First results from GeMS/GSAOI forSUNBIRD: Supernovae UNmasked By Infra-Red Detection

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Image processing courtesy Mischa Schirmer (Gemini Obs.)

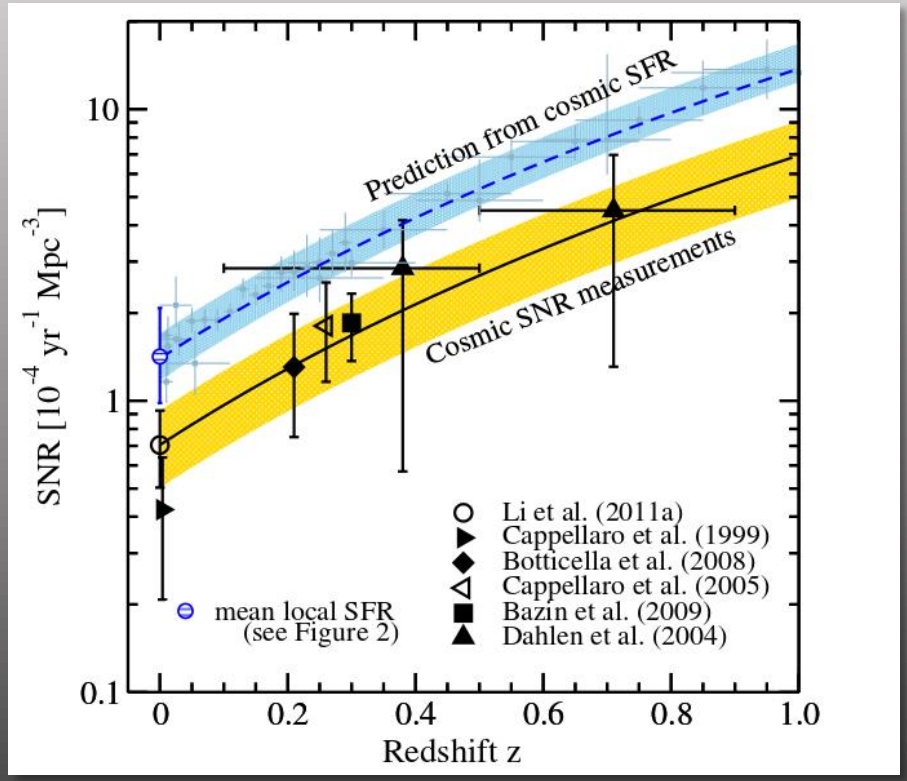
Australian Government, Department of Industry and Science

AAO

Introduction

Horiuchi+2011: *"Supernova rate problem"*

- Dim or "dark" CCSNe, direct collapse
- Hidden nuclear CCSNe

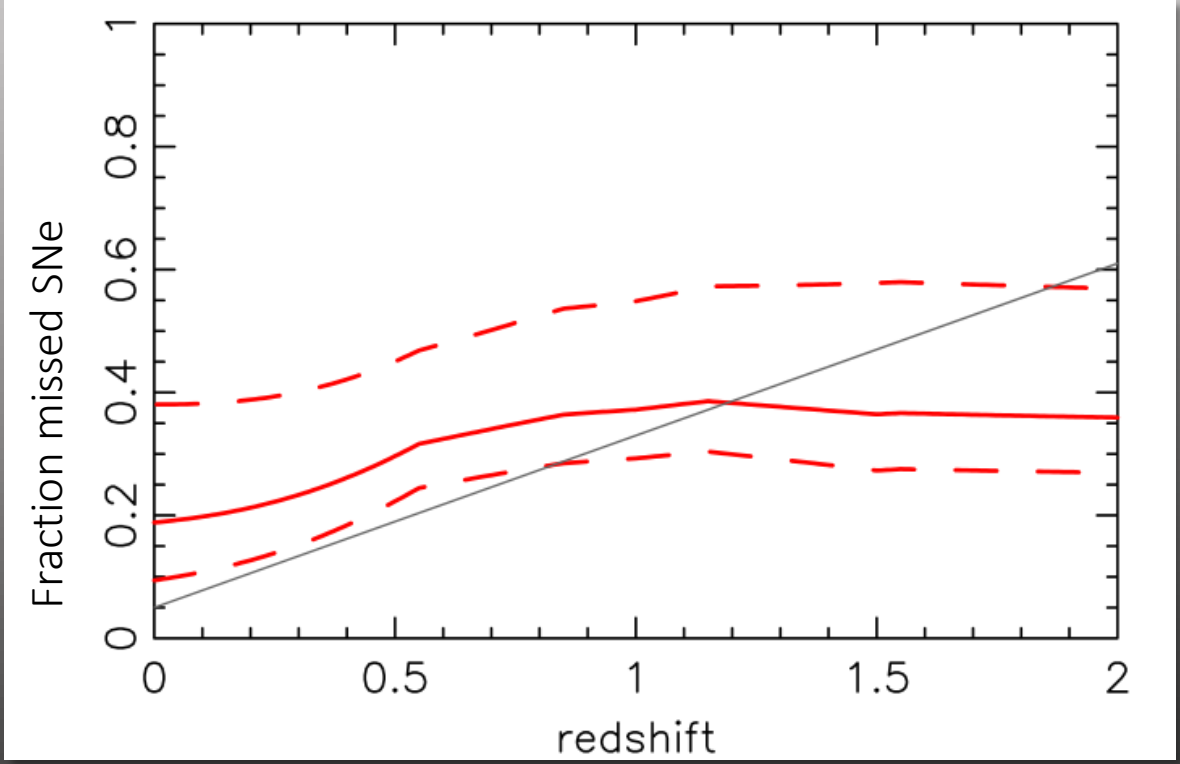


Supernova rate (SNR) measurements vs. prediction from SFR
(Horiuchi et al., 2011)

Introduction

Missed fraction correction

- Monitoring of LIRG Arp 299
  - Host to 5 SNe since ‘98
  - Model for galaxies at increasing redshift



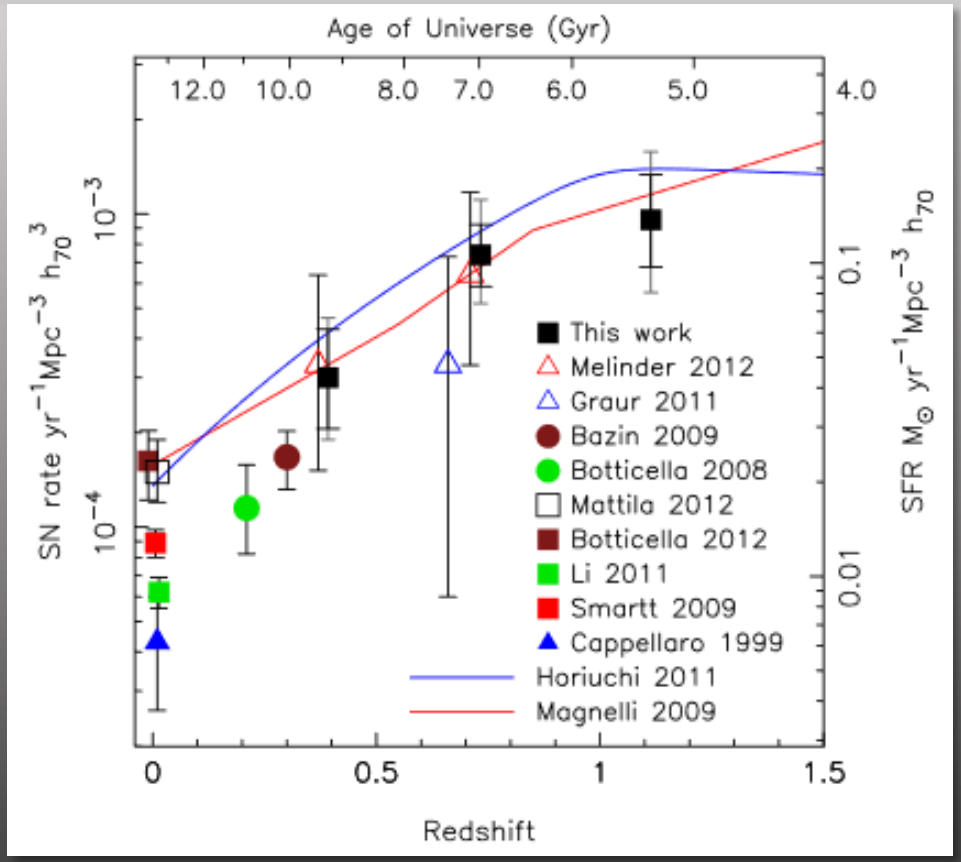
First empirical limits on missed SNe fraction

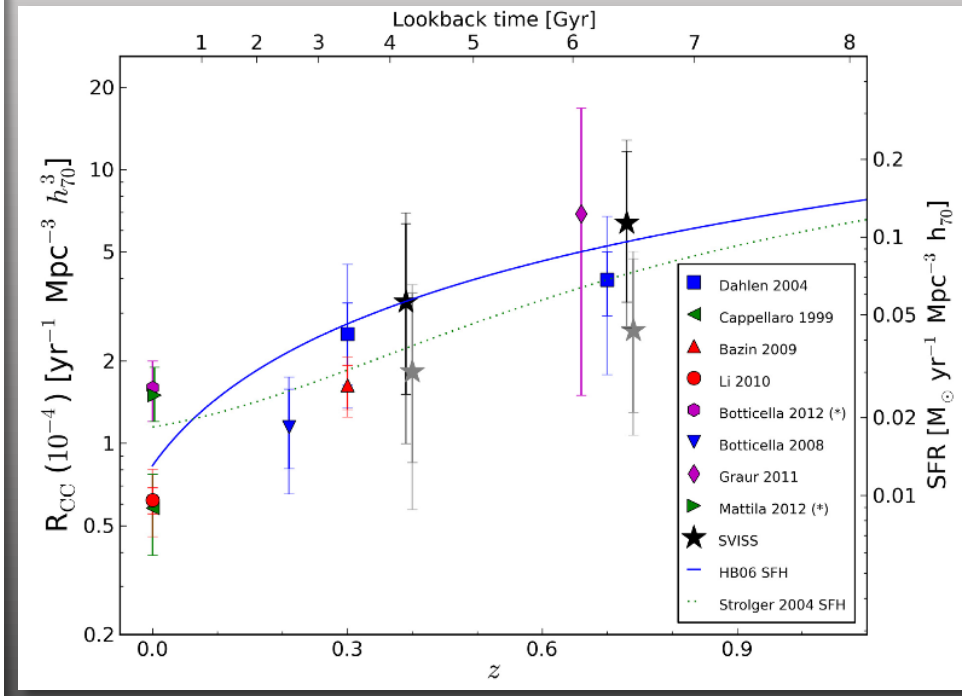
(Mattila et al., 2012)

Introduction

Corrected rates

- Missed fraction correction by Mattila et al. 2012





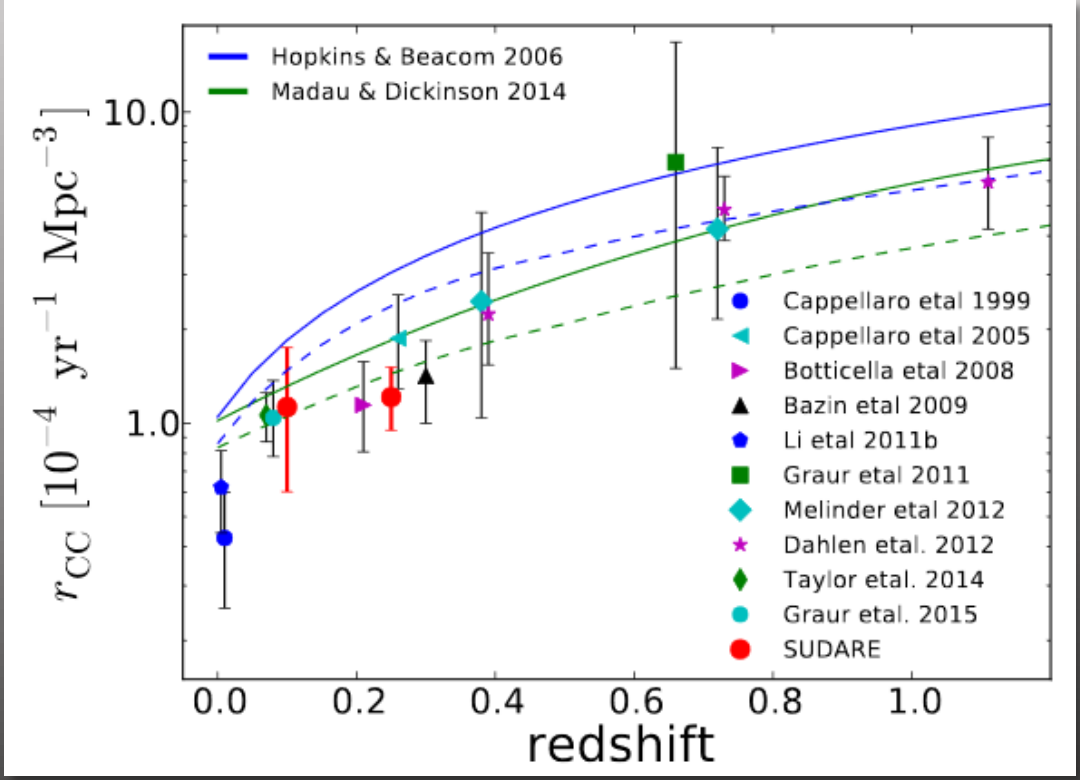
Supernova rate measurements vs. prediction from SFR

(Dahlen et al., 2012, Melinder et al., 2012)

Introduction

No *"Supernova rate problem"* ?

- Cappellaro+2015: Statistic and systematic errors still "*too large to invoke an SN rate problem*"



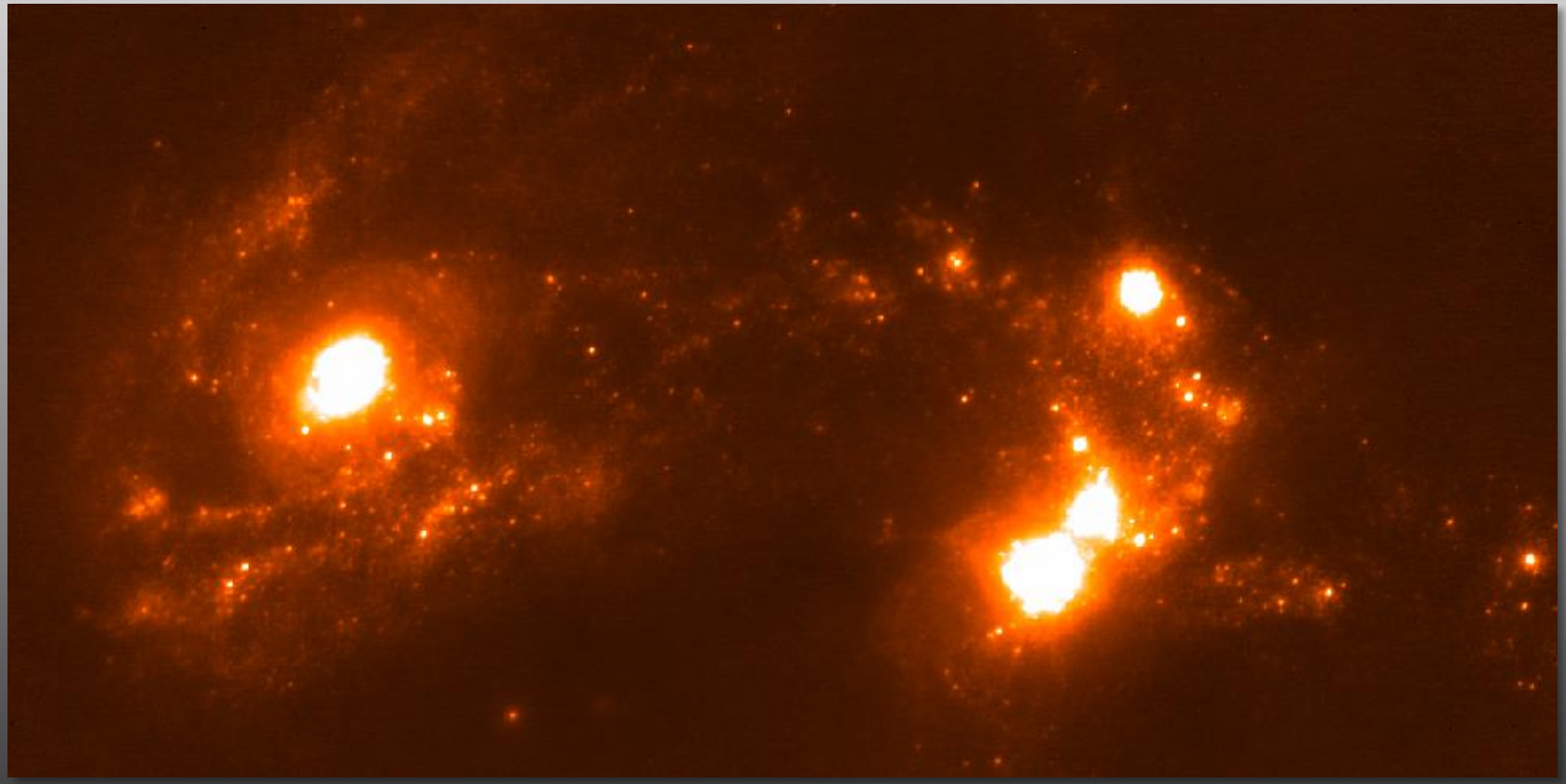
Supernova rate measurements vs. prediction from SFR

(Cappellaro et al. 2015)

Introduction

Luminous Infrared Galaxies (LIRGs)

- $L_{IR} > 10^{11} L_{\odot}$, concentrated sites of star formation and dust
- Fraction of SF in (U)LIRGs increases with redshift



Arp 299, K_s-band, Keck AO

Introduction

CCSNe in LIRGs

- LIRGs from IRAS Revised Bright Galaxy Sample
- Mattila & Meikle 2001: $r_{SN} = 2.7 \times 10^{-12} \times L_{FIR}/L_{\odot}\,yr^{-1}$.
- Collective expected CCSN rate in LIRGs: ~250/yr
- *A77* reported CCSN discoveries in near-IR/optical from seeing limited surveys: ~50

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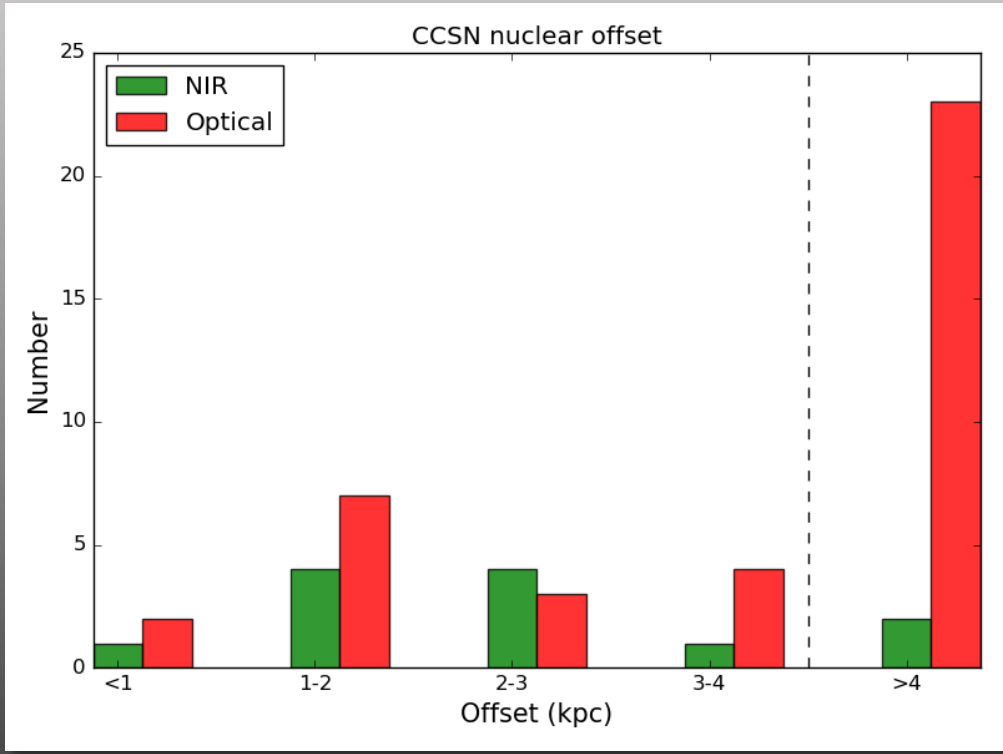


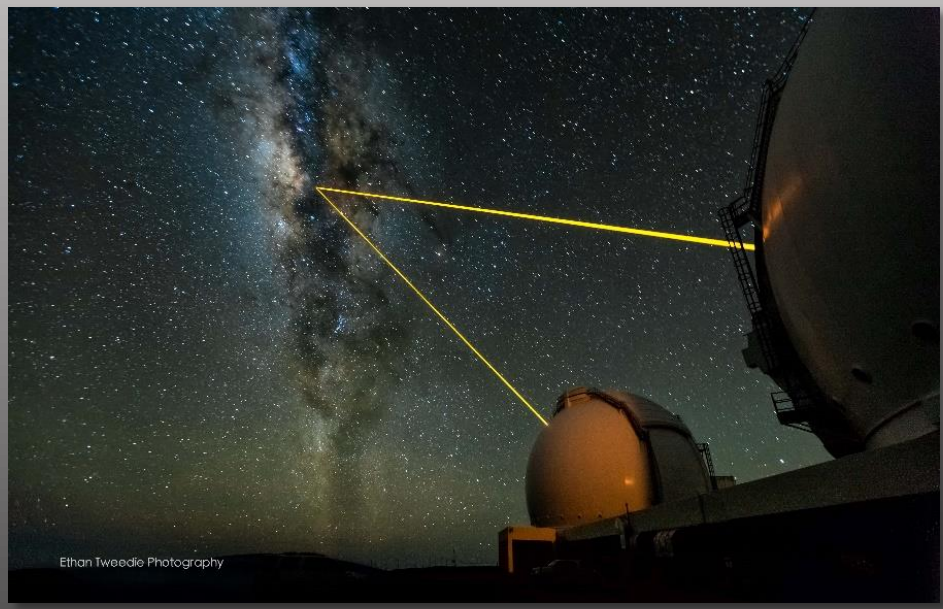
Nuclear offset distribution all seeing limited near-IR/optical CCSN discoveries

SUNBIRD project

Supernovae Unmasked by InfraRed Detections

- Near-IR: dust extinction
- Laser guide star AO: 0.06” - 0.1” image quality
- Explore regime missed nuclear/high extinction CCSNe
- Provide meaningful constraints on missed CCSNe fraction

GeMS/GSAOI on
Gemini South telescope

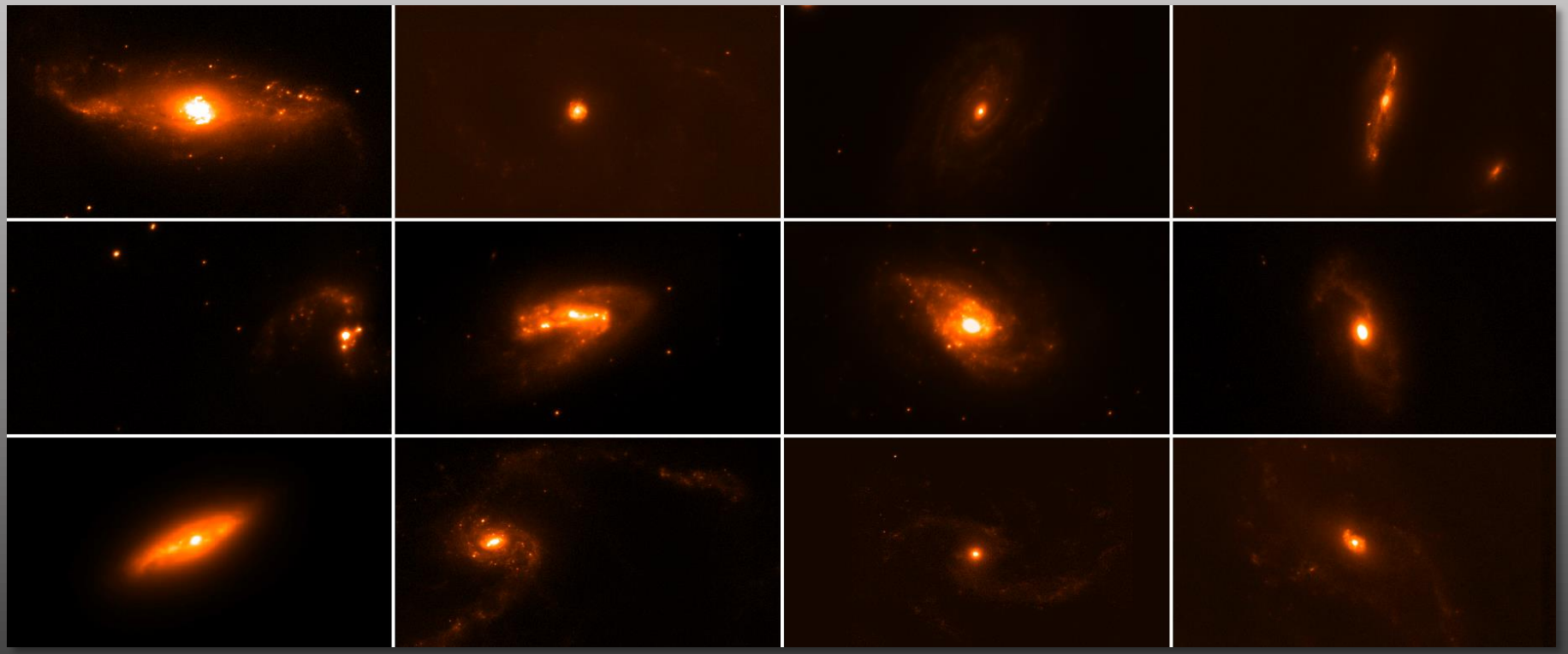


NIRC2 on Keck telescope

SUNBIRD project

LGSAO data

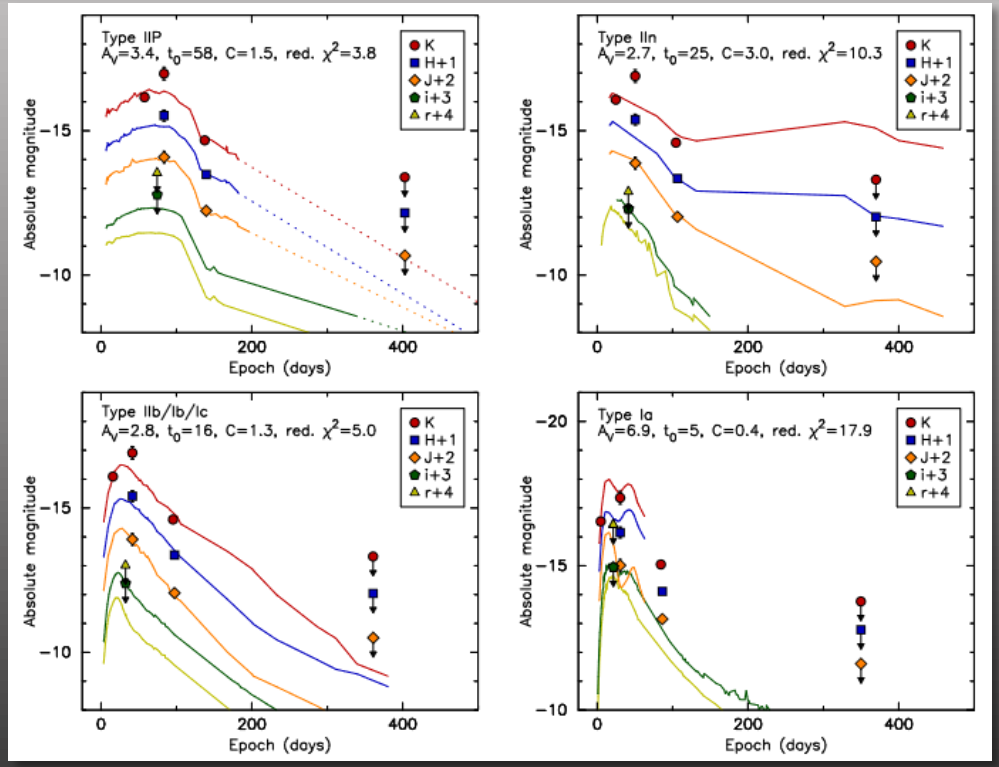
- Epochs for 36 LIRGs (50-150 Mpc), most with multiple epochs
- Three photometrically confirmed SNe, three candidates



SUNBIRD project

Observing strategy and analysis

- Difference imaging, match PSF
- Optimize cadence
- SN search in K_s, follow up on JHK_s + radio + spectra
- Magnitudes fitted to lightcurve templates to obtain subtype



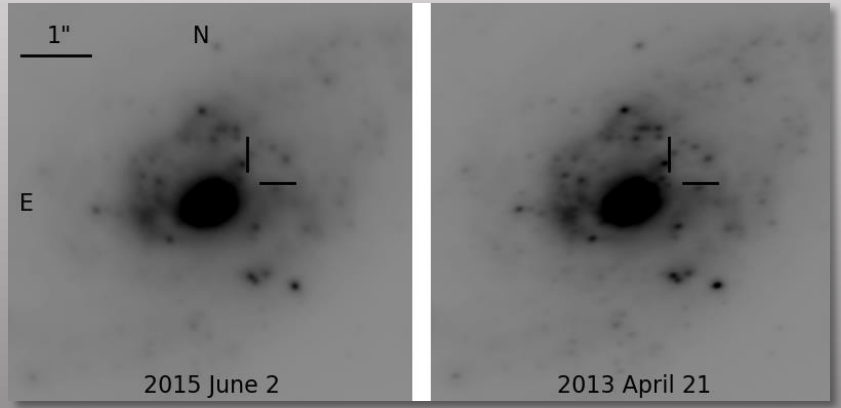
SN 2015ca template light curve fits

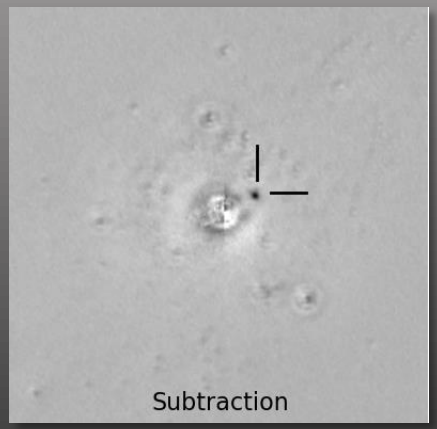
(Kool et al., 2017)

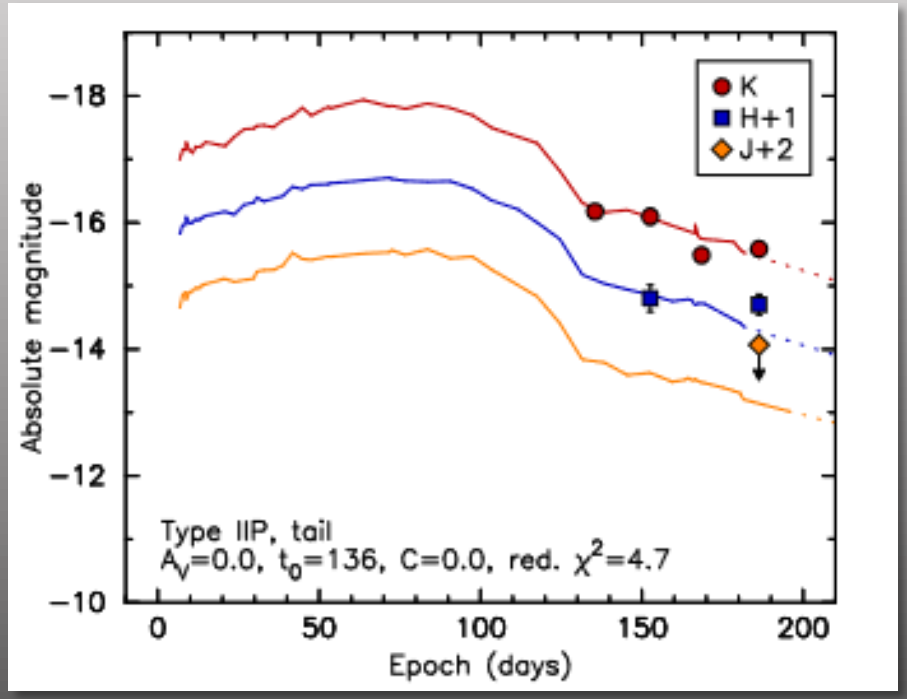
Results with GeMS/GSAOI

SN 2013if in IRAS 18293-3413

- 200 pc nuclear offset
- Type IIP with A_V = 0







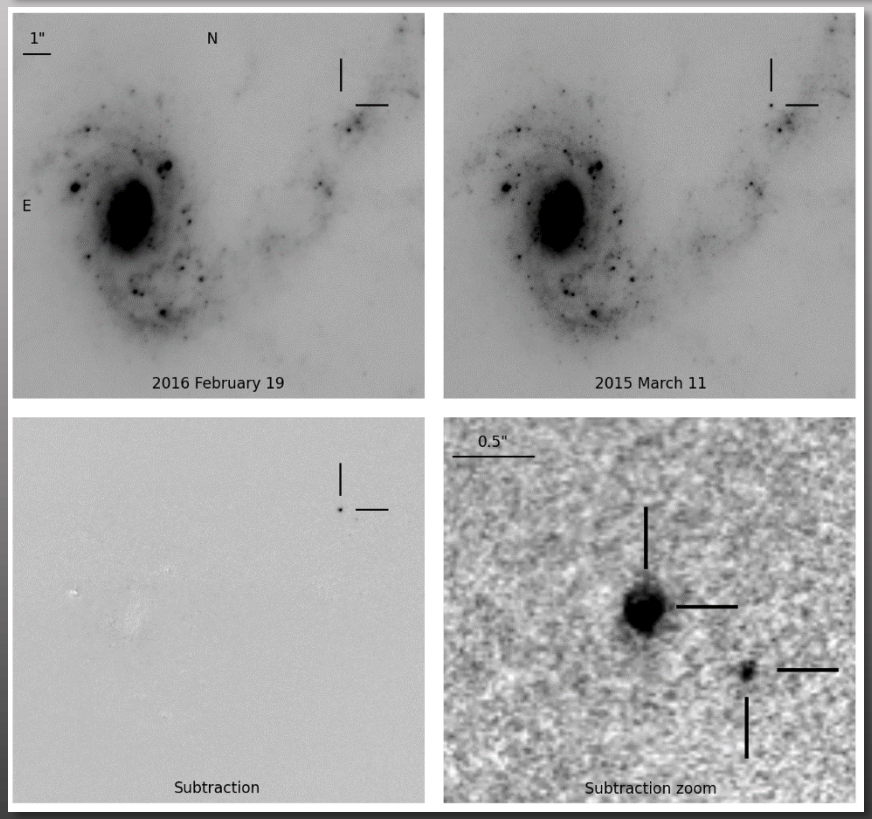
SN 2013if in IRAS 18293-3413: only 200 pc from nucleus

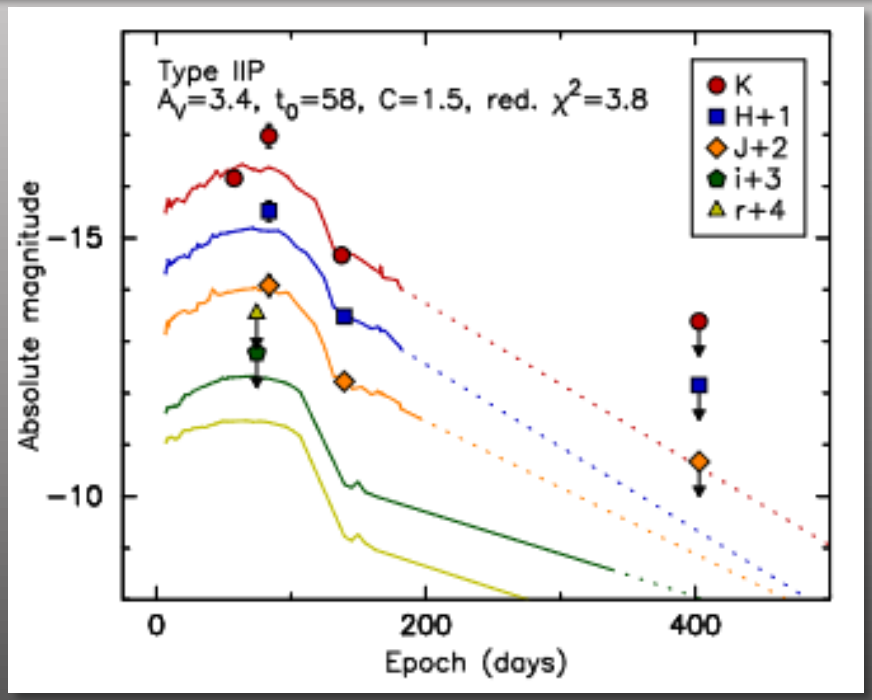
(Kool et al., 2017)

Results with GeMS/GSAOI

SN 2015ca and AT 2015cf in NGC 3110

- 3.3 kpc nuclear offset
- 0.7” separation between detections
- 2015ca Type IIP with A_V = 3.4, 2015cf Type II?





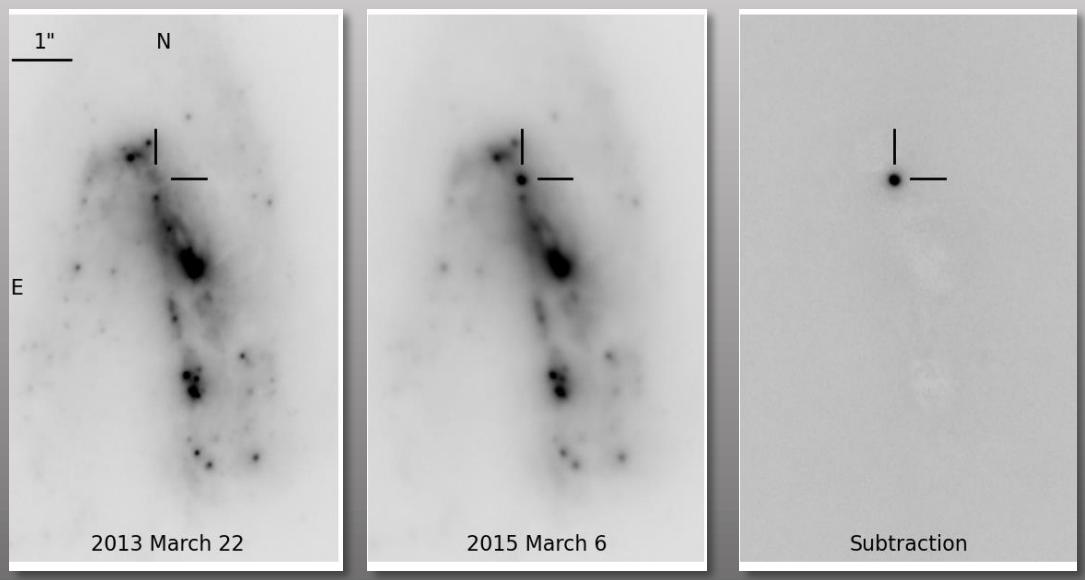
Supernova detections in NGC 3110, March 2015

(Kool et al., 2017)

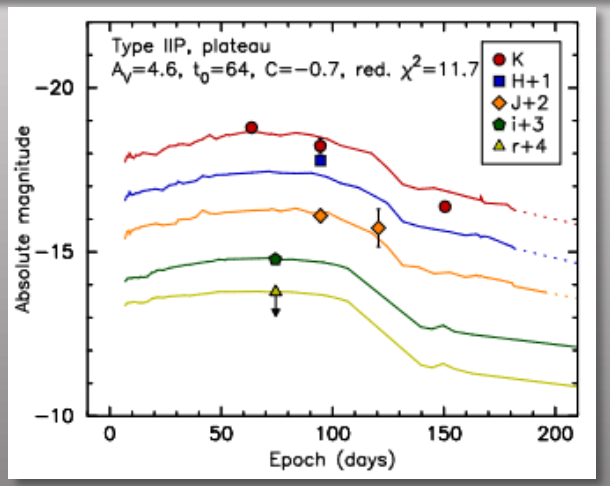
Results with GeMS/GSAOI

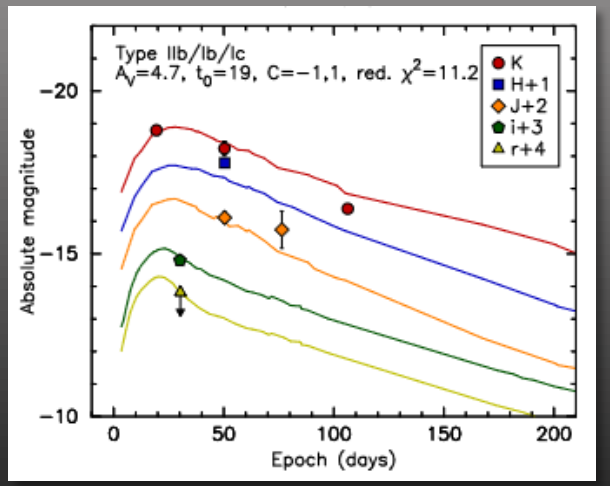
SN 2015cb in IRAS 17138-1017

- 600 pc nuclear offset
- A_V = ~5



SN 2015cb in IRAS 17138-1017
(Kool et al., 2017)

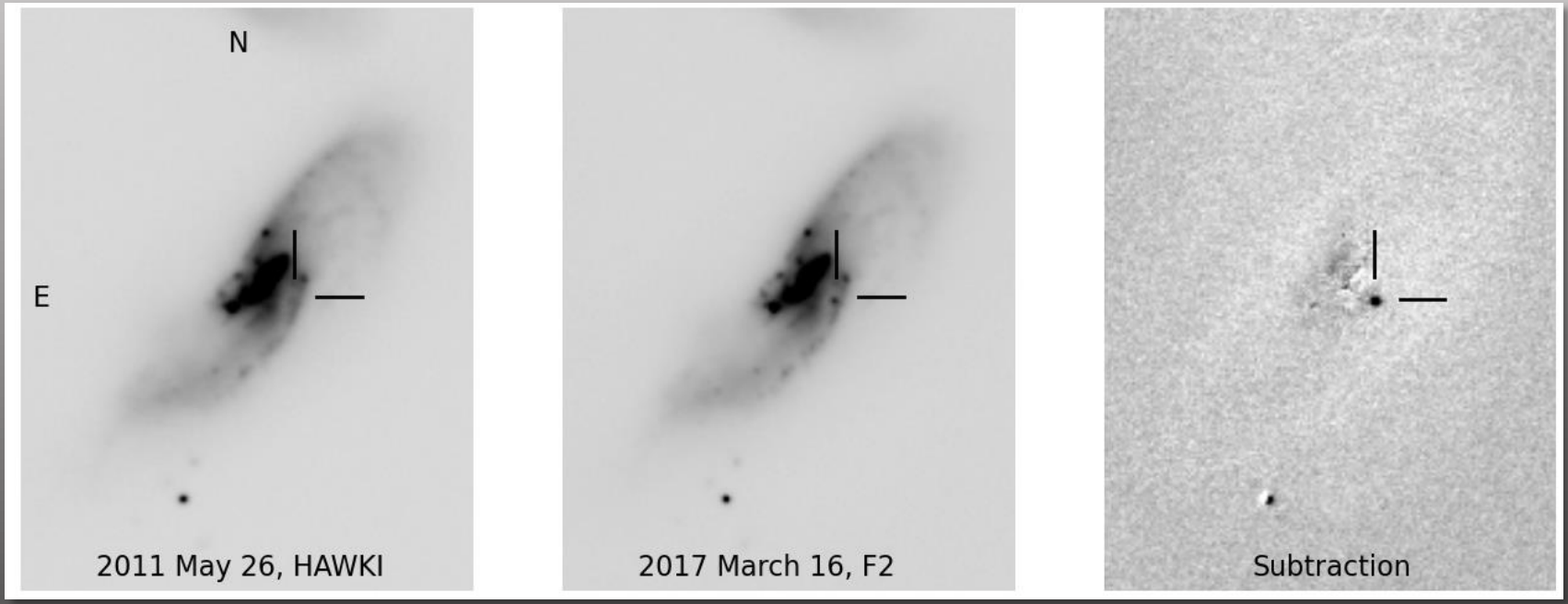




Results from Keck

AT 2017chi in NGC 5331

- Discovered in K-band with Flamingos 2 on Gemini
- Rapid follow-up with NIRC2 on Keck in JHK



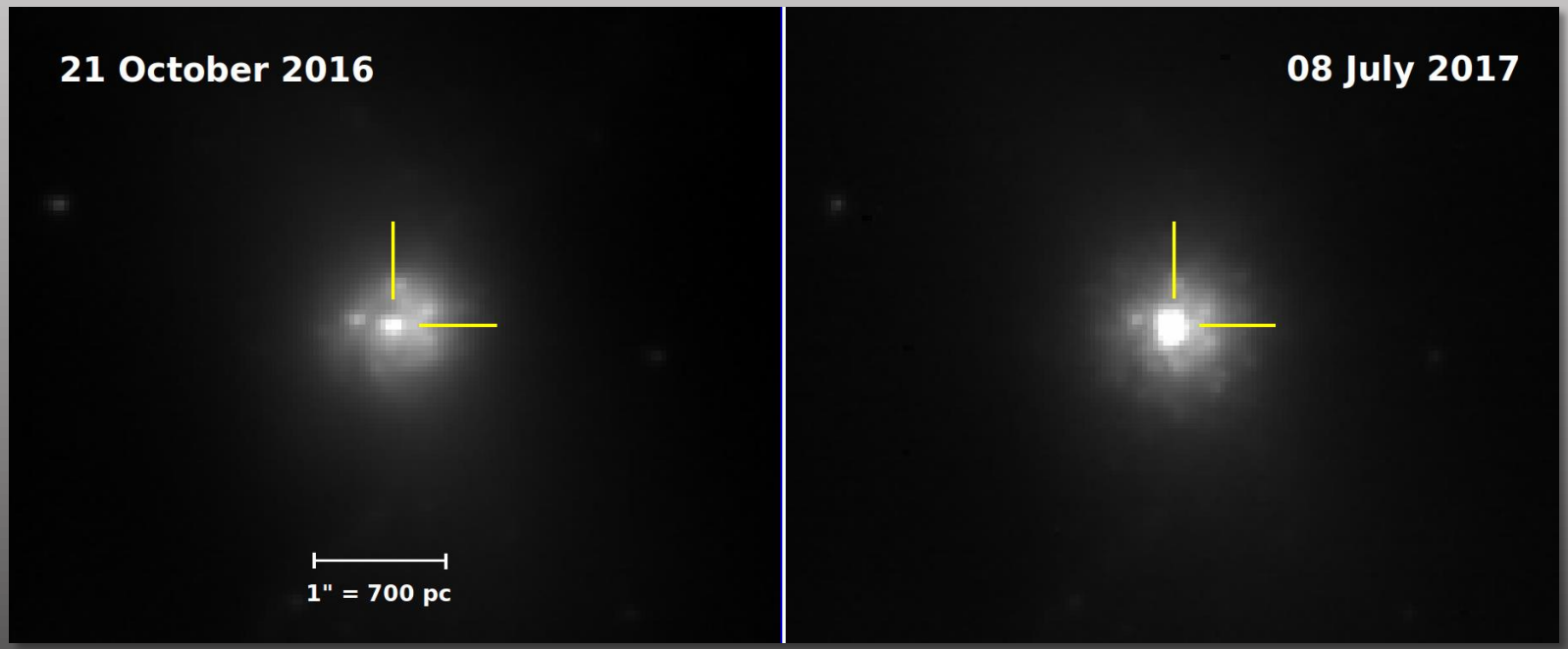
AT 2017chi in NGC 5331

(Kool et al., in prep)

Results from Keck

AT 2017gbl in IRAS 23436+5257

- Very bright nuclear transient
- SN nature unlikely



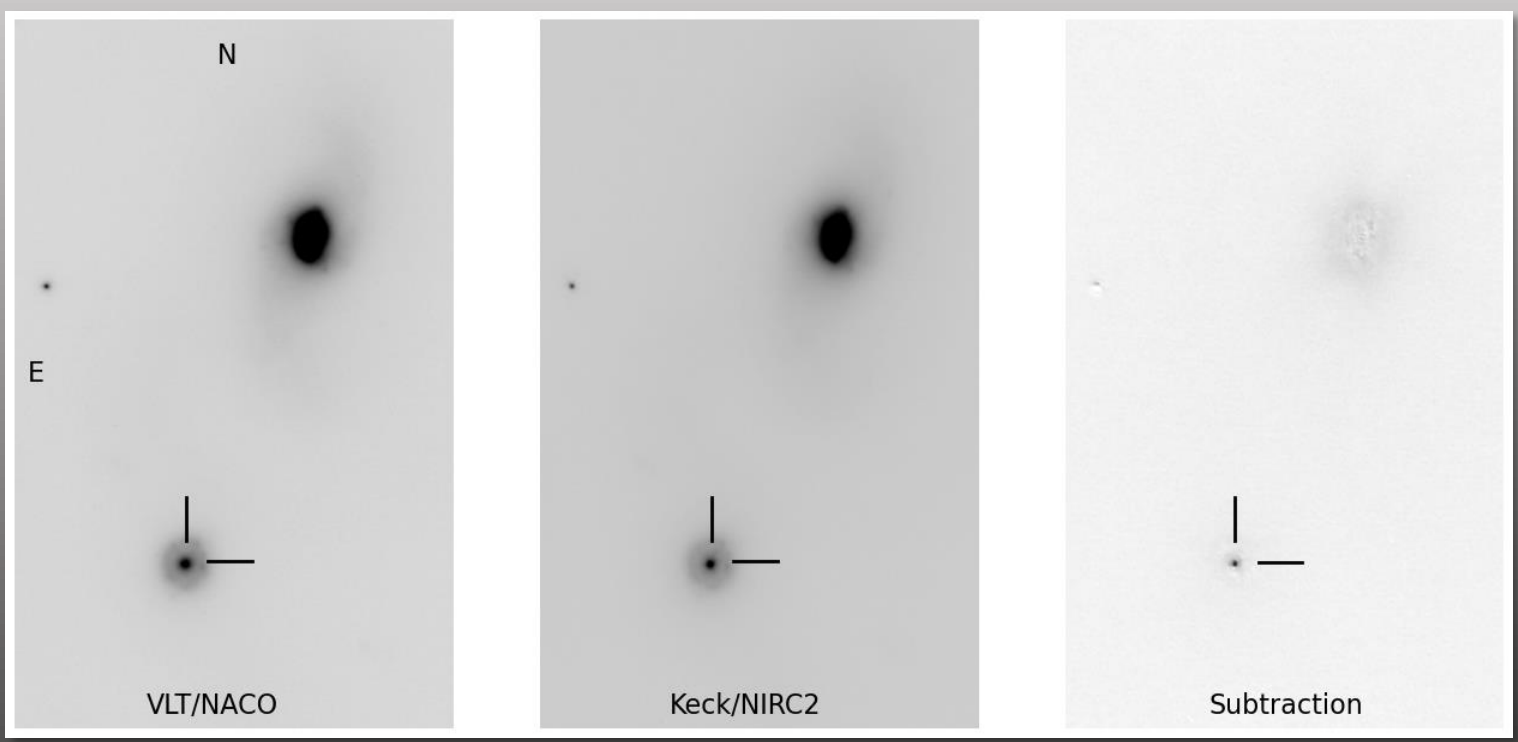
AT 2017gbl in NGC 5331

(Kool et al., in prep)

Results from Keck

Nuclear transient in IRAS F06076-2139

- Superimposed on nucleus
- Optical IFU immediate follow-up with KOALA



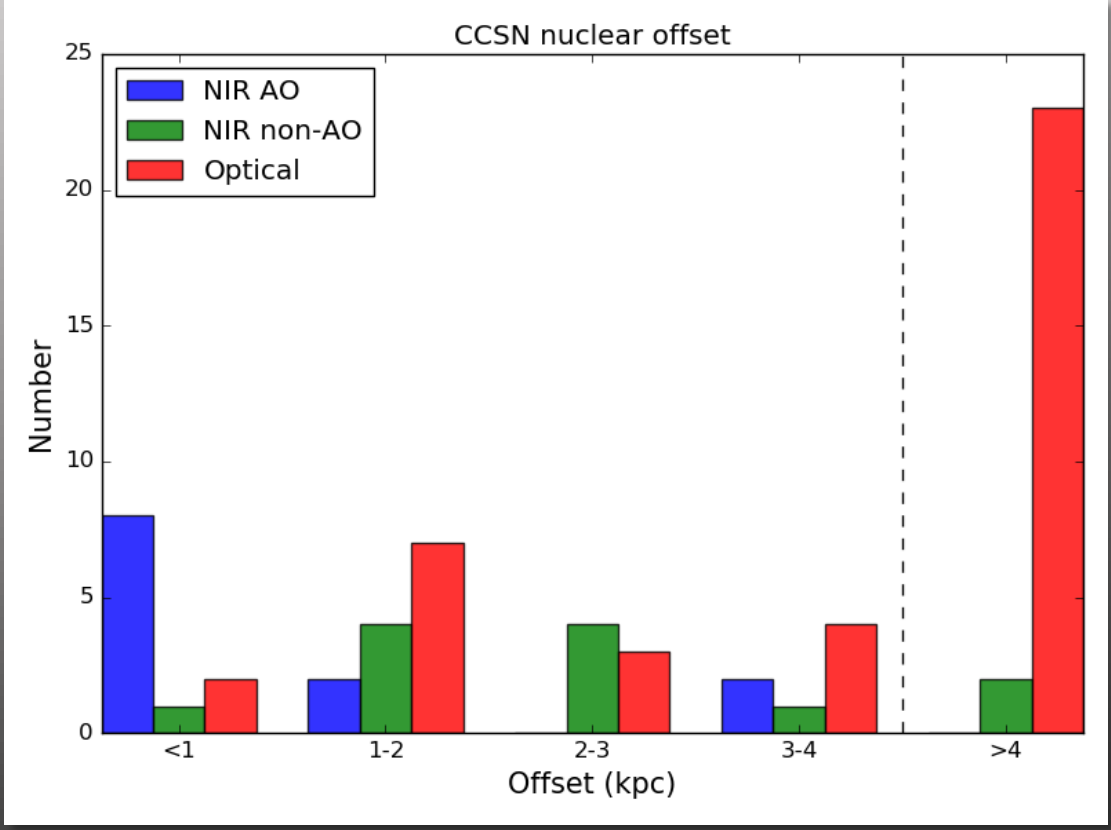
Transient in IRAS F06076-2139

(Kool et al., in prep)

Impact LGSAO on CCSNe in LIRGs

SUNBIRD plus preceding LGSAO programs

- Gemini N./ALTAIR (Kankare+2008/2012) and VLT/NACO (Reynolds+, in prep)
- 12 additional CCSN LIRG discoveries

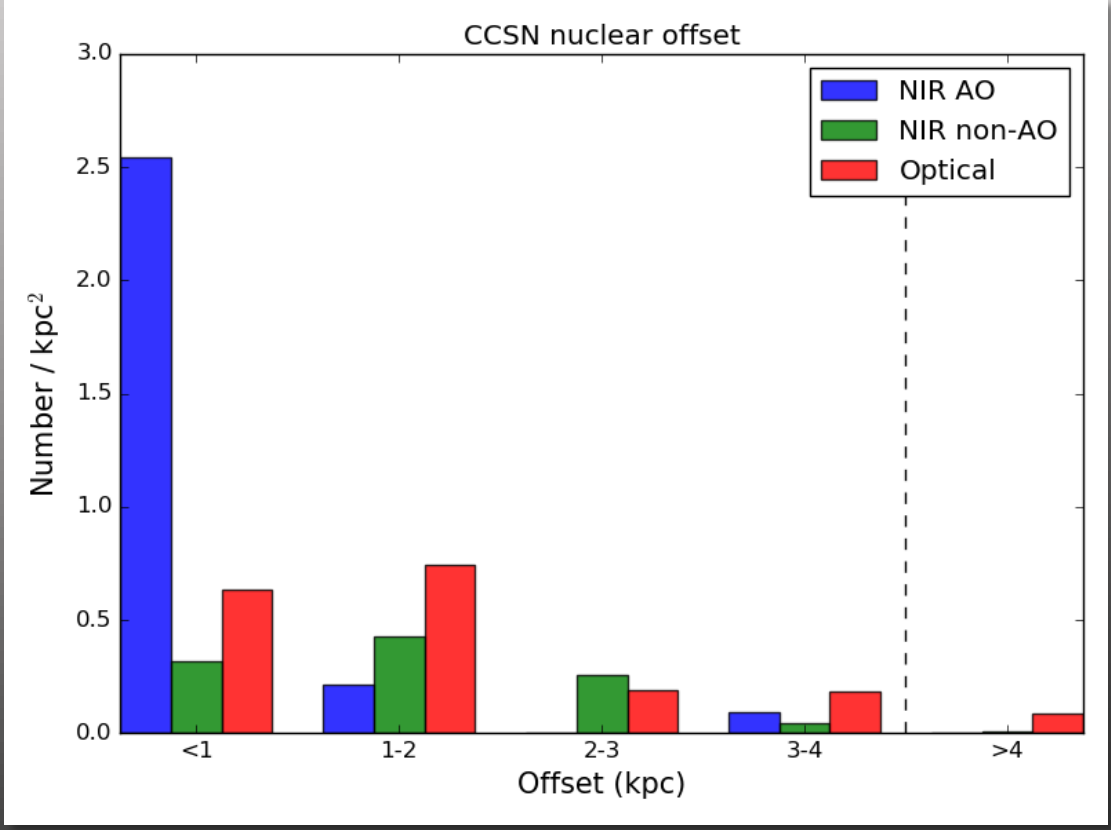


Nuclear offsets all CCSN near-IR/optical discoveries LIRGs
(Kool et al., 2017)

Impact LGSAO on CCSNe in LIRGs

SUNBIRD plus preceding LGSAO programs

- LGSAO singularly effective at uncovering nuclear CCSNe
- Time coverage: optical >>> near-IR non-AO >> near-IR AO



Nuclear offsets LIRG CCSNe, normalized for bin area

Summary

SUNBIRD

- Gemini South and Keck telescopes
- Explore regime of missed high extinction nuclear CCSNe
- Six new (candidate) CCSN discoveries to date
- AO imaging in near-IR singularly effective

Finally

- Detection efficiency → Supernova rate analysis