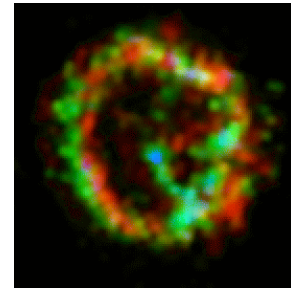
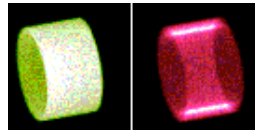


SNR E0102: Measured Velocities and Geometric Musings

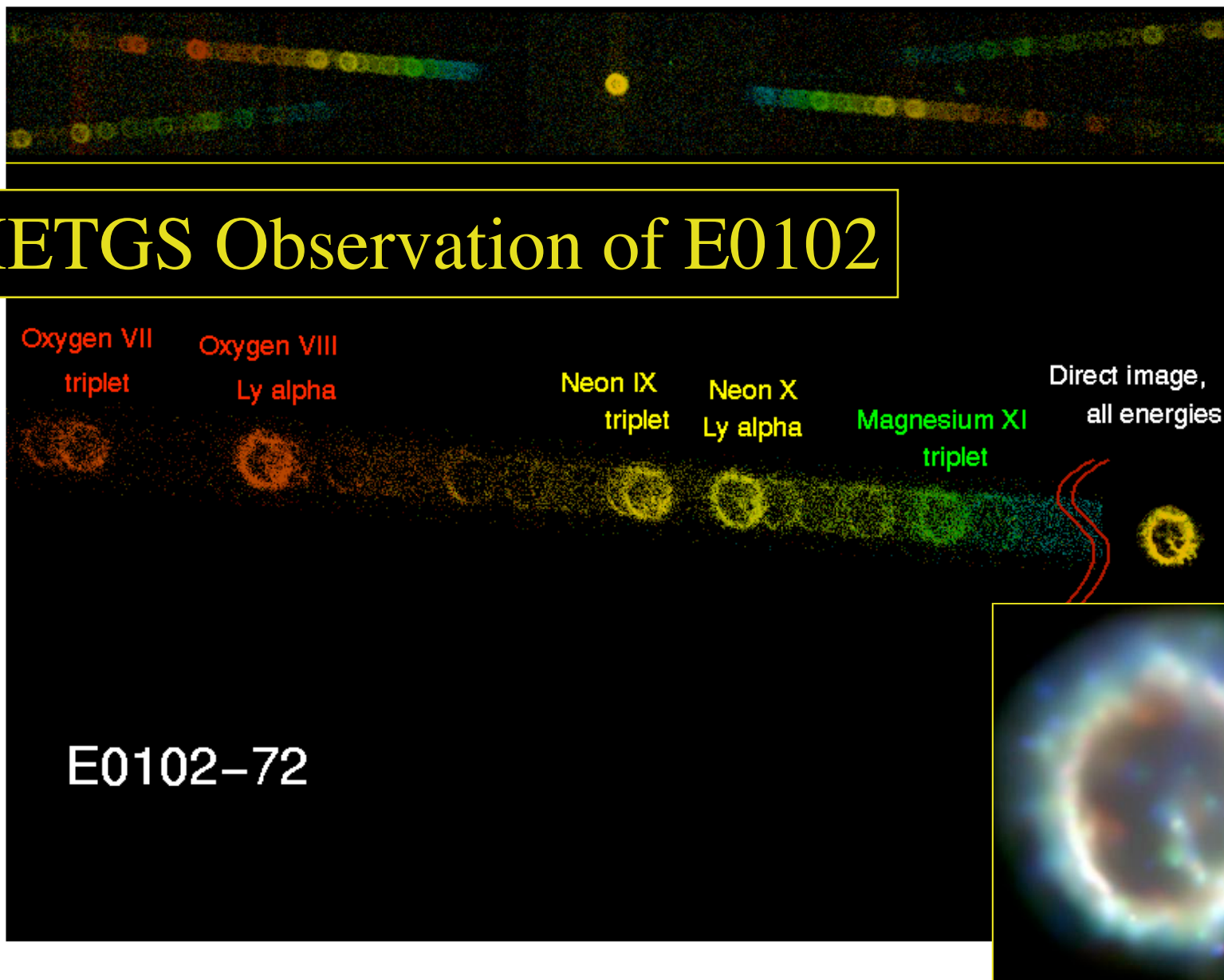
by Dan Dewey, MIT

- ❑ Extraction of spatial-velocity information from HETGS observation

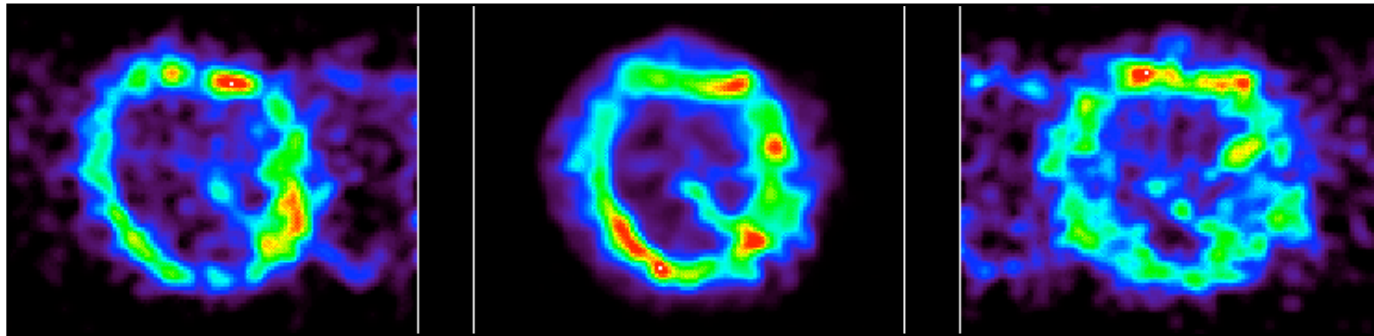


- ❑ 3-D modeling of E0102 Ne X emission
- ❑ Are SNRs Optically thin? Everywhere?

HETGS Observation of E0102



Ne X line images

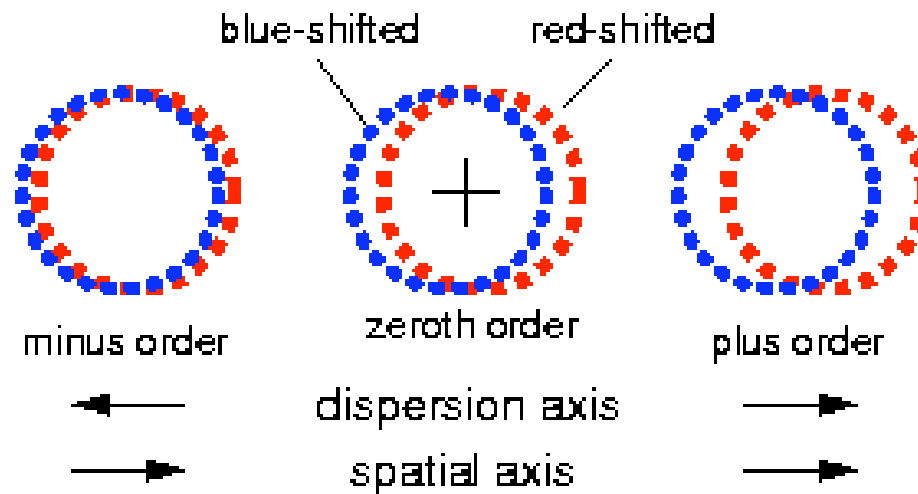


Minus order

Zeroth-order

Plus order

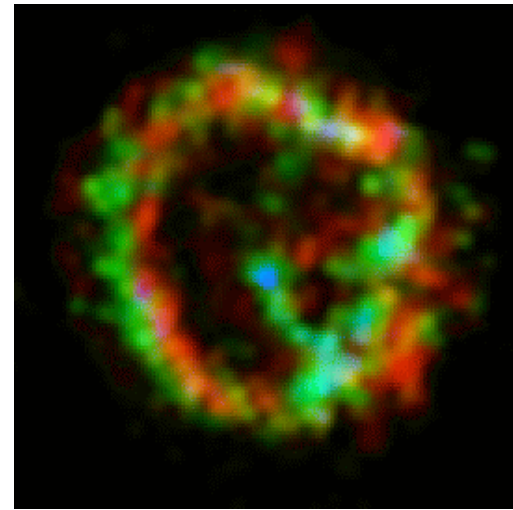
- Usefulness of plus, minus, and zeroth order data
- Asymmetry in Ne X image: simple explanation:



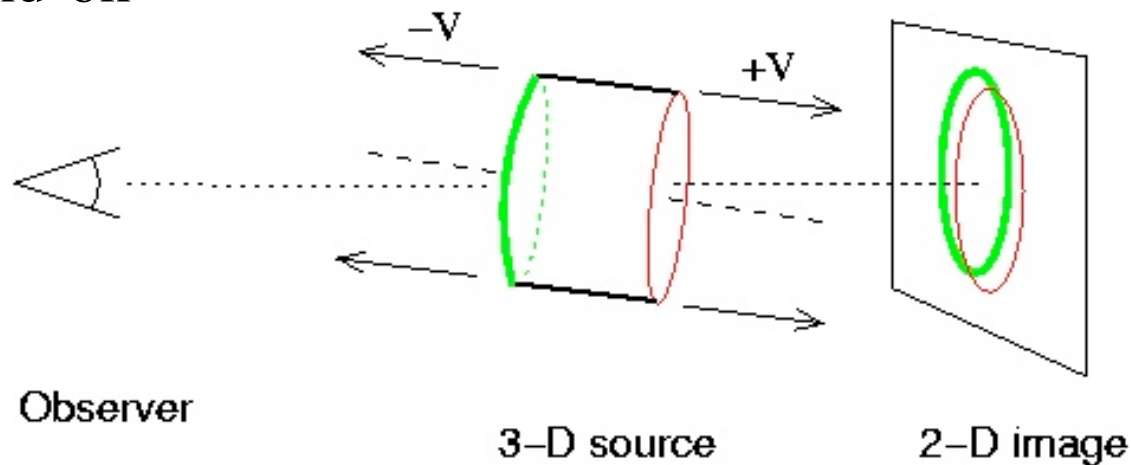
Color-velocity image results

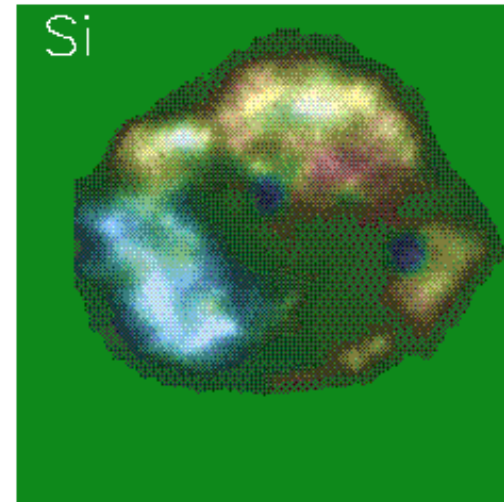
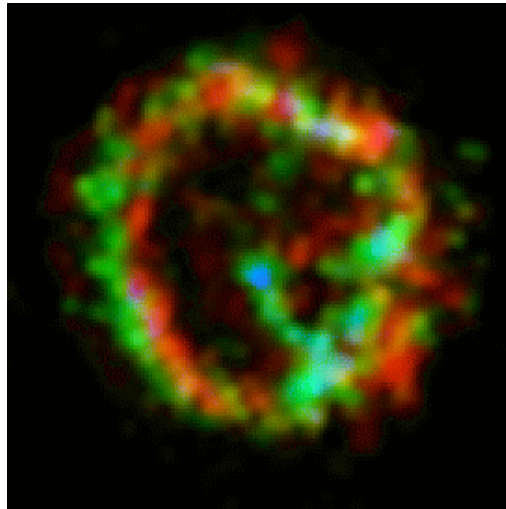
Regions of red and blue shift appear as displaced rings.

- Red: 900 and 1800 km/s
- Green: -900 km/s
- Blue: -1800 km/s

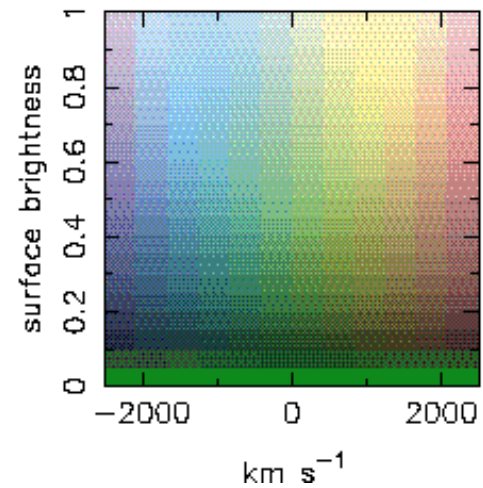


- Interpretation as cylinder viewed almost end-on



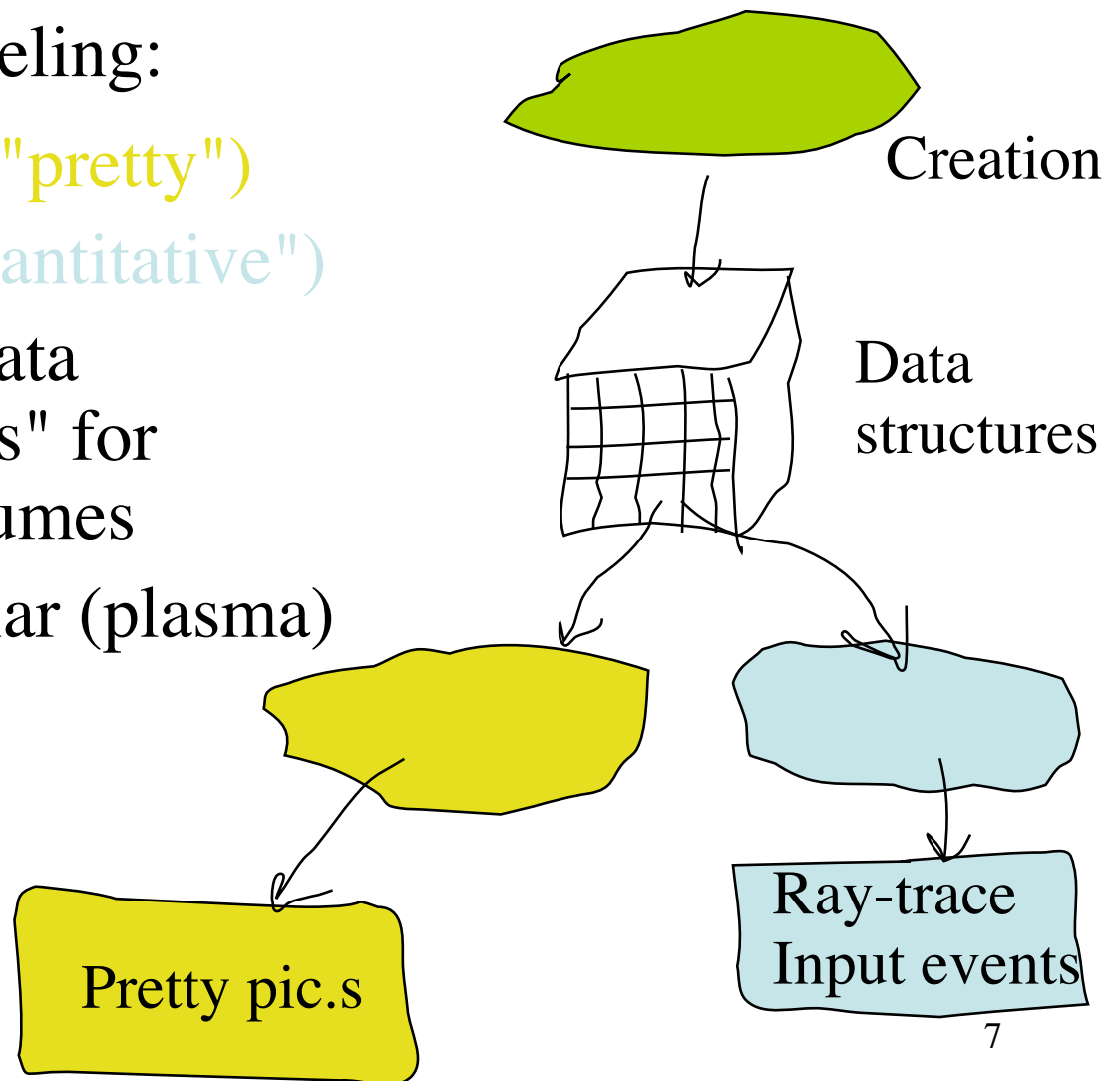


- Contrast the E0102 velocities distribution with Cas A velocities (Willingale 2002, Figure 7)
- Cas A is an inclined ring with red and blue shifted emission generally segregated.



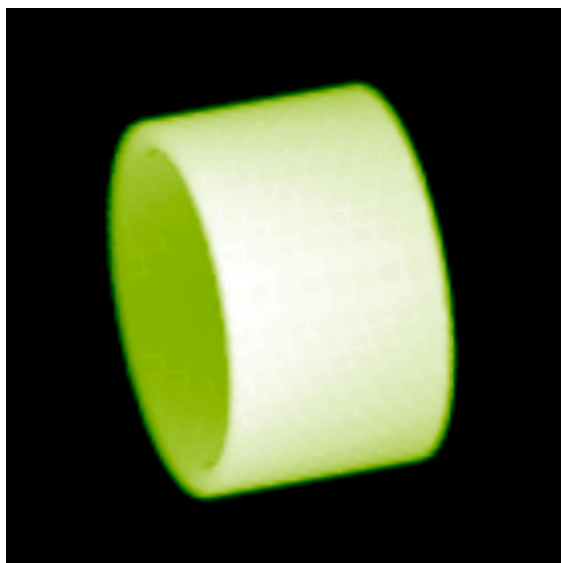
3-D Modeling & Ne X distribution

- Purposes for modeling:
 - Visualization ("pretty")
 - Modeling ("quantitative")
- Building model data structures, "voxels" for optically thin volumes
- 3-D arrays of scalar (plasma) parameters...



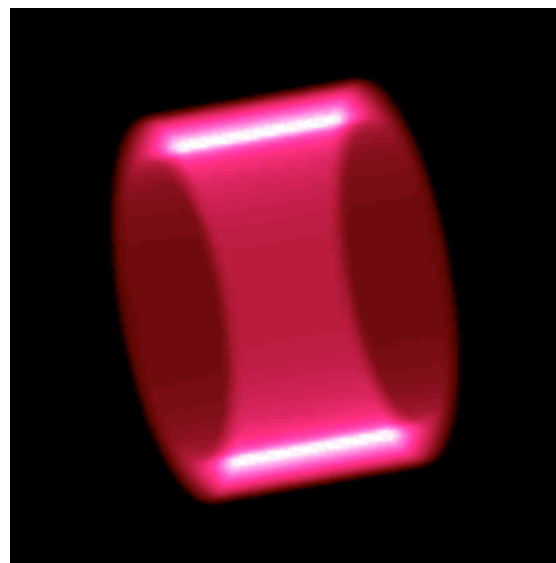
Visualizing E0102 cylinder model

- IDL project_vol.pro used here.
- Optically thick and thin views of the cylinder intensity array.



Optically thick view

- Maximum value along a ray is used.
- The material has an opacity.
- Depth cuing darkens distant points.

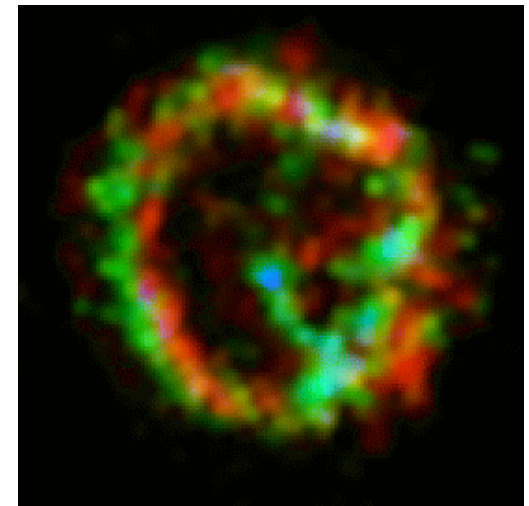
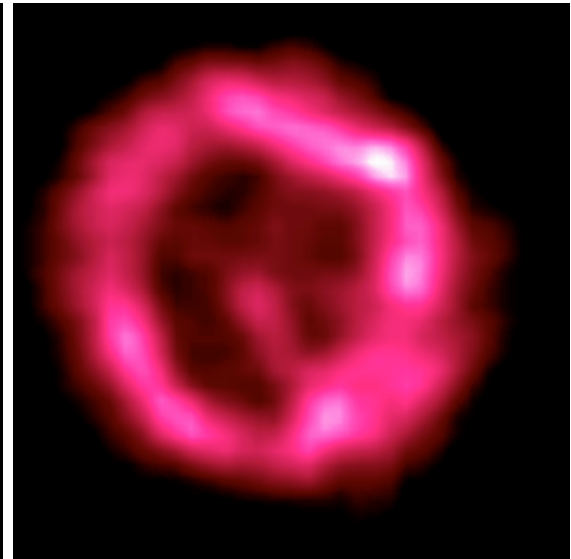


Optically thin view

- Sum of values along a ray is used.
- The material has NO opacity.
- No change in intensity with distance.

Model of E0102 nominal viewing angle

E0102 Ne X image



Middle of ring left out

Projection with middle left out - mimics the intensity distribution from the high-V planes.

Are SNRs Optically thin? Everywhere?

- E0102 Ne optically thin?
 - Assuming 1 M_{solar} of Ne in the cylinder volume get $n_{\text{Ne}} \sim 0.02/\text{cm}^3$. Times length of cylinder, $1.6e+19$ cm, gives n_{H} equiv for the Ne of $\sim 0.3e+22 / \text{cm}^2$: varabs shows 90% transmission above Ne edge - Yes, it's THIN!
- Other [O-rich] SNR? (Cas A, N132D, G292,...)
 - G292.0+1.8: metal rich knots: $1e+17$ cm, $n \sim 10\text{-}1000/\text{cm}^3$ (Parviz Ghavamian, CfA talk)
 - $1e+18$ ions/ cm^2 is amount in "solar" N_{H} of $10^{21}(\text{O})$ to $3 \times 10^{22}(\text{Si})$
 - O edge transmission = 60% for $N_{\text{H}} = 1e+21$
 - Si edge transmission = 85% for $N_{\text{H}} = 3e+22$

Comments

- E0102 Ne X (12A, 1keV) result made possible by:
 - spatial resolution at scale of few arc seconds
 - Sensitive to $V \sim 900$ km/s FWHM ($E/dE > 300$)
 - Second E0102 observation at 90 deg. Roll will improve Ne X; do Ne IX also; similar analysis for O VIII
- 3-D useful for Visualization and Astrophysics
 - Move beyond "uniform volume" models for SNR (and other objects!)
- Are SNRs optically thin?
 - Metal-rich features/knots may be quasi-thin...
 - Is there a way to make quantitative measures to confirm optically thin based on the images themselves?