

Full Stokes Polarized Radiative Transfer in 3D Relativistic Jet Simulations:

Application of the TRISTAN, PLUTO, and RADMC-3D Codes



MAX-PLANCK-GESELLSCHAFT

Nicholas MacDonald
Max Planck Institute for Radio Astronomy



Max-Planck-Institut
für Radioastronomie

Extra-Galactic Jets At All Scales

June 17

Talk Outline

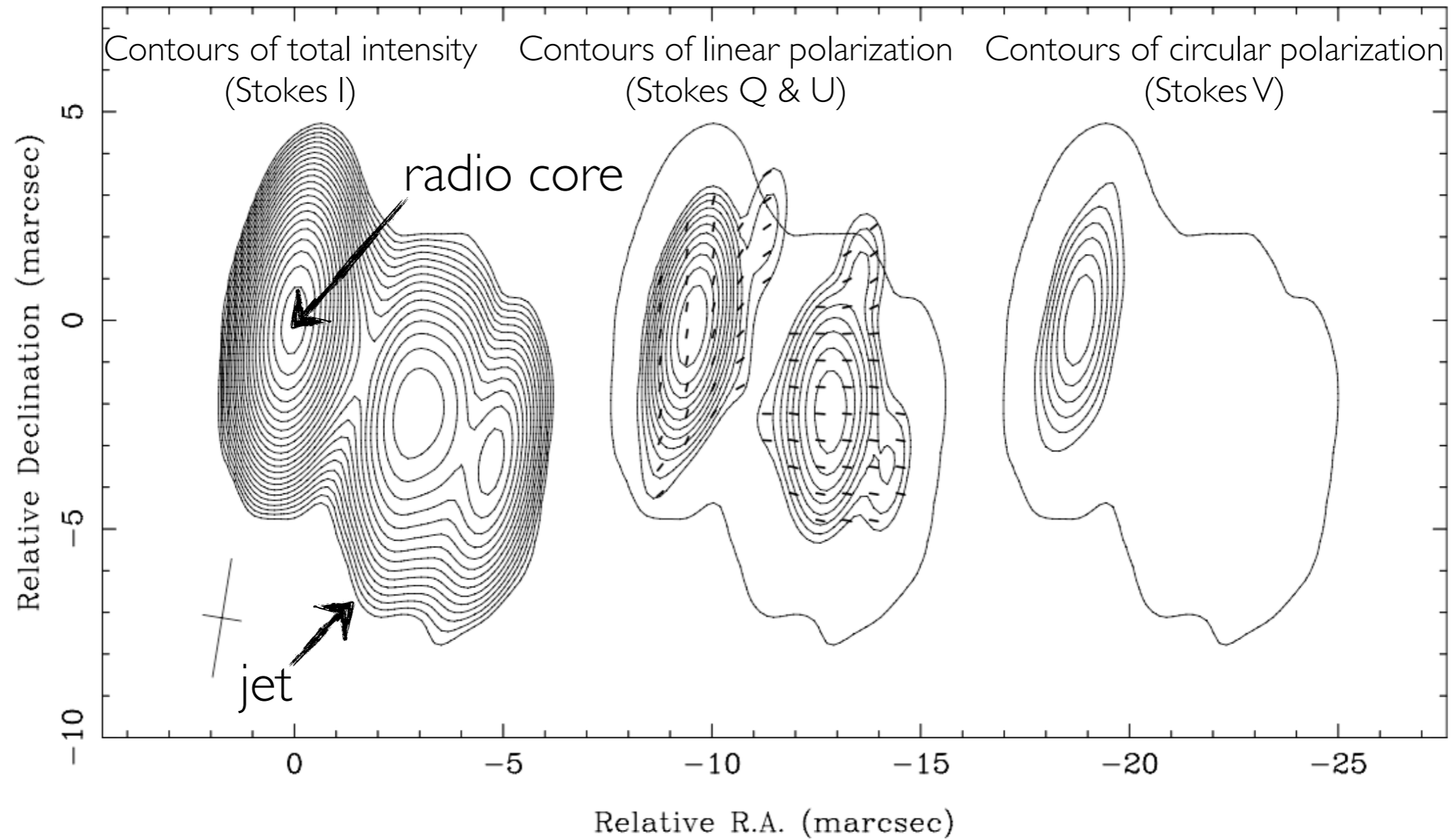
Relativistic Magnetohydrodynamic (RMHD) Jet Modeling

Relativistic Particle-in-Cell (PIC) Jet Modeling

Extra-Galactic Jets At All Scales

June 17

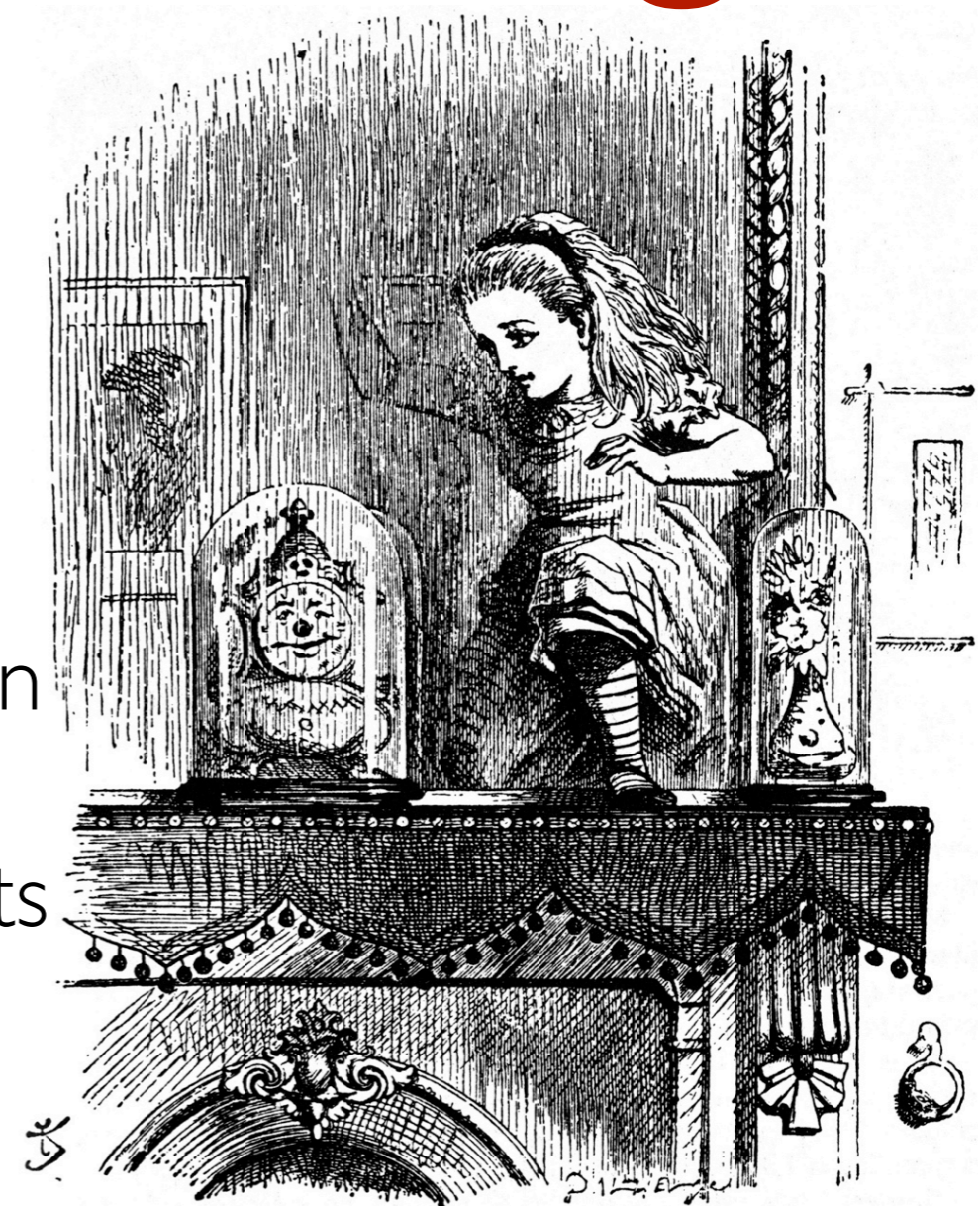
The Stokes Parameters:



Through The Looking Glass

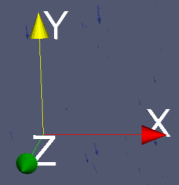


Faraday Conversion
in
Turbulent Blazar Jets

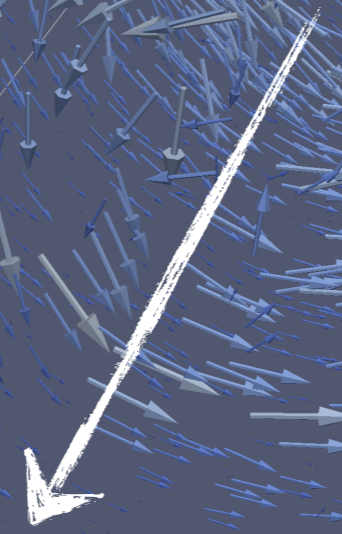


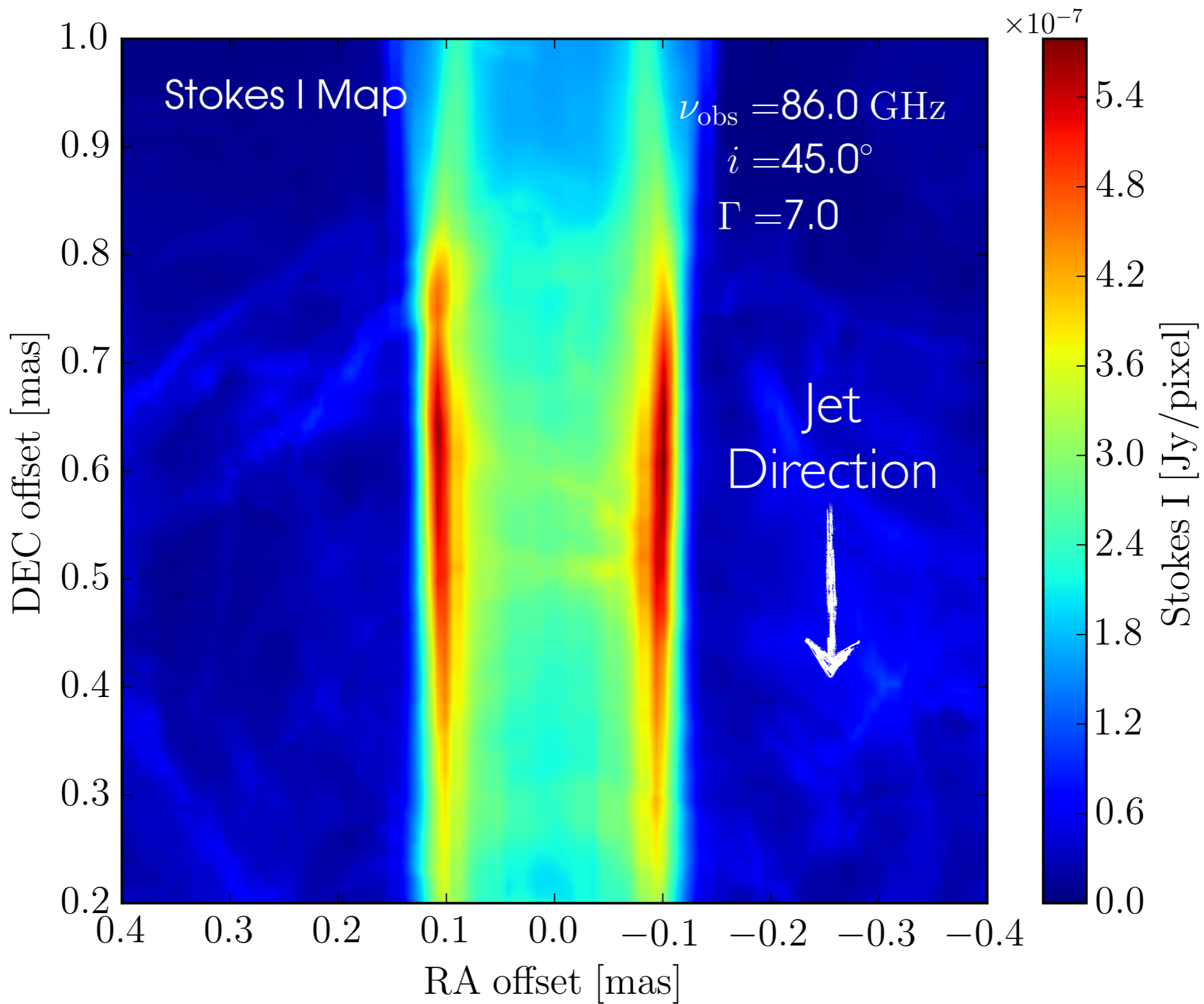
The Full Stokes Equations of Polarized Radiative Transfer:

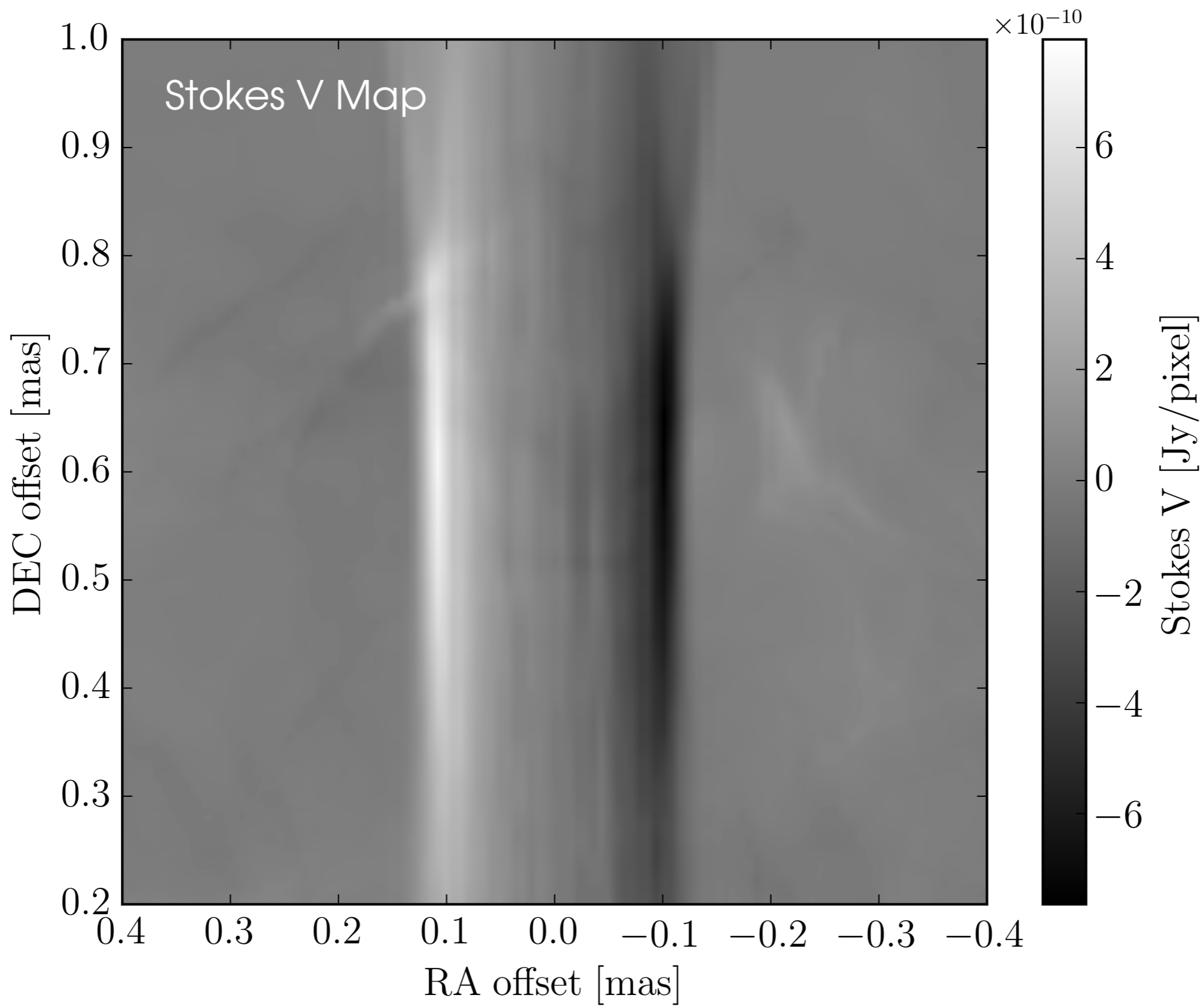
$$\begin{pmatrix} \left(\frac{d}{dl} + \kappa_I\right) & & & \\ \kappa_Q & \left(\frac{d}{dl} + \kappa_I\right) & & \\ \kappa_U & -\kappa_V^* & \left(\frac{d}{dl} + \kappa_I\right) & \\ \kappa_V & \kappa_U^* & -\kappa_Q^* & \left(\frac{d}{dl} + \kappa_I\right) \end{pmatrix} \begin{pmatrix} I_\nu \\ Q_\nu \\ U_\nu \\ V_\nu \end{pmatrix} = \begin{pmatrix} \eta_\nu^I \\ \eta_\nu^Q \\ \eta_\nu^U \\ \eta_\nu^V \end{pmatrix}$$

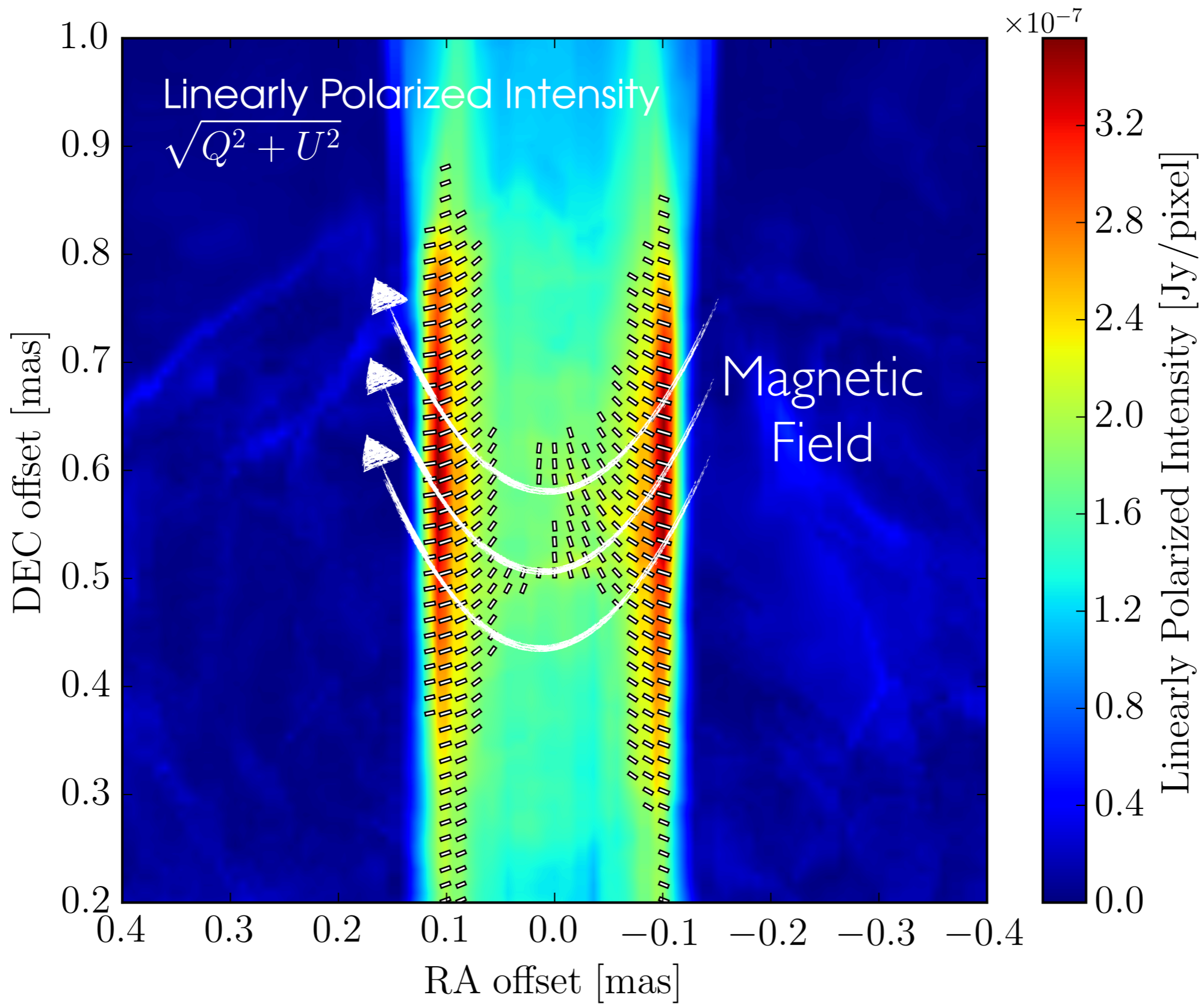


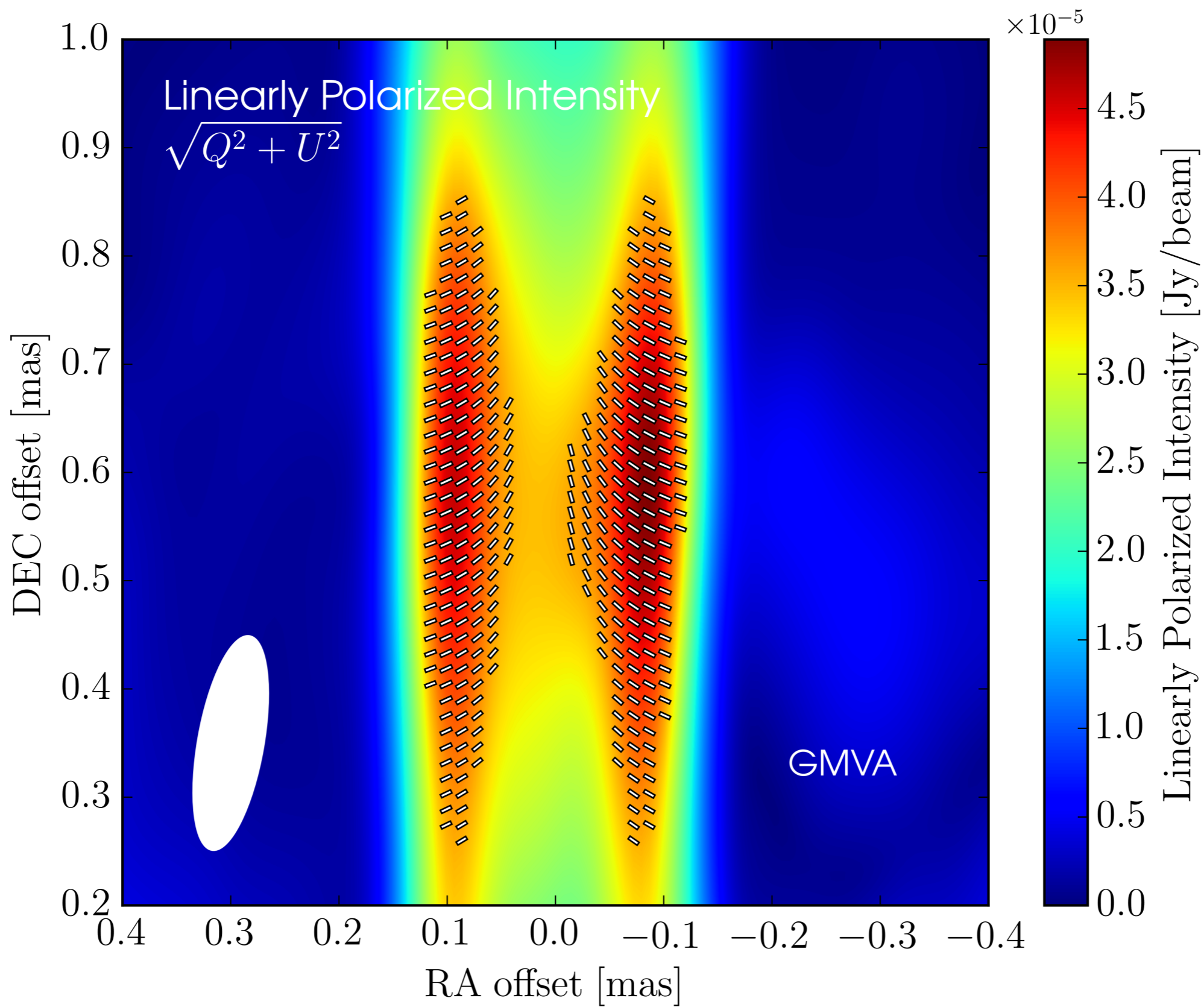
Jet Direction











Global VLBI



Image Credit: ESO/ L. Calçada

Relativistic Magnetohydrodynamic (RMHD) Jet Modeling

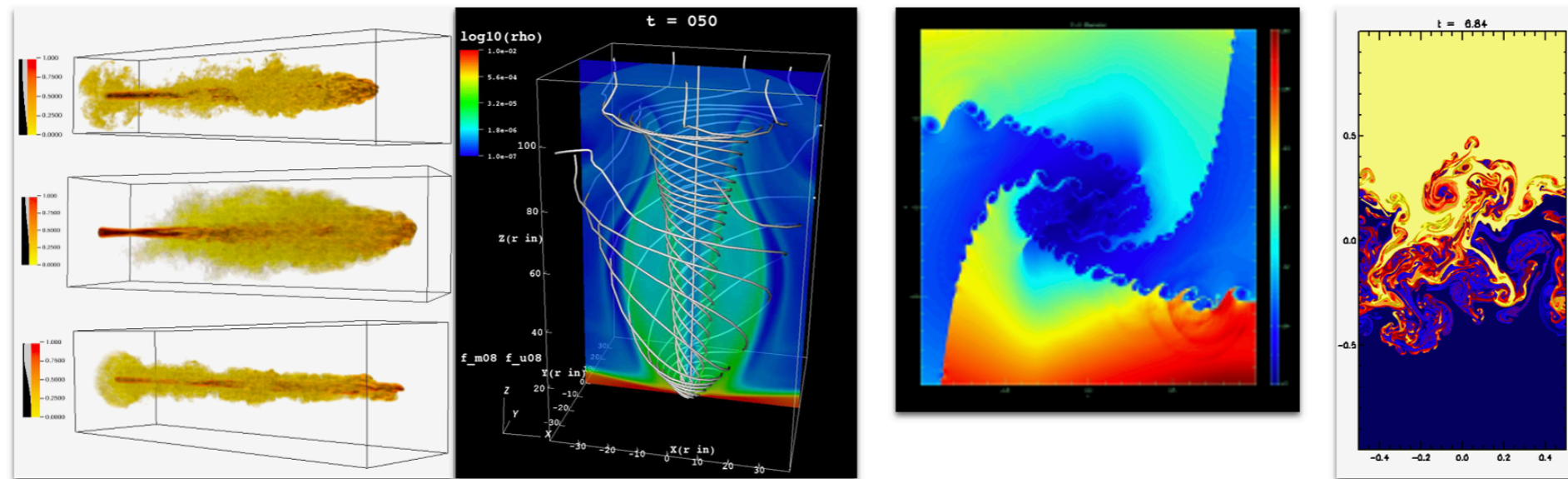
The PLUTO Code for Astrophysical GasDynamics



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DI TORINO

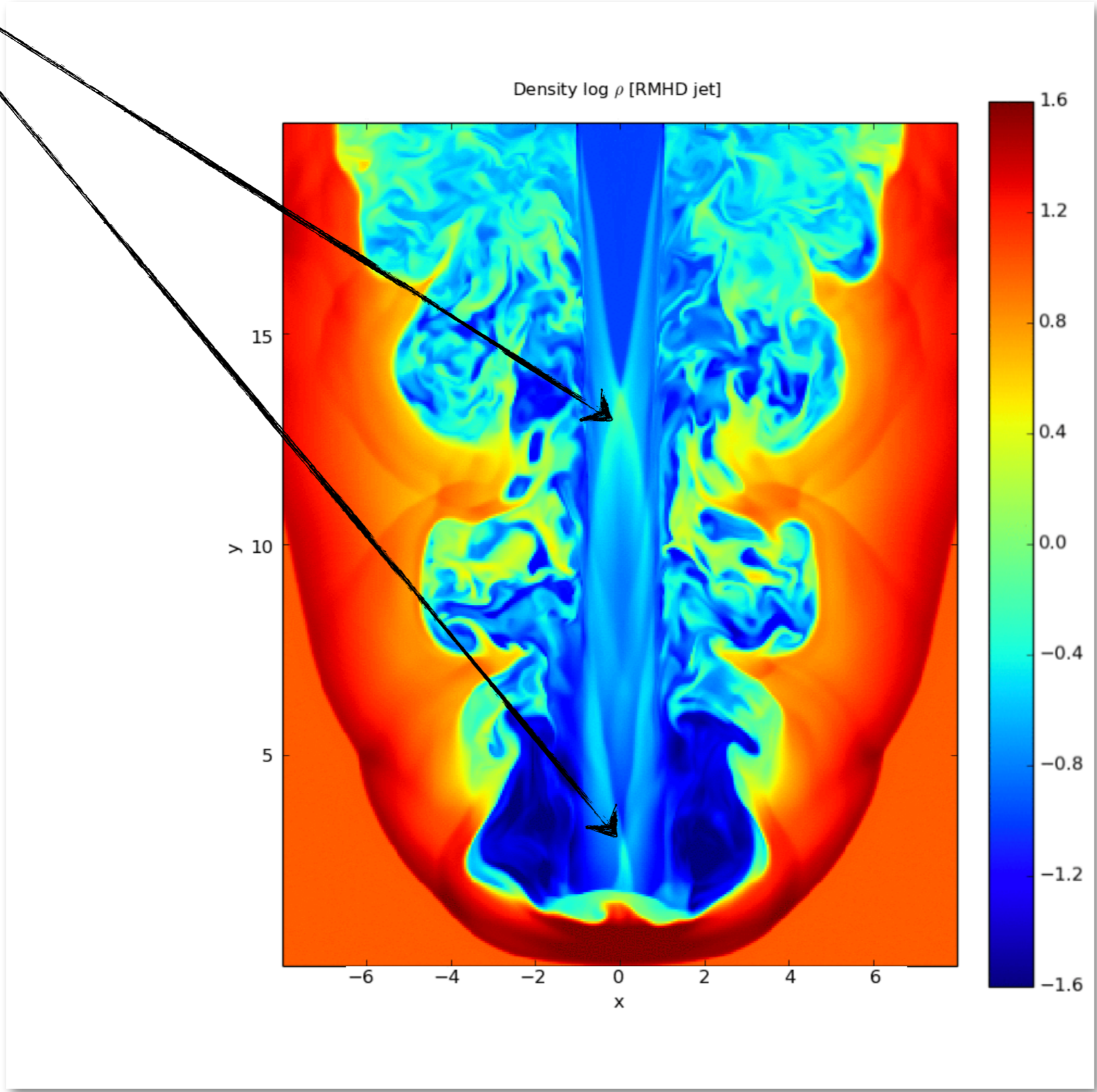


The PLUTO Code



Code Version: 4.4 (Nov 2020)

Recollimation Shocks



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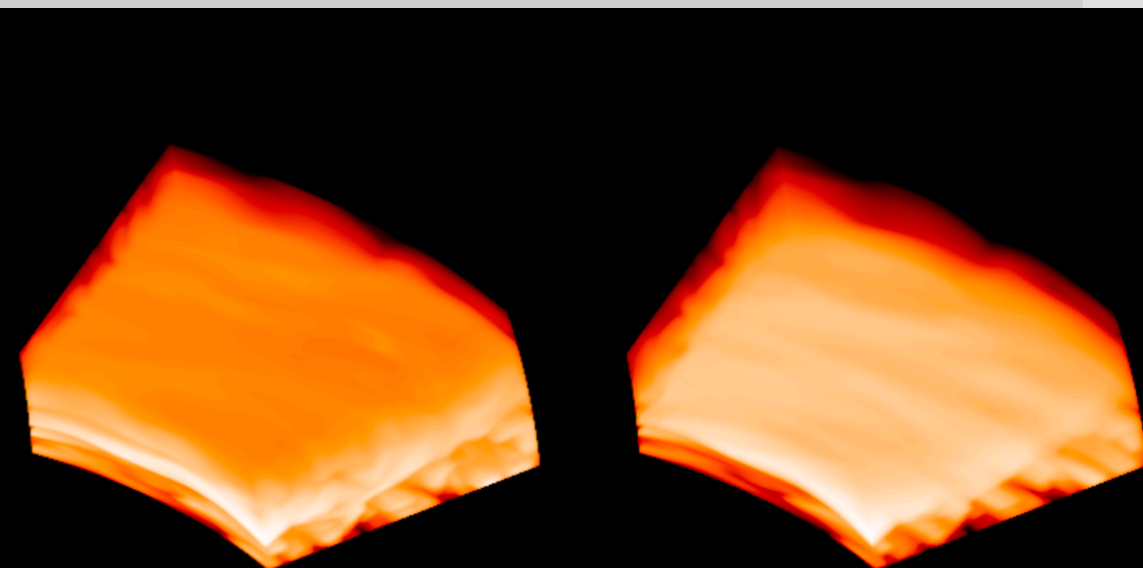
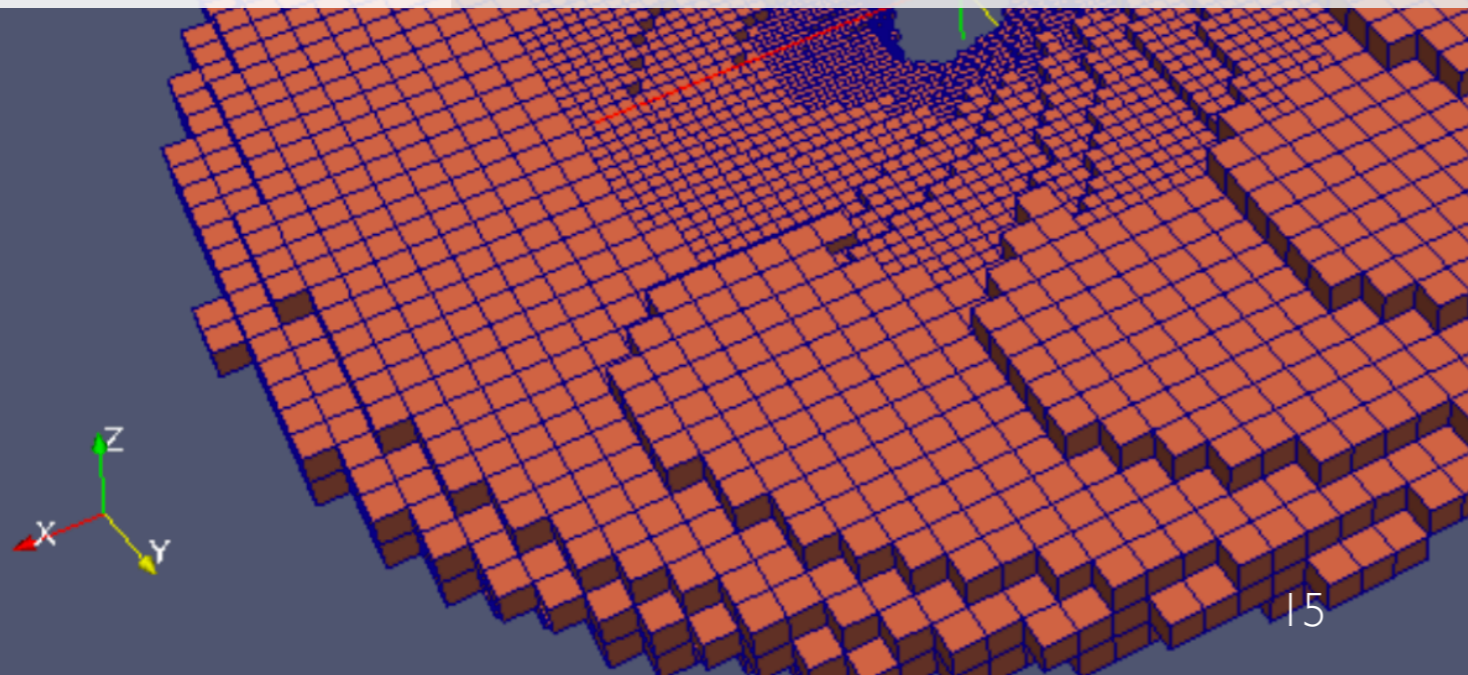
RADMC-3D

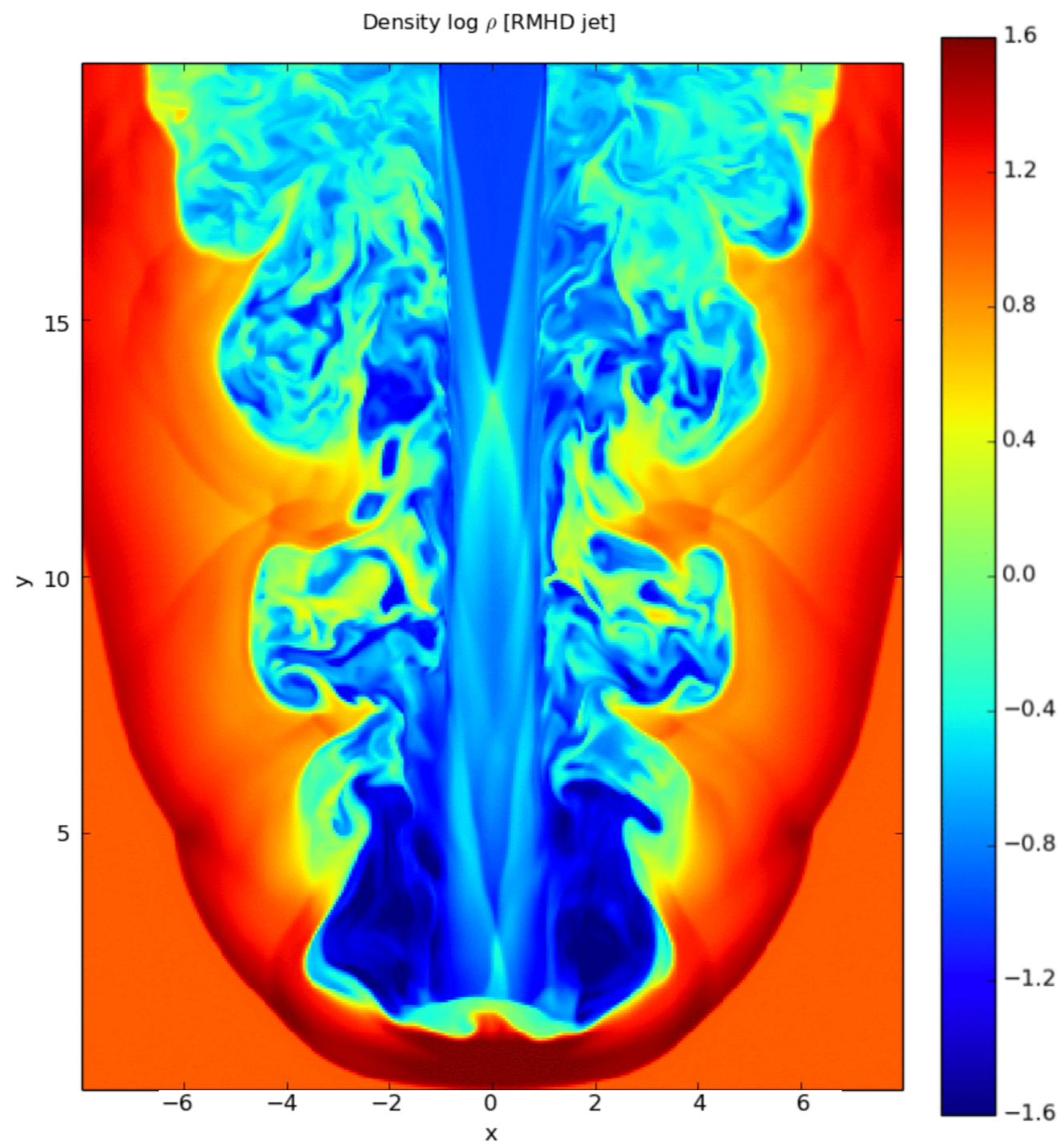
RADMC-3D is a code package for diagnostic radiative transfer calculations in astronomy and astrophysics. It calculates, for a given geometrical distribution of gas and/or dust, what its images and/or spectra look like when viewed from a certain angle, allowing modelers to compare their models with observed data.

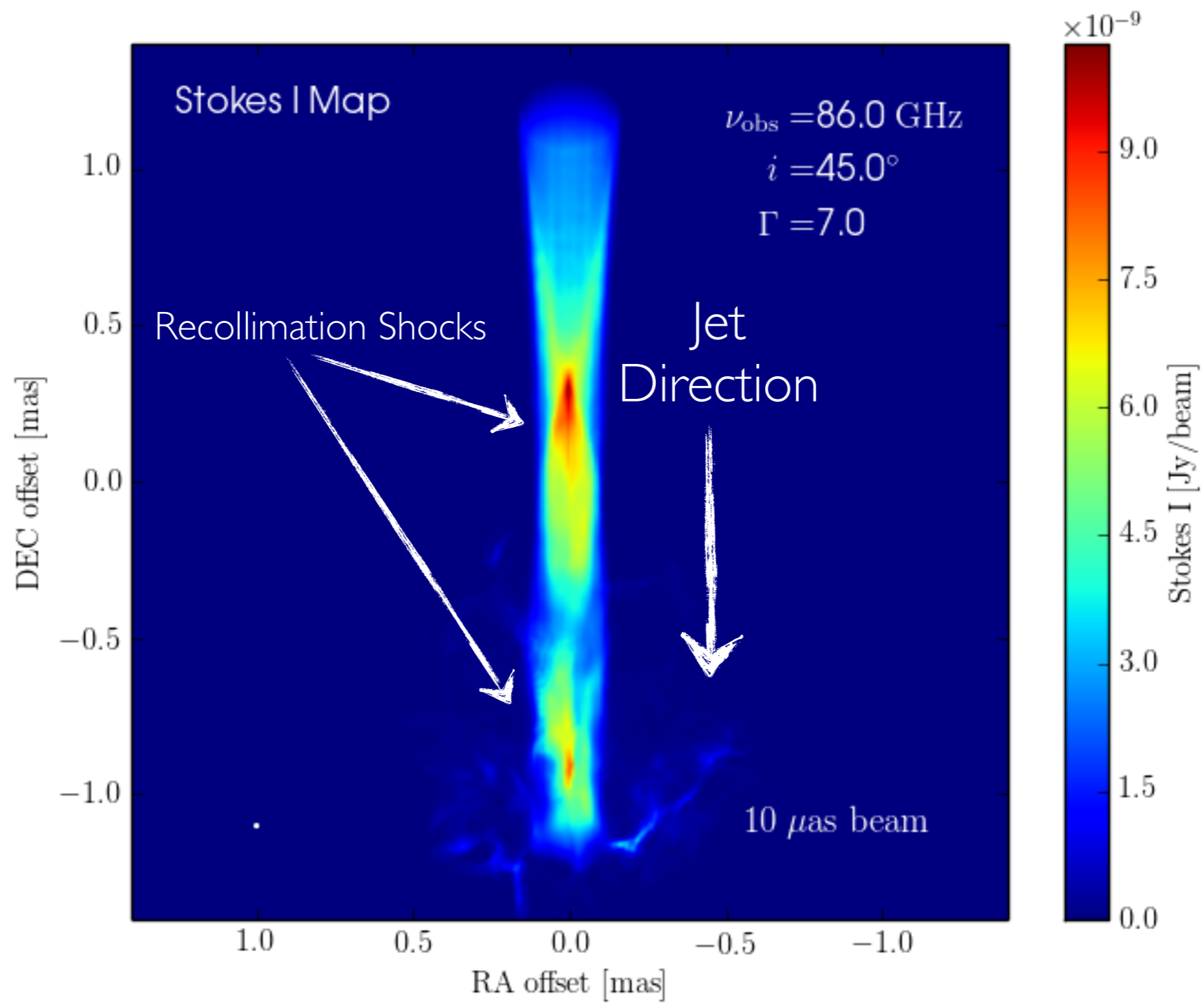
Typical applications are dusty molecular clouds, protoplanetary disks, circumstellar envelopes, dusty tori around AGN and models of galaxies. But the code is also regularly applied to other kinds of objects.

The code package is well documented and has numerous simple examples that can be used as templates for one's own models.

The RADMC-3D code is freely available and open source. It runs on linux and OS X. The main code is written in Fortran 90, but all interaction with the code is done through Python interfaces.

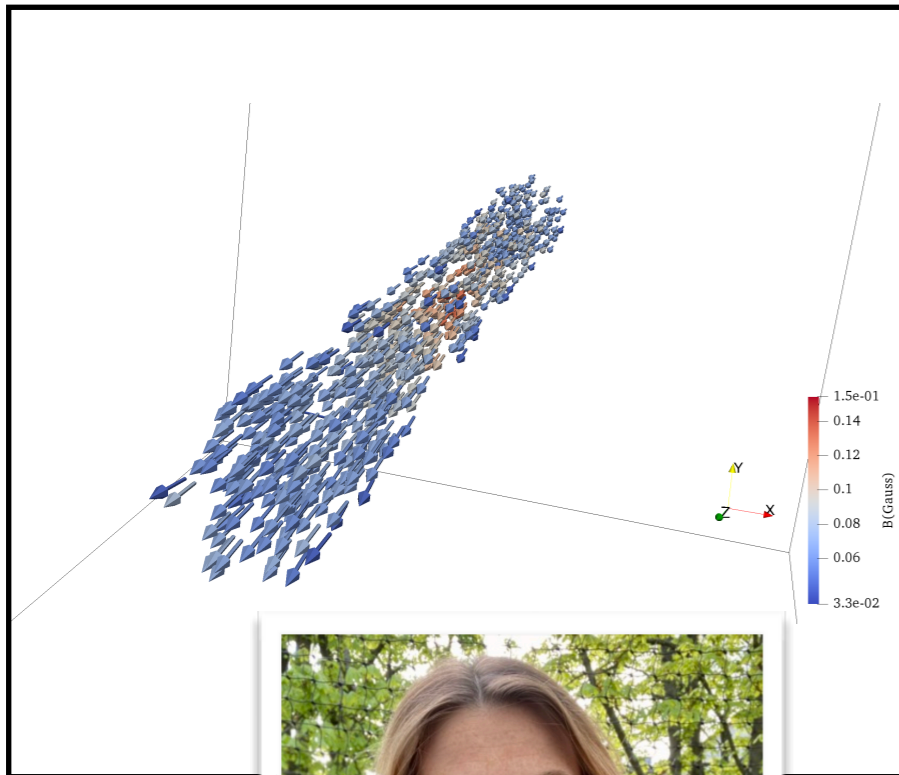




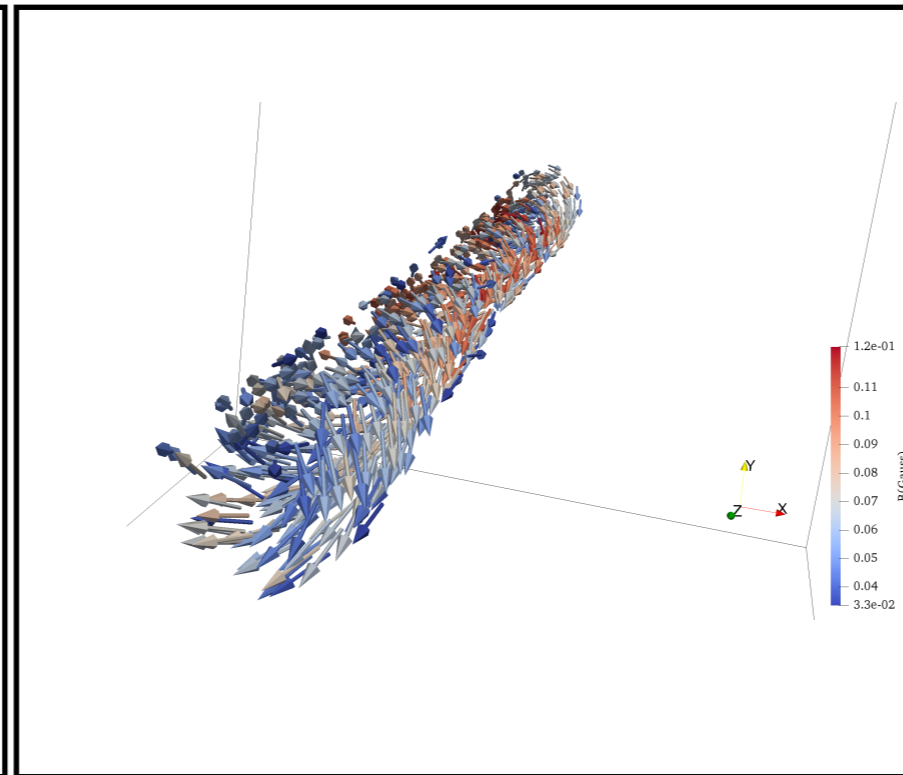


A Bank of Magnetic Field Models

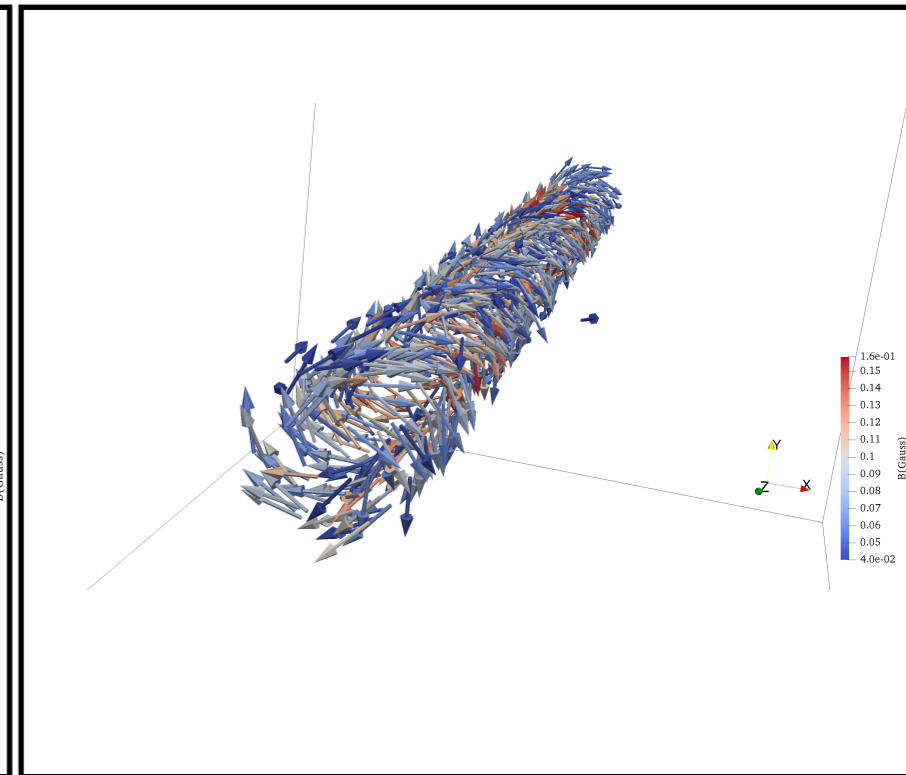
Poloidal



Helical



Toroidal

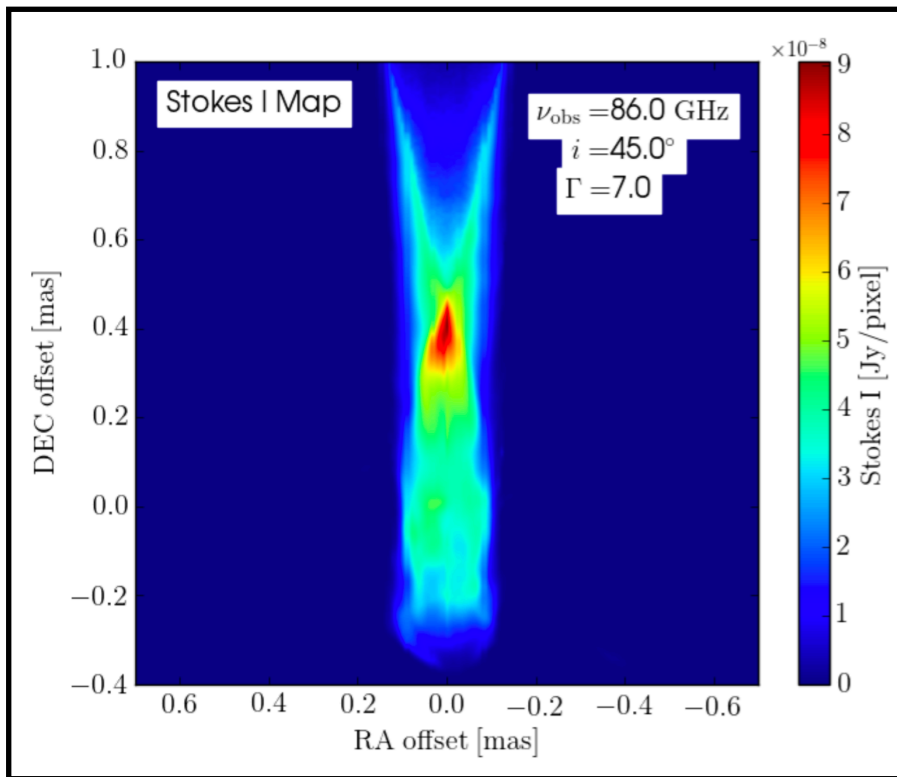


Joana Kramer

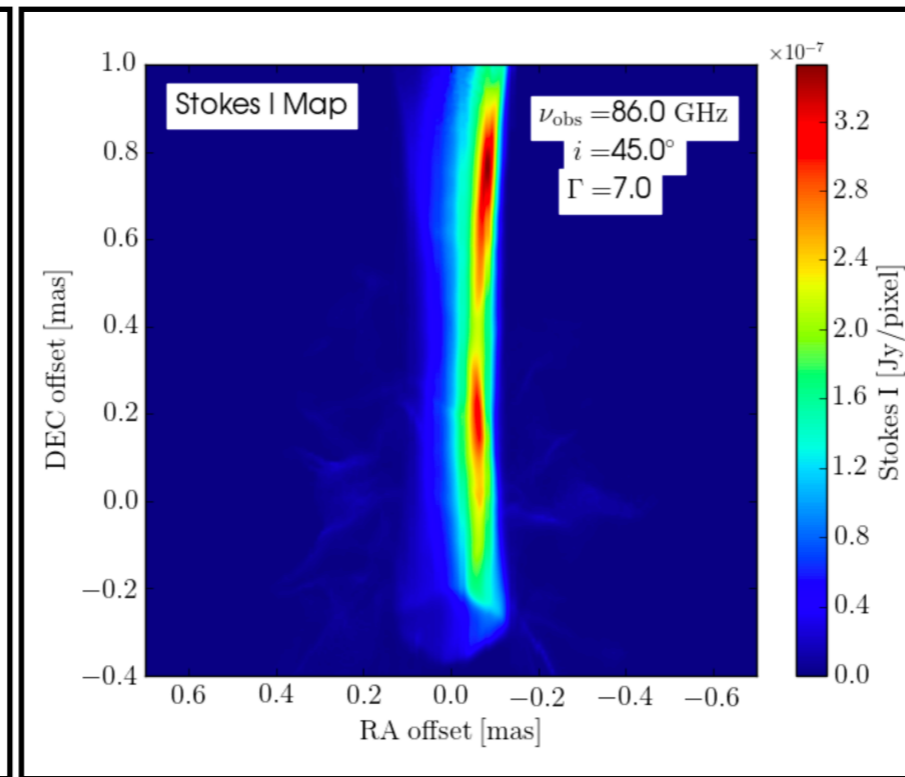
Kramer & MacDonald
(submitted)

A Bank of Magnetic Field Models

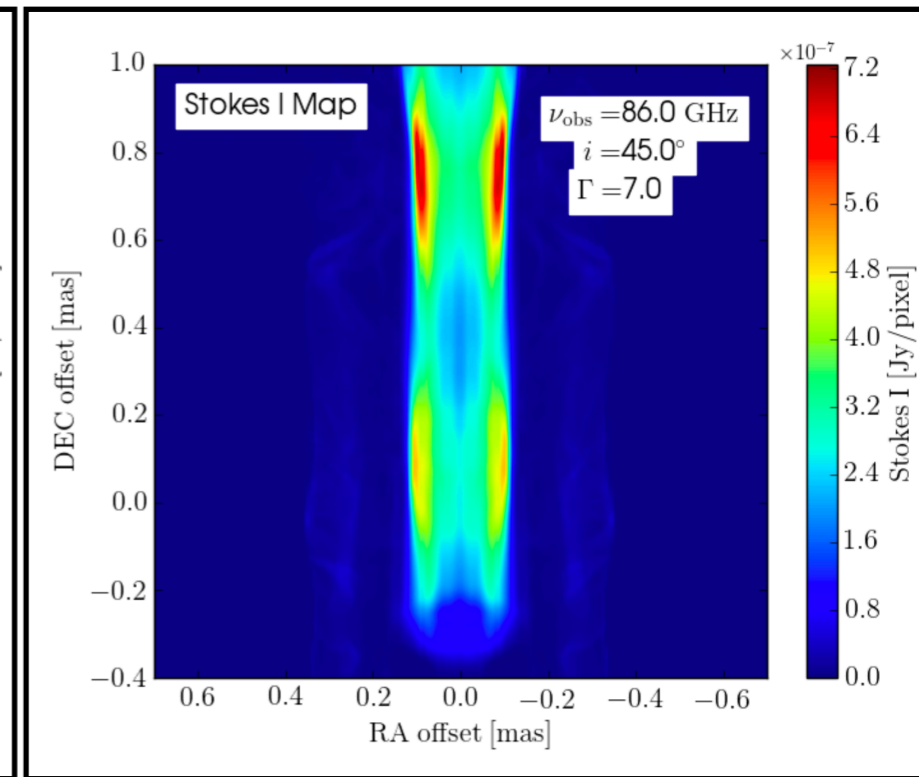
Poloidal



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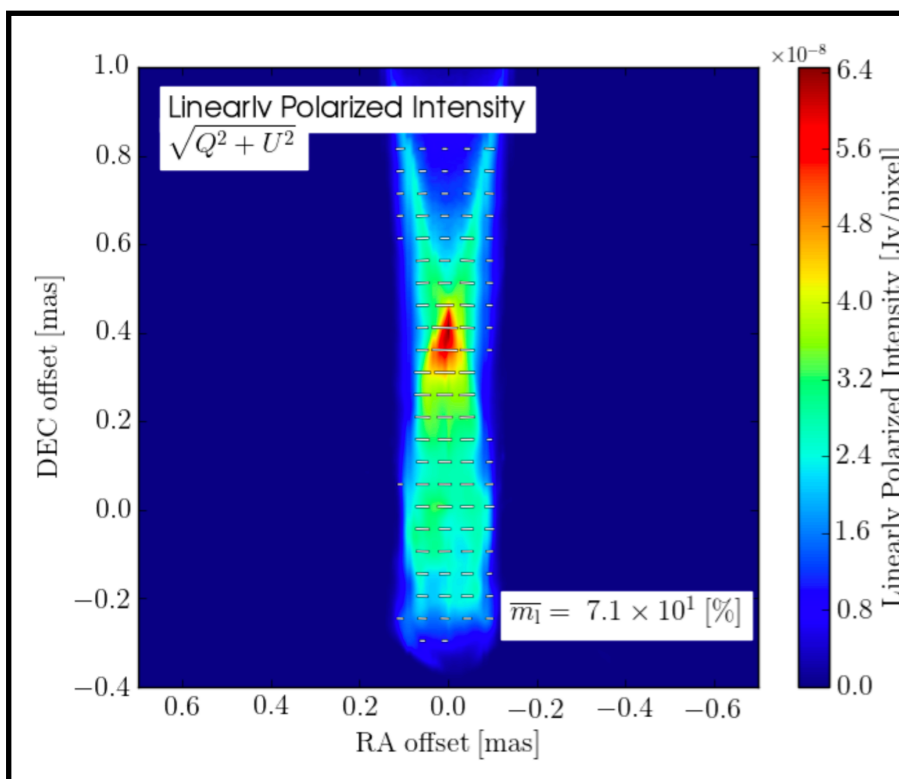
Toroidal



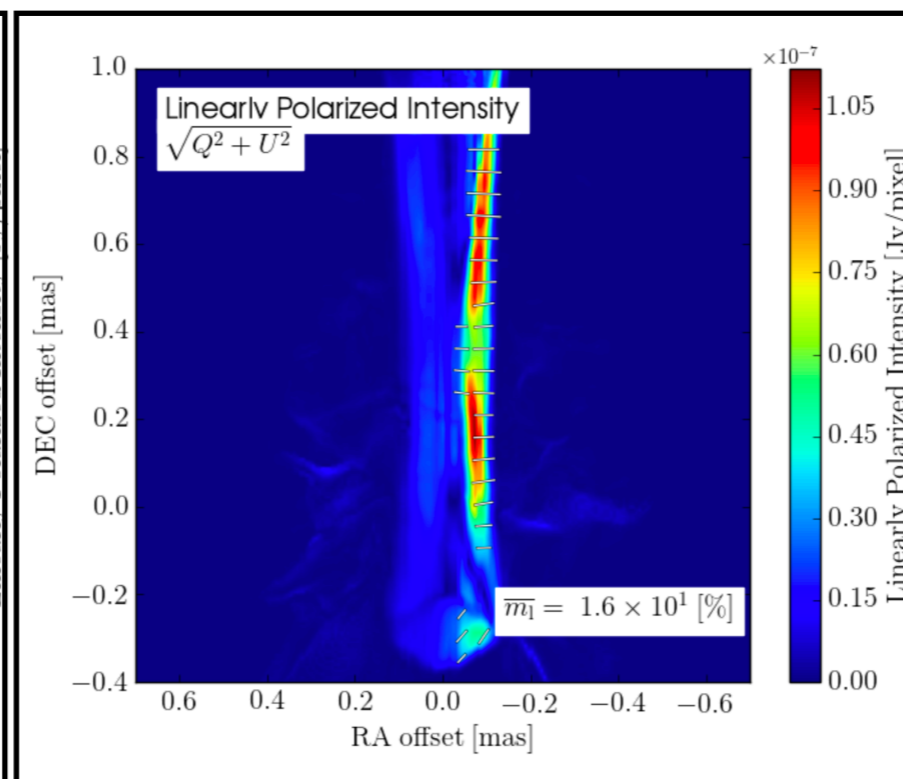
Kramer & MacDonald
(submitted)

A Bank of Magnetic Field Models

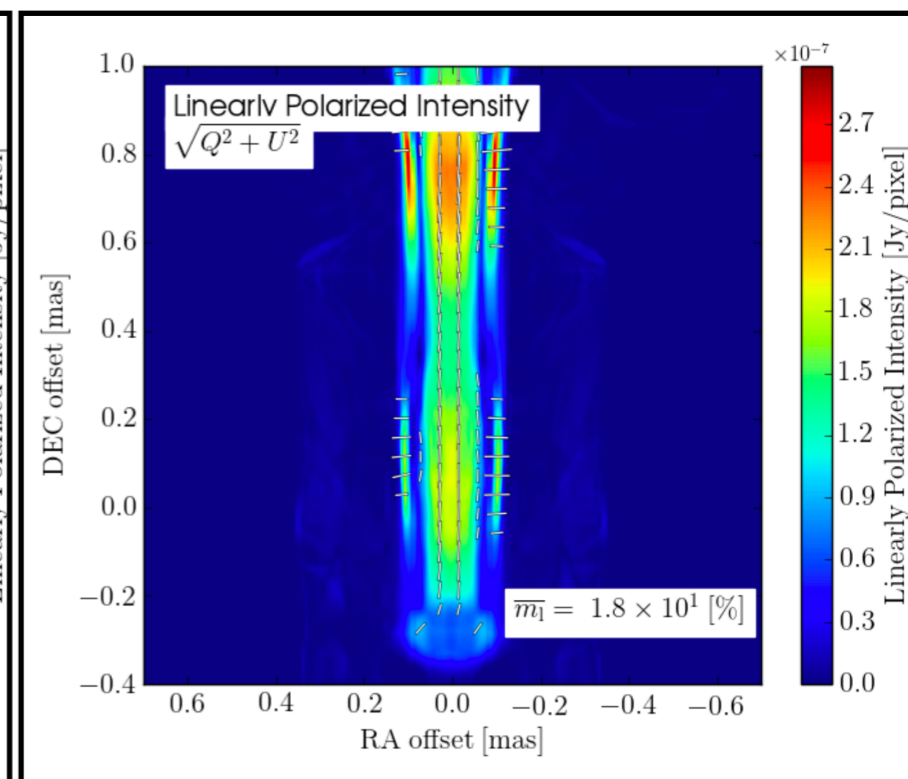
Poloidal



Helical



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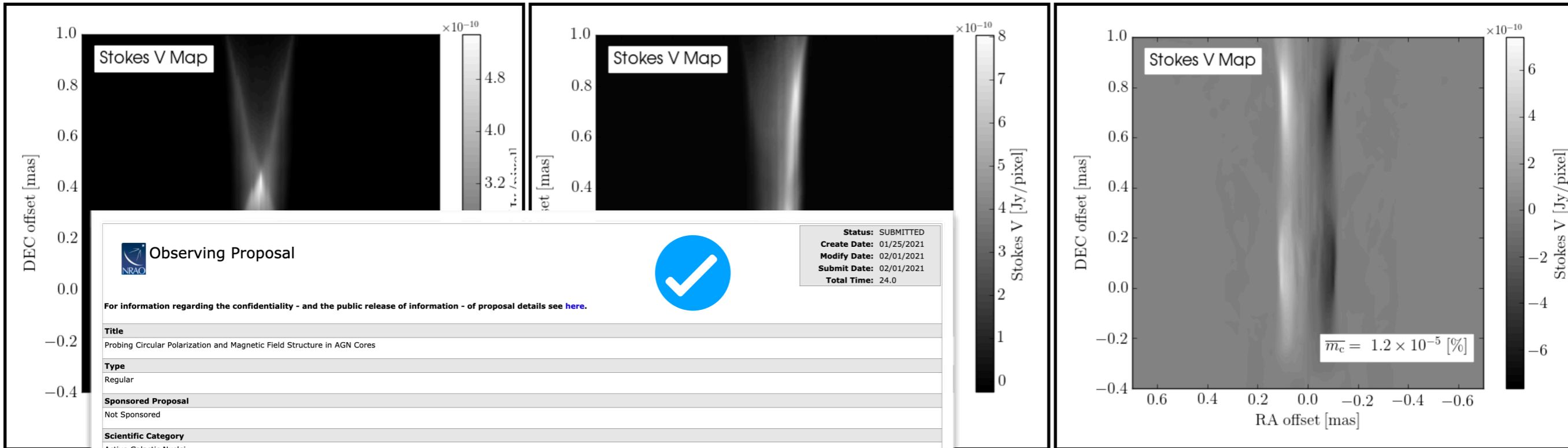
Kramer & MacDonald
(submitted)

A Bank of Magnetic Field Models

Poloidal

Helical

Toroidal



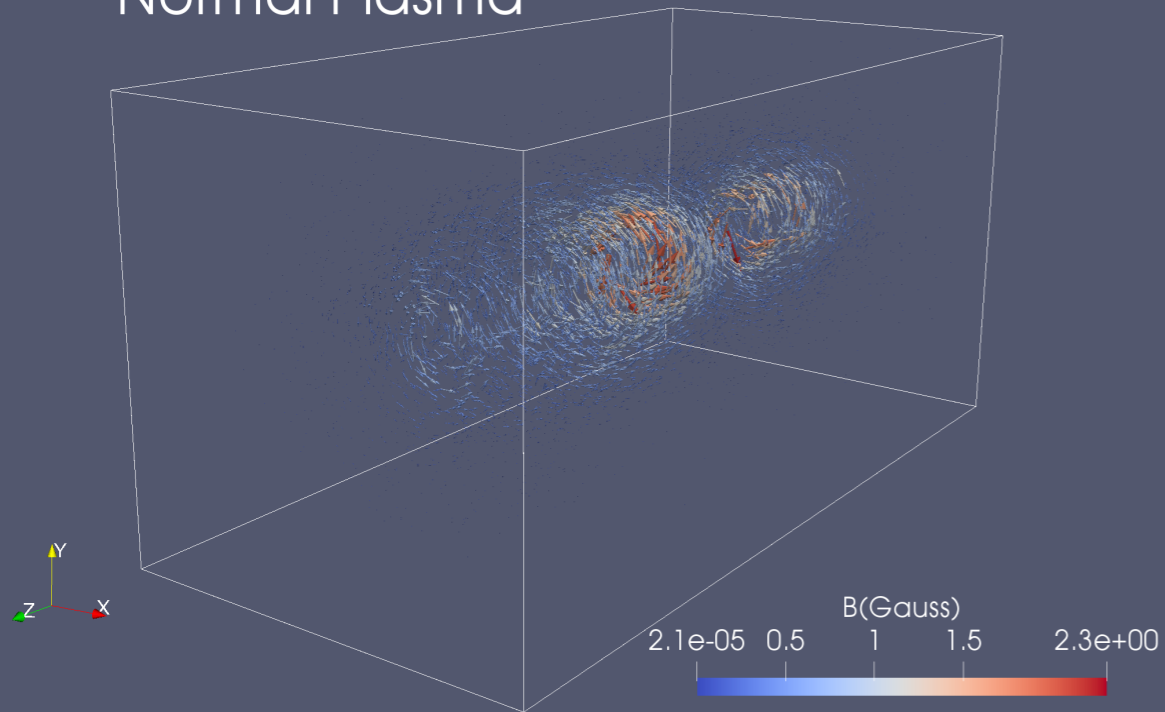
Kramer & MacDonald
(submitted)

Relativistic Particle-in-Cell (PIC) Jet Modeling



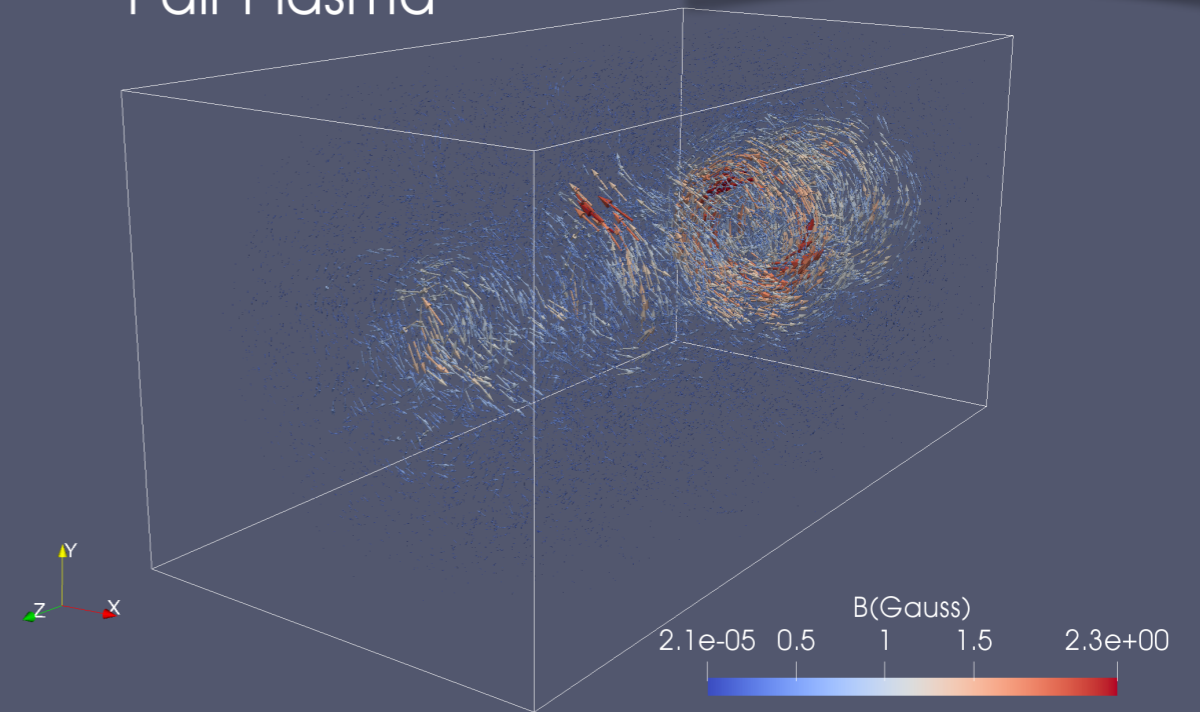
PIC Jet Imaging

Normal Plasma



$e^- p^+$ Jet

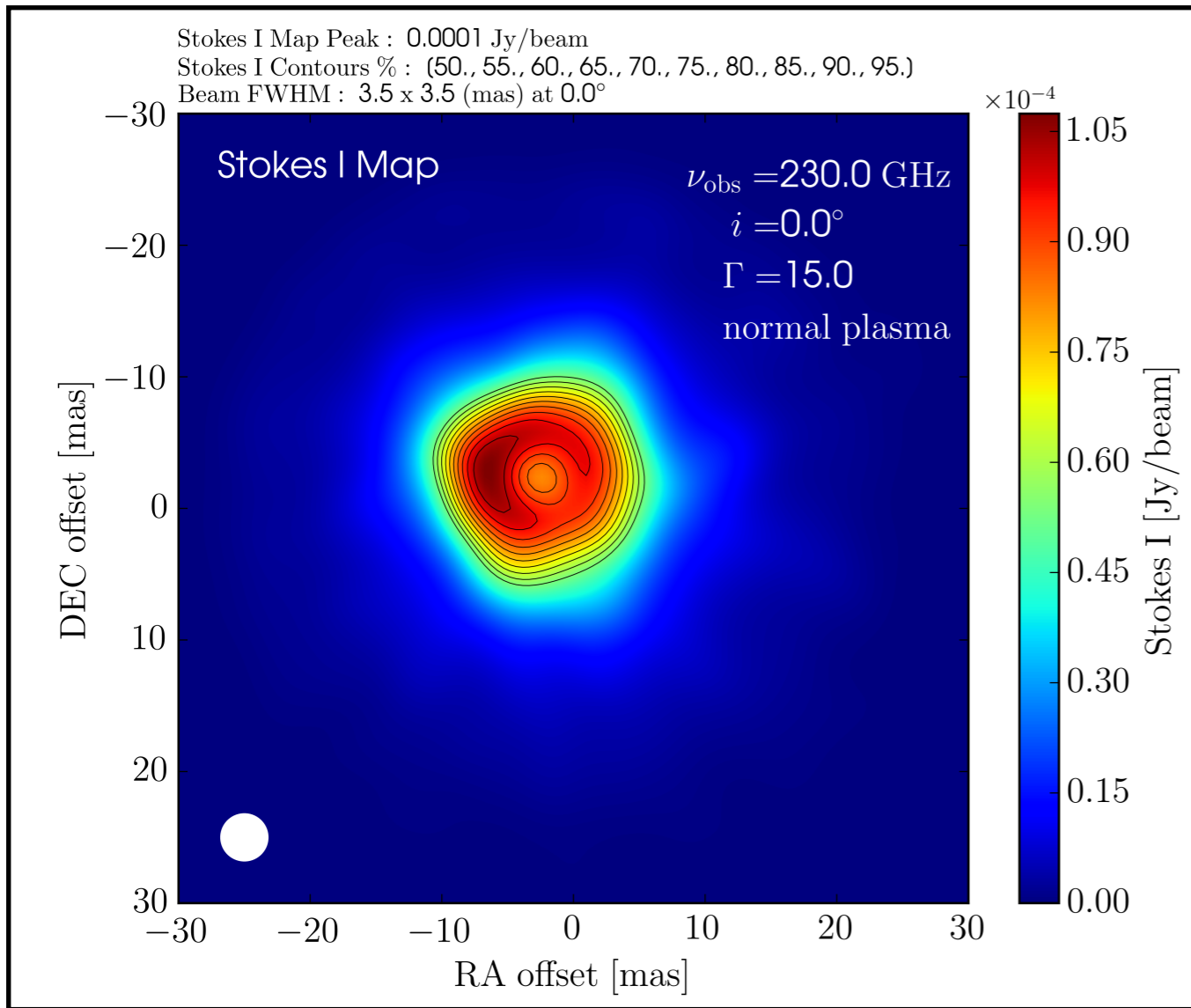
Pair Plasma



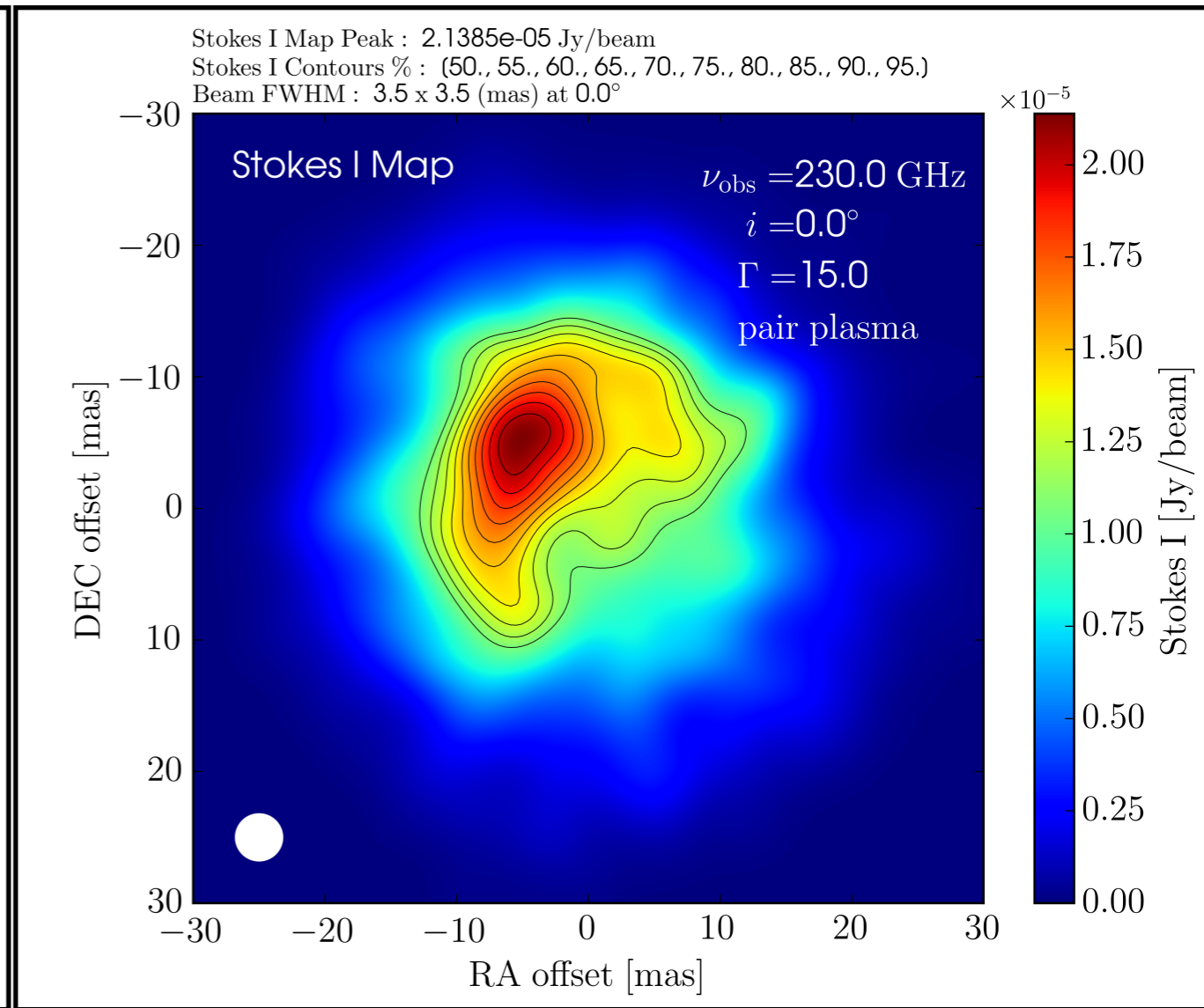
$e^- e^+$ Jet

MacDonald & Nishikawa
(accepted)

PIC Jet Imaging



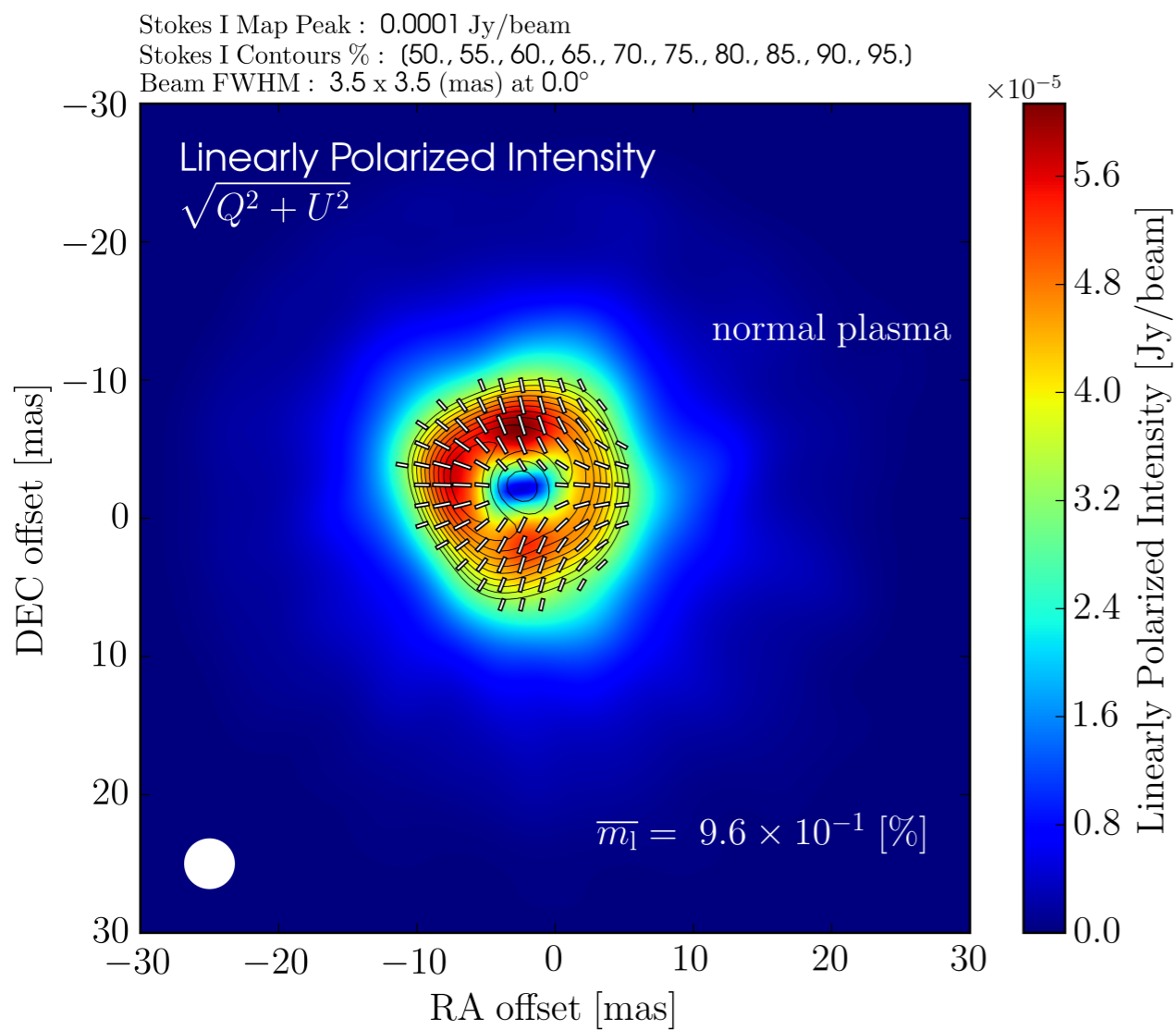
$e^- p^+$ Jet



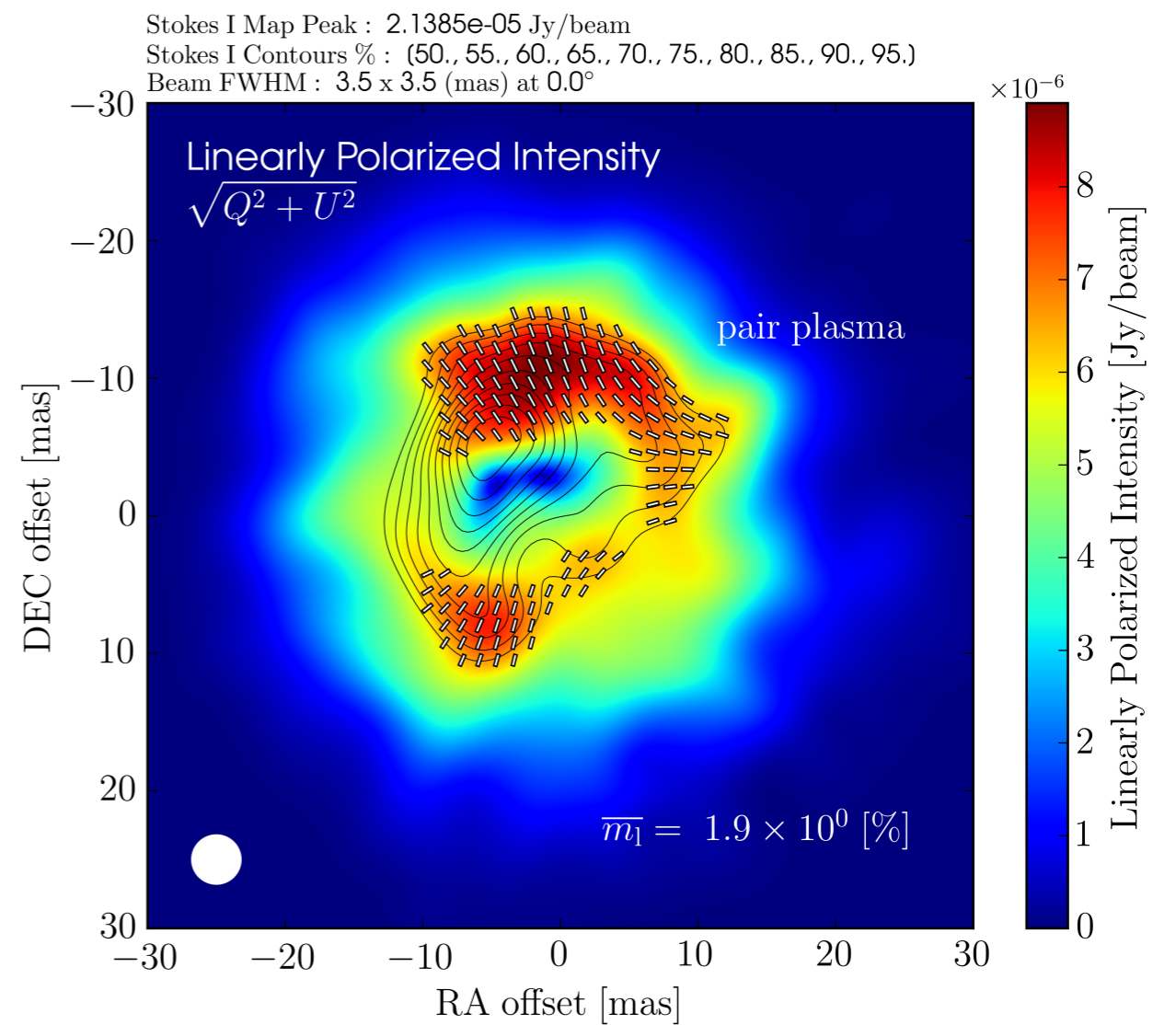
$e^- e^+$ Jet

MacDonald & Nishikawa
(accepted)

PIC Jet Imaging



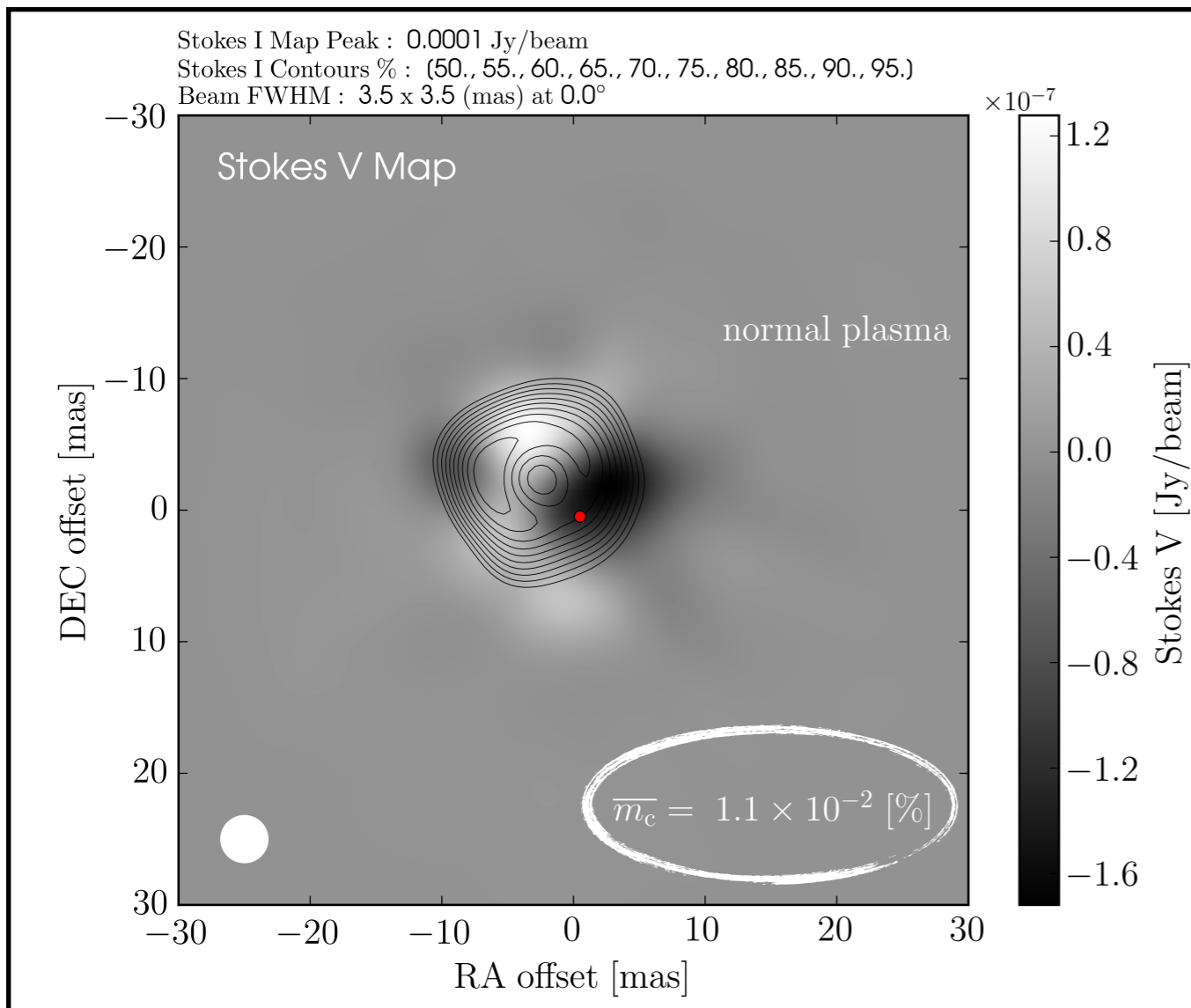
$e^- p^+$ Jet



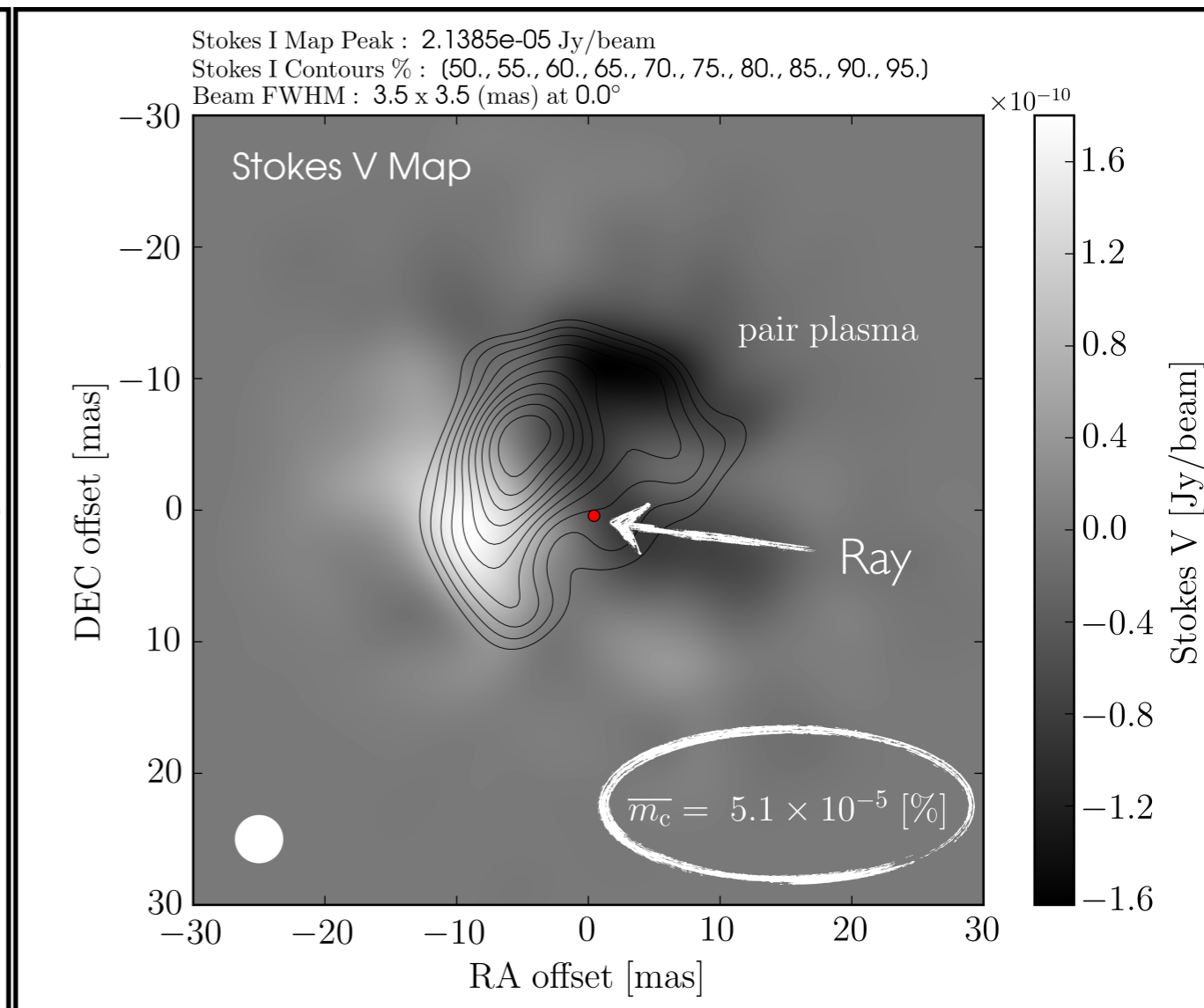
$e^- e^+$ Jet

MacDonald & Nishikawa
 (accepted)

PIC Jet Imaging



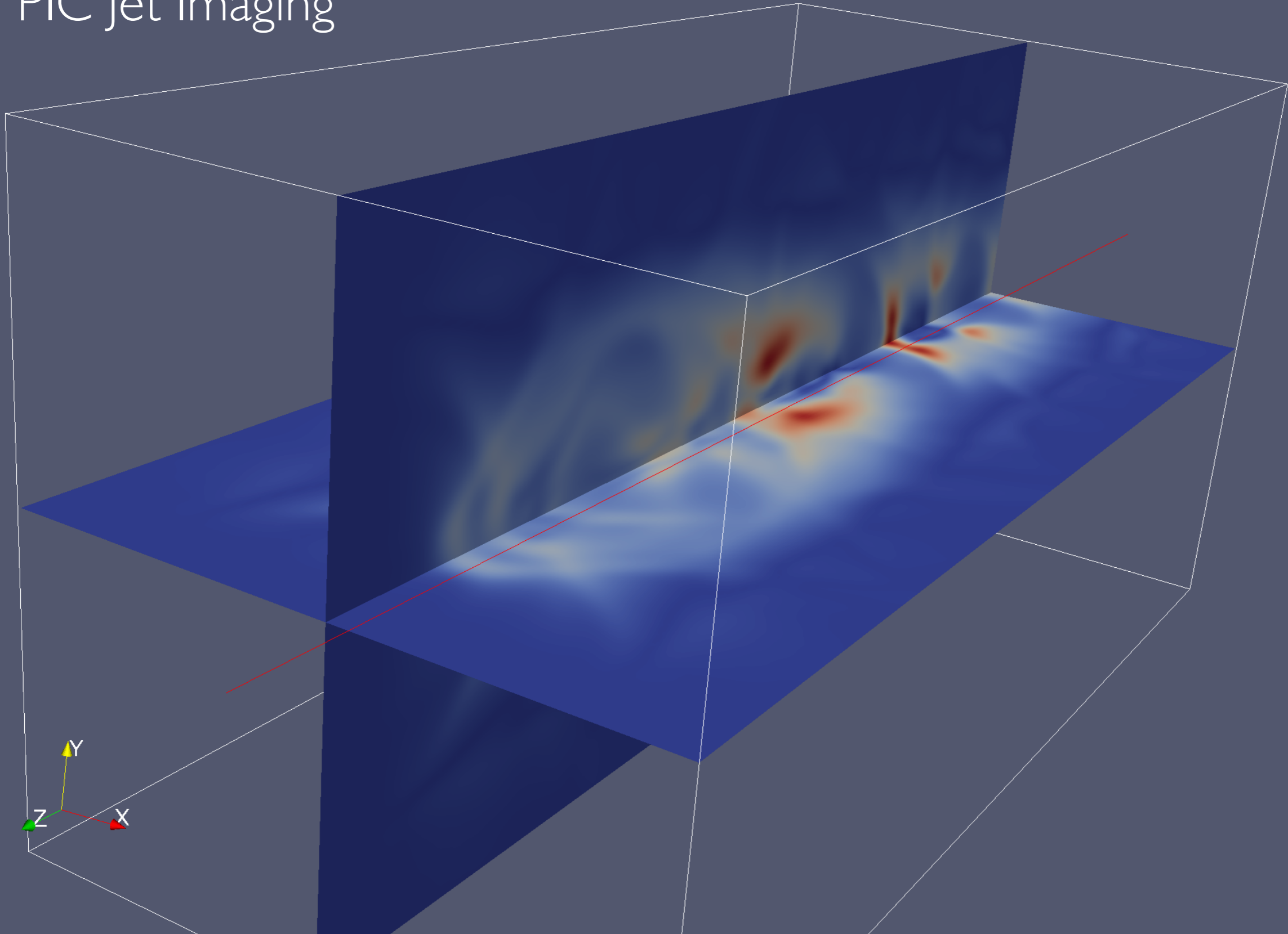
$e^- p^+$ Jet



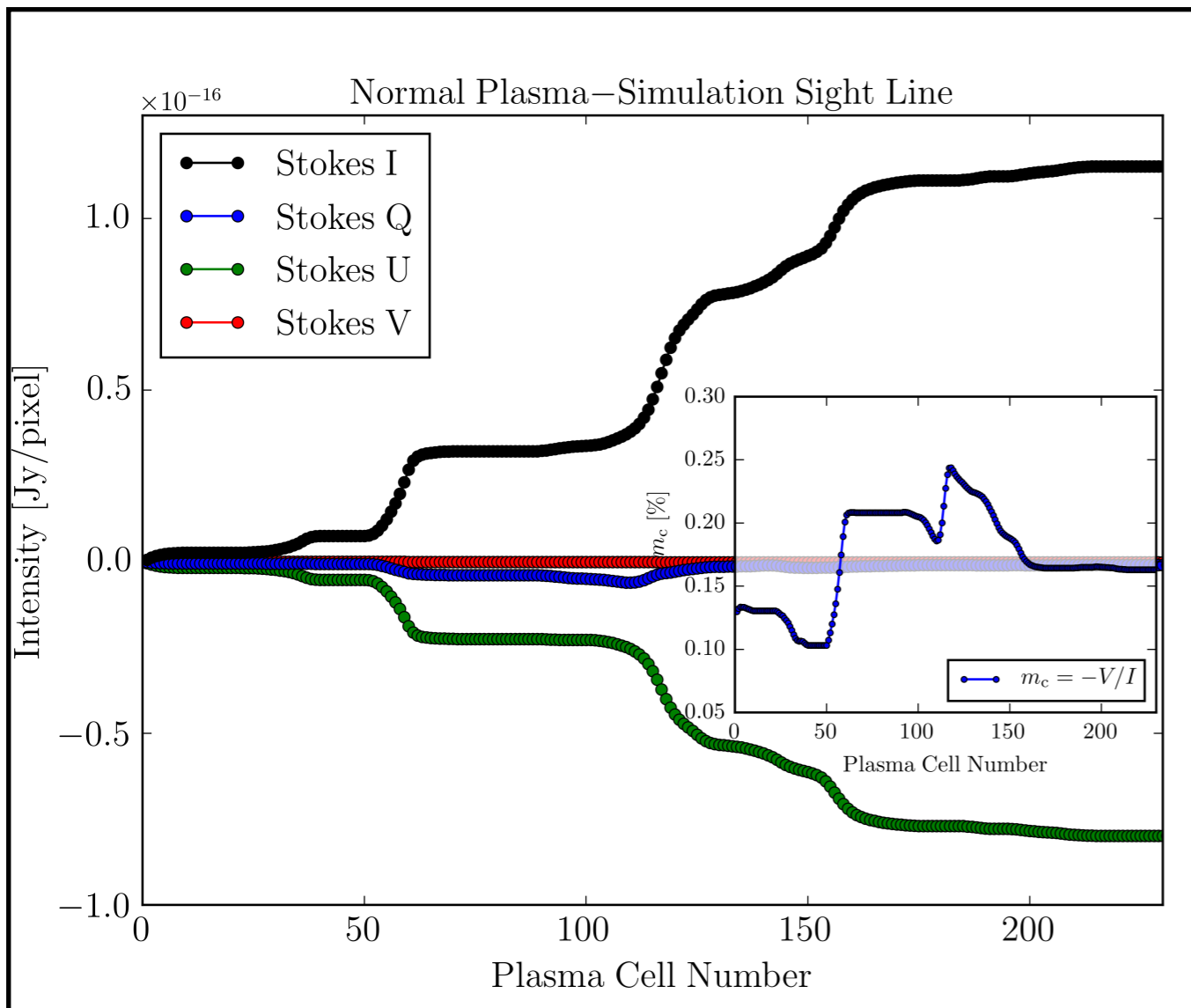
$e^- e^+$ Jet

MacDonald & Nishikawa
 (accepted)

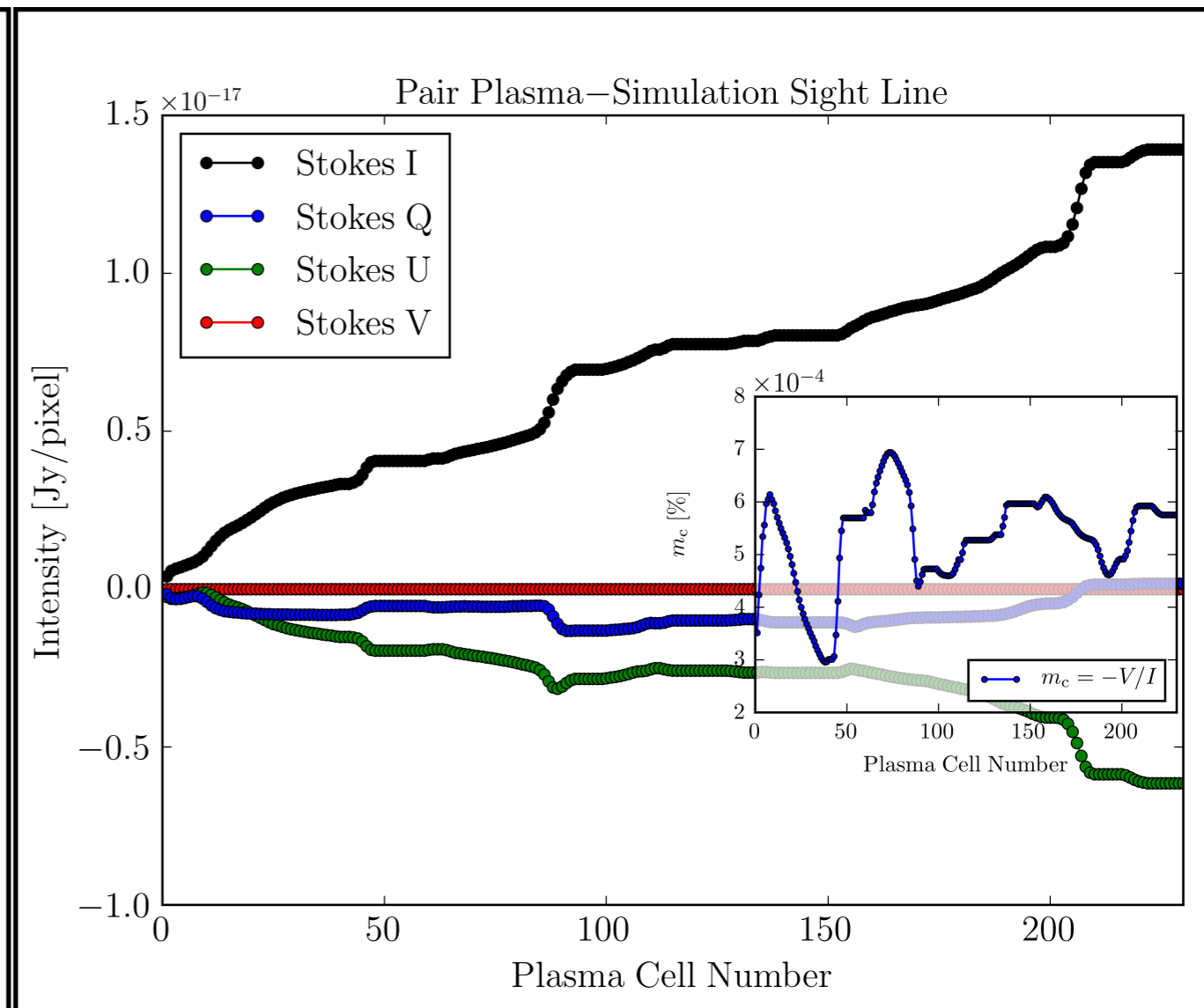
PIC Jet Imaging



PIC Jet Imaging



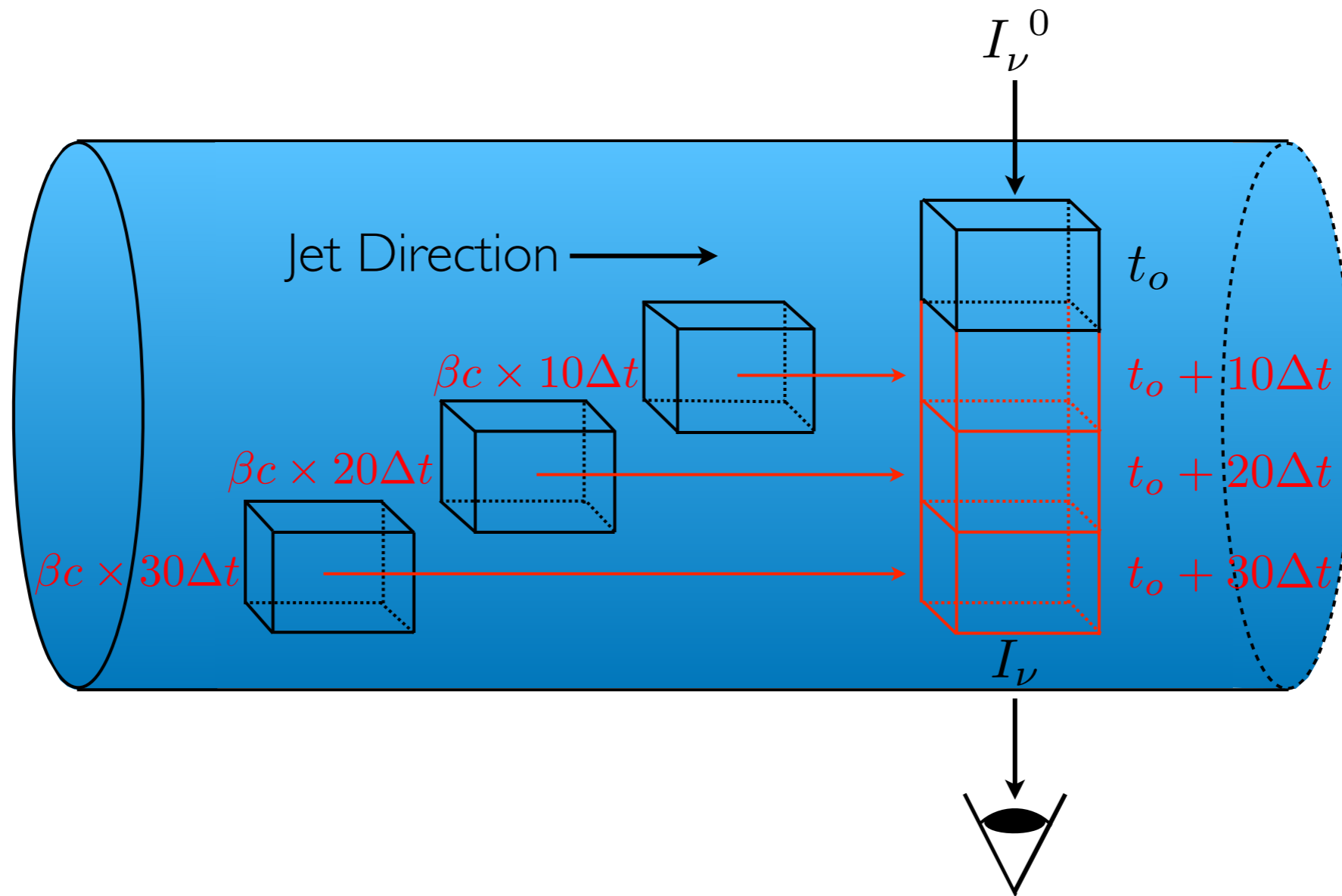
$e^- p^+$ Jet



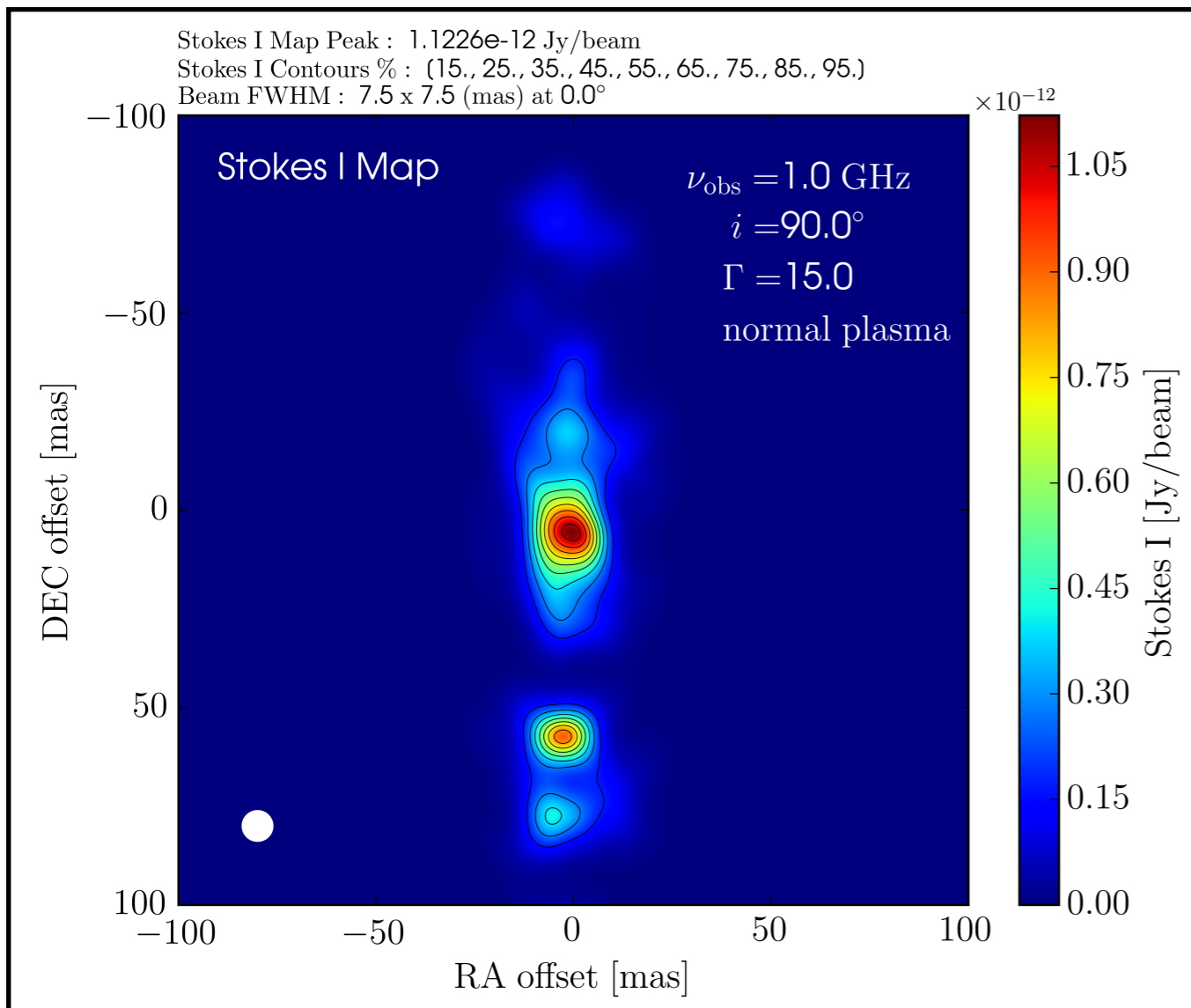
$e^- e^+$ Jet

MacDonald & Nishikawa
(accepted)

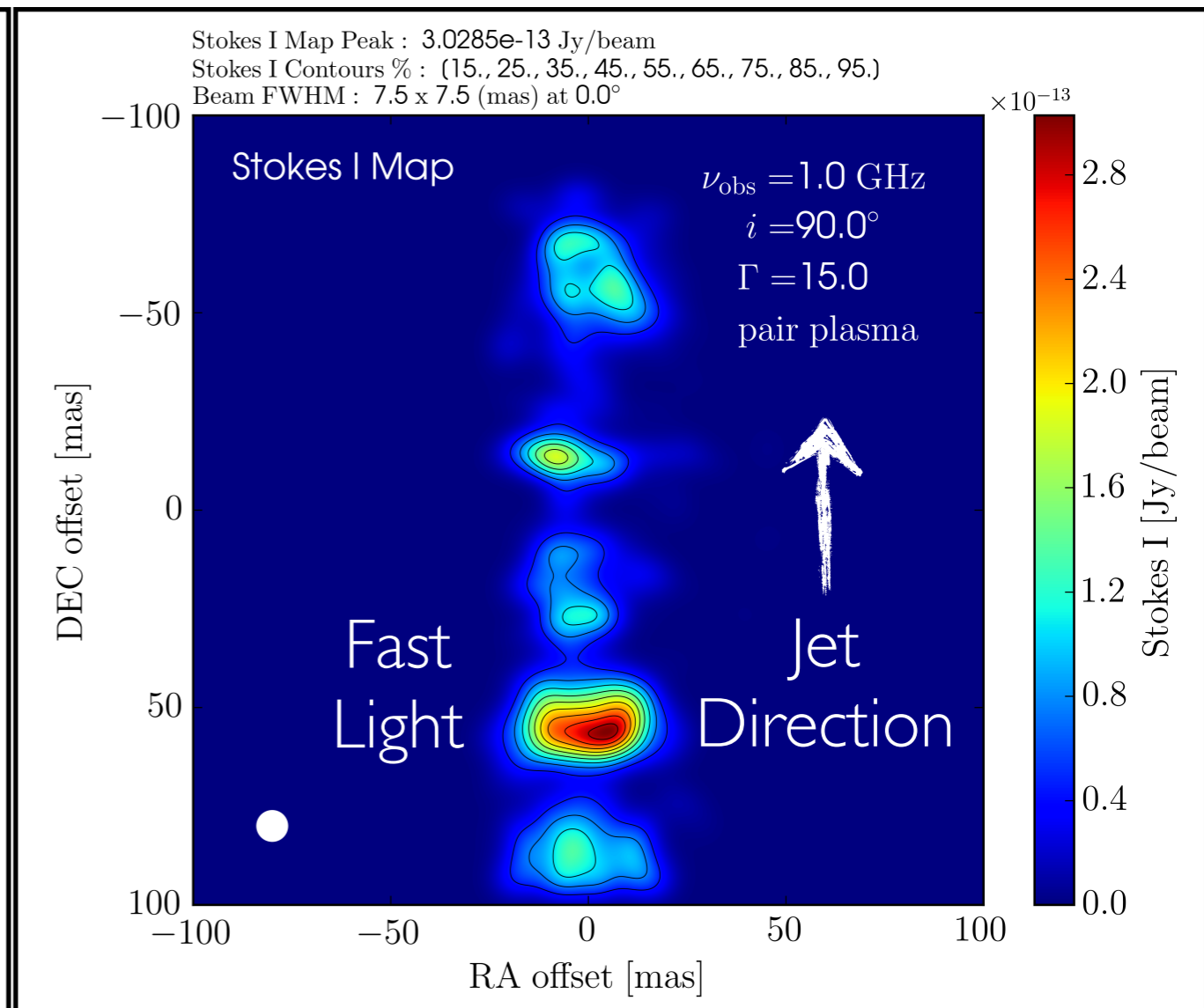
Slow Light Interpolation



PIC Jet Imaging



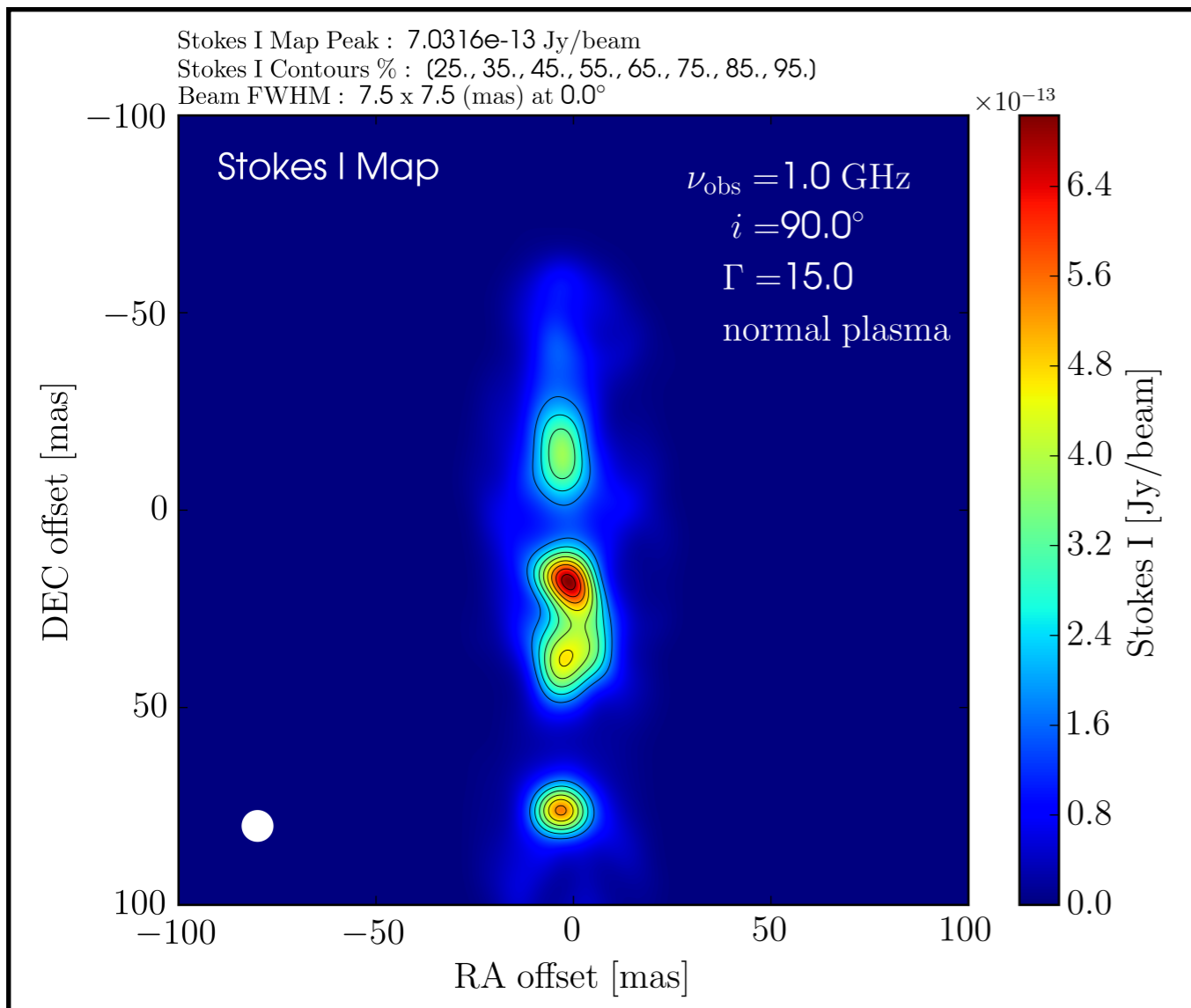
$e^- p^+$ Jet



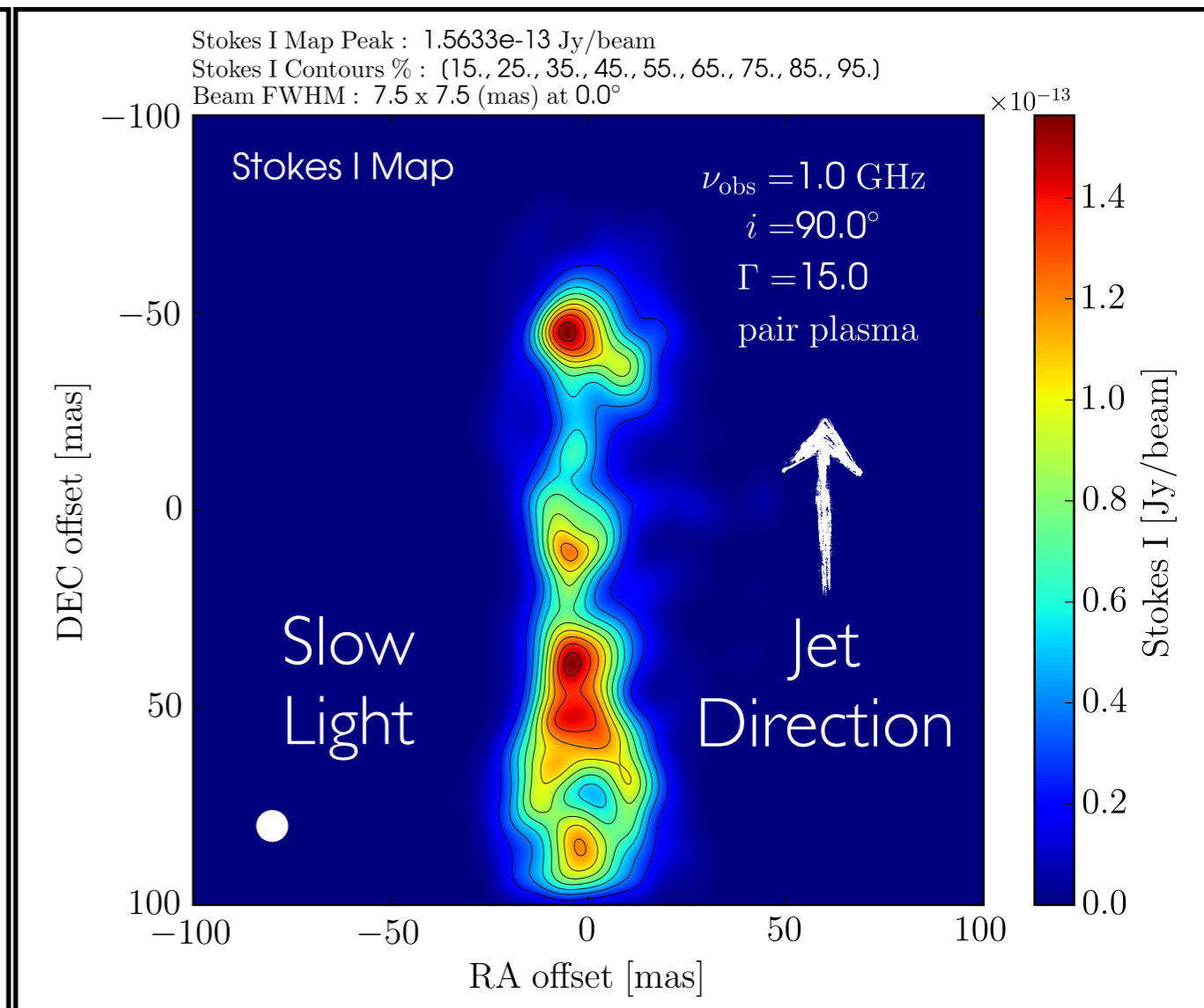
$e^- e^+$ Jet

MacDonald & Nishikawa
 (accepted)

PIC Jet Imaging



$e^- p^+$ Jet



$e^- e^+$ Jet

MacDonald & Nishikawa
 (accepted)



Image Credit: Frontera - The University of Texas at Austin

A blue-toned image of a galaxy with a bright central core and a white line pointing to the text "Questions?".

Questions?