Accurate Timing with USB Video Cameras

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What do I mean by USB video camera

- I really mean a digital video camera recording directly to a PC hard disk
- In order to be video, it must autonomously generate a series of frames at a steady pace driven by its own clock – i.e. no handshaking with or waiting on the receiving device
- Interface could be USB, FireWire, Ethernet – as long as the camera generates frames based on its own clock (this is important)

Why digital video?

- Direct read of signal at each, square pixel
- Full control over exposure, gain, etc.
- No tie to some fixed output frame rate
- No proprietary black box processing
- Arbitrary frame rate, binning, cropping, etc. possible with a good capture app.
- More than 8-bit output
- No analog transmission or raster conversion
- Digital video cameras are becoming cheaper and more common, along with LCD displays – making the future of CRT-based technology uncertain

Why NOT digital video

- Much harder to time stamp accurately
- Capture requires dedicated PC (currently)
- Security camera with old camcorder is an extremely robust and inexpensive occultation setup
- Greater chance of dropped frames, depending on the PC and hard disk

How to timestamp accurately?

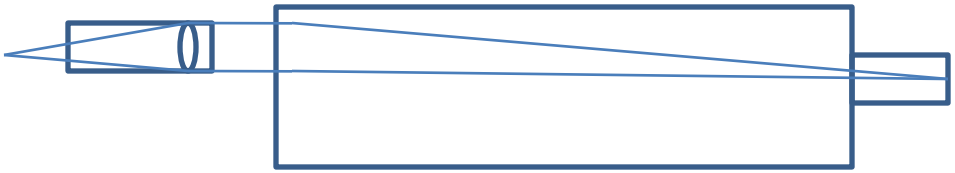
- Intercepting USB image stream is much harder than NTSC/PAL signal – but such devices may appear in a few years
- For now, best way appears to be with optical timing signal embedded in video
- How to inject this light signal?
- What pattern should it have?

Ways to insert GPS optical signal

- GPS 1pps output plus LED and resistor gives nice 20ms pulse on each second
- Can dangle this in front of OTA to make flashes in the background that are detectable
- Can also insert the LED in a small adapter in front of the camera so it flashes indirectly
- But these methods illuminate the whole field, rather than just a part

Reverse finder mode

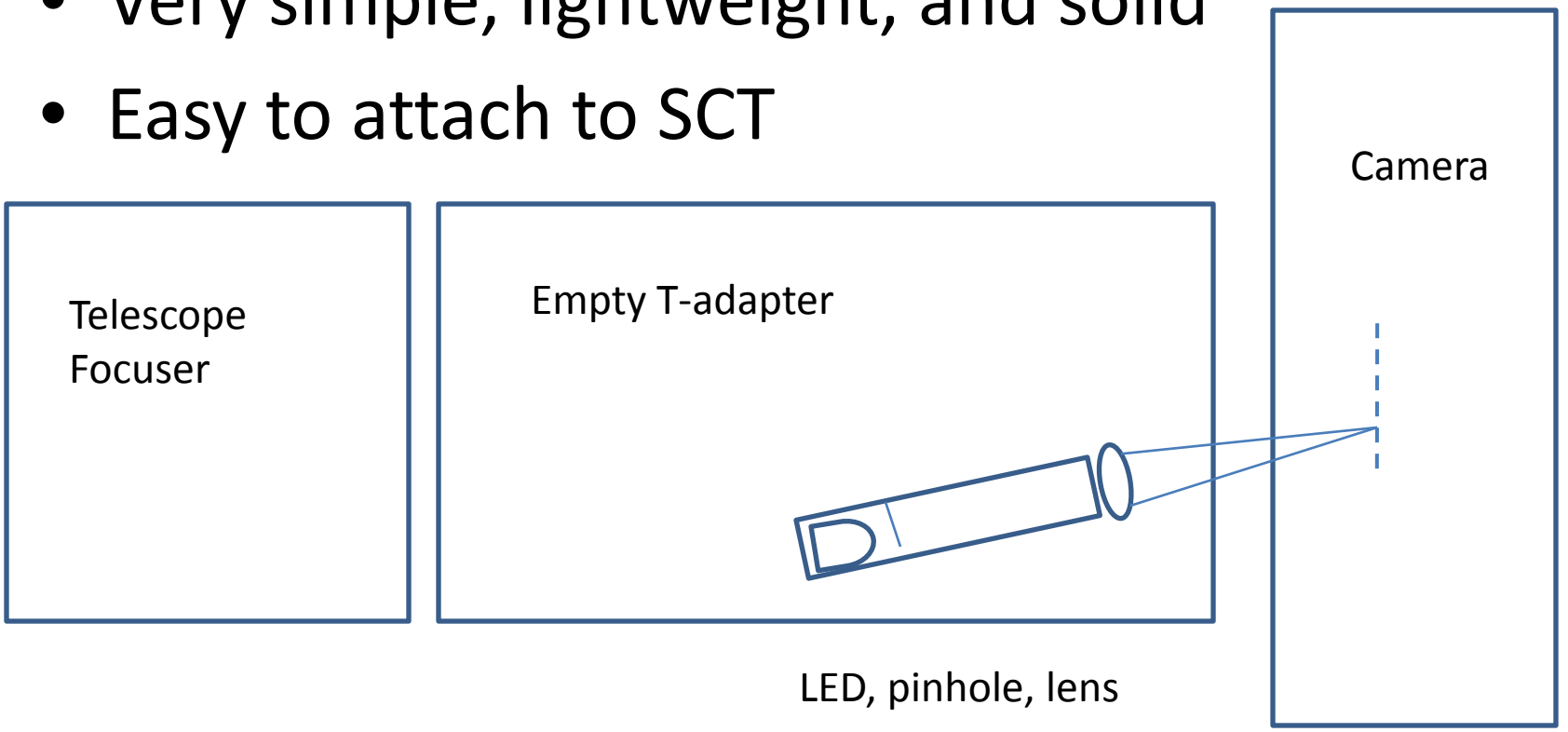
- Pinhole illuminated by LED is aimed through finder INTO front of telescope



Problem – the pinhole is magnified by the ratio of the telescope focal lengths

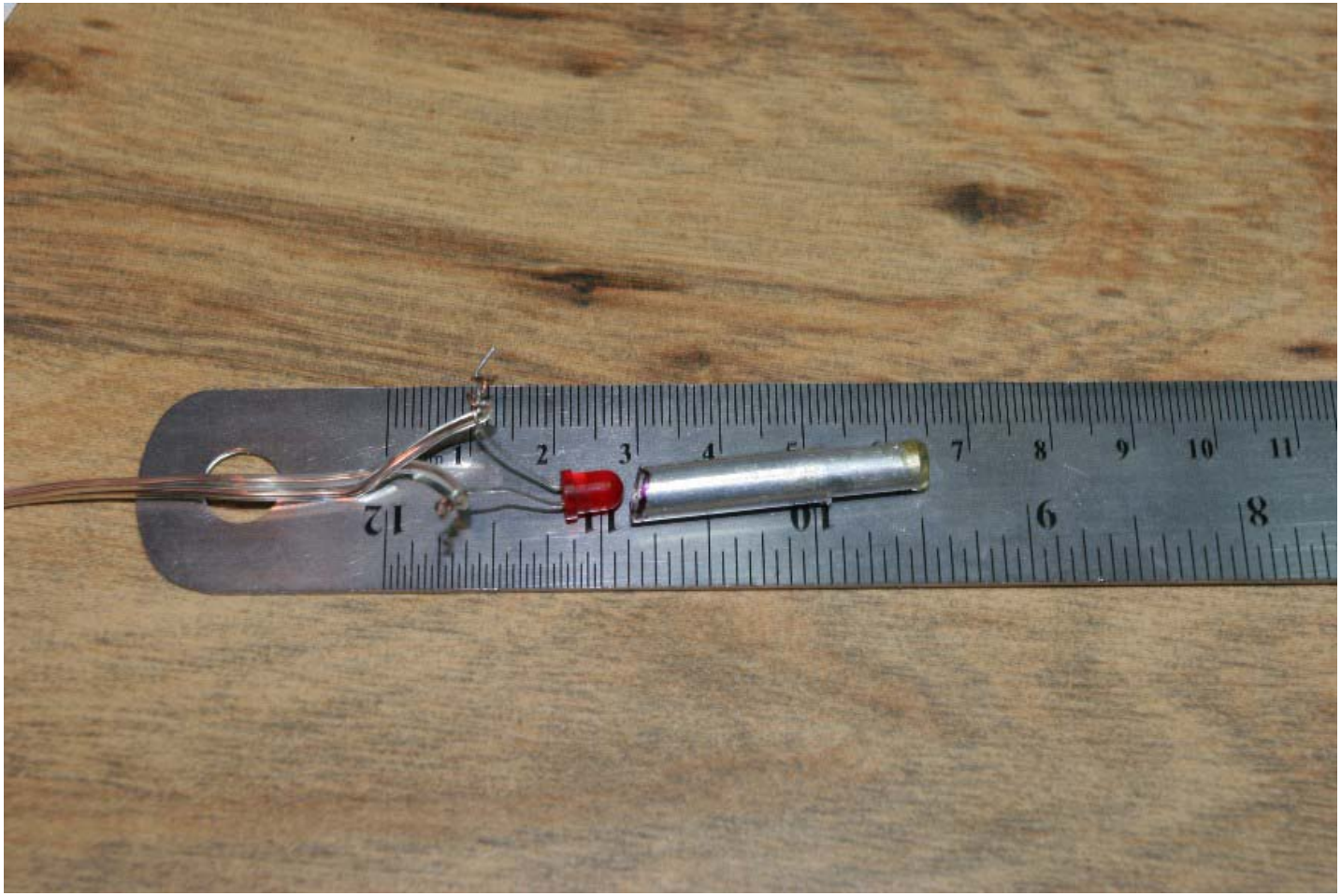
My approach to optical insertion

- T-extender with small LED/lens assembly
- Allows focus and tilt, and control of intensity
- Very simple, lightweight, and solid
- Easy to attach to SCT



LED inserted in focusing lens assembly

LED -> 25um pinhole (Edmund) -> 5mm AR coated lens, glued to front
Front tube slides in LED tube for focus – held in place by friction

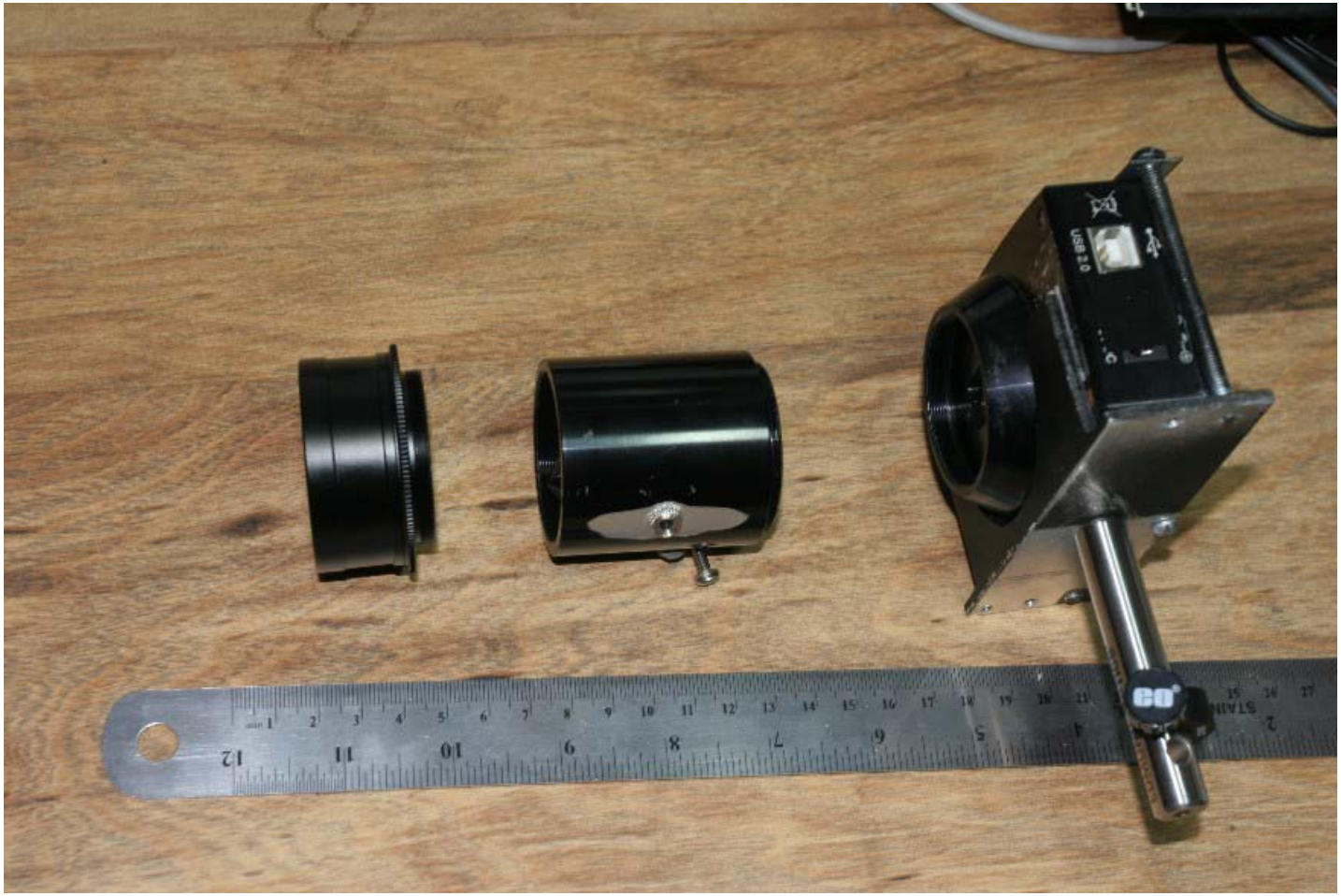


How to drive LED?

- PIC microcontroller and simple code driven by 1pps signal from GPS
- I consider this a “software phase-locked-loop” (PLL) but MUCH work on the web refers to this as a “GPS-disciplined oscillator”
- Goal is to make triangle ramp signal with steps every 1ms driving DAC, which drives LED
- Ramp signal allows detection of dropped frames – if any
- 1ms is a LONG TIME to a microcontroller so this is easy

Occultoscope setup for Emma last night

Coma corrector->Optical Time Inserter->Lumenera



View of USB camera and timer in occultoscope on motorized focuser

GPS/USB Timing Unit

3 LED's:
Raw 20ms pulse
Ramped LED signal
Faux 0.5s occultation blinker
for testing

One knob for controlling
LED intensity

Switch to turn on/off LED

Wire in for GPS
Wire out for LED
12V power in

Insides

Simple and inexpensive

PIC 16F or 18F
about $8 US

PIC ready board $29

DAC module $18

Simple app. Written in C

http://www.mikroe.com
for PIC development tools

LED Inserter showing lens
No machine shop, so all hand tools

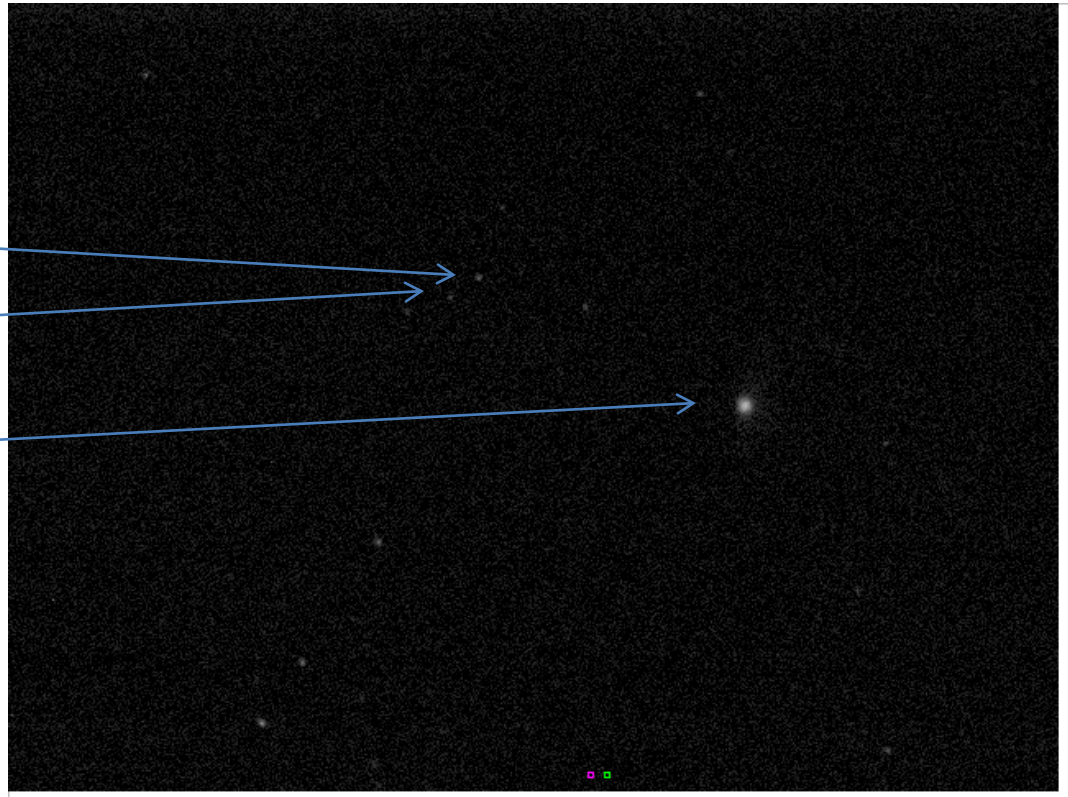
View of Emma and star, 12+ mag
10” f/3.6 reflector with Lumenera at 4 fps, single frame

Field view at 4 fps

Emma

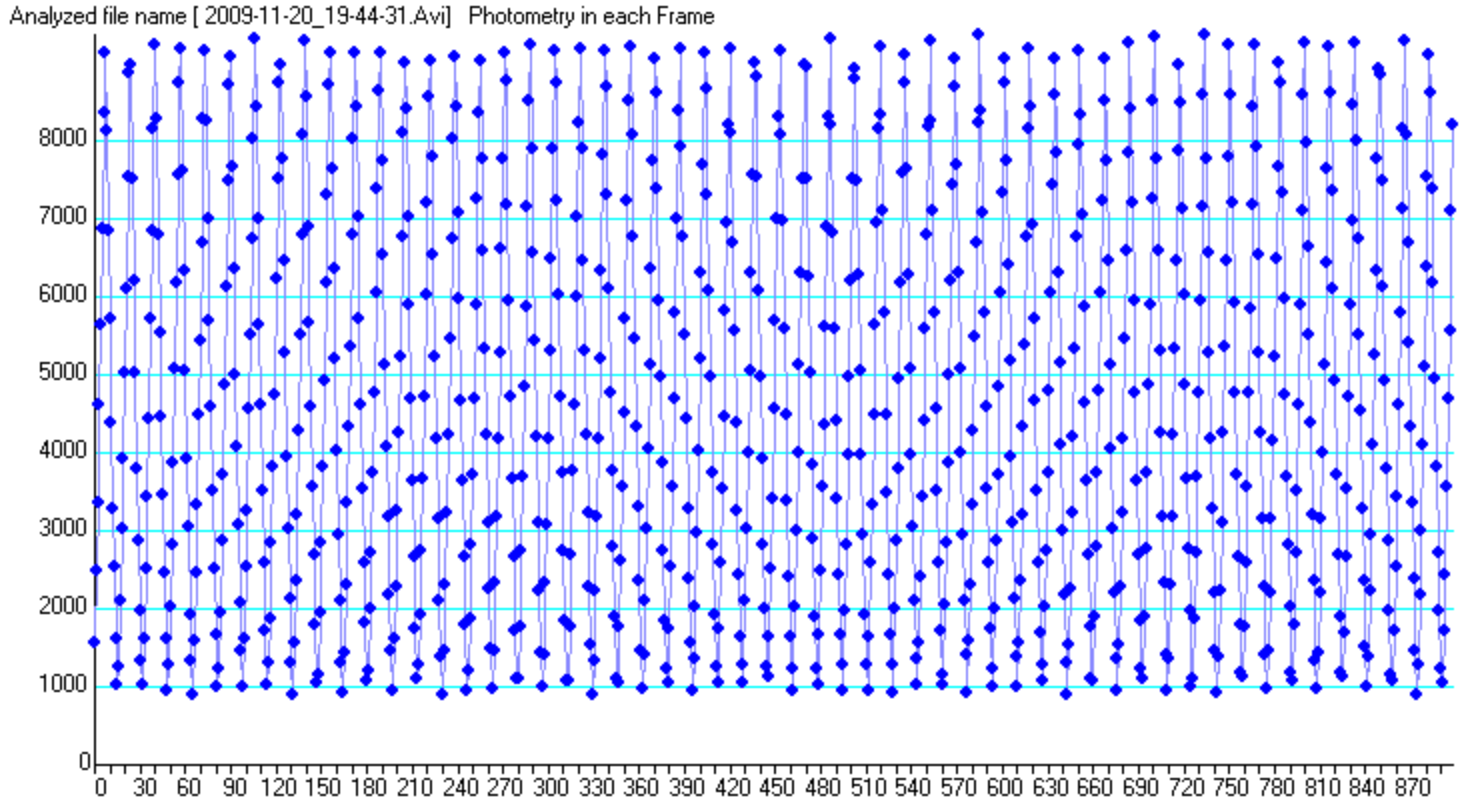
Star

Optical signal



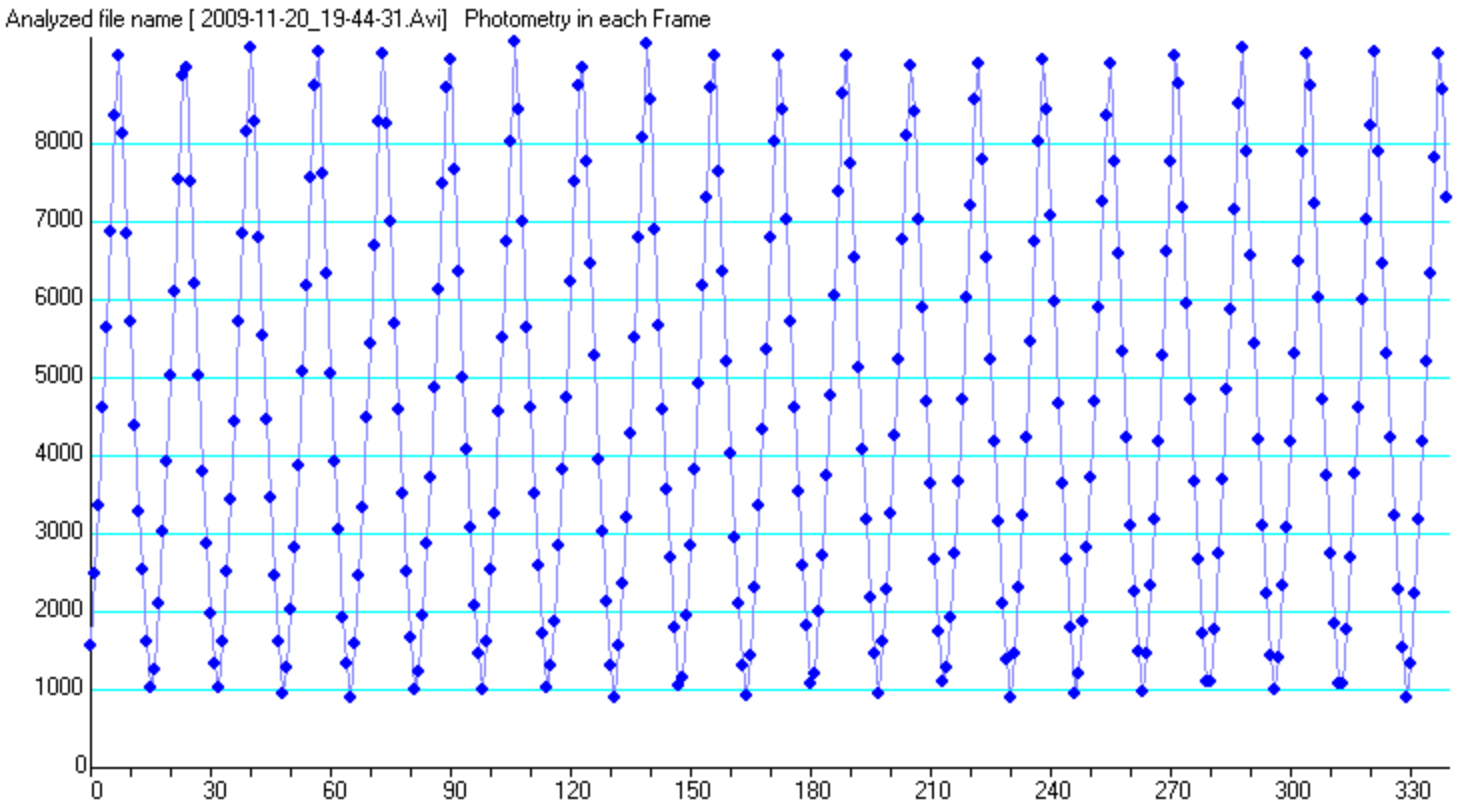
It’s nice to be able to lower frame rate to 4 fps to see field better,
then speed it up for the event to the point where star is still visible

Recorded 12+ mag event at 17 fps
17 fps signal from Emma event
Regular pattern shows consistency of frame times



Close up

Even though frames are 1/17 s, they are regular and can be interpolated accurately to give time on the millisecond scale



The Which Second problem

- This timer is very simple because it doesn't read the gps time – it only gives time within each second
- How do you know WHICH second it is?
- LucamRecorder notes the PC time of each incoming frame
- Need not be accurate – just about 0.4 seconds
- Can also manually blink the light at the 59 second point to mark the minute using hand held gps clock
- Ideally timer device would read gps time and mark the minute automatically

Future plans

- The “AllTimer” for both USB and NTSC/PAL cameras
- Only USB connects to computer – no serial or 1pps
- USB provides GPS time signal for PC clock
- LED driver output for USB camera timing
- Video in/out with embedded time and frame count in BINARY format not readable by human
- Allow disconnect of GPS so frame count continues
- Include standalone realtime clock for redundant check and sustained time count if gps removed

- Inexpensive and fairly simple. Fun to build. Plan to make prototype over next months.

Occultoscope also good for imaging http://www.astrogeeks.com/Bliss/MetaGuide