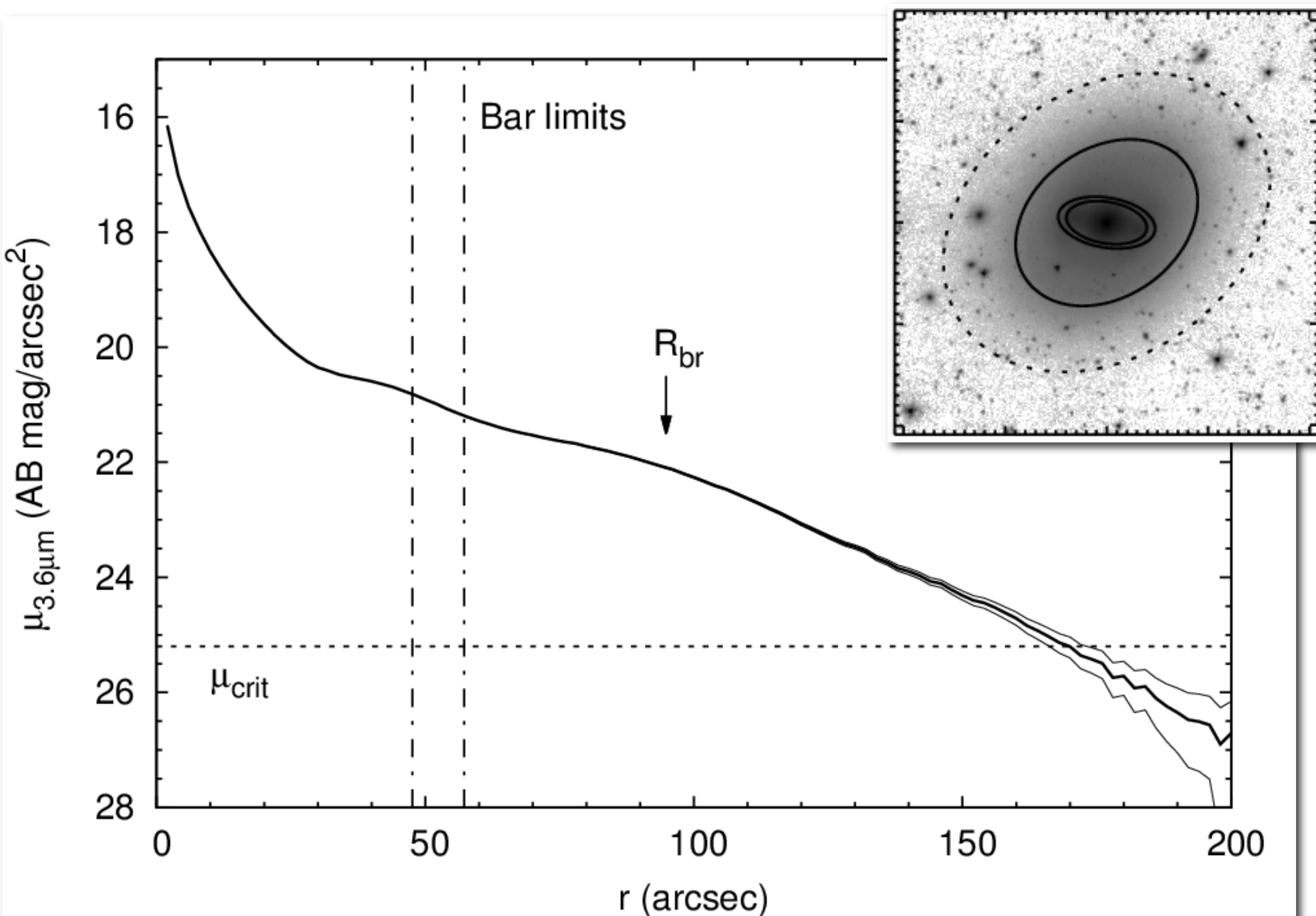
irsa.ipac.caltech.edu/data/SPITZER/S4G





Muñoz-Mateos et al. (2015)
Salo et al. (2015)
Querejeta et al. (2015)

Measuring breaks and bars



Muñoz-Mateos et al. (2013)

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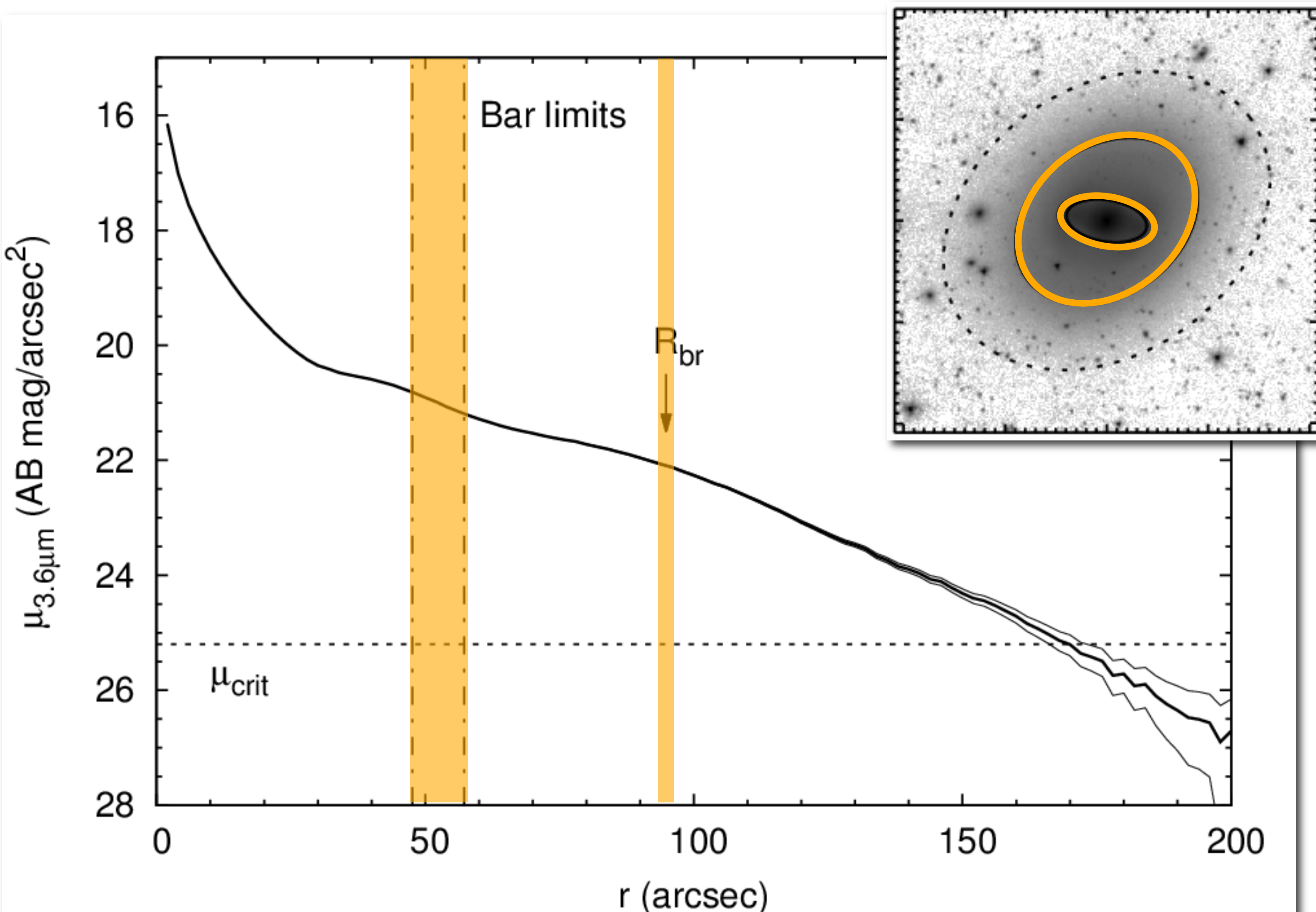

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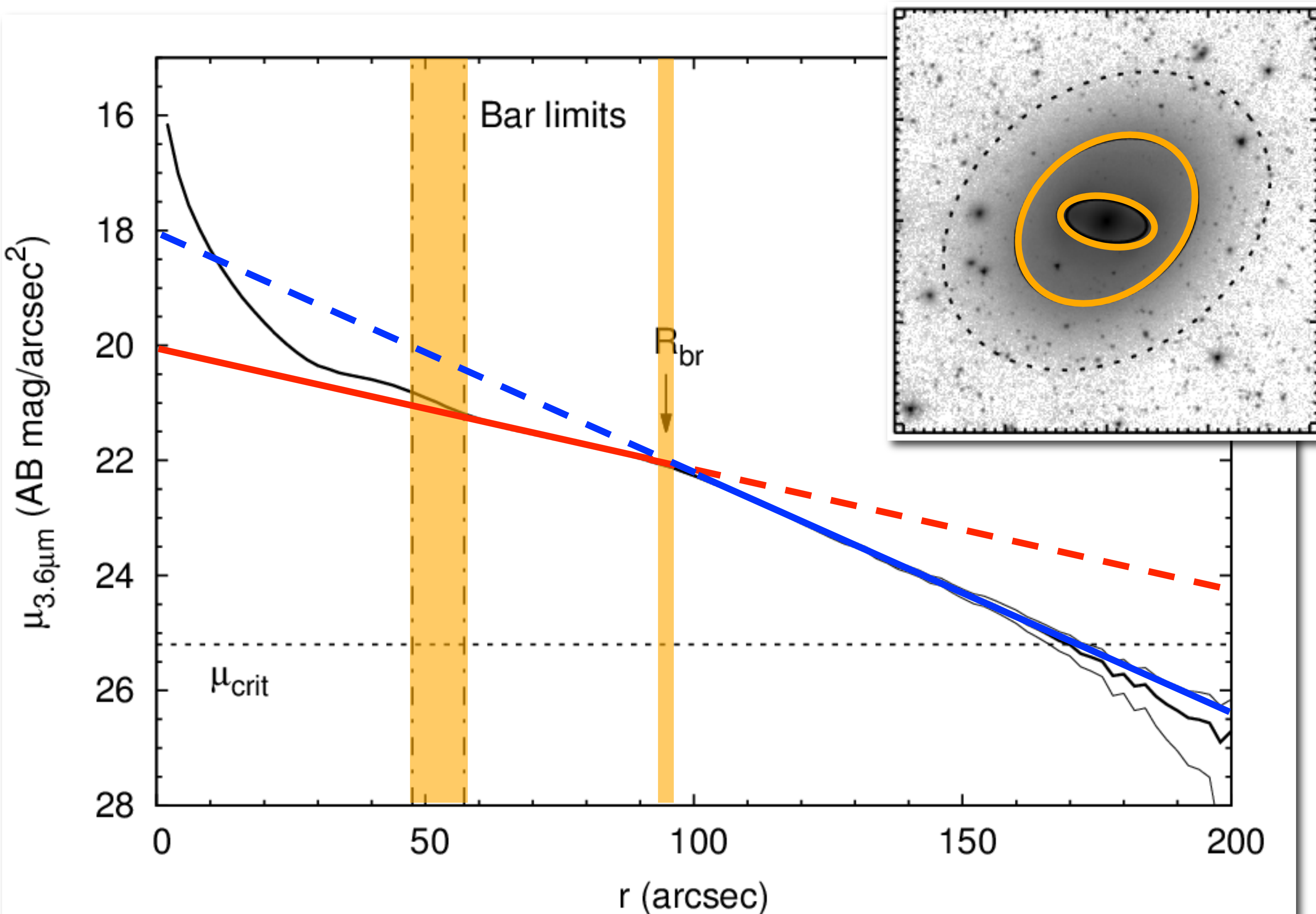
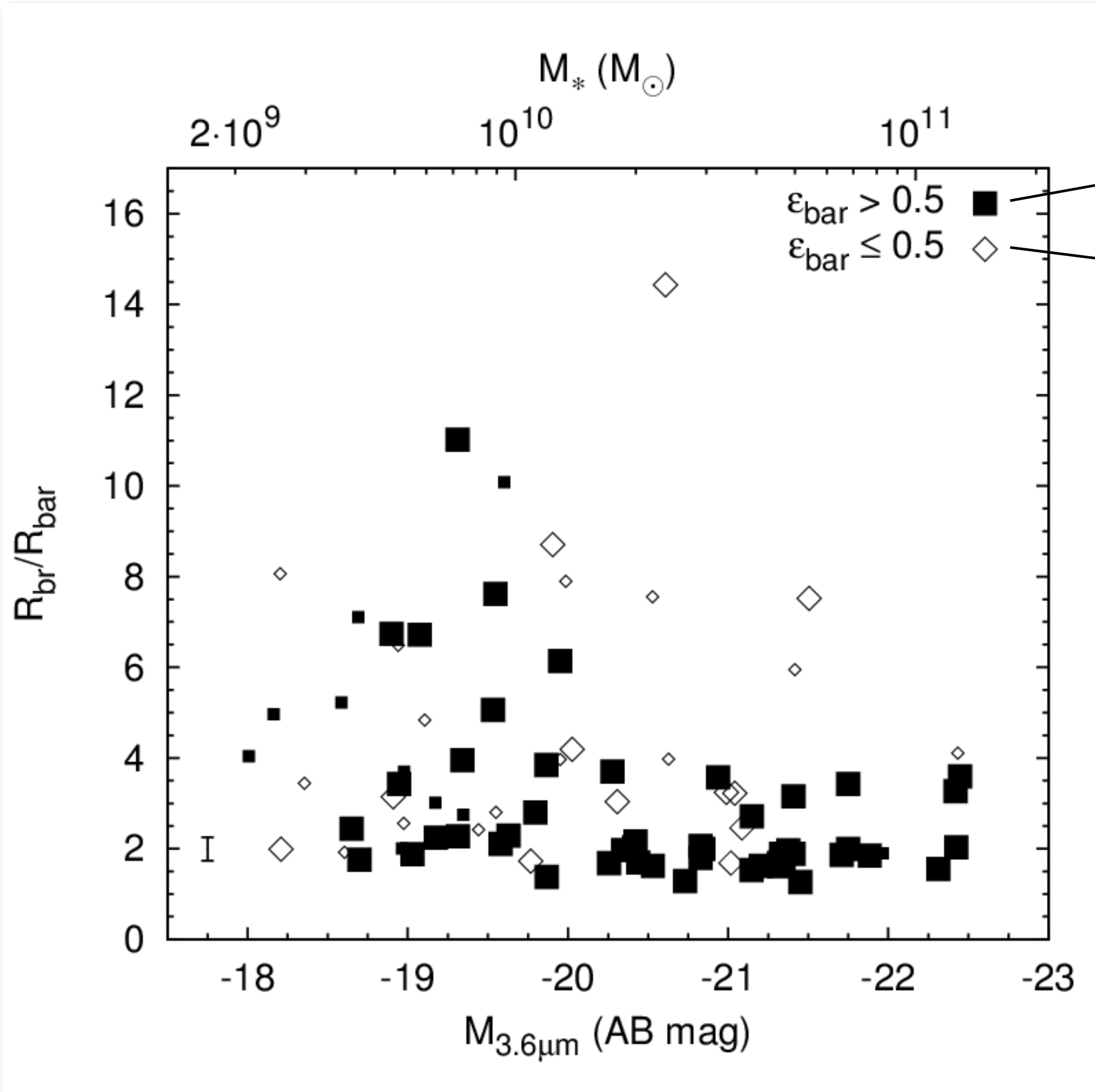
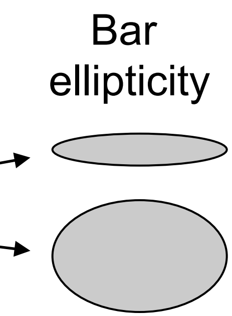


Muñoz-Mateos et al. (2013)

The break/bar ratio depends on mass



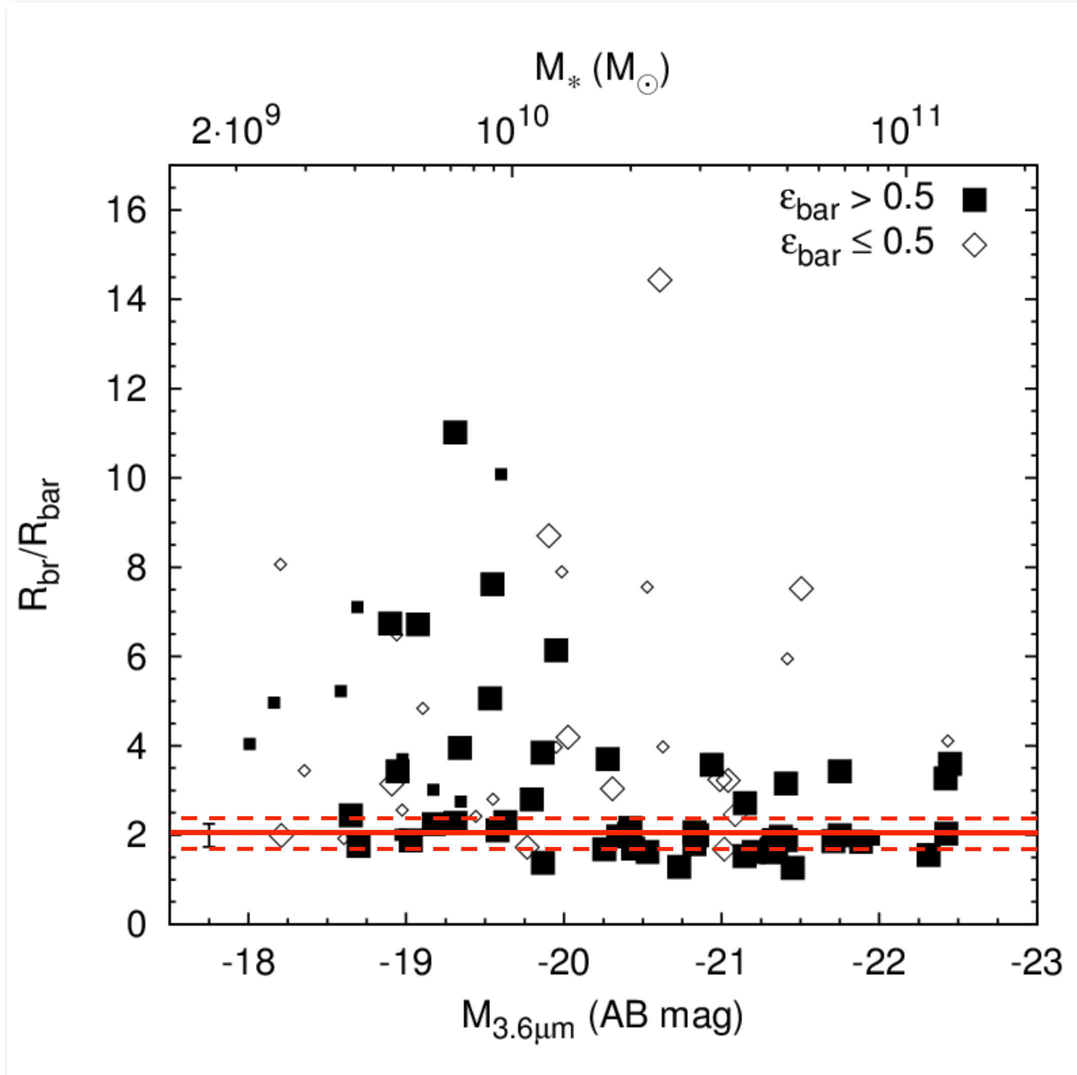


Muñoz-Mateos et al. (2013)

Many breaks lie at the bar OLR

- For a flat rotation curve:
  - V = constant
  - $\Omega \propto 1/r$
  - $R_{OLR} \sim 1.7\ R_{CR}$
- In general:
  - $R_{CR} \sim 1.2\ R_{bar}$

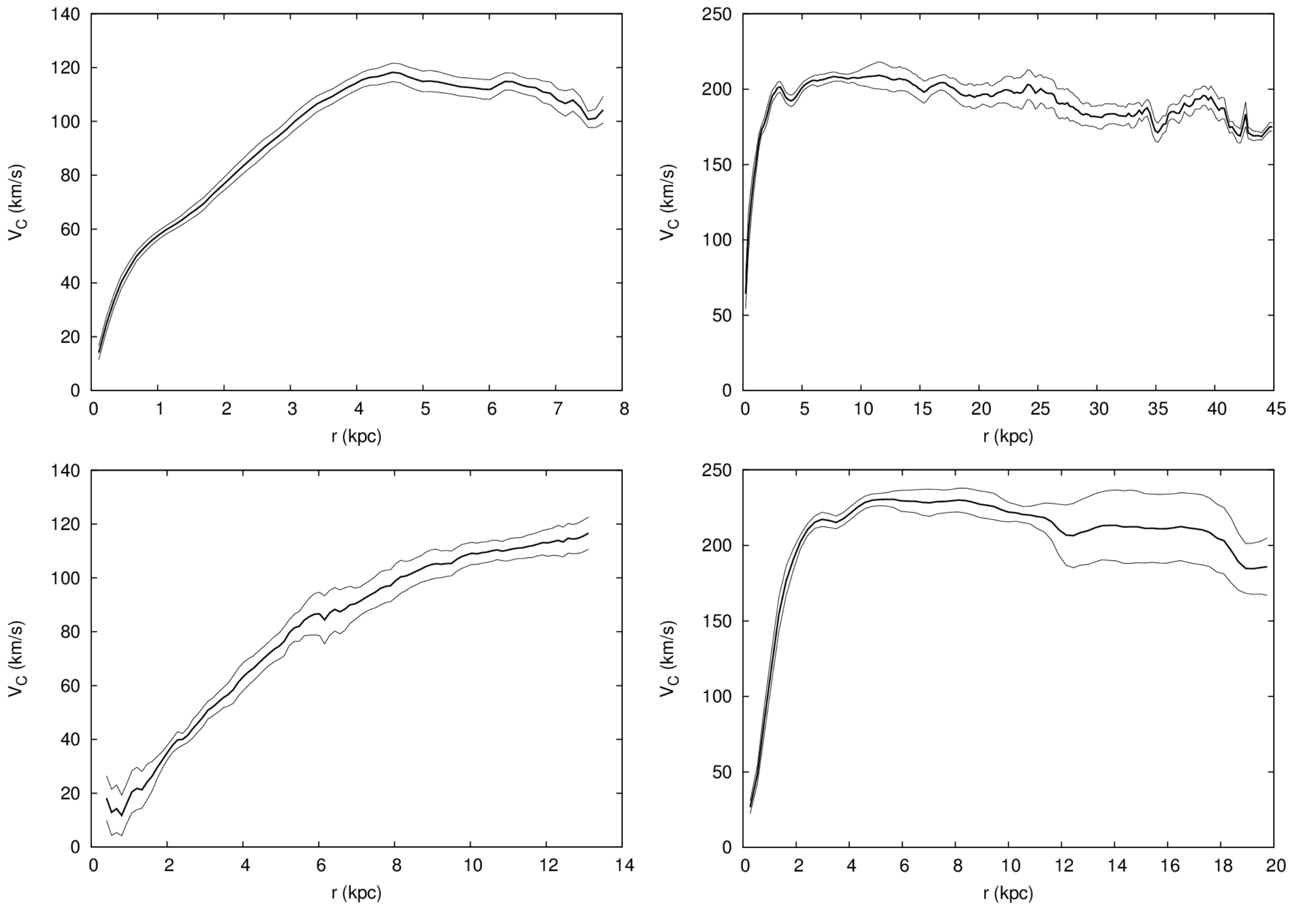
  (e.g. Elmegreen et al. 1996)
- Therefore:
  - $R_{OLR} \sim 2\ R_{bar}$



Muñoz-Mateos et al. (2013)

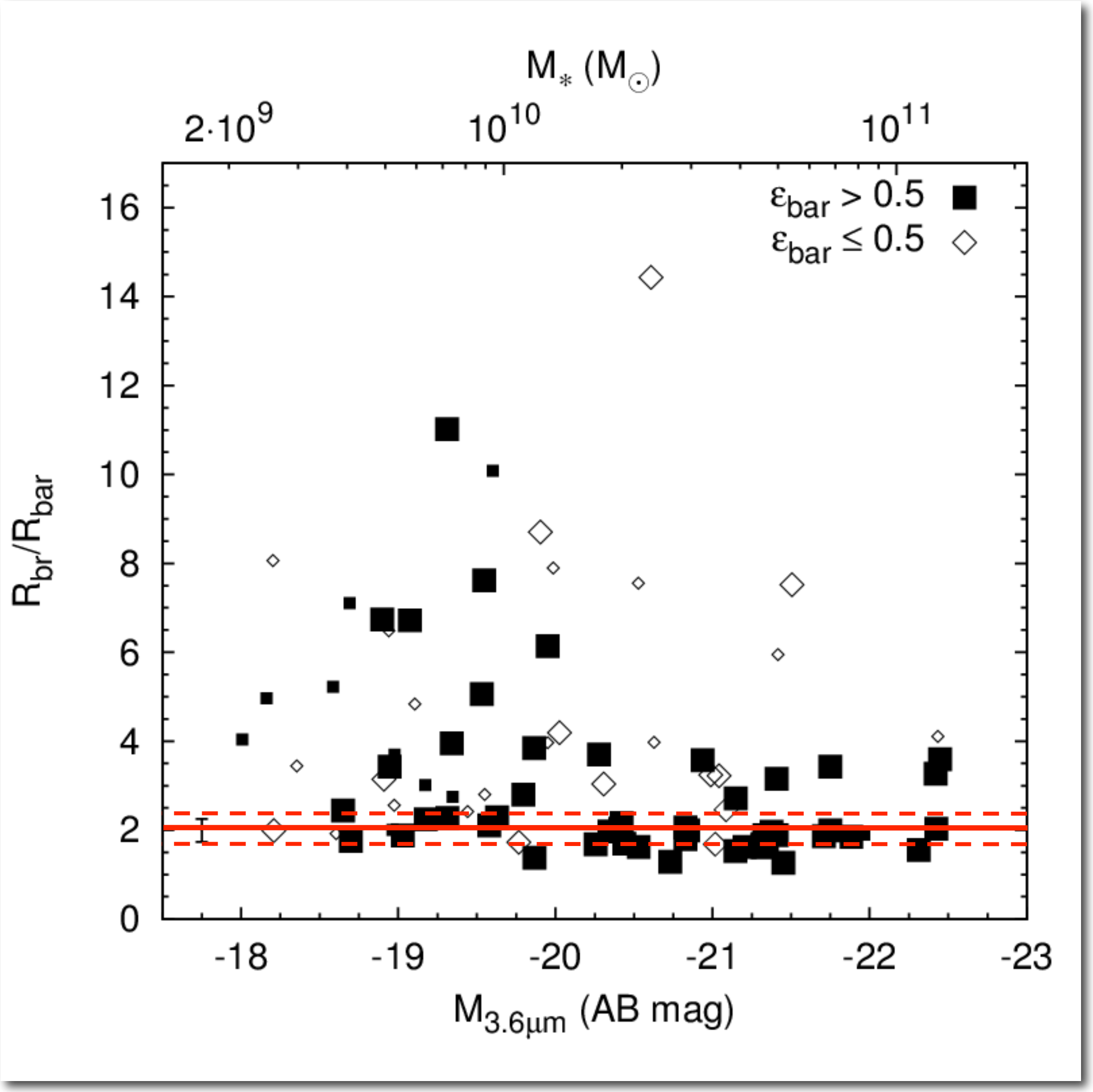
Rotation curves are not always flat

Low mass High mass



de Blok et al. (2008)

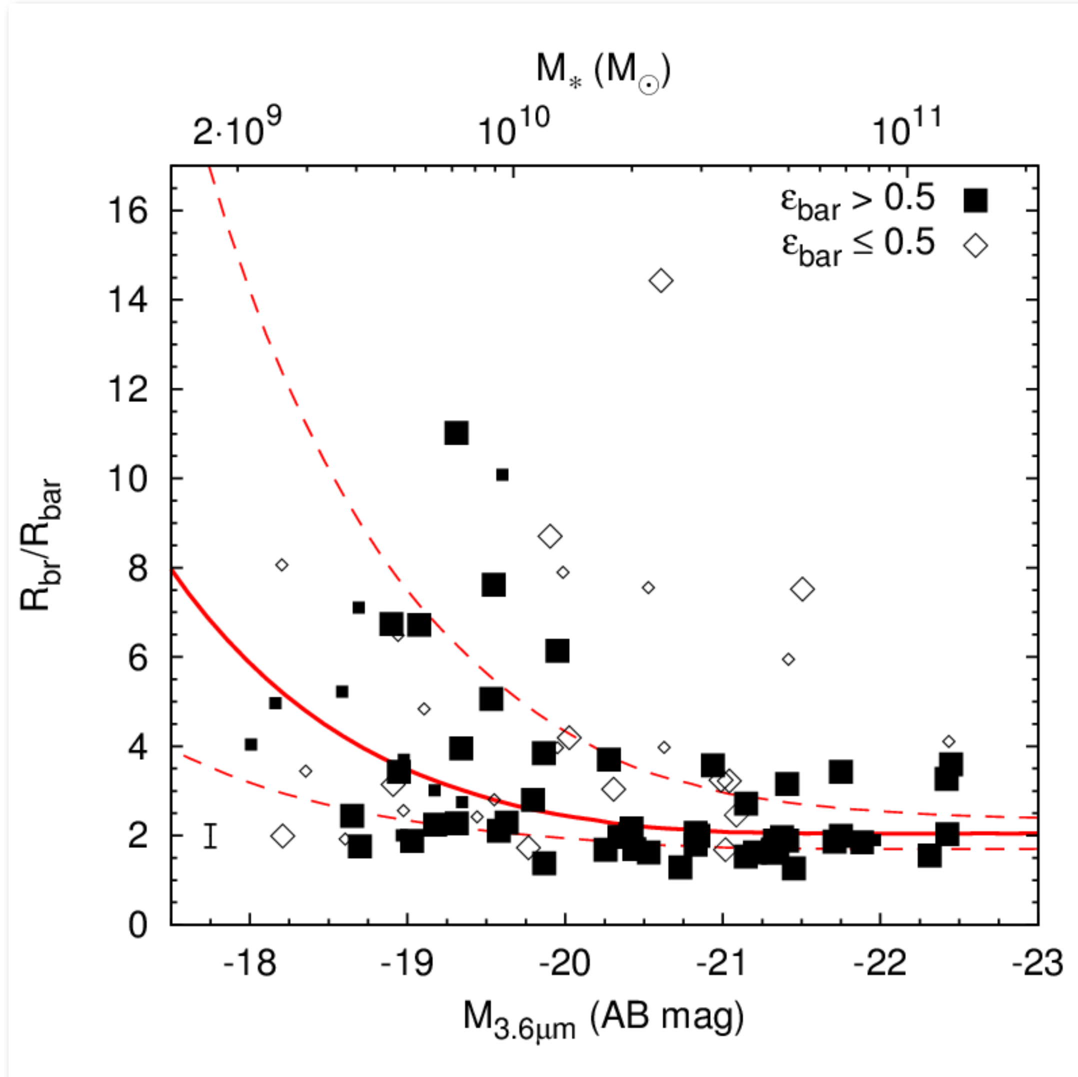
Rising rotation curves push the OLR further out



Muñoz-Mateos et al. (2013)

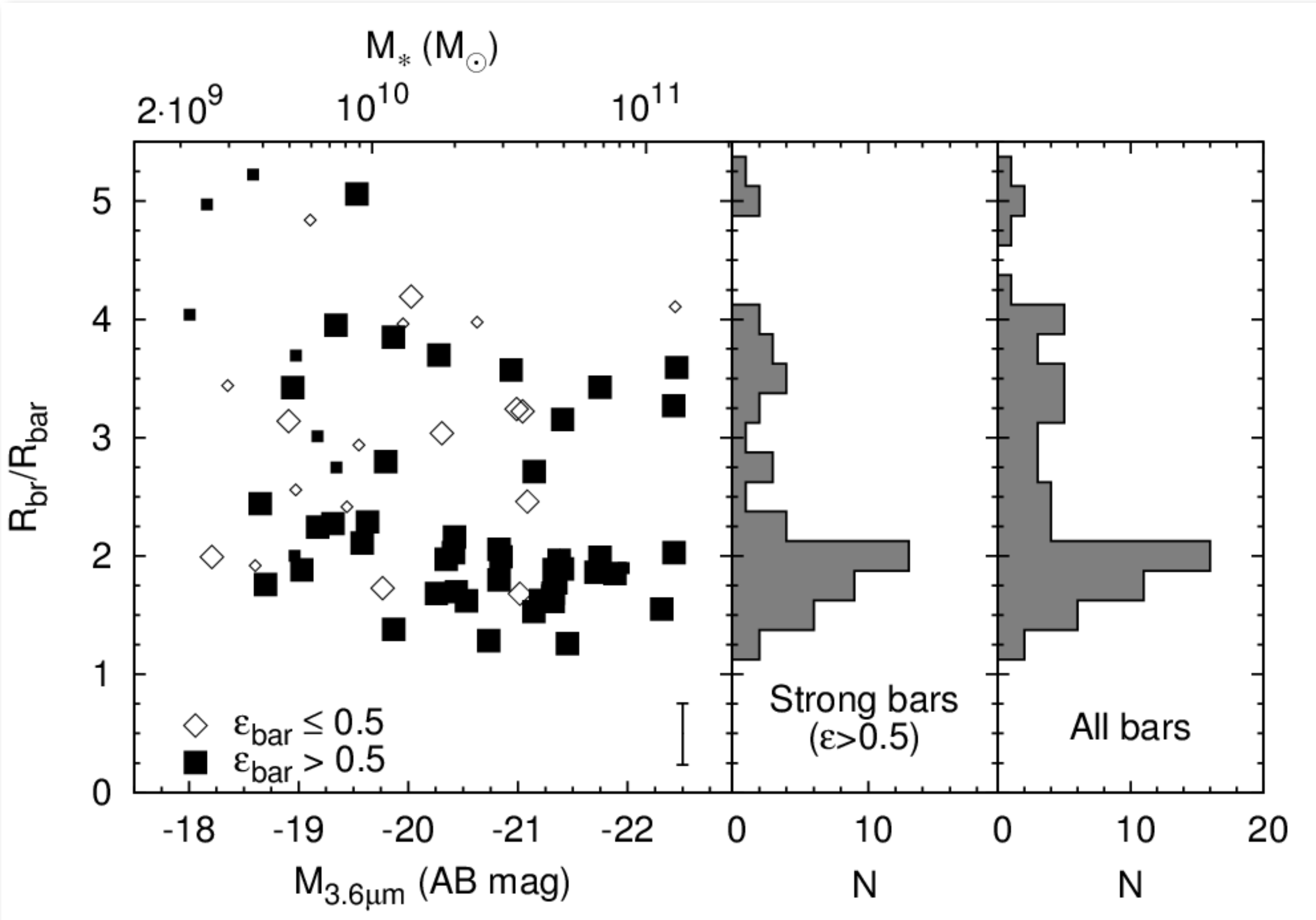
Rising rotation curves push the OLR further out

- Breaks at large radii in low-mass disks could still have a dynamical origin!



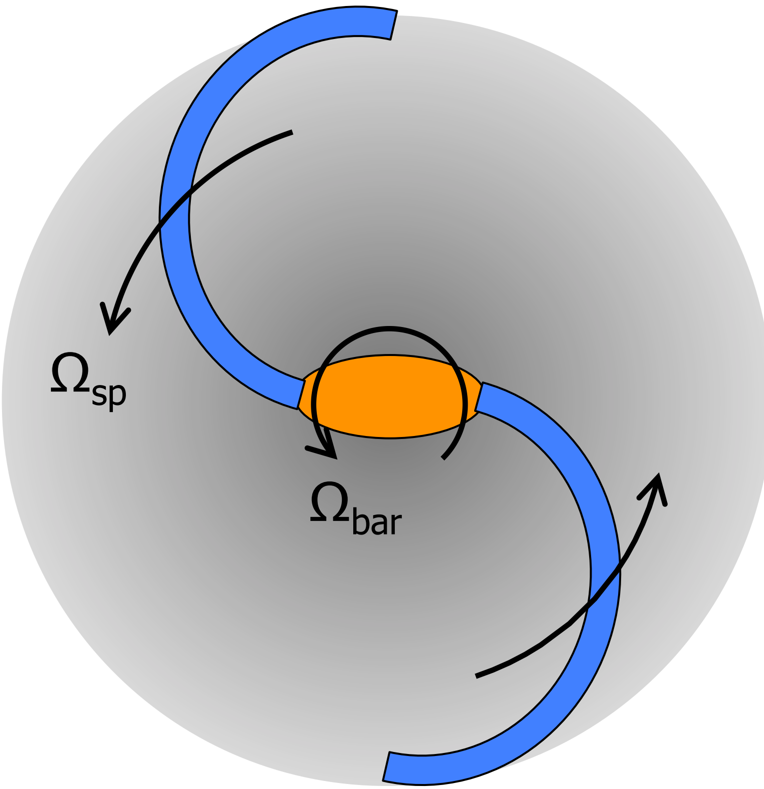
Muñoz-Mateos et al. (2013)

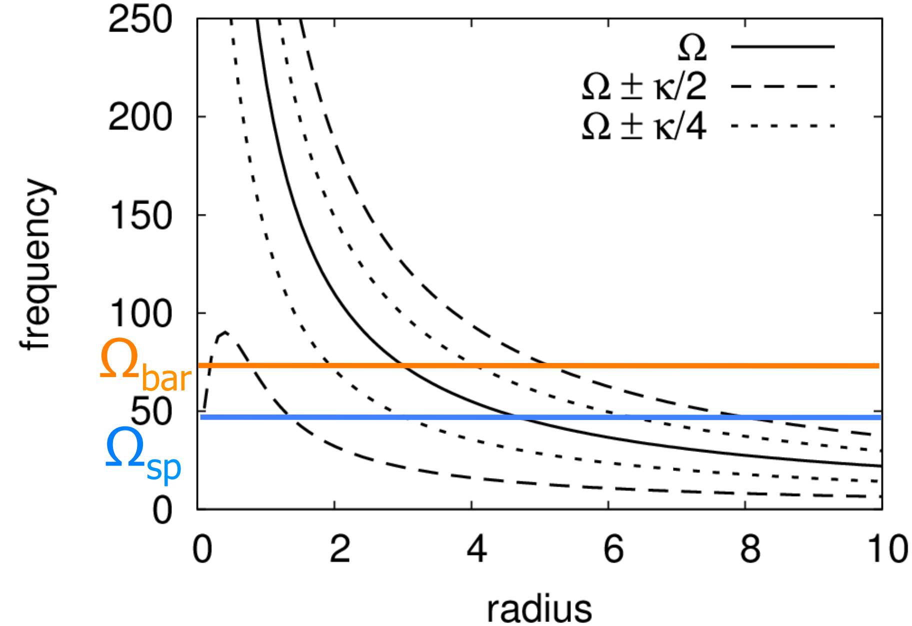
A second family of breaks at 3-4 R_{bar}



Muñoz-Mateos et al. (2013)

Bars and spiral arms can couple





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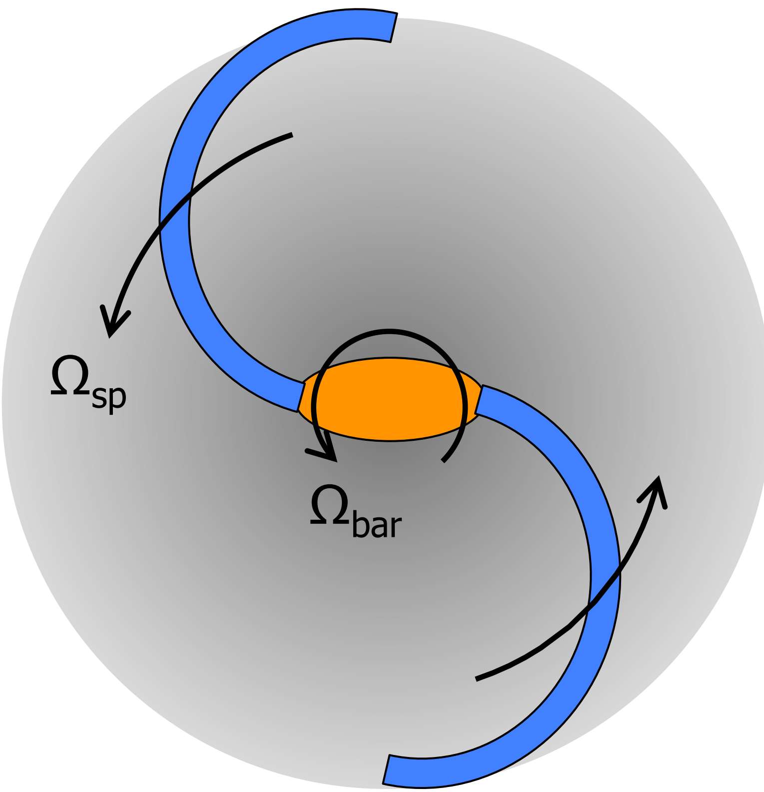

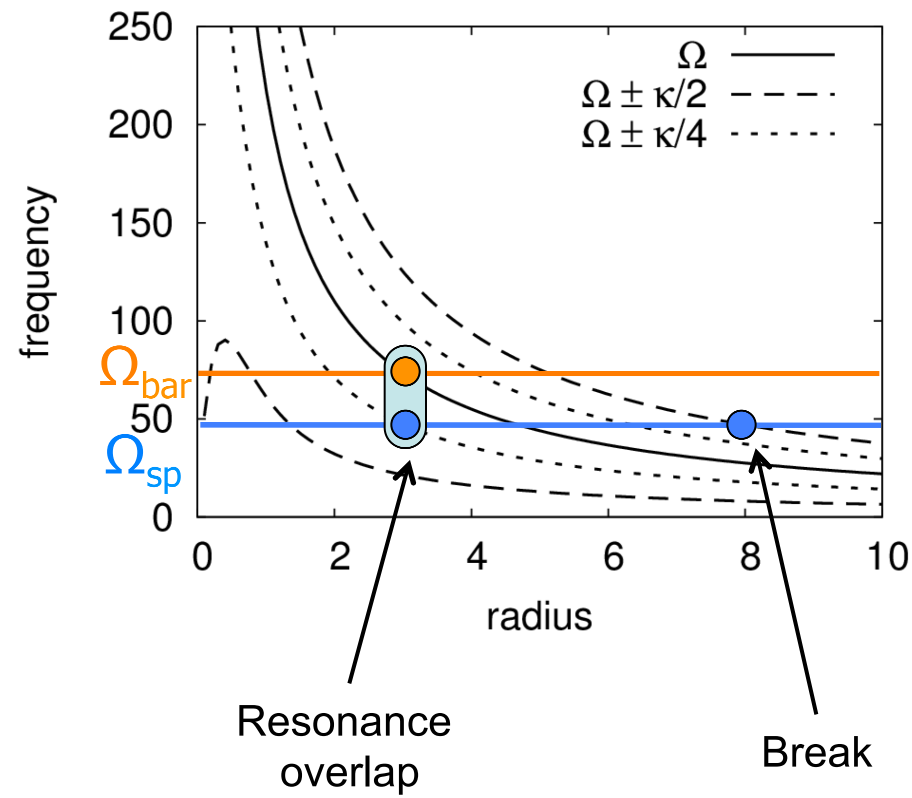

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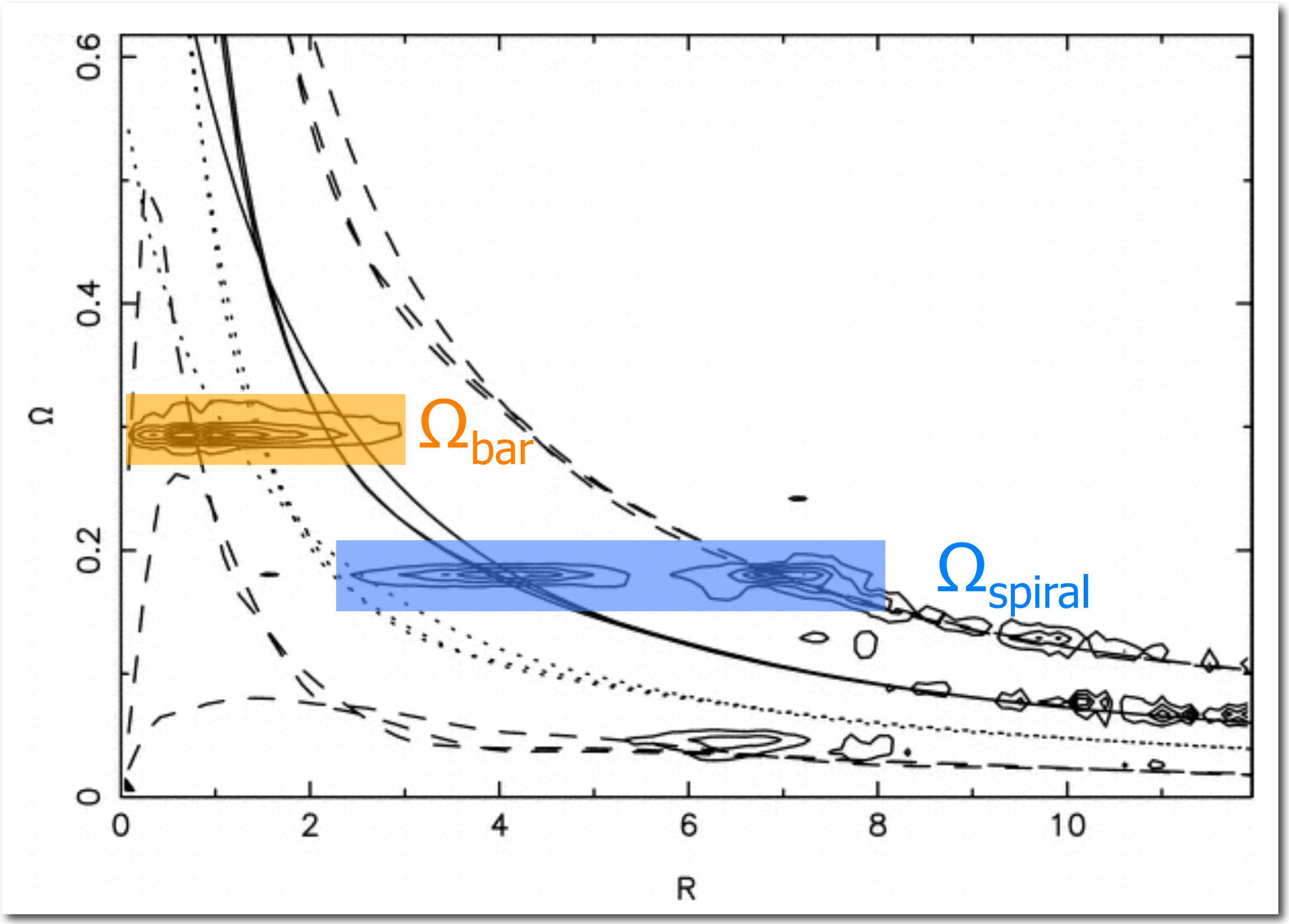
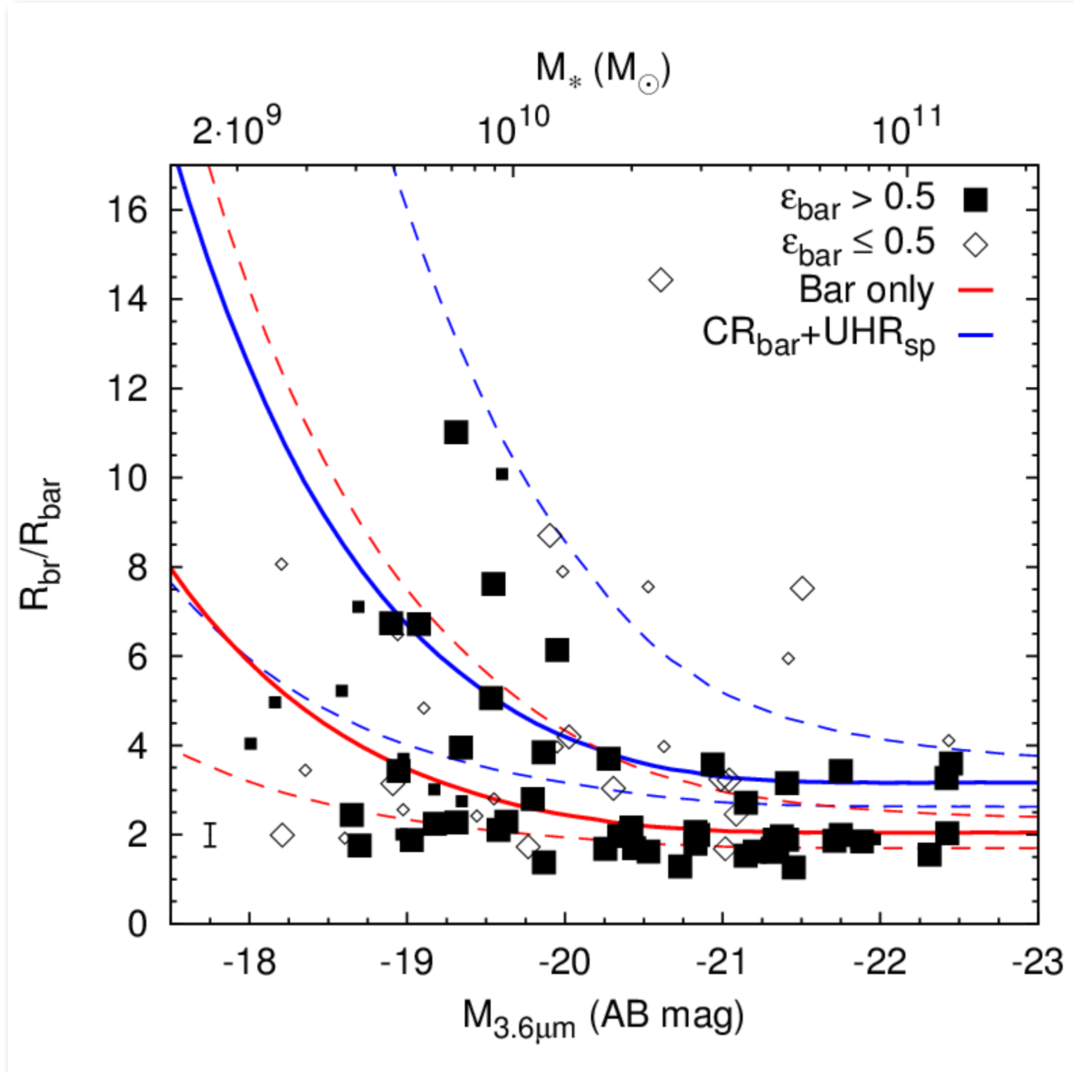


Debattista et al. (2006)

Bar/spiral coupling can yield breaks at large radius

- More efficient than a single pattern.
- Radial mixing in only ~ 3 Gyrs! (Minchev et al. 2010).



Muñoz-Mateos et al. (2013)

Is the H_2 profile broken too?

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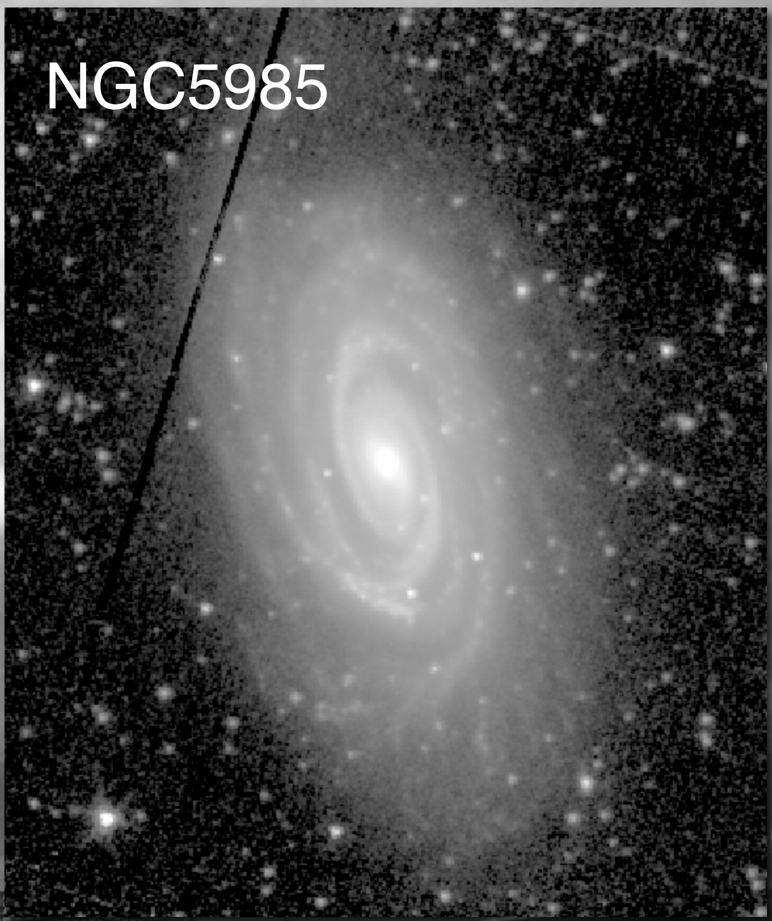

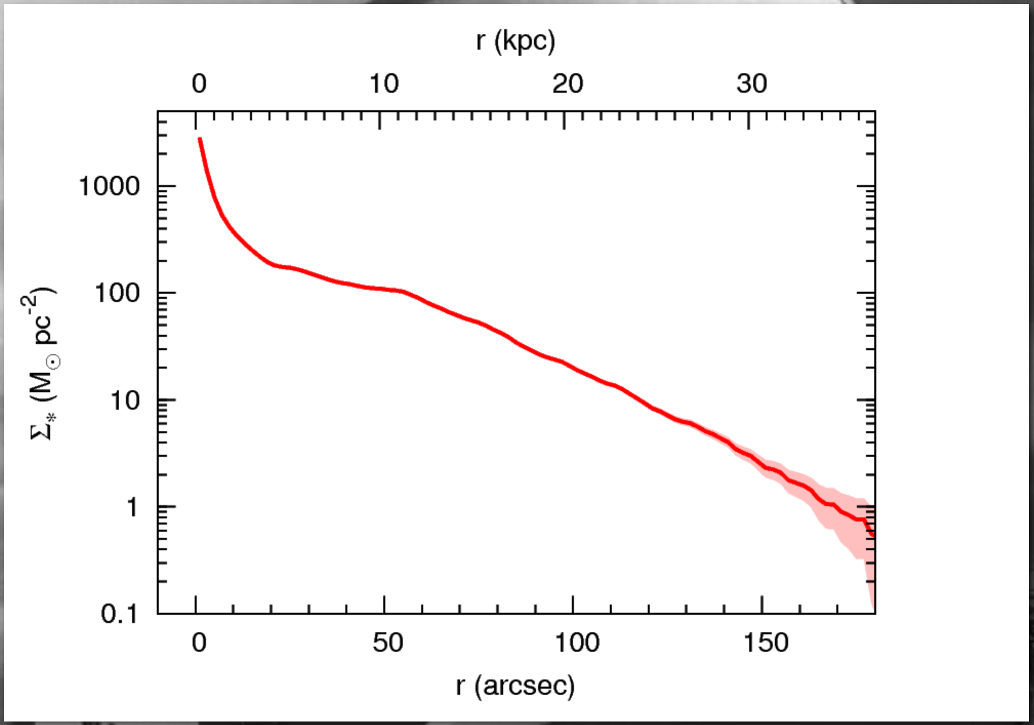

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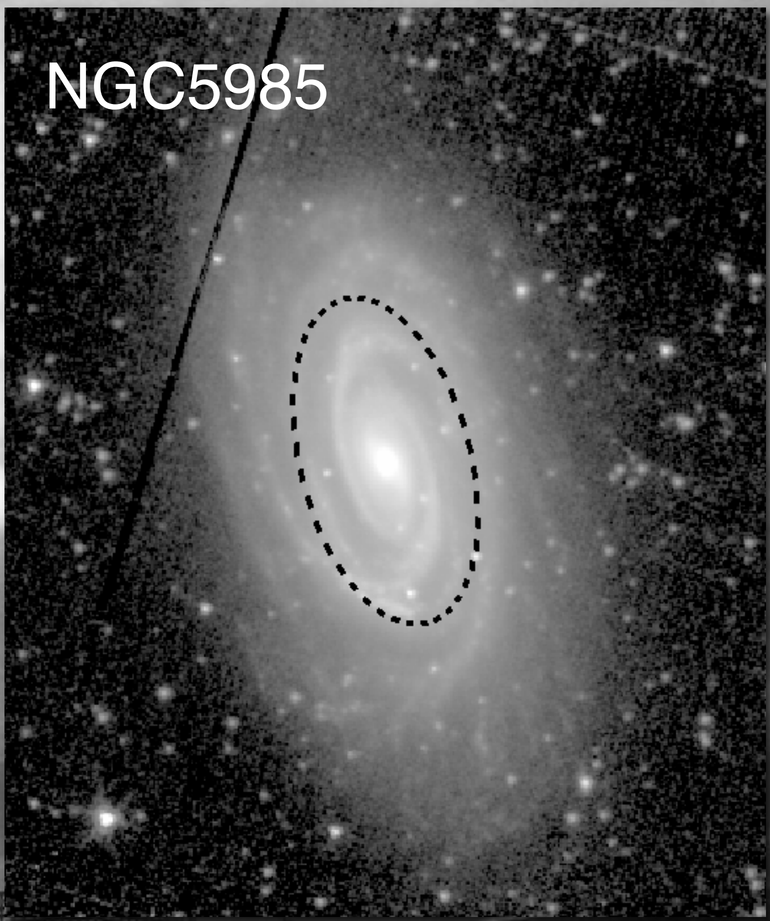

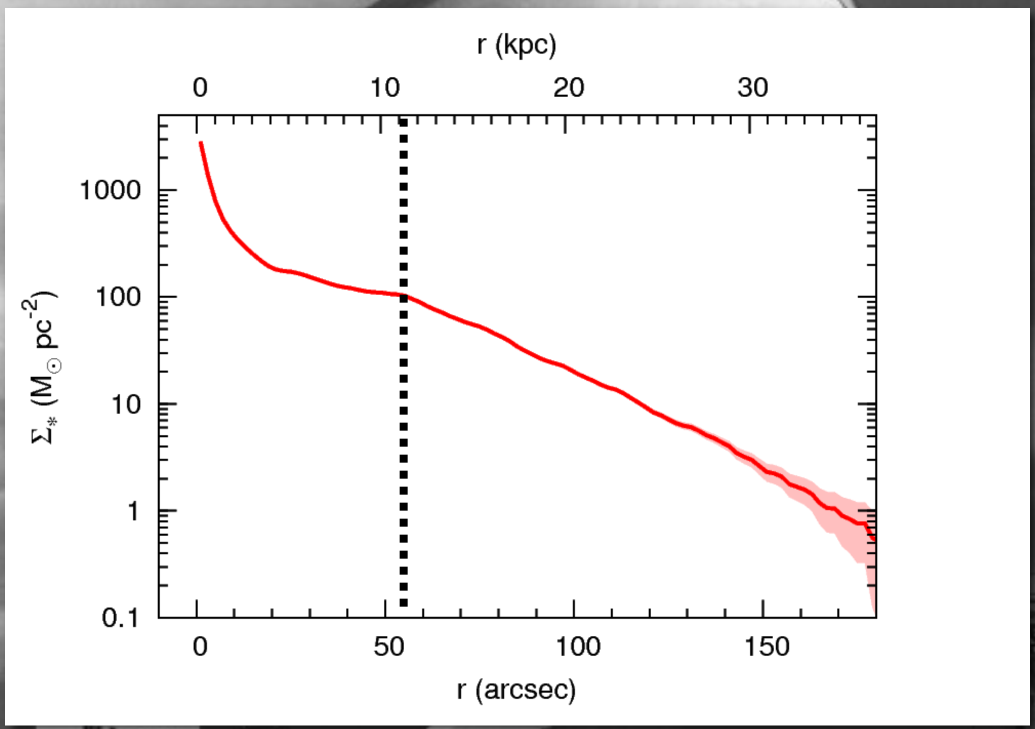

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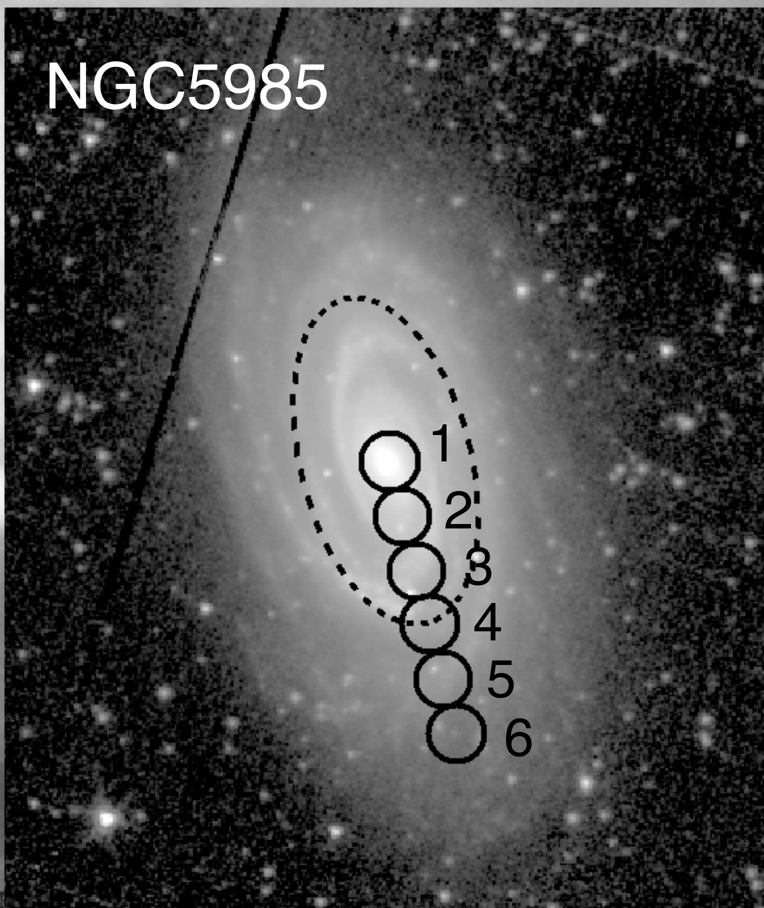

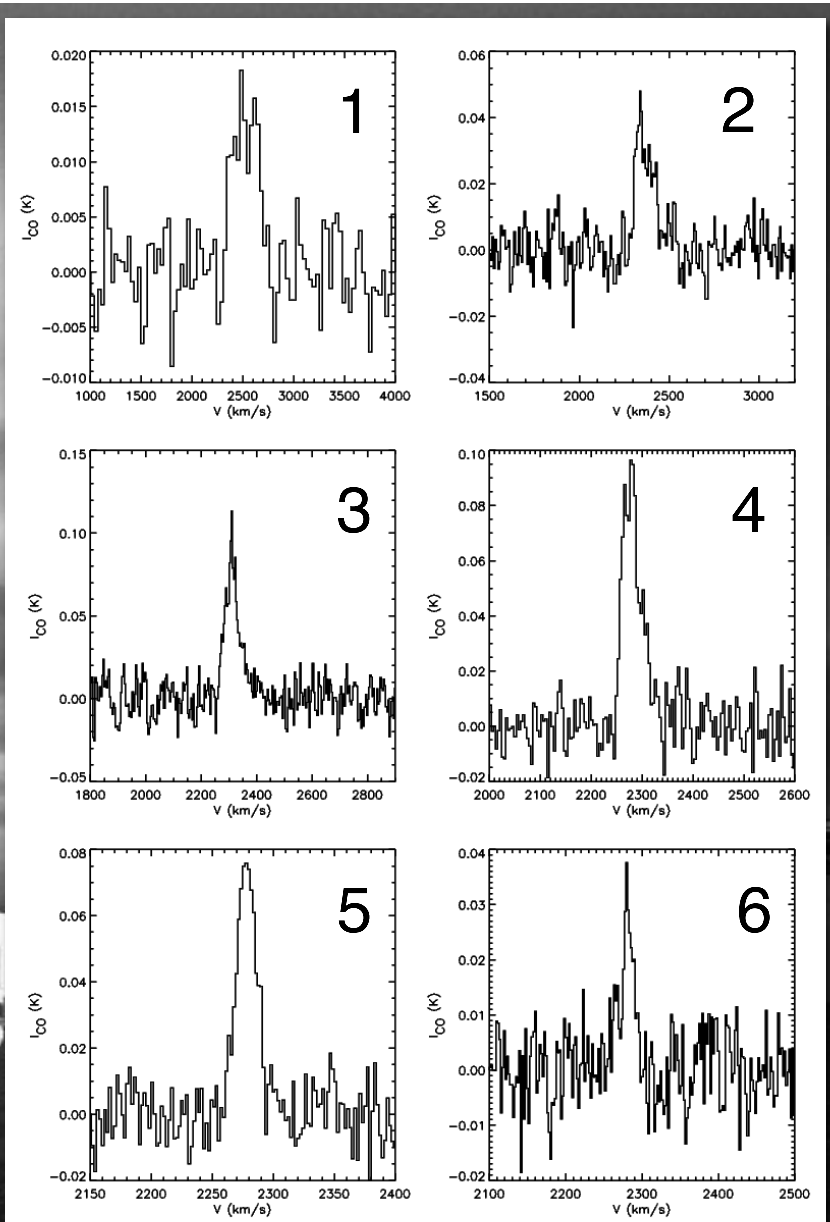

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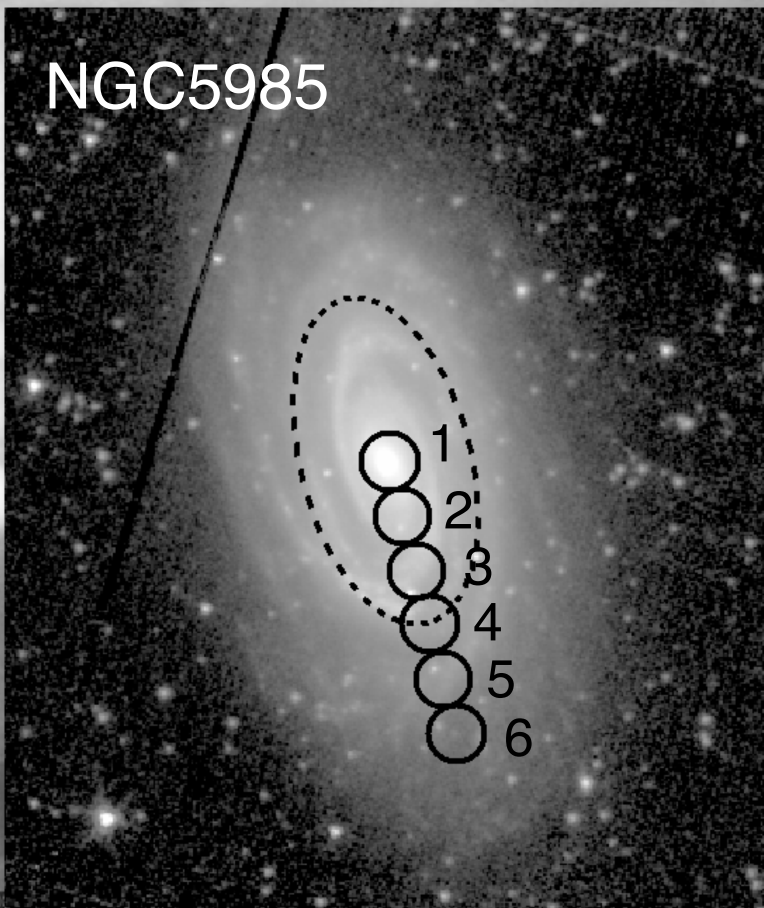

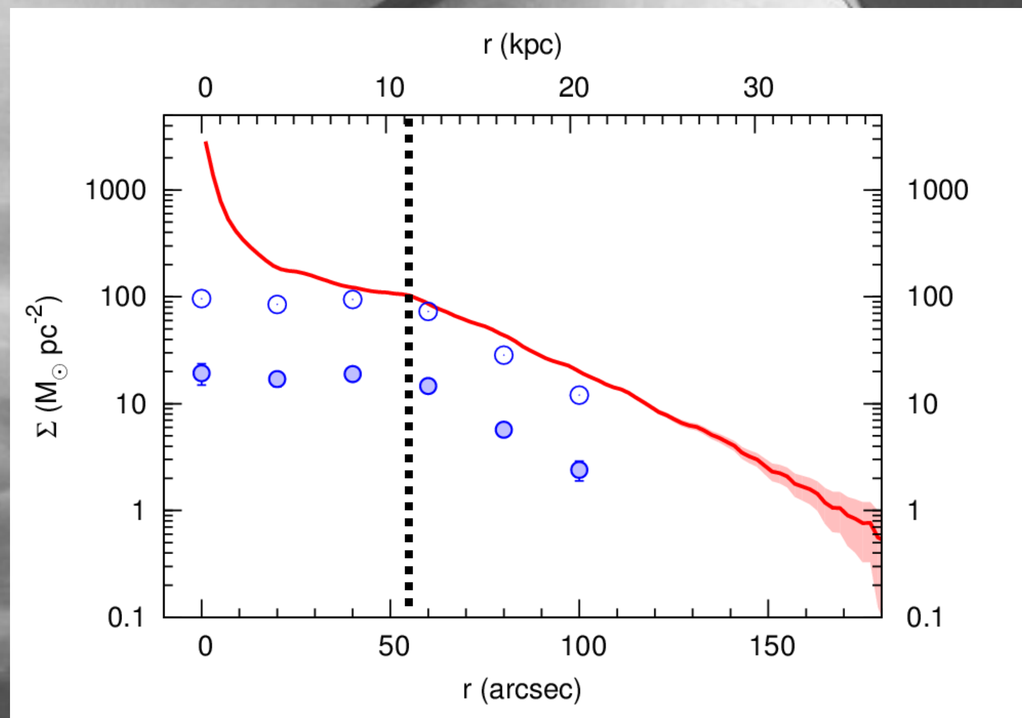

Conclusions

- Breaks are signposts of disk assembly.
  - In-situ star formation?
  - Radial stellar migration?

- Migration can create breaks at large radii.
  - Rising rotation curves (in low mass disks).
  - Spiral/bar coupling.

- Molecular profiles are broken too.
  - Sharper break than in the stellar profile.