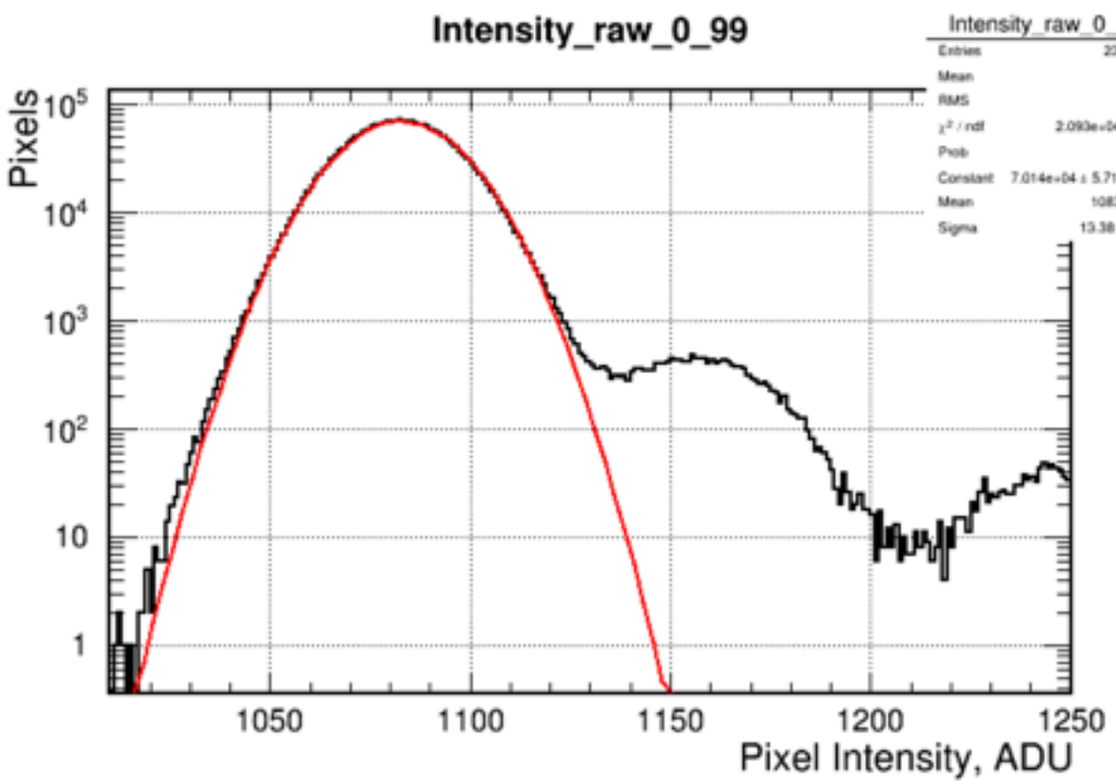
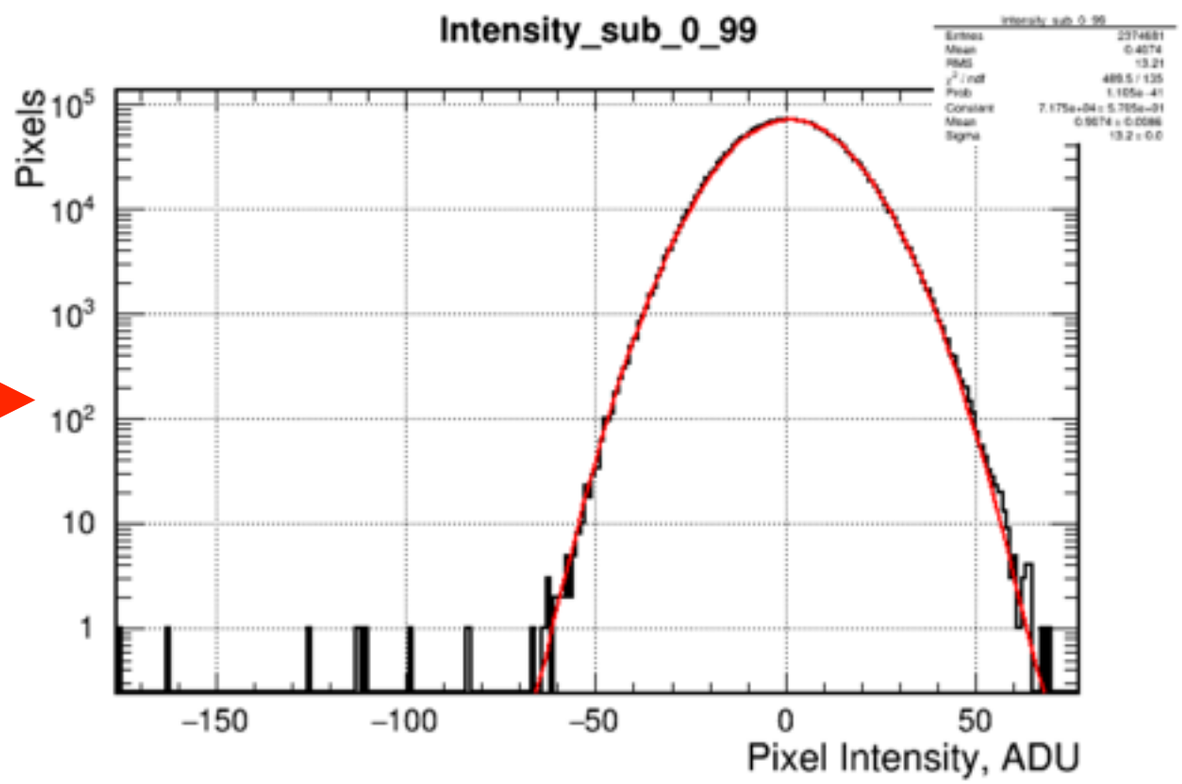
Bias Frames

- At start of every run, take *n* images with shutter closed
- These are averaged and subtracted from events
- Gets rid of hot/dead pixels, dark noise. These are camera specific and time dependent: CCDs are Peltier cooled so temperature of readout electronics is cyclic, and also depends on how long ago they were switched on; cosmics hit individual pixels which remain hot for a while etc
- Initially just used dmtpc::core::Dataset::biasAvg(i) (literally just average and subtract)
- Takes us from this: To this:

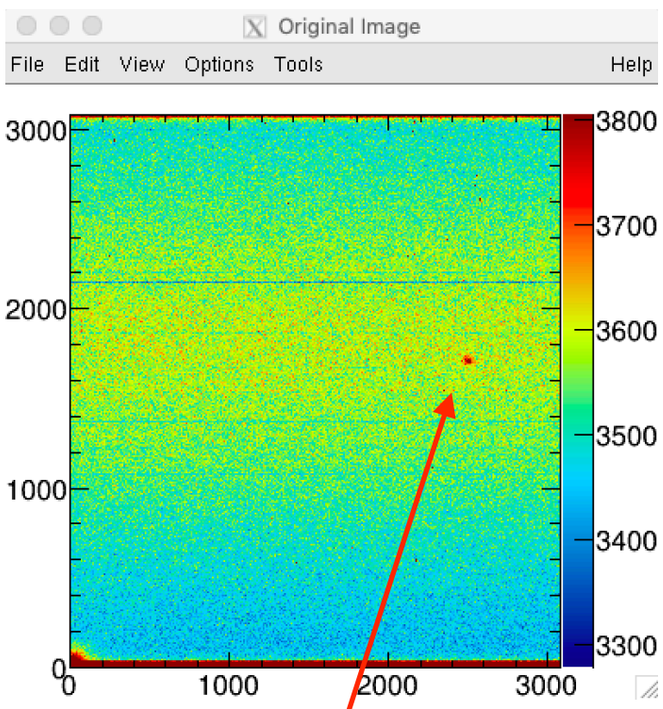


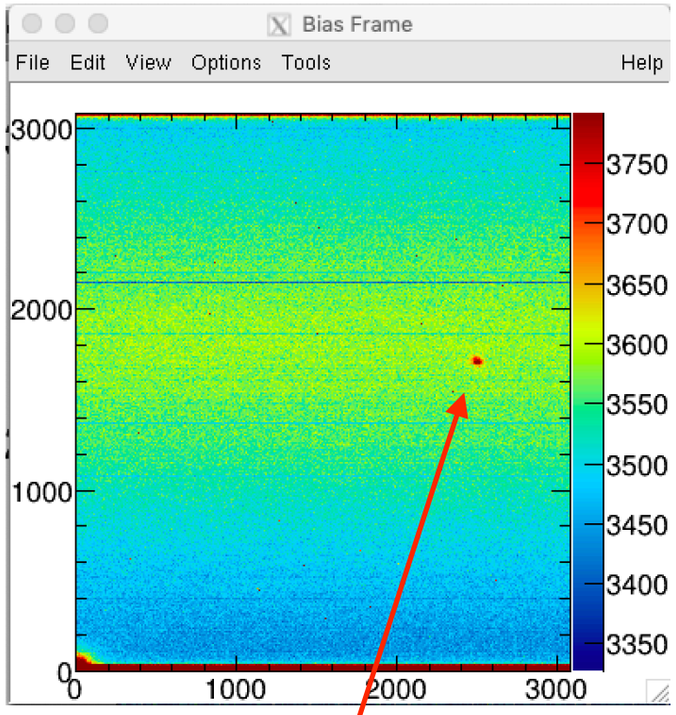


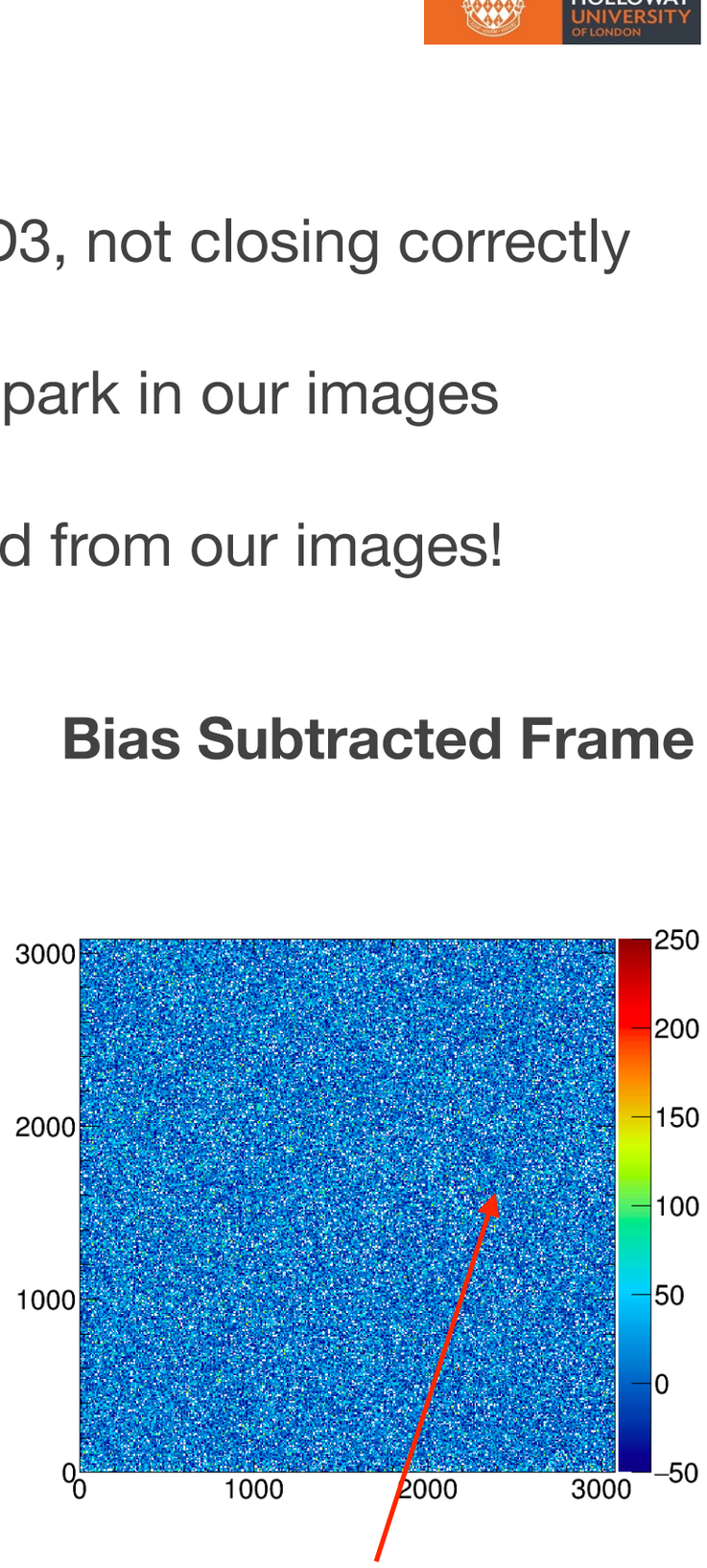
Problems

- We've had issues with the shutters, particularly for CCD3, not closing correctly
- If spark seen in bias frames, get negative 'shadow' of spark in our images
- If source seen in the bias frames, it then gets subtracted from our images!

Raw Image **Average Bias Frame** **Bias Subtracted Frame**







Blob

Will Parker

Blob

2

No Blob!

10.01.19

Current Solutions

- Calculate RMS of each individual bias frame 1D Z-projection, and check if it's below a predetermined threshold for sparks
  - This threshold is temperature, binning, exposure time and CCD specific, and also changes with external conditions (temperature of lab, voltage etc.) so needs to be updated regularly
- Can then either average over remaining bias frames, or use first *n* event frames which pass the cut to get sufficient biases (want to average over more biases to reduce effect of frame by frame differences)
  - This gets rid of sparks from bias frames, but **not** sources
  - For known sources, could check integral of box around location, compare to empty region of image and subtract if significantly larger

Bias Cleaning

- Once we have our bias frames (original bias or non-sparky image frames), we then use differences between successive bias frames to clean them
- If a pixel is > 4 standard deviations from mean of pixel intensity for frame *n*, look at same pixel in frame *n+1*. If that pixel is below the threshold replace it in frame *n*
- Gets rid of hot pixels which don't occur in all bias frames before averaging
- Can also bias subtract from the bias to further eliminate the effect of frame specific noise

Code Summary

- DMTPC Functions:
  - dmtpc::core::Dataset::biasAvg(i) returns average of all available biases
  - dmtpc::core::Dataset::getBiases(i) returns vector of all available biases
- General Functions:
  - handleBias, decides which frames to use for bias depending on spark cut. Lives in hptpc-daq/HPTPCLightAnalysis/lightsum.C on Alexander's branch
  - cleanBiasFramesUsingDifferences, cleans bias frames before subtraction. Also in hptpc-daq/HPTPCLightAnalysis/lightsum.C on Alexander's branch