Examining images with ds9

Things you type in a terminal window are shown in **`bold Courier font`**.
ds9 drop-down instructions are shown in *italic font* with "⇒" to indicate submenuing

Step 1: Set up (For classroom linux machines)

- Open a terminal window by right clicking on "Activities" (top left of screen), right clicking on the terminal window (looks like a screen icon) in the menu that appears
- In this terminal window, type the following to move into the CCDIntro directory and start ds9:
  - **`cd CCDIntro <return>`** (note: "CCDIntro" is case sensitive)
  - **`ds9 & <return>`**

Note: After starting ds9, you can start an ipython session by typing **`ipython`** in that terminal window. That's helpful to have going if you want to calculate something on the fly.

Step 2: Examining an individual zero image

- Open the image
  - *File ⇒ Open ⇒ pzero0419025.fits*

- Examine the image
  - Mouse wheel zooms in and out
  - Center click (mouse wheel) re-centers on mouse position, or left click and drag the box in panner frame
  - Right click/hold/drag changes the brightness and contrast

- Doing simple stats in a region
  - Left click and drag to create a region
  - Double-left-click inside the region to get a region menu
  - In that menu, do *Analysis ⇒ Statistics*
  - Note that dragging the region around will update the statistics

Helpful Tip: if you accidently generate unwanted regions (green circles), single-left-click them to activate them, then hit delete key to delete them.

- **Estimate the noise in the image** (look at the standard deviation, stddev)
    - **In counts/ADU**
    - **In electrons** (note: CCD gain is 2.5 electrons/ADU)
    - **If we average 25 individual zeros together, what noise level do we expect for the output image** (in counts)?

Step 3: Compare to a nightly master zero

- Initialize a new ds9 frame, load the image into the new frame, and lock the two frames together:
    - *Frame ⇒ New Frame*
    - *File ⇒ Open ⇒ Zero041909.fits*
    - *Frame ⇒ Lock ⇒ Frame ⇒ Image*
- Now you can hit the tab key to toggle back and forth between the images and compare them. If you pan/zoom one, the other will be adjusted accordingly. Try it!
- **How does the noise level (stddev) in this image compare to the noise level in a single zero, measured above**?
- **How much does the average level change across the image**?

Step 4: Examine a flat field image:

- *File ⇒ Open ⇒ SkyFlat2009B.fits*
- **What is the difference in intensity between the upper and lower half of the image**?
- Find various artifacts: bad columns, spots on CCD, dust spot. **What is the sensitivity difference between these regions and the surrounding parts of the detector?**
- Note the edge vignetting.

Step 5: Examine a raw object frame

- *File ⇒ Open ⇒ pobj0419029.fits*
- Zoom around and look. What do you see? **Find the flat fielding artifacts**.
- **What is overall sky level (in ADU)? What is the noise level in the sky?**
- Note WCS info (RA, dec coordinates) in the information panel

- Open (or switch to) a new frame and load the reduced image:
  - *Frame* ⇒ *New Frame*
  - *File* ⇒ *Open* ⇒ *reduced.fits*
- Lock the two frames together in position and display:
  - *Frame* ⇒ *Lock* ⇒ *Frame* ⇒ *WCS*
  - *Frame* ⇒ *Lock* ⇒ *Scale*
  - *Frame* ⇒ *Lock* ⇒ *Colorbar*
- Compare raw and reduced frames. Look at the places where the flat field correction has "fixed" things!
- Changing intensity scaling: *Scale* ⇒ *Scale Parameters*
- Changing intensity mapping: *Scale* ⇒ *Log*
- Look at header info: *File* ⇒ *Display Header*
  - OBJECT: target name
  - DATE-OBS: date/time of exposure
  - EXPTIME: exposure time
  - WCS information, in particular pixel scale (CD1_1, CD1_2, etc) in degrees per pixel.
  - Other information varies by dataset

Step 6: Make a radial profile of a star:

- Zoom in tight on a non-saturated star.
- Make sure Region functions are activated (*Edit* ⇒ *Region*, should be a dot next to Region)
- Switch to annular regions (*Region* ⇒ *Shape* ⇒ *Annulus*)
- Left-click and drag to create a region
- Double click region to get info box.
- Enter region parameters:
  - switch from degrees to arcseconds
  - radius: inner = 0, outer = 15
  - annuli = 15
  - click Generate and Apply
  - Lock the region: *Property* ⇒ *Can Edit* (untick)
- Drag the region on top of a star. Center as best you can, you can tweak with the arrow keys on the keyboard.
- Generate an annular profile by clicking *Analysis* ⇒ *Radial Profile*
- If the profile looks "flat topped", it's a saturated star; try a fainter star.
- **Estimate the FWHM (in pixels) of the stellar profile.**

Step 7: On Your Laptop:

- Download and install ds9 (ds9.si.edu)
- Download reduced image (all files available at http://burro.case.edu/Academics/Astr306/CCDIntro/)
- Start ds9. (How you do this depends on your OS and how ds9 got installed.)
- Set ds9 preferences: SAOimageDS9 ⇒ Preferences ⇒ Menus and Buttons
  (note: Preferences may be under File menu in some ds9 versions)
  - Edit/Menu ⇒ Region (makes regions active by default)
  - Scale/Menu ⇒ ZScale (autoscales intensity map by default).
  - Save preferences
- Open the image (from where ever you put it when you downloaded it).
- Play around!
- A helpful guide: http://www.jb.man.ac.uk/~gbend/Sci/DS9guide.pdf