Suzaku Observations of Thermal and Nonthermal X-Ray Emission from the Middle-Aged SNR G156.2+5.7

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9/10 @ Johns Hopkins University

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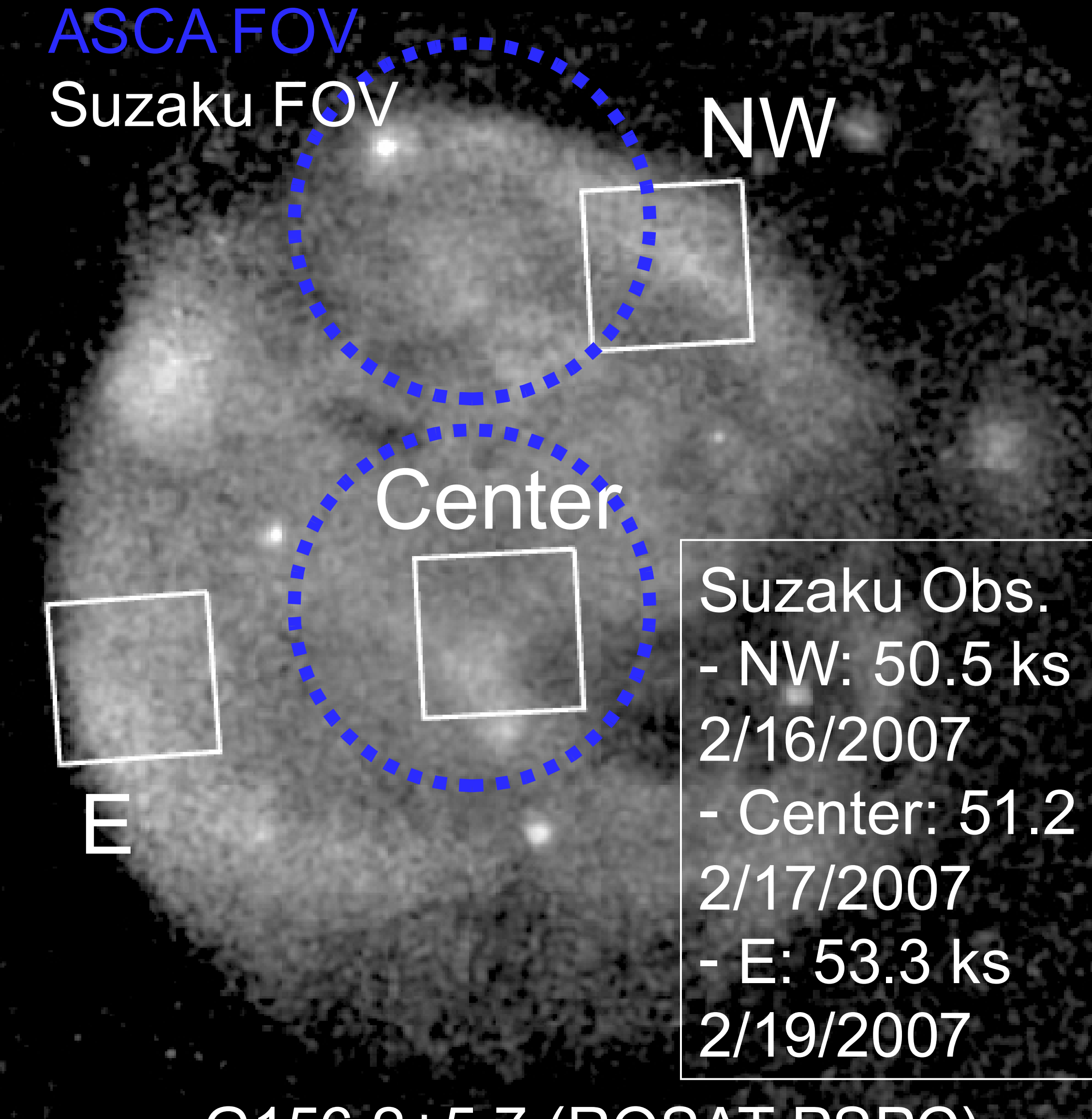
Suzaku Observations of G156



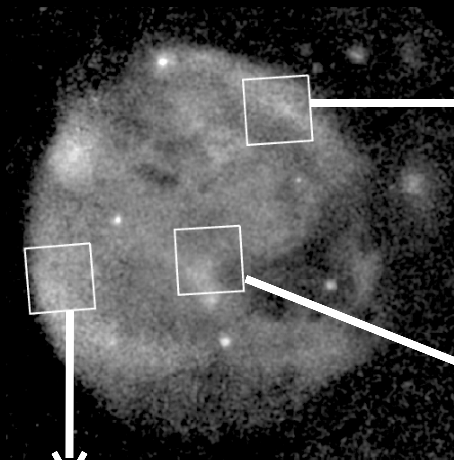
G156.2+5.7 (ROSAT PSPC)

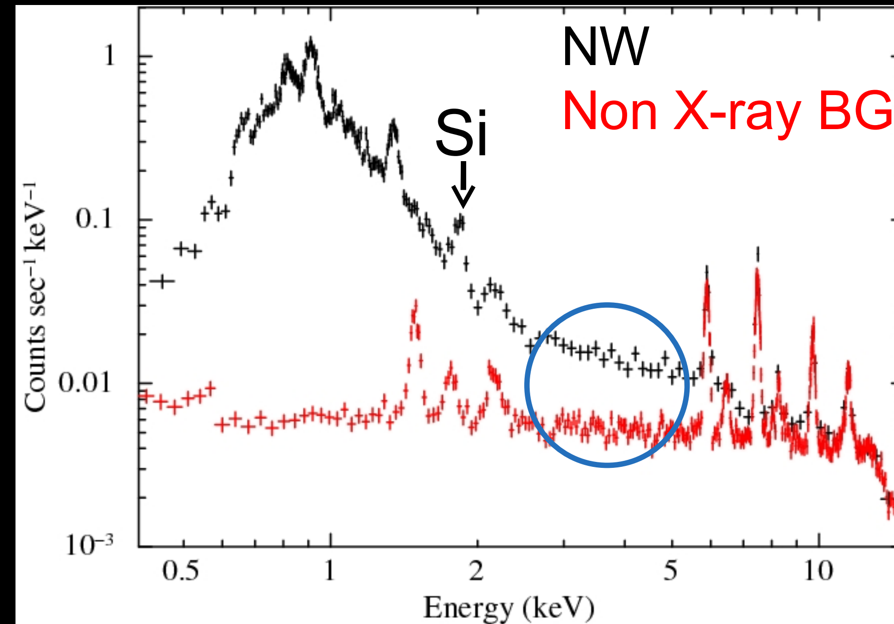
Suzaku Obs.
- NW: 50.5 ks
2/16/2007
- Center: 51.2 ks
2/17/2007
- E: 53.3 ks
2/19/2007

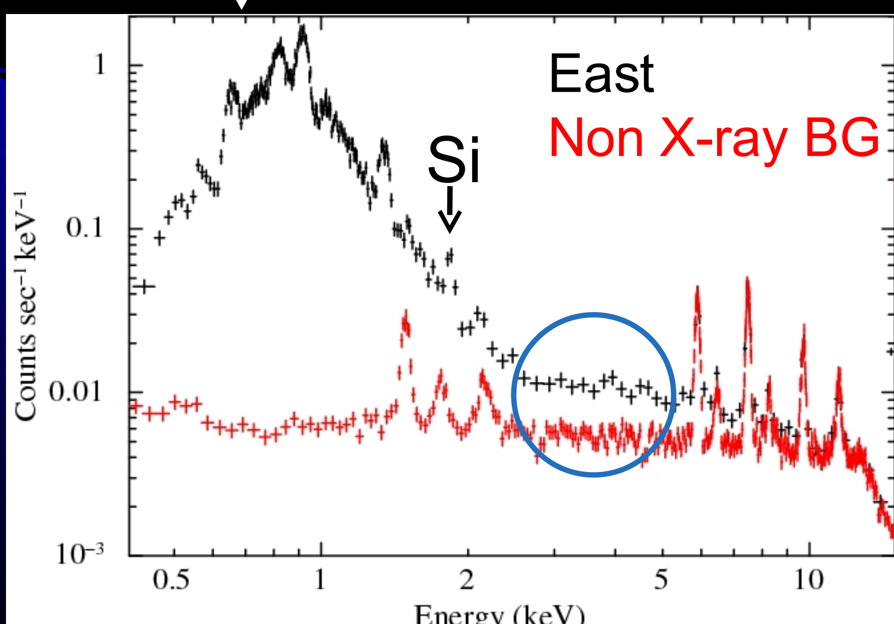
G156.2+5.7

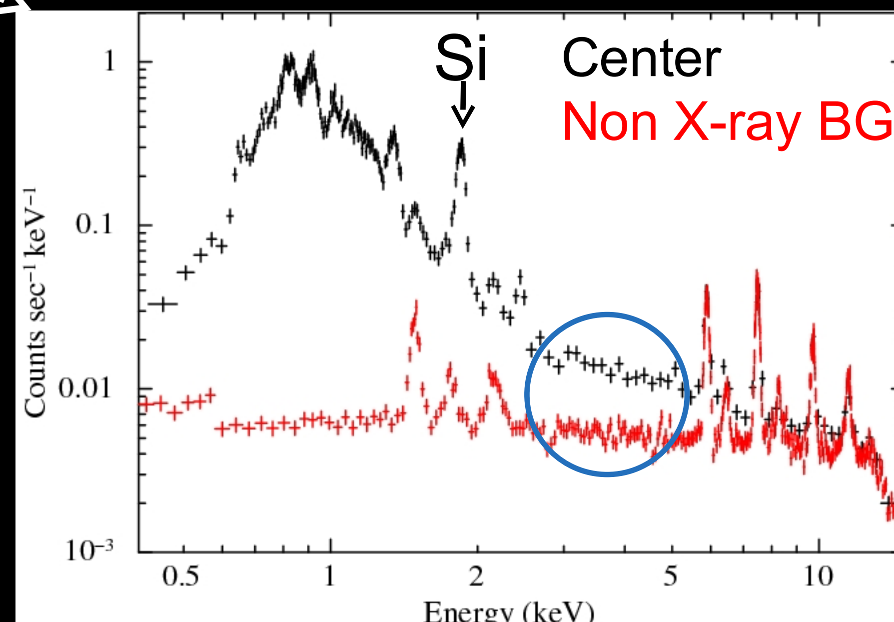
- R~50'
  (=>~15 pc @1 kpc)
- Age ~15,000 yr
- X-ray bright
  (Pfeffermann+ 1991)
  Radio dim
  (Reich+ 1992)
- ASCA results
  (Yamauchi+1999)
  North: soft (ISM) and hard-tail emission.
  Center: soft (Si S-rich ejecta) and hard-tail emission.

XIS Spectra in the Entire FOV



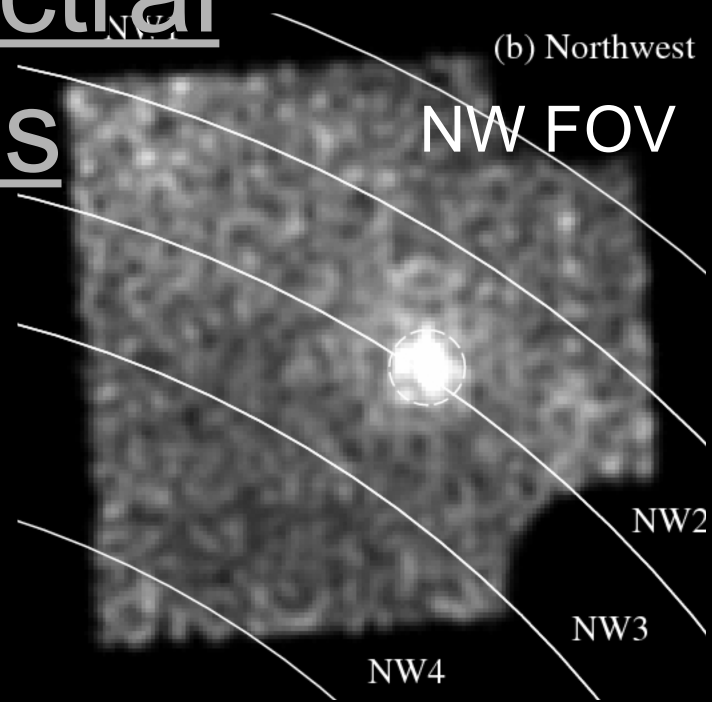


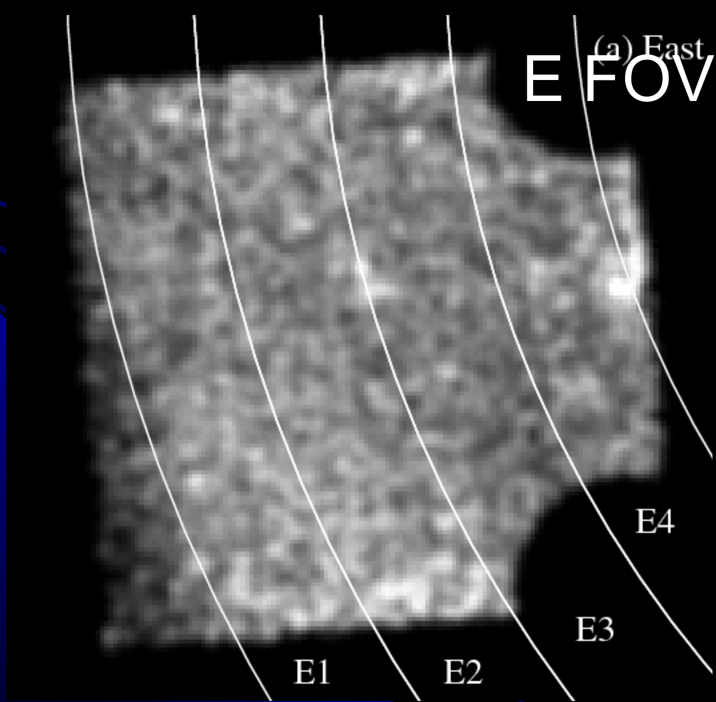


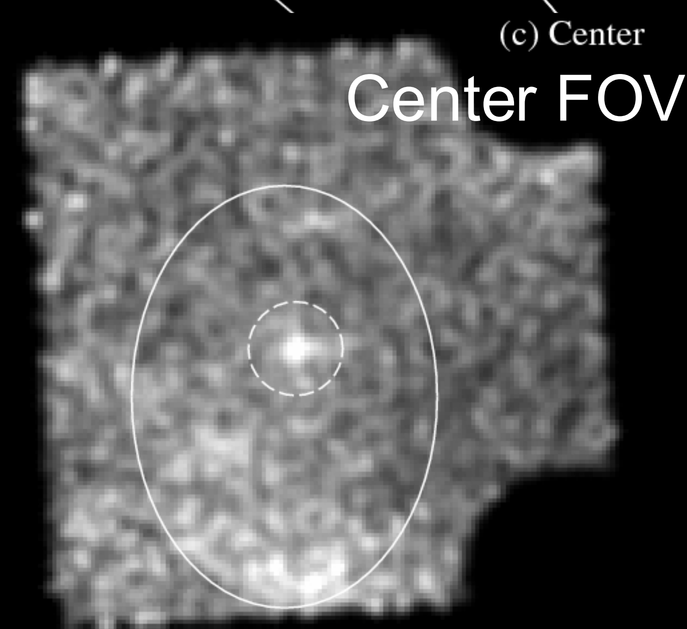


XIS Images and Spectral Extraction Regions

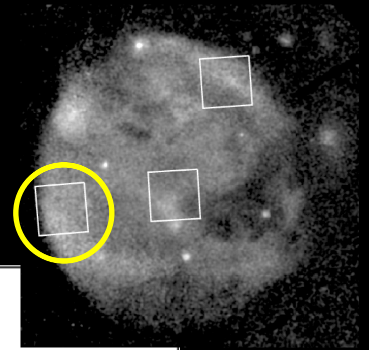
XIS images (NXB-subtracted vignetting-corrected).



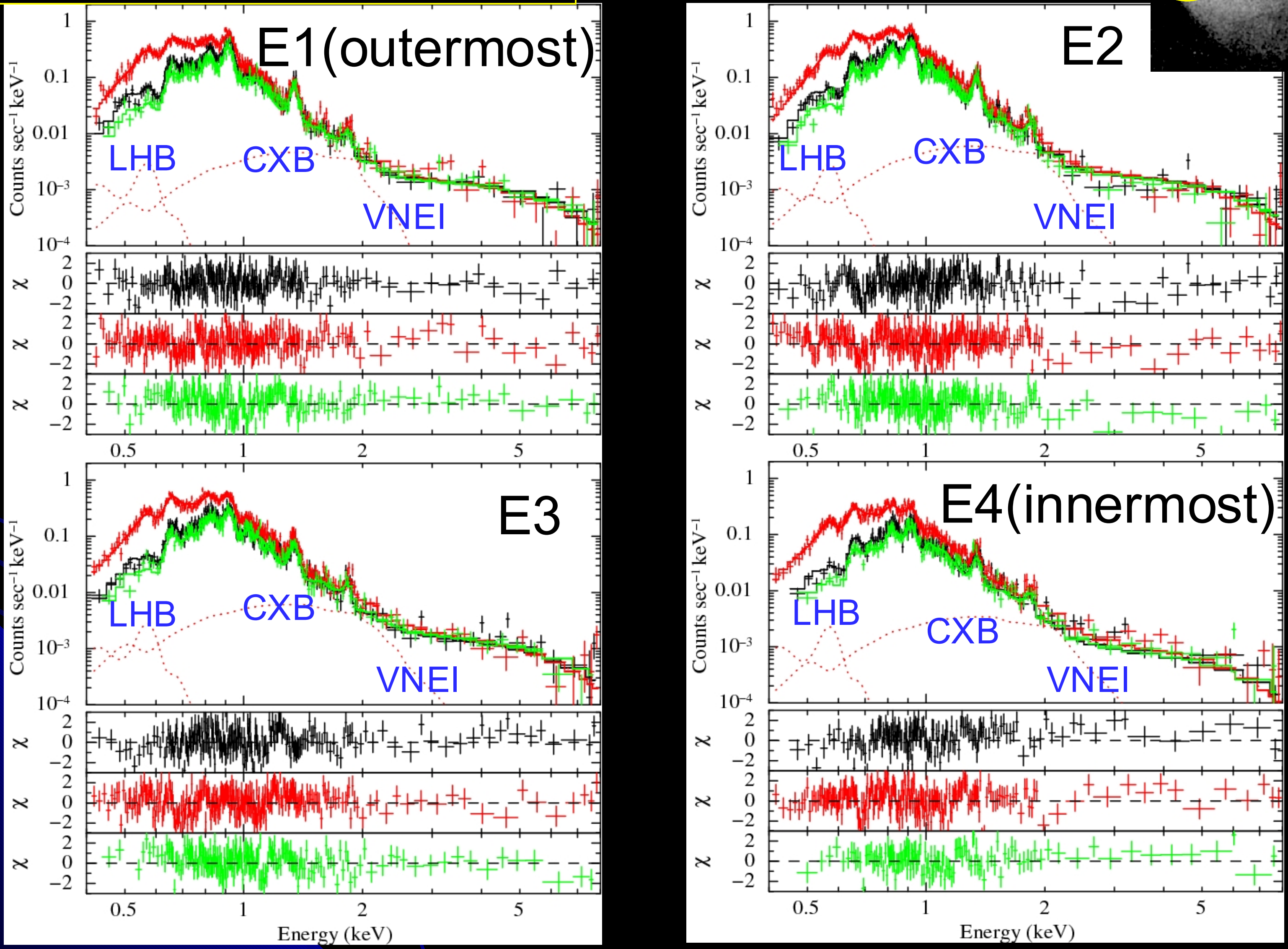




East Rim

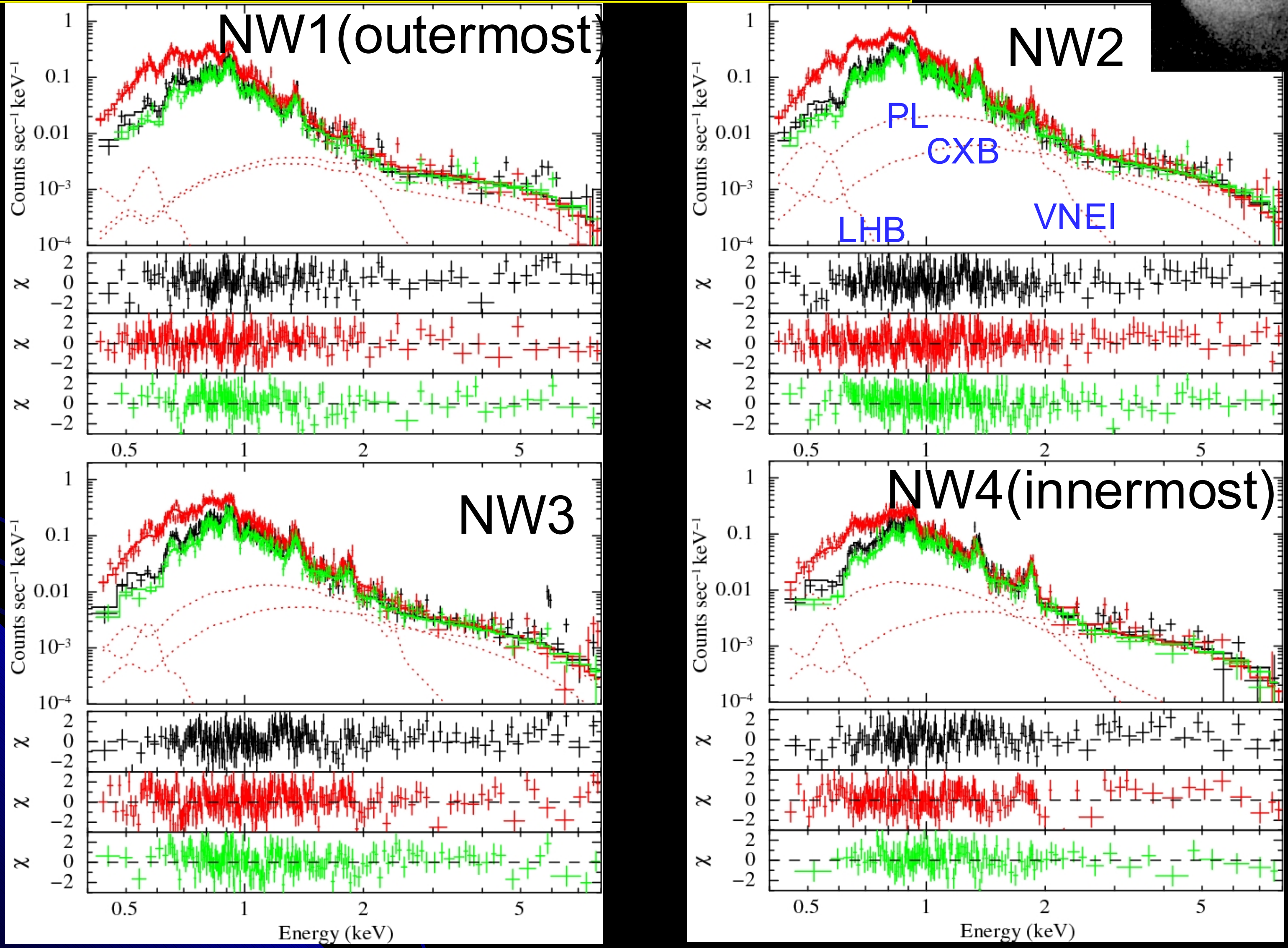


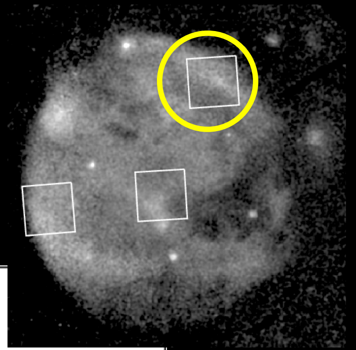
Model = wabs x (vnei)



NW Rim

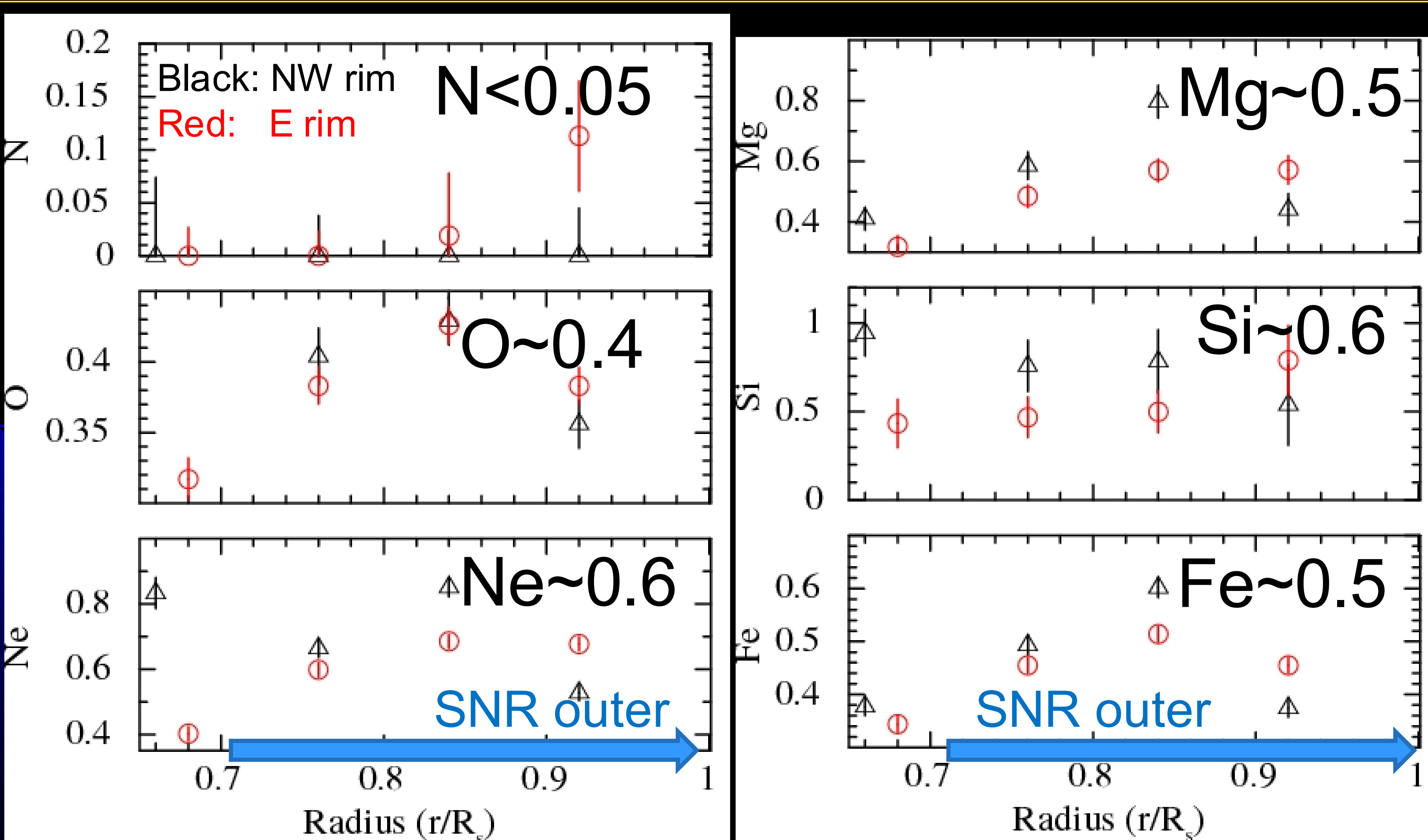
Model = wabs x (vnei + power-law)



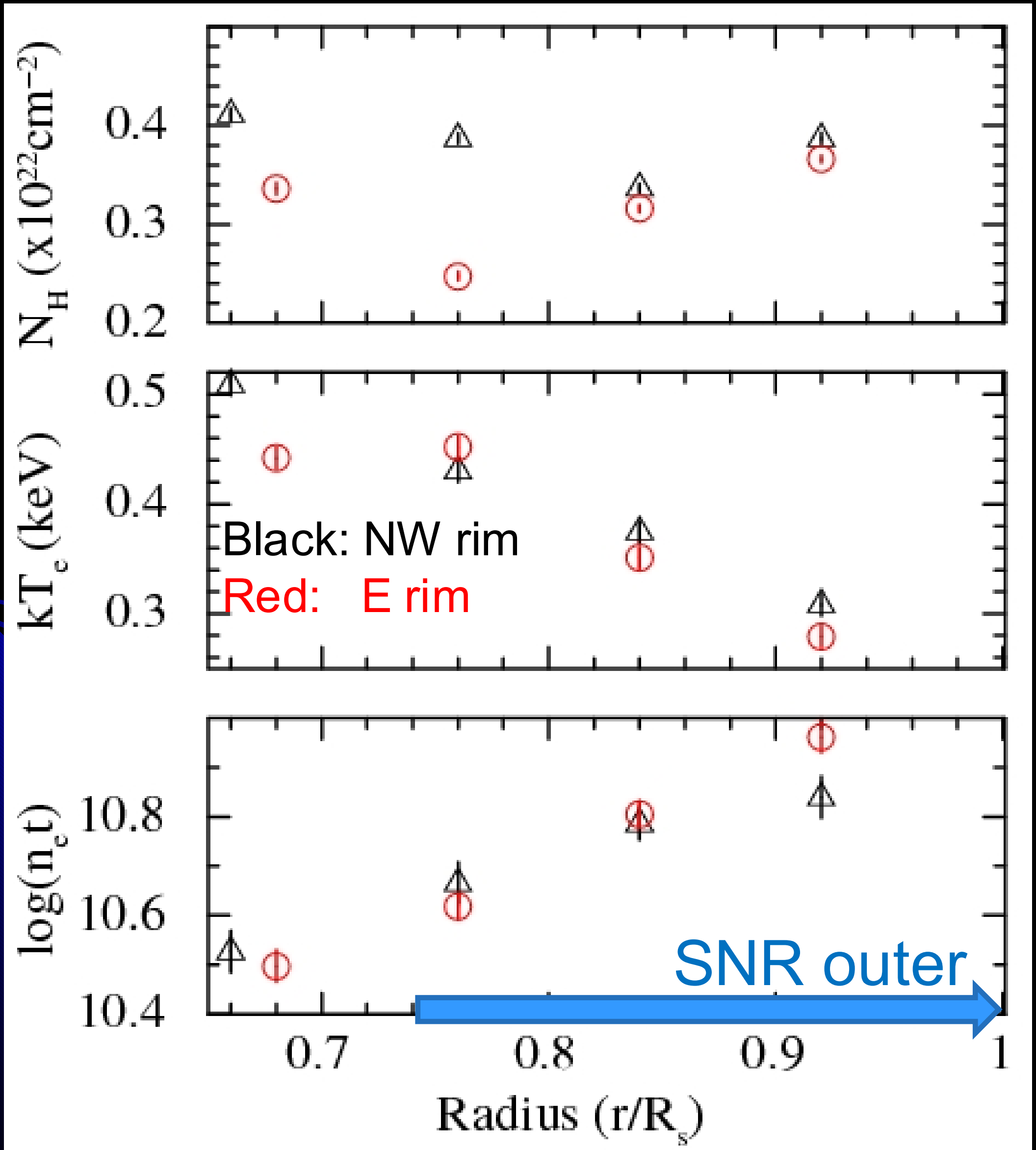


Abundances in the E and NW rims

Sub solar abundances are derived => ISM origin for these plasma



N_H, kT_e, n_et in the E and NW rims



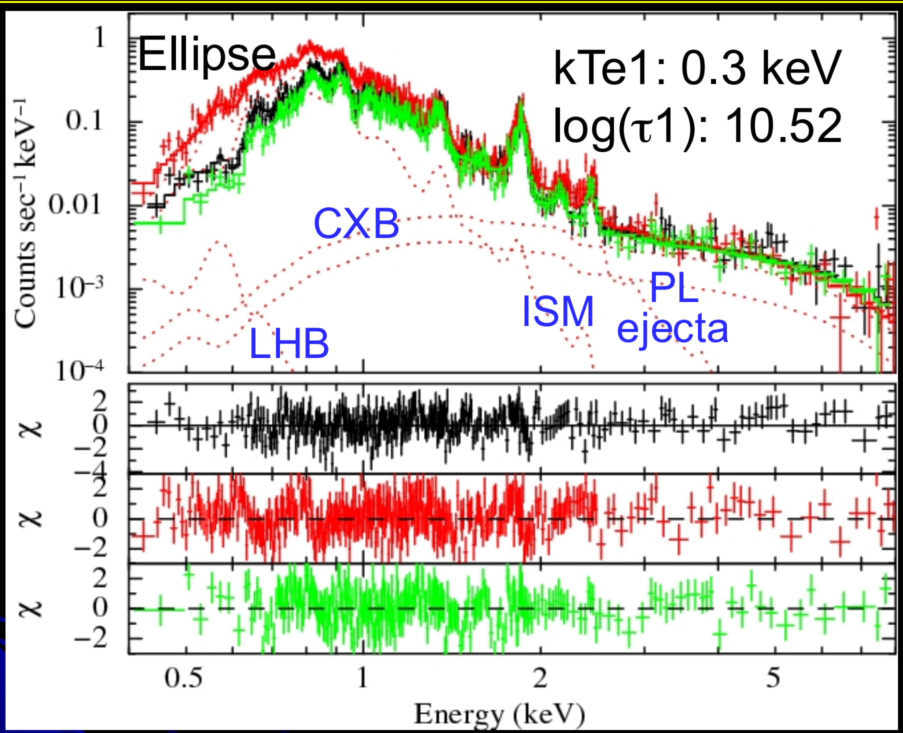
N_H~0.3-$0.4x10^{22}$ cm^{-2}
=>consistent with ASCA results

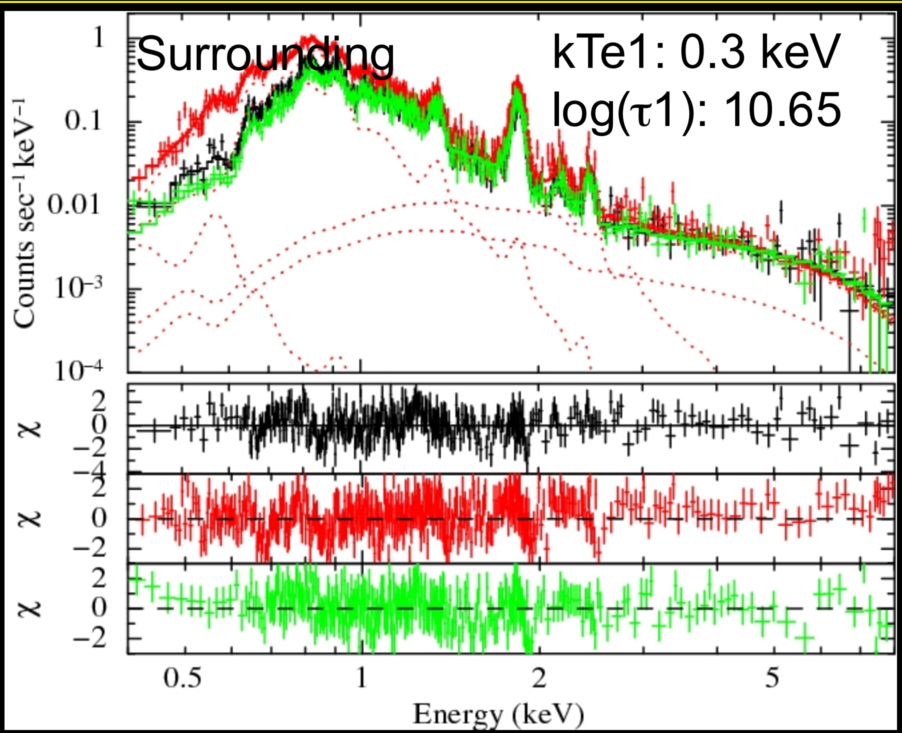
kT_e decreases toward the shock front to ~0.3keV.
The forward shock velocity is estimated to be ~500 ($kTe/0.3$ keV)$^{0.5}$ km/sec.

NEI condition everywhere.
It decreases from the edge (~10^{11}) toward the center ($0.3x10^{11}$).

Center

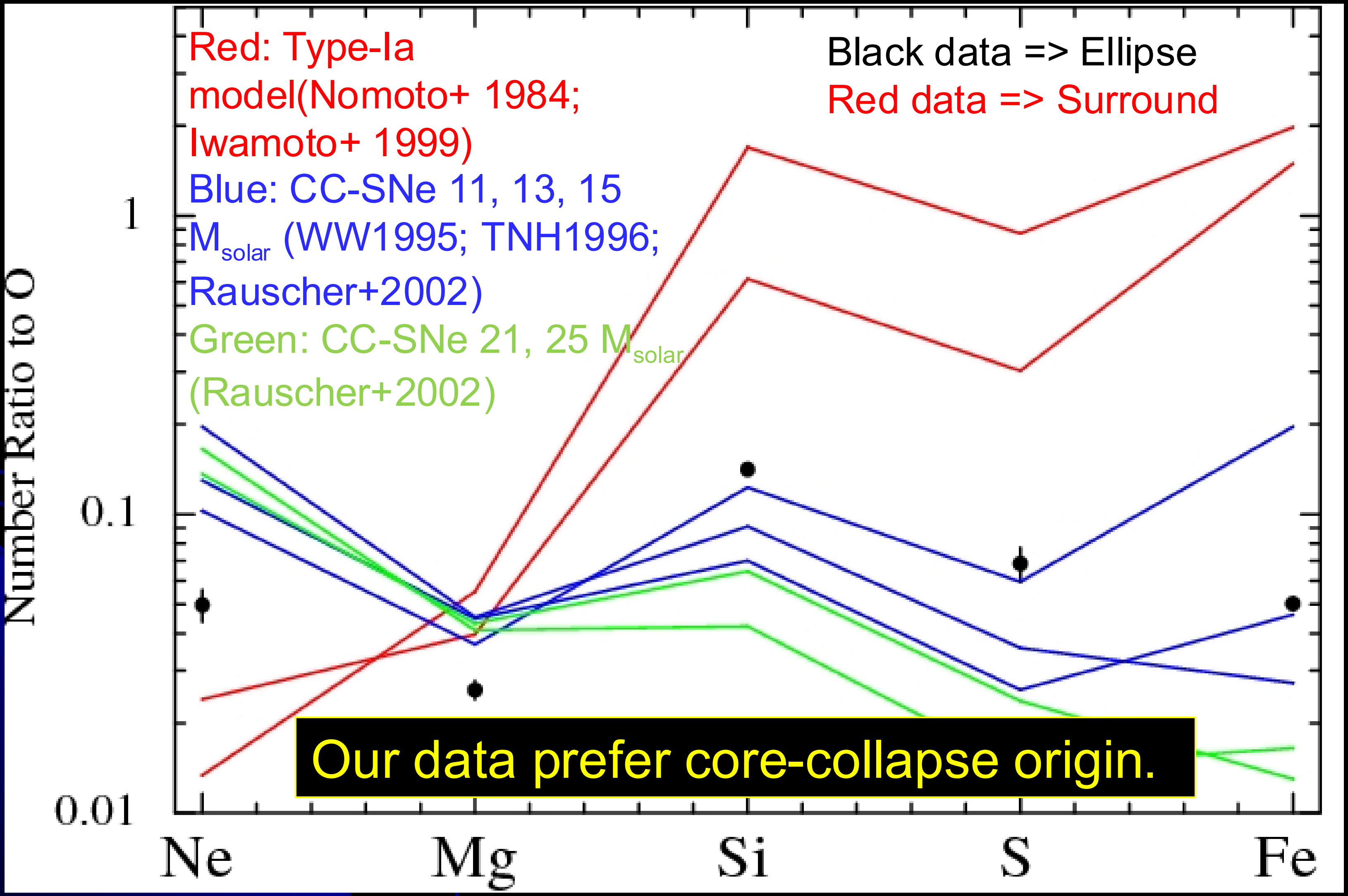
Model = wabs x (vnei(ISM) + power-law + vnei(ejecta))





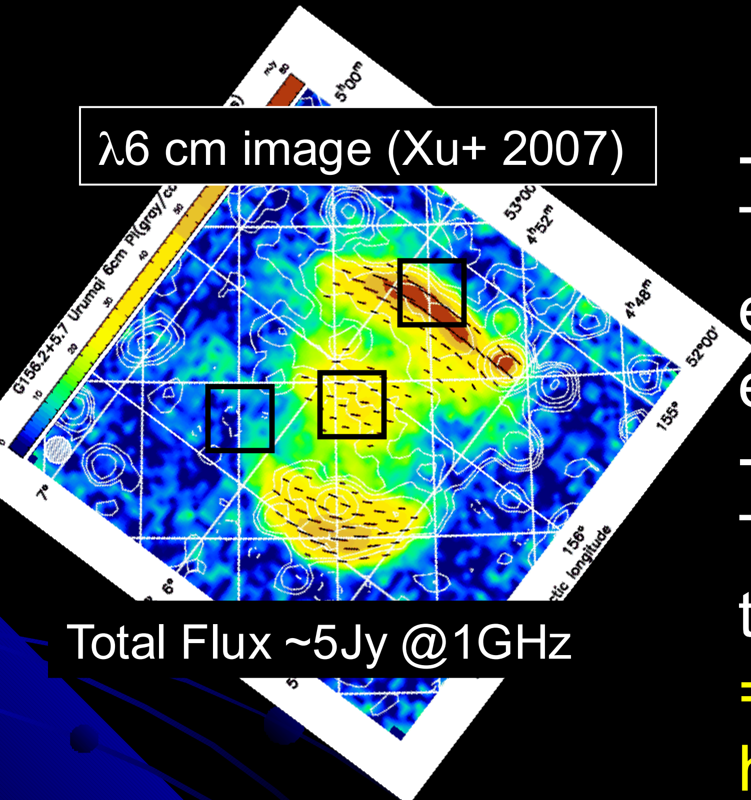
	Ellipse				Surrounding		
N_H:(x10^{22})	0.42 +/- 0.01			N_H:	0.42 +/- 0.01		
kT_e2:	0.50 +/- 0.01			kT_e2:	0.54 +/- 0.01		
log(τ2):	11.12 +/- 0.03			log(τ2):	11.32 +/- 0.02		
N=O:	0.52 +/- 0.04			N=O:	2.6 +/- 0.2		
Ne:	0.27 +/- 0.03	Mg:	0.43 +/- 0.04	Ne:	0.9 +/- 0.1	Mg:	1.5 +/- 0.1
Si:	1.8 +/-0.1	S:	2.9 +/- 0.5	Si:	8.8 +/-0.3	S:	9.3 +/- 1.2
Fe:	0.68 +/- 0.02			Fe:	2.4 +/- 0.1		
Γ:	1.4 +/- 0.1			Γ:	1.5 +/- 0.2		

Ejecta Abundances: Comparison with Nucleosynthetic Models



Origin of the Hard-tail Emission

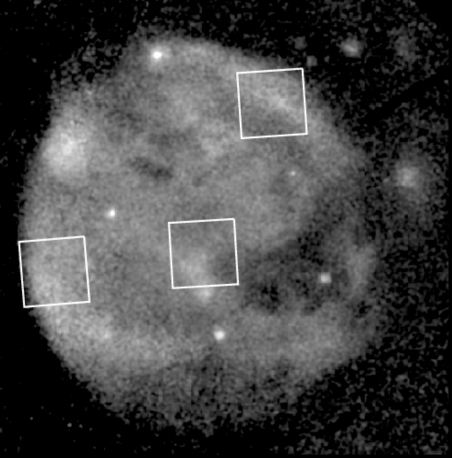
λ6 cm image (Xu+ 2007)



Total Flux ~5Jy @1GHz

- Comparison with the radio morphology:
The distribution of the X-ray hard-tail emission matches that of the radio emission.
- Spectral features:
The SRCUT model well fits our data and the radio data.
=>Support the non-thermal origin for the hard-tail emission.

Non-thermal X-ray emission from a slow forward shock of ~500 km/sec.

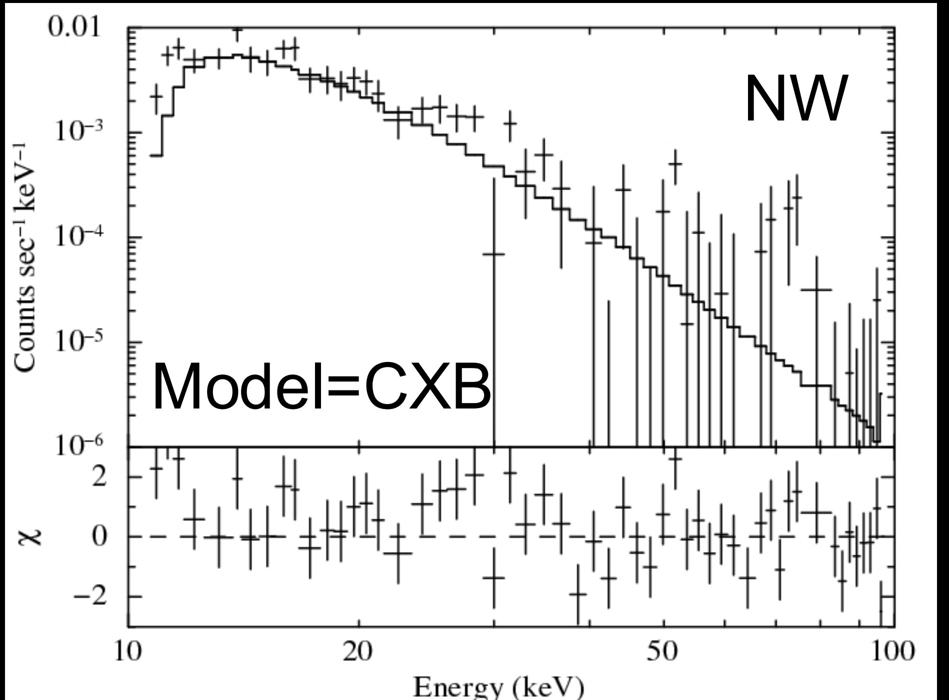


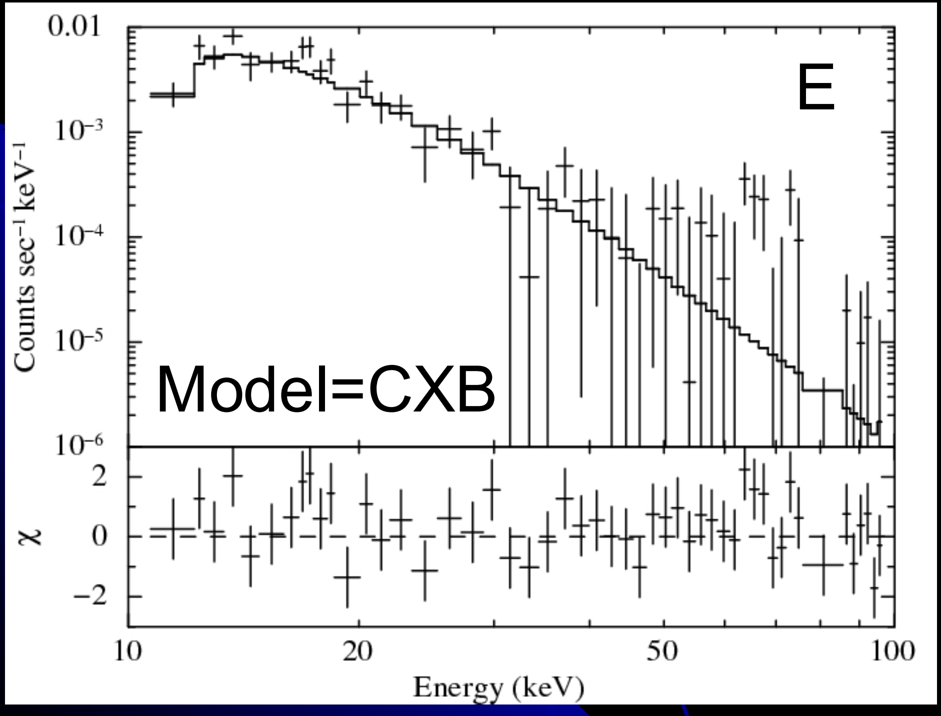
Summary

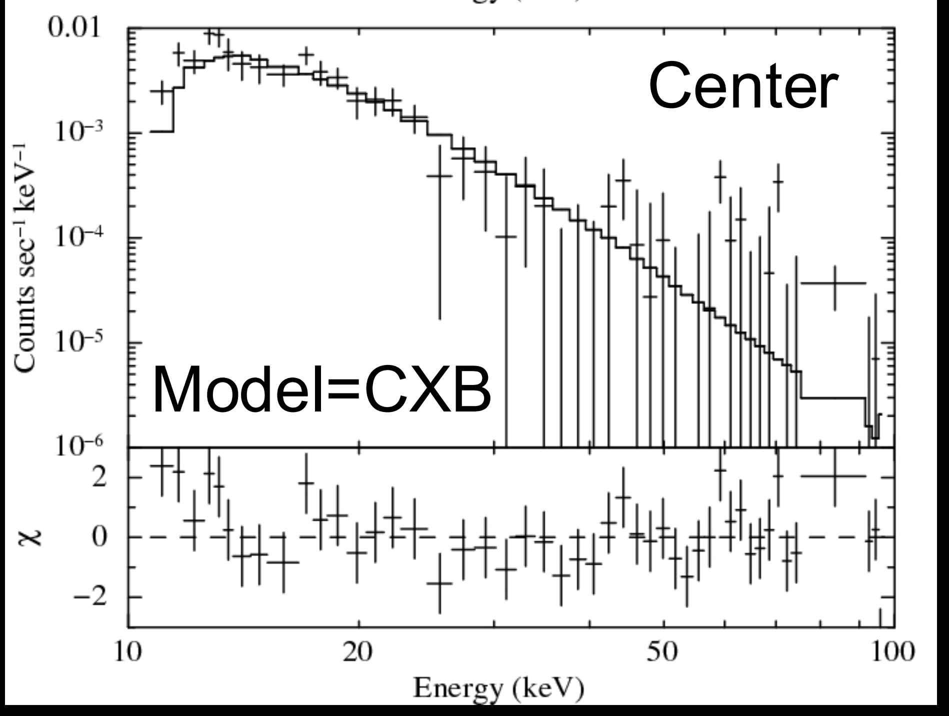
- We have observed the NW rim, the center, and the east rim of SNR G156.2+5.7 with Suzaku.
- In the NW rim and the center, we confirm that the X-ray spectra consists of soft and hard-tail emission, while in the E rim we find no significant hard-tail emission. The soft emission in the NW and E rims is the ISM plasma. In the center, the soft emission is ISM+ejecta plasma.
- The relative abundances in the ejecta component suggest that G156.2+5.7 is a remnant from a core-collapse SN explosion whose progenitor mass is less than 15 solar masses.
- The origin of the hard-tail emission is highly likely non-thermal synchrotron emission from relativistic electrons accelerated by the forward shocks. The relativistic electrons seem to be accelerated by a forward shock with a slow velocity of ~500 km/sec.

HXD PIN Spectra

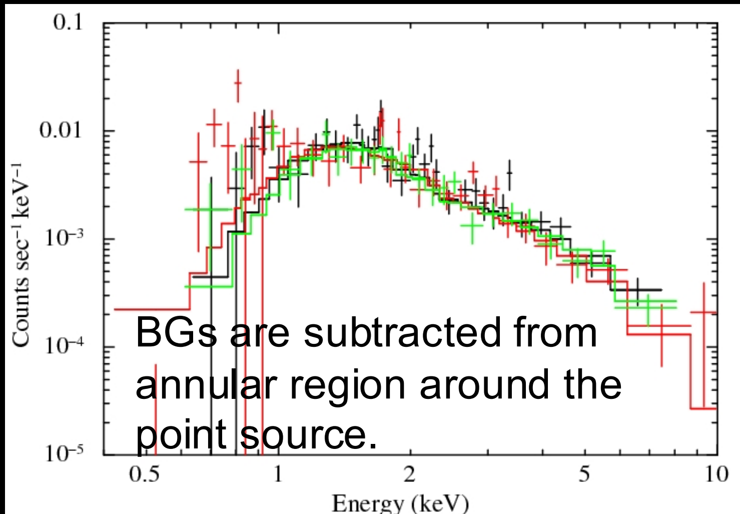
Consistent with the CXB.

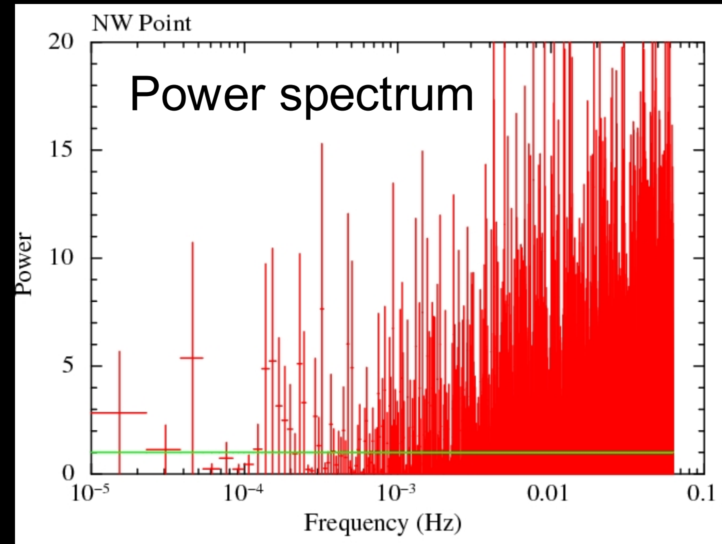






Point Source 1 (NW)





NH: ~0.75×10^{22} cm^{-2}

Γ: ~2.4

Observed Flux: 3.4×10^{-13} erg cm^{-2} sec^{-1}

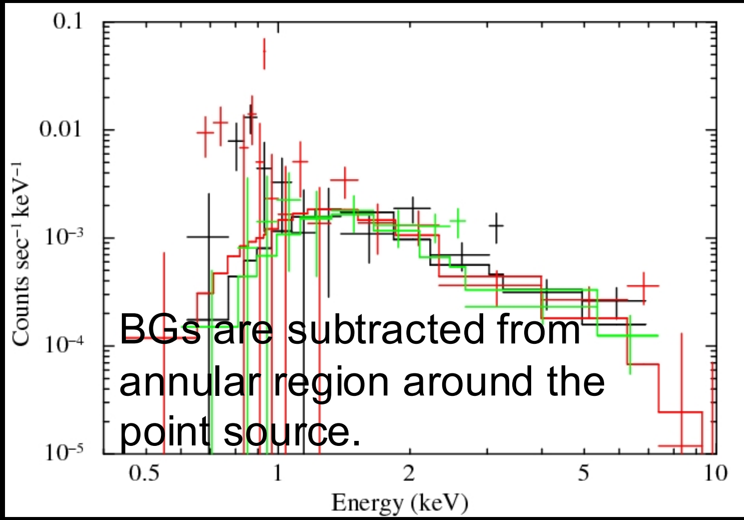
Luminosity: 7.0×10^{31} erg sec^{-1} at a distance of 1.3 kpc

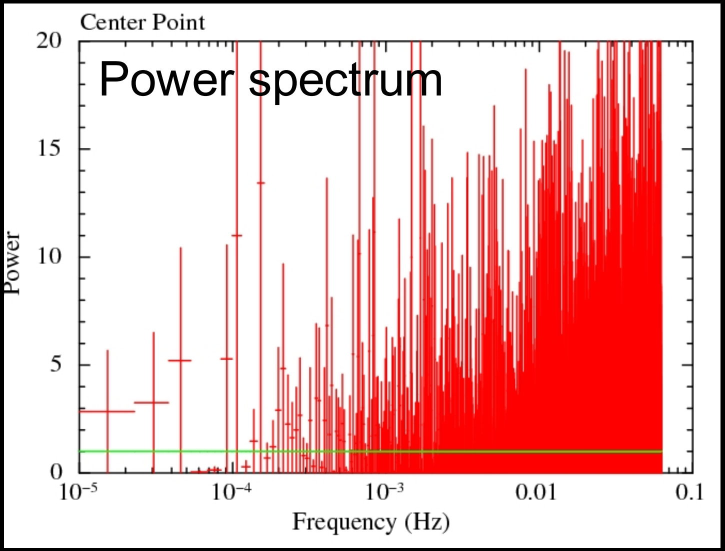
TABLE 1. List of the seven "confirmed" CCOs and of their basic X-ray properties. Flux is in the 0.5-8 keV energy range; the bolometric luminosity is computed for a purely thermal model (either single or double blackbody). The possible variability reported for the CCO in Cas A refers to indirect evidence for a large flare occurred around A.D. 1953. See text for details and references.

SNR	Age (ky)	Distance (kpc)	Observed flux 10^{-12} erg cm^{-2} s^{-1}	Luminosity 10^{33} erg s^{-1}	Variability	Period	Pulsed fraction
RCW103	2	3.3	0.8-60	1.1-80	factor 100	6.67 hour	12-50%
G296.5+10.0	7	2.2	2.	1.2	$< 5\%$	424 ms	$\sim 10\%$
Kes 79	7	7.1	0.2	3	$< 15\%$	105 ms	$\sim 80\%$
Cas A	0.3	3.4	2.	2	Flares?	...	$< 13\%$
Puppis A	3.7	2.2	4.8	5	$< 5\%$	...	5%? ($< 7\%$)
G347.3-0.5	2	1.3	3.	0.6	$< 5\%$	...	$< 7\%$
VelaJr.	1	1	1.3	0.25	$< 5\%$	...	$< 7\%$

De Luca (2008)

Point Source 2 (Center)





NH: fixed at 0.5×10^{22} cm^{-2}

Γ: ~2.0

Observed Flux: 3.4×10^{-13} erg cm^{-2} sec^{-1}

Luminosity: 1.9×10^{31} erg sec^{-1} at a distance of 1.3 kpc

EM profile: Comparison with Sedov Model