Introduction to Basic Image Frame Calibration*

CCD, Video & DSLR

* Also known as reduction

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INTRODUCTION

- Amateur astronomy has entered the digital « universe » - (CCD, Video, DSLR)

  - CCD and DSLR are imaging cameras …
    - capture images for later calibration and processing

  - Video cameras are designed for digital observing …
    - « + » image frame capture
    - « + » simultaneous calibration and processing on the fly

INTRODUCTION

- Basic image frame calibration (reduction)

  – Principles

  – Worked example for CCD

  – Principal challenges in Video

  – Evolving world of DSLR

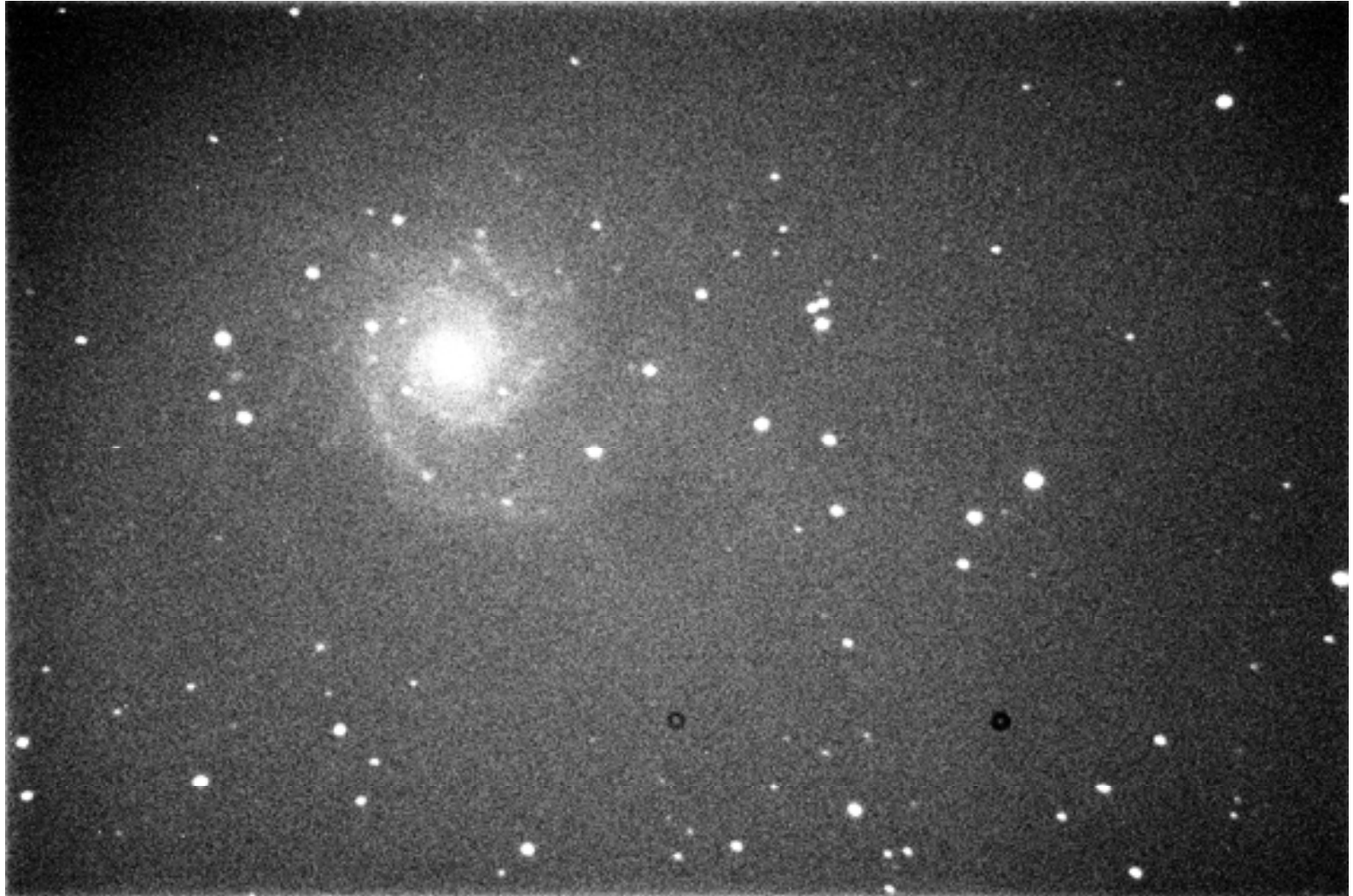 (Sub)Frame *vs* Image   …

Calibration

- What is it?
  - Cleaning up « errors » and noise

- Why do it?
  - Optical « noise »
    - Dust & Dirt
    - Uneven illumination
    - Vignetting
  - Electronic or thermal noise
    - Hot pixels
    - Amplifier glow

Dust & Dirt

Vignetting

Amplifier Glow

Calibration cont'd

- What it won't do !!!

    - Correct for …
        - tracking errors
        - field rotation
        - poor focus
        - field curvature
   - Coma

- Garbage in … garbage out !

WHAT'S REQUIRED?

- How is it done?
  - subtract images of the optical and electronic/thermal « noise » from the captured astronomical frame

    - Subtract Flat frames to remove optical "noise"

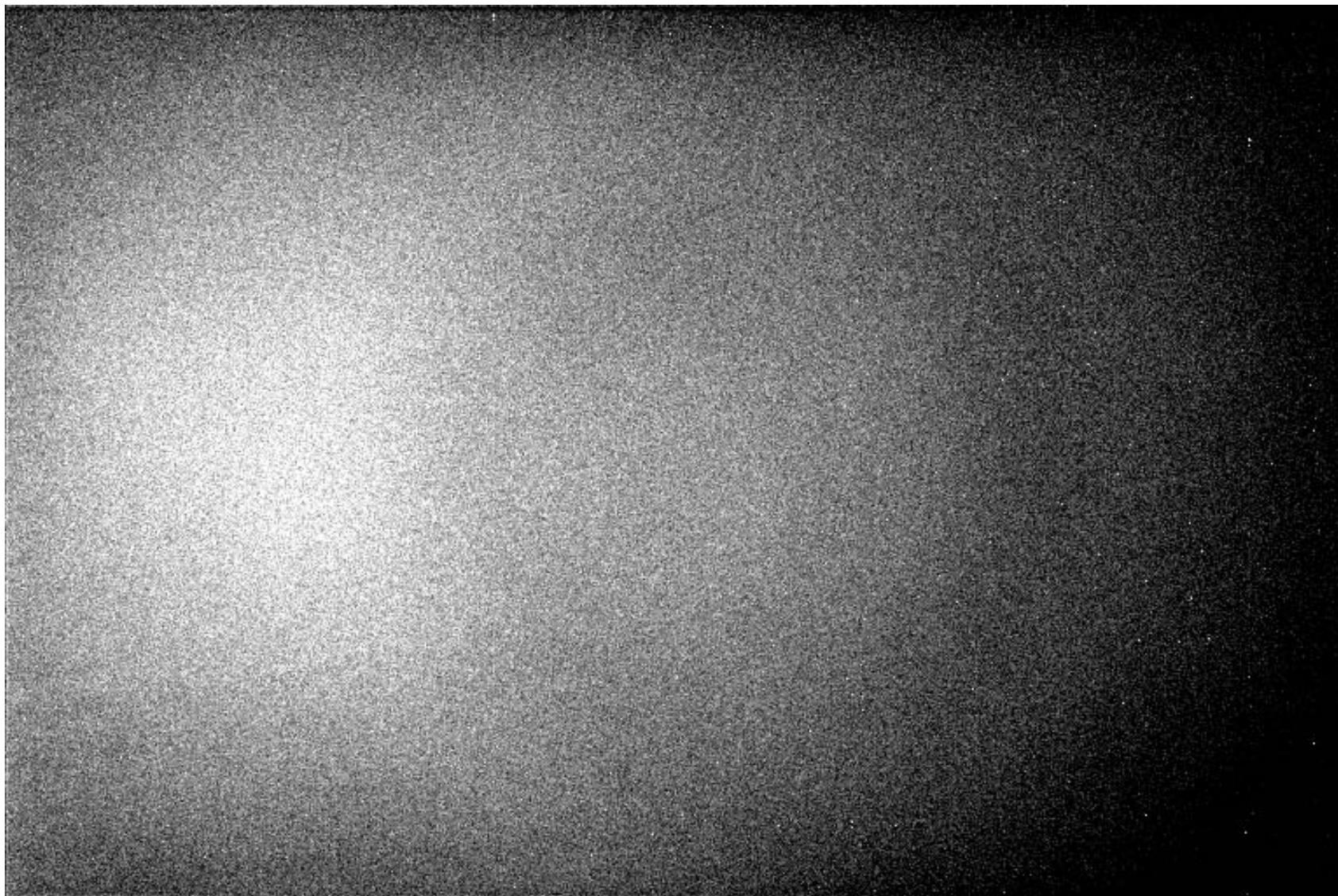   - Subtract Dark frames to remove electronic/thermal noise

FLAT FRAME

- An image of light passing through the telescope with no « object »

  - Use exactly the same telescope set-up as for the « real » frame capture

  - 1° Technical requirement : 33-50% pixel « saturation »

FLAT FRAME
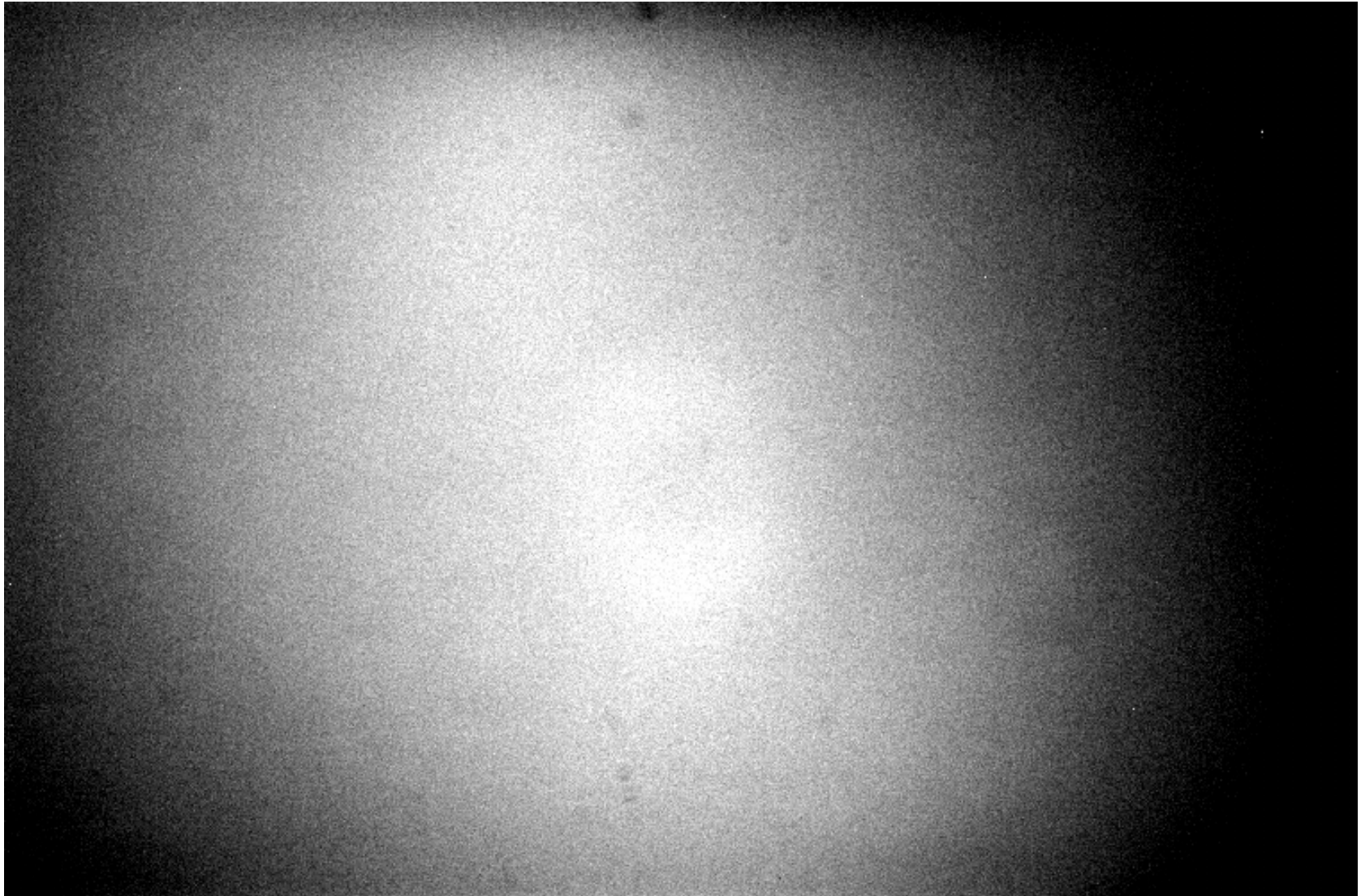
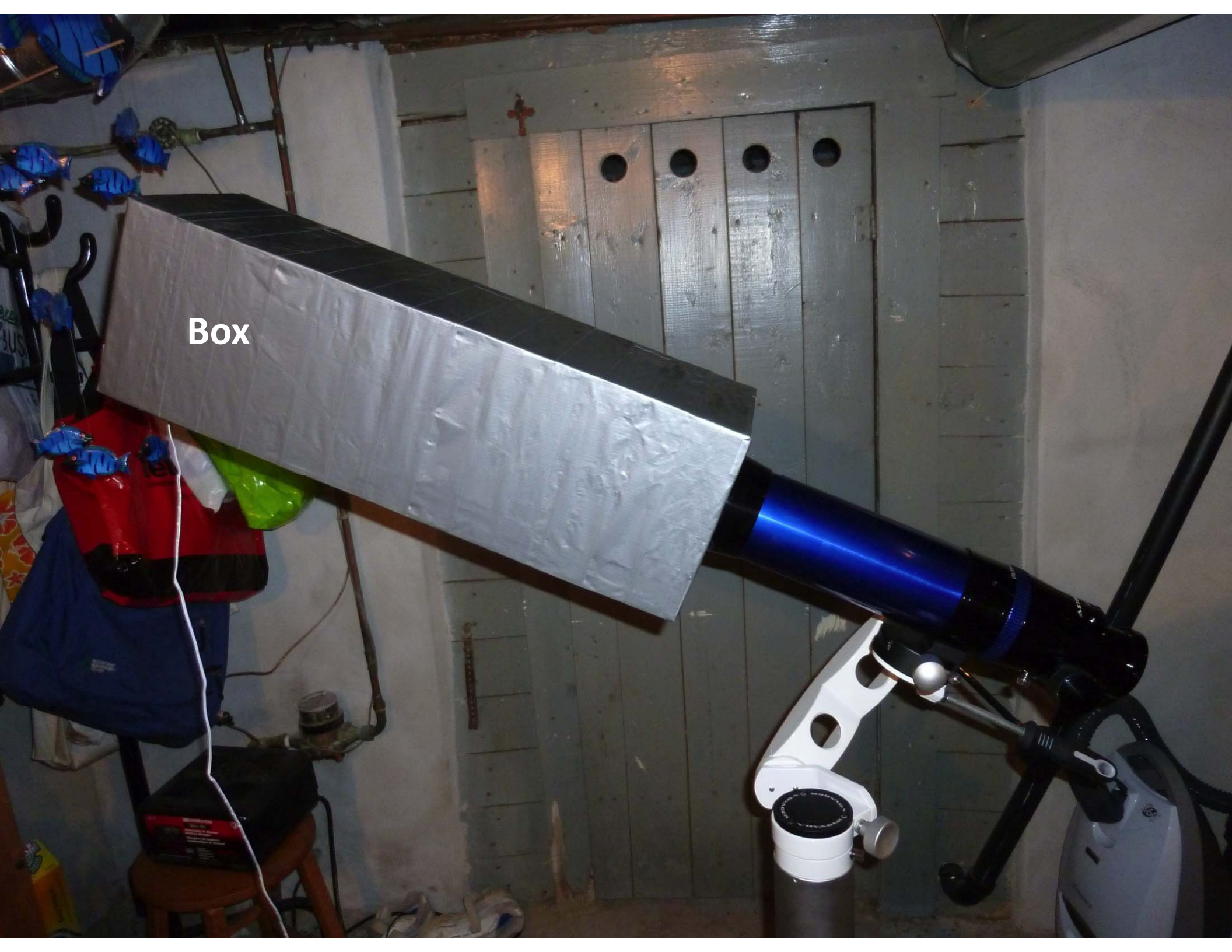FLAT FRAME

FLAT FRAME

- An image of light passing through the telescope with no « object »

  - Requires even, diffuse illumination of the telescope/camera system
    - T-shirt method
    - Light box method
    - Flat panel method
  - 2° Technical requirement : minimum 2 seconds exposure

T-Shirt …

Box

Panel

DARK FRAME

- An image of « bright » pixels when no light is falling onto the camera chip

  - Must use same chip temperature and exposure time as will be used during astro frame capture

  - Hardware set-up and camera orientation are not constrained

  - Frames valid for up to 3-6 months

Dark Frame

DARK FRAME cont'd

- An image of « bright » pixels when no light is falling onto the camera chip

    - Includes "Darks for Flats" !!

BIAS FRAME

- A dark frame – using the minimum exposure time available for your camera

  - Image of the fundamental electronic/thermal behaviour of the pixels

 - Bias frames used when astro capture exposure and/or temperature ≠ dark frames

Bias Frame

CALIBRATION - WORKED EXAMPLE

- In relation to CCD cameras …

  – Abundant comprehensive software available … we'll look at CCDSoft v5

  – CCD cameras are designed to make capture and calibration easy … I use an SBIG ST8-XME

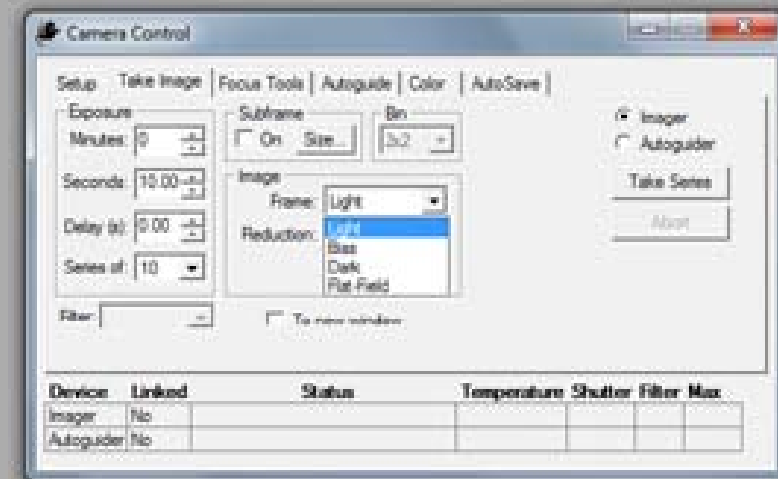 – We'll now look at both these aspects … in B&W : working in colour can require 3 times more work

CCDSoft – camera control set-up
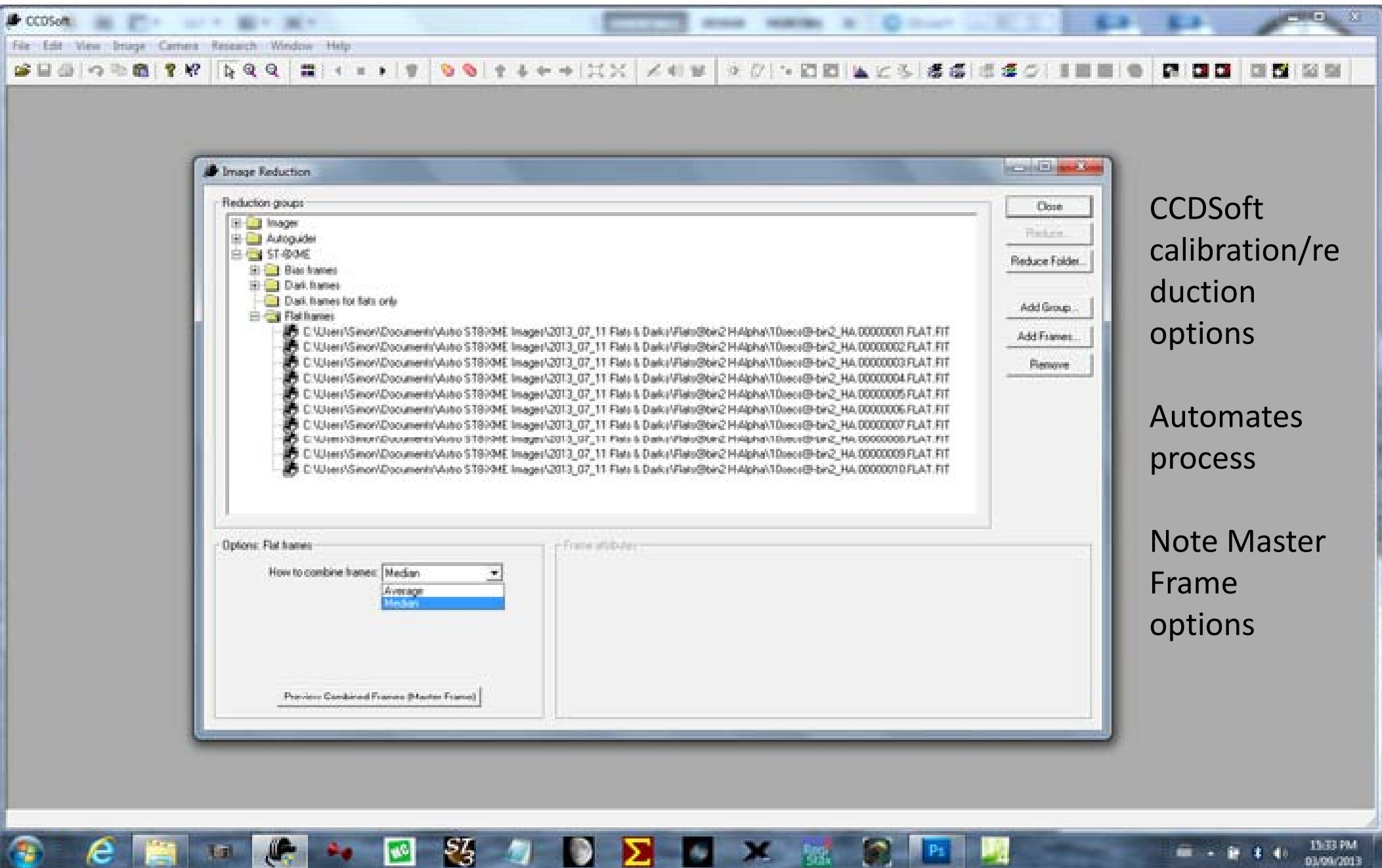
Note chip temperature control + autoguider
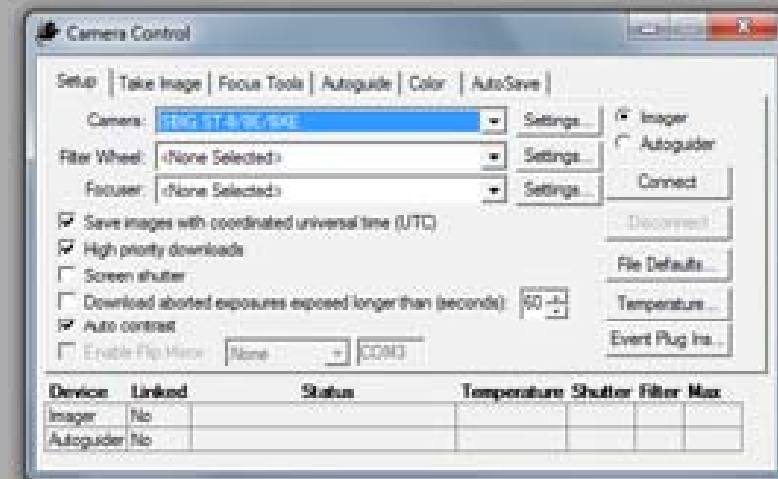
CCDSoft – Take Image options

Camera equipped with mechanical shutter for darks

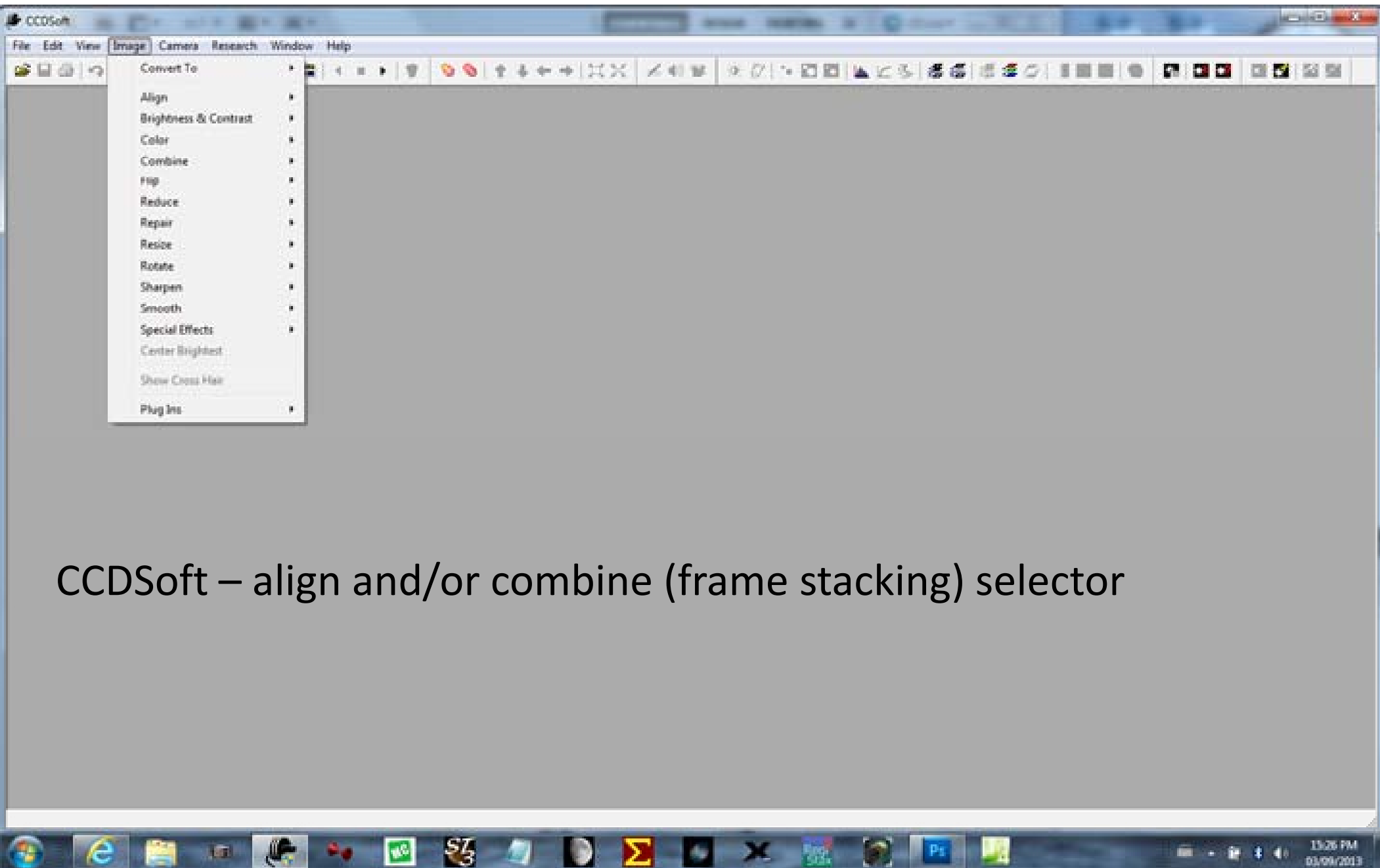CCDSoft calibration/reduction options
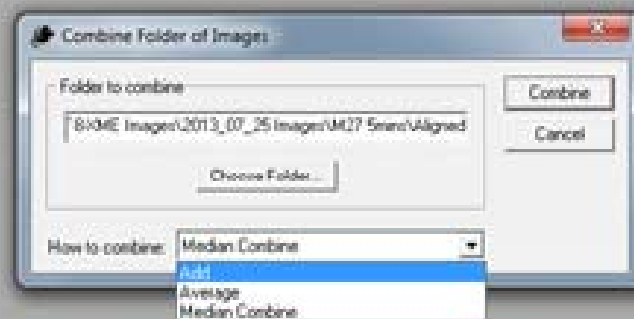
Automates process

Note Master Frame options

CCDSoft – align and/or combine (frame stacking) selector

CCDSoft – combine (frame stacking) options

HURDLES IN VIDEO CALIBRATION

- Camera …

  – Estimating exposure i.e. % pixel saturation for Flat frames

  – Covering the scope for Dark and Bias frames

  – Determining the T°C of the camera chip for Dark and Bias frames

HURDLES IN VIDEO CALIBRATION

- Camera cont'd …

    - 100% duty cycle = more thermal noise

    - High gain = more electronic noise and amp glow

    - Data fidelity limits « correction » potential

HURDLES IN VIDEO CALIBRATION

- Software…

  – No comprehensive package specifically for astro Video control + image frame calibration

  – Free- and Share-Ware packages, plus relatively inexpensive commercial software

  – It's up to you to find the appropriate packages for the calibration workflow …

  – It's up to you to perform the work-arounds …

HOWEVER … if you're lucky !

- I captured 15 x 120 sec sub exposures and stacked them using Maxim DL along with my typical work flow in PSCS3 for the majority of the post processing

- Capturing the data is so easy and fast with a MC Xtreme and the post processing was about 15 minutes tops

- *There was no image calibration involved*

DSLR CALIBRATION

– DSLRs, with their larger size imaging chip, are usually used in wide field imaging

– Flats are especially important because the size of the imaging chip is large

– This will almost always result in uneven field illumination appearing as vignetting

– See also Dark & Bias frames (below)

DSLR CALIBRATION cont'd

– Other inherent issues

- Mirrors
- Sensor Cleaning
- Noise Mapping
- Noise Reduction

DSLR Camera Features

– Mirror Lock

- BackYard EOS

– Noise Reduction

- Turn it off !

– File Type

- Start with JPEG !

DSLR Image Calibration

- Collecting DSLR Flats, Biases and Darks is tedious and confusing. Software can significantly reduce the effort.

- DeepSky Stacker (Freeware) organizes Lights Darks, Flats and Bias Frames and automatically applies them

- Astro Photography Toolshttp://www.ideiki.com/astro/ (~$20 CDN) automatically organizes and manages the capture of all calibration frames

DSLR FLATS

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DSLR FLATS cont'd

– Dust motes on the chip are usually less obtrusive (especially in a DSLR with a Sensor Cleaning utility)

– Uneven light can result in either drop-off of details around the edges of the image, or an increase of noise in the center if the light drop-off at the edges is corrected.

– Amp glow is rarely a problem, however it may become evident in very long exposures (<10 minutes).

– Ideally Flats should be taken on a 1:1 ratio with the lights. Good practice is to have at least 30 Flats to average out.

DSLR FLATS cont'd

- Flats need to be taken with the camera in the identical orientation and focus as the light frames
- Leave the camera untouched on the telescope
  - Take Flats either indoors with light screen

  or
- Leave camera/telescope on the mount
  - Take Flats the next morning against a clear blue sky opposite the sun
- Set camera in AV mode
  - Let camera select the correct exposure
  - Take note of the shutter speed/exposure time
  - Shoot as many Flats as Light frames

DSLR FLATS

Original Light Frame : (M33, 6in f/5 astograph, Canon D1000

180 seconds at ISO 800 – single frame)

DSLR FLATS cont'd

Artificially stretched to illustrate uneven illumination

DSLR FLATS cont'd

Example of Master Flat

DSLR FLATS cont'd

After applying the Flat to the Light

DSLR FLATS cont'd

Artificially stretched to illustrate illumination correction

DSLR FLATS cont'd

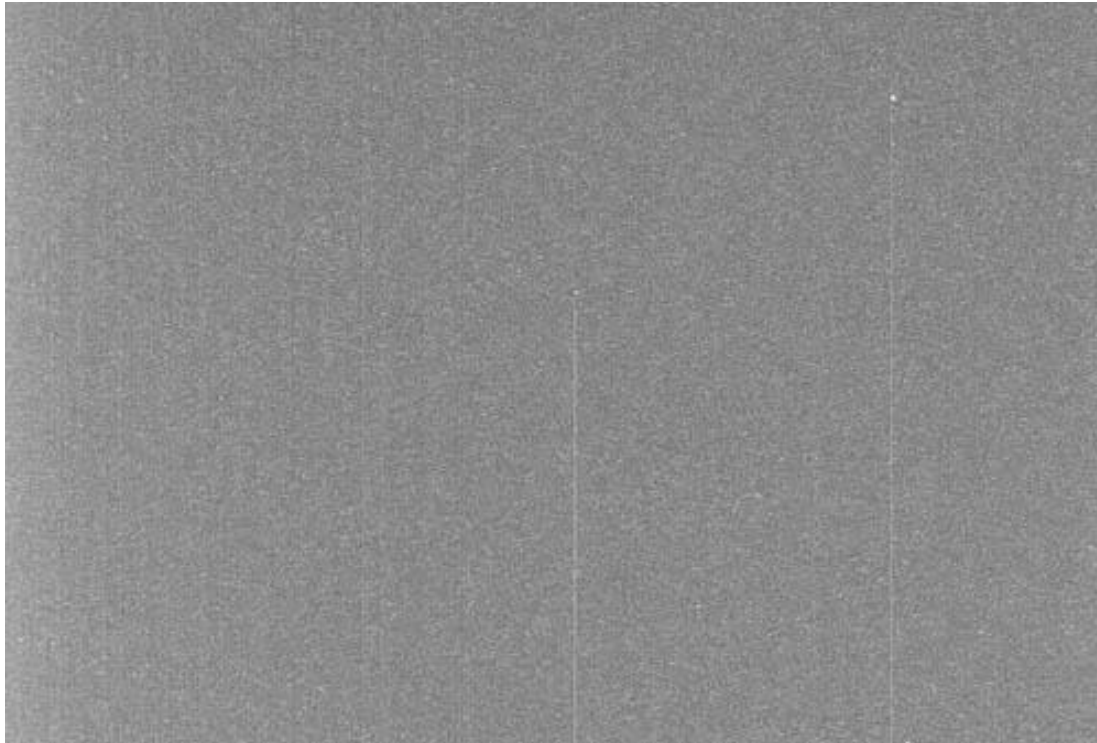

After subsequent post processing

DSLR DARKS

- Dark frames will record hot pixels (red spots) and inherent noise (typically seen as horizontal or vertical banding)

- Removing these errors greatly improves the final image and is a superior method than dealing with hot pixels and banding in post-processing.

DSLR DARKS

DSLR DARKS cnt'd

- Collect your Dark frames at the same time as your Light frames

- They must be taken at the same camera settings and temperature as the lights, BUT with the telescope cap on

- Ideally, shoot at a 1:1 ratio with the Light frames

DSLR BIAS

– Bias Error is when the CMOS or CCD chip of the camera generates a signal that is created by the internal electronics of the camera just by reading the content/data

– Collect Bias frames the same time as Light frames

– Ideally, shoot at a 1:1 ratio with the Light frames

– Set the camera in Manual mode and dial to the fastest shutter speed available