Recent Star Formation in Early Type Galaxies hosting AGNs

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MOTIVATION

Demography of massive dark objects (MDOs) in local spheroids (Ferrarese 02)

QSO optical (z ~ 6) and X ray (z ~ 3) luminosity functions (Fan et al. 03, Cristiani et al 04)

→ AGN activity is common transient phenomenon (Cavaliere & Vittorini 02)

single engine + triggering mechanism

central MDO | destabilization of the gas (dynamical interaction)

high z → violent aggregation processes during spheroid formation

low z → mild interactions of host galaxies in the field

→ Dynamical interaction is accompanied by star formation

- theoretical studies of the merging process (e.g. Kojima, M & Noguchi, M., 97)
- spectroscopic studies of local field early type galaxies in pair or showing shells (Longhetti et al 00, Bressan et al 06)

→ Common mechanism responsible of two different phenomena

QSO shining and SP rejuvenation

The stellar population content of QSO host galaxies

To cast light on this point, many imaging studies have been performed in recent years on the host galaxies of nearby and distant AGNs

(Bahcall 97, Mobasher et al. 93, Falomo et al 00 ,Percival et al. 01, Dunlop et al. 03, Pagani et al 03, Falomo et al 04, 05)

Imaging studies: → global properties: morphology, luminosity, scale-lengths

The host galaxy properties of luminous AGN ($z < 0.5$)

- RLQ preferentially found in luminous E exceeding L* by 1—2 mag
- RQQ in E & S of lower luminosity (E for luminous RQQs)
- BL Lac (nuc L factor 5-10 < typical QSO) found in *unperturbed* E

Imaging studies: → unable to address the issue of stellar content of these galaxies

Presence of young stellar populations ?

(but for very preliminary insights with multicolor images e.g. Jahnke et al. 01; Labiano et al. 05)

Strategy: adequate spectroscopy of the surrounding nebulosity

Till now only pioneering work has been done on this side

(e.g. Boroson et al 85; Nolan et al 01)

off-nuclear spectroscopy of about 20 QSO galaxies

poor S/N, inadequate seeing, effects of QSO scattered light

Somewhat more detailed study on individual sources

(e.g. Canalizo& Stockton 00, Labiano et al 05)

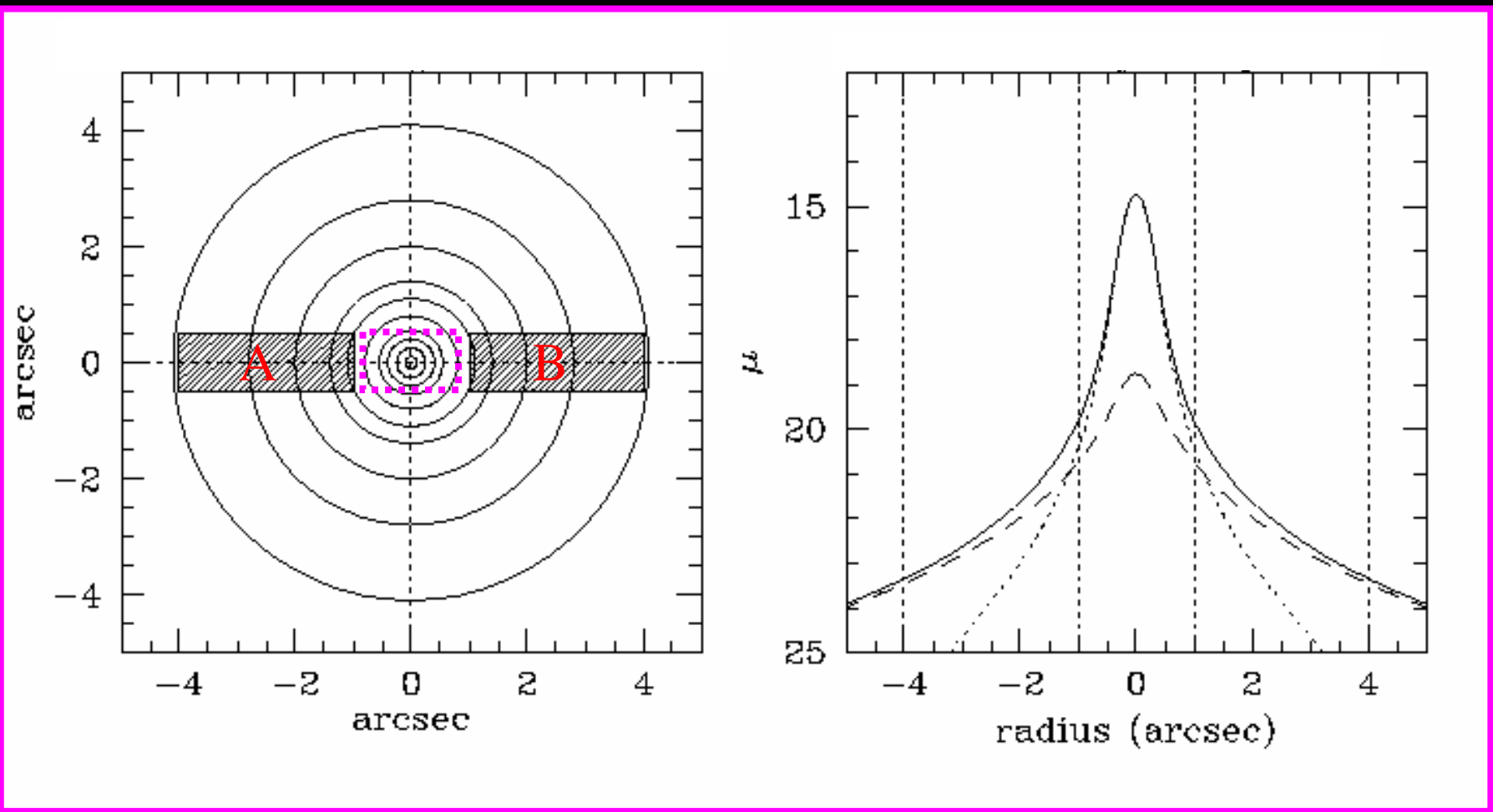
We are carrying out a spectroscopic study of early type galaxies hosting AGNs

Sample

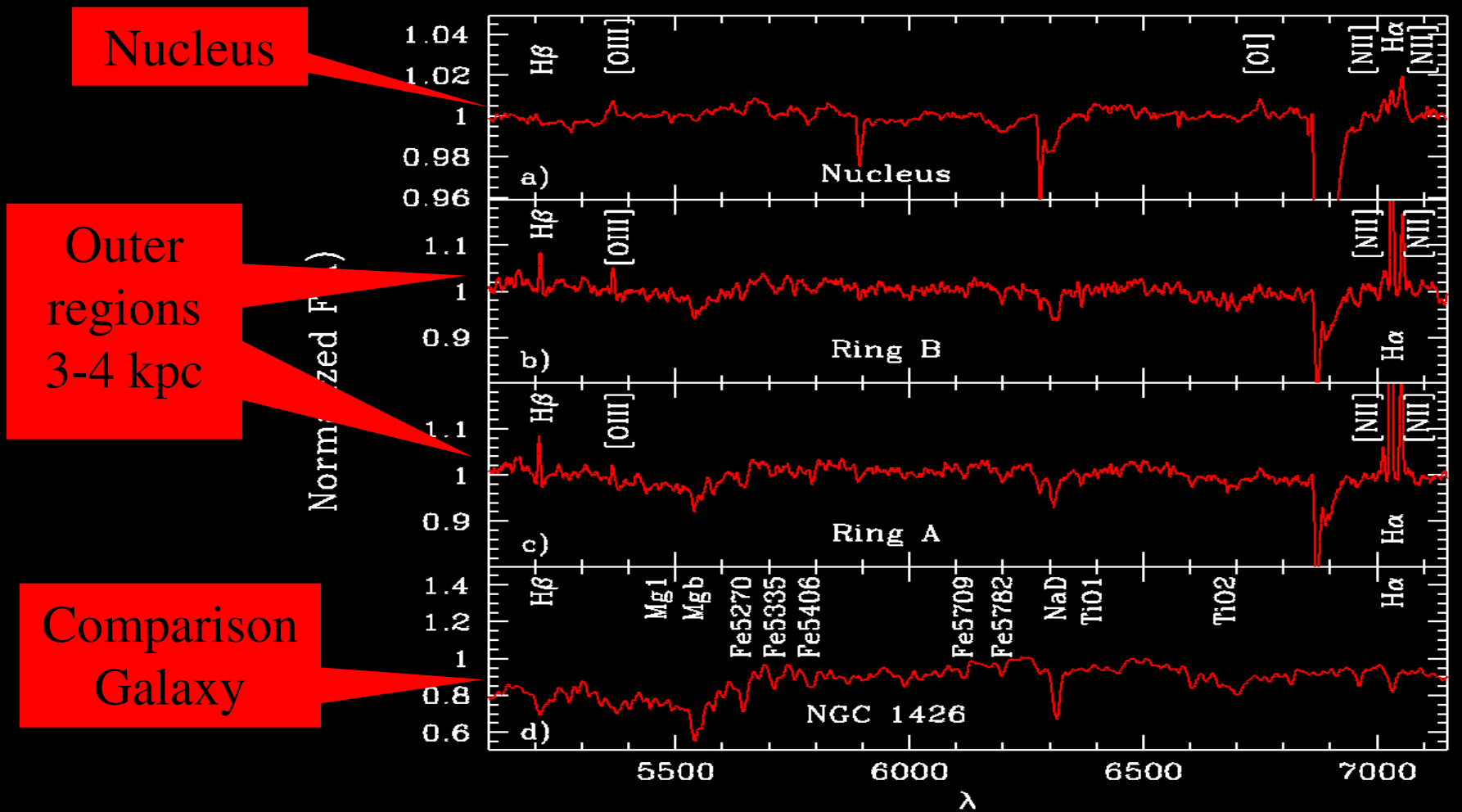
Name	z	RC3
PKS2005-489	0.0711	BLLAC
2215-037	0.2418	RQQ Sy1
AP-LIB	0.0486	BLLAC
2135-147	0.2003	Opt.var. Sy1
PKSB2201+044	0.0270	BLLAC, Sy1
2355-082	0.2110	QSO
2356-309	0.1651	BLLAC

We report on the discovery of ongoing/recent star formation in PKS 2005-489 (Bl Lac) & 2115-037 (RQQ)

Observations



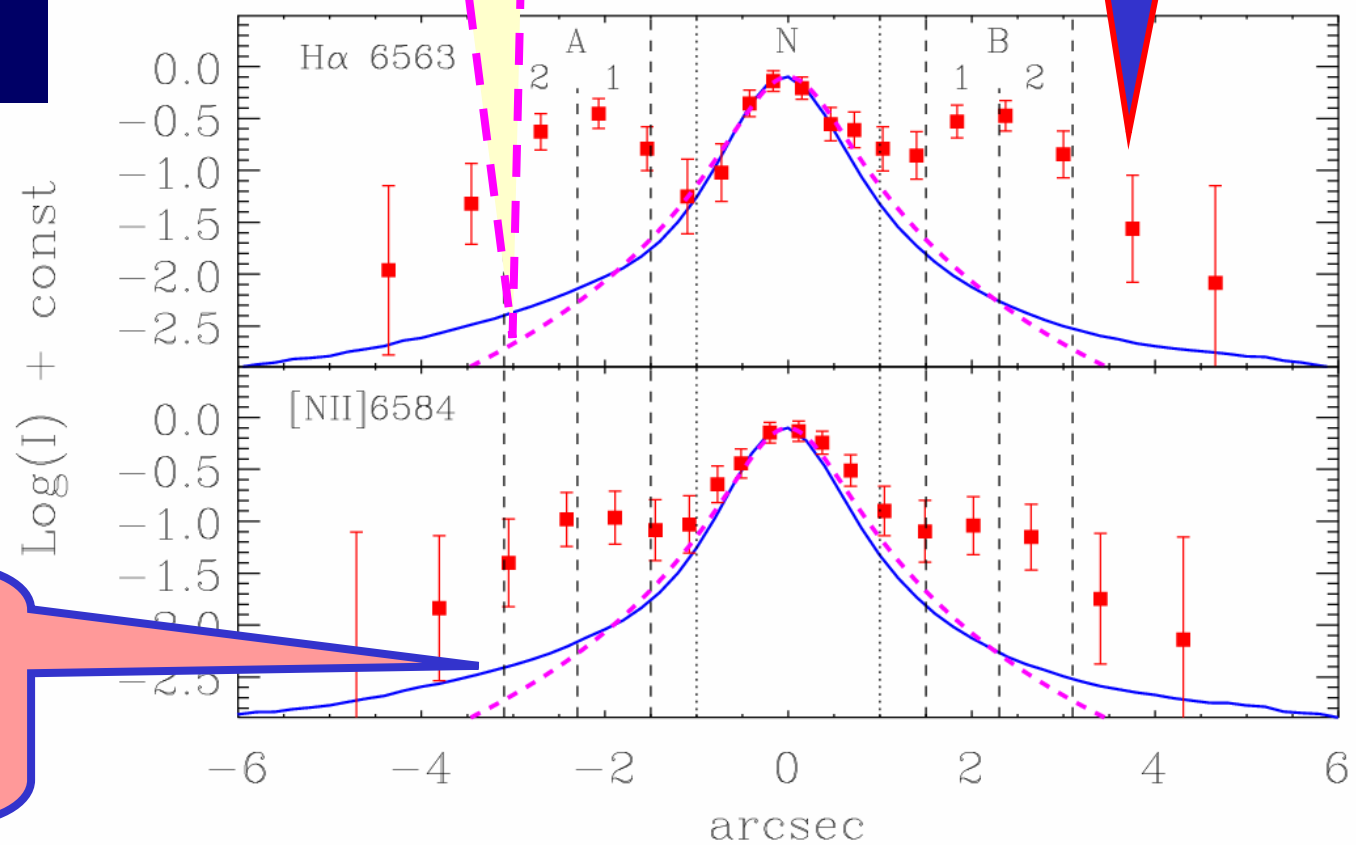
PKS 2005-489


Nucleus
Outer regions 3-4 kpc
Comparison Galaxy
Hβ
[OIII]
[OI]
[NII]
Hα
[NII]
a)
Nucleus
b)
Ring B
c)
Ring A
Mg1
Mgb
Fe5270
Fe5335
Fe5406
Fe5709
Fe5782
NaD
TiO1
TiO2
d)
NGC 1426
1.04
1.02
1
0.98
0.96
1.1
1
0.9
1.4
1.2
0.8
0.6
5500
6000
6500
7000
λ

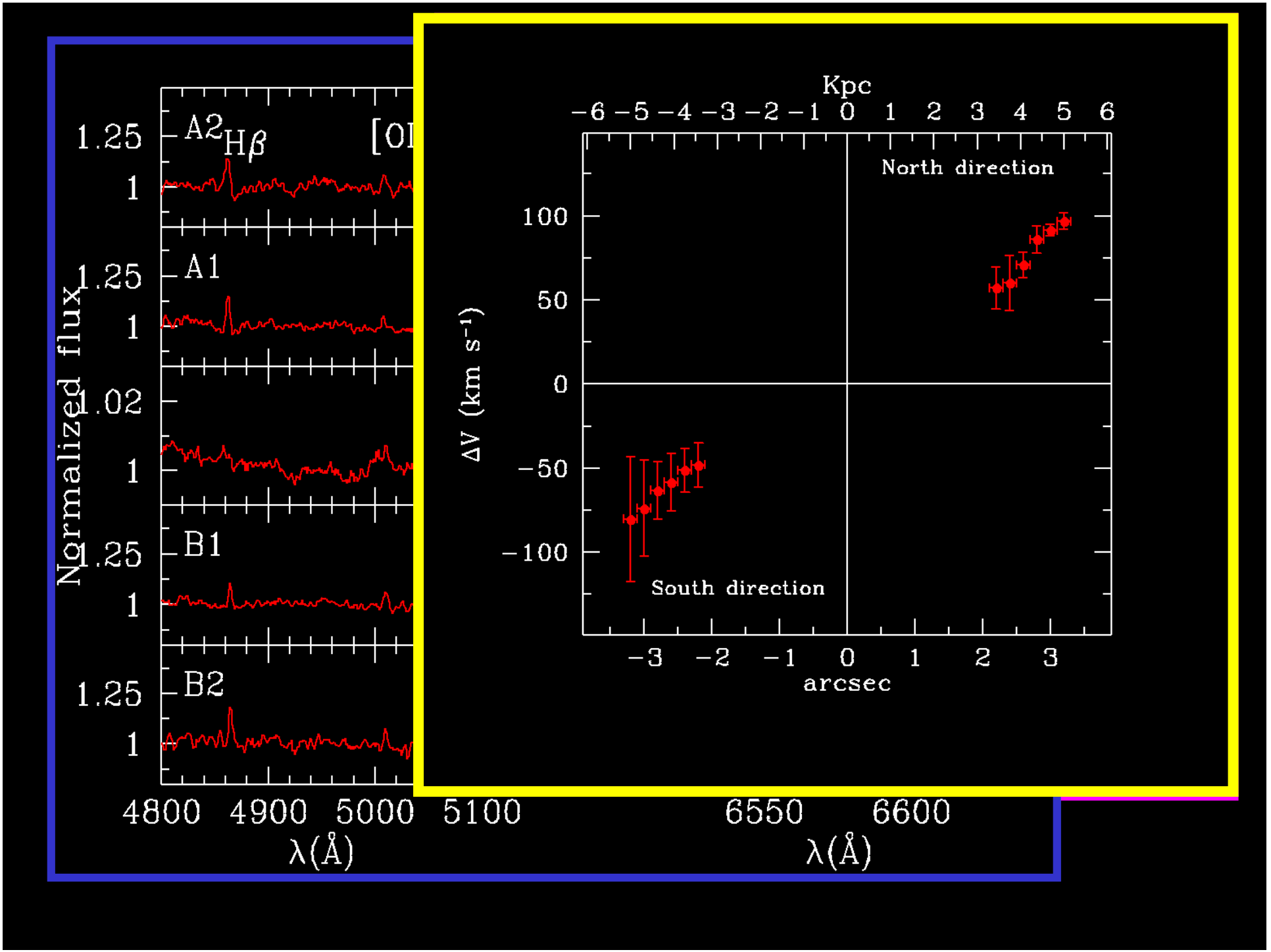
Spatial profile

Star profile

Intensity of the emission



Flux in the nearby continuum


A2
Hβ
[OI
A1
B1
B2
1.25
1
1.02
Normalized flux
4800
4900
5000
5100
λ(Å)
6550
6600
λ(Å)
Kpc
−6 −5 −4 −3 −2 −1 0 1 2 3 4 5 6
North direction
South direction
100
50
0
−50
−100
ΔV (km s⁻¹)
−3 −2 −1 0 1 2 3
arcsec

Conclusions a)

Spatial intensity profile of the line emission regions together with the kinematics and emission diagnostics of the gas show presence of a rotating ring with ongoing star formation at 4 kpc from the nucleus

SFR ≃ 1.2 Mo/yr (Panuzzo et al 03 models)

SFR ≃ dM/dt_{ACC} (≃ 0.8 Mo/yr) from L_{BOL} (Xie et al. 2004) and $Log(M_{BH})$ ≃ 8.9 (Falomo et al 03)

M_{Burst}= SFR x 1E8 yr ≃ 1.2E8 Mo ≃ 0.03\% M_{HOST} (≃ 4 E11 Mo from R=-23.1)

!! Tiny rejuvenation episode !! much below typical 1% observed in ETGs

Intrinsic velocity of the ring should be V_C ≃ 420 km/s

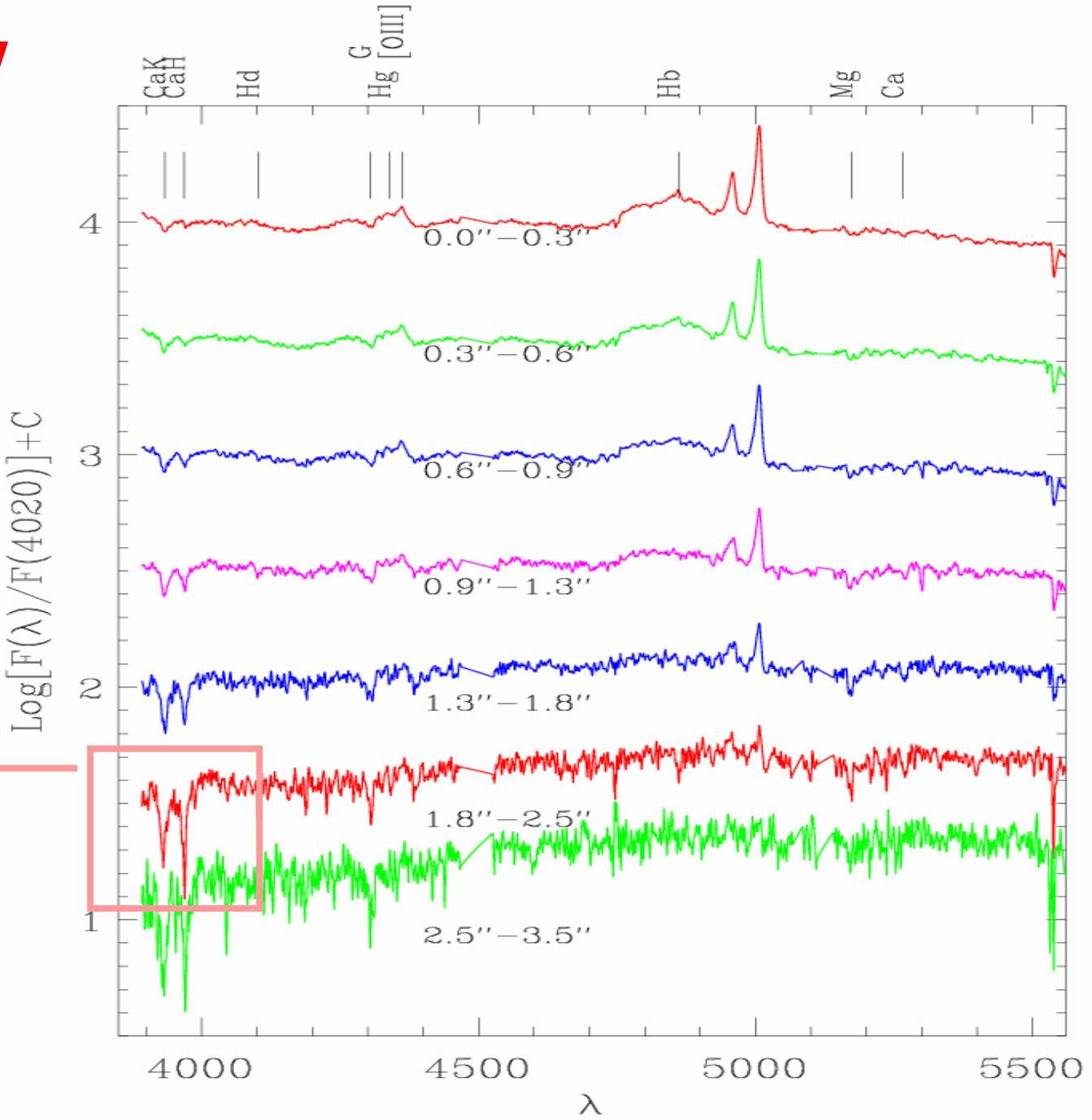
from V_C - σ_C relation (Pizzella et al 05) & σ_C ≃ 250 km/s (from R Mag)

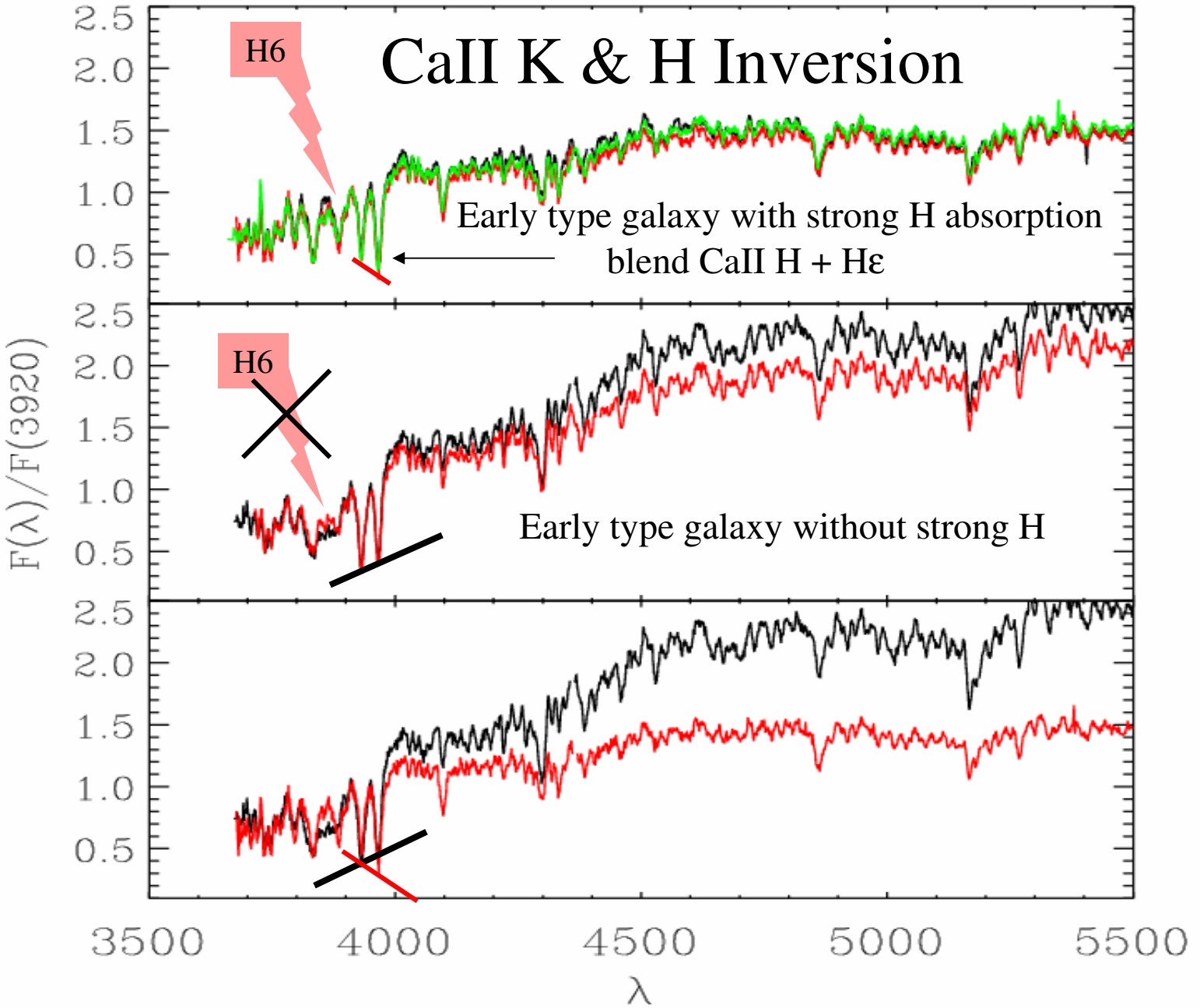
Since V_r ≃ 75 km/s inclination angle of the ring is 80 degrees : ring almost face on

SF ring nearly perpendicular to the radio jet (*like 3C218 - Hydra A- Melnick et al. 1997)*

2215-037

CaII K & H Inversion





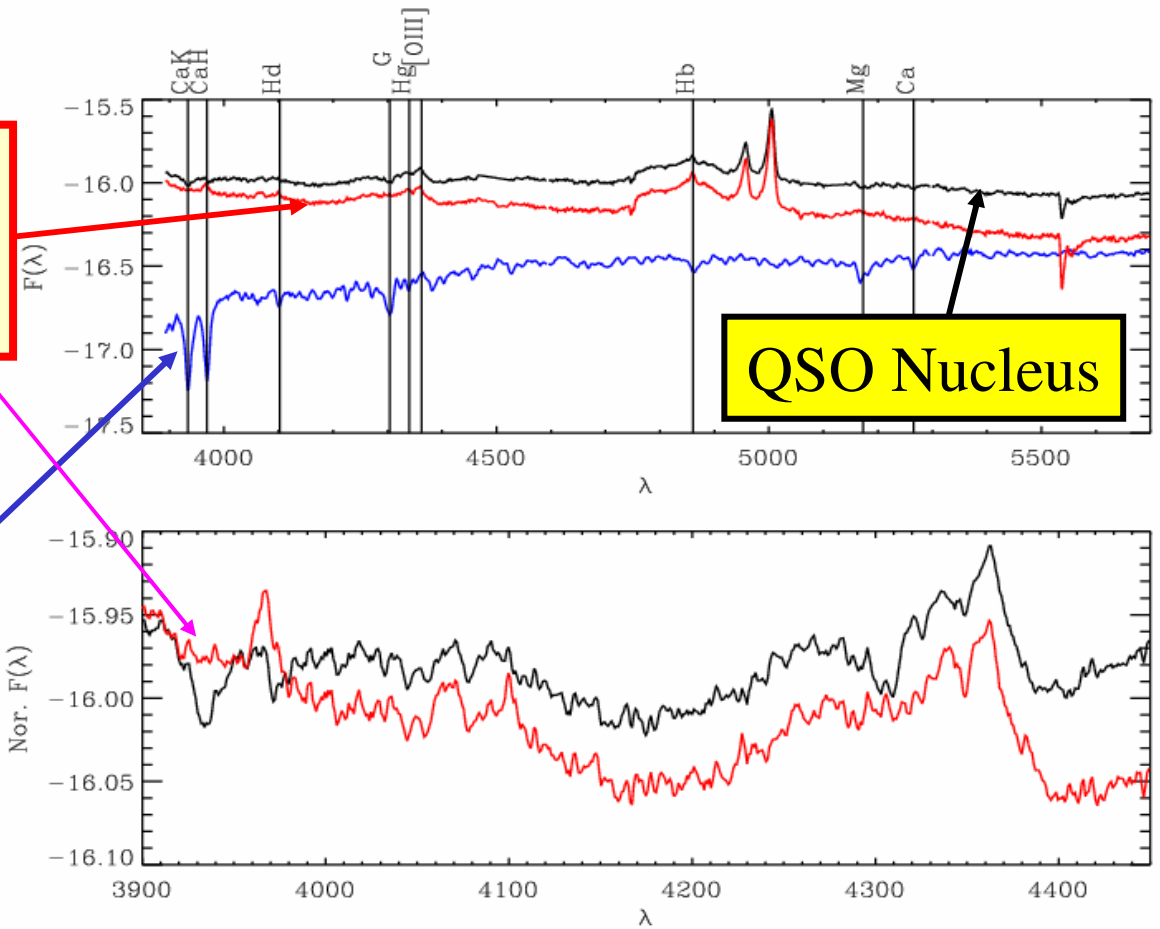
SDSS E type galaxies (Clemens et al. 2006)

Template QSO =

QSO Nucleus – galaxy

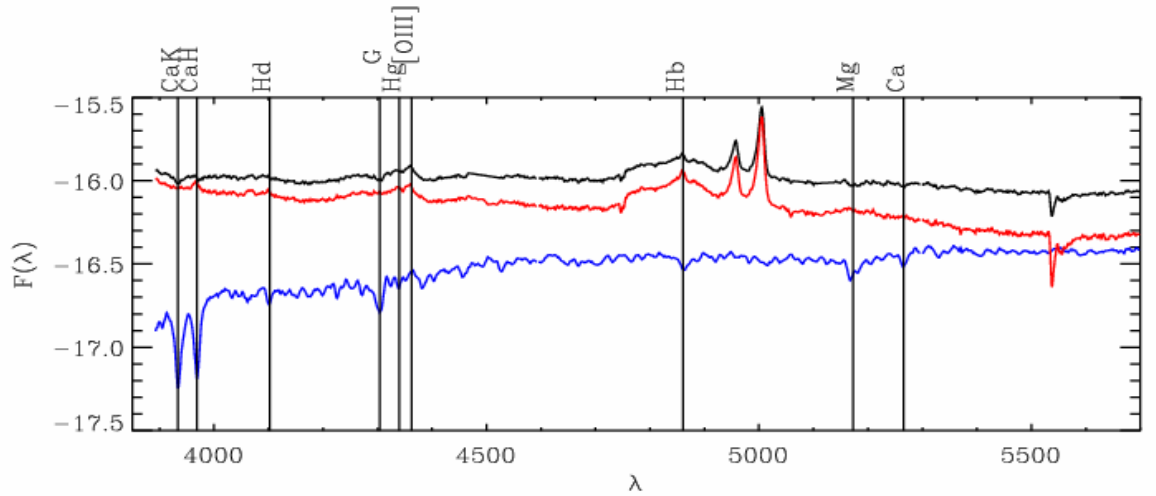
(until CaII K disappears)

Template galaxy

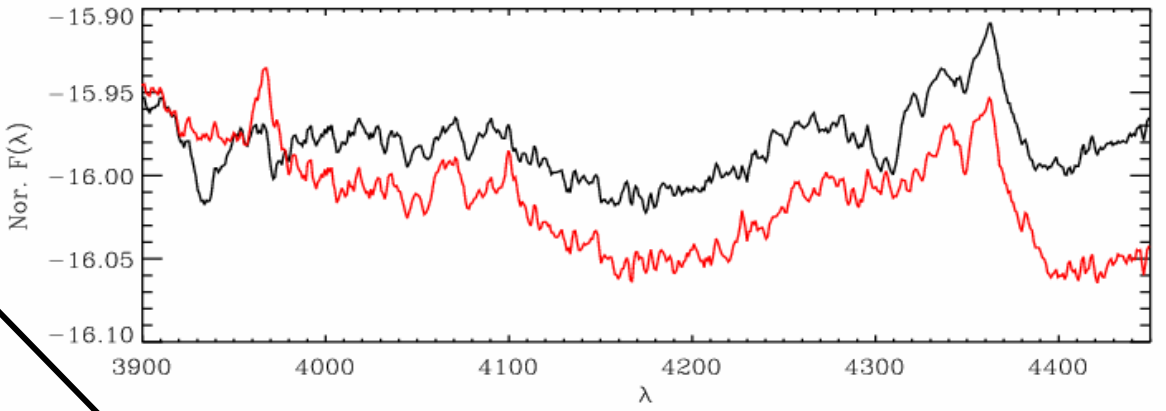


Host Galaxy

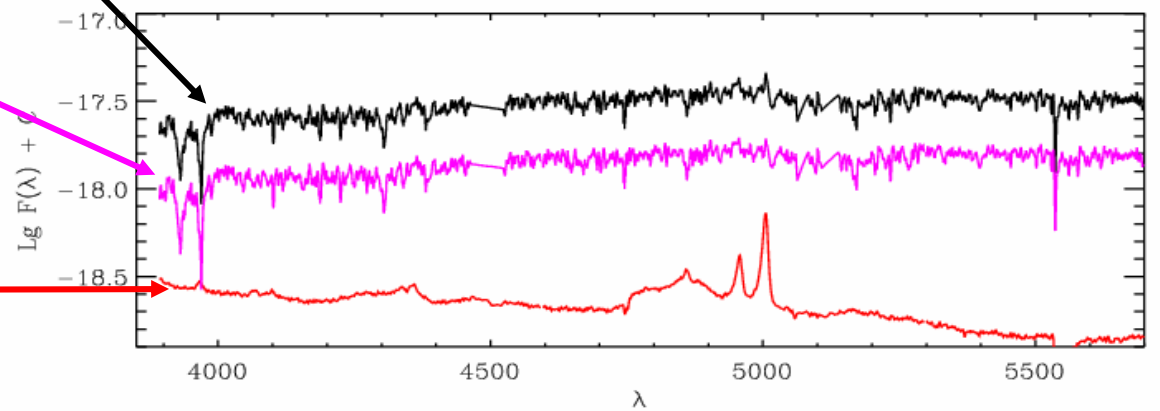
(outer region)



Host Galaxy

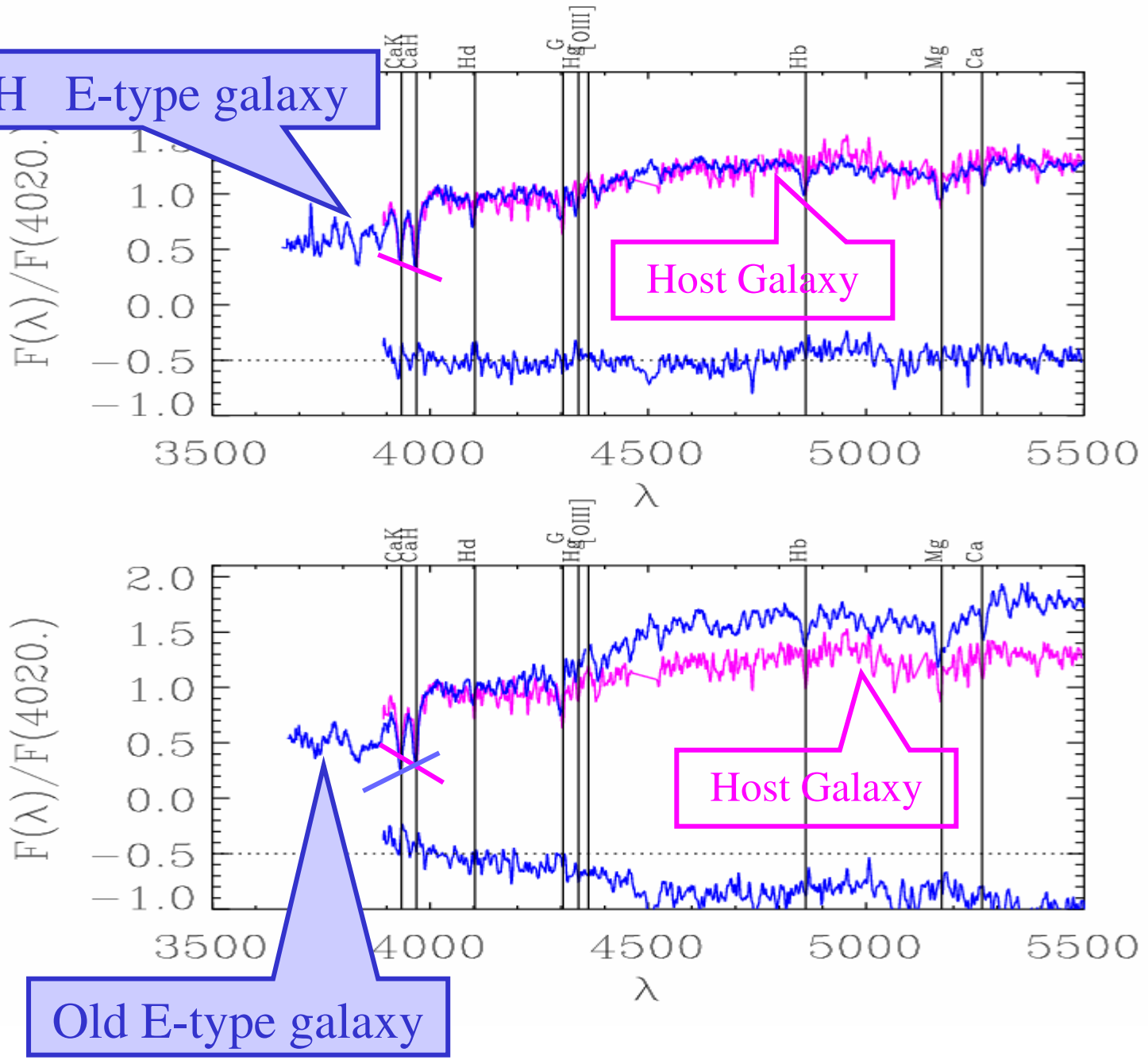


Host QSO subtracted (shifted)



% QSO Estimated from [OIII] lines

? What kind stellar pop. in host galaxy ?



Conclusions b)

We detected CaII K & H inversion in
2115-037 host galaxy spectrum

It usually indicates contamination by A stars
(Leonardi & Rose 96)

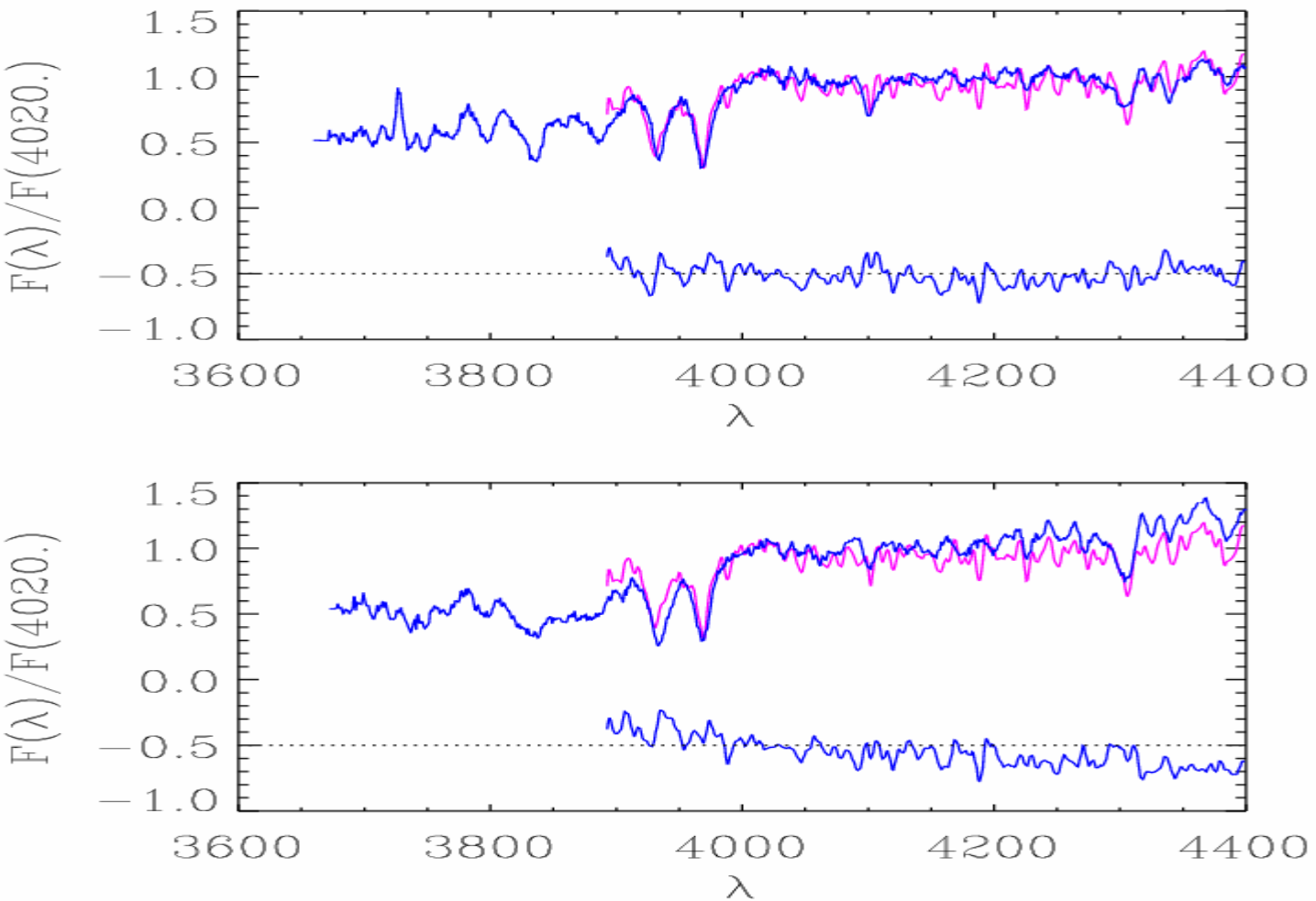
High S/N allows subtraction of galaxy template
from nuclear spectrum

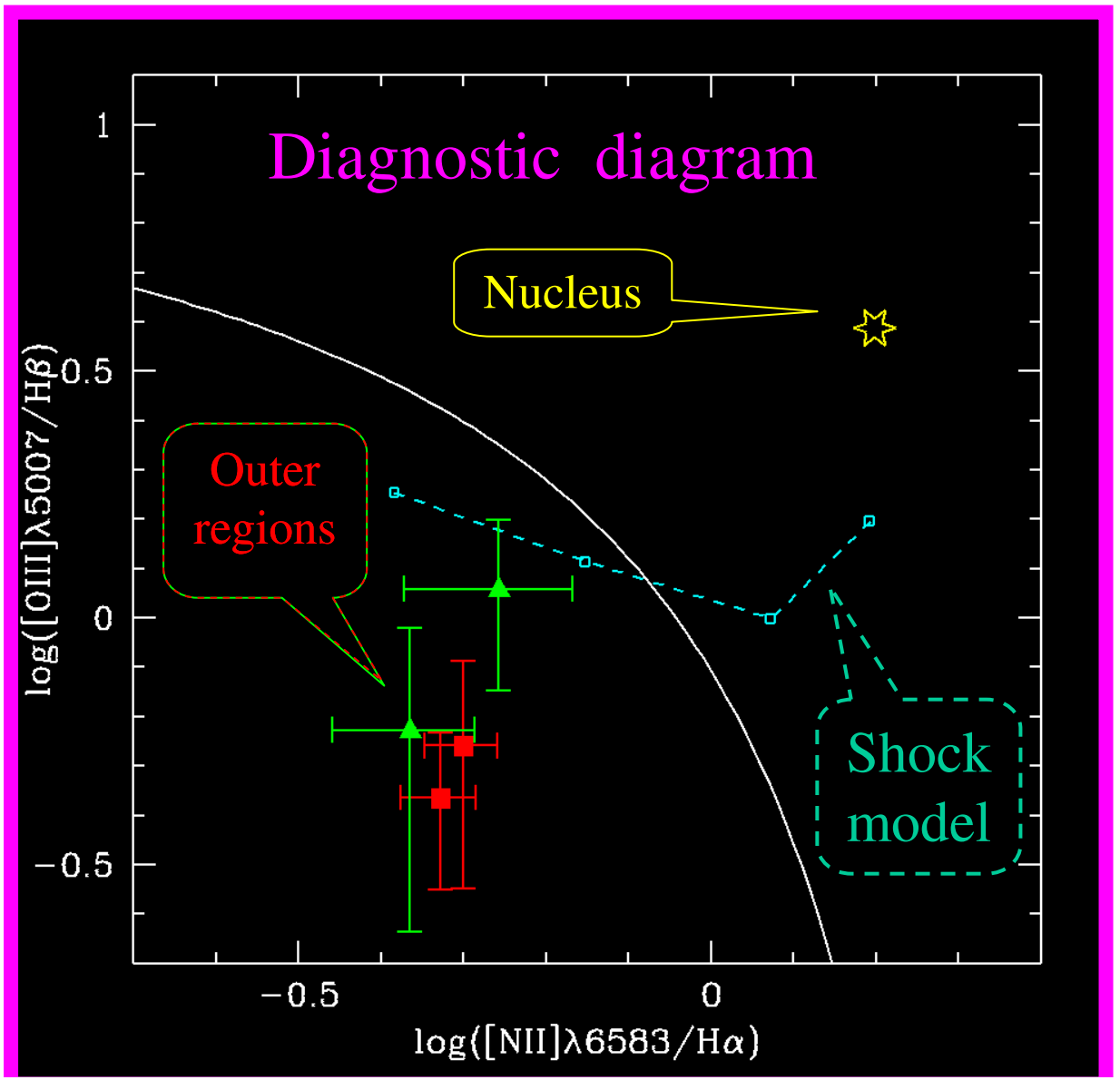
-> QSO Template

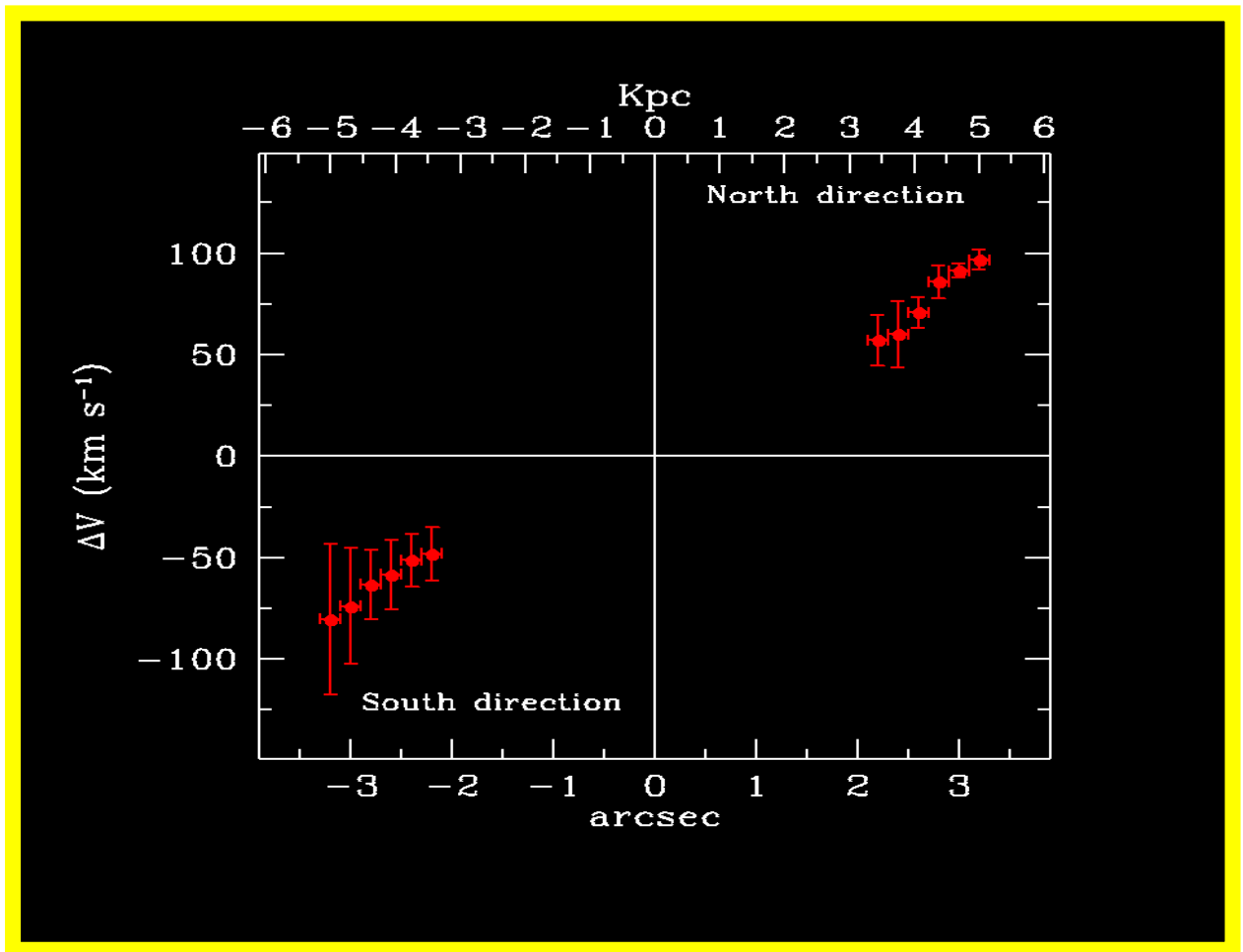
-> QSO contamination

QSO host galaxy spectrum consistent with presence of young stars

Young population best traced in 3700-4100 A region


F(λ)/F(4020.)
1.5
1.0
0.5
0.0
−0.5
−1.0
3600
3800
4000
4200
4400
λ
F(λ)/F(4020.)
1.5
1.0
0.5
0.0
−0.5
−1.0
3600
3800
4000
4200
4400
λ


Diagnostic diagram
Nucleus
Outer regions
Shock model
1
0.5
0
−0.5
−0.5
0
log([OIII]λ5007/Hβ)
log([NII]λ6583/Hα)

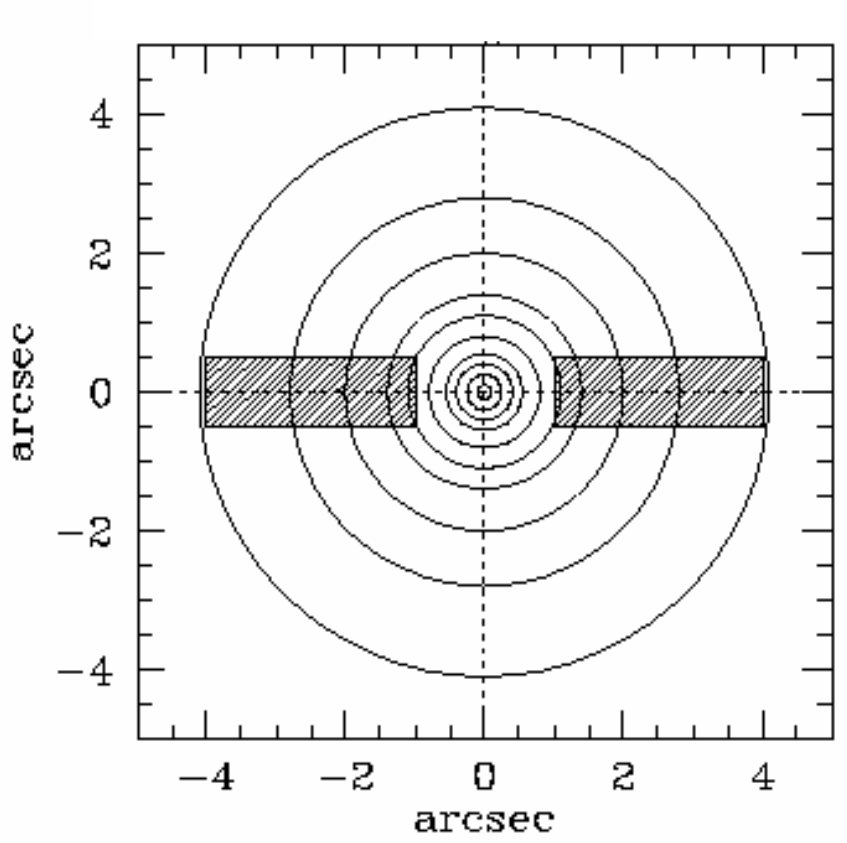

Kpc
−6 −5 −4 −3 −2 −1 0 1 2 3 4 5 6
North direction
South direction
100
50
0
−50
−100
ΔV (km s⁻¹)
−3 −2 −1 0 1 2 3
arcsec

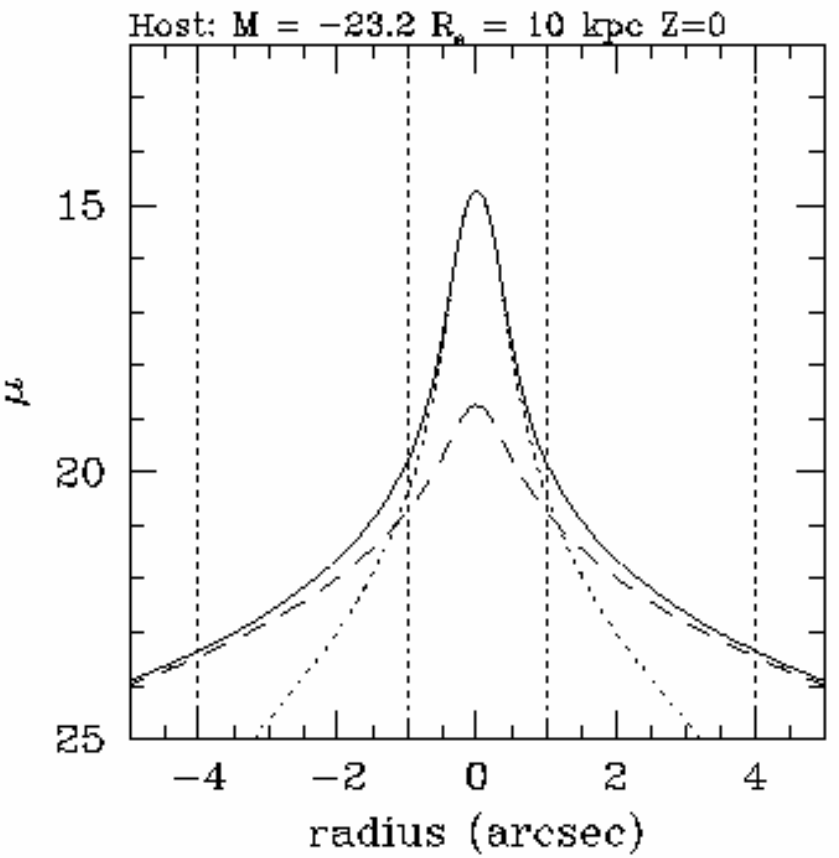
We propose

- Spectroscopic observations of nearby ($z \leq 0.2$) active galaxies (Radio Quiet Quasars, Radio Loud Quasars, BL Lac objects and Radio Galaxies) to investigate their stellar population content: 25 QSOs 10 BL Lacs 10 RG
- This spectroscopic survey, together with previous studies, based on the images of the sources yielding the morphological and photometrical properties of the host galaxies, will allow us to probe the link between nuclear activity and stellar content in the host galaxies.
- The results will be consistently compared among matched sub-samples and with a control sample of local early-type galaxies of similar luminosity.

The Method

Long slit spectra of the targets, taken on-axis, are extracted at various spatial positions in order to optimise the signal from the host galaxy and to provide a clean subtraction of the nuclear light contamination.





• A number of observational evidences for a tight link between star formation and nuclear activity have been reported

(Bressan et al 02, Heckman et al. 04, DellaValle e al 05, Canalizo et al. 06)

• However, whether these rejuvenation episodes are triggered by a reactivation of the SMBH (Ho 2005), or the reactivation is only concomitant with the SFR, still remain a very debated issue

• To cast light on this point, many imaging studies have been performed in recent years on the host galaxies of nearby and distant AGNs

(Bahcall 97, Dunlop et al. 03, Pagani et al 03, Falomo et al 04, 05).

•Test connection between the re-activation of the central MDO and the star formation