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Lunar Impact Flash Toolkit & Upload Interface

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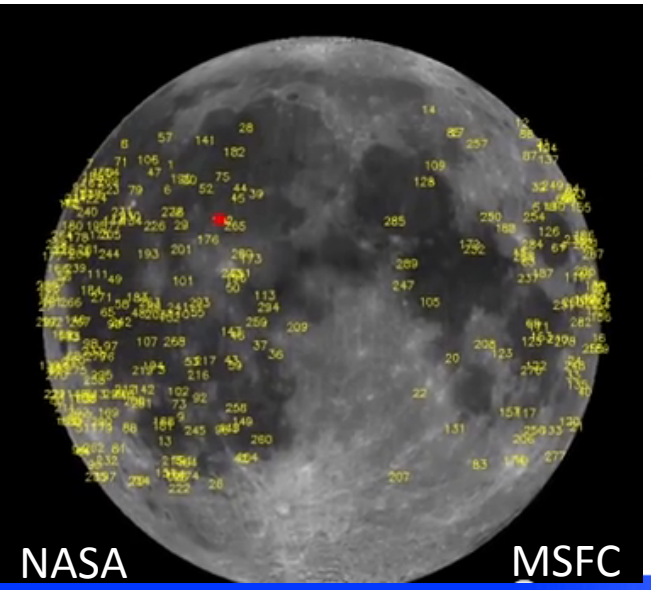
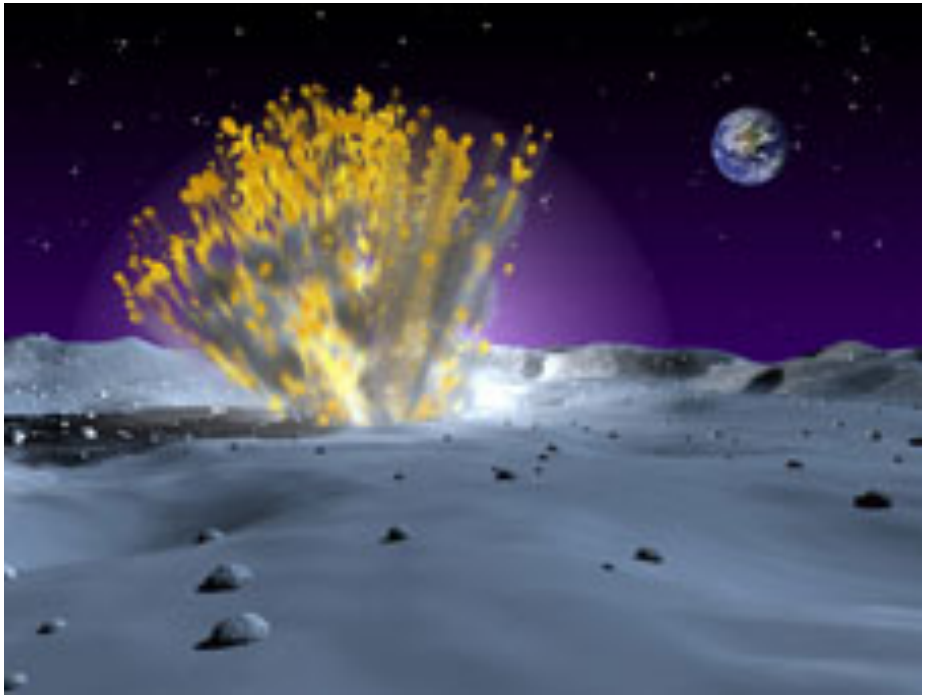




NASA MSFC

Solar System Physics
Ffiseg Cysawd yr Haul

What We Know:

1. Meteoroids strike the lunar surface at e.g. 10 to 75 km/s
2. The K.E. (½ mv^2) is released almost instantly e.g. < 0.1 sec
3. Impact Fireball probably initially black body radiation ~1.5-3K
4. The luminous efficiency is of the order of the percent level
5. Magnitudes of the flashes seen from Earth typically +7 to +10
6. Occasional, much brighter/longer flashes have been seen
7. Glancing blow impacts last longer than perpendicular impacts
8. Impact flashes also been detected on Jupiter, Comet Tempel-2, and from various spacecraft targeted at the Moon

Why Study Impact Flashes?

1. We need to know the present day impact population in the lunar environment and their geographical distribution

2. This is very useful for interpreting present day and past crater count statistics, which in turn can be used to date the surface

3. Very important also for lunar surface exploration
   - Fortunately direct impacts on astronauts are rare
   - But there is a km scale distribution of impact ejecta with velocities of ~1 km/s – very dangerous for astronauts !
   - Not to mention a blinding flash of light

4. Fresh impact craters are exploration targets of opportunity as they can be studied for residual volatiles and space weathering effects over time

5. Useful analogs for other airless surfaces too !

Spin Offs

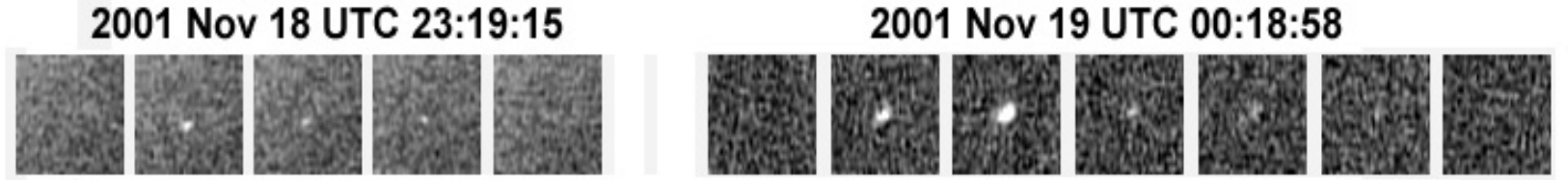
1. As we have to study the Earthshine for our best chances of seeing impact flashes, this could be a good way to monitor the Earth's Albedo over time

2. Whilst monitoring Earthshine, occultations of stars can occur and this is an independent way to check up on star diameters and double star separations

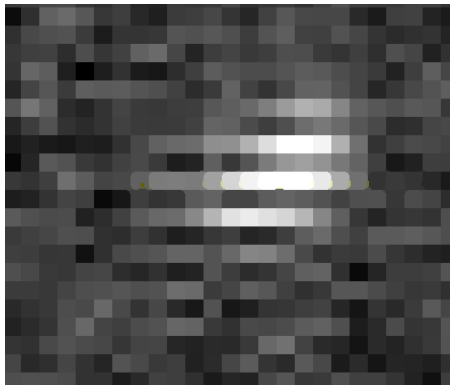
3. Can tell future surface exploration missions where to find extremely fresh impact craters for future study

4. Monitoring the night side of the Moon may occasionally pick up sun glint from dead orbiting spacecraft, and so provide a means of tracking these

What do Impact Flashes Look Like?



Non-interlaced 1/60th sec image sequences of 2 lunar Leonid impact flashes: 20cm f/5 Newtonian + Watec 902HS CCD camera - Tony Cook, Alexandria, VA, USA



Close up of "Jail Bar" Effect as a result of TV field interlacing of odd and even lines

N.B. Impact flashes, as seen from Earth occur approximately once per 10-20 hours of observing

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The 2013 Sep 11 Impact Flash

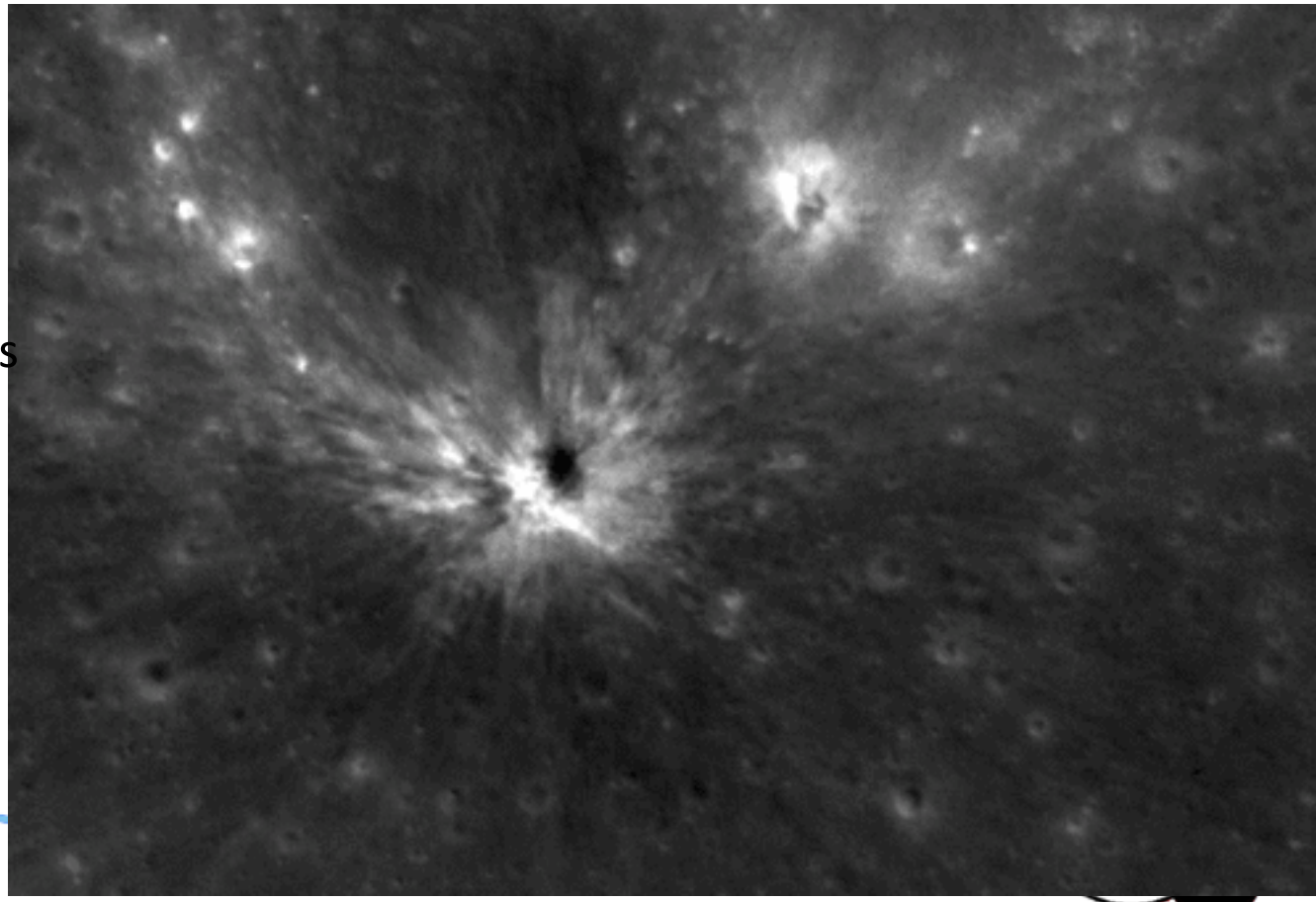
•These have been known about since Earth-based astronomers have been looking for flashes of light on the Moon from meteorite impacts

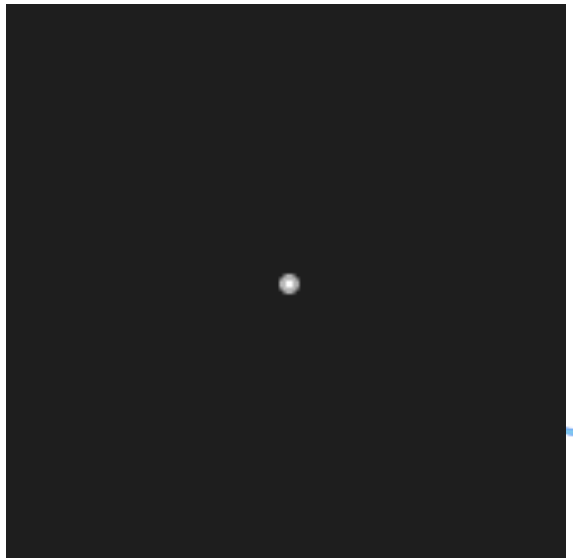
•> 300 impact flashes have been imaged

•On 11 Sep 2013 a team of astronomers in Spain, led by Prof Jose Madiedo videoed an impact flash that lasted several sec

•400 kg metre sized rock made a 40m diameter crater!

•This was confirmed by NASA's LRO spacecraft with before & after images





Who Observes Impact Flashes?

- NASA's Marshall Flight Center

- MIDAS Project - Spain

- Change' 4 – Farside mission **will** have an impact flash camera on the orbiter

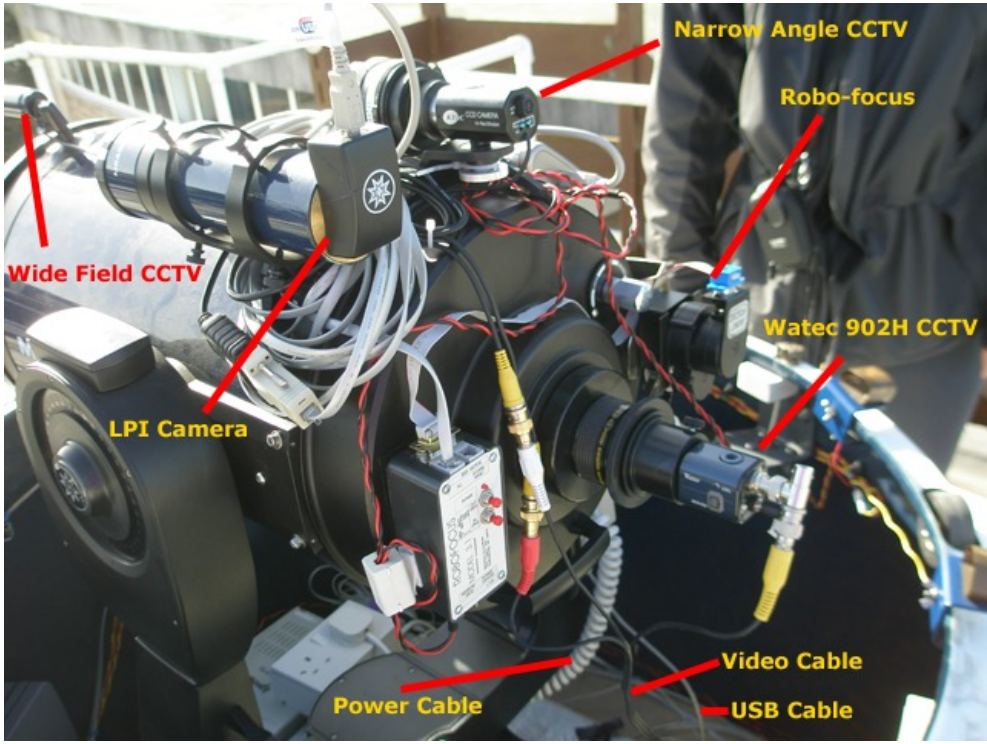
- Amateur Astronomers – can work for free and you can have tens to hundreds of them if you motivate them !

What Amateur Astronomers Use?:

A camera

From Dafydd Evans

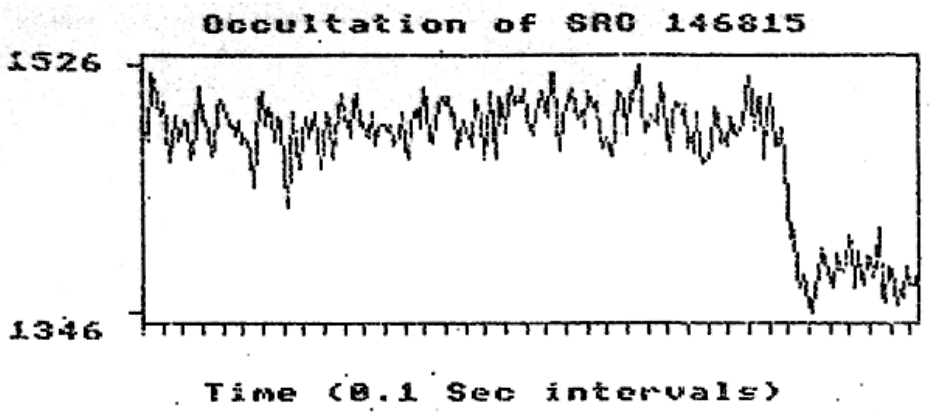
A low f/No. telescope (or two)

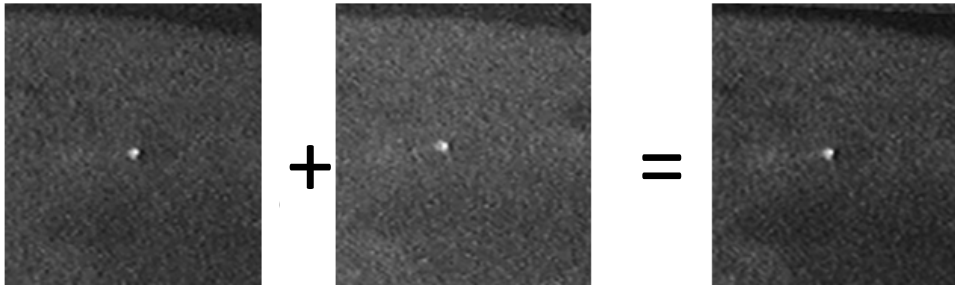


A video recording device e.g. an Osprey (View Cast) Video or USB 3.0 Capture Device

An accurate time source e.g. MSF or GPS time

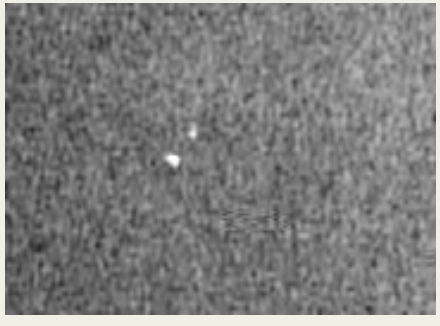
Why > 2 Telescopes are Useful?





Oritz *et al. 2006*

- To help identify and reduce atmospheric turbulence effects by combining signals together, improving S/N in light curves, or images



•. To help identify and eliminate false detections from cosmic rays etc

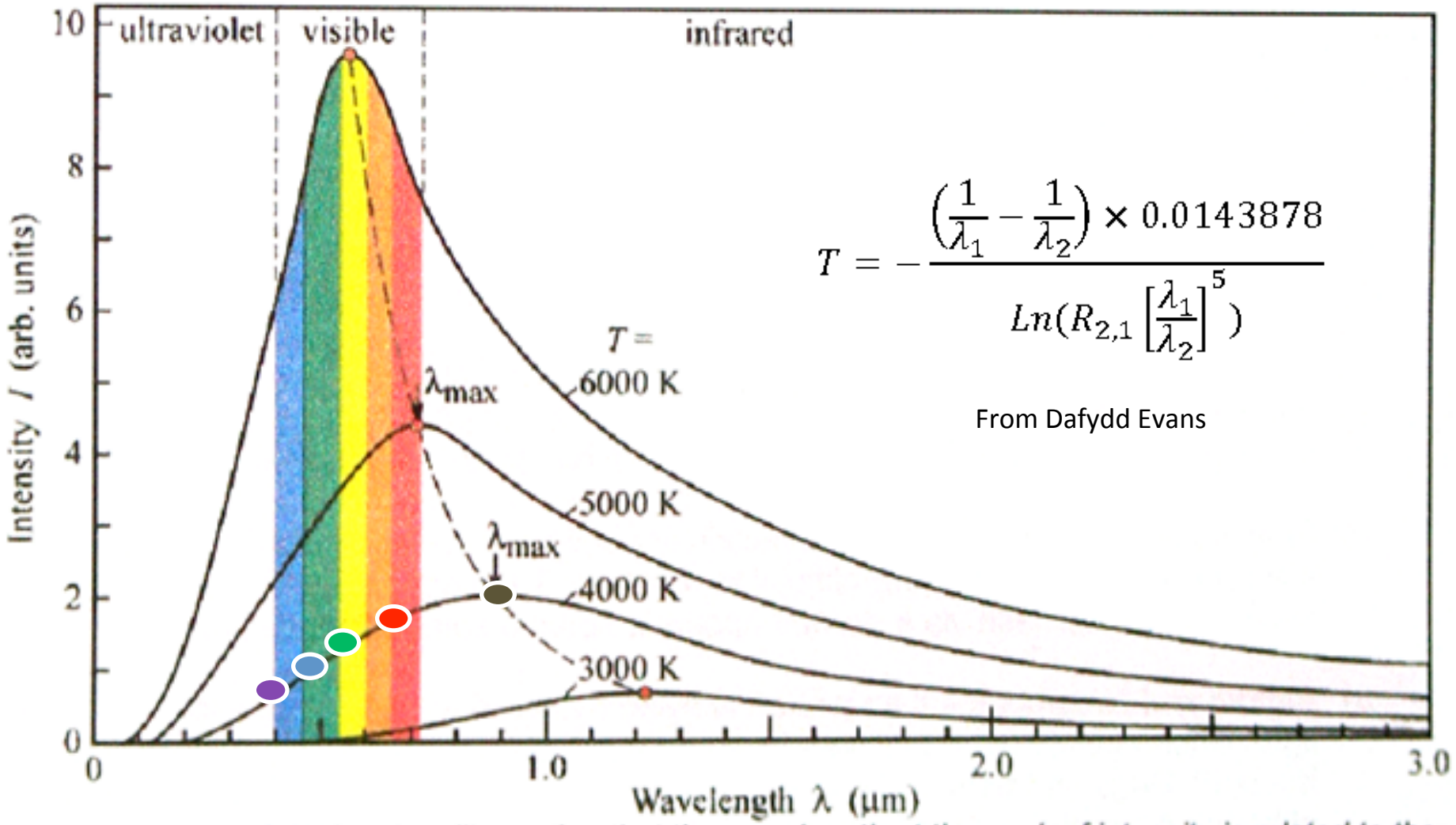
Calibration Issues

- Ask amateurs to use UBVRI (or at least RGB) filters

- Ask amateurs to image stars close to the lunar limb of known UBVRI magnitudes

- Or stick a neutral density filter over the camera and use the bright side of the Moon for calibration purposes

Impact Flash Temperatures



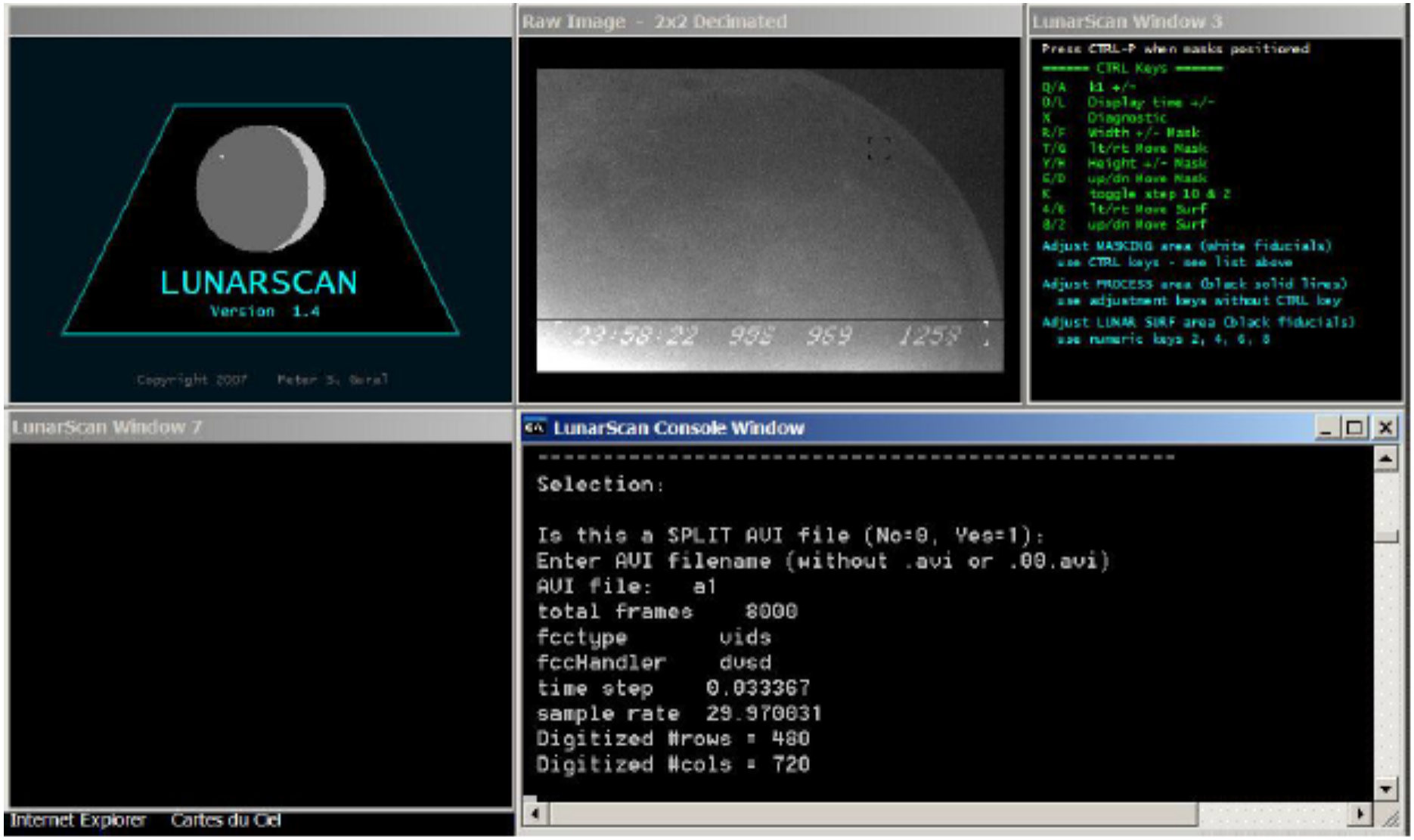
$$T = -\frac{\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) \times 0.0143878}{Ln(R_{2,1}\left[\frac{\lambda_1}{\lambda_2}\right]^5)}$$

From Dafydd Evans

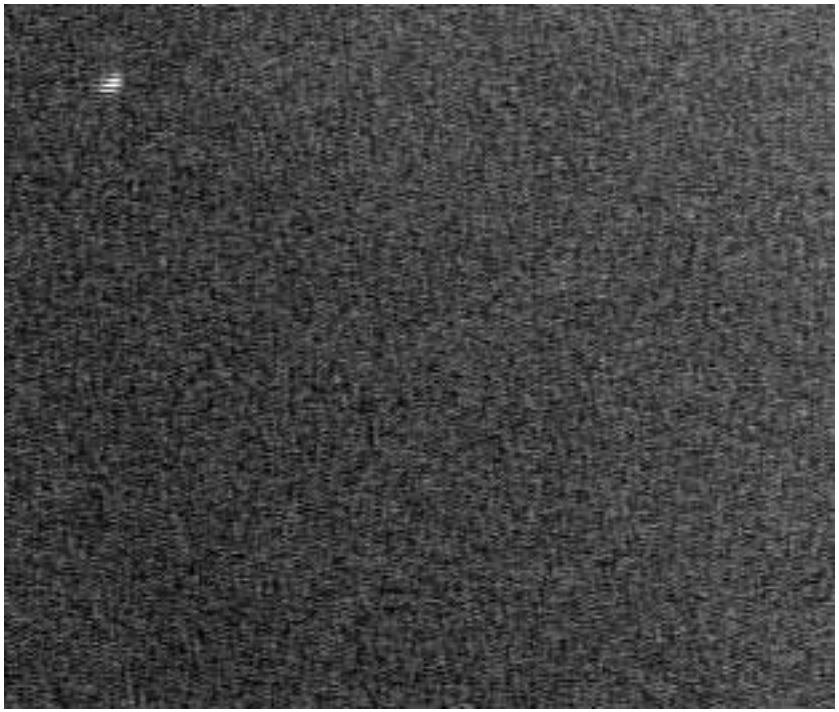
Picture courtesy of Wikipedia – illustrating that the wavelength at the peak of intensity is related to the temperature of the emitting object.

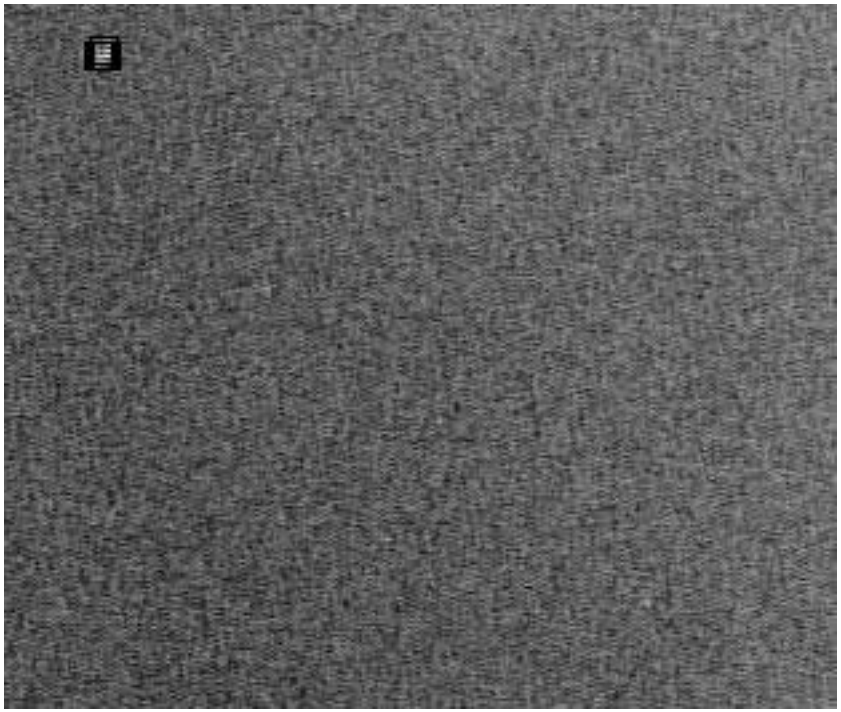
Existing Software: Lunar Scan

http://www.gvarros.com/lunarscan15.zip



Comparison Lunar Scan Vs “Video 2015”





Surprisingly the flash in the left image was not detected by Lunar Scan (possibly because of image drift) but it was detected in the right image by Video 2015

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Existing Software – "Video 2015"

Hierarchical Search Strategy – developed by Tony Cook:

Stage 1 - Finds any pixel, in an image which exceeds a threshold of "A" standard deviation of its surrounding 8 pixels – if so go onto stage 2
Stage 2 - Now check if the given impact flash pixel exceeds a threshold of "B" standard deviation in the time domain – if so goto Stage 3
Stage 3 – Sometimes there maybe several detections in an image due to movement of edge of Moon/terminator of Cosmic Ray Air Shower – we can threshold out the No. of flashes found e.g. if No. of flashes detected in an image > "C "and < "D" then goto stage 4
Stage 4 – Output an colour ".BMP" image containing the primary flash image in the green channel, the previous image in blue, and next image in red channel with a box centred on the flash
Stage 5 – Check manually the flashes detected

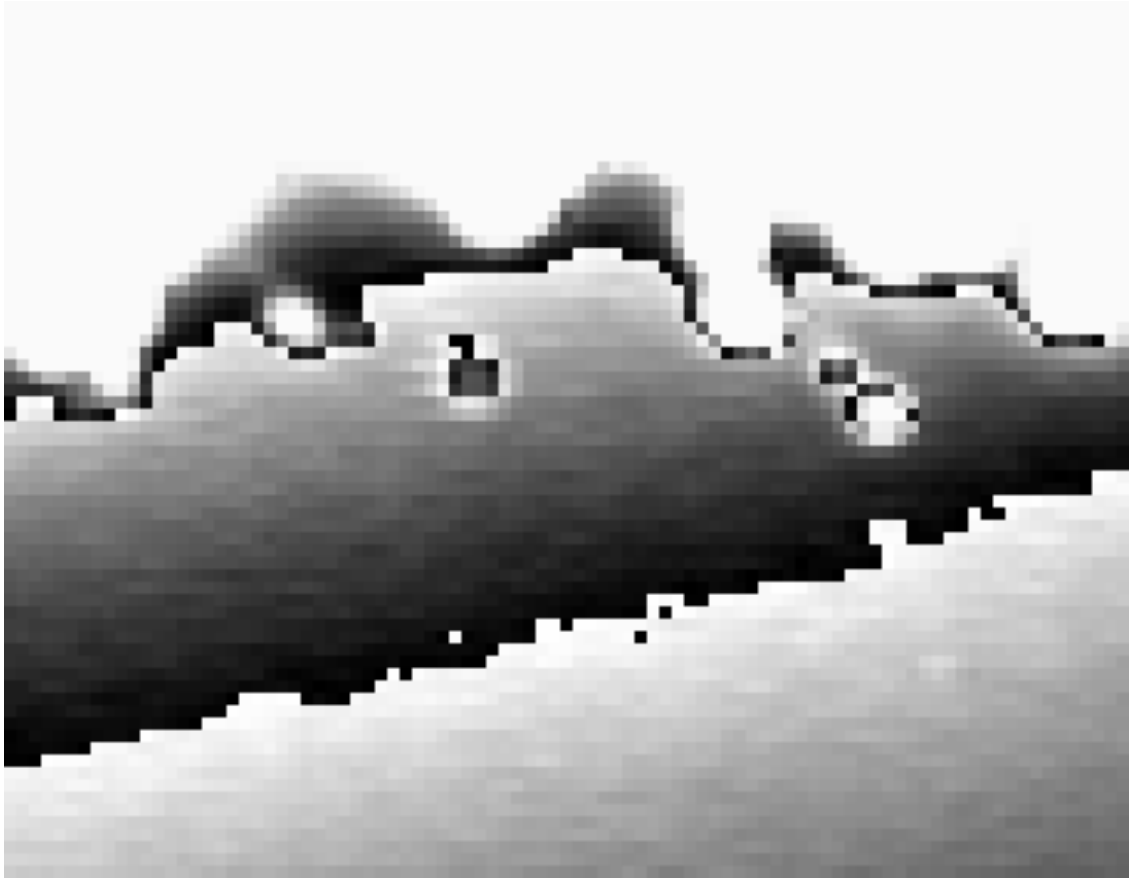
Existing Software – “Video 2015”

This is why we need stage 3, - in this case 3 large flashes detected from muons in a cosmic ray air shower, but many individual flashes detected by the software

Existing Software – “Video 2015”

Video 2015 must be able to cope with oddities, for example determining impacts and subsequent ejecta clouds near the terminator

Here is a candidate impact by GLR observer Marco Iten (Switzerland) from 20165 Feb 25



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Existing Software: MIDAS

http://www.uhu.es/josem.madiedo/obs/e_midas_software.html

Goals:

Improve Video2015:

- Add a GUI
- Inform observes the optimal times to observe Earthshine
- Add a Gaussian fit to help robustly discriminate between point-based image noise and real impact flashes
- Cater for flashes of different sizes – re-run the test bur for video frame sizes that vary in resolution (scale) by factors of 2
- Cater for flashes of different durations – re-run the test but for video frame rates that vary by factors of 2
- Modify the sensitivity to work on the dayside of the Moon and terminator in case there are longer duration ejecta clouds in sunlight?
- Photometry and position determination of flashes?

Goals:

Modify an observational upload site for impact flash observations
We have already hosted at Aberystwyth an Amateur Astronomer Observational **AAO** Upload Website for lunar observations – mostly lunar dayside images

But this also supports the upload of small video files

It would not take much effort to modify the PHP code to handle the .BMP files and to make a “special section “of the website available for impact flash observations

Goals:

Modify an observational upload site for impact flash observations
We would display impact flash candidate images and encourage users to post their comments, and rate the images – this would provide a social appeal/atmosphere

A discussion forum would be provided to assist new users

We also need to record when people observer and do not detect impact flashes – we need statistics on how common flashes are

We also need to know limiting magnitude information as observing conditions can vary

AAO

IMAPS Computing Support - Amateur Astronomy Outreach

Upload Data - Create Record

Year: 2016

Feature: Kunowsky

Month:

Day:

Start UT:

End UT:

File:

t required for images

Upload Dat

Last updat GMT 2013 by mjv08

- Kreiken
- Krieger
- Krogh
- Krusenstern
- Krylov
- Kugler
- Kuhn
- Kuiper
- Kulik
- Kundt
- Kunowsky
- Kuo_Shou_Ching
- Kurchatov
- L_Clark
- La_Caille
- La_Condamine
- La_Perouse
- Lacchini
- Lacroix

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Logistics:

It is anticipated that the Video 2015 and upload website will be completed this year, probably over the Summer

Tony Cook will attempt both this and a modification to AAO as he has a good knowledge of C for the completion of Video 2015 (we will think of a better name)

... and can quickly learn PHP to finish off the Impact flash upload site

However if difficulties are encountered with the PHP language, this will be offloaded to Alun Jones, our Institute IT expert and systems programmer – we will try to establish whether this is needed by May

Where and how to store impact flash data T.B.D.
– any suggestions are welcome?

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