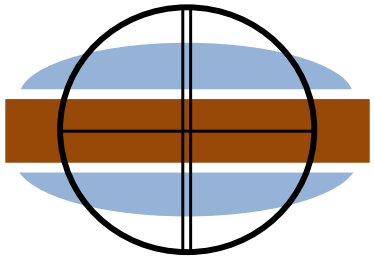
CHIPOLATA

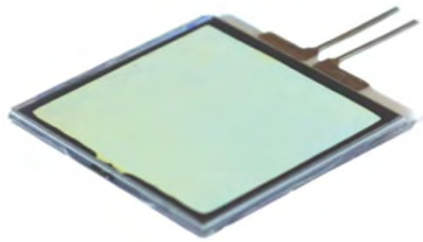
Felix Bettonvil



Introduction

- Digital All sky camera with LC optical shutter
- Idea: LC's usable for high-res observing too?
- Aim: Determination of distribution of orbits.

Optical chopper



	X-FOS(G2)	*X-FOS(G2)-AR*
Open state transmittance[5]	≥37.5%	≥36.5%
Open state color	u'=0.203 ± 0.01 v'=0.501 ± 0.01	u'=0.203 ± 0.01 v'=0.501 ± 0.01
Contrast	≥1,800:1 @ V_D=18V	≥1,800:1 @ V_D=18V
Angular dependence	Contrast @ V_D=18V ≥ 100:1 -31° ≤ θ ≤ +31° horizontal, -28° ≤ θ ≤ +25° vertical	Contrast @ V_D=18V ≥ 100:1 -31° ≤ θ ≤ +31° horizontal, -28° ≤ θ ≤ +25° vertical
T_{50} voltage	2.15V ± 0.2V	2.15V ± 0.2V
Closing time (T_{100}-T_{10})	≤50µs @ V_D=18V	≤50µs @ V_D=18V
Opening time (T_0-T_{90})	≤1.6ms @ V_D=18V	≤1.6ms @ V_D=18V
Reflectance per surface	≤2%	≤0.5%
Surface quality	N/A	60/40 scratch/dig
Beam deviation	N/A	≤1 arc min
RMS average power consumption[6]	≤12mW	≤12mW
Peak current[6]	≥28mA	≥28mA

Some optimization

Highrescam lens onderzoek

brandpuntsa	openingsverl	meteorengev	beeldhoek [g	meteorengevo tov 50 f/1,8 incl LC	x pop index	meteoren oogst**			nauwkeurigheid		
f	O	D2/f		D2/f / 15,4)	D2/f / 15,4)^r	%	resolutie ["]	ratio	%	**statistische**	OPM
50	*1,8*	*15,4320988*	*24,81*	*1*	*1*	*100*	*29,7778045*	*5142,85714*	*100*	***100***	*op film*
video CAMS (schatting)						*100000*	*60*	*5400*	*105*	***3320,39154***	*video**
200	2,8	25,5102041	*6,30*	1,256326531	0,743885111	7,420835142	*7,55543064*	42883,0619	833,837315	**227,147373**	
200	2,8	25,5102041	*6,30*	5,025306122	5,263078095	52,50331578	5,66657298	57177,4159	1111,78309	**805,588817**	
200	4	12,5	*6,30*	0,6156	-1,581570362	-15,7774	7,55543064	42883,0619	833,837315	**#NUM!**	
200	4	12,5	*6,30*	2,4624	2,937622623	29,30508068	5,66657298	57177,4159	1111,78309	**601,854516**	
135	2,5	21,6	*9,32*	1,0637568	0,201484501	5,809312238	11,1798099	28980,8149	563,515845	**135,82149**	
135	2,5	21,6	*9,32*	4,2550272	4,720677485	136,1091767	8,3848574	38641,0865	751,35446	**876,573974**	
135	2	33,75	*9,32*	1,66212	1,656339688	47,75649936	11,1798099	28980,8149	563,515845	**389,423696**	
135	2	33,75	*9,32*	6,64848	6,175532673	178,0563638	8,3848574	38641,0865	751,35446	**1002,59058**	
85	1,4	43,3673469	*14,75*	2,135755102	2,473684738	171,1892553	17,6970393	18308,1472	355,991751	**465,777158**	
85	1,4	43,3673469	*14,75*	8,543020408	6,992877723	483,9361746	13,2727795	24410,8629	474,655668	**1044,17362**	
50	1,8	15,4320988	*24,81*	0,76	1	100	29,7778045	10880,5873	211,566975	**211,566975**	
50	1,8	15,4320988	*24,81*	3,04	3,624553936	362,4553936	22,3333533	14507,4497	282,089299	**537,048979**	
28	*2,8*	*3,57142857*	*42,90*	*0,175885714*	*-5,665463204*	-1806,58903	*51,4745672*	*6294,37055*	*122,390539*	***#NUM!***	
28	*2,8*	*3,57142857*	*42,90*	*0,703542857*	*-1,146270219*	-365,51984	*38,6059254*	*8392,49407*	*163,187385*	***#NUM!***	
high-res CAMS											
50	1,8	*15,4320988*	*24,81*	*48,64*	*12,66293991*	3798,881972	*45,2616622*	*7158,37607*	*139,190646*	***857,902533***	
85	1,4	*43,3673469*	*14,75*	*136,6883265*	*16,03126369*	2773,575033	*26,6692887*	*12148,8055*	*236,226773*	***1244,0822***	

1 = minder dan 50/1.8

combinatie r	comb/prijs	prijs lens	prijs body*	totaal**
18,94				
89,56				
#NUM				
66,91				
7,653				
65,86				
21,94				
75,33				
16,58				
49,56				
4,476				
15,1				
#NUM				
#NUM				
11,94				
29,38				

* we gaan uit van 1 station

Eisen
hogere plaatsnauwkeurigheid dan 50/1,8 op film
minstens even veel meteoren als 50/1,8 lens op 350D
statistische relevantie beter dan CAMS

Conclusie
beste resolutie geeft 1100D + 135. (met er wordt dan voldaan aan alle gestelde eisen)
beste relevantie geeft 135F2/1100D
beste combinatie resolutie*relevantie is gelijk aan bovenstaande
goedkoopste is 100D +85F1.4 en voldoet aan alle eisen.
beste performance/prijs ratio is er niet: vrijwel allemaal even goed
Beste 350D optie is 85/1.4.
Conclusie: 135/F2 met 1100D maar kan niet met 350D.

****NB: lange telelens heeft veld van 2*11mm/200mm * 100km = 11km op 100km hoogte. Simultaan betekent dit dat volume 11 x 11km is. Standaardlenzen/groothoeklenzen hebben altijd hoogte van 40km x breedte veld. Daar gaat het dus lineair met beeldhoek, maar bij grote hoeken
Dus alles groter dan 113mm moet kwadratisch genomen worden.

- Longer focal length
- Optimum between resolution vs. yield. '*Statistical relevance*'
- Accuracy ≈ *f*
- *Yield ≈ 1/f* ^{3}
- *Choice for first test:* ***50mm F1.8 lens***

350D	*60*
350D	*60*
1100D 1x	*150*
fisheye	*300*
controllers 2x	*30*
DCF	*60*
functiegenerator 2x	*70*
135F2	300
135F2	300
behuizing	37
behuizing 1x	*37*
connectors (2x)	*25*
kabelklemmen	50
voeding	*155*
UPS	30
stuurkast 1x	*100*
glaasjes	*60*
LCDs	200

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Highrescam lens onderzoek

brandpuntsa	openingsverl	meteorengev
f	O	D2/f
50	*1,8*	*15,4320988*
video CAMS (schatting)		
200	2,8	25,5102041
200	2,8	25,5102041
200	4	12,5
200	4	12,5
135	2,5	21,6
135	2,5	21,6
135	2	33,75
135	2	33,75
85	1,4	43,3673469
85	1,4	43,3673469
50	1,8	15,4320988
50	1,8	15,4320988
28	*2,8*	*3,57142857*
28	*2,8*	*3,57142857*
high-res CAMS		
50	1,8	*15,4320988*
85	1,4	*43,3673469*

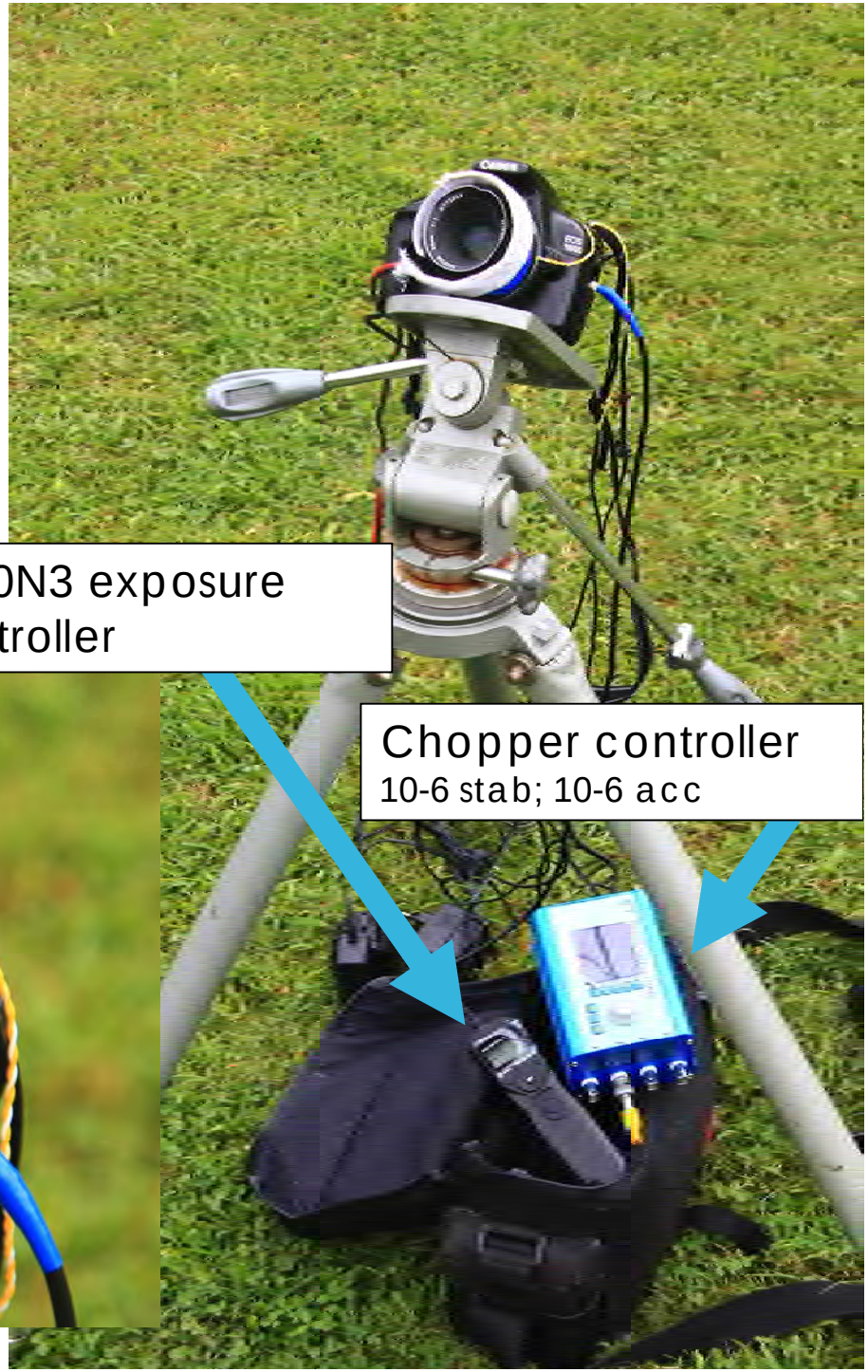
Test setup

Canon 1100D + 50mm/F2 (2.8)

LC-TEC chopper

TC80N3 exposure controller

Chopper controller
10-6 stab; 10-6 acc

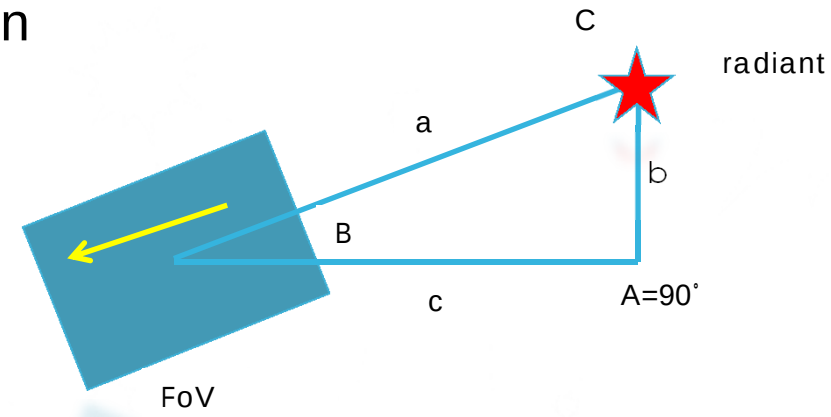


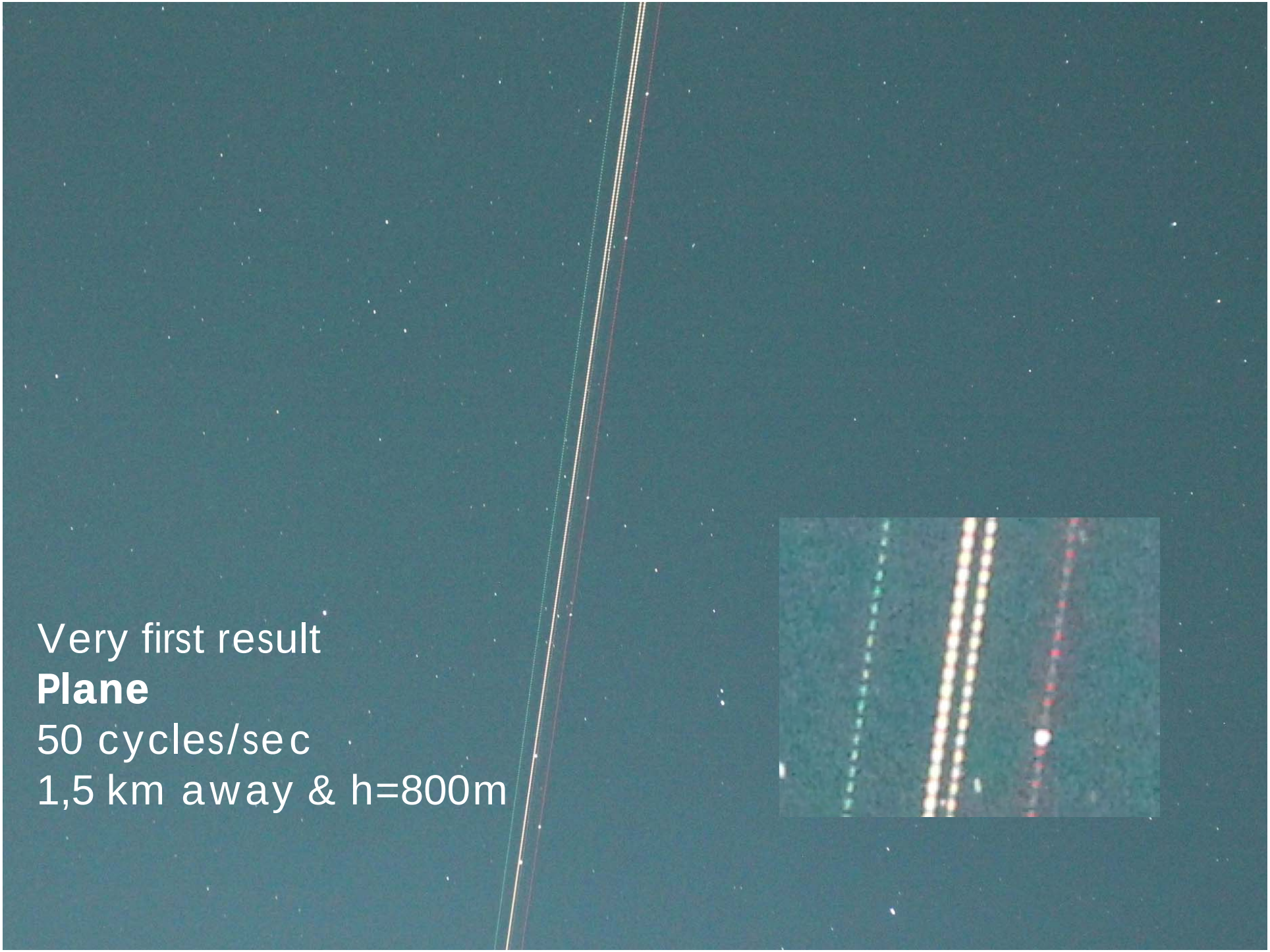
Test setup

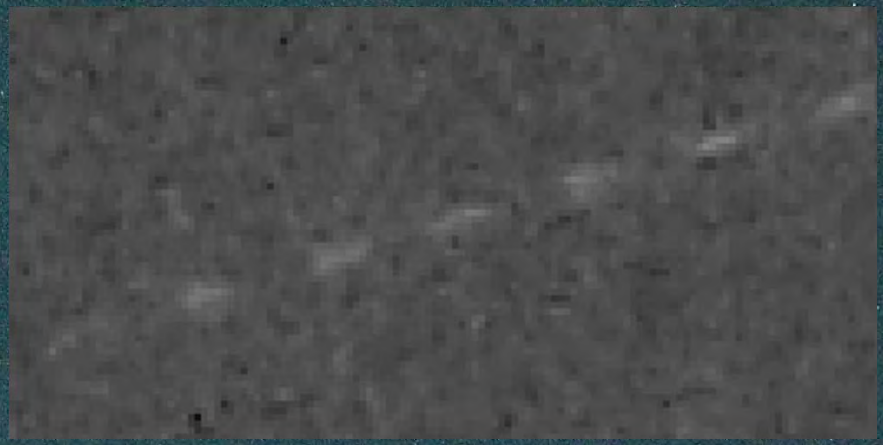
- Rotation compensation
- Single station…
- ISO 6400, F/2.8
- 15 sec exposure time

- Perseids 2014, in dark Bosnia
- Although hampered by moon

- 9 nights, 13000 exposures
- 50-100-200 cycl/sec.
- **10 trails**




Very first result
Plane
50 cycles/sec
1,5 km away & h=800m



Perseid, 82 breaks, trail 1500 pxl long,
0,3s duration, only last part

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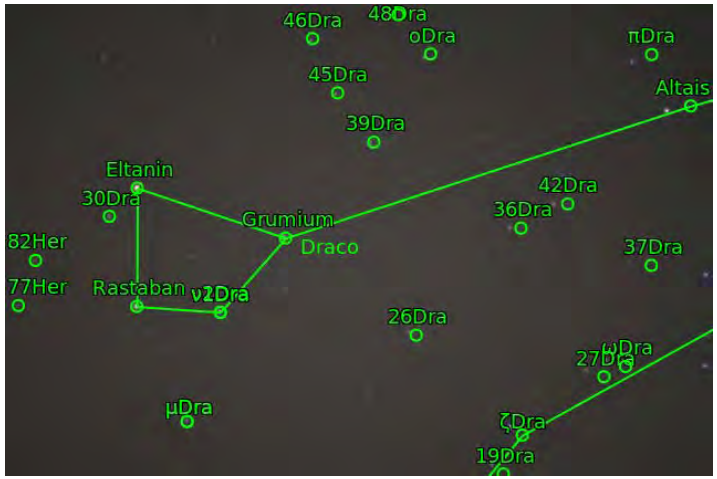
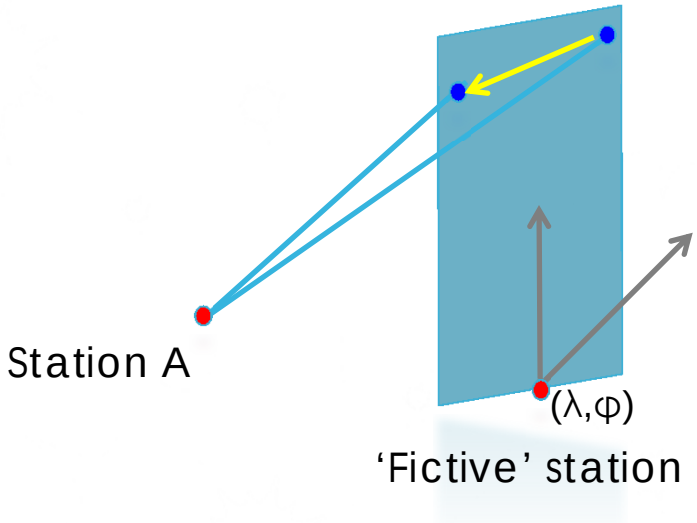
August 11, 2014, 20.33 UT: Perseid +1 in Dra/UMa, crop 14˚x 14˚
Canon 1100D + Nikkor 50mm/F2.8, 200 cycl/sec, ISO6400, T=15s
Međeđa, Bosnia & Herzegovina

Analysis

- Astrometry: astronomy.net
- Photometry: $M_v = +1$



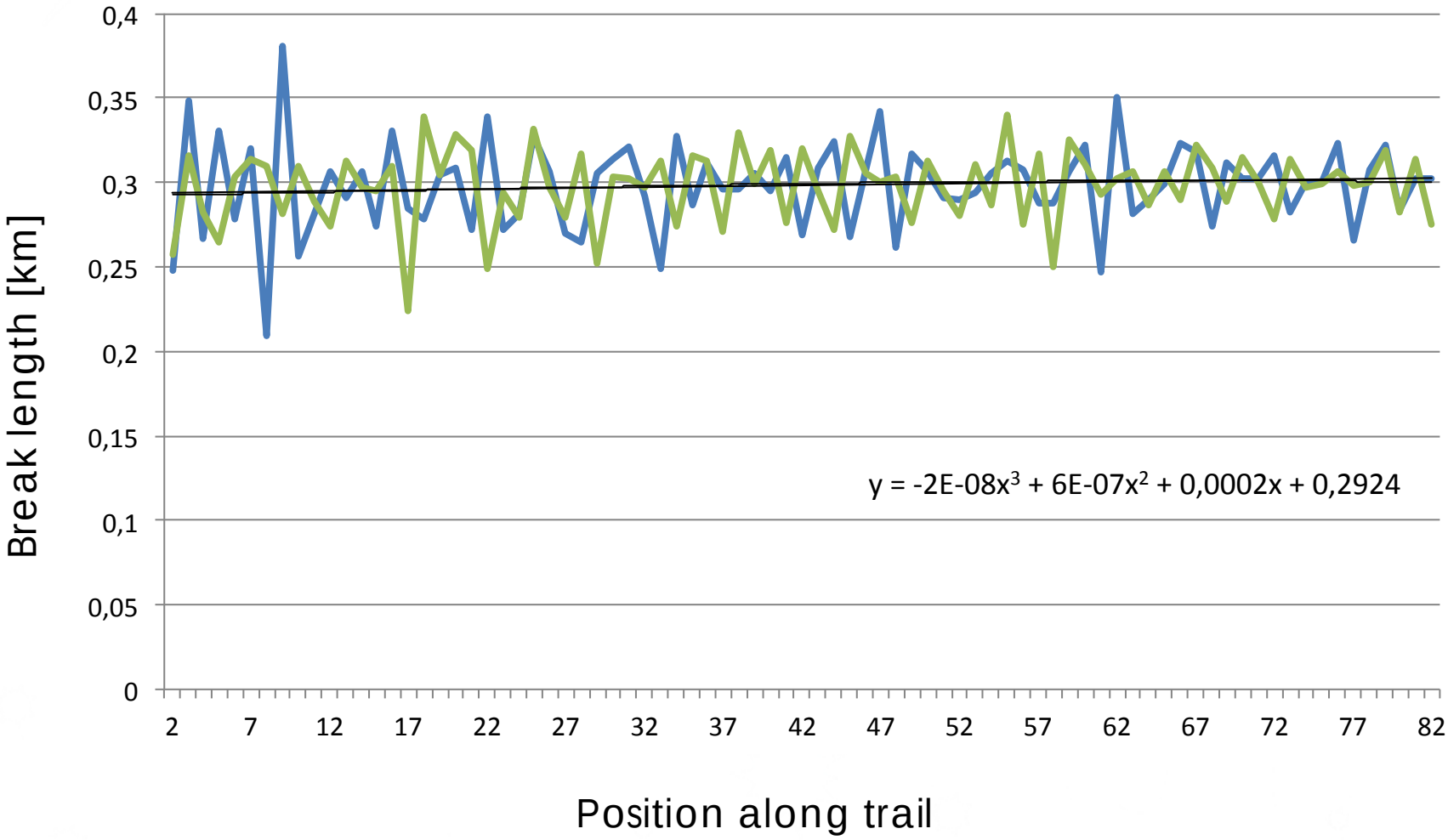
- Atmospheric trajectory



Atmospheric trajectory

```
 Results Radiant & Atmospheric Trajectory
 ----------------------------------------------------------------------------
                                                    |
<1> RADIANT Rght.Asc.  Declinat  Visible?           | <2> RADIANT (PRECISION)
      Mede:  41 43  8  54 10 37  above horizon      | Rms Radial      : --.-- [deg]
                                                   ----
<3> VELOCITY Mean                                  |  <6> TRJ (PRECISION)
      Mede:  59.654 [km/s]                         |      Rms Radial      :     18 [m]
                                 -------------
<4> TRJ (LENGTH) Total           | <7> TRJ (MISCELLANEOUS)
      Mede:     24.160 [km]      |     Convergence Angle  : 128 [deg]
                                 |     Point of Impact, Lg: --- -- --  Lt: -- -- --
                                 |     Angle of Impact    : -- [deg]
                                 |
<5> TRJ (BEGIN/END)  Rght.Asc.  Declinat.  Tot.Lgt.      Height
    begin   Mede:    284 51 38   45 59 54   0.000 [km]  103.789 [km]
    end     Mede:    284 42  0   45 50 13  24.160 [km]   94.173 [km]
```

Deceleration?



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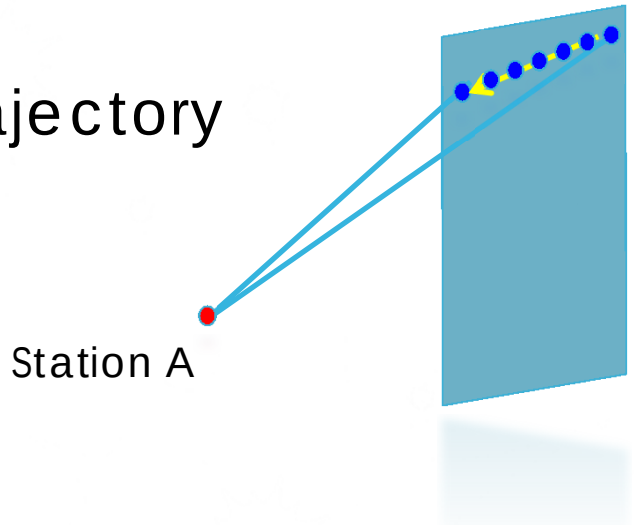
Velocity determination

centroid X	centroid Y	RA	Decl
4234.7	1243.7	13 33 52.1	66 20 51.6
4216.2	1248.2	13 34 09.0	66 14 50.5
4200.0	1253.2	13 34 20.6	66 09 22.7
4184.7	1258.0	13 34 31.3	66 04 14.2
4167.2	1263.2	13 34 44.1	65 58.21.9
4149.2	1269.2	13 34 55.4	65 52 13.2
4131.2	1274.5	13 35 08.8	65 46 11.7

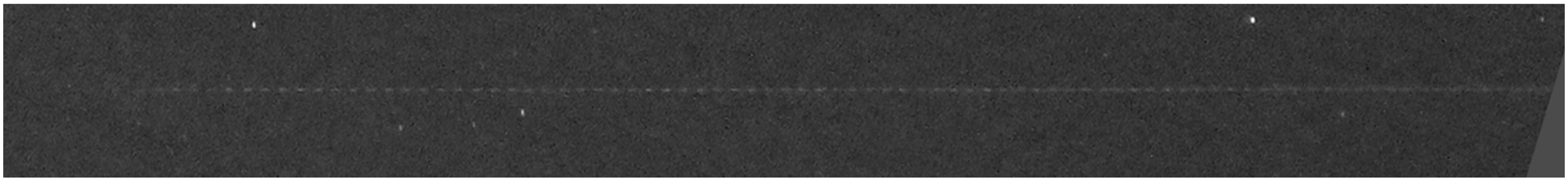
- Centroiding

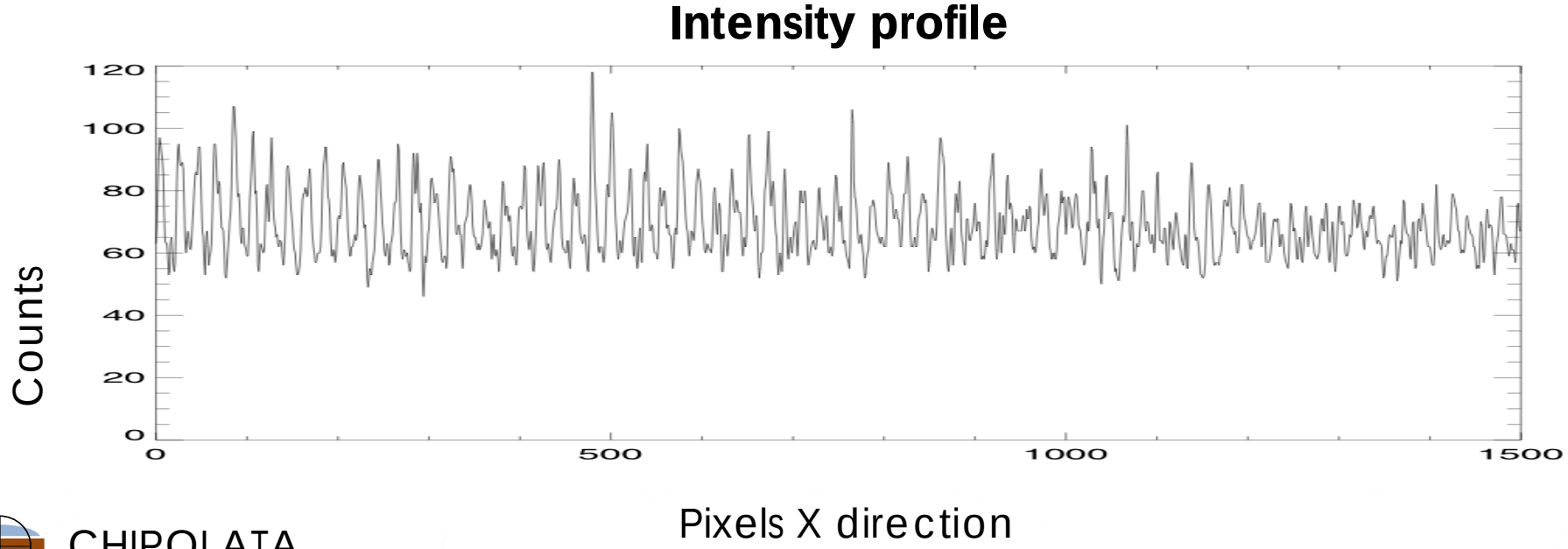
- Project on atmospheric trajectory
- >> Velocity



FFT method

- Compute dominant frequency





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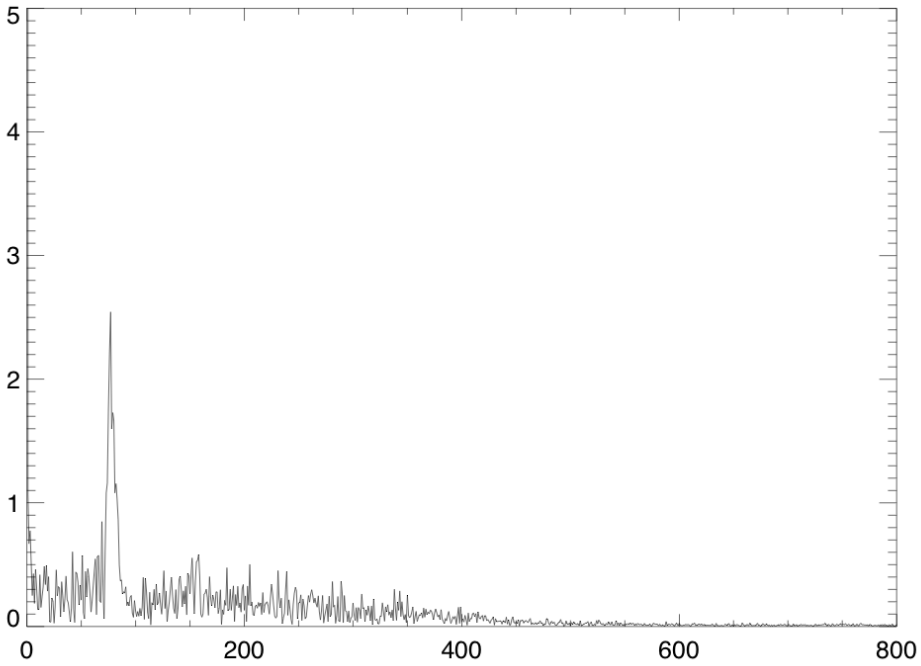
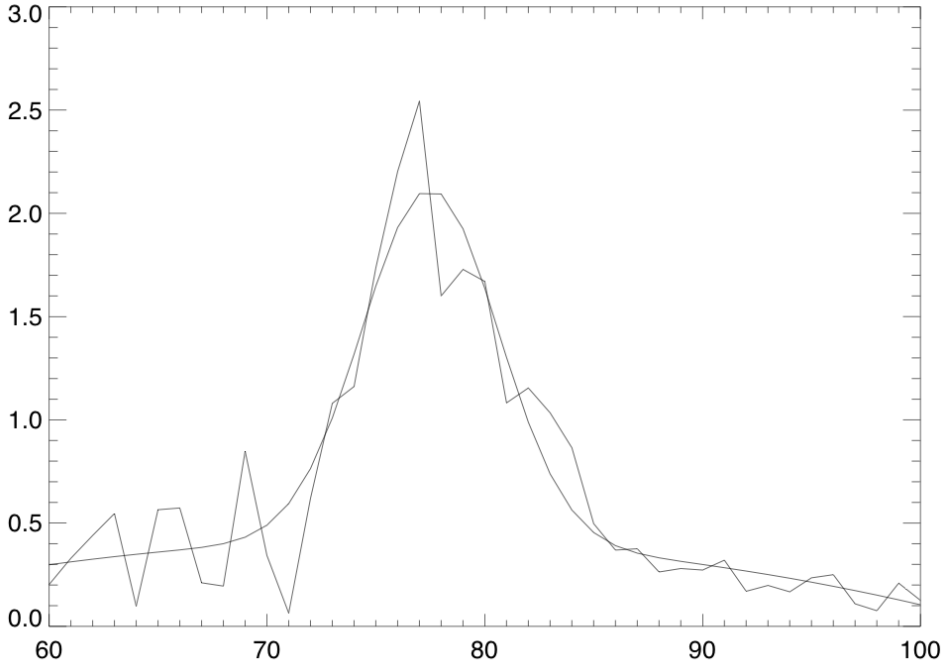
FFT method

Frequenct spectrum



Frequency

Fit



Frequency

Results

Spatial measurement (Centroiding)	59,63 ± 0,04 km/s (± 0,06%)
FFT method	59,61 ± 0,04 km/s (± 0,06%)

Orbit

Semi major axis: connected to origin of meteor particles.

```
Date                [dd mm year]:  11  8 2014
Time (UT)             [hr mm ss]:  20 33 34
Julian date 0h UT  (calculated):  2456880.5
Sun's longitude (calc.)   [deg]:  138.903
Standard equinox                :  2000.0

Atmospheric trajectory:
   Longitude          [deg]:   16.242   +/- 0.000
   Latitude           [deg]:   45.998   +/- 0.000
   Altitude            [km]:  103.789   +/- 0.000

Radiant:                        Observed    Geocentric  Heliocentric
   Right ascension    [deg]:   41.719      42.719                 +/- 0.000
   Declination        [deg]:   54.177      53.910                 +/- 0.000
   Astr. longitude    [deg]:                                70.880  +/- -.---
   Astr. latitude     [deg]:                                60.933  +/- -.---

Velocity              [km/s]:  59.654      58.443      38.944     +/- 0.040

Orbit:
   Astr. longitude of ascending node (OMEGA) [deg]:  138.901  +/- 0.000
   Inclination                       (i)     [deg]:  117.268  +/- 0.026
   Argument of perihelion            (omega) [deg]:  155.361  +/- 0.067
   Semi major axis                   (a)      [AU]:    3.7898 +/- 0.0468
   Distance sun ~ perihelion         (q)      [AU]:    0.9741 +/- 0.0001
   Distance sun ~ aphelion           (Q)      [AU]:    6.6055 +/- 0.0936

Velocity              [km/s]:  62.300      61.135      41.384     +/- 0.040

Orbit:
   Astr. longitude of ascending node (OMEGA) [deg]:  138.901  +/- 0.000
   Inclination                       (i)     [deg]:  118.906  +/- 0.023
   Argument of perihelion            (omega) [deg]:  158.985  +/- 0.044
   Semi major axis                   (a)      [AU]:   23.2836 +/- 2.0413
   Distance sun ~ perihelion         (q)      [AU]:    0.9805 +/- 0.0001
   Distance sun ~ aphelion           (Q)      [AU]:   45.5868 +/- 4.0824
```

Distribution

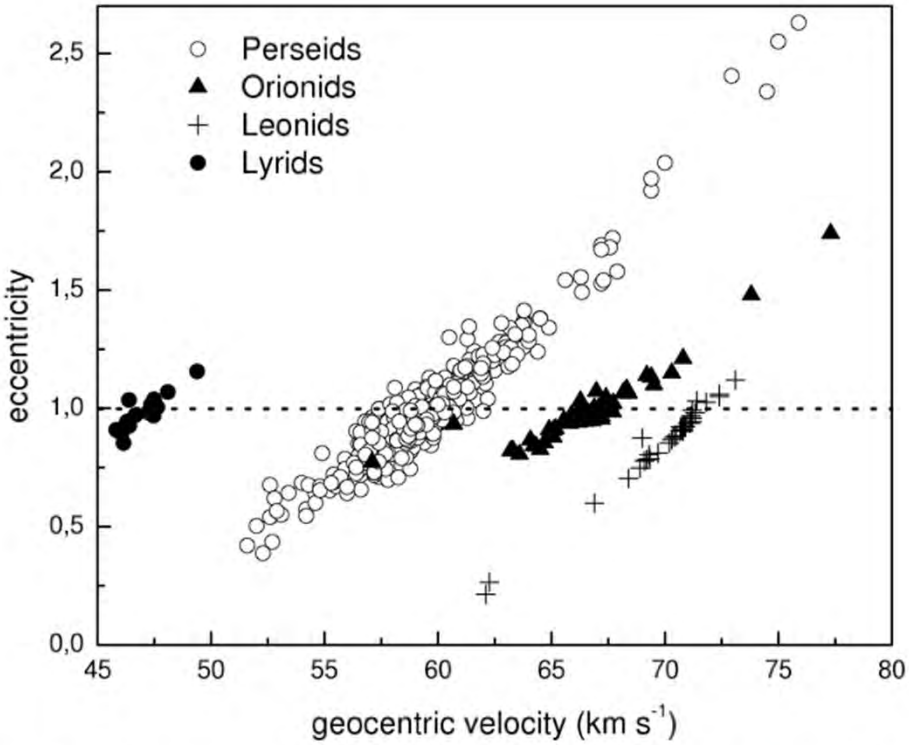
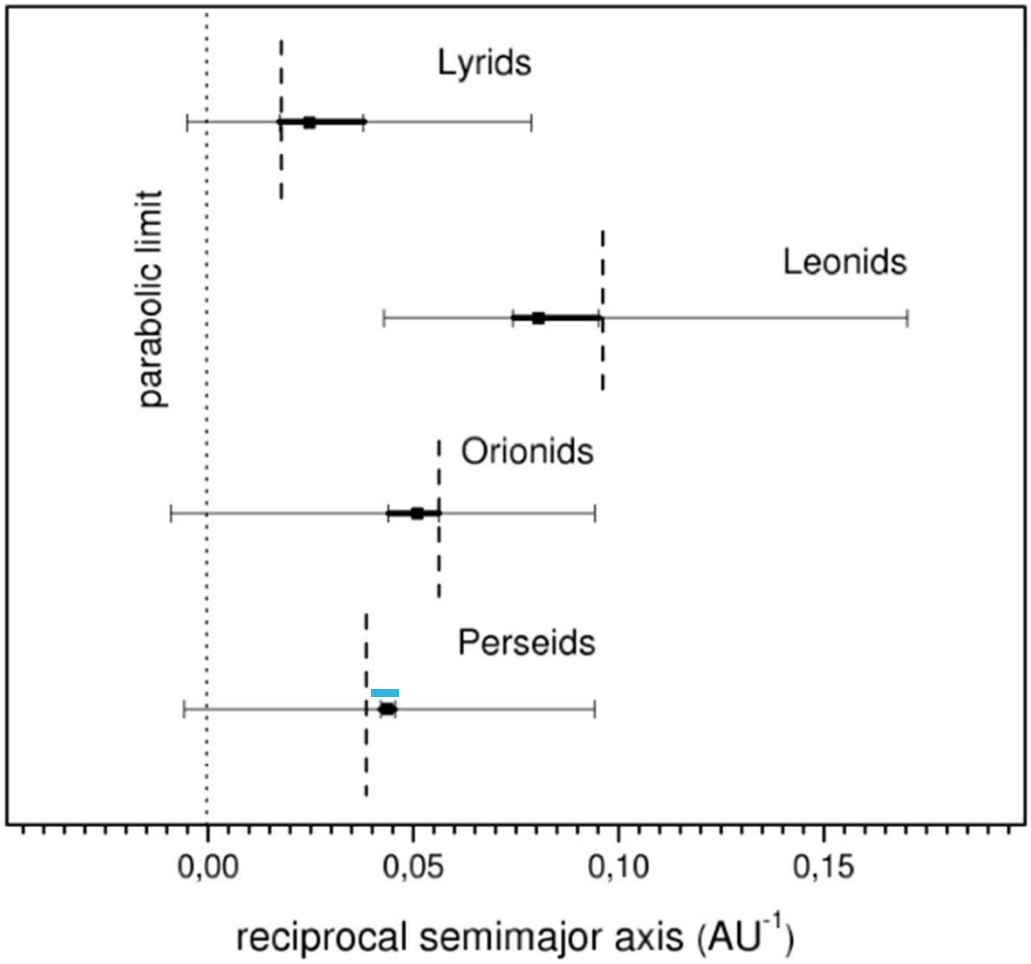


Figure 1. Eccentricities and velocities of the 4 selected meteor showers in the photographic catalogues IAU MDC show that the errors in velocity determination can reach the value $\sim 10\,kms^{-1}$. The horizontal dotted line - parabolic limit.

M.Hajduková, Jr. (2010)

Distribution



M.Hajduková, Jr. (2010)

Conclusions

- Great that it works
- More data
- With following improvements:
  - double station
  - RAW format
  - motorized mount
  - … higher resolution

Why CHIPOlatA?

fast **CH**opp**I**ng **P**h**O**tographic meteor camer**A**