Polarization Leakage

IN BINGO OBSERVATIONS

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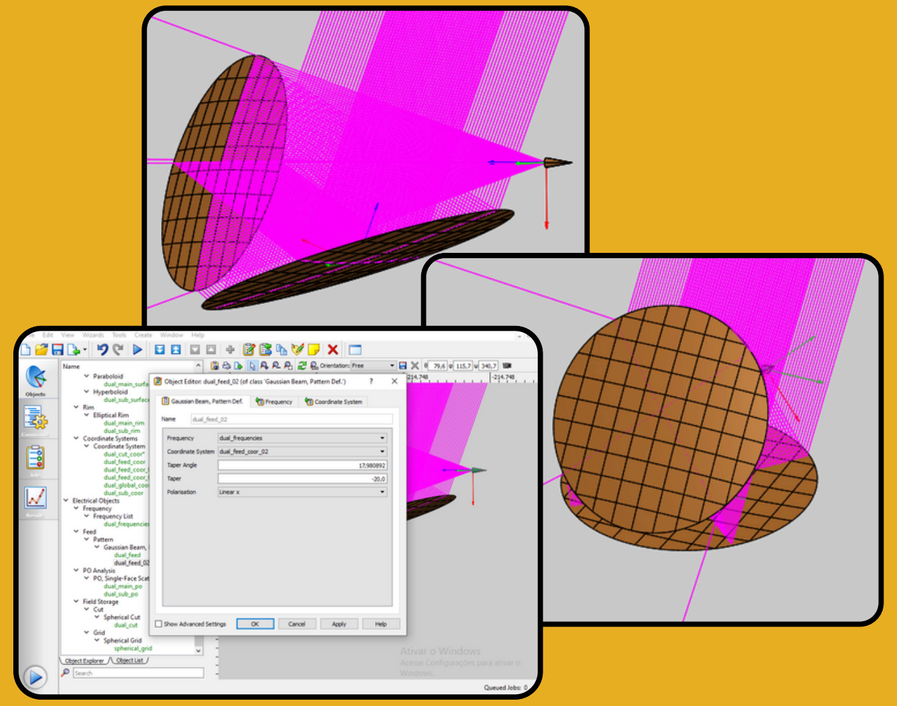
GRASP (General responsibility assignment software patterns)

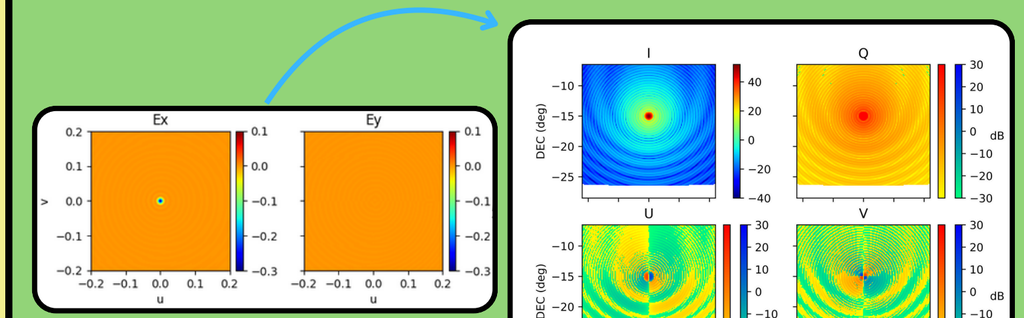
BINGO BEAM SIMULATION

- Analysis and design of reflector antennas;
- Physical Optics method to calculate the reflected electromagnetic field;
- BINGO arrangement (paper III).



$$s = \begin{bmatrix} I \\ Q \\ U \\ V \end{bmatrix} = \begin{bmatrix} e_x e_x^* + e_y e_y^* \\ e_x e_x^* - e_y e_y^* \\ e_x e_y^* + e_y e_x^* \\ -i(e_x e_y^* - e_y e_x^*) \end{bmatrix}$$

Stokes
Parameters



How to measure
the Leakage?

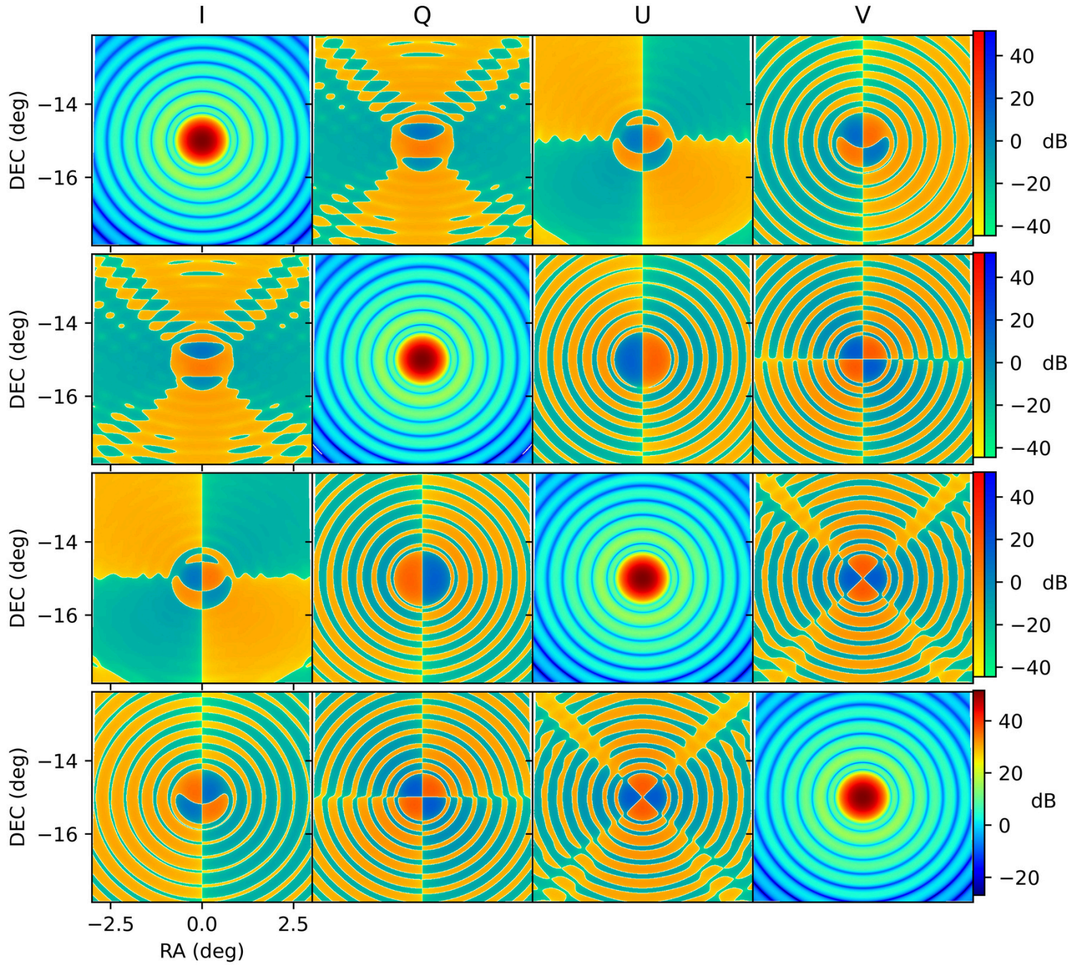
$$s' = Ms$$

$$\mathbf{M} = \begin{bmatrix} I \to I' & Q \to I' & U \to I' & V \to I' \\ I \to Q' & Q \to Q' & U \to Q' & V \to Q' \\ I \to U' & Q \to U' & U \to U' & V \to U' \\ I \to V' & Q \to V' & U \to V' & V \to V' \end{bmatrix}.$$

Mueller
matrix

Mueller Matrix

at 1100MHz



$$\mathbf{M} = \begin{bmatrix} I \to I' & Q \to I' & U \to I' & V \to I' \\ I \to Q' & Q \to Q' & U \to Q' & V \to Q' \\ I \to U' & Q \to U' & U \to U' & V \to U' \\ I \to V' & Q \to V' & U \to V' & V \to V' \end{bmatrix}.$$

Mueller matrix scheme.

Imperfections in optical components can cause a portion of one polarization state to “leak“ into another.

This polarization leakage is described by off-diagonal terms.

ZERNIKE MODEL

for Mueller Matrix components.

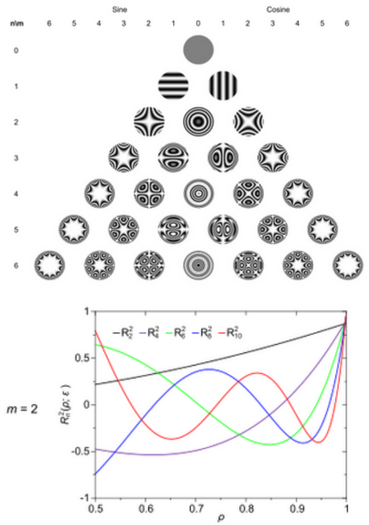
Zernike
Polynomials

$$G(\rho,\varphi) = \sum_{m,n} \left[a_{m,n} Z_n^m(\rho,\varphi) + b_{m,n} Z_n^{-m}(\rho,\varphi) \right]$$

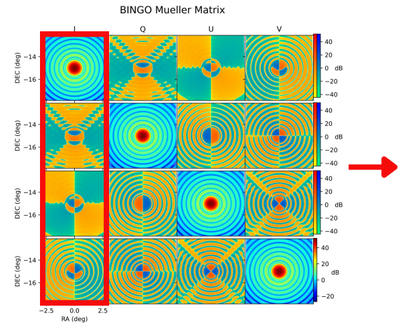
$$Z_n^m(\rho,\varphi) = R_n^m(\rho)\,\cos(m\,\varphi)$$

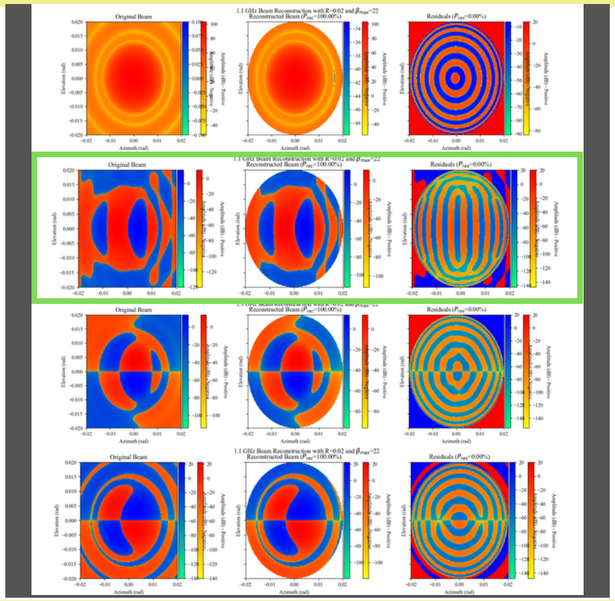
$$Z_n^{-m}(\rho,\varphi) = R_n^m(\rho)\,\sin(m\,\varphi)$$

$$R_n^m(\rho) = \sum_{k=0}^{\frac{n-m}{2}} \frac{(-1)^k\,(n-k)!}{k!\left(\frac{n+m}{2}-k\right)!\left(\frac{n-m}{2}-k\right)!}\,\rho^{n-2k}$$



MM beam reconstrution

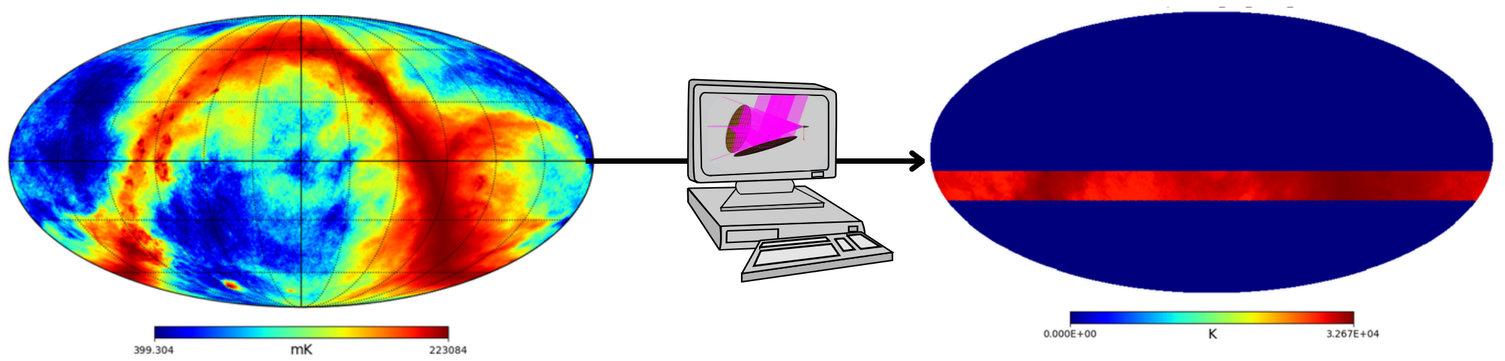




HIDE (HI DATA EMULATOR)

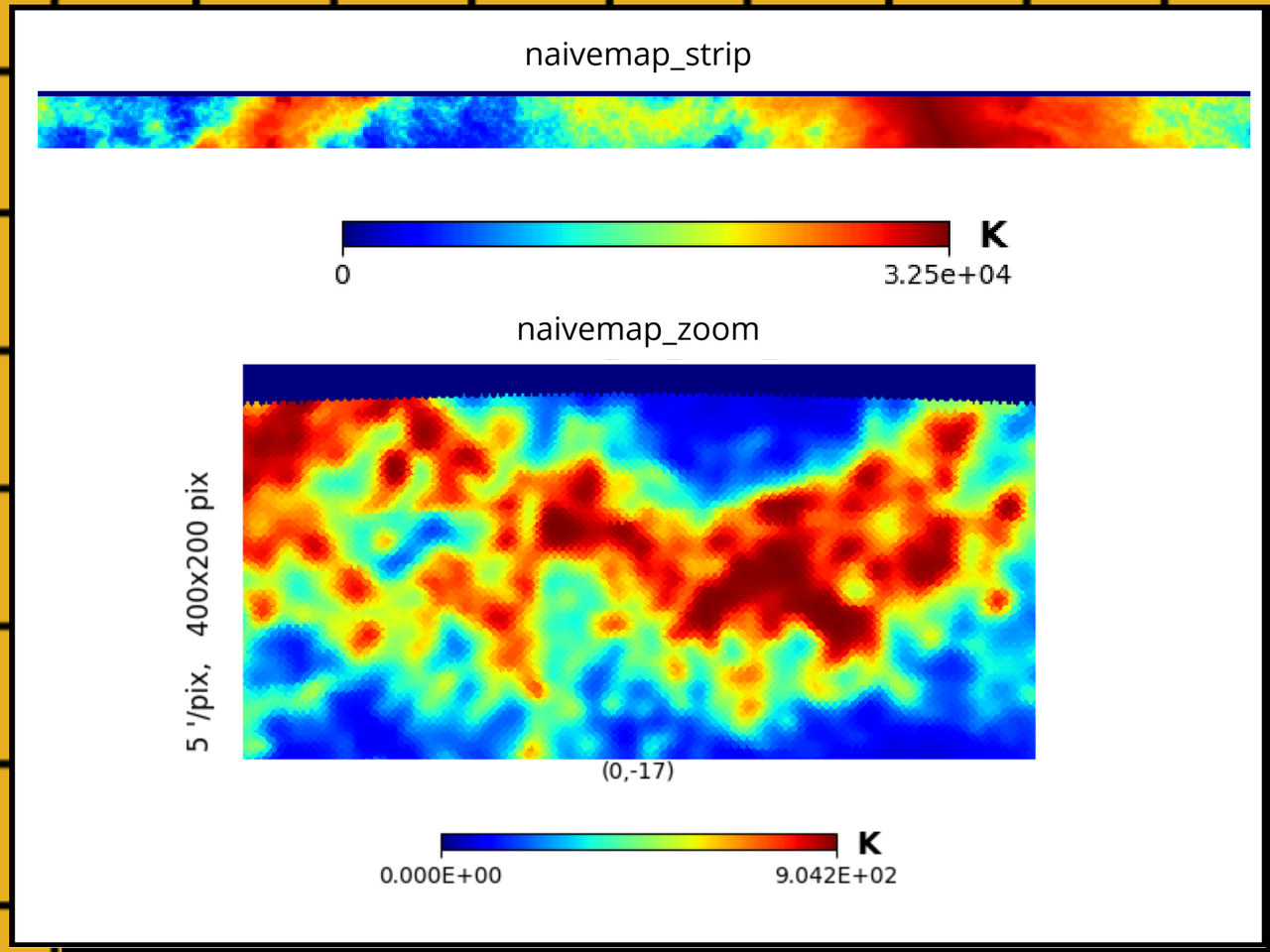
HIDE (HI Data Emulator) simulate single-dish radio survey data

HIDE forward models the entire radio survey system chain



BINGO MAPS

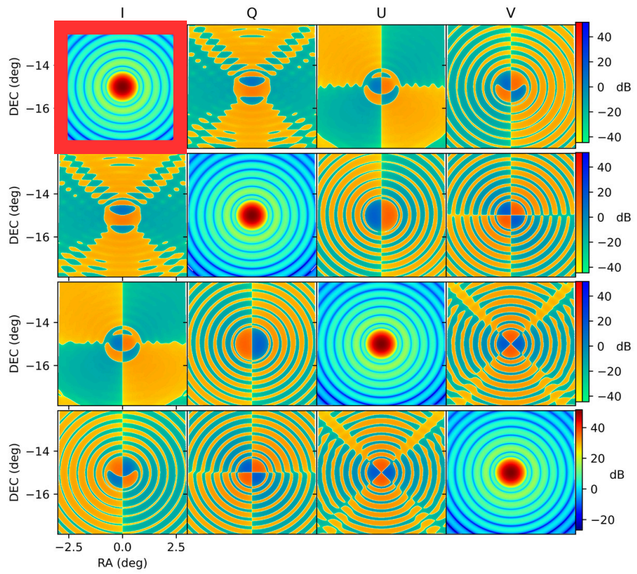
HIDE output for a Gaussian beam, at a frequency of 1100MHz



BINGO MAPS

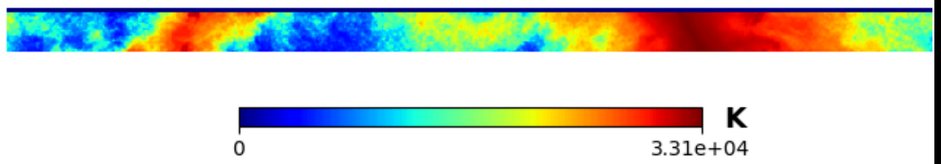
$I \rightarrow I'$

HIDE output for the zernike models of MM elements, for a sky map nside = 256

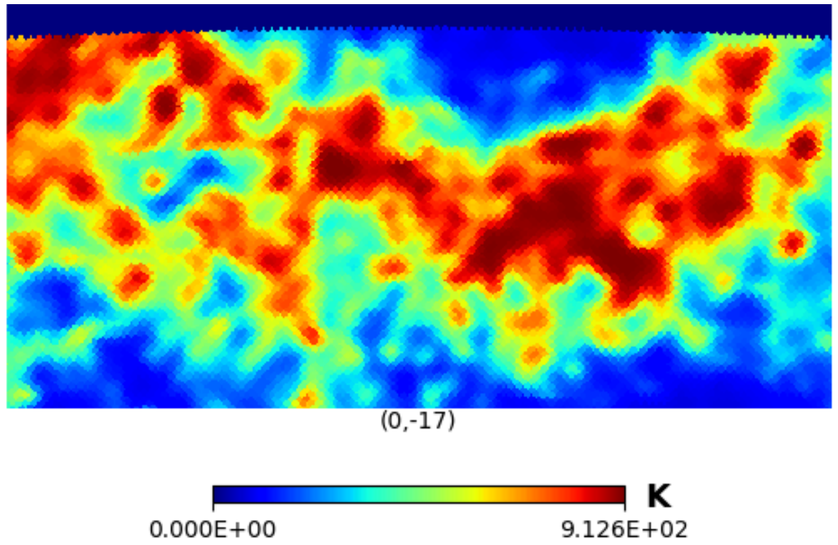


naivemap_strip

$I \rightarrow I$



naivemap_zoom

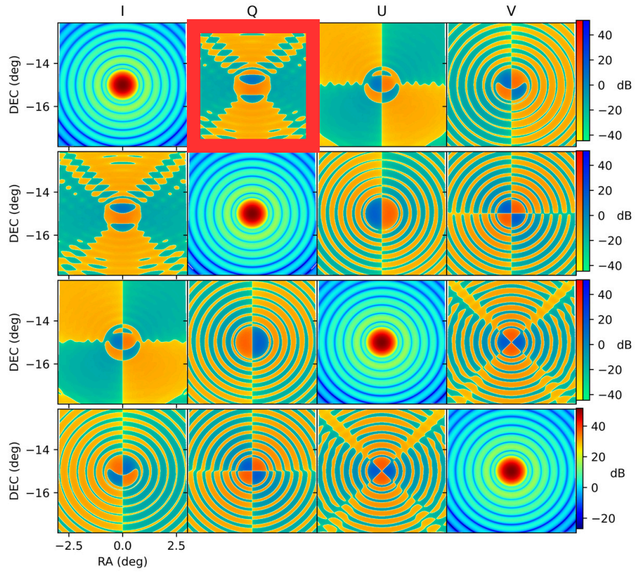


BINGO MAPS

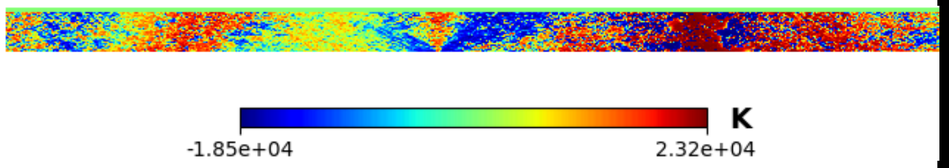
$Q \rightarrow I'$ **Leakage**

HIDE output for the zernike models of MM elements, for a sky map nside = 4096

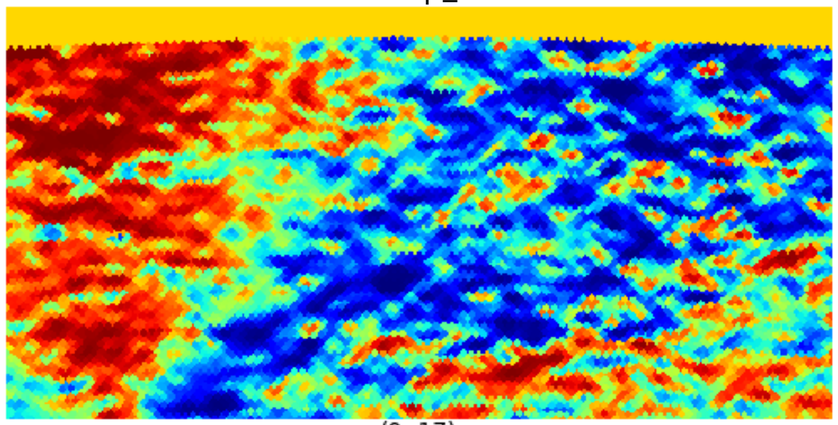
$$I_{Q \rightarrow I'} = M_{12} Q_{sky}$$



naivemap_strip



naivemap_zoom



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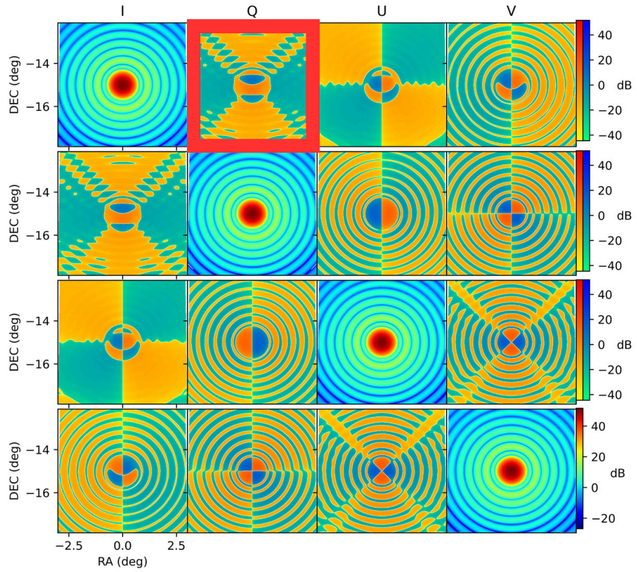

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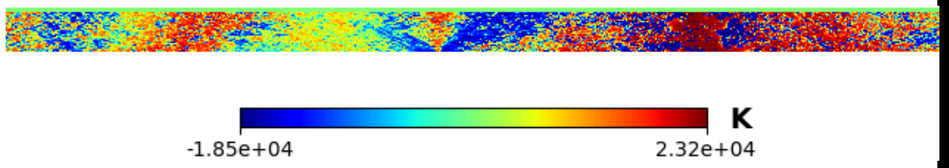

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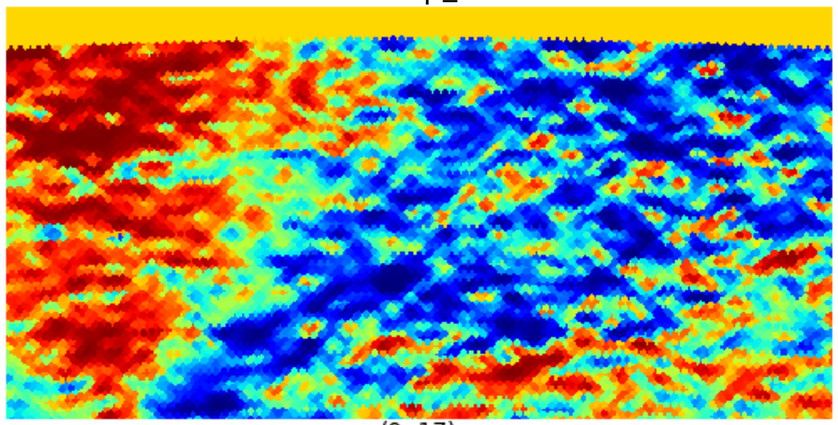
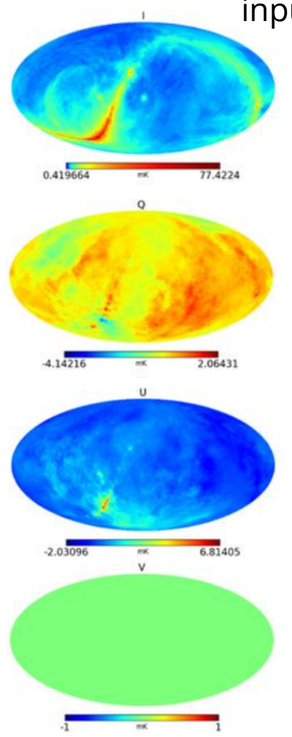


NEXT STEPS

June/2025

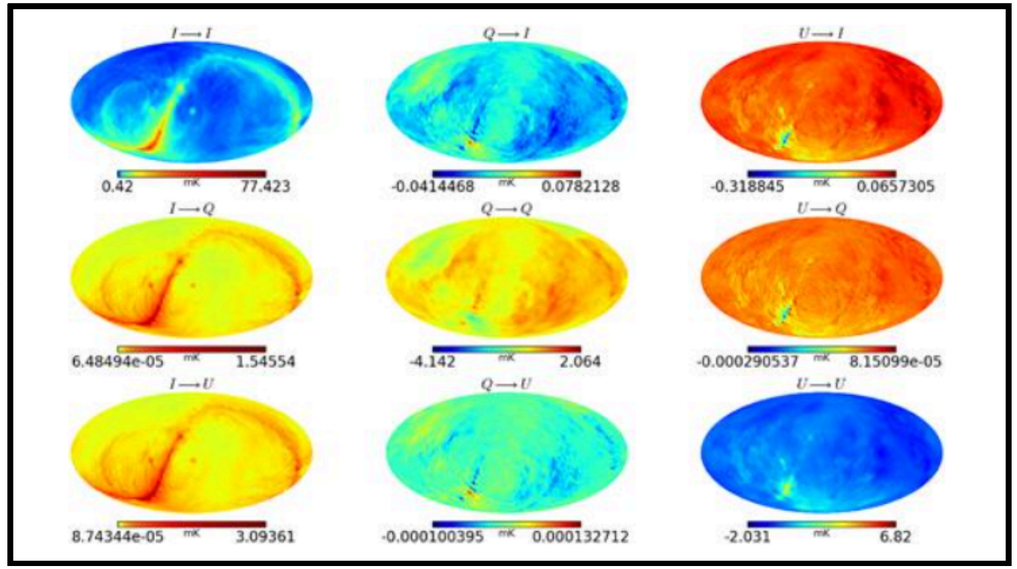
Using the Stokes maps I, Q, U, and V to generate polarized maps.

input maps*



$M_{mueller}$ →

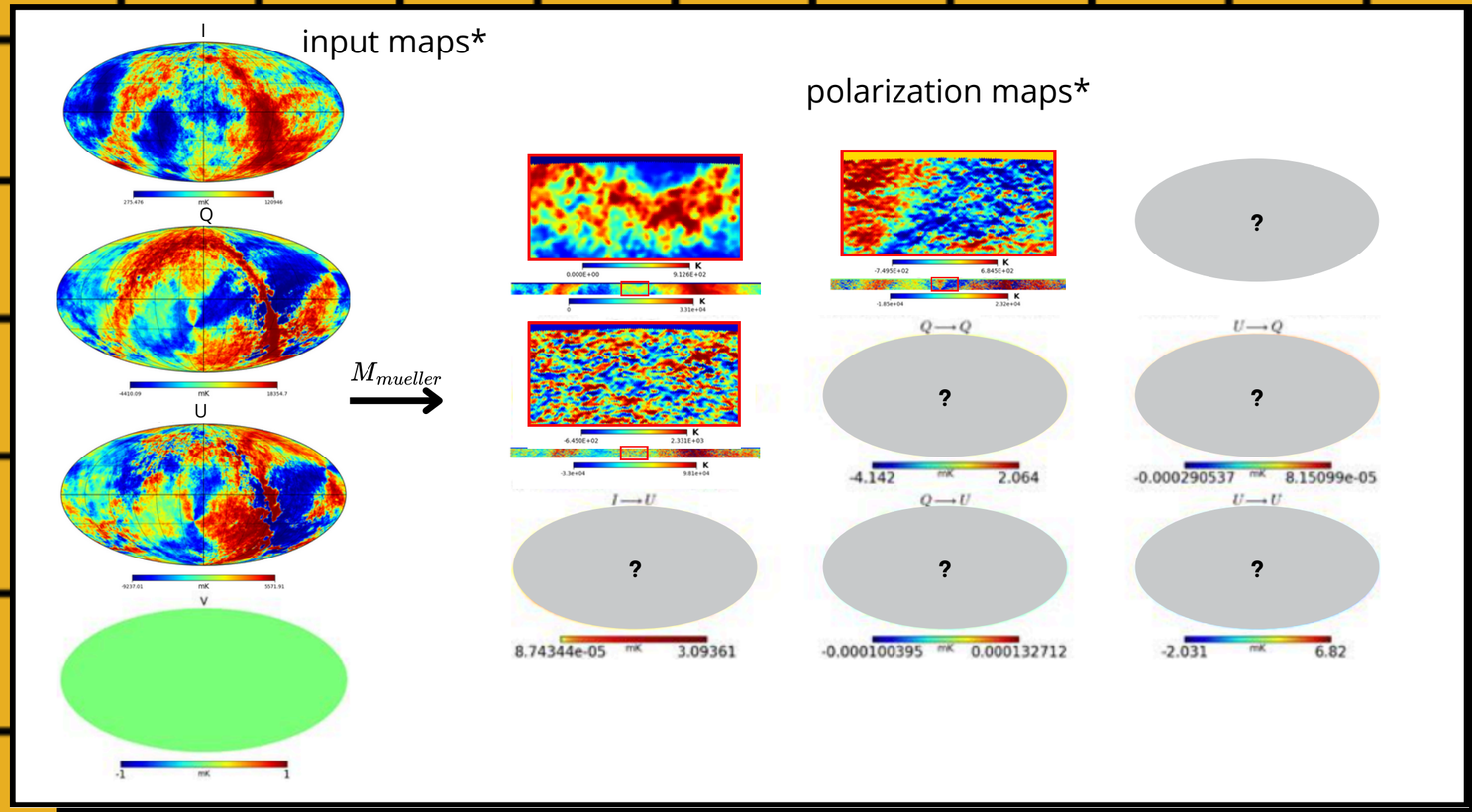
polarization maps*



*images taken from the Ansah-Narh et al. (2018) article

CURRENT STEP

Using the Stokes maps I, Q, U, and V to generate polarized maps.




Thanks