

# The Connection between Supernova Remnants and the Galactic Magnetic Field

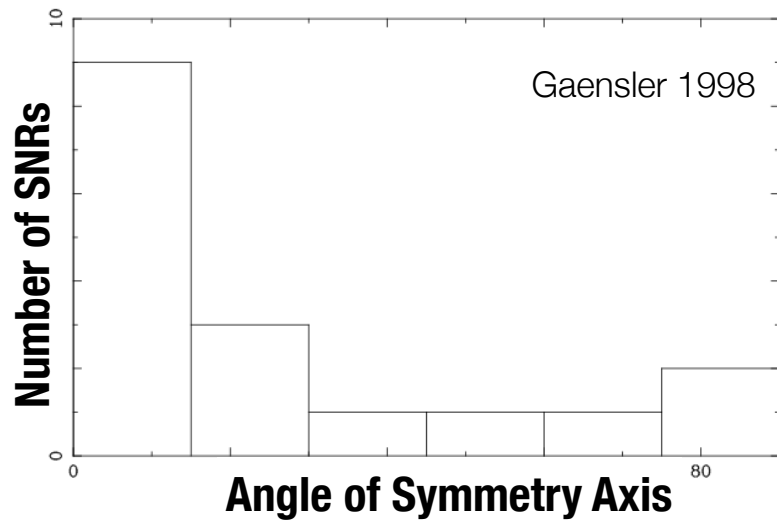
(A&A, under revision)

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Collaborators: Tess Jaffe (IRAP, Toulouse, France), Roland Kothes (NRC Herzberg, Canada), Tom Landecker (NRC Herzberg, Canada), Tyler Foster (Brandon U., Canada)

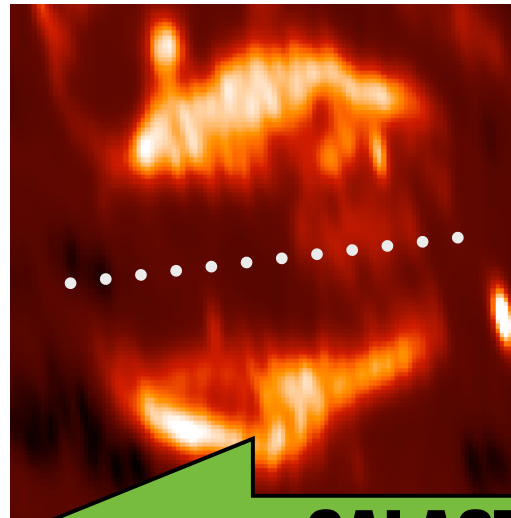
# Is there a connection between the Galactic Magnetic Field and Supernova Remnants?



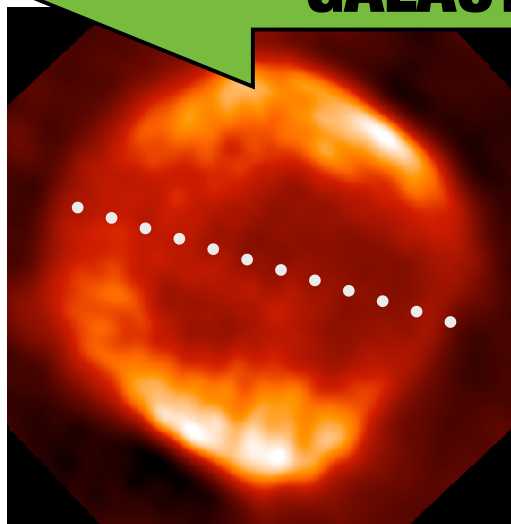
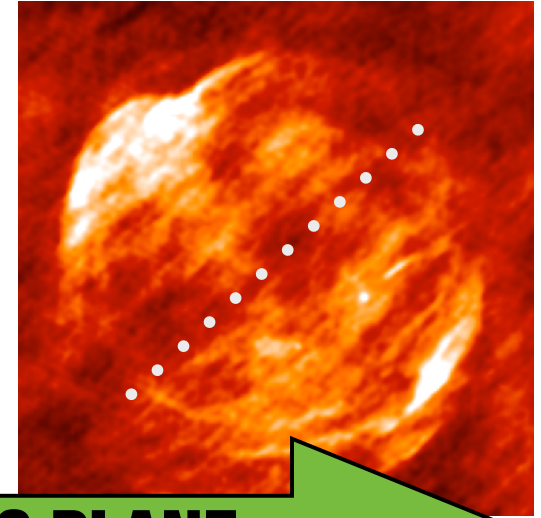
Gaensler (1998): a highly significant tendency for the axes of these SNRs to be aligned with the Galactic plane

Leckband et al. (1989): no preferred orientation between the angle of symmetry and the Galactic plane

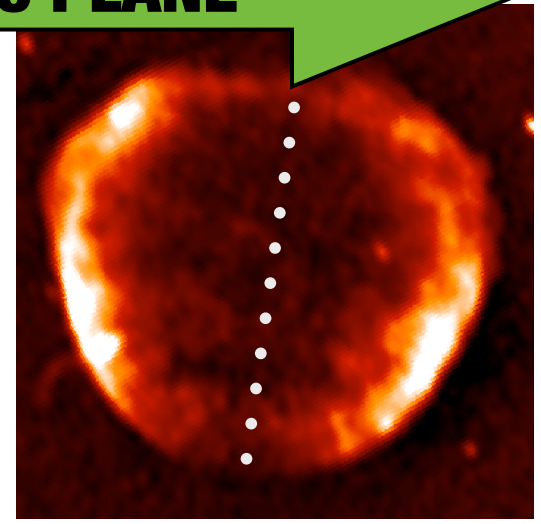
G003.8-00.3



G046.8-00.3

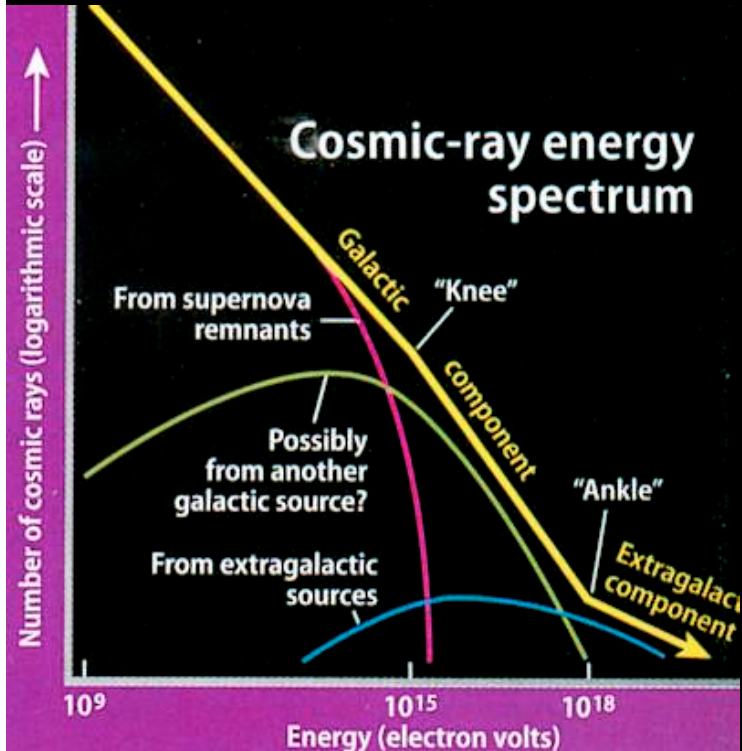


G332.0+00.2



G327.6+14.6 (SN1006)

What can magnetic fields tell us about cosmic ray acceleration?



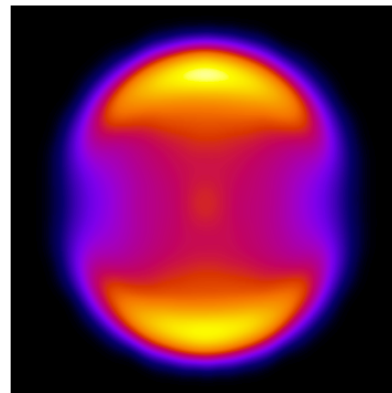
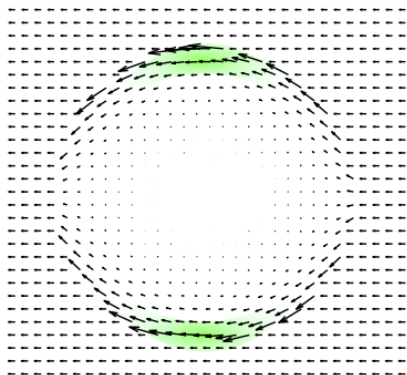
**Soft X-Rays**  
**Hard X-Rays**

Credit: NASA/CXC/Middlebury College/F.Winkler

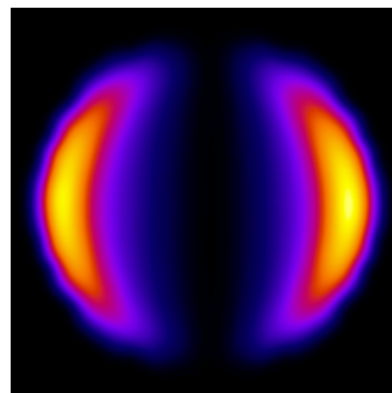
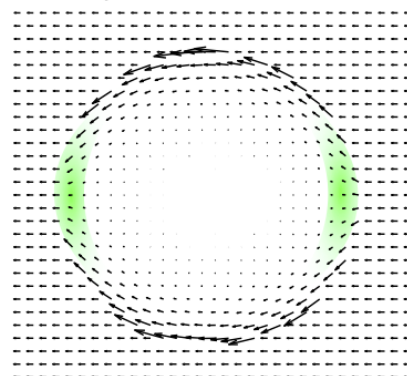
**Magnetic field lines (black)  
and cosmic ray electron  
distribution (green)**

**Simulated radio  
synchrotron emission**

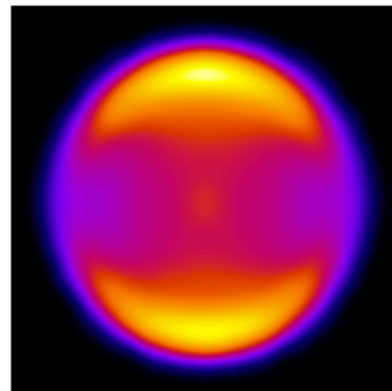
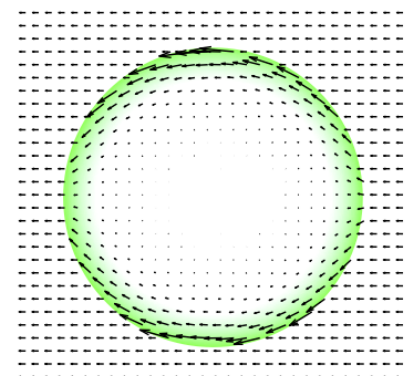
Quasi-perpendicular



Quasi-parallel



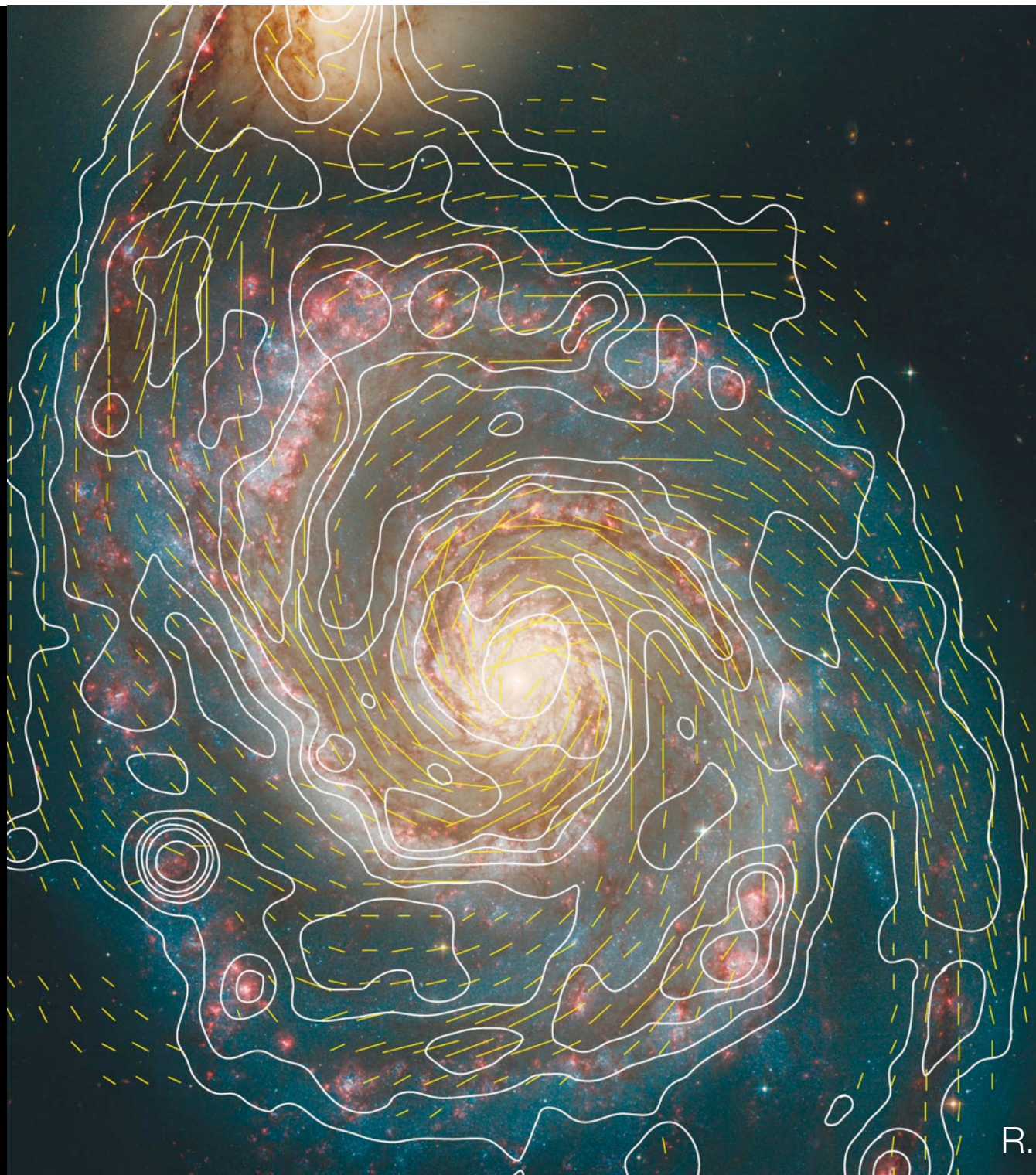
Isotropic



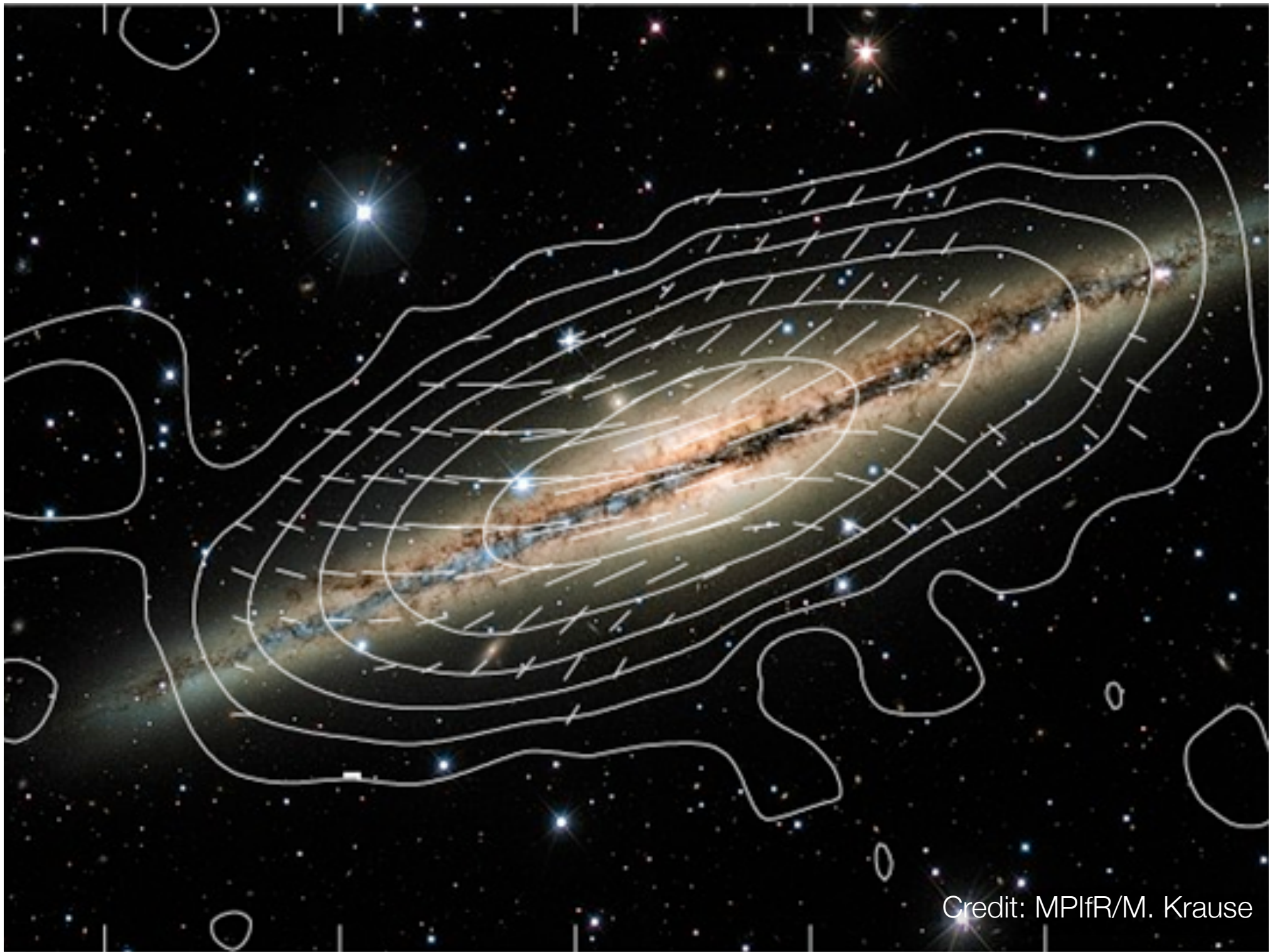
**Method:** Use a model of the Galactic magnetic field to model the appearance of SNRs at their specific location in the Galaxy

What do we know about the magnetic field of the Milky Way Galaxy?

How do we know its shape?

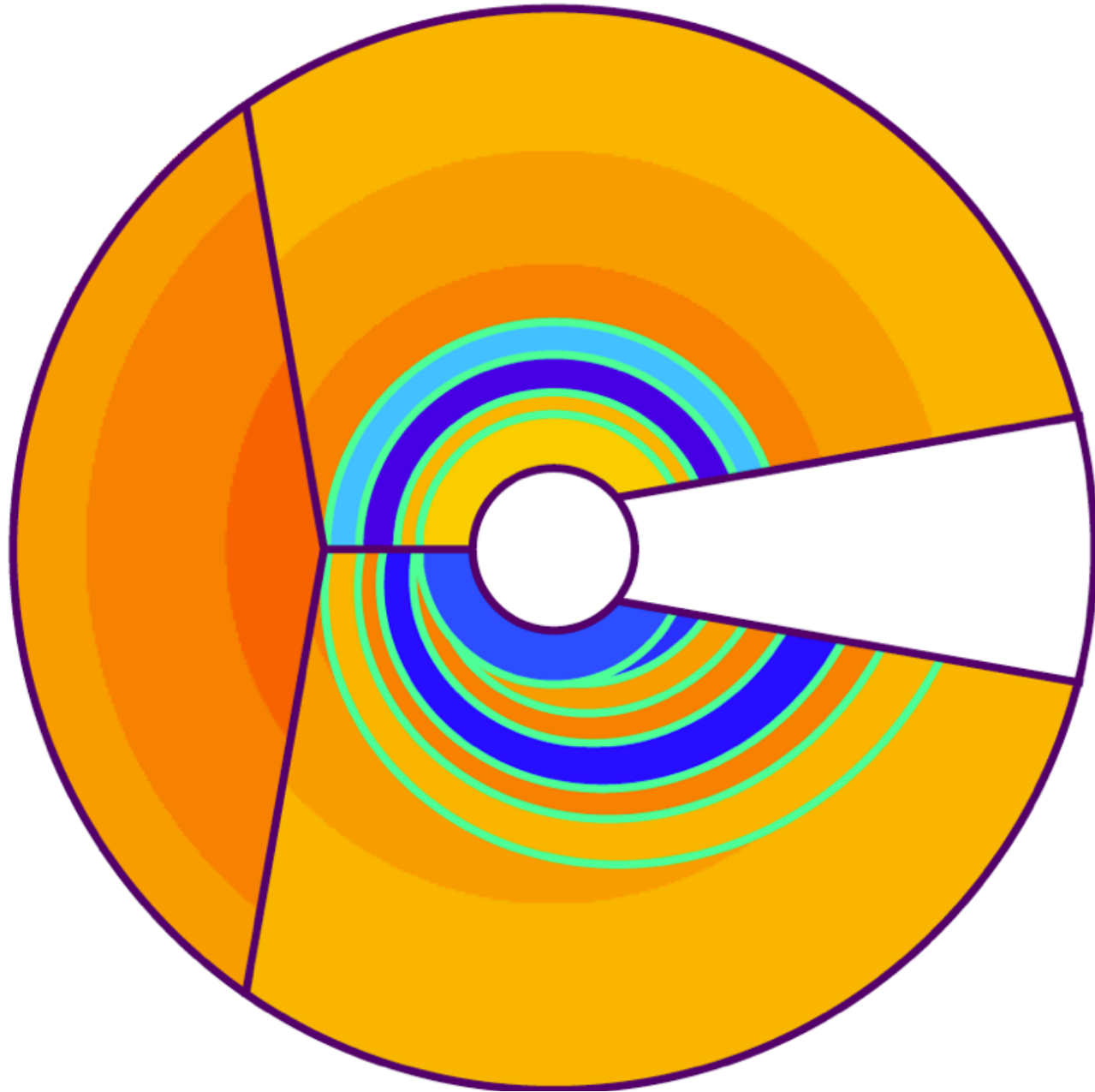


Credit: MPIfR/  
R.Beck/A.Fletcher



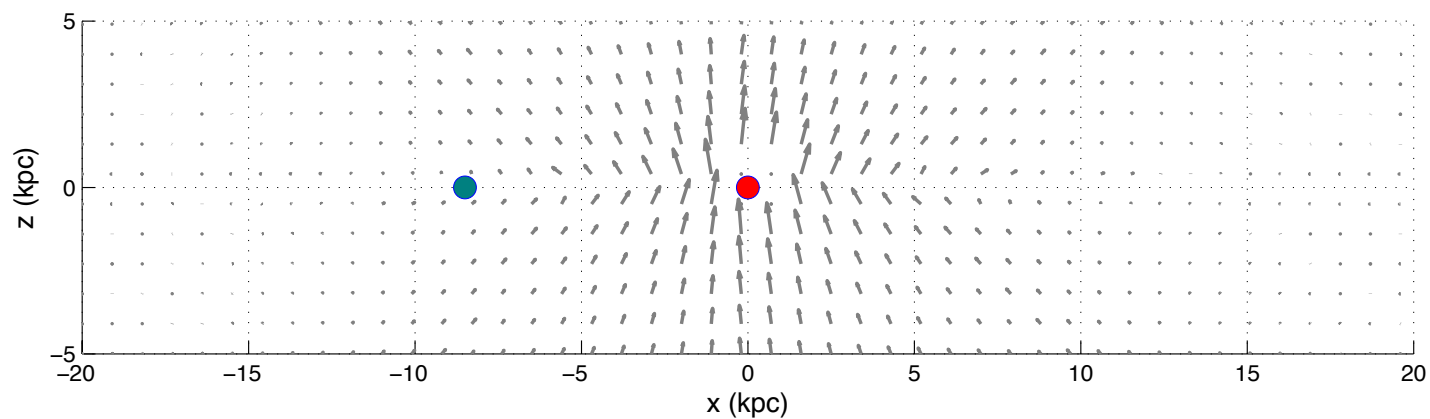
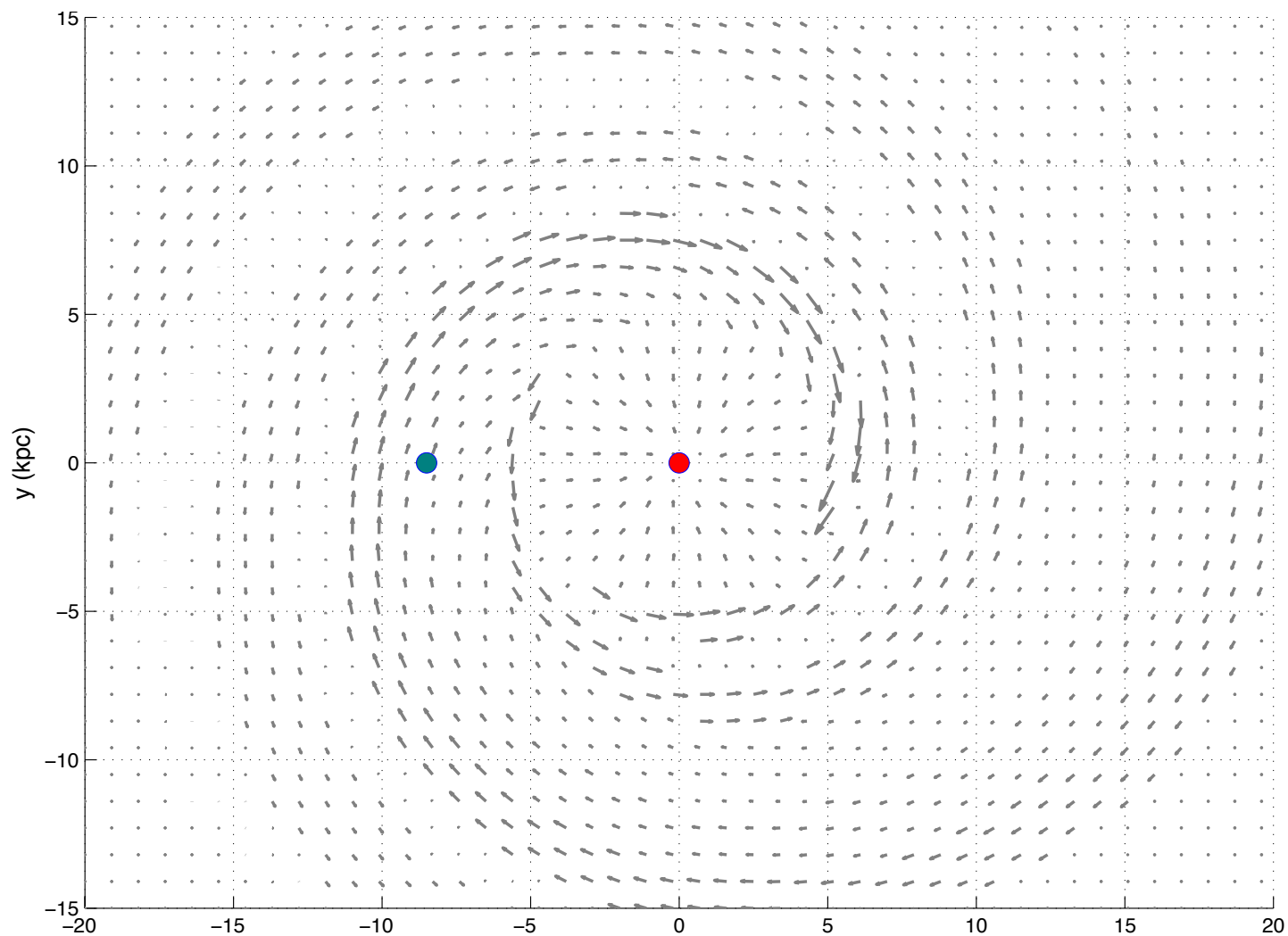
Credit: MPIfR/M. Krause

# Rotation measure studies of extra-galactic point sources



Credit: VanEck/Brown

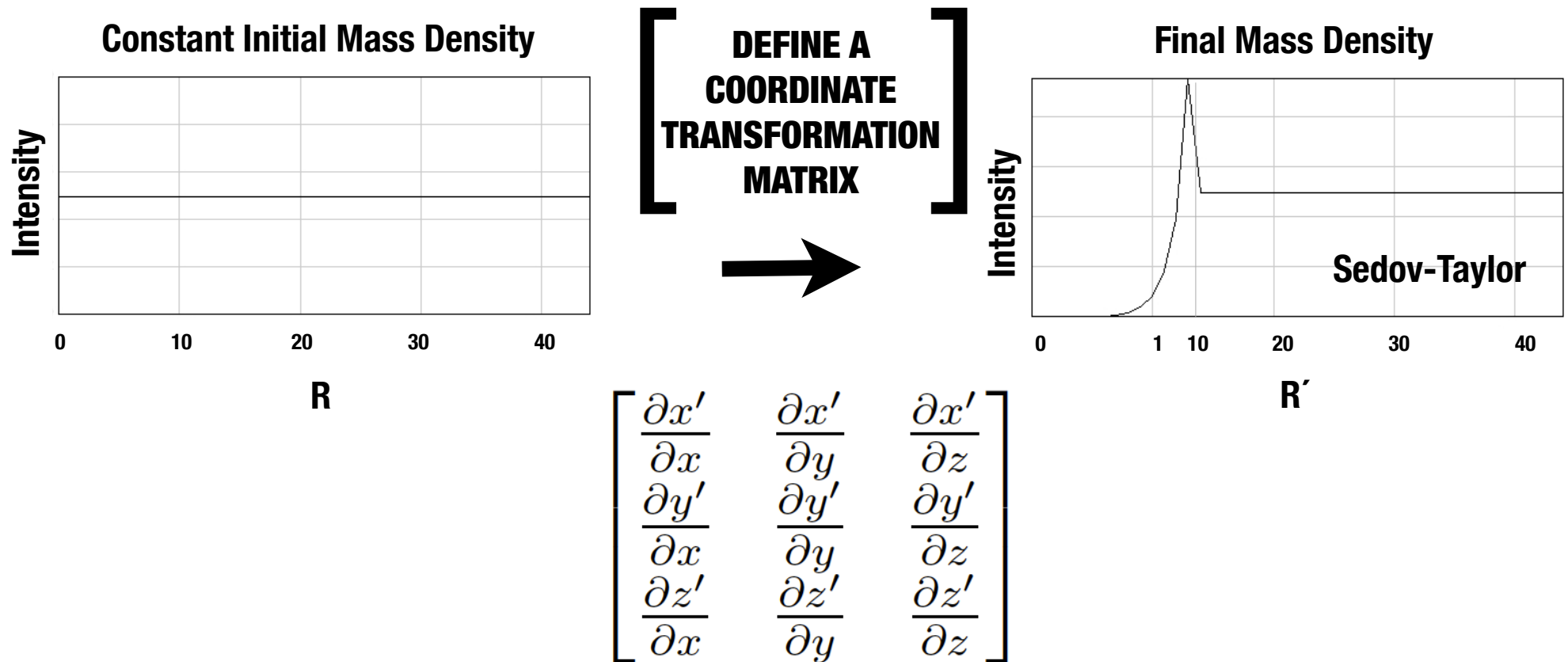
Galactic  
Magnetic Field  
model of  
Jansson &  
Farrar, 2012



# Modelling SNRs in the Galaxy

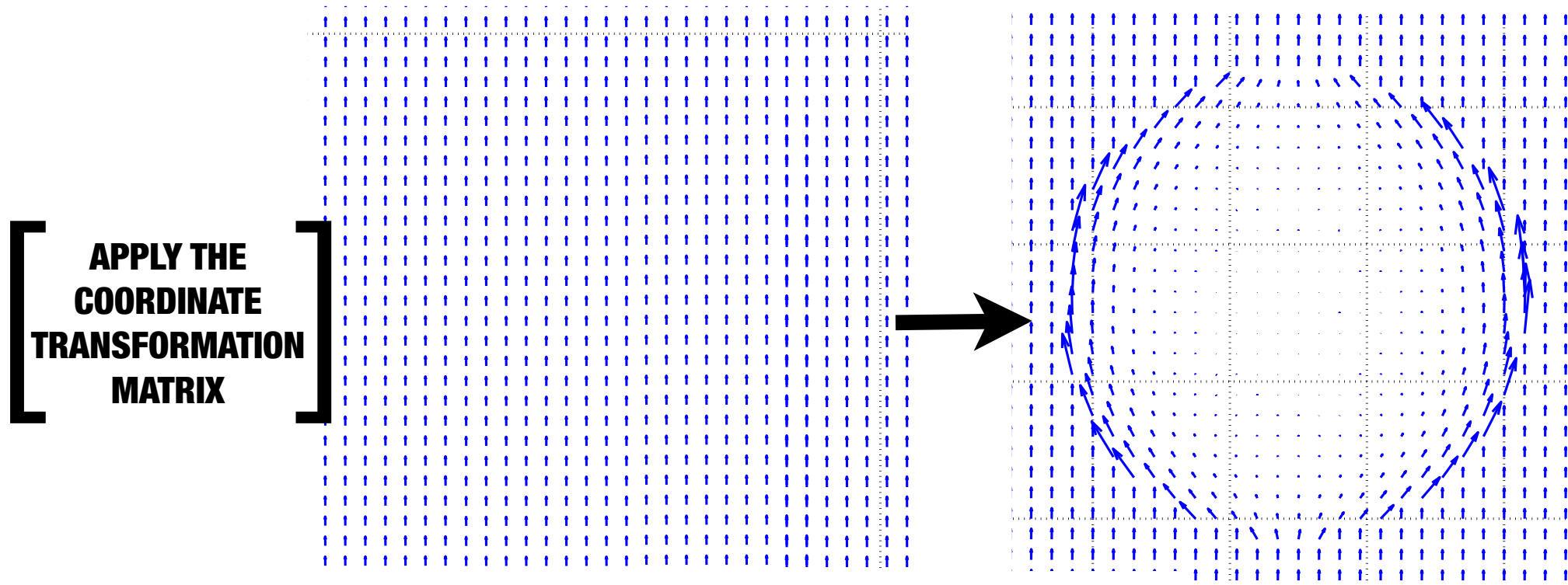
# Modelling the Supernova Remnant

Define a coordinate transformation which transforms  $R$  to  $R'$  while mass is conserved.



# Use the Coordinate Transformation Matrix to Transform the Magnetic Field in 3D

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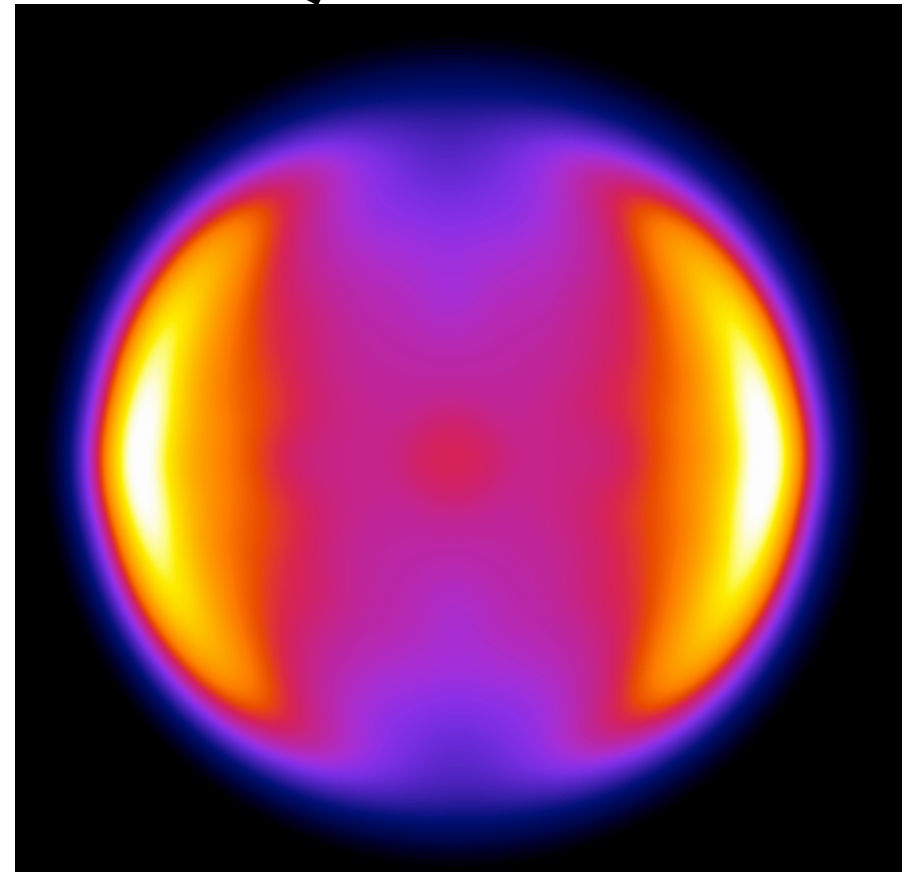
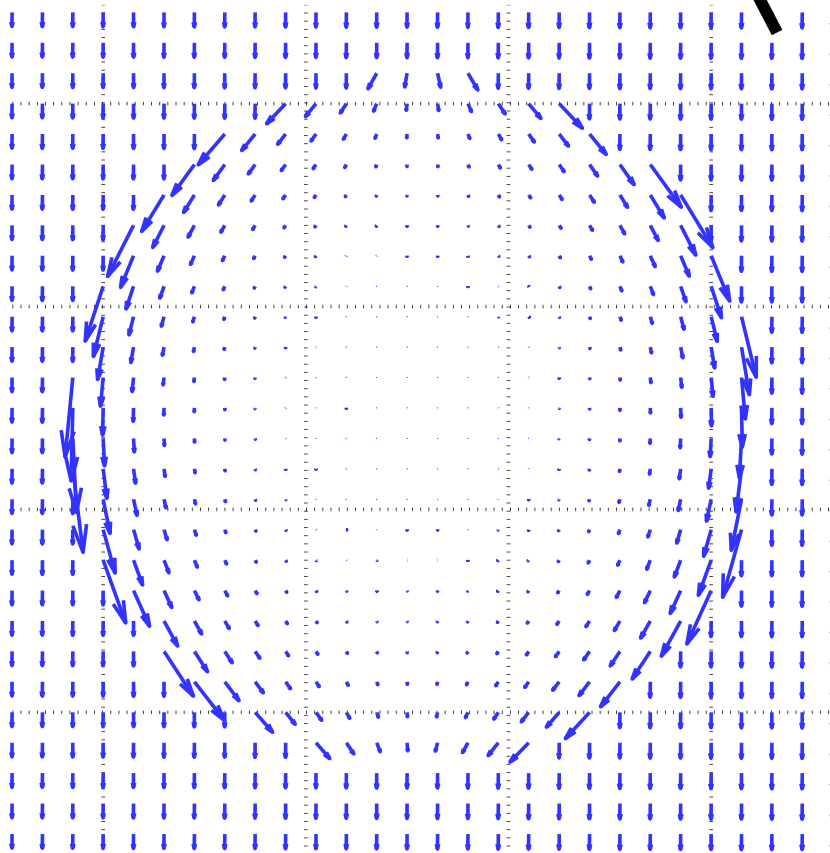


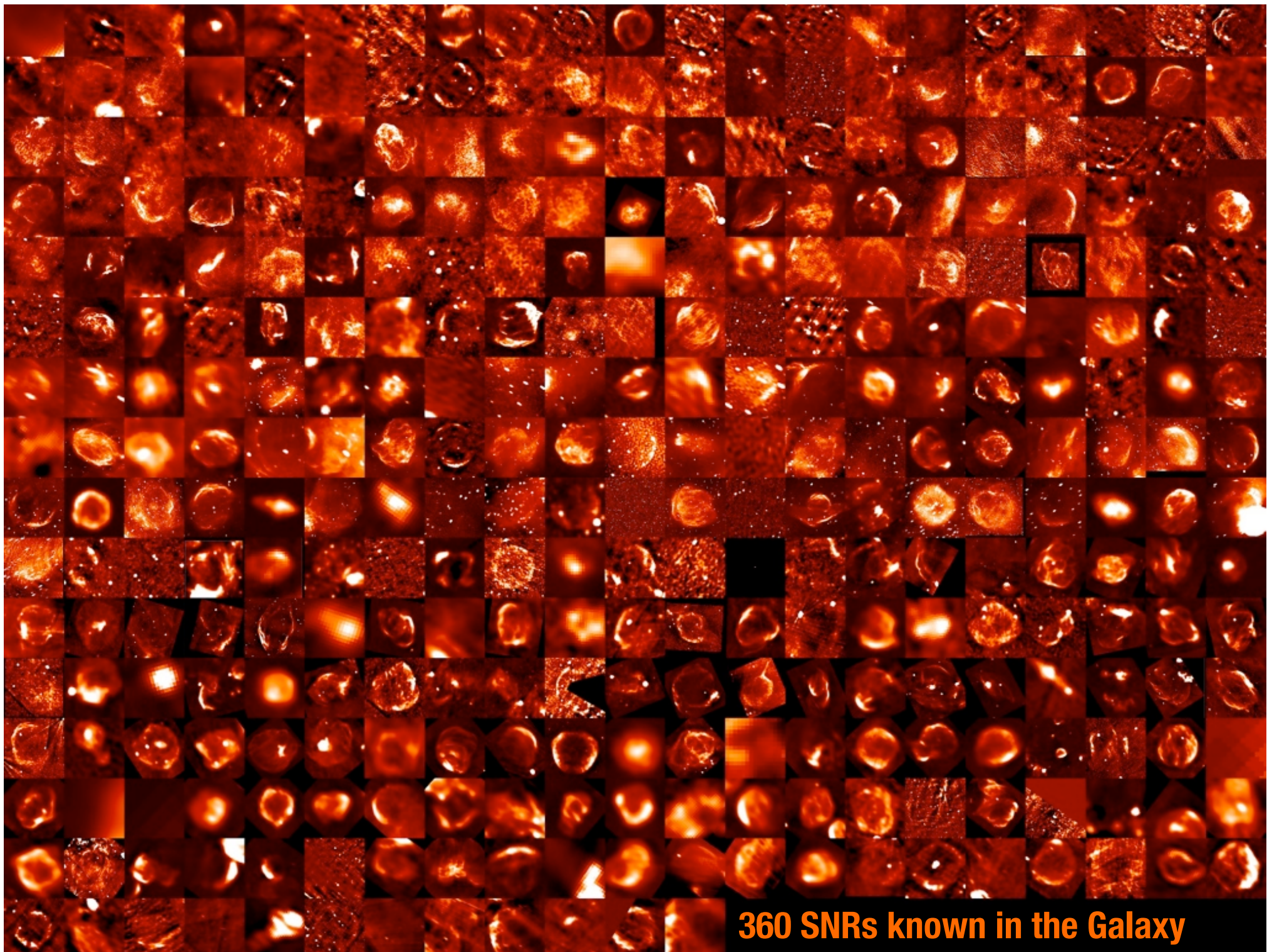
$$\frac{1}{\det \mathbf{J}} \begin{bmatrix} \frac{\partial x'}{\partial x} & \frac{\partial x'}{\partial y} & \frac{\partial x'}{\partial z} \\ \frac{\partial y'}{\partial x} & \frac{\partial y'}{\partial y} & \frac{\partial y'}{\partial z} \\ \frac{\partial z'}{\partial x} & \frac{\partial z'}{\partial y} & \frac{\partial z'}{\partial z} \end{bmatrix} \begin{bmatrix} B_x \\ B_y \\ B_z \end{bmatrix} = \begin{bmatrix} B_x' \\ B_y' \\ B_z' \end{bmatrix}$$

# Model Synchrotron Intensity

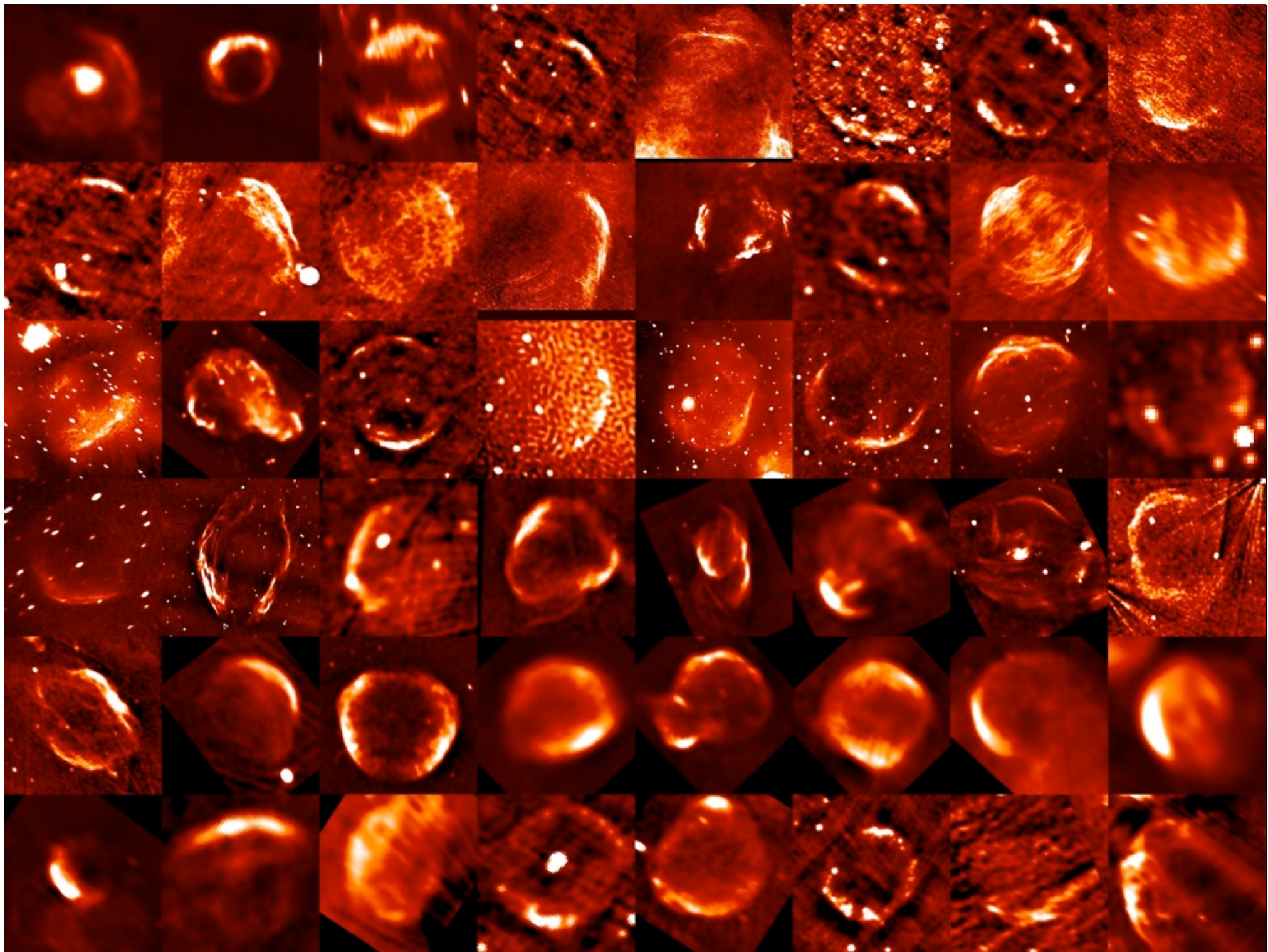
(constant CRE distribution)  $\rightarrow$   ~~$K(\alpha)$~~   $B_{\perp}^{\alpha+1} \nu^{-\alpha} = j_{\nu}$

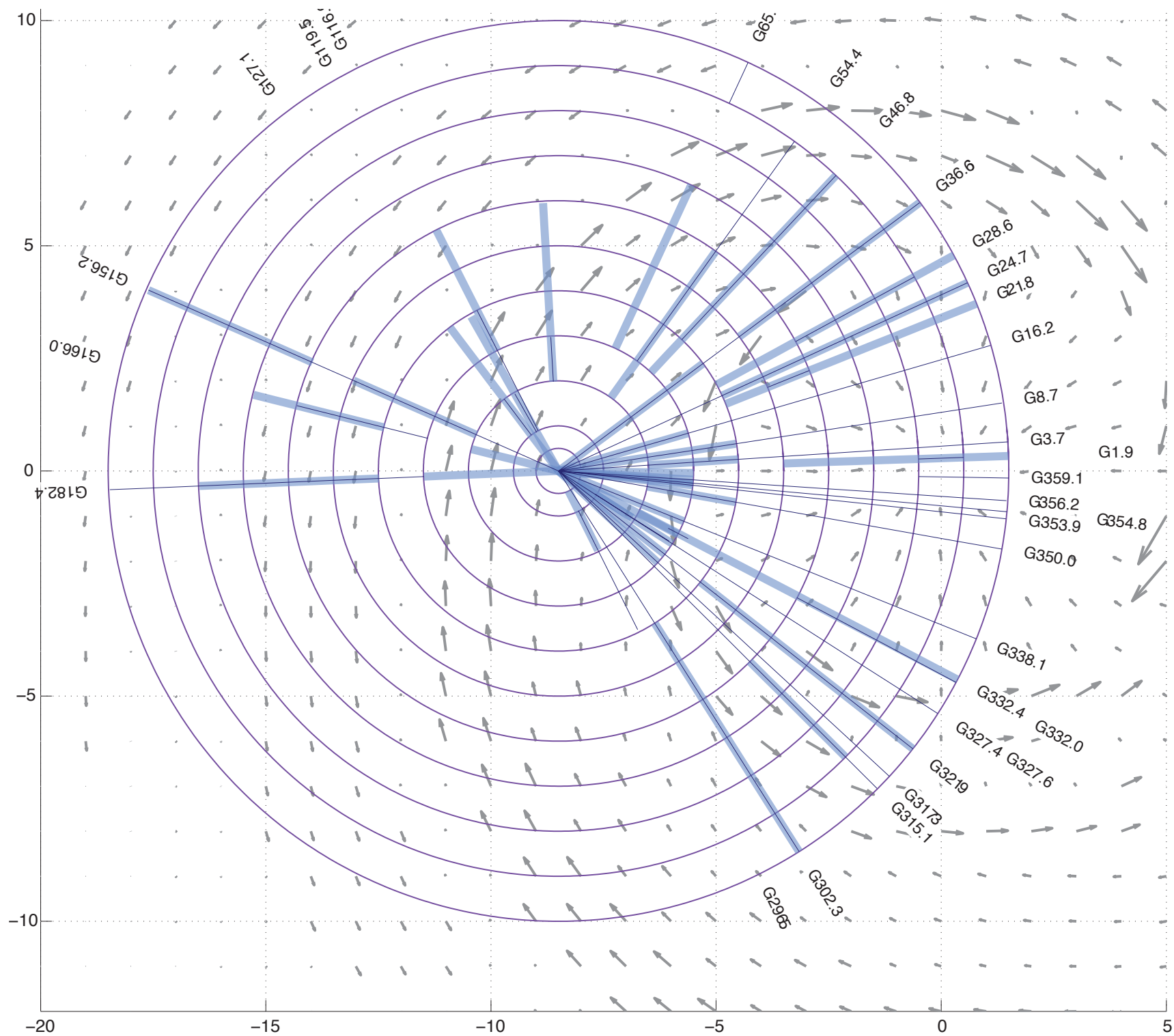
$\alpha$  = spectral index  
 $\nu$  = observation frequency  
 $j_{\nu}$  = synchrotron intensity



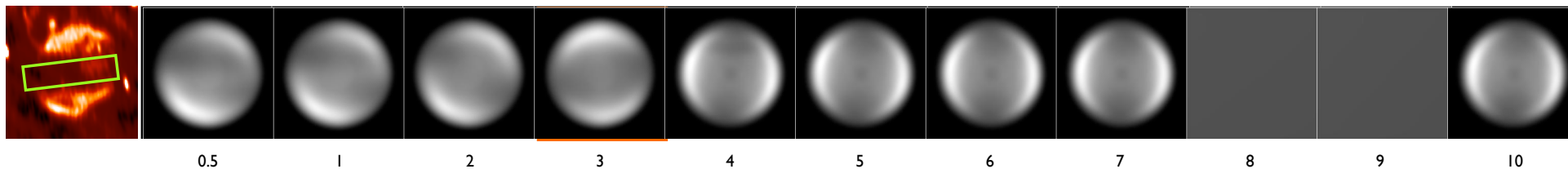


**360 SNRs known in the Galaxy**

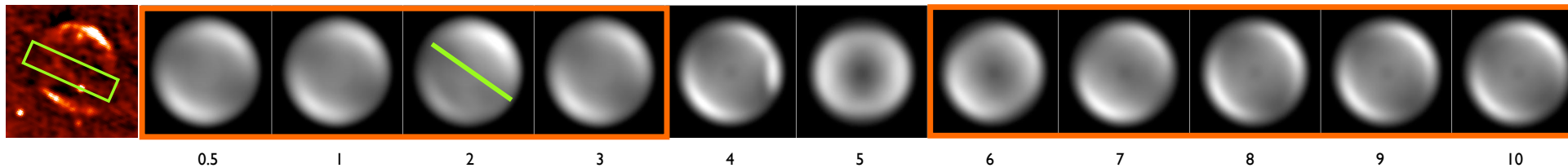




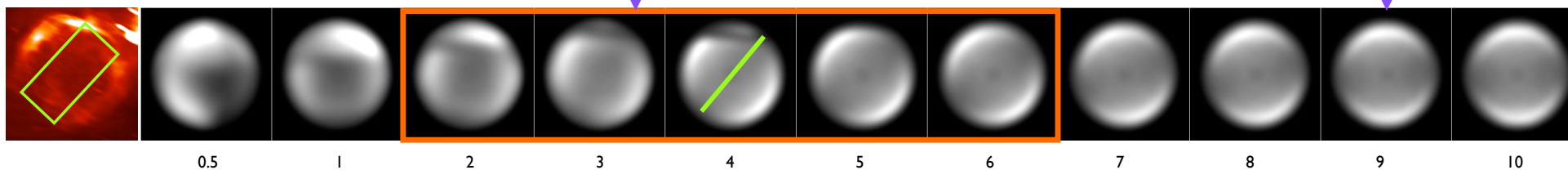
**G003.7-00.2**



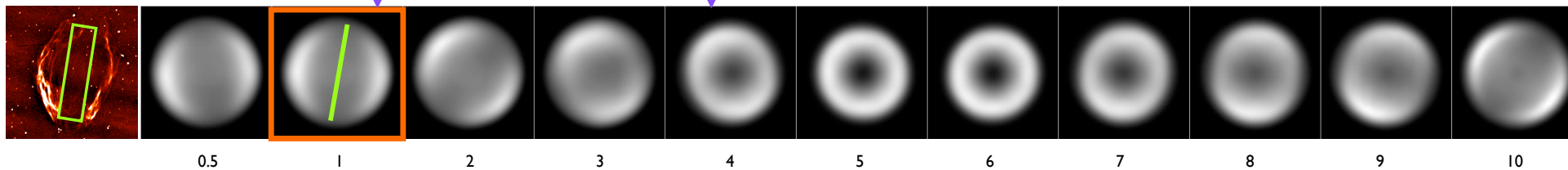
**G036.6+02.6**



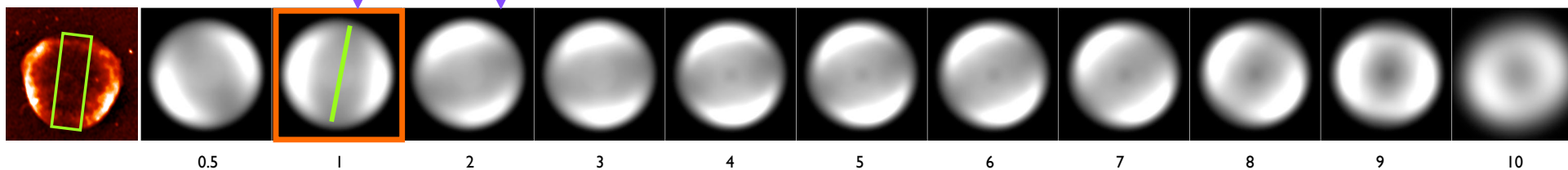
**G054.4-00.3**

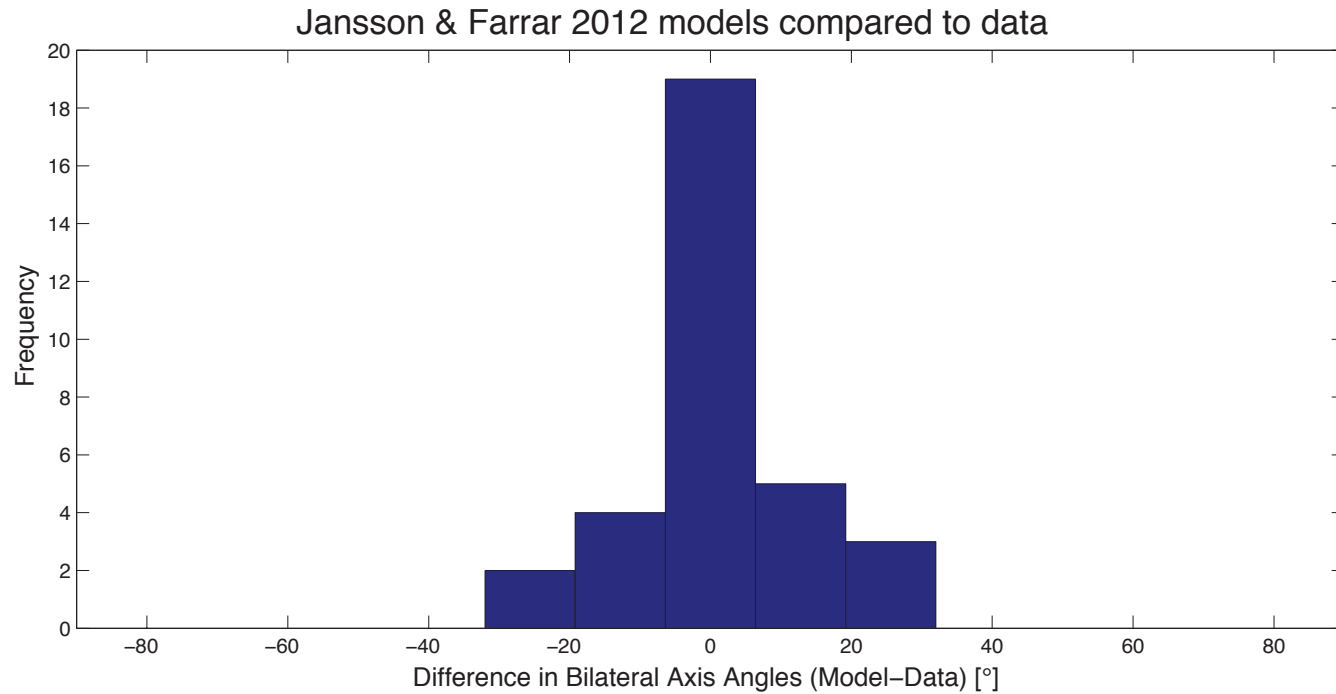


**G296.5+10.0**

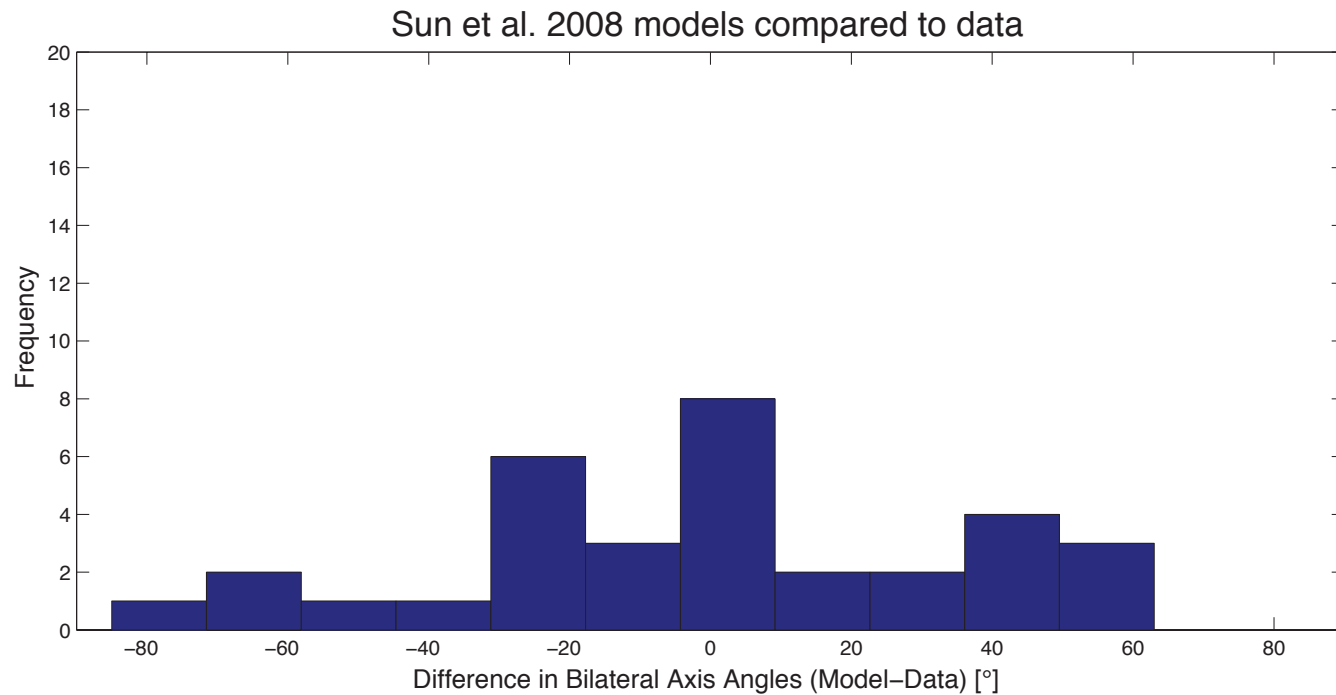


**G327.6+14.6**

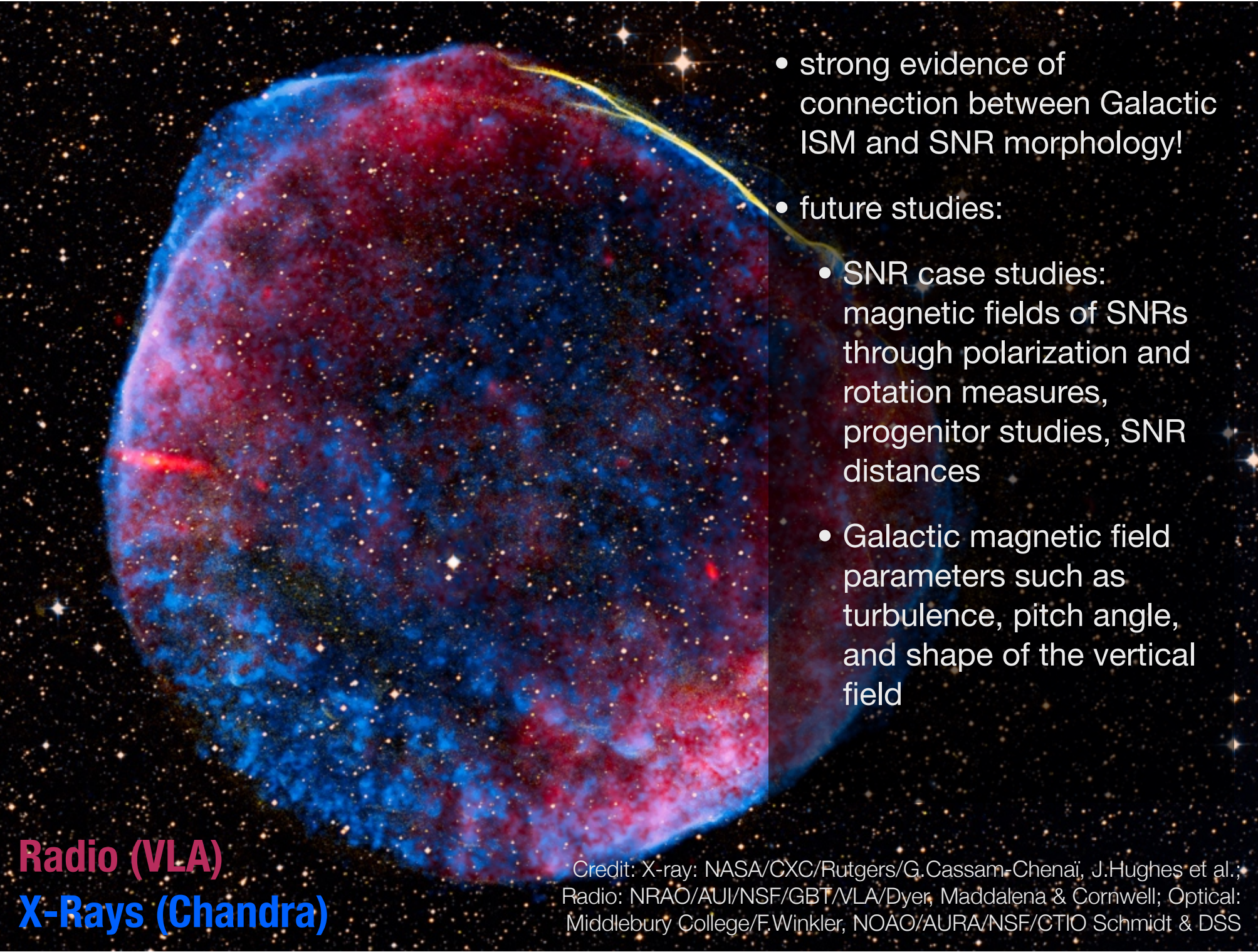




Galactic  
magnetic  
field model  
with an **X-  
shaped halo  
component**



Galactic Field  
model with  
**no vertical  
component**  
(toroidal halo  
component  
only)

- 
- strong evidence of connection between Galactic ISM and SNR morphology!
  - future studies:
    - SNR case studies: magnetic fields of SNRs through polarization and rotation measures, progenitor studies, SNR distances
    - Galactic magnetic field parameters such as turbulence, pitch angle, and shape of the vertical field

**Radio (VLA)**

**X-Rays (Chandra)**

Credit: X-ray: NASA/CXC/Rutgers/G.Cassam-Chenaï, J.Hughes et al.;  
Radio: NRAO/AUI/NSF/GBT/VLA/Dyer, Maddalena & Cornwell; Optical:  
Middlebury College/F.Winkler, NOAO/AURA/NSF/CTIO Schmidt & DSS

# Supernova remnant Models & Images at Radio Frequencies (SMIRF)

<http://www.physics.umanitoba.ca/snr/smurf/>

