The supergiant optical counterpart of ULX P13 in NGC7793

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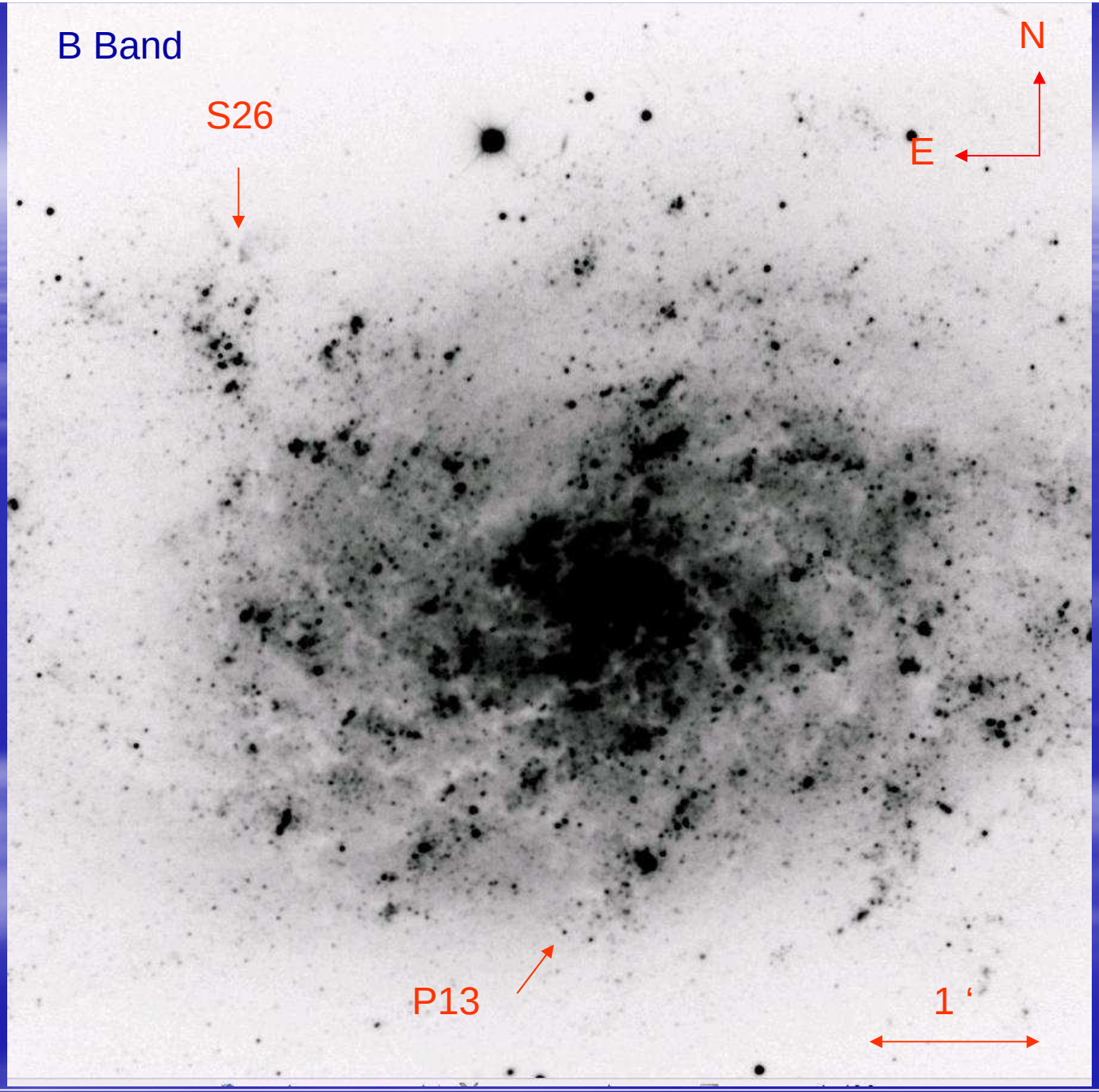
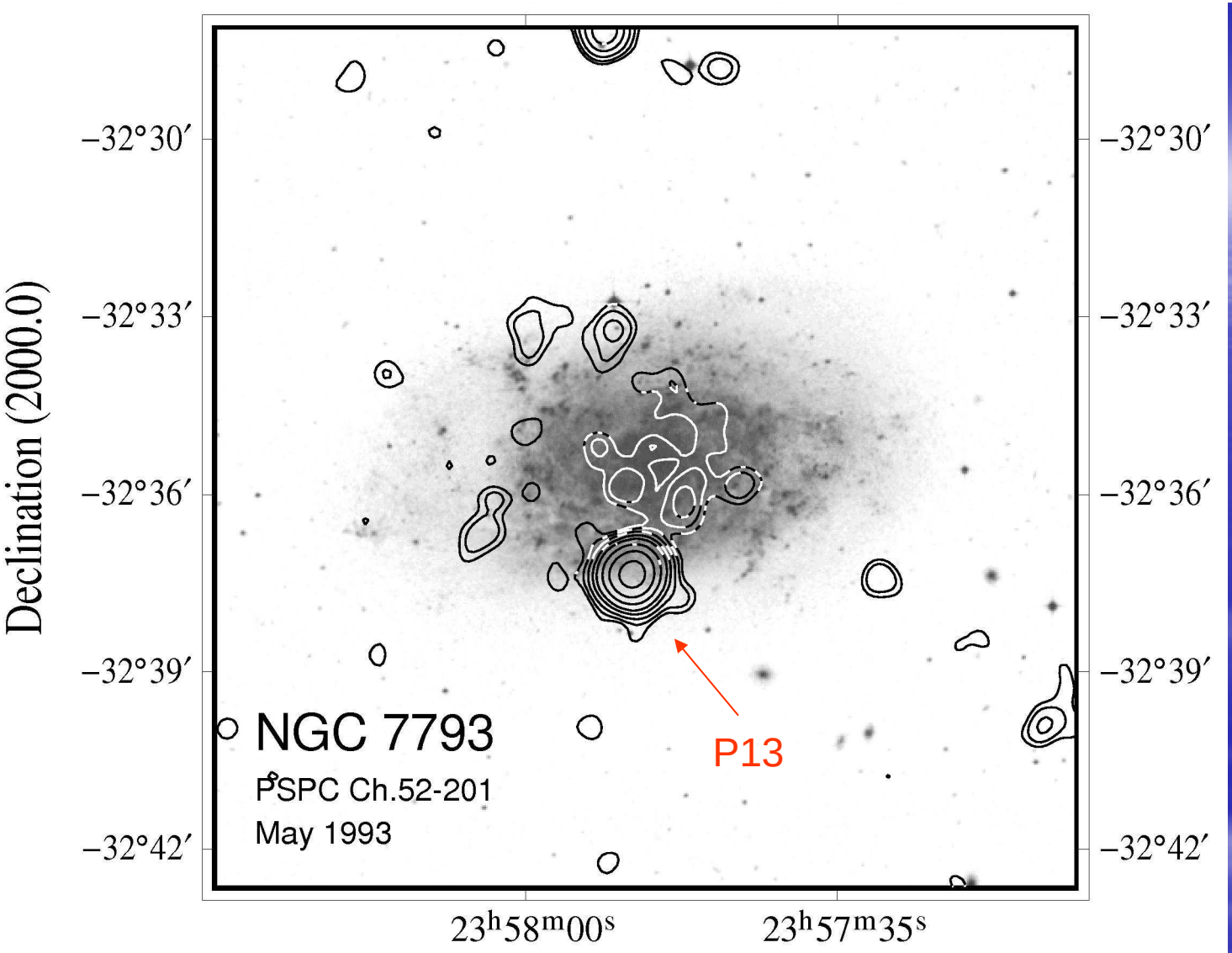
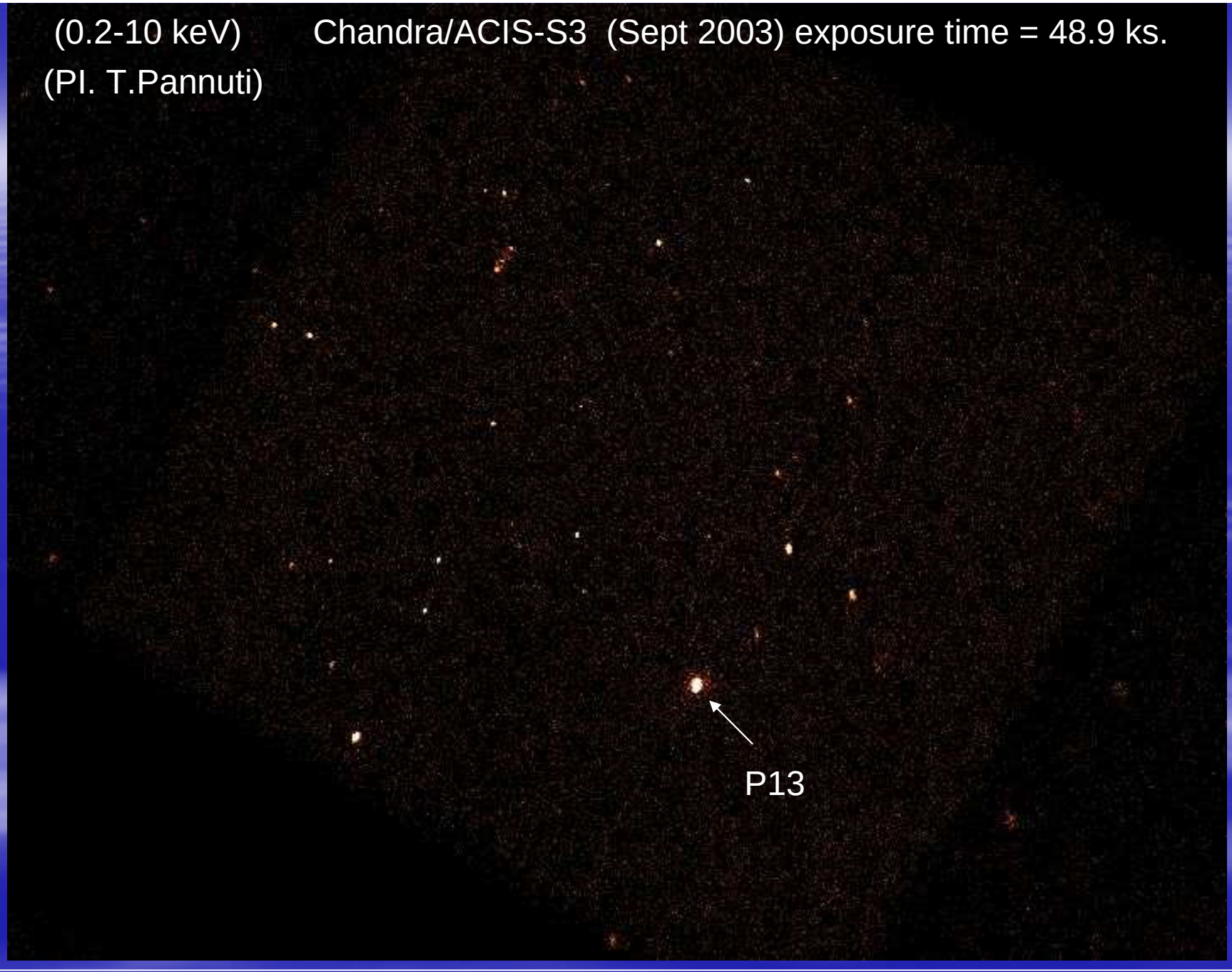
NGC 7793 and P13

- belongs to the Sculptor galaxy group
- morphological type Sd
- d ~ 3.4 Mpc (assumed)
- $N_H \sim 1.14\ 10^{20}\ cm^{-2}$
- X-ray emission dominated by a single ULX (P13) located on the southern edge of NGC 7793


B Band
S26
N
E
P13
1 ‘



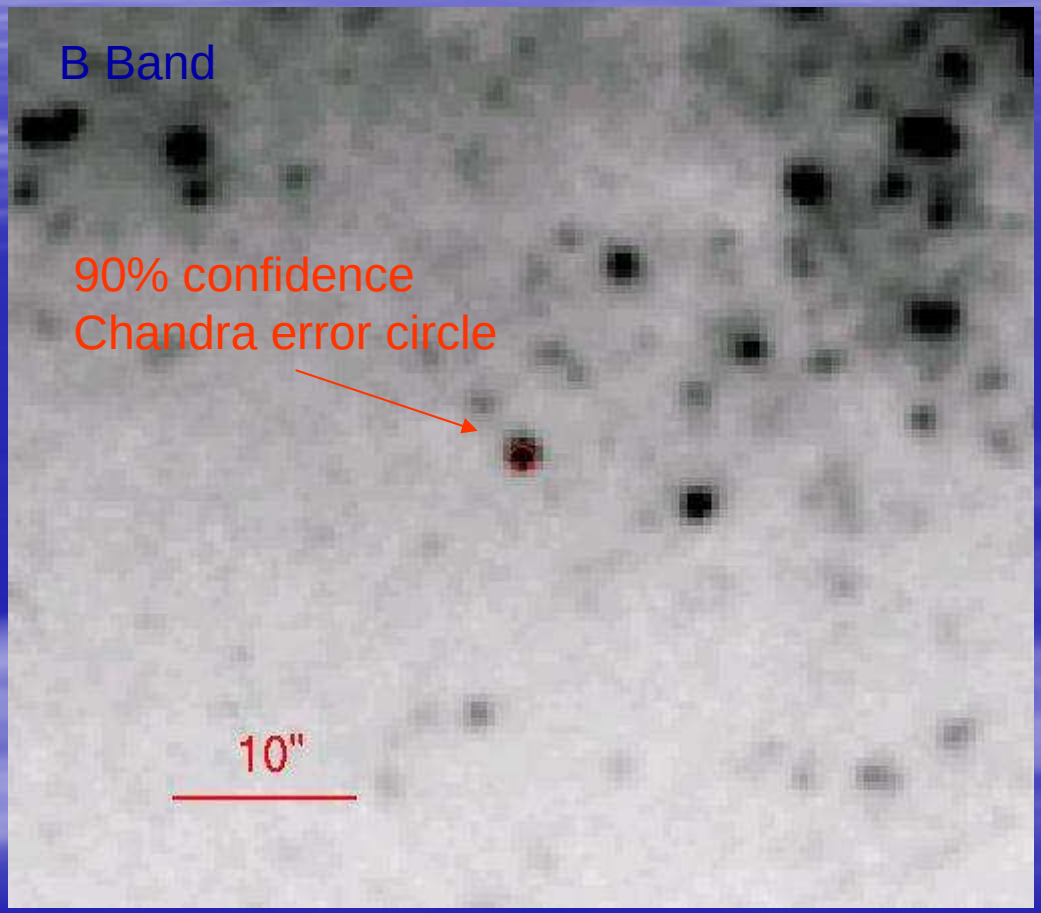
Read & Pietsch (1999)


(0.2-10 keV) Chandra/ACIS-S3 (Sept 2003) exposure time = 48.9 ks.
(PI. T.Pannuti)
P13

X-ray properties of P13

- ROSAT PSPC observations *(Read & Pietsch 1999)*
  - ~40% variability over 5 months
  - Photon index ~1.76 $\pm$ 0.45
  - Lx ~ 1.8 10^{39} ergs/s (0.1-2.4 keV)
- Chandra observations
  - No variability within 50ksec
  - Power law only excluded
  - Acceptable fits:
    - PI + hot BBody (Γ = 2.14 + kT = 1.72 keV)
    - PI + cold BBody (Γ = 1.11 + kT = 0.18 keV)
    - Comptonized spectrum (kT in = 0.19 keV; kT plasma = 100keV; τ ~3)
  - Lx ~ 3.1 10^{39} ergs/s (0.2-10.0 keV)

The optical counterpart of P13

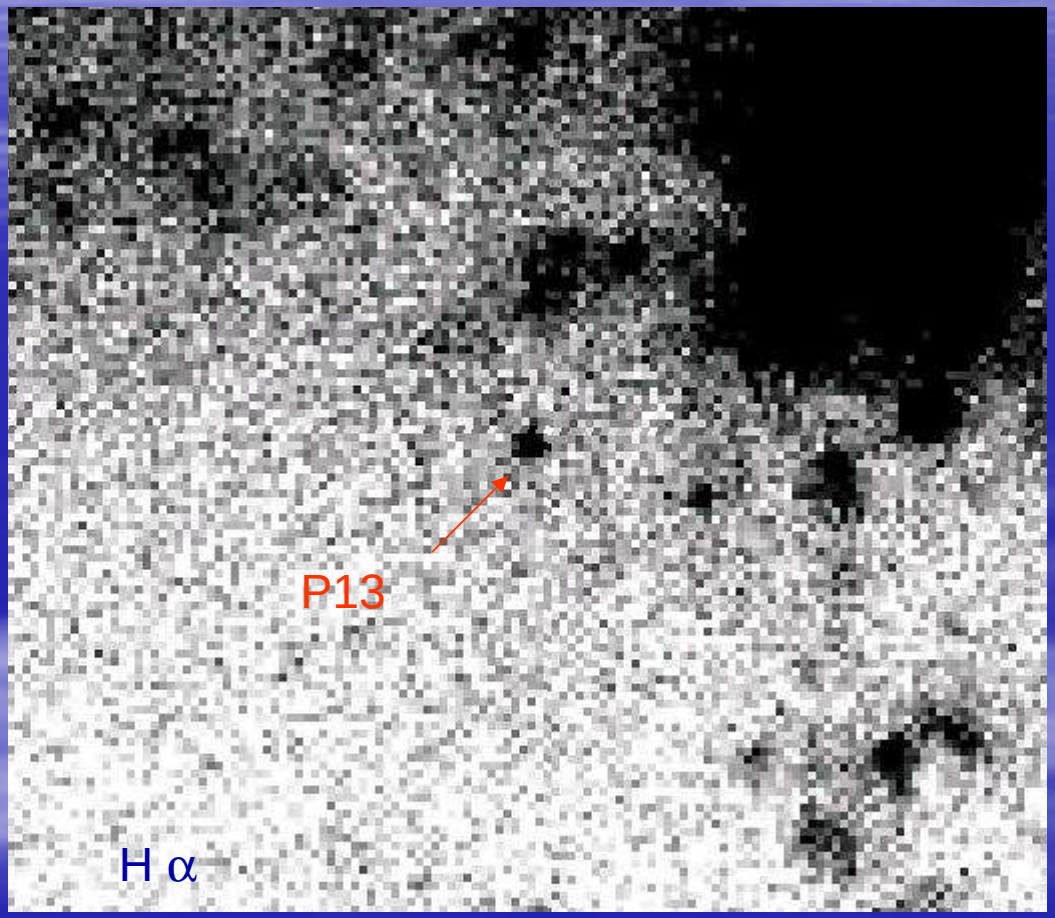


First identified by M. Pakull

Clear identification with a blue V ~ 20.5 object in NGC 7793

The optically brightest of all known ULX counterparts ..

The optical counterpart of P13



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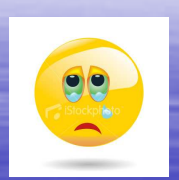
Clear identification with a blue V ~ 20.5 object in NGC 7793

The optically brightest of all known ULX counterparts ..

Hα emitter. At the rim of prominent HII region and star cluster

ESO observations

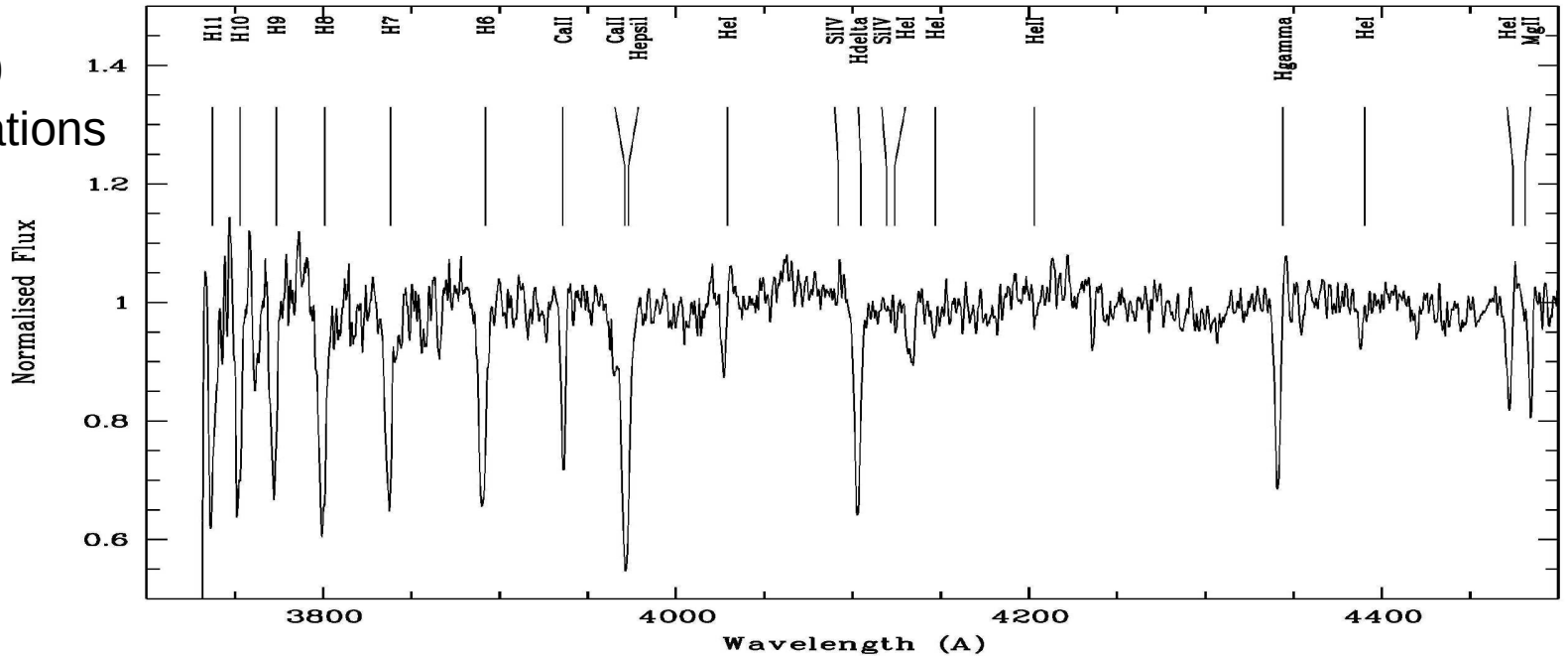
- 10 x 40mn of ESO-VLT + FORS time granted in 2008 (P82) -> 2 observations done only !
  - FORS2 + GRIS_600B (R~600;3500-6000)

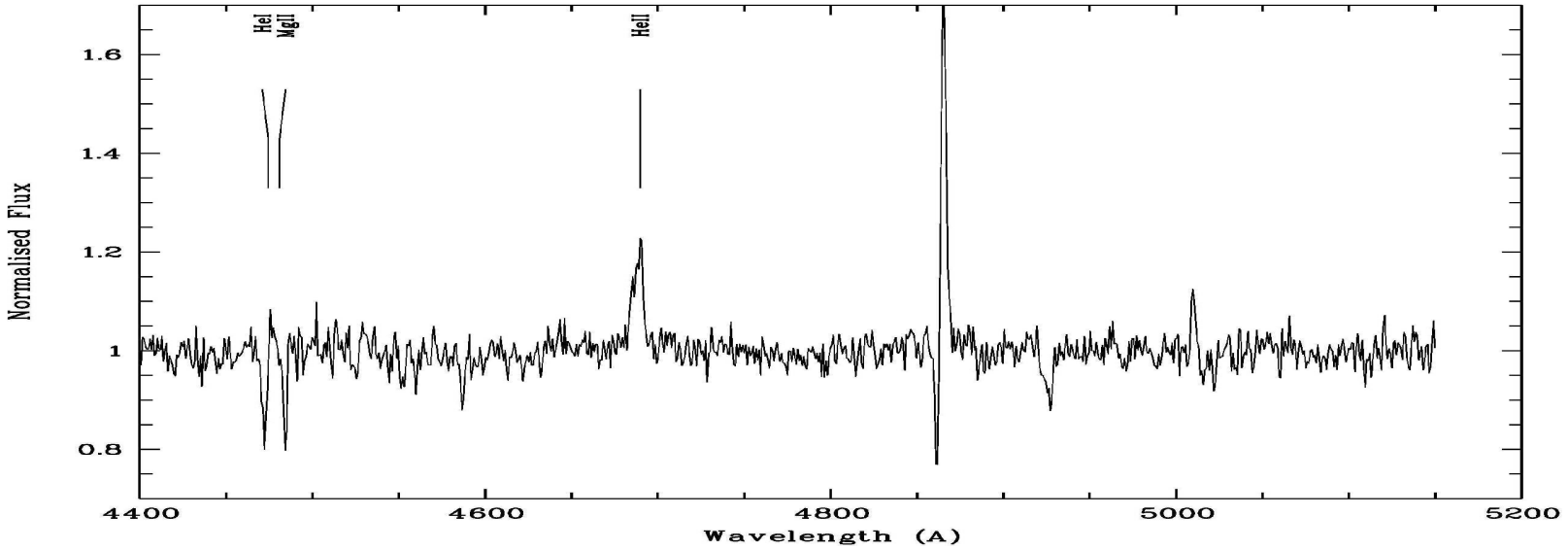


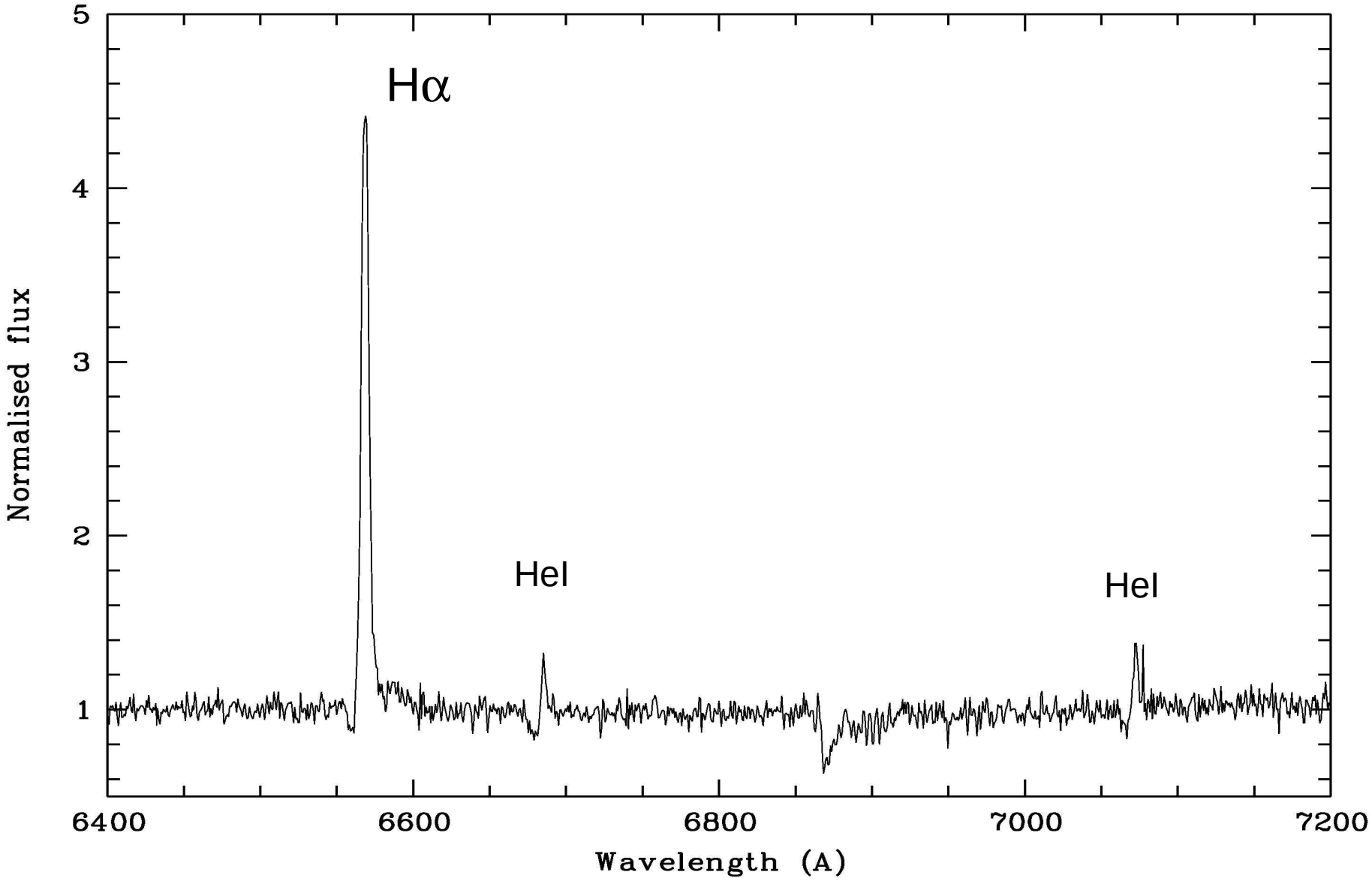
- 19 x 40mn of ESO-VLT + FORS time granted in 2009 (P84) -> 5 observations done only !
  - From November 17 to December 14 2009
  - FORS2 + GRIS_1200B (R~1600; 3700-5200 A)
  - Manual wavelength calibration + monitoring of the object position in slit -> 5 km/s accuracy

- More observations scheduled in P85

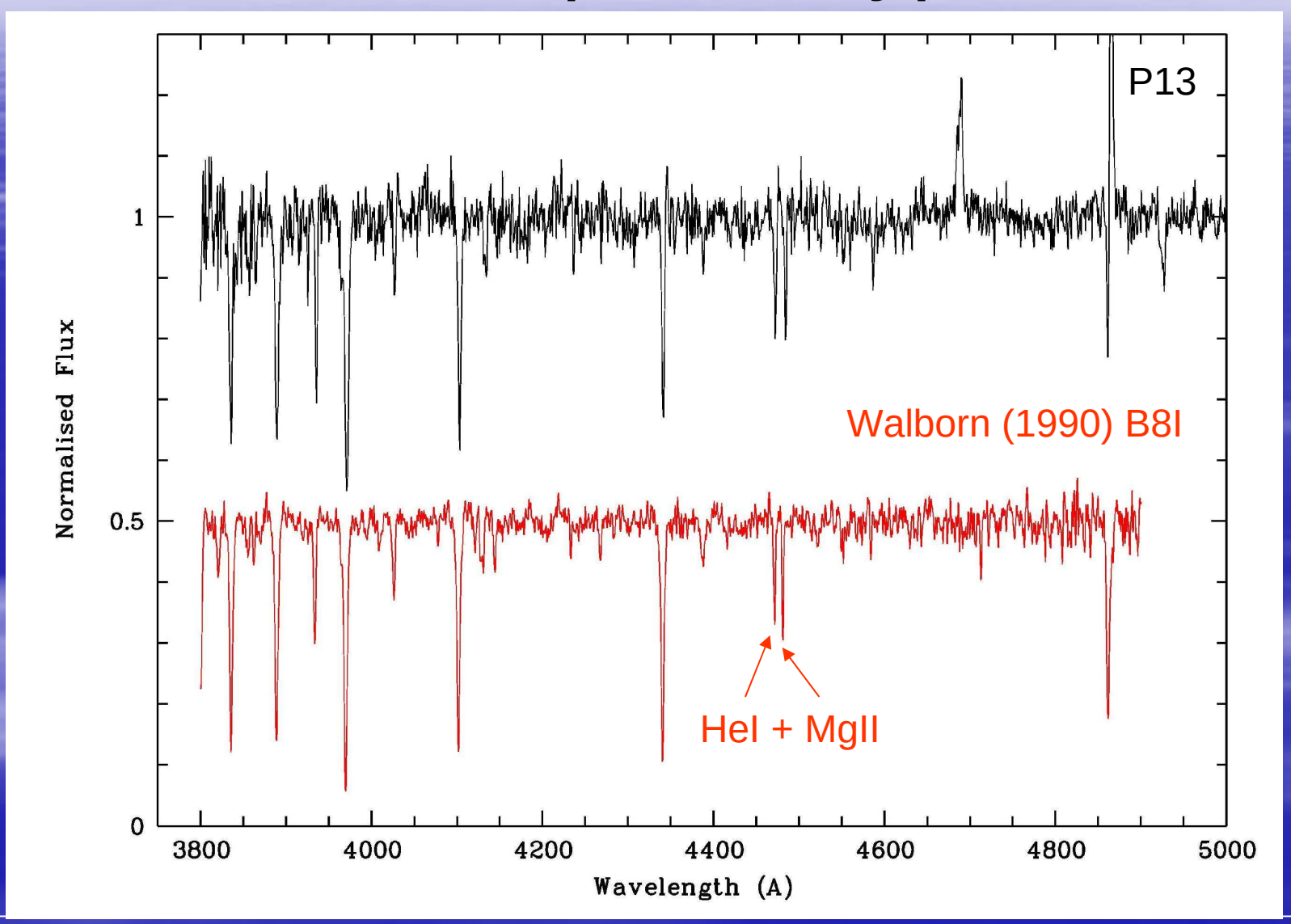
Sum of all 2009 observations (3h)



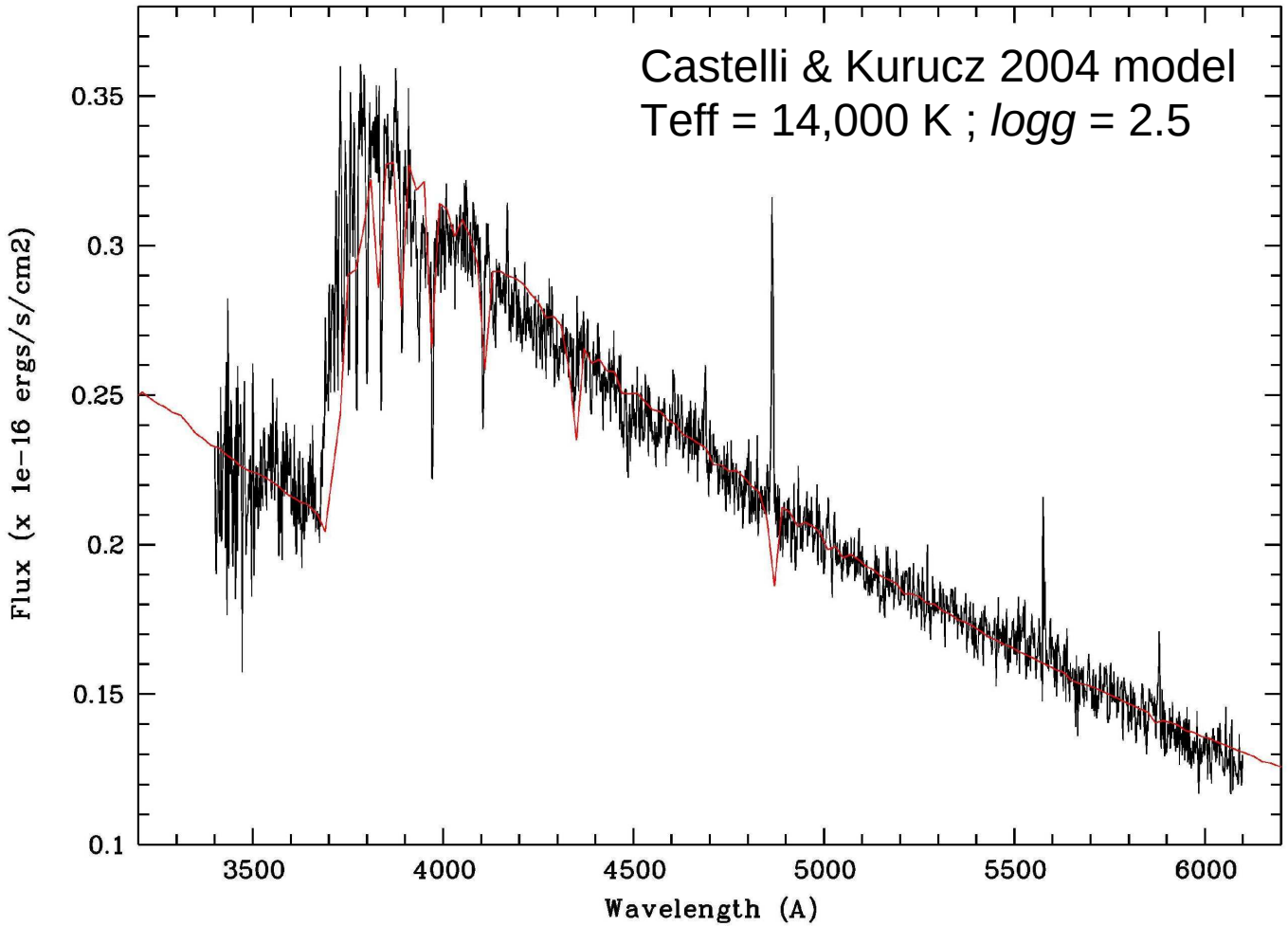



Hα
HeI
HeI
Normalised flux
Wavelength (A)
5
4
3
2
1
6400
6600
6800
7000
7200

a B8I spectral type



a B8I spectral type



Balmer lines and Balmer jump suggest *log g* ~2.0

Mv ~ - 6.7

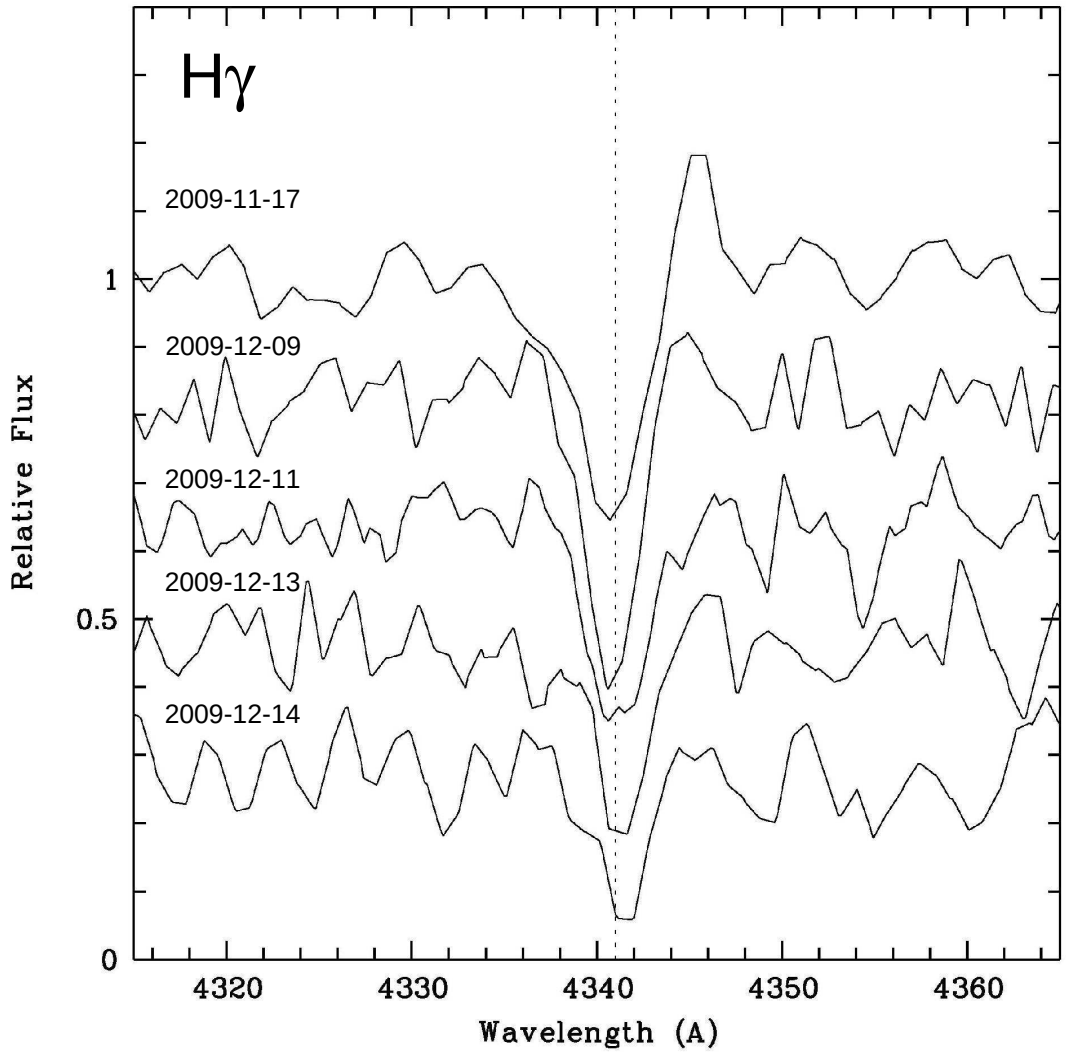
Lbol ~ 5 10^{38} erg/s

M ~ 10-20 Msol

R ~ 60 Rsol

Lx/Lbol ~ 6

Balmer line absorptions



Velocity variations are clearly seen in Balmer absorption lines

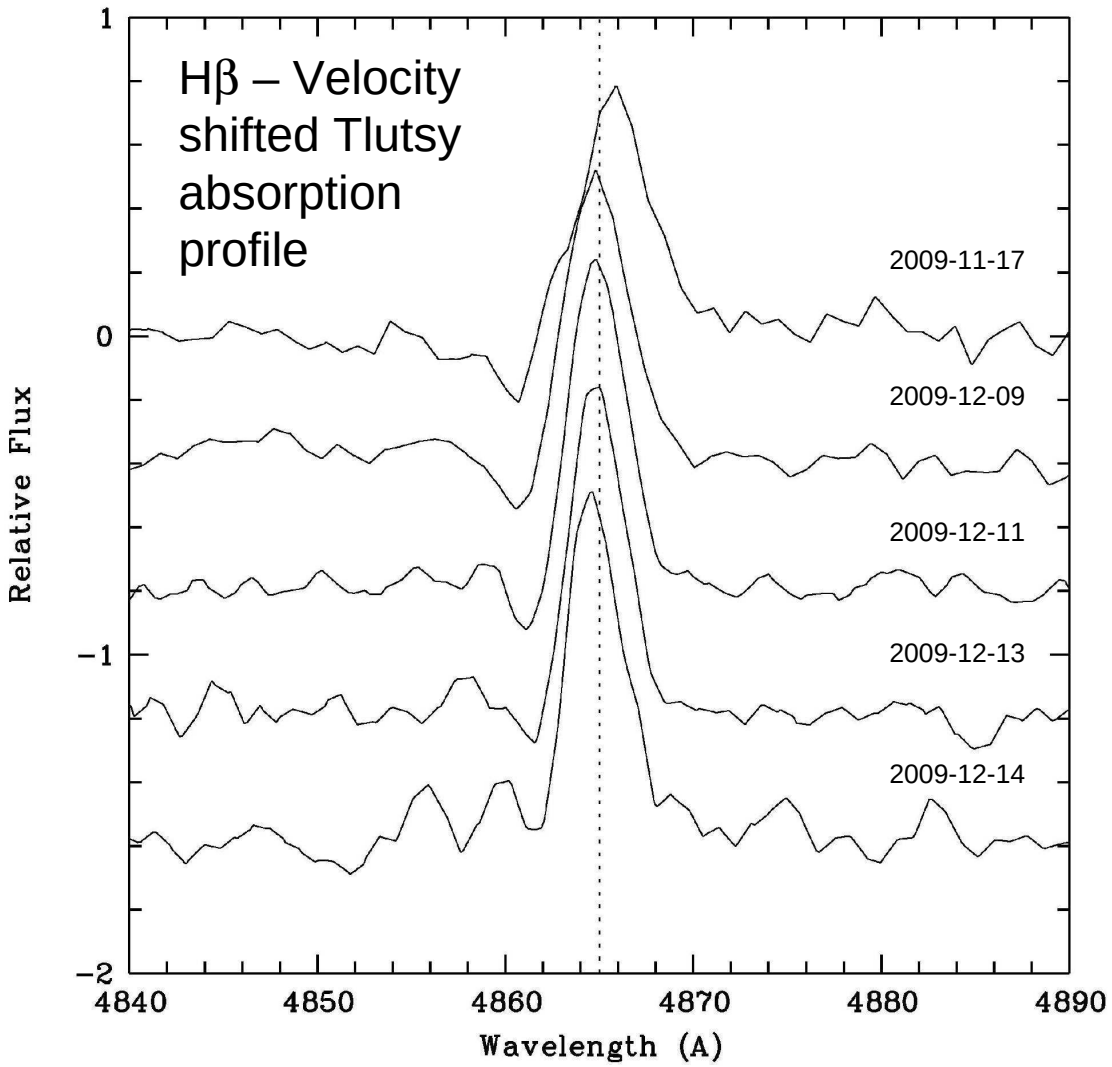
Hγ profile is still somehow contaminated by emission

Higher order Balmer lines are emission-free and can be used to measure stellar velocities.

A cross-correlation method using Hδ, Hε and H6-H10 lines yields errors of ~ 7 km/s

Several templates tested:
-Velocity corrected sum
-a TLUTSY (BSTAR06)
Teff=15,000, *log g* = 2.0 model

Balmer line emissions



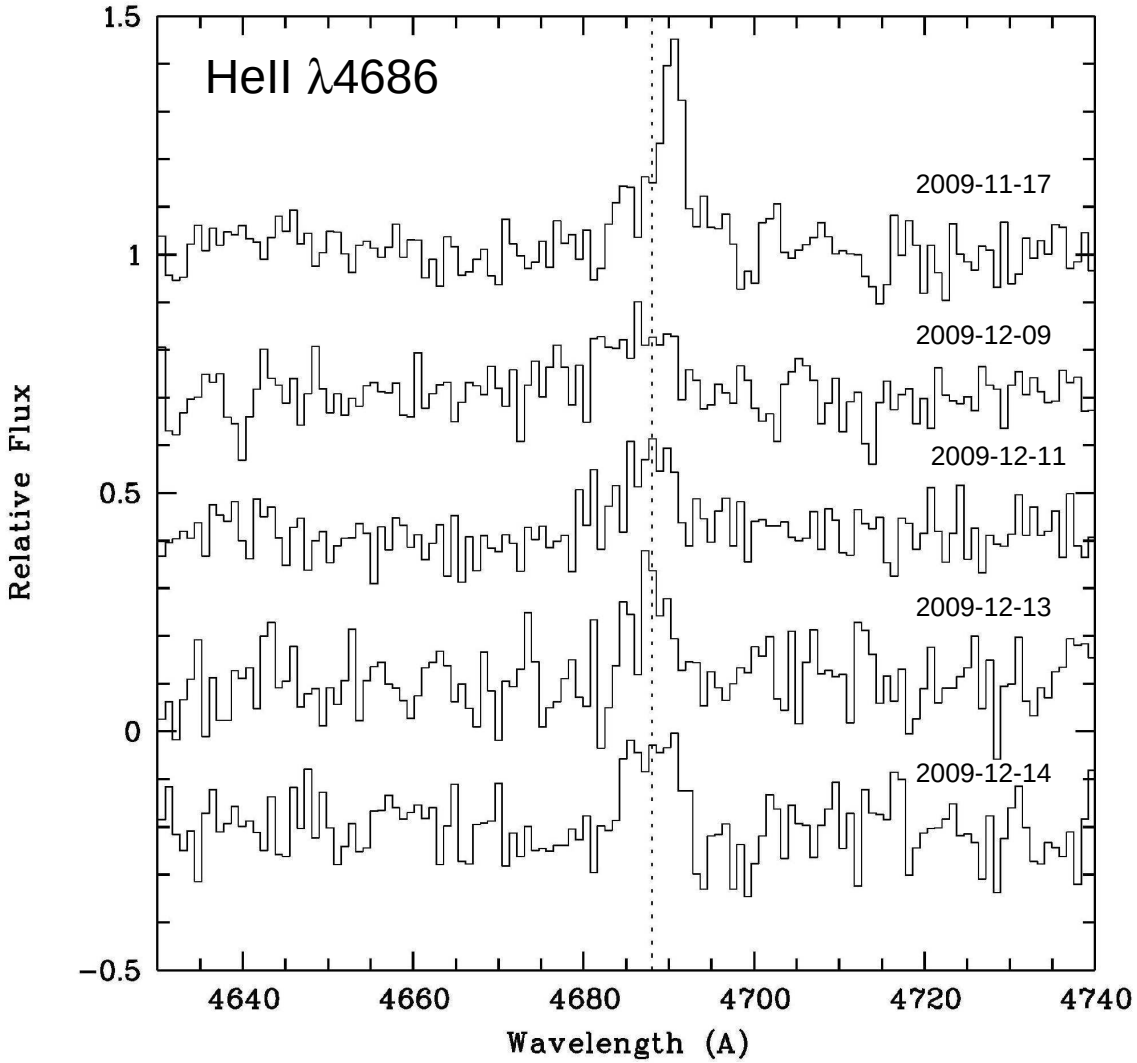
Hβ emission corrected for the underlying Hβ absorption profile shifted at the velocity of the high order Balmer photospheric absorption lines

Hβ emission velocity and high order Balmer absorptions move in opposite directions

Hβ emission has a small P Cyg profile in some spectra

EW ~ 3.5 A steady

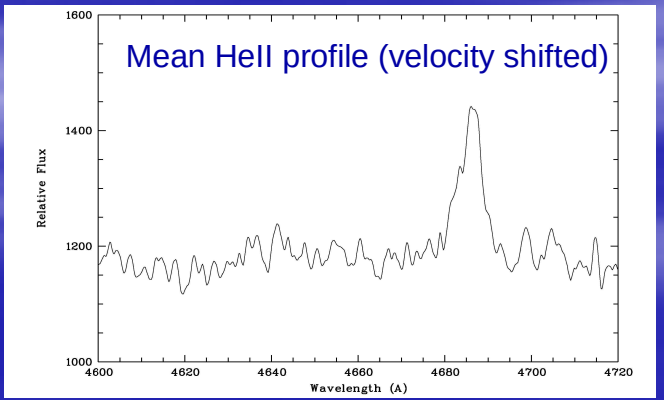
HeII emission



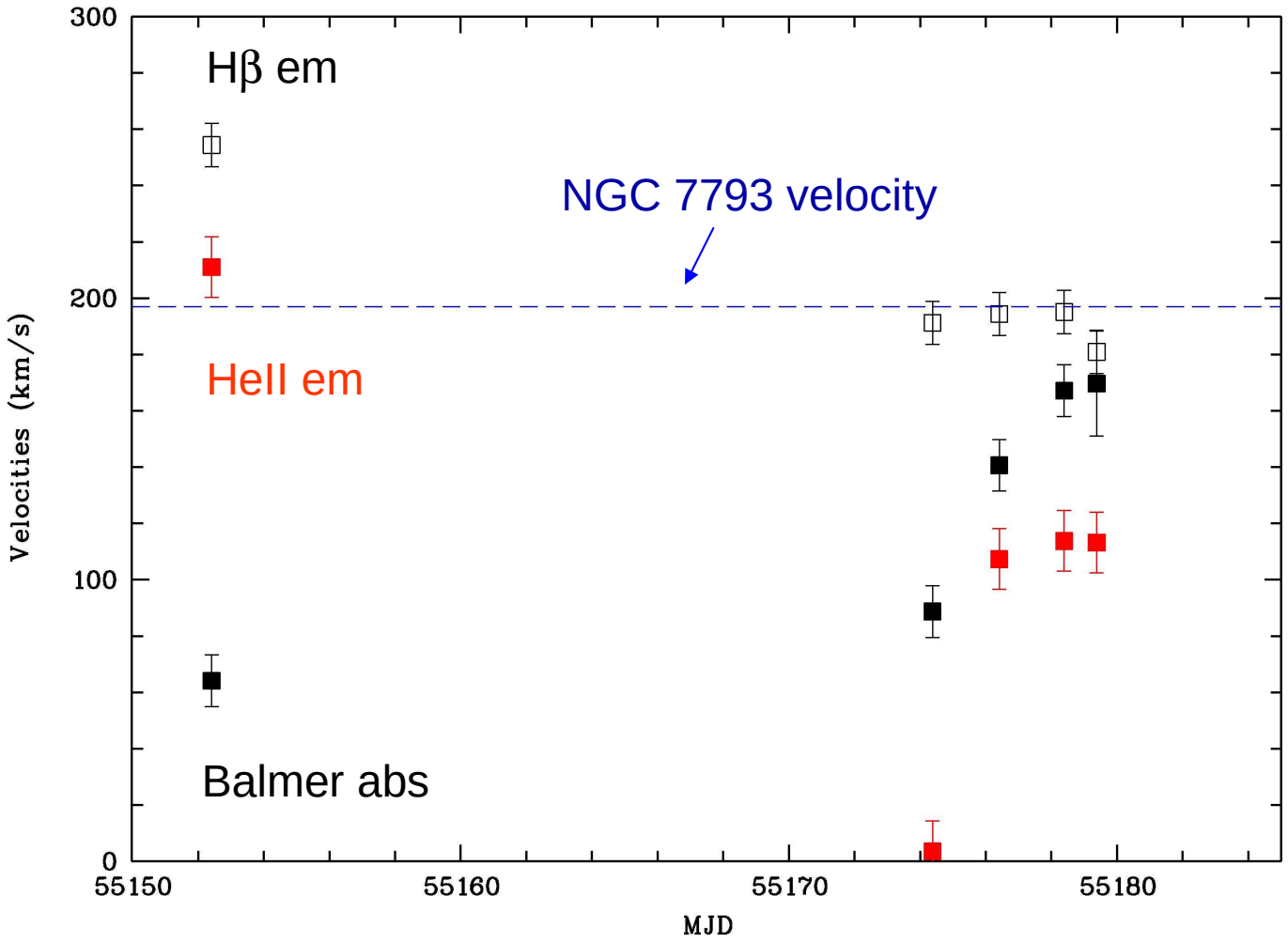
HeII λ4686 emission profile is highly variable
EW ~ 0.9-2.2 A

Broad component + one "narrow" component seen on 2009-11-17

Velocity changes visible in the "broad" component. Roughly in phase with Hβ emission



Line velocities



Hβ emission :
73 ± 11 km/s

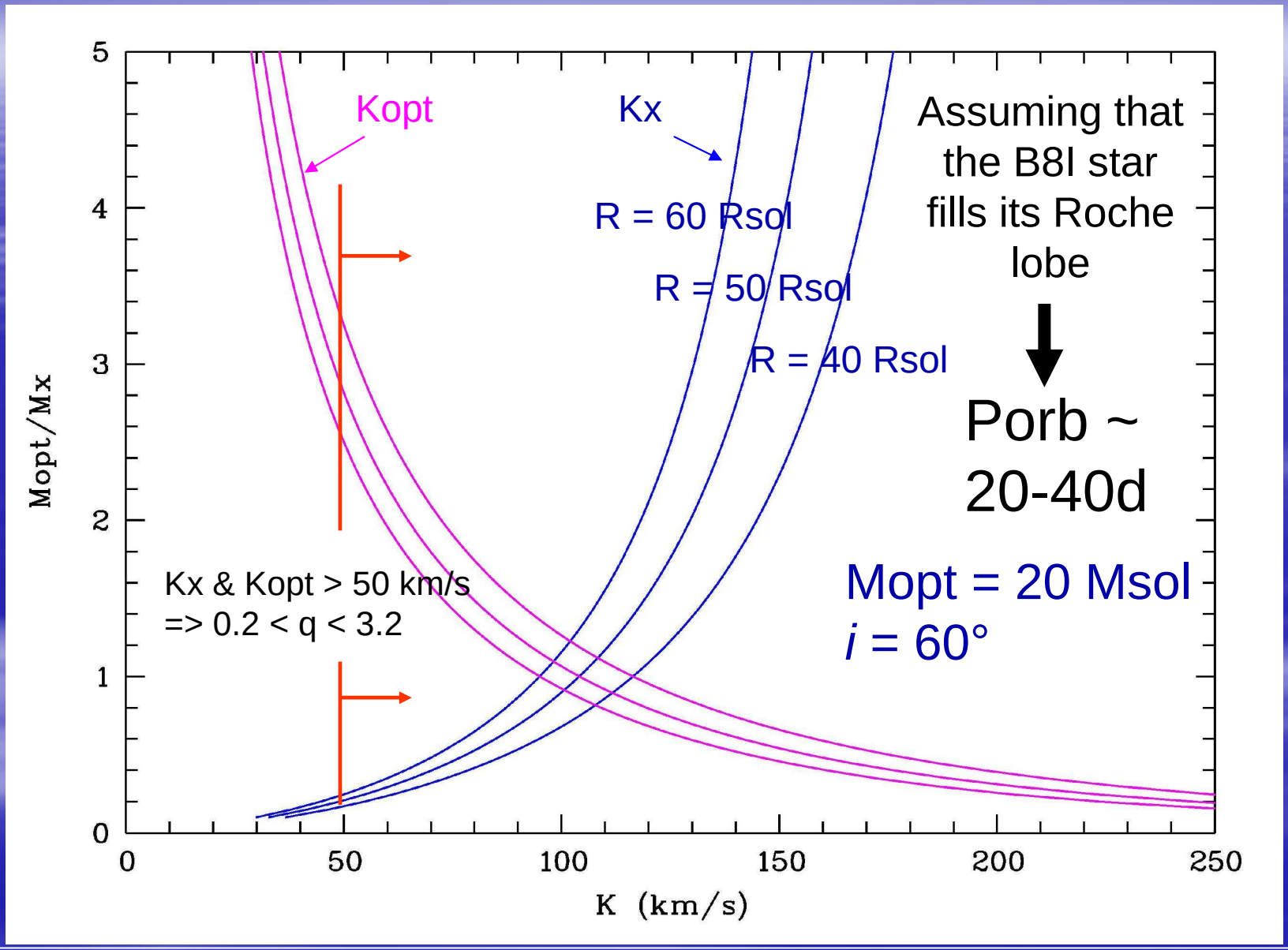
HeII emission:
104 ± 15 km/s
(ignoring 2nd low EW observation)

H6-H10 absorption:
105 ± 13 km/s

What do line radial velocities tell ?

- Velocities of Balmer absorption lines and of Hβ & HeII emission lines roughly vary in opposite directions over a time interval of 26 days.
  - Consistent with a “double line spectroscopic binary”
- However details of variations within 5 days do not fit well this picture. => P13 is a “dirty” system …
- Possible complications:
  - Strong (and variable ?) X-ray heating effects (Lx/Lbol ~ 6)
  - Enhanced anisotropic wind
  - eccentricity
  - Shadowing by accretion disc
  - etc ..
- Need for more data …

Possible orbital periods and mass ratios



Constraints on BH mass

- Observed velocity variations + Roche lobe filling constraints:

  i = 60° => 0.2 < Mopt/Mx < 3.2 (true K is 2x that observed)

  => M_{BH} ~ 3 - 100 Msol

  Assuming Kopt ~ Kx ~ 50km/s => Mopt/Mx ~ 1 (i = 25-30°)

- ΔV(heII) ~ ΔV(Balmer abs)

  => Mopt/Mx ~ 1 likely

  => M_{BH} ~ 10 - 20 Msol

Conclusions

- P13 is the optically brightest known ULX
- Donor is a B8Ia type (short active phase ~ 10^5yr)
- P13 is apparently a double line spectroscopic binary with good prospects for measuring masses of the two components
- Current observations strongly suggest

  Mopt ~ MBH ~ 10-20Msol

  No IMBH in P13 ….