Unveiling oxygen-rich supernova remnants

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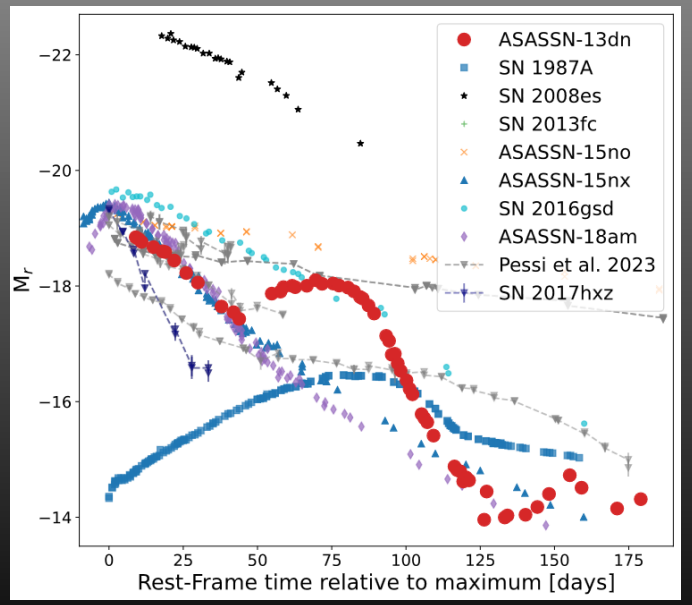
What are supernova remnants?

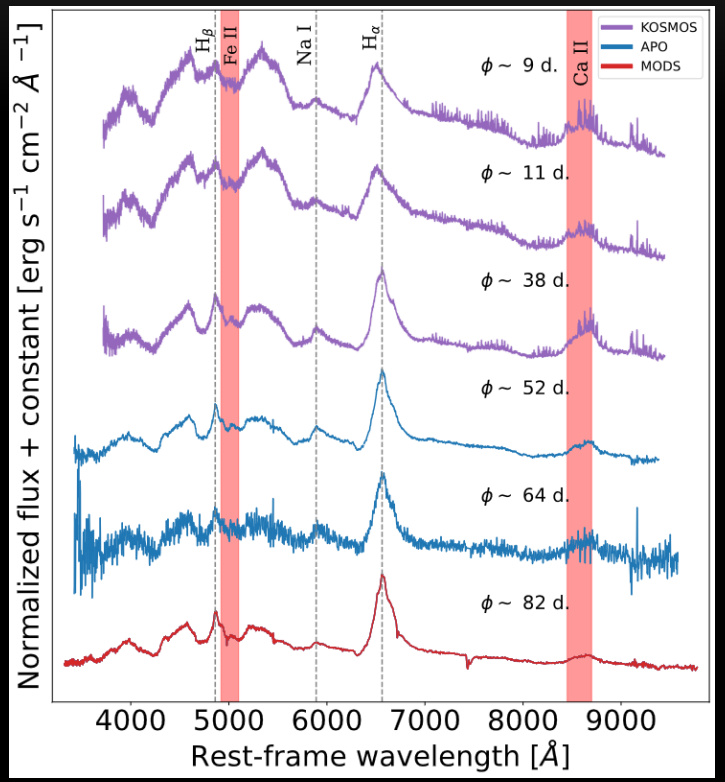
days - years

Wolf-Rayet star

Red supergiant



Hueichapán+25

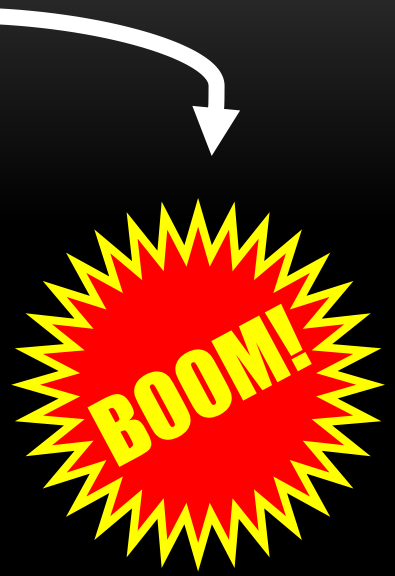


What are supernova remnants?

days - years

years - kyrs

Wolf-Rayet star



???

Red supergiant

What are supernova remnants?

days - years

years - kyrs

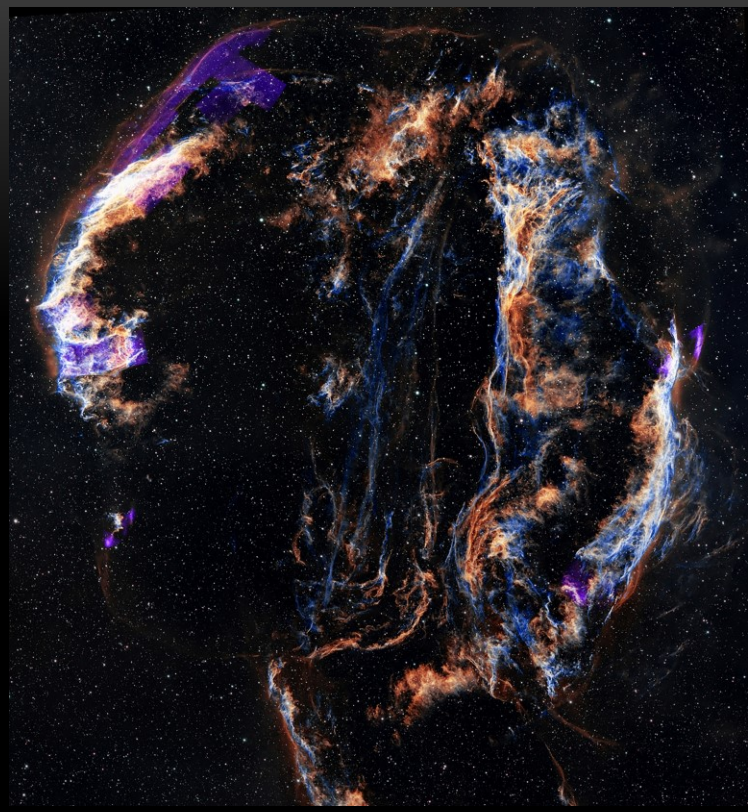
Cygnus Loop ~10 kyr

Wolf-Rayet star

BOOM!

???

Red supergiant



NASA/SAO/CXC

What are supernova remnants?

days - years

Wolf-Rayet star

Red supergiant

NASA/HST

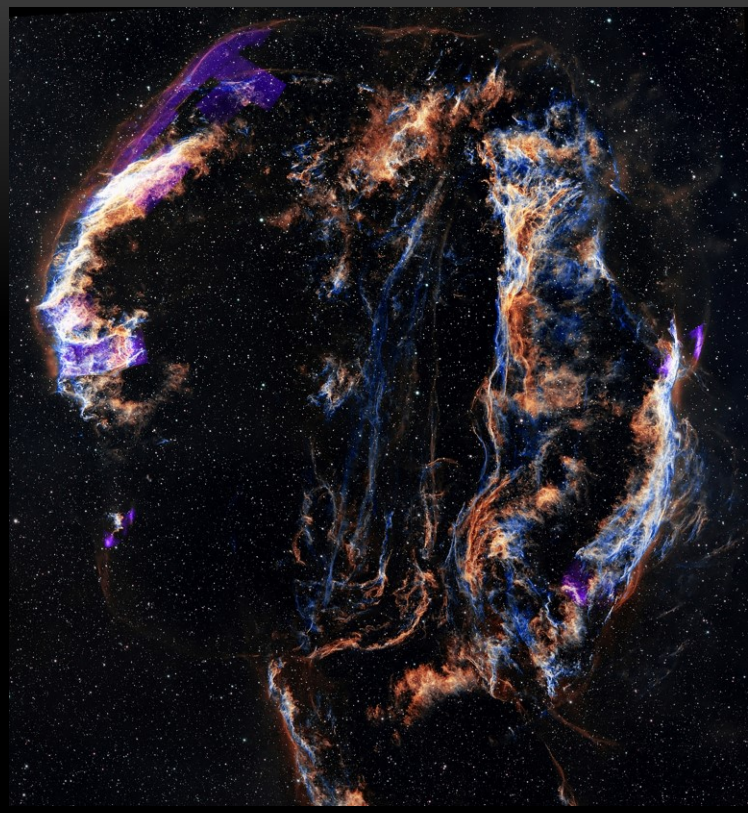
BOOM!

years - kyrs

Cas A ~350 yrs

NASA/SAO/CXC

Cygnus Loop ~10 kyr



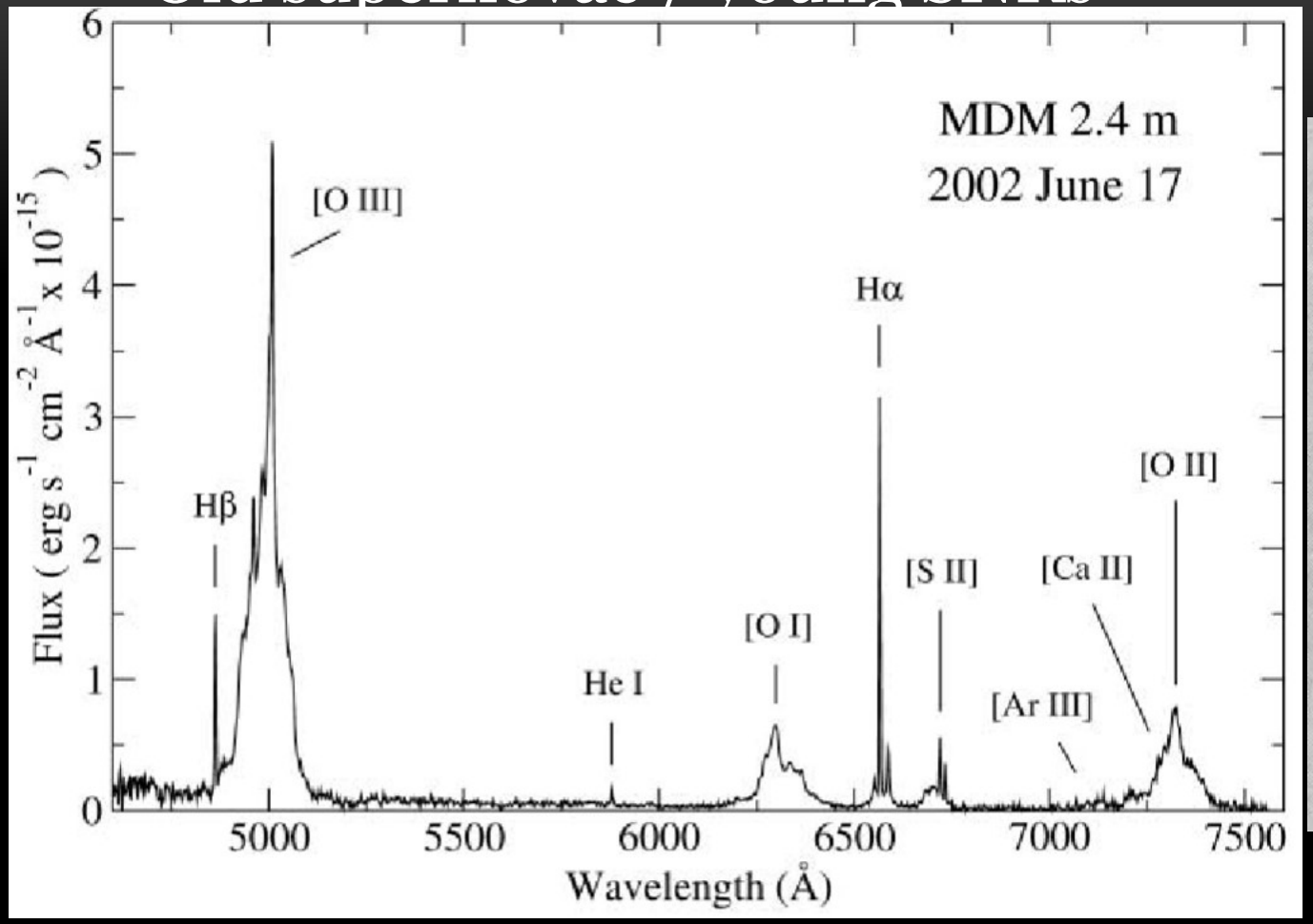
NASA/SAO/CXC

Oxygen-rich SNRs?

- Old supernovae / young SNRs
- Bright and broad oxygen emission
  - O-rich ejecta interaction
- X-rays – 10^{37} - 10^{38} erg/s
- Mid-IR emissions
- Radio (?)

Oxygen-rich SNRs?

- Old supernovae / young SNRs



RADIO EMISSION FROM A POSSIBLE SUPERNOVA REMNANT IN THE GALAXY NGC 4449

E. R. SEAQUIST
Department of Astronomy, University of Toronto, Toronto, Ontario, Canada
AND
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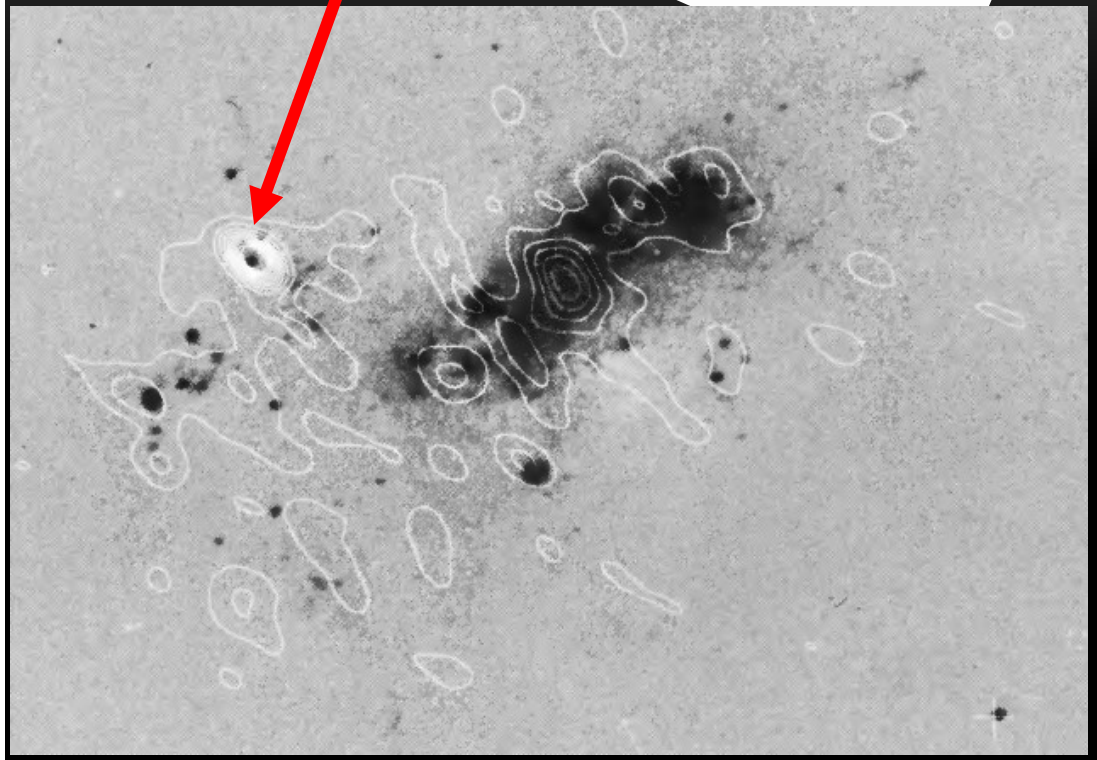
National Radio Astronomy Observatory,* Socorro, New Mexico 87801

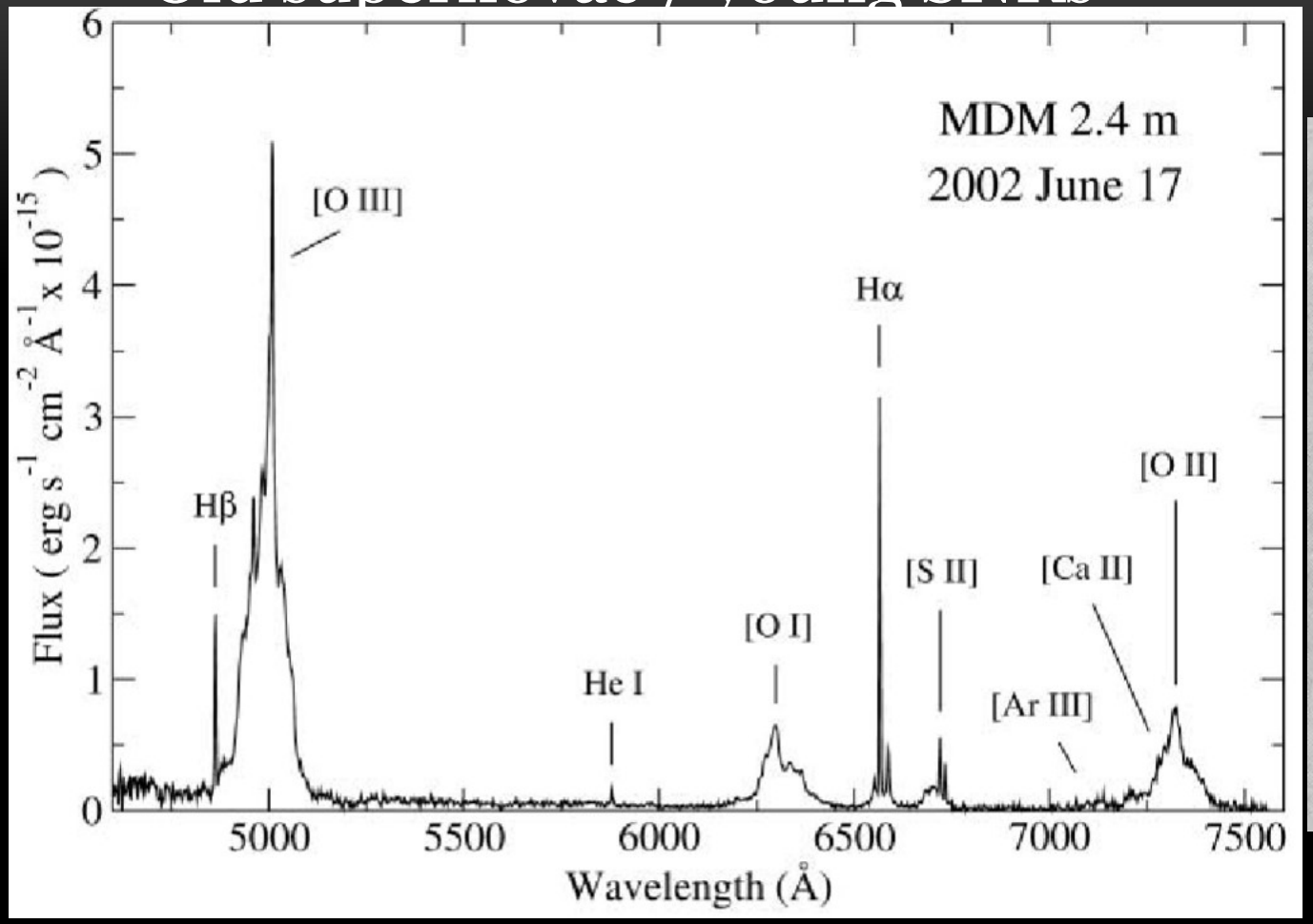
Received 1978 June 29; accepted 1978 August 16



Milisavljevic+07

Oxygen-rich SNRs?

- Old supernovae / young SNRs



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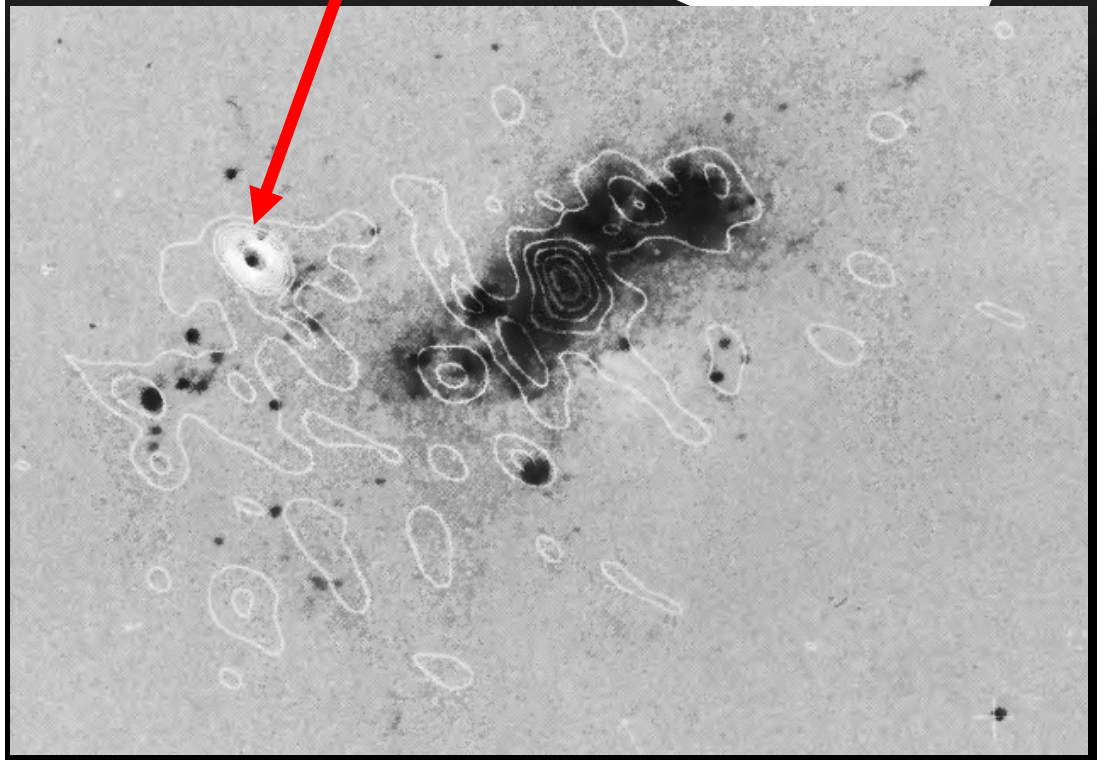
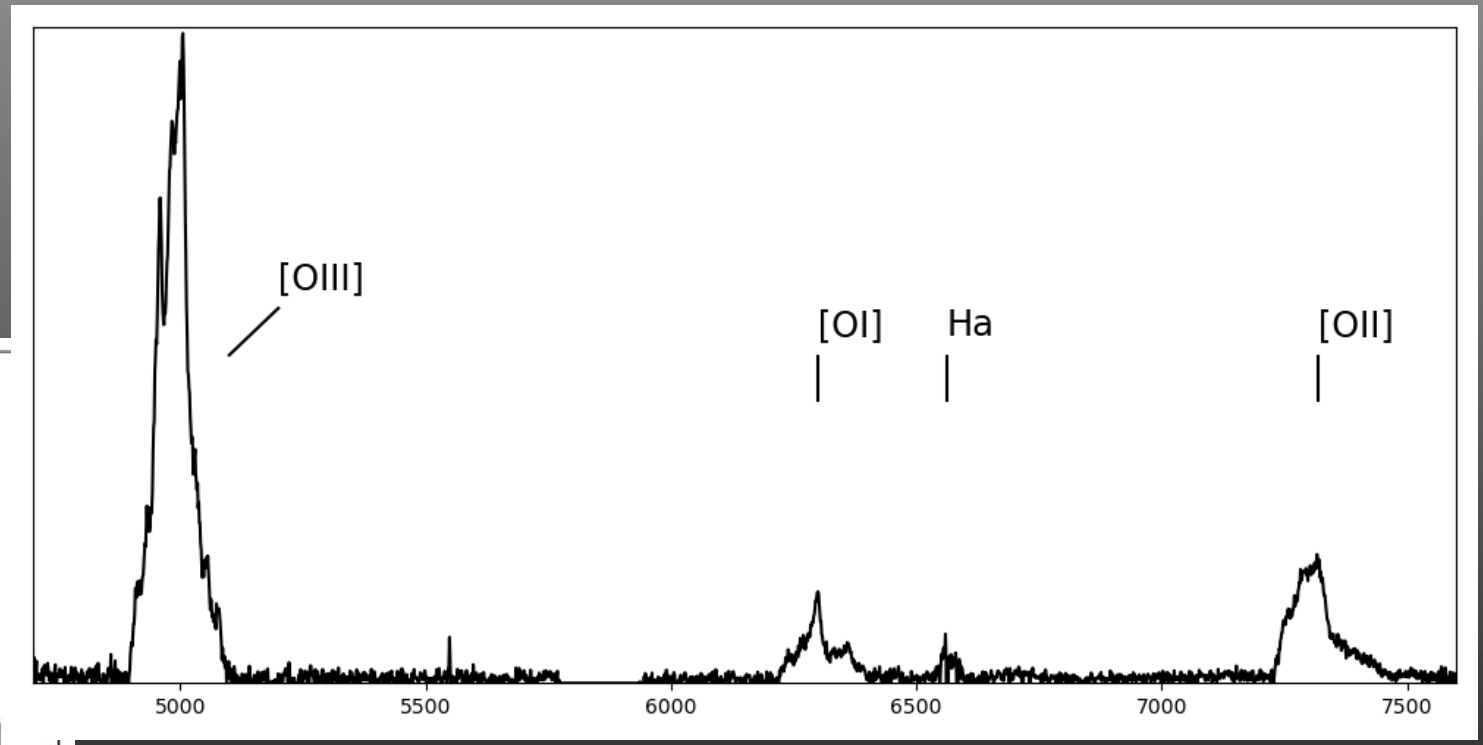


Milisavljevic+07

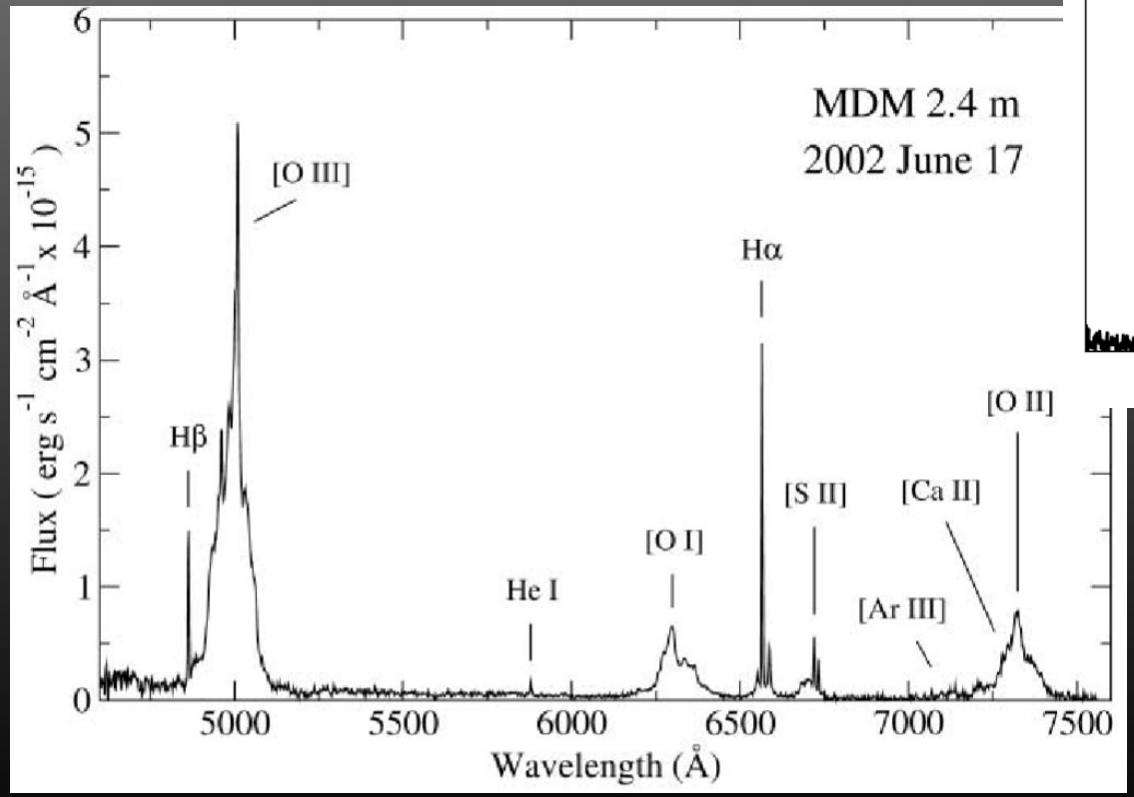
Discovery of young, oxygen-rich supernova remnants in PHANGS-MUSE galaxies

T. Kravtsov[1, 2, 3], J. P. Anderson[1, 4], H. Kuncarayakti[2, 3], K. Maeda[5], and S. Mattila[2, 6]

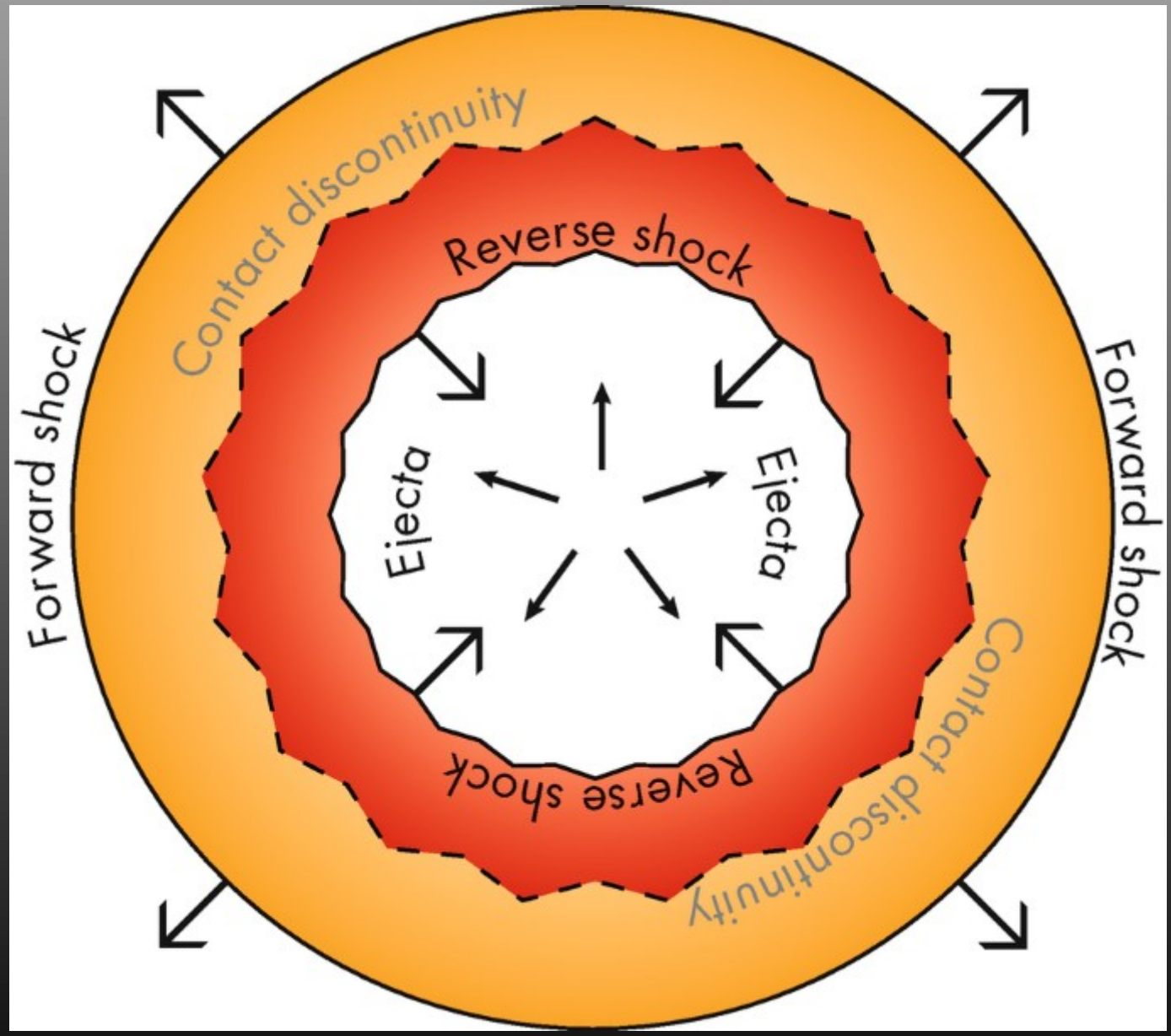
SNR 4303-46



SNR 4449-1



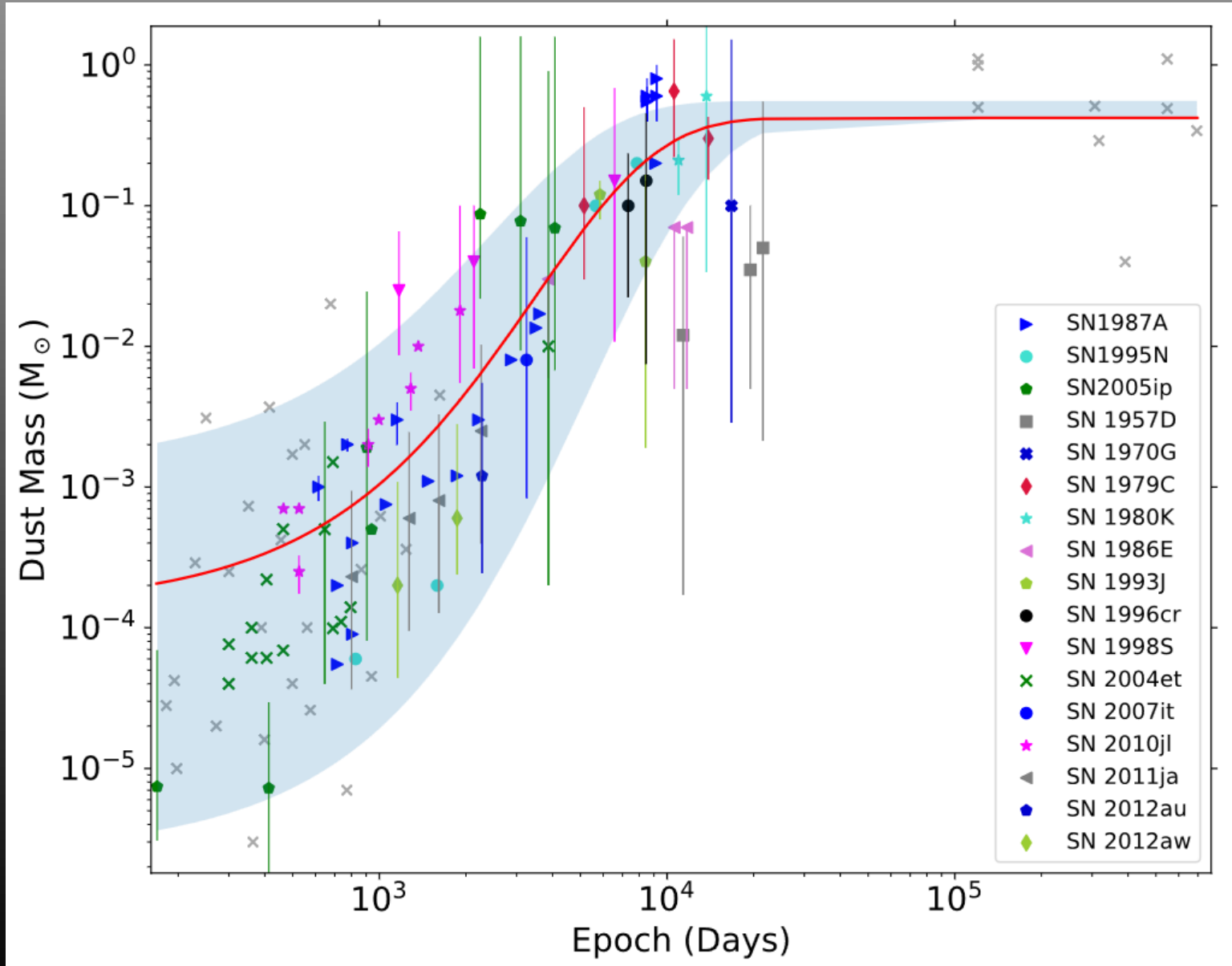
Milisavljevic+07


Contact discontinuity
Reverse shock
Forward shock
Forward shock
Ejecta
Ejecta
Reverse shock
Contact discontinuity

Vink 2020

Dust production in SN(R)s

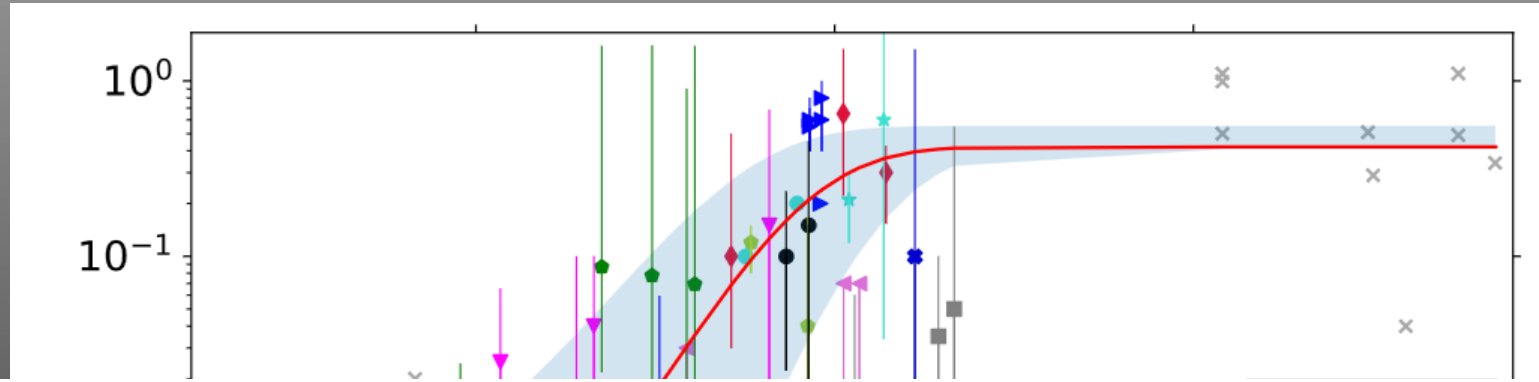
- SN(R)s produce dust

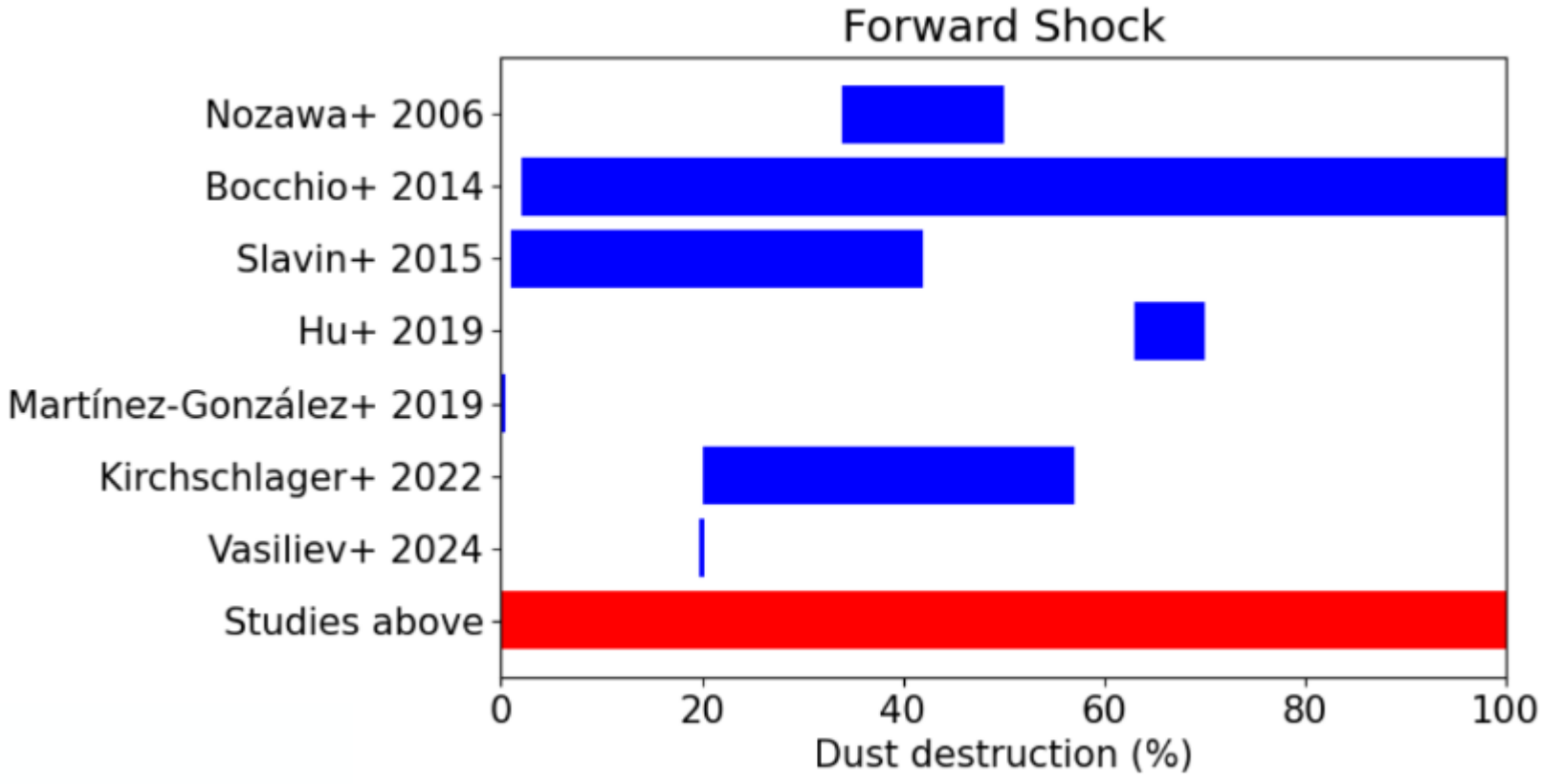


Niculescu-Duvaz+22

Dust production in SN(R)s

- SN(R)s produce dust
- SN(R)s destroy dust!



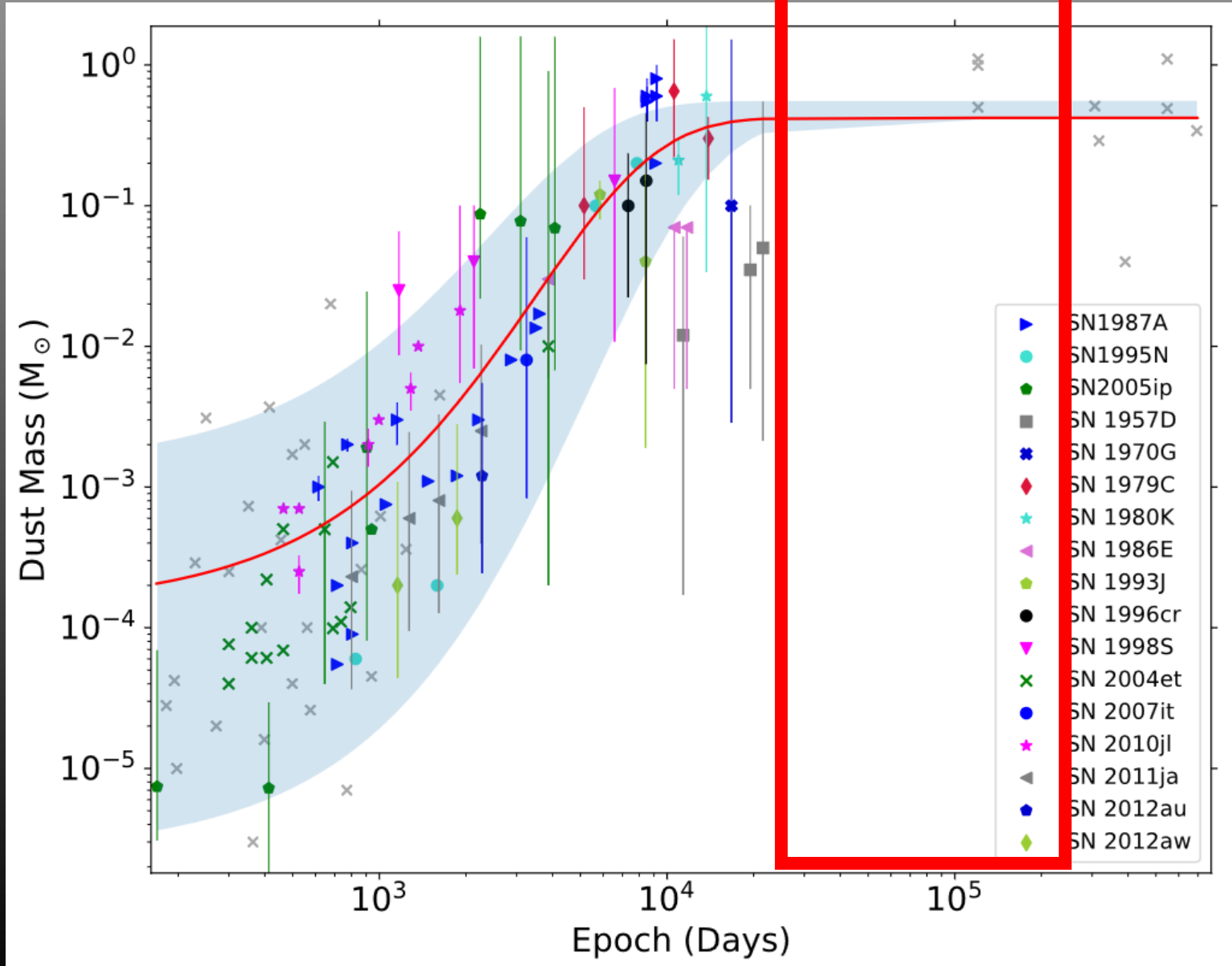


De Looze&Scheffler 24

Dust production in SN(R)s

O-rich SNRs go here!

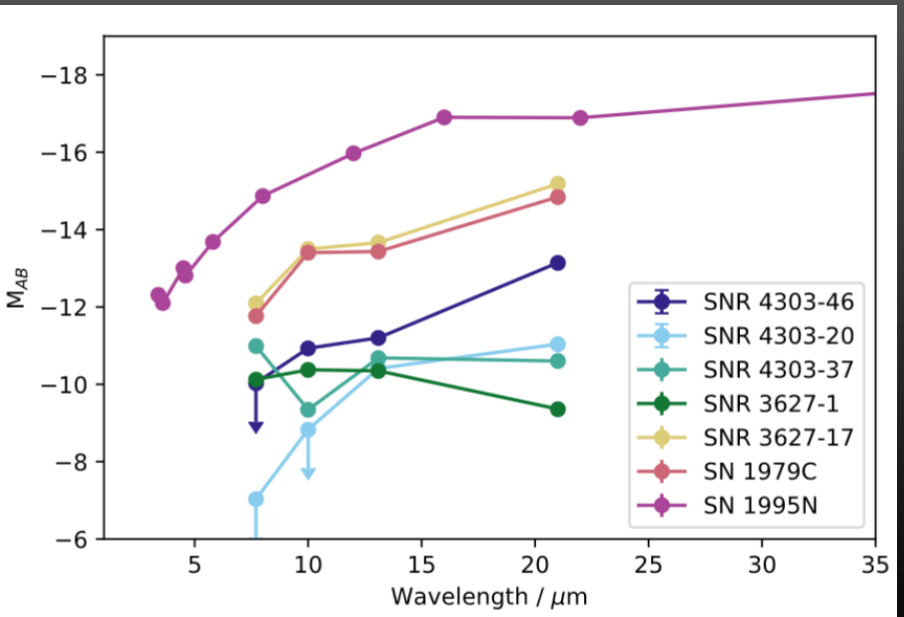
- SN(R)s produce dust
- SN(R)s destroy dust!
- O-rich SNRs as probes of dust
- Reverse shock a problem as well

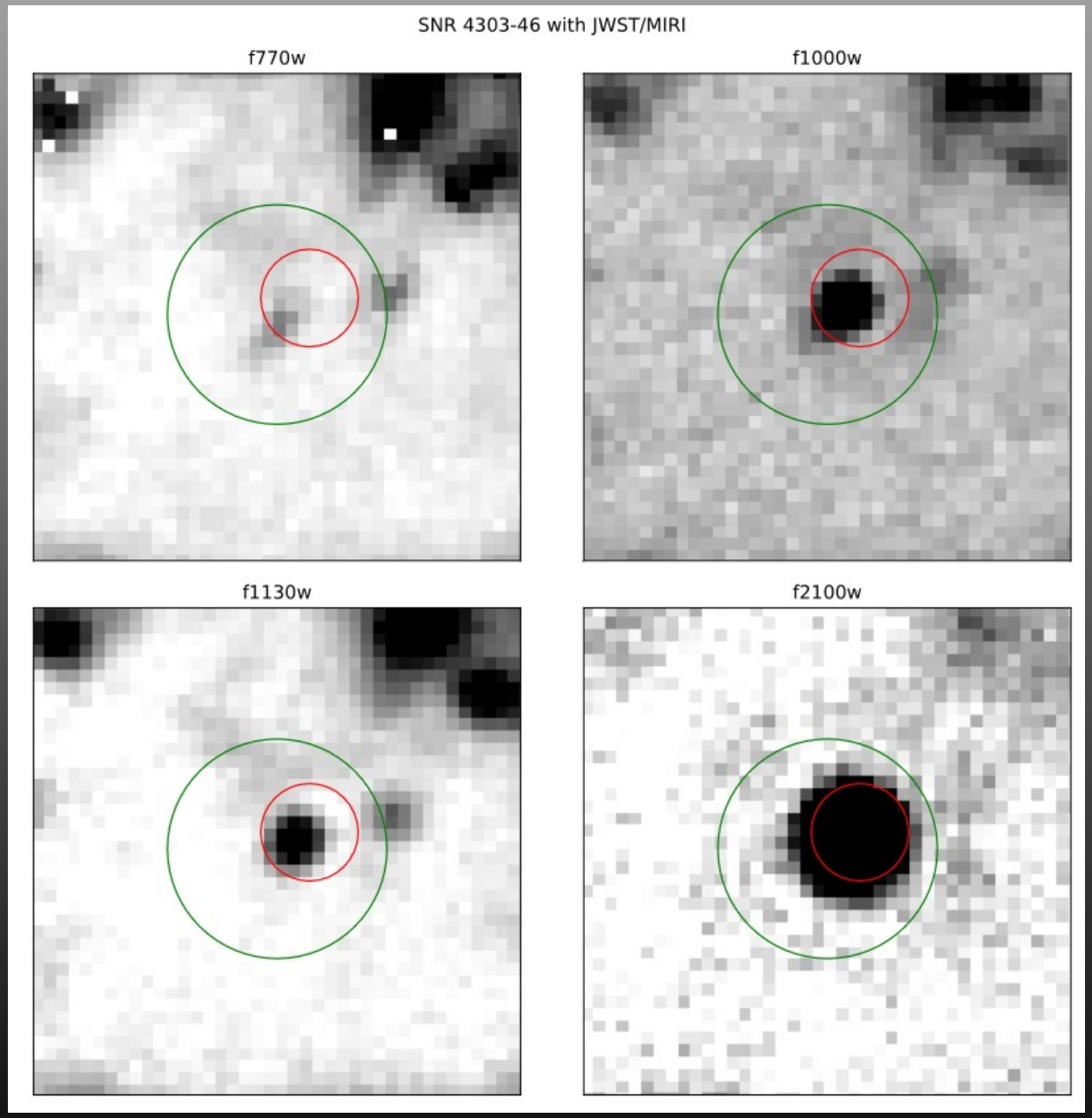


Niculescu-Duvaz+22

JWST observations

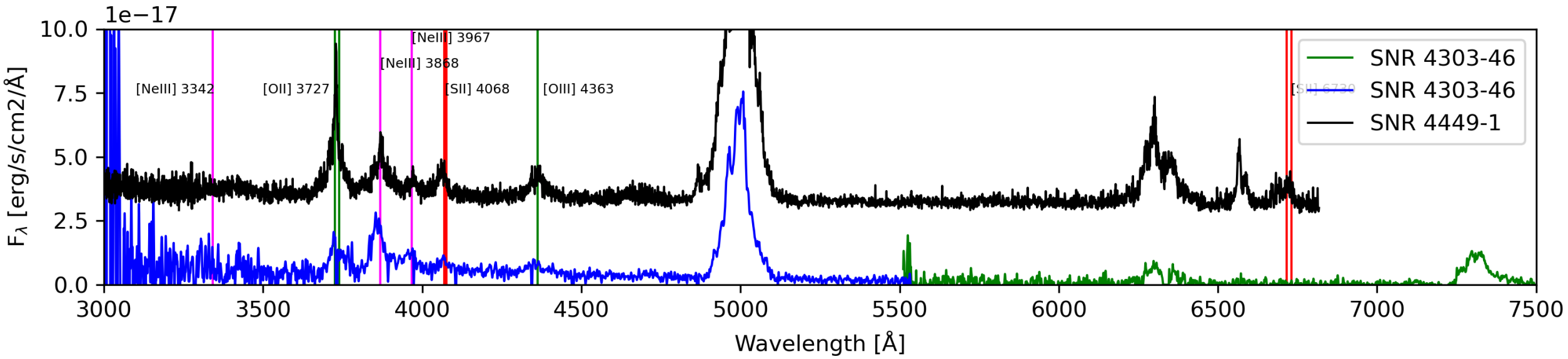
- Indication of massive dust formation and retention
- Cool dust dominates
  - Possibly Si-rich
  - ~0.5 $M_\odot$ still exists





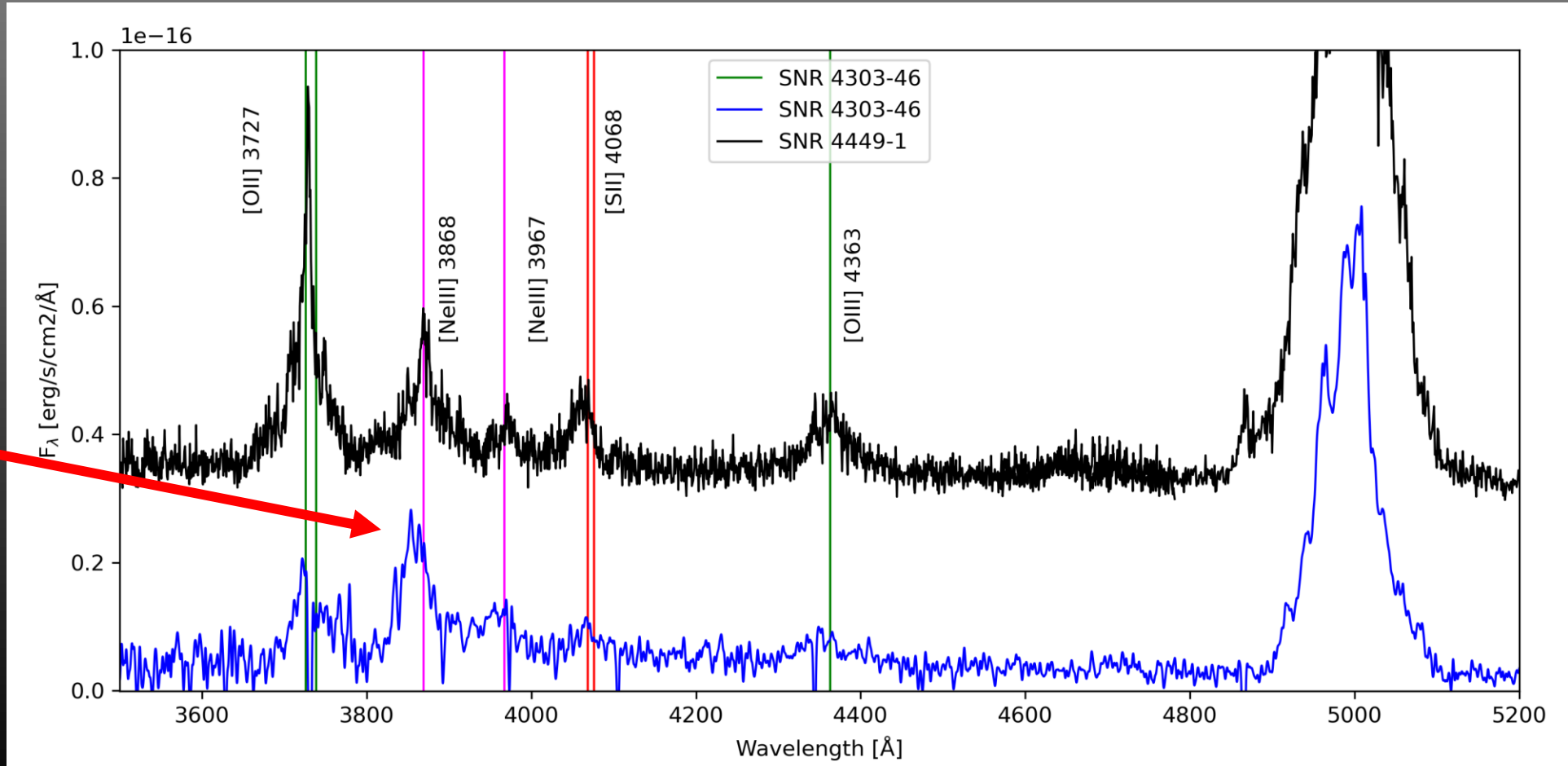
Onwards to new observations!
What powers an O-rich SNR?

- X-Shooter observations in 2025
- Clear detections of Ne emissions
  - Looking at it a bit closer…



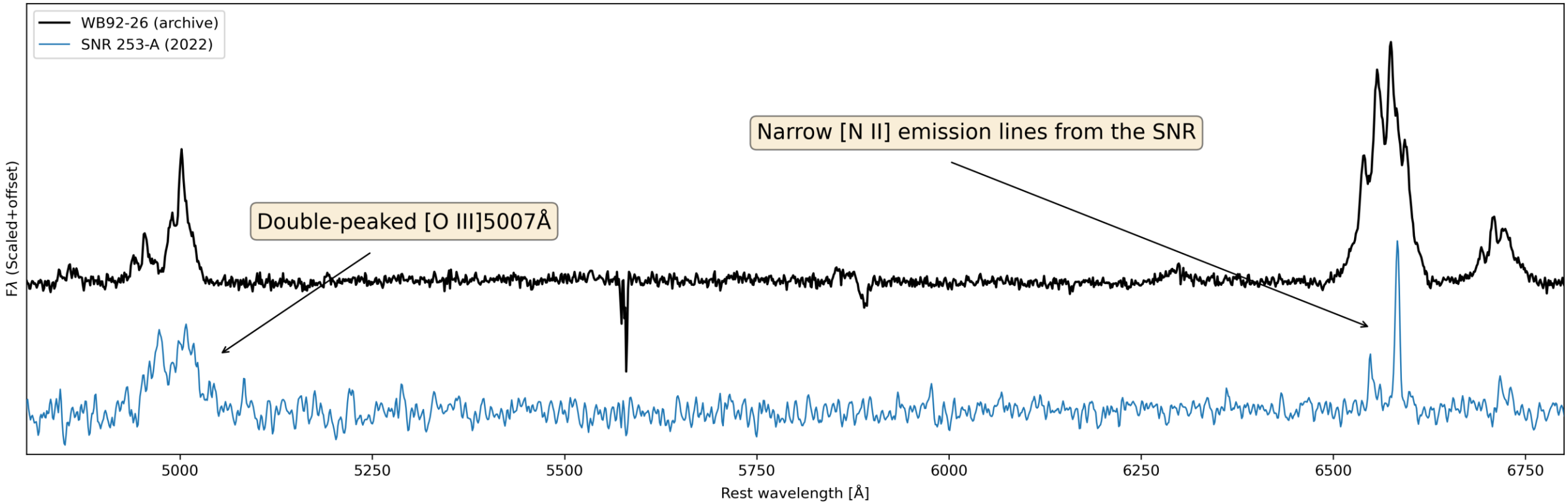
Onwards to new observations!
What powers an O-rich SNR?

Blueshifted [NeIII] line



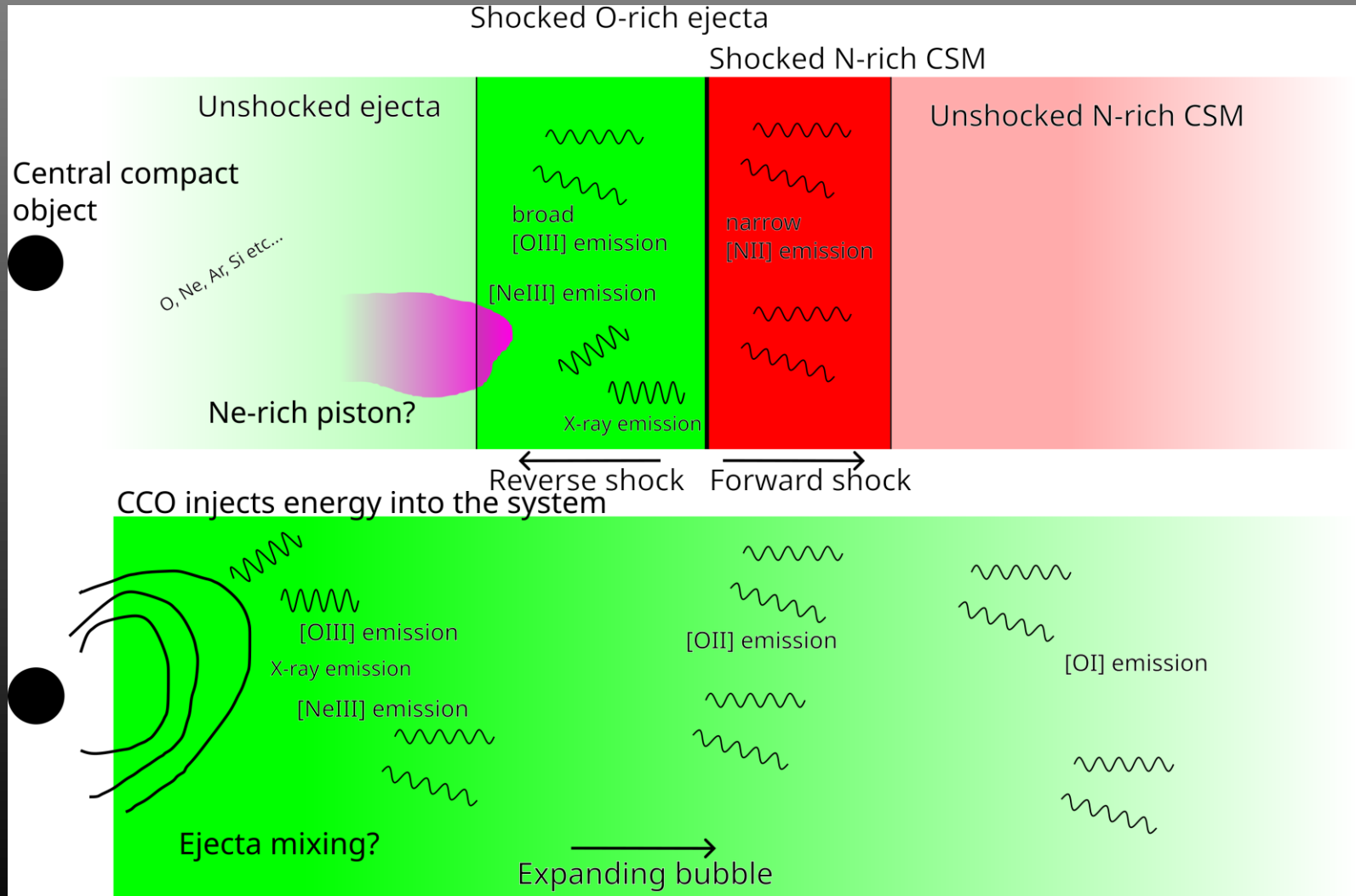
New O-rich SNR in NGC253

- Kravtsov+26 (in prep.) out very soon!
- Non-detection in JWST



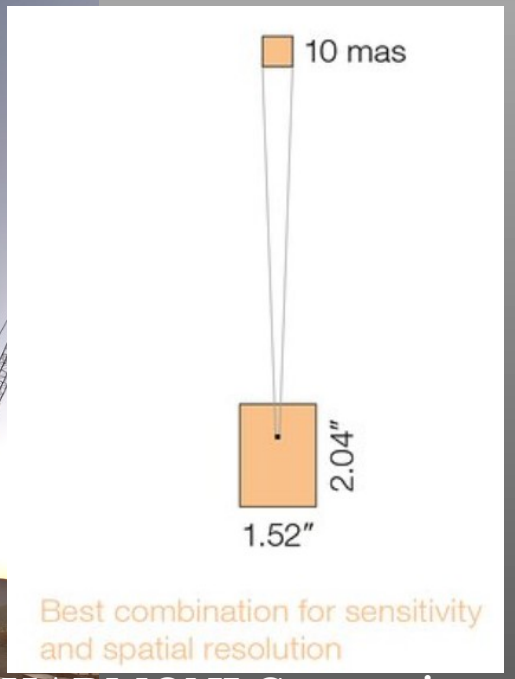
Powering the remnants

- Challenging to identify
- Old school model based around shocks
- Pulsar Wind Nebula an alternative

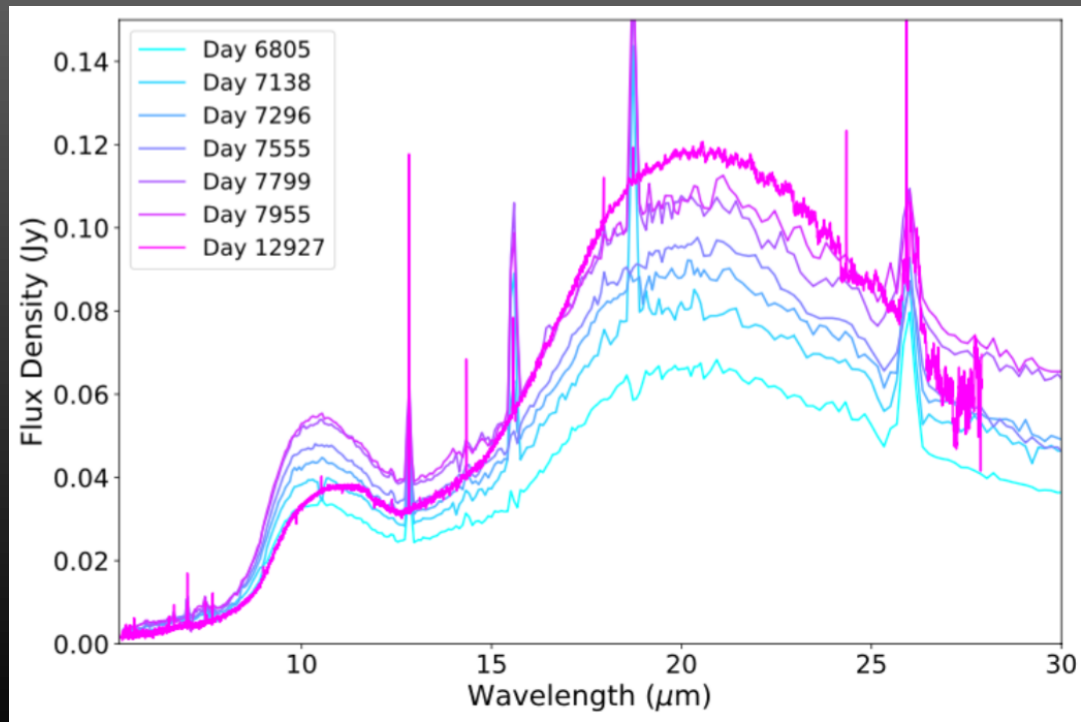


Future prospects

- JWST/MIRI spectra
- ELT/HARMONI
- Radio observations?



HARMONI Consortium



Summary

- We keep finding O-rich SNRs
  - Bright in many wavelengths!
  - Why only some SNe turn into O-rich SNRs?
- Asymmetries in emission lines indicate complex structure
  - Pistons, clumps, filaments, CSM and more!
- Mid-IR shows a lot of dust
  - What happens to that dust?
- We still need to figure out things (more observations…)
  - How are they powered?
  - What are their actual ages?