X-ray and Radio (and Optical) Observations of Cassiopeia A

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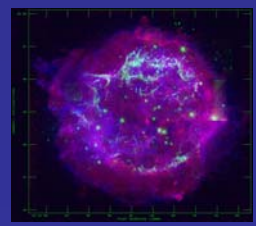
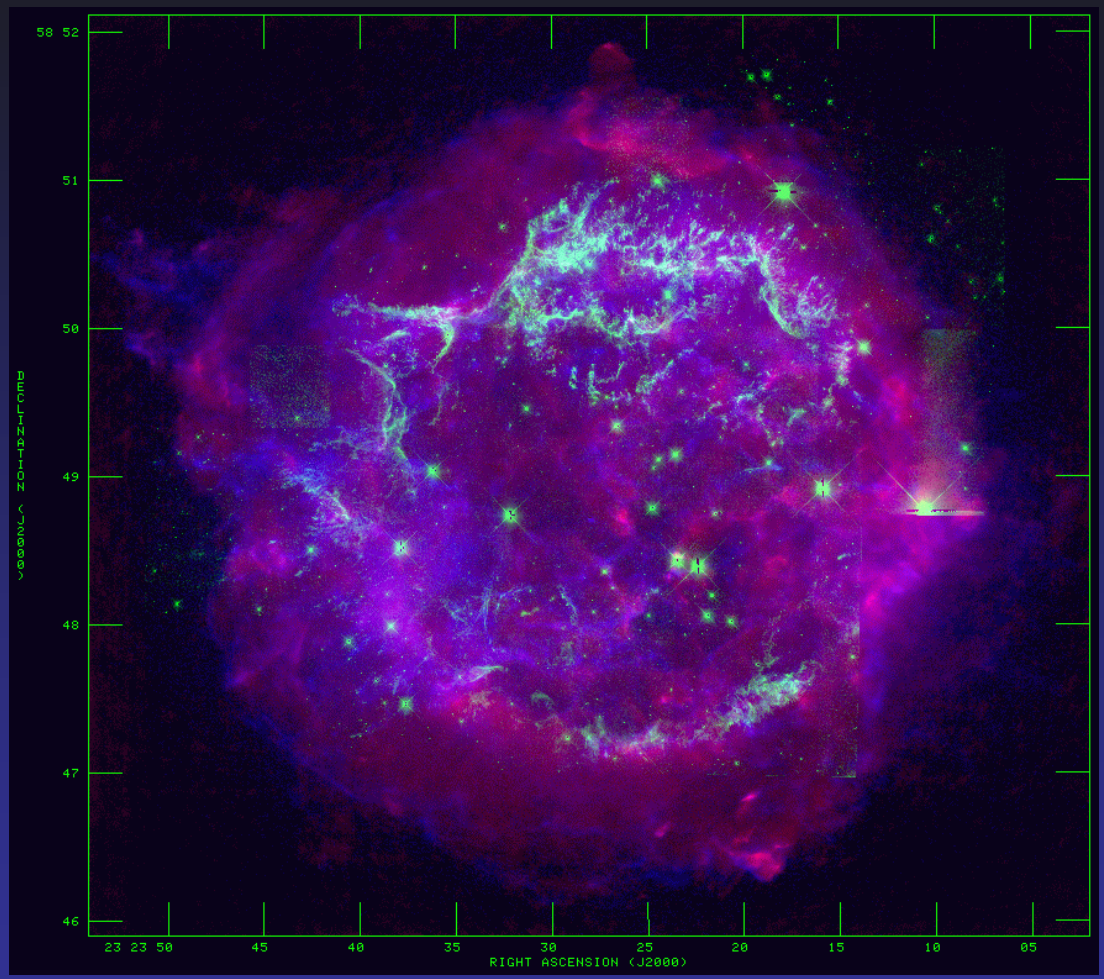


Composite X-ray, Optical & Radio Cas A Image



Red: VLA
Blue: Chandra
Green: HST

Type Ib or Type IIn SN

~20-25 M_{sun} progenitor

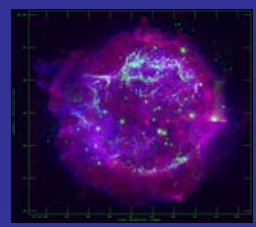
≈ 320 years old

M_{ej} ~ a few M_{sun}

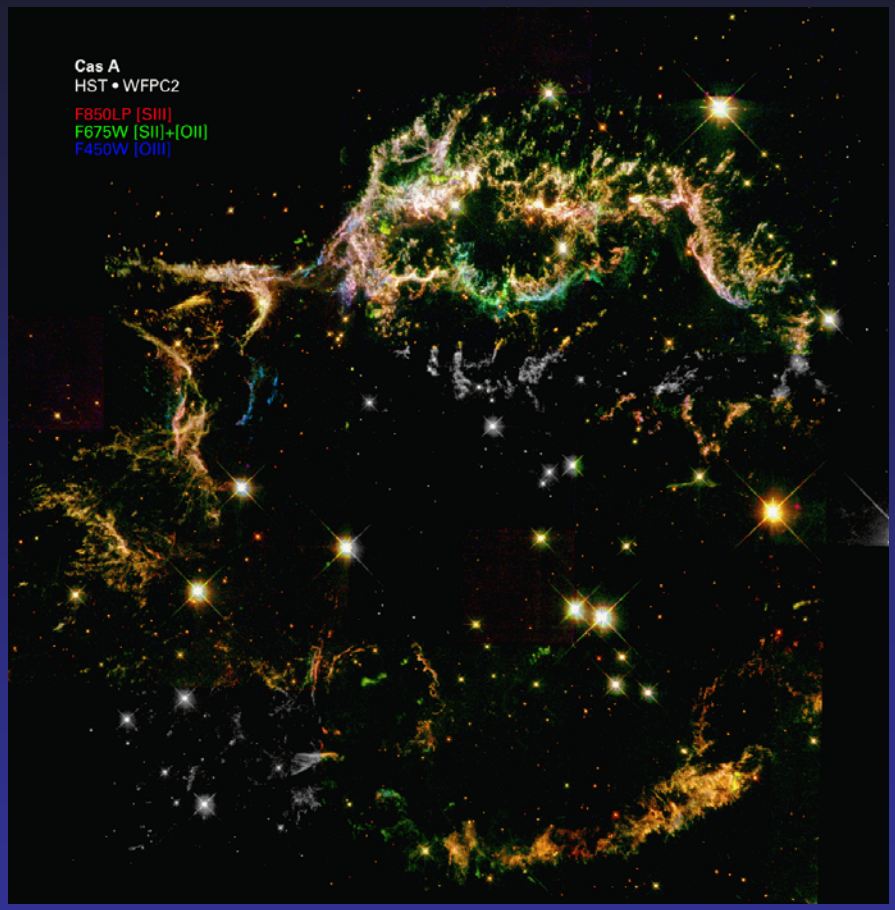
$M_{swept} \geq M_{ej}$

Moderately asymmetric explosion

Probably expanding into red giant wind



Optical



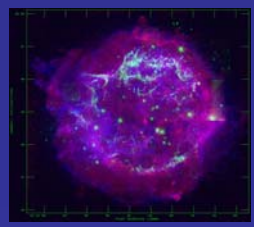
Dominated by fast-moving knots FMKs

reverse shock - ejecta

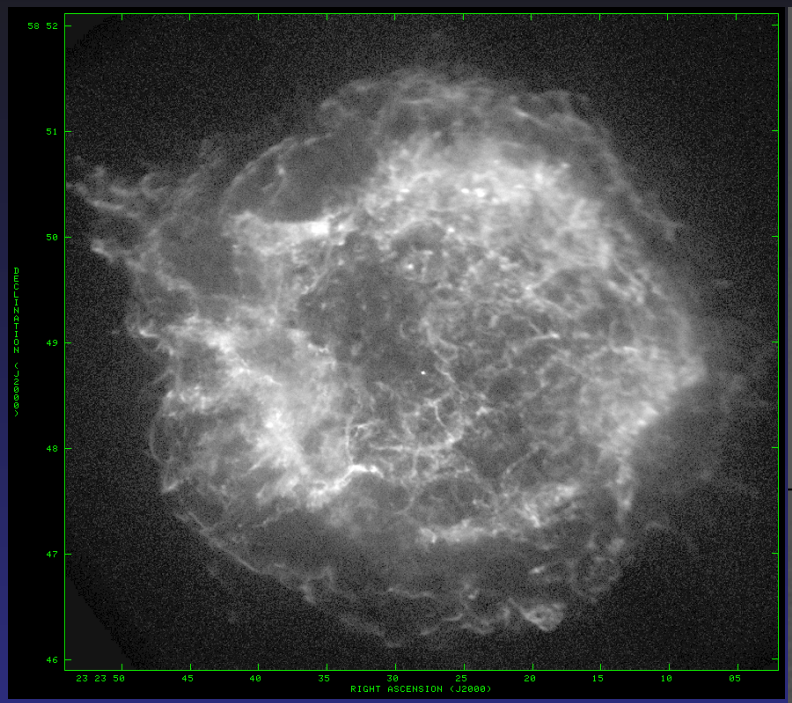
Also quasi-stationary flocculi QSFs

forward shock – CSM wind

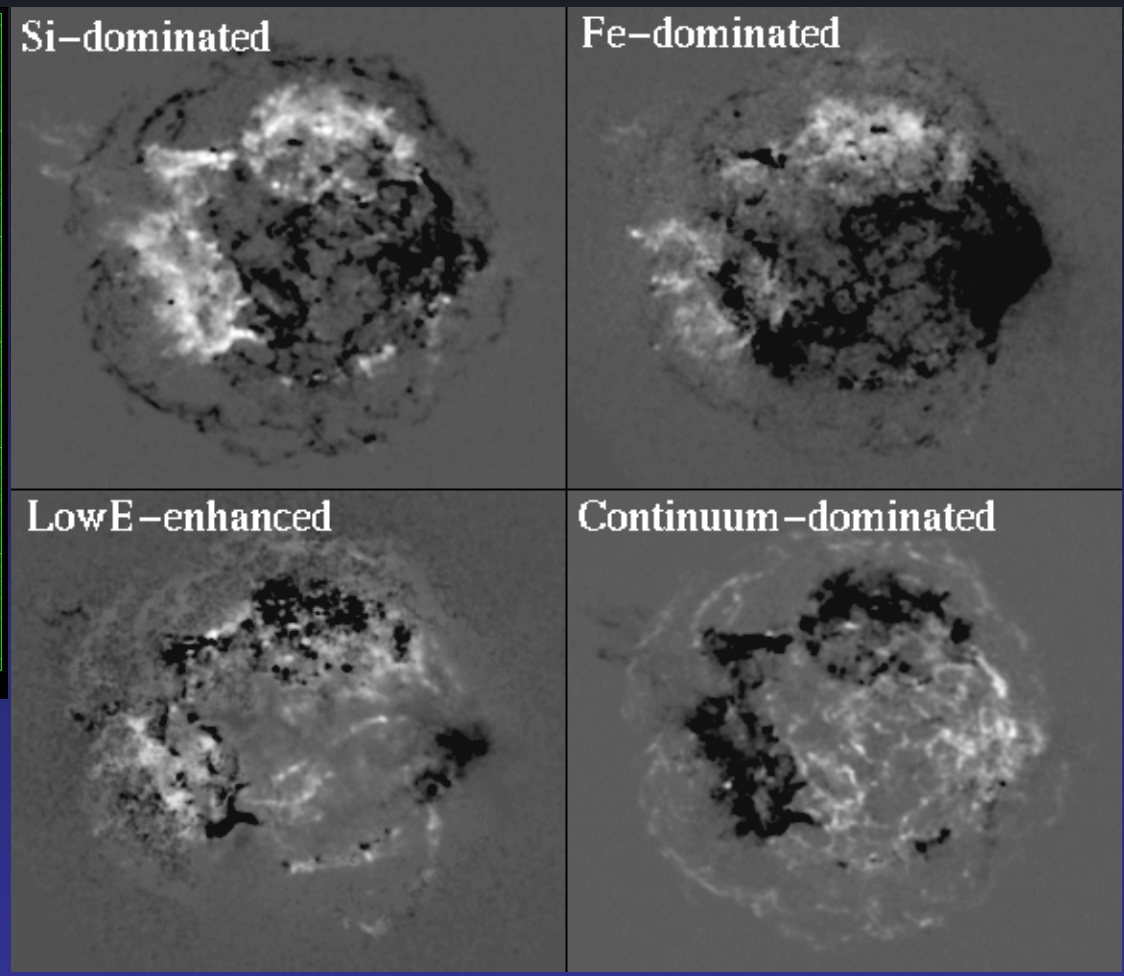
R. Fesen



X-ray



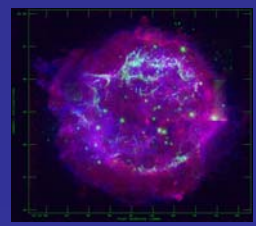
0.3-10 keV



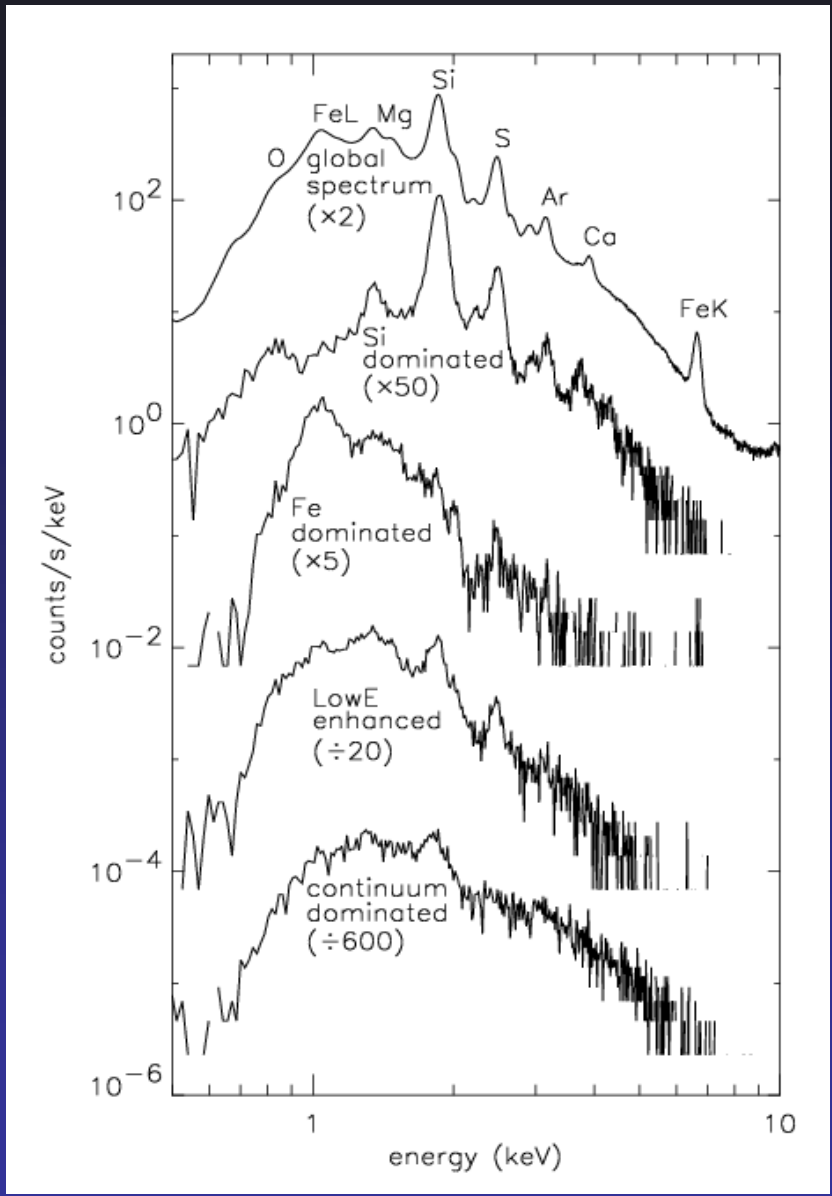
Dominated by enriched ejecta
Si-group, Fe – reverse shock

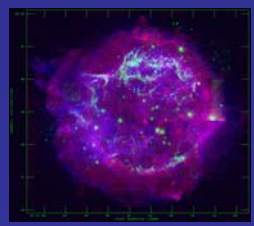
continuum-dominated – forward shock – diffuse CSM

low-energy enhanced – also forward shock – clumpy CSM



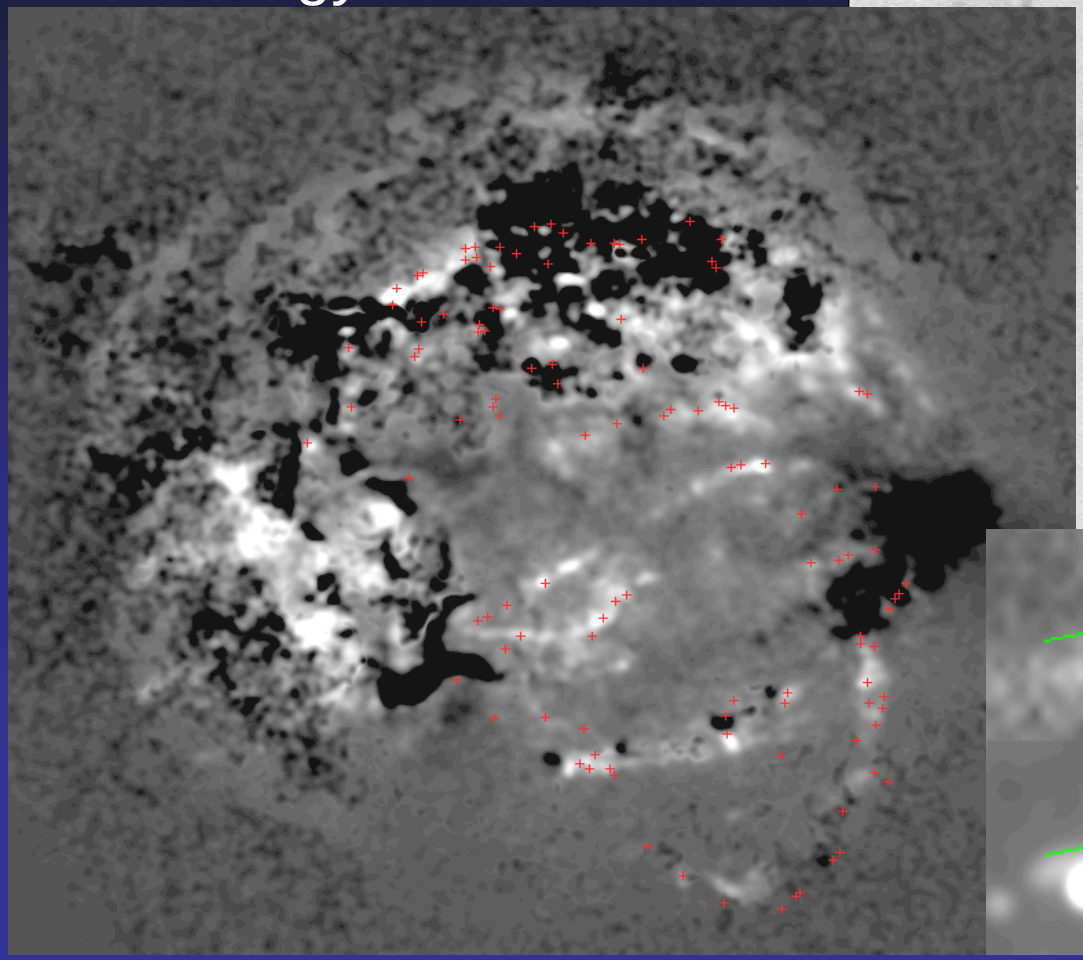
X-ray components

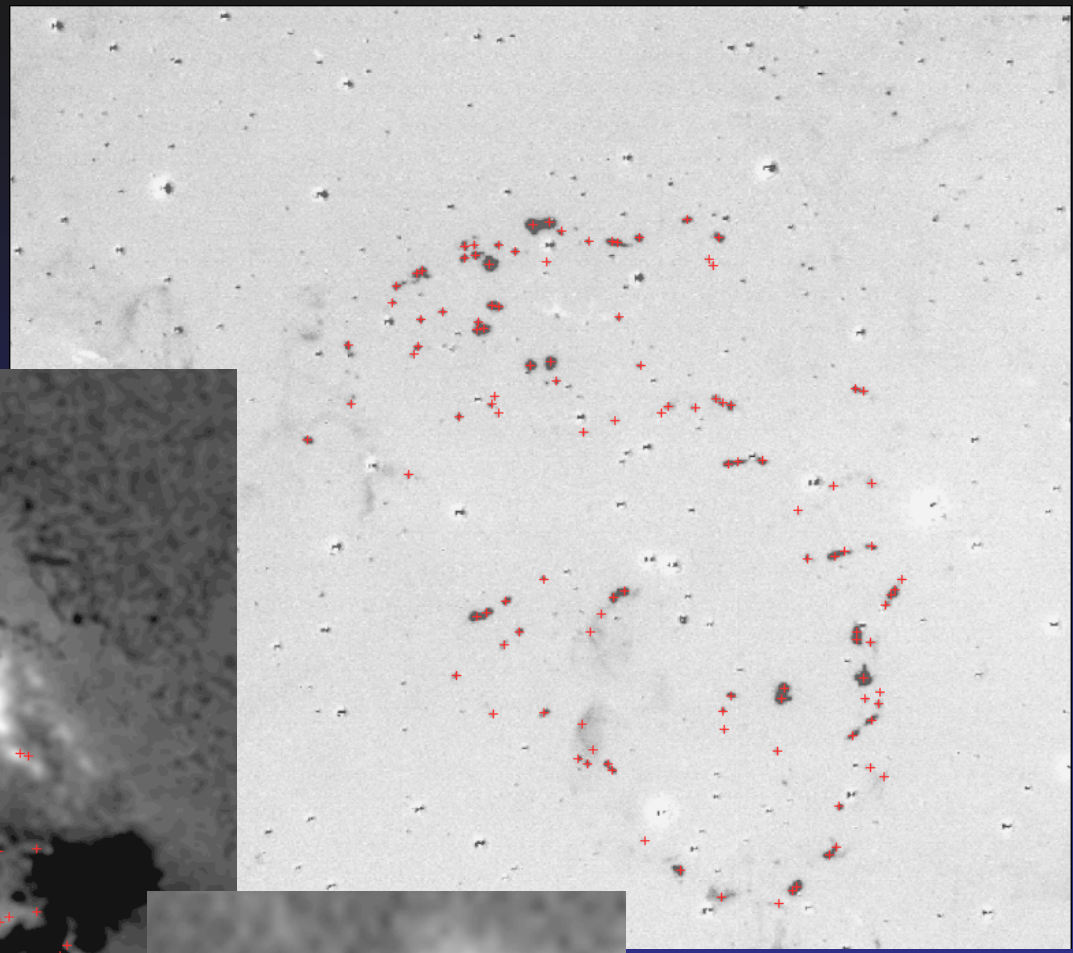


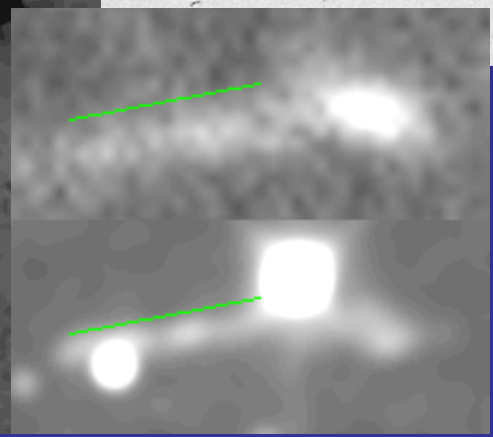


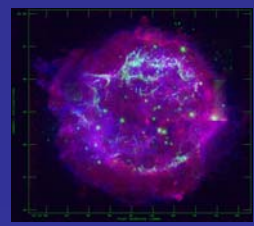
QSF emission
Fesen 1998

Low-energy enhanced

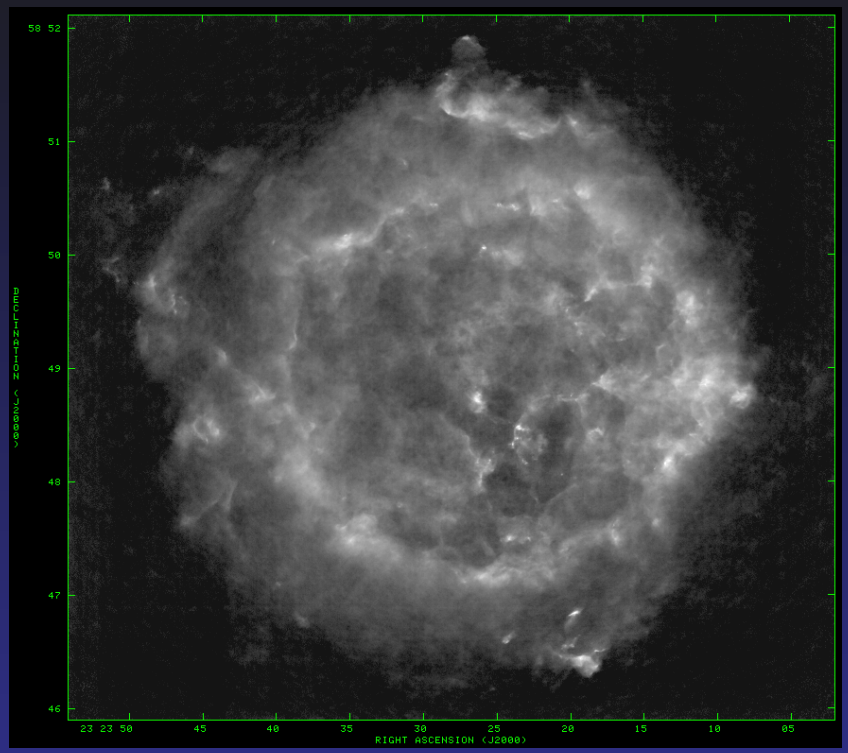




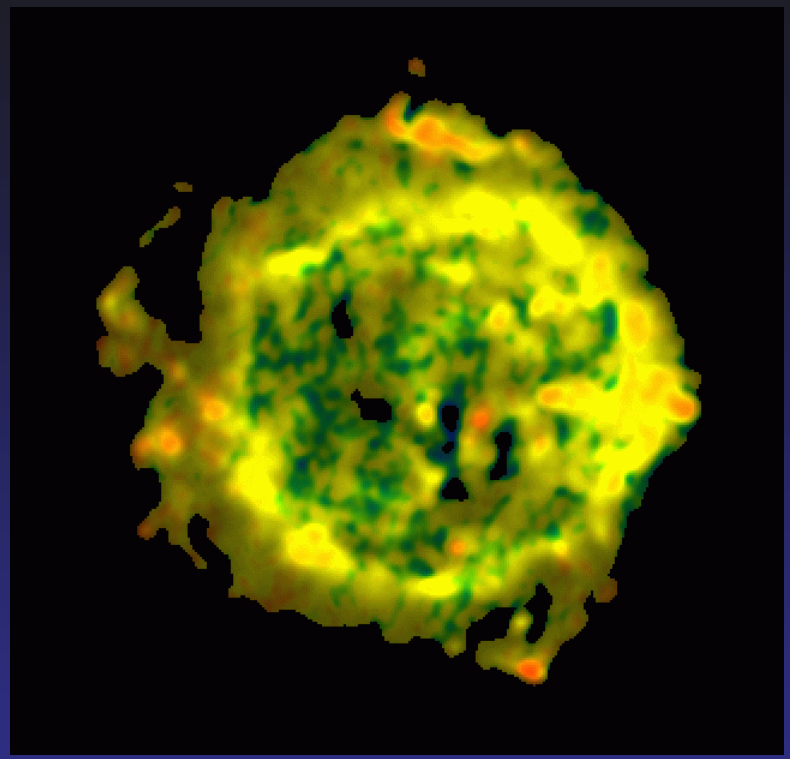




Radio

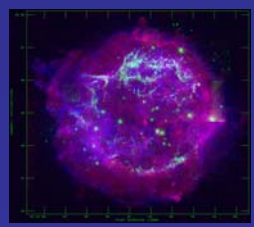


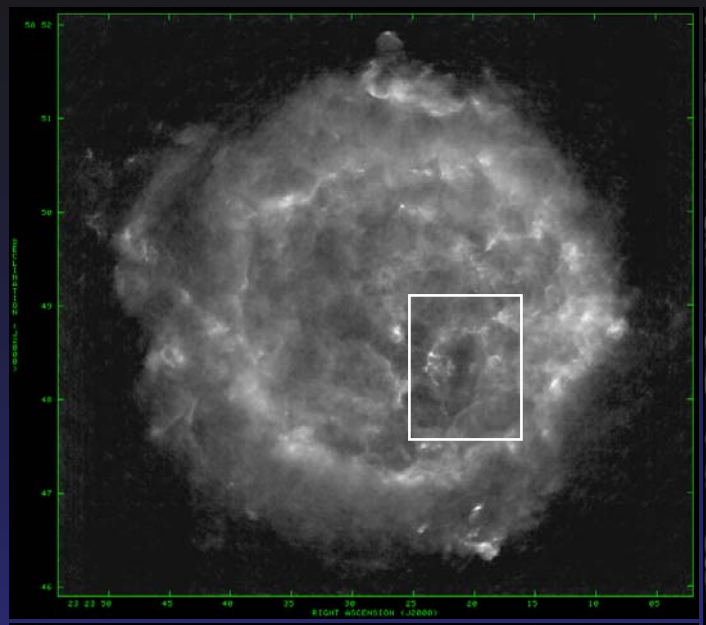
VLA 6 cm

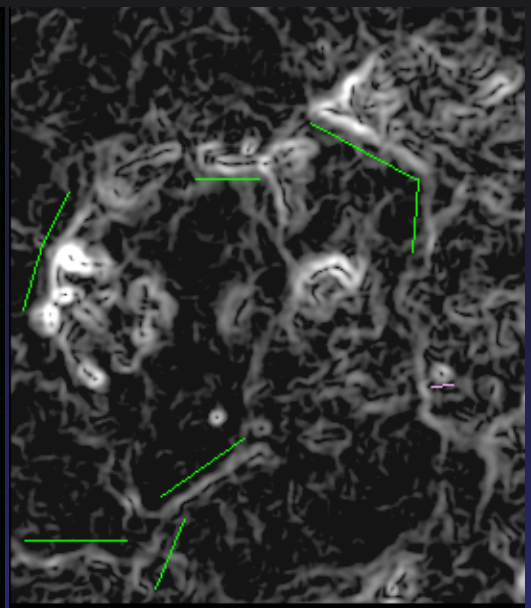


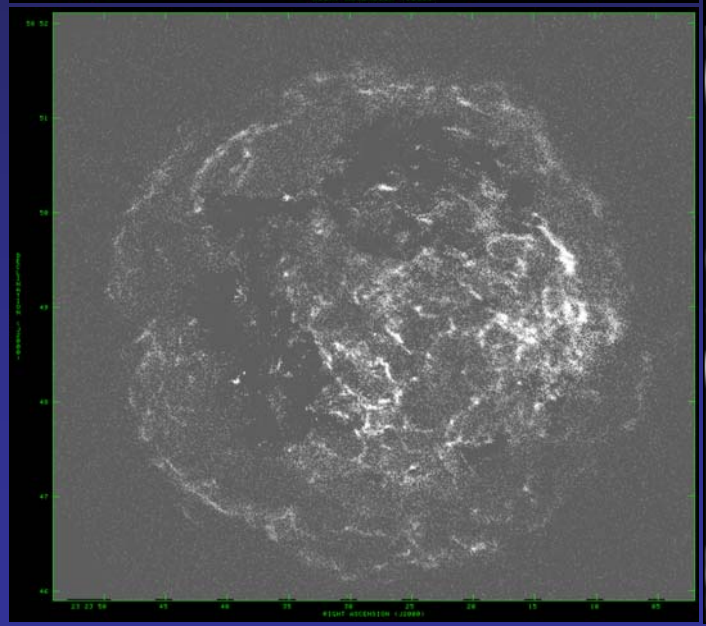
Spectral Index 20 cm to 90 cm
red=-0.9,blue=-0.6

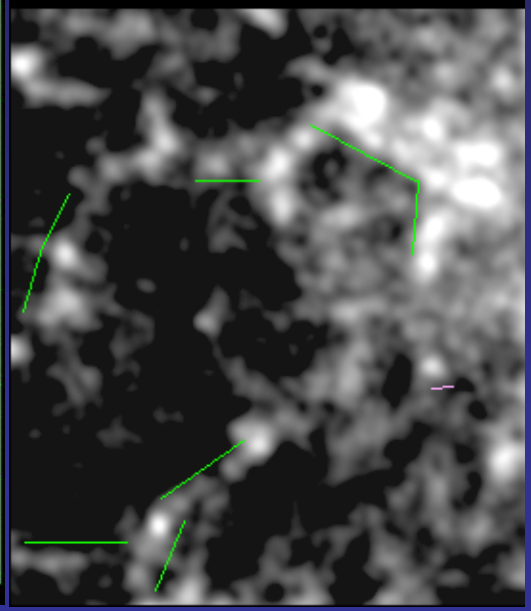
Bright ring – flatter spectral indices – ejecta
Plateau – steeper spectral indices – CSM







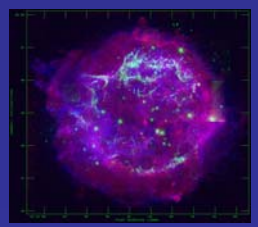


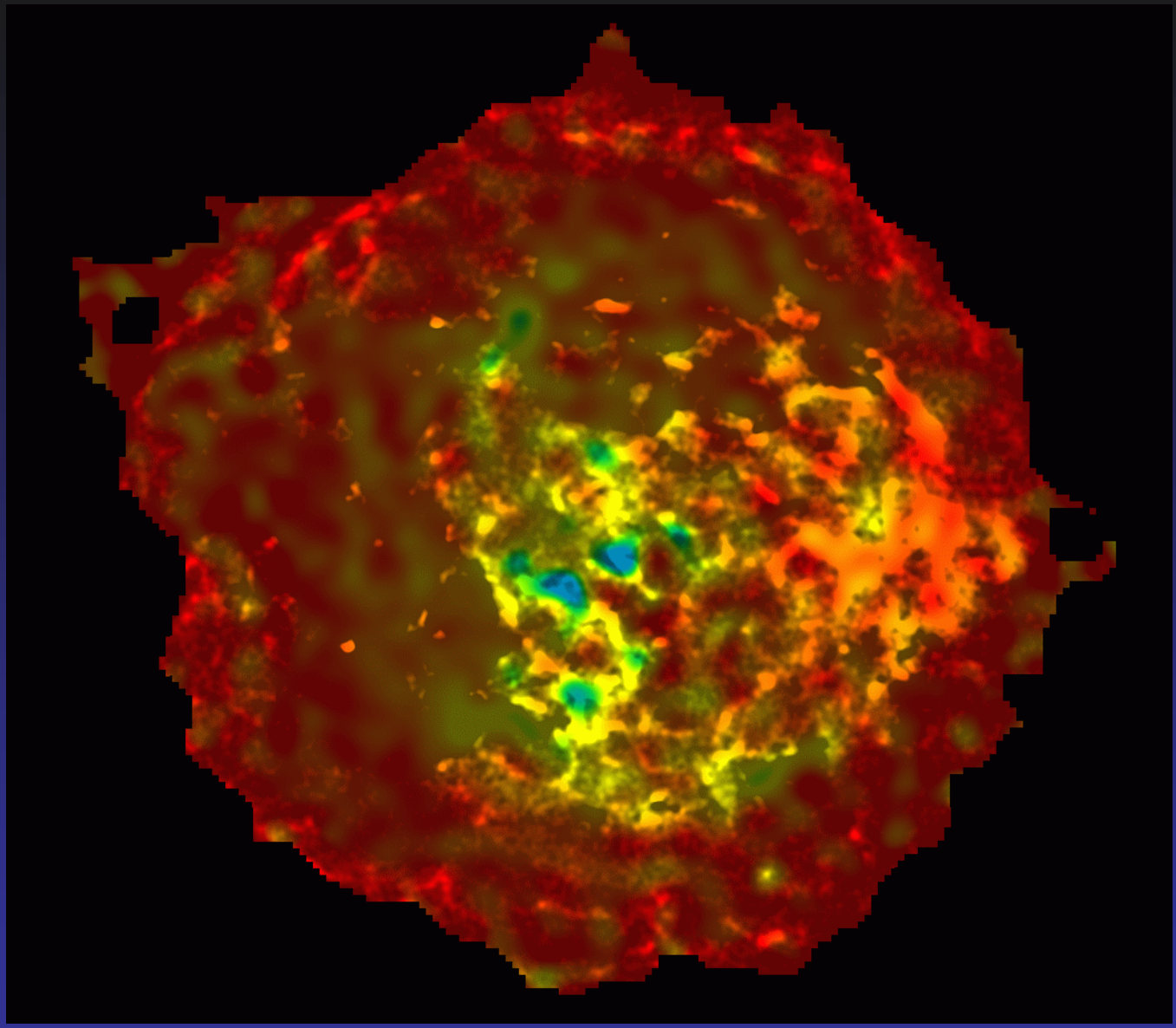


Radio

Radio filament and edge emission correlated with continuum-dominated X-ray emission

Continuum-dominated X-rays





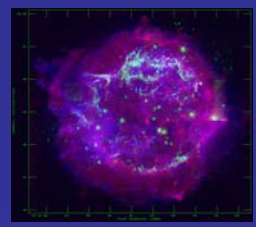
Spectral index from 4m to 90cm

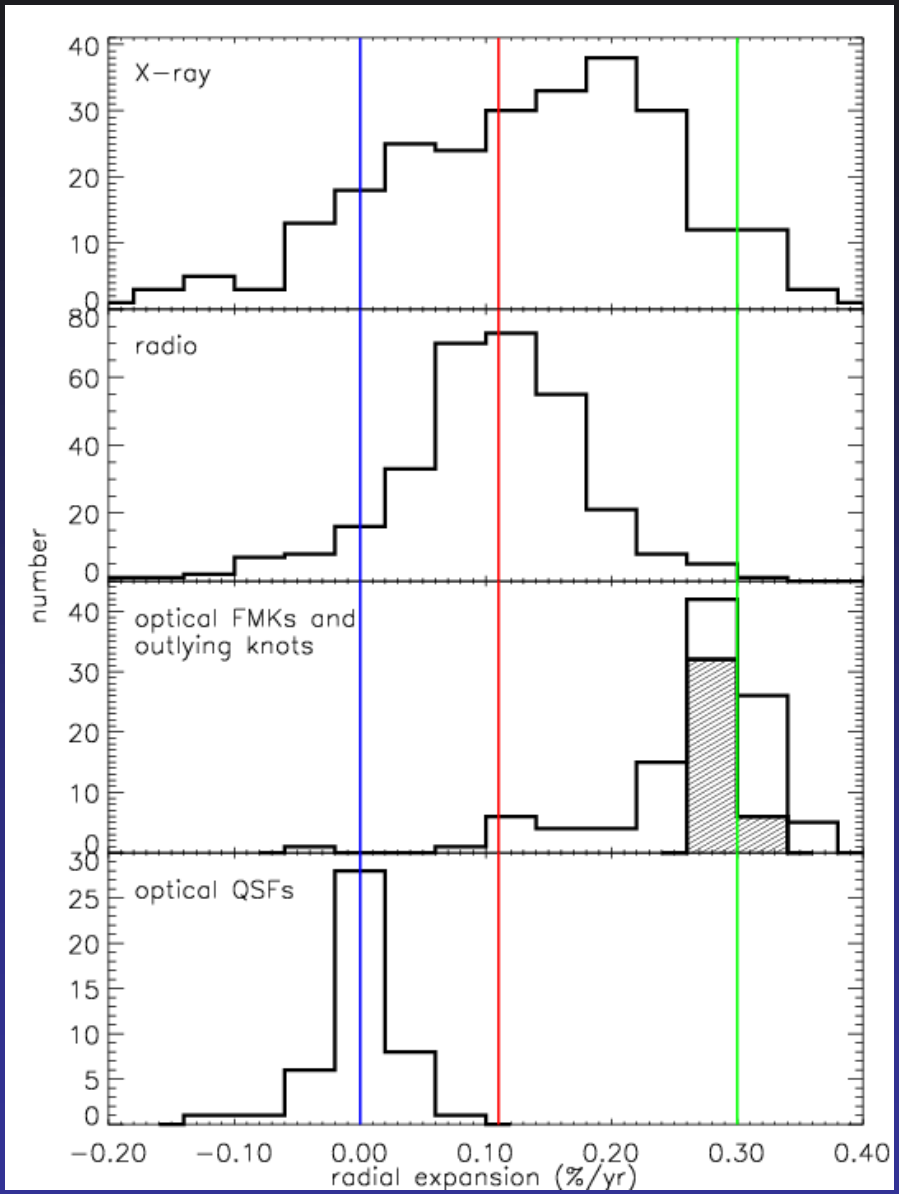
red=-0.9
blue=-0.35

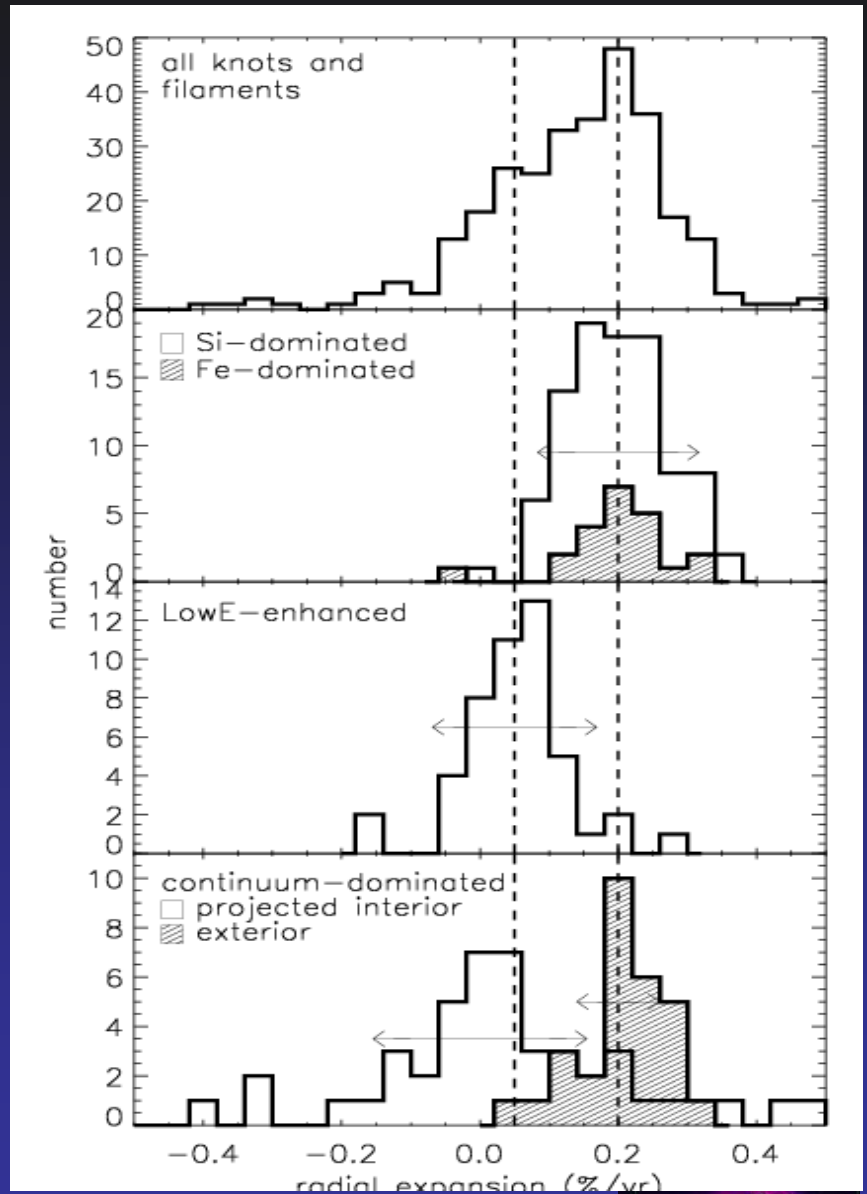
Strong absorption from unshocked ejecta

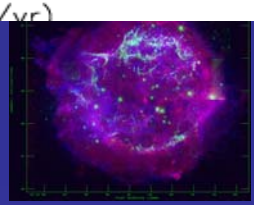
See N. Kassim Poster

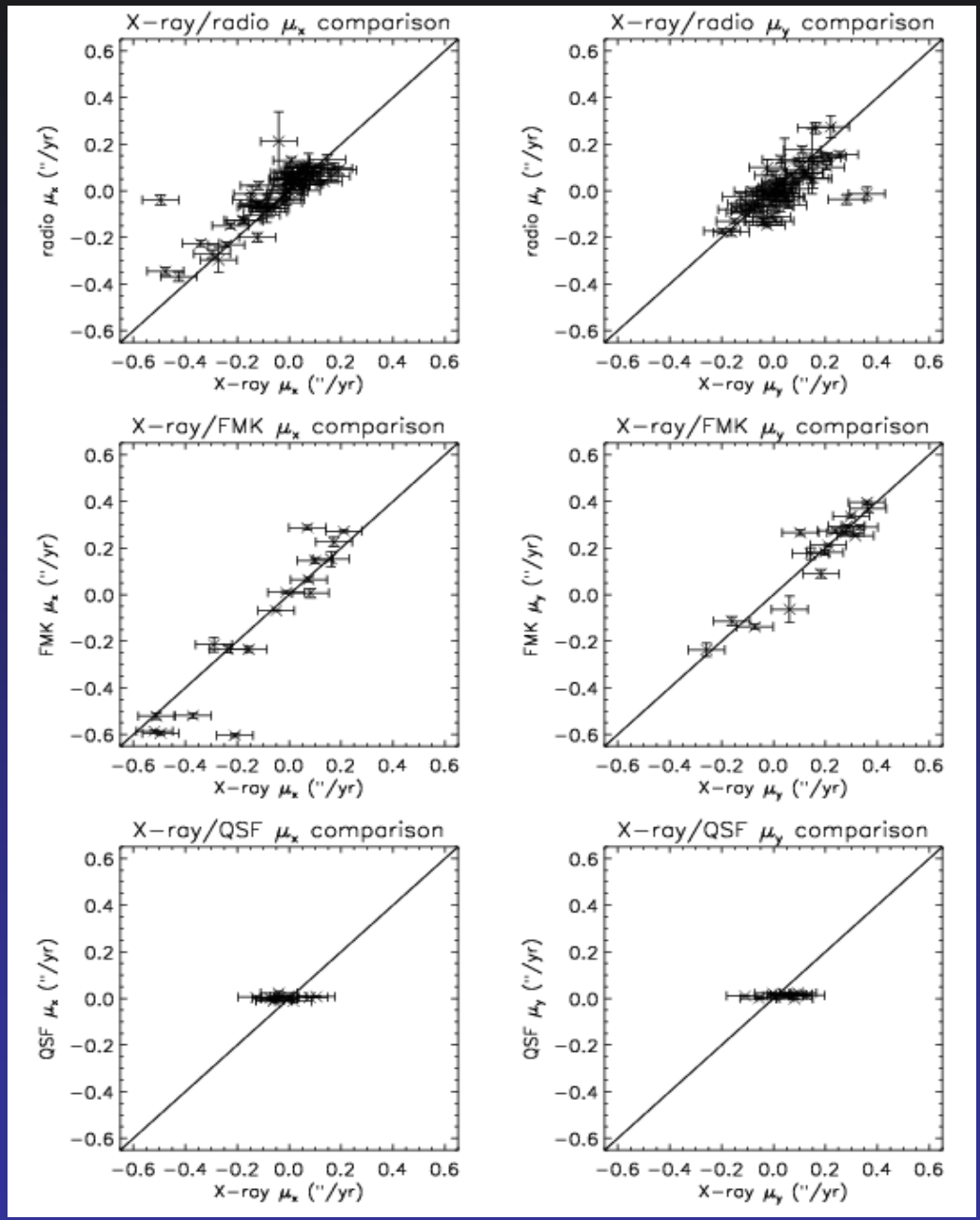
Collaborators: R. Perley, N. Kassim




X−ray
radio
optical FMKs and
outlying knots
optical QSFs
number
radial expansion (%/yr)

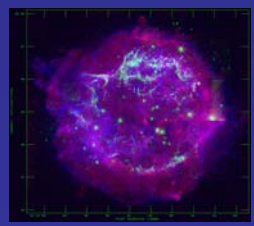

all knots and
filaments
Si−dominated
Fe−dominated
LowE−enhanced
continuum−dominated
projected interior
exterior
number
radial expansion (%/yr)





Corresponding feature motions match

Ejecta evolution based on density/deceleration



Conclusions

Combined, multi-band, high resolution imaging & spectroscopy of Cas A provide a powerful new tool.

Some initial insights:

Isolated the forward and reverse shocks.

Resolved puzzle over different expansion rates of bright ring features.

Linked some QSF, radio and X-ray features with encounter of forward shock with dense CSM.