The role of spiral arms of star formation in the Milky Way

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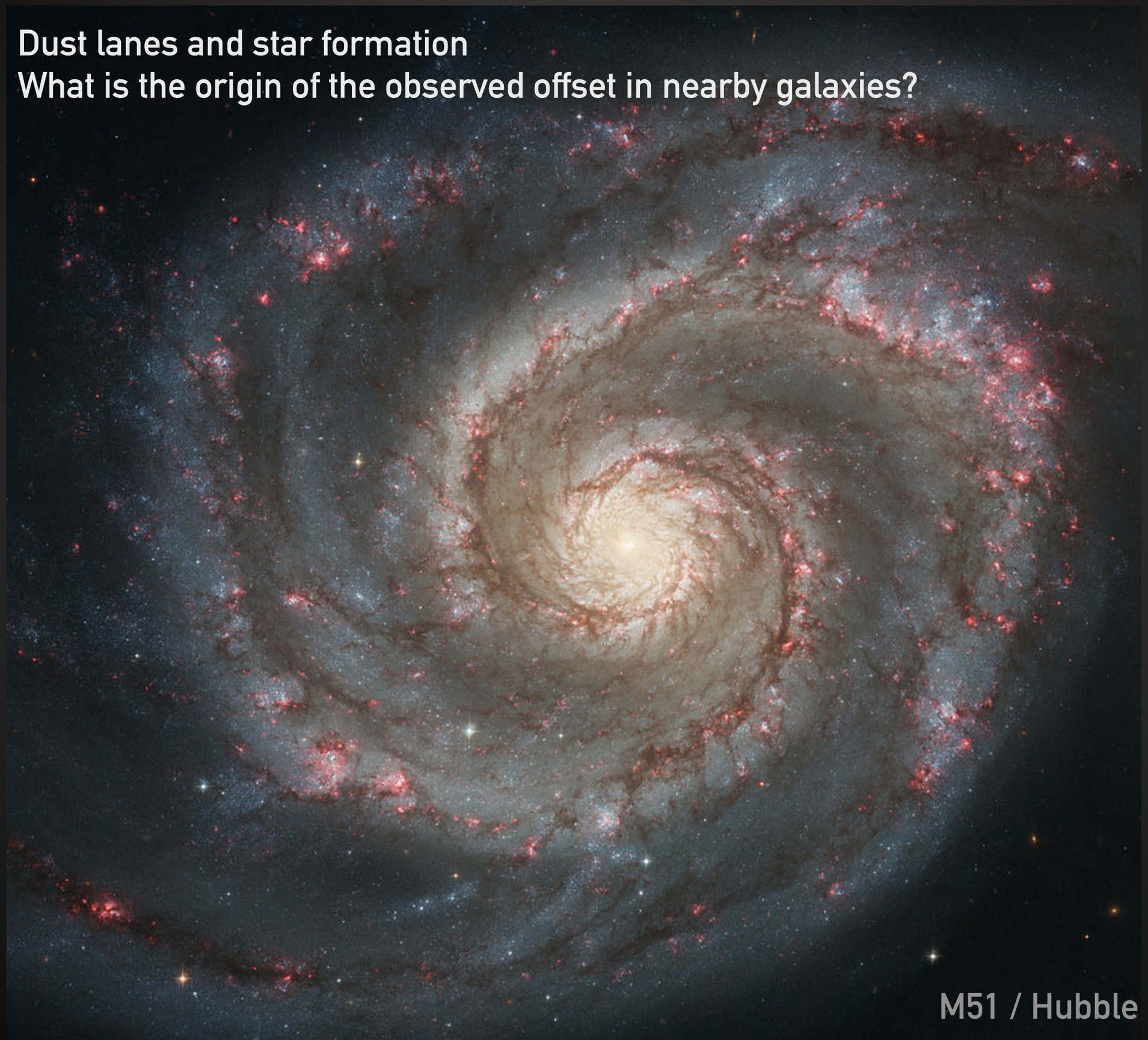
CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

MARIE CURIE ACTIONS

STAR FORMATION IN SPIRAL GALAXIES

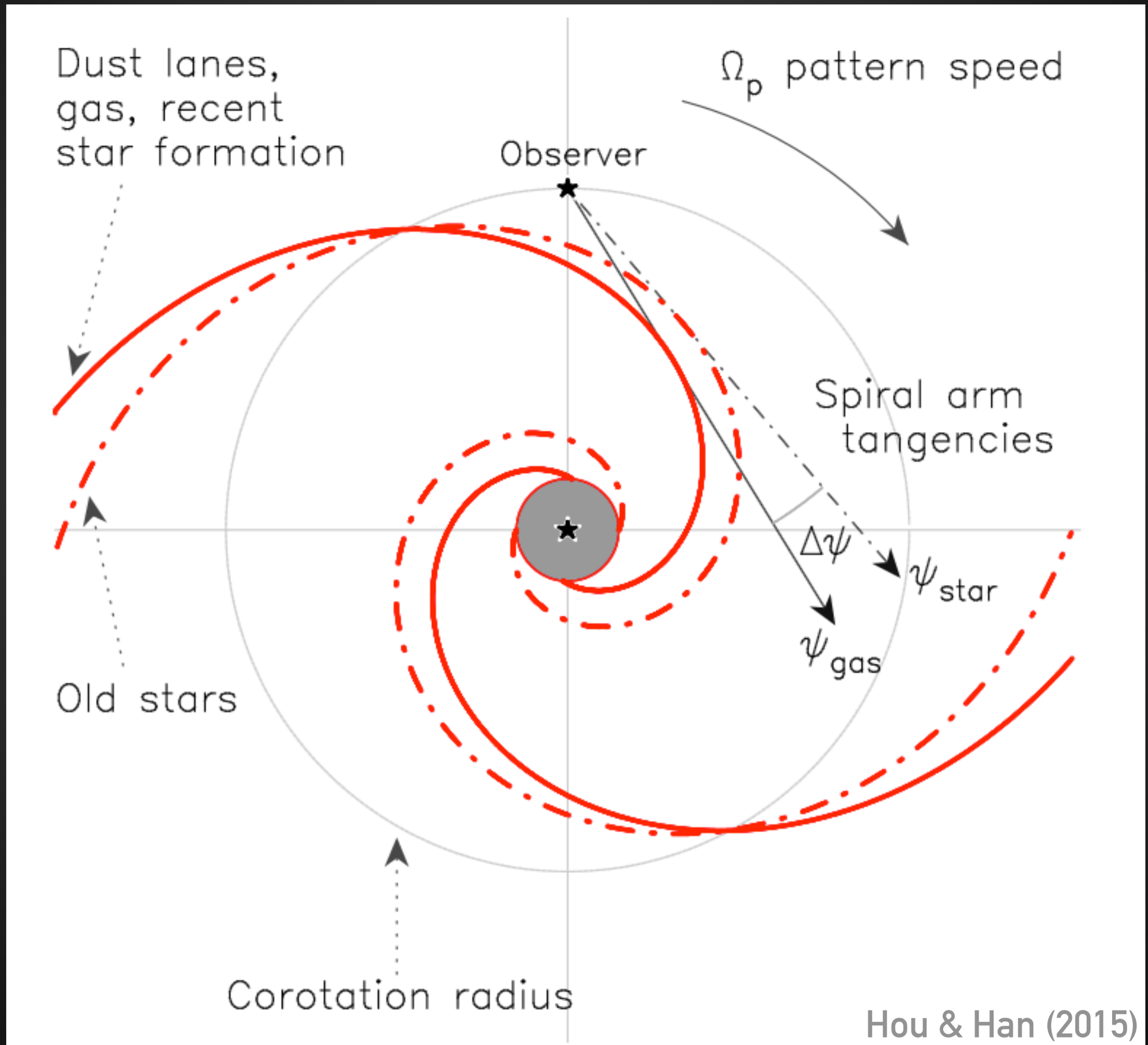
Dust lanes and star formation

What is the origin of the observed offset in nearby galaxies?



M51 / Hubble

STAR FORMATION IN SPIRAL GALAXIES



Hou & Han (2015)

SPIRAL ARM TANGENT POINTS: MILKY WAY PERSPECTIVE

LEAVING

ENTERING

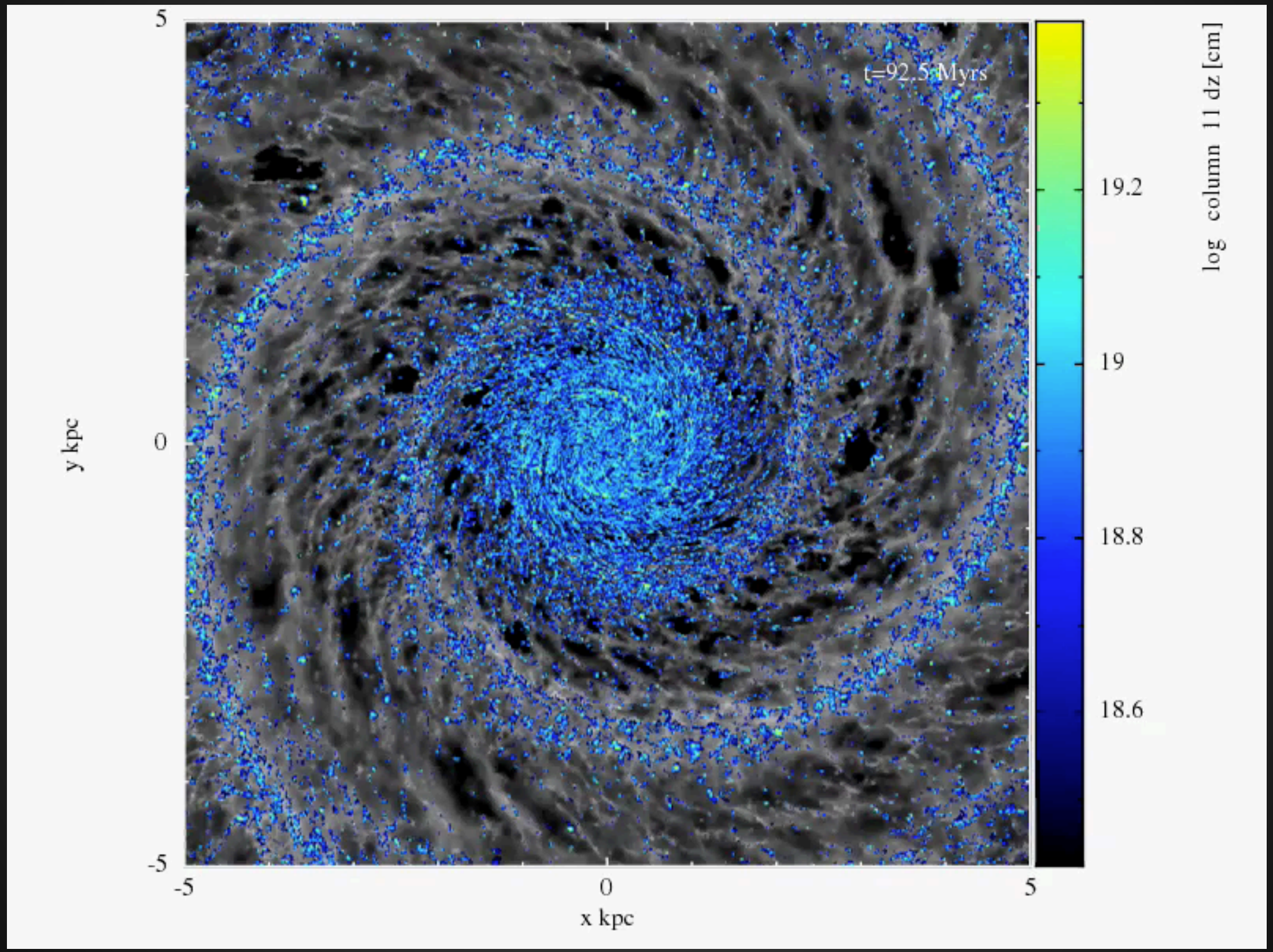
"OLD STARS"

GAS / DUST

| LONGITUDE |

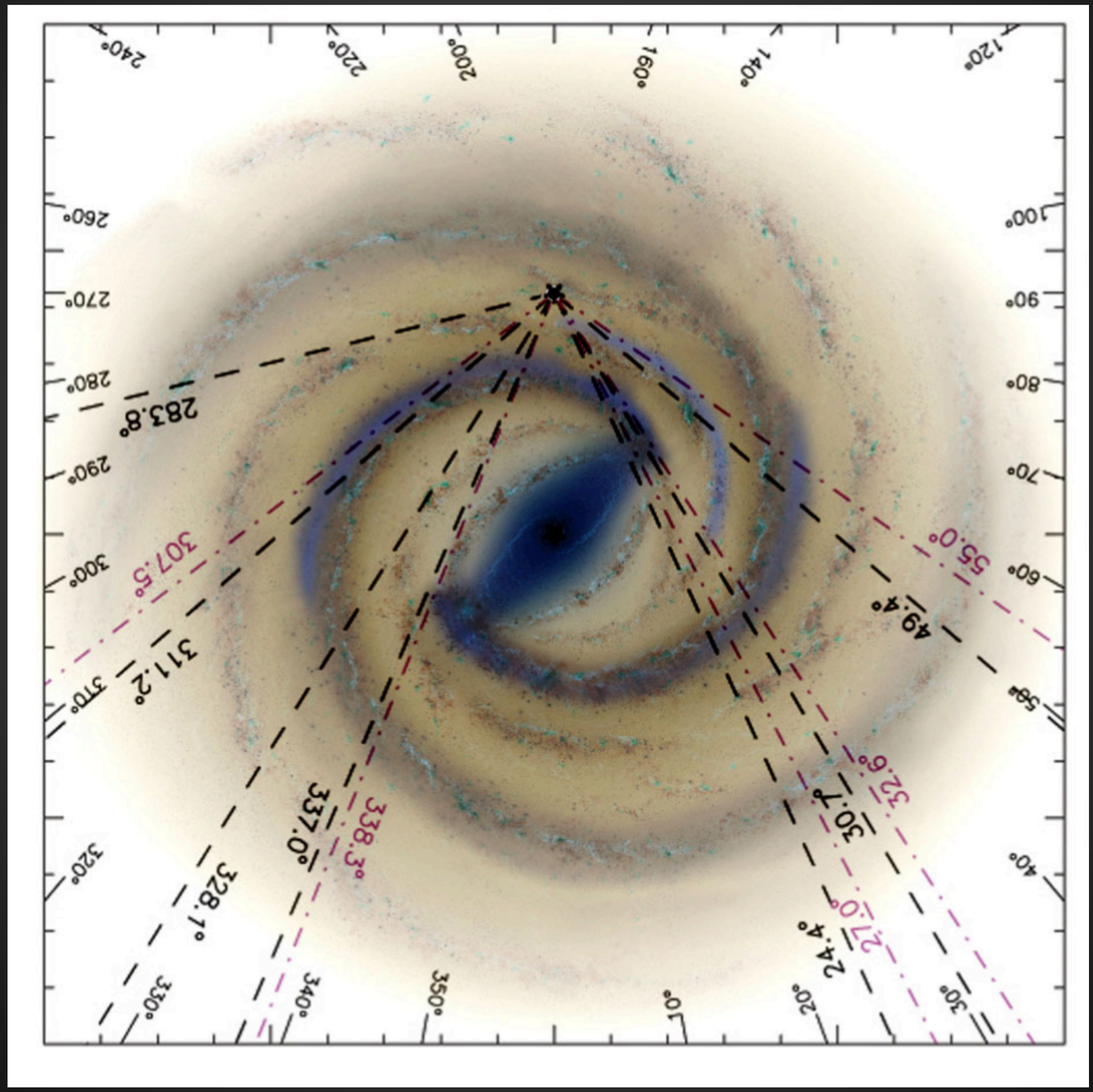
Hou & Han (2015)

DYNAMICS OF SPIRAL GALAXIES: THE CYCLE OF MATERIAL THROUGH ARMS



Dobbs & Pringle (2013)

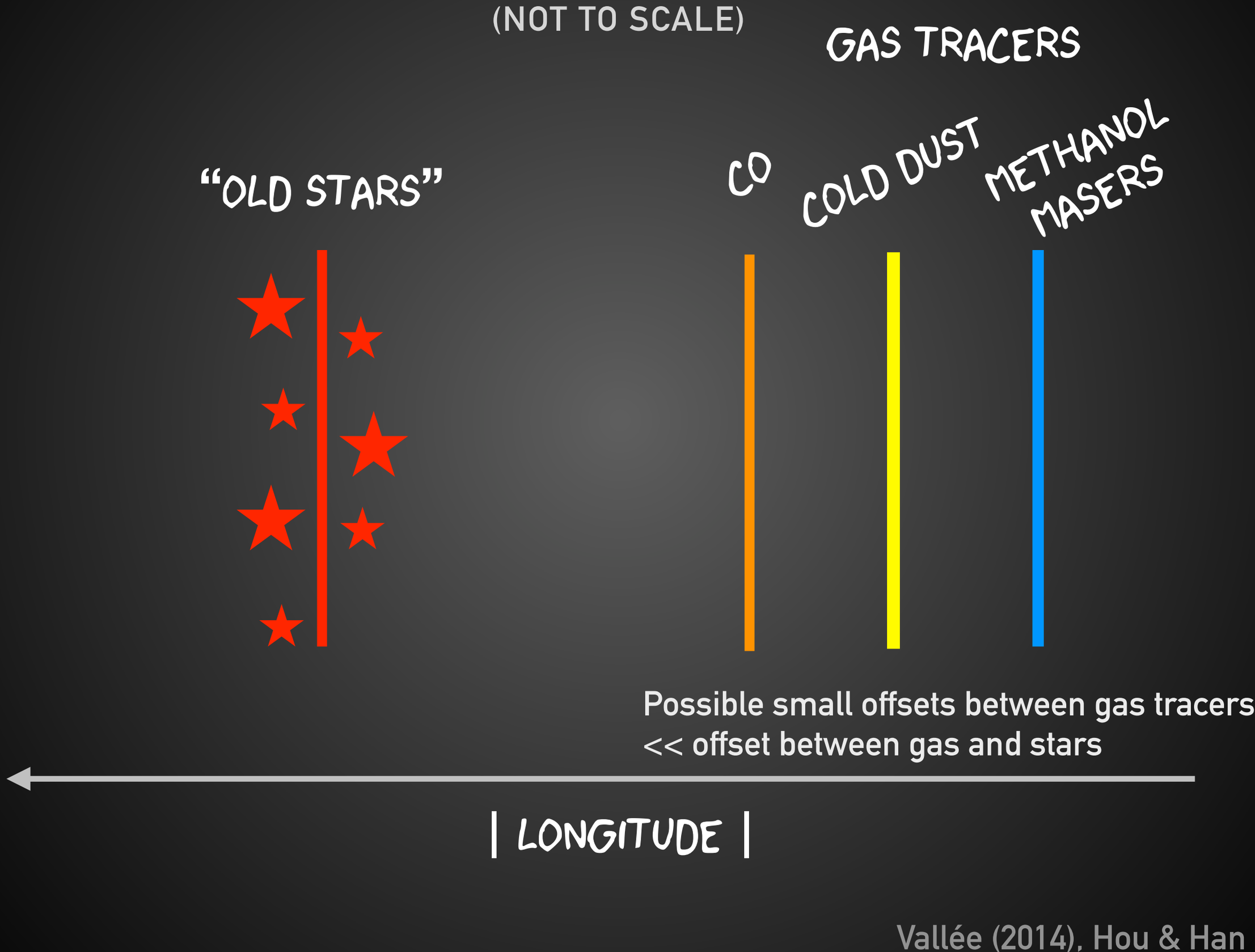
SPIRAL ARM TANGENT POINTS IN THE MILKY WAY



Hou & Han (2015)

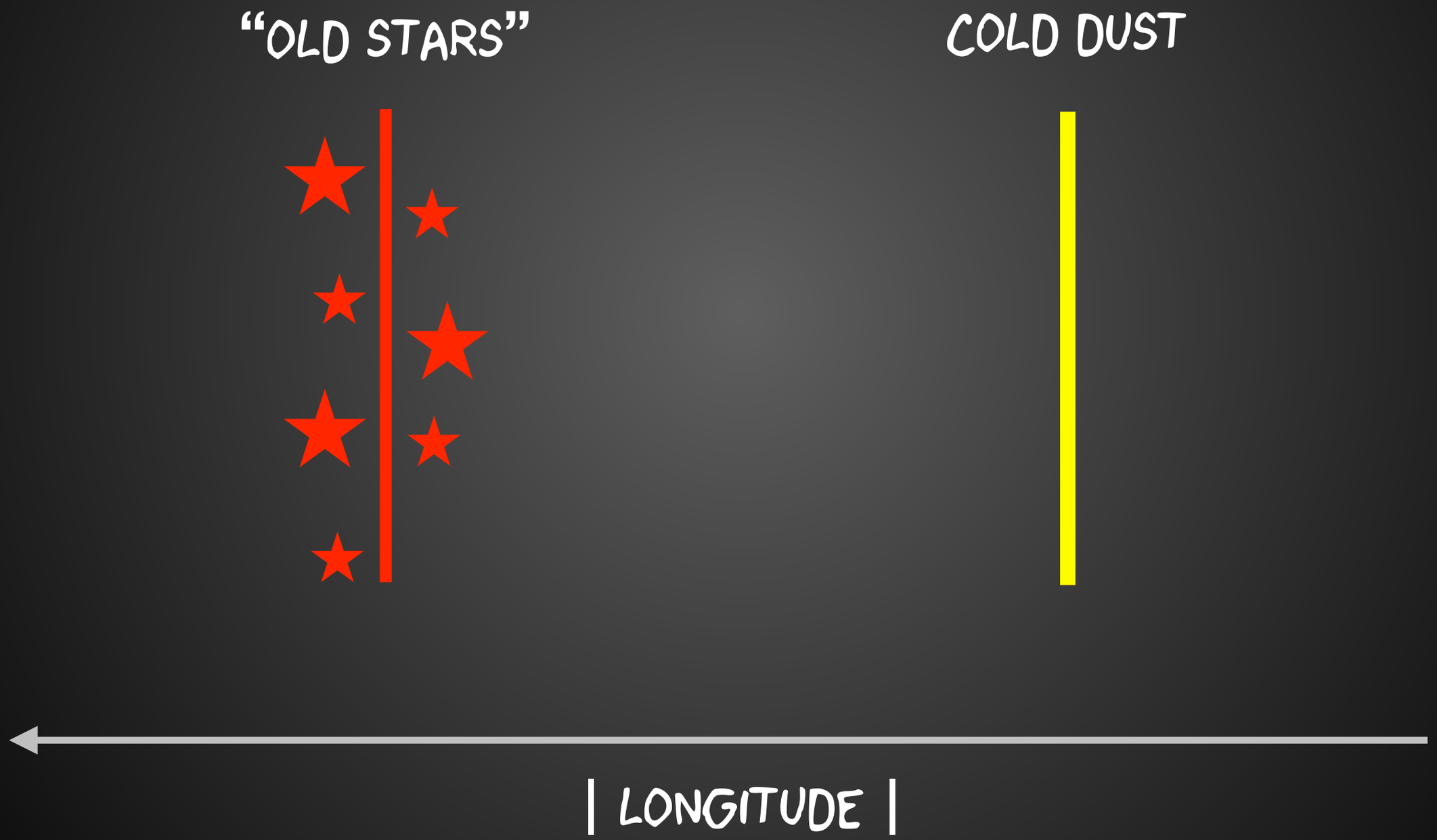
SPIRAL ARM TANGENT POINTS IN THE MILKY WAY

(NOT TO SCALE)



Vallée (2014), Hou & Han (2015)

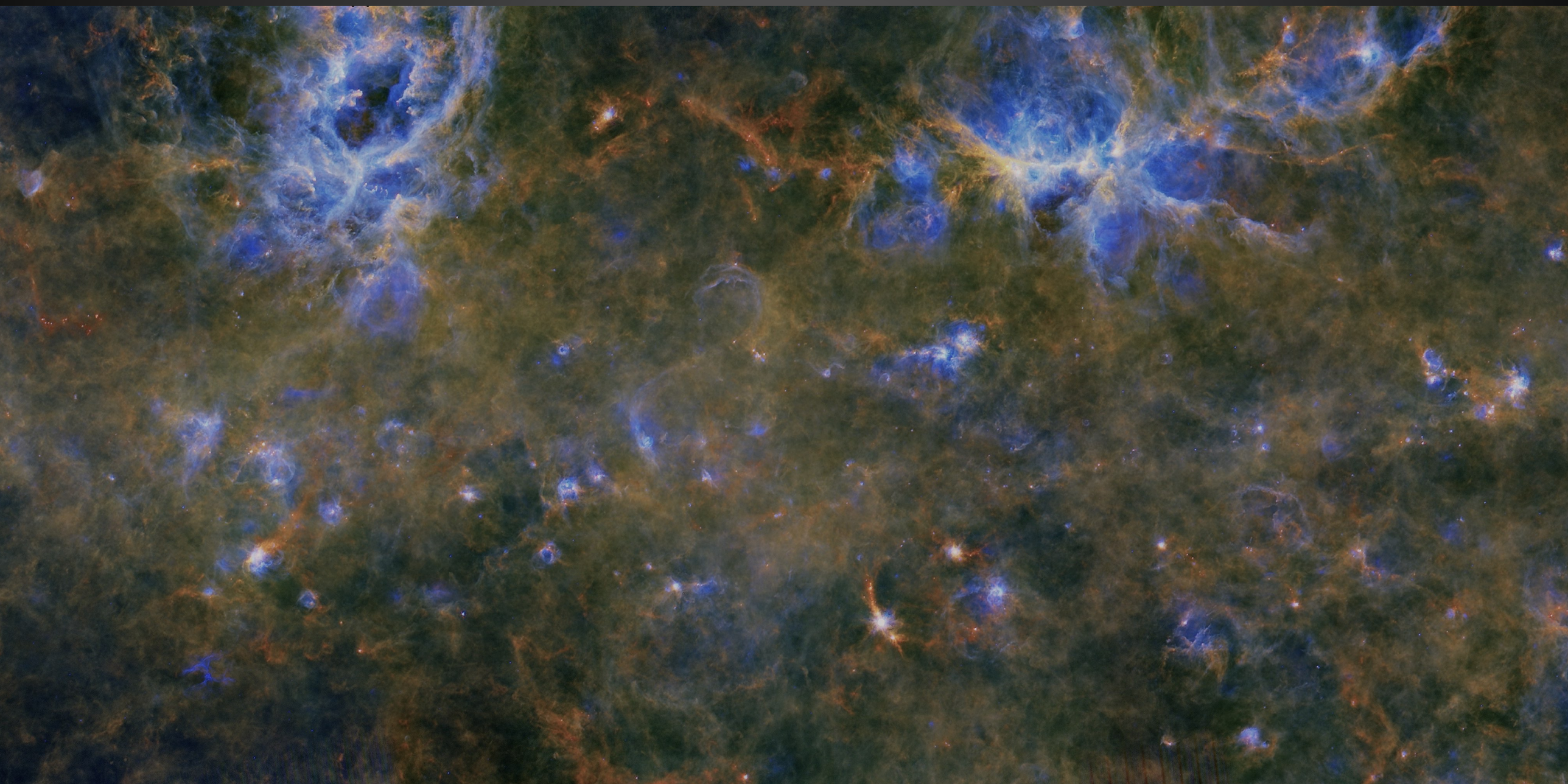
SPIRAL ARM TANGENT POINTS IN THE MILKY WAY



Vallée (2014), Hou & Han (2015)

HI-GAL: HERSCHEL INFRARED GALACTIC PLANE SURVEY

- Simultaneous five band (70, 160, 250, 350 & 500μm) continuum mapping of Milky Way plane ($|b| < 1^\circ$) PI: Sergio Molinari
- Compact source catalogue (10^5 sources in $|\ell| < 70^\circ$; Elia et al. accepted MNRAS, in press)



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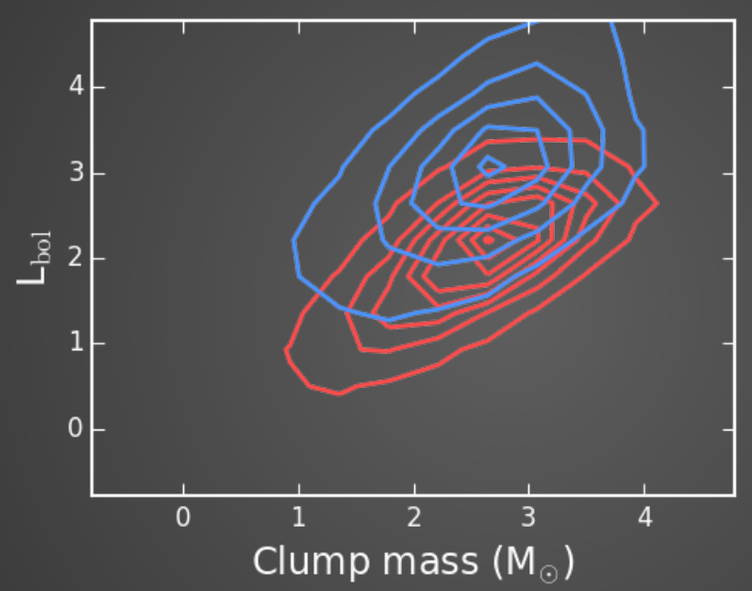
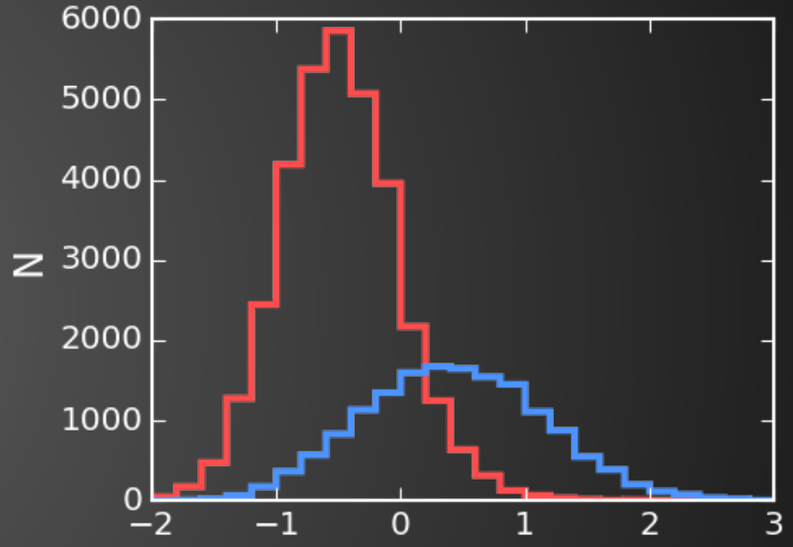
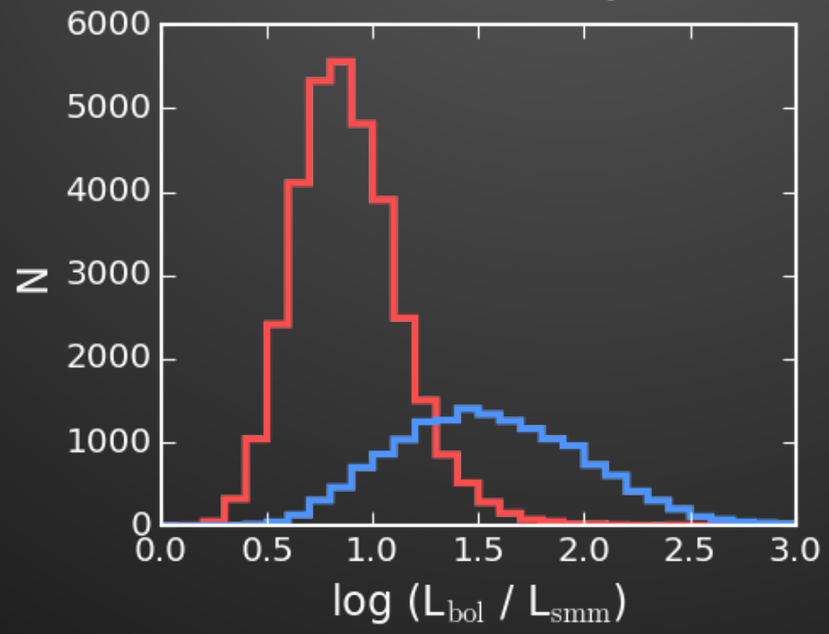
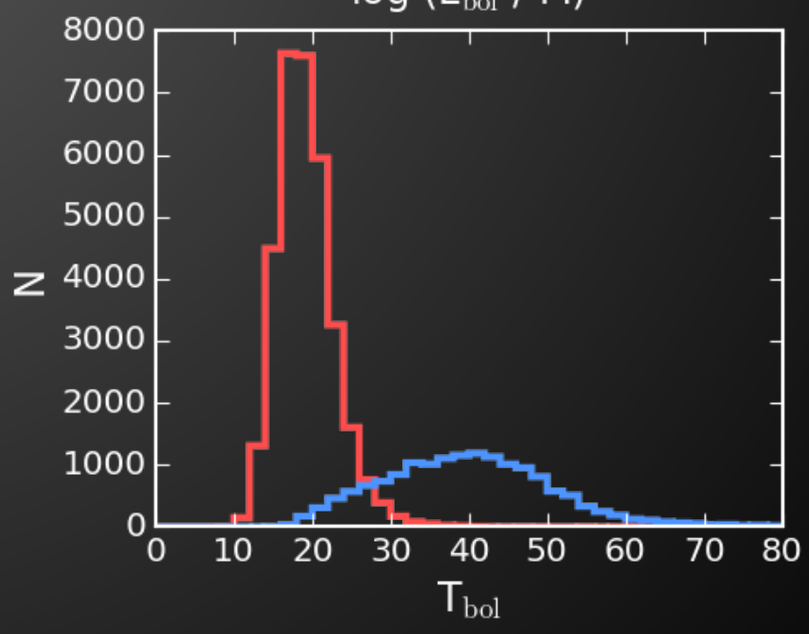
Pre-stellar
70μm-dark

Proto-stellar
70μm-bright









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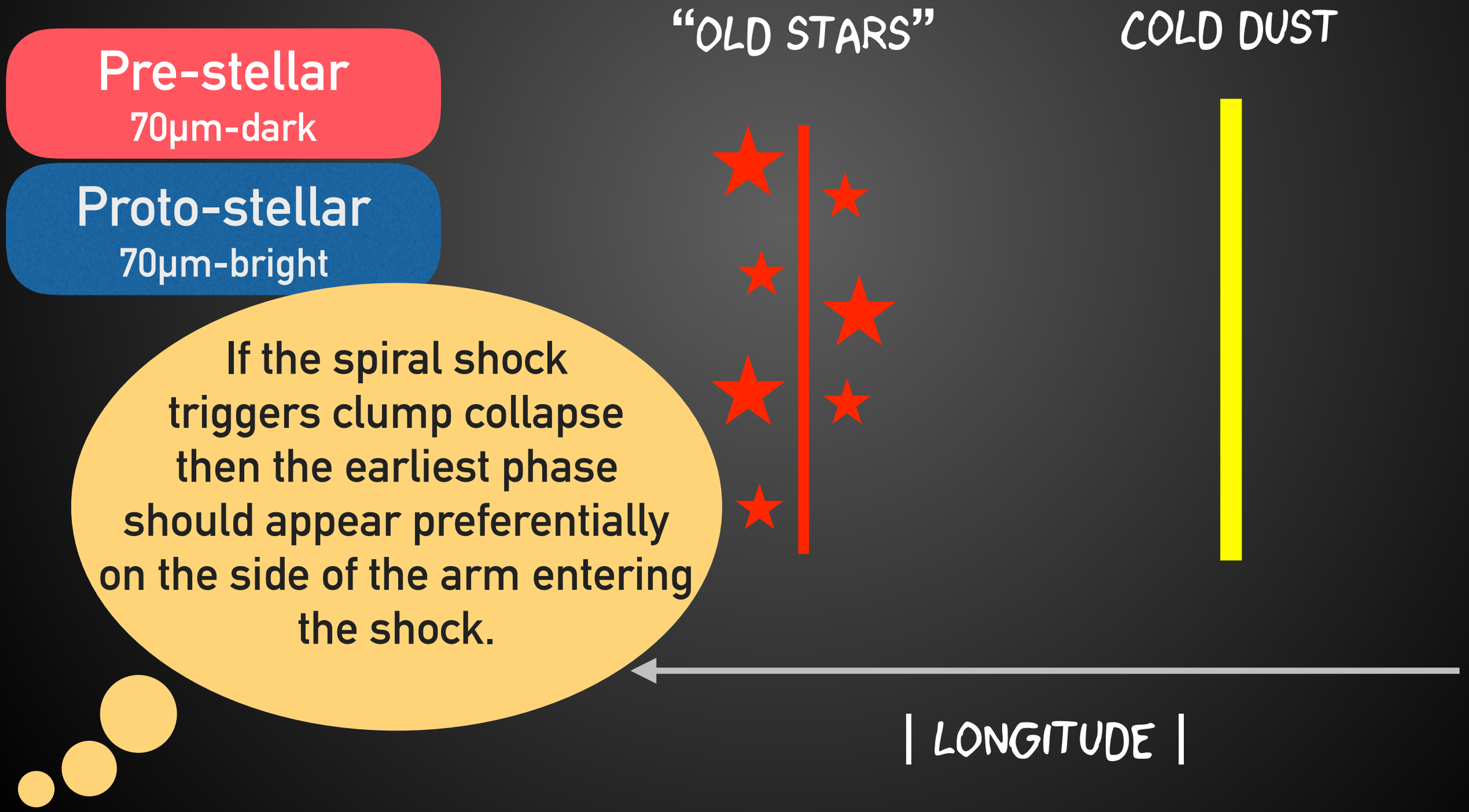

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Pre-stellar
70μm-dark

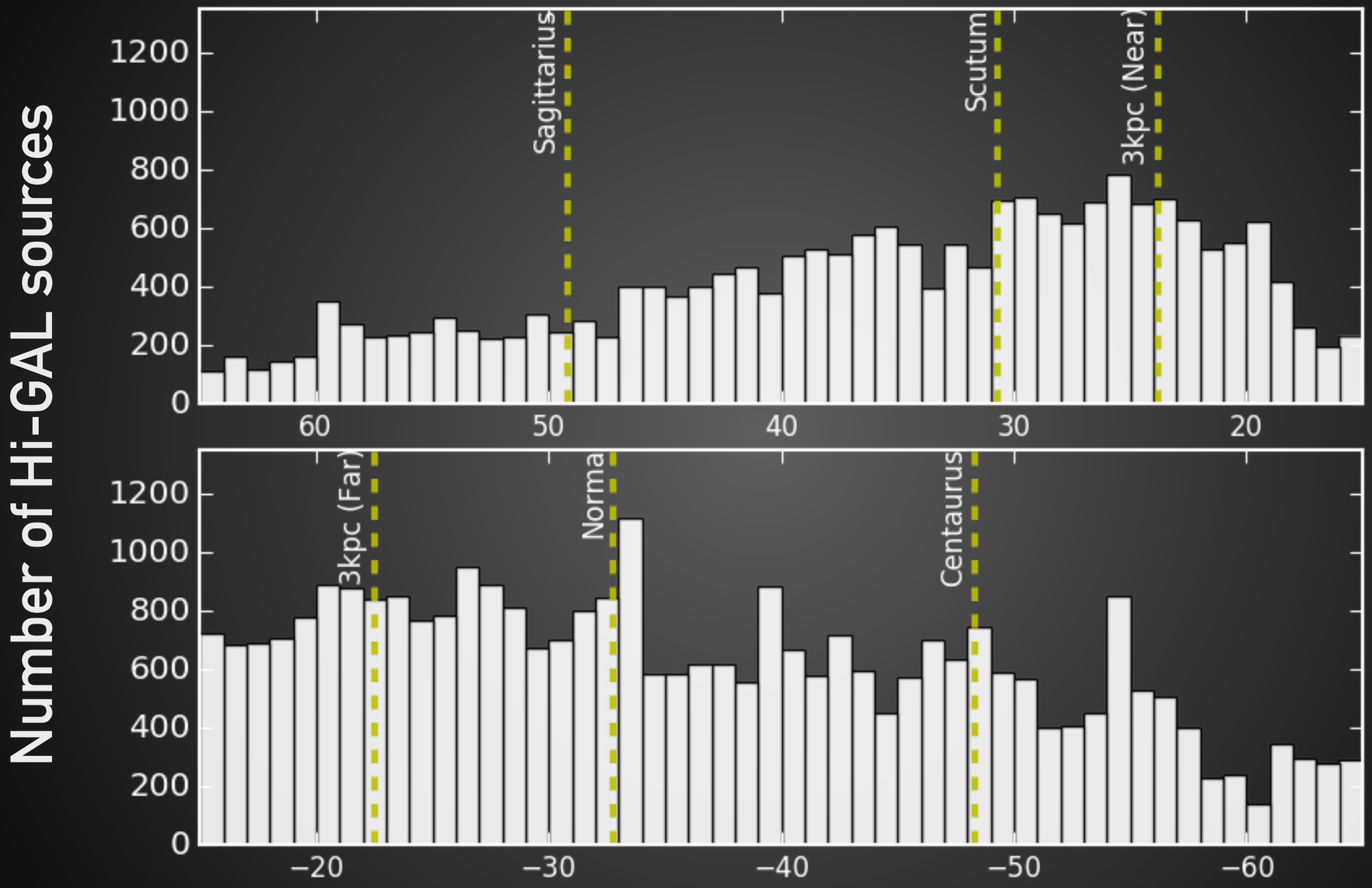
Proto-stellar
70μm-bright

If the spiral shock triggers clump collapse then the earliest phase should appear preferentially on the side of the arm entering the shock.

| LONGITUDE |

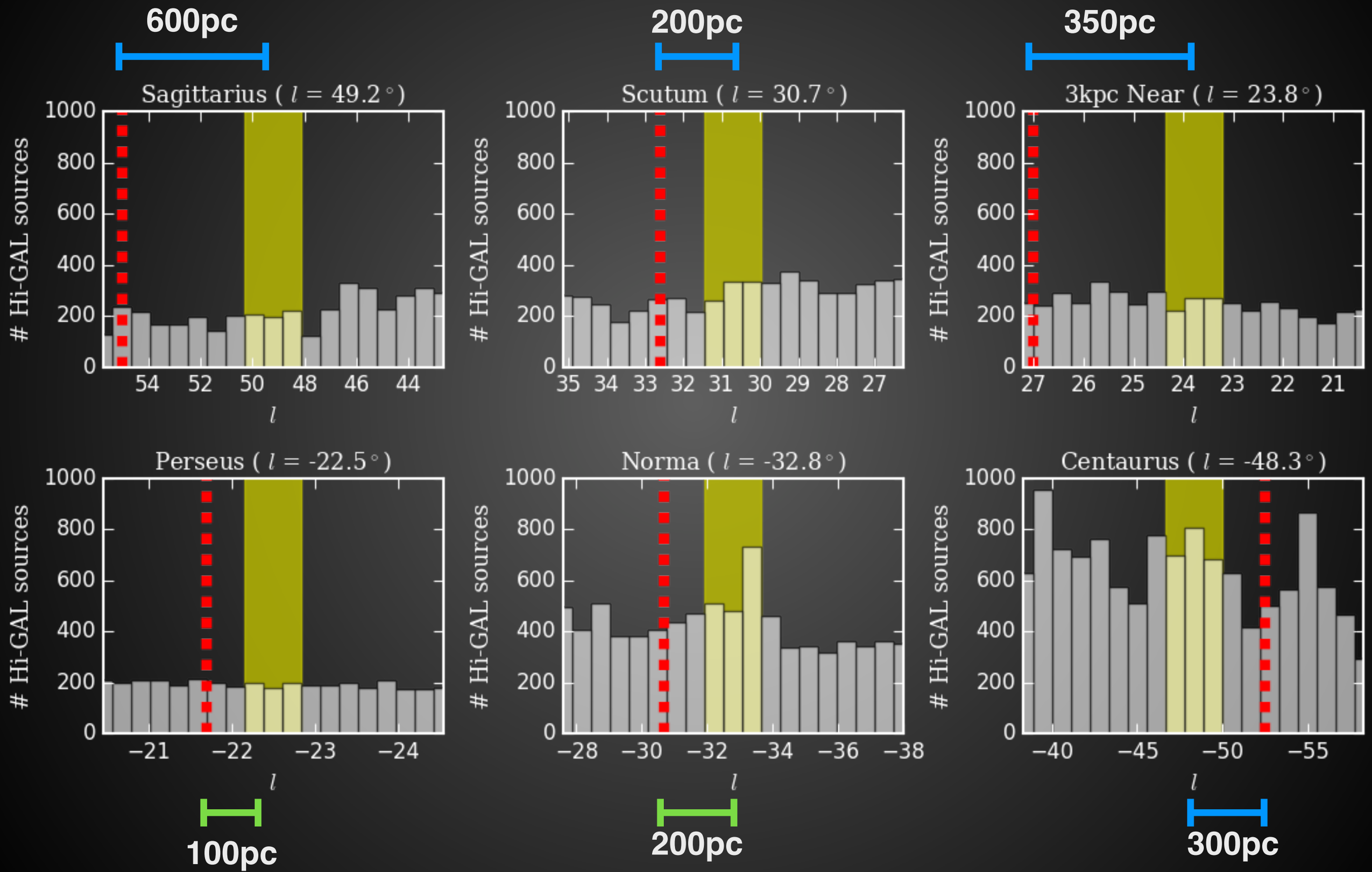
HI-GAL SOURCE DISTRIBUTION WITH LONGITUDE

(FIXED BIN WIDTH)



Elia et al (2017), Ragan et al. (to be submitted)

HI-GAL SOURCE DISTRIBUTION WITH LONGITUDE

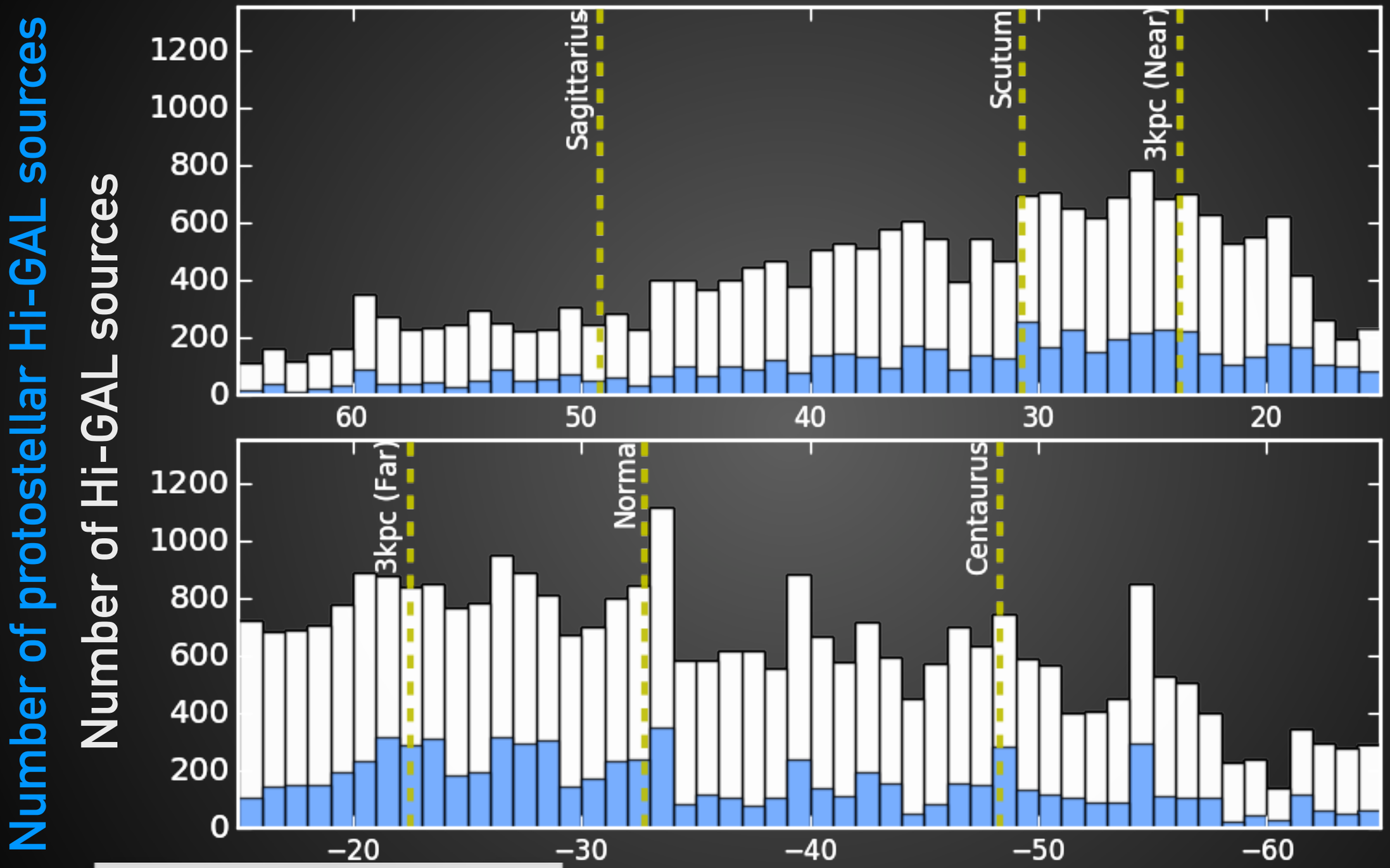


(ARM WIDTH FROM REID ET AL. 2014)

(OLD STAR LONGITUDE FROM HOU & HAN 2015)

THE STAR-FORMING FRACTION (SFF)

(FIXED BIN WIDTH)

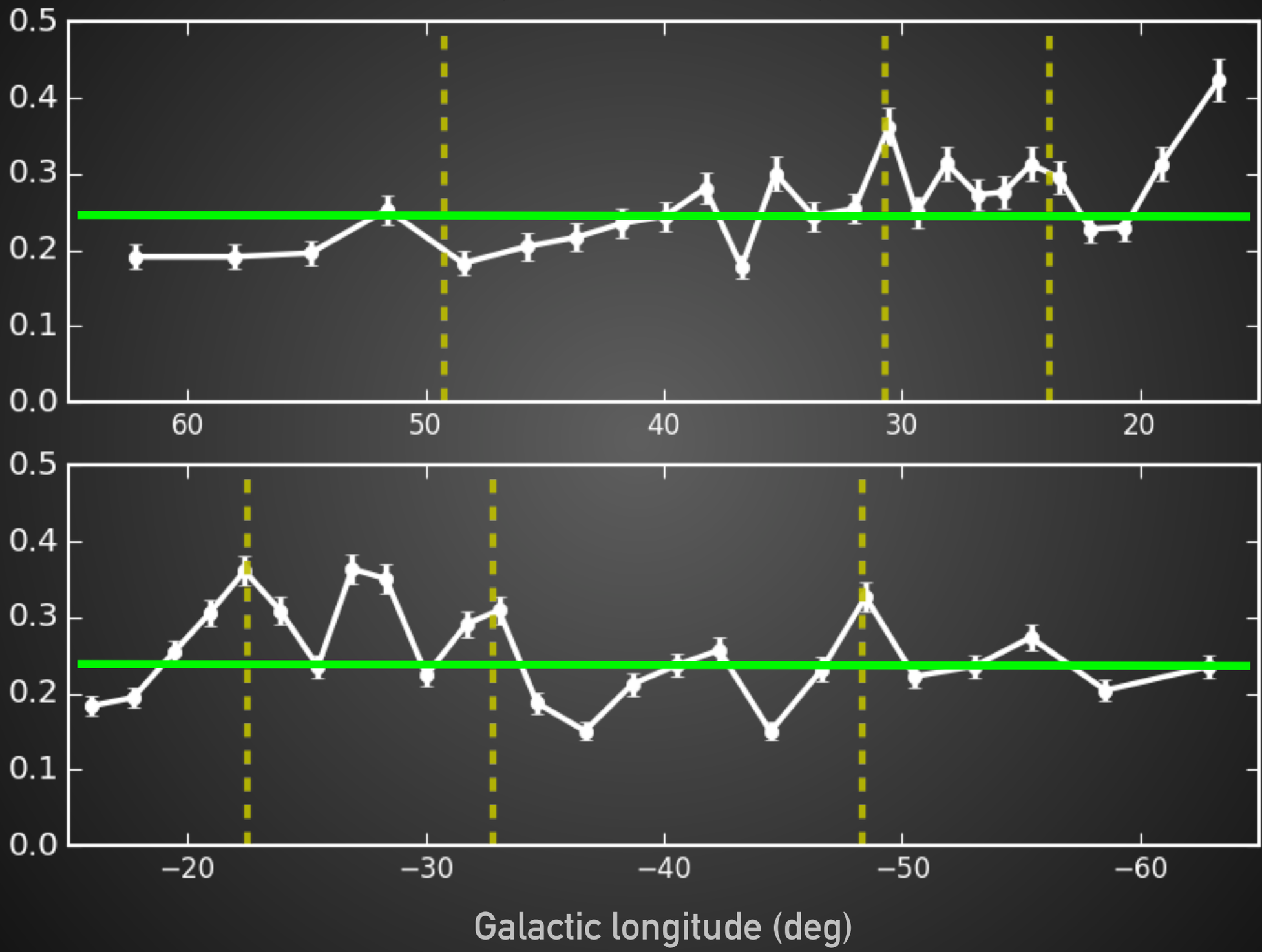


$$\mathrm{SFF} = \frac{N_{\mathrm{protostellar}}}{N_{\mathrm{total}}}$$

Ragan et al. (to be submitted)

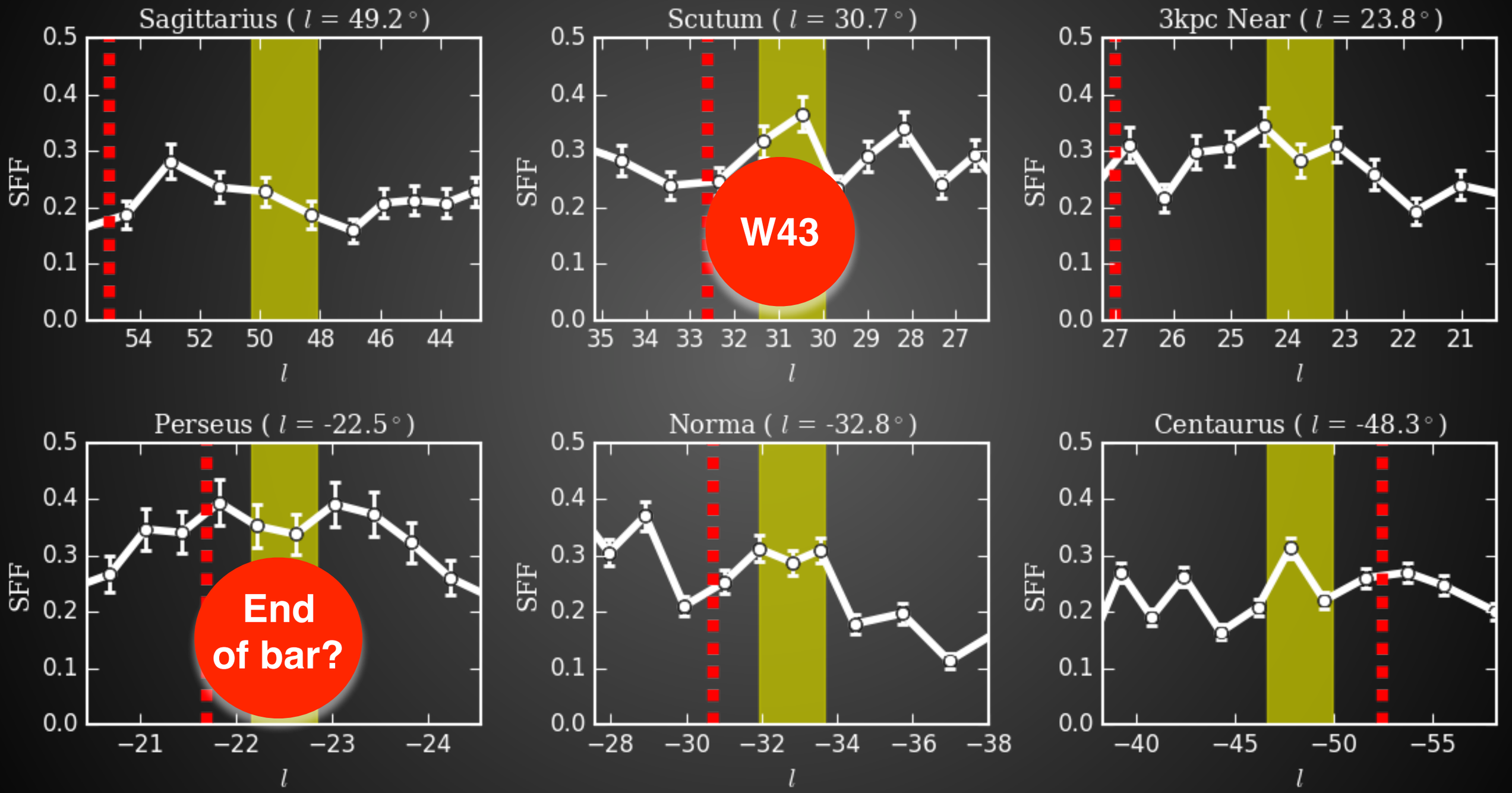
SFF DISTRIBUTION WITH LONGITUDE

(FIXED N PER BIN)



Ragan et al. (to be submitted)

DO SPIRAL ARMS AFFECT STAR FORMATION?



- Significant peak (Scutum arm, top middle) is completely due to the W43 star-forming complex.
- Broad SFF excess at Perseus arm / bar end

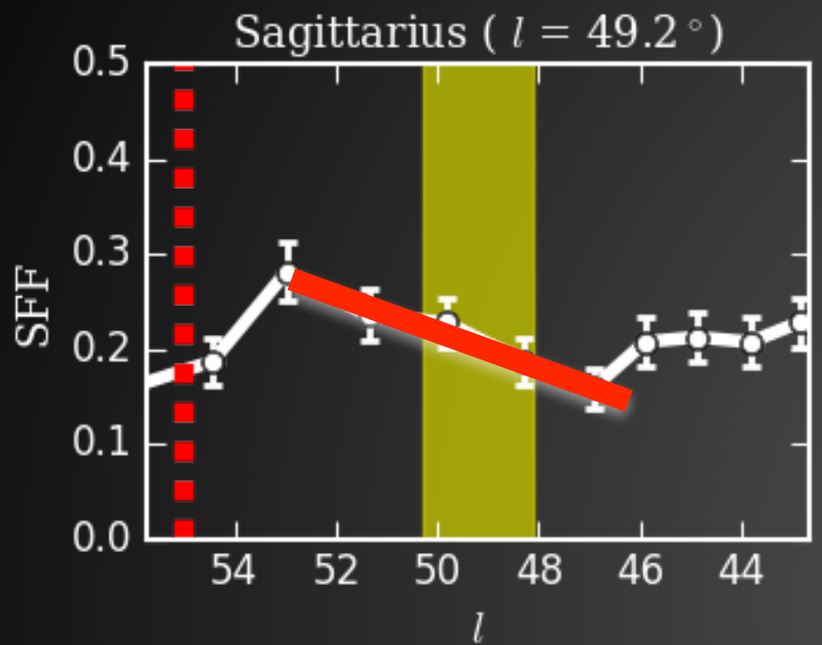
Ragan et al. (to be submitted)

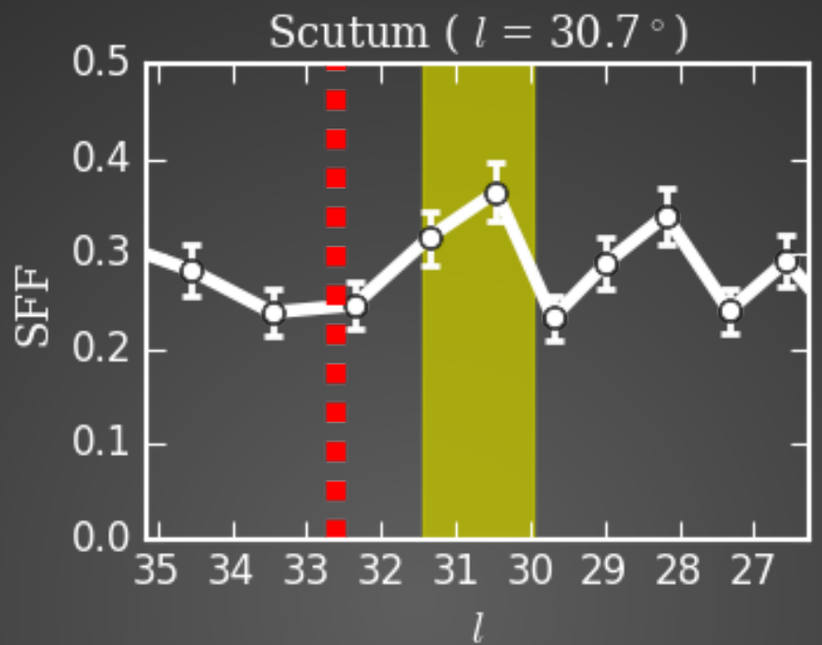
DO SPIRAL ARMS AFFECT STAR FORMATION?

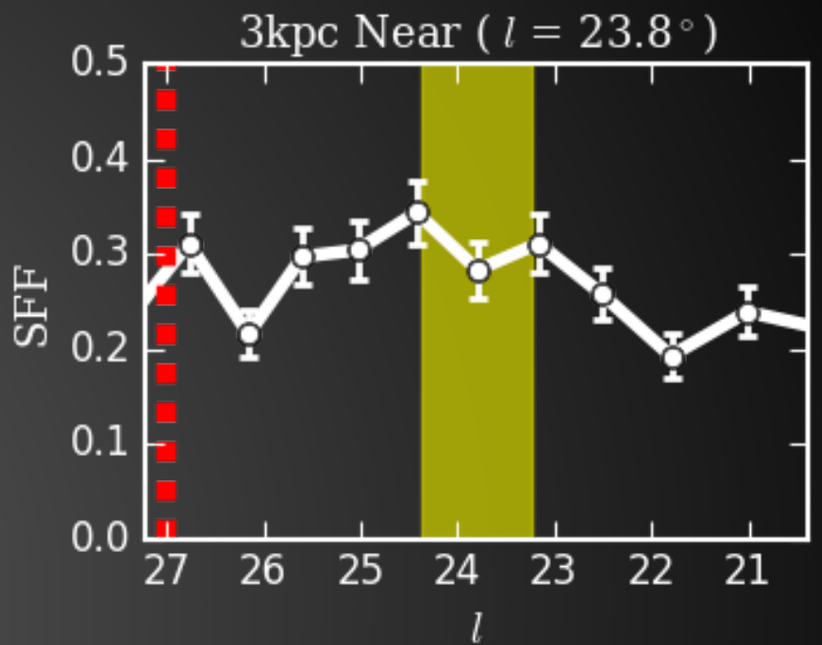
600pc

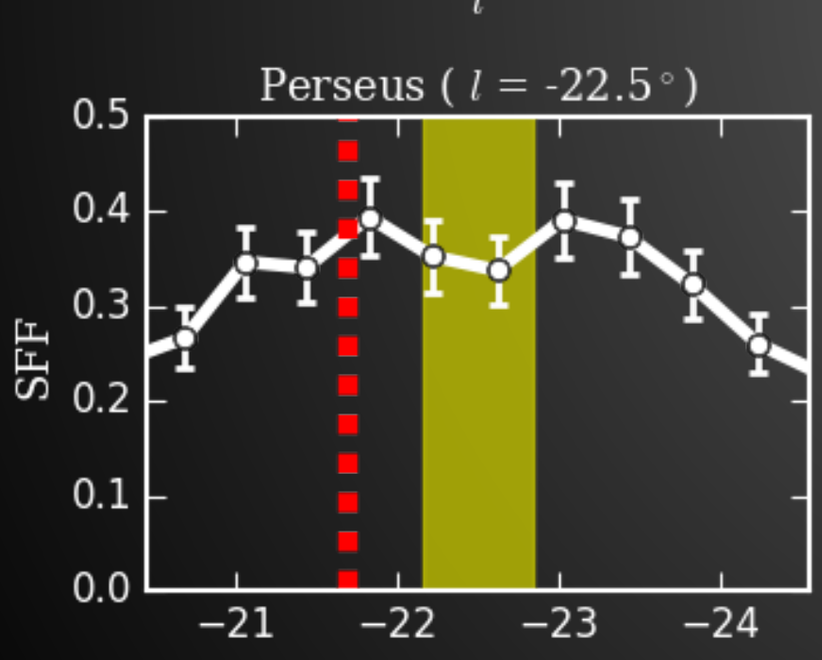
200pc

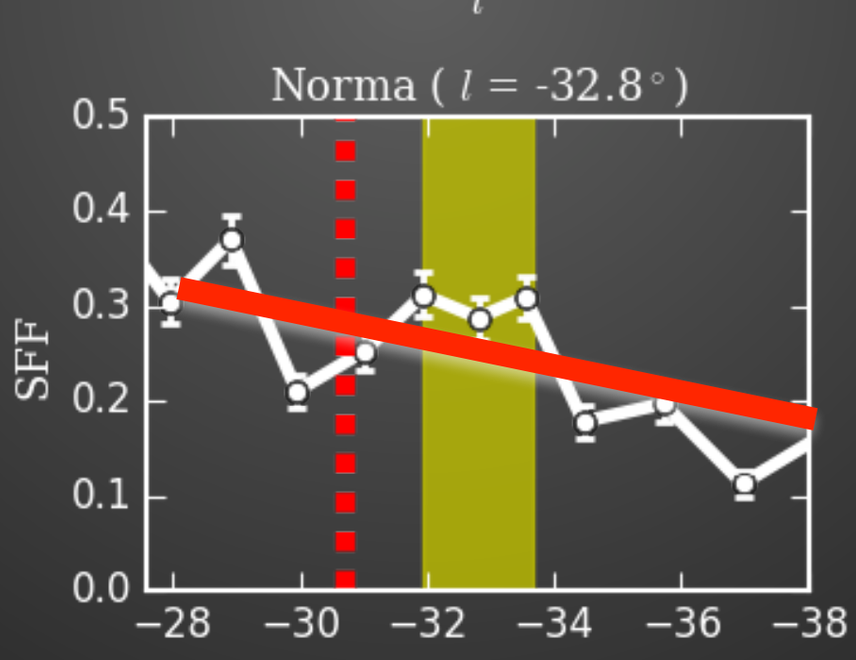
350pc

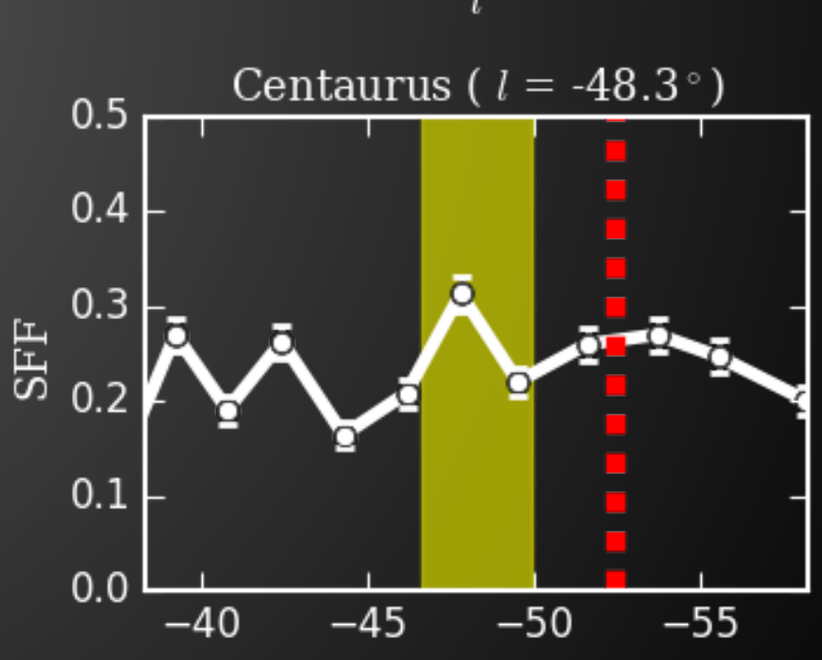












100pc

200pc

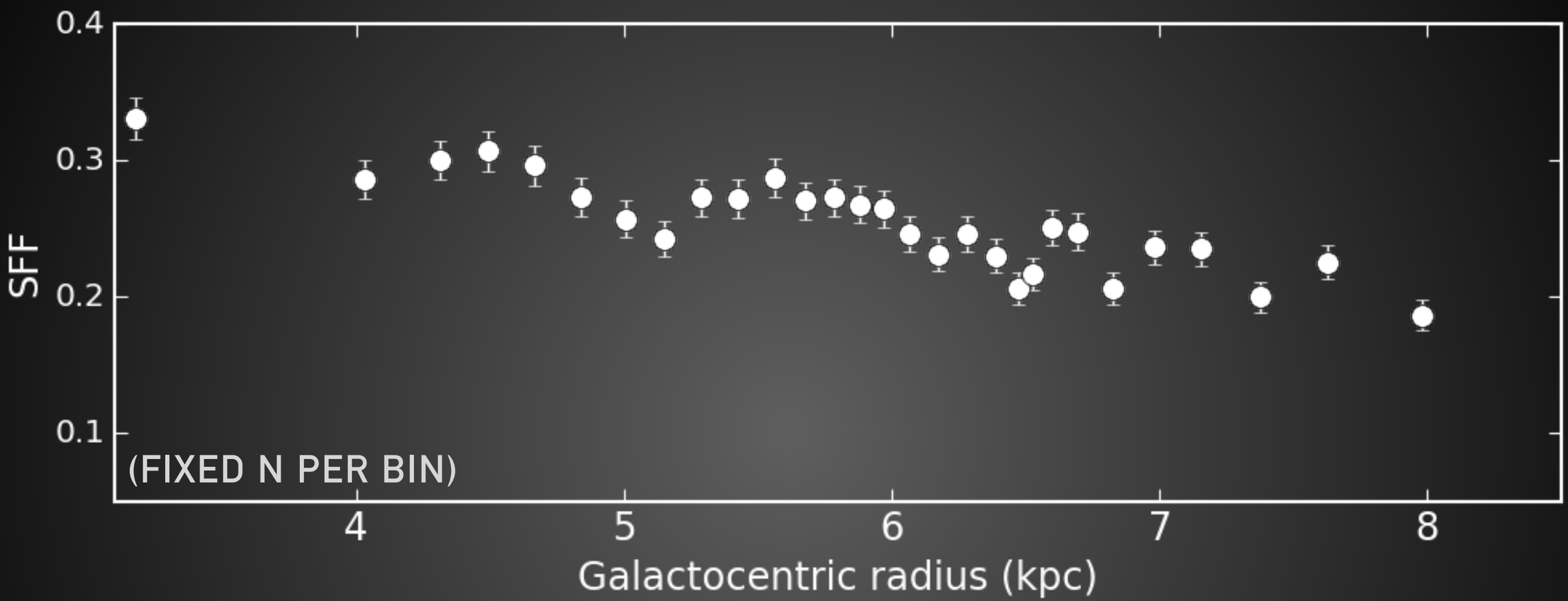
300pc

Ragan et al. (to be submitted)

SUMMARY: SFF AT SPIRAL ARM TANGENTS

- Weak / no evident patterns of clump evolutionary stage near tangent lines of sight (Ragan et al., to be submitted)
  - Spiral arms accumulate clouds but show no strong evidence of enhanced star formation per unit mass
  - Agrees with previous studies (e.g. Moore et al. 2012, Eden et al. 2012, 2013, Urquhart et al. 2014)

SFF VS GALACTOCENTRIC RADIUS



Ragan et al. (2016)

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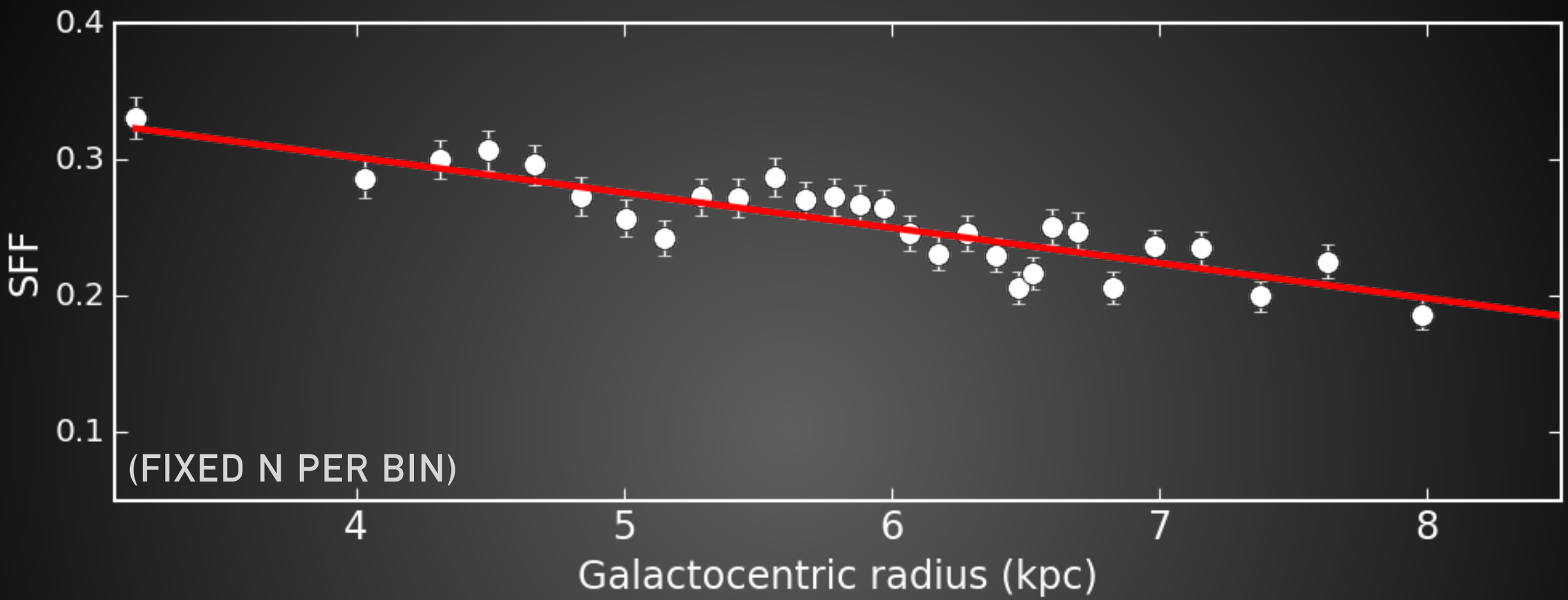
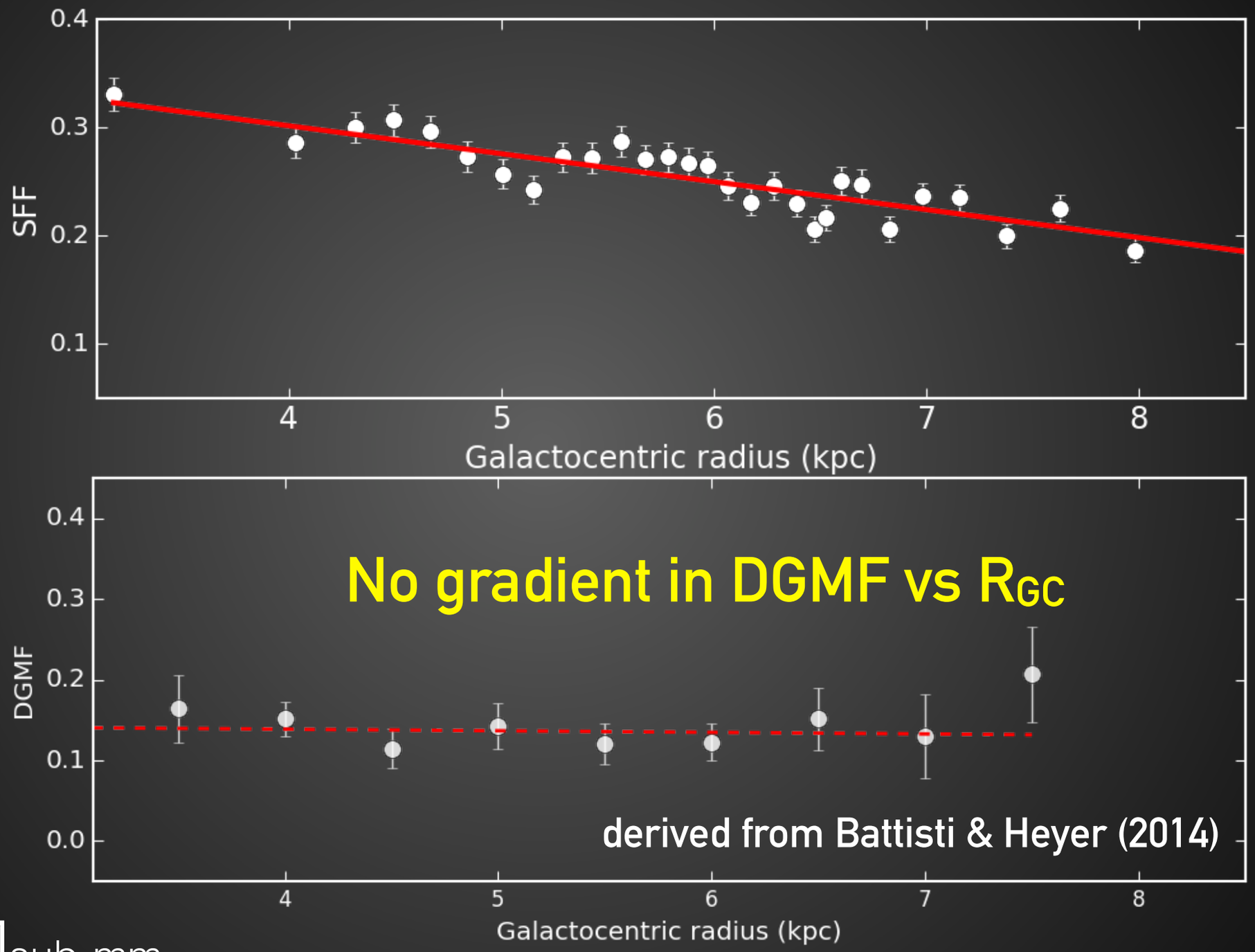


$$SFF = (0.406 \pm 0.003) - (\mathbf{0.026} \pm 0.002)R_{GC}$$

$$\rho_s = -0.91$$

Ragan et al. (2016)

SFF & DGMF VS GALACTOCENTRIC RADIUS

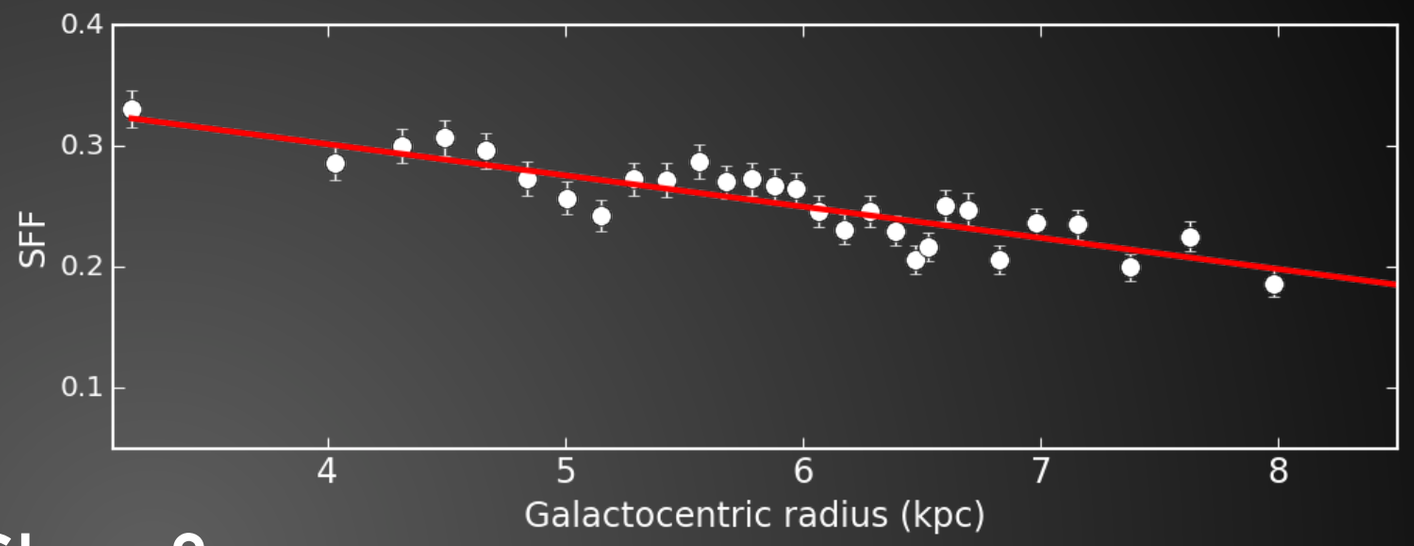


$$\text{DGMF} = \frac{M_{\text{sub-mm}}}{M_{^{13}\text{CO}}}$$

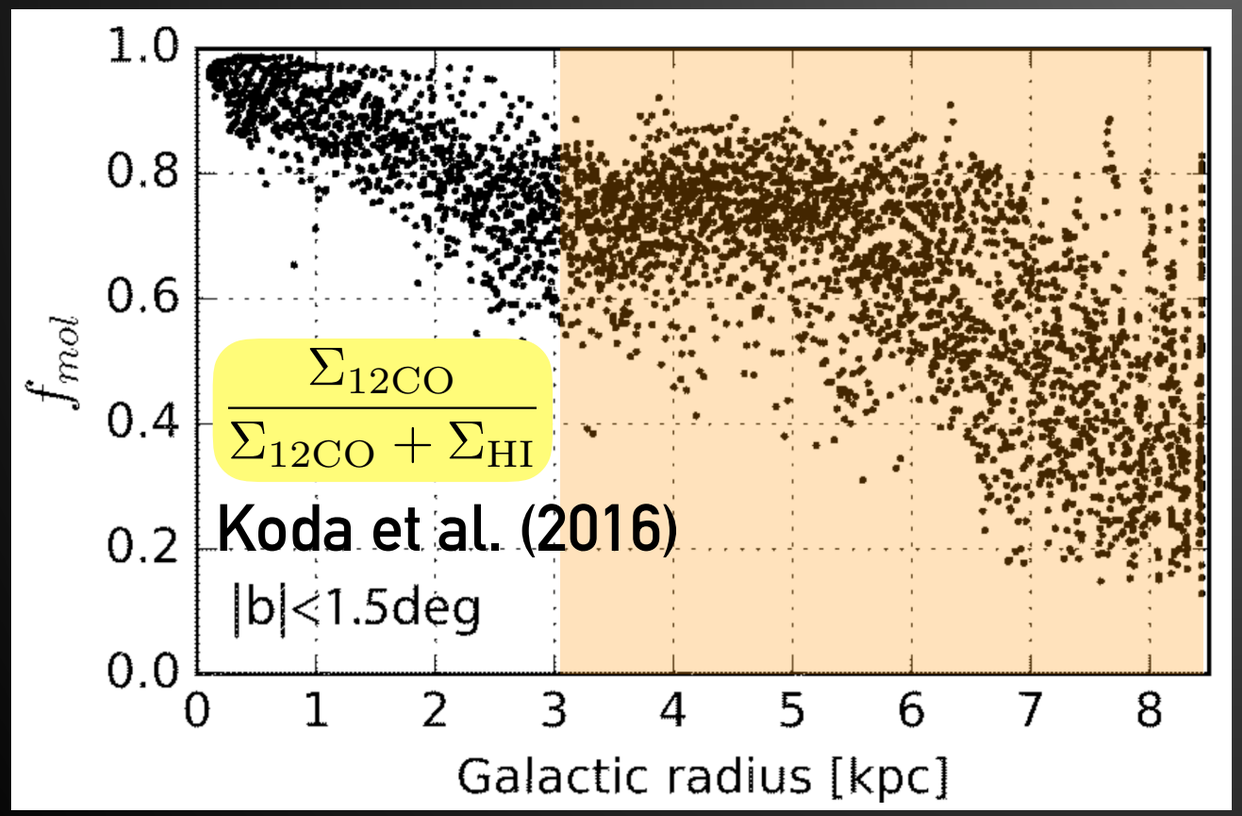
Ragan et al. (2016)

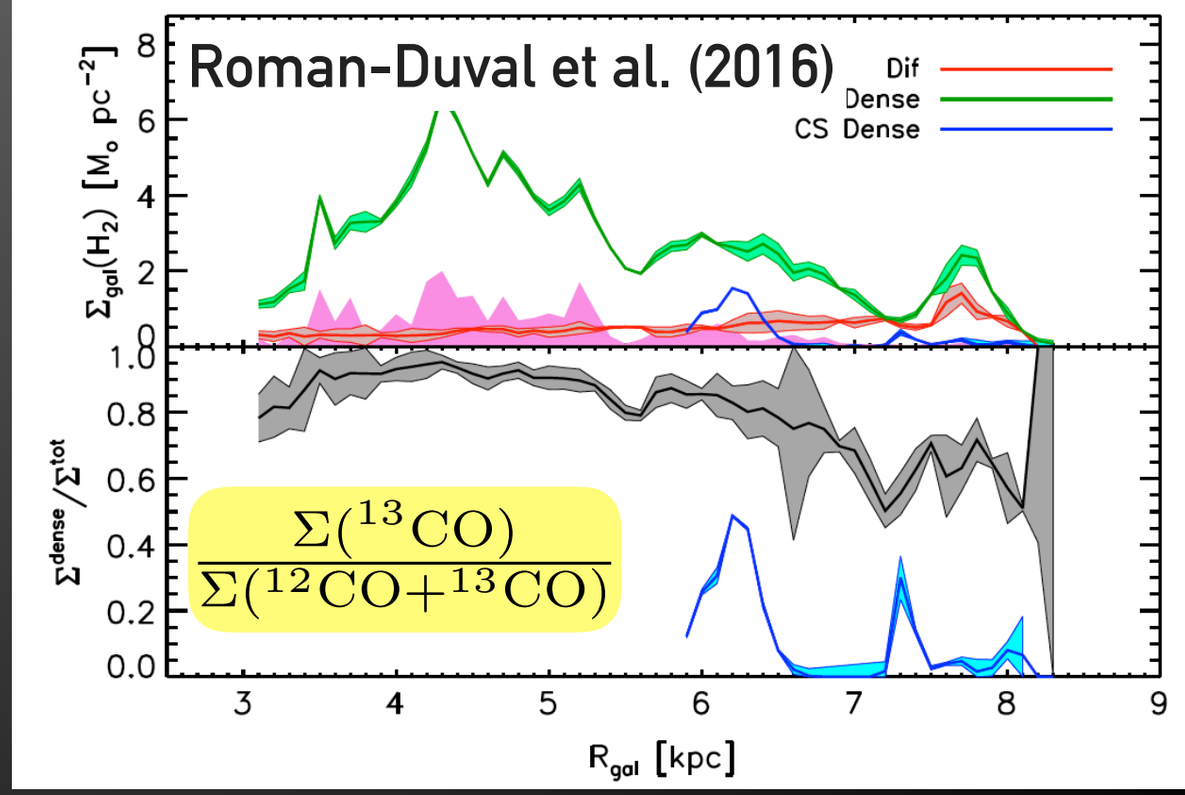
LARGE SCALE GRADIENTS IN THE MILKY WAY

Is the SFF set by large-scale physical conditions?



ISRF? Metallicity? Shear?





Ragan et al. (2016)

SUMMARY

- Weak / no evident patterns of clump evolutionary stage near tangent lines of sight (Ragan et al., to be submitted)
  - Spiral arms accumulate clouds but show no strong evidence of enhanced star formation per unit mass
  - Agrees with previous studies (e.g. Moore et al. 2012, Eden et al. 2012, 2013, Urquhart et al. 2014)
- We observe a robust gradient in SFF with R_{GC} in the inner Galaxy (3kpc < R_{GC} < 8kpc) of -2.6%/kpc (Ragan et al. 2016)
  - Dense Gas Mass Fraction does not vary with R_{GC}
  - Is the SFF determined by / inherited from large-scale physics?