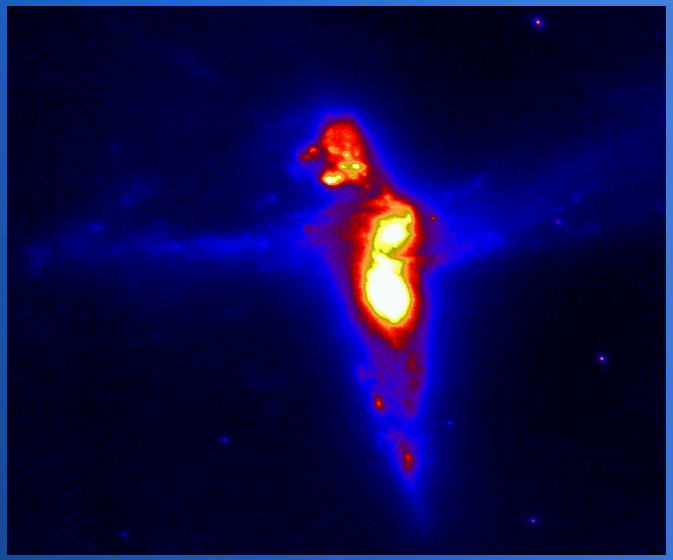
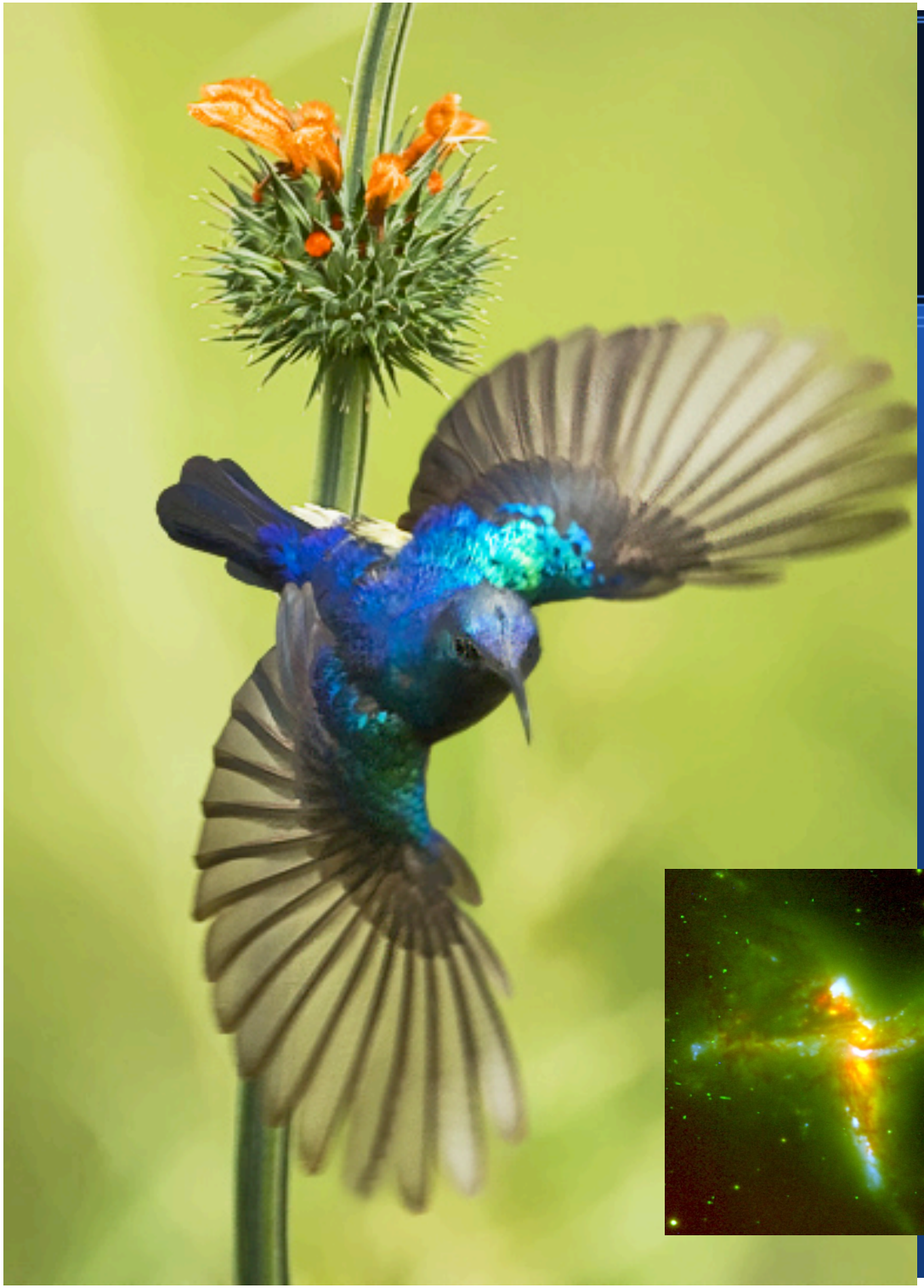
Time-stamping a LIRG merger



Petri Väisänen (SAAO / SALT)

Rajin Ramphul, Moses Mogotsi, Zara Randriamanakoto
Jari Kotilainen, Seppo Mattila, Juha Reunanen, Peter Johansson
Cristina Romero-Canizales, Jay Gallagher (UWisc), Miguel Perez-Torres (Granada),
Stuart Ryder (Gemini/AAO)



SUNBIRD -

SuperNovae & star-Bursts in the InfraRed

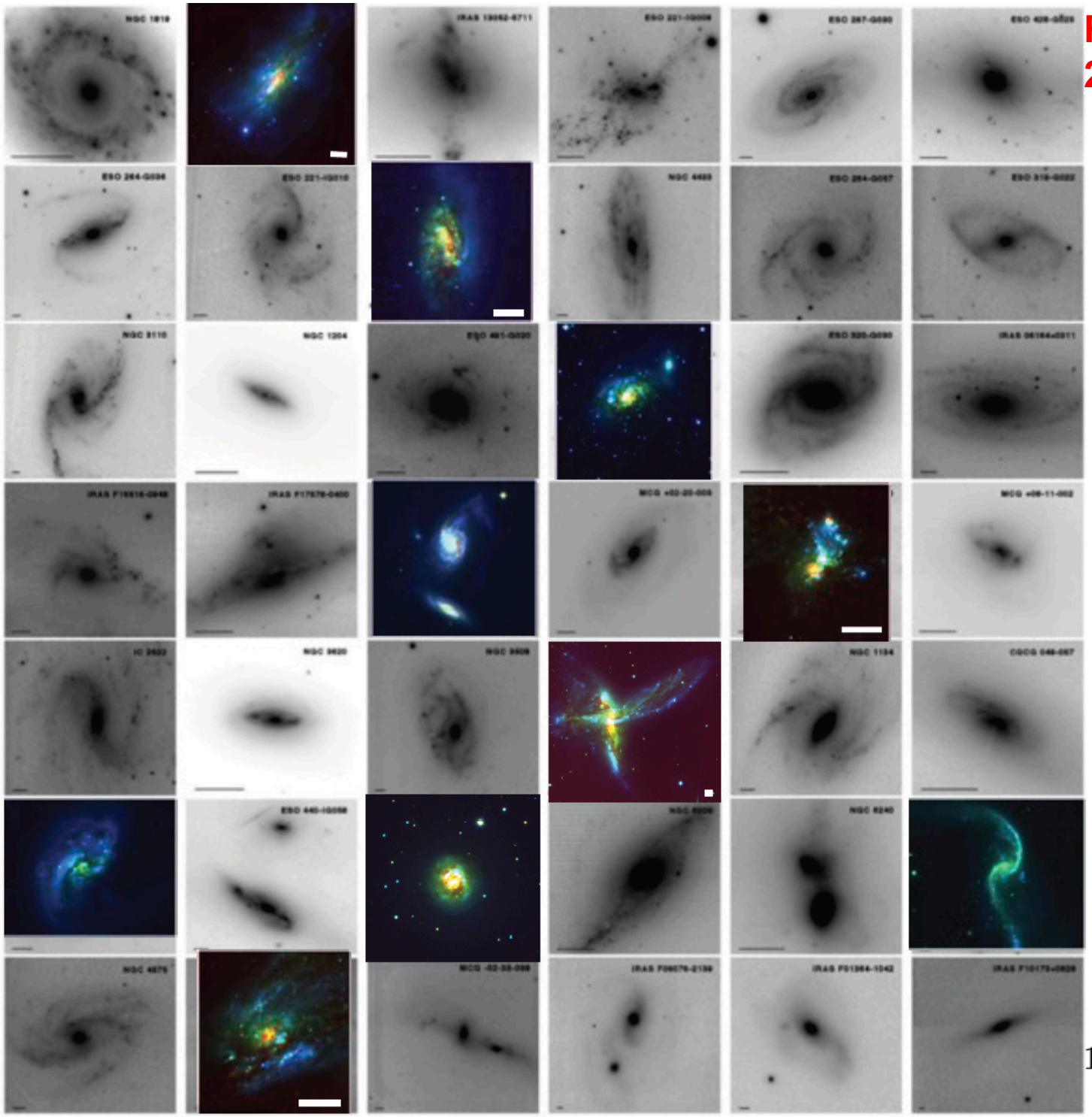
VLT/NACO/Sinfoni and Gemini/Altair/GEMS **adaptive optics imaging** in the NIR

SALT spectroscopy

+ archival HST, Spitzer

~ 40 LIRGS
~ 40 lower lum SBs

Mainly 20-100 Mpc



Randriamanakoto et al. 2013a,b

The sample

~40 infrared luminous galaxies

PSF resolution ~ 0.1”

- VLT & Gemini
- HST
- eVLA

$$30 \lesssim D_L(\mathrm{Mpc}) \lesssim 200$$

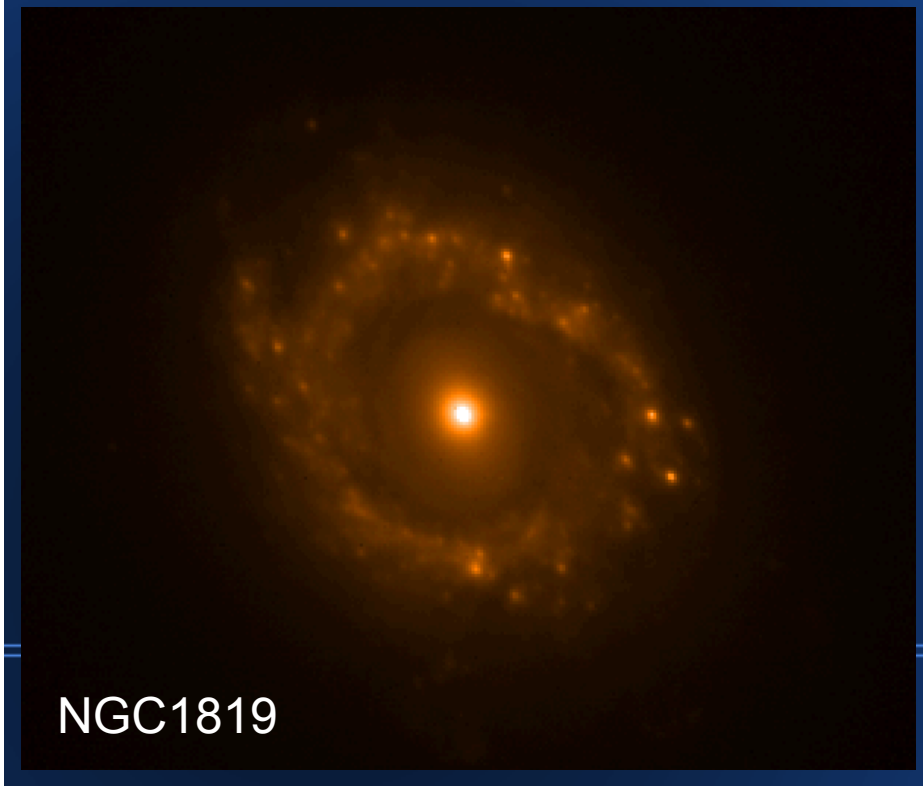
$$10.59 \leq \log L_{IR}(\mathrm{L}_\odot) \leq 11.87$$

Young massive clusters

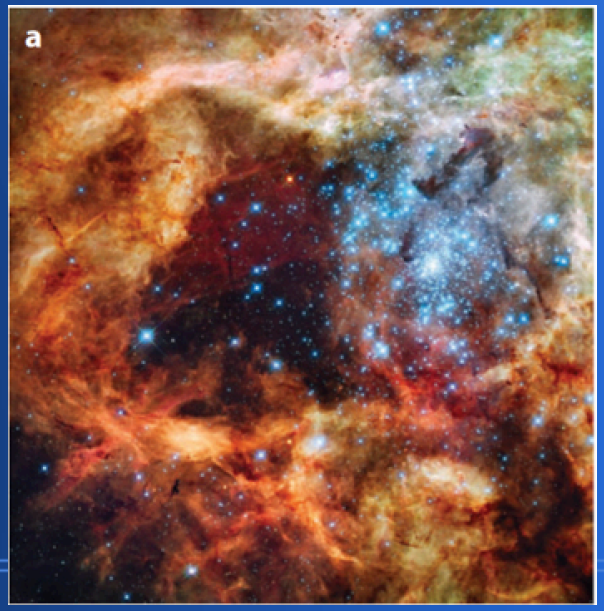
Most massive population of stellar clusters.

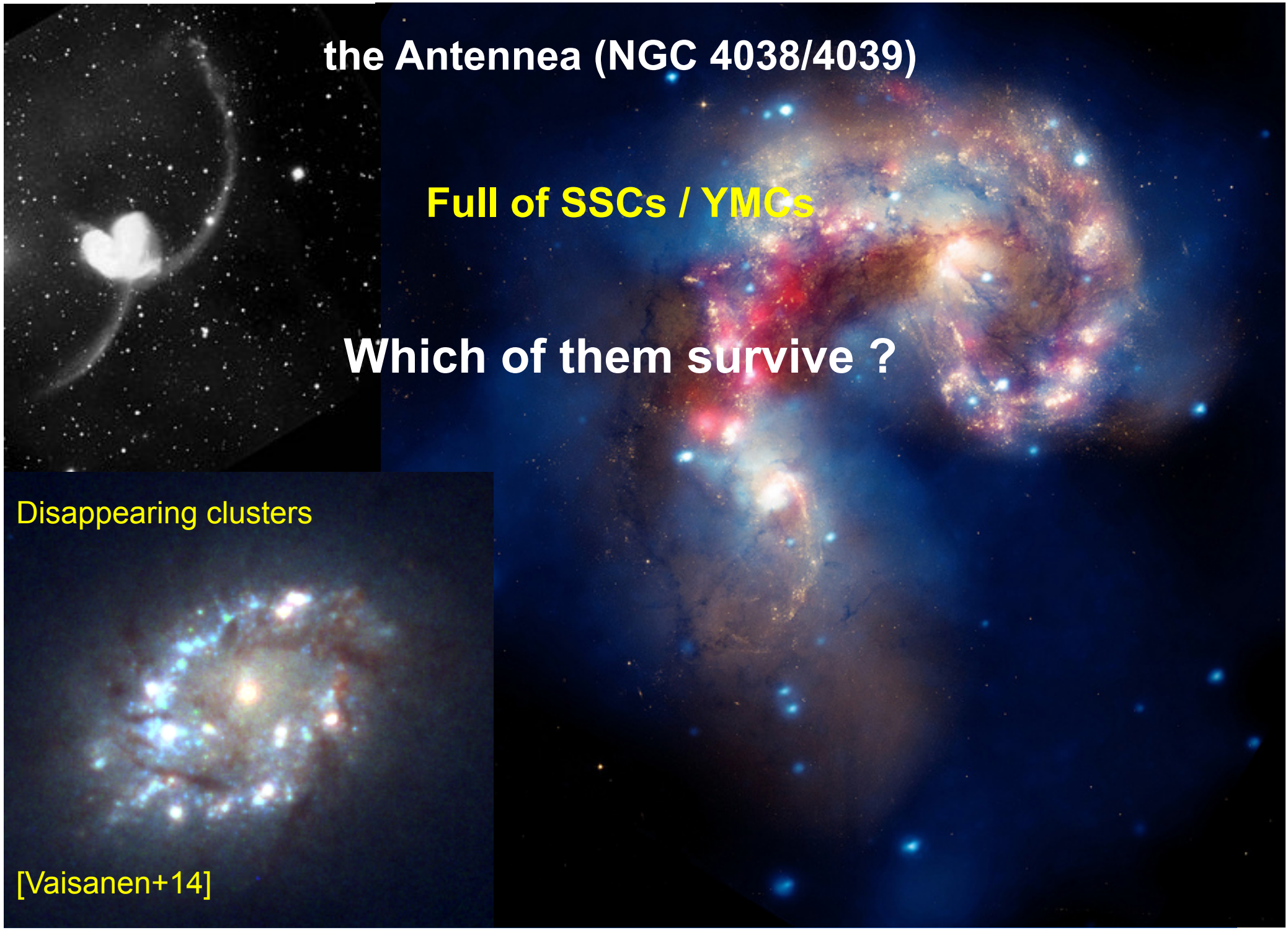
Globular cluster progenitors ?

Are cluster formation and disruption affected by the host galaxy conditions ?



NGC1819




the Antennea (NGC 4038/4039)
Full of SSCs / YMCs
Which of them survive ?
Disappearing clusters
[Vaisanen+14]

MNRAS **431,** 554–569 (2013)
Advance Access publication 2013 March 07
doi:10.1093/mnras/stt185

The *K*-band luminosity functions of super star clusters in luminous infrared galaxies, their slopes and the effects of blending

Z. Randriamanakoto,[1,2]★ P. Väisänen,[1,3] S. Ryder,[4] E. Kankare,[5] J. Kotilainen[6] and S. Mattila[5,6]

[1]*South African Astronomical Observatory, PO Box 9, Observatory, Cape Town, South Africa*

THE ASTROPHYSICAL JOURNAL LETTERS, 797:L16 (5pp), 2014 December 20
doi:10.1088/2041-8205/797/2/L16

STAR CLUSTERS IN A NUCLEAR STAR FORMING RING: THE DISAPPEARING STRING OF PEARLS

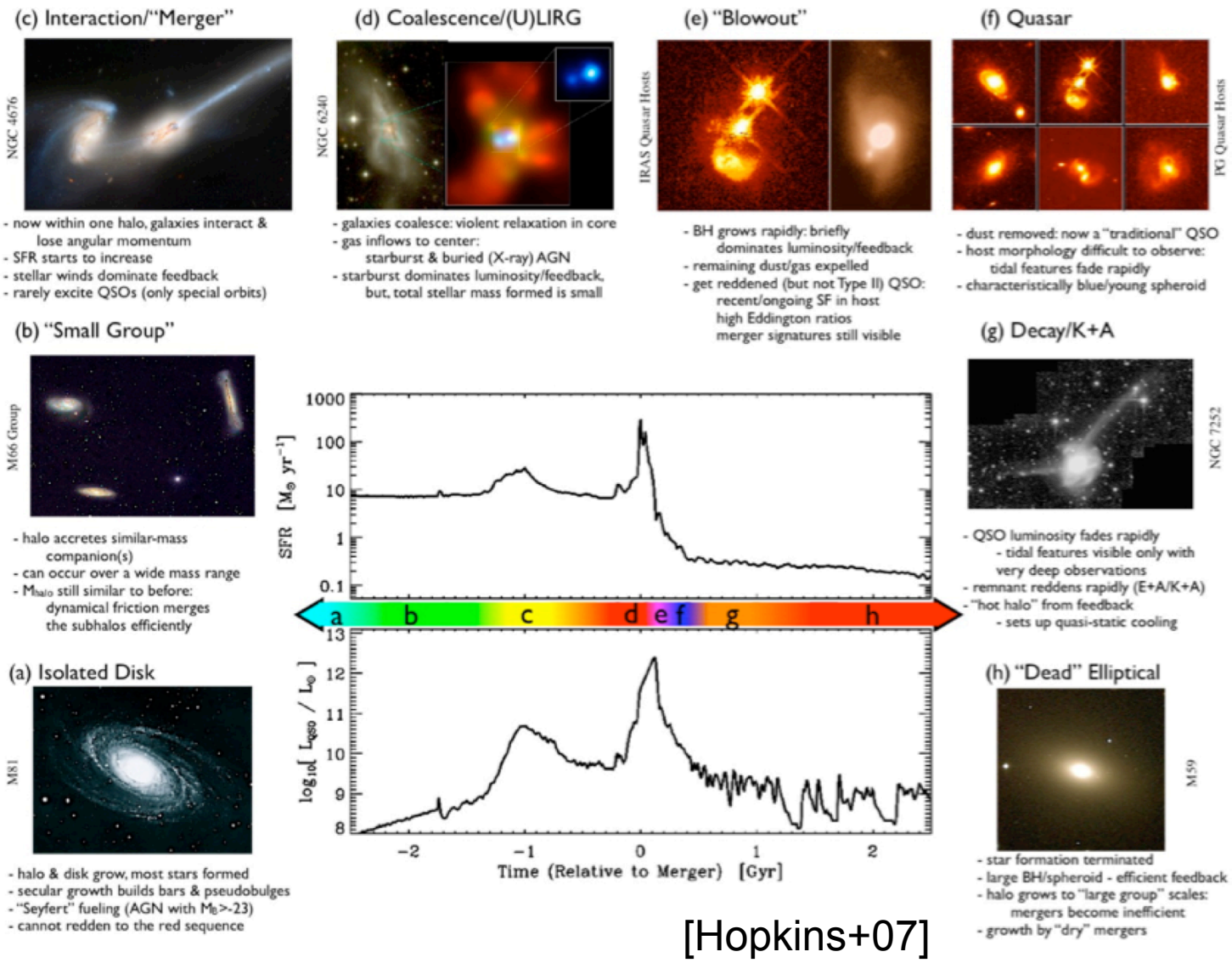
PETRI VÄISÄNEN[1,2], SUDHANSHU BARWAY[1], AND ZARA RANDRIAMANAKOTO[1,3]
[1] South African Astronomical Observatory, P.O. Box 9 Observatory, Cape Town, South Africa; petri@saao.ac.za

THE ASTROPHYSICAL JOURNAL LETTERS, 775:L38 (6pp), 2013 October 1
doi:10.1088/2041-8205/775/2/L38

NEAR-INFRARED ADAPTIVE OPTICS IMAGING OF INFRARED LUMINOUS GALAXIES: THE BRIGHTEST CLUSTER MAGNITUDE–STAR FORMATION RATE RELATION

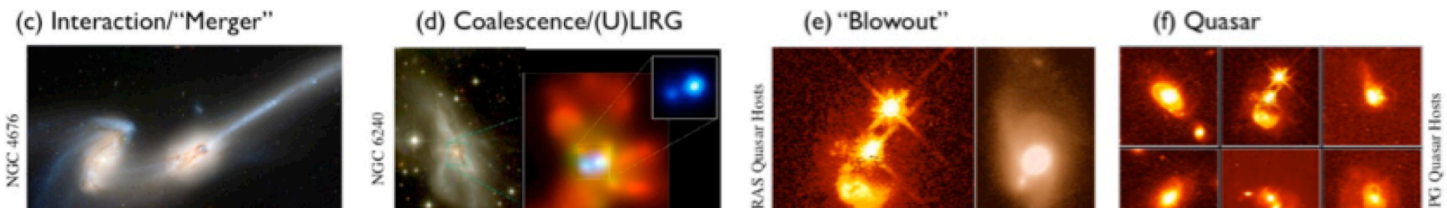
Z. RANDRIAMANAKOTO[1,2], A. ESCALA[3], P. VÄISÄNEN[1,4], E. KANKARE[5], J. KOTILAINEN[5], S. MATTILA[5], AND S. RYDER[6]
[1] South African Astronomical Observatory, P.O. Box 9, 7935 Observatory, Cape Town, South Africa; zara@saao.ac.za

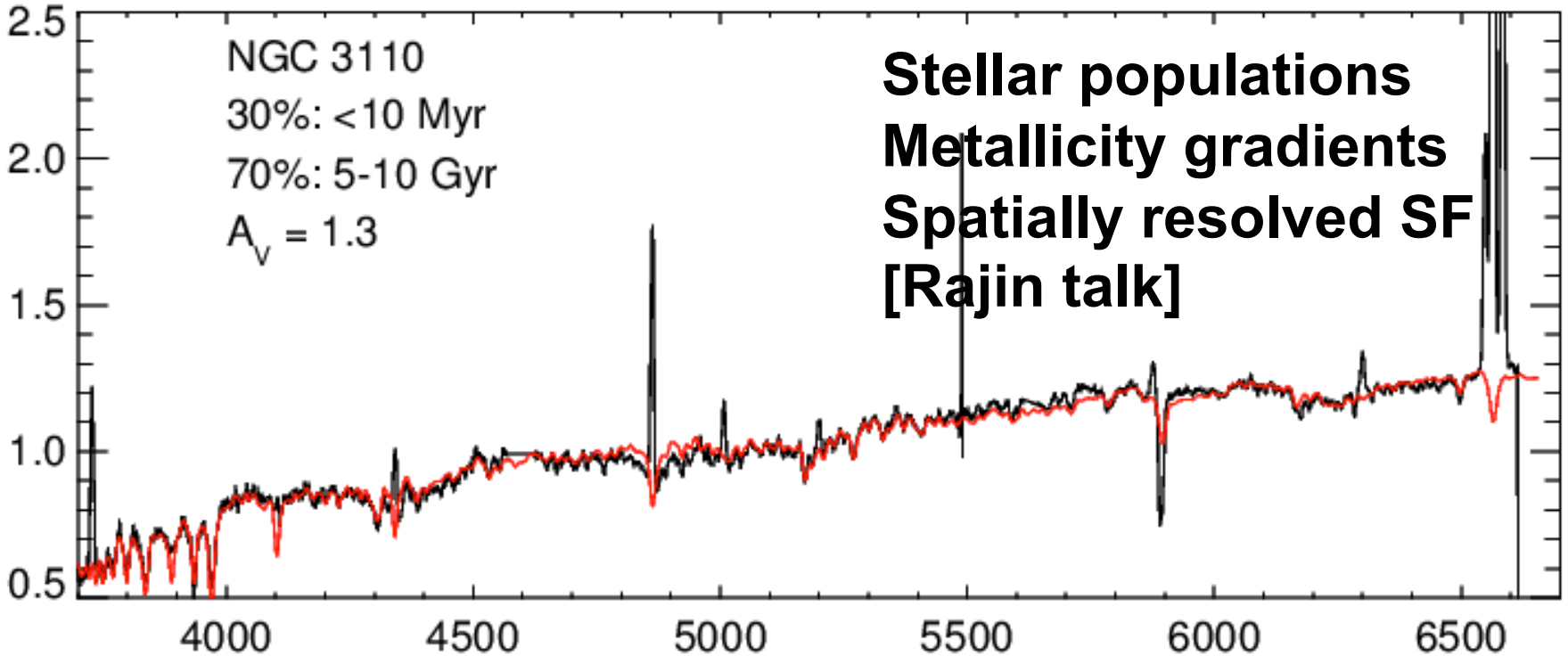
LIRG evolution



[Hopkins+07]

LIRG evolution





Stellar populations
Metallicity gradients
Spatially resolved SF
[Rajin talk]

[Hopkins+07]

Mon. Not. R. Astron. Soc. **384,** 886–906 (2008) doi:10.1111/j.1365-2966.2007.12703.x

Adaptive optics imaging and optical spectroscopy of a multiple merger in a luminous infrared galaxy★

P. Väisänen,[1]† S. Mattila,[2,3] A. Kniazev,[1] A. Adamo,[4] A. Efstathiou,[5] D. Farrah,[6] P. H. Johansson,[7] G. Östlin,[4] D. A. H. Buckley,[1] E. B. Burgh,[8] L. Crause,[1] Y. Hashimoto,[1] P. Lira,[9] N. Loaring,[1] K. Nordsieck,[8] E. Romero-Colmenero,[1] S. Ryder,[10] M. Still[1] and A. Zijlstra[1,11]

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THE ASTROPHYSICAL JOURNAL, 689: L37–L40, 2008 December 10

A PAIR OF LEADING SPIRAL ARMS IN A LUMINOUS INFRARED GALAXY?[1]

PETRI VÄISÄNEN,[2] STUART RYDER,[3] SEPPO MATTILA,[4] AND JARI KOTILAINEN[4]

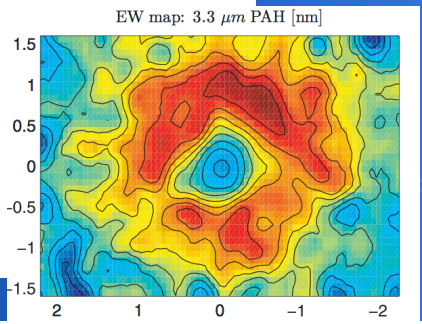
Received 2008 August 28; accepted 2008 October 16; published 2008 November 5

Mon. Not. R. Astron. Soc. **420,** 2209–2220 (2012) doi:10.1111/j.1365-2966.2011.20186.x

The nuclear polycyclic aromatic hydrocarbon emission of merger system NGC 1614: rings within rings

Petri Väisänen,[1,2★] Vinesh Rajpaul,[3] Albert A. Zijlstra,[4] Juha Reunanen[5] and Jari Kotilainen[6]

[1]*South African Astronomical Observatory, PO Box 9, Observatory 7935, Cape Town, South Africa*



The Astrophysical Journal, 786:156 (12pp), 2014 May 10 doi:10.1088/0004-637X/786/2/156

A MULTI-WAVELENGTH VIEW OF THE CENTRAL KILOPARSEC REGION IN THE LUMINOUS INFRARED GALAXY NGC 1614

Rubén Herrero-Illana[1], Miguel Á. Pérez-Torres[1,2,3], Almudena Alonso-Herrero[4,13], Antxon Alberdi[1], Luis Colina[5], Andreas Efstathiou[6], Lorena Hernández-García[1], Daniel Miralles-Caballero[7], Petri Väisänen[8,9], Christopher C. Packham[10], Vinesh Rajpaul[11], and Albert A. Zijlstra[12]
[1] Instituto de Astrofísica de Andalucía-CSIC, P.O. Box 3004, E-18008 Granada, Spain

MNRAS **471,** 2059–2076 (2017) doi:10.1093/mnras/stx1685
Advance Access publication 2017 July 21

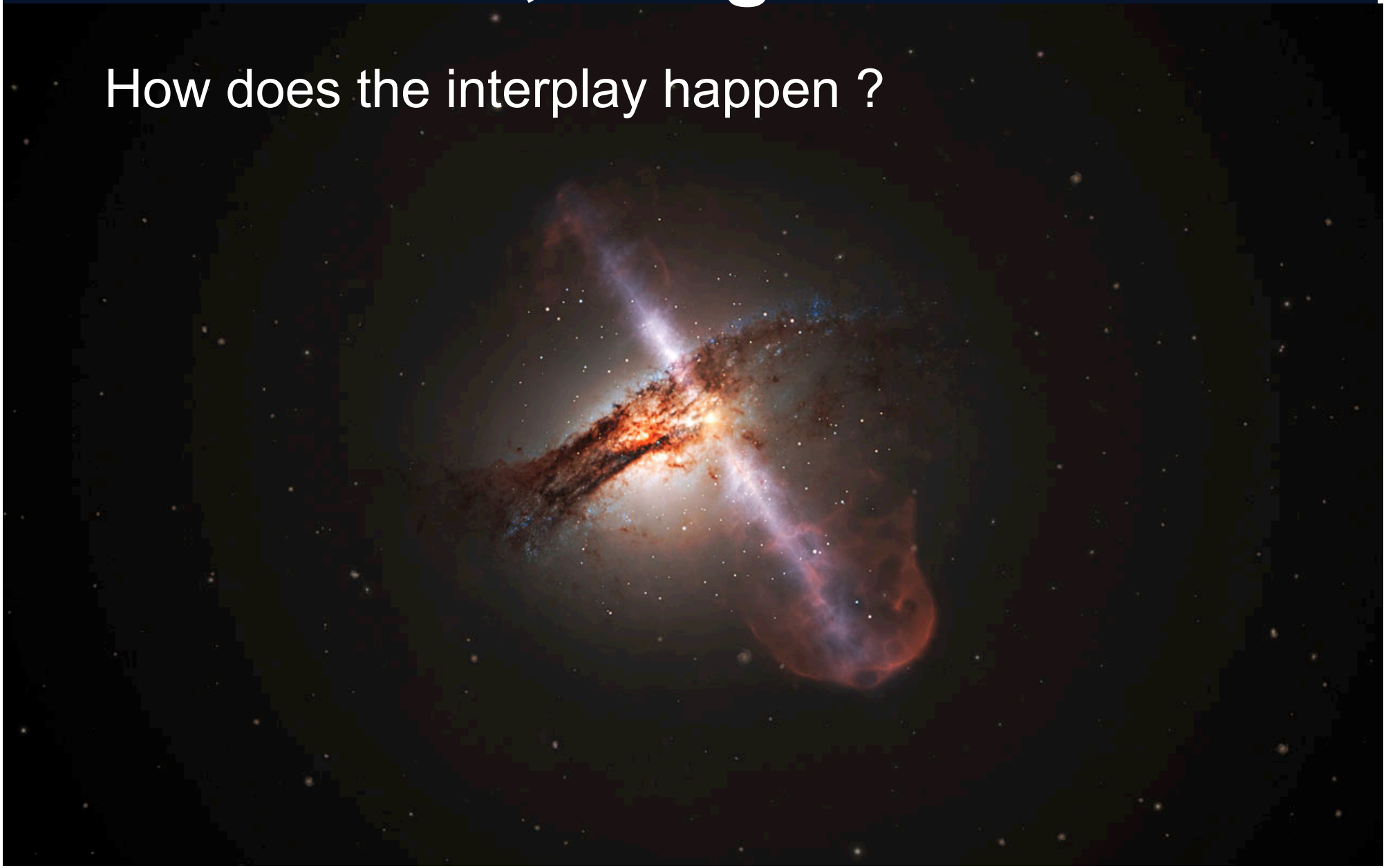
Shutting down or powering up a (U)LIRG? Merger components in distinctly different evolutionary states in IRAS 19115−2124 (the Bird)

Petri Väisänen,[1,2★] Juha Reunanen,[3] Jari Kotilainen,[3,4] Seppo Mattila,[4] Peter H. Johansson,[5] Rajin Ramphul,[1,6] Cristina Romero-Cañizales[7,8] and Hanindyo Kuncarayakti[3,4]

[1]*South African Astronomical Observatory, PO Box 9, Observatory, 7935 Cape Town, South Africa*

Starbursts, mergers and AGN

How does the interplay happen ?



Starbursts, mergers and AGN

MNRAS **471,** 1634–1651 (2017)
Advance Access publication 2017 July 5
doi:10.1093/mnras/stx1672

Star formation and AGN activity in a sample of local luminous infrared galaxies through multiwavelength characterization

Rubén Herrero-Illana,[1,2★] Miguel Á. Pérez-Torres,[1,3] Zara Randriamanakoto,[4] Antxon Alberdi,[1] Andreas Efstathiou,[5] Petri Väisänen,[6,7] Erkki Kankare,[8] Erik Kool,[9,10] Seppo Mattila,[11,12] Rajin Ramphul[4,6] and Stuart Ryder[9]

[1] *Instituto de Astrofísica de Andalucía (IAA-CSIC), Glorieta de la Astronomía s/n, E-18008 Granada, Spain*

A&A 543, A72 (2012)
DOI: 10.1051/0004-6361/201218816

Astronomy & Astrophysics

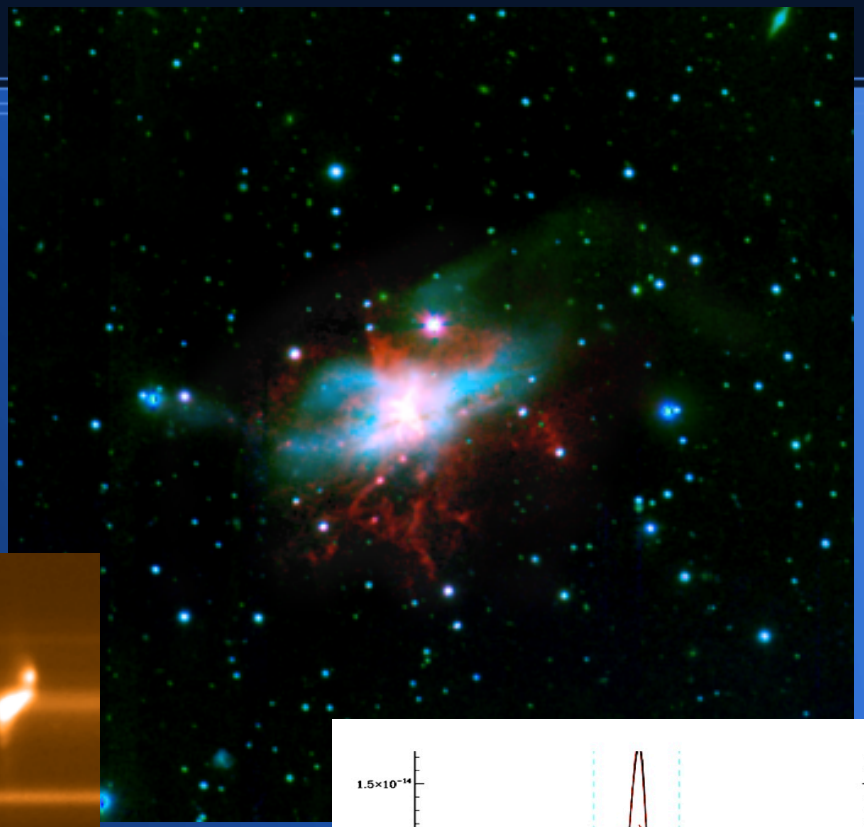
e-MERLIN and VLBI observations of the luminous infrared galaxy IC 883: a nuclear starburst and an AGN candidate revealed

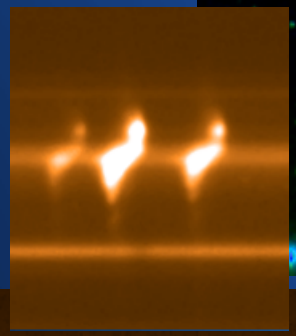
C. Romero-Cañizales[1,2], M. A. Pérez-Torres[1], A. Alberdi[1], M. K. Argo[3,4], R. J. Beswick[4], E. Kankare[2], F. Batejat[5], A. Efstathiou[6], S. Mattila[2], J. E. Conway[5], S. T. Garrington[4], T. W. B. Muxlow[4], S. D. Ryder[7], and P. Väisänen[8]

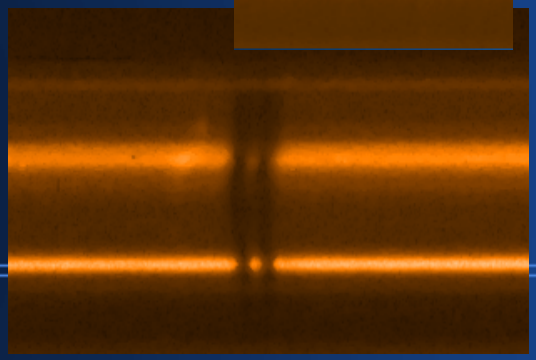
[1] Instituto de Astrofísica de Andalucía – CSIC, PO Box 3004, 18008 Granada, Spain

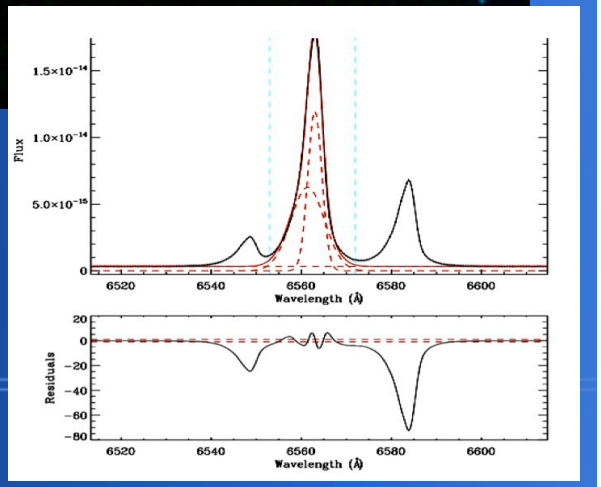
Gas outflows

- Fundamental part of general galaxy evolution models
- But how do gas flows work, as a function of type, environment, and how far do they reach
- Fast and massive? Or e.g. “dripping faucet” type?

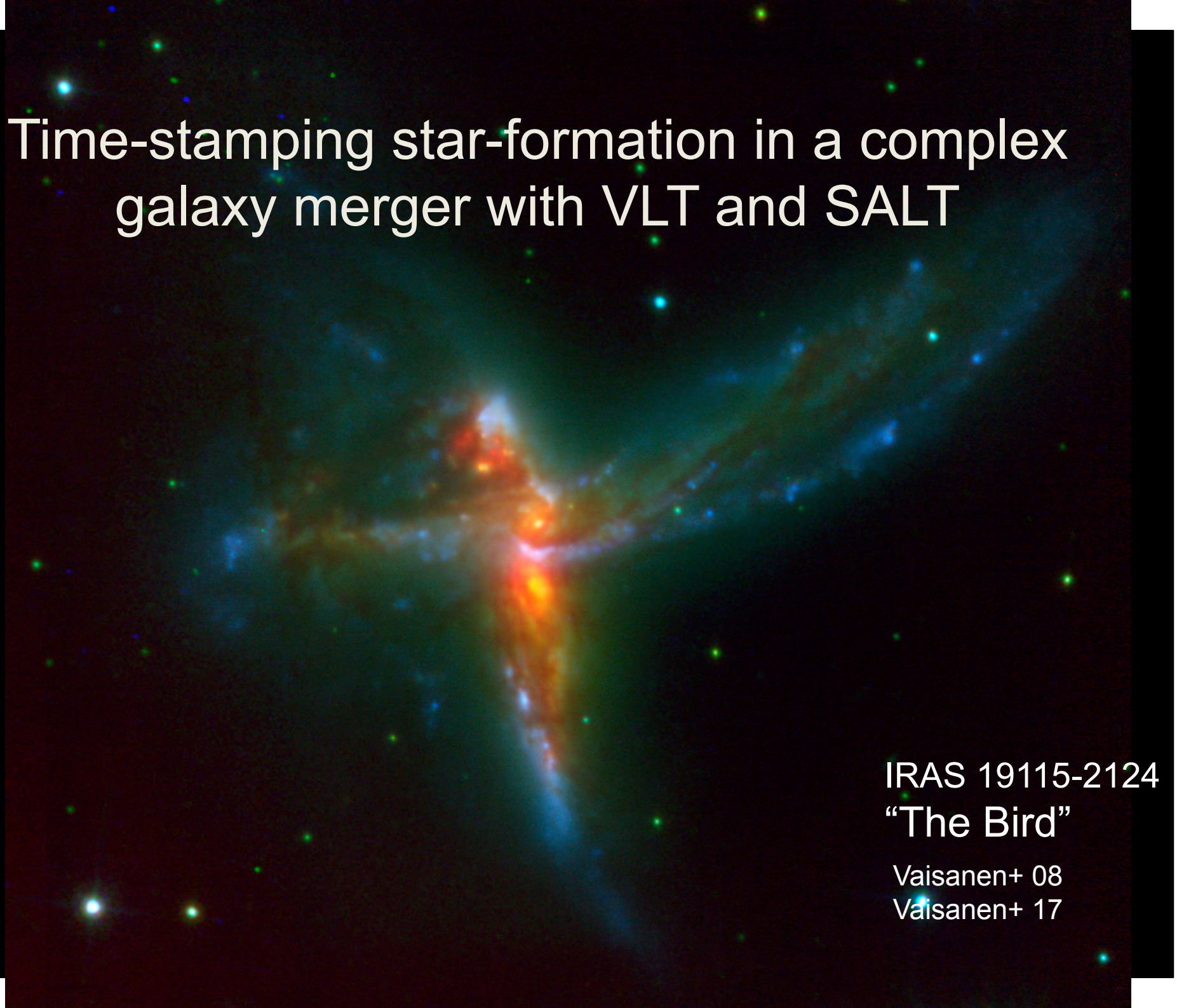








Time-stamping star-formation in a complex galaxy merger with VLT and SALT



IRAS 19115-2124

"The Bird"

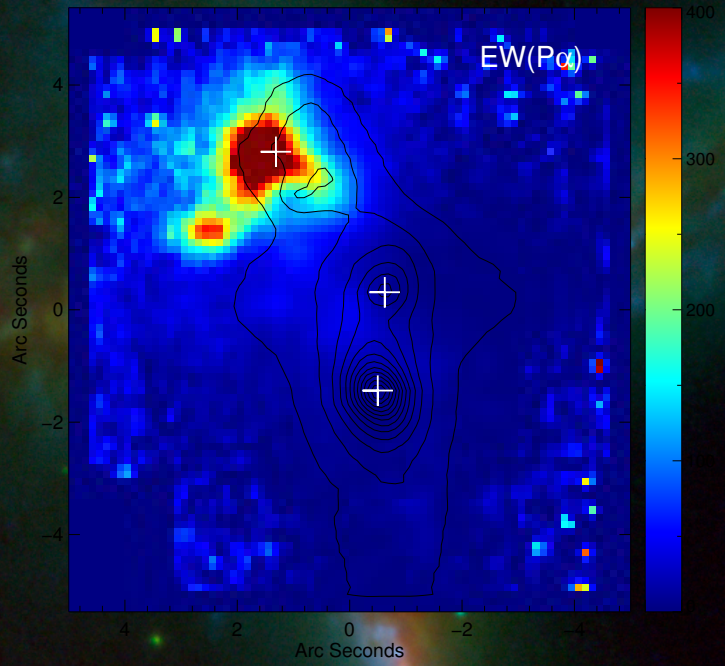
Vaisanen+ 08

Vaisanen+ 17

IRAS 19115-2124
"The Bird"

Vaisanen+ 08
Vaisanen+ 17

SF dominated by a minor component [VLT/Sinfoni]

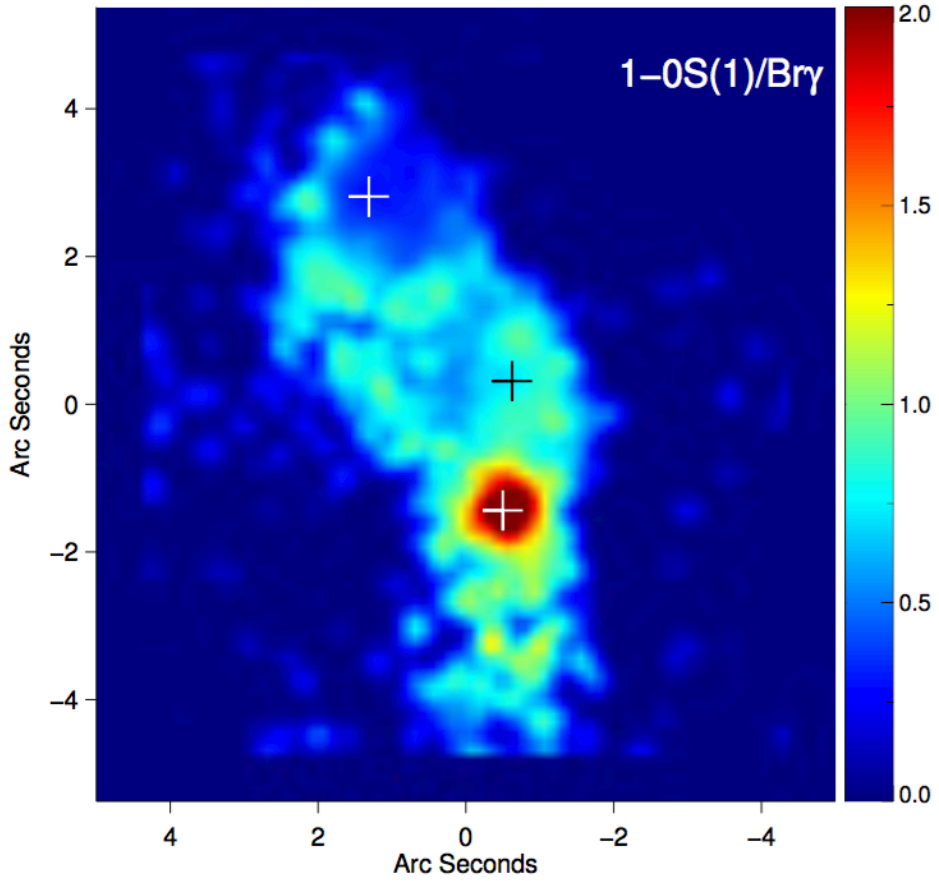


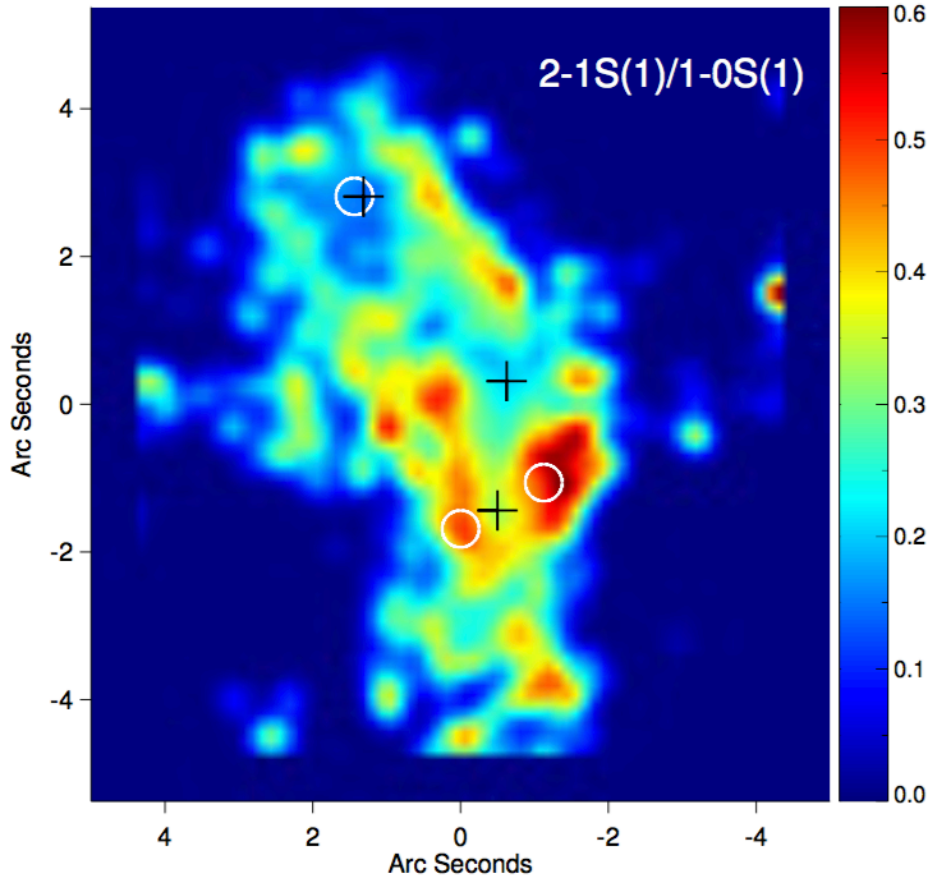
IRAS 19115-2124
"The Bird"

Vaisanen+ 08
Vaisanen+ 17

Shock heating around the nuclei

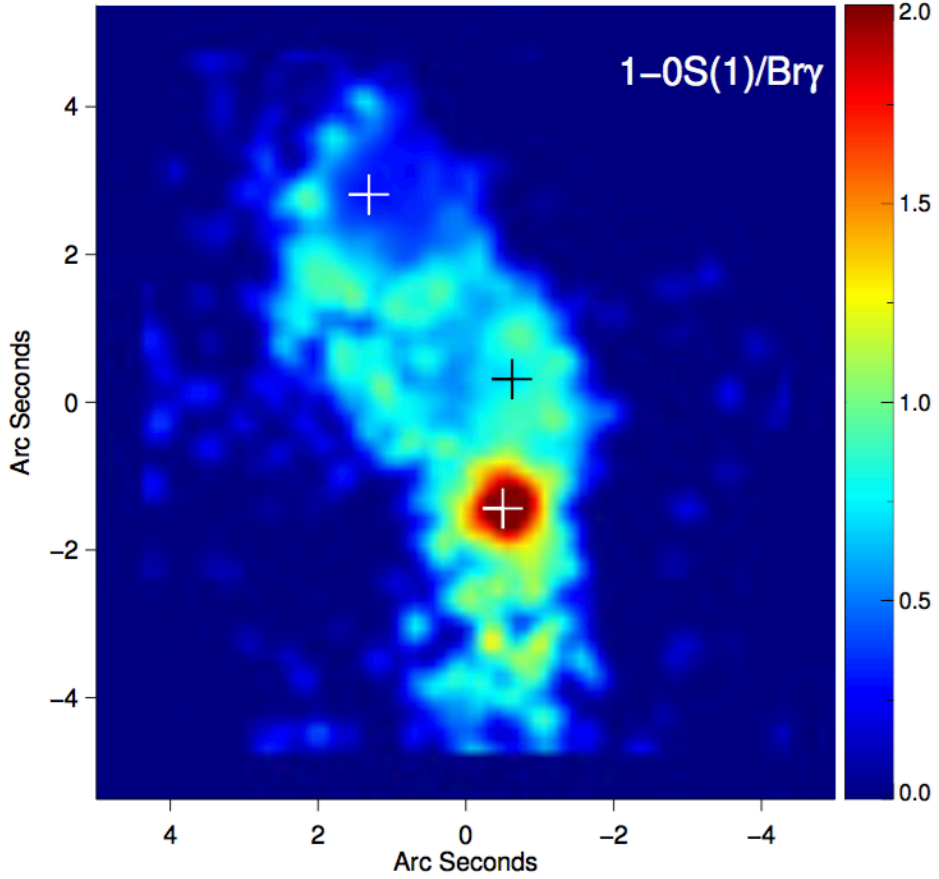
Sinfoni J+K cubes (line ratios)

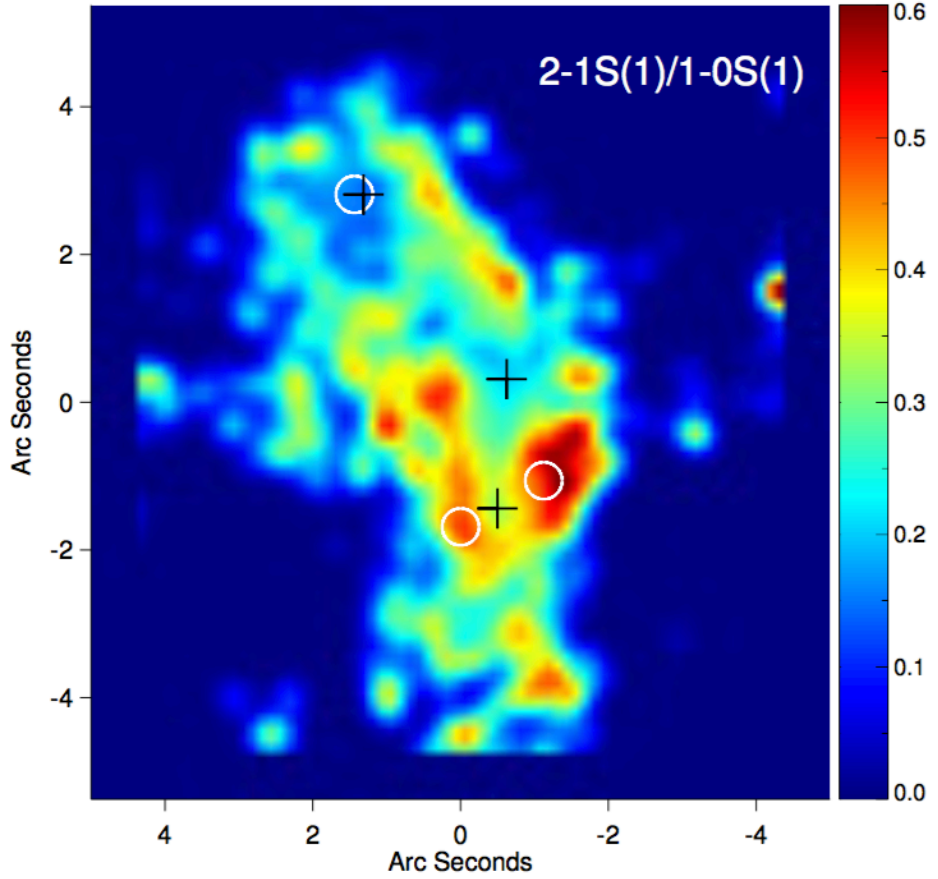




Budding AGN activity in massive component ?

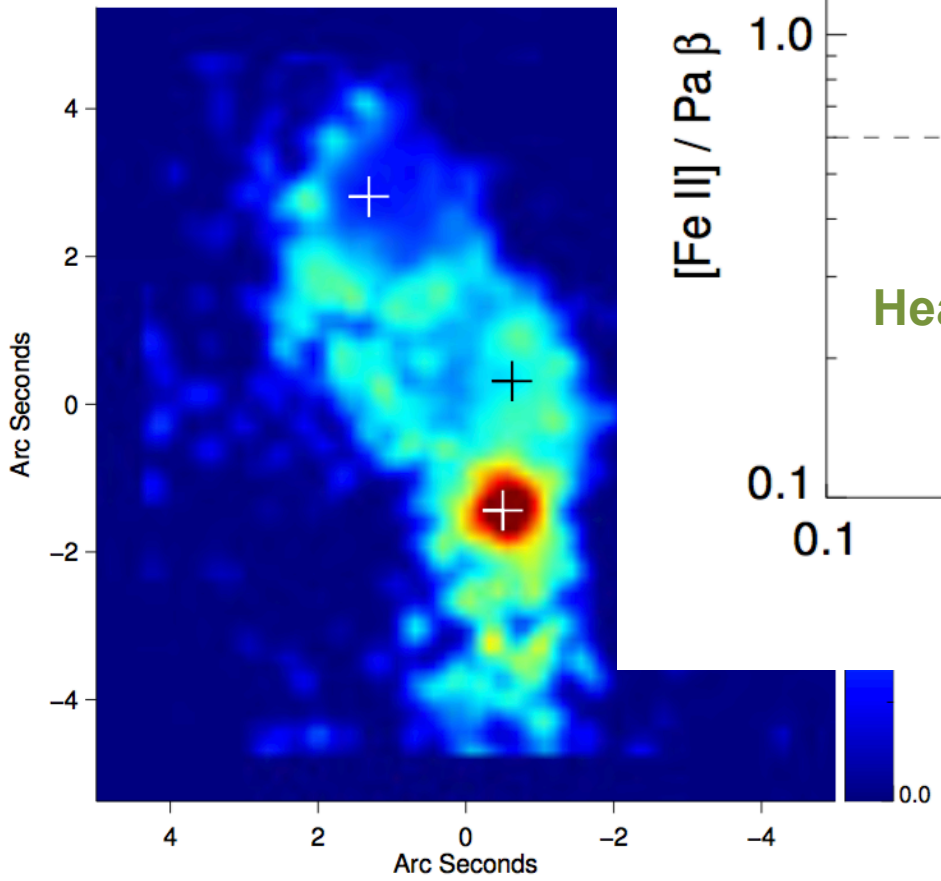
Sinfoni J+K cubes (line ratios)

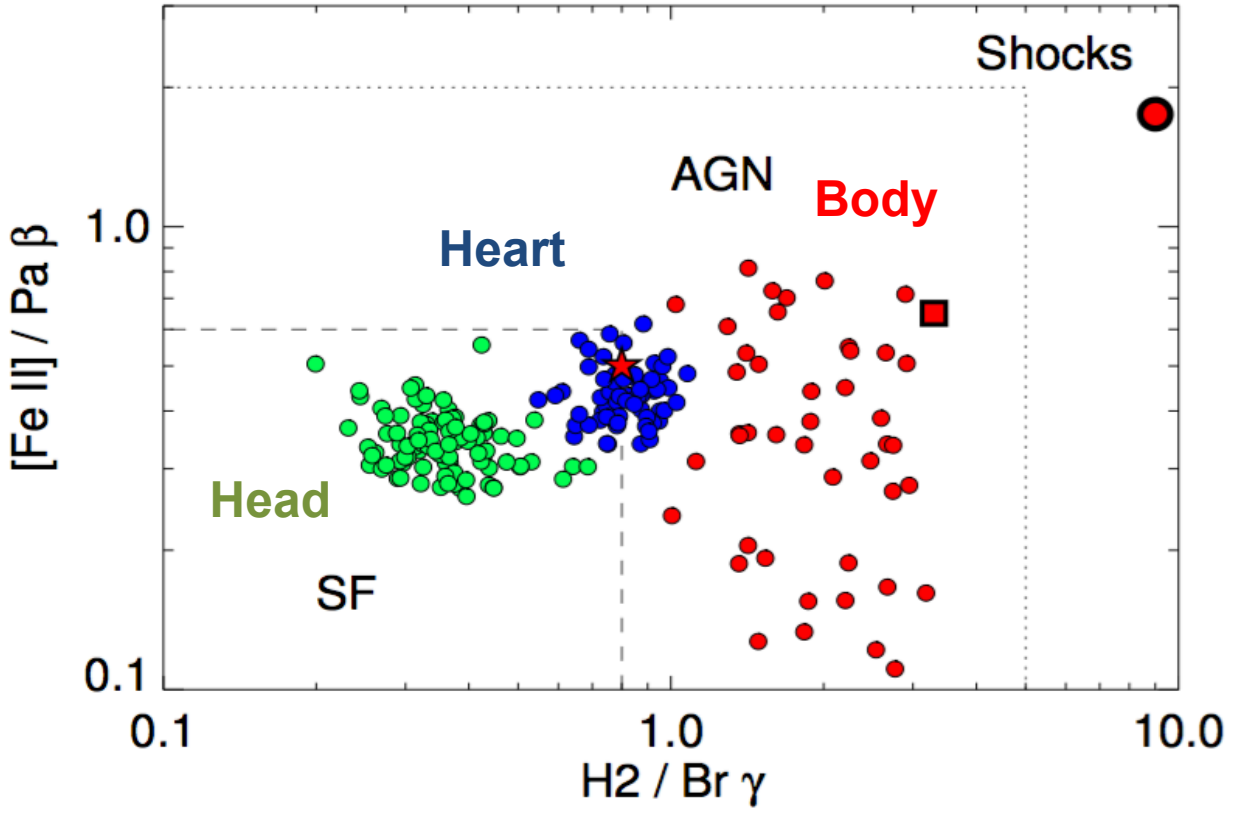


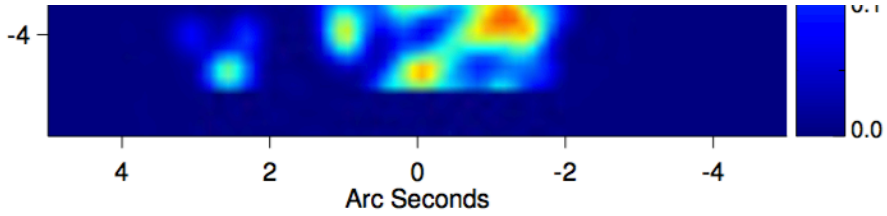


Budding AGN activity in massive component ?

Sinfoni J+K cubes (li

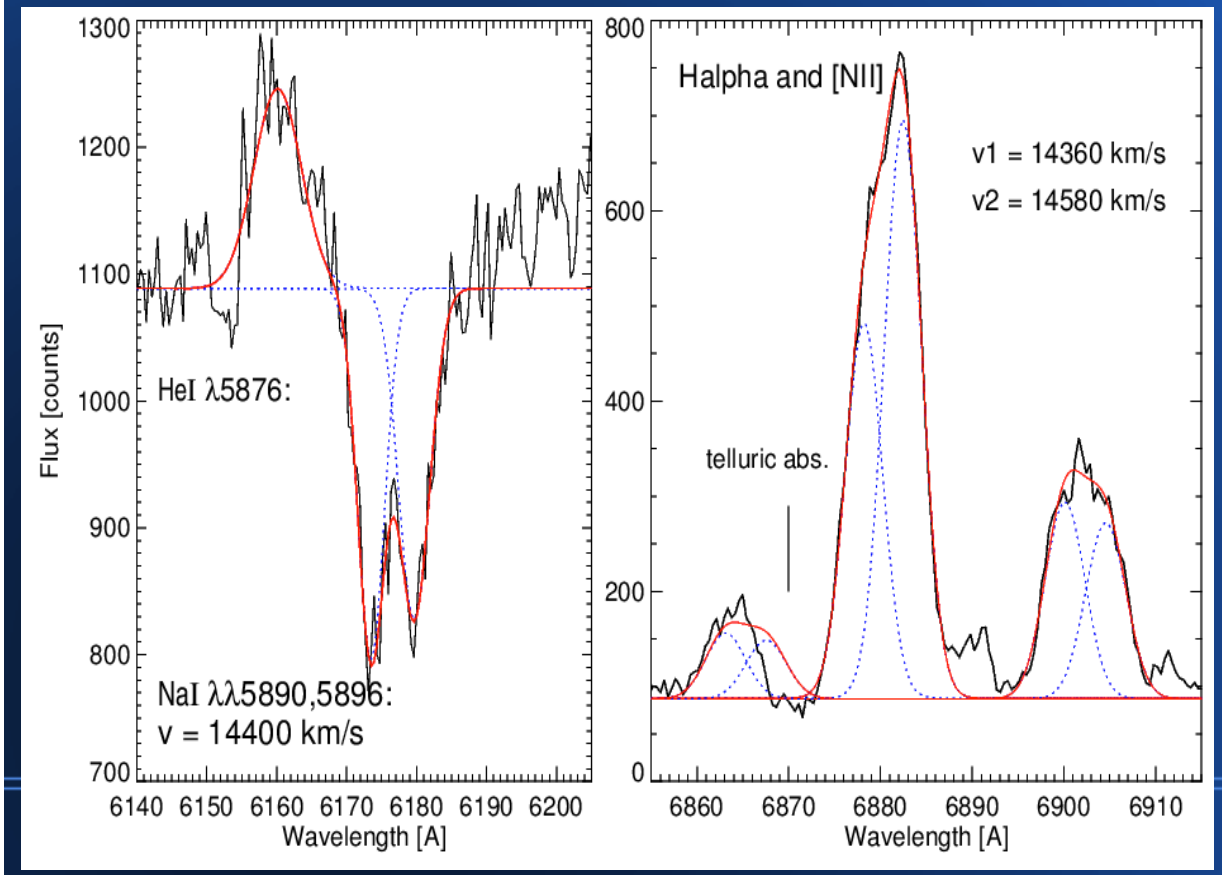


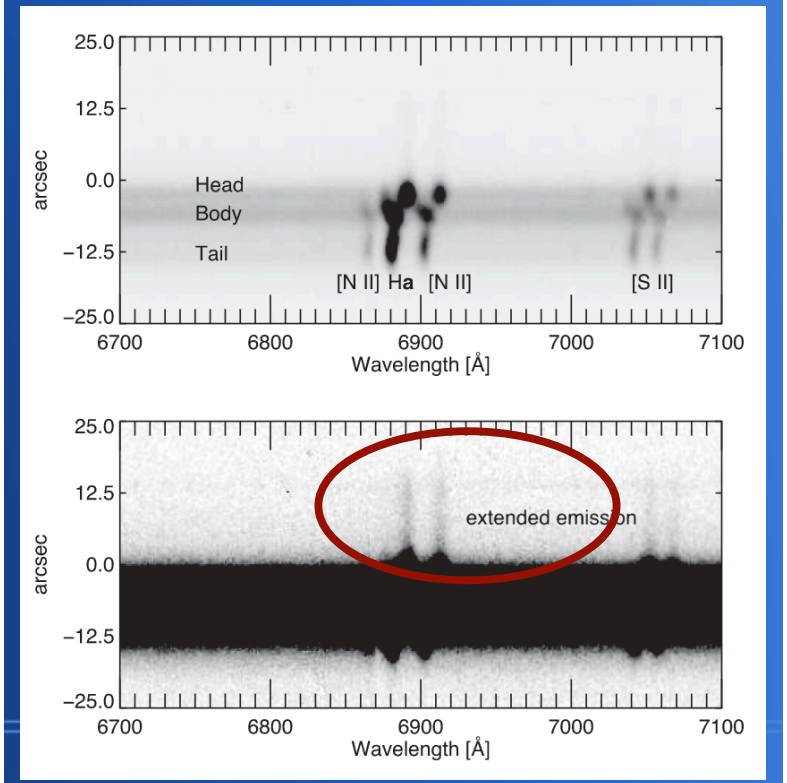




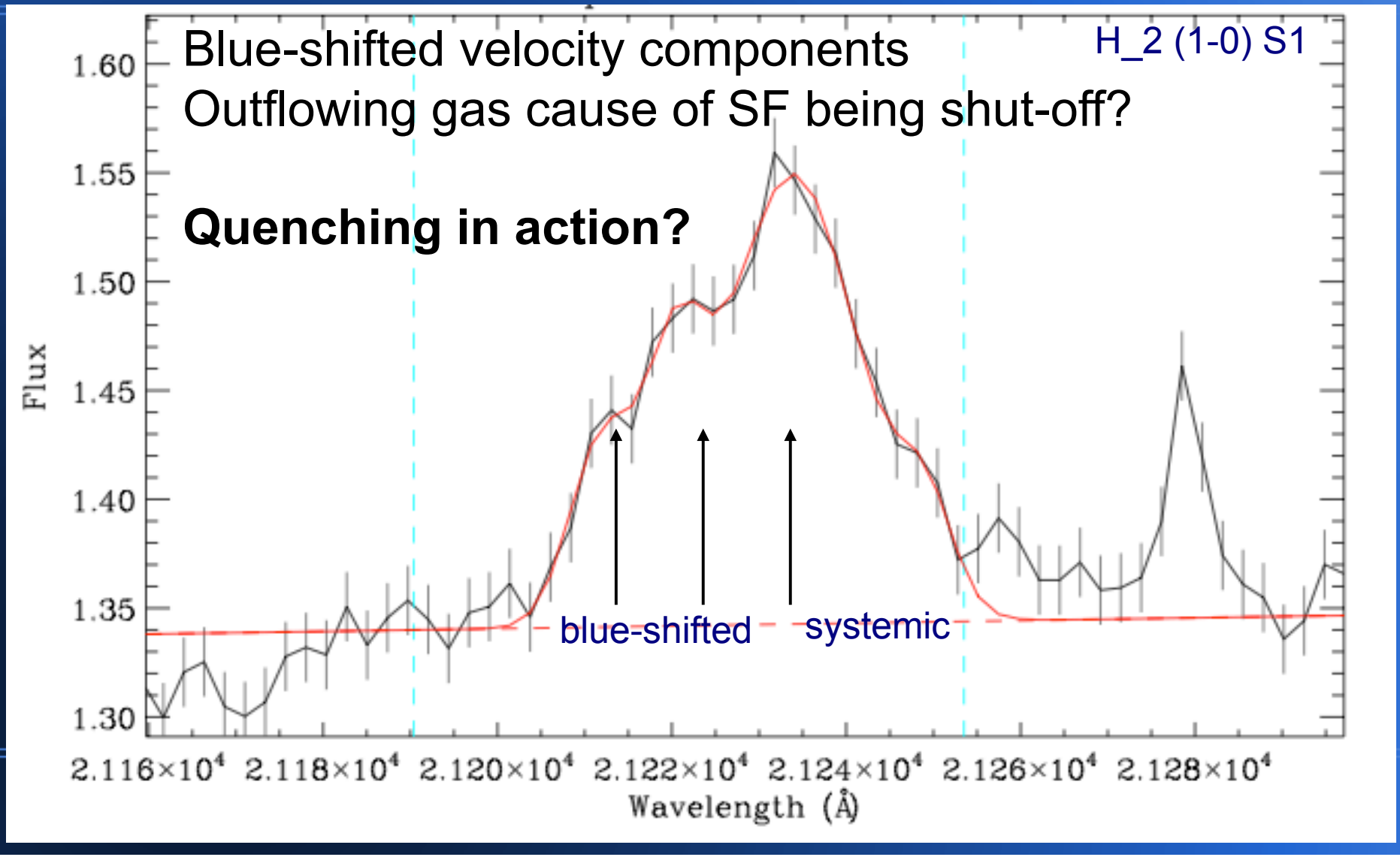
Gas flows

Blue-shifted velocity components all over



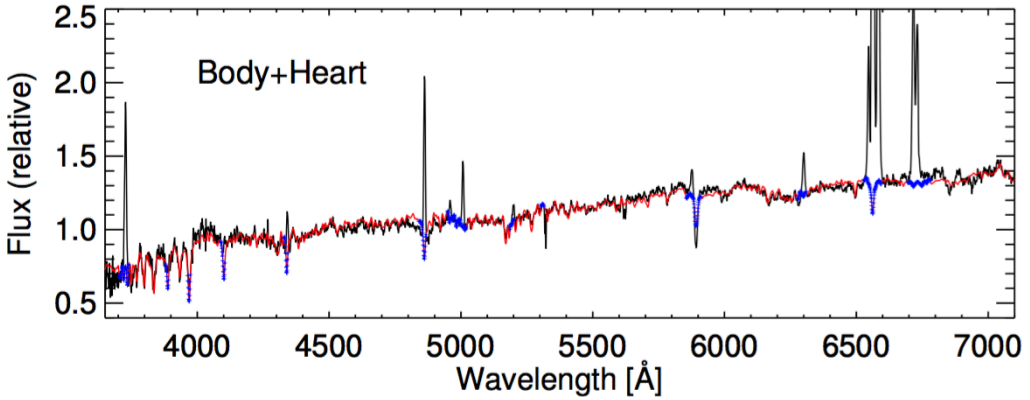


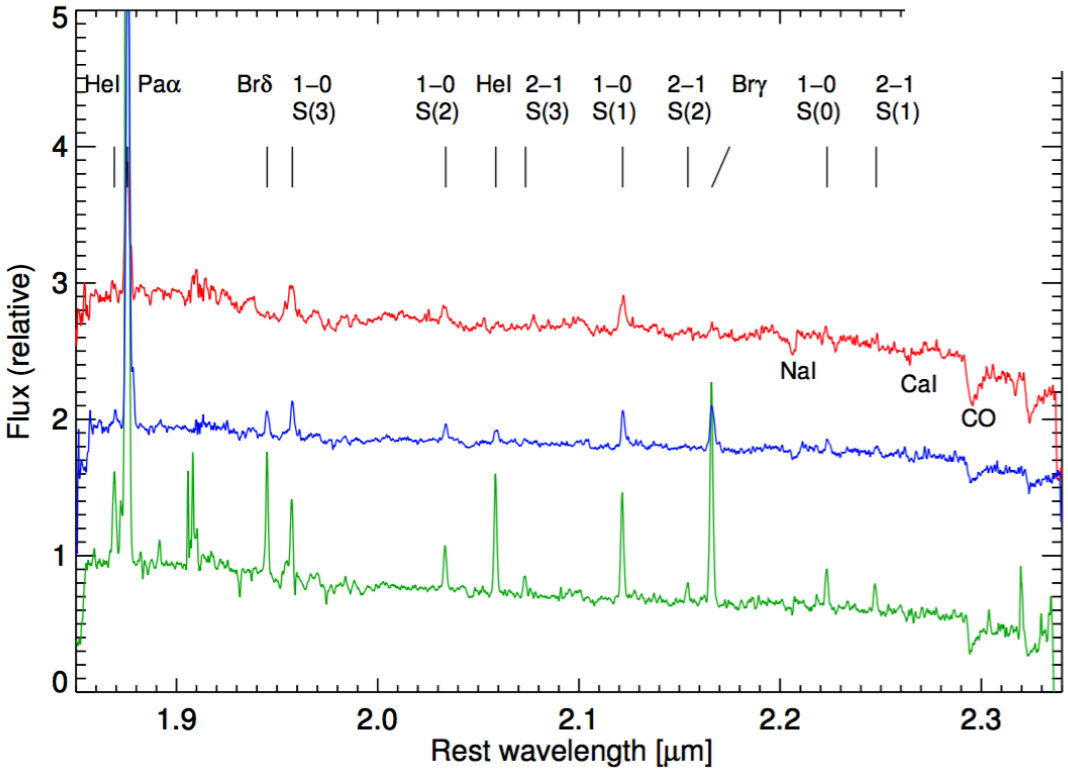
Gas flows


Blue-shifted velocity components
Outflowing gas cause of SF being shut-off?
Quenching in action?
H_2 (1-0) S1
blue-shifted
systemic
Flux
1.60
1.55
1.50
1.45
1.40
1.35
1.30
2.116×10⁴ 2.118×10⁴ 2.120×10⁴ 2.122×10⁴ 2.124×10⁴ 2.126×10⁴ 2.128×10⁴
Wavelength (Å)

Difference in Star Formation Histories

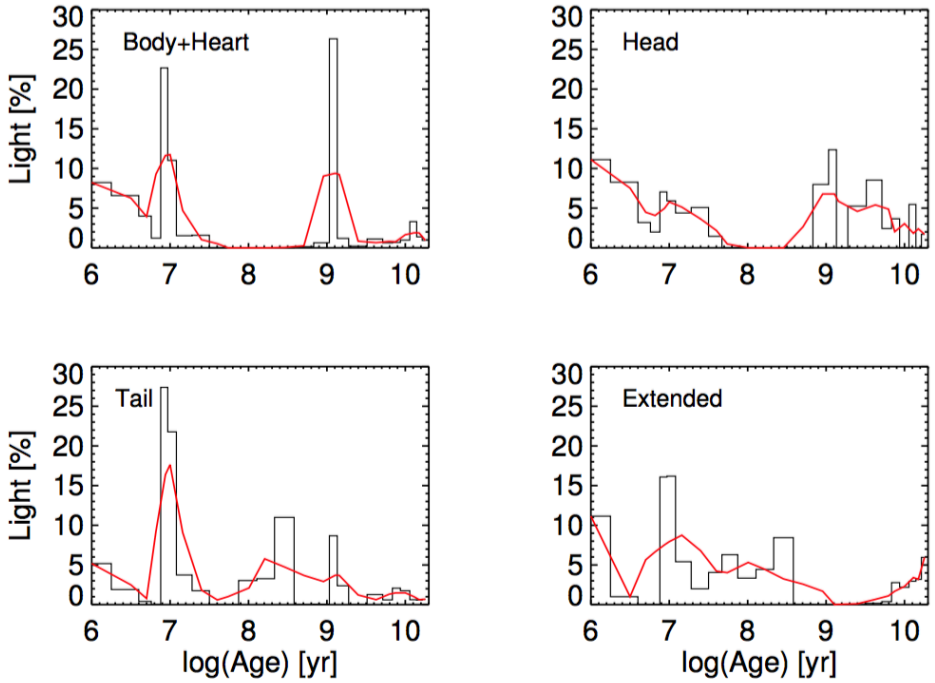
SALT spectra (STARLIGHT)
Sinfoni J+K cubes (EW of abs lines)





Difference in Star Formation Histories

	CO 2.30 μm	Al I 1.13 μm	Si I 1.21 μm	Ca I 2.27 μm	Paα	Brγ	SB age [Myr]	SP age [Myr]
Body-nuc	19	1.2	2	1.5	14	< 2	40	1000
Heart-nuc	18	1.2	3	2.5	85	13	8	1000
Head	13	< 0.6	–	< 0.5	220	31	6–7	10
Head-peak	< 7	–	–	–	720	105	4	< 9
Tail	16	1.3	< 1	< 1	95	14	8	10, 1000



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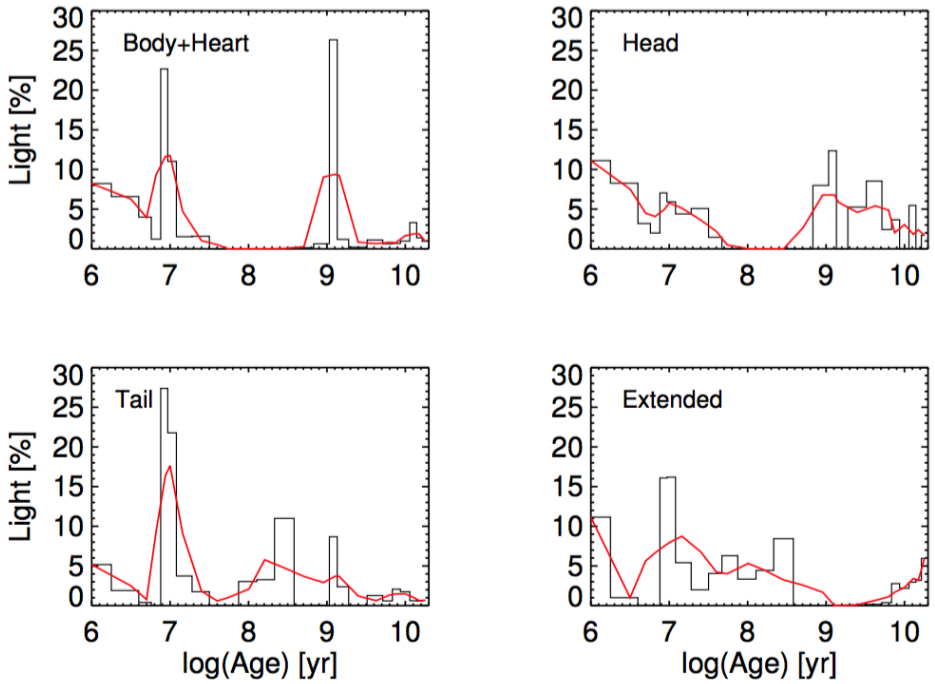
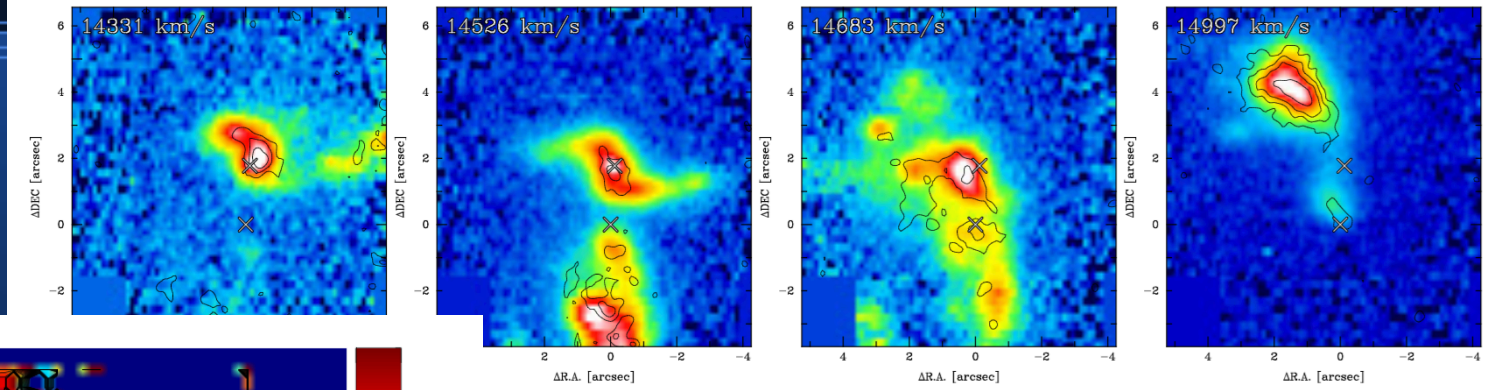
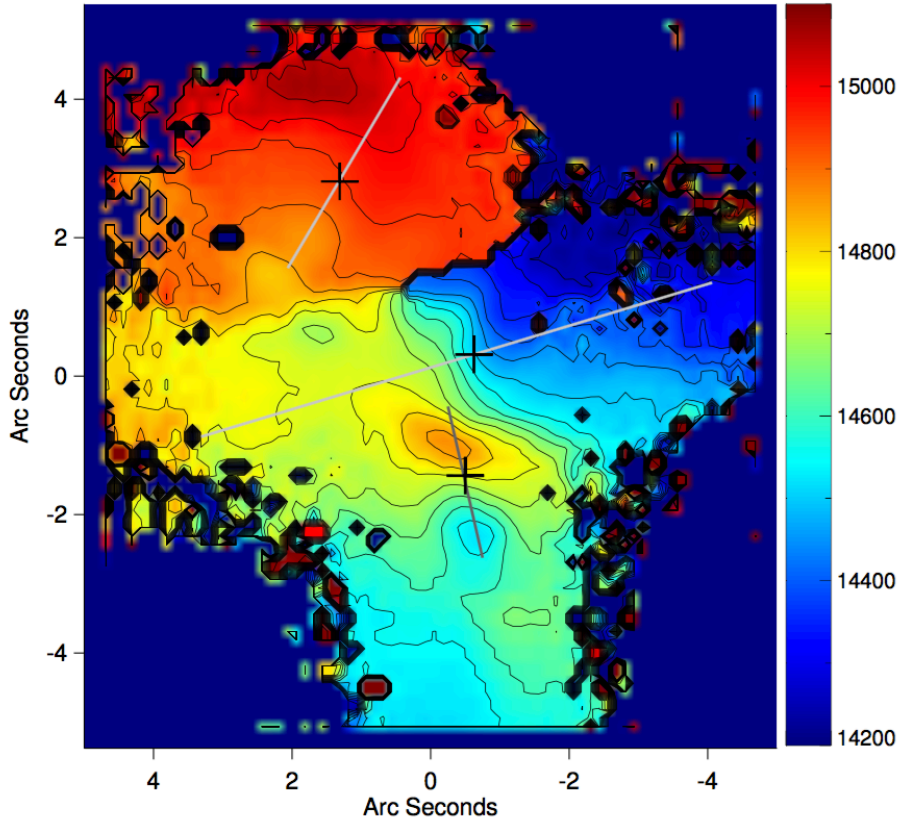
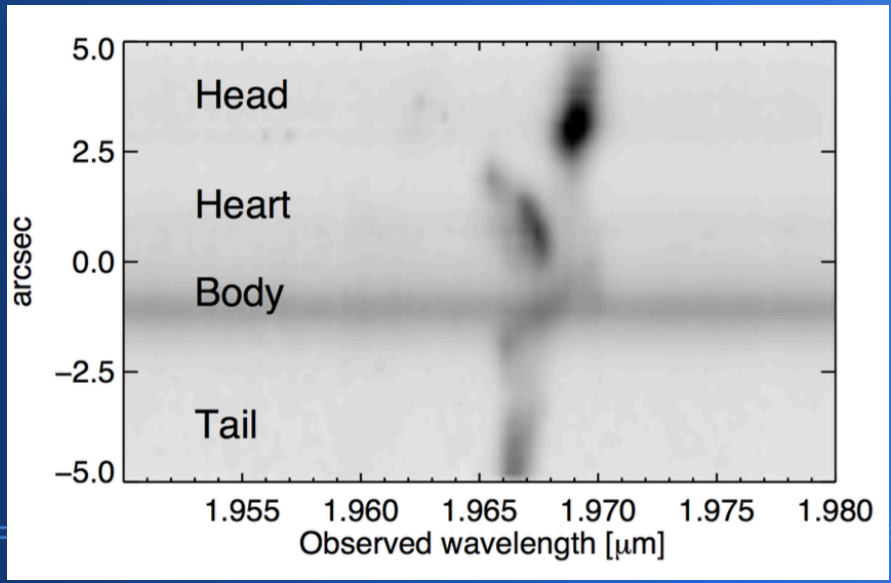


Bird kinematics and dynamics





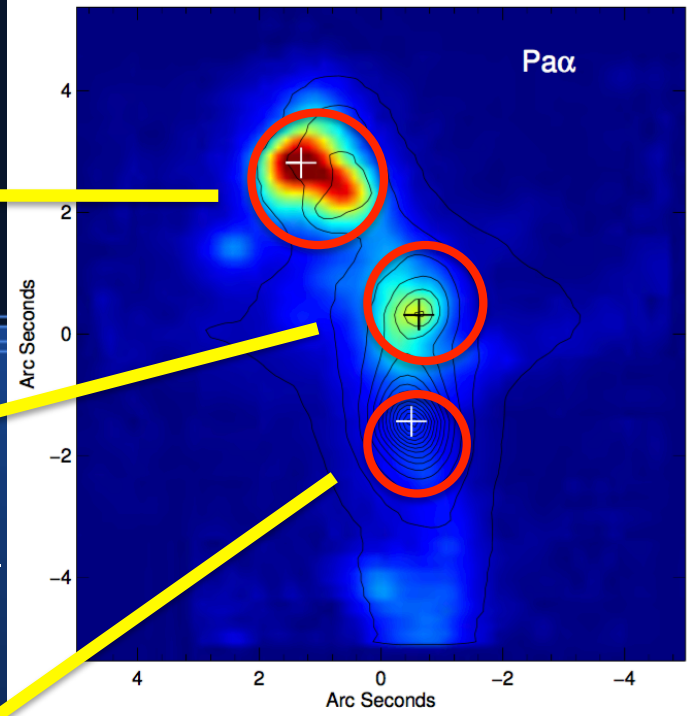


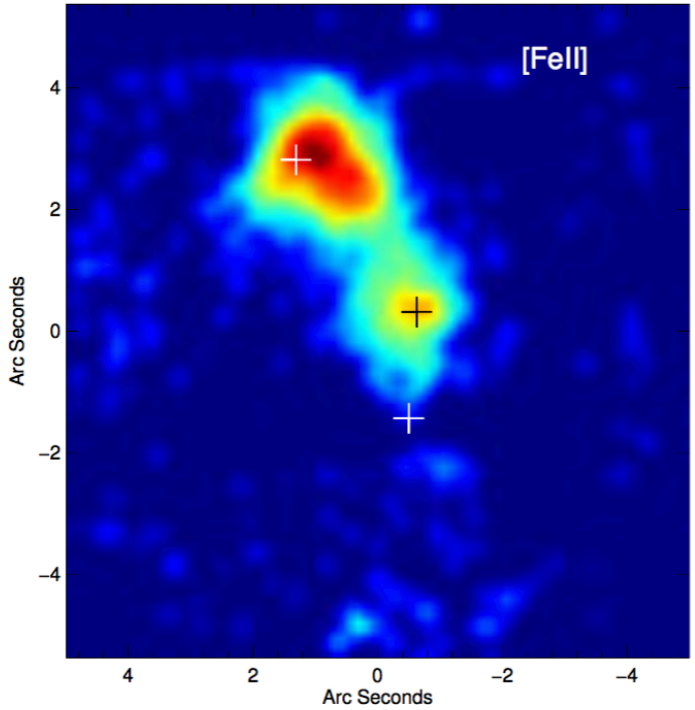
Strong starburst
<6My age
weak outflow

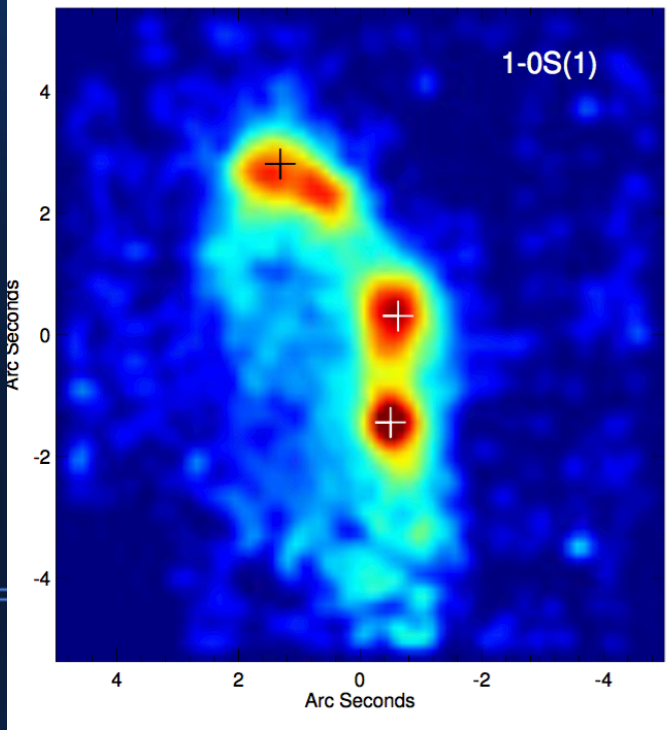
7-10 Myr SF
Ionised gas outflow

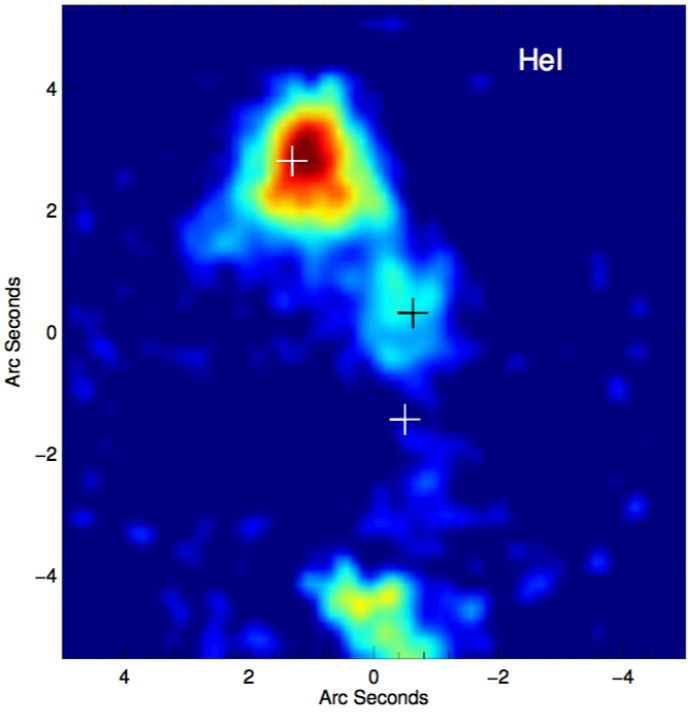
No current SF,
SB age >40 Myr

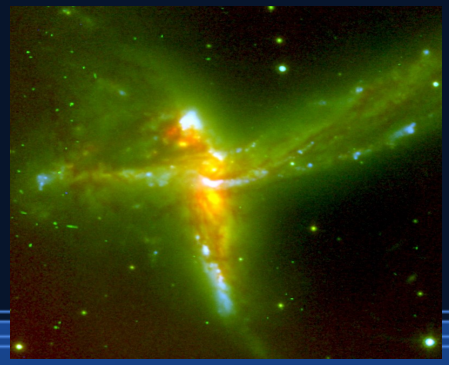
Very strong galaxy-wide ionised, molecular, neutral cool+cold ISM outflows











Bird Summary

- LIRGS provide a lab to study many key
- BIRD observed in AO-IFU and SALT : able to age-date SF histories and correlate to outflows and (possible) AGN growth
- Three components of the Bird appear to be in very distinct evolutionary stages
  – *beware of interpreting global (U)LIRG properties*
- Superwinds shape galaxy evolution – we see quenching *in action*
  – work on-going