Magnetic fields in HVCs

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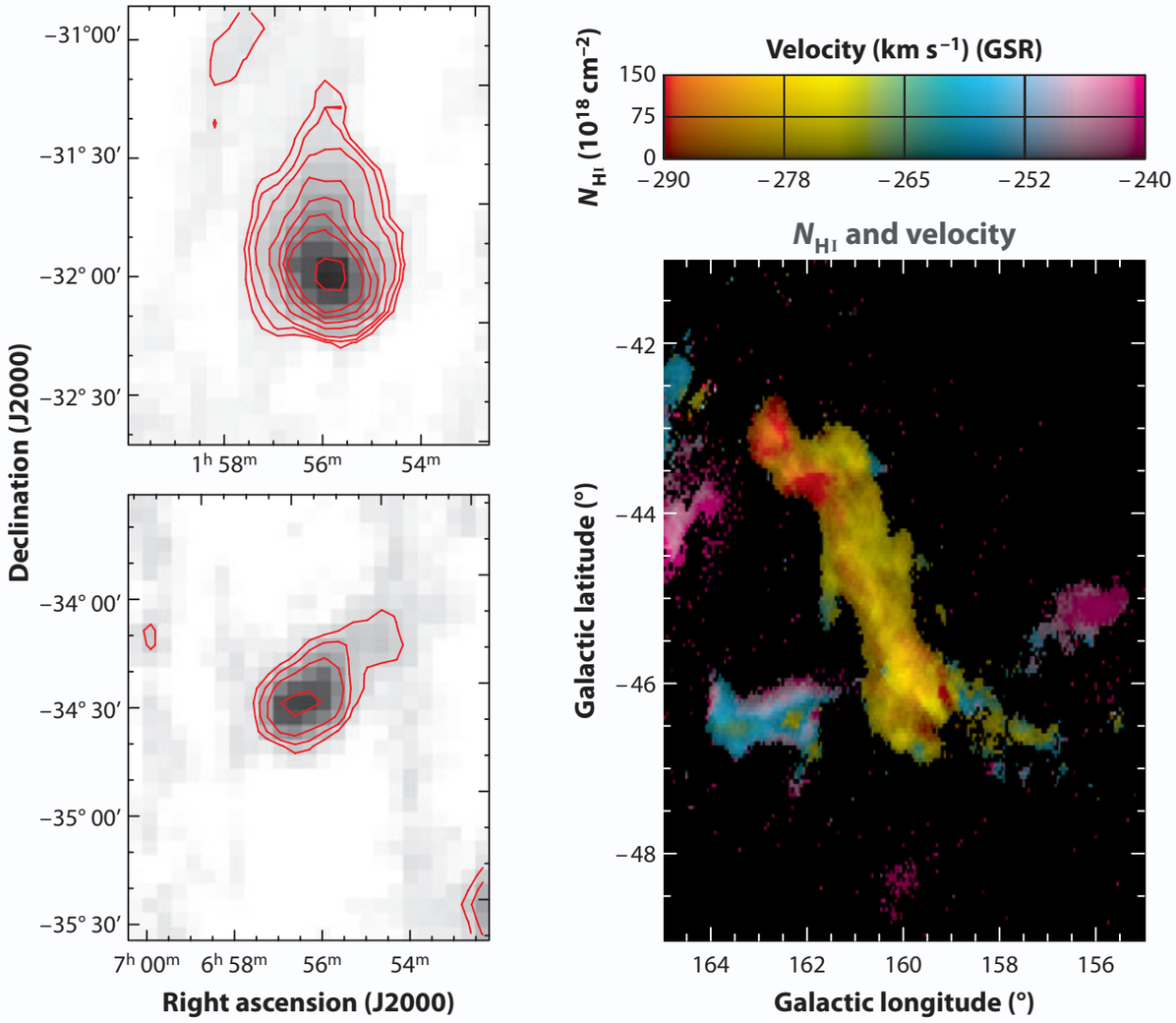
Cloud lifetime



Putman, Peek, & Joung (2012 ARA&A)
Putman, Saul, & Mets (2011 MNRAS)
Peek et al (2007 ApJ)

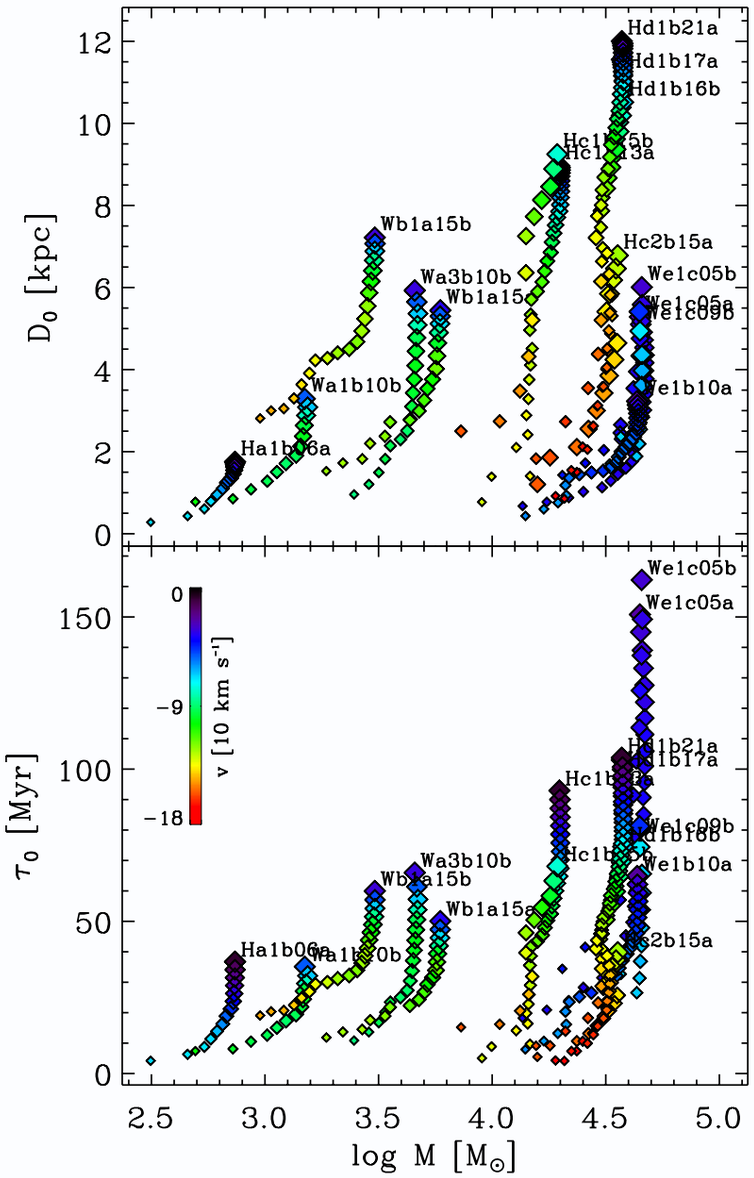


Figure 5. Distance D_0 and timescale τ_0 within which a cloud of given mass will lose its total H I content. Each "track" represents the time sequence of one model, with each point indicating D_0 or τ_0 of the largest fragment (see Equations (3) and (4) and text). Thus, the disruption rate dM/dt increases over time. Colors denote the cloud velocities, showing that faster clouds are shorter-lived. Symbol sizes indicate model times, with large symbols for early times and small ones for late times. Note that D_0 is not a distance above the plane, but a disruption length scale.

Heitsch & Putman (2009 ApJ)

Magnetic fields

Hydrodynamics: HVCs should lose much of their neutral H before reaching the disk

- Magnetic fields could stabilise clouds
- Few numerical simulations (Konz et al 2002, Santillan et al 2004) or observations to date

Measure rotation measure using Faraday rotation

- RM $\propto \int n_e B_{||} ds$

Rotation measure

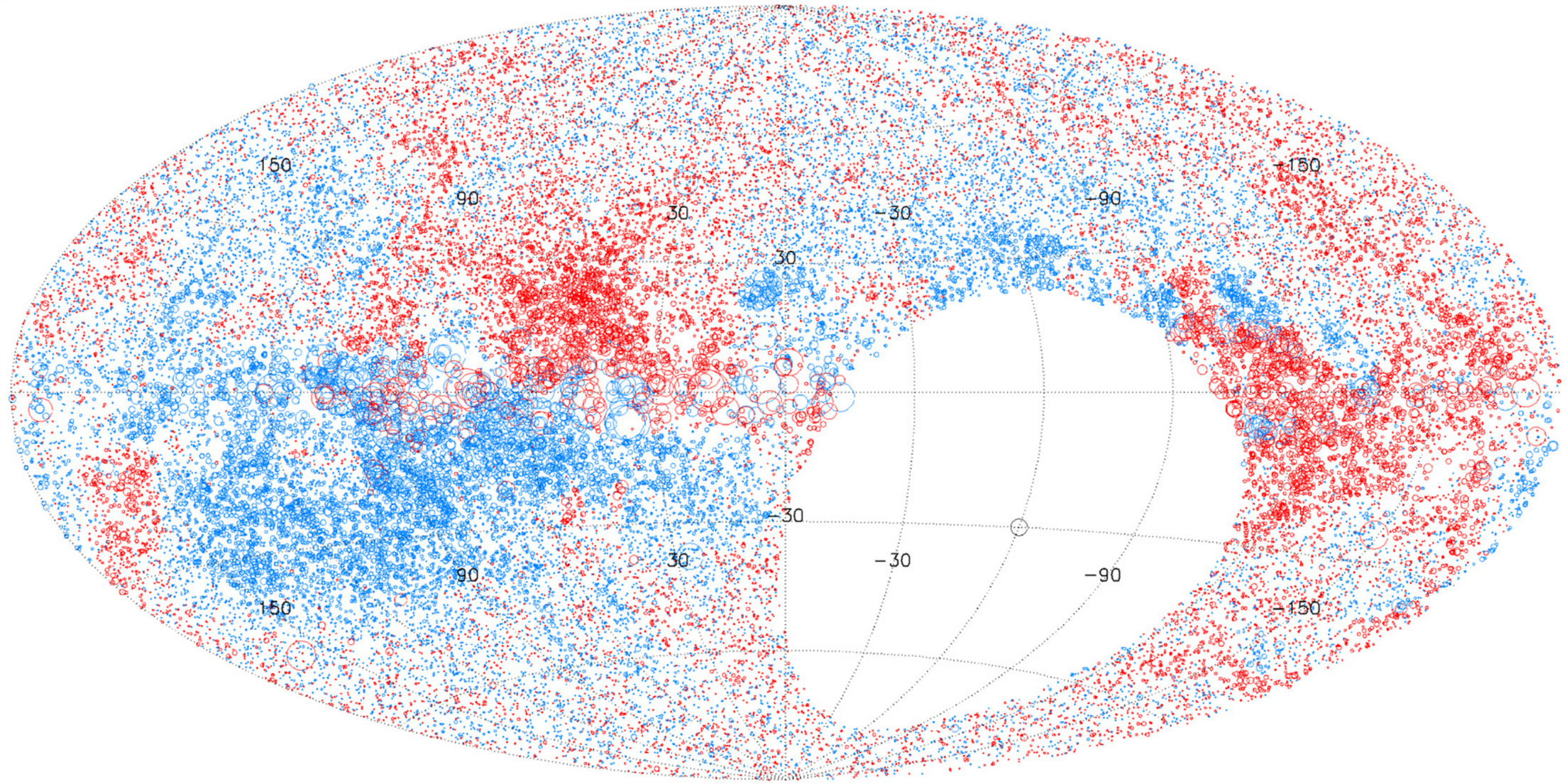


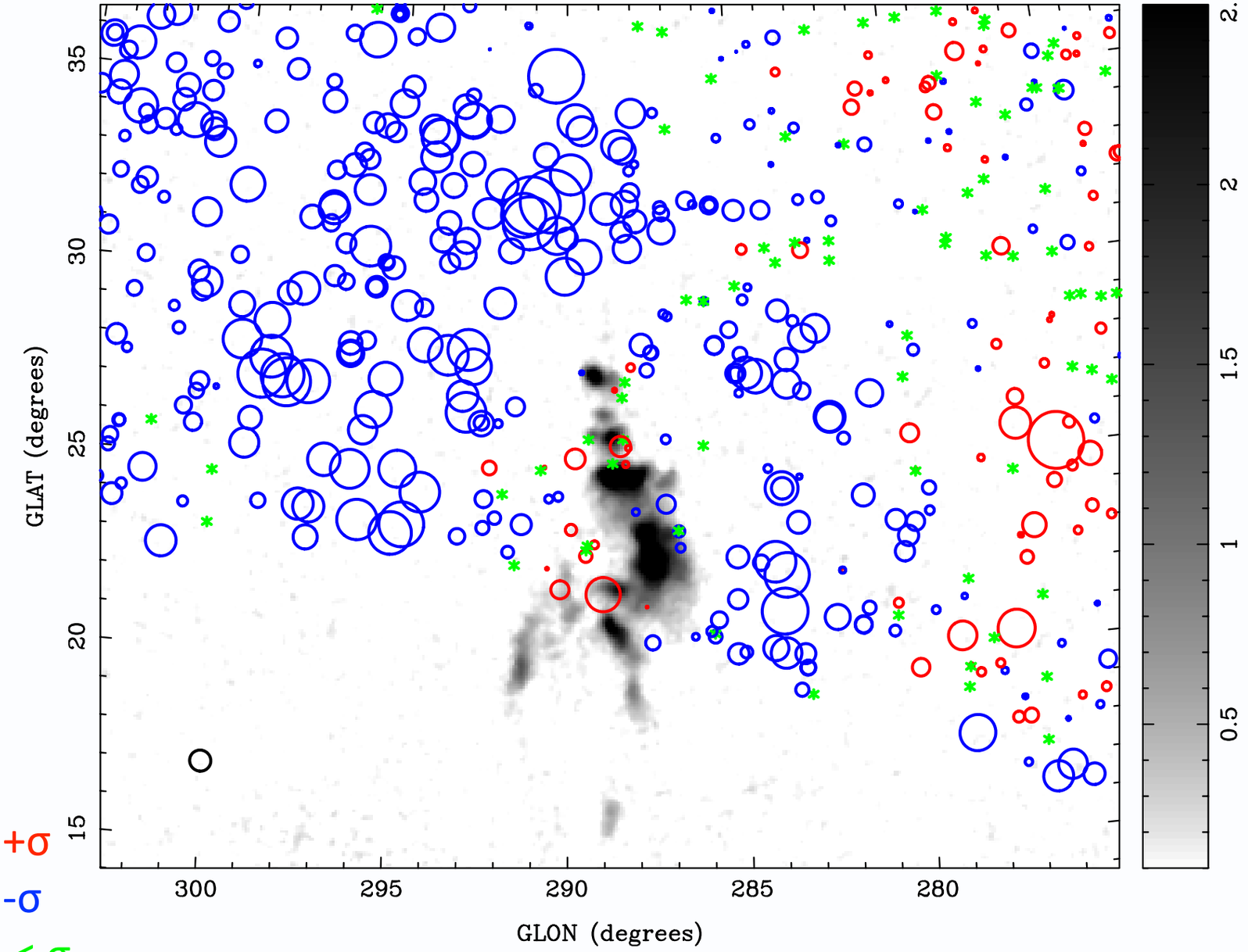
Figure 3. Plot of 37,543 RM values over the sky north of $\delta = -40^\circ$. Red circles are positive rotation measure and blue circles are negative. The size of the circle scales linearly with magnitude of rotation measure.

Faraday rotation towards extragalactic point sources from NVSS, $p > 0.4$ mJy
Taylor et al (2009 ApJ)

HVC287.5+22.5+240

HVC in Leading Arm of Magellanic System

- Head-tail morphology



H I

RM > +σ

RM < -σ

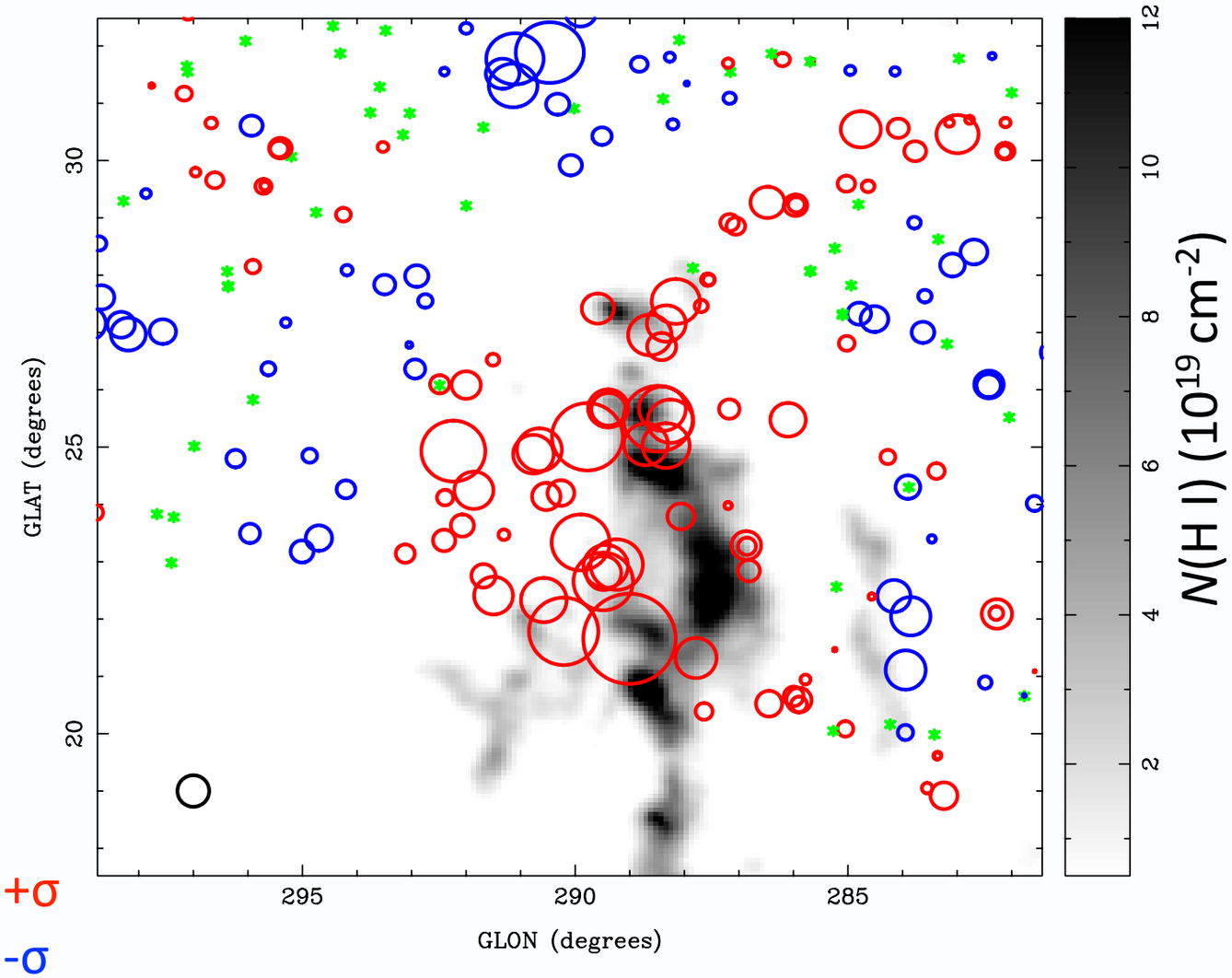
|RM| < σ

McClure-Griffiths et al (2010 ApJ)

HVC287.5+22.5+240

Estimate magnetic field

- WHAM Hα: EM < 0.09 pc cm^{-6}
  - with assumptions,
    $N(H^+) \lesssim 3.6 \times 10^{19}$ cm^{-2}
  - N(H I) > 2×10^{19} cm^{-2}
- RM $\propto n_e B_{||} L$ implies $B_{||} \gtrsim +6$ μG (towards observer)



H I

$RM_{HVC} > +\sigma$

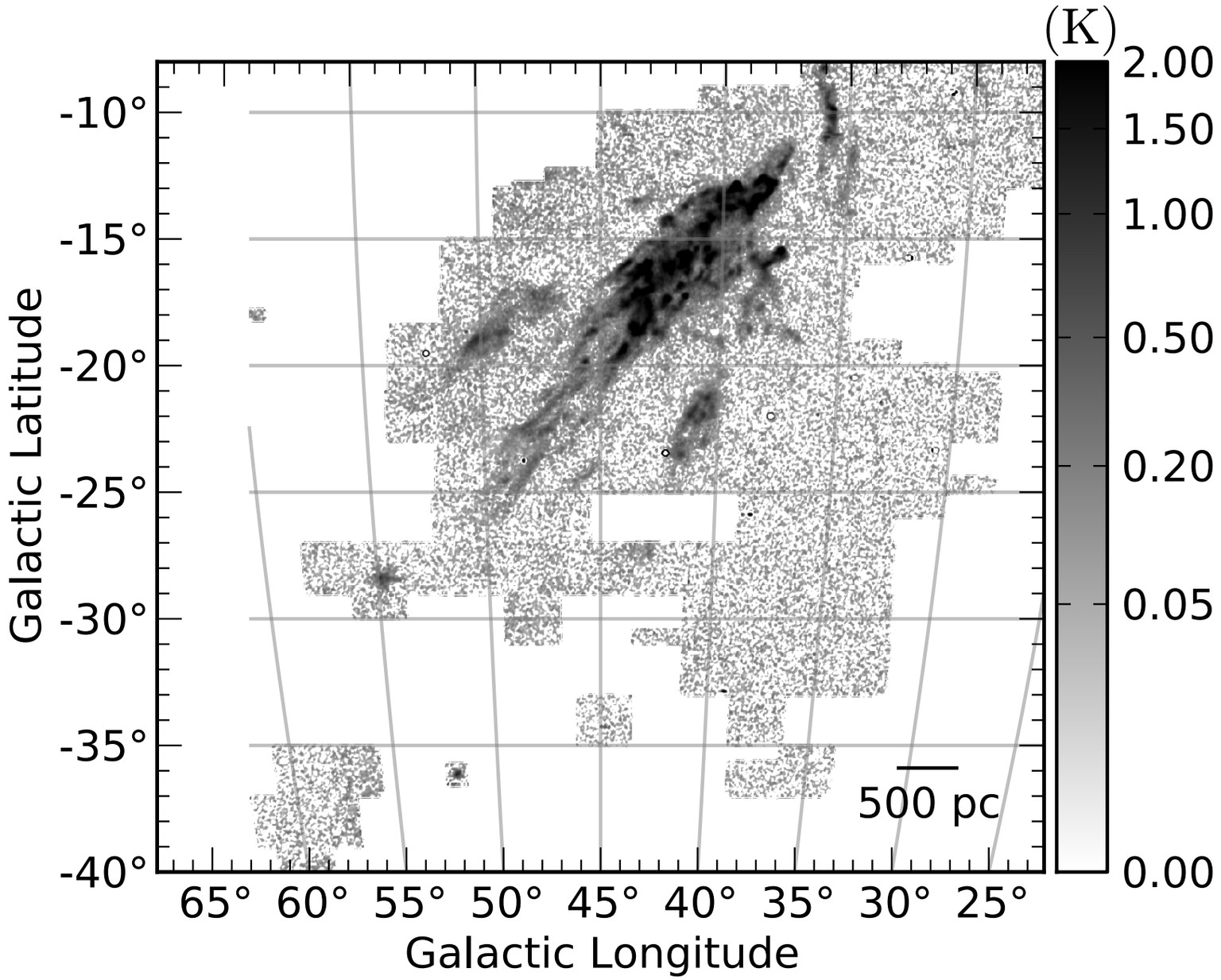
$RM_{HVC} < -\sigma$

$|RM_{HVC}| < \sigma$

McClure-Griffiths et al (2010 ApJ)

Smith Cloud

H I v_{GSR} = +247 km/s
(v_{LSR} = +100 km/s at head)



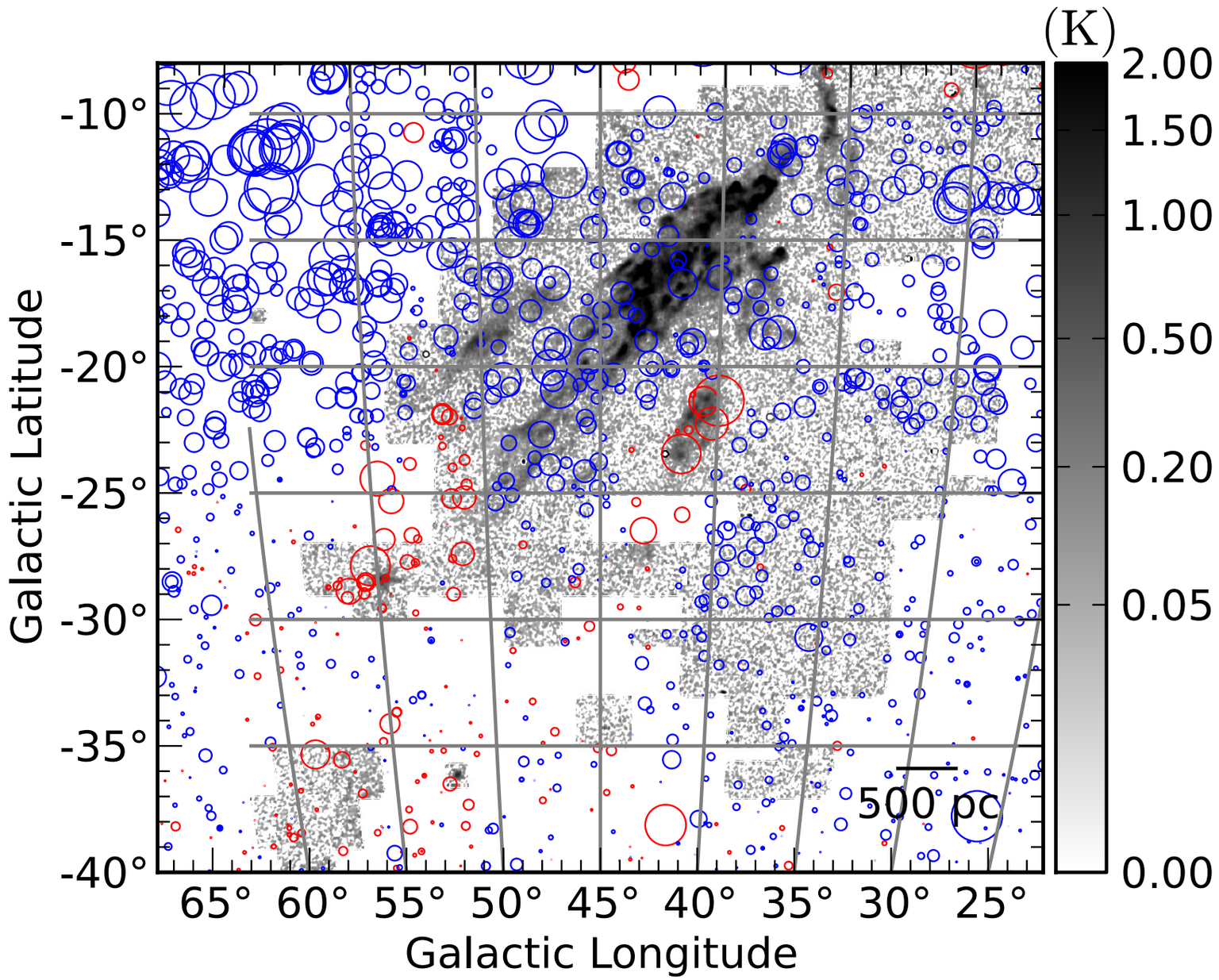
Hill, Benjamin, Mao, Lockman, & McClure-Griffiths in prep

Smith Cloud

H I v_{GSR} = +247 km/s
(v_{LSR} = +100 km/s at head)

RM > 0

RM < 0



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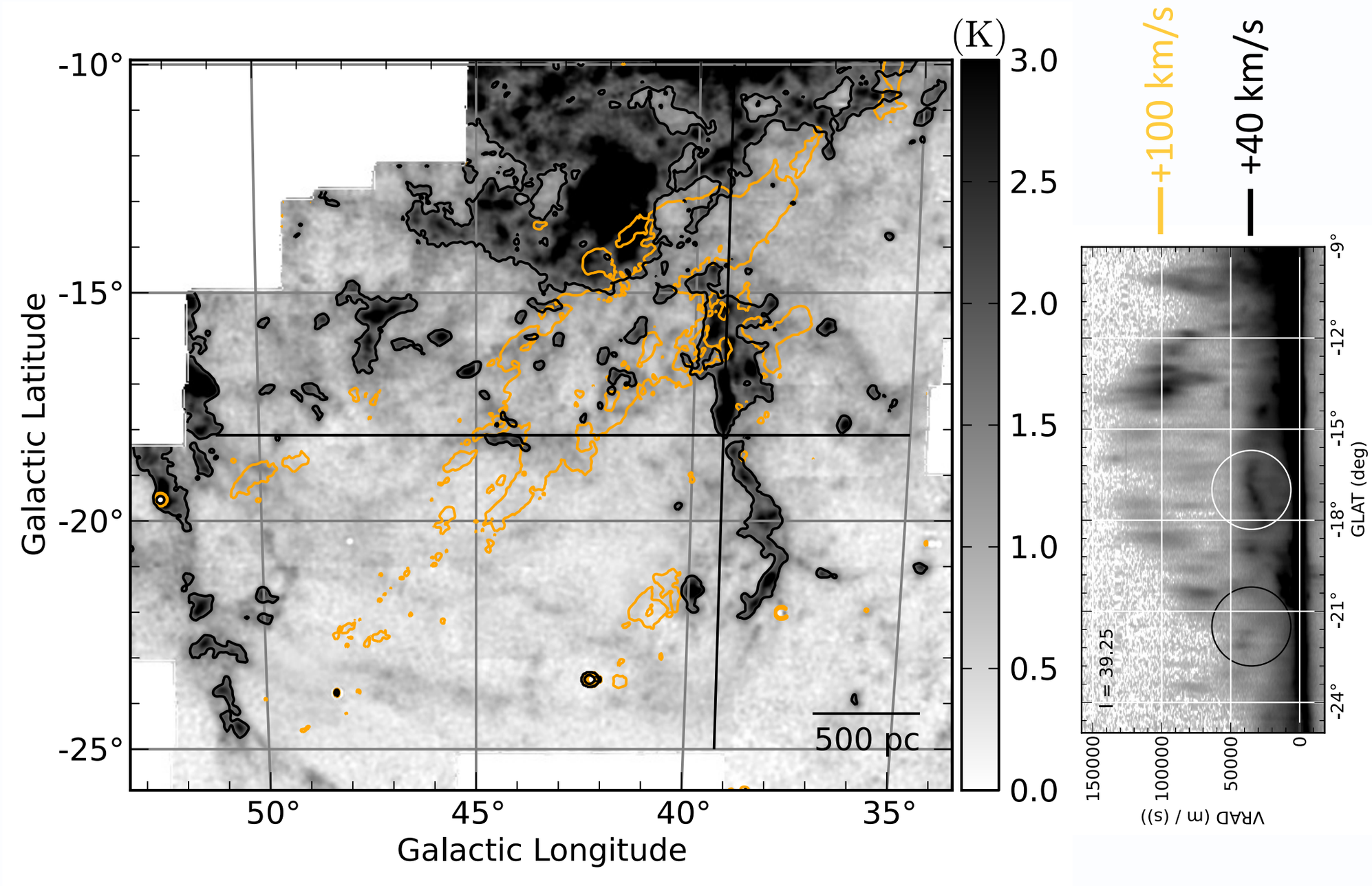
Decelerated gas



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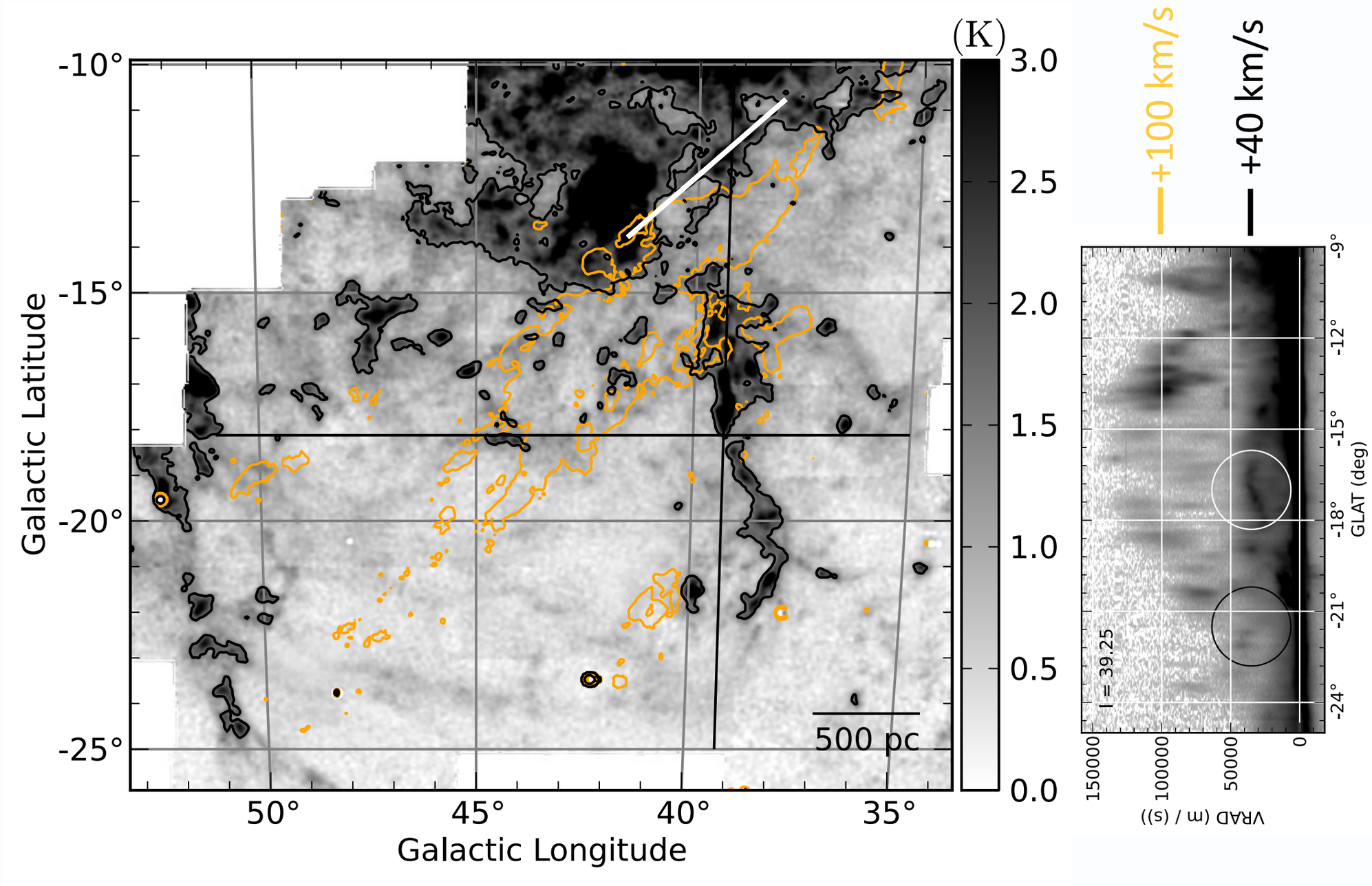

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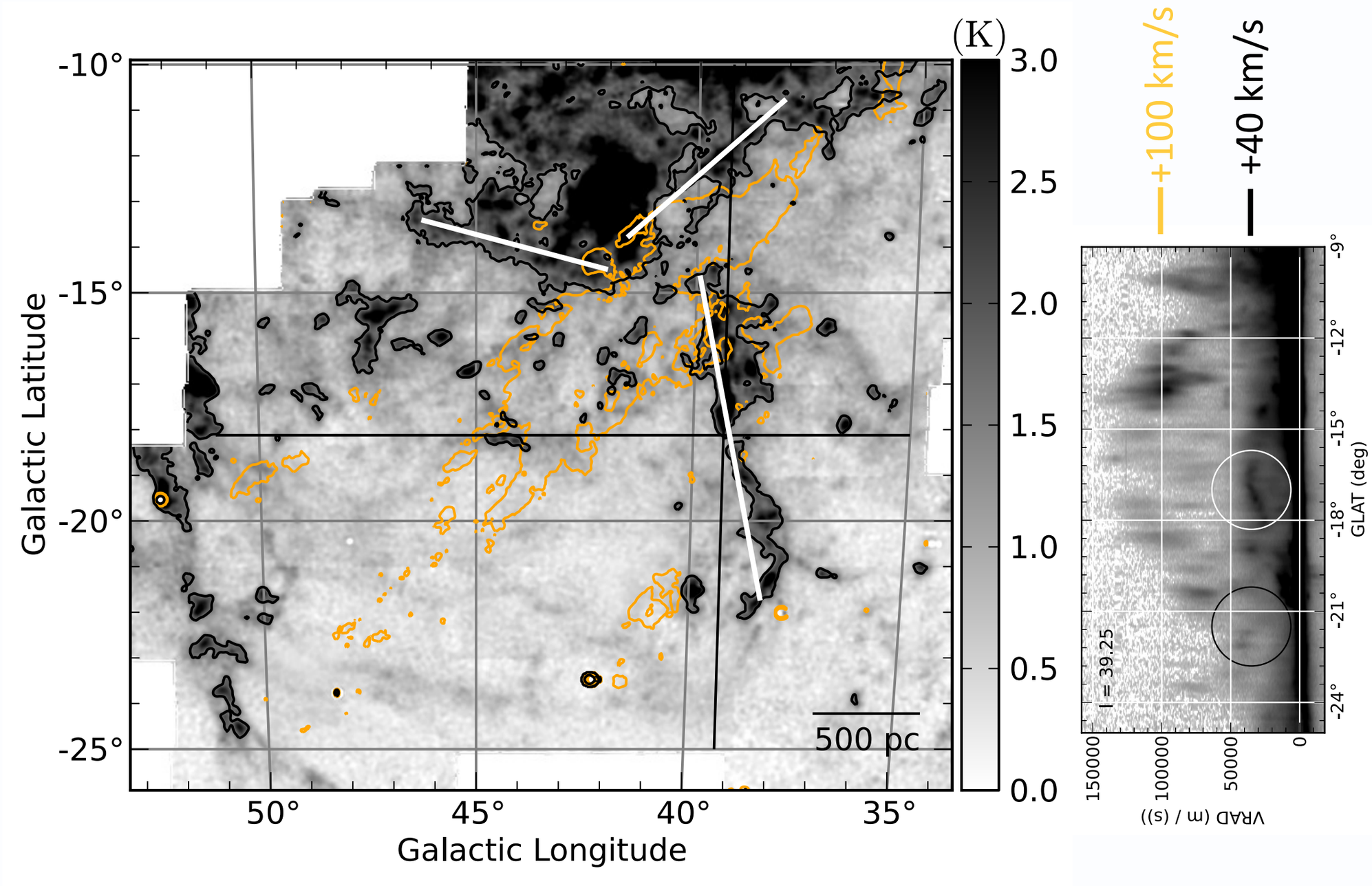

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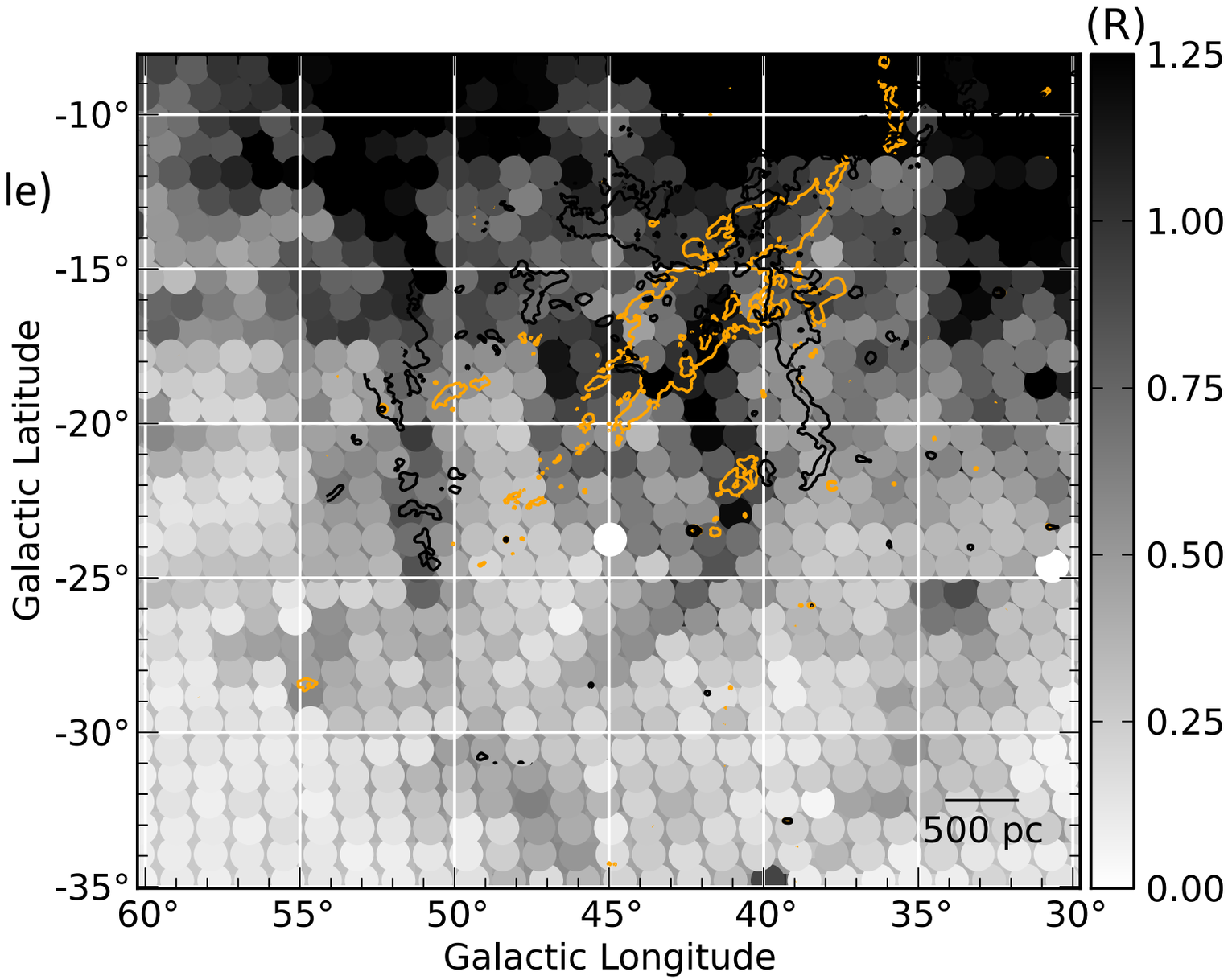
Hα, H I, and RMs

+40 km/s H I
+100 km/s H I
+40 km/s WHAM-NSS Hα (grayscale)



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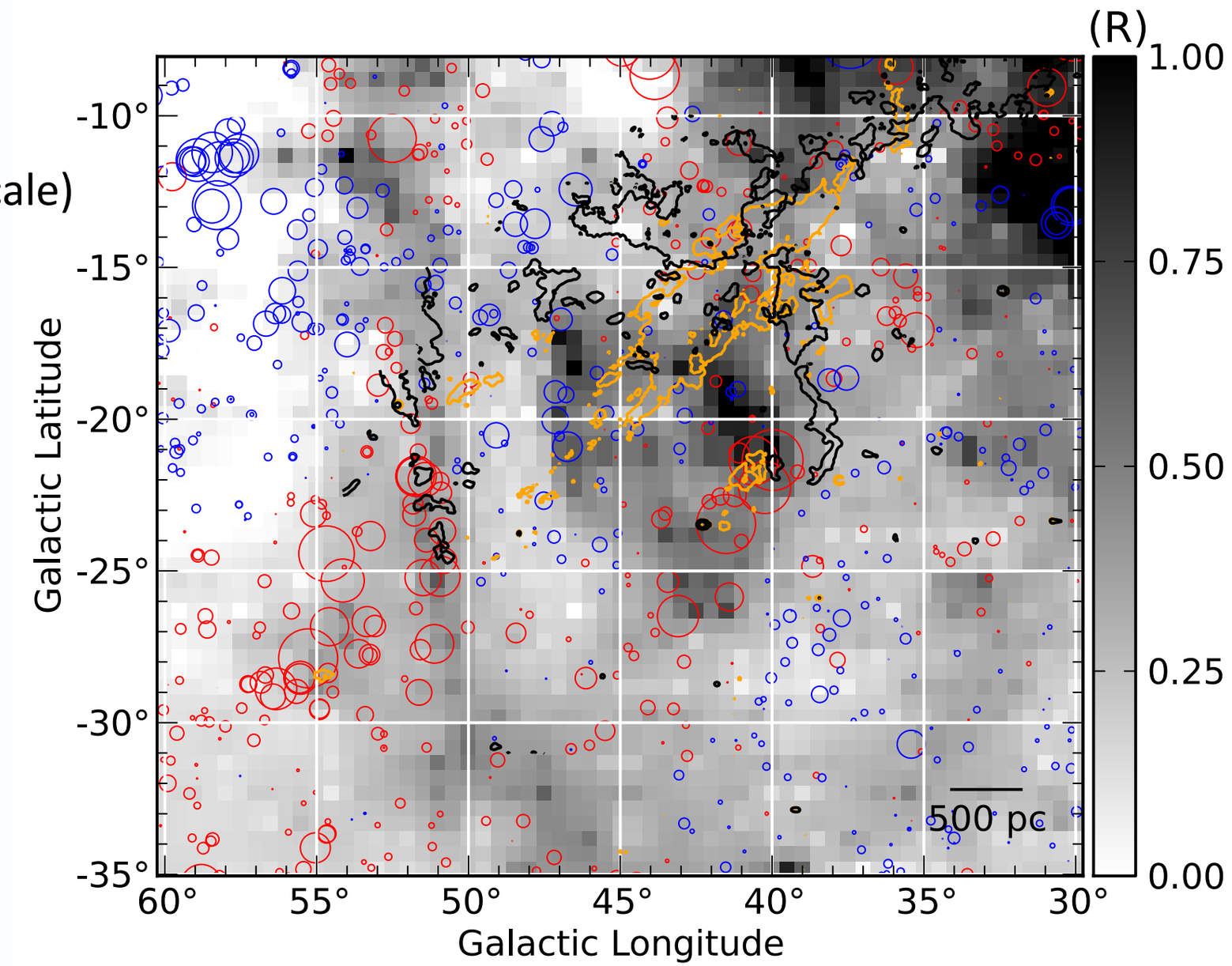

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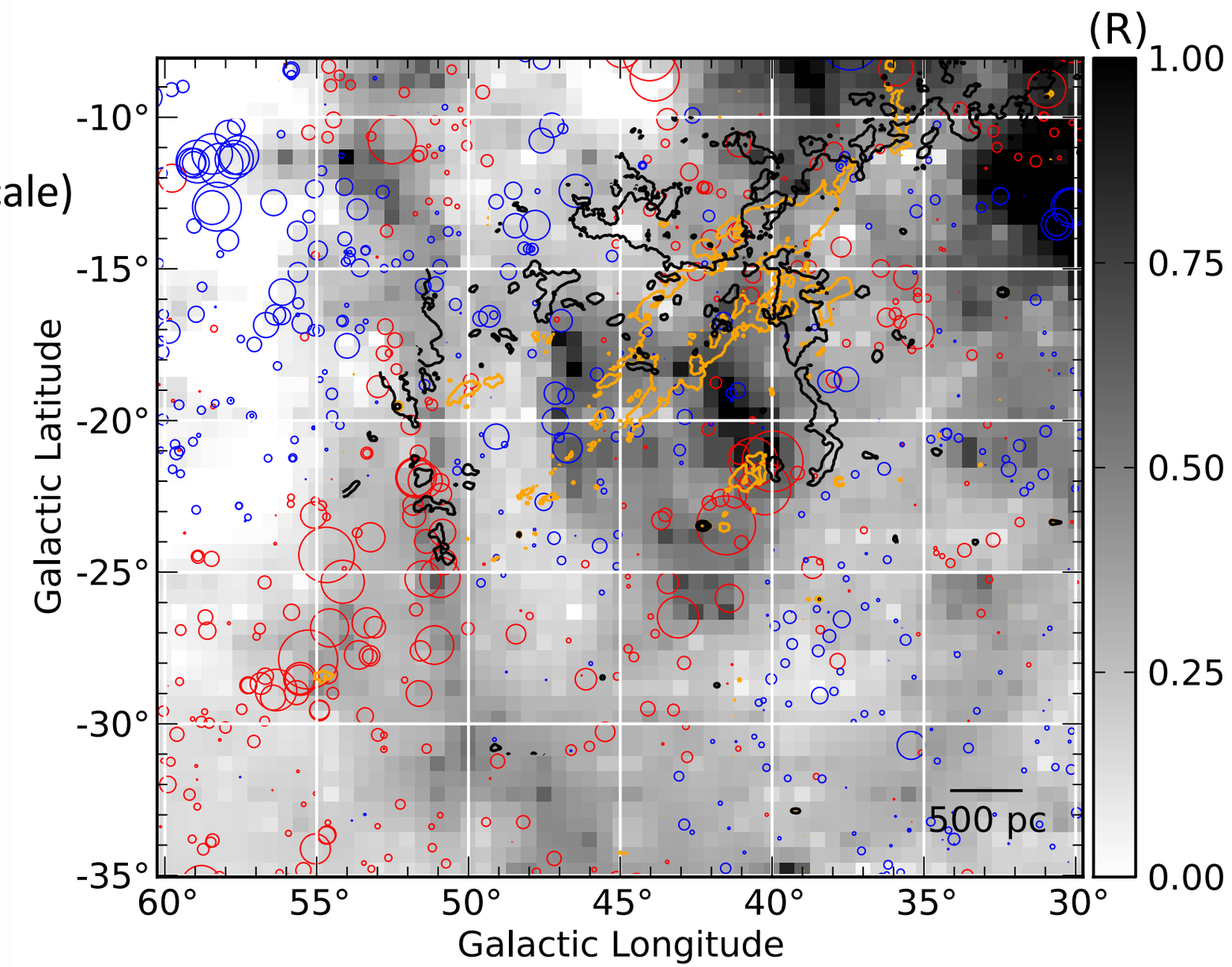
$$n_e \approx \sqrt{\frac{\mathrm{EM}}{L_{\mathrm{H^+}}}}$$

$$B_{||} \approx \frac{\mathrm{RM}}{0.81 n_e L_{\mathrm{H^+}}} = \frac{\mathrm{RM}}{0.81 (L_{\mathrm{H^+}} \mathrm{EM})^{1/2}}$$



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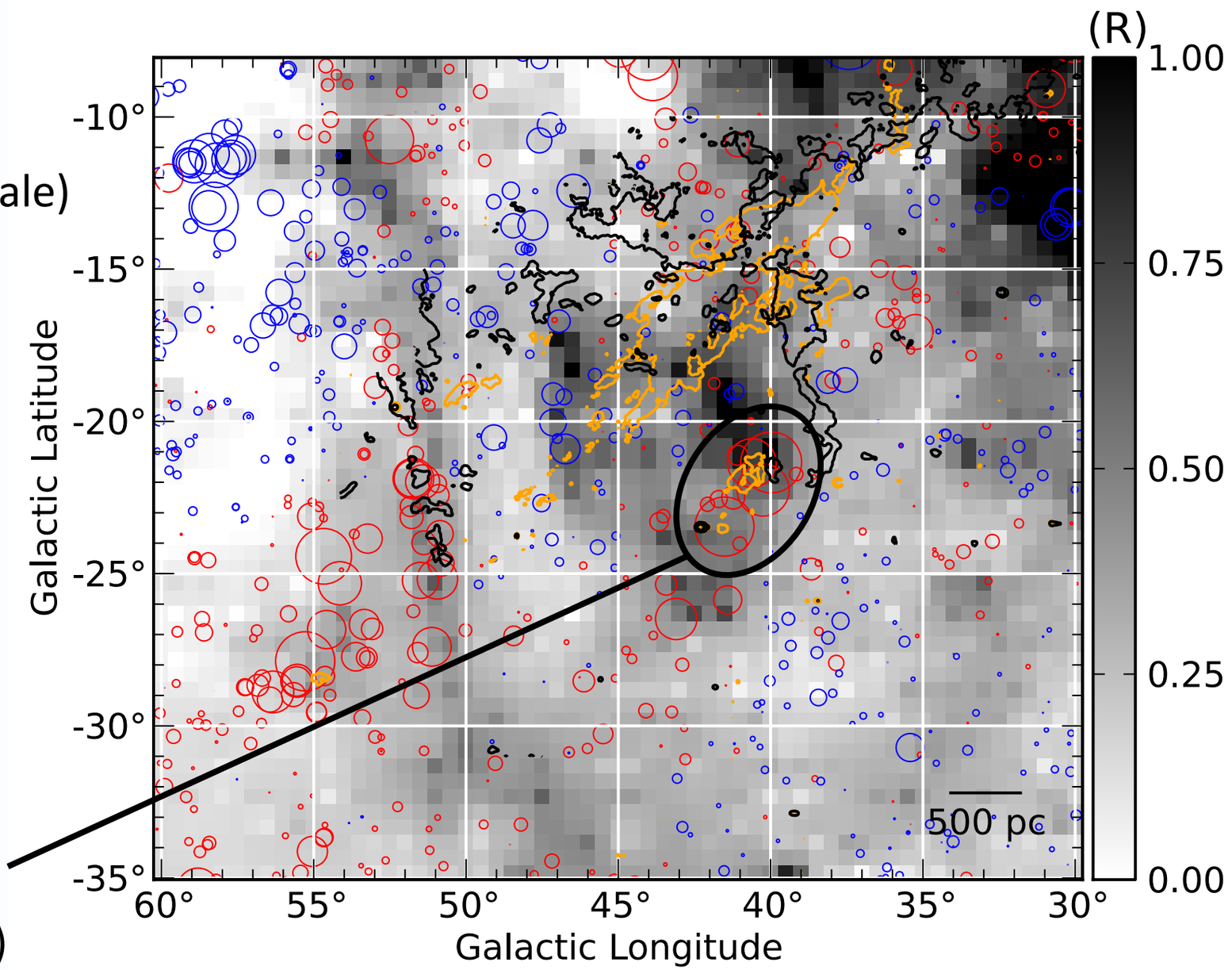
$\langle RM \rangle = 95$ rad m^{-2} (σ =23 rad m^{-2})

$\langle EM \rangle = 1.1$ pc cm^{-6} (σ=0.7 pc cm^{-6})

$B_{||} \geq +6$ μG (towards observer)



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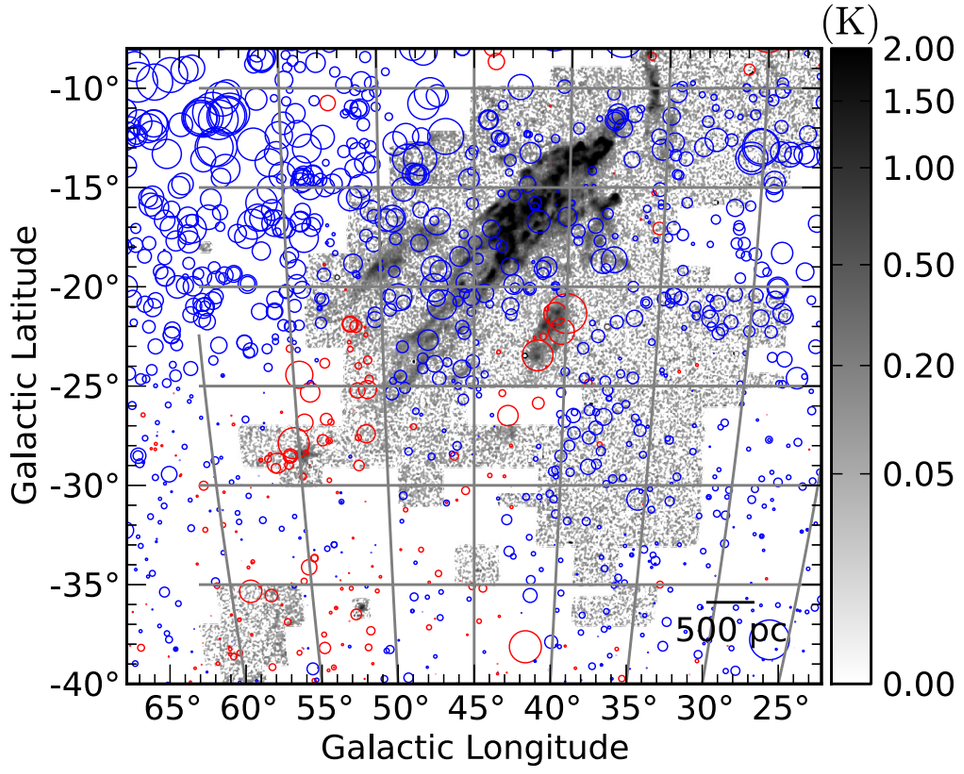
Conclusions

RM signature evident in two HVCs

- Correlated with H I emission from HVC 287.5+22.5+240 in Leading Arm
  - non-detection of Hα
- Correlated with decelerated H I and Hα in Smith Cloud
  - not correlated with (smooth) Hα at Smith Cloud velocity
- lower limit on $B_{||}$ of ≈6 μG in each case
  - $B \sim 4$ μG sufficient to balance ram pressure for Leading Arm HVC



These head-tail HVCs are in very different environments

- Real data for MHD simulations?

Thank you

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