

## Messier Mania

### How to take 110 Mediocre Images in one *Stressful* Night

By Alex McConahay

A Messier Marathon is hard enough. But last month, I tried an *Imaging* Messier Marathon. It was stressful. So many things to go wrong. So many things to disqualify the evening. A cloud. A hung up cable. A dumb mistake. The inevitably rising sun...

As stressful as it was, the evening turned out quite rewarding.

An Imaging Marathon is not a new idea. Ralph Megna and Frank Boecker had teamed a few years back, trying to get all the objects in one night. Others have taken on the challenge and posted their results on the web. But this would be my first attempt.

#### SOME ASSUMPTIONS

This was not to be a night for “on the wall” quality images—the kind you would print out and frame. I wanted 110 objects on one page.

**It takes more than an hour and a half to get dark after “sunset.” Similarly, it starts getting light before sunrise. This cuts into imaging time. Some of the images are taken in twilight. And there is only enough “darkness” to devote about five minutes to each object.**

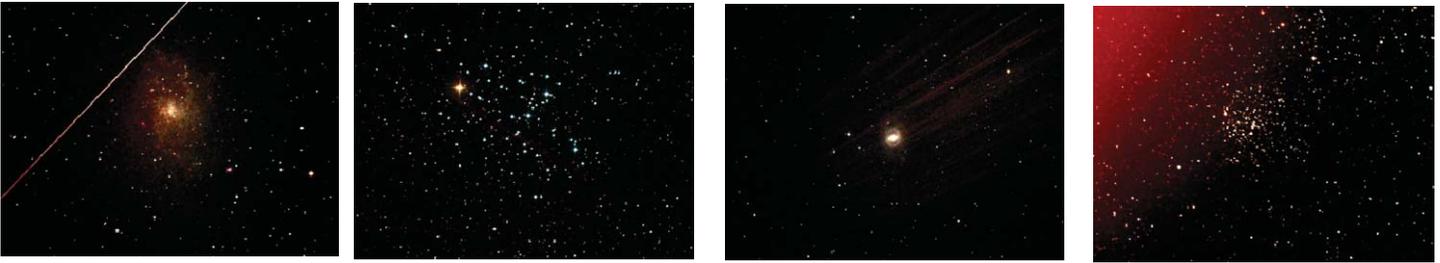
So, they would necessarily be small. This helped quite a bit. Small images do not show mistakes, graininess, out of focus-fuzziness, bad tracking streakiness, and all the other problems that are obvious with an enlargement.

But I would want a pretty chart—so I would do it in color, even if that made it more difficult.

I also knew time would be critical. It’s a simple thing to take 110 pretty snapshots at the Grand Canyon on a sunny day. It is a whole different story for deep space images. You must wait until “dark” to start, and must finish 110 objects before the sun starts to rise in the east. Between sunset (18:48) and sunrise (6:46) there are 12 hours. But twilight robs the imager of almost three of those hours. In fact, there were only 574 minutes of “darkness” the night I chose for my marathon. Divide by 110 objects, and you wind up with 313 seconds per object. Just over five minutes to find, aim, take the picture, and move on. And this does not count time for getting the equipment ready, for focusing, and—most importantly—for anything going wrong.

Astro-images rely on long exposures, and many of them. The longer you can gather photons, the higher the signal (the image you want) rises above the noise (the junk you do not want). Furthermore, the more individual pictures you add together, the cleaner the result. A piece of random junk in one picture is “averaged” out by combining many images. That is why, when you look at the Image Gallery at the end of the Prime Focus, you see statements like “36 subexposures, 240 minutes total exposure.” But all that works only if one has the time.

	Solar Altitude	Evening	Morning
<b>Sunset/Rise</b>	0	18:48	6:46
<b>Civil</b>	-6	19:24	6:20
<i>Safe (legal) to drive without headlights</i>			
<b>Nautical</b>	-12	19:53	5:52
<i>Horizon easily visible</i>			
<b>Astronomical</b>	-18	20:22	5:22
<i>Dim Naked Eye stars not yet visible</i>			
<b>Night</b>	-18+		
<i>Dark as it will get</i>			



Normally, an astroimager would reject images spoiled by (from left to right) a satellite track in Luminance, a satellite track in red subexposure only, lens flare (from an off axis star), or other anomalies (who knows??—probably a red flashlight somehow making its way down the tube at the wrong time. In a marathon, one simply heads on to the next object.

The small picture size got around some of this in several ways. Not only does the small size hide the flaws visible in an enlargement, but it allows for faster imaging. The camera has 3326 pixels across the frame. One can fill a computer screen with only a thousand or so, and make a stamp size photo for a wall chart with fewer still. Binning (combining) groups of up to sixteen (4x4) pixels make one larger pixel. These larger pixels are more sensitive, enabling the camera to capture photons at a faster rate. And, with far fewer pixels to download, this cuts the “overhead” of getting the information from the camera to the computer (A full size image takes 29 seconds to download, but a 4x4 binned image takes only three or four seconds.)

Another assumption was that each image had to be large enough to show detail, but small enough to fit the field of view. This can be a challenge, considering that Messier’s objects vary in size from M31’s 109 x 62 arc minutes

down to M40’s tiny double-star, separated by 50 arc seconds.)

Since the “size” of an object in an image depends on the optics and sensor, I would need two systems—wide field and narrow. The wide field was a short focus TeleVue 85 refractor with my Canon 450 modified DSLR. This gave a field of view of 85 x 128 arc minutes. The enlarged would be a Meade 10 inch F 4.5 Newt with a QSI 583. This narrower field (and correspondingly higher magnification) would be 35 x 47 arc minutes. This was not my first-choice planning, but it was what I wound up with.

The tyranny of time also eliminated guiding from the usual arsenal of imaging tools. Normally, an imager centers on the subject, focuses, and then turns control of his or her equipment over to the mount and a little external camera that corrects for the imperfections of the mount. Together, they track the stars for as long as needed. To do so requires finding a



Single astroimages (like the one at far left) usually contain lots of random noise, and a few hot pixels caused by gamma ray strikes (the small white dot in the upper left corner is one). But combining a dozen or so of these, and averaging them out, produce a cleaner picture (right). (Images from Bob Fera)

suitable nearby star, doing some calibrations (a two minute process, sometimes repeated for every object), and taking two to four second pictures of that star in rapid succession, correcting the aiming of the telescope in between each shot. Meanwhile the main imaging camera is just working away independently. Without guiding, the camera suffers from tracking errors. Alas, there was no time for guiding. Luckily, since these images are so small, and since the exposures are so short, these errors would not show as they would in standard astro-images.

A standard assumption in a visual Messier marathon—that one must star-hop without computer assistance—does not go for an imaging marathon. You want the best telescope aiming “goto” you can find. For me it was an observatory mounted Astro-Physics 1200. I used the handpaddle and MaxIm DL software to point the telescope quite satisfactorily.

### PLANNING AND PRACTICE

With these assumptions, it was time to do some planning.

The first step is to make a list of the objects. Such lists are available in several places. They prioritize the objects that are setting in the west first, since you need to see them early. Their priorities make some assumptions that are useful for the *visual* astronomer, but actually hurt the *imaging* marathoner. More about this later under “lessons learned.” Early planning involves looking through these lists with an eye towards two things:

- **What can be grouped?** M 42 and 43, or M 65-66 can fit together in almost any reasonable frame. Other combinations, like M81-82, M 97-108 fit together in some wider frames.
- **Which camera is needed for which object?** Assuming you have the ability to use a wide field and a narrow, you have to de-



**M 65 and M66, twin galaxies in Leo, fit nicely together in a frame. They can be imaged together, saving five minutes in the marathon.**

cide which camera will be used for which objects.

Both these questions relate to the pointing of the scope. To get two objects together, you will want to aim the scope between them, not at one or the other. Furthermore, they determine how many images must be taken. Each time you group a couple of objects, you cut down the number of exposures. This makes more time and gives you more leeway.

And then, one needs to practice. When one must very methodically crank out a series of images one right after the other, with no time to go back or fix things, or devise work-arounds, one must be familiar with the process. If something does not work in regular astro-imaging, it means figuring a way to fix it and starting the image acquisition sequence five minutes later. In an imaging marathon there are no “five minutes later.” If you miss five minutes, you miss an object.

For about five or six evenings spread over the months before my Marathon, I did a dress rehearsal. Using the same checklist, the same configuration of camera, equipment, software,

and physical settings, I tried to gather a dozen images in an hour. I did not at first succeed.

Practice teaches. My original choice of cameras, for instance was a modified Canon on the wide field, and an unmodified Canon on the higher magnification narrow field. This would mean better reds from the modified camera on the larger nebulae, with better full spectrum color in the smaller globes, clusters, and galaxies on the narrow field. Most importantly, it would be one-shot-color—so much simpler than the monochrome CCD with colored filters and multiple exposures. But, I could not get my pointing software to work with the DSLR. It was happy with the CCD, but would simply not plate solve and point properly even after a month of working on it. So, I had to abandon the one-shot color solution in favor of the monochrome CCD. This meant I would have to shoot four sub-exposures (Luminance, red, green, and blue) instead of one longer one-shot-color frame.

I also learned it was easier to coordinate two computers (one for the CCD, the other for the DSLR) than to switch back and forth between the software packages on one laptop.

One other thing I learned was the importance of being ready to image the moment it gets dark enough to capture the first object. Most imagers know that the first hour or so of most sessions is spent making sure the cables are connected, the devices are popping up on the right ports, the mount is polar aligned, a pointing model (if needed) is built, and the pointing is synched to the celestial coordinates. Some of this can be done before the sun sets. But, let's face it. You have to wait for dark before you drift align, calibrate the pointing, and really focus a star. Therefore, you have to prepare the night before for much of this. Then, the evening of the marathon, as soon as Sirius pokes out from the evening sky, it is time to sync the scope and refocus. (Those lucky enough to have fixed observatories can avoid some of this stress.!)

**MARATHON NIGHT**

With the assumptions assumed, the decisions decided, and the practice practiced, the night of the marathon should have no surprises. And, I had only one that night.

I had planned to do my marathon Friday night. I went out Wednesday to do a final setup and practice run. The run was going so well, I just kept on going, and when the sun rose the next morning I had met the challenge two nights early! Nice surprise (made even nicer by the spotty cloud cover for the rest of the weekend).



The process was really rather simple. I had a checklist telling me the order of the shots. Also noted were the few groupings

**A wide-field camera allows even larger objects to fit in one frame. Here M42 and 43 appear together in the DSLR's wider field.**

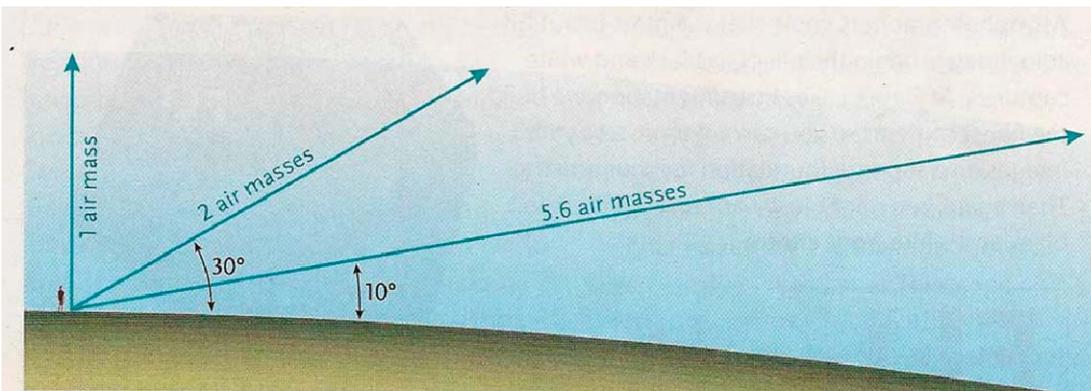
and the few objects that needed the wide-field setup.

I turned on the system by 6:30, started the cooler, and made sure my two scopes were aimed at the same point. I defined a series of exposures and save parameters in Backyard EOS(for the Canon) and the Autosave function in MaxIm for the CCD.

I found Sirius and used a Bhatinov mask to focus by 7:30. I synced on Sirius, and checked by pointing to Betelgeuse and then syncing the scope on Hamal. Then, by 7:45 I told the mount via hand paddle to go to M74. I could still see a glow in the sky overhead, and was sure (although I did not look beyond the walls of the observatory) that the horizon mountains would be clearly defined in the twilight. A series of 30 second test exposures on the CCD, even using higher stretches, could not identify anything except a few stars rising above the background glow. Finally at about 7:54, I saw something emerging from the darker sky on the test images. I started the pre-set Autosave sequence of a 90 second Luminance (3x3 bin) and 40 second R, G, B (4x4 bin). When the L finally came down from the camera, a good histogram stretch showed an obvious something in the upper right of the frame—I had my first object, one of the two most difficult—and the Marathon had started.

I penciled the time on my list. As the autosave function was taking exposures, I set the hand paddle to find the next object (M77) and as soon as the fourth of M74's sub exposures was finished, I pushed the buttons, sending to M77. The software started grabbing frames. I was not hopeful for the next set—M31, 32, and 110. My list said that they would not be attainable from my site because they were too close to the horizon in the Northwest. But the scope, seemingly up on its little tippie-toes to see over the wall of the observatory, managed to grab enough photons to show the big galaxy and its satellites. Feeling heady, I started the DSLR with a 230 second exposure. This was just barely short enough for me to click the start button on the CCD control program, click start in the DSLR control software, and have the DSLR finish its one exposure just before the last of the CCD subexposures ended and I sent the scope off to the next target. This means I had a wide field of all three as well as individual snaps of each. I had gotten five objects by 8:30 and felt good. Then I realized that I was already behind schedule. M33, which was supposed to start about 8:15, was not going until 8:37.

At about 9:00 I was finally able to calibrate MaxIm's scope control. Until now, I would go to an object using the hand paddle, and take a three second test exposure. If the object were not centered, I had to use the handpaddle to recenter. I had not had the time and enough



The lower a star appears over your horizon, the more air its light has to go through to reach you. The amount of air straight over your head (whatever your height above sea level) is called one air mass.

One of the downsides of imaging the first and last few objects is that they are on the horizon. Right overhead, only one "air mass" disturbs the view and dims the object. At 10 degrees, more than 5 times as much air messes things up. (from Sky and Tel, May, 2012)

stars of the right magnitude to do the calibration. After the successful calibration, MaxIm could go to the object, and if it were not centered, could correct the aim. And the pace picked up.

About 1:00 in the morning I looked how far I had come and realized that unless I picked up the pace, I would miss by about ten objects (50 minutes). So, I shortened the exposures from 90 to 60 seconds on the luminance and 40 to 20 on the RGB's. I refocused again. And kept going.

One fear that kept nagging me was the possibility of dumb little mistakes that I could be making and not realizing. For instance, one of the tasks in autosave was to change the title of the saved shot from one M number to the next. I forgot to do that several times, saving one object under another's number. I would still get the shot, and the meta-data in the file would remember which object it really was despite what I had called it. But if I not only had forgotten to change the number, but had also neglected to send the scope to the new object—I would blithely mark off the object as imaged when in fact I had just taken an extra set of exposures on the previous object. And I could not easily figure that out because there was not

**Even in a marathon, M20 is a pretty sight.**



really enough time to check the meta-data in the file as the images kept downloading. I was so intent on doing what I was doing, I could only worry about the mistake—not check on it.

So it went until the rosy fingers of dawn started to spread across the eastern sky. (That is just poetic license. It was still dark, but there was a discernable glow by 5:30.) Exposure on M2 had started at 5:16 and unless I had done something dumb, I only had one more object to go—M30. I sent the scope towards M30, but it appeared to be pointing at the wall of the observatory. I took a test exposure. I got a picture of the wall of the observatory. M30 had just cleared the horizon but my scope could not get that low. I continued to take test exposures in the brightening sky until at last, at 5:34, I saw something that was not a blurry star, and I started the last of the exposures. Five minutes later it was finished, and I could see a dim trailed glob buried in the upper right corner of a hazy glow.

I set CCD Autopilot to do some darks and flats and went to bed.

## PROCESSING

I had not looked forward to the processing. Before anything is done to the raw image, a computer must use special “dark” and “flat” frames to correct flaws in the camera and optical system (called “calibration”). What is left is a very dark image, with no detail. All of the image data is scrunched up in this dark, and must be “stretched.” In short, there are no “bright” points. The darkest points have to stay dark and the less dark points have to become bright, with the intermediate points distributed across this brightness range.

Luckily much of this can be automated. In Maxim, I defined which images were flats and darks. Then, using the “stack” function, I imported all 400 some ccd image files. MaxIm



**Globs (M13 here) and open clusters imaged well in the marathon.**

read the file's meta data to determine where the telescope had been pointing and which color filter had been used, matched and sorted the images from the various objects, calibrated, aligned, and combined them, leaving 108 color images. (Two of them had to be done individually since there had been a problem with one subexposure in each.) Then, using the batch process function, I converted them all to sixteen bit TIFF files. I used Images Plus to do the calibration on the DSLR images.

In Photoshop, I opened each file, stretched the information into the proper brightness range, and reset the level of the blackest points to make a pleasant image. I relied heavily on pre-defined actions to do this. I had defined one action to set a standard "digital development" curve. (This means dark data is brightened quite a bit, but less dark data not so strongly—what imagers call the "Standard" curve.) Simply pushing "F2" would apply this standard curve to the image—saving some fifteen seconds, three screens, and a dozen keystrokes,

mouse movements, and clicks. Another action converted the information to a jpg file for easy storing. I also used Photoshop to label the photos with the object number and time of acquisition. I did not do extensive processing to control the noise, sharpen the detail, remove the gross imperfections, or really improve the pictures. There simply was not enough data to work with, and I liked the somewhat raw look. This was, after all, a marathon (think sweat and blisters and exhaustion) and not a pretty picture event.

The images were placed together using Digital Photo Professional, a piece of software shipped free with every Canon DSLR. I used their "Contact Sheet" function and printed to a pdf. Then I called this pdf into Photoshop to prettify it and add titles.

### LESSONS LEARNED

Pay some attention to the order of the list. My list had emphasized the relative proximity of the objects to each other. This makes sense if you are visually star hopping trying to get your objects in a marathon. One hop leads to another. It makes sense to sweep the southern most objects when you are pointed south, for instance. However, when using goto, it might not help as much, and may in fact hurt. It becomes critical is as you move from the westernmost objects to the east and approach the meridian. Crossing the meridian with a Dob means nothing. But with a German Equatorial Mount, this calls for a meridian flip. The scope must twist 180 degrees in both right ascension and declination. This can be a challenge. And it takes a couple of minutes, counting making sure everything

worked as it should. While near the meridian using a list made for visual observing, the scope may need to flip back and forth many times (I had about eight meridian flips.)

The next time I do this, I plan to minimize meridian flips in a couple of ways. First, I will prioritize the list pretty much by right ascension, using the westernmost objects first, rather than worrying about their proximity to each other as a visual marathoner would. Secondly, when the scope gets within ten or fifteen degrees of the meridian, I will do one flip and then go a few hours further east, and image for an hour or two. Then I will flip back west to catch what had passed the meridian in the meantime. Finally, I can flip once more to the east to continue with the list.

Secondly, I will have to finish installing my mount and tube better. Until now I have had "pretty good" polar alignment. This enables me to find the object virtually every time I send the scope to an object. I did have a problem after a meridian flip. This was caused by the mounting rings not being absolutely the same size. (One was off by the thickness of two strips of metal about the thickness of the skin on a can of diet Coke.) This meant that my two axes of rotation were not perfectly at right angles. The pointing software needs absolute orthogonality or it points wrong. These issues do not matter very much on a typical night of imaging because they were very slight. However on a marathon night, it would be better to have everything perfect. Losing time to recentering the target could be eliminated by better mounting of the scope. (By the way, in the last month, I have largely corrected these issues.)

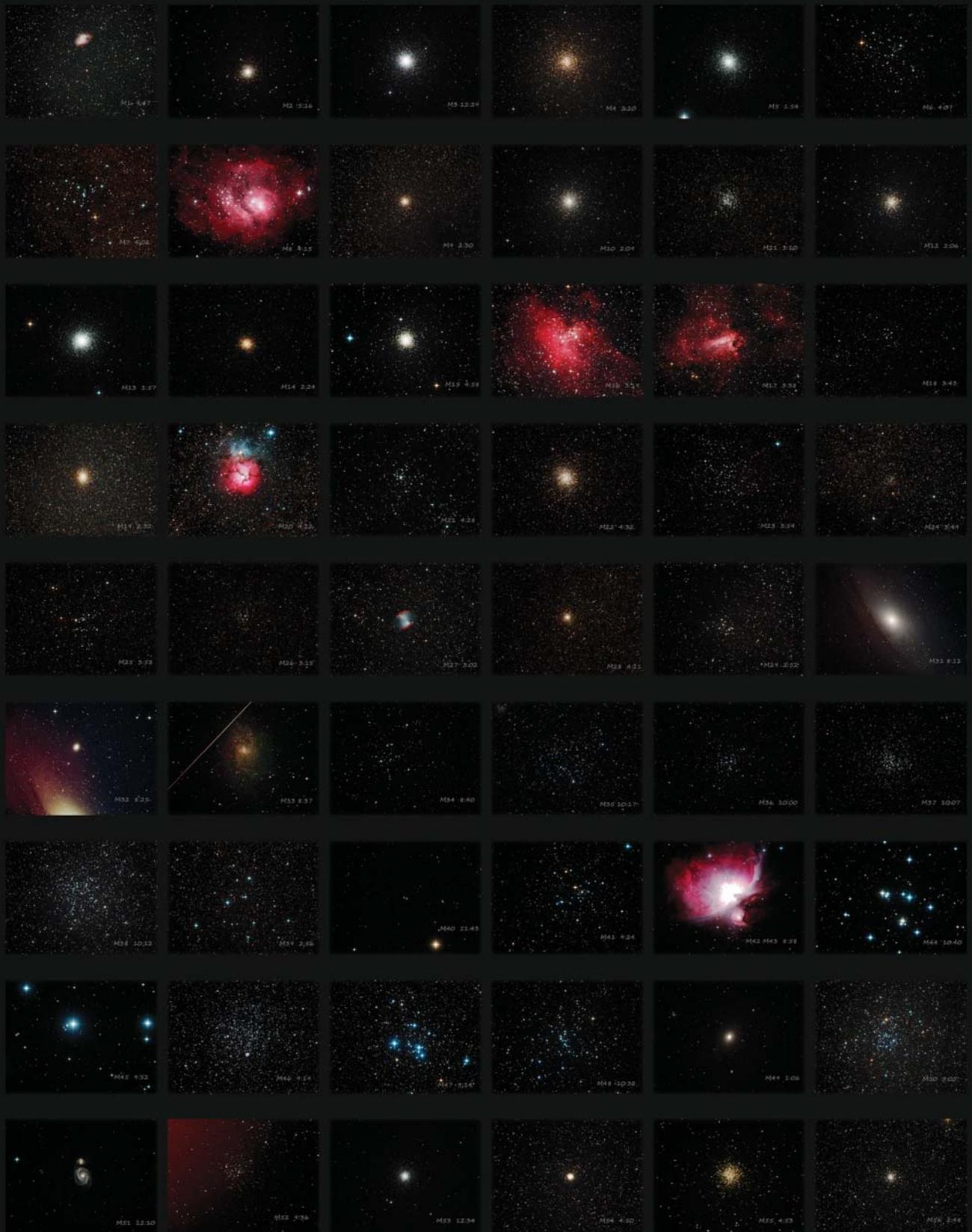
Of course with alternative equipment and a little more experience, it would have been easier to pull this off. A Hyperstar camera, which can image very much faster than a traditionally mounted camera, could have obtained many

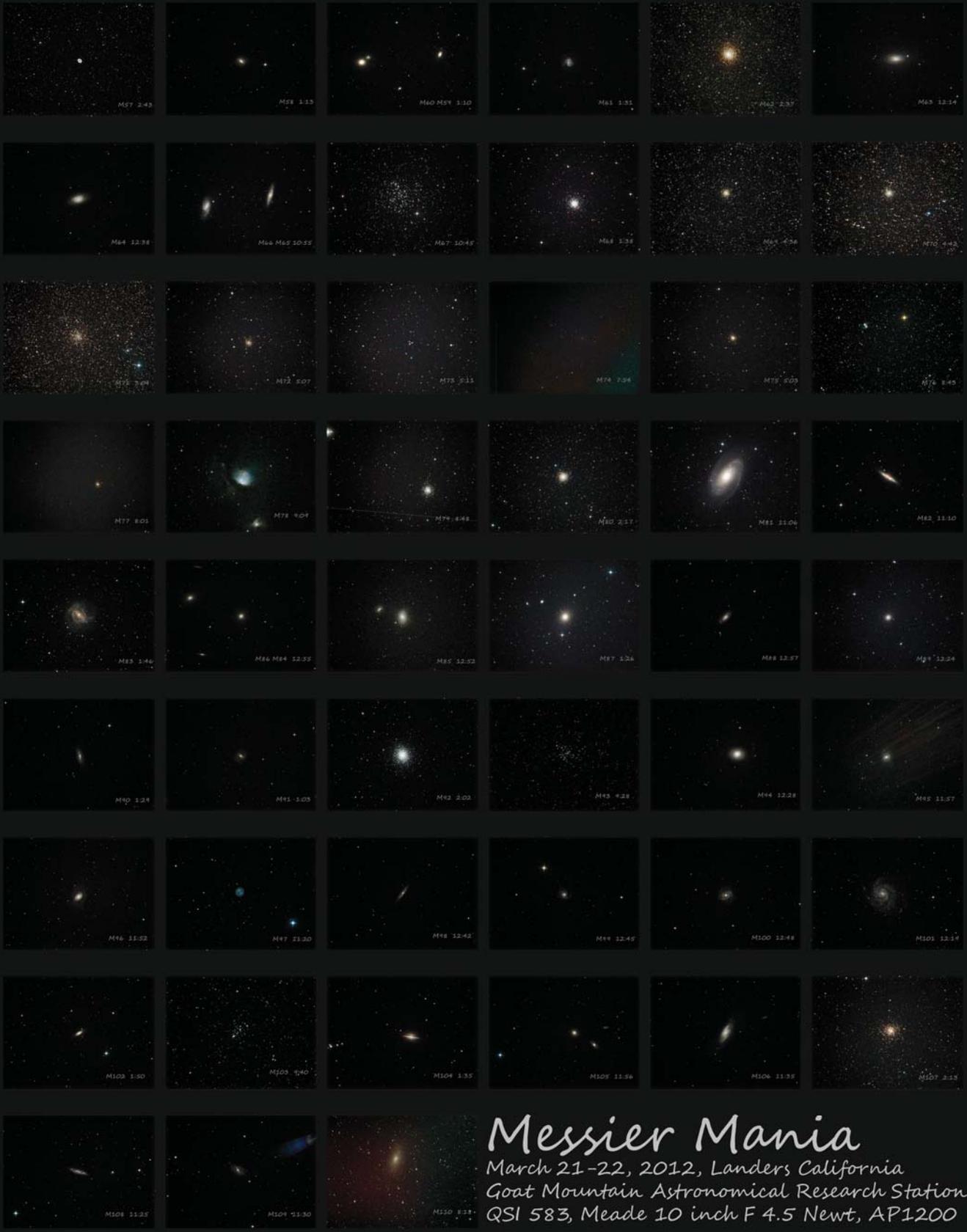
more images. (Norm Van Treeck had some 50 objects imaged with his Hyperstar the next night when the clouds came in.) A one-shot color camera could have eliminated the intricacies of multiple sub exposures with the monochrome CCD with filters, and the extra download times. Had I been able to get MaxIm to communicate and control the DSLR better (or had I borrowed a OSC ccd camera), I would have had such a one-shot-color setup. I could also have decided to use one camera/scope and change the scaling by simply cropping the pictures. Certain software packages allow an imager to put in a number of "targets" and then the software runs the camera and scope all night automatically. Would such software accept a list of 110 objects? Yes, there are many things that could be done differently. And I may give them a try next year.

### LOOKING BACK

It was a pleasant night overall. The weather was perfect (well, it was pretty cold!). And all the equipment worked without glitches. No lost cables, no power failures, no software bugs stopping the process. It was long, tedious at times, and stressful not knowing whether in fact it was running perfectly or some hidden error had already been made, or something was about to fail, or the sun would come up before I finished, or ...

But as far as what I had to do, it was not a difficult night. Just tell the scope to go somewhere, make sure it got there, click a mouse to start the imaging, make notes on the observing list, wait for things to finish, and get on to the next object to do the same thing. One hundred ten times. Perfectly. Without messing up at all. But then again it is pretty easy to run a regular marathon. Just put one foot in front of another, follow the course, avoid blisters and broken shoelaces, drink plenty of fluids, don't hurt, and don't fall down. For three hours. For 26 miles. For sure! No problem.





*Messier Mania*  
March 21-22, 2012, Landers California  
Goat Mountain Astronomical Research Station  
QSI 583, Meade 10 inch F 4.5 Newt, AP1200