

VELOCITIES AND 3D STRUCTURE OF SNRS **CAS A** AND **SN 1987A**

DAN DEWEY (MIT KAVLI INSTITUTE)
W/ C.R. CANIZARES (GTO) AND COLLABORATORS

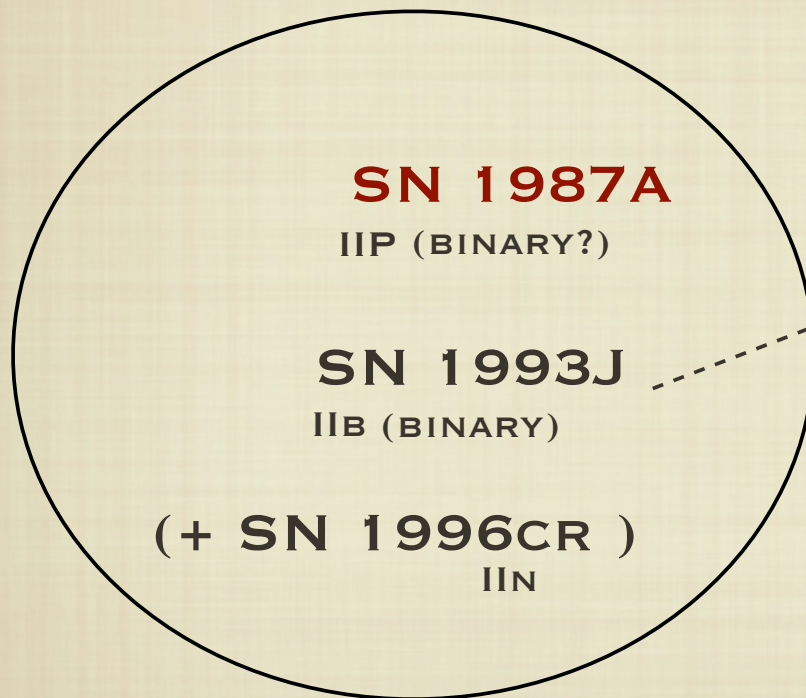
MSSL WORKSHOP No.3 ON
HIGH RESOLUTION X-RAY SPECTROSCOPY
20 MARCH 2009

CORE-COLLAPSE

SNE AND SNRS

X-RAY SNE*

IC, II, IIB, IIN, IIP, IIL



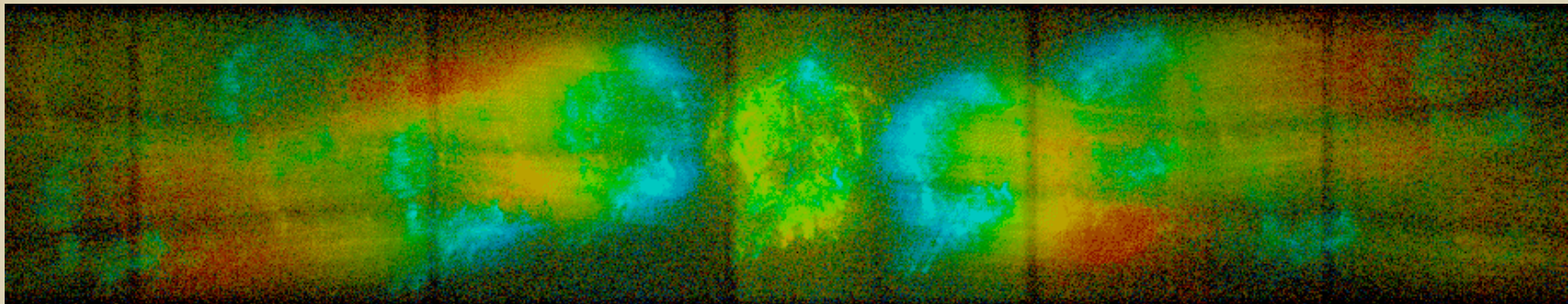
O-RICH SNRS

METAL-RICH, RADIATIVE



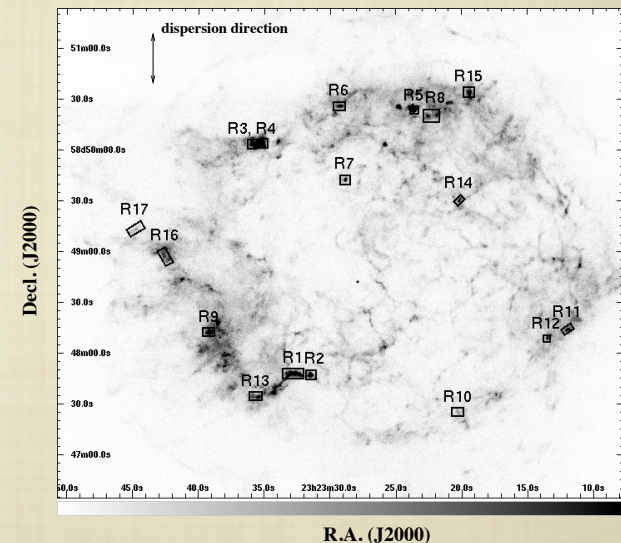
[*] IMMLER & LEWIN '02

CAS A WITH THE HETG

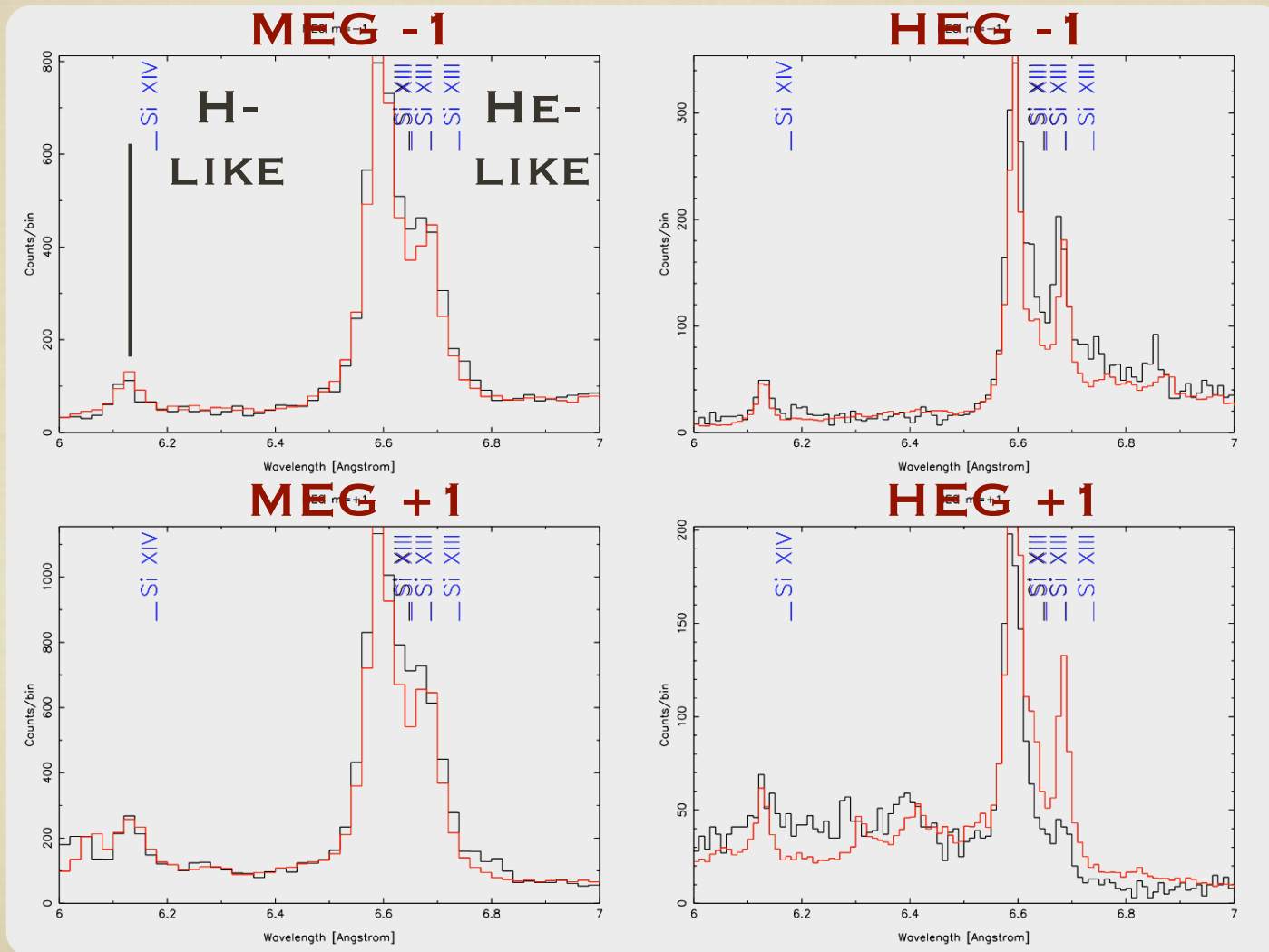


0.5 TO 2.3 KEV (DEWEY+ 2007)

- LAZENDIC+ (2006)
- 17 BRIGHT Si KNOTS/FEATURES
- MEASURE DOPPLER SHIFTS
 - -2500 TO +4000 KM/S
- Si LINE RATIOS TOO

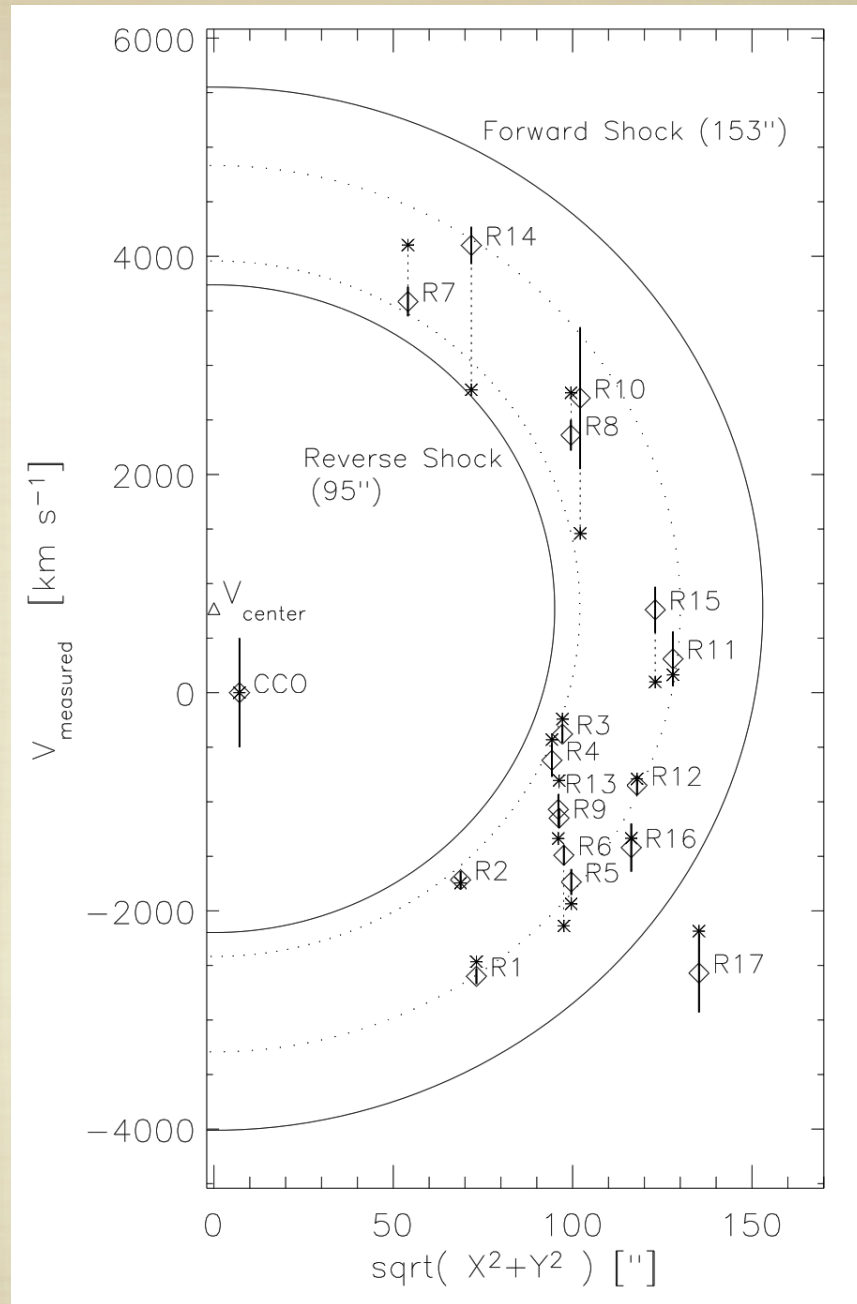


CAS A Si LINES

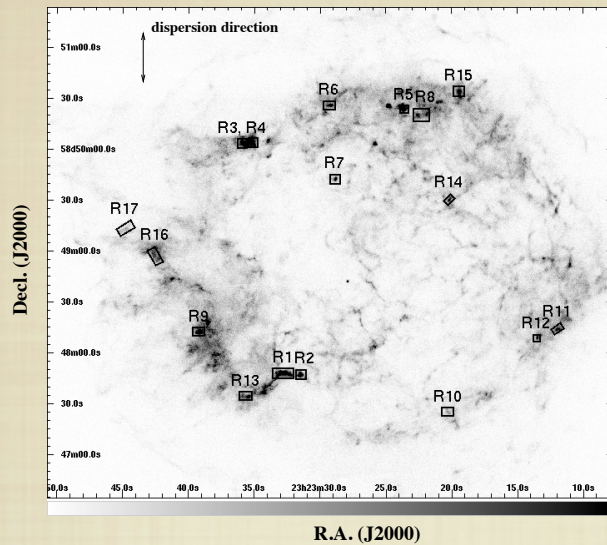


CAS A: V TO Z

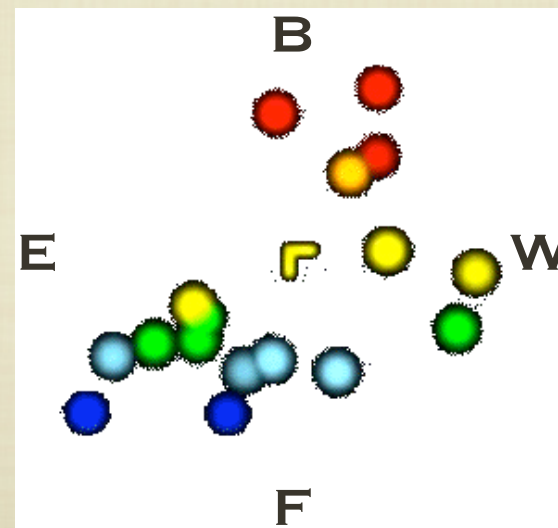
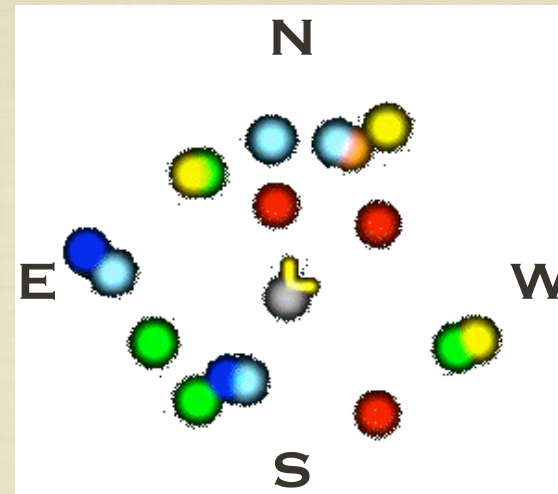
- PLOT L.O.S. VELOCITY VS 2-D RADIUS FROM EXPANSION CENTER
- "HUBBLE-LIKE" EXPANSION
 - $|V| \sim R$
 - CIRCLES OF CONST V,R
 - 0".032 PER KM/S
- --> 0.19 %/YEAR
SAME AS FORWARD SHOCK (DELANEY+ 2004)
- So, ASSUME $Z \sim V_{\text{LOS}}$



CAS A KNOTS IN 3D

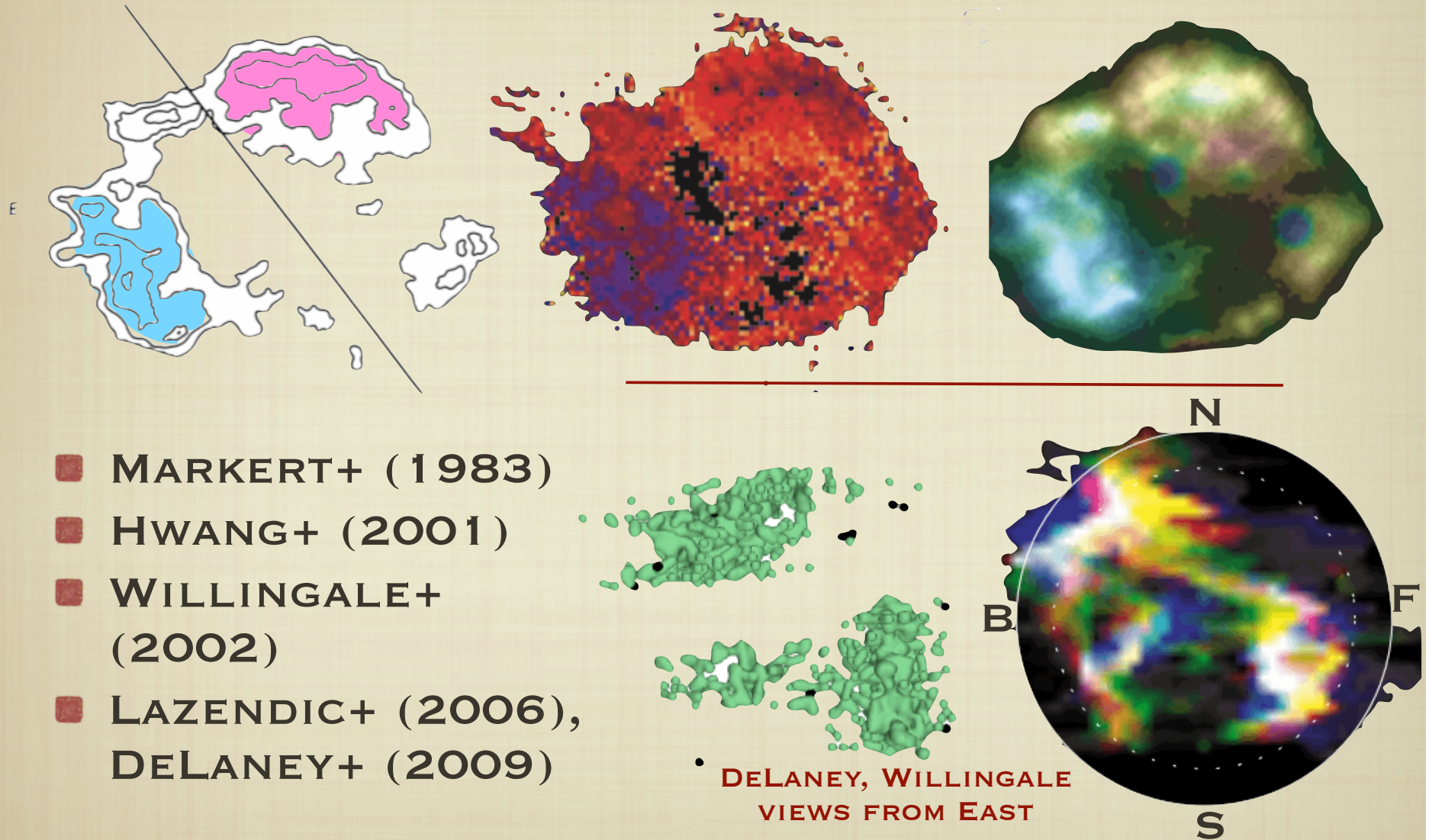


- USE Z TO LOCATE THE KNOTS/FEATURES IN 3D
- VIEW THE SNR FROM OTHER VANTAGE POINTS



A SUMMARY OF

CAS A X-RAY DOPPLER

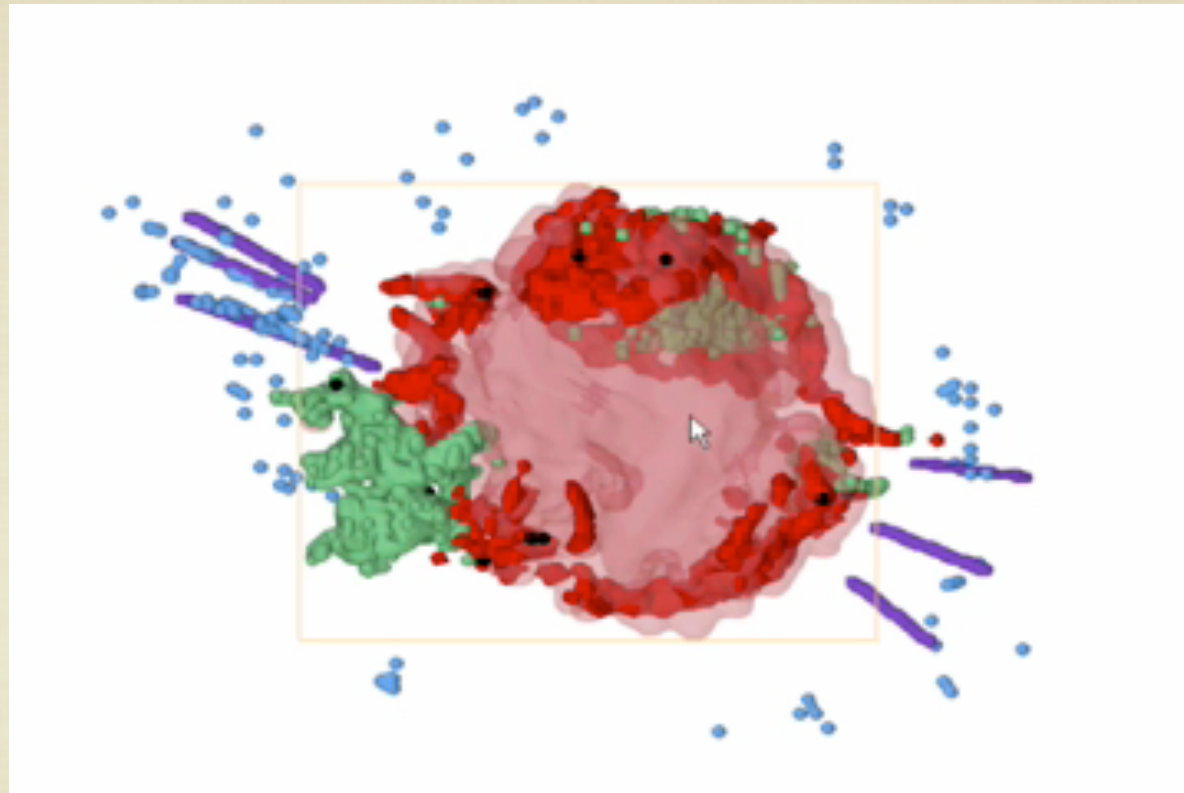


DELANEY'S 3-D CAS A !

2009

3D
PDF

HETG
HELPED:
SI RASINS
:-)

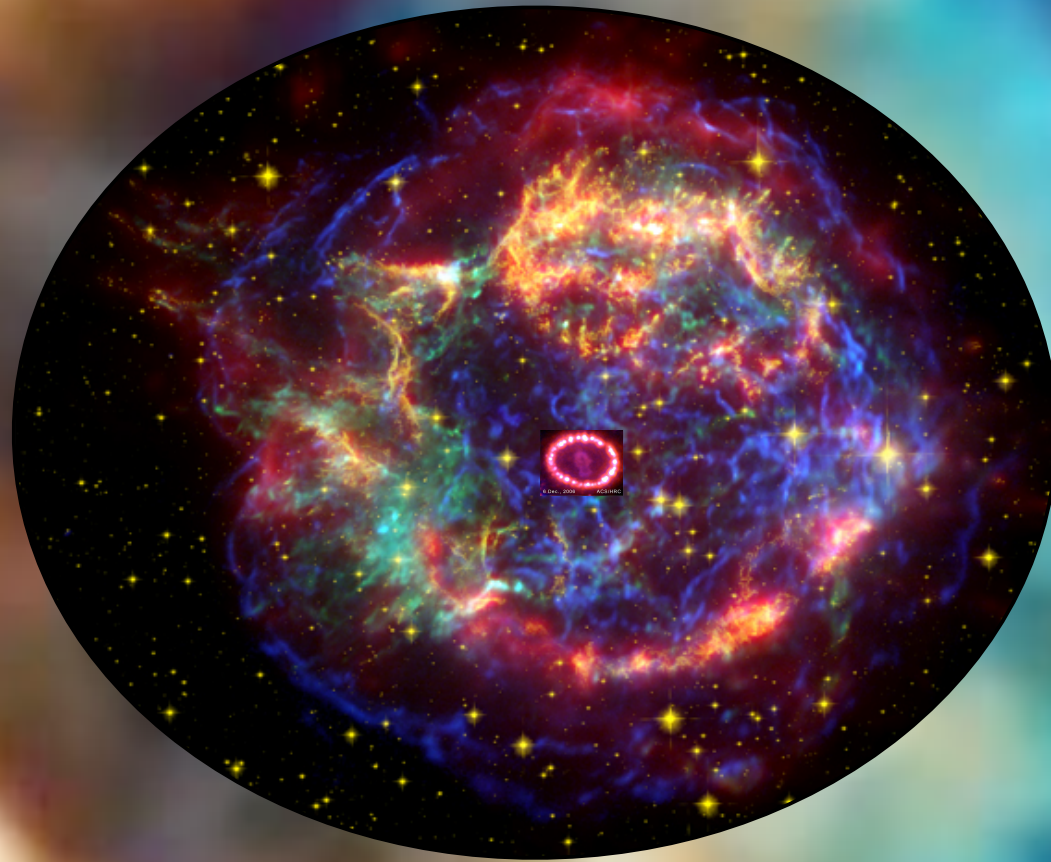


- SI XIII,XIV: HETG FE-K: CHANDRA 1 MS
 SI II, AR II: SPITZER IRS (LONG-SLIT SPECTRO'ER)

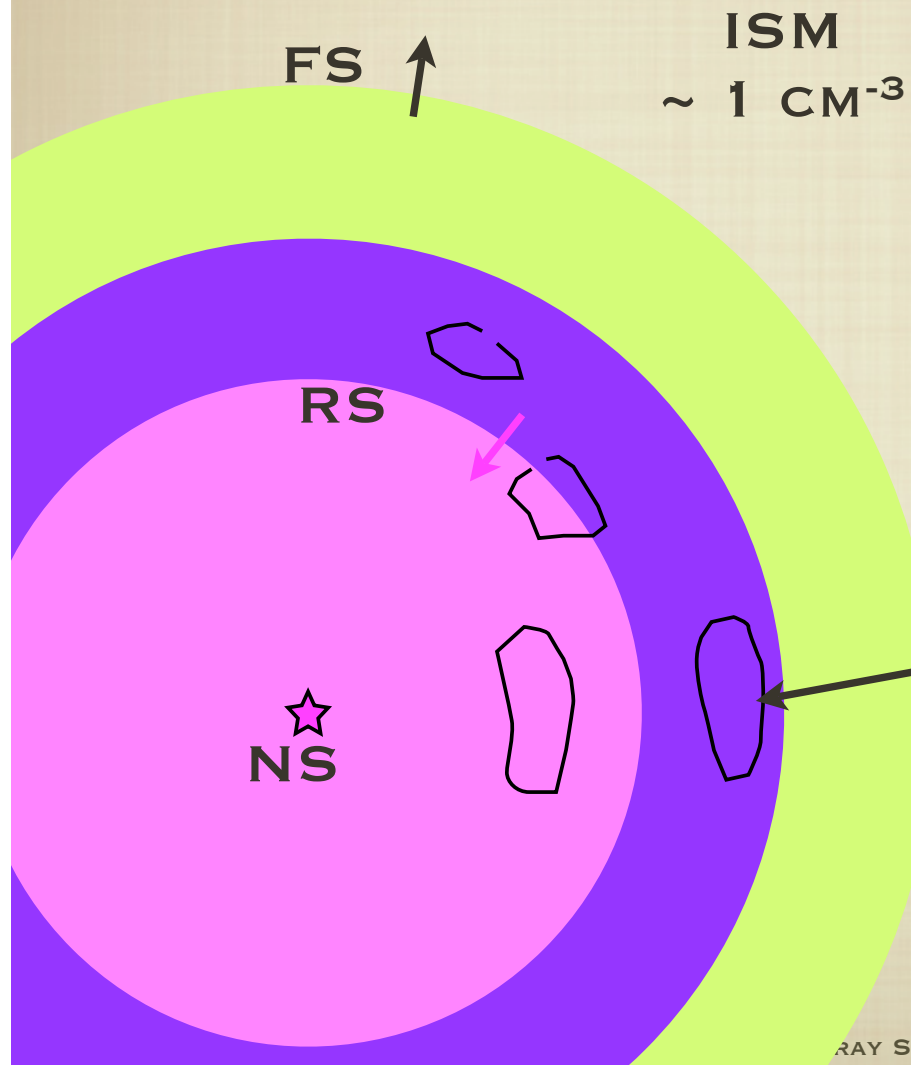
- [HTTP://CHANDRA.HARVARD.EDU/PHOTO/2009/CASA2/](http://chandra.harvard.edu/photo/2009/casa2/)

CAS A AND SN 1987A

- IMAGES ARE ON THE SAME LENGTH SCALE
- AND EO102 TOO



CARTOON OF CAS A

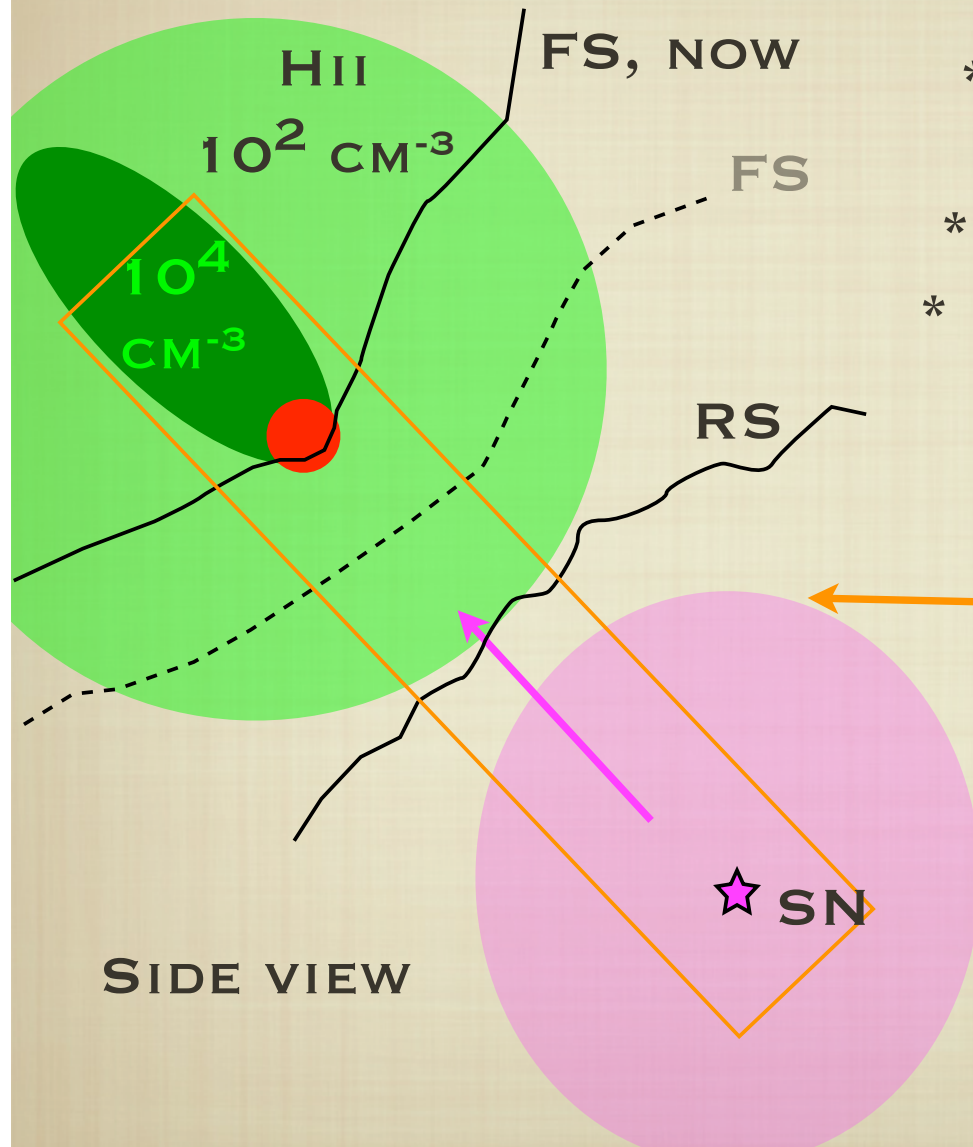


* FS AND RS
WELL DEVELOPED

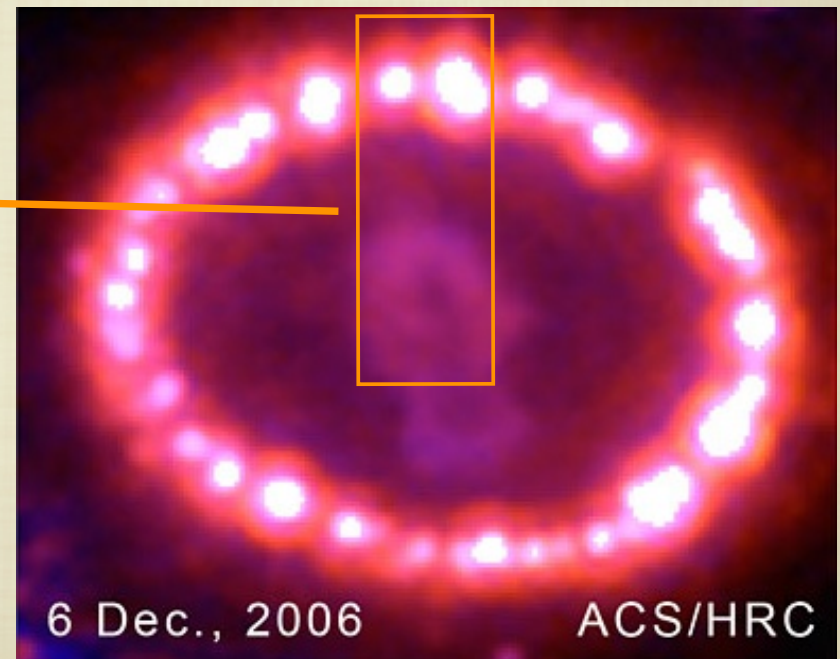
* FS MOVING INTO
RELATIVELY LOW
DENSITY MATERIAL

SHOCK-HEATED EJECTA
W/~ HOMOGENEOUS
SUB-REGIONS
E.G., O-RICH, SI-RICH,
FE-RICH

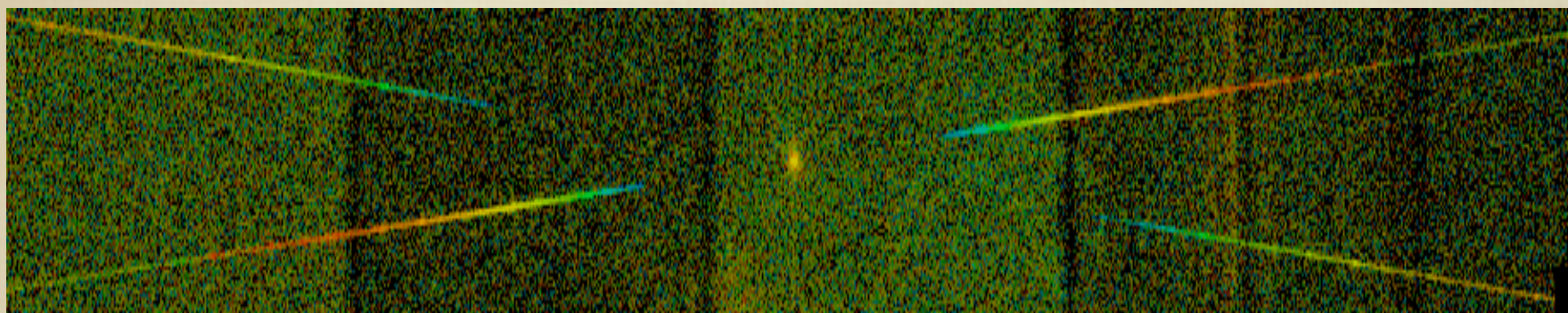
CARTOON OF '87A



- * BEGINNING TO INTERACT WITH THE DENSE ER
- * X-RAY EMISSION FROM FS
- * NO/FEW X-RAYS FROM RS ?



'87A WITH HETG, 360KS



2 keV

1 keV

0.65 keV

MEG minus

plus

HEG minus

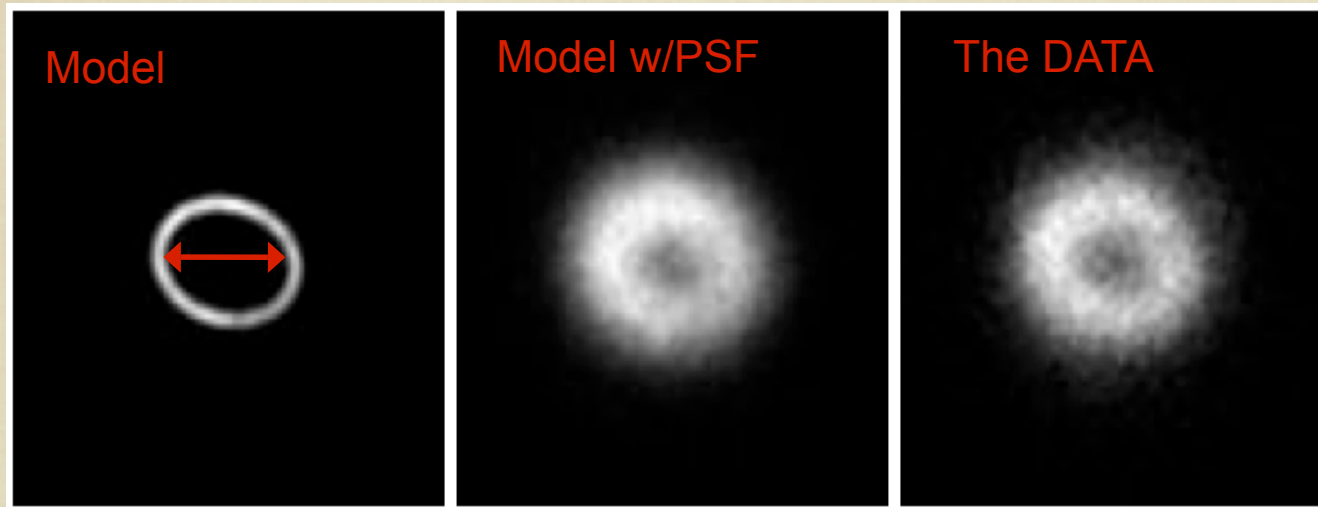
plus

2 Å

12 Å

20 Å

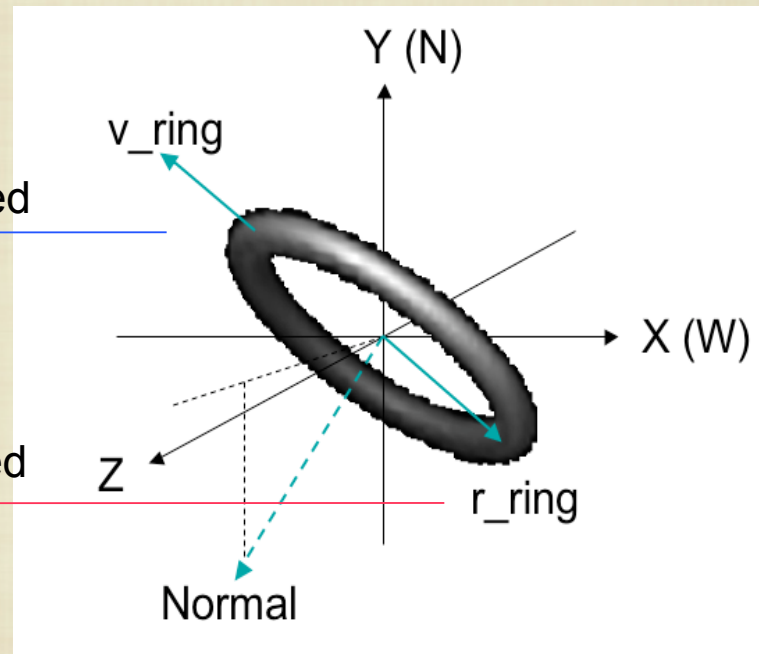
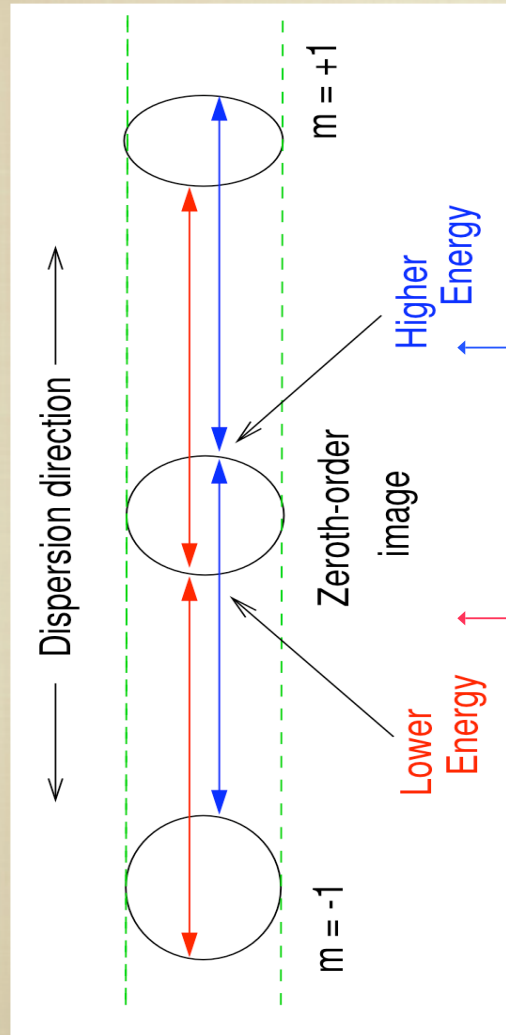
'87A IS RESOLVED



- RING DIAMETER $\sim 1.7''$
- ACIS MONITORING PROGRAM: BURROWS(PI)
 - PARK ET AL. 200X PAPERS
- --> SPATIAL - SPECTRAL[DOPPLER] EFFECTS

EFFECT OF RING VEL'ITY

From the Chandra POG



Blue shifted

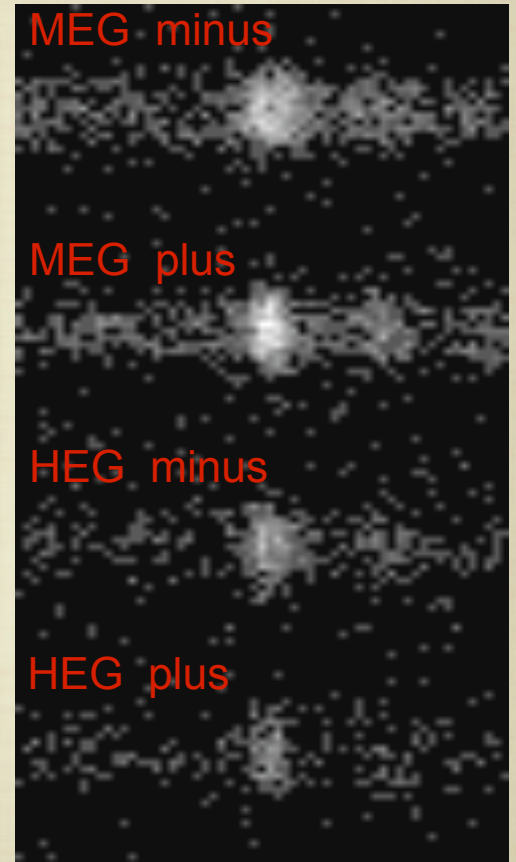
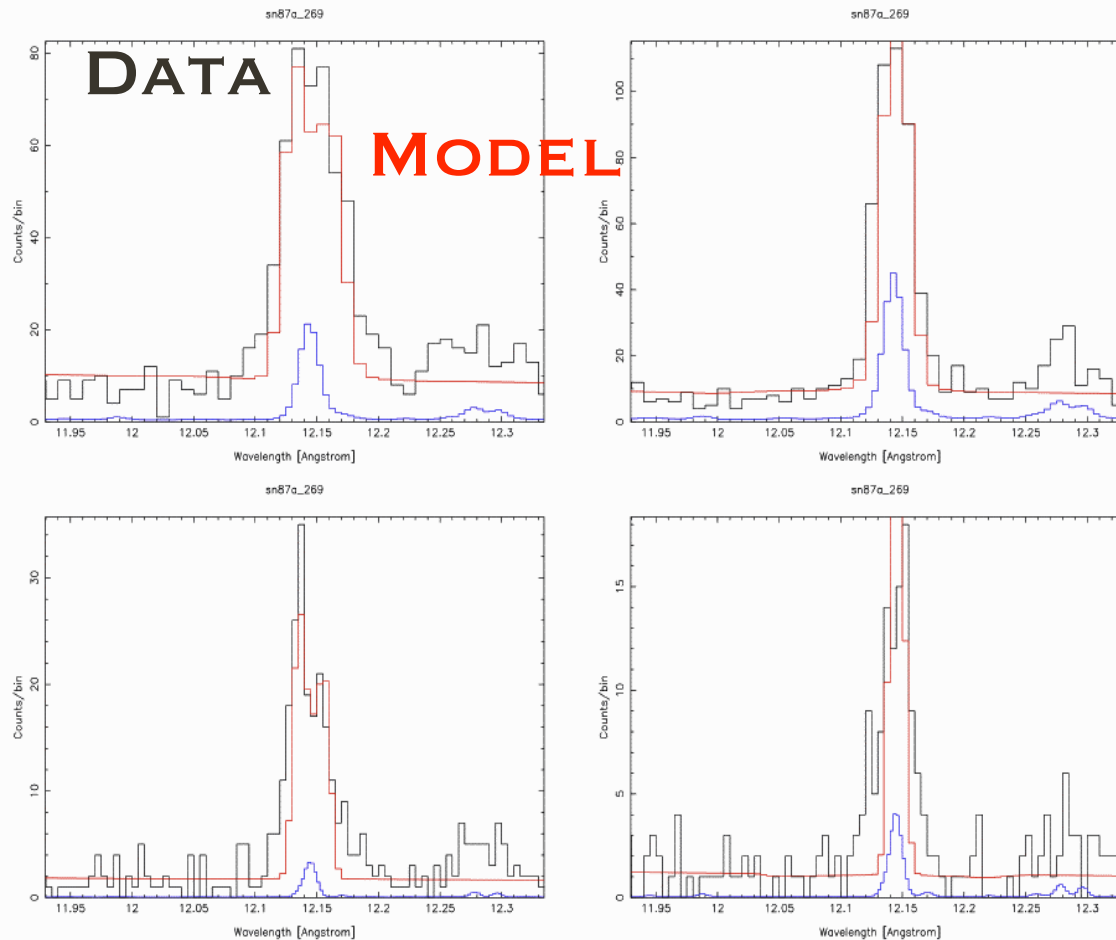
Red shifted

A GOOD IDEA:

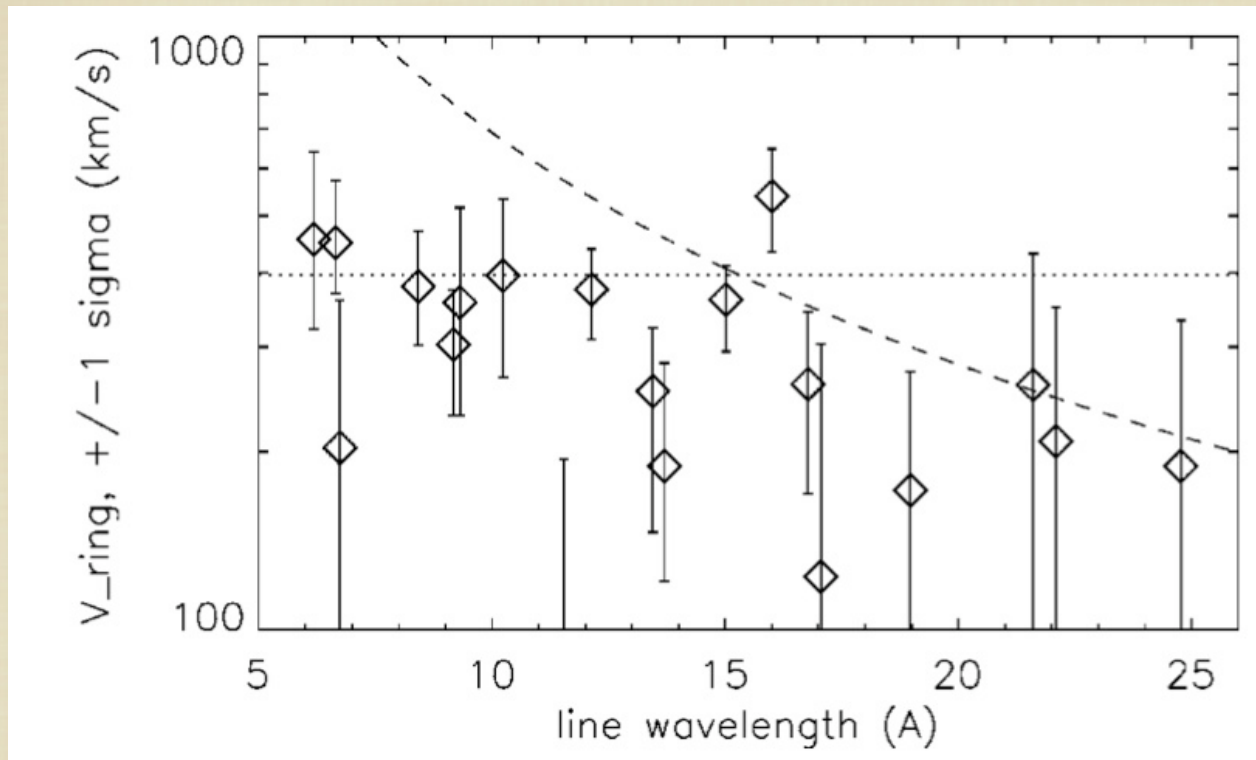
*** ZHEKOV ET AL. 2005**

LINE SHAPES IN HETG

NE X LINE



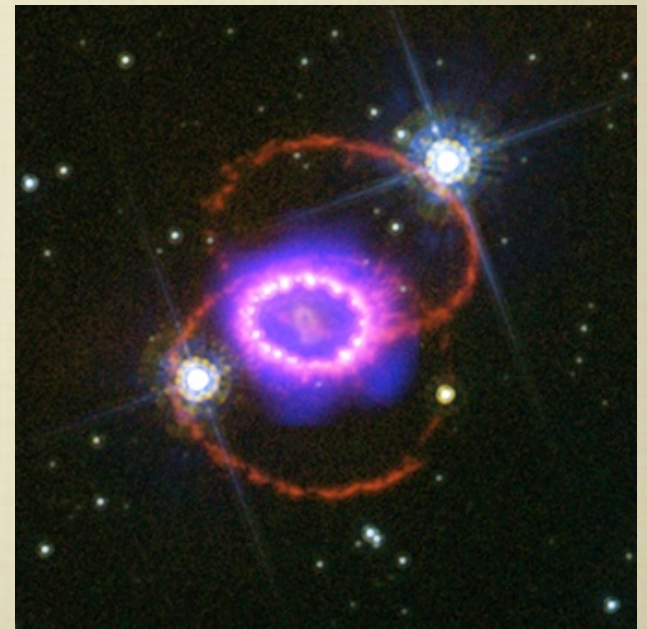
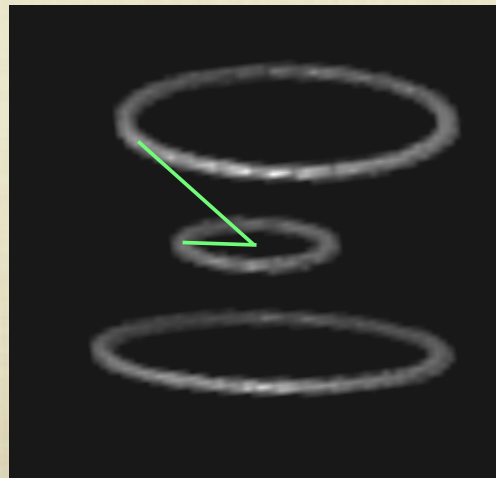
'87A: MEASURE V_RING



- $V_{\text{RING}} \sim 200 \text{ --- } 500 \text{ km/s}$, **DEWEY+ 2008**
- CONFIRMS RING EXPANSION FROM SHOCK
- VELOCITIES ARE SOMEWHAT LOWER THAN SIMPLE SHOCK EQUATION GIVES FROM THE TEMPS.

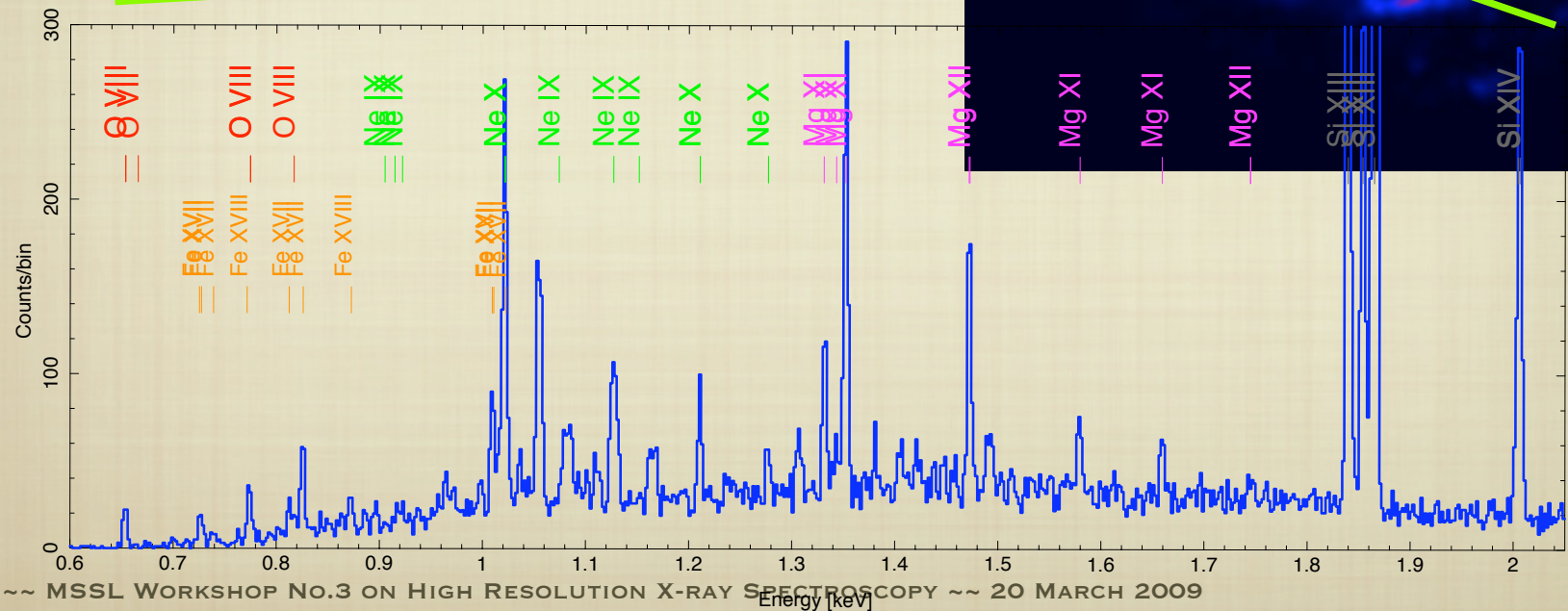
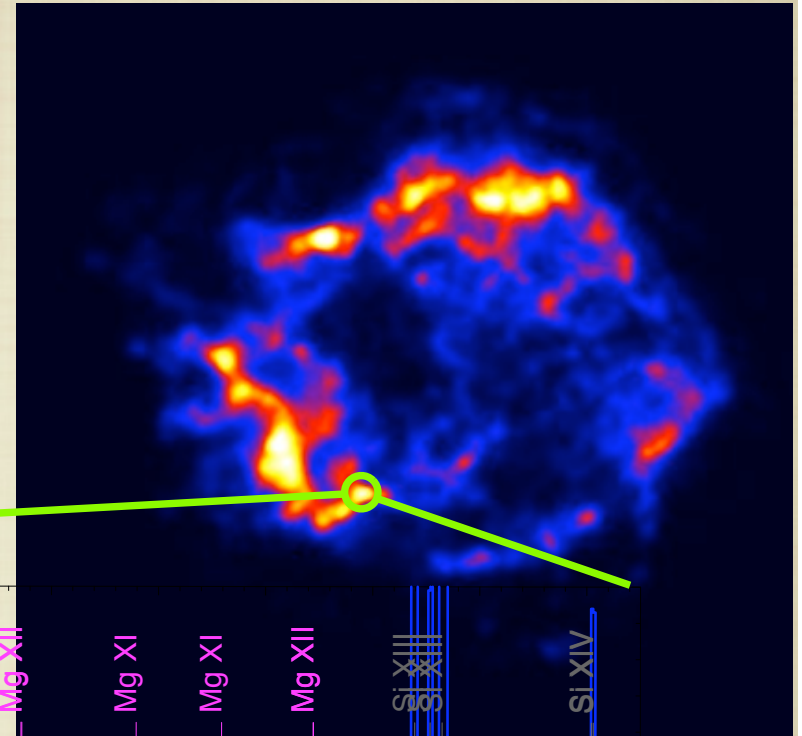
'87A: IT'S NOT OVER YET

- INTERACTION WITH THE EQUATORIAL RING IS CONTINUING.
- LIKELY GROWTH OF REVERSE SHOCK EMISSION.
- INTER-PROTRUSION EMISSION.
- INTERACTION WITH OTHER MASS/STRUCTURES, E.G., OUTER RINGS.
- TARGET FOR IXO



IXO ~ VIEW OF CASA

- HIGH-RES SPECTRUM OF EACH KNOT/FEATURE
- KINEMATICS OF MANY ELEMENTS: Si, Mg, Ne, Fe



■ THANK YOU