Managing IR in Video Astronomy
by Jim Thompson, P.Eng
Test Report #4 – February 18th, 2012

Objectives:
My objective on this evening's test was to do a thorough test of a large number of different filter combinations on a typical galaxy, and determine how they affect the view produced by a Mallincam astro-video camera. I have done a number of filter tests on galaxies to-date, this one is meant to be the be-all-and-end-all. Of particular interest to me was how the DGM GCE filter performs, a filter designed specifically for viewing galaxies. I am also interested in the Meade Narrowband and O-III filters which my analysis suggests should perform better than the Astronomik UHC. The following filters were tested:

1. no filters
2. Astro Hutech IDAS LPS-P2
3. DGM Galaxy Contrast Enchancer (GCE)
4. Astronomik UHC
5. Astronomik Hβ
6. Meade Narrowband Nebular
7. Meade O-III
8. Meade Broadband Nebular
9. Lumicon #29 Dark Red
10. generic 650nm High-Pass
11. generic 680nm High-Pass

Methodology:
I used a single deep-sky object as my target: M33 the Triangulum Galaxy. I used my Maxvision ED80 with MFR5 focal reducer, giving a focal ratio of f/3 and field of view of roughly 93' by 70'. The telescope was mounted to my Orion Atlas mount, and remotely controlled through my laptop from inside the house.

I used my Mallincam Xtreme to capture all image data. The camera and capture device were running with the following settings:

- AGC 4
- gamma 1
- APC vert & horz 4
- white balance ATW
- contrast 70 (full)
- hue 62

- saturation 35, 0 for Hβ, #29, 650nm Pass, & 680nm Pass filters
- sharpness 1
- TEC set to "off"

Brightness and Integration time were adjusted throughout the testing, as will be described below. I did not reset the white balance after doing it an initial time at the beginning of the testing when in the "no filters" configuration. I did adjust the saturation from the default of 35 down to zero when testing filters that mono-chromatic.

Results:
Testing was done on October 28th, 2011 during a very clear (100%) night with below average transparency (2/5) and below average seeing (2/5). There was no Moon for the entire evening, but Jupiter was located conveniently nearby providing a great target for refocusing between filter changes. M33 was located high in the southern sky for the duration of the testing, at altitudes ranging from 50° to 70°.

All the images captured were done at a range of INT times, stepping up from 2sec to whatever maximum INT gave a brightness setting of 0 and started to wash out the background. The first batch of images below compares all the filter configurations to each other at the maximum INT time that could be achieved with each filter (ie. BRT=0 with reasonably dark background). The impact of adding a light pollution filter is to increase the length of INT time required, but also in some cases the resulting contrast is greatly improved. One thing that really struck me was how poor the white balance was using the GCE. The auto white balance simply was not able to correct for this filter, but for the other filters it was.


No filter, INT 9 sec

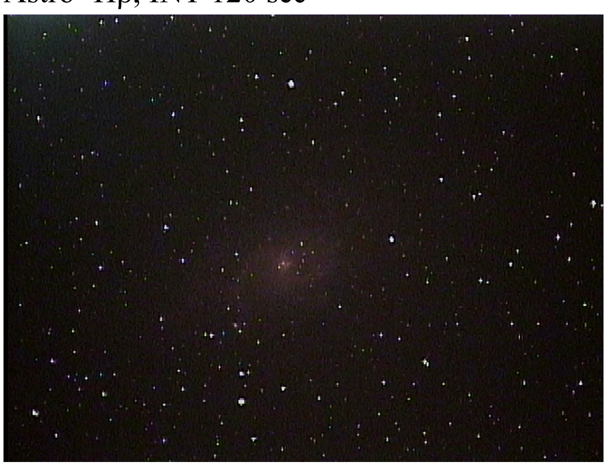

LPS-P2, INT 22 sec

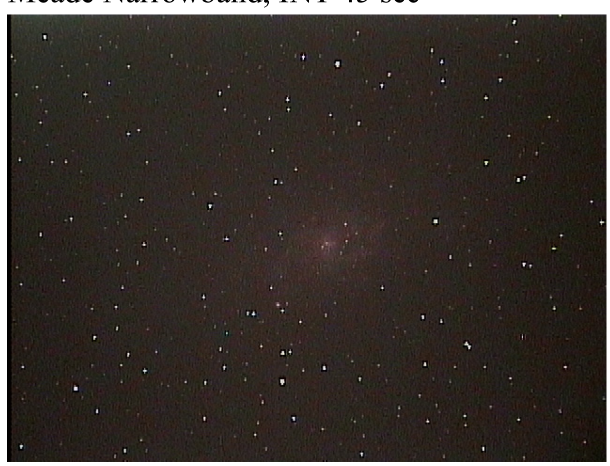

DGM GCE, INT 16 sec


Astro’ UHC, INT 46 sec


Astro’ Hβ, INT 120 sec


Meade Narrowband, INT 45 sec


Meade O-III, INT 48 sec


Meade Broadband, INT 38 sec

#29 Dark Red, INT 55 sec

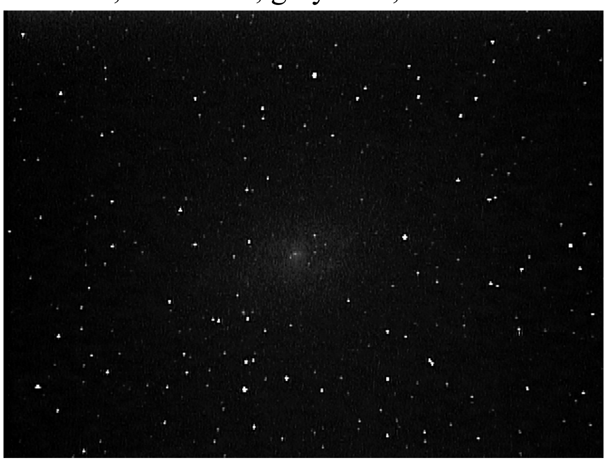
650nm Pass, INT 80 sec

680nm Pass, INT 120 sec

For the next batch of images I post processed the Max INT captures from above so that they are all 8-bit greyscale, and have their tone carefully balanced so the brightest pixels are at 255 RGB and the darkest is at 0 RGB. My purpose for doing so was to make the images as comparable to each other visually as possible. This processing also allowed me to do a histogram analysis on the images to measure the RGB level difference between background and galaxy. I sampled a 38 pixel x 38 pixel area for use in my analysis. The resulting RGB level differences that I measured were then compared to what I predicted using my fancy analysis technique (see my magazine articles #5 and #6). I have plotted the results in the graph below. The solid circles are my measured RGB level difference values, and the hollow circles are my predictions. I was very pleased to find that in most cases my predictions very closely matched my measurements. This gives some validity to my prediction method.

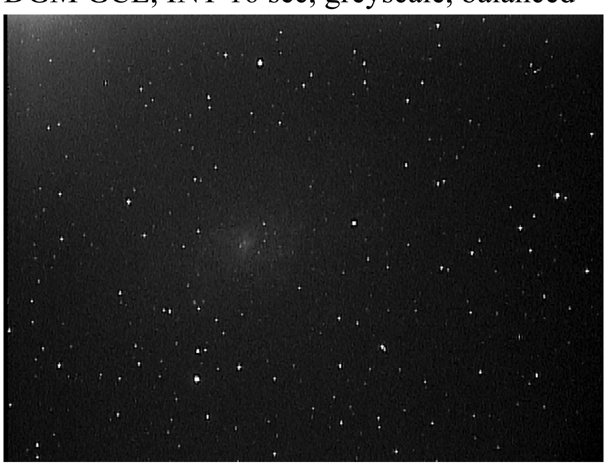
No filter, INT 9 sec, greyscale, balanced

LPS-P2, INT 22 sec, greyscale, balanced



DGM GCE, INT 16 sec, greyscale, balanced

Astro' UHC, INT 46 sec, greyscale, balanced



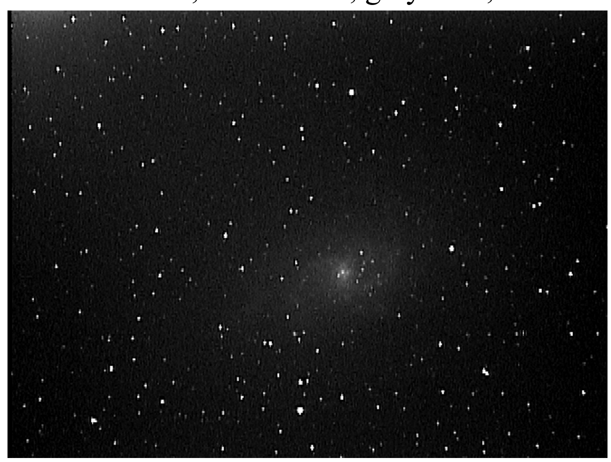
Hβ, INT 120 sec, greyscale, balanced

Meade Narrow, INT 45 sec, greyscale, balanced

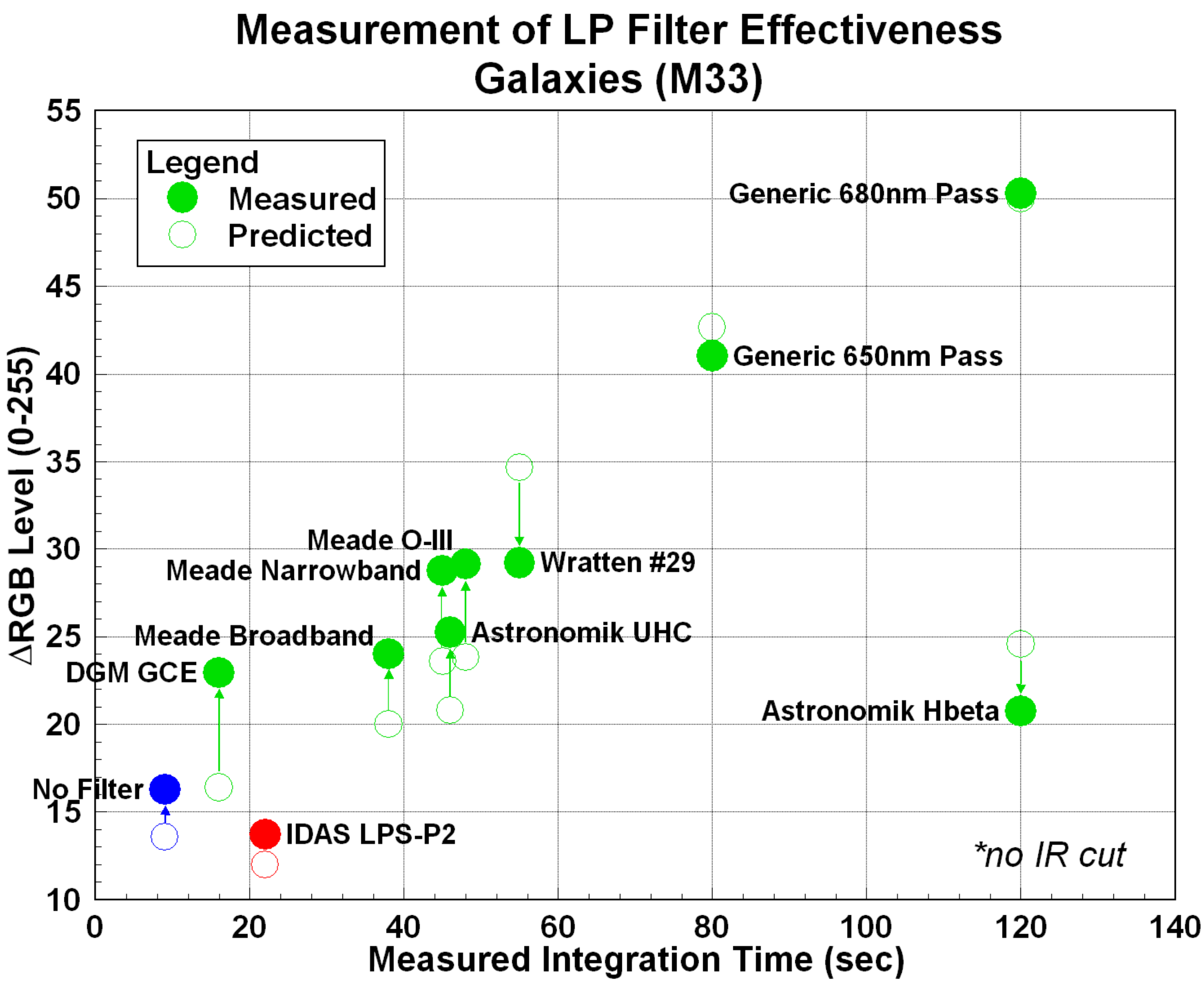

Meade O-III, INT 48 sec, greyscale, balanced


Meade Broad, INT 38 sec, greyscale, balanced


#29, INT 55 sec, greyscale, balanced

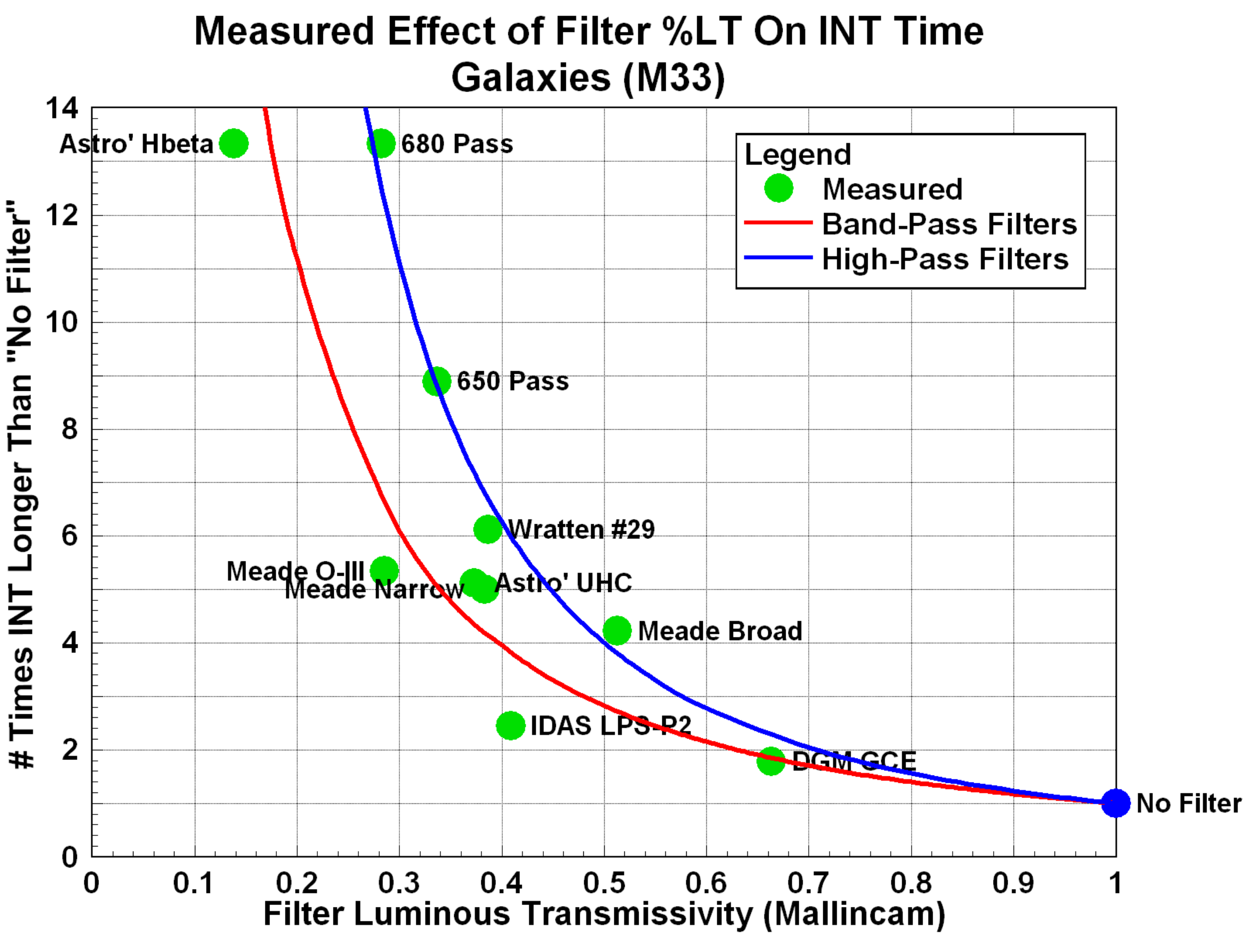

650nm Pass, INT 80 sec, greyscale, balanced


680nm Pass, INT 120 sec, greyscale, balanced



The shift in filter performance, measured versus predicted, I think is due to my pushing the INT time with some filters and not others. For example all the Meade filters, the UHC, and GCE all measured better than predicted. If you look at the source images for those filters, my background was not all that dark suggesting maybe I tweaked a bit more galaxy contrast out by going slightly longer on the INT. The #29 and Hβ filters look like I should have tried to go a bit longer INT with them to tweak out more contrast as is predicted to be possible by analysis.

Another useful piece of information that I was able to extract from this test was a relationship between filter luminous transmissivity and required integration time. Luminous transmissivity is a single number that describes the average transmission through the filter across the range of wavelengths for which the Mallincam is sensitive, a measure of how "dark" the filter is effectively. The graph below plots each filter's %LT value versus the number of times longer I had to go on INT compared to the no filter case.



There seems to be a trend in the data, as I have shown with the curve fits. The trend seems to be different depending on whether it is a band-pass filter (ie. Nebular/LP filter) or high-pass filter. From this we can roughly calculate how much longer INT is needed for any filter knowing its %LT. I have calculated %LT values for a huge array of filters. You can find that data in the FILES area or by contacting me directly. The curve fits shown above are simple hyperbolics:

Band-Pass Filters: $\# \text{Times} = 1 / \%LT^{1.5}$

High-Pass Filters: $\# \text{Times} = 1 / \%LT^{2}$

Conclusions:

1. The measured performance of the tested LP filters matched well with my predictions. This gives me confidence that my analysis method is valid.
2. It seems that going a bit longer on INT time, so the background is not fully dark, can allow you to tweak an extra bit of contrast out of your image. I have done this

traditionally in the past, but based on what appeared nicer to my eye and not any sort of analysis.

3. Even though the DGM GCE results in awful looking white balance with the Mallincam, it actually provides good performance; a good increase in contrast for a small increase in INT time. Perhaps cutting back the saturation and/or using manual white balance would make this filter more usable.
4. LP filters can provide a reasonably good improvement in galaxy contrast, as long as the filter passes IR. Note the poor performance of the LPS-P2 that has a built-in IR cut.
5. High-pass filters, as shown in previous tests, provide the highest level of contrast improvement. The best contrast was achieved with the 680nm pass filter, however the resulting long INT time caused the image to suffer from extensive amp glow.
6. The relationship between %LT and INT time is not simply 1/%LT as I thought. The impact of progressively narrower filters on INT time increases exponentially. I would expect to get a similar relationship to what I measured in this test if my target was something other than a galaxy.

If you have any questions, please feel free to contact me.

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