International Meteor Conference 2010
Armagh, Northern Ireland, 15-16 Sep

Design of the 'optimal' All-sky camera for amateurs

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What is optimal?

Specifications and requirements:

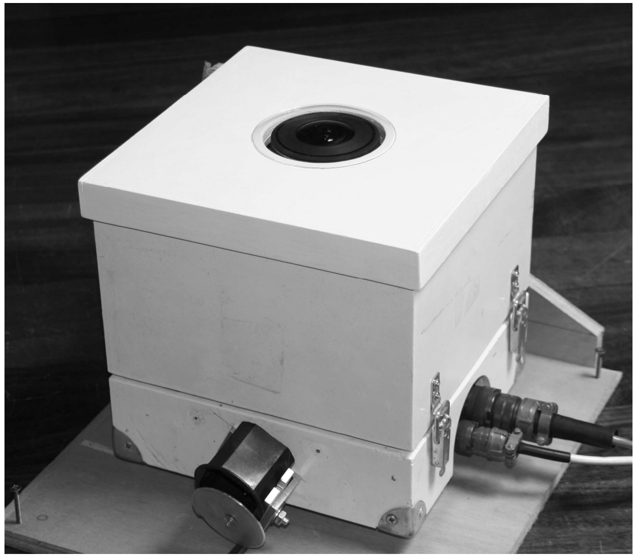
1. **Accurate astrometry** (error in semi major axis <0.01AU)
2. **Accurate velocity determination** (idem)
3. **Good photometry** (for mass estimate, no value yet)

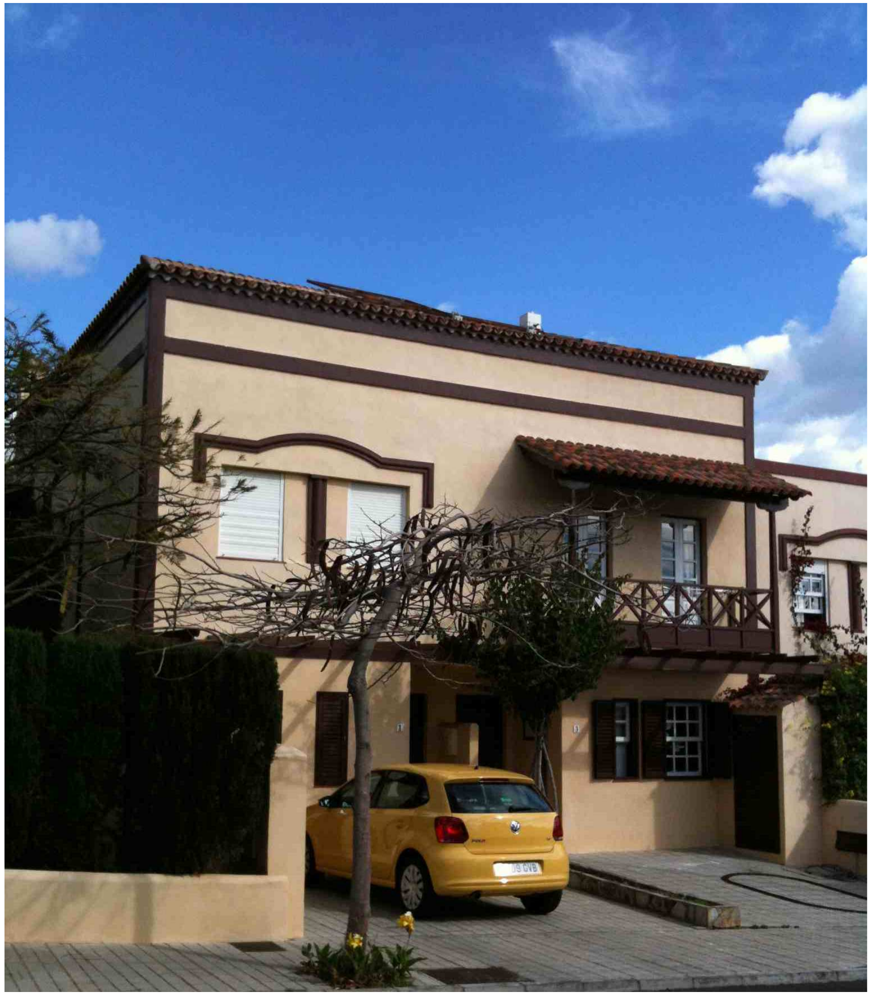
- Aim at bright fireballs (<-6), full sky
- autonomous operation for 2-4 weeks
- reliable
- easy to built and easy in use
- Costs <1000 EUR

❖ SETUP

Camera	Canon EOS 350D – 6 Mpxl	'High-res', 200EUR
Lens	Full frame Sigma 4.5mm/ F2.8 fisheye	Full sky, 500EUR
Exposure control	Canon TC80N3 timer controller, twilight switch, no PC	Autonomous, reliable
Timing	DCF clock for reference marks in star trails	For accuracy
Chopper	LC-TEC optical shutter (10-100Hz) Between lens and camera	High accuracy, no moving parts, 100EUR
Storage	8GB CF Card	Easy, no capture software

❖ SETUP





Astrometric accuracy = 5-6'

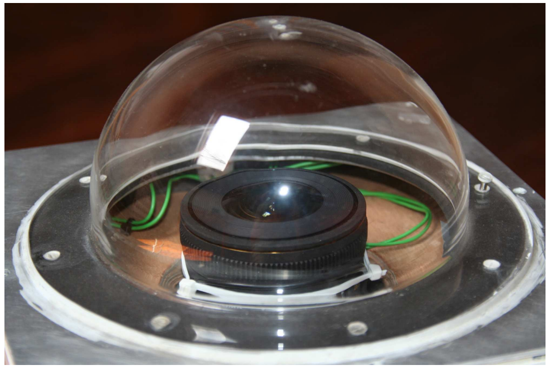
1. Astrometric accuracy

Aquarid 'test' meteor

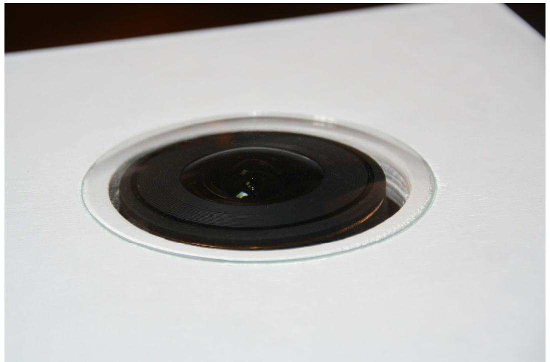
Radiant				
Radiant	Observed	Geocentr.	Heliocentric	Error A
R.A. [˚]	342˚,959	343˚,201		±0,100
Decl [˚]	-05˚,281	-07˚,367		±0,100
Heliocn. Longitude [˚]			288˚,647	-
Heliocent. Latitude [˚]			-0˚,179	-
Velocity [km/s]	32,292	30,183	34,967	-
Orbital elements				
Longitude of ascending node [˚]		(Ω)	322˚,528	±0,339
Inclination [˚]		(i)	0˚,322	±0,161
Argument of perihelion [˚]		(ω)	131˚,029	±0,432
Semi major axis [AU]		(a)	1,6758	±0,0095
Perihelion distance [AU]		(q)	0,2415	±0,0012
Aphelion distance [AU]		(Q)	3,1102	±0,0178
Eccentricity [AU]		(e)	0,8559	±0.0001

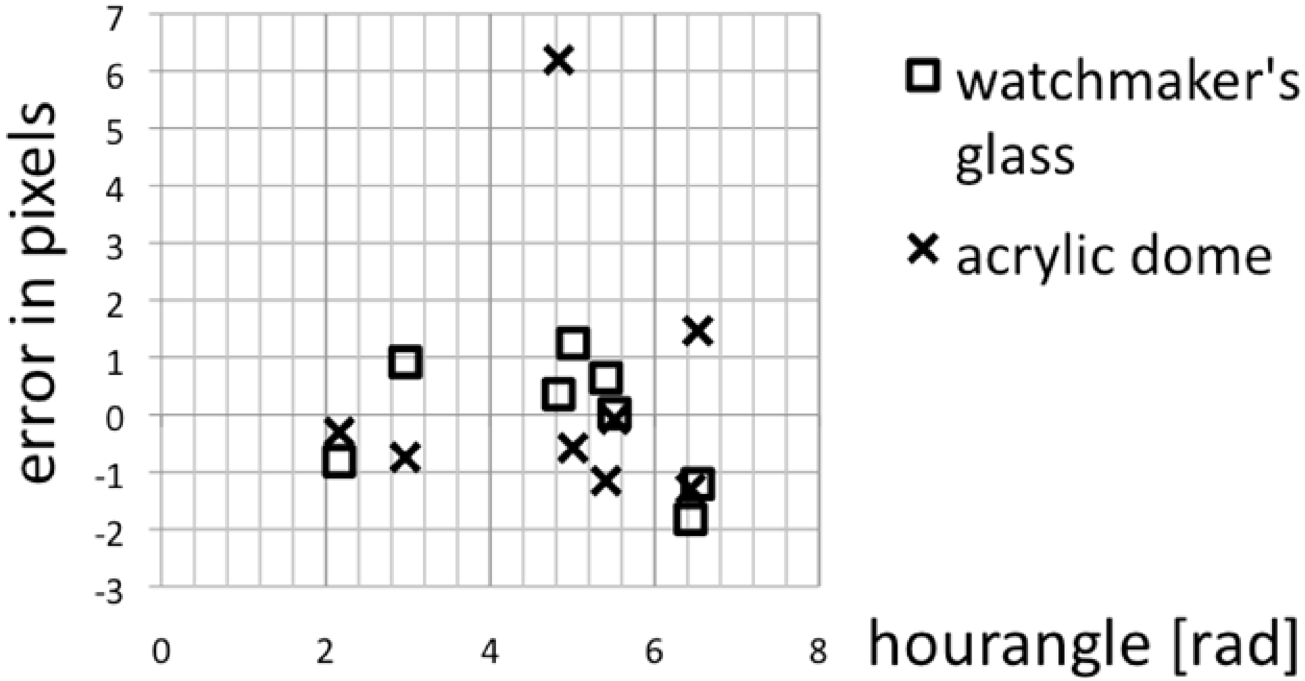
1. Astrometric accuracy

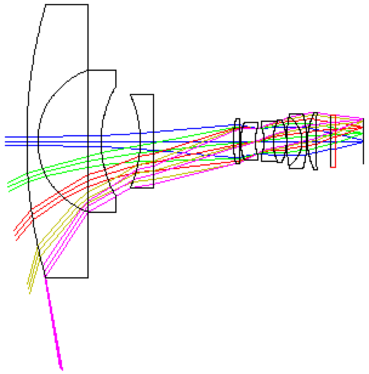
Acrylic dome



Watchmaker's glass





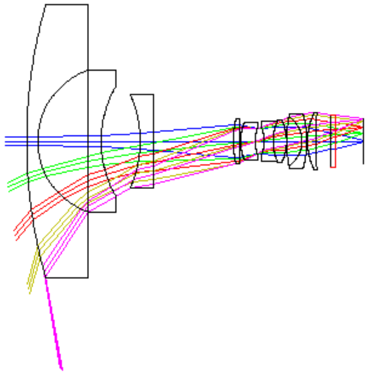


2. Velocity accuracy

Radiant				
Radiant	Observed	Geocentr.	Heliocentric	Error A
R.A. [°]	342°,959	343°,201		±0,100
Decl [°]	-05°,281	-07°,367		±0,100
Heliocn. Longitude [°]			288°,647	-
Heliocent. Latitude [°]			-0°,179	-
Velocity [km/s]	32,292	30,183	34,967	-
Orbital elements				
Longitude of ascending node [°]		(Ω)	322°,528	±0,339
Inclination [°]		(i)	0°,322	±0,161
Argument of perihelion [°]		(ω)	131°,029	±0,432
Semi major axis [AU]		(a)	1,6758	±0,0095
Perihelion distance [AU]		(q)	0,2415	±0,0012
Aphelion distance [AU]		(Q)	3,1102	±0,0178
Eccentricity [AU]		(e)	0,8559	±0.0001

Velocity accuracy = 0,3%

2. Velocity accuracy



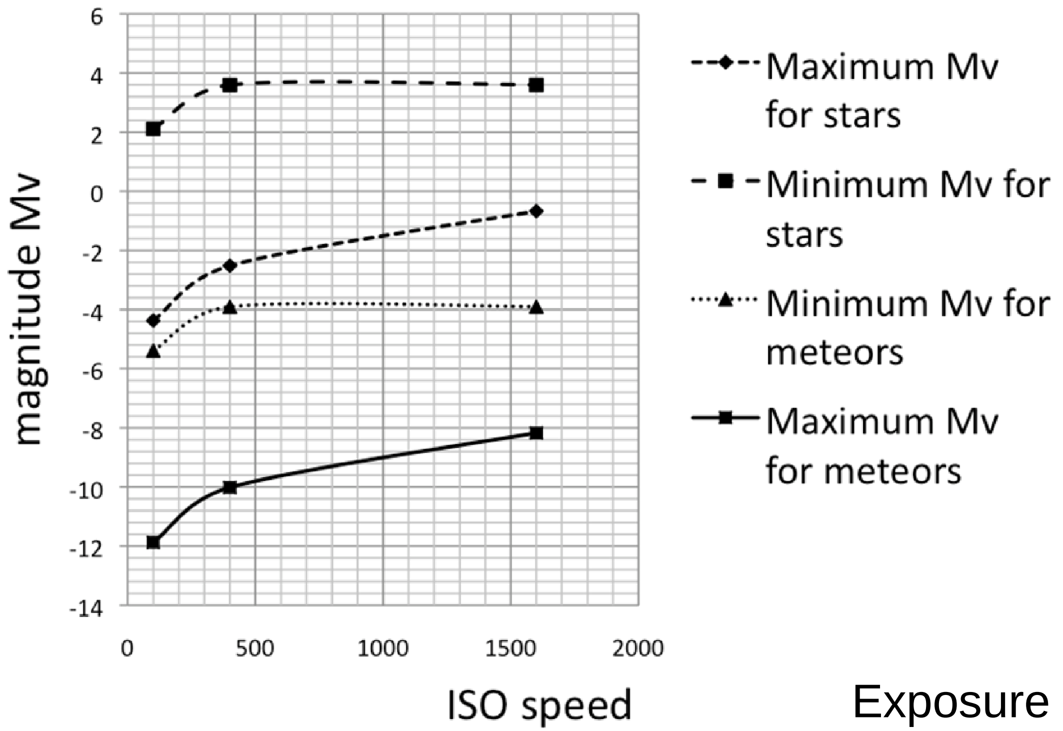
Radiant					
Radiant	Observed	Geocentr.	Heliocentric	Error A	Error B
R.A. [°]	342°,959	343°,201		±0,100	-
Decl [°]	-05°,281	-07°,367		±0,100	-
Heliocn. Longitude [°]			288°,647	-	-
Heliocent. Latitude [°]			-0°,179	-	-
Velocity [km/s]	32,292	30,183	34,967	-	±0,096
Orbital elements					
Longitude of ascending node [°]		(Ω)	322°,528	±0,339	±0,024
Inclination [°]		(i)	0°,322	±0,161	±0.019
Argument of perihelion [°]		(ω)	131°,029	±0,432	±0,057
Semi major axis [AU]		(a)	1,6758	±0,0095	±0,0135
Perihelion distance [AU]		(q)	0,2415	±0,0012	±0,0011
Aphelion distance [AU]		(Q)	3,1102	±0,0178	±0,0282
Eccentricity [AU]		(e)	0,8559	±0.0001	±0,0018

3. Photometry

-10-15 bit dynamic range, but reduced by noise & dark level due to integration
- For good photometry also saturation is to be avoided

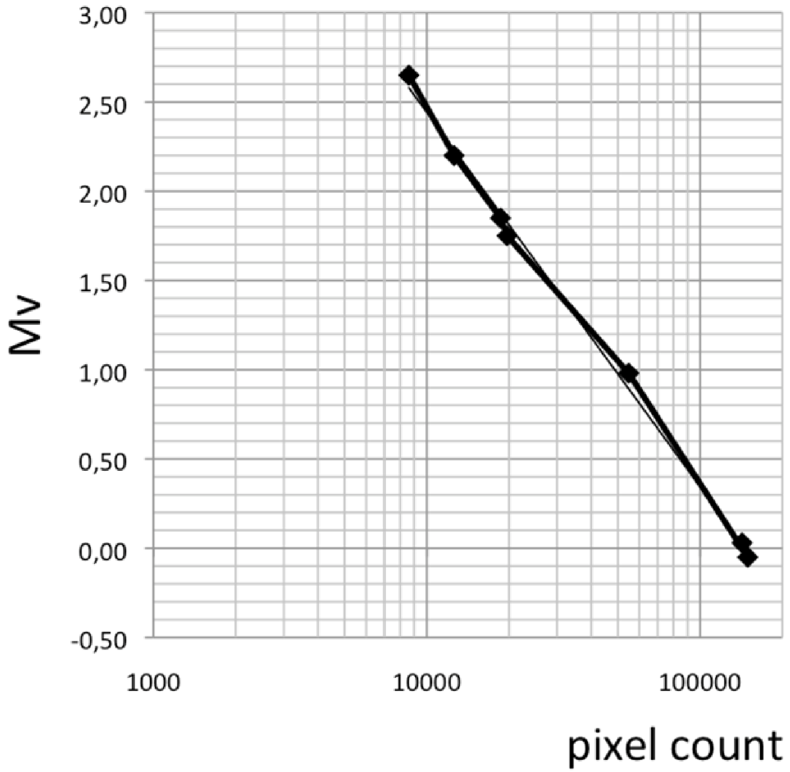
Chose for:
- short exposure times
- low camera sensitivity
- ‘cool’ camera
- substraction of successive images

3. Photometry



Exposure time 2.5’

3. Photometry



$$\log M = 6.31 - 0.4 m_v^{abs} - 3.92 \log V_\infty - 0.41 \log(\sin(h_r))$$

Jenniskens 2006

For cometary fireballs, V=25 km/s, d=100km, h=30˚, an error in magnitude of 0.1 results in a mass error of 10%

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August 11/12, 2010.
02.39UT, Mededa, Bosnia
Perseid, ~ -8, 1600 ISO

Conclusions

- Both valuable astrometry and velocity determination as well as useful photometry can be done with DSLR camera's
- A reliable, easy to operate All-sky camera, has successfully been built
- Operation with low sensitivity (ISO100) as well as short exposures is recommended