The First X-ray Maps of Sgr A East

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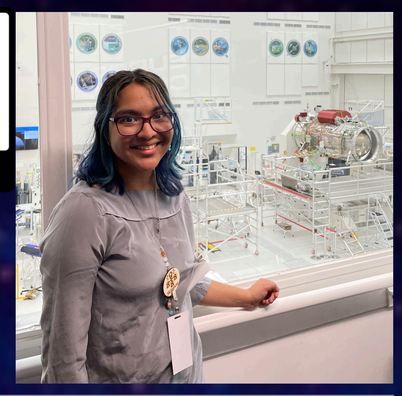
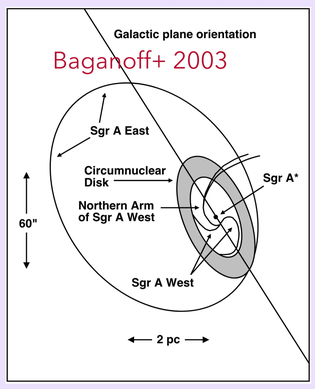
SCAN ME



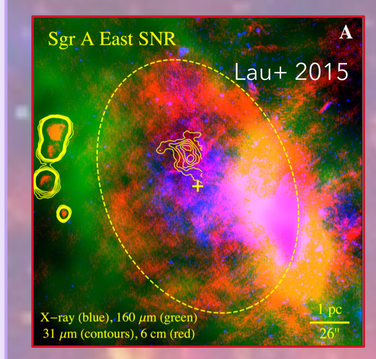
ABSTRACT

We apply signal separation technique Generalized Morphological Component Analysis (GMCA) on Chandra ACIS-I observations of the Galactic Center (GC) in order to separate supernova remnant (SNR) Sgr A East from the Sgr A* accretion flow, which have remained entangled in analyses for decades. We stacked 1.5 Ms of Chandra ACIS-I observations of the GC. Applying GMCA to the 5-8 keV data cube, we find two major components: the SNR and plasma around Sgr A*. However, the 2-5 keV data cube shows five different emission components. **We find that the remnant's size decreases with increasing energy, with a concentrated iron line core, and that the hot plasma around Sgr A* appears confined within the circumnuclear disk (CND).** The X-ray morphology clearly shows that the shock has been interacting with plasma structures since the beginning of the free expansion.



BACKGROUND

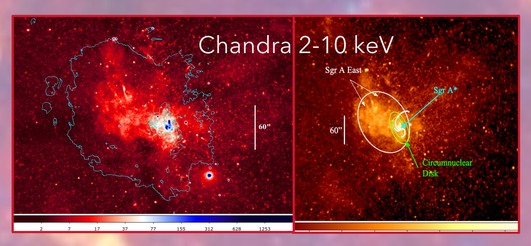
SNR Sgr A East



Infrared: Dust emission seen in outer regions of remnant (Lau et al. 2015) → core of remnant is too hot for dust to survive

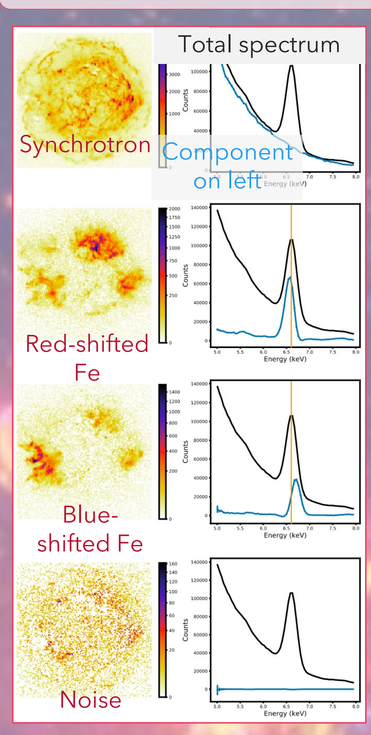
Sub-mm: Maser emission seen at edges of remnant → It is interacting with nearby molecular clouds (Tsuboi et al. 2019)

X-rays: Fe line emission is more compact than radio shell (Maeda et al. 2002) → Mixed-morphology supernova remnant



Radio: Shell-like synchrotron emission appears to be absorbed by Sgr A West → Sgr A East likely lies behind Sgr A West (McEwen et al. 2016)

GMCA



GMCA is a signal separation technique first applied in Astronomy to extract a CMB image from Planck data (Bobin et al. 2015). In Picquenot et al. 2019, GMCA was applied to Chandra data of SNR Cassiopeia A and retrieved distinct emission maps of the blue- and red-shifted elements while also creating separate maps of the synchrotron and thermal components.

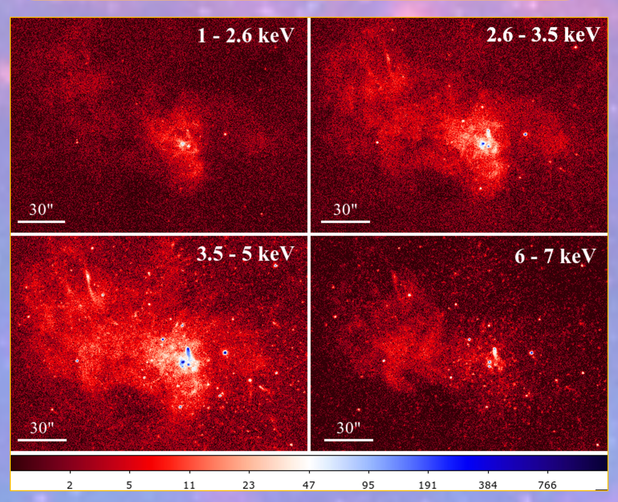
GMCA is optimized for separating spatially overlapping but spectrally distinct extended sources of similar brightness

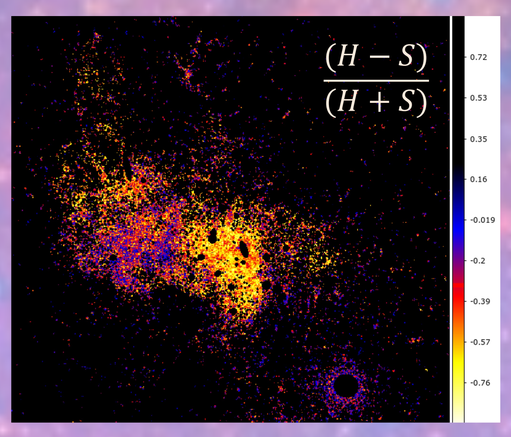
X-rays are uniquely suited to probe the hot plasma components within Sgr A East, but disentangling its emission from the plasma environment of Sgr A* along our line of sight has remained a challenge.

THE CHANDRA DATASET

GUIDING QUESTIONS

1. What is the distance to Sgr A East?
2. What are the abundances of Sgr A East?
3. Did Sgr A* have an impact on Sgr A East's evolution?
4. How does the X-ray emission compare with the radio morphology?



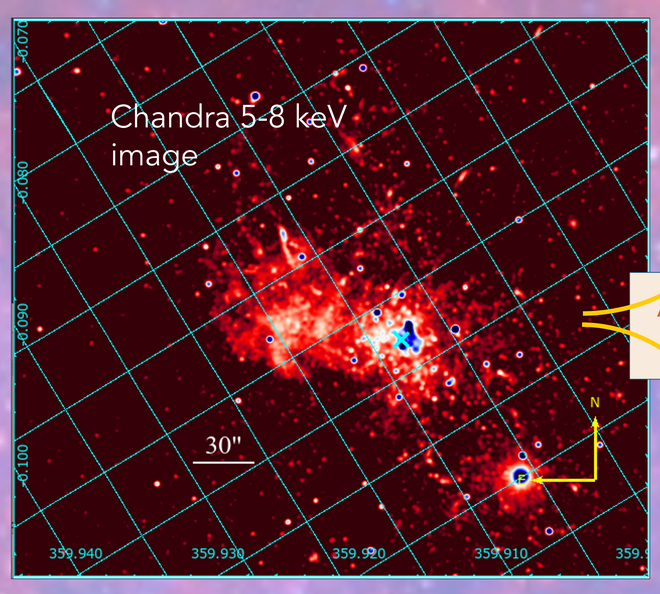


LEFT: 1.5 Ms of ACIS-I archival observations, cleaned for Sgr A* and background flares, presented with different energy cuts.

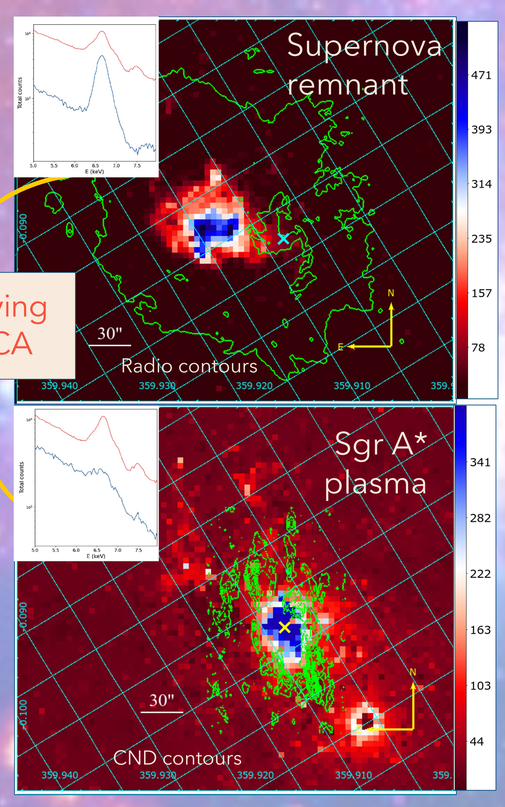
1-2.6 keV → The SNR is not visible, while plasma around Sgr A* is. Extinction is high, $N_H \sim 10^{23}$ cm^{-2}

6-7 keV → Fe Kα emission from the remnant is more clearly visible

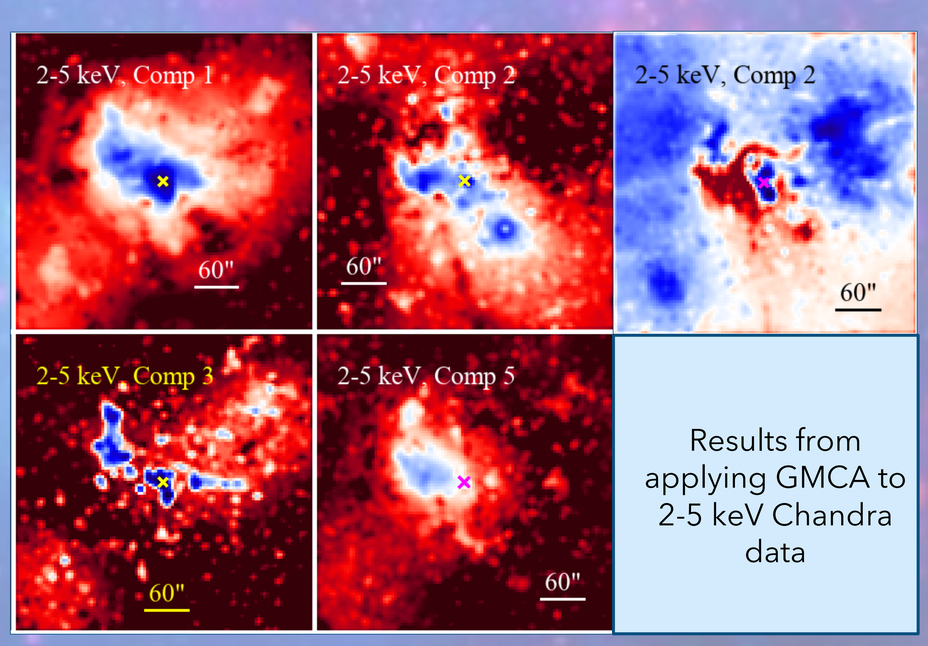
APPLYING GMCA



Applying GMCA



The cleaned, stacked dataset contains distinct components that can be explored to some extent through hardness ratio maps and data manipulation. However, **applying GMCA effectively disentangles these components in a data-driven manner**, providing unprecedented clarity in analyzing the spectral shape and morphology of different components present in the data.

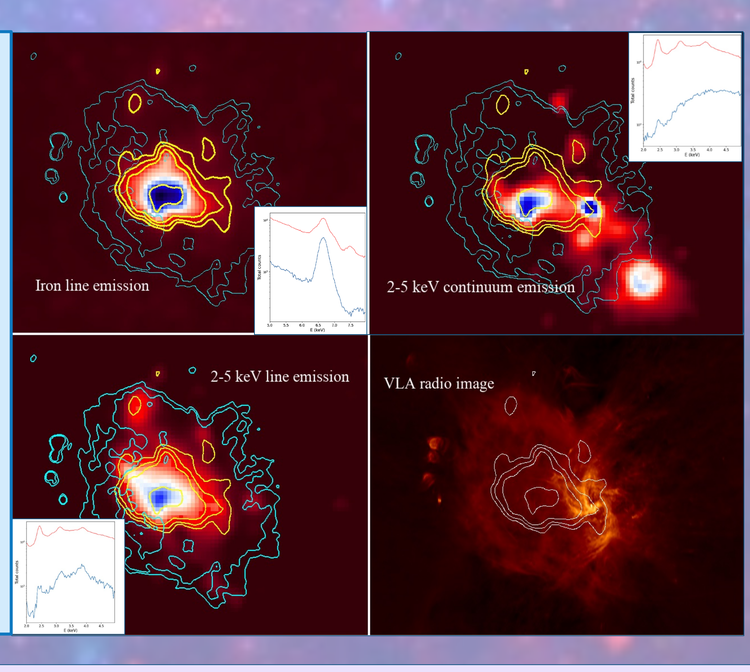


2-5 keV, Comp 2

60"

Results from applying GMCA to 2-5 keV Chandra data

GMCA components associated with Sgr A East. 2-5 keV emission from the remnant is more extended than the 5-8 keV emission.



REFERENCES

Bobin, J.; Sureau, F.; Starck, K. L., 2016, 591, A50
Lau, R. M.; Herter, T. L.; Morrins, M. R.; Li, Z.; Adams, J. D., 2015, Science, 348, 6233
Maeda, Y.; Baganoff, F. K.; Feigelson E. D.; Morris, M.; Bautz, M. W.; Brandt, W. N.; Burrows, D. N.; Doty, J. P.; Garmire, G. P.; Pravdo, S. H.; Ricker, G. R.; Townsley, L. K., 2002, ApJ, 570, 2
McEwen, B. C.; Sjouwerman, L. O.; Pihlström, Y. M.; 2016, ApJ, 832, 2
Picquenot, A.; Acero, F.; Bobin, J.; Maggi, P.; Ballet; Pratt, G. W., 627, A139
Tsuboi, M.; Kitamura, Y.; Uehara, K.; Miyazaki, A.; Miyawaki, R.; Tsutsumi, T.; Miyoshi, M.; 2019, PASJ, 71, 6
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NEXT STEPS: Multiwavelength comparisons, final GMCA runs, interpretations