Activity at the Center of Galaxies: The Case of Hydra-Centaurus Group of Galaxies.

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UBU, 2015 April ,workshop to honor K. Bronnikov’s 70th birthday

Resume

0- Present paradigm of galaxies and BHs Assemby
1- Hidra-Centaurus Group of Galaxies
2- The galaxy M83.
3- M83 pseudo-bulge.
4- NGC 4258 BH (Daniel Alf Drehmer)
4- Hα and CHANDRA spectroscopy of J133658.3-295105 (z < 0.02).
5- Kick-off models
6- Conclusions and perspectives.

The three first slides shows respectively :
s2-the evolution of the Star Formation Rate,
s3-the Black Holes Accretion Rate and
s4- the Core Collapsed Supernovae.

As quoted by Madau & Dickinson AARA 2014, the evolution of SFR and BHAR evolve closely. They evolve up to a maximum around 10 Gyr and then both decrease up to now.

Also the SNIe formation rate goes closely to that of the SFR.

Note the scales of SFR and BHAR. Look details in Madau and Dickinson paper.

*Star Formation Ra*te, (Madau & Dickinson ARAA 2014)

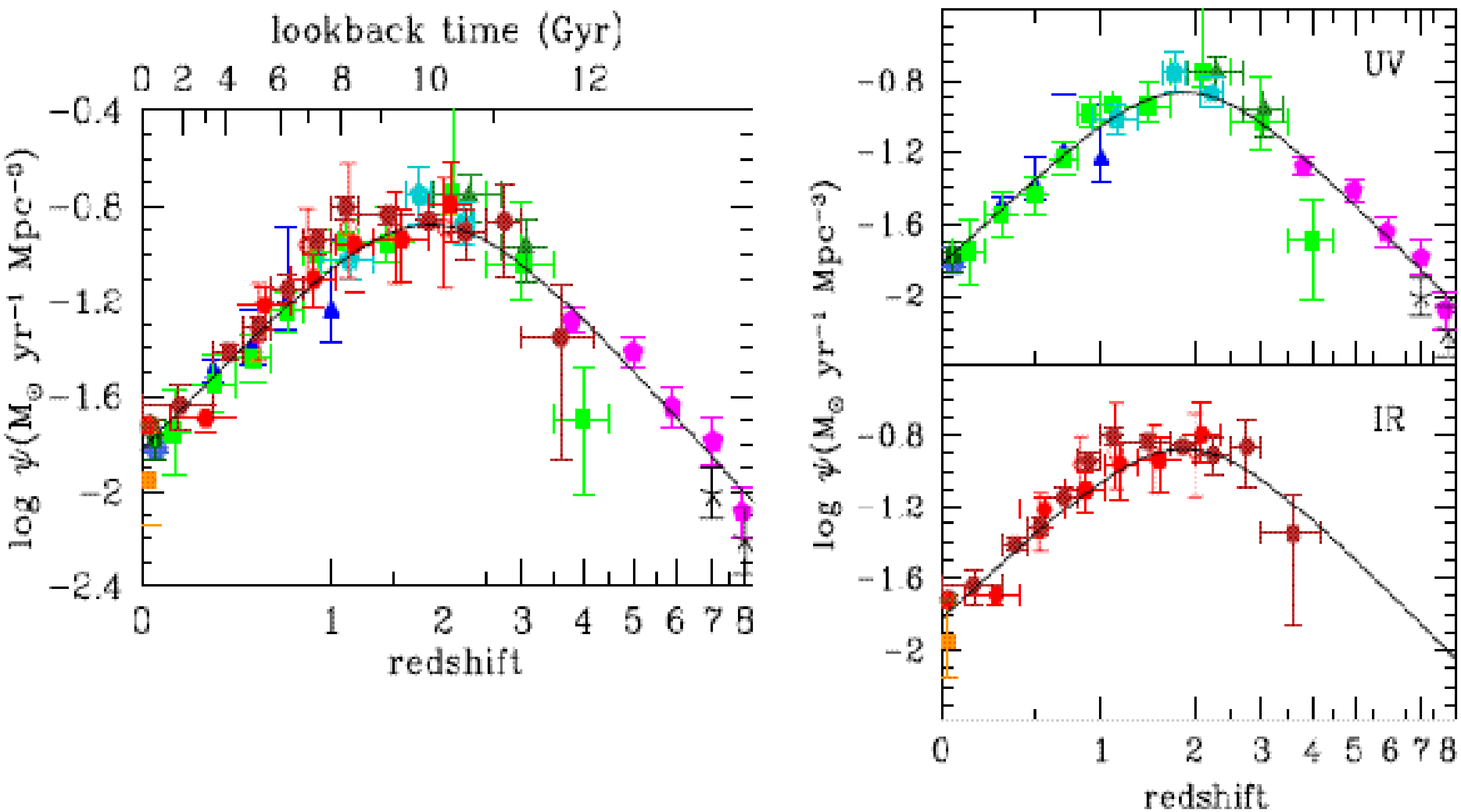
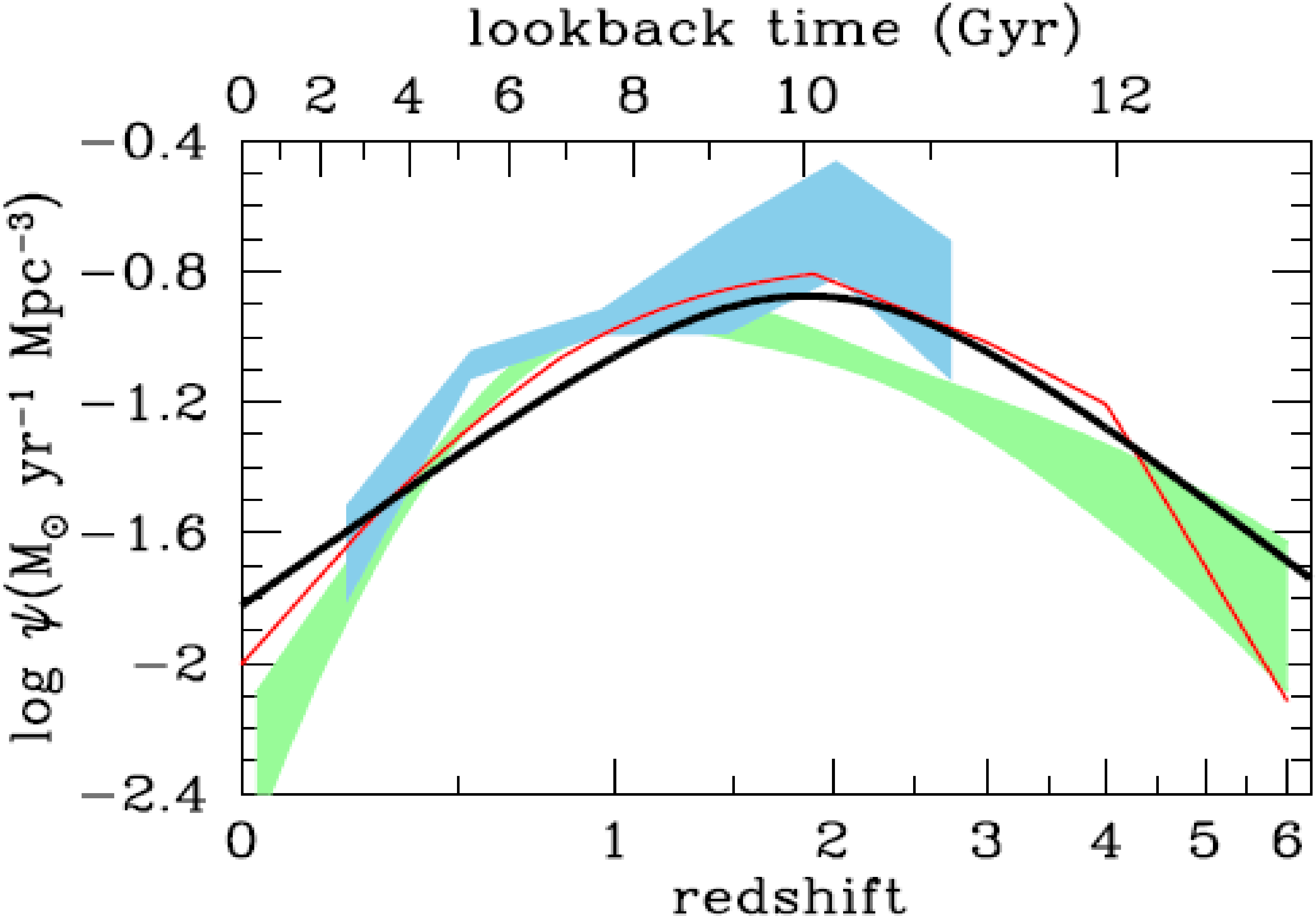


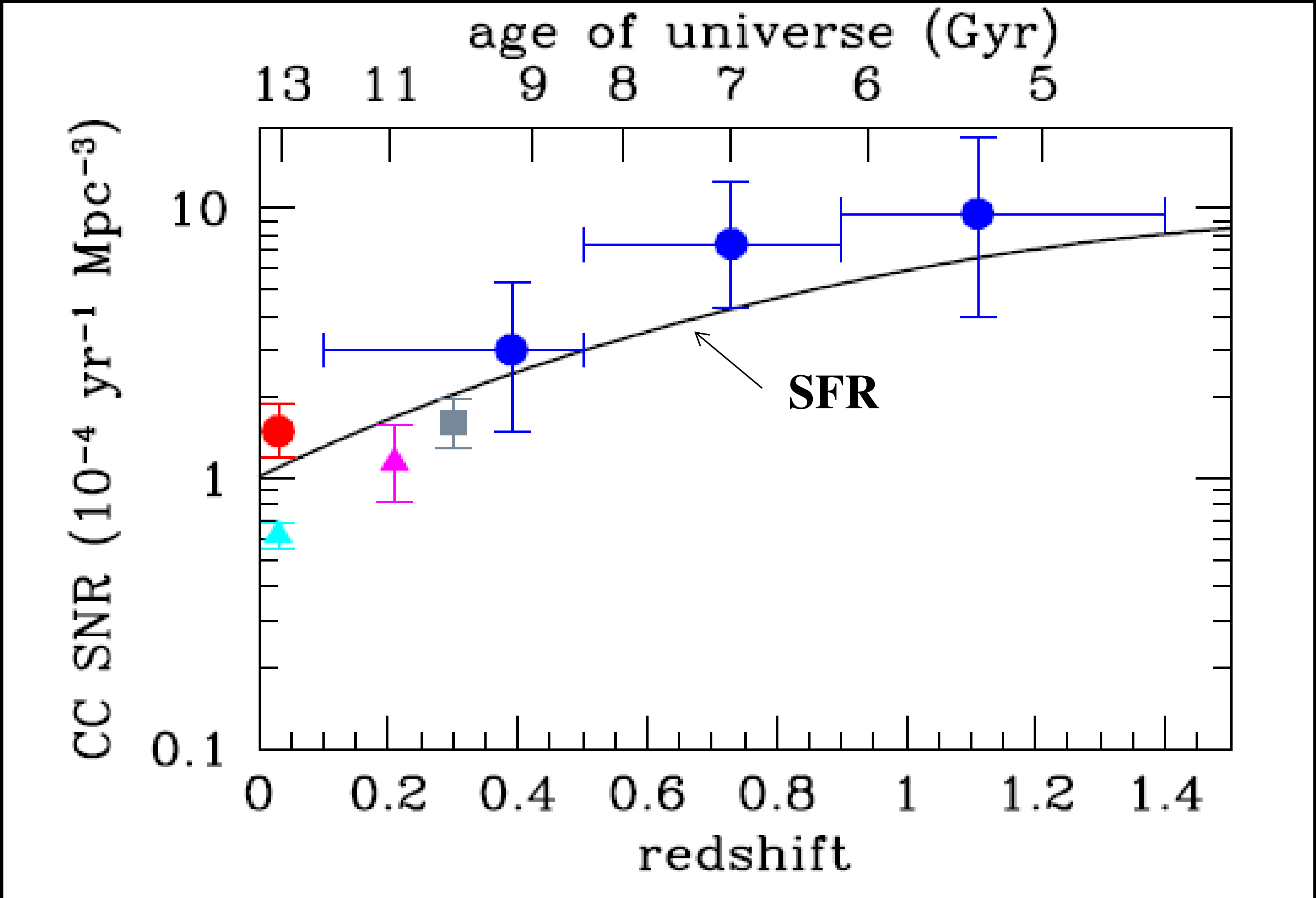
Figure 9: The history of cosmic star formation from (top right panel) FUV, (bottom right panel) IR, and (left panel) FUV+IR rest-frame measurements. The data points with symbols are given in Table 1. All UV luminosities have been converted to instantaneous SFR densities using the factor $\mathcal{K}_{FUV} = 1.15 \times 10^{-28}$ (see Equation 10), valid for a Salpeter IMF. FIR luminosities (8–1,000μm) have been

SFR vs BHah (Madau & Dickinson AARA2014)

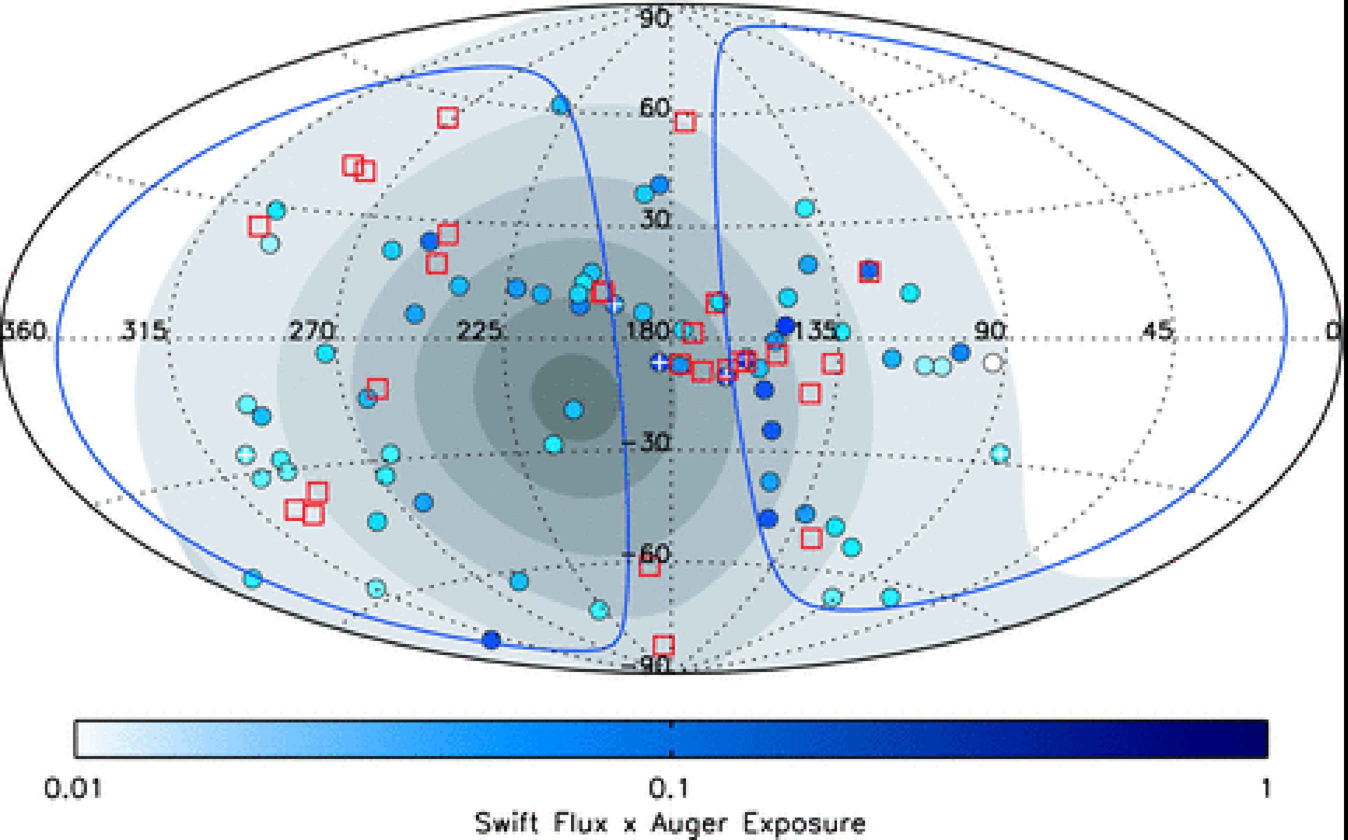


Comparison of the best-fit star formation history (thick solid curve) with the massive black hole accretion history from X-ray [red curve (Shankar et al. 2009); light green shading (Aird et al.2010)] and infrared (light blue shading) (Delvecchio et al. 2014) data.

cc SNIe rate, (Madau & Dickinson, ARAA 2014)



THE HIDRA-CENTAURUS GROUP OF GALAXIES.



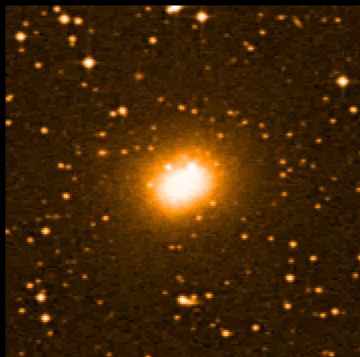
Map of Auger UHECRs (open red squares) and BAT AGN within 100 Mpc (filled blue circles) in supergalactic coordinates

The blue colour depth is scaled by the hard X-ray flux and Auger exposure, relative to Cen A. The six AGN in the catalogue within 20 Mpc are marked with white crosses, with Cen A at (159˚.7, −5˚.2).

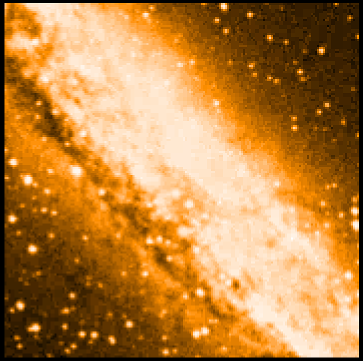
Grey contours have equal integrated exposures. Blue boundaries show where the AGN catalogue is incomplete due to the Galactic plane, |*b*| < 15˚.

http://mnrasl.oxfordjournals.org/content/388/1/L59/F1.expansion.html

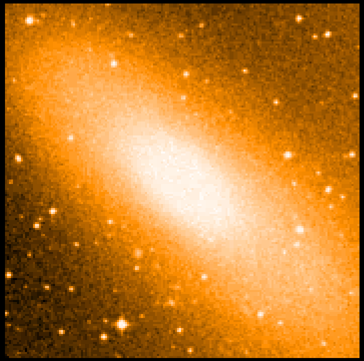
The Centaurus Group



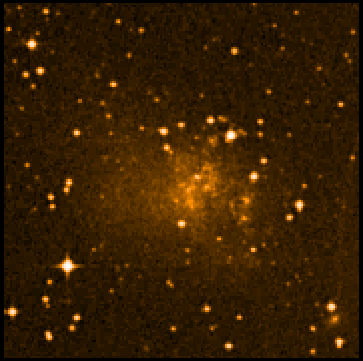
NGC 5237



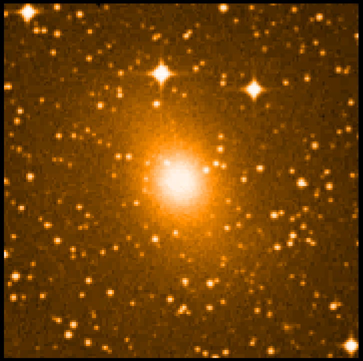
NGC 4945



NGC 5102



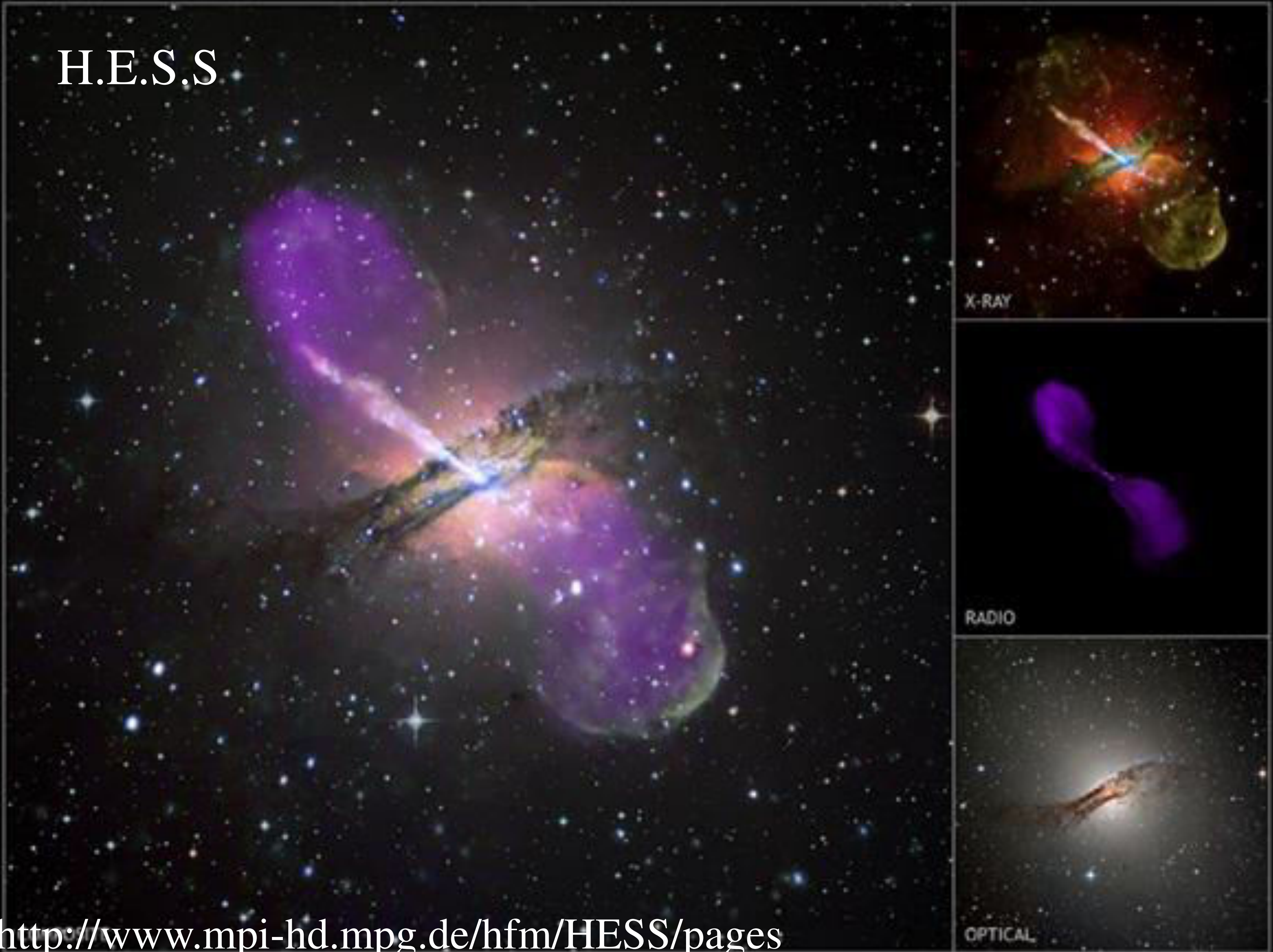
PGC 47171



NGC 5206

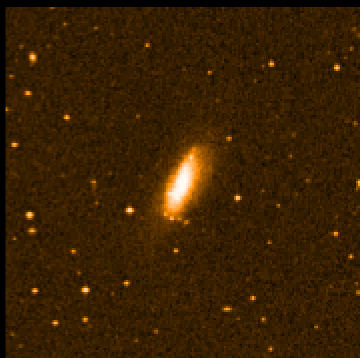
25 confirmed members
(Karachentsev et al.2006)

H.E.S.S

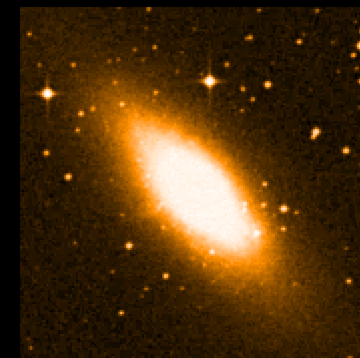


http://www.mpi-hd.mpg.de/hfm/HESS/pages

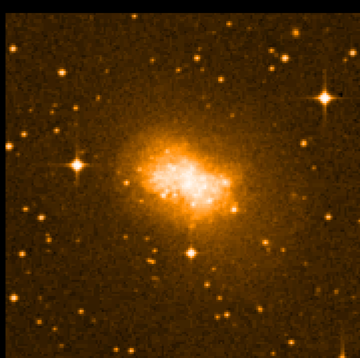
The M83 Group



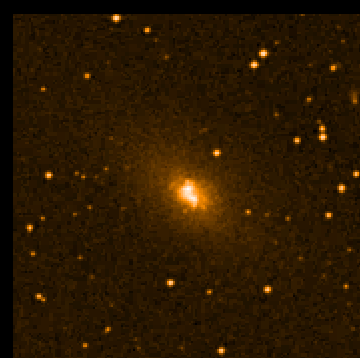
IC 4247



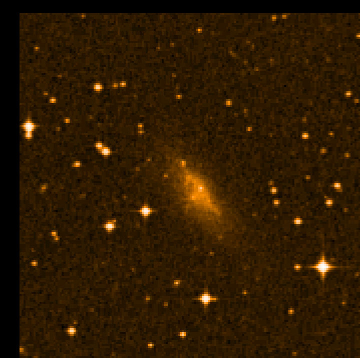
NGC 5253



NGC 5264



IC 4316



UGCA 365

9 confirmed members

(Karachentsev et al 2006)

Nuclear Starburst

Are accretion onto SMBH and violent star formation co-evolving phenomena or necessary partners of the activity?

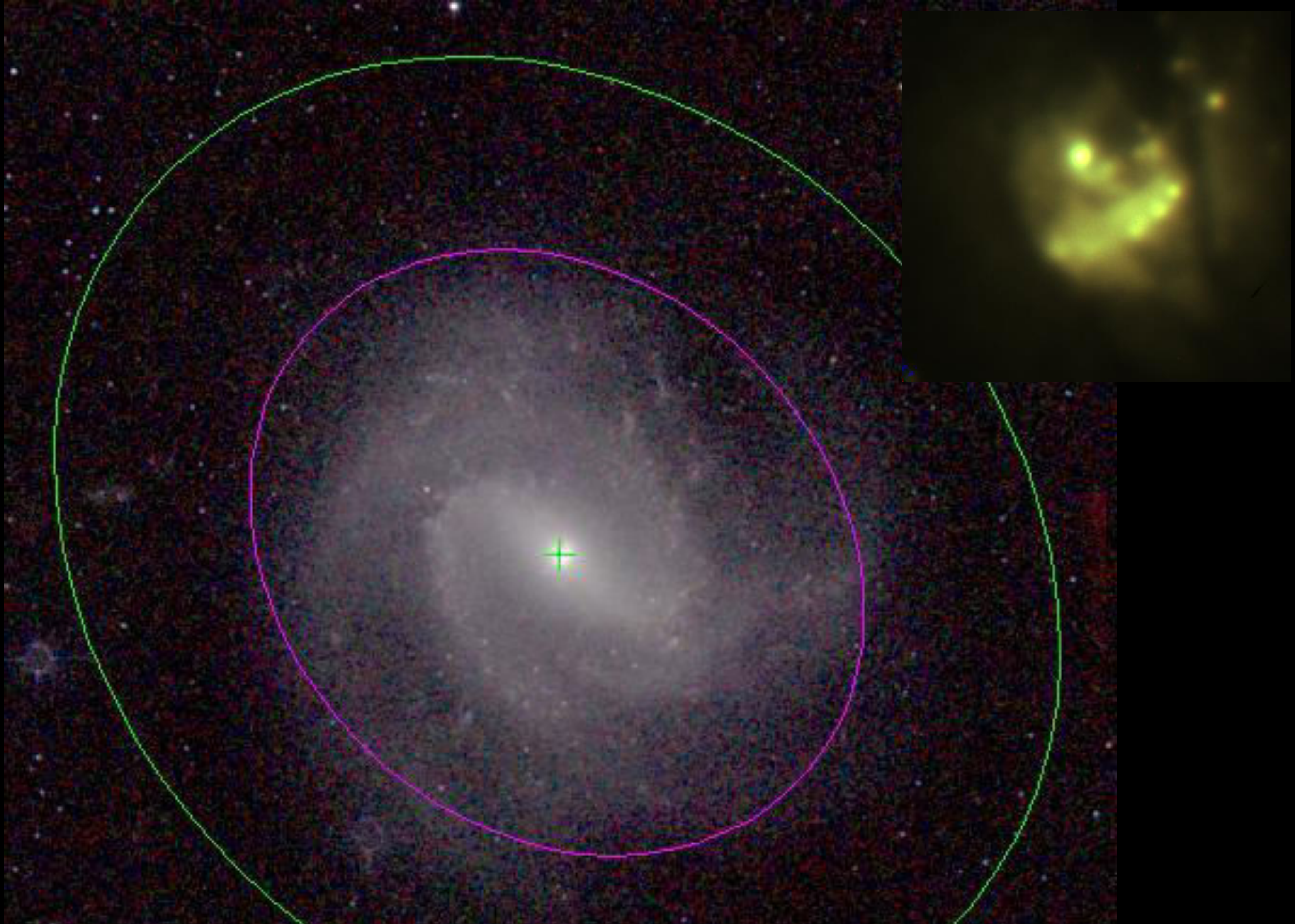
Mechanisms triggering the nuclear extended star formation

Relationship of the triggering mechanisms to galaxy evolution

Spiral Galaxy Messier 83 (VLT ANTU + FORS1)

ESO PR Photo 41/99 (29 November 1999)

D= 3.7 Mpc (h=0.75) [~ 18 pc (")$^{-1}$]
Diameter (arcmin) : 12.9 x 11.5
Clasification : SB(rs)b



From 2-mass. The external isophotes center coincides with the bulge Center.

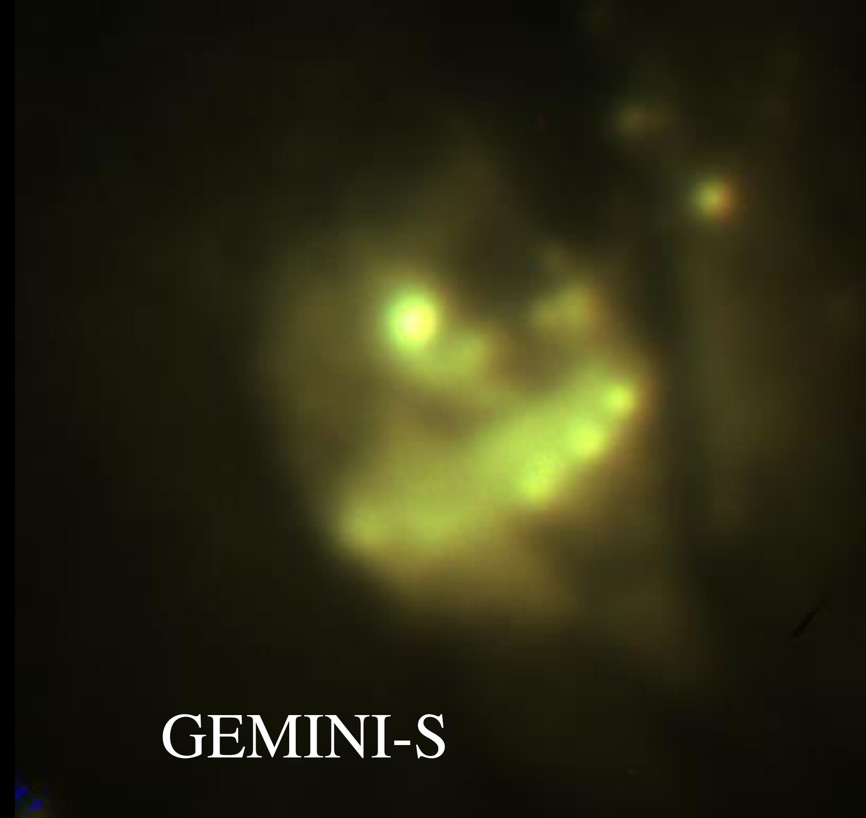
The next 2 images show the extraordinary structure of M83 central 500 pc (N up and E left).

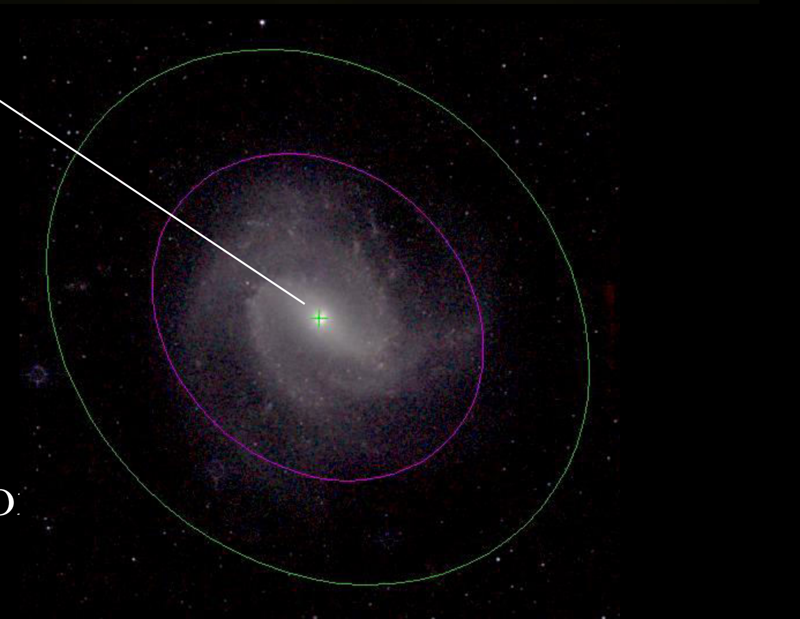
S15: right image is from GEMINI-S and the left one the HST one (Harris et al 2001), showing the richness of details: the arc of HII regions formation (arc-like white structure below); the optical nucleus (ON) is the redish structure 3” to the NE. And arc of dust to the W.

S16: shows a intruder cloud detected in 6cm and 10 um whose tail seems to embed the chain of HII regions.

Unveiling the nature of

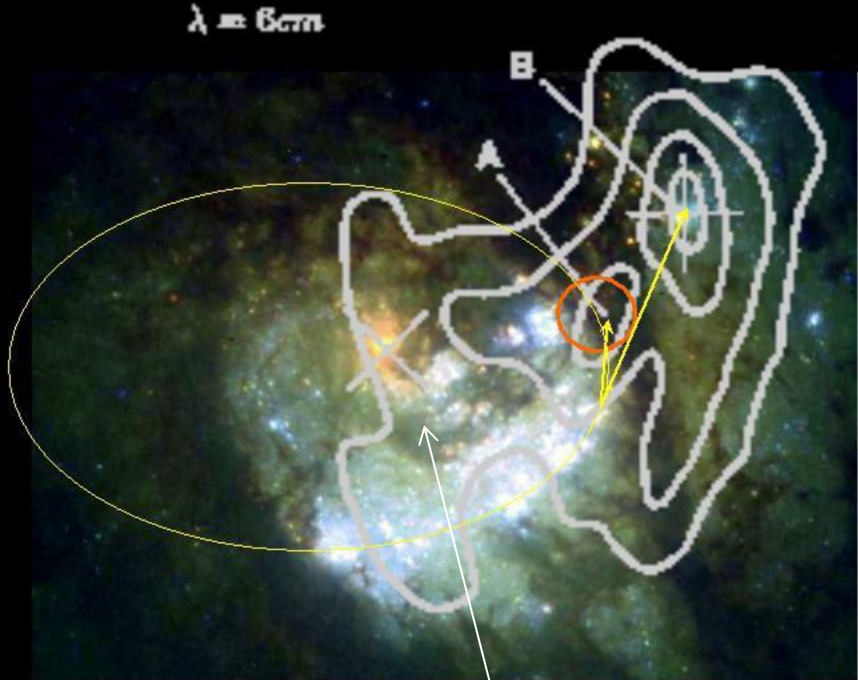
Harris et al. (2001)



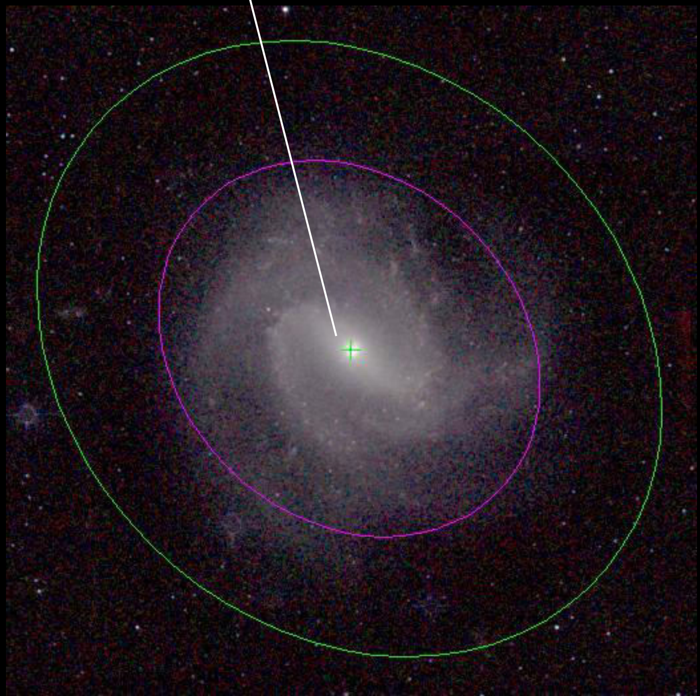


Giant arc:

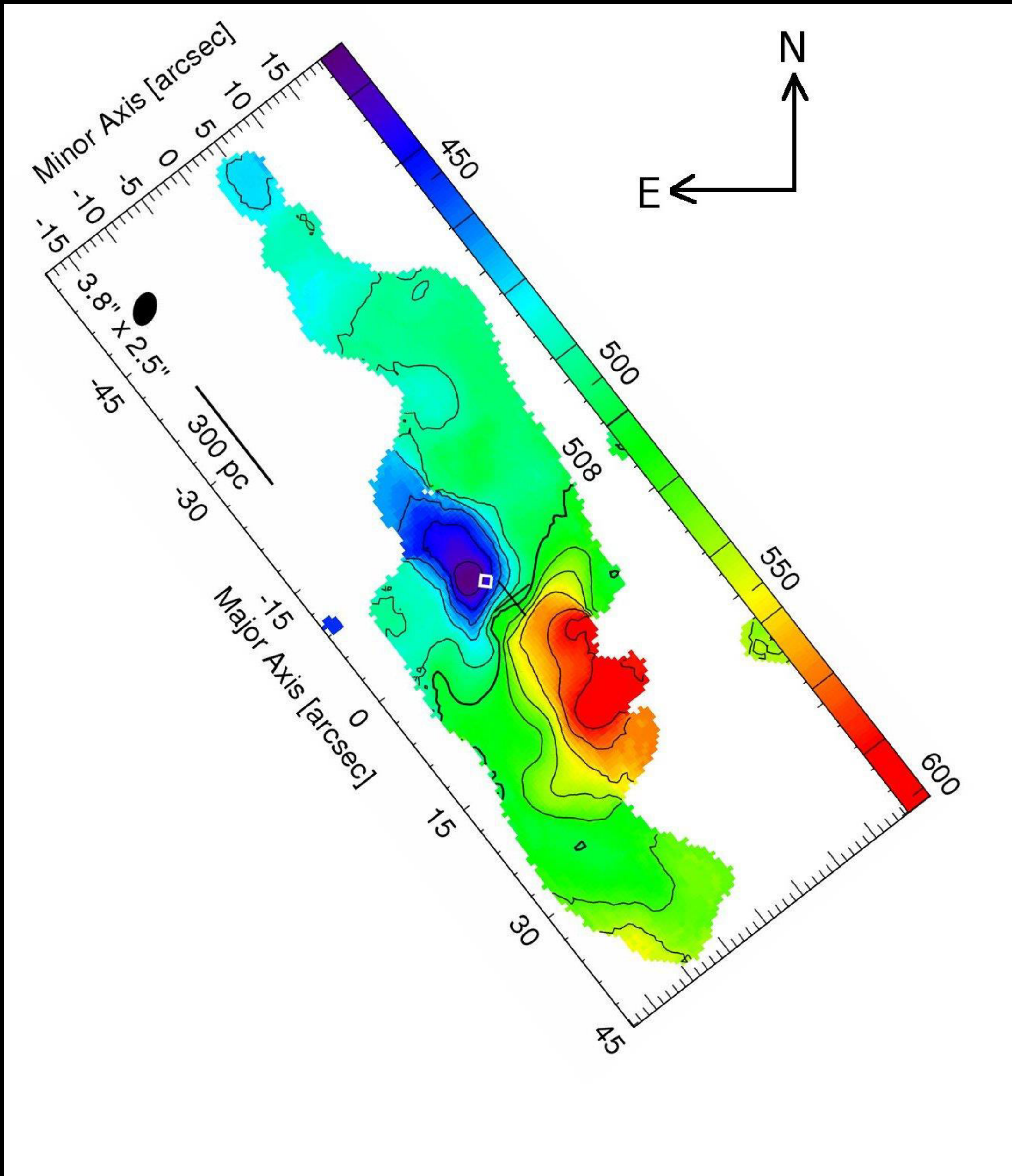
- 3”and 7” from galaxy center.
- Spans 15” (225 pc)
- Includes 20 massive young clusters ~30 Do
- The starburst began ~10 Myr ago.



Radio map 6cm, Telesco 88



FIR 10mu, Telesco 88

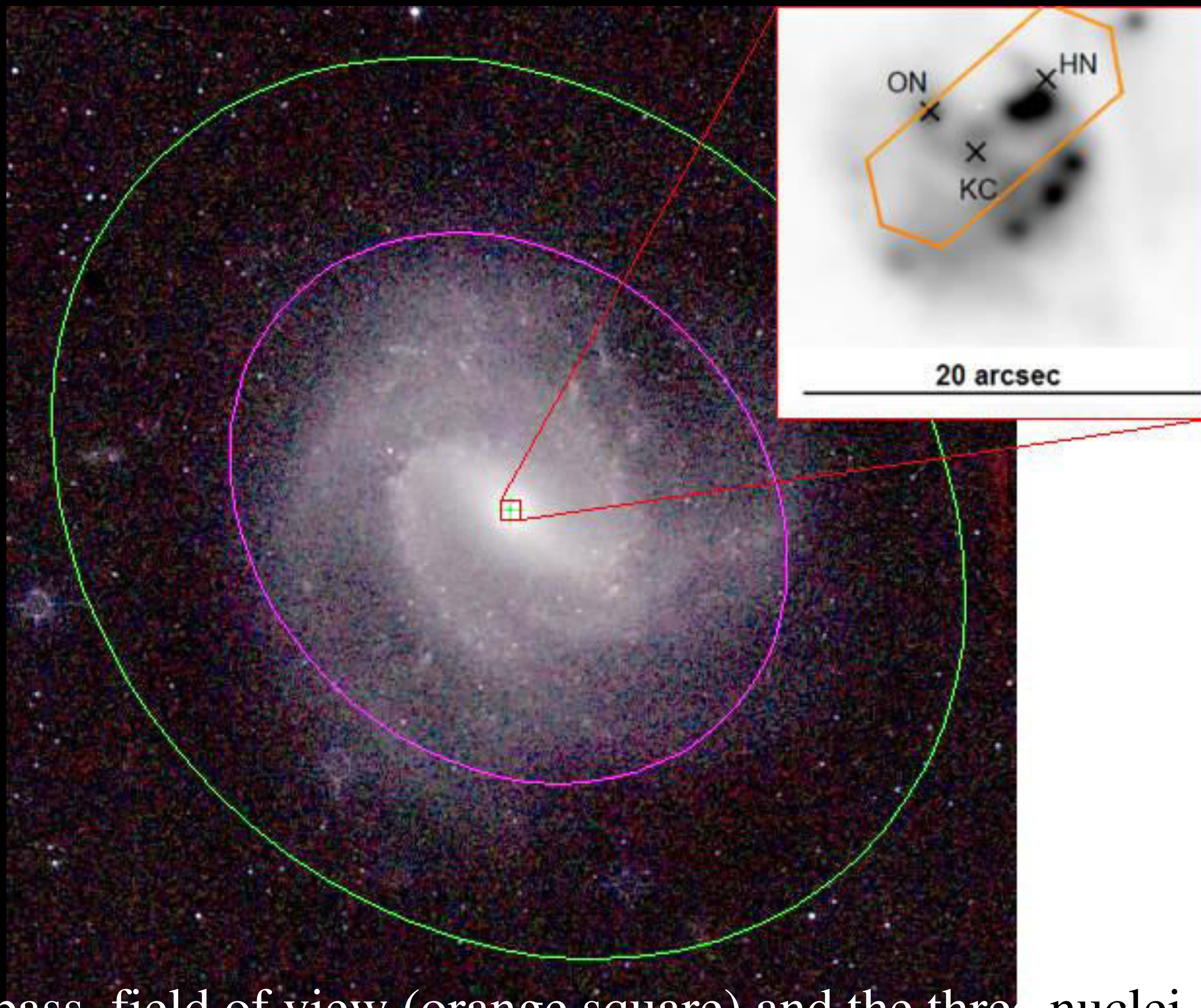


Sakamoto et al. 2004
CO emission
Submillimeter Array

The distribution and kinematics of the molecular gas is typical for barred galaxies down to 1 kpc

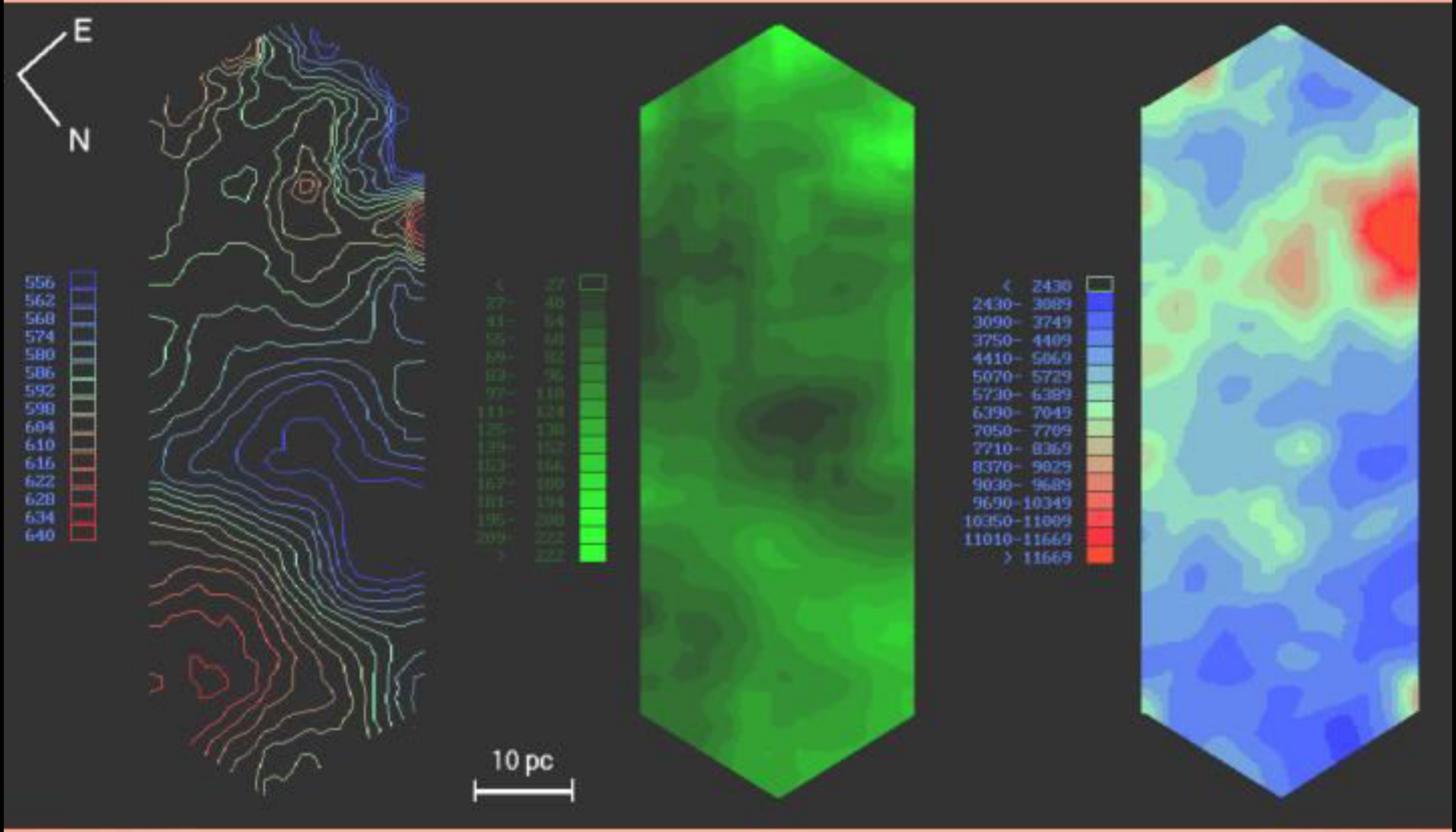
Unusual kinematics around the double nucleus in the central ~ 300 pc. O= Optical Nucleus (ON)

Resol. ~3". **+** =Kinematic Center (KC) coincides with the center of the bulge.



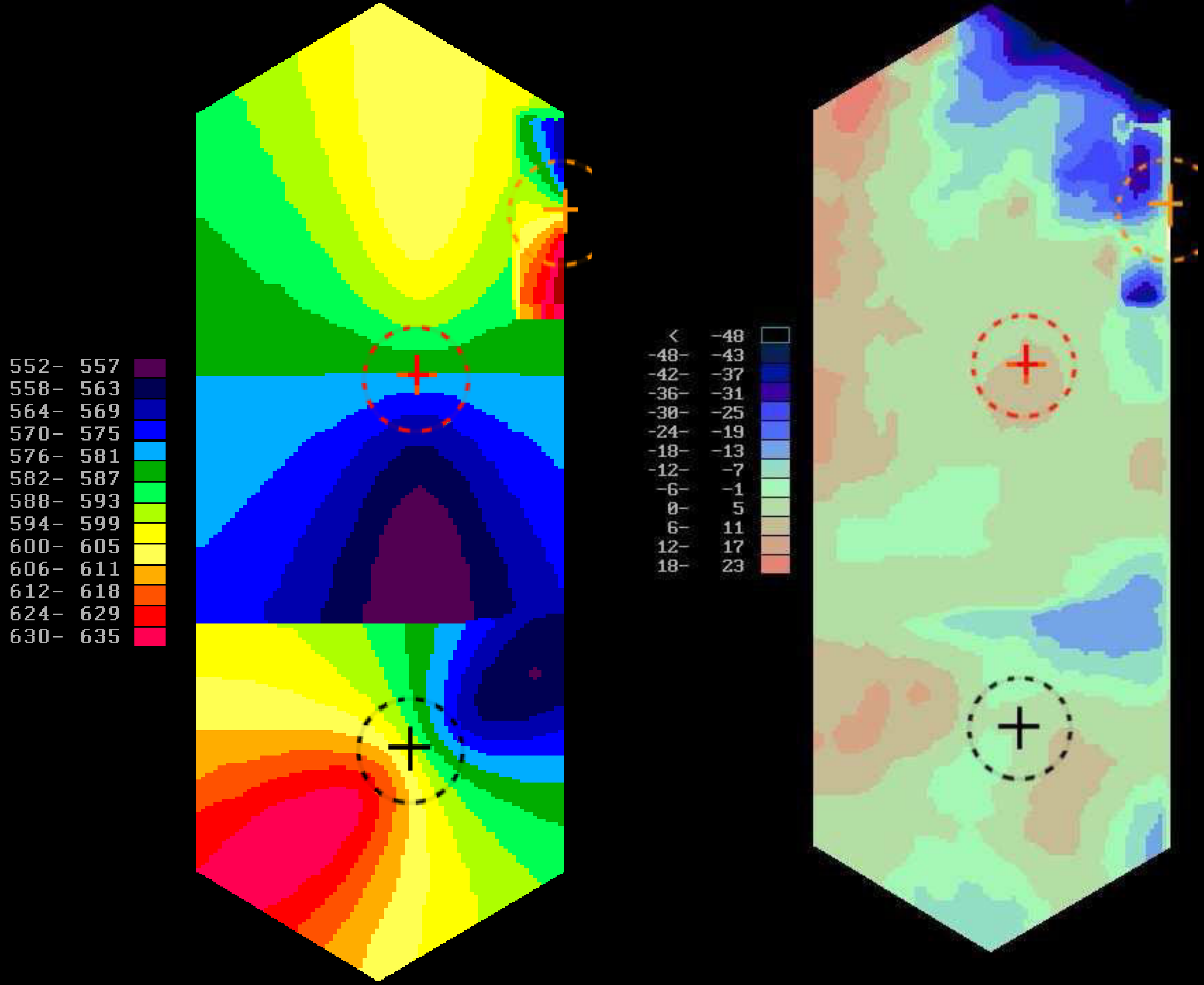
Cirpass field of view (orange square) and the three nuclei position.

Left: isovelocity curves; center: dispersion velocity; right: image. Regioncovered by cirpass field.



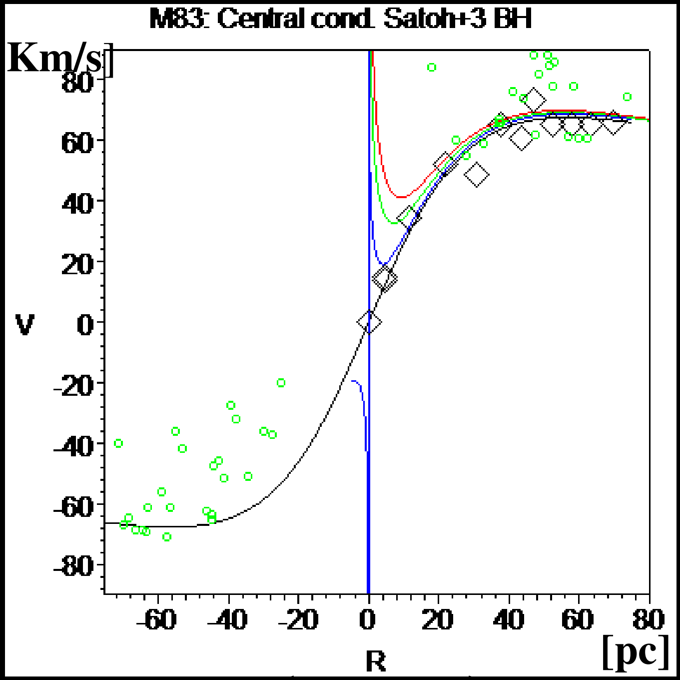
Next Slide (S21): left shows the three disks models,
for ON, KC and HN. Right: the Velocity Dispersion
map, indicating with crosses the position of the 3 nuclei and the addoptedVel. Disp. to adjust the BHs models (S22).

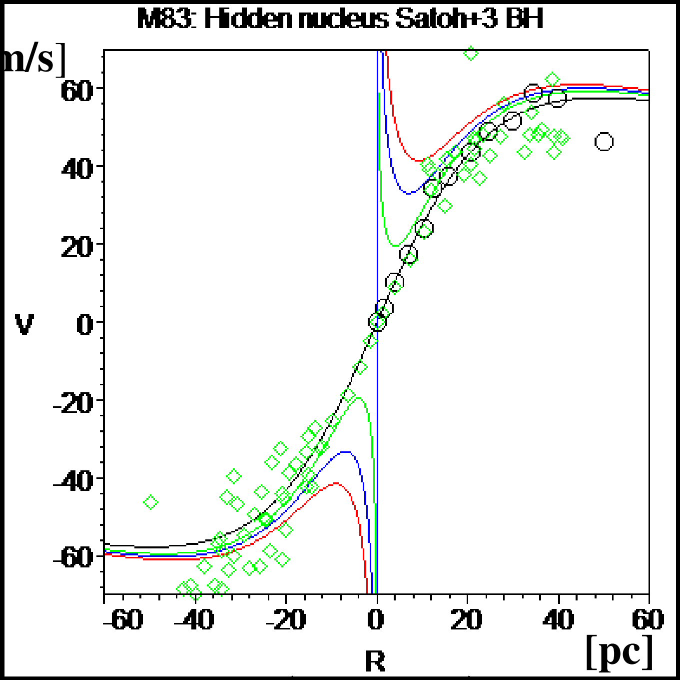
The resulting BHs, that bether adjust the Velocity Dispersion, without manifesting the keplering motion, are shown in the table of S23.



552- 557
558- 563
564- 569
570- 575
576- 581
582- 587
588- 593
594- 599
600- 605
606- 611
612- 618
624- 629
630- 635
< -48
-48- -43
-42- -37
-36- -31
-30- -25
-24- -19
-18- -13
-12- -7
-6- -1
0- 5
6- 11
12- 17
18- 23

Central Body, Hidden Nucleus and putative BH masses

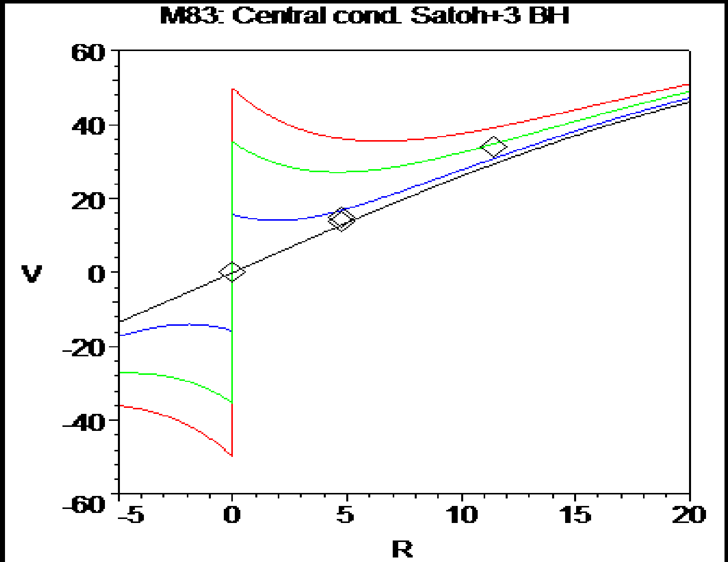


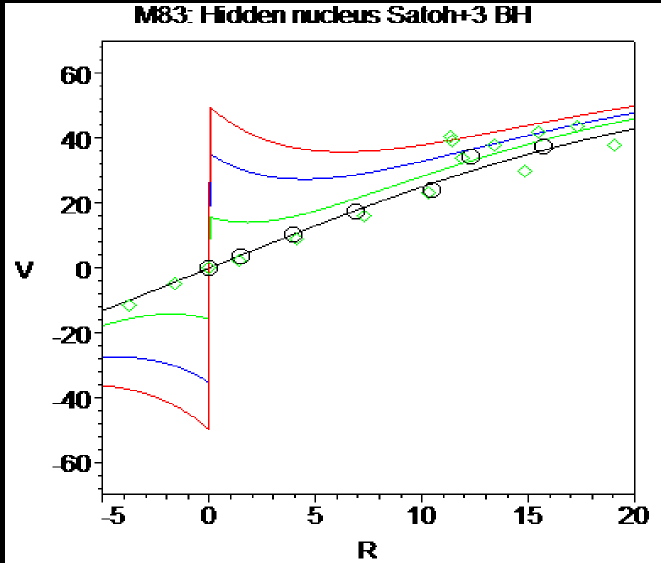


2 10^5 Msun

1x10^6 Msun

2x10^6 Msun





Putative BHs

M_{ph}* Elmegreen et al 96

	r [pc]	V [km/s]	$\sigma[km/s]$	M_k [MsxE6]	M_{ph} [Ms xE6]	M_{BH} [MsxE6]
ON	8 ± 1	46 ± 9	110 ± 10	3.7 ± 1.2	4.0	**1.0**
KC	65 ± 5	63 ± 8	82 ± 10	6.0 ± 1.2		0.2- 1.0
HN	40 ± 5	58 ± 11	96 ± 10	3.0 ± 1.2		**1.0**

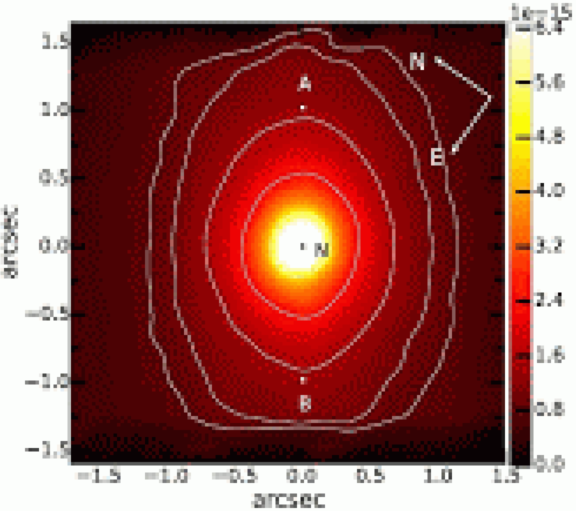
S25: The merging process of the central objects of M83 including ON, KC and HN plus the set of HII regions has been modelled by Rodrigues and collaborators and. The total process, take around 200 Myr. This simulation shows how the cloud of stars around each clusters merge in only one cloud where the original components can not be anymore differentiated.
Nevertheless, it does not guarantees the merge of the central BHs, which have to be modelled separatelly using GR.

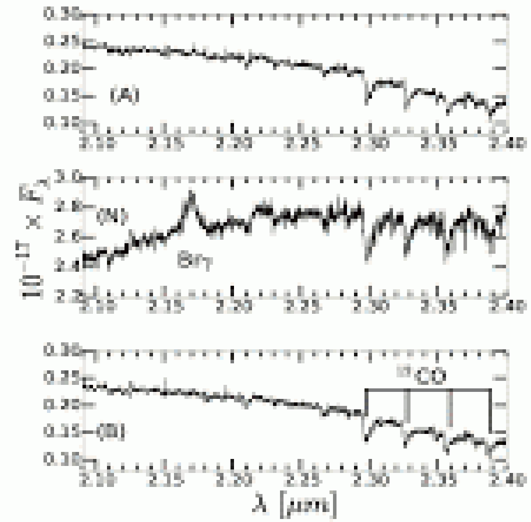
The Astronomical Journal, 137:4083–4090, 2009 May
Rodrigues et al.
MODEL OF THE INNER REGION OF M 83 MERGE PROCESS.

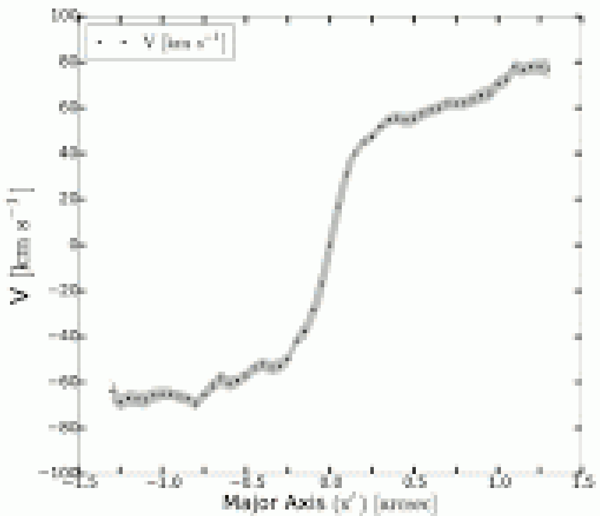
As a matter of comparison, we show (S27) the mass and other parameters determination for the BH at the center of NGC 4258, kindly ceded by Daniel Alf Drehmer , from his Thesis (IF-UFRGS, March 10th, 2015).

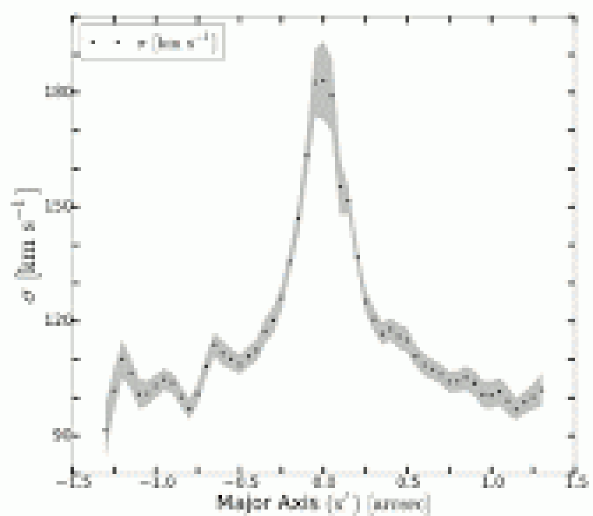
NGC 4258 – IFU SPECTROSCOPY

GEMINI NORTH
NIFS + ALTAIR
K-band
HK_0603
λ = 1.99 to 2.40 μm
R=5290
S/N = 50









$v_{\mathrm{los}} \approx \pm 80 \text{ km s}^{-1}$

$\delta v_{\mathrm{los}} \approx \pm 3.3 \text{ km s}^{-1}$

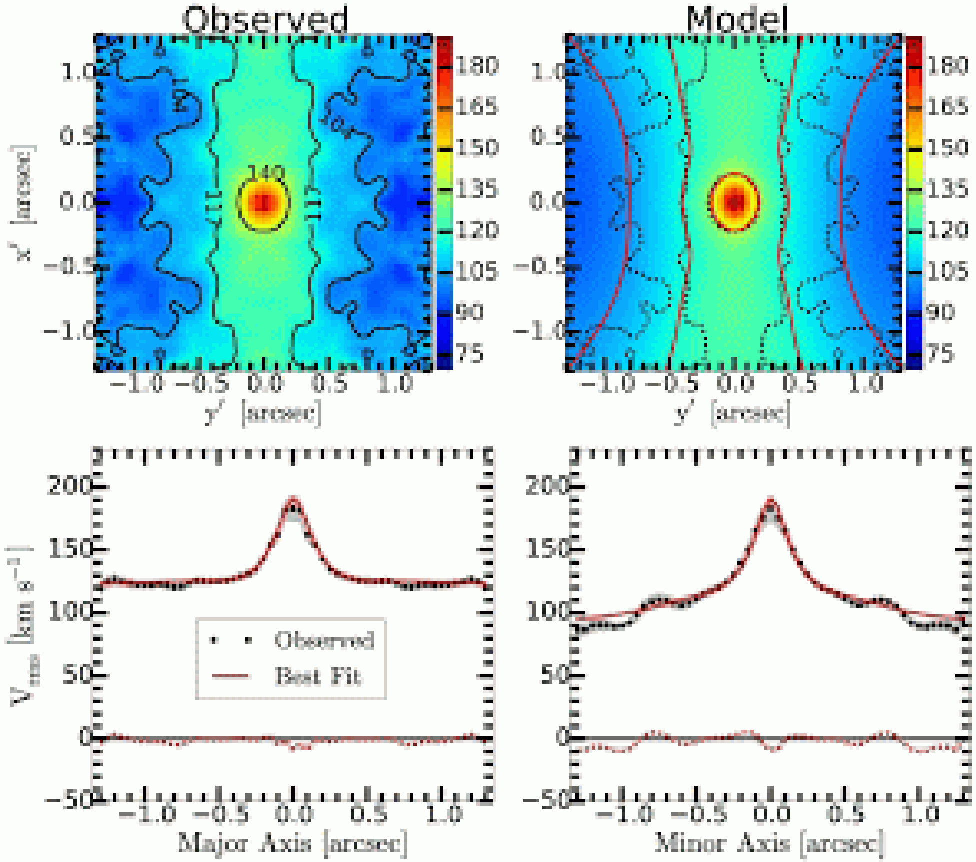
$\sigma_{\mathrm{los\ Min}} \approx 80 \text{ km s}^{-1}$

$\sigma_{\mathrm{los\ Max}} \approx 183 \text{ km s}^{-1}$

$\delta \sigma_{\mathrm{los}} \approx \pm 4.1 \text{ km s}^{-1}$

NGC 4258 – SMBH Mass Determination

Jeans Dynamical Model – Velocity Second Moment



Best-fitting Parameters:

$i = 64°$

$M_{BH} = 4.8^{+0.8}_{-0.9} \times 10^7 M_{Sun}$

$\Gamma_K = 4.1^{+0.4}_{-0.5}$

$R_{INF} \approx 15$ pc

Accepted in MNRAS

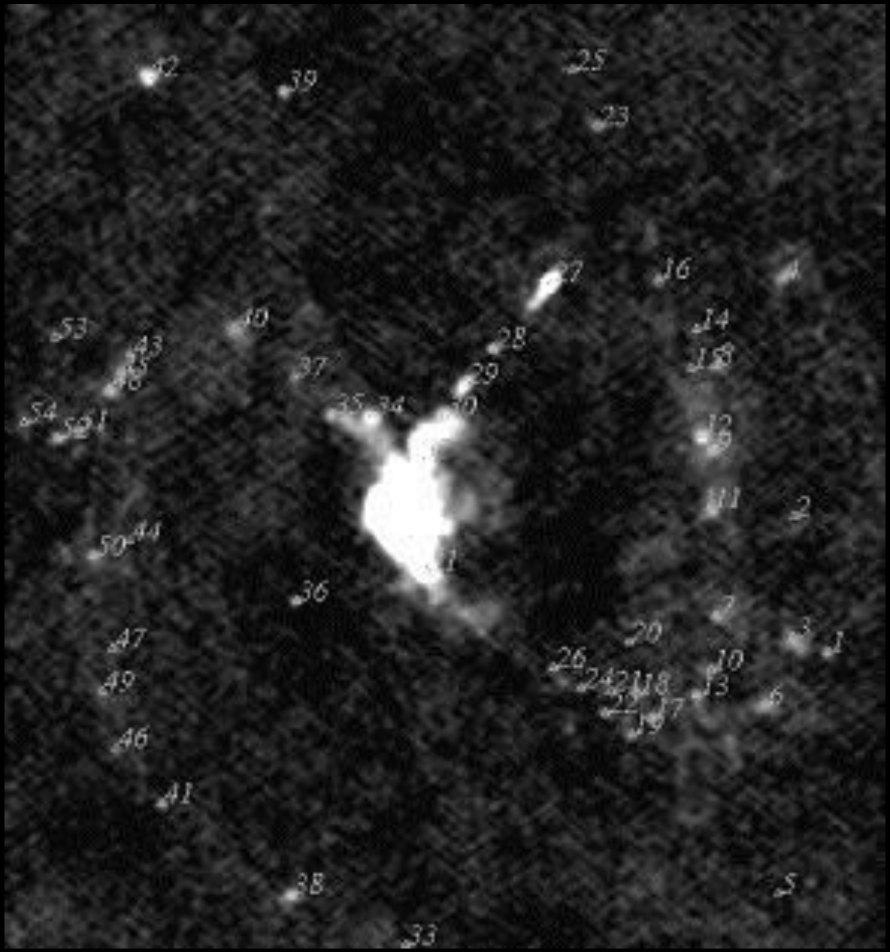
D. A. Drehmer et al.

http://arxiv.org/abs/1503.04540v2

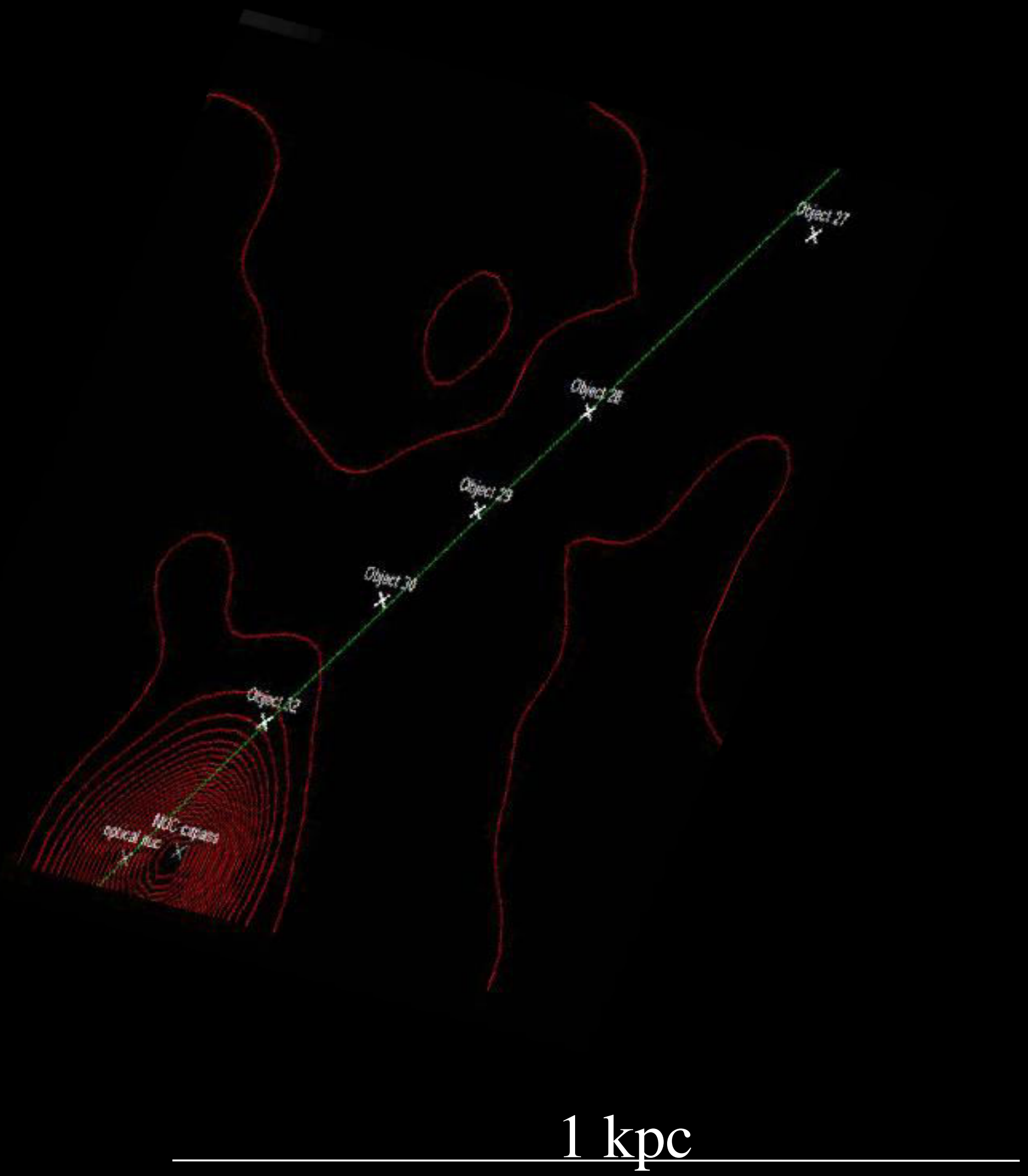
Is the radio-source RS28 (Maddox et al 2006, AJ vol 132, pg 306) a Kick-Off from M83?

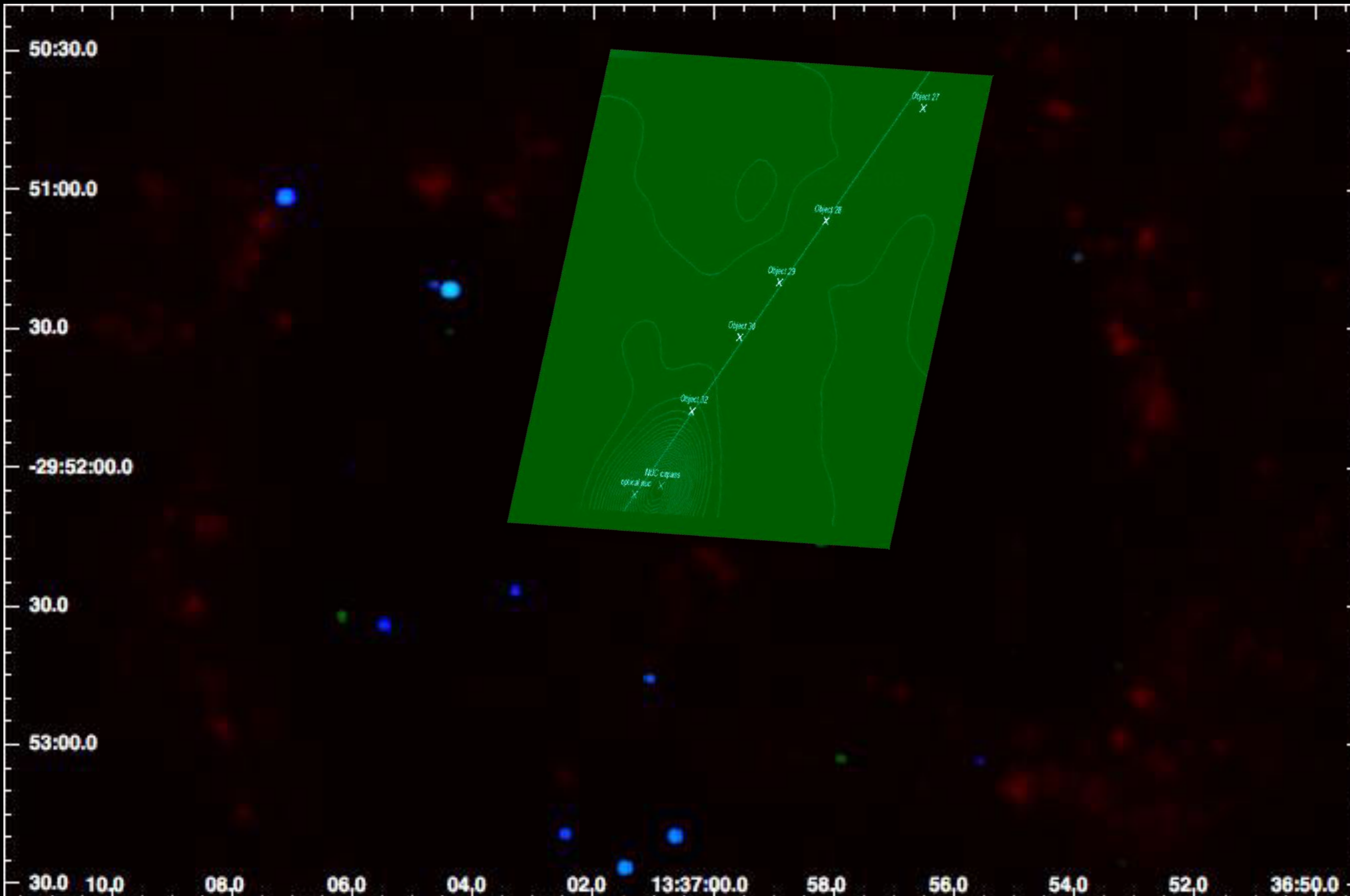
After the detailed radio-map of Maddox et al (2006) of M83 (S31), the possibility arosses the object RS28 to be na ejecta from the nucleus of M83 (S31 and S32 and S33 too).
S34-RS 28 coincides with the X-ray source *J 133658.3–295105*. *S35-* shows the Hα line obtained at the position of RS28 (green line) compared to that of a nearby HII region of M83 taken simultaneously (yellow line). RS28 shows a small reddening with regard to M83.

Maddox, 2006, AJ 132, 306



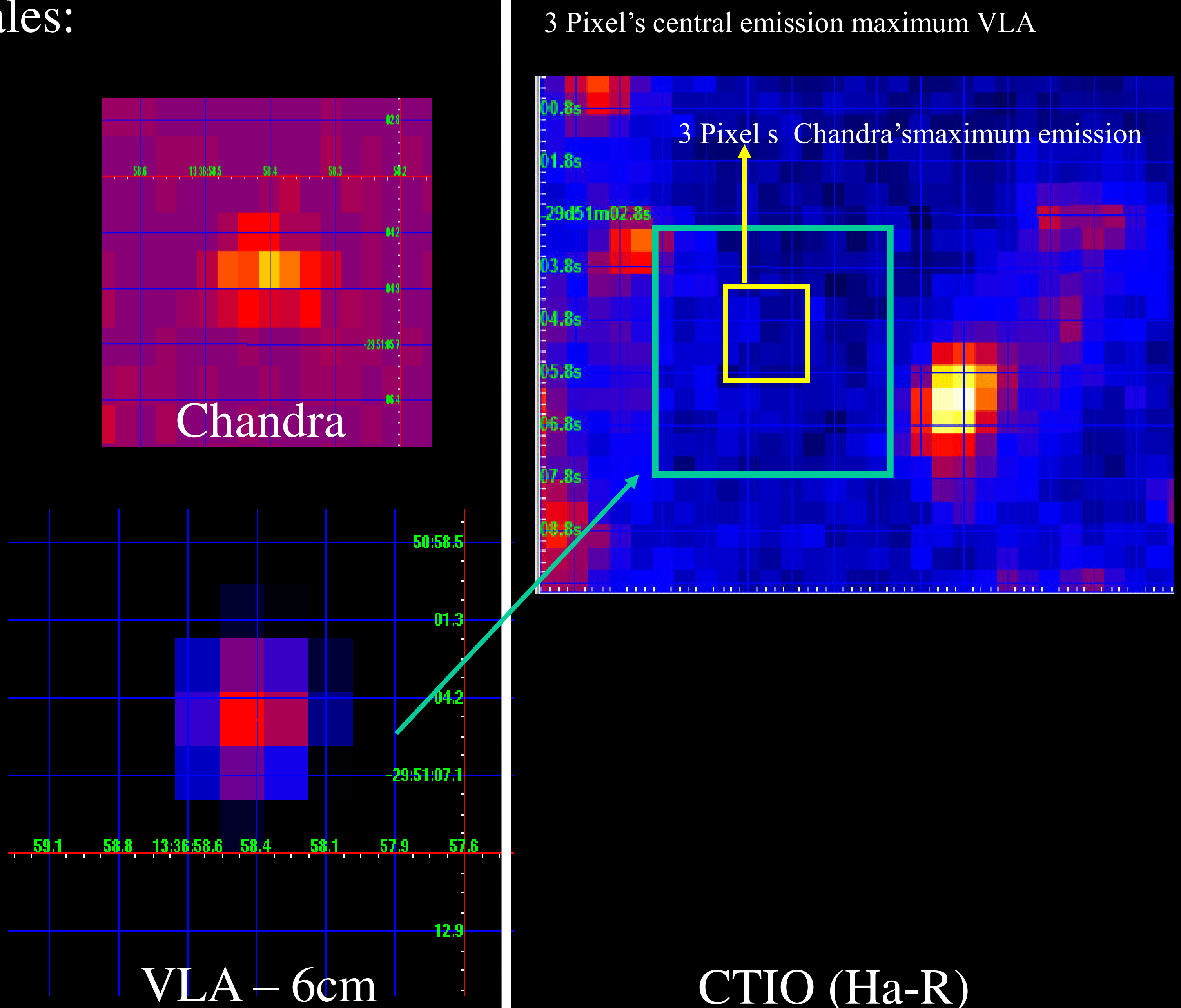
Contato em GA-IAU 2006


Object 27
Object 28
Object 29
Object 30
Object 32
1 kpc



50:30.0
51:00.0
30.0
-29:52:00.0
30.0
53:00.0
30.0
10.0
08.0
06.0
04.0
02.0
13:37:00.0
58.0
56.0
54.0
52.0
36:50.0
Object 27
Object 28
Object 29
Object 30
Object 32

scales:


3 Pixel's central emission maximum VLA
Chandra
VLA – 6cm
50:58.5
01.3
04.2
-29:51:07.1
12.9
59.1
58.8
13:36:58.6
58.4
58.1
57.9
57.6
3 Pixel s Chandra'smaximum emission
00.8s
01.8s
29d51m02.8s
03.8s
04.8s
05.8s
06.8s
07.8s
CTIO (Ha-R)

GEMINI-S Observations

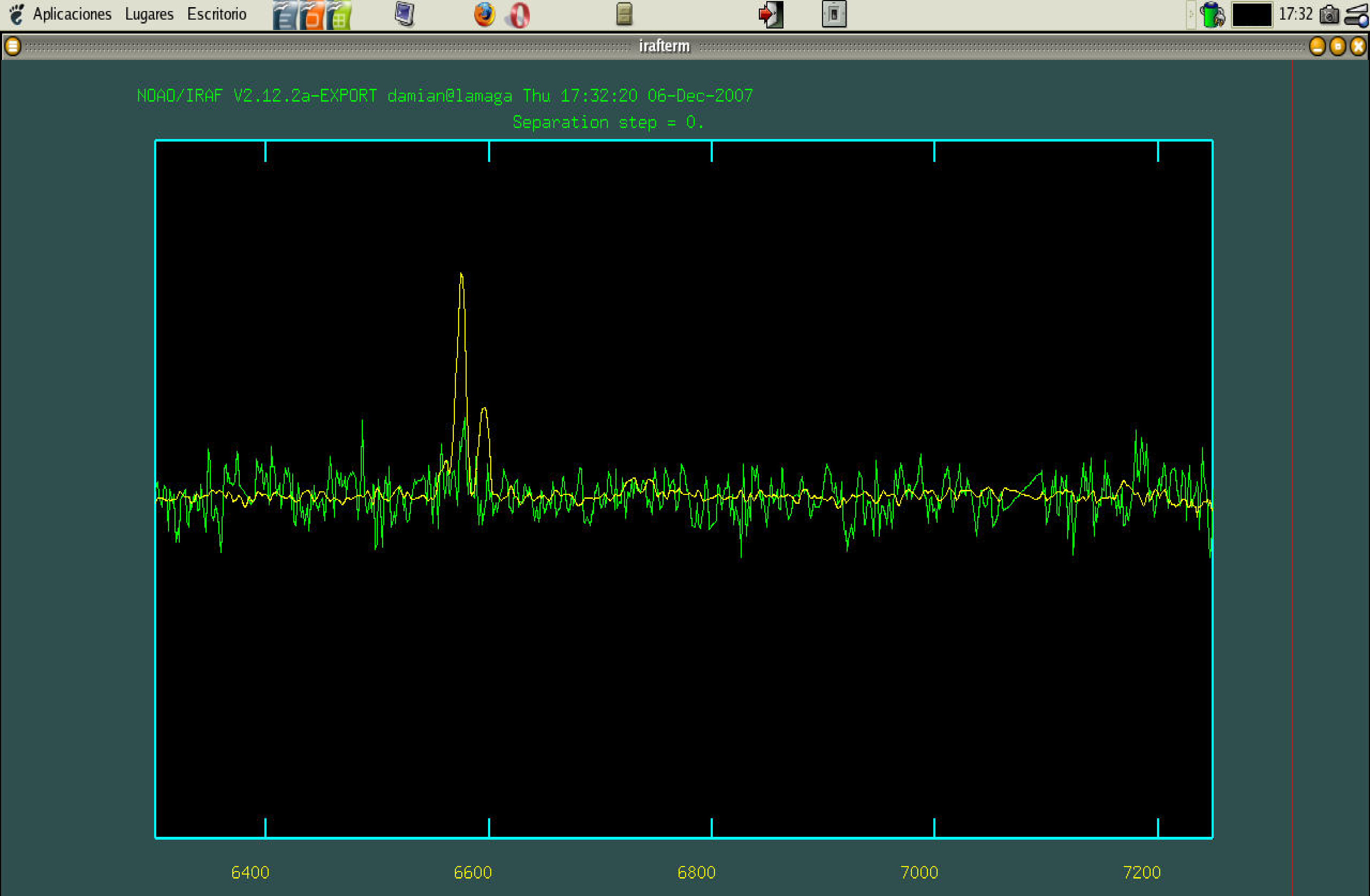
RS 28 GMOS-S at GEMINI South June 2007 (program GS-2007ADD-17).

broad and narrow band imaging in the range 500 to 950 nm, centered at the position of the radio source emission peak with average seeing of 0.*8"*.

bands and exposure times *: 90 s; [OIII]: 121 s; [OIII]C: 121 s; H®: 91.5 s;* H®*C: 91.5 s; [SII]: 91.5 s; i: 60 s; CaT: 60 s and z: 91.5 s*.

L. Slit spectroscopy between 572-988nm , effective exposure time of 3600 s and average seeing of 0.*8"*.

A 1.5" long slit was positioned on RS 28 and oriented along the line of radio sources.



Detalhe da região de Halpha. Amarelo,:RHII de referência, verde : espectro da M28, mostrando. Uma emissão a S/N~ 3.

Is J 133658.3-295105 a Radio Source at z >= 1.0 or at the distance of M 83?

The Astronomical Journal, Volume 136, Issue 6, pp. 2468-2472 (2008).

Dottori, H., Díaz, R., Mast, D.

Detection limit at *S/N » 3*, m*i = 23.5 ± 0.5. This is based on an average seeing of 0.8", disk absorption 1-1.3mg* ➔ *m_i=22.2mg*.

We could detect 80% of the BL and NL AGN in SEXSY sample!! (Eckart06).

If Cen A was located at *z » 1, NGC5128* would shine at m*I =21.5 mg, or mI =23.1mg if located at z = 2. Cen A radiolobes are at ~600kpc twice that quoted by soria & Wu (2003) for R28.*

(Hewitt & Burbidge 1993)*: [OII] ¸ 3727 Å (0.34,1.4); [NV] ¸ 3426 Å (0.46,1.77);*[MgII] *¸ 2798 Å (0.8,2.4); [CIII] ¸ 1909 Å (1.6,3.9); [HeII] ¸ 1640 Å (2.1,4.7); [CIV] ¸ 1549 Å* (2.2,5.1); [SIV] *¸ 1402 Å (2.6,6.7); [NeV] ¸ 1240 Å (3.4,7.6).* ➔ 2<*z*<3 *for large radio galaxies.*

If local , RS 28 would have a projected size ~*0.5-1.0 kpc*.

Is RS 28 a gravitational recoil?, Question remains open.

Ejecta RS 27 and RS 29 ➔ accretion disk like microQSO and QSO.

Why RS 27 and 29 sit along line of kick line? unclear.

Physical properties of accreting black holes (temperature, ejecta size, etc) scale with some power of the BH mass (Mirabel & Rodrıguez 1999).

If ejecta size scales with the BH mass, a direct comparison with the microquasar 1E1740.7-2942 (M*BH ~ 10Ms, size~5 pc)* lead to a mass for a RS 28 BH ~*1000 to 2000Ms*.

BB temperature for Eddington-limit accretion (Rees 1984; Mirabel & Rodr ́ ıguez 1999) should be *T = 10^7 (M/Ms)^(−1/4) ~1/3 to 1/5 of that of a galactic microquasar.*

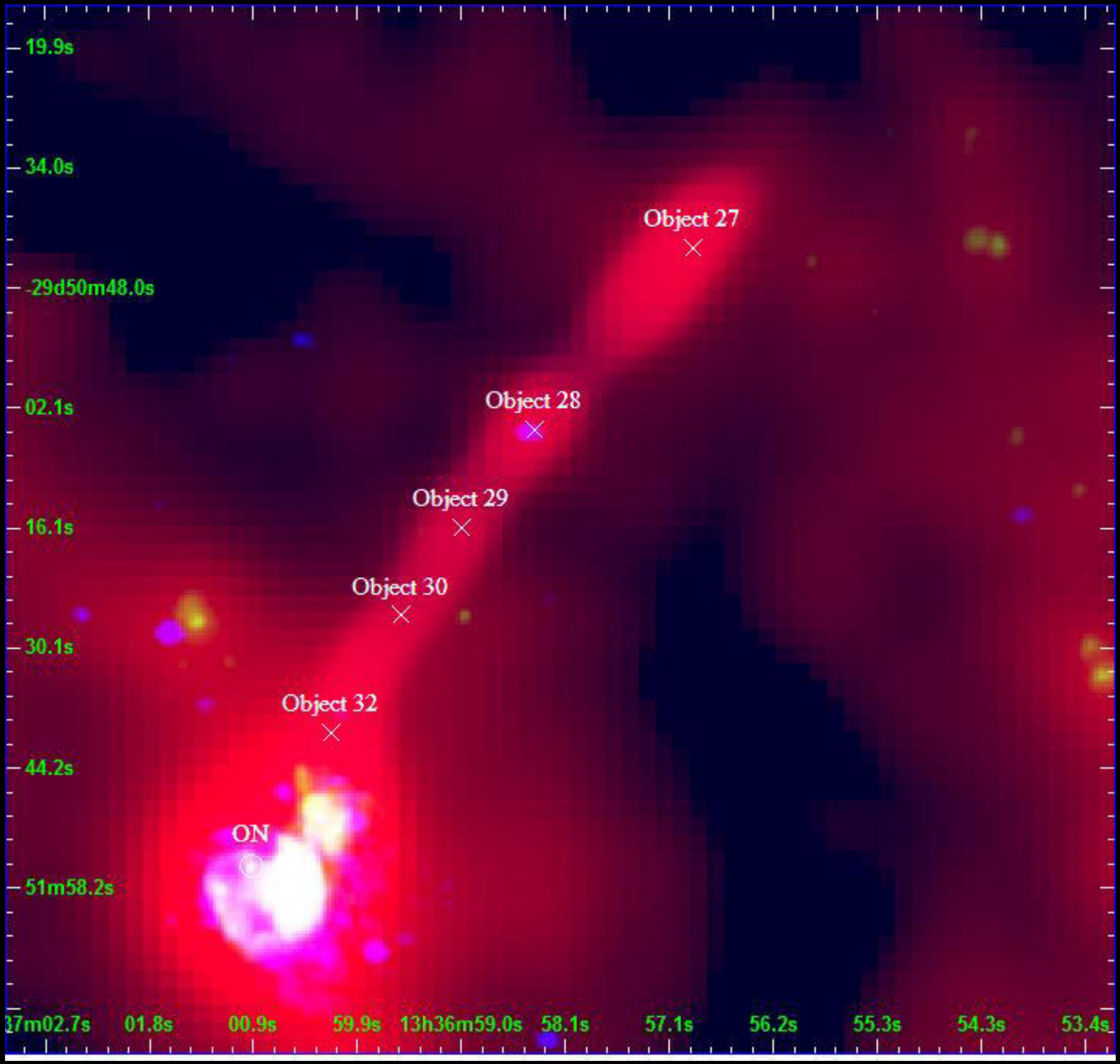
X-ray and/or NIR spectroscopic observations will be necessary to scan redshifts 2.5 < z <5.0 and also around z ~ 0 to unequivocally determine the distance to and the nature of J 133658.3–295105.

The missing Goliath's Slingshot: Massive black hole Recoil at the nucleus of M 83

Dottori, H., Diaz, R., Mast, D. & Albacete-Colombo, J. F.

Astrophysical Journal 2010, 717, Let 42.

The Fanaroff-Riley II radio source J133658.3–295105, which is also an X-ray source, appears to be projected onto the disk of the barred-spiral galaxy M83 at about 60" from the galaxy's optical nucleus. J133658.3–295105 and its radio lobes are aligned with the optical nucleus of M 83 and two other radio sources, neither of which are supernova remnants or H II regions. Due to this peculiar on-the-sky projection, J133658.3–295105 was previously studied by Gemini+GMOS optical spectroscopy, which marginally revealed the presence of Hα in emission receding at 130 km s^{-1} with respect to the optical nucleus. In this Letter, we reanalyze the *Chandra* spectroscopy carried out in 2000. We show that J133658.3–295105 presents an Fe Kα emission line at a redshift of $z = 0.018$. This redshift is compatible with a black hole at the distance of M 83. We discuss similarities to the recently reported micro-quasar in NGC 5408. This finding reinforces the kicked-off black hole scenario for J133658.3–295105.



19.9s
34.0s
-29d50m48.0s
02.1s
16.1s
30.1s
44.2s
51m58.2s
Object 27
Object 28
Object 29
Object 30
Object 32
ON
37m02.7s
01.8s
00.9s
59.9s
13h36m59.0s
58.1s
57.1s
56.2s
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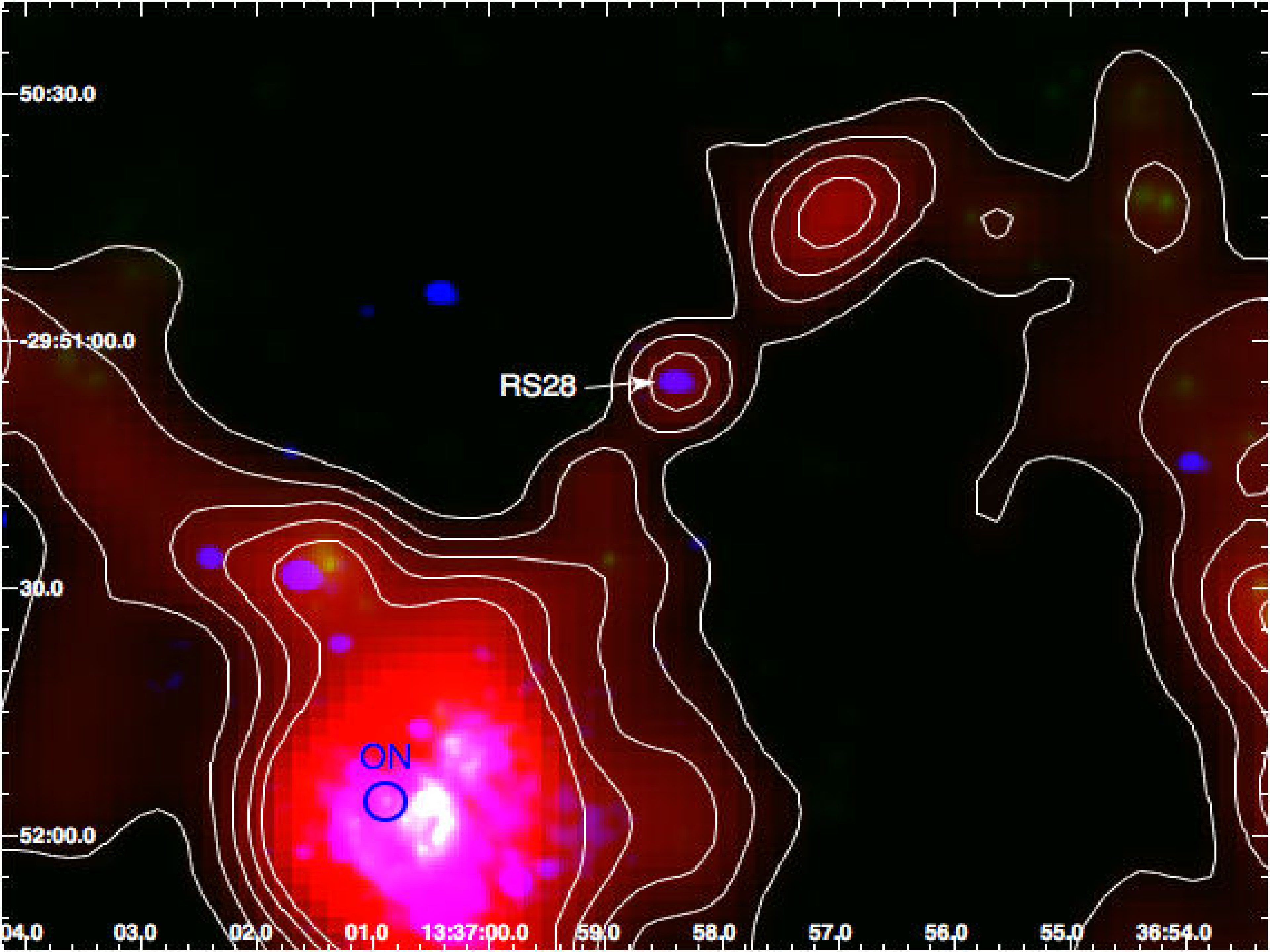
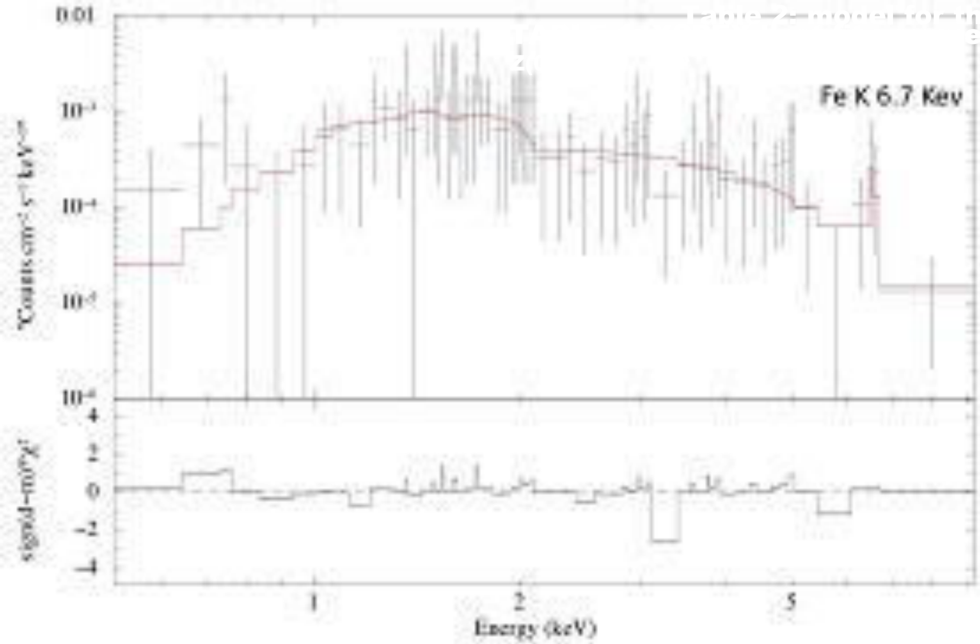
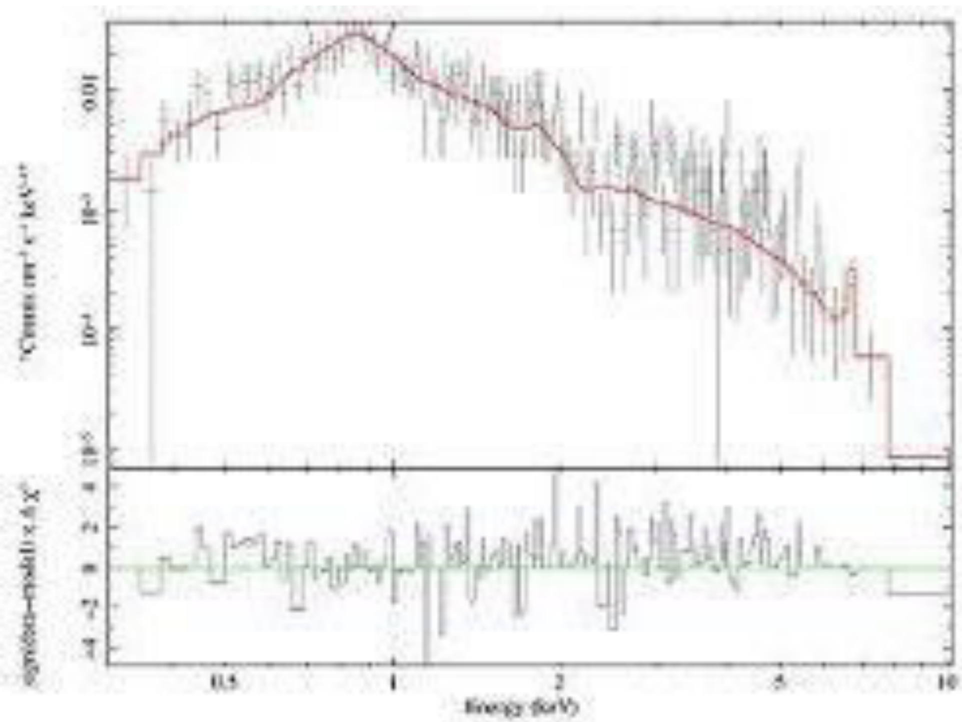
54.3s
53.4s



50:30.0
-29:51:00.0
30.0
52:00.0
RS28
ON
04.0
03.0
02.0
01.0
13:37:00.0
59.0
58.0
57.0
56.0
55.0
36:54.0



$(wabs_{Gal}$ X wabs X (diskline + aspec)	
$N_H(10^{21}\ cm^{-2})$	7.0 ± 0.38
$T_{diskline}$(keV)	6.47 ± 0.07
T_{apec}(keV)	6.9 ± 4.0
$F_{X\ 0.3\text{-}10}\ (10^{-14}$ erg s^{-1} $cm^{-2})$	$3.37^{+0.5}_{-0.3}$
$I_{Fe\text{-}K\alpha}\ (10^{-15}$ erg $s^{-1})$	7.0
z $(10^{-2}$ Fe-Kα)	$2.1 \pm^{0.8}_{0.4}$
X^2_v	0.47(111)
$L_{0.5\text{-}10}\ (10^{38}$ erg $s^{-1})$	2.2 ± 0.4



$(wabs_{Gal}$ x wabs x BB1 x BB2)	
$N_H(x10^{21}\ cm^{-2})$	1.01 ± 0.38
T_{BB1}(keV)	0.66 ± 0.04
T_{BB2}(keV)	6.70 ± 1.90
$F_{X\ 0.3\text{-}10}\ (x10^{-14}$ erg s^{-1} $cm^{-2})$	$12.6^{+0.5}_{-0.3}$
$I_{Fe\text{-}K\alpha}\ (10^{-15}$ erg $s^{-1})$	1.3
z $(10^{-3}$ Fe-Kα)	$6.0 \pm^{9.0}_{4.0}$
Chi-sq(dof)	0.82 (286)
$L_{0.3\text{-}10}\ (10^{38}$ erg $s^{-1})$	8.8 ± 1.3 !!!

NUMERICAL SIMULATIONS

Modeling the Black hole Recoil from the Nucleus of M 83
Guilherme G. Ferrari

Gonçalves Ferrari, G., Dottori, H., Díaz, R.

Journal of Modern Physics 2013, Vol 4, No7a, pg55-63

In our approach, Post-Newtonian equations are employed in all interactions in which at least one SMBH is present, while interactions between individual stars are computed in Newtonian form with a softening length ~1/N, where N is the total number of particles. We use a symplectic integration method based on the time-transformed leap-frog scheme, modified to account for the correct time symmetry of the Post-Newtonian equations during the numerical solution. The time symmetry was accomplished by a semi-implicit trapezoidal rule, which results in only one (Newtonian and Post-Newtonian) force calculation per timestep, while keeping energy conservation within a difference of ≤10^−12 relative to the initial value. The simulations ended when the particles reached separations of the order of 3 RSch (Schwarzschild radii) or when the endtime was reached. We emphasize that the symplectic integrators respect the system's Hamiltonian structure, conserving the symplectic form itself.

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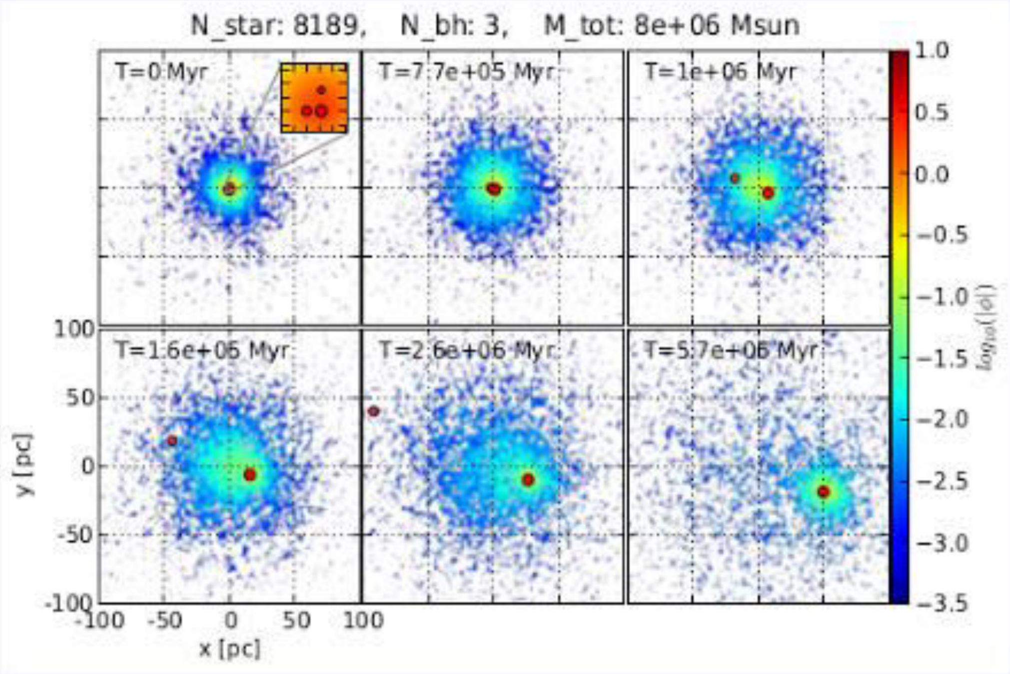
Modeling the gravitational recoil in NGC 5236



Hernquist profile (10 runs)

- 2 or 3 SMBHs
- $N \sim 4 - 8 \times 10^3$ stars
- $R_{Virial} \sim 10\,\mathrm{pc}$
- $M_{total} \sim 10^7\,\mathrm{M}_\odot$
- $\sum M_{SMBH} \sim 0.25 M_{total}$
- Post-Newtonian corrections

Main results

- Triple SMBHs models are the ones that better reproduces the observed situation
- "ON"-like object: $D_{recoil} \sim 30 - 200\,\mathrm{pc}$, $V_{recoil} \sim 40 - 90\,\mathrm{km/s}$
- "J133658.3-295105"-like object: $D_{recoil} \sim 0.4 - 4\,\mathrm{kpc}$, $V_{recoil} \sim 100 - 400\,\mathrm{km/s}$

Concluding Remarks:

The time for the process of merge of ON, KC, HN and the chain of HII regions in the central region of M83 is of the order of 100-500 Myrs, while the ejection of a kick-off ocurrs at typical velocities of 400-4000 km/sec. Assuming a value of 1000 km/sec, and a distance of ~1 kpc for RS28, it hapened a million years ago, roughly speaking. That suggest that the second process can be considered as instantaneous compared to the first. Then it is possible that the Kick-off ejection and the off-center ON may be, according to the simulation, the by-product of the same process indicating that ON should host at least 2 BHs .

It might be argued that the kick-off is so young that it is tremendous coincidence that we are just now adays witnessing the phenomenon and that all may be just a flaw. We agre that it is possible, but we call your attention to the fact that a new process of merging is in course and if the previous analysis is correct, ON must have a couple of BHs in its interior. Tha is why the study of this group of galaxies is so important.

COMPLEMENTARY SCENARY.

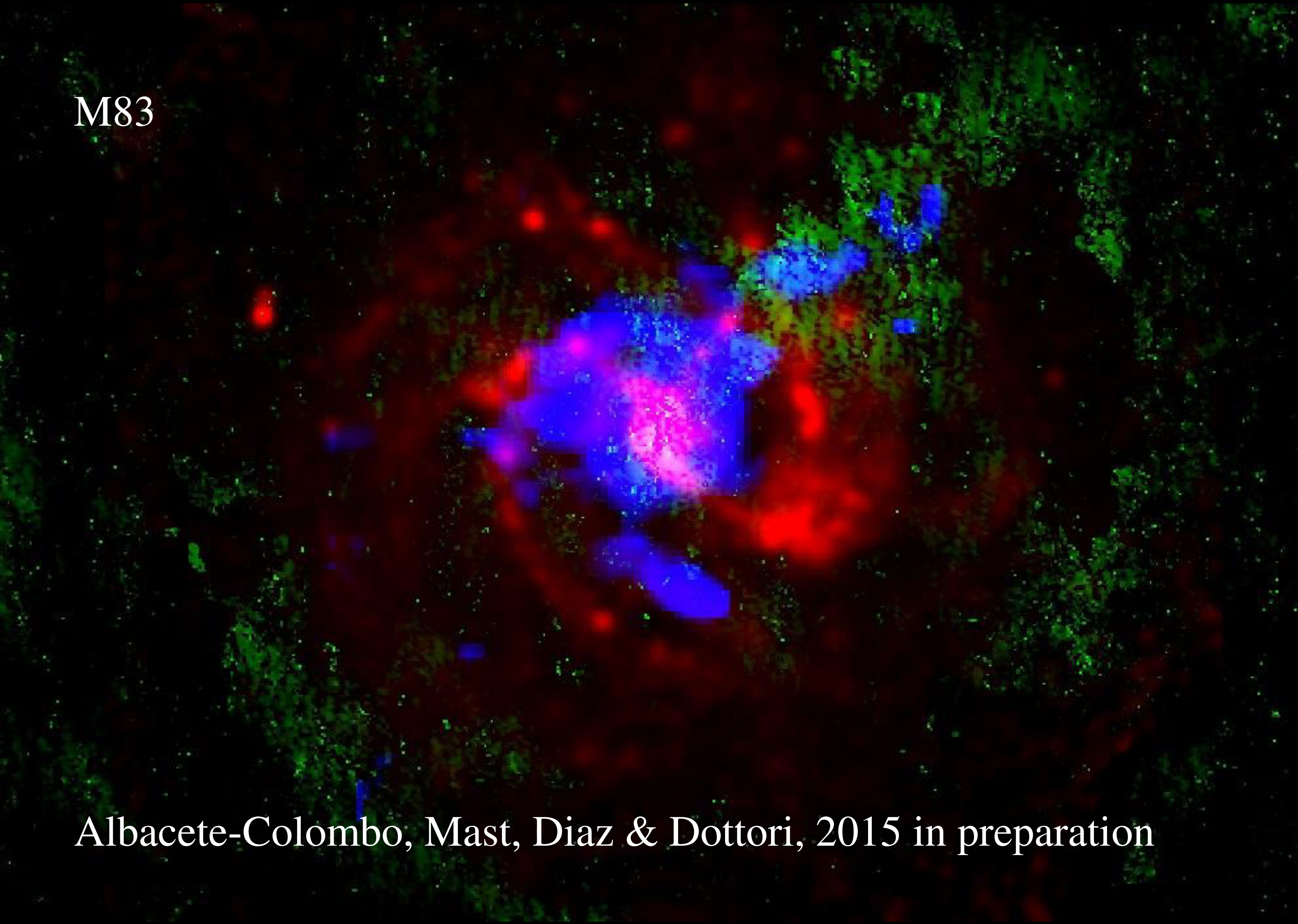
MINOR SATELLITES CANIVALISM

"Naked Nuclei"

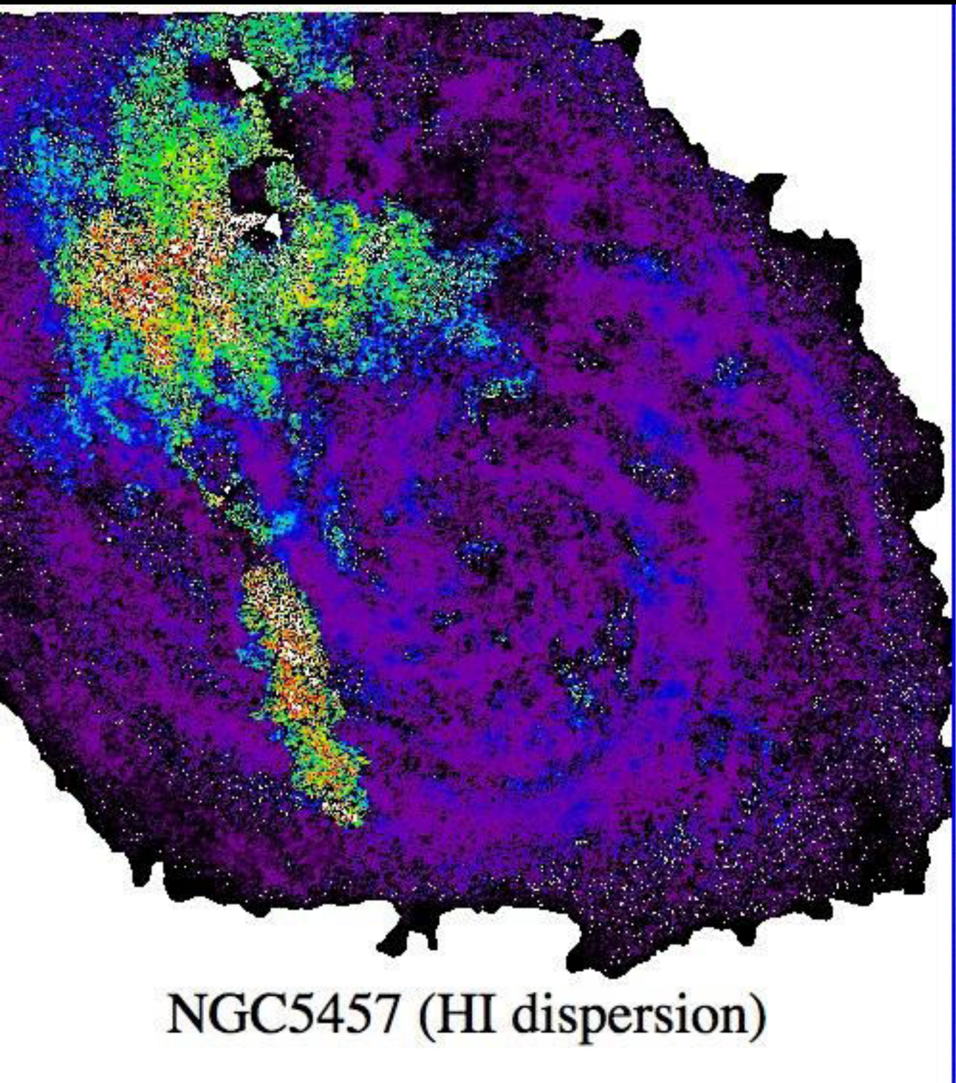
A couple of examples follow showing that process of canivalization is
A common one in the near Universe, such that in NGC 4651. Foster, C. et al. http://adsabs.harvard.edu/abs (2014, MNRAS 442, 3544). Steams are also detected in the halo of M83 (S54) Albacete-Colombo J., Mast , D., Díaz, R. & Dottori, H. in preparation.

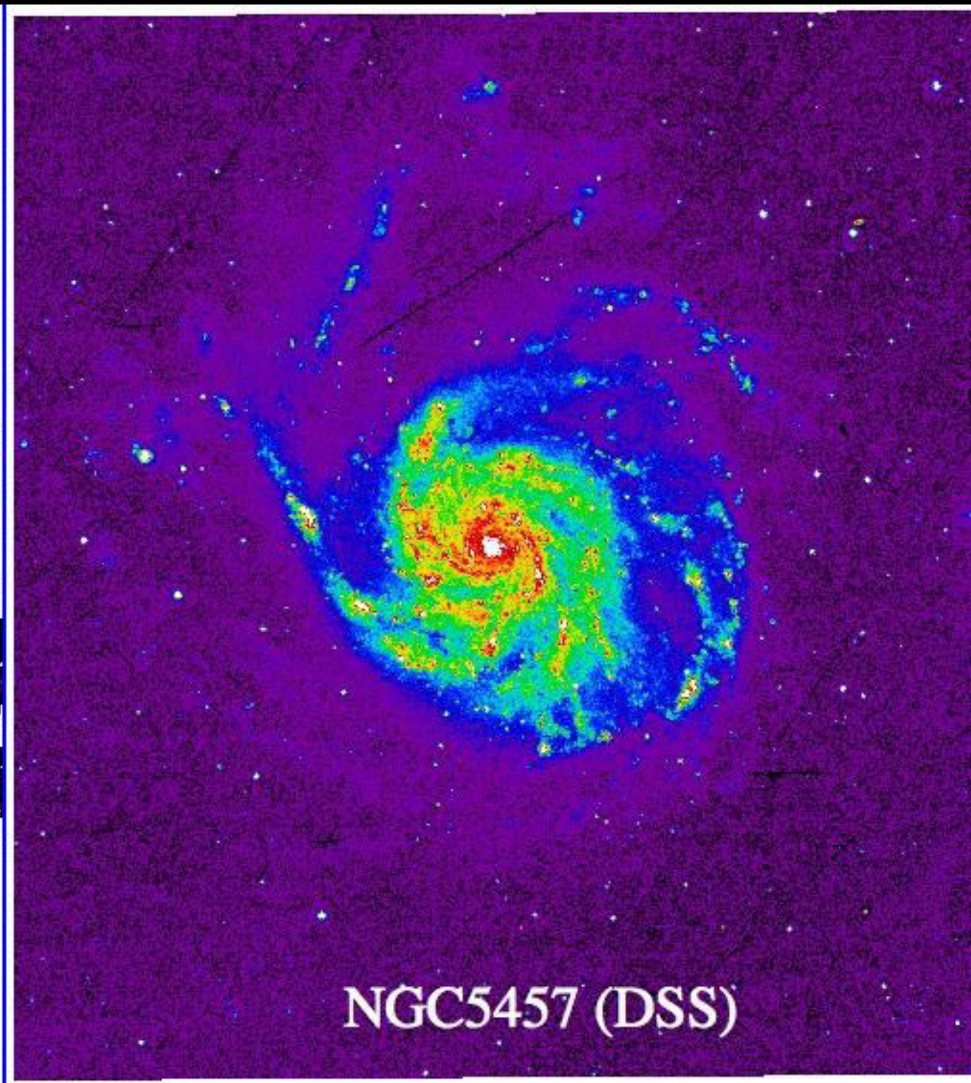
NGC 4651, GaBany et al.

http://apod.nasa.gov/apod/image/1407/lrg_gabany-subaru_ngc4651.jpg


M83
Albacete-Colombo, Mast, Diaz & Dottori, 2015 in preparation

NGC 5457 (Wong et al. 04, ApJ 605, 183)





THANKS!