

A new nearby PWN overlapping the VelaJr SNR

F. Acero¹, Y. Gallant¹, R. Terrier², M. Renaud¹, J. Ballet³

(1) LUPM, CNRS/Université Montpellier 2
(2) APC, CNRS/Université Paris Diderot-Paris 7
(3) AIM, CEA/CNRS/Université Paris Diderot-Paris 7

Summary

Context: Nearby pulsars are the prime contributors to the e^-/e^+ spectrum received at Earth. A good knowledge of the properties of those pulsars is thus required in order to model the observed spectrum.

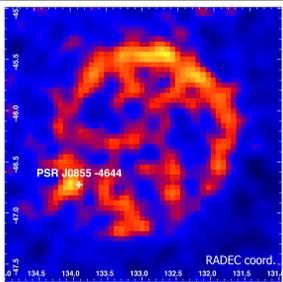
The case of PSR J0855-4644:

This energetic PSR ($\dot{E} = 1.1 \times 10^{36}$ ergs/s, $P=64$ ms, $\tau_c=140$ kyrs) was recently discovered to lie on the edge of the VelaJr SNR in the radio Parkes Multibeam Survey [1].

First X-ray detection and distance estimate:

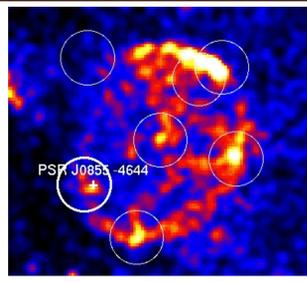
Our new XMM-Newton observation has revealed the X-ray counterpart of the pulsar and its nebula. The comparison of the X-ray absorption column on the pulsar and in several regions of the VelaJr SNR shows that the pulsar and the SNR lie in the foreground of the Vela Molecular Ridge which distance is estimated to be $d_{VMR} = 700 \pm 200$ pc. This upper limit to the distance of the pulsar is much different from the one estimated with the radio dispersion measure ($d=4$ kpc) and therefore implies that PSR J0855-4644 could significantly contribute to the e^-/e^+ spectrum.

VelaJr: HESS



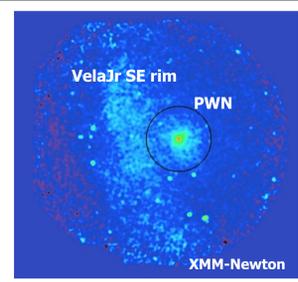
HESS excess map in the TeV energy range [2]
The pulsar PSR J0855-4644 (white cross) is in spatial coincidence with an enhancement in gamma-rays that could represent the nebula surrounding the PSR.

VelaJr: ROSAT



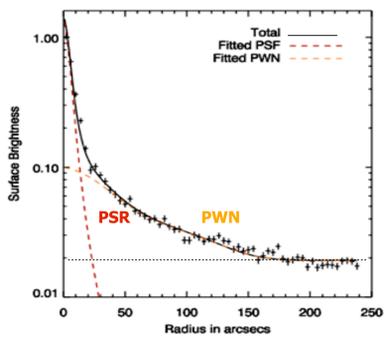
X-ray map for $E > 1.3$ keV [3]
An enhancement is also seen at the PSR position. The XMM-Newton existing observations are shown by circle. Our new XMM pointing is represented by the thick circle.

VelaJr: XMM



X-ray map for $1.2 < E < 6$ keV
Our new 50 ks XMM-Newton observation has revealed the X-ray counterpart of PSR J0855-4644 embedded in an extended emission i.e. the PWN.

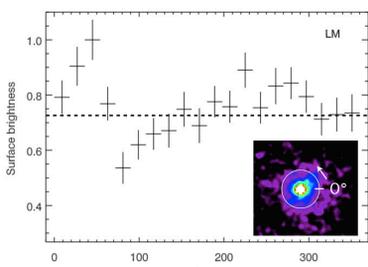
A new PWN



X-ray radial profile centered on the PSR position in the 1.2-6 keV energy band.

X-ray detection of PSR J0855-466 and its nebula

The radial profile around the pulsar clearly shows an extended emission up to $\sim 150''$. This is the first detection of the X-ray counterpart of PSR J0855-4644 and the discovery of a nebula.

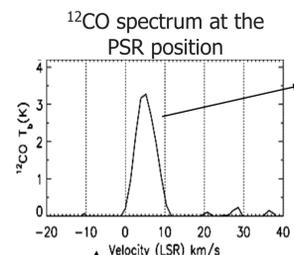


X-ray azimuthal profile extracted from the annulus region ($20'' < R < 70''$) shown in the inset.

Jet structures near the pulsar ?

The azimuthal profile of the nebula in the region close to the pulsar suggests a possible jet structures as observed in other pulsars (Crab, Vela, 3C58, ...). However, the limited angular resolution from XMM-Newton hampers any firm conclusion on the presence of such jets.

A new distance estimate

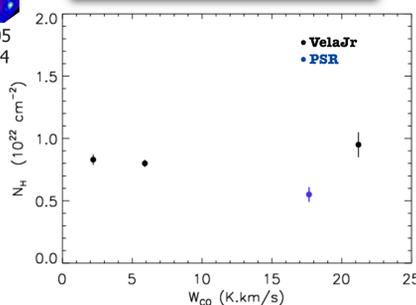
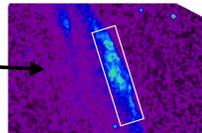
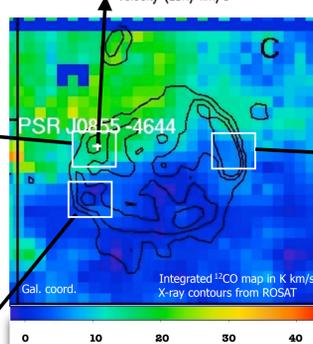
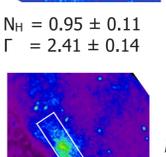
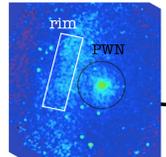


Vela Molecular Ridge

The VMR is a complex of several molecular clouds and one of the nearest massive star-forming regions. Its distance is estimated to be:

$$d_{VMR} = 700 \pm 200 \text{ pc [4]}$$

XMM observations



Method

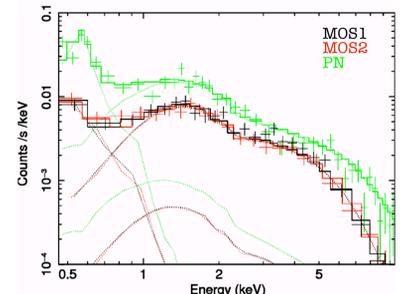
In order to derive the distance to the PSR, we have compared the X-ray absorption N_H along several lines of sight and the corresponding ^{12}CO column density (tracing the dense gas) using the data from [5]. We are taking advantage of the fact that the Vela Molecular Ridge is encompassing part of the VelaJr SNR.

Results

We found no correlation between the integrated ^{12}CO column density and the N_H strongly suggesting that the SNR lies in the foreground of the VMR. By consequence, the PSR (which an N_H value significantly lower) is in the foreground of the VMR and the SNR.

We have therefore derived an upper limit to the distance of PSR J0855-4644 $d_{PSR} < 700$ pc ($\ll 4$ kpc as derived from the radio dispersion measure).

PSR J0855-4644



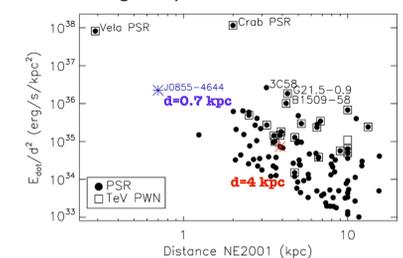
XMM-Newton spectra extracted from a $15''$ circular region around the pulsar for the 3 instruments onboard the satellite.

X-ray properties of PSR J0855-466

$$N_H = 0.55 \pm 0.08 \quad \Gamma = 1.24 \pm 0.06$$

$$F_{2-10\text{keV}} = (2.9 \pm 0.4) \times 10^{-13} \text{ ergs/cm}^2/\text{s}$$

The properties of the pulsar have been derived assuming an absorbed powerlaw. Below 1 keV the spectrum is dominated by the thermal emission from the Vela SNR which parameters have been fixed using a template model from an annulus surrounding the pulsar.



Distribution of the pulsars \dot{E}/d^2 value as a function of the distance (derived from the radio dispersion measure). Only pulsar with $\dot{E} > 10^{35}$ ergs/s from the ATNF catalog [6] have been selected.

Implication for the e^-/e^+ spectrum

- With a revised upper limit distance of 0.7 kpc, PSR J0855-4644 is a highly energetic and nearby pulsar.
- Therefore this pulsar could have a significant contribution to the e^-/e^+ spectrum received at Earth.
- Nearby pulsars could also explain the observed increase in positron fraction with energy (see [7] and reference therein).

References

- [1] Kramer, M., Bell, J. F., Manchester, R. N., et al. 2003, MNRAS, 342, 1299
- [2] Aharonian, F., Akhperjanian, A. G., Bazer-Bachi, A. R., et al. 2007, ApJ, 661, 236
- [3] Data from the ROSAT All Sky Survey - <http://www.xray.mpe.mpg.de/cgi-bin/rosat/data-browser>
- [4] Liseau, R., Lorenzetti, D., Nisini, B., Spinoglio, L., & Moneti, A. 1992, A&A, 265, 577
- [5] Dame, T. M., Hartmann, D., & Thaddeus, P. 2001, ApJ, 547, 792
- [6] Manchester et al., Astron. J., 129, 1993-2006 (2005) - www.atnf.csiro.au/research/pulsar/psrcat/
- [7] Delahaye, T., Laval, J., Lineros, R., Donato, F., & Fornengo, N. 2010, A&A, 524, A51+