

FARADAY CONVERSION

In Turbulent Blazar Jets

Nicholas MacDonald
Boston University

Polarised Emission from Astrophysical Jets
June 13th 2017

Talk Outline

A brief introduction to Faraday Conversion

Can a turbulent multi-zone blazar emission model produce circularly polarized radiation?

What do changes in the sign of circular polarization tell us about conditions in the jet?

How sensitive is circular polarization to the plasma composition of the jet?

Future Work: Particle-in-Cell Jet Simulations

Polarised Emission from Astrophysical Jets
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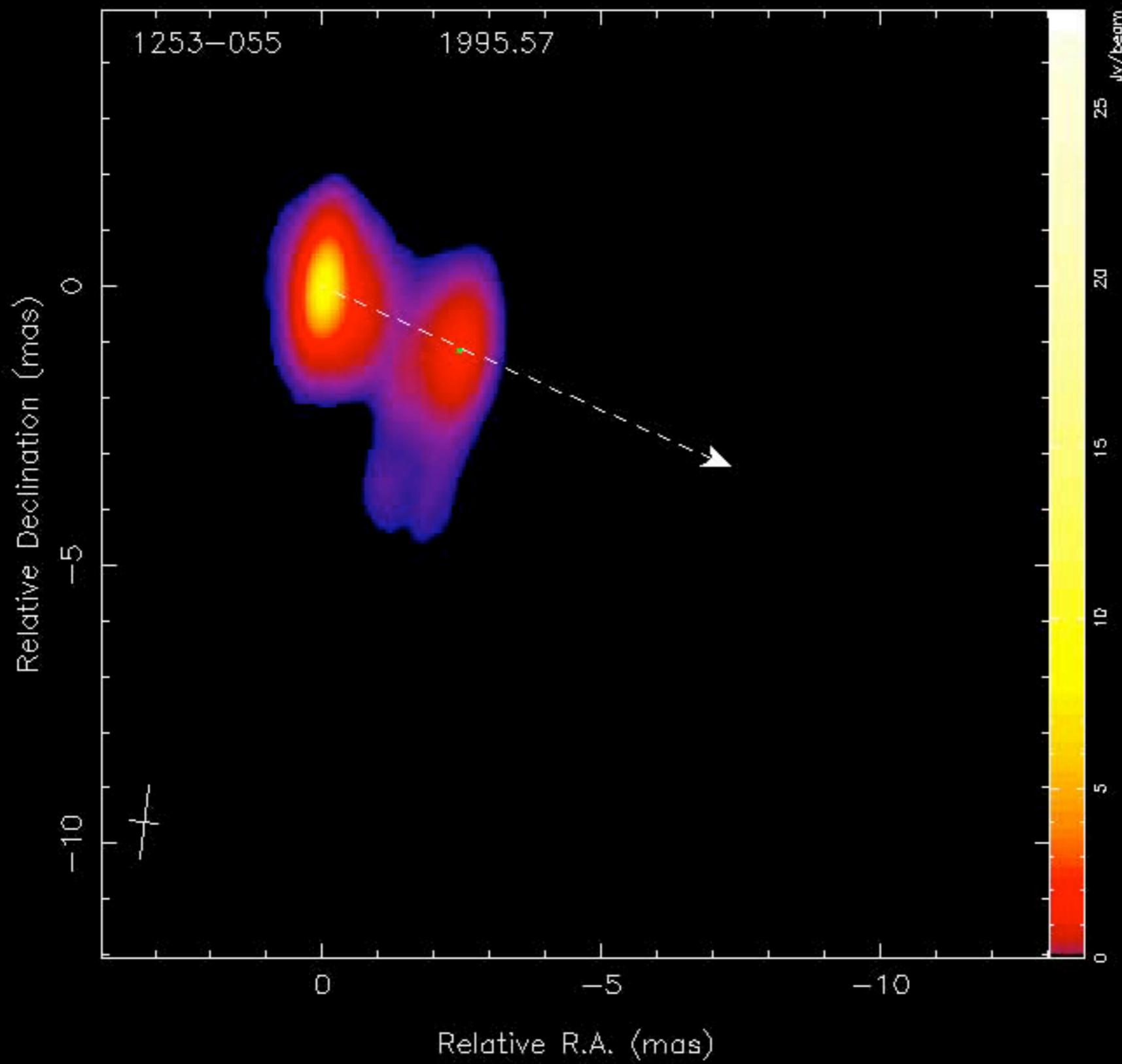
A brief introduction to Faraday Conversion

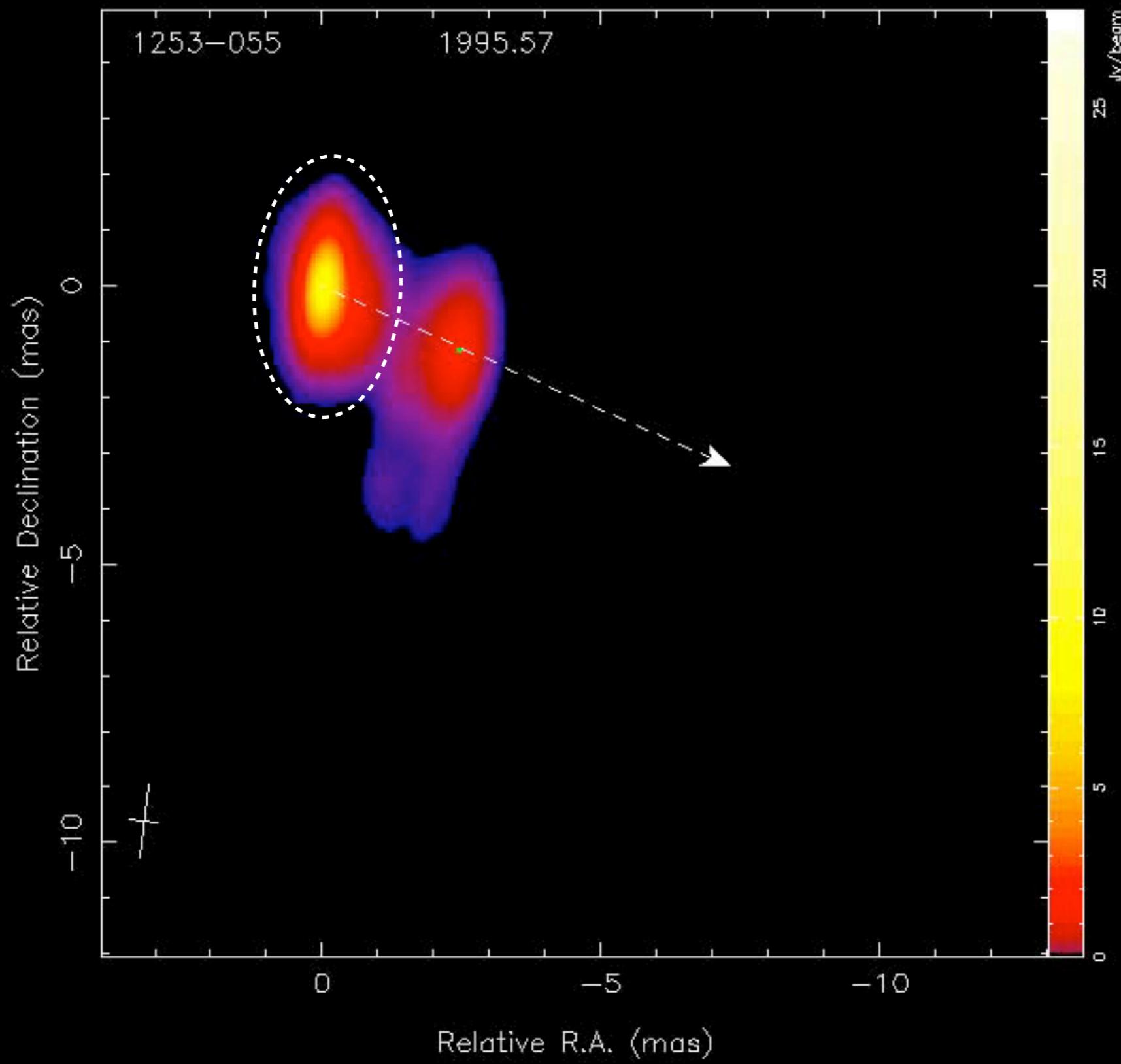
The Very Long Baseline Array





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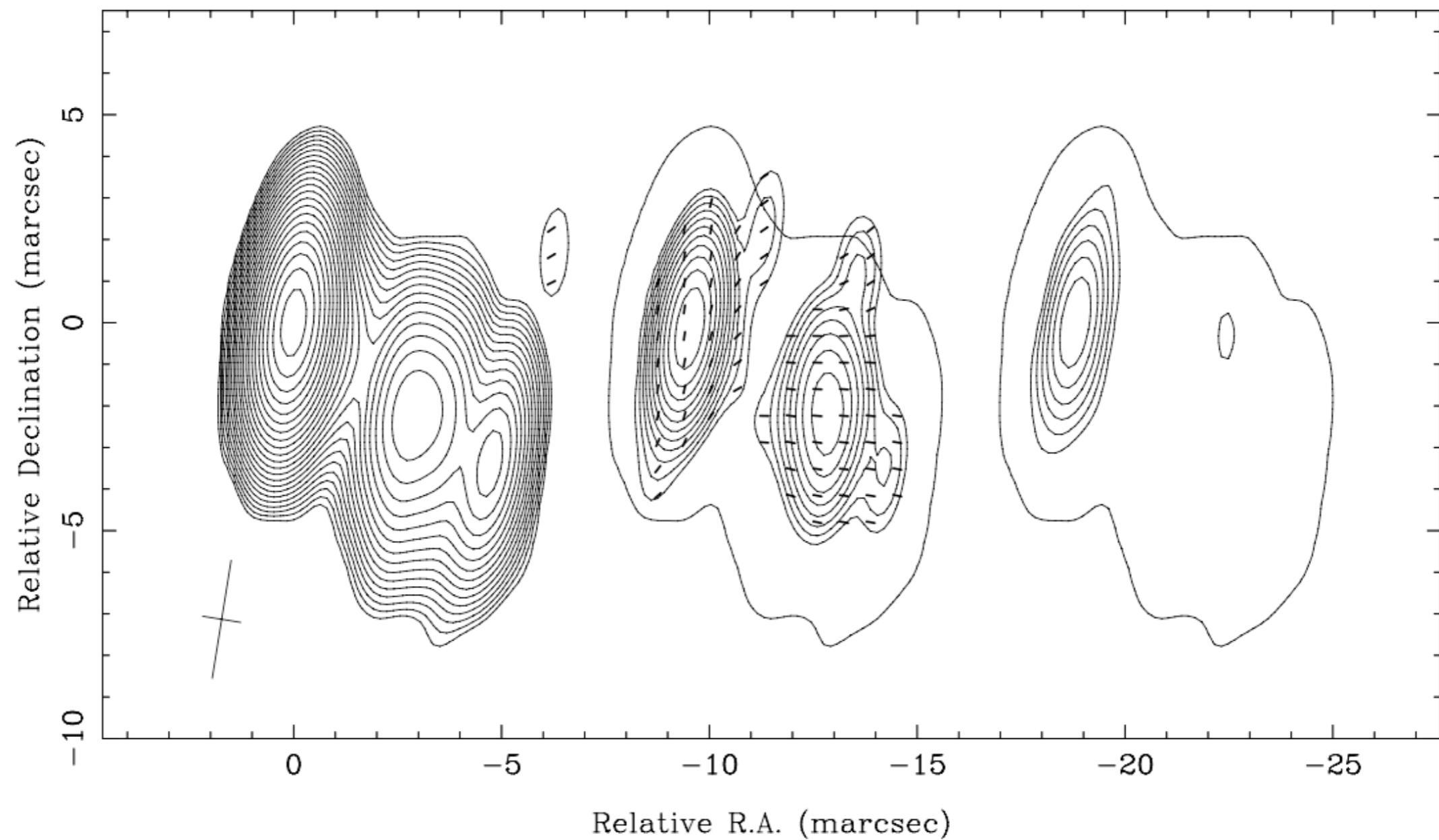






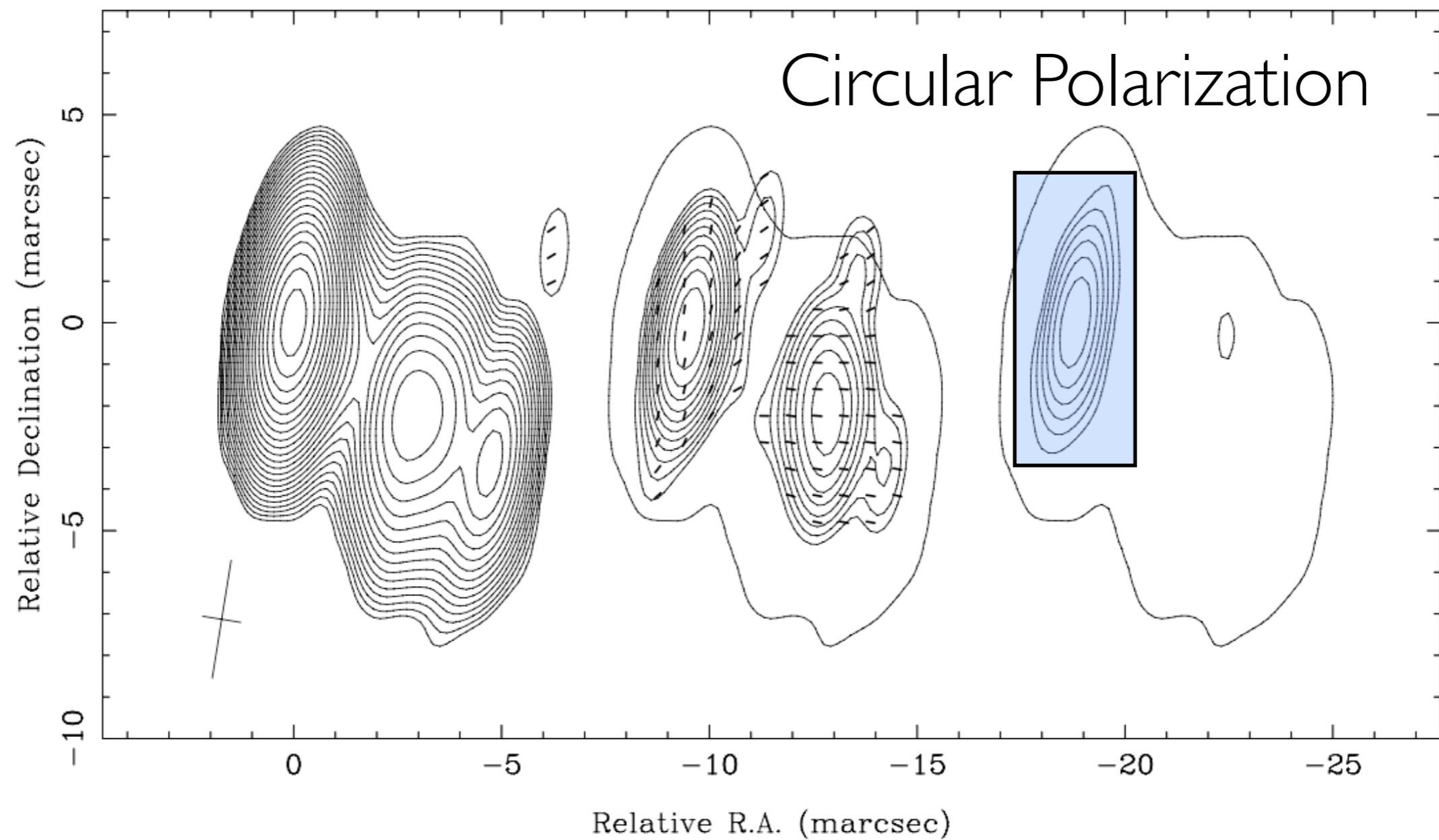
Recollimation Shock

3C 279



Homan et al. (2009)

3C 279



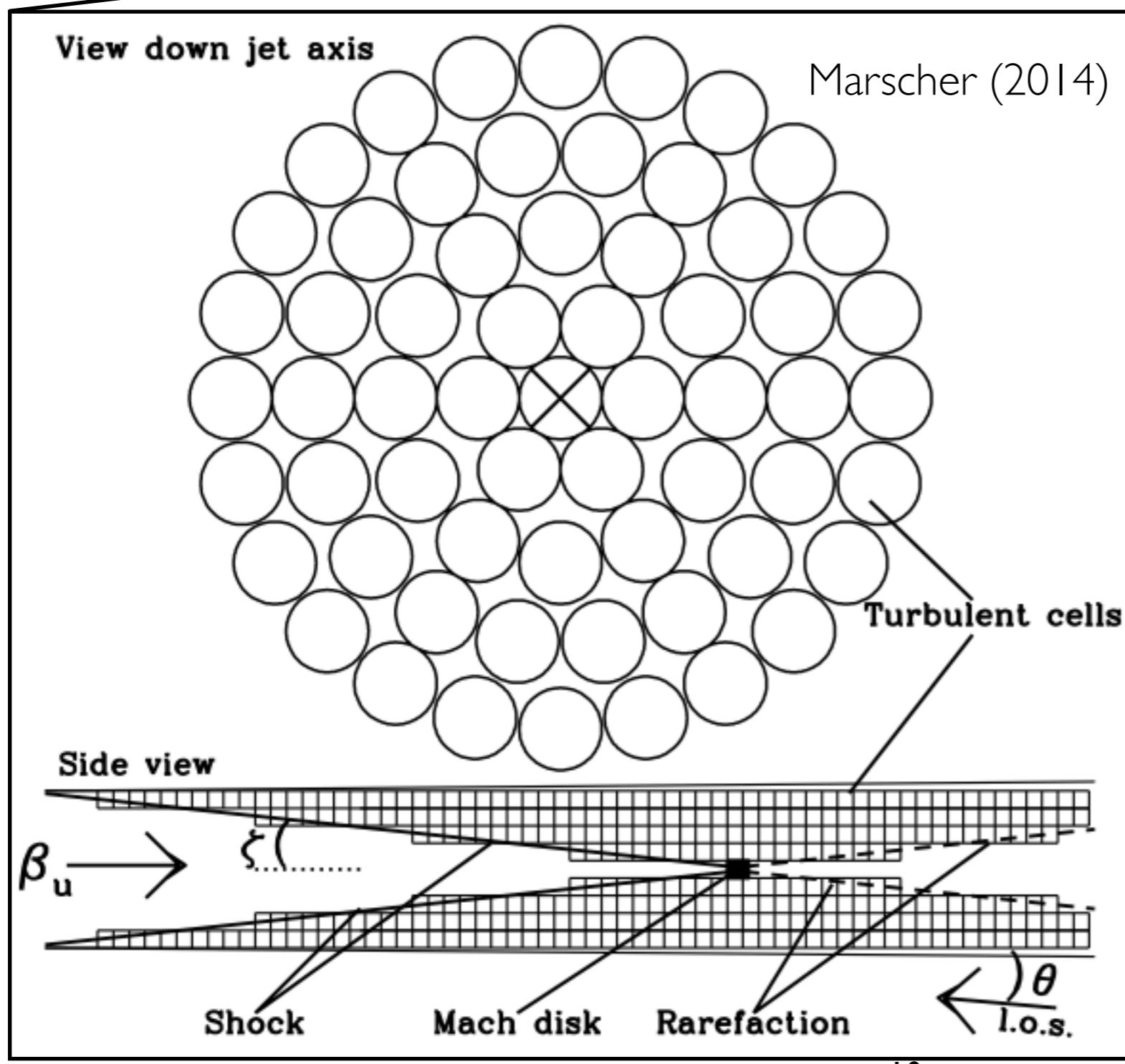
Homan et al. (2009)



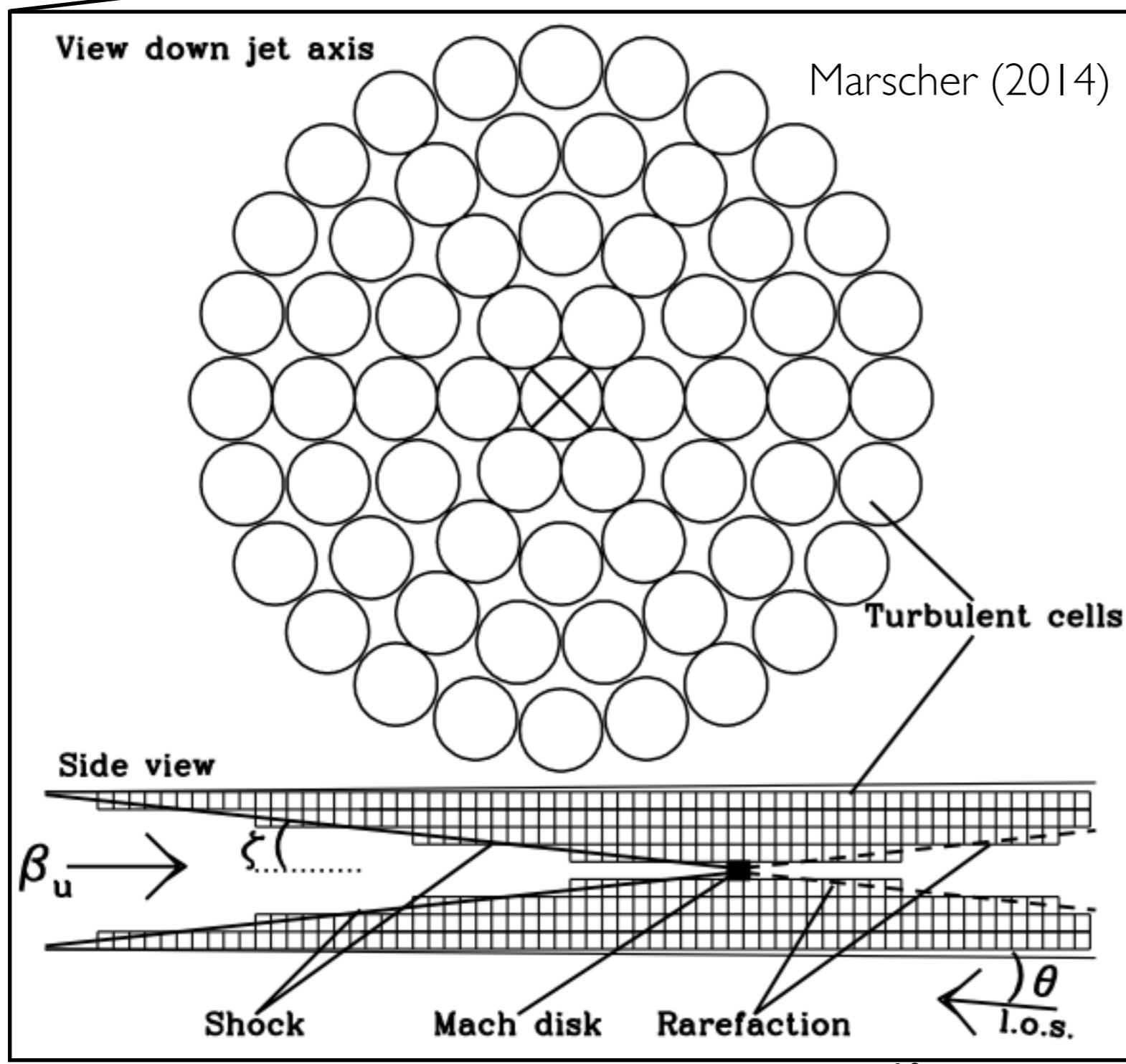


Turbulence

The Turbulent Extreme Multi-Zone (TEMZ) Model



The Turbulent Extreme Multi-Zone (TEMZ) Model



?

Solving the Full Stokes Equations of Polarized Radiative Transfer

THE ASTROPHYSICAL JOURNAL, 214: 522-539, 1977 June 1

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TRANSFER OF POLARIZED RADIATION IN SELF-ABSORBED SYNCHROTRON SOURCES.
I. RESULTS FOR A HOMOGENEOUS SOURCE

T. W. JONES

National Radio Astronomy Observatory*

AND

S. L. O'DELL

Department of Physics, University of California, San Diego

Received 1975 June 16; revised 1976 October 26

ABSTRACT

The solution to the equation of transfer of polarized radiation in a stationary, homogeneous, rarefied medium is applied to self-absorbed synchrotron sources. Relativistic electrons (independent of the presence of any cold plasma) can quite easily produce in such sources significant Faraday rotation and/or conversion of linear to circular polarization. Structural inhomogeneities do not obviate the importance of these phenomena in cosmic, compact nonthermal sources. Contrary to the calculation of Pacholczyk and Swihart, the circular polarization for a homogeneous source changes sign just below the self-absorption turnover as the source becomes opaque, even when polarization conversion dominates; however, for a physically realistic source, structural inhomogeneity may alter this behavior. The observational evidence bearing upon these effects is reviewed.

Subject headings: polarization — radiative transfer — radio sources: variable — synchrotron radiation

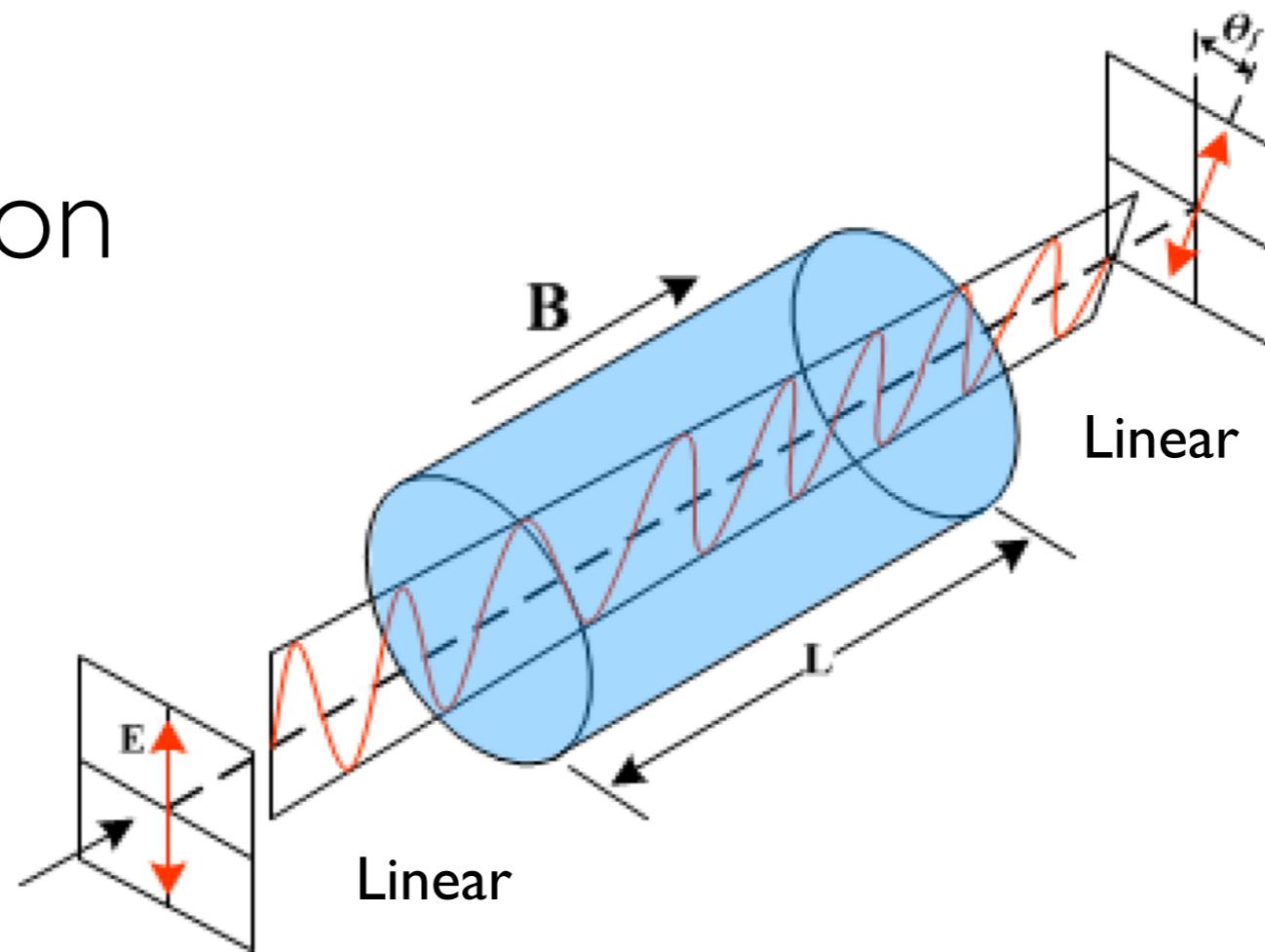
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\left(\frac{d}{dl} + \kappa_I \right) & \kappa_Q & \kappa_U & \kappa_V & I_\nu \\
\kappa_Q & \left(\frac{d}{dl} + \kappa_I \right) & \kappa^*_V & -\kappa^*_U & Q_\nu \\
\kappa_U & -\kappa^*_V & \left(\frac{d}{dl} + \kappa_I \right) & \kappa^*_Q & U_\nu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

Jones & O'Dell (1977)

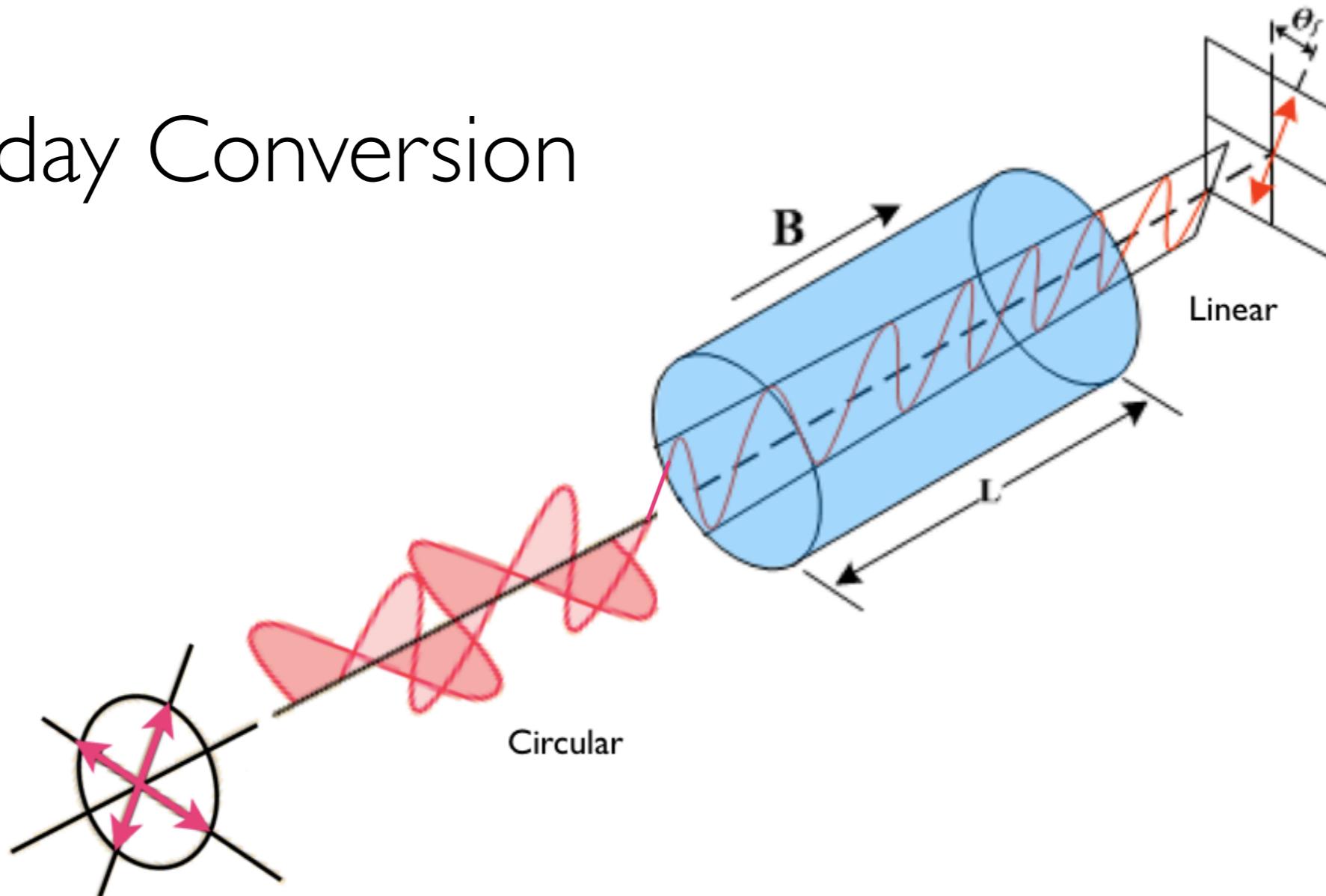
$$\begin{array}{ccccc}
 \left(\frac{d}{dl} + \kappa_I \right) & \kappa_Q & \kappa_U & \kappa_V & \\
 \kappa_Q & \left(\frac{d}{dl} + \kappa_I \right) & \kappa^*_V & -\kappa^*_U & \\
 \kappa_U & -\kappa^*_V & \left(\frac{d}{dl} + \kappa_I \right) & \kappa^*_Q & \\
 \kappa_V & \kappa^*_U & -\kappa^*_Q & \left(\frac{d}{dl} + \kappa_I \right) & \\
 \end{array}
 = \begin{array}{c}
 \boxed{I_\nu} \\
 Q_\nu \\
 U_\nu \\
 V_\nu
 \end{array} = \begin{array}{c}
 \eta_\nu^I \\
 \eta_\nu^Q \\
 \eta_\nu^U \\
 \eta_\nu^V
 \end{array}$$

Jones & O'Dell (1977)

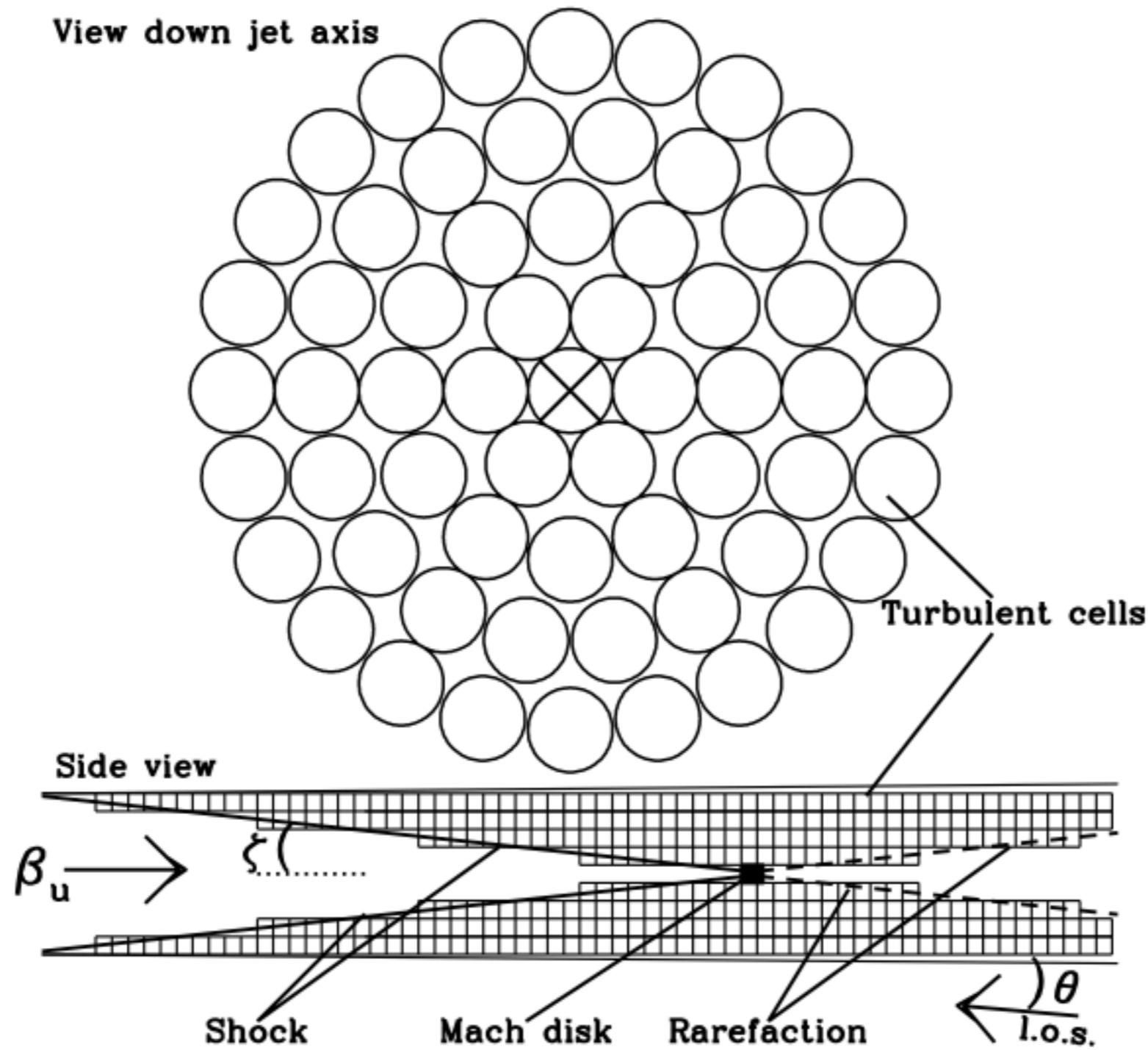
Faraday Rotation



Faraday Conversion

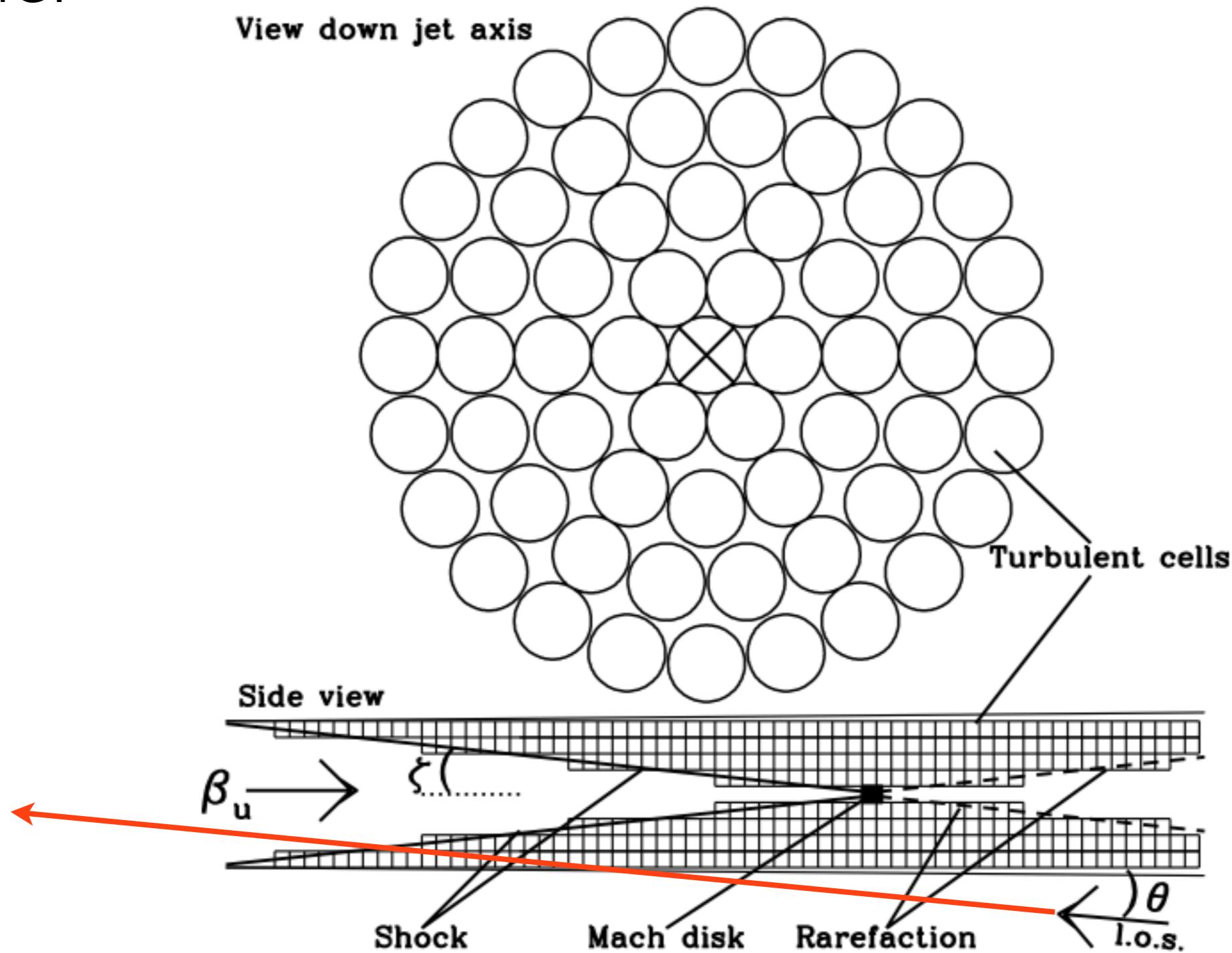


The Turbulent Extreme Multi-Zone (TEMZ) Model



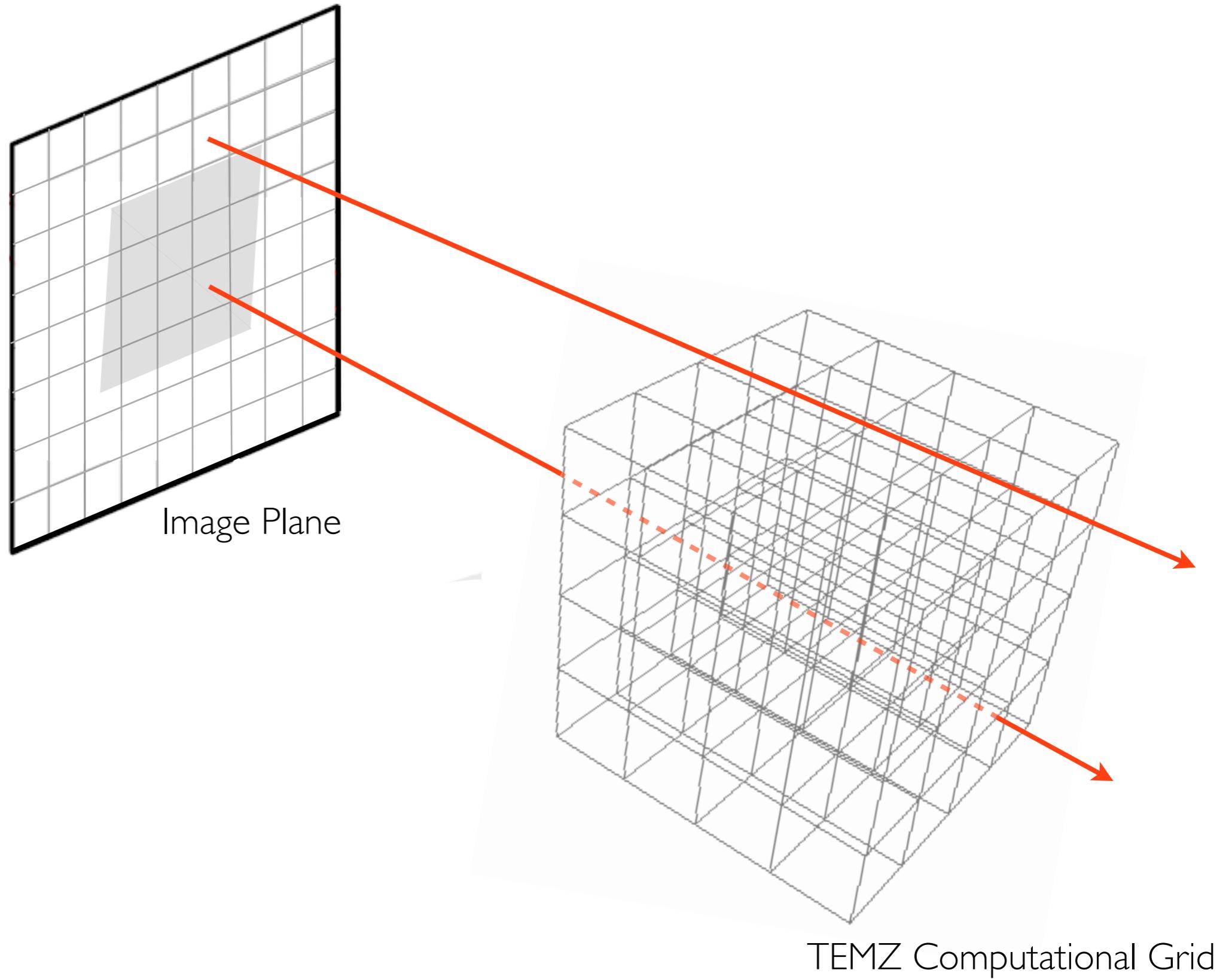
Marscher (2014)

The Turbulent Extreme Multi-Zone (TEMZ) Model

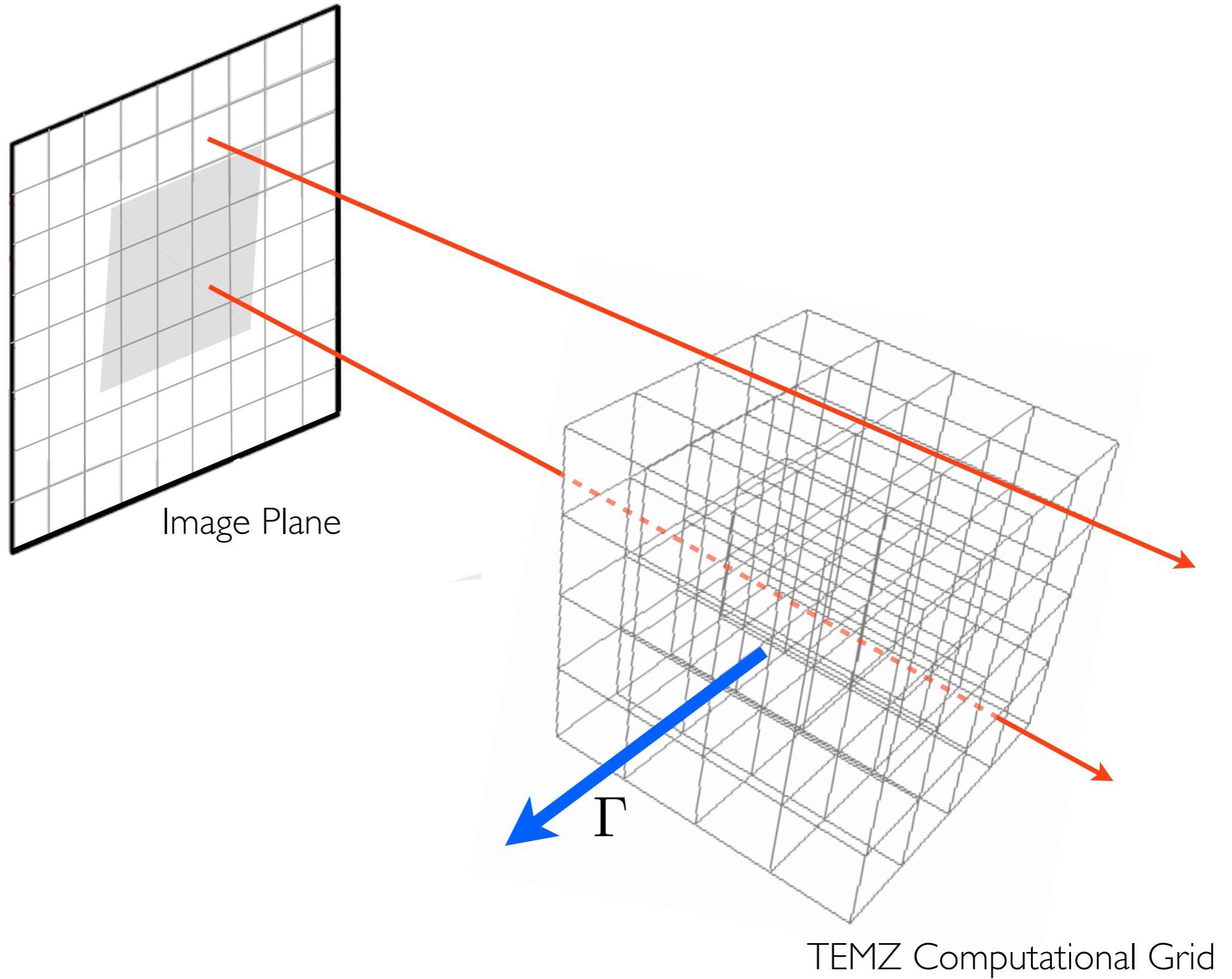


Marscher (2014)

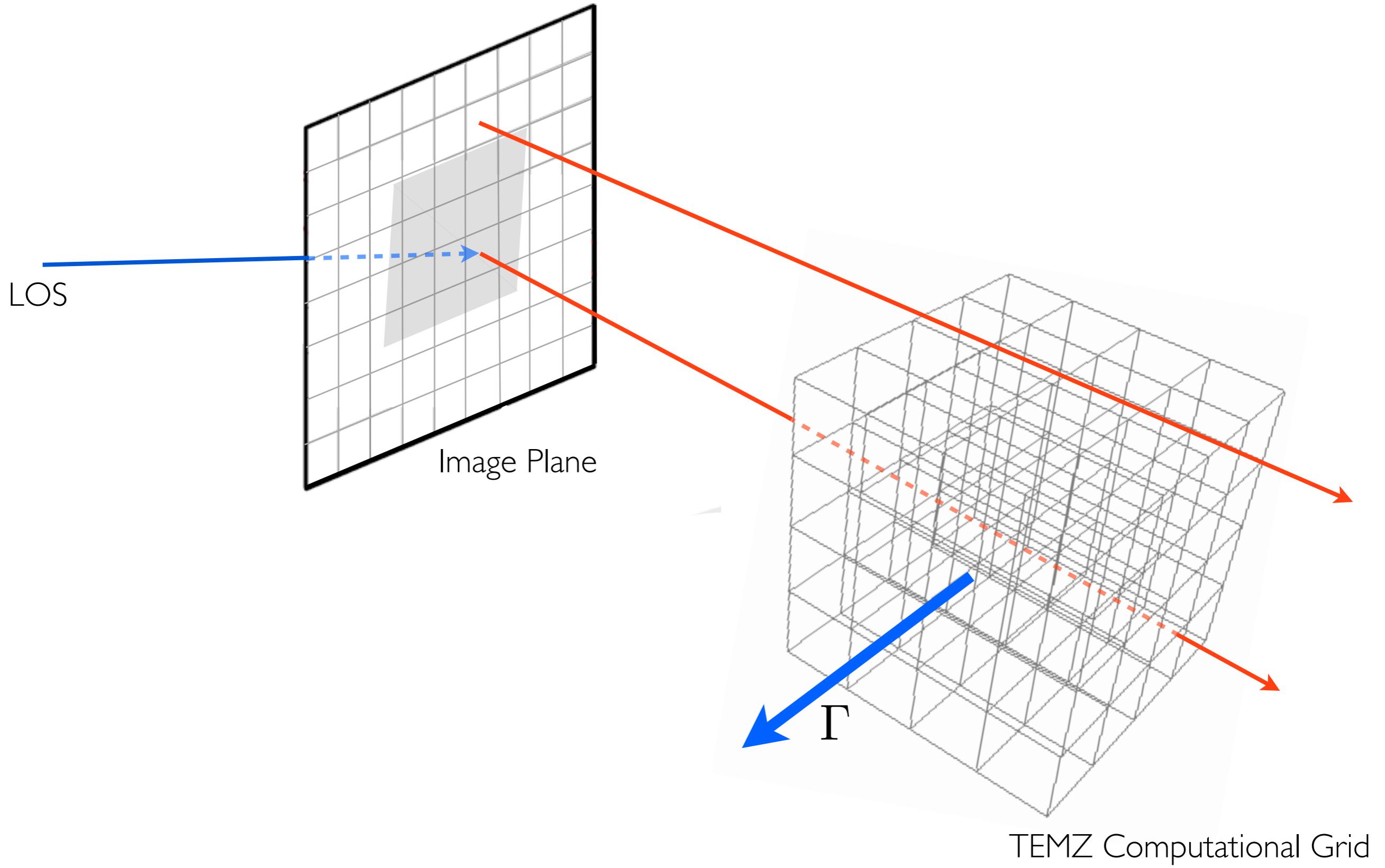
Ray Tracing Algorithm



Ray Tracing Algorithm



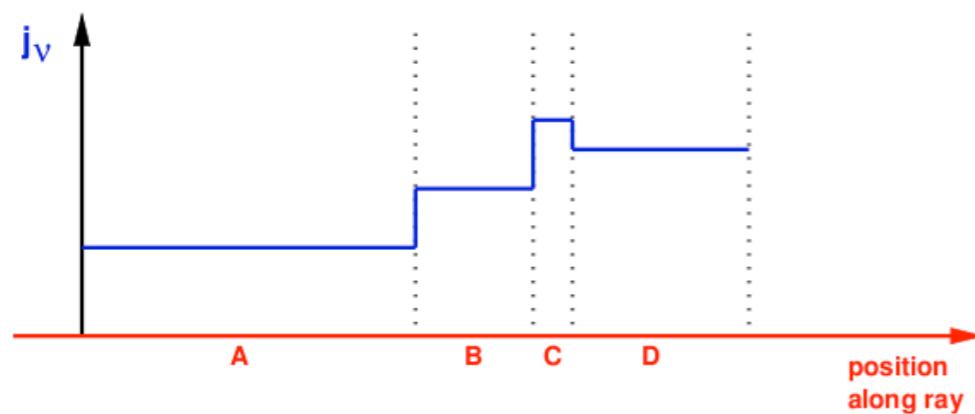
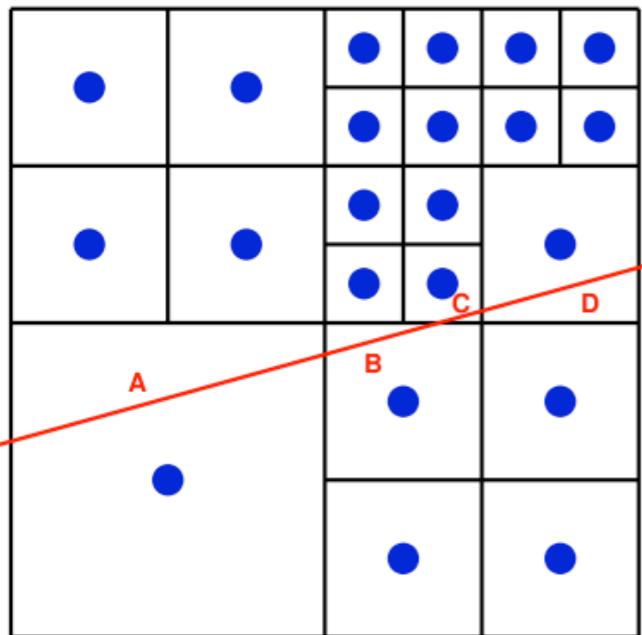
Ray Tracing Algorithm



The RADMC-3D Code

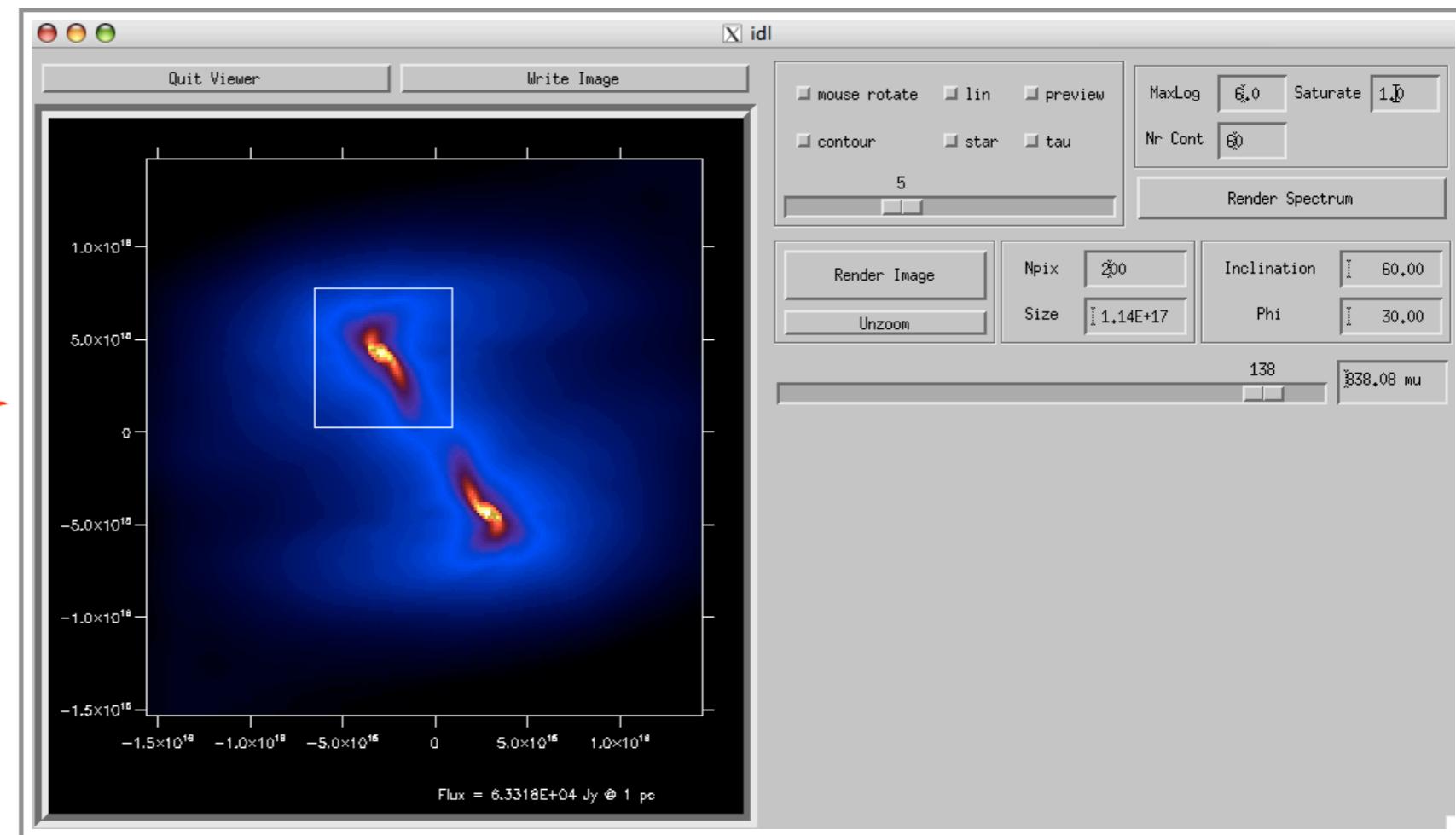


MAX-PLANCK-GESELLSCHAFT



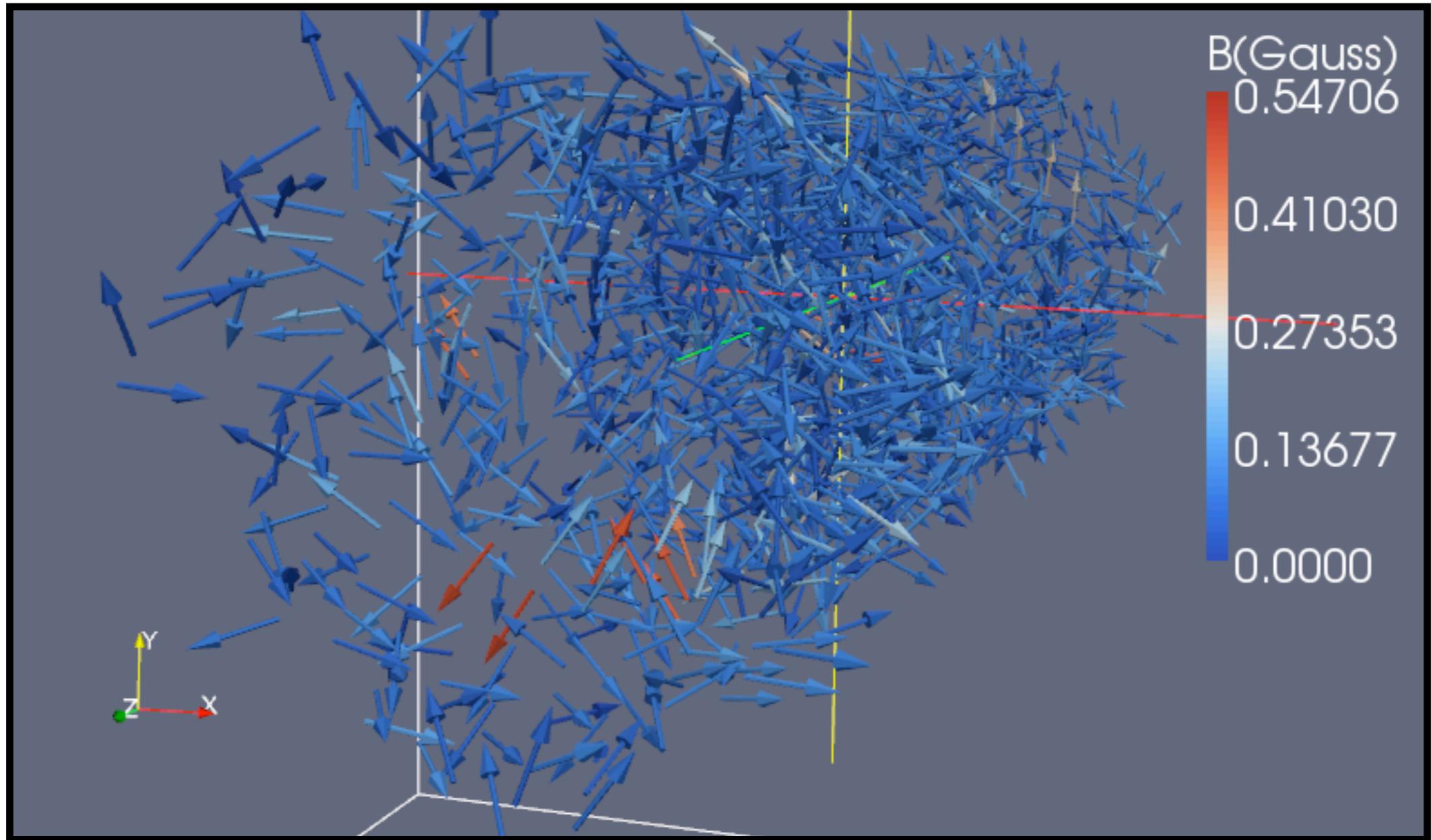
radmc3dPy

Attila Juhasz



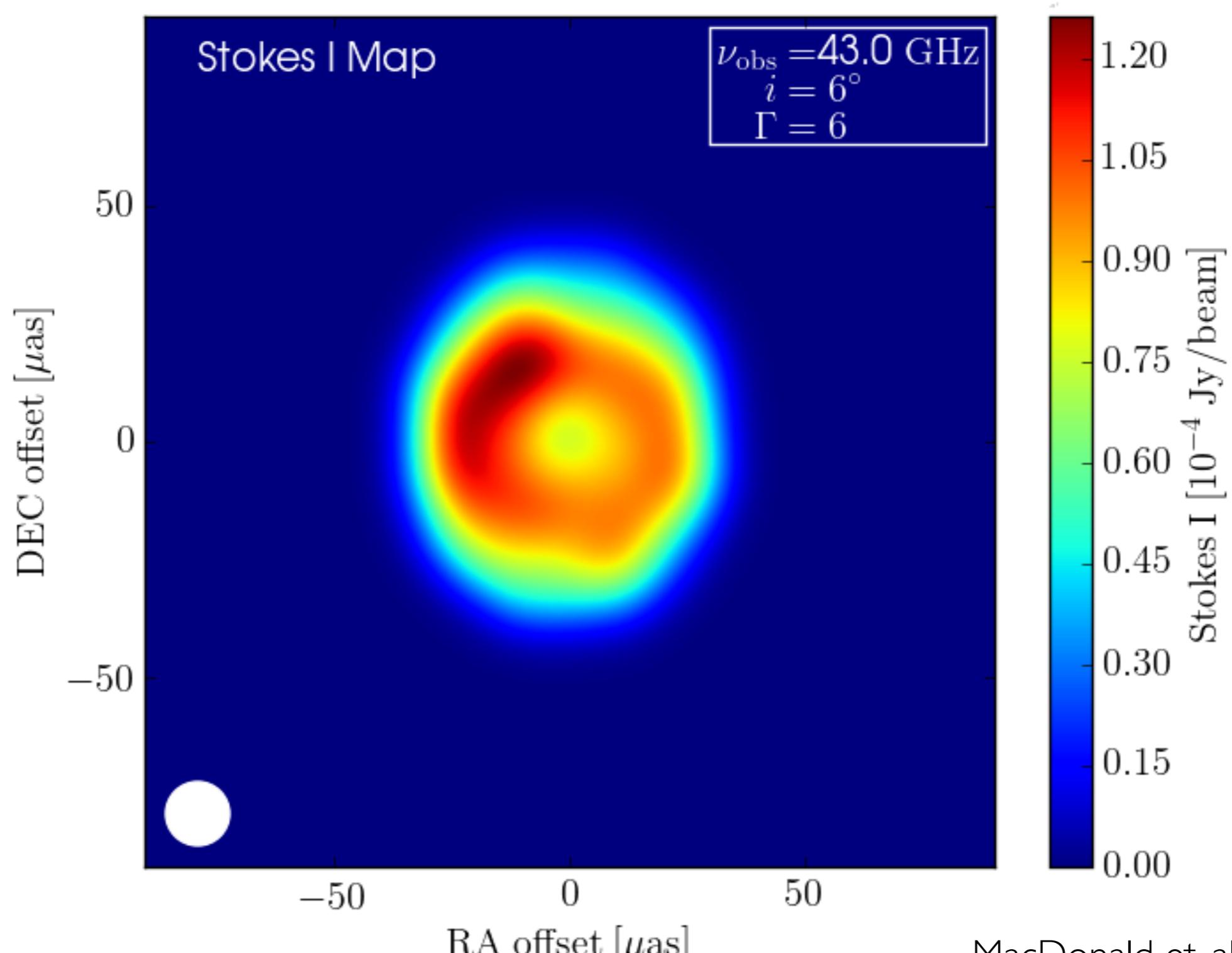
Can a turbulent multi-zone blazar emission model produce circularly polarized radiation?

TEMZ Model

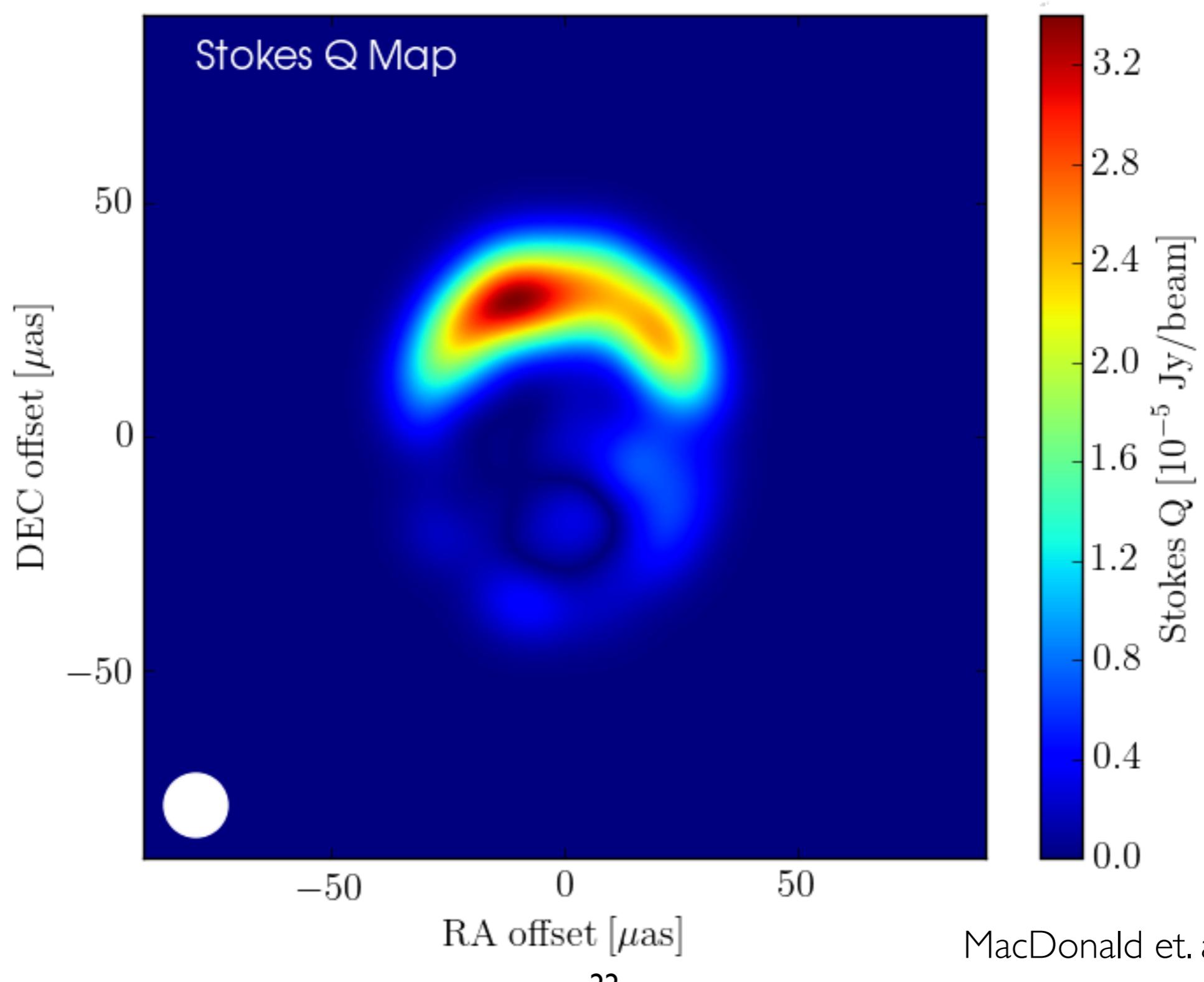


MacDonald et. al (submitted)

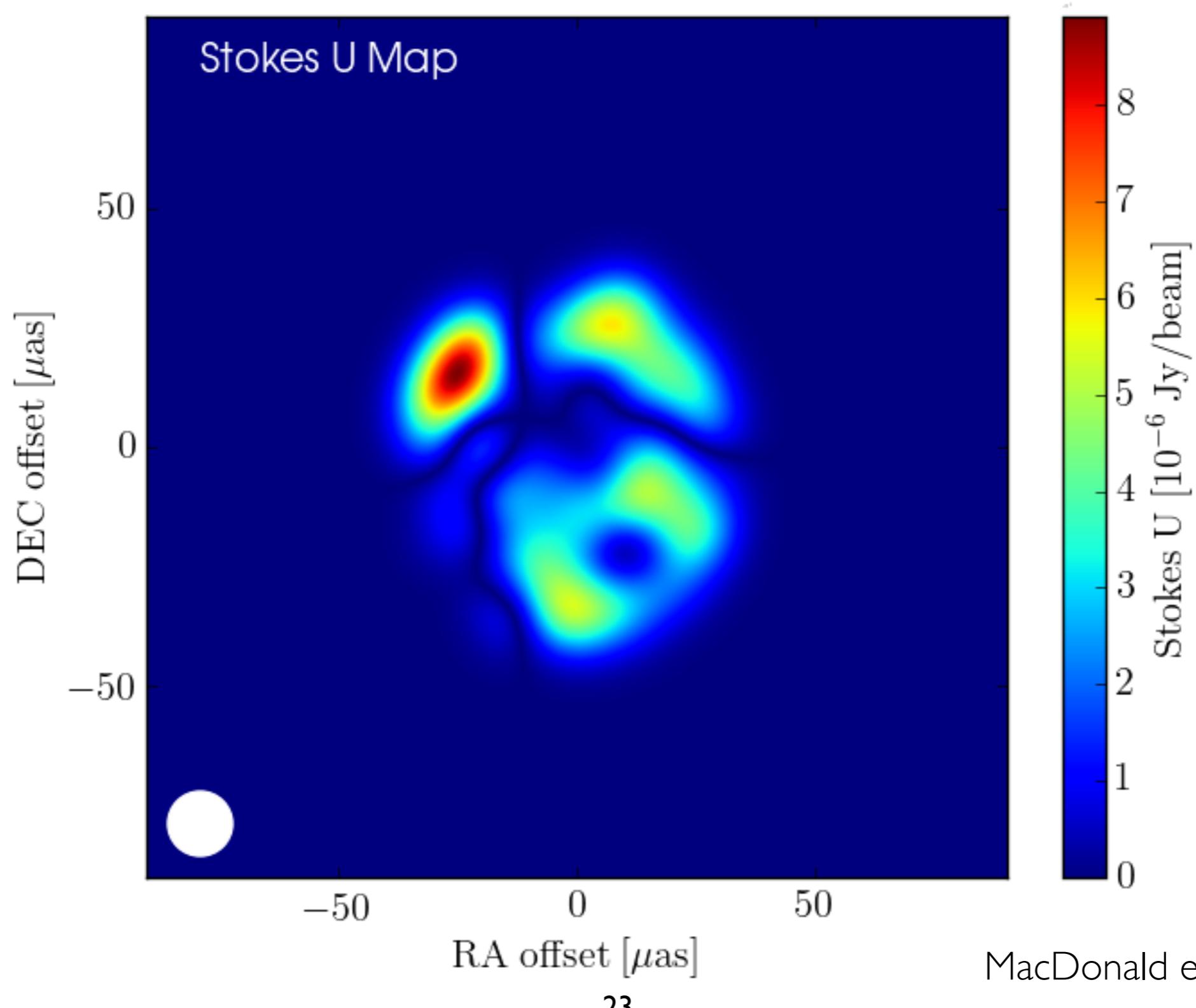
TEMZ Model



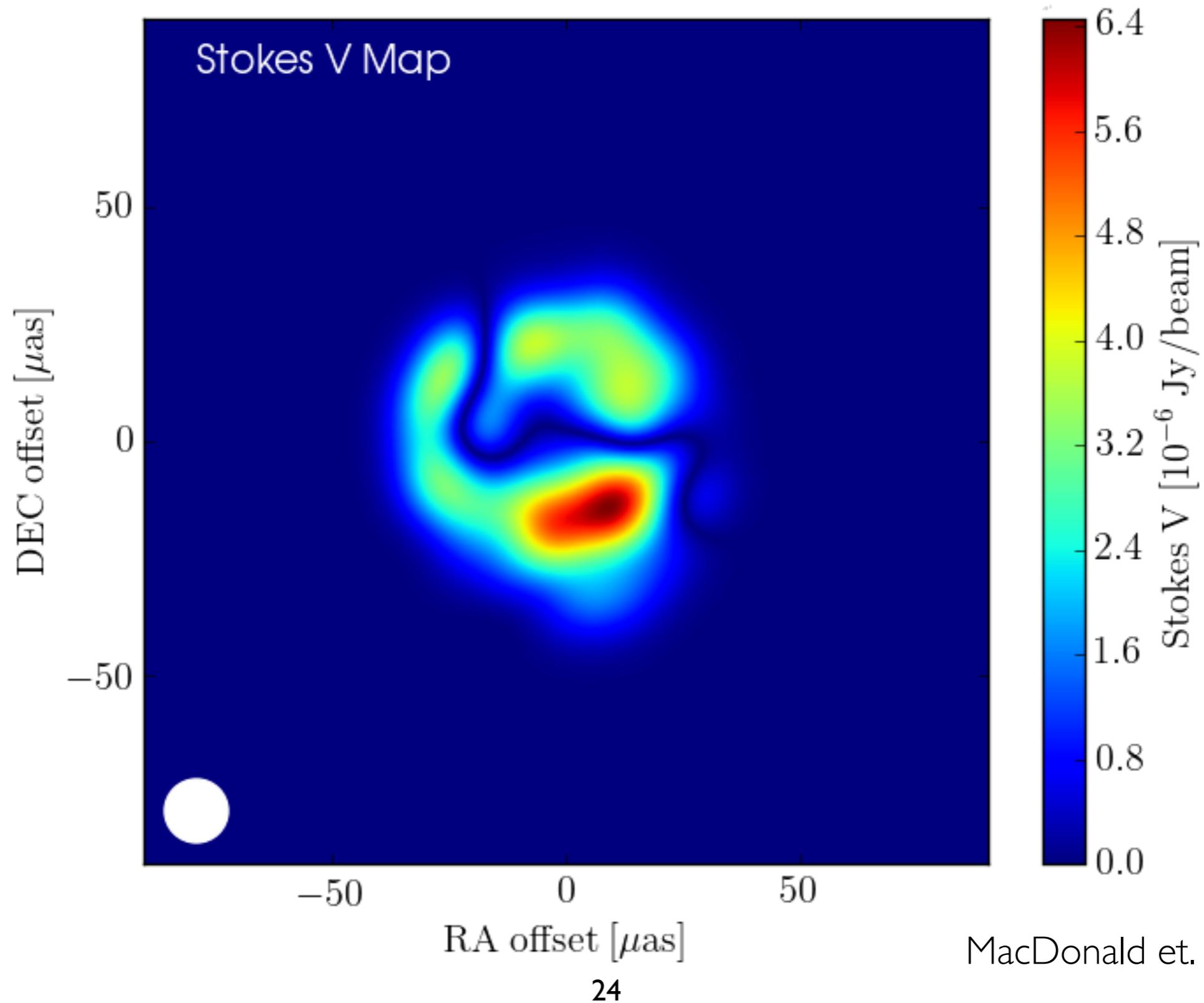
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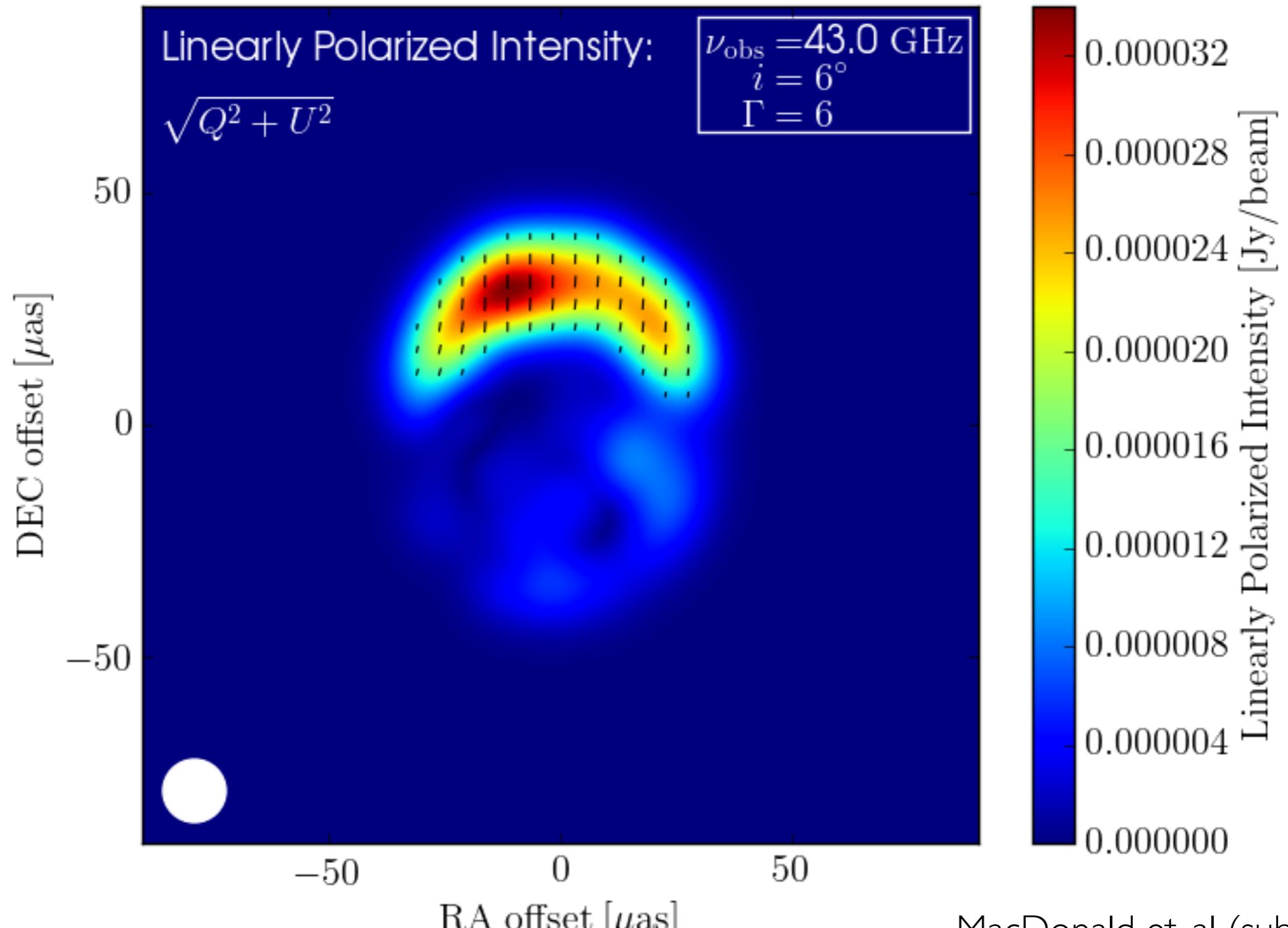
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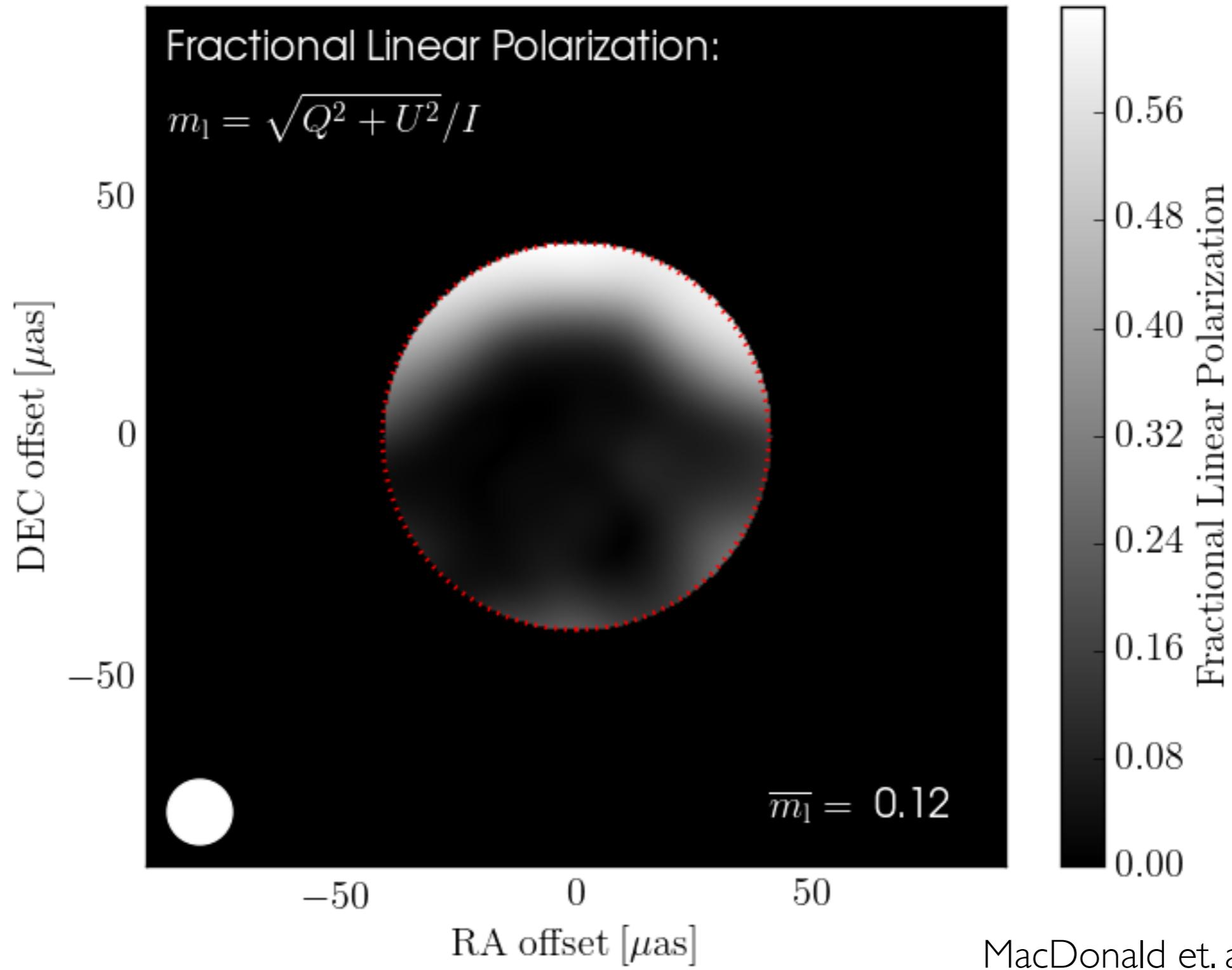
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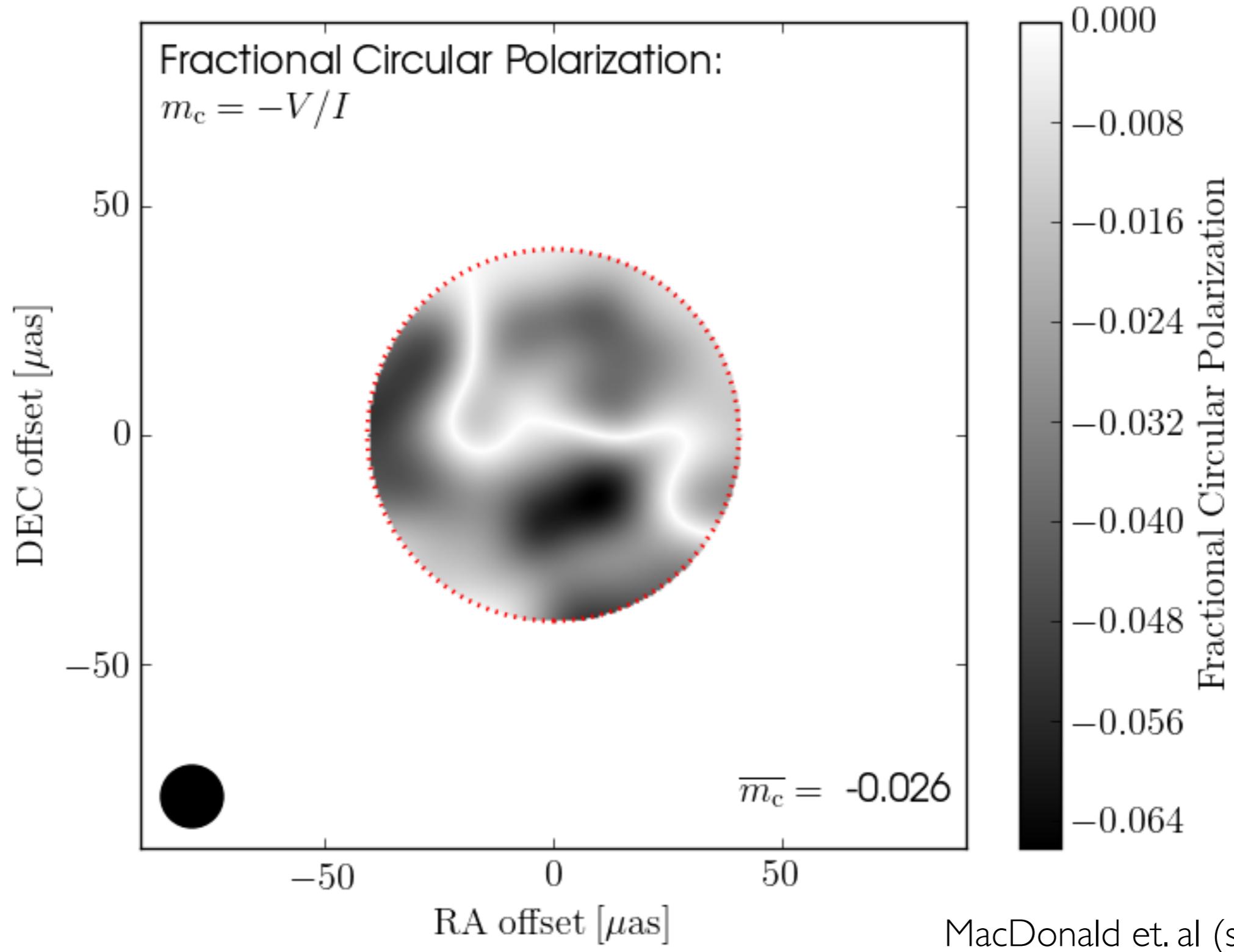
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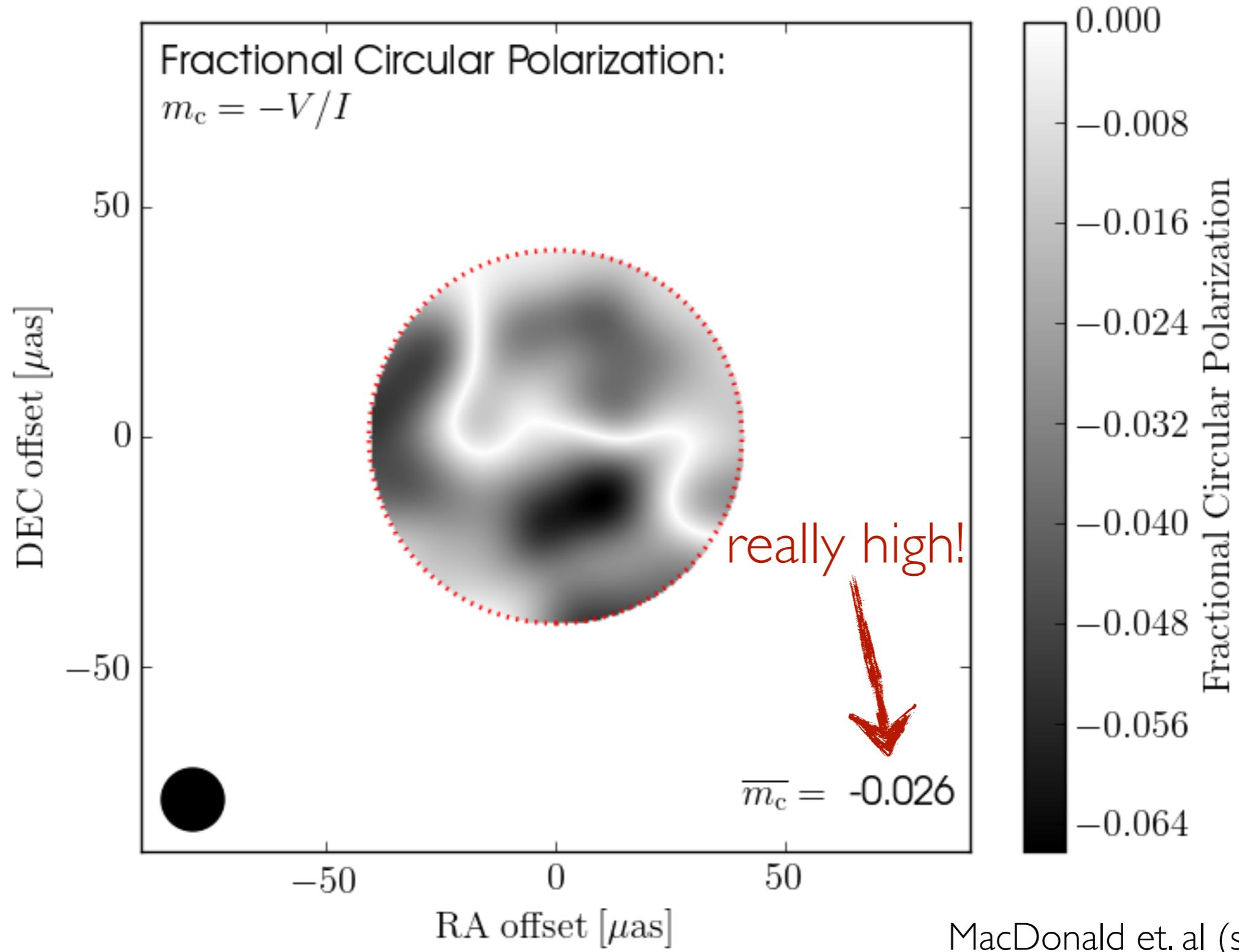
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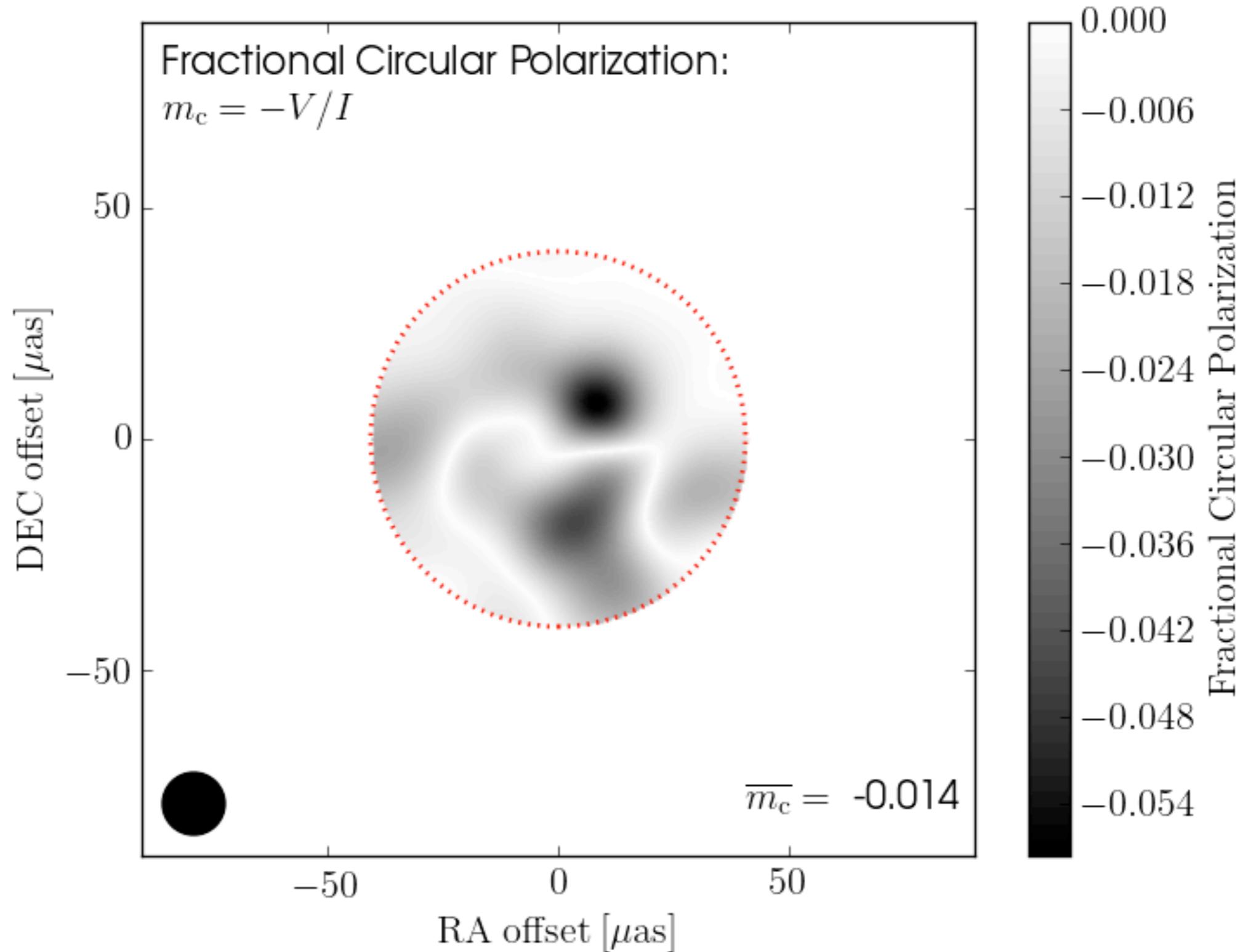
TEMZ Model



TEMZ Model



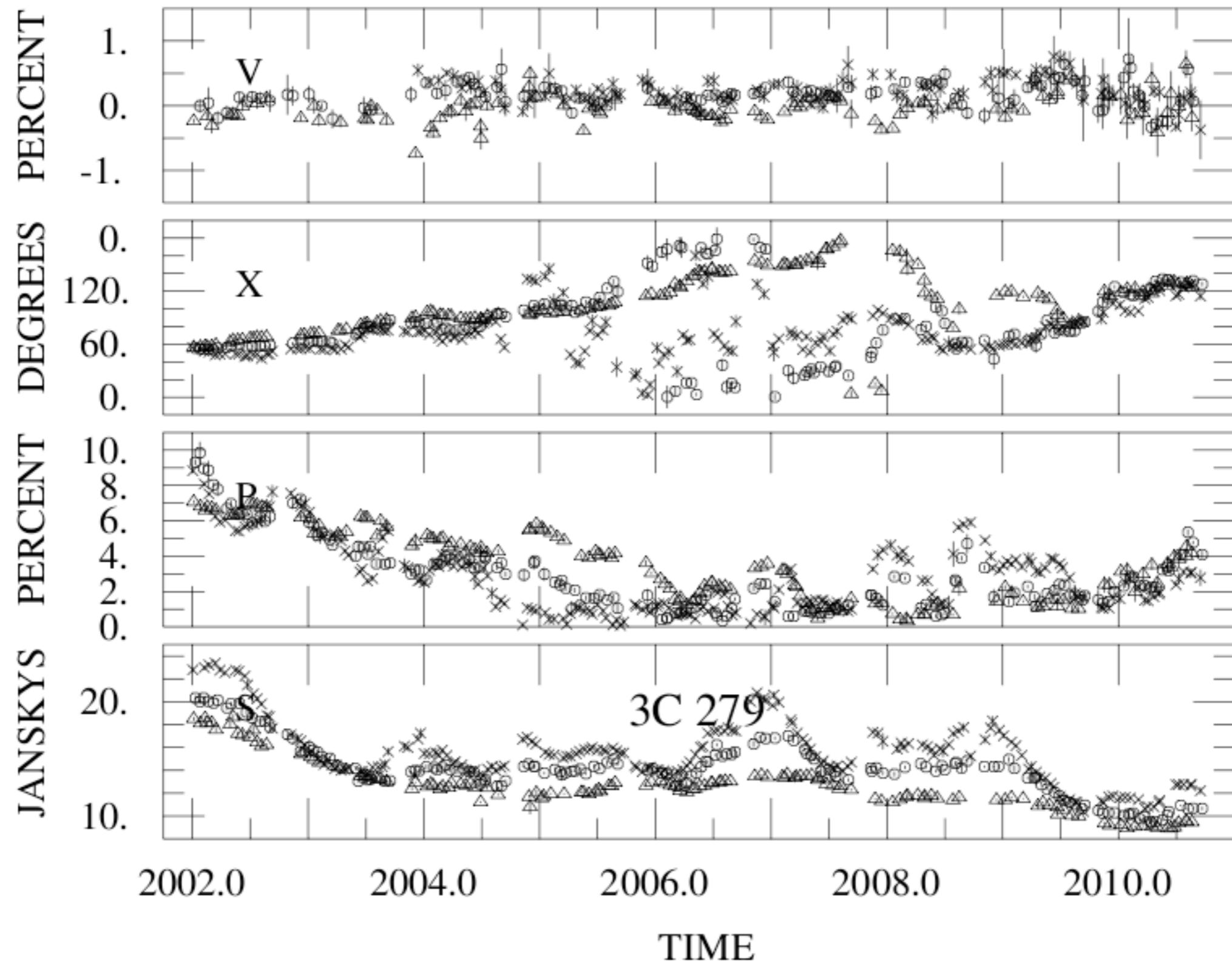
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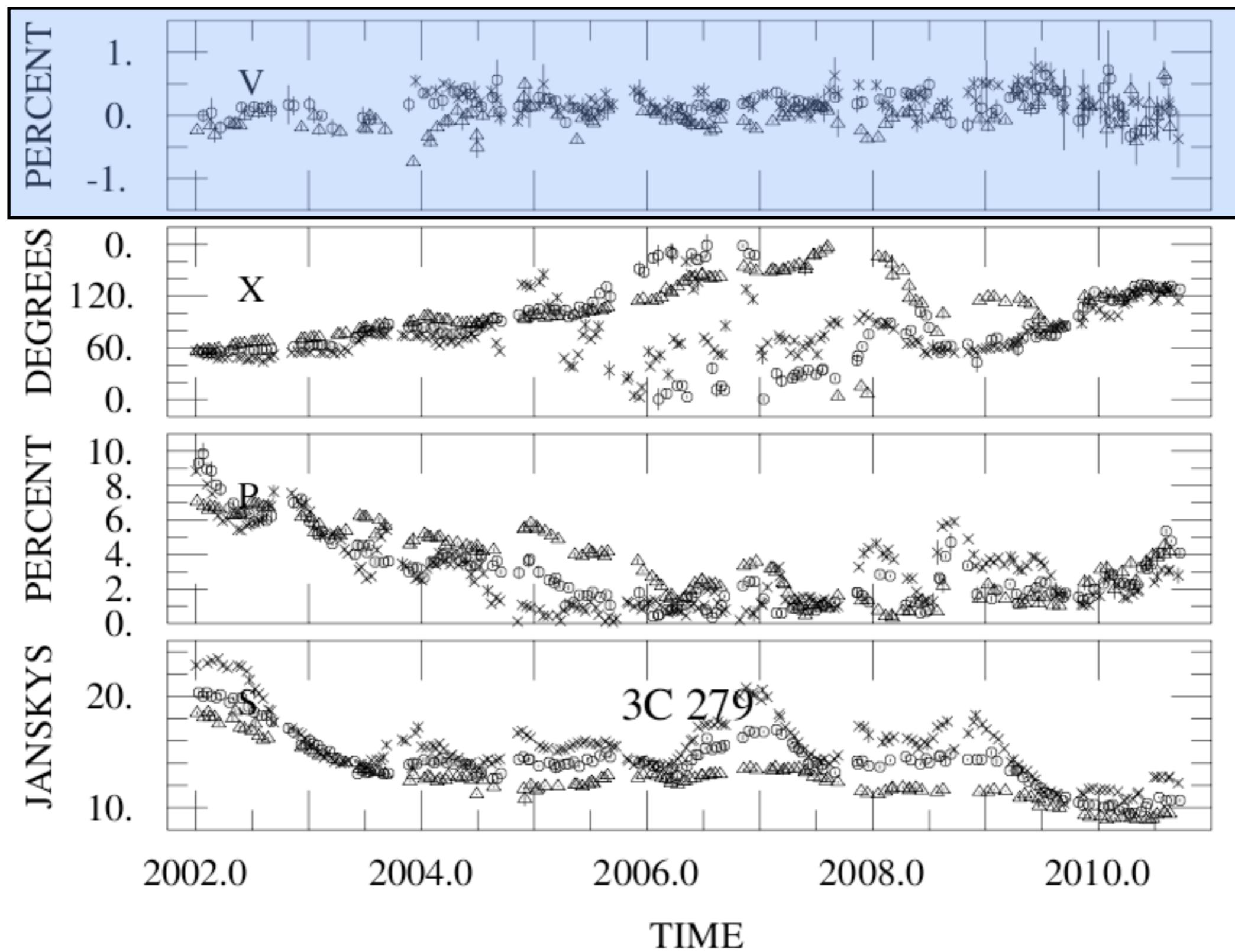


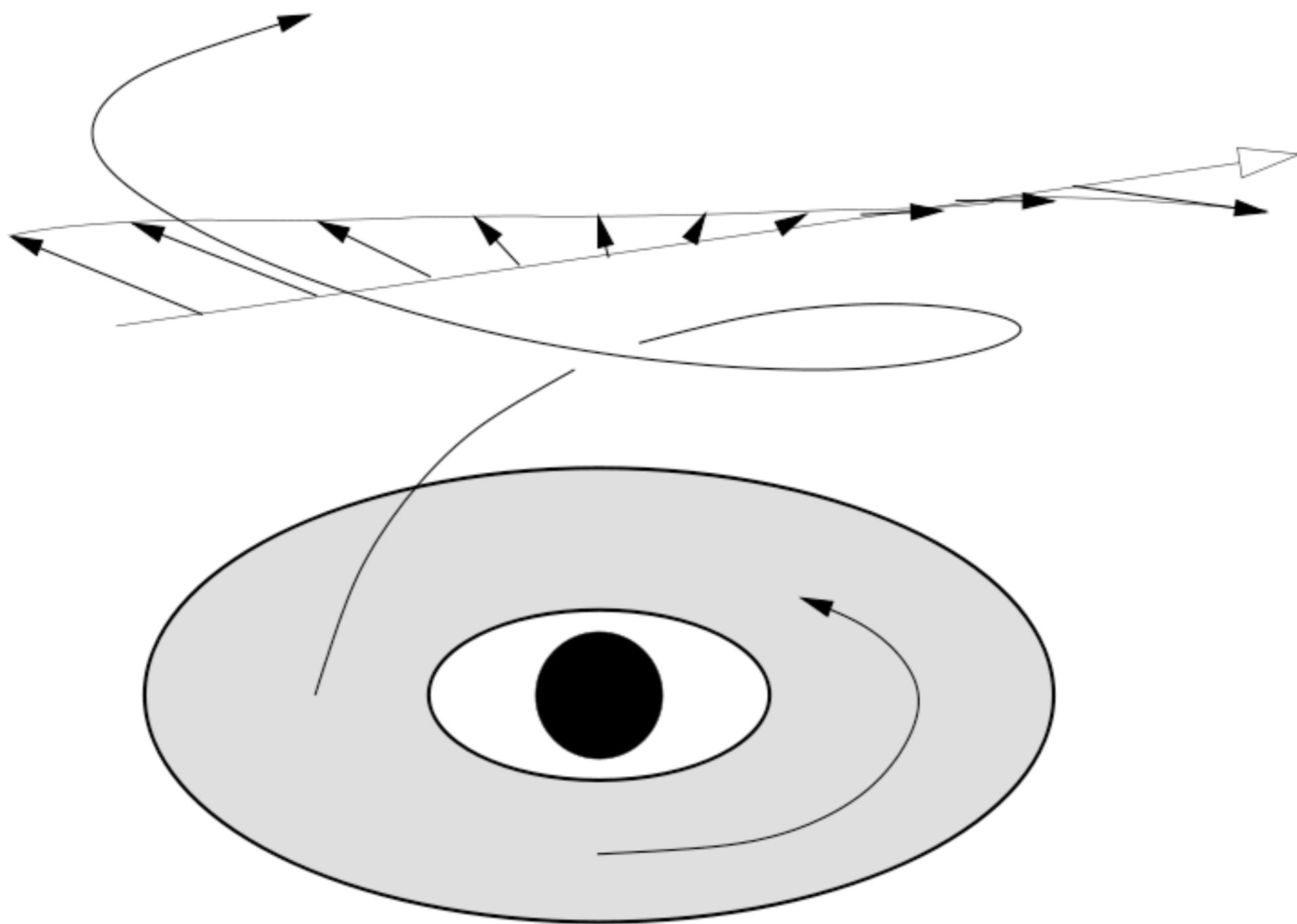
What do changes in the sign of circular polarization tell us about conditions in the jet?

University of Michigan Radio Telescope

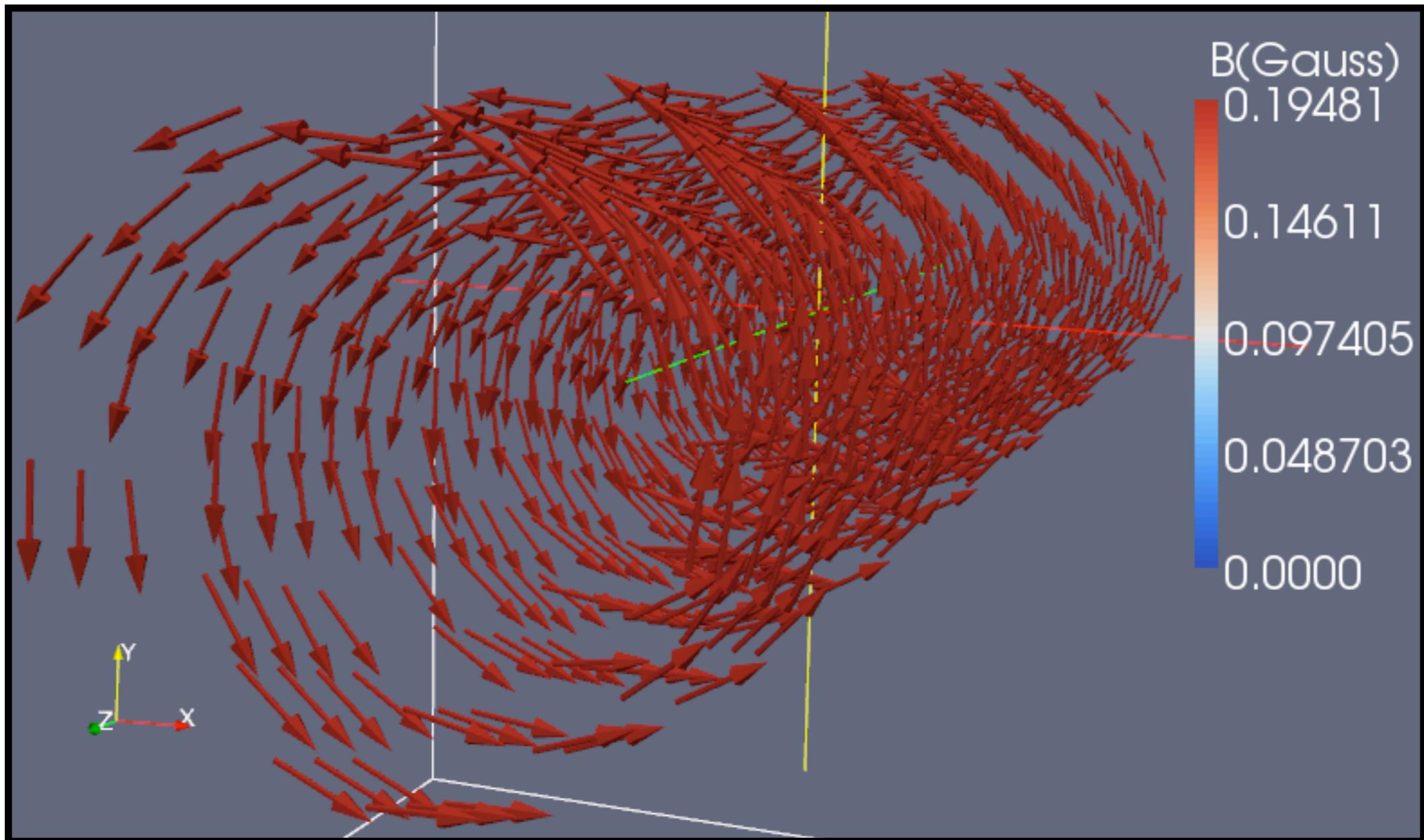






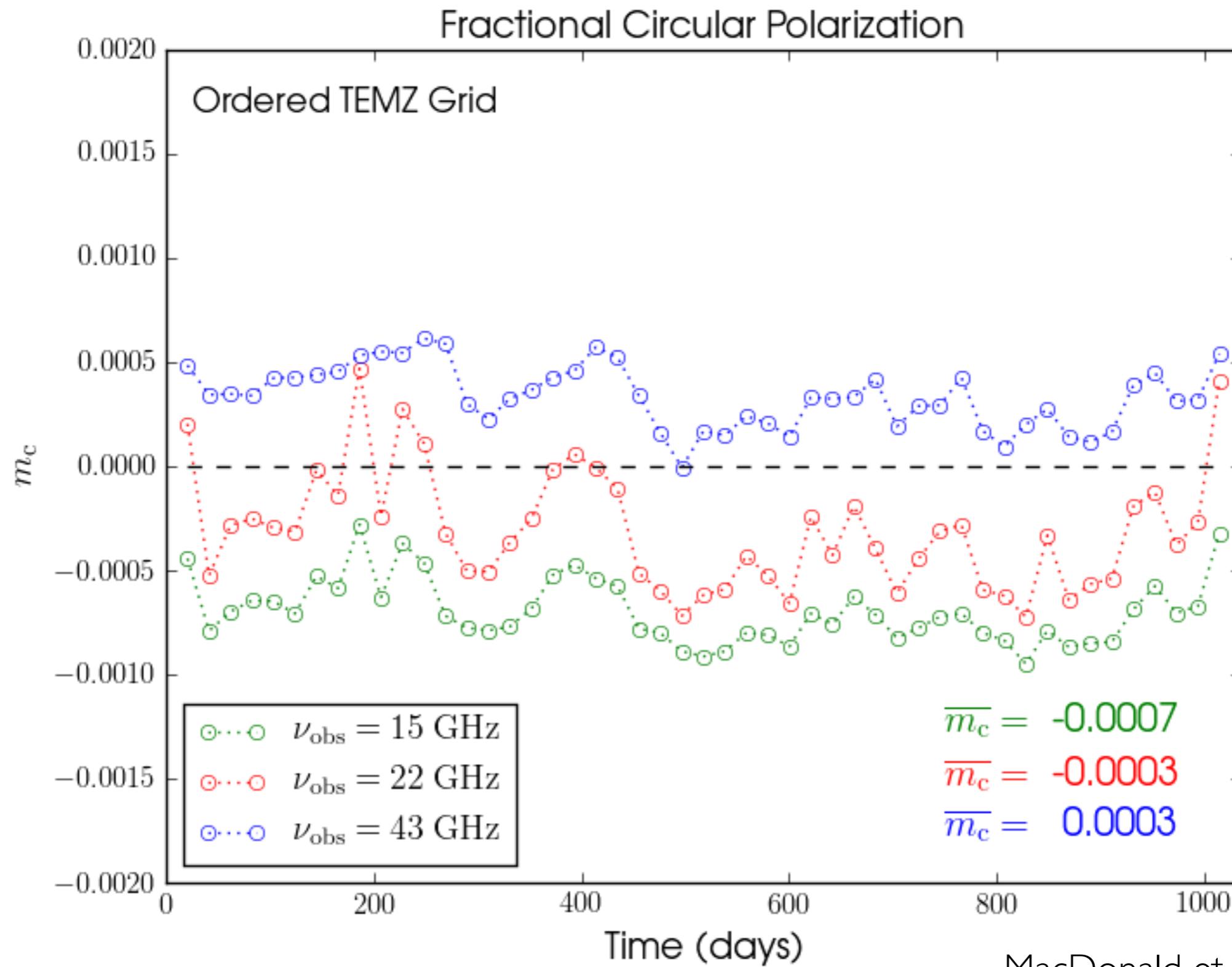


TEMZ Model (Order)

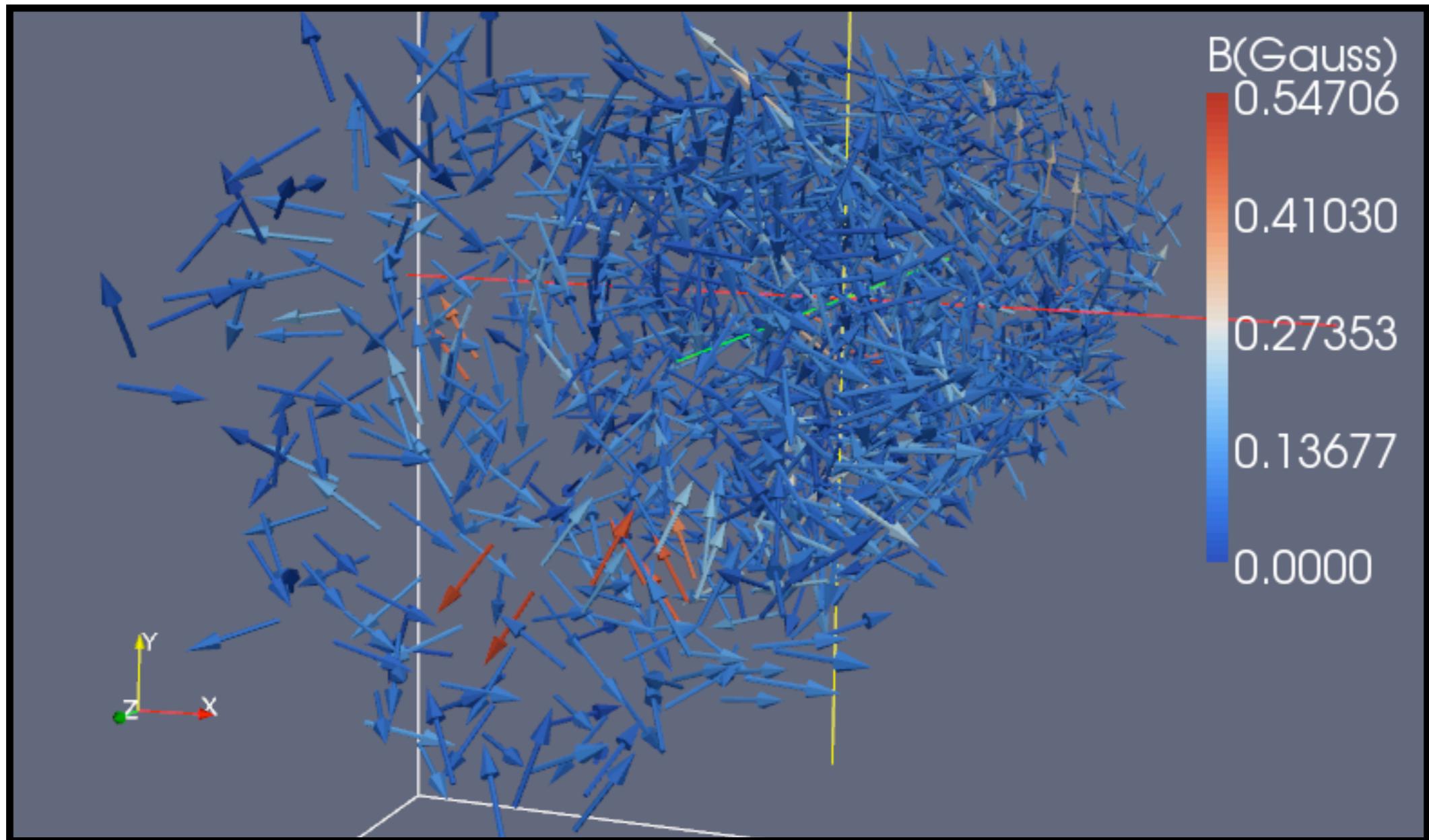


MacDonald et. al (submitted)

TEMZ Model (Order)

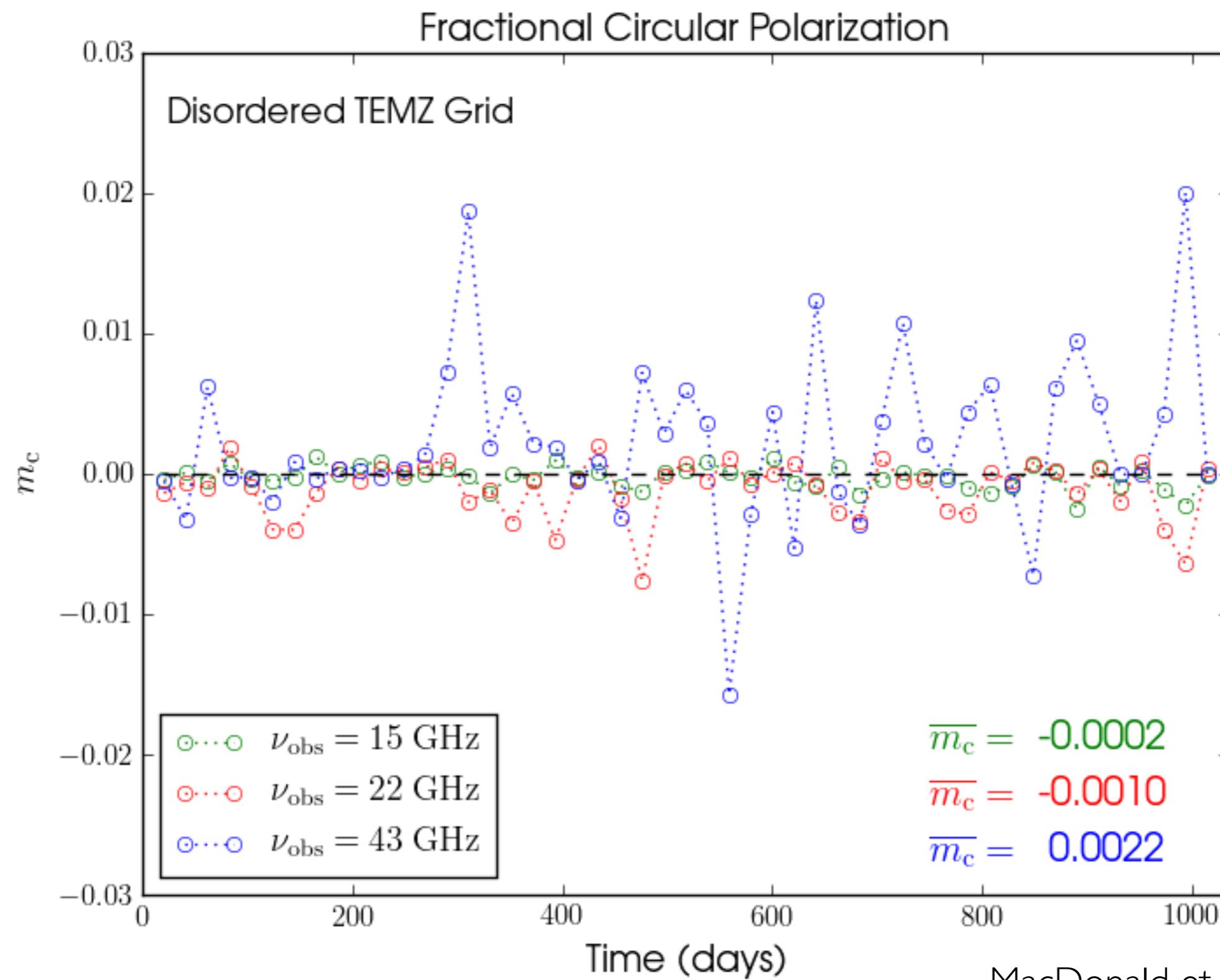


TEMZ Model (Disorder)



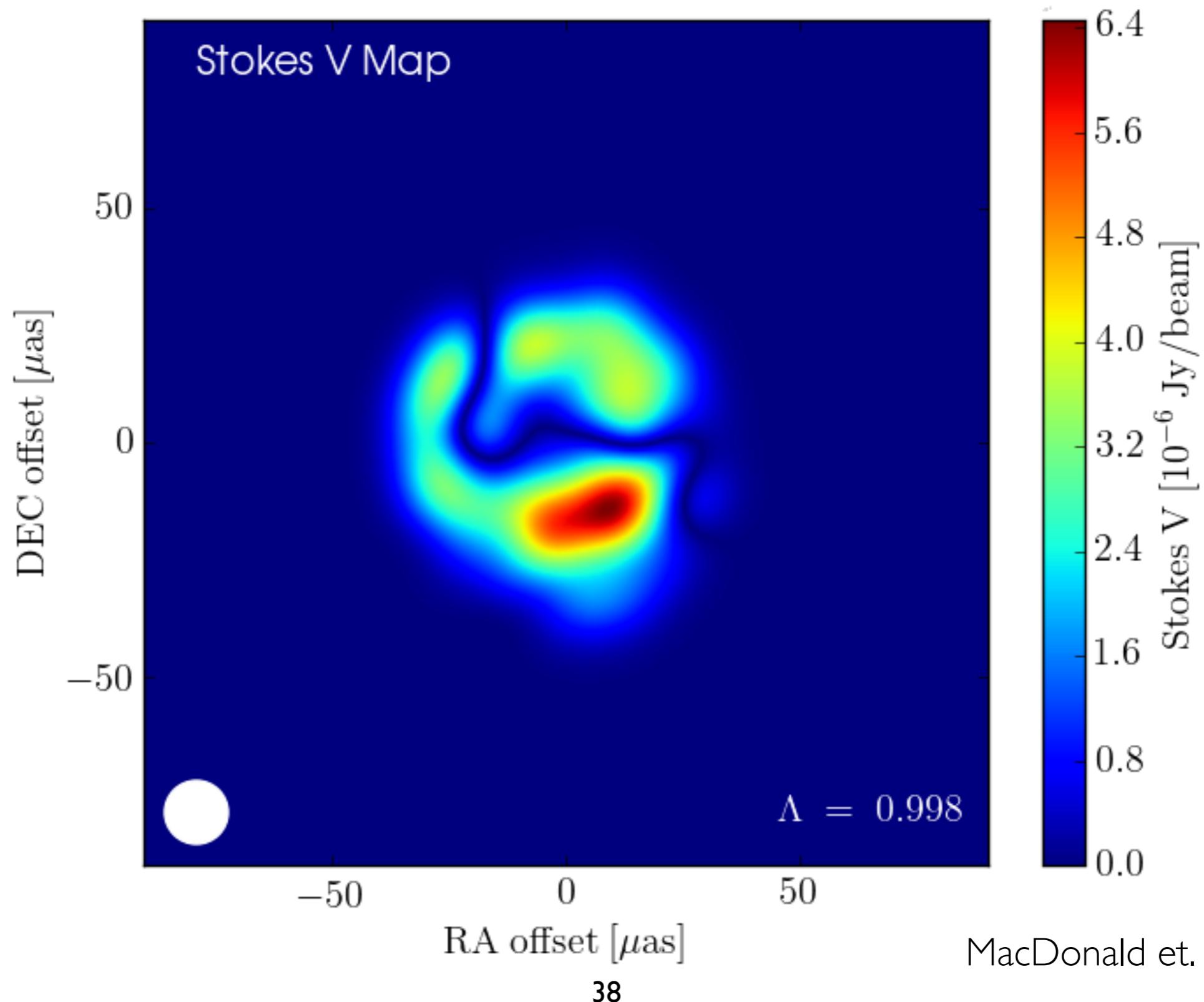
MacDonald et. al (submitted)

TEMZ Model (Disorder)

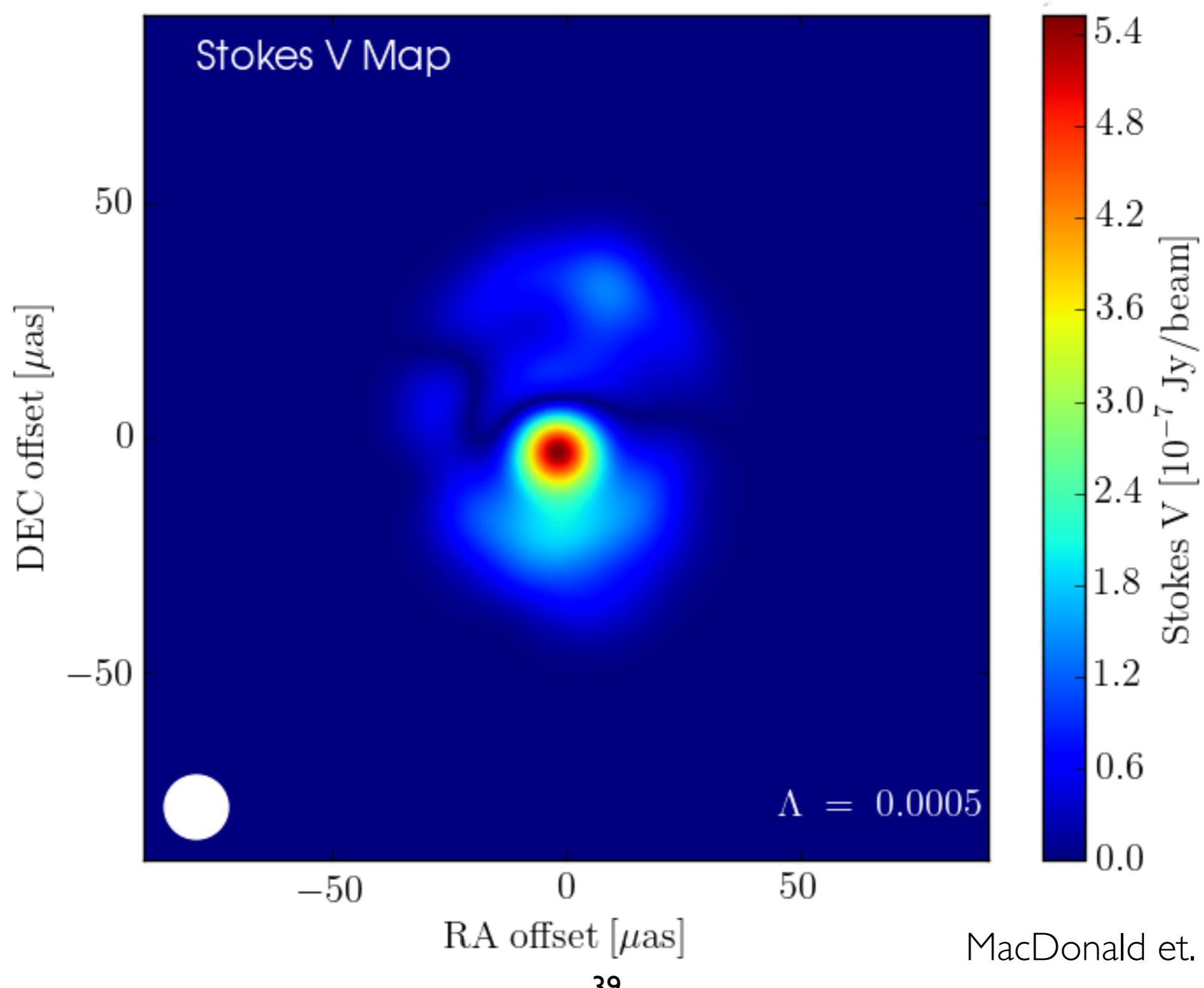


How sensitive is circular polarization to the plasma composition of the jet?

Plasma Composition Study



Plasma Composition Study

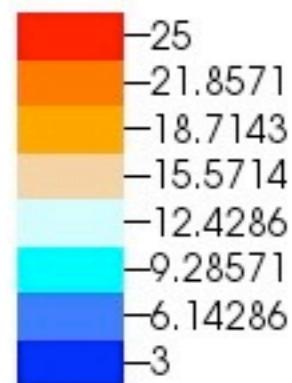


Future Work: Particle-in-Cell Jet Simulations

PIC Model

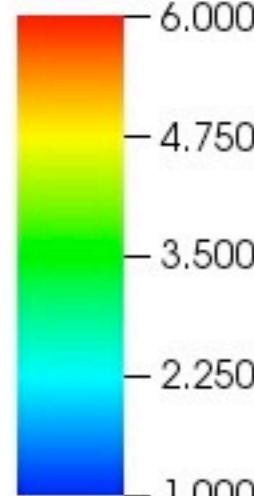
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Cycle: 26 Time:26

Contour
Var: Jet_EL_Lor

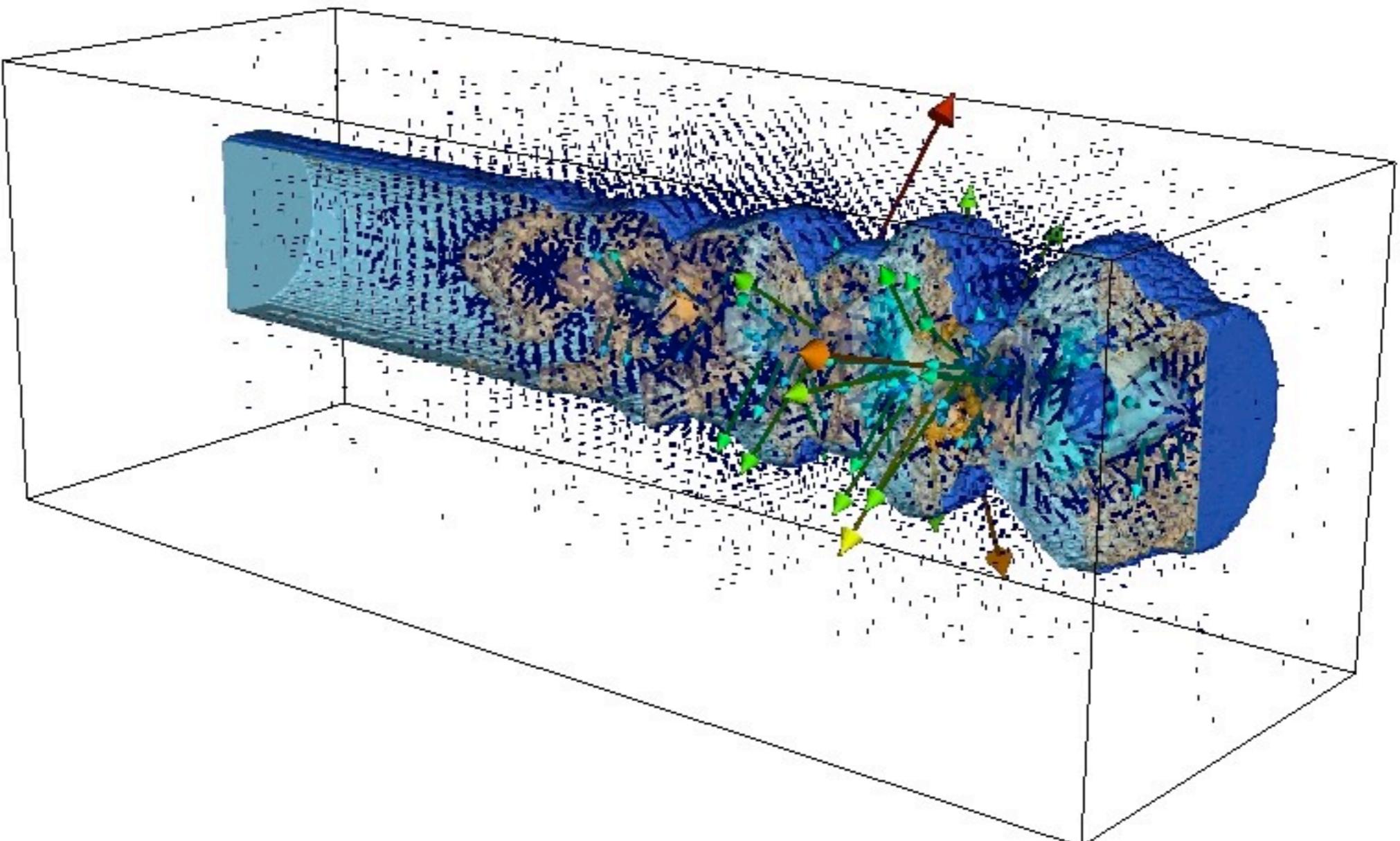


Max: 23.00
Min: 1.000

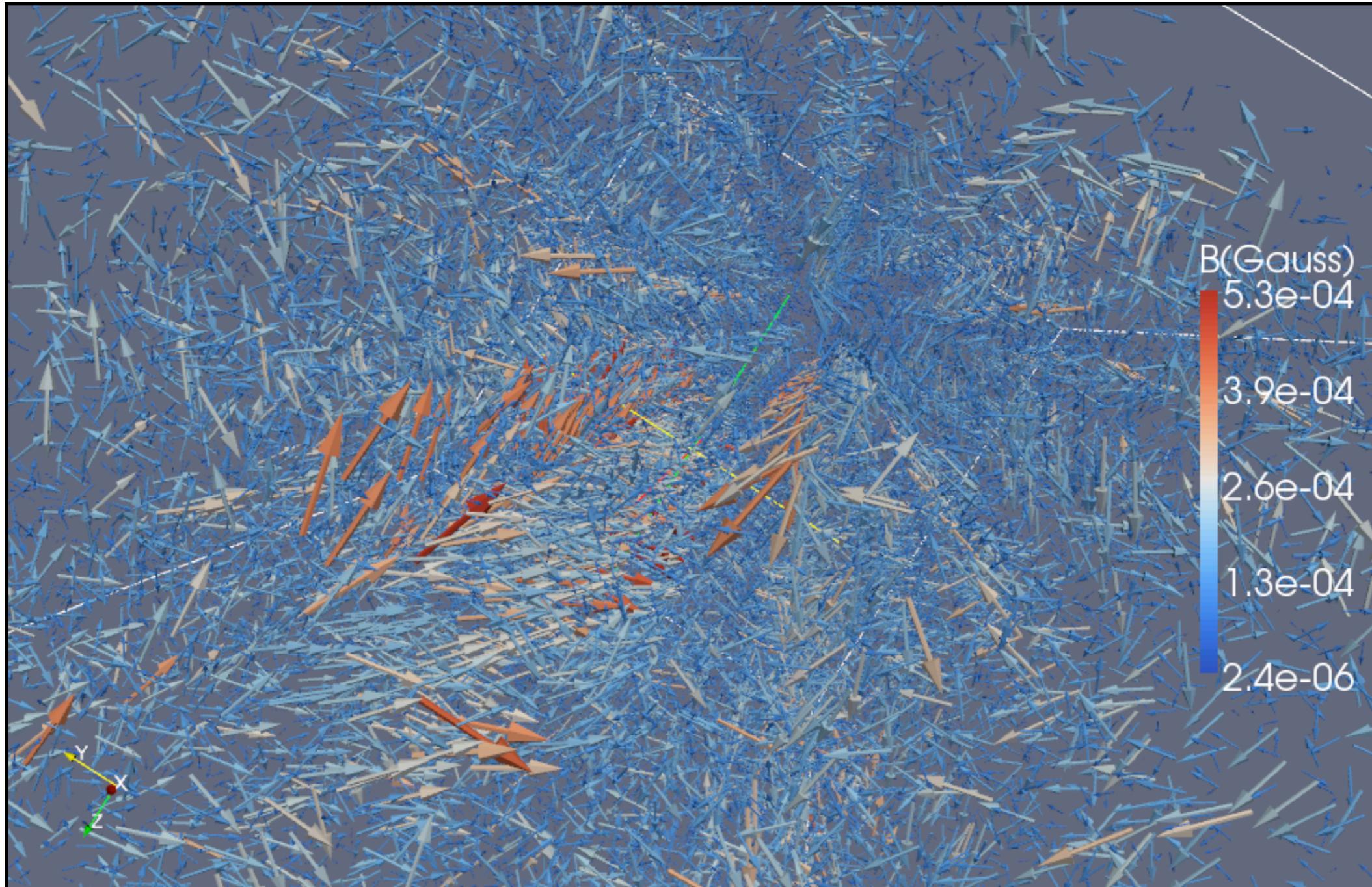
Vector
Var: E-field



Max: 5.976
Min: 9.013e-06



PIC Model



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Questions?

