ACT View of the Galactic Center

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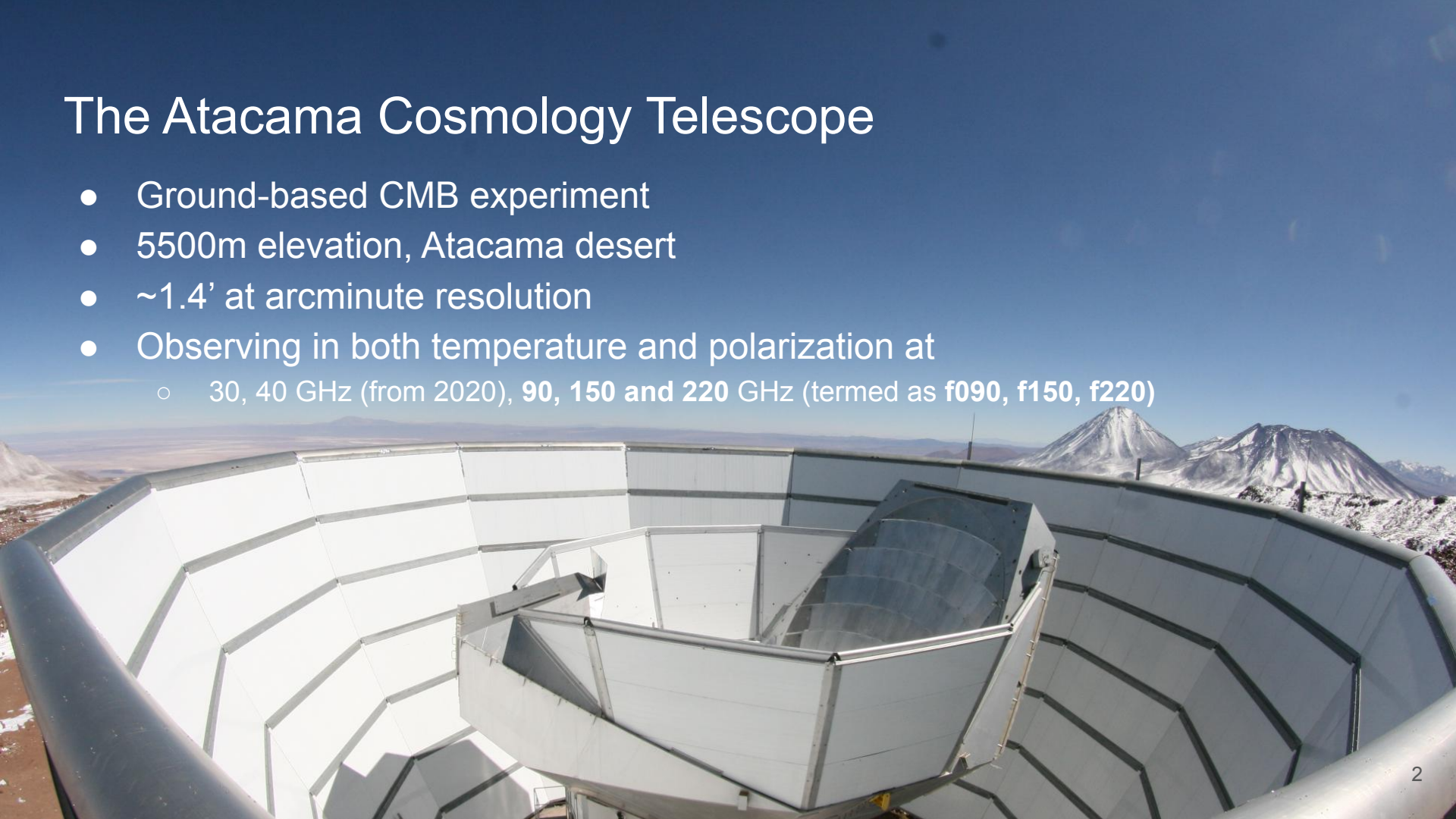
Guan et al. (2021)
arXiv:2106.12467

The Atacama Cosmology Telescope

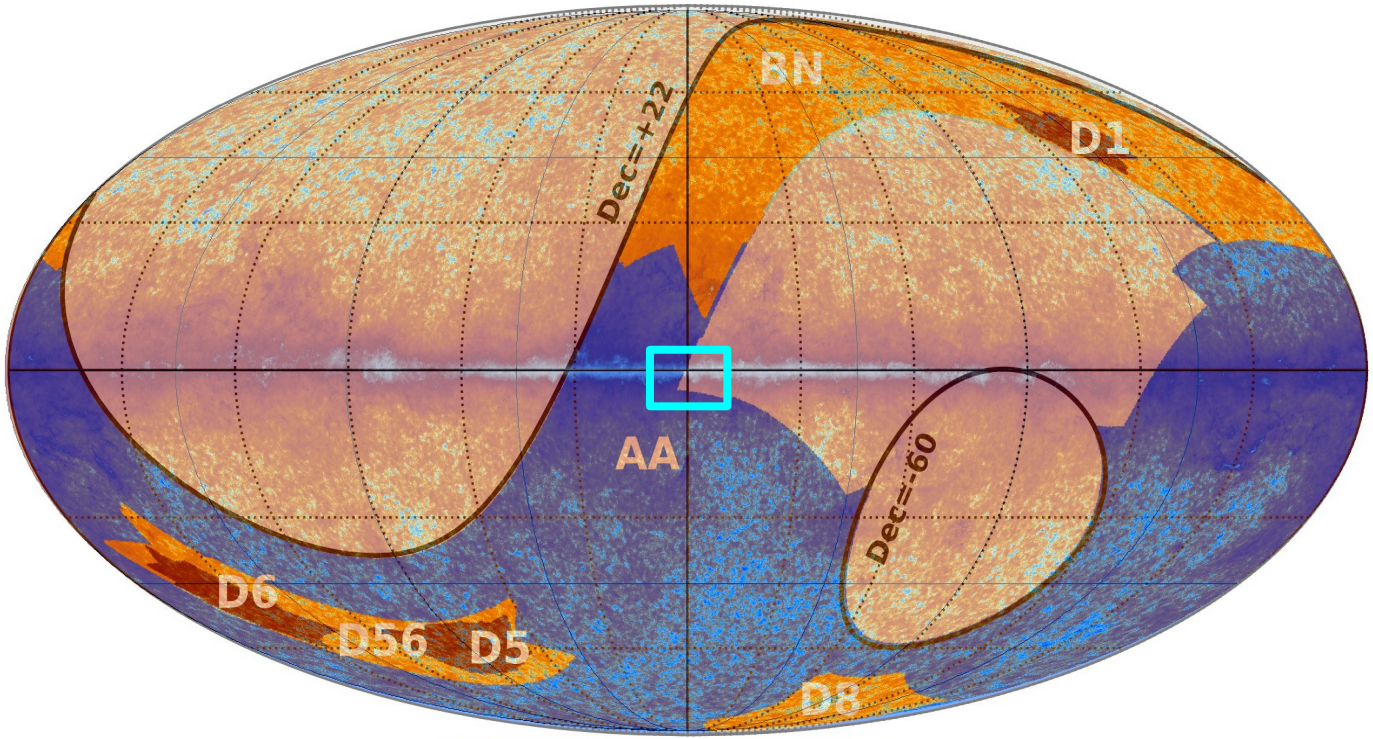
- Ground-based CMB experiment
- 5500m elevation, Atacama desert
- ~1.4’ at arcminute resolution
- Observing in both temperature and polarization at
  - 30, 40 GHz (from 2020), **90, 150 and 220** GHz (termed as **f090, f150, f220)**



Motivations

- Galactic center region in Milky way is physically rich and extreme environment
  - Densest concentration of molecular gas
  - Surprisingly low star formation rate
  - Supermassive blackhole Sgr A*, magnetar, ++
- Targets of multifrequency observations
  - Observations at microwave frequencies are often limited in one of
    - Field of view
    - Angular resolution
    - Polarization sensitivity
- Map galactic center region with ACT

Galactic Center Survey



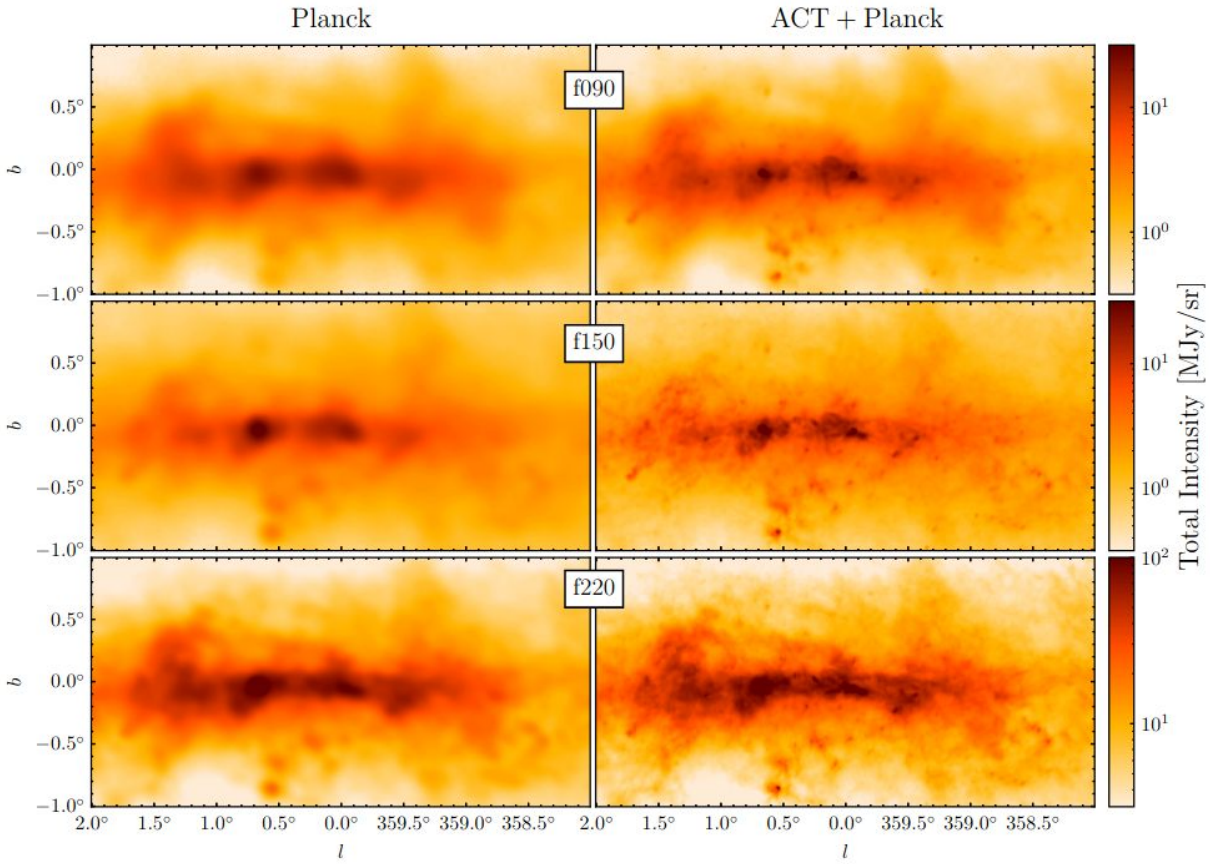
- Extended the ACT observational field to include a **~ 100 deg^2** field around Galactic center since 2019
- Total observation hours in 2019
  - f090: ~ 23 hours
  - f150: ~ 35 hours
  - f220: ~ 12 hours

Aiola et al. 2020

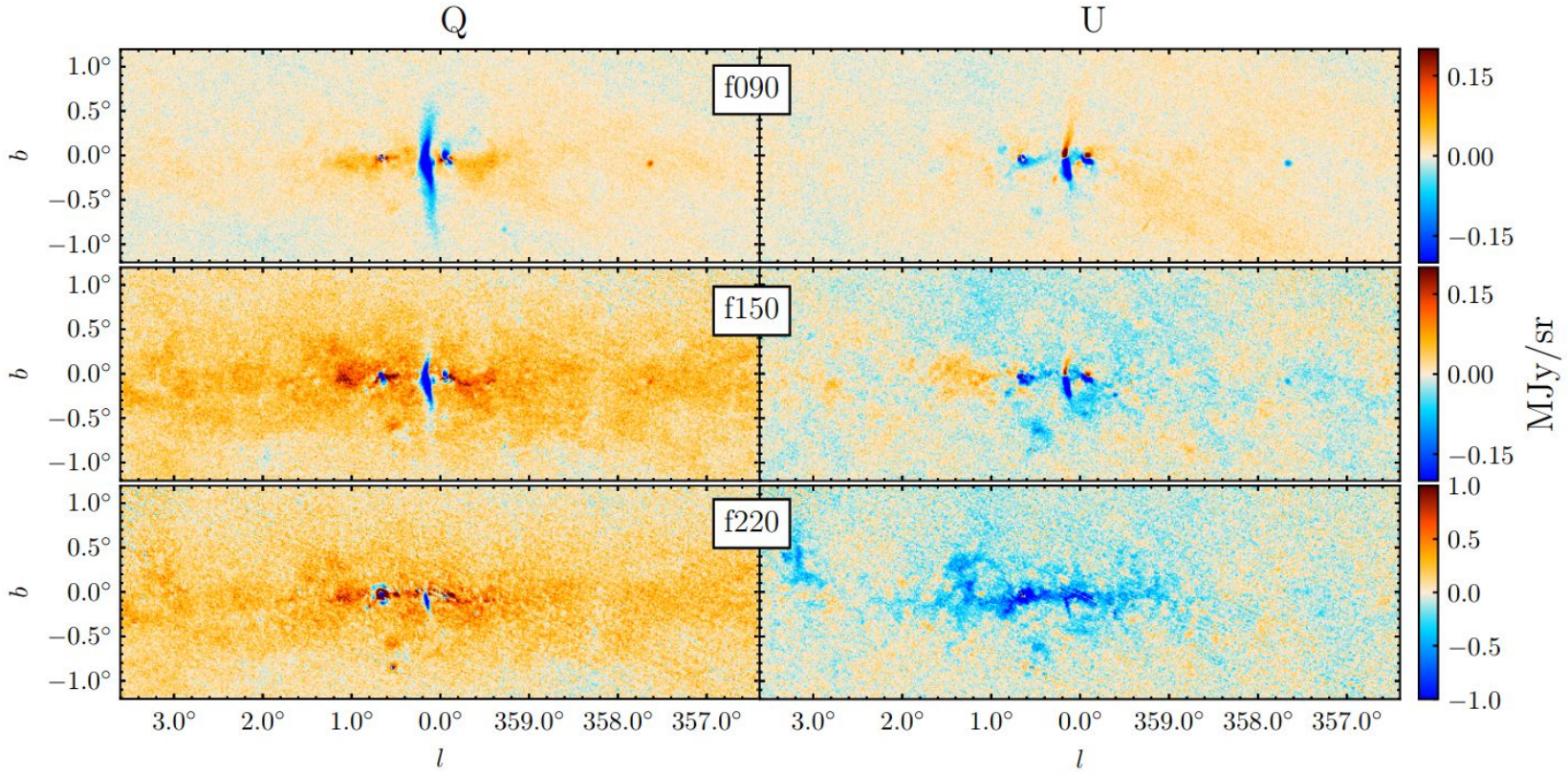
Mapmaking

- Map Galactic center data obtained in 2019 (nighttime only)
  - Map 32 $\deg^2$ field ($-4<l<4$, $-2<b<2$) centered around the Galactic center
- Same mapmaking algorithm as ACT DR4 (Aiola et al. 2020)
- Co-add Planck maps to complement ACT data as done in DR5 (Naess et al. 2020)
  - ACT f090 + Planck 100 GHz
  - ACT f150 + Planck 143 GHz
  - ACT f220 + Planck 217 GHz

Mapmaking: ACT+Planck Co-adds



Maps: polarized intensity



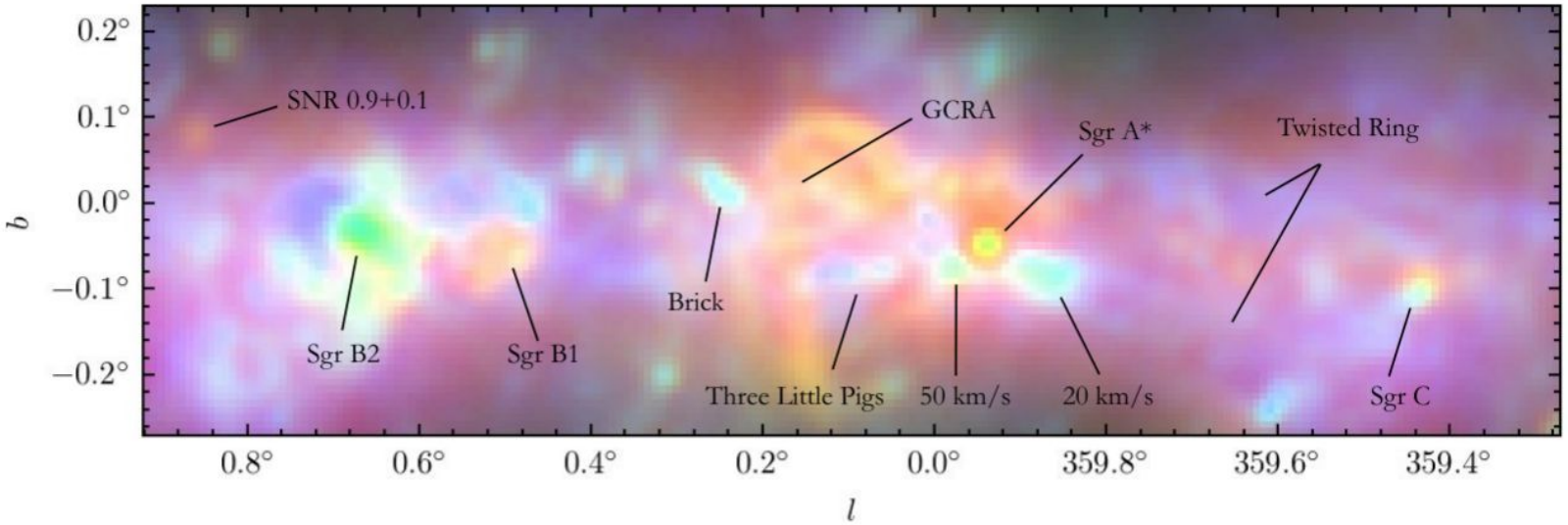
Galactic Emission in Three Frequencies

- Synchrotron
  - Cosmic ray electrons spiraling in Galactic magnetic fields
  - Strongest at the lowest frequencies (f090) in intensity and polarization
- Dust
  - Thermal vibrational emission by dust grains heated to ~20K by the interstellar radiation field
  - Strongest at the highest frequencies (f220) in intensity and polarization
- Free-free
  - “Braking radiation” from electrons decelerated by protons
  - Relatively flat spectrum, intensity only
- CO Lines
  - Rotational line emission that can dominate the signal in Galactic center even in broad passbands
  - In Planck 100 GHz but not ACT f090!

ACT View of Galactic Center

- Red = f090, expected to highlight synchrotron and Planck CO
- Green = f150, mostly dust, some synchrotron and free-free
- Blue = f220, dust dominated

Total intensity



ACT View of Galactic Center

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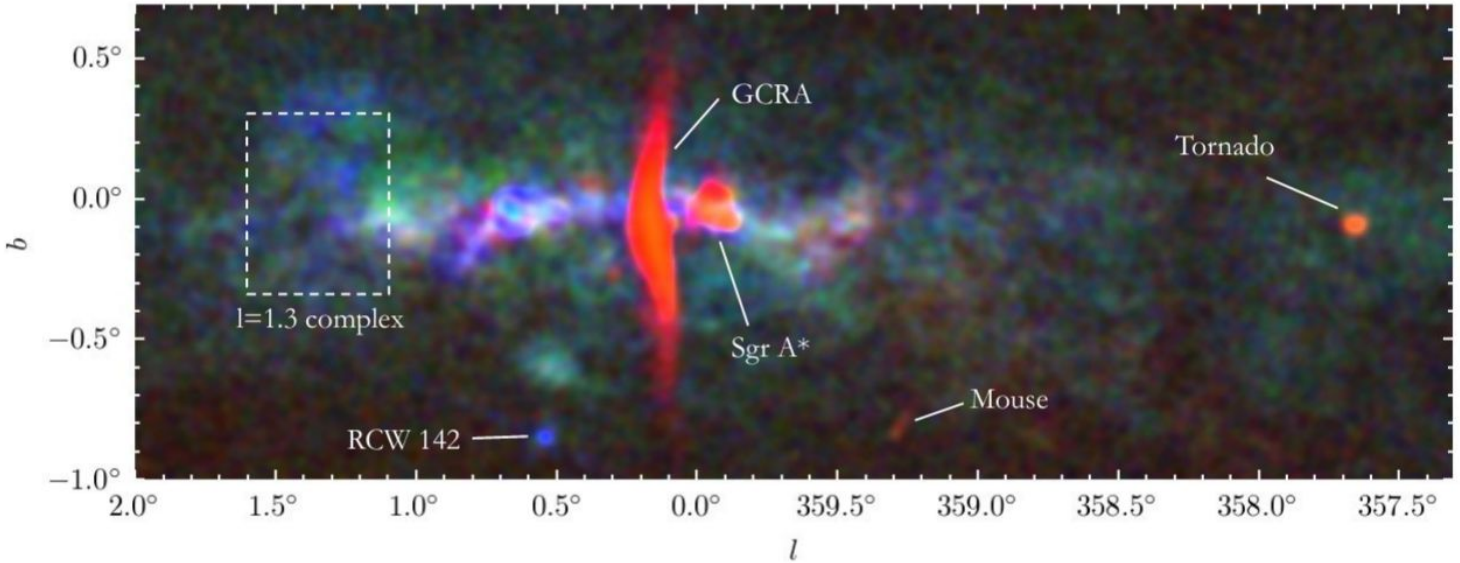
Polarized intensity



Galactic Magnetic Field

- Magnetic field tracers:
  - dust, synchrotron
  - B-field orthogonal to polarization angle

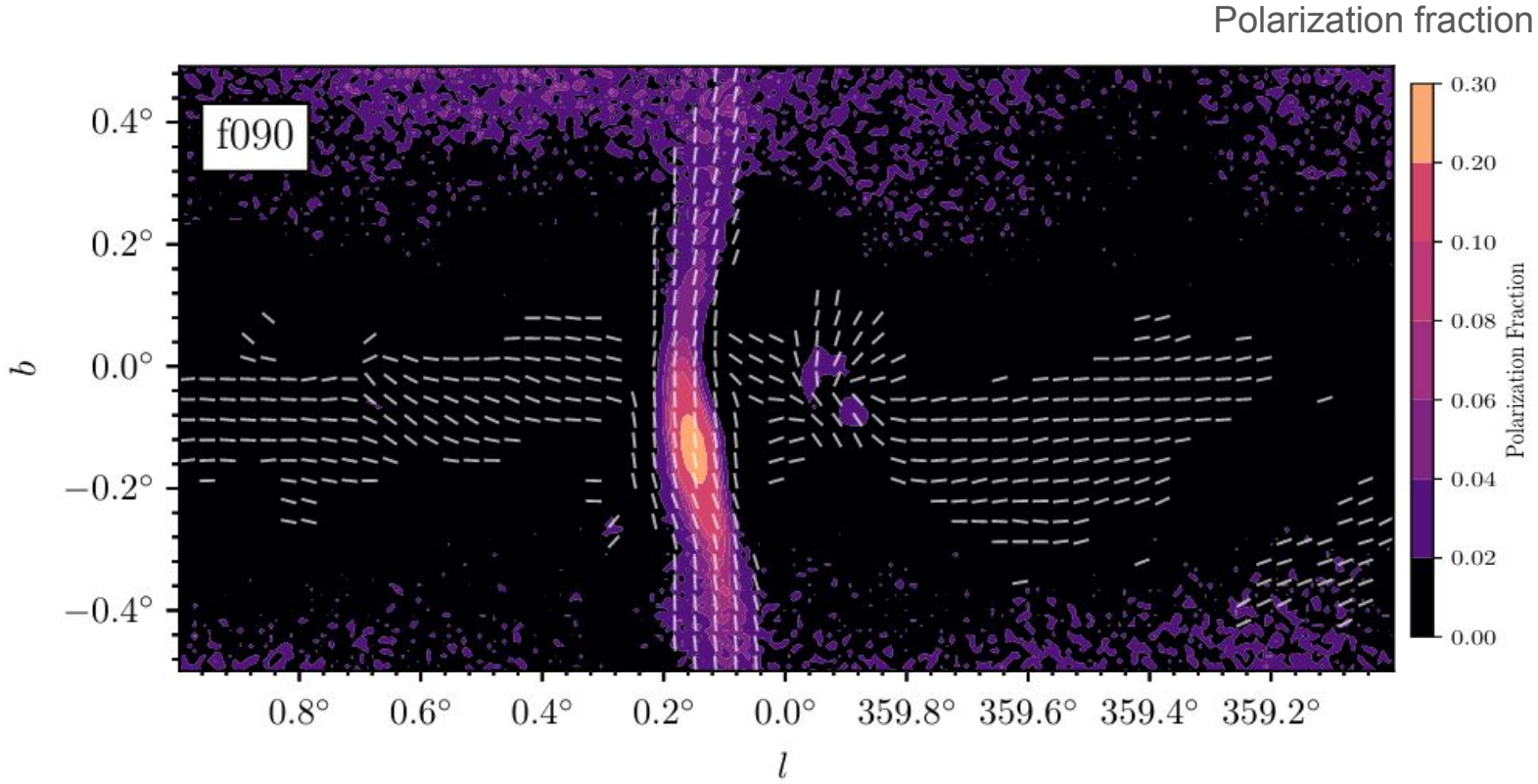
Total intensity

Contours trace magnetic field lines seen in f090

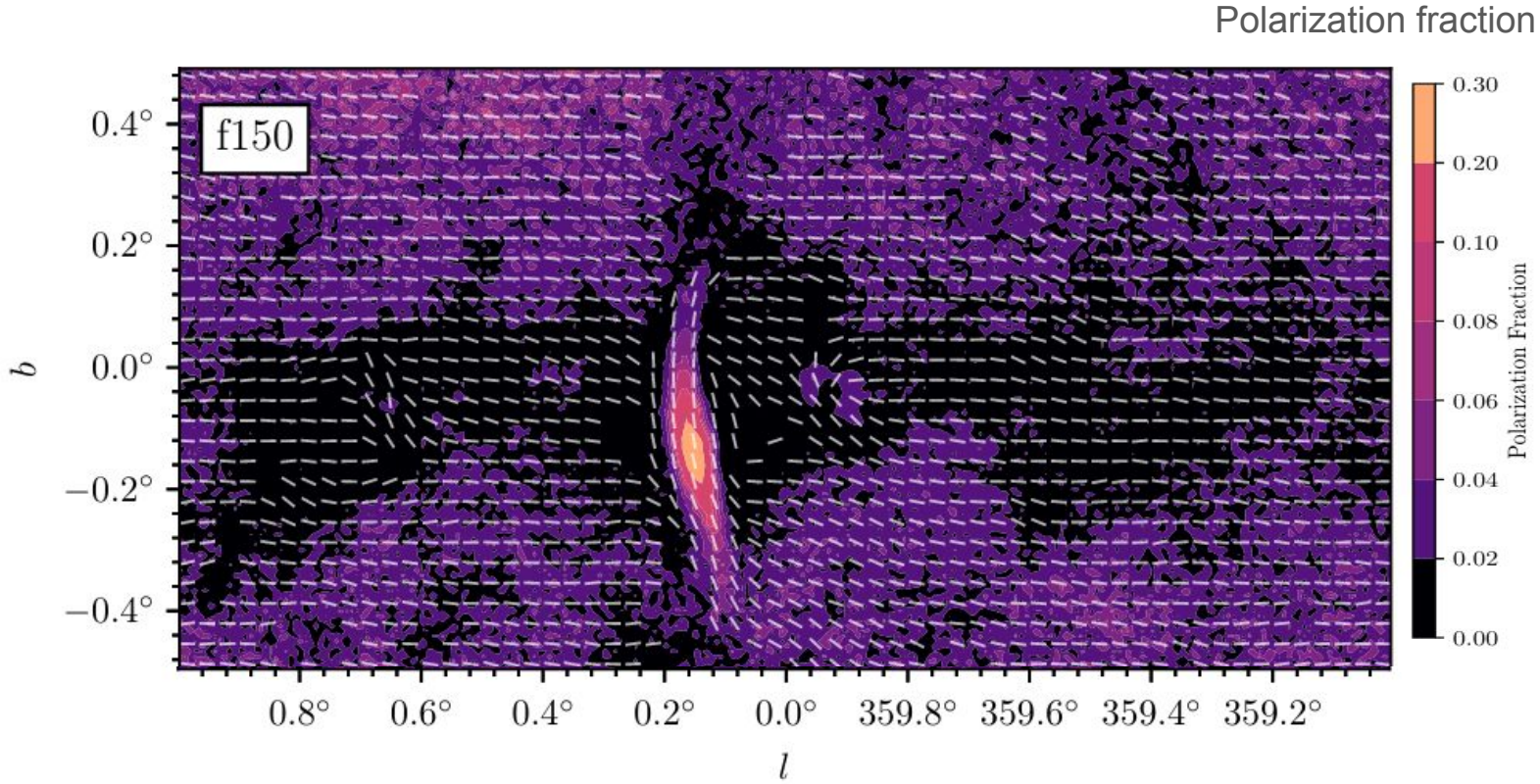
The Galactic Magnetic Field

- Magnetic field morphology changes with frequency as we go from synchrotron to dust
- In f090 and f150, large scale field is parallel to the plane
- In f220, field is tilted by ~20° with respect to the plane. Also seen in higher frequency PILOT data
- Can see imprint of Galactic Center Radio Arc clearly in f090 and f150 field lines, mostly gone in f220. Consistent with it being a strong synchrotron source

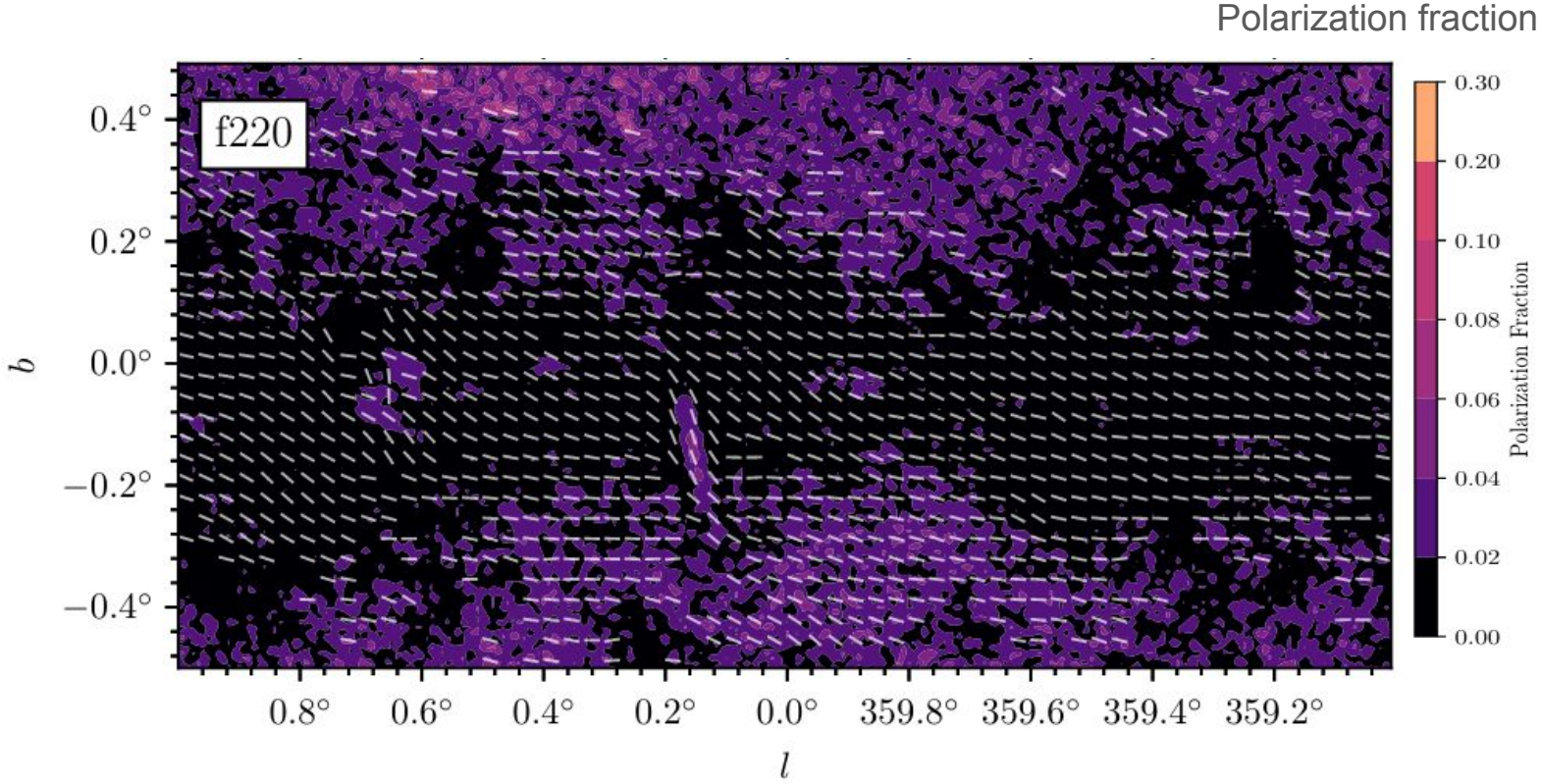
The Galactic Magnetic Field



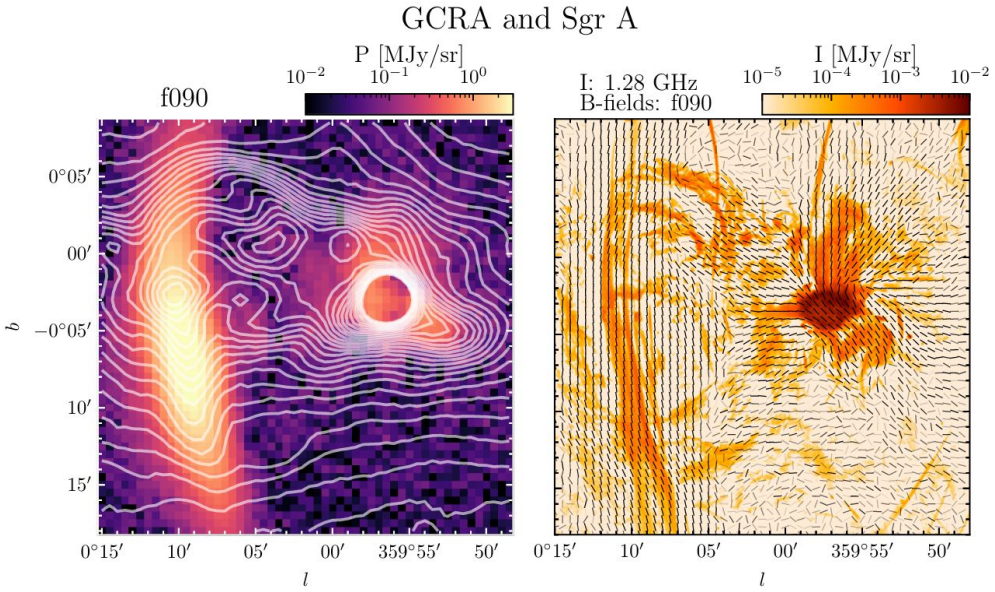
The Galactic Magnetic Field

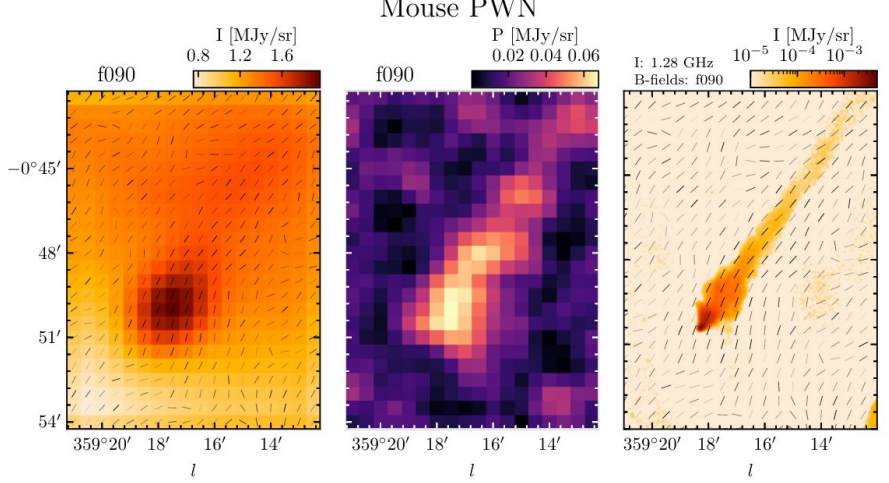


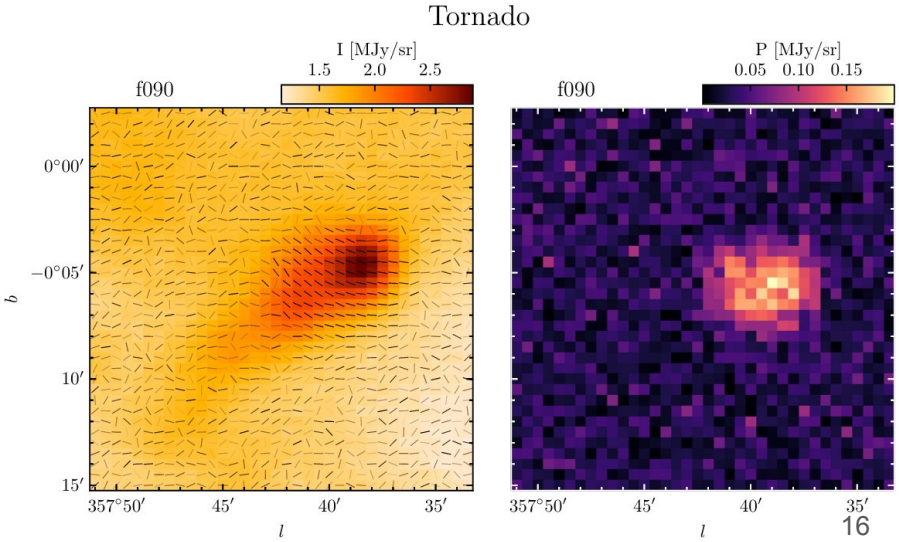
The Galactic Magnetic Field



Radio Sources

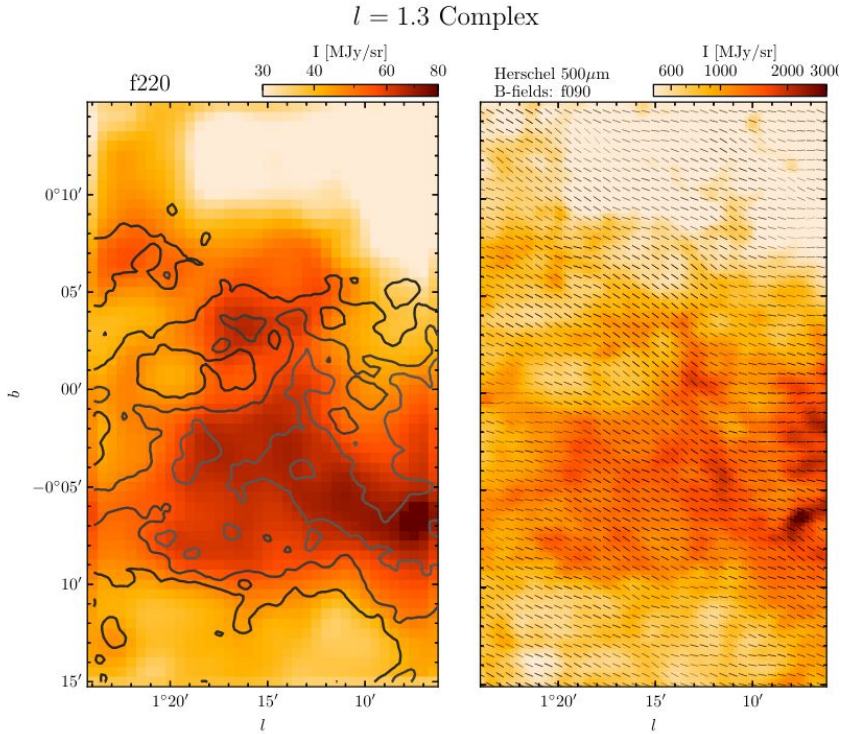


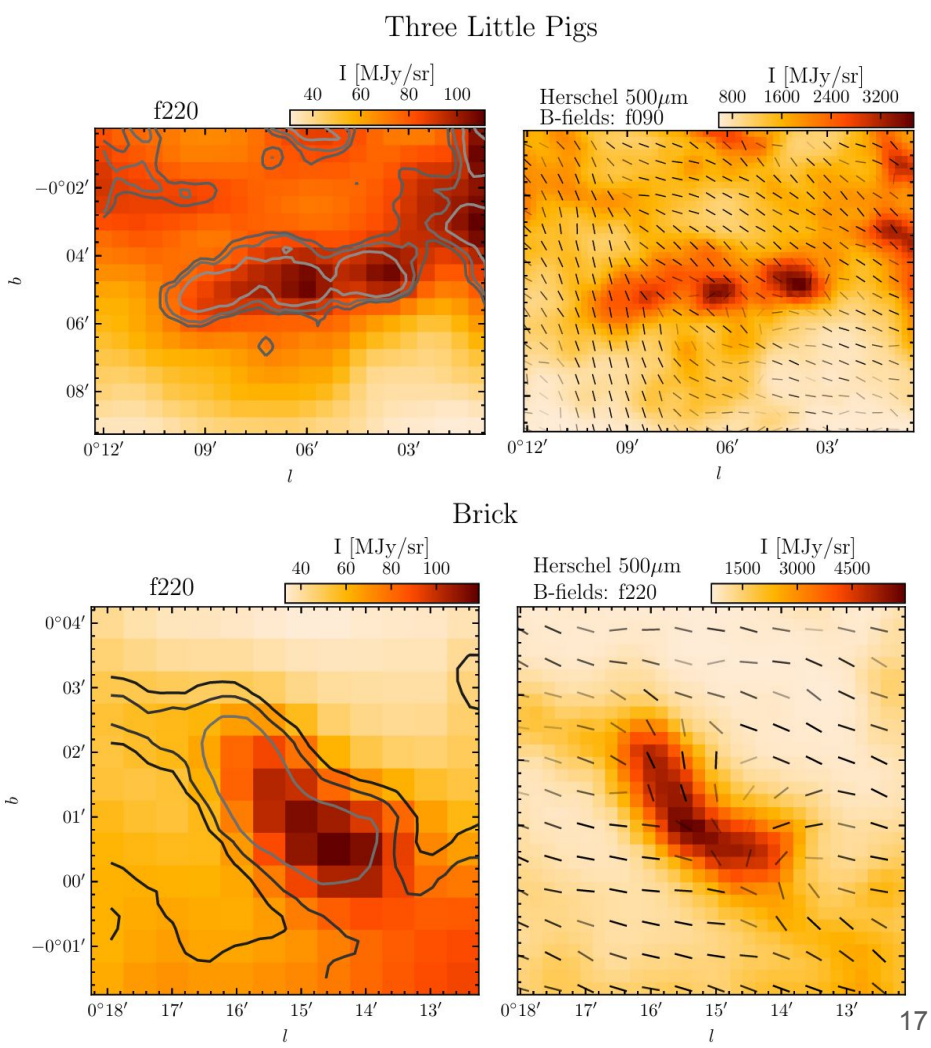




Molecular Clouds

- Study magnetic field morphology in both dense and diffuse molecular clouds





Summary

- We have presented arcminute resolution IQU maps of the Galactic center from ACT
- Frequency coverage allows to study different emission mechanisms and thus different magnetic field morphologies
- See https://arxiv.org/abs/2105.05267 for more details
- Co-add maps are available on LAMBDA