Exploring the Galactic Center Magnetic Field at High Spatial Resolutions

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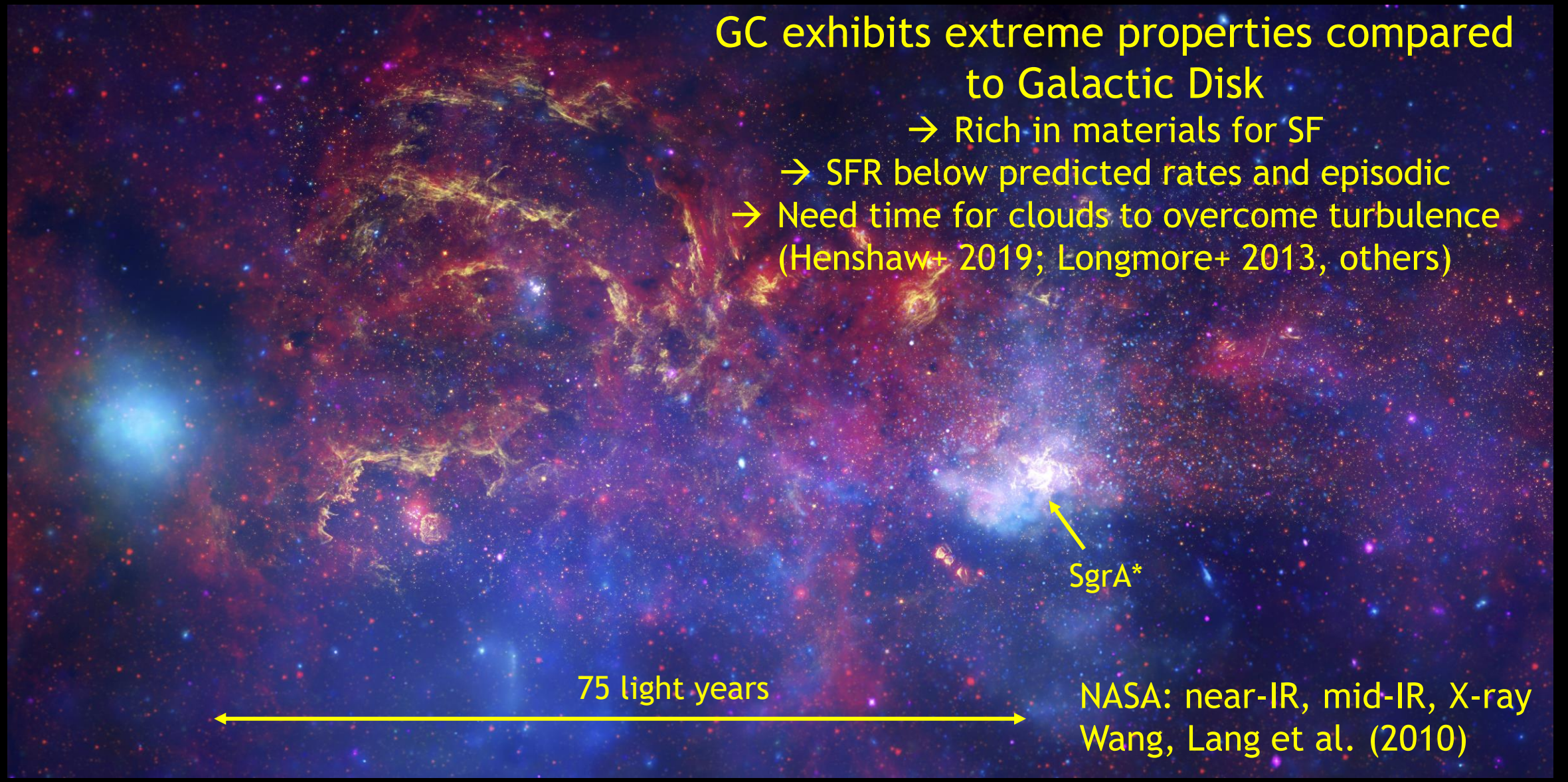
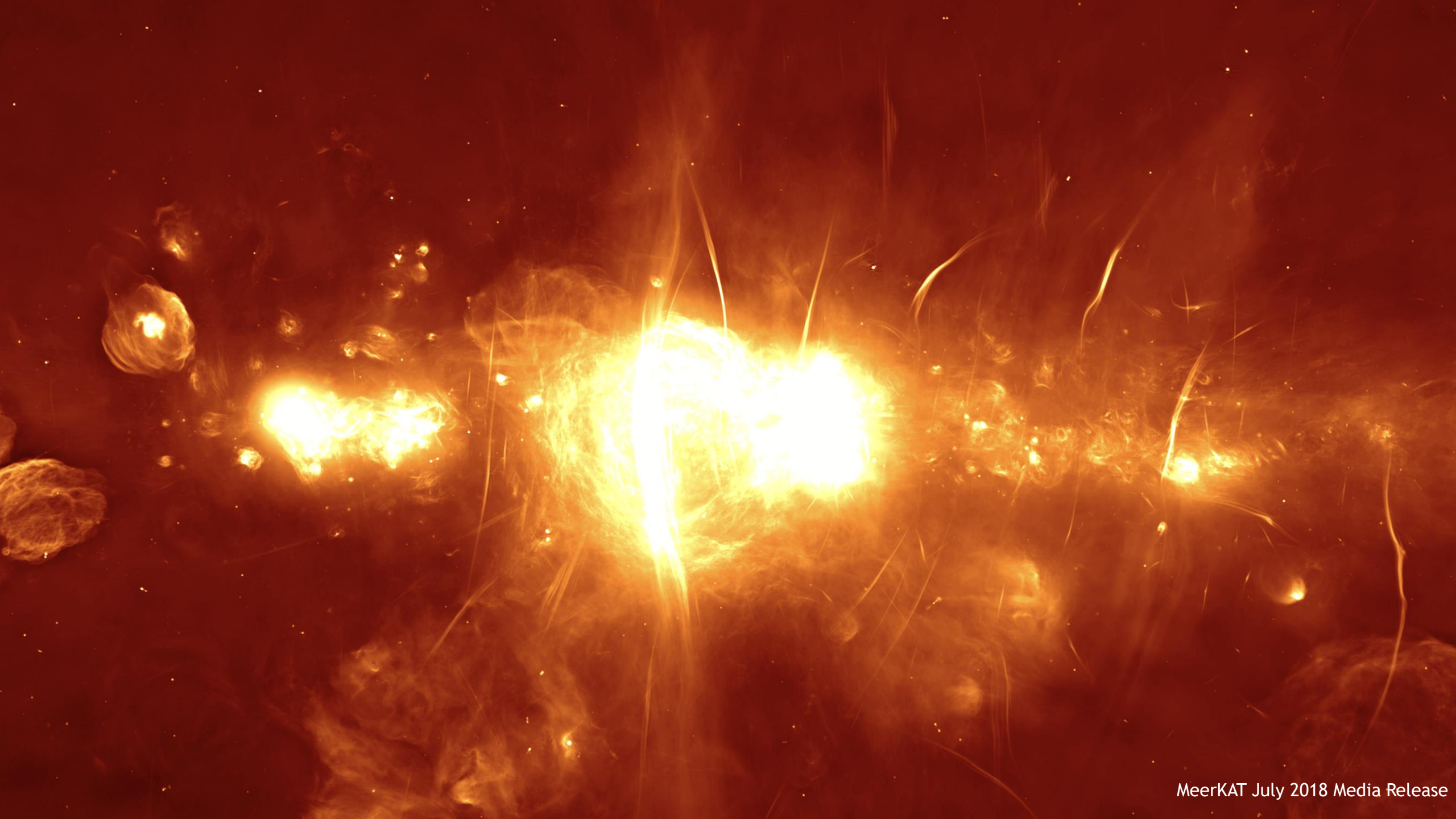
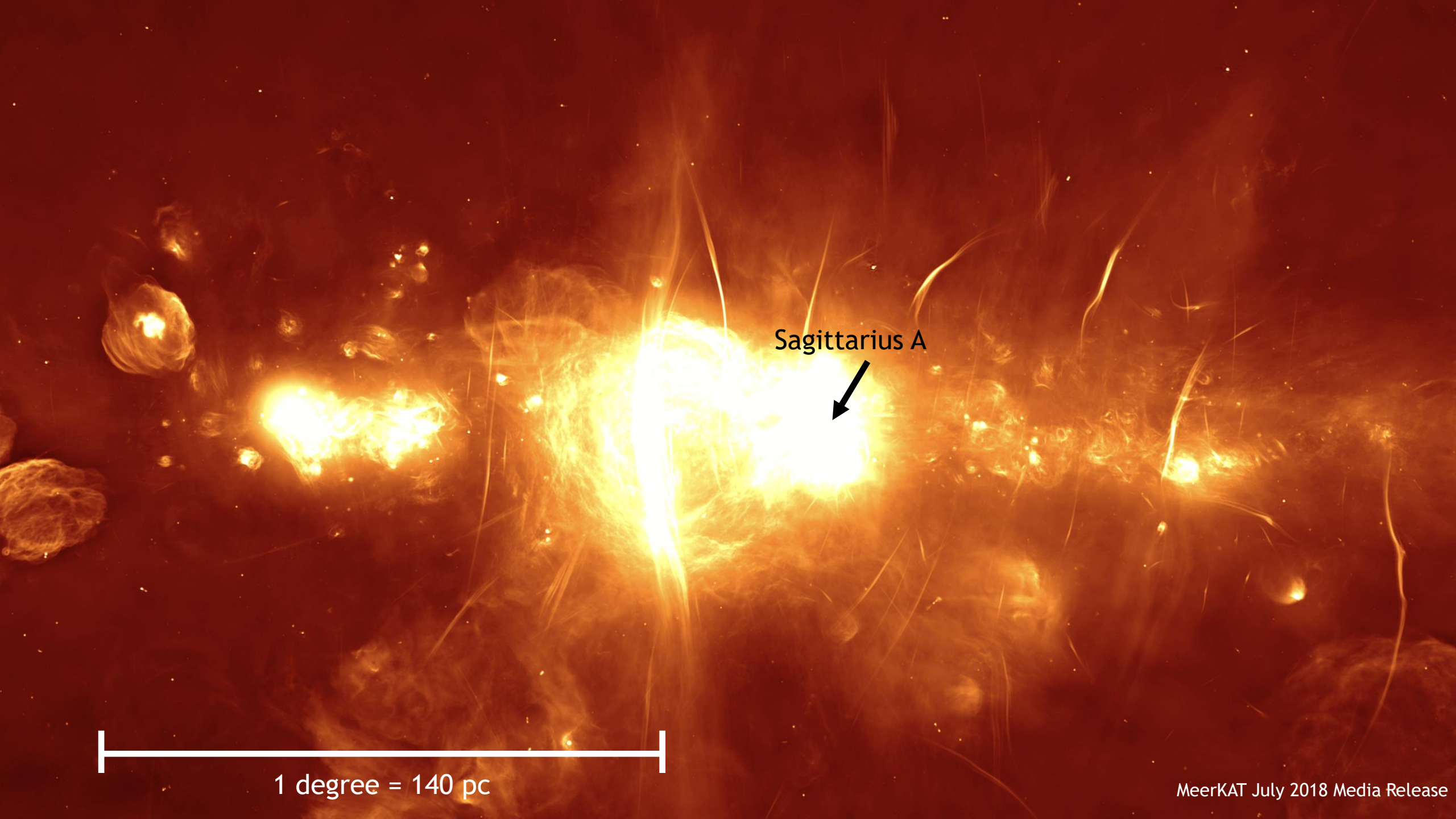
Under the Advisement of Dr. Cornelia C. Lang

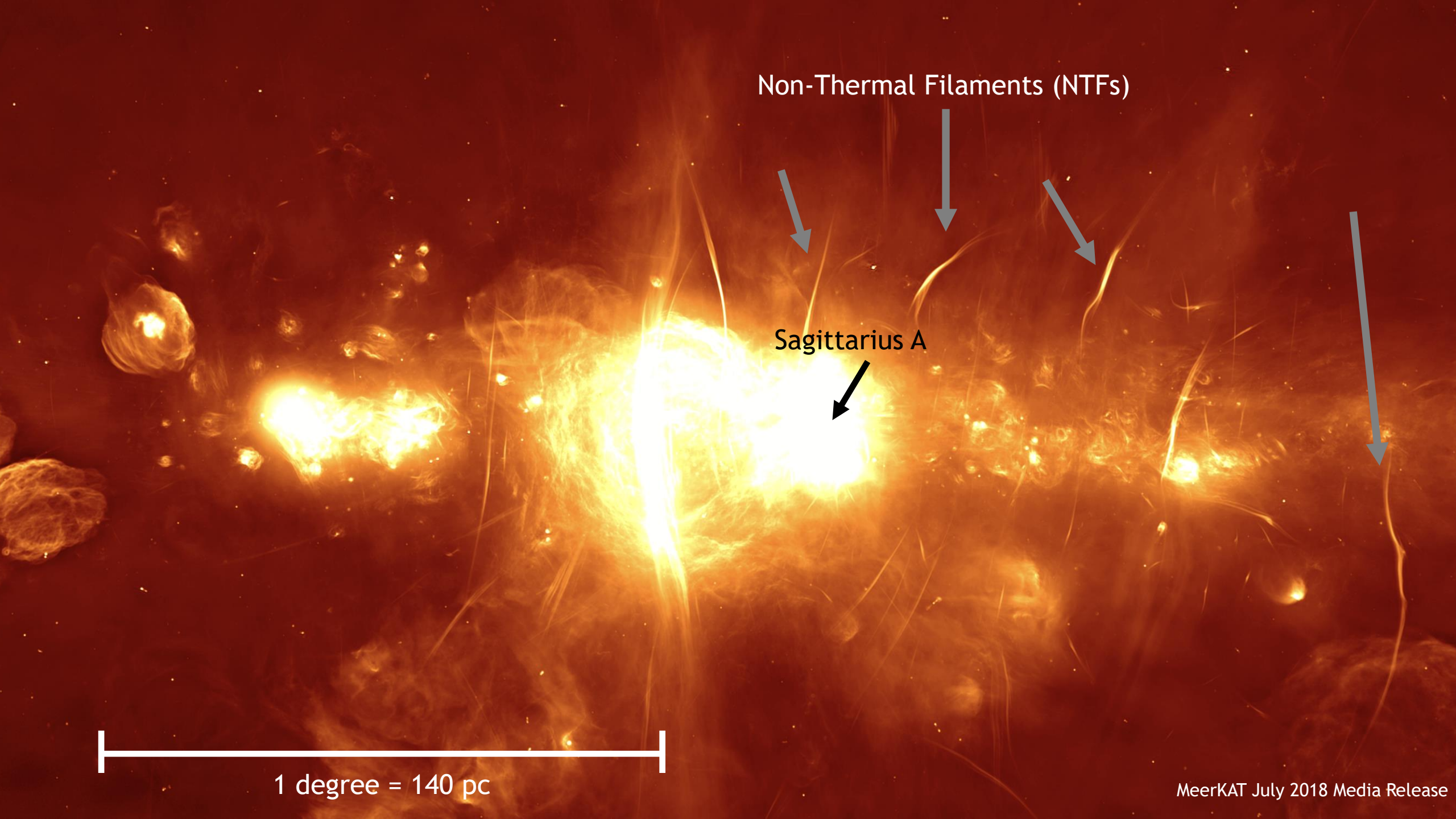
2022 Our Galactic Ecosystem

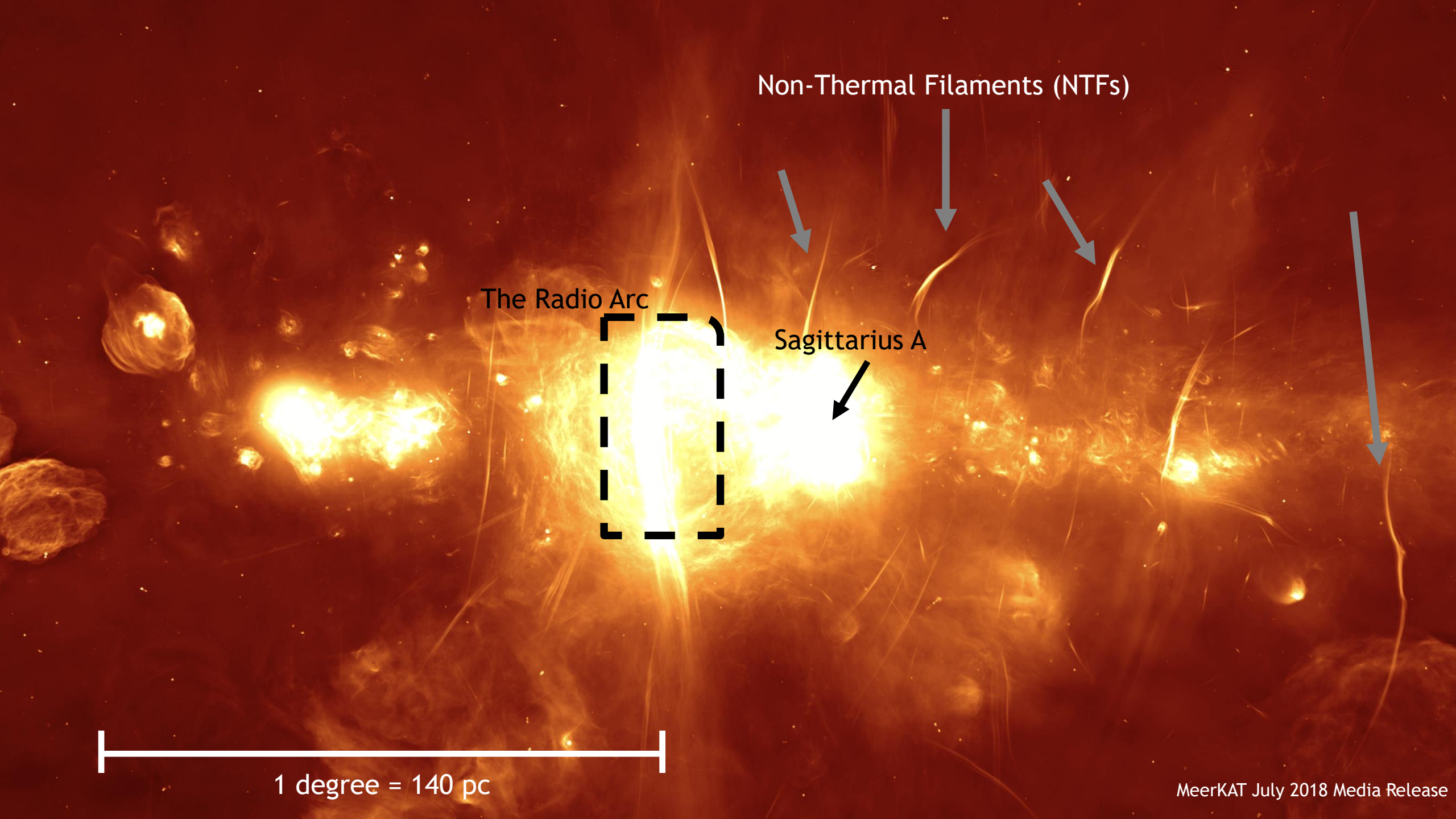
Infrared & X-ray Tri-color Image of the GC




MeerKAT July 2018 Media Release

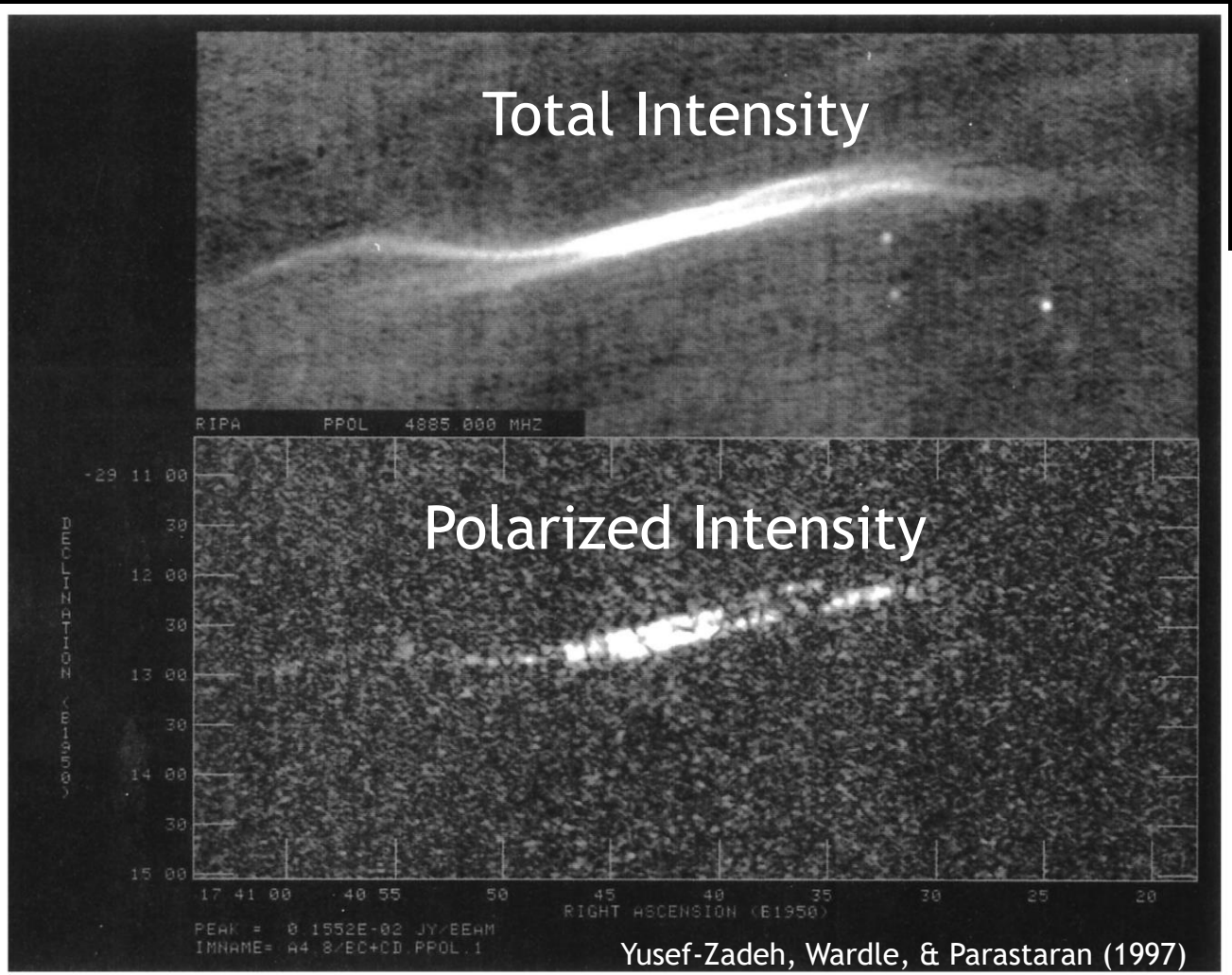

Sagittarius A
1 degree = 140 pc
MeerKAT July 2018 Media Release


Non-Thermal Filaments (NTFs)
Sagittarius A
1 degree = 140 pc
MeerKAT July 2018 Media Release


Non-Thermal Filaments (NTFs)
The Radio Arc
Sagittarius A
1 degree = 140 pc
MeerKAT July 2018 Media Release

Rotation Measure and B-field Properties

NTF: G359.54+0.18

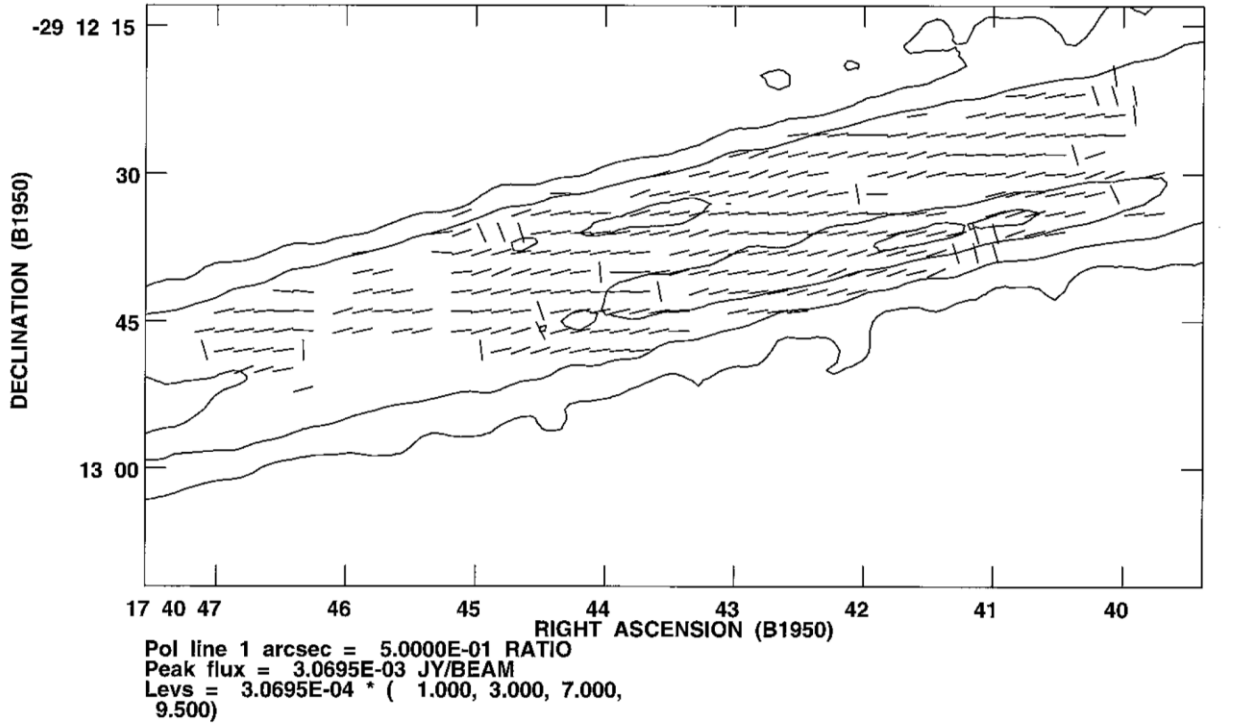


Yusef-Zadeh, Wardle, & Parastaran (1997)

- Thread-like total intensity
- Magnetic field traces total intensity orientation

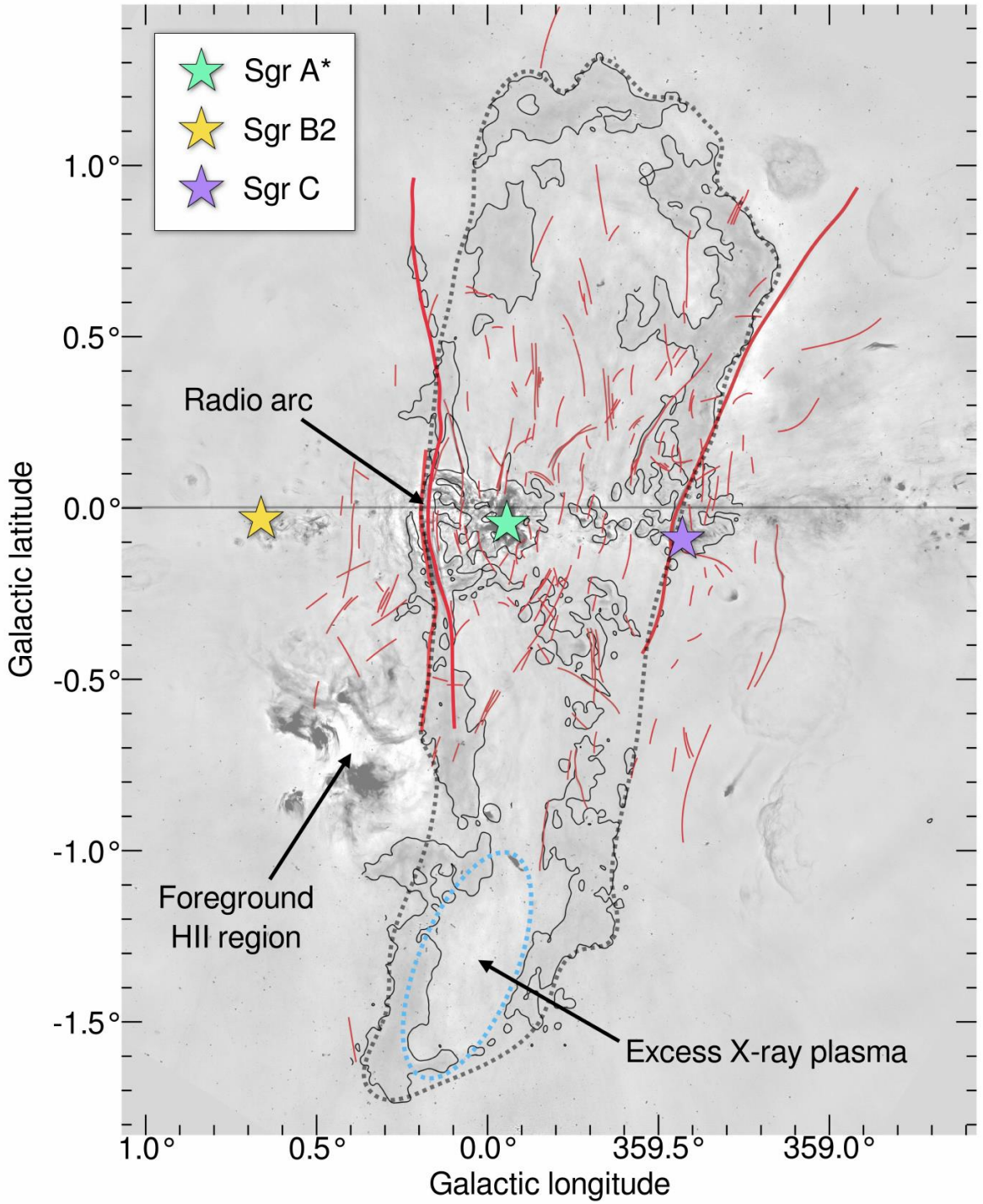
$$RM = 0.81 n_e B_{||} L$$

$$\chi = RM \cdot \lambda^2 + \chi_0$$



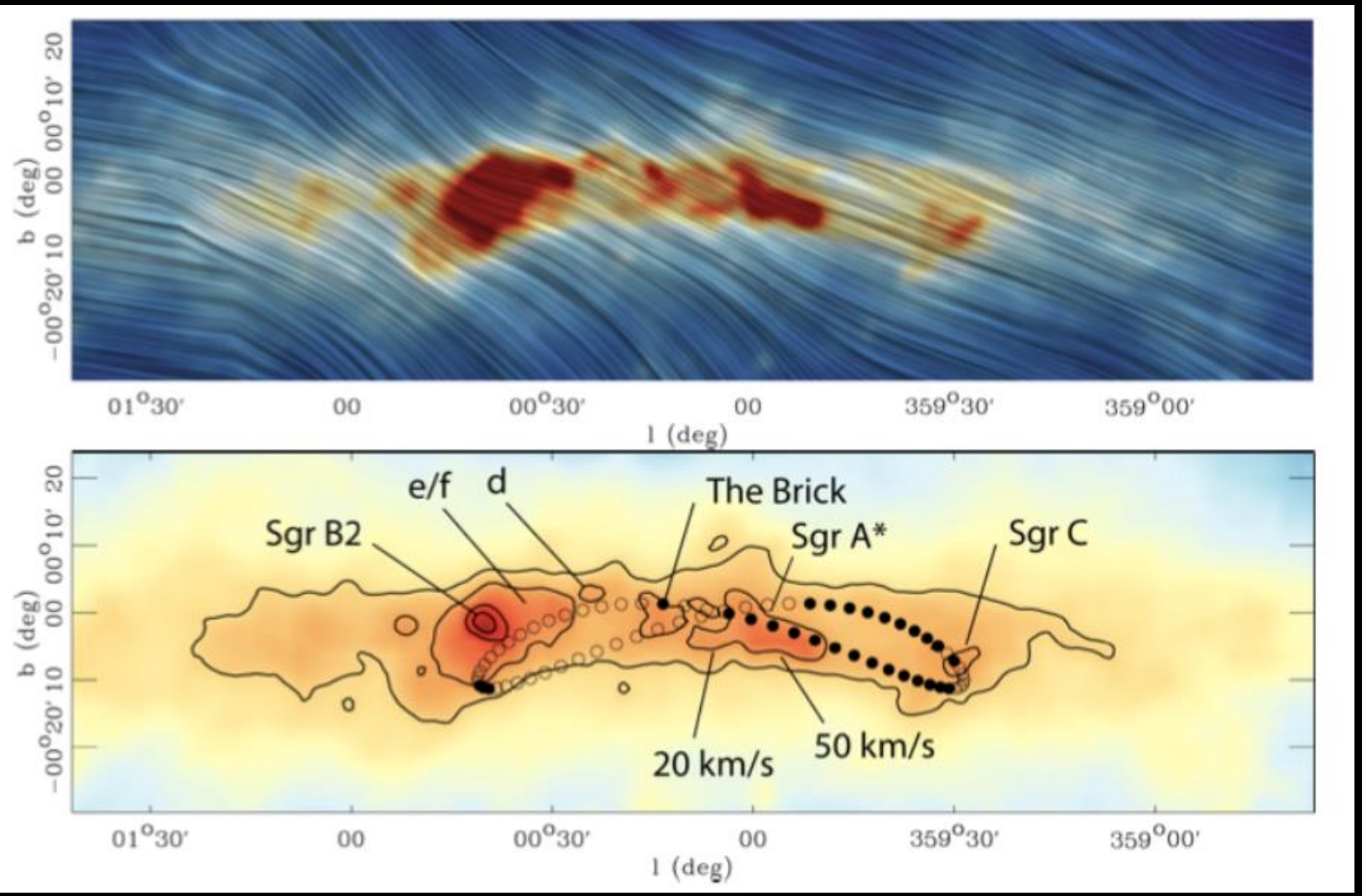
Distribution of the NTFs in the GC

- NTFs may be related to larger synchrotron structures
- Recent study suggests energetic outflow
- NTFs appear to trace perpendicular B-field



Heywood et al. (2019)

Magnetic field from Dust Polarization in the GC

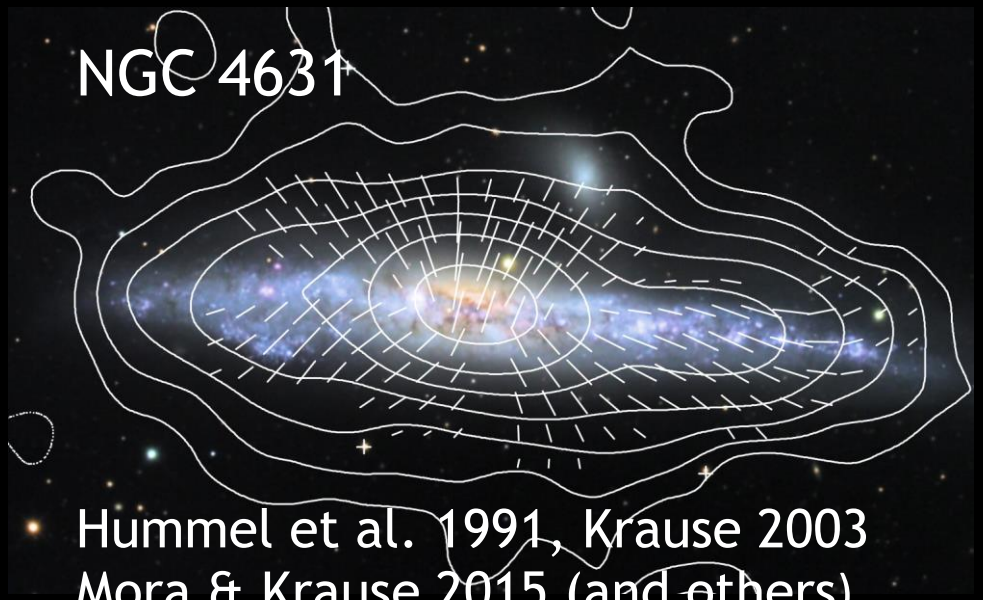


- First CMZ far-IR (240 mm) dust emission polarization of GC (PILOT balloon)
- Reveals a magnetic field that is remarkably well-ordered
- Field has an average tilt angle of ~20 degrees with respect to Galactic plane and aligned along molecular cloud lengths

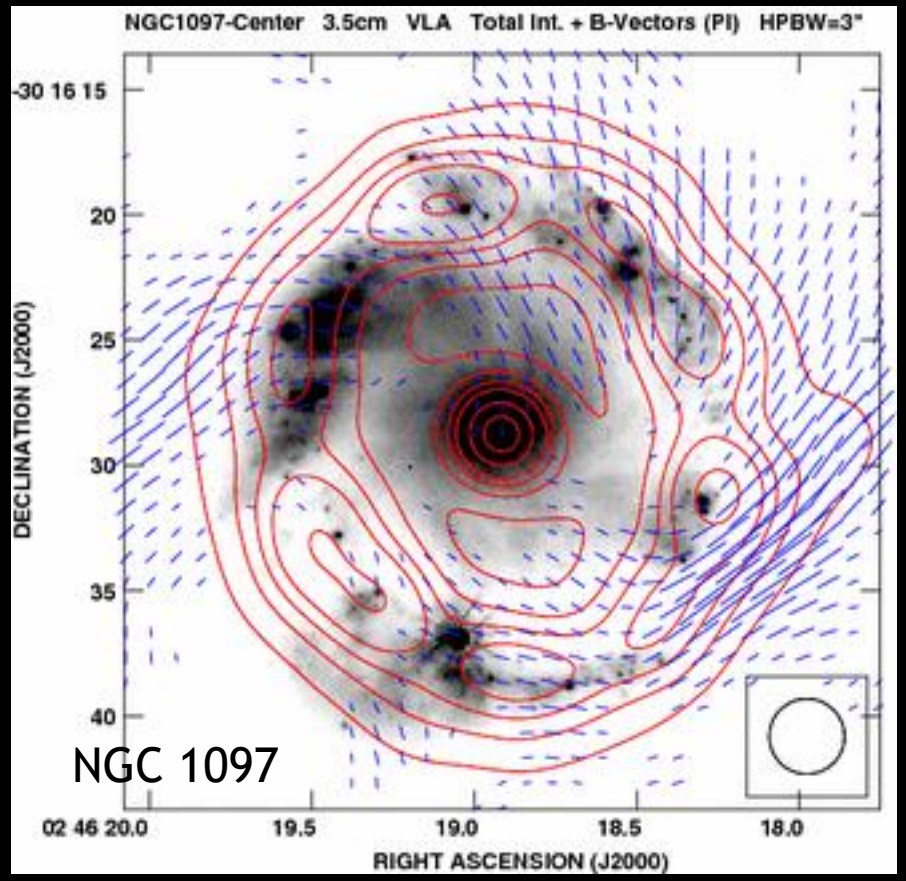
Mangilli et al (2019)

Magnetic Fields in Galactic Nuclei

Observations show vertical B-fields originate near nucleus and may help to transport energetic materials (hot plasma) out of galaxy

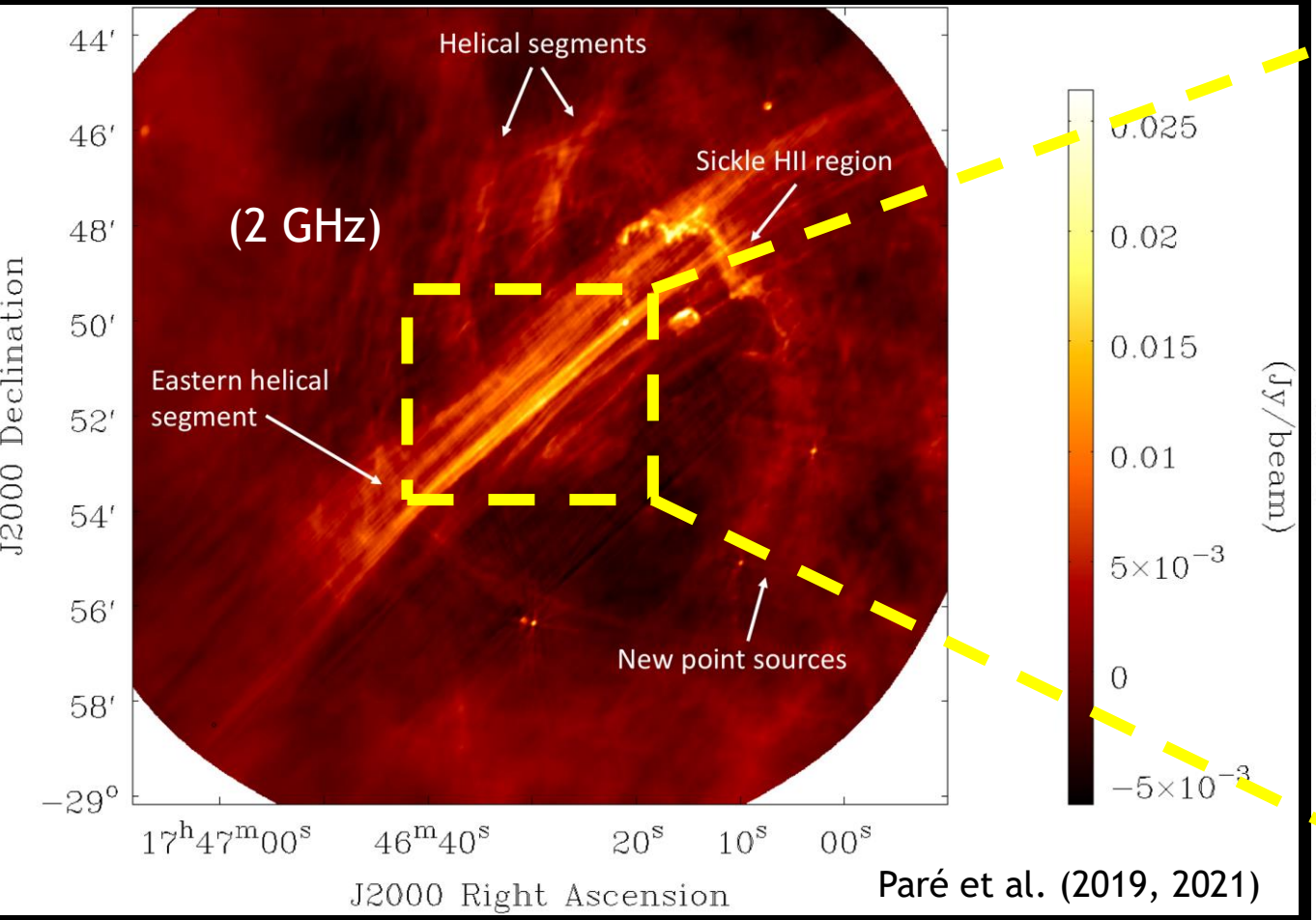


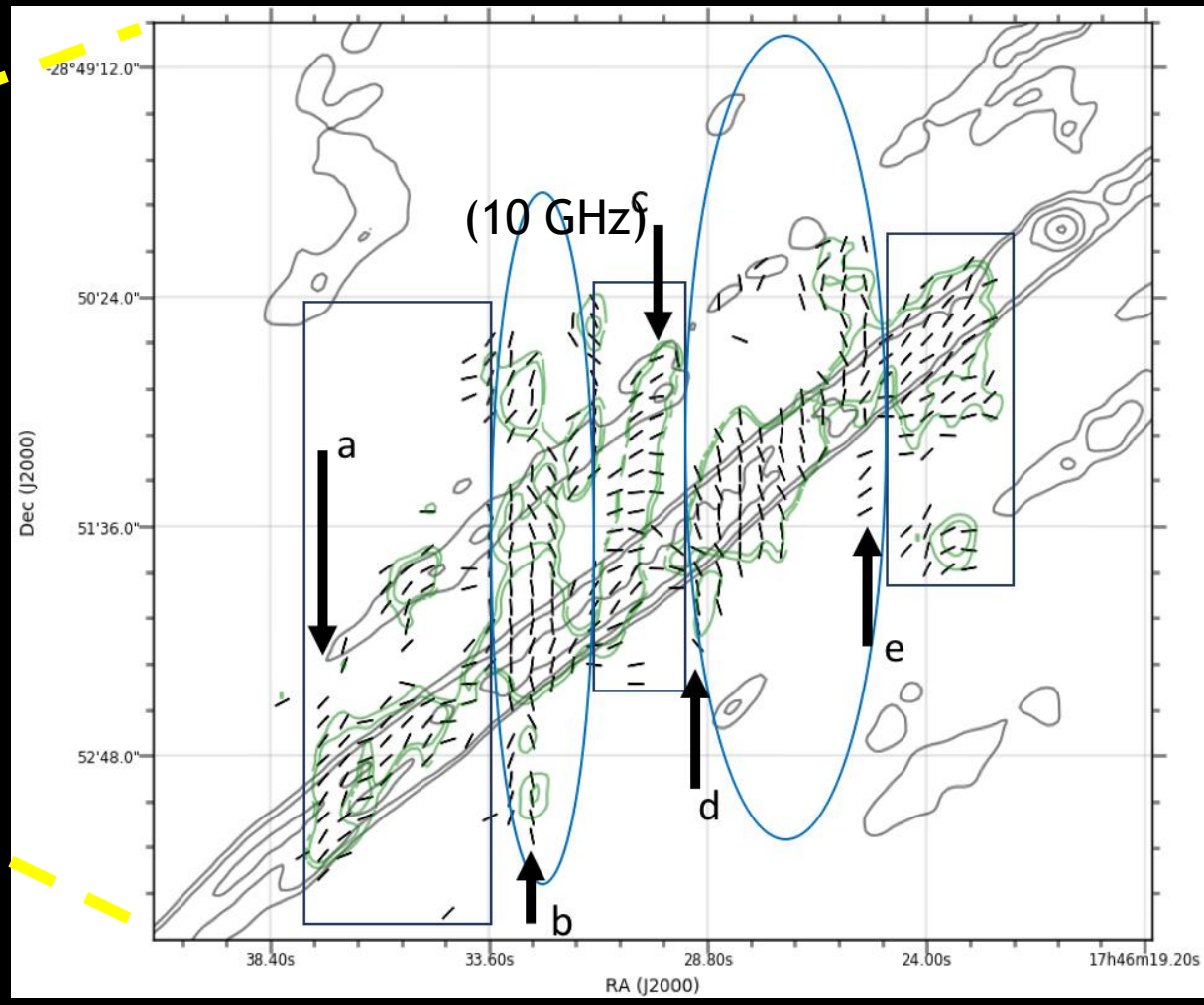
Hummel et al. 1991, Krause 2003
Mora & Krause 2015 (and others)



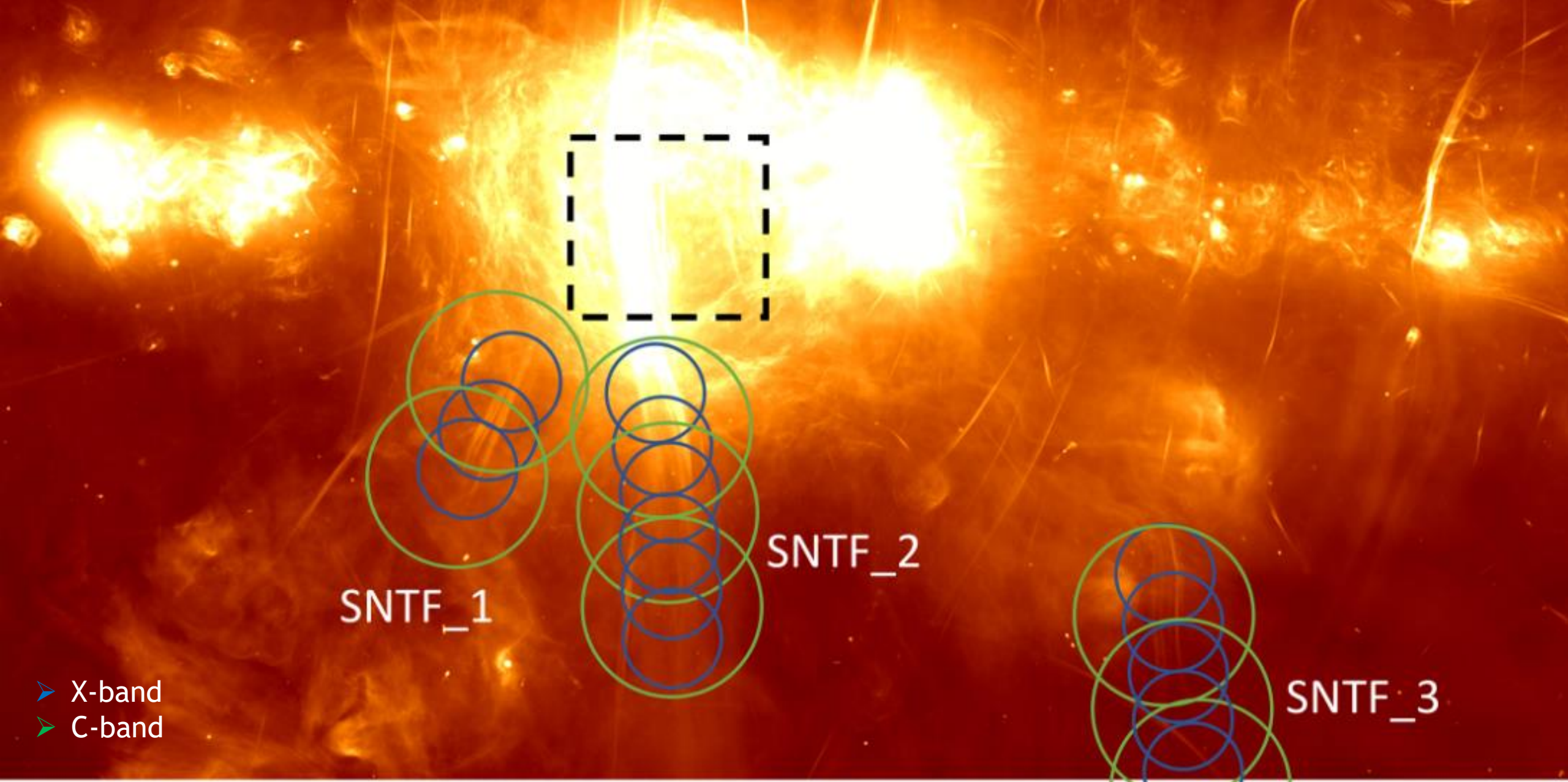
Magnetic stress in circumnuclear rings can drive gas inflow (Balbus & Hawley 1998); also for barred galaxies, gas inflow also affected by magnetic field (Beck et al. 2005)

Recent Radio Arc Results Using the VLA





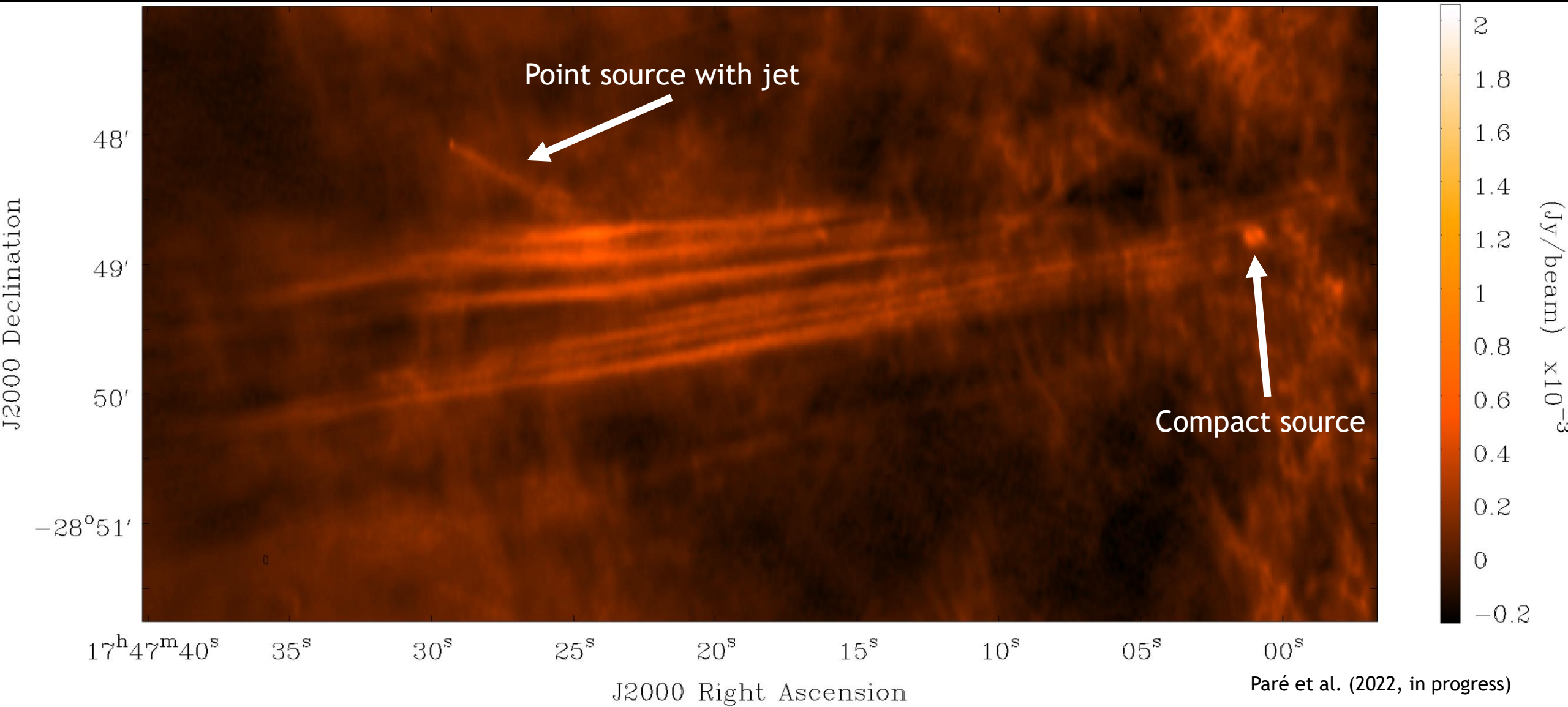
Paré et al. (2019, 2021)



- X-band
- C-band

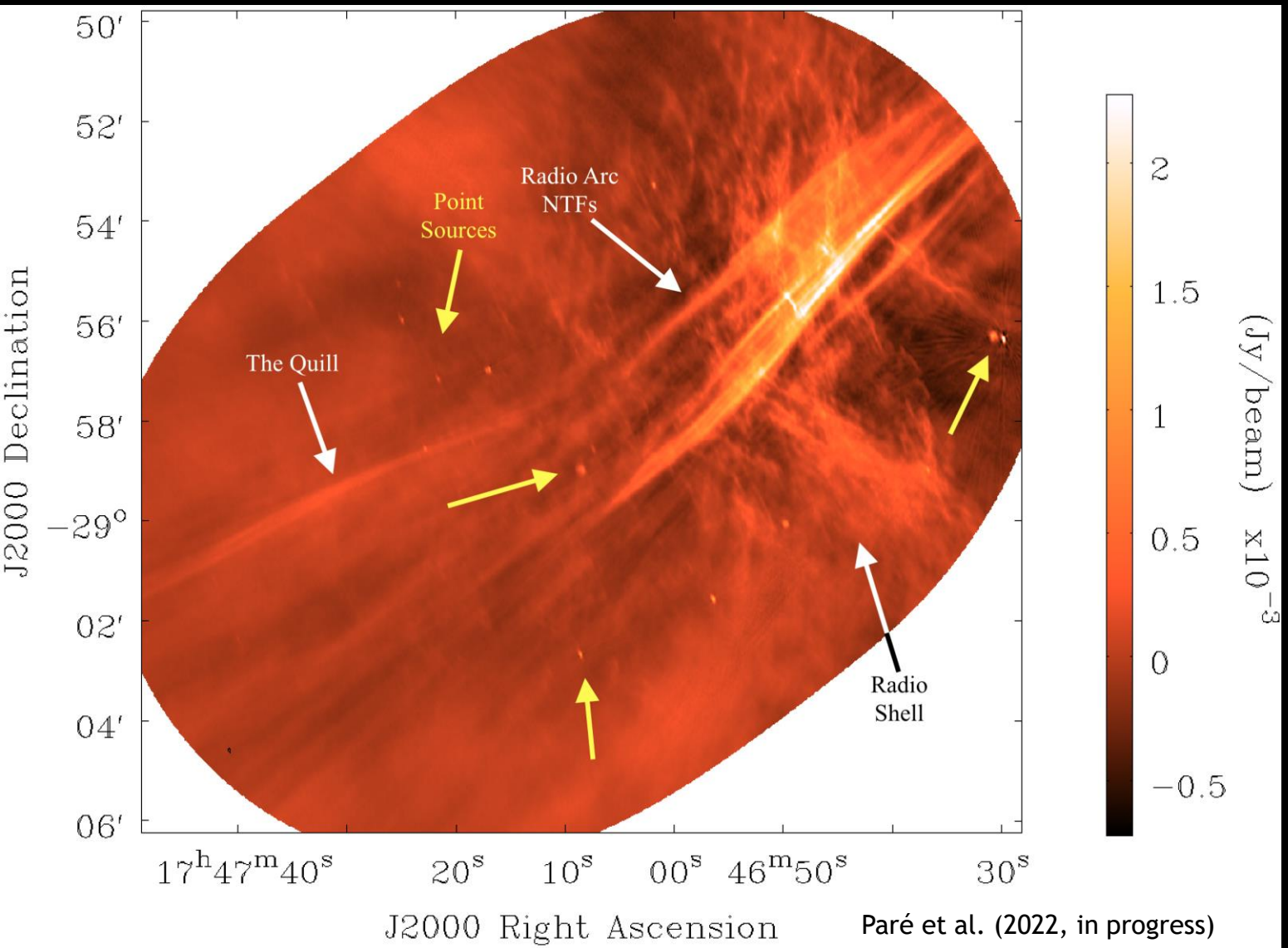
See also Heywood et al. (2022) and Yusef-Zadeh et al. (2022)

High Resolution View of SNTF1



Paré et al. (2022, in progress)

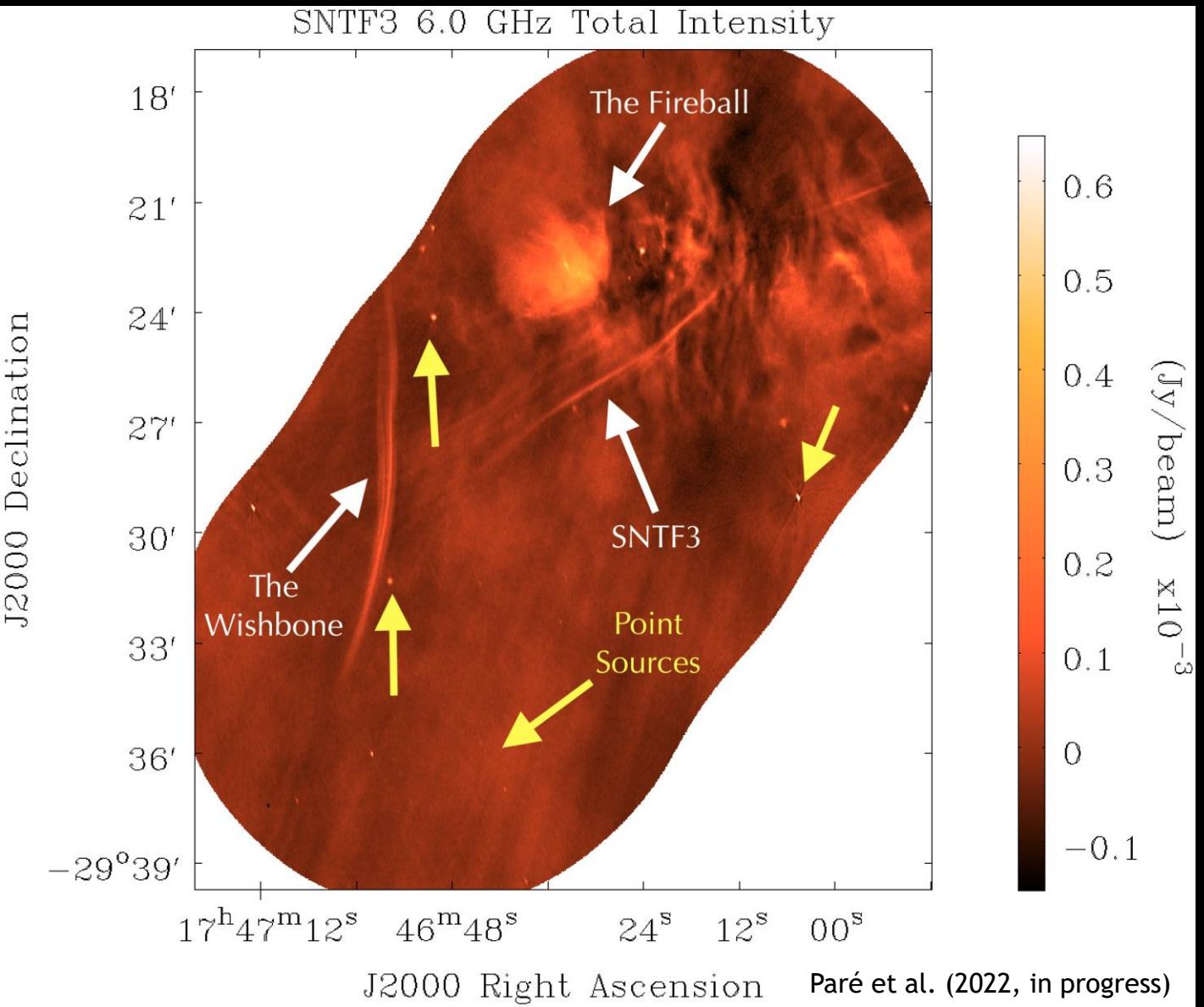
SNTF2 is Southern Extent of Radio Arc



Paré et al. (2022, in progress)

- Multiple individual filaments making up the Radio Arc
- Significant brightness variation within the filaments
- Isolated “Quill” filament also observed
- Evidence of other total intensity structure “Radio Shell”

SNTF3 in Complex Region of the GC

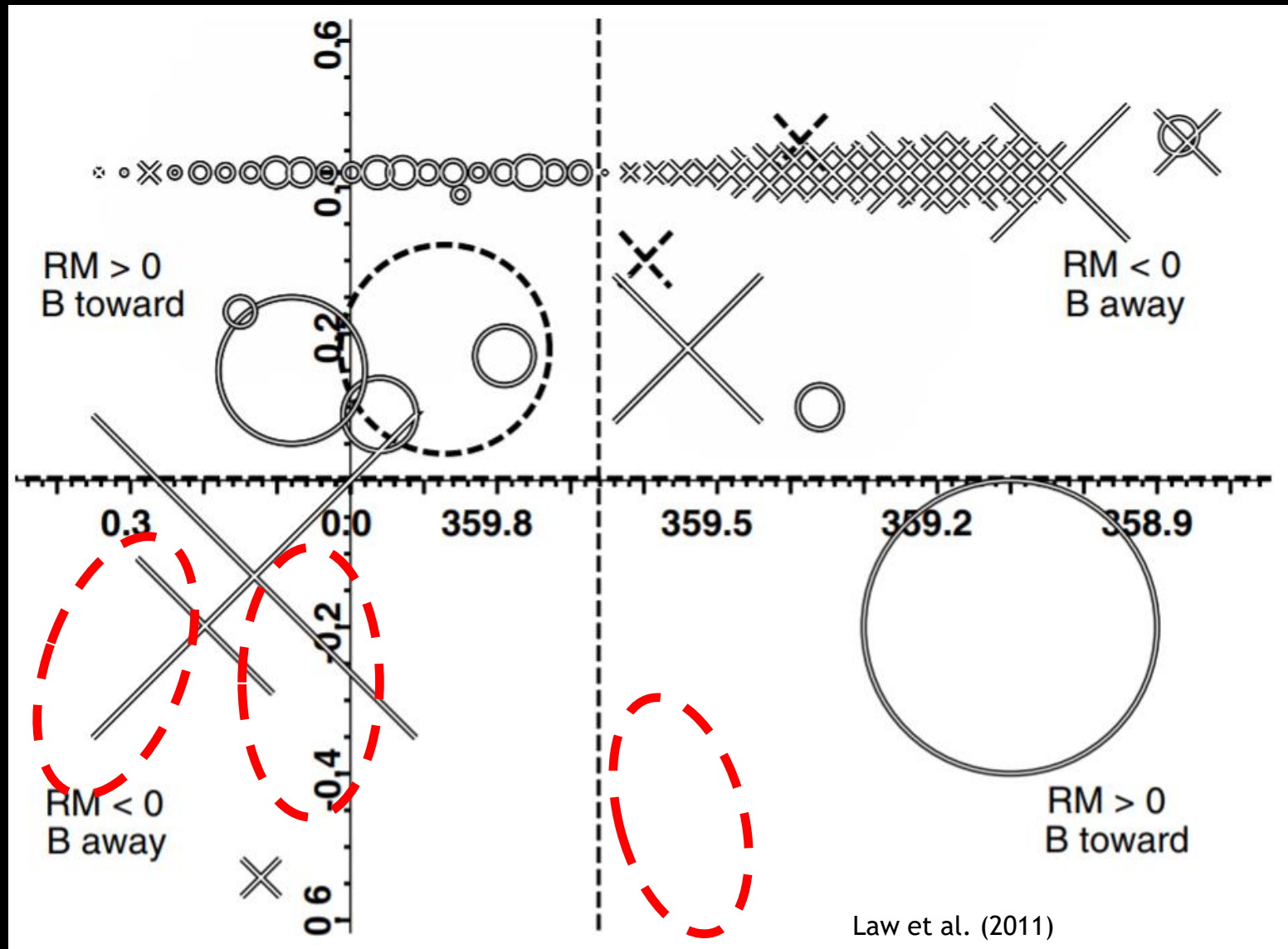


Paré et al. (2022, in progress)

- Multiple filamentary structures comprising SNTF3
- One bright and several faint filaments within SNTF3
- Isolated filament (“the Wishbone”) at termination of filaments of SNTF3
- Multiple other structures seen local to the NTFs like “The Fireball” and multiple point sources

Polarized Intensity Calibration Underway

- Finalizing the calibration
- Will produce polarized intensity, RM, and intrinsic magnetic field distributions for all three targets
- Will be able to assess whether B-field connects to dust polarization B-field



Law et al. (2011)

Ongoing HAWC+ Observations of the GC

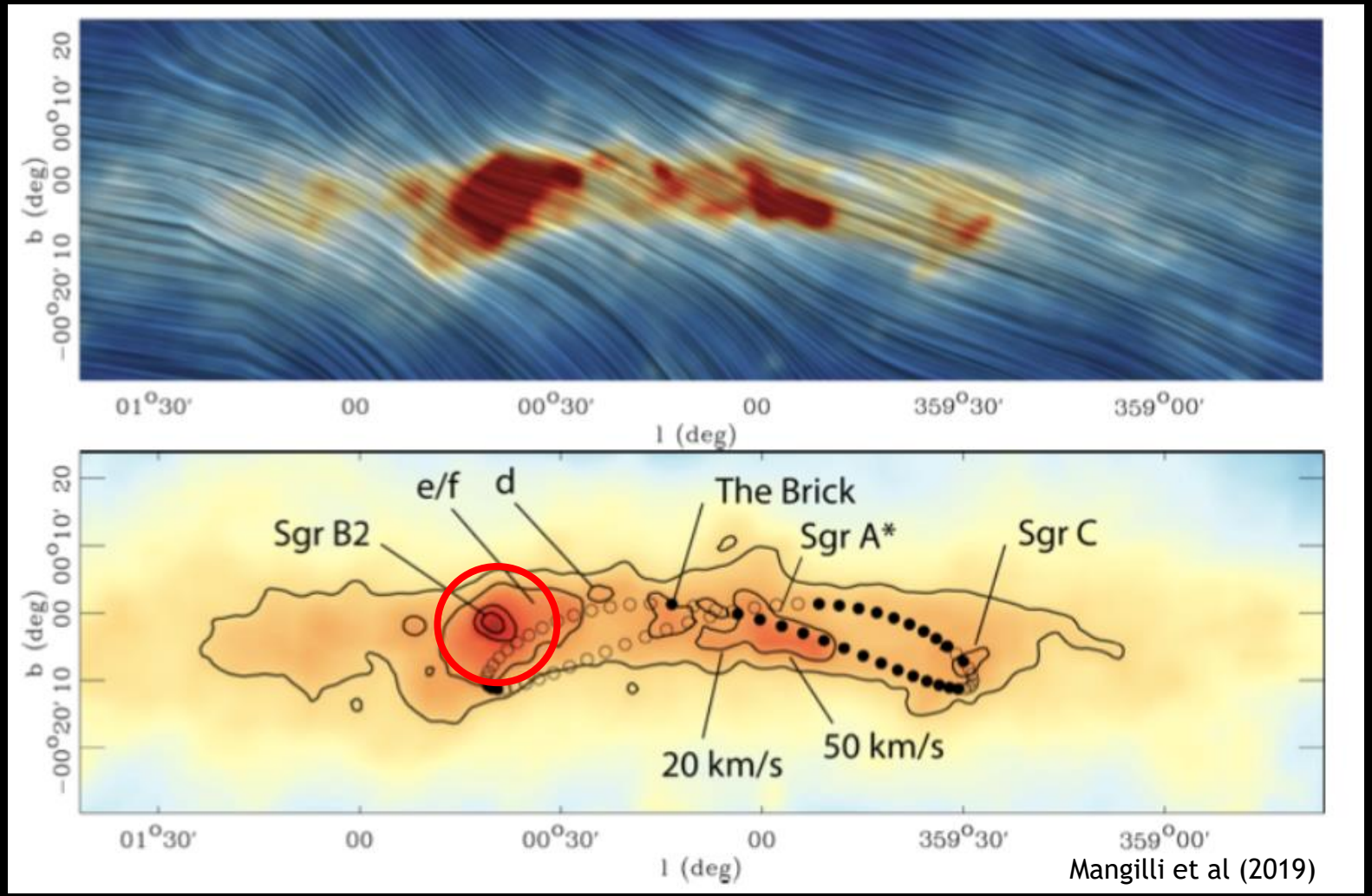
A Two-Color Polarimetric Survey of the Galactic Center

Principal Investigator	David Chuss
Proposal ID	09_0054
Category	STAR_FORMATION
Keywords	GALACTIC CENTER MOLECULAR CLOUDS STAR FORMATION

Abstract

We propose a Legacy program to utilize HAWC+ to map the central region of the Galaxy at both 214 um and 89 um. We will utilize the shared-risk scan mode polarimetry observing strategy. The 214 um map is proposed as a test case because the total integration time is modest. Upon successful completion of the 214 map, (and the approval of the Cycle 9 TAC), we will proceed with the 89 um survey in the second year of the program. The resulting data products will yield a transformative data set for understanding the magnetic fields in both the cool dust ring in the central 200 pc and the warmer dust component and its relationship to the hot features of the Galactic center. Such a data set would elicidate the role of the magnetic field in Galactic center dynamics from the 200 pc scale down to scales below a parsec.

ALMA Cycle 9 Proposal to Observe Sgr B2



Mangilli et al (2019)

- Will mosaic entire Sgr B2 region at 1 mm at 0.4” resolution
- Corresponds to physical resolution of ~1000 AU
- Will compare to 10,000 AU scale B-field observed with HAWC+

Exciting Prospects for GC Magnetic Fields

- Ongoing and upcoming research efforts will help elucidate the connection between the non-thermal and the dust polarization magnetic fields in the GC
- Will be able to study the role of magnetic fields in star formation in an extreme region like the GC at high resolution.
- Could provide insight into role of magnetic fields during the epoch of reionization

Let me know if you're interested in being involved with the Sgr B2 proposal: dylan-pare@uiowa.edu