

# ACCRETION AND OUTFLOW ACTIVITY IN NGC 2264

Rosaria (Sara) Bonito

INAF – Osservatorio Astronomico di Palermo

Giusi Micela, Loredana Prisinzano,  
Laura Venuti,  
Francesco Damiani et al.

INAF-Osservatorio Astronomico di Palermo

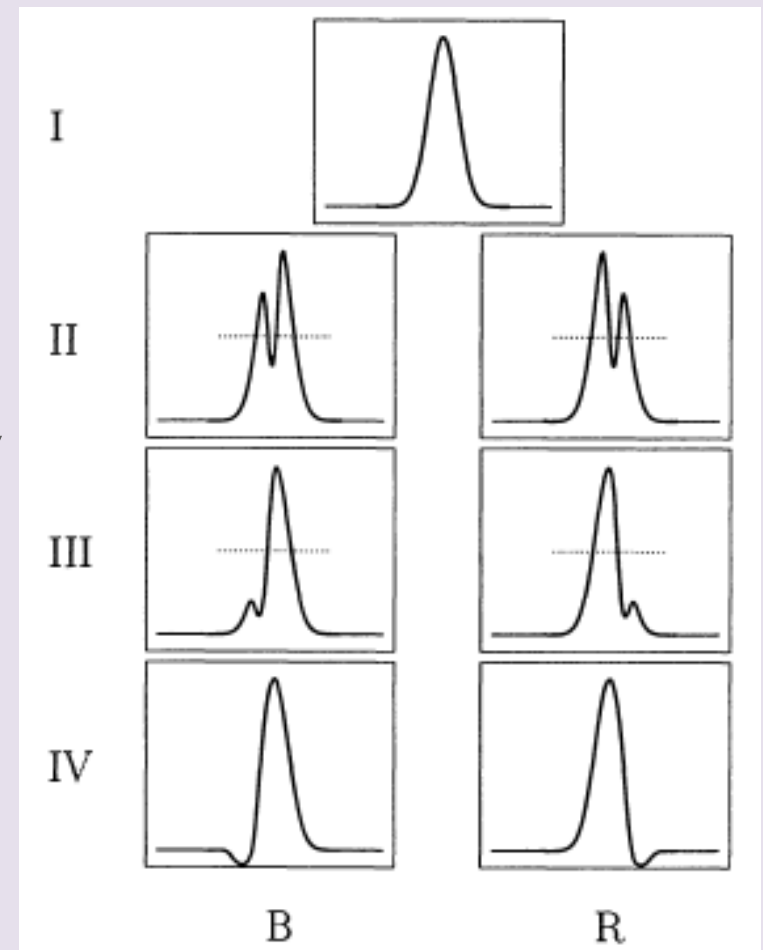
Elisabetta Rigliaco, Germano Sacco,  
Antonio Frasca,  
Katia Biazzo et al.  
GES collaboration

# H $\alpha$ EMISSION LINE AND ACCRETION/OUTFLOW

(Reipurth et al. 1996)

H $\alpha$  emission line:

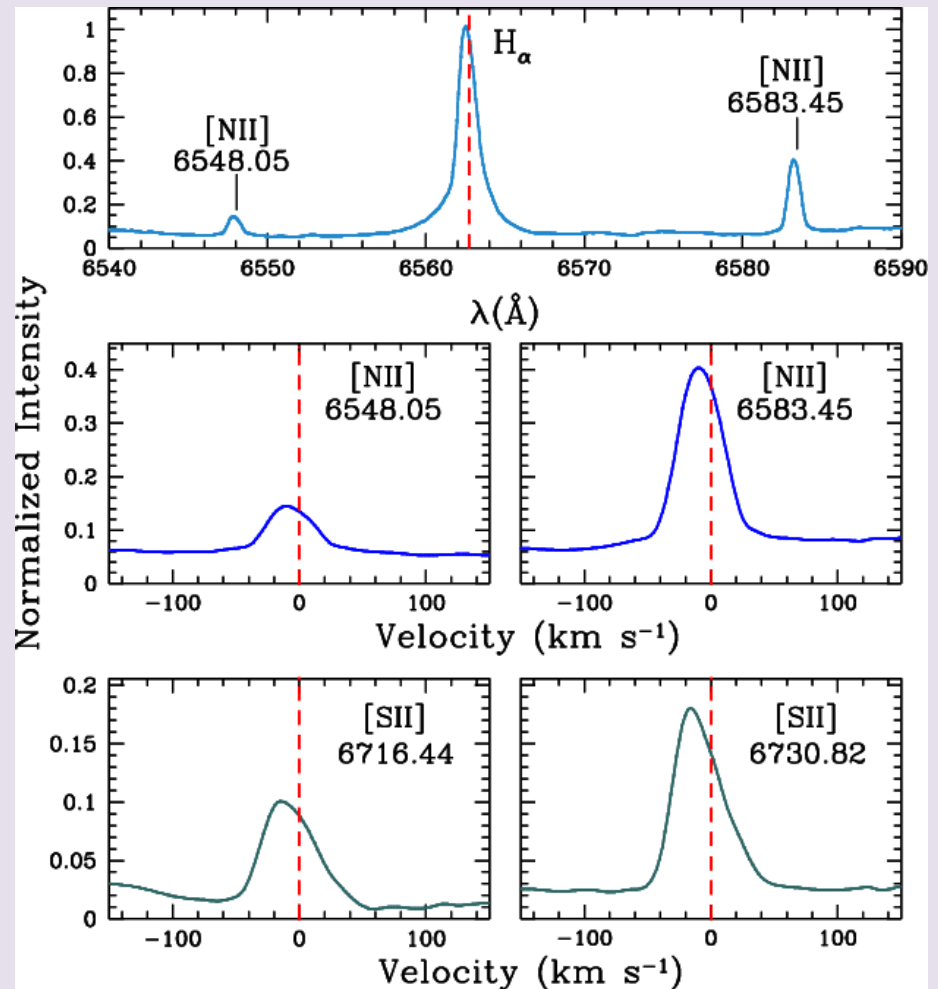
- ◆ proxy accretion/outflow
- ◆ variability



# FORBIDDEN EMISSION LINES (FELs) AND OUTFLOW

- ◆ identify outflow
- ◆ physical properties from line ratio ( $n_e$ ,  $\dot{M}_{\text{wind}}$ , ...)
- ◆ variability

$\sigma$  Ori  
(Rigliaco et al. 2009)



# SELECTED OBJECTS: NGC 2264

- ◆ GES + Chandra + COROT data
  - CSI 2264 project
- ◆ Traven et al. 2015
- ◆ Jackson et al. 2016
- ◆ Venuti et al. in press
- ◆ Bonito et al. in preparation
- ◆ Sacco et al. in preparation

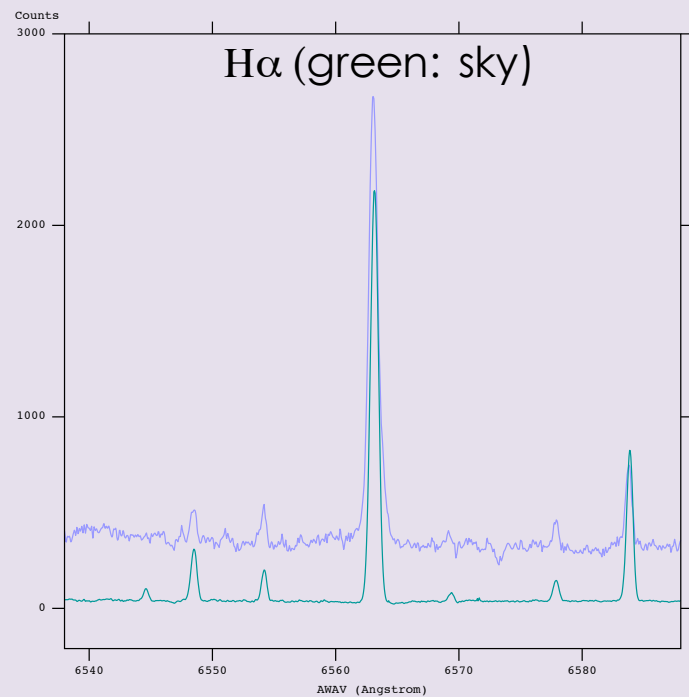
# OHaNA IN GES

- ◆ Objects with  $H\alpha$  emission and strong Nebular contribution to Accretion/outflow activity (OHaNA) (several GES clusters: NGC 2264, NGC 6530; see also: NGC 6611 – [Bonito et al. 2013](#))
- ◆ Accretion/outflow activity in young cluster members:  $H\alpha$  and forbidden emission lines (FELs)

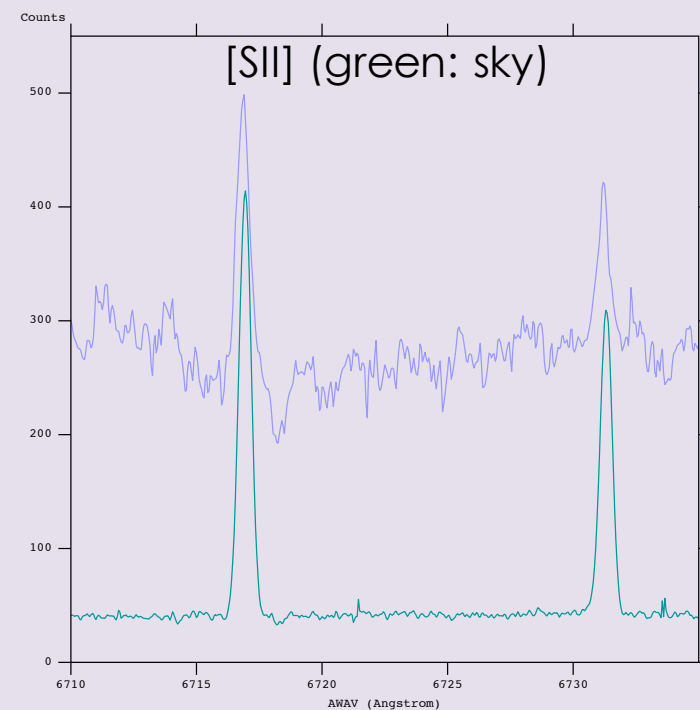
# SKY SUBTRACTION & EMISSION LINES

- ◆ Nebular contribution to both  $H\alpha$  and FELs
- ◆ Narrower than stellar ( $H\alpha$ )
- ◆ FWZI method: EW and  $H\alpha_{10\%}$  are not reliable

gir\_06404487+1014114\_H665.0.0001.fits\_0



gir\_06404487+1014114\_H665.0.0001.fits\_0



# SKY SUBTRACTION & EMISSION LINES

- ◆ Nebula
- ◆ Narrow

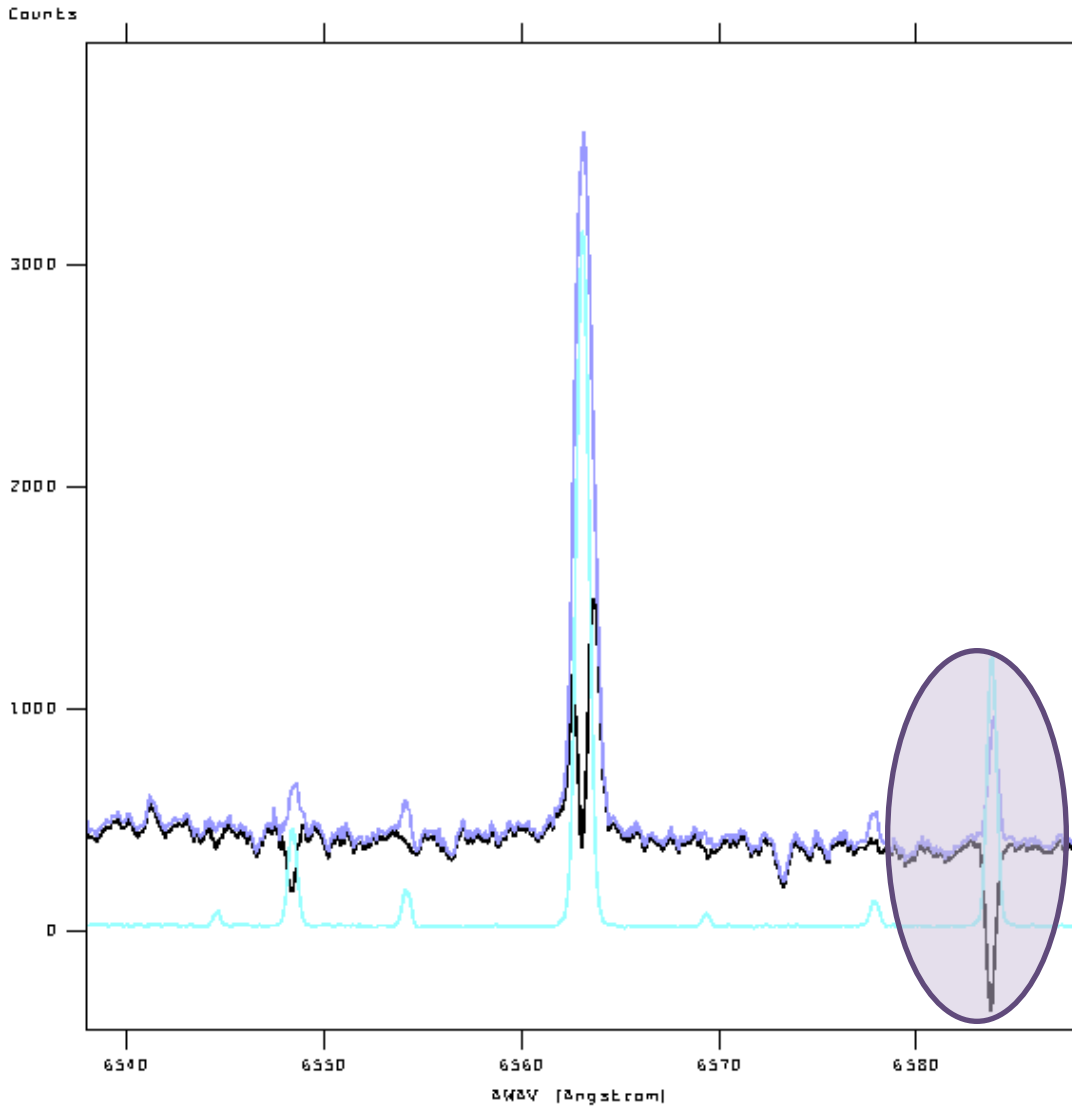
◆ FWZI m

and FELs

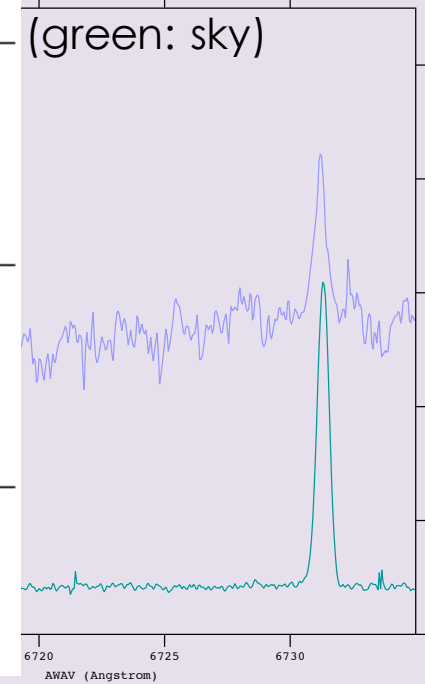
reliable

(green: sky)

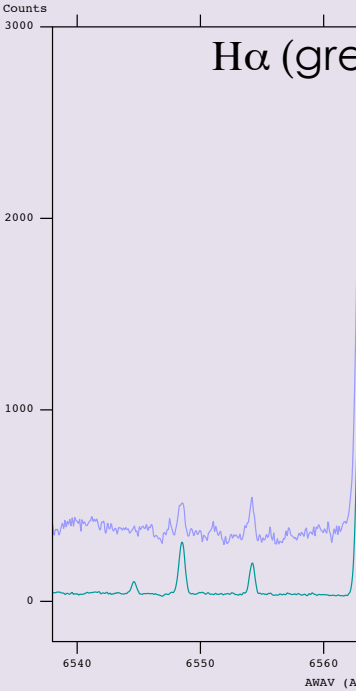
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+1014114\_H665.0.0001.fits\_0



gir\_06404487+101411



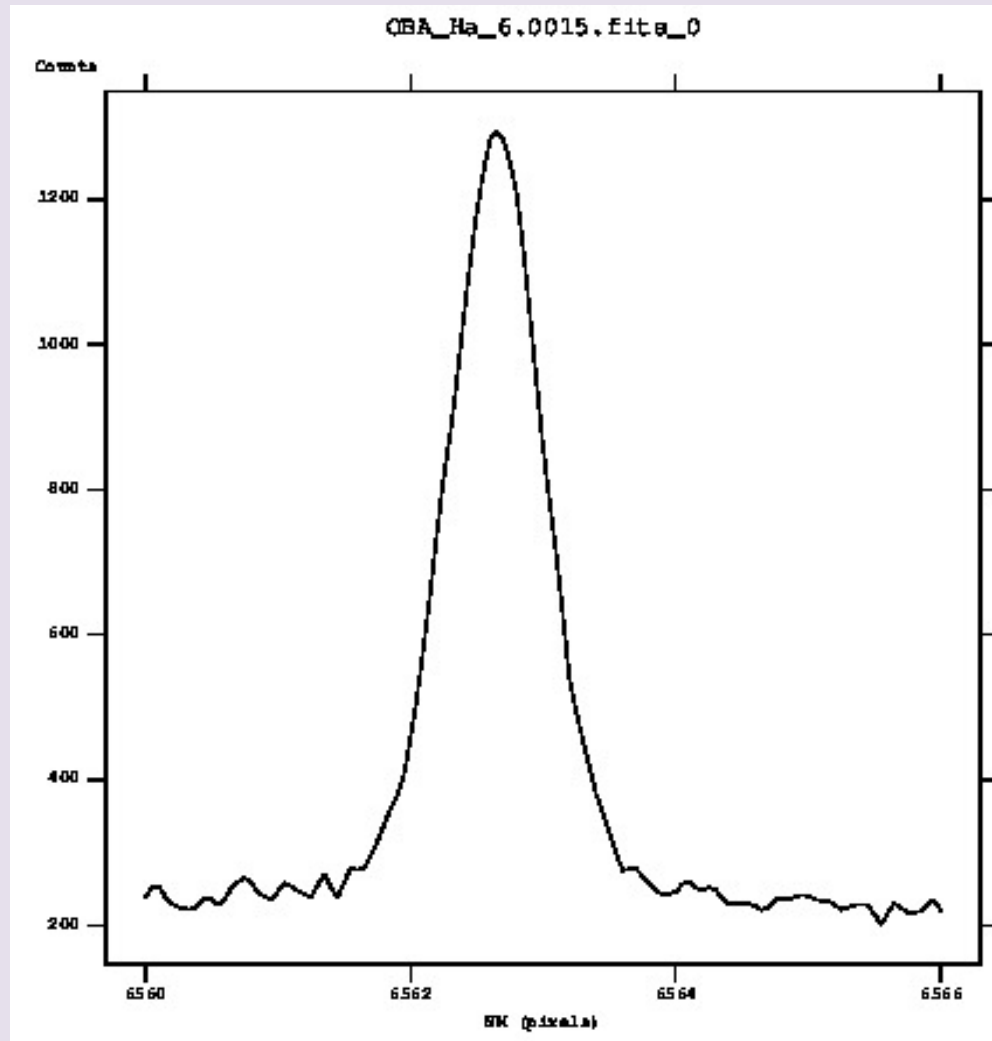


# SKY SUBTRACTION: SPURIOUS LINES

- ◆ H $\alpha$  line profile:
  - ✓ implication on accretion/outflow activity
- ◆ [SII] and [NII] absorption lines:
  - ✓ implication on outflow activity

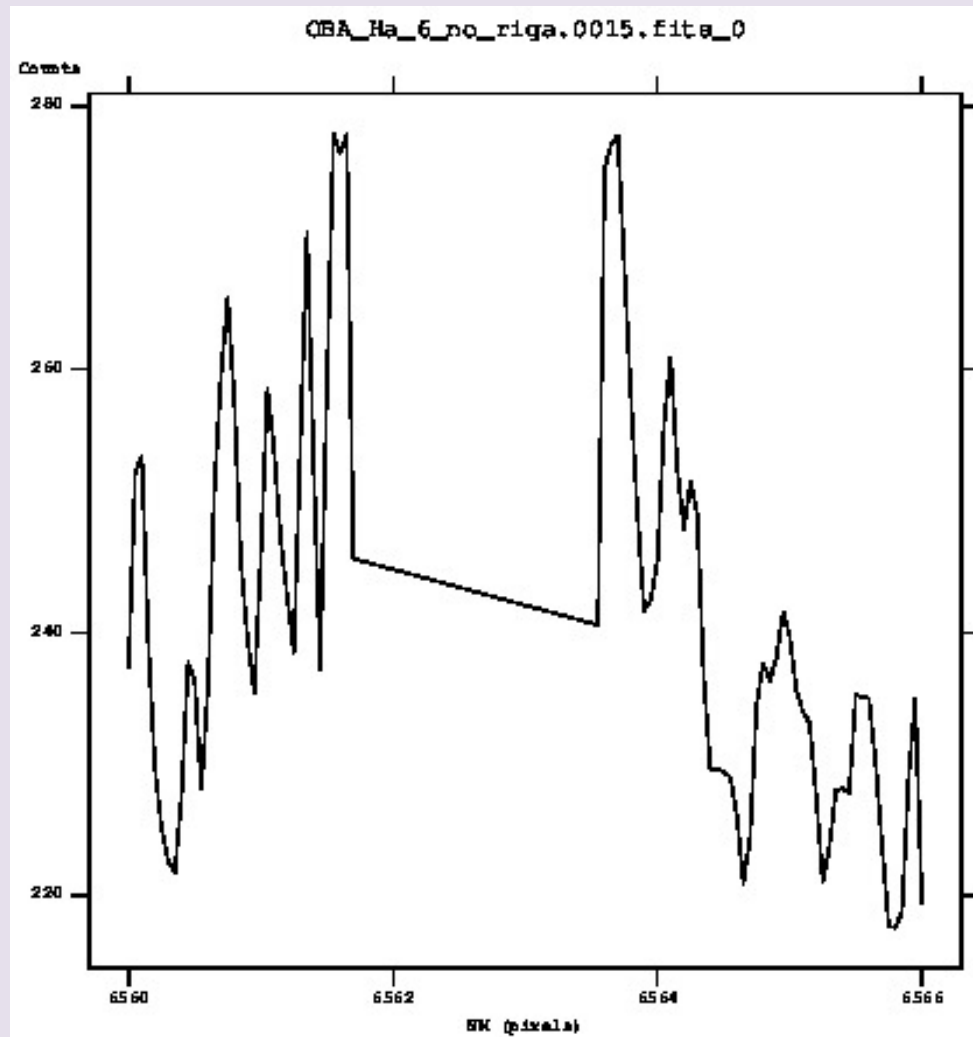
# FWZI METHOD (1)

- ◆ Zoom around the emission line



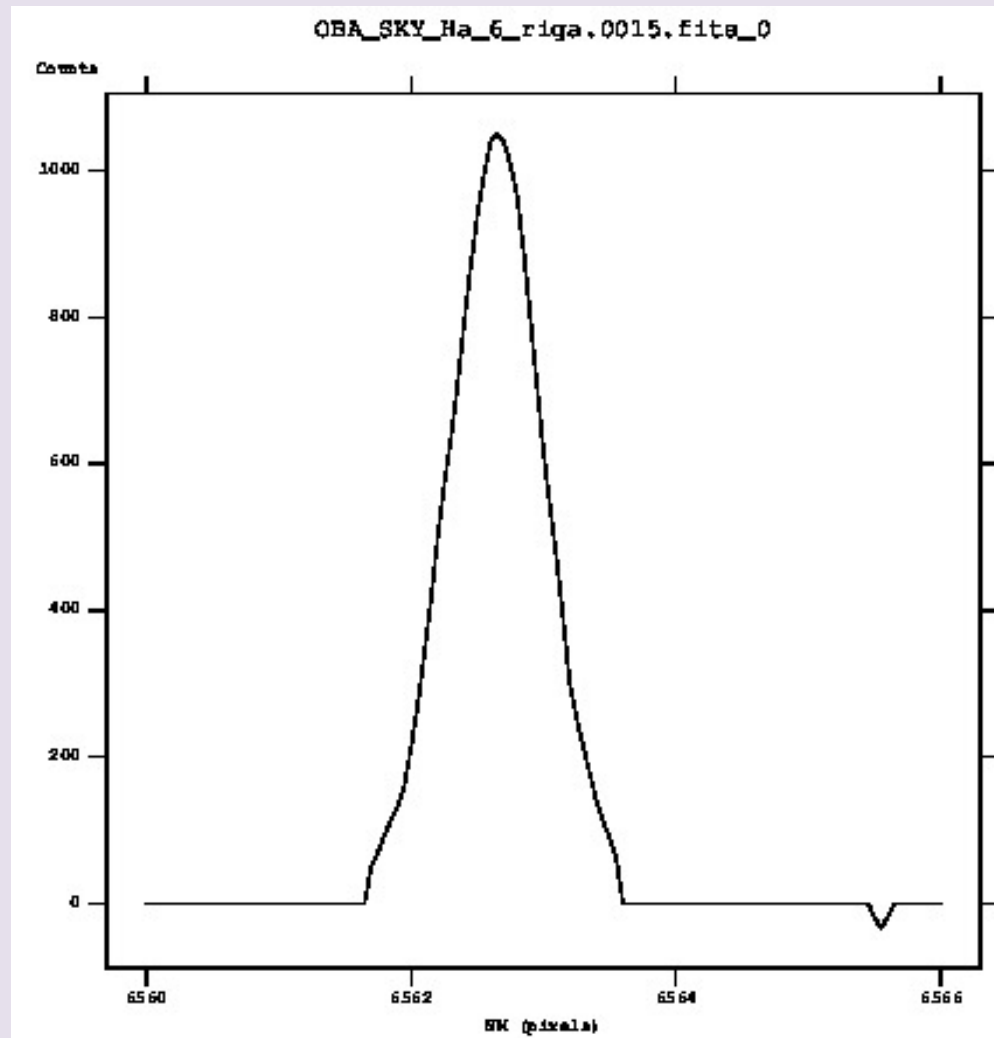
# FWZI METHOD (2)

- ◆ Normalize: spectrum without the emission line



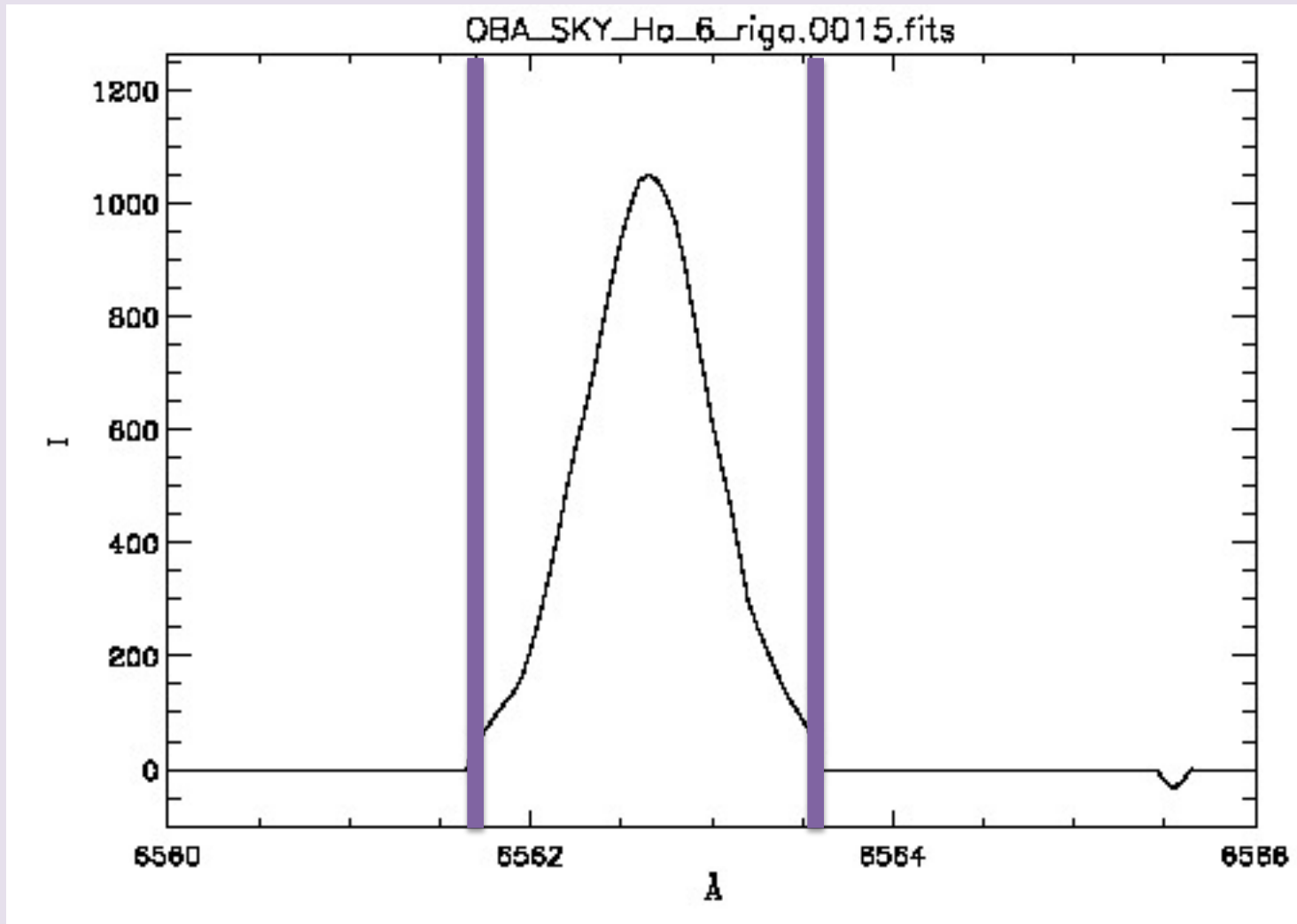
# FWZI METHOD (3)

- ◆ Ratio or difference between the spectrum and spectrum without the emission line



# FWZI METHOD (4)

- ◆ FWZI(H $\alpha$ ) sky < 3 Å



# FELs AS A PROXY FOR SKY SUBTRACTION

- ◆ Tool to flag spurious absorption FELs
- ◆ Warning for a bad sky subtraction
- ◆ Use the original spectra
- ◆ FWZI measurement is reliable (EW and  $H\alpha_{10\%}$  are not)

Flagged spectra:

over-subtracted sky contribution

avoid misinterpretation of the physical properties

- 20% flagged spectra: [SII] doublet in absorption
- 50% [SII] spurious absorption single line

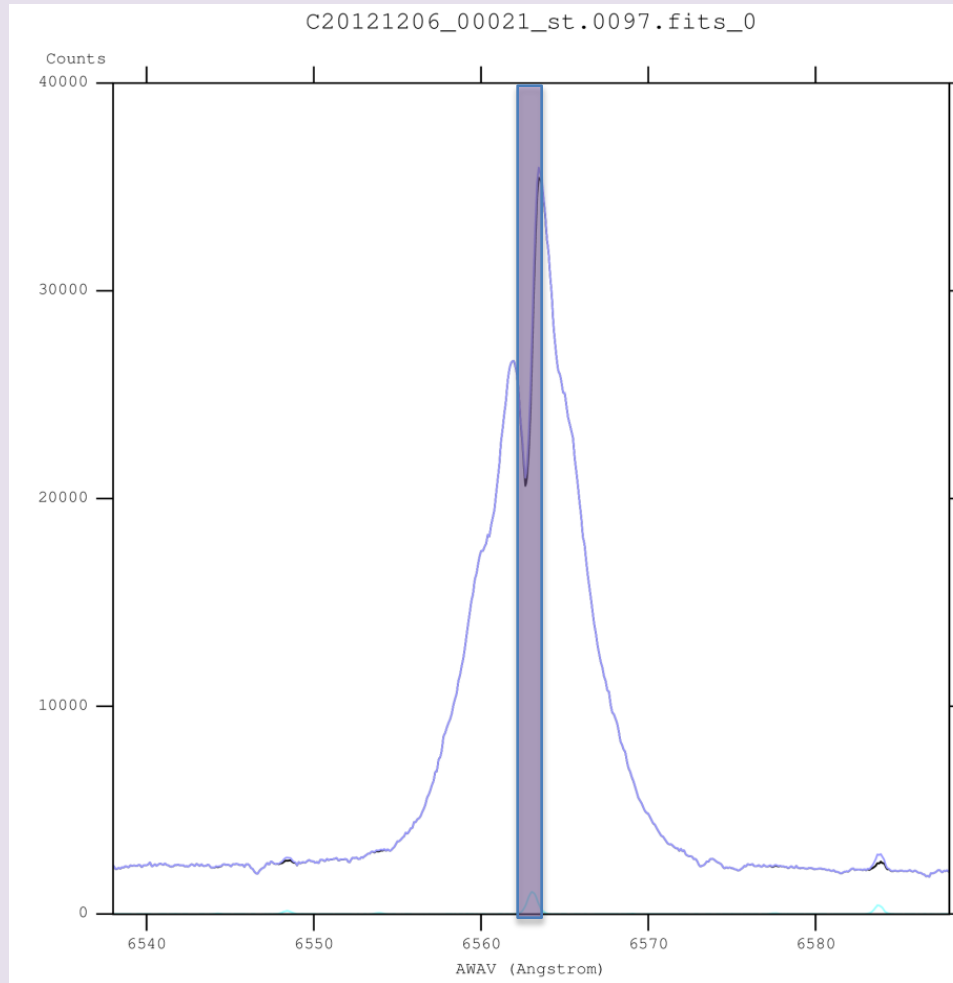
35 accretors (> 22%) in Venuti et al., in press (next talk)

OHaNA: also among not flagged spectra

Compare original spectra with sky subtracted spectra

# NO FLAG + GOOD SPECTRA

- ◆ FWZI( $H\alpha$ ) star  $\gg$  FWZI( $H\alpha$ ) sky
- ◆ Parameters released: reliable



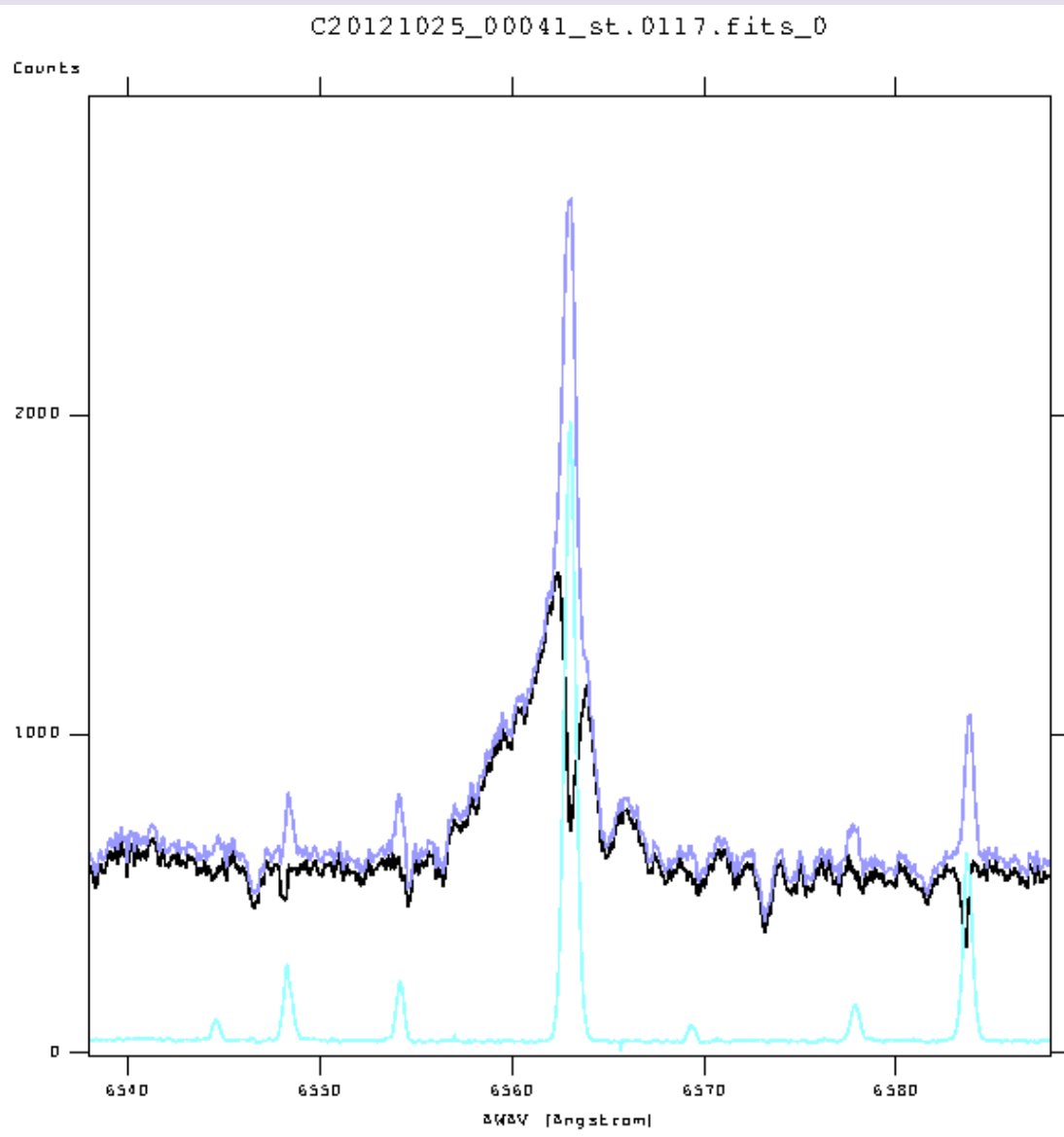
(See also the case of NGC 6611, Bonito et al. 2013)

NGC 2264:  
X-ray source

(06411678+0927301  
CS1877,  
Venuti  
et al., in press)

(Bonito et al. in prep.)

# FLAG: WARNING!



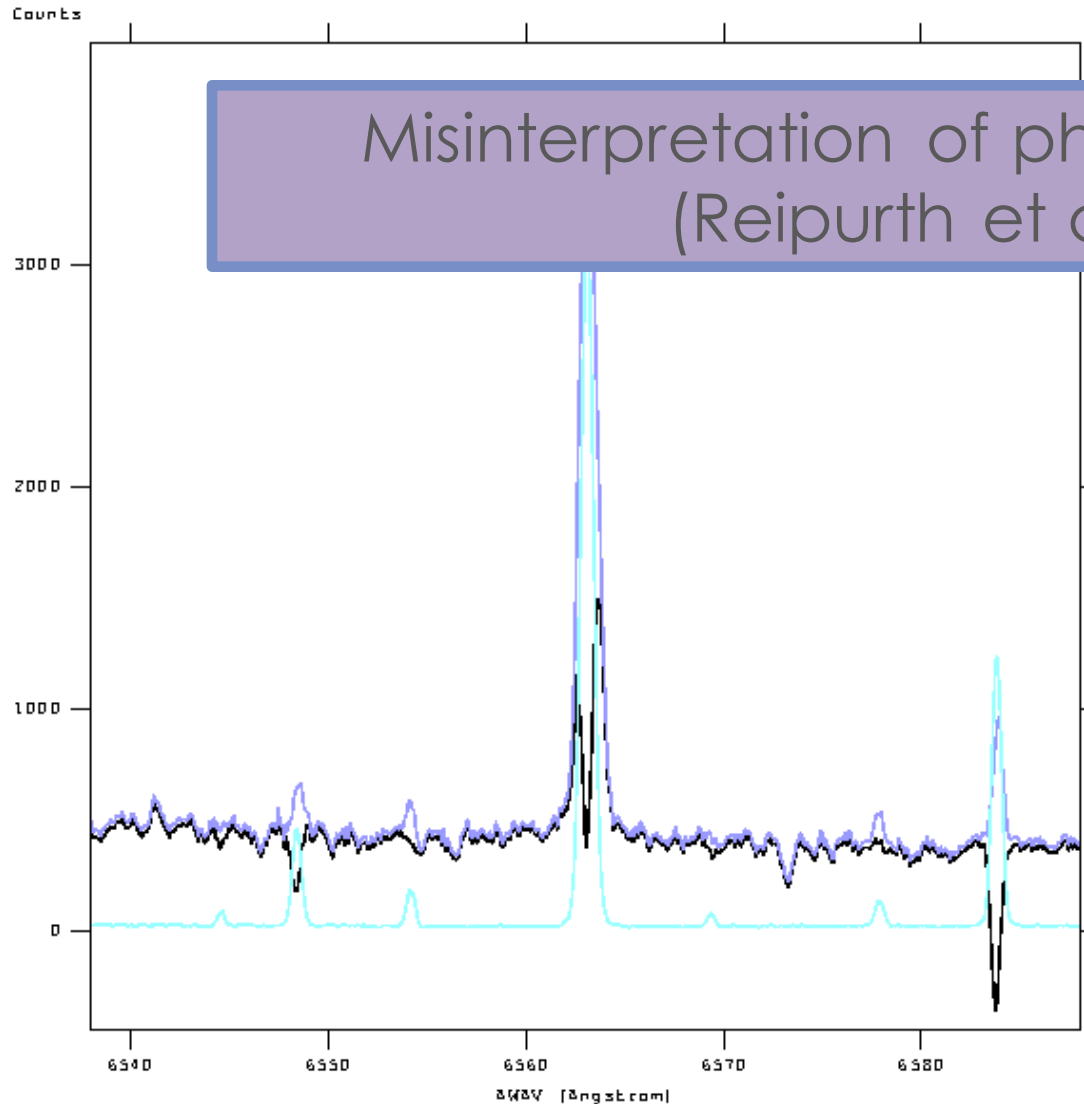
- ◆ GES spectrum
- ◆ Original spectrum
- ◆ SKY spectrum

(Bonito et al. in prep.)



# FLAG: "BAD" SKY SUBTRACTION

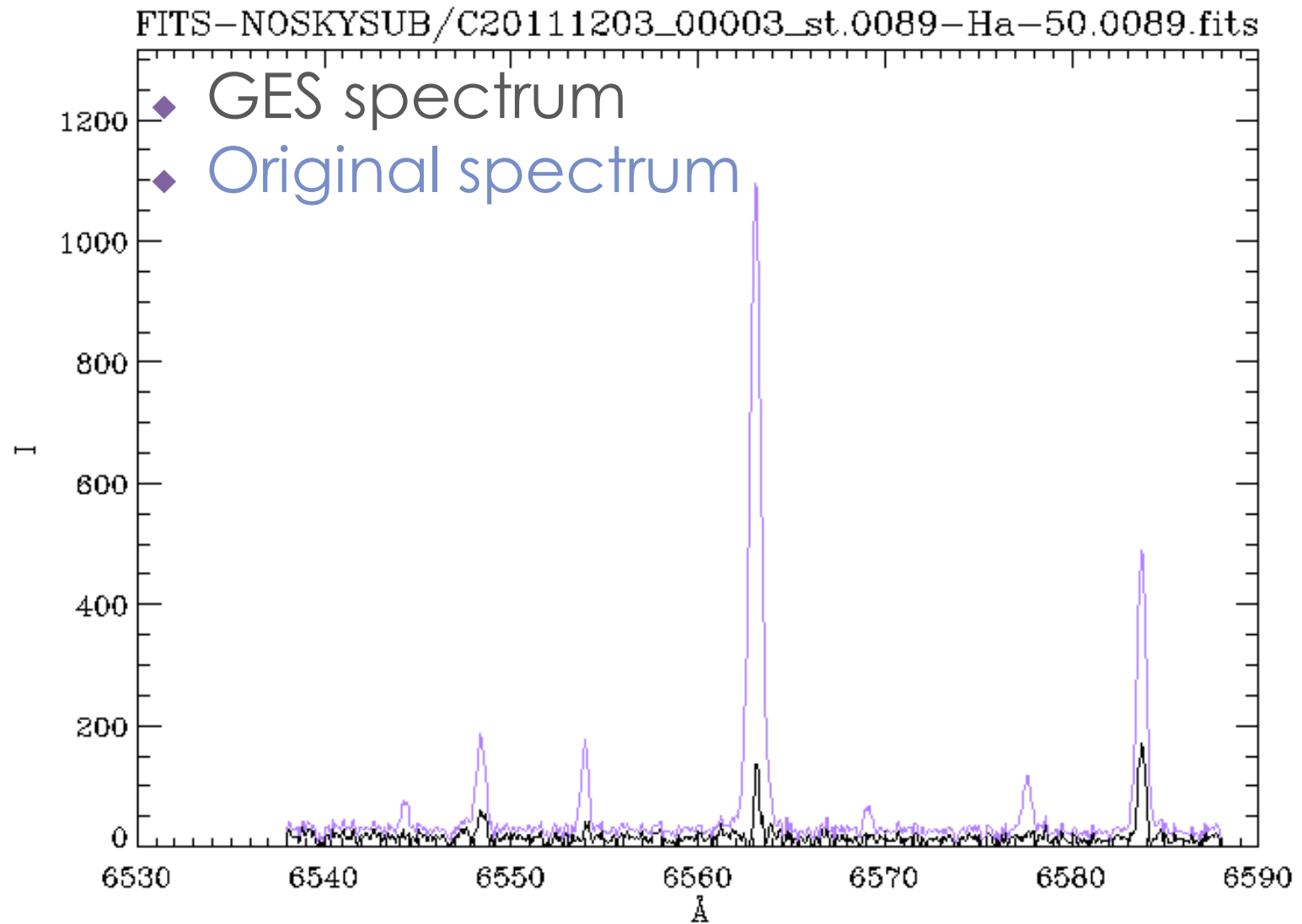
C20121024\_00039\_st.0127.fits\_0



Misinterpretation of physical properties  
(Reipurth et al. 1996)

- ◆ GES spectrum
- ◆ Original spectrum
- ◆ SKY spectrum

# NO FLAG: “BAD” SKY SUBTRACTION



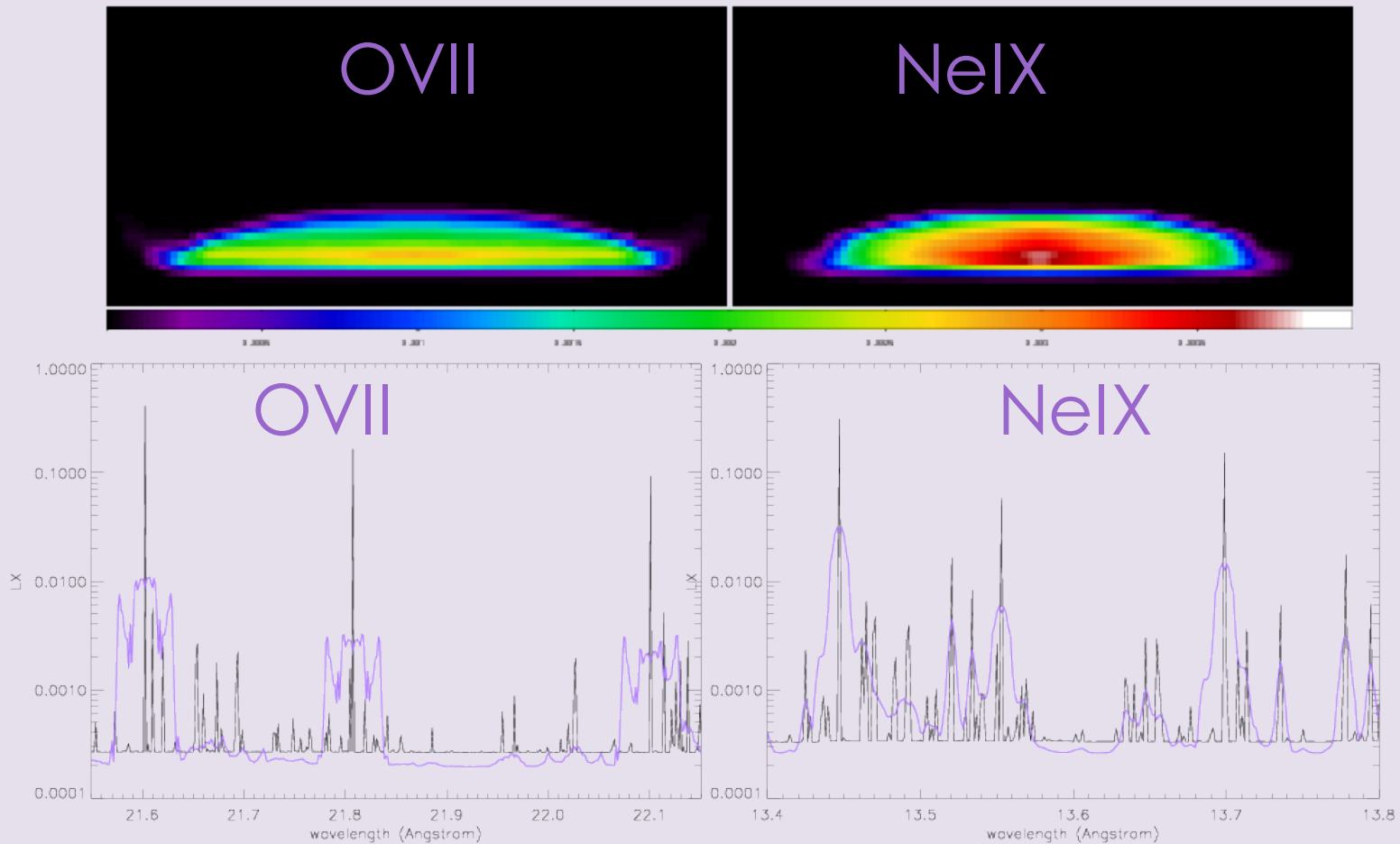
# RESULTS

- ◆ Accretion/outflow parameters in NGC 2264
  - ◆ FWZI quantitative measurements:  
for all spectra (good and “bad”!)
  - ◆ Density diagnostic (info on spatial distribution)
  - ◆ % affected accretors
- 
- ◆ Plasma speed from the wings (infall/outflow)
  - ◆ Discrimination of active/inert disks (broad/narrow;  
see also Bonito et al. 2013 for the cluster NGC 6611)
  - ◆ Different timescales involved  
(accretion/disk dissipation)

# CONCLUSIONS

- ◆ Accretion/outflow in NGC 2264
- ◆ Sky subtraction
  - FWZI method ( $H\alpha$  and FELs)
  - Spurious absorption lines:
    - FELs useful both for physics (outflow activity) and as a proxy for sky subtraction:
    - flag if absorption:
    - warning better to use the original spectra and FWZI

# LABORATORY EXPERIMENTS



(Revet et al. submitted; Albertazzi, Ciardi, Nakatsutsumi, Vinci, Beard, [Bonito et al. Science 2014](#) for the outflow)