



Canada

On Distance and Age of Pulsar Wind Nebula 3C58

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National Research Council Canada

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PWN 3C 58

Pro and Contra 1181
A.D.

New Distance
Determination

Impact of the new
Distance

Summary

PWN 3C 58

Pro and Contra 1181 A.D.

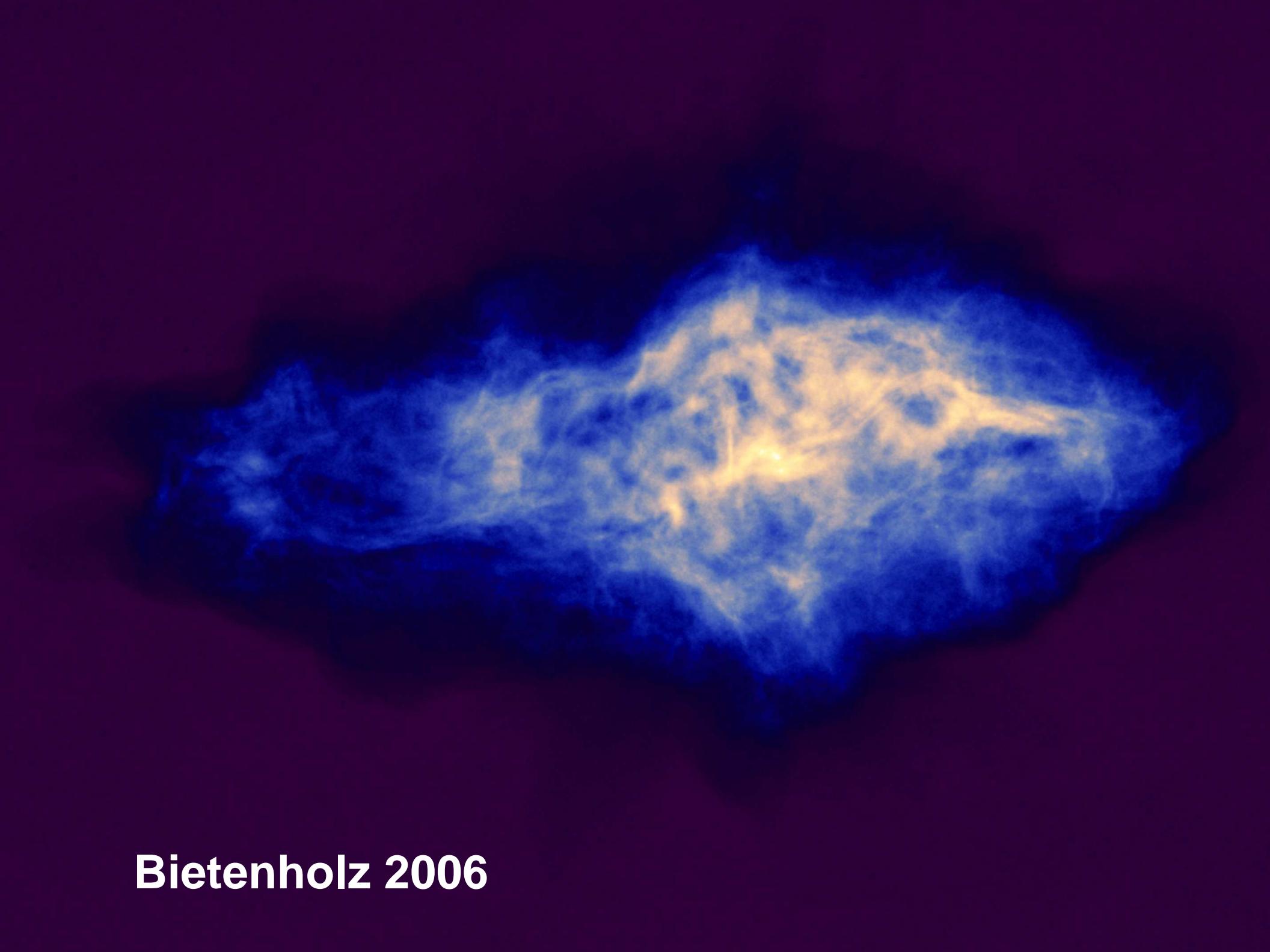
New Distance Determination

Impact of the new Distance

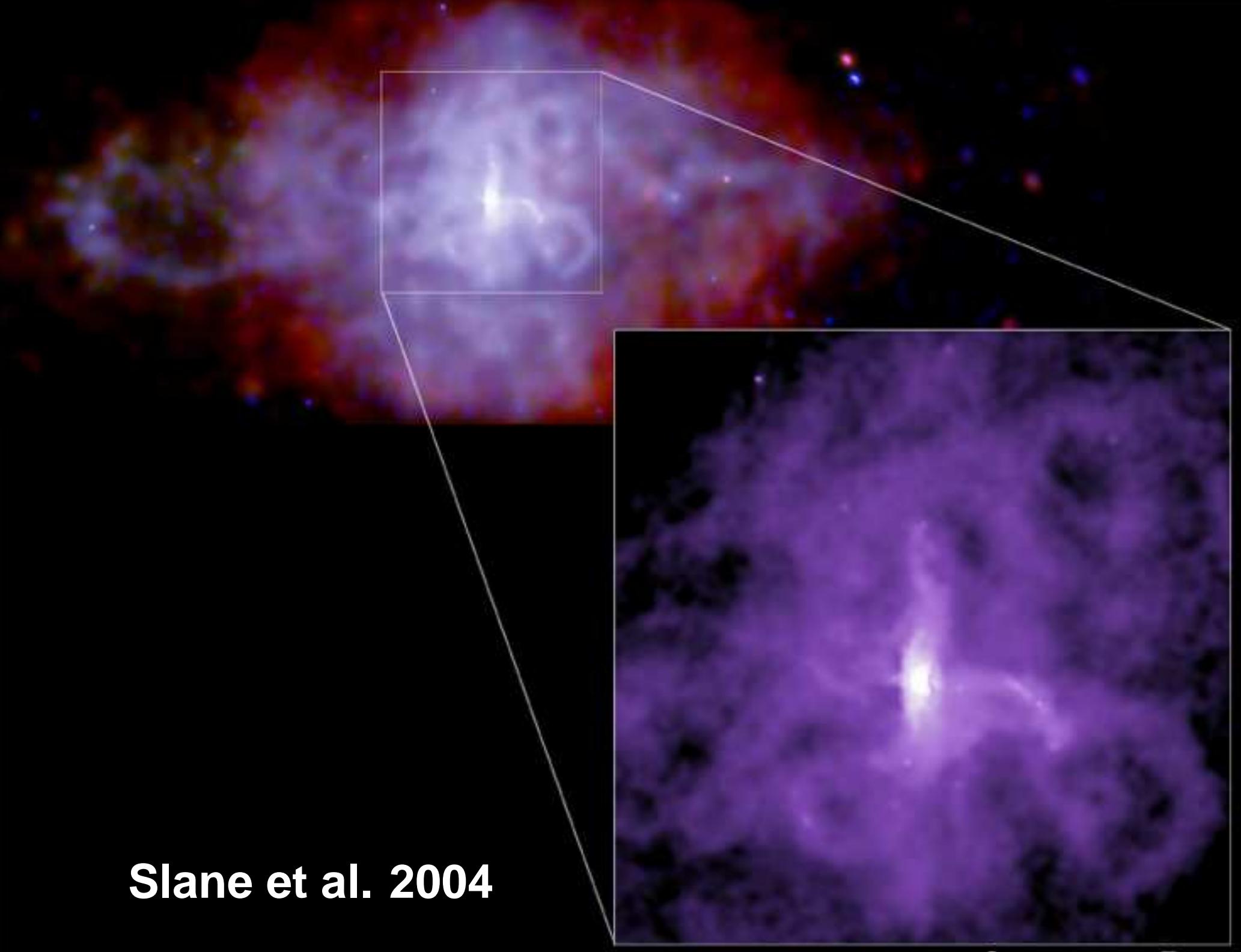
Summary

Mainly based on: Kothes R., 2013, A&A 560, 18



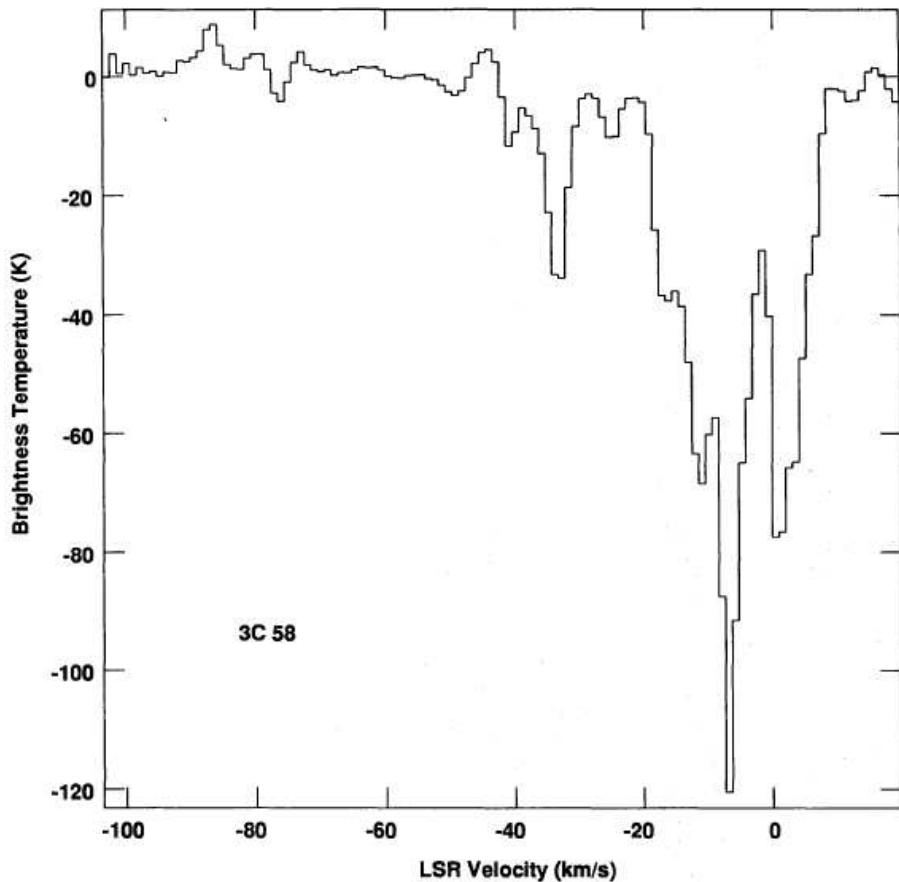


Bietenholz 2006



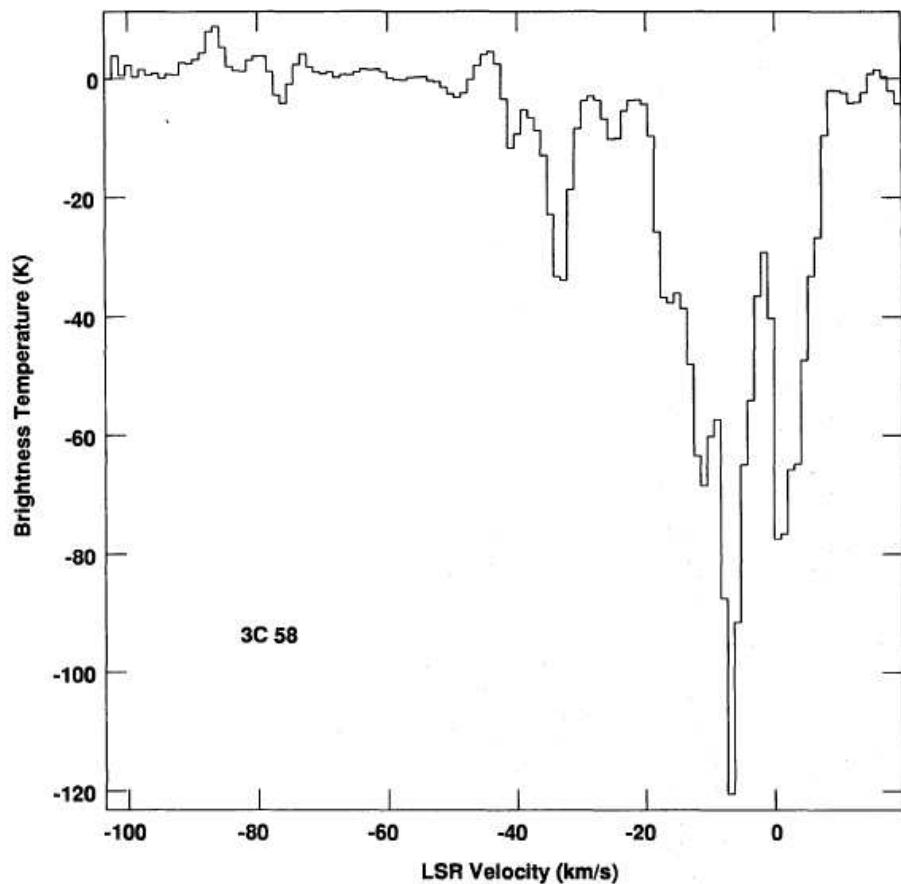
Slane et al. 2004

Distance and Environment

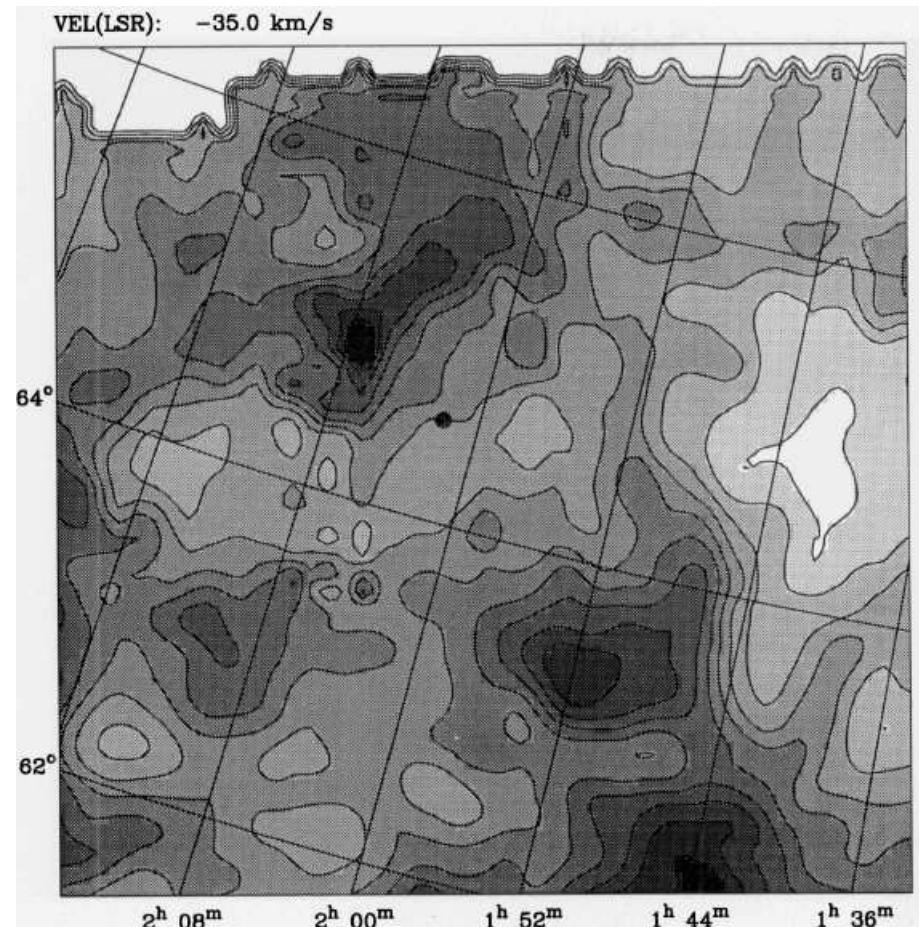


Roberts et al. 1993

Distance and Environment

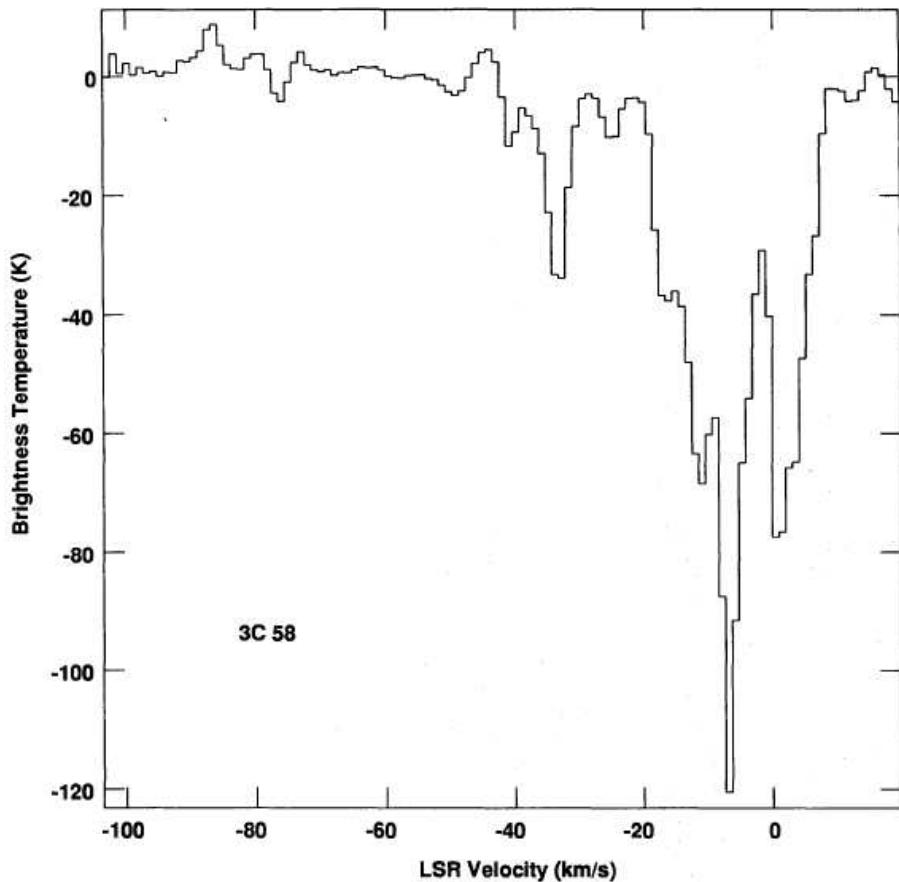


Roberts et al. 1993



Wallace et al. 1994

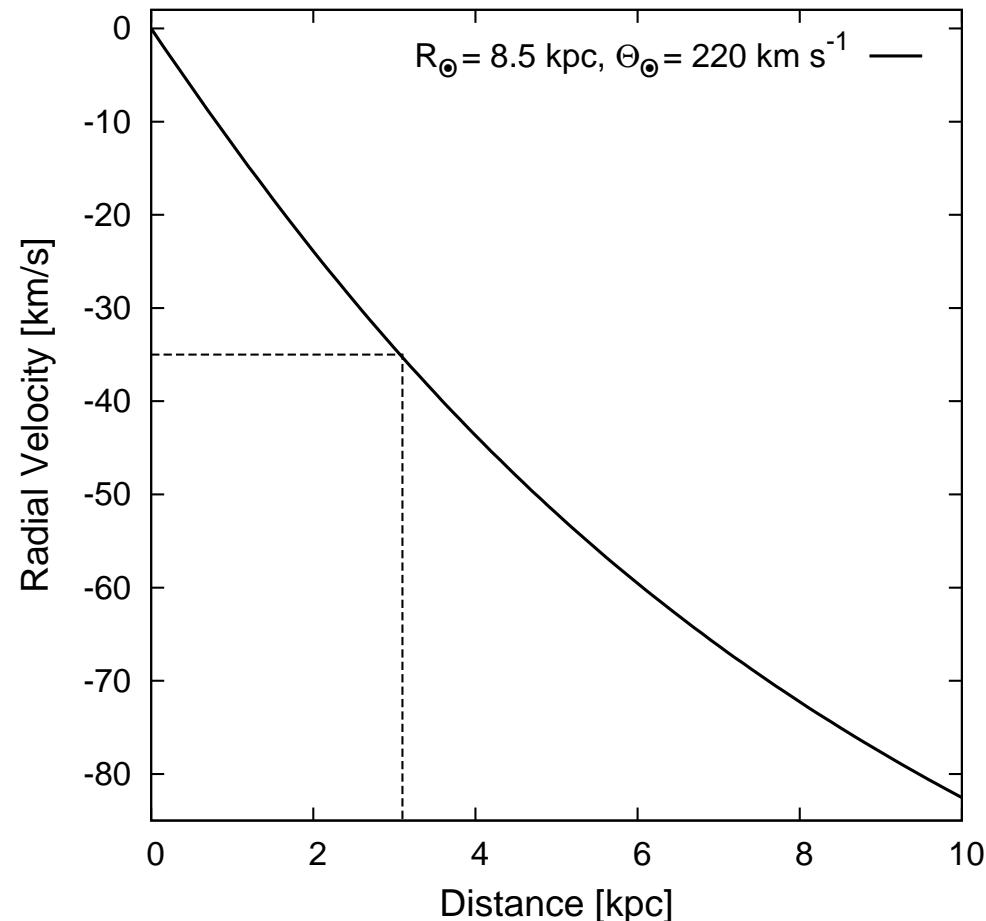
Distance and Environment



Roberts et al. 1993

$$R_{\odot} = 8.5 \text{ kpc}$$

$$d = 3.2 \text{ kpc}$$



Wallace et al. 1994

$$v_{\odot} = 220 \text{ km s}^{-1}$$

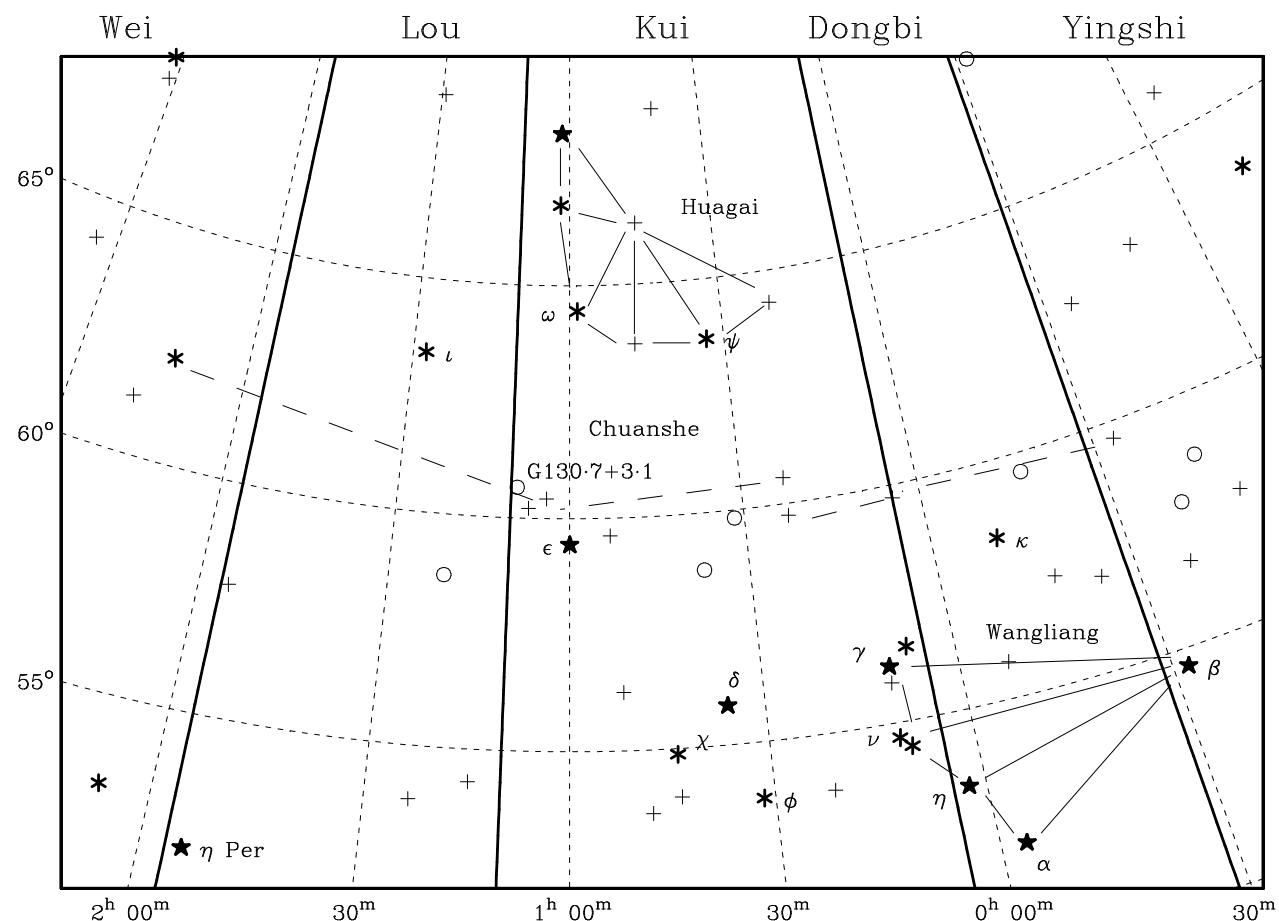
Pro and Contra 1181 A.D.

Property/Observation	Age	Reference
1181 A.D. Guest Star		Stephenson & Green, 2002



Historical Records

八年六月己巳客星出奎宿犯
傳舍占客星亦妖星天之使者見於天而無常所入列
舍以示休咎星大者事大而禍深色白其分有兵喪今
客星出紫微外座傳舍星宜備姦使邊夷侵境又云出
奎宿爲兵姦臣僞惑天子於是金虜遣使來爭執進書
儀甲戌客星守傳舍第五星 九年正月癸酉客星始
不見自去年六月己巳至是凡一百八十五日乃消伏
時虜使久在館至是乃去



Stephenson & Green, 2002

Pro and Contra 1181 A.D.

Property/Observation	Age	Reference
1181 A.D. Guest Star	835 yr	Stephenson & Green, 2002
PWN M_{sw} and Energy		Chevalier 2004

PWN Evolution and Energy

$$M_{\text{sw}} \sim R_{\text{PWN}}^{-2} \times t^3 = 0.0054\text{-}0.012 M_{\odot}$$

(predicted, Chevalier, 2004)

$$M_{\text{sw}} \sim R_{\text{PWN}}^{2.5} = 0.1 M_{\odot}$$

(observed, Bocchino et al., 2001)

Minimum Energy required for observed synchrotron emission:

$$E_{\text{min}} \approx 1.0 \times 10^{48} \text{ erg}$$

Total energy lost by the pulsar:

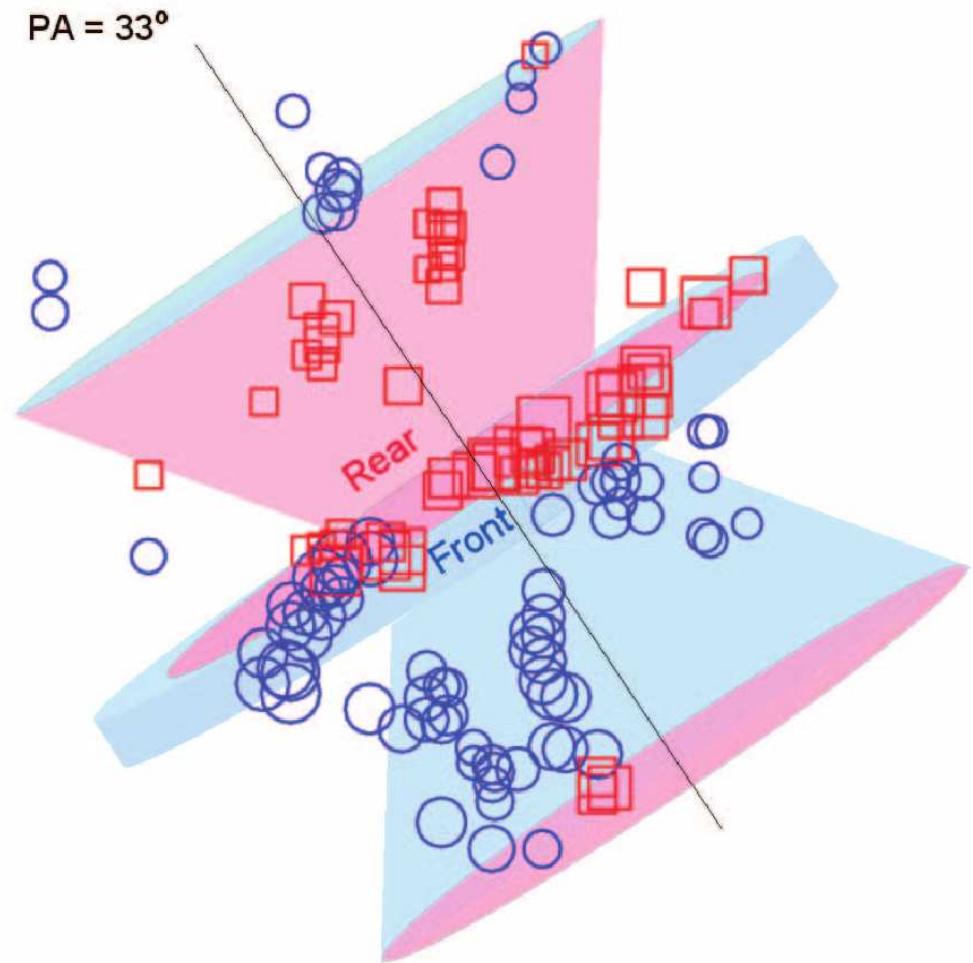
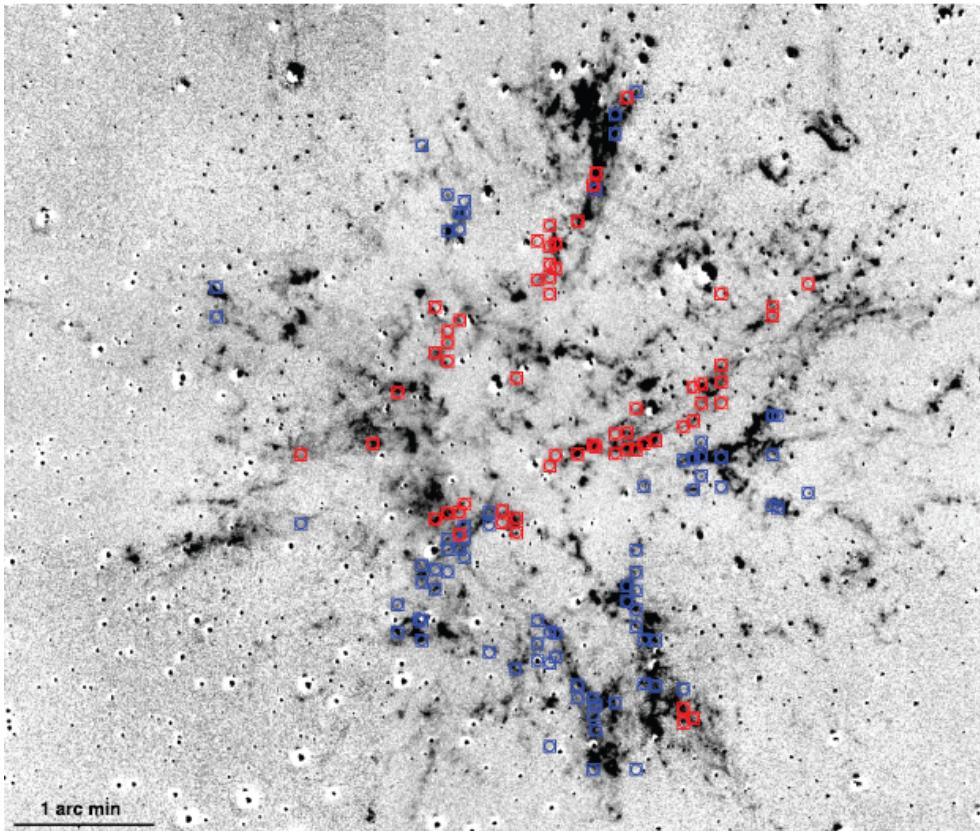
$$E_{\text{tot}} \approx 0.84 \times 10^{48} \text{ erg}$$



Pro and Contra 1181 A.D.

Property/Observation	Age	Reference
1181 A.D. Guest Star	835 yr	Stephenson & Green, 2002
PWN M_{sw} and Energy Optical Knots Study	~ 2500 yr	Chevalier 2004
		Fesen et al., 2008

Optical knots expansion study

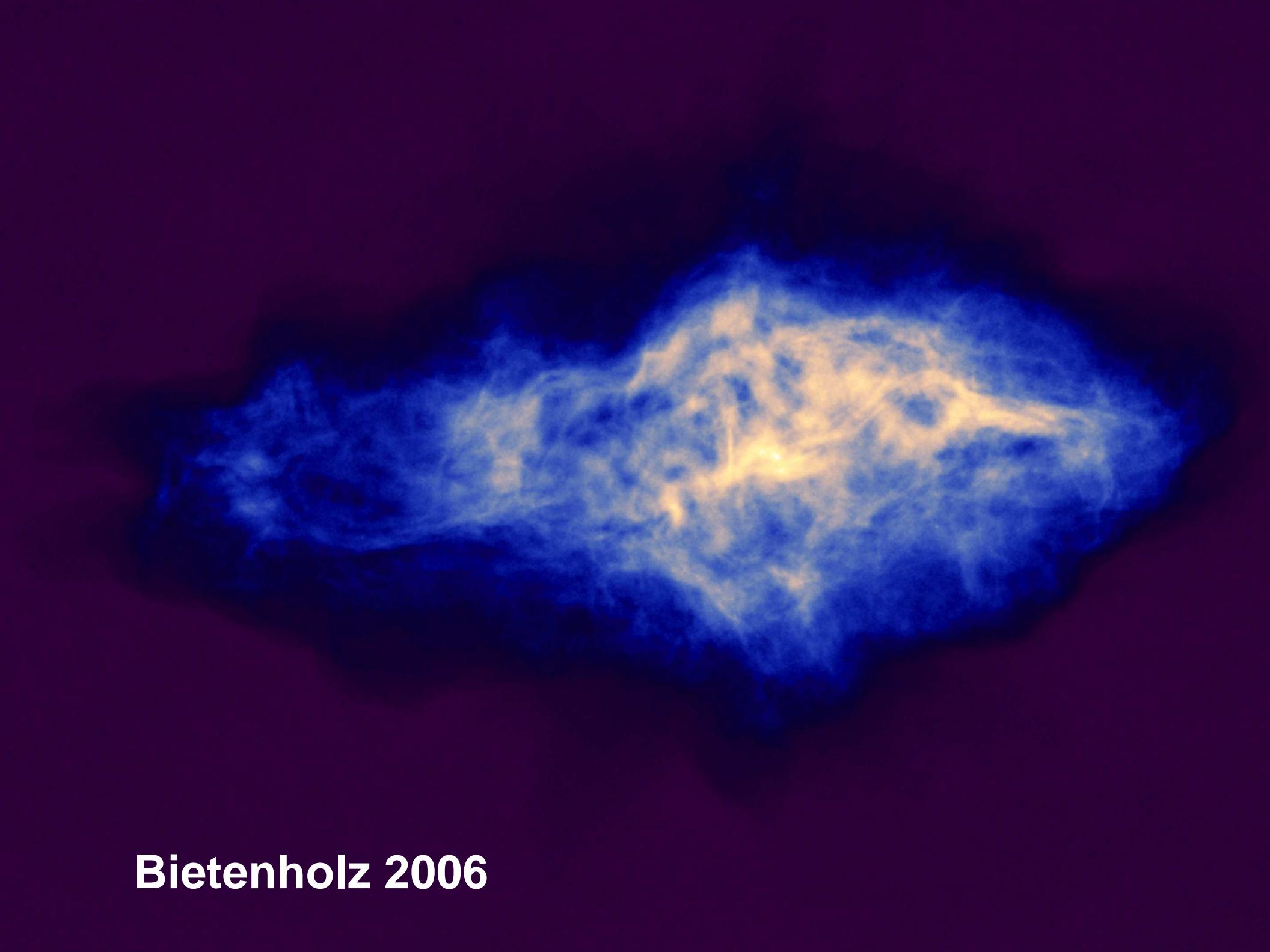


Fesen et al., (2008)

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Radio Expansion		Bietenholz et al., 2006





Bietenholz 2006

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Radio Expansion	≤ 7000 yr	Bietenholz et al., 2006
SN1181 Peak Brightness	???	Stephenson & Green, 2002
Pulsar Characteristics	???	many



HI emission around 3C 58

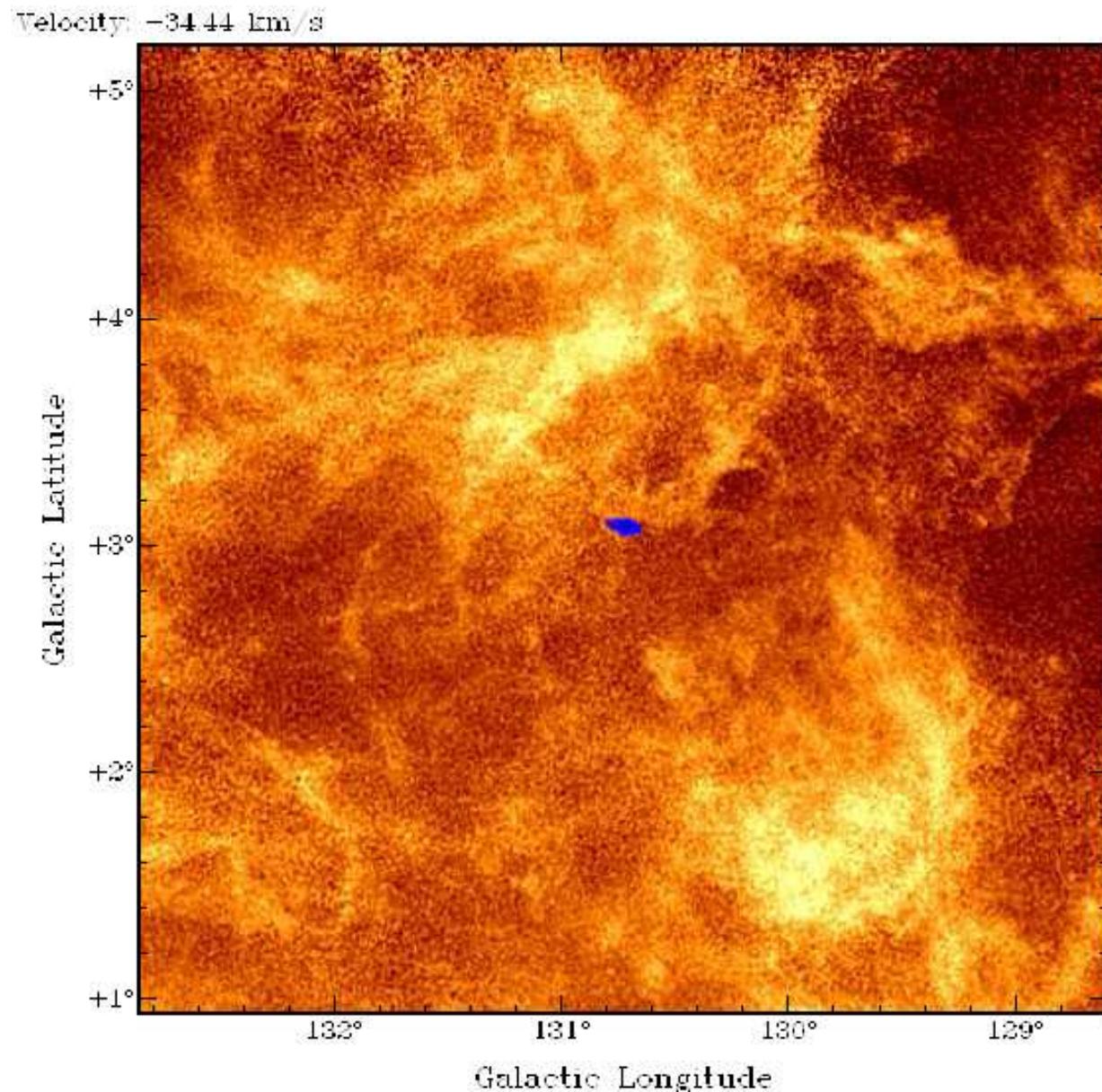
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HI emission around 3C 58

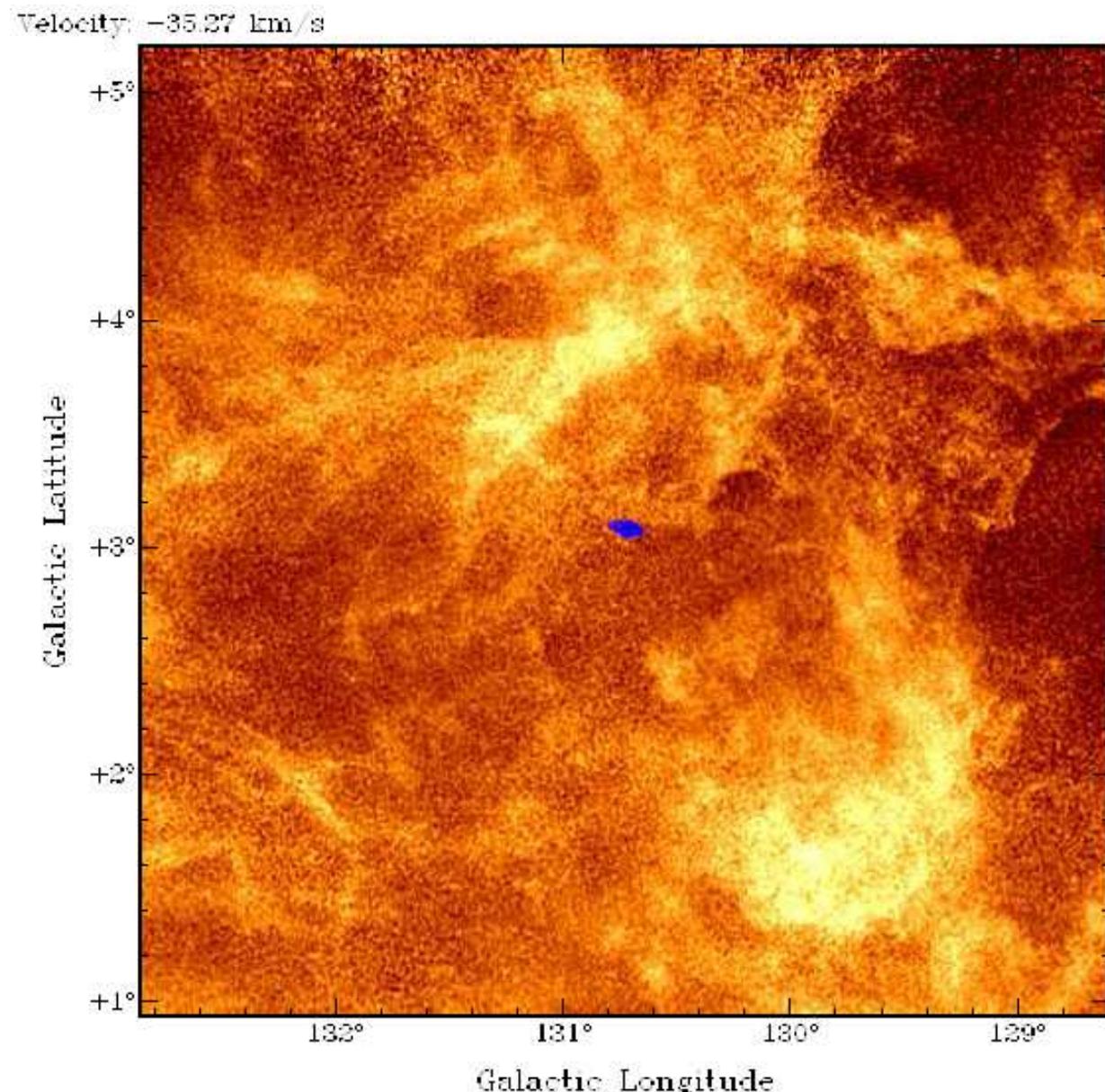
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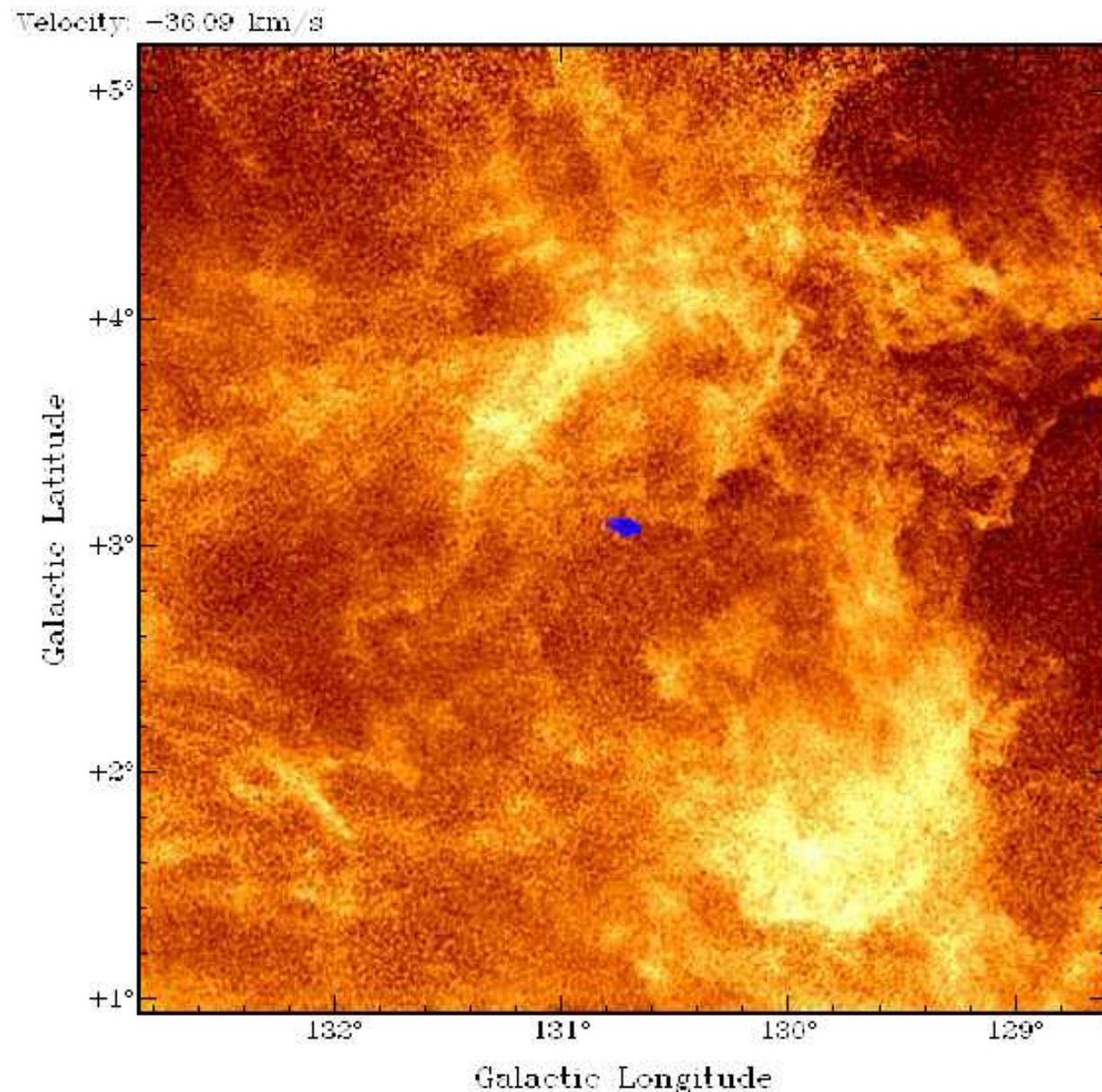
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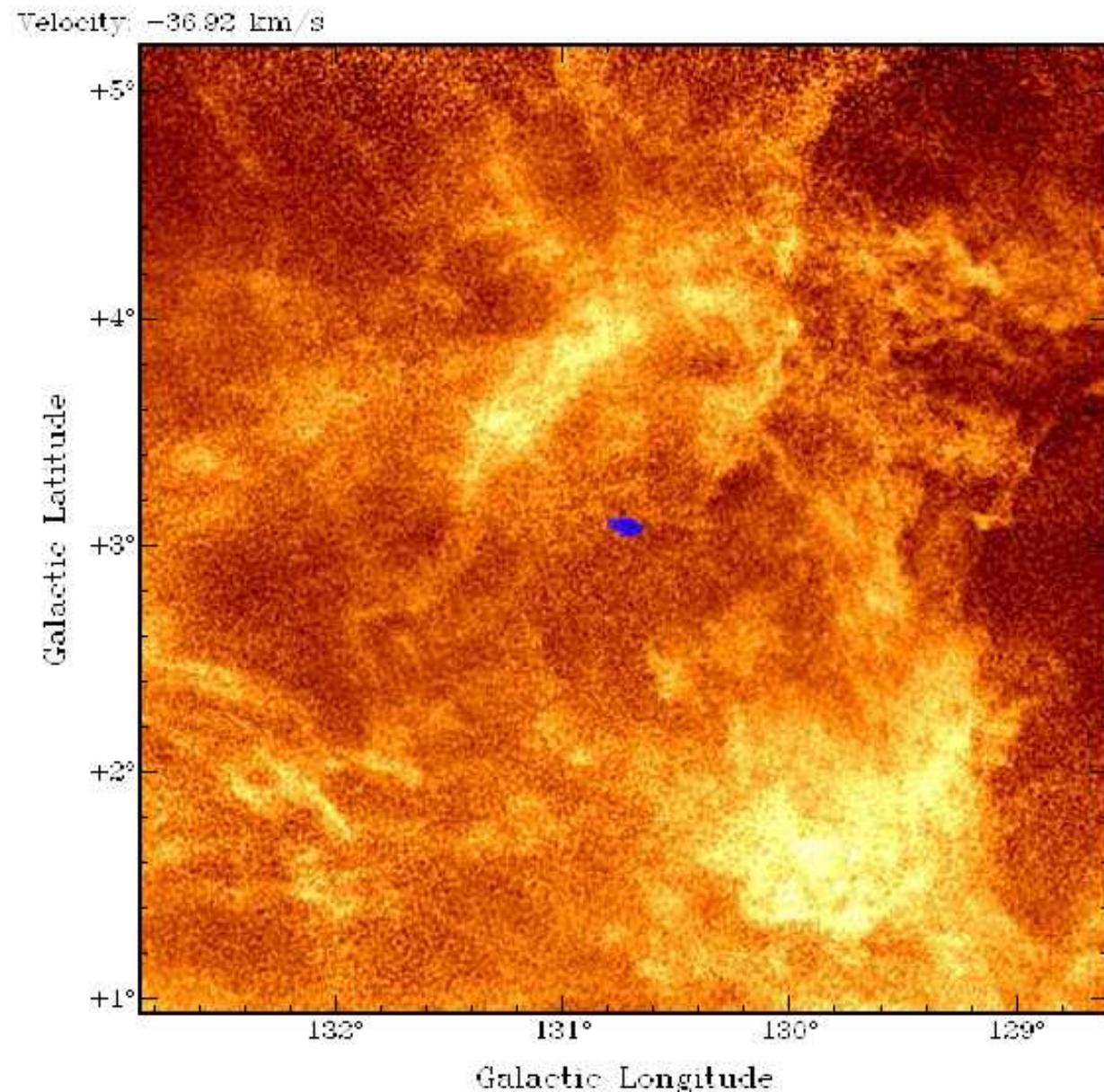
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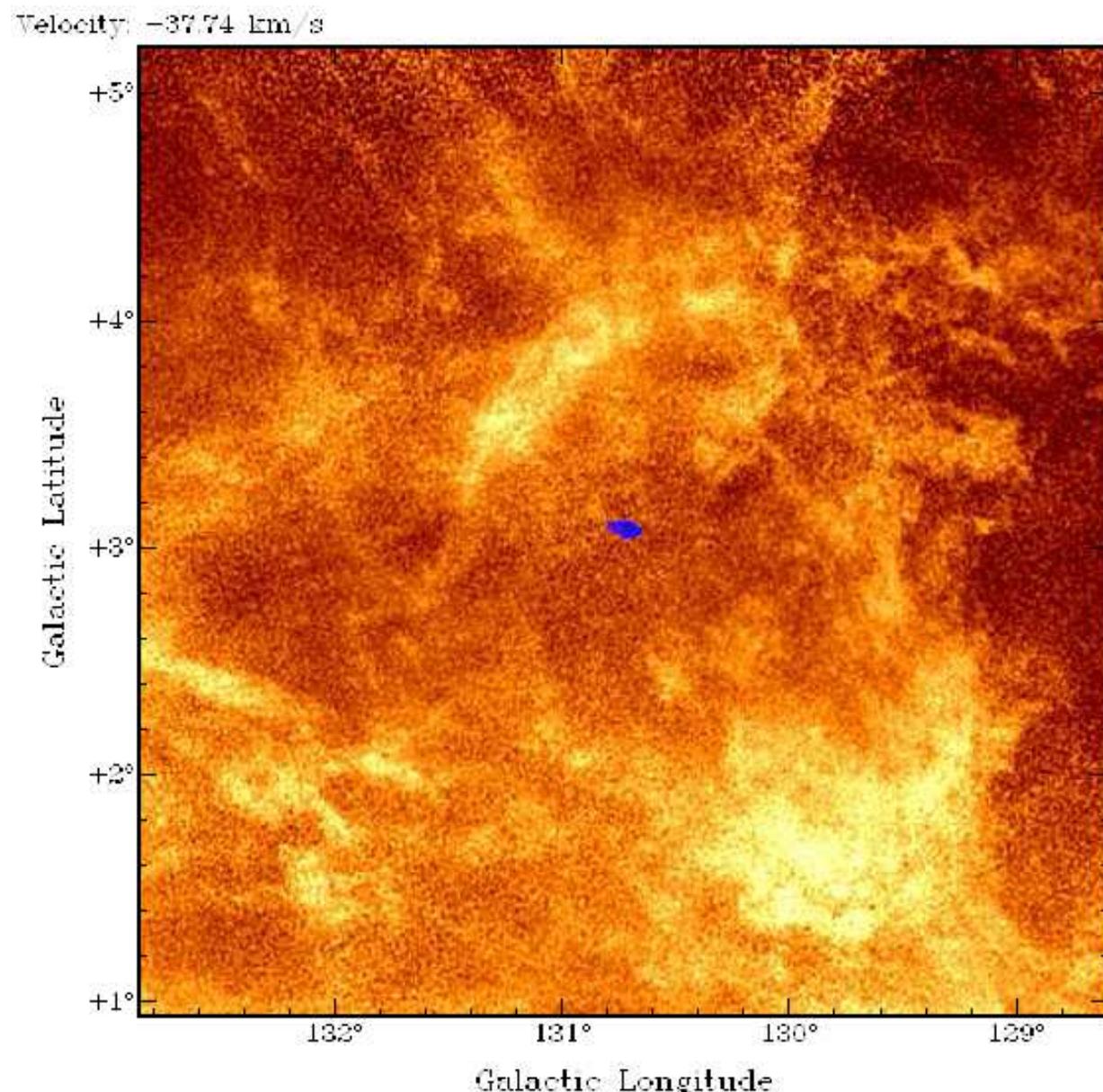
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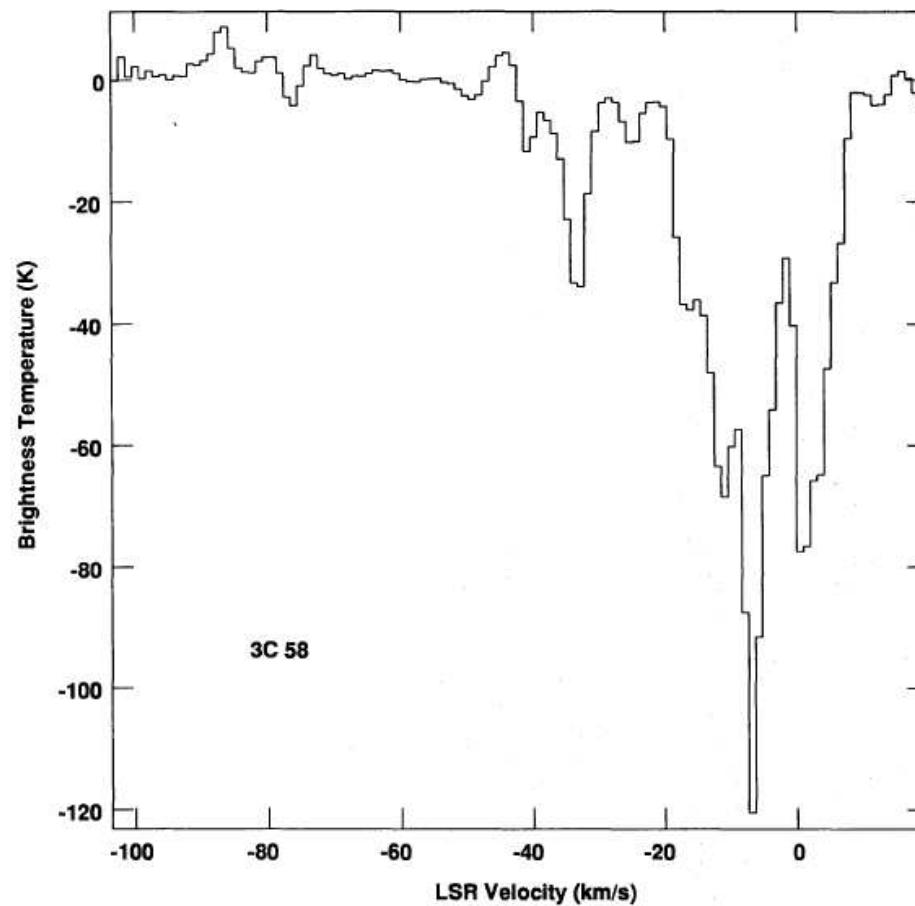
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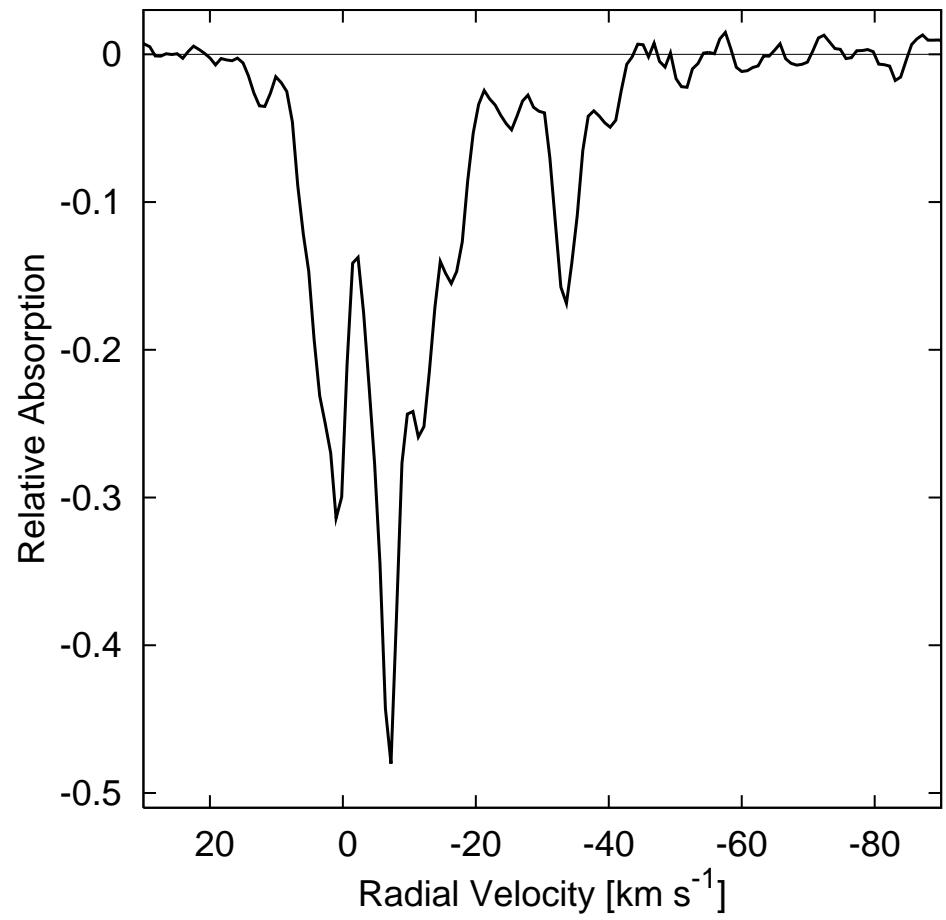
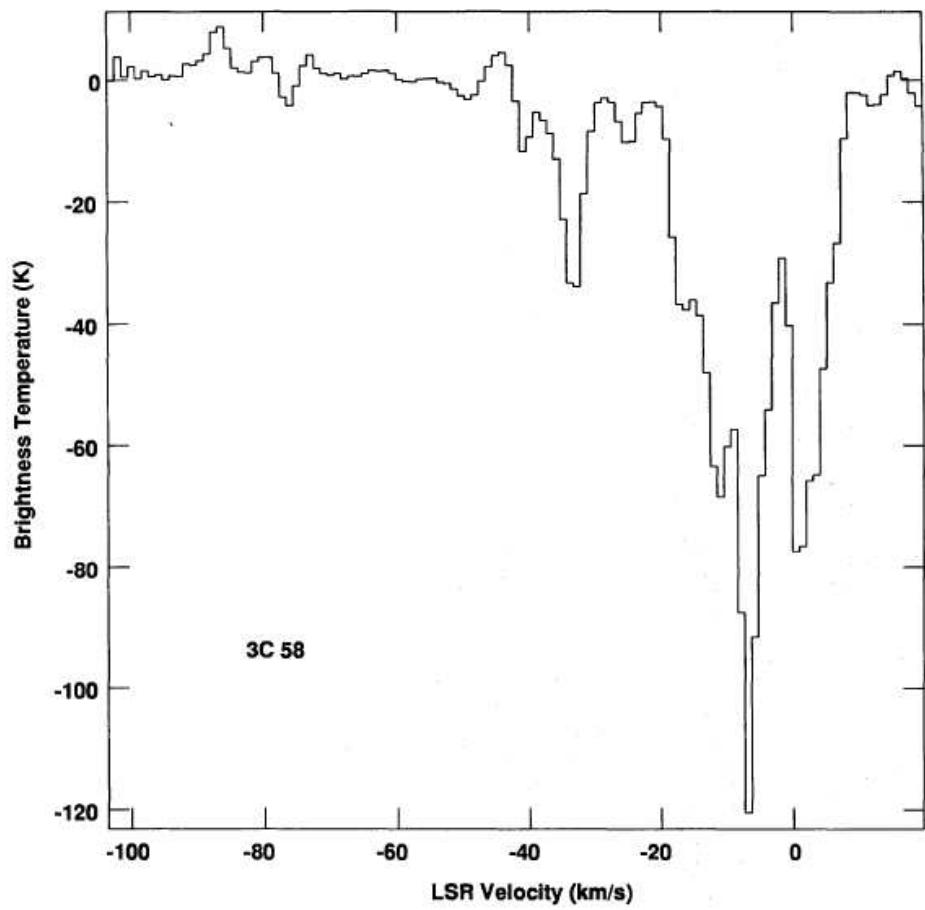
Summary



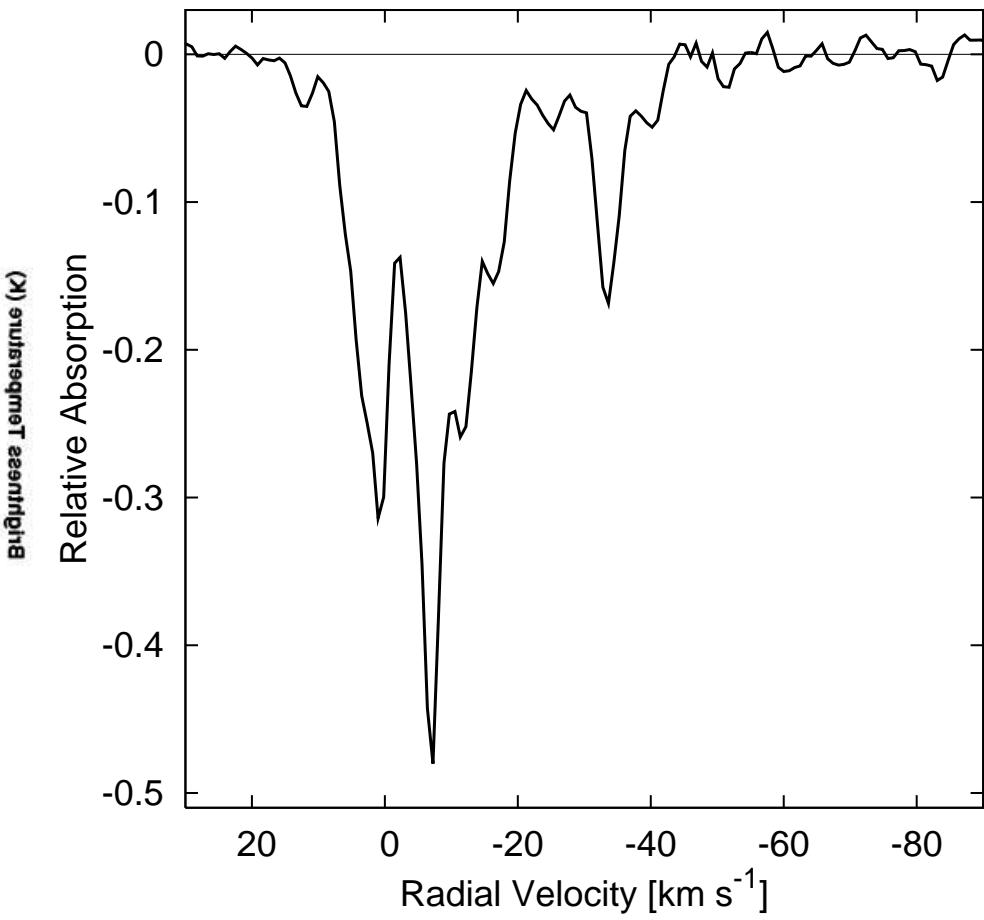
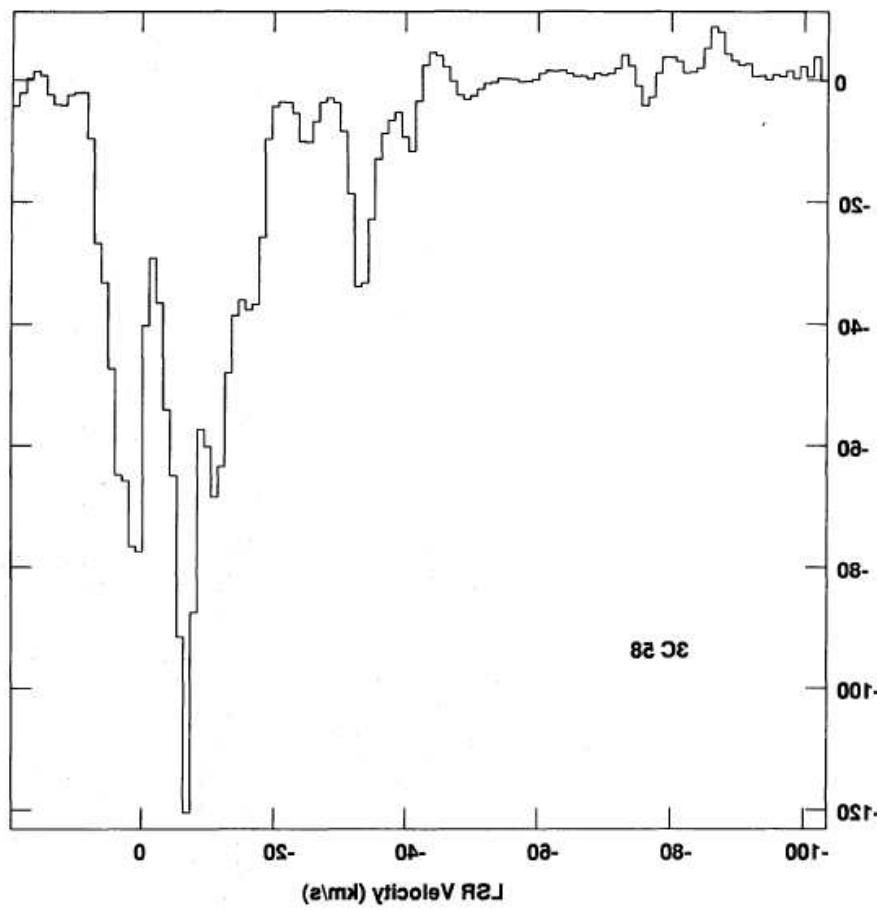
3C 58 in the CGPS



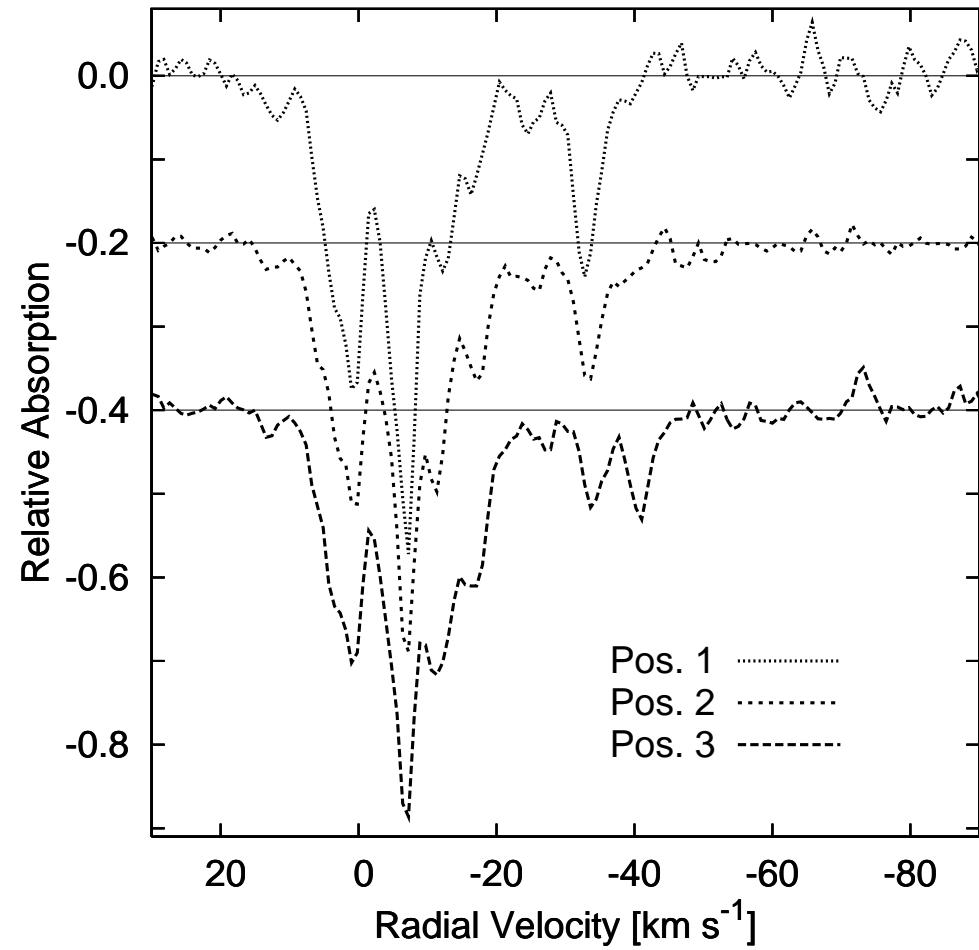
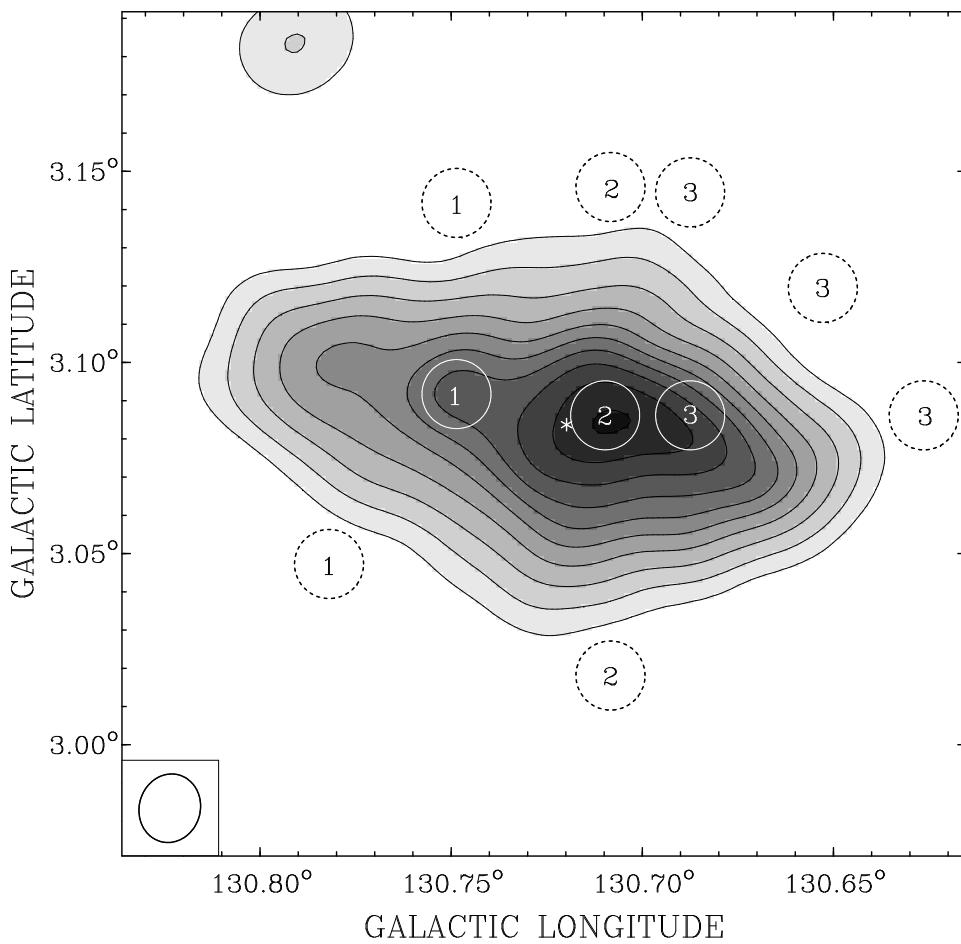
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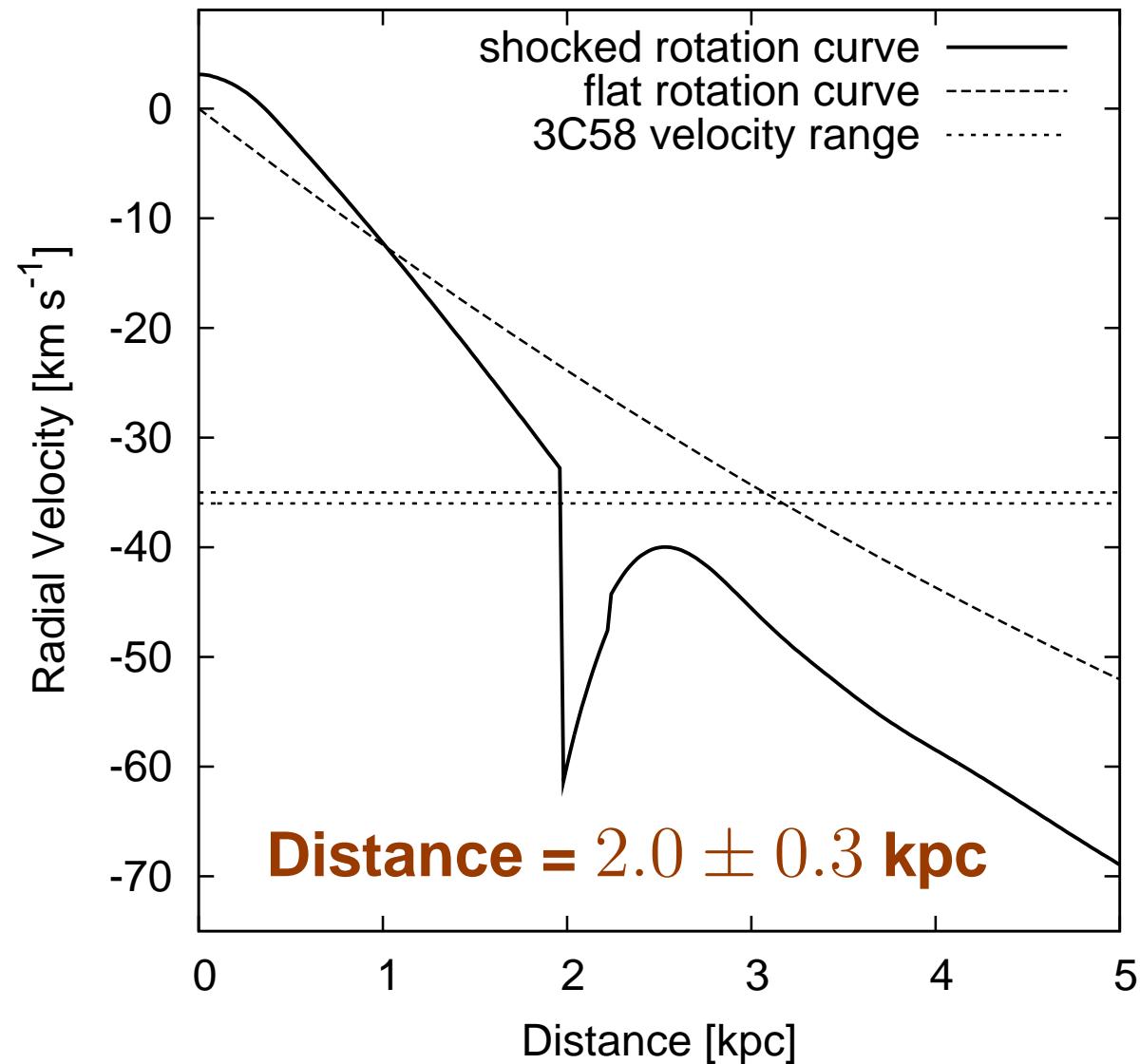


New Distance and Environment



New Distance of 3C 58

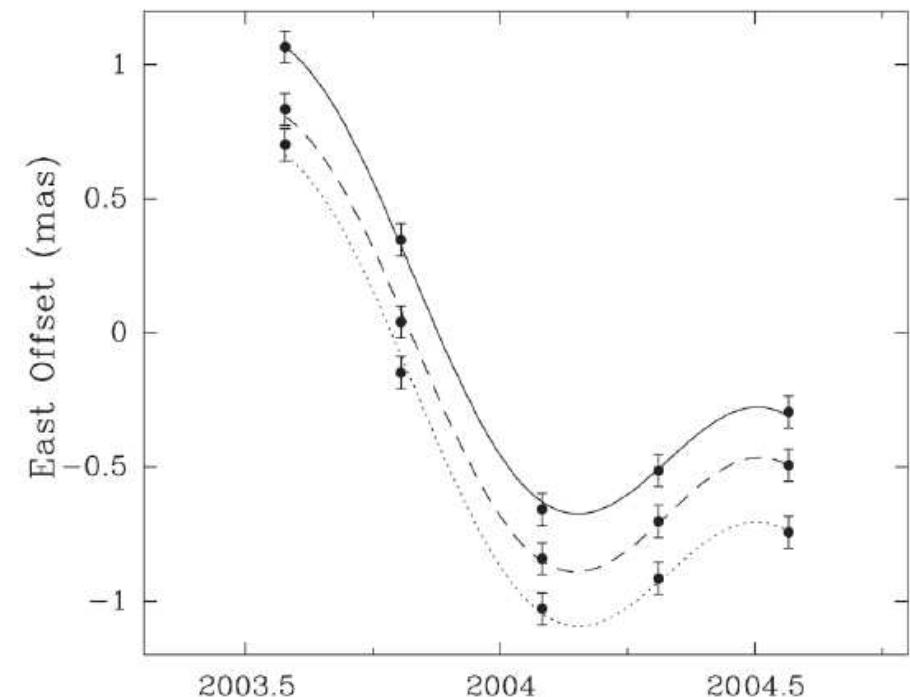
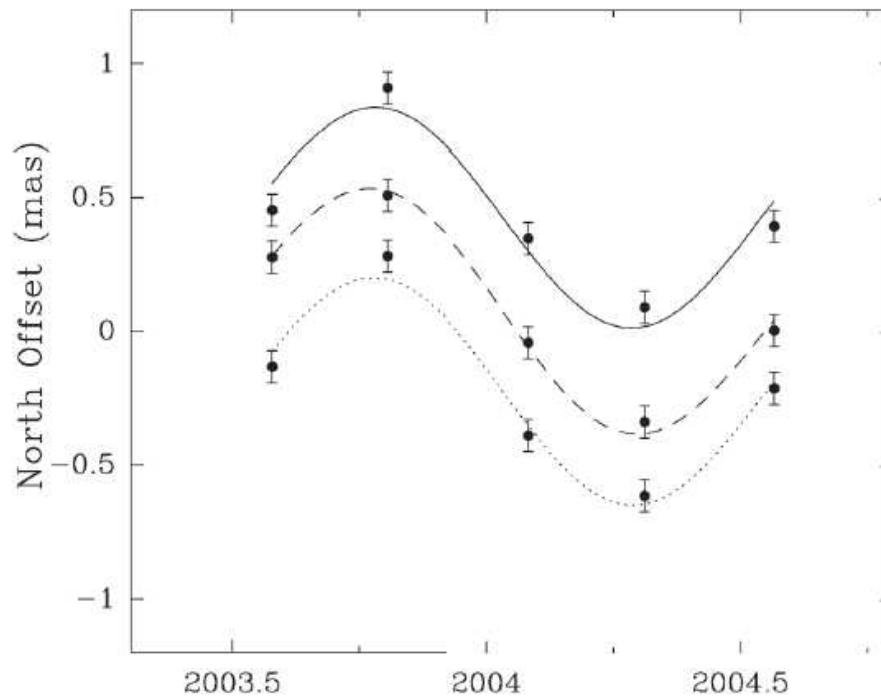
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Foster & MacWilliams, 2006



New Distance of 3C 58



Distance = 2.0 kpc

Xu et al., 2006

Hachisuka et al., 2006

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1181 A.D. Guest Star	835 yr	Stephenson & Green, 2002
PWN M_{sw} and Energy	~ 2500 yr	Chevalier 2004
Optical Knots Study	~ 3000 yr	Fesen et al., 2008
Radio Expansion	≤ 7000 yr	Bietenholz et al., 2006
Radio Flux Evolution	≤ 850 yr	Green, 1987
SN1181 Peak Brightness	???	Stephenson & Green, 2002
Pulsar Characteristics	???	many



PWN Evolution and Energy

$$M_{\text{sw}} \sim R_{\text{PWN}}^{-2} \times t^3 = 0.0054\text{-}0.012 M_{\odot}$$

(predicted, Chevalier, 2004)

$$M_{\text{sw}} \sim R_{\text{PWN}}^{2.5} = 0.1 M_{\odot}$$

(observed, Bocchino et al., 2001)

Minimum Energy required for observed synchrotron emission:

$$E_{\text{min}} \approx 1.0 \times 10^{48} \text{ erg}$$

Total energy lost by the pulsar:

$$E_{\text{tot}} \approx 0.84 \times 10^{48} \text{ erg}$$



PWN Evolution and Energy

$$M_{\text{sw}} \sim R_{\text{PWN}}^{-2} \times t^3 = 0.014\text{-}0.028 M_{\odot}$$

(predicted, Chevalier, 2004)

$$M_{\text{sw}} \sim R_{\text{PWN}}^{2.5} = 0.031 M_{\odot}$$

(observed, Bocchino et al., 2001)

Minimum Energy required for observed synchrotron emission:

$$E_{\text{min}} \approx 0.4 \times 10^{48} \text{ erg}$$

Total energy lost by the pulsar:

$$E_{\text{tot}} \approx 0.84 \times 10^{48} \text{ erg}$$



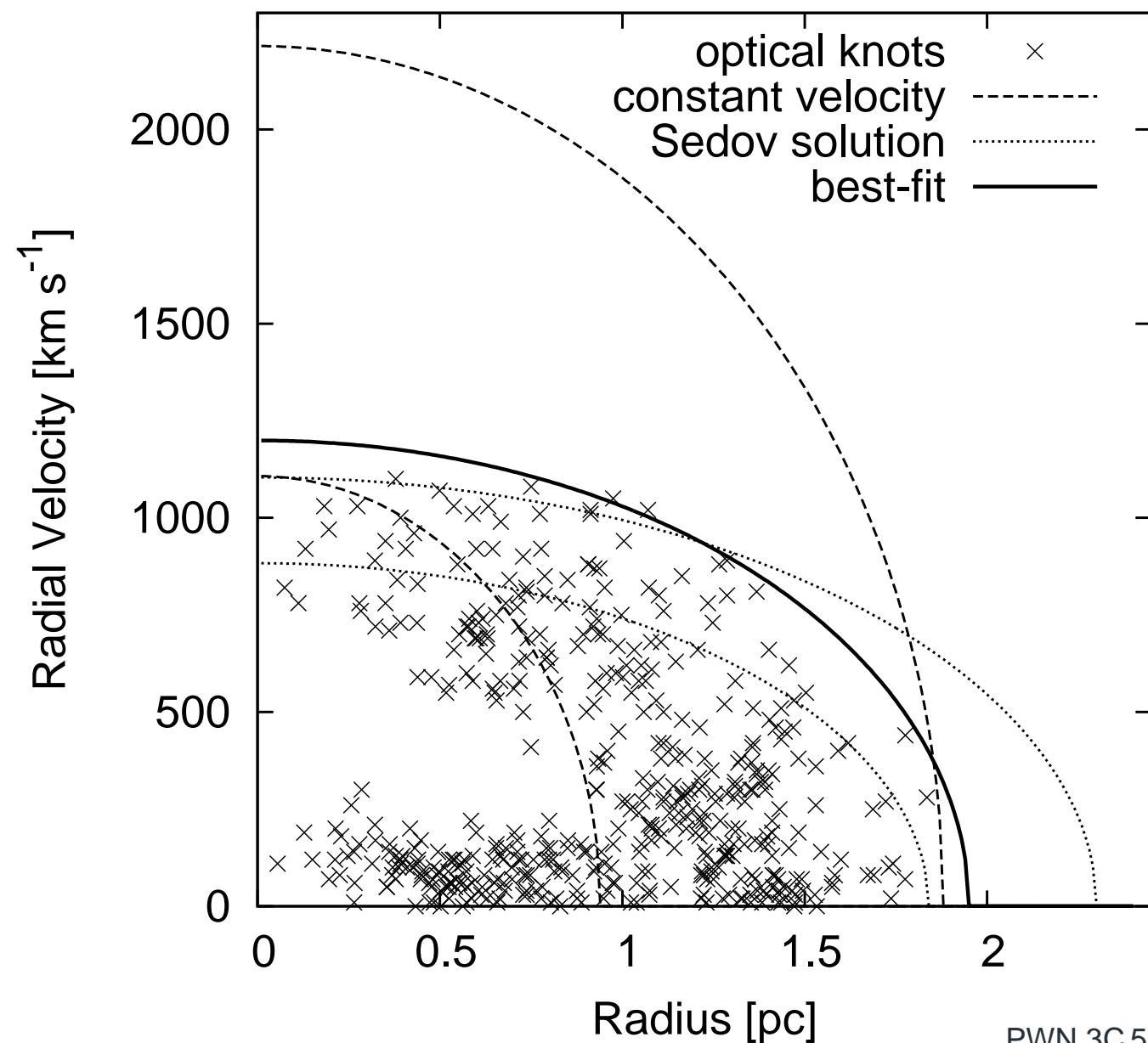
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Optical Knots

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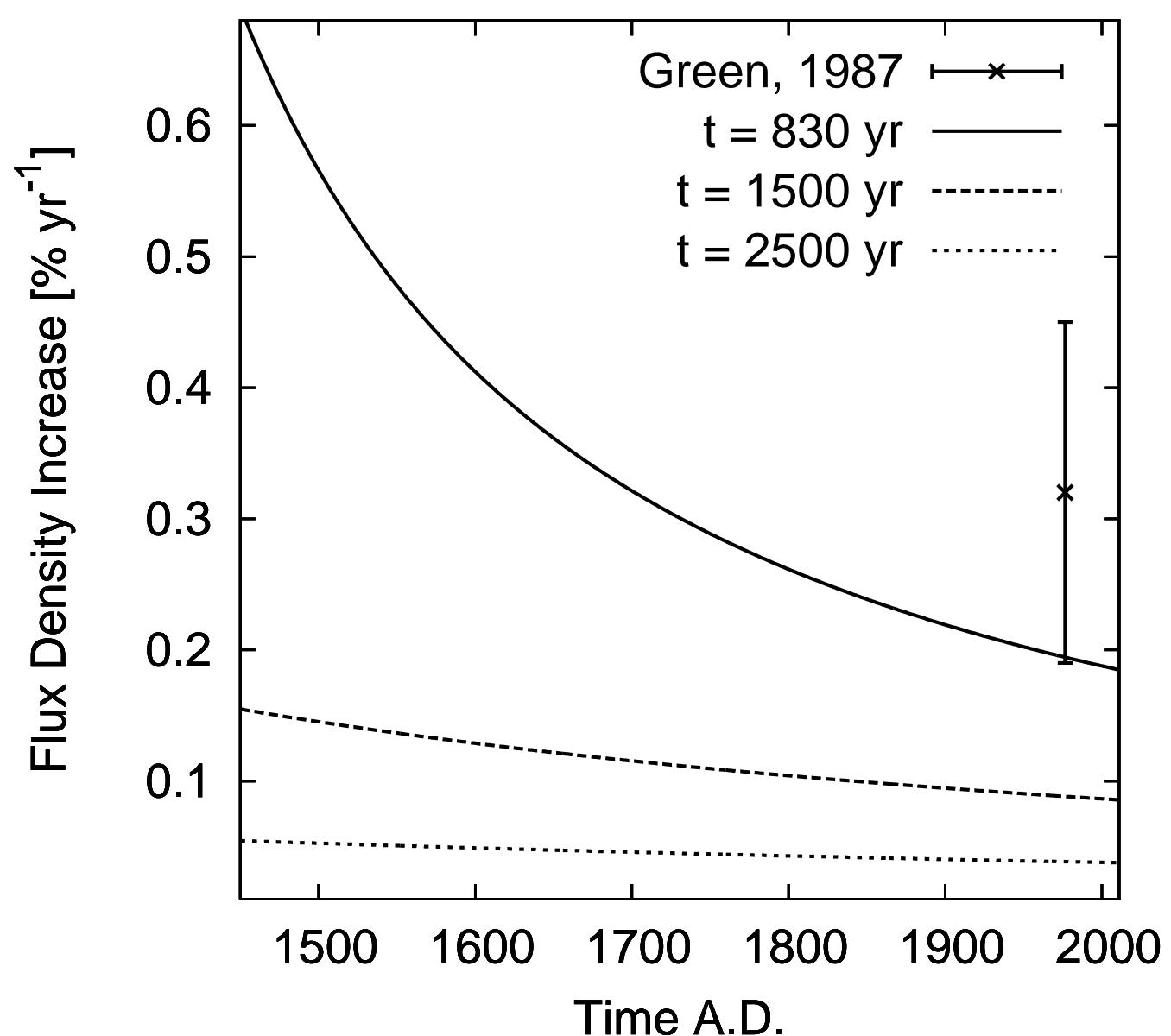
Pro and Contra 1181 A.D.

Property/Observation	Age	Reference
1181 A.D. Guest Star	835 yr	Stephenson & Green, 2002
PWN M_{sw} and Energy	860-1000 yr	Chevalier 2004
Optical Knots Study	630-1600 yr	Fesen et al., 2008
Radio Expansion	≤ 7000 yr	Bietenholz et al., 2006
SN1181 Peak Brightness	???	Stephenson & Green, 2002
Pulsar Characteristics	???	many



Radio Flux Evolution

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Summary

- New CGPS HI absorption and Emission data support the systemic velocity and the proposed location inside an HI cavity.
- A more reliable distance of 2.0 kpc to 3C 58 has been established.
- The new distance gives 3C 58 dimensions similar to the Crab Nebula, supporting a young age.
- A connection of the pulsar wind nebula 3C 58 with the historical supernova event of 1181 A.D. is strongly supported.

