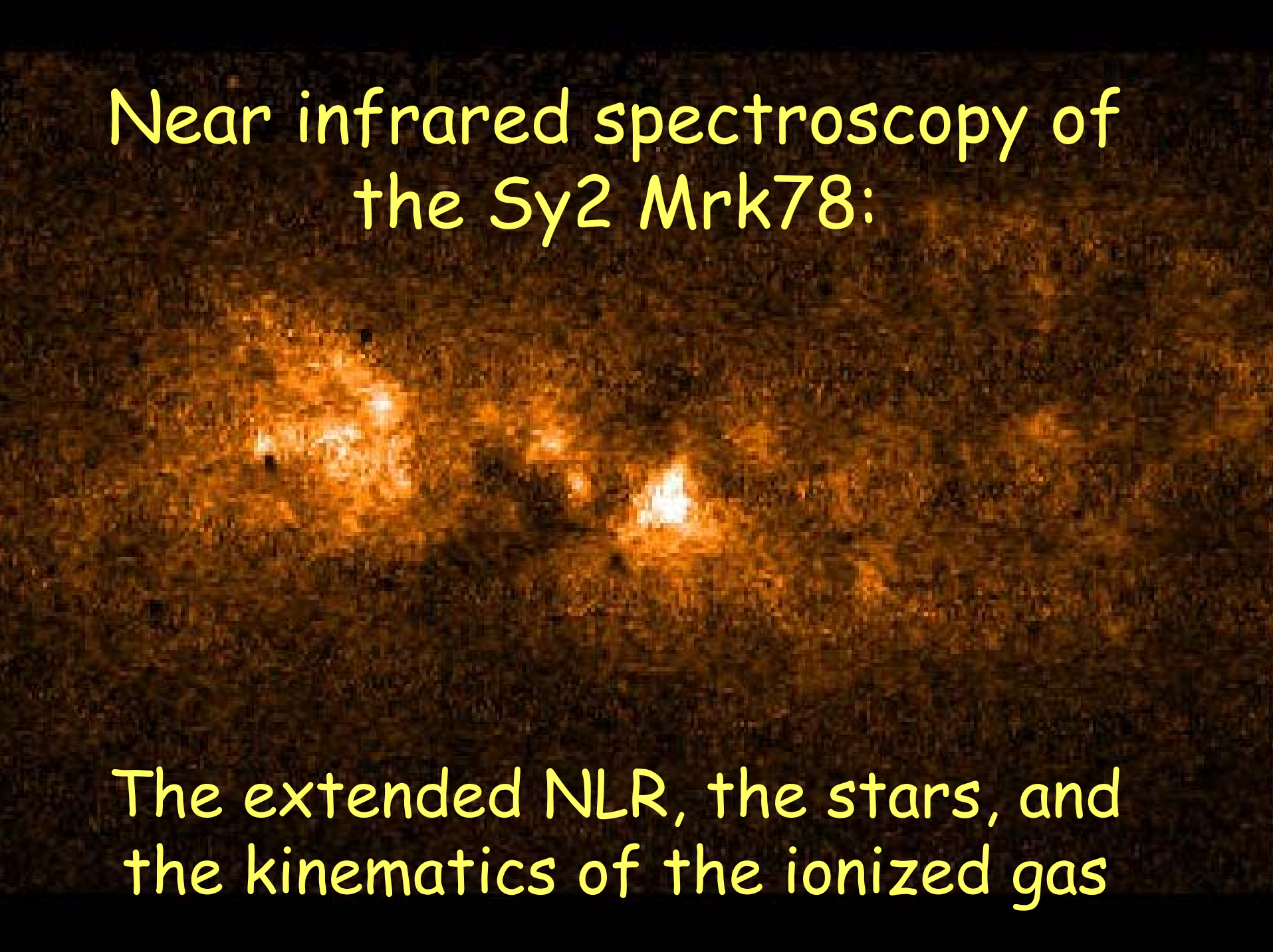
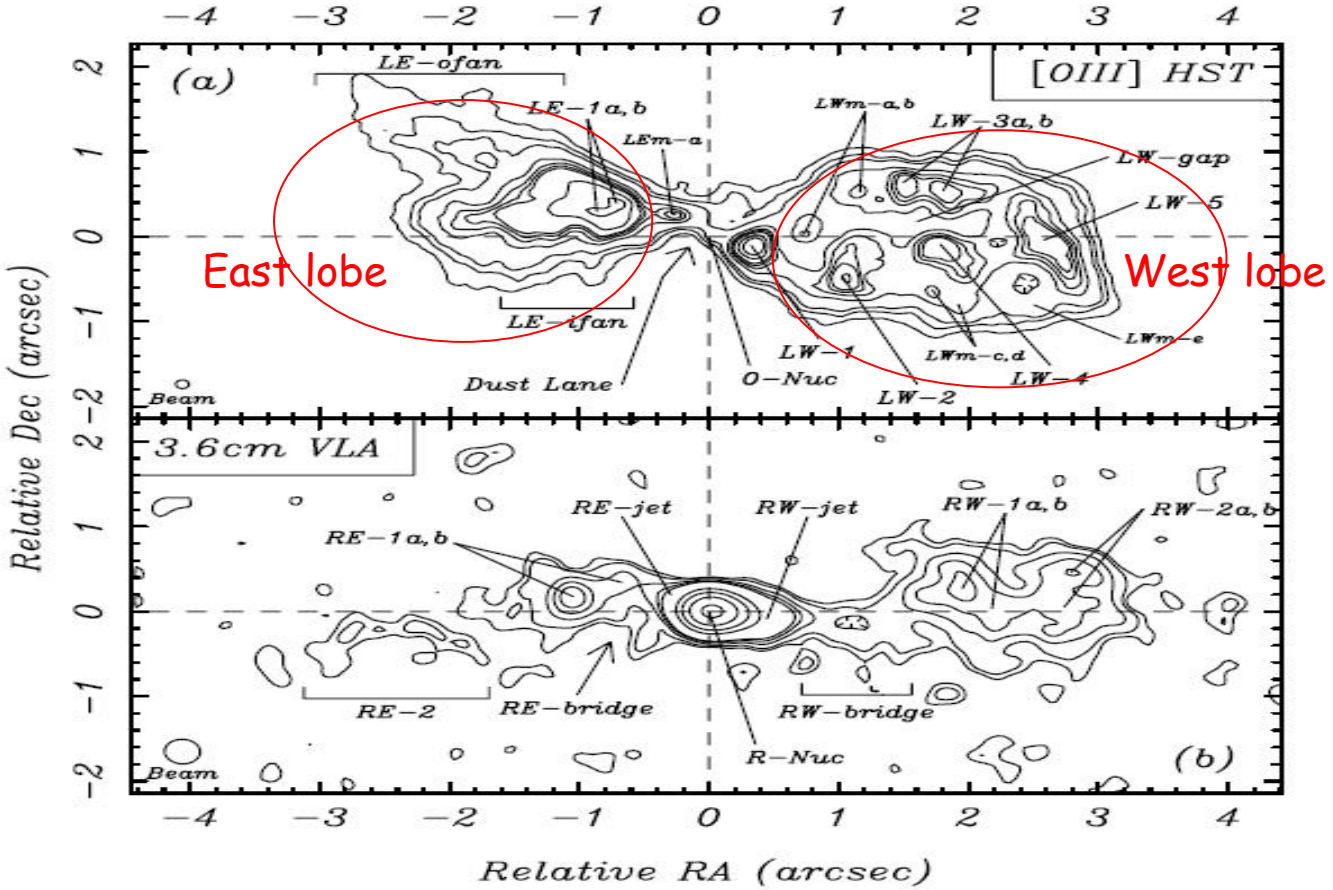
Near infrared spectroscopy of the Sy2 Mrk78:



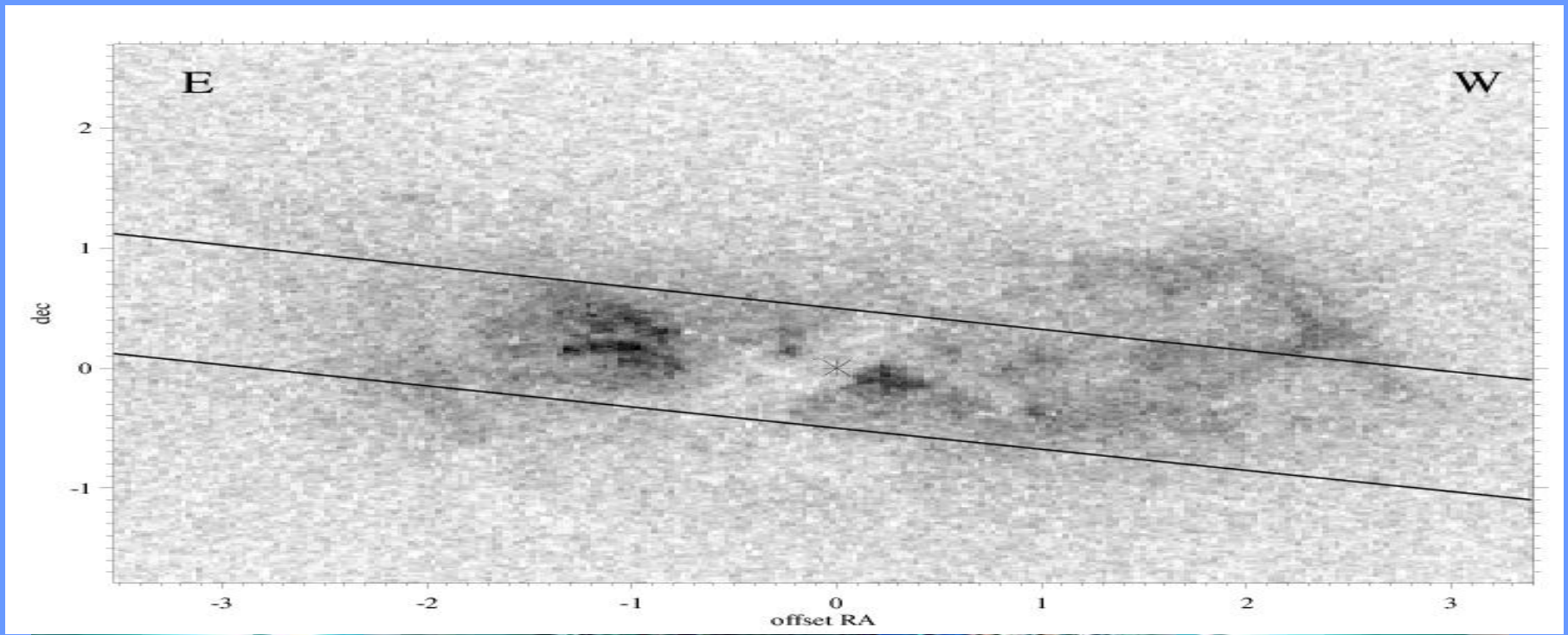
The extended NLR, the stars, and the kinematics of the ionized gas

INTRODUCTION

- Mrk78 is a classical example of AGN with jet-gas interaction.



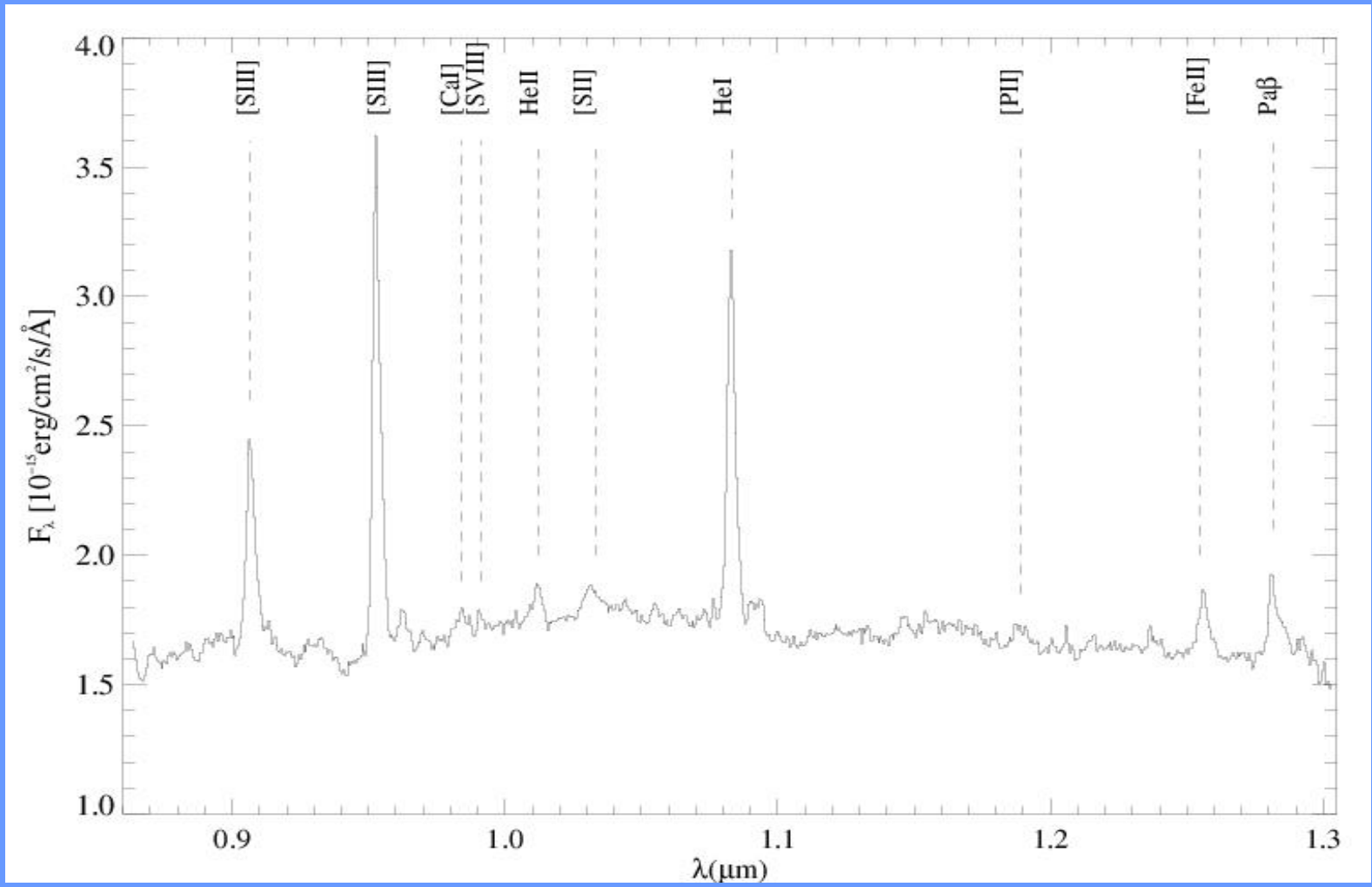
Whittle & Wilson (2004)



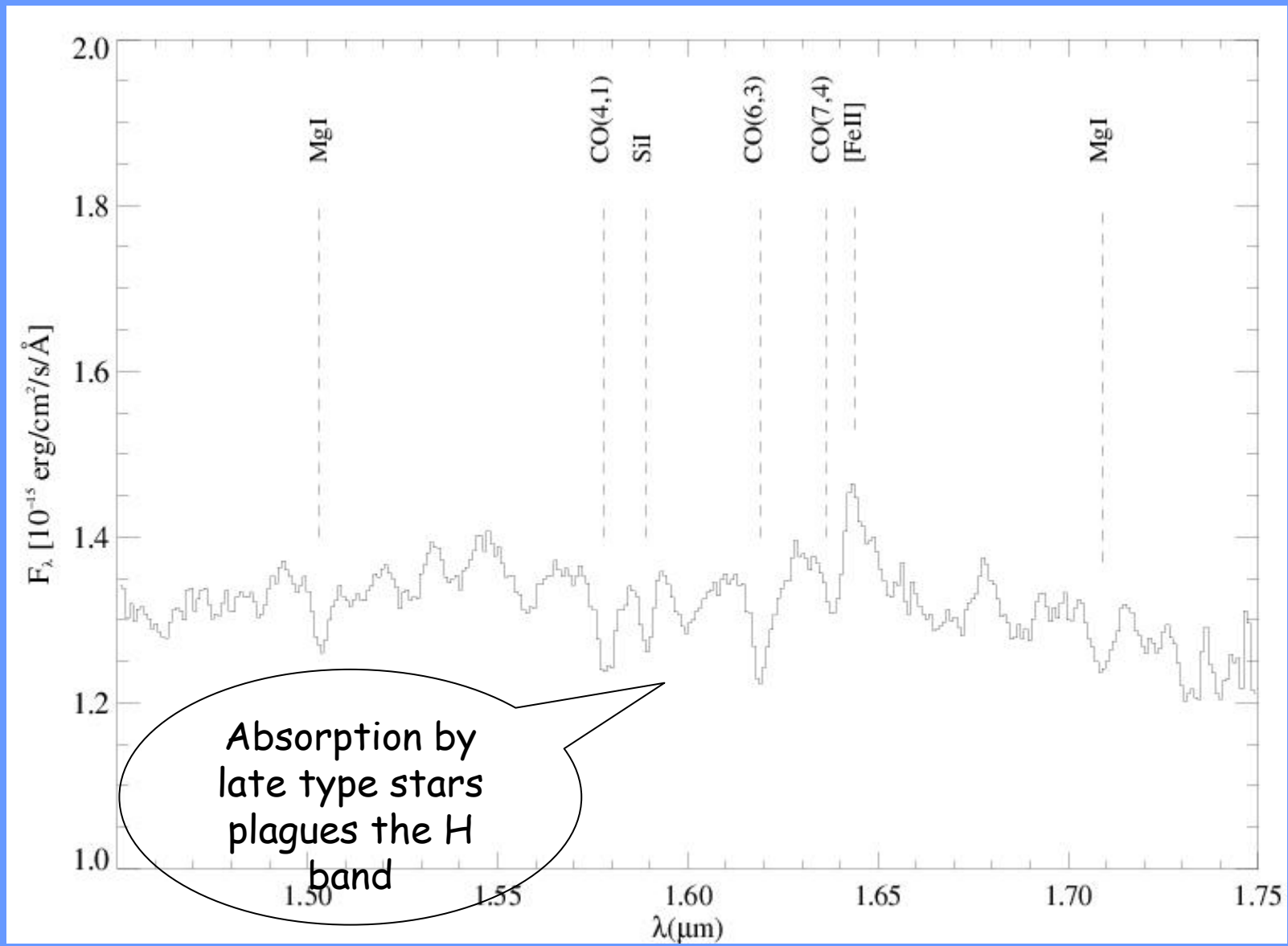
Two-dimensional spectra clearly show extended emission.

NUCLEAR EMISSION

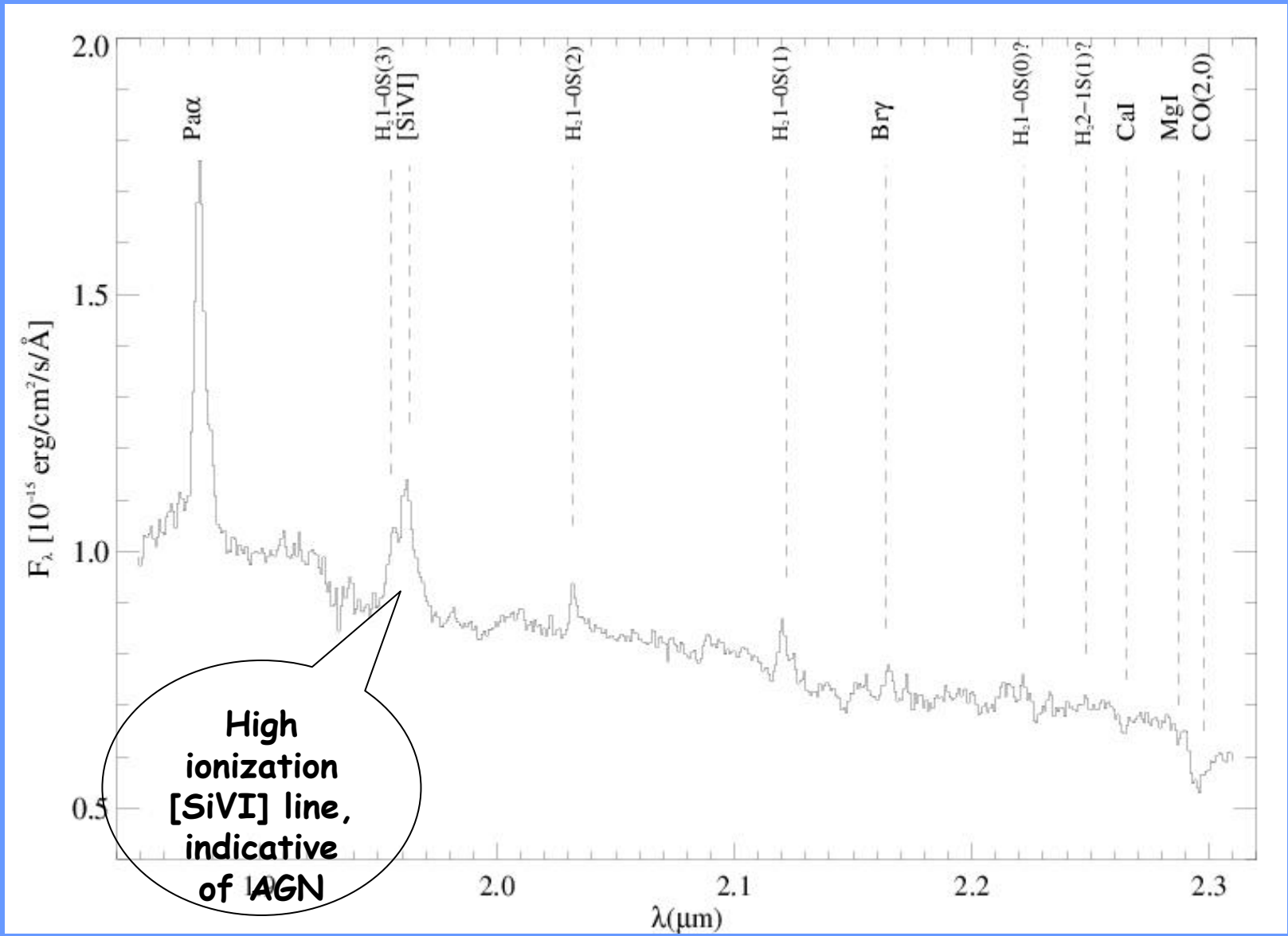
NIR spectra from 0.8-2.4 microns (ZJ and HK bands) covering 1.25 arcsec, centered in the maximum of galaxy profile.



Z and J bands

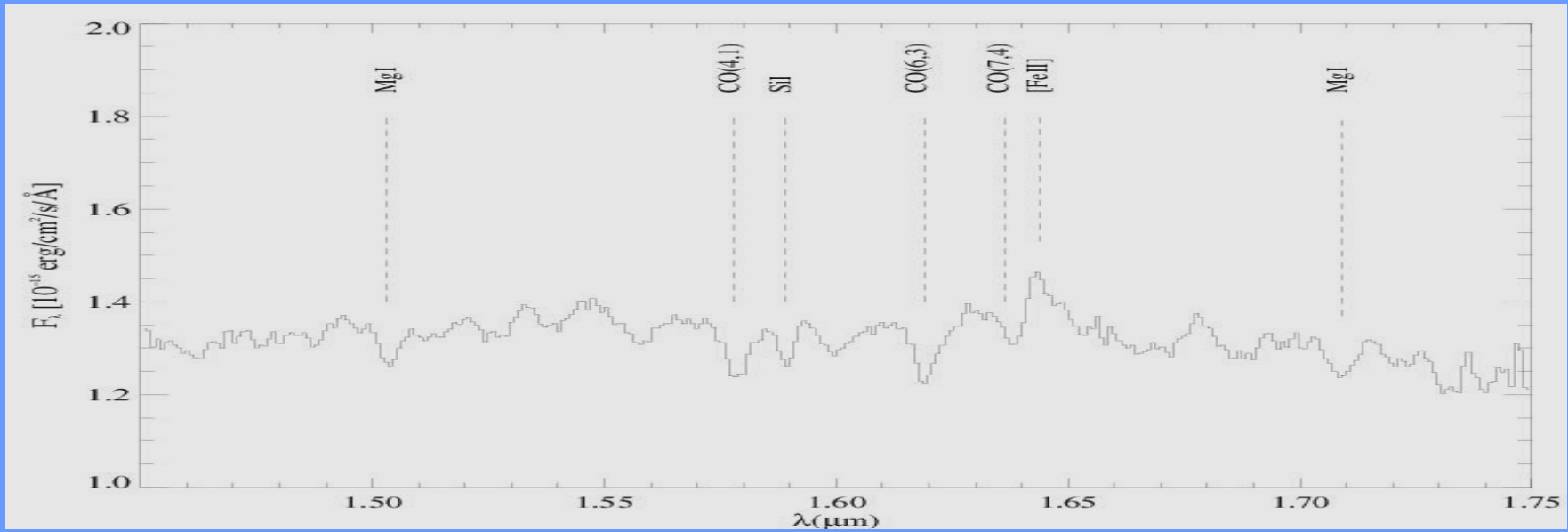

MgI
CO(4,1)
SiI
CO(6,3)
CO(7,4)
[FeII]
MgI
2.0
1.8
1.6
1.4
1.2
1.0
F_λ [10^{-15} erg/cm^2/s/Å]
1.50
1.55
1.60
1.65
1.70
1.75
λ(μm)
Absorption by late type stars plagues the H band

H band


Paα
H2 1–0S(3)
[SiVI]
H2 1–0S(2)
H2 1–0S(1)
Brγ
H2 1–0S(0)?
H2 2–1S(1)?
CaI
MgI
CO(2,0)
2.0
1.5
1.0
0.5
Fλ [10⁻¹⁵ erg/cm²/s/Å]
2.0
2.1
2.2
2.3
λ(μm)
High ionization [SiVI] line, indicative of AGN

K band

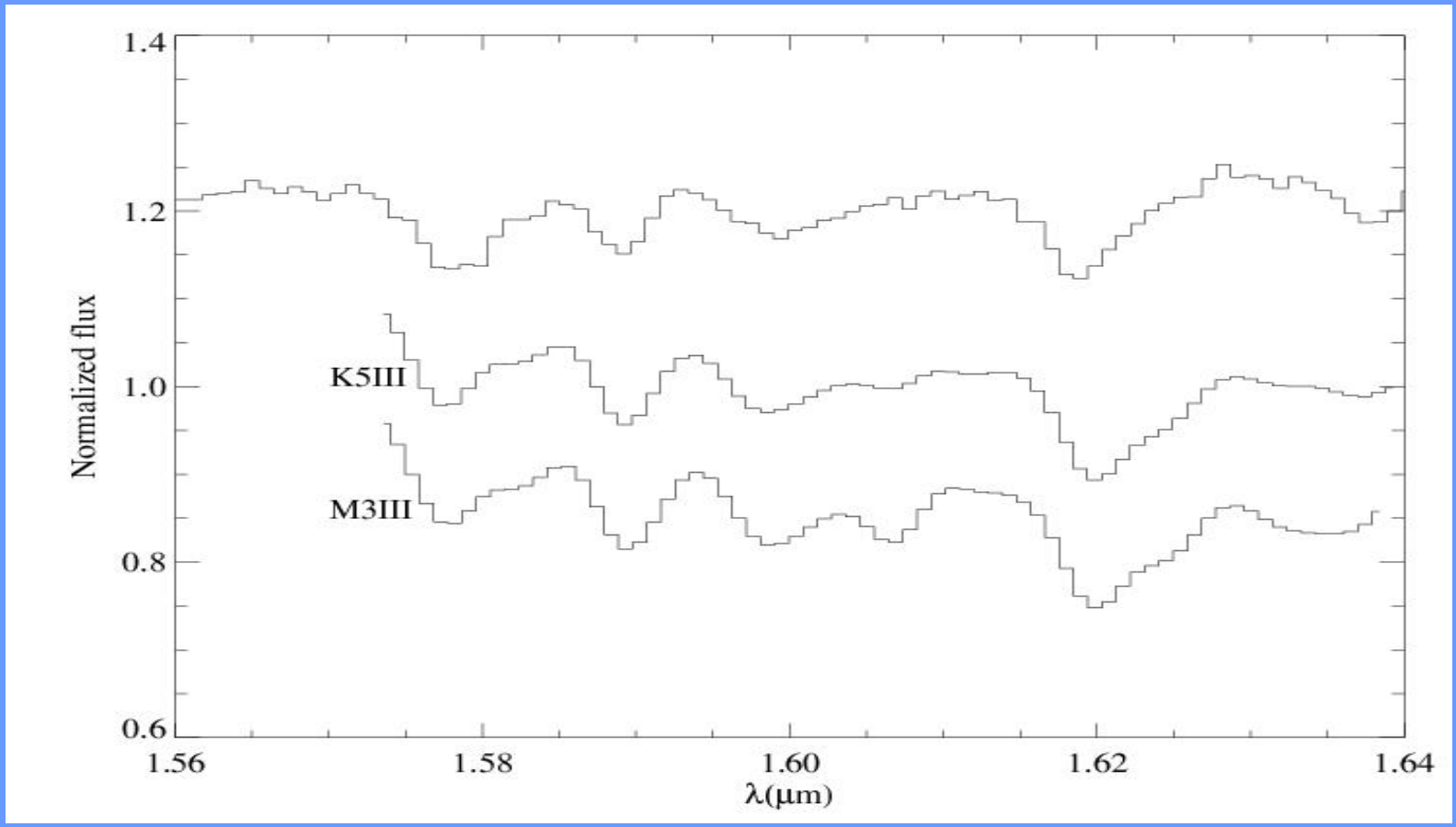
THE STELLAR POPULATION



EW(CO 1.62)/EW(Si I 1.59) → good T indicator for late-type stars (Origlia et al. 1993; Förster Schreiber 2000) → spectral types K5 III to M3 III → age of several hundred Myr for the stellar system.

CO(2,0) band gives another estimation of the age. A narrow CO index (Ivanov et al. 2000) agrees with the previous estimate.

Comparison of our H band spectra with digitally available stellar templates from Dallier et al. (1996)



Estimations of starlight dilution:

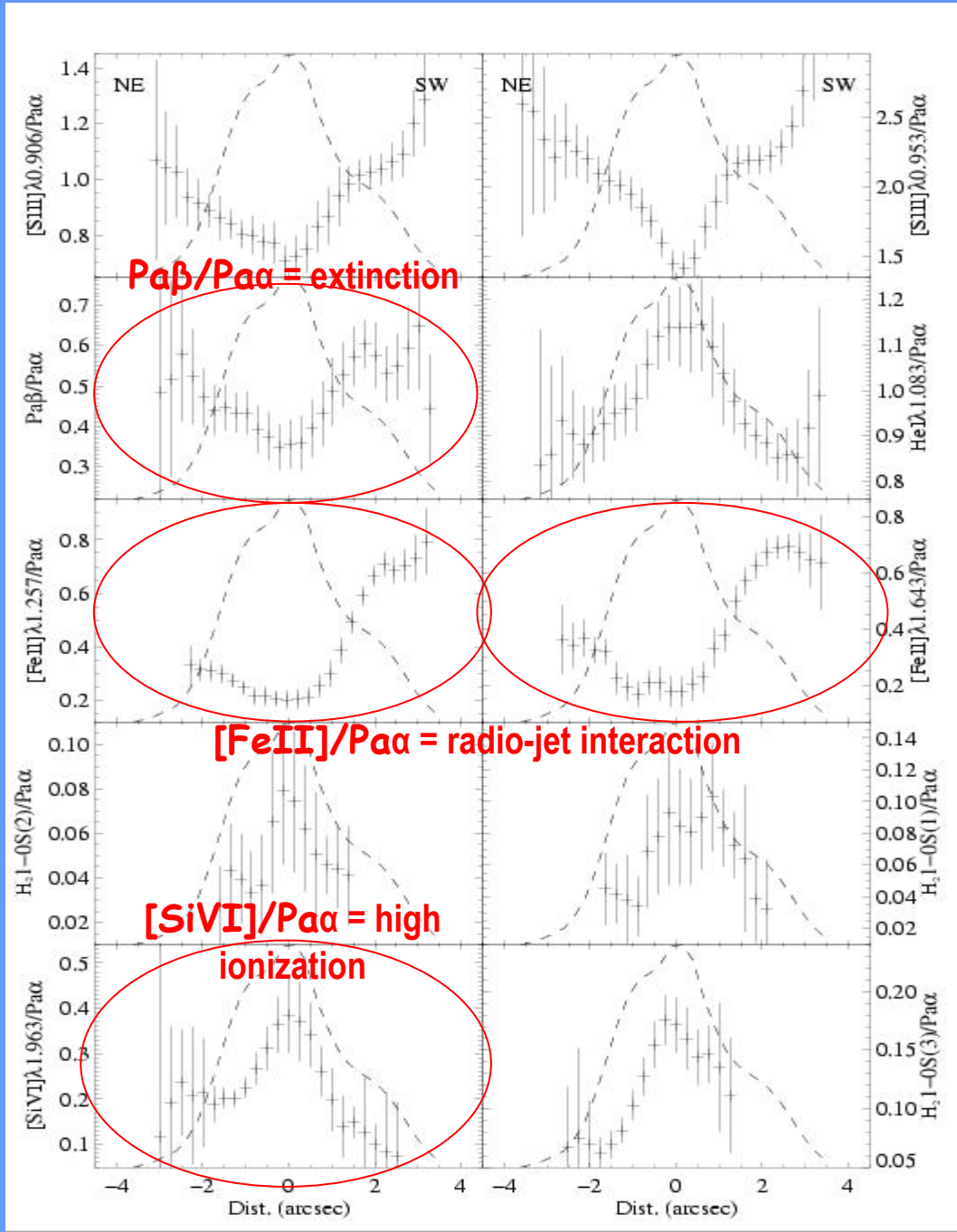
H band = 30-37% (*CO 1.62*)

K band = 43-47% (*CO 2.29*)

EXTENDED NLR

Extended emission on both sides of the nucleus along the slit.

Line ratios from spectra (three columns coadded along the spatial direction = 0.75 arcsec.)



Scenario:

*Prominent highly ionized nucleus, obscured by dust.

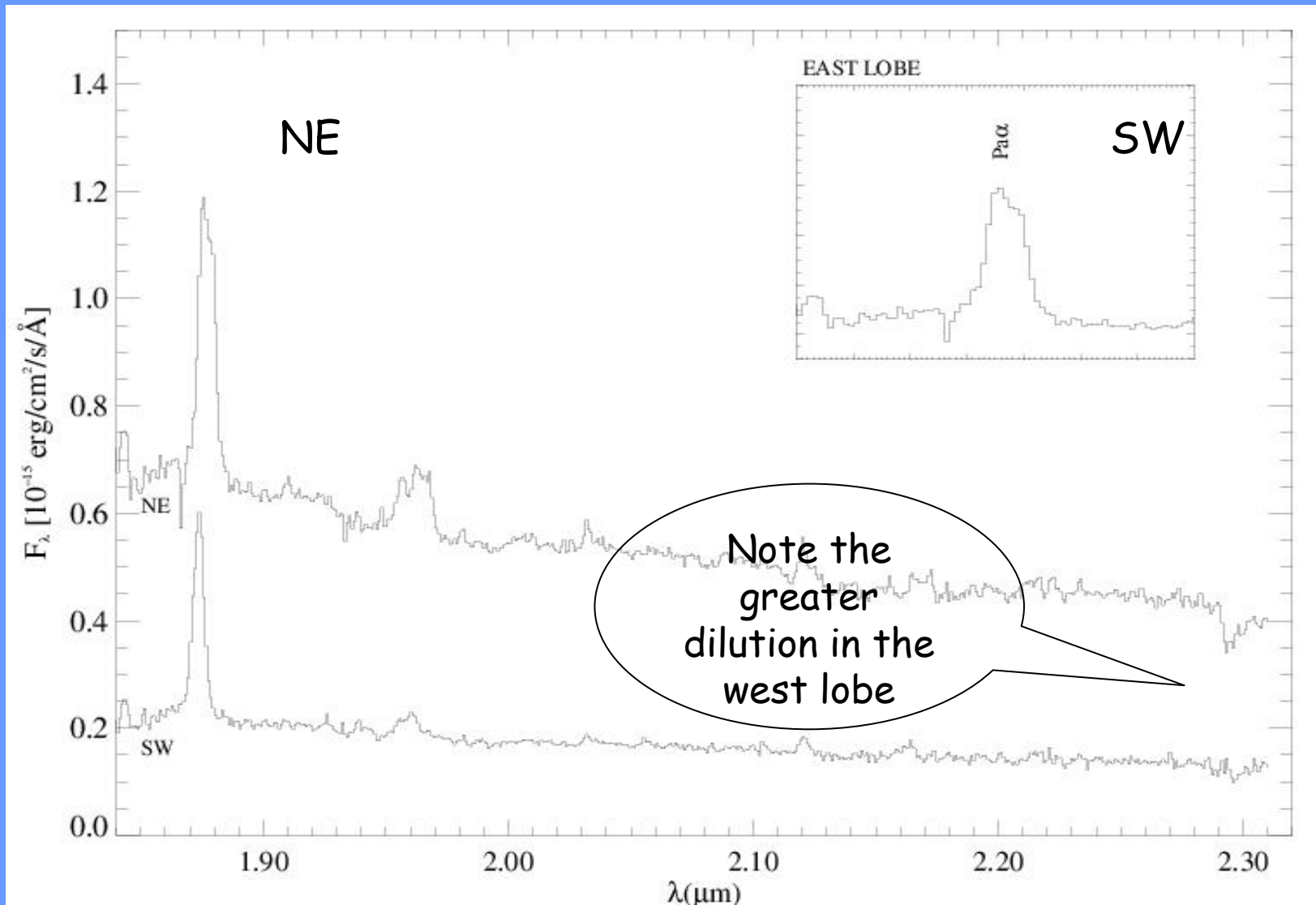
*Eastern lobe with very high ionization parameter according to the [SiVI] emission.

*Western lobe with higher [FeII] emission due to higher radio-jet interaction there.

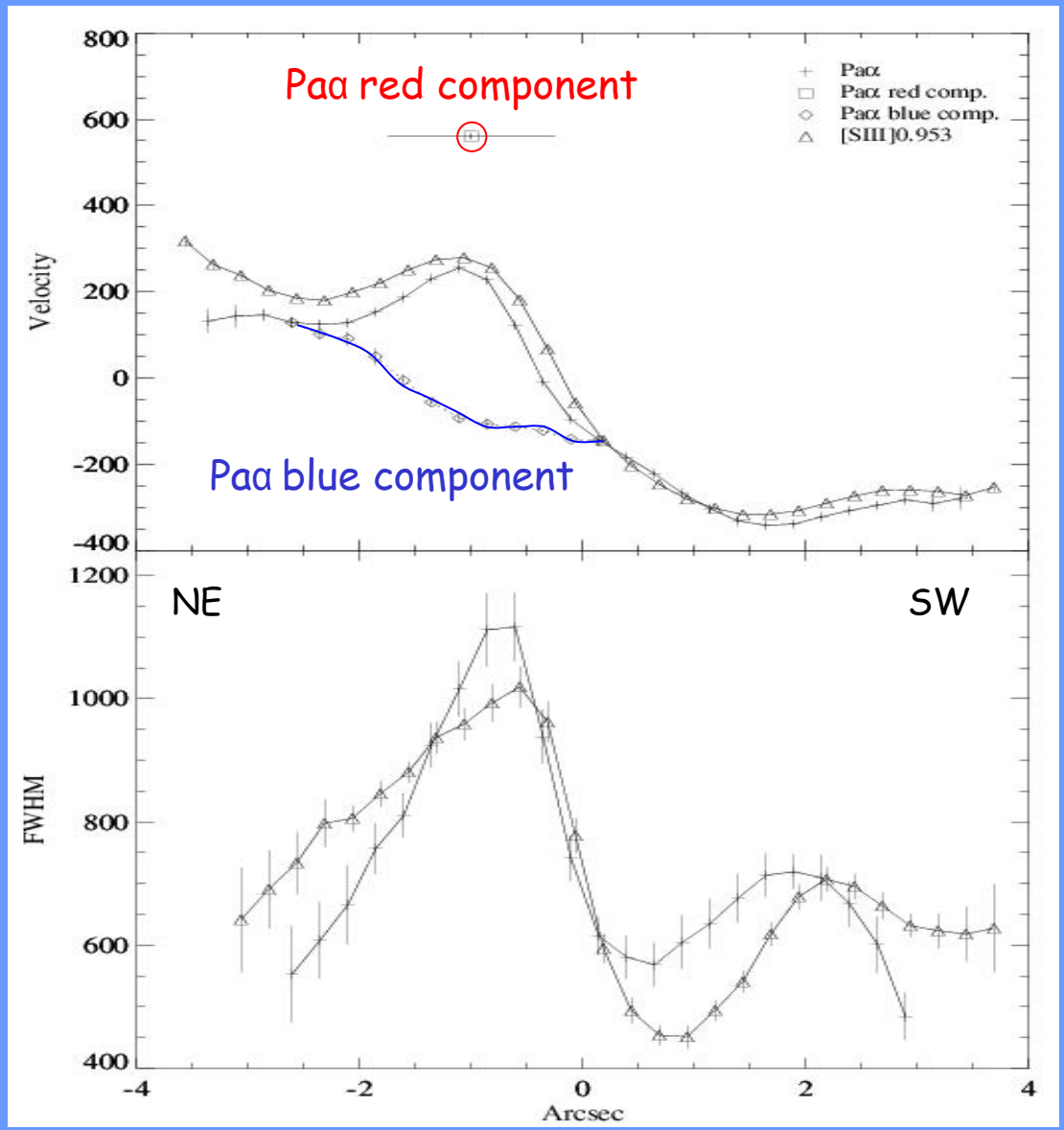
*Both lobes less affected by extinction than the nucleus.

Eastern and Western Emission

Line width variation along the slit increases noticeable around two positions = 1″ to the east and 2″ to the west, covering 1.5 arcsec.



KINEMATICS OF THE IONIZED GAS

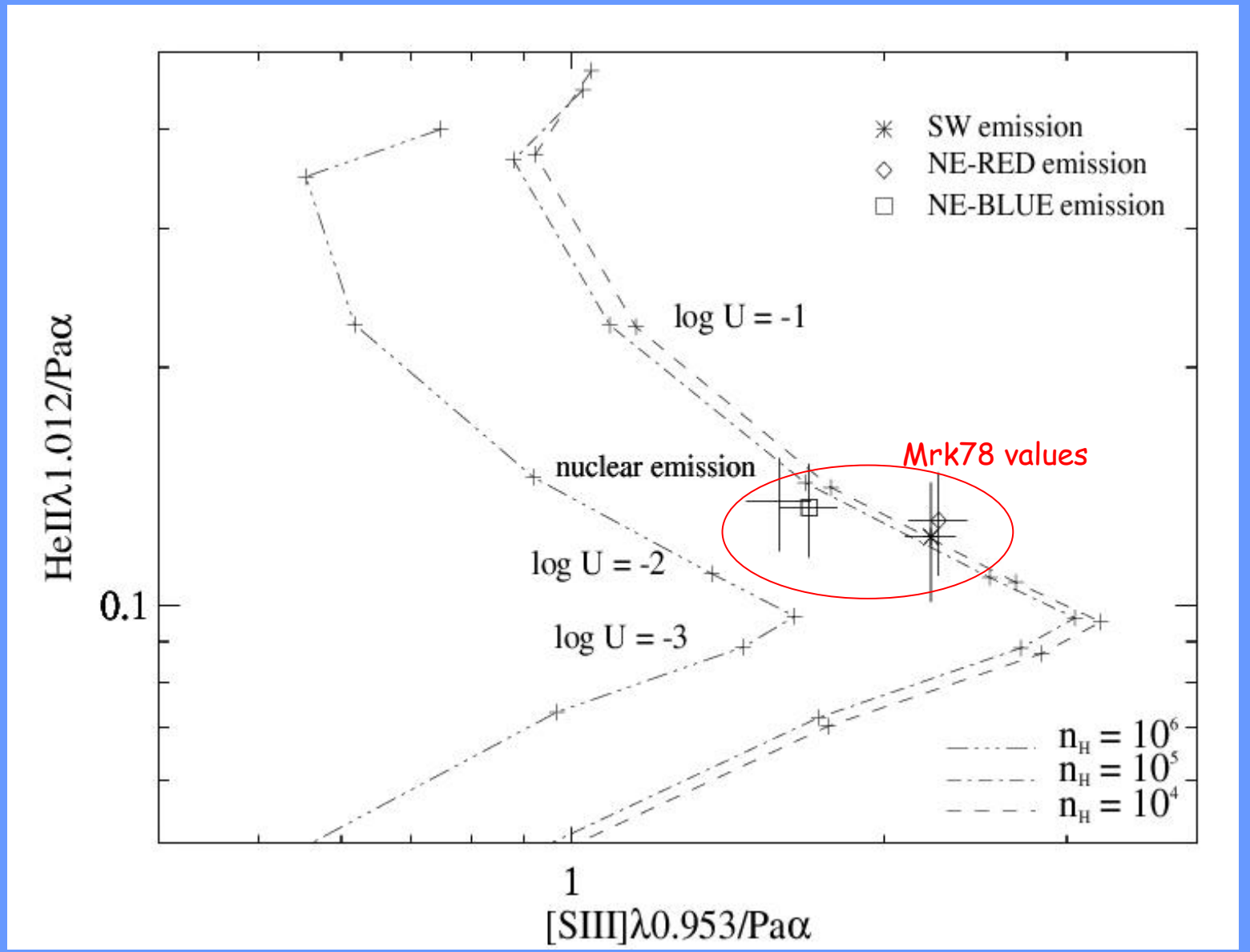


Most intense emission lines describe clear rotation curves (half amplitude of ~300 km/s) redshifted towards the east and blueshifted towards the west.

DISCUSSION

Both very high and low ionization lines present = wide variety of physical conditions coexisting in Mrk78

- Most features characteristic of photoionized gas
- [SiVI] emission uniquely associated with Sy nuclei. Can only be produced by photoionization by a hard nuclear continuum.
- [FeII]λ1.634/Paα and [FeII]λ1.257/[PII]λ1.188 ratios also indicative of photoionization by the AGN
- Photoionization code CLOUDY reproduces the line ratios from our spectra, employing a power-law continuum + typical physical conditions in NLRs.


SW emission
NE-RED emission
NE-BLUE emission
log U = -1
nuclear emission
Mrk78 values
log U = -2
log U = -3
$n_H = 10^6$
$n_H = 10^5$
$n_H = 10^4$
HeIIλ1.012/Paα
0.1
1
[SIII]λ0.953/Paα

CONCLUSIONS

- Nuclear and extended NLR spectra produced by photoionization by a hard UV-X-ray continuum = existence of hidden active nucleus in Mrk78.

- Stellar absorptions in the H and K bands due to K-M giants. Nuclear stellar emission dilution ~34% in H band and ~45% in K band.

- Enhancement of [FeII] emission outside the nucleus (west lobe) due to interaction with radio jet.