An ESO/RadioNet Workshop
ESO Garching, 10–14 March 2014

3D2014

Gas and stars in galaxies: A multi-wavelength 3D perspective

Highlight talk session 5
Wednesday 10:05

- **Privon**
- **Gallazzi**
- **Reeves**
- **James**
- **Kelz**
- **Kyoko**

Dynamical Models of Galaxy Mergers as a Tool to Constrain Star Formation Models

George Privon

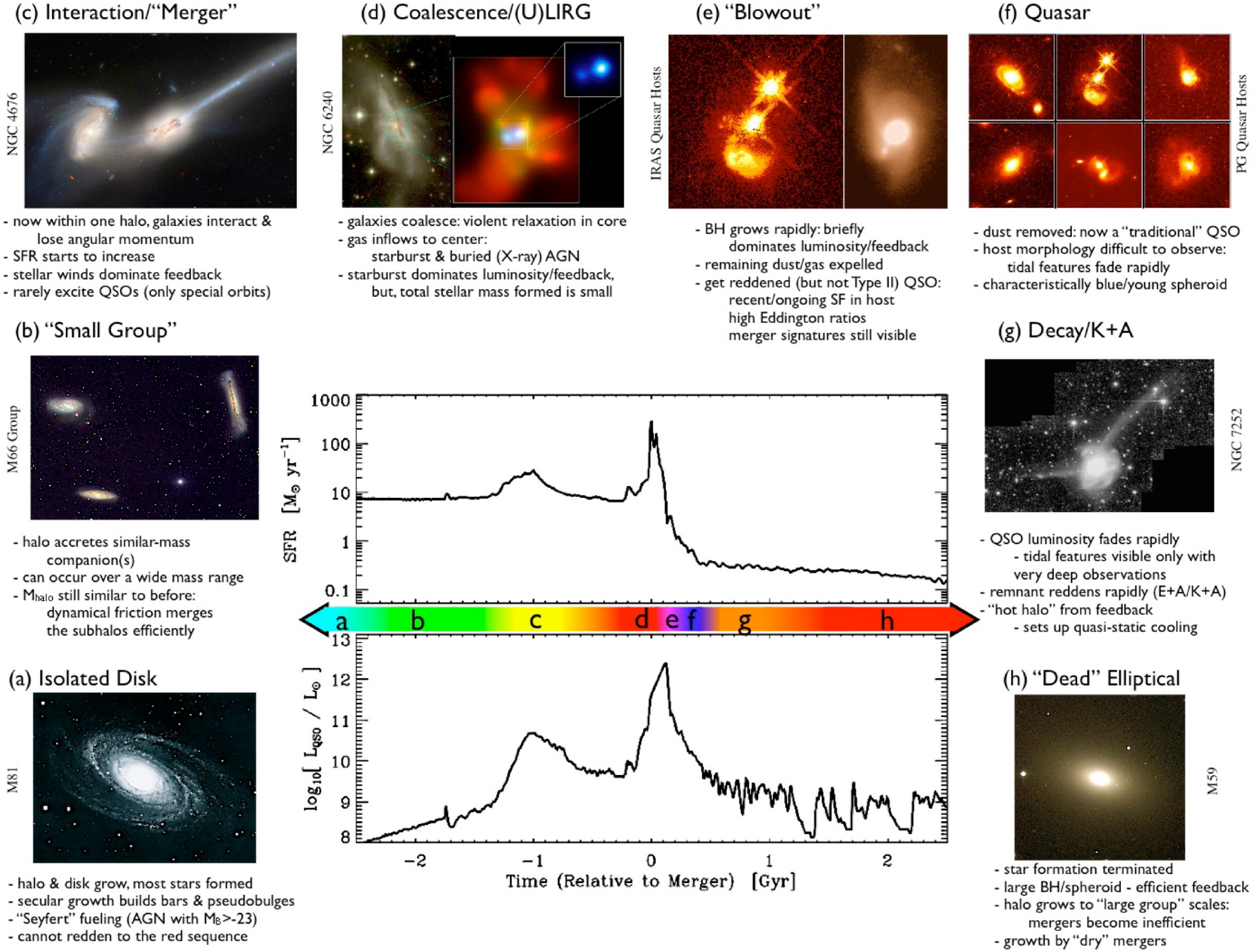
University of Virginia

3D2014 Highlight Talk (& Poster #31)

A. Evans (UVa/NRAO), J. Barnes (IfA), J. Mazzarella (IPAC/Caltech), J. Hibbard (NRAO), L. Armus (IPAC/Caltech), and the GOALS collaboration

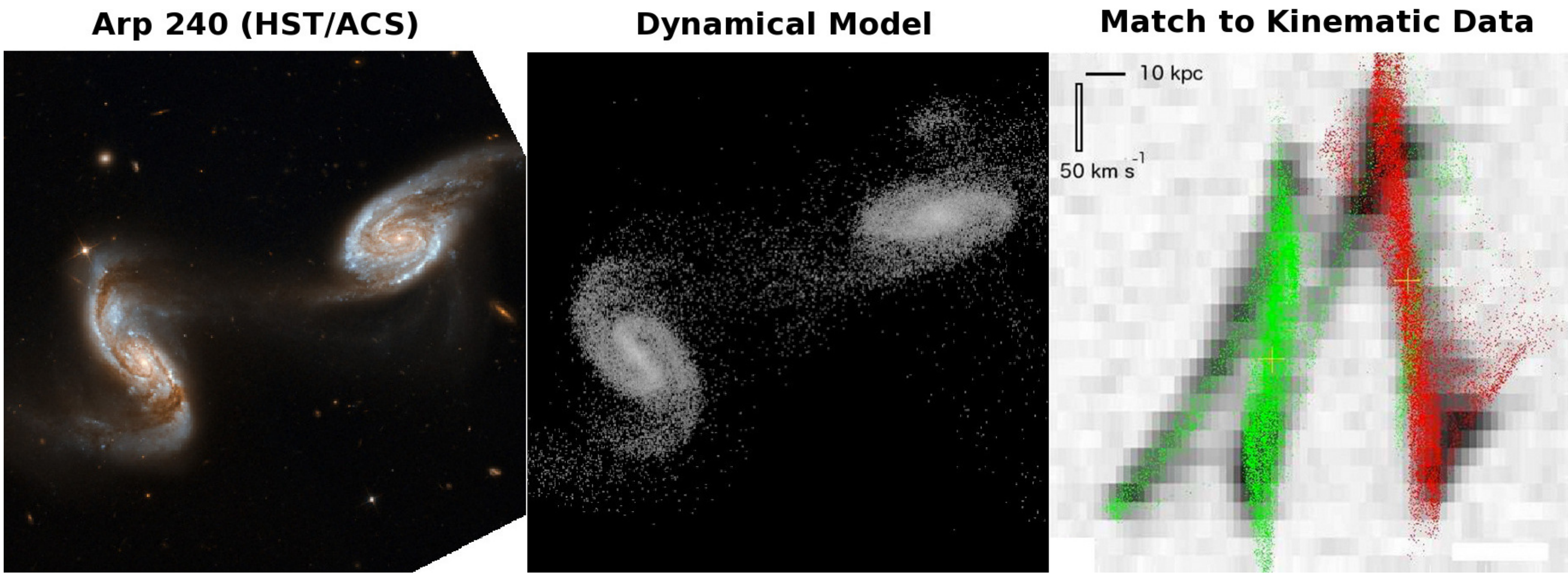
http://goals.ipac.caltech.edu

Merger Driven Activity



(e.g., Hopkins+ 2008, Sanders+ 1988)

Modeling Example: Arp 240

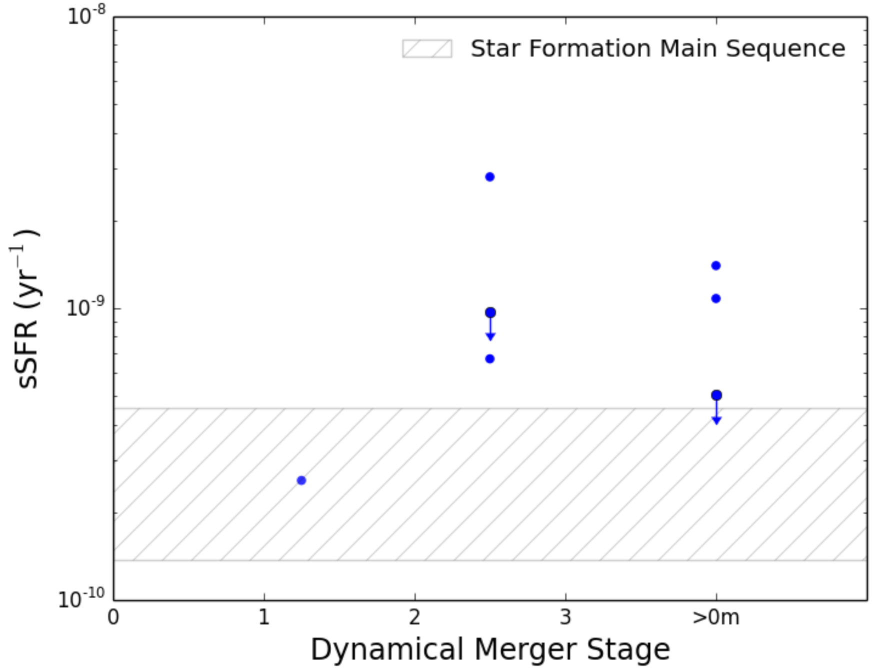


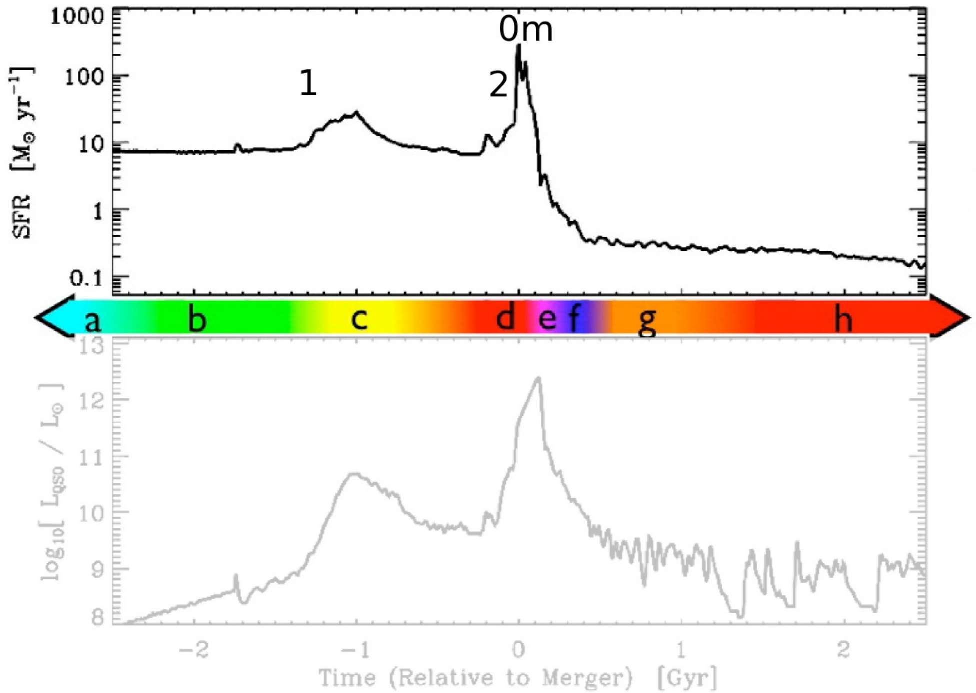
Early stage prograde-prograde encounter, wide pass ($\sim$ 7 disk scale lengths) of 2 roughly equal-mass galaxies. Viewed 230 Myr after first pass, merger in $\sim$ 1.2 Gyr.

(Privon+ 2013)

Merger Driven Activity – Star Formation

With dynamical models for a *sample* of systems...



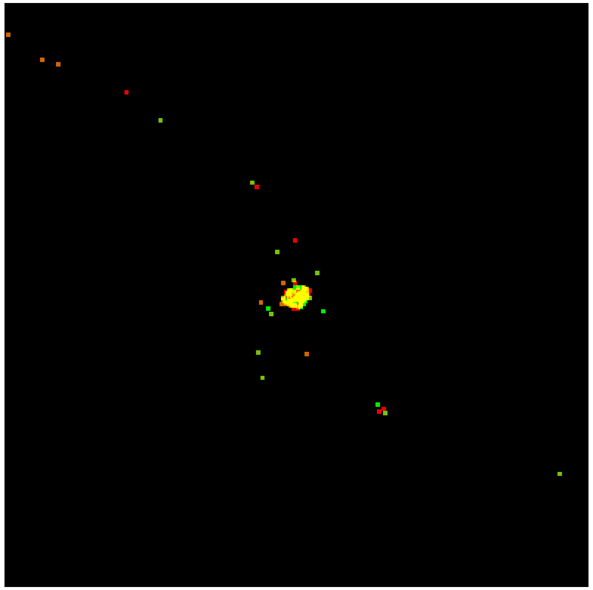


(Howell+ 2010, Elbaz+ 2011, Privon+ *in prep*)

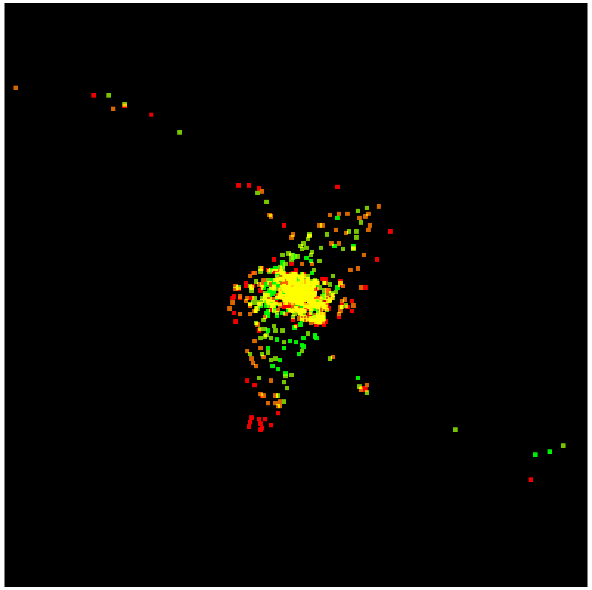
(Hopkins+ 2008)

Testing Star Formation Models – NGC 2623

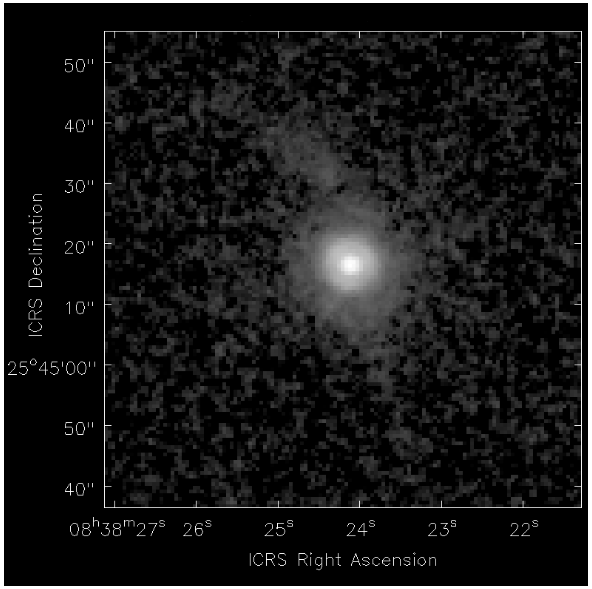
$\rho_{\rm sfr} \propto \rho_{\rm gas}^{1.5}$ – KS relation



$\rho_{\rm sfr} \propto \dot{u}_{\rm int}^{0.5}$ – shocks



IRAC ch4 (8 μm PAH)



Simulated SF in the past 50 Myr (Red – older stars, green – younger).

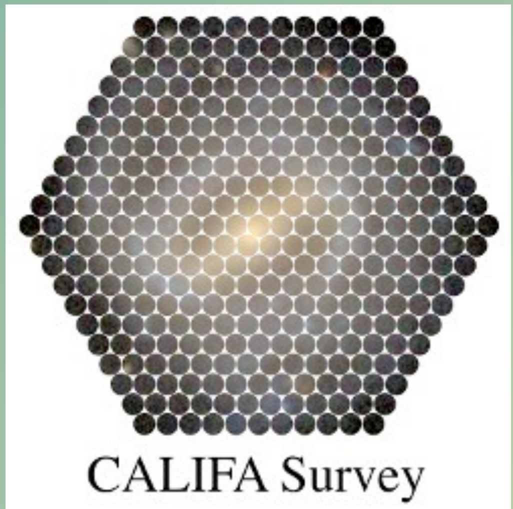
(Privon+ *in prep*)

Stellar Populations and Mass Maps of nearby galaxies: toward an unbiased view with CALIFA

Anna Gallazzi
Stefano Zibetti, Elena Tundo
INAF - Osservatorio Astrofisico di Arcetri

and the CALIFA collaboration

Co-funded by the European Union



PI: S.Sanchez, PS: J.Walcher

~400 galaxies observed so far

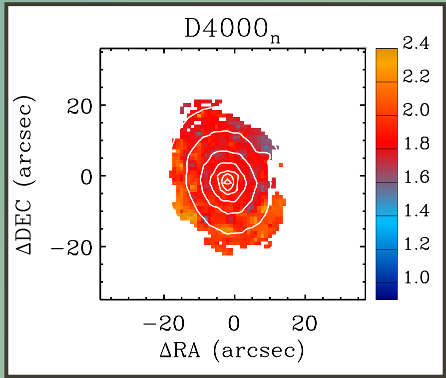
DR of 200-300 galaxies in the Fall

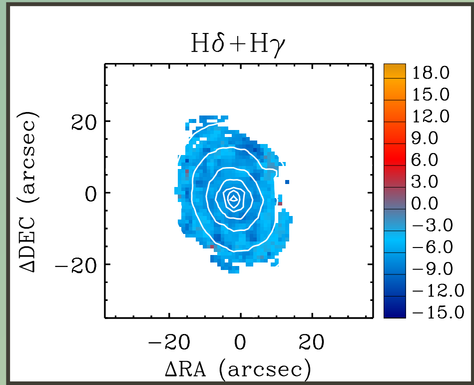
- ★ The age and metal abundance of stellar populations are related to galaxy mass on a global scale
- ★ **Spatially resolved information** to 1) link these properties with galaxy structure **on local** (Gonzales-Delgado et al 2013, Sanchez et al 2013) and 2) **reassess global scaling relations**
- ★ **Correct for biases** in derived physical properties **due to incomplete and unresolved coverage**: affect comparison with galaxy formation models and assessment of redshift evolution
- ★ good leverage in galaxy morphological type and stellar mass

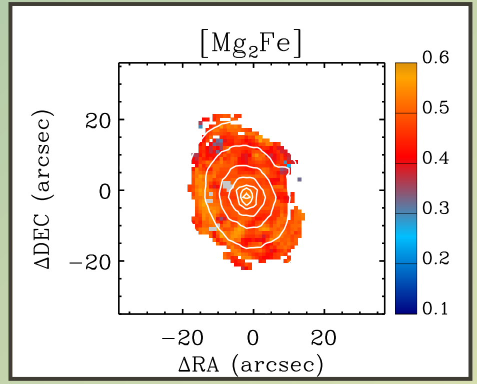
adaptive smoothing of cubes to ensure S/N>20 out to ~2Re (see S. Zibetti's talk)

absorption features from individual spectra after continuum-emission line separation

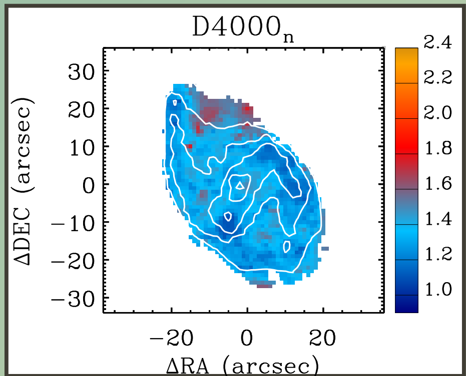
NGC 6515 - **E**
logM*=10.72

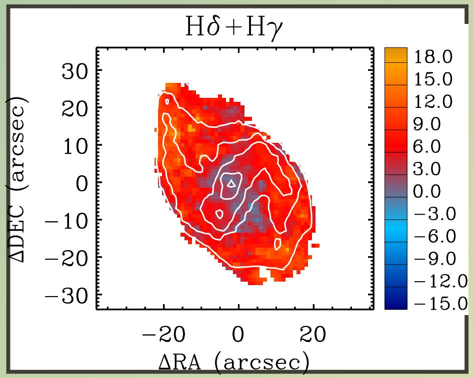


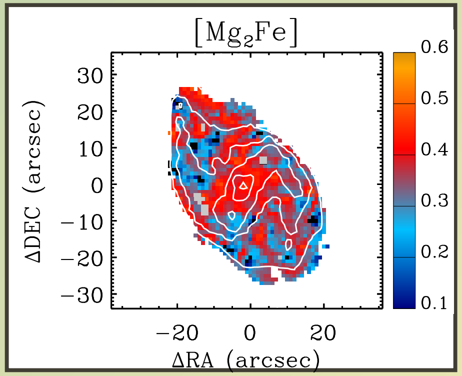




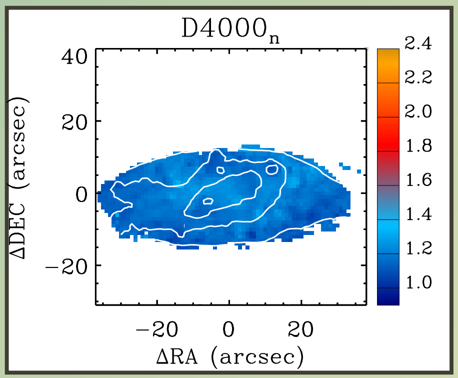
NGC 7549 - **SB(s)cd pec**
logM*=10.70

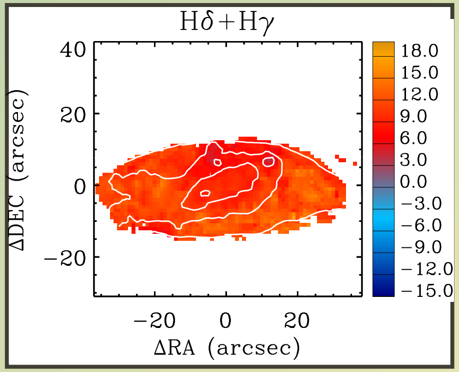


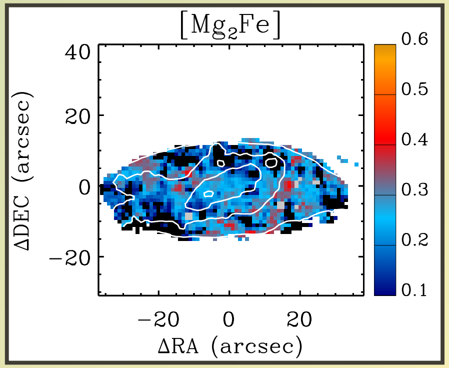




NGC 5630 - **Sdm**
logM*=9.53

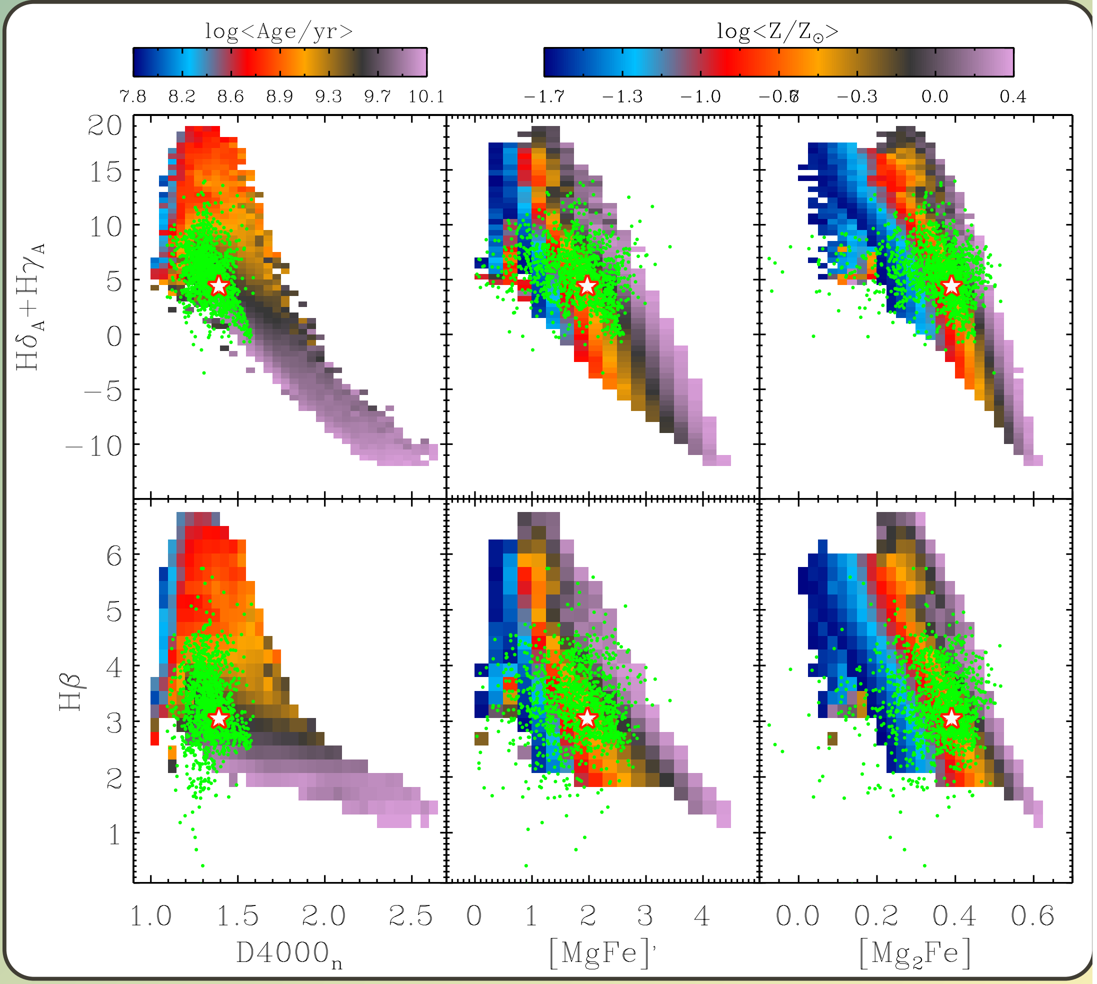






Age- and metallicity-sensitive absorption features
Individual regions versus integrated value

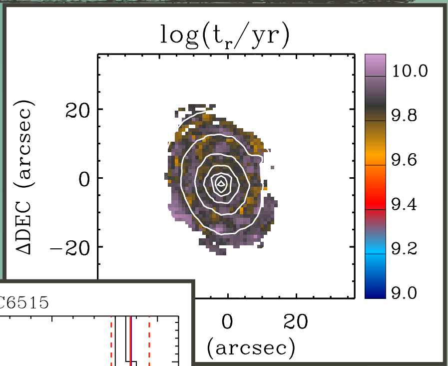
- ★ Optimal set of absorption features: D4000, Hβ, Hγ+Hδ, $[Mg_2Fe]$, [MgFe]'
- ★ g-i SDSS color to account for dust attenuation and constrain stellar mass
- ★ MONTE CARLO LIBRARY OF COMPLEX SFH AND METALLICITIES: exponential SFH + random burst; metallicity fixed for each model (i.e. no chemical evolution) - based on BC03; 2-parameter dust model a la Charlot&Fall2000
- ★ build full probability density function of STELLAR MASS, LUMINOSITY- AND MASS-WEIGHTED AGE, STELLAR METALLICITY

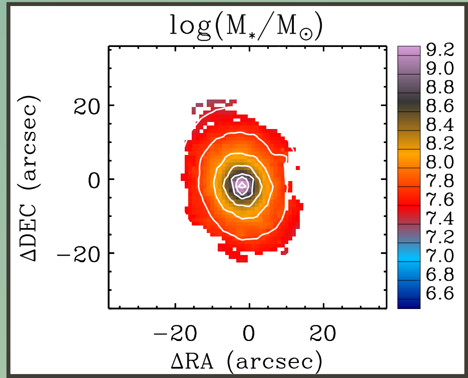


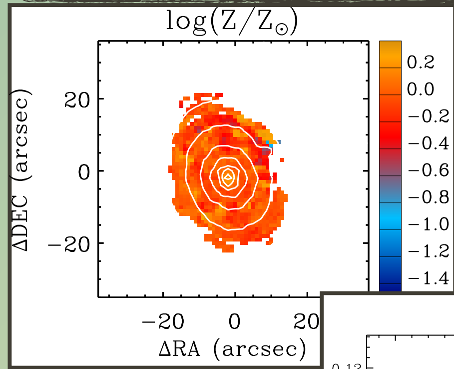
Light-weighted Age

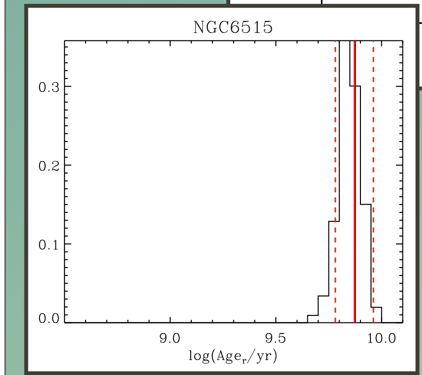
Stellar Mass Map

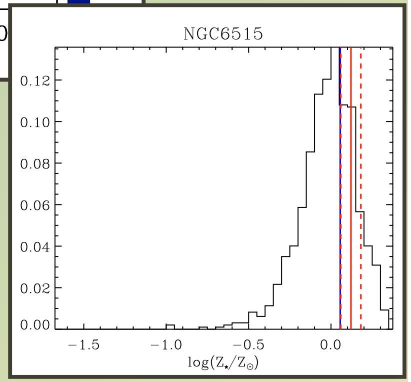
Stellar Metallicity







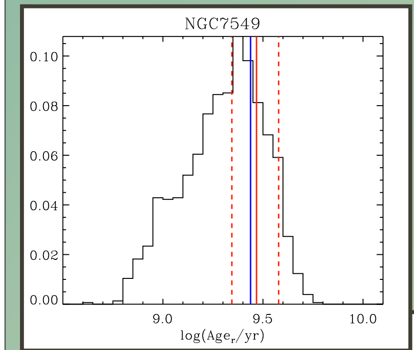


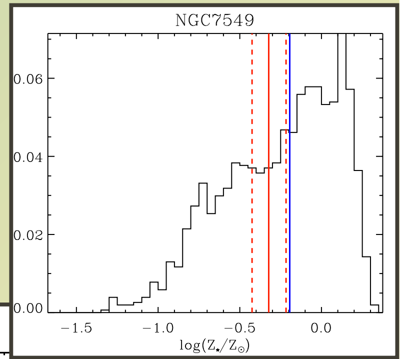


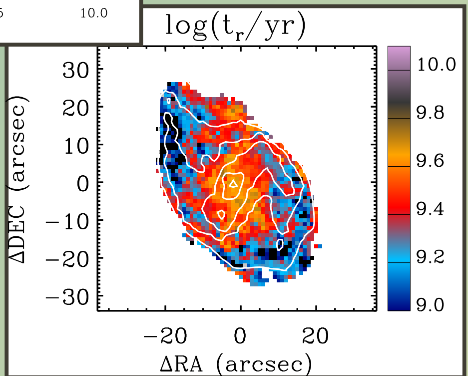
- ★ Global physical parameters and their spatial distribution depend on galaxy mass structure, even at similar total stellar mass

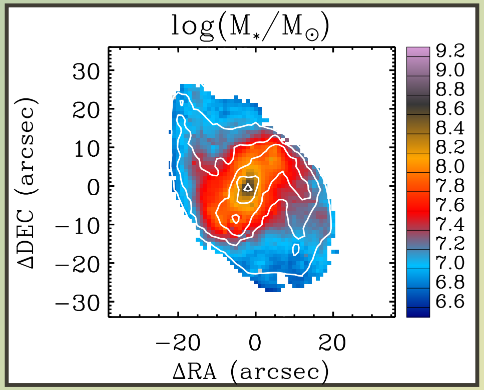
- ★ Stellar population parameters from **integrated spectra** compared to **resolved information**: **systematic differences in non-smooth galaxies and lower-mass galaxies**

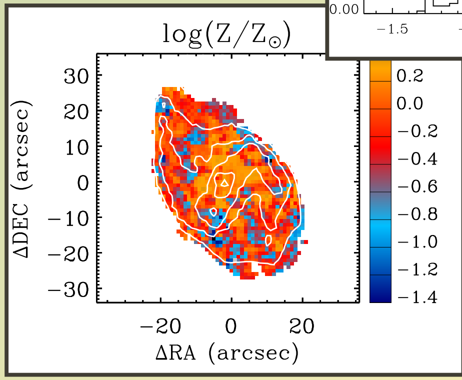
- ★ What are the effects on the zero-point and slope of galaxy scaling relations derived from fixed-aperture spectroscopy?











A search for HI absorption in nearby galaxies

Sarah Reeves

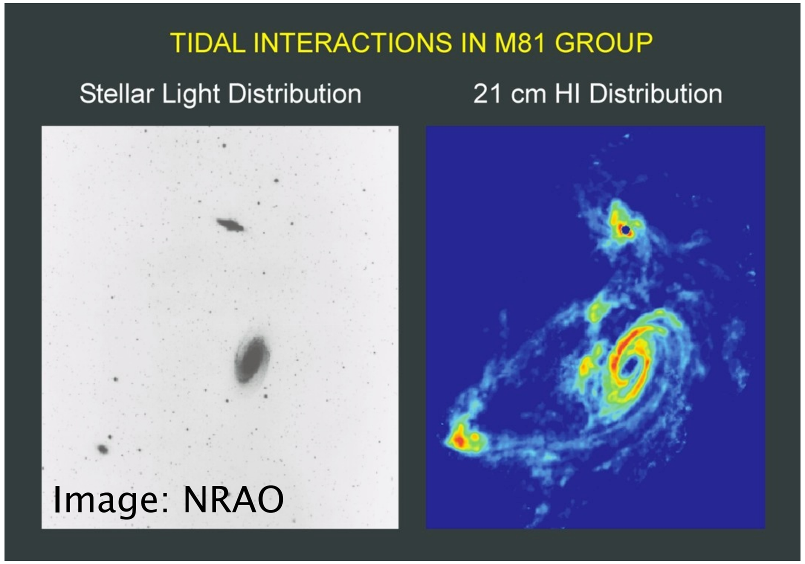
Elaine Sadler, James Allison,
Baerbel Koribalski,
Stephen Curran, Michael Pracy

CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

THE UNIVERSITY OF SYDNEY

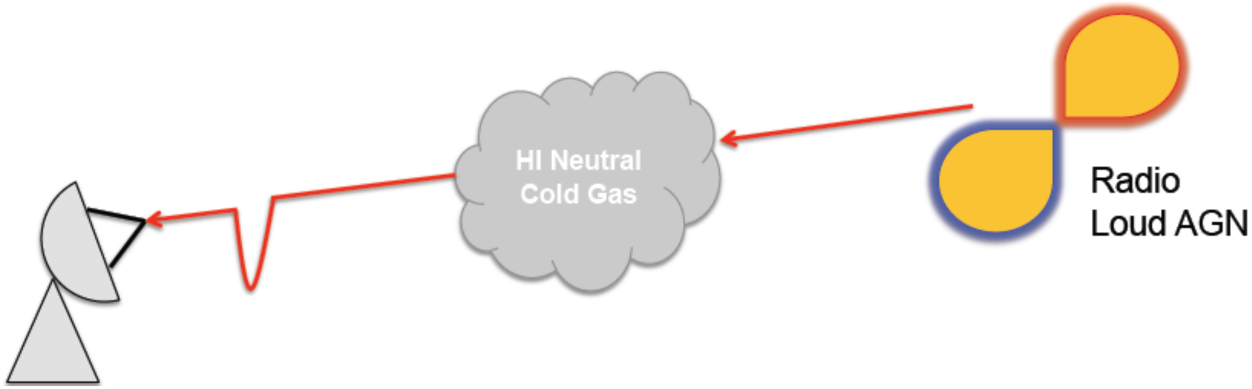
AUSTRALIA TELESCOPE NATIONAL FACILITY CSIRO

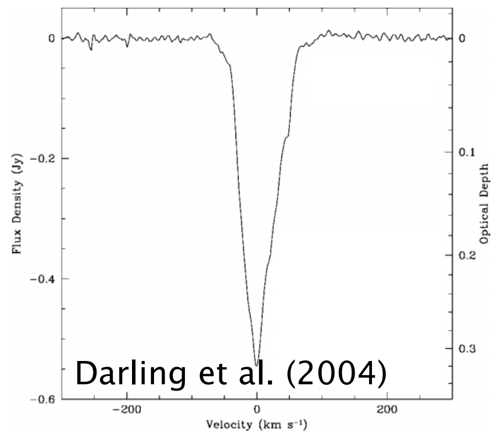
Intervening HI absorption



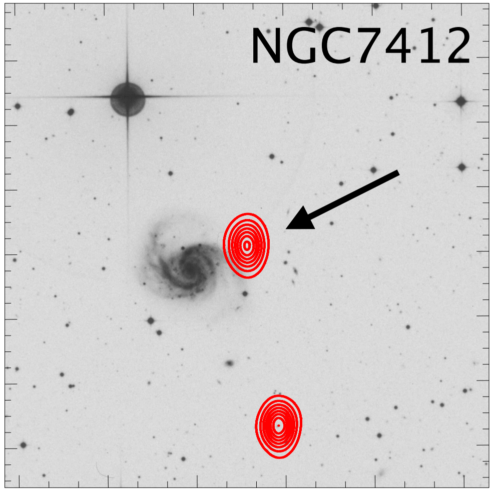
- HI absorption-line studies provide a **distance-independent** probe of the neutral gas in galaxies

$$N_{HI} \approx 1.823 \times 10^{18} \, \frac{T_S}{f} \int \tau_{obs}(v) \, dv$$



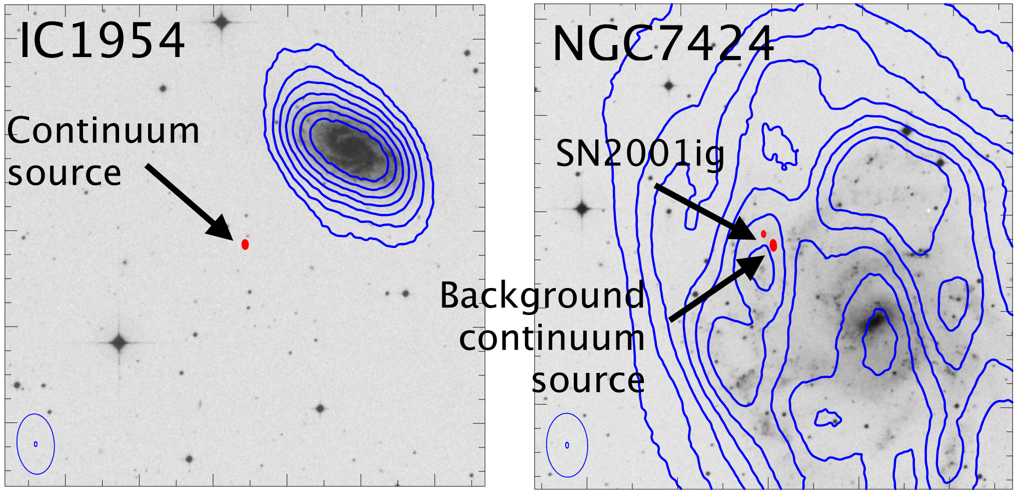


A search for intervening absorption in nearby galaxies

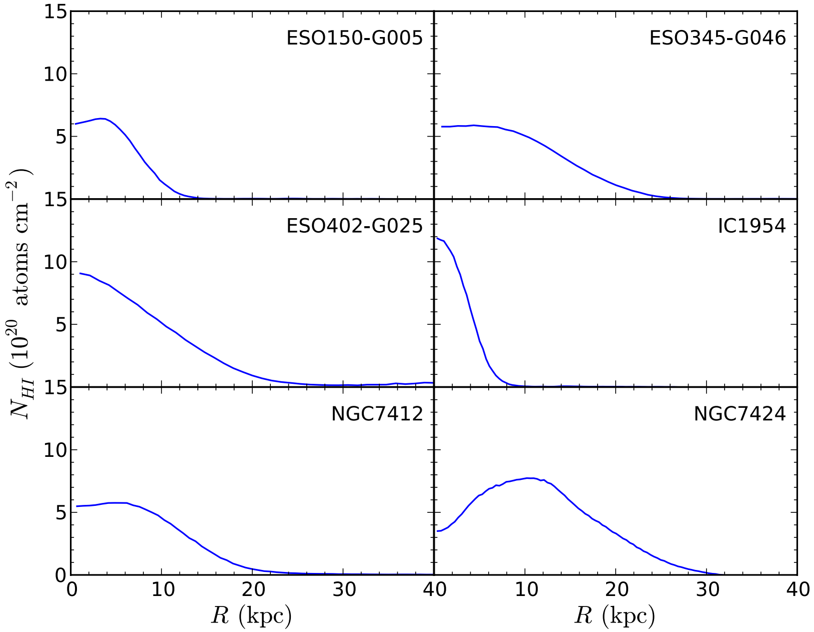


- Conducting a **targeted search** for intervening absorption with the ATCA
- Sample: **16 nearby, gas-rich galaxies** (selected from the HIPASS Bright Galaxy Catalogue; Koribalski et al. 2004)
- By targeting nearby galaxies we are able to simultaneously map the galaxies in HI - allows us to **directly relate gas distribution to the absorption-line detection rate**
- Investigate the detection rate of intervening absorption as a function of impact parameter
- Combined emission- and absorption-line data allows us to estimate the spin temperature of the gas

Emission and Absorption Results



Blue contours: ATCA HI distribution
Greyscale: optical image (SuperCOSMOS)



- **7/15 sight-lines intersect the HI disk** of the foreground galaxy
- **One intervening absorption-line detection** (7% detection rate)
- Find low detection rate is largely due to the structure of the background sources
- This provides important information about the expected detection rate of future absorption-line surveys

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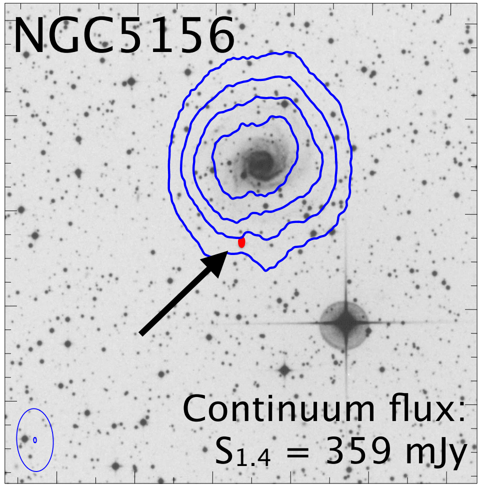
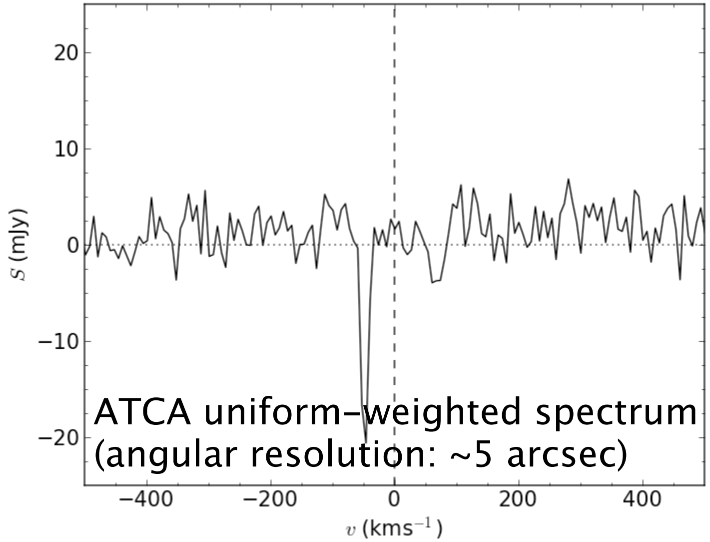
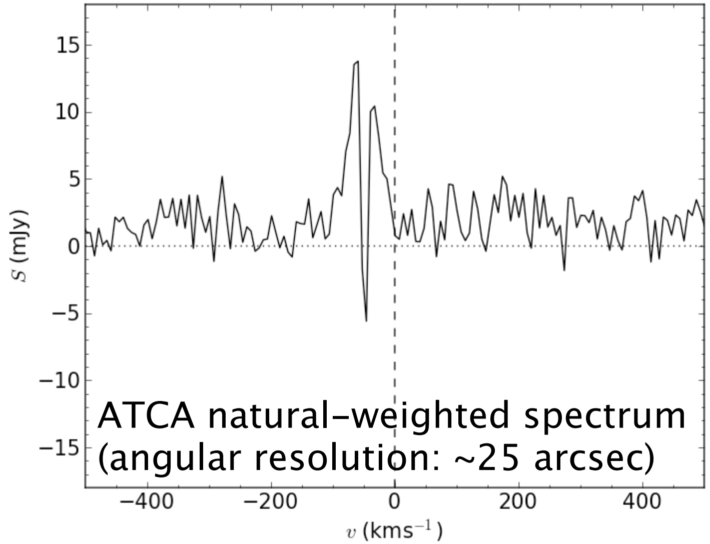
Detection in NGC5156







- **Absorption-line:** optical depth τ_{peak} ~ 0.06, line-width ~13 km s^{-1} (2 channels)
- **HI column density:** N_{HI} ~ 1.1 ×10^{21} cm^{-2} (for T_S/f = 100 K)
- **Spin temperature:** estimate T_S/f ~ 160 K

Further details:
POSTER 33

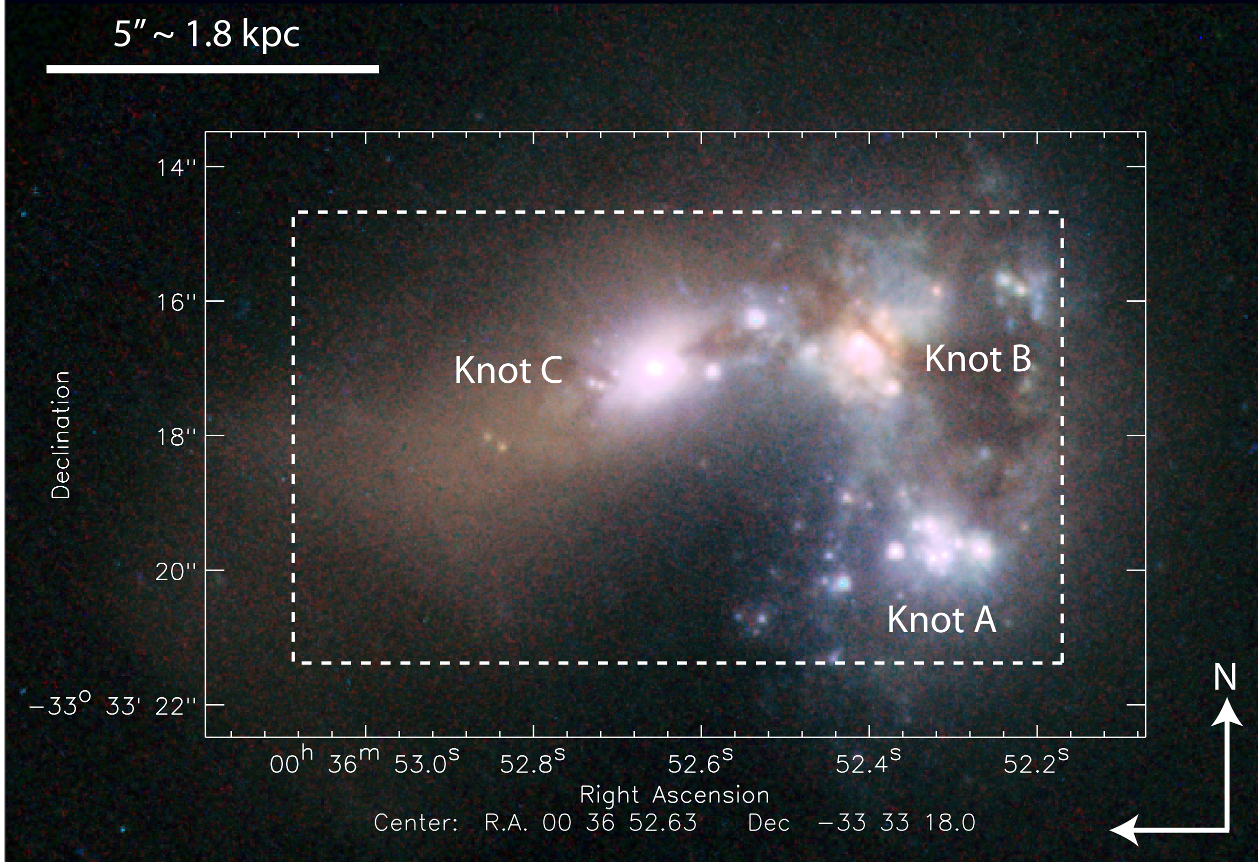
- Currently conducting follow-up observations (high spectral resolution)

A spatially resolved chemodynamical analysis of Haro11

B. James, Y. Tsamis, M. Barlow, J. Walsh & M. Westmoquette, 2013b, MNRAS

Property	Value	Reference
RA (J2000)	00h36′52.5″	NED[a]
Dec (J2000)	-33deg33′19″	NED[a]
z	0.020558	this work
Distance / Mpc	83.6	this work[b]
Velocity / $km\,s^{-1}$	6146±17	this work
Stellar mass / $M_\odot$	$\sim10^{10}$	Adamo et al. (2010)
Gas mass / $M_\odot$	2×10^9	Bergvall et al. (2000)
Cluster masses / $M_\odot$	10^3–10^6	Adamo et al. (2010)
Present SFR / $M_\odot\,yr^{-1}$	22±3	Adamo et al. (2010)
L_{IR} / $L_\odot$	1.9×10^{11}	Bergvall et al. (2000)

VLT-FLAMES IFU observations:
11.5”x7.3” FoV
0.52” spaxels
3620Å → 7180Å



ACS-HRC F220W, F330W & F814W, with ACS-WFC F435W and F550W

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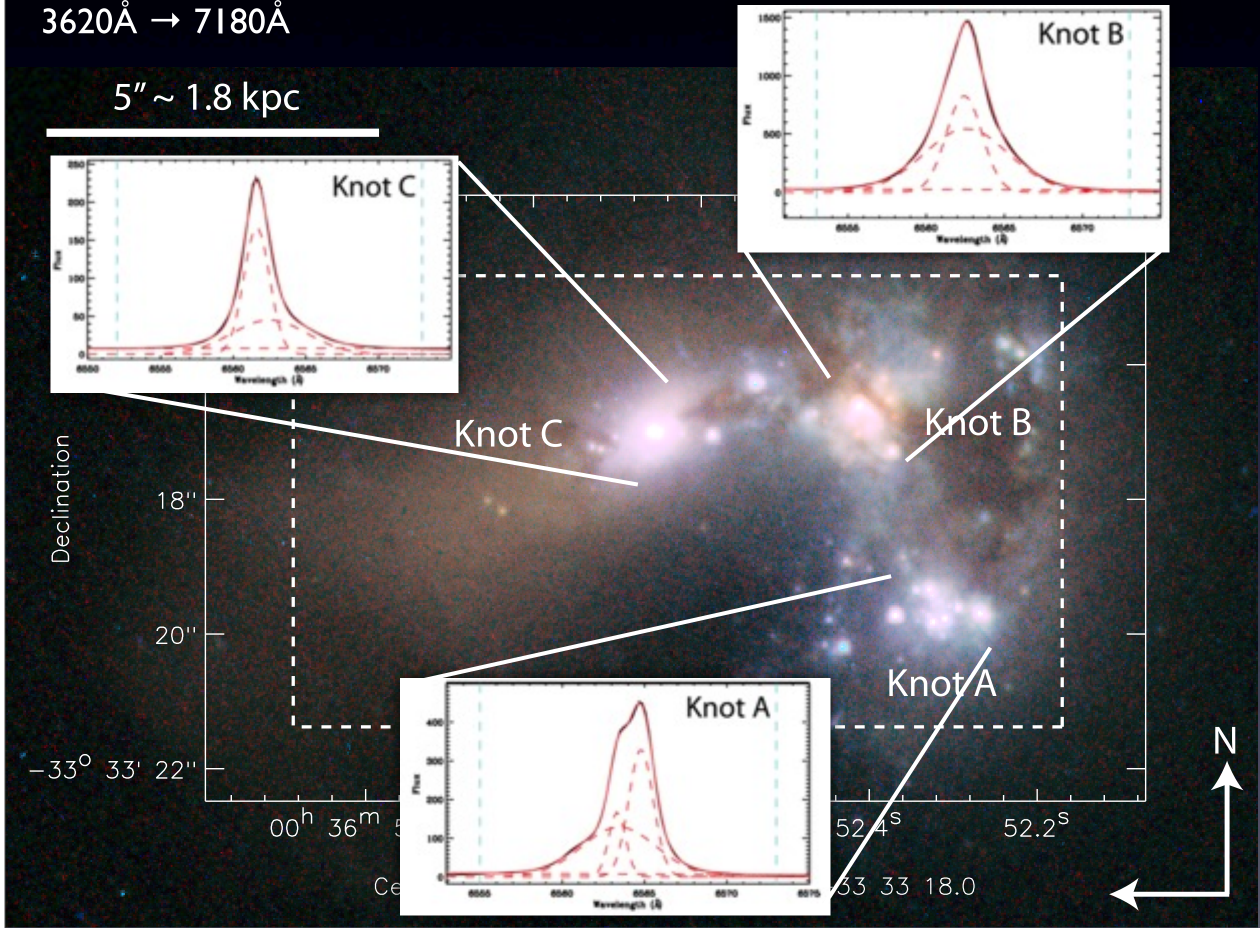

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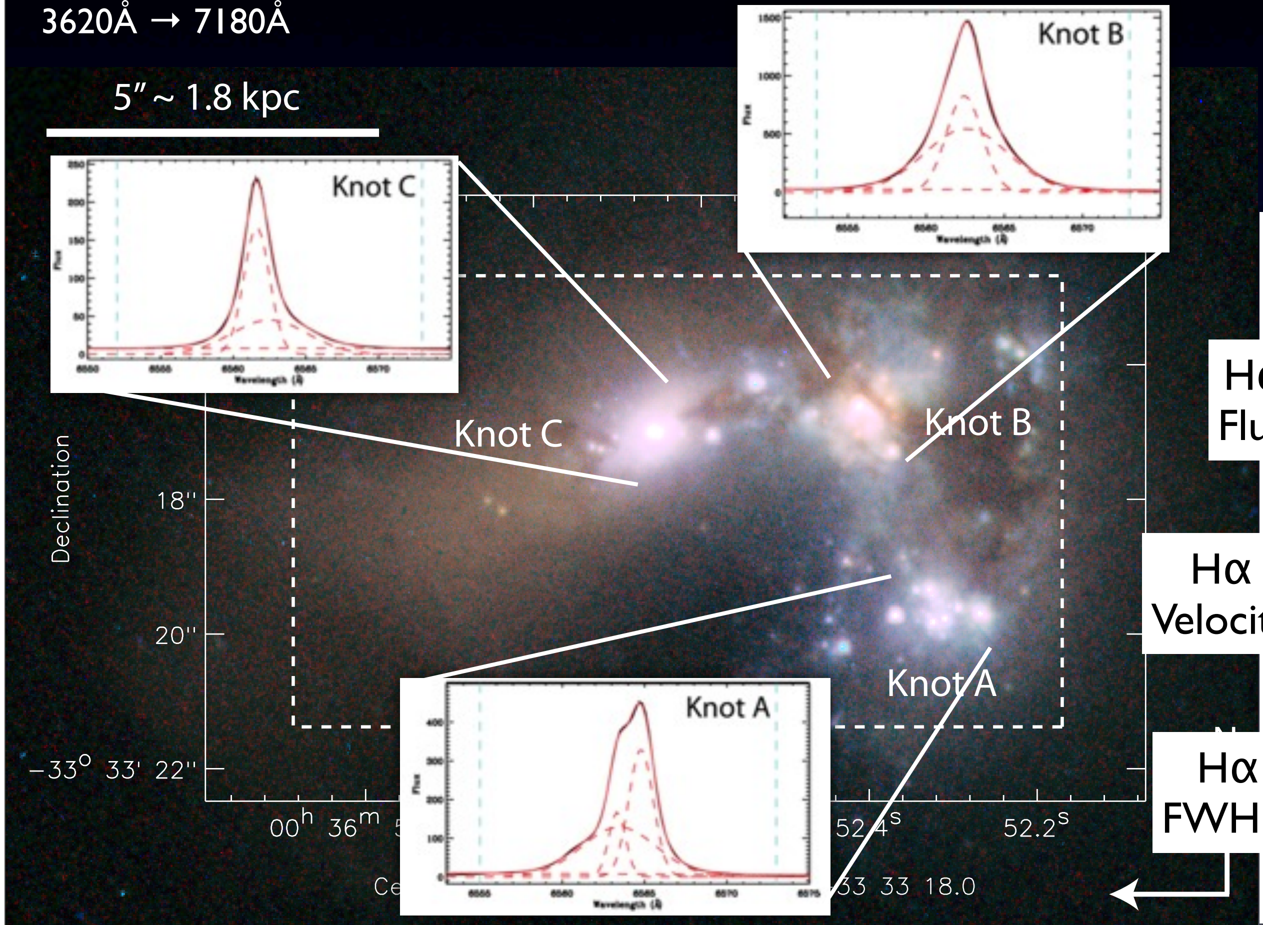

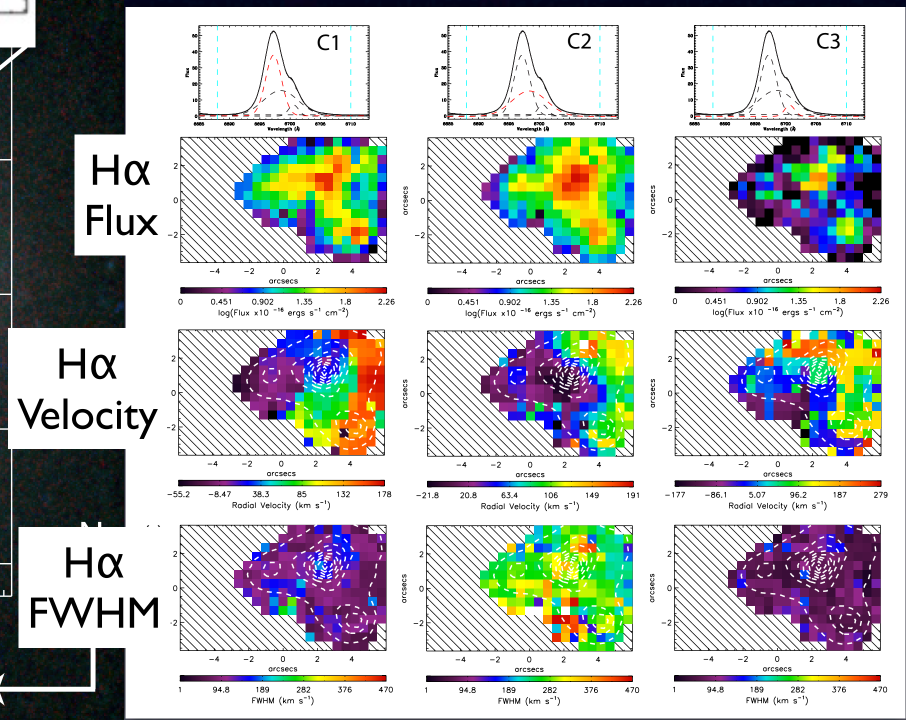

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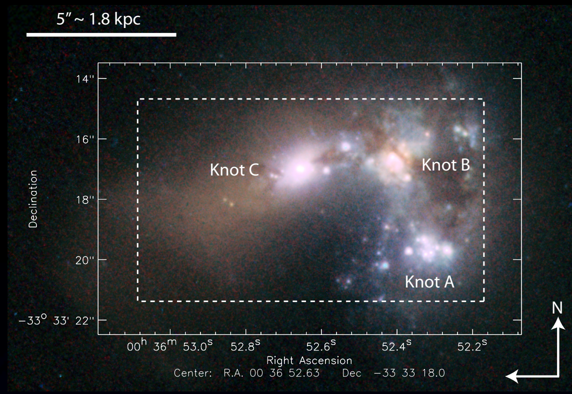
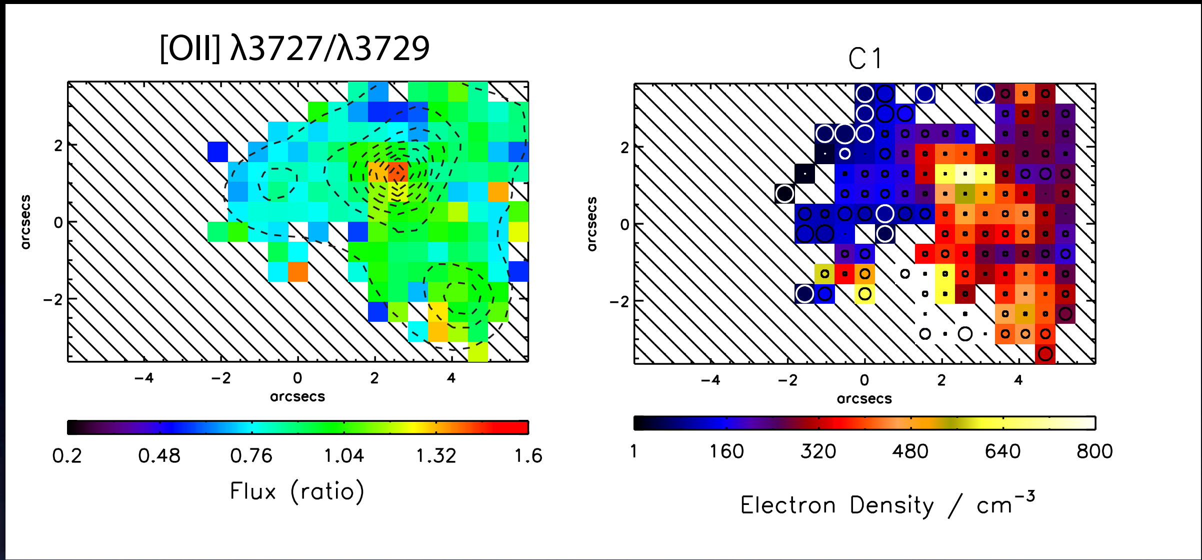
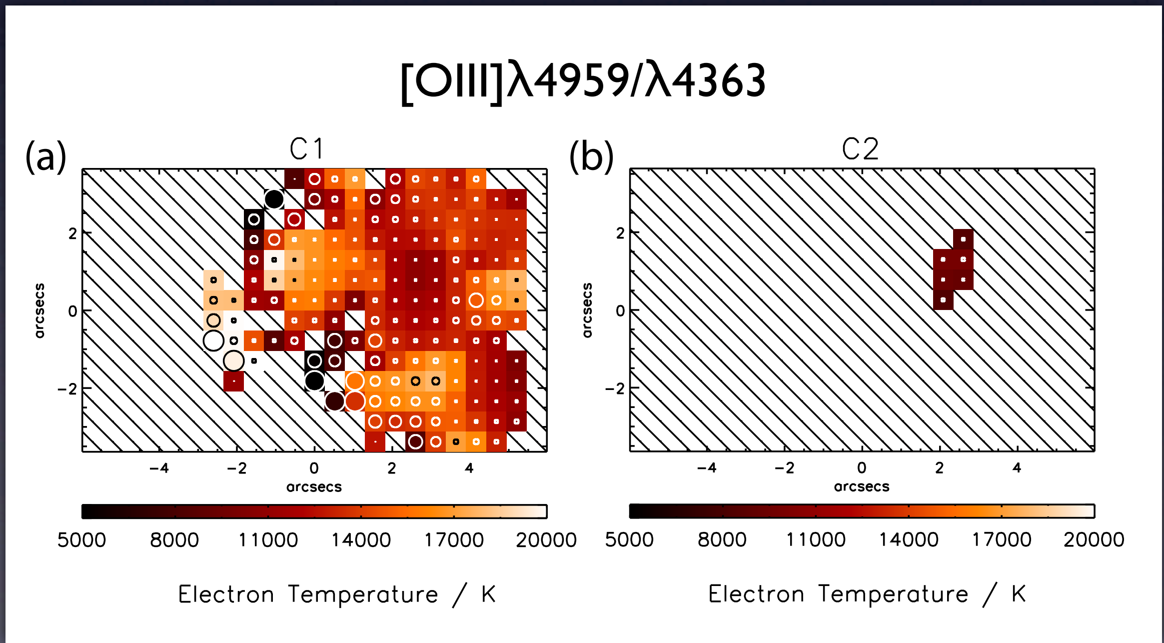
Haro 11:
Electron Temperature and Density Maps







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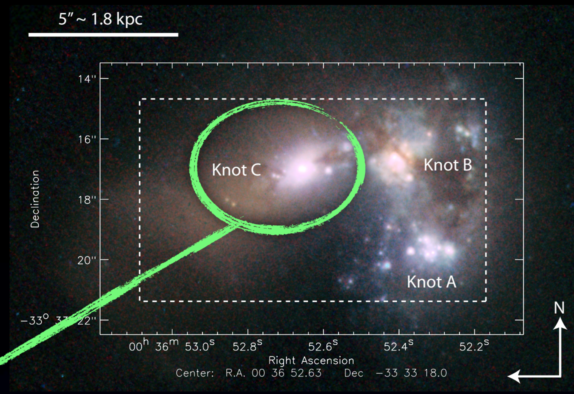
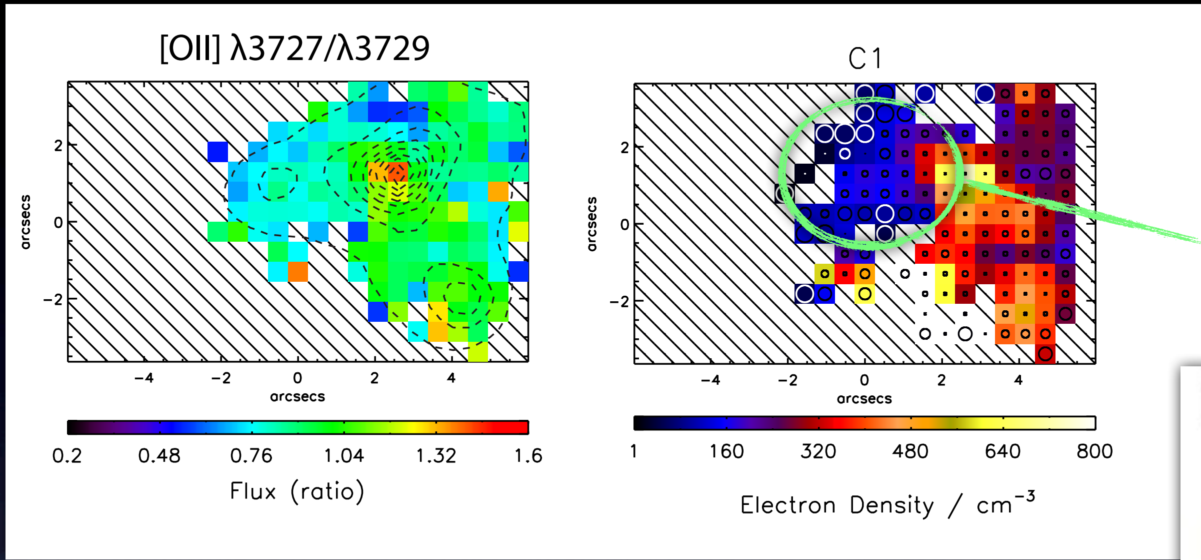
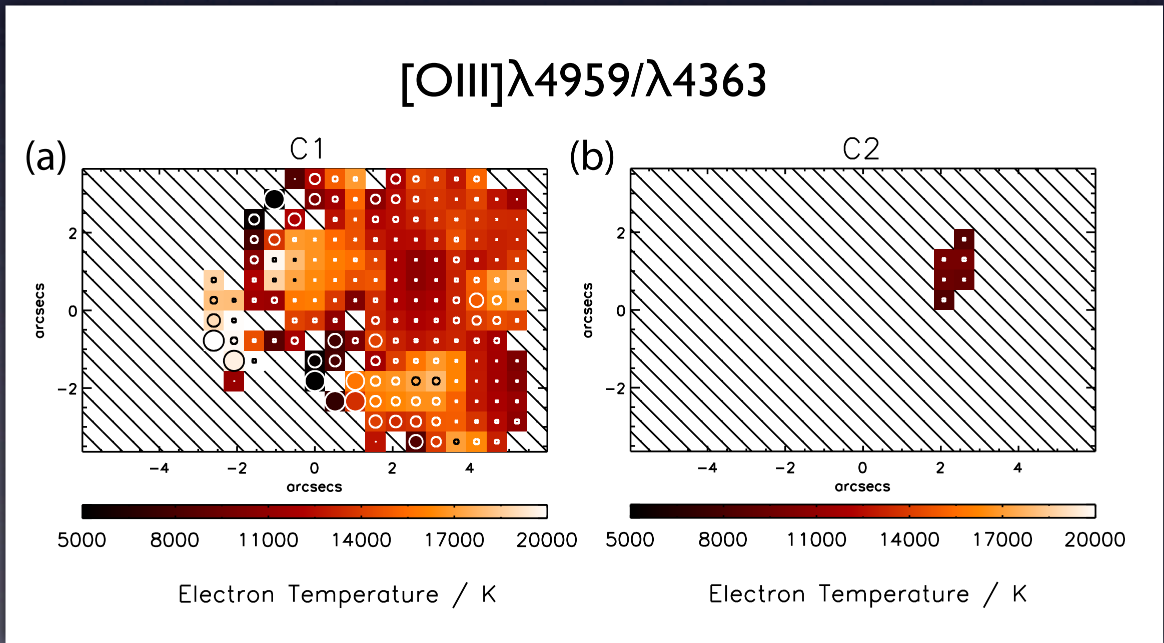
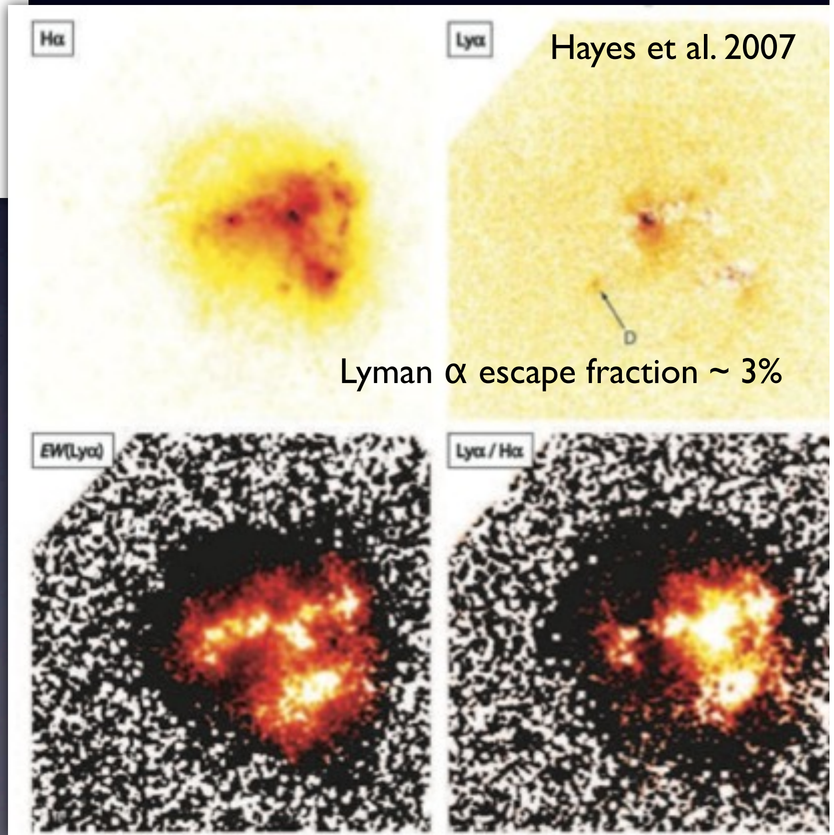




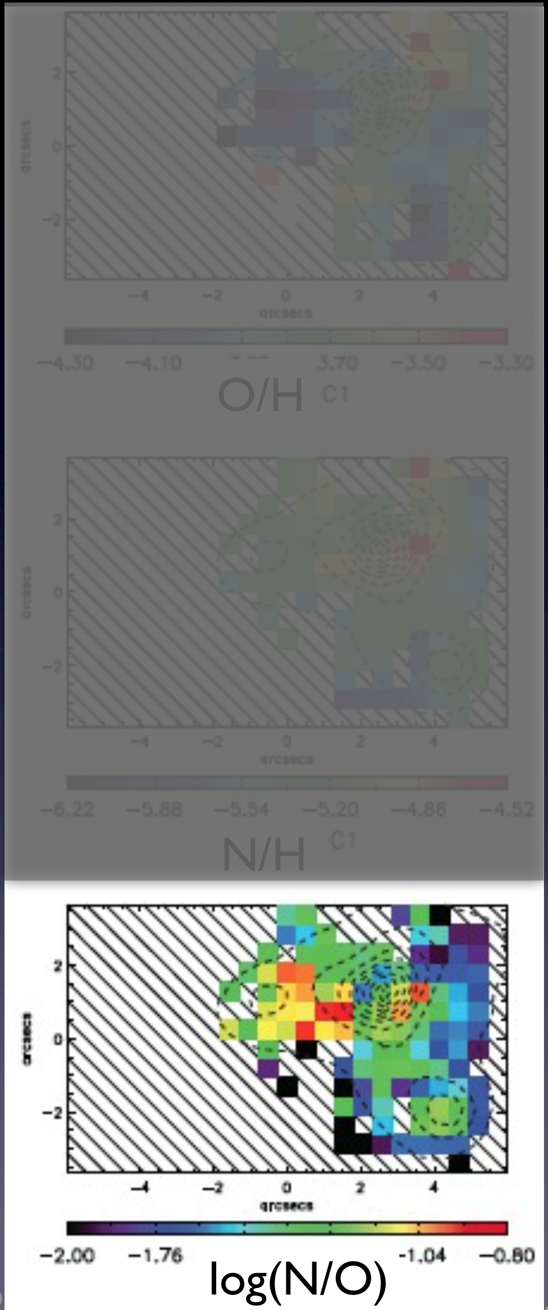
Escape of Lyα photons

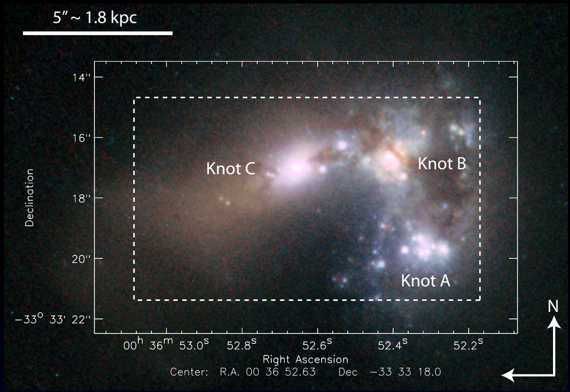




Haro11: N enrichment?

James et al. 2013b





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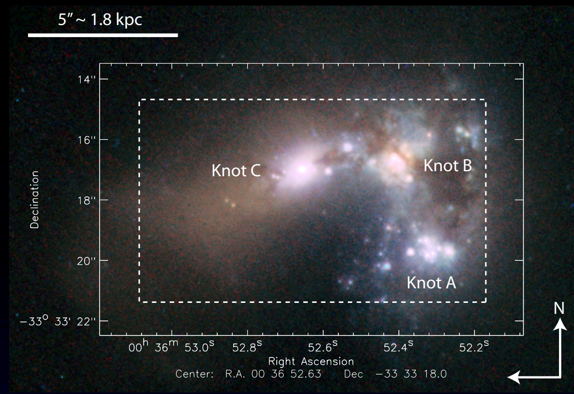
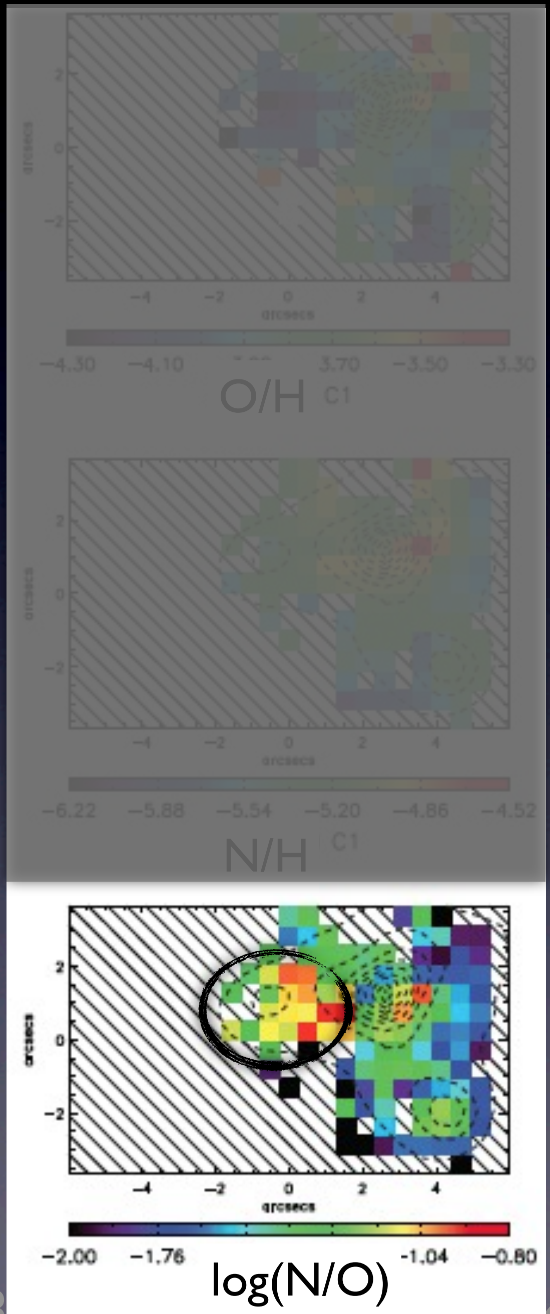
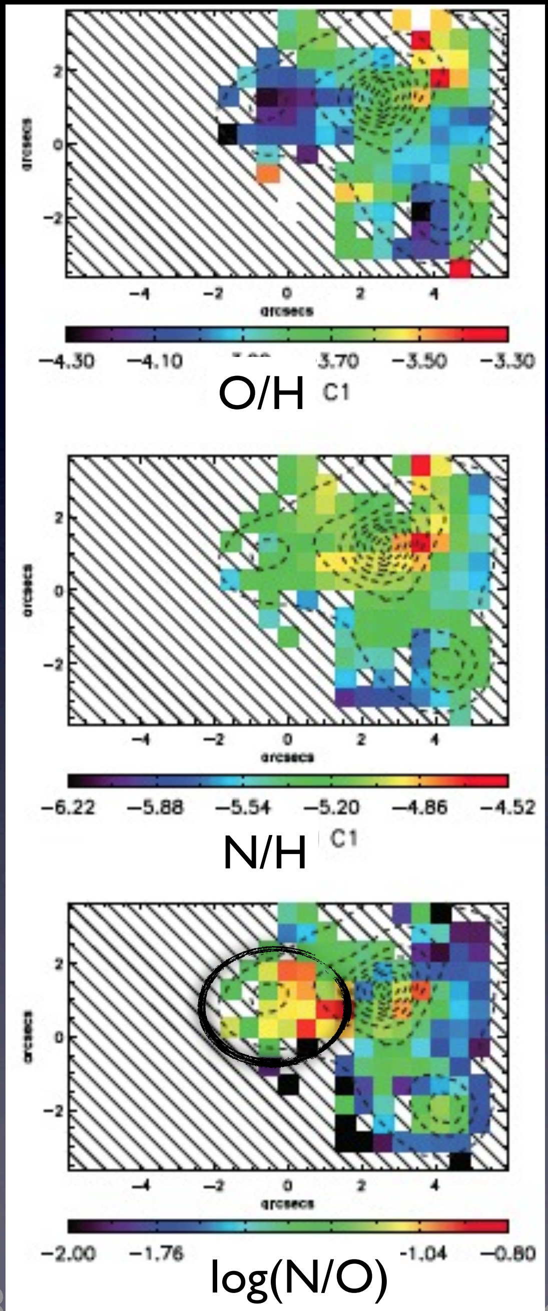
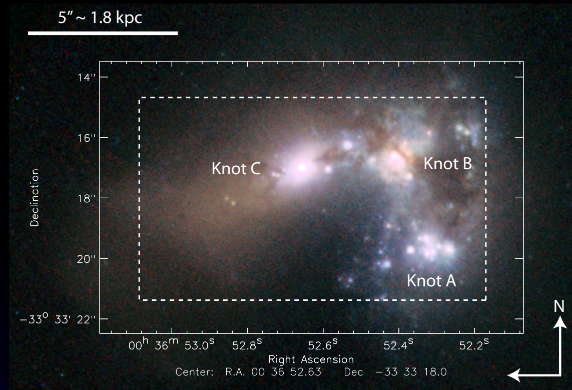




Haro11: N enrichment?

James et al. 2013b





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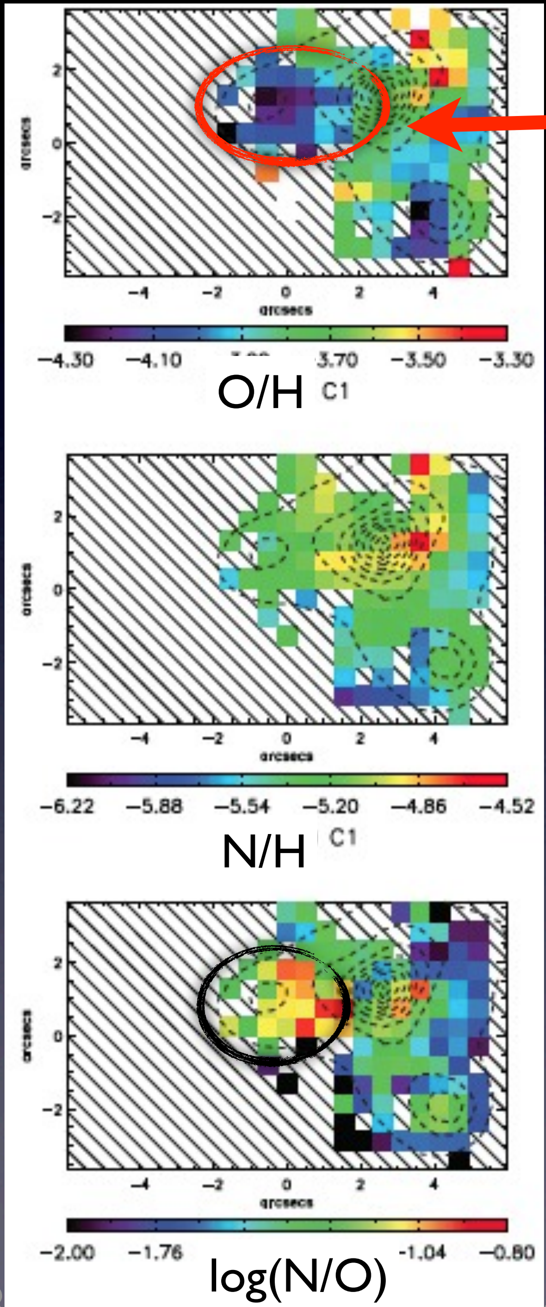
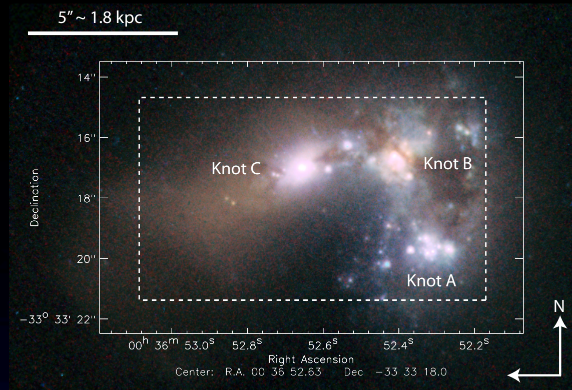


Accretion of metal-poor gas?
Outflow of O-enriched gas?



James et al. 2013b

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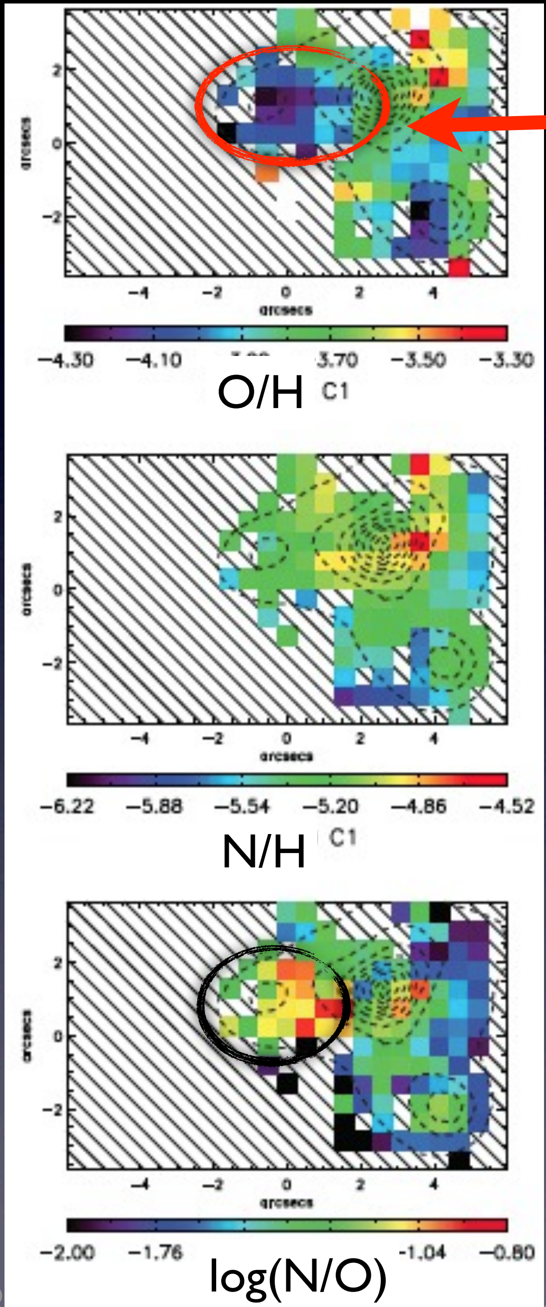

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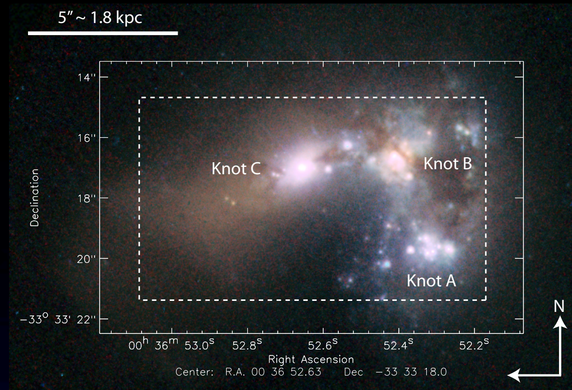
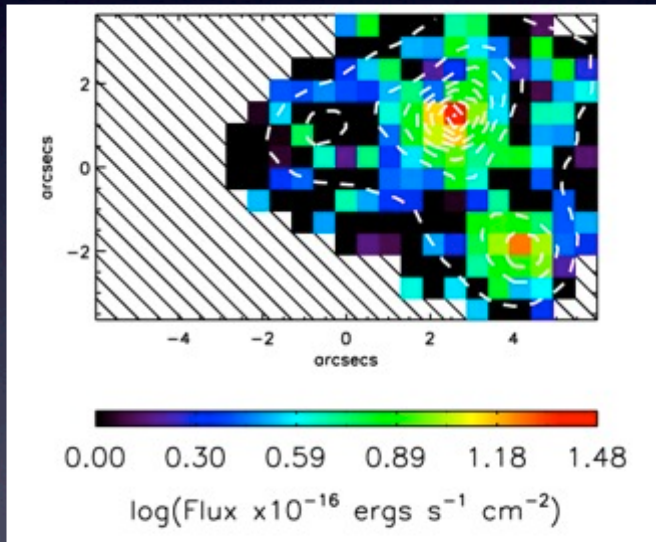
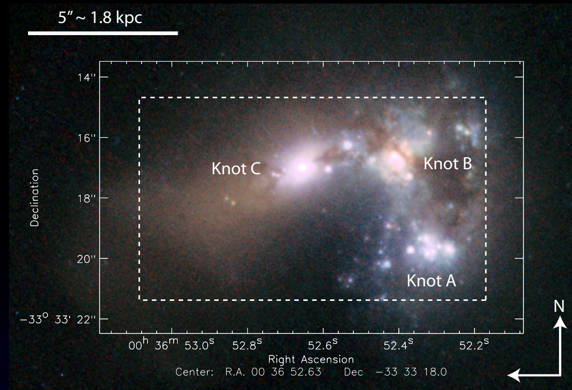


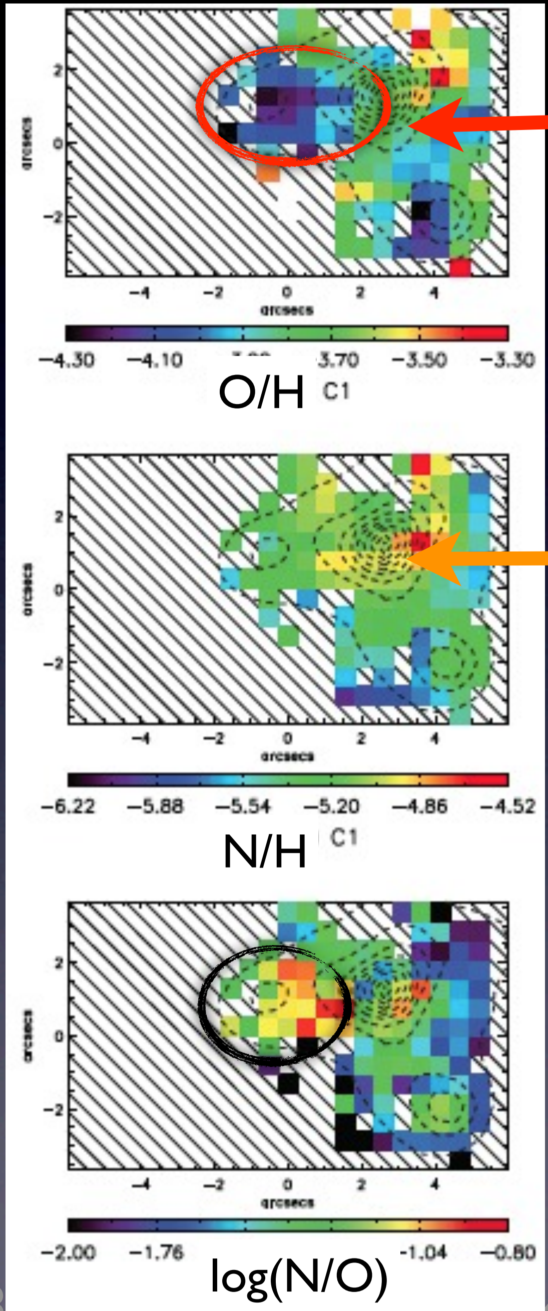
WR emission



Haro11: N enrichment?

James et al. 2013b





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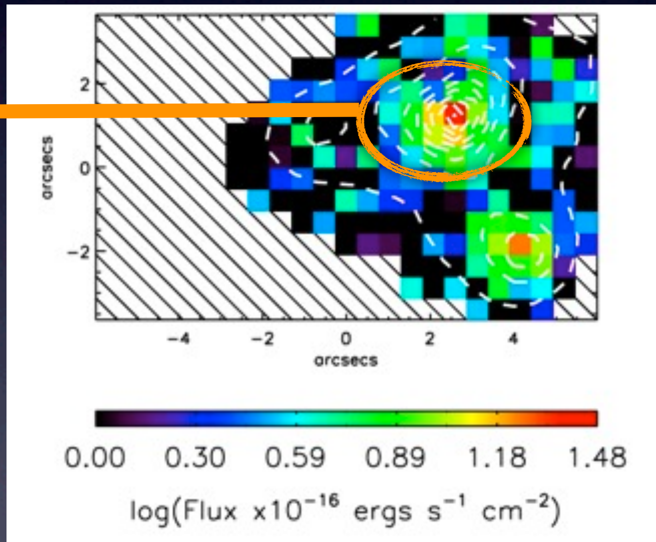
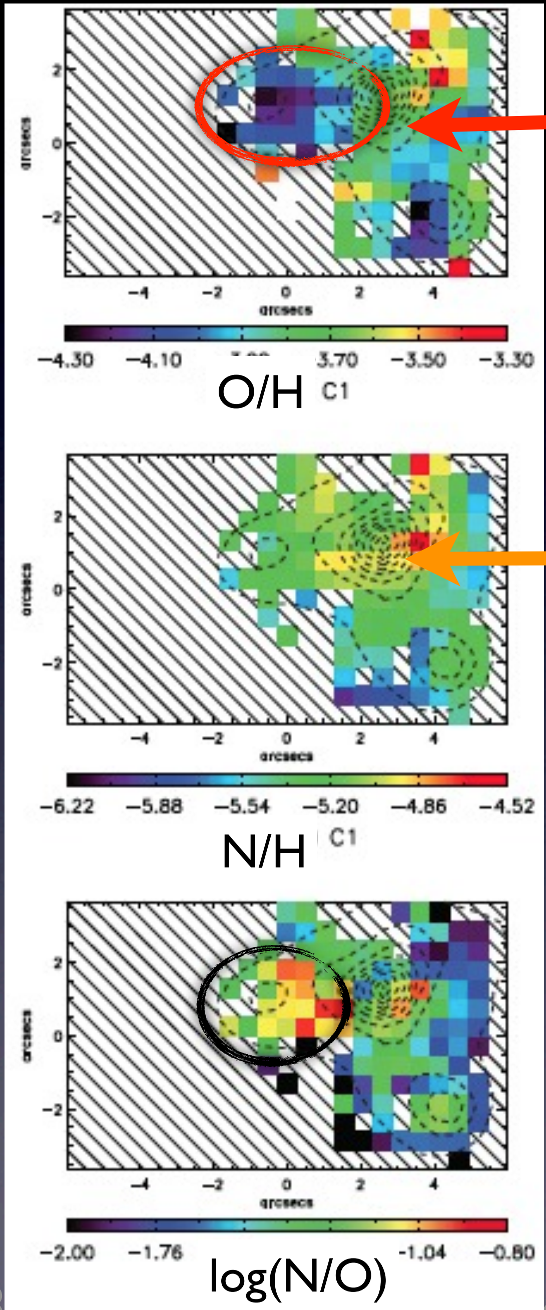


Ejecta of WR stars haven't had time to cool/mix?
Spatial res^{n} not high enough to see N/O enhancement?

James et al. 2013b

Haro11: N enrichment?



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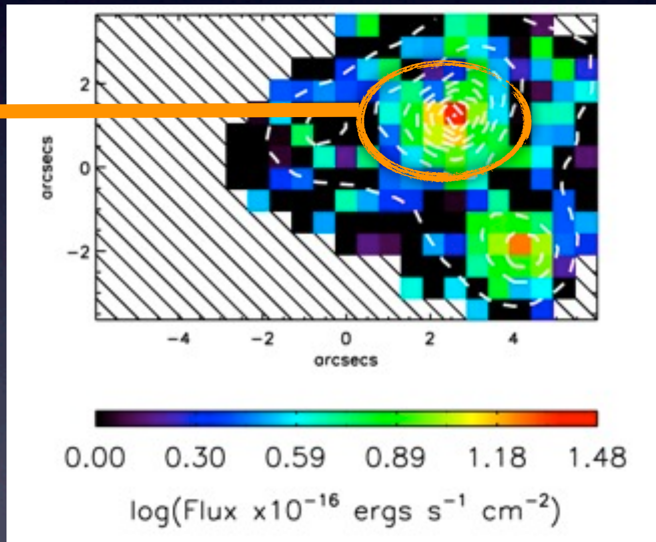

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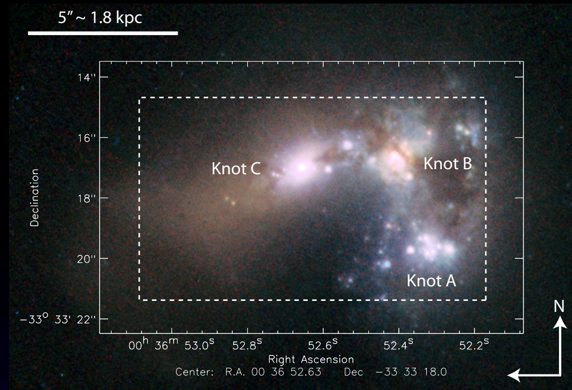
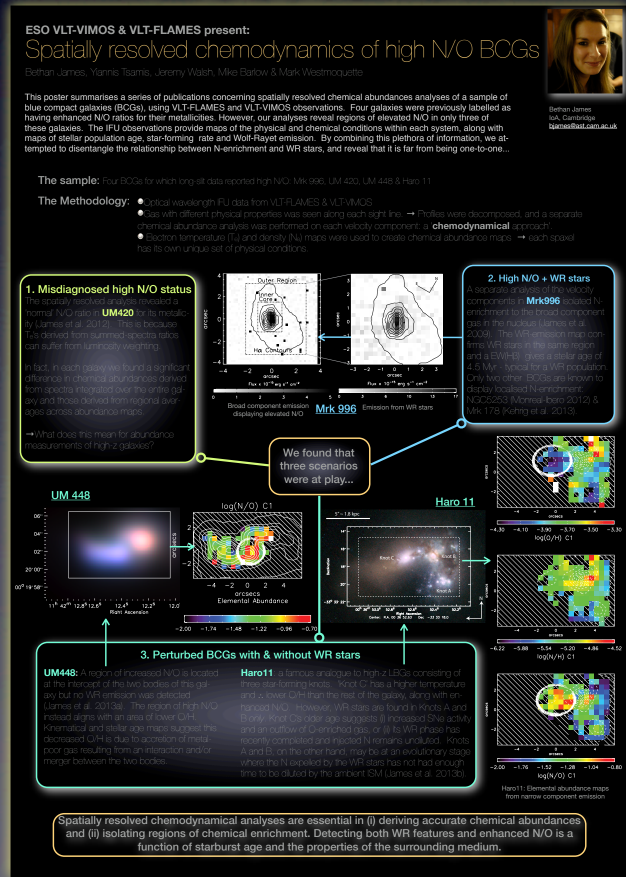
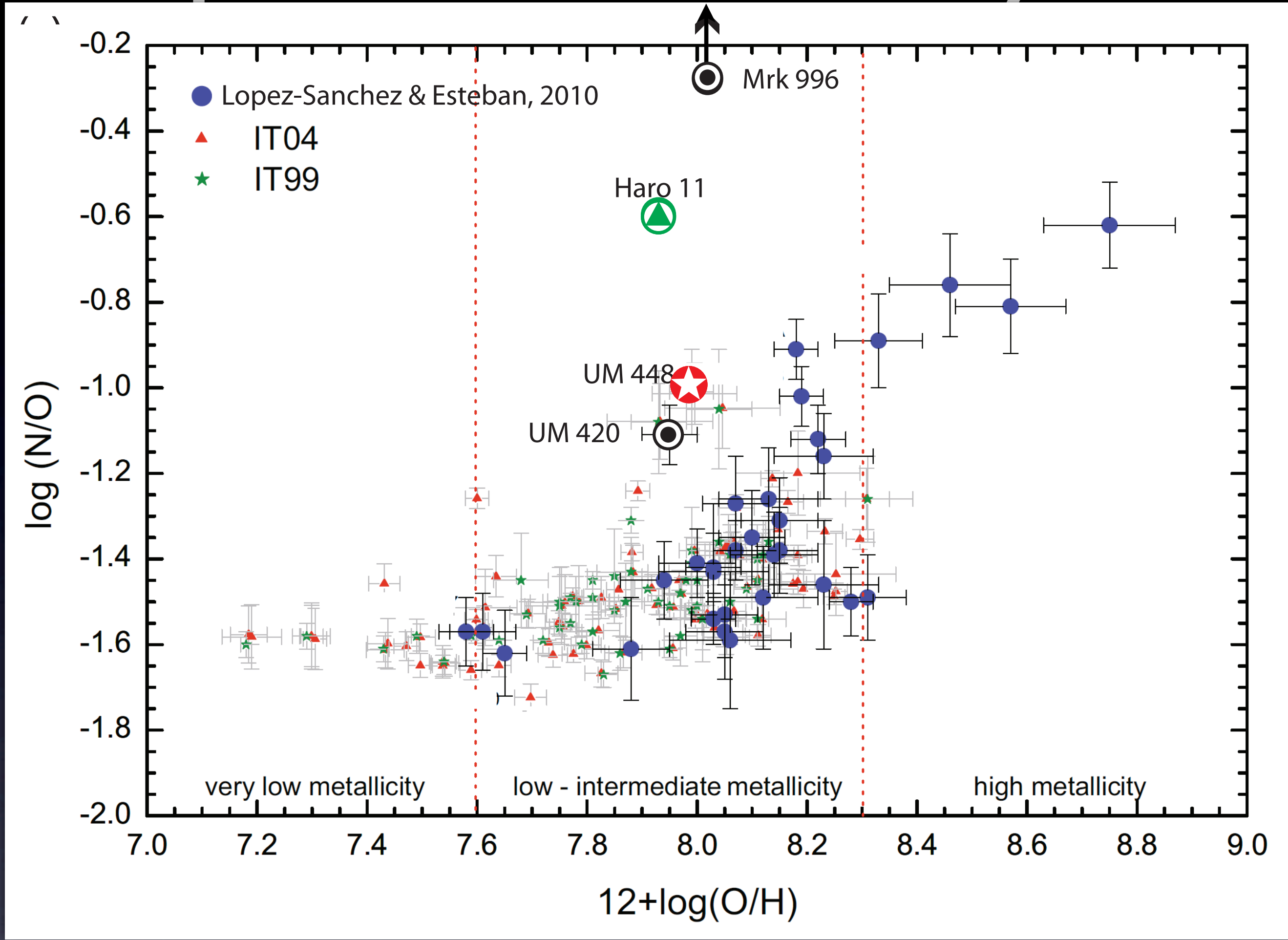


Poster #14



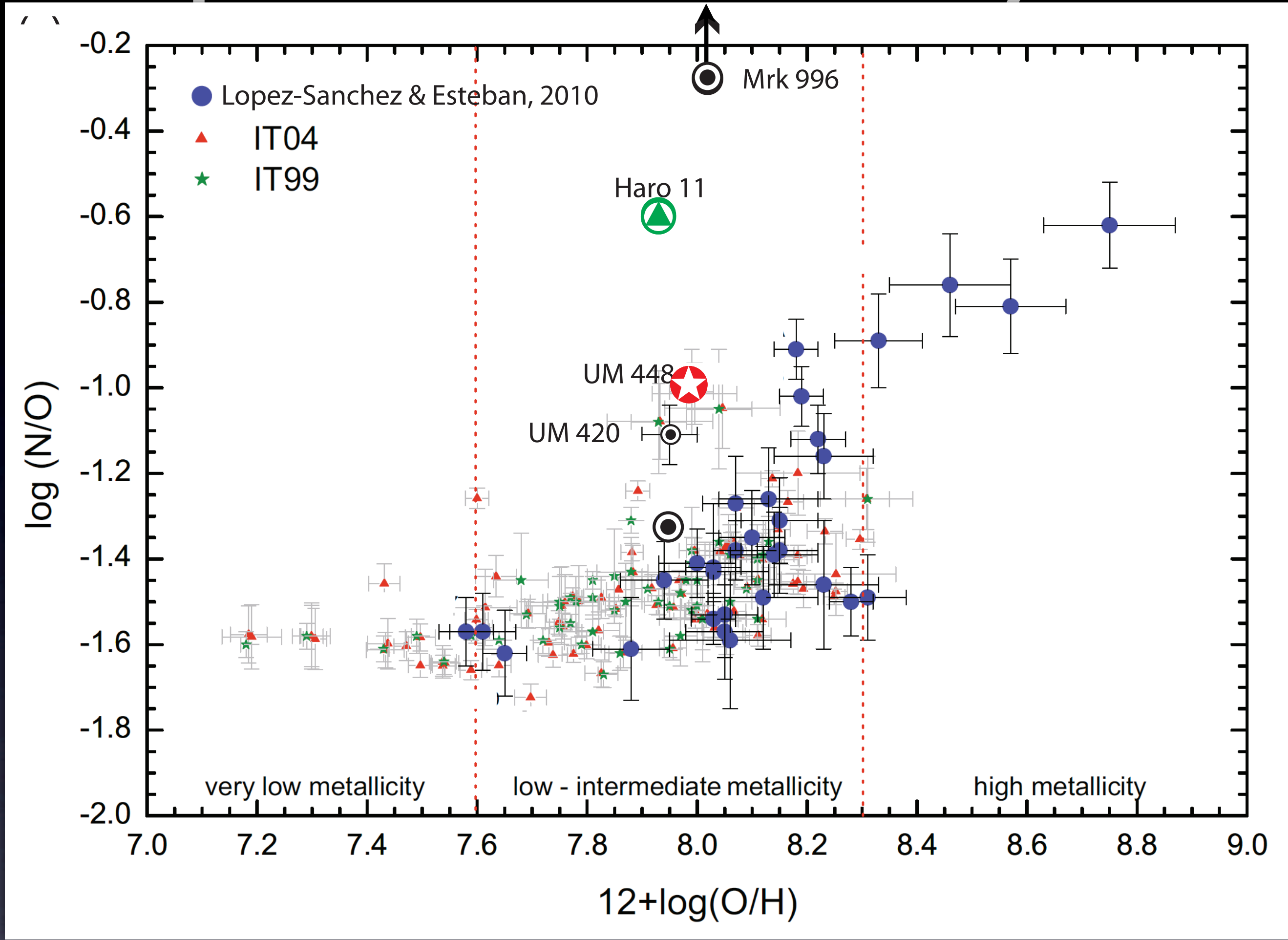
Poster #14

Impact of IFU Analysis



Impact of IFU Analysis

Poster #14



Impact of IFU Analysis

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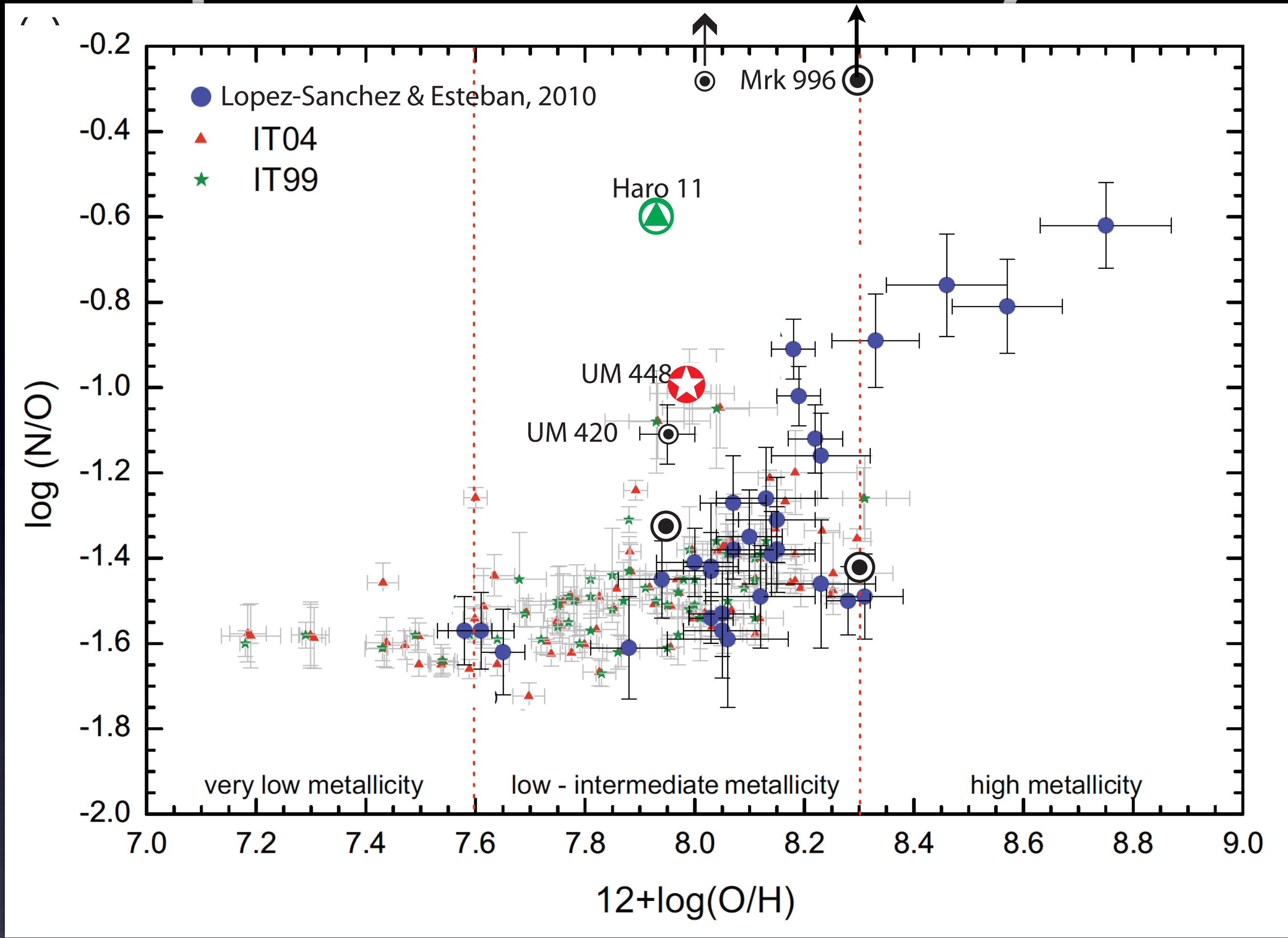
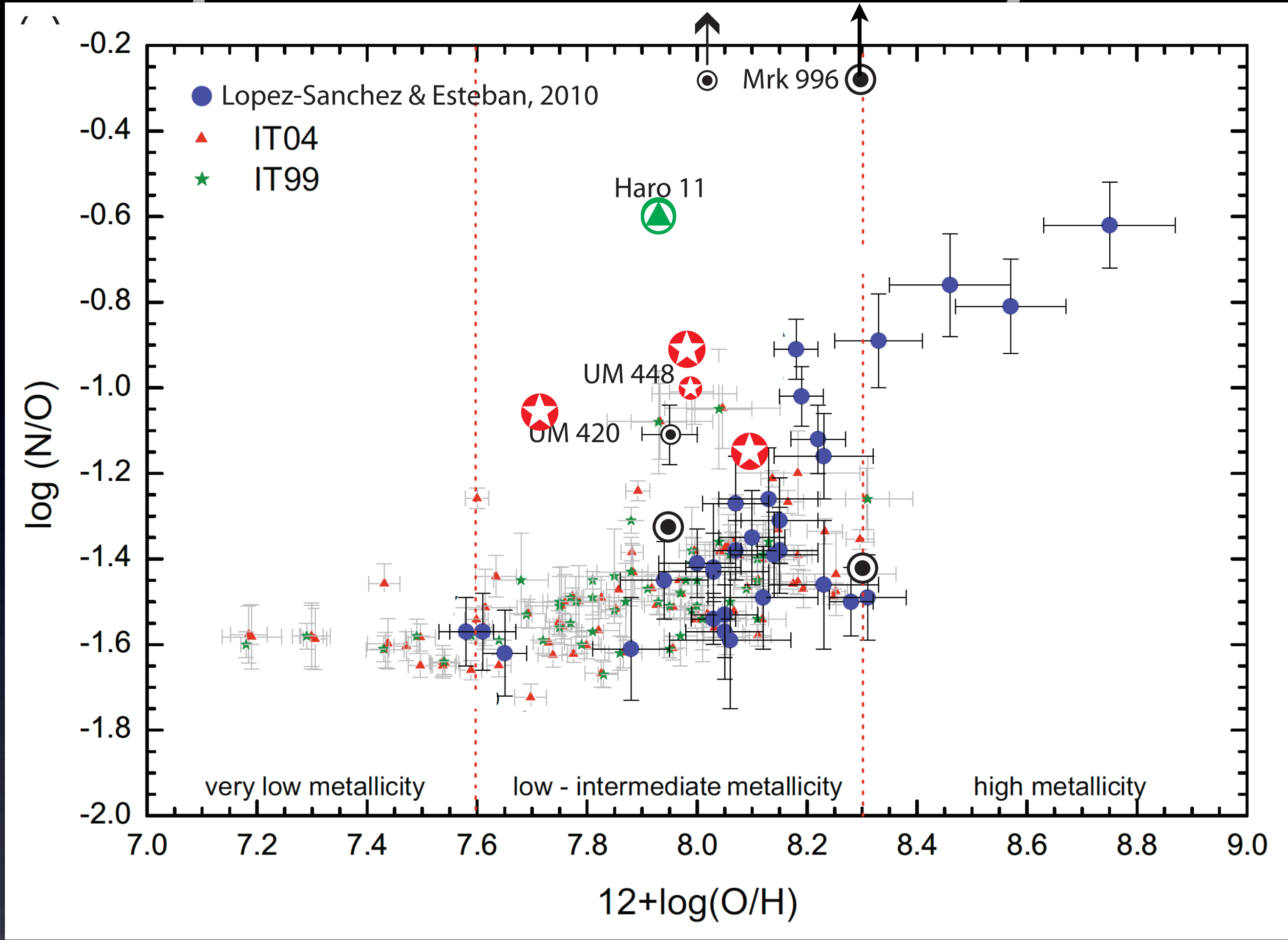


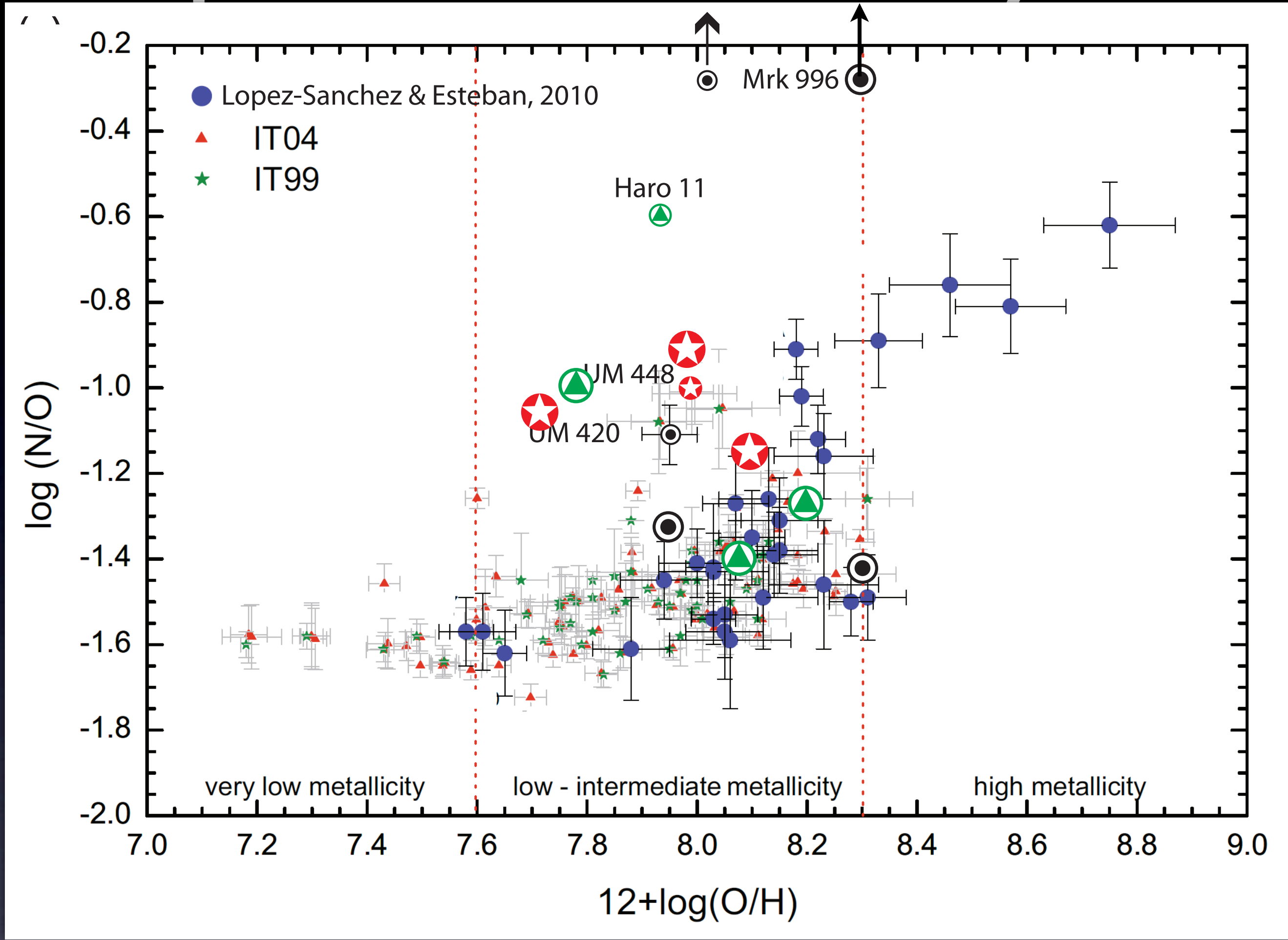
Poster #14

Impact of IFU Analysis



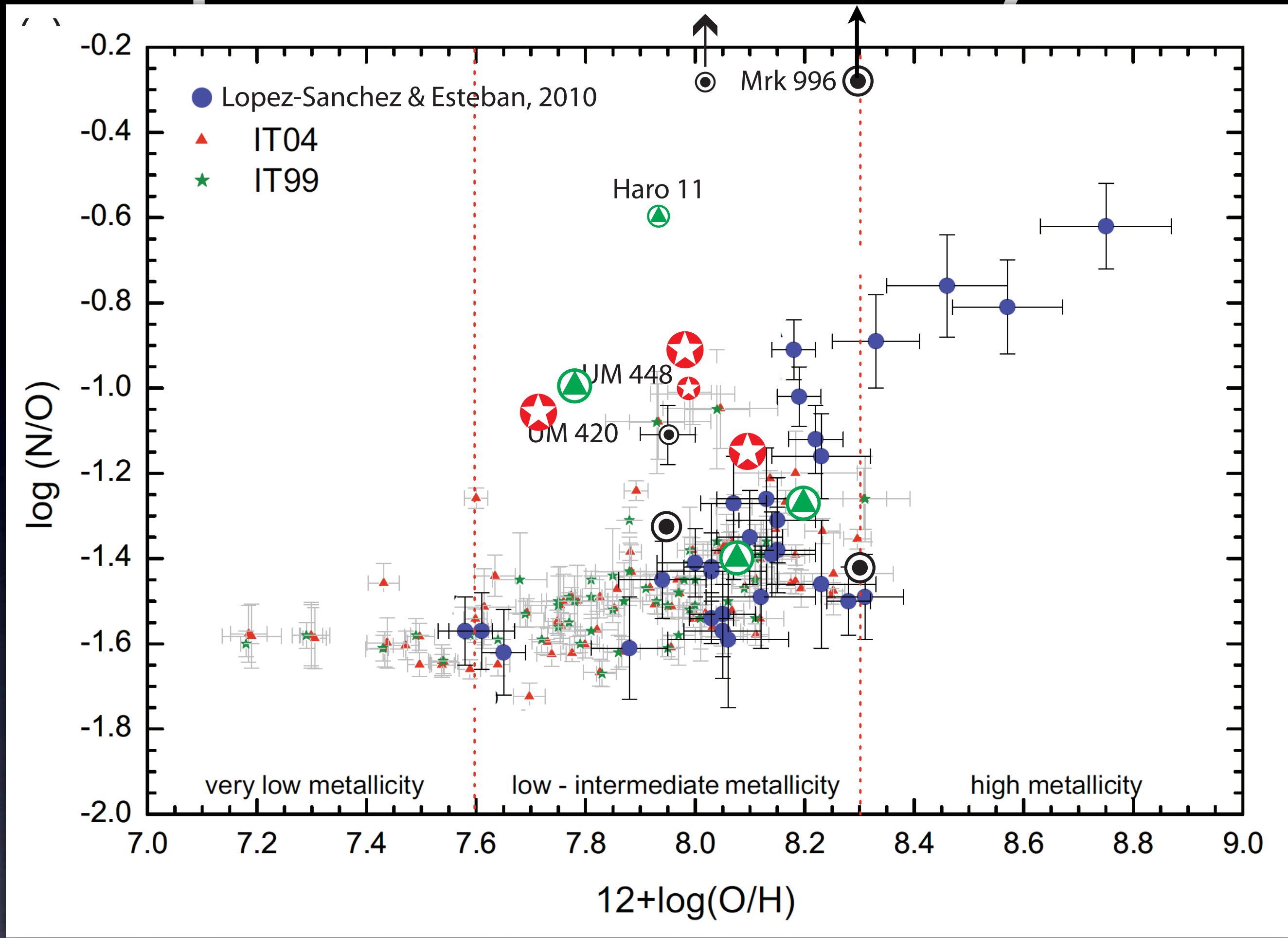
Impact of IFU Analysis

Poster #14



Impact of IFU Analysis

Poster #14



Spatially resolved, multi-component spectroscopic analyses
→ revised metallicities + isolate localised N-enrichment

Can we rely on luminosity-weighted measurements (i.e. long-slit, global spectra etc) to reliably represent the physical properties of high-z galaxies?

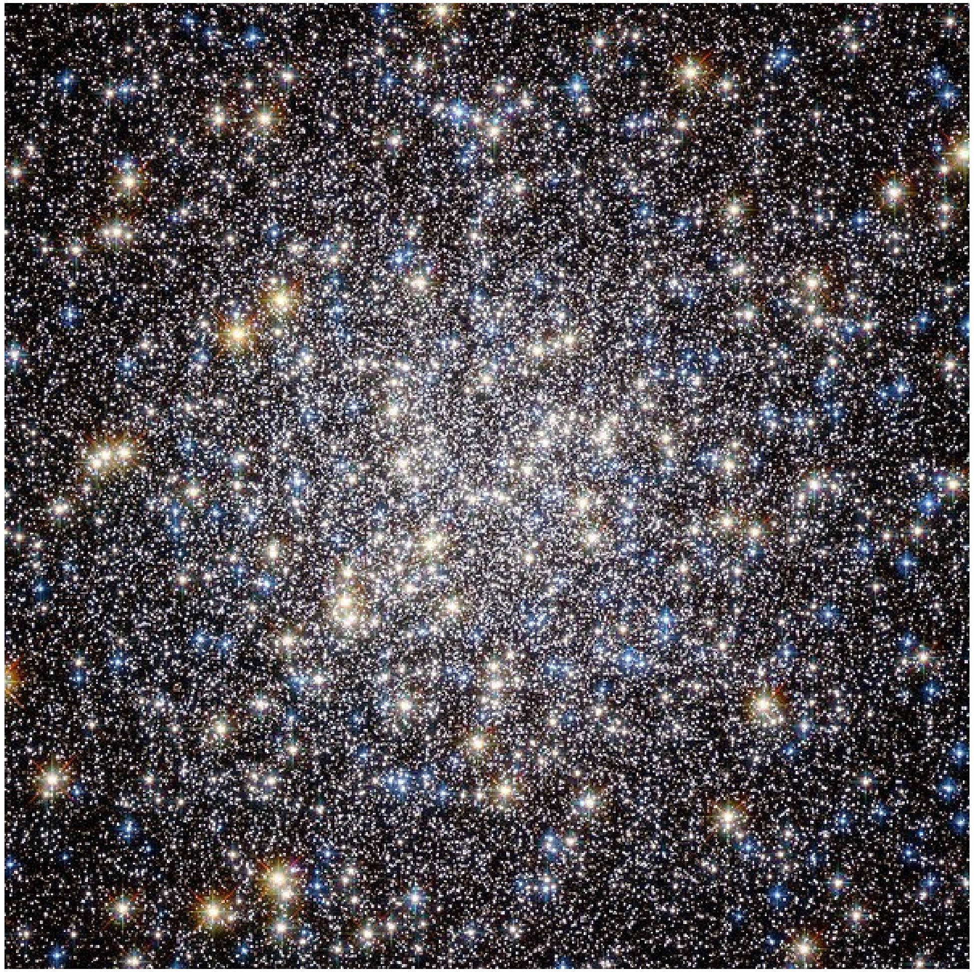
See: e.g. Kobulnicky et al. 1999, Pilyugin et al. 2012, Perez-Montero et al. 2011.

Crowded Field 3D Spectroscopy in Globular Clusters

Sebastian Kamann
Stefan Dreizler
Tim-Oliver Husser
Andreas Kelz
Martin Roth
Peter Weilbacher
Lutz Wisotzki

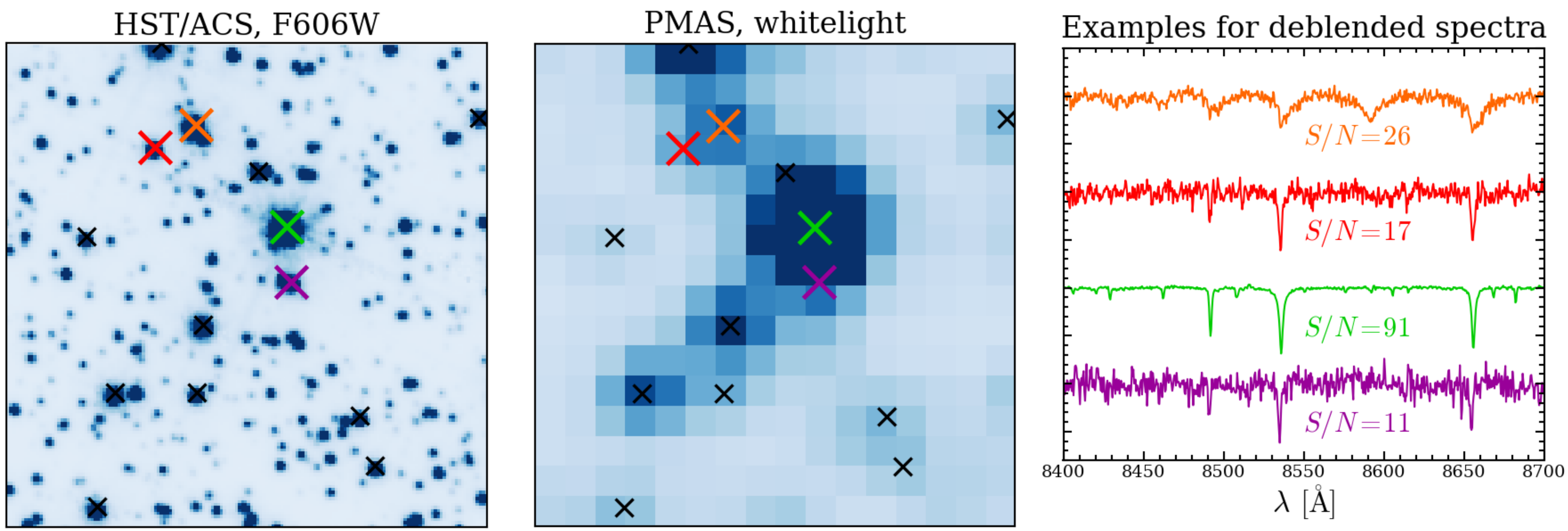
Leibniz-Institut für Astrophysik Potsdam (AIP)

Institut für Astrophysik, Universität Göttingen (IAG)



M13

3D spectroscopy in M13 with PMAS

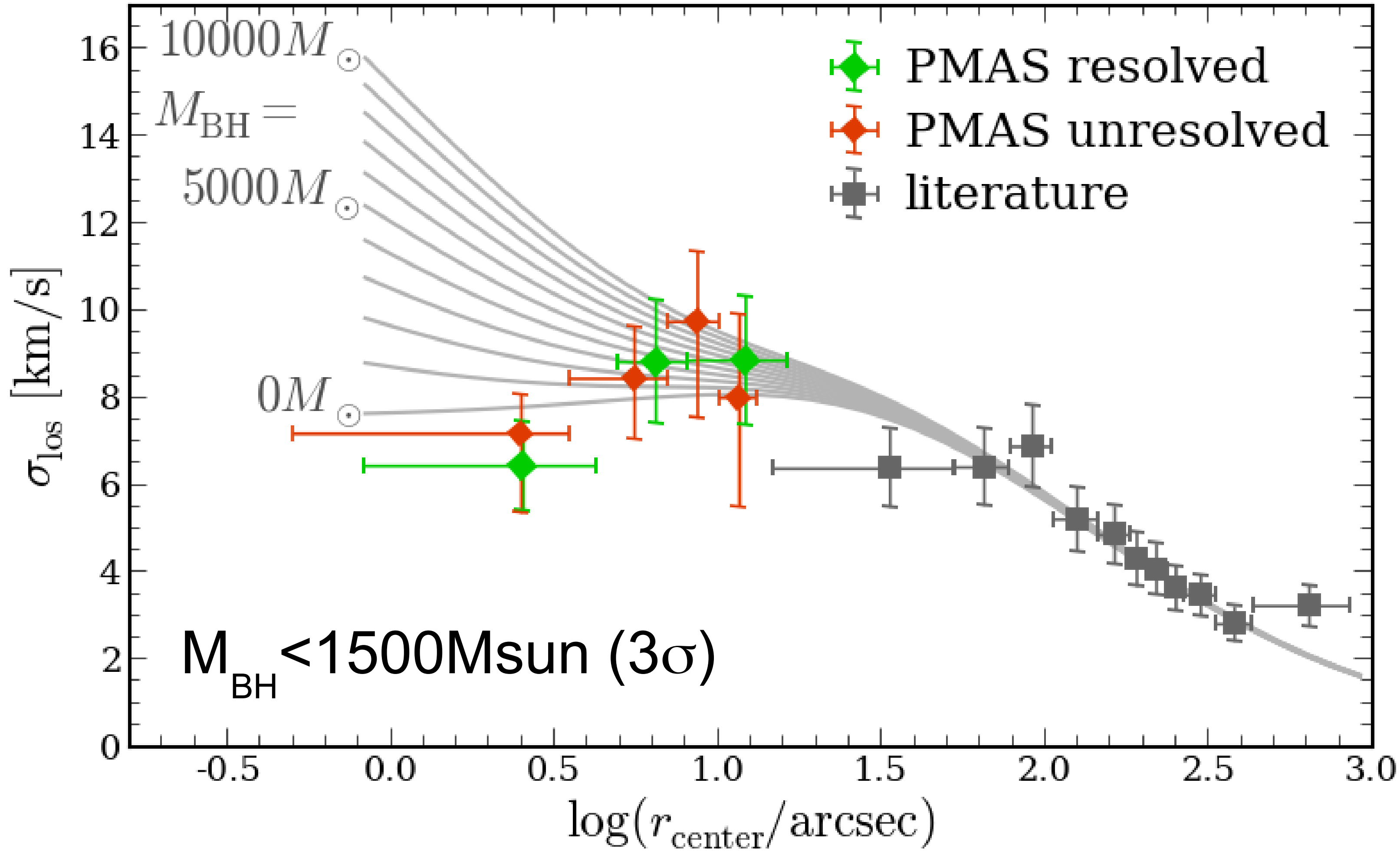


Kamann et al. (2014), A&A (submitted)

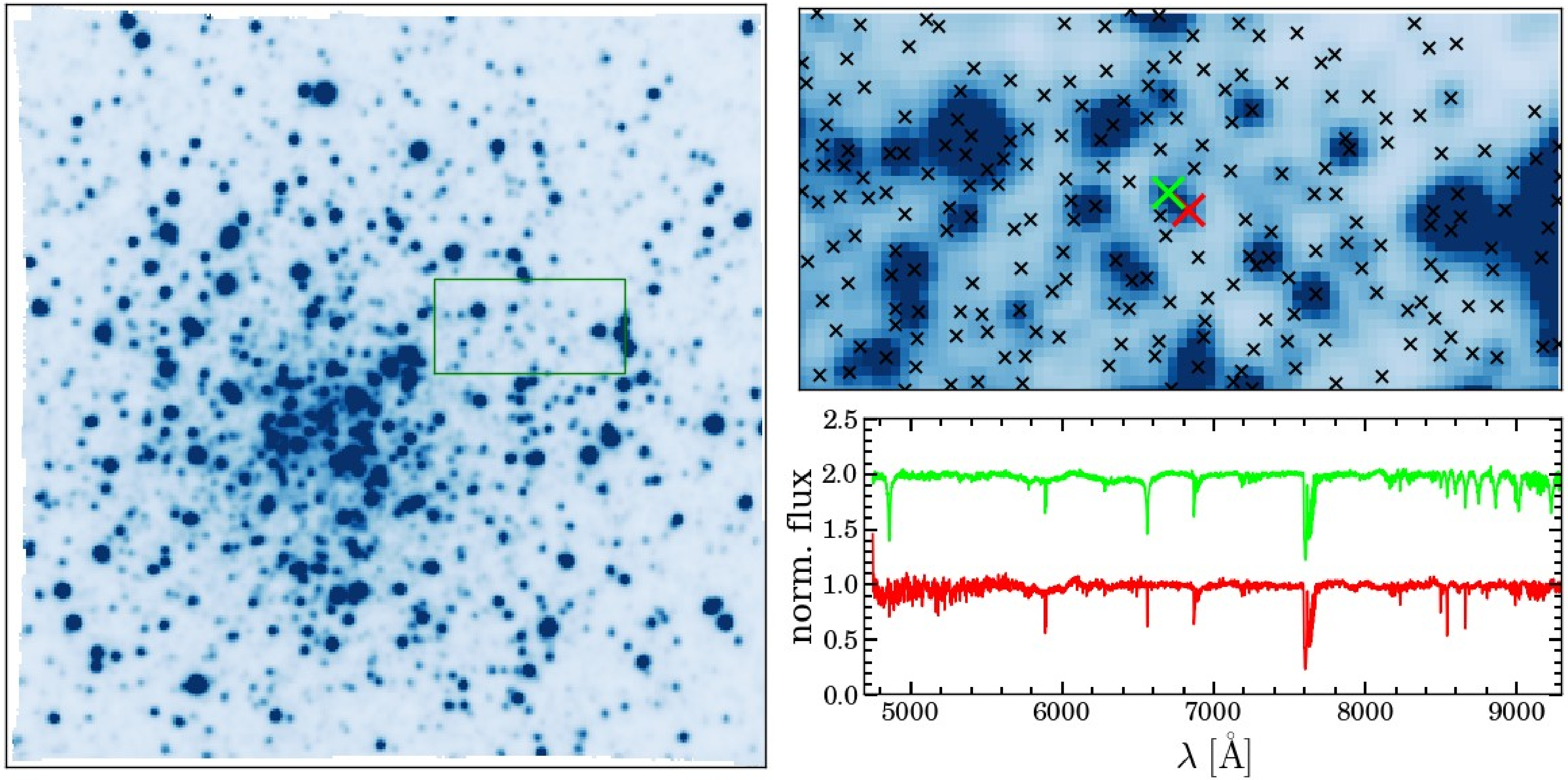
Advantages of using PSF fitting techniques

- S/N optimization
- Source deblending

Intermediate-mass black hole in M92?



3D spectroscopy with MUSE in NGC 6266



>5000 useful spectra, most of them not accessible via traditional spectroscopic techniques!

see Poster #15

Black-hole mass estimation of NGC 1097 with ALMA Cycle 0 Data

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[4]The University of Tokyo

BH plays an important role in galaxy evolution

- **(BH mass) – (host galaxy properties) relation**

  suggests the coevolution process of galaxy and BH.

  e.g., BH mass- host galaxy bulge luminosity, bulge mass,
  stellar velocity dispersion

- what kind of coevolution process they indicate?
- AGN feedback process? (DiMatteo et al. 2005; Sijacki et al. 2007)
- redshift dependence? (Peng et al. 2006; Sijacki et al. 2007)
- dependence on galaxy type? (McConnell & Ma 2013)
- no correlation for psudobulge hosts? (Kormendy & Ho 2013)

BH plays an important role in galaxy evolution?

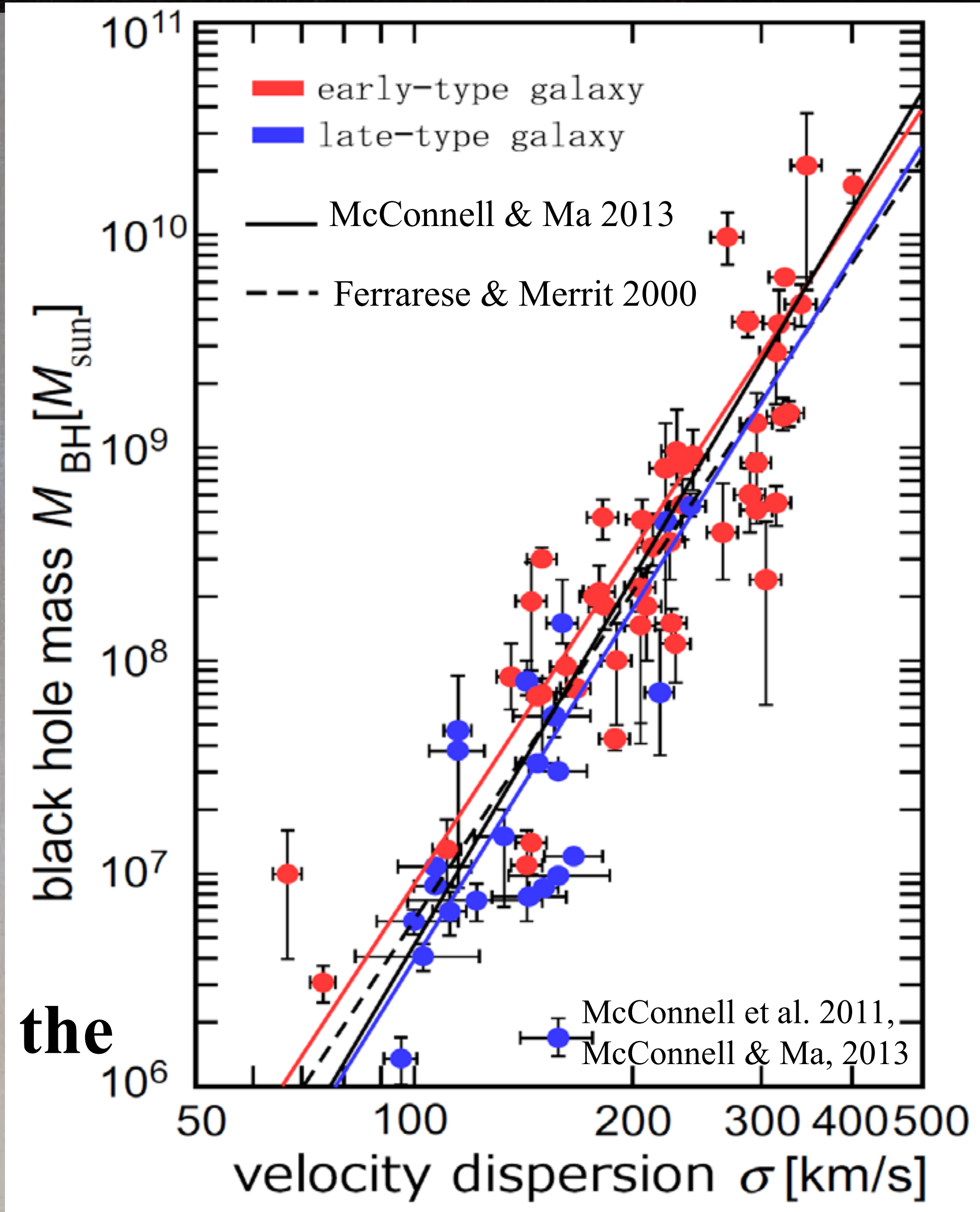
We need more samples to discuss on a couple of problems…

- **M_{BH}-σ relation**
  - the tightest correlation
  - indicates the coevolution process?
  - different trend with galaxy types?

    McConnell & Ma 2013
  - do not arise in psudobulge hosts?

    Kormendy & Ho 2013

Need more samples!

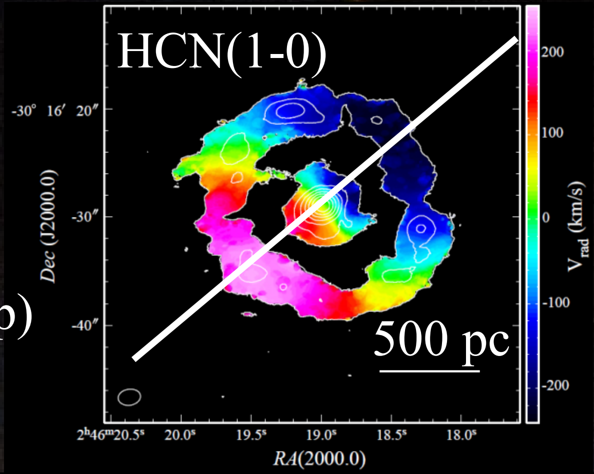


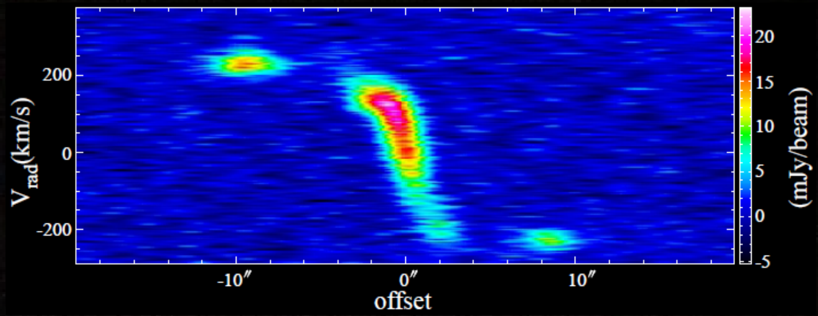
Increasing the number of galaxy samples is not straightforward. Using molecular gas dynamics is the most possible method!
(see Davis's talk on session 3!)

We used molecular gas dynamics to estimate the BH mass in NGC 1097

Observation :

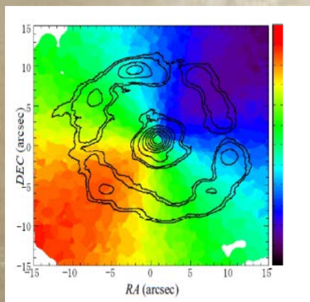
ALMA Cycle0
Band3
(Kohno et al. in prep)

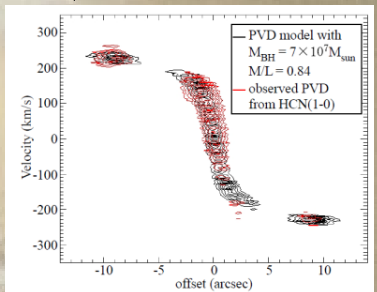




Model:

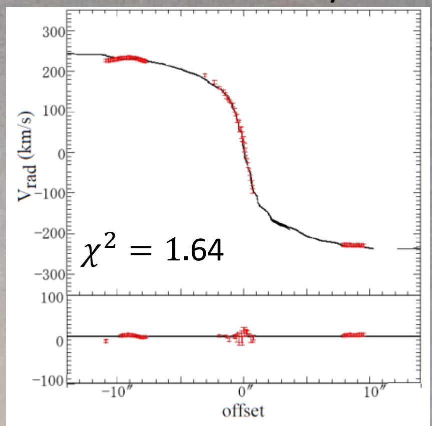
- mass profile (stellar mass + BH mass)
- velocity field (JAM, Cappellari 2008)
- observational effects (KinMS, Davis+ 2013)
- parameters : M/L ratio, BH mass

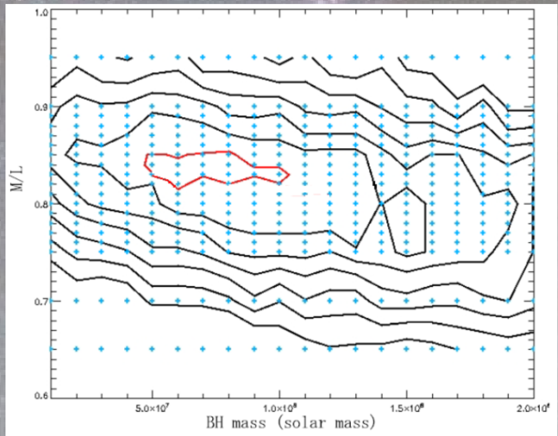




Fitting :

BH mass = $0.7^{+0.3}_{-0.2} \times 10^8 M_\odot$
M/L=0.84

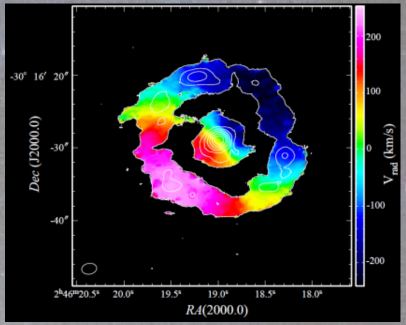




See Poster No. 28!

To summarize…

- BH plays an important role in galaxy evolution
- We need more samples to discuss on a couple of problems
- Increasing the number of galaxy samples is not straightforward
- Using the dynamics of molecular gas is the most possible method to increase the sample of measurable BH mass
- We estimated the BH mass of NGC 1097 with ALMA Cycle 0 data
  - HCN(1-0) and HCO^+(1-0) line was used to trace the velocity
  - derived BH mass is $0.7^{+0.3}_{-0.2} \times 10^8 M_\odot$



- Please come and see my poster No. 28!
- see also Dr. Timothy Davis's talk on session 3!