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

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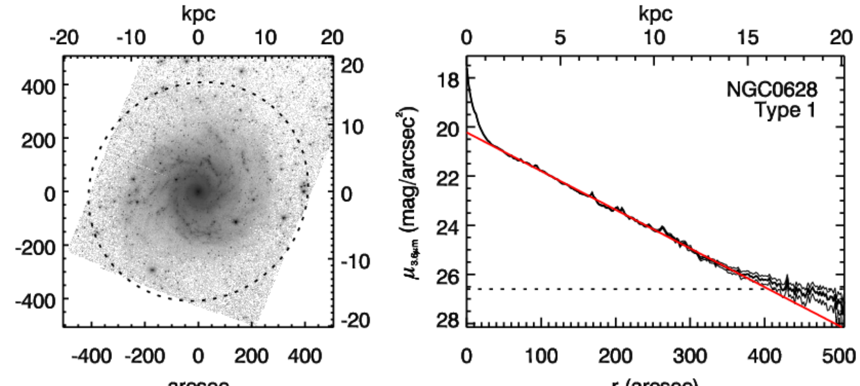
+ the S^4G team

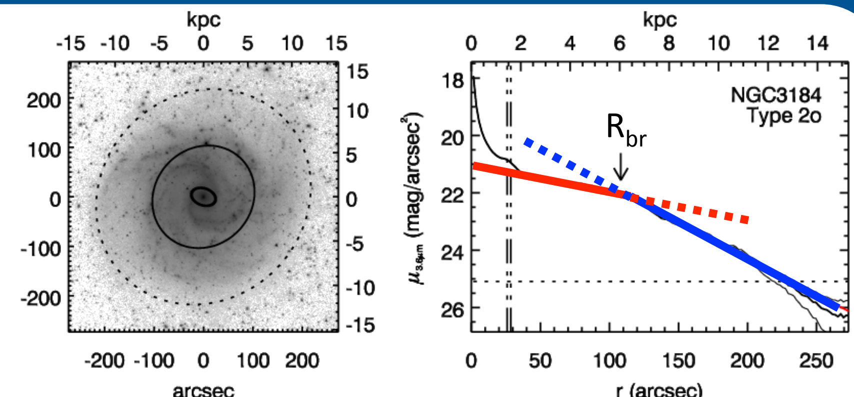
Exponential Disks in Galaxies
Oct 5-9 2014
Flagstaff

Disks come in three flavors

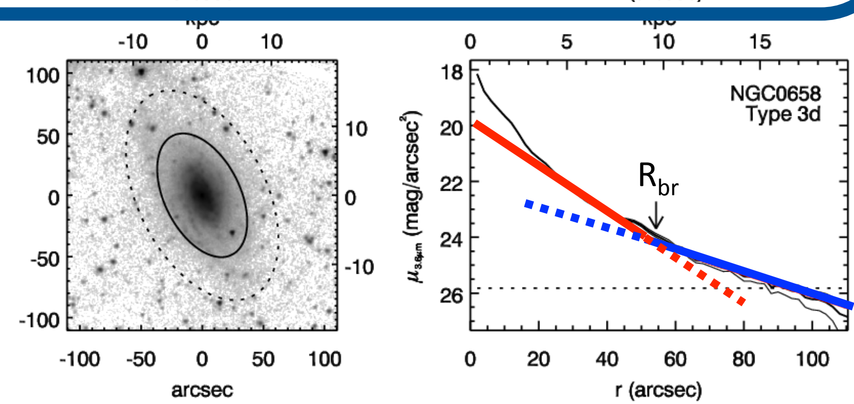
- Type I (10%)
  Single exponential



- Type II (60%)
  Downbending exponential



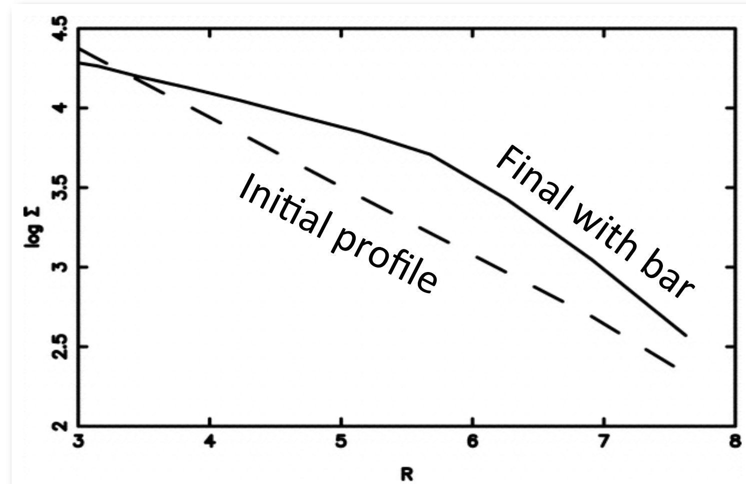
- Type III (30%)
  Upbending exponential



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

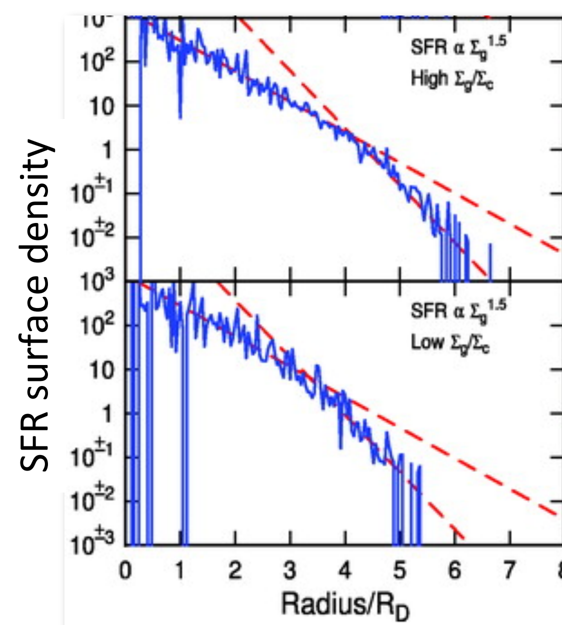
Two(-ish) scenarios for break formation

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



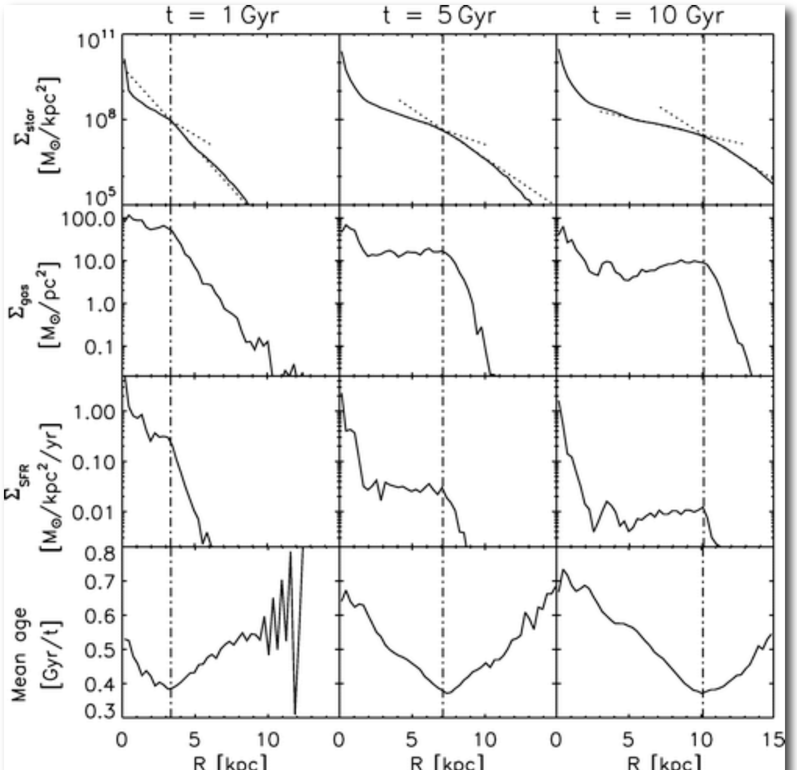
Debattista et al. (2006)

- Radial changes in the star formation efficiency.

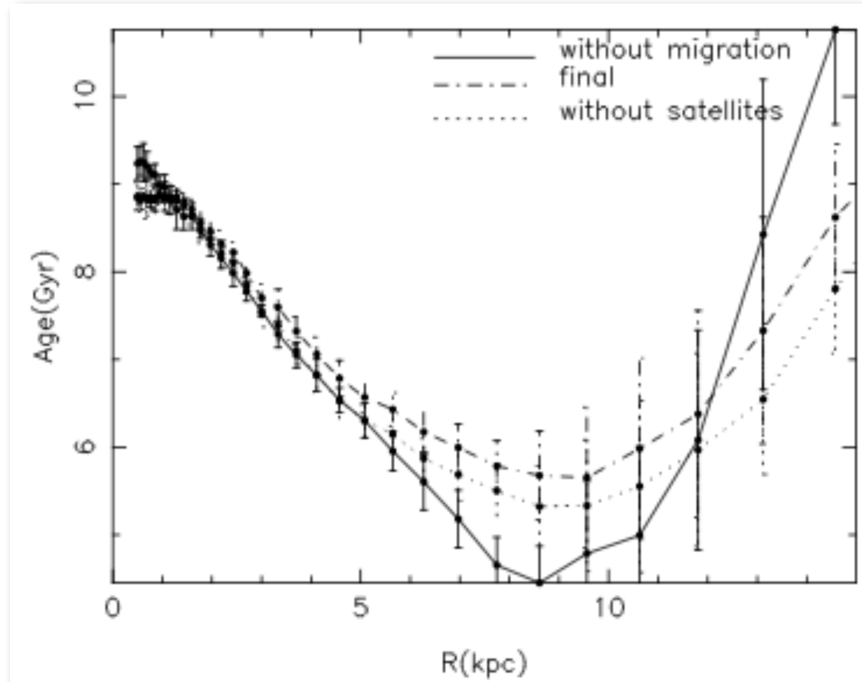


Elmegreen & Hunter (2006)

Lots of old stars beyond the break!



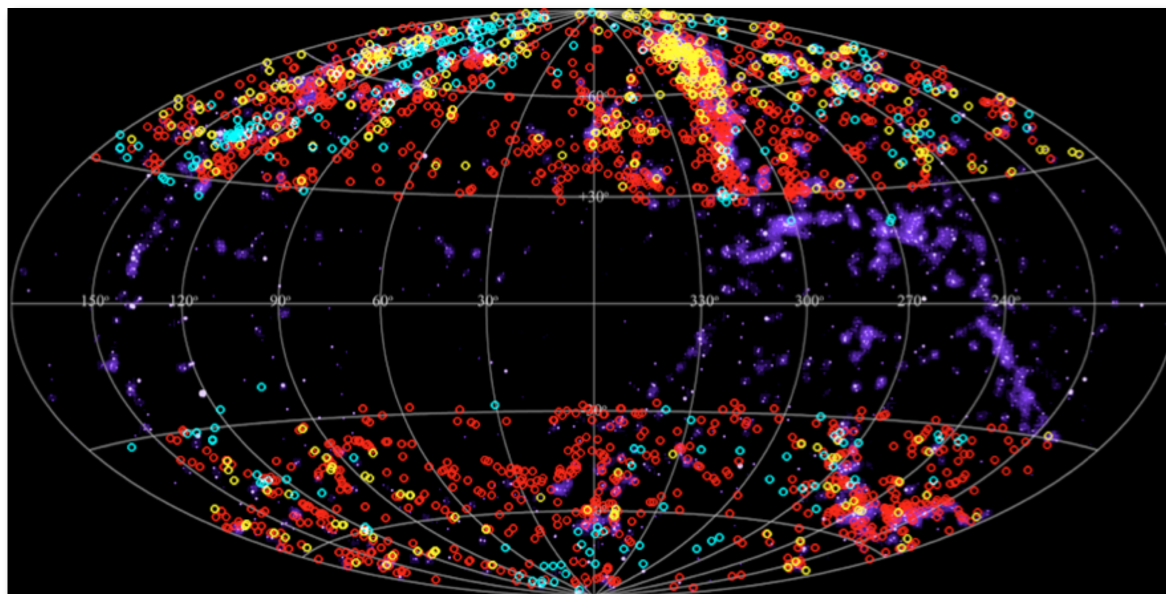
Roskar et al. (2008)
Idealized disk



Sánchez-Blázquez et al. (2009)
Full cosomological simulation

The S^4G survey

- Spitzer Survey of Stellar Structure in Galaxies (Sheth et al. 2010).
  - Legacy Science Exploration Program.
  - 637.2 hrs
  - 4 min/pixel
  - $\mu_{3.6\mu m} \sim 27$ ABmags/arcsec^2 ($\sim 1\ M_\odot/pc^2$)
- Over 2300 nearby galaxies observed at 3.6 and 4.5μm.
  - D < 40 Mpc
  - |b| > 30º
  - $m_{Bcorr} < 15.5$
  - $D_{25} > 1'$



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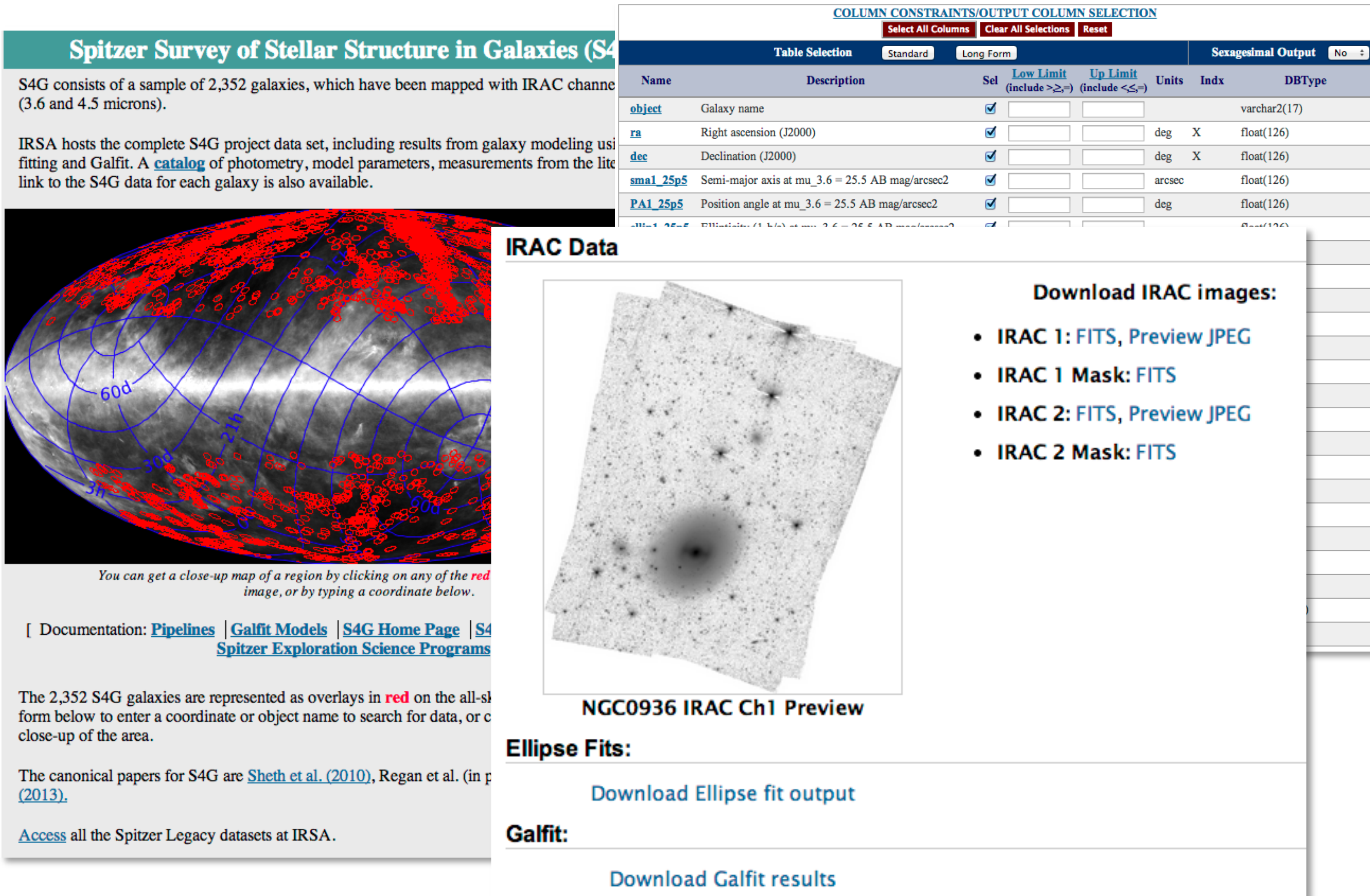
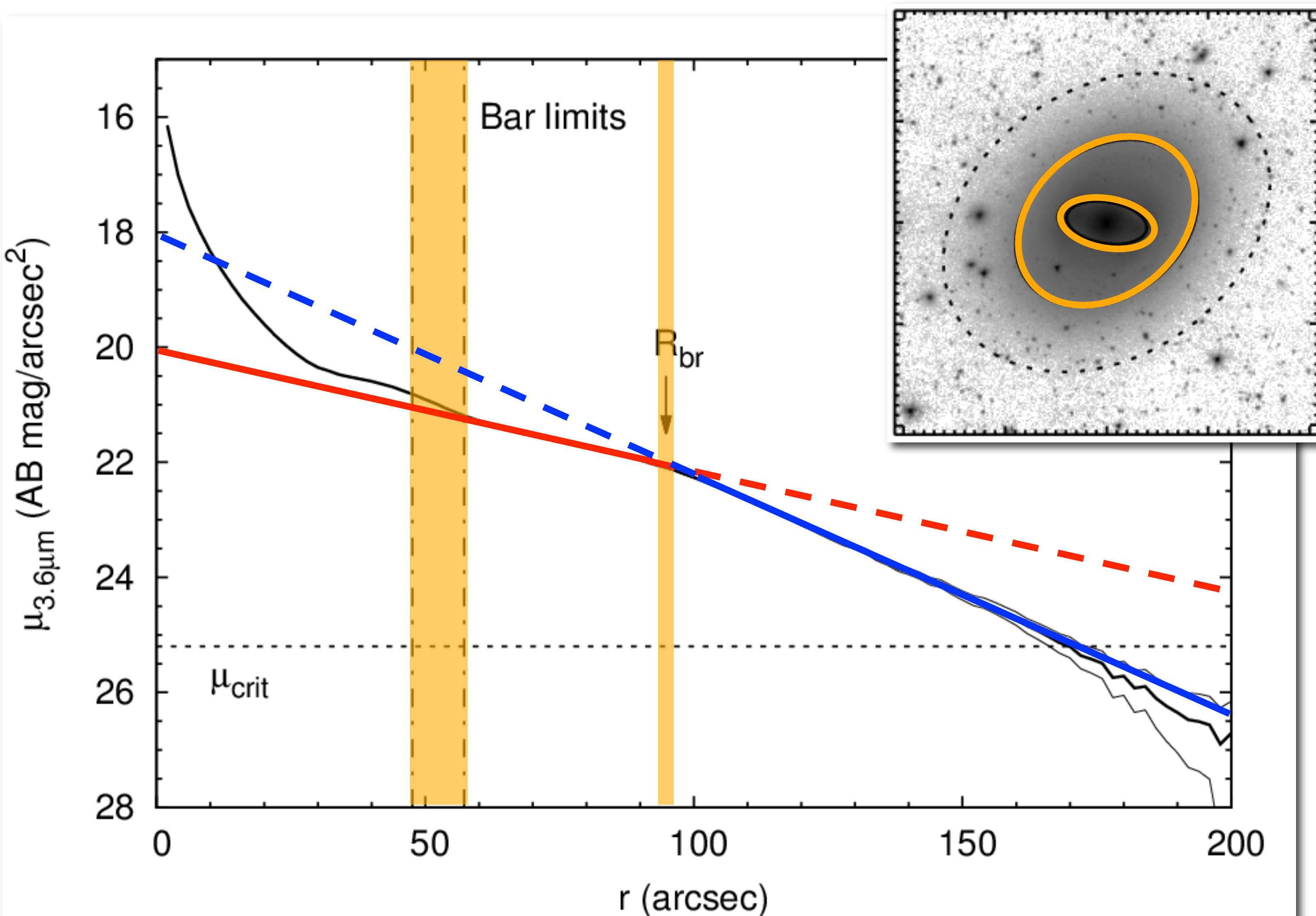
Data access at IRSA

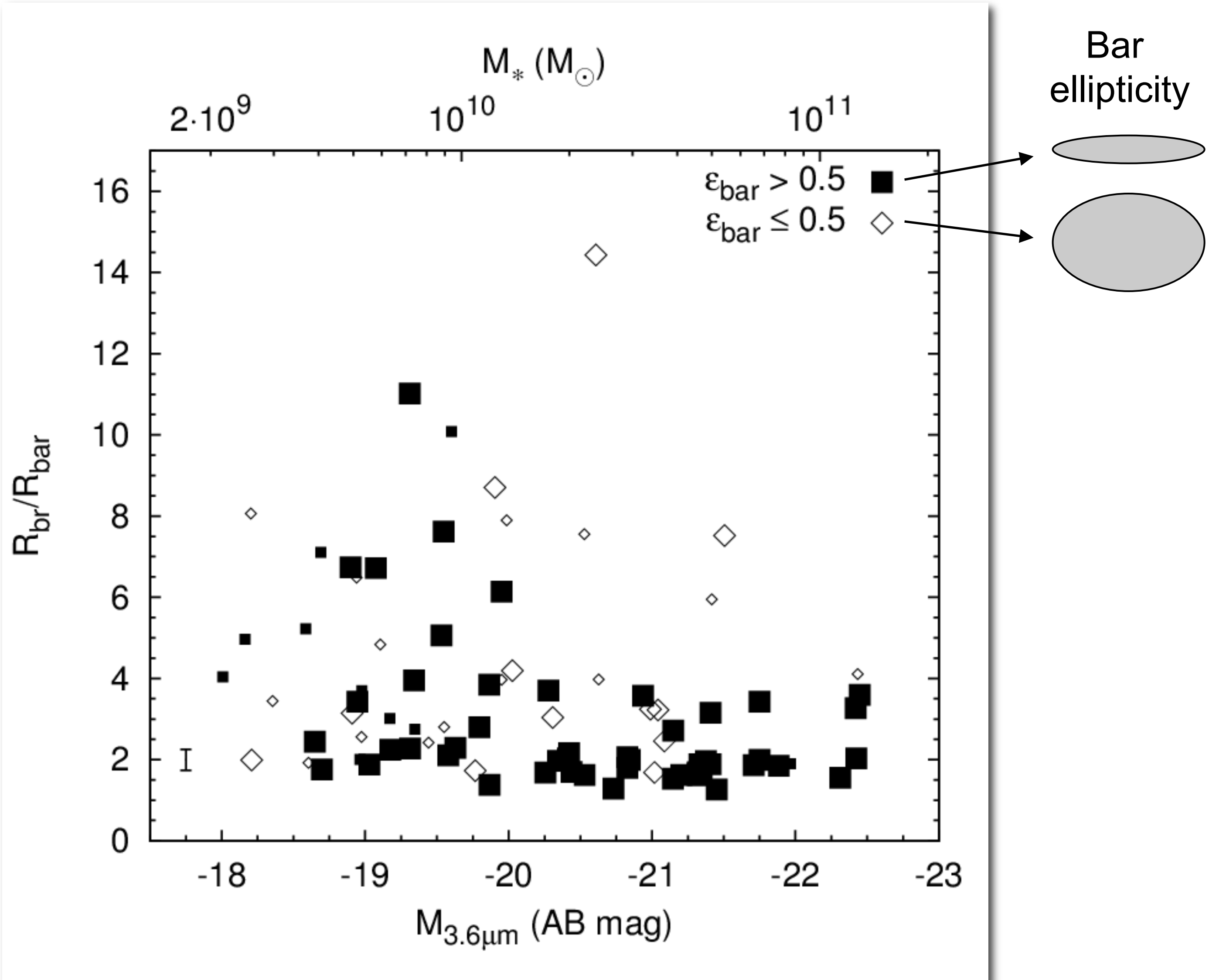
irsa.ipac.caltech.edu/data/SPITZER/S4G



Measuring breaks and bars



The break/bar ratio depends on mass

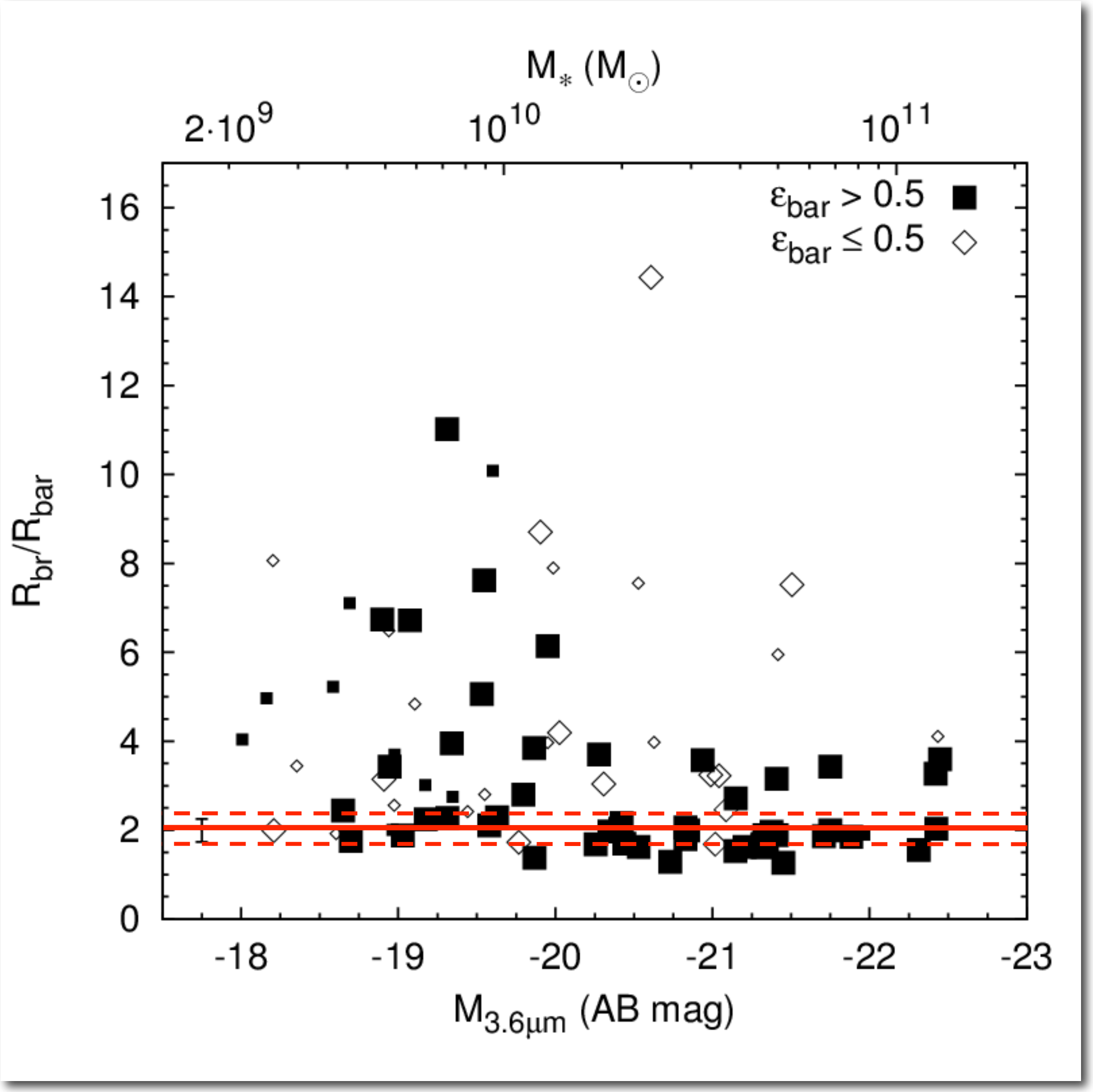


Muñoz-Mateos et al. (2013)

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:
  - $R_{CR} \sim 1.2\ R_{bar}$

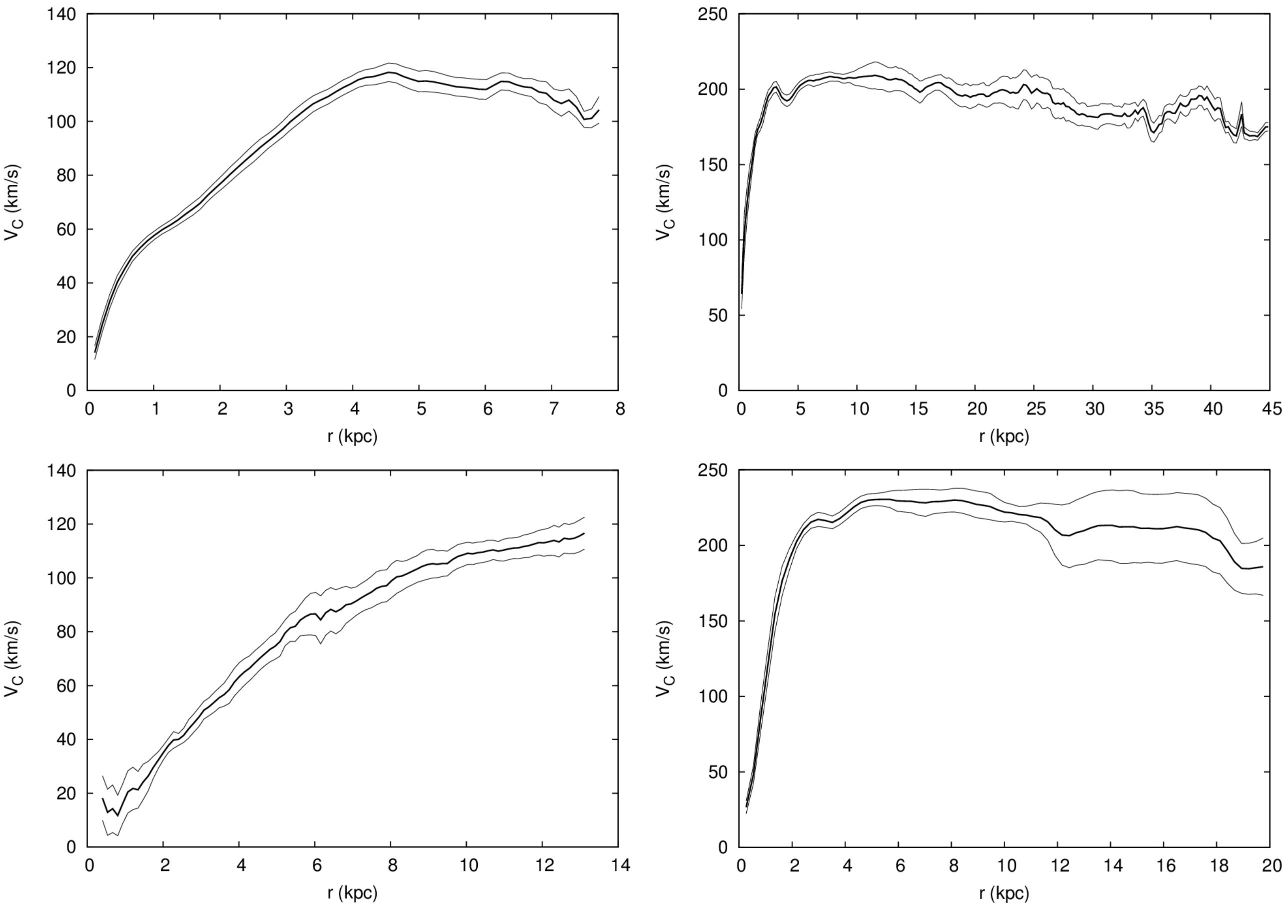
  (e.g. Elmegreen et al. 1996)
- Therefore:
  - $R_{OLR} \sim 2\ R_{bar}$



Muñoz-Mateos et al. (2013)

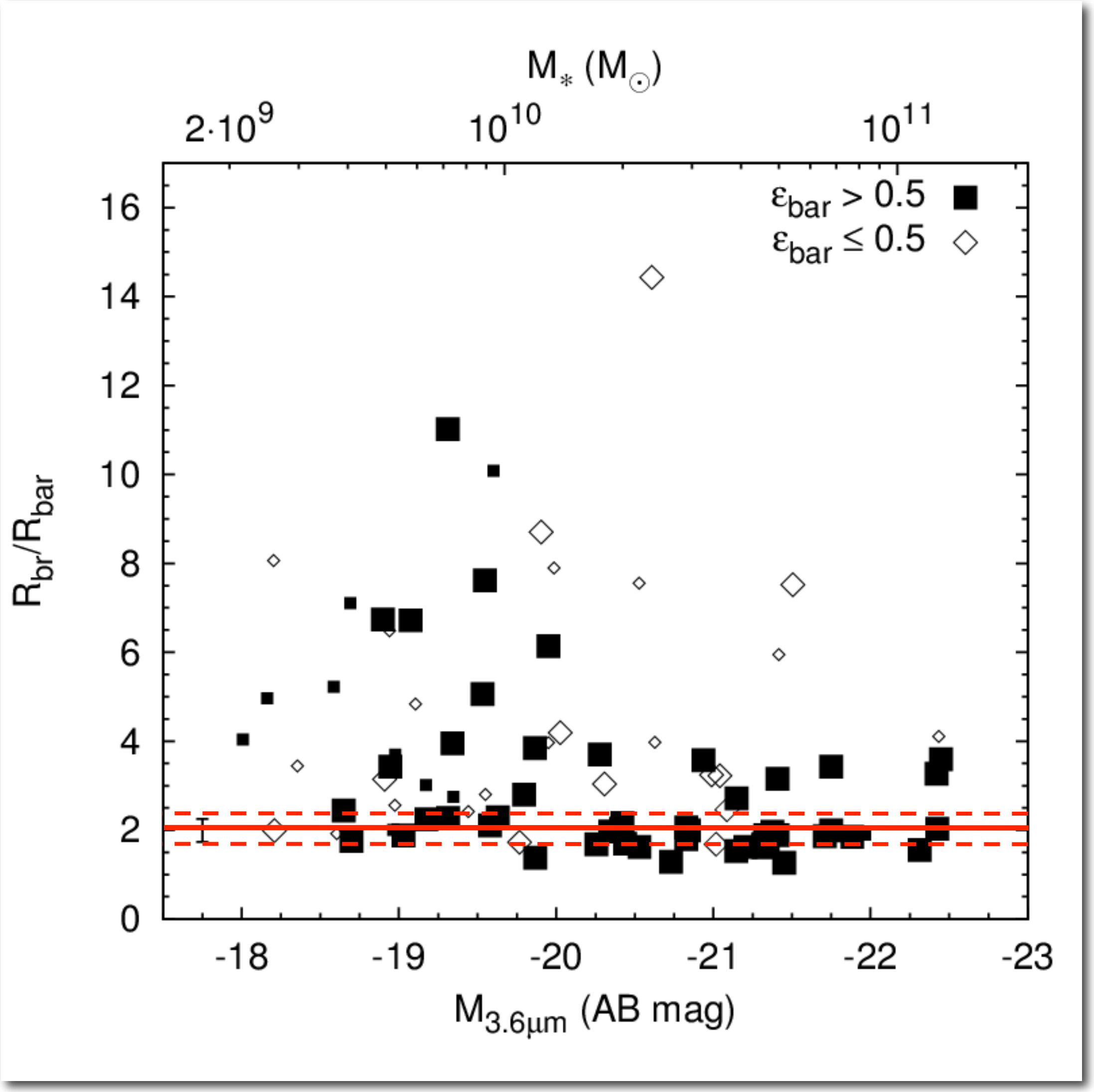
Rotation curves are not always flat

Low mass | High mass



de Blok et al. (2008)

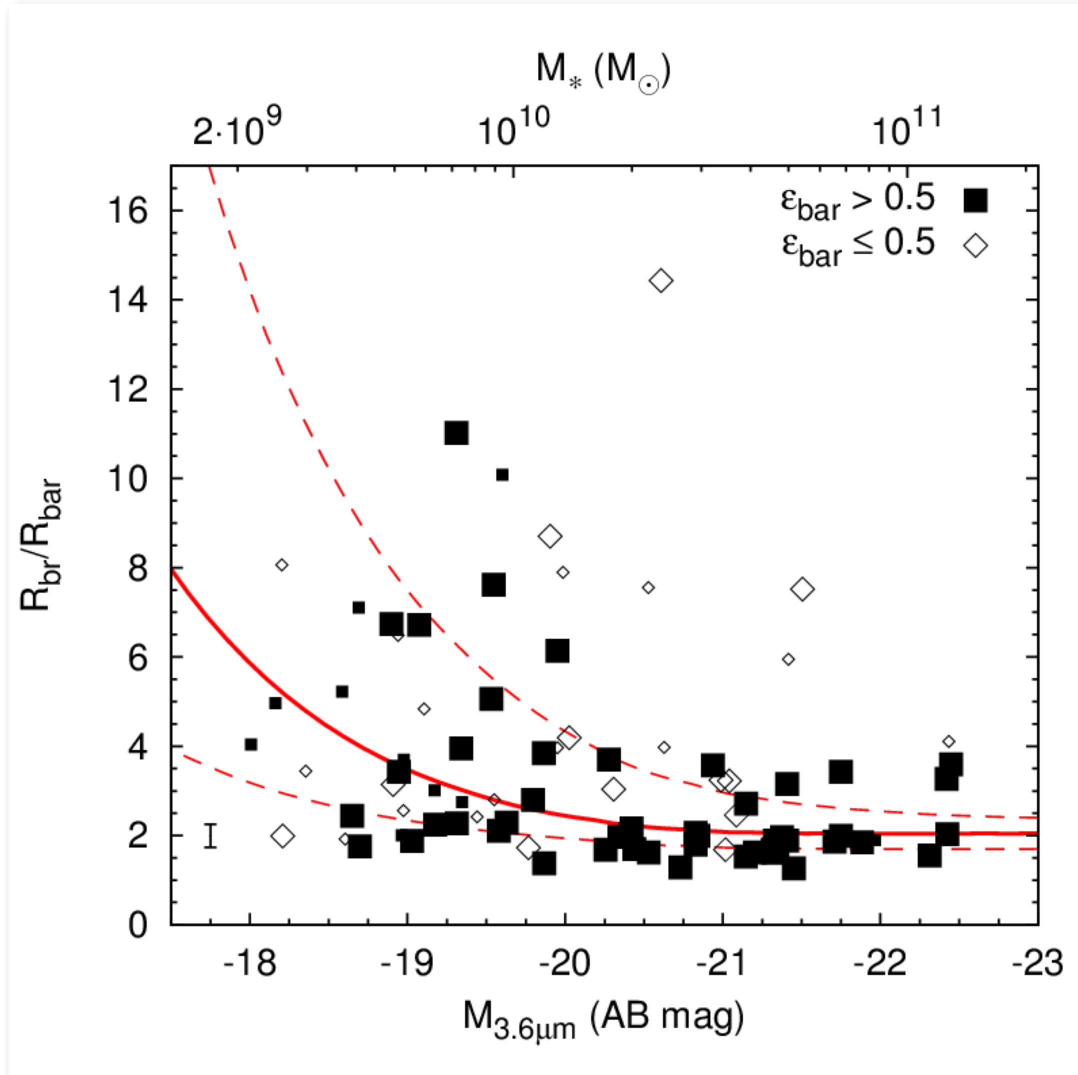
Rising rotation curves push the OLR further out



Muñoz-Mateos et al. (2013)

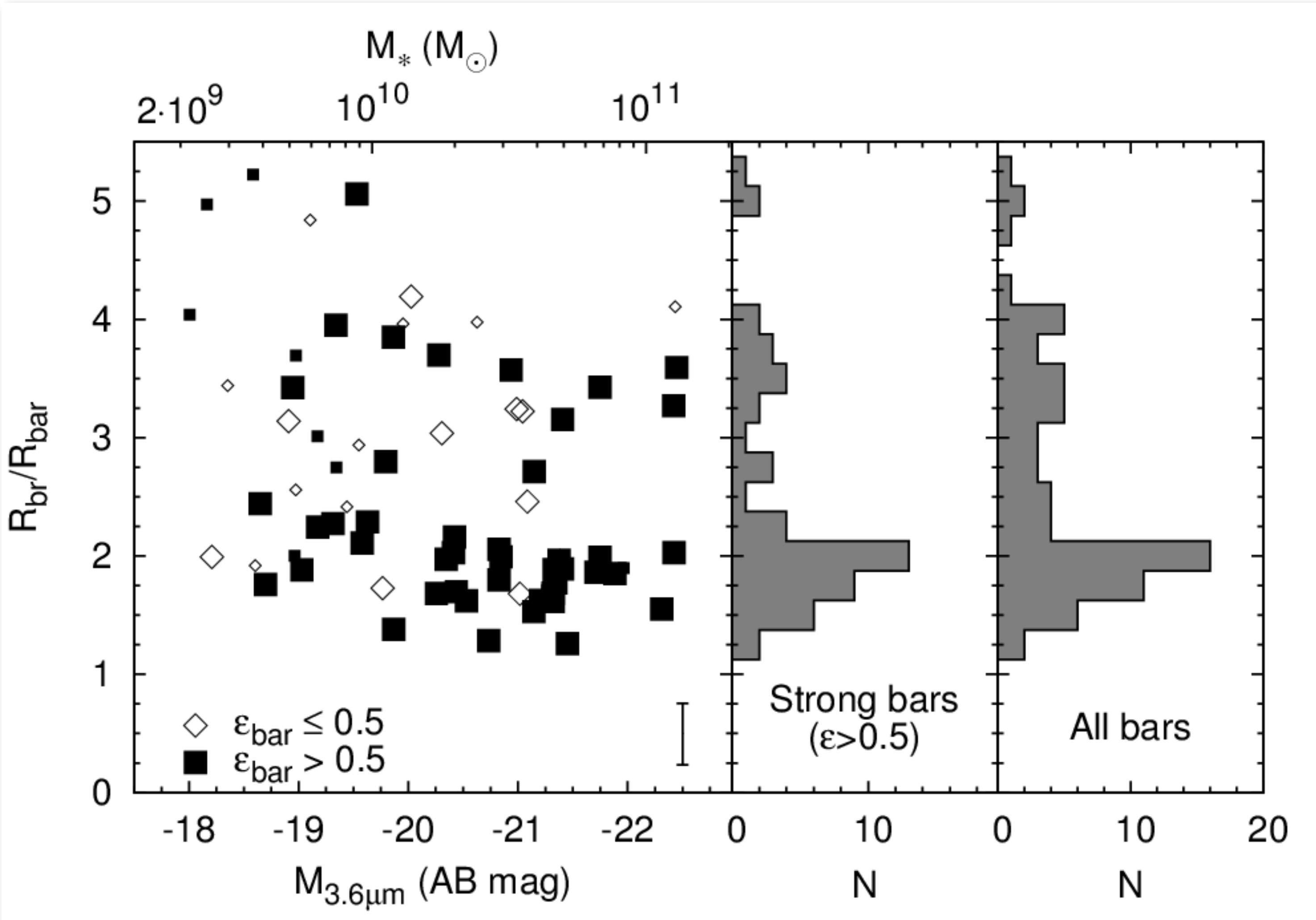
Rising rotation curves push the OLR further out

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



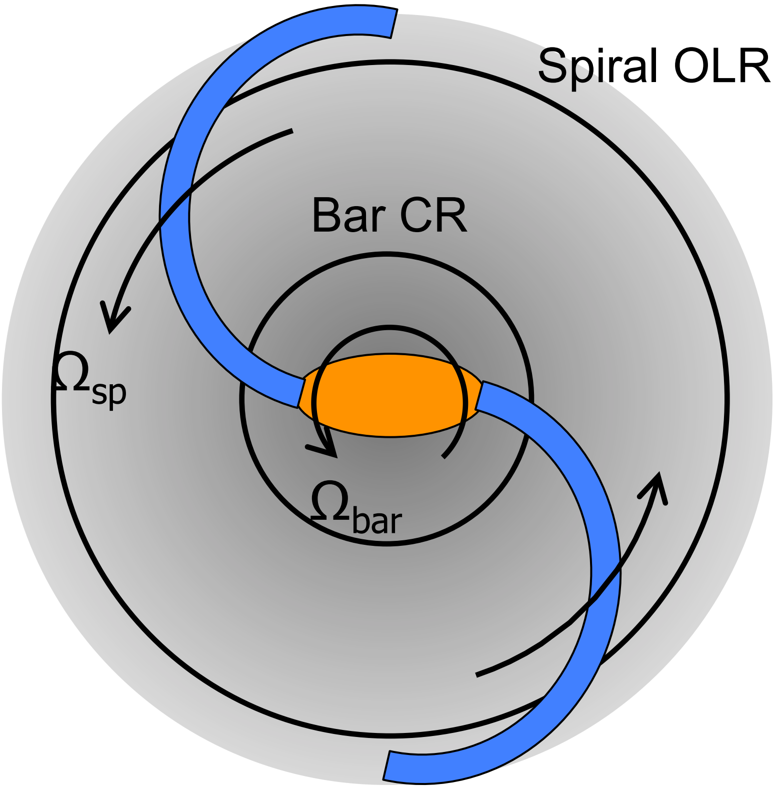
Muñoz-Mateos et al. (2013)

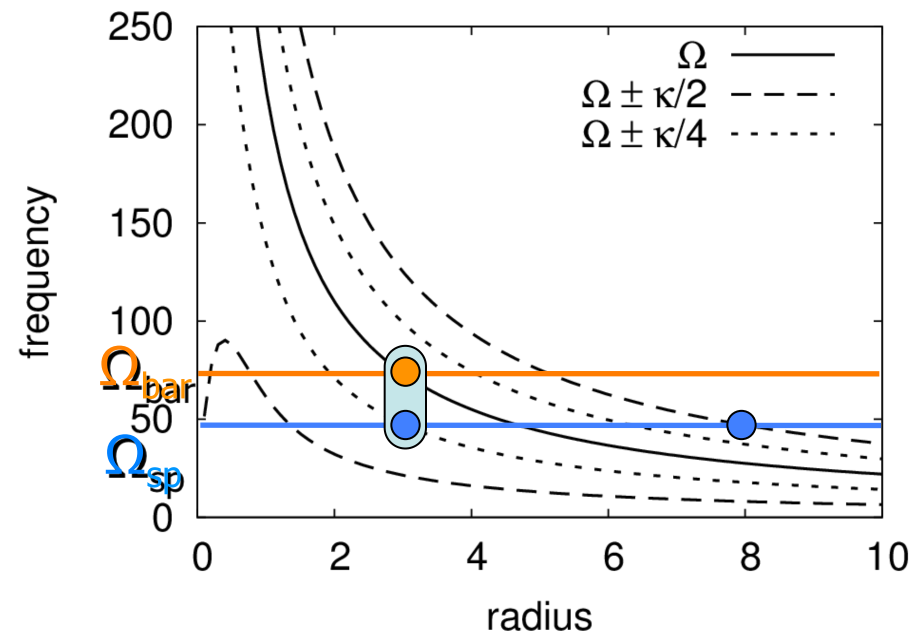
A second family of breaks at 3-4 R_{bar}



Muñoz-Mateos et al. (2013)

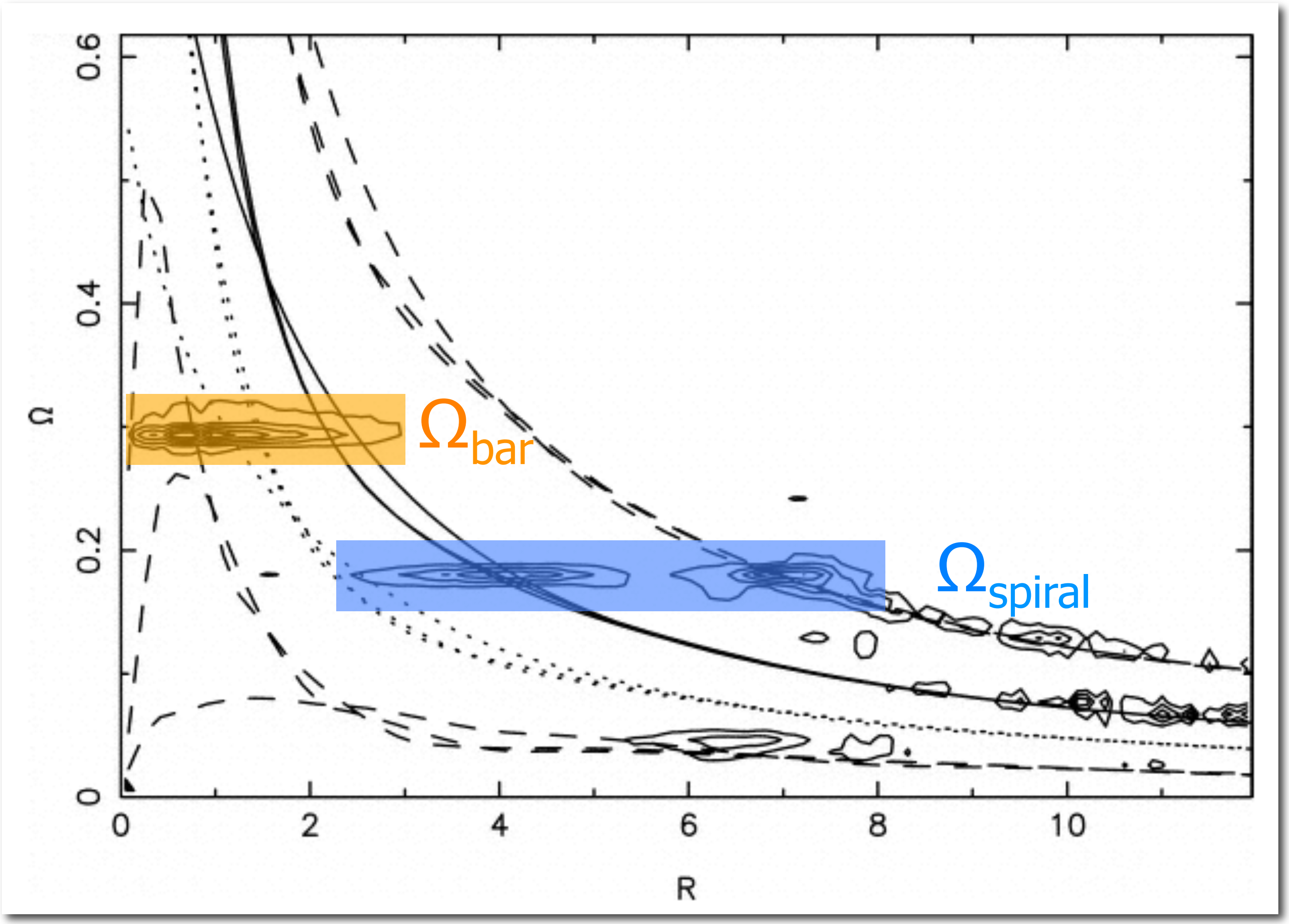
Bars and spiral arms can couple





- The bar and spiral pattern speeds can be different.
- If resonances overlap, angular momentum is carried much further out!

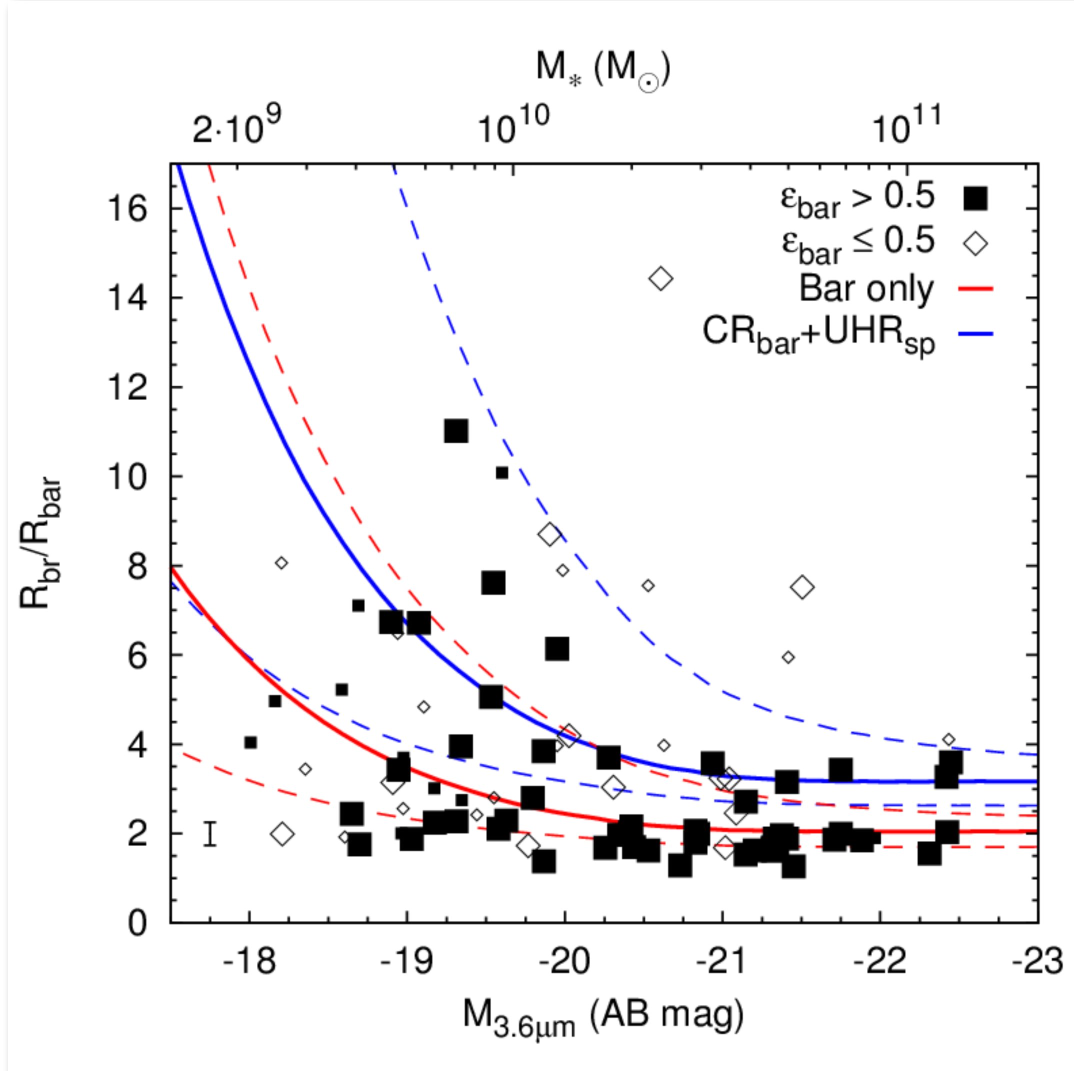
Bars and spiral arms can couple



Debattista et al. (2006)

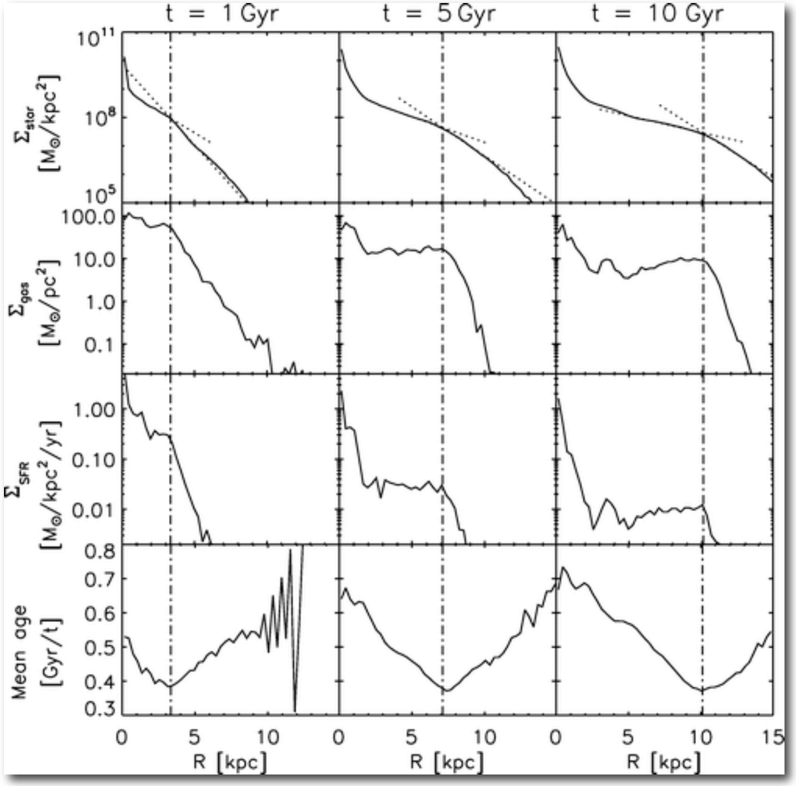
Bar/spiral coupling can yield breaks at large radius

- 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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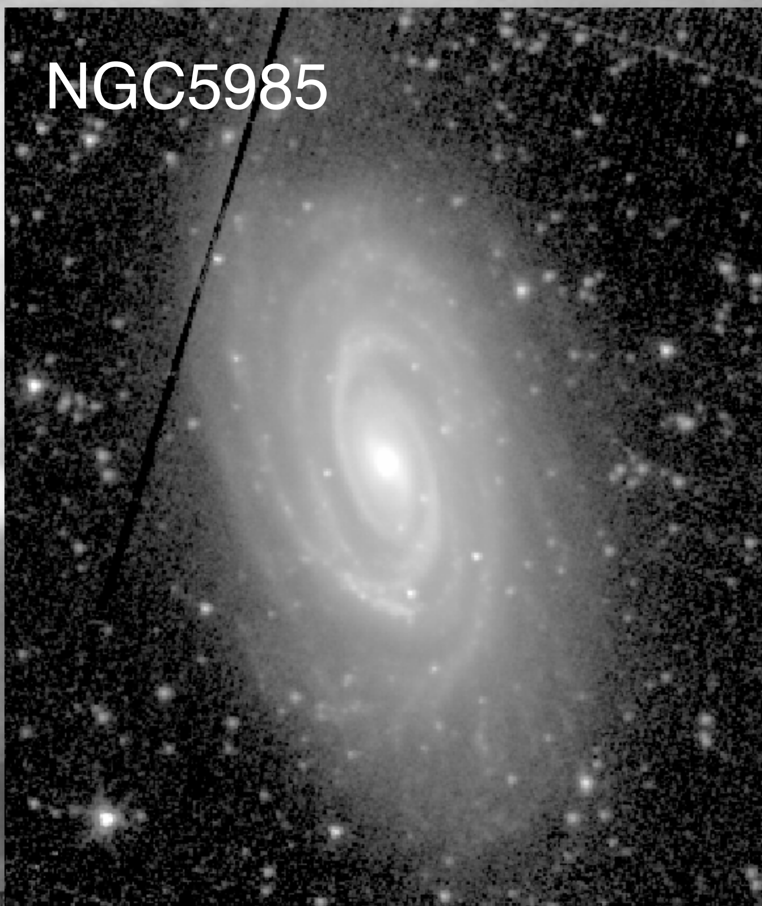

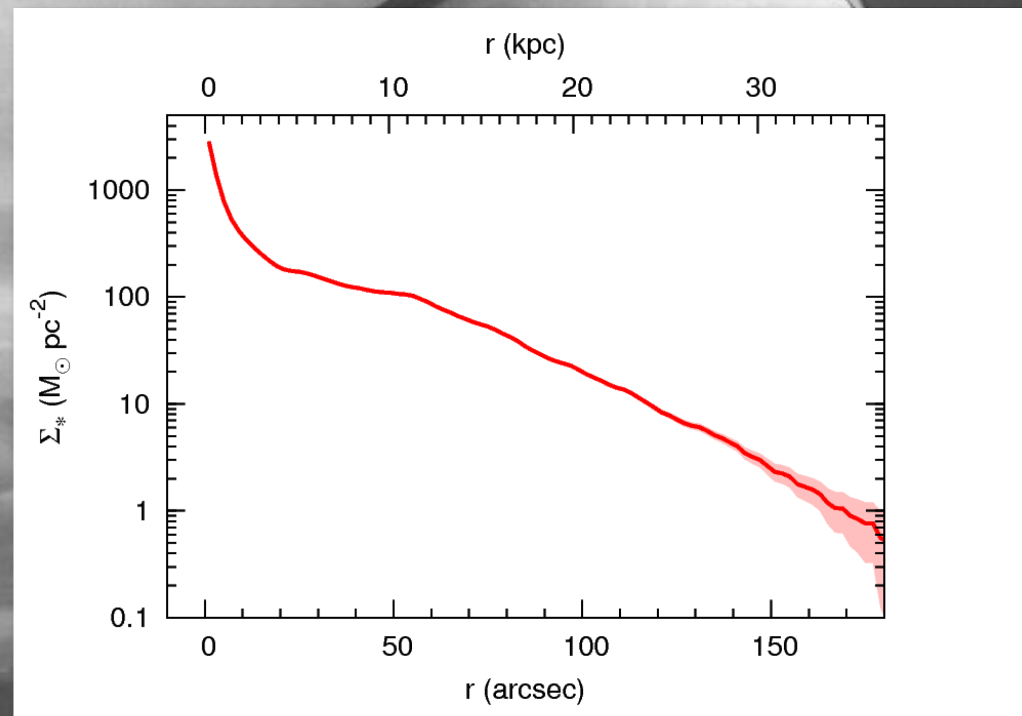

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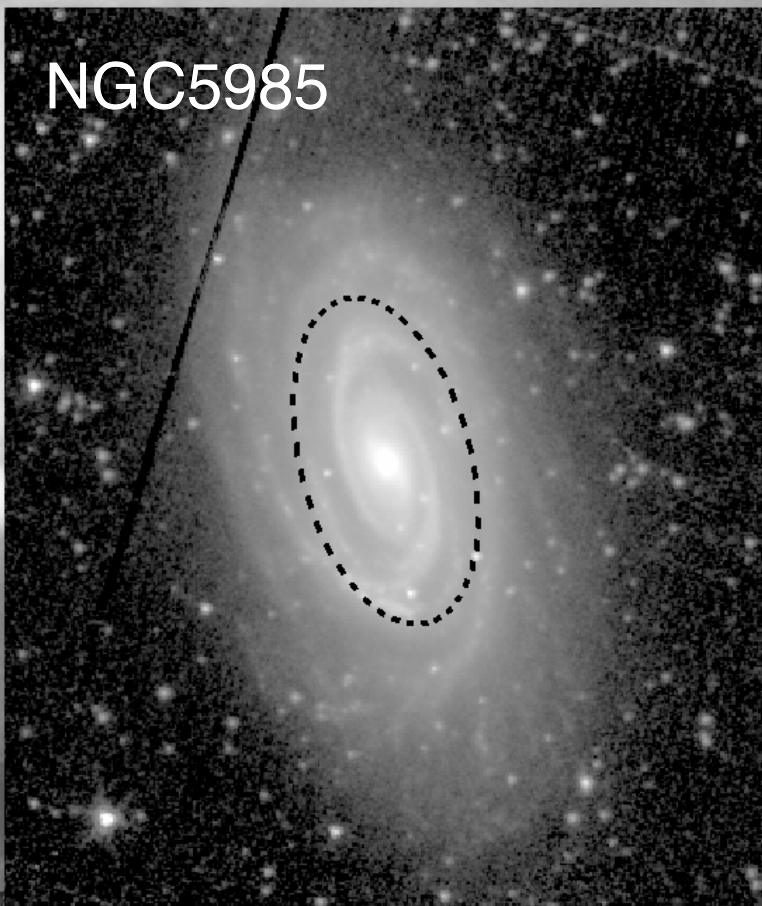

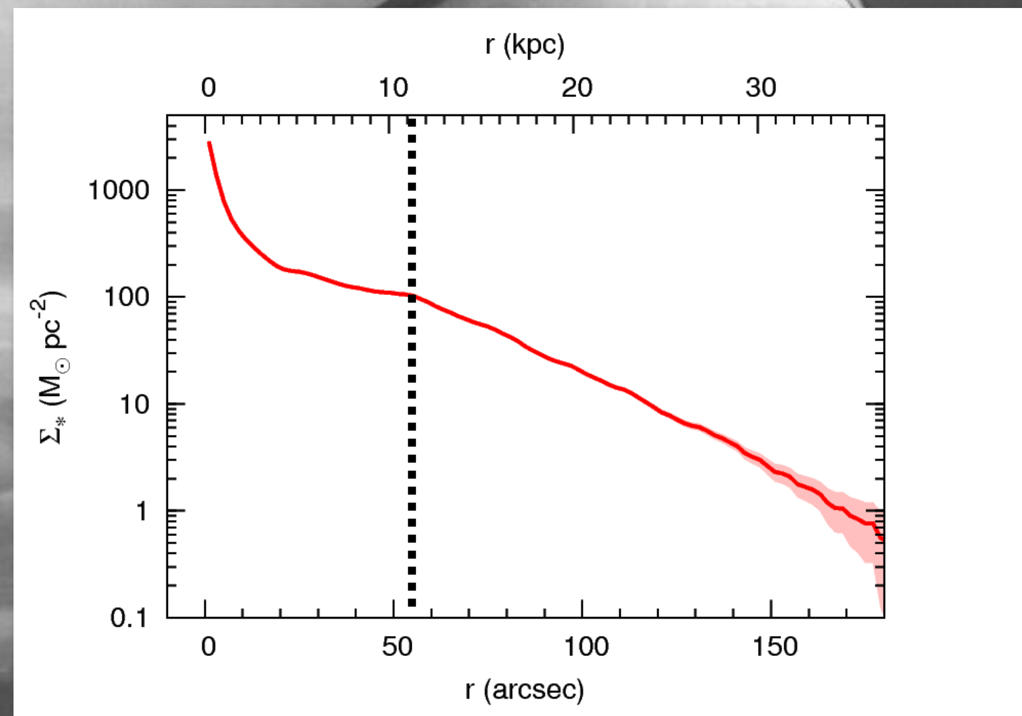

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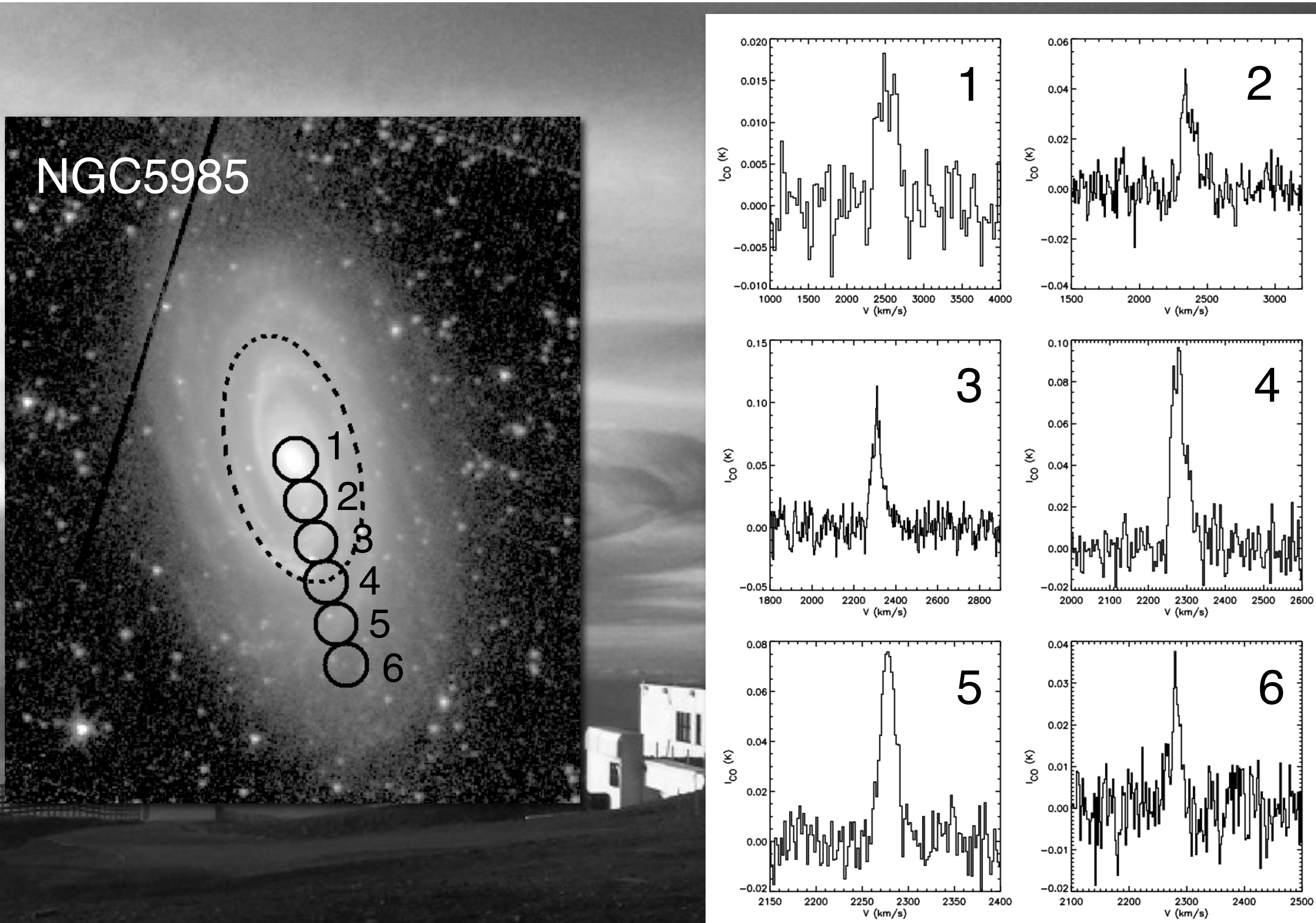

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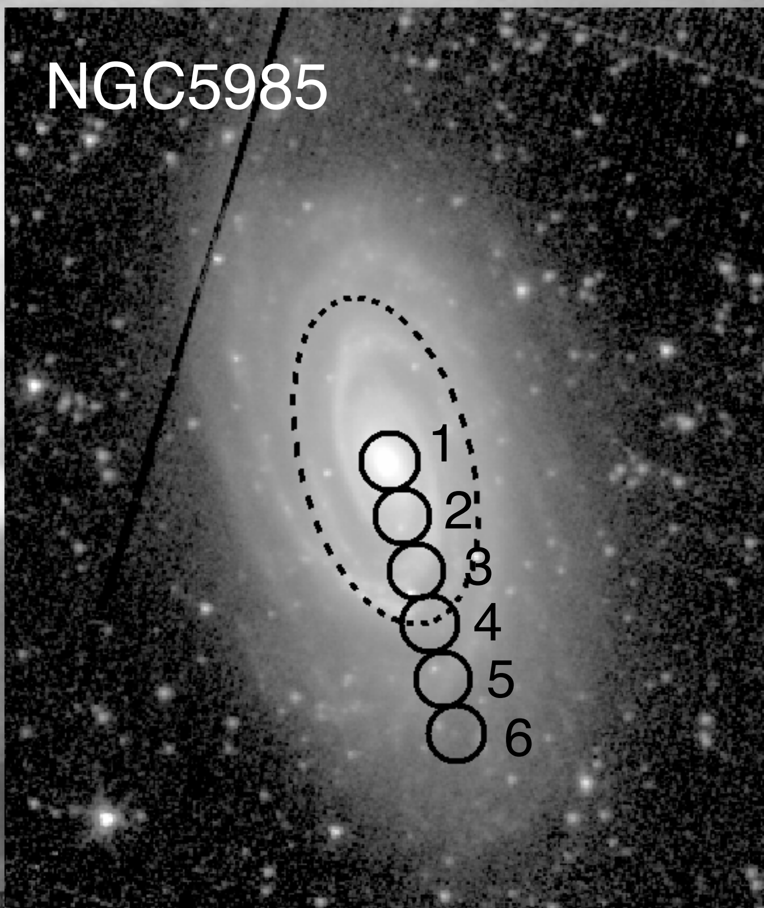

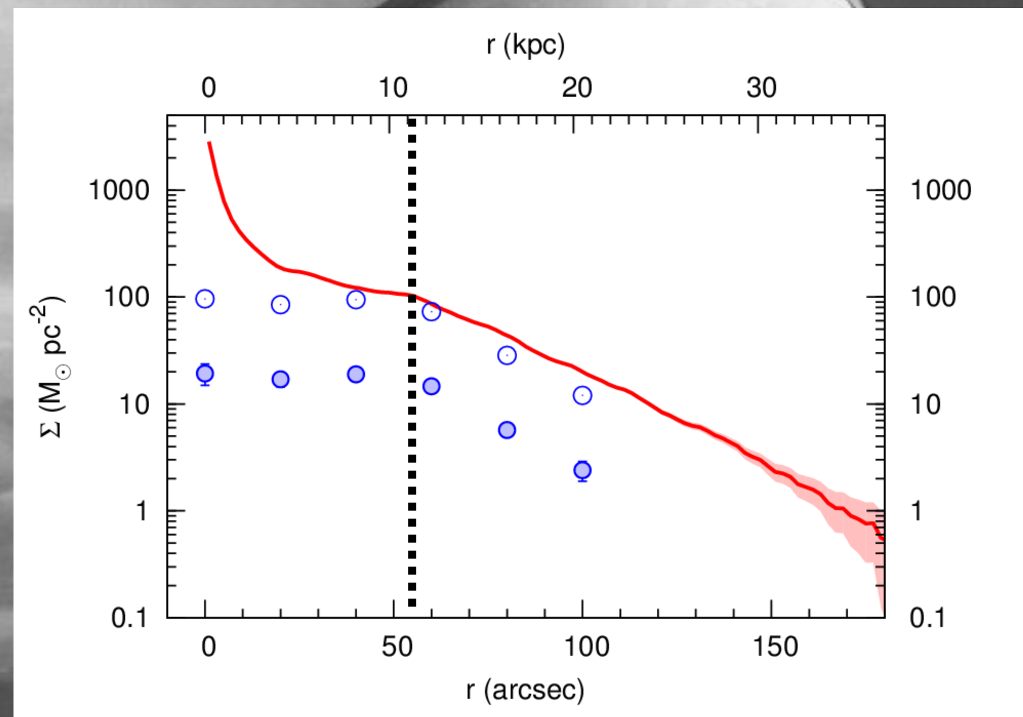

Conclusions

- 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.