An AGN-blown Nuclear Bubble Triggers Star Formation in a Face-on Analogue to our own Milky Way

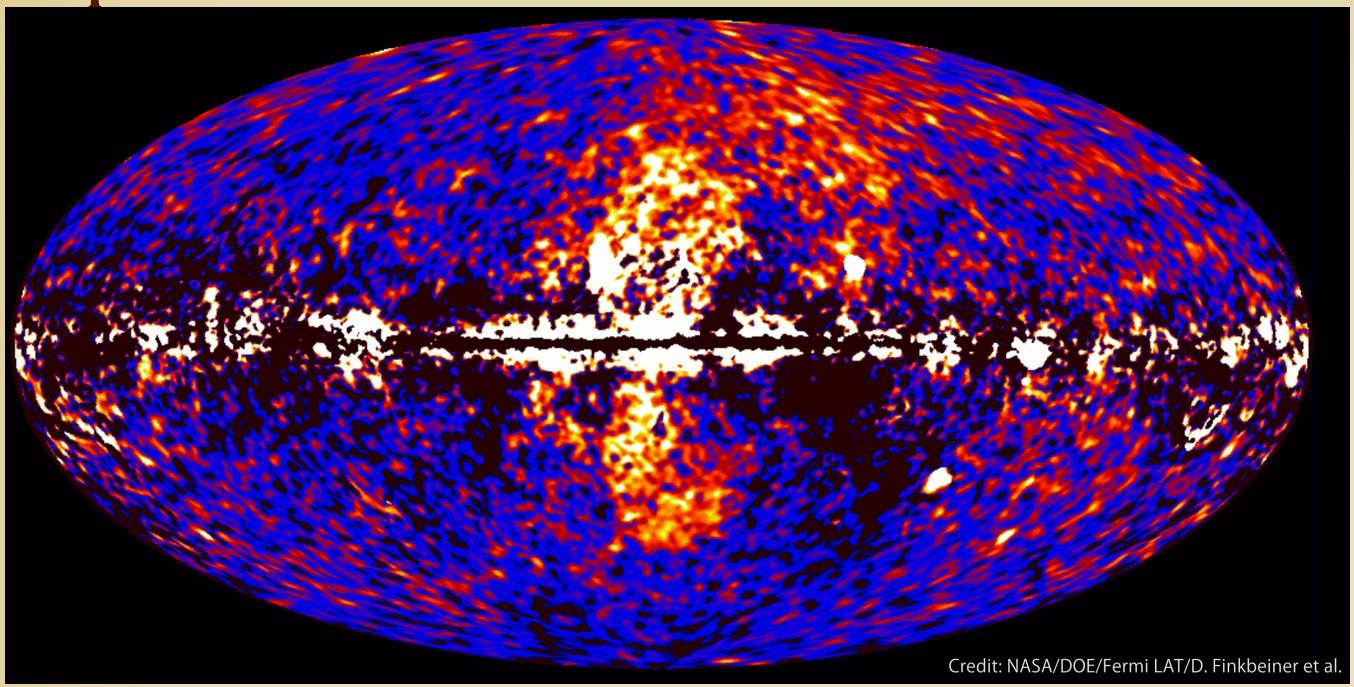
Emily Freeland

Collaborators : Laura Chomiuk, Nathaniel Doane, Christian Farnier, Barry Rothberg, Kyle Westfall, Eric M. Wilcots, Ashley Zauderer, Ellen Zweibel

Stockholm University

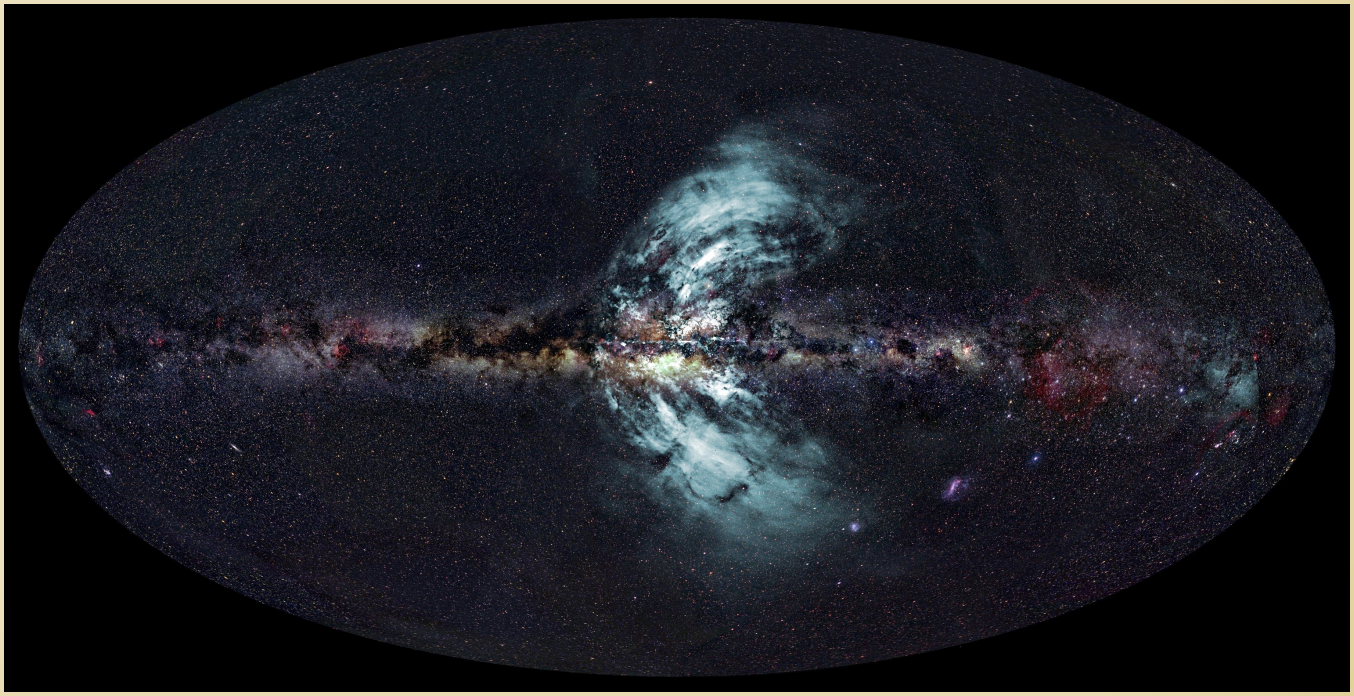
Oskar Klein centre

Bipolar bubbles emanate from the center of our galaxy.

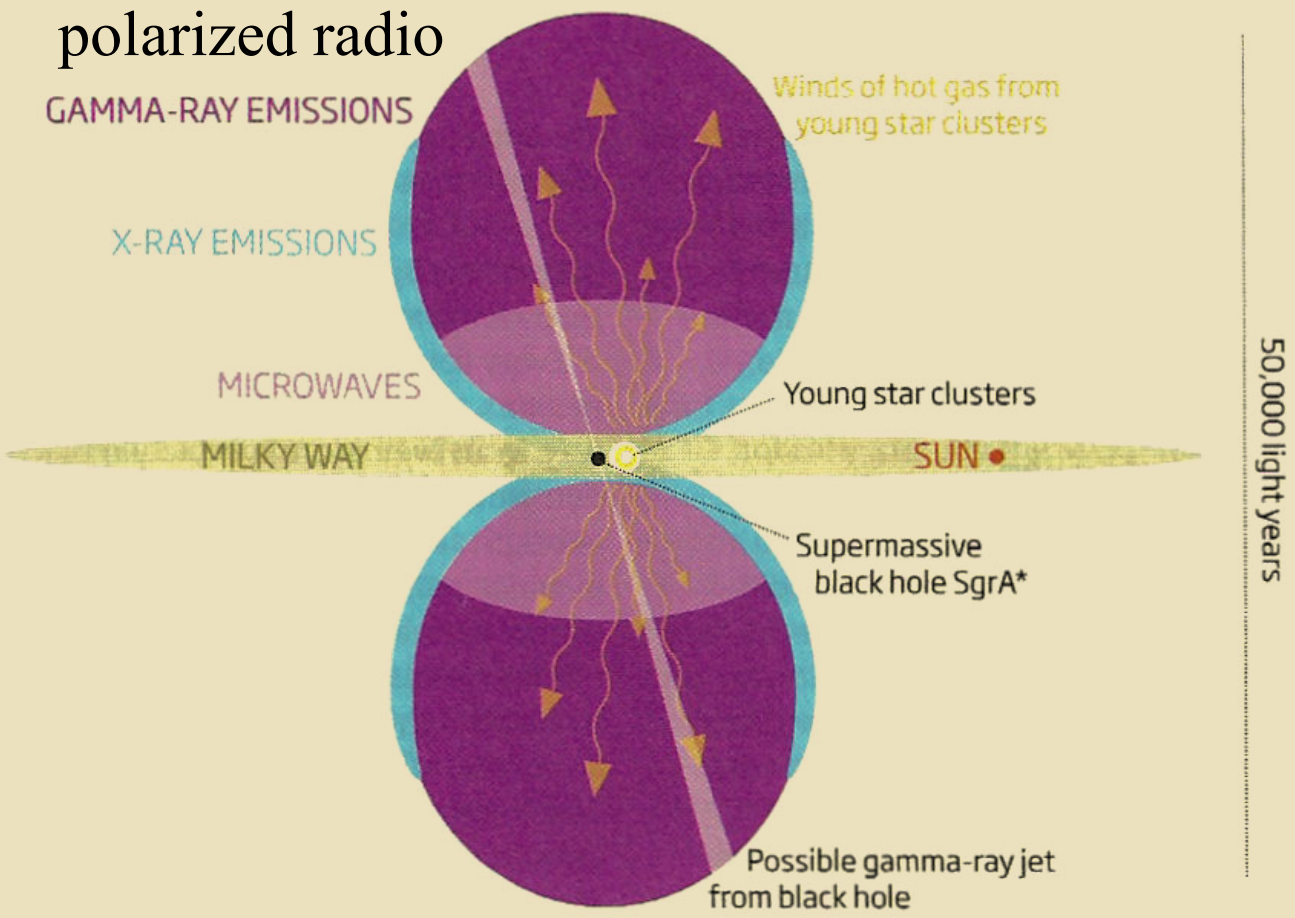


gamma-rays
(Su+2010)

2.3 GHz
polarized
radio continuum
(Carretti+2013)



The bubbles are detected to different extents at various wavelengths.

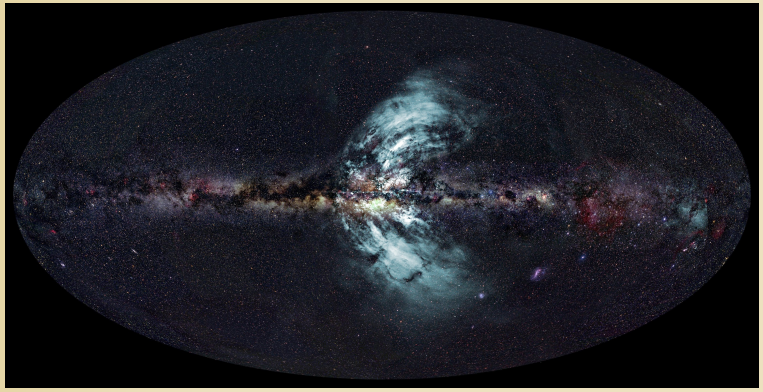


There are many open questions related to these bubbles.

Are they driven by black hole activity or star formation?
What determines their morphology?
What process produces the gamma-rays?
How are magnetic fields involved?
Are they long-lived or transient?
Are they still expanding?

The Galactic Center is obscured due to orientation, extinction, absorption, and depolarization.

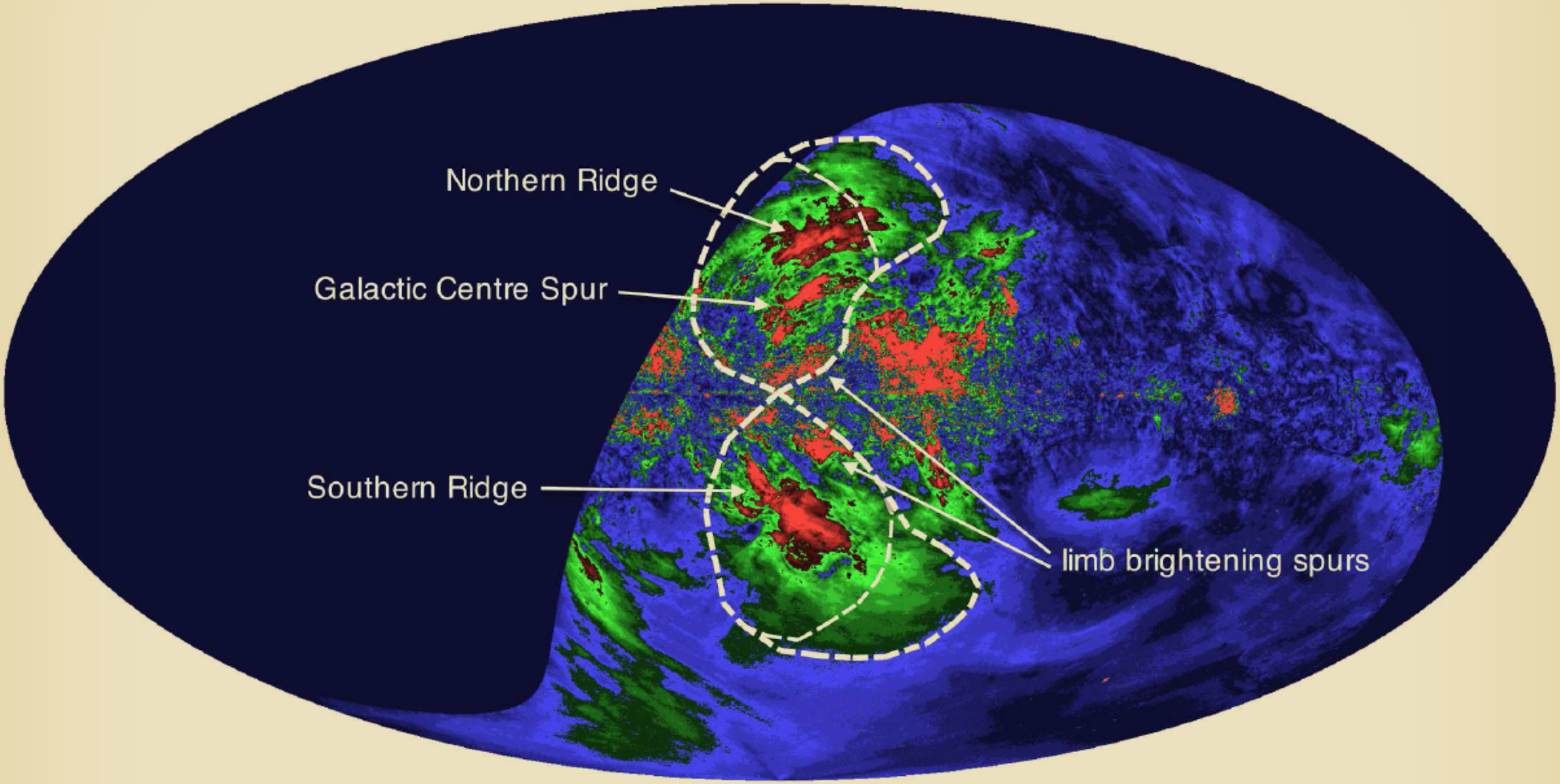
Would love to rotate the galaxy and see an unobscured view of the Galactic Center.



Look for bubbles (but not using gamma-rays) in face-on galaxies similar to our own.

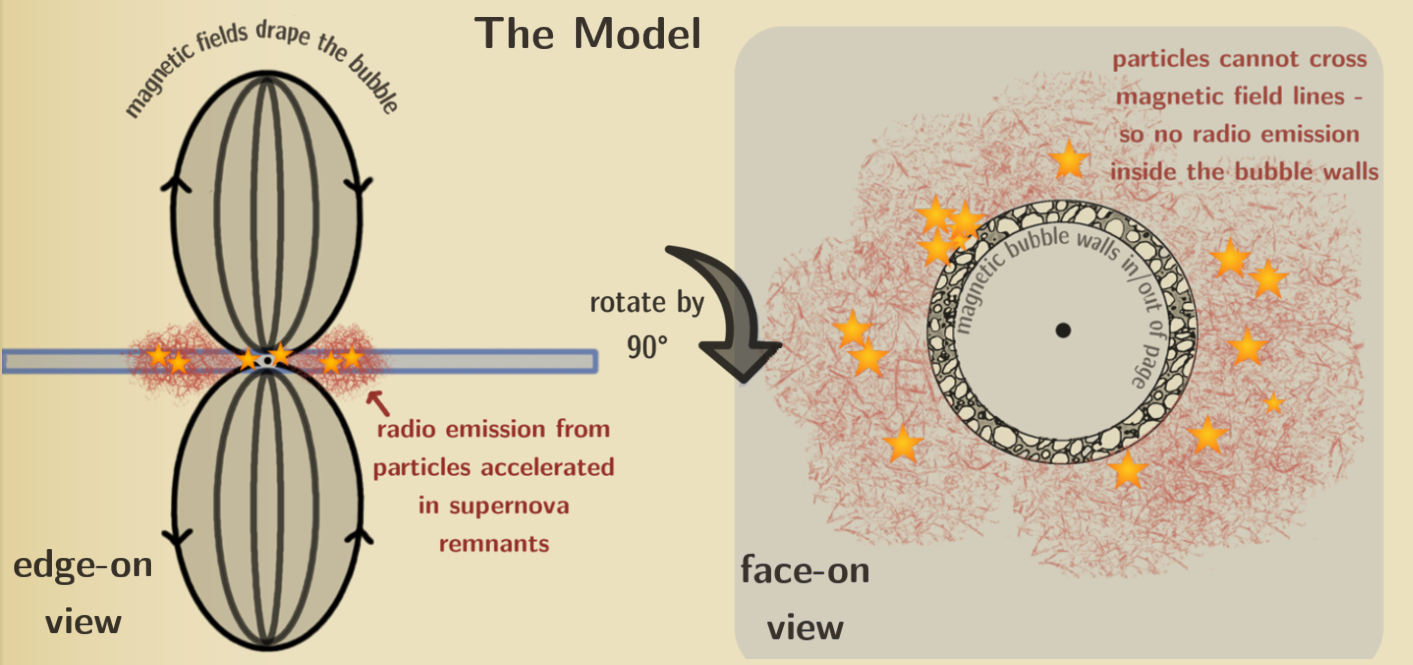
Our first candidate...

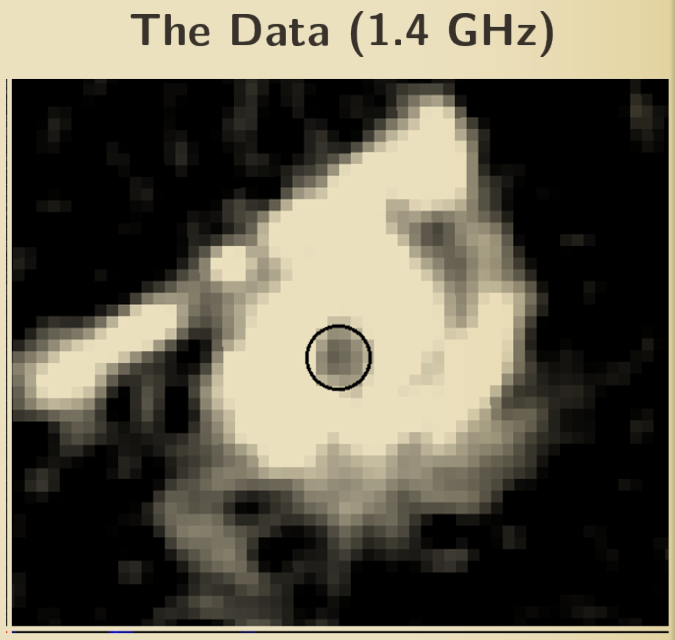
The Milky Way bubbles are draped in magnetic fields.



2.3 GHz polarized
radio synchrotron emission
(Carretti+2013)

We require magnetic draping to understand the radio continuum emission we see from NGC 3631.

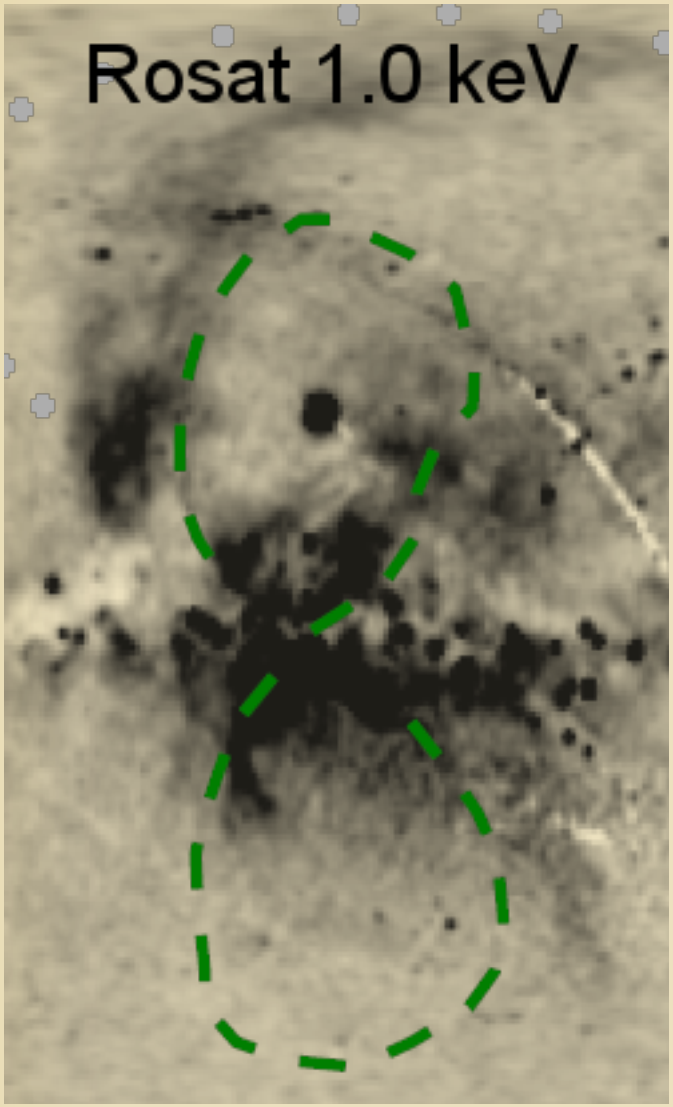




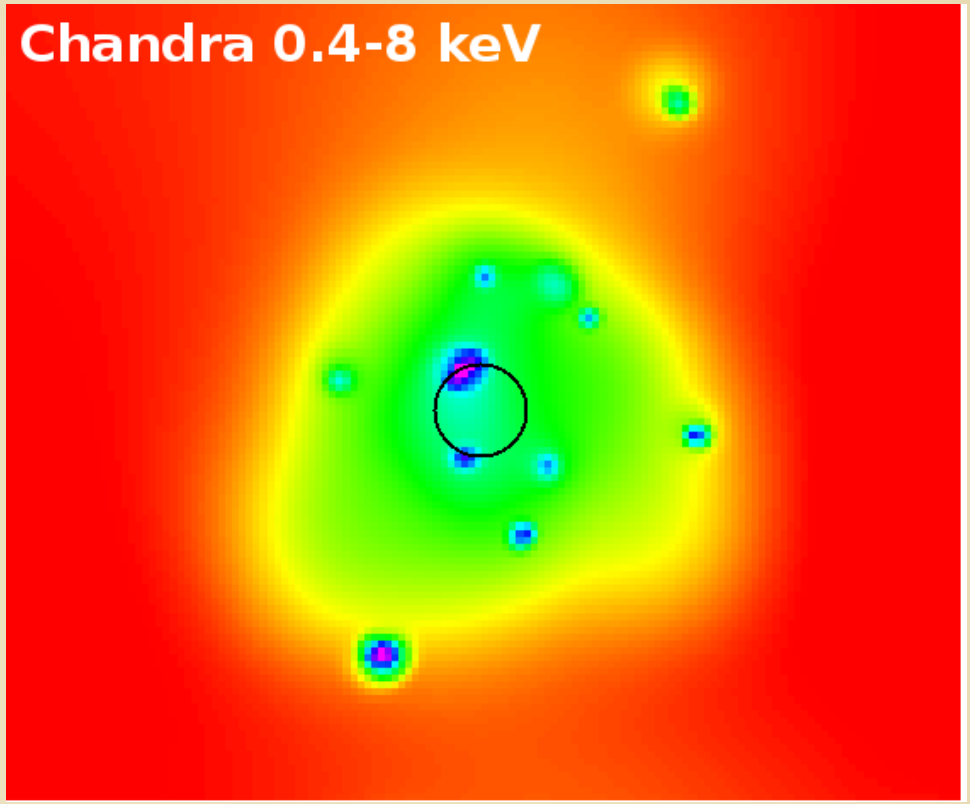
(linear feature is a background radio galaxy)

Diffusion timescale to fill the hole with radio emission is < 1 Myr.

Both bubbles have diffuse X-ray emission.



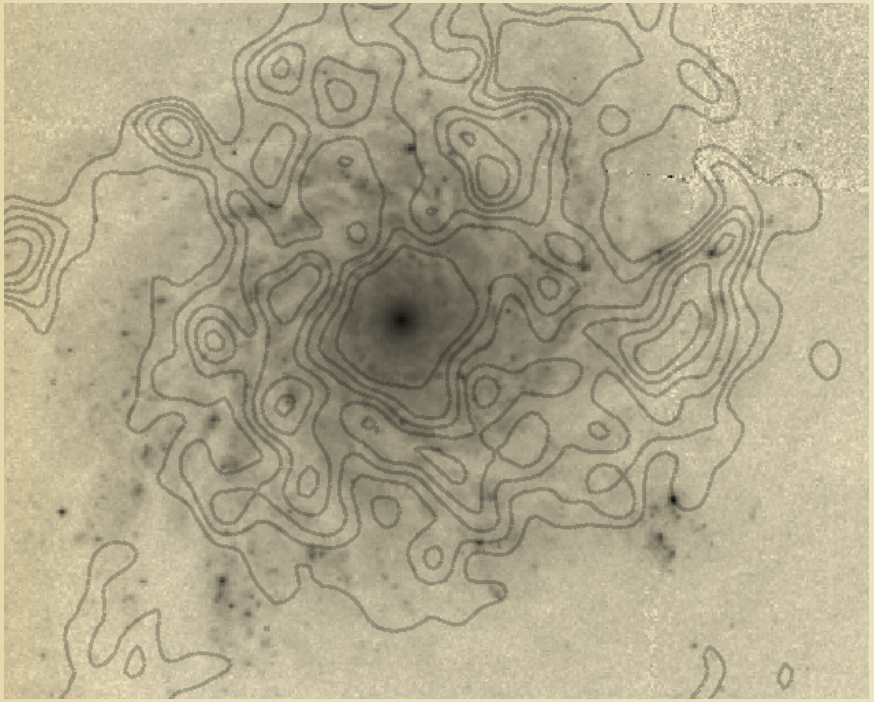
Milky Way
(Su+2010)



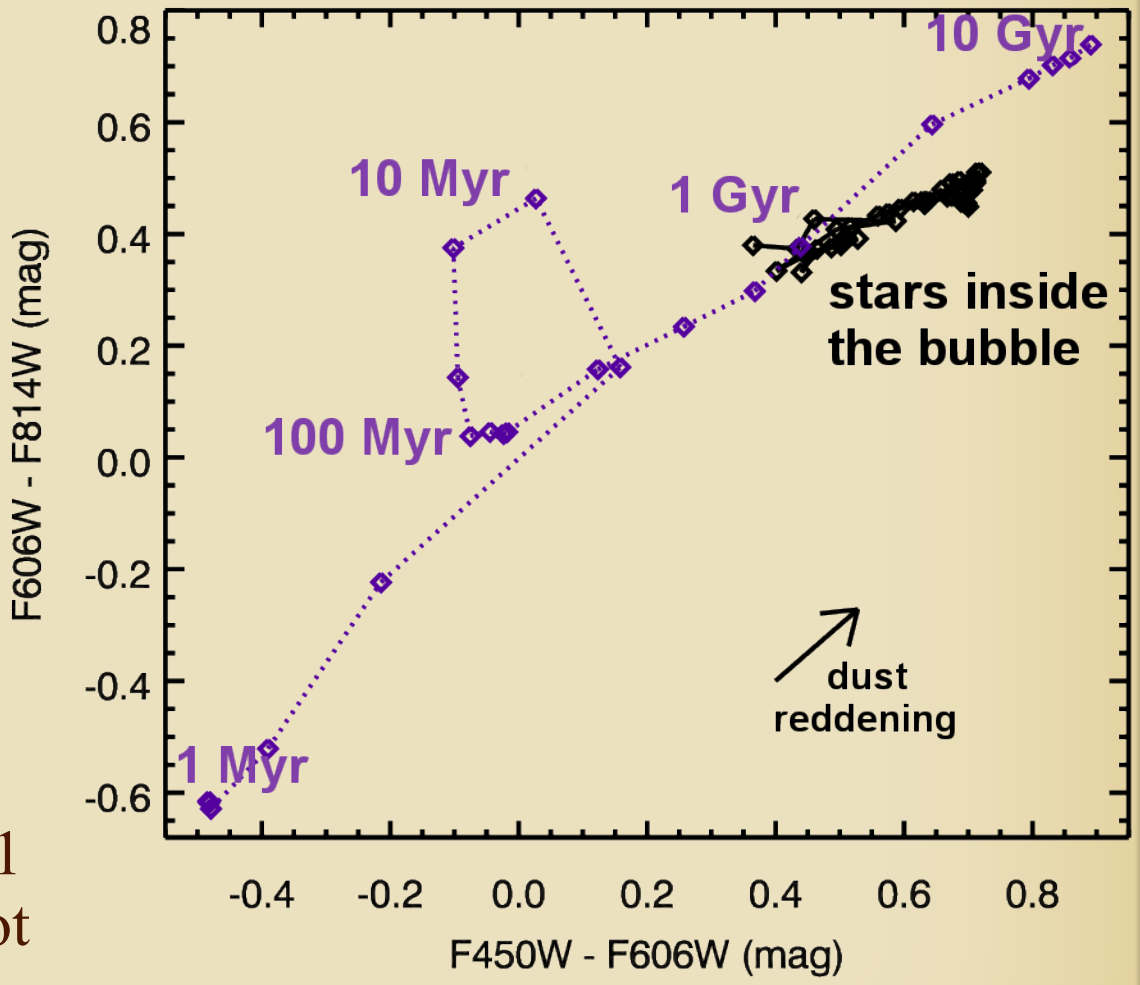
NGC 3631

X-ray emitting gas is overpressured.

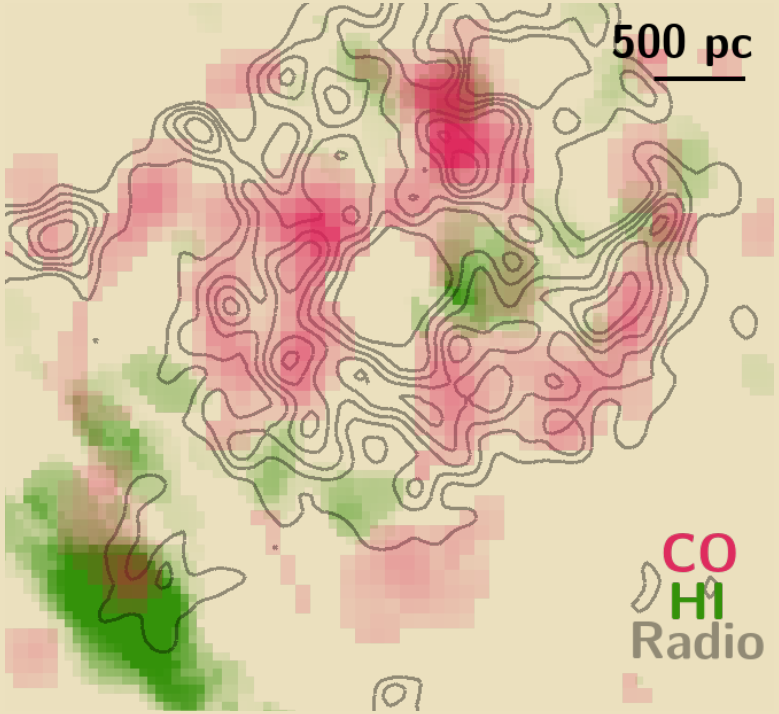
The bubble in NGC 3631 must be driven by recent AGN activity since star formation has not occurred inside the bubble in the last few billion years.



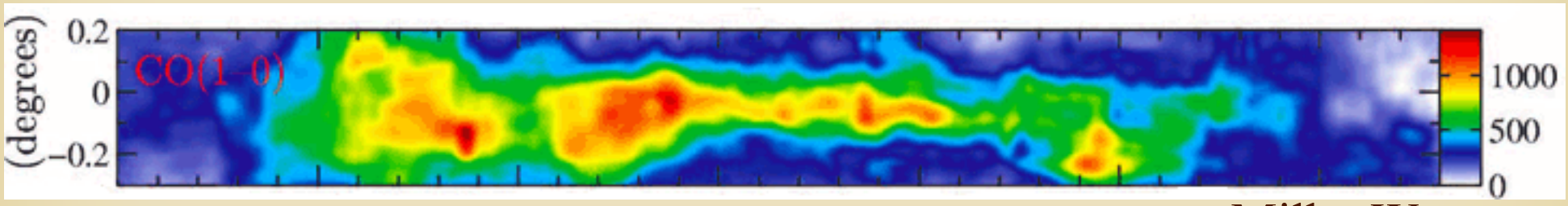
The central black hole in NGC 3631 (similar to the one in the MW) is not currently active.



These bubbles are cinched at the waist by a ring of neutral and molecular gas.

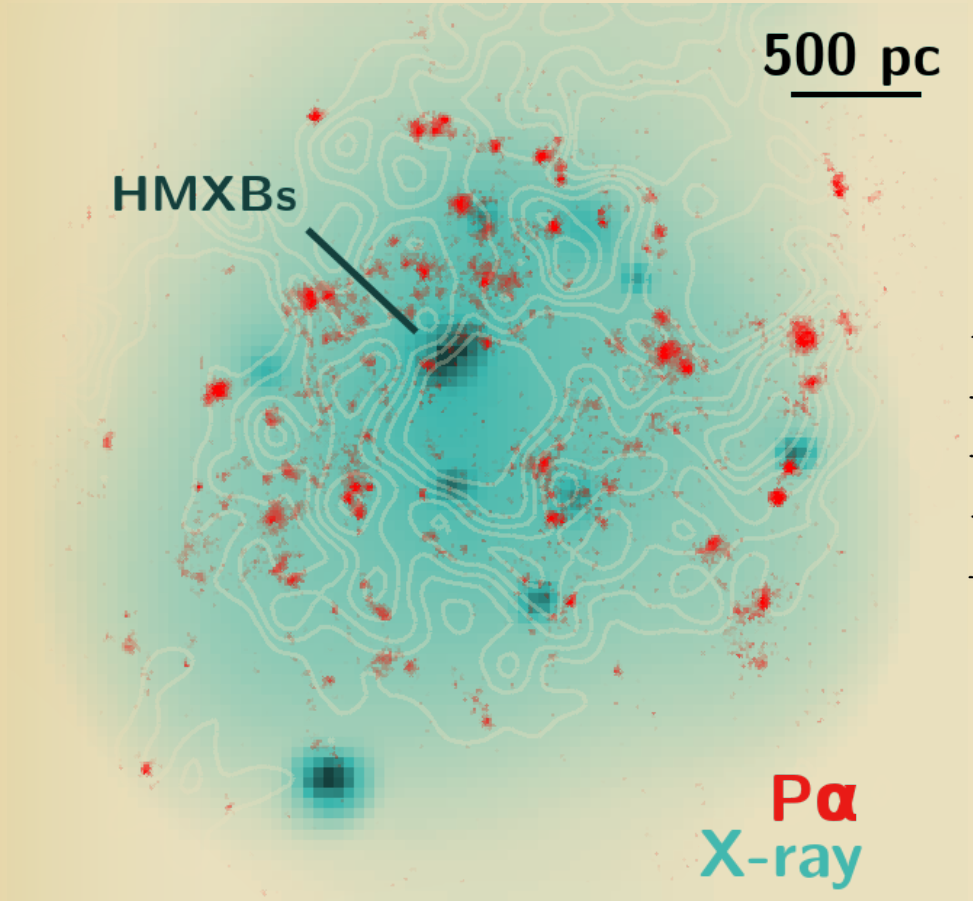


NGC 3631

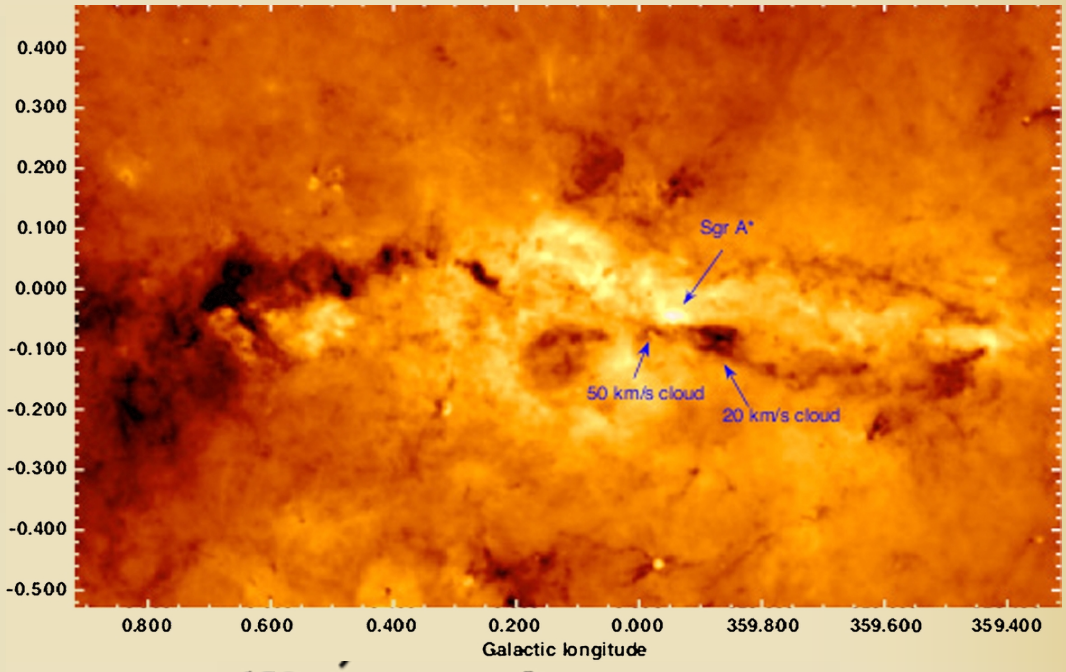


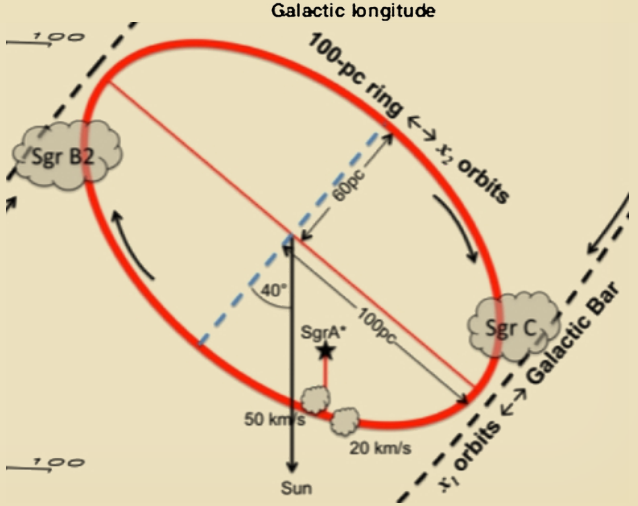
Milky Way
(Martin+2004)

New stars are forming just outside the bubble walls indicating that the bubble was formed/expanded recently.



NGC 3631

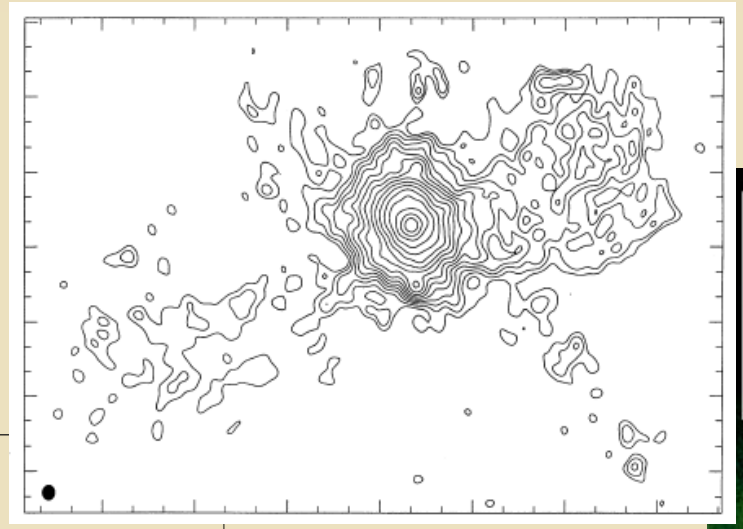




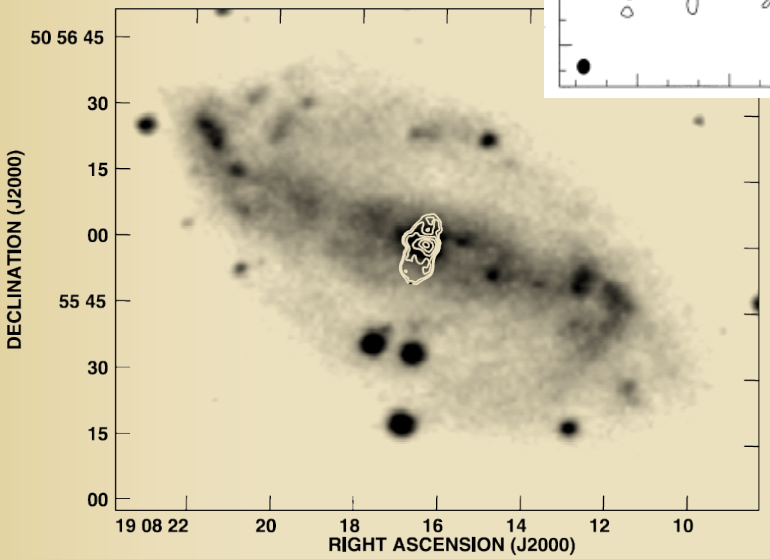
Molineri+2011

Milky Way

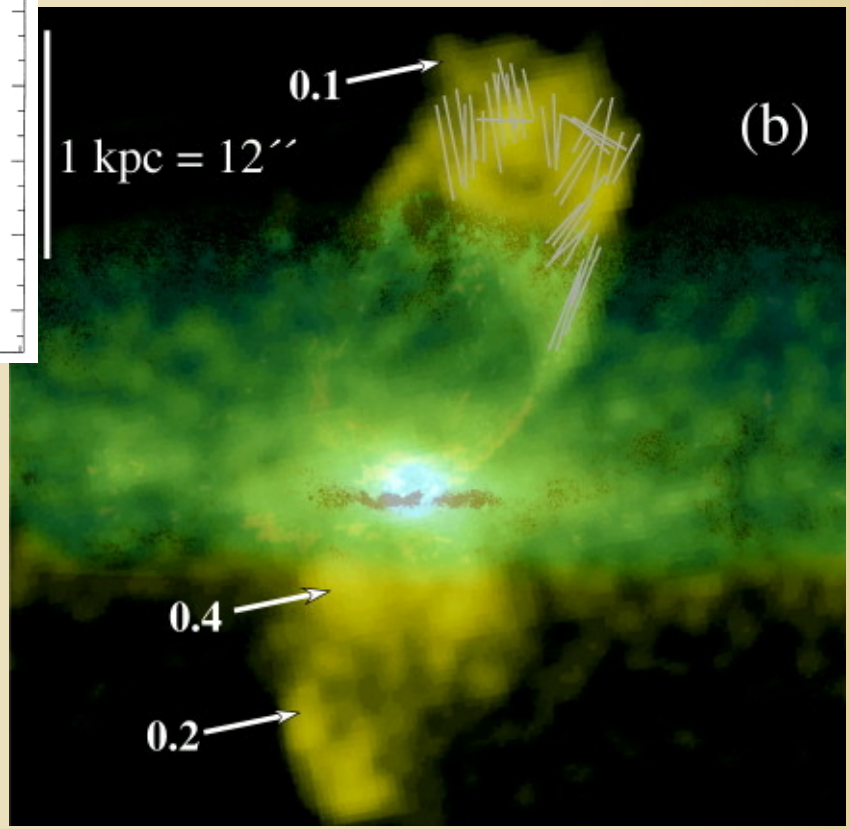
Although neither the MW or NGC3631 contain AGN, there are galaxies with kpc-scale radio bubbles that do.



Circinus (Elmouttie+98)



NGC 6764 (Croston+2008)



NGC 3079 (Cecil+2001)

"Our study demonstrates that kiloparsec-scale radio sources may be more common than previously thought and are found across all redshifts, luminosities and radio-loudness. Kiloparsec-scale radio sources are found in > 42% of Seyfert galaxies with jet-like structures."

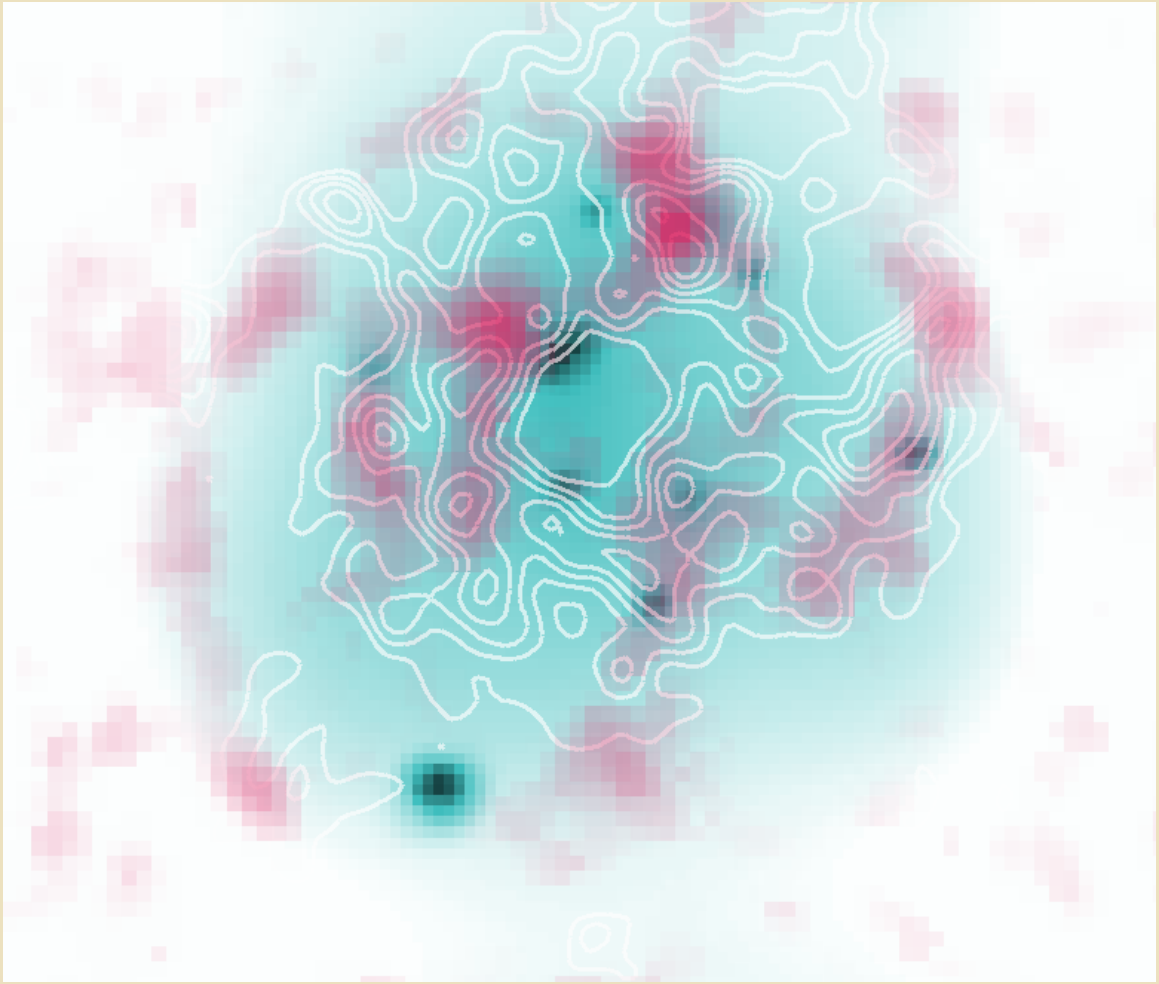
Singh+2015

Summary

In NGC 3631 we probe the conditions in the center of the galaxy immediately after the black hole activity has stopped. Similarities between the bubble in NGC 3631 and the one in the Milky Way indicate that our own galaxy also recently finished a period of time as a Seyfert.

We can use these sources to better understand the effects of Seyfert activity on galaxy nuclei including the ways in which magnetic structures can help to extend the influence of the black hole to larger scales.

Molecular gas has been swept up or created at the edge of the bubble.



The events : AGN episode (< 10 Myr ago) blows/expands bubble and triggers SF.