



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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Overview

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

VLASS Imaging workflow

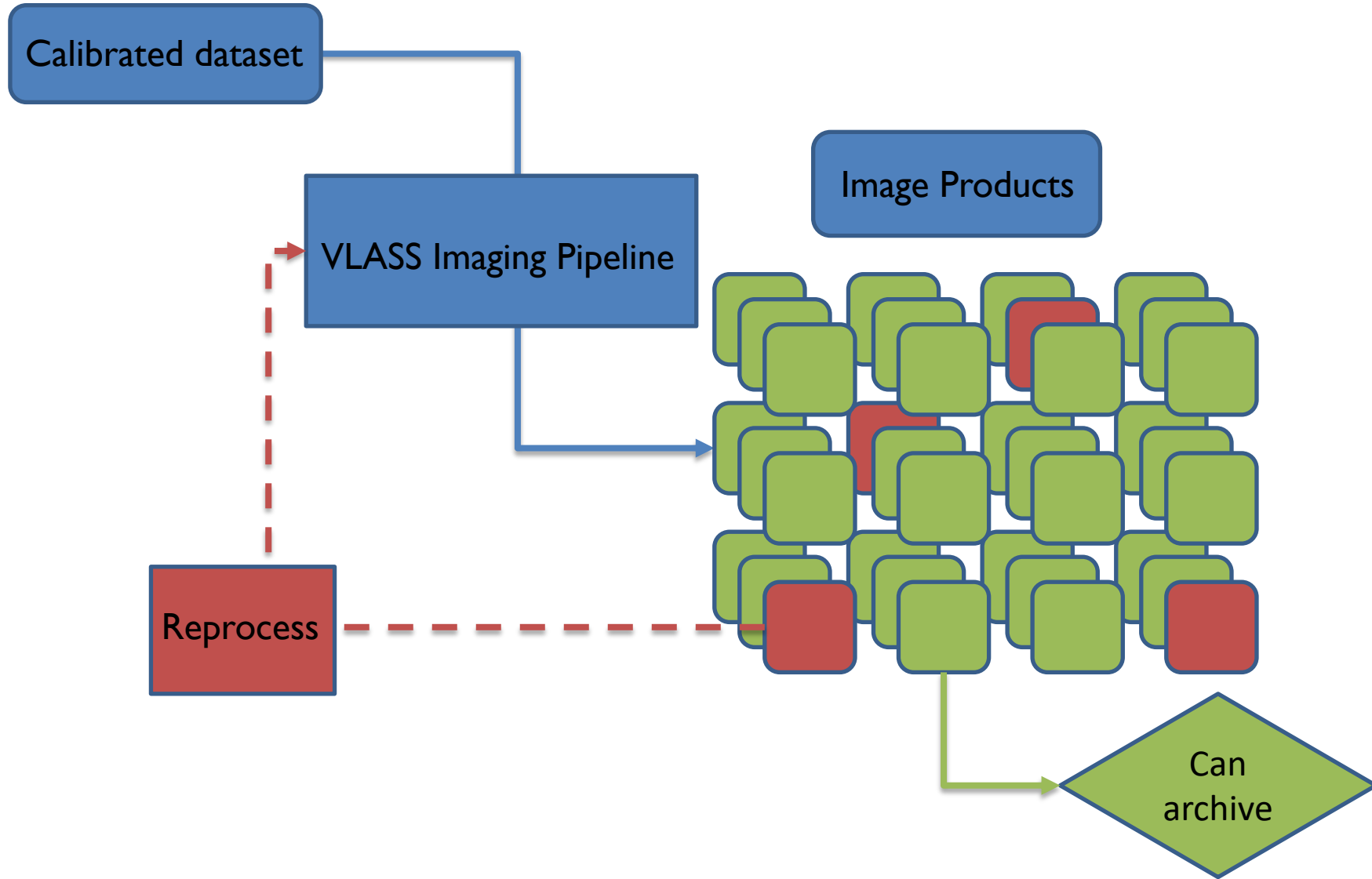


Image Quality Assurance Standards

- 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

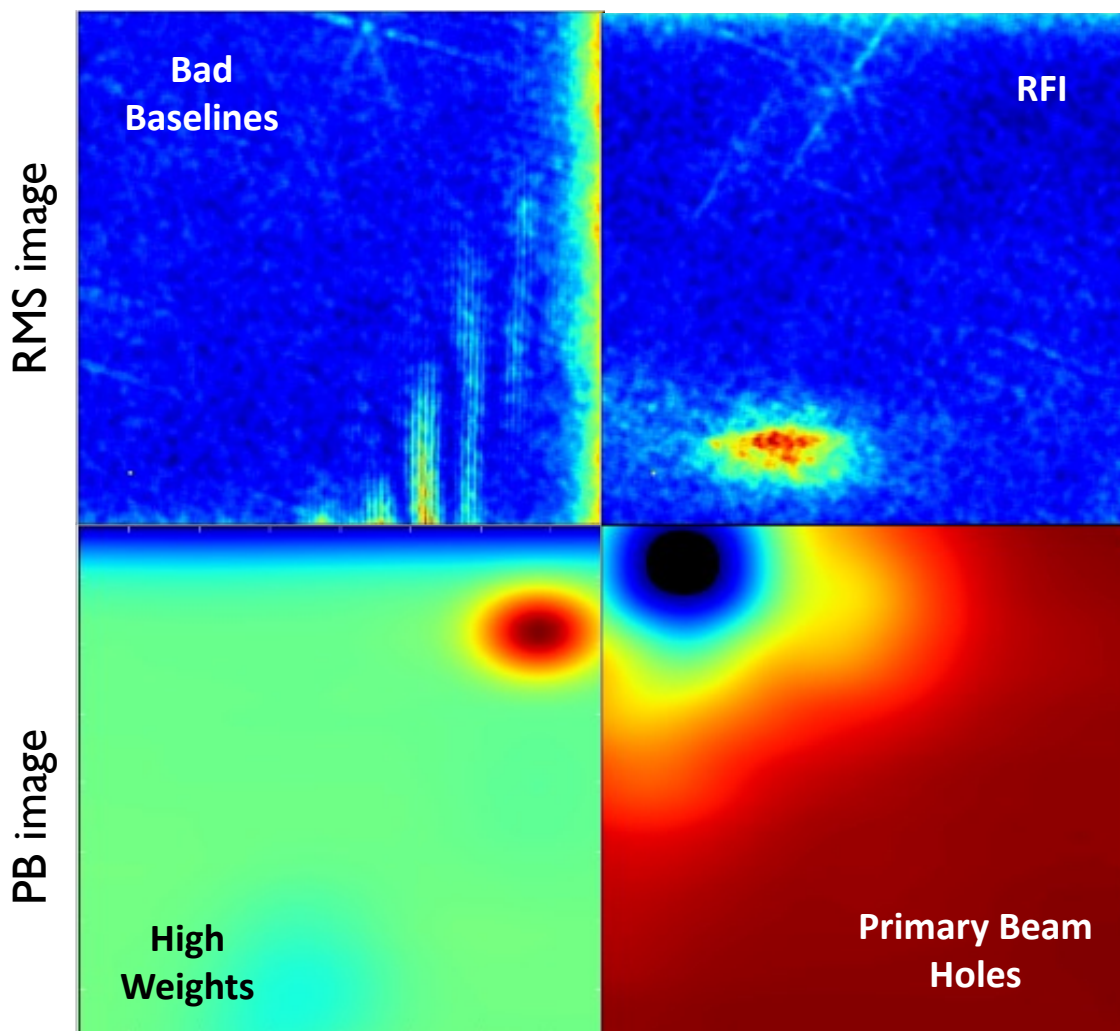


Image Quality Assurance workflow

- 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

Tasks in execution order

1. hifv_importdata
2. hifv_editimlist
3. hifv_transformimagedata
4. hifv_makeimages (mfs)
5. hifv_pbcor
6. hifv_makermssimages
7. hifv_makermssimages
8. hifv_flagdata

7. Make Cutout Images

BACK

Make cutouts of requested imaging products.

	pbcor restored	pbcor residual
max	3.0884e-02 Jy/beam	7.5519e-04 Jy/beam
min	-8.8900e-04 Jy/beam	-7.5333e-04 Jy/beam
sigma	1.6987e-04 Jy/beam	1.6255e-04 Jy/beam
MADrms	1.6633e-04 Jy/beam	1.6226e-04 Jy/beam
max/MADrms	185.6727	4.6543
max/sigma	181.8074	4.6459

	non-pbcor restored	non-pbcor residual
max	2.8261e-02 Jy/beam	6.7929e-04 Jy/beam
min	-8.3396e-04 Jy/beam	-6.8155e-04 Jy/beam
sigma	1.5744e-04 Jy/beam	1.5066e-04 Jy/beam
MADrms	1.5433e-04 Jy/beam	1.5056e-04 Jy/beam
max/MADrms	183.1163	4.5119
max/sigma	179.4977	4.5088

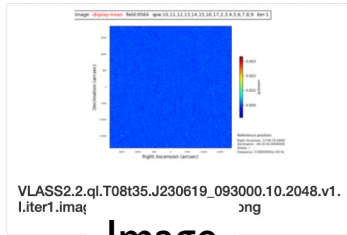
	RMS
max	2.3118e-04 Jy/beam
min	1.3920e-04 Jy/beam
mean	1.6637e-04 Jy/beam
median	1.6641e-04 Jy/beam
sigma	7.1779e-06 Jy/beam
MADrms	6.9715e-06 Jy/beam

	primary beam
max	9.8823e-01
min	8.8693e-01
mean	9.2798e-01
median	9.2073e-01

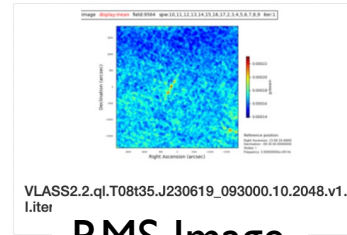
Fraction of pixels with $\leq 120 \mu\text{Jy RMS}$	0.00 %
Fraction of pixels with $\leq 168 \mu\text{Jy RMS}$	59.06 %
Fraction of pixels with $\leq 200 \mu\text{Jy RMS}$	99.88 %
Image size (x, y)	3722px, 3722px
Image size (RA, DEC)	3722.00", 3722.00"
Masked pixel count	0
Fraction masked	0.00 %

Cutout images

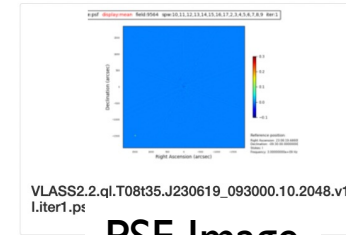
VLASS2.2.sb41086922.eb41226280.59609.81940616899_split.ms



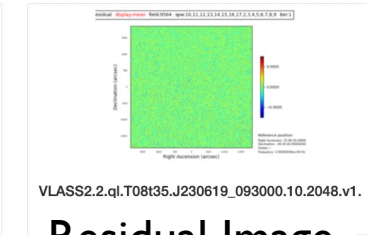
Image



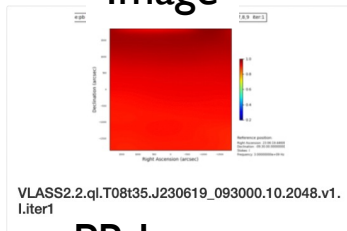
RMS Image



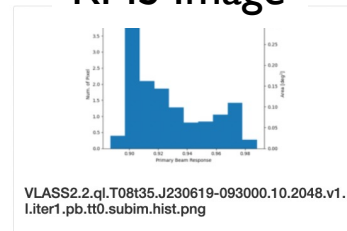
PSF Image



Residual Image



PB Image



VLASS2.2.ql.T08t35.J230619_093000.10.2048.v1.l.iter1.pb.tt0.subim.hist.png

Pipeline

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:

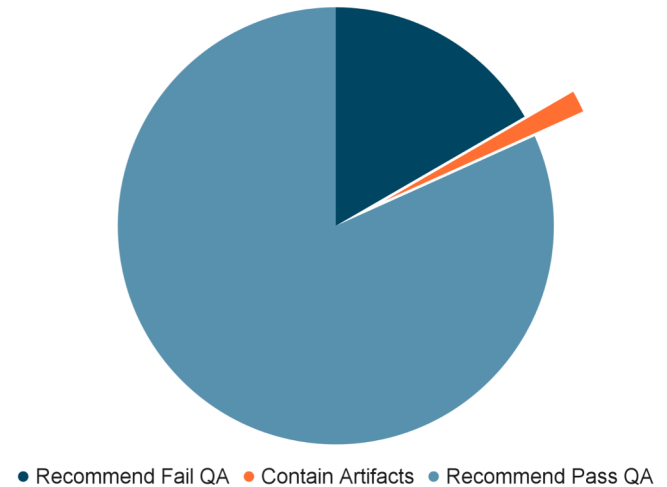
- ~80% have acceptable statistics

- ~2% of images with acceptable statistics contain artifacts

- ~20% of images have unacceptable statistics

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

VCLASS2.2 Quicklook Image QA recommendations

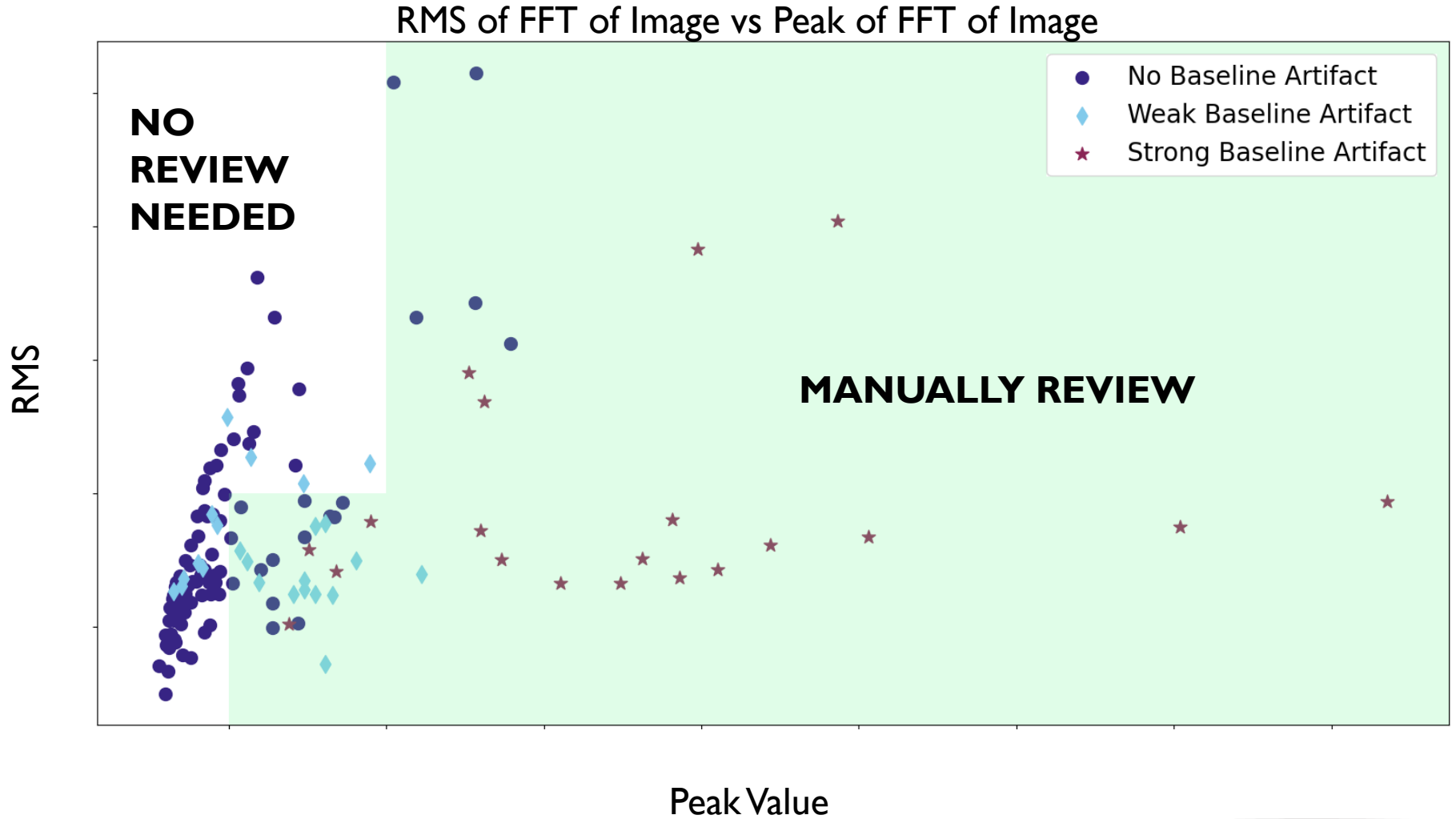


Path of Automation

- 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

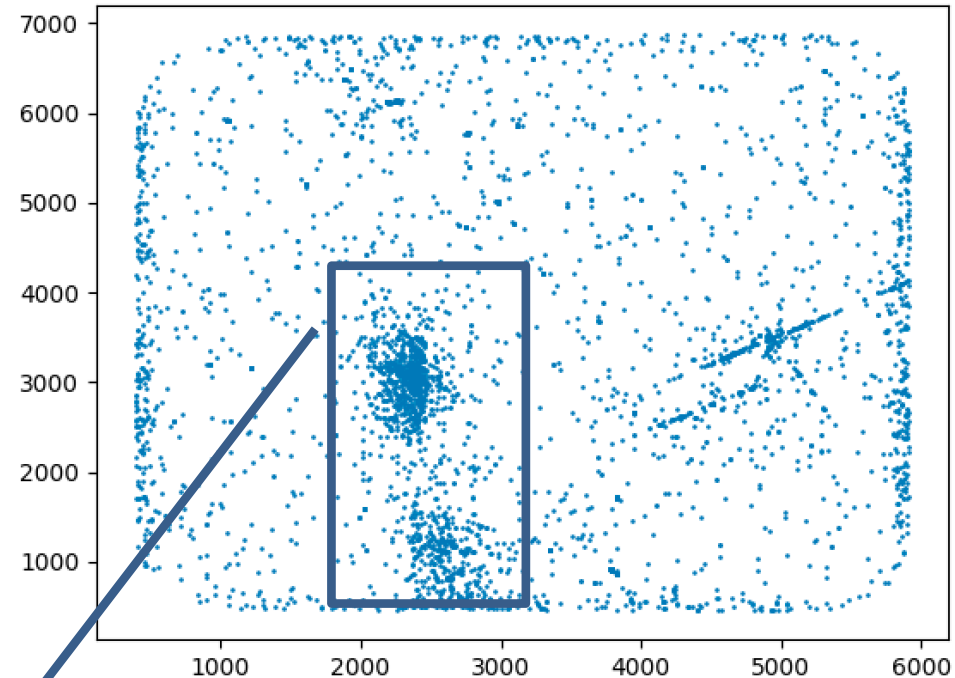


Artifact detection

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



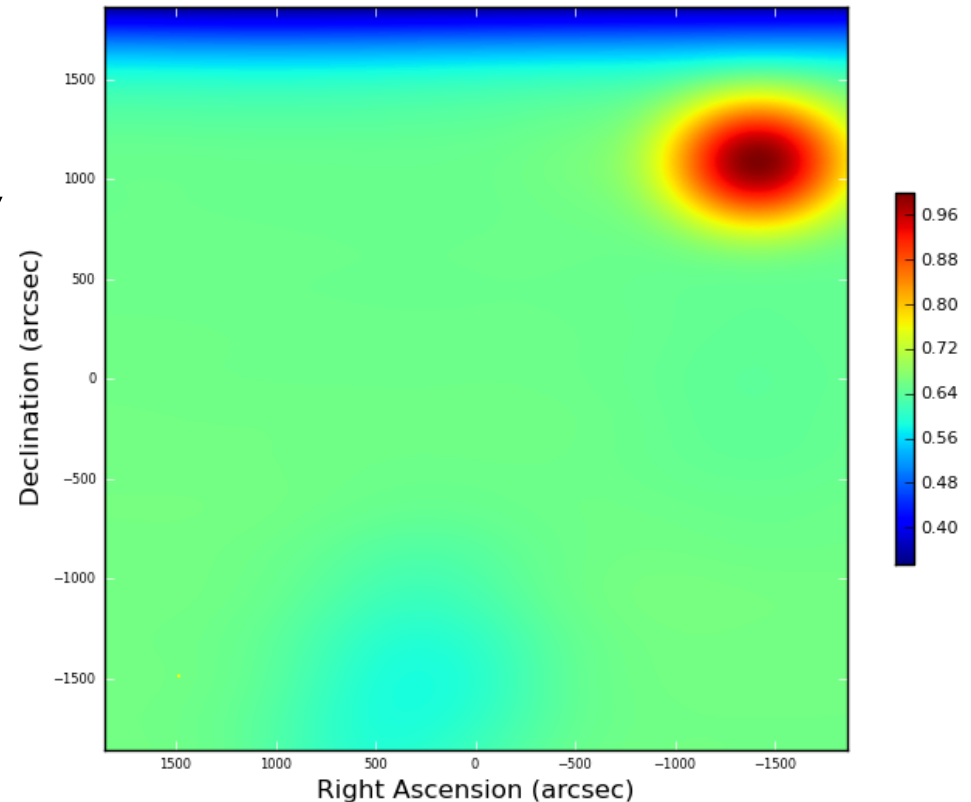
RFI artifact

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

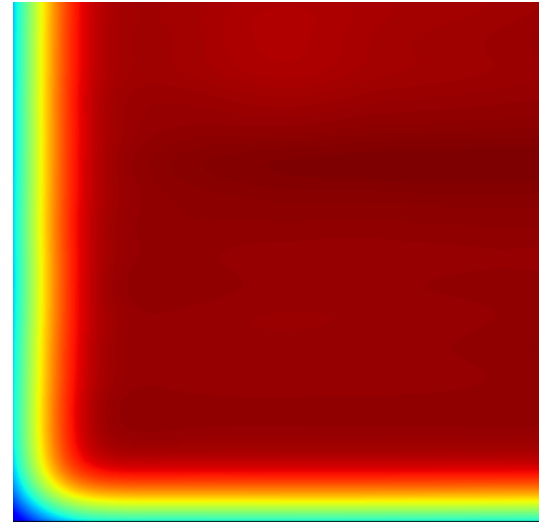


Artifact detection

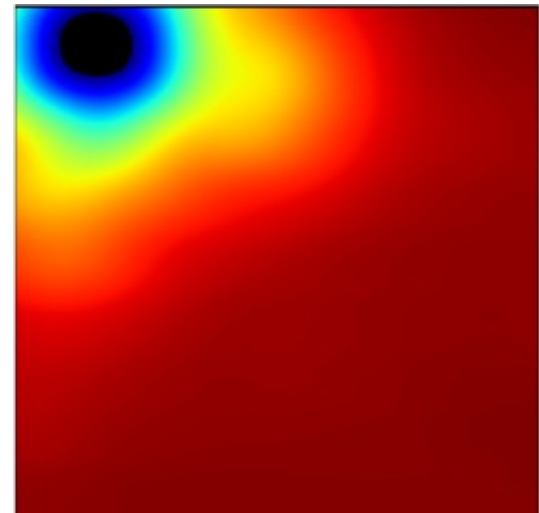
Primary Beam Holes

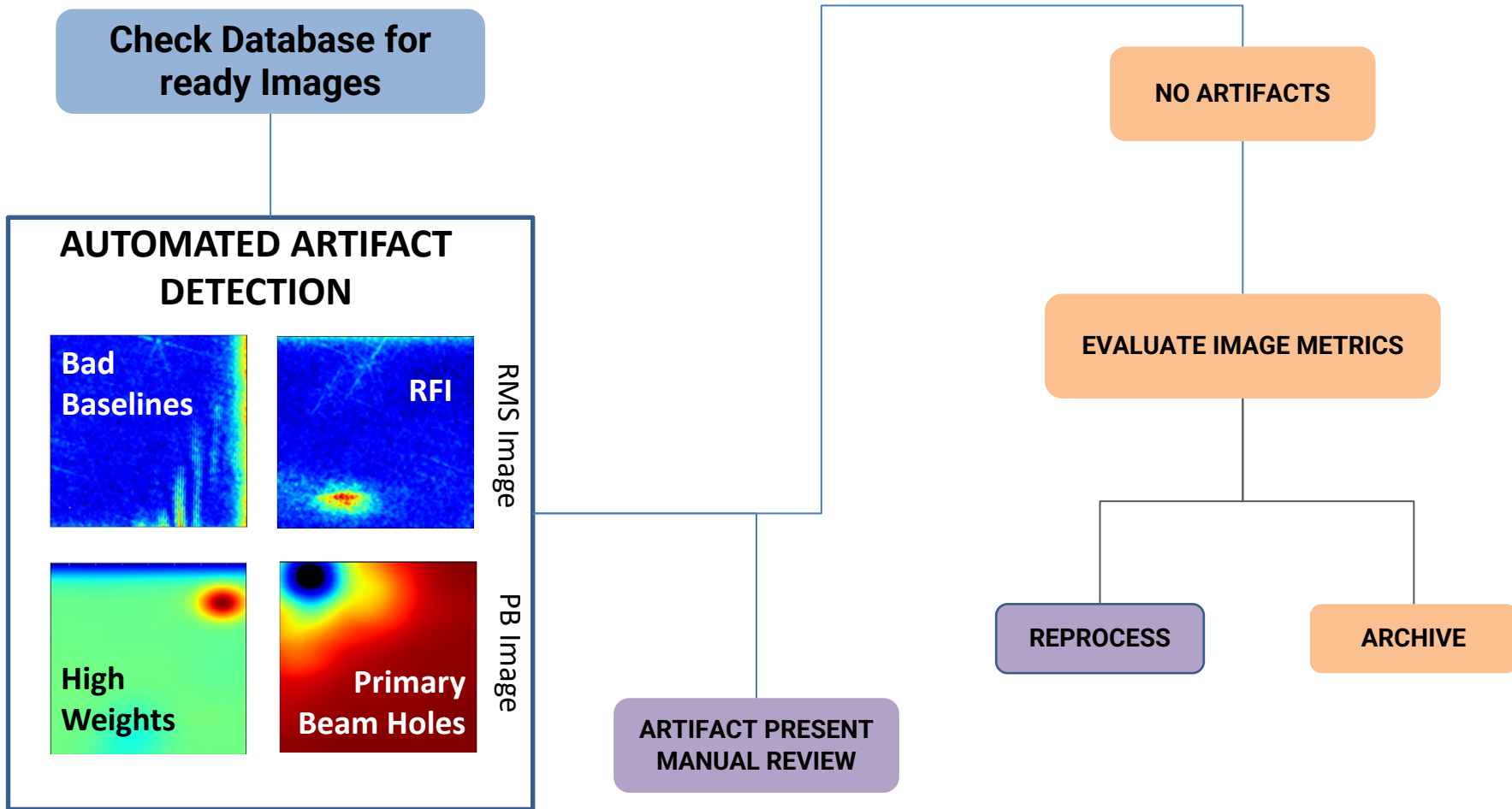
- Very bright sources down-weight regions below masking threshold
- Results in masked “hole” regions in image
- Two detection methods
 - Heuristic method checks image masks
 - Convolutional Neural Network method

Primary Beam Image without artifacts

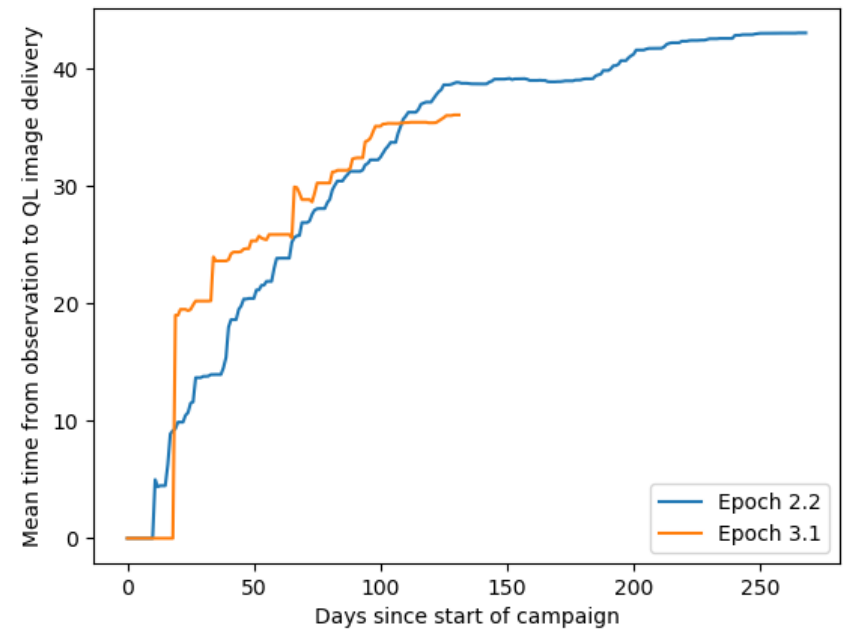
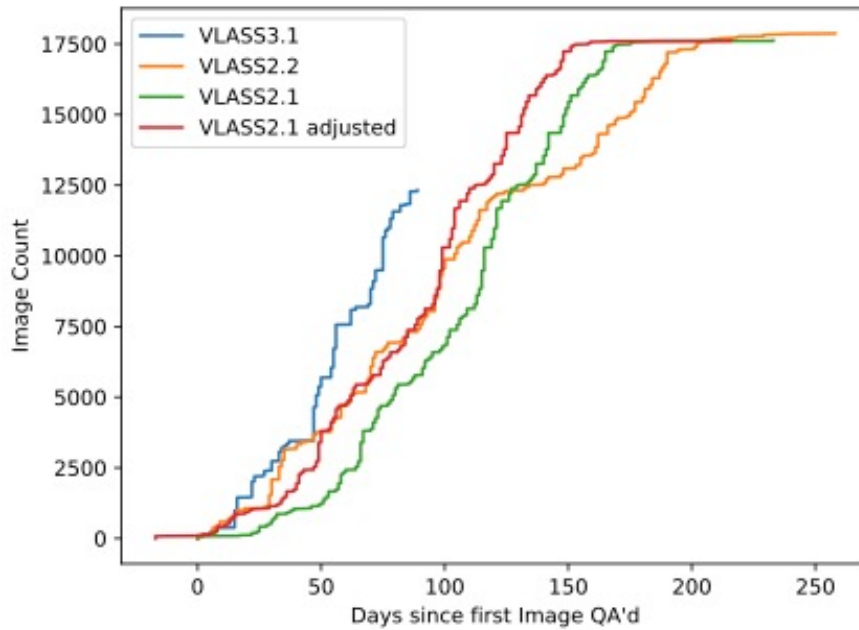


Primary Beam Image containing PBH artifact





VCLASS Automation Results



Artifact	VCLASS3.1 B config only	VCLASS2.2	VCLASS2.1
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

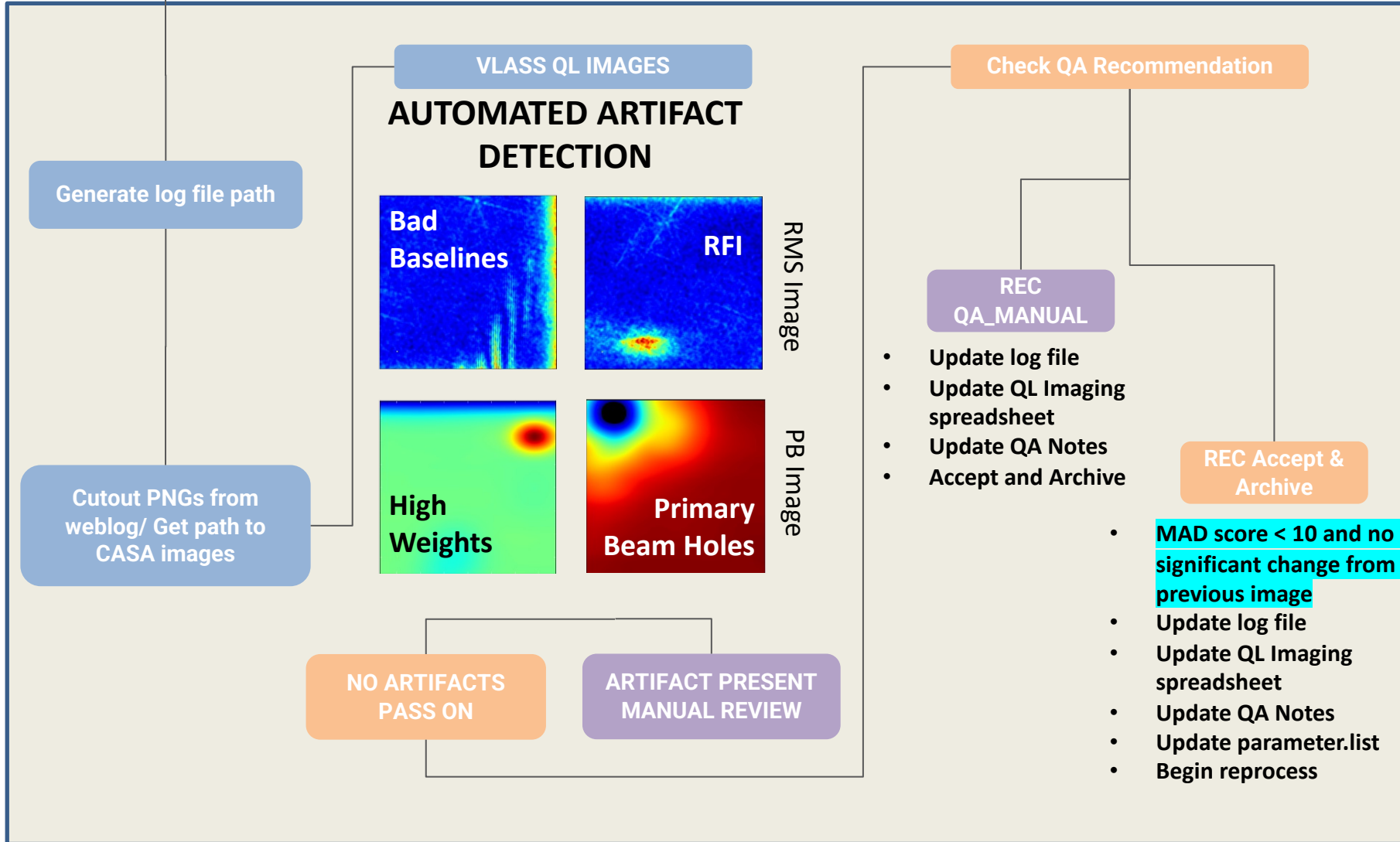


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Check Manager for QA_READY Images

PER IMAGE







The VLASS manager


 VLA SKY SURVEY MANAGER



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PRODUCTS
JOBS
EXECUTIONS






Epoch: Epoch 2 ▾ Queue: Quicklook ▾ Status: QA_ACCEPTED ▾ 111573
 Sort By: ID ▾ ASC ▾ 
1 - 1 of 1
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 after 7 days

Id	Name	Dates	Status	Archive Status
111573	VLASS2.2_T08t35.J230619-093000_P96979v1_2022_01_30T18_11_20.331  	May 31, 2022 12:11 PM Start Jun 1, 2022 7:19 PM End 1d 7h 7m Duration	QA_ACCEPTED ▾	UNARCHIVED

SDM ID: VLASS2.2.sb41086922.eb41226280.59609.81940616899

Lustre: [/lustre/aoc/cluster/pipeline/vlass_prod/spool/quicklook/VLASS2.2_T08t35.J230619-093000_P96979v1_2022_01_30T18_11_20.331](#) 

Weblog: http://archive-new.nrao.edu/vlass/weblog/quicklook/VLASS2.2_T08t35.J230619-093000_P96979v1_2022_01_30T18_11_20.331

Notes 

TS

```

=====
QA Report:
Beam minor axis: 2.19 arcsec
Beam major axis: 3.20 arcsec
Beam geometric mean: 2.65 arcsec
Beam axis ratio: 1.46
Final threshold: 0.000681      Warning final threshold greater than 0.0006
Peak/(scaled MAD): 4.51
Stopping criterion: n-sigma      Major cycles: 18
Percentage below 200Jy: 99.88

Overall recommendation: Accept & Archive
          
```

Job

77262	VLASS2.2_T08t35.J230619-093000_P96979v1 ▾ VLASS2.2.sb41086922.eb41226280.59609.81940616899	02/11/2022, 11:16:56 PM	QA_ACCEPTED
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Tasks

4266262.nmpost-serv-1.aoc.nrao.edu - PrepareWorkingDirectoryJob.vlass.p1.8e680eac-0908-4260-9717-a2279f5ef06b	05/31/2022, 06:11:21 PM Start	05/31/2022, 06:11:28 PM End	SUCCESS
4266265.nmpost-serv-1.aoc.nrao.edu - get-files.sh.vlass.p1.1c8ec48f-632b-44f5-b6b3-d3a2b1f828bf	05/31/2022, 06:12:26 PM Start	05/31/2022, 06:12:30 PM End	SUCCESS
4266268.nmpost-serv-1.aoc.nrao.edu - casa-imaging-pipeline.sh.vlass.p1.31324c9d-1ff9-46bb-8641-ce9d971d03a3	05/31/2022, 06:13:30 PM Start	06/02/2022, 01:18:56 AM End	SUCCESS
4267759.nmpost-serv-1.aoc.nrao.edu - performAutoQa.sh.vlass.p1.8b4a46b1-1405-4638-86b5-0e1b7605ba63	06/02/2022, 01:18:56 AM Start	06/02/2022, 01:19:02 AM End	SUCCESS
4267760.nmpost-serv-1.aoc.nrao.edu - vlass-delivery.sh.vlass.p1.f62e379b-111c-421e-8b80-c3056f446296	06/02/2022, 01:19:02 AM Start	06/02/2022, 01:19:09 AM End	SUCCESS