A 0.5 MS CHANDRA OBSERVATION OF THE O-RICH SNR G292.0+1.8

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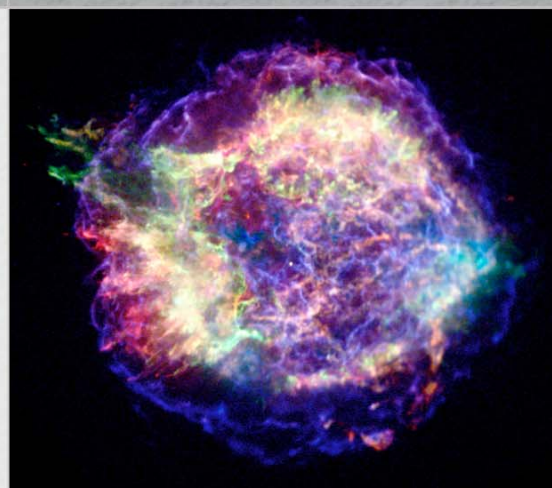
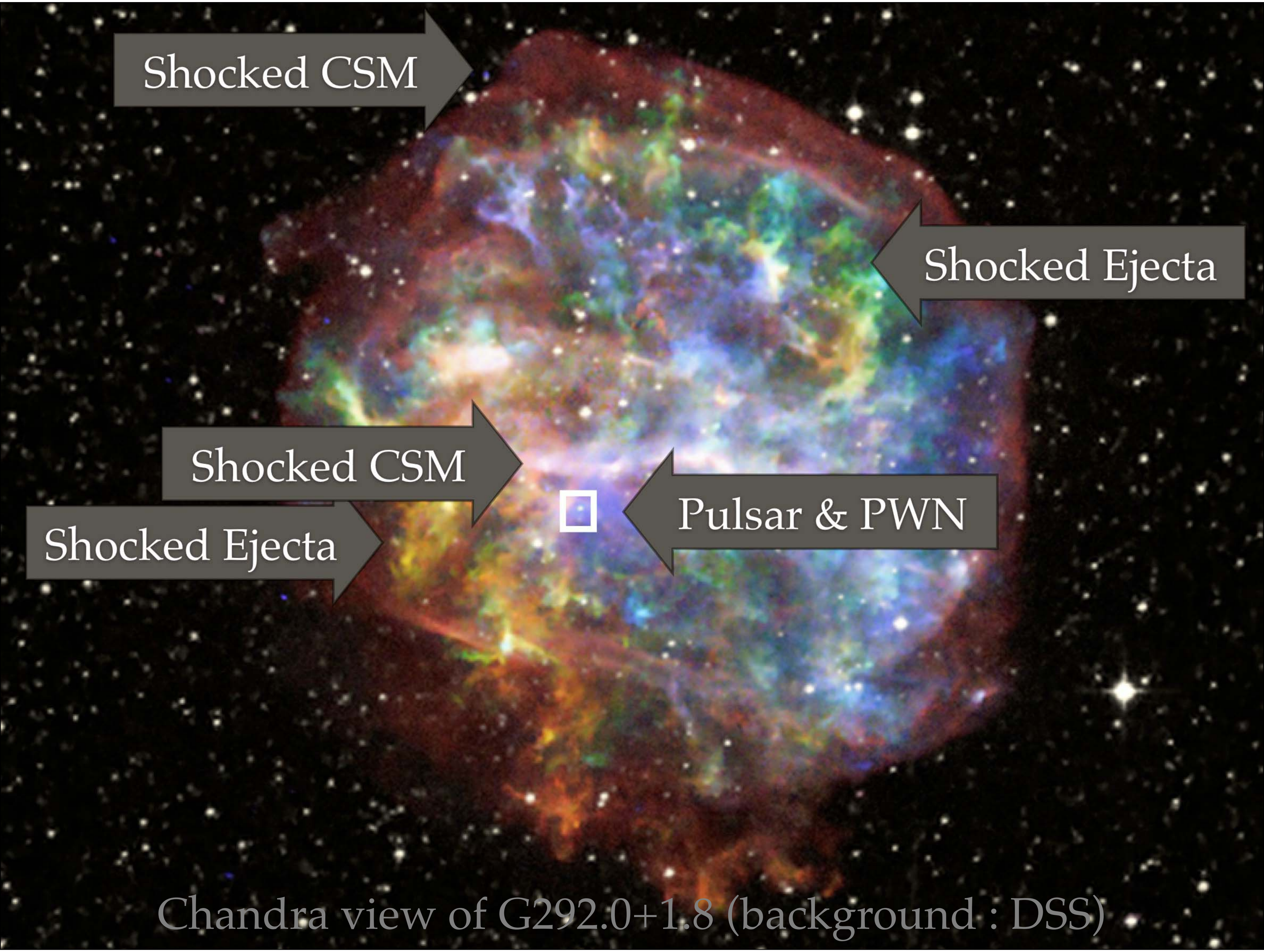
YOUNG CORE-COLLAPSE SNRS

- O-rich SNR : fast moving O-rich optical ejecta knots

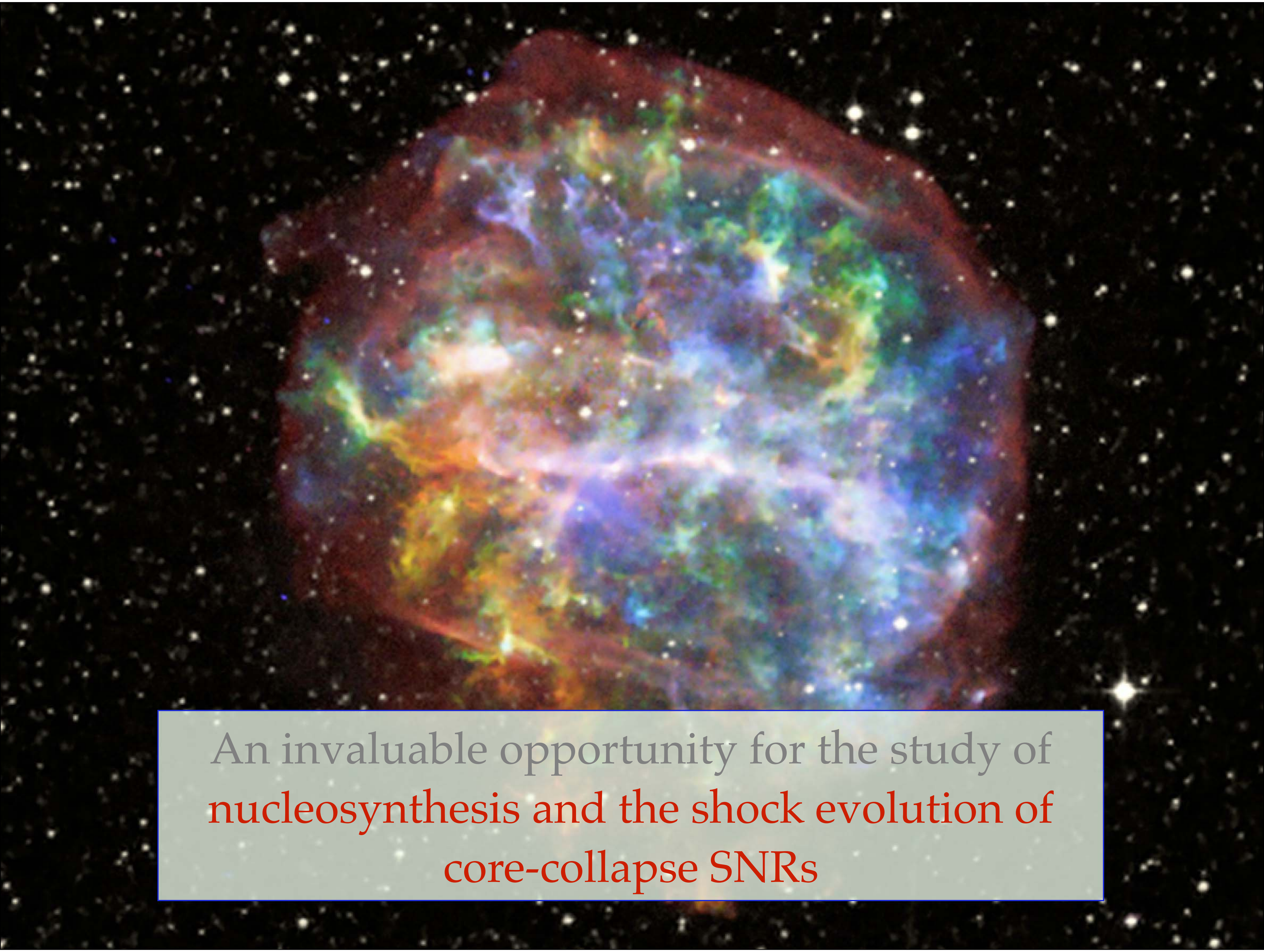
	Cas A	G292.0+1.8
		
Age	~320 yrs	~3,000 yrs
Radius	~2.5'	~4'
	~2.4 pc @ 3.4 kpc	~7.7 pc @ 6 kpc

G292.0+1.8 : THE TEXTBOOK EXAMPLE OF YOUNG CORE-COLLAPSE SNR

- An active pulsar and its wind nebula
- Fast moving stellar ejecta enriched in light elements like Oxygen, Neon and Magnesium.
- Evidence for blast wave interaction with circumstellar material



Chandra view of G292.0+1.8 (background : DSS)



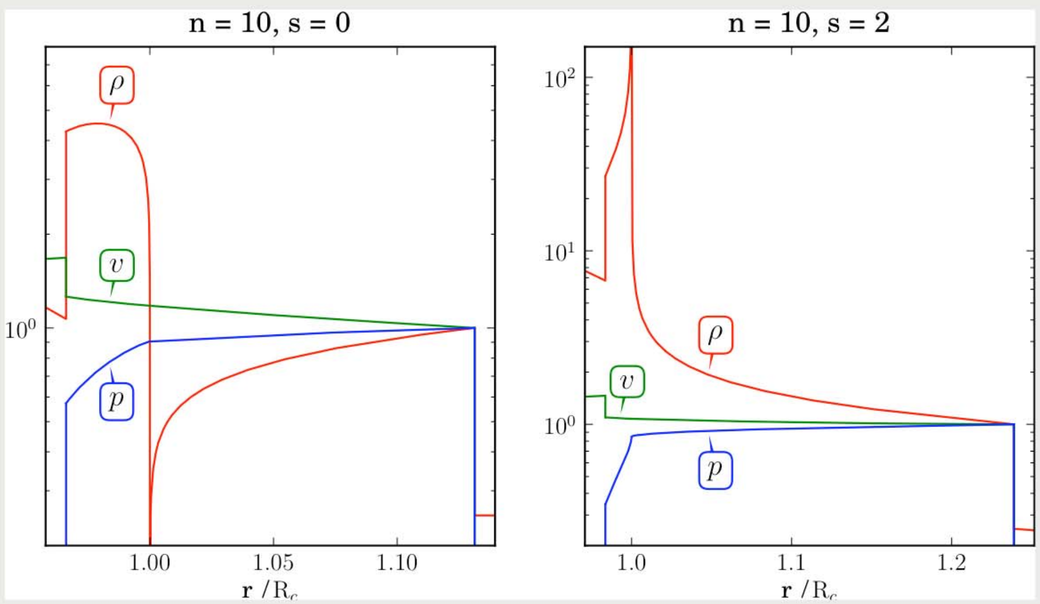
An invaluable opportunity for the study of
nucleosynthesis and the shock evolution of
core-collapse SNRs

CHANDRA LARGE PROJECT

- First Chandra observation (ACIS-S3) in AO1 (40 ksec) : GTO target.
- Deep (~500 ksec) Chandra observation (ACIS-I) in AO7 : GO Large Project (PI: Sangwook Park)
  - John P. Hughes (Rutgers) Patrick O. Slane (CfA), David N. Burrows (Penn State), B. M. Gaensler (U. of Sydney), Parviz Ghavamian (STScI)

1. NATURE OF THE AMBIENT MEDIUM

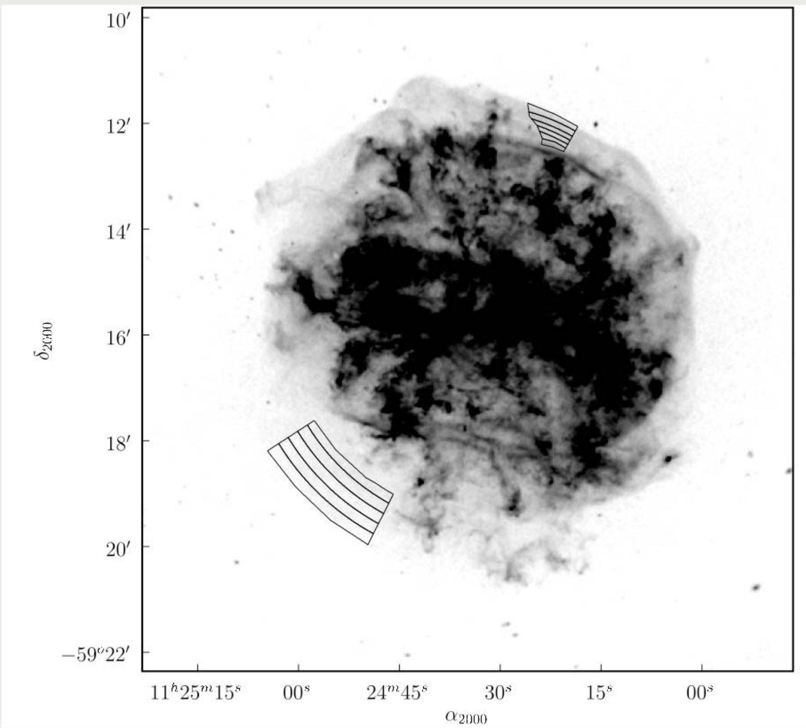
- Young C-C SNRs are expected to expand inside the wind.
- The shocked ambient gas of the SNR expanding in the wind ($\varrho \propto r^{-2}$) shows different radial structure from those expanding in the uniform medium.

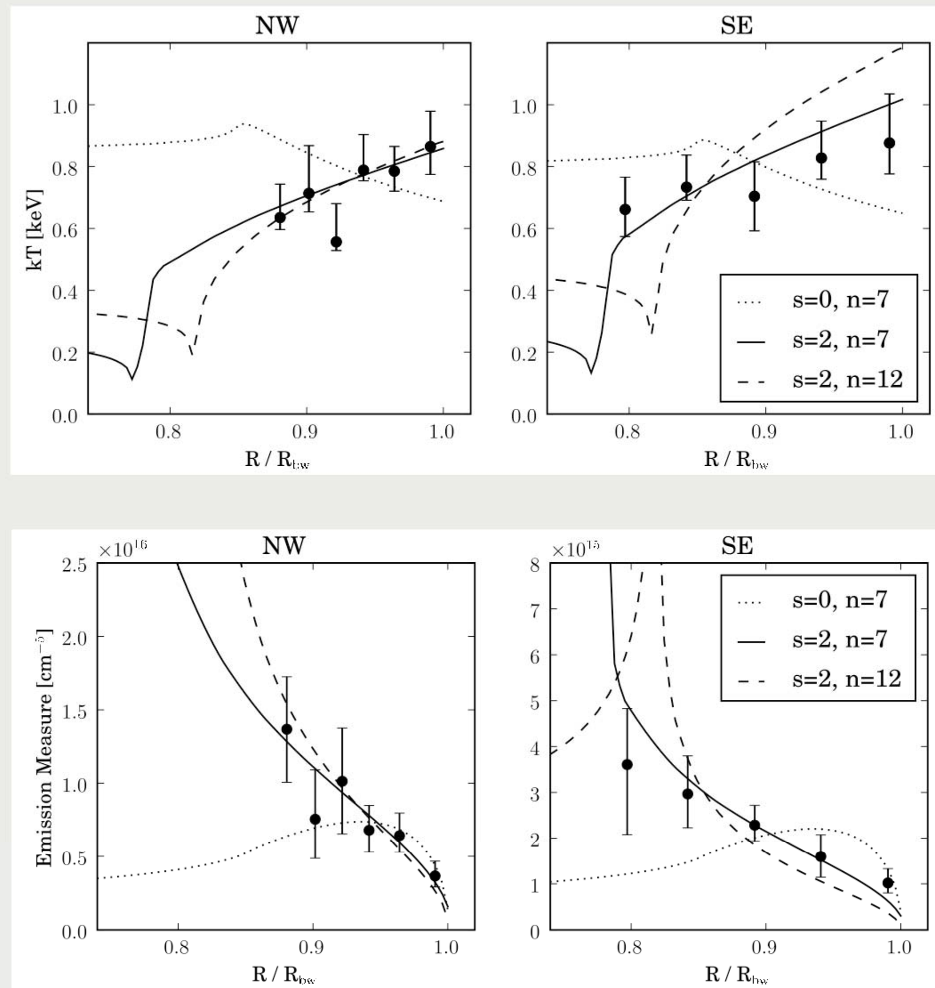


Self-Similar solution by Chevalier (1982)

at CD	Density	Temperature
Uniform (s=0)	0	∞
Wind (s=2)	∞	0

SPECTRAL ANALYSIS





- regions are selected with minimal ejecta contamination
- single plane-parallel shock model (vpshock)
- sub-solar metal abundances

Lee et al. ApJ submitted

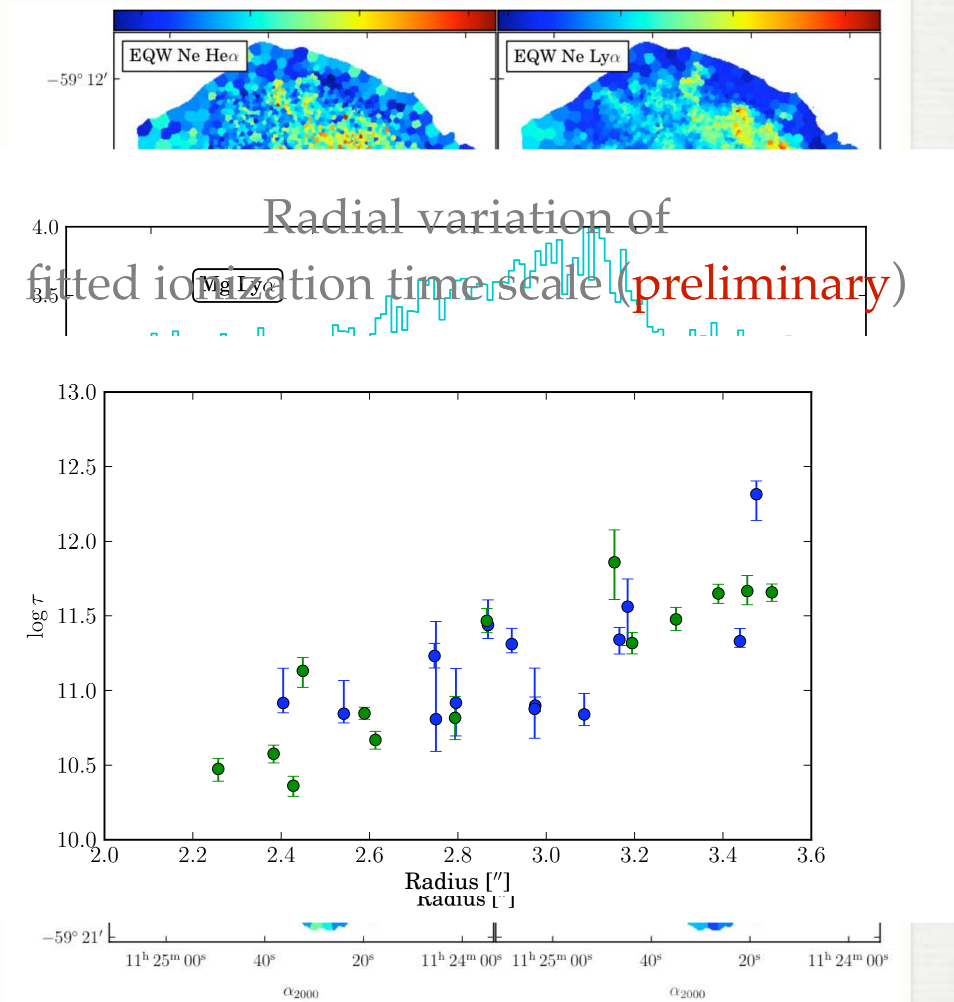
- The structure of shocked ambient gas is consistent with models of the remnant expanding in the circumstellar wind.
- The estimated wind density ($n = 0.1 \sim 0.3\ cm^{-3}$) at the current outer radius (~ 7.7 pc) suggests a slow wind from a red supergiant star.
  - $\dot{M}$: $2 \sim 5 \times 10^{-5}\ M_{\odot}\ yr^{-1}$ w/ $v_w = 10\ km\ s^{-1}$
  - $M_w = 15 \sim 40\ M_{\odot}$
- The overall kinematics of G292.0+1.8 are consistent with the remnant expanding inside the RSG wind.

- Our results provide a direct evidence that G292 is expanding inside the dense RSG wind from the progenitor star.

2. SPATIAL DISTRIBUTION OF SHOCKED EJECTA EMISSION

- Equivalent-width(EQW) map of individual lines shows different spatial distribution.
- In NW, ions with high ionization potentials (IP) are found outside those w/ lower IP. It traces the radial variation of the ionization time scale.
- The observed trend can be explained by a reverse shock propagating inwards (as in E0102.2-7219, Gaetz et al 2000)

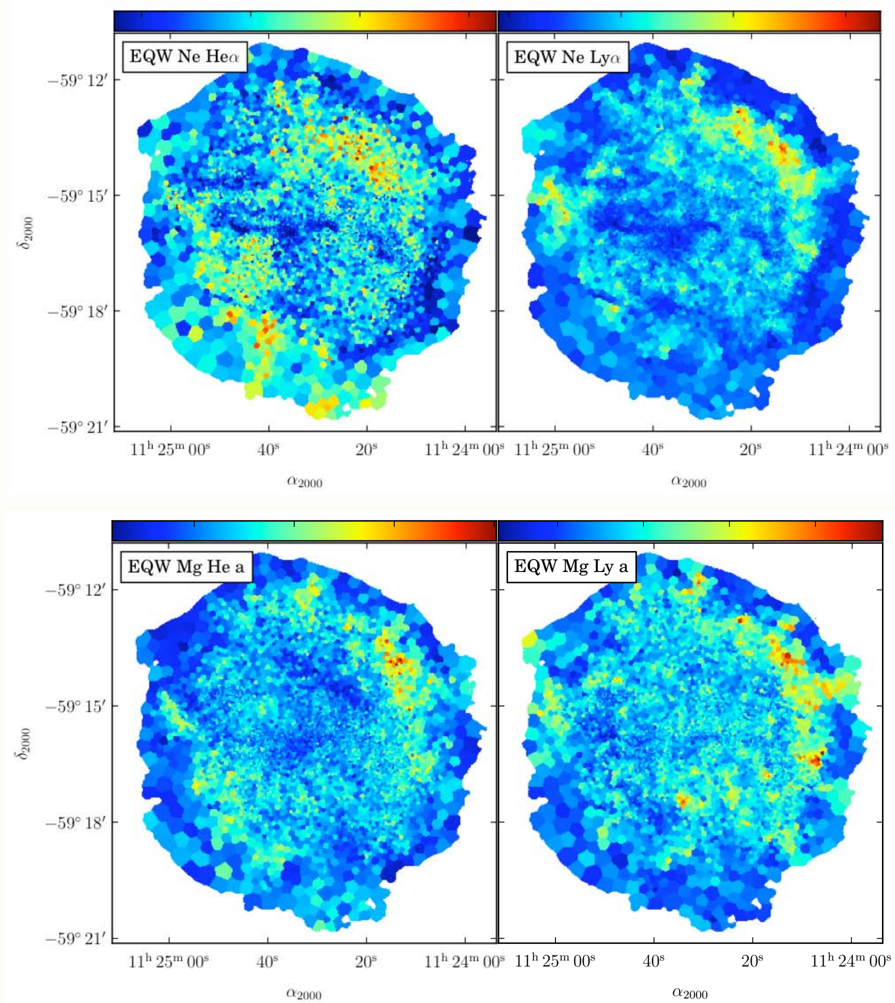
Radial variation of fitted ionization time scale (preliminary)



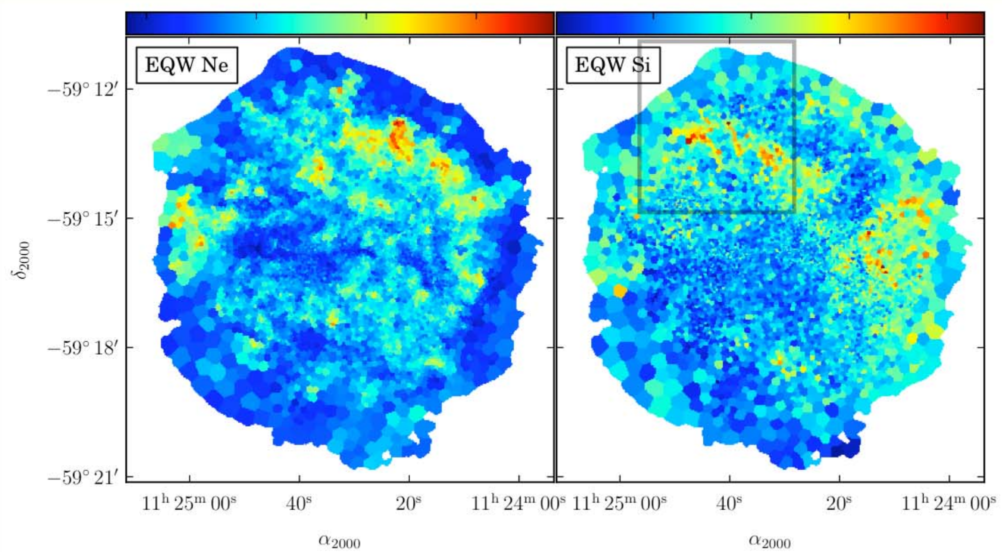
(Lee et al. in prep.)

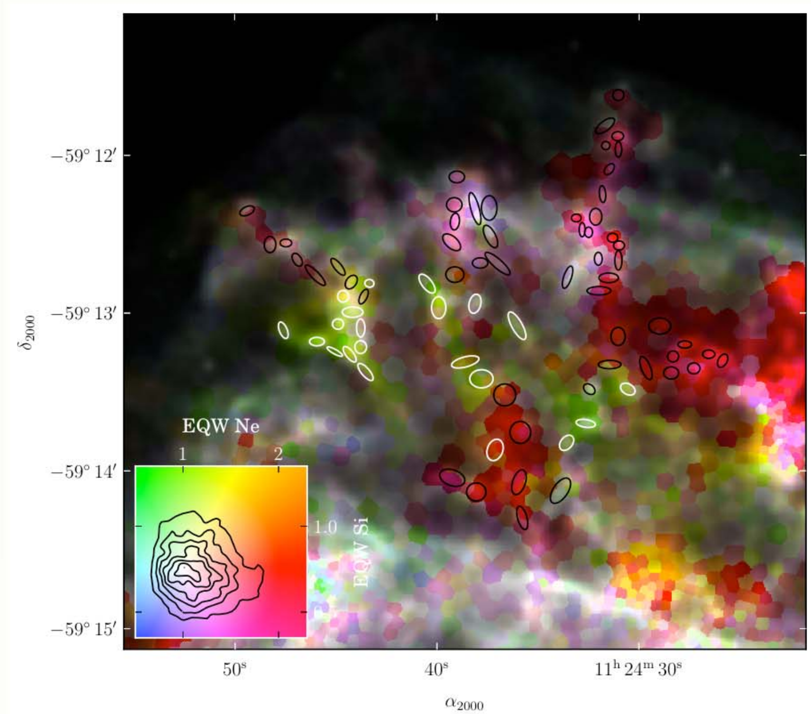
EXPLOSION ASYMMETRY?

- The asymmetric distribution of ionization states is likely due to the asymmetric nature of the explosion.
- The location of the explosion center seems controversial (Winkler et al., 2008; H.-G. Lee 2009)

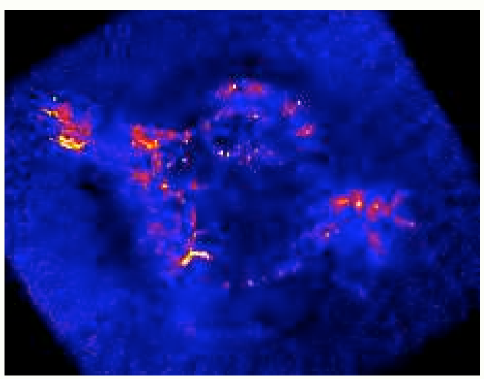


DISTRIBUTION OF SILICON





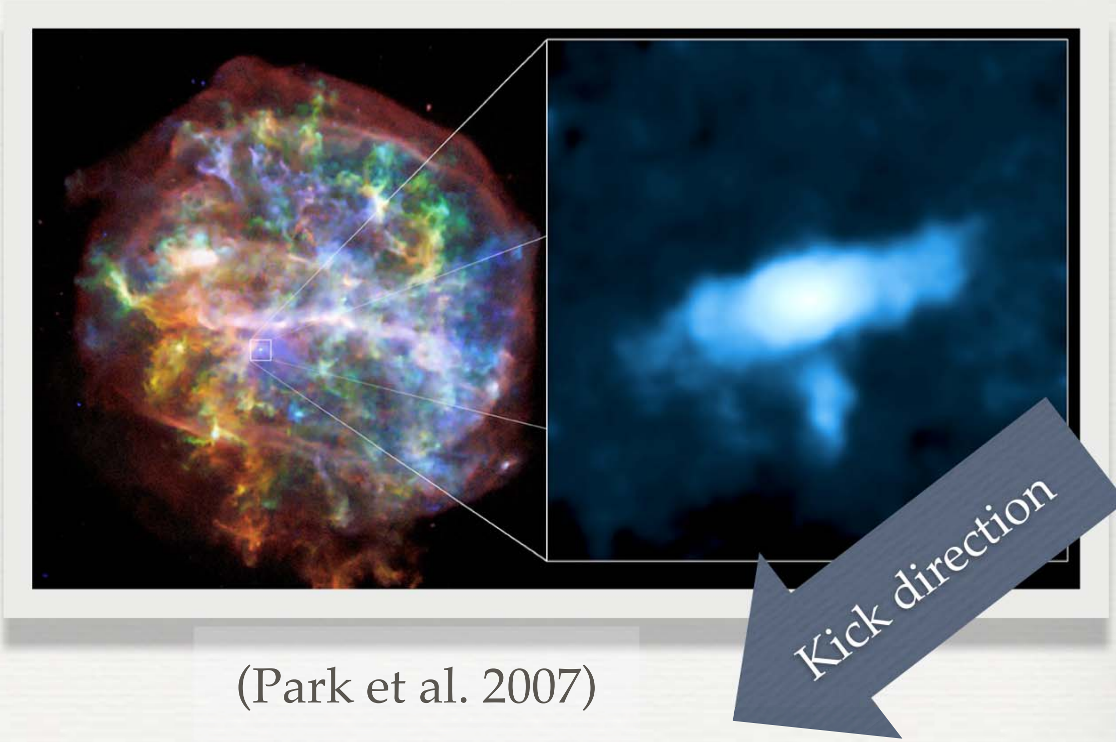
White : High Si Black : Low Si



Silicon in Cas A (Hwang et al. 2004)

3. PULSAR & PWN

- Our deep ACIS-I observation reveals faint emission suggestive of a jet/torus structure.
- Contrast to the strong tendency toward spin-kick alignment claimed by Ng & Romani (2007)



(Park et al. 2007)

SUMMARY

- Our Chandra observation of G292.0+1.8 shows a consistent picture of late-stage evolution of massive star, where it loses a significant amount of its initial mass as stellar wind and undergoes an asymmetric explosion to leave a neutron star with high spatial velocity.