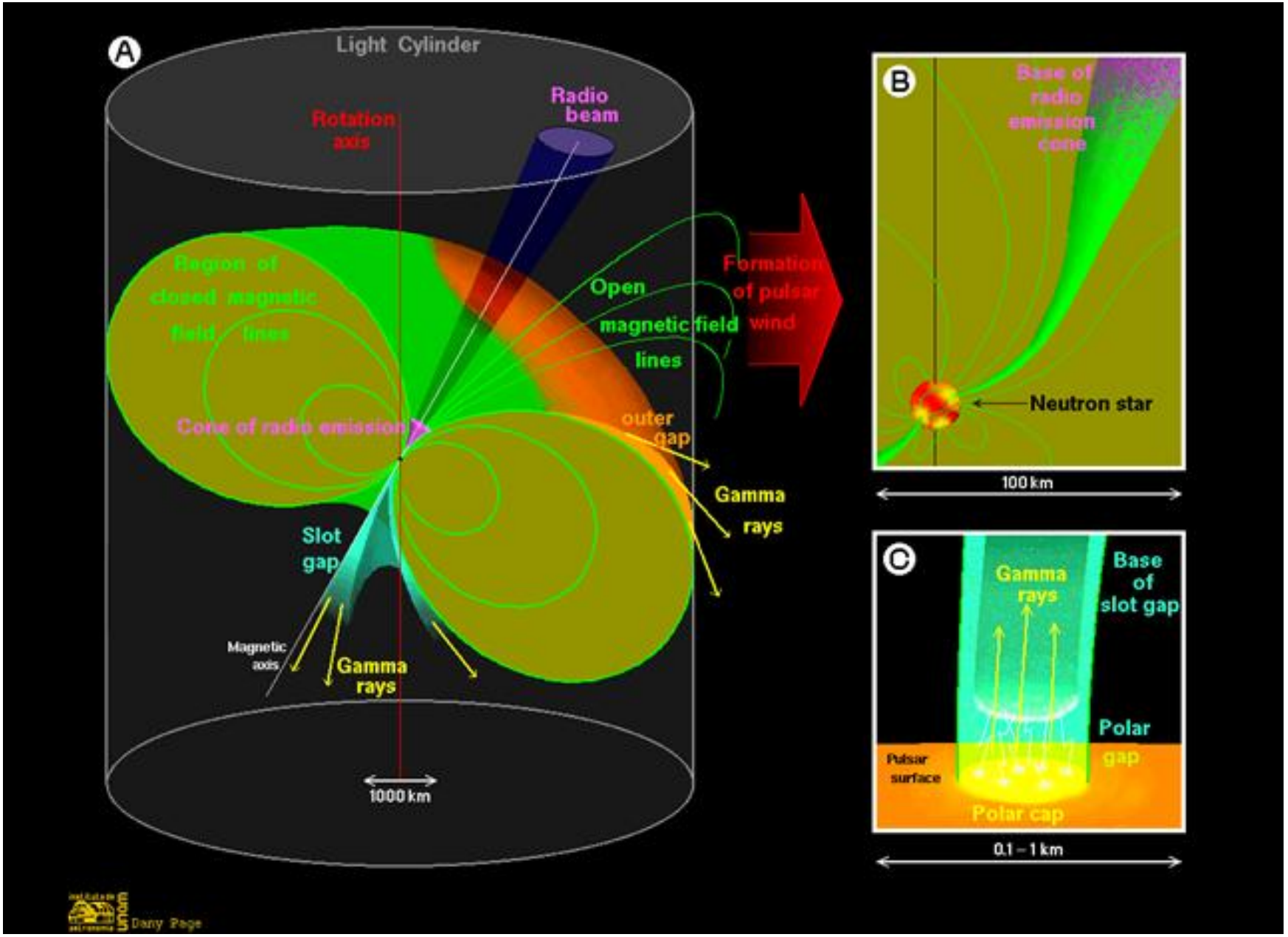
# Mapping the *B*-Field Structure of Elongated PWNe

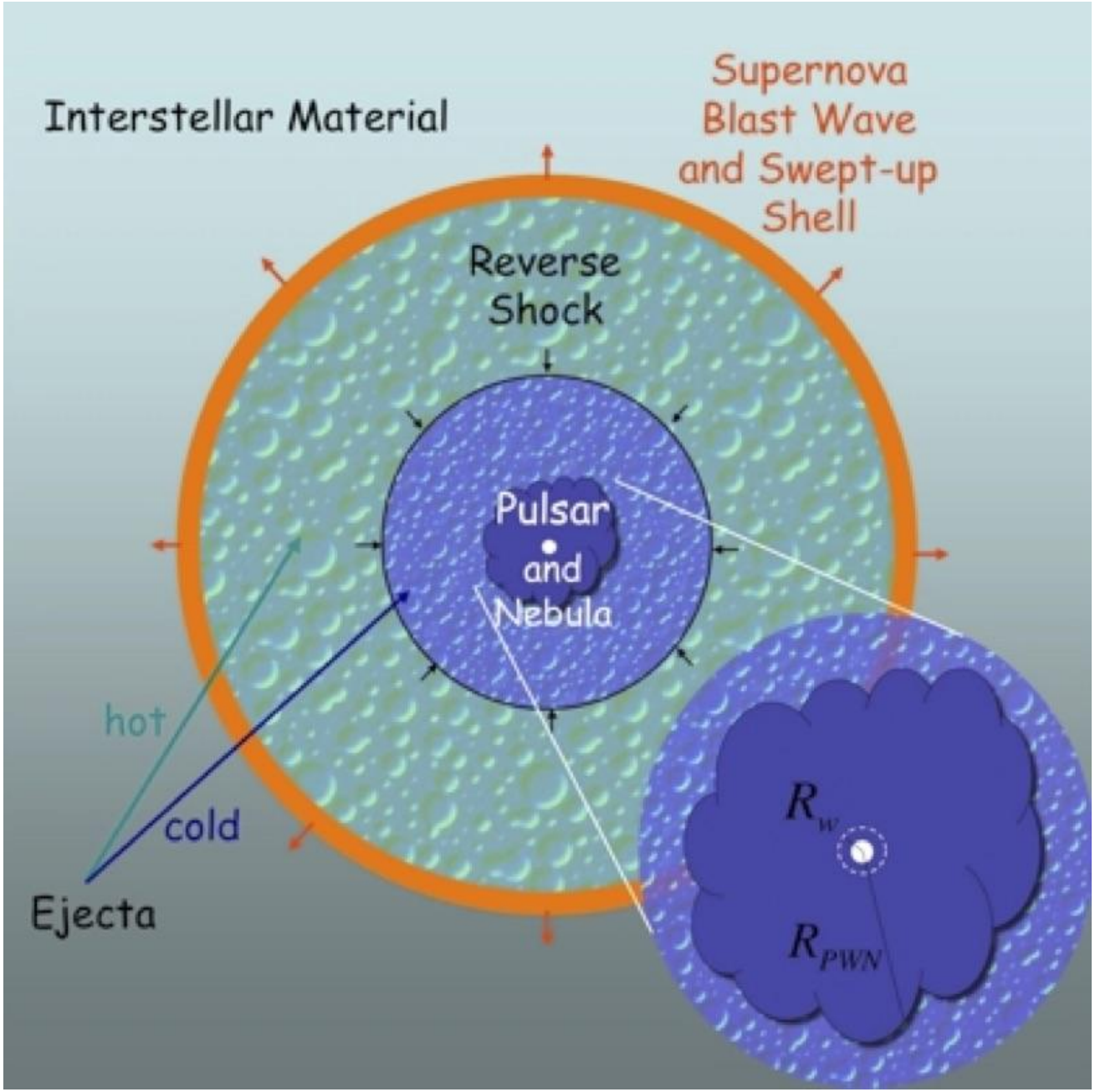
Stephen C.-Y. Ng

HKU

# Collaborators

- Y. K. Ma (student)
- W. Y. Leung (student)
- R. Wen (student)
- P. O. Slane
- N. Bucciantini
- T. Temim
- B. M. Gaensler
- Z. Wang


A
Light Cylinder
Radio beam
Rotation axis
Region of closed magnetic field lines
Open magnetic field lines
Formation of pulsar wind
Cone of radio emission
outer gap
Gamma rays
Slot gap
Magnetic axis
Gamma rays
1000 km
B
Base of radio emission cone
Neutron star
100 km
C
Gamma rays
Base of slot gap
Polar gap
Pulsar surface
Polar cap
0.1 – 1 km
Dany Page

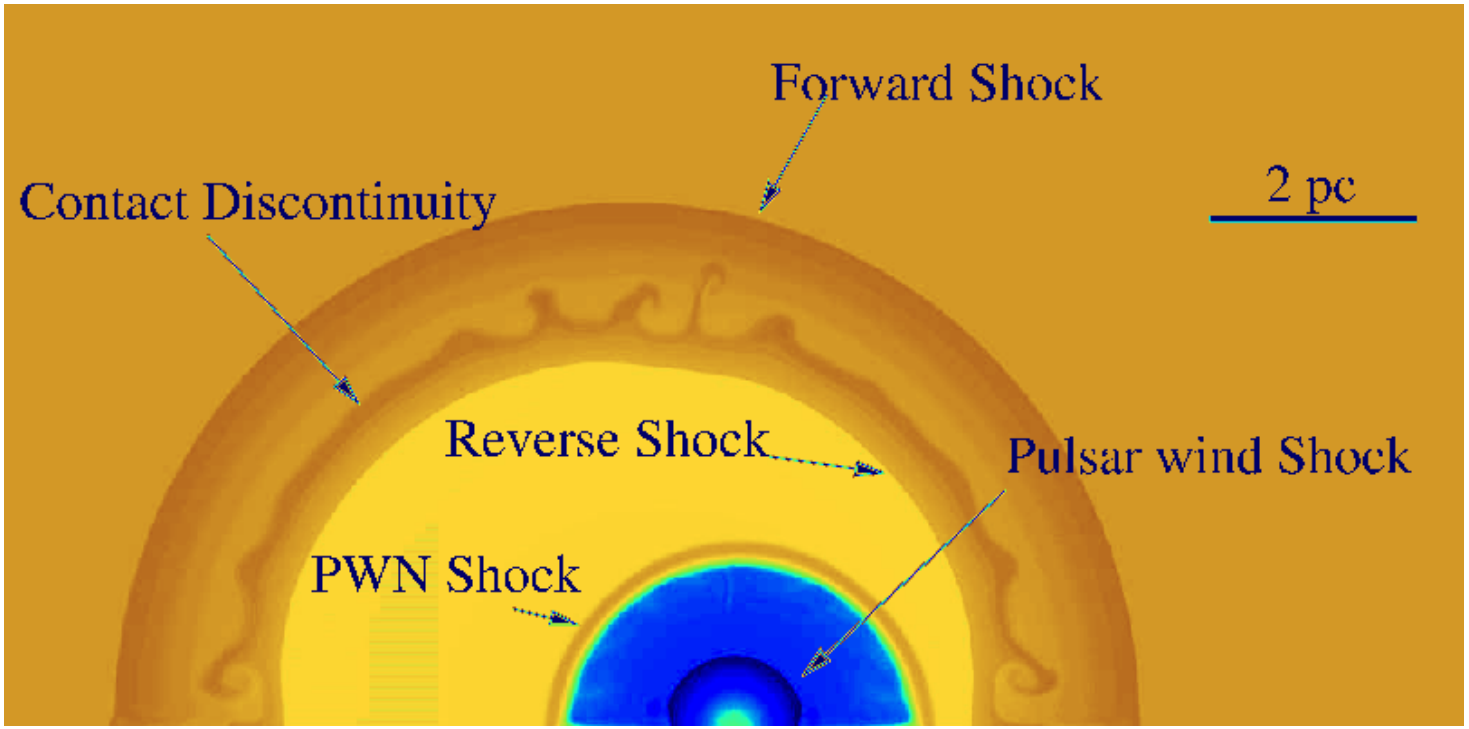





Gaensler & Slane (2006)

# PWN Evolution

- Free expansion phase
- Reverse shock interaction
- Bow shocks




van der Swaluw et al. (2004)

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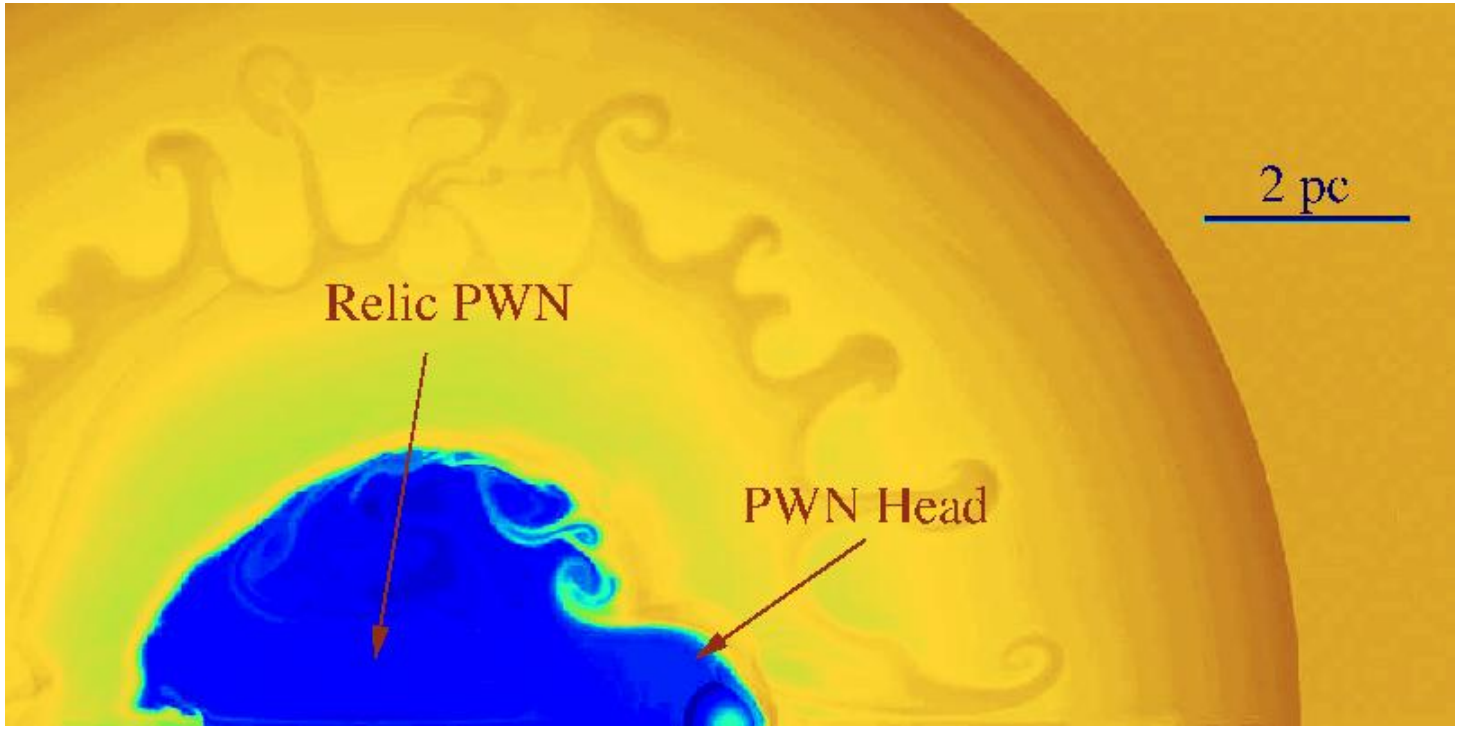


van der Swaluw et al. (2004)

# PWN Evolution

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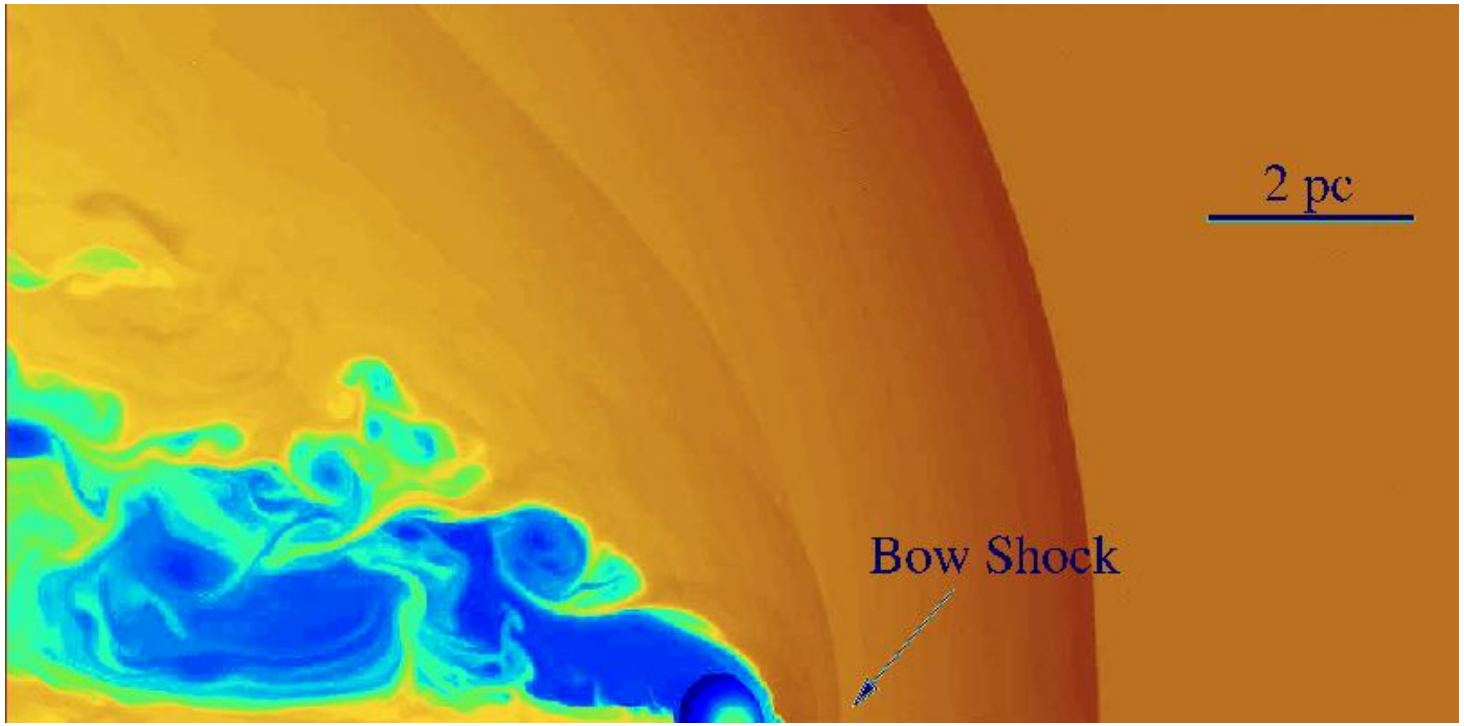
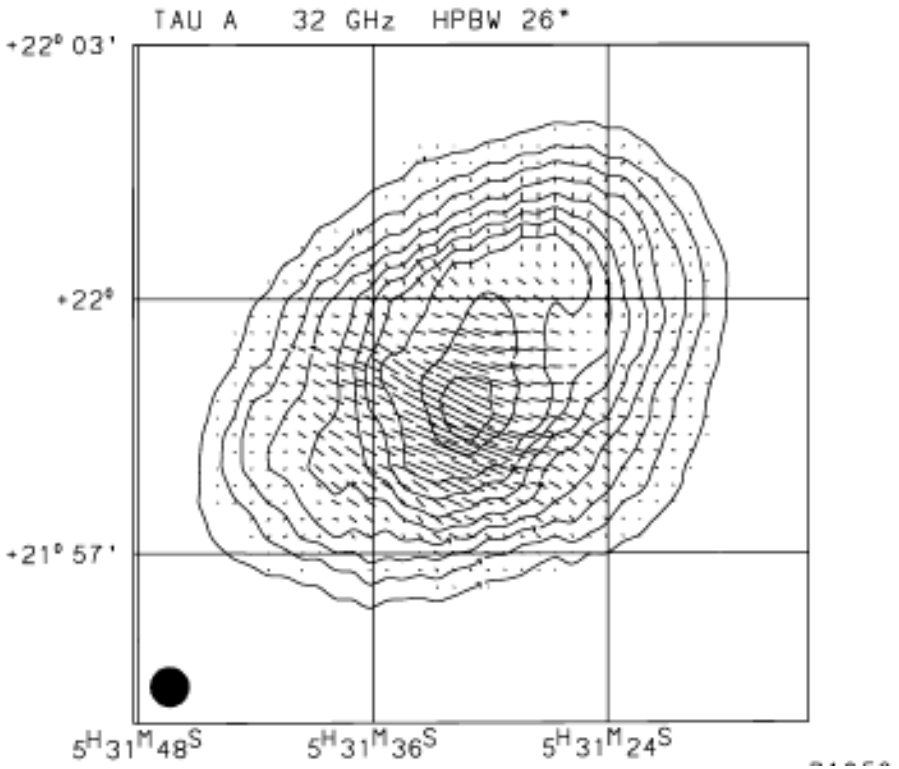


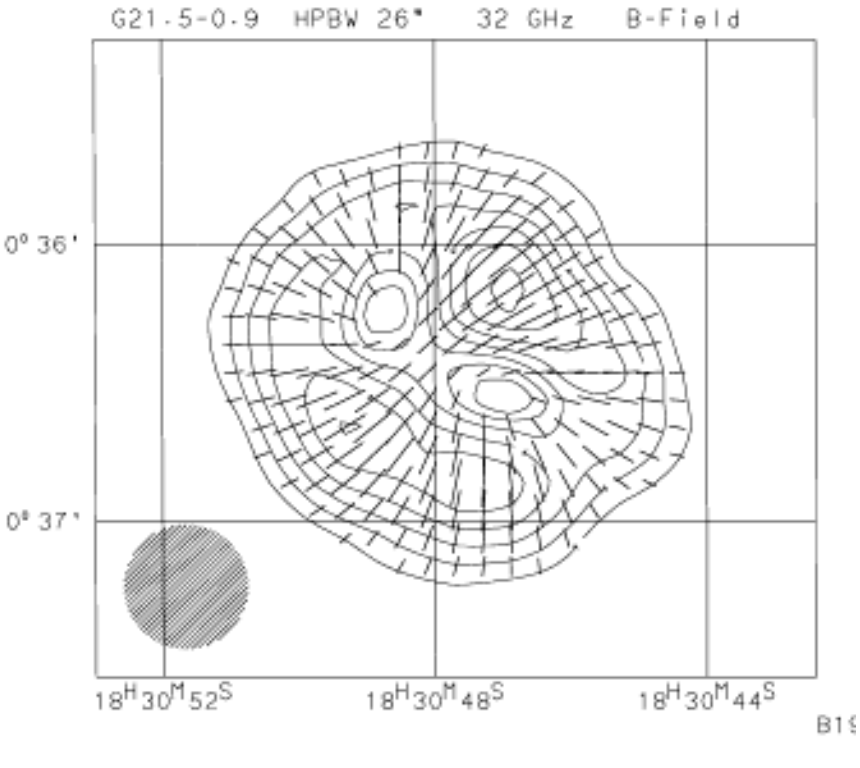

van der Swaluw et al. (2004)

# Important Questions

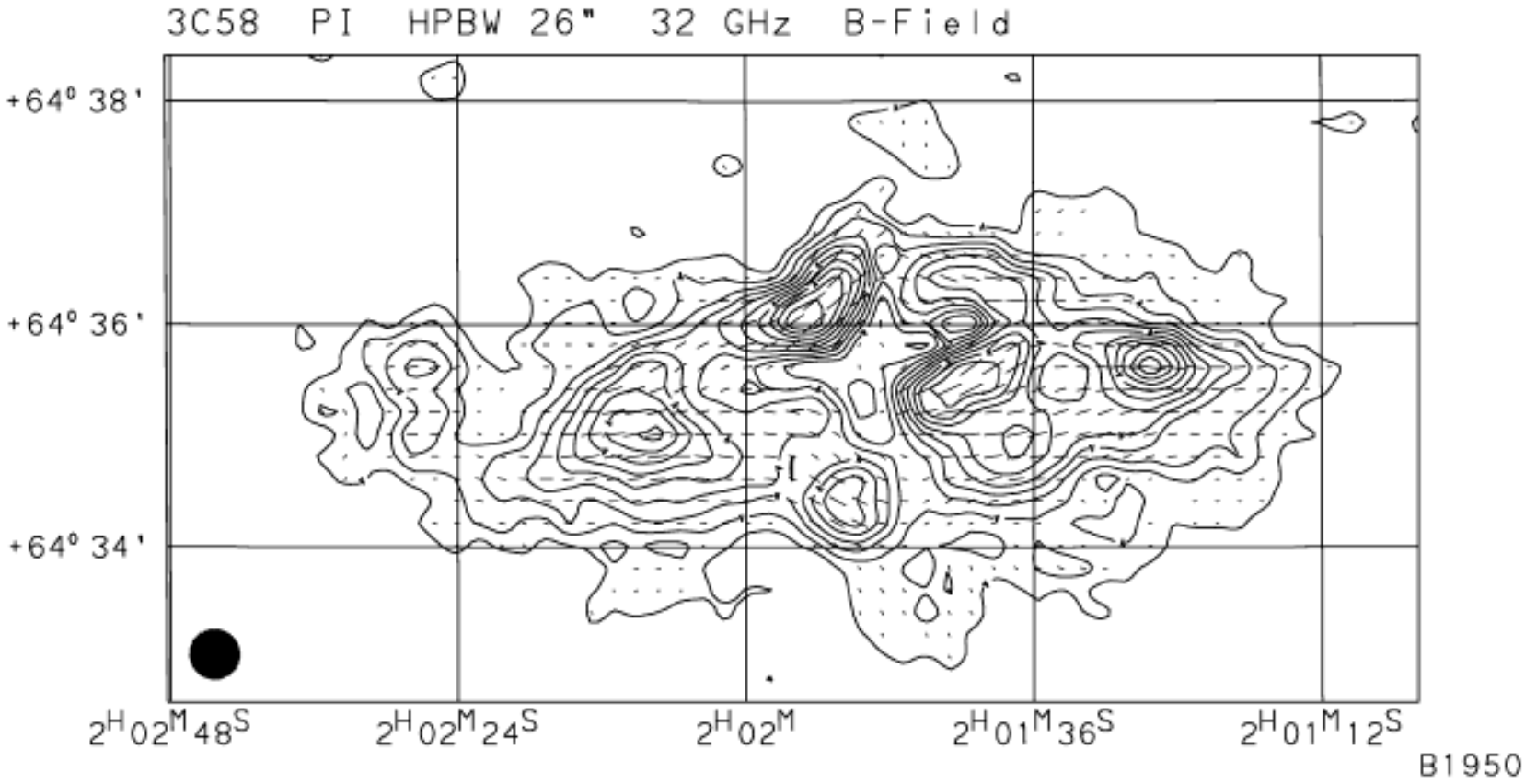
- What is the *B*-field structure of PWNe?
- What determines the *B*-field configurations?
- Connection with particle acceleration and transport?

# Previous Studies

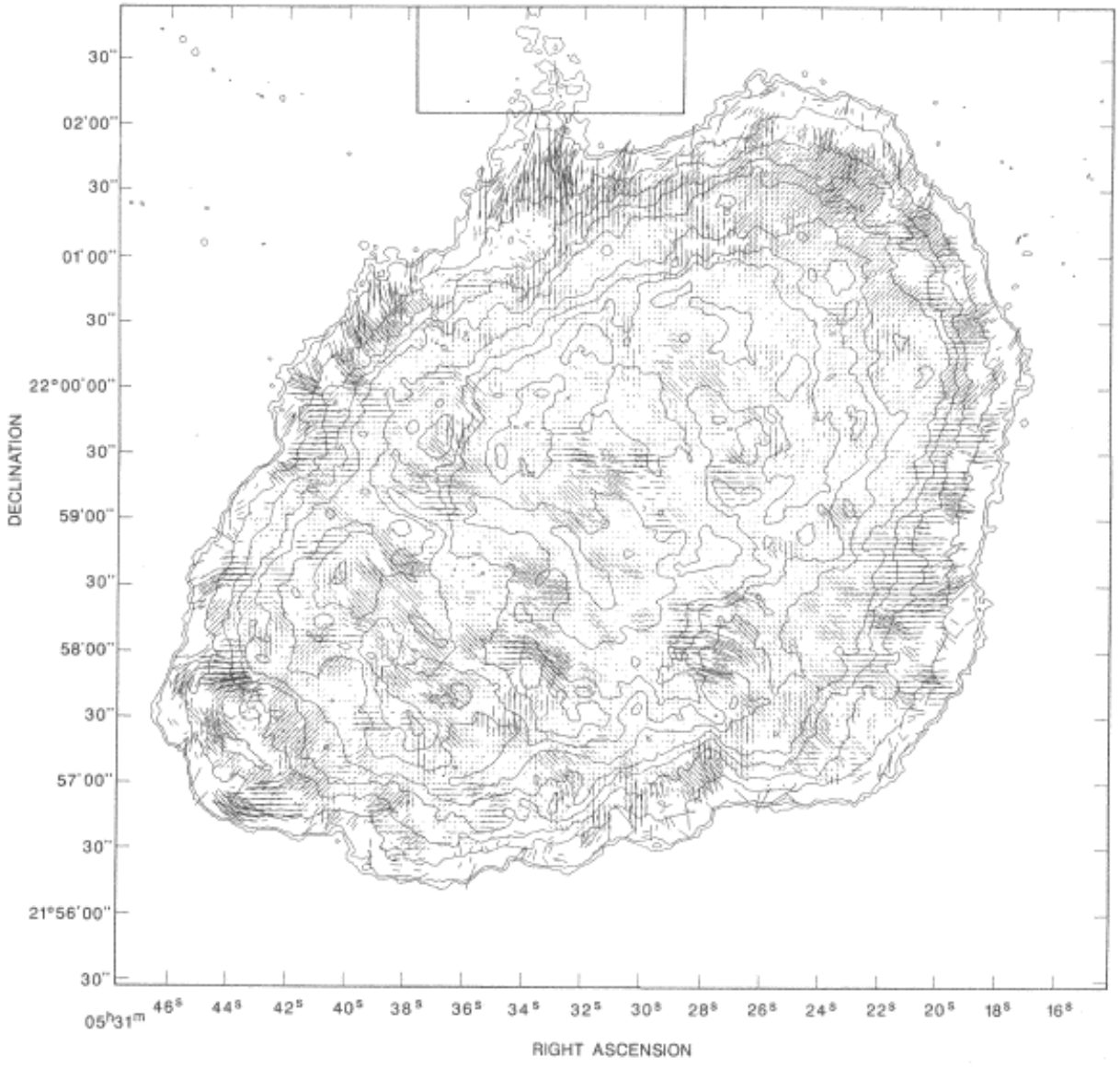



Reich (2002)


3C58 PI HPBW 26" 32 GHz B-Field
+64° 38'
+64° 36'
+64° 34'
2H02M48S
2H02M24S
2H02M
2H01M36S
2H01M12S
B1950

Reich (2002)

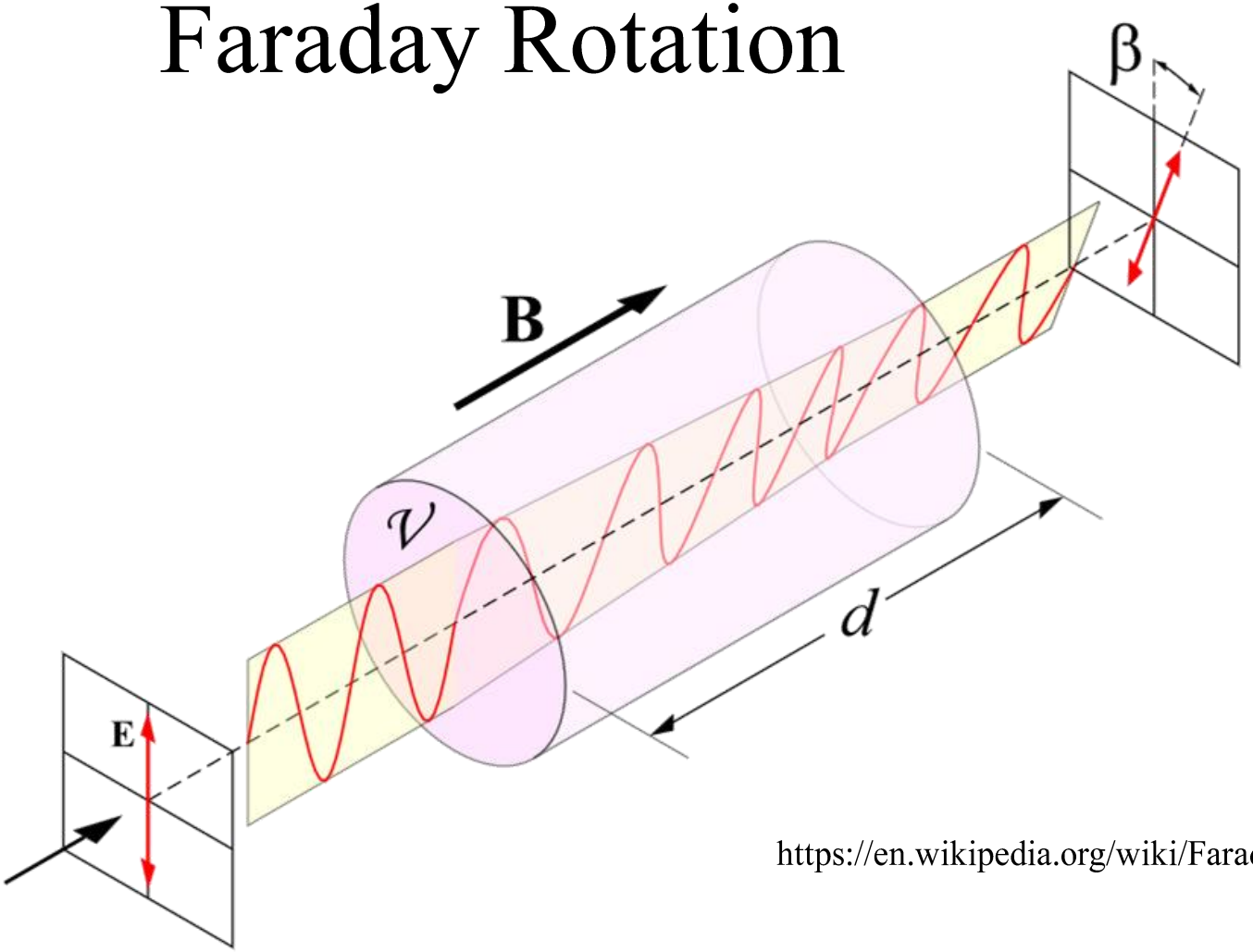



Bietenholz & Kronberg (1990)

ATNF/CSIRO

W. Grammer, NRAO/AUI/NSF

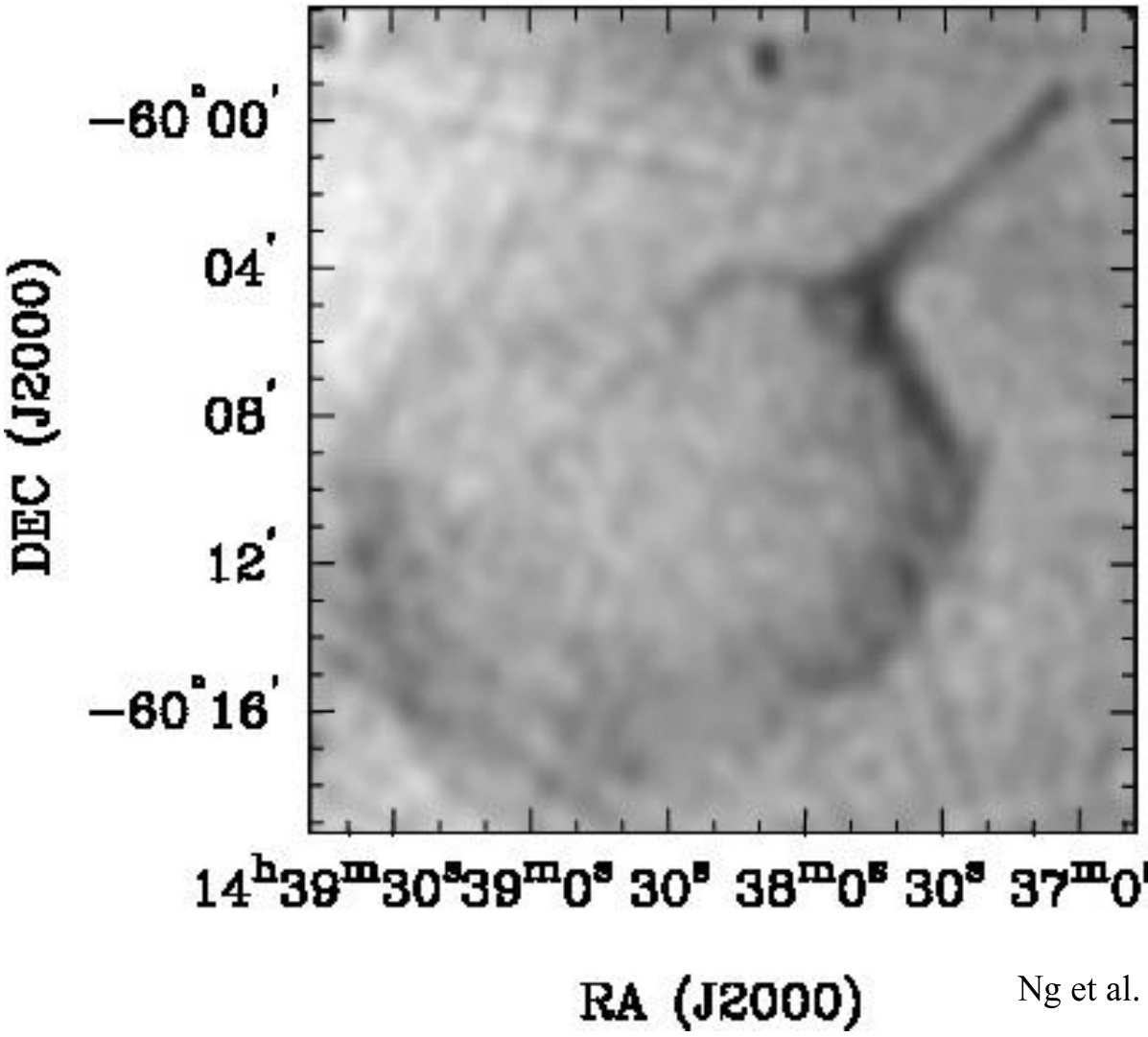
# Faraday Rotation

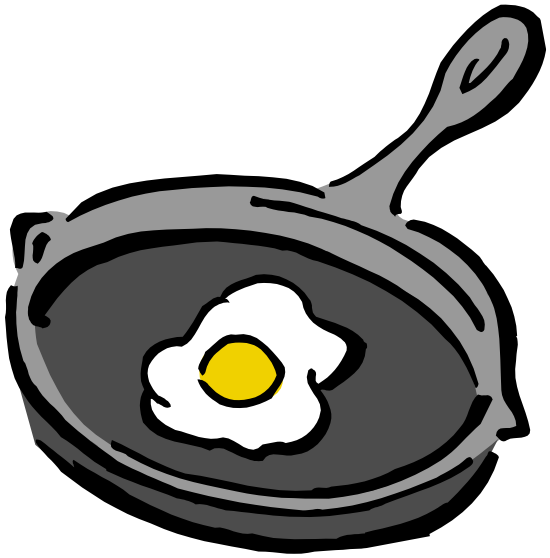



https://en.wikipedia.org/wiki/Faraday_effect

$$\Delta\chi = \frac{e^3}{8\pi^2\epsilon_0 m_e^2 c^3}\lambda^2 \int_0^d n_e(s) B_{\parallel} \mathrm{d}s \equiv \mathrm{RM}\lambda^2$$

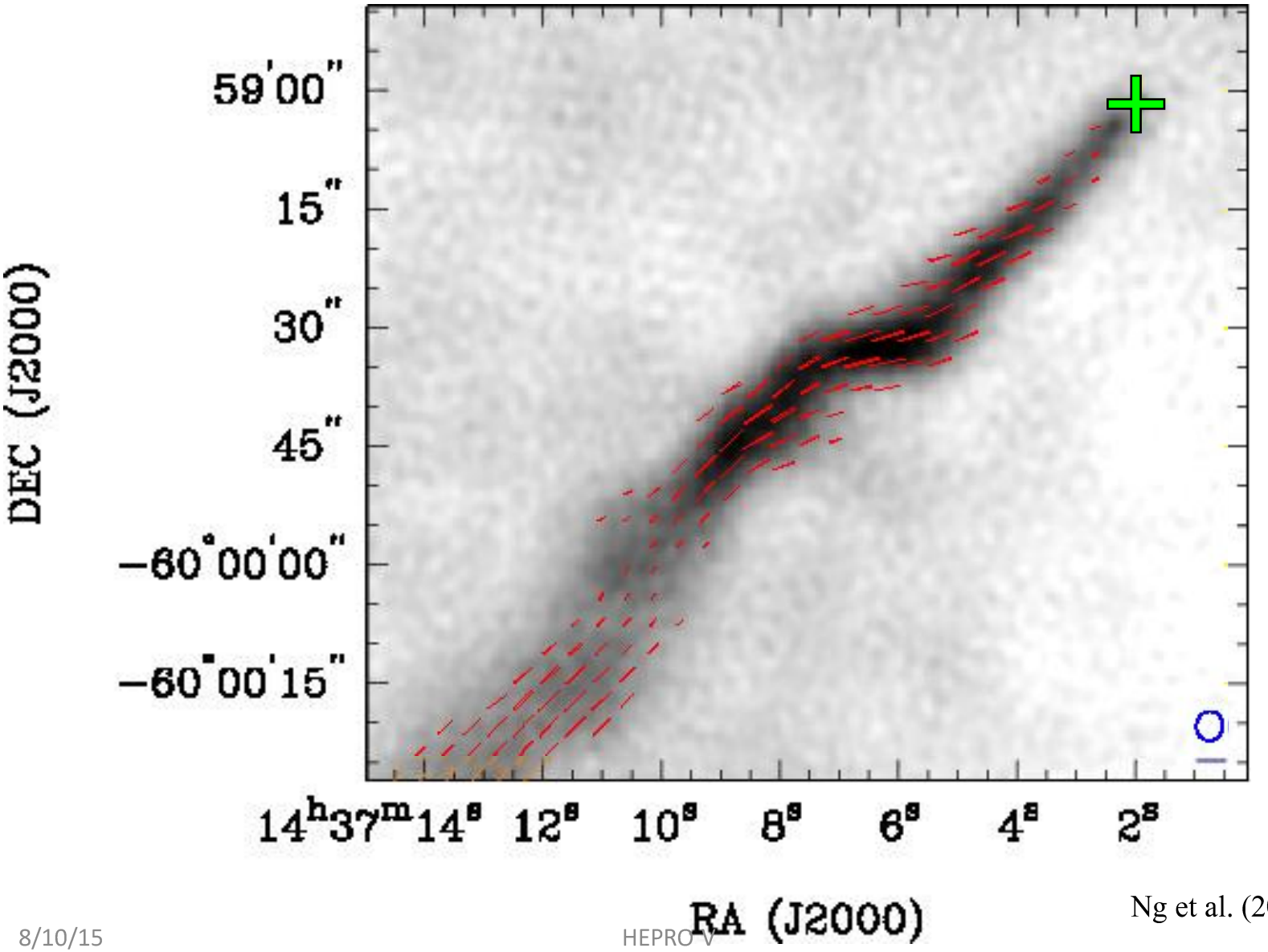
# G315.9–0.0: the Frying Pan



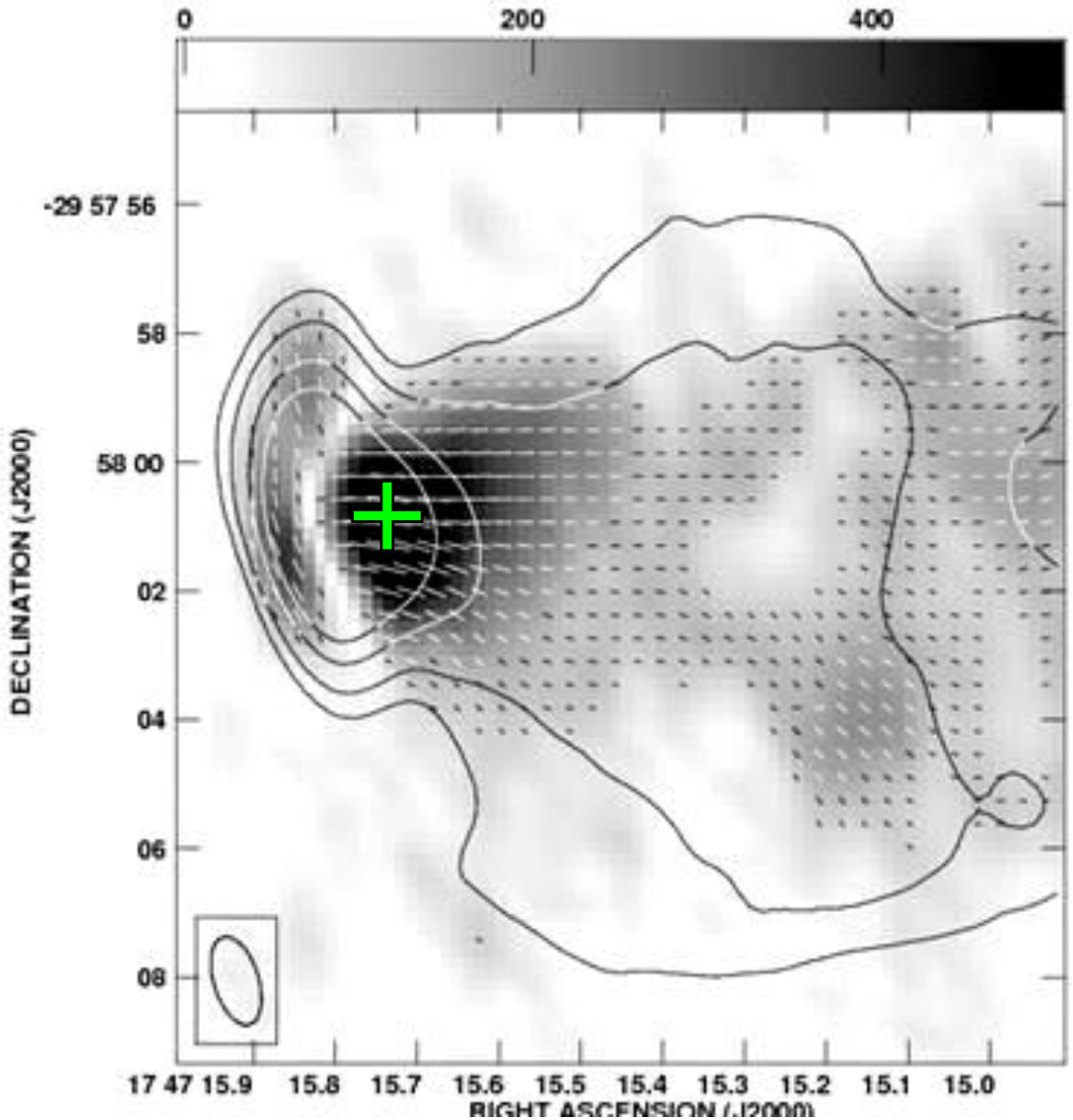
Ng et al. (2012)

# ATCA 6cm



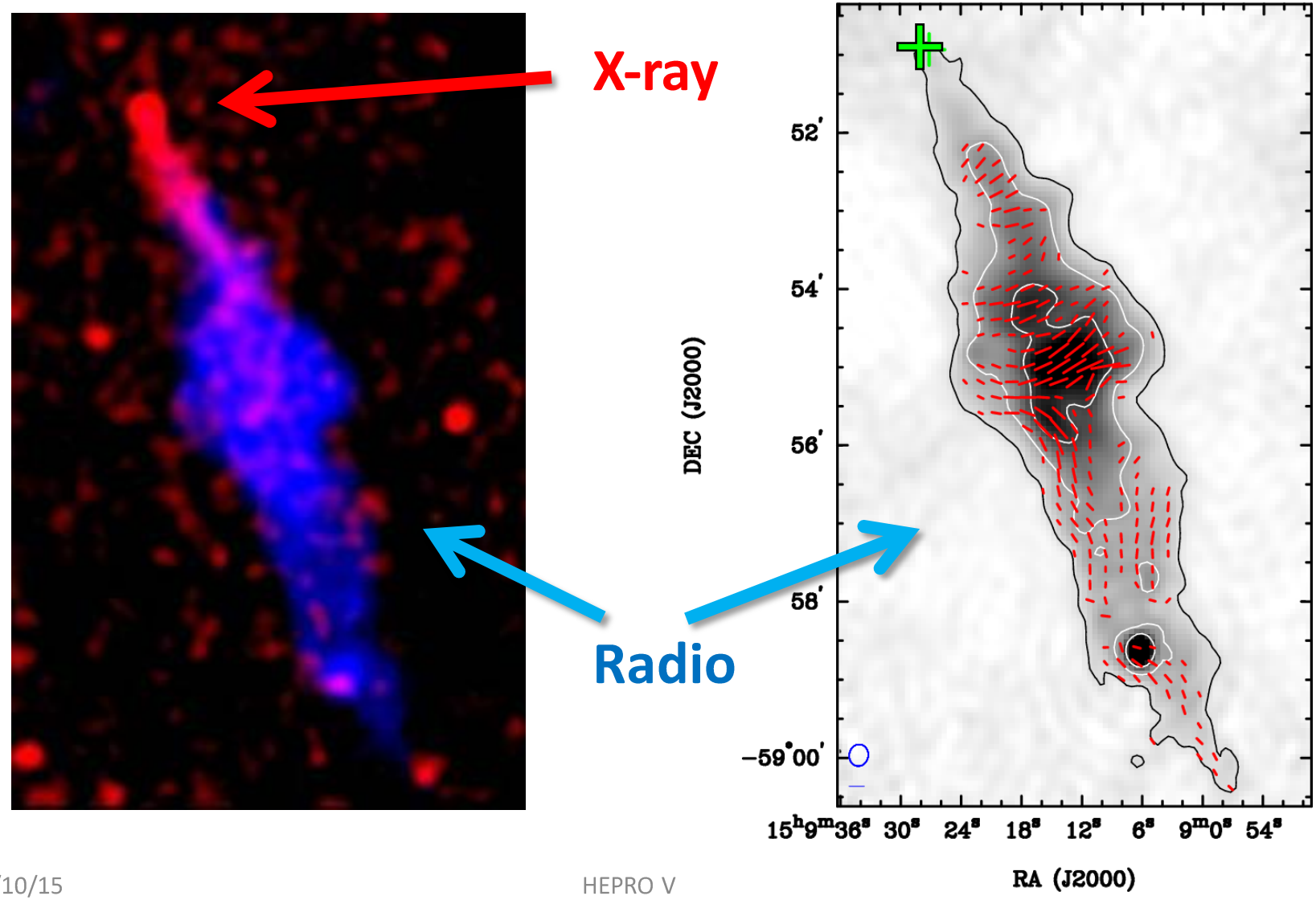

Ng et al. (2012)

# The Mouse / PSR J1747-2958



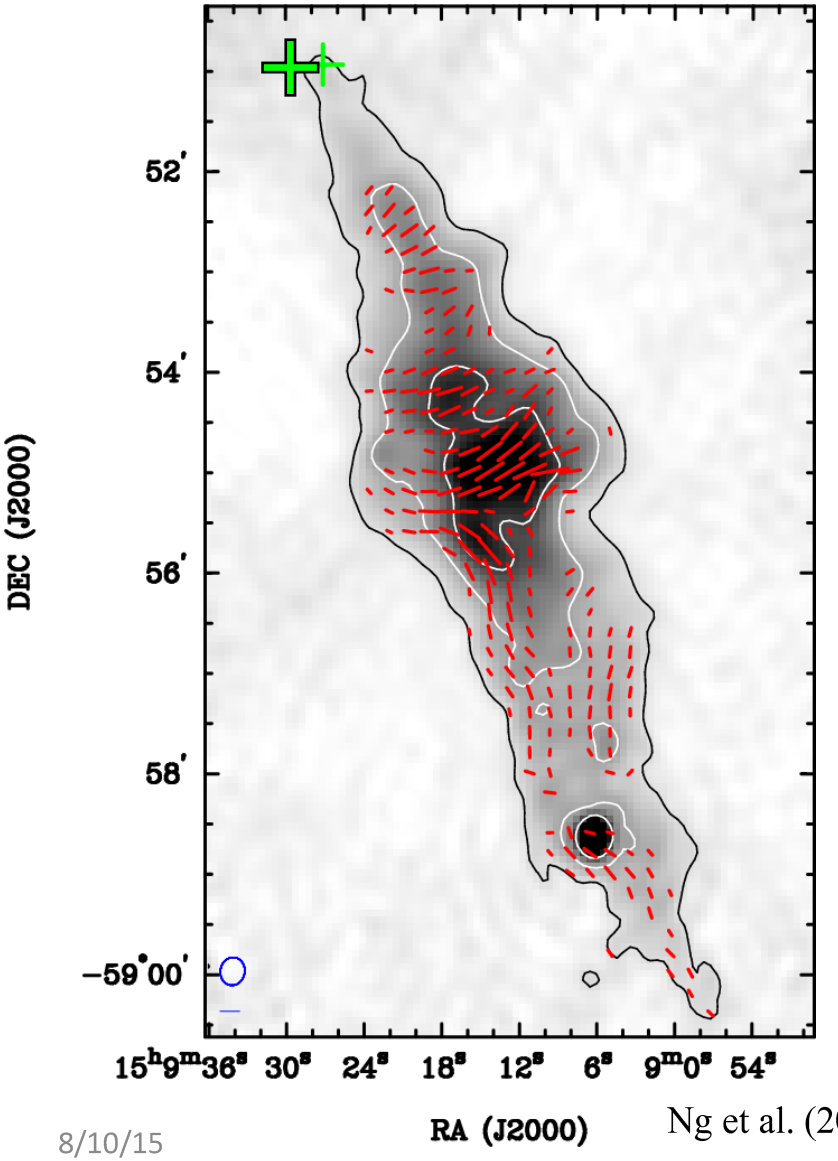

Yusef-Zadeh & Gaensler (2005)

# G319.9-0.7 / PSR J1509-5850

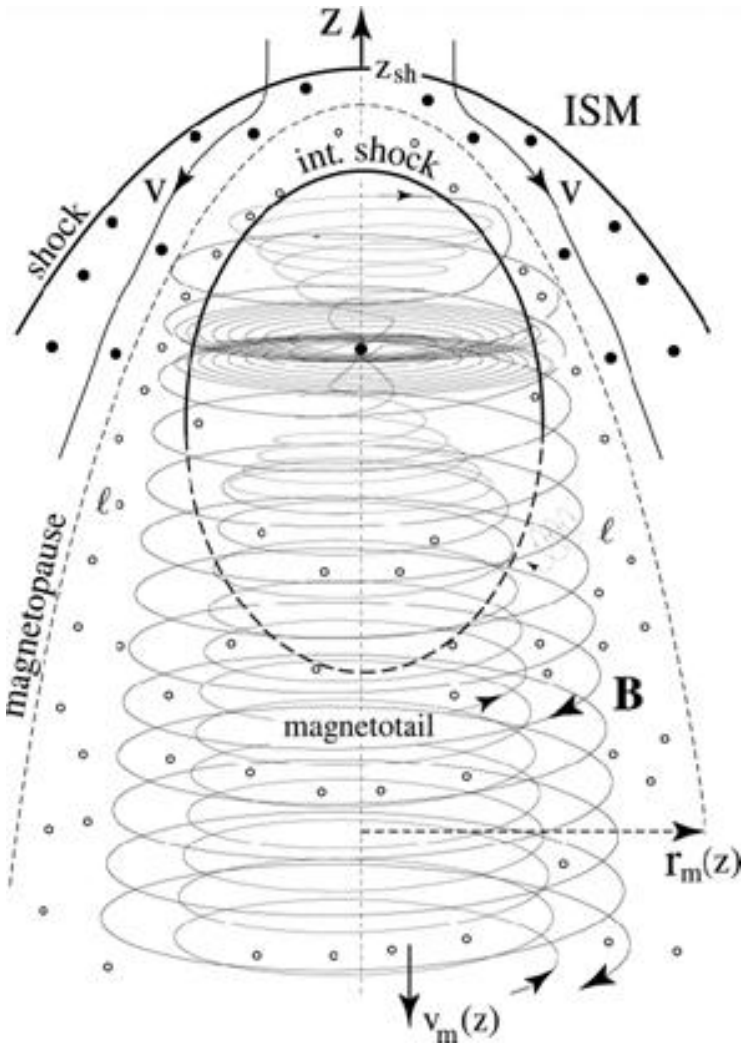



Ng et al. (2010)

# G319.9-0.7 / PSR J1509-5850



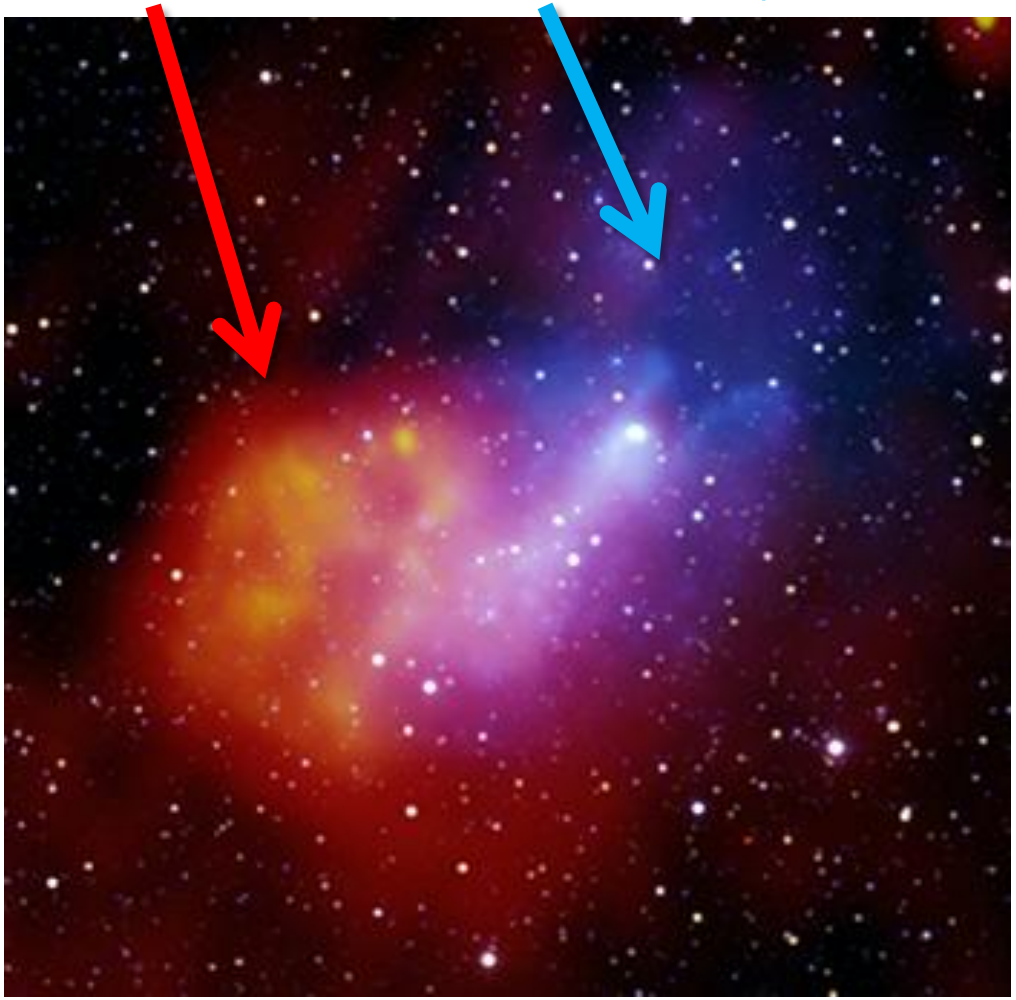

Ng et al. (2010)



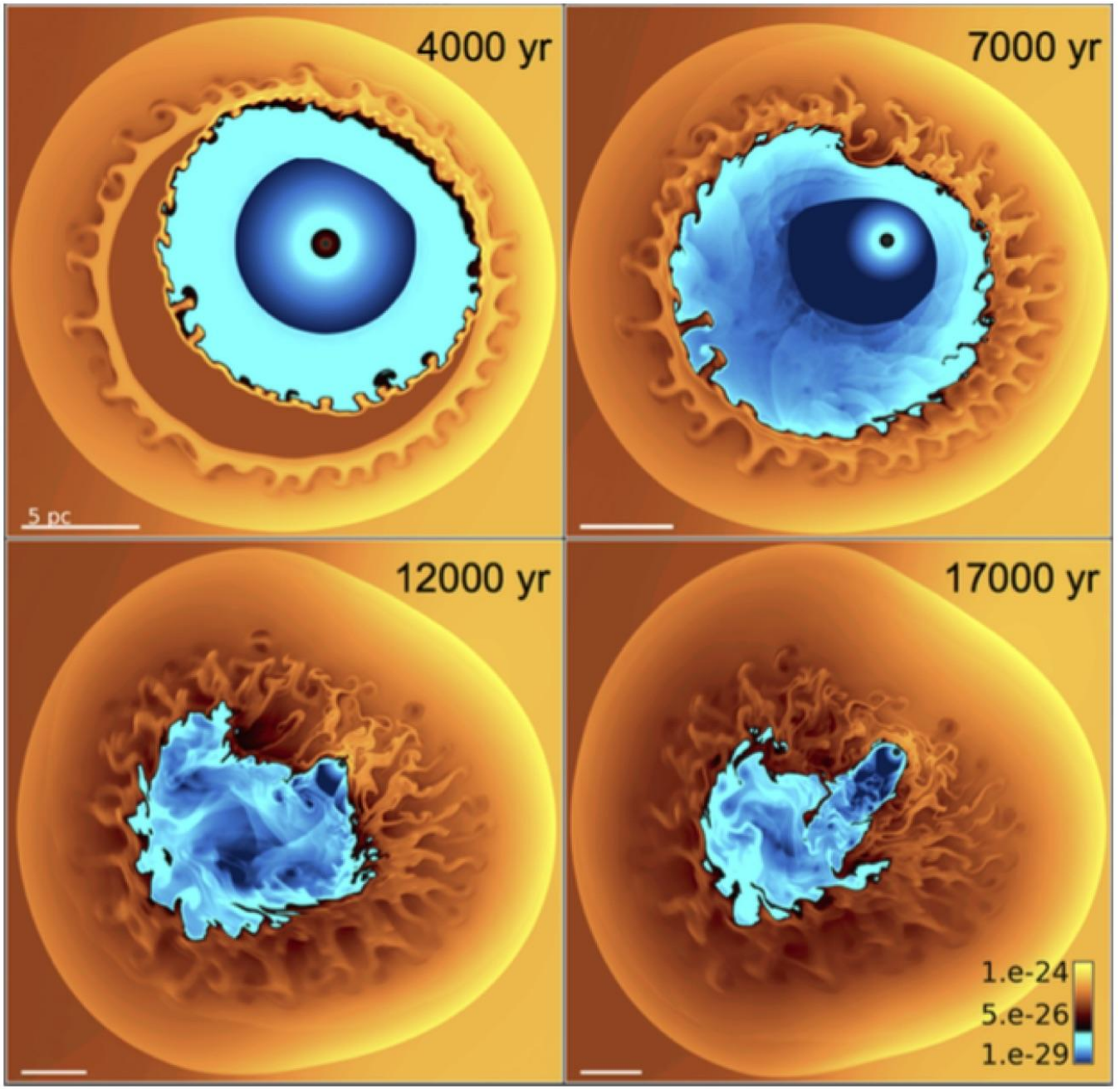

Romanova et al. (2005)

# The Snail G327.1-1.1

**ATCA 6cm** ***Chandra* X-ray**



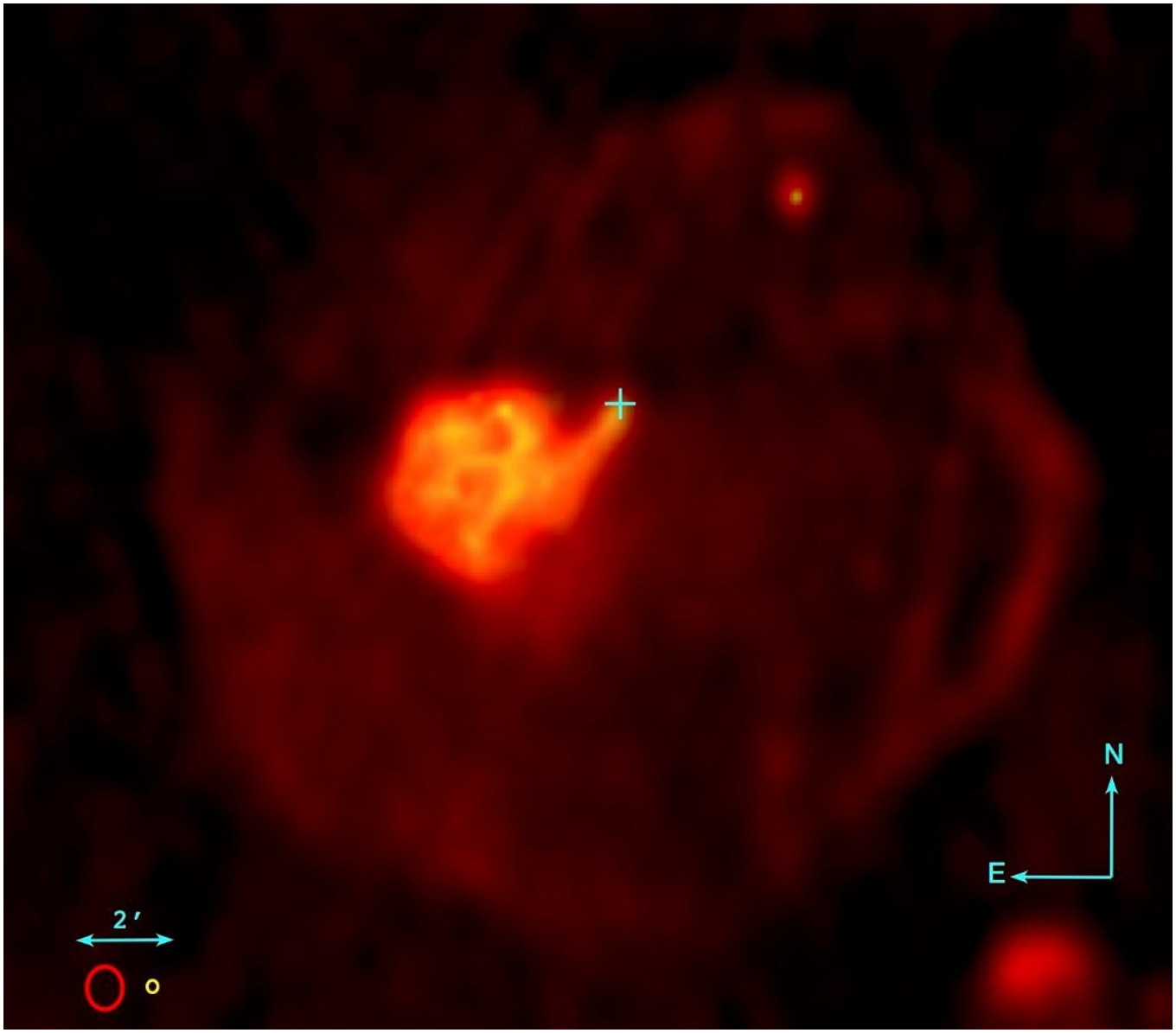
Temim et al. (2009)





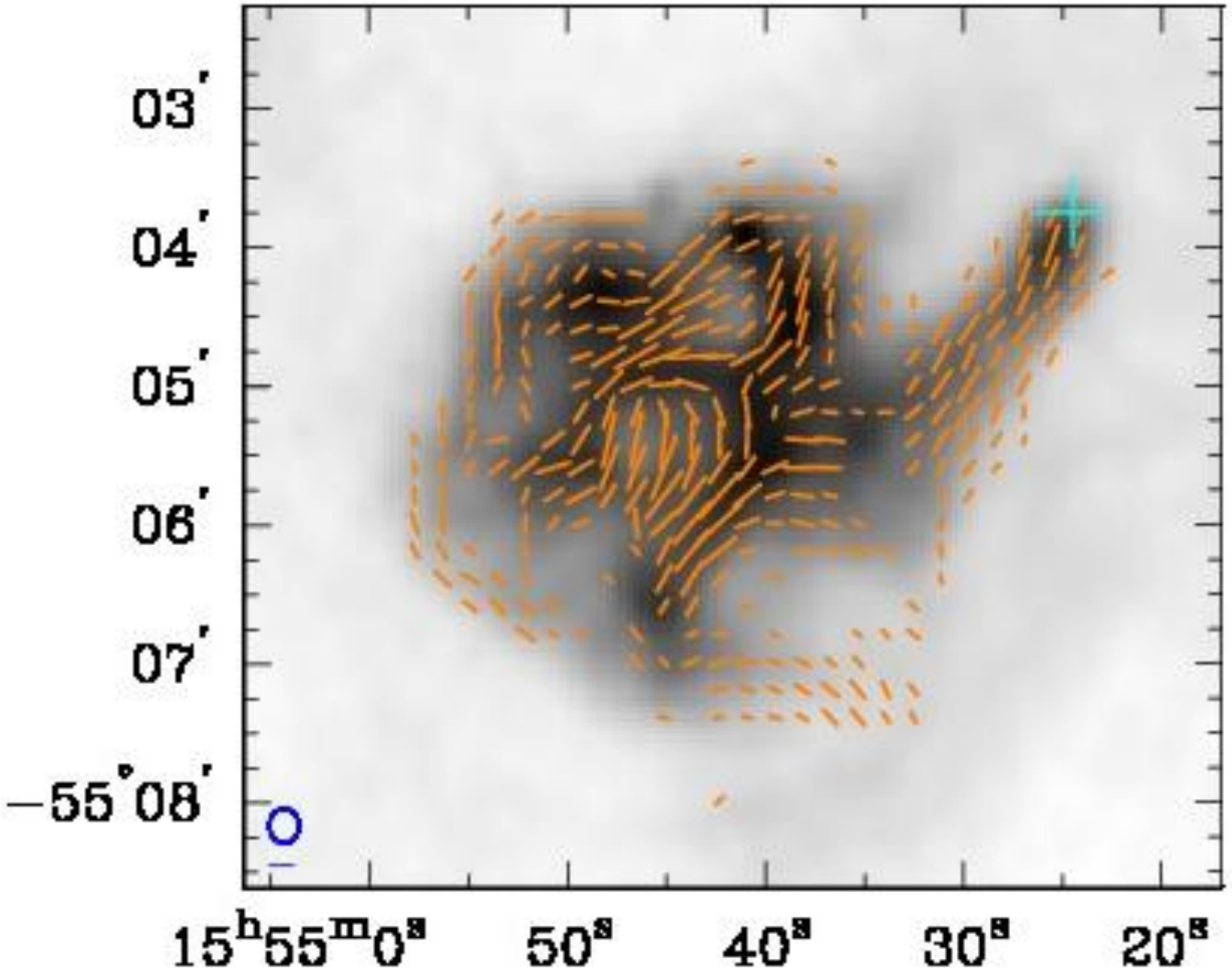

Temim et al. (2015)

# The Snail G327.1-1.1



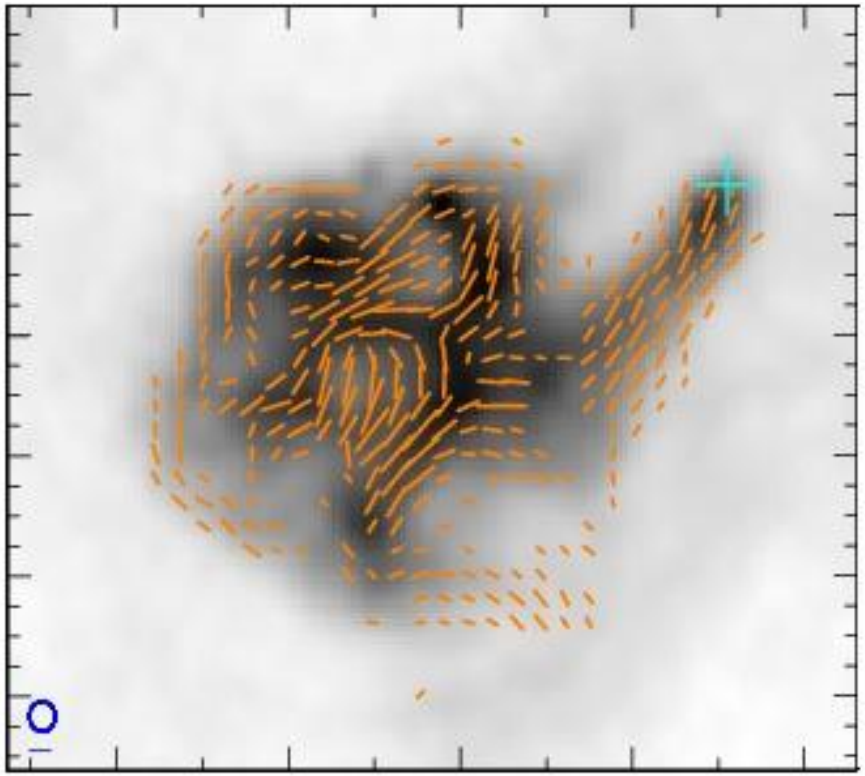

Ma, Ng, et al. (2015)

# The Snail G327.1-1.1

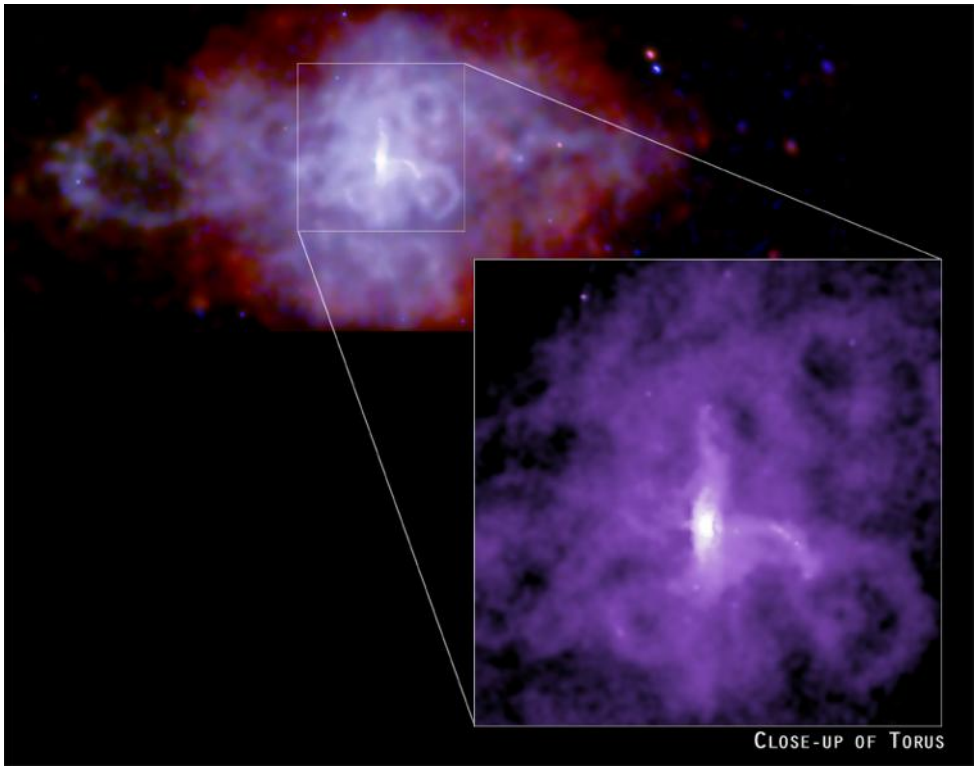



Ma, Ng, et al. (2015)

# Magnetic Loops



Ma, Ng, et al. (2015)



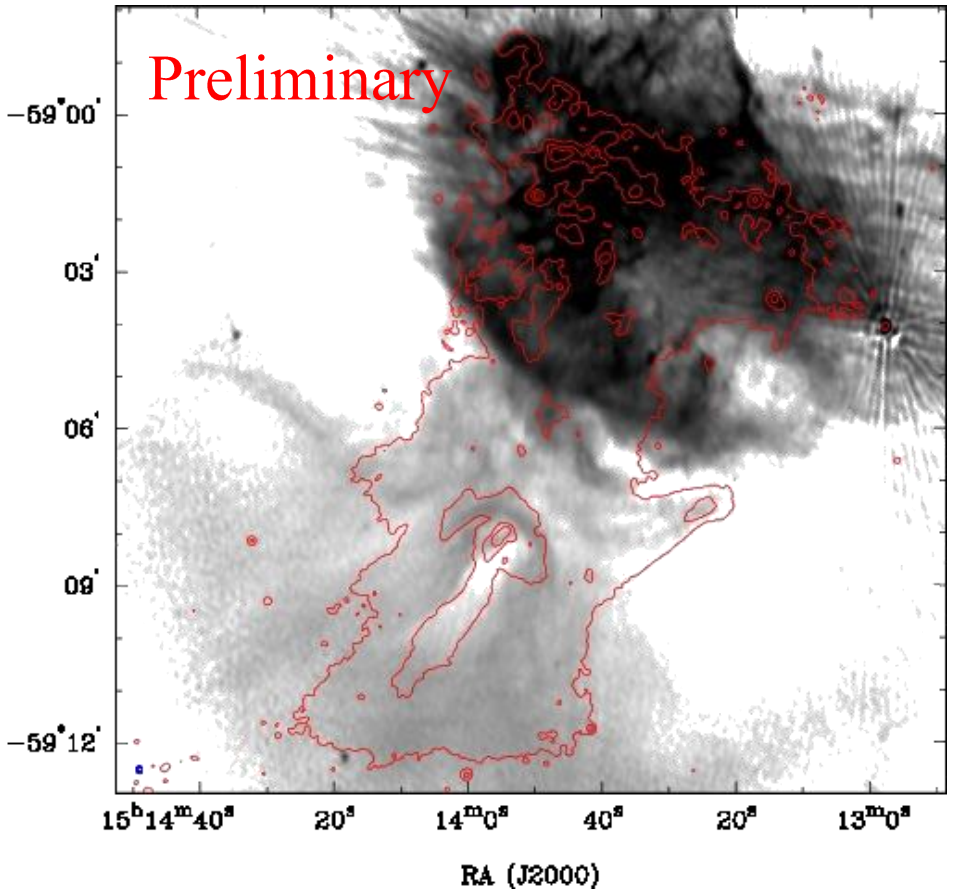

Slane et al. (2004)

# The Cosmic Hand: MSH 15-52

X-ray (*Chandra*)

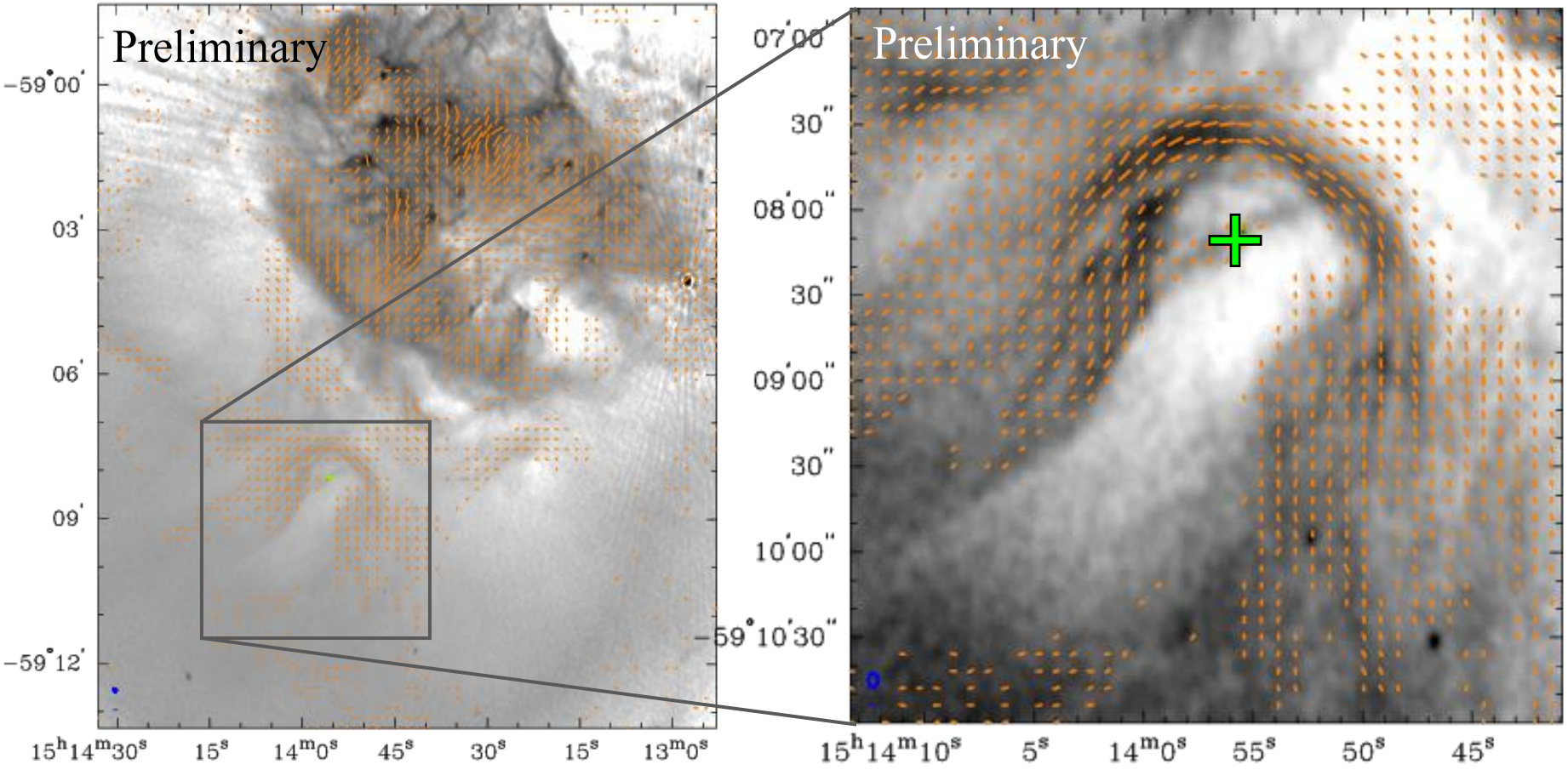
NASA/CXC/SAO/P.Slane, et al.

Radio 6cm (ATCA)




Leung, Ng, et al. (in prep.)

# The Cosmic Hand: MSH 15-52




Leung, Ng, et al. (in prep.)

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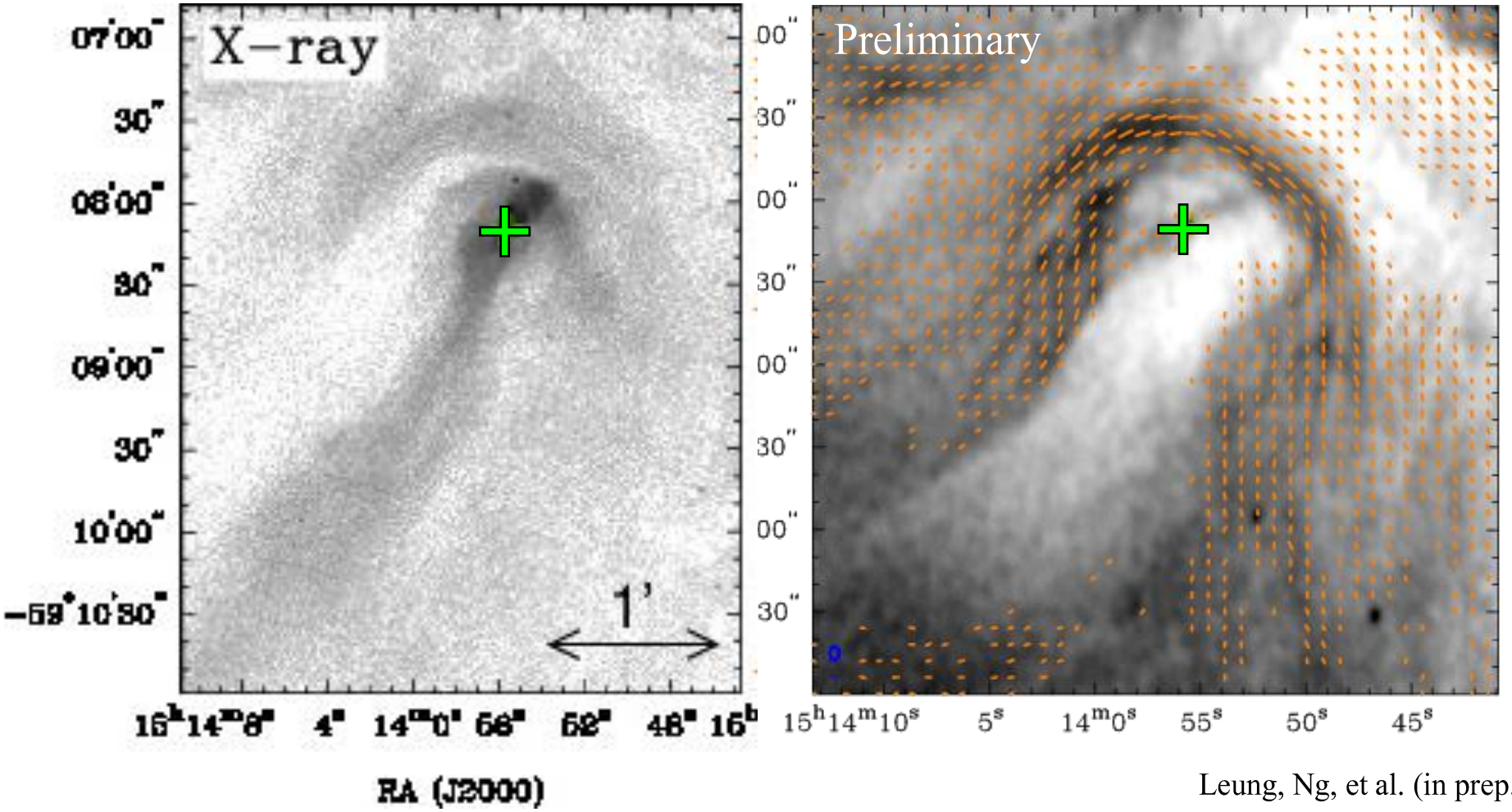
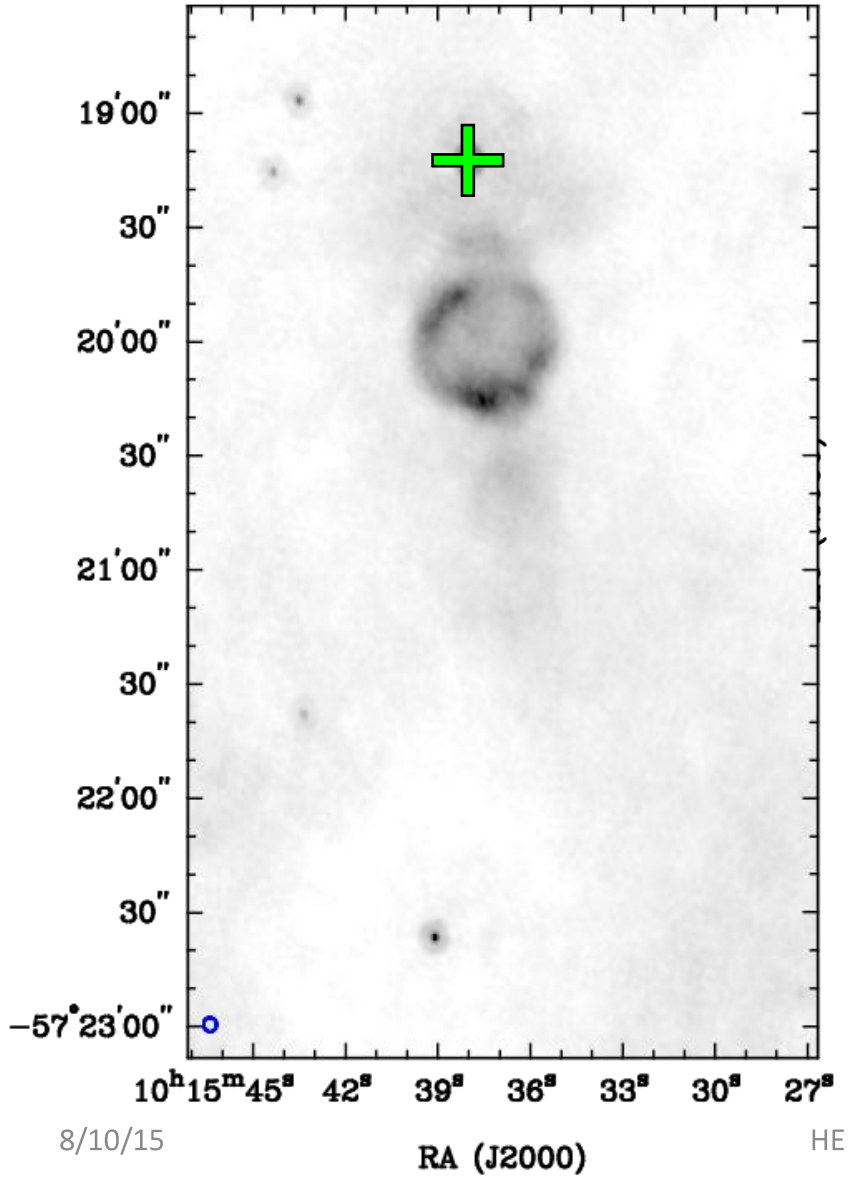


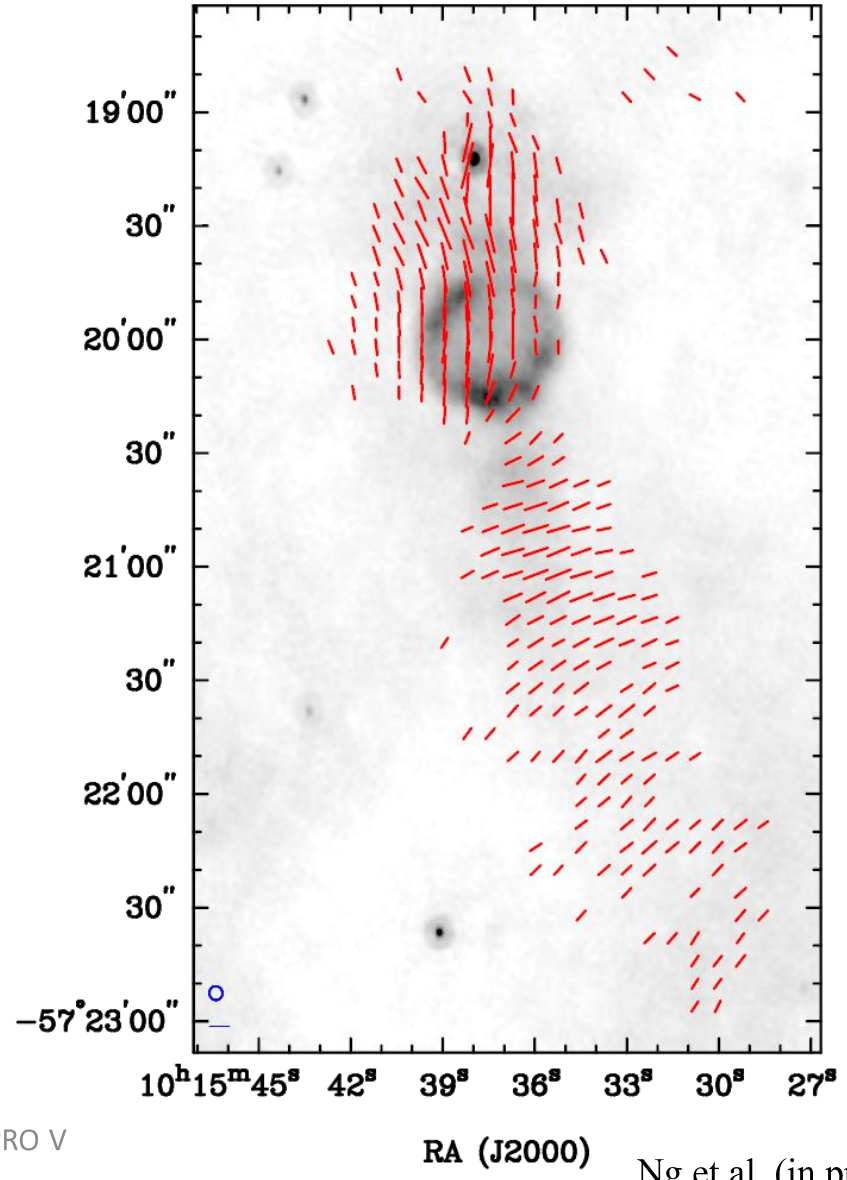

Leung, Ng, et al. (in prep.)

# PSR J1015-5719

Radio 6cm (ATCA)

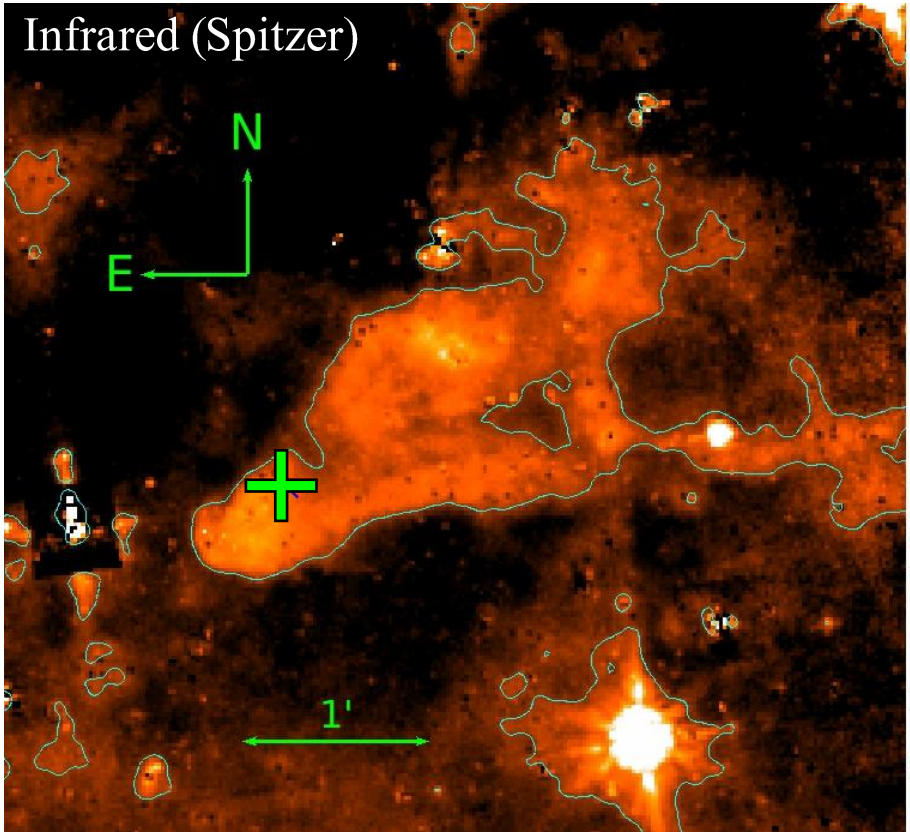


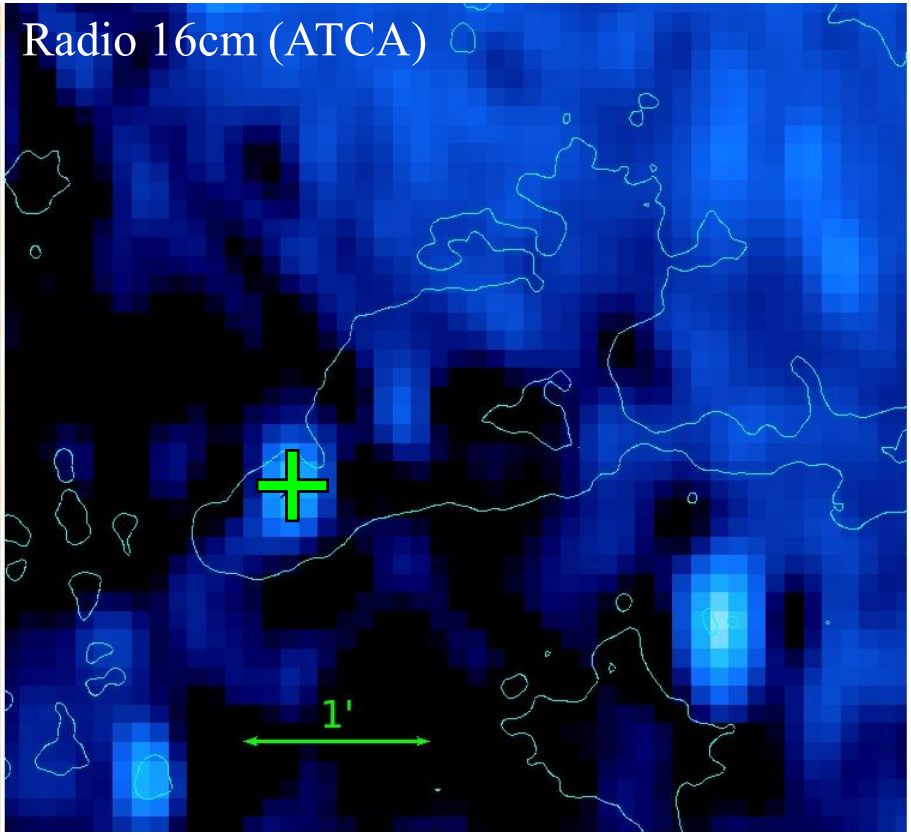

*B*-field configuration




Ng et al. (in prep.)

# IR Bow-shock PWN J1549-4848?

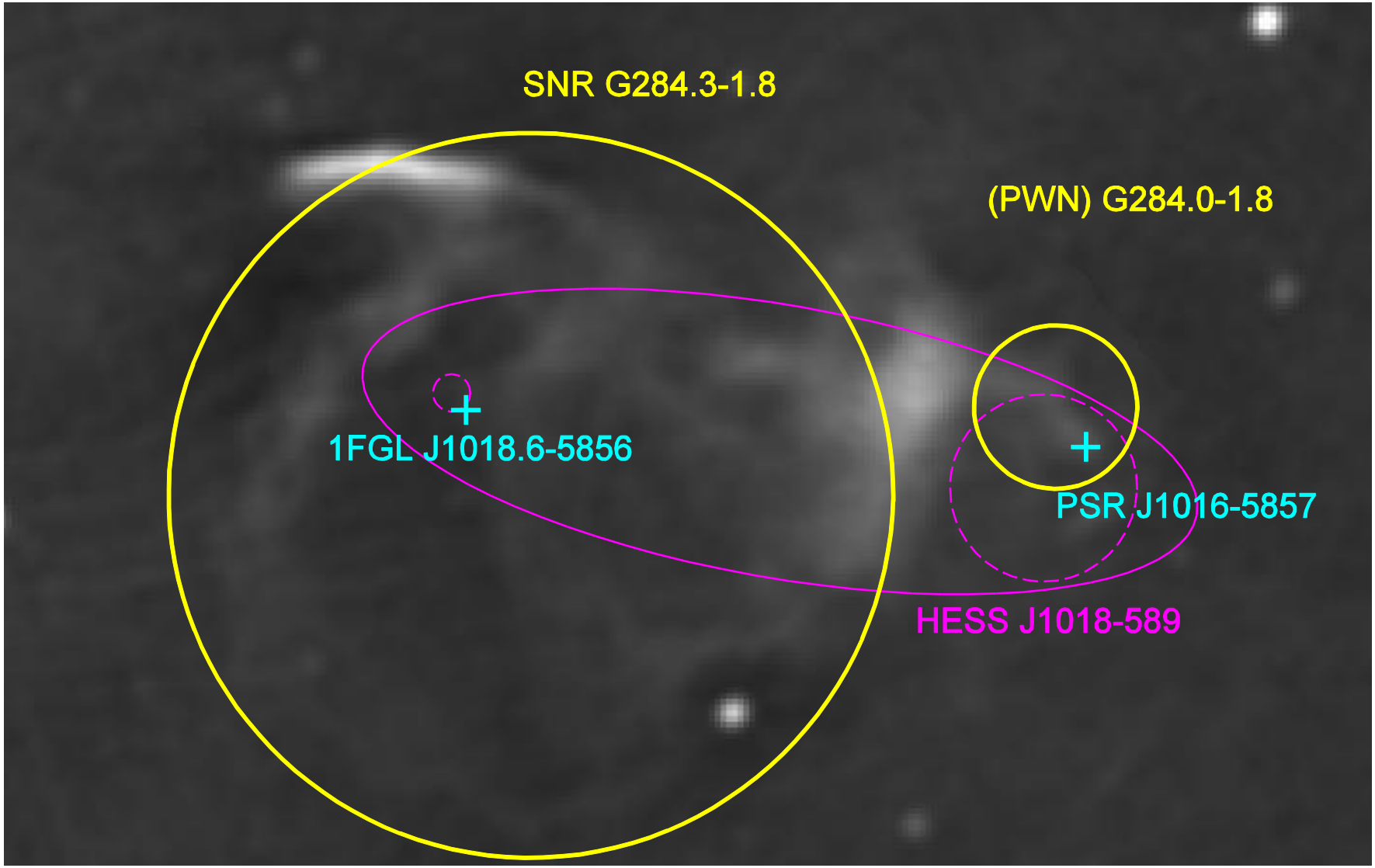


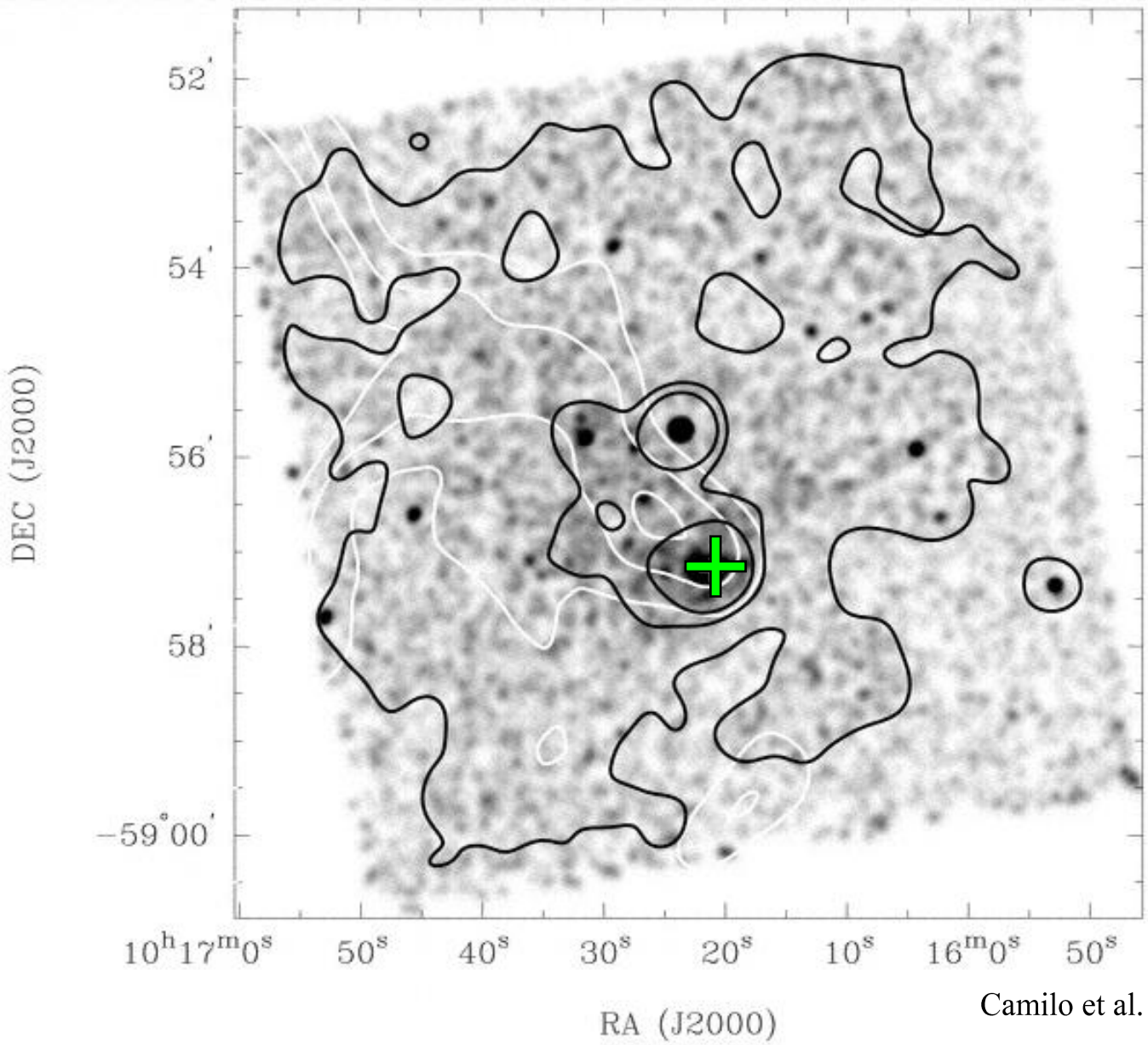

Wang et al. (2013)

Ng et al. (in prep.)

# G284.0-1.8/PSR J1016-5857

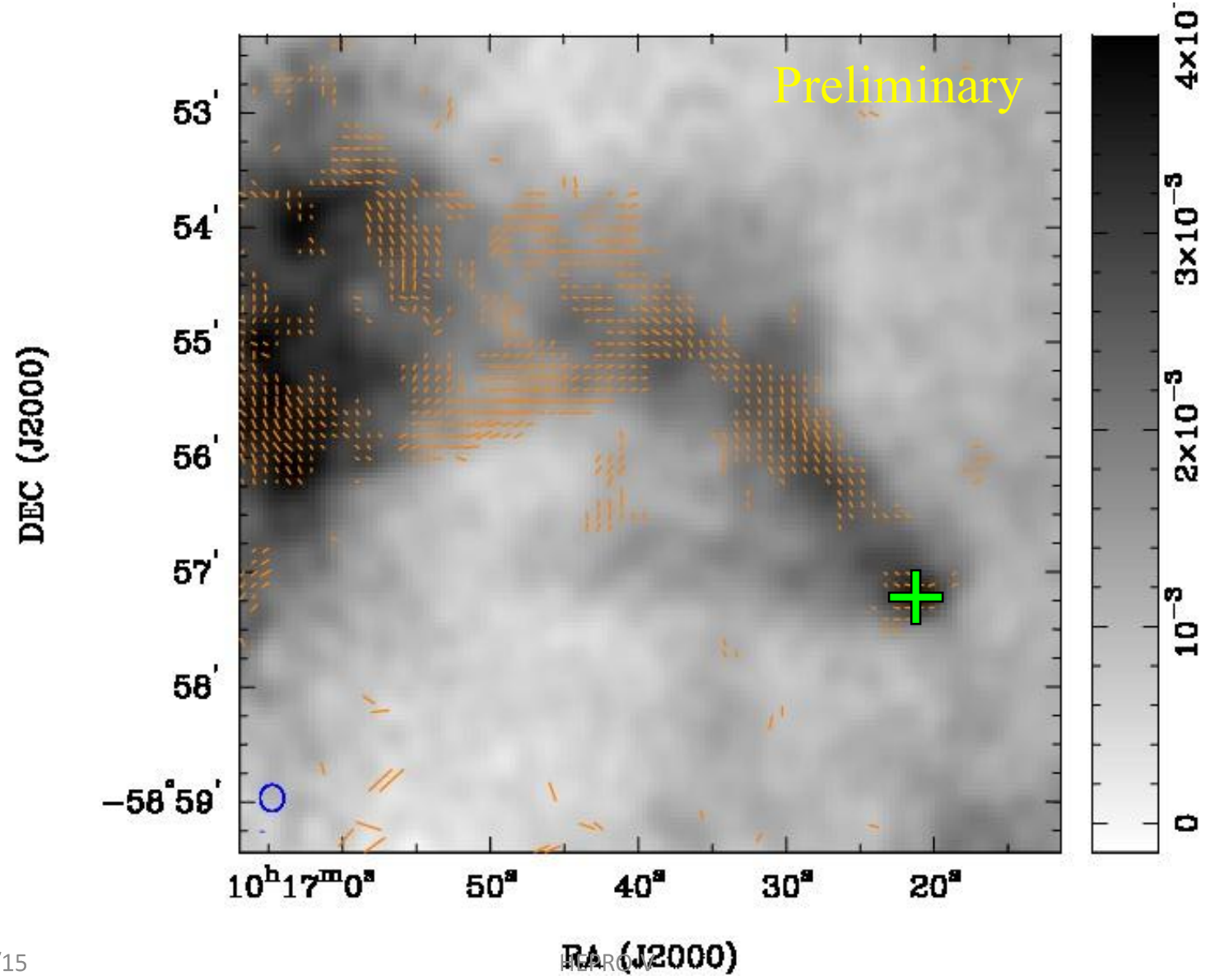


# G284.0-1.8 X-ray (*Chandra*)

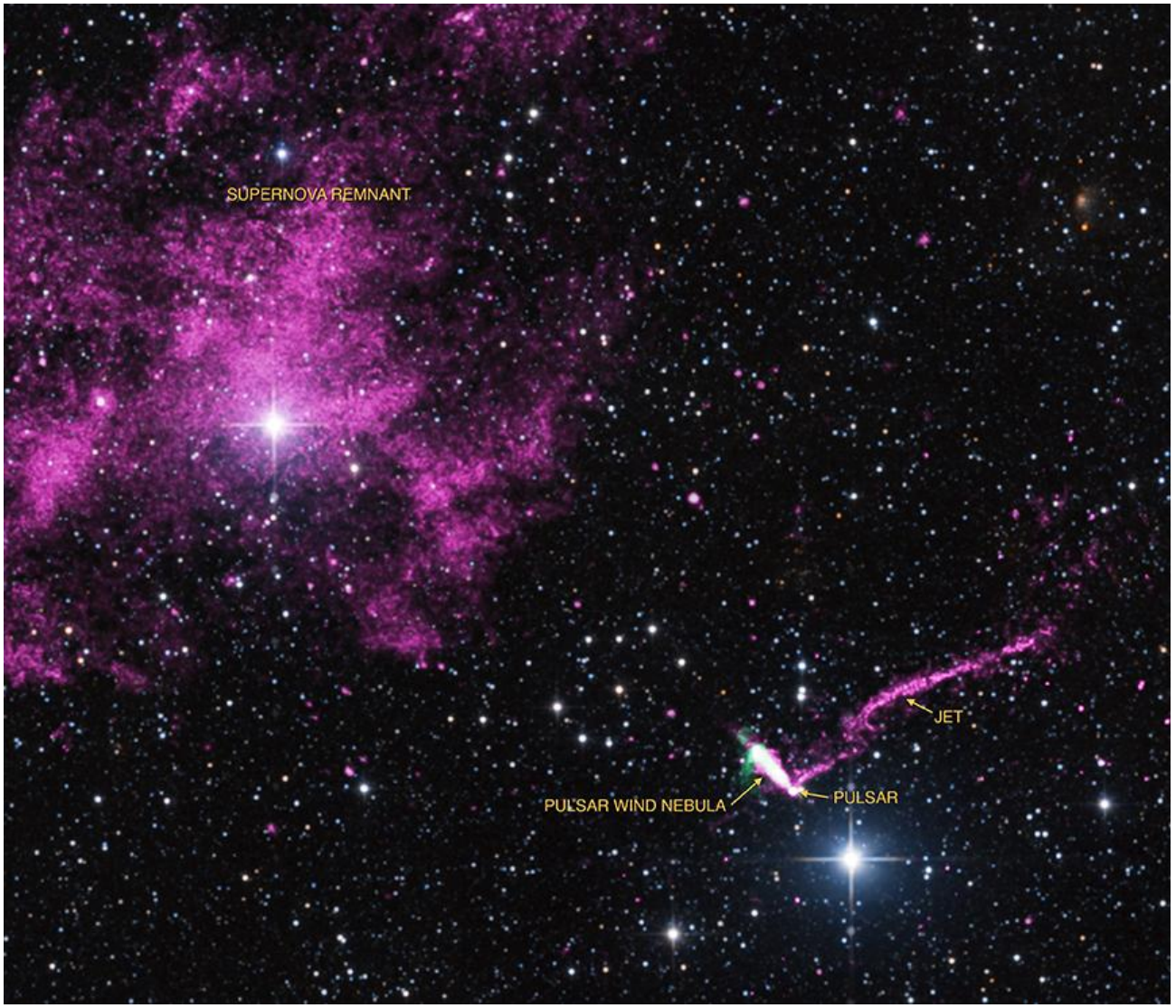



Camilo et al. (2004)

# G284.0-1.8 ATCA 6cm

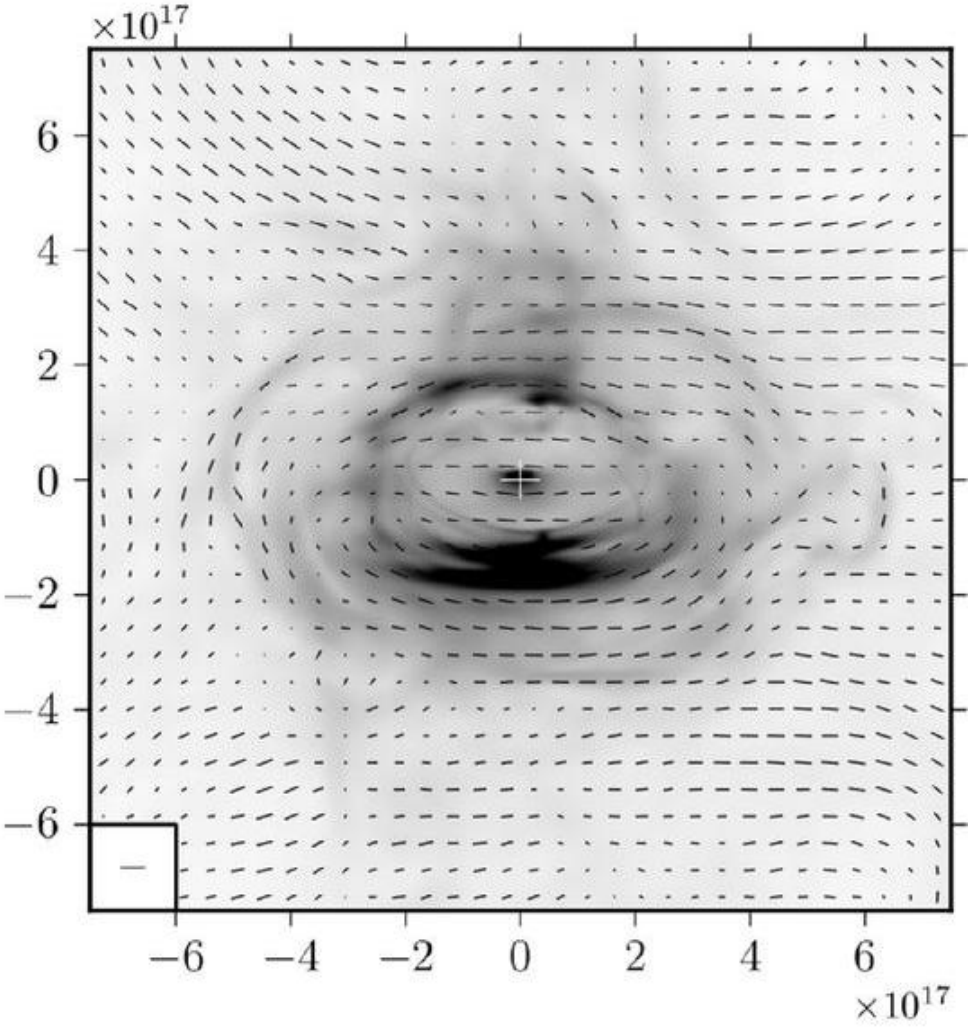


# Lighthouse Nebula/IGR J11014-6103



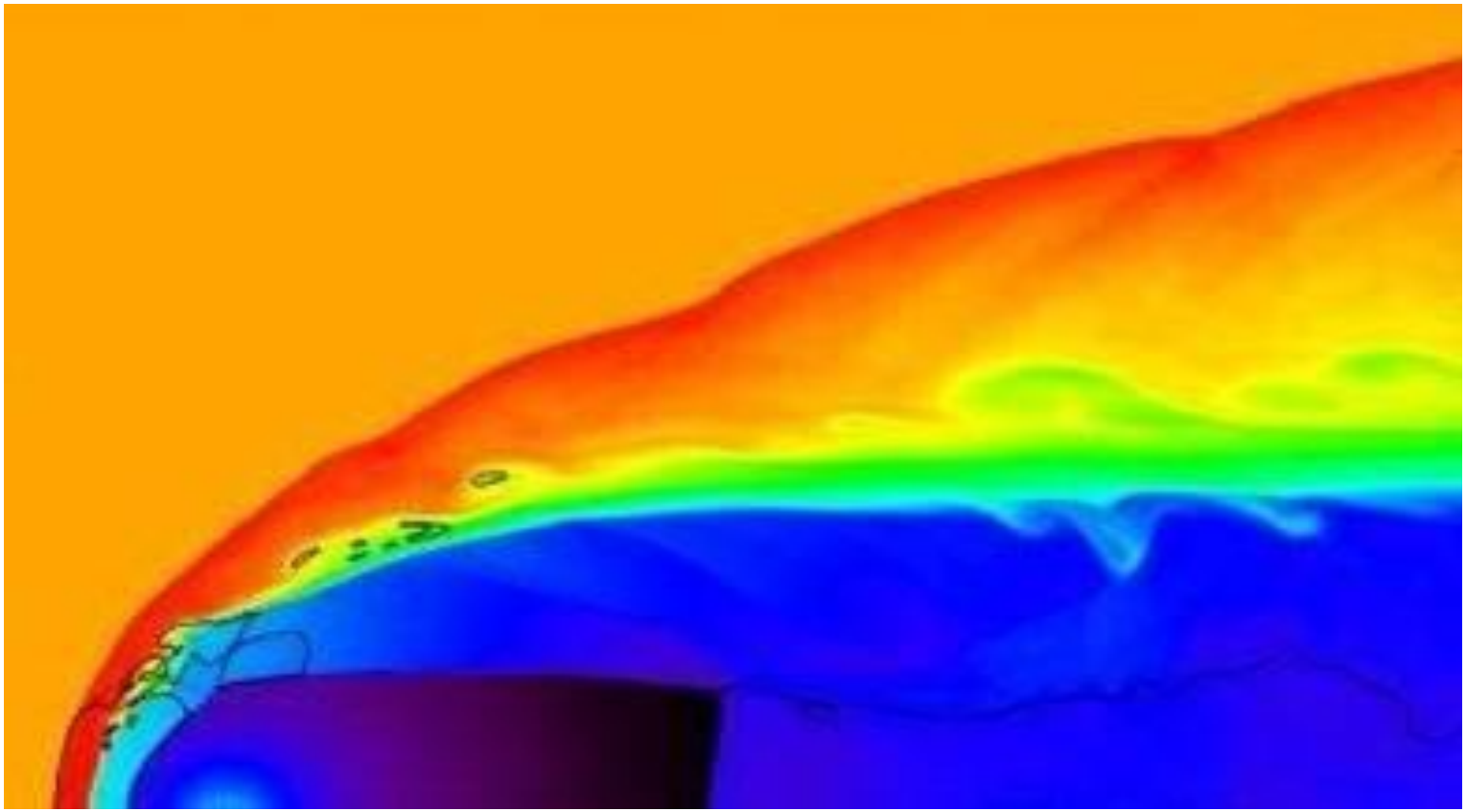

Pavan et al (2014)

# Modeling



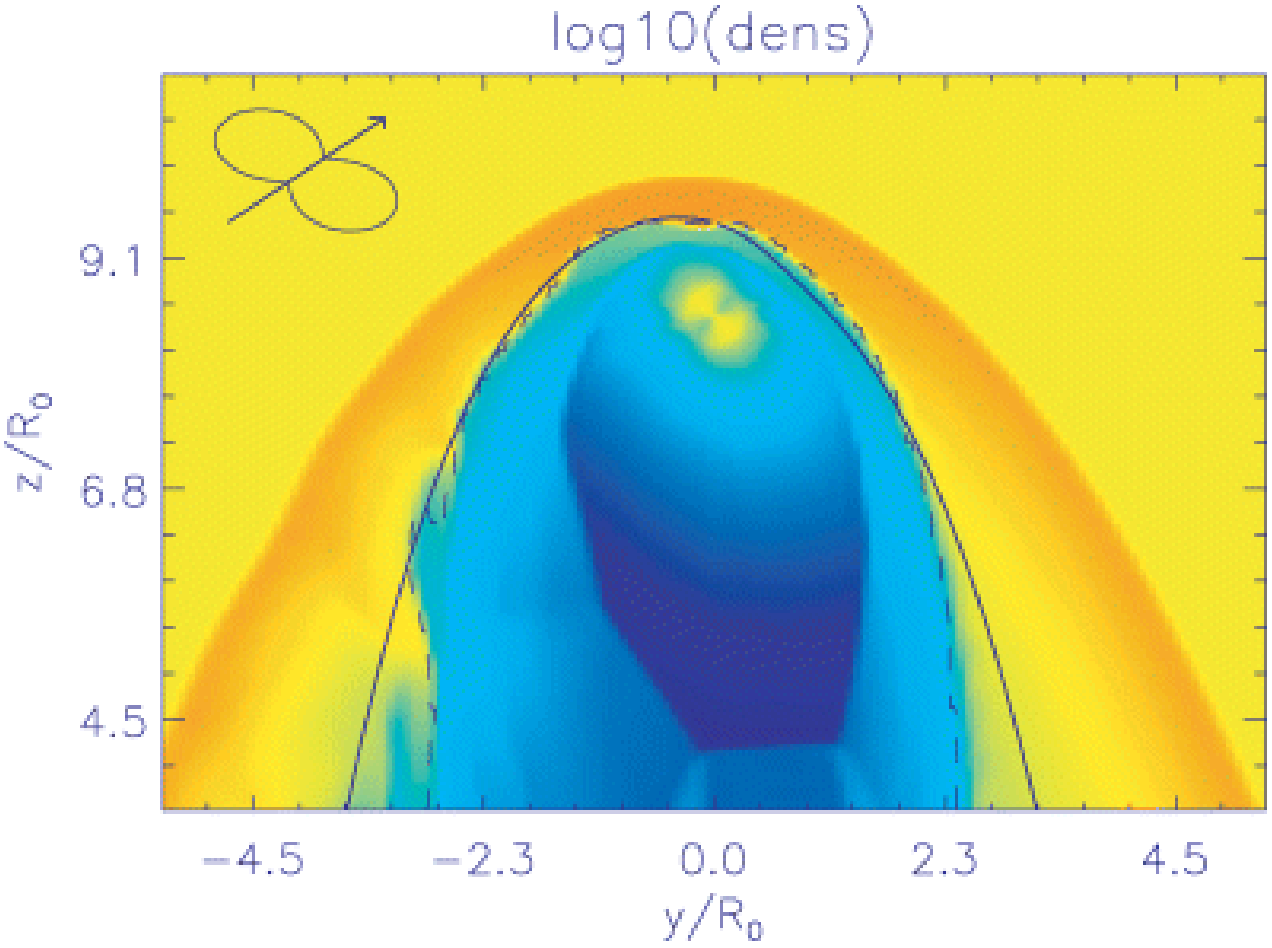

Porth et al. (2014)

# Modeling



Bucciantini et al. (2005)

# Modeling




Vigelius et al. (2007)

# Summary

- Radio polarization measurement as a powerful tool

- Large diversity in field geometry:
  - Parallel / perpendicular *B*-field in bow-shocks
  - Highly ordered field in crushed PWNe
  - Filamentary structure in young objects

- Theoretical modeling and MHD simulations needed:
  - Connection with other physical parameters, e.g. Mach number, pulsar spin orientation.
  - Particle acceleration and transport