Finding Hidden Supernovae with Laser Guide Star Adaptive Optics on Gemini

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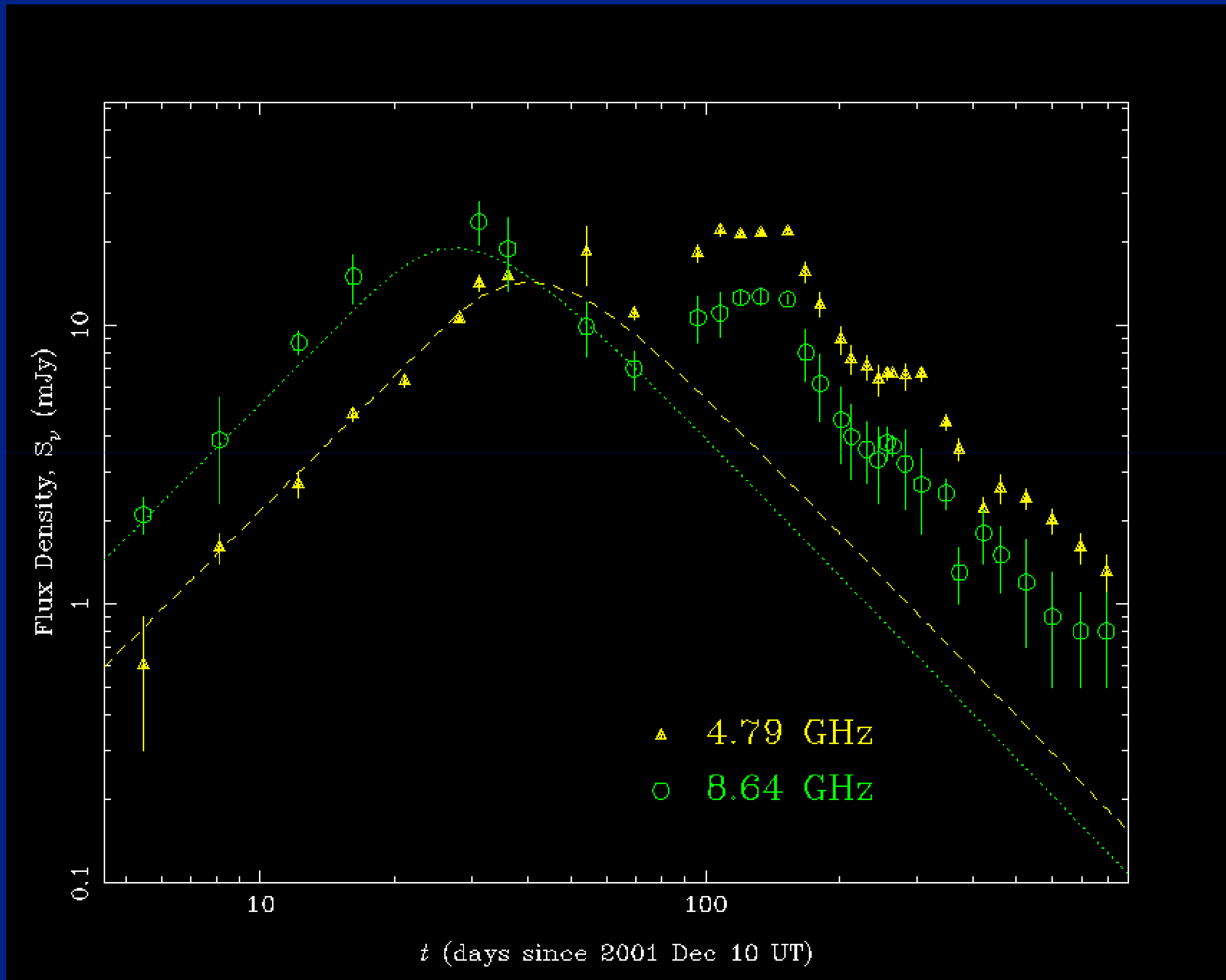
Where are all the missing SNe?

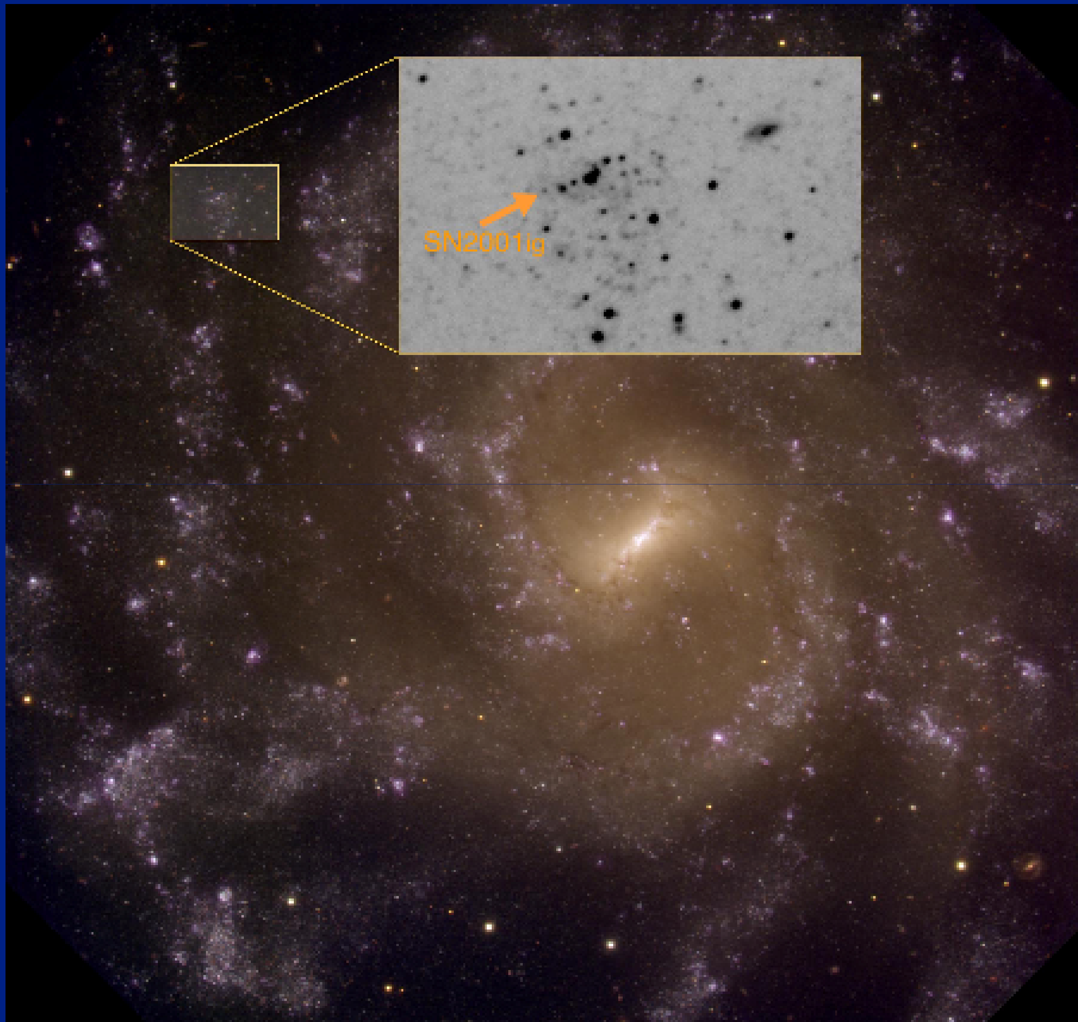
- Optical searches (amateur + robotic) found 584 SNe in 2007, but only 279 in 2008.
- Core-collapse supernova (CCSN) rates directly trace SFR(z) via IMF, key input to galactic chemical evolution models.
- Radio monitoring of CCSNe probes circumstellar medium, recreates mass-loss history of progenitor.

The Type IIb SN 2001ig



Ryder et al. 2004, MNRAS, 349, 1093

The Type IIb SN 2001ig



Ryder et al. 2006, MNRAS, 369, L32

Supernova Safari

- LIRGs (L_{FIR}>10^{11} $L_{\odot}$) and ULIRGs (L_{FIR}>10^{12} $L_{\odot}$) ideal "hunting grounds" for SNe.
- *BUT* LIRGs have:
  - High dust content (use NIR)
  - Complex nuclear structure (high spatial resolution)
  - Extended nuclear + disk structure (few natural guide stars)

$\Rightarrow$ Laser Guide Star Adaptive Optics!

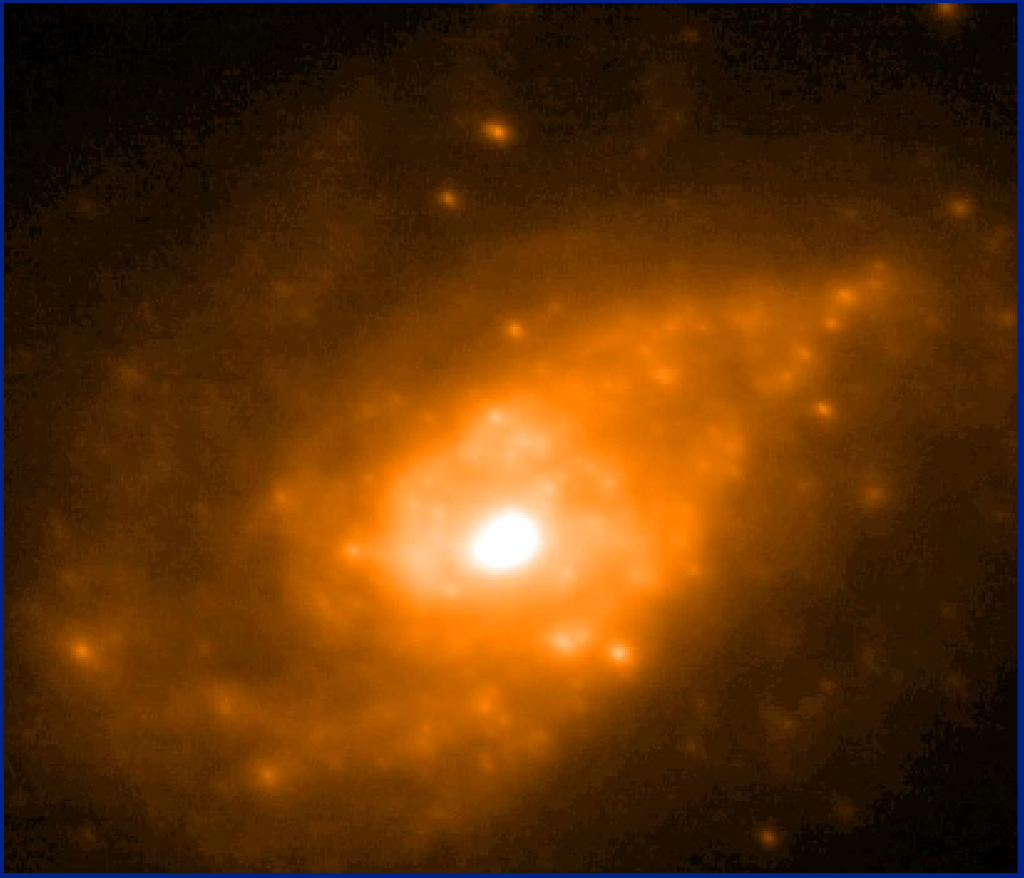
- Mattila, Ryder, et al. (2007) found SN 2004ip in IRAS 18293-3413 with NACO + NGS on VLT
  First adaptive optics-assisted SN discovery

AAO

The Hunt

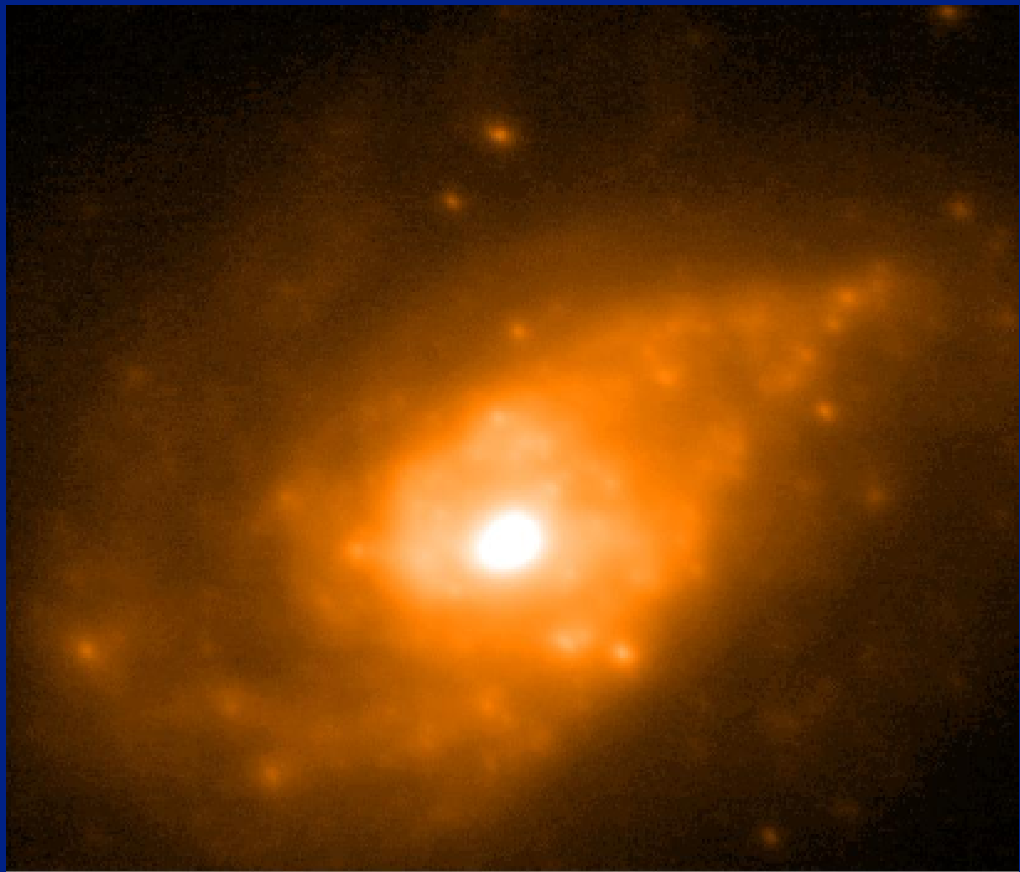
- 2008A – 2010A: Monitor 8 LIRGs with NIRI/ALTAIR + LGS on Gemini North at 2 – 6 month intervals.
- LIRGs from IRAS RBGS with d < 100 Mpc, no AGN contribution, R<18.5 TTGS within 25".
- Expect 8 CCSNe/yr in sample, simulations indicate 6 recovered over 5 semesters.
- 9 × 30 sec integrations in K on target and sky, < ½ hr per visit, FWHM ~0.1".
- Optimal Image Subtraction (Alard 2000) uses space-varying convolution kernel to match images from different epochs before subtraction.

IRAS 18293-3413



2004 May 4.3
VLT/NACO

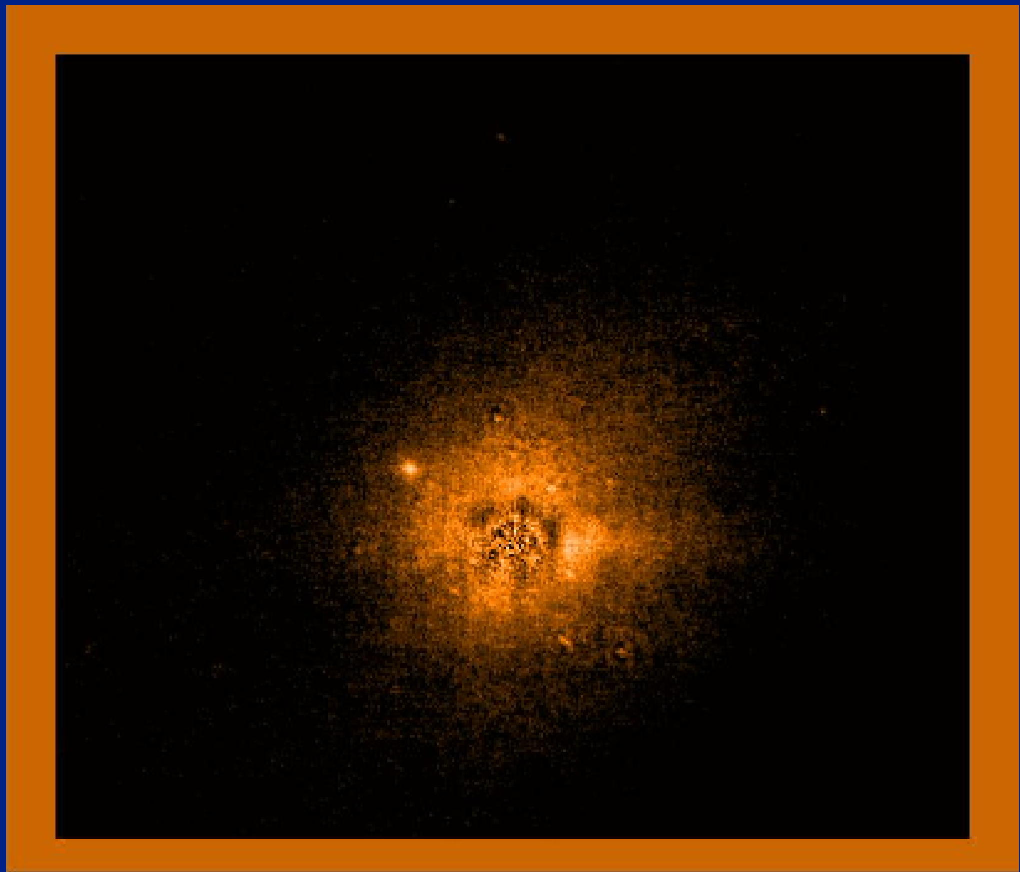
IRAS 18293-3413



2004 Sep 15.0
VLT/NACO

SN 2004ip in IRAS 18293-3413

Mattila et al. 2007, ApJL, 659, L9
Perez-Torres et al. 2007, ApJL, 671, L21



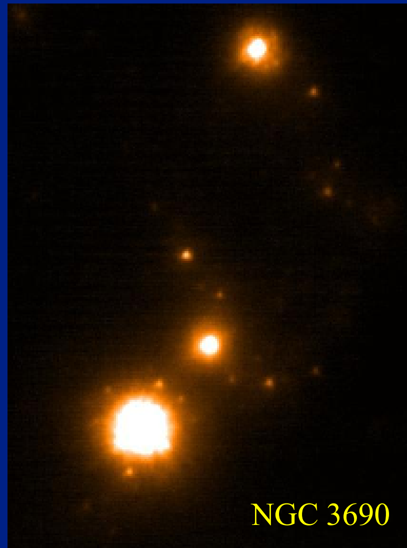
Sep – May

Meet the LIRGs

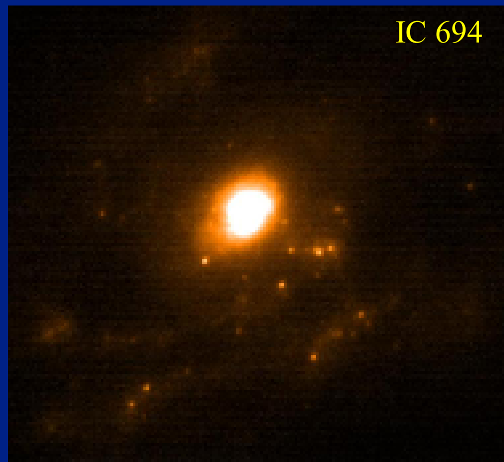
CGCG 049-057

IRAS F16516-0948

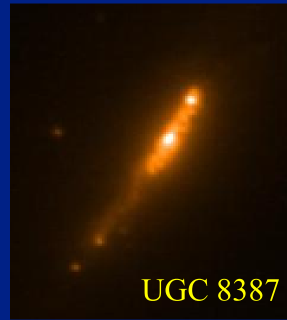
IRAS F17578-0400



NGC 3690

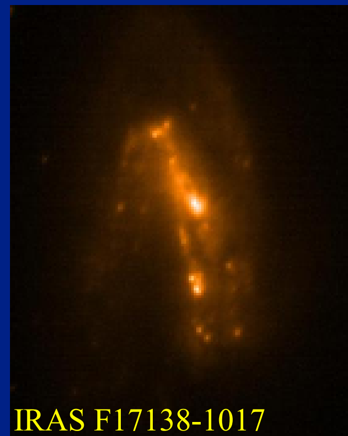


IC 694



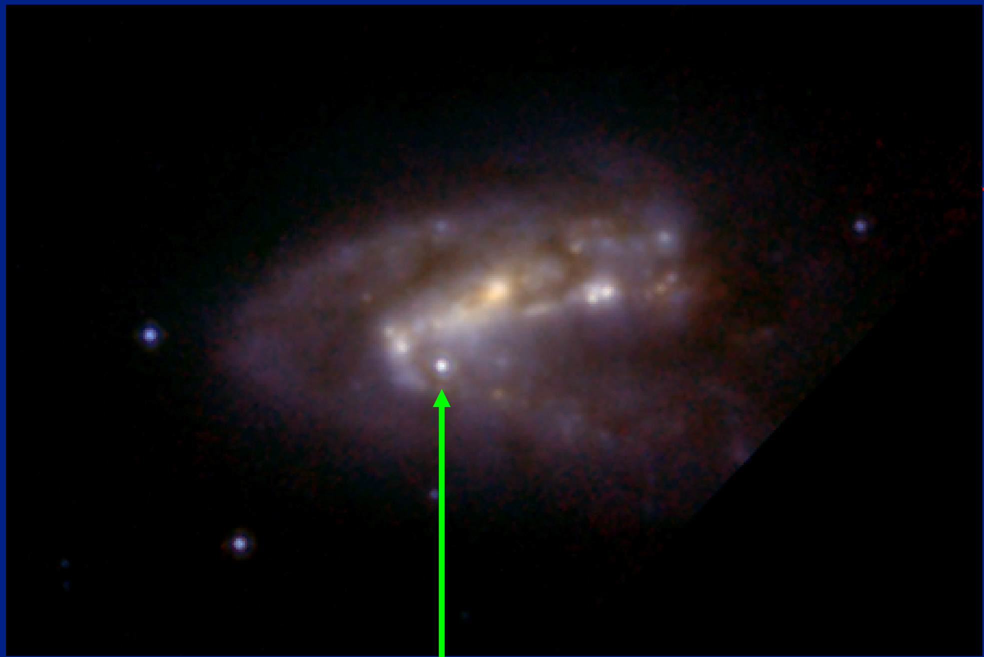
UGC 8387

MCG +08-11-002



IRAS F17138-1017

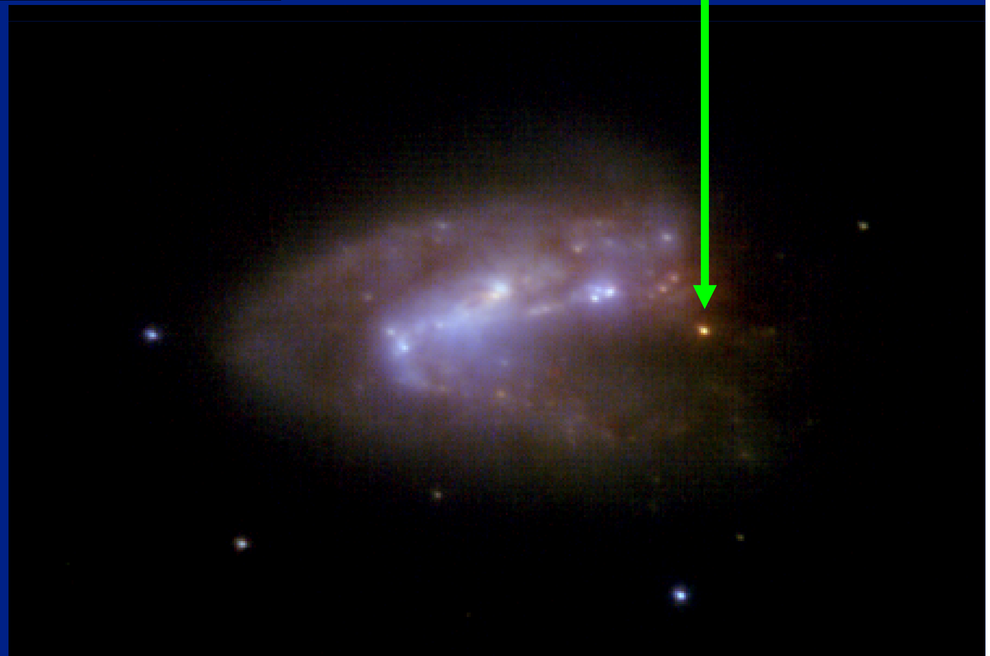
Two for one!



IRAS 17138-1017
HST/NICMOS
2004 Sep 23

SN 2004iq

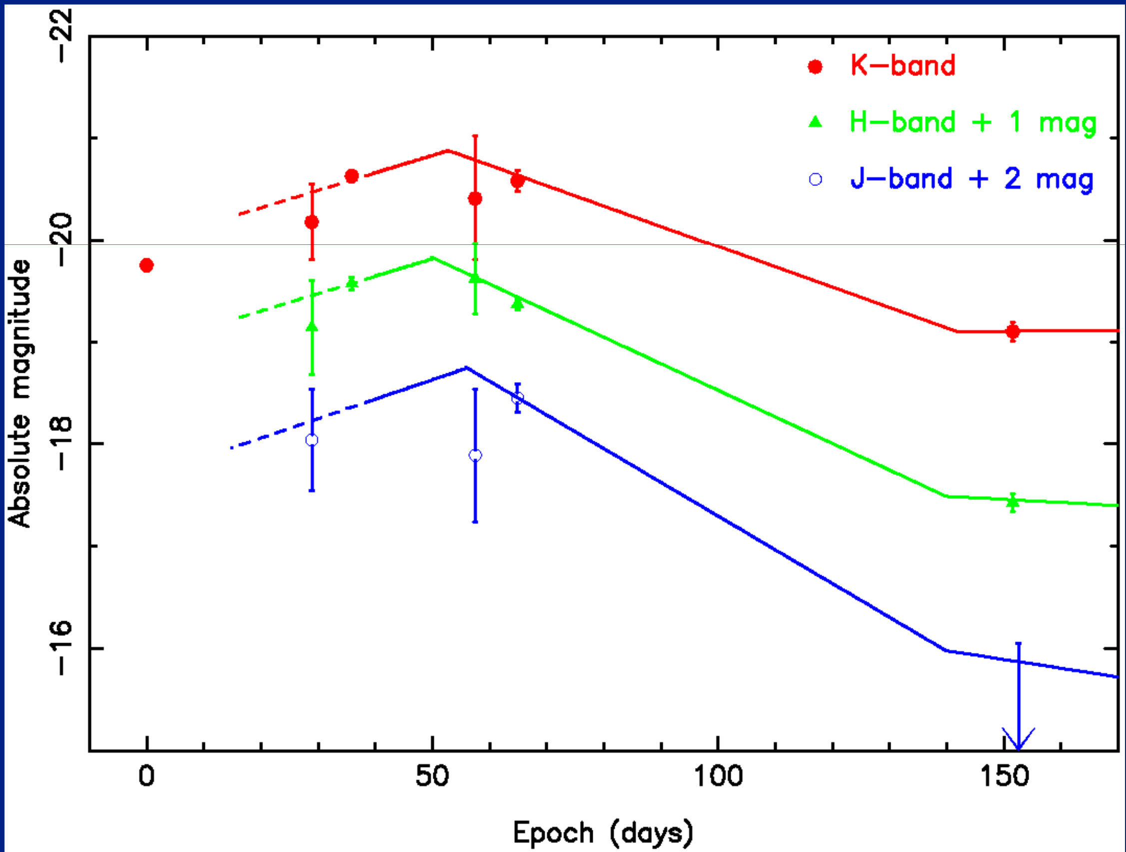
SN 2008cs



IRAS 17138-1017
Gemini/ALTAIR
2008 June 25

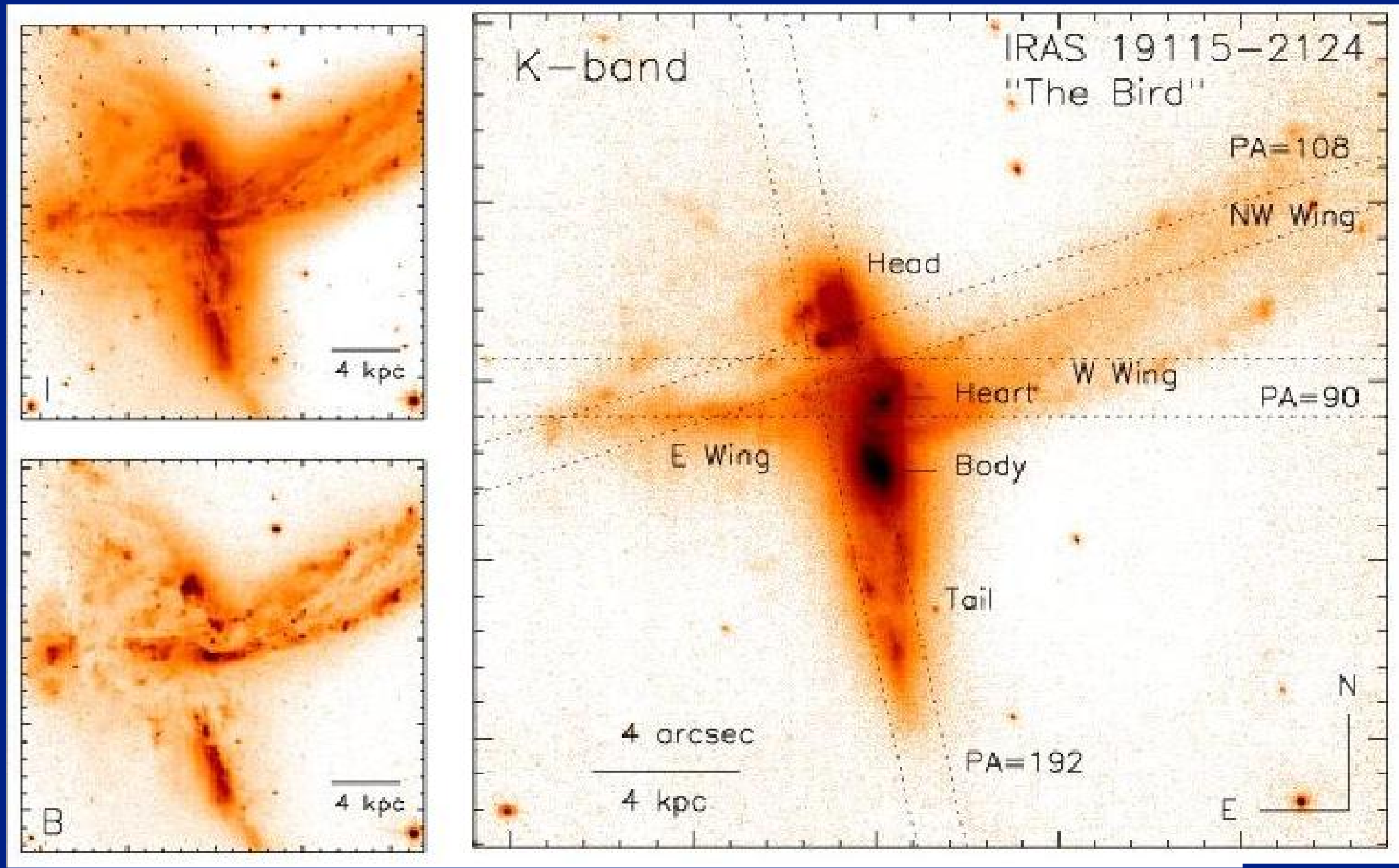
Out of sight

- Template fits ⇒ $A_K \sim 1.8$, or $A_V \sim 18$ mag
- < 1 in 10^6 optical photons escape!



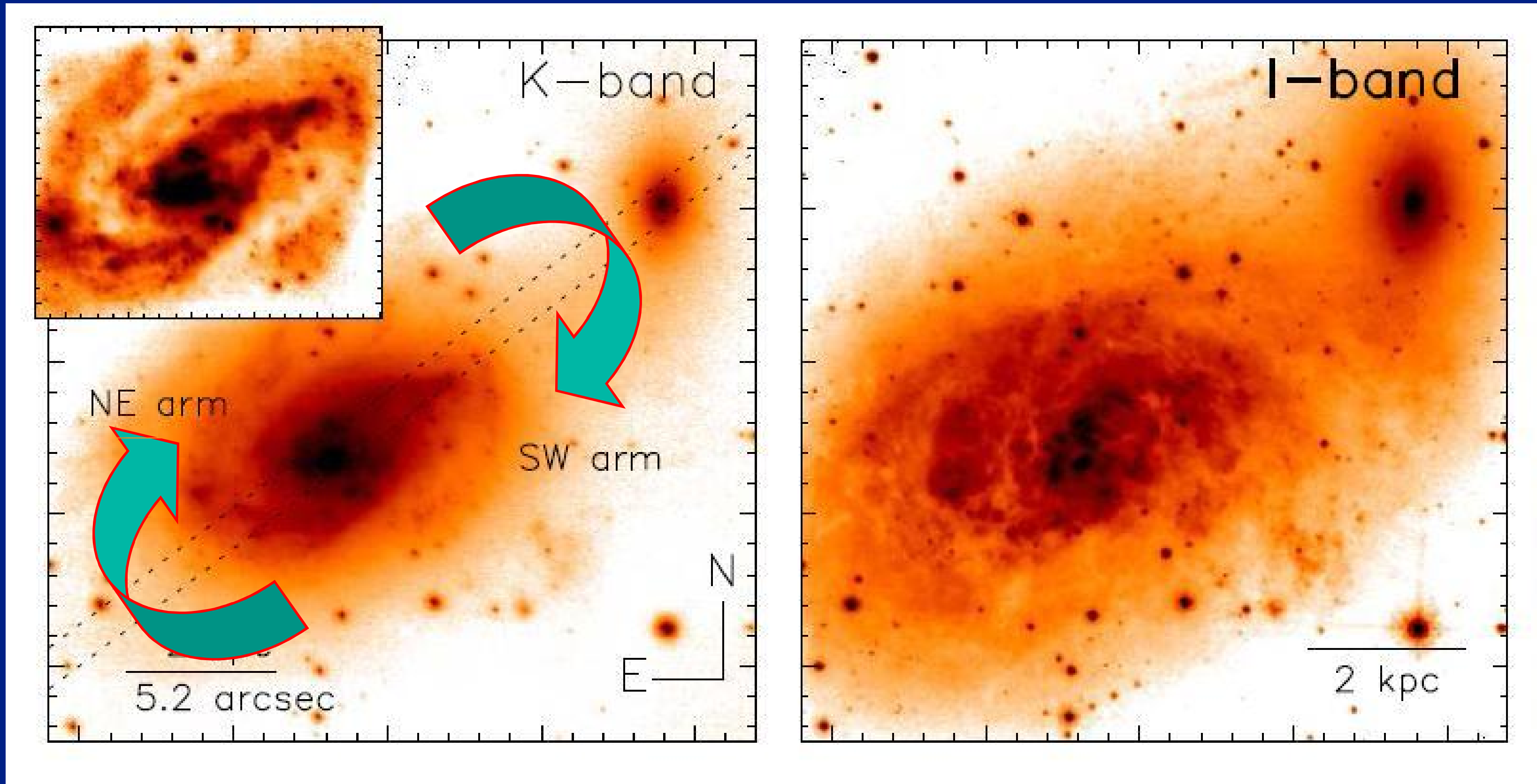
Kankare et al. 2008, ApJL, 689, L97

“Value-added” science I



IRAS 19115-2124: “The Bird”
VLT/NACO
Väisänen et al. 2008, MNRAS, 384, 886

"Value-added" science II



IRAS 18293-3413: Leading Spiral Arms?
VLT/NACO
Väisänen et al. 2008, ApJ, 689, L37

One possible explanation is that science's understanding of stars is wrong. Another is that dying stars, "like cockroaches dying unseen under the couch", are easily missed.


Mon 5 January 2009

The Sydney Morning Herald

Laser explodes mystery of how a star is born

Richard Macey

High beam ... the giant laser guide at the Gemini telescope in Hawaii seeks out supernovae.

Summing Up

- Expect ~6 new SNe after 2 years – found one so far!
- If no more are found, then
  - Template lights curves and MC simulations of blending too optimistic?
  - LIRGs even dustier than assumed?
  - FIR luminosity over-predicts SFR?
- MCAO + GSAOI will greatly expand SN search
- Gemini's (and Subaru's) current + future instrumentation are great stellar forensic tools