

Detection of hot gas in the Circumgalactic Medium of the Milky Way

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What is the Circumgalactic Medium (CGM)?

What is the CGM?

It is all the gas and dust outside the disk and within the virial radius of a galaxy.

Structure of a spiral galaxy

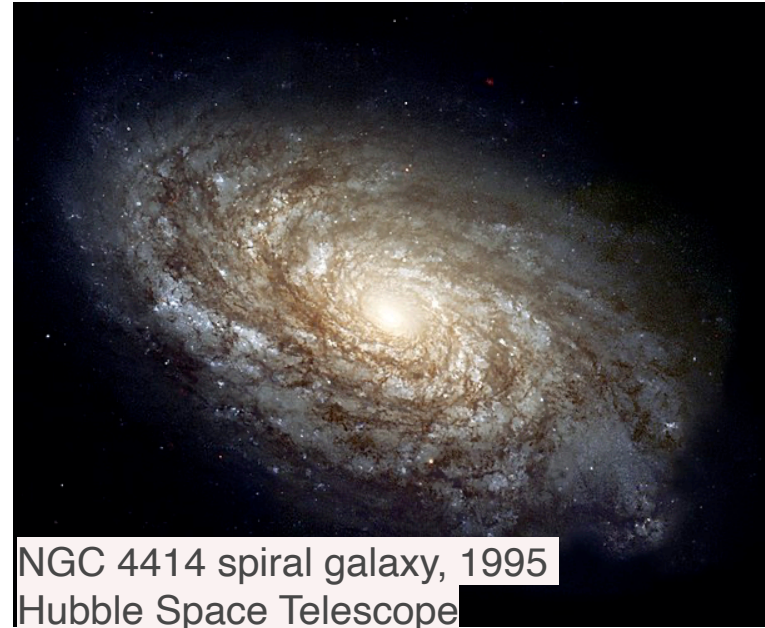
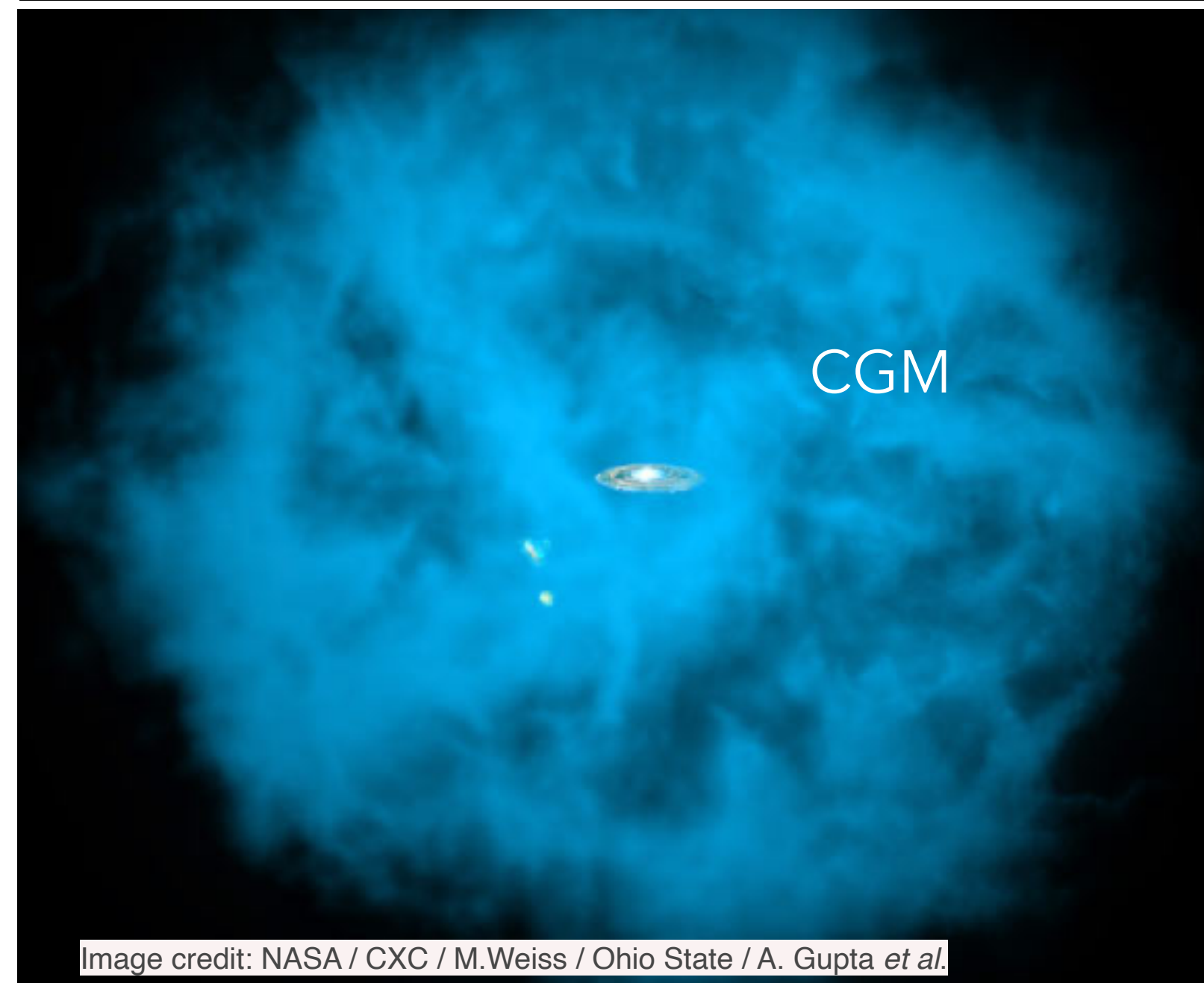


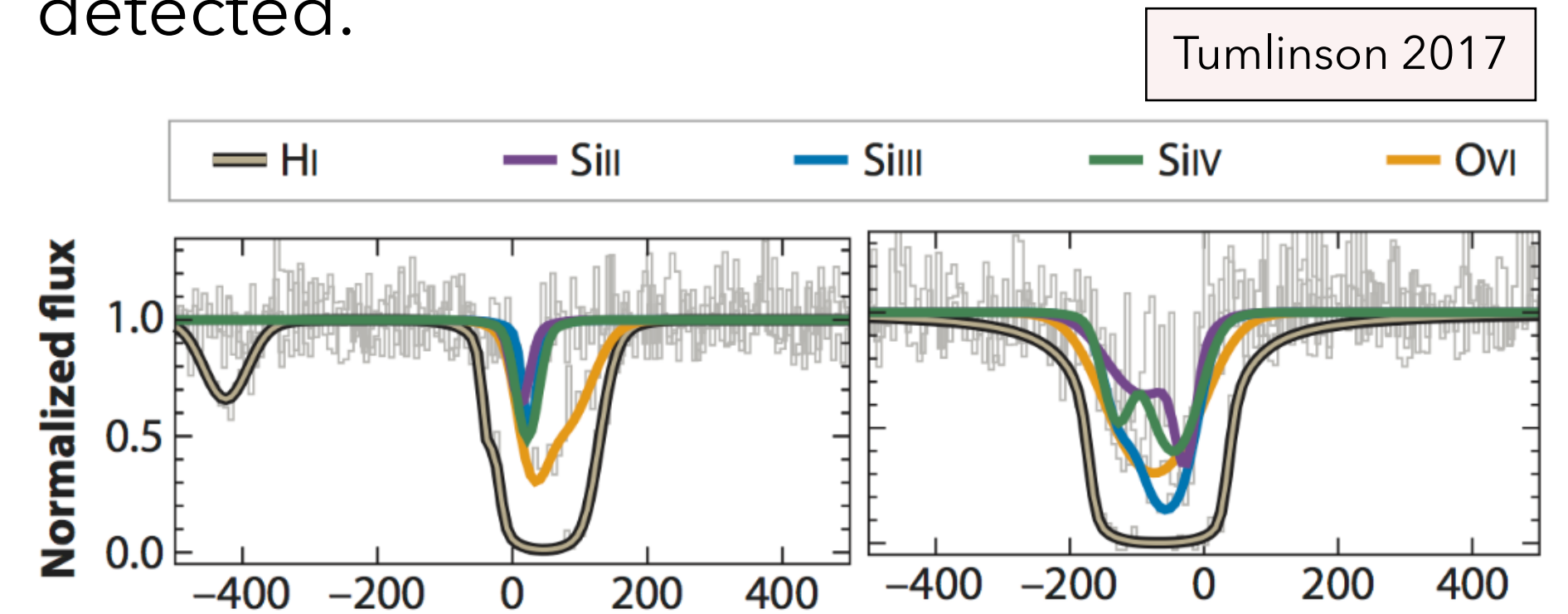
Illustration of the CGM enveloping the Milky Way.



Around galaxies there is a lot of gas and dust.

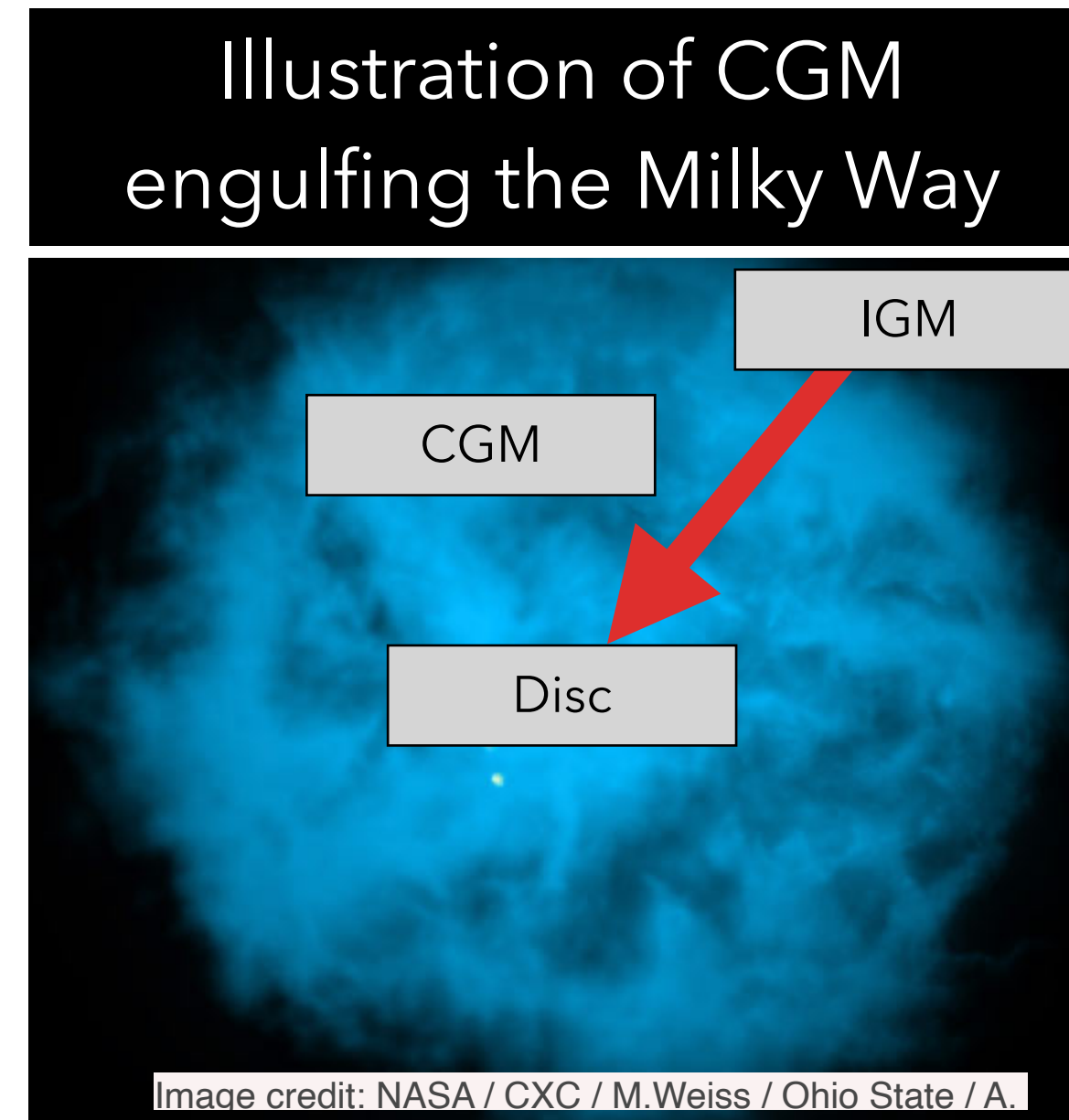
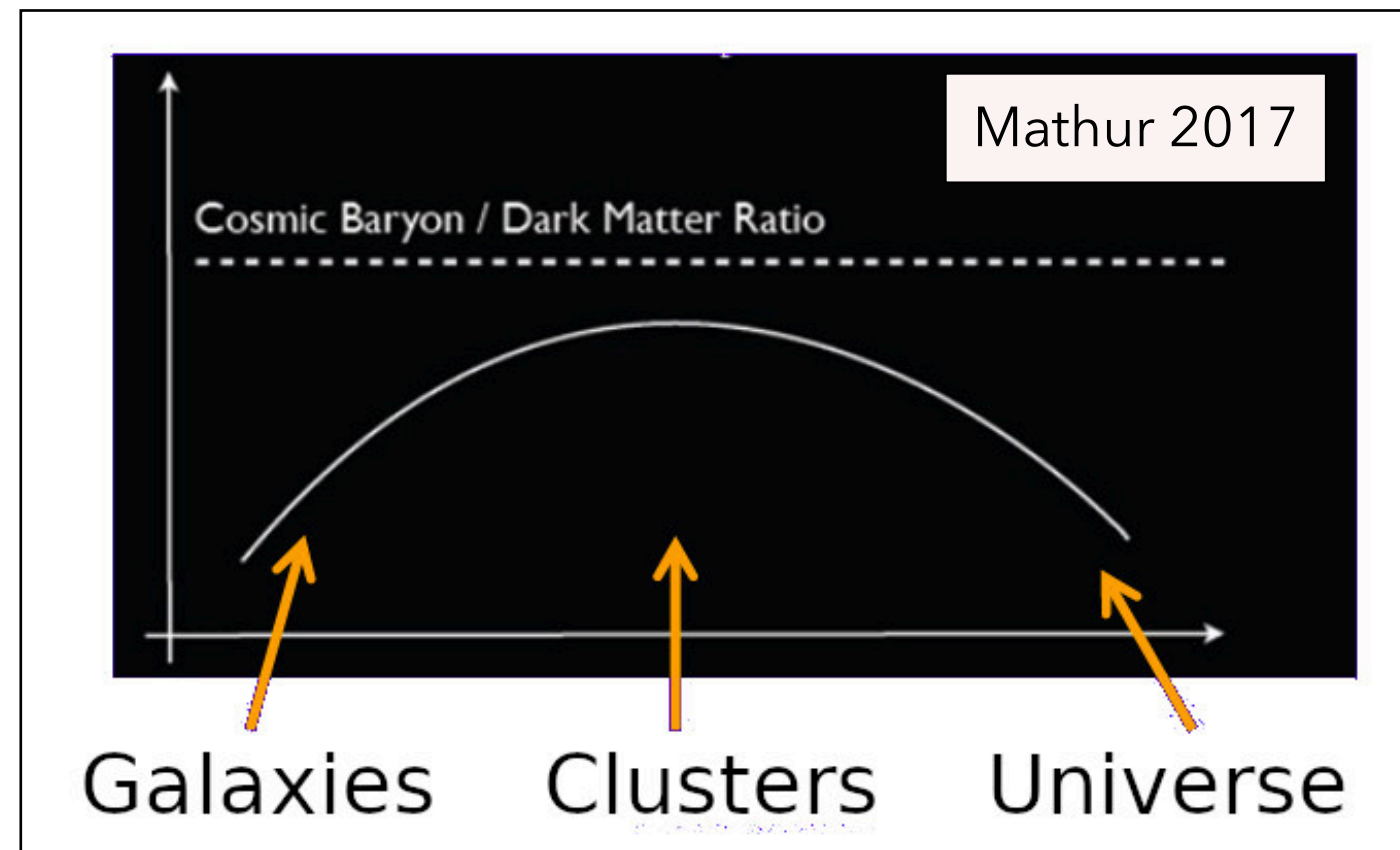
How do we know it exists?

Mainly in UV low ionization lines have been detected.

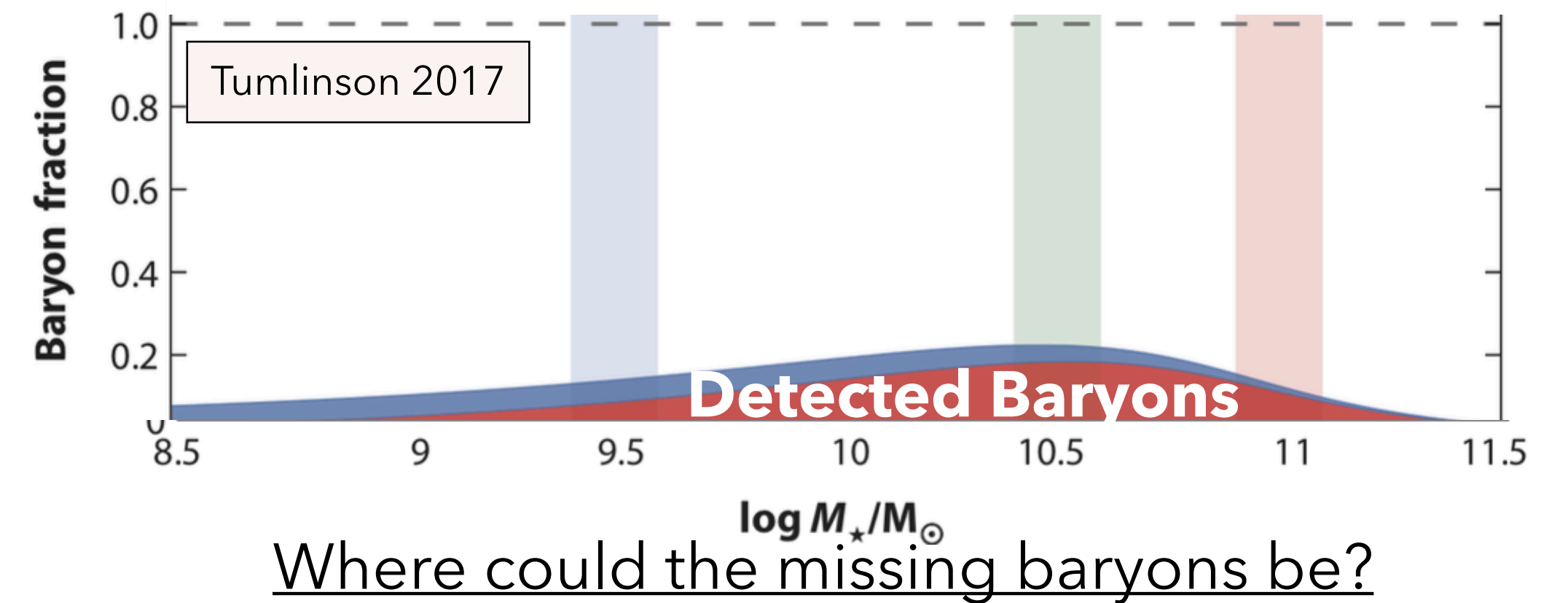


1. We need to understand how oxygen, which is produced in stars, ends up in the CGM
2. Its location make it a large reservoir of materia
3. Might contain the missing baryons and metals at galactic scales

Missing Baryon Problem



The baryons forming stars or spread out in the interstellar medium are only a small fraction of the total number of baryons expected in galaxies.



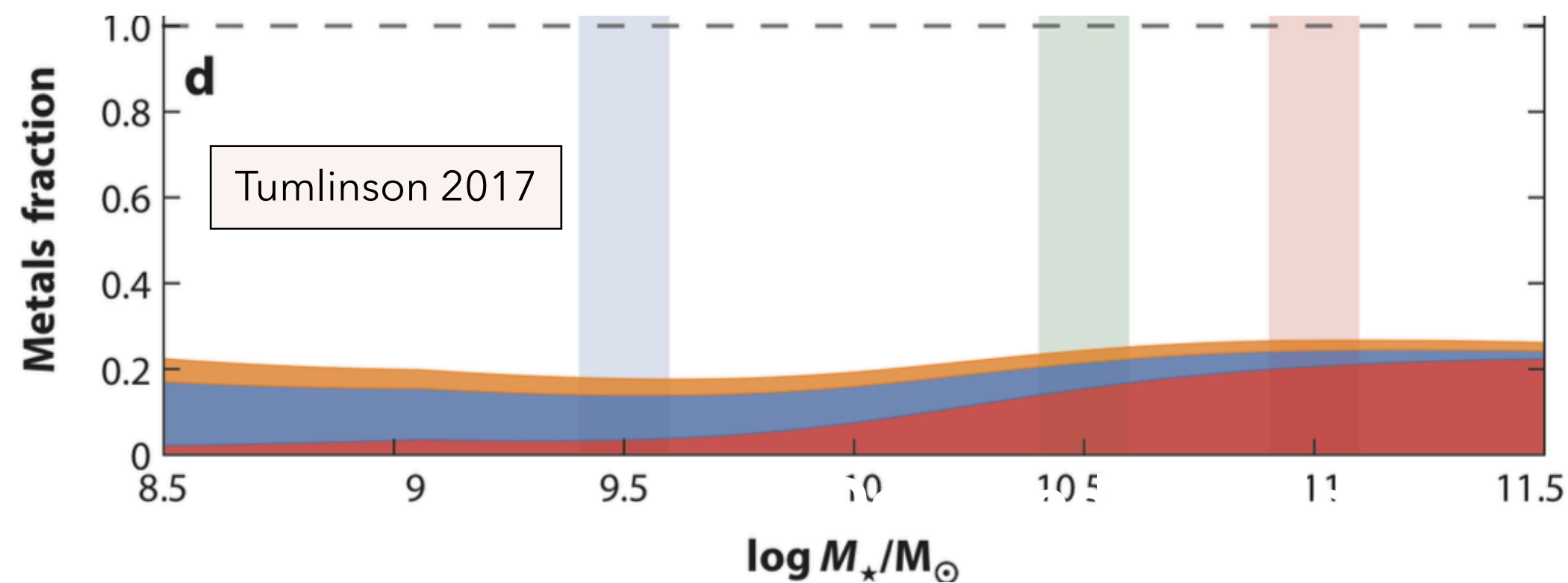
The expected baryon fraction at galactic and cosmological scales is not observed for $z < 2$.

1. They have not fallen to disk
2. They already fell and were expelled from the disk

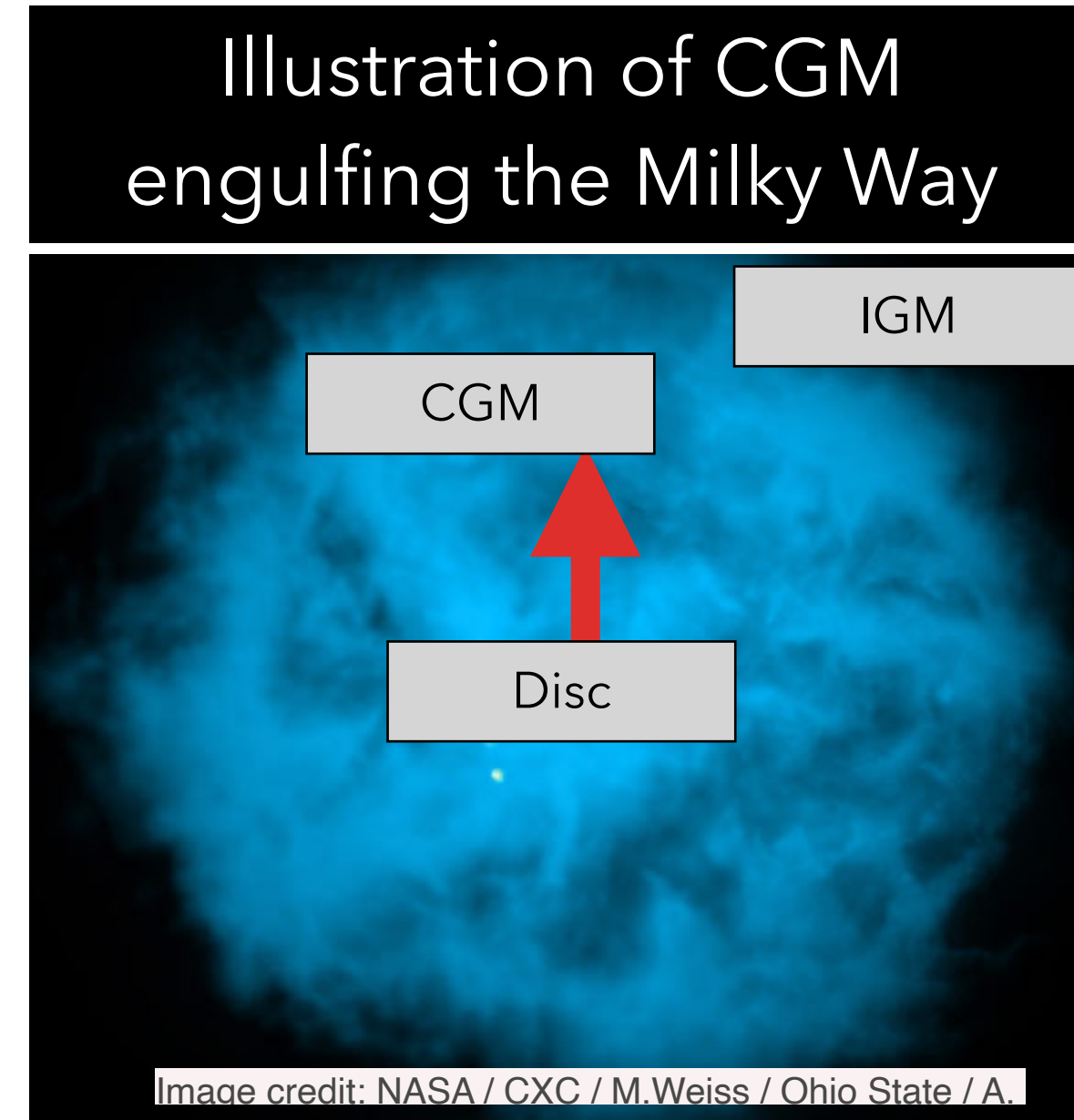
Missing Metals Problem

From the star formation history of galaxies and the number of stars we see, it is inferred how much metal galaxies should have.

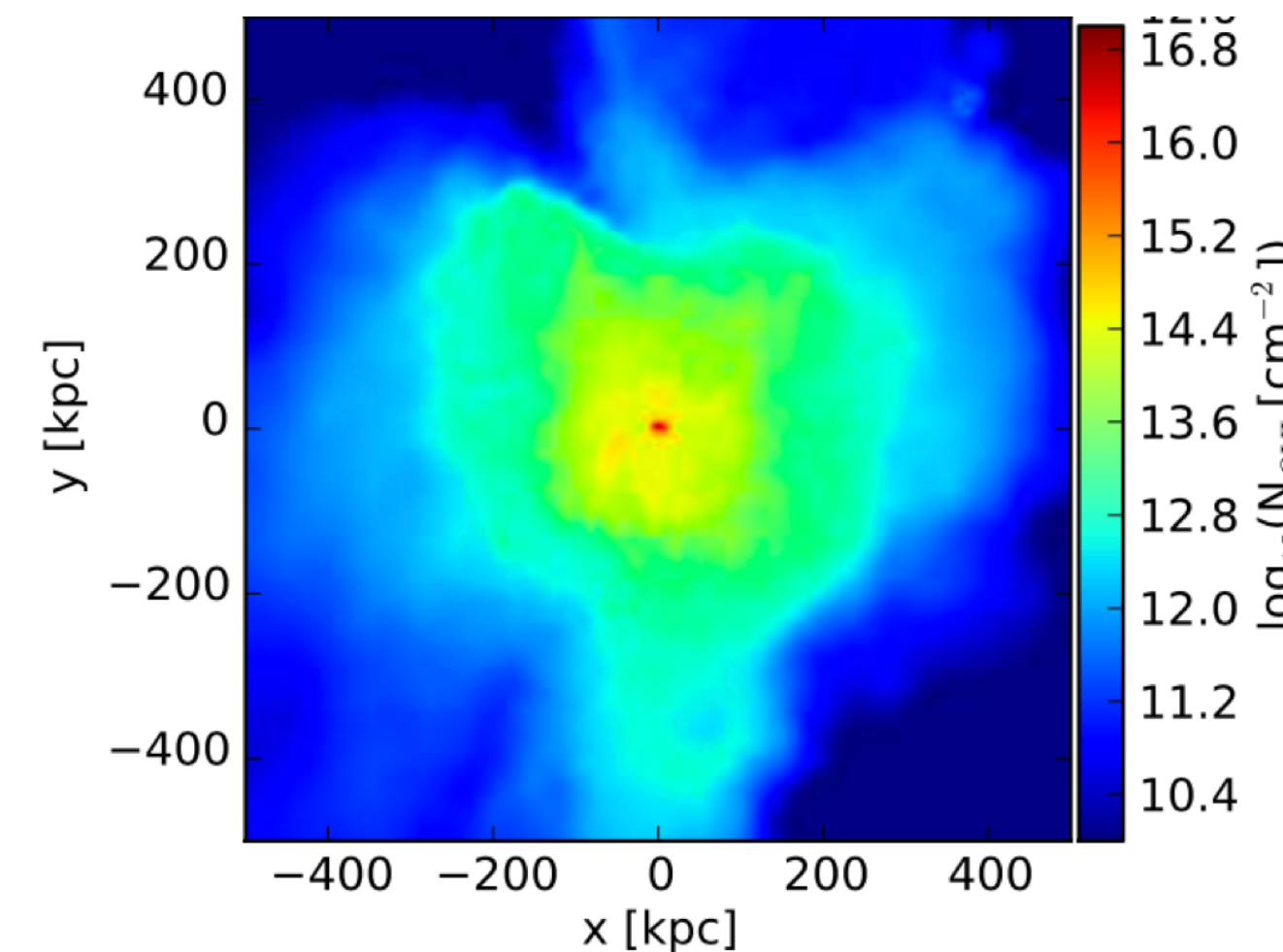
Fraction of metals retained in galaxies



The galactic disk only contains 20% of the metals produced in stars.

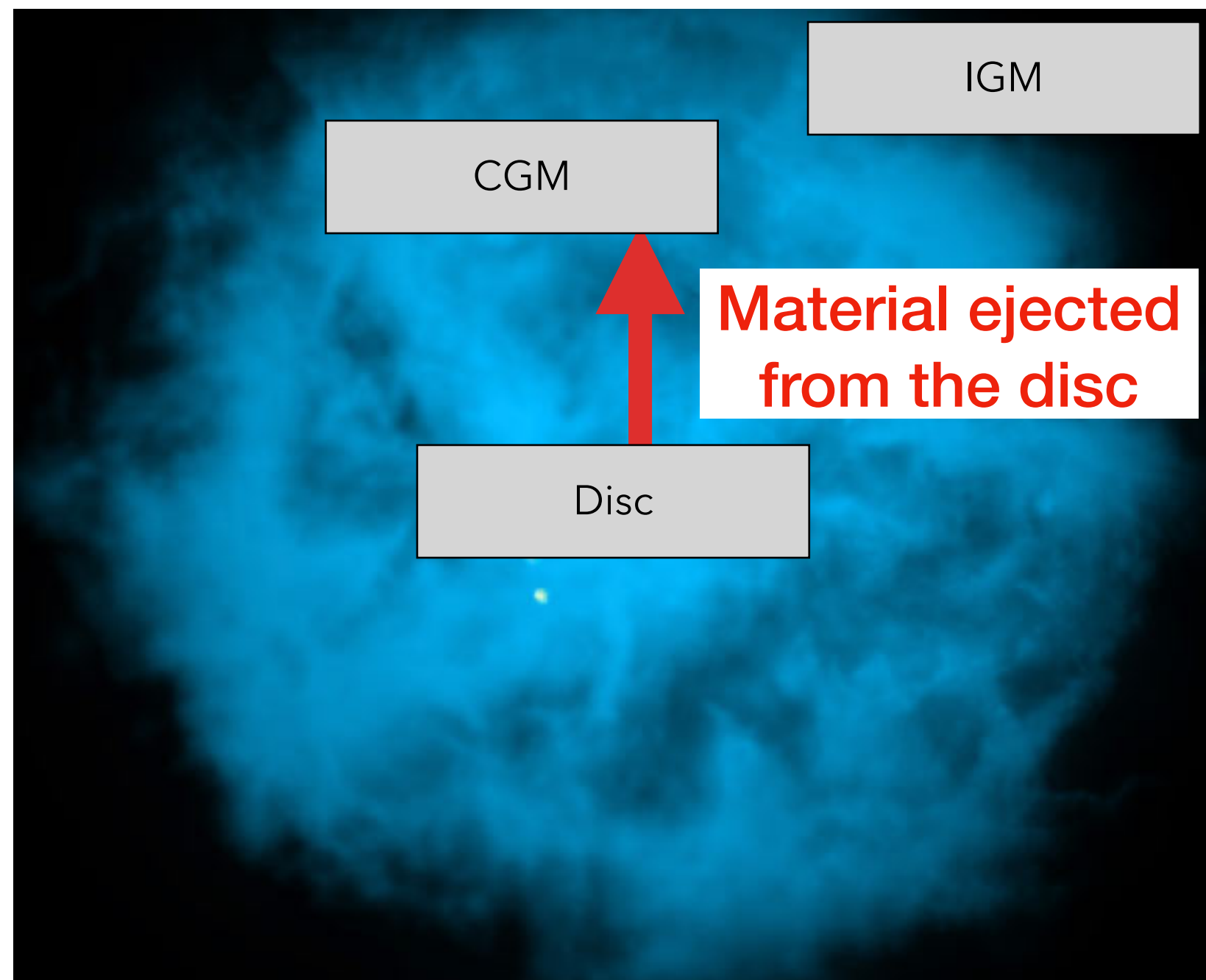
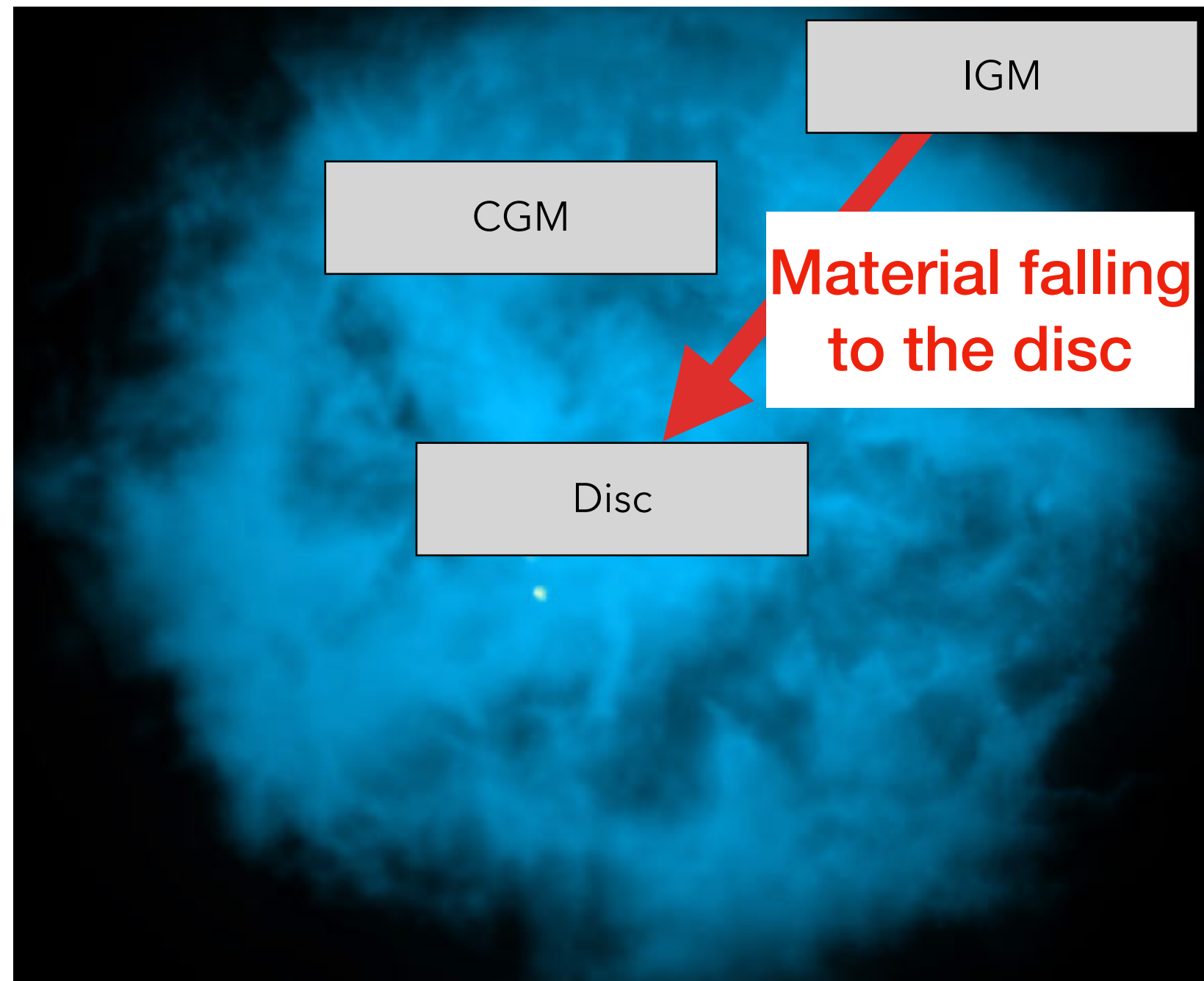


The metals are formed on the disc and then ejected to the CGM



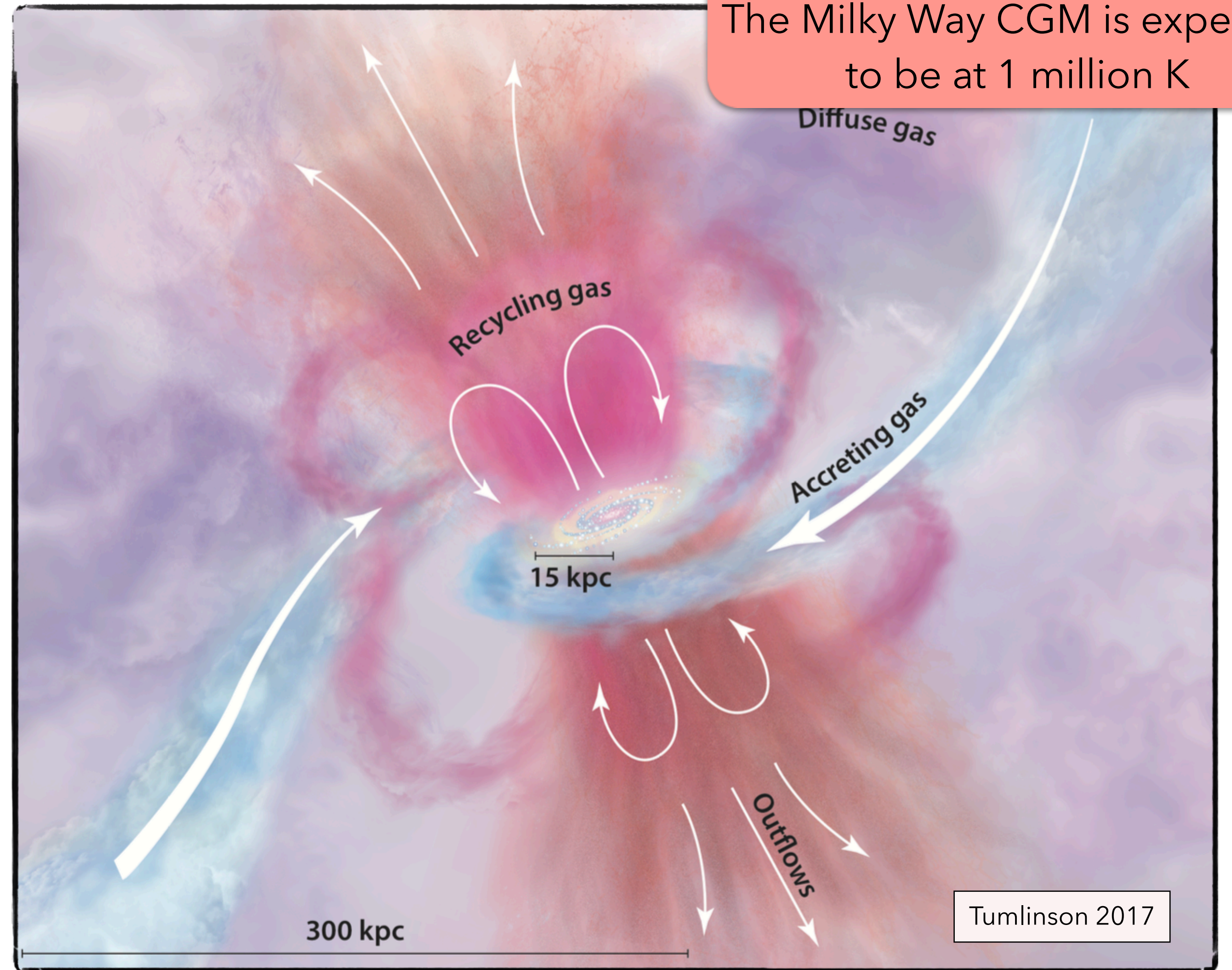
Simulations help us explain the presence of this material around galaxies.

General Idea



The missing baryons and metals could be in the CGM in hot and diffuse phase.

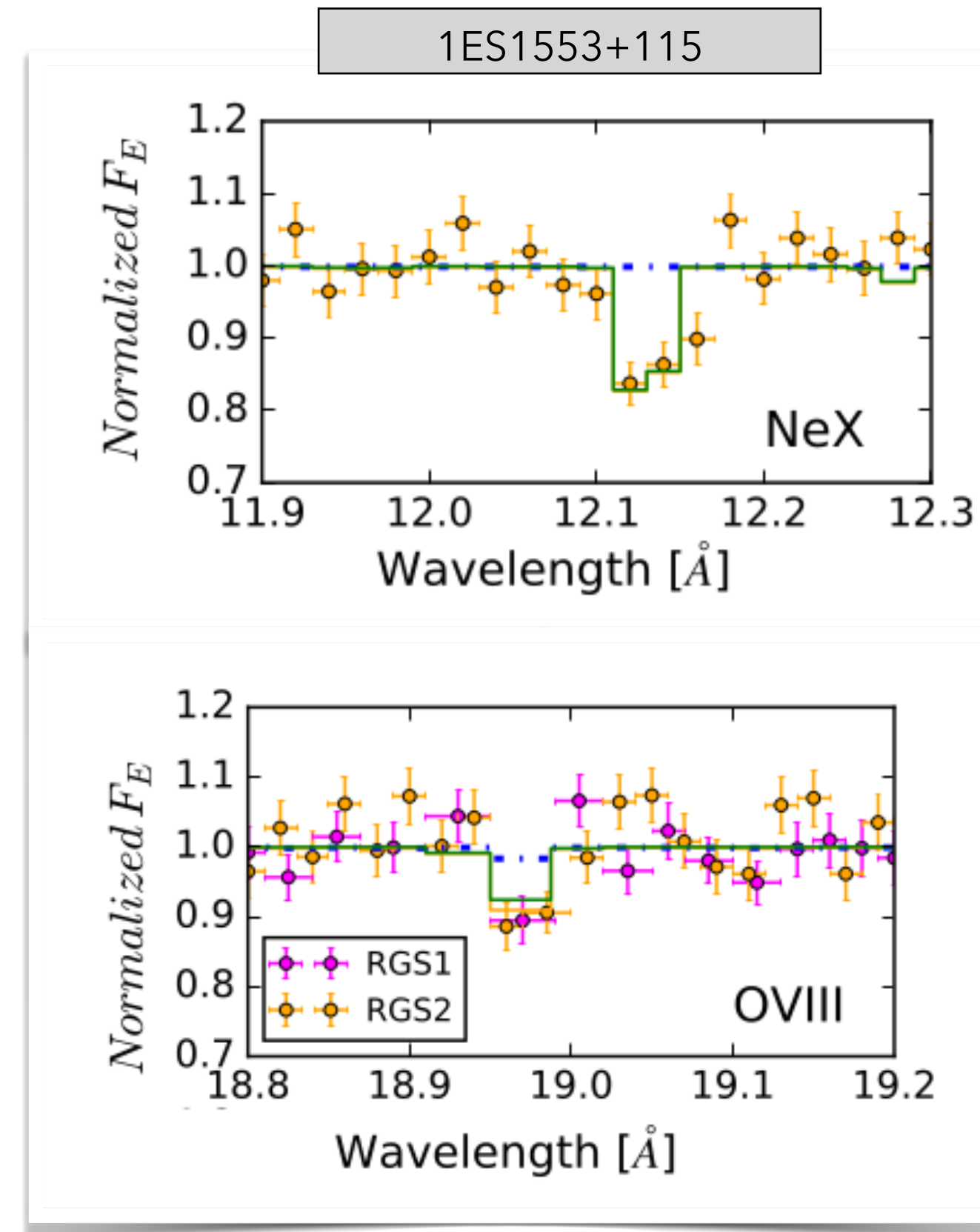
The Milky Way CGM is expected to be at 1 million K



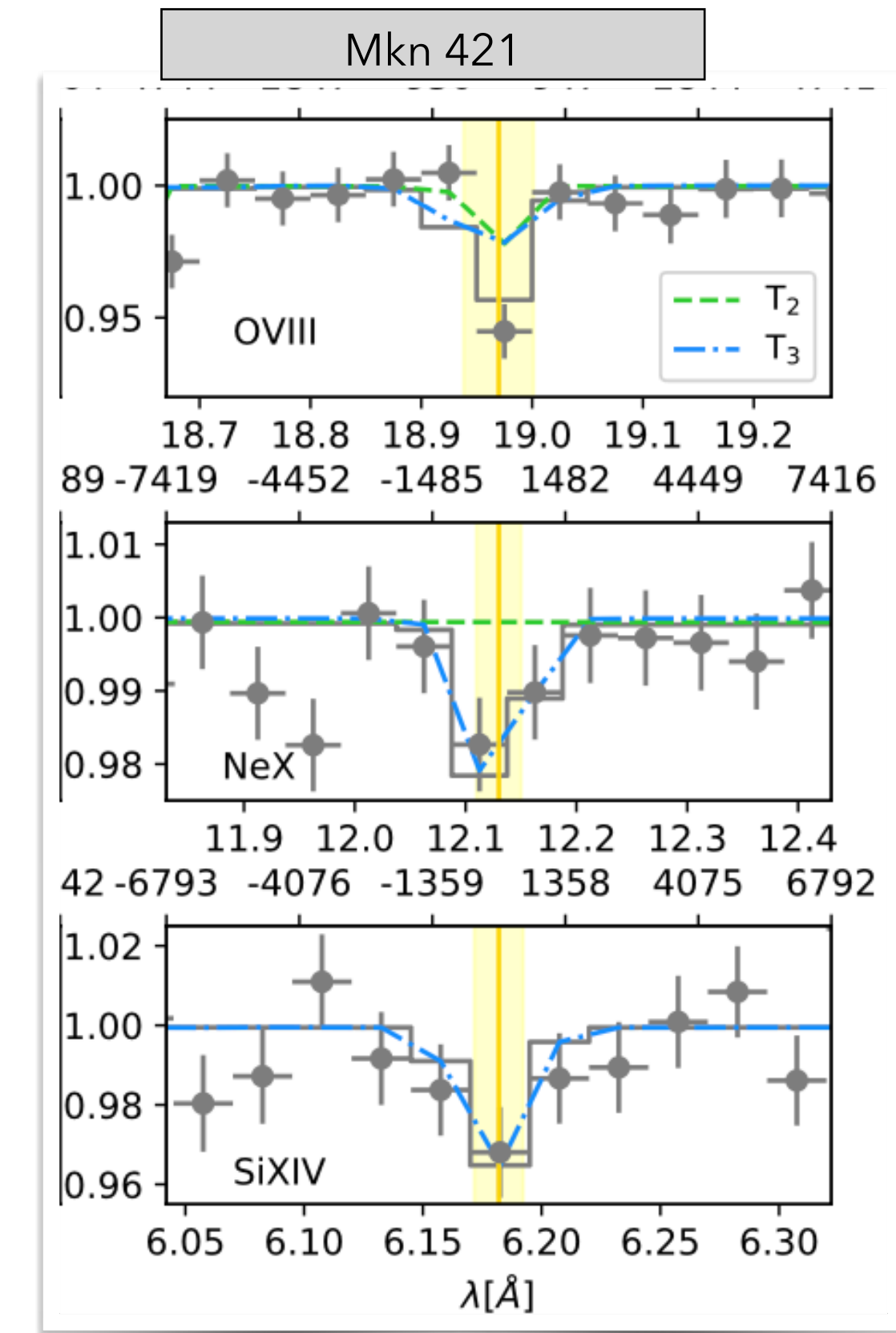
Detection of the hot CGM

Detection of absorption lines in the CGM of the Milky Way associated with a very hot ($10^{7.5}$ K) and very diffuse gas phase.

In addition to the 1 million K component, a hotter phase of the order of $10^{7.5}$ K has been found.



Das et al., 2019



Das et al., 2021

Absorption lines in the reference frame of the Milky Way.

Our Work: Studying the CGM through multiple Sight-Lines

We use high-resolution grating spectra.

Stacked Lines of Sight:

46 - HETG

9 - LLETG

We remove sources that have t_{exp} of millions of seconds so they don't dominate the signal-to-noise of the summed spectrum.

ACIS-S HETG-MEG

Spectral range: (2.5 - 31 Å)

Spectral resolution: (0.023Å)

Effective area: (59 cm² at 12.4 Å)

ACIS-S LETG

Spectral range: (1.2 - 60 Å)

Spectral resolution: (0.05 Å)

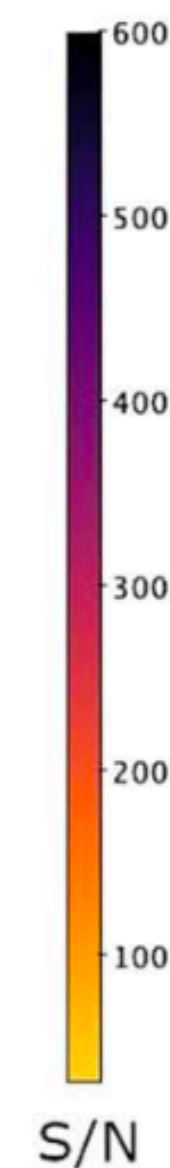
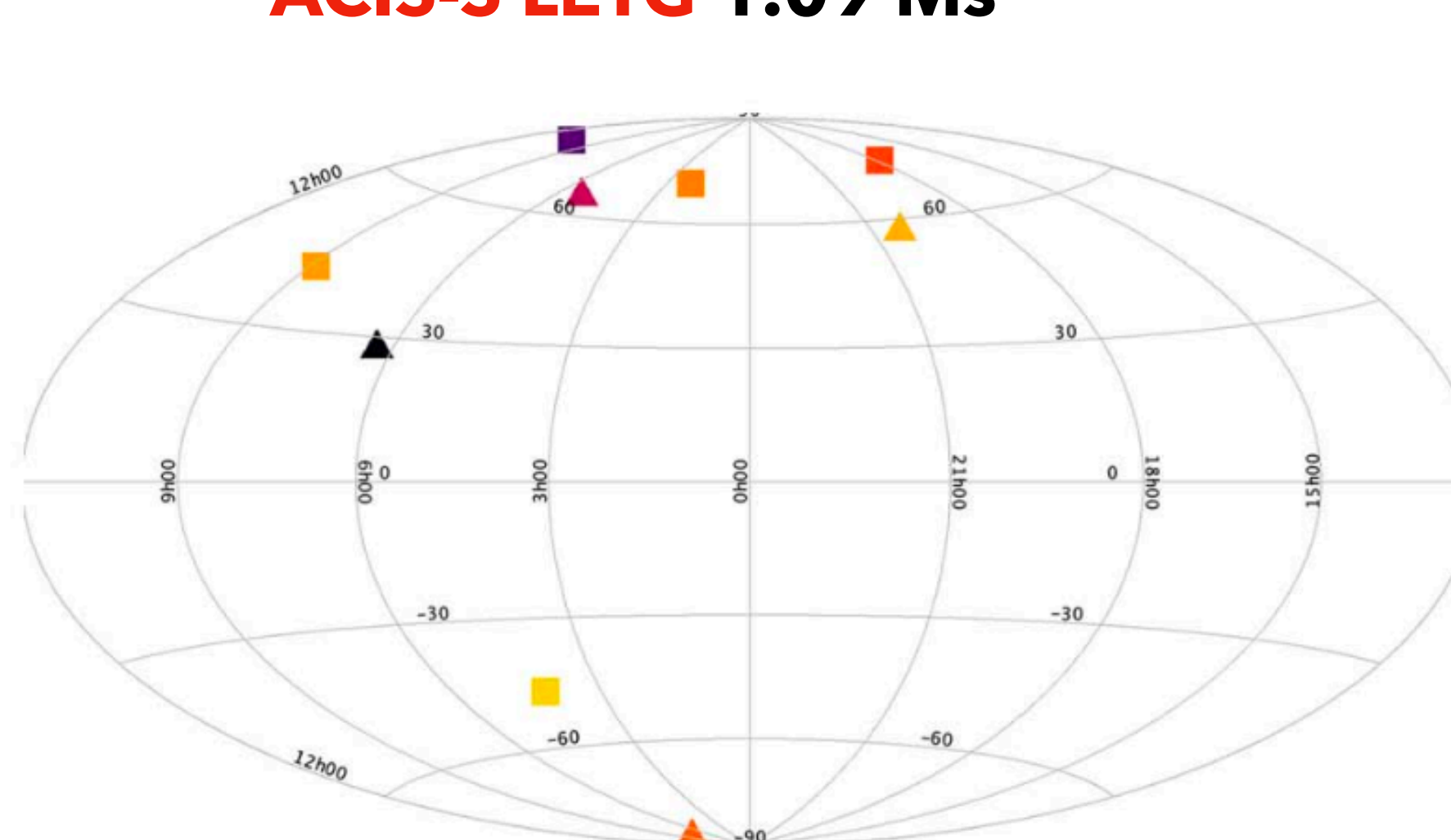
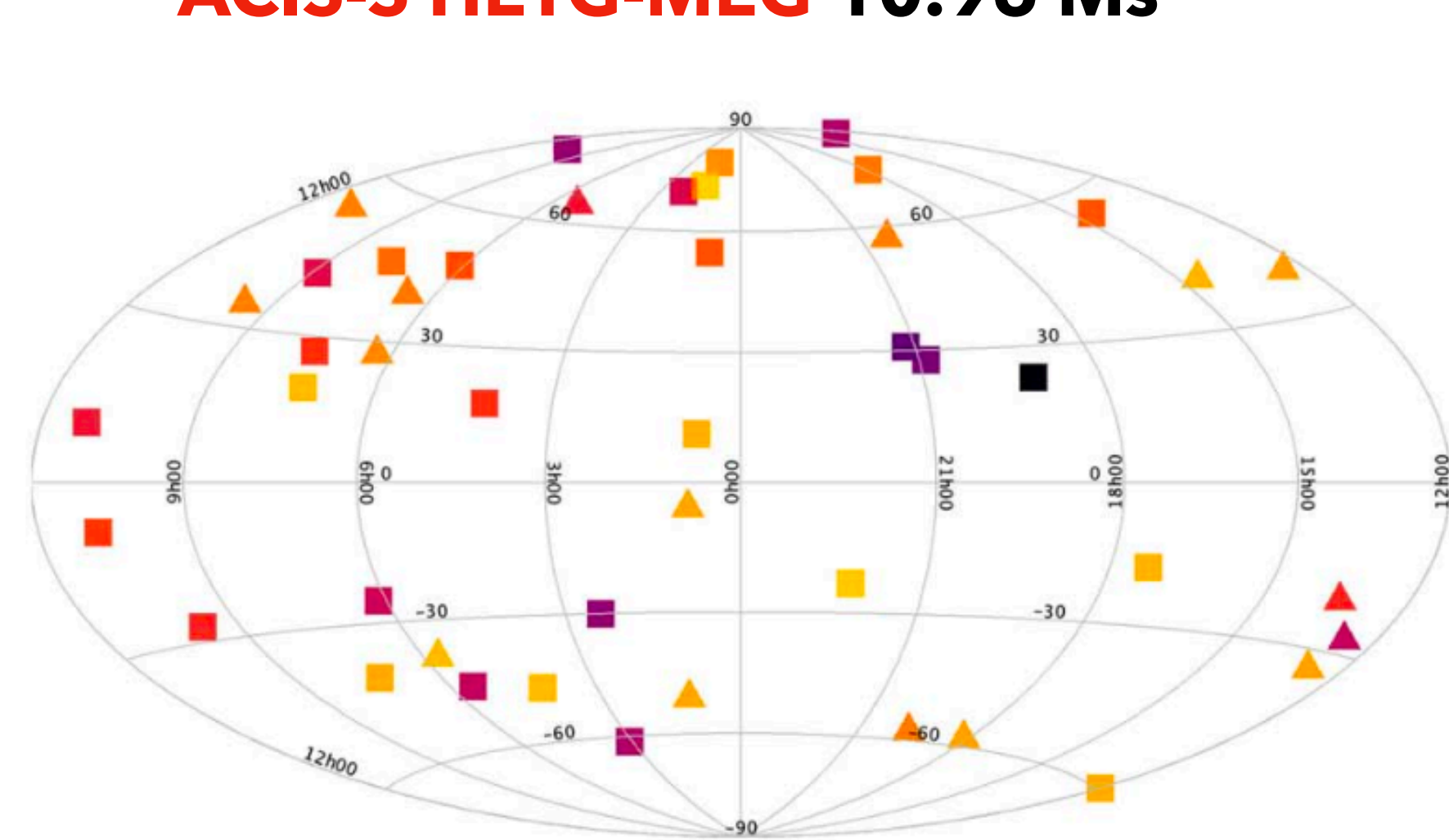
Effective area: (1 - 100 cm²)

Stacked Lines of Sight of Our Sample

Armando Lara-Dí et al., 2023

ACIS-S HETG-MEG 10.96 Ms

ACIS-S LETG 1.09 Ms



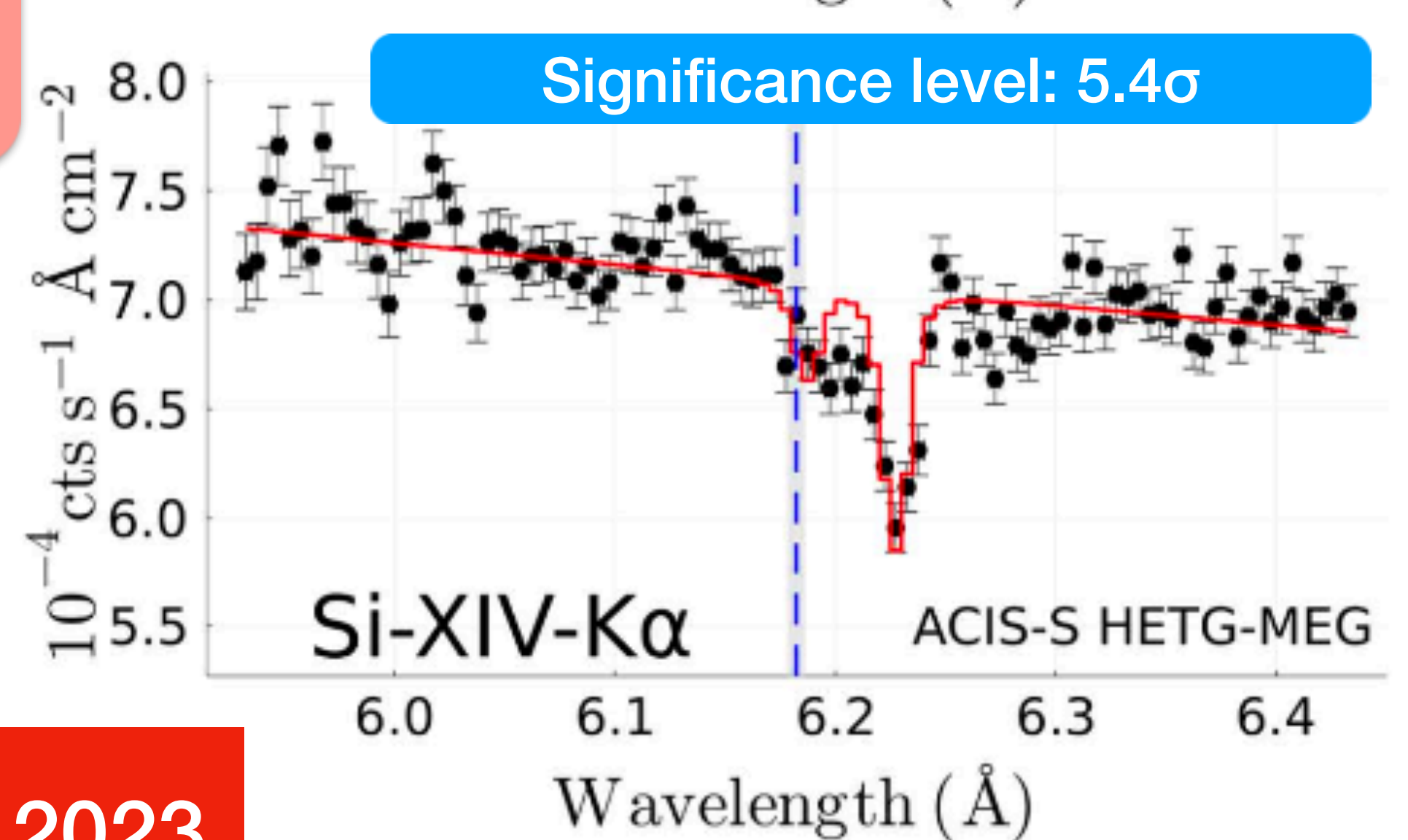
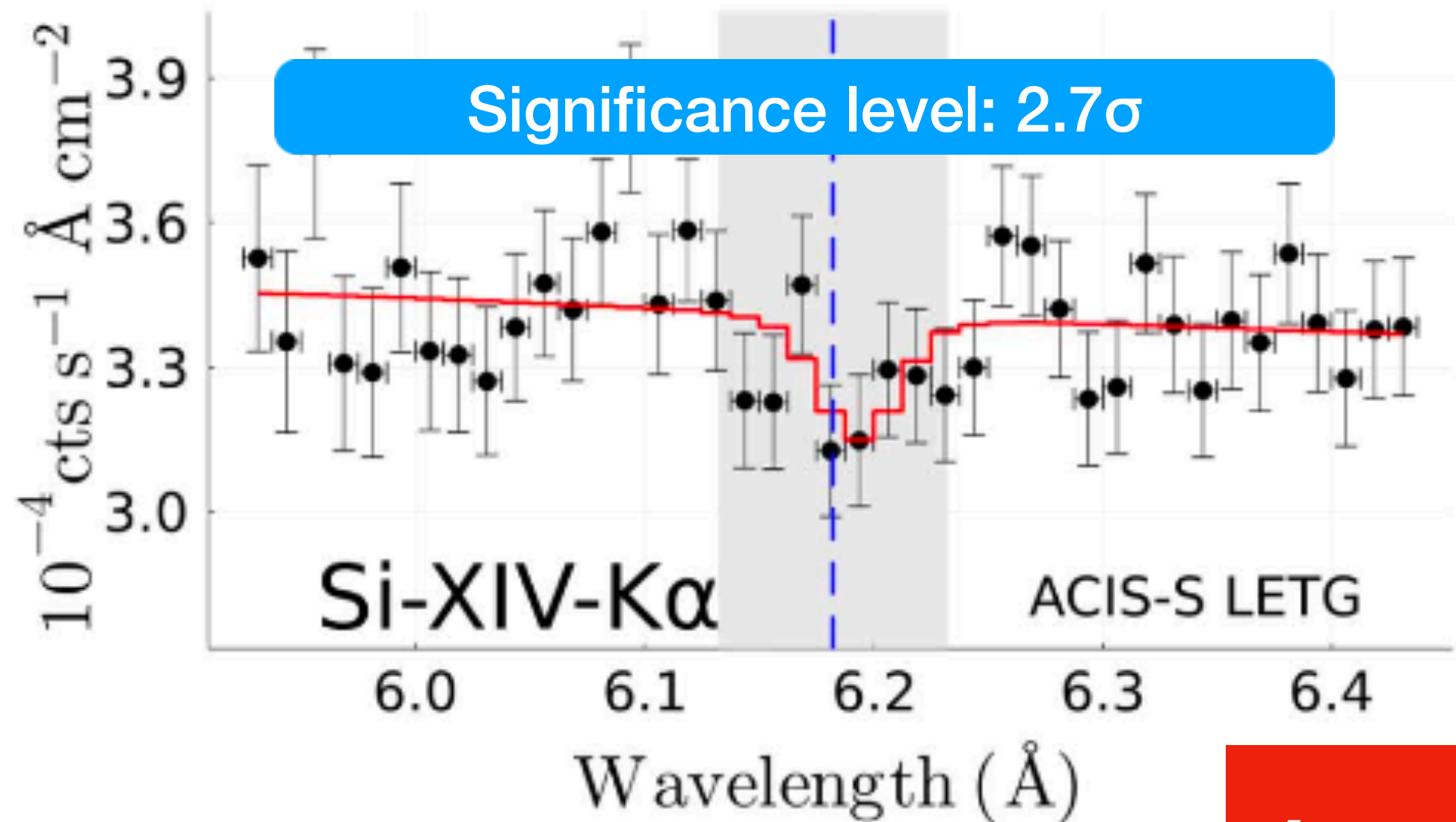
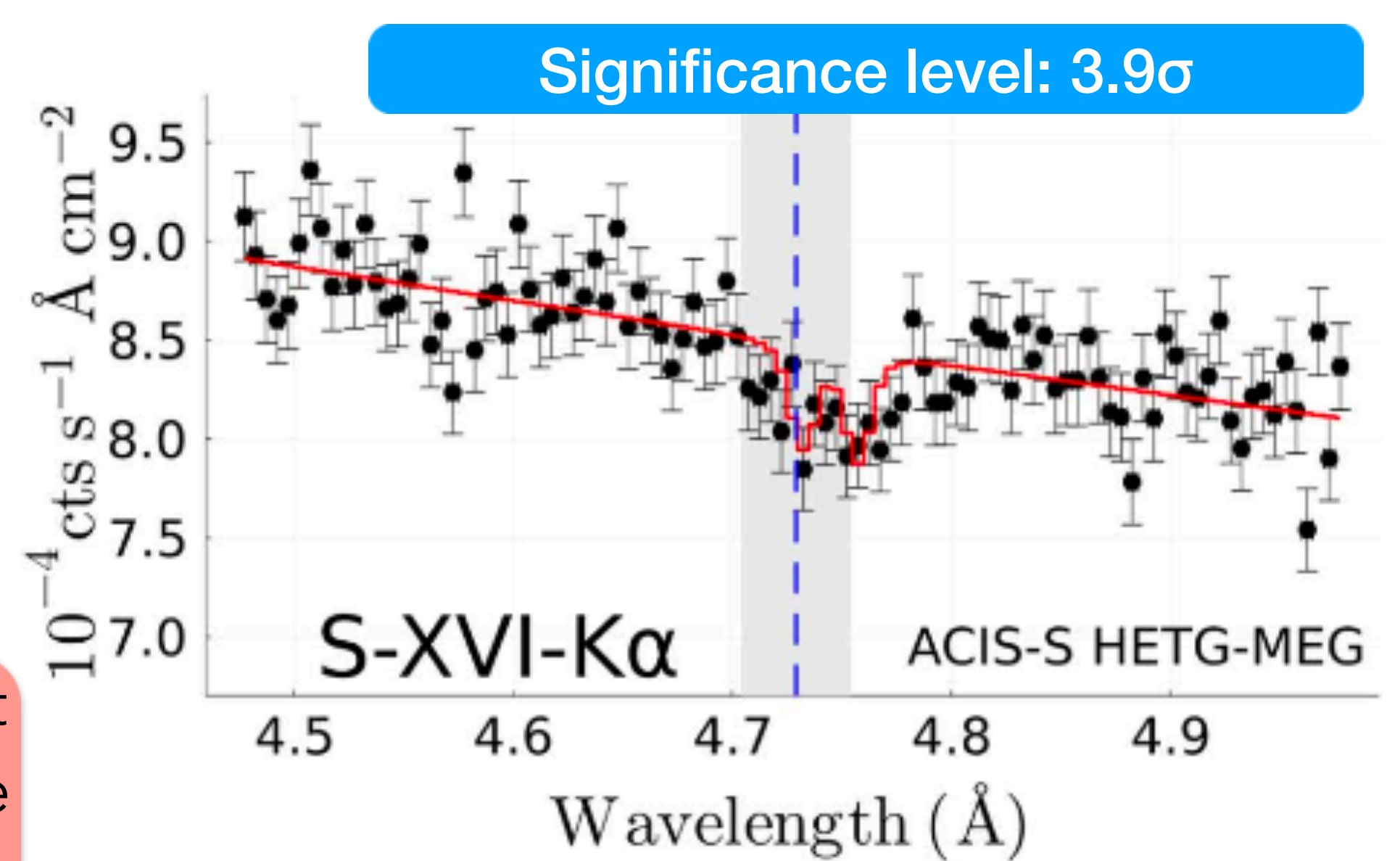
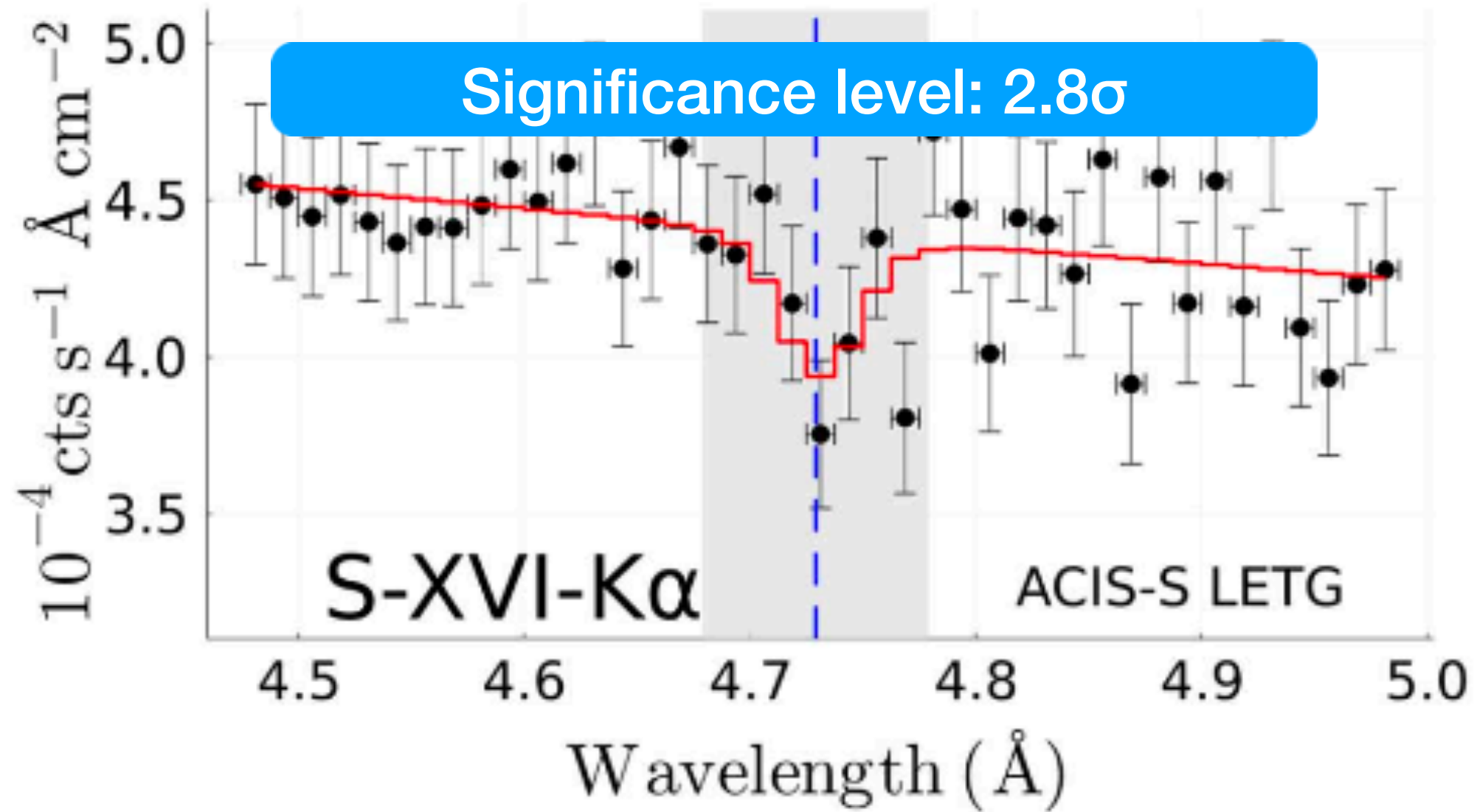
HETG: High Energy Transmission Grating Spectrometer.

MEG: Medium Energy Grating

LETG: Low Energy Transmission Grating Spectrometer

ACIS: Advanced CCD Imaging Spectrometer

Our results confirm the hot CGM



We detect the super hot phase in the CGM of the Milky Way through the lines of Si XIV and S XVI

Armando Lara-Dí et al., 2023

Conclusions

1. We have confirmed the presence of the super-virial component in the CGM of the Milky Way. Our stacked spectra through differing lines of sight confirm that this hot component is spread throughout the halo.
2. The hot gas phase is not predicted by simulations. So, what could possibly be heating it? Perhaps shock heating processes?
3. The hot component is not confined to the Fermi Bubbles because our observations span multiple lines of sight.

In conclusion: Understanding the nature of this super-virial gas phase will significantly contribute to our comprehension of CGM and to the galactic processes and their implications.