Sorry I couldn’t make it. Blame Delta. Thanks to Jeremiah for presenting.

A couple new results concerning mergers (less ambitious than my abstract because I’m not there):

- transients from mergers (V1309 Sco, V838 Mon, and NGC4490-OT)
- Eta Car and its eruptive history from proper motions
Background: Examples of Stellar Mergers in the Milky Way

**V1309 Sco**  
Tylenda et al. 2011

Pair of solar-mass stars in eclipsing binary that were observed to merge.

Produced bright nova-like transient (-7 mag) lasting several weeks.

Very dusty aftermath

**V838 Mon**  
Bond+03, Sparks+08, Munari+ 2002, 2007

Another likely stellar merger. More massive stars (B star) based on small cluster of B stars, and B-type companion engulfed by expanding dust.

More luminous (-10 mag) transient lasting 3 months. Irregular, multi-peaked light curve. Spectacular light echo.
Something new:
Bally: Please feel free to interject!

HST archive = progenitor.
Luminous, blue, unobscured star.
At least $10^5$ Lsun.

Irregular multi-peaked light curve, similar to V1309 Sco and V838 Mon.

We suggest similar mechanism (merger): Longer duration = more energy = more massive stars merging.
Spectral evolution of transient also very similar to V838 Mon (except stronger Halpha). Also similar to Eta Car light echoes (Rest et al. 2012).

Very asymmetric Halpha emission at late times. Strong asymmetry? One sided?
Perhaps most important:

Very late time IR source seen by Spitzer (red SED at left) was as luminous or more than progenitor (blue at left). (Best guess is ~2x more luminous.)

Too late, too hot, and too unchanging to be an IR echo.

Star survived as heavily dust enshrouded luminous star, just like V1309 Sco and V838 Mon…. and Eta Car.

Was Eta Car a merger too?
If NGC4490-OT was a massive stellar merger, there are implications things worth noting:

1. Most massive stellar so far (recognized as such, although there may be many others).

2. V1309 Sco, V838 Mon, and NGC4490-OT seem to suggest a trend – with increasing stellar mass we get brighter transient and longer duration. This makes sense. More massive stars = more orbital energy to dissipate; more ejected mass = longer diffusion time. Kochanek et al. 2014 already claimed that mergers are common, and noted the trend in peak luminosity with increasing mass among sample of lower-mass objects.
Eta Carinae as a Merger

Hmmm… much to discuss. Too much data. This could be a separate talk (and it is: Simon Portegies Zwart).

On some days, I like the idea of Eta Car's 1840s eruption being a merger or collision of some sort:

1. Nice way to get 1e50 erg, non-terminal explosion.
2. Very asymmetric nebula.
3. Spectra, post-outburst dust enshrouded state, irregular multi-peaked light curve... resembles mergers.
Eta Carinae as a Merger

Hmmm… much to discuss. Too much data. This could be a separate talk (and it is: Simon Portegies Zwart).

On some days, I like the idea of Eta Car’s 1840s eruption being a merger or collision of some sort:

1. Nice way to get 1e50 erg, non-terminal explosion.
2. Very asymmetric nebula.

On other days, I am bothered by these points:

1. It is still a binary, and the well known orbital period now seems to have been almost the same before the 1850s.

If it was originally a hierarchical triple, it had to survive that way for at least 3 Myr. This is a POST main sequence object, very N-enriched.

2. It has done this before.
   (Next slide)

Note that with L=R^2T^4, the stellar photosphere during eruption was bigger than the periastron separation. Hmmm…Collision?

Extrapolated times of periastron (red = 5% shorter period… it lost 15 Msun). Hmmm…. 
Eta Carinae as a Merger

Work led by my student Megan Kiminki as part of her PhD thesis, with help from the other Megan (Reiter, in the audience). Paper to appear soon: Kiminki, Reiter, & Smith (2016)

Proper motions in HST images. Color coded vectors show speed and ages as function of locations.

Major eruptions before the 1843 eruption:

Red = early 19th century (could be from 1843 but decelerated…maybe…)

Green = mid 16th century.

Blue = mid 13th century.

Seems to have very different geometry in previous eruptions.

Bottom line: If the 1843 eruption was a merger, then what caused the earlier events?
LBVs and their role in single-star evolution

STANDARD SINGLE-STAR PARADIGM:

Early O type → LBV → WN → WC → SN Ibc

LBVs are supposedly at the end of the main sequence, before He burning.
O stars behave as expected. More massive ones are more clustered.

WR stars are evolved and skewed to right – as expected. WN younger than WC.

LBVs don’t behave as expected. They should be in between O stars & WN… but they are as dispersed (or more so) than WC stars.

B[e] supergiants are also much more dispersed than expected from their high luminosity.

This long-held paradigm is wrong:

Early O type → LBV → WN → WC → SN Ibc
LBVs must have very long lifetimes (>>3Myr). How can this be?

More massive

Mass gainer
Increases M, L, spins up, becomes N-rich, etc.

Mass loser
RLOF strips H envelope

WR star? or low-L, weak-wind He core

becomes an LBV (eventually)
Rapid rotator, longer lifetime, weird core/envelope mass,
Could be single after SN#1

Might get a kick.

Supernova
Type Ib/Ic

Supernova
Type IIln (?)

Many implications:

Age & mass inferred from single-star models will differ from surrounding stars. (Mass gainers are rejuvinated)

Mass gainer may become an LBV after a delay. Donor (SN Ibc prog) hard to detect.

Same $M_{ZAMS}$ / different fates.

Asymmetric CSM.

Is binarity linked to the physical mechanism of LBV eruptions?