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<b>Authors</b>	PAIANO, Simona, Falomo, R., Treves, A., LANDONI, Marco, Scarpa, R., Righi, Chiara
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ISTITUTO NAZIONALE  
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FOR ASTROPHYSICS



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

# GTC optical spectroscopy of TeV blazars

Speaker: S. Paiano – (INAF-OAPD)

Collaborators: R. Falomo, A. Treves,  
M. Landoni, R. Scarpa,  
C. Righi

AGN12 meeting – Napoli – 29 Settembre 2016

# Aim of the work

Blazars represent the most abundant extragalactic population at GeV-TeV energies

Contrary to most AGNs with prominent emission features, Blazars/BL Lacs often lack its redshift (or it is very uncertain)  
[see Landoni's talk]




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[see Landoni's talk]

 For the interpretation of emission models

 To study the EBL

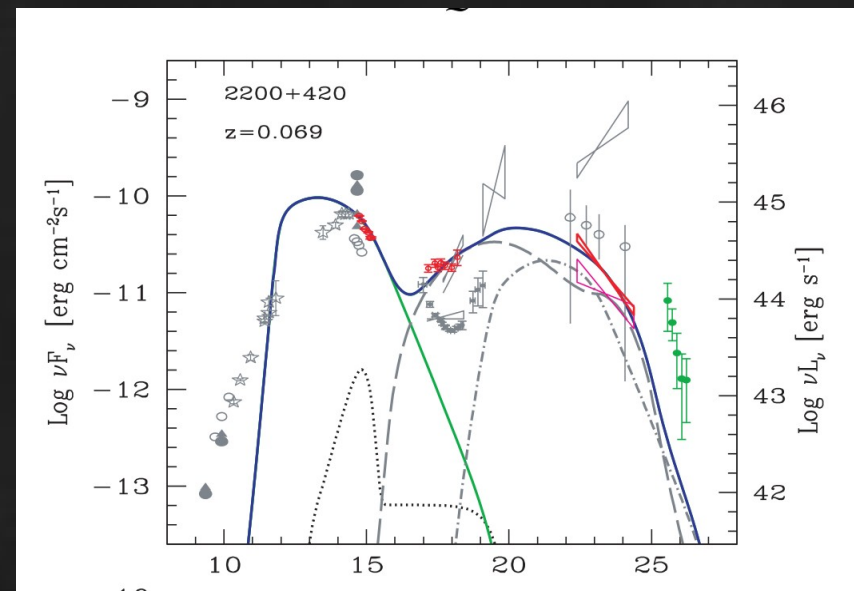
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Ghisellini+2011

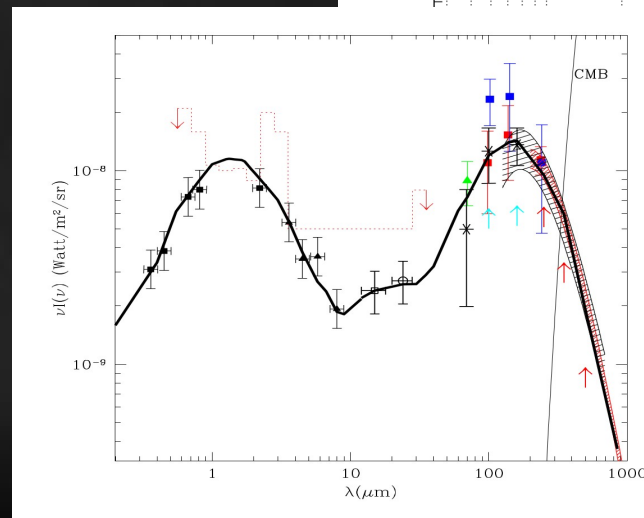
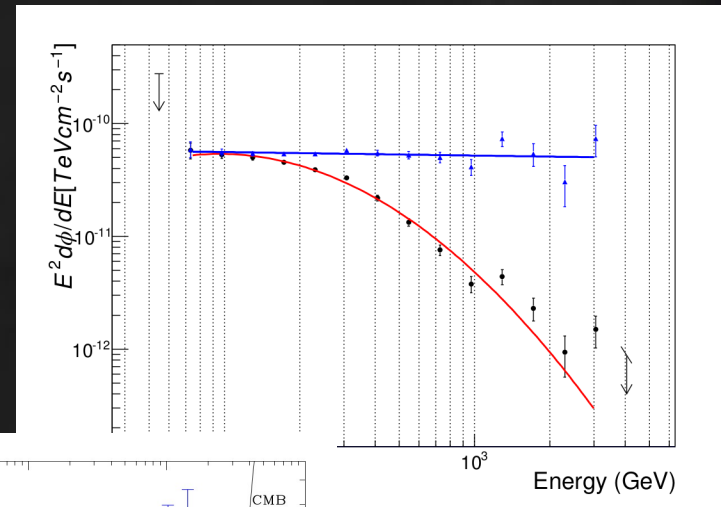
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[see Landoni's talk]

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Ahnen+2016  
(MAGIC coll.)

Franceschini+2016


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• For the inter-  
of emission

• To study

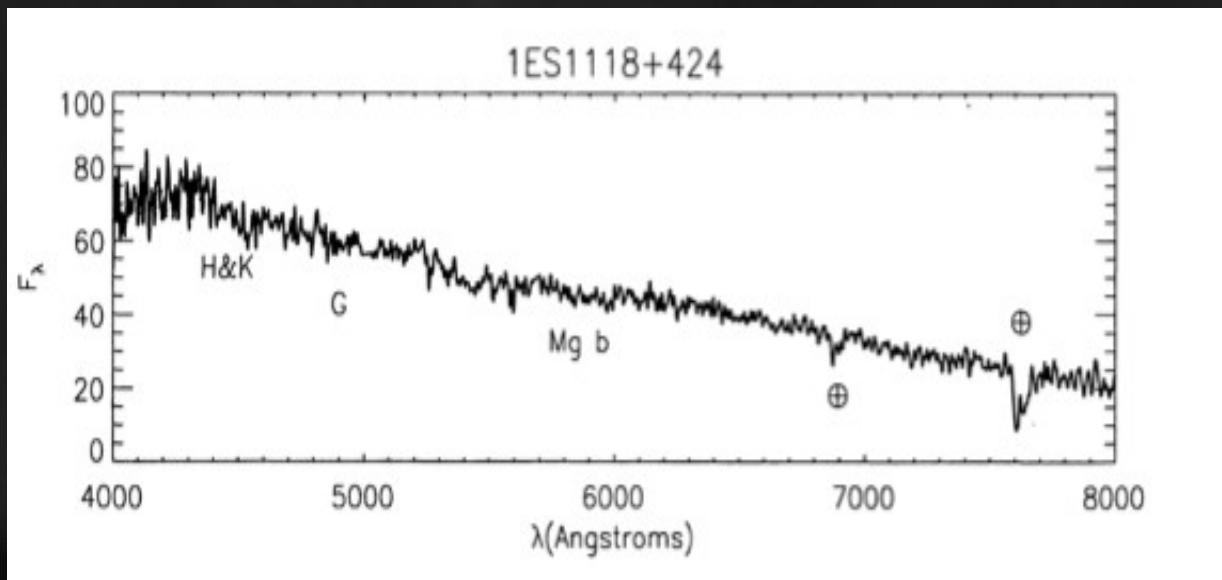


We present the results of a  
**spectroscopical campaign**  
carried out  
at the GTC for a sample of  
**21 TeV**  
(or candidate TeV) blazars  
with  
**unknown/uncertain redshift**

# The Sample

14 TeV blazars and 7 TeV candidates of BZCAT  
With unknown or uncertain redshift

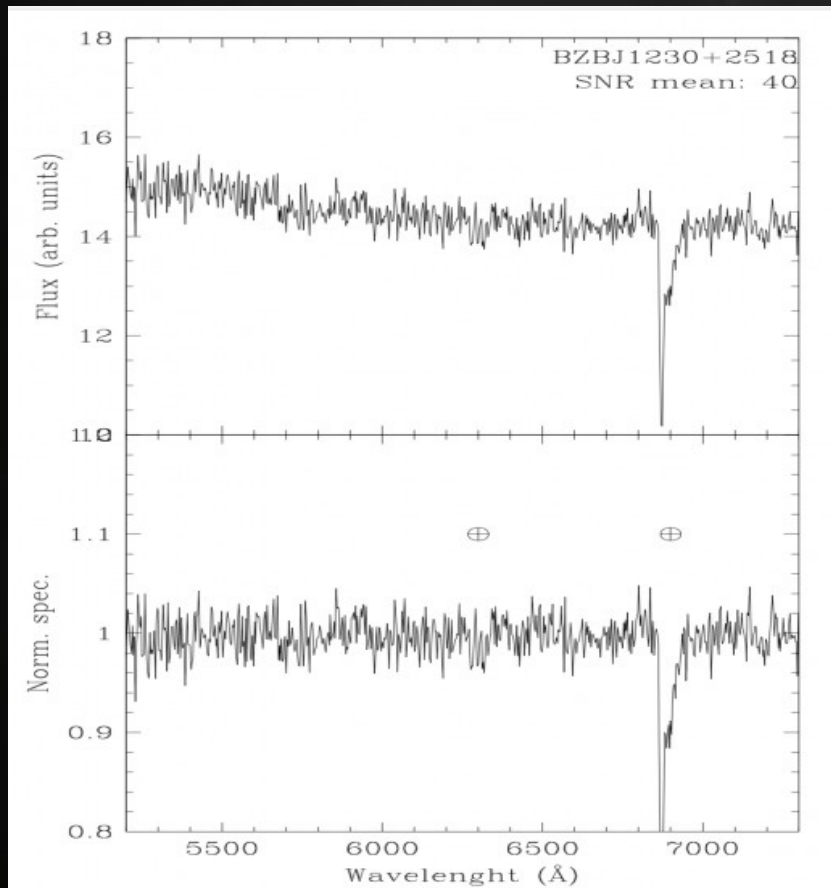
BZB J1120+4212 (RBS0970)  $\rightarrow z=0.124$  (?)



Perlman+1996

# The Sample

14 TeV blazars and 7 TeV candidates of BZCAT  
With unknown or uncertain redshift



S3 1227+255

$Z=0.135$  (?)

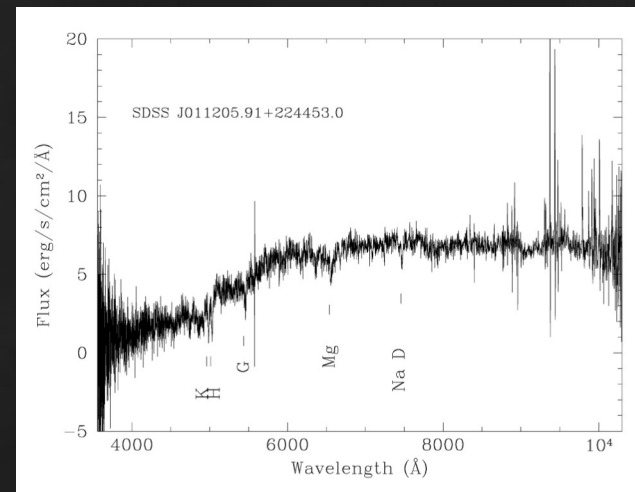
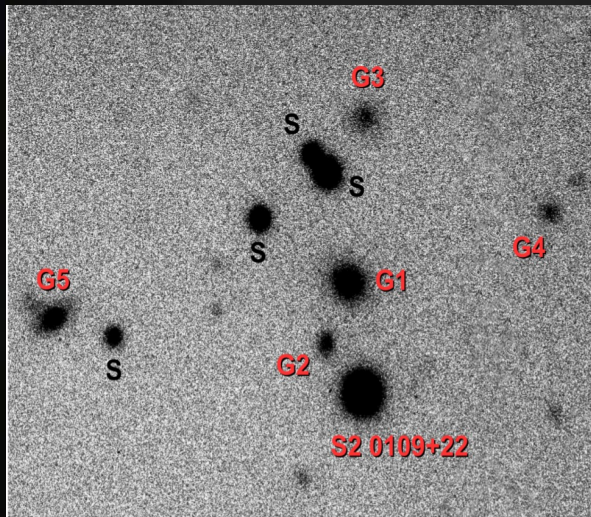
So far no spectrum  
published

Massaro+2015

# The Sample

14 TeV blazars and 7 TeV candidates of BZCAT  
With unknown or uncertain redshift

S2 0109+22  $z=0.26$

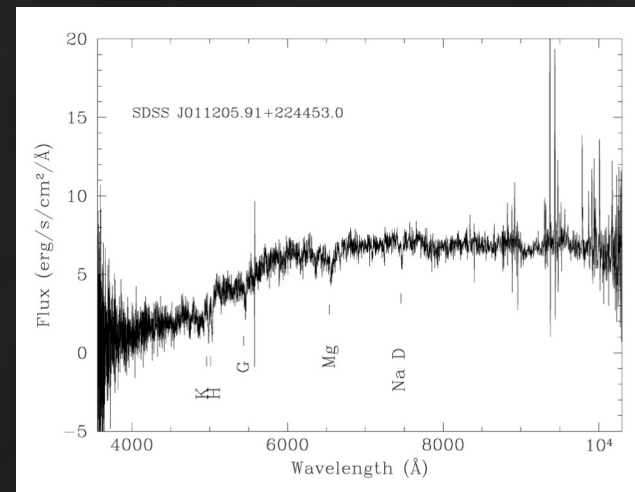
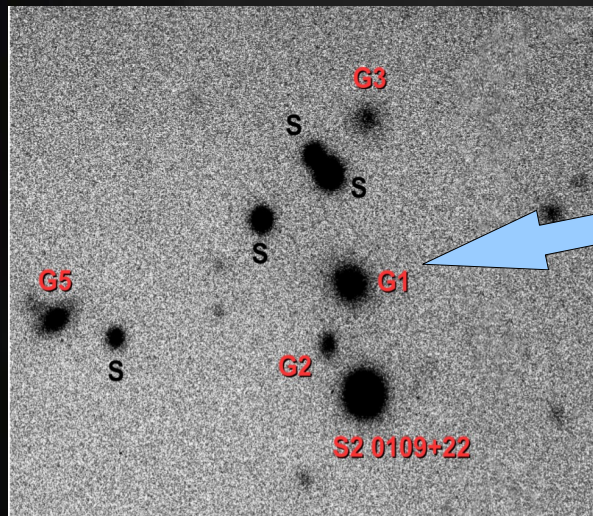


SDSS spectrum,  
Healey+2008, Shaw+2012

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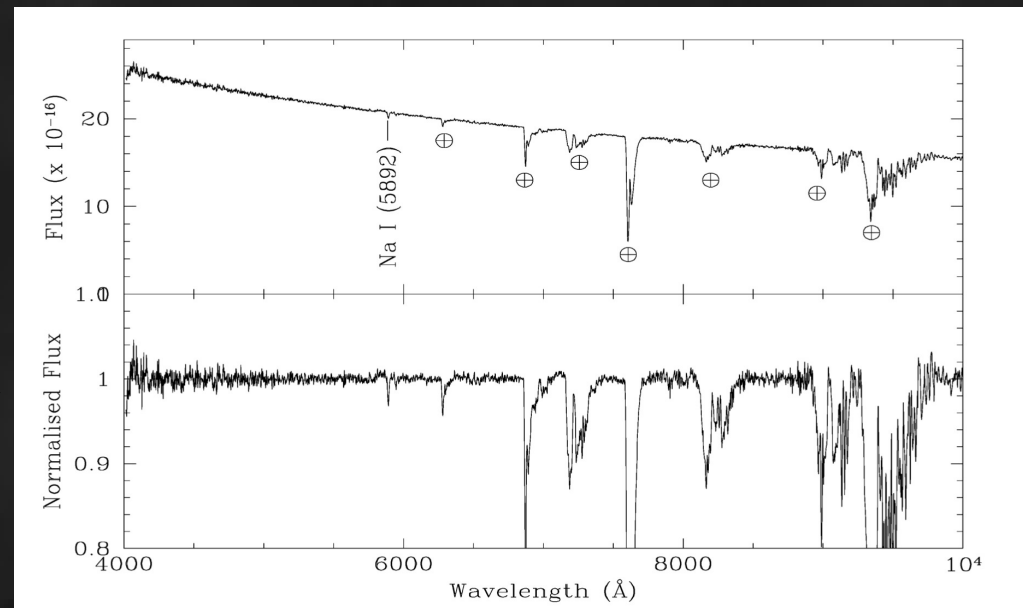
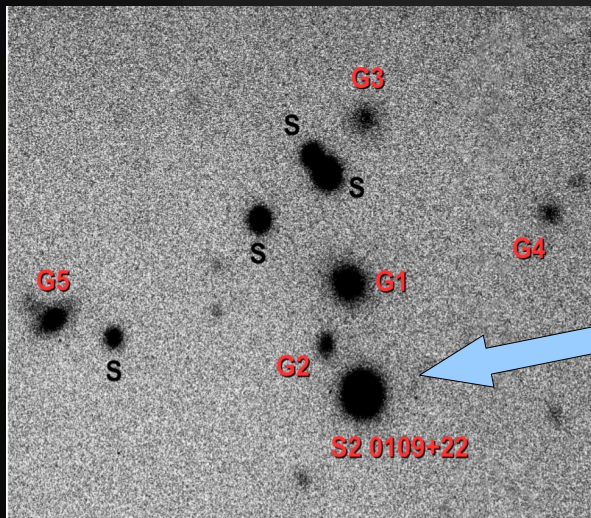


SDSS spectrum,  
Healey+2008, Shaw+2012

# The Sample

14 TeV blazars and 7 TeV candidates of BZCAT  
With unknown or uncertain redshift

S2 0109+22  ~~$z=0.26$~~  = still unknown



Paiano+2016

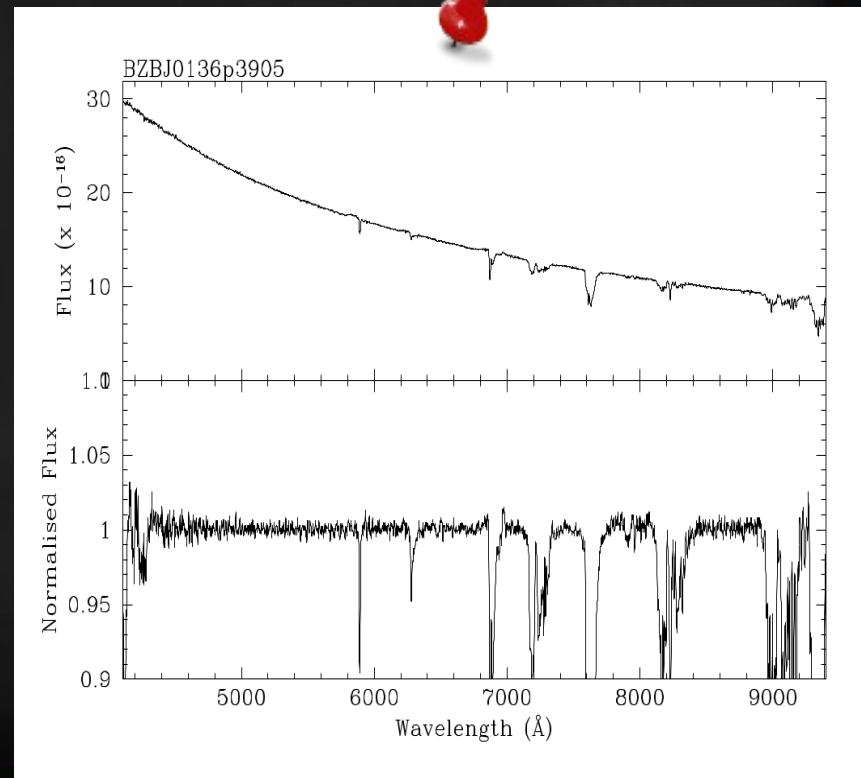
# GTC observations

Spectra (4000–10000 Å)  
obtained with  
OSIRIS@GTC

Details in Landoni's talk

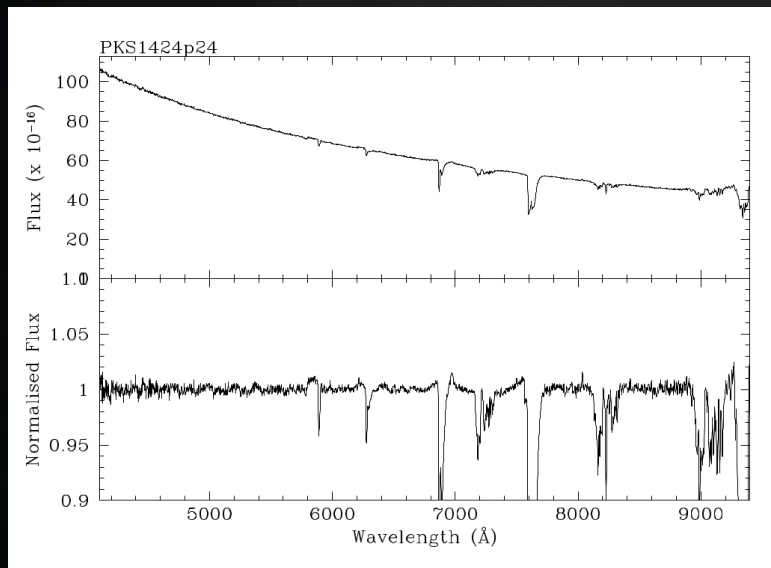


Spectra with  
high SNR  $\rightarrow \sim 100-500$



Results: search for em/abs features

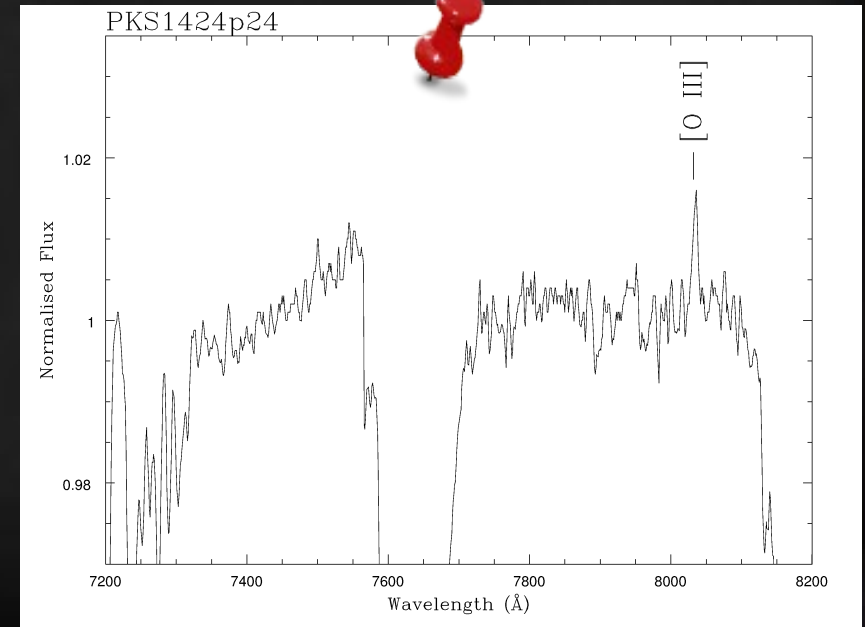
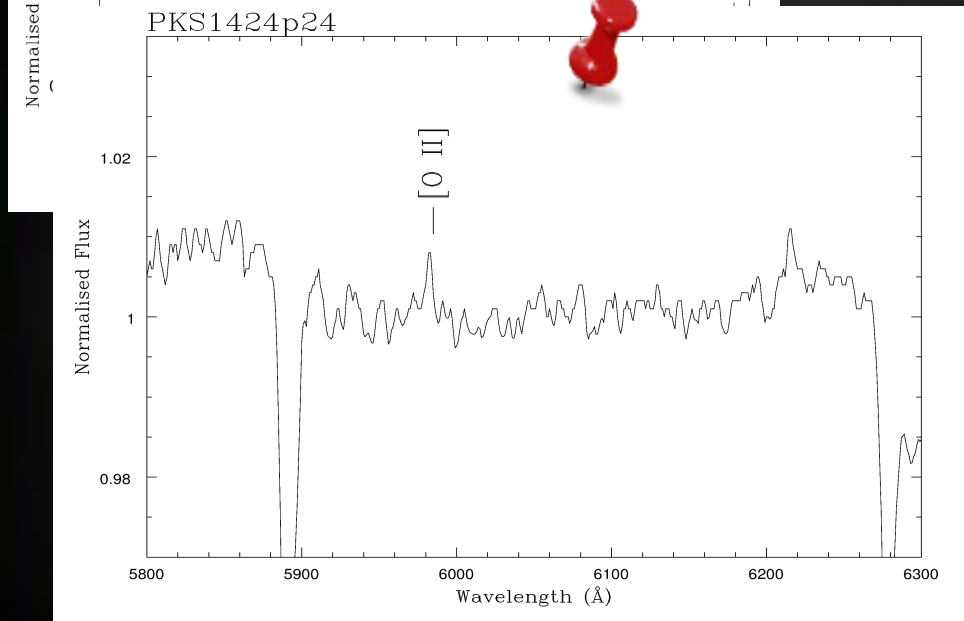
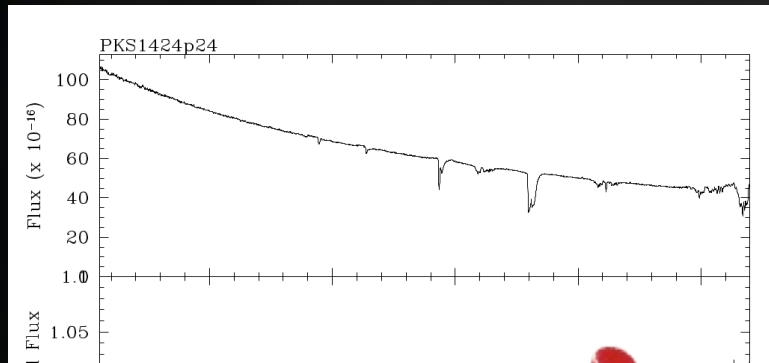
New Redshift for PKS 1424+240



# Results: search for em/abs features

## New Redshift for PKS 1424+240

[OII] 3727 Å ; [OIII] 5007 Å  
@z = 0.604

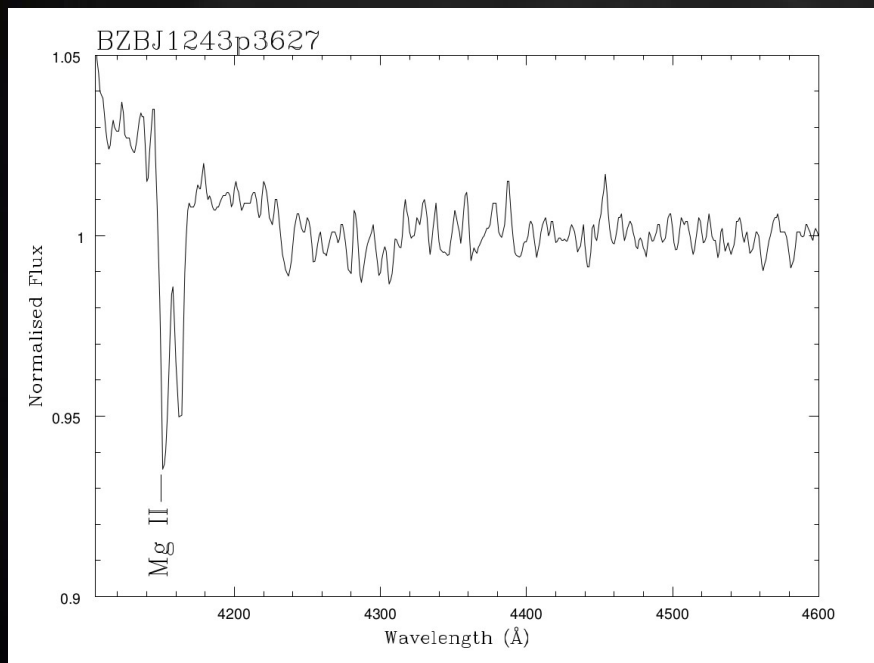


# Results: search for em/abs features

## MgII abs lines for BZB1243 & BZB1540

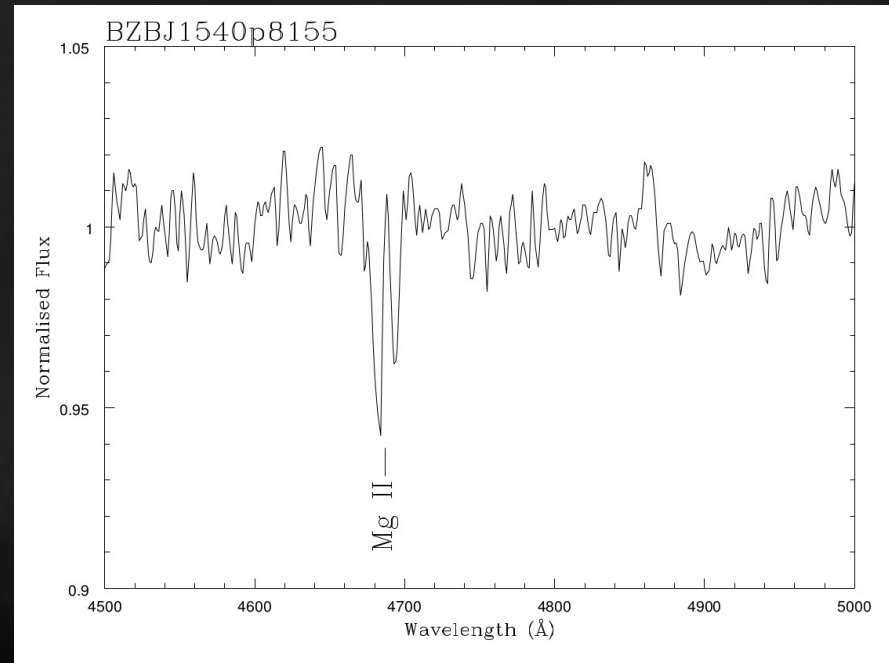
BZBJ1243+3627

MgII 2800A @  $z > 0.48$



BZBJ1540+8155

MgII 2800A @  $z > 0.67$

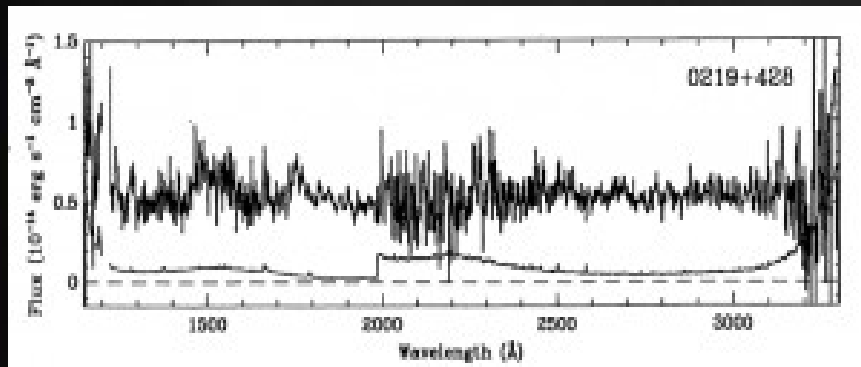


# Results: search for em/abs features

4 targets with confirmed redshift

6 targets with no-confirmed redshift and still unknown

3C 66A  $\rightarrow z=0.444(?)$



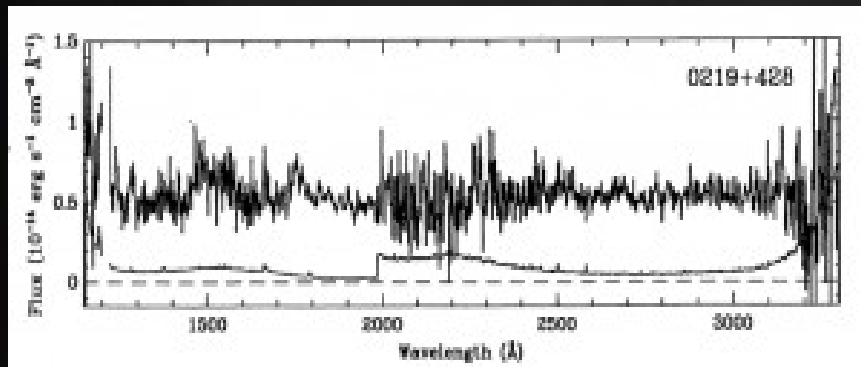
Miller+78 (MgII ?),  
Spectrum above from  
Lanzetta+1993

# Results: search for em/abs features

4 targets with confirmed redshift

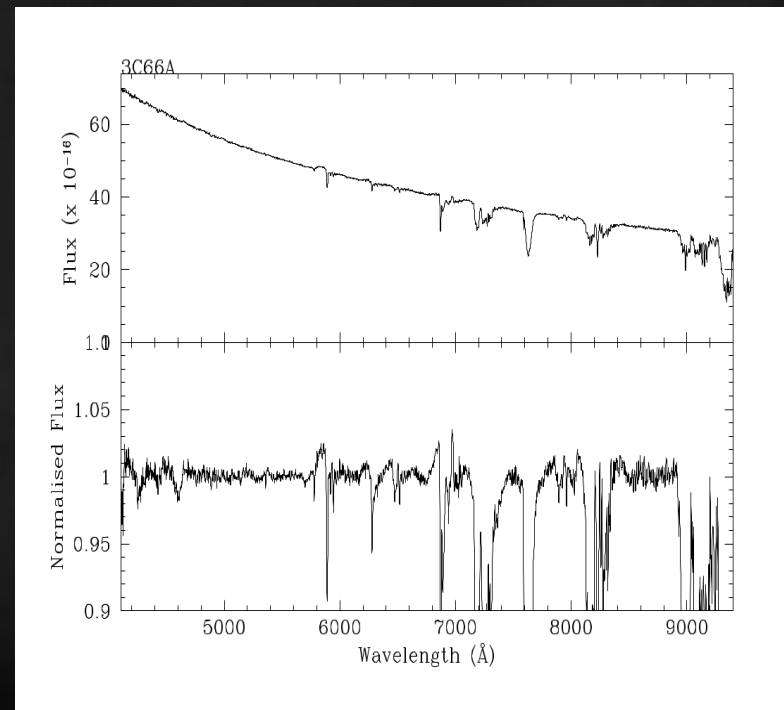
6 targets with no-confirmed redshift and still unknown

3C 66A →  ~~$z=0.44(?)$~~  → not confirmed



Miller+78 (MgII ?),  
Spectrum above from  
Lanzetta+1993

SNR=300 —  $E_{wmin}=0,1 \text{ \AA}$  —  $z > 0.1$



# Results: search for em/abs features

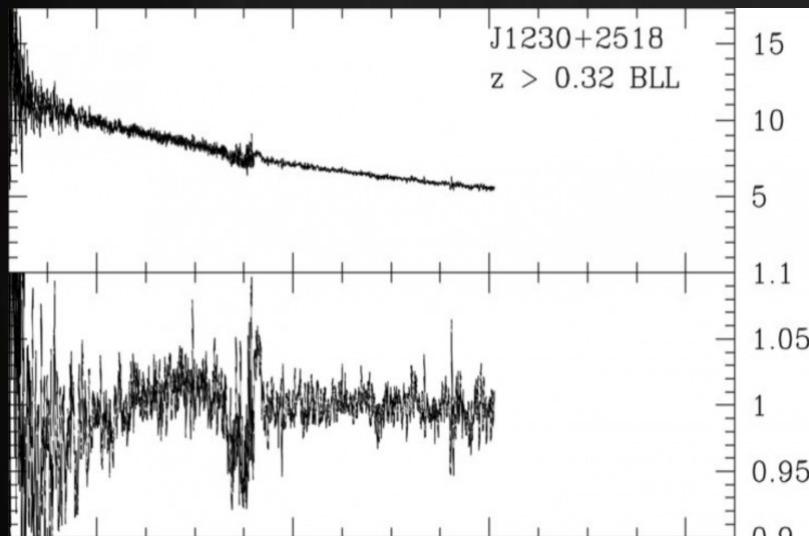
4 targets with confirmed redshift

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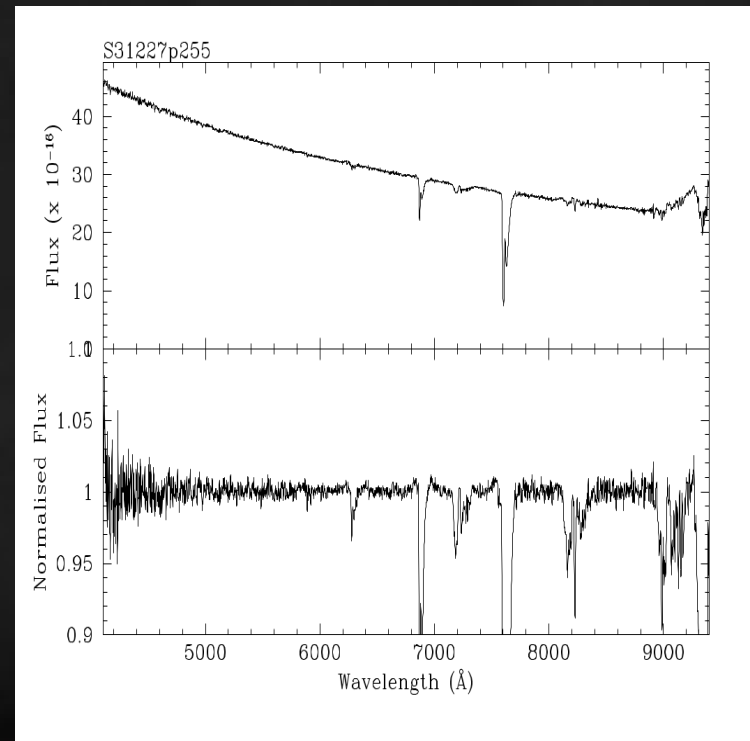
S3 1227+255  $\rightarrow z=0.135(?) \rightarrow$  not confirmed

Nass+96  $\rightarrow$  No spectrum  
No info

SNR=300 -  $E_{wmin}=0,09 \text{ \AA}$  -  $z > 0.1$



Shaw+2013



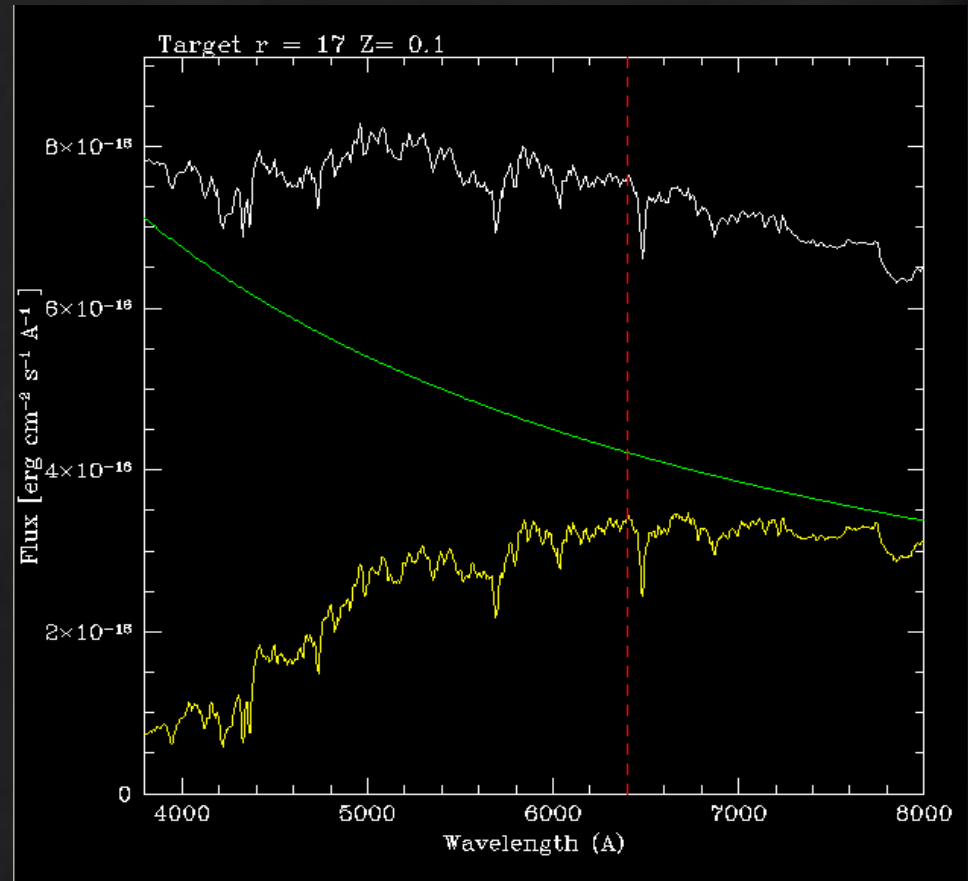
# Results: Lower Limits on the redshift

Non-thermal Nucleus +  
Elliptical host galaxy =

Mag=17  $z=0.10$  Diluted EW=1,60Å

---

Spectrum observed !



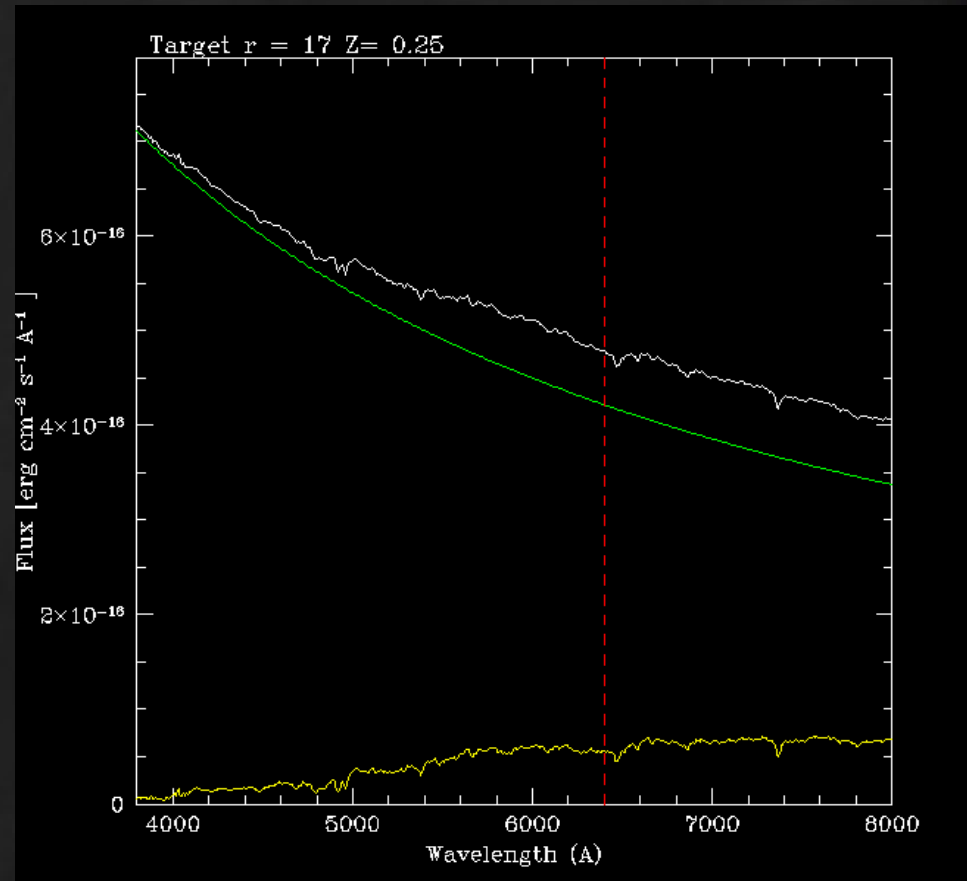
# Results: Lower Limits on the redshift

Non-thermal Nucleus +  
Elliptical host galaxy =

Mag=17  $z=0.25$  Diluted EW=0,49A

---

Spectrum observed !



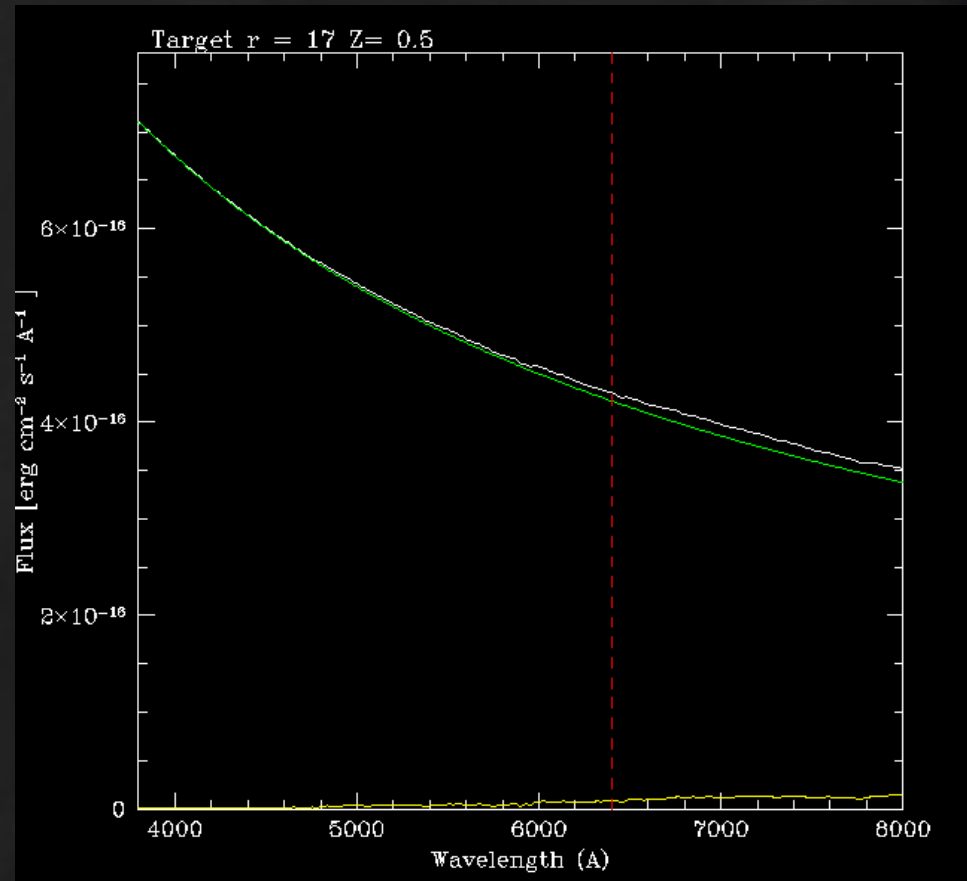
# Results: Lower Limits on the redshift

Non-thermal Nucleus +  
Elliptical host galaxy =

---

Mag=17  $z=0.50$  Diluted EW=0,15A

Spectrum observed !



# Results: Lower Limits on the redshift

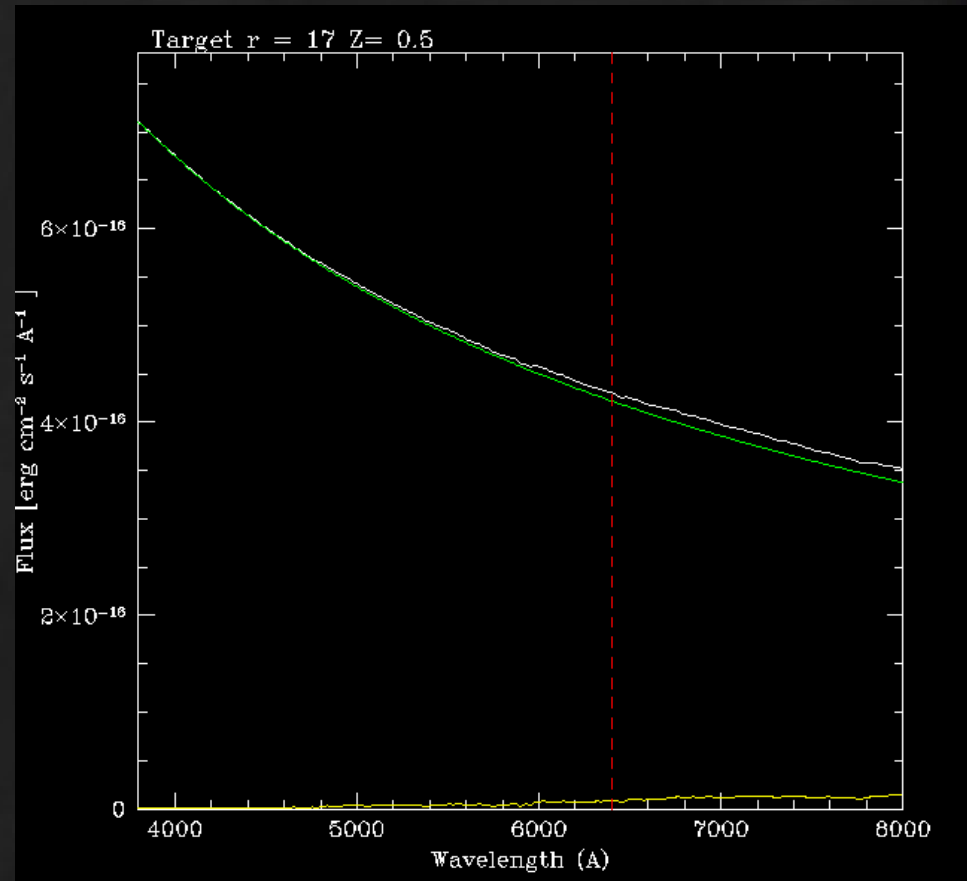
Non-thermal Nucleus +  
Elliptical host galaxy =

Mag=17  $z=0.50$  Diluted EW=0,15A

Spectrum observed !



With wide range and  
high SNR spectra,  
we can derive EW upper limits  
and Redshift lower limits



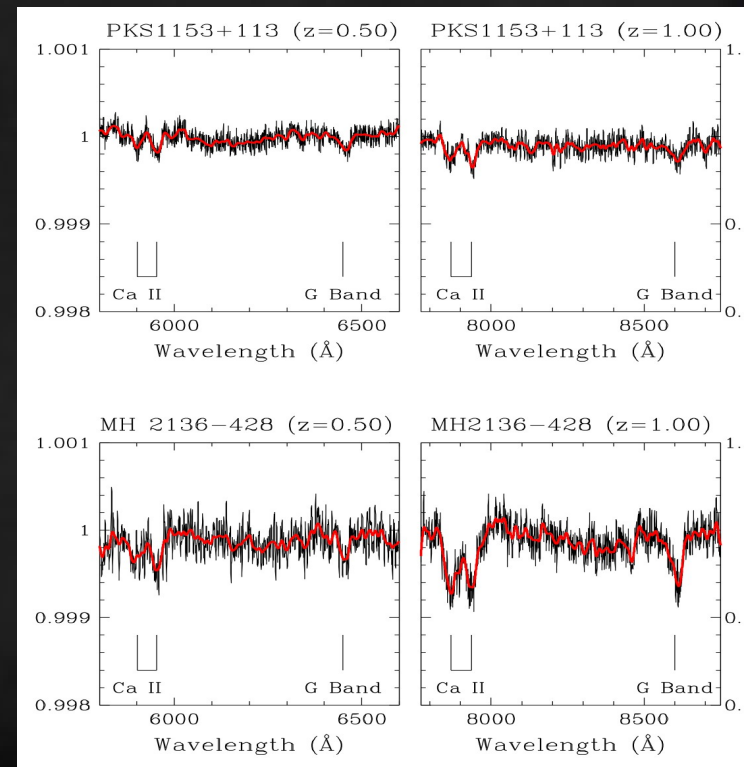
We derive redshift lower limits ( $>0.1 - 0.90$ )  
for all of our targets with unknown redshift

# Towards the Future ..

For our sample we have new redshift,  
but for many targets the previous values are not confirmed:  
Several TeV blazars have still unknown redshift

- Waiting for the EELT (39m)  
equipped with  
a Xshooter-like (@VLT)  
instrument

$T_{\text{exp}} = 3600 \text{ sec}$   
 $N_{\text{Nuc/Host}} = 2500$



Landoni+2014