The hot gas distribution, X-ray luminosity and baryon budget in L-Galaxies

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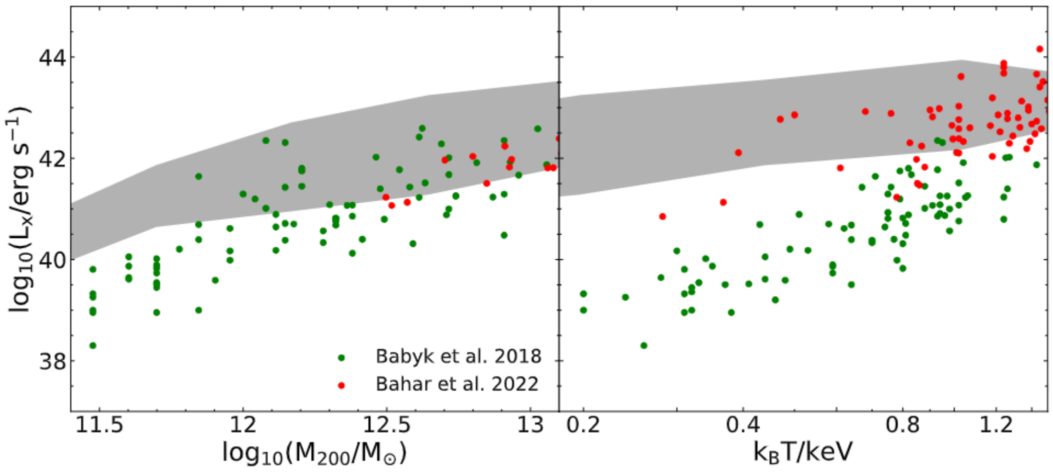
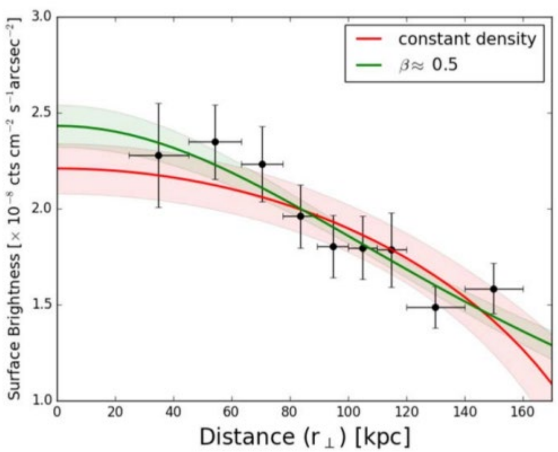
Motivation: prediction X-ray luminosity in L-Galaxies



- isothermal sphere($\rho \propto r^{-2}$) too high at the inner region

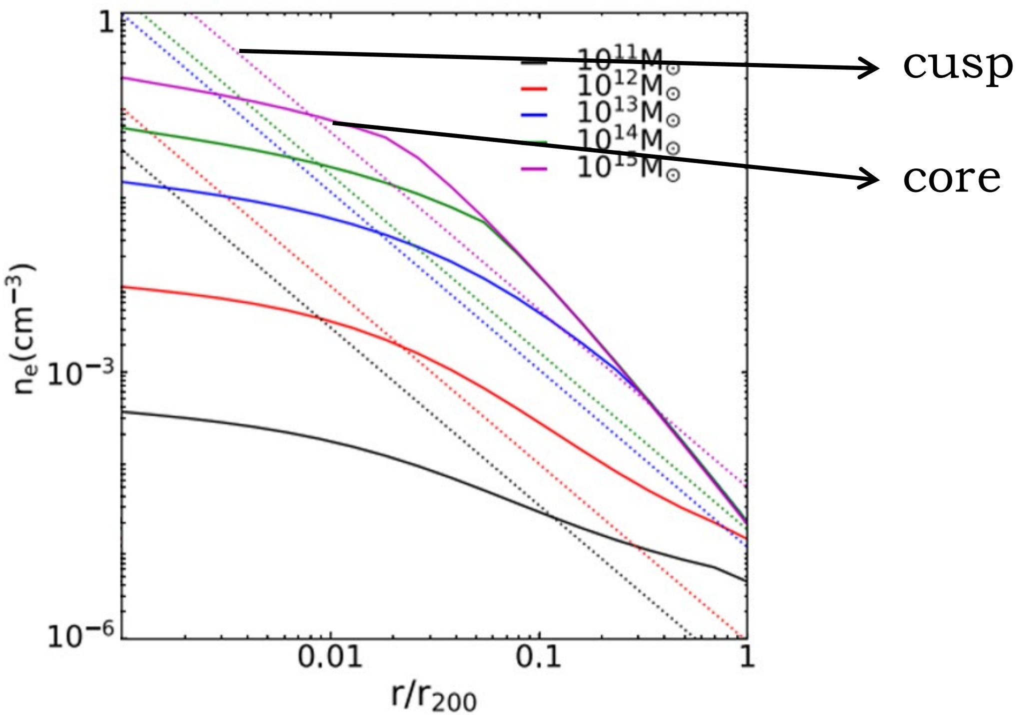
- constant T_{gas} profile

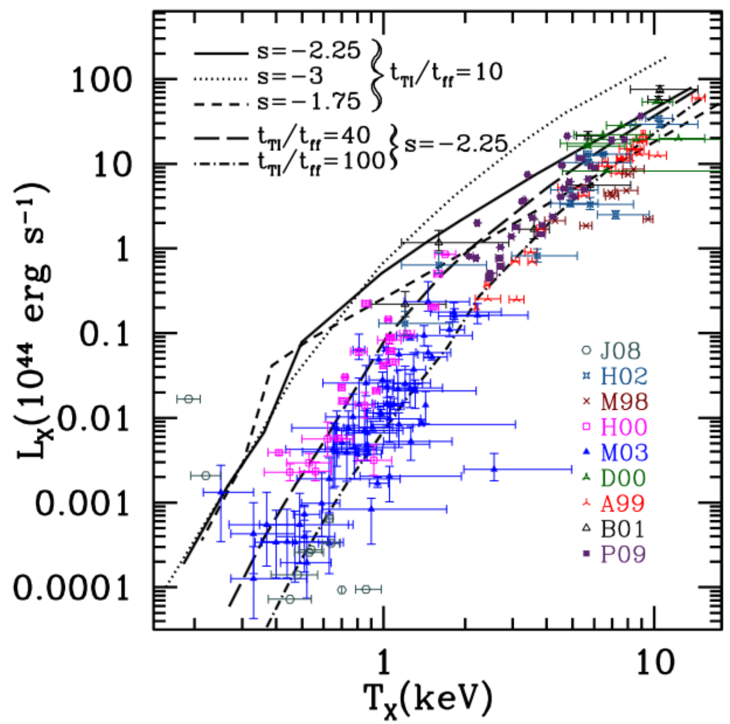


β model or else maybe more consistent with observations.

Radial density profiles of hot ionized gas in CGM /IGM

- thermal instability models by Sharma et al. (2012)
- 1D radial distribution of hot gas profiles





Model parameters: M_{200}, f_b, c, f_d, redshift

Sharma12 profiles into L-Galaxies

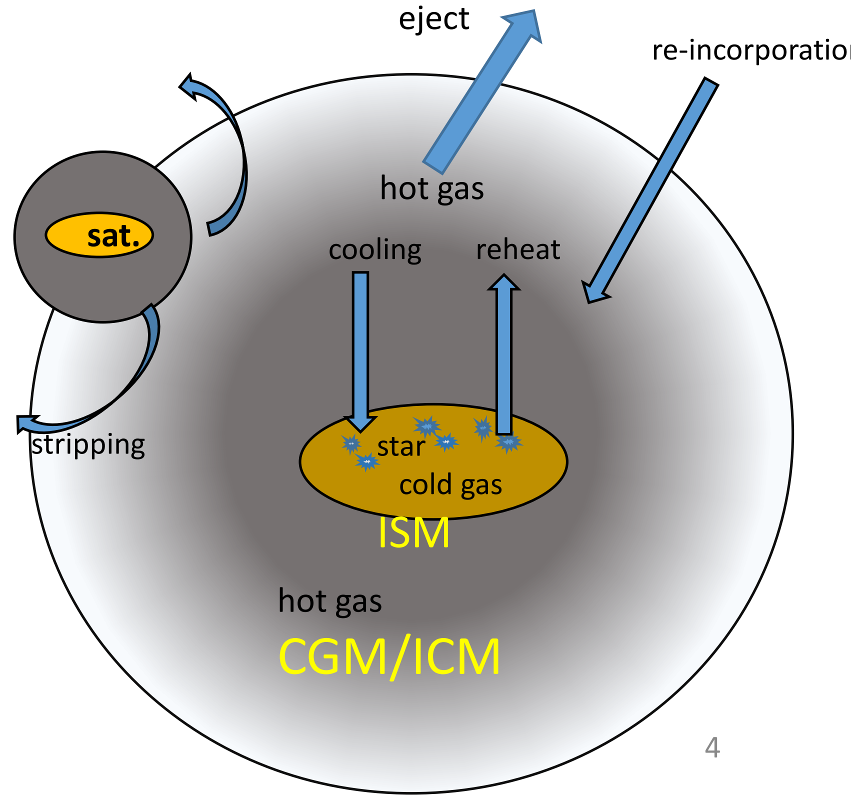
M_{vir}, f_b, λ, z from L-Galaxies

↓ M_{200}, f_b, c, f_d, redshift

1D model code Sharma12+ → $\rho_{gas}(r)$, $T(r)$ → Baryonic processes in L-Galaxies 2015 → Model outputs

Prescriptions related to hot gas

- Cooling and infall
- Stripping: ram pressure & tidal
- Feedback: SN & AGN



Infall and cooling prescription

Quasi-static cooling

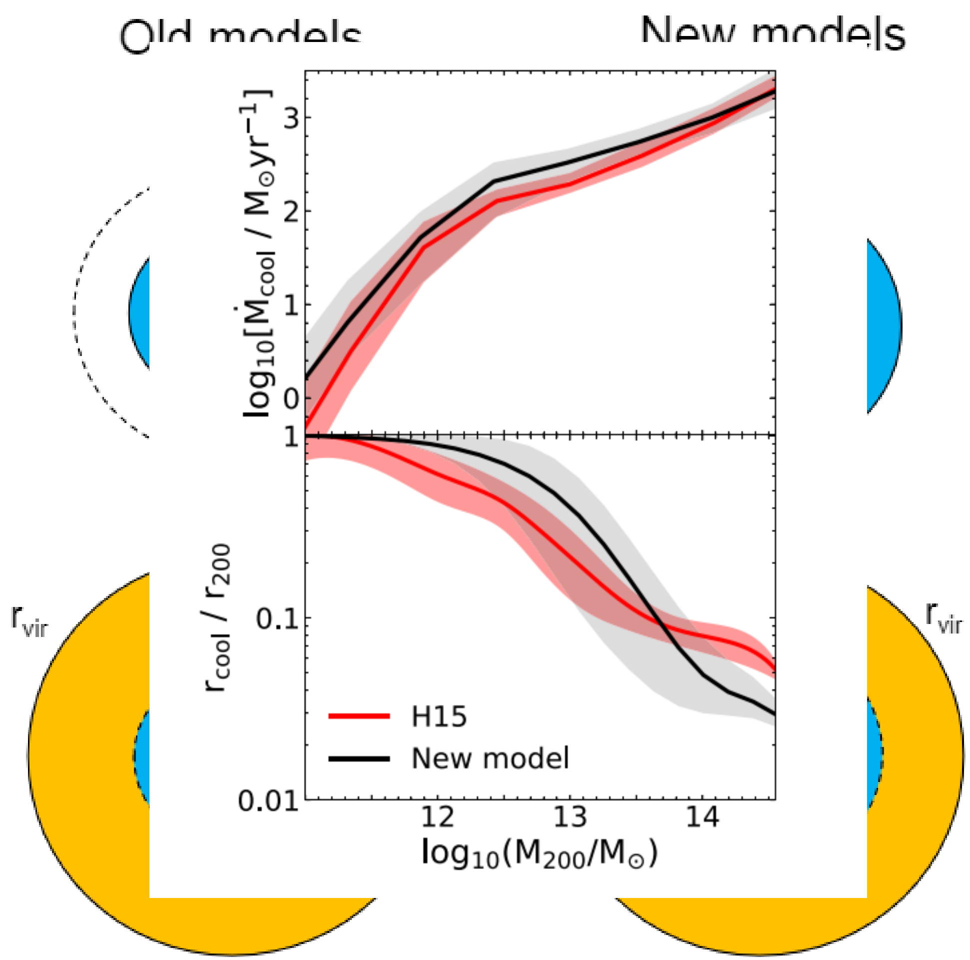
- old: cooling region ($t_{cool}<t_{dyn}$)
- new: cool core ($t_{TI}/t_{ff}<10$)

Rapid cooling

- old: $r_{cool}=r_{vir}$
- new: $t_{TI}/t_{ff}<10$ at r_{vir}

Cooling time scale

- old: t_{dyn}
- new: $t_{infall}=r_{core}/v_{vir}$



Prescriptions of ram pressure & tidal stripping

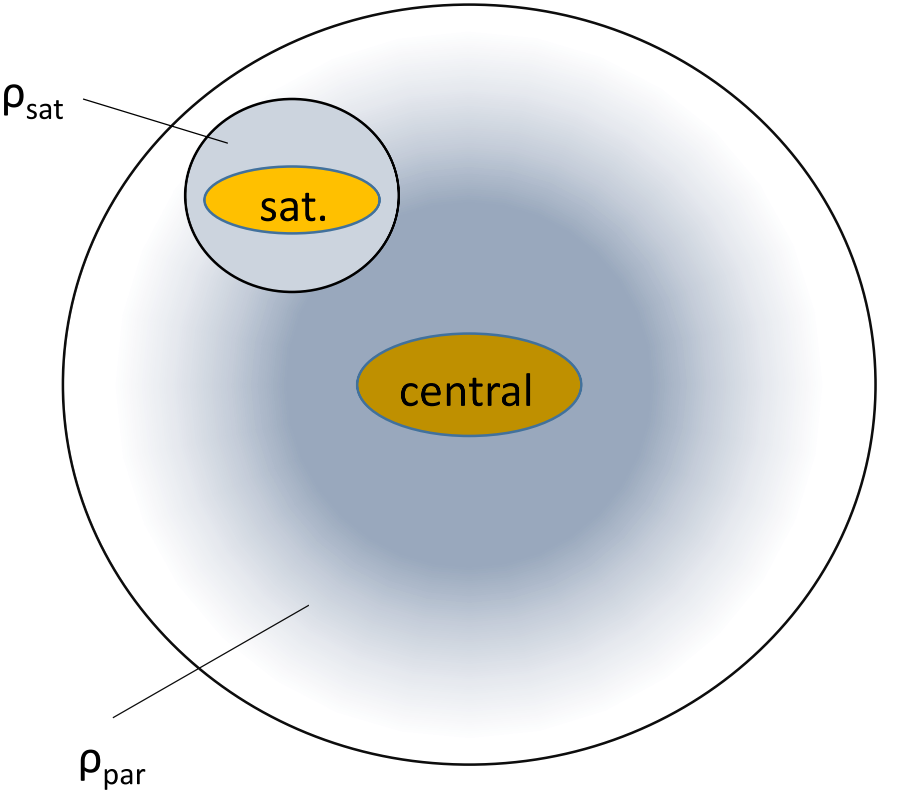
- tidal stripping

  $r_{\rm tidal}$

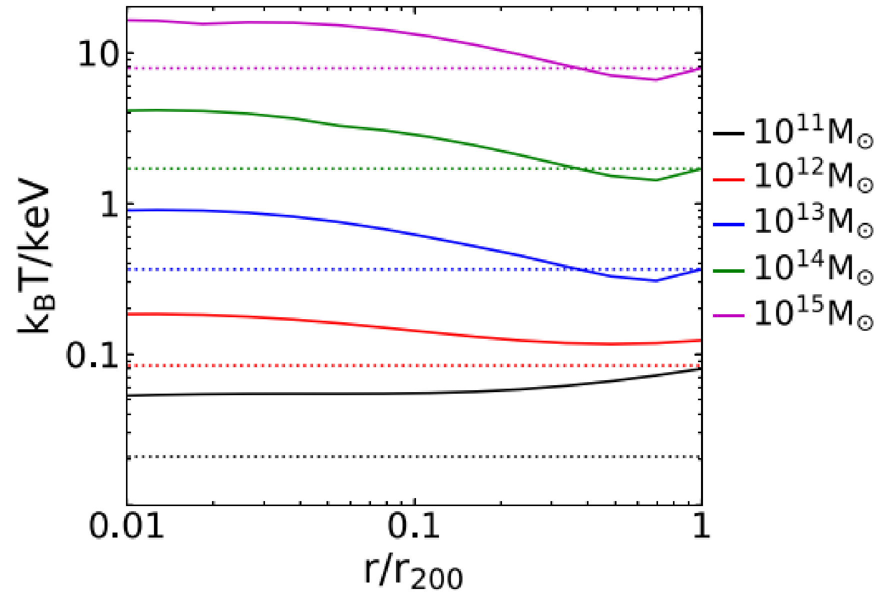
- ram pressure stripping

$$\rho_{\rm hot,sat}(r_{\rm rp})v_{\rm sat}^2 = \rho_{\rm hot,cen}(r)v_{\rm orbit}^2$$

$$r_{\rm strip} = \min\left(r_{\rm tidal}, r_{\rm rp}\right)$$



Feedback prescriptions

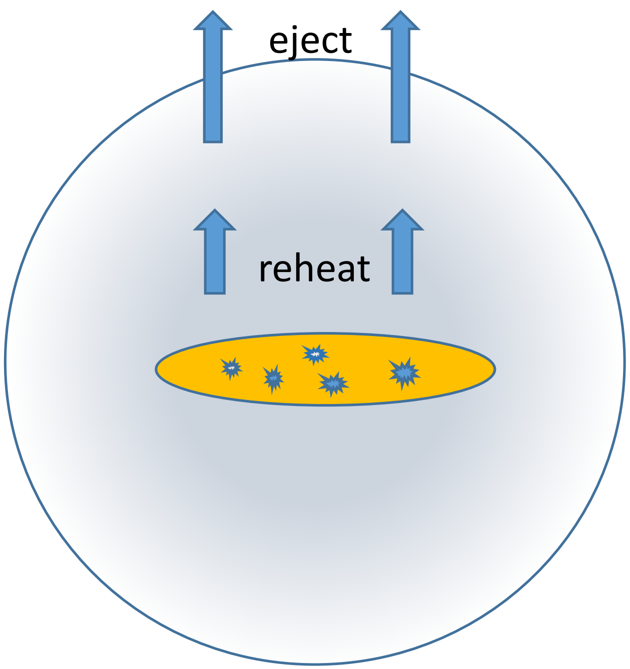


SN reheating and ejection

old: $\mathbf{T_{vir}}$ of the DM halo;

new: $\mathbf{T_{hot}}$ of the new gas profile.

mass of SN ejection $\left(\Delta E_{\mathrm{SN}} > \Delta E_{\mathrm{reheat}}\right)$

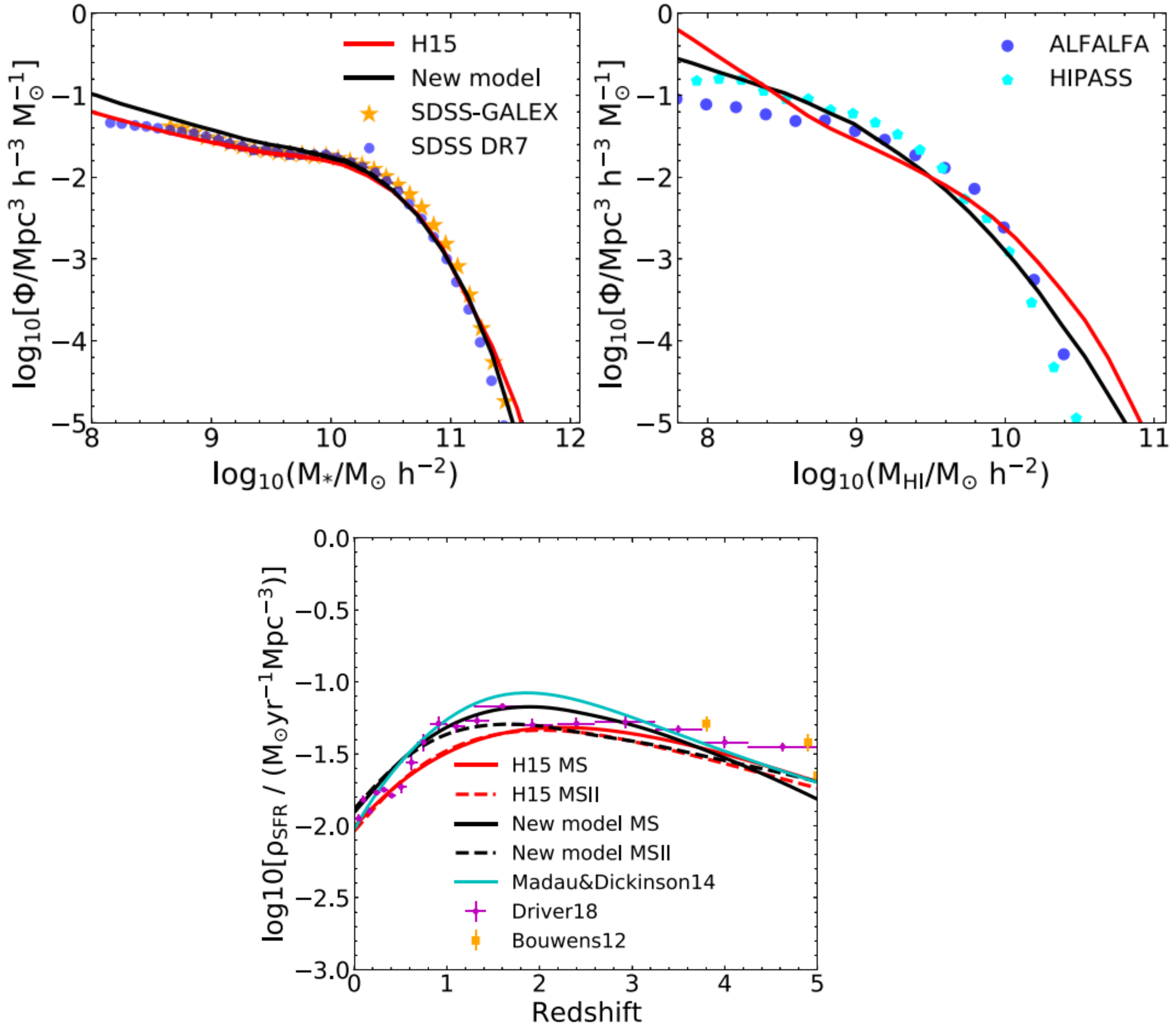


AGN feedback (radio mode)

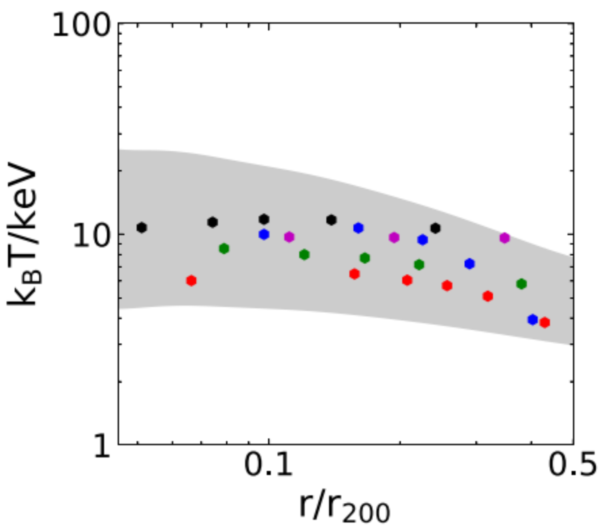
$$\text{old}: \ \dot{m}'_{\mathrm{cool}} = \dot{m}_{\mathrm{cool}} - \frac{L_{\mathrm{BH}}}{v_{\mathrm{vir}}^2 / 2}$$

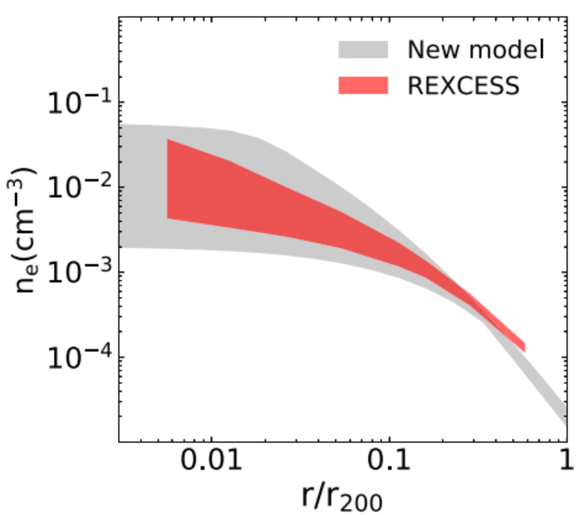
$$\text{new}: \ \dot{m}'_{\mathrm{cool}} = \dot{m}_{\mathrm{cool}} - \frac{L_{\mathrm{BH}}}{3k_B \overline{T}_{\mathrm{hot}} / 2\bar{\mu} m_{\mathrm{H}}}$$

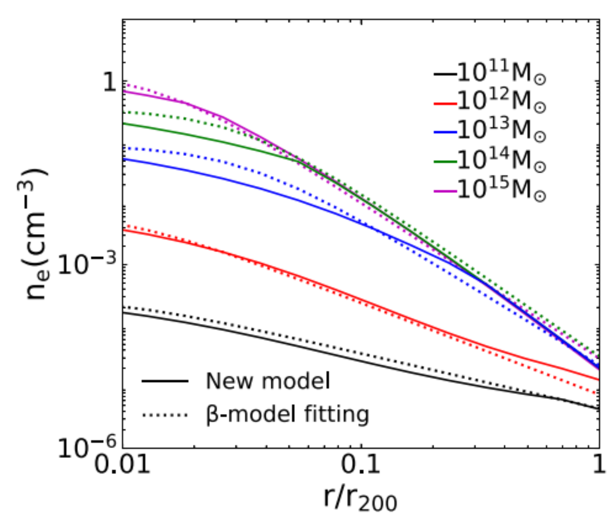
Model calibrations with observational constraint



Gas Density & Temperature profiles



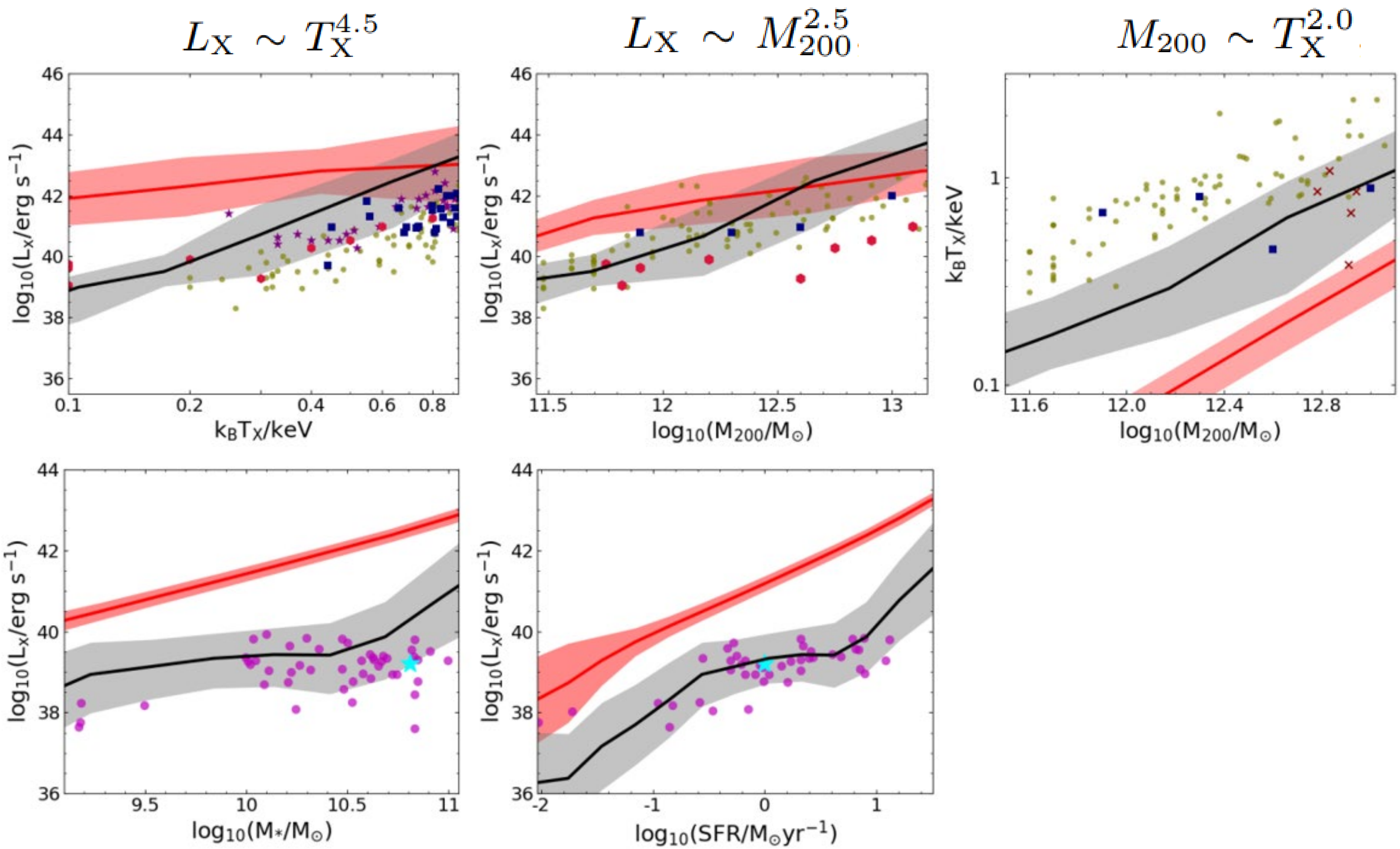




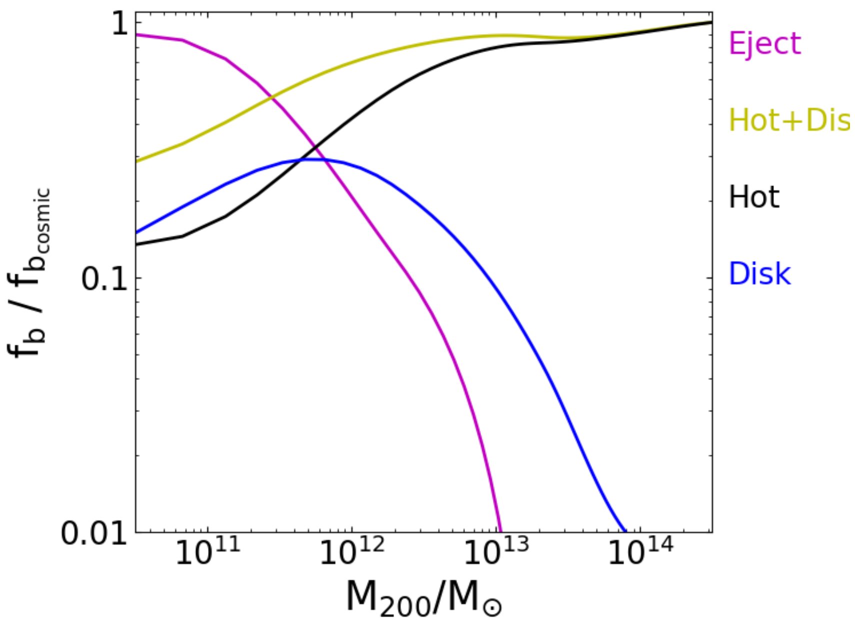
Results: scaling relations of soft X-ray emission from hot gas

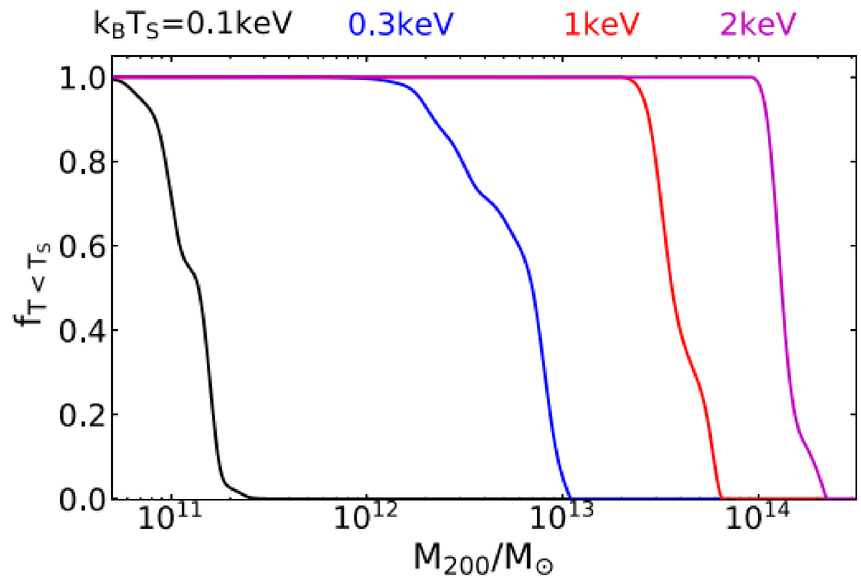
$$L_X = 4\pi \int n_e(r) n_i(r) \Lambda(T(r), Z) r^2 dr$$

$$T_{\rm X} = \frac{4\pi \int_0^{r_{\rm vir}} T(r) n_e(r) n_i(r) \Lambda(T(r), Z) r^2 dr}{4\pi \int_0^{r_{\rm vir}} n_e(r) n_i(r) \Lambda(T(r), Z) r^2 dr}$$



Baryon Budgets and missing baryons



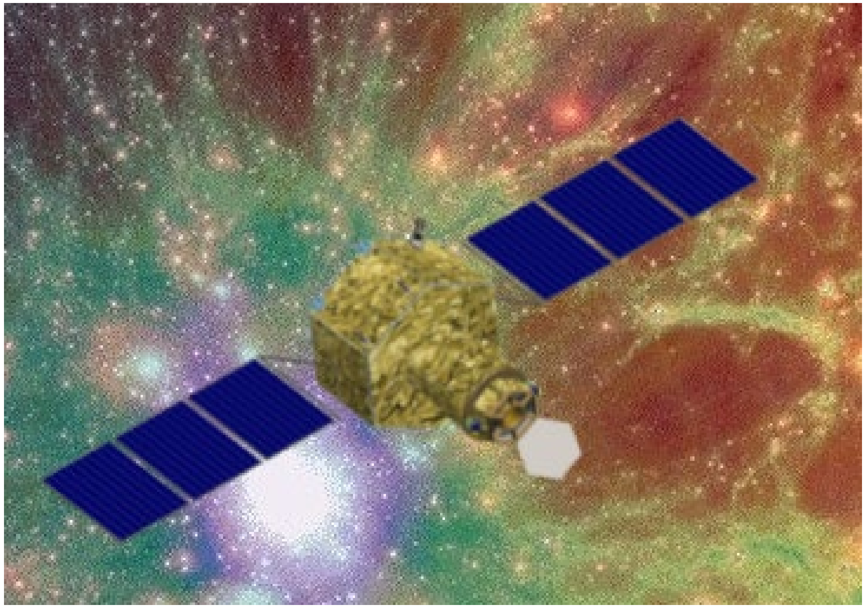


Unbounded reservoir out of halo potential

Hot gas in low mass haloes

Mock X-ray observations for hot gas components

Key parameters	
Energy range	0.1-2 keV
Field of View	1° × 1°
Agular resolution	1′
Number of pixels	60×60
Effective area	500 cm^2
Spectral resolution	2 ev (main array) 0.6 ev (central)



Summary

- The new model returns a much better match to X-ray observations compared with the previous model. The main reason for this is flatter cores in the inner halo, rather than the "cusps" present in the isothermal sphere approximation.

- The temperature of the hot gas is **higher than T_{vir}** in most haloes, which is mainly caused by the high temperature gas undergoing thermal instability and infall in the cool core region.

- Our model suggests that the ionized gas in the unbounded reservoir out of halo potential and low temperature intergalactic gas bounded in low mass haloes should be the main components of the "missing baryons".

Thank you!