The local environment of SNe Ia seen with Integral Field Spectroscopy

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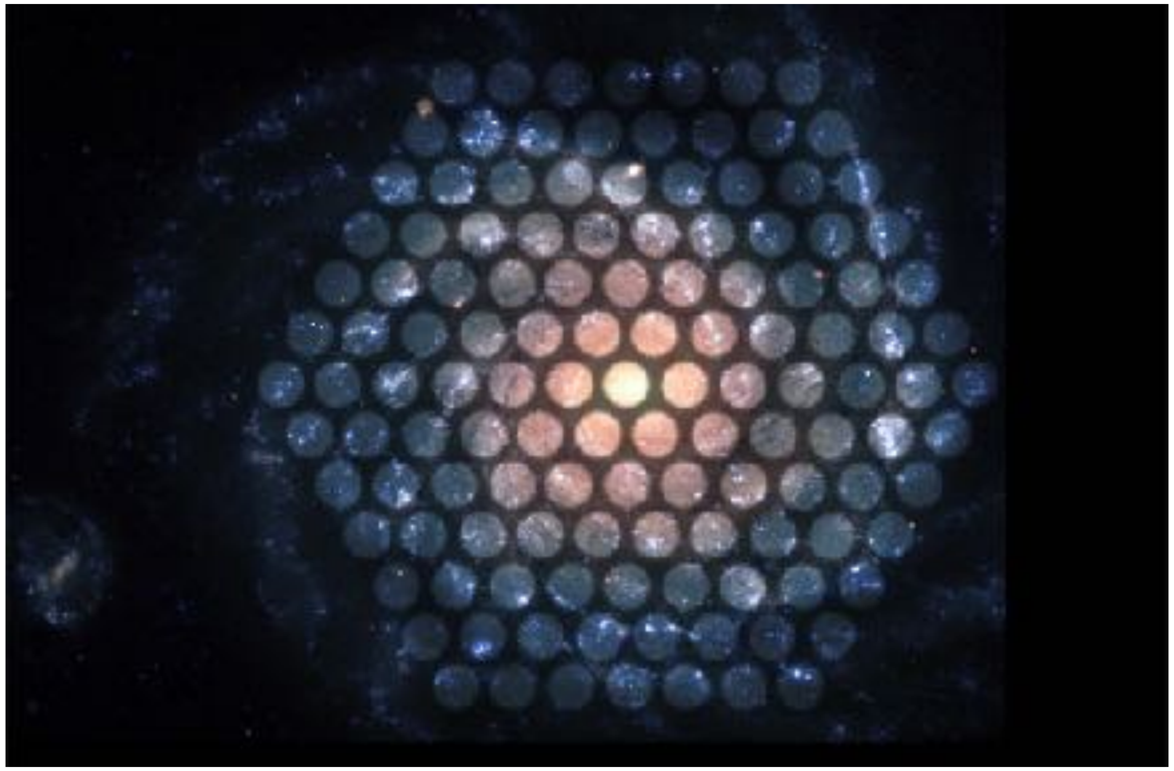
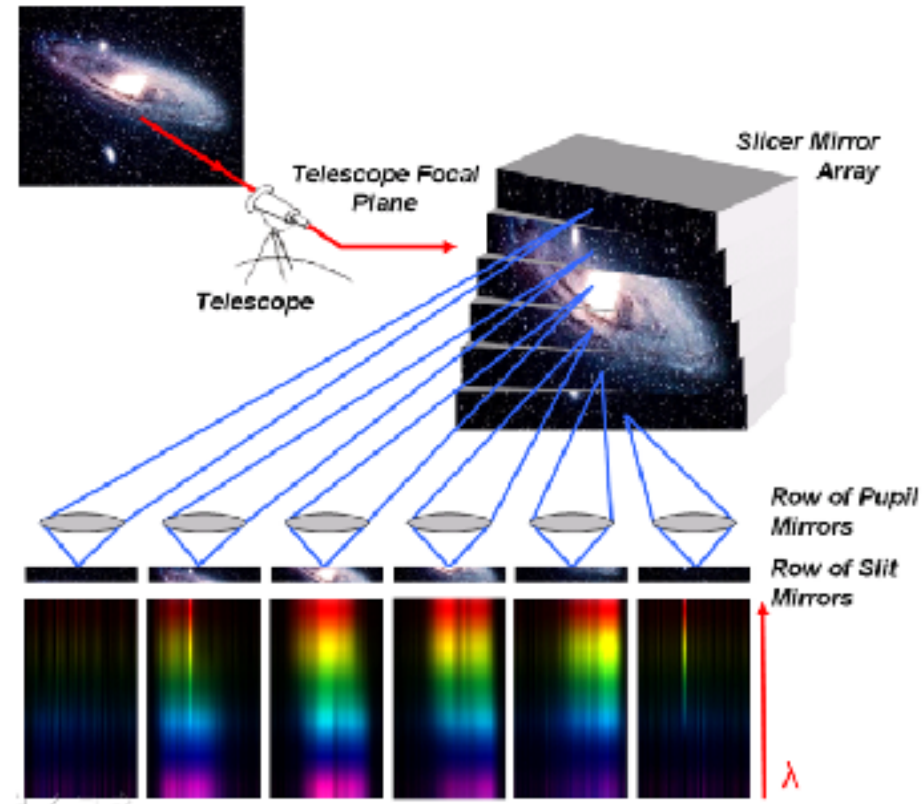
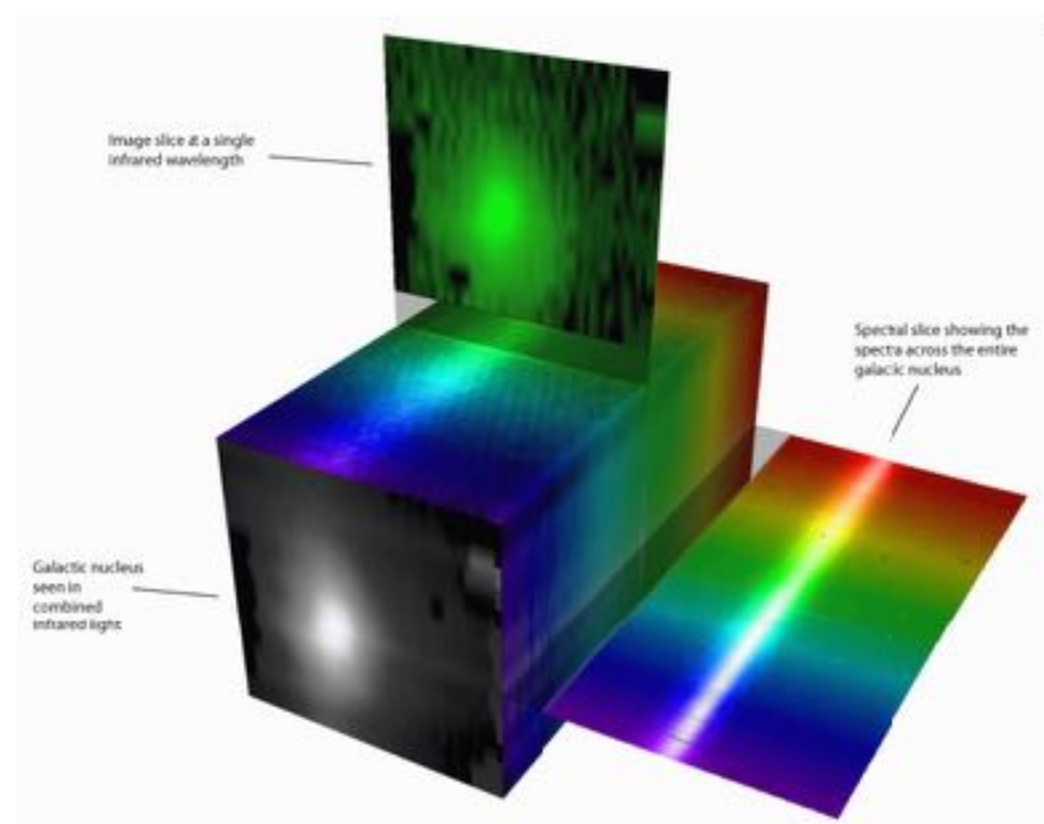
+
Eric, Chris, Mark…

Integral Field Spectroscopy

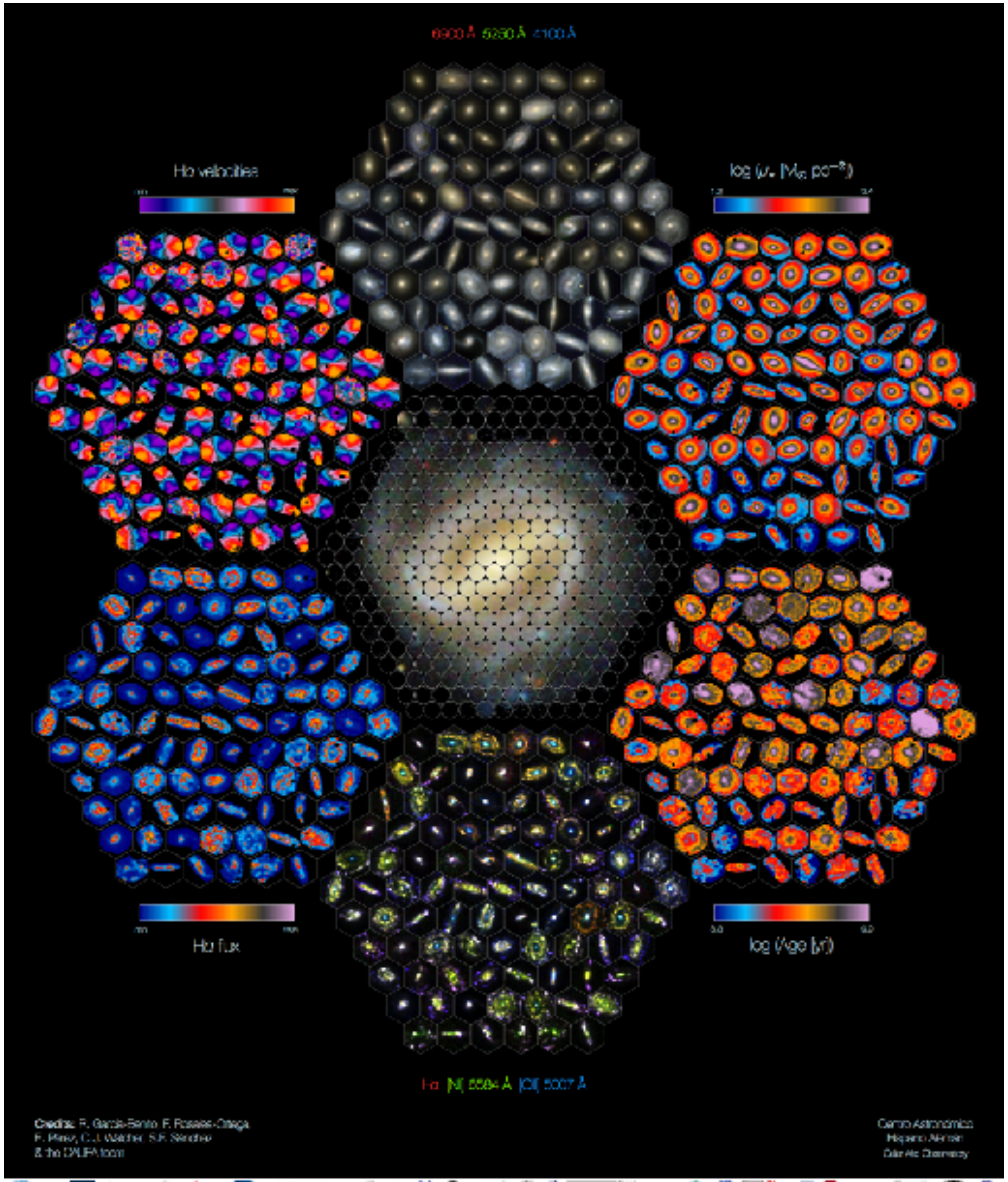






The Calar Alto Legacy Integral Field Area (CALIFA) survey

sánchez+12



- survey of ~600 galaxies of all types at z=0.005 to 0.03
- diameter selected from SDSS DR7, 45 < D_{25} < 80, to fit in the IFU FOV

  CALIFA mother sample: 939 galaxies

- IFS using PPAK @ 3.5m CAHA

  2 setups: mid (V500) and high-res (V1200)

  spectral coverage [3700-7000 A]

  spatial resolution ~1 arcsec

  FoV ~1′ x ~1′

- ~3000 spectra per galaxy
- data has been already freely distributed to the community:

  DR1 (100 galaxies), husemann+13
  DR2 (200 galaxies), garcía-benito+15
  DR3 (670 galaxies), sánchez+16

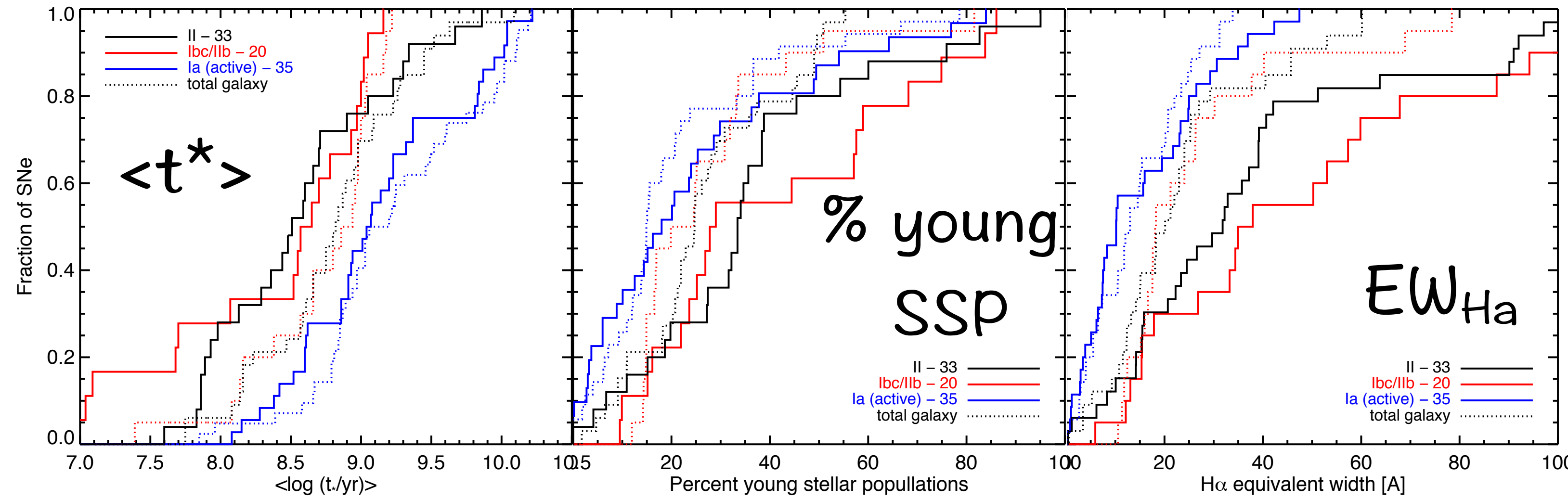
Nearby supernova host galaxies from the CALIFA Survey:

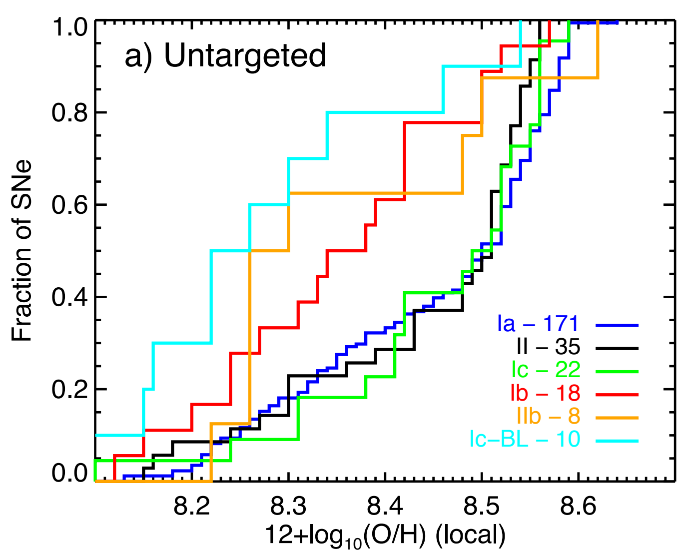
I. Sample, data analysis, and correlation to star-forming regions

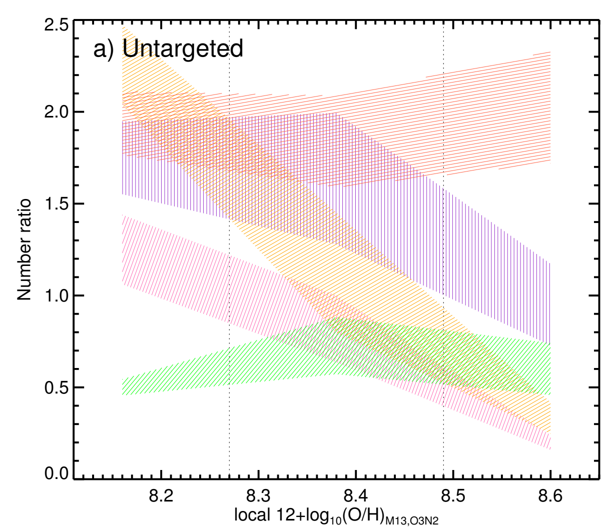
Galbany et al. 2014, A&A, 572, A38

81 galaxies / 95 SNe

(33 II, 20 Ibc, 42 Ia)







Nearby supernova host galaxies from the CALIFA Survey:

II. SN environmental metallicity

Galbany et al. 2016a, A&A, 591, A48

115 galaxies / 132 SNe

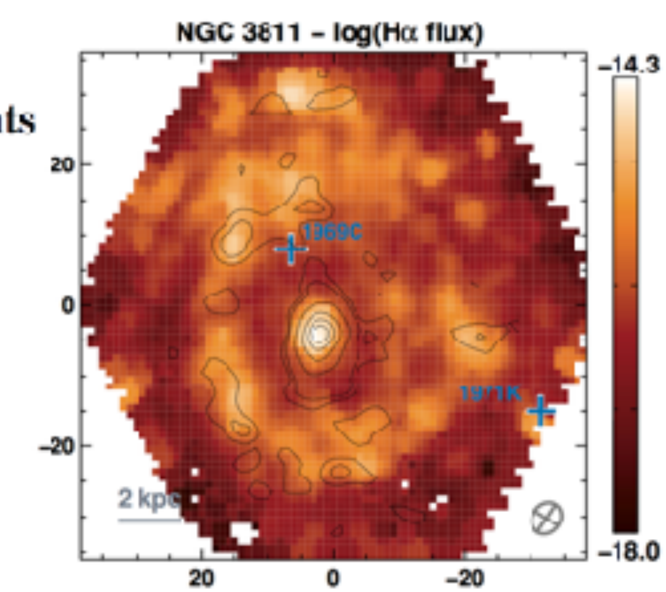
(47 II, 27 Ibc, 58 Ia)

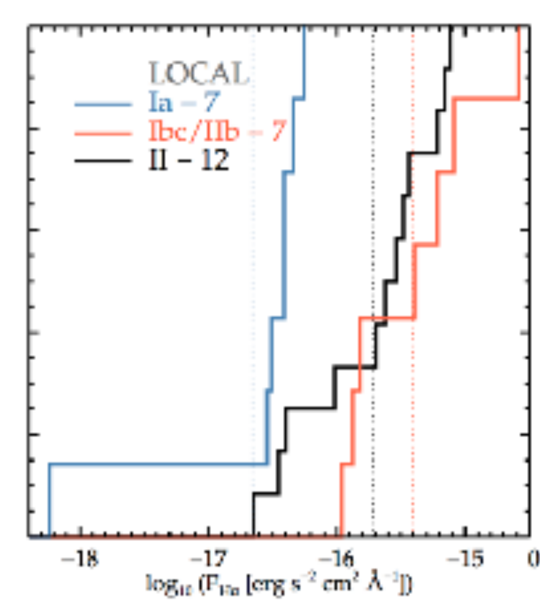
Molecular gas in supernova local environments unveiled by EDGE

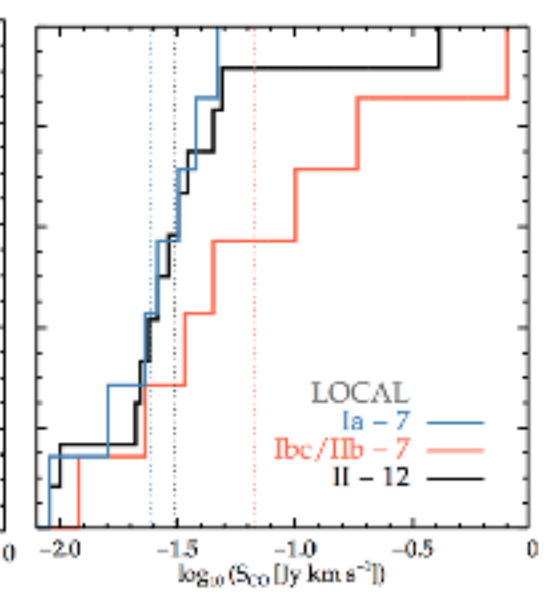
Galbany et al. 2017, MNRAS, 468, 628

23 galaxies / 26 SNe

(12 II, 7 Ibc, 7 Ia)







Pisco

the Pmas/ppak Integral-field Supernova host COmpilation

- 8/12 galaxies/SNe from the PINGS Survey (PI: Rosales-Ortega)
- 4/5 galaxies/SNe from H09-3.5-068 (Local SNe Ia properties; PI: Stanishev)
- 4/4 galaxies/SNe from the CALIFA pilot study (PI: Sánchez)
- 102/116 galaxies/SNe from CALIFA DR3
- 14/17 galaxies/SNe from CALIFA-extensions (PIs: Van den Ven, Barrera-Ballesteros, García-Benito, Marino)

- 45/54 galaxies/SNe from H15-3.5-004 (Low-mass CC SNe hosts; PI: Galbany)
- 21/27 galaxies/SNe from F16-3.5-006 (SNe with strong Na I D absorption; PI: Galbany)
- 9/11 galaxies/SNe from H16-3.5-012 (SNe Ia in the NIR; PI: Galbany)
- 12/13 galaxies/SNe from F17-3.5-001 (SNe Ia in the NIR II; PI: Galbany)
- 13/13 galaxies/SNe from H17-3.5-001 (SNe Ia in the NIR III; PI: Galbany)

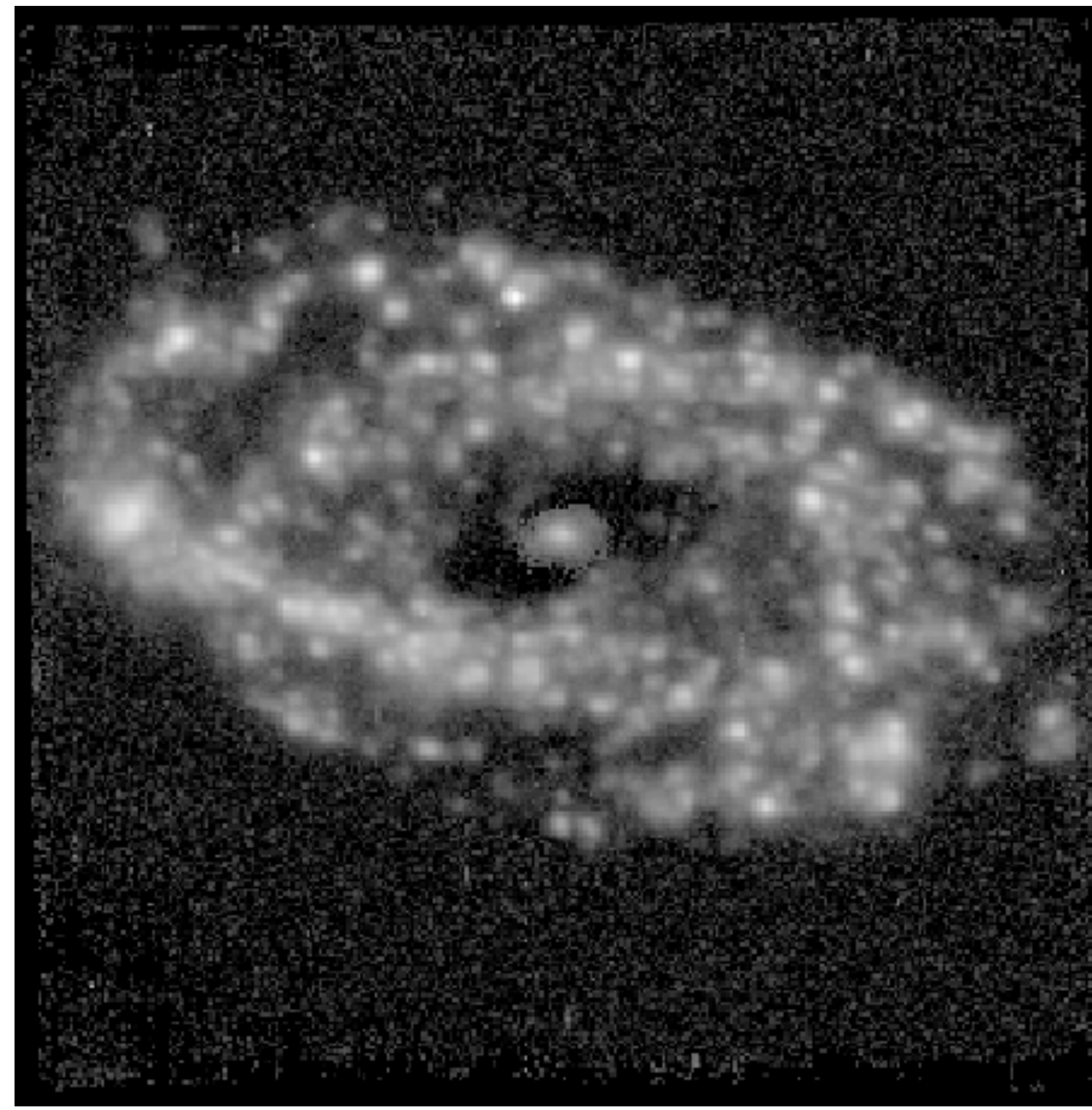
- 232/272 galaxies/SNe (120 Ia, 152 CC: 95 II (75 II incl. 1 pec, 19 n), 57 SE (12 IIb 19 b 20 c)

Galbany et al. submitted to ApJ …in two weeks!

THE AMUSING SURVEY

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

- **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.
- Supernova: Overall aim is to use MUSE to further understand supernova progenitors/explosions. Study SN environment and all other regions within the host.
- Integral-field: 1’x1' FoV, 0.2” pixel scale. Image-like resolution but with ‘spaxels’.
- Nearby: Allows in-depth study of gas and stellar populations. Classical assumptions for IFU work break-down.
- Galaxies: 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

Second order corrections: Environment

Look for dependences of the SN properties on the host galaxy properties (focused on global characteristics of the host)

As they evolve with redshift, such dependences would impact the cosmological parameters

Hamuy et al. (1996)	Bright events occur preferentially in **young** stellar environments.
Hamuy et al. (2000)	Luminous SNe are produced in **metal-poor** neighborhoods
Gallagher et al. (2005)	**high-metallicity** galaxies host SNe Ia with negative HR *(after LC-corr)*
Sullivan et al. (2006)	Brighter events are found in systems with ongoing **star-formation**
Gallagher et al. (2008)	**Progenitor age** primarily determines the peak luminosity
Hicken et al. (2009)	SN Ia in **spiral** hosts are intrinsically fainter *(after LC-corr)*
Howell et al. (2009)	**more massive** progenitors give rise to less luminous explosions
Neill et al. (2009)	**Older** hosts produce less-extincted SNe Ia
Cooper et al. (2009)	SNIa are more luminous or more numerous in **metal-poor** galaxies
Brandt et al. (2010)	Luminous SNe associated with recent **star-formation** and **young** prog.
Sullivan et al. (2010)	SNIa are brighter in **massive** hosts (metal-rich) and with low **SFR** *(after LC-corr)*
Kelly et al. (2010)	SN Ia in physically **larger**, more **massive** hosts are ~10% brighter
Lampeitl et al. (2010)	introduce the stellar **mass** of the host in the parametrization
D'Andrea et al. (2011)	SNe are 0.1 mag brighter in **high-metallicity** hosts after corr.
Gupta et al. (2011)	**older** galaxies host SNe Ia that are brighter
Konishi et al. (2011)	SNe Ia in host galaxies with a higher **star formation** rate show brighter events
Galbany et al. (2012)	SNe that explode **further** are less extinguished, and have **lower metallicity**
Childress et al. (2013)	correlation between SN Ia intrinsic color and host **metallicity**
Johansson et al. (2013)	more luminous SNe Ia appear in **younger** stellar progenitor systems
Rigault et al. (2013)	SNe Ia with **local Hα emission** are redder and drives the HR-**mass** relation
Pan et al. (2014)	fainter, faster declining SNe Ia are hosted by **older**/**massive**/**metal-rich** galaxies
Moreno-Raya et al. (2016)	SNe Ia luminosities tend to be higher for galaxies with **lower metallicities**
…	

SNIa local environments

Rigault et al. 2013 SFR

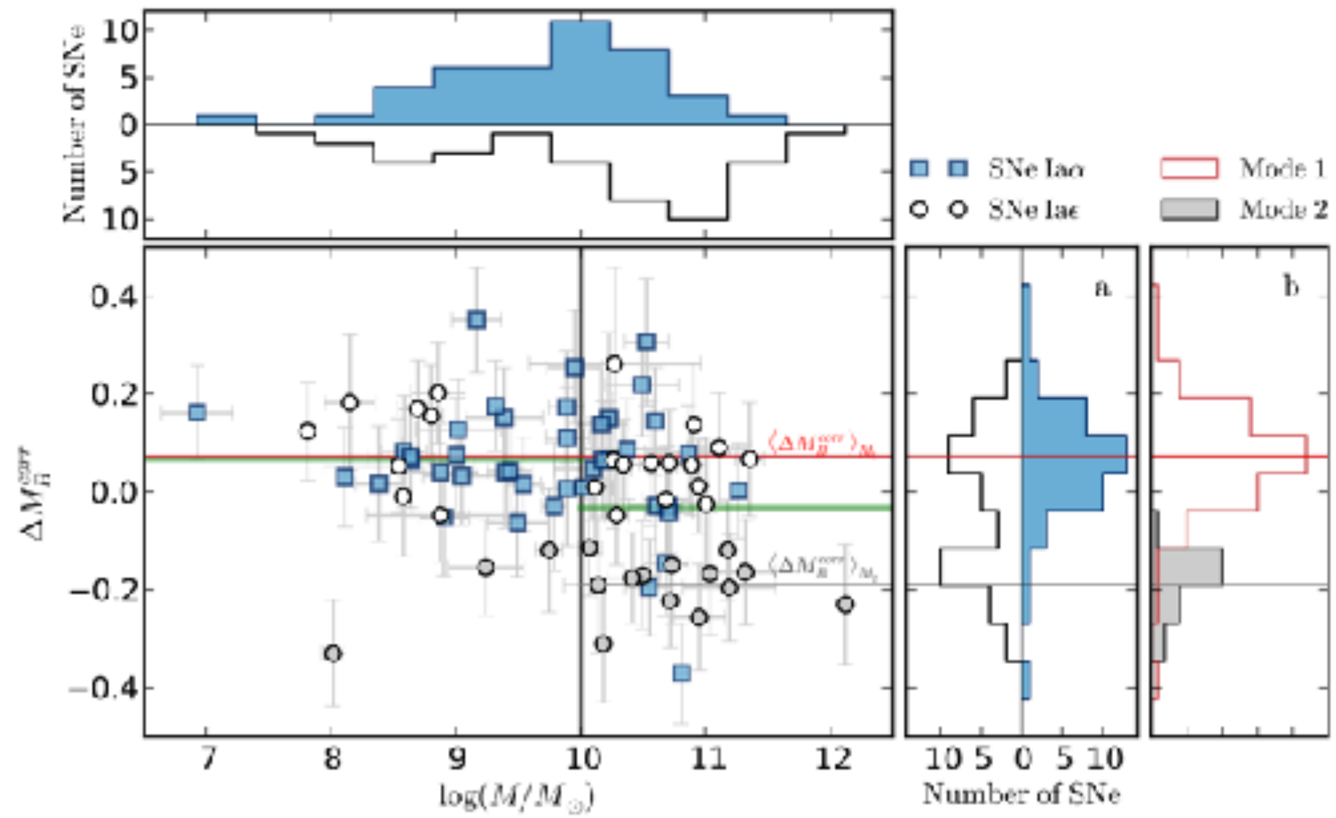
IFU ~1kpc

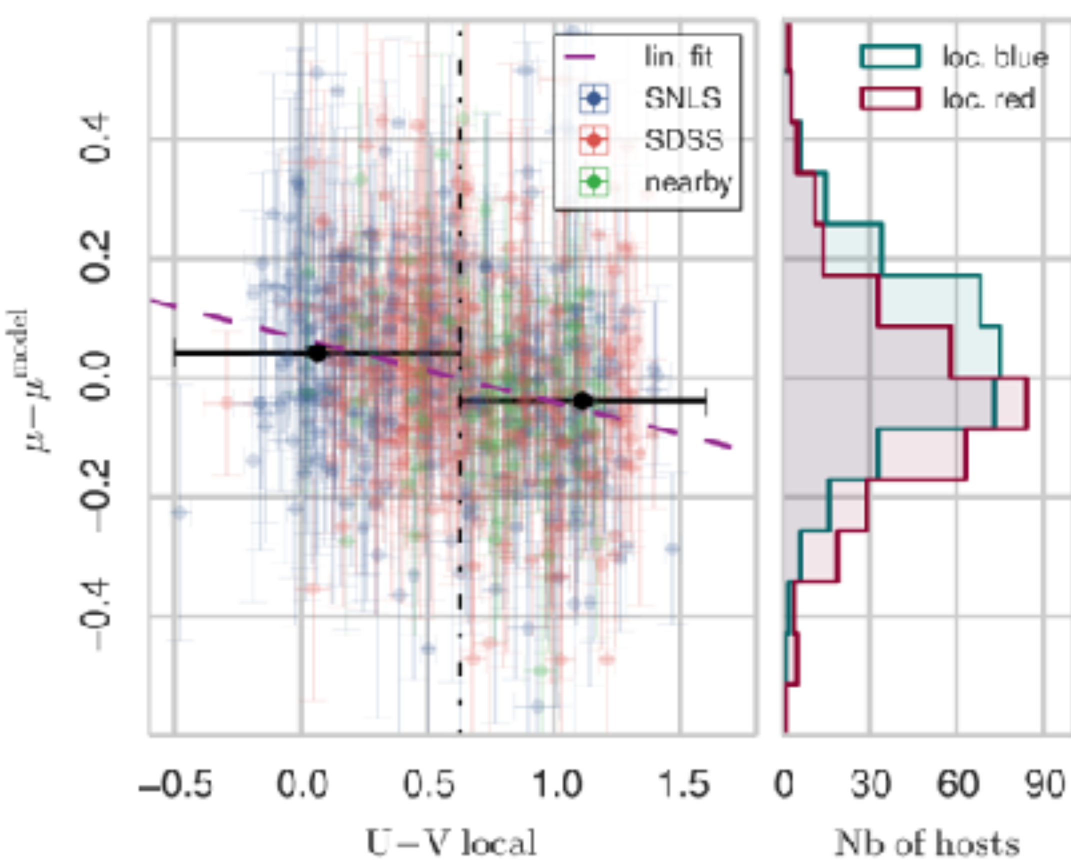
Moreno-Raya et al. 2016 OH

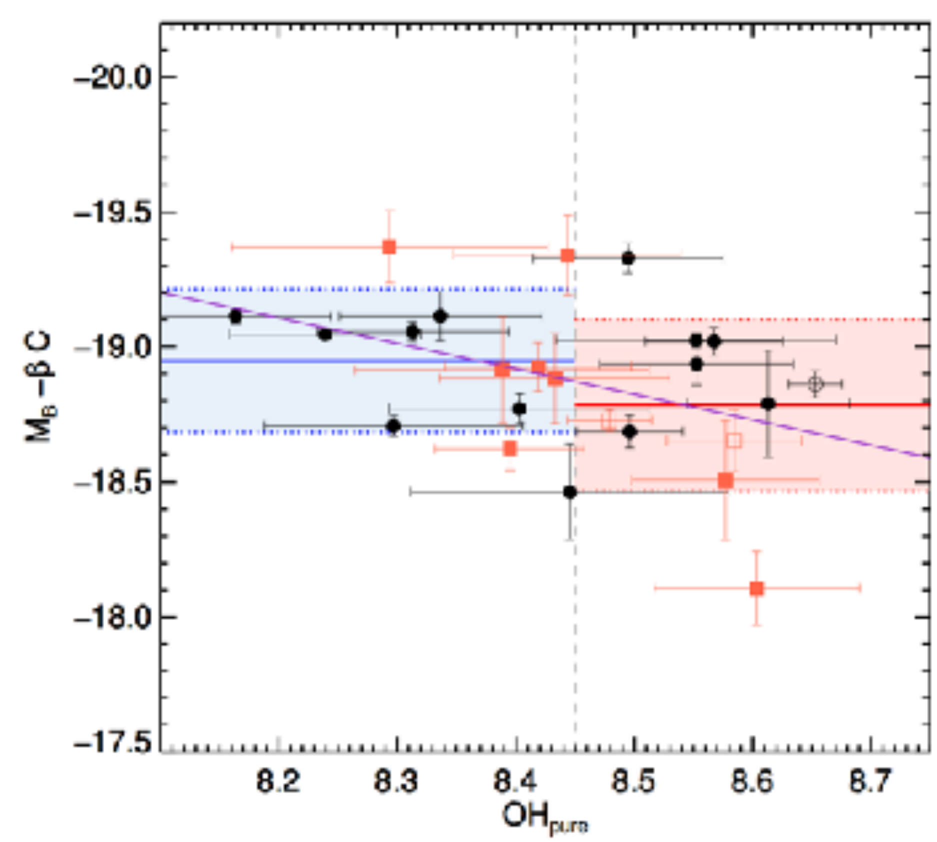
LS ~ 1arcsec

Roman et al. 2017 U-V

Phot ~3kpc








PMAS
Calar Alto 3.5m
MUSE
Paranal 8.2m
BOSS
APO 2.5m
KOALA
Siding Spring 3.9m

CALIFA

70"x70"
R~500-1200
~5,000 sp
1"/spaxel
3700-7500

MaNGA

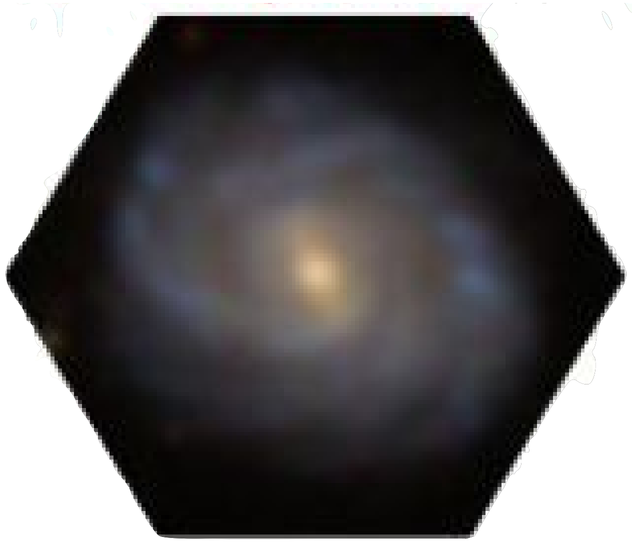
30"x30"
R~1700-3500
~2,000 sp
0.2"/spaxel
4650-9300

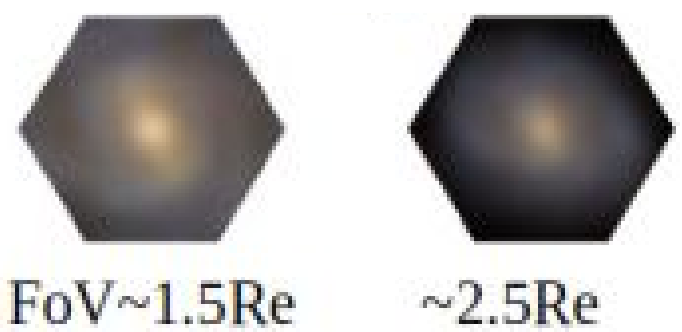
MUSE

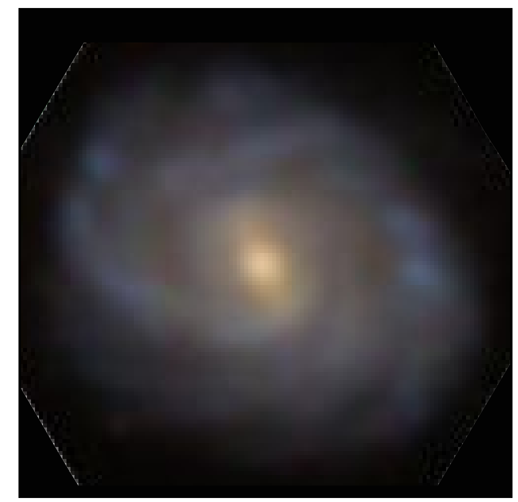
60"x60"
R~1700-3500
~90,000 sp
0.2"/spaxel
4650-9300

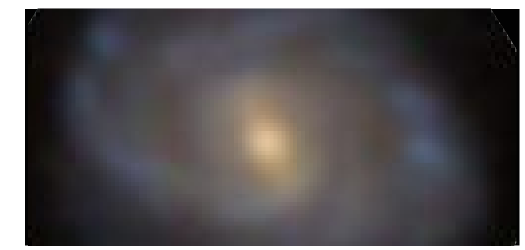
KOALA

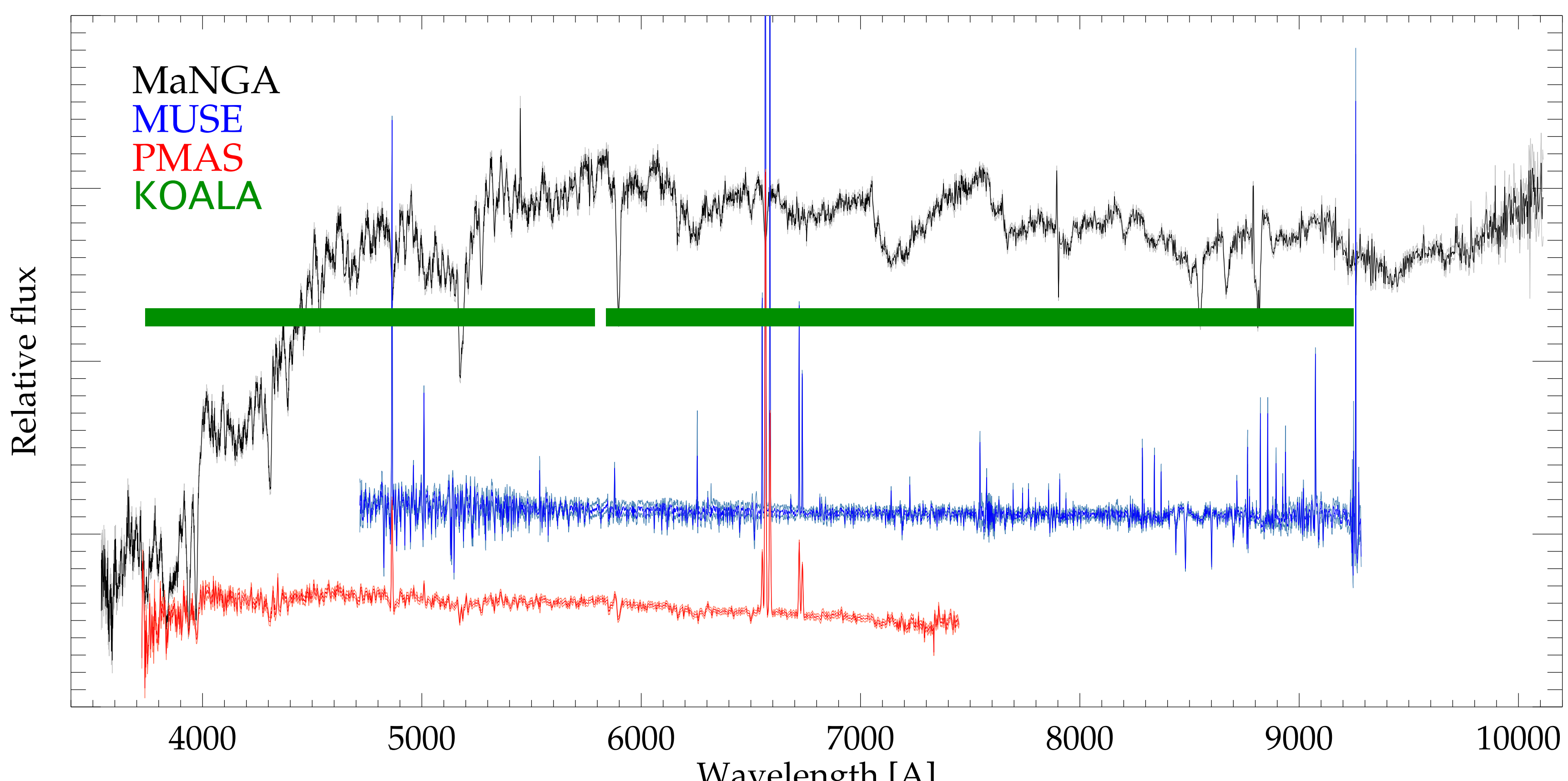
30"x60"
R~1700-3500
~1,000 sp
1"/spaxel
3750-9300





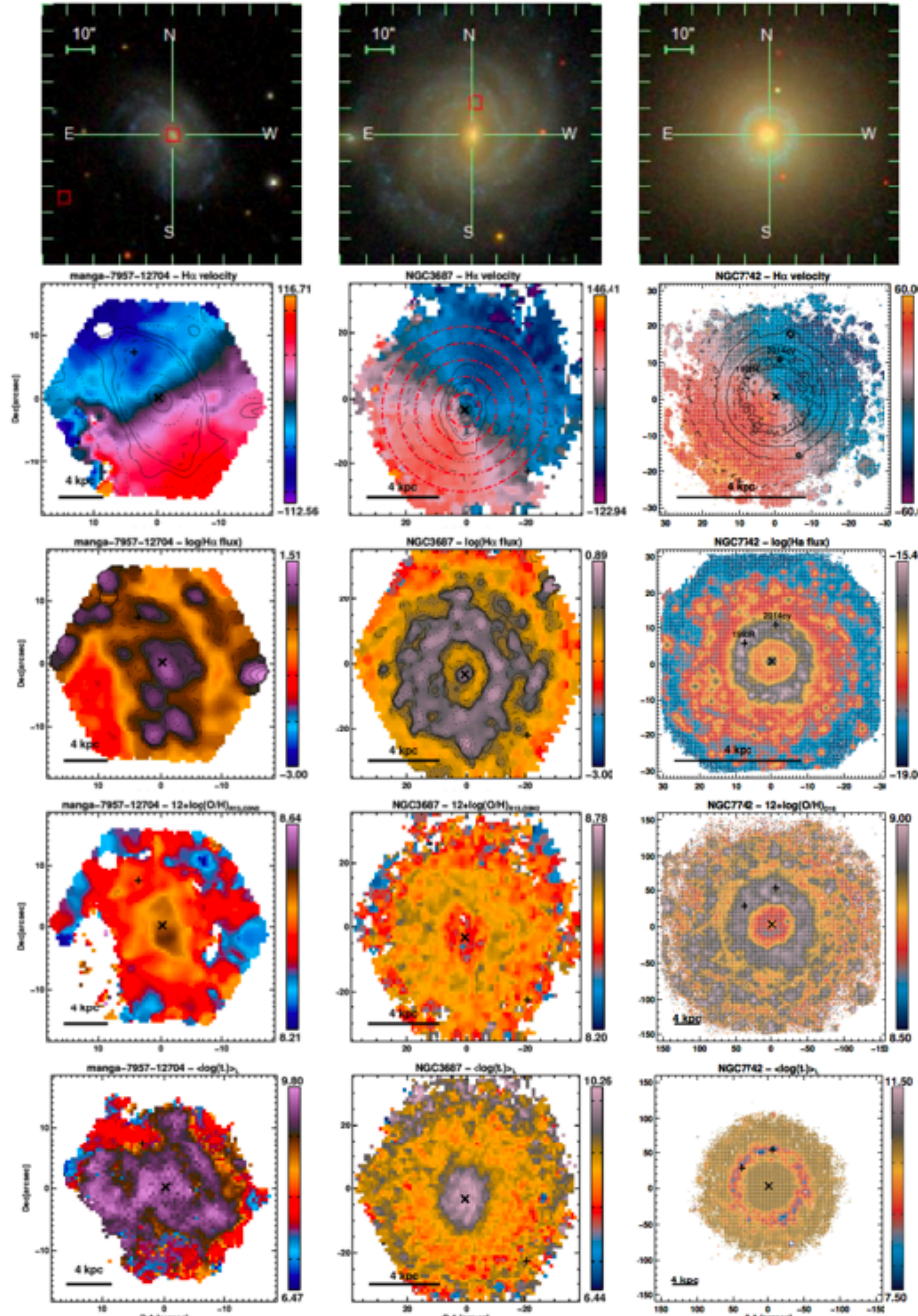






IFS data available

- PISCO (+CALIFA)
  - 232 galaxies (+ >500)
- AMUSING
  - 305 (P95-P98)
  - + P99, P100, arx
- MaNGA
  - 46 SN hosts (+ >3000)
- KHALIFA (from 2018)



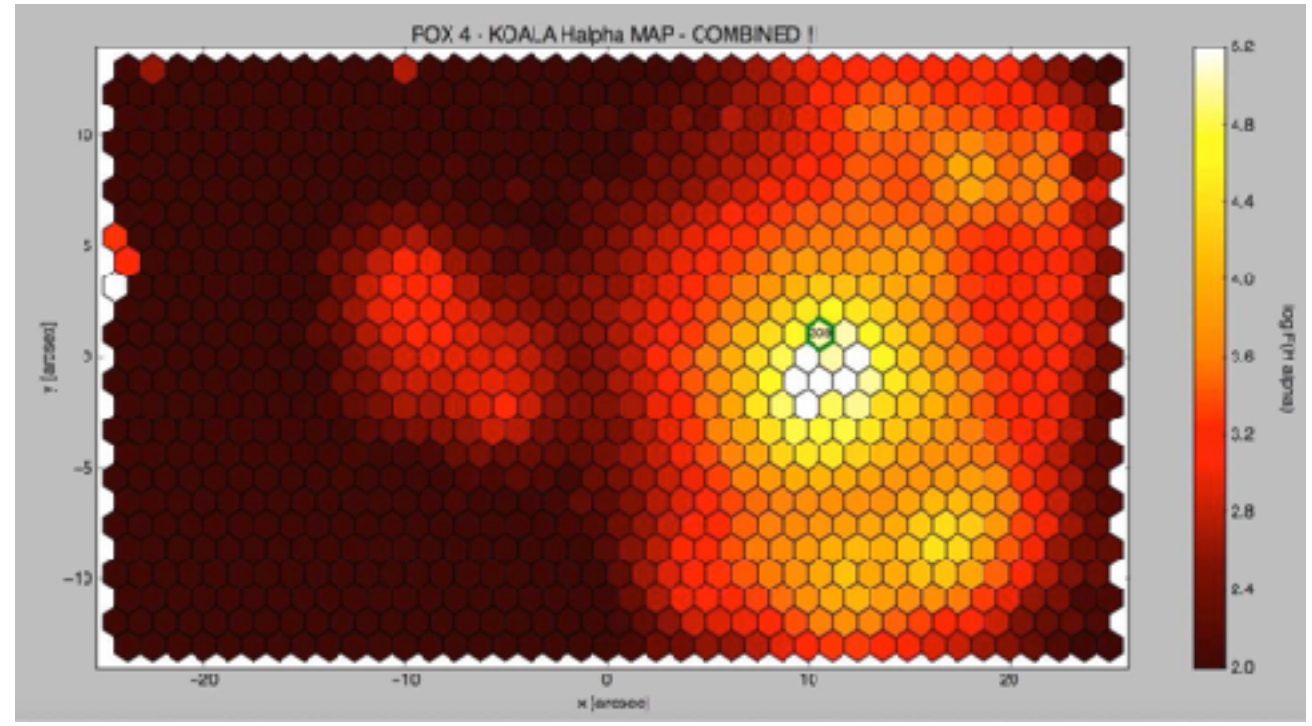
Current proposals

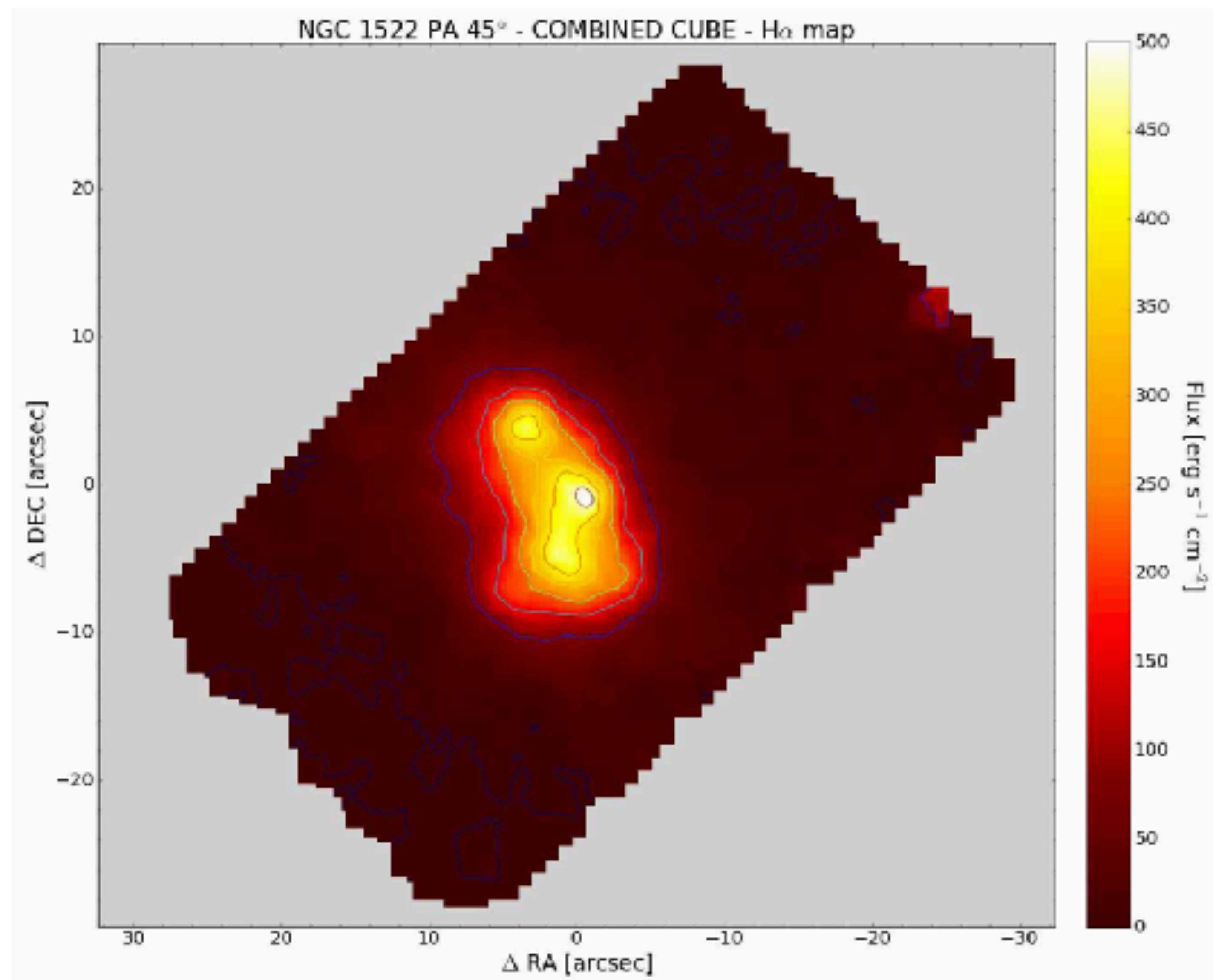
- MaNGA ancillary program
- CSP I (134):
  - PMAS 18A (20)
  - AMUSING P101 (20)

    16 overlap with Koala
  - AAT - KOALA (40)

    38 CSP I (22 only here) + 2 CSP II
- CSP II (242): *(MMP just said 116+111)*

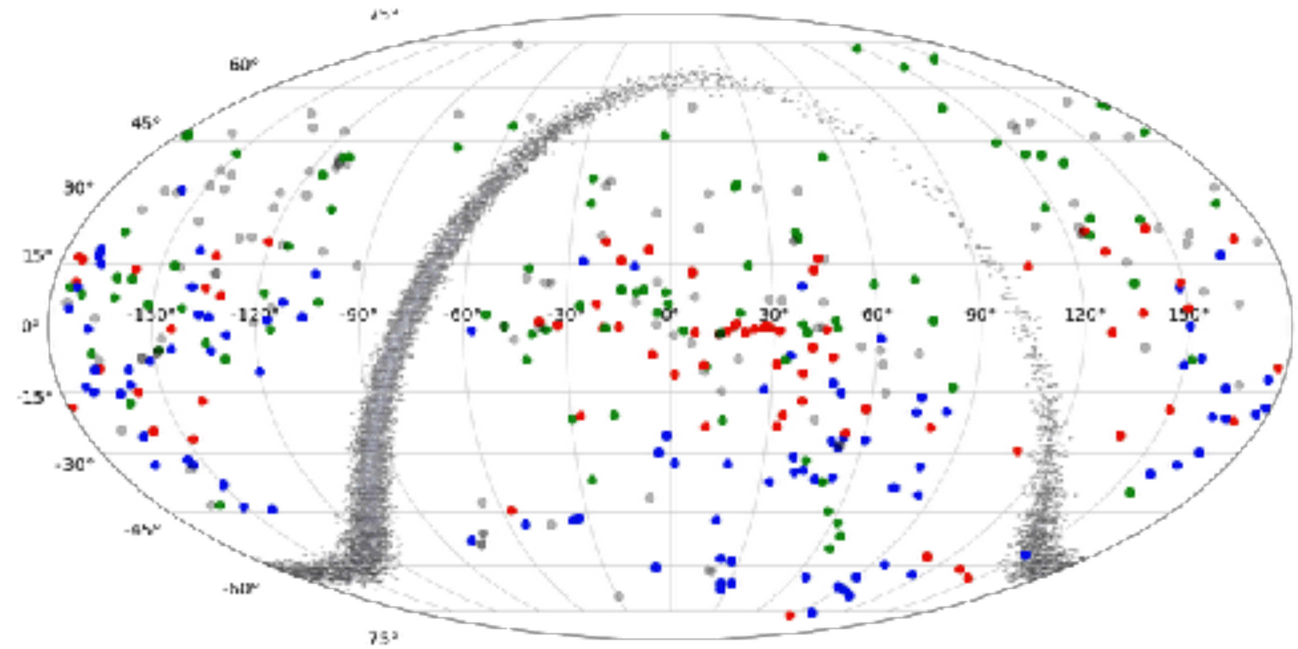
  96% from blind searches
  - 145 still missing

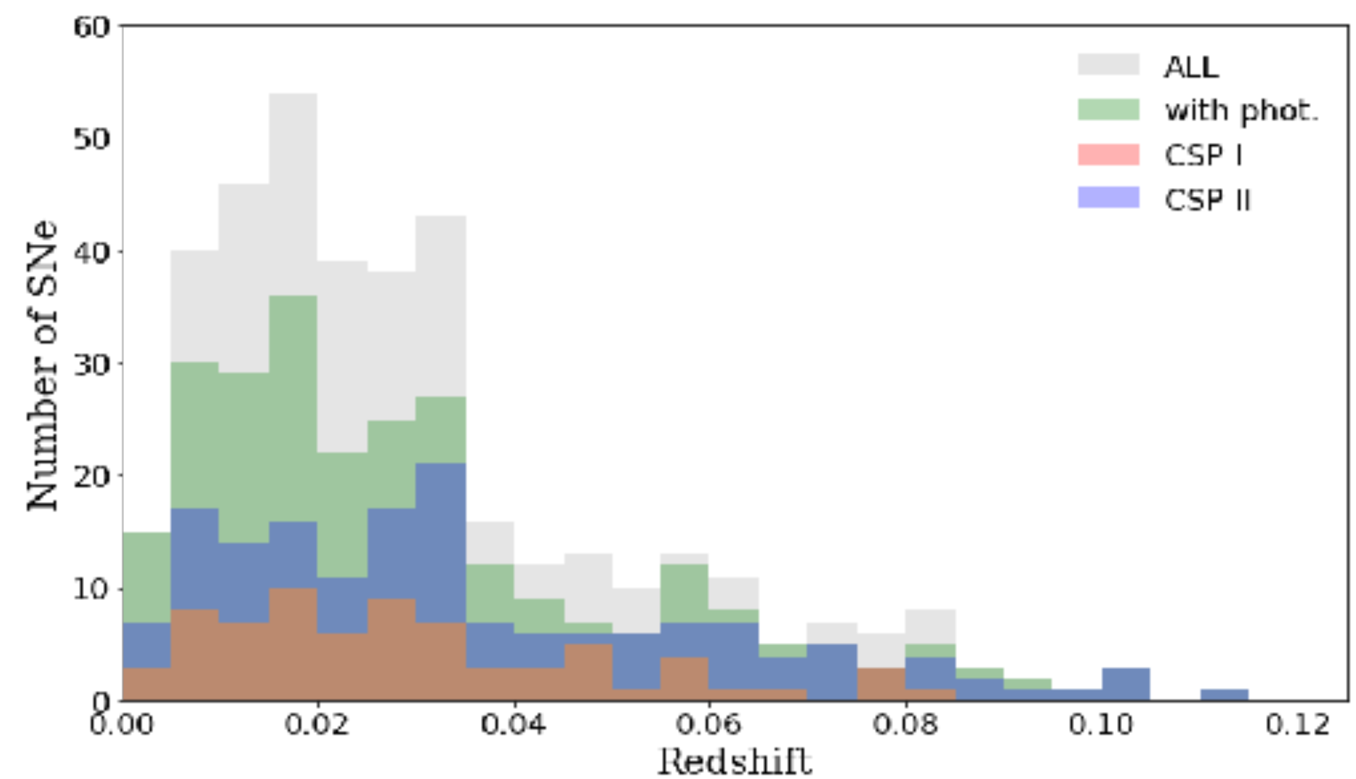




CSP project on SNIa env.

- Dedicated proposals:
- **AMUSING**
  - **P95** (SNe Ia CSP I-II)
  - **P98**, **P99** (SNe Ia NIR - SwSp + CSP)
- **PISCO**
  - **16A**, **17A**, **17B** (SNe Ia NIR - SwSp + CSP)
- **MaNGA**
  - 17 hosts so far





391 environments so far (not all SN with

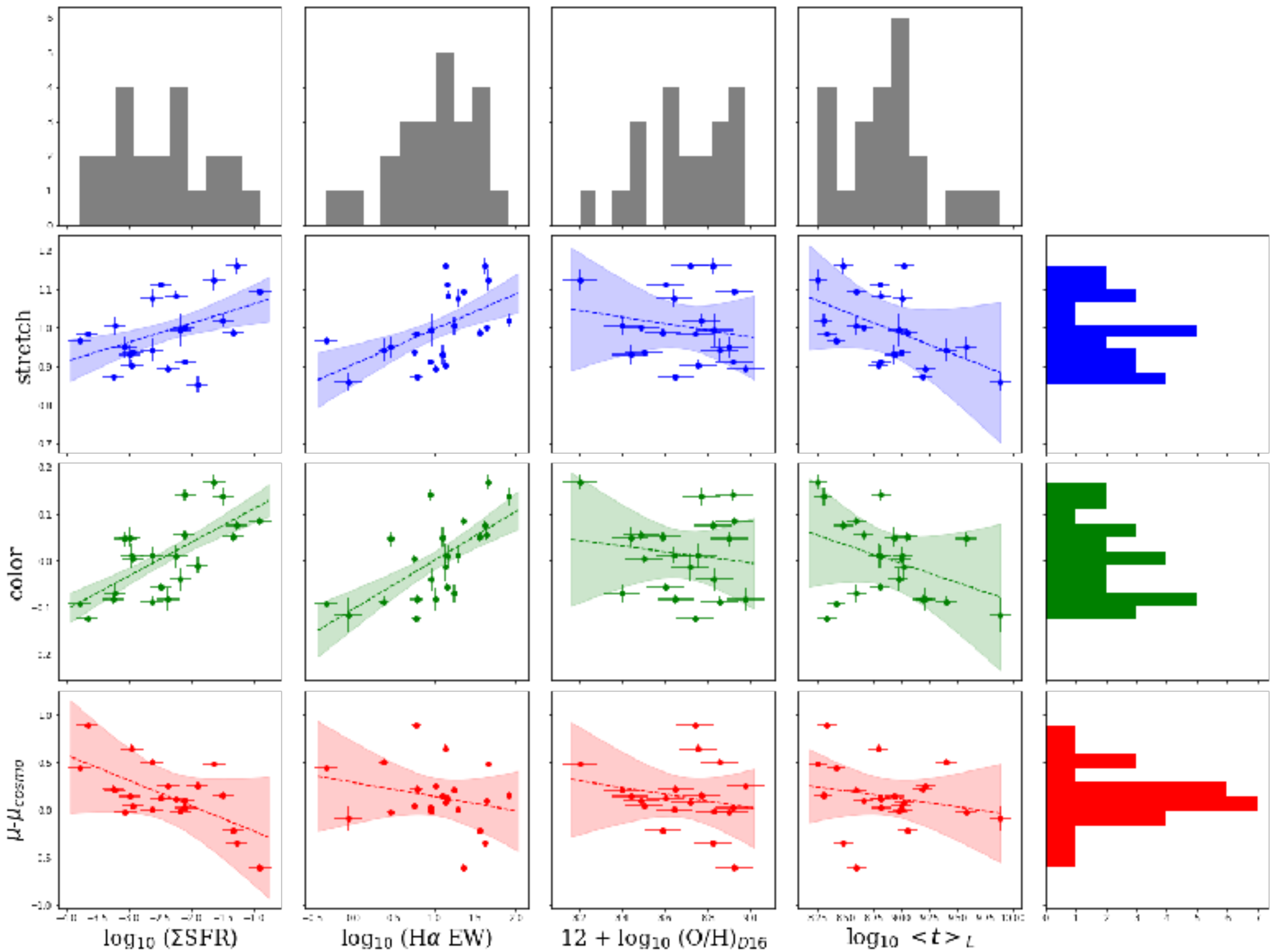
169 CSP hosts, 72 from CSP I and 97 from CSP II

+100 with public photometry (upper limit)

Currently working on SNII environments but…

Preliminary results: 26 objects in PISCO (including 7 CSP I and 4 CSP II)

After LC cuts



(near-)Future [from now to mid 2018]

- Analyze all MUSE data (on-going)
  - Density (1/kpc), seeing, global/local…
- Refit LCs, play with models…
  - x1/Dm15/s, c/Av
  - Hubble residuals (cosmologies)
- Correlations