Indirect detection of Dark Matter with radio observation

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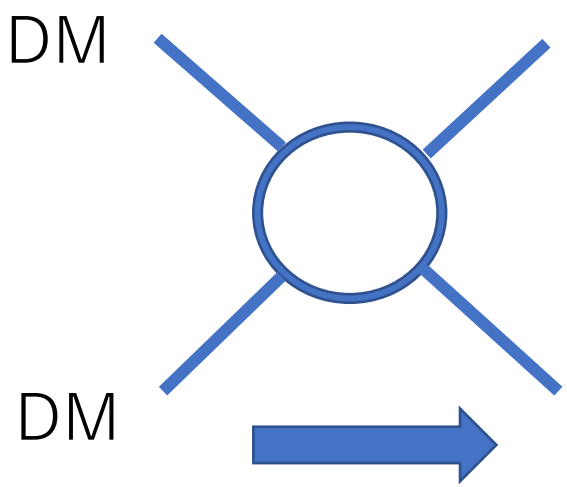
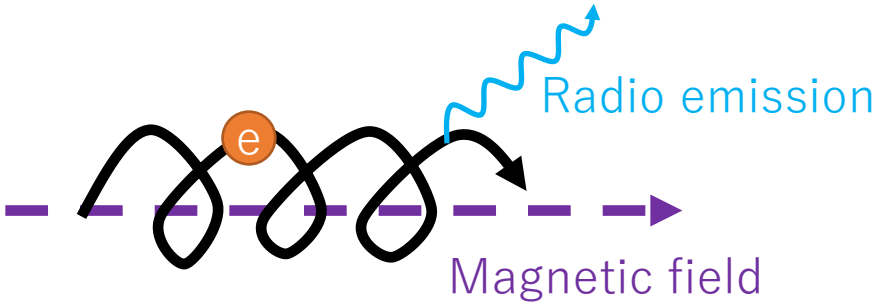
Introduction



decay

Higher than 100GeV



Synchrotron radiation

- A few hundred GeV Neutralino DM is motivated from the muon g-2 anomaly.
- WIMP model predicts that SM particles are produced through the Self-Annihilation of DM and finally decay into high-energy electrons. Such electrons emit a radio signal through synchrotron radiation.
- Our goal is to detect such a signal by observing the Draco dSph by using radio interferometry.

Expected signal

Dwarf spheroidal galaxy:

- Dark Matter dominated
- low background

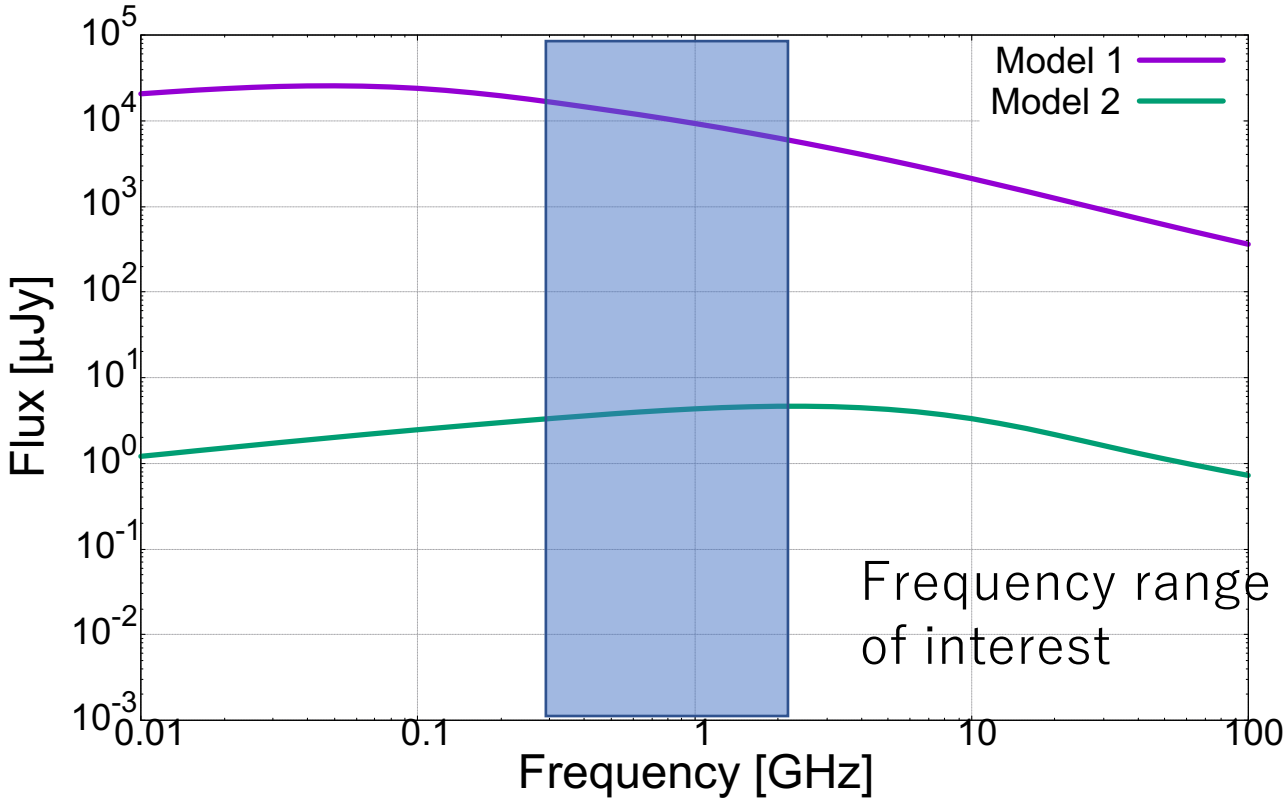
  → **promising target**

Draco

- Half Light Radius:10[arcmin]
- Location:17h20m12.4s +58d54m55s
- Large J-factor

The expected flux densities were calculated by assuming two benchmark scenarios.

	Magnetic Field[μG]	DM mass[GeV]	Diffusion coefficient[cm^2/s]
Model 1	5.0	300	10^{27}
Model 2	1.0	500	$3*10^{28}$



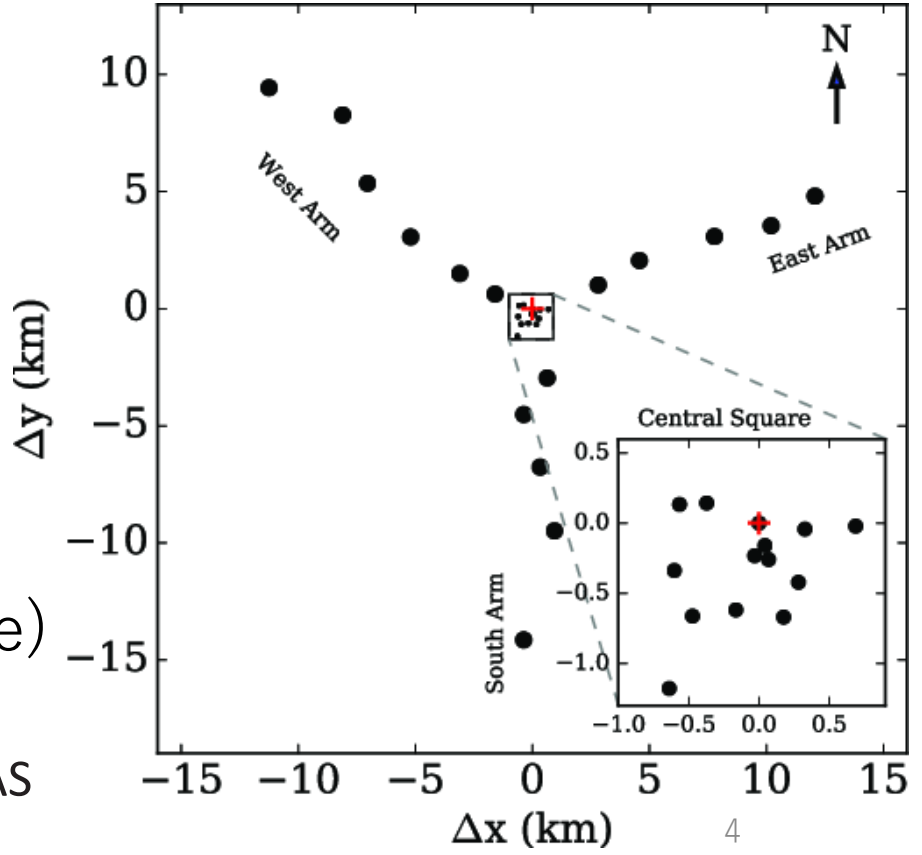
- **The expected emission is 10[μJy]~A few[mJy] and on a few [arcmin] scale.**
- (1Jy = 10^{-26} W/m^2/Hz)

Radio Interferometry

- Radio Interferometry measures “visibility,” which is related to the brightness of the sky through Fourier transformation.

Baseline Length	short	long
Spatial Frequency	Large spatial scale (Diffuse emission)	Small spatial scale (point source)

- Missing flux: By the limitations of minimum baseline length, a flux of extended emission could be lost because of the lack of large scale information.



GMRT(@India Pune) Array configuration (N.N.Patra et al., MNRAS 483, 3007–3021 (2019))

Analyzed Data

- Observation(GSB)

  Date : 2019/09/22

  Project Code : 36_065

  On source time : 150 [min]

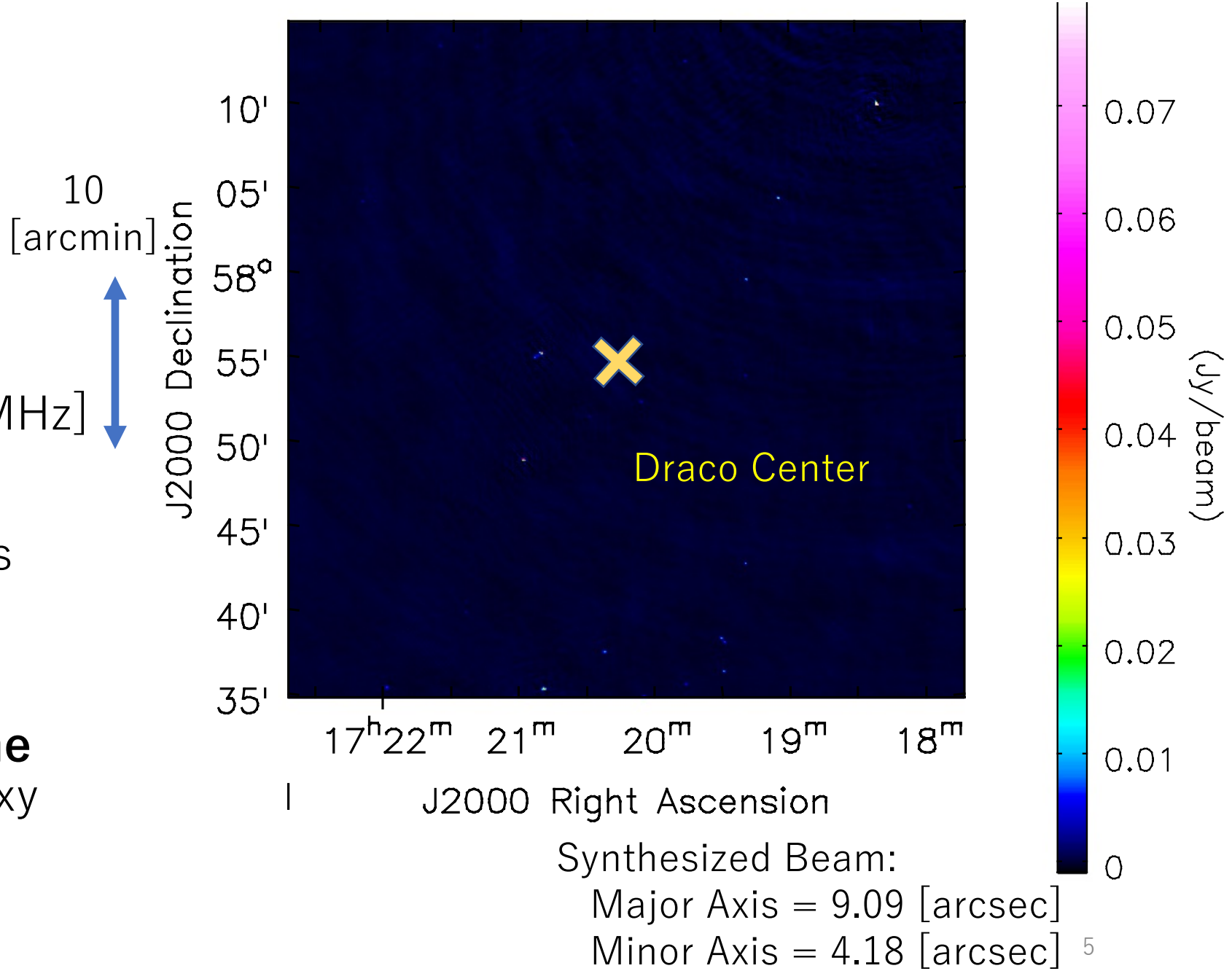
  Bandwidth : 33.3 [MHz]

  Central Frequency : 607.7[MHz]

- Analysis :

  Calibration and Imaging was done by using CASA.

Bright nearby sources in the ROI (AGN, star forming galaxy and so on)



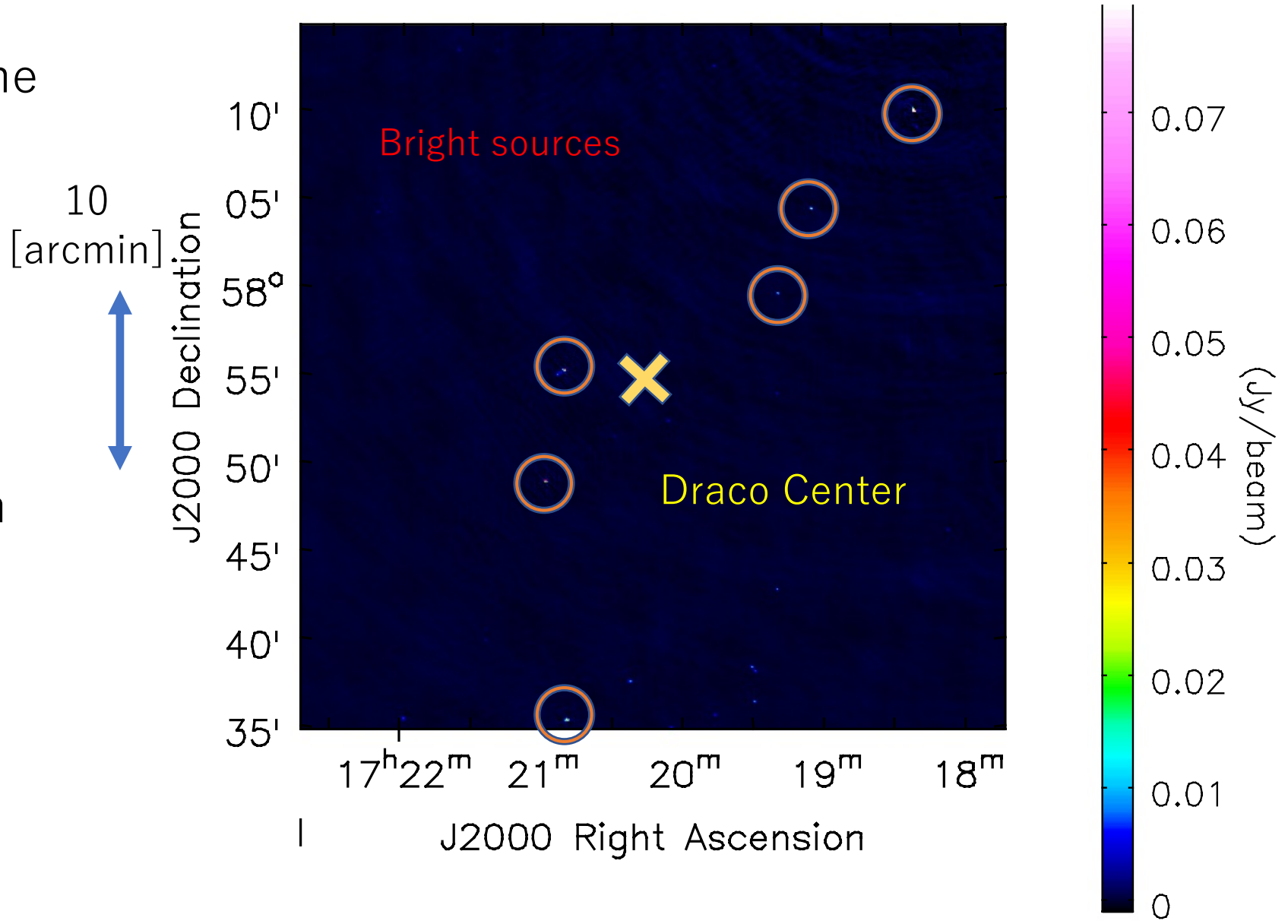
Point Sources

- Nearby bright sources in the ROI → **main background**

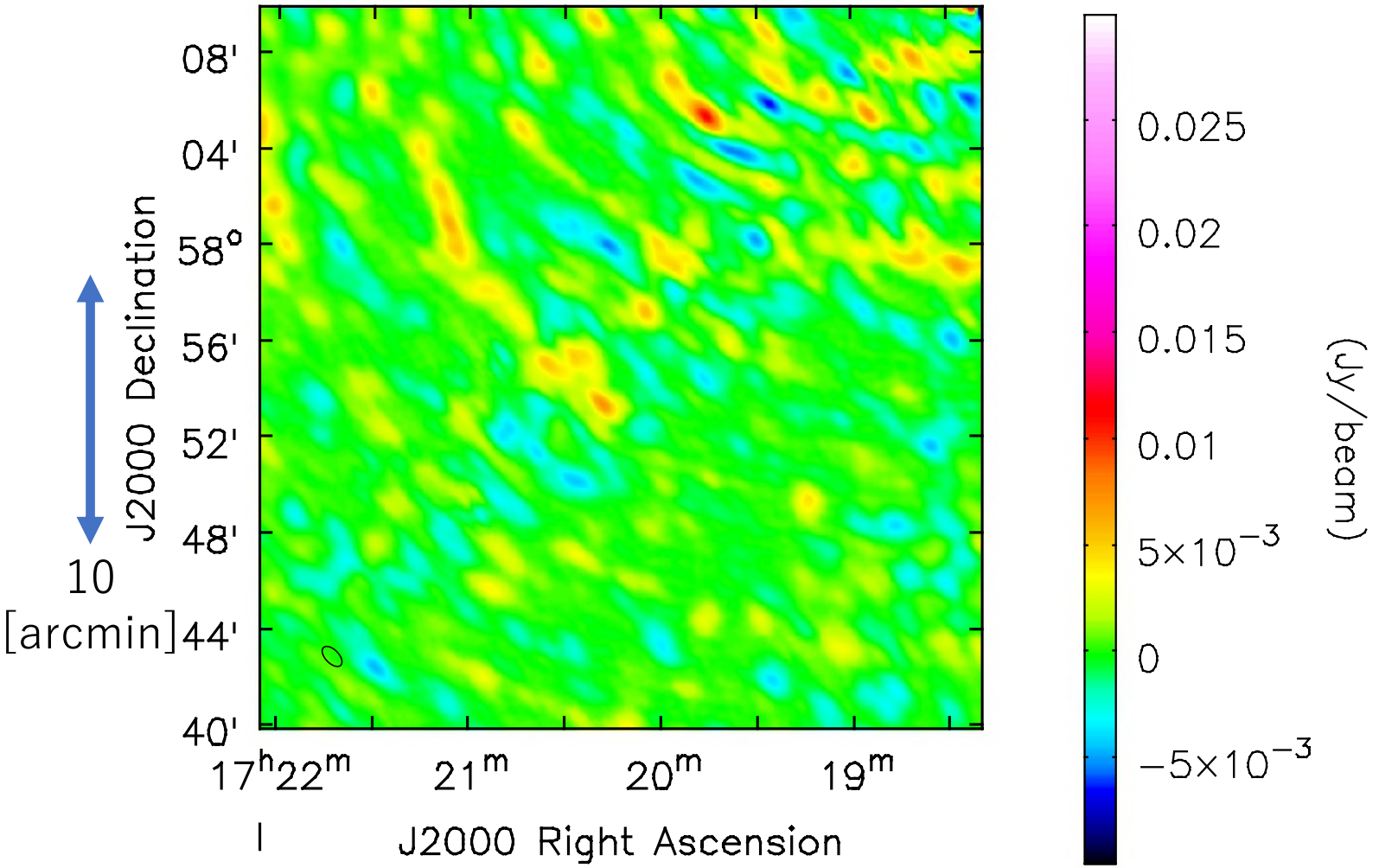
- Position and flux of point sources were detected by using PyBDSF. (2015ascl.soft02007M)

  →~50 sources detected in the FoV

- After detecting these sources, we subtract them from the data



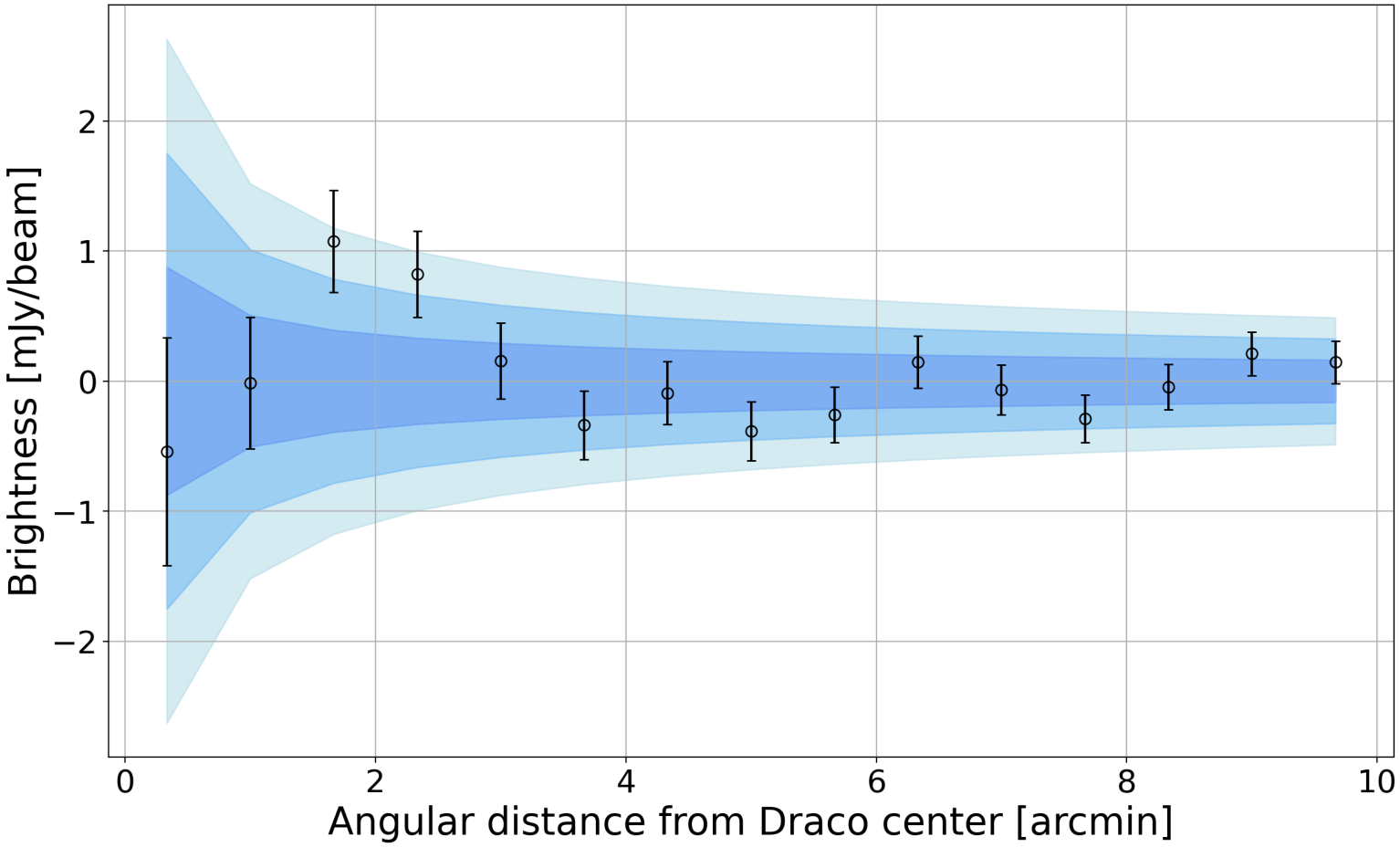
Resulting image (Preliminary Result)



Synthesized Beam:
Major Axis = 61.7 [arcsec]
Minor Axis = 33.7 [arcsec]

- Subtracting point sources and imaging again with Gaussian taper (down-weighting long baseline)
- Resulting image sensitivity σ_{rms}=1.28 [mJy/beam]
- Ripple-like artifact caused by bright source on upper-right

Radial distribution (Preliminary Result)



← Radial distribution of point-source subtracted image

Horizontal axis: Angular distance from Draco center[arcmin]
Vertical axis: Brightness [mJy/beam]

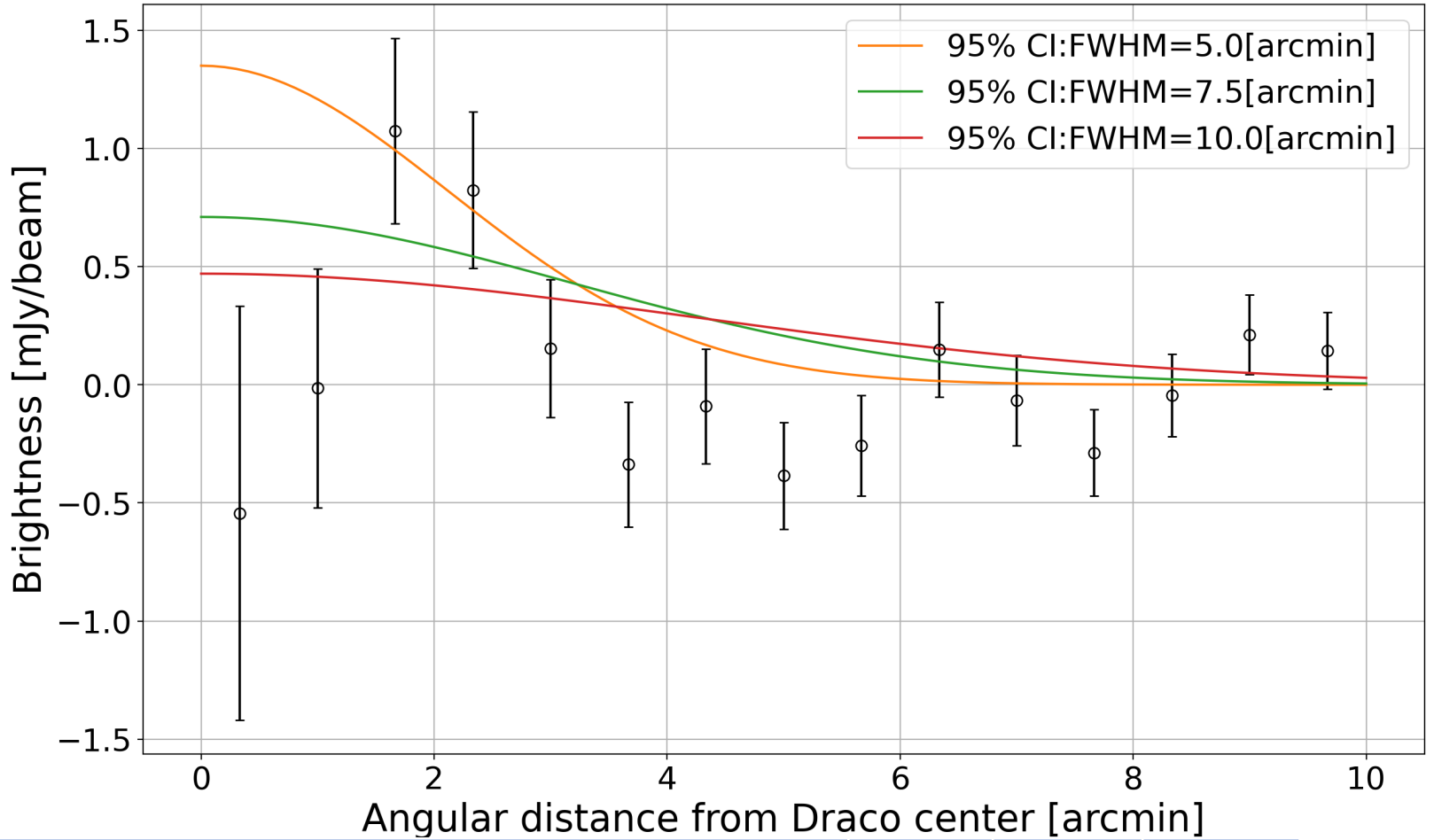
Shaded region is 1,2,3σ noise level.

The radial distribution of brightness was modeled with a Gaussian and statistical significance at which null detection case is rejected were calculated.

FWHM [arcmin]	5.0	7.5	10.0
Statistical significance	2.06 σ	1.34 σ	0.87 σ

→No firm evidence of diffuse emission

Upper Bounds(Preliminary Result)



The limits on the flux were calculated and results are summarized in the table below.

Same Gaussian shape assumed as a brightness distribution.

We have not evaluated the effect of missing flux yet. (This could worsen upper bound on flux)

FWHM [arcmin]	5.0	7.5	10.0
Upper Bound on Integrated Flux [mJy] without missing flux	58.4	69.1	81.4

→ **This limit cannot exclude even Model1.**

+Missing Flux

Summary and Future

Observing Application

Date:	Feb 01, 2023
Proposal ID:	VLA/23B-173
Legacy ID:	AK1109
PI:	Chikara Kawai
Type:	Regular
Category:	Normal Galaxies, Groups, and Clusters
Total time:	40.0

AN ULTRA-DEEP SEARCH FOR DARK MATTER ANNIHILATING SIGNAL IN THE DSPH DRACO

- **Summary：**
- A search for DM-induced signal have been conducted.
- We find no diffuse emission.
- **Future：**
- We are calculating upper bound on flux including the effect of Missing Flux.
- We have submitted the observing proposal to VLA to conduct a deeper search for DM annihilation signal. (waiting for result now!)