Results from the Nearby Supernova Factory

R. C. Thomas for the SNfactory

KITP: 2007-03-23

A/K/A (it's okay)

Rollin**s** Thomas

Tom Rollins

Roland Thomas

Collaboration

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B. Weaver

Yale
C. Baltay
N. Ellman
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LPNHE
P. Antilogus
J. Li
R. Pain
R. Pereira
C. Wu

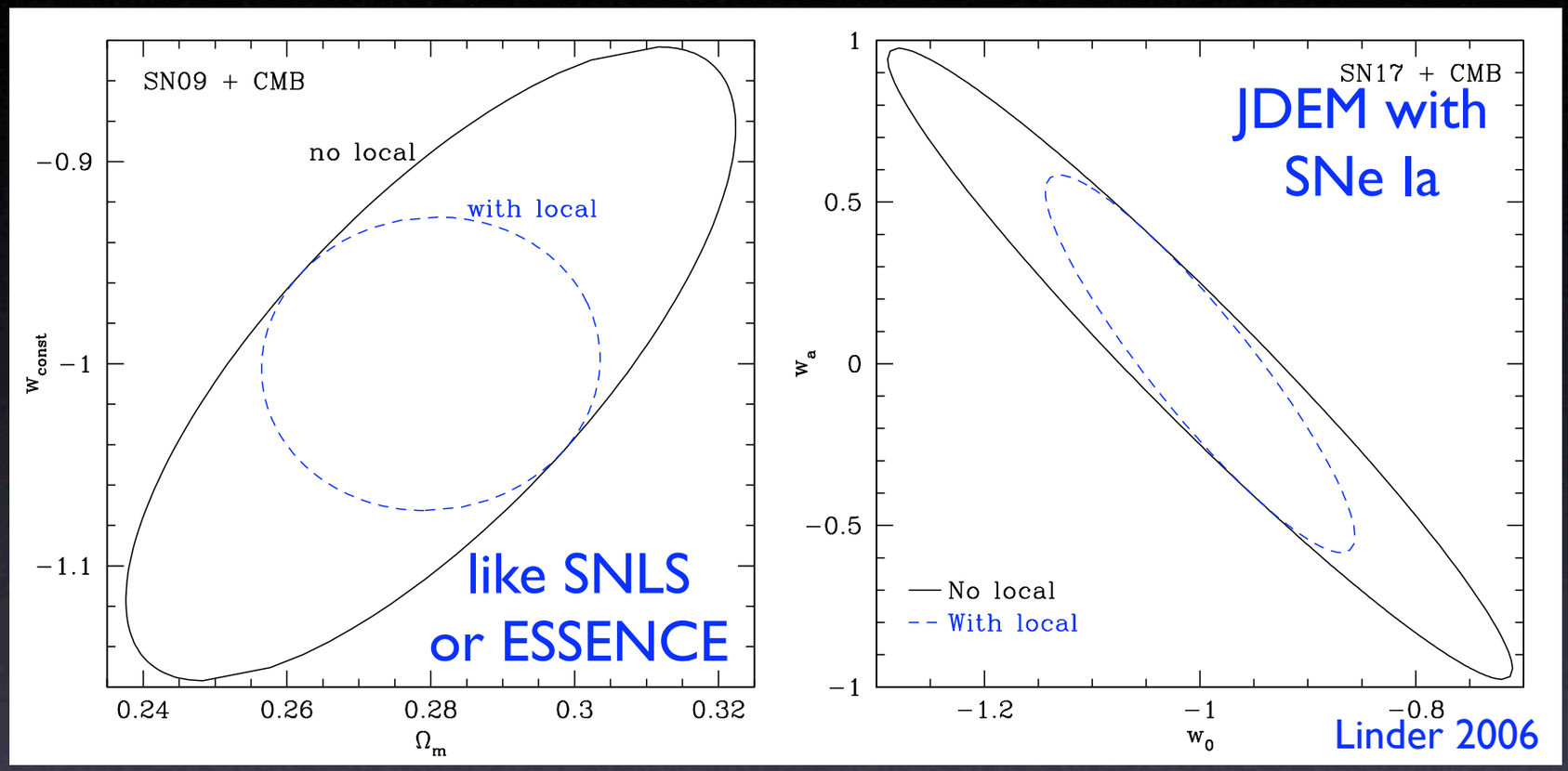
IPNL
C. Buton
Y. Copin
E. Gangler
G. Smadja

CRAL
E. Pecontal
G. Rigaudier

Scientist/Faculty, Postdoc, Grad Student

SNfactory Science Goals

Few hundred SN Ia light curves between $0.03 < z < 0.08$ to reduce Dark Energy statistical uncertainty.



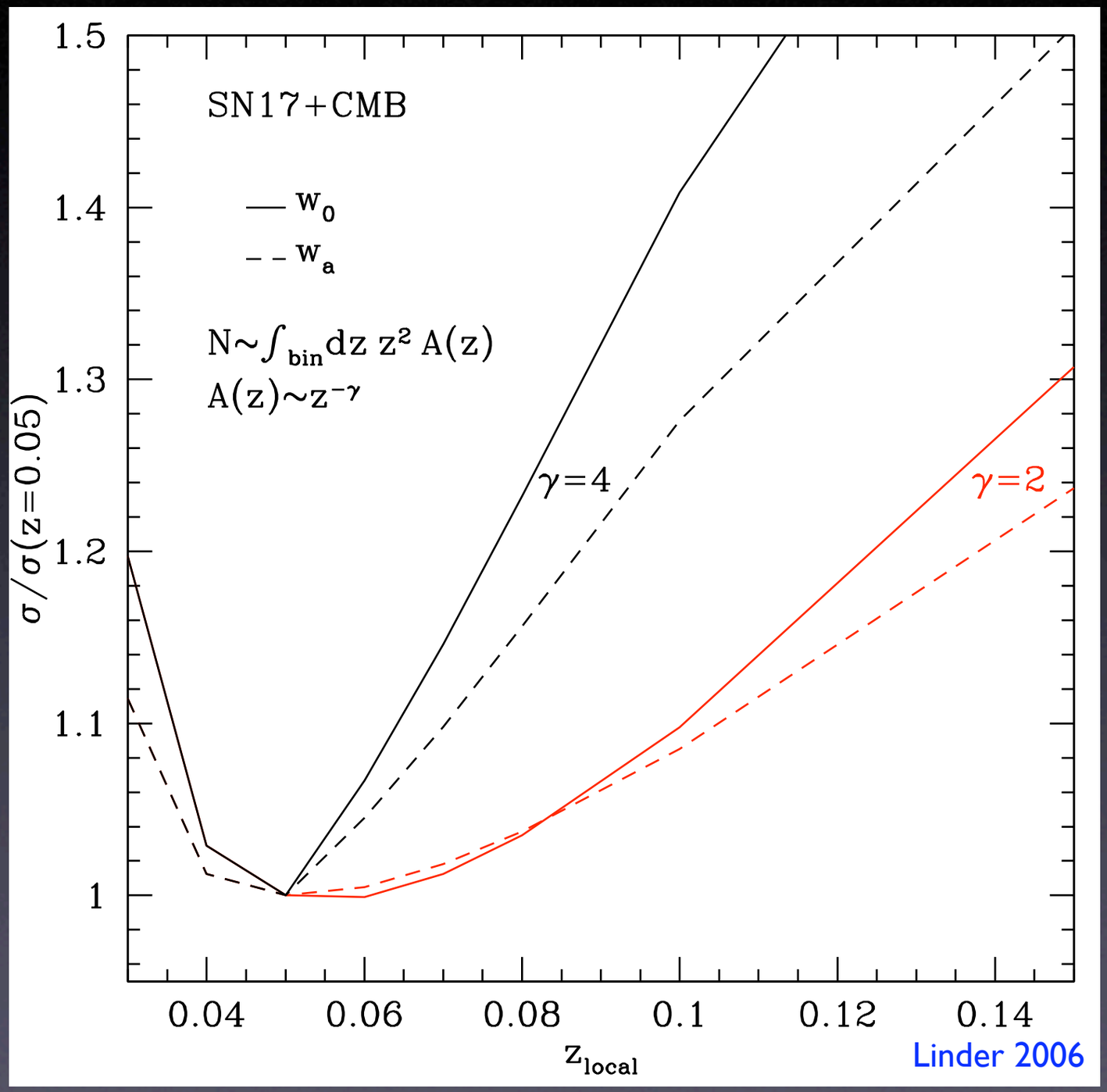
SN Ia light curves and spectra in time series to study to enable the control of supernova systematic uncertainty.

Analysis of the data set to improve our understanding of SN Ia physics and better calibrate them as standardized candles.

Motivation

DETF

For SN - detailed spectroscopic and photometric observations of 500 nearby supernovae to study the variety of peak explosion magnitudes and any associated observational signatures of effects of evolution, metallicity, or reddening, as well as improvements in the system of photometric calibrations.



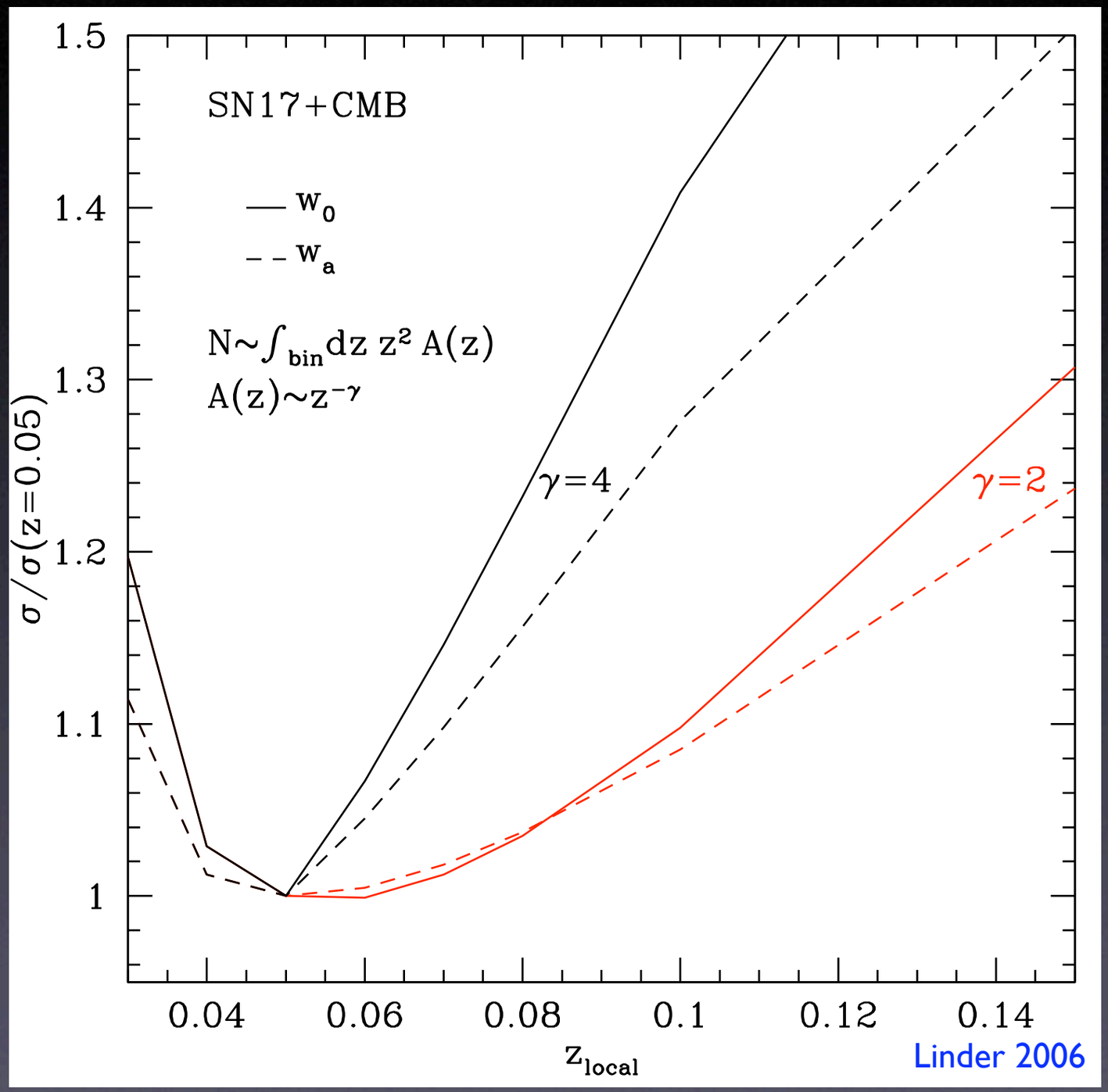
Motivation

DETF

For SNAP - detailed spectroscopic and photometric observations of 500 nearby supernovae to study the variety of power explosion magnitude, host galaxy associated observational signatures of effects of evolution, metallicity, or reddening, as well as improvements in the system of photometric calibrations.

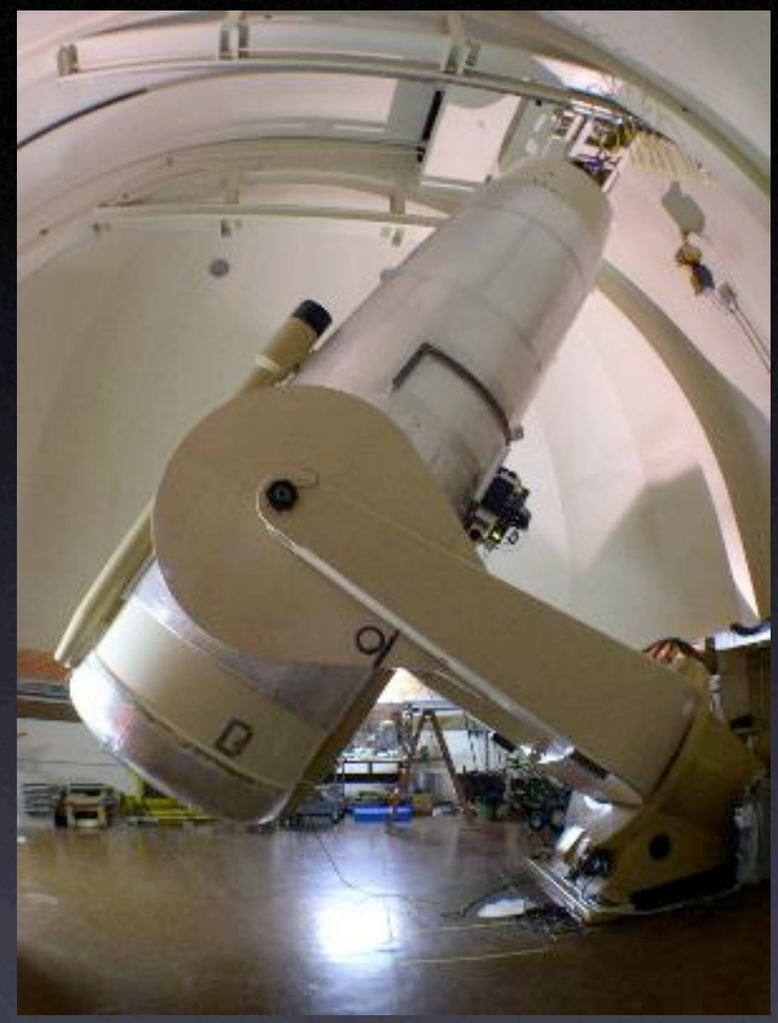
BORING

SNe Ia are also interesting physical phenomena!



Search Overview

Palomar 1.2-m, QUEST-II camera (NEAT/QUEST surveys, piggybacked).



Search pipeline at LBL for rapid (<24h) turnaround on large sky area.

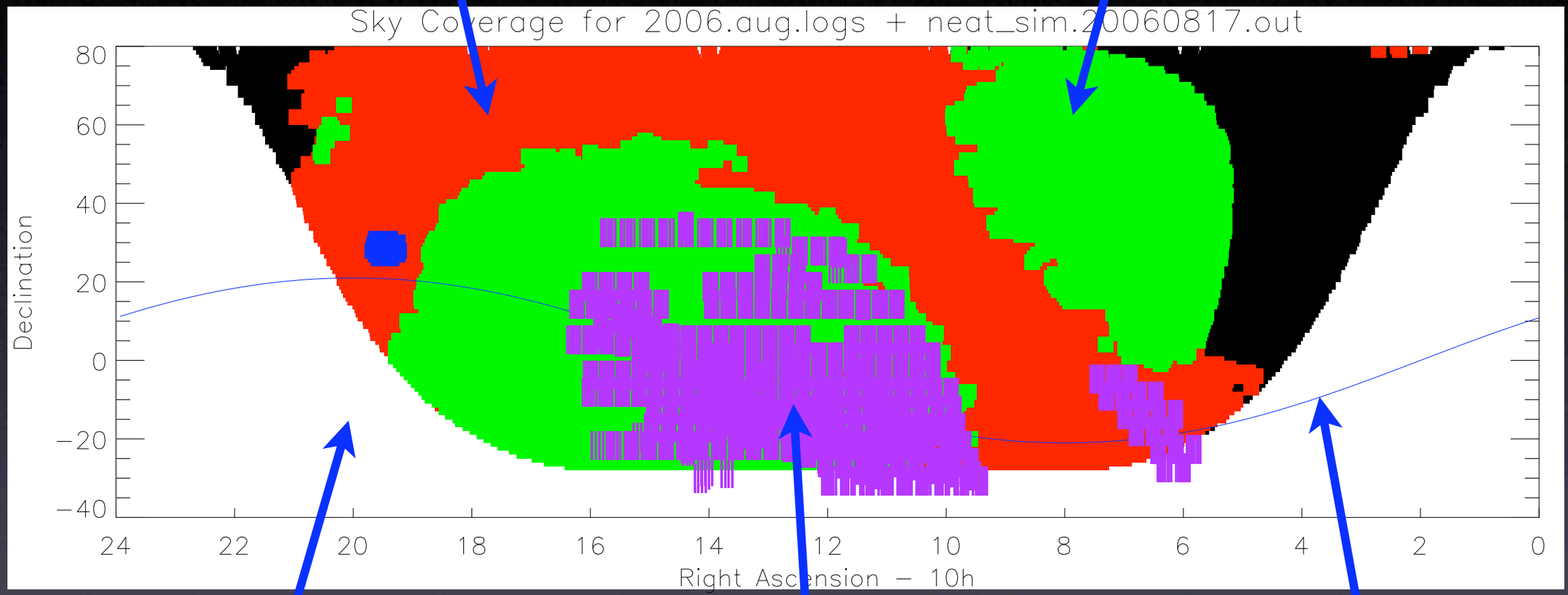
Processing/subtraction code from SCP with added infrastructure to scale up 100x or 1000x throughput.

Reliance on distributed computing, distributed long term storage through NERSC facilities at LBL.

Sky Coverage

Milky Way

Followup Area



Daytime

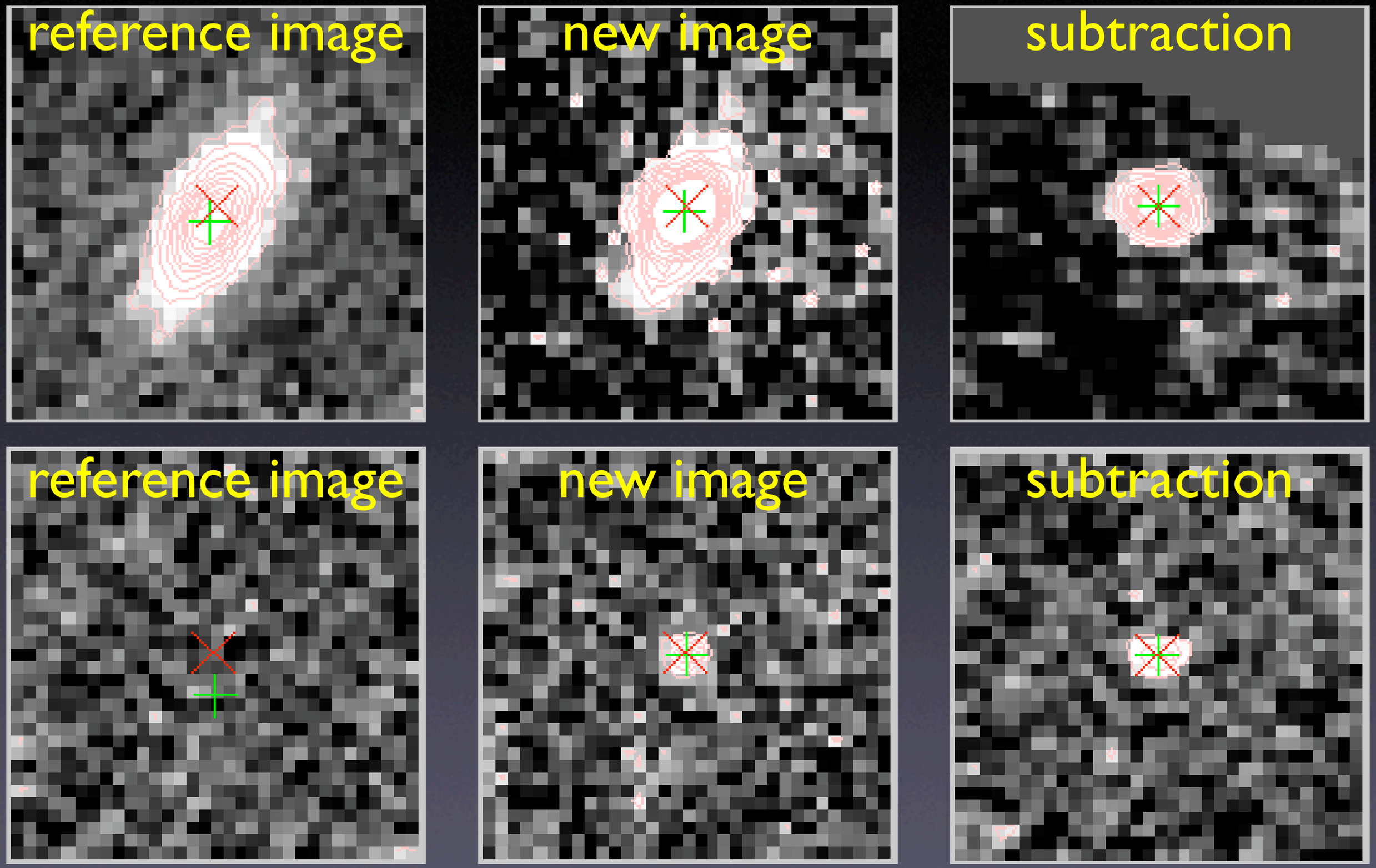
NEAT Pointings

Ecliptic

Point+Track: 2500-3000 sq deg/month.

Drift-scan: 100-200 sq deg/month.

“Backseat Driver” Search



Search Pipeline

PALOMAR

New Images Collected

HPWREN

NSF

HPSS

Raw New Images

Processed Images

Subtractions

PDSF

Preprocessing
Object Finding
Astrometry

Reference Cache
New/Ref Matching

Subtractions
Generated,
Events Scored

Candidates
Scanned by
Humans

Less than 24 h turnaround is critical.

30000-40000 (50GB) images/night.

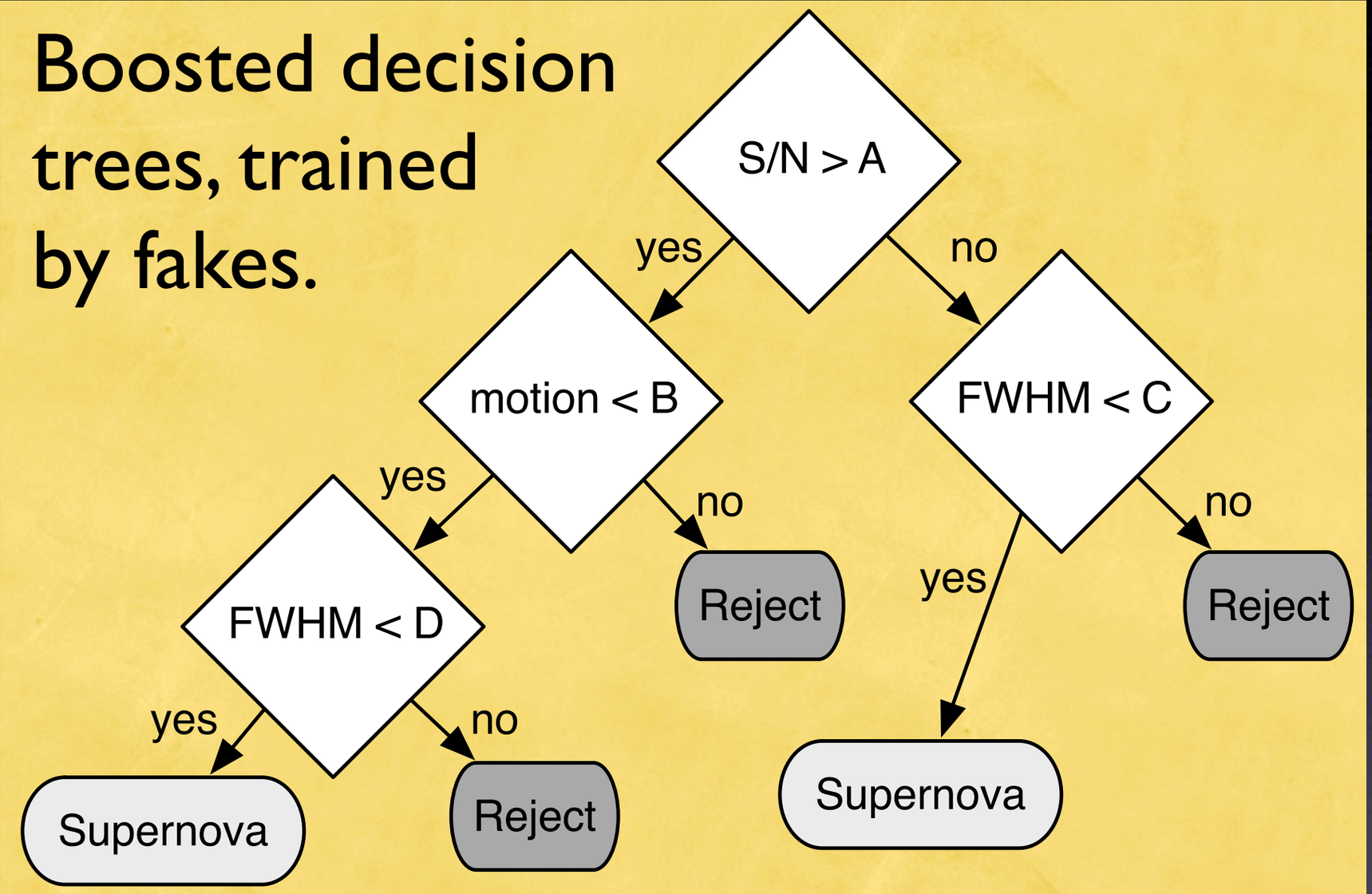
Machine Learning Classifiers

Candidates live in ~20 dimensional score space.

Hyperplane "cuts" retain too much garbage.

~ 1000 candidates requiring human scanning.

Boosted decision trees, trained by fakes.



Reduced human scanning load to 100 candidates/day.

Bailey, et al. 2007 (ApJ, submitted)

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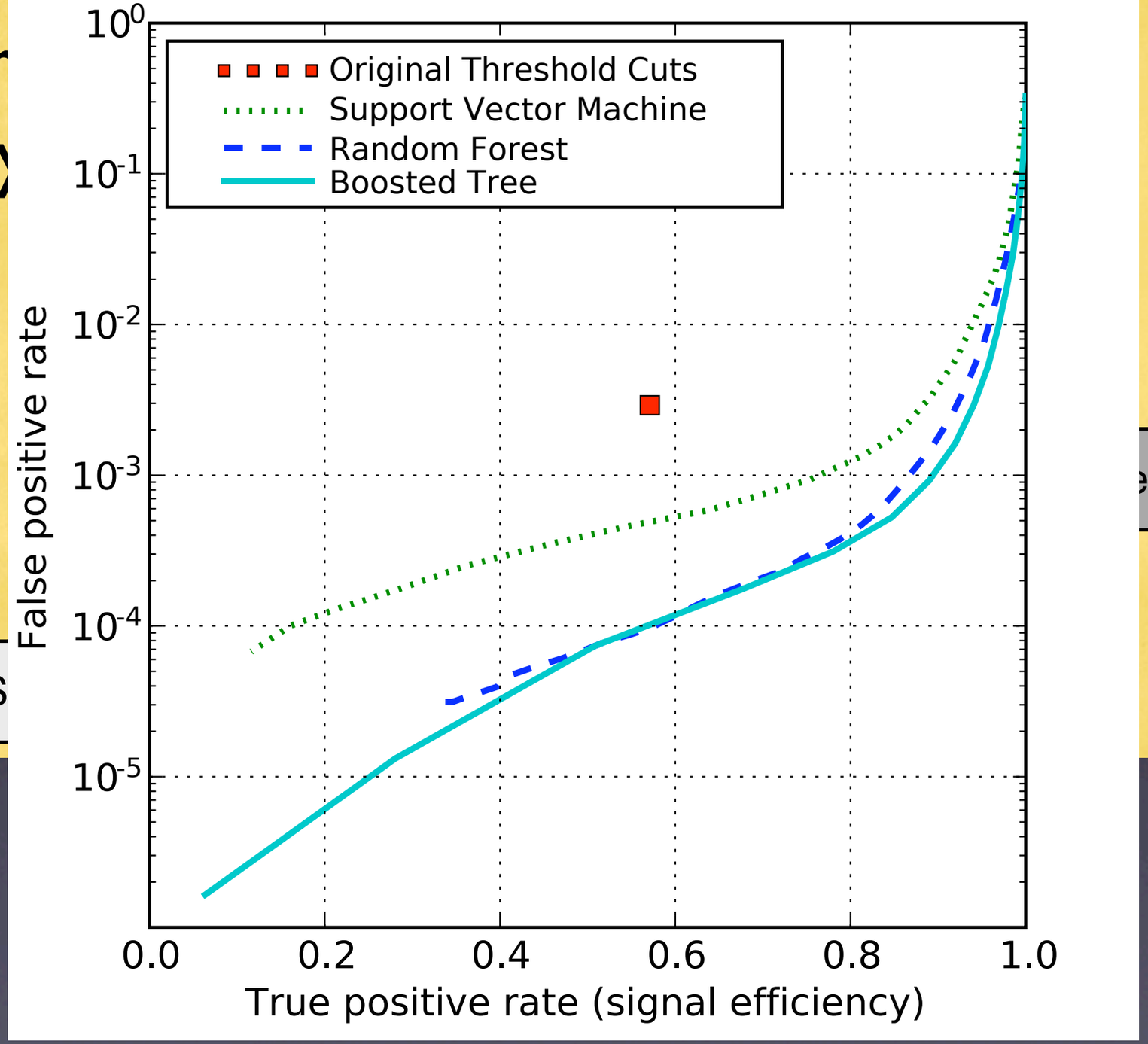


Bailey, et al. 2007 (ApJ, submitted)

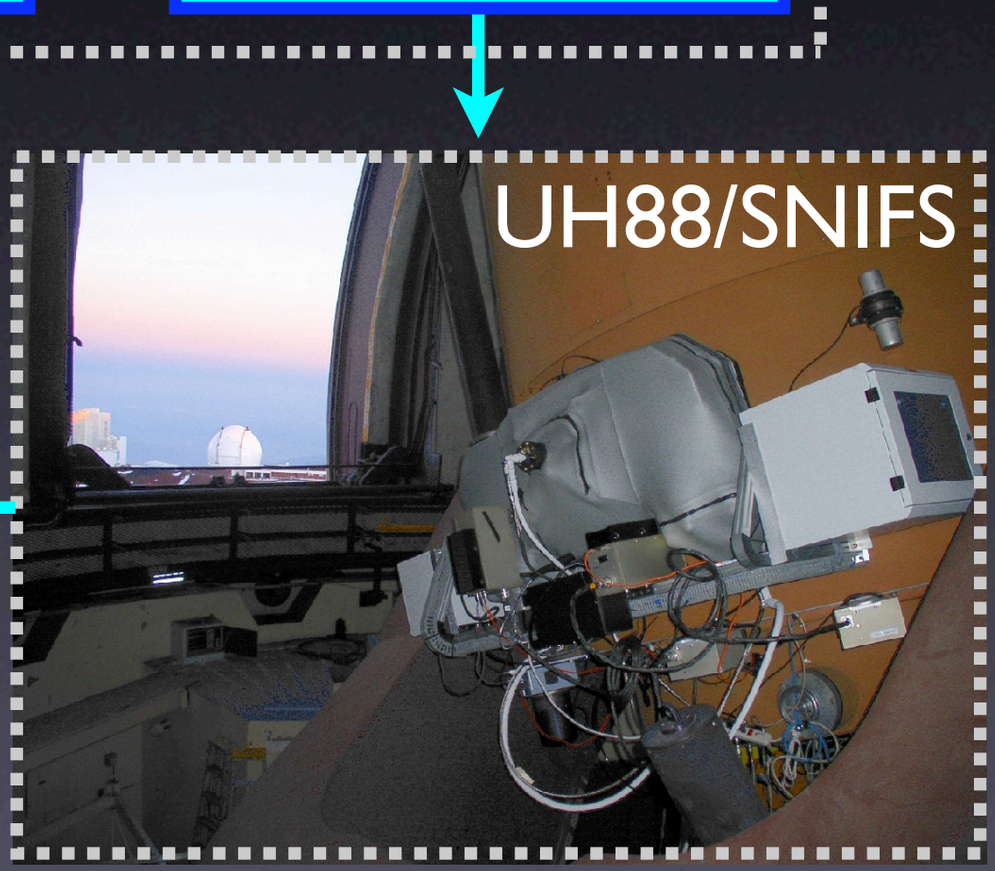
Followup Overview

LBL

Subtractions → Events (scored) → Candidates (scanned, vetted)

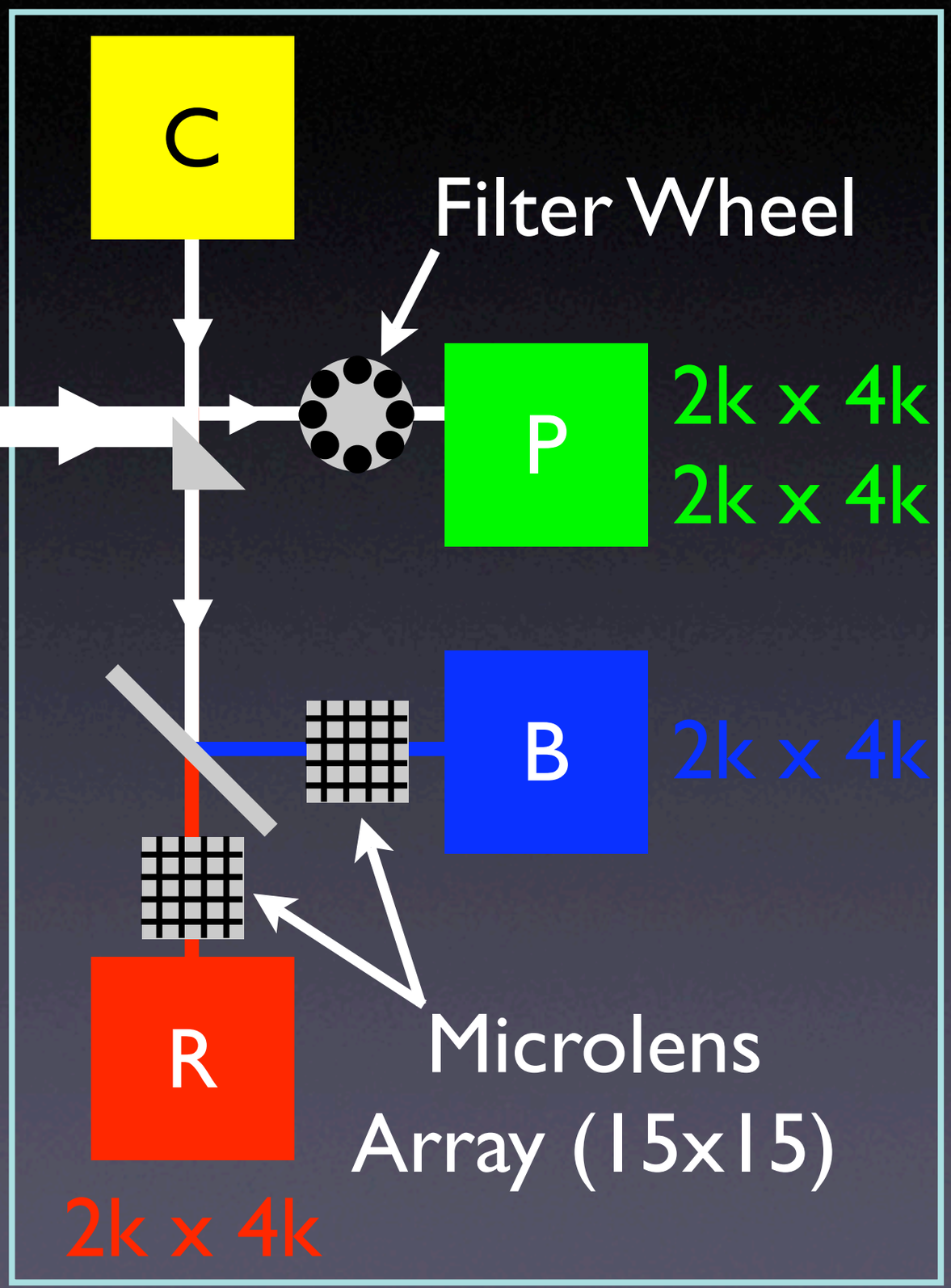
IN2P3 (France)

Storage Resource Broker/Central SNIFS Processing → Postmortem Analysis



30% share of UH88 time
2-3 nights per week

SNIFS



"SuperNova Integral Field Spectrograph"

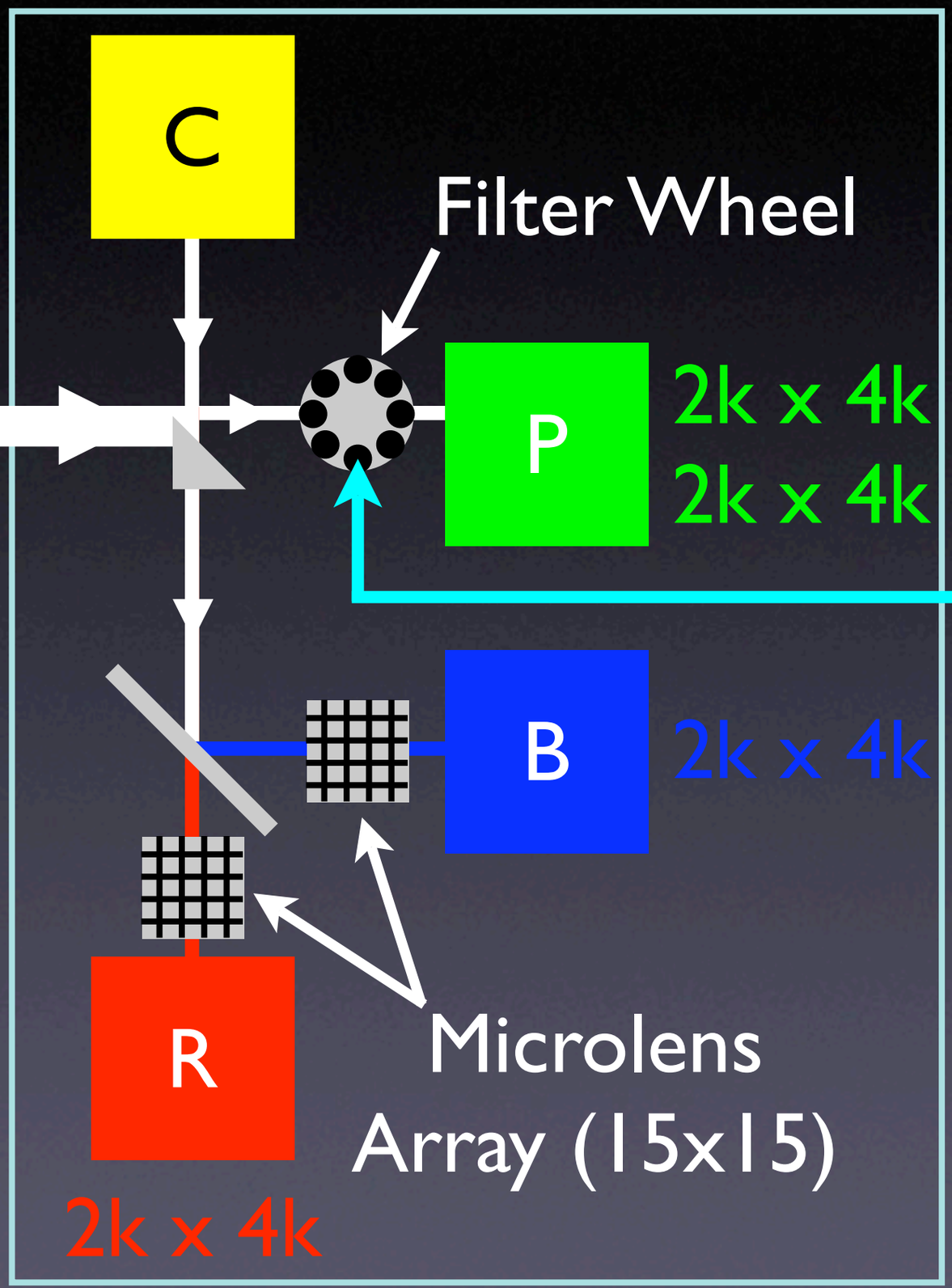
Spectroscopy channels
- Blue: 320 - 520 nm
- Red: 510 -1100 nm
- MLA FOV 6"x6"

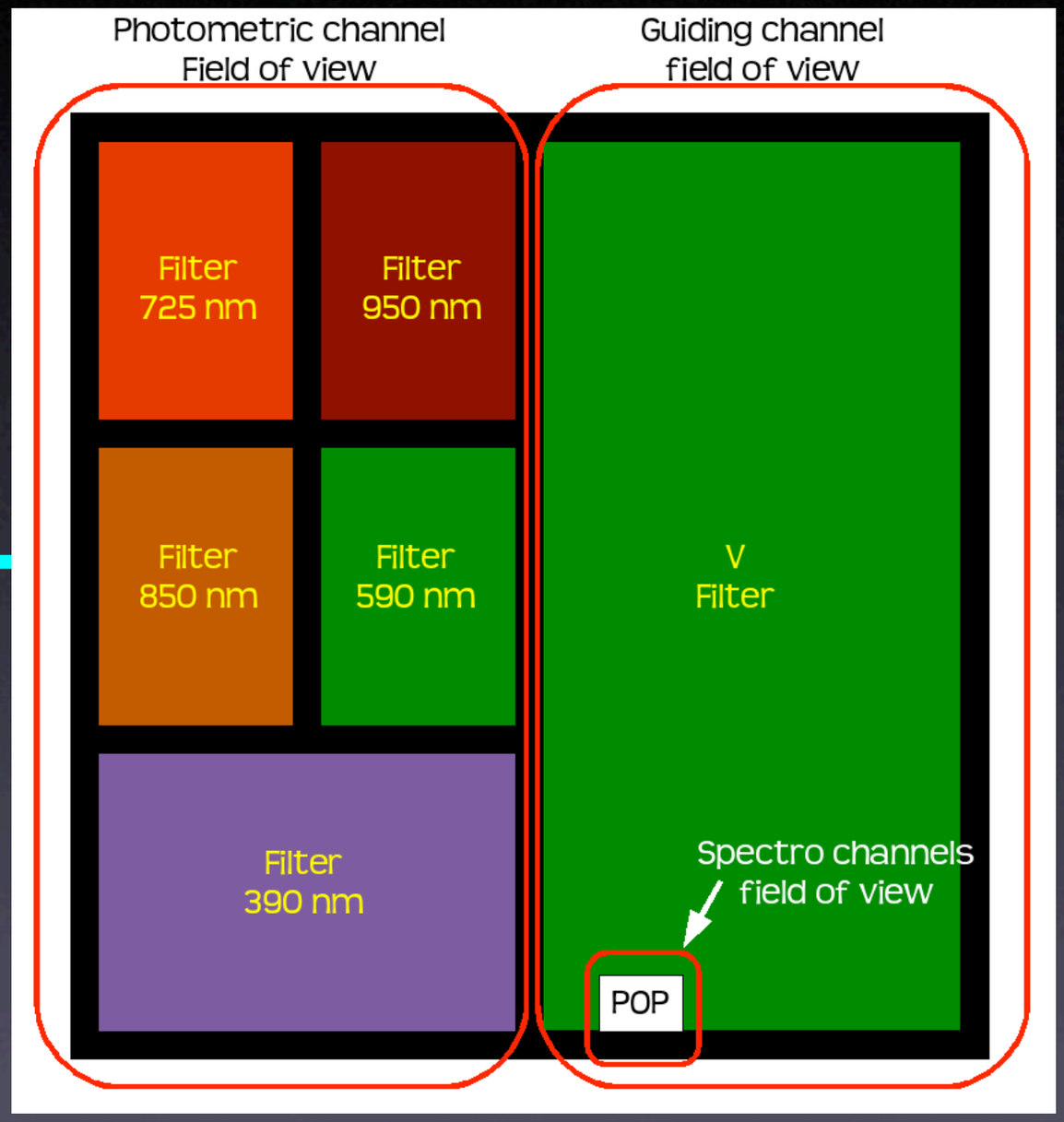
Calibration unit
- arc lamps
- continuum lamps

Photometric channel
- ~ 9' x 9' FOV
- automated acquisition
- guiding
- extinction monitoring

SNIFS

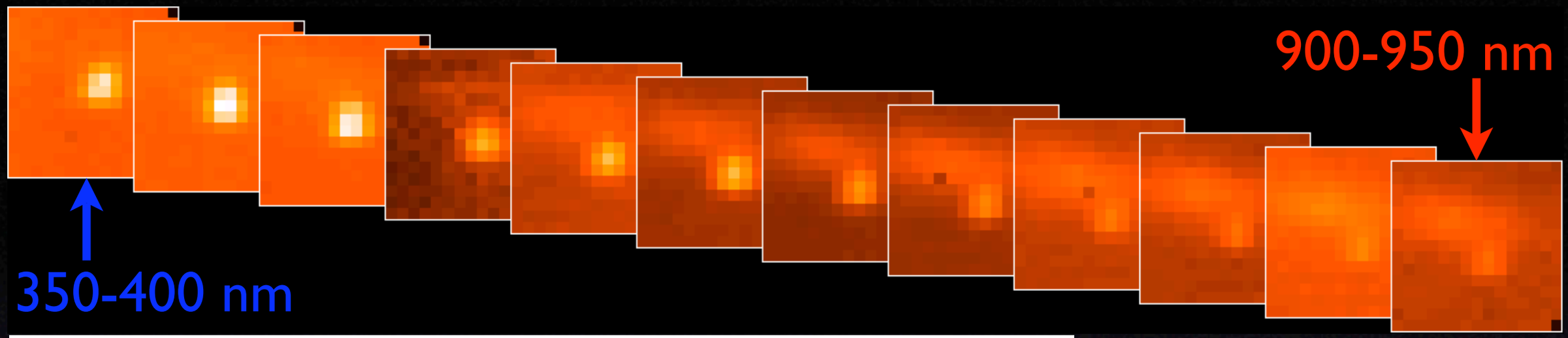
"SuperNova Integral Field Spectrograph"

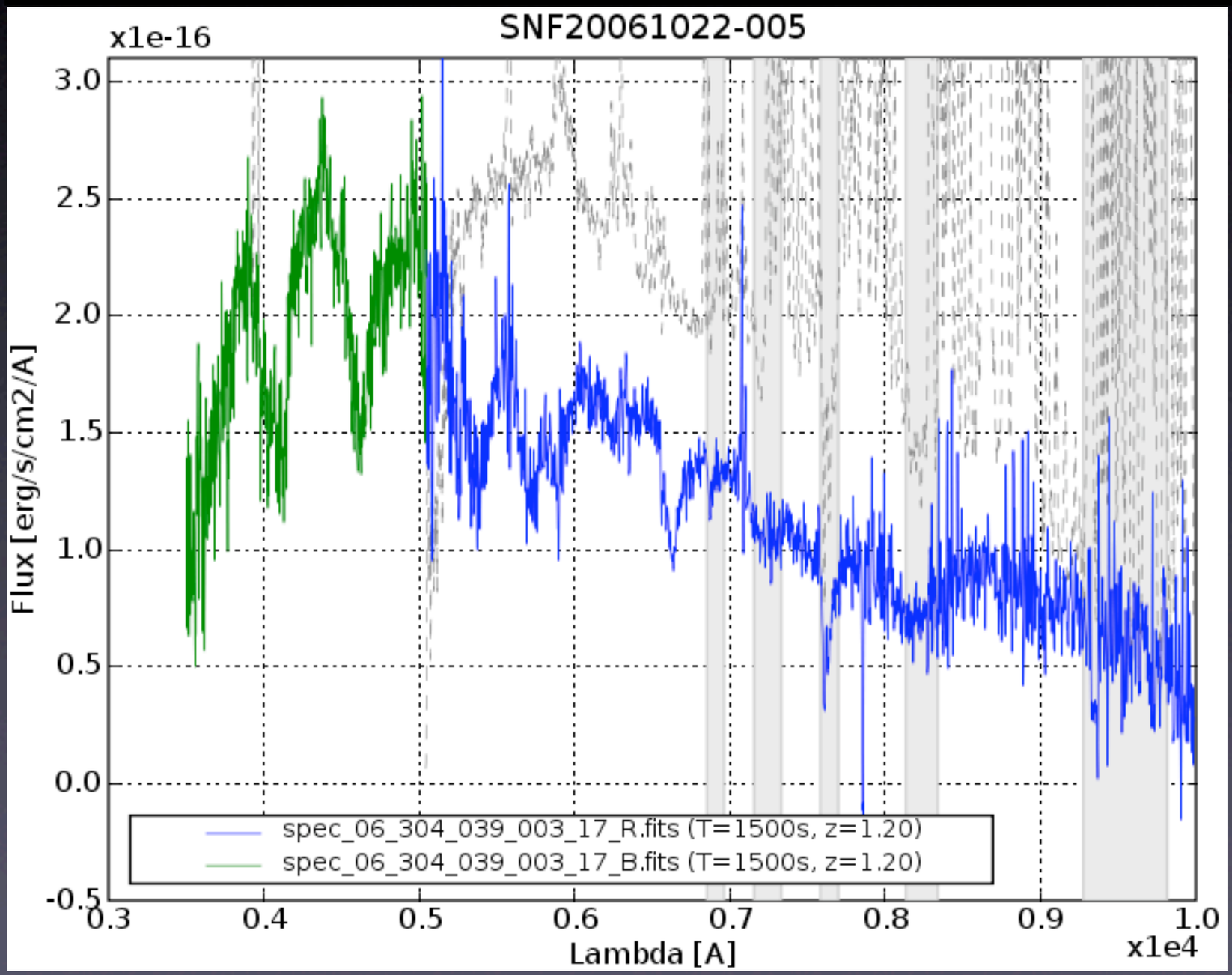




extinction monitoring

guiding





Individual lenslet spectra mapped into datacubes.

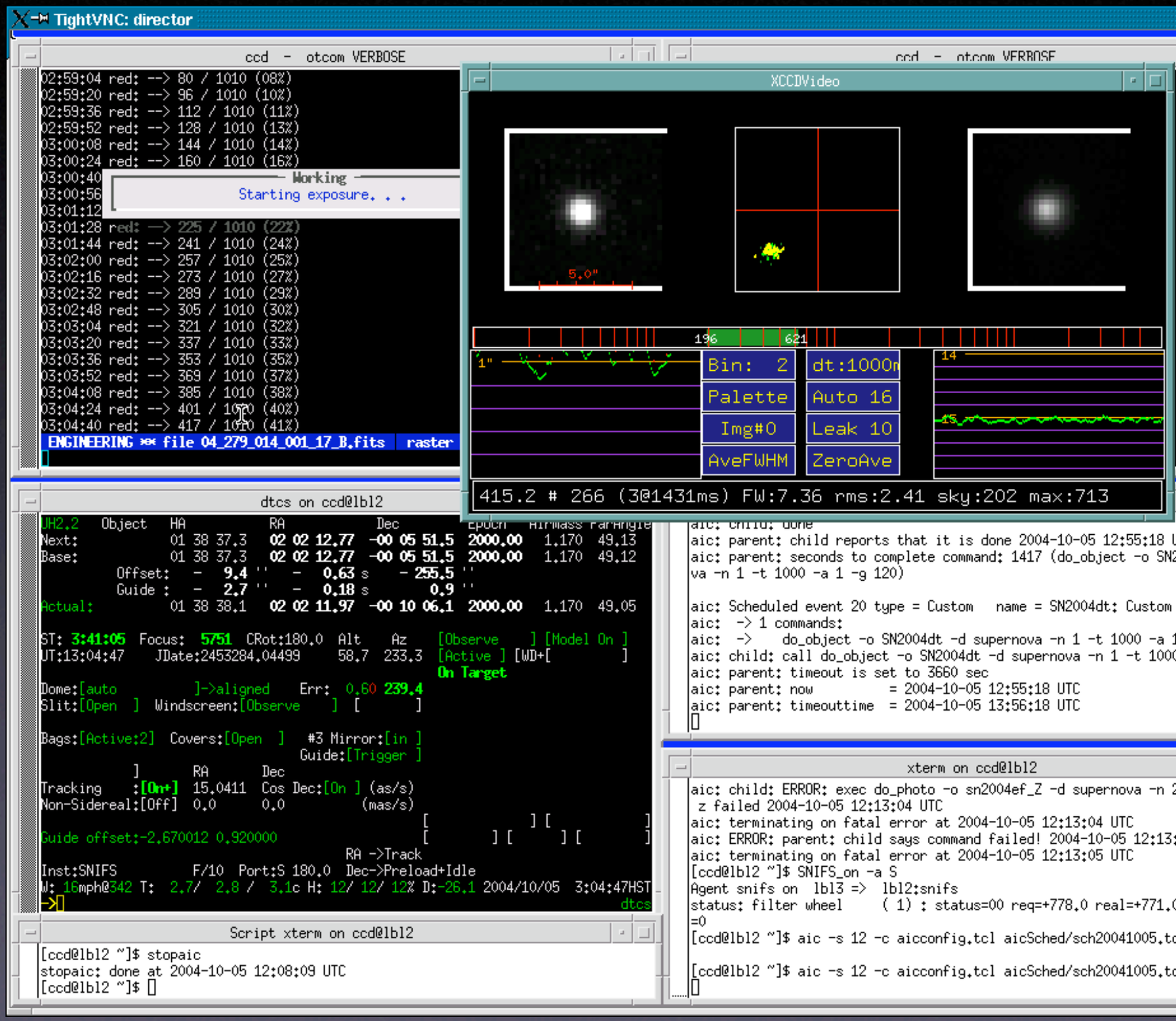
Quickie aperture extraction for realtime feedback.

Automated Spectroscopy

Remote observe from anywhere via VNC.

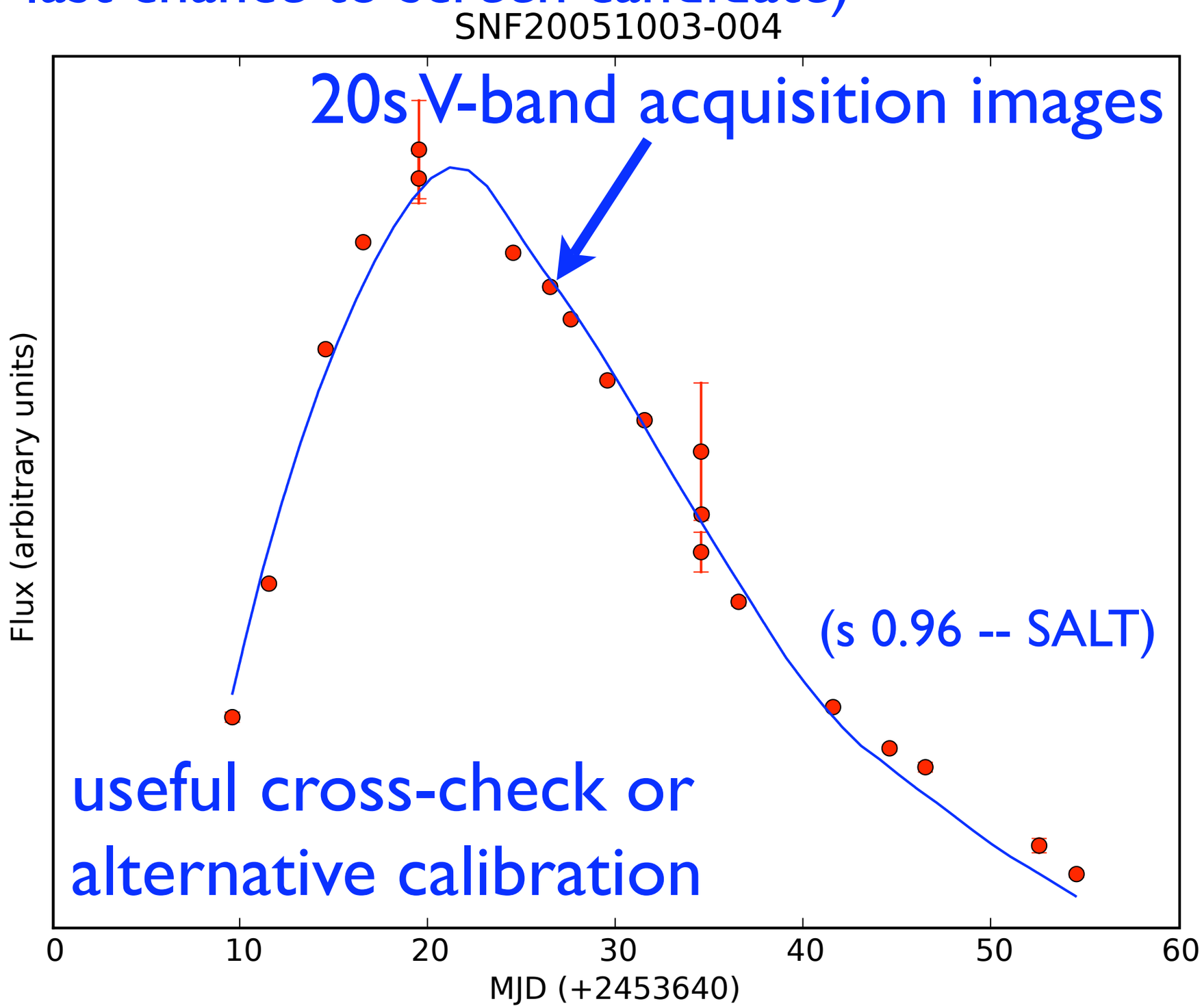
2-3 day cadence, shifts done in France (daytime)

UH observers have used SNIFS for comets, AGN and asteroids.

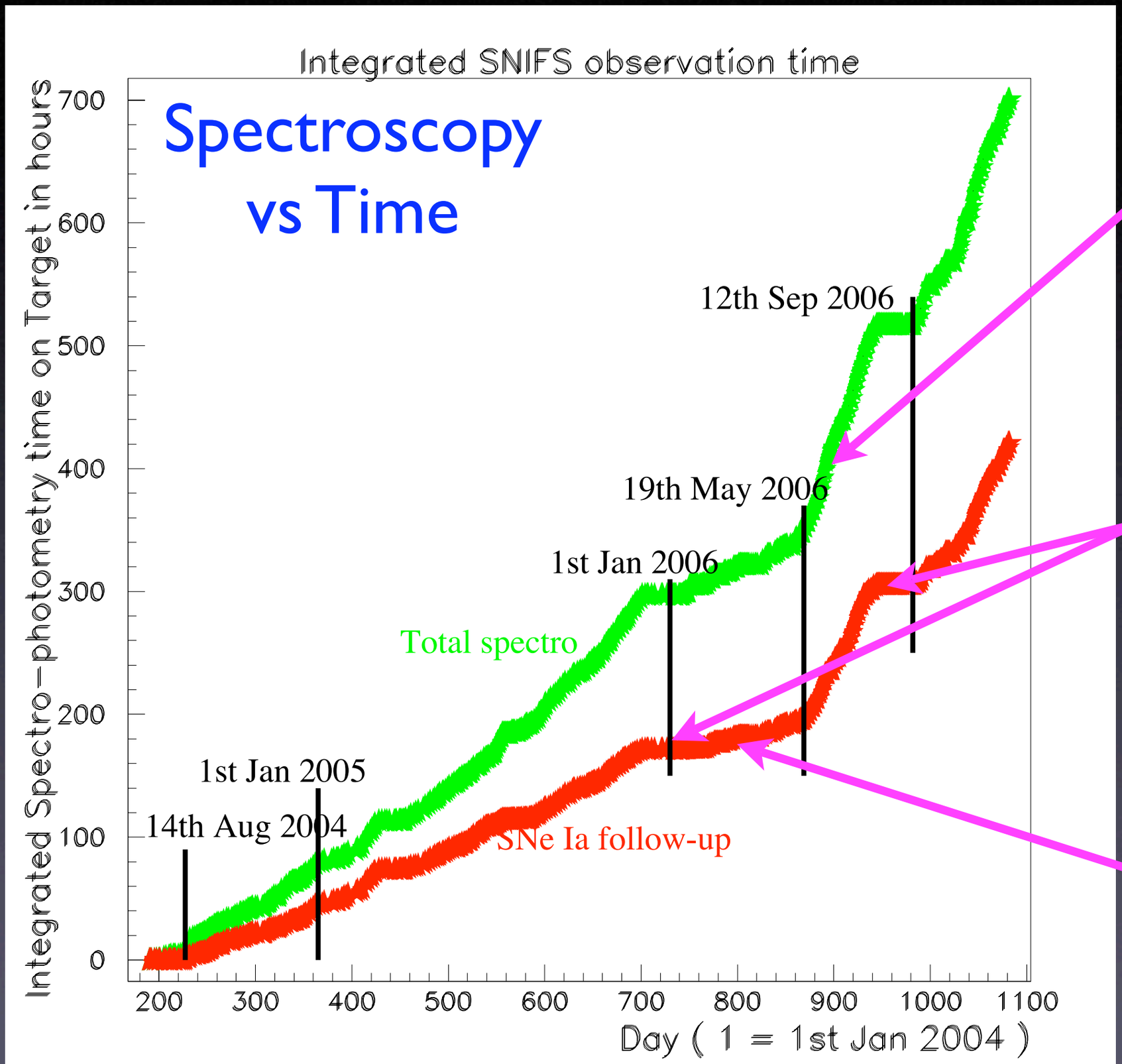


P Channel Acq Light Curves

(also last chance to screen candidate)



SNIFS Productivity



Increase in slope at 19 May due to full night transition.

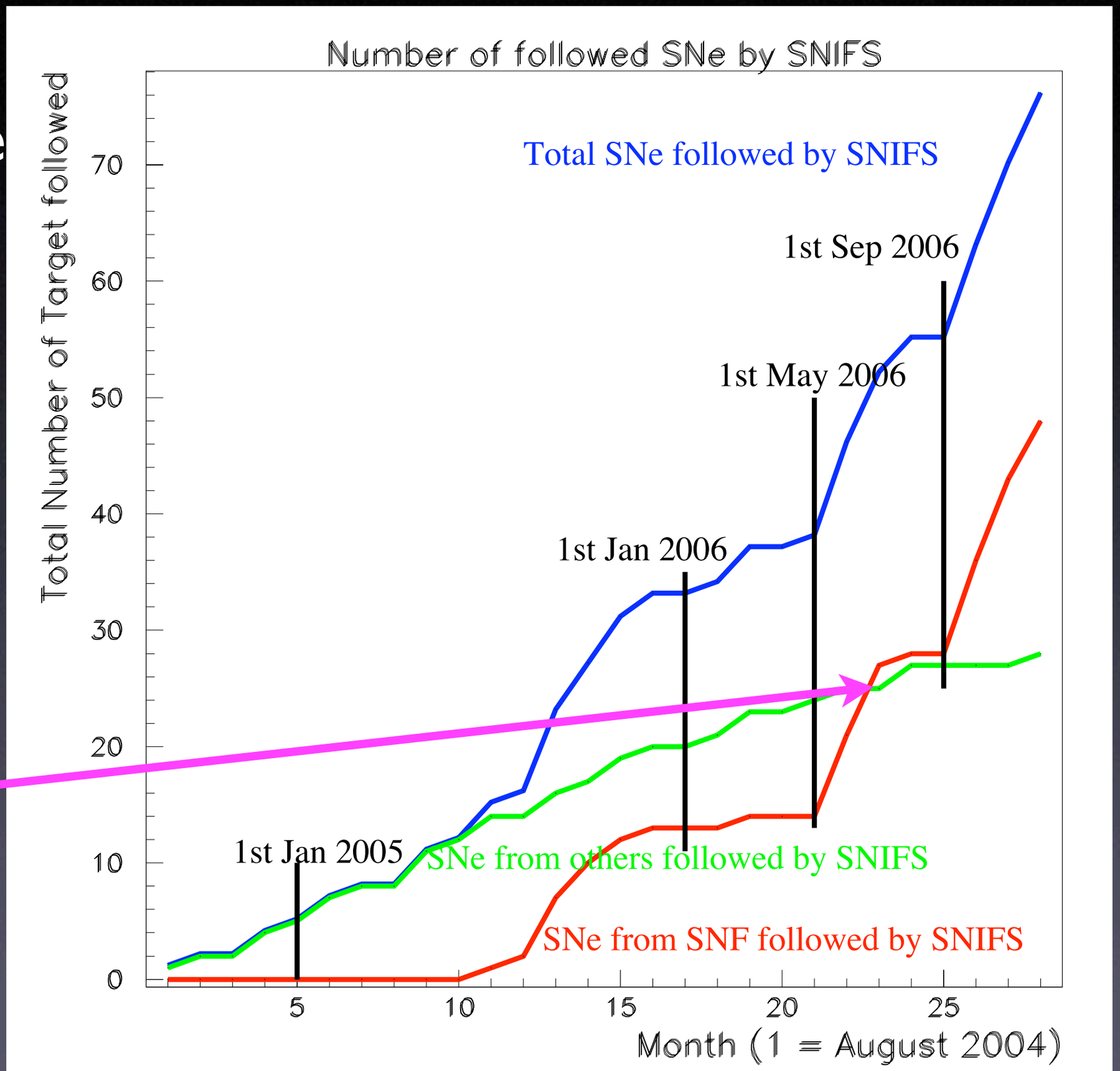
LIPS incident, POP motor problem responsible for flat portions.

First 3 months of 2006 had the worst weather in decades on Mauna Kea.

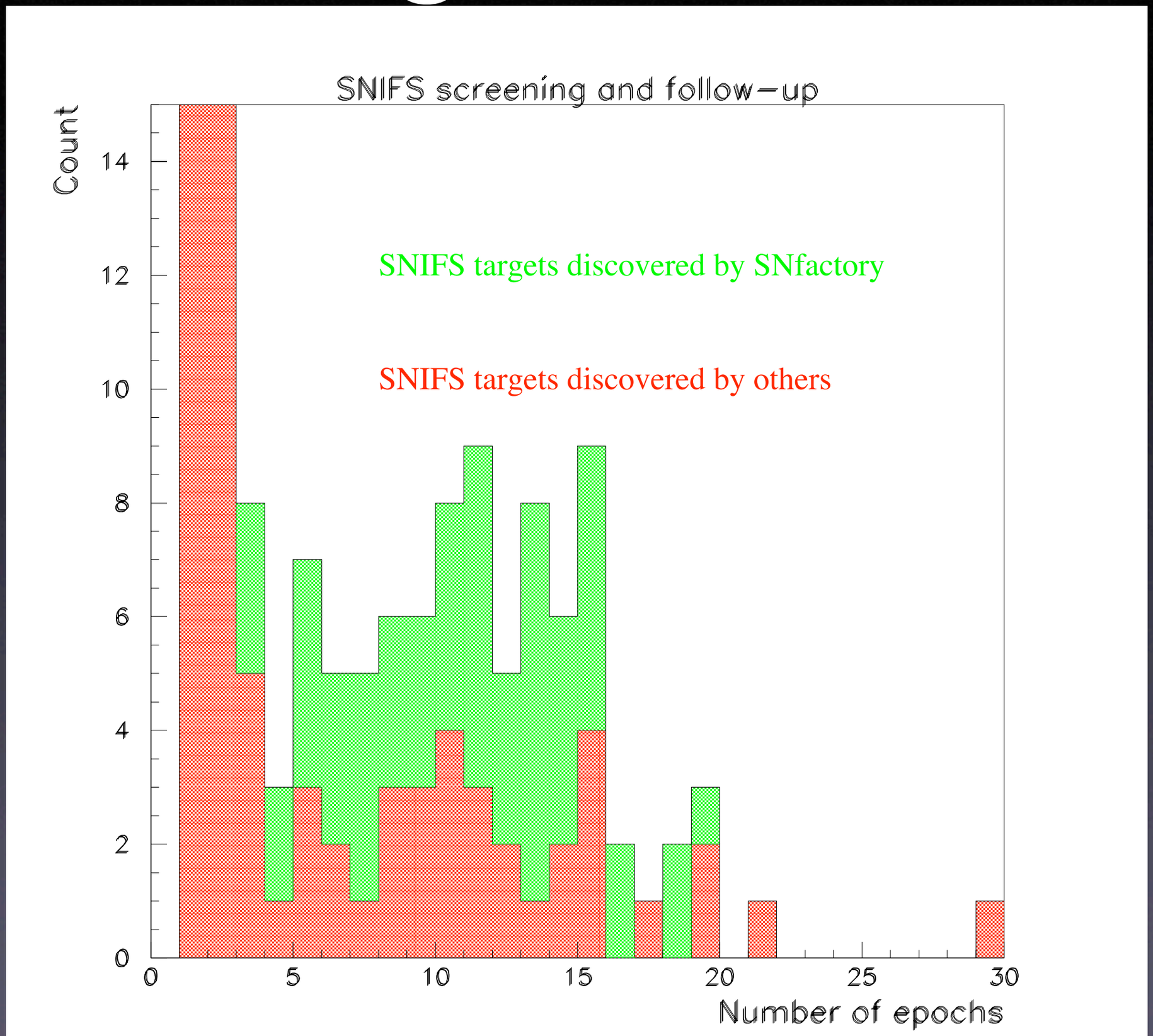
SNIFS SN Ia Followup

Historically we have supplemented our search with IAUC SNe.

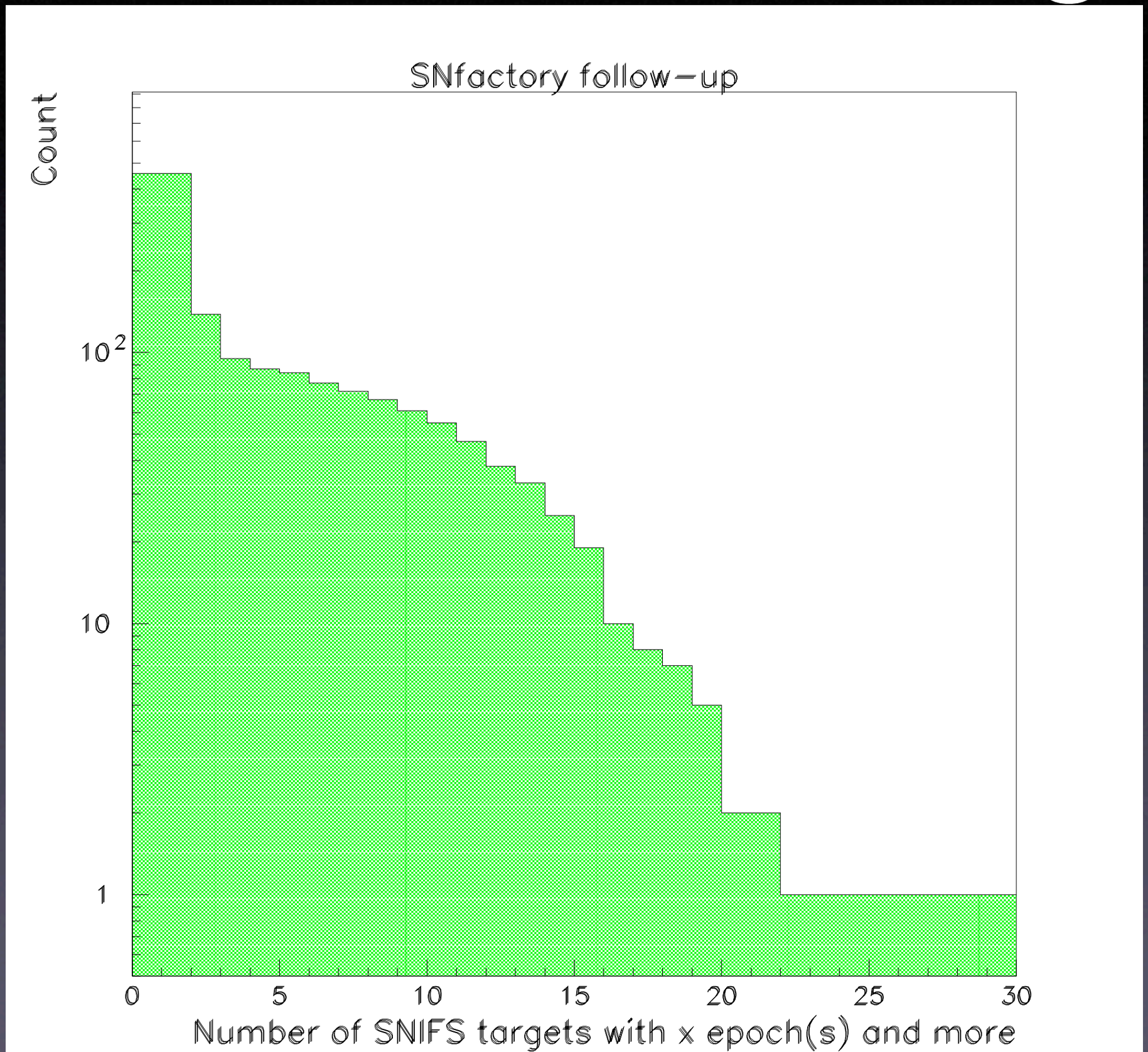
Search productivity increase has reduced our time available for IAUC targets.



Screening and Followup

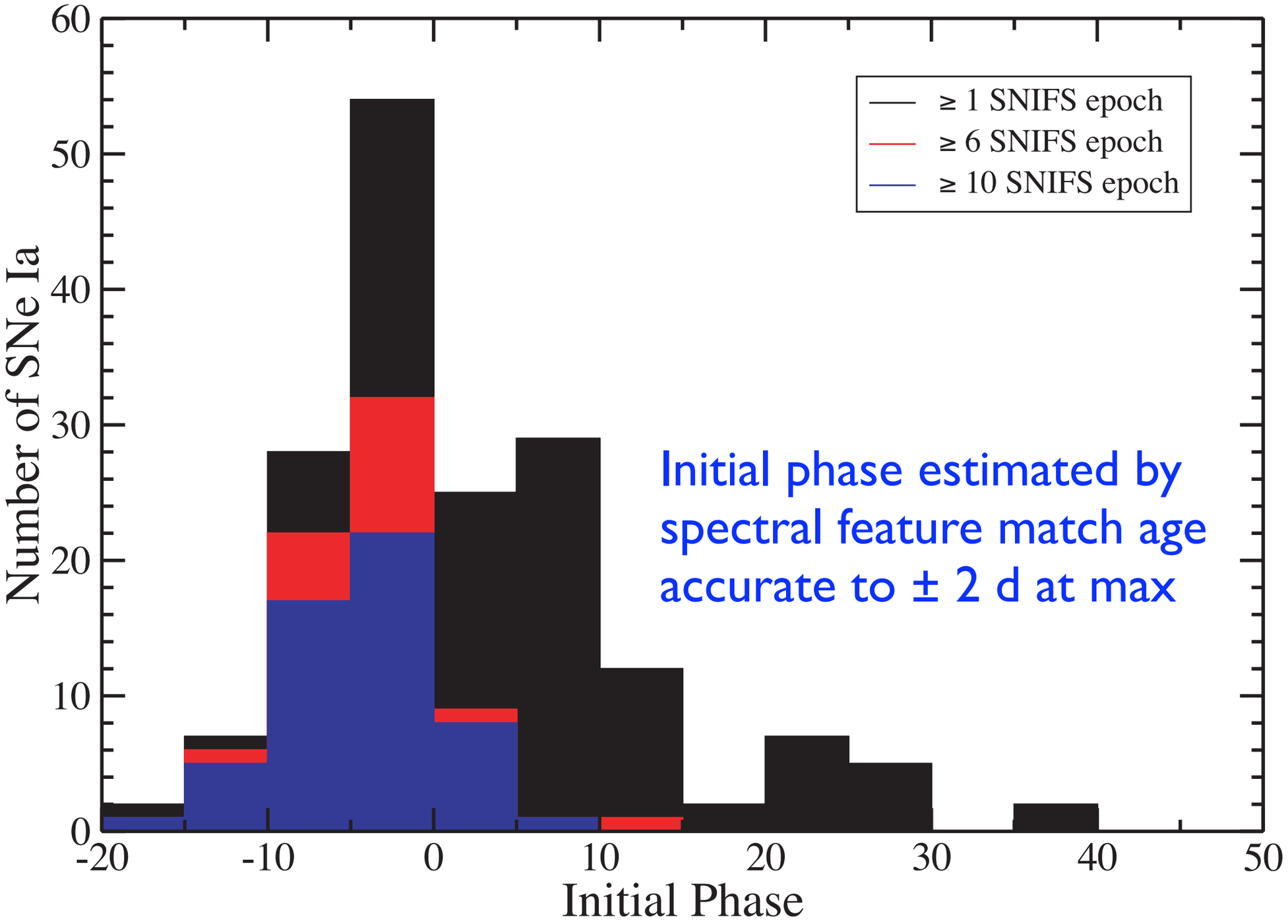


Time Series Coverage



Initial Phase Distribution

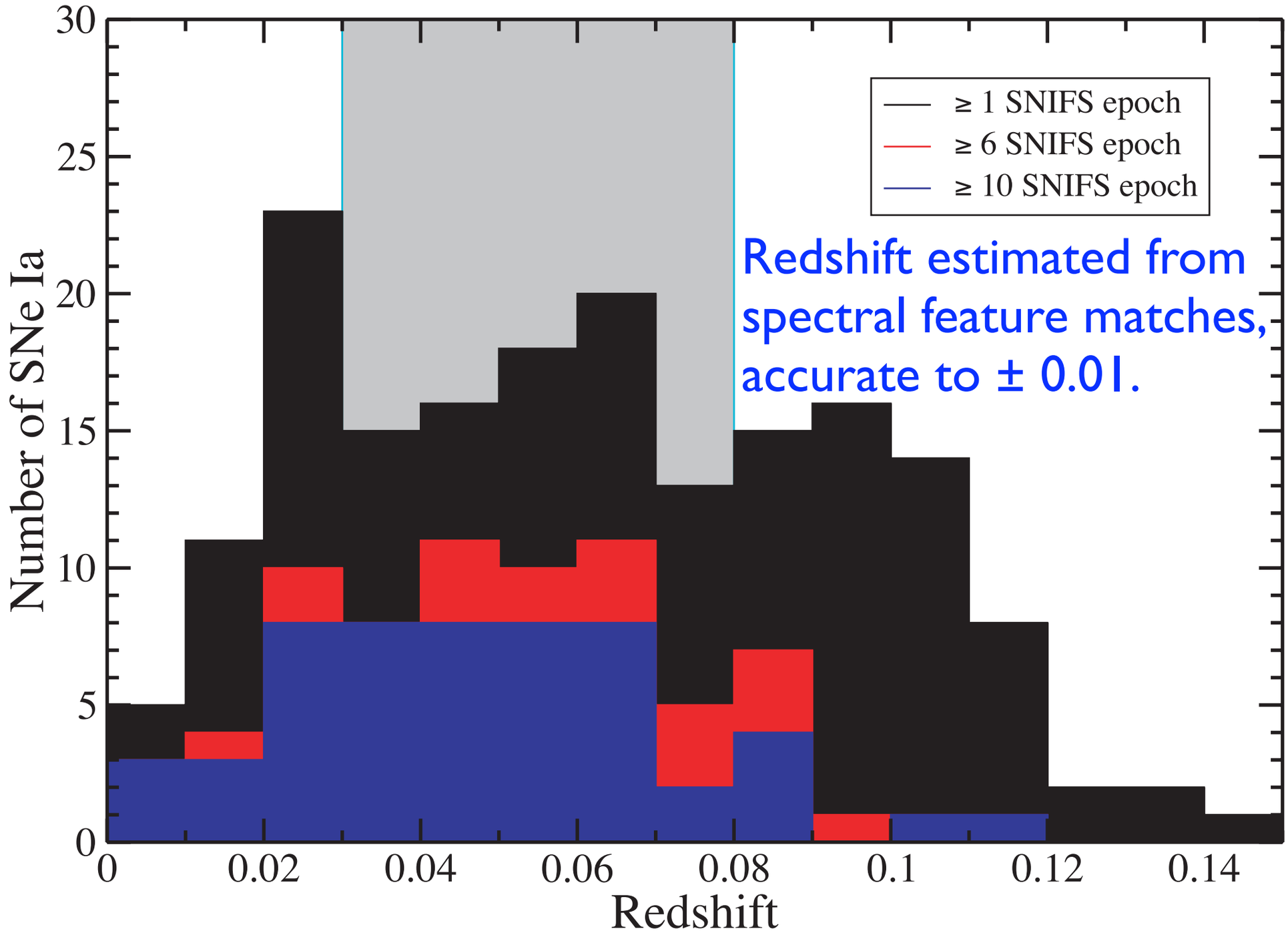
SNe Ia discovered early
receive most extensive followup



Initial phase estimated by
spectral feature match age
accurate to ± 2 d at max

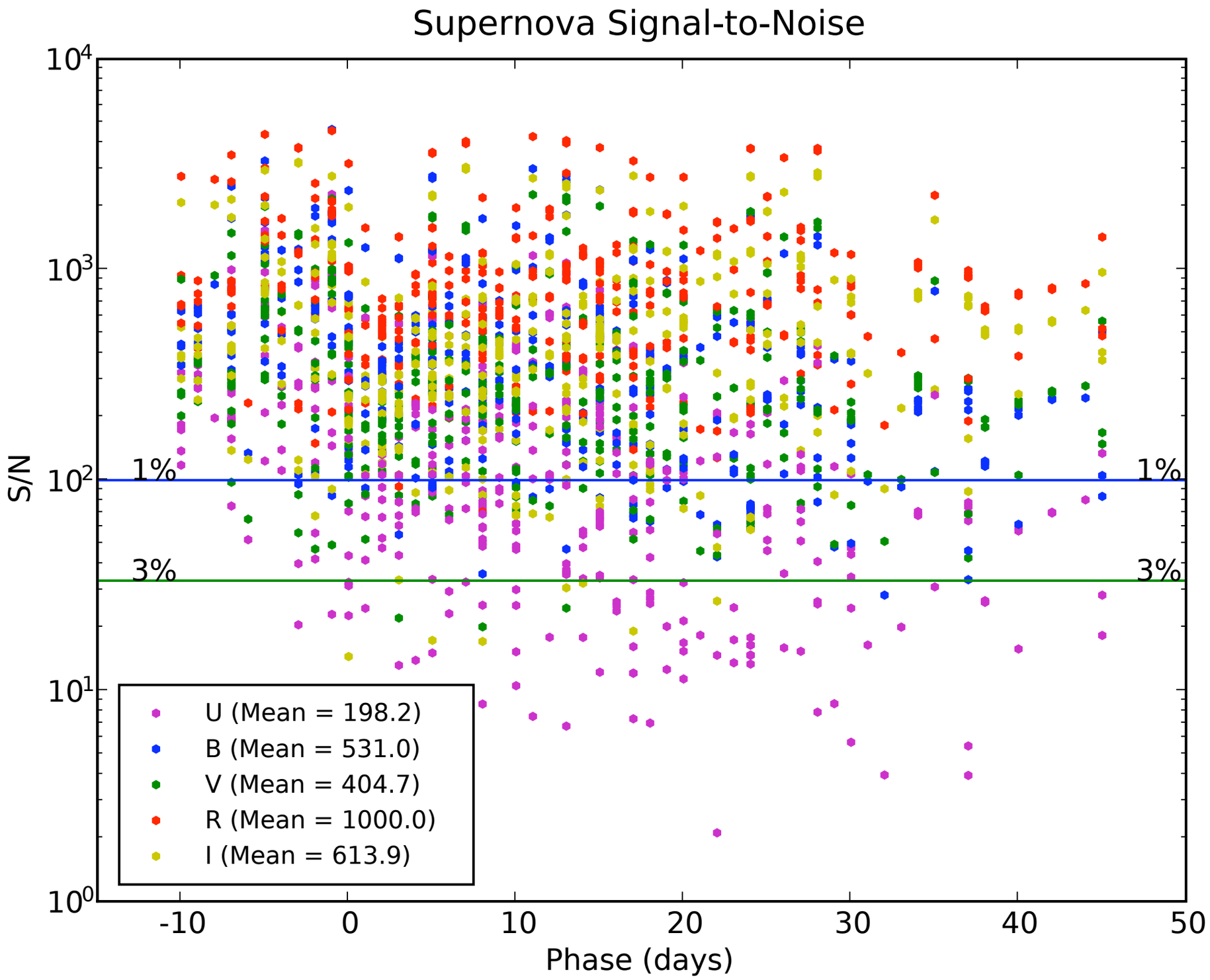
Redshift Distribution

SNfactory sample has good overlap with local Smooth Hubble Flow

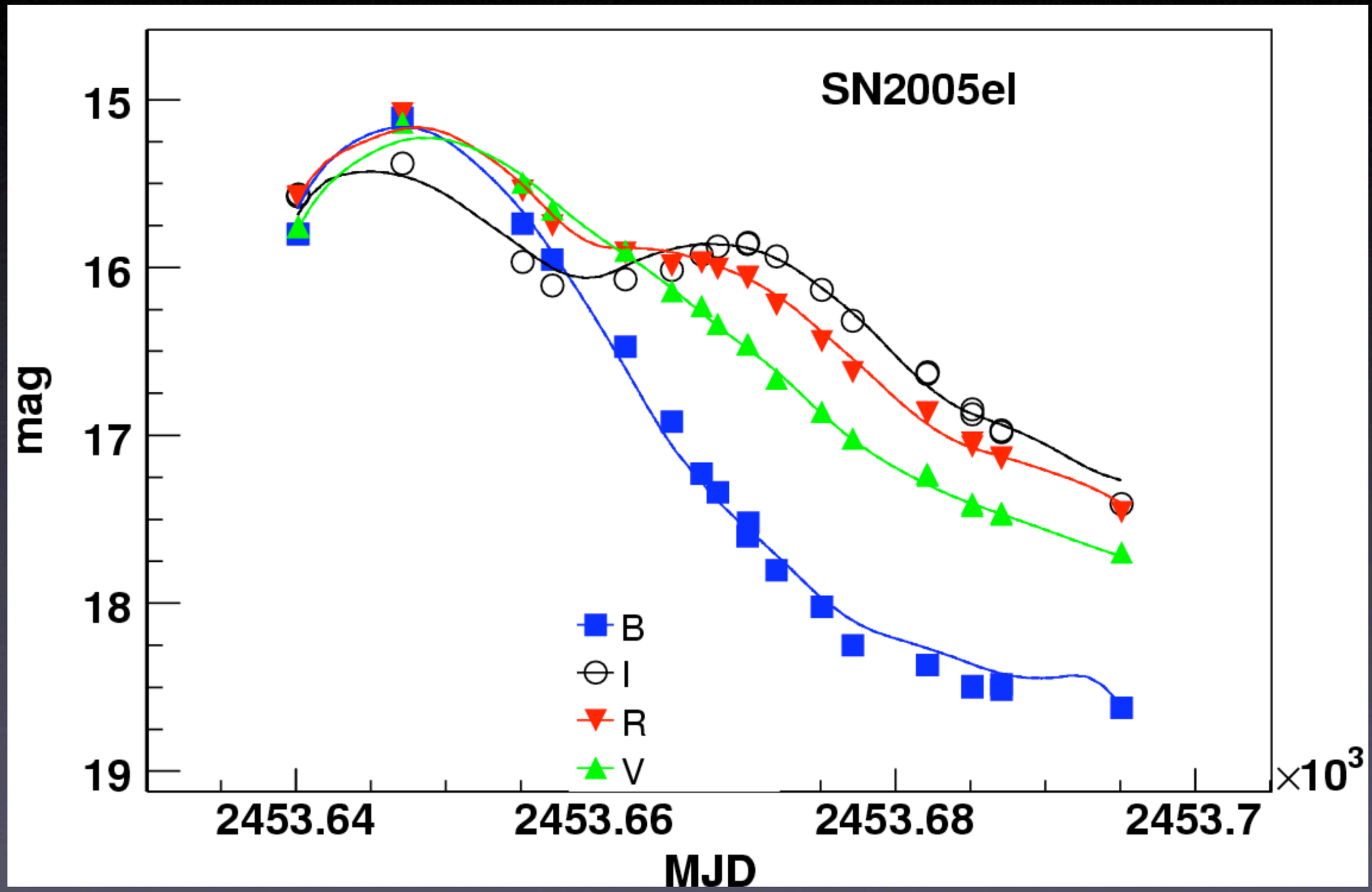


Redshift estimated from spectral feature matches, accurate to ± 0.01.

Synthetic Photometry S/N



Synthesized Light Curve



Since August 2004

- 1200 spectra of individual supernovae.
- ~300 SNe with one spectrum or more.
  - 2/3 from SNfactory search.
  - 1/3 from other sources.

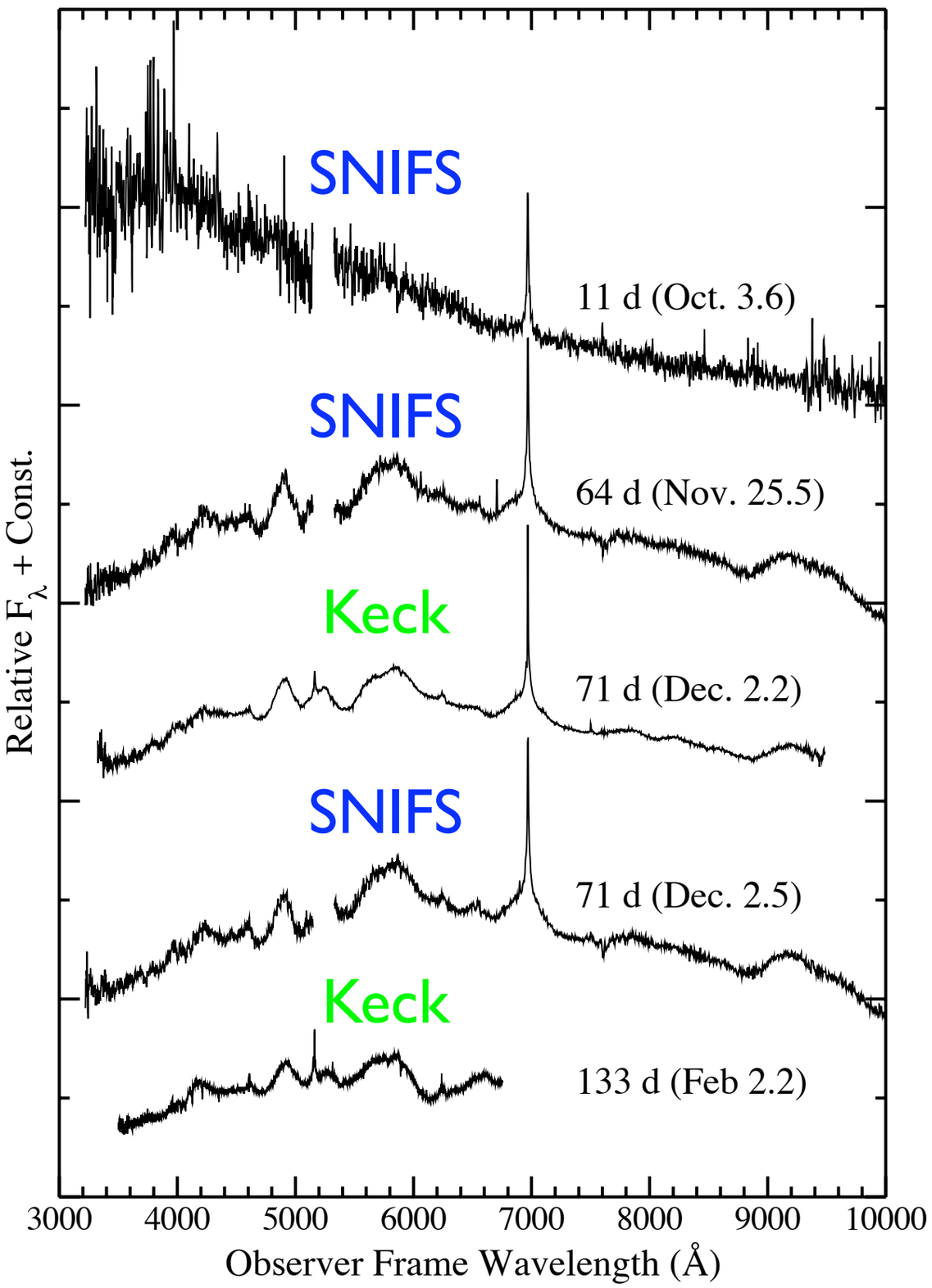
TDC : *Tête de cuvée*
Initial phase $t < 0$
$0.03 < z < 0.08$
23 since May 2006

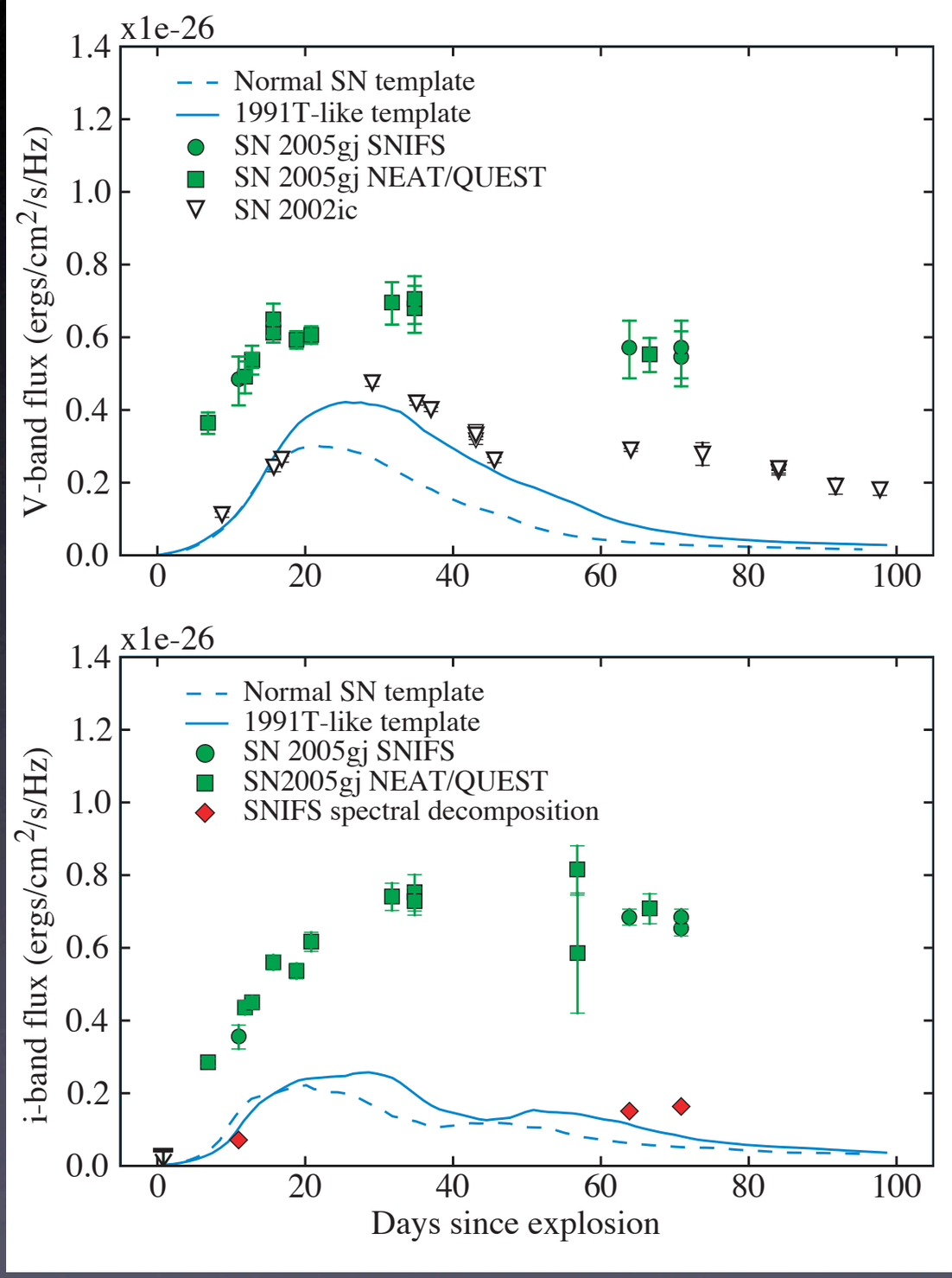
Epochs	SNe Ia		Spectra	
	Total	TDC	Total	TDC
≥6	76	38	912	465
≥10	55	29	754	396

Current Challenges

- Increasing pre-maximum (t < -1 wk) purity.
  - Rolling trigger search.
  - Photometric screening aside from SNIFS.
- Increasing SNIFS throughput (12-14 per night).
  - Not much room for operations improvements.
  - Long-term schedule optimization
- SNIFS data pipeline -- primary issue is extraction.
  - Host + Sky + Supernova -- blind source separation.
  - Use of final reference subtraction.

SN 2005gj

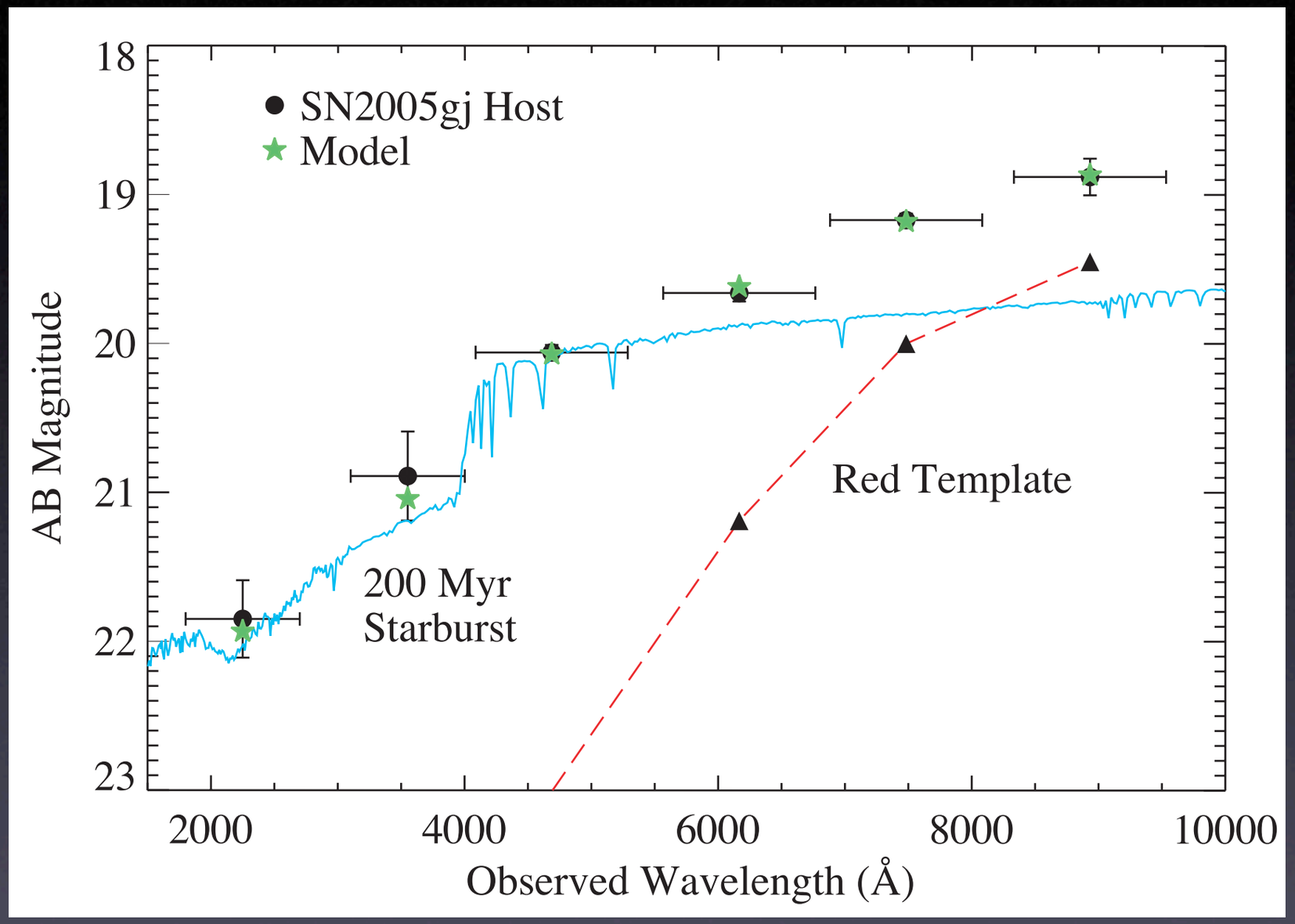




Aldering, et al., 2006

Progenitor/Host

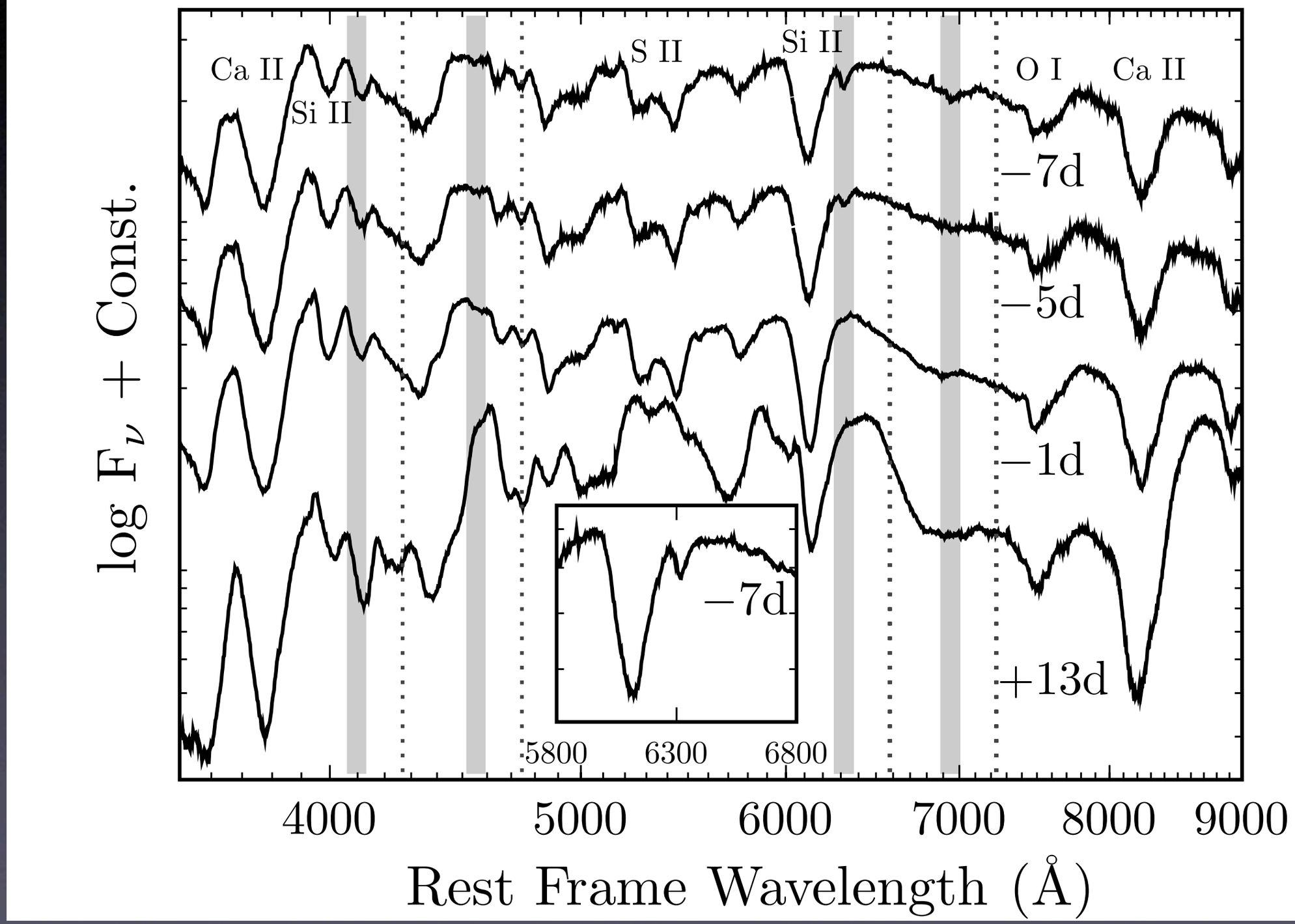
Host is low metallicity, Z < 0.3 solar



Starburst age is consistent with 3 solar mass progenitor.

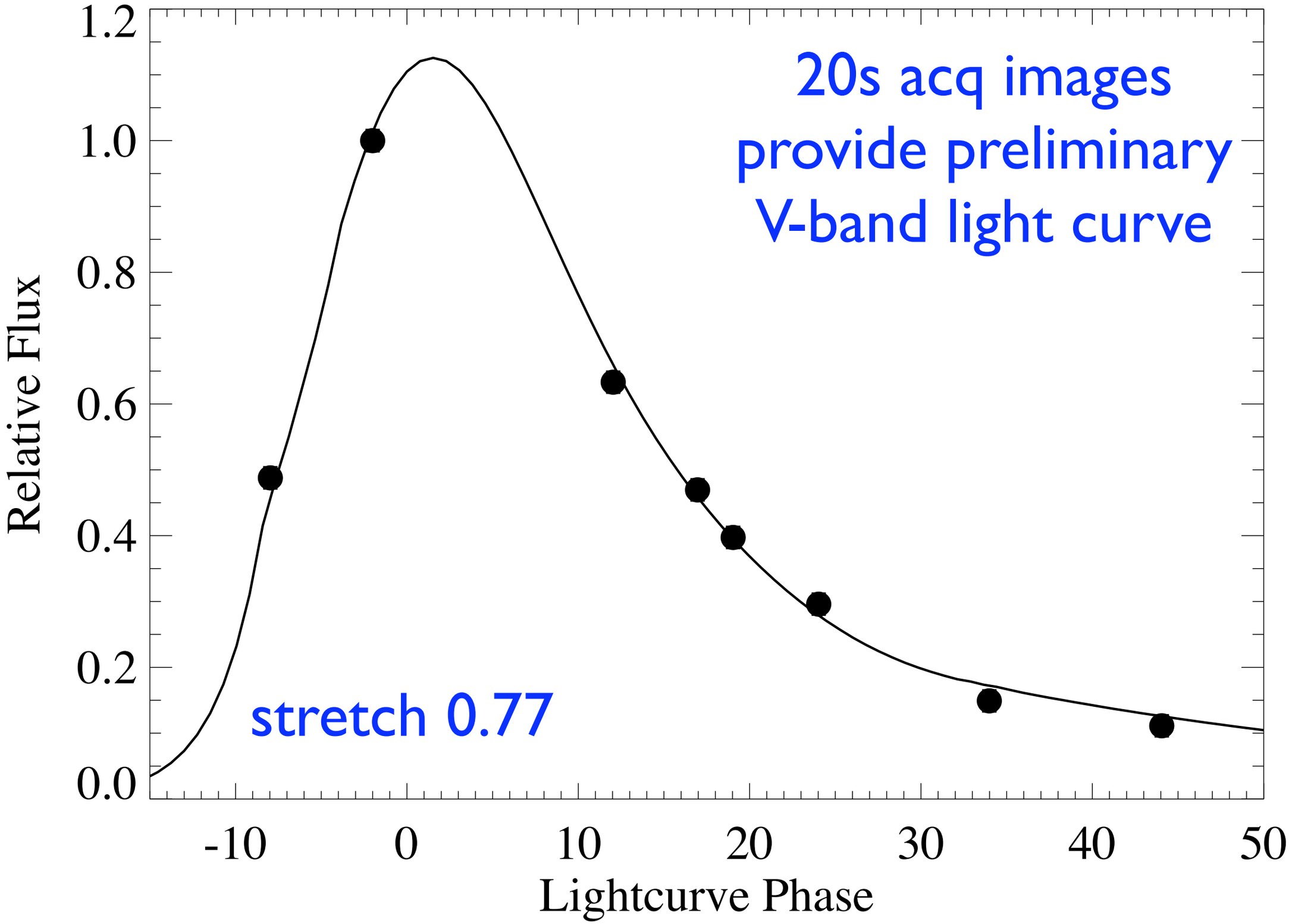
3 solar mass donor, loses 2 solar masses, WD already near Mch?

SN 2006D with SNIFS

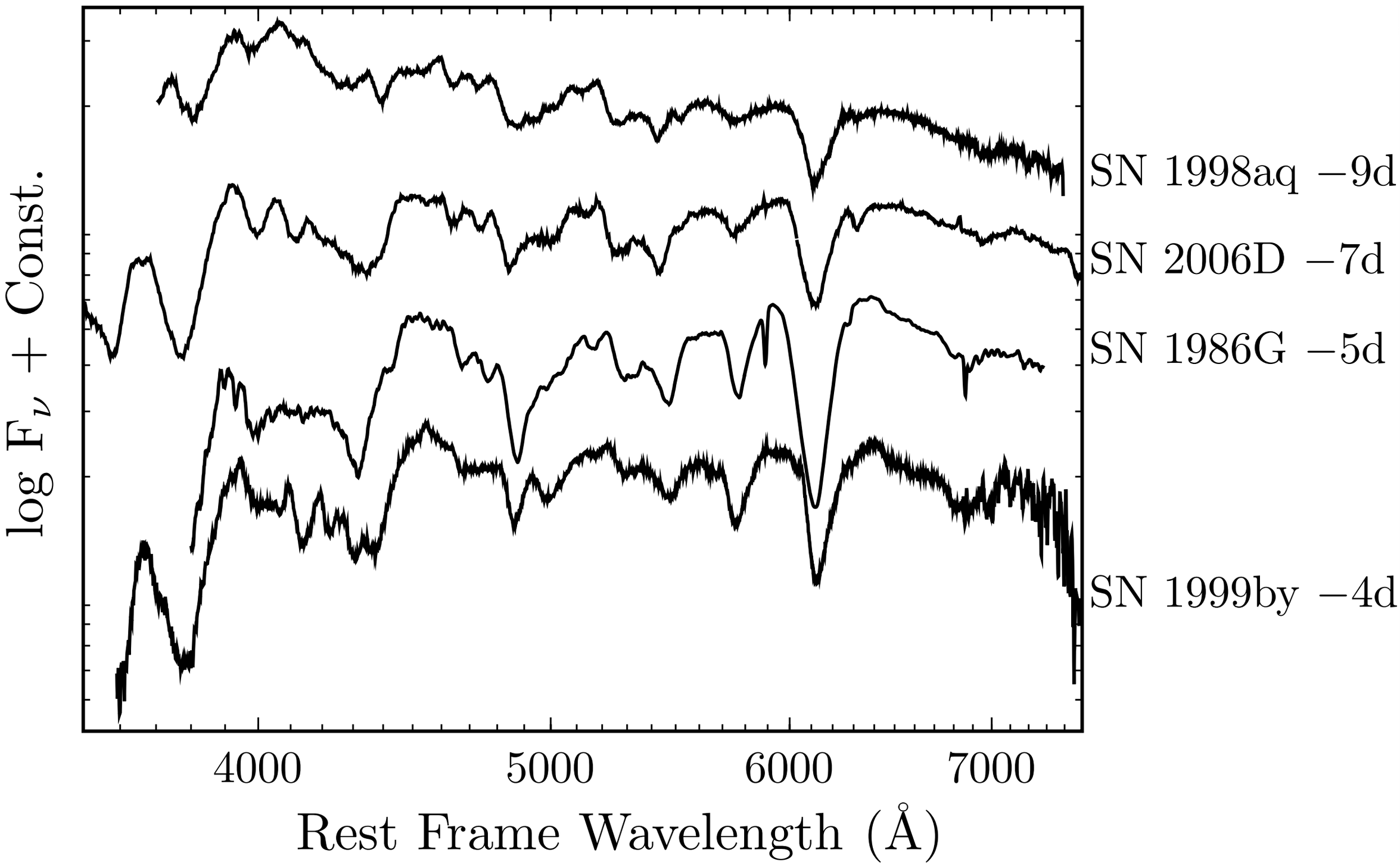


Thomas, et al. 2007

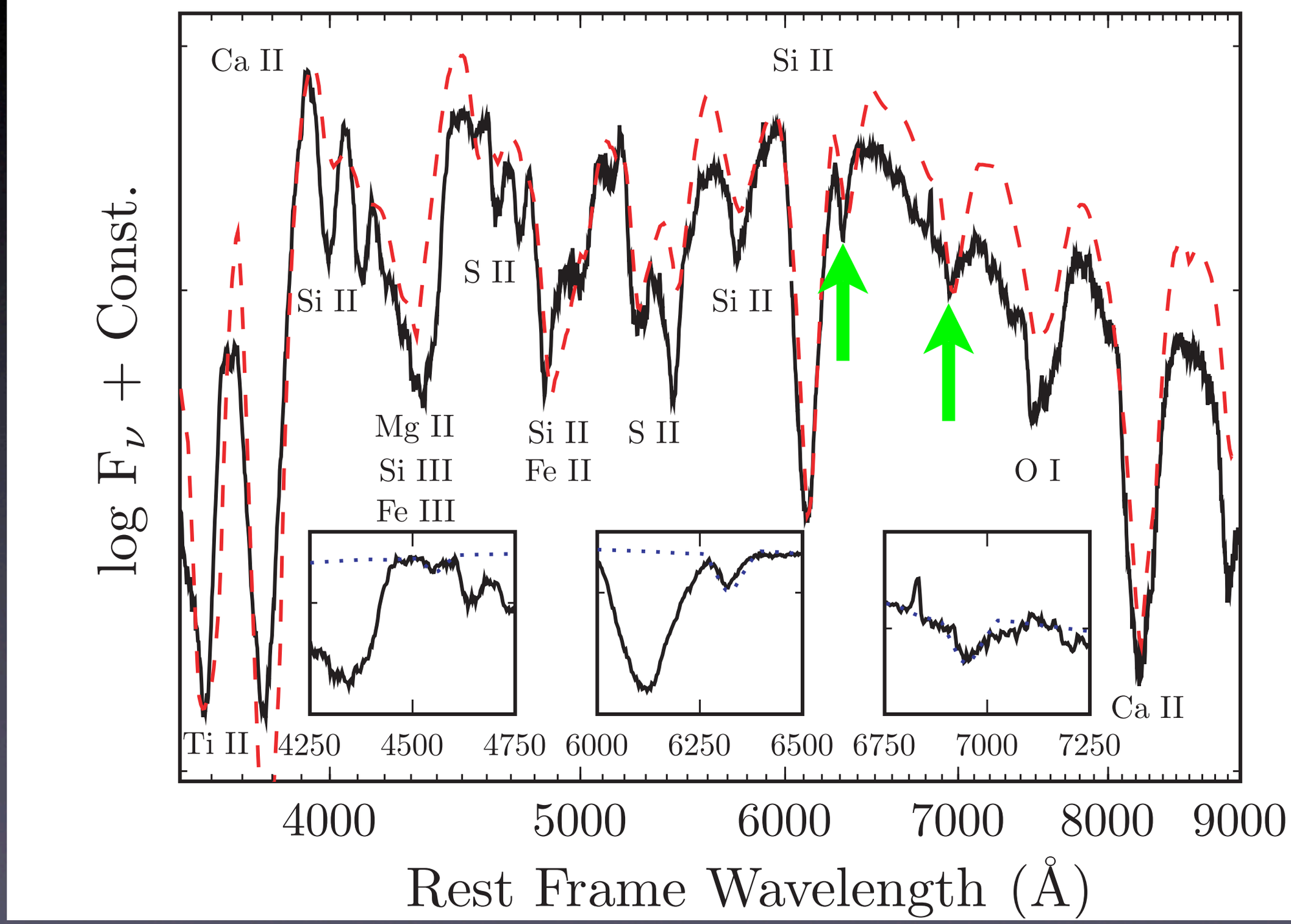
SN 2006D Acq LC



Comparisons

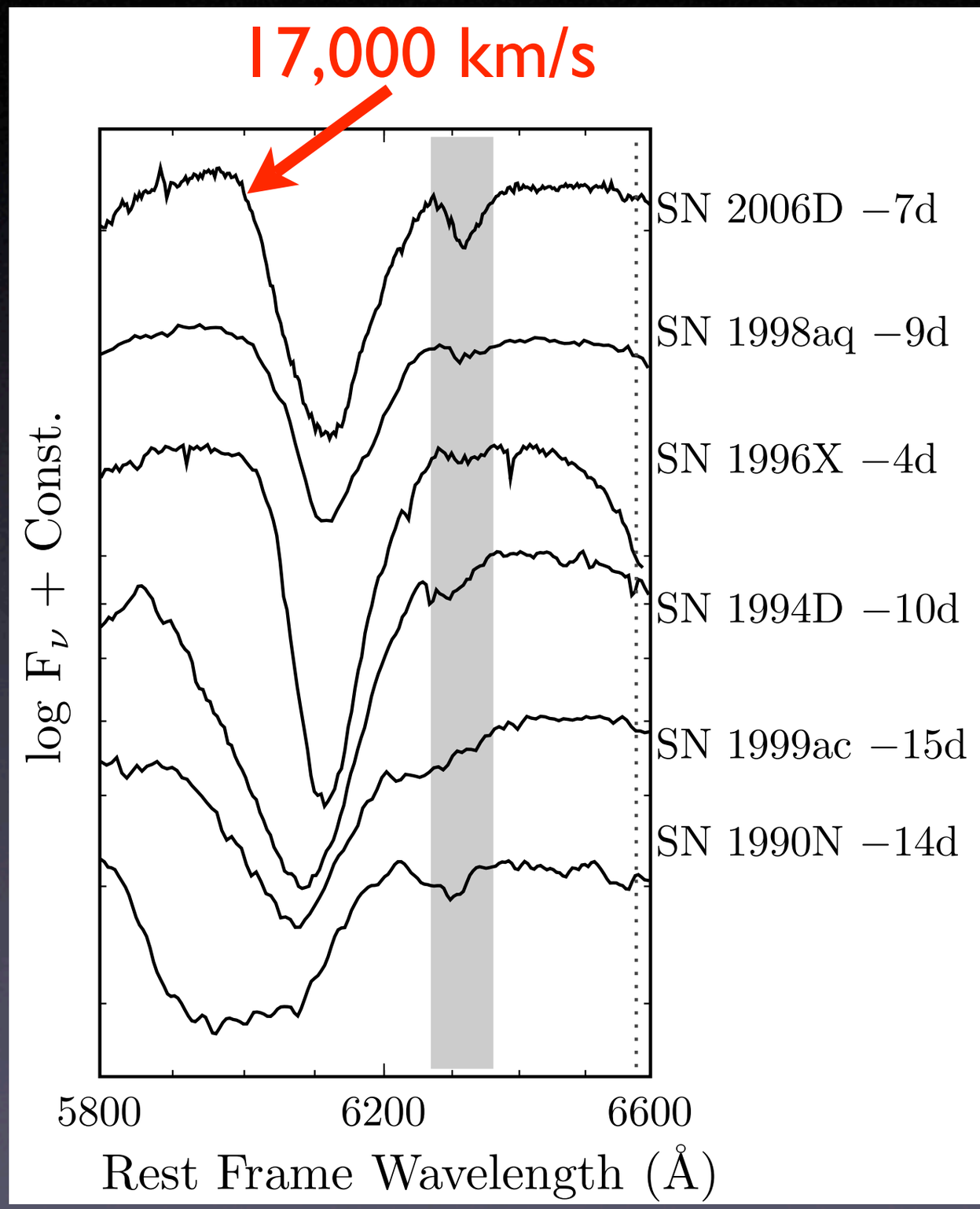


Synthetic Spectrum



How Sporadic is Carbon?

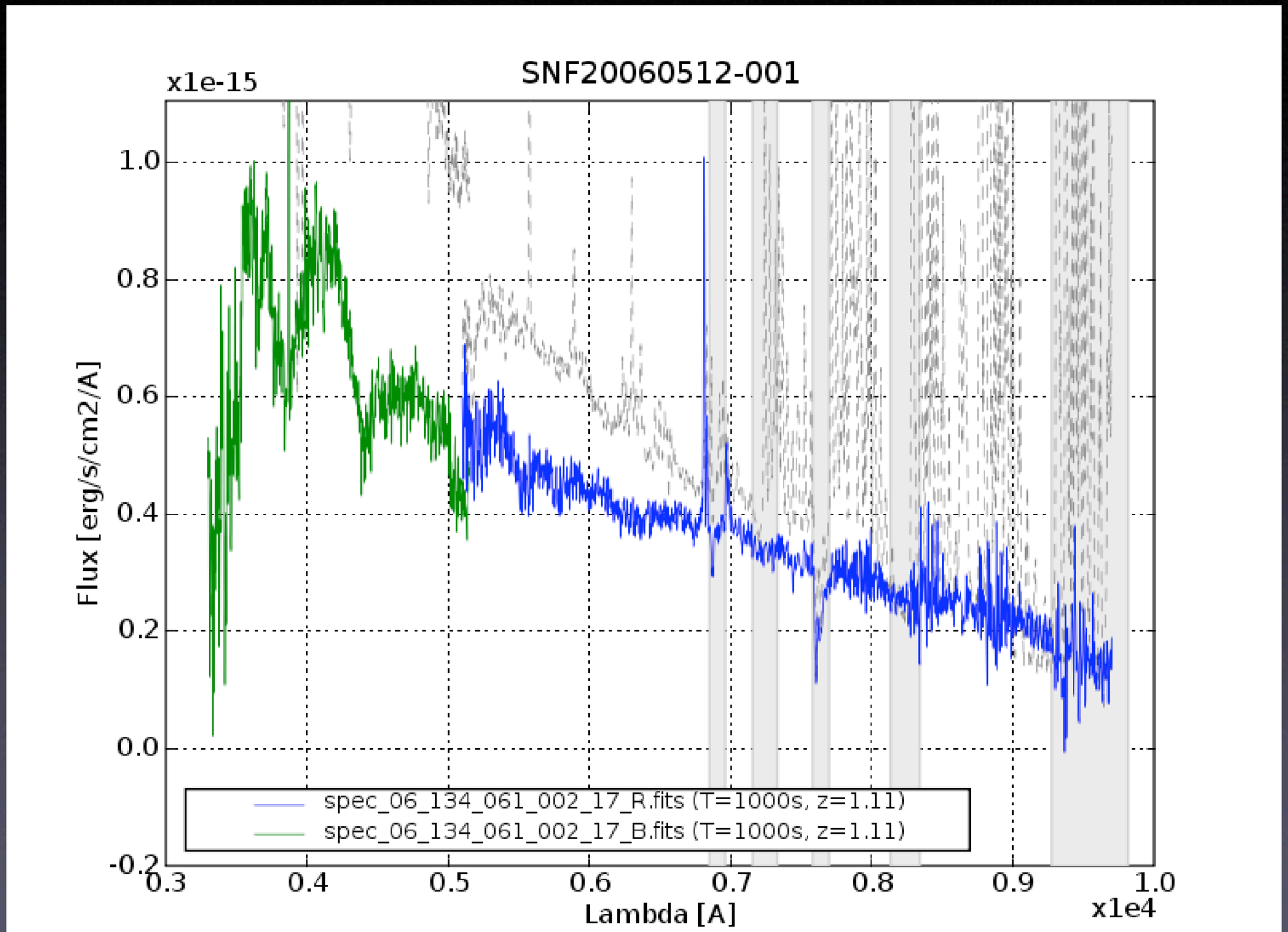
- Temperature/ionization?
- Explosion model parameters?
- Geometry?
  - Small clumps of unburned material may always be present.
- Sparse distribution and small cross-section could account for sporadic observation.
- Polarization signature?



2007-2008

- Arranged search/follow-up time to take the best 9 months of weather at both sites: April-December.
- Expect Palomar QUEST-II search to continue until at least Fall 2008 (end of Palomar+QUEST MOU).
- Expect UH88 SNIFS follow-up to be possible until at least Spring 2009 (UH88 demolition for PanSTARRS).
- Investigating additional imaging at Mt. Helmos 2.3-m.
- Investigating rolling trigger search at Palomar 1.2-m to reject old SNe, reduce SNIFS screening load, increase early-phase purity.

Want More Like This



2009 and Beyond?

- Sample size at end of 2008 ~ 200 SNe Ia.
- Move SNIFS to another telescope?
- Build a new SNIFS on another telescope?
- Use a different search camera?
- Use a different/additional search telescope?
- Partner with other searches coming online?

Conclusion

- The Nearby Supernova Factory has been discovering, and obtaining spectral time series of SNe Ia in the nearby smooth Hubble flow since late 2004.
- Writing some papers on interesting supernovae.
- We envision continuing operations until the end of 2008.
- We are investigating multiple options for continuing operations beyond that point.
- Look for light curves, spectra, and cosmology fits in the coming year.