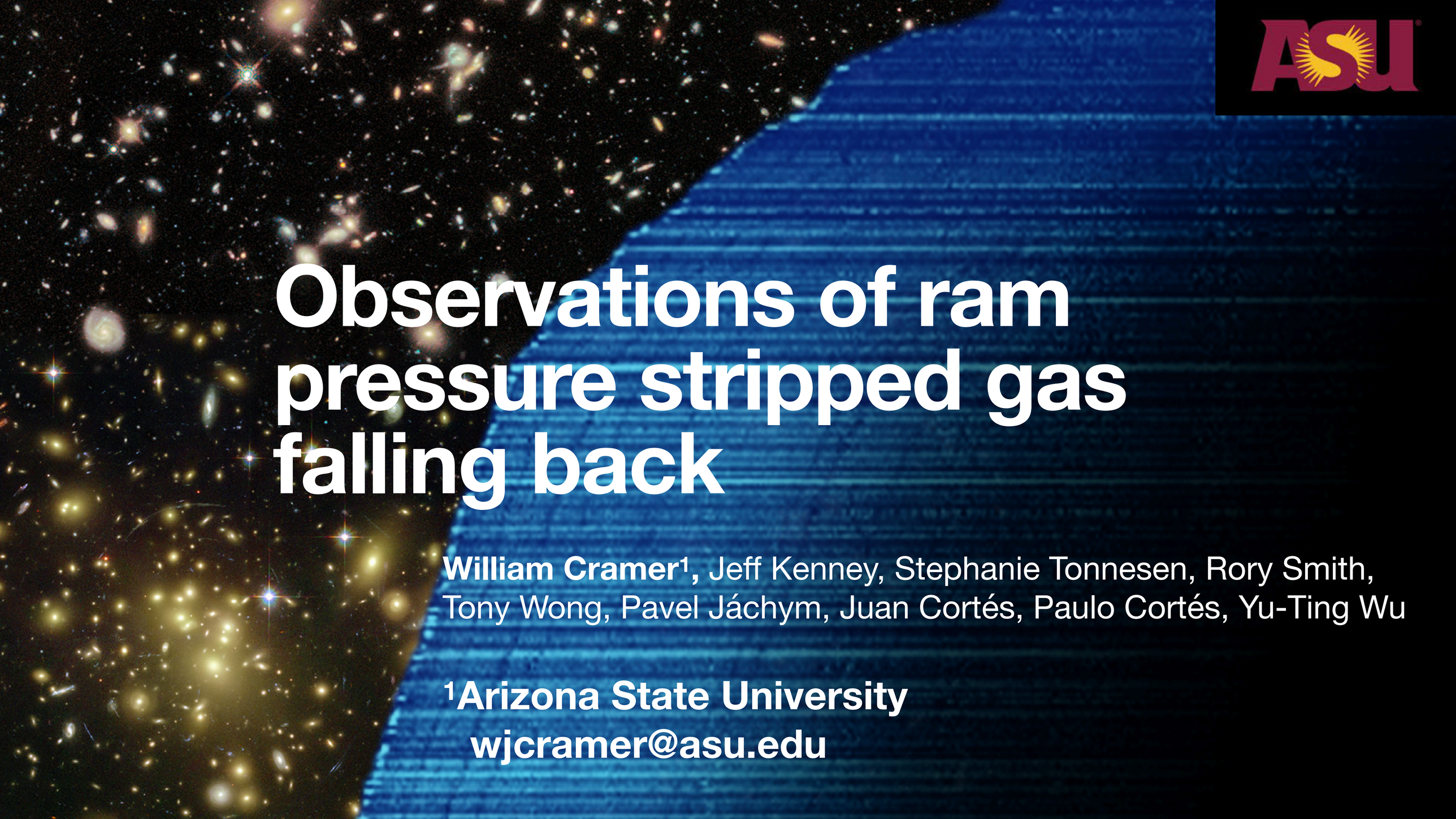

Observations of ram pressure stripped gas falling back

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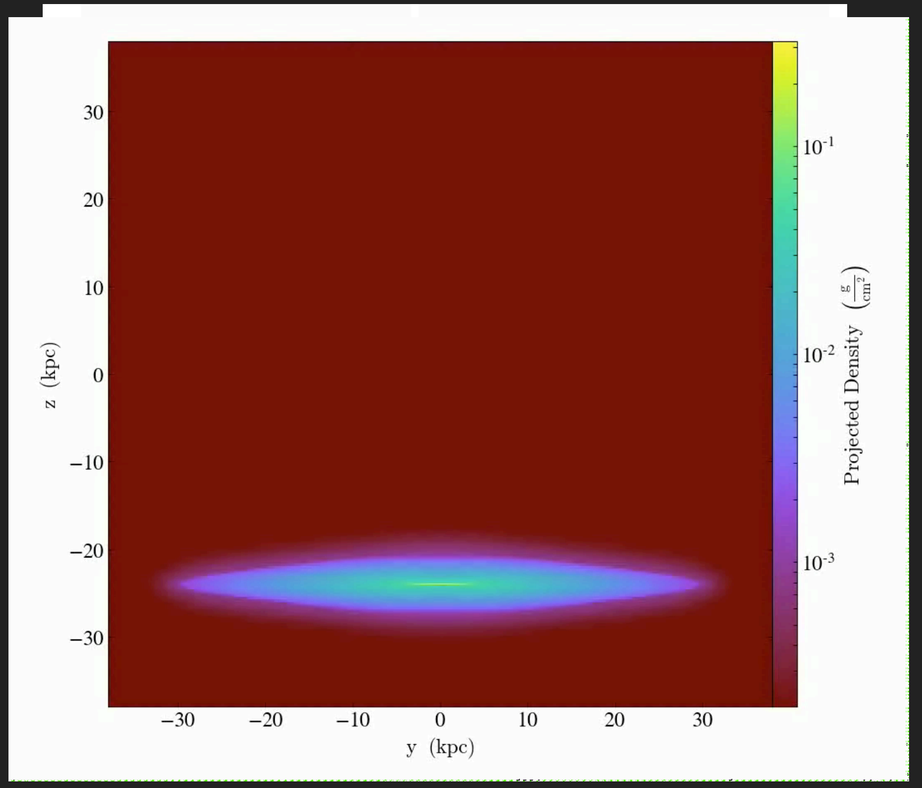
WHAT IS RAM PRESSURE?

- If ram pressure exceeds gravitational potential, gas begins to be accelerated out of the galaxy
- If ram pressure decreases in some cases previously stripped gas can fall back
- How does fallback, and the amount of fallback, affect galaxy quenching, structure, and evolution?

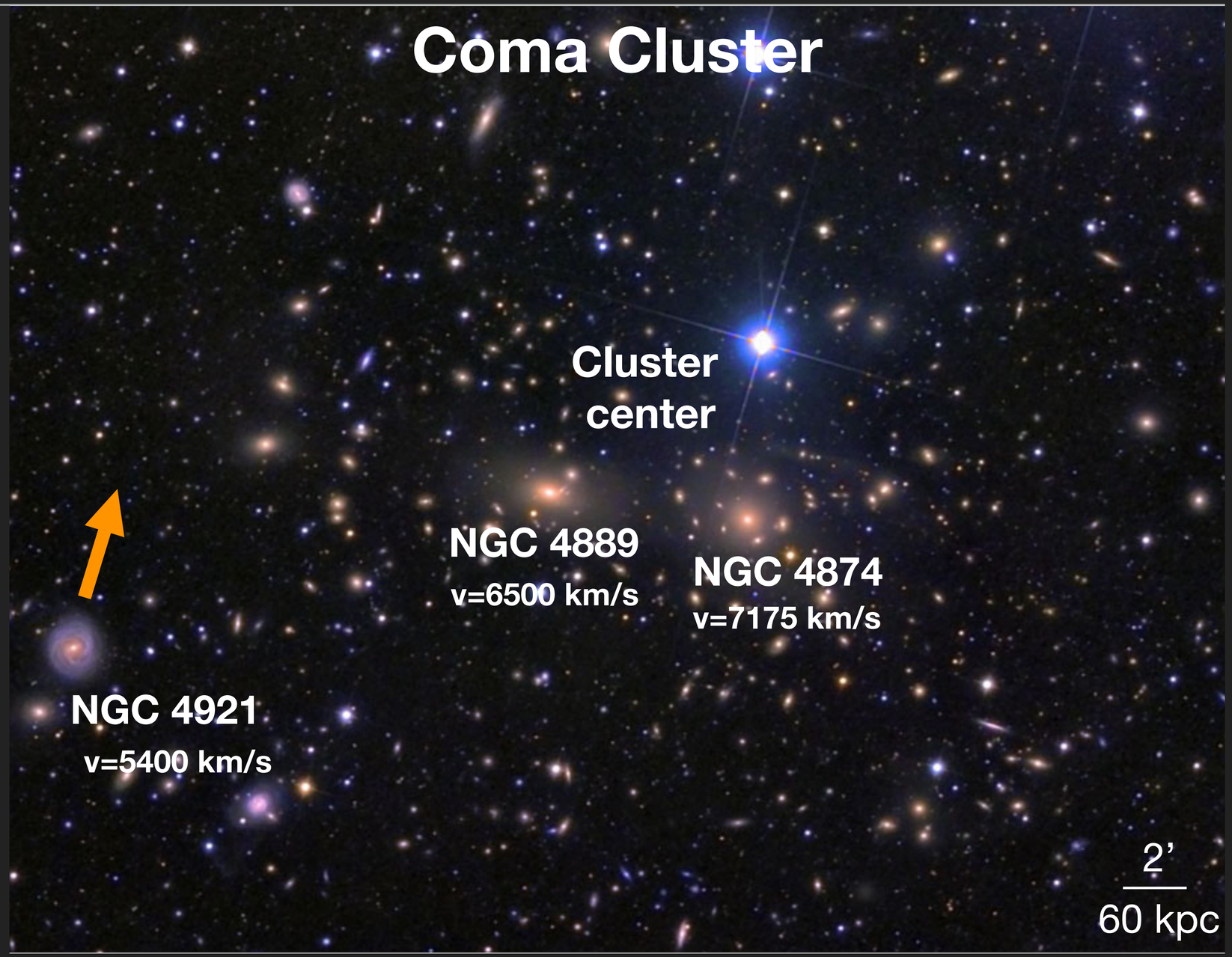
GUNN & GOTT (1972) CRITERIA FOR STRIPPING

$$\rho_{ICM} v^2 \geqslant \Sigma_{ISM} \frac{d\Phi}{dz}$$



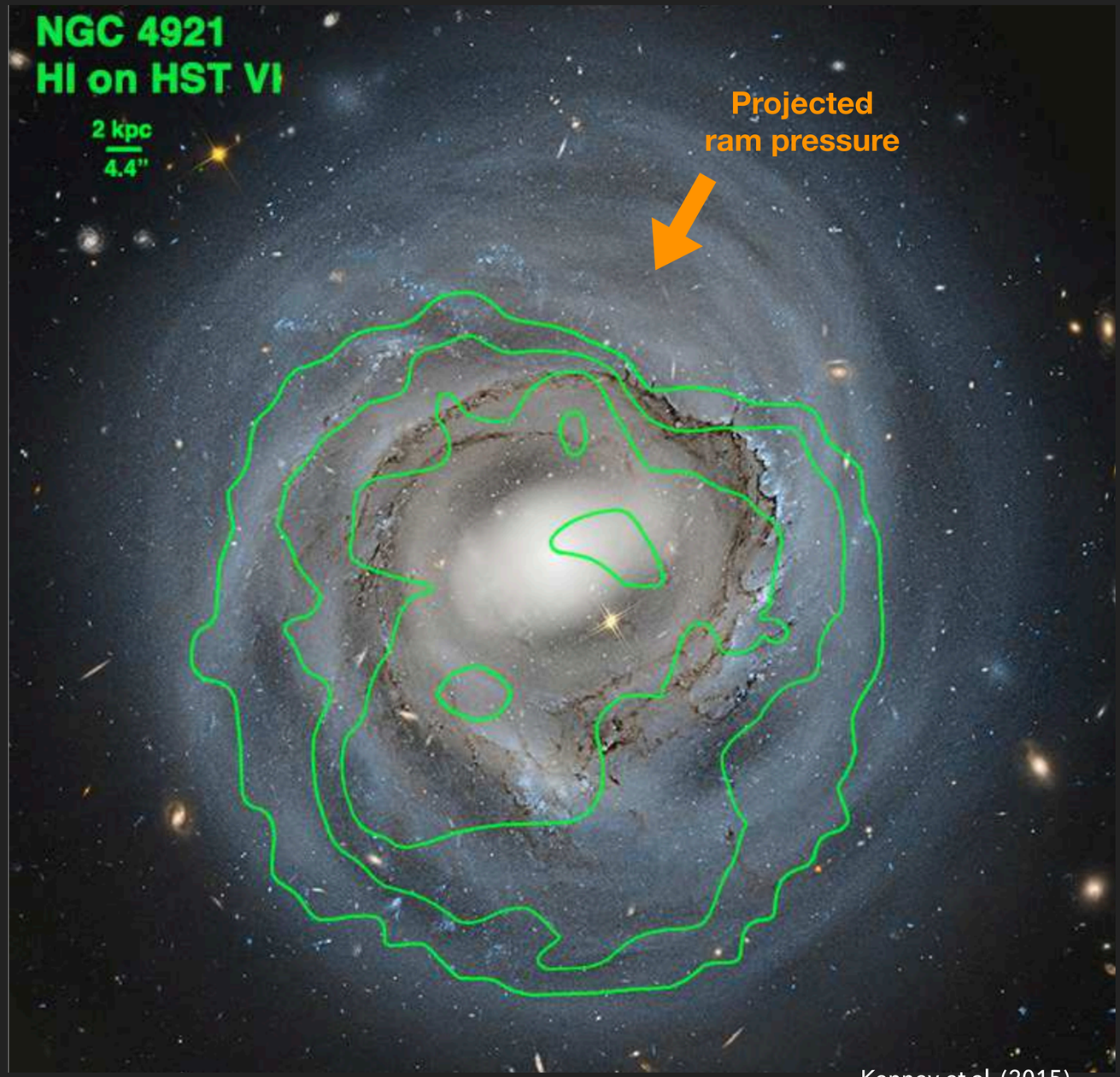
Tonnesen et al. (2010)

- Coma is the nearest massive cluster (10x mass of Virgo)
- NGC 4921 is a massive (MB=-22) spiral, 700 kpc from cluster center



NGC 4921

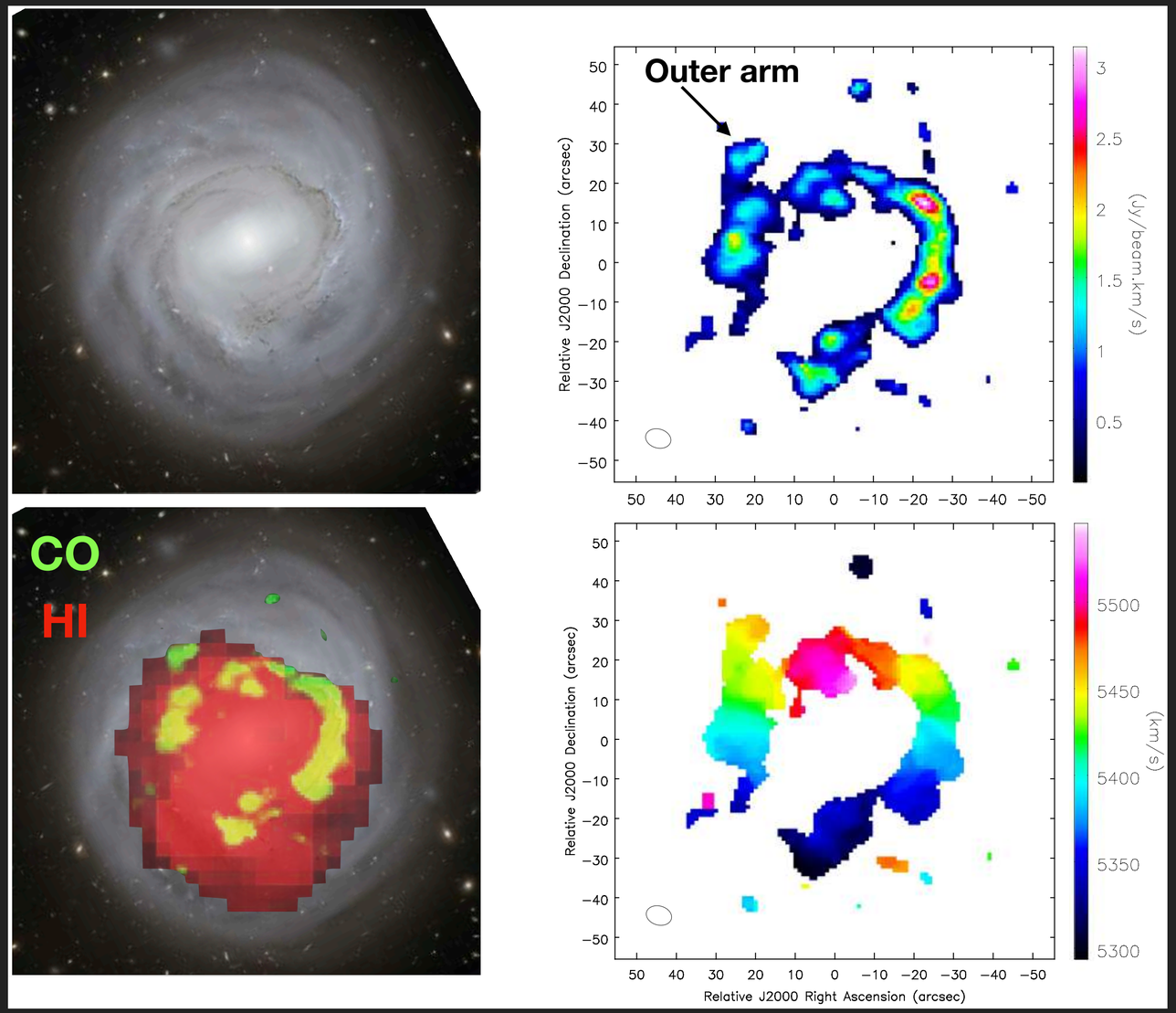
- Truncated HI disk, with head-tail asymmetry indicates that this galaxy is being ram pressure stripped
- Galaxy is moving toward us, so any ram pressure stripped gas will be redshifted



Kenney et al. (2015)

CARMA CO (1–0) OBSERVATIONS

- Peak CO surface brightness is on the leading quadrant of the galaxy
- CO truncation radius about the same as HI on the leading side
- Relatively normal velocity field (symmetry about major axis)

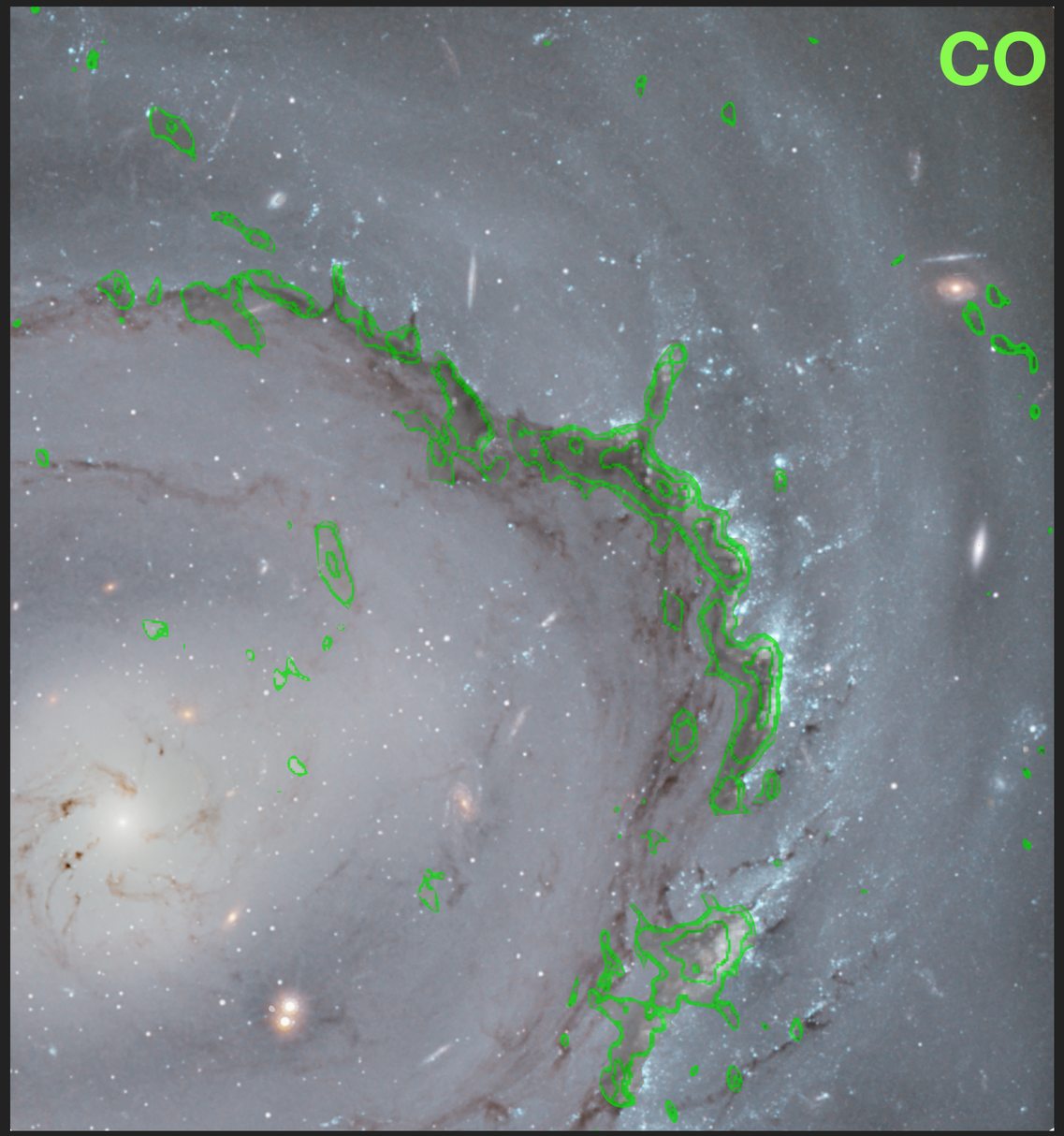


CARMA data from Tony Wong

Cramer et al. (submitted)

NEW ALMA OBSERVATIONS OF THE LEADING SIDE

- ALMA 12m+7m observations at ~0.2″ (100 pc) resolution of the leading side, where ram pressure is strongest
- Observations reveal more information about unique dust structure on the leading side including:
  - kpc scale filaments with stars at the head
  - C shaped concavities
  - Fallback clouds



Cramer et al. (submitted)

WHAT OBSERVABLES INDICATE RPS GAS IS FALLING BACK?

- If gas is behind the galaxy (actively falling back)
  - Can be investigated with CO/dust extinction ratio

DUST EXTINCTION – WHAT DOES IT TELL US ABOUT WHERE THE DUST IS?

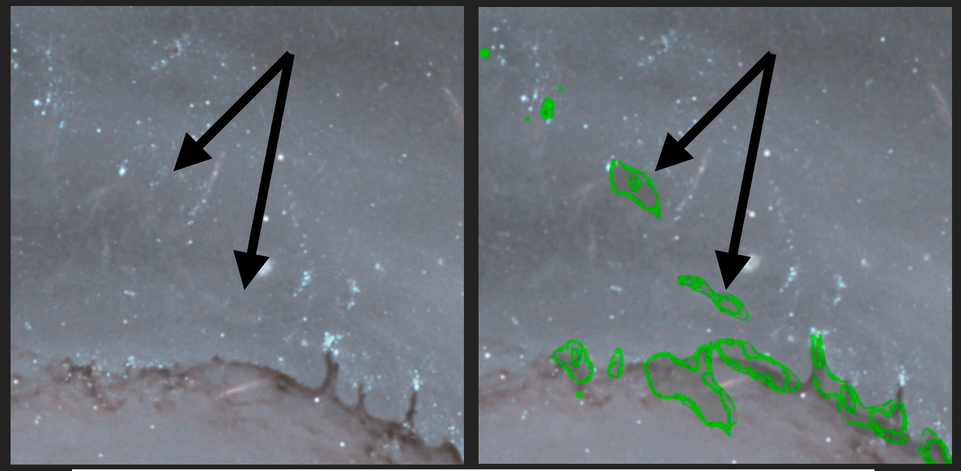
Normal distribution

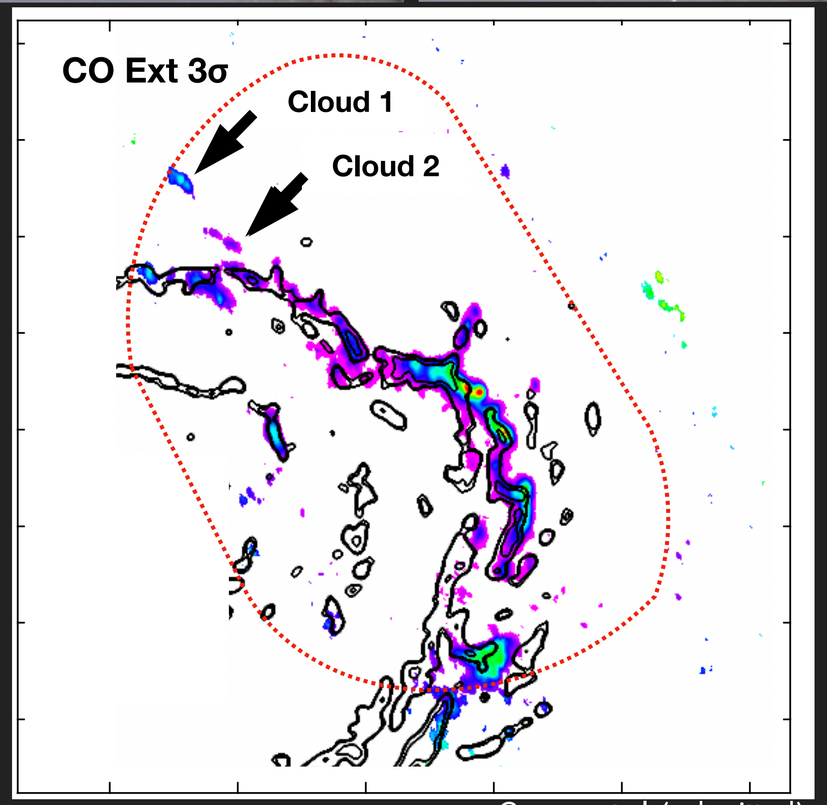
Max extinction

No extinction

DUST TO CO CORRELATION

- Dust and CO tend to be correlated. If dust is in front of the stars, we'll see it in dust extinction
- There are two prominent clouds with no dust extinction but significant CO emission





Cramer et al. (submitted)

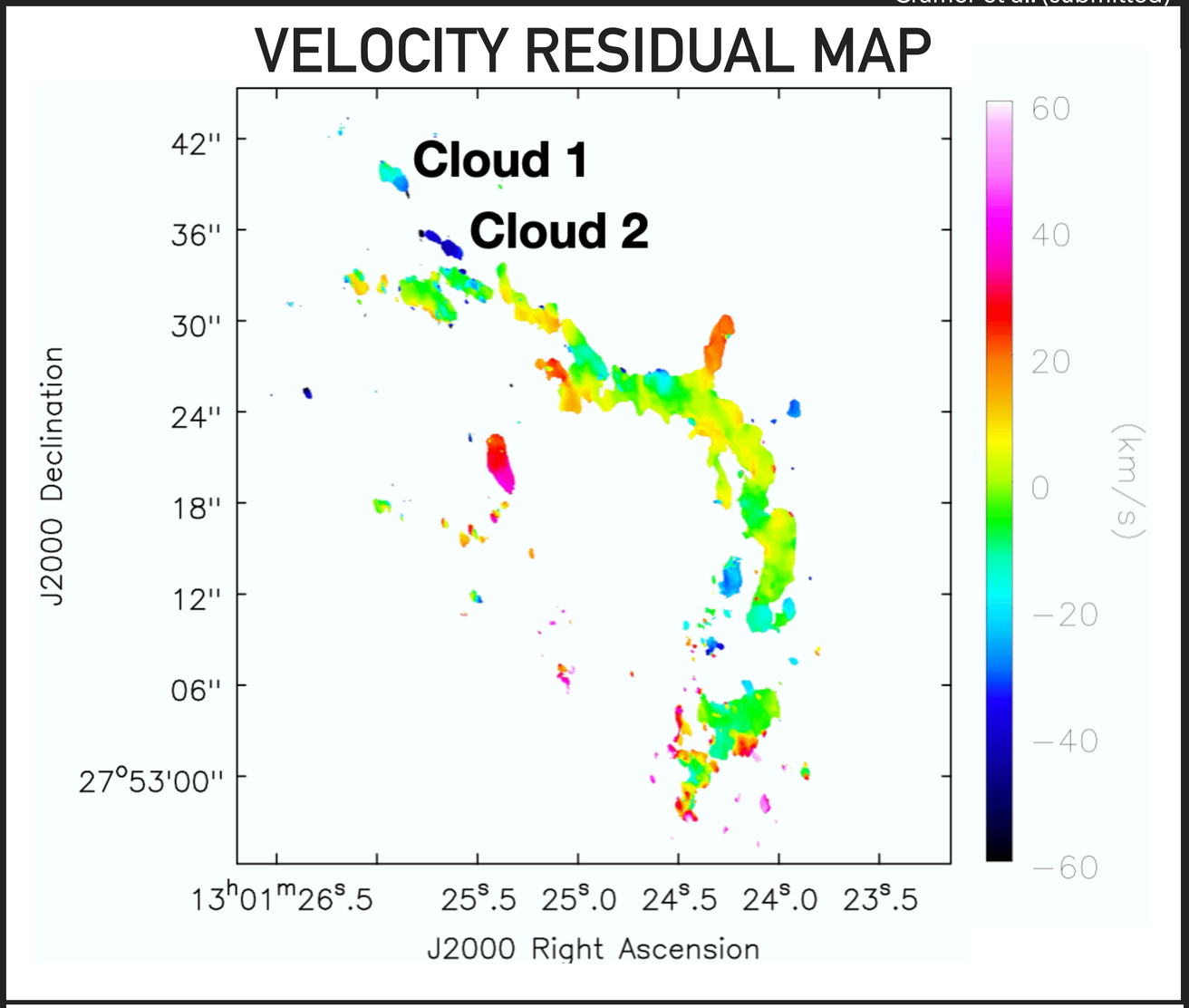
WHAT OBSERVABLES INDICATE RPS GAS IS FALLING BACK?

- If gas is behind the galaxy (actively falling back)
  - Can be investigated with CO/dust ratio
- If gas has velocity opposite the ram pressure stripping direction
  - In this case, gas would be blue shifted

KINEMATICS OF THE LEADING SIDE

- Using DiskFit tilted ring velocity modeling, we subtract the rotation curve from the rotation field
- Residuals indicate the deviation from regular circular motion in the gas
  - Residuals can be some combination of Vz, Vt, Vr
- The two clouds noted before have very blue shifted velocity (opposite the direction of ram pressure)

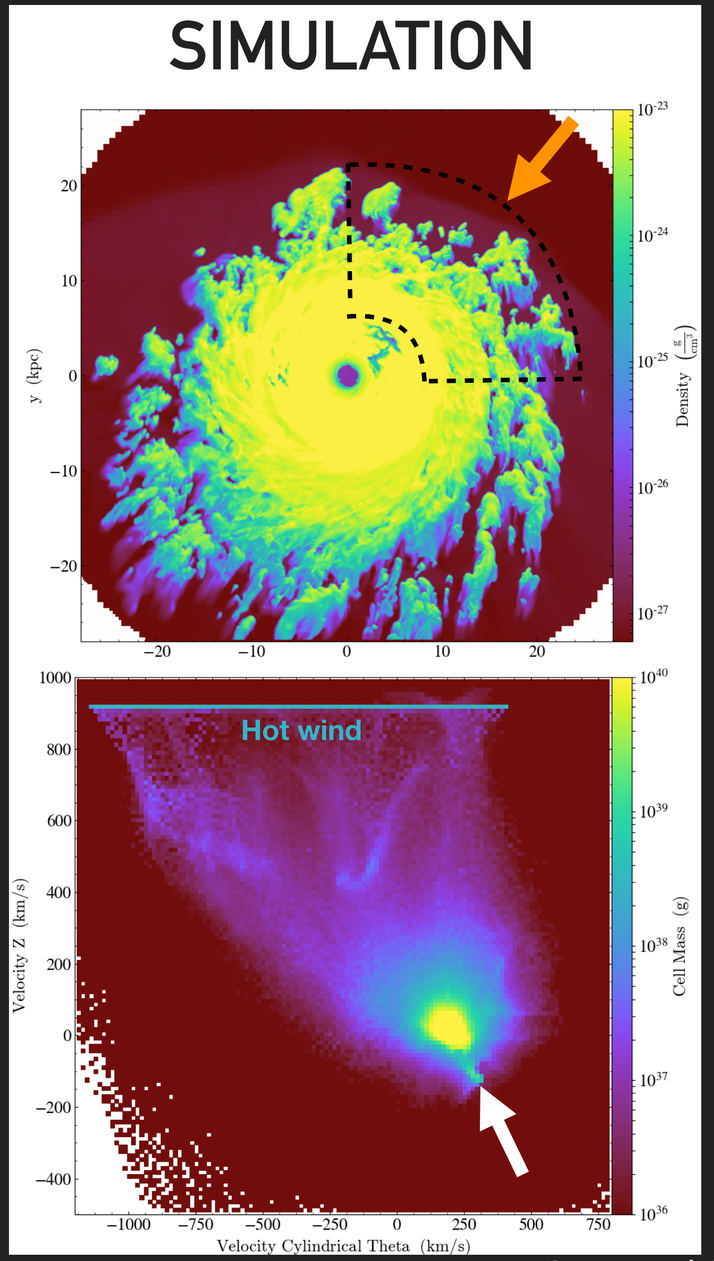
Cramer et al. (submitted)



$$V_{\mathrm{residual}} = V_z \cos i + \sin i\left[V_t \cos\theta + V_r \sin\theta\right]$$

CAN GAS IN THE LEADING QUADRANT FALL BACK?

- Simulations find fallback in the same quadrant of the disk we observe.
- Dense clumps found in the bottom plot have negative V_z i.e. fallback
- No gas cooling in these sims, cooling may be a key component to fallback occurring



Cramer et al. (submitted)

IN SUMMARY

- With both CARMA and ALMA data, we've managed to make an approximate model of the expected circular velocity in the disk.
- Velocity residuals when compared to the model reveal interesting kinematics in features like outer clouds blueshifted by 25-50 km s^{-1}.
- We find the first observational evidence for gas fallback in a ram pressure stripped galaxy!