# LANL Light-Curve Effort

Chris Fryer, John Dahl, Chris Fontes, Lucy Frey, Aimee Hungerford, Tim Kelley, Gabe Rockefeller, Todd Urbatsch + Paolo Mazzali, Stefan Immler (and Swift team – Brown, Bufano, Holland, Milne), Joggerst, Whalen, progenitor collaborators…

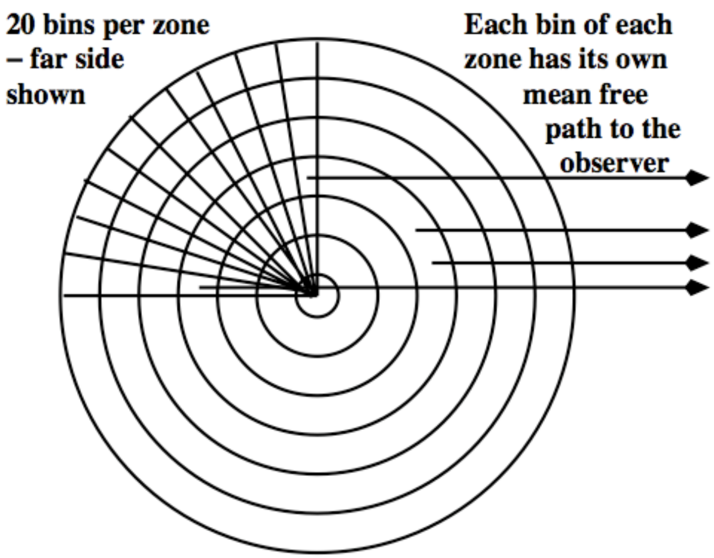
- LANL Code and Process
- Radiation-Hydrodynamics
- Applications
- Issues to work on

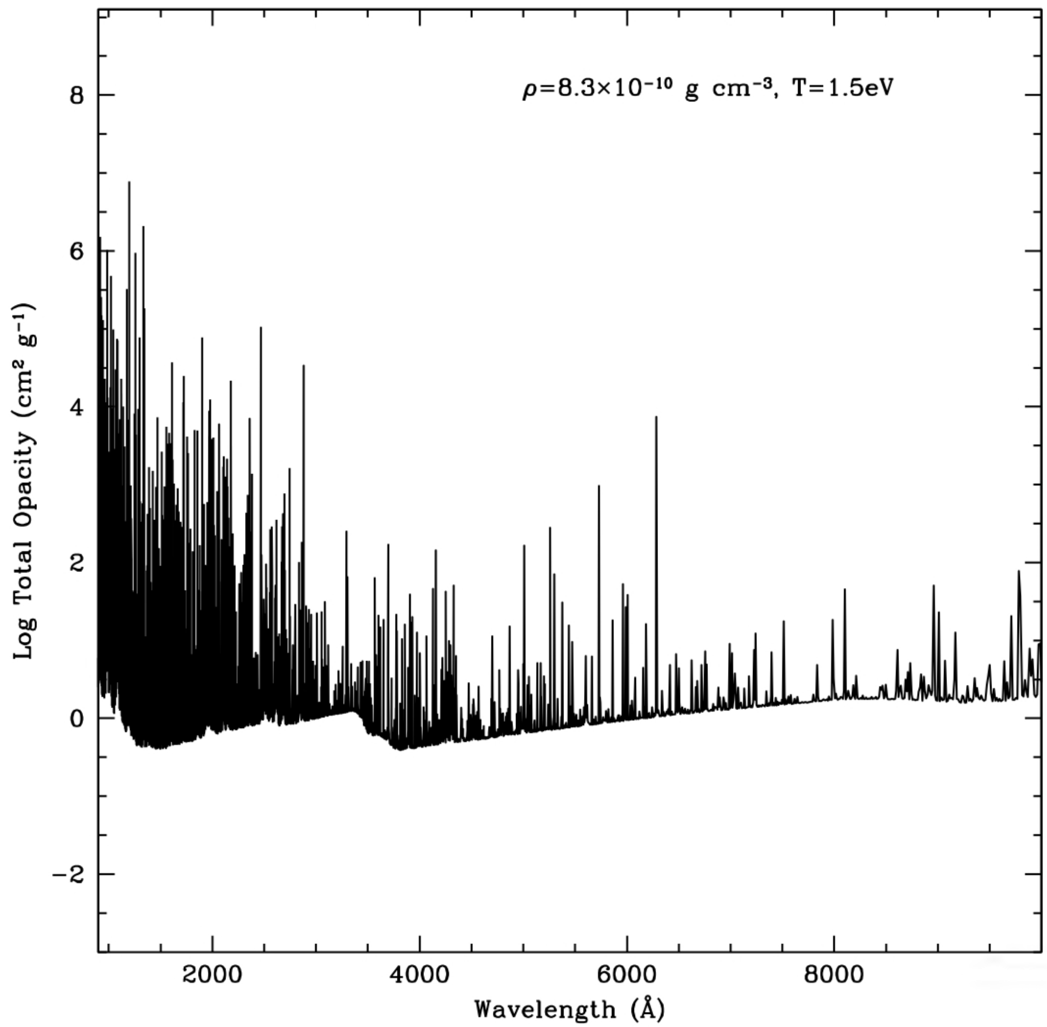
# Precision Models of Supernova Spectra

Precision measurements require advanced codes: Here's than LANL approach

- Leverage off of LANL's 1-,2-, and 3-dimensional Radiation Adaptive Grid Eulerian (RAGE) code: an AMR code with flux-limited diffusion radiation transport
- LANL atomic opacities
- Added $S_n$ transport for gamma-rays
- Now running production runs in 1-dimension
- "embiggening" feature in code
- Studying NLTE effects
- IMC capability
- Ideal when shock heating important (can't be done in simulations assuming matter/ radiation equilibrium)

# Post-process includes detailed LANL opacities

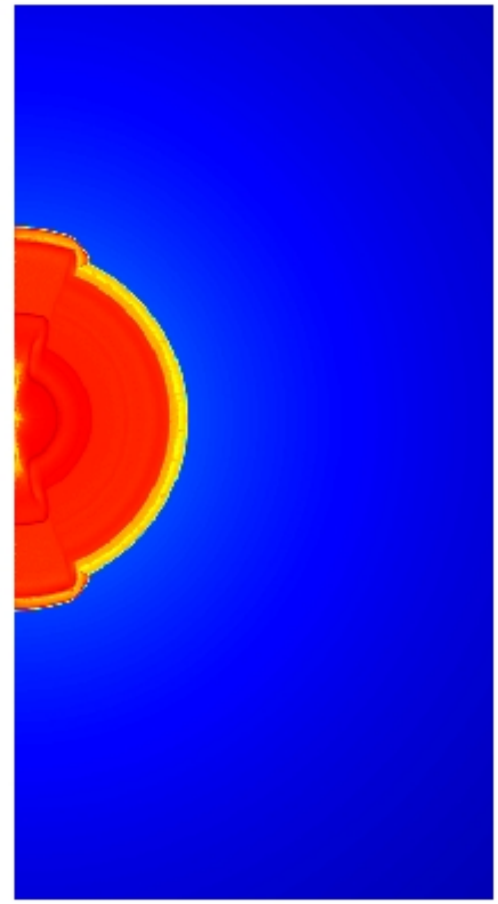



But we are still assuming the atomic levels are in equilibrium!

# Modeling with Roadrunner

- LANL (Tim Kelley) has ported IMC to the cell architecture on Roadrunner (domain decomposed, diffusion/IMC), allowing us to use Monte Carlo transport. Now running 2D simulations.
- Multi-dimensional radiation hydrodynamics with Implicit Monte Carlo on heterogeneous machines with Roadrunner eliminates post-process.
- This experience places LANL in an ideal position to help others port codes to heterogeneous machines.



Code team: Densmore, Hungerford, Kelley, Rockefeller, Thompson, Urbatsch

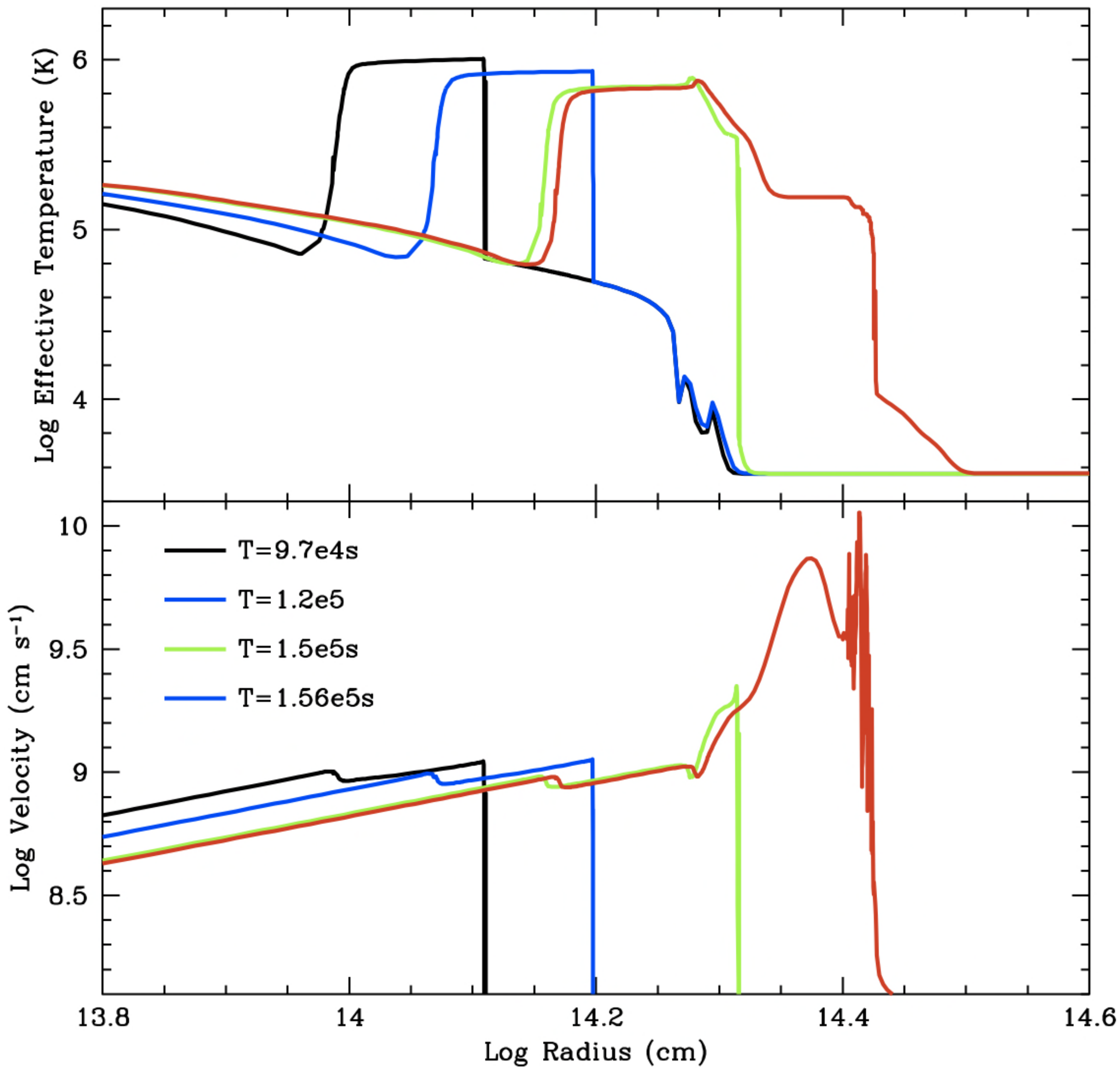
# Collaboration on SciDAC

This effort is very similar to the rad-hydro efforts at CAC (Howell, Kasen). But 2 efforts have many benefits.

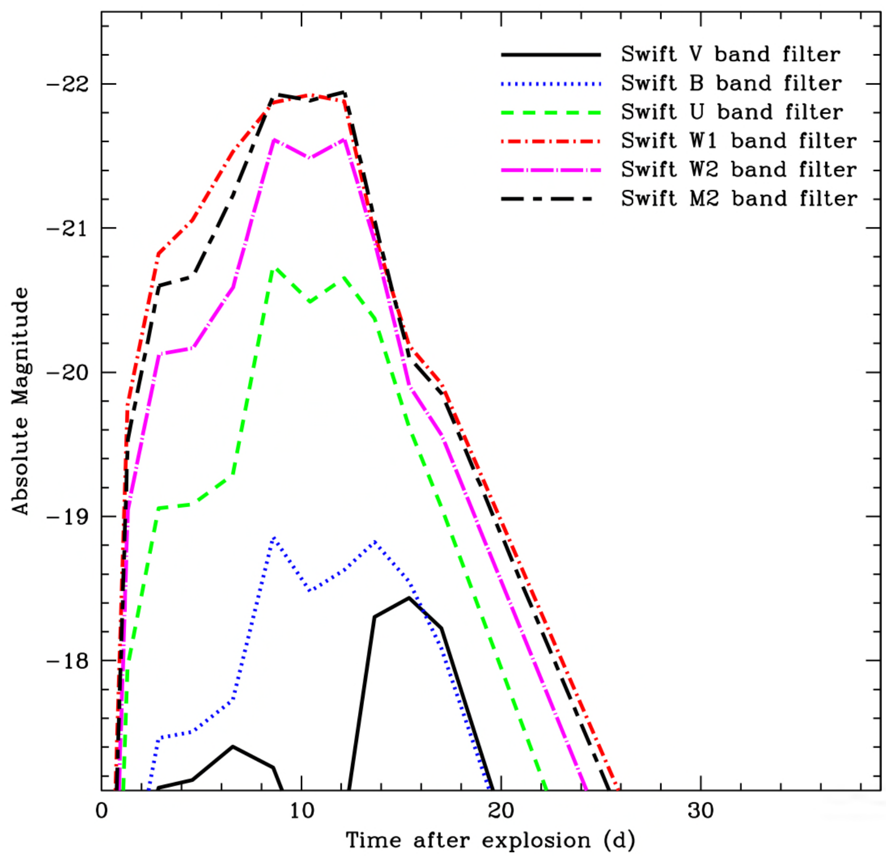
- Radiation-Hydrodynamics for photons is not trivial. Two groups, communicating, will solve issues faster (e.g. instability issues, opacities, …).
- Code Comparison
- Ties the SciDAC more strongly with ASC interests – there are a number of technology transfer opportunities (both directions) with NNSA/ASC.
- Opens up obvious ties for joint student/post-doc projects

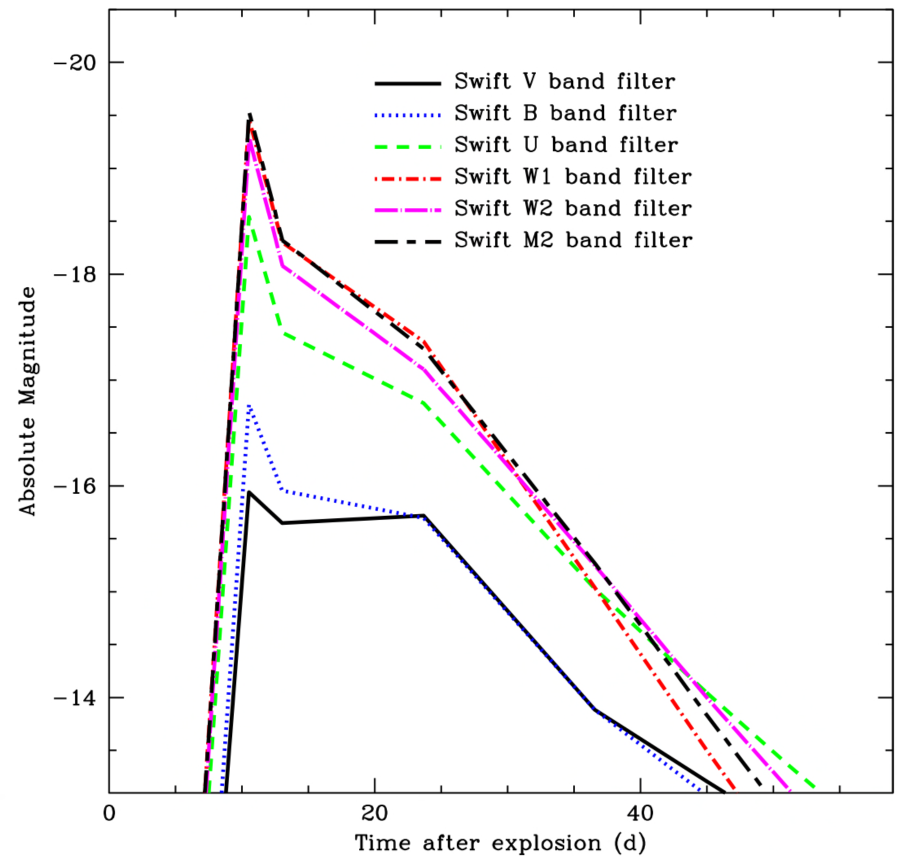
# More Shock Breakout Features

- Even when the radiation is trapped, it can lead the shock – the shock position moves faster than Sedov solution would predict.
- Just after breakout, the radiation begins to decouple from the material.



# What do AICs Look Like? It depends on surroundings and explosion energy.

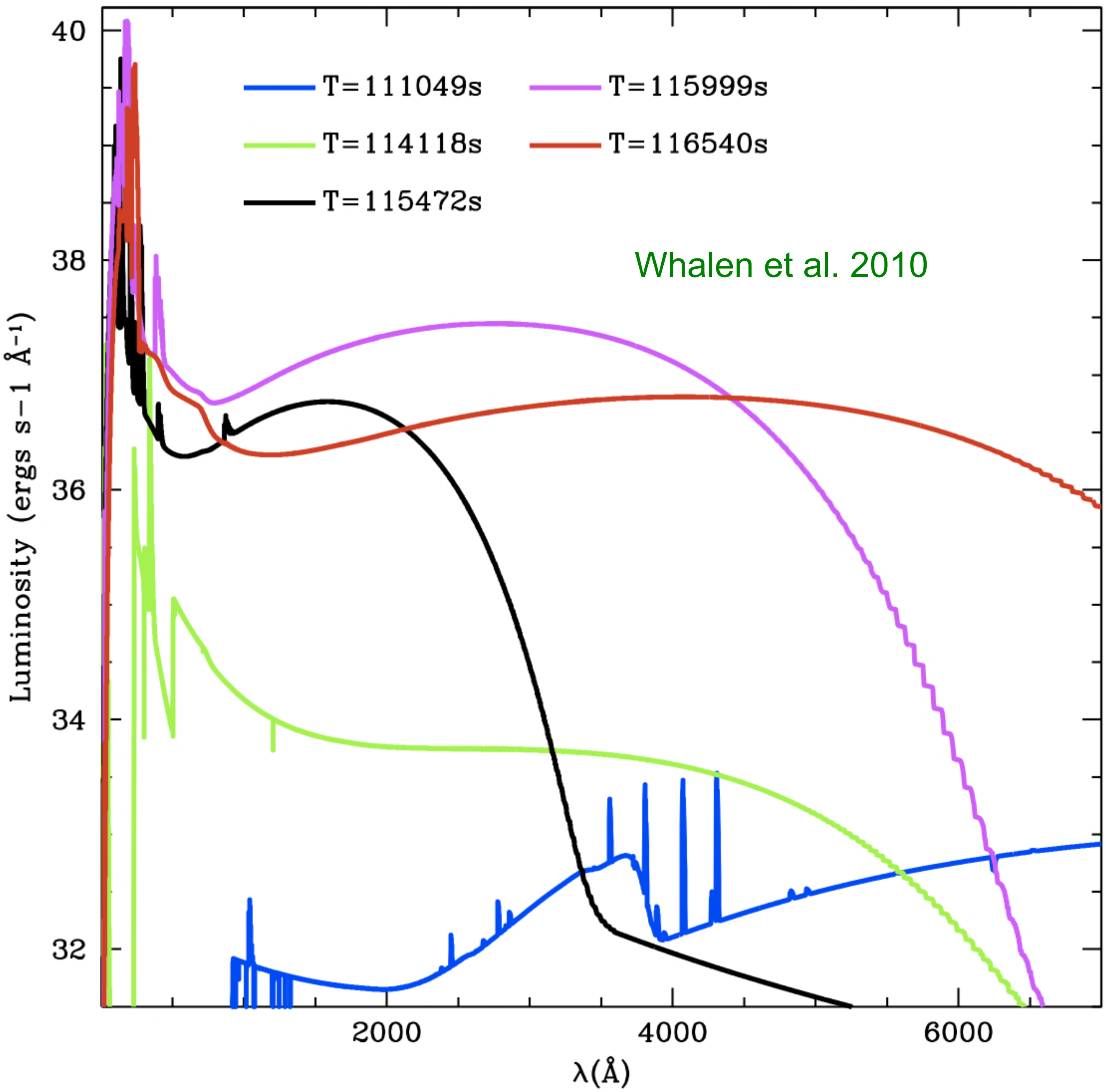


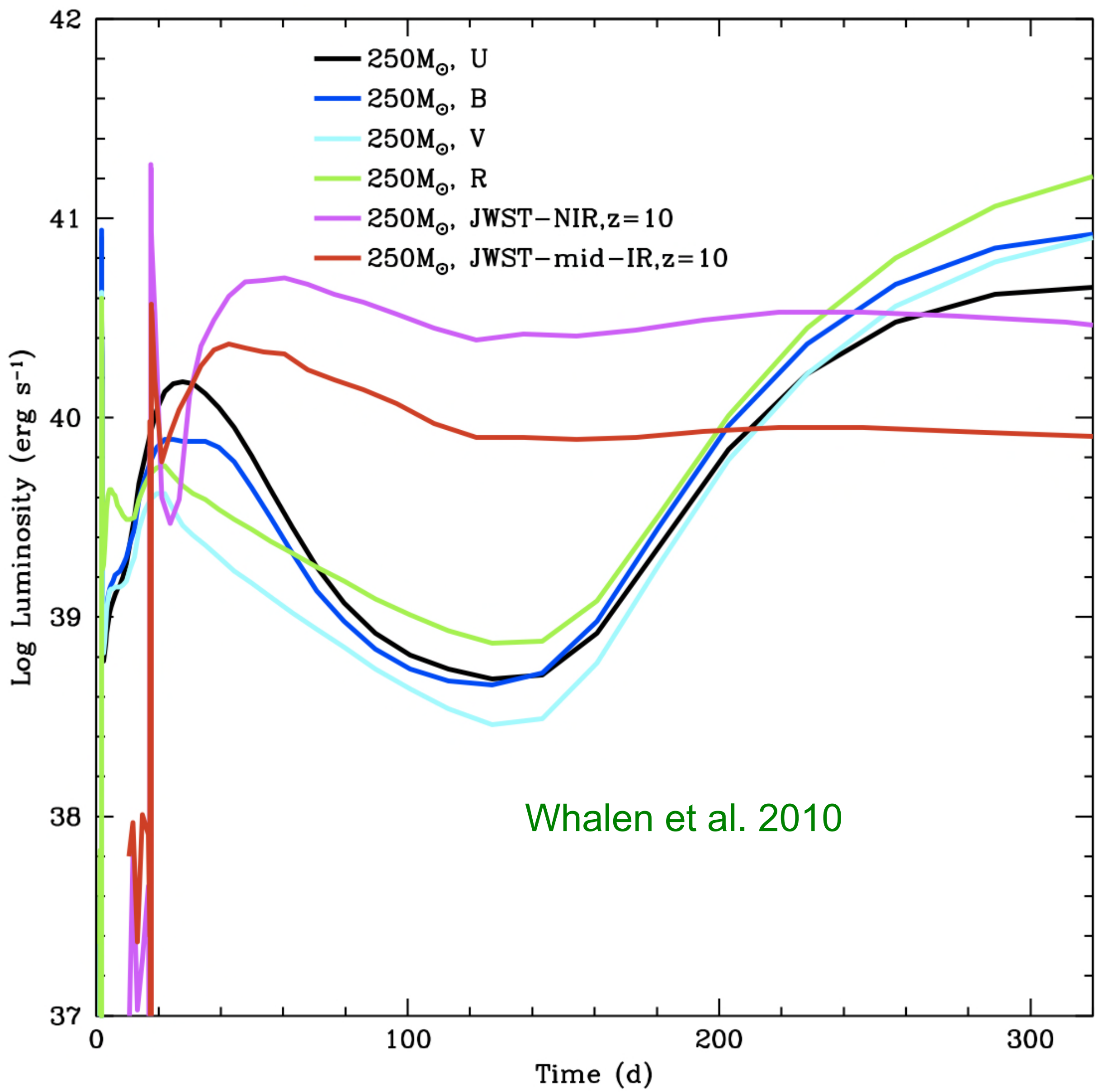

Fryer et al. 2009

# First Stars Breakout Spectra

- The breakout spectra evolve rapidly as the front cools (need higher resolution in our post-process)

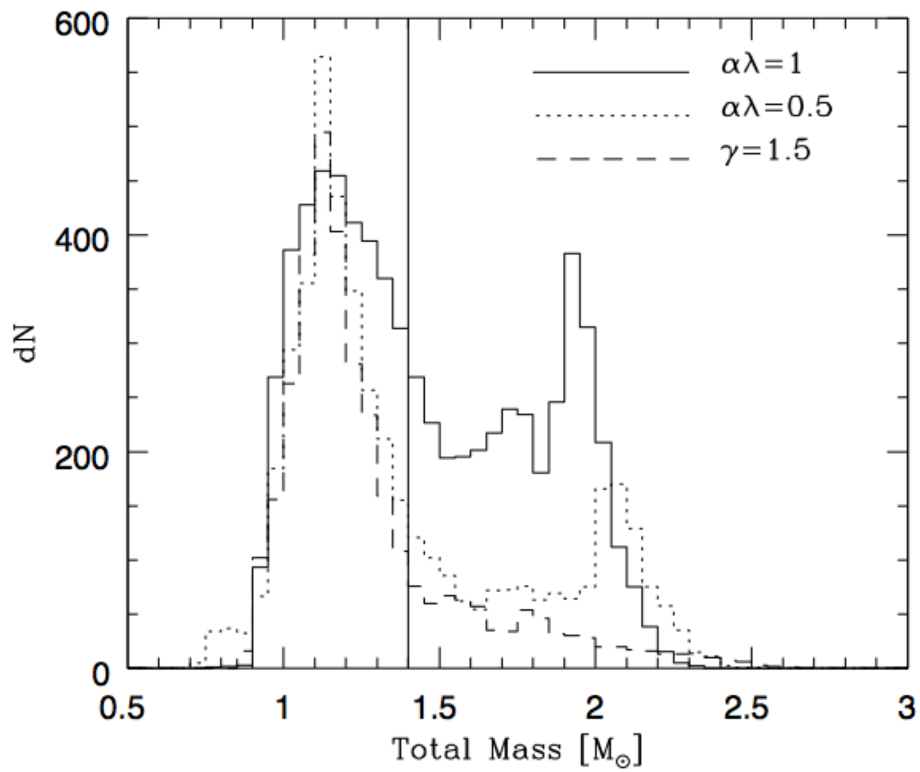


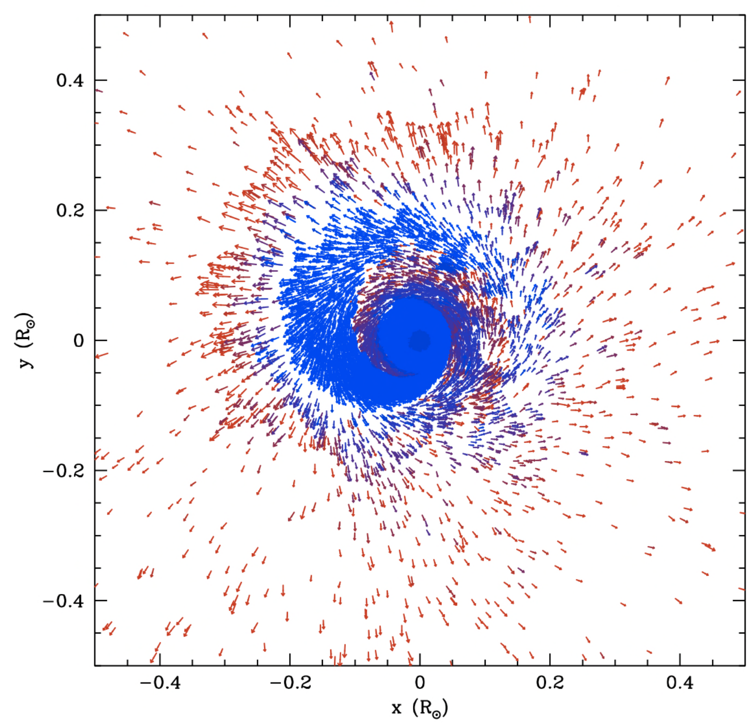
- Long term light-curve evolution:
  The burst at z=10 is both stretched and reduced by the Ly-$\alpha$ forest. Such bursts may be difficult to detect in transient searches.



# CO Mergers as Type Ia progenitors

- Population synthesis predicts much higher rate of CO mergers than any other progenitor.  But these mergers tend to have system masses well in excess of the Chandrasekhar mass.
- Merger calculations produce broad debris distributions (LANL working with both LSU and ASU to calibrate mergers).

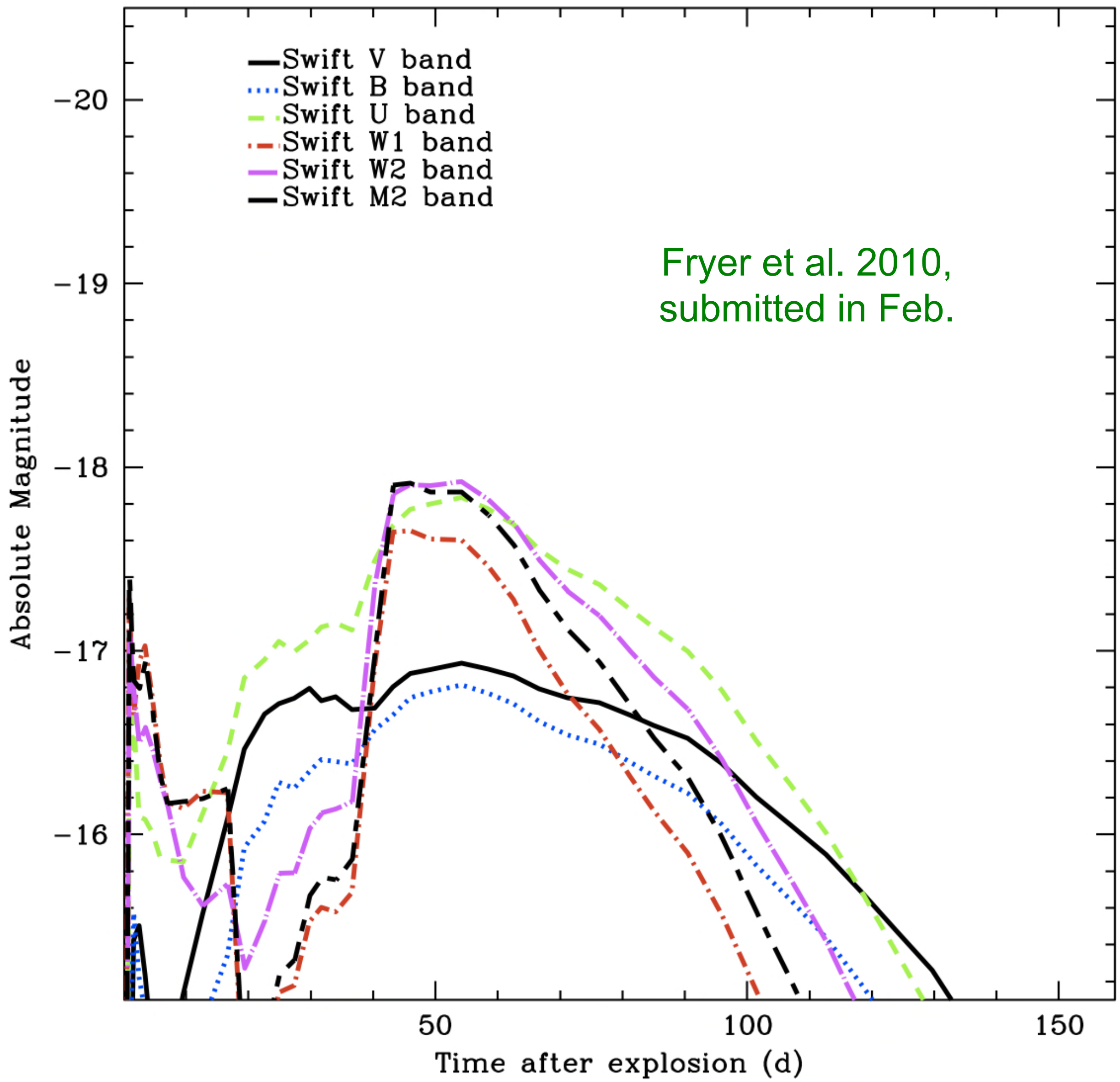



Fryer et al. 2010

# CO merger Ia LCs

The light-curves of enshrouded type Ias produced in CO mergers do not fit the current set of observations: populations synthesis could be wrong.



# Issues

- At breakout, the matter/radiation coupling is rapid – must be careful with our operator split coupling for radiation-hydrodynamics.
- Diffusion plus free streaming regimes: solved by having a diffusion Monte Carlo scheme. However, most of the energy is in the diffusion region – we must strongly weight the packets to get reasonable resolution above the photosphere.
- Atomic level states are not in equilibrium – working on new set of opacities (at least 2 temperature).
- …