MiniTAO/ANIR Observing Proposal: Deep optical-NIR imaging of nearby supernova sites

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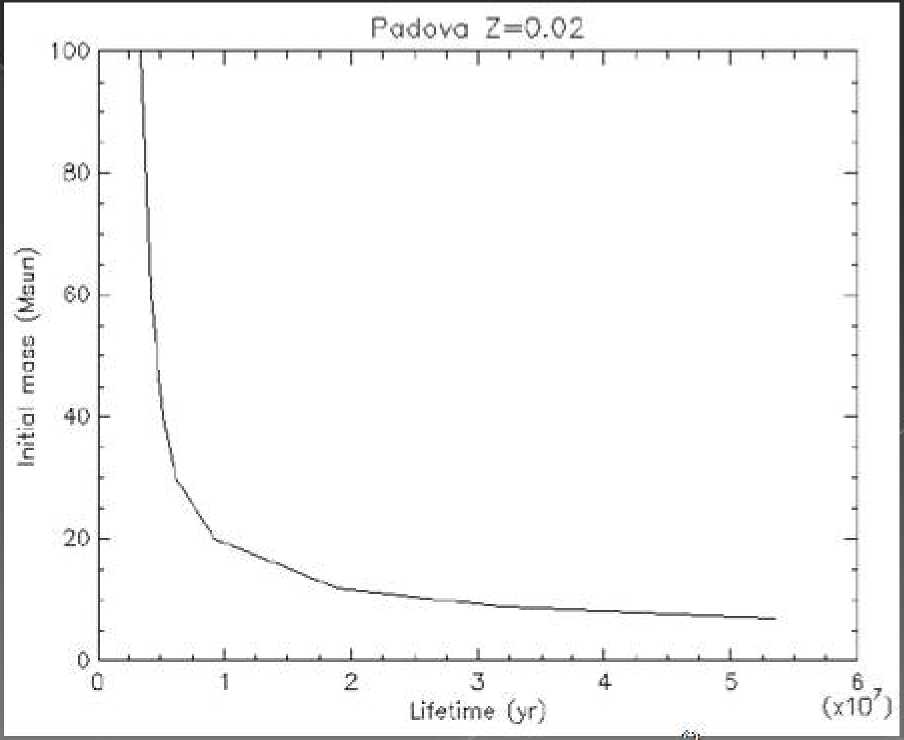
Background

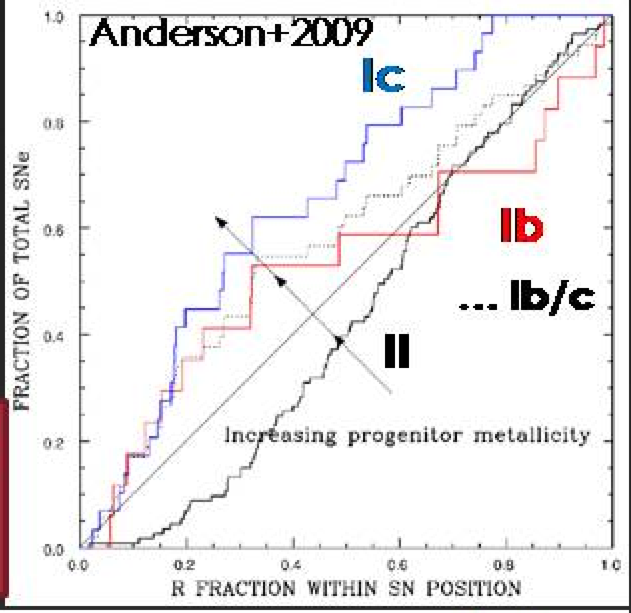
- Many core-collapse supernova (CCSN) has been observed
- Current understanding of CCSN progenitors is still limited: massive stars
- Progenitor **mass** is the main parameter
- **Metallicity**: important mostly in stripped CCSNe (type-Ib/c)

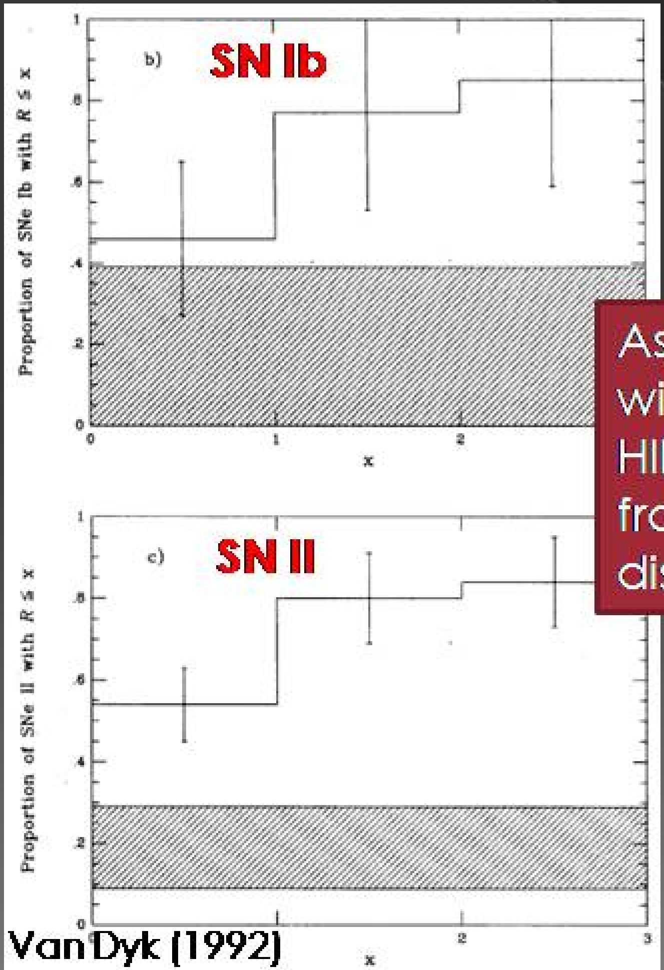


Current efforts on SN progenitor study

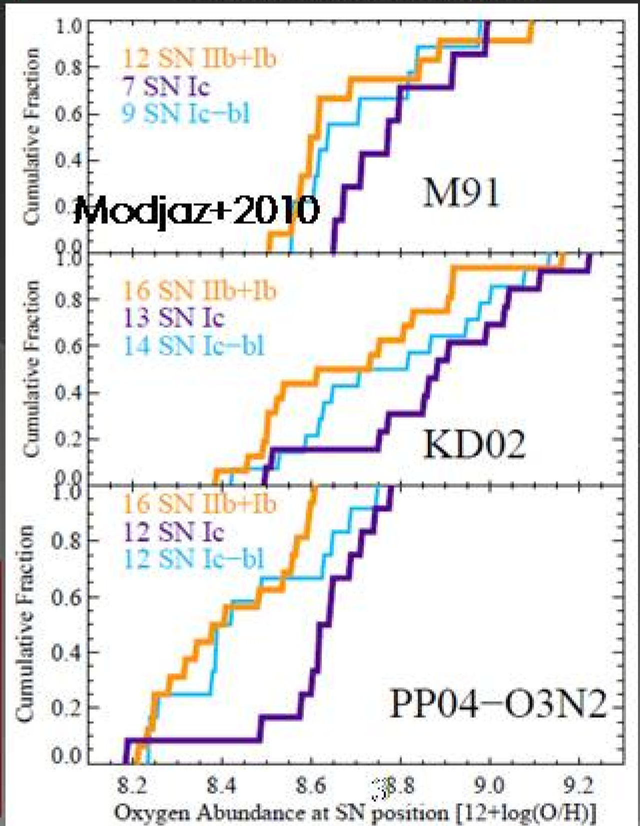
- Inferred properties from host galaxy or local environment studies

Metallicity from position in host galaxy





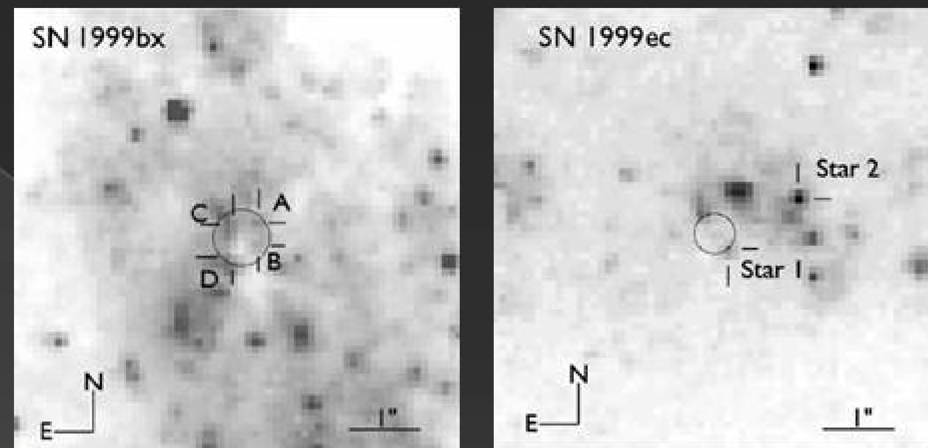
Association with nearby HII region from radial distance



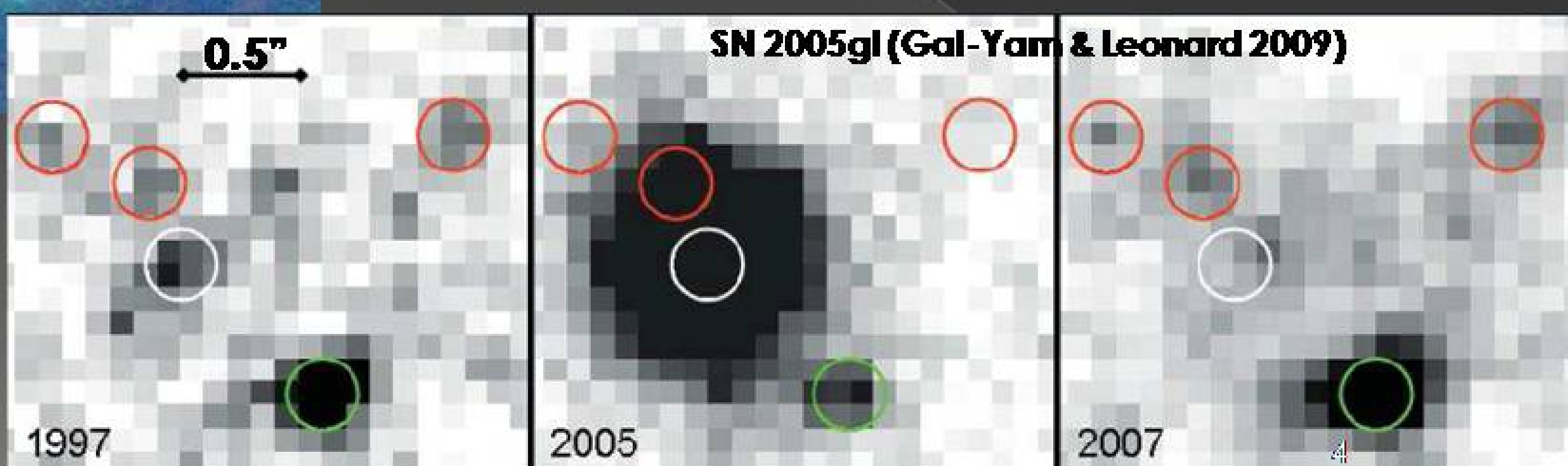
Metallicity from explosion site spectra

Pre-explosion direct progenitor imaging

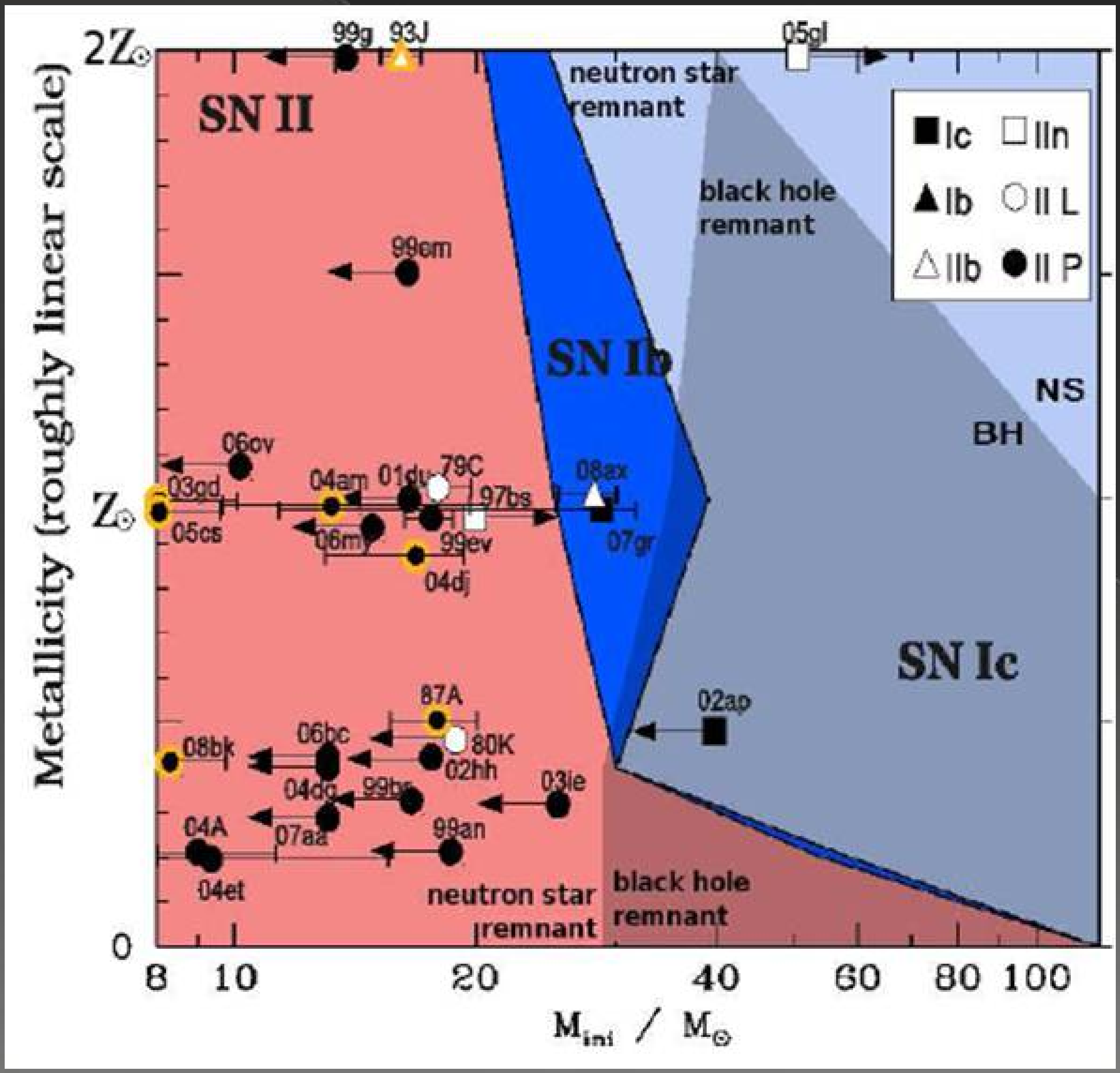
- Powerful, but not economical nor systematic
- Data mostly from HST, some from 8m-class+AO
- Archival data: limited information (e.g. color, depth)
- Ambiguity, nondetection is not uncommon
- Mass could be inferred but not metallicity



Van Dyk+ (2003)



CCSN progenitors: theoretical prediction vs. observed



reliable estimate ("gold" samples)

- Model is still not well-constrained by observational data!

Our strategy: progenitor mass & metallicity from host star cluster study

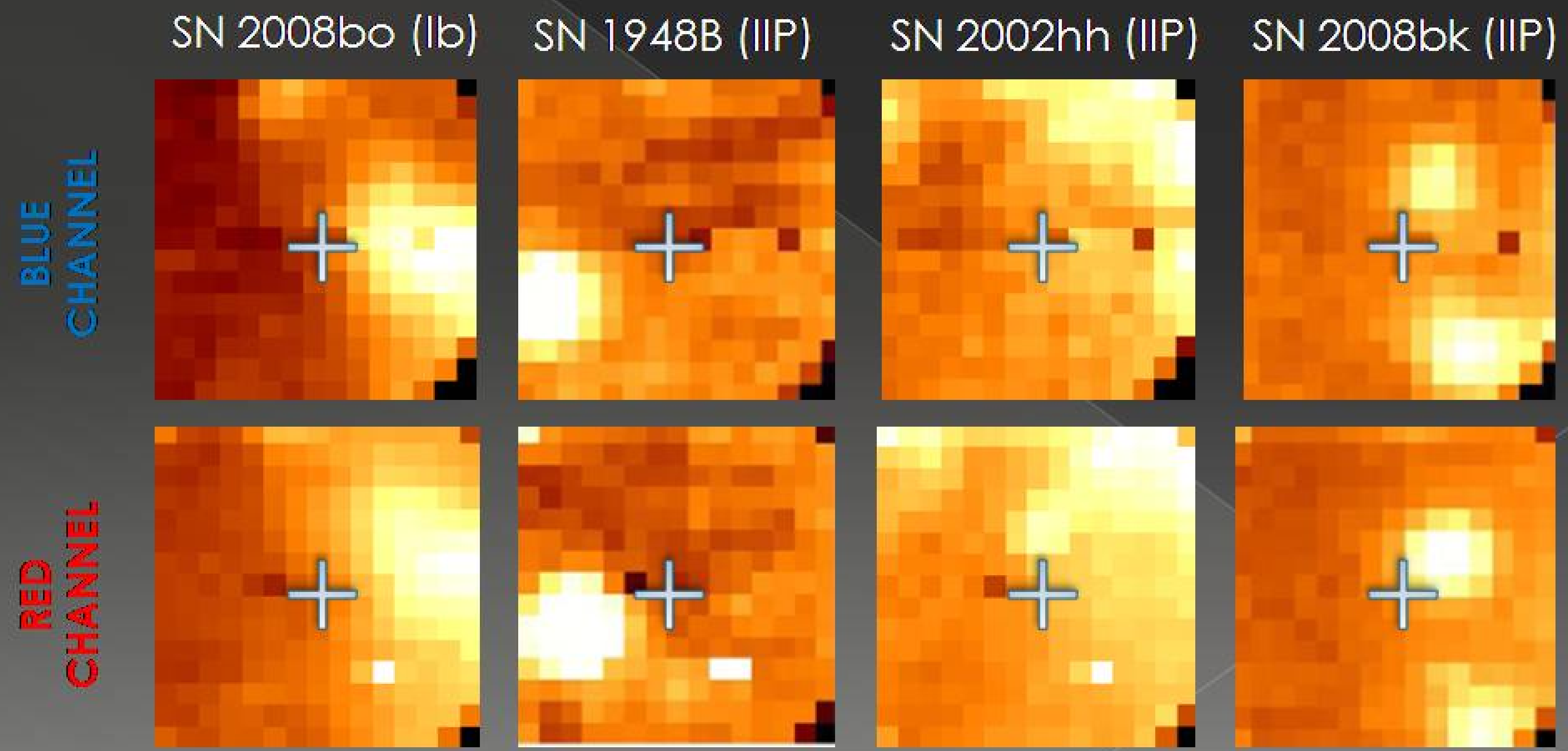
- Basis:
  - Most stars are born in star clusters
  - Cluster members: same age & metallicity
  - CCSN progenitor should have had short lifetime → no time to get far from parent cluster
- Method:
  - Observe SN host star cluster found at explosion site
  - Determine SN progenitor mass & metallicity from host cluster
- Ongoing work: spectroscopy of host clusters using UH88/SNIFS, compare with simple stellar population (SSP) models

SNIFS observation

- University of Hawaii 2.2m (UH88) + SuperNova Integral Field Spectrograph (SNIFS) at Mauna Kea
- Integral field spectroscopy → (x,y,λ) information on SN sites & host cluster
- 6"x6" FOV @ 0.4"/spaxel
- 3200-10000 Å @ $\Delta\lambda$ = 2.38 Å (blue), 2.93 Å (red)
- Aug 2010 (1 night), Mar 2011 (5 nights) observing runs

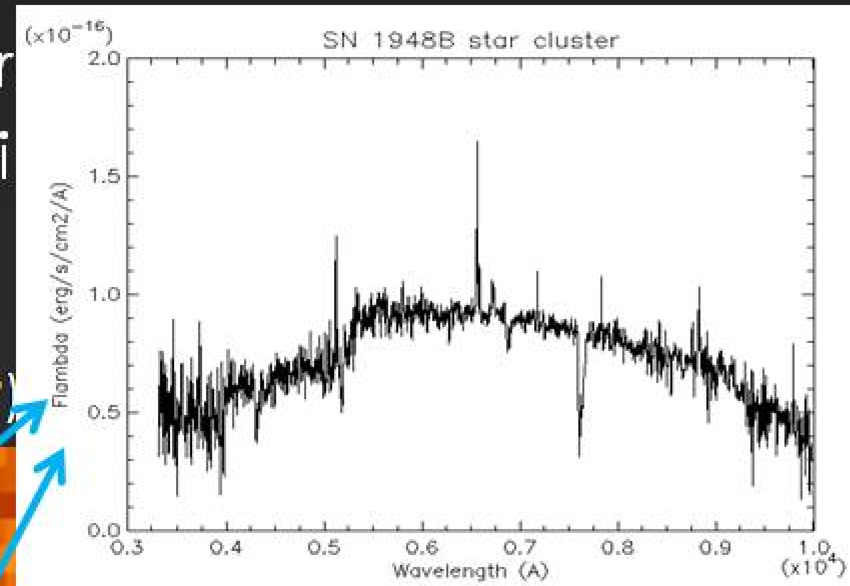
SNIFS Aug 2010 result

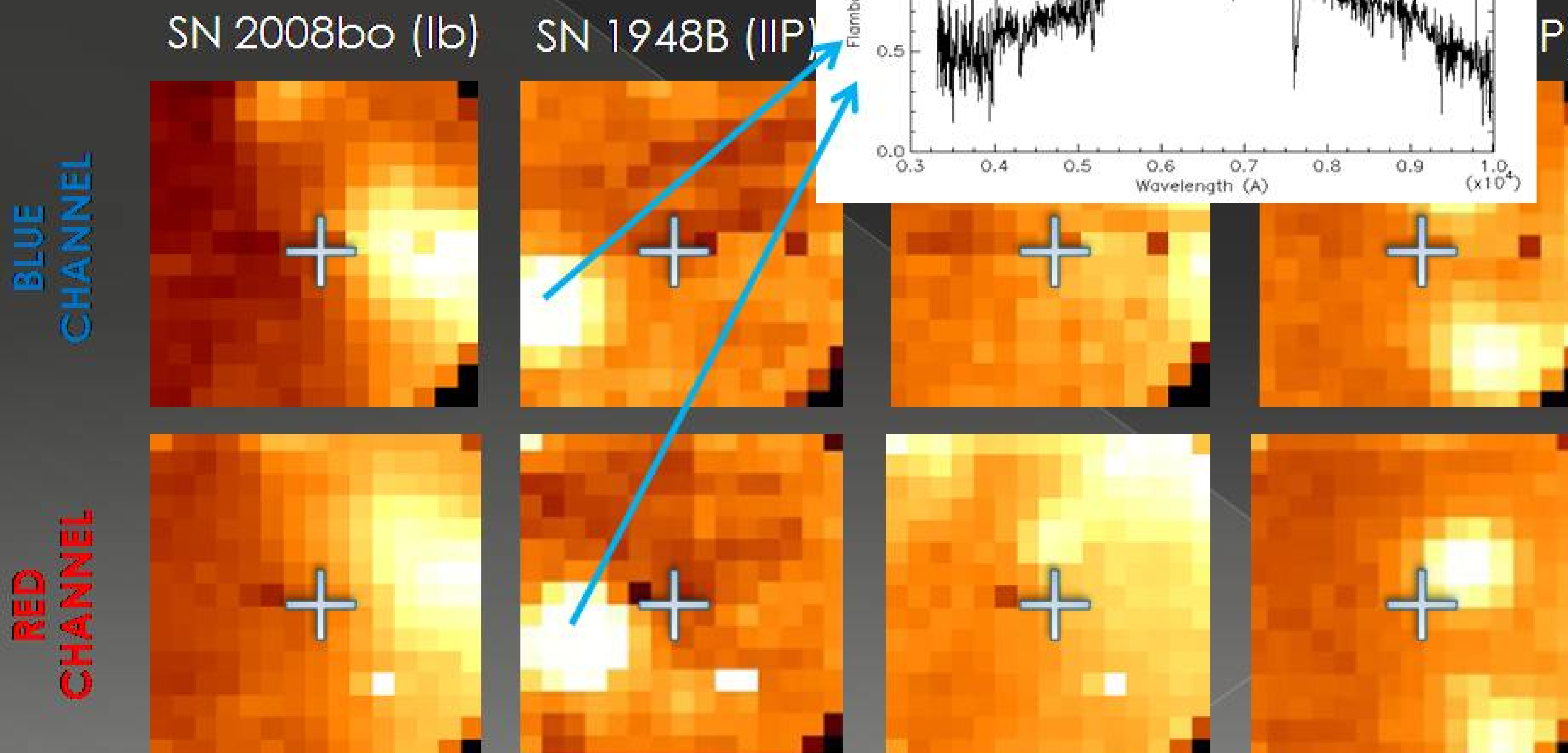
- Below: Integrated light from red/blue channel, 6"x6" FOV
- SN position at the center of field of view
- Limiting magnitude V~19



SNIFS Aug 2010 result

- Below: Integrated light from r … V
- SN position at the center of fi
- Limiting magnitude V~19





Proposed miniTAO/ANIR observation

- **Deep imaging of CCSN sites in nearby galaxies**
  - Optical/NIR simultaneous broadband (*BVRJHK*)
  - NIR narrow band (Paβ)
- Will also serve as follow-up observation for our SNIFS March targets

Information we hope to get from miniTAO/ANIR observations

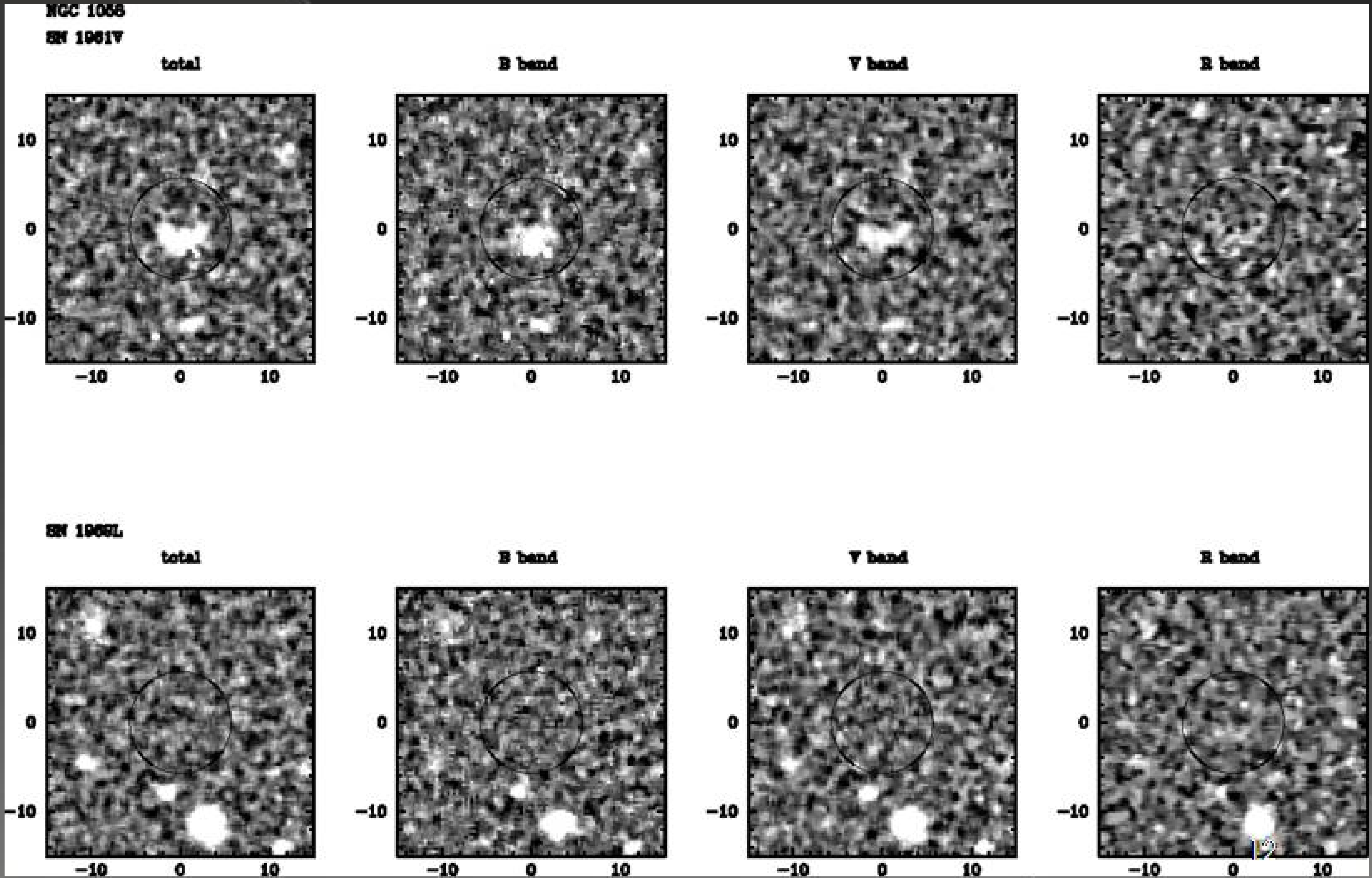
- Why some SNe seem to be hostless?
  - Not formed in cluster/runaway?
  - Cluster/extension too faint?

With ANIR imaging:
We will reach V~23, 4 mag deeper than SNIFS

- How large is the probability of chance superposition?

With ANIR imaging (5'x5' vs. 6"x6" SNIFS):
- **Estimation from radial distance distribution**
- **Estimation from fractional area covered by clusters**

Boffi+(1999): search for SN light echoes but detected star clusters instead



Information we hope to get from miniTAO/ANIR observations

- How accurate is our SNIFS spectrophotometry?

With ANIR imaging:
We will be able to cross-check with *BVR* photometry

- How good is our extinction estimate from SNIFS data?

With ANIR imaging:

- **We will be able to cross-check ANIR Paβ with SNIFS Balmer decrement (Hα, Hβ)**
- **Optical/NIR photometry → color-color diagrams to estimate cluster age, reddening**

Targets

- Total 21 targets
- Multi-SN galaxies → more samples of SN sites within ANIR FOV (N_{SN}>>21)
- Cover 12/18 of our March SNIFS target

SN site	SNtype	Host glx	Multi-SN	SN RA2000	SN Dec2000	Paβ
SN 1983N	Ib	NGC5236	yes (5)	13:36:51.24	-29°54' 02.70"	yes
SN 2004dk	Ib	NGC6118	no	16:21:48.93	-02°16' 17.29"	no
SN 2007uy	Ib	NGC2770	yes (3)	09:09:35.28	33°07' 09.19"	no
SN 1994I	Ic	NGC5194	yes (2)	13:29:54.07	47°11' 30.52"	no
SN 1983I	Ic	NGC4051	yes (3)	12:03:09.00	44°32' 06.00"	yes
SN 1964L	Ic	NGC3938	yes (3)	11:52:49.07	44°07' 45.08"	no
SN 2000ew	Ic	NGC3810	yes (2)	11:40:58.60	11°27' 55.80"	no
SN 2004gt	Ic	NGC4038	yes (3)	12:01:50.37	-18°52' 12.68"	no
SN 1970G	II L	NGC5457	yes (2)	14:03:00.83	54°14' 32.78"	no
SN 1979C	II L	NGC4321	yes (6)	12:22:58.63	15°47' 51.76"	no
SN 1999gi	II P	NGC3184	yes (5)	10:18:16.66	41°26' 28.21"	no
SN 1965L	II P	NGC3631	yes (3)	11:21:03.00	53°10' 17.00"	no
SN 2006ov	II P	NGC4303	yes (6)	12:21:55.30	04°29' 16.69"	no
SN 1986I	II P	NGC4254	yes (3)	12:18:52.04	14°24' 44.10"	no
SN 2001bq	II P	NGC5534	no	14:17:42.14	-07°25' 00.70"	no
SN 2002ed	II P	NGC5468	yes (4)	14:06:38.22	-05°27' 28.01"	no
SN 1999br	II P	NGC4900	no	13:00:41.82	02°29' 45.38"	no
SN 1998A	II P	IC2627	yes (2)	11:09:50.33	-23°43' 43.10"	no
SN 2001gd	IIb	NGC5033	yes (3)	13:13:23.89	36°38' 17.70"	no
SN 1987K	IIb	NGC4651	yes (2)	12:43:41.17	16°23' 44.92"	no
SN 2000ch	IIn	NGC3432	no	10:52:41.40	36°40' 08.51"	no

Time justification

- 21 targets: 5σ source detection at *BVR* ~ 23 and *JHK* ~ 21 → 600s exposures
- Simultaneous *BVR*/*JHK*
  - 600 s x 3 filters = 1800 s/target
  - 21 x 1800s = 10.5 hours total
- Paβ on+off:
  - 3600 s x 2 filters x 2 targets = 4 hours total
- Total requested observing time: 14.5 hours, including overheads & standard stars: ~20 hours

Summary

- We propose miniTAO/ANIR deep imaging in *BVR-JHK-Paβ* of nearby core-collapse SN sites
- Main purpose: to strengthen our SNIFS results on SN progenitor mass & metallicity,
- Total requested observing time: 20 hours (14.5 hours science exposure)

Thank you very much