Meteor Spectroscopy
First Steps

Martin Dubs

AGG, FMA

Content

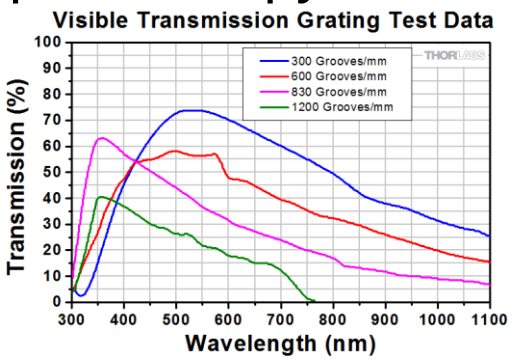
- Introduction
- Hardware
- Software
- Spectrum extraction
- Summary

Meteor spectroscopy

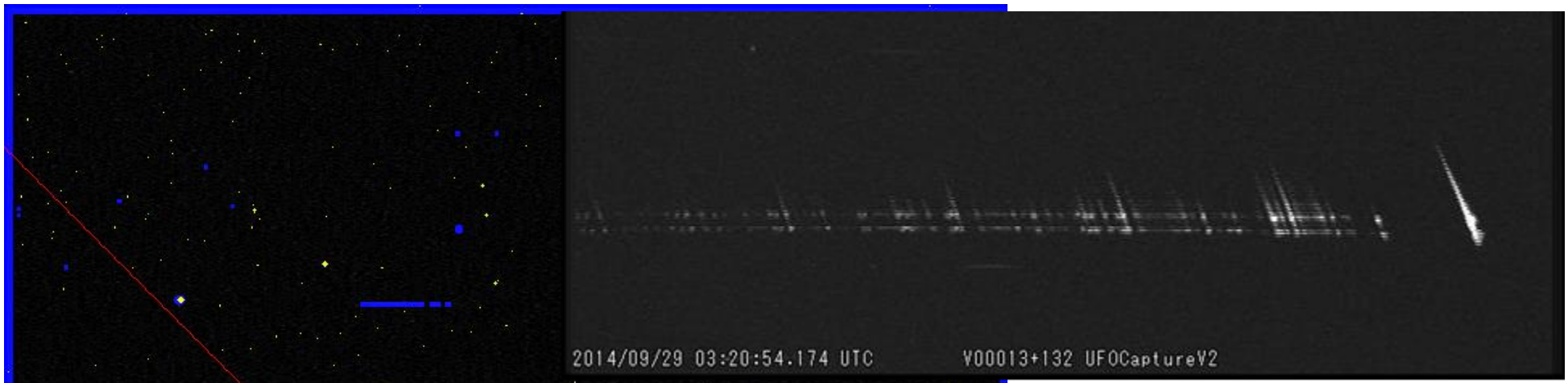
- Additional information
  - Composition of the meteoroid
  - Temperature
  - Interaction with atmosphere
  - Meteor trail
- Problems
  - Reduced sensitivity
  - analysis
  - Compromise between spectral resolution, field of view and sensitivity
  - Saturation

Hardware

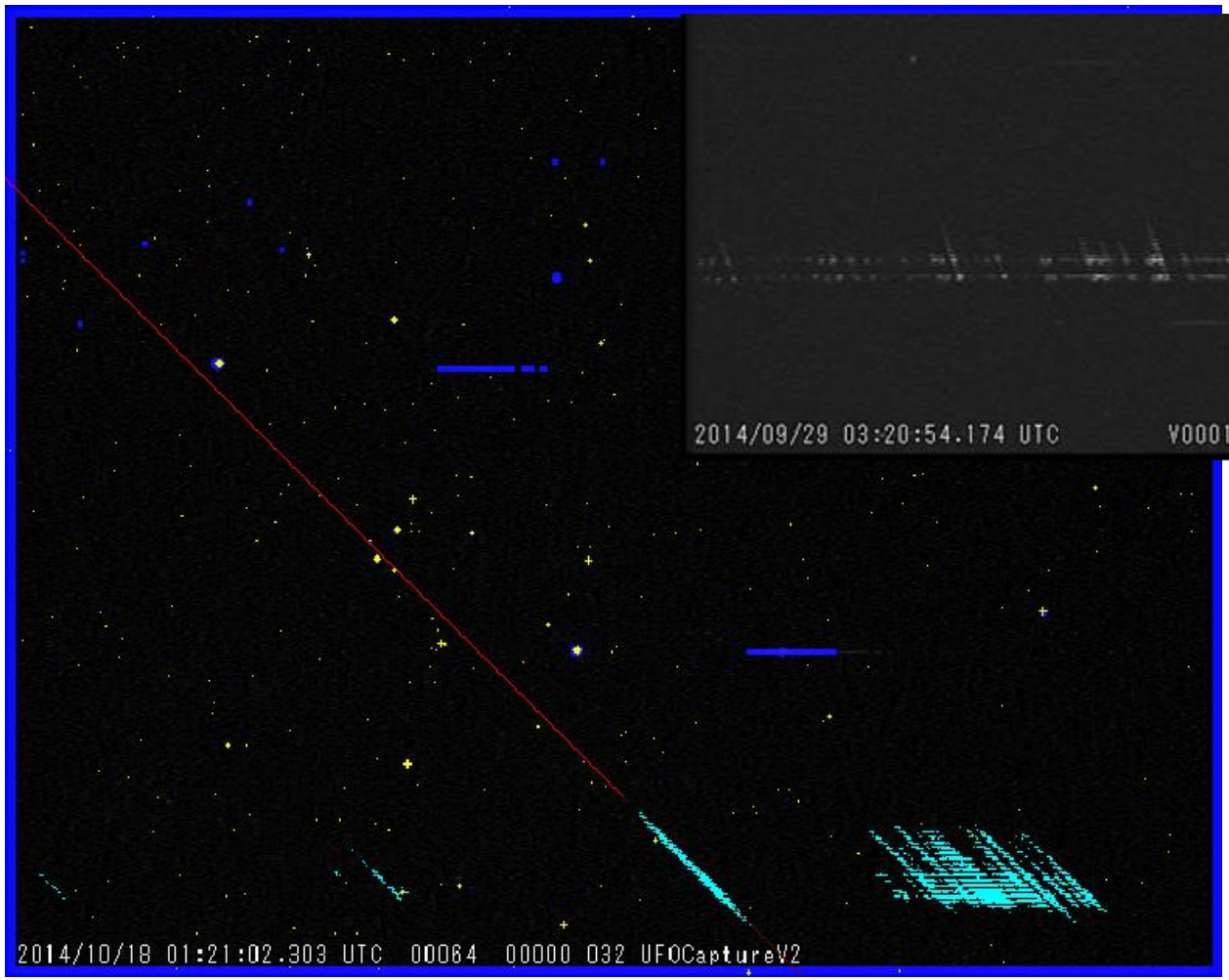
- Watec 902B (path) Computar HG2610AFCS-HSP F/1 2.6mm fl
- 902H2 ultimate (spectroscopy) Tamron 12VG412ASIR F/1.2, ≈7mm fl
- Plasticbox with cutout for window (compact, low heat loss)
- Grabber and USB 12V converter built in (used for heating)
- Single cable connection
- 2nd camera with transmission grating for spectroscopy Thorlabs 300 L/mm



Meteor spectra



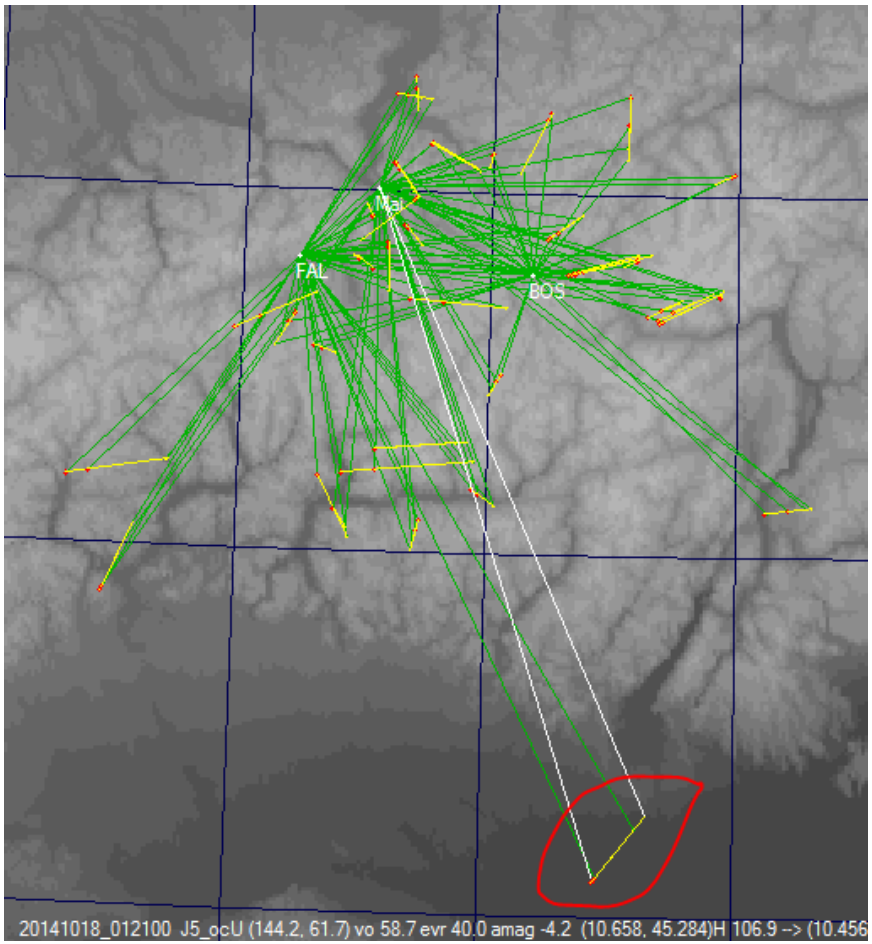
f = 4mm, -4mag



f = 7mm, -2mag

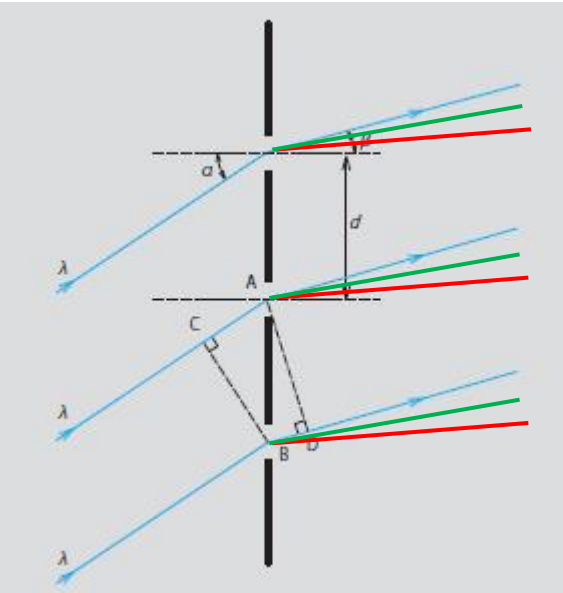
Meteor 20141018_012100

- Ground Path from FMA Database Data 1. – 18. Oct.
- Calculated with UFO Orbit October Ursae Majorids
  v_g = 58 km/sec (54.4 km/sec ocU)
  v_s = 42.0 – 43.3 km/sec
  (parabolic, hyperbolic)



Spectrograph, theory

- Video camera with transmission grating in front of lens
- Grating equation:
  - **$m * \lambda * G = (\sin \alpha - \sin \beta) * \cos \gamma$**
  - m: grating order, G: grating lines / mm
  - λ: wavelength
  - α, β: angle of incidence, transmitted beam
    γ: cross, out of plane angle
- Blazed grating: most light in first order (m = 1)
- Dispersion: $d\beta/d\lambda = m*G/(\cos \beta \cos \gamma)$
  - Nearly constant for small β
- Inverse dispersion per pixel: $d\lambda/dx = (\cos \beta \cos \gamma)/(m*G*f)*p$ (p: pixel size)
  - Example: f = 7 mm, p = 8.6 µm, G: 300L/mm $\beta = 0 \rightarrow d\lambda/dx = 41$A/pixel



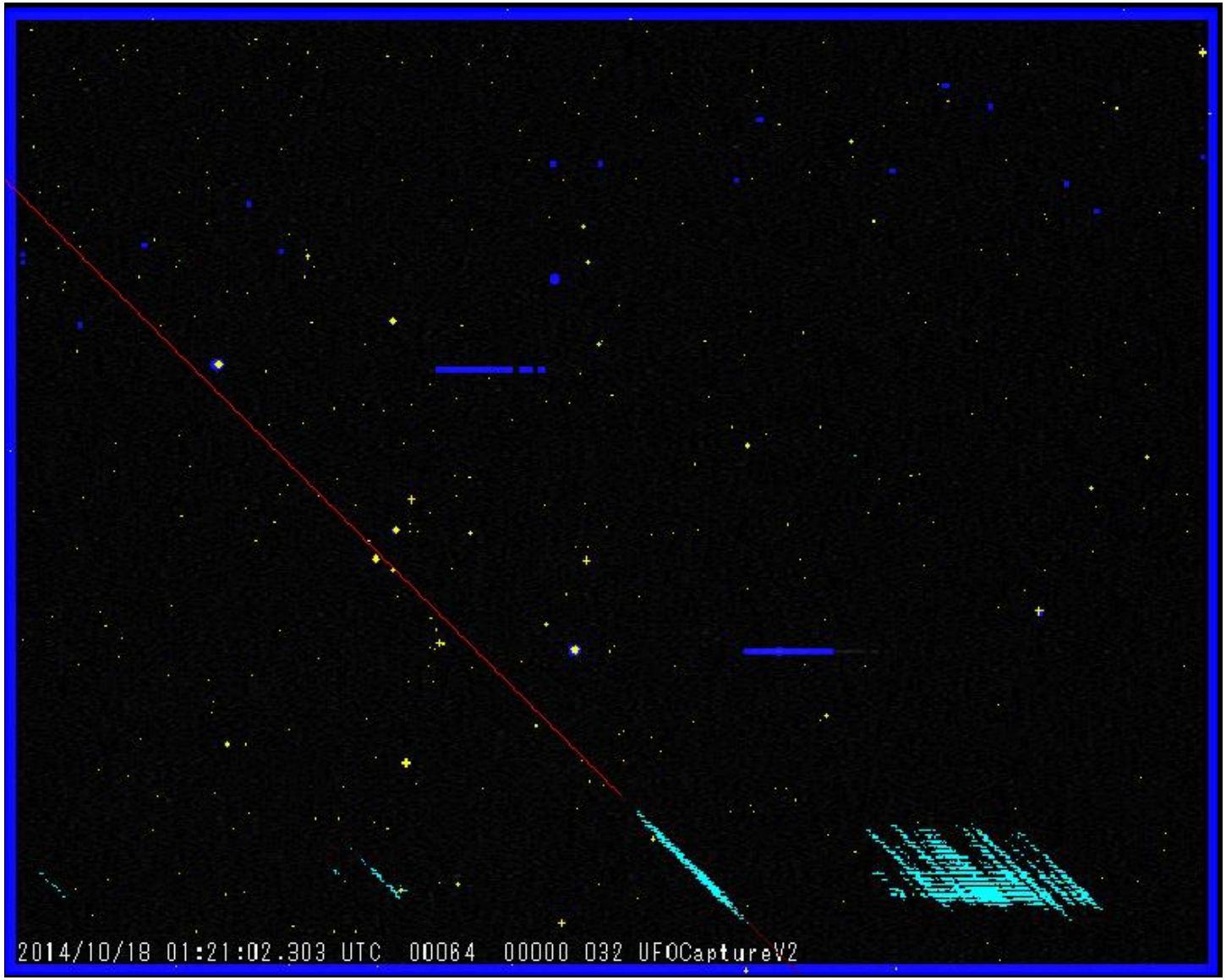
Spectrum recording and processing software

- UFO Capture for trigger and record video
  - [Lagarith video compressor http://lags.leetcode.net/codec.html
  - VirtualDub (for uncompressing video files)]
- IRIS (http://www.astrosurf.com/buil/us/iris/iris.htm)
  astronomical image processing and spectroscopy software
  http://www.astrosurf.com/buil/iris/nav_pane/CommandsFrame.html
- ISIS (http://www.astrosurf.com/buil/isis/isis_en.htm)
  advanced (more specialized) spectroscopy software
  - Both by Christian Buil

Spectra processing overview

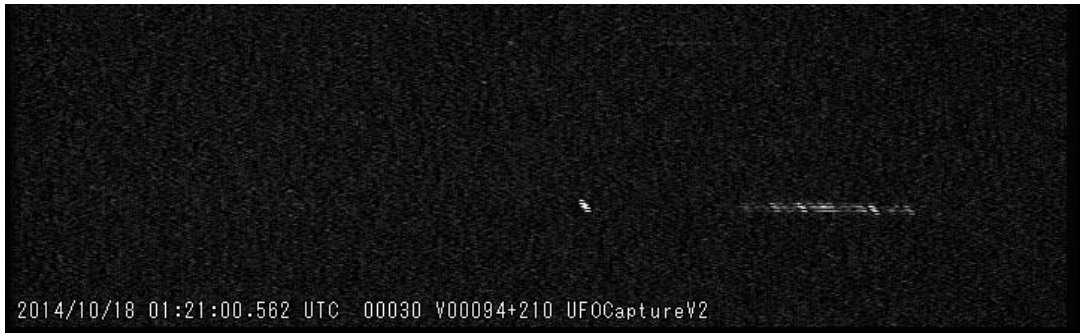
- IRIS
  - Extract images from uncompressed AVI (File – AVI conversion)
  - Measure background image with stars only (ADD_MEAN)
  - Subtract background from meteor images (SUB2)
  - register meteor images (TRANS, ADD) several times
  - Extract raw spectrum, whole range (2D image → 1D spectrum) (L_ADD, I_PLOT)
- ISIS Wavelength calibration (Profile – Dispersion – fit polynom)
- IRIS: Special tools to enhance resolution (SCALE, RL)
- Analyze spectrum (assign chemical elements)

AVI clip
Oct. 18.

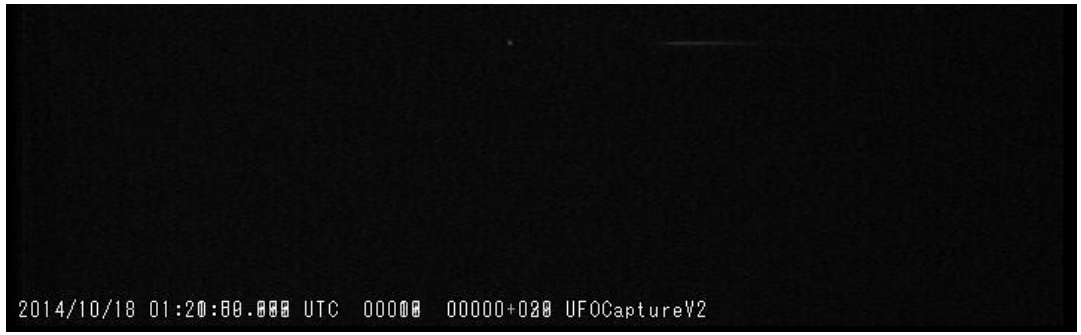


Preprocessing

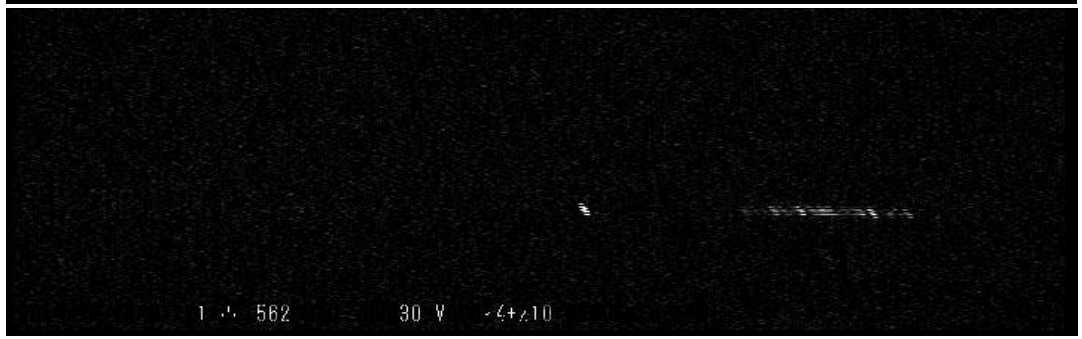
- Extract image (i30)



- Background ADD_MEAN < I1 … I20 >

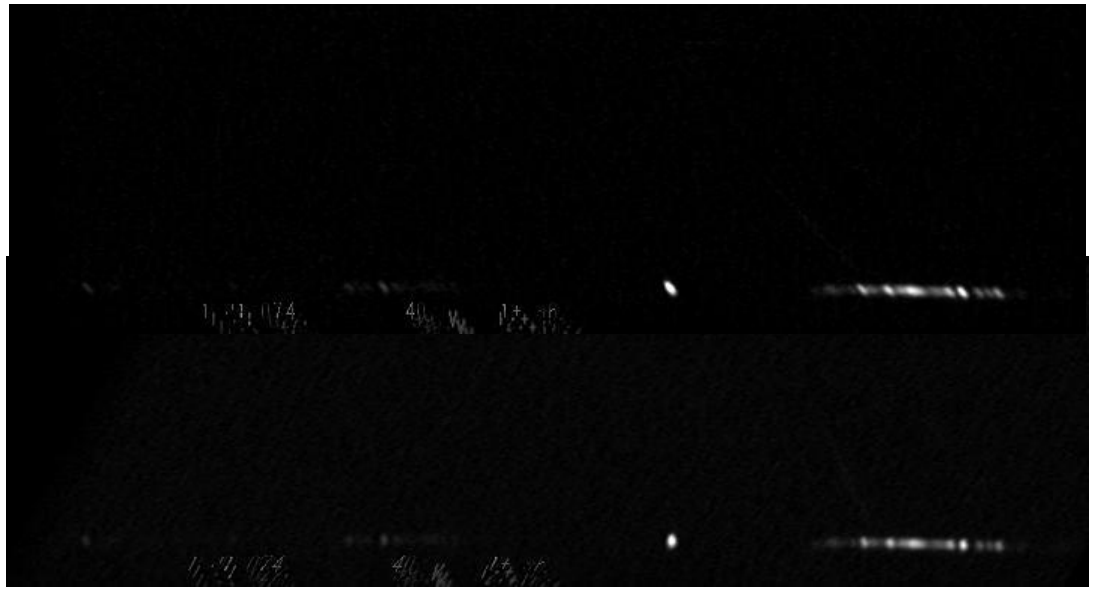


- Subtraction SUB2



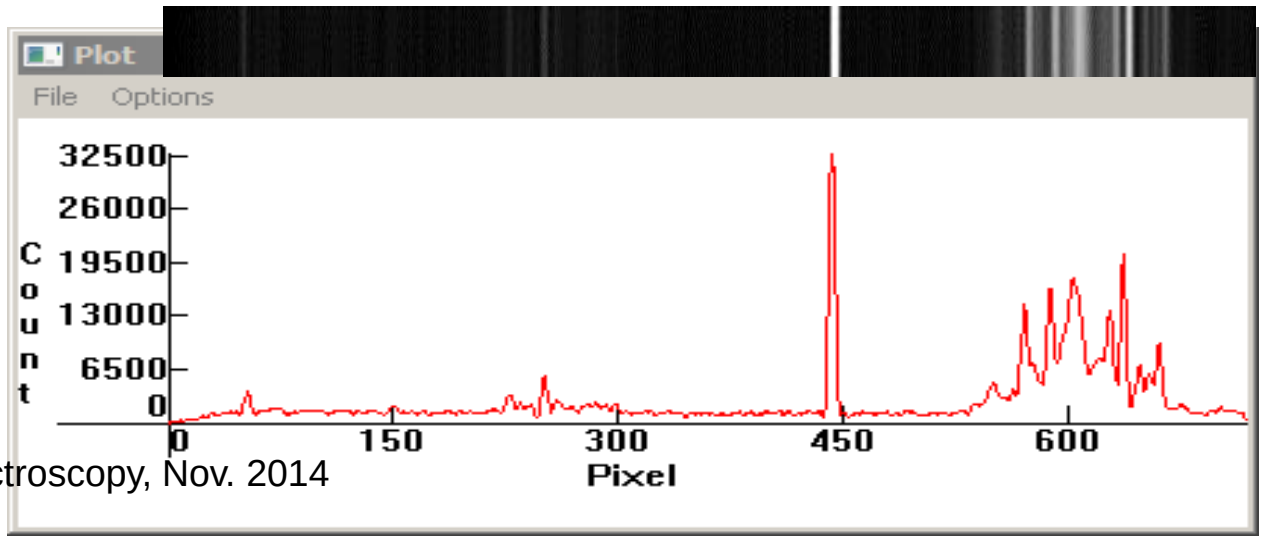
Processing 2

- Add
  TRANS, ADD
  ib34-ib40



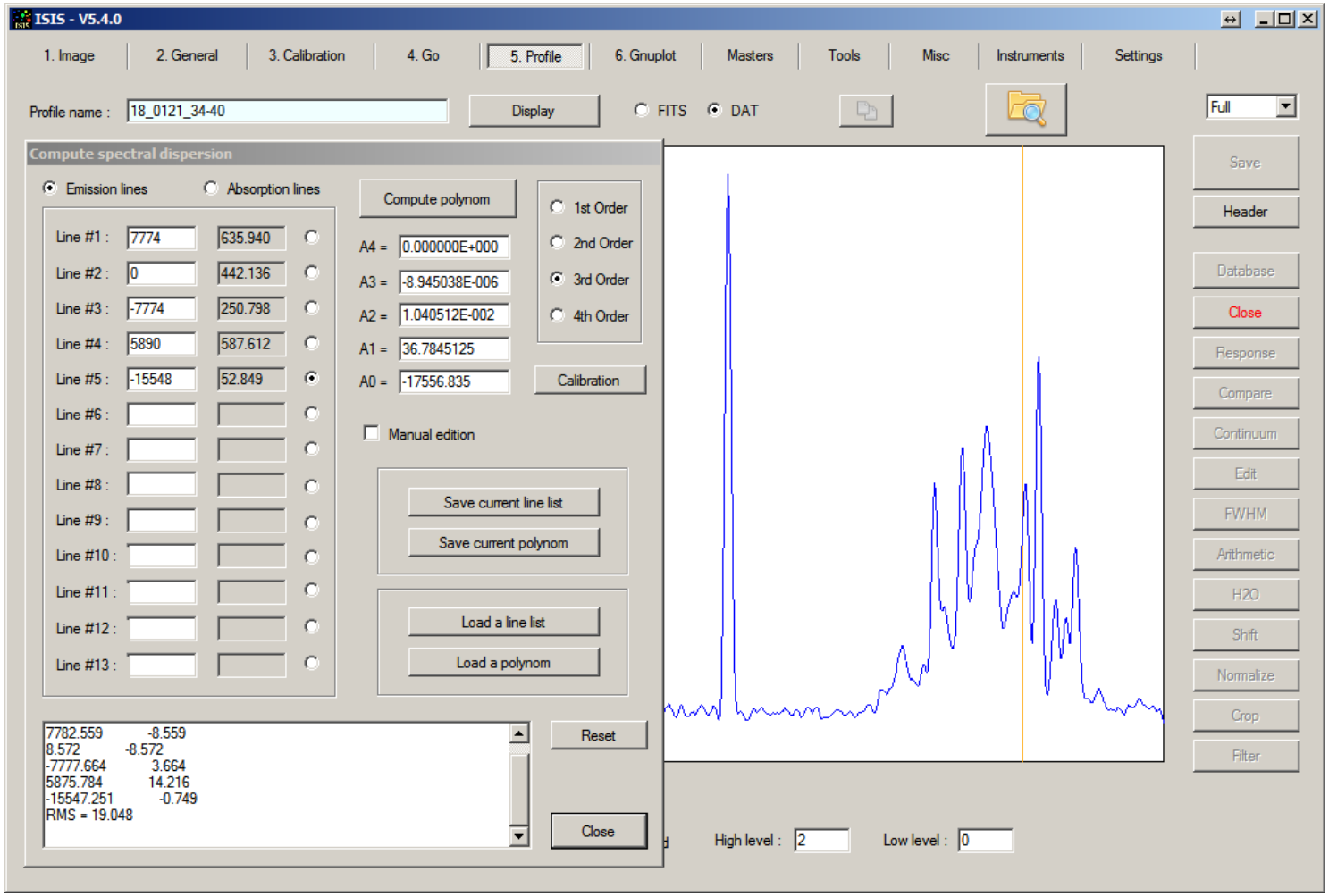
- Slant 28 30

- L_ADD
- L_PLOT
  save file.dat



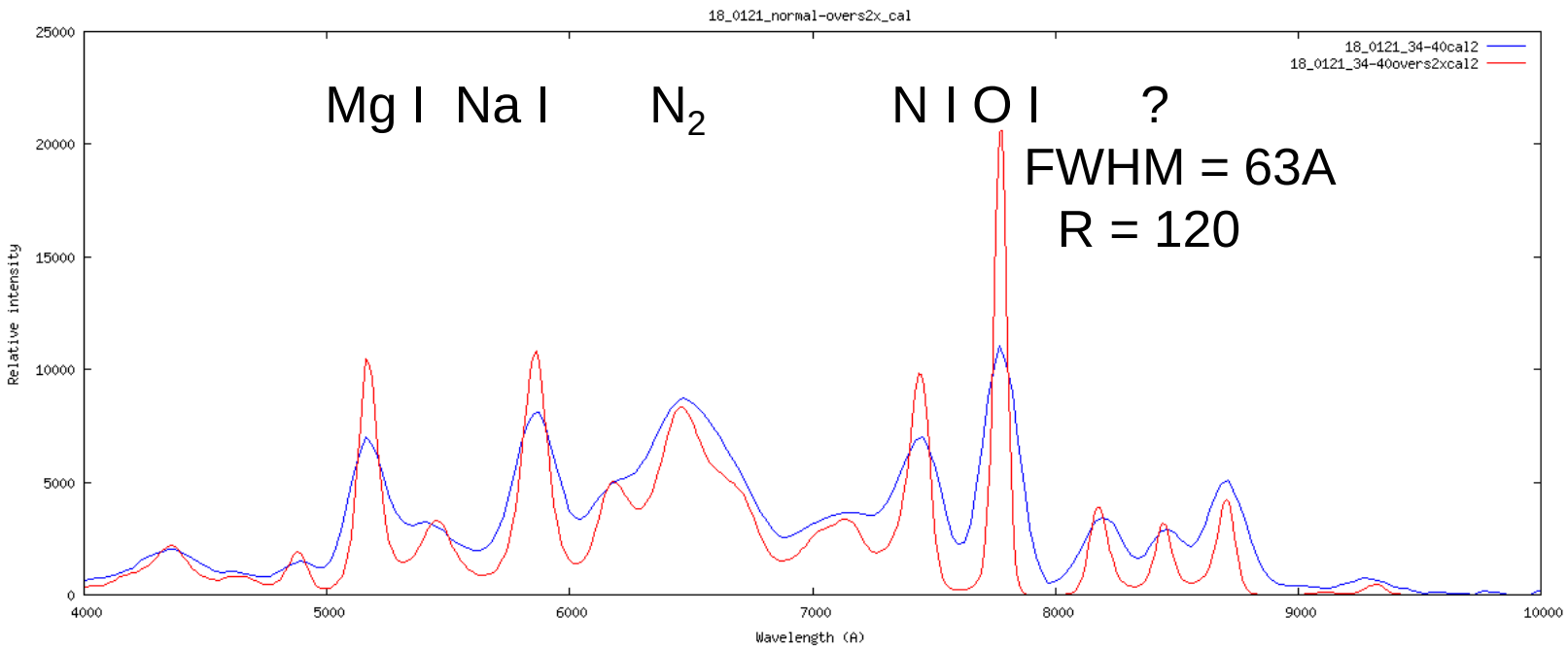
Calibration

- In ISIS, with polynom save result



Resolution enhancement

- In IRIS:
  - Image oversample (SCALE 2 2 2)
  - Richardson-Lucy deconvolution command (RL 30 0) (use with care)
  - After recalibration (blue before, red after deconvolution):



Conclusion

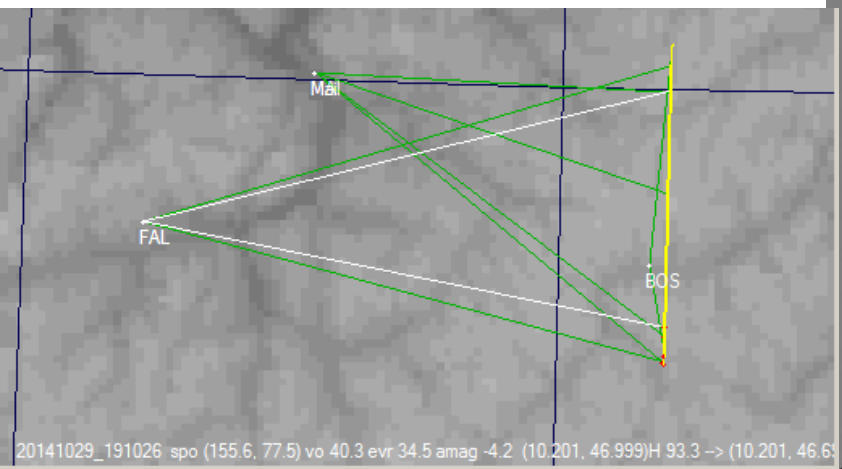
- Short focal length
  - Large field of view
  - Low spectral resolution
  - Low sensitivity
  - Nonlinear dispersion over field of view
  - Different orders visible
- Long focal length
  - Small field of view
  - High spectral resolution
  - High sensitivity
  - Few meteor spectra of higher quality

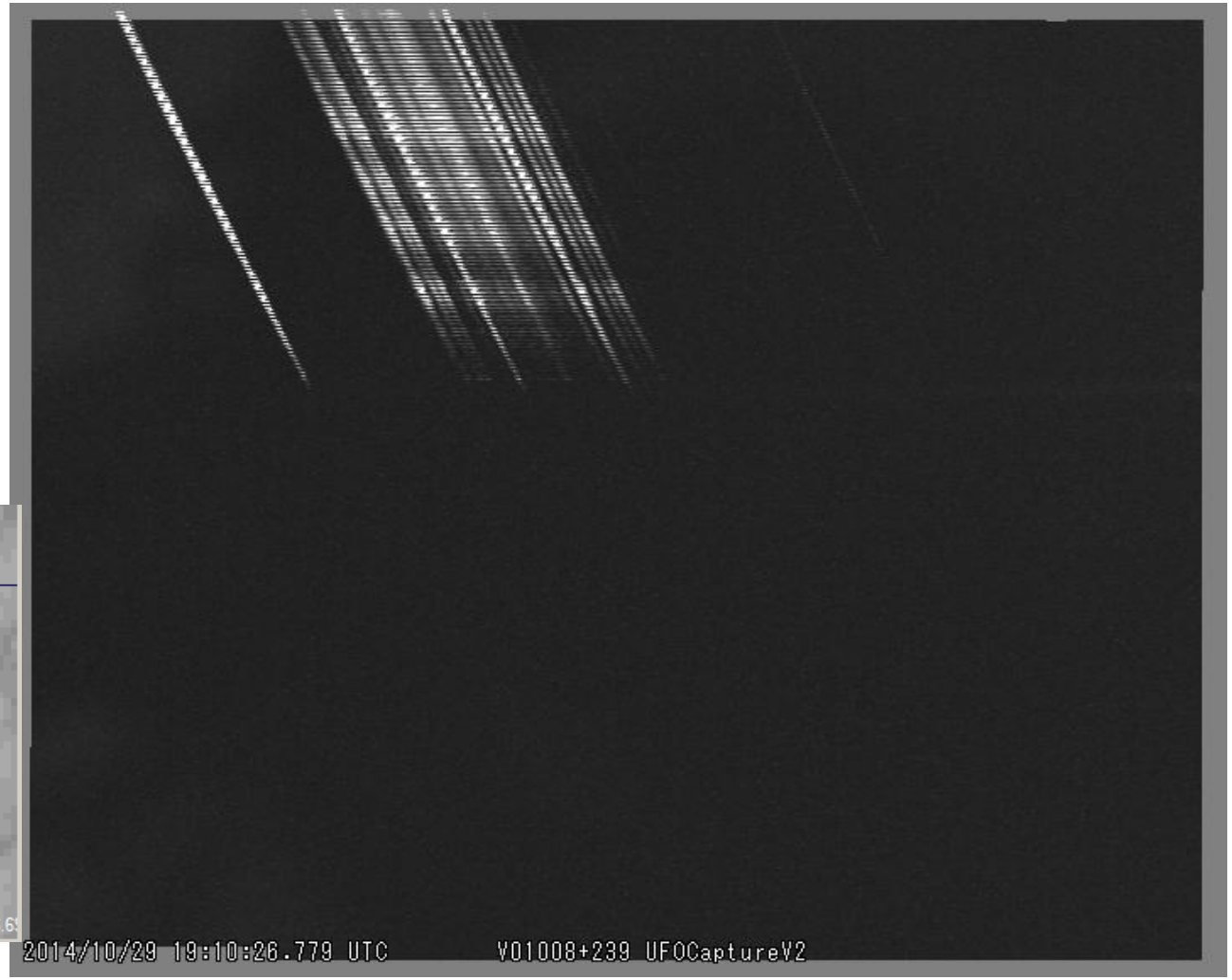
- Grating with 300 to 1000L/mm mounted perpendicular to axis
- Next: Spectral response

- 6 – 12mm focal length for ½" CCD
- Limit magnitude -1 … -2

Waiting for next meteor spectrum, patience required!

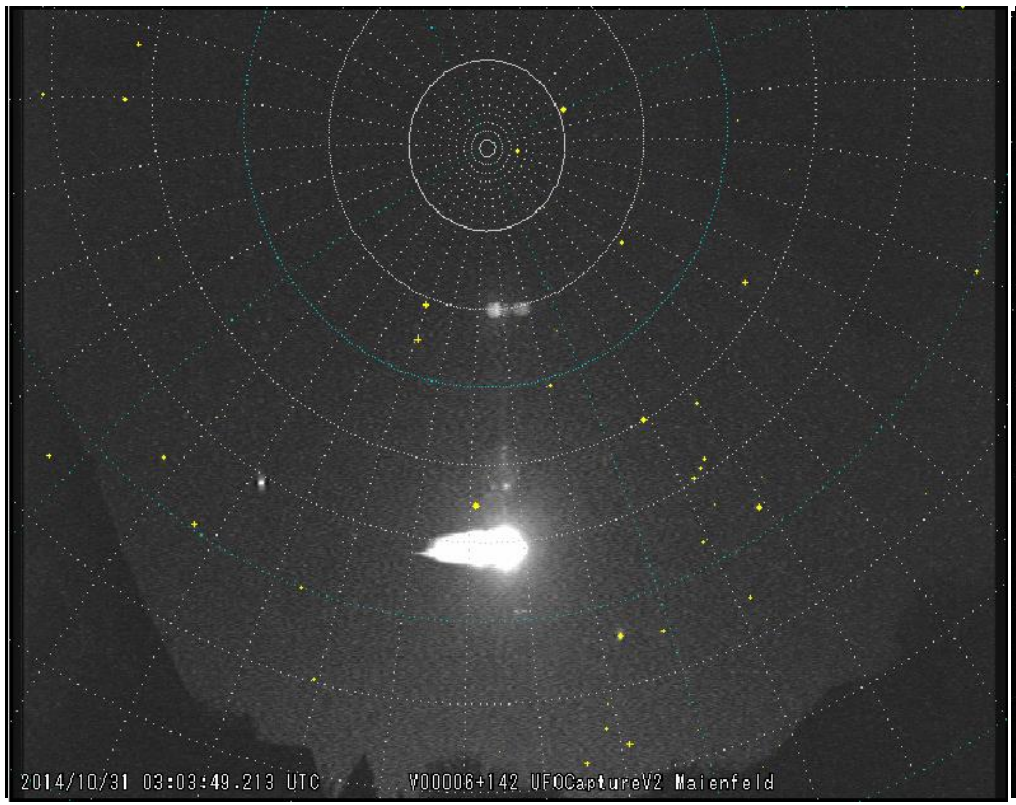
(Latest) spectrum, Okt. 29, 19:10:25



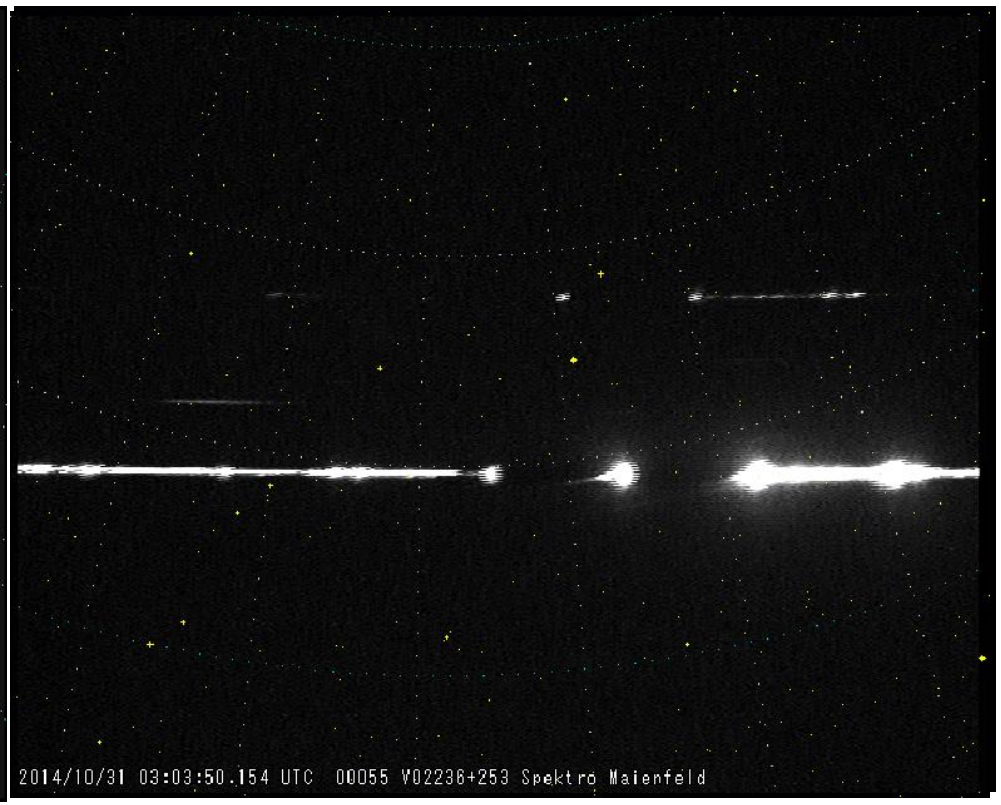


Spectrum Oct. 31, 030349

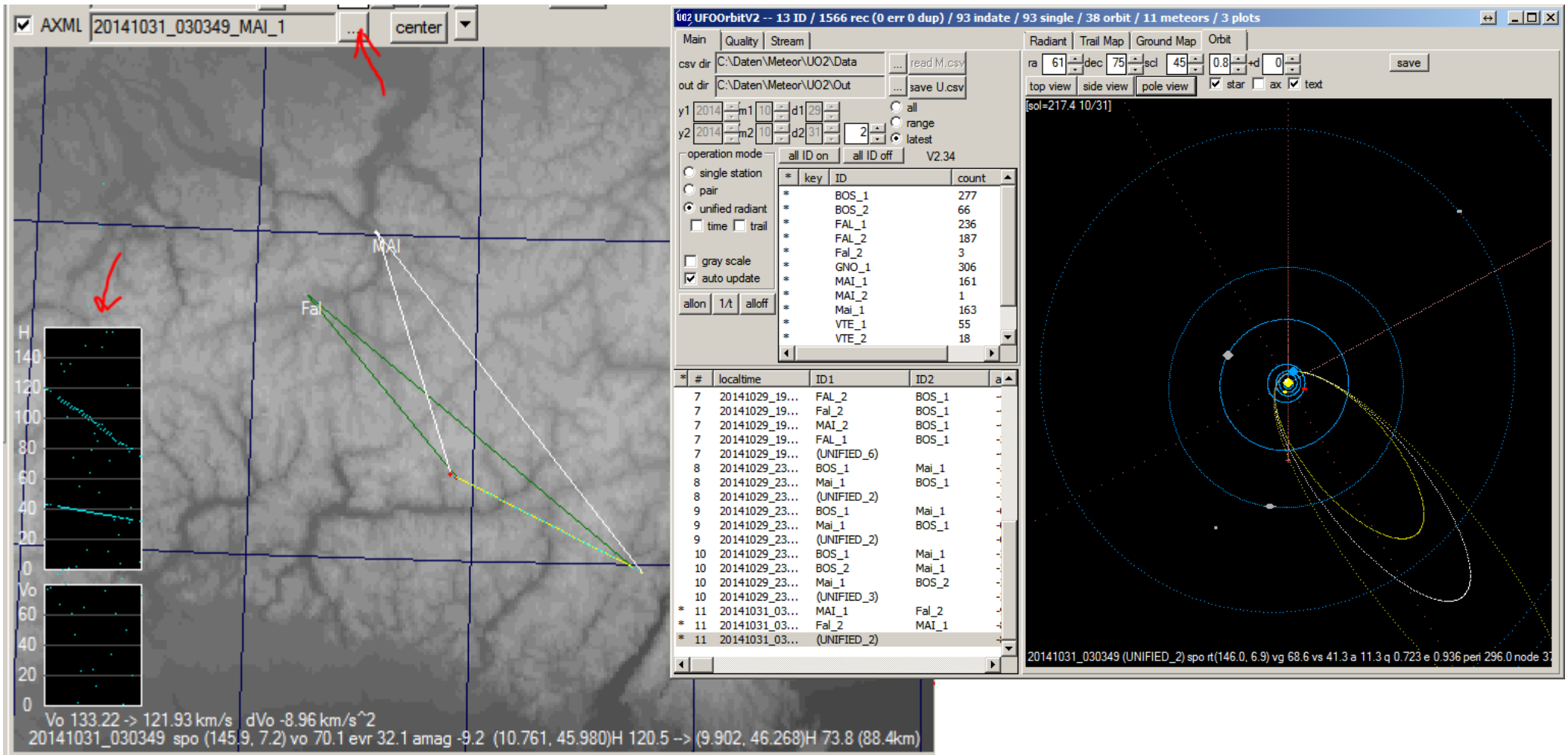
Watec 902B



Watec 902H2 ultimate



Oct. 31, 030349, UFO Orbit



Path and orbit, Oct. 31, 030349

UOrbits.csv

OK Cancel

*	1	mag	-7.850000	evro	0.000000
#	11	av	0.000000	evrt	30.618080
localtime	20141031_030349	Voa	0.000000	Nts	62
mjd	56961.127653	Pra	0.000000	Nos	54
sol	217.410873	Pdc	0.000000	leap	12.760416
ID1	(UNIFIED_2)	GPlng	336.402130	rstar	95
ID2		GPlat	-38.581375	ddeg	0.057470
amag	-8.752377	ra1	0.000000	cdeg	0.109735
ra_o	145.910904	dc1	0.000000	drop	-1
dc_o	7.161516	az1	0.000000	inout	3
ra_t	146.006210	ev1	0.000000	tme	1.000000
dc_t	6.865579	lng1	10.761362	dt	0.059998
elng	145.922623	lat1	45.979656	GD	0.000000
elat	-6.379227	H1	120.547630	Qc	9.789941
vo	69.758331	LD1	0.000000	dGP	0.000406
vi	69.758331	Qr1	0.000000	Gm%	96.341400
vg	68.609039	Qd1	0.000000	dv12%	0.367340
vs	41.332958	ra2	0.000000	zmv	0.310687
a	11.293717	dc2	0.000000	Ed	0.000000
q	0.723036	az2	0.000000	Ex	0.000000
e	0.935979	ev2	0.000000	QA	0.673431
p	37.969082	lng2	9.902083	No	2
peri	295.966125	lat2	46.268467	Qp	0.000000
node	37.409683	H2	73.776443	pdeg_sd	0.000000
	167.596130	LD2	0.000000	rao_sd	0.000000
stream	spo	Qr2	0.000000	dco_sd	0.000000
dr	-1.000000	Qd2	0.000000	vo_sd	0.519497
dv%	-1.000000	LD21	88.352104	rat_sd	0.000000
dur	1.260000	az1r	116.087616	dct_sd	0.000000
Qo	16.329866	ev1r	32.116646	vg_sd	0.000000

Links

- SonotaCo Forum
  http://sonotaco.jp/forum/viewtopic.php?t=3065
- IMC2014
  http://www.imo.net/imc2014/2014-20-rudawska-final.pdf
- Ed Maiden (historic)
  http://www.bcmeteors.net/index.php/spectroscopy-methods
- Thorlabs grating
  http://www.thorlabs.de/newgrouppage9.cfm?objectgroup_id=1123

Thank you!