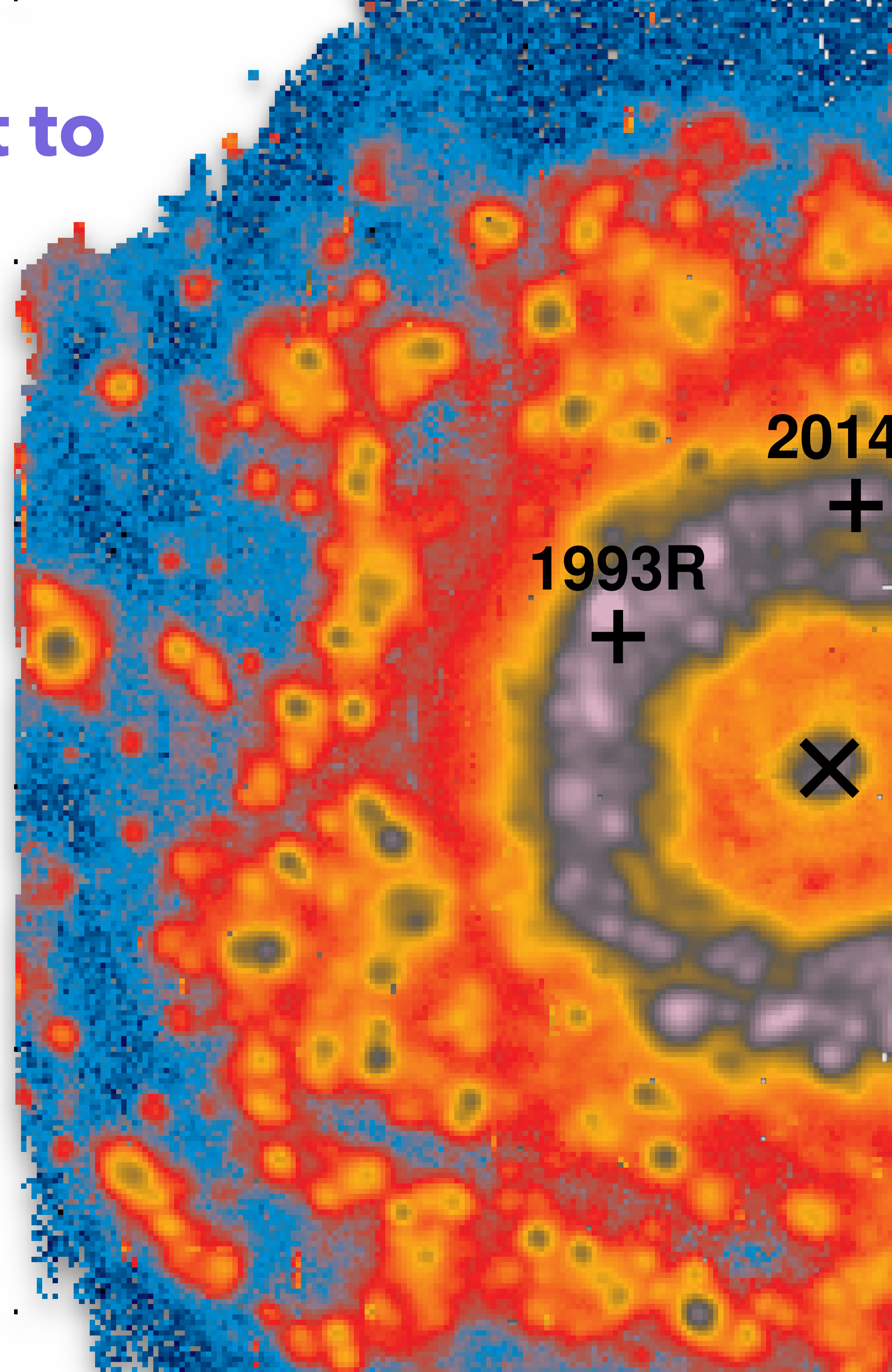
Using the environment to infer SN progenitor properties

or “the results of (a few) **amusing pisco**(s)”

Lluís Galbany (Pitt), Joe P. Anderson (ESO), Santiago González-Gaitán (Lisbon), Mark Phillips (LCO), **Nídia Morrell (LCO)**, Eric Hsiao (FSU), Chris Ashall (FSU), Max Stritzinger (Aarhus), Francisco Forster (CMM), Peter Hoeflich (FSU), Alessandro Razza (ESO), Mario Hamuy (U Chile?), …

…Hanin Kuncarayakti (Turku), Sebastián F. Sánchez (UNAM), Manuel E. Moreno-Raya (CAHA), Inma Domínguez (UGR), Héctor Martínez-Rodríguez (Pitt), Ana M. Mourão (Lisbon), Matt Smith (Southampton), Mark Sullivan (Soton), Vallery Stanishev (UL), Mercedes Mollá (CIEMAT), Á. R. López-Sánchez (Macquire), J. Vílchez (IAA), F. Fabián Rosales-Ortega (INAOE), C. Badenes (Pitt), W. M. Wood-Vasey (Pitt), etc…



University of Pittsburgh

Bariloche, 18 Nov 8

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1 2018arXiv181009252P 2018/10

Carnegie Supernova Project-II: Extending the Near-Infrared Hubble Diagram for Type Ia Supernovae to $z \sim 0.1$

Phillips, M. M.; Contreras, Carlos; Hsiao, E. Y. *and 41 more*

2 2018arXiv181008213H 2018/10

Carnegie Supernova Project-II: The Near-infrared Spectroscopy Program

Hsiao, E. Y.; Phillips, M. M.; Marion, G. H. *and 42 more*

3 2018MNRAS.479.3232G 2018/09 cited: 1

Type II supernovae in low-luminosity host galaxies

Gutiérrez, C. P.; Anderson, J. P.; Sullivan, M. *and 29 more*

4 2018arXiv180906801B 2018/09

Unravelling the infrared transient VVV-WIT-06: the case for an origin in a classical nova

Banerjee, Dipankar P. K.; Hsiao, Eric Y.; Diamond, Tiara *and 6 more*

5 2018NatAs...2..574A 2018/07 cited: 3

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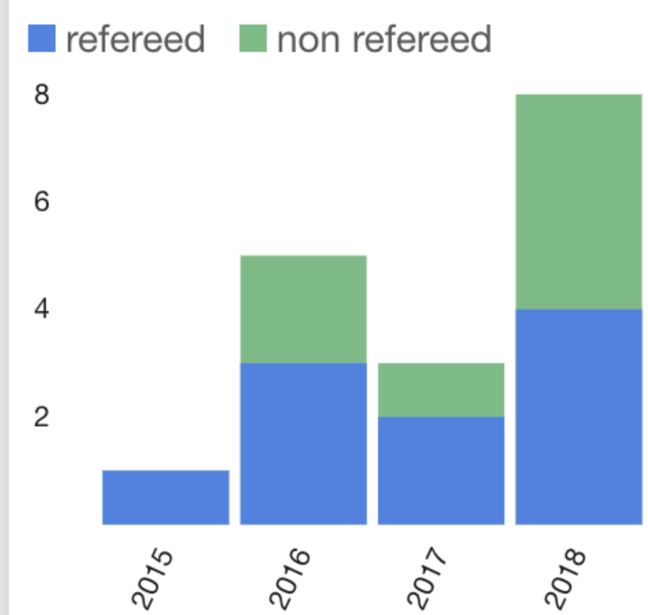


The Astronomical Journal, 151:33 (25pp), 2016 February doi:10.3847/0004-6256/151/2/33

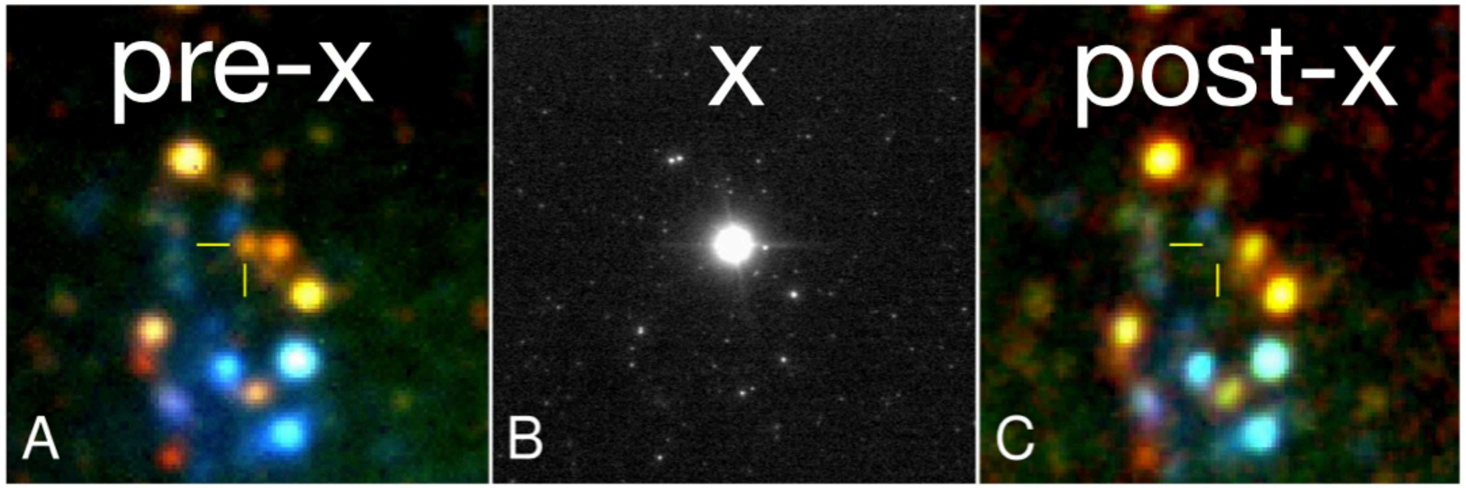
UBVRIz LIGHT CURVES OF 51 TYPE II SUPERNOVAE

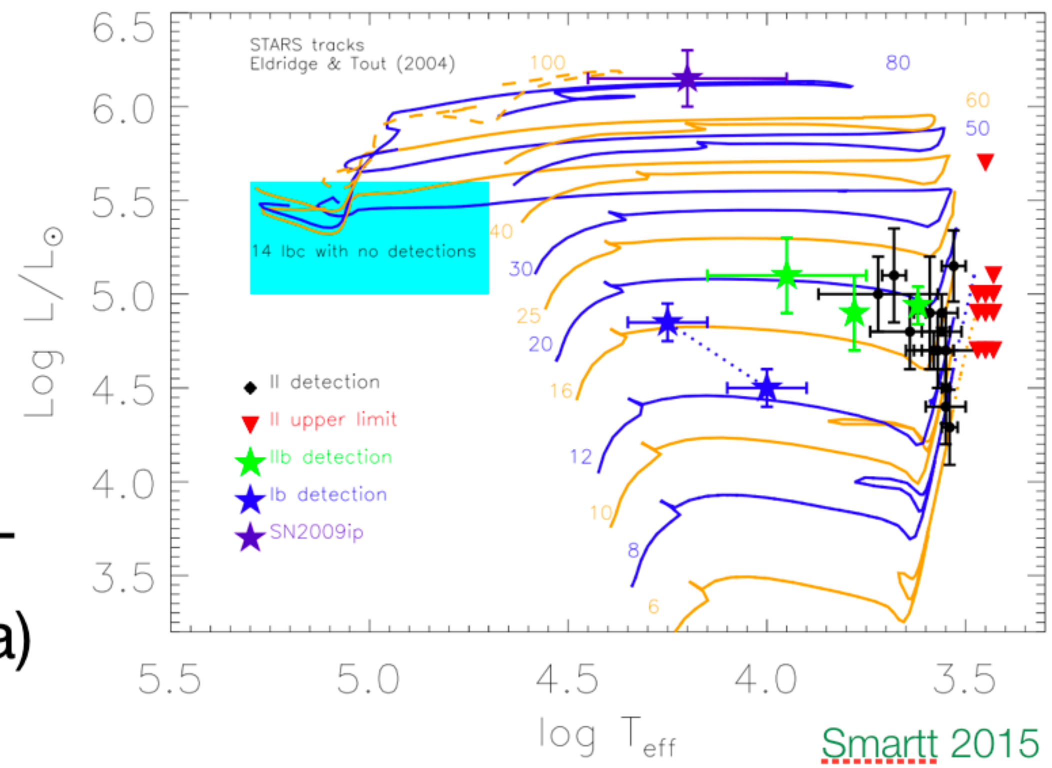
Lluís Galbany[1,2], Mario Hamuy[1,2], Mark M. Phillips[3], Nicholas B. Suntzeff[4,5], José Maza[2], Thomas de Jaeger[1,2], Tania Moraga[1,2], Santiago González-Gaitán[1,2], Kevin Krisciunas[6], Nidia I. Morrell[3], Joanna Thomas-Osip[3], Wojtek Krzeminski[7], Luis González[2], Roberto Antezana[2], Marina Wishnjewski[2,27], Patrick McCarthy[8], Joseph P. Anderson[9], Claudia P. Gutiérrez[1,2,9], Maximilian Stritzinger[10], Gastón Folatelli[11], Claudio Anguita[2,27], Gaspar Galaz[12], Elisabeth M. Green[13], Chris Impey[13], Yong-Cheol Kim[14], Sofia Kirhakos[15,16], Mathew A. Malkan[17], John S. Mulchaey[8], Andrew C. Phillips[18], Alessandro Pizzella[19], Charles F. Prosser[20,27], Brian P. Schmidt[21,22], Robert A. Schommer[15,27], William Sherry[23], Louis-Gregory Strolger[24], Lisa A. Wells[25], and Gerard M. Williger[26]

We present a compilation of $UBVRIz$ light curves of 51 type II supernovae discovered during the course of four different surveys during 1986 to 2003: the Cerro Tololo Supernova Survey, the Calán/Tololo Supernova Program (C&T), the Supernova Optical and Infrared Survey (SOIRS), and the Carnegie Type II Supernova Survey (CATS). The photometry is based on template-subtracted images to eliminate any potential host galaxy light contamination, and calibrated from foreground stars. This work presents these photometric data, studies the color evolution using different bands, and explores the relation between the magnitude at maximum brightness and the brightness decline parameter (s) from maximum light through the end of the recombination phase. This parameter is found to be shallower for redder bands and appears to have the best correlation in the B band. In addition, it also correlates with the plateau duration, being this shorter (longer) for larger (smaller) s values.

Direct progenitor detection in pre-explosion images
=X

Mattila 2010



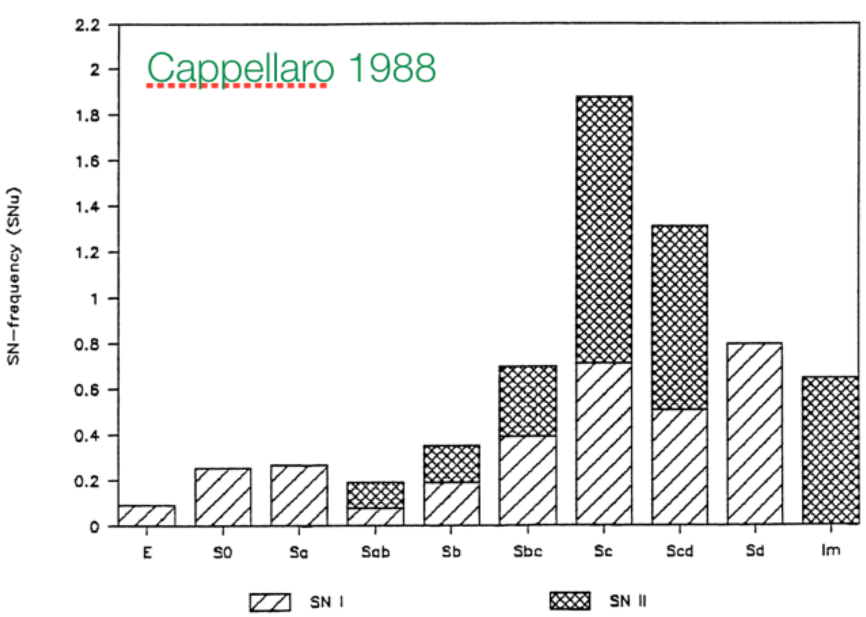


Smartt 2015

Around 30 direct detection of SN progenitors in HST pre-explosion images. All CCSNe (~80% SN II, no Ia)

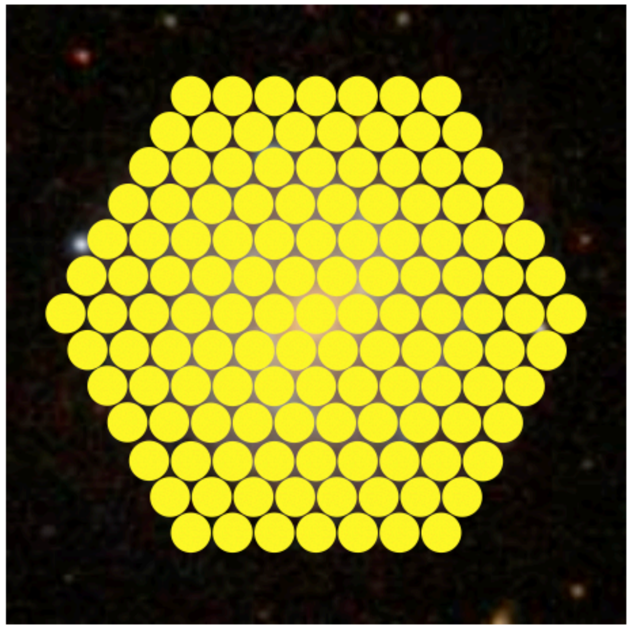
Ex: Habergham 10 & 12 & 14, Galbany 14 & 16a & 16b & 17
Kuncarayakti 13a & 13b, Kangas 13 & 17, Lyman 13 & 14 & 16 & 17

But: Low statistics, Binarity, RSG problem…

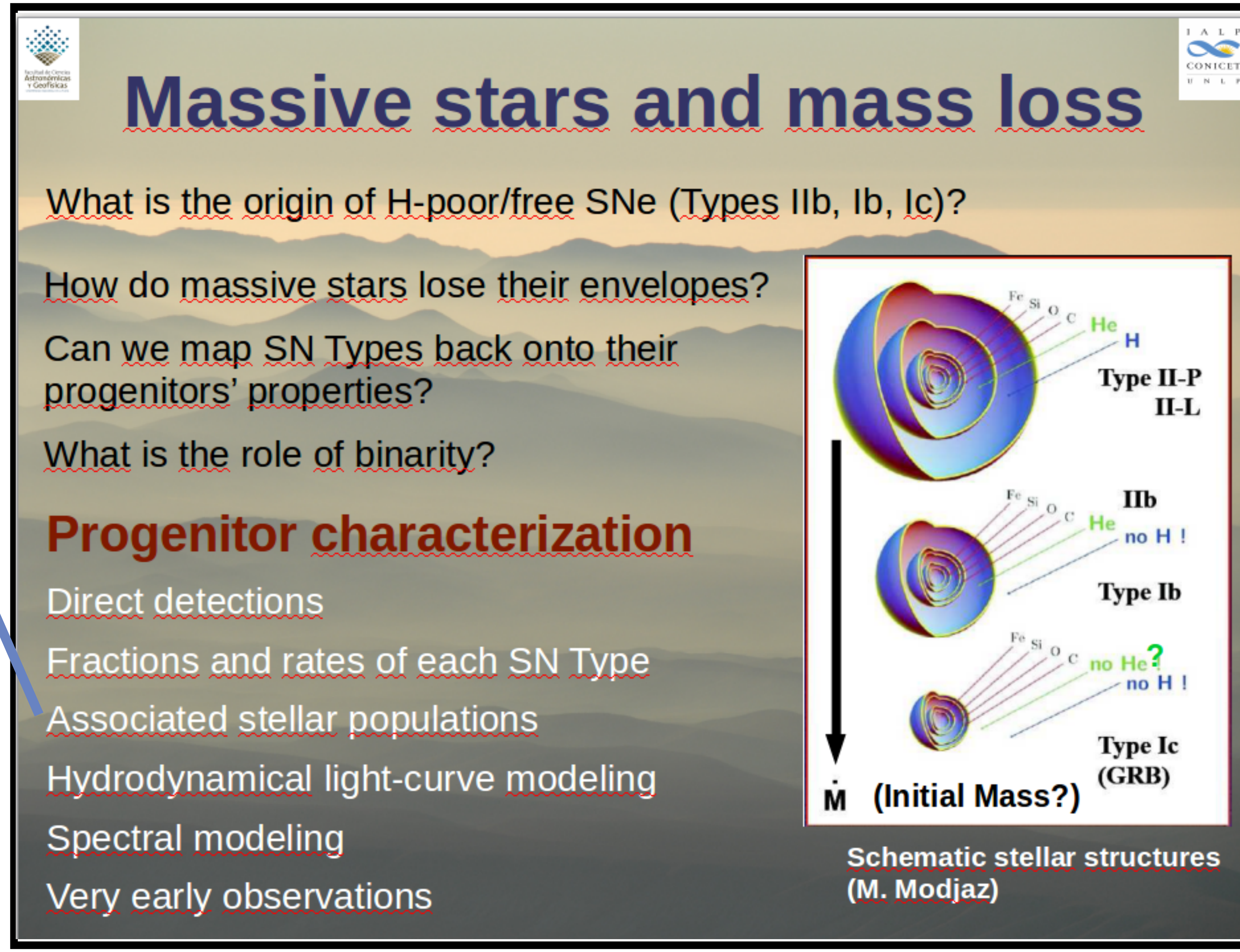


Alternative methods include studies of statistical samples of **SN environments:**

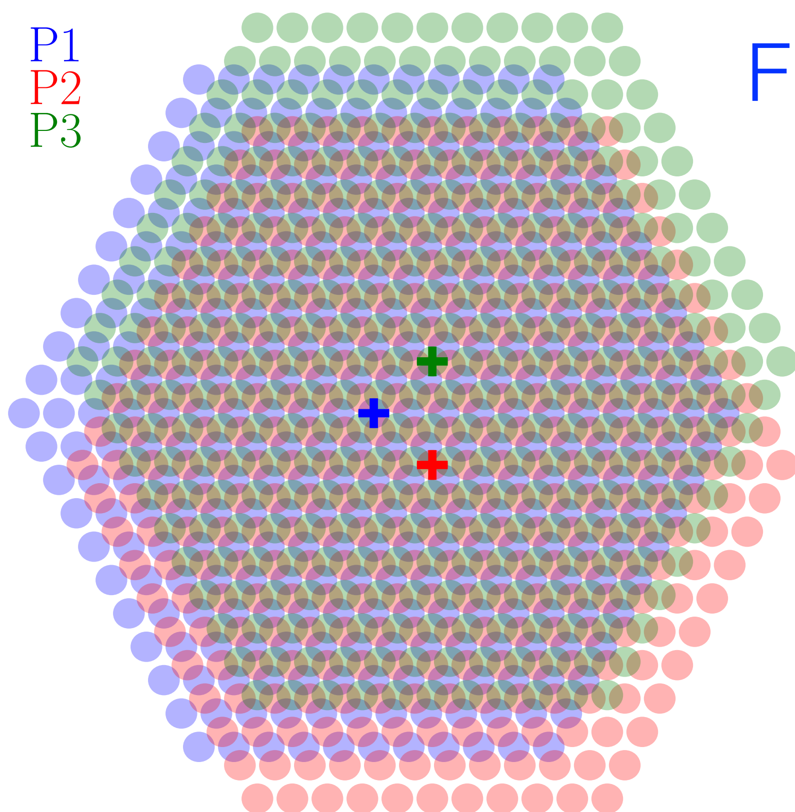
- Photometry / imaging
- Fiber / long-slit spectroscopy
- **Integral Field Spectroscopy (IFS)**



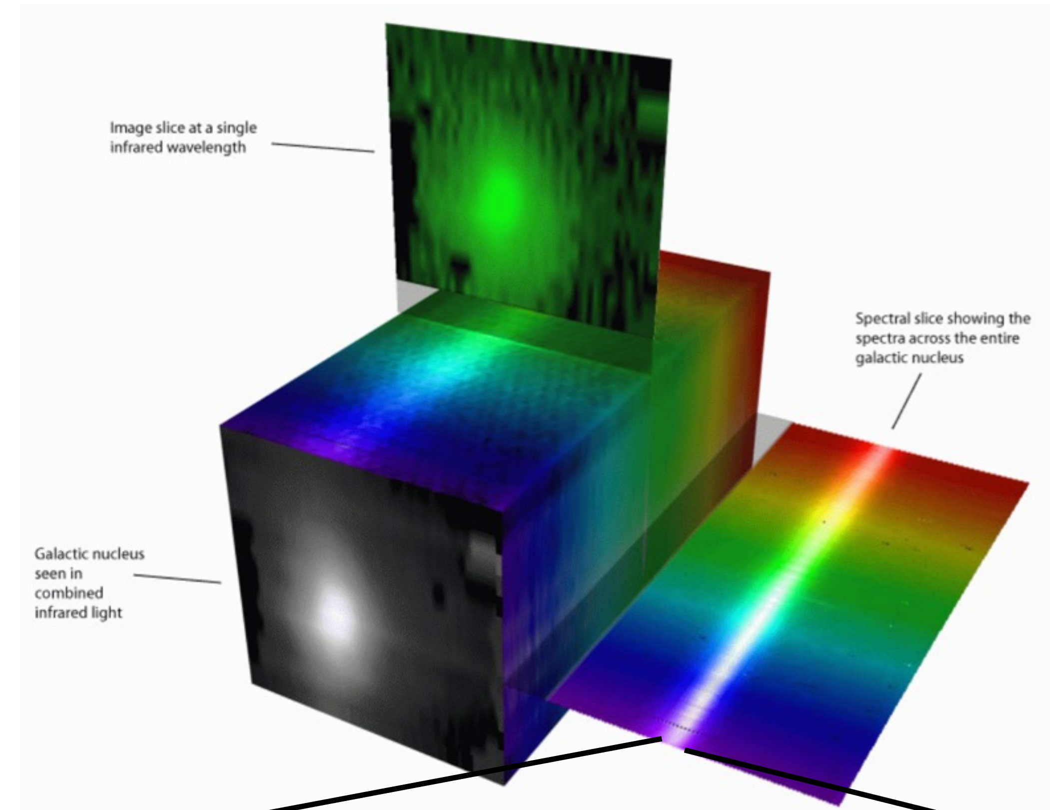
Motivation

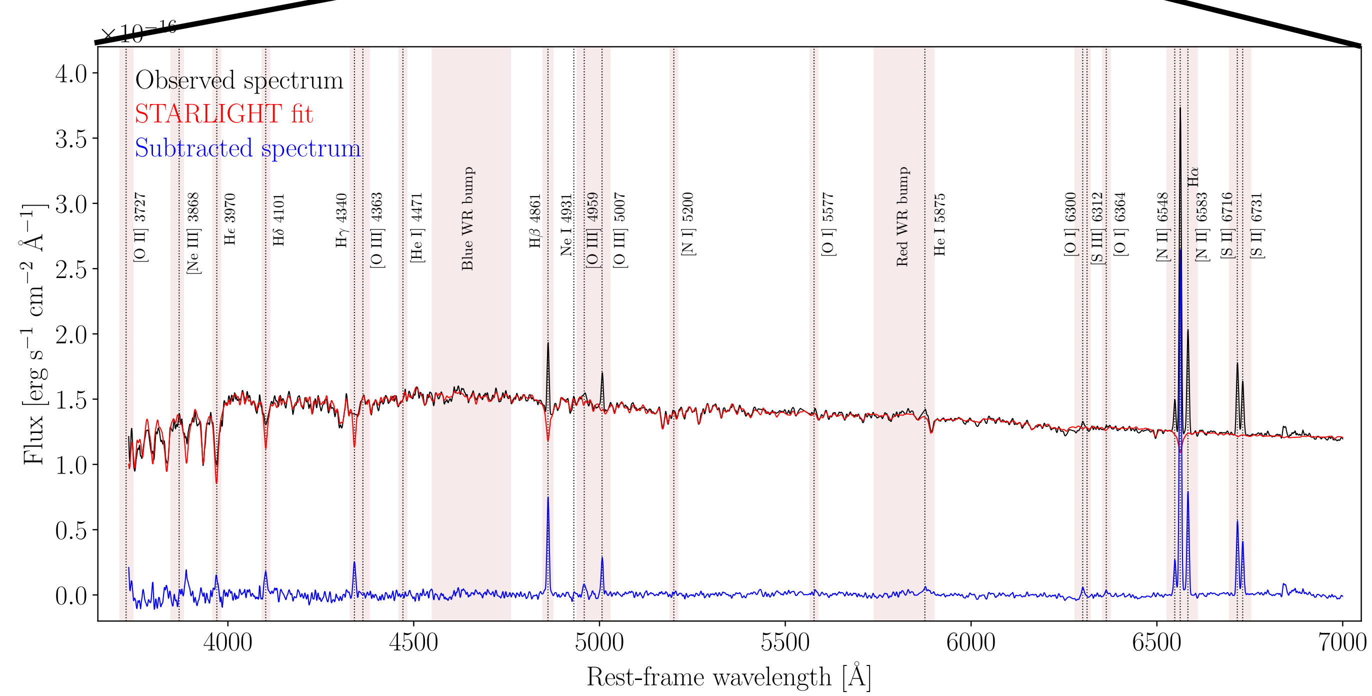

Massive stars and mass loss
What is the origin of H-poor/free SNe (Types IIb, Ib, Ic)?
How do massive stars lose their envelopes?
Can we map SN Types back onto their progenitors' properties?
What is the role of binarity?
Progenitor characterization
Direct detections
Fractions and rates of each SN Type
Associated stellar populations
Hydrodynamical light-curve modeling
Spectral modeling
Very early observations
Fe Si O C He H
Type II-P
II-L
IIb
no H !
Type Ib
no He?
no H !
Type Ic
(GRB)
Ṁ (Initial Mass?)
Schematic stellar structures
(M. Modjaz)

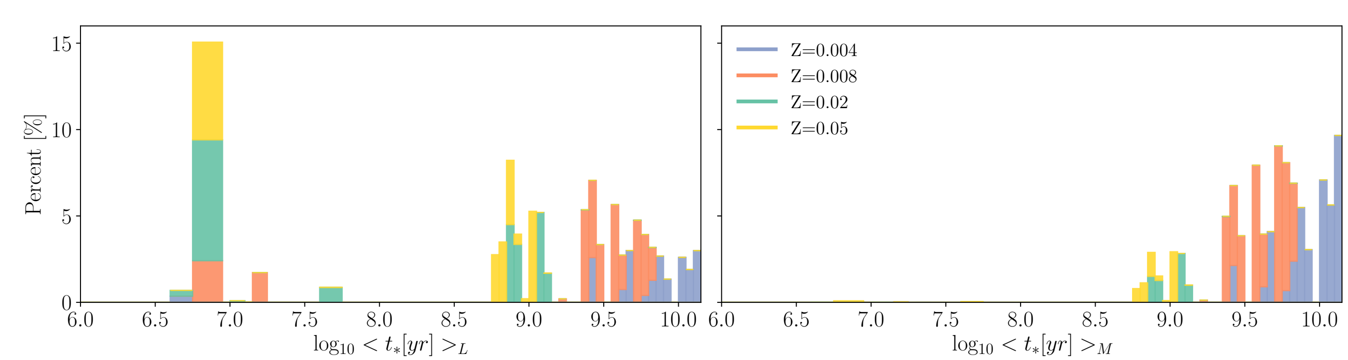
Integral Field Spectroscopy



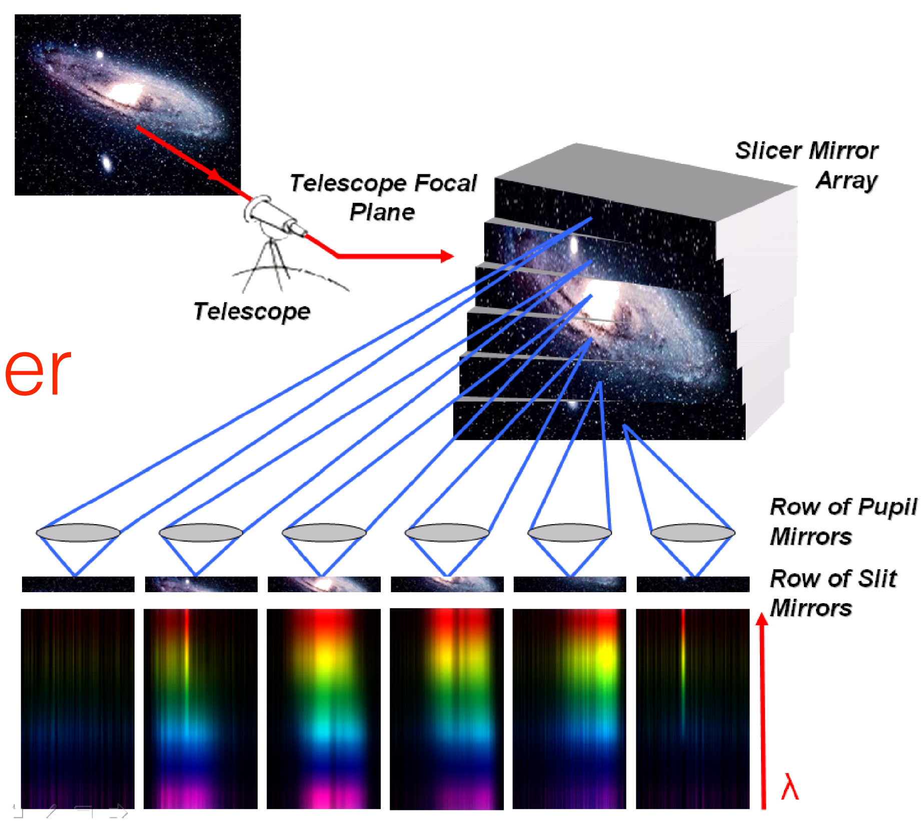
Fiber bundle







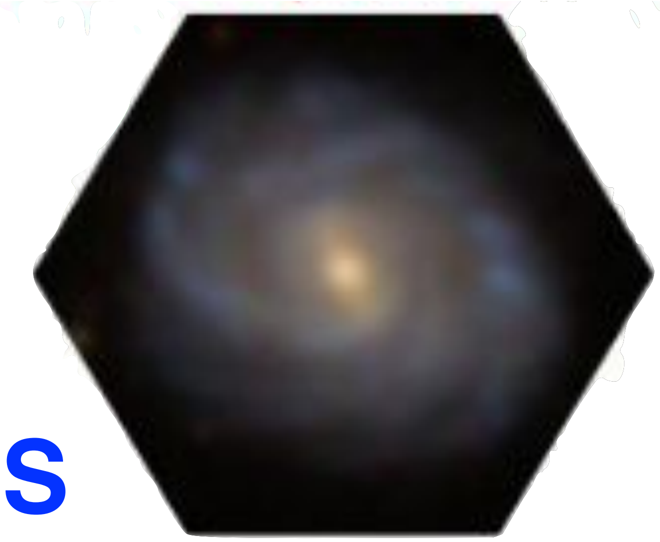
Slicer



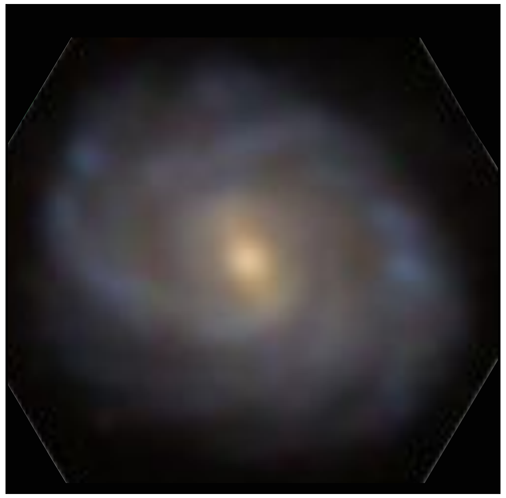
Instruments

PMAS	MUSE	
70”x70”	60”x60”	Field of view (“)
R~500-1200	R~1700-3500	Spectral Resolution
~5,000	~90,000	Number of spectra
1”/spaxel	0.2”/spaxel	Spatial Resolution
3700-7500	4650-9300	Wavelength coverage (A)

pisco



PMAS



amusing

MUSE

Pisco

the Pmas/ppak Integral-field Supernova host COmpilation

HG/SNe

- 8/12 from the PINGS Survey (PI: Rosales-Ortega)
- 4/5 from H09-3.5-068 (Local SNIa prop.; PI: Stanishev)
- 4/4 from the CALIFA pilot study (PI: Sánchez)
- 105/120 from CALIFA DR3
- 18/21 from CALIFA-extensions

139/162

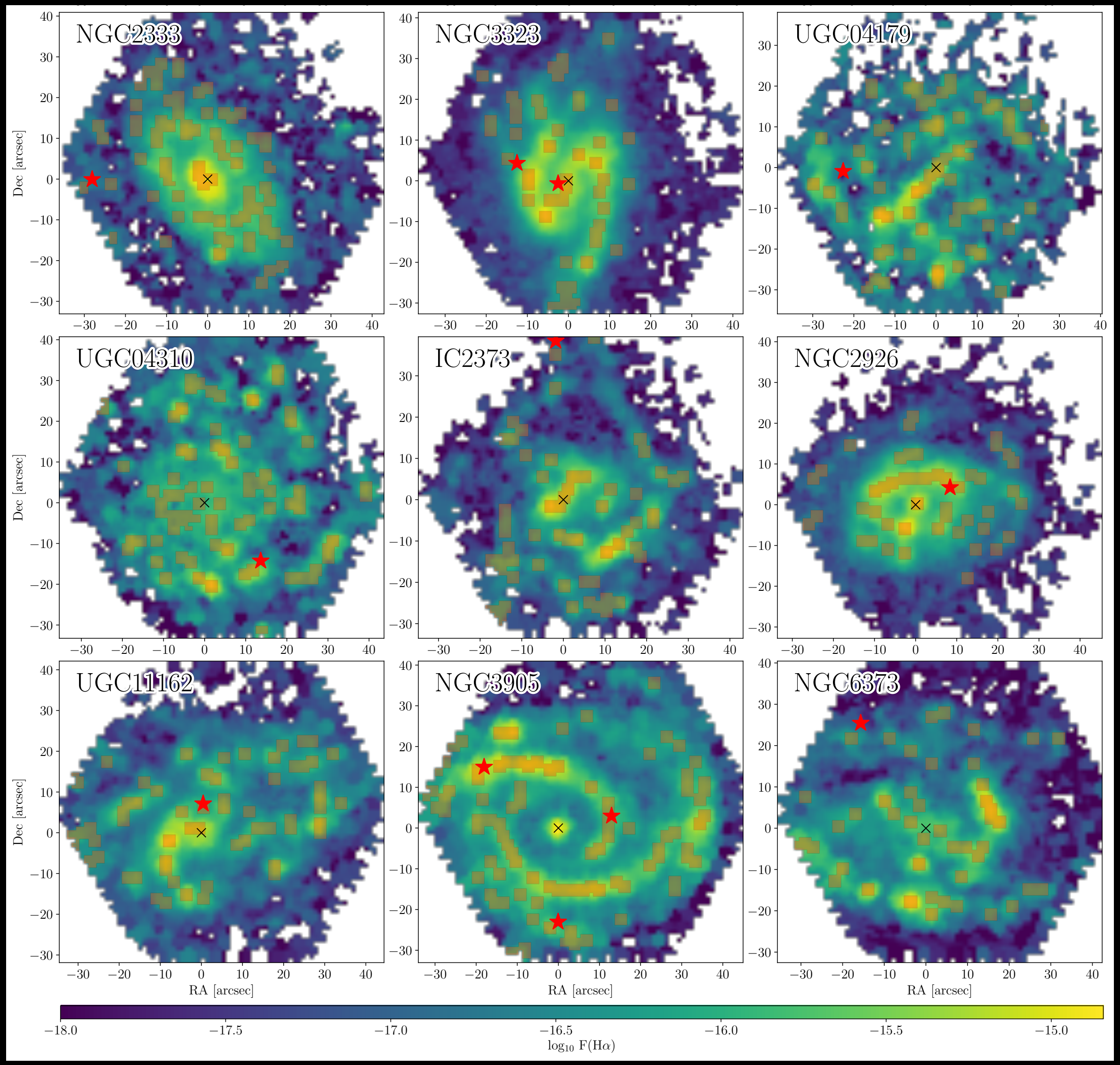
7 semesters

- 45/55 from H15B-3.5-004: Low-mass CC SNe hosts
- 21/27 from F16A-3.5-006: SNe with strong Na I D
- 9/11 from H16B-3.5-012: SNe Ia in the NIR
- 12/13 from F17A-3.5-001: SNe Ia in the NIR II
- 13/13 from H17B-3.5-001: SNe Ia in the NIR III
- 16/16 from F18A-3.5-013: CSP SNe Ia
- 31/37 rom H18B-3.5-008: CSP SNe Ia

147/172

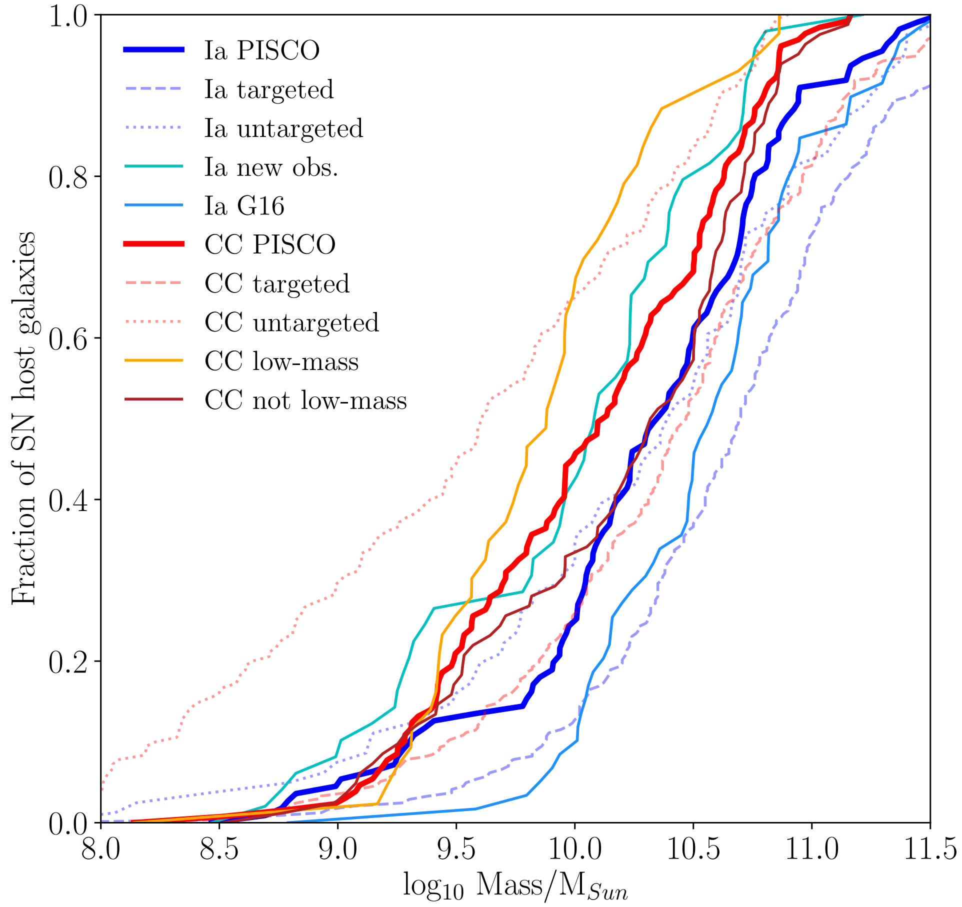
286/334 galaxies/SNe

168 Ia, 166 CC: 105 II (incl. 22 n), 61 SE (20 b 22 c 13 IIb)



LG et al. 2018, ApJ 855:107

PISCO results

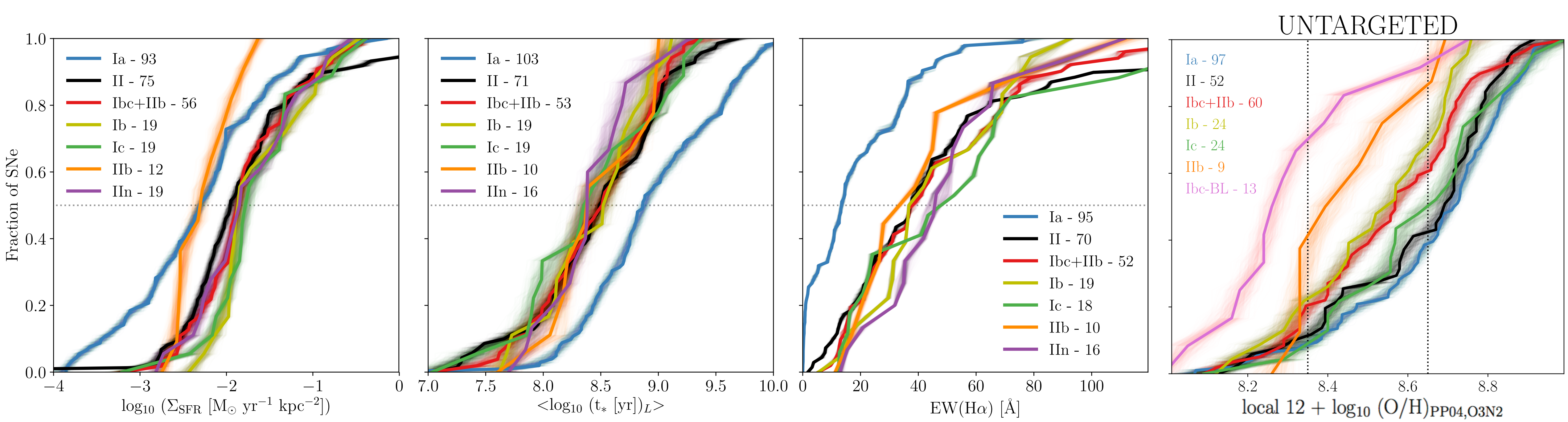


Correct bias from targeted surveys for SNIa hosts

CCSN hosts in PISCO closer but still biased towards high-mass hosts

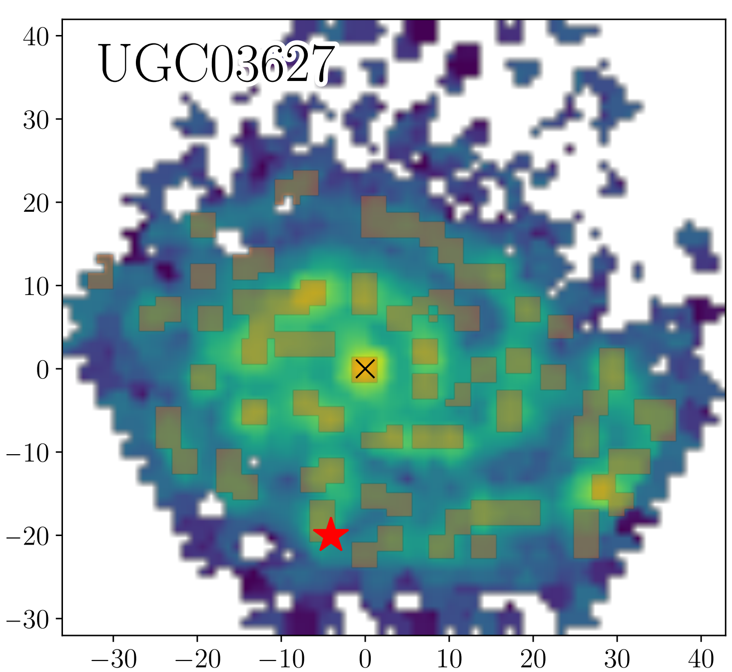
Previous results (SFR association and metallicity) recovered with:

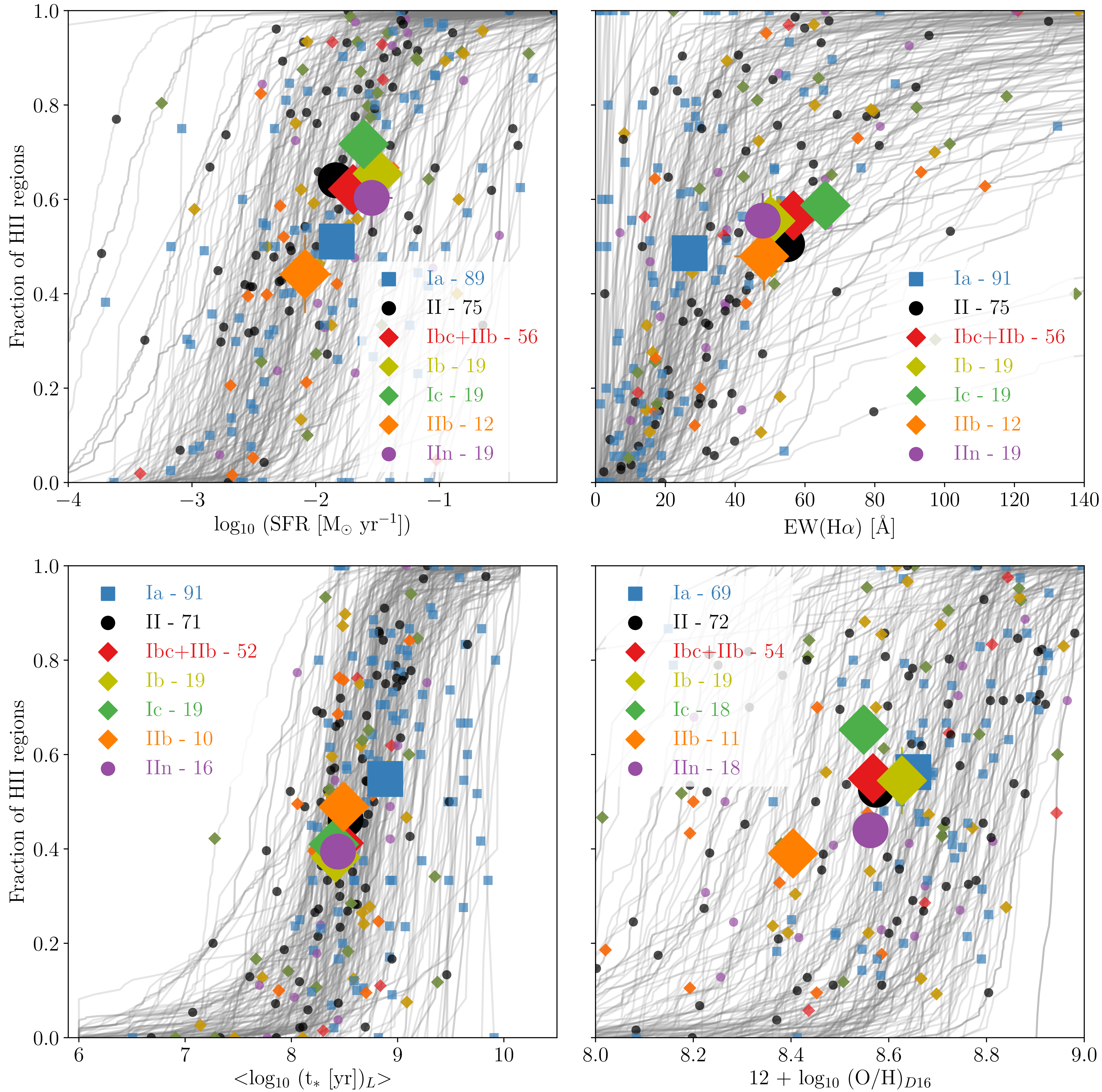
- larger statistics
- Split in SN subtype



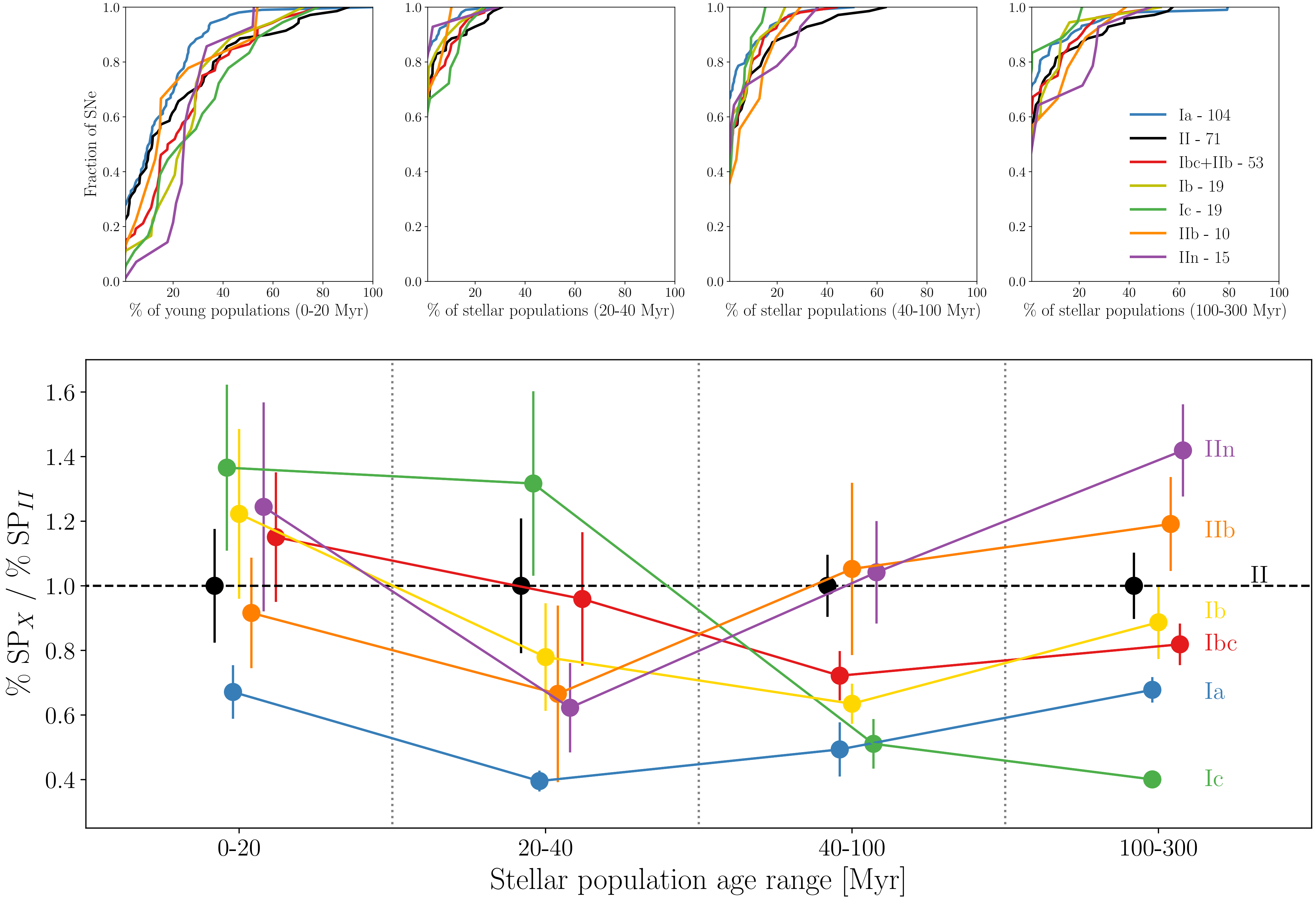
HII region stats

SN locations in context within their hosts to overcome the bias introduced by sample selection

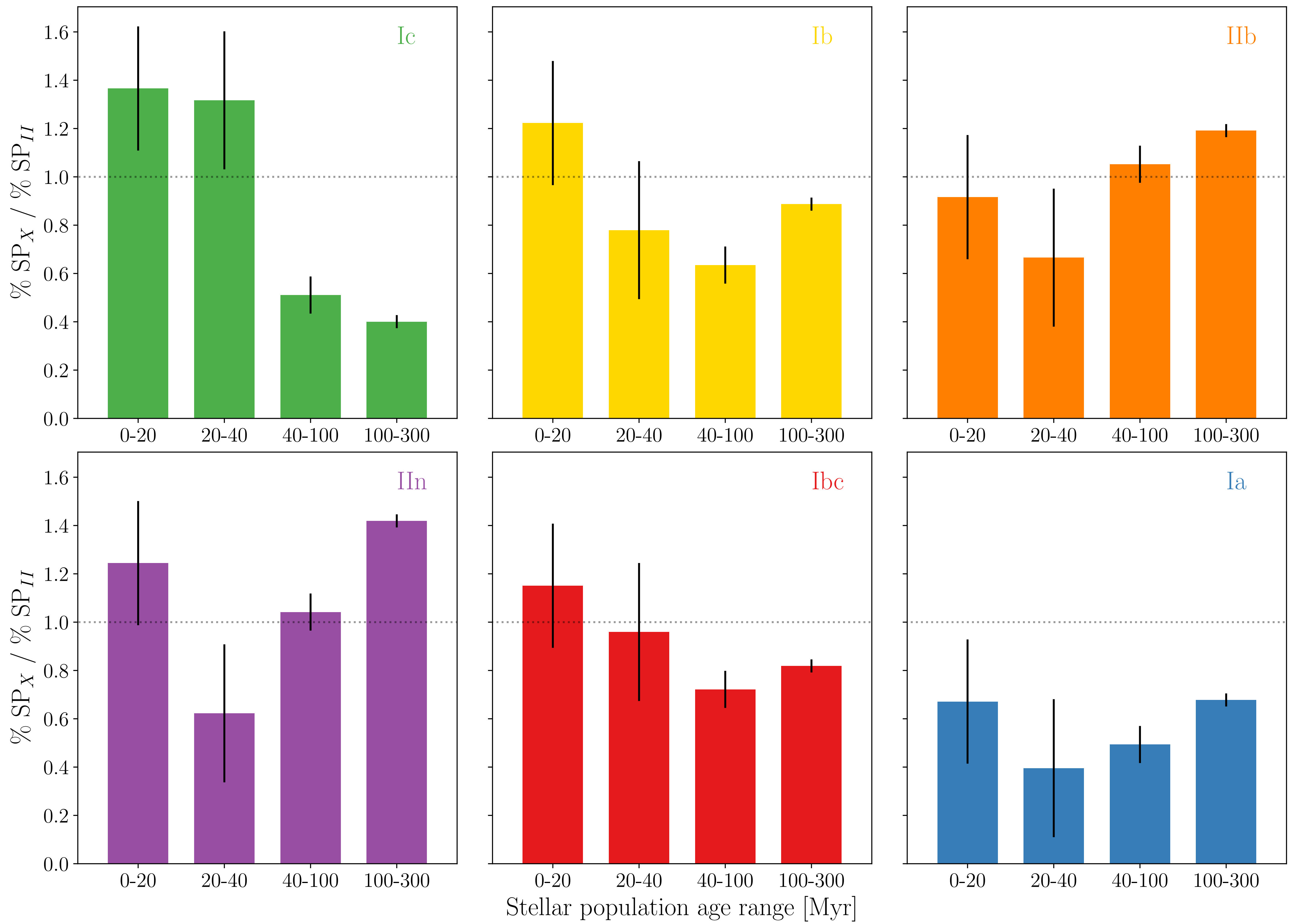




Star formation histories (0-300 Myr)



Star formation histories (0-300 Myr)



Star formation histories (0-300 Myr)

II: ~SFR, ~Z — ***RSG***

Ic: High SFR -> large mass, low age
High Z -> Single star + winds — ***SP***

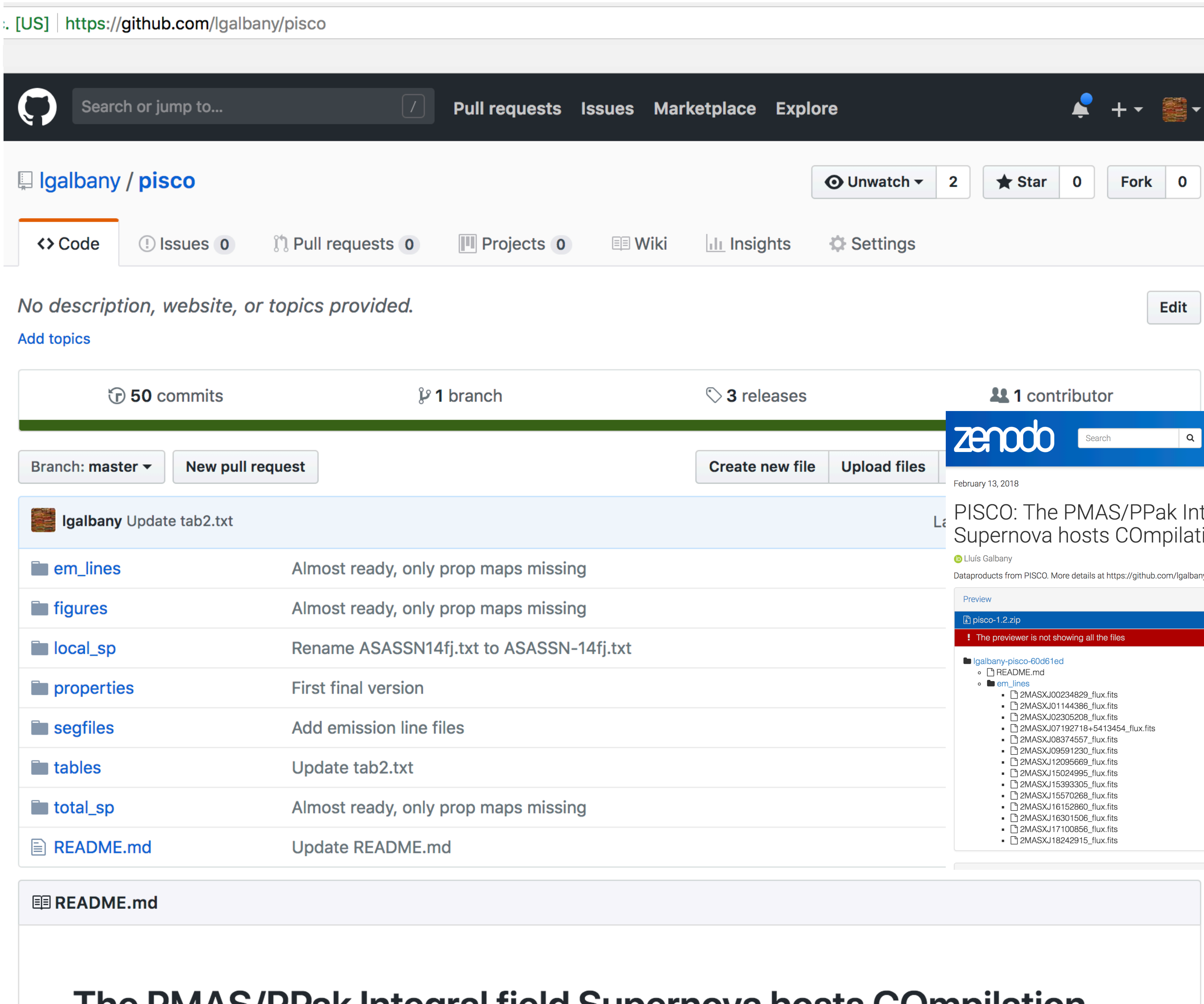
Ib: High SFR -> large mass, low age
Lower Z -> Single star + winds
Keep He — ***S+BP***

IIb: Low SFR -> older progenitor
Low Z -> keep He, ~H — ***BP***

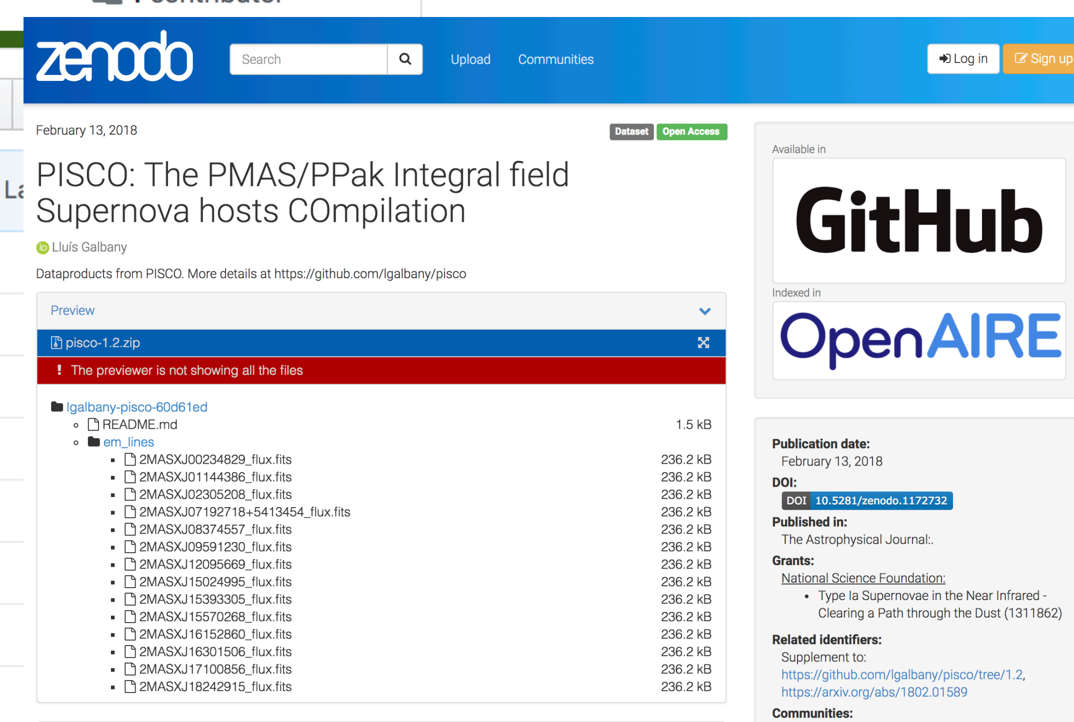
IIn: Two components -> Young
Old — ***RSG(CSM) + LBV***

Open access

github.com/lgalbany/pisco



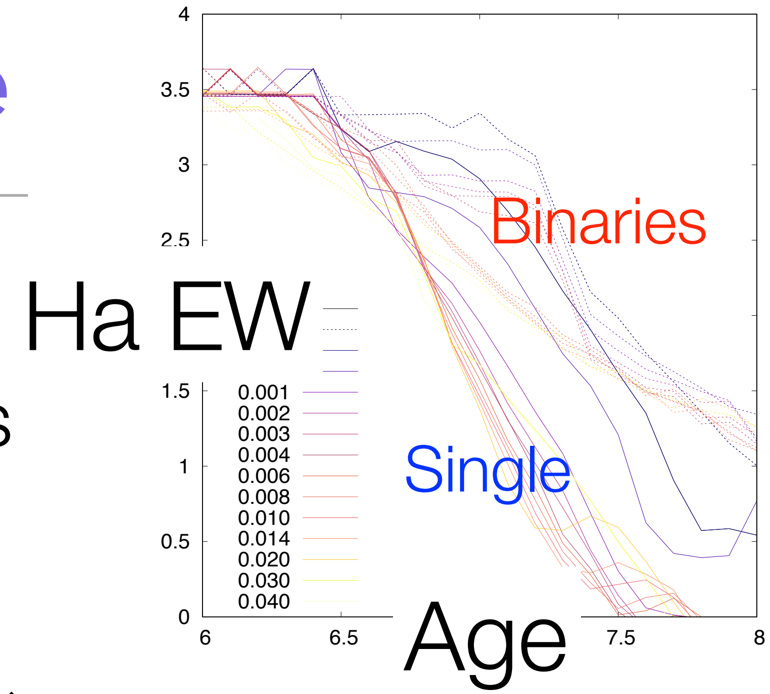
Also

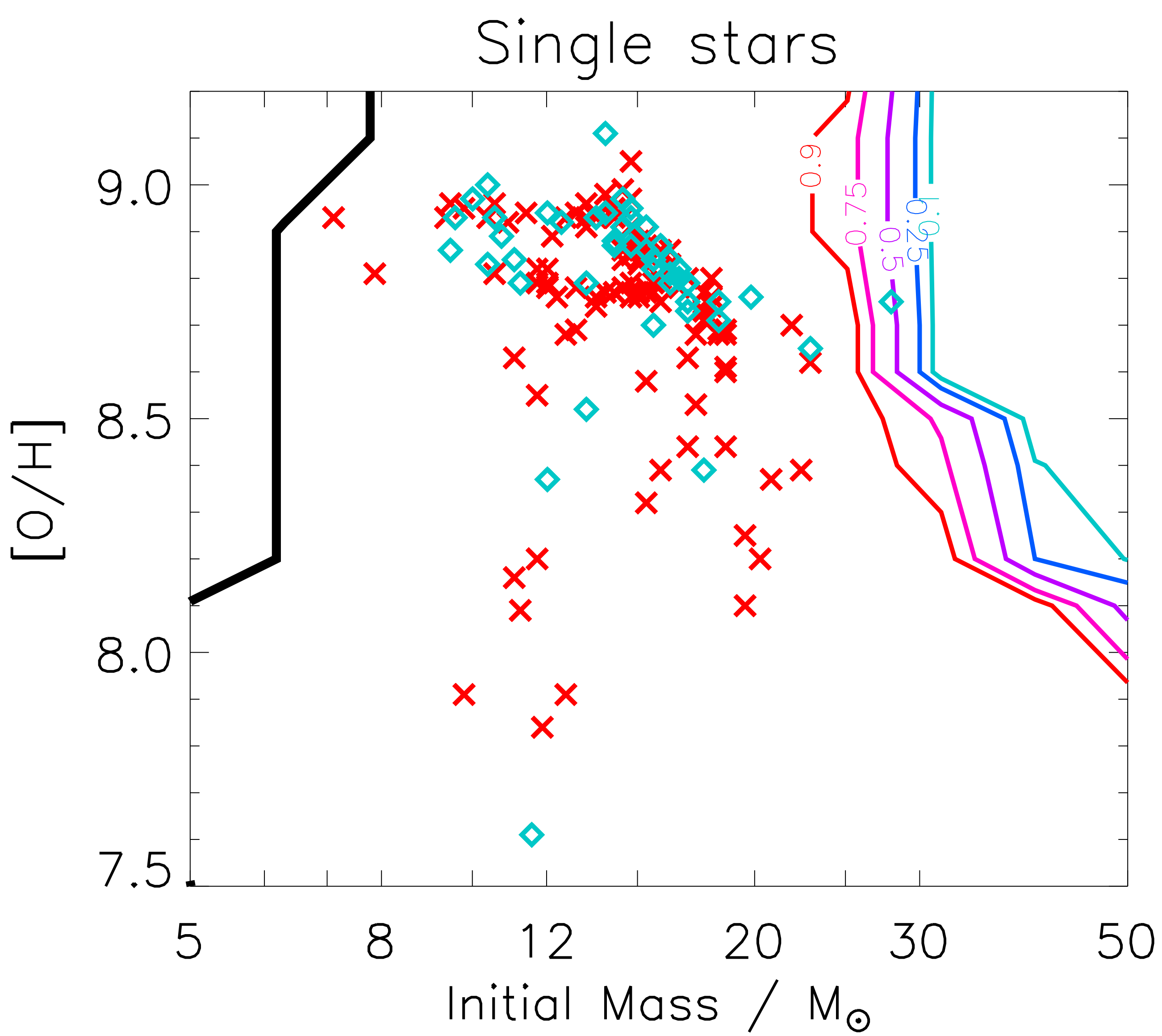


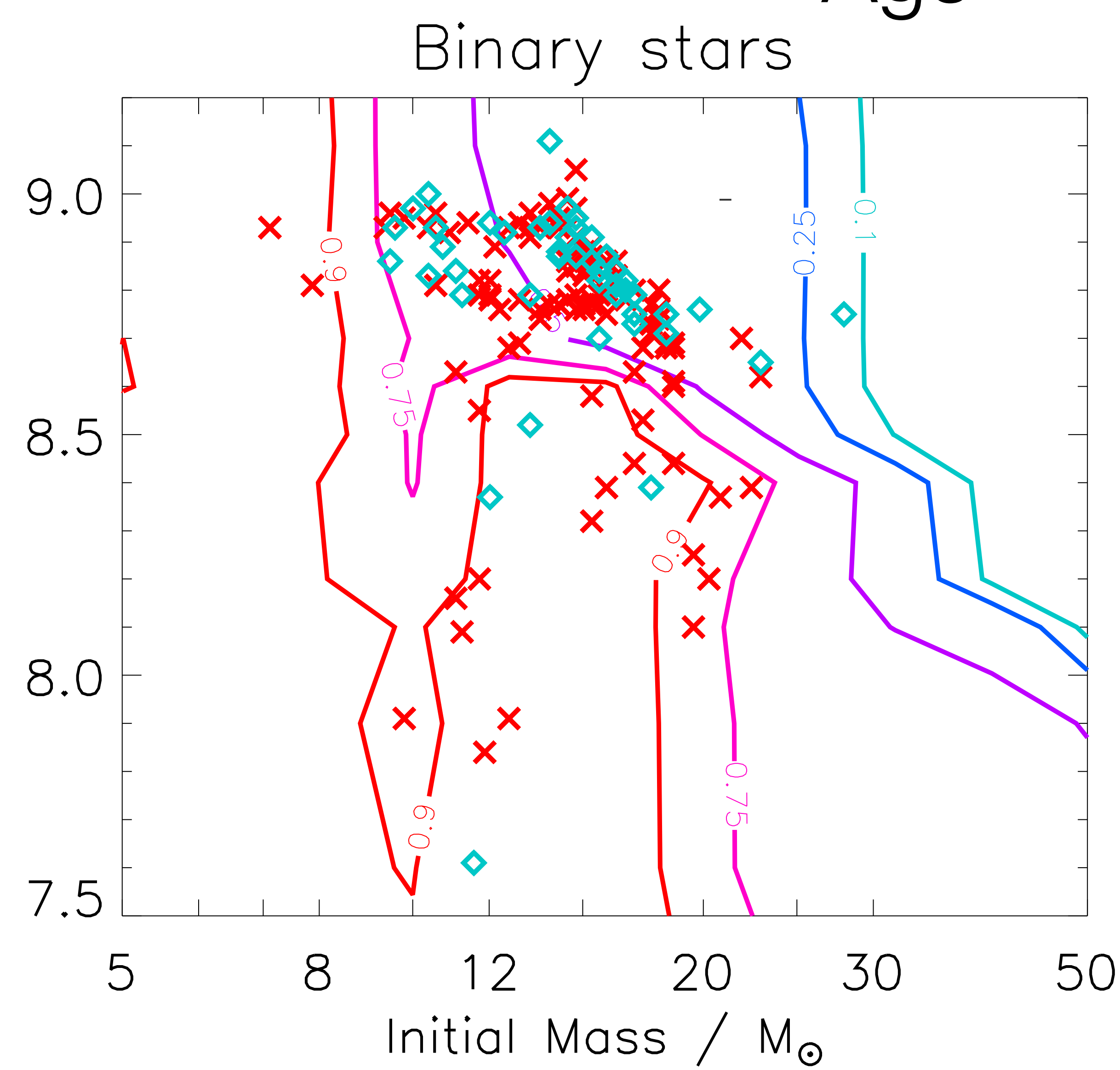
Binary progenitor models for CCSNe

Comparing gas emission lines from local environments with BPASS binary population models

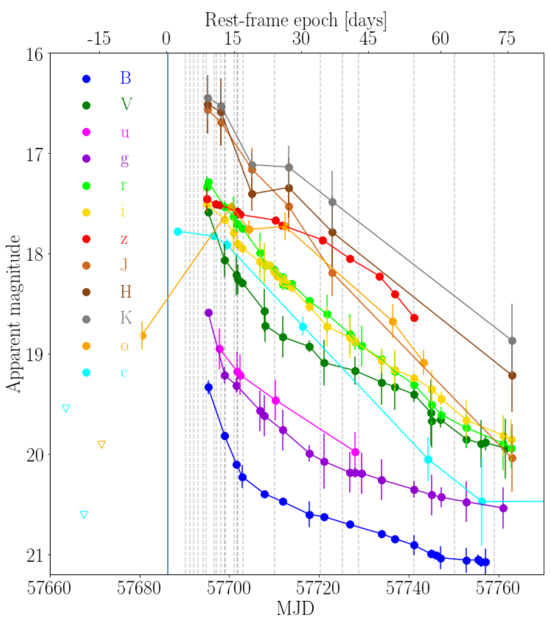
__Lin Xiao__, LG, Eldrige, Stanway, 2018, MNRAS, accepted







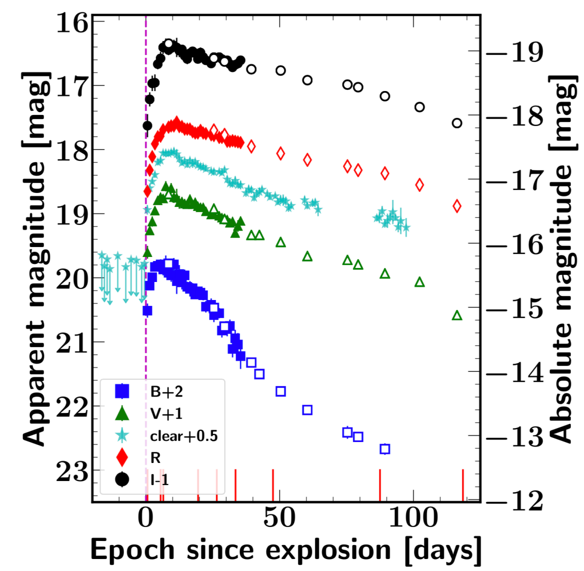
Single SN papers



LG, CA, PH, et al
In prep

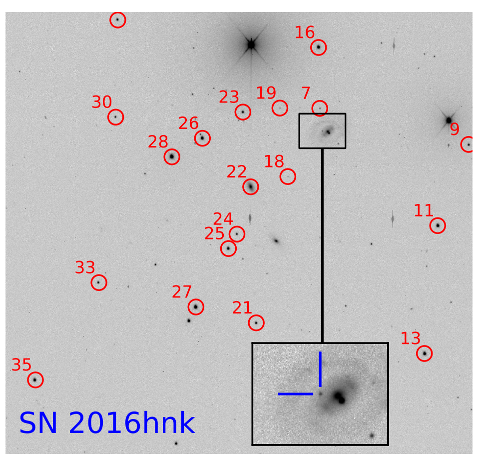
SN 2016hnk
Peculiar Ca-rich
Type Ia

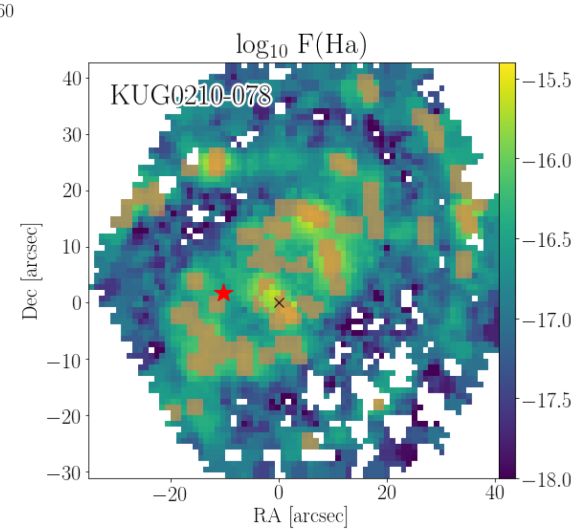
Thomas de Jaeger

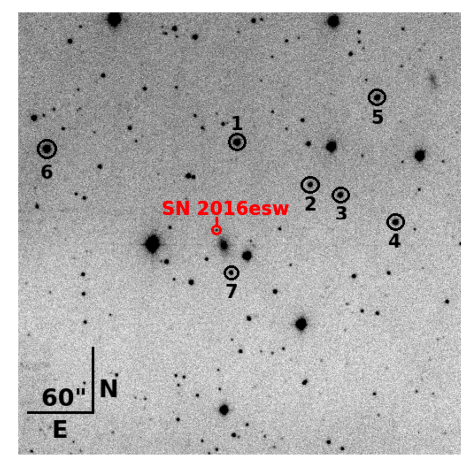


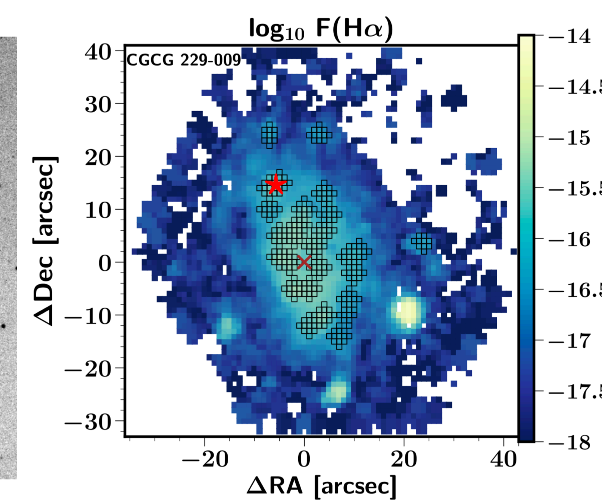
SN 2016esw
overluminous
Type II

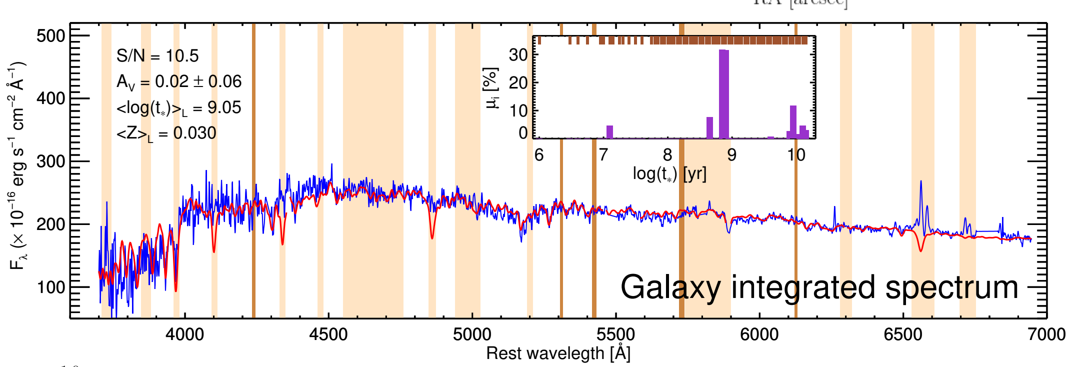
arXiv:1805.03205

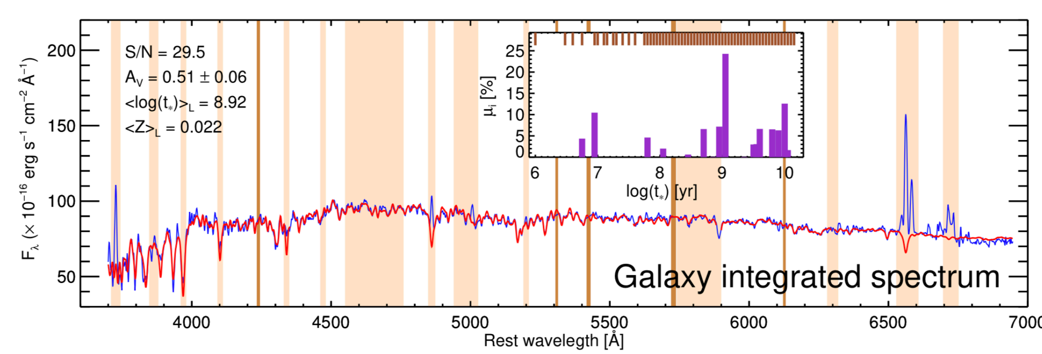


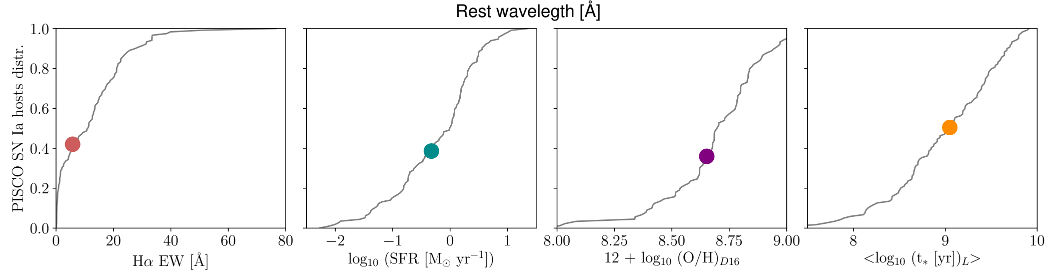


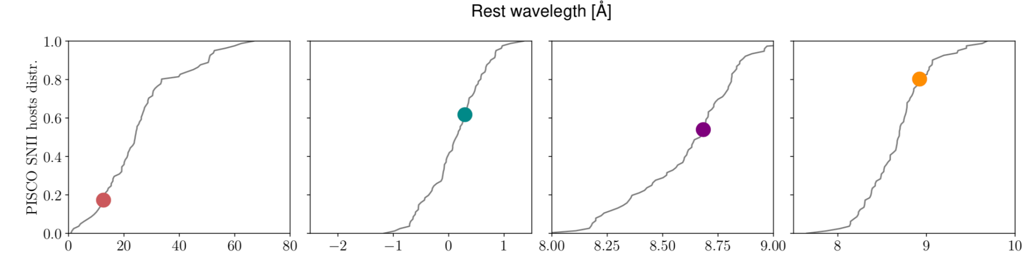




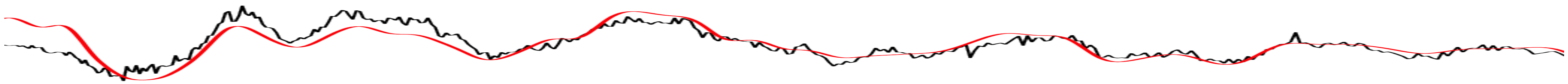








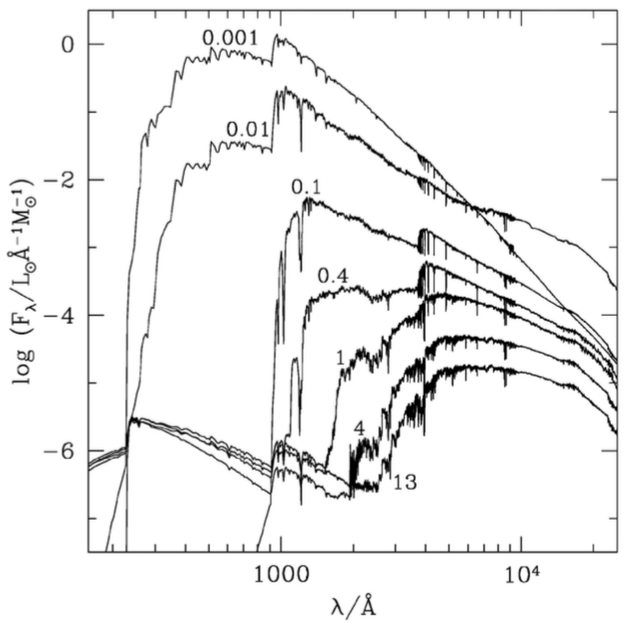
SFH reconstruction and DTD



Carles Badenes

Single Stellar Population (SSP) synthesis

Spectral templates with different t and Z



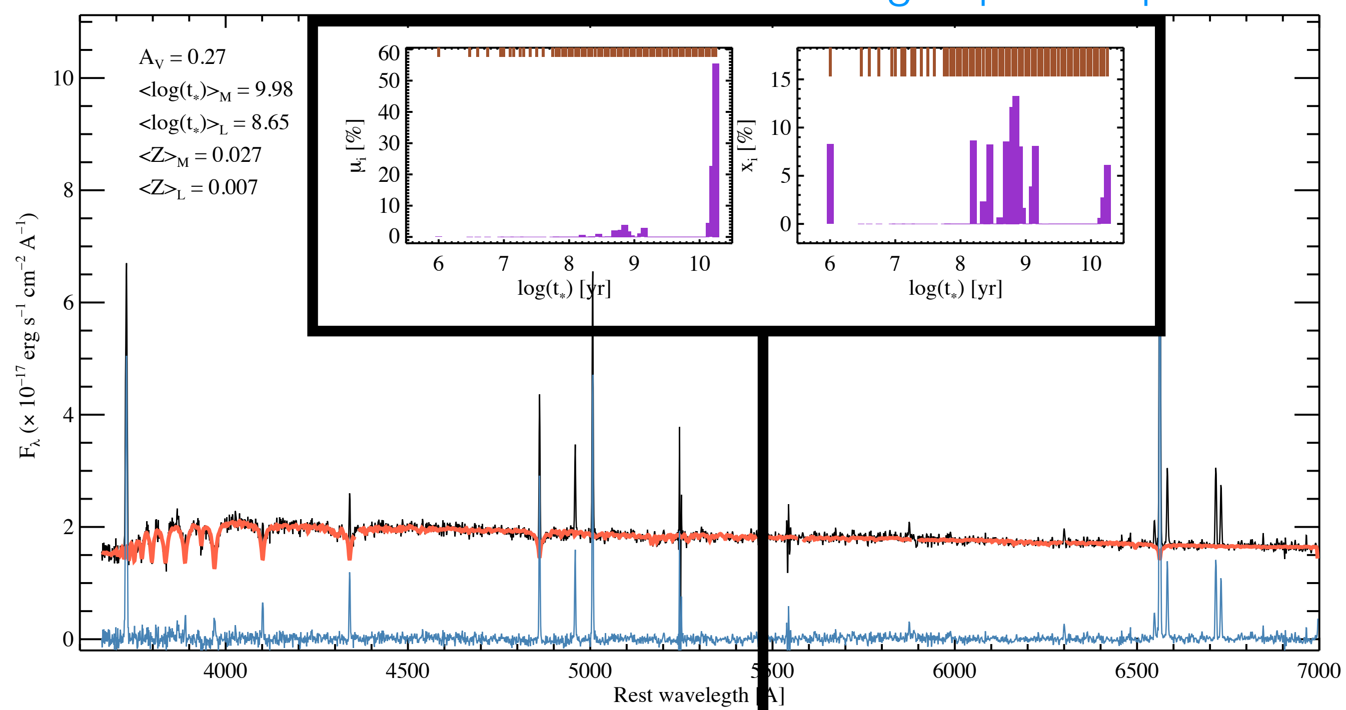
STARLIGHT

(or other)

Observed spectrum

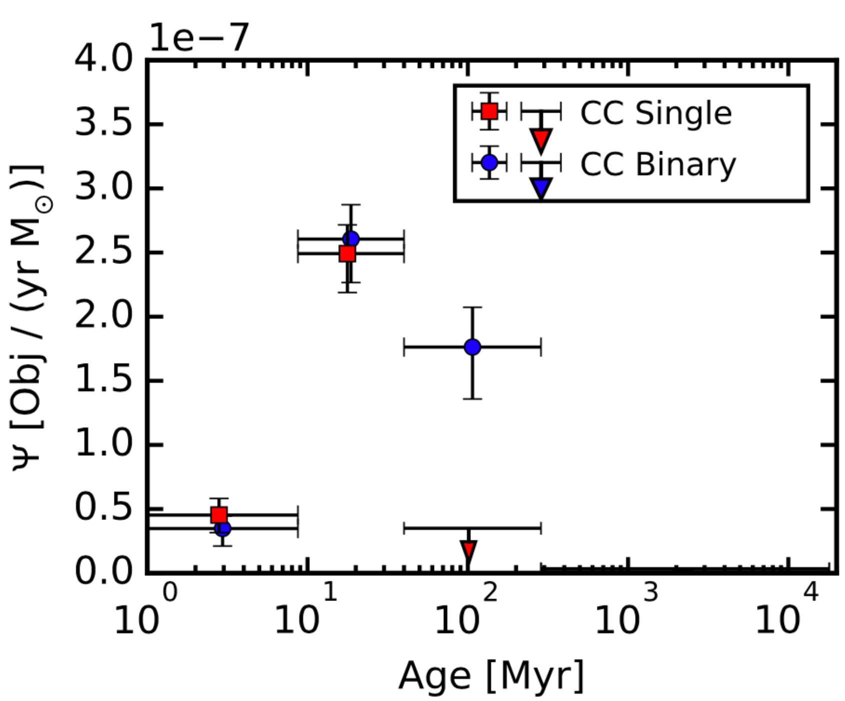
Best SSP fit

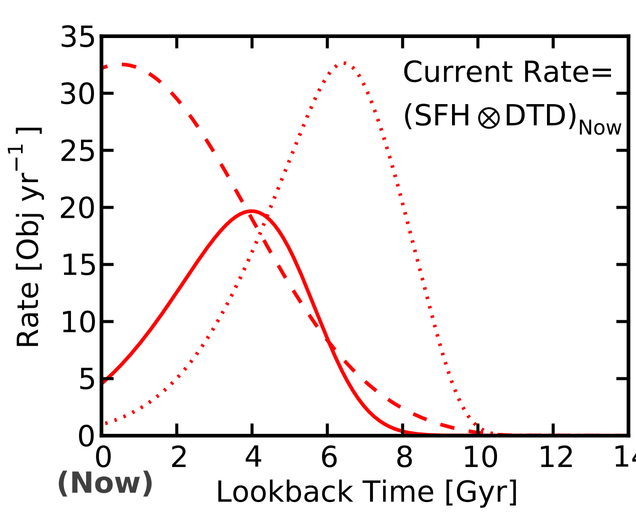
Residual: gas-phase spectrum

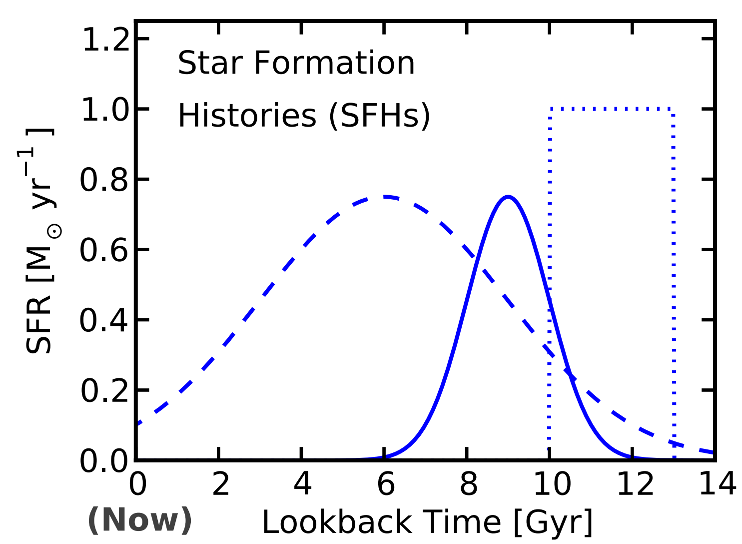


SFH reconstruction

SN rate = (DTD x SFH)

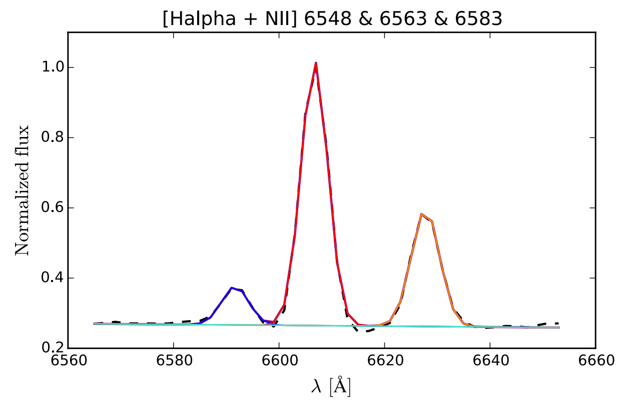


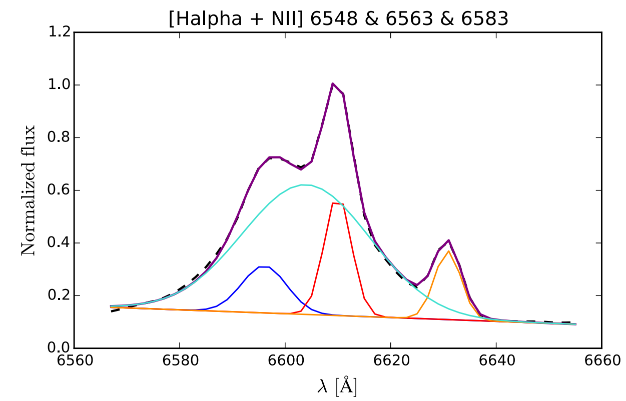




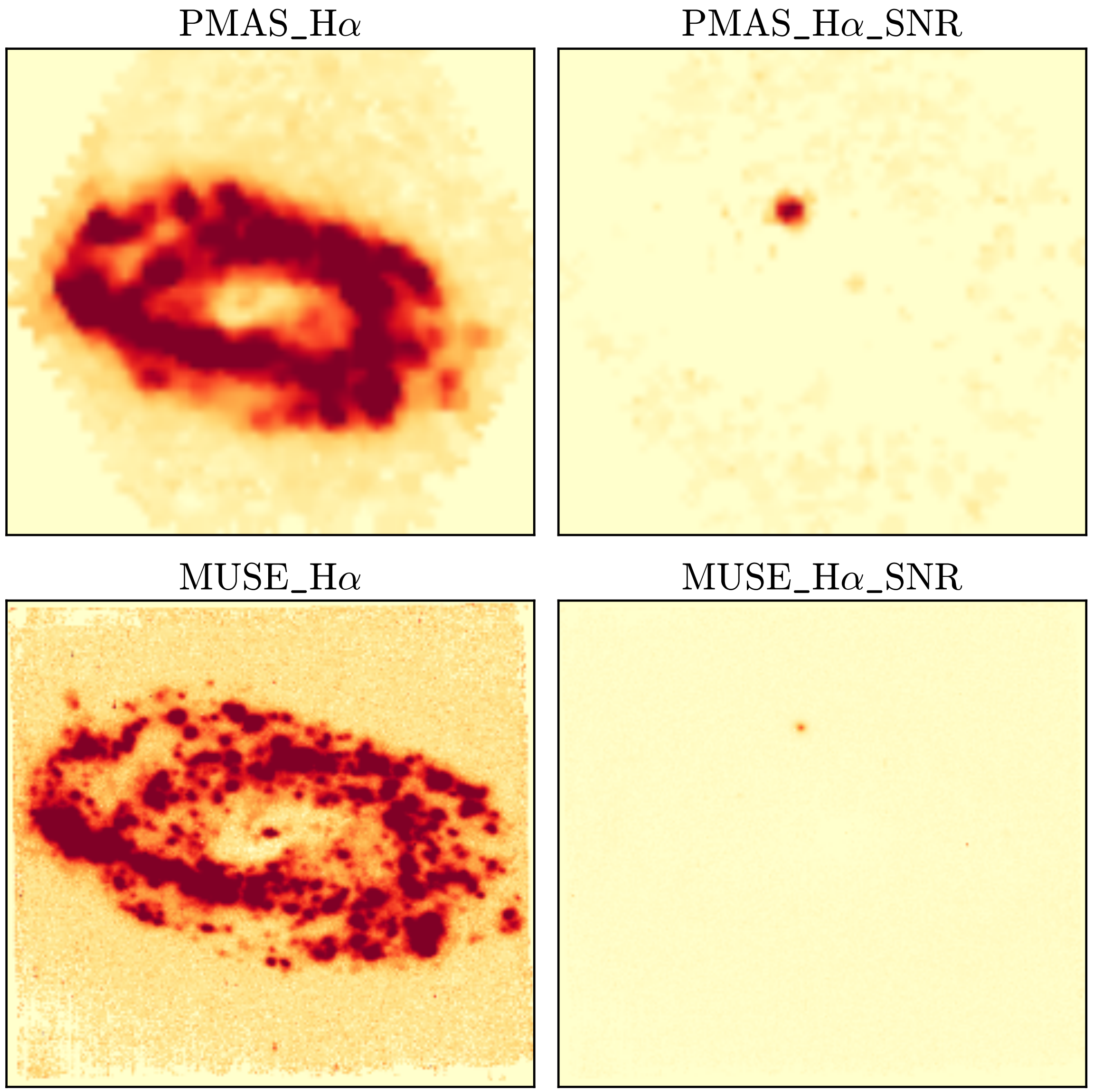
Young SN remnant detection/discovery

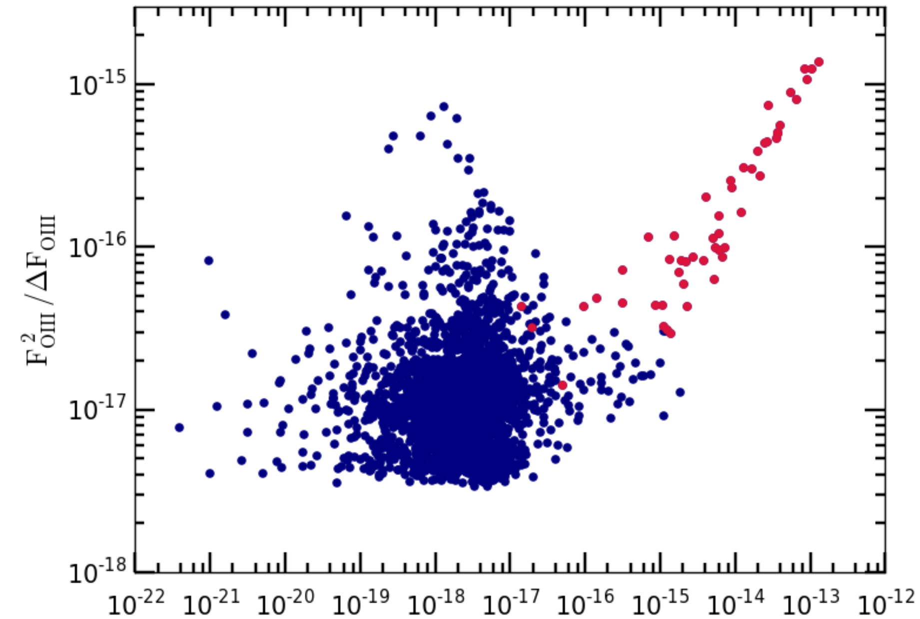
Halpha broad emission

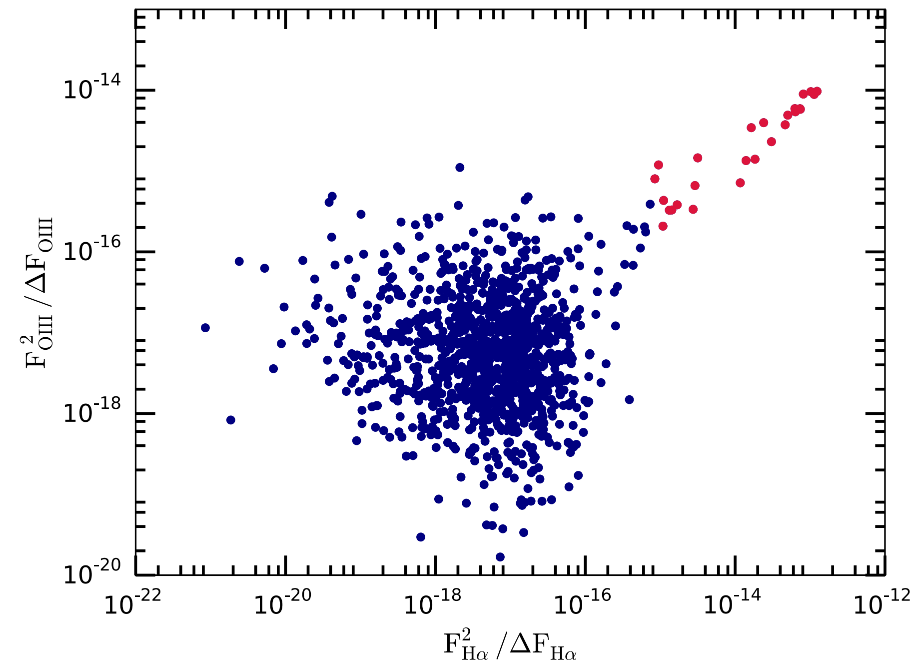




Héctor Martínez Rodríguez

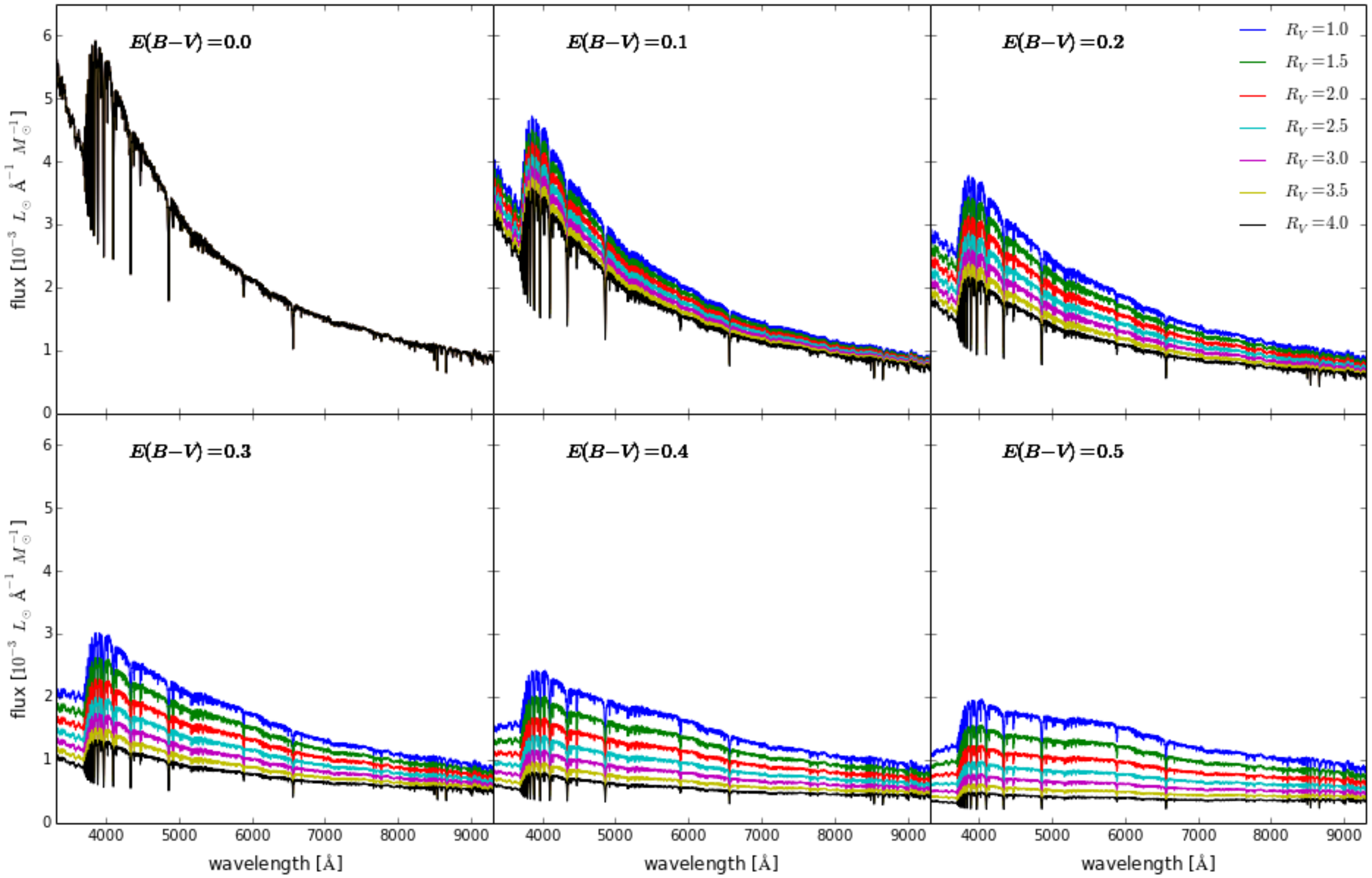






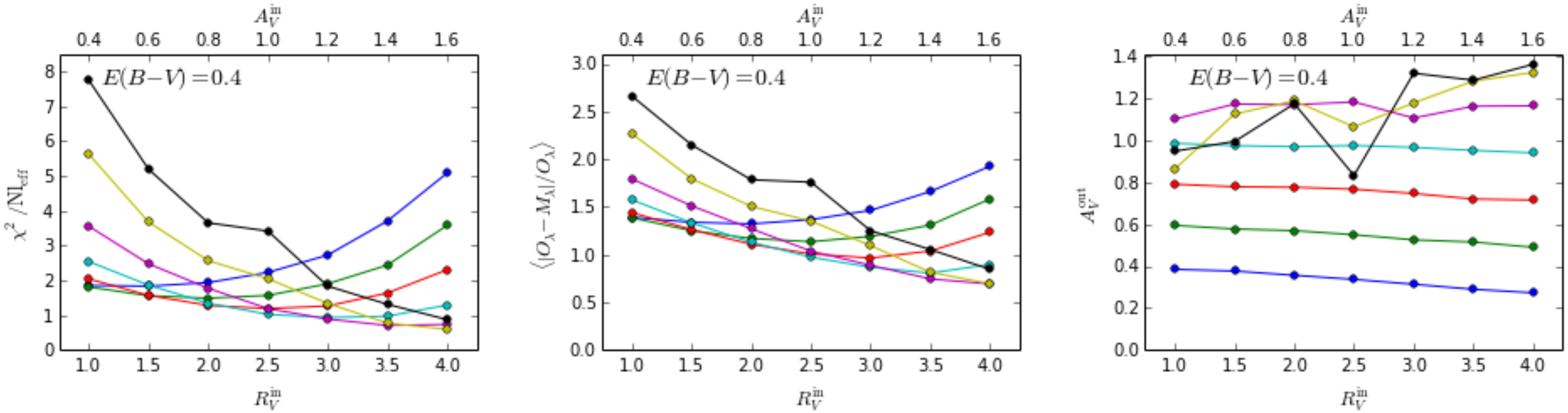
Dust extinction studies

Alessandro Razza



SEE POSTER!

Simulating dust with varying Rv



THE AMUSING SURVEY

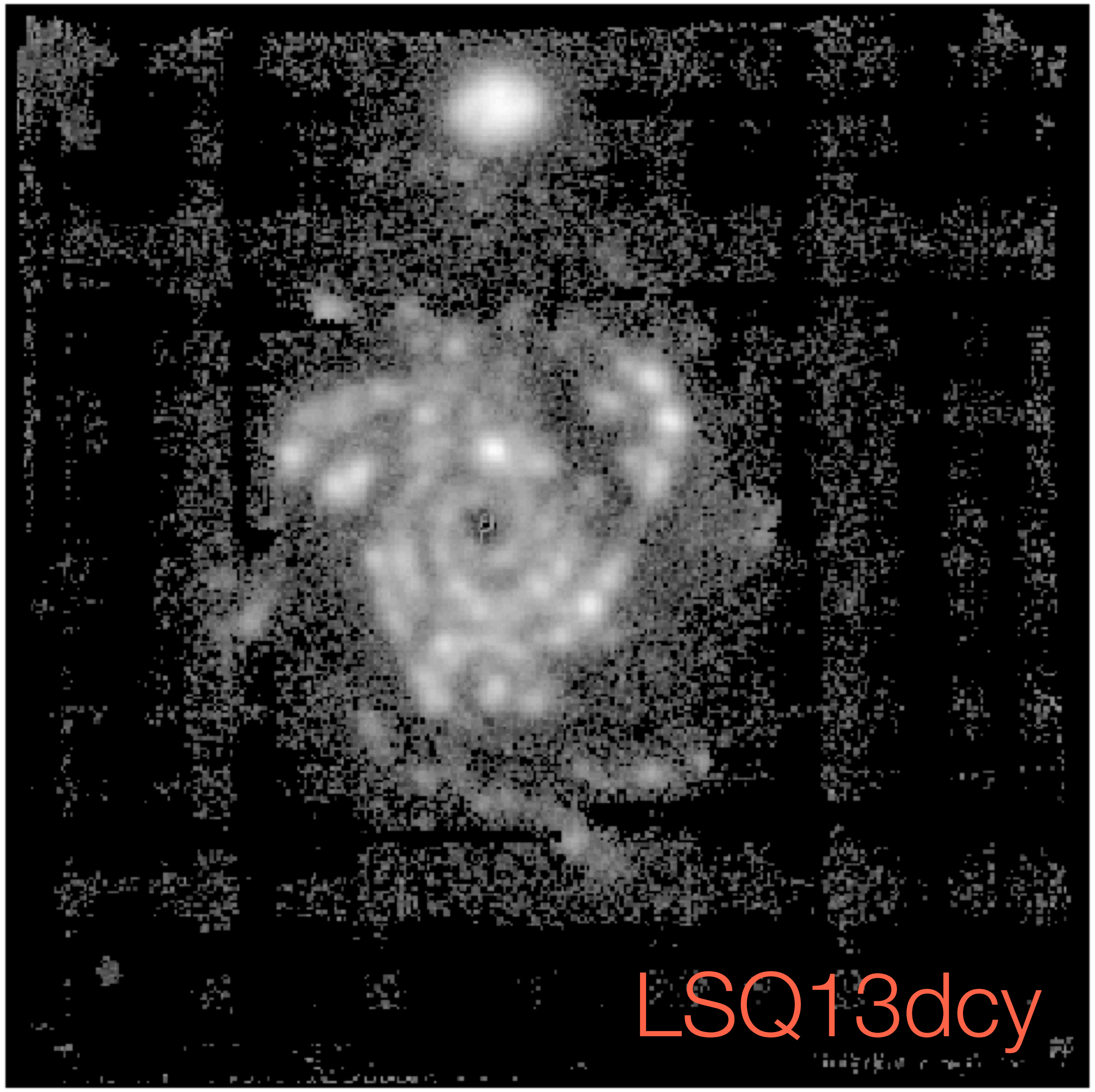
(All-weather MUse Supernova Integral field of Nearby Galaxies)

PIs: Anderson (ESO) & Galbany (Pitt)

8 semesters: P95 to P102

349 SN hosts (365 SNe)

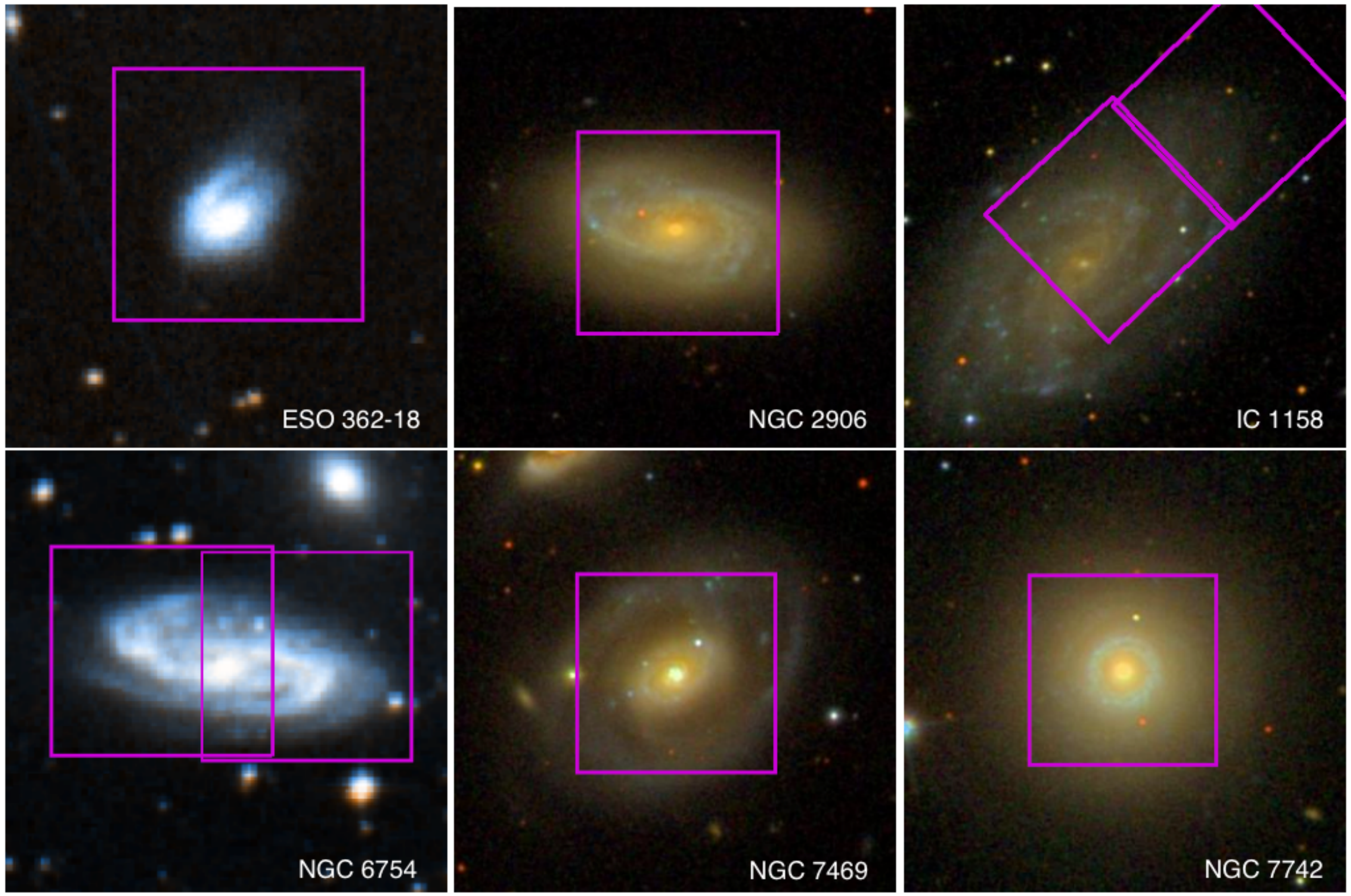
- **A**LL-WEATHER: makes use of non-optimal weather of Paranal. Many observations done in bright, THN conditions (avg. seeing 1.1”, from 0.7” to 1.5”).
- **MU**SE: very efficient instrument. 3GB per cube, >4800 A. Basis for driving big data spectroscopic astronomy.
- **S**upernova: Overall aim is to use MUSE to further understand supernova progenitors/explosions. Study SN environment and all other regions within the host.
- **I**ntegral-field: 1’x1' FoV, 0.2” pixel scale. Image-like resolution but with ‘spaxels’.
- **N**earby: Allows in-depth study of gas and stellar populations. Classical assumptions for IFU work break-down.
- **G**alaxies: Allows cross-field collaborations. Galaxy studies: evolution, dynamics, stellar populations…

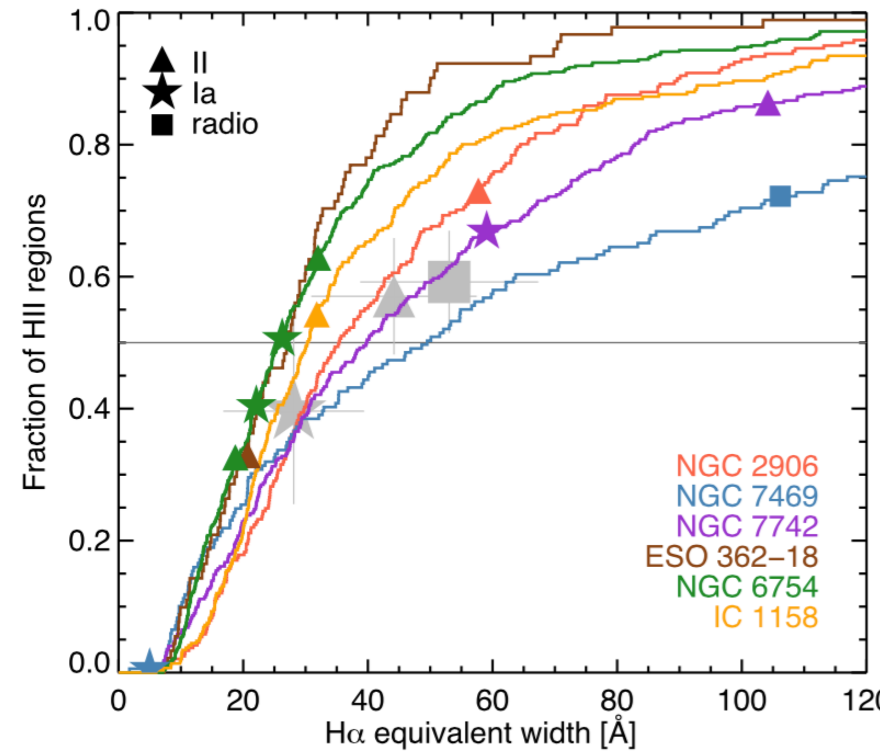


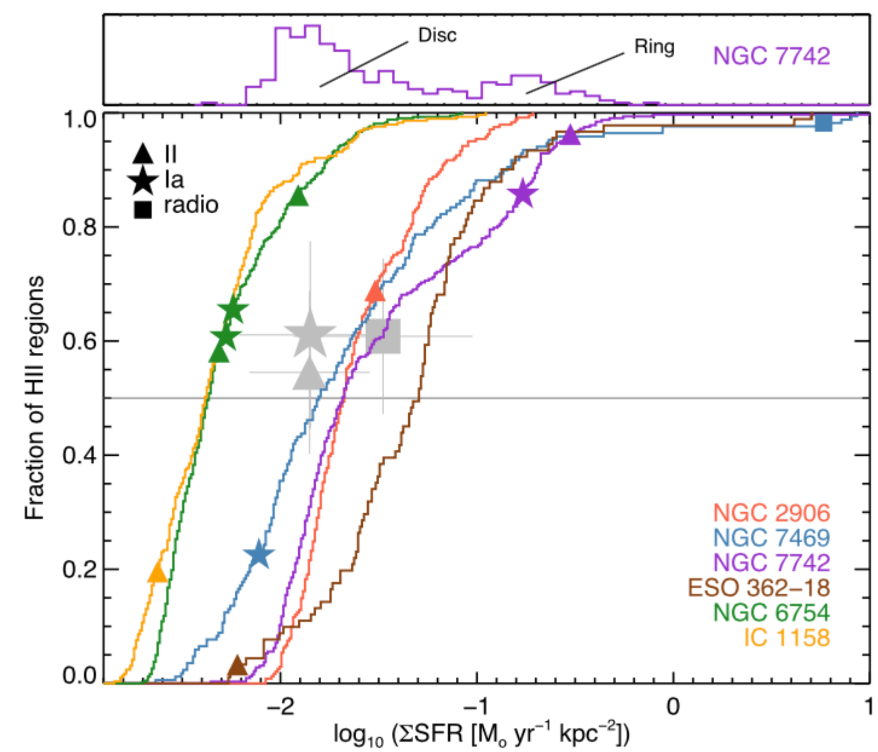
Aimed to be an open collaboration with regular data releases including all kinds of data products

1st data release expected for Jun 2019! Will include ~200 cubes

MUSE-SV: Pilot study of 6 galaxies that hosted 11 SNe



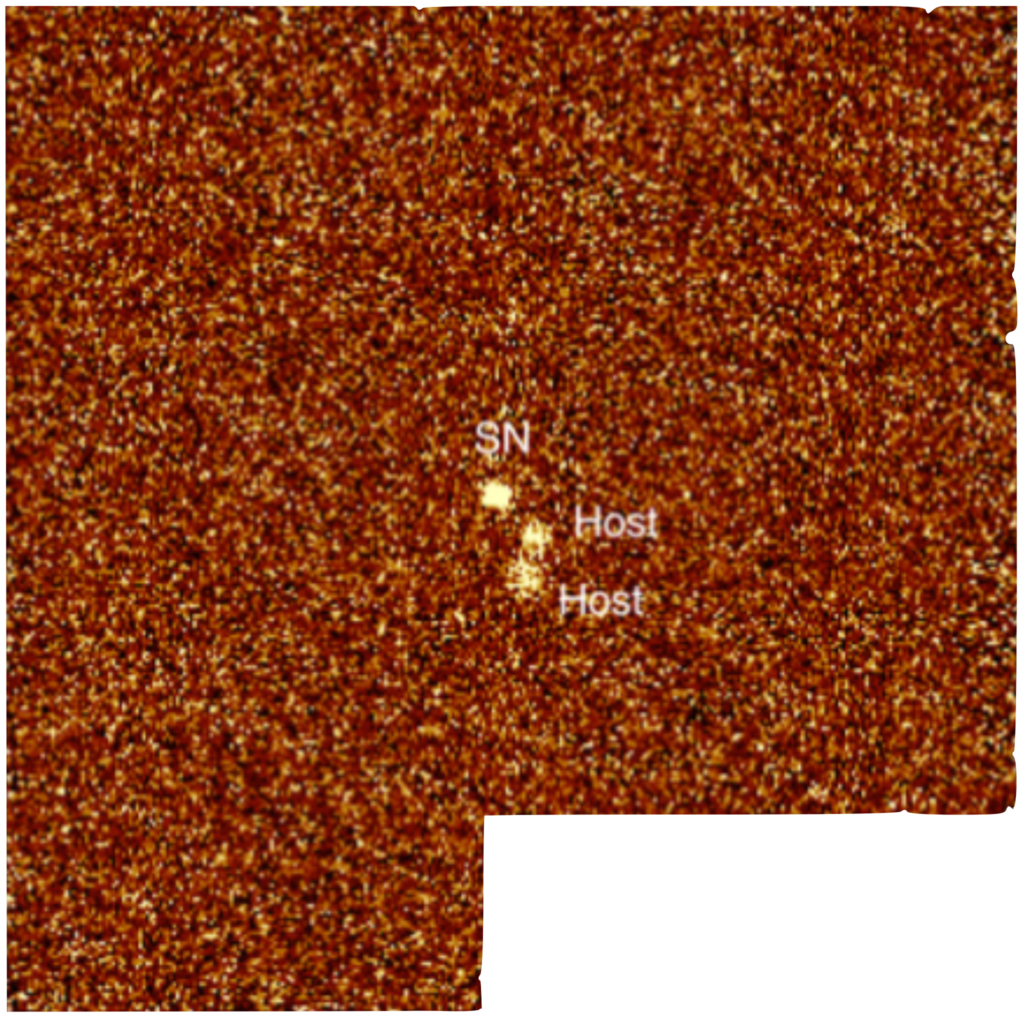


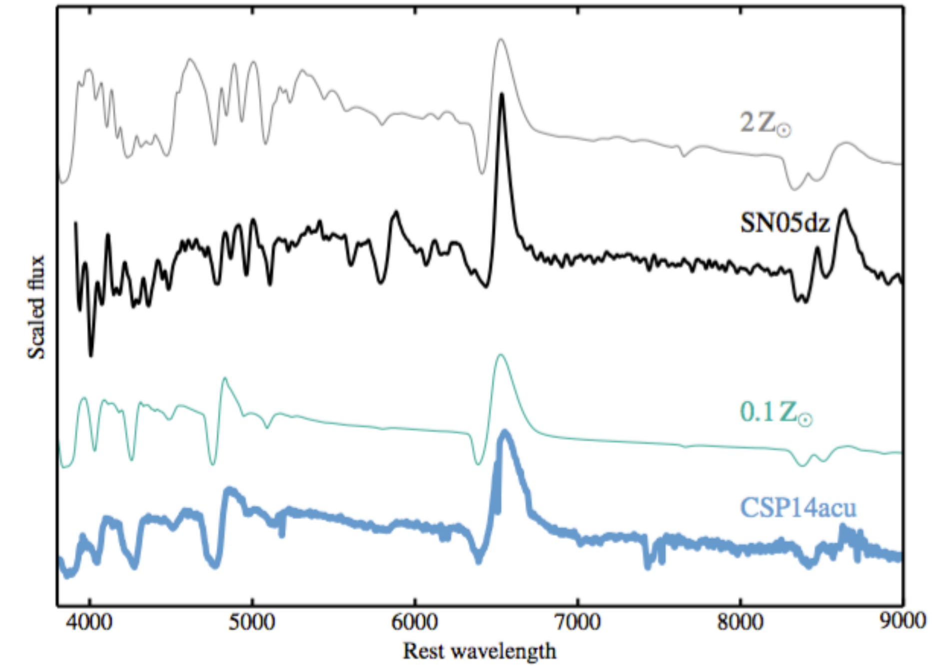


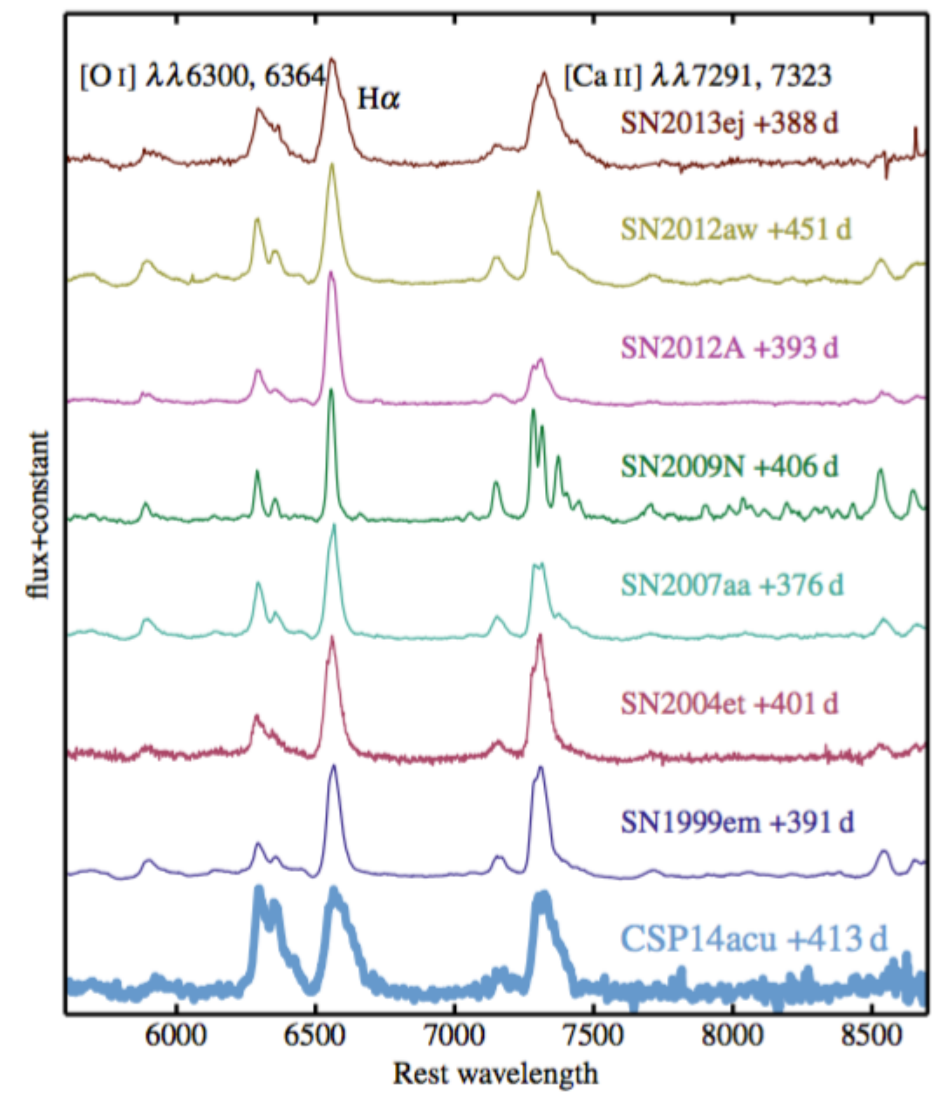
- ***HII region statistics:*** Distributions of SFR, oxygen abundance, Av extinction, and EW(Ha) measured in ALL HII regions in the galaxy, and characterization of the SN parent HII region.

LG et al. 2016b, MNRAS, 455, 4099

SN2015bs: high-M low-Z progenitor



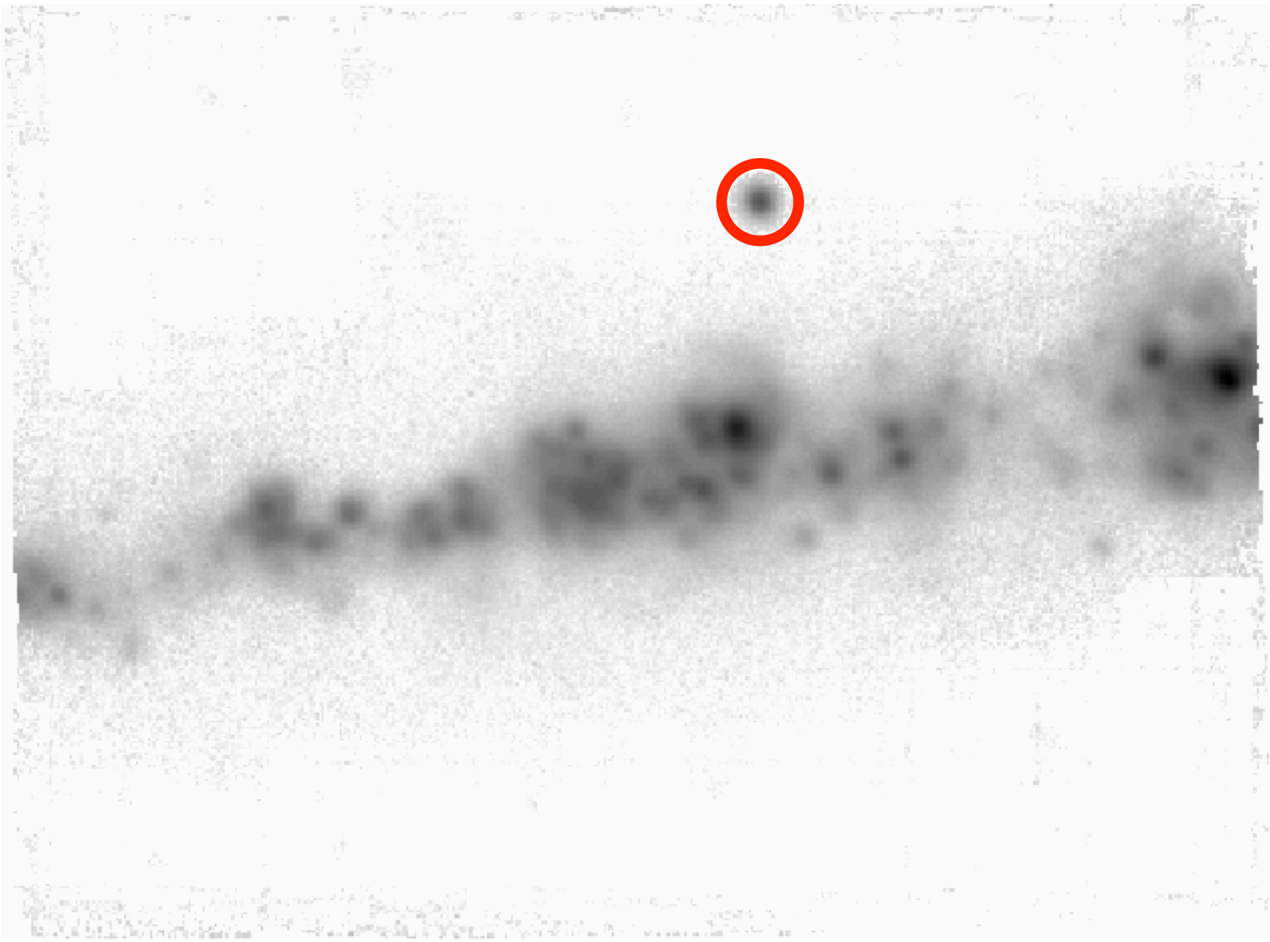




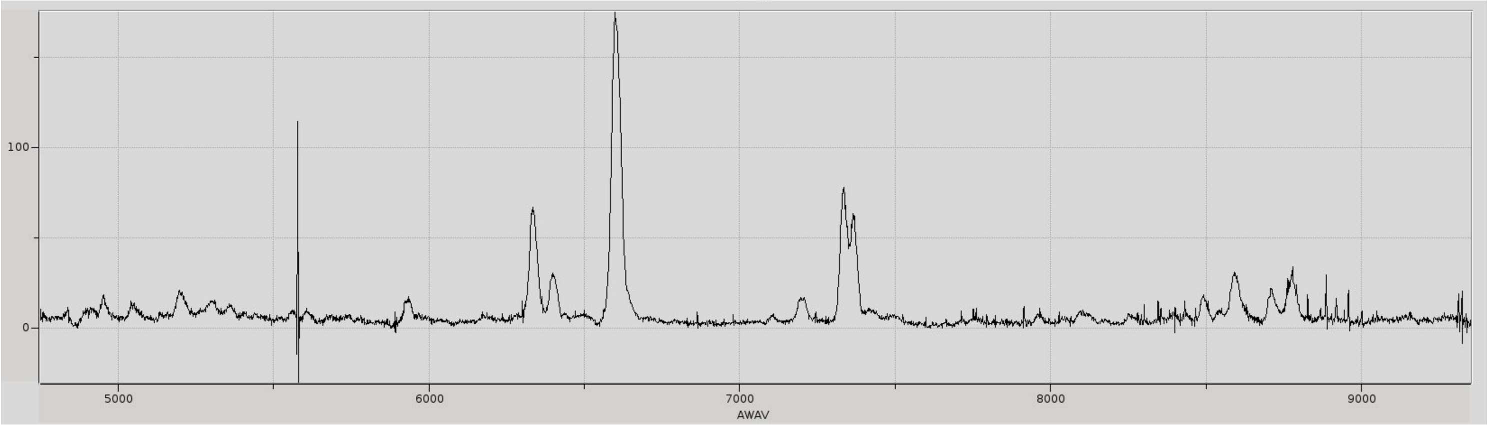
- MUSE constrained its host galaxy
- the SNII with the lowest Z to date
- strong [OI] w.r.t Ha (very broad) and [CaII], which means means more massive Helium core and more massive initial progenitor mass

Joseph P. Anderson

ASASSN-14jb: normal SNII very far from any SF region



- Edge-on galaxy (scale height ~400pc)
- SN progenitor exploded at >2kpc (lifetime of ~10Myr)
- needs a pec. vel. of 50 km/s

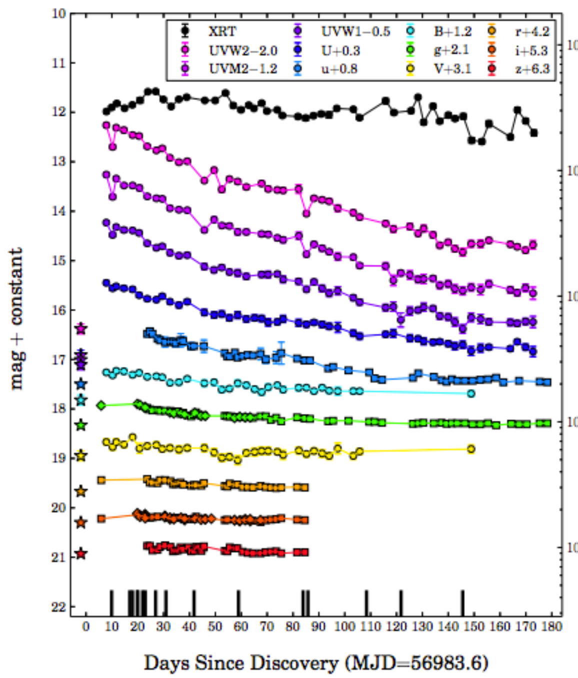


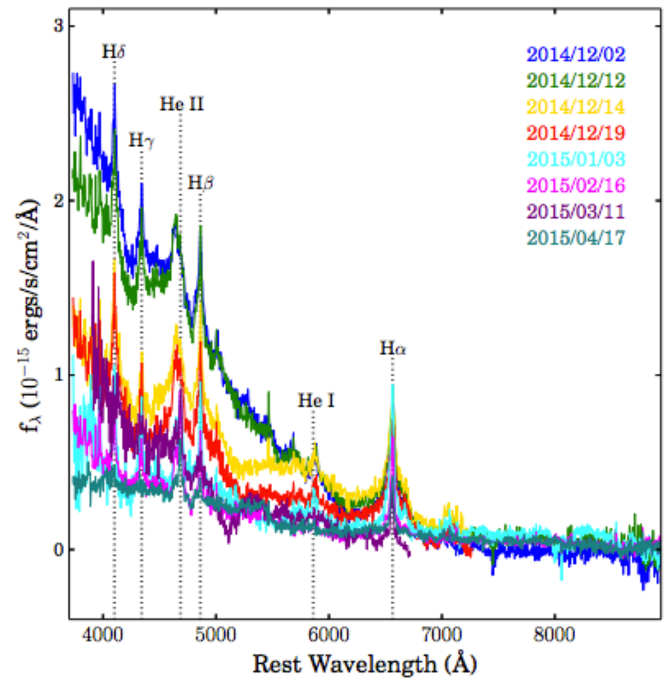
- Options?
  - kick from a SN in a binary system
  - triple interaction
  - ...
- It also has low Z

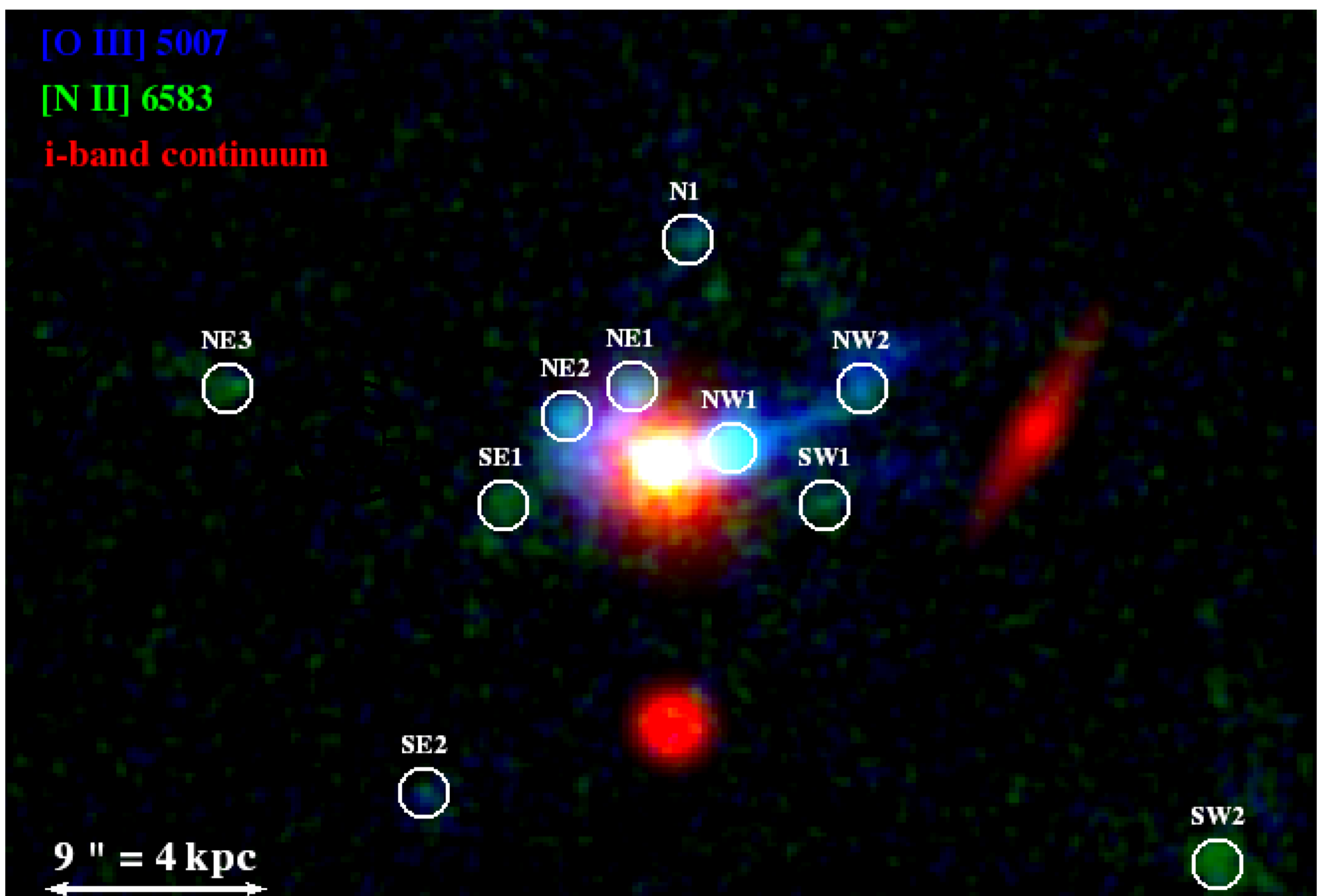
Nico Meza

José L. Prieto

ASASSN-14li: a nearby Tidal Disruption Event







- One of the closest TDE, and the best studied ever (from X-ray to radio)
- post-starburst galaxy (TDE rate is 30 times higher in E+A galaxies)
- Recent interaction (merger triggered the starburst)
- Gas ionized by an AGN

Summary

- 2 dedicated SN host galaxy surveys (PISCO: North, AMUSING: South)
- SN local env. populations show significant differences for different SN types, clues of progenitor scenarios:

  Ic: single   Ib: both
  IIb: binary IIn: two channels

- The study of the galaxy provided the clue for the SN analysis