A SEARCH FOR RADIO NEBULAE AROUND PULSARS PSR J0358 + 5413, PSR J1809 − 1917 AND PSR B1800 − 21

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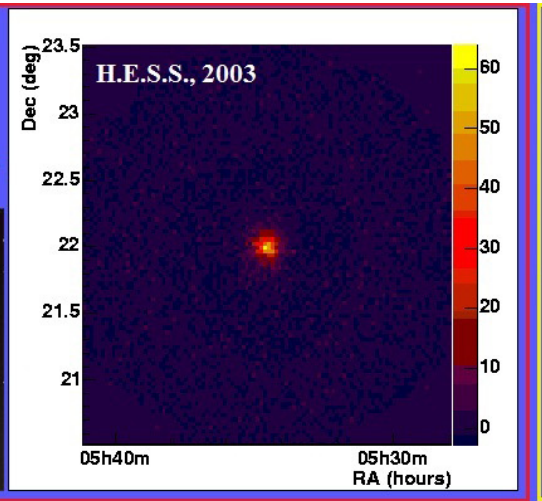
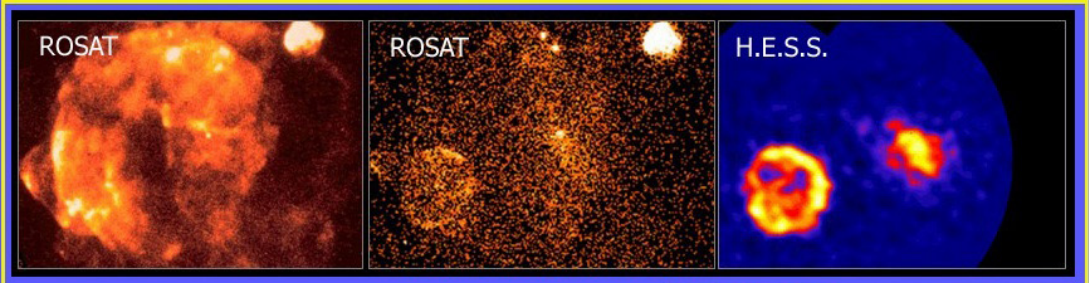
Philadelphia, Commonwealth of Pennsylvania, USA.

19 September 2012

Crab Nebula

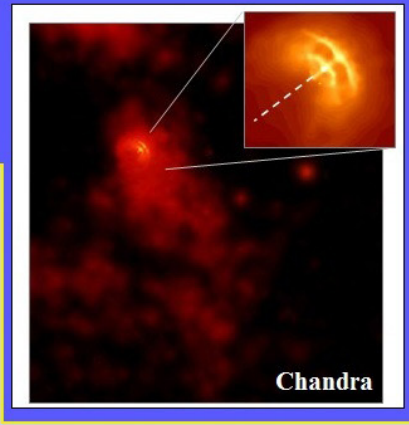
F. Aharonian et al.,
Astropart. Phys. 22 (2004) 109-125

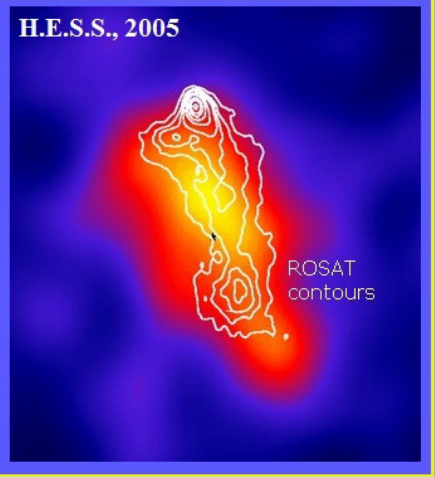




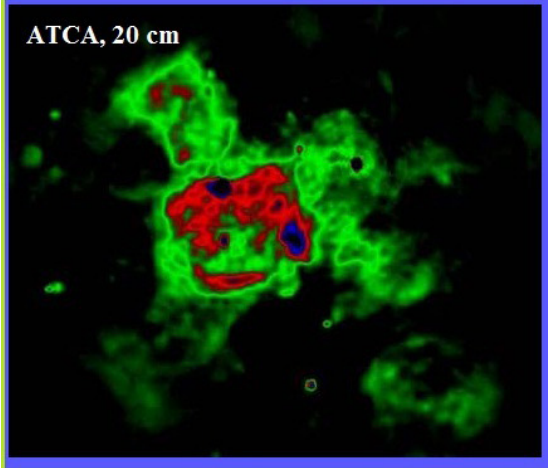
Vela X

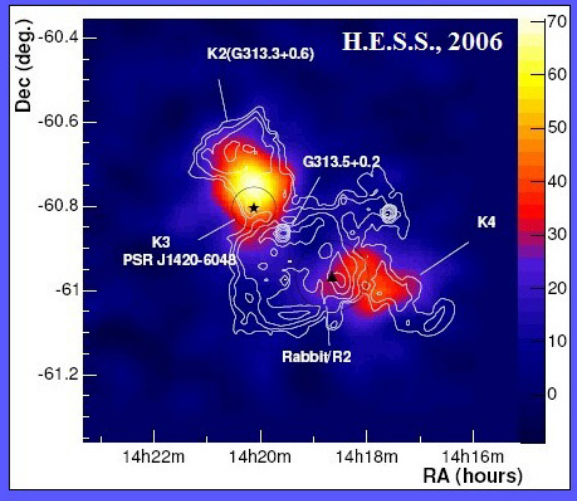
F. Aharonian et al.,
Astronomy &
Astrophysics. 448
(2006) L43-L47



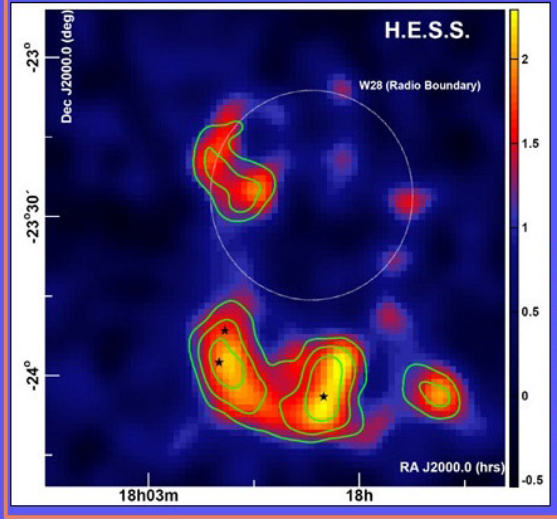


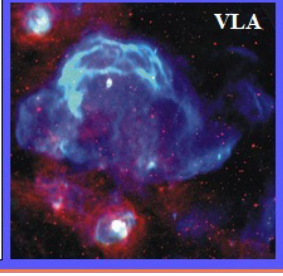
The Wings of the Kookaburra





SNR W28





H.E.S.S. sources:

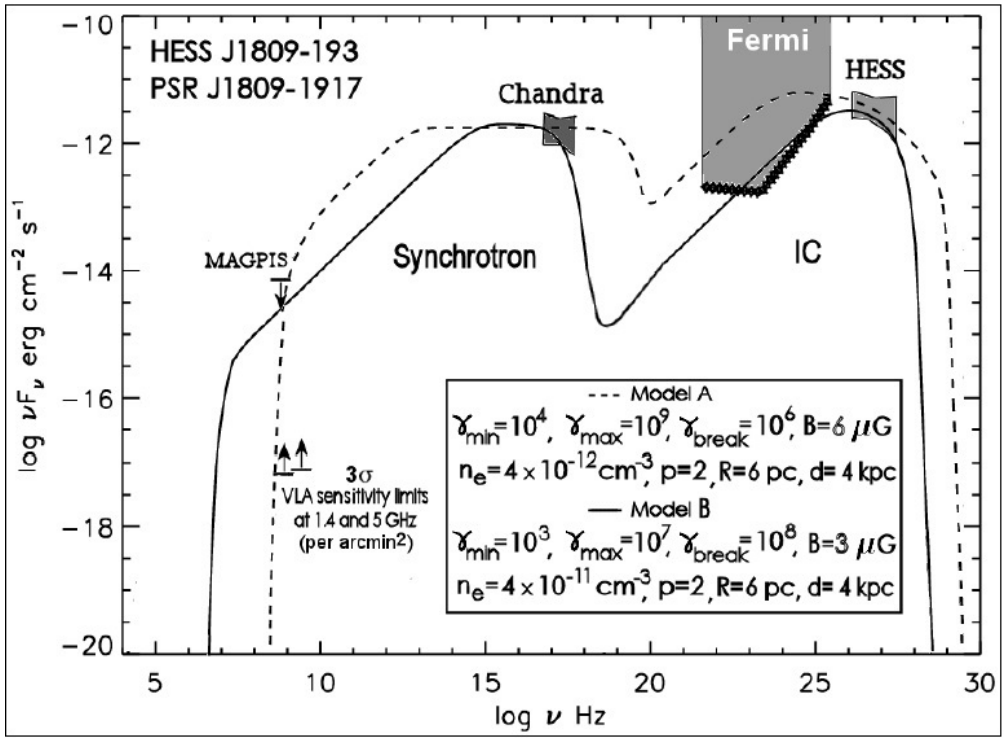
http://www.mpi-d.mpg.de/hfm/HESS/pages/home/sources/

Main idea - comparison of multiwavelength spectral models with the observational data

Band	Radiation mechanism	Provided information about:
Radio	Synchrotron emission	1) history of the pulsar energy losses 2) propagation of the wind 3) low-energy part of the wind electron spectrum
X-ray	Synchrotron emission	constraints of the combination of the magnetic field and electron Lorentz factor
MeV – GeV	IC scattering of the CMB and IR background photons	1) true maximum energy of the electron spectrum 2) magnetic field inside the PWN
TeV	IC scattering $\pi^0 \rightarrow \gamma + \gamma$ decay	1) constraints of the upper boundary of the electron energy spectrum 2) contribution from the hadronic pulsar wind component

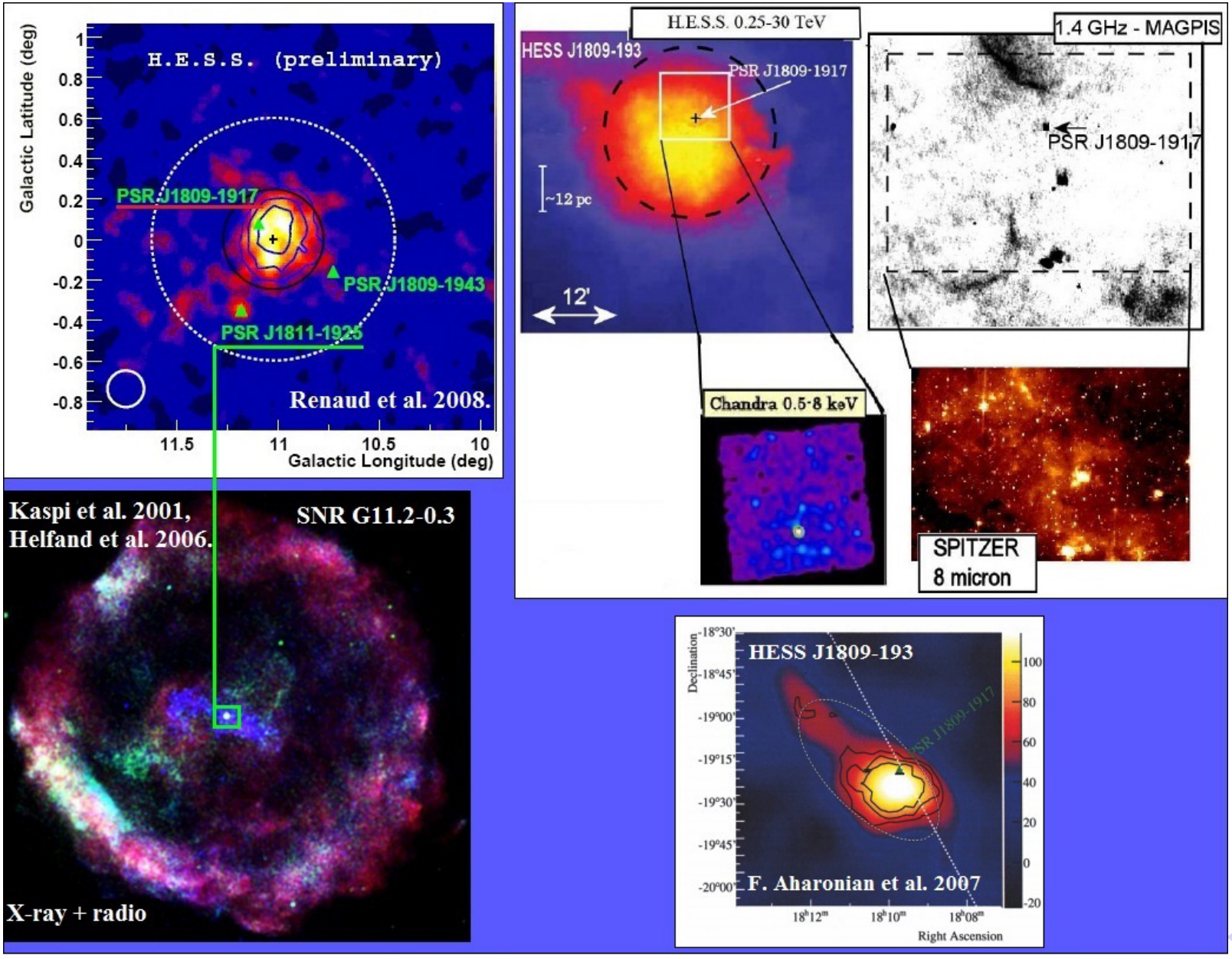
Kargaltsev and Pavlov, proposal "Crushed plerions from radio to γ-rays"

The overall spectrum depends on the pulsar-wind parameters (p, γ_{min}, γ_{max}, n_e, B, PWN volume) and on the external parameters.

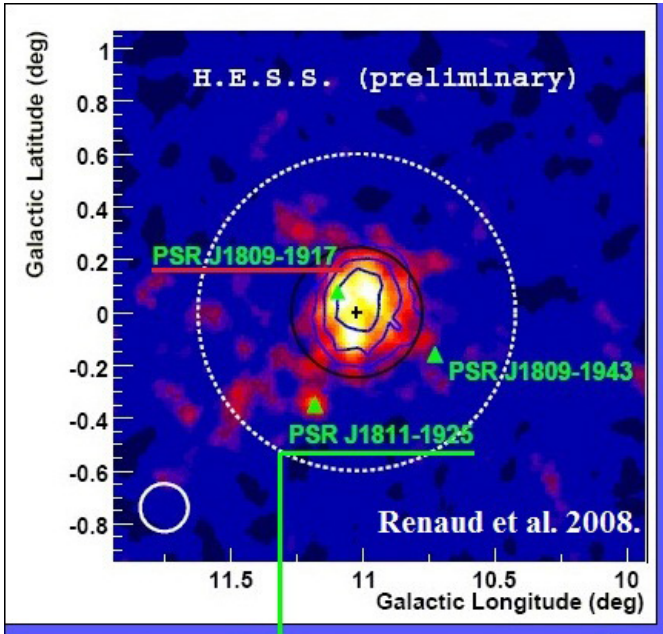


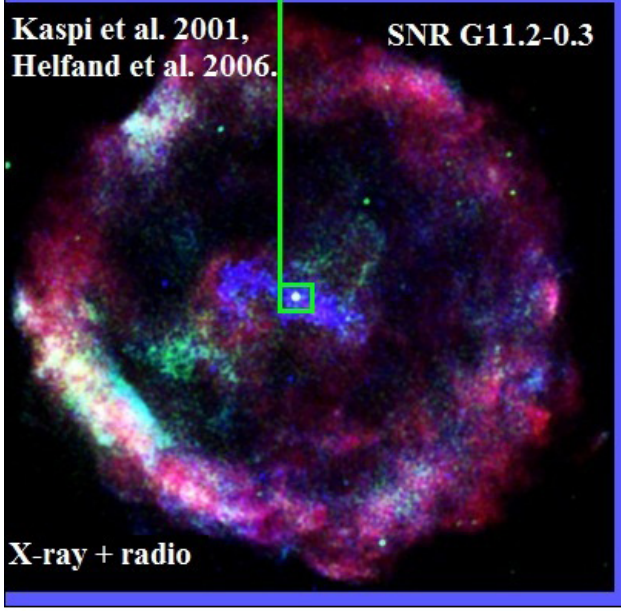
The addition of the radio and GeV data severely constrains possible models and physical parameters of the wind.

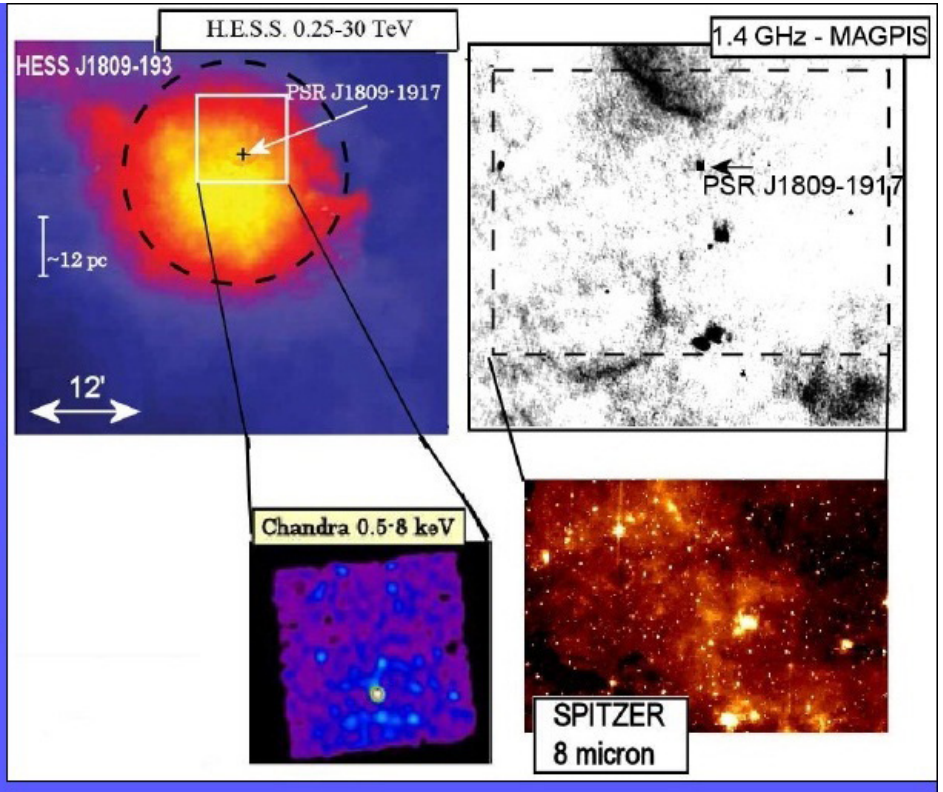
H.E.S.S. J1809 – 193



H.E.S.S. J1809 – 193







PSR J1809-1917 (rotation-powered):

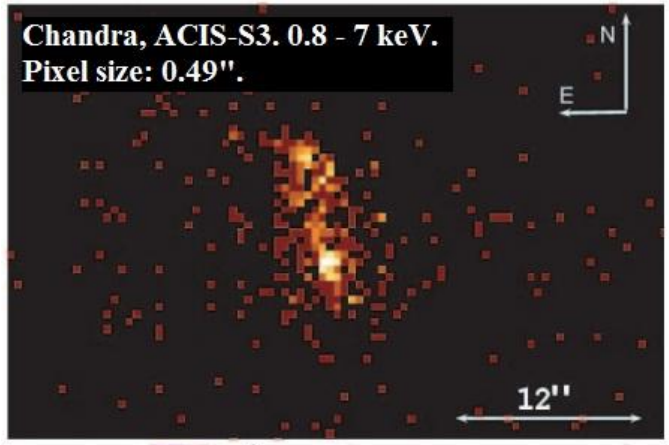
$$P = 82.7 \text{ ms},$$

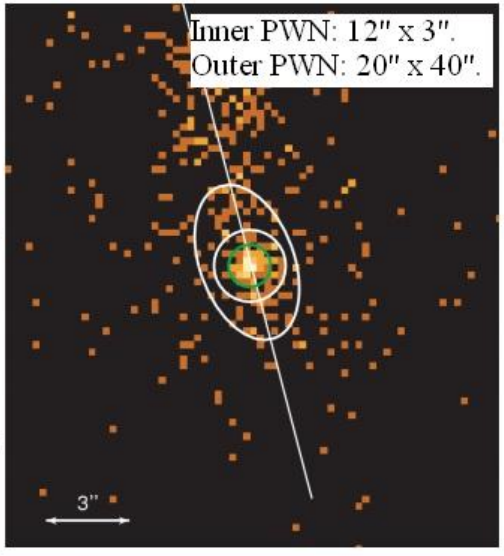
$$\tau = \frac{P}{2\dot{P}} = 51 \text{ kyr (middle-aged)},$$

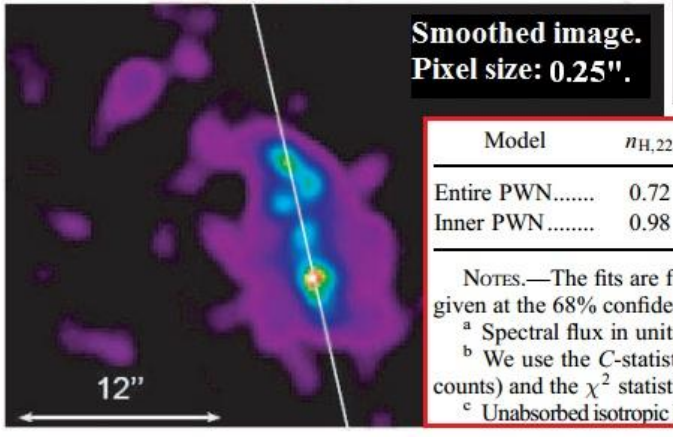
$$\dot{E} = 4\pi^2 I \dot{P} P^{-3} \simeq 1.8 \times 10^{36} \text{ erg/s}.$$

H.E.S.S. J1809 – 193

O. Kargaltsev and G. Pavlov, Astrophysical Journal 670 (2007) 655-667.







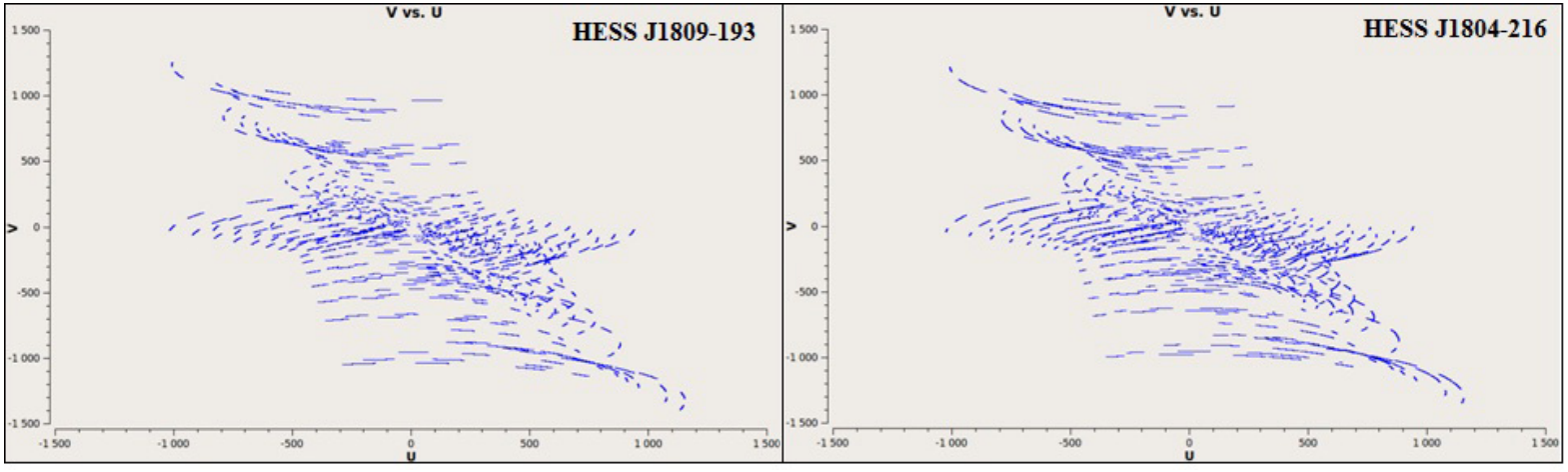
Model	$n_{H,22}$	$\mathcal{N}^a$	Γ	$(C$ or $\chi^2)^b$/dof	$L_X{}^c$
Entire PWN.....	0.72	$35.6^{+4.6}_{-3.8}$	$1.41^{+0.12}_{-0.11}$	0.82/34	$3.89^{+0.24}_{-0.27}$
Inner PWN.....	0.98	$30.6^{+5.3}_{-4.6}$	$1.85^{+0.17}_{-0.17}$	335/526	$2.21^{+0.19}_{-0.17}$

NOTES.—The fits are for fixed $n_{H,22} \equiv n_H/10^{22}$ cm^{-2}. The uncertainties are given at the 68% confidence level for a single interesting parameter.
[a] Spectral flux in units of 10^{-6} photons cm^{-2} s^{-1} keV^{-1} at 1 keV.
[b] We use the C-statistic (Cash 1979) for the inner PWN (which has fewer counts) and the χ^2 statistic for the entire PWN.
[c] Unabsorbed isotropic luminosity in the 0.5–8 keV band, in units of 10^{32} ergs s^{-1}.

Cometary morphology of the PWN $\Rightarrow$ bow shock created by the pulsar moving supersonically in the southern direction (Del Zanna et. al., 2006).

VLA, AK713:HESS J1809 – 193 and HESS J1804 – 216

Conditions	L (20 cm)	C (6 cm)
Frequency	1.4 GHz	5 GHz
Configuration	C	DnC
Ang. resolution	12.5″	14.0″
FOV	30′	9′
Bandwidth	25 MHz	25 MHz
IFs/channels	4/8	4/8
Exposure	4 (10) hours	4 (10) hours



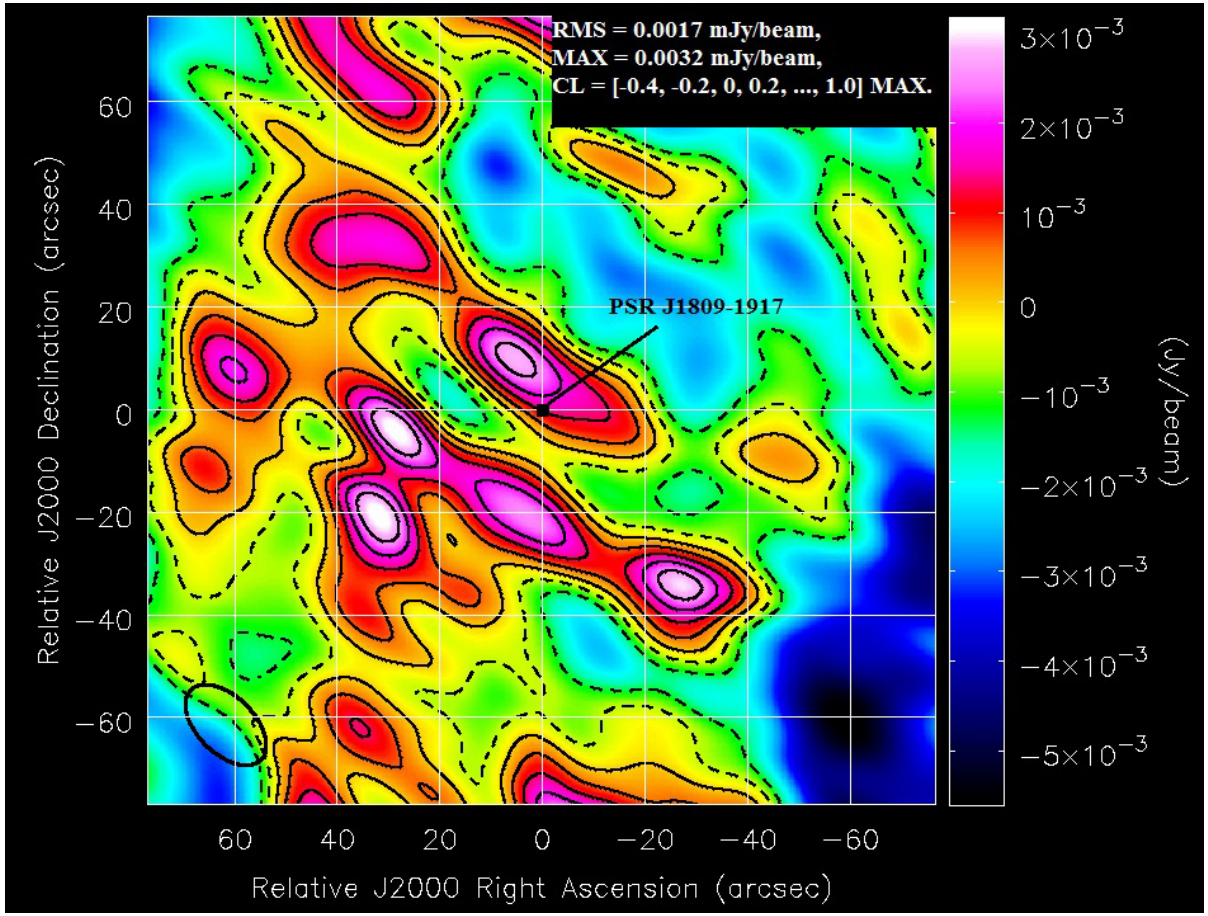
VLA, AK713:HESS J1809 – 193 and HESS J1804 – 216

Data were corrupted:

//FISF 112.500000 212.500000
//* ***Warning*** Maximum shadowing of 0.5 meters.
//* phase calibrator
1811-209 16 15 08 18 11 06.8000 -20 55 03.444C CC T 1111 0.31
//DS 4 3
//LO 0.0 0.0 3860 3810 0000
//FISF 112.500000 212.500000
//* ***Warning*** Maximum shadowing of 0.7 meters.
//* target source 2
J1809-193 16 45 33 18 09 46.0850 -19 20 33.800C CC 1111
//DS 4 3
//LO 0.0 0.0 3860 3810 0000
//FISF 112.500000 212.500000
//* ***Warning*** Maximum shadowing of 2.7 meters.
//* target source 1
J1804-216 17 15 58 18 04 05.2800 -21 36 54.980C CC 1111
//DS 4 3
//LO 0.0 0.0 3860 3810 0000
//FISF 112.500000 212.500000
//* ***Warning*** Maximum shadowing of 2.2 meters.
//* phase calibrator
1811-209 17 19 21 18 11 06.8000 -20 55 03.444C CC T 1111 0.31
//DS 4 3
//LO 0.0 0.0 3860 3810 0000
//FISF 112.500000 212.500000
//* ***Warning*** Maximum shadowing of 4.8 meters.
//* backup phase calibrator
1820-254 17 22 56 18 20 57.8486 -25 28 12.584C CC A 1111 1.30
//DS 4 3
	10Oct 18:48:40
	Please note that using the EVLA antennas is a shared-risk operation and we cannot guarantee that useful data will be produced by these antennas. Users should consult the web page http://www.vla.nrao.edu/astro/guides/evlareturn for known problems and workarounds in using the EVLA antennas with the VLA. We would like your input and feedback on the use of the EVLA antennas in your project; please send all comments and/or questions to gvanmoor@aoc.nrao.edu.
	
	10Oct 18:48:40 11Oct 04:51:30 T100675 1.00 602.8
	Antenna 6 (Data: Lost): EVLA
	Antenna is undergoing EVLA conversion and/or testing.
	
	10Oct 18:48:40 11Oct 04:51:30 T100418 1.00 602.8
	Antenna 17 (Data: Lost): EVLA
	Antenna is undergoing EVLA conversion and/or testing.
	
	10Oct 18:48:40 11Oct 04:51:30 Other 1.00 602.8
	Antenna(s) 13 (Data: Lost): EVLA
	Does not have a C-band receiver installed.
	
	10Oct 18:49:10
	SHADOWING IS OCCURRING! Some antennas are blocking the view of your radio source from other antennas. You may have to edit your data. Observing data: Corrupted.
	
	10Oct 21:50:00

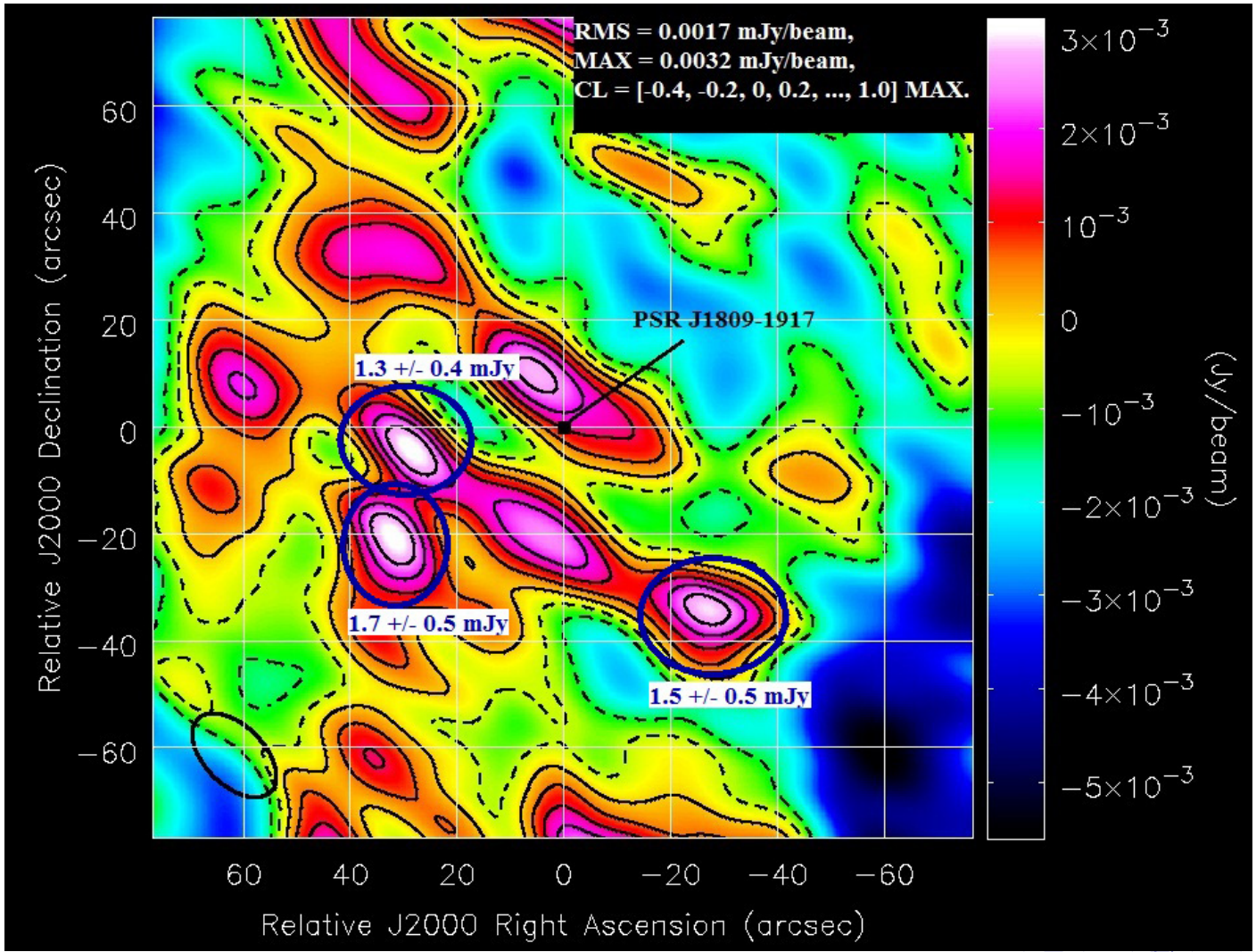
"Radio mapping has always been a bit of an art, because radio interferometers greatly under sample the Fourier plane, which means that there are an infinite number of possible images that fit the data. The art of making radio images is to find an image that both fits the data, and looks astronomically reasonable..."

Martin Shepherd, DIFMAP.



HESS J1809 – 193, C – band. Results. CASA.

Rule of thumb for self-calibration: $\left(\frac{S}{N}\right)_i \sim RMS \cdot \sqrt{N_{antennas} - 2} \geq MAX$.
No self-calibration.



HESS J1809 – 193, C – band. Results. CASA.

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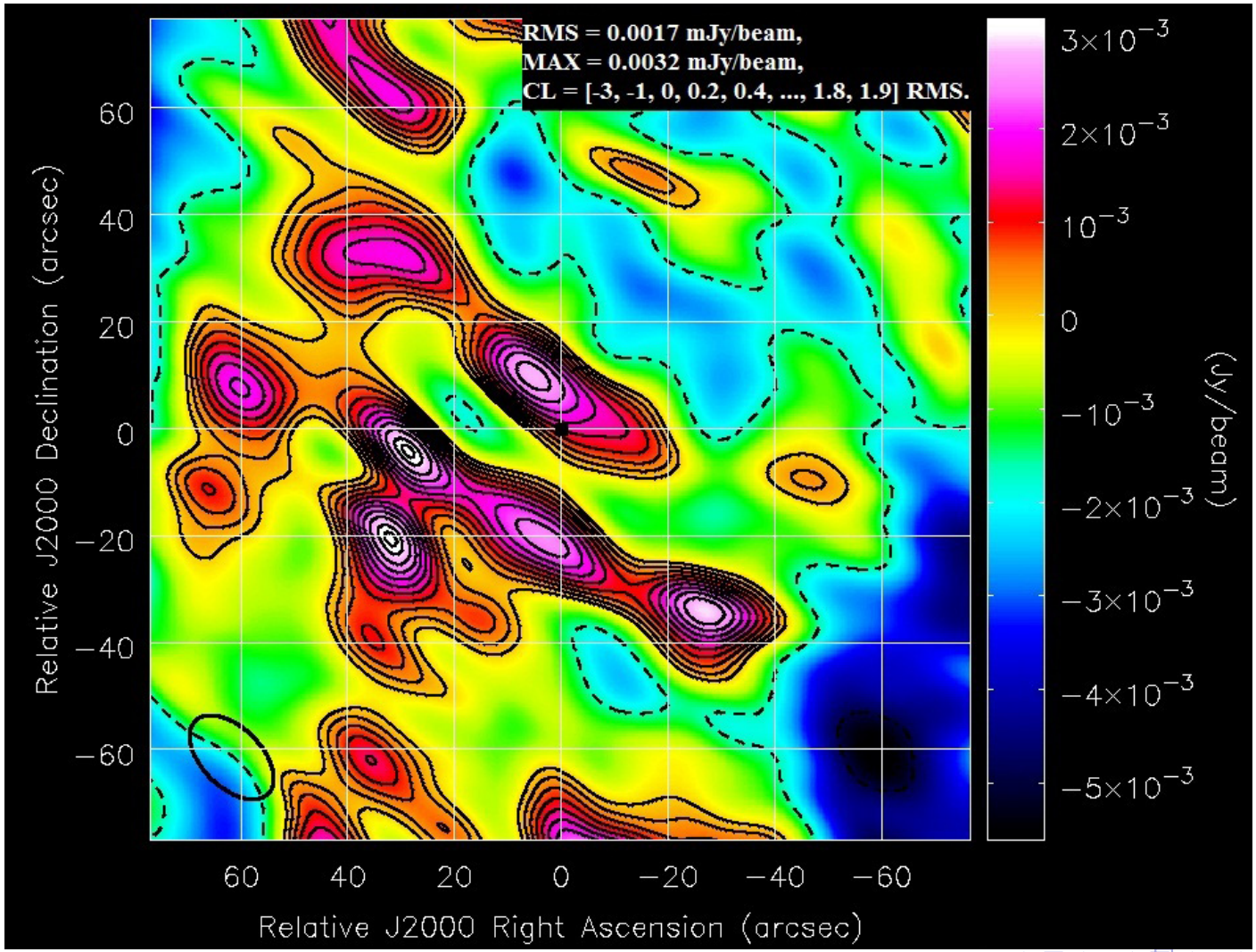
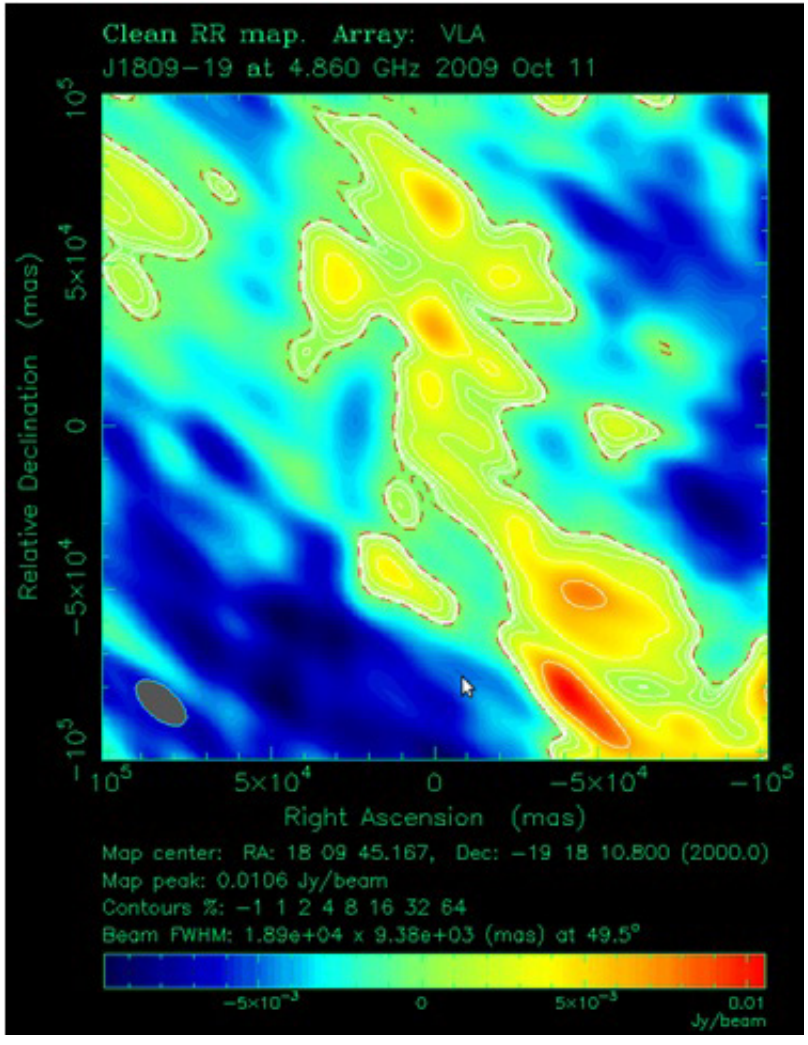
No self-calibration.



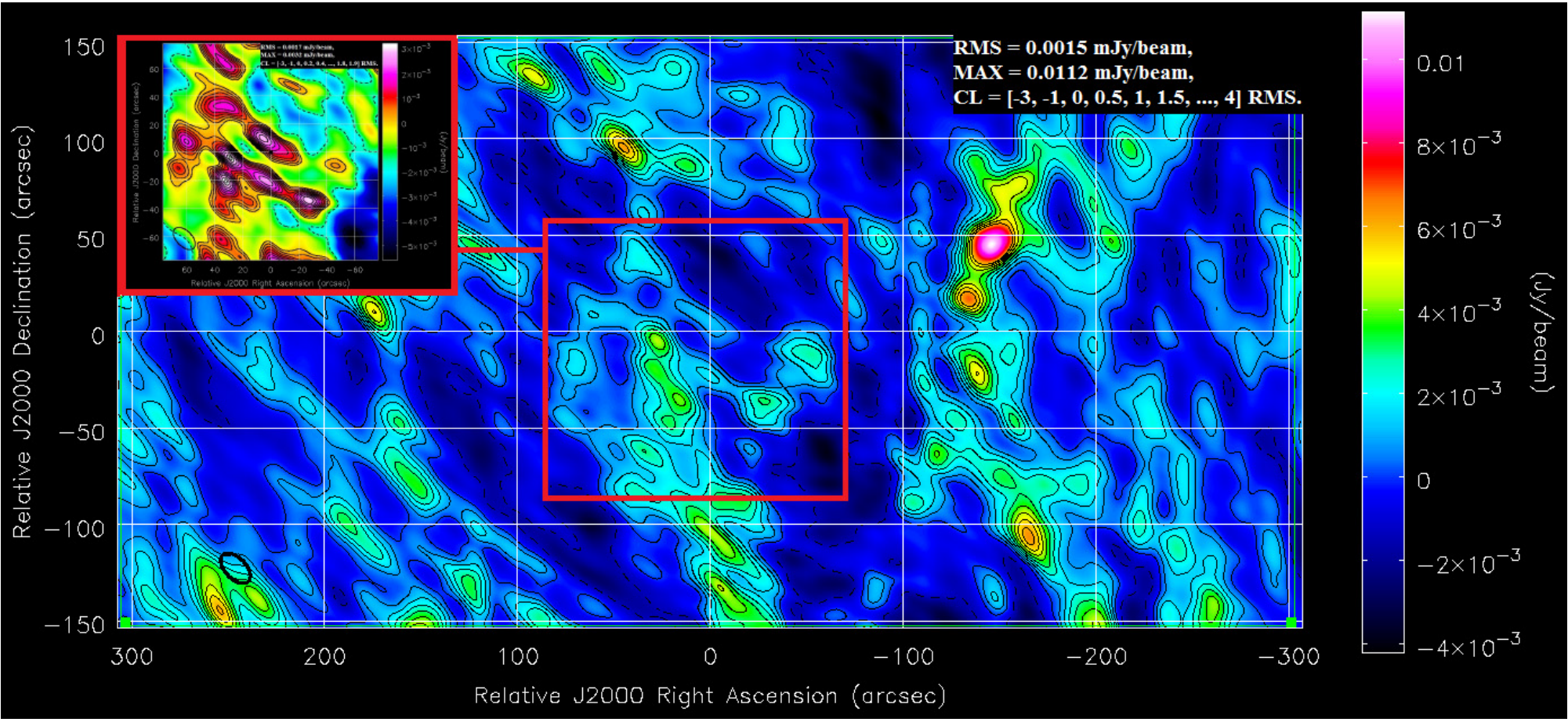
HESS J1809 – 193, C – band. Results. AIPS.

Rule of thumb for self-calibration: $\left(\frac{S}{N}\right)_i \sim RMS \cdot \sqrt{N_{antennas} - 2} \geq MAX$.
No self-calibration.



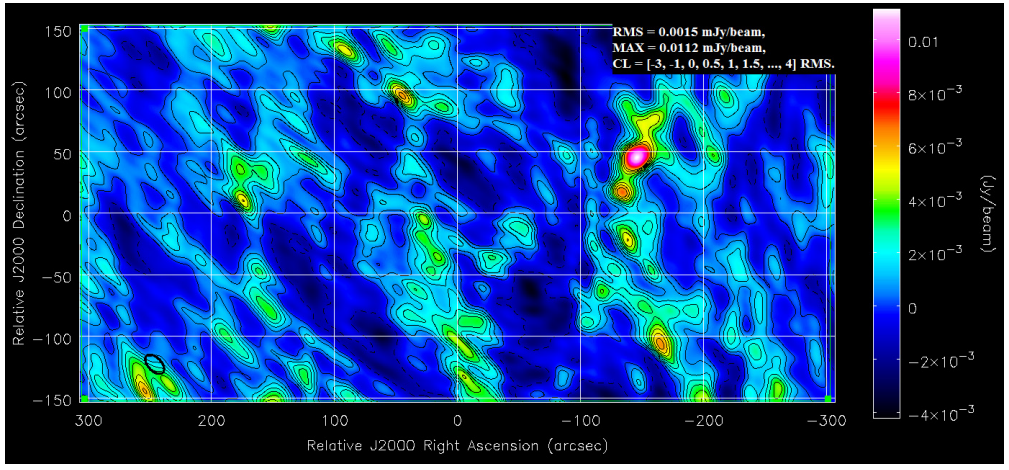
HESS J1809 – 193, C – band. Results. CASA.

No self-calibration.

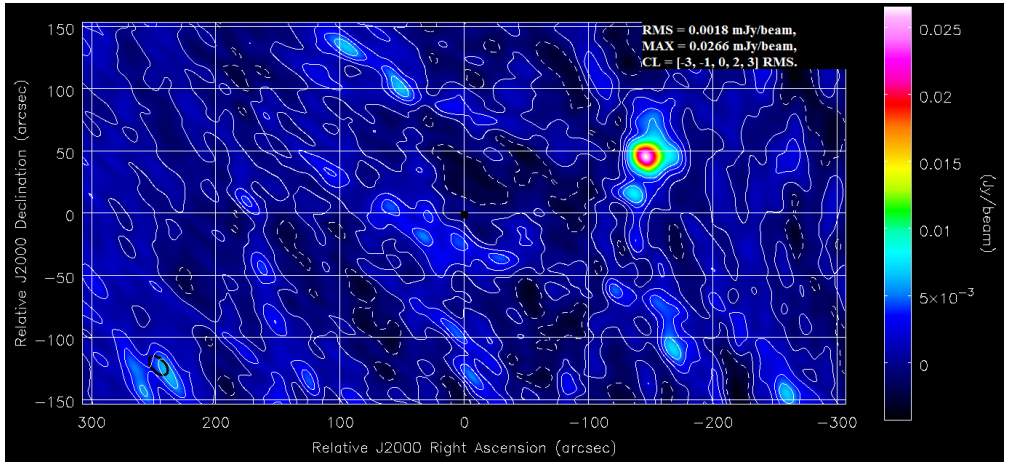


HESS J1809 – 193, C – band. Results. CASA

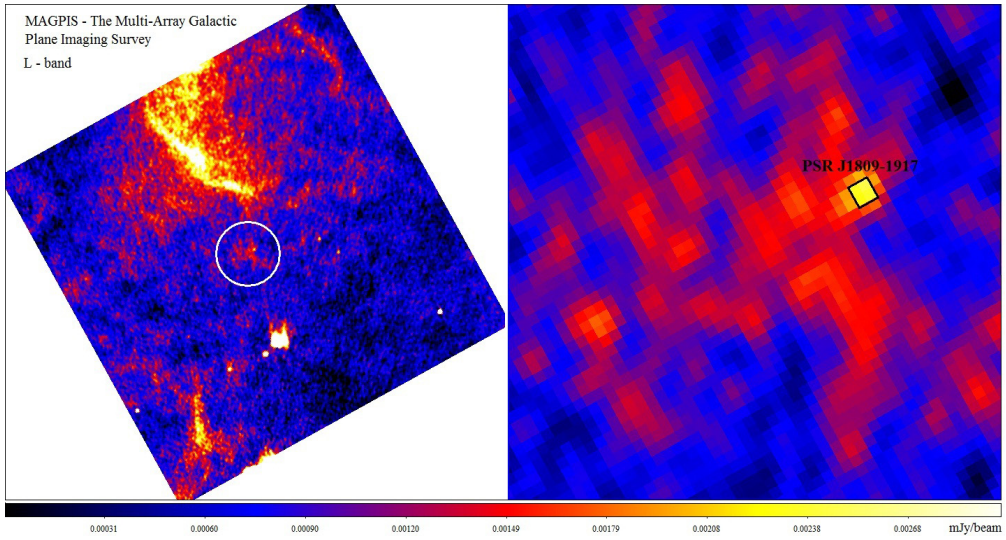
No self-calibration.



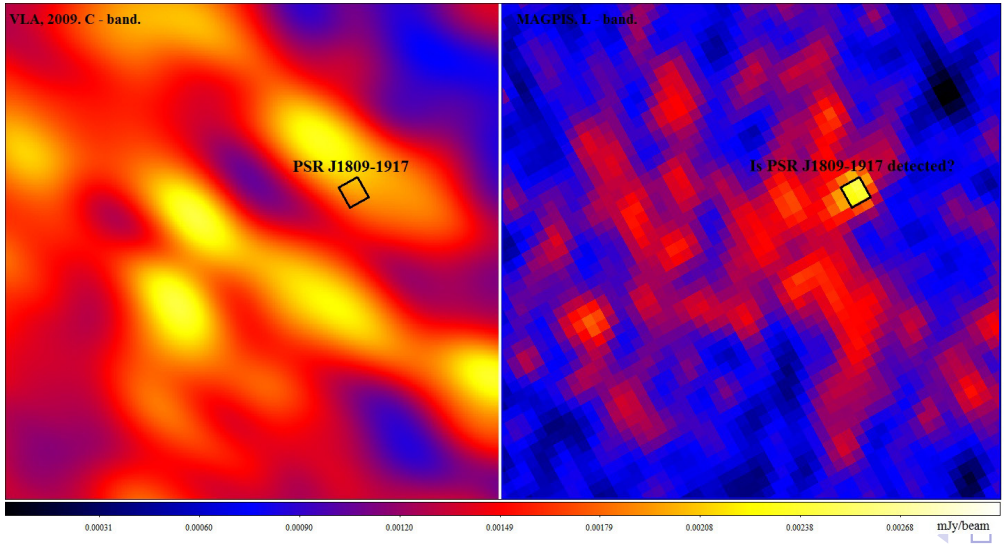
Self-calibration.



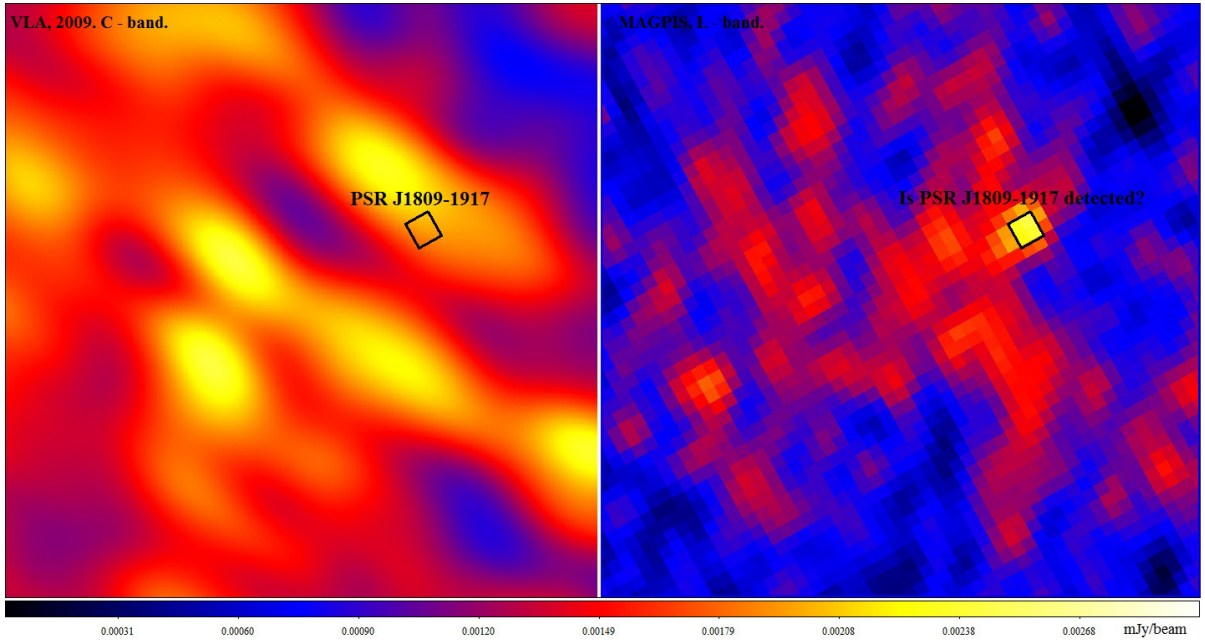
Comparison with the MAGPIS data.



Region size $\sim 2'$:



Comparison with the MAGPIS data.

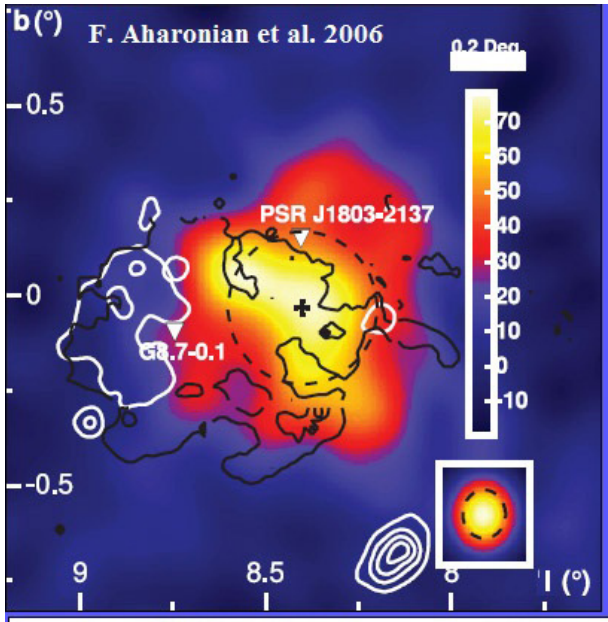


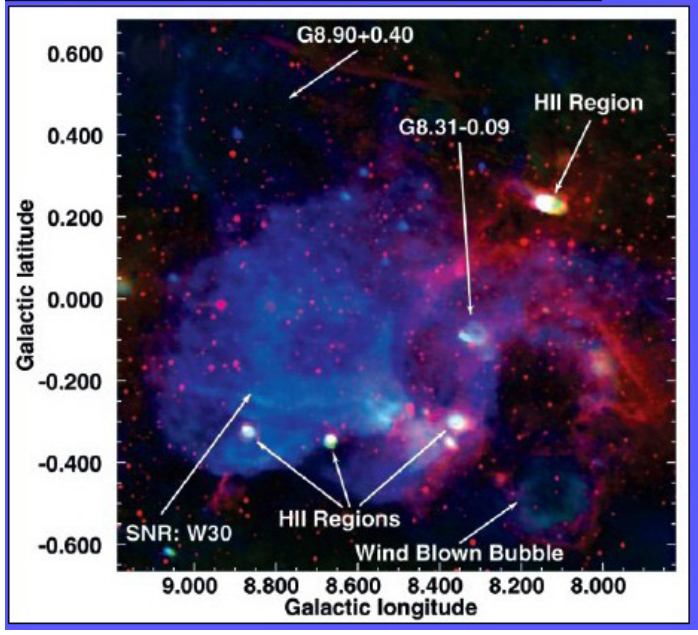
Criteria for statistical significance of the source: $B_{src} - B_{bkg} \geq 3\sigma_{bkg}$.
For MAGPIS data:
$B_{src} = 3.20$ mJy/beam,
$B_{bkg} = 0.40$ mJy/beam,
$\sigma_{bkg} = 0.84$ mJy/beam.
$B_{src} - B_{bkg} = 2.80$ mJy/beam $\geq 3\sigma_{bkg} = 2.52$ mJy/beam.
The excess of the brightness in the location of the PSR J1809-1917 is statistically significant at the level 3.3σ.

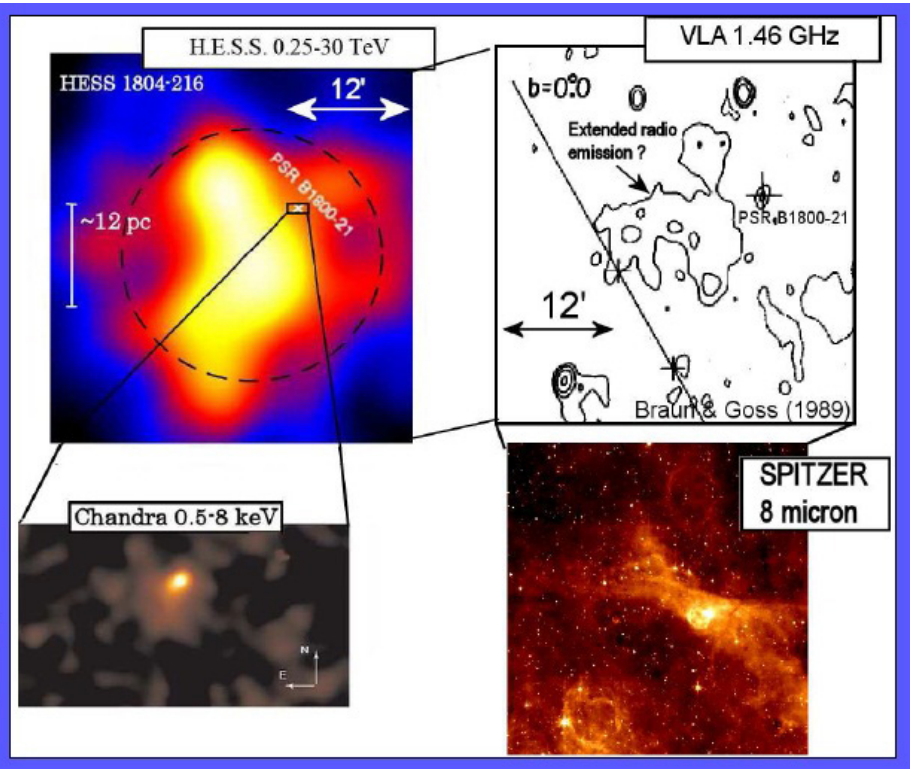
HESS J1809 – 193, C – band. Results.

1. The VLA project AK713 (C - band) was processed using modern software packages CASA and AIPS.
2. We got radio maps of the vicinity of the PSR J1809 – 1917 size $2'$ and $10'$. The CASA and the AIPS maps are identical to each other.
3. The complicated extended structure was detected on these maps.
We suggest that this extended source is PWN. The fluxes from the brightest regions of the PWN amount to about 2 mJy.
4. There is a mismatch between MAGPIS (L-band) and VLA (C-band) results. There is a significant source in the location of the PSR $J1809 - 1917$ on the MAGPIS maps. But there is not a pulsar on the VLA maps.
It's concluded that there is a need for additional observations (multichannel and, possible, single-dish).

H.E.S.S. J1804 – 216







PSR B1800-21 (rotation-powered):

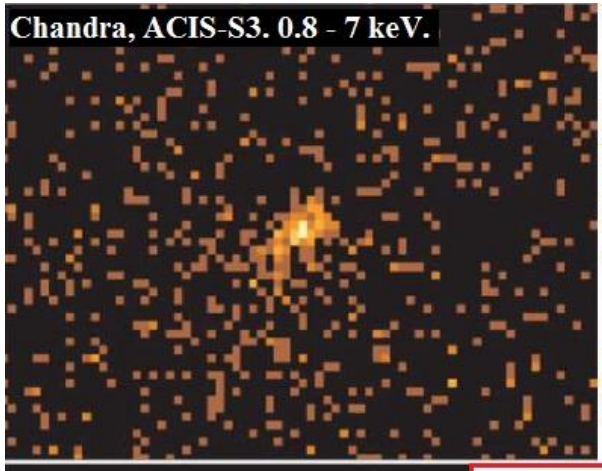
$$P = 134 \text{ ms},$$

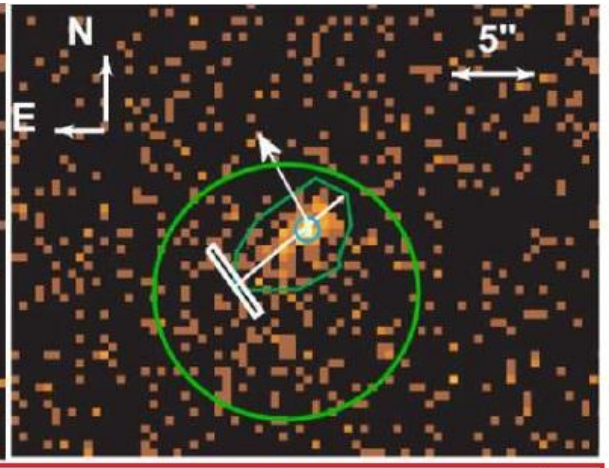
$$\tau = \frac{P}{2\dot{P}} = 16 \text{ kyr},$$

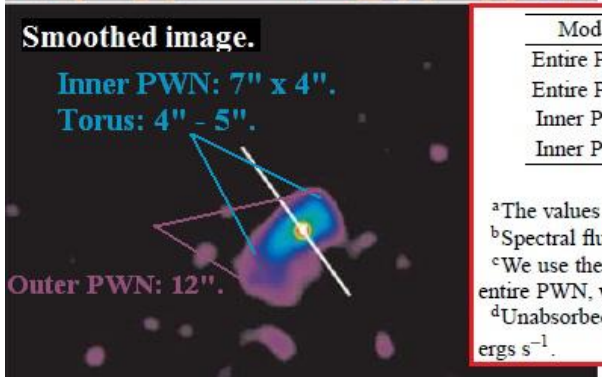
$$\dot{E} = 4\pi^2 I \dot{P} P^{-3} = 2.2 \times 10^{36} \text{ erg/s}.$$

H.E.S.S. J1804 – 216

O. Kargaltsev, G. Pavlov and G. Garmire, Bulletin of the American Astronomical Society 38 (2006) 359-369.





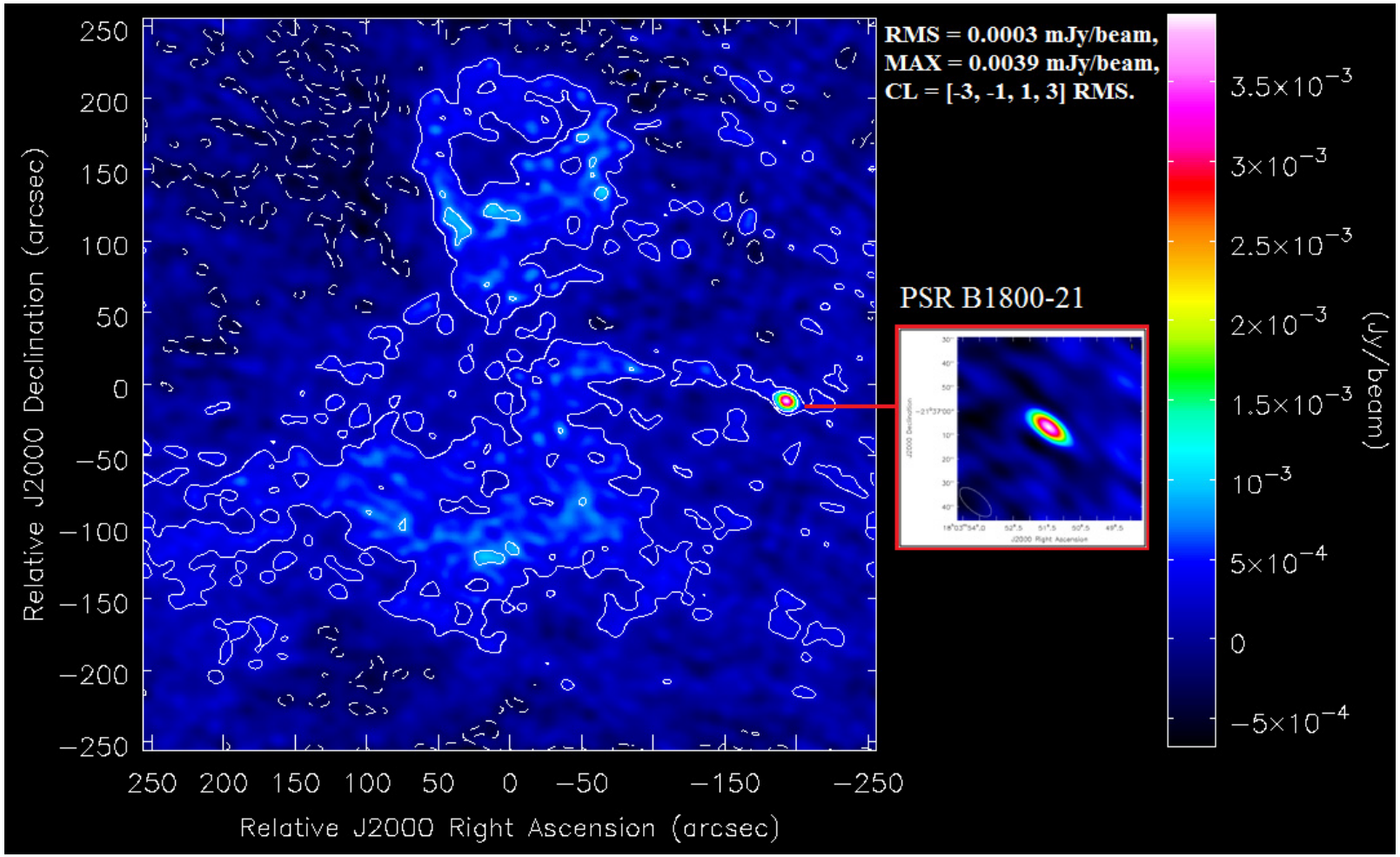


Model	$n_{H,22}$[a]	$\mathcal{N}$[b]	Γ	(C or χ^2)[c]/dof	L_X[d]
Entire PWN	1.38	$13.8^{+3.5}_{-3.5}$	$1.58^{+0.25}_{-0.25}$	0.93/3	$1.65^{+0.16}_{-0.17}$
Entire PWN	0.72	$6.0^{+1.5}_{-1.3}$	$1.01^{+0.23}_{-0.18}$	2.16/4	$1.35^{+0.11}_{-0.18}$
Inner PWN	1.38	$9.7^{+3.7}_{-2.7}$	$1.79^{+0.29}_{-0.32}$	1.34/3	$0.96^{+0.16}_{-0.13}$
Inner PWN	0.72	$3.3^{+1.2}_{-0.8}$	$1.04^{+0.29}_{-0.26}$	1.34/4	$0.70^{+0.11}_{-0.10}$

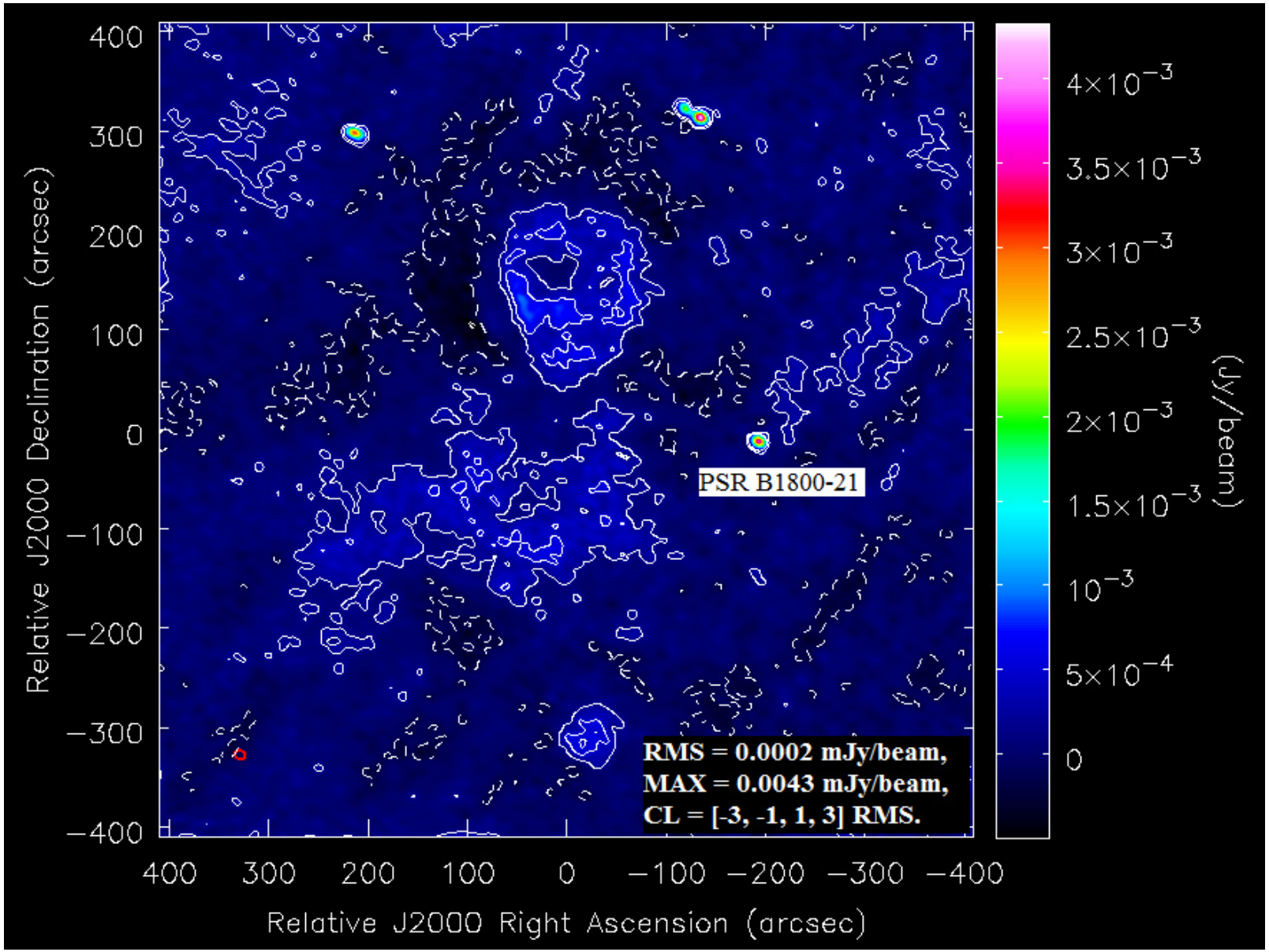
[a]The values of hydrogen column density are frozen in the fits.
[b]Spectral flux in units of 10^{-6} photons cm^{-2} s^{-1} keV^{-1} at 1 keV.
[c]We use the C statistic (Cash 1979) for the inner PWN and χ^2 statistic for entire PWN, which has a larger number of counts.
[d]Unabsorbed isotropic luminosity in the 0.5–8 keV band in units of $10^{32} d_4^2$ ergs s^{-1}.

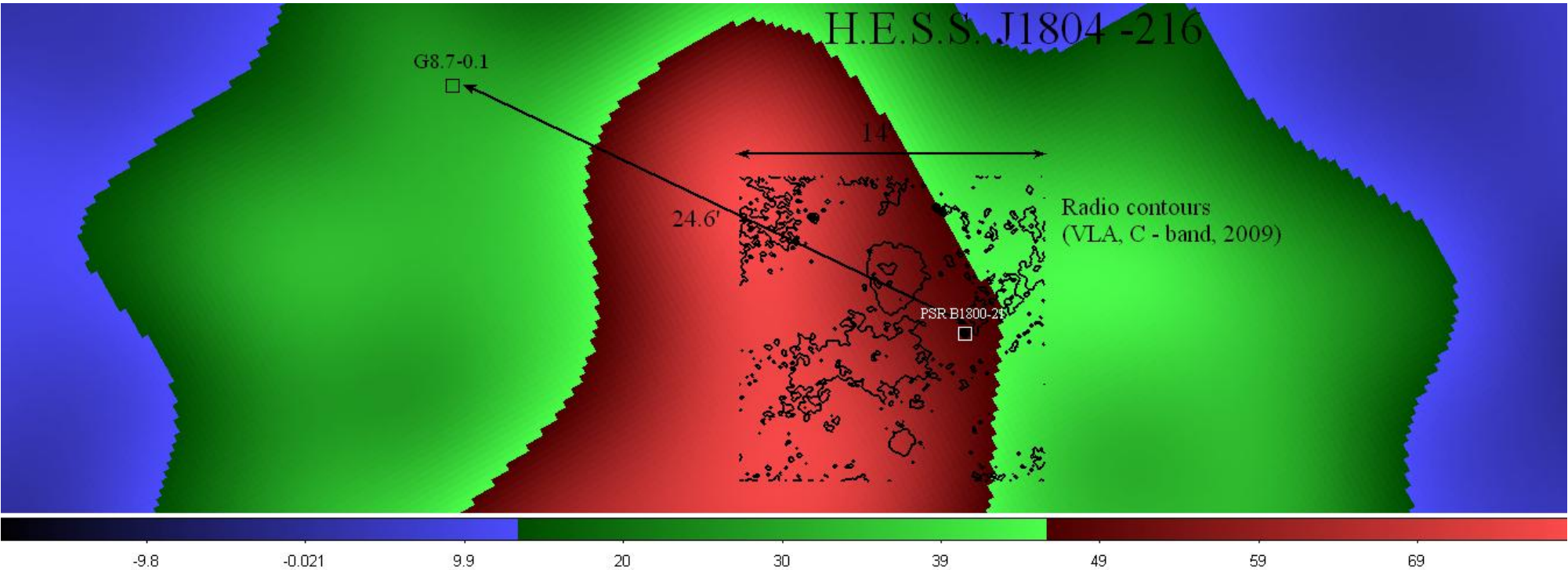
Toroidal morphology of the PWN and lack of the bow shock $\Rightarrow$ pulsar is still moving subsonically in the SNR. SNR wasn't detected on the Chandra images.

HESS J1804 – 216, C – band. Results. CASA



HESS J1804 – 216, C – band. Results. CASA




H.E.S.S. J1804 -216
G8.7-0.1
14
24.6'
Radio contours
(VLA, C - band, 2009)
PSR B1800-21
-9.8
-0.021
9.9
20
30
39
49
59
69

HESS J1804 – 216, C – band. Results.

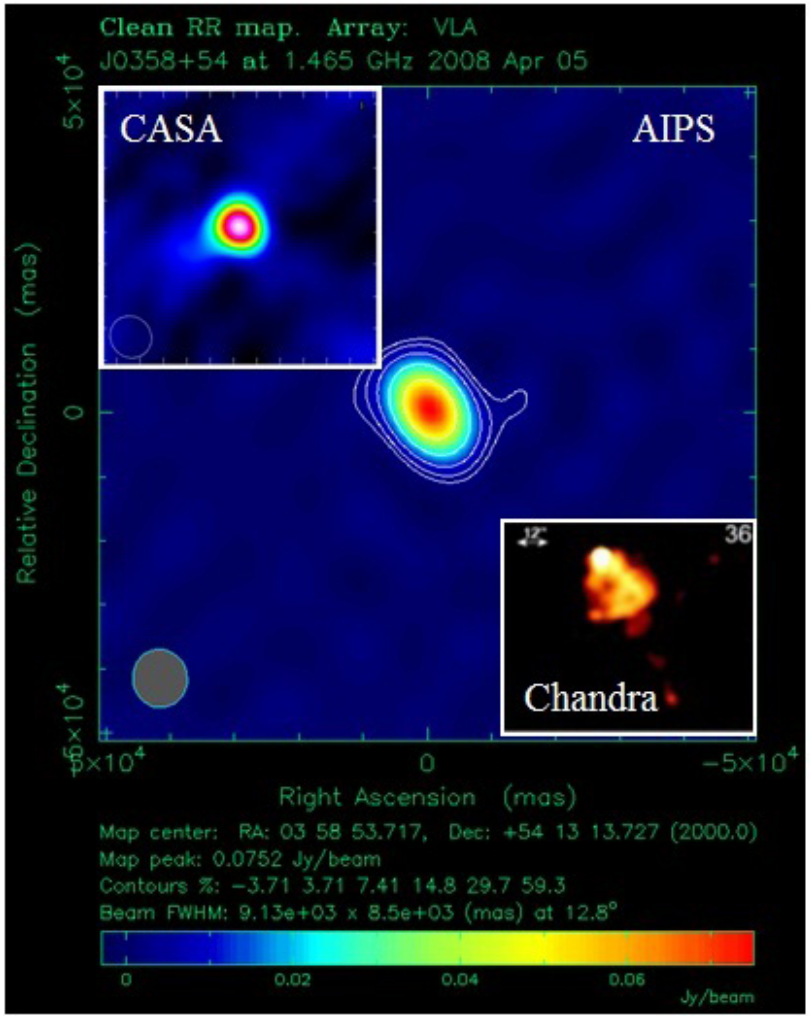
1. The VLA project AK713 (C - band) was processed using modern software packages CASA and AIPS.
2. We got radio maps of the vicinity of the PSR B1800 – 21 size $8.3'$ and $13.3'$.
3. The PSR B1800 – 21 and complicated extended structure were confidently detected on these maps.

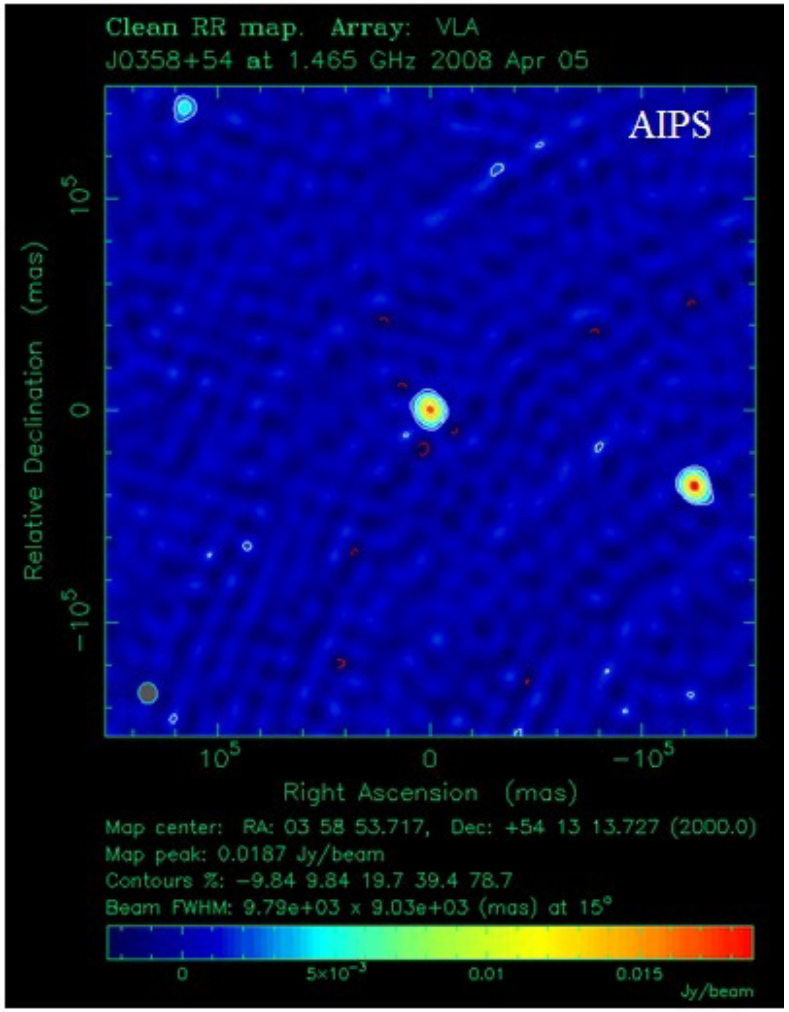
The extended structure is located to the north-east of the pulsar. One can suppose that this emission is connected with PWN. The flux from the brightest region of the PWN is about 1.17 ± 0.5 mJy.

It's concluded that there is a need for additional observations (multichannel and, possible, single-dish) to investigate a spectrum of the putative PWN.

PSR J0358 + 5413, L – band. Results.

AK688: C – configuration, ang. resolution $\sim 12.5''$.





PSR J0358 + 5413 was detected. PWN wasn't detected.