VLASS Imaging Quality Assurance

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What is Quality Assurance in VLASS?

- Standards to compare data products against
- Methods used to evaluate all deliverable products for VLASS
- **Ensure VLASS data meet survey requirements**

VLASS Data Analysts

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- Tina Güth
- **Aaron Lawson**
- **Drew Medlin**
- **Karlee Radford**
- Jose Salcido
- Alex Sobotka
- Angie Vargas

Overview

- VLASS Imaging Workflow
- Standards for Quality Assurance
- Image Quality Assurance workflow
- Automation of Quality Assurance
  - Automated artifact detection methods

VLASS Imaging workflow

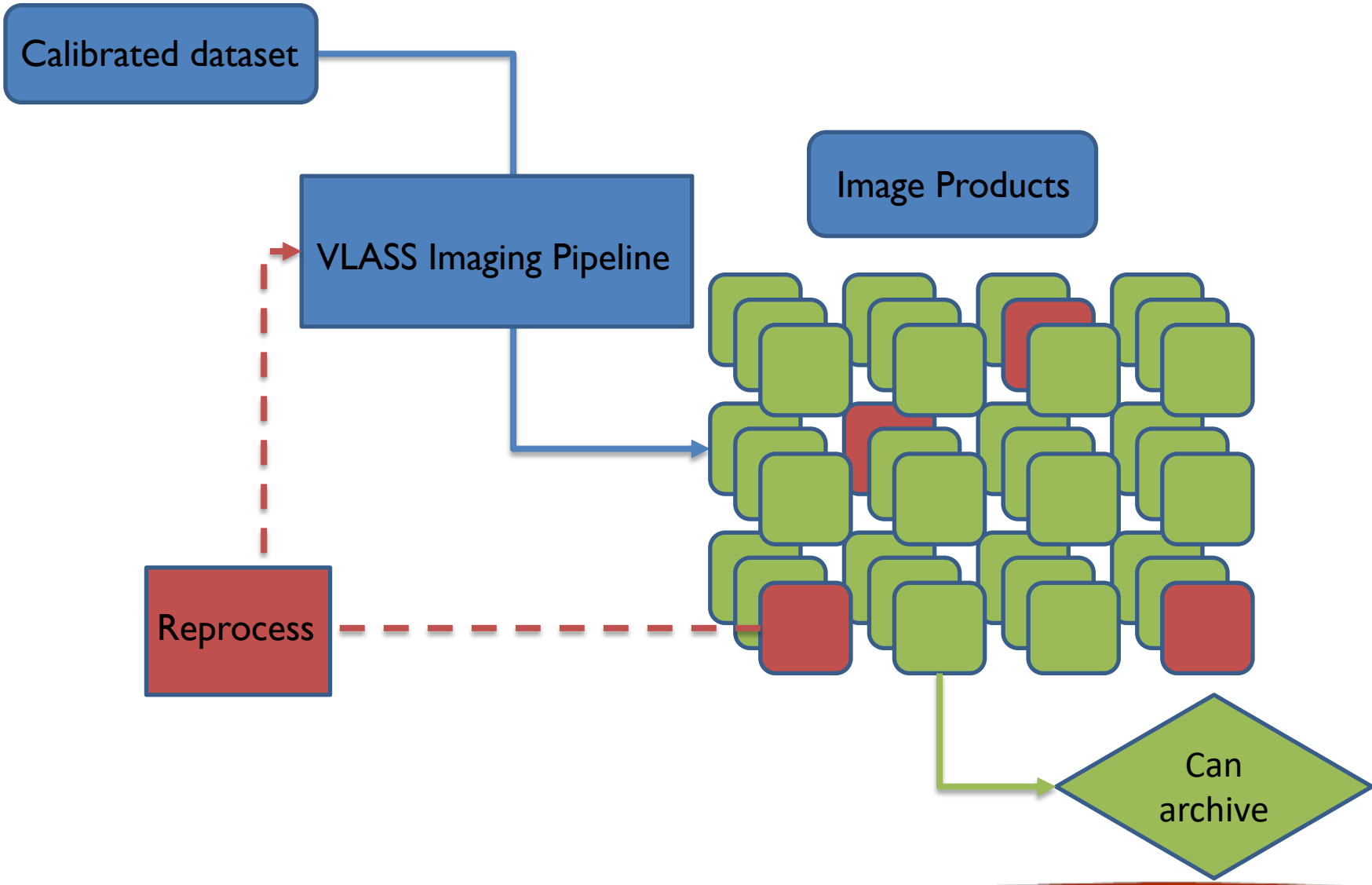


Image Quality Assurance Standards

- Imaging standards ensure images meet science requirements
  - Free of artifacts
    - Radio Frequency Interference, Primary Beam Holes, Bad Baselines, and High Weights
  - Images must reach an acceptable halting criterion in CASA tclean
    - n-sigma or iter-limit but not be diverged
  - Beam axis ratio and size are normal (between 1 and 6 arcsec)
  - Peak value/RMS within acceptable limits (less than 6)

Common artifacts in VLASS images

Artifact	# in VLASS2.2
RFI	48
PBH	26
HW	1
Bad Baselines	100+

*Images that are not rejected get flagged and remade to remove the artifact

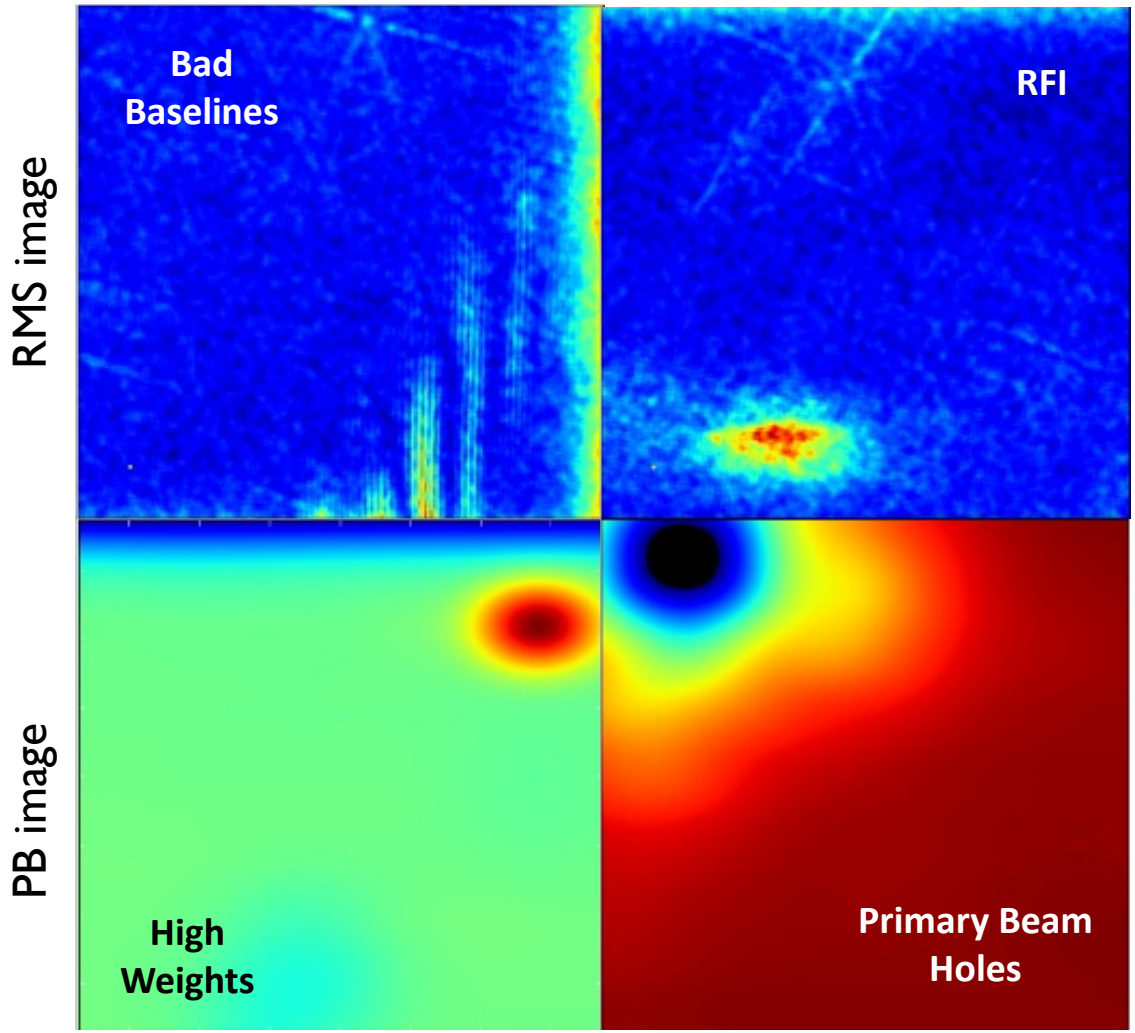
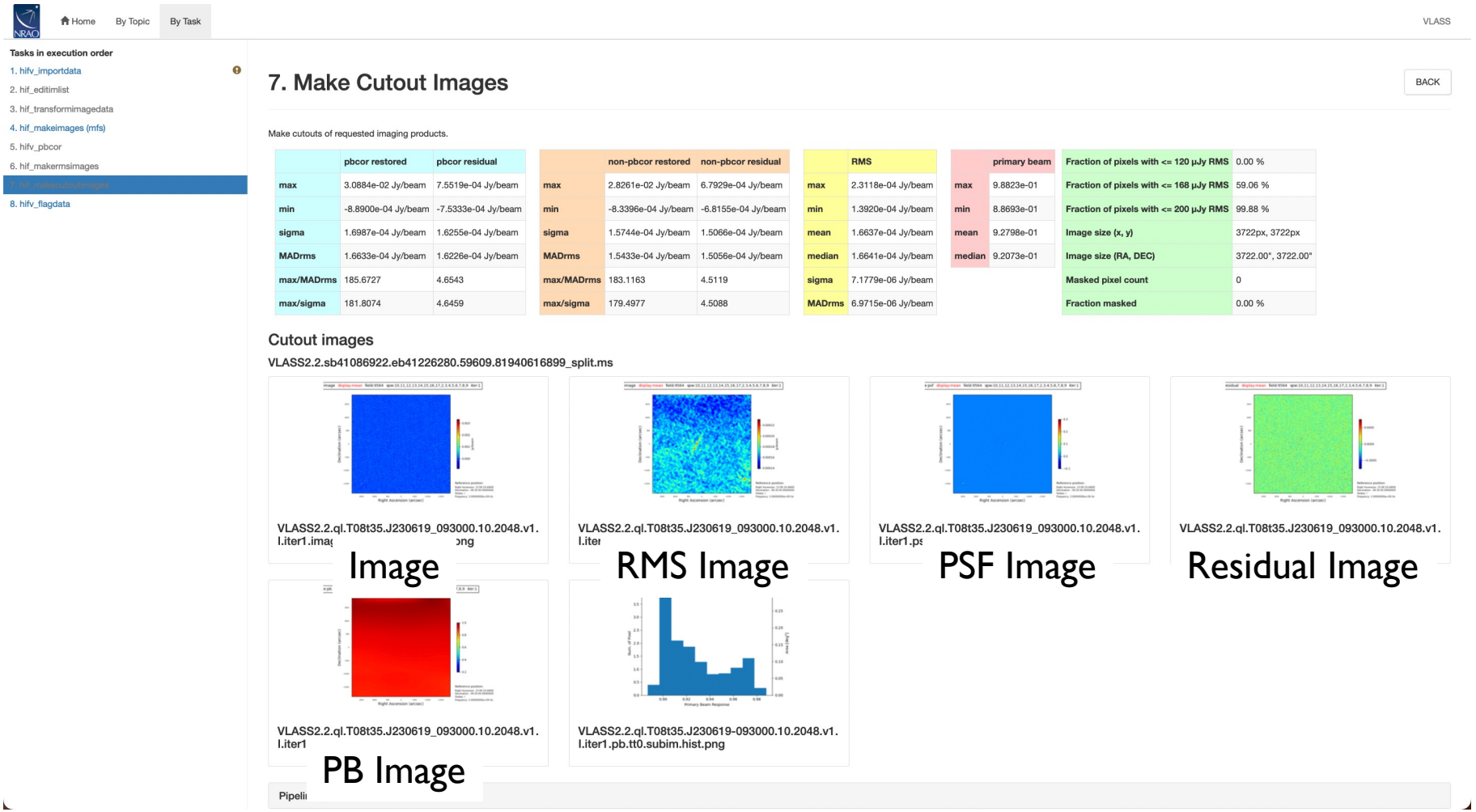


Image Quality Assurance workflow

- Examine QA suggestion based on Image Pipeline metrics
- Visually inspect images for artifacts via pipeline weblog
- Flag data in images with artifacts + remake image
- Reprocess images with unacceptable statistics
  - Repeat QA process once image is finished reprocessing
- Reject images that do not pass QA
  - QL Rejected Epoch 1: 0.63% (222 out of 35,500)
  - QL Rejected Epoch 2: 0.72% (254 out of 35,500)
- Archive good images

VLASS Imaging Pipeline weblog



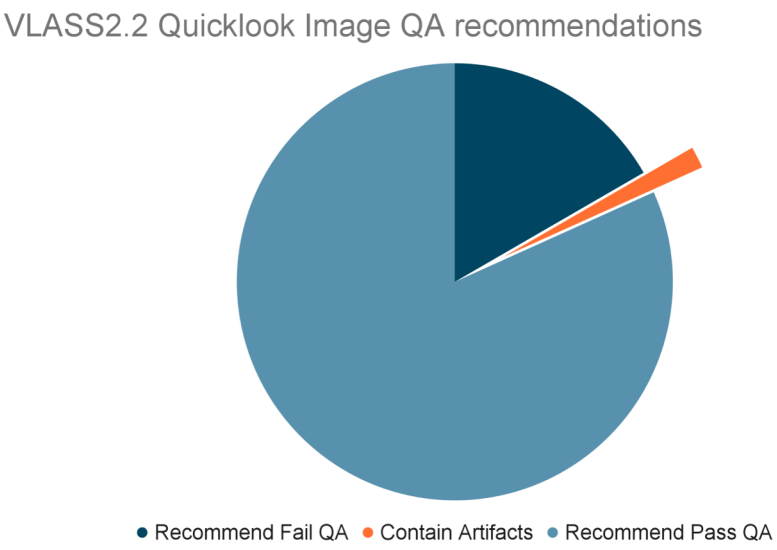
VLASS Image Products

- There are 35500 1sq^2 segments of sky
  x multiple image products
  x 3 Epochs of observation
- ... lots of images are produced and each one must be inspected
  - Stats alone are not enough for detecting artifacts

(also each individual image product may need to be reprocessed multiple times)

Automating Quick-look QA

- Based on initial statistics of images:
  - ~80% have acceptable statistics
  - ~2% of images with acceptable statistics contain artifacts
  - ~20% of images have unacceptable statistics



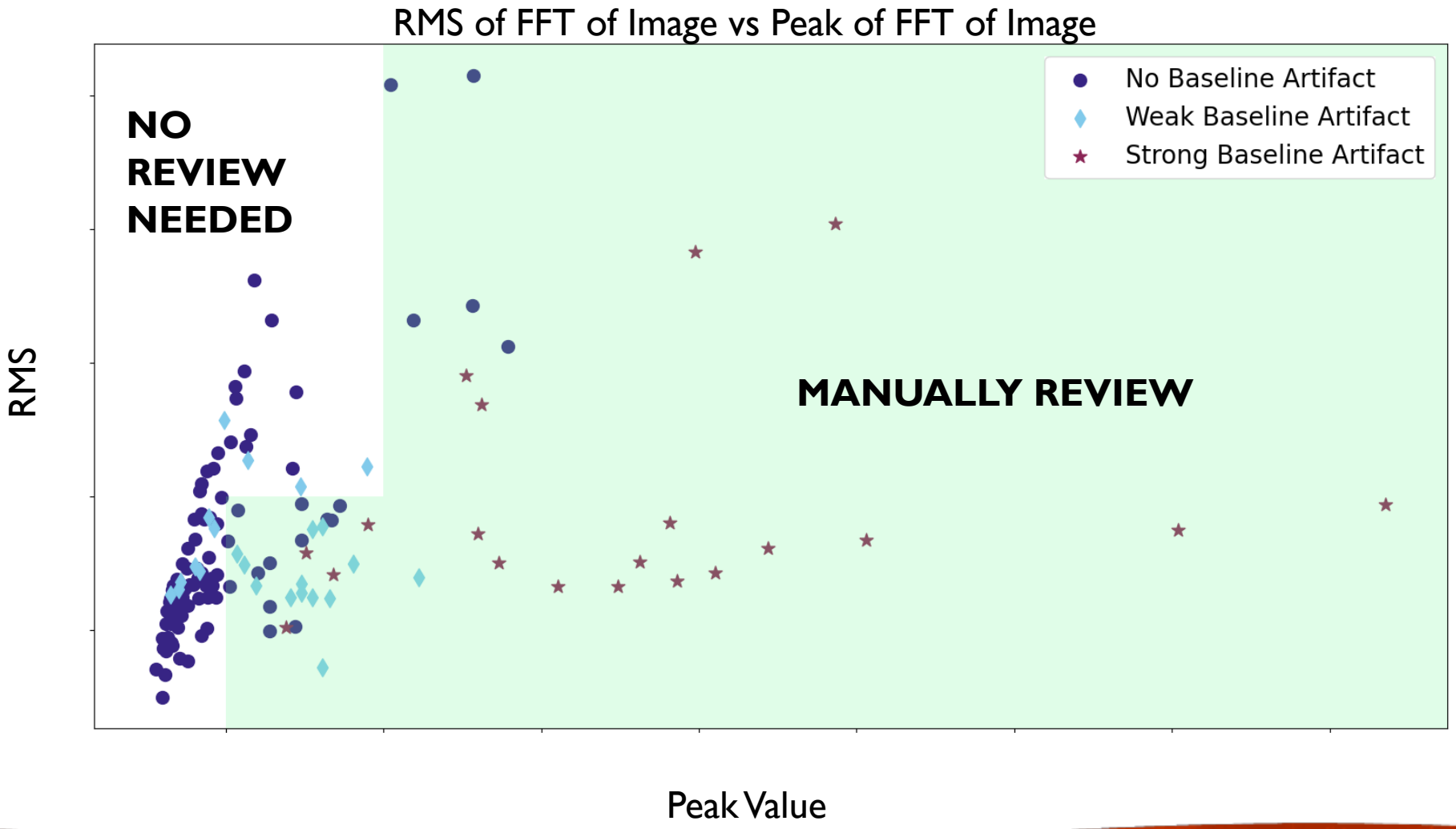
- **Majority of images shouldn't need human intervention**

Path of Automation

- QA ruleset has been well defined after 2 epochs of VLASS
- Scope of automated QA workflow:
  - Encode ruleset to manage workflow
    - VLASS workflow actions (Archive, reprocess, …)
    - Reprocessing images follows naïve (simple) approach
    - Identify images for manual intervention
  - Automatic artifact detection
    - Heuristic methods and Convolutional Neural Network find artifacts
  - Tracking workflow status of products
- Quick-look QA automation can serve as model for further use cases

Artifact detection

Bad baselines

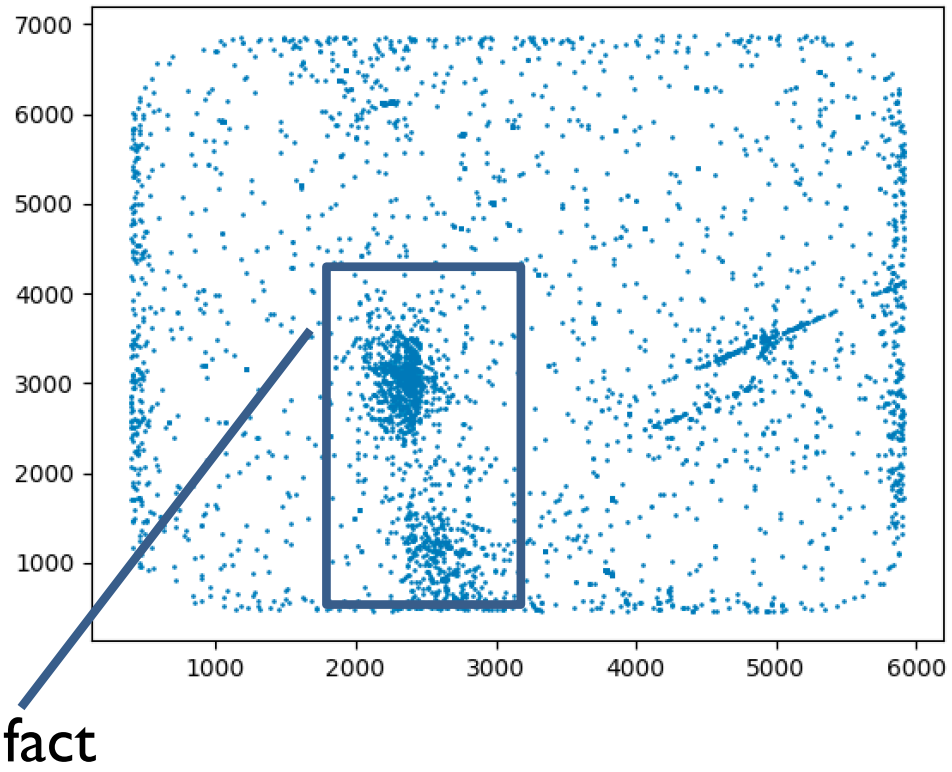


Artifact detection

RFI

- RFI morphologically appear as "blobby" due to VLASS field mosaicking
- Model points in CASA tclean model image reproduce RFI
- RFI is found as irregular clusters of points the size of VLASS fields

CASA tclean model image with RFI

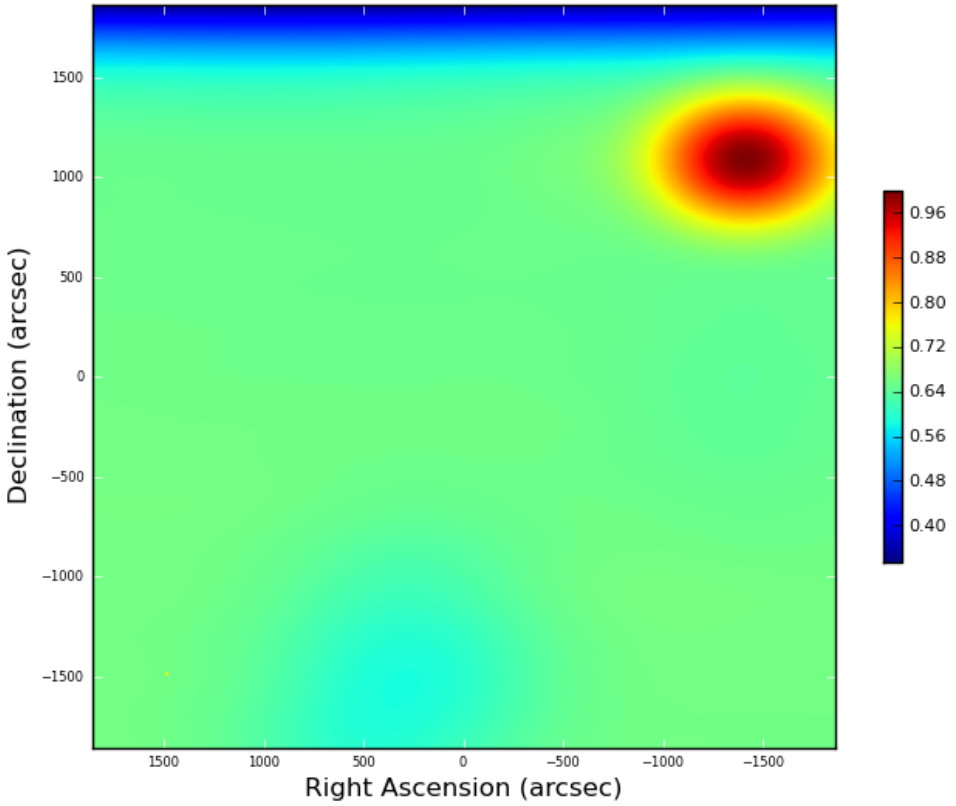


Artifact detection

High Weights (HW)

- Anomalous high weighting from CASA statwt
- Rarest form of artifacts (only two or three per epoch)
- Empirically derived selection criterion relies on statistical mode of pixel values
  - Screen for HW via primary beam image
  - Large spread in statistical mode for images with HW vs without

Primary Beam image containing HW artifact

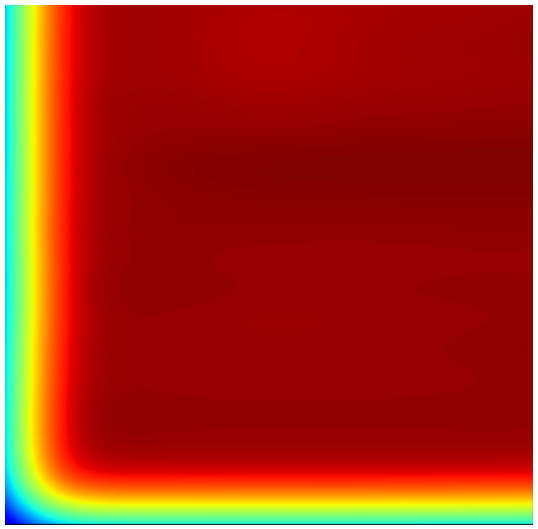


Artifact detection

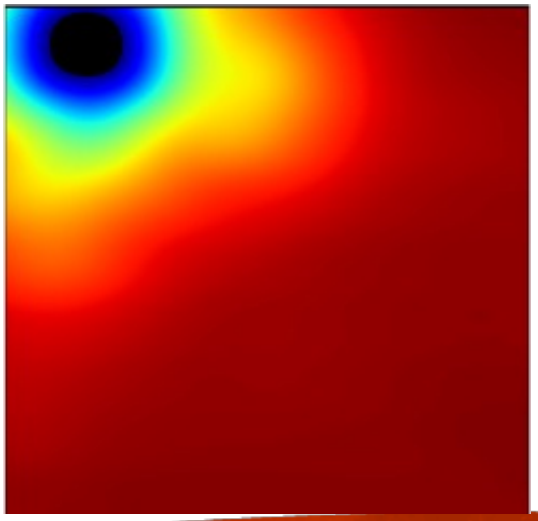
Primary Beam Holes

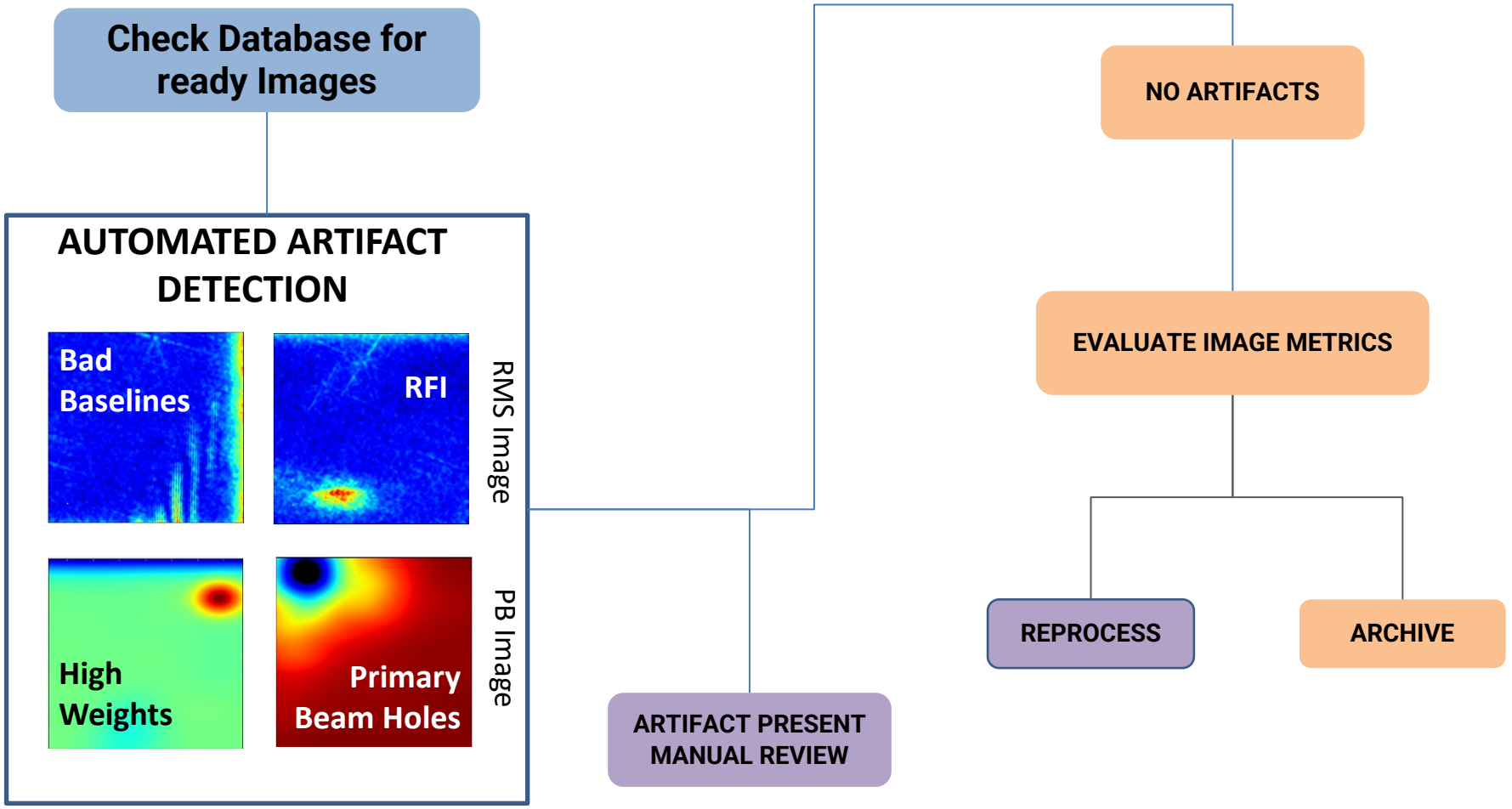
- Very bright sources down-weight regions below masking threshold
- Results in masked "hole" regions in image
- Two detection methods
  - Heuristic method checks image masks
  - Convolutional Neural Network method

Primary Beam Image without artifacts

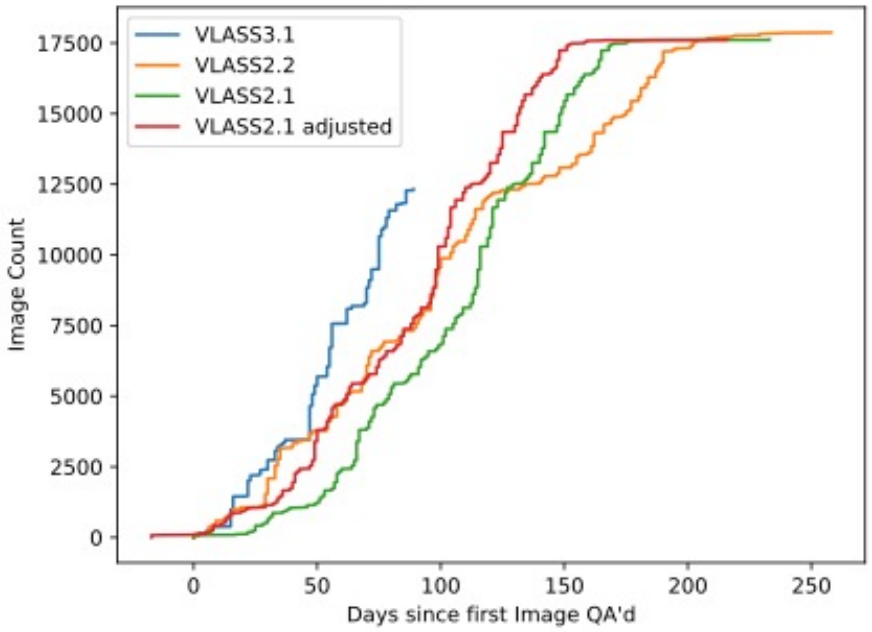


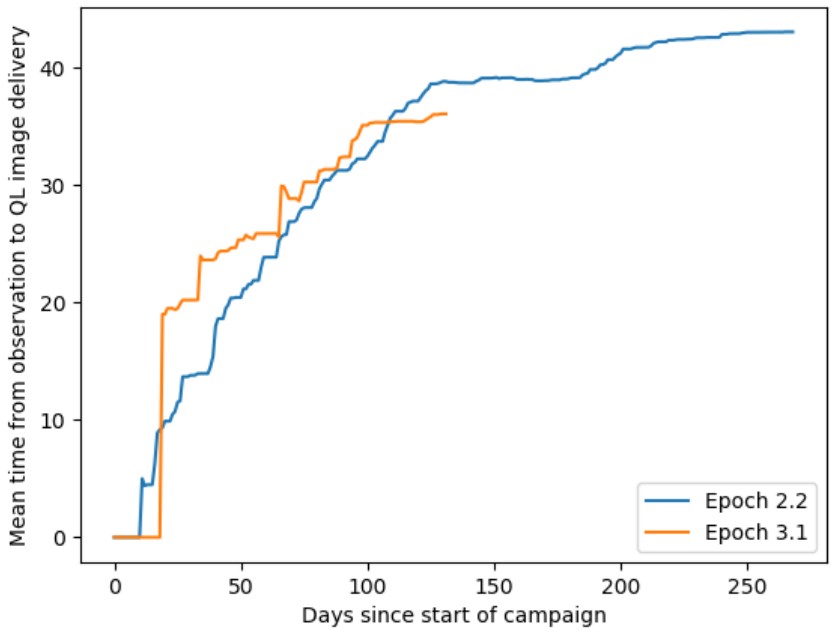
Primary Beam Image containing PBH artifact




Check Database for ready Images
AUTOMATED ARTIFACT DETECTION
Bad Baselines
RFI
RMS Image
High Weights
Primary Beam Holes
PB Image
ARTIFACT PRESENT MANUAL REVIEW
NO ARTIFACTS
EVALUATE IMAGE METRICS
REPROCESS
ARCHIVE

VLASS Automation Results





Artifact	VLASS3.1 B config only	VLASS2.2	VLASS2.1
RFI	44	48	n/a
PBH	11	26	16
HW	2	1	2
Bad Baselines	186	100+	n/a

Summary

- Quality Assurance ensures VLASS image products meet science requirements
- QA is governed by a well defined ruleset
- QA'ing images is time consuming
- A new automated QA workflow has been developed
  - Automated artifact detection via heuristics and CNN methods
  - Automated imaging QA may be expanded to other use cases

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Check Manager for QA_READY Images

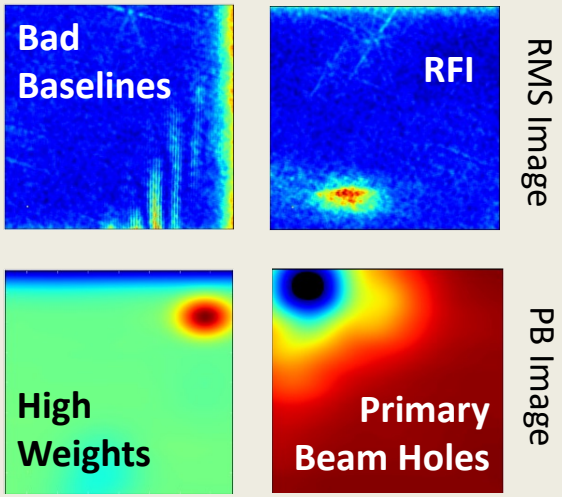
PER IMAGE

Generate log file path

Cutout PNGs from weblog/ Get path to CASA images

VLASS QL IMAGES

AUTOMATED ARTIFACT DETECTION



NO ARTIFACTS PASS ON

ARTIFACT PRESENT MANUAL REVIEW

Check QA Recommendation

REC QA_MANUAL

- Update log file
- Update QL Imaging spreadsheet
- Update QA Notes
- Accept and Archive

REC Accept & Archive

- MAD score < 10 and no significant change from previous image
- Update log file
- Update QL Imaging spreadsheet
- Update QA Notes
- Update parameter.list
- Begin reprocess

The VLASS manager