Dependence of Spectra on Metallicity in Type Ia Supernova Models

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Fifty One Ergs
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STUDY OVERVIEW

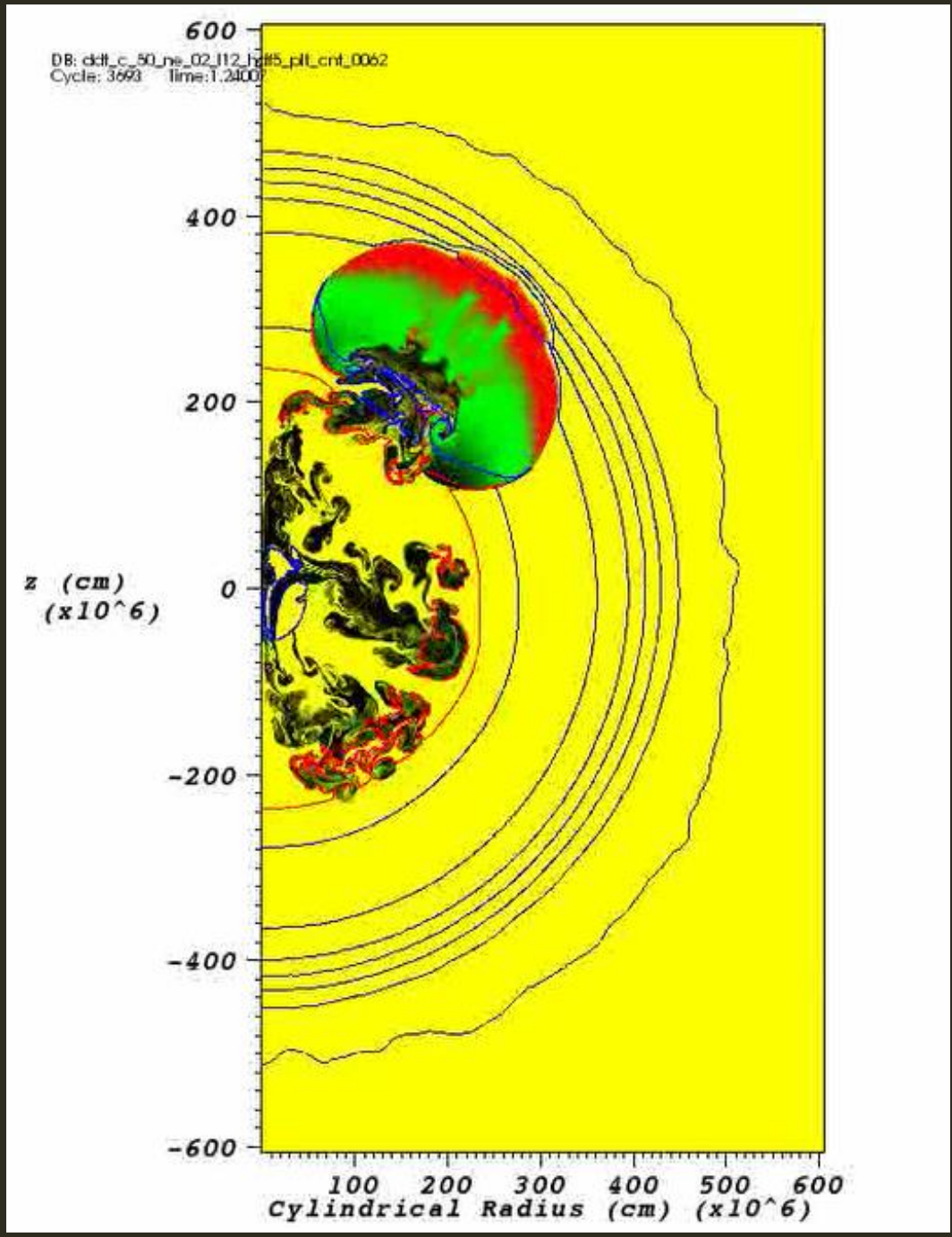
Through a combination of hydrodynamic simulations, particle post-processing, and radiative transfer calculations, we investigate the effects of progenitor metallicity on multiple features of type Ia supernovae:

- Nucleosynthetic yields
- Spectra

(Townsley, personal web)

PROGENITOR MODELS

- Selected two previously studied models from Krueger et al 2012
- 2D
- DDT
- DDT-H (D20 R01)
  - .8$M_\odot$ ^{56}Ni
- DDT-L (D20 R10)
  - .7$M_\odot$ ^{56}Ni



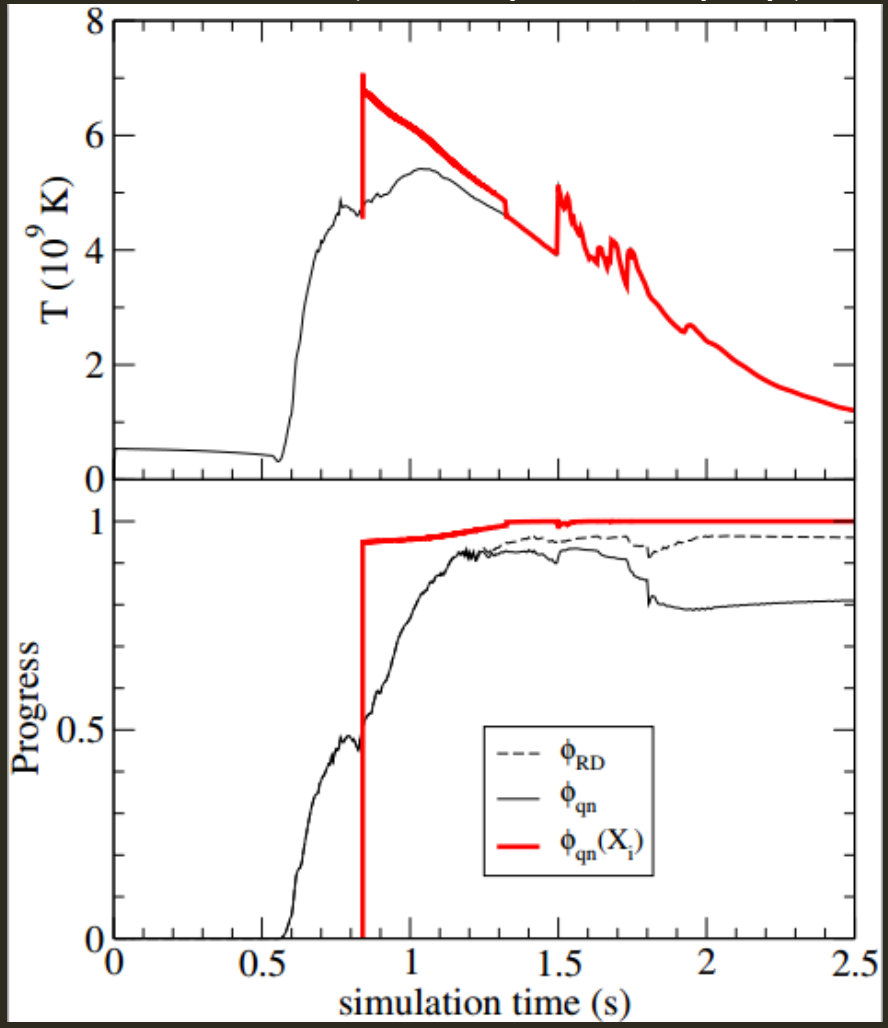
HYDRODYNAMICS

- FLASH 3.0
- Run for 4 seconds of simulation time
- Both hydro simulations run at one metallicity
- 100,000 Lagrangian tracer particles produced for post-processing.

PARTICLE POST PROCESSING

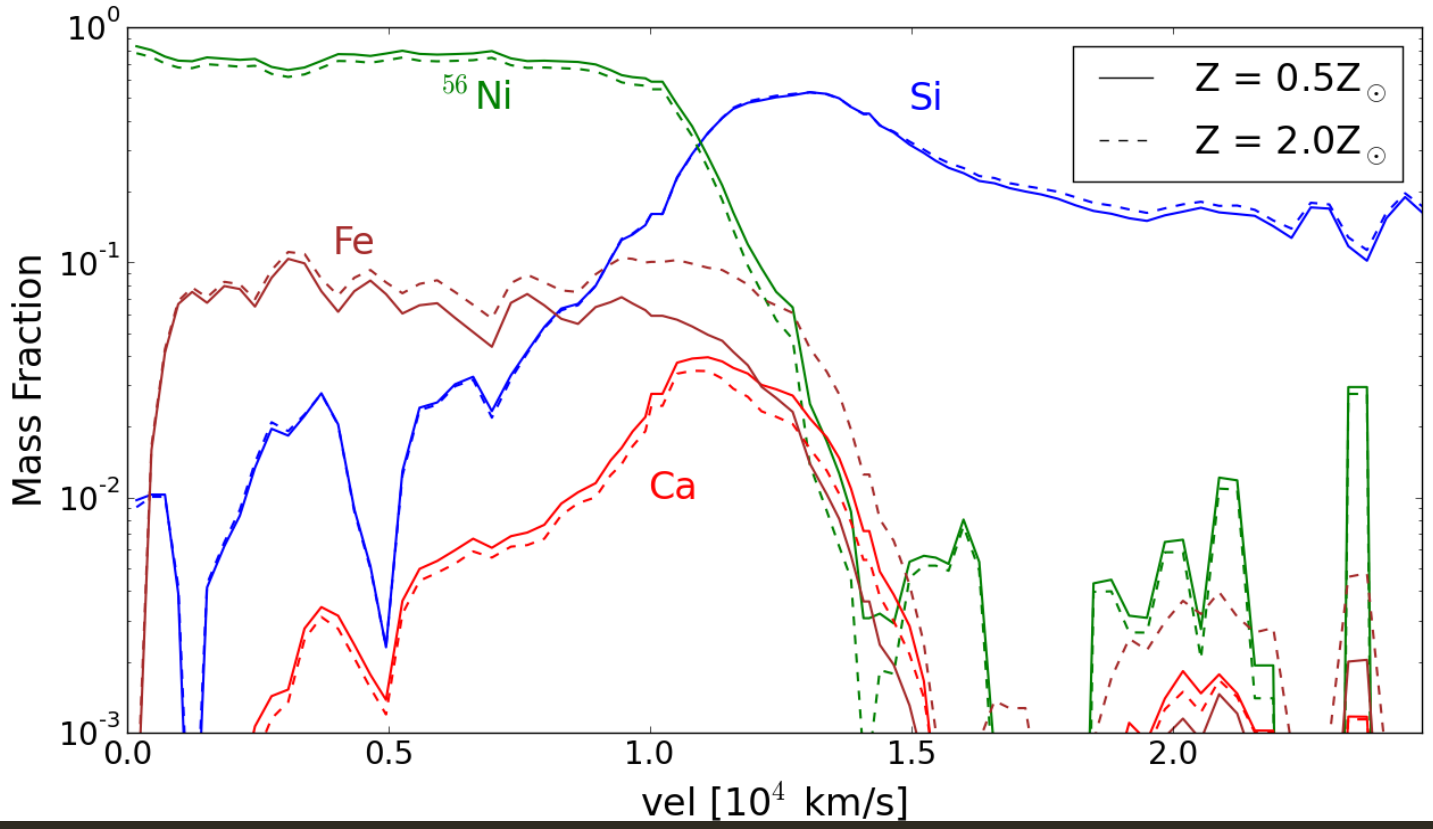
- Lagrangian temperature-density histories post-processed through 225-specie nuclear network
- Initial abundances are varied with metallicity
  - $Z/Z_{\odot}$ = 0.1, 0.5, 1.33, 2.0, 3.0, 4.0

(Townsley et al, in prep)



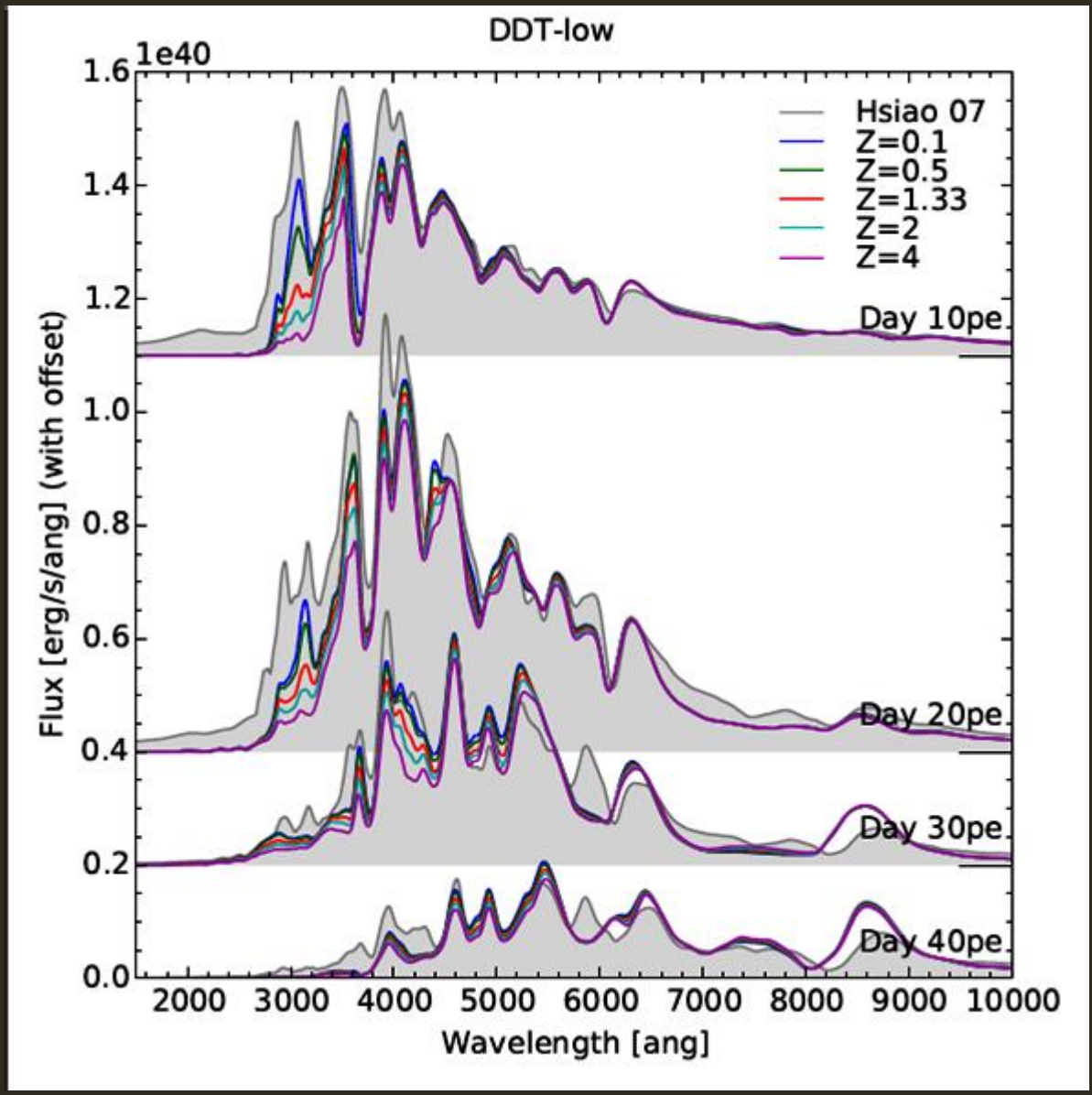
YIELD PROFILES

How does the distribution of ejecta material change with metallicity?



SPECTRA

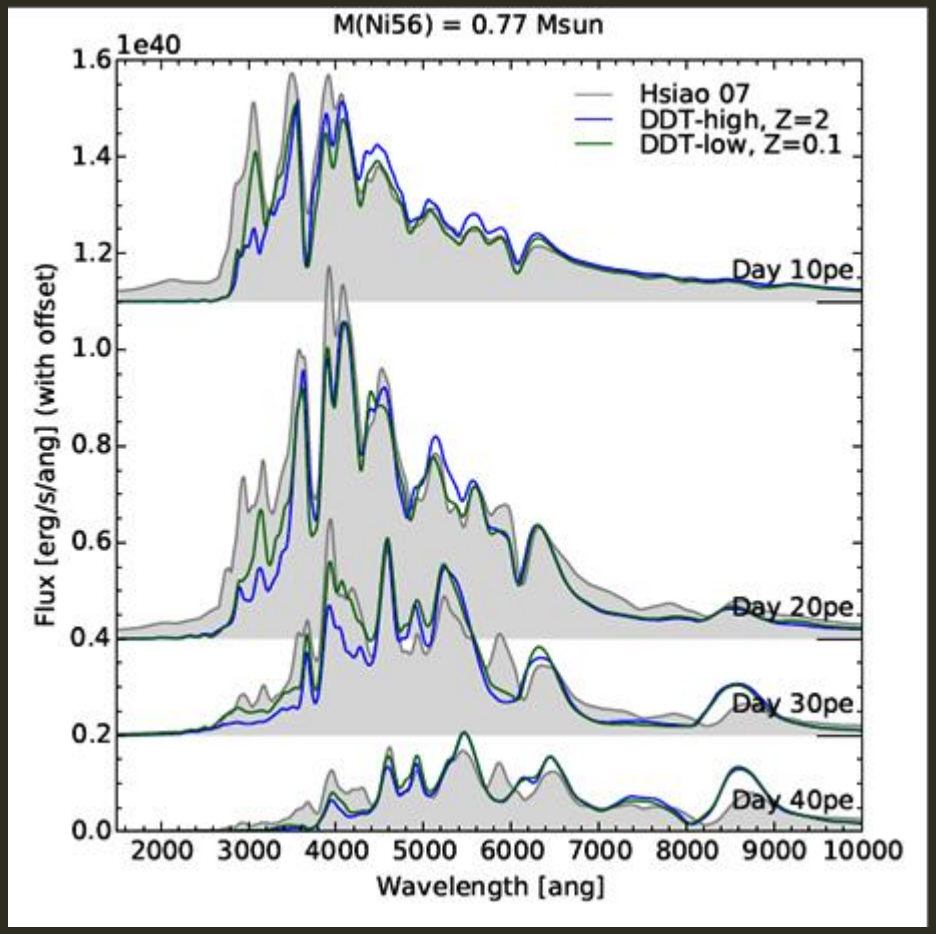
- Characteristic Si (6150Å) feature remains fairly static
- Changes with metallicity are most readily seen in days 10, 20, and 30.

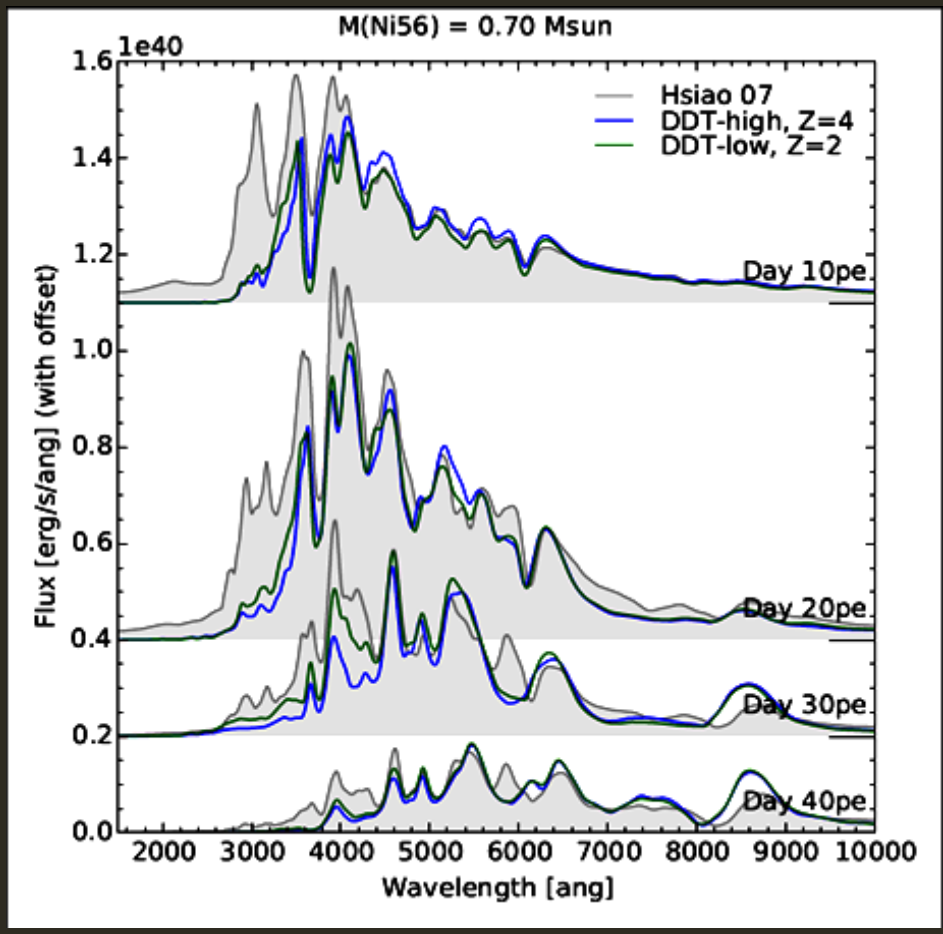


SPECTRA

- An increase in metallicity causes a decrease in ^{56}Ni production.
  - This affects the temperature of the ejecta which in turn affects spectral color
  - So how do we differentiate between temperature and abundance effects?

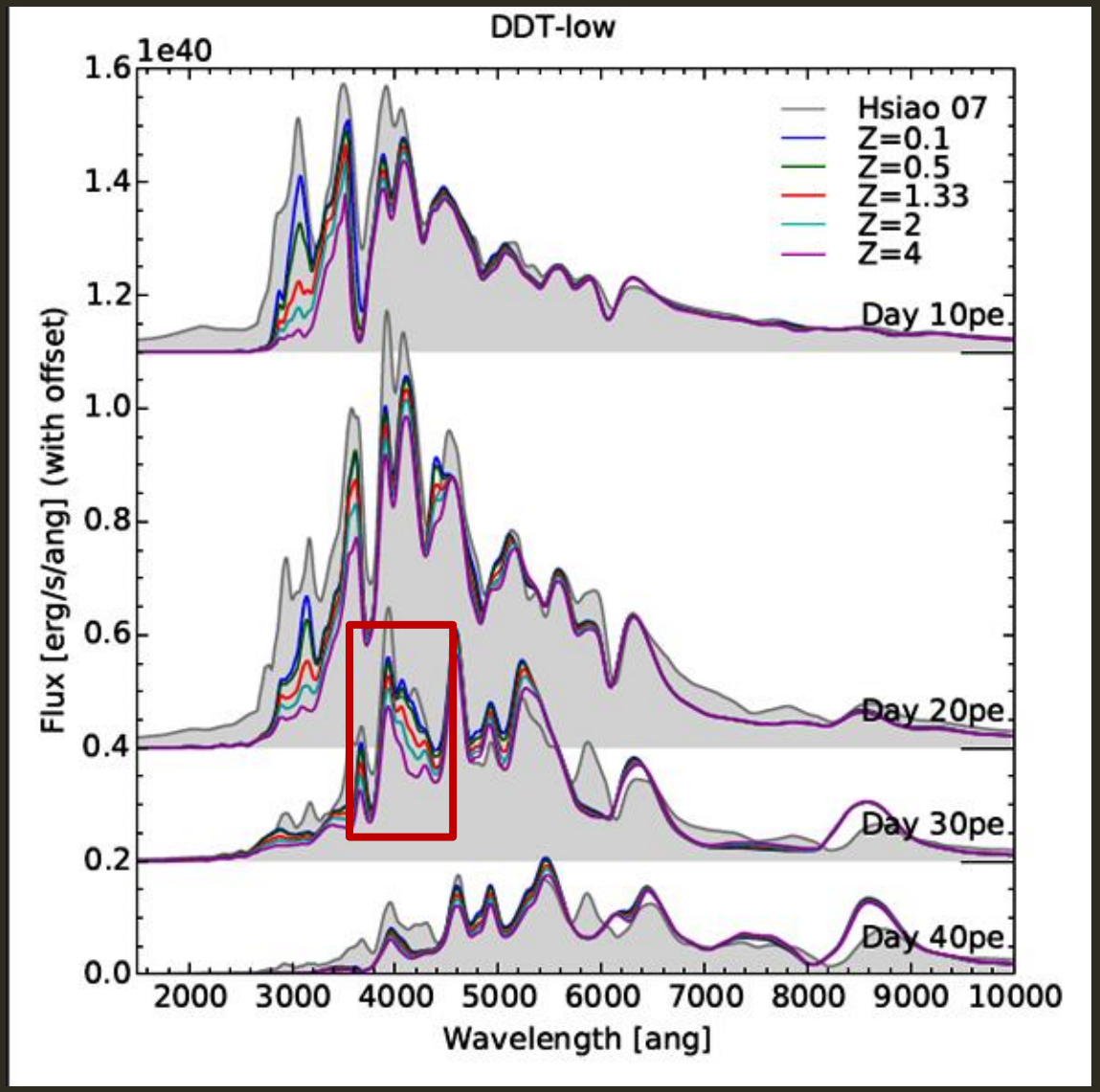
SPECTRA


M(Ni56) = 0.77 Msun
1e40
Hsiao 07
DDT-high, Z=2
DDT-low, Z=0.1
Day 10pe
Day 20pe
Day 30pe
Day 40pe
Flux [erg/s/ang] (with offset)
Wavelength [ang]


M(Ni56) = 0.70 Msun
1e40
Hsiao 07
DDT-high, Z=4
DDT-low, Z=2
Day 10pe
Day 20pe
Day 30pe
Day 40pe
Flux [erg/s/ang] (with offset)
Wavelength [ang]

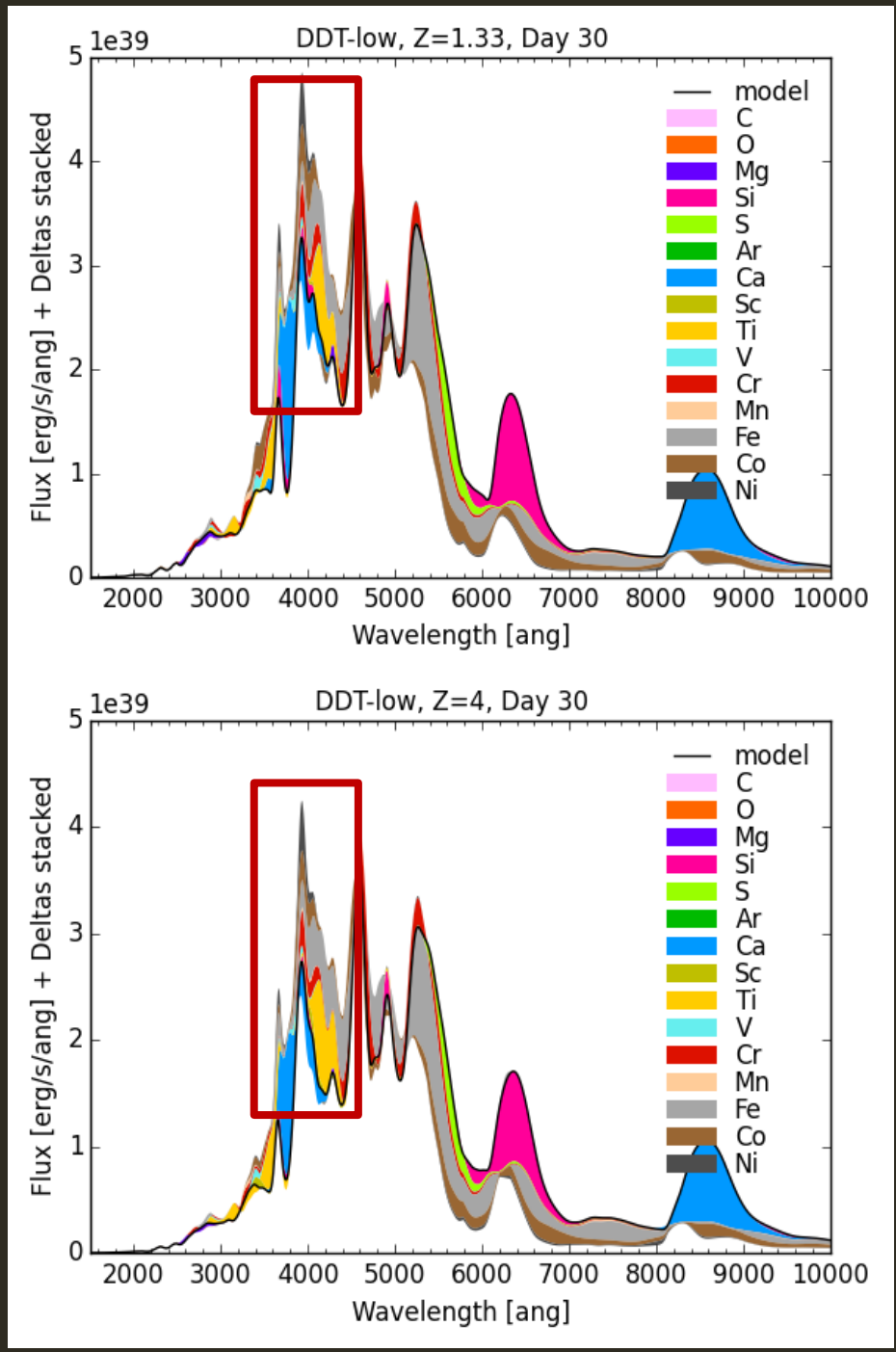
SPECTRA

- It appears at the feature around 3200 Å is being strongly affected by the change in temperature
- A feature at 4200Å at day 30 appears to be changing due to abundance changes
- What elements can it be attributed to?



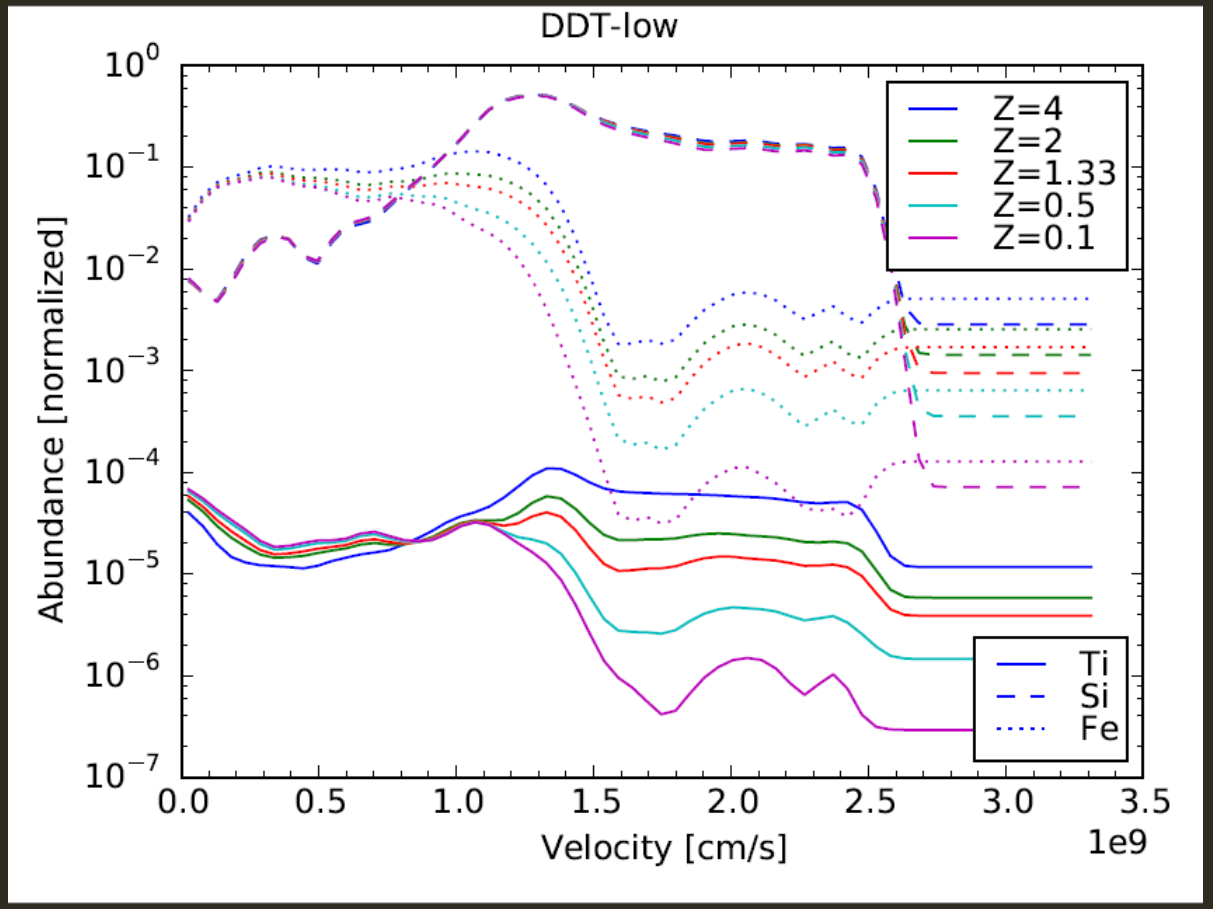
KNOCKOUT SPECTRA

- Contribution by elements
  - Above continuum: absorption
  - Below continuum: emission
- The feature at 4200 Å is most affected by the production of Ti and Fe



TI AND FE YIELD PROFILES

- Though not a very abundant constituent, Ti has a strong absorption effect
- Ti and Fe are both very sensitive to the progenitor metallicity



CONCLUSIONS

We post-processed and ran radiative transfer calculations over two, 2D simulations to attempt to find an indicator of progenitor metallicity in Type Ia supernovae spectrum

- It may be difficult to differentiate between temperature effects from ^{56}Ni production and abundance effects
- Two features from Ti and Fe at 4200 and 5000 Å provide possibilities when used in conjunction with the relatively static Si feature at 6150 Å