EXTENDING THE RUN04 BAD AREA CUT

^{14}C data

Rachel Mannino

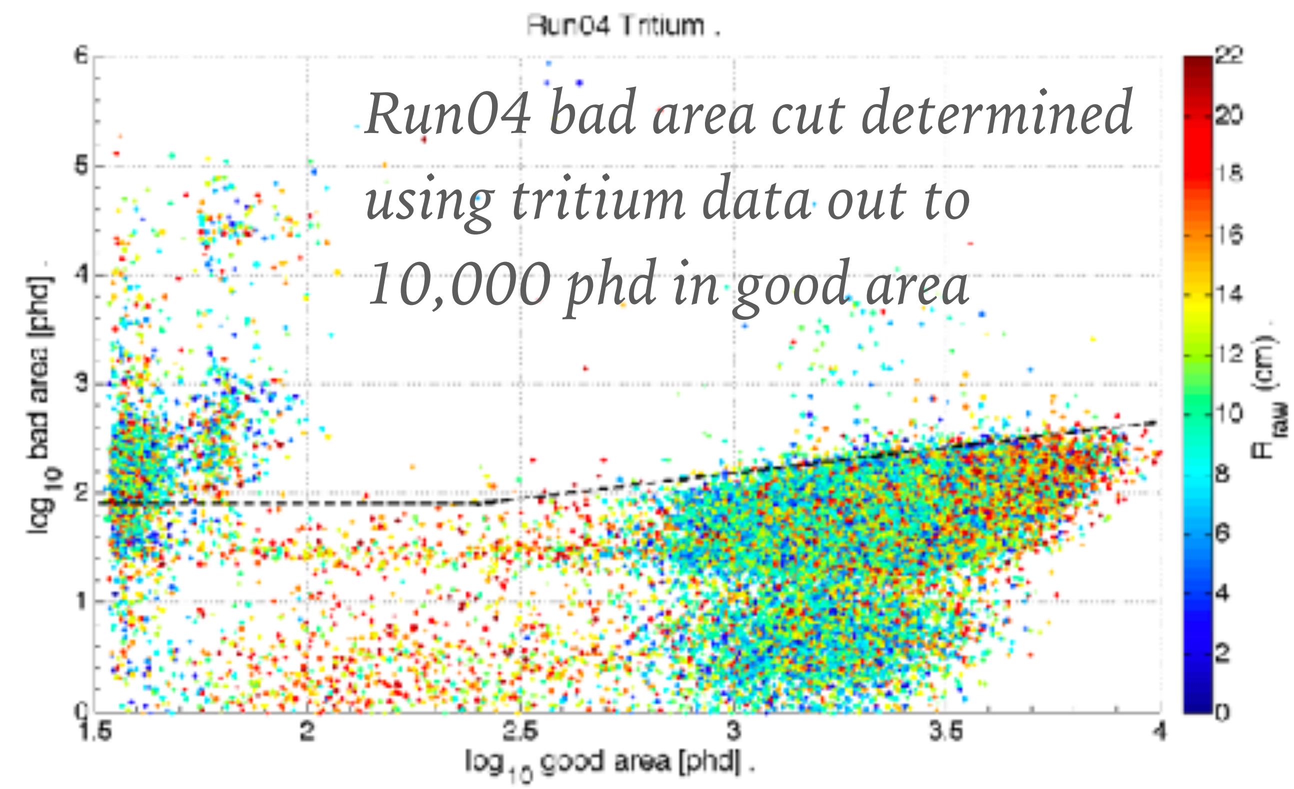
6 December 2017

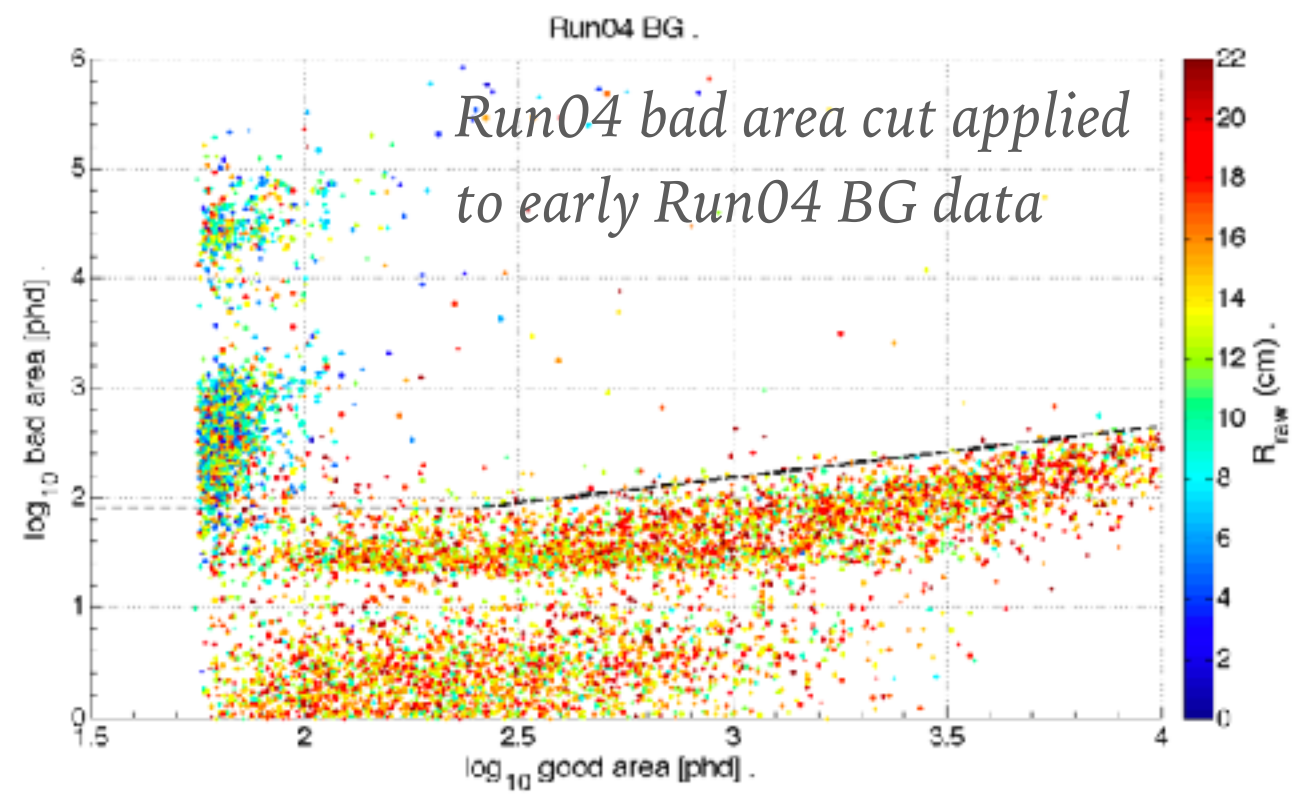
RUN04 ^{14}C DATASETS

- Using c14_endofLUX_09262017.mat
  - Evan created this filtered dataset of single scatters.
  - Corrections to the filter code have not been applied.
- Plan: Use ^{14}C data to extend bad area cut to higher energies.
  - ^{14}C decays via β- with Q = 156.5 keV
  - Jon's presentation on ^{14}C (link to slides) noted that ^{131m}Xe events overlapped the ^{14}C dataset.
    - ^{131m}Xe decays via 163.9 keV gammas

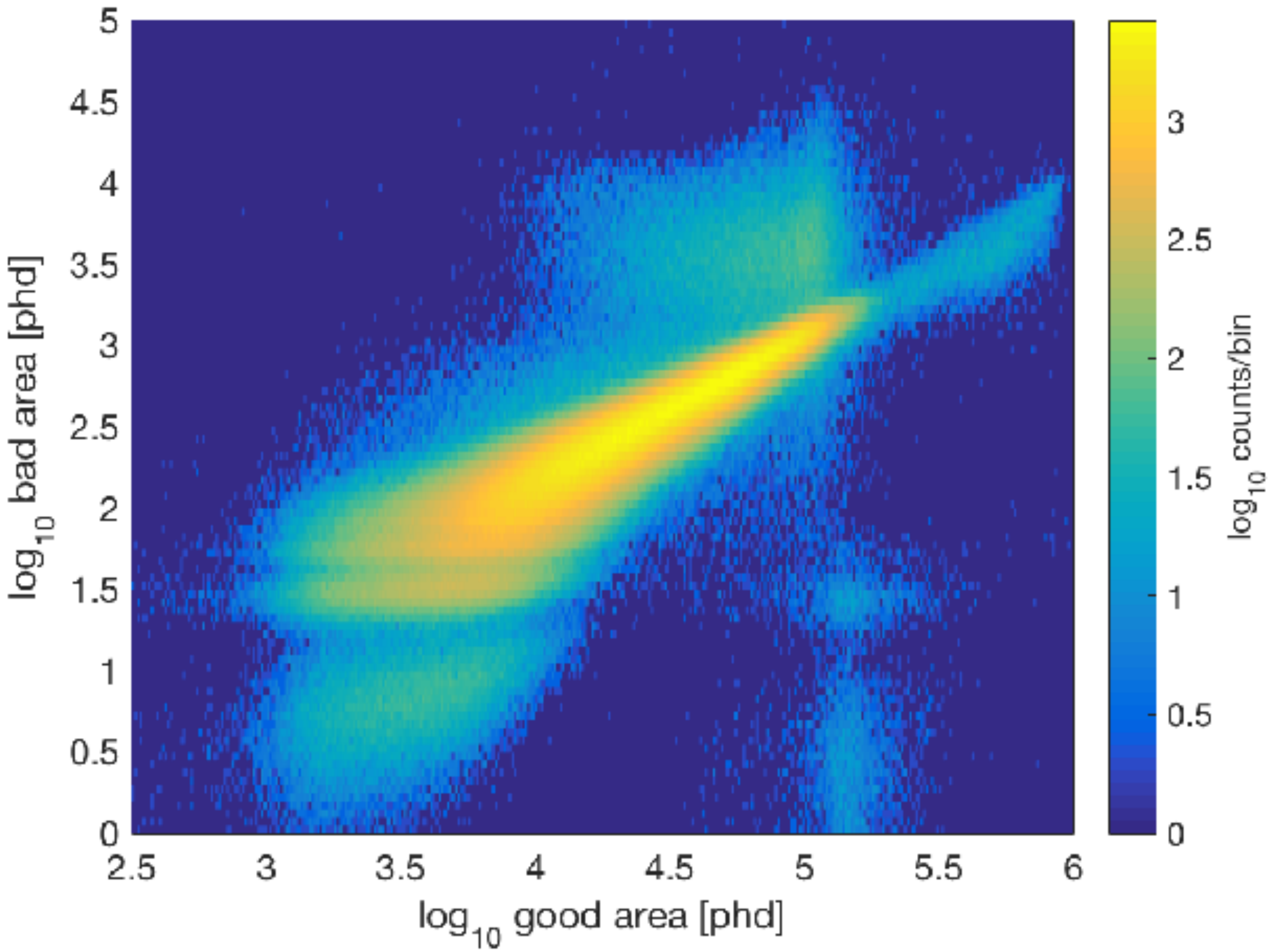
GOOD AREA AND BAD AREA

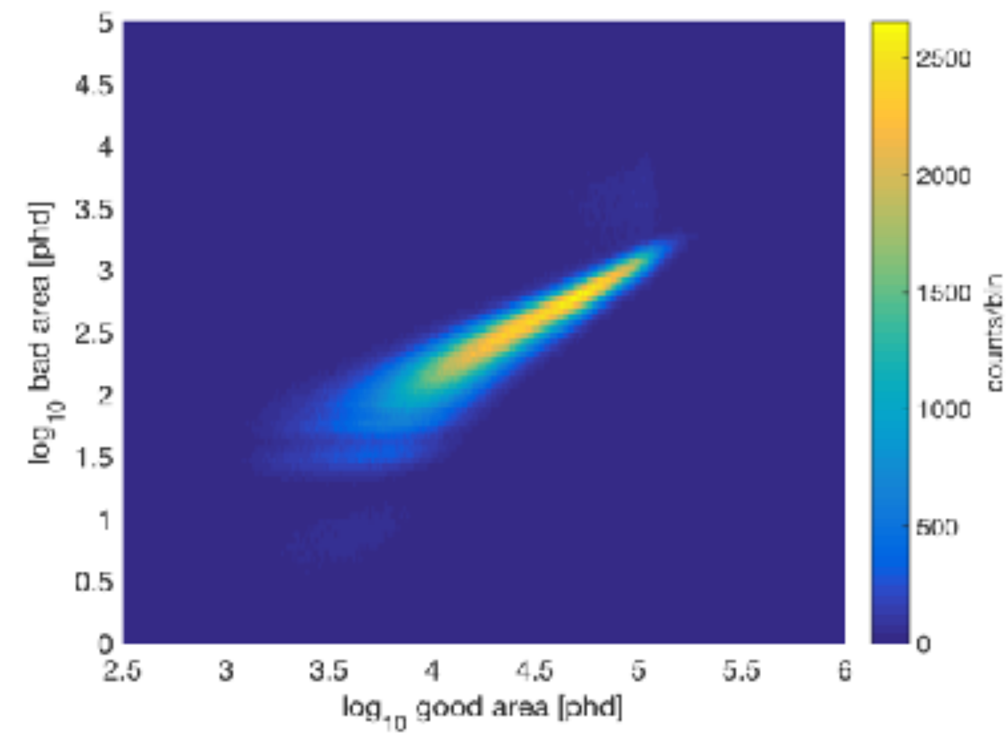
- Good area = S1 + S2;
- Bad area = full event area - good area;
- Bad area cut removes events where the event window has anomalies such as electron trains, glow, etc.
  - LUX only keeps 10 pulses/event, so using the full_event_area_phe RQ captures the area of all signal area above baseline, even if the PulseFinder did not classify it as a pulse.
  - Designed for single-scatter events.
  - Calibrate bad area cut using high statistics datasets such as tritium (*earlier incarnation of Run04 bad area cut*) or ^{83m}Kr (*now*).
- Filter code creates "goodarea" and "badarea" RQs using uncorrected, raw S1 and S2 areas.





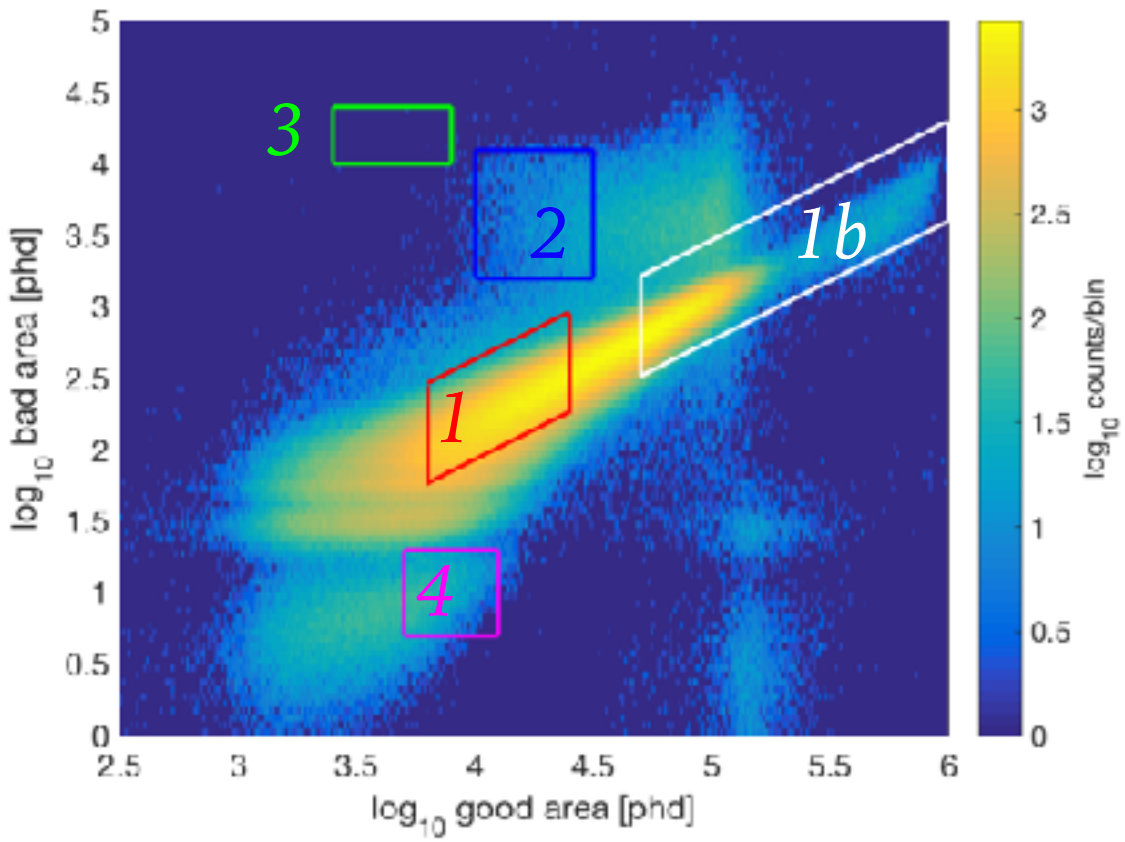
LOG$_{10}$(BAD AREA) VS. LOG$_{10}$(GOOD AREA)



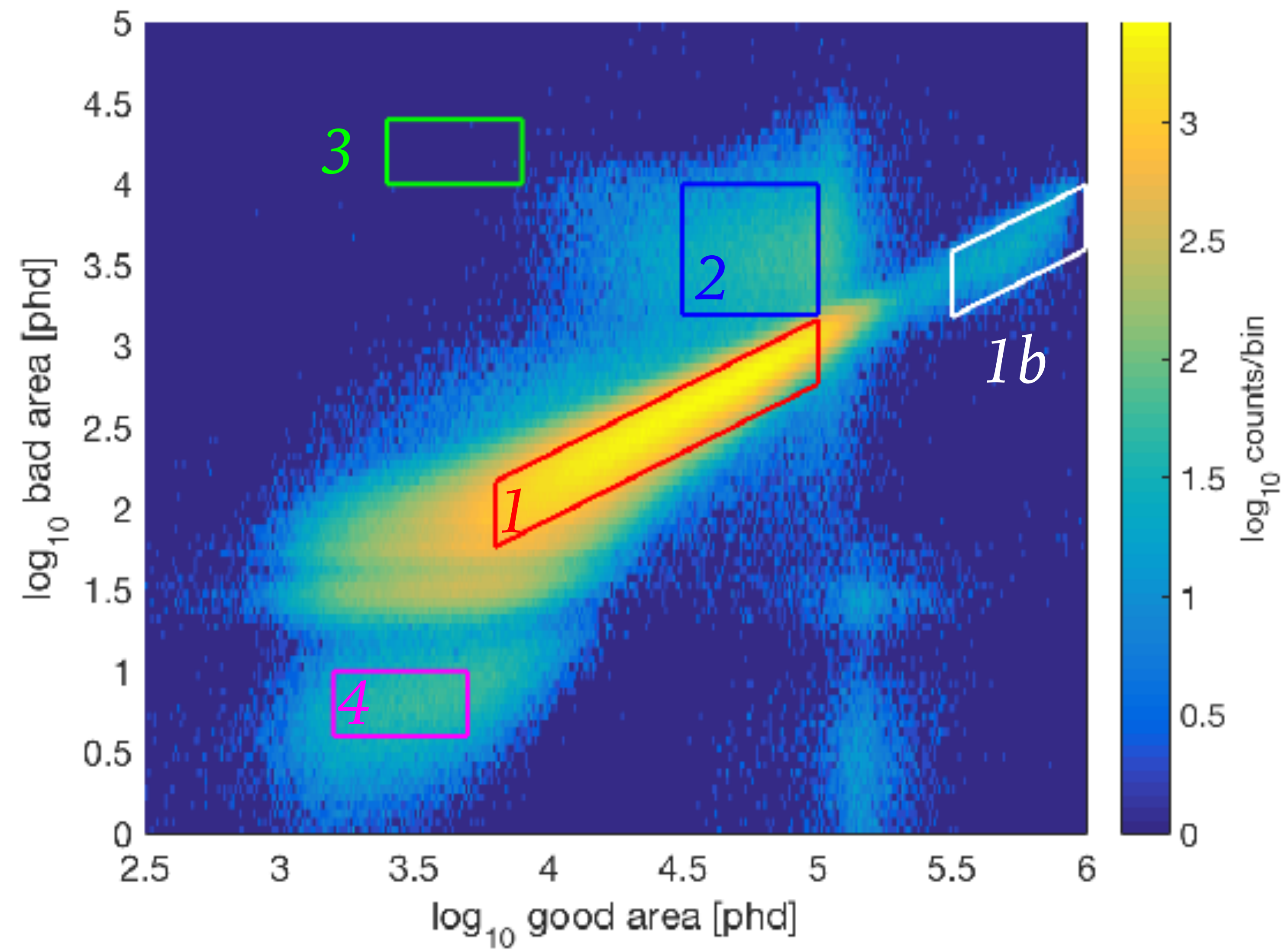


- Plot $\log_{10}$(bad area) vs. $\log_{10}$(good area) for the Run04 ^{14}C data.
  - *(left)* Color scale is in units of $\log_{10}$(counts/bin).
  - *(above)* Color scale is in units of counts/bin.

LOG$_{10}$(BAD AREA) VS. LOG$_{10}$(GOOD AREA)



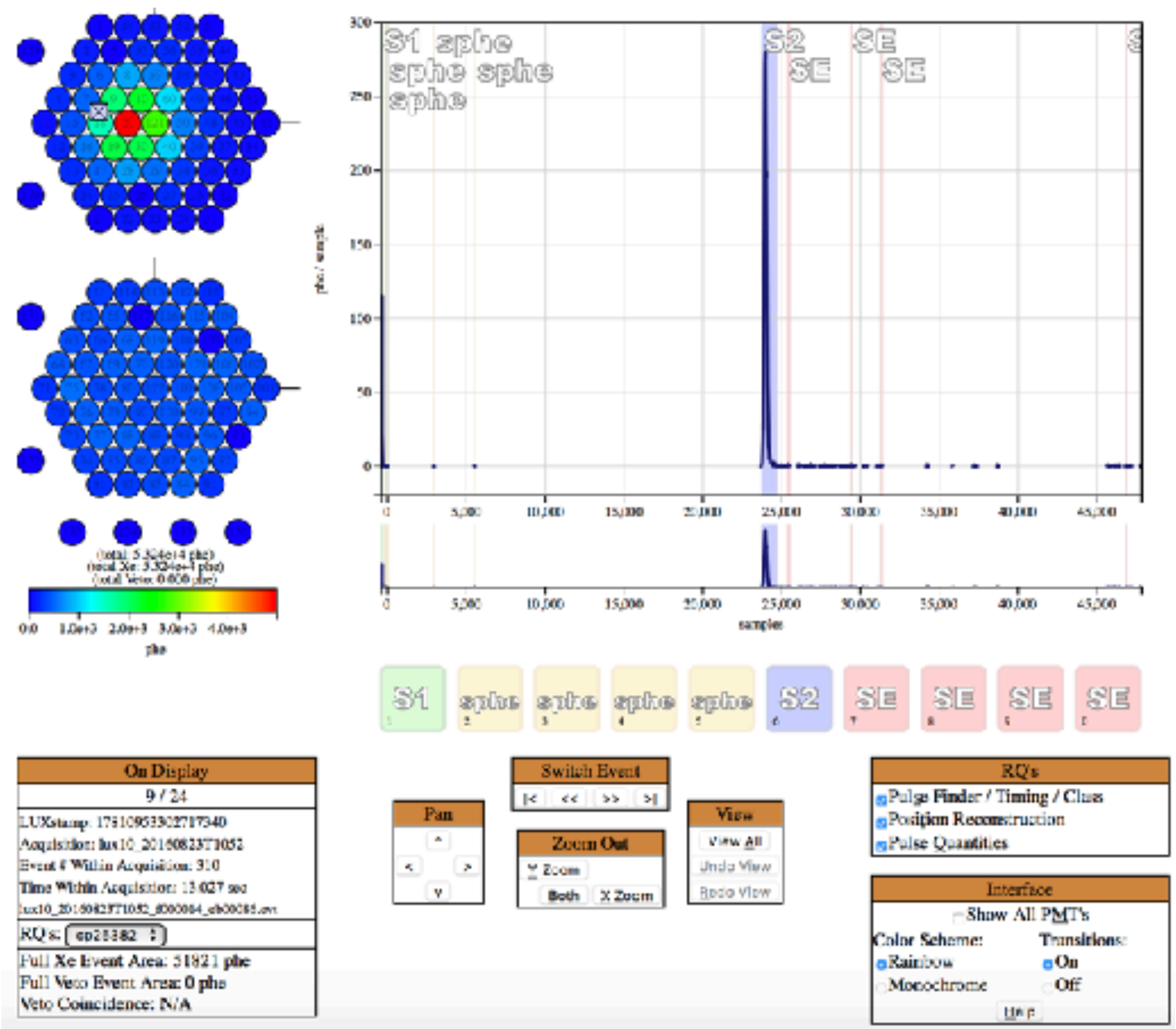
- Roughly classify events into populations to study S1 & S2 areas, energies, and any anomalies in Visualux.
  - *(red)* Population 1
  - *(white)* Population 1b
  - *(blue)* Population 2
  - *(green)* Population 3
  - *(magenta)* Population 4

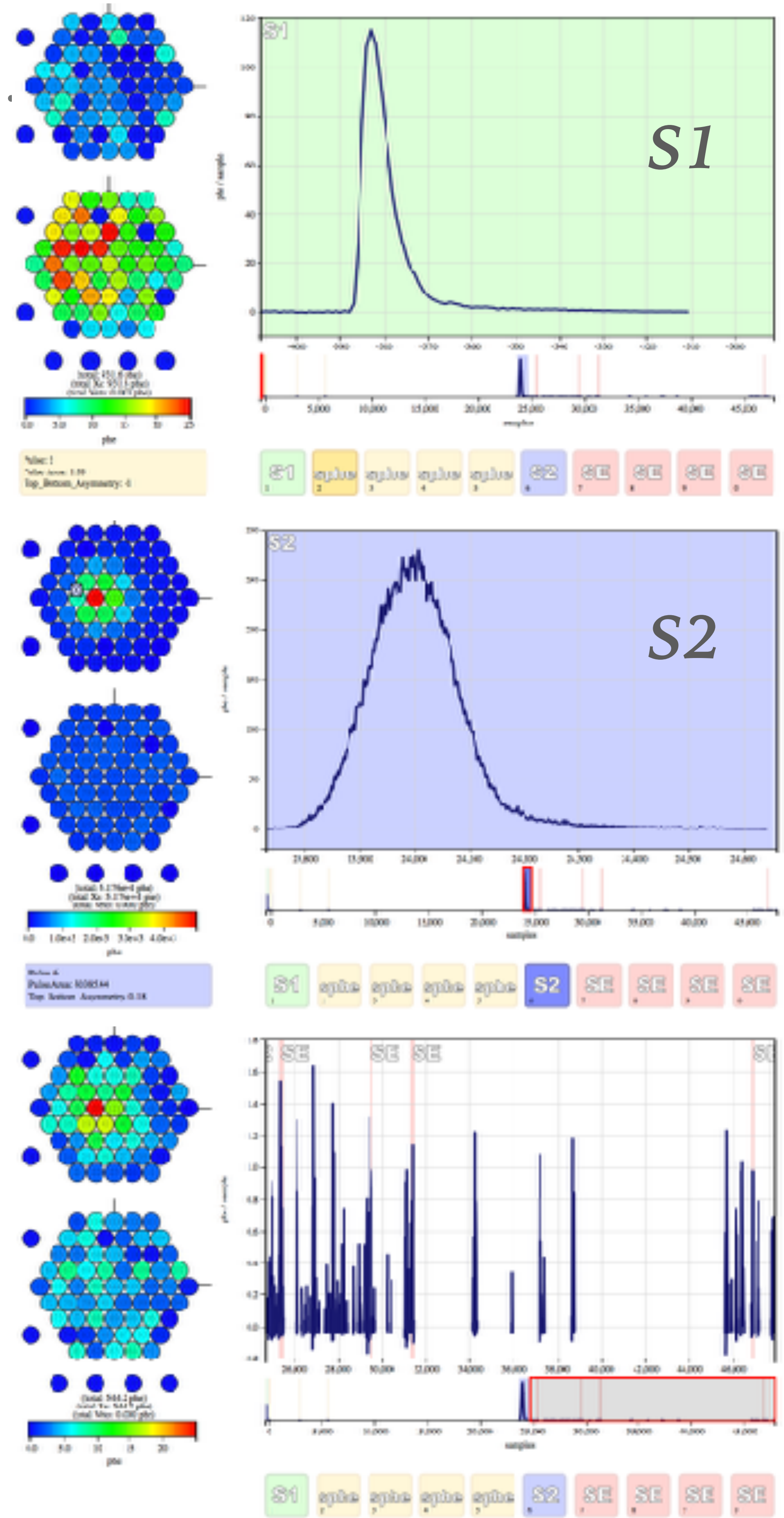


(left) ^{14}C data with ^{83m}Kr population cuts blindly applied. These are not selecting the correct populations.

(right) ^{14}C data with slightly modified cuts.

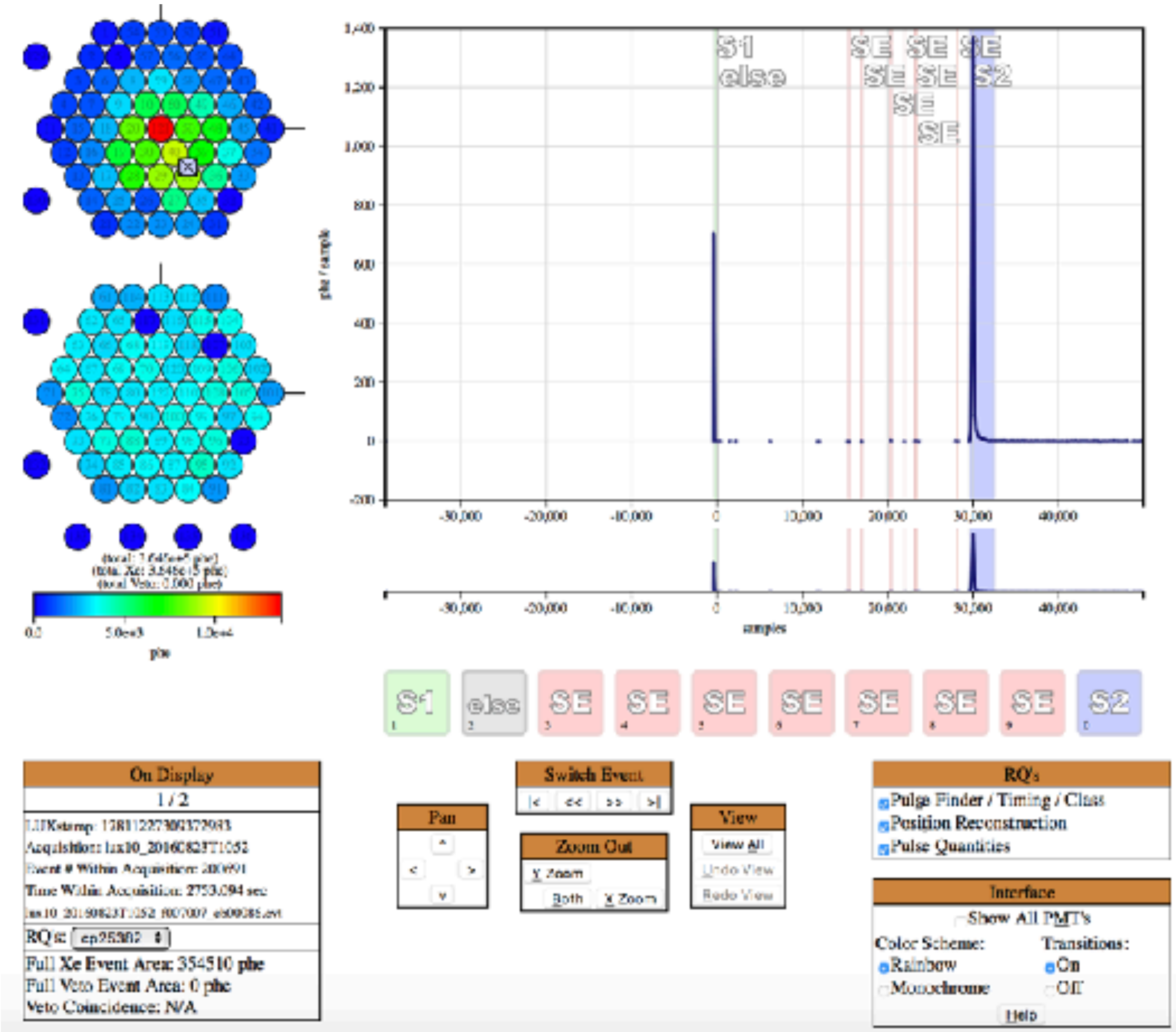
VISUALUX: POPULATION 1

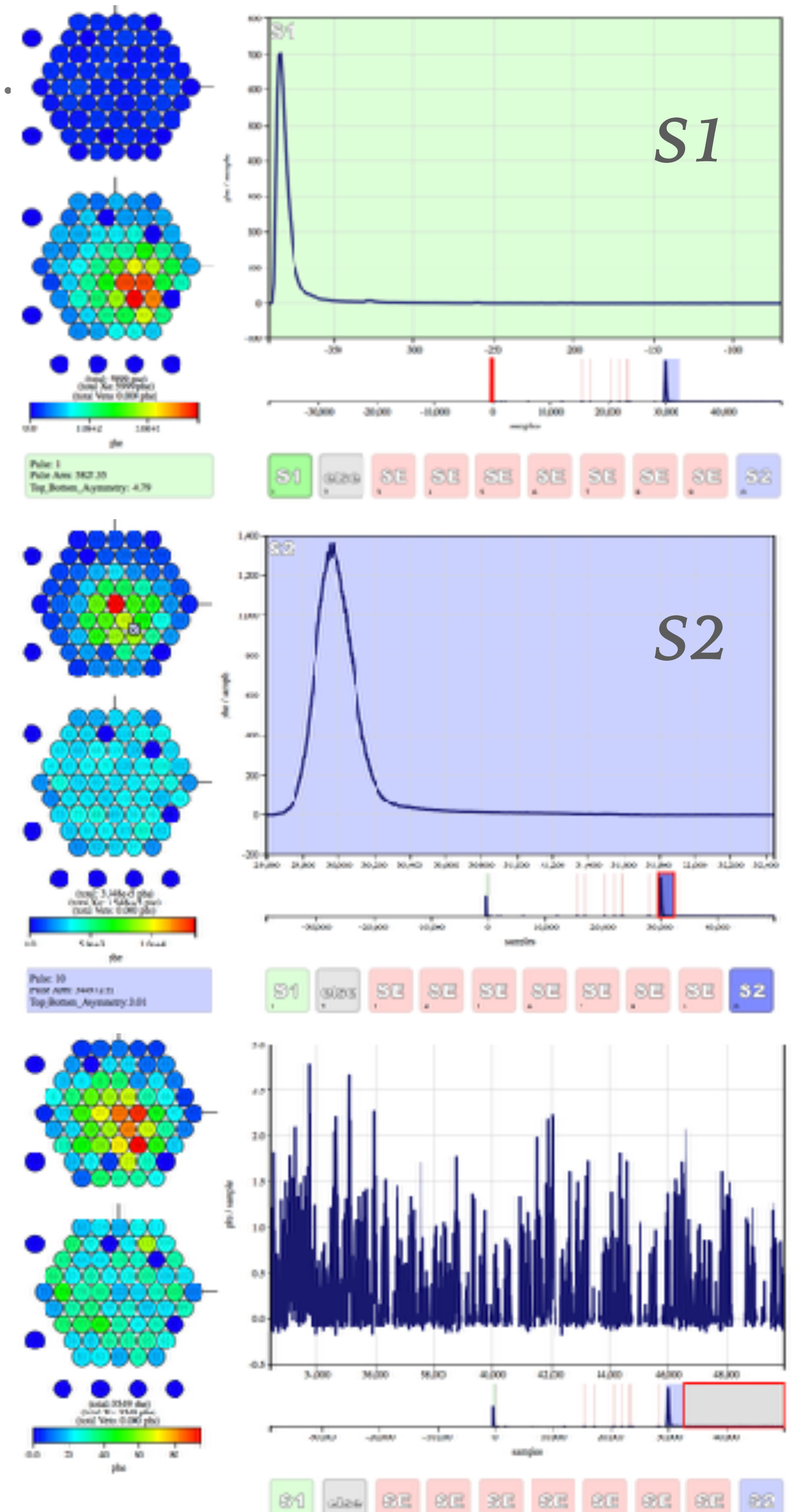




- Scanned 100 events of pop1 in VisuaLux; 95% events are single-scatter with the S2 followed by several-to-dozens of SE and SPE.
  - 5% of events had an S2 which looked like a misclassified double scatter.
- *(lower right)* View of typical pulses following an S2. These don't qualify as e-trains, but there are >10 pulses/event.

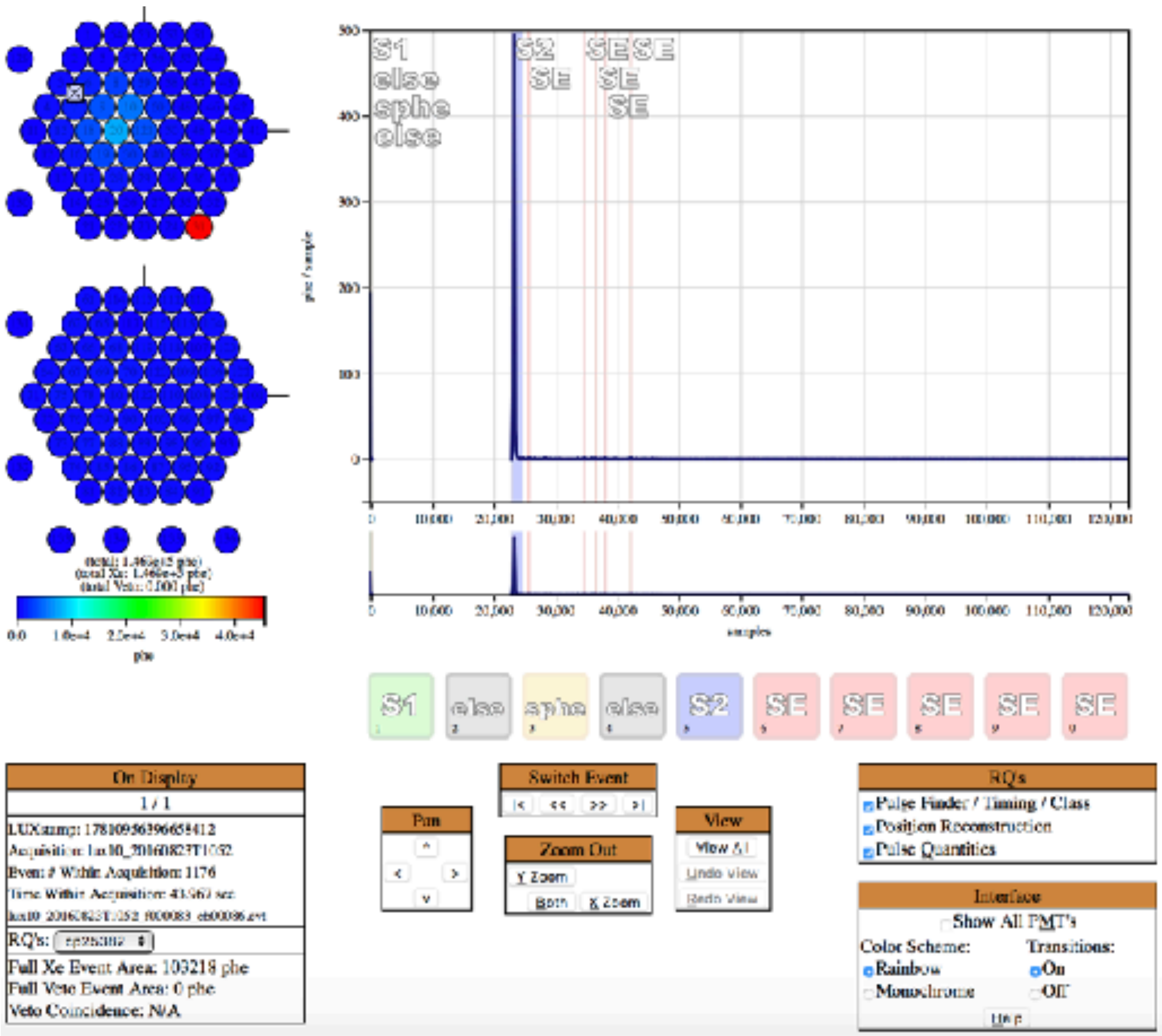
VISUALUX: POPULATION 1B

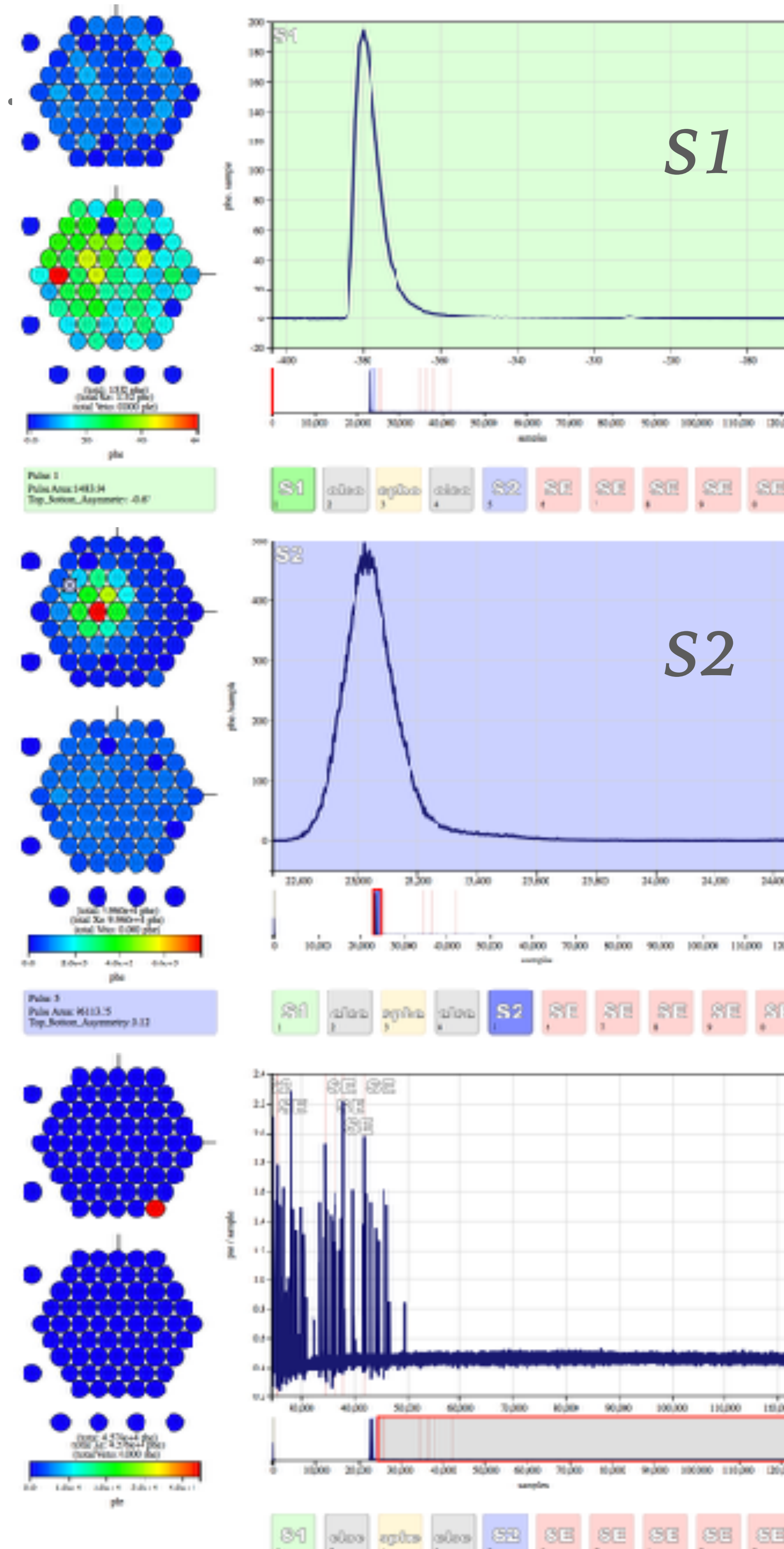




- Scanned 100 events of pop1b in VisuaLux; 65% events are single-scatter with the S2 followed by an electron train *(pictured here)*.
  - 23% had double scatters, 10% were 3 or more scatters, 2% have baseline issues.
- *(lower right)* View of typical pulses following an S2. These are e-trains.

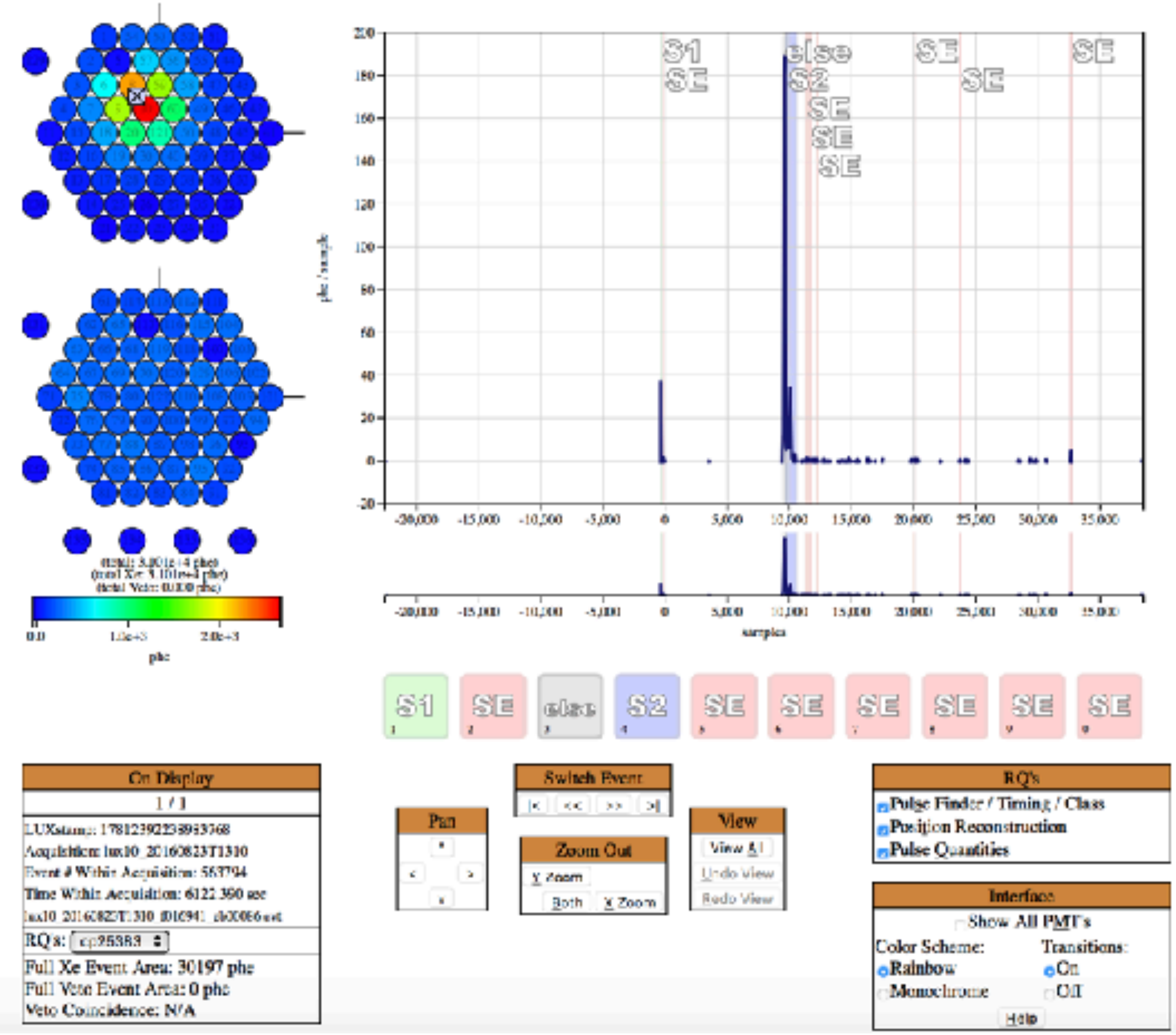
VISUALUX: POPULATION 2

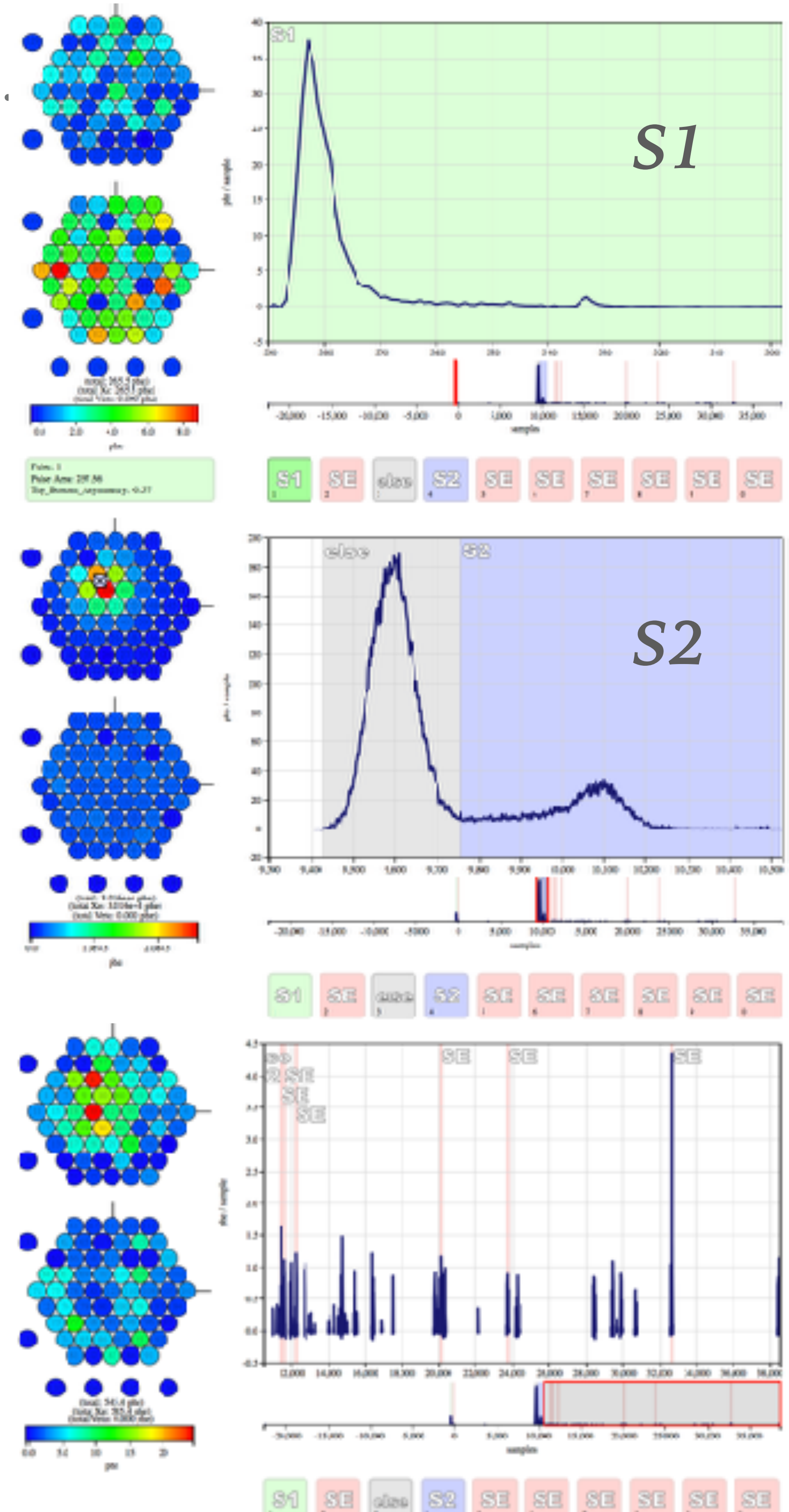




- Scanned 100 events of pop2 in VisuaLux; 96% events are single-scatter with the S2 followed baseline issues.
  - 4% of events had >1 S2 with baseline issues.
  - 66% in PMT 31, 8% in PMTs 3/4, 8% in PMT 25/26, rest in other PMTs
- *(lower right)* View of typical pulses following an S2. This is a baseline shift which contributes to the event's large amount of bad area.

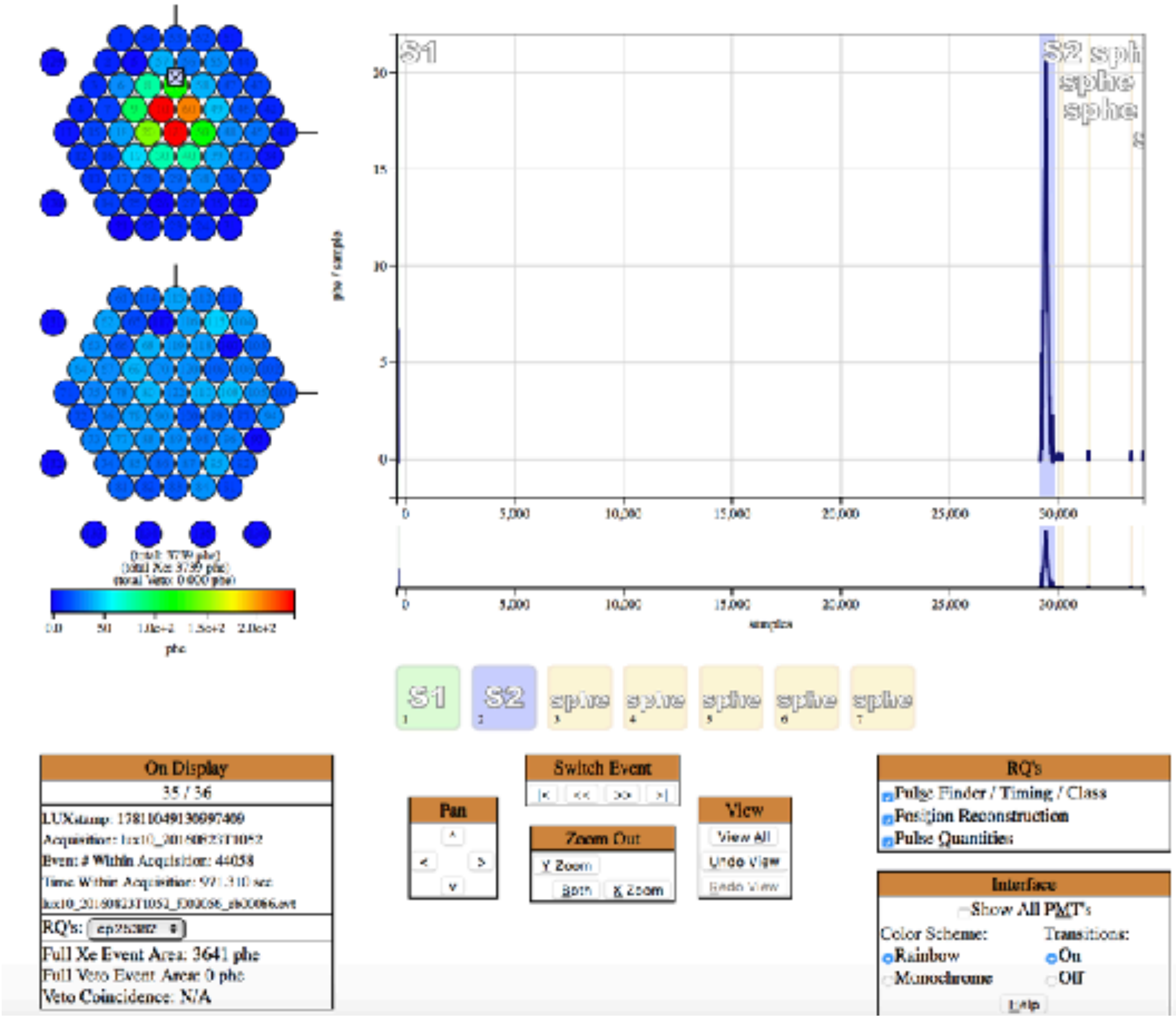
VISUALUX: POPULATION 3

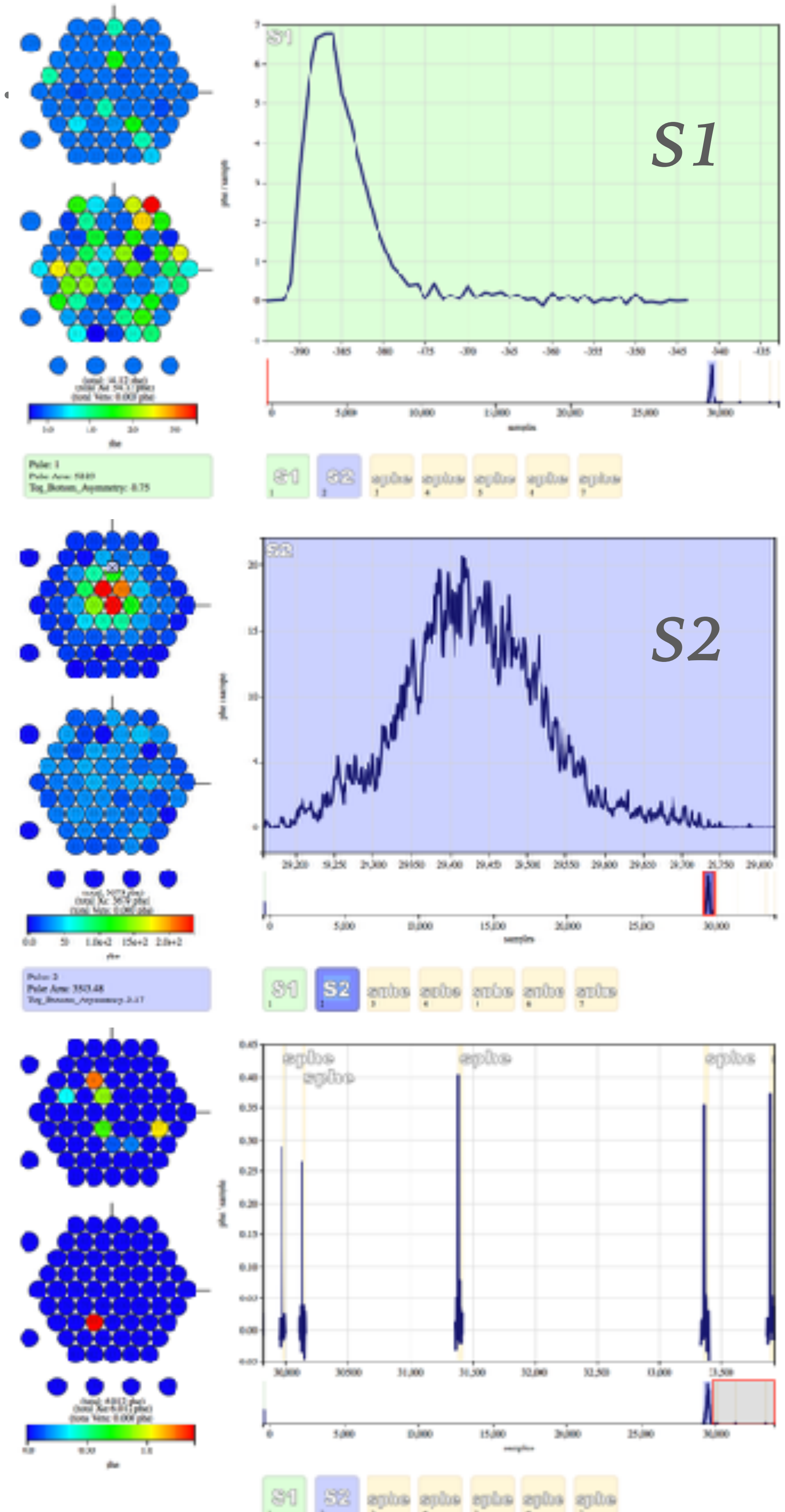




- Scanned the 66 events of pop3 in VisuaLux; 53/66 events are misclassified double scatters where the initial S2 is classed as an “else”. This was a significant population for Kr-83m but ***not for C-14***.
  - 7 events had baseline issues, and 5 events have weird extra pulses.
- *(lower right)* View of typical pulses following an S2. These are typically a mix of SE and SPE.

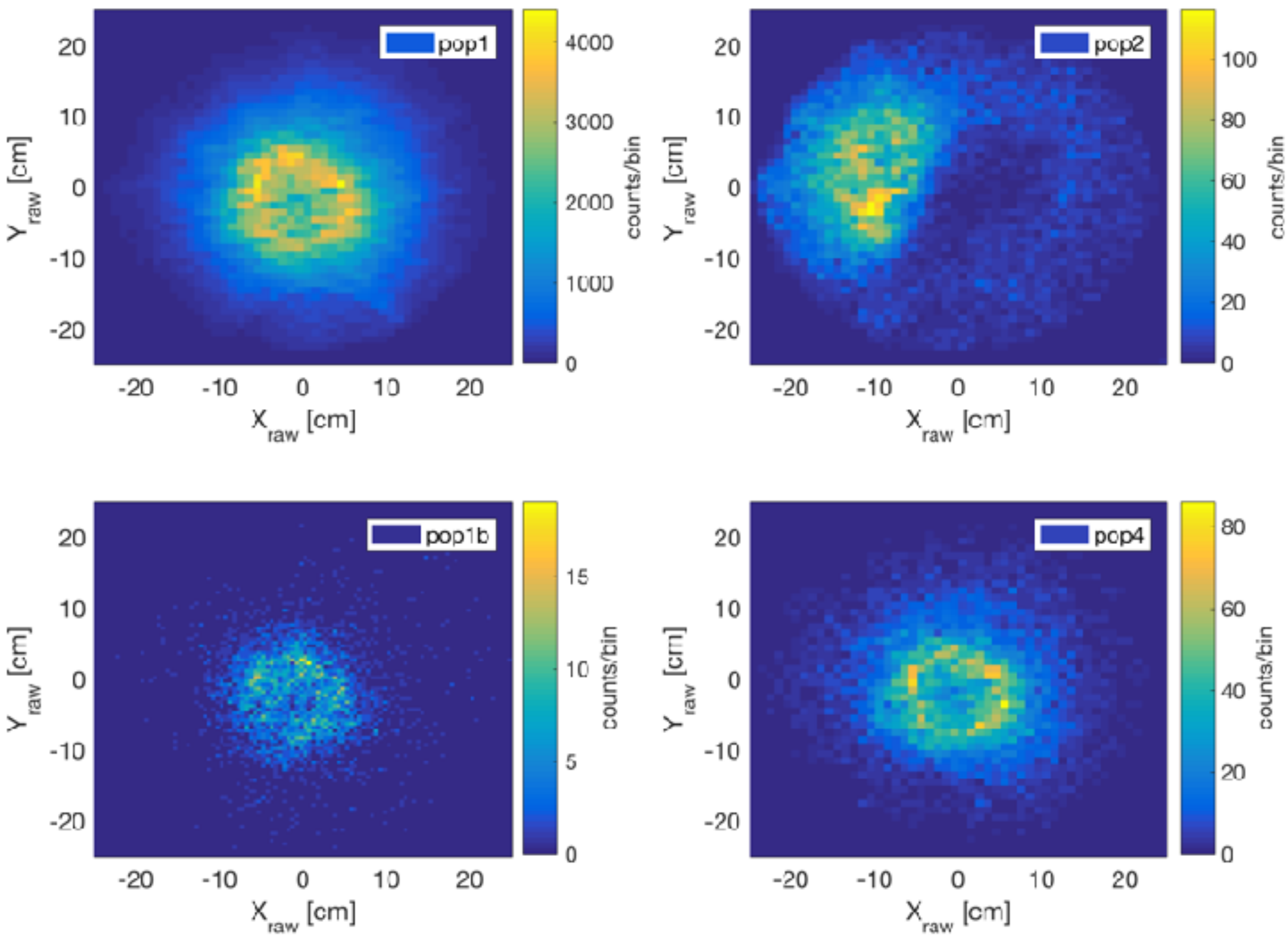
VISUALUX: POPULATION 4





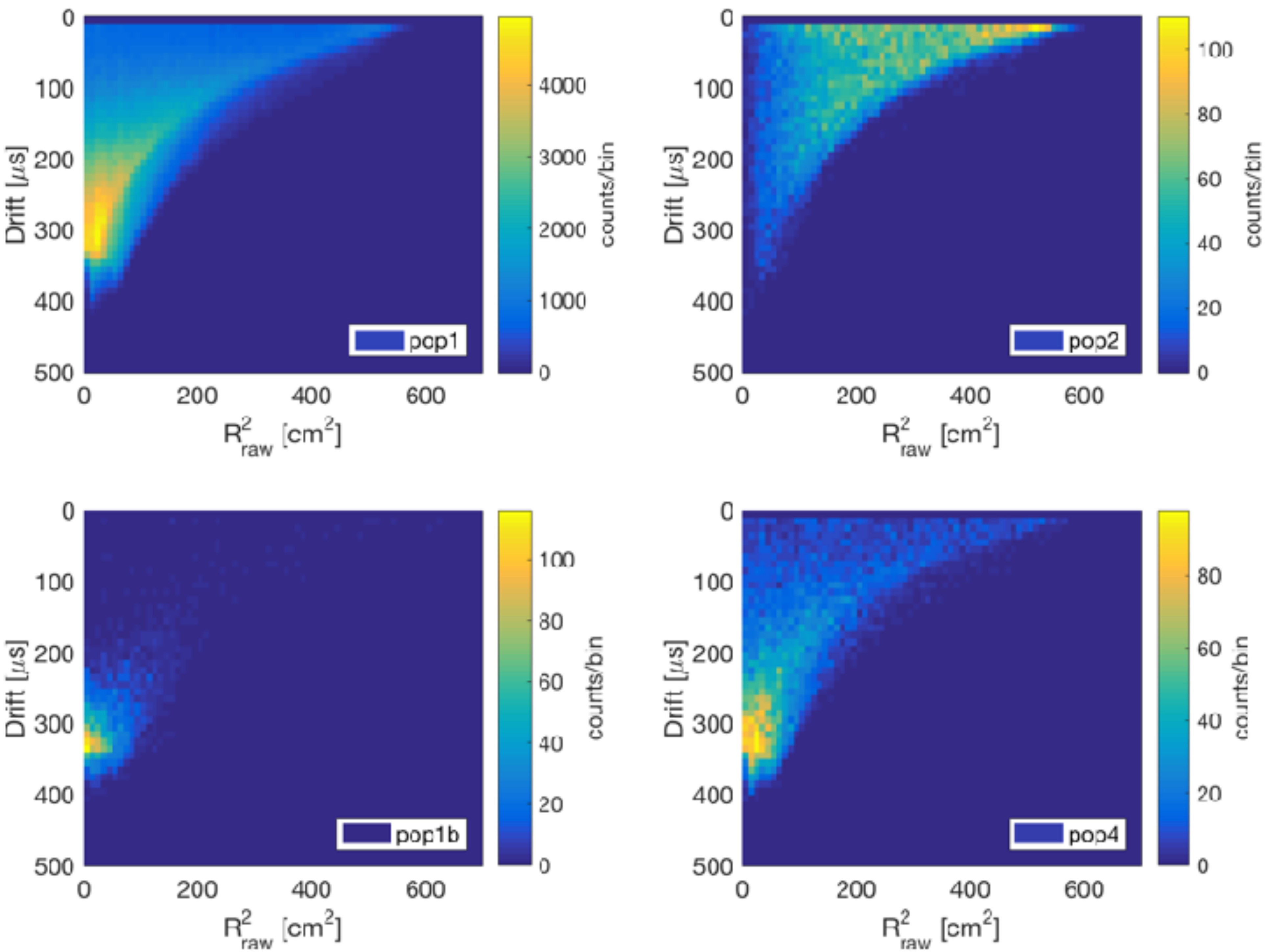
- Scanned 100 events of pop4 in VisuaLux; 96% events are single-scatter with the S2 followed by only a few SPE.
  - 3% of events had an S2 followed by an SE in addition to SPE; 1% of events had an S2 which looked like a misclassified double scatter.
- *(lower right)* View of typical pulses following an S2.

XY POSITIONS OF THE POPULATIONS



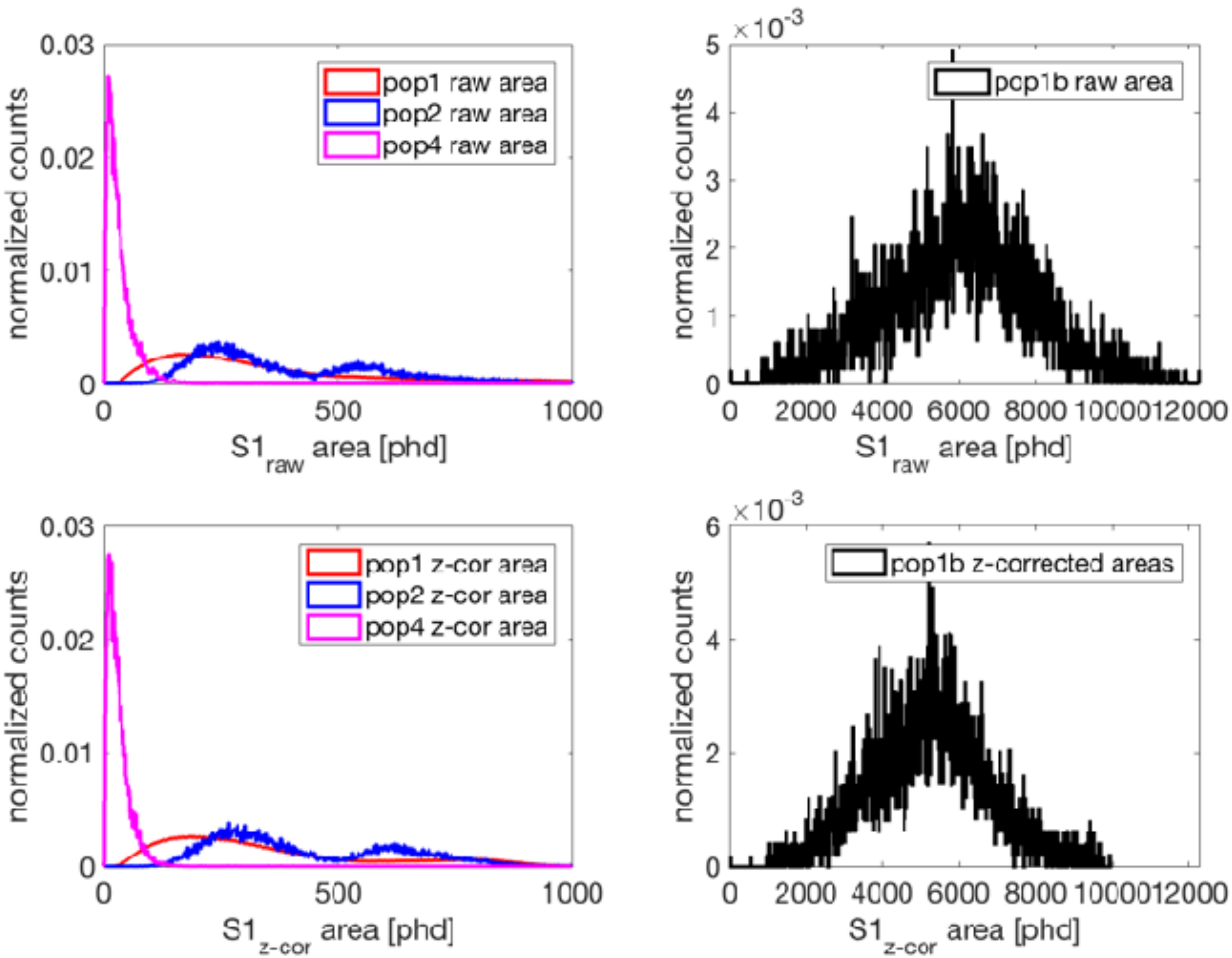
- Delensed variables not available.
- *(upper left)* Population 1 has a fairly uniform distribution in x-y.
- *(upper center)* Population 2 is concentrated at -x near the 9:00 panel.
- *(lower left)* Population 1b is mostly uniform, but small xy ranges imply long drift times.
- *(lower right)* Population 4 is fairly uniform.

DRIFT POSITIONS OF THE POPULATIONS



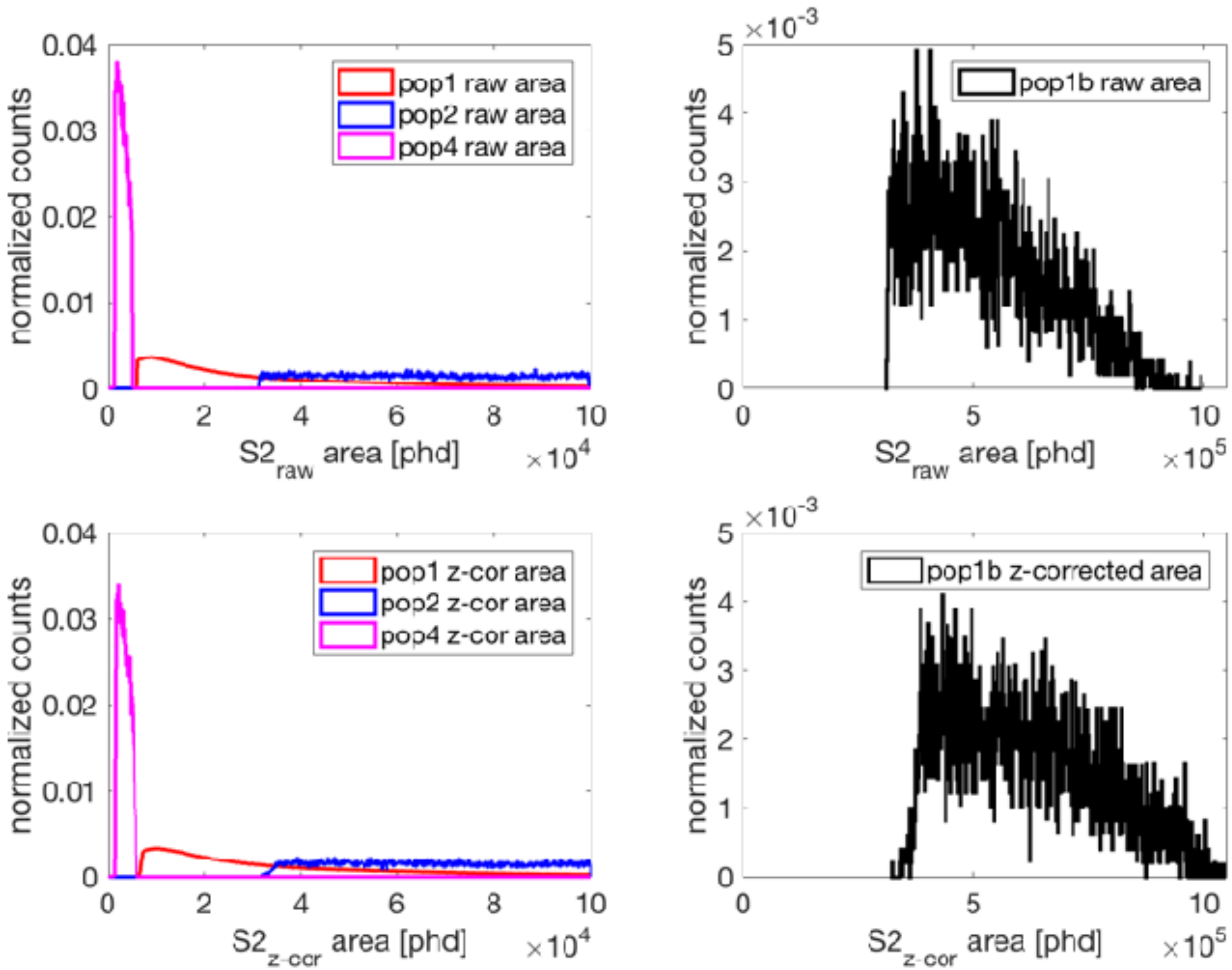
- *(upper left)* Population 1 is somewhat uniform in drift vs. r^2.
- *(upper center)* Population 2 is concentrated toward the top of the detector.
- *(lower left)* Population 1b is concentrated near the bottom of the detector.
- *(lower right)* Population 4 is fairly uniform.

S1 AREAS



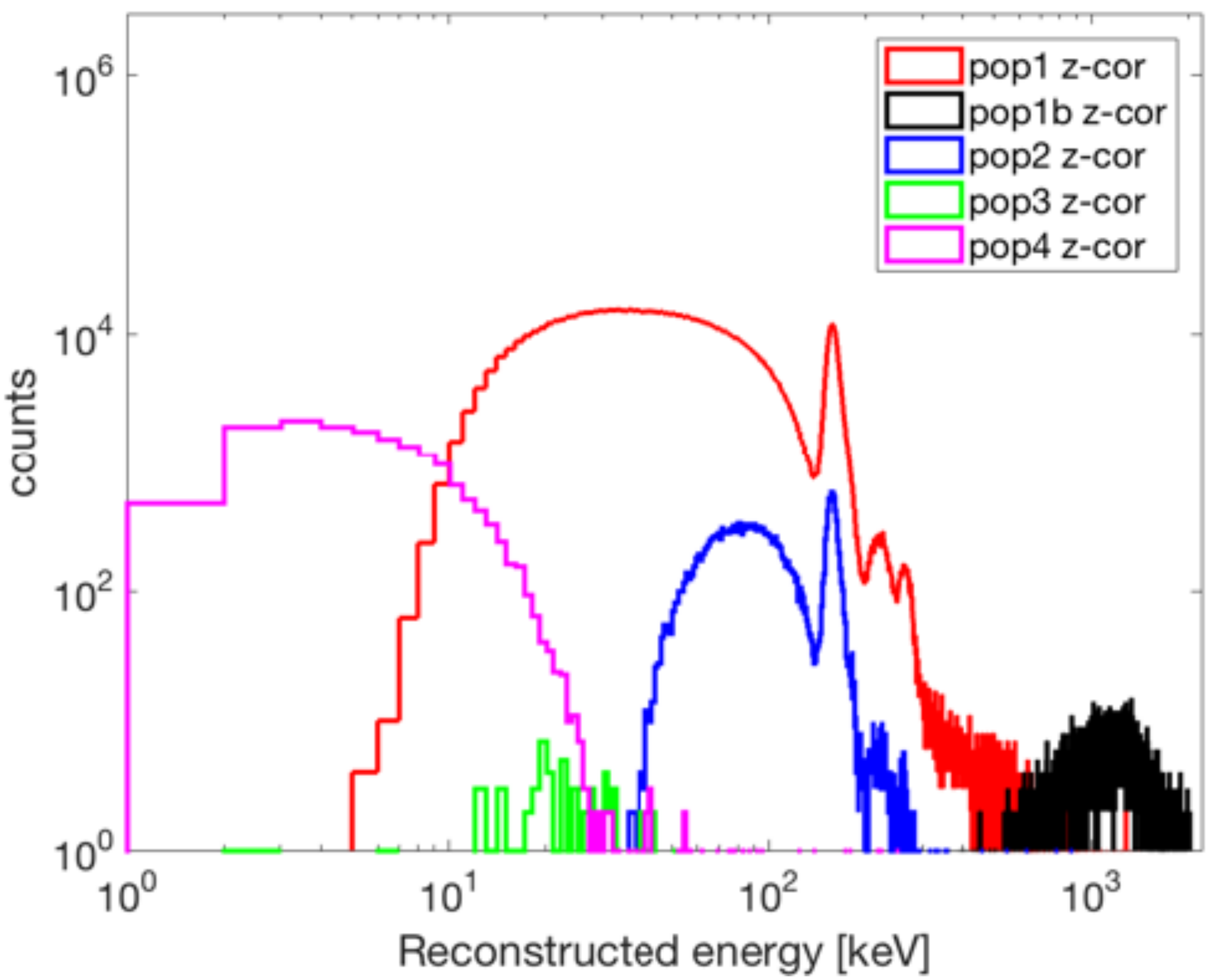
- Histograms of the S1 pulse area size for populations 1, 1b, 2, and 4 are plotted in raw area *(top row)* and z-corrected area *(bottom row)*.

S2 AREAS



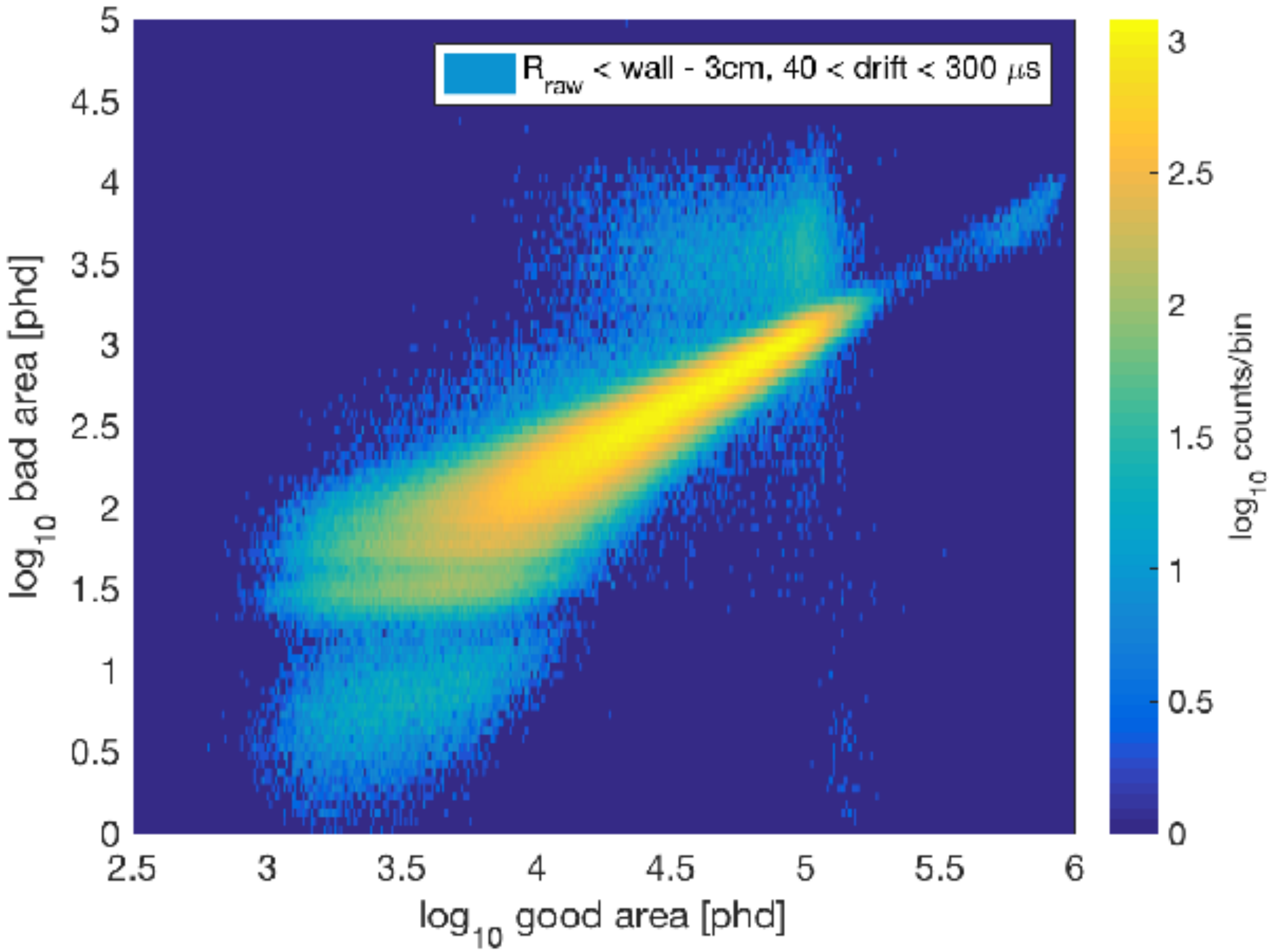
- Histograms of the S2 pulse area size for populations 1, 1b, 2, and 4 are plotted in raw area *(top row)* and z-corrected area *(bottom row)*.

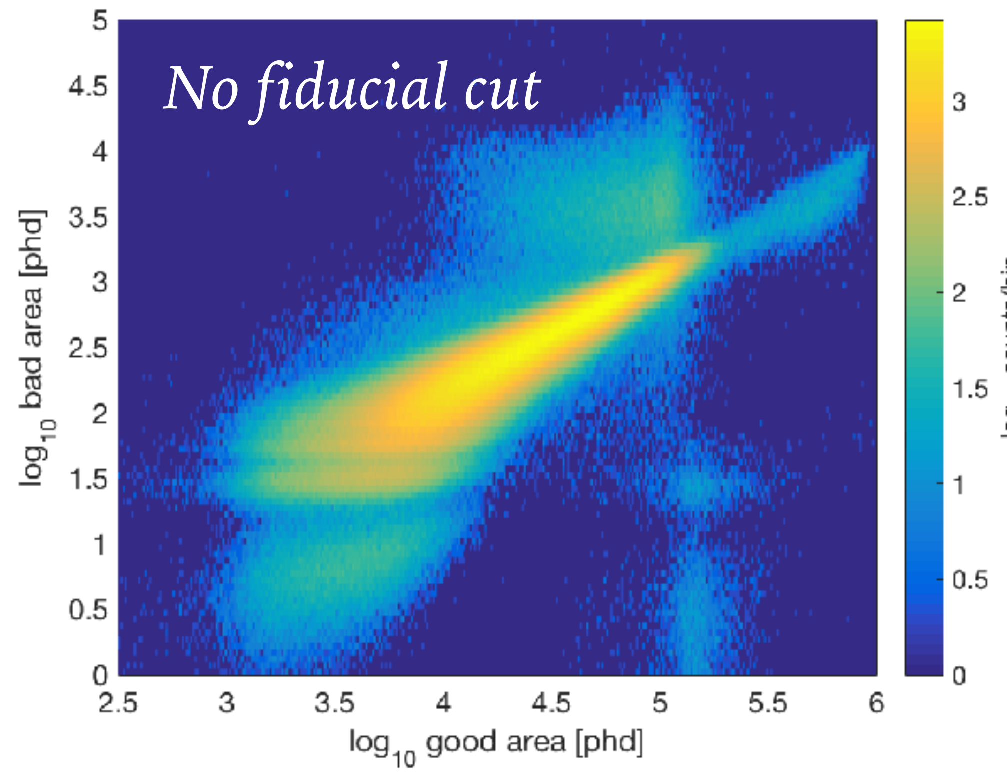
RECONSTRUCTED ENERGIES



- *(left)* Histograms of the reconstructed energy calculated from the z-corrected S1 and S2 pulse areas with g1= 0.0977 and g2 = 18.76 for each of the populations.
  - Kelsey presented these values in Aug 3, 2017 Run04 BG meeting. These may be appropriate for lower energies.
- Populations 1 *(red)* and 2 *(blue)* have peaks near ~158 keV which is probably the ^{131m}Xe peak strangely shifted.
- ^{14}C should have an endpoint energy ~156 keV which is not consistent with population 1b *(black)* which was beset by e-trains.

APPLY RUN04 FIDUCIAL CUT



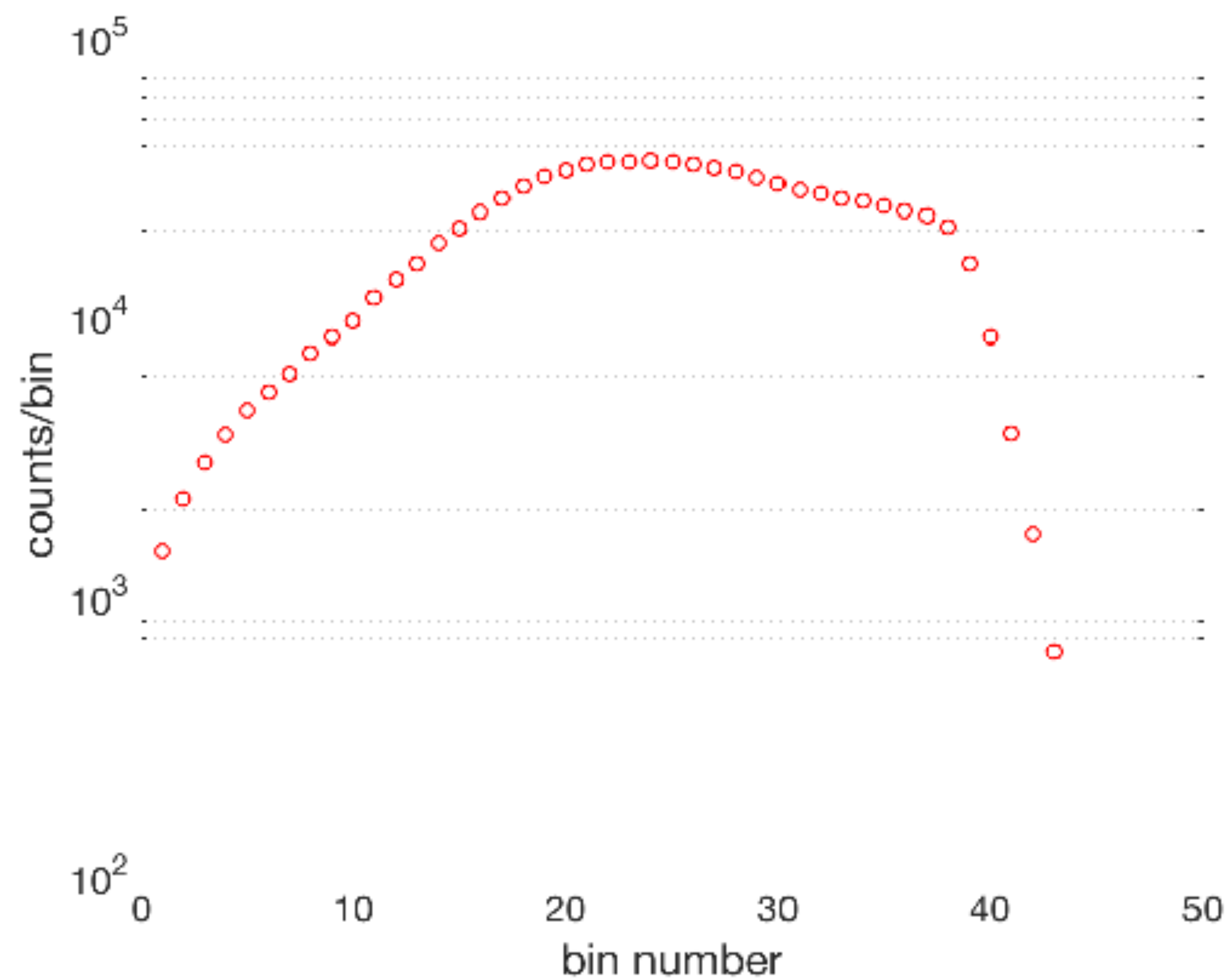


- *(above)* For comparison, this is the plot of log10(bad area) vs. log10(good area) ***without*** a fiducial cut applied.
  - Many "extra" populations that were not classified as 1, 1b, 2, 3, or 4 will disappear with a fiducial cut.
  - Many events in population 1b disappear with the fiducial cut.
  - The colorbar re-scaled, so the counts are relatively smaller with the fiducial cut.

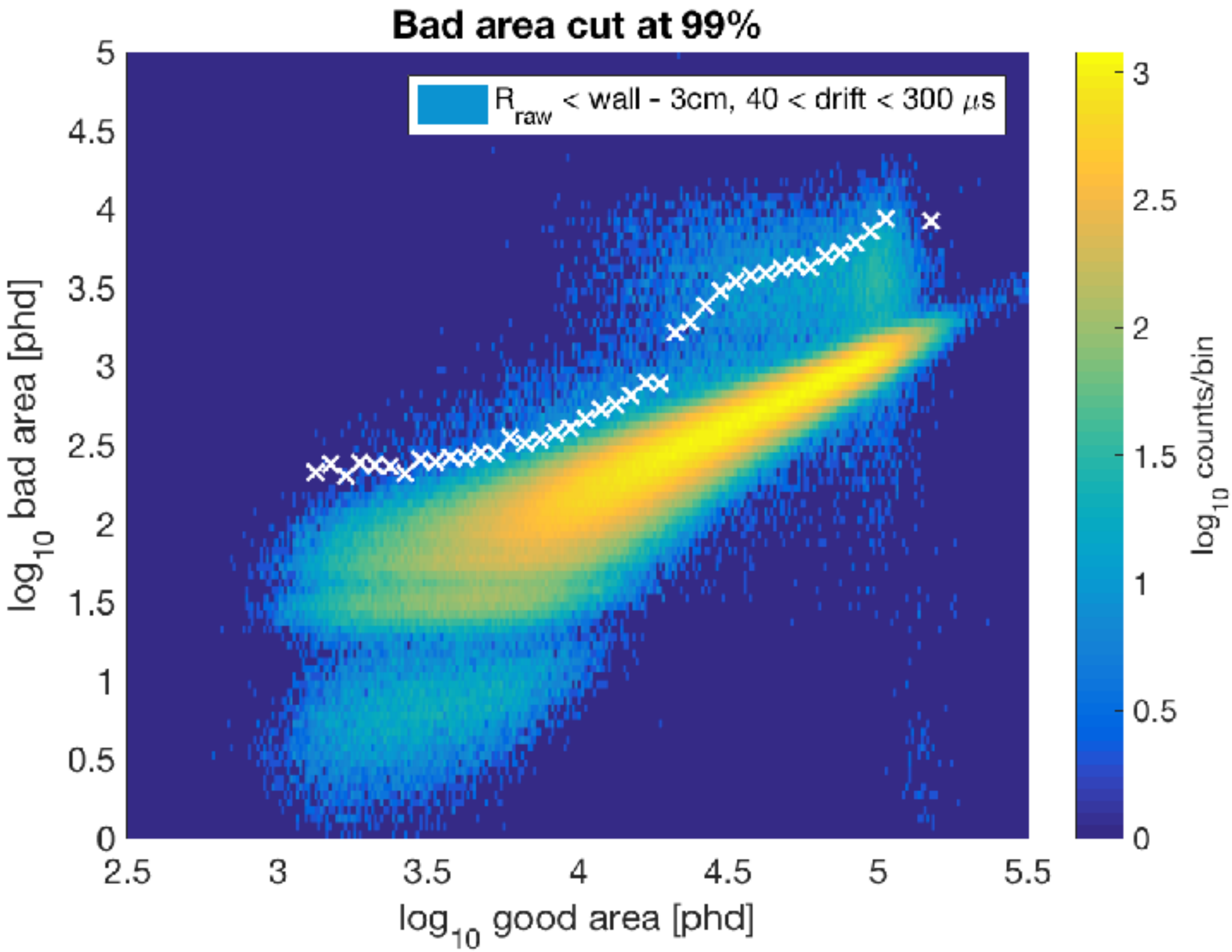
- *(above)* Apply the Run04 fiducial cut which uses the raw radius to cut 3 cm in from the wall as calculated in the script setRMax using look-up tables. The fiducial cut also cuts on drift time: 40 < drift time < 300 μs.

CONSTRUCTING A NEW BAD AREA CUT WITH ^{14}C, FIDUCIAL CUT

1. Bin log10(good area) in the vicinity of C-14 data distribution with fiducial cut applied. Bin edges range from 3.1 to 5.25 for a total of 43 bins. *(right)* Plot the number of counts/bin vs. bin number.
2. Calculate the log10(bad area) value at which X% of the data in the bin of log10(good area) is below.
   - Initial Run04 bad area cut determined from tritium data kept **99%** (X=99) of the data within the log10(good area) bin. This only cut 1% of the events as having too much bad area.
3. Determine the best value of X (ie., what percentile to keep).
4. Fit the log10(bad area) values at X% to calculate a cut line as a function of log10(good area) and log10(bad area).

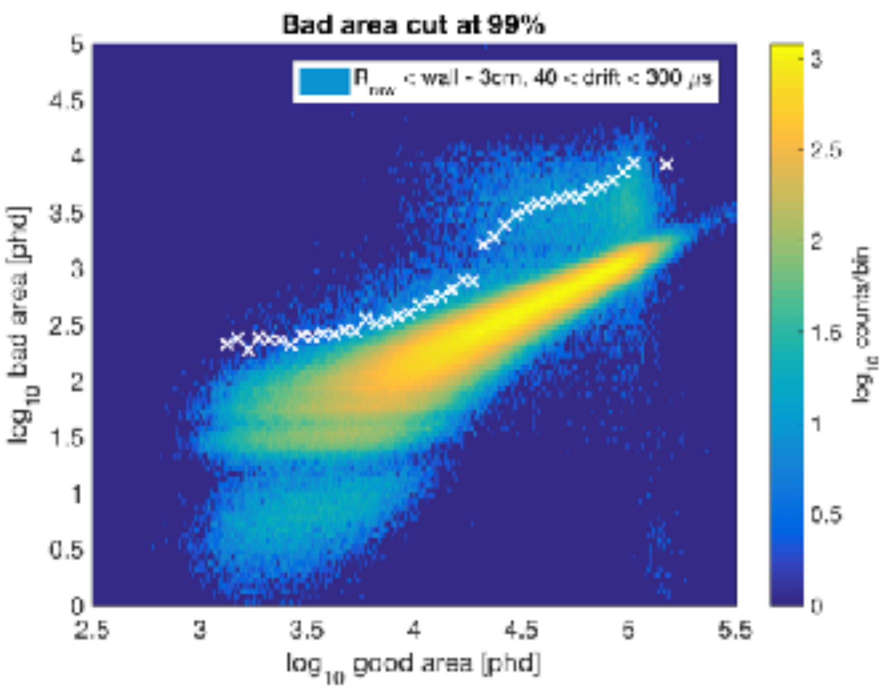


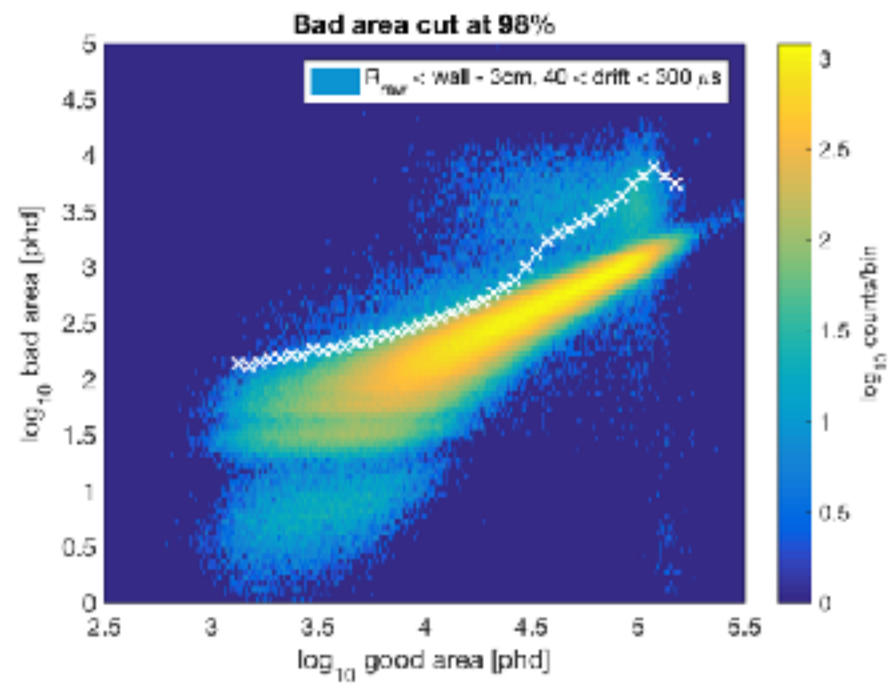
FIND THE 99% VALUE IN EACH BIN OF GOOD AREA

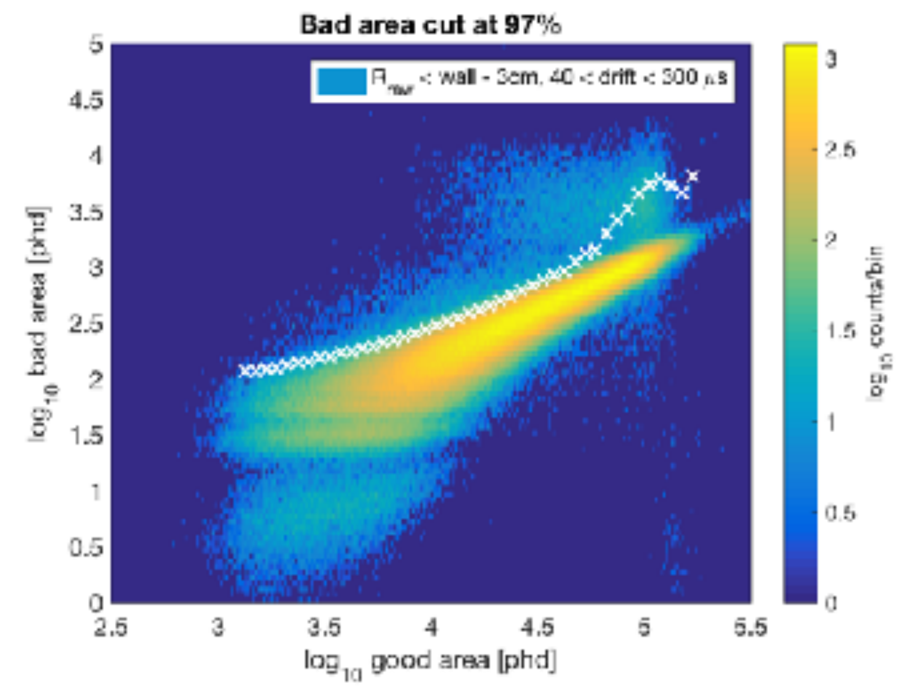


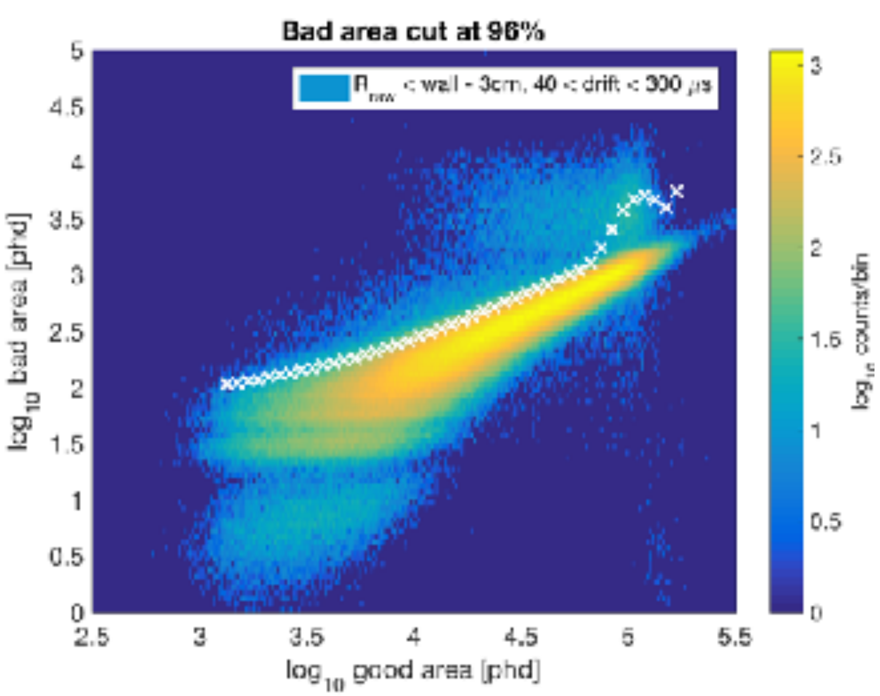
- *(left)* Find the value of bad area at which **99%** of the events in the bin of $\log_{10}$(good area) are below. This 99% value in each bin is drawn as a white X.
- Bins 40, 41, and 43 do not have a 99% value shown as outliers skewed these pointe.
- Bins 25+ zag upward to let in bad area from population 2.

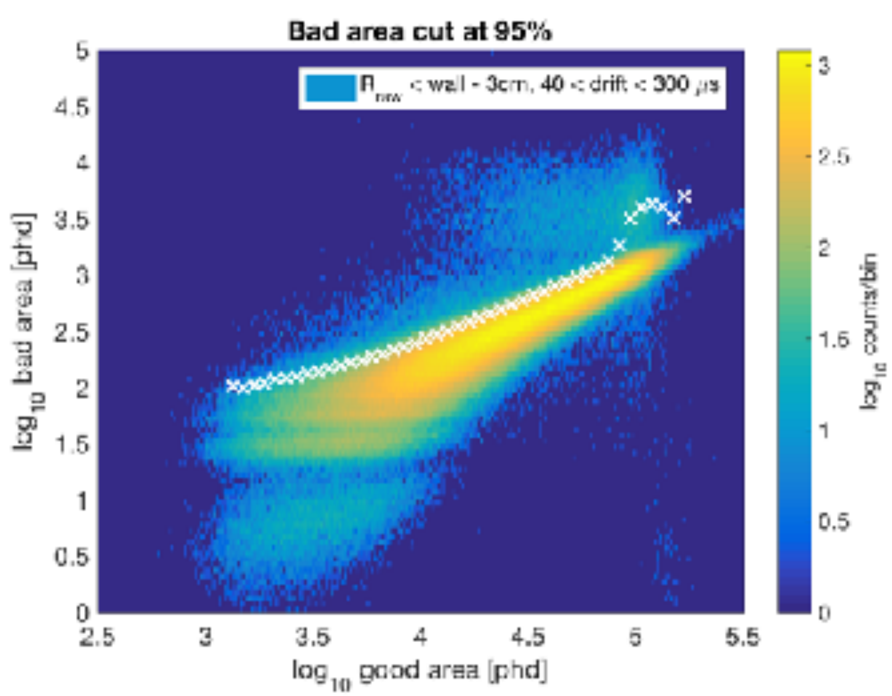
TESTING DIFFERENT X% VALUES, FIDUCIAL CUT APPLIED







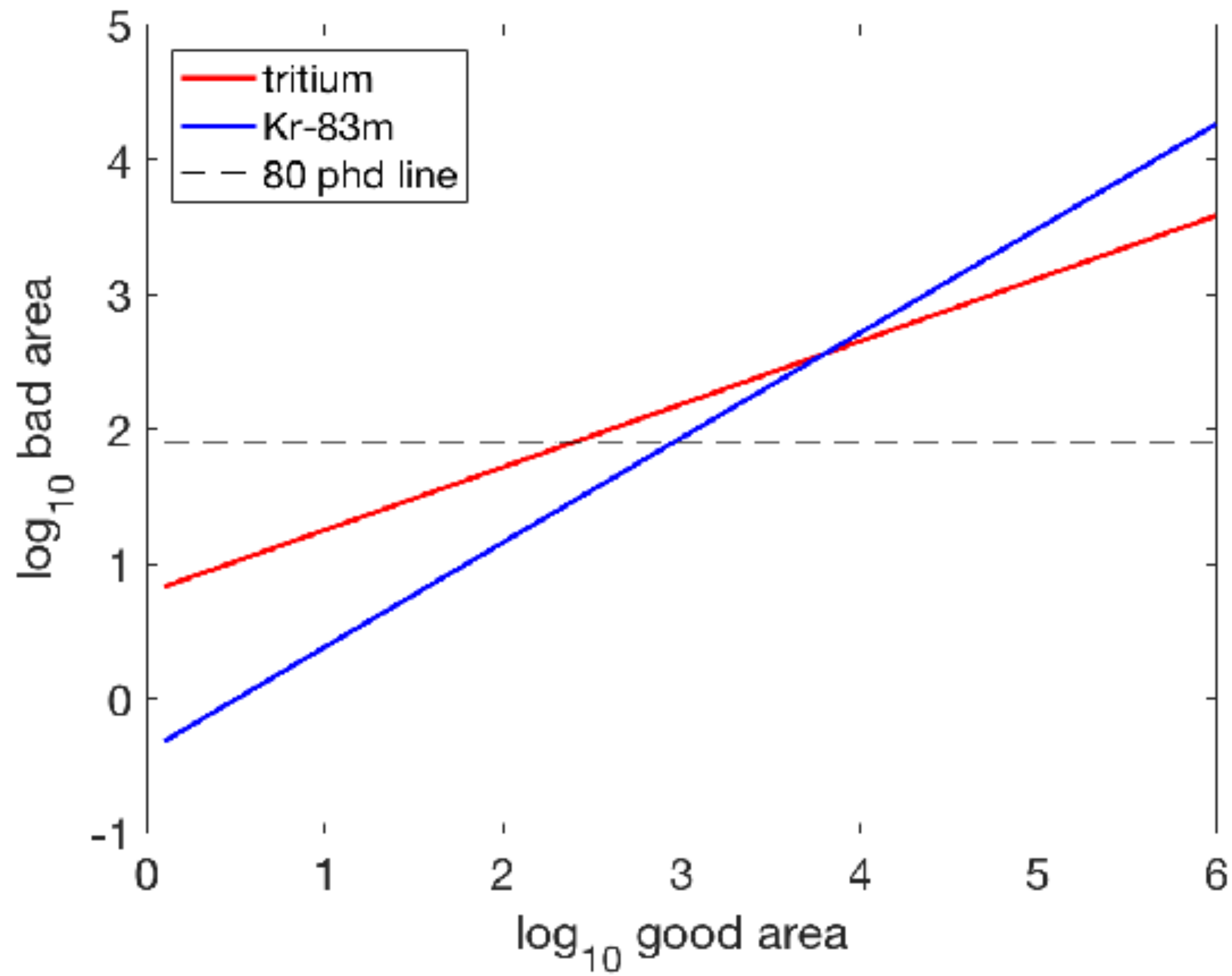




- Mark the value of $\log_{10}$(bad area) at which X% of the events in each bin are below with a white “x”.
- *(top left)* Setting the bad area cut at 99% is too stringent as it lets in events from population 2 which was plagued with baseline issues and other high bad area anomalies.
- *(top center)* Setting the bad area cut at 98% (or 97%) seems optimal as it does not keep events from population 2 but doesn’t cut too deeply into the main Kr-83m blob.

NEXT STEPS

- Determine whether larger bins help relieve bump at high good area.
- Fit these X% values. It will likely be 98% or 97%.
- Compare with bad area cuts from tritium and Kr-83m studies.
  - Is it reasonable to combine these cuts?



(above) Plot the bad area cuts for Run04 from tritium data (red) and Kr-83m data (blue). The black dashed line is at 80 phd in bad area. The bad area cut used in Run04 WS analysis was at 80 phd until it met the red tritium line, then it followed the tritium line.