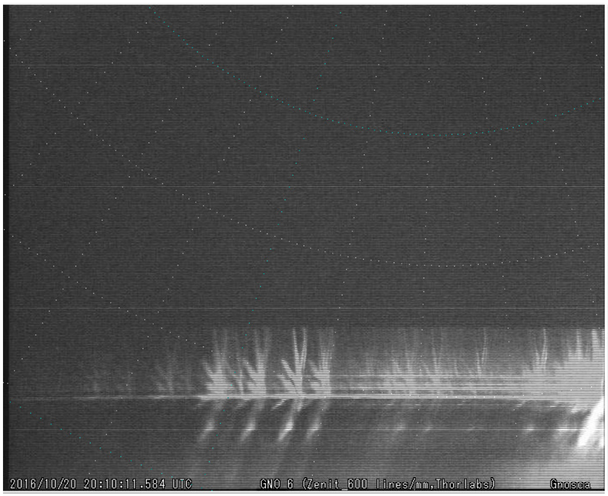
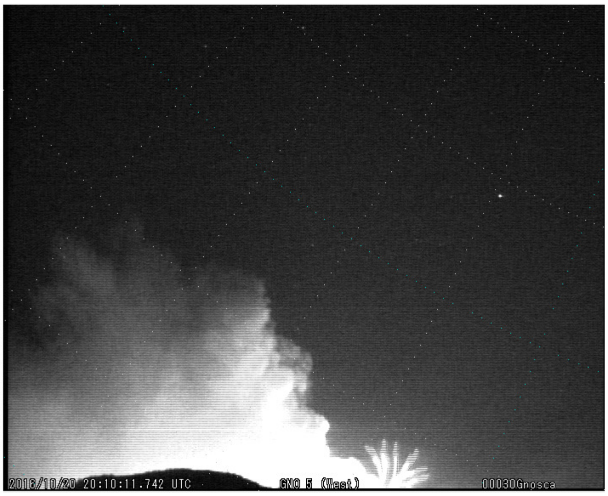
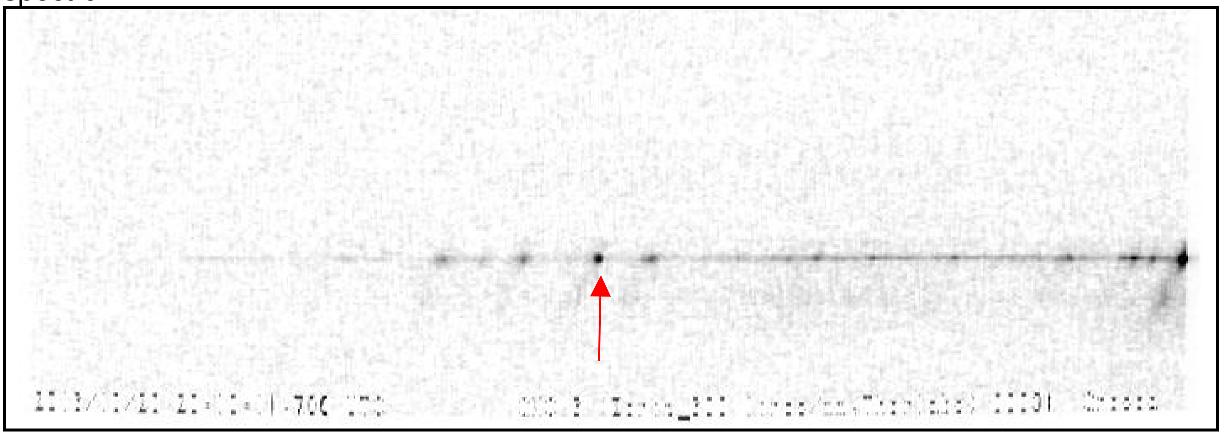
Processing of LTE spectrum, Gnosca, M20161020_201011

This event was observed by two video cameras from the same location by Stefano Sposetti. Watec 902H2 ultimate equipped with Computar f 8mm F/1 lens

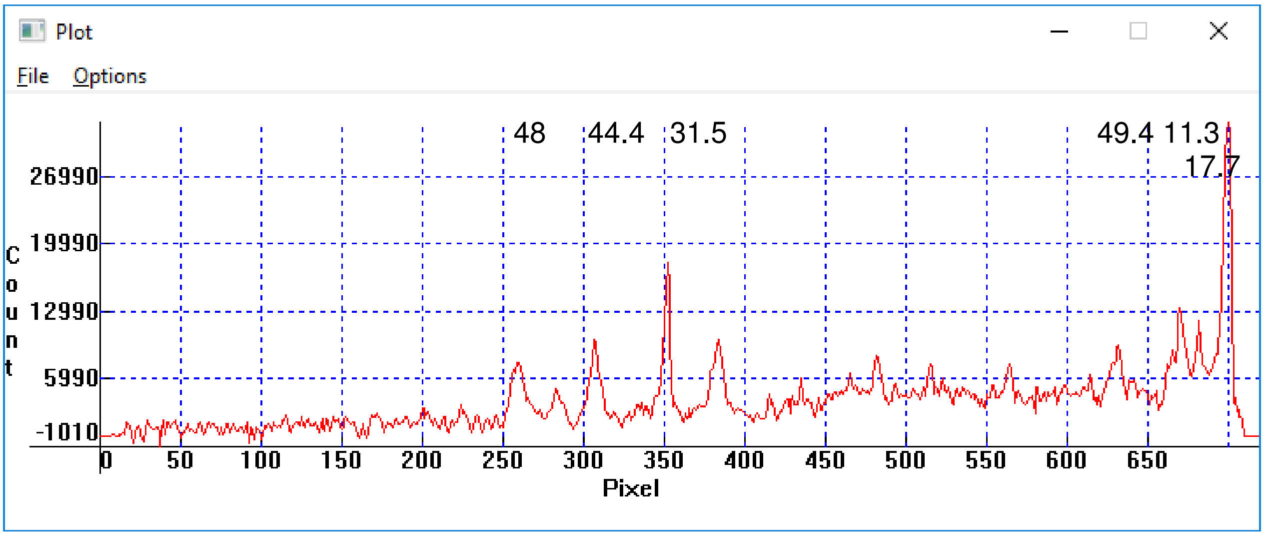




The spectrum at left was taken with a camera pointing to the zenith, the image at right shows the event in the west. Measuring the coordinates of the flash in both images gave an angle of about 72° for the grating incidence angle α. For a 600 L/mm grating this corresponds to a wavelength of about 800 nm in 2^{nd} order for the spectral features in the centre of the left image (order*λ = sin(72°)/G =0.95/600*1e6 nm ≅ 1600 nm).
The video was de-interlaced in order to increase time resolution and the images exported with VirtualDub.
After background subtraction the images were transformed to an orthographic projection with ImageTools in order to get linear spectra.
The highest light intensity occurred in field 60, saturating most spectral lines and showing the tree structure. Especially interesting was the following field 61, showing an almost star like spectrum



(d7_mb11w.jpg)
10 rows containing the spectrum were added and plotted as a function of column number:
Notice that wavelength increases to the left; from the previous calibration of the grating the dispersion is approximately 1nm/pixel in second order. From the line spacings some lines could be identified, the line at 350 pixels corresponds to the O I line at 777.4 nm.

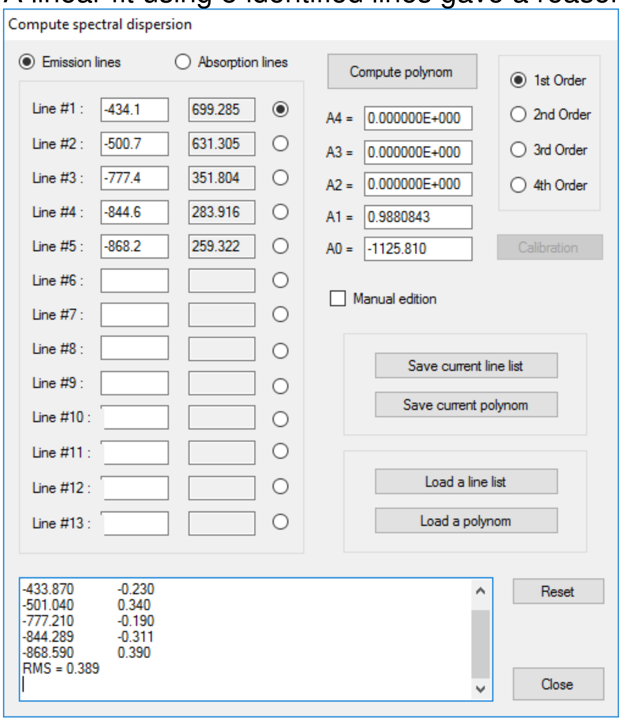


For the identification of the lines a table of atmospheric lines observed in meteor spectra was helpful (V. Vojacek et. al., A&A 580, A67 (2015)):

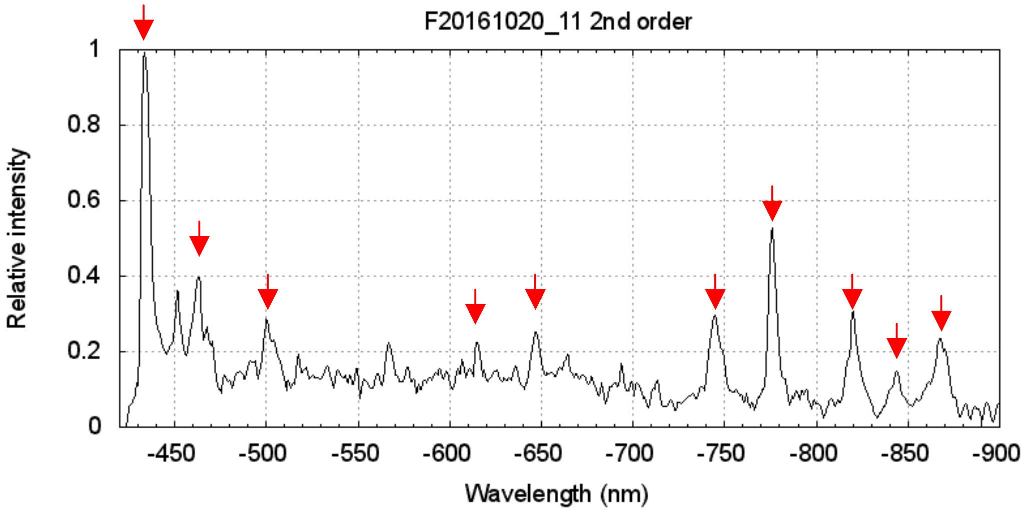
Atmospheric lines and bands		
5330	OI	12
5700–6000	N_2 1st. positive	$\Delta v = 4$
6200–6800	N_2 1st. positive	$\Delta v = 3$
7000–7500	N_2 1st. positive	$\Delta v = 2$
6157	O I	10
6455	O I	9
6484	N I	21
7424, 7442, 7468	N I	3
7774	O I	1
8186, 8218, 8143	N I	2
8446	O I	4
8682	N I	1
Train lines		
5577	[O I]	3F

Notes. The lines are only given individually within the multiplet when they are well enough separated to be resolved in the video spectra. The multiplet numbers are given according to Moore (1945).

A linear fit using 5 identified lines gave a reasonable fit:



Negative wavelengths were entered corresponding to the wrong (negative) order of the spectrum, because the software expects increasing wavelengths with increasing pixel position. This eliminates the need to flip the image and shows which order is analysed. The rms error was 0.39 nm; this shows that the assignment is correct.
Calibrate spectrum, normalize peak height to 1 →



No instrument response for 2nd order at this extreme angle (α ≅ 78°)

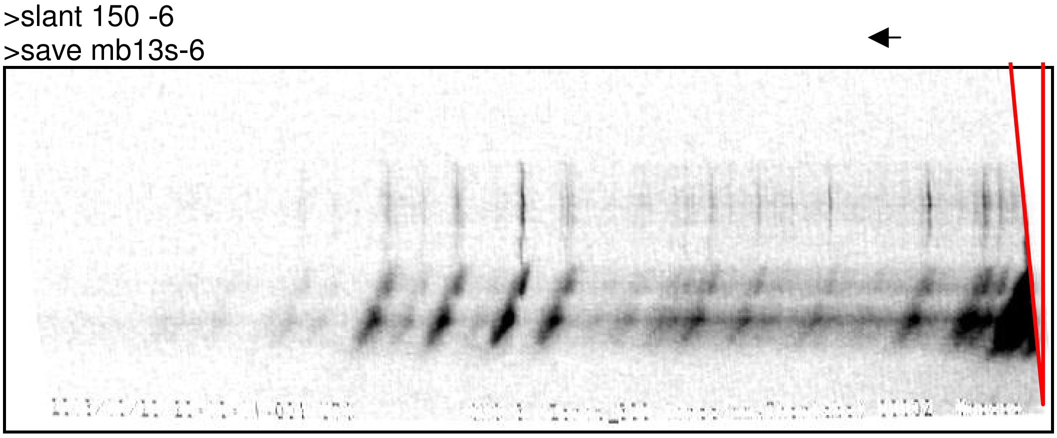
Red arrows: identified lines

Measured		Reference
433.9	N I	868.2/2 (first order)
462.5	? N II	463.0
501.2	O II	500.7
616.0	O I	615.7
648.2	N I	648.2
746.2	N I	(745)
777.2	O I	777.4
821.1	N I	(820.6)
844.3	O I	844.6
868.6	N I	868.2

Straight line spectrum, d7_mb13

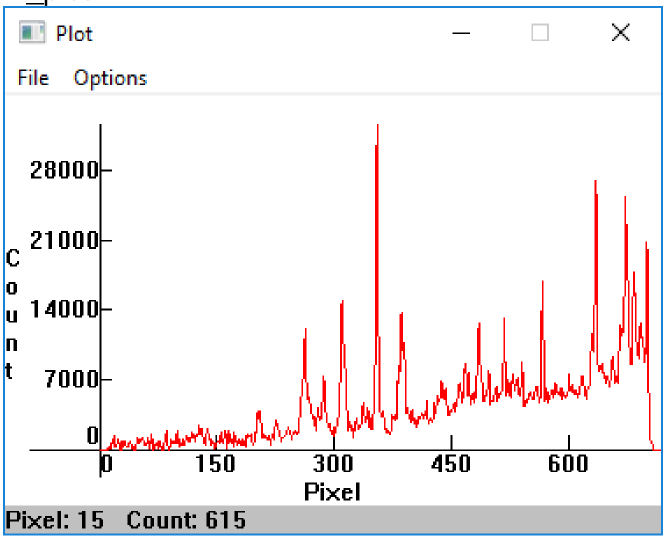
Field 63 (mb13.fit) showed an almost straight section of the flash. After correction of distortion and removal of a residual background this was made vertical with the slant command and then the spectrum of the straight section was extracted:

```
>load d7_mb13
>offset -4
>slant 150 -6
>save mb13s-6
```



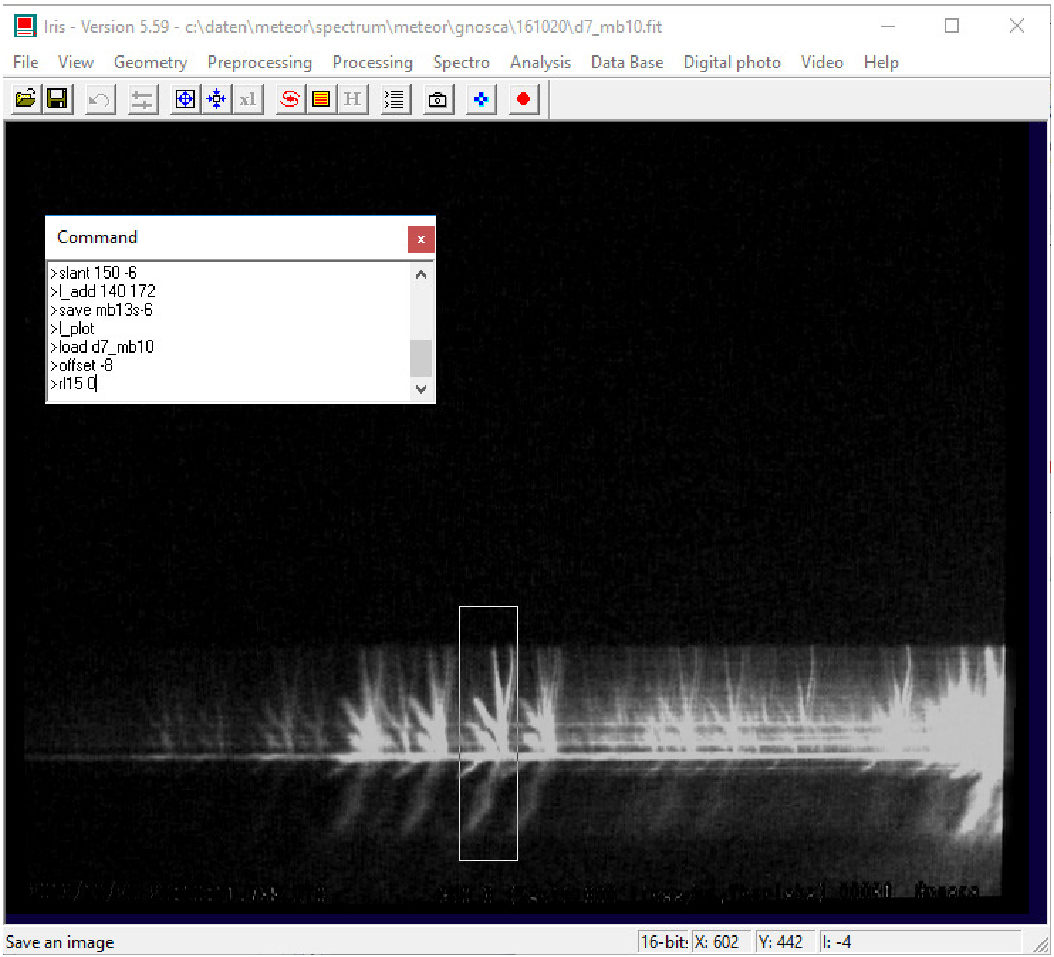
mb13s-6w

>l_add 140 172
>l_plot



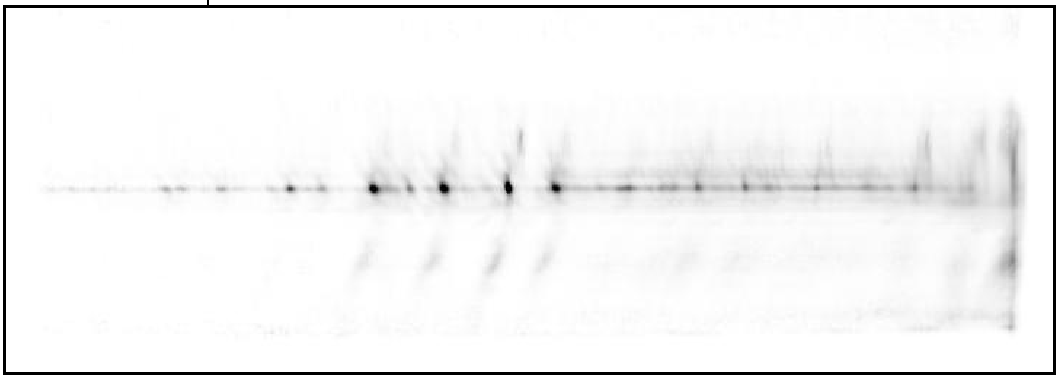
Most intense spectrum, d7_mb10

Field 60 (mb10.fit) showed the most intense spectrum, heavily overexposed, with multiple filaments. The 2-dimensional spectrum is the convolution of the flash image with the dispersed line spectrum. In order to extract the line spectrum a deconvolution was tested. The Richardson-Lucy algorithm is implemented in IRIS and was used. An “isolated” line was selected for the flash image (normally one would use the zero order images) and after some iterations a “line spectrum” obtained:
>load d7_mb10
>offset -8



```
>rl 15 0
>save mb10rl15
>visu 0 2000
>window 1 1 720 250
>savejpg mb10rl15w 2
```

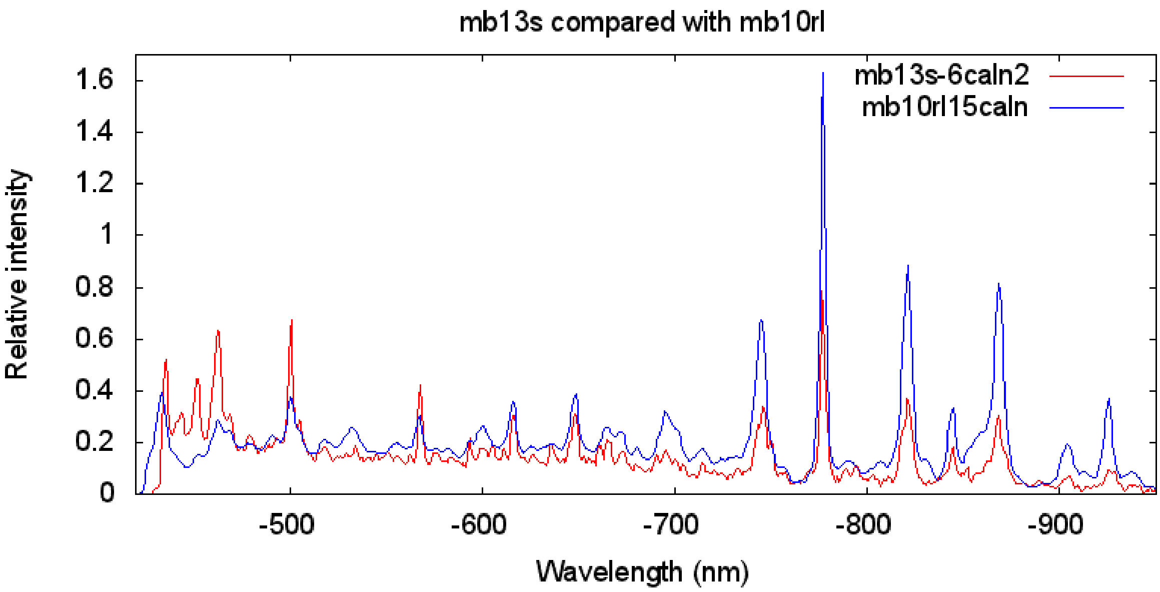
For details on the deconvolution, see:
http://www.astrosurf.com/buil/iris/tutorial12/doc30_us.htm
Deconvoluted spectrum:



Most of the spectrum is concentrated in a narrow range, which is extracted just as the other spectra:

```
>load mb10rl15
>l_add 120 130
>l_plot
```

The following plot shows a comparison of the spectrum extracted from field 63 (straight line section visible) in red with the spectrum extracted by deconvolution from field 60 in blue. Where the lines are separated enough so that the images of the individual spectral lines do not strongly overlap the spectrum could be reconstructed fairly well. In the heavily overexposed section below 500 nm the reconstruction does not work.



Red: spectrum from field 63 (straight line spectrum)
Blue: spectrum reconstructed with Richardson-Lucy algorithm from field 60 (overexposed spectrum of flash with multiple filaments.

This deconvolution method may be applicable successfully for LTE spectra, preferably with the zero order visible.