The intriguing double torus-jet PWN around PSR J0855-4644

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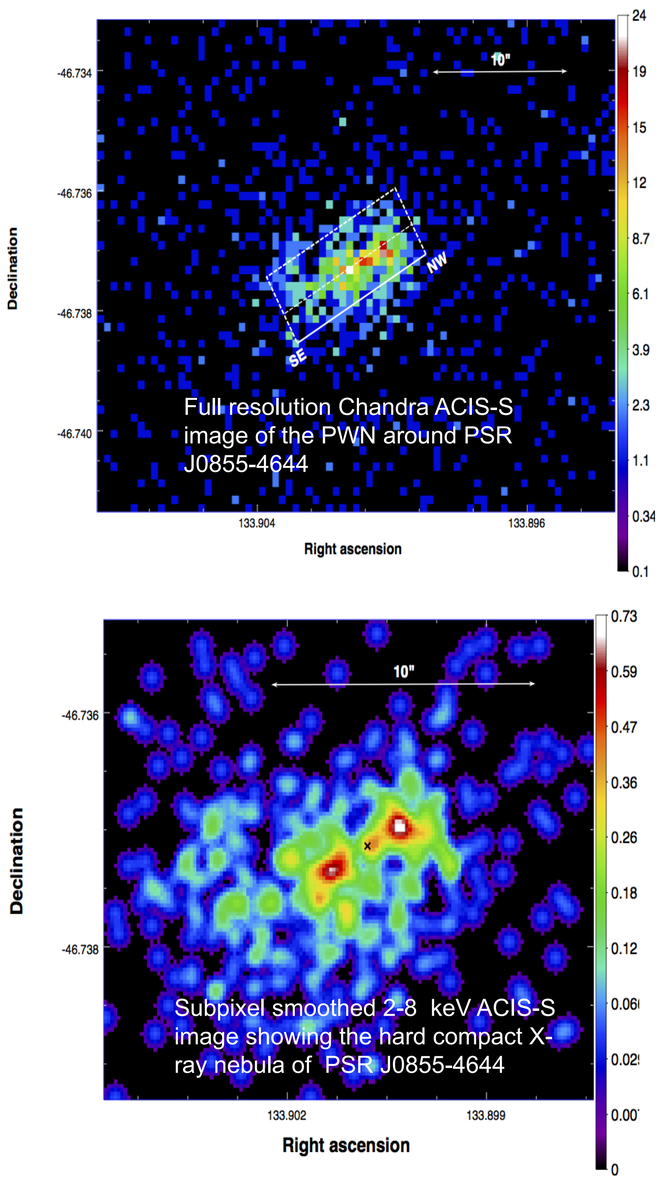
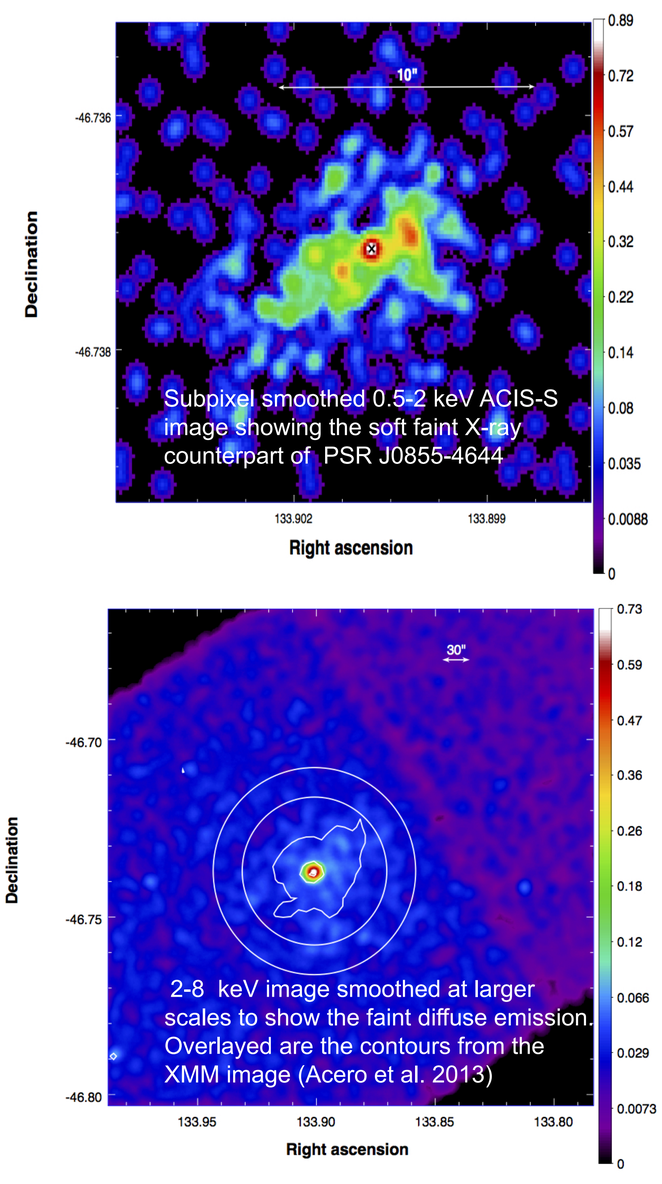
ABSTRACT

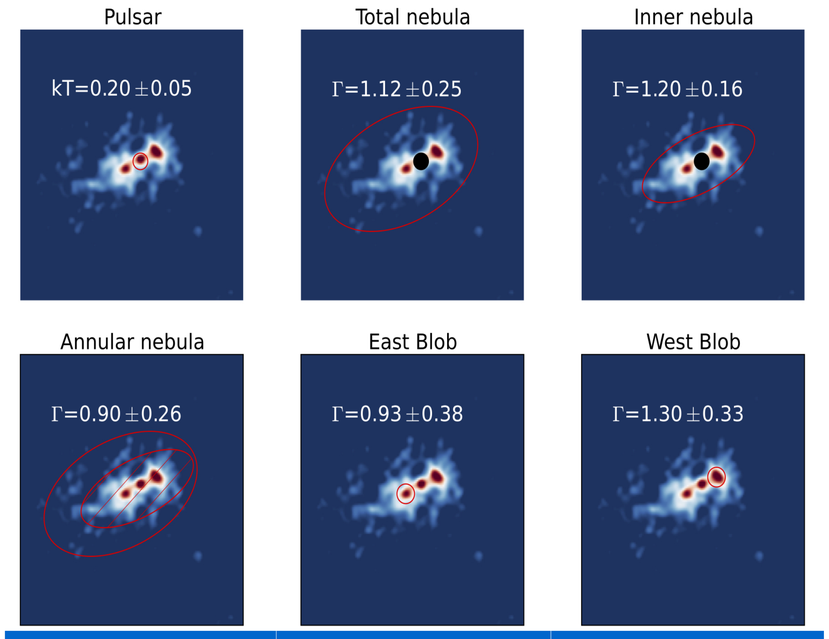
PSR J0855-4644 is a nearby, fast spinning (P=65 ms) and energetic (Ė=1.1 x 10^{36} erg/s) radio pulsar spatially coincident with the rim of the supernova remnant RX J0852.0-4622 (aka Vela Jr). XMM Newton observations have shown an arcminute scale pulsar wind nebula (PWN) around PSR J0855-4644. We present results from the small scale structure of the nebula provided by a Chandra observation. This observation has revealed an arc second scale compact PWN showing a possible double 'torus+jet' morphology. The X-ray counterpart of the pulsar represents ~1% of the flux of the nebula and its spectrum is well described by a blackbody of kT=0.2 keV, while the surrounding nebula has a much harder spectrum of Γ=1.1. The extended emission can be modelled by a double torus model with spin-inclination angle ζ~ |21| ±14°. Independent constraints from geometric light curve modelling yields α ≤ 40°,ζ ≤ 40° and 10°≤ |α-ζ| ≤ 25°. The lack of non-thermal X-ray emission from the pulsar further supports small viewing angles. Such a geometry would explain (in the standard caustic pulsar emission model picture), the radio loud and γ-ray quiet pulsar with high Ė/d² system

High Resolution Chandra image: compact PWN with 'torus+jet'





Spatially resolved spectroscopy



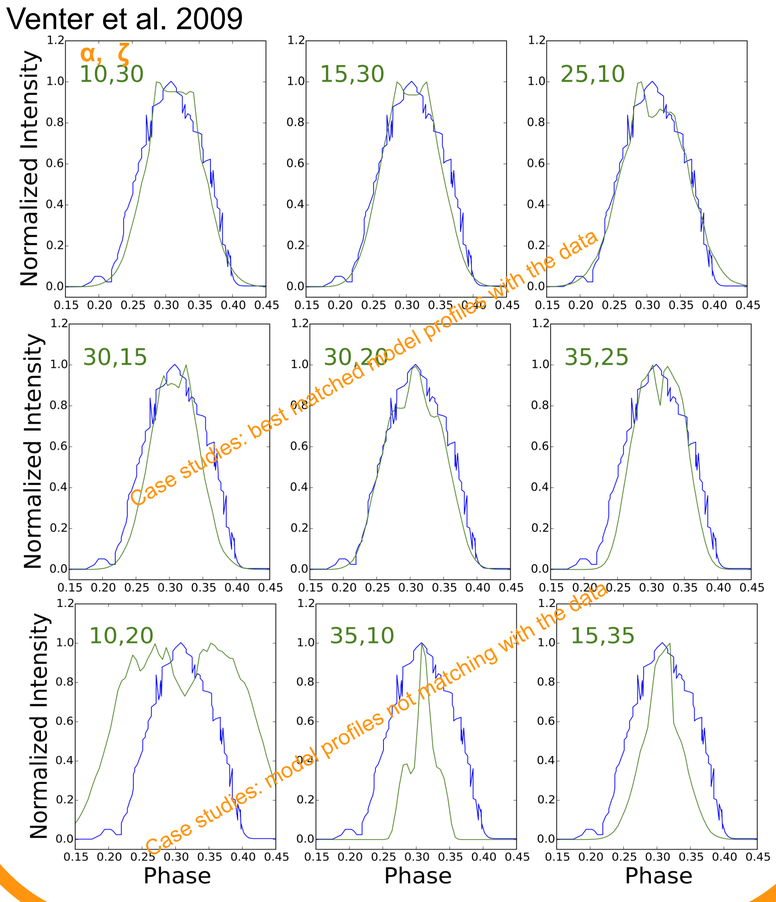
REGION	UNABSORBED LUMINOSITY	COMMENTS
PULSAR	**1.3 x 10^{30} erg/s**	kT=0.2 keV corresponds to R_{off} **~1.5 km** suggesting emission from hot spots (poles) of neutron star
TOTAL NEBULA	**3.3 x 10^{31} erg/s**	

N_H is consistent with that obtained from XMM-Newton (Acero et al. 2013) but with reduced systematics. Reconfirms distance at 900 pc.

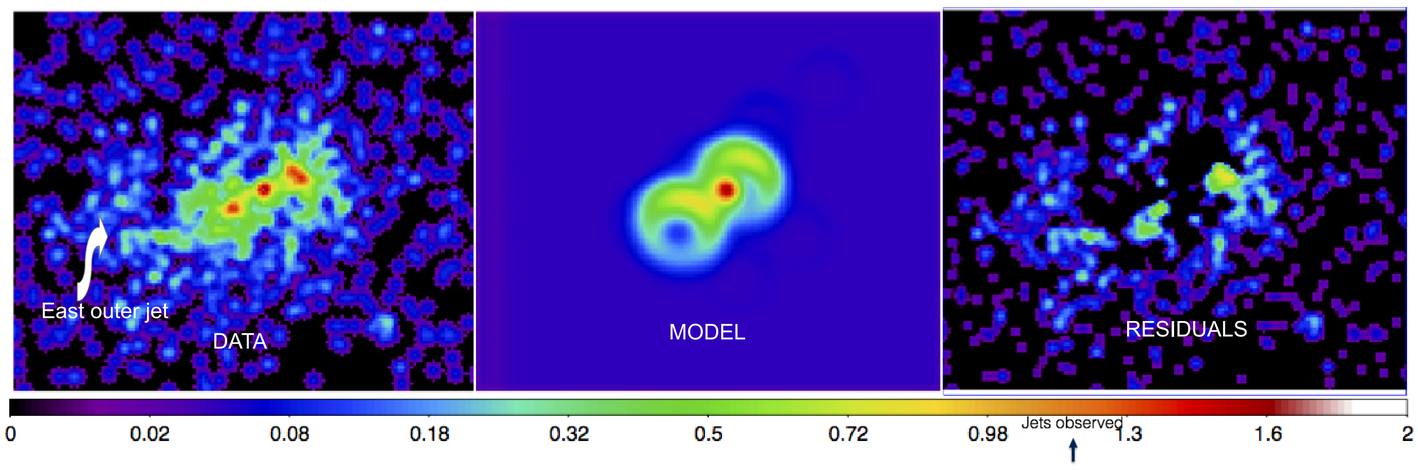
Constraints from geometric light curve modelling

- **PSR J0855-4644 Radio loud γ-ray quiet pulsar with high Ė/d²**
- **Radio peak multiplicity & radio width** can also be compared to obtain constraints on geometry

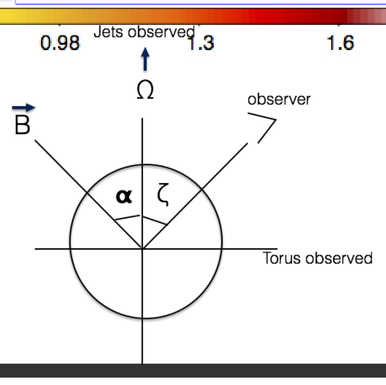
Predictions of geometric light curves from the **TPC model** and **OG model** in conjunction with semi- empirical hollow-cone radio model compared with observed radio profile (Kramer et al. 2003) to obtain **α, ζ,** and **|β|=|α-ζ|.** Details in Venter et al. 2009



Spatial modeling: Double torus model (Ng & Romani 08)



PARAMETER	VALUE
Position angle (South to East)	346.4 ± 6.3°
ζ	|21| ±14°
Torus radius	4.5" (fixed)



Morphology & properties of the compact PWN

- Second system after PSR J2021+3651 & Vela to show double torus + jet morphology.
- Ė (spin-down power) similar to Vela and Vela like pulsars.
- Physical size of compact PWN 0.06 pc at a distance of 900 pc. This is similar to inner PWN of Vela (~0.1 pc).
- Nebula efficiency ($\eta = L_{PWN}/\dot{E}/d^2 \sim 10^{-5}$) similar to Vela like pulsars

PSR J0855-4644: A consistent picture for a high Ė/d² pulsar with no γ-ray pulsations

Viewing geometry close to the magnetic poles of the pulsar

- X-ray spatial modelling of the compact PWN by double torus model indicates **ζ < |35|°**
- Radio/γ-ray light curve modelling indicates **α, ζ < 40°,** and **10° ≤ |β| ≤ 25°**
- Lack of non-thermal X-rays from the PSR implies emission only from heated polar cap, implying small **|β|** angles

[1] C. Maitra et al., Constraining the geometry of PSR J0855-4644, A&A (submitted), 2016
[2] F. Acero et al., A nearby pulsar wind nebula overlapping the RX J0852.0-4622 supernova remnant, A&A, 551, A7 (2013)
[3] M. Kramer et al., The Parkes Multibeam Pulsar Survey - III, New J. Phys. 13, 065021 (2003)
[4] C. Venter et al., Probing millisecond pulsar emission geometry using light curves from the Fermi/LAT, ApJ, 707, 800 (2009)

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