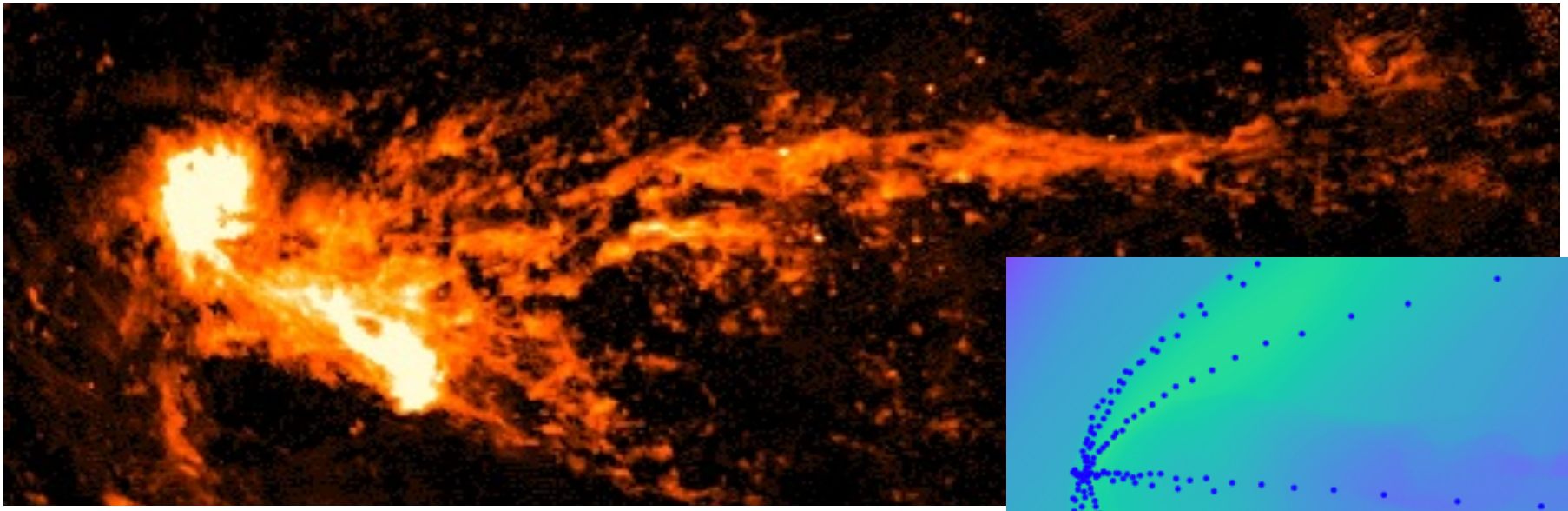
Ram Pressure Stripping of the Magellanic System

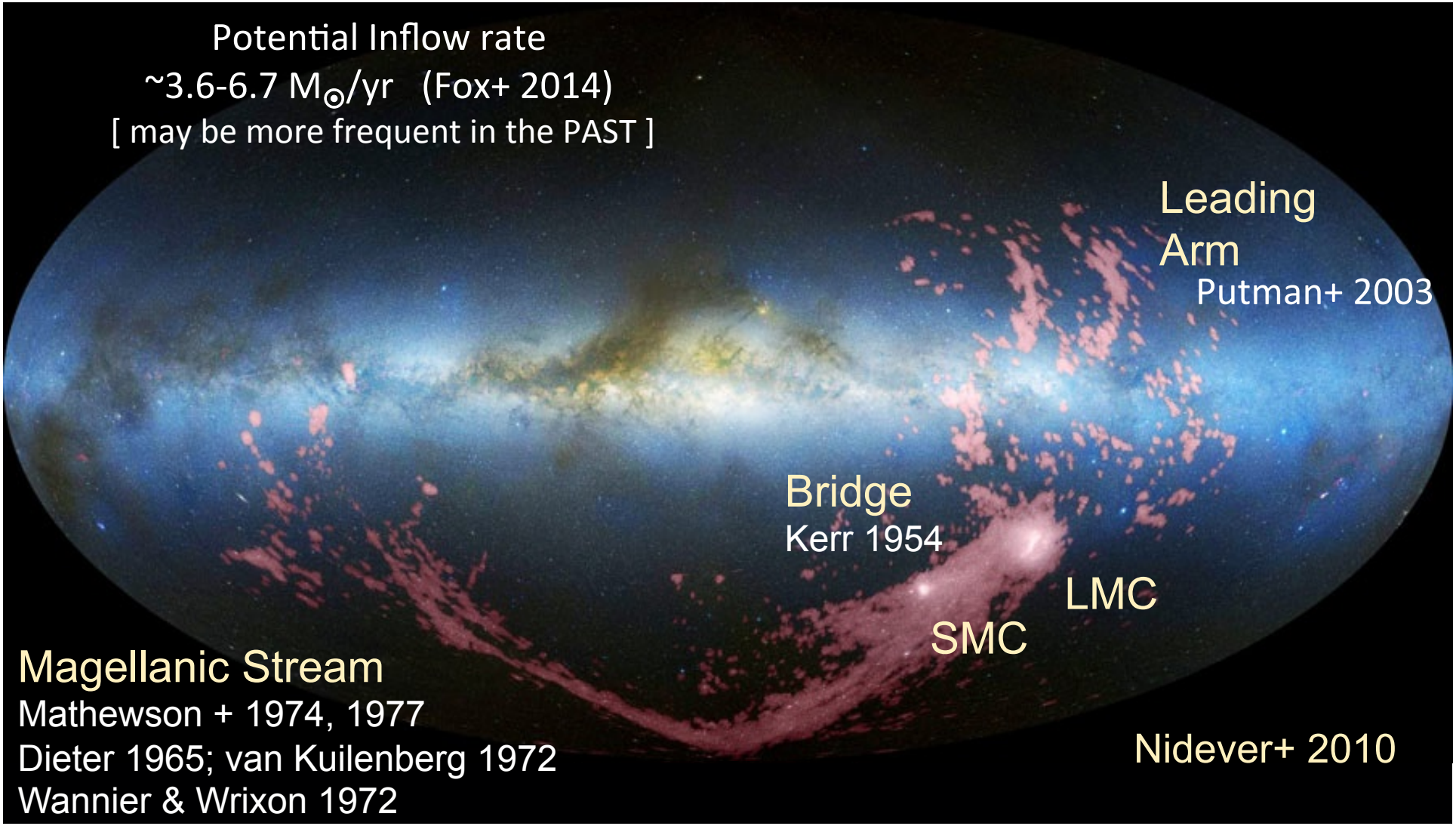


Gurtina Besla
(U. Arizona)

David Setton, Munier Salem

Greg Bryan, Mary Putman, Roeland van der Marel, Nitya Kallivayalil

The Magellanic System



$M_{Gas\ outside} \sim \mathbf{2 \times 10^9\ M_\odot} (d/55\ kpc)^2 > 2 \times M_{Gas\ LMC+SMC}$ Fox + 2014

What is the Dominant Formation Mechanism of the Extended HI Structures?

1. **MW Tides**

   Murai & Fugimoto 1980, Lin+1995, Gardner & Noguchi 1996, Yoshizawa & Noguchi 2003, Bekki & Chiba 2005, Connors+ 2005, Ruzicka+2010

2. **Ram Pressure Stripping of LMC**

   Moore & Davis 1994, Heller & Rohlfs 1994, Mastropietro + 2005, 2009, Salem, Besla+2015

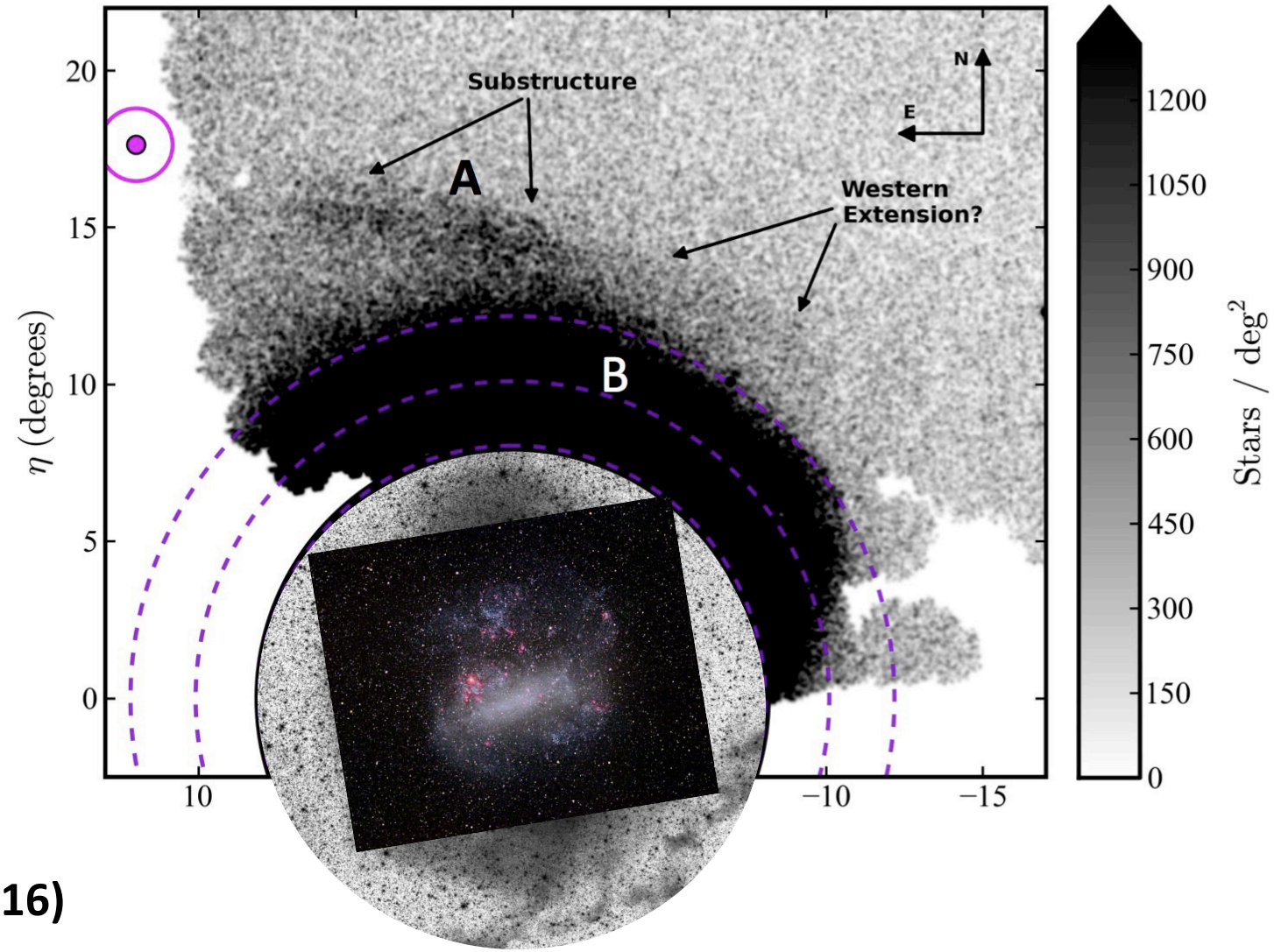
3. **LMC-SMC Interactions (Bridge)**

   High Mass LMC: Besla + 2010, 2012, 2013

   Low Mass LMC: Diaz & Bekki 2012, Guglielmo+2014

MW Tides? But the LMC Radius > 18.5 kpc

SMC also has an extended stellar component ~11 kpc (Nidever + 2011)

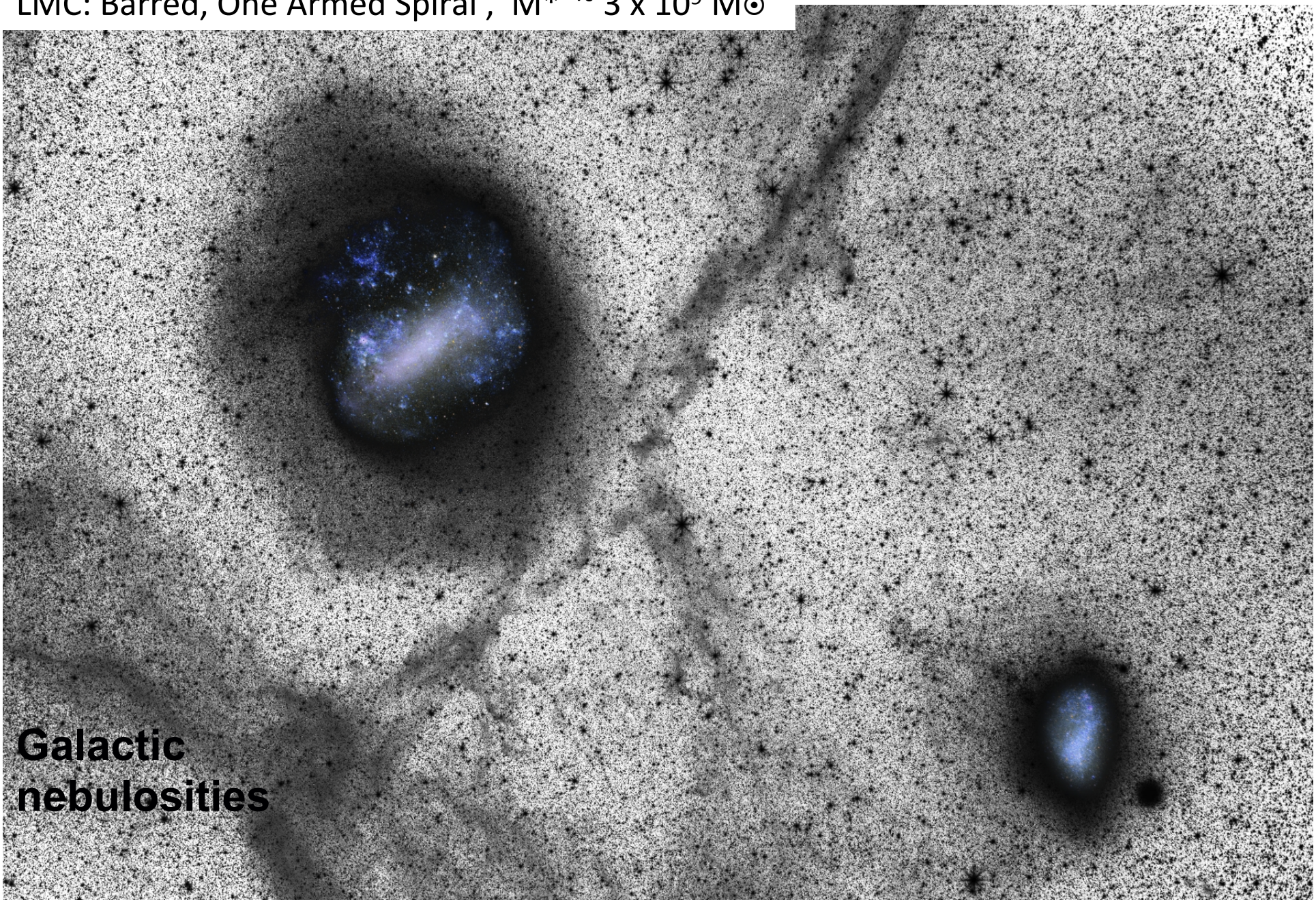


Inner:
Besla+2016

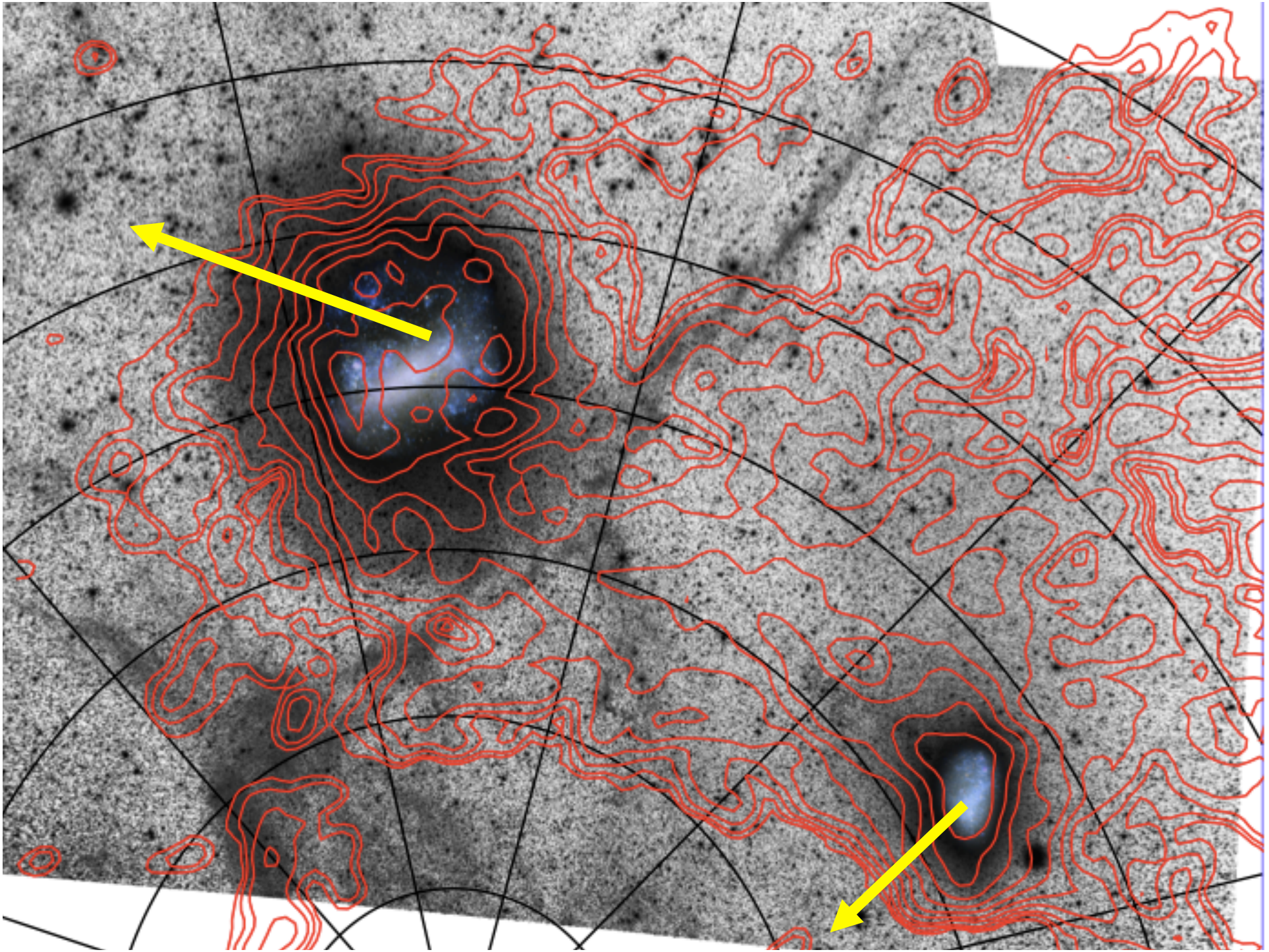
Outer:
DES
(Mackey+2016)

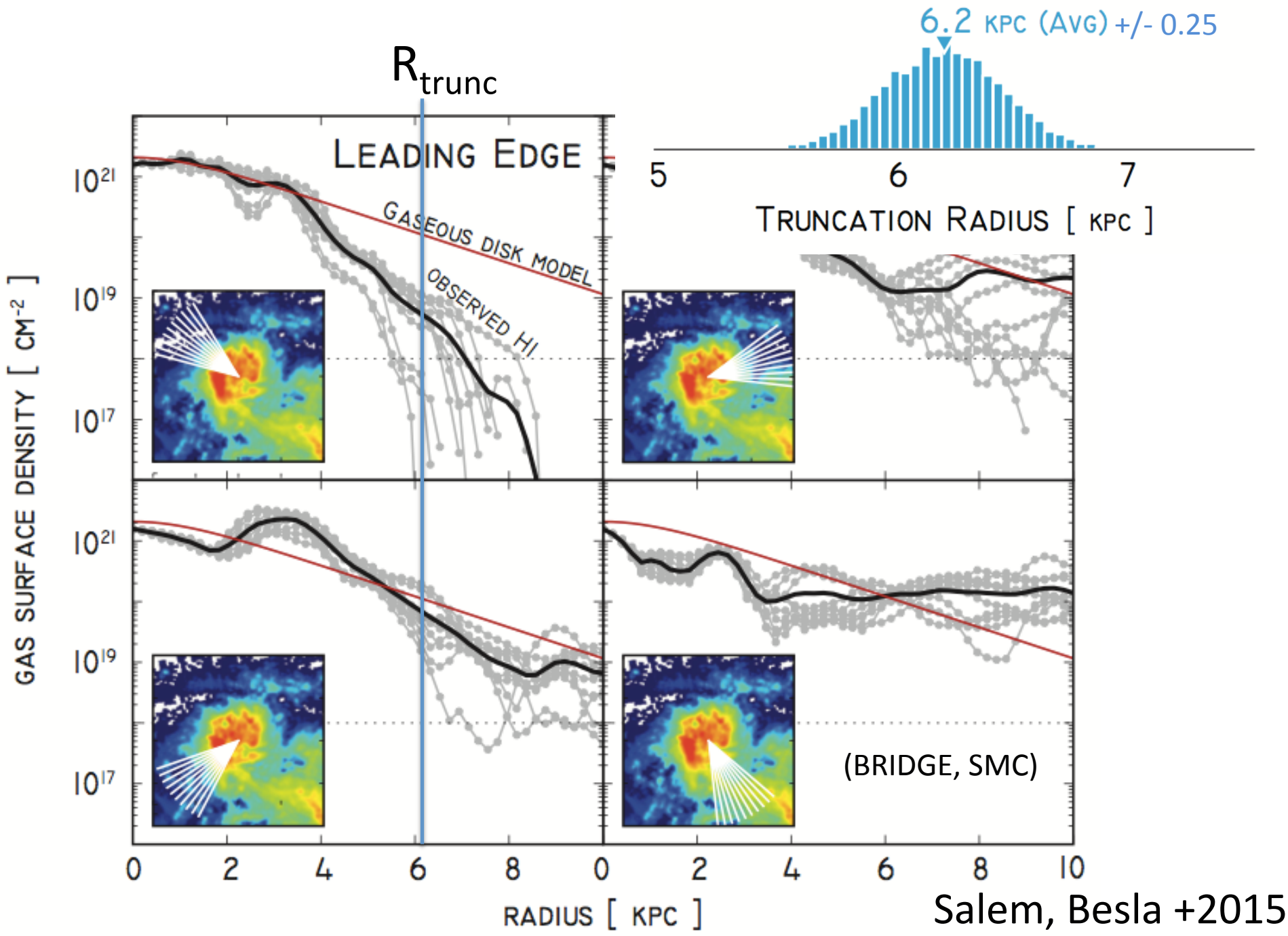
See also: Balbinot et al. 2015; Saha et al. 2010

LMC: Barred, One Armed Spiral , M* ~ 3 x 10^9 M⊙



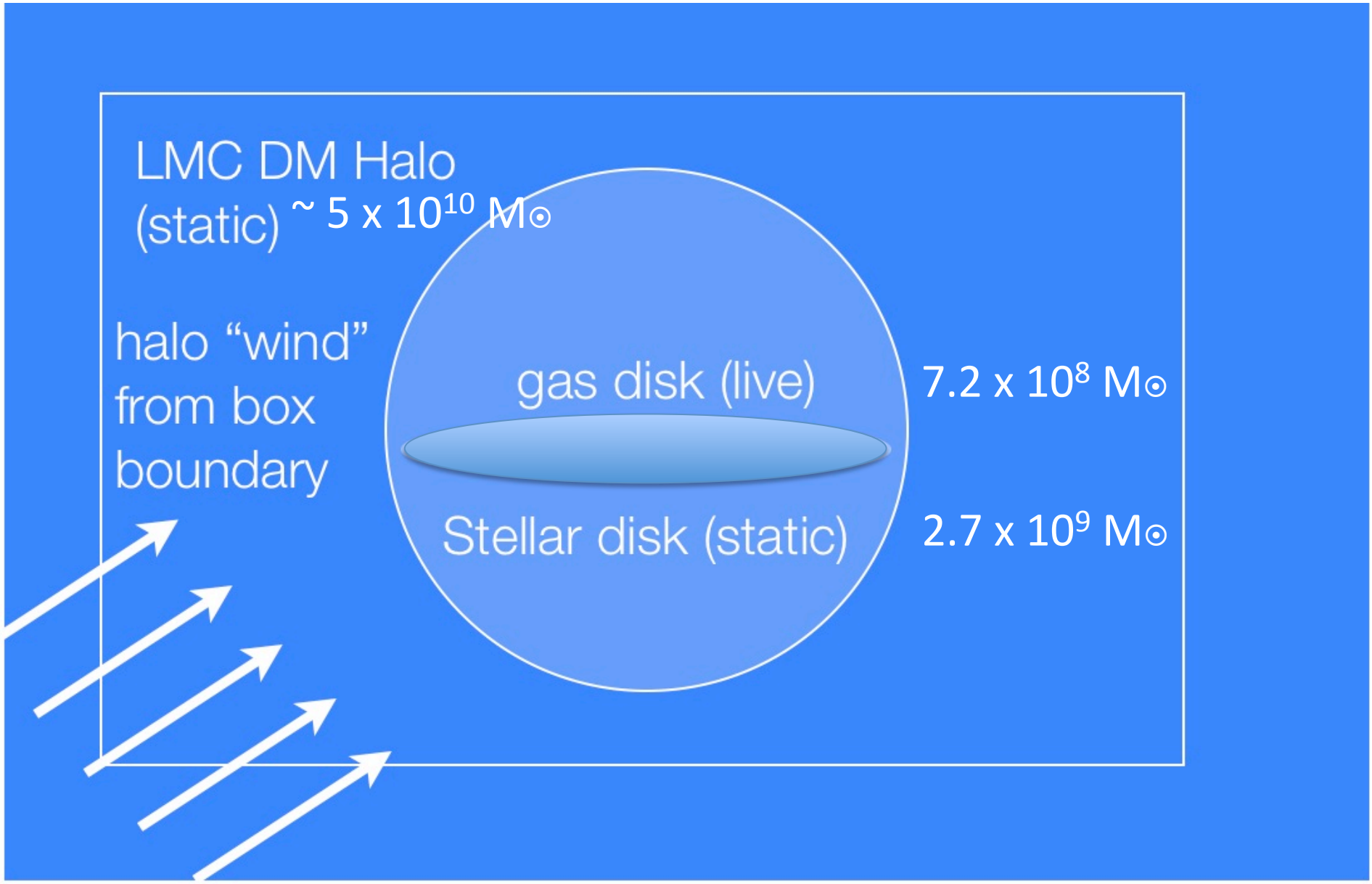
Besla, Martinez-Delgado+2016





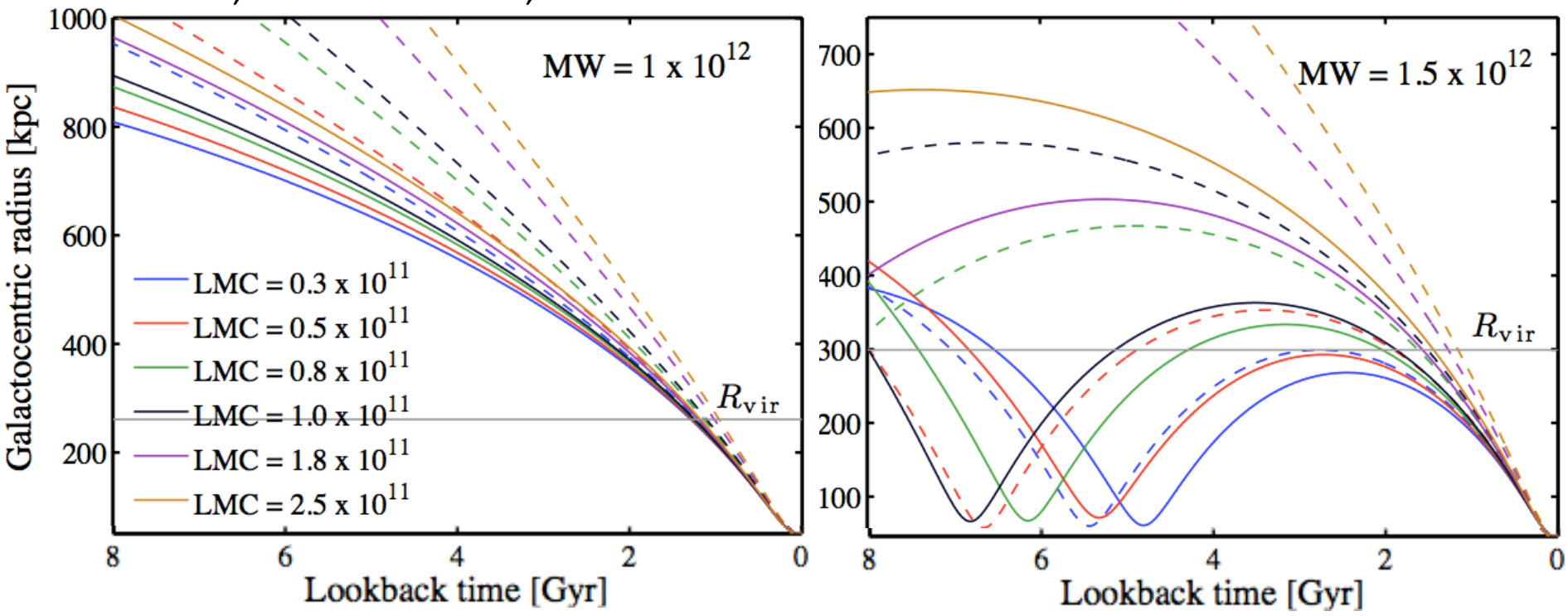
Salem, Besla +2015

Simulation Set Up



The Recent Pericentric Passage of the LMC about the MW is Model Independent

Gomez, Besla et al. 2015 ;



$r_p = 48.1 \pm 2.5$ kpc $\quad v_p = 340 \pm 19$ km/s

$t_p = 46.4 \pm 8.5$ Myr

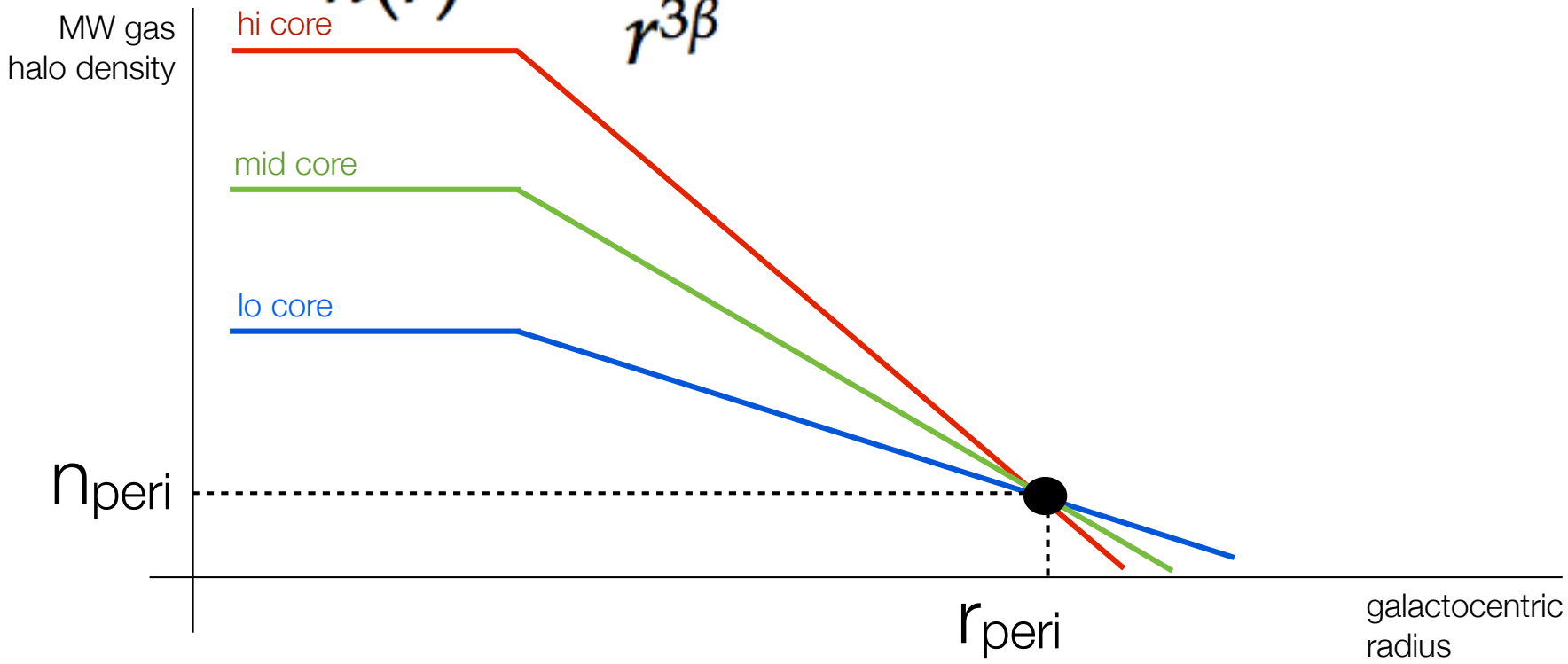
Kallivayalil, van der Marel, Besla et al. 2013

Maximal Stripping at Peri: $\rho_{(peri)} v^2_{(peri)} = 2\pi G \Sigma_\star \Sigma_{gas(Rtrunc)}$

KNOWN

Assuming a Beta Profile:

$$n(r) \approx \frac{n_0 r_c^{3\beta}}{r^{3\beta}}$$



Temp profile: Hydrostatic equilibrium
(10^{12} M⊙ halo) Makino 1998

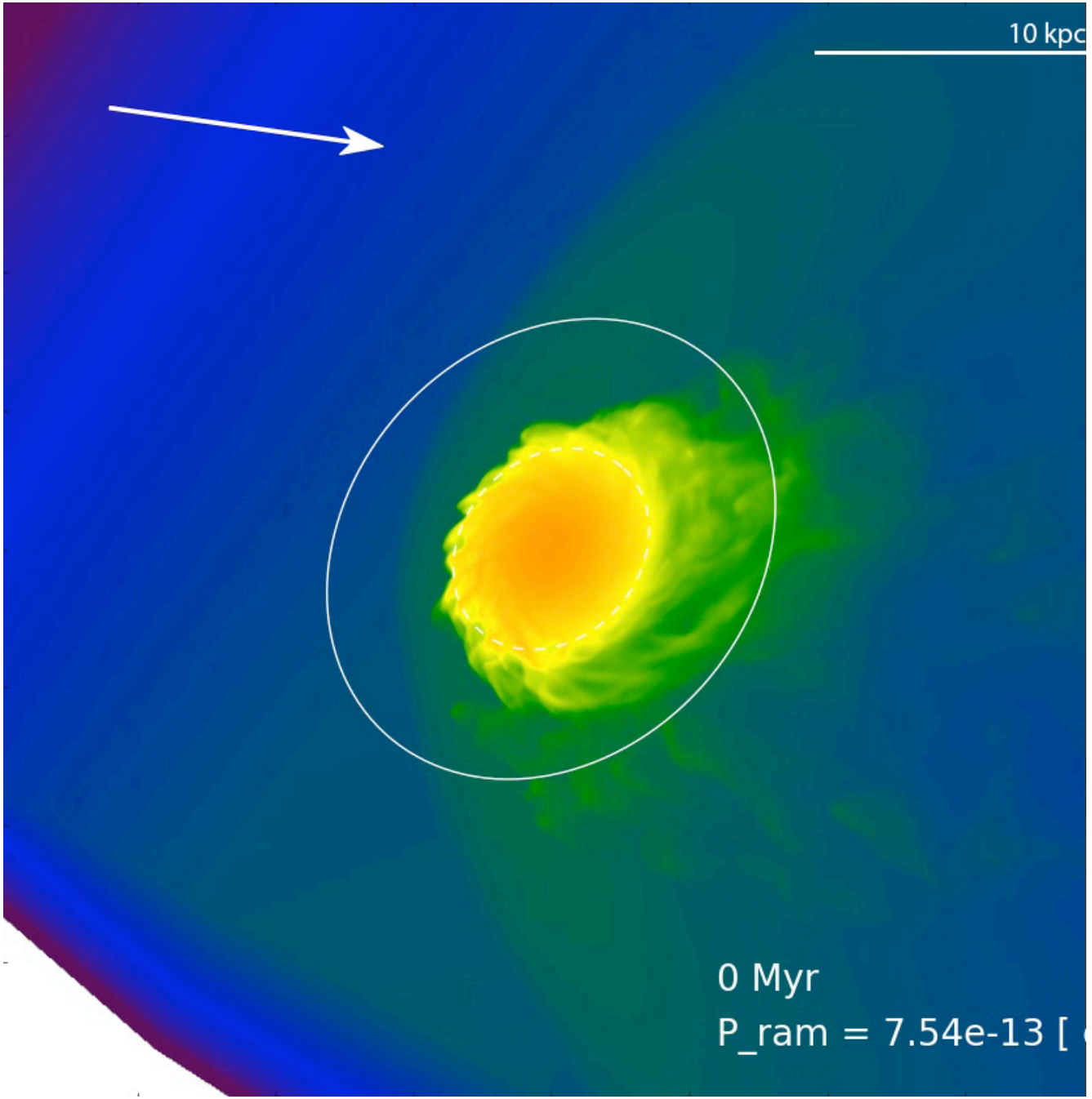
48.1 ± 2.5 kpc

Enzo AMR
Simulations

Resolution:
30 pc

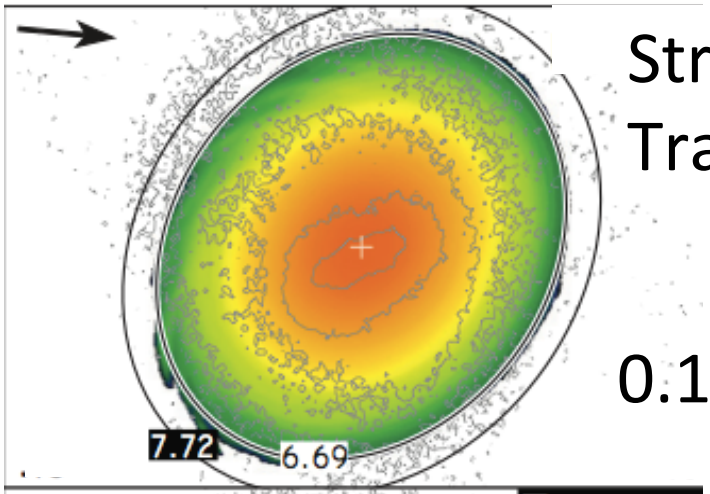
No cooling.

Gas initially
at 10^6 K

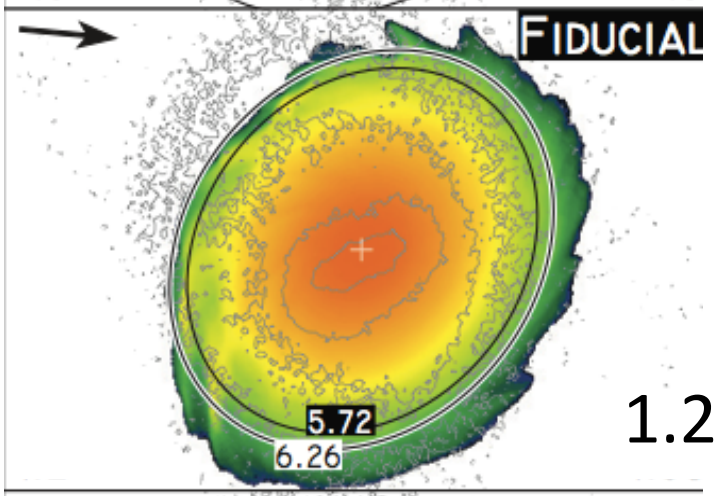


Salem, Besla +2015

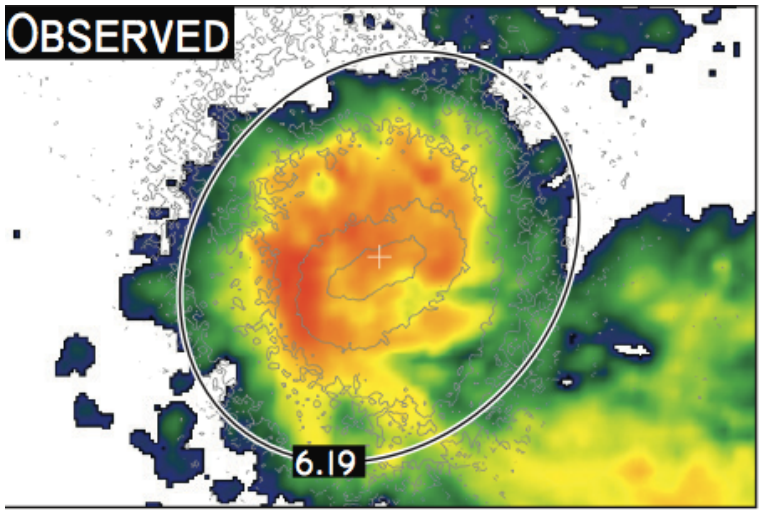
Stripping is insensitive to halo gas profile
Traces density at pericenter

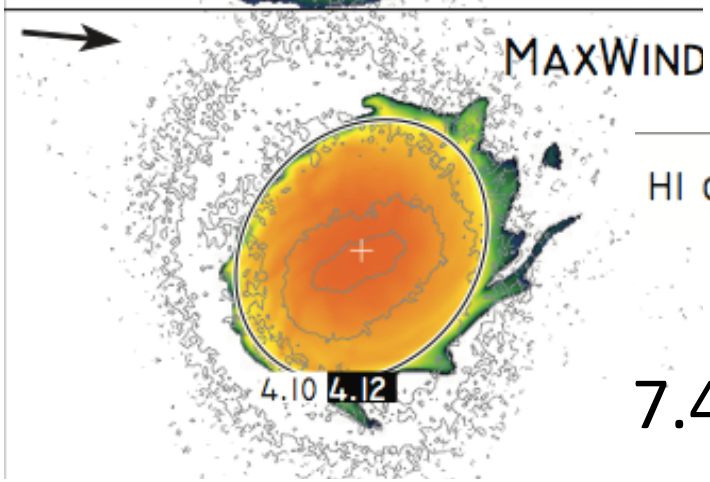


0.13×10^{-4} /cm^3



1.2×10^{-4} /cm^3





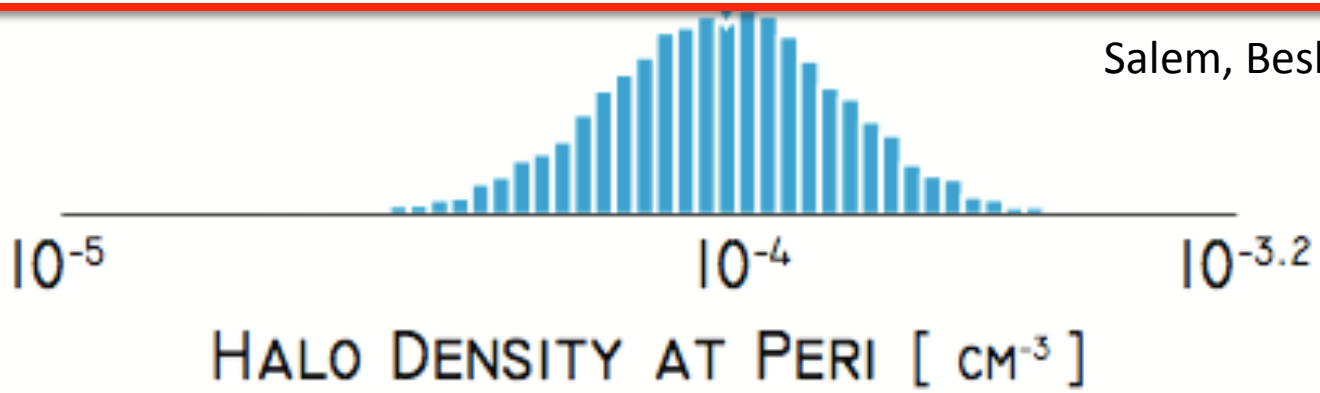
7.44×10^{-4} /cm^3

Salem, Besla +2015

Constraints on CGM density at ~ 48 kpc

$$n_{\rm MWHalo}(R = 48.2 \pm 2.5\ {\rm kpc}) = 1.1^{+.44}_{-.45} \times 10^{-4}\ {\rm cm}^{-3}$$

Salem, Besla +2015



Estimates at ~ 50kpc from stripping simulations of other MW Satellites:

Gatto, Fraternali et al. (2013) $(1.3 – 3.6) \times 10^{-4}$ /cm^3

Grcevich & Putman (2009) $(0.1\text{-}10) \times 10^{-4}$ /cm^3

IF BETA PROFILE:

$$M_{\rm gas\ \mathbf{smooth}}\ (R < 300\ {\rm kpc}) = 2.6\ (+/-\ 1.4) \times 10^{10}\ M\odot$$

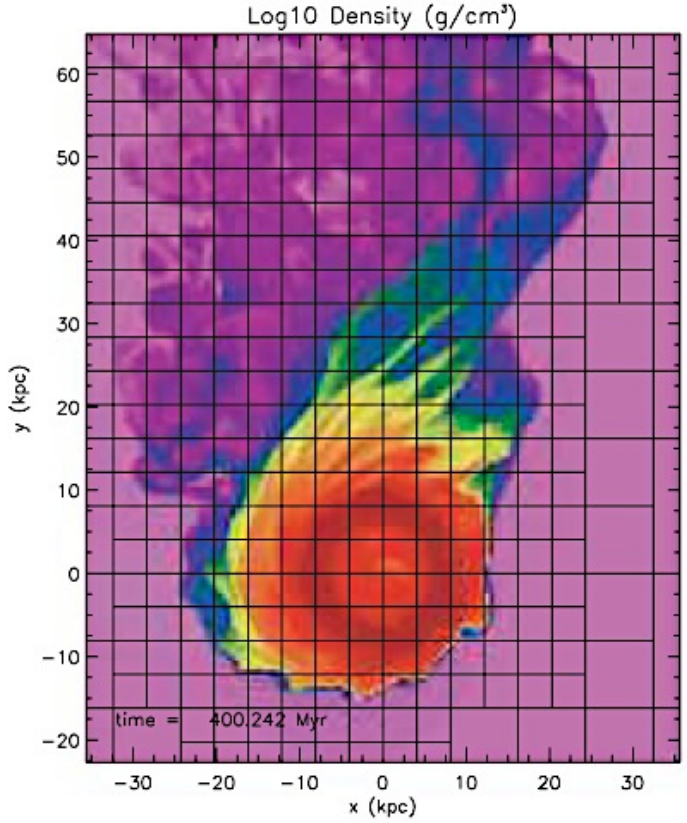
(7-24% of Expected Baryons in 1e12 halo)

Similar to that inferred for M31 (Lehner et al. 2015)

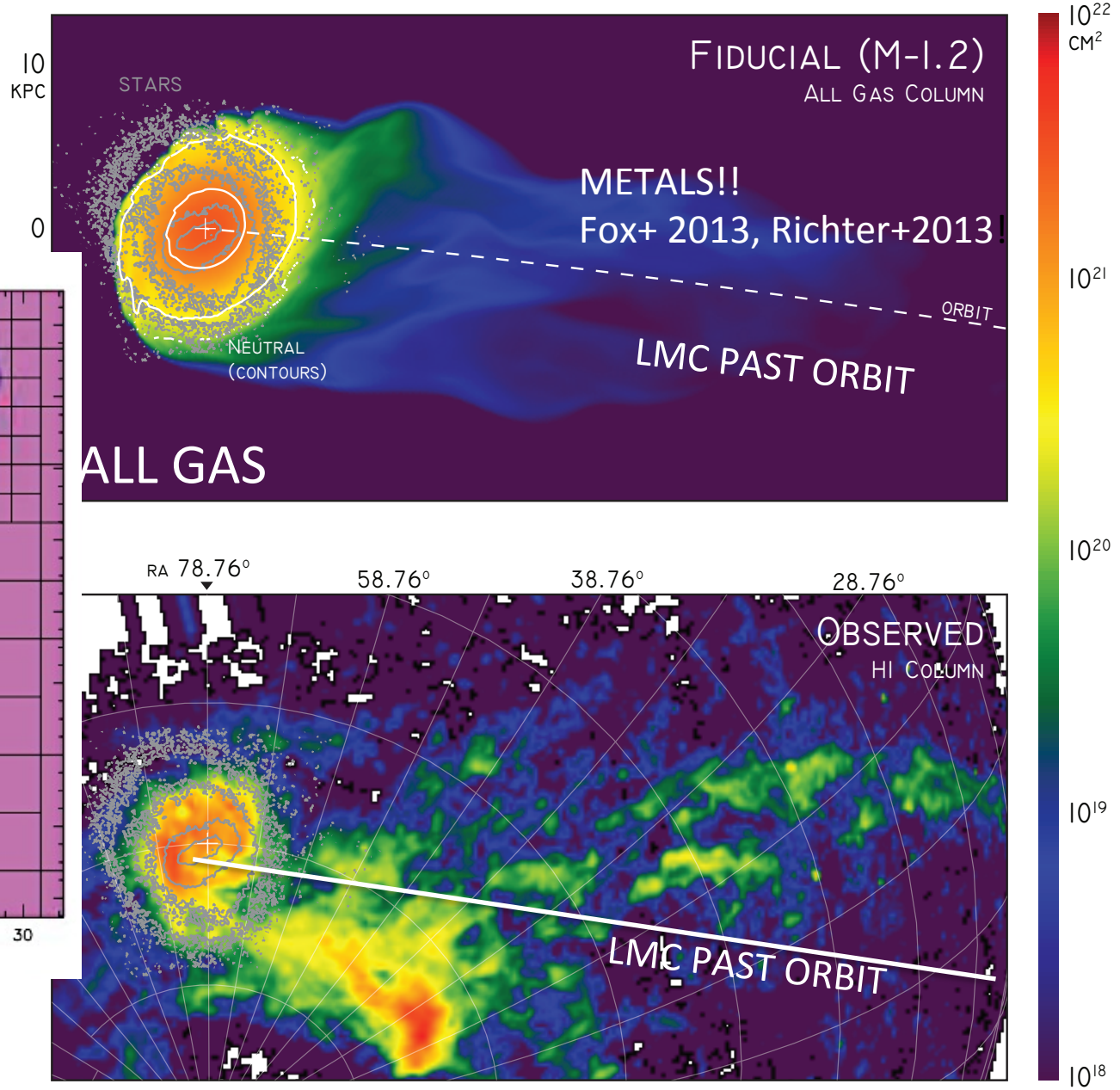
Contribution to the Mag. Stream/CGM?

~ 7×10^6 $M_\odot$

~ 1% of MS



Roediger & Brüggen 2006



Conclusions

- The LMC's HI disk shows evidence of truncation by ram pressure stripping in the direction of motion (r_{trunc}= 6.2 +/- 0.25 kpc)
- **This provides a direct constraint on the gas density of the MW's CGM at ~ 48 kpc**

$$n_{\rm MWHalo}(R = 48.2 \pm 2.5\ {\rm kpc}) = 1.1^{+.44}_{-.45} \times 10^{-4}\ {\rm cm}^{-3}$$

- **LMC will generate a bow shock 30 kpc in radius** : increased mixing in CGM and satellites will exist within the shock.
- Ram pressure stripping from the LMC contributes negligibly to the mass content of the HI Stream
- Instead, LMC tides strip material from the SMC: pre-processing in small dwarf group environment may aid in the removal of gas and quenching of small systems.