SRON
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Spectroscopic follow-up of iPTF16fnl: a uniquely nearby tidal disruption event

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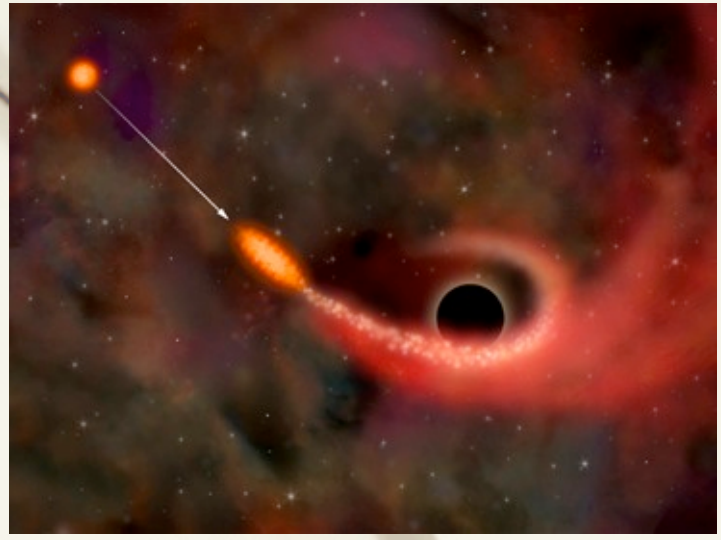
What are tidal disruption events (TDE)?

When a star comes too close to a black hole it is disrupted by tidal forces. This result in a stream of debris that falls back onto the SMBH and powers a luminous flare.



Observational:

- Nuclear transients
- Typical flare duration of month/years
- Typical emission decline $t^{-5/3}$
- Blue continuum + broad H and He II emission lines (~10^4 km/s)
- Absolute magnitude ~ -19 – -21
- Preferred host galaxies: E+A (post-merger)

The UV/optical emission mechanism and the geometry and composition of the emitting region are still open questions

What are tidal disruption events (TDE)?

Three different origins for the optical/UV emission have recently been proposed:

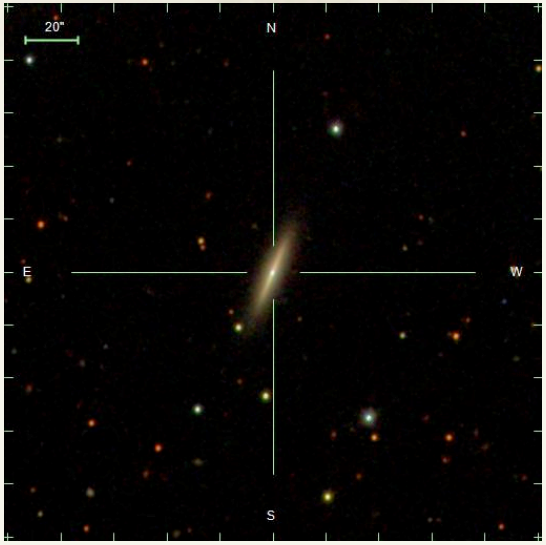
- Photon-driven; line-driven or circularization-driven outflows
- Emission by shocks from intersecting debris streams
- Thermal reprocessing of accretion power by a layer of gas at large radii

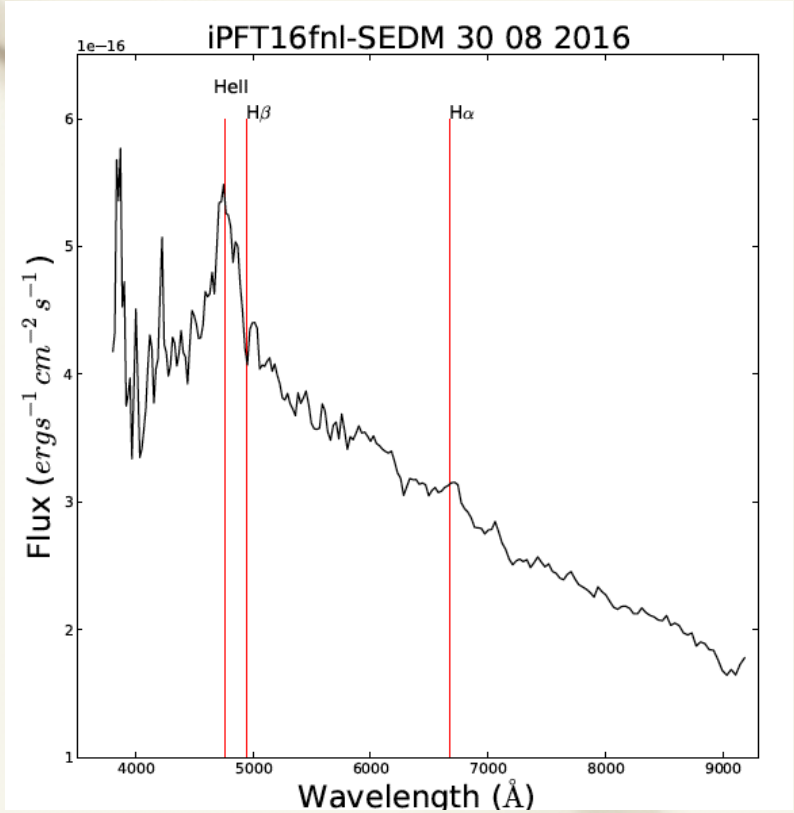
We need a dense coverage of spectral evolution of TDEs over the whole flare phase to to disentangle the optical emission mechanisms

iPTF16fnl: the discovery

Not alert from Gaia!
(see Zuzanna's talk)

Discovery date: August 26 2016, in Mrk 950 at z=0.0163 = 65 Mpc
(ATel #9433 - Gezari et al 2016)





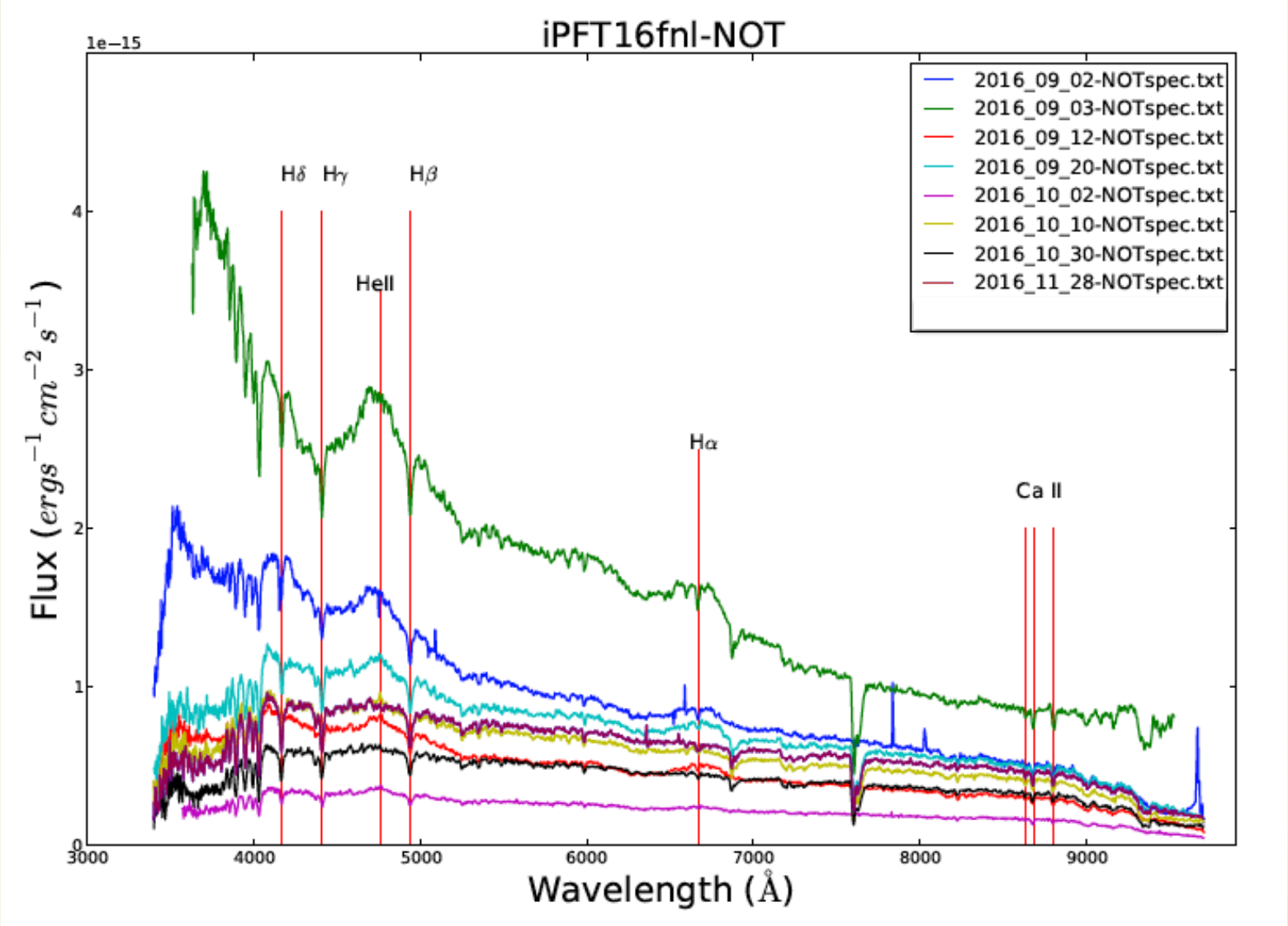
- Nuclear transient
- Detection at g= 17.4
- Blue continuum + broad He II and H emission lines
- Host consistent with and E+A

The closest TDE

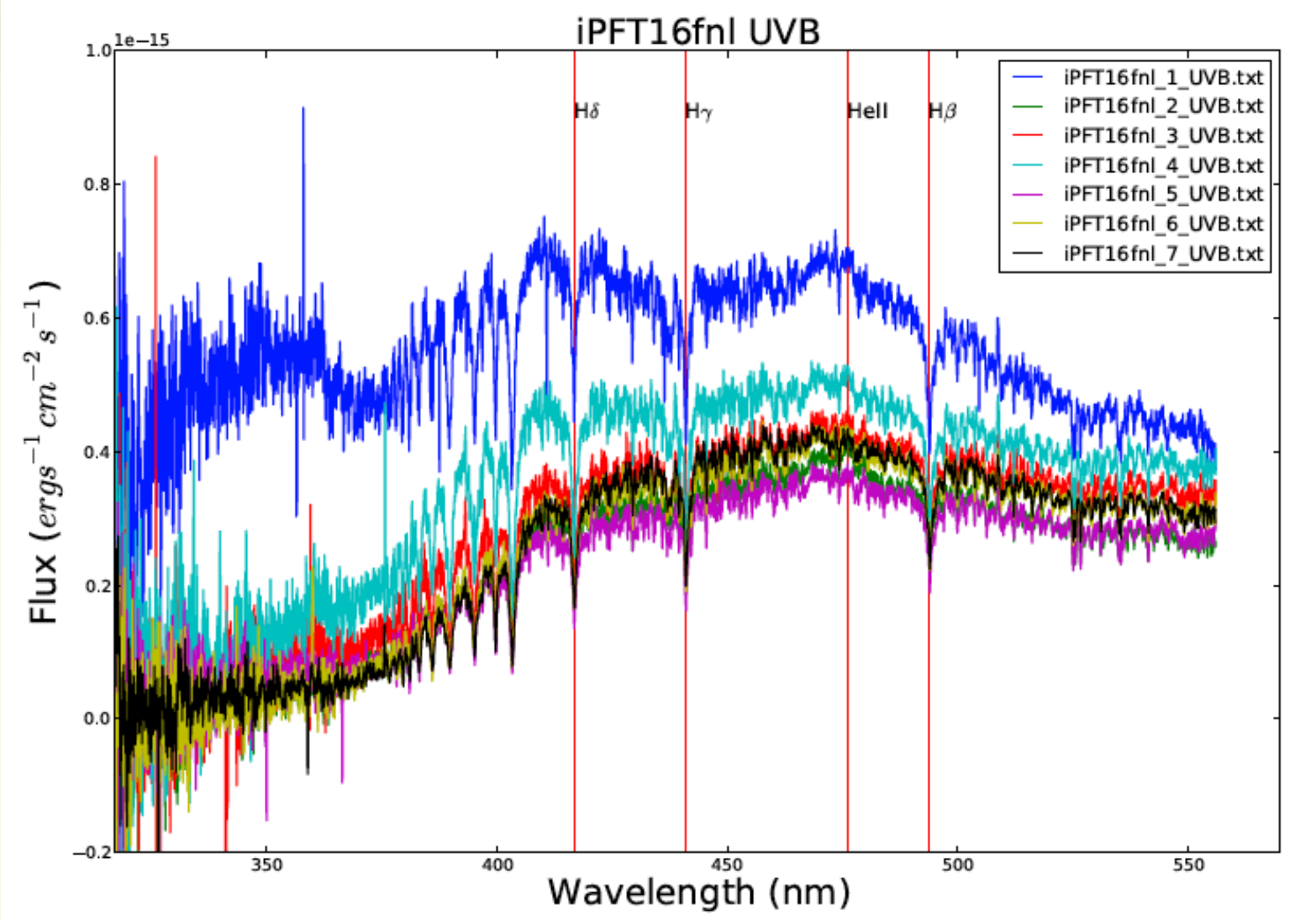
iPTF16fnl: the observations

- 8 NOT spectra (grism#4; slit=1.0, R=360)
- uBVgriz NOT imaging
- 7 X-shooter spectra starting from 13 sept 2016 (DDT – slit= 0.8x11/0.7x11/0.6x11; R=6200/10600/7780 for UVB/VIS/NIR)
- + late time spectra with WHT/ISIS (17A submitted)

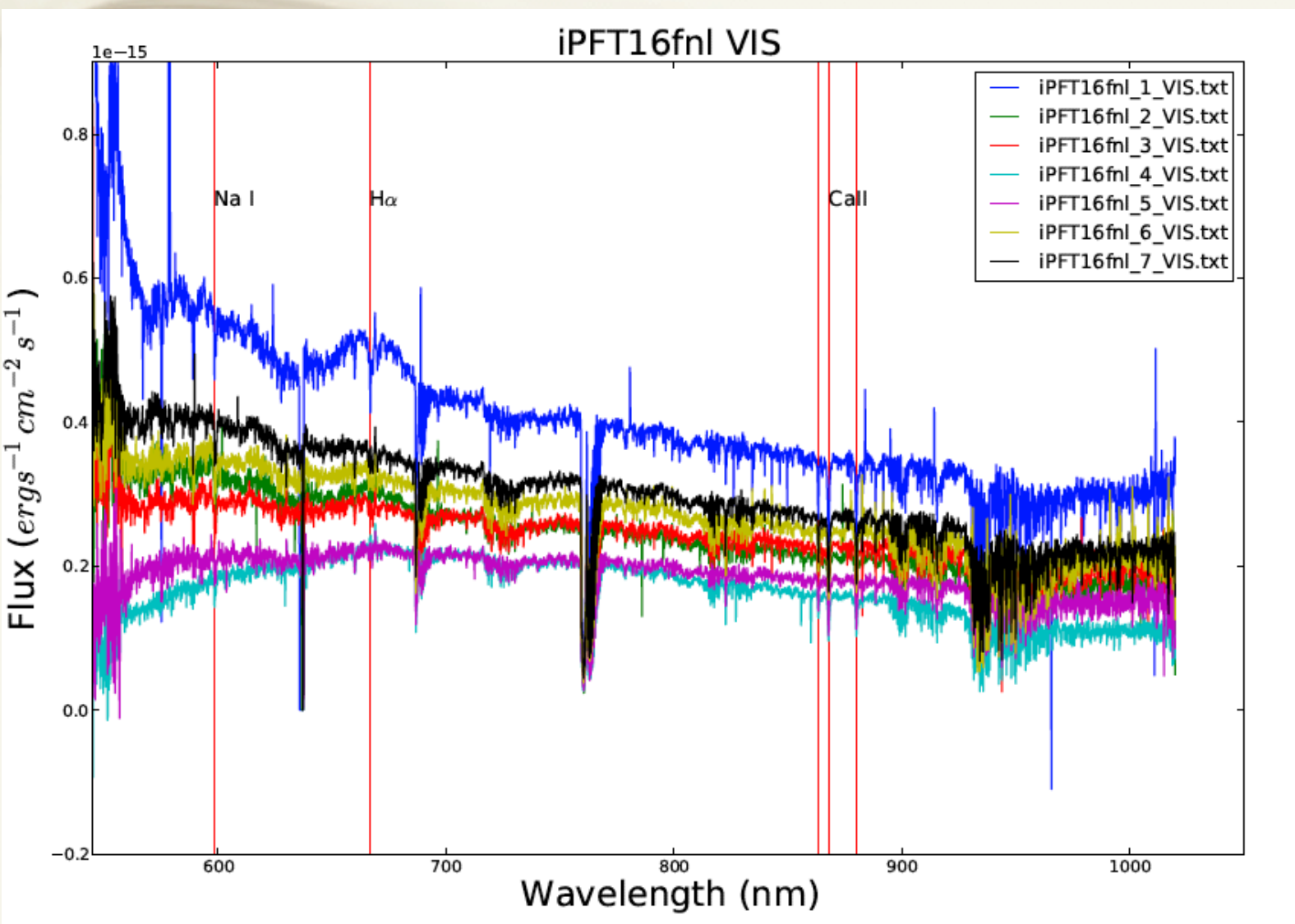
iPTF16fnl: the observations - NOT spectra



iPTF16fnl: the observations – X-shooter spectra



iPTF16fnl: the observations – X-shooter spectra



The broad line profile

iPTF16fnl: preliminary line fit analysis

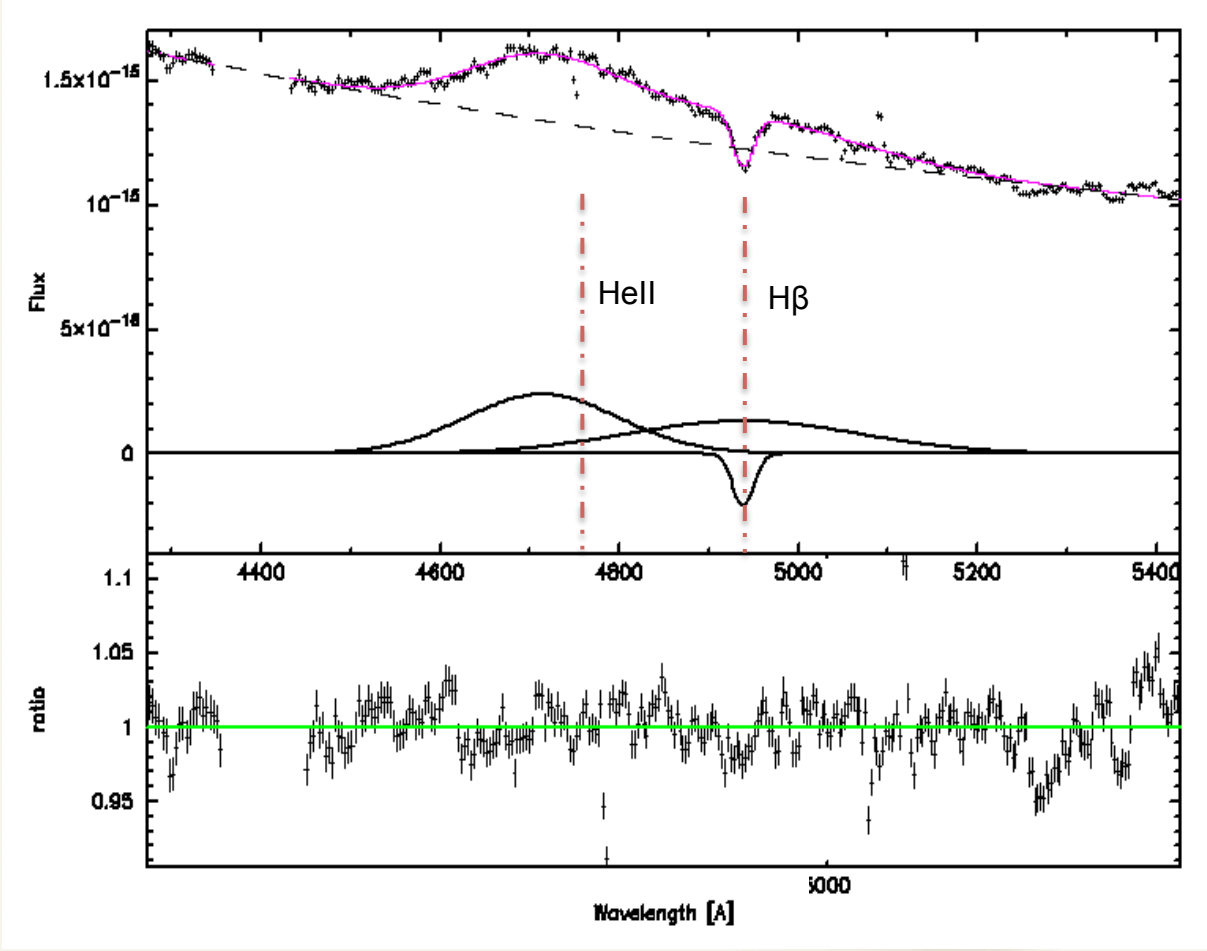
NOT spectrum of 2 September: HeII λ4686 + Hβ

- He II broad
- Hβ broad + absorption

Only HeII show a blueshift:
Δv~3000 km/s

HeII FWHM ~12700 km/s

Hβ FWHM ~ 18200 km/s



iPTF16fnl: preliminary line fit analysis

NOT spectrum of 2 September: Hα region

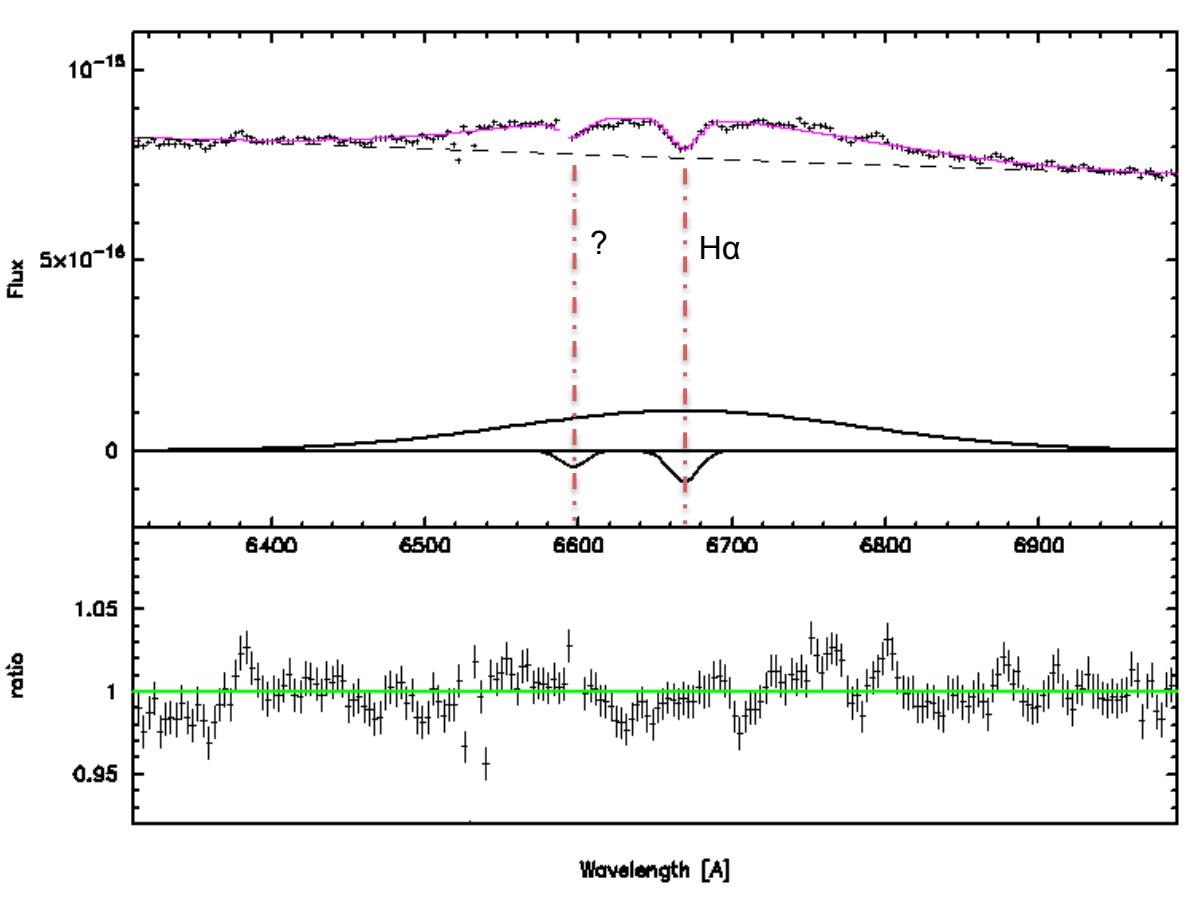
- Hα broad + absorption
- An absorption at λ_0=6490.2 (compatible with O II)

No shift found
for the H components

HeII FWHM ~12700 km/s

Hβ FWHM ~ 18200 km/s

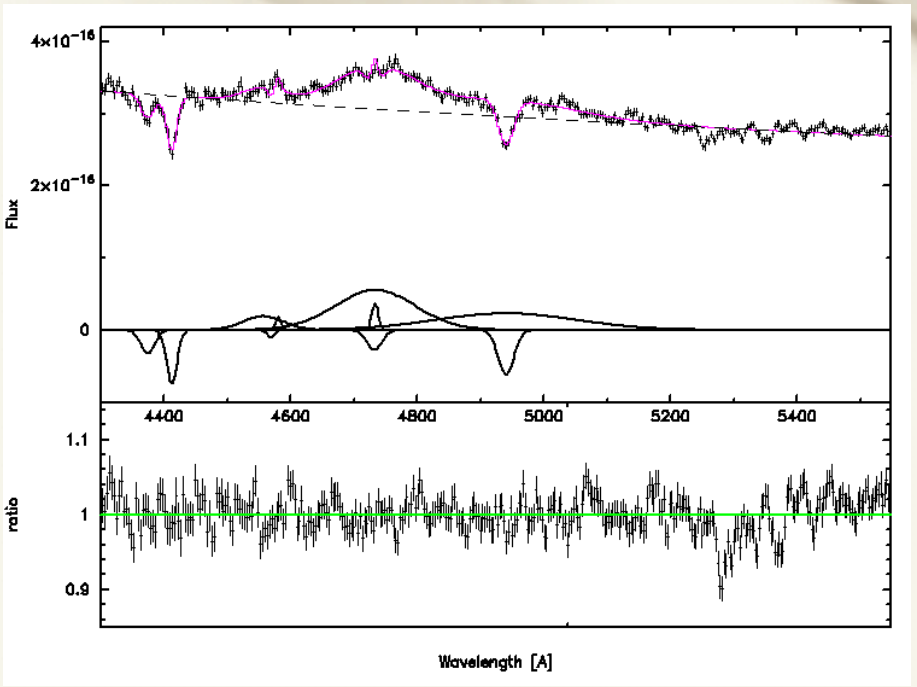
Hα FWHM~ 11800 km/s



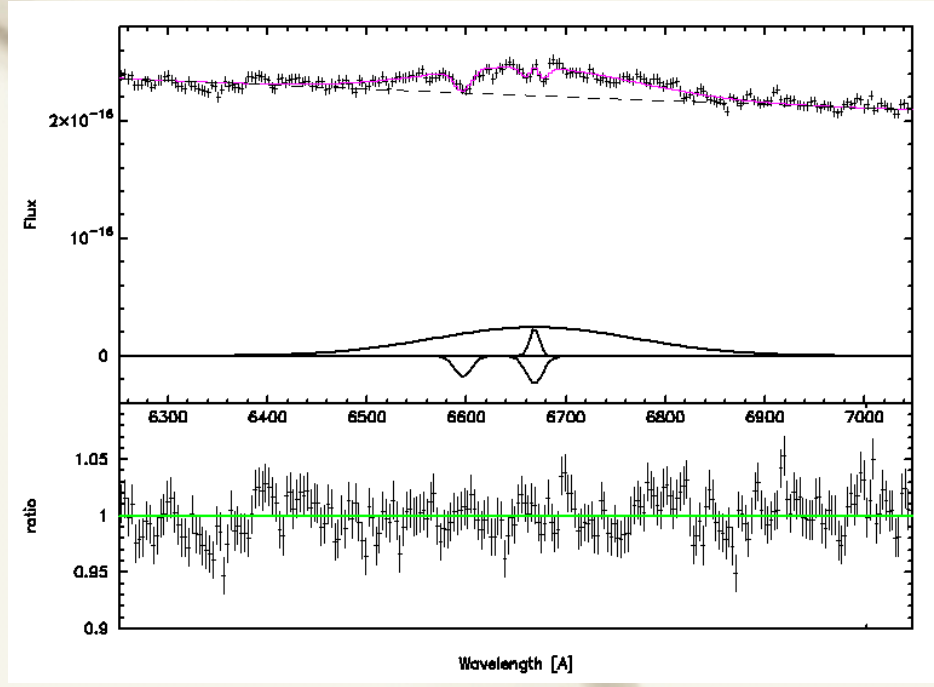
iPTF16fnl: preliminary line fit analysis

NOT spectrum of 2 October: HeII λ4686 + Hβ and Hα region

HeII+Hβ



Hα



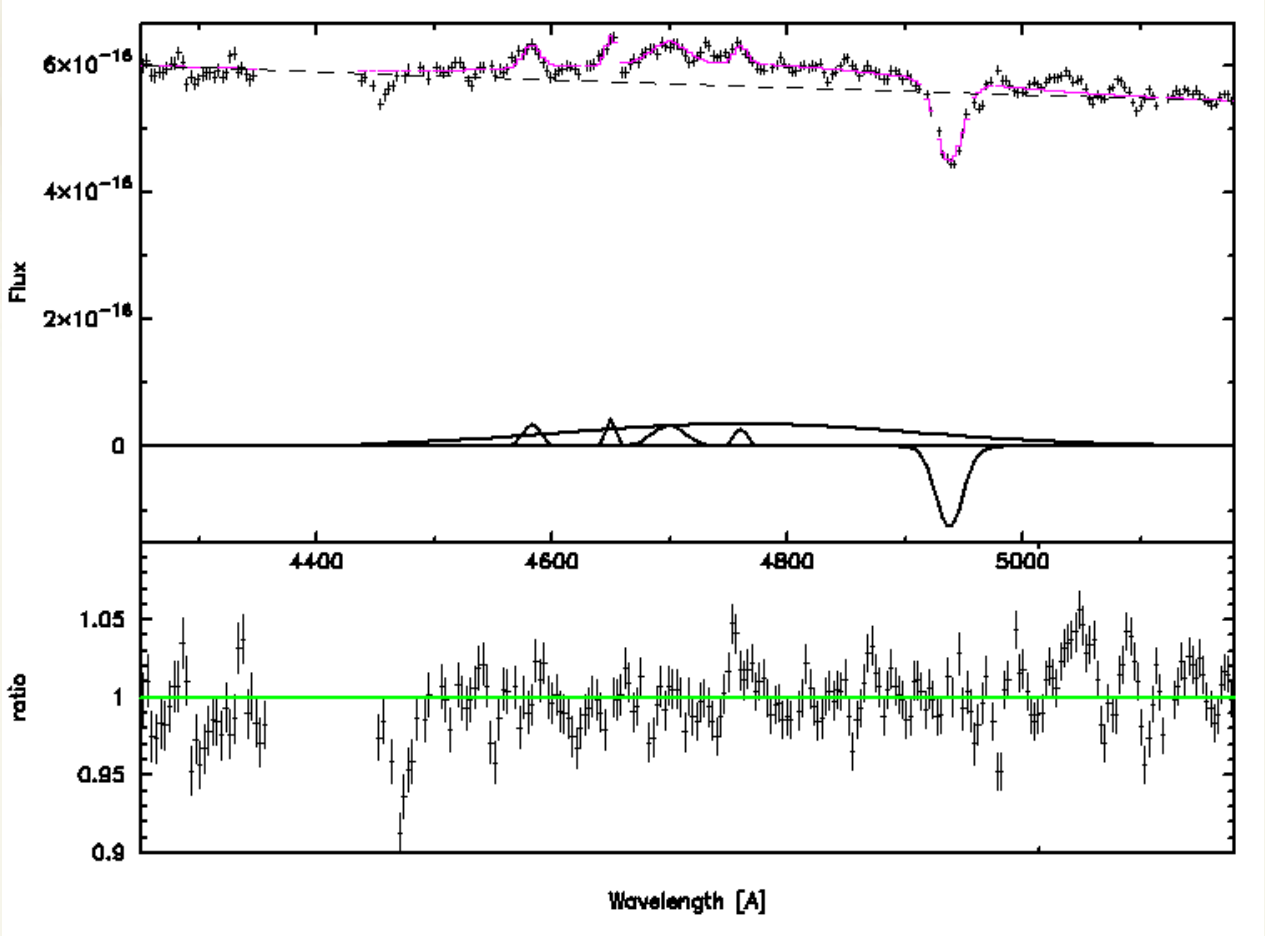
A new component in the HeII region at λ_0= 4507 (compatible with Fe II)
HeII blueshifted of ~1700 km/s

HeII FWHM ~9400 km/s Hβ FWHM ~ 15600 km/s Hα FWHM~ 10600 km/s

iPTF16fnl: preliminary line fit analysis

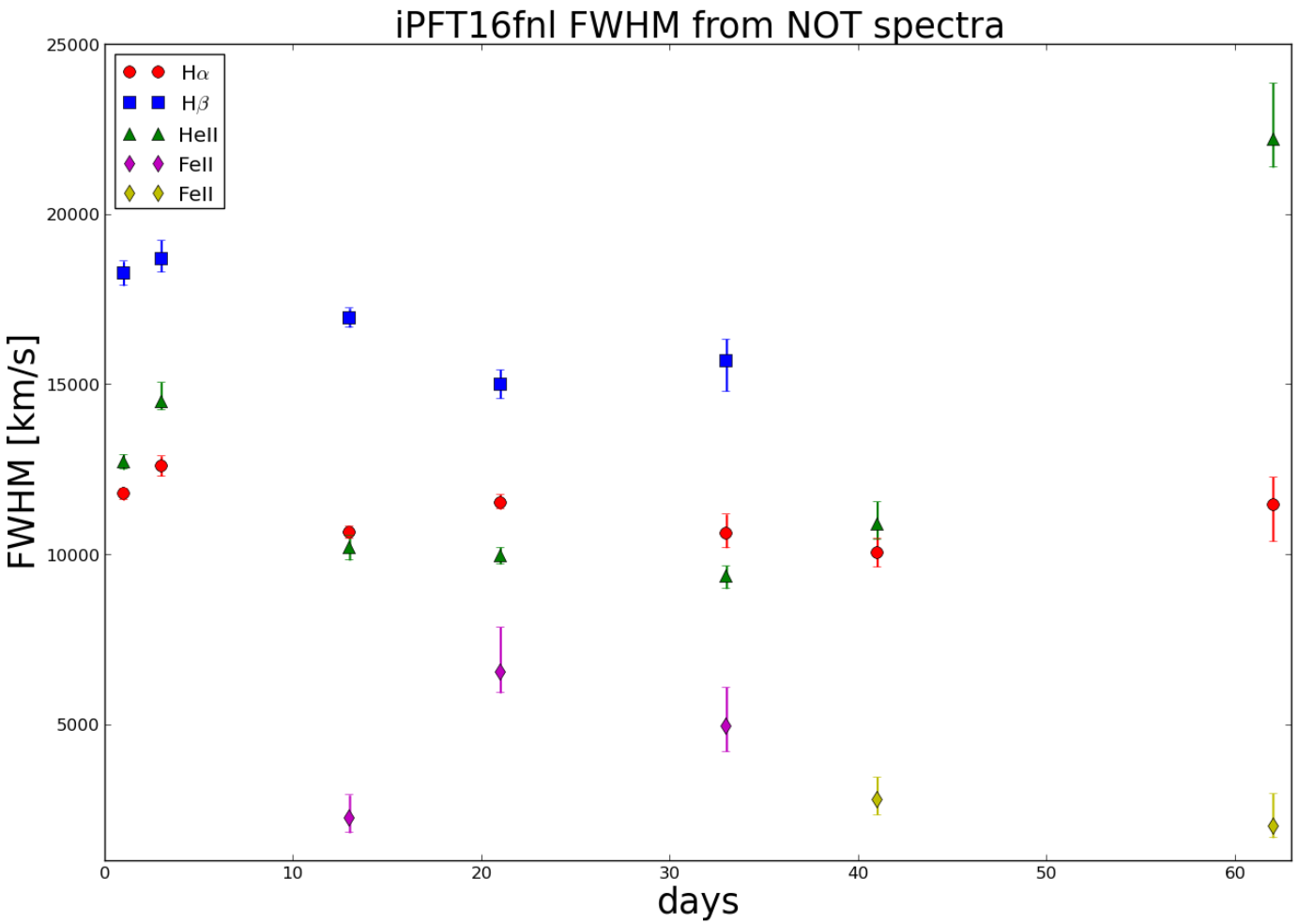
NOT spectrum of 30 October: HeII λ4686 + Hβ

- No more blueshift for HeII
- No Hβ broad but still a broad Hα
- Nebular phase

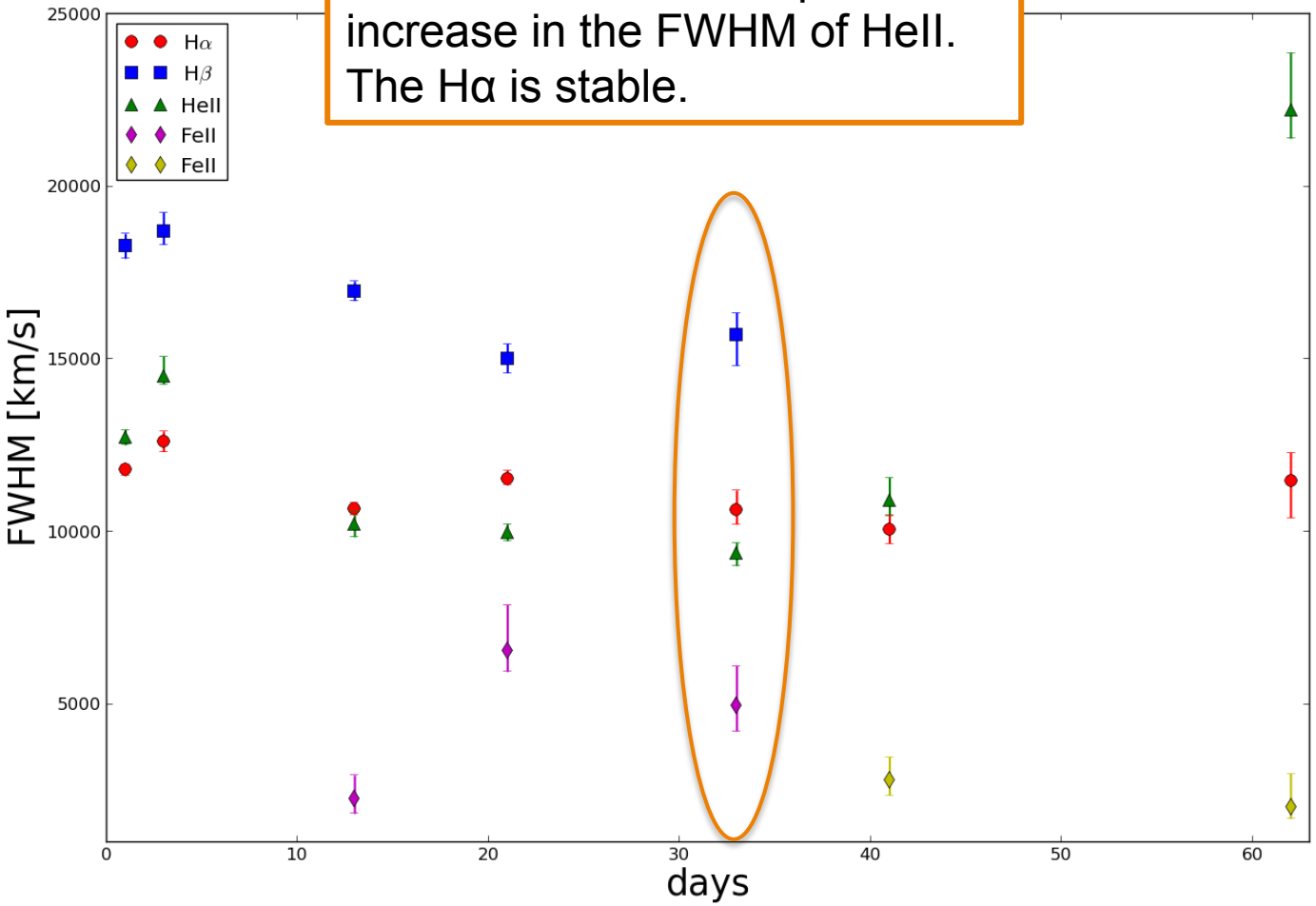


The FWHM and EW evolution

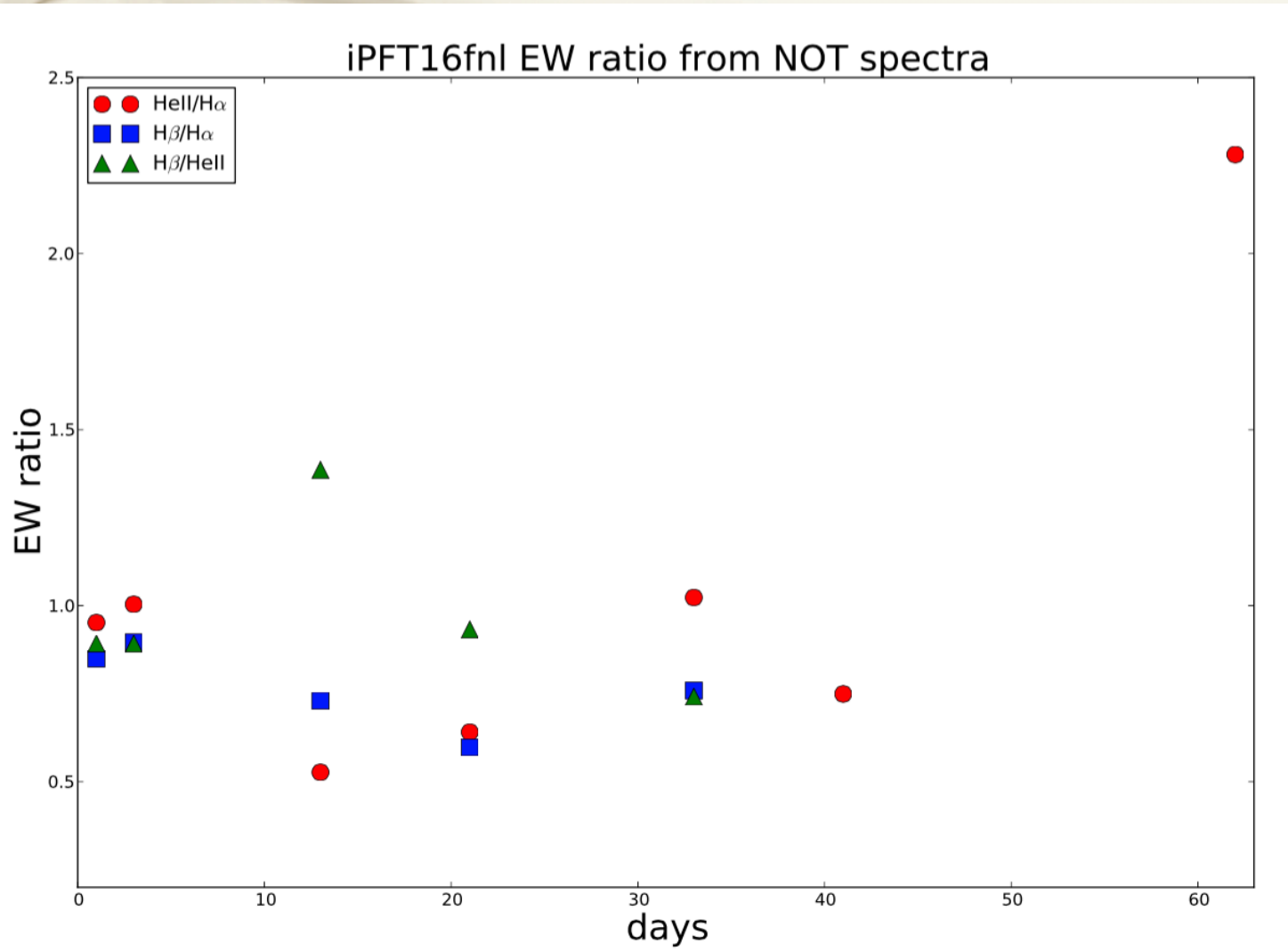
iPTF16fnl: FWHM time evolution



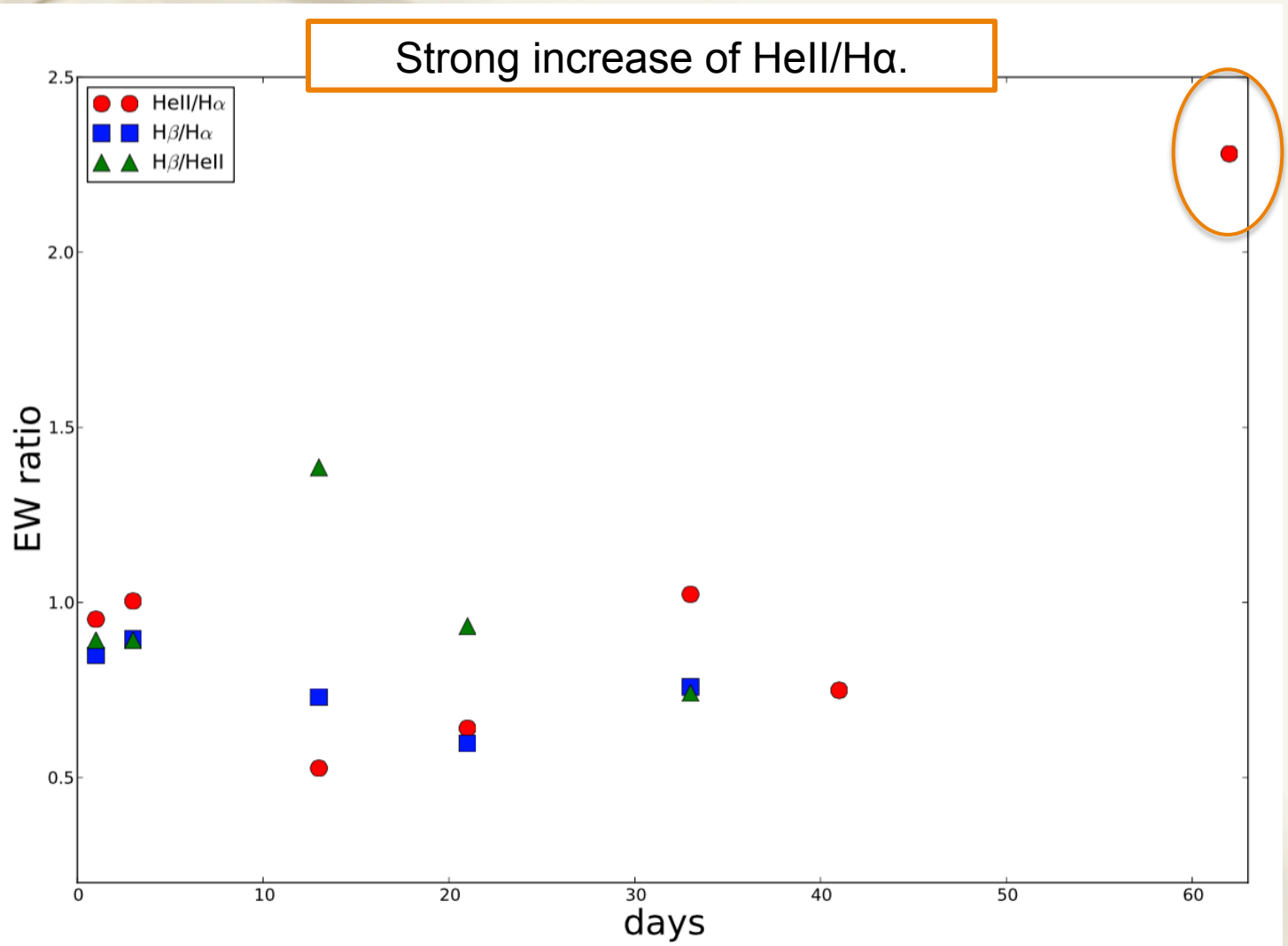
iPTF16fnl: FWHM time evolution



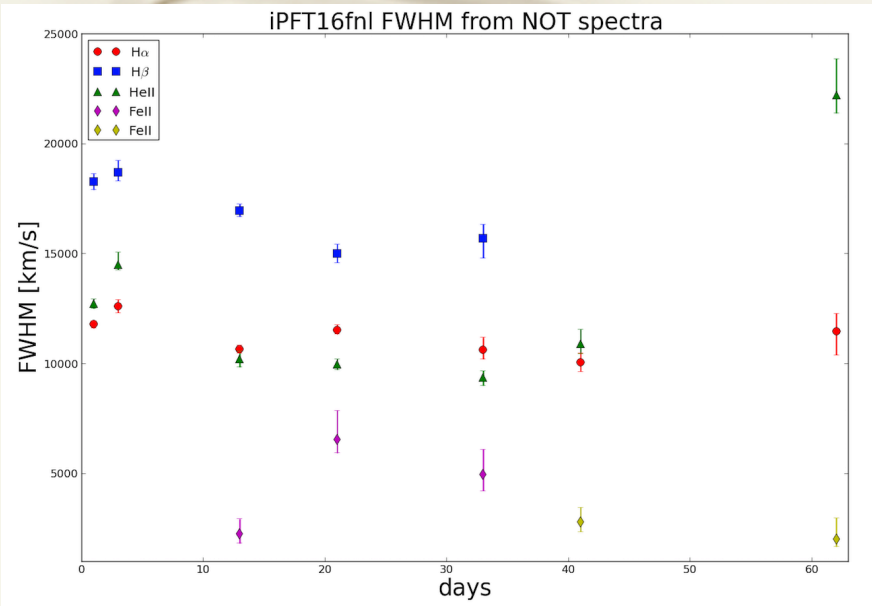
iPTF16fnl: EW ratio evolution

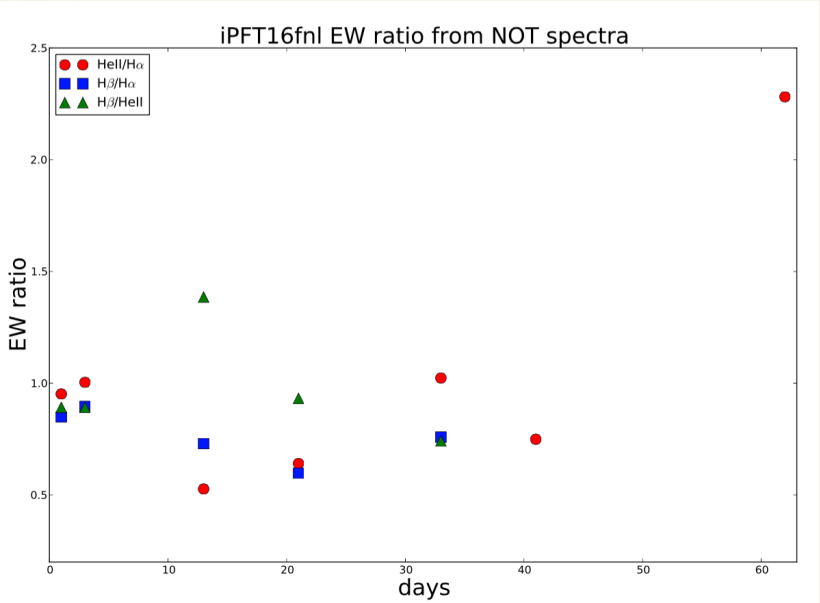


iPTF16fnl: EW ratio evolution



iPTF16fnl: EW ratio and FWHM evolution



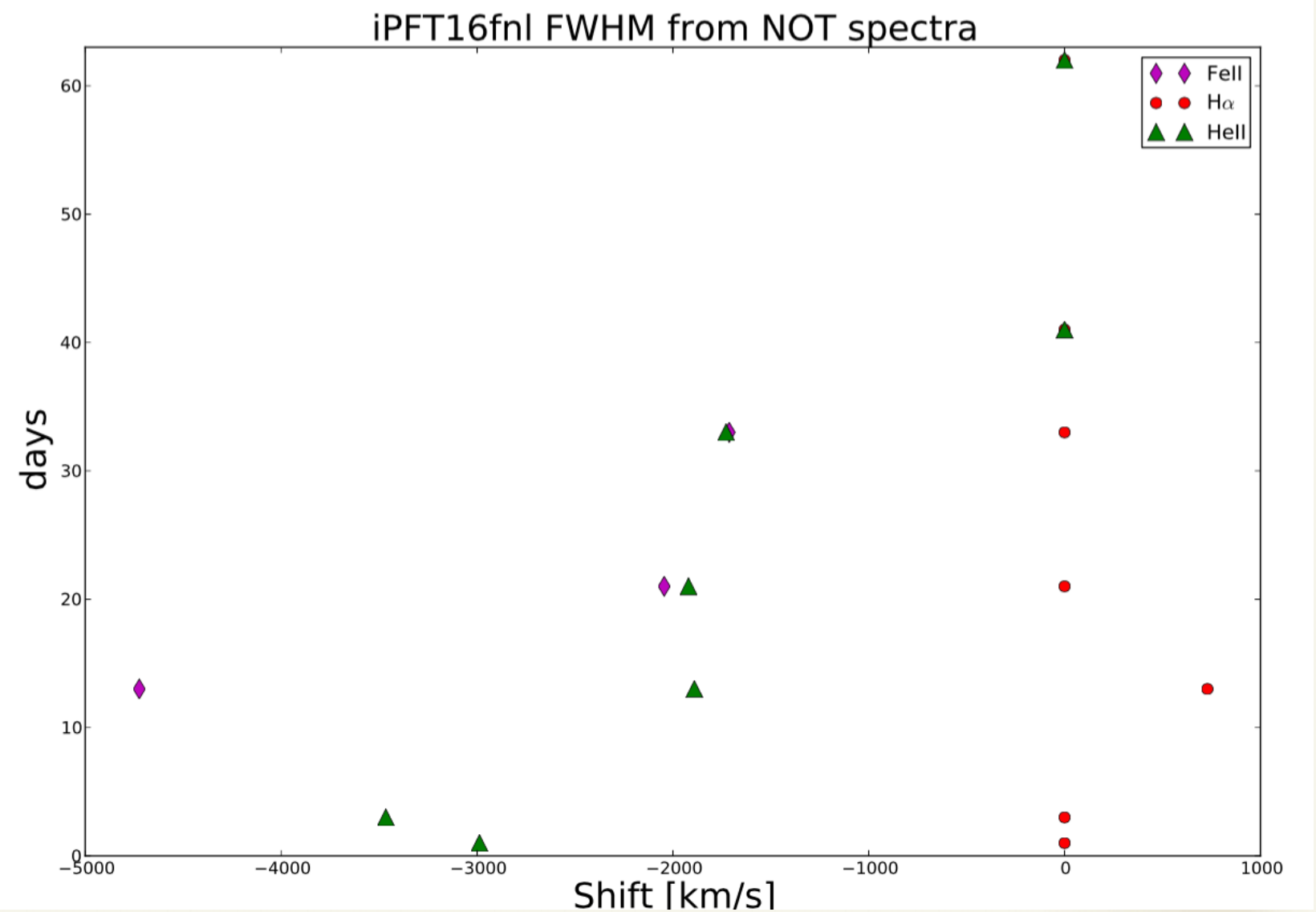


After day 32:

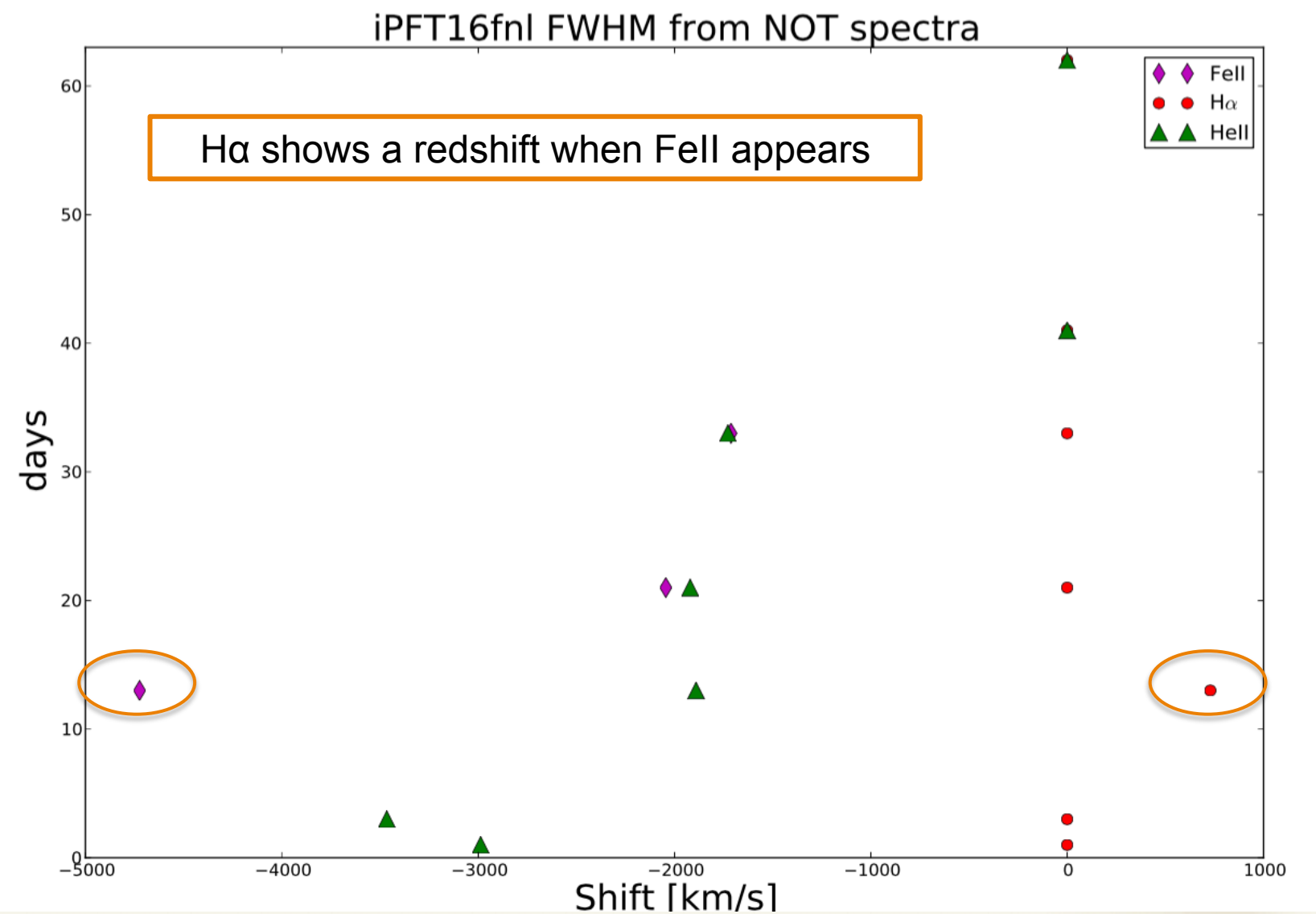
- No broad Hβ but still broad Hα
- Strong increase in the HeII FWHM and in its EW → increase in the ionization continuum

The blueshift evolution

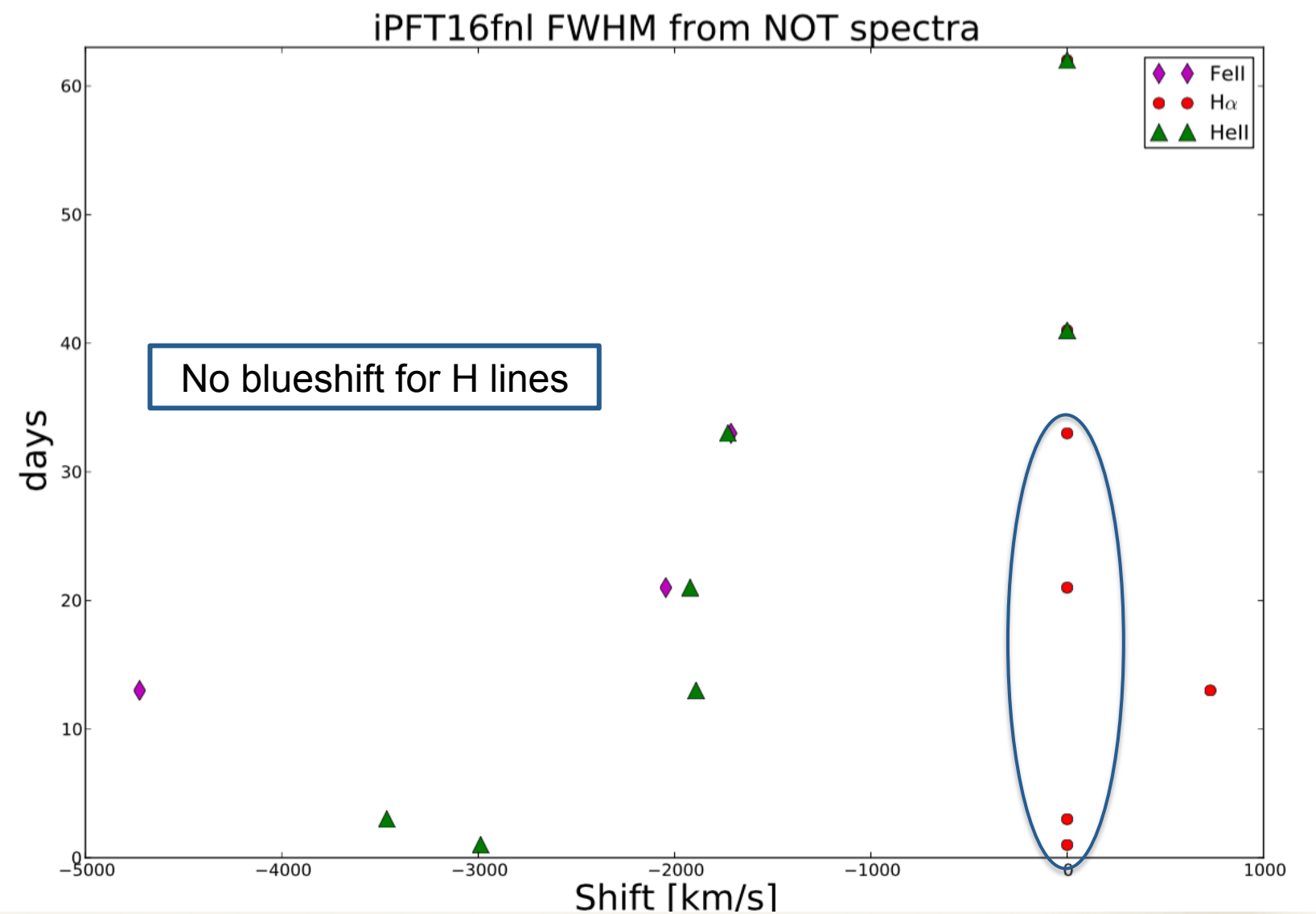
iPTF16fnl: blueshift evolution



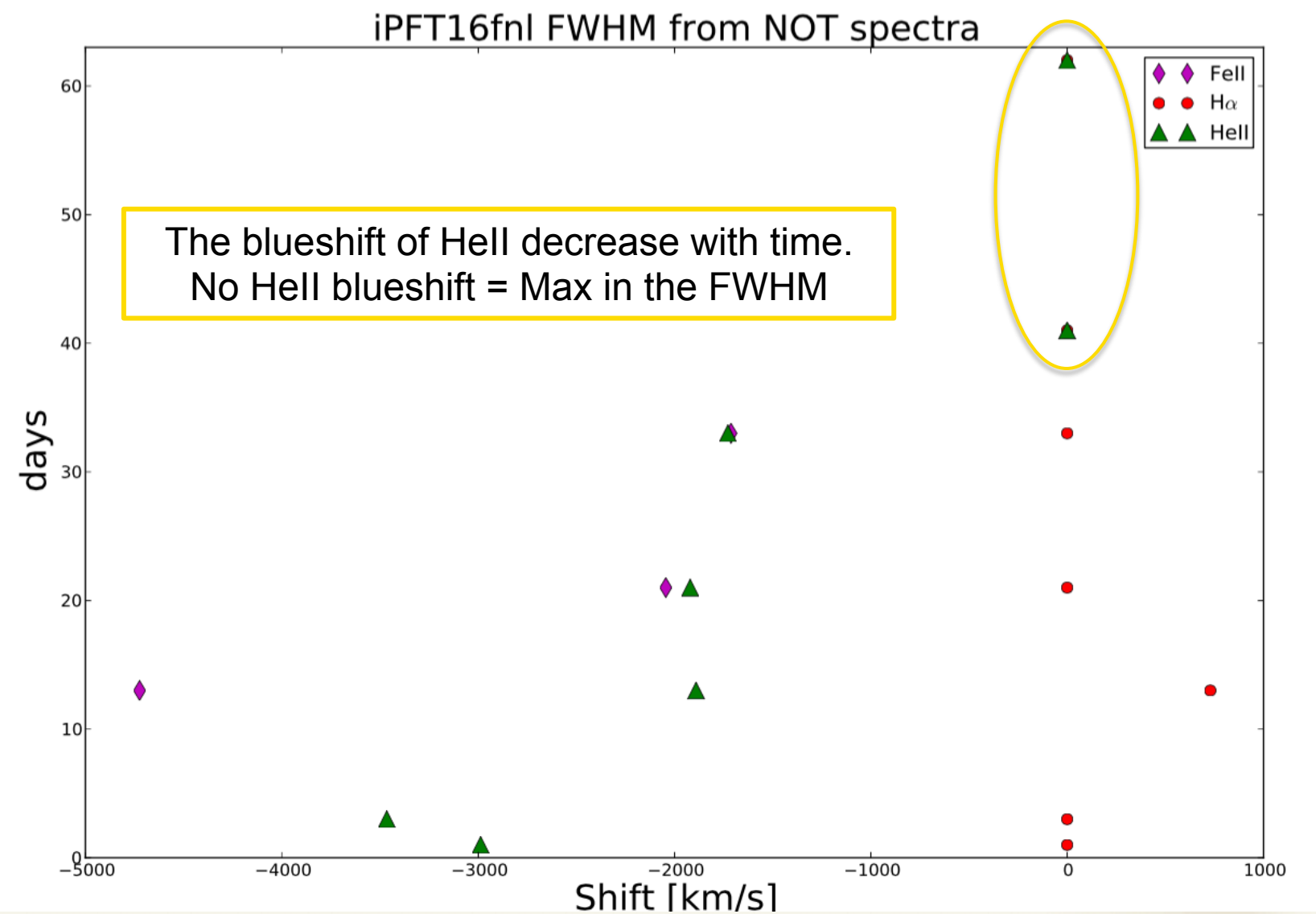
iPTF16fnl: blueshift evolution



iPTF16fnl: blueshift evolution



iPTF16fnl: blueshift evolution



A preliminary model:

- The FWHM and EW evolution suggests an increase in the continuum ionization
- Only HeII and FeII show blueshift:
  - H come from bound material in a disk
  - FeII and HeII came from unbound material
- Evolution of the HeII blueshift and FWHM:
  - Are we seeing circularization?

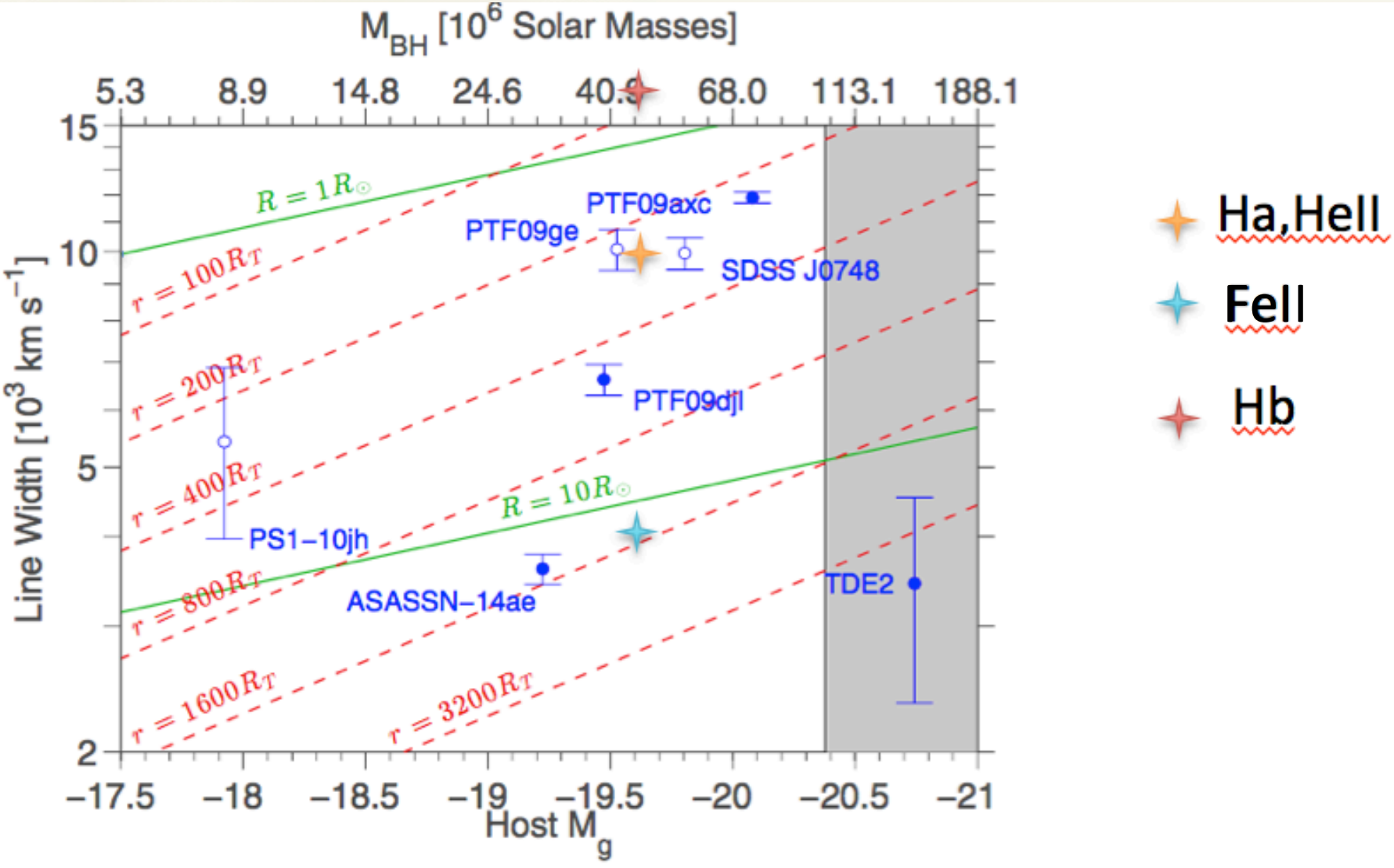
Conclusions

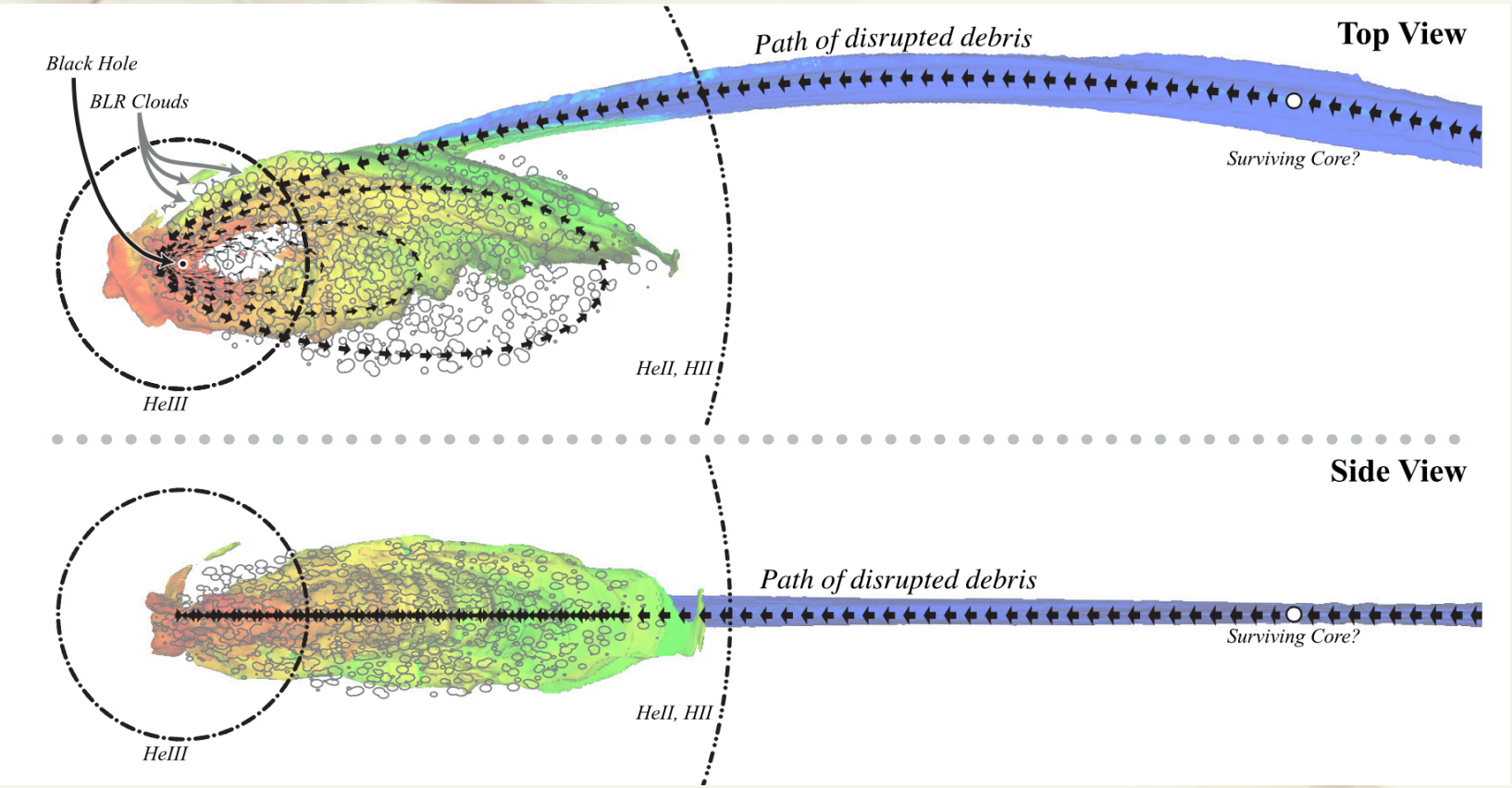
- iPTF16fnl is the closest TDE ever found which can be studied in great detail
- It show a H+He rich spectrum
- We are monitoring the spectroscopic evolution with NOT and X-shooter

From the line profile analysis:

- Broad He II, Hβ and Hα
- From day 12 we found Fe II components in the HeII region
- There is an evolution in FWHM and in EW
- The H lines have no blueshift
- The Fe II and HeII lines show strong blueshift with time evolution.

To be continued..


M_BH [10^6 Solar Masses]
5.3
8.9
14.8
24.6
40.3
68.0
113.1
188.1
Line Width [10^3 km s^-1]
15
10
5
2
R = 1R⊙
R = 10R⊙
r = 100R_T
r = 200R_T
r = 400R_T
r = 800R_T
r = 1600R_T
r = 3200R_T
PTF09axc
PTF09ge
SDSS J0748
PTF09djl
PS1−10jh
ASASSN−14ae
TDE2
−17.5
−18
−18.5
−19
−19.5
−20
−20.5
−21
Host M_g
Ha,HeII
FeII
Hb



Guillochon et al. 2014