

# Two for one:

a long GRB and a broad lined Type Ic supernova from a single central engine

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Einstein Symposium  
October 12, 2017

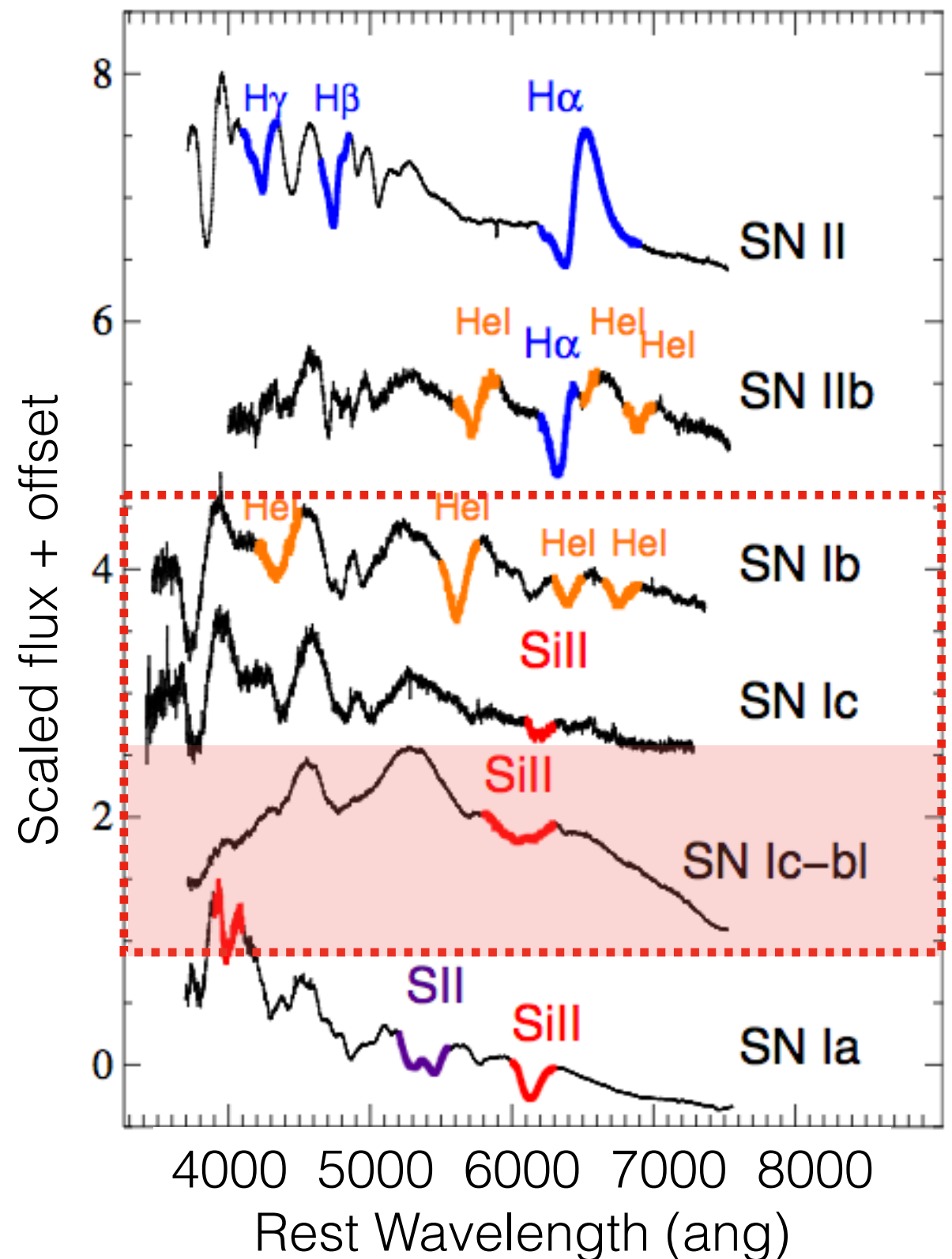
with: Paul Duffell, Dan Kasen, Maryam Modjaz, Yuqian Liu,  
Andrew MacFadyen

# SNe Type Ibc

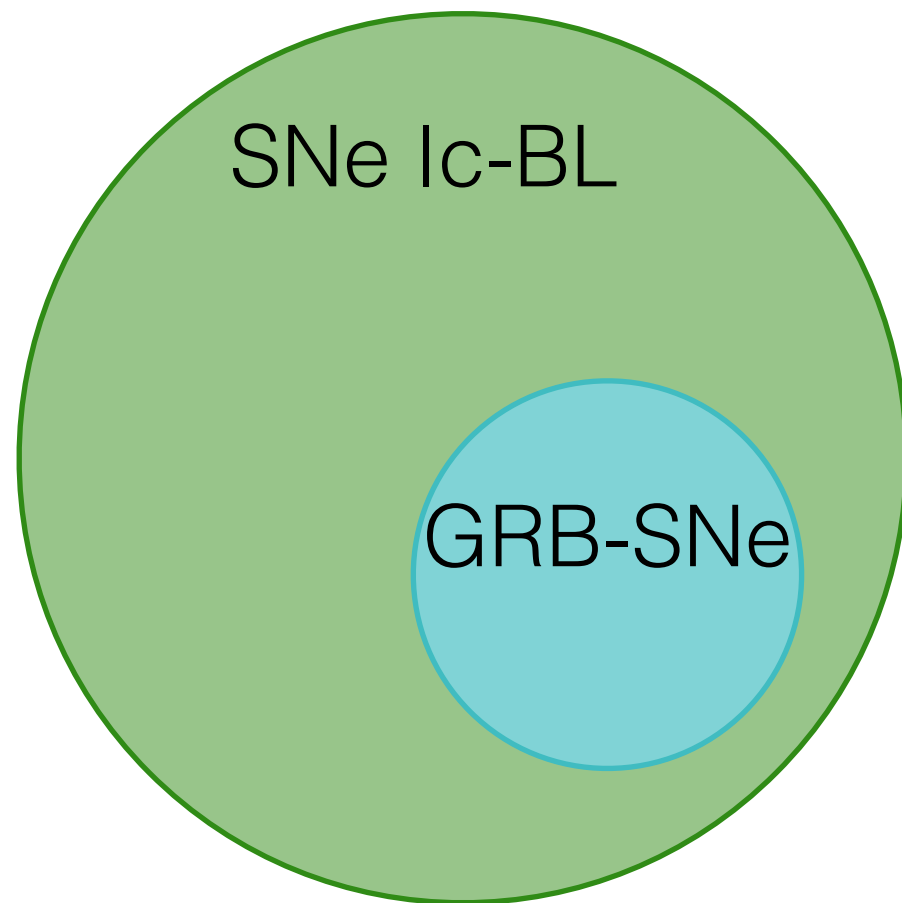
- Core collapse of stripped massive stars
- Spectra lack Hydrogen (Ib, Ic), and may lack Helium (Ic)
- Subset of SNe-Ic exhibit very broad lines and strong line-blending



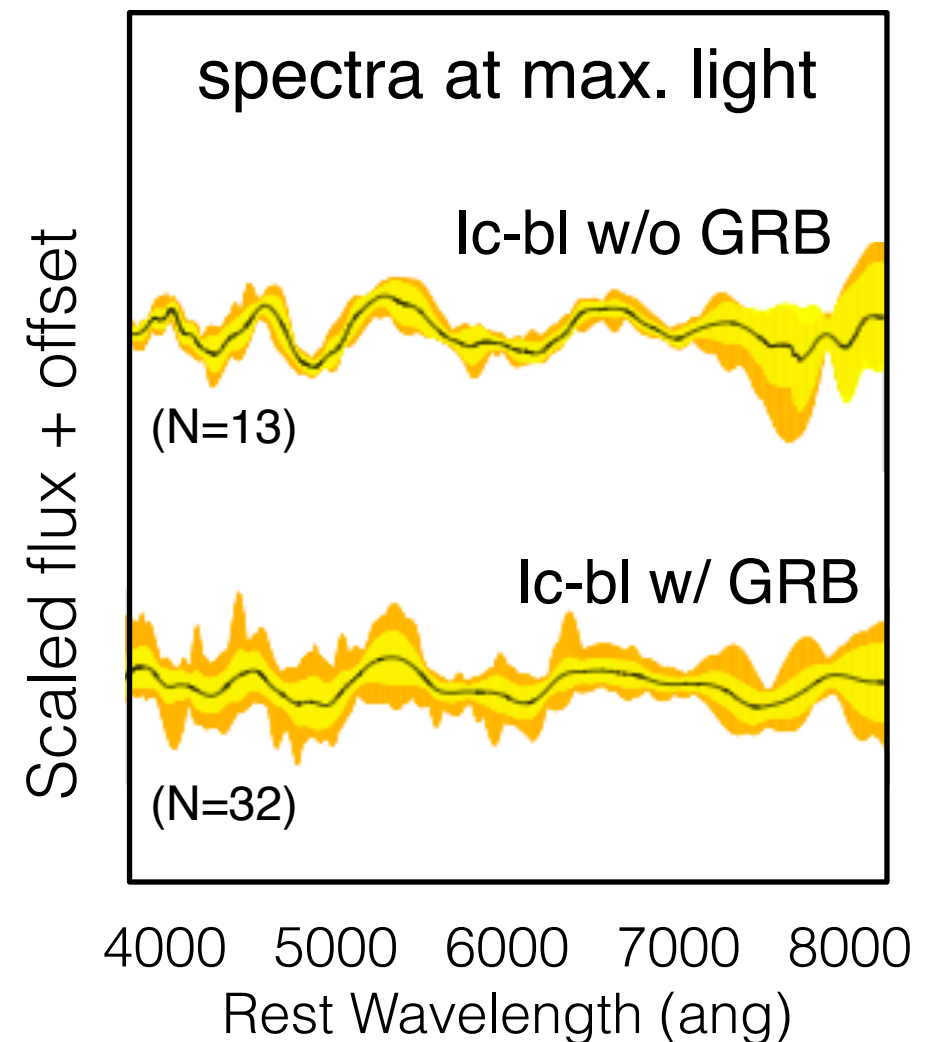
“broad-lined Ic”



# The Ic-BL/GRB connection



(not to scale!)



adapted from Modjaz+ 2016

- What is the source of the extreme kinetic energies ( $10^{52}$  erg) implied by these broad lines?
- What is the nature of the GRB/Ic-BL connection?









(Paul Duffell)





(Paul Duffell)



jet





Wolf-Rayet Star

jet



(Paul Duffell)



JET (m.m. rel. hydro)



Wolf-Rayet Star

jet

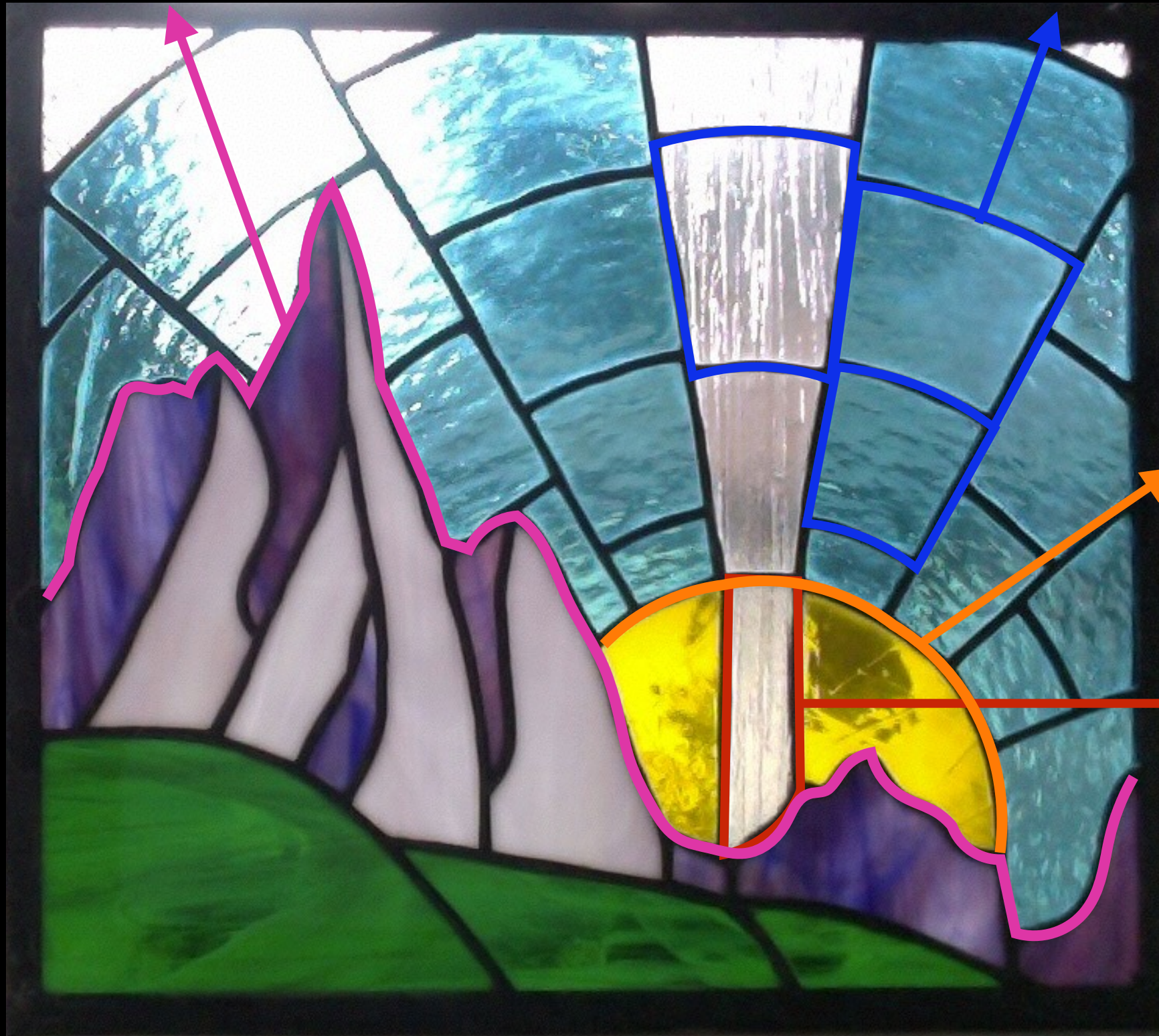


(Paul Duffell)



Sedona  
Light curves, spectra

JET (m.m. rel.  
hydro)



Wolf-  
Rayet  
Star

jet



(Paul Duffell)



Sedona  
Light curves, spectra

JET (m.m. rel.  
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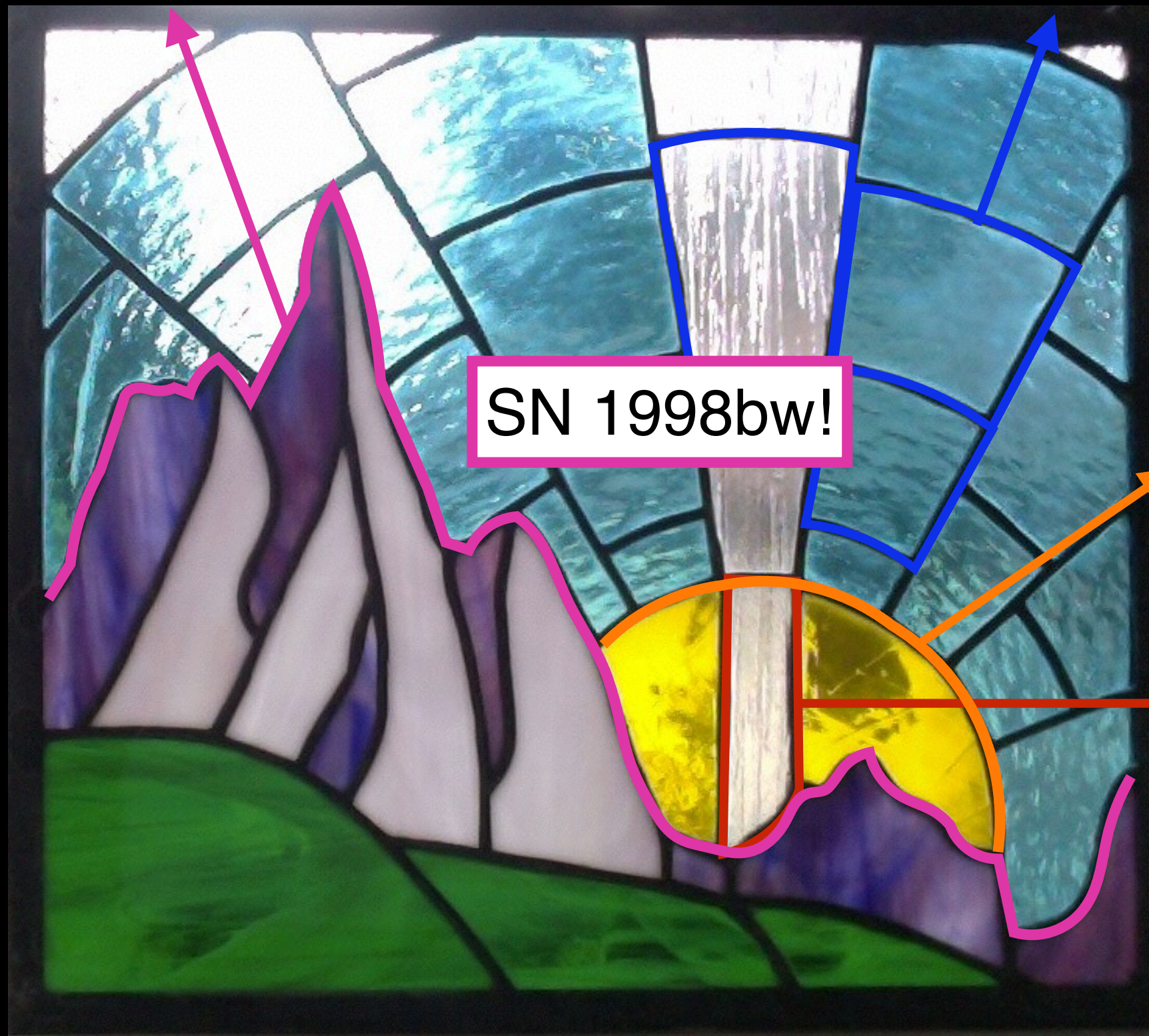
SN 1998bw!

Wolf-  
Rayet  
Star

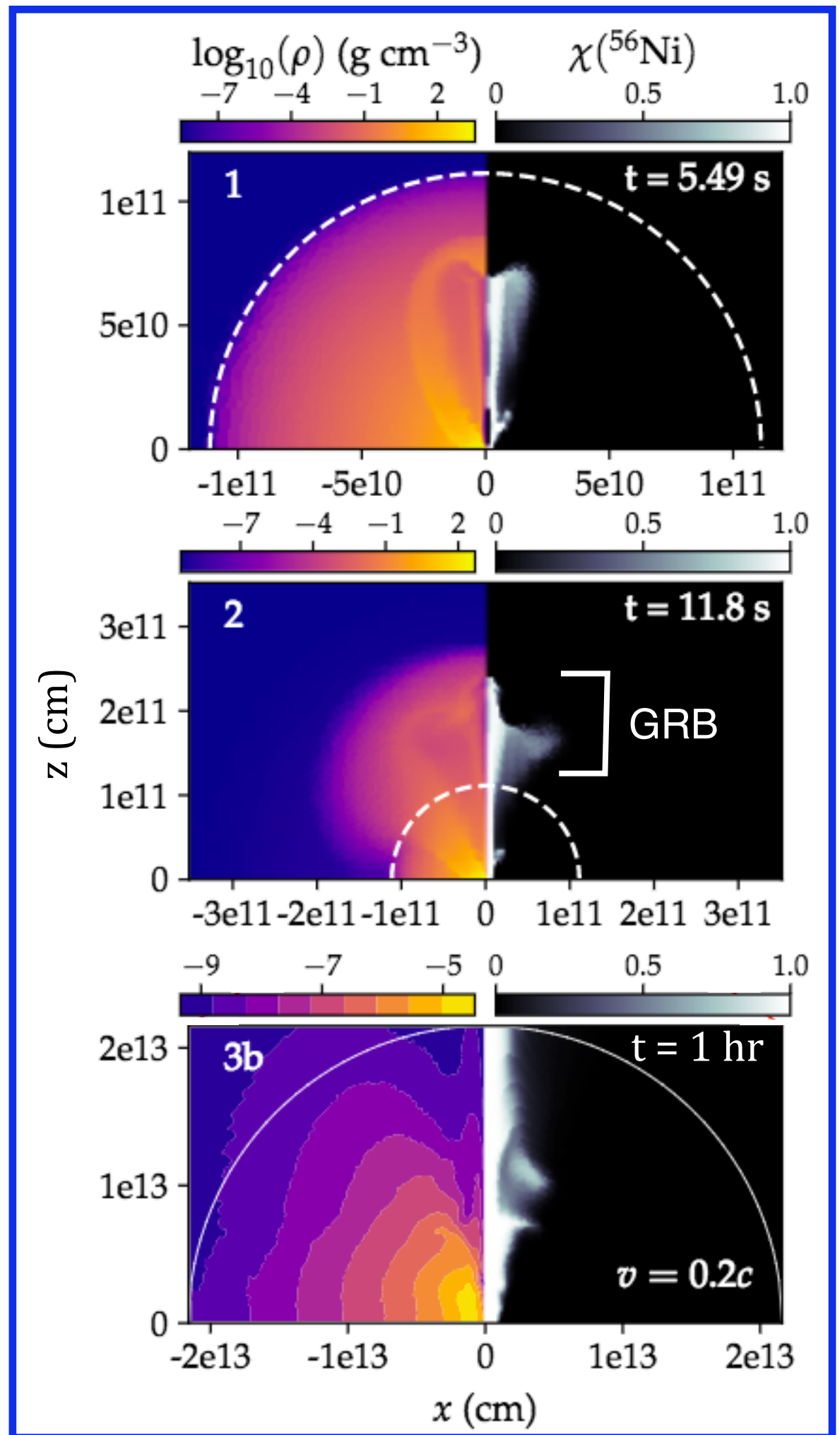
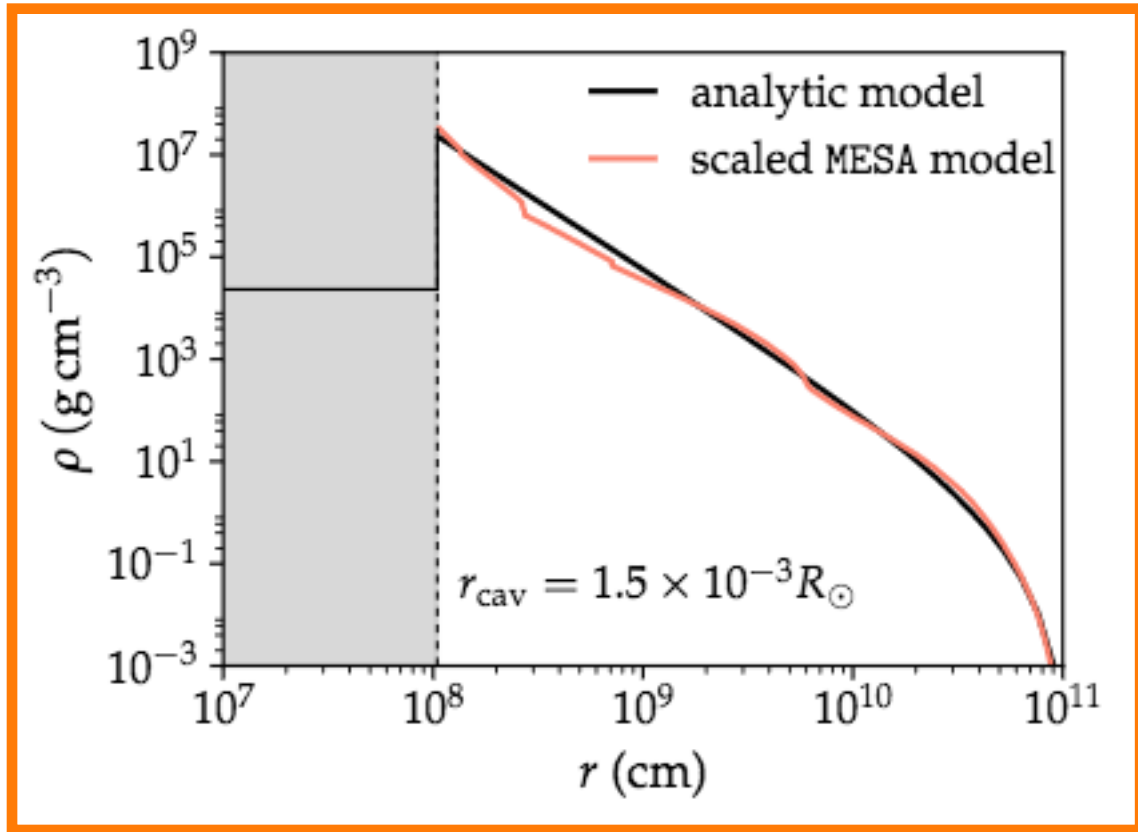
jet



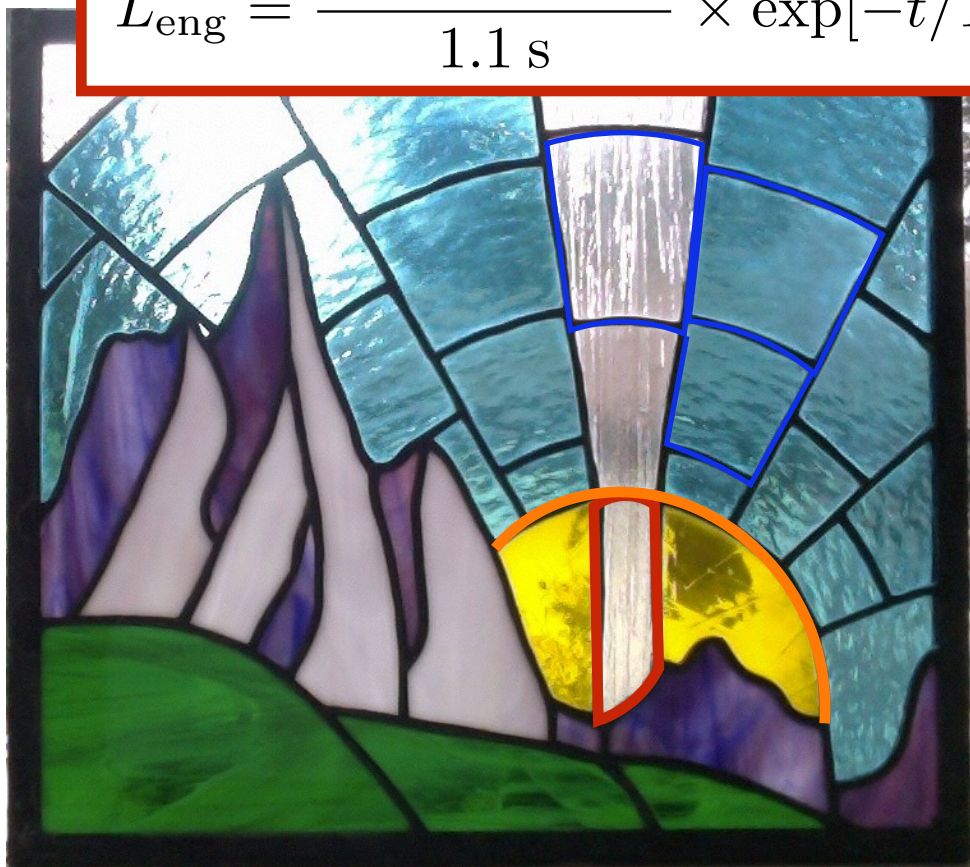
(Paul Duffell)





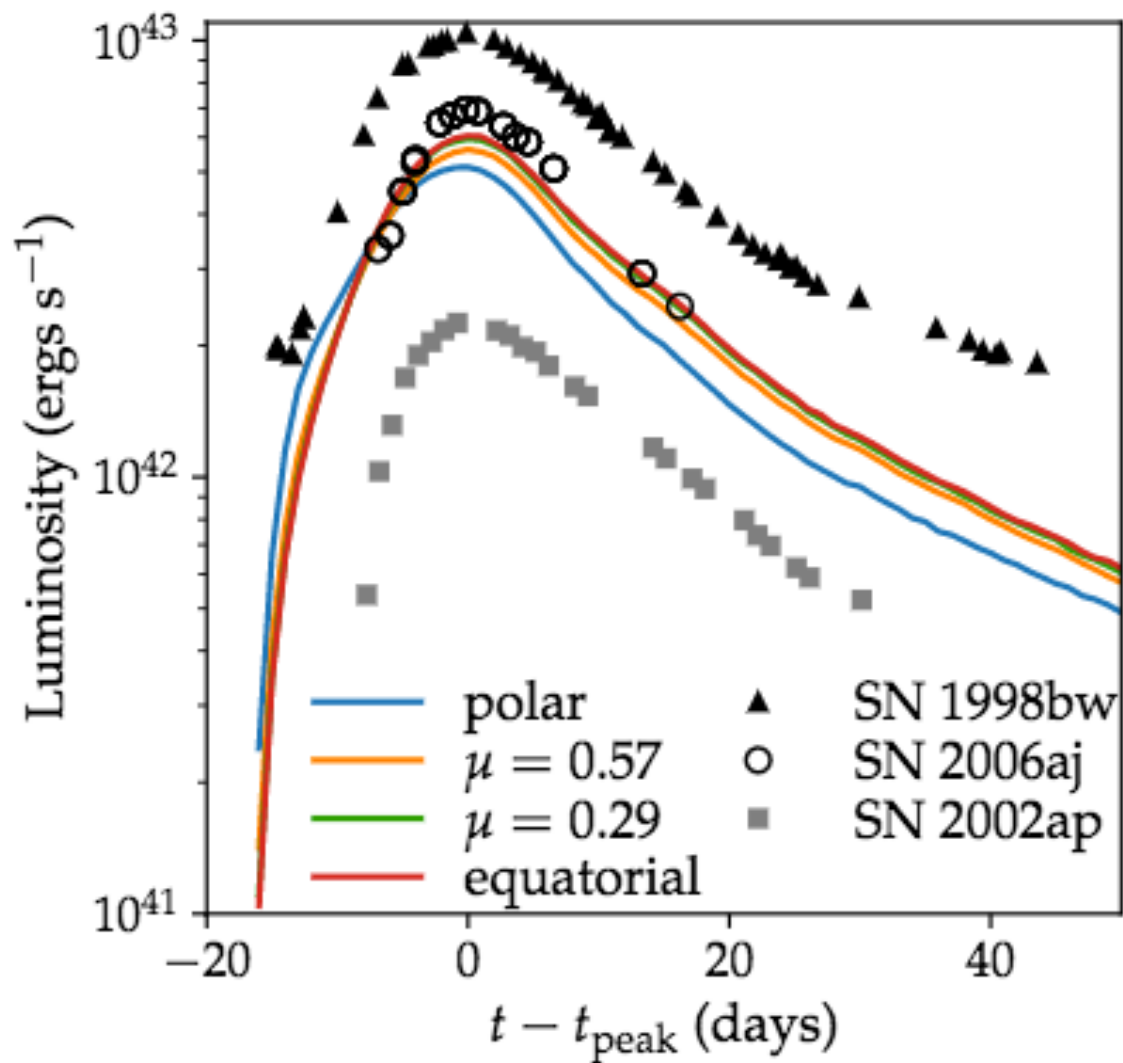


$$L_{\text{eng}} = \frac{1.8 \times 10^{52} \text{ erg}}{1.1 \text{ s}} \times \exp[-t/1.1 \text{ s}]$$

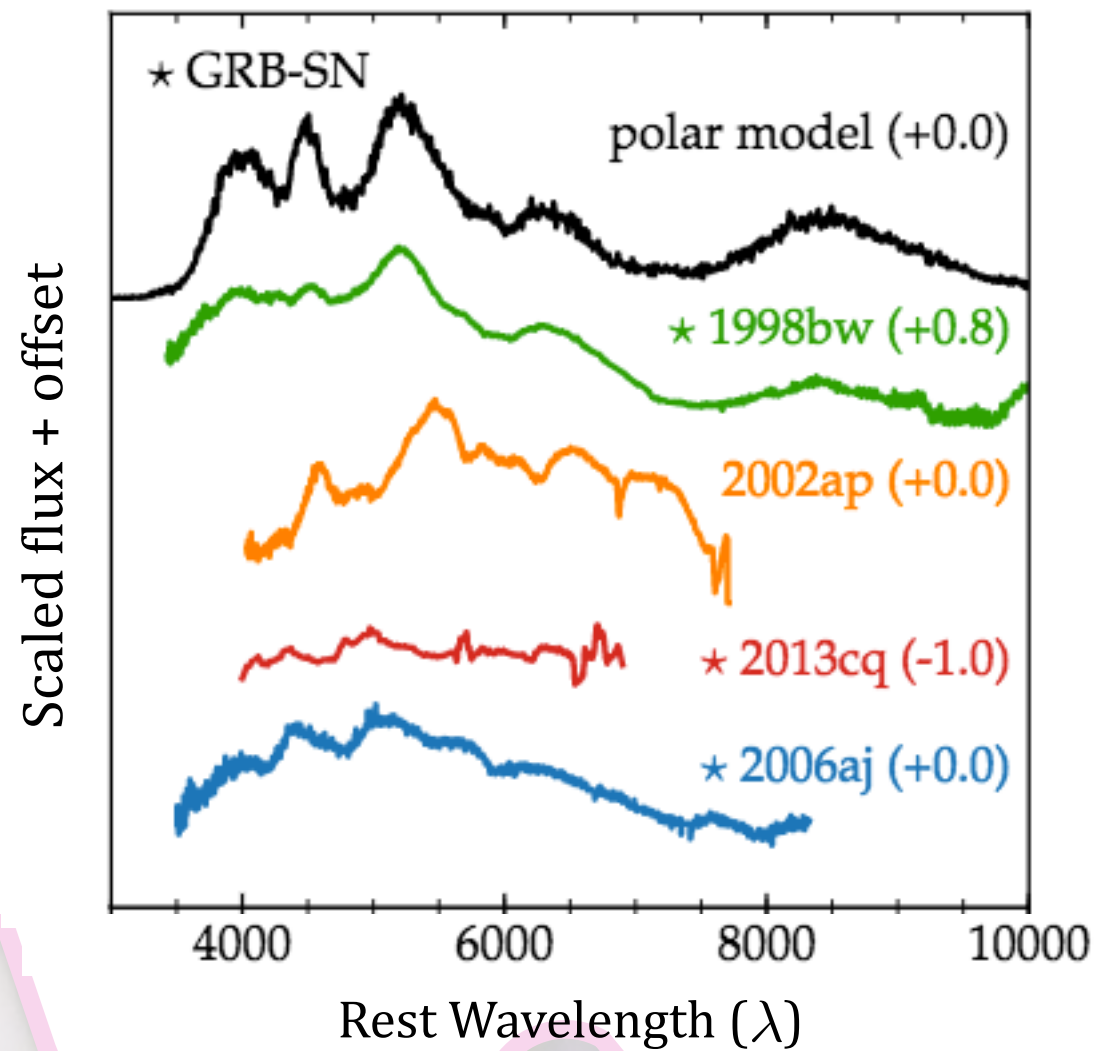




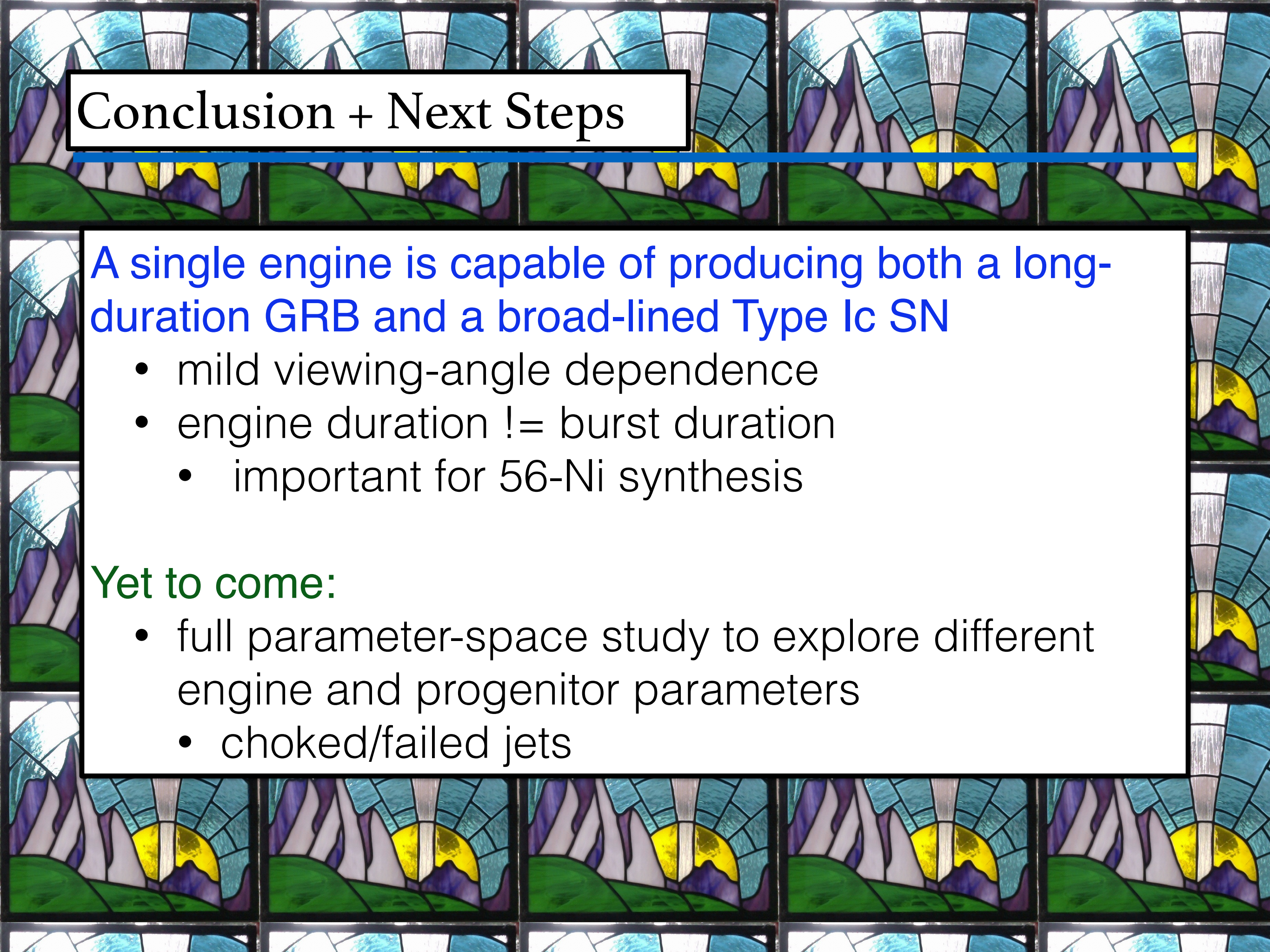
# Bolometric light curves



# Spectrum at peak







## Conclusion + Next Steps

A single engine is capable of producing both a long-duration GRB and a broad-lined Type Ic SN

- mild viewing-angle dependence
- engine duration  $\neq$  burst duration
  - important for  $^{56}\text{Ni}$  synthesis

**Yet to come:**

- full parameter-space study to explore different engine and progenitor parameters
  - choked/failed jets