EUROPEAN ARC
ALMA Regional Centre

I-TRAIN with the European ARC Network

#1. Imaging with the ALMA Science Pipeline

Daniel Tafoya - Nordic ARC

L. T. Maud - ESO

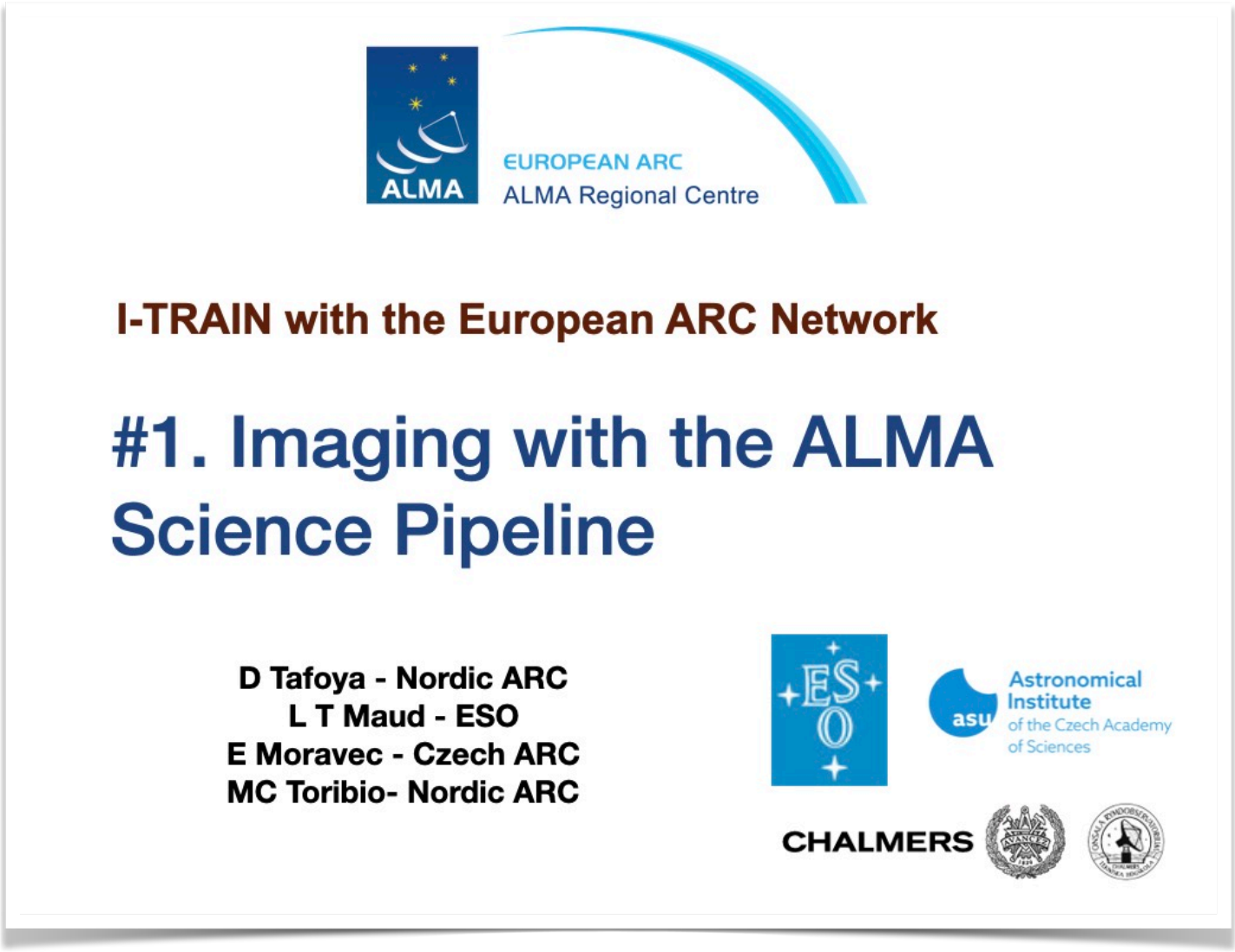
Emily Moravec - Czech ARC

MC Toribio- Nordic ARC

CHALMERS

Astronomical Institute of the Czech Academy of Sciences

This tutorial assumes that you followed the instructions indicated in the following 'INSTRUCTIONS' document:



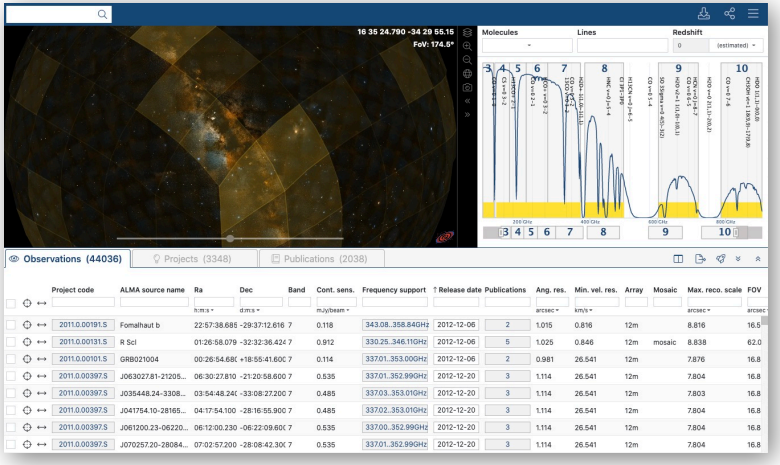
You can get the document from here:
https://almascience.org/tools/eu-arc-network/i-train

Overview:

- The data and the working directory
- Starting CASA with the pipeline
- List of steps to be run
- Hands-on tutorial
- Final remarks

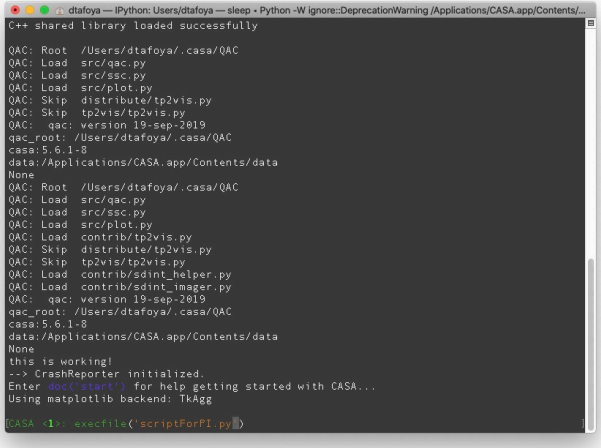
These steps were already done:

Data download from the ALMA Science Archive (ASA)
(including raw data and calibration tables)



scriptForPI.py has been run

```
execfile('scriptForPI.py')
```



calibrated

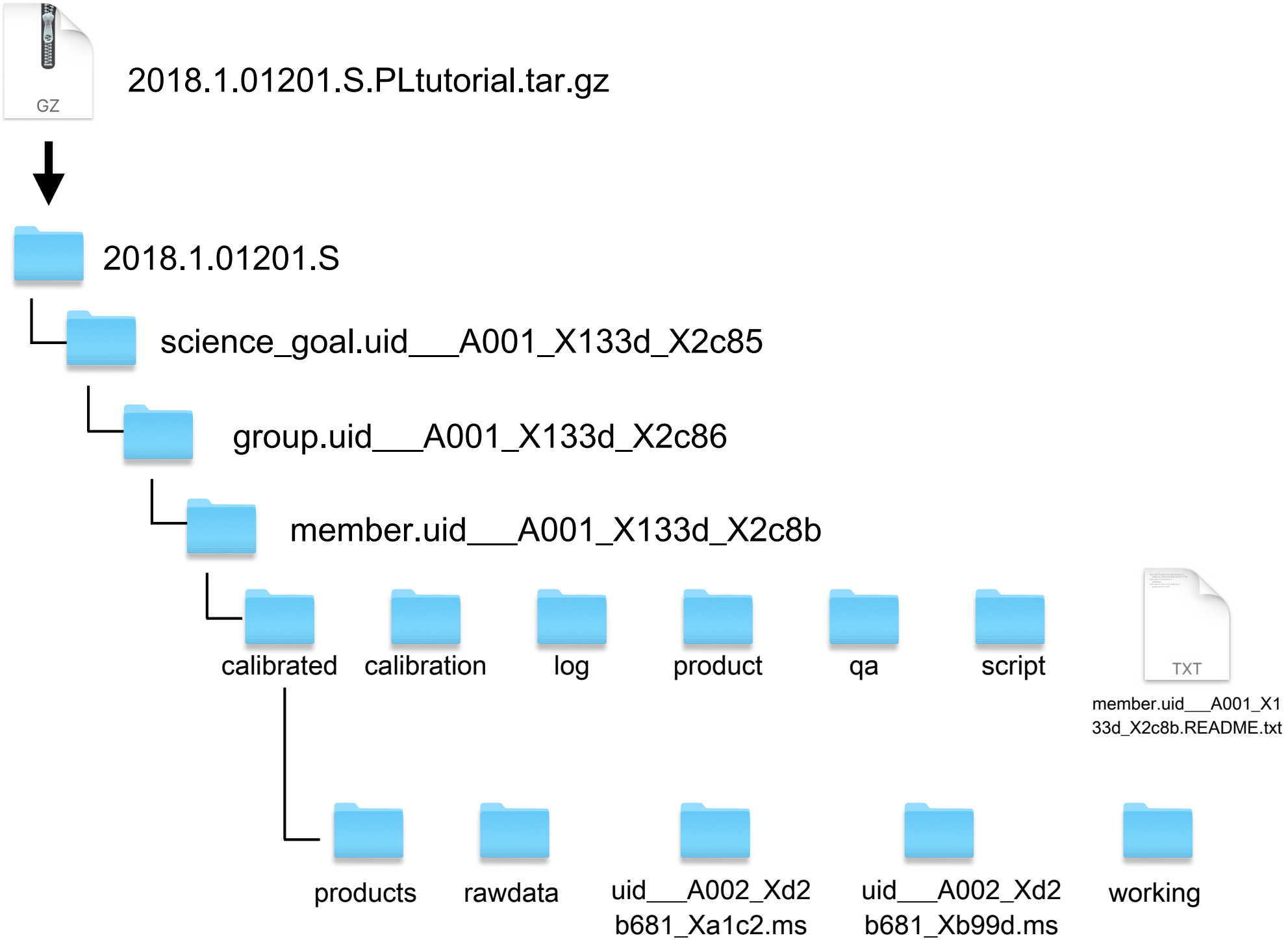
products

rawdata

uid___A002_Xd2b681_Xa1c2.ms

uid___A002_Xd2b681_Xb99d.ms

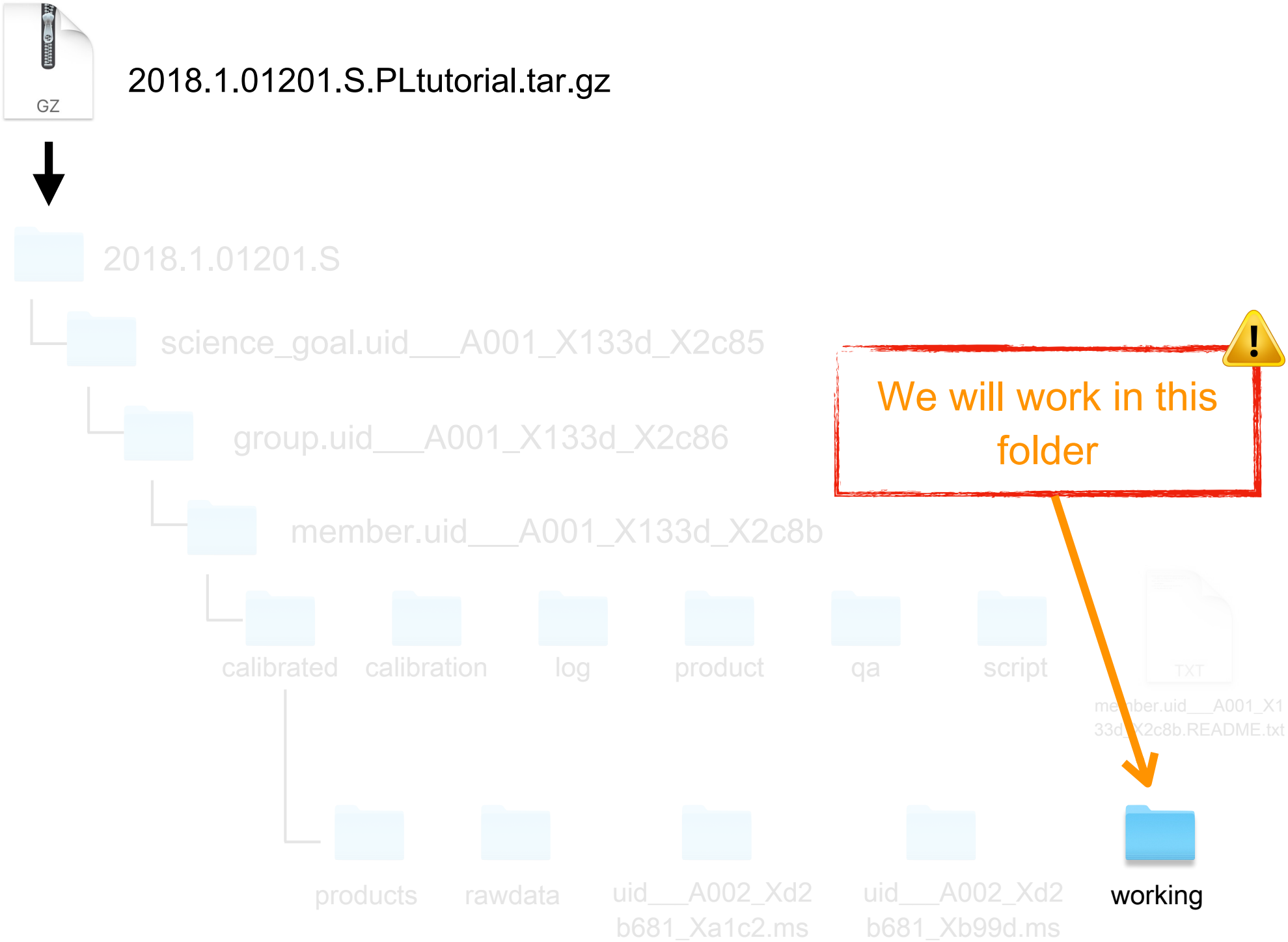
working


GZ
2018.1.01201.S.PLtutorial.tar.gz
2018.1.01201.S
science_goal.uid___A001_X133d_X2c85
group.uid___A001_X133d_X2c86
member.uid___A001_X133d_X2c8b
calibrated
calibration
log
product
qa
script
TXT
member.uid___A001_X133d_X2c8b.README.txt
products
rawdata
uid___A002_Xd2b681_Xa1c2.ms
uid___A002_Xd2b681_Xb99d.ms
working

2018.1.01201.S.PLtutorial.tar.gz

This is the directory tree that you will have after running scriptForPI.py when downloading data from the ASA.

- 2018.1.01201.S
  - science_goal.uid___A001_X133d_X2c85
    - group.uid___A001_X133d_X2c86
      - member.uid___A001_X133d_X2c8b
        - calibrated
          - products
          - rawdata
          - uid___A002_Xd2b681_Xa1c2.ms
          - uid___A002_Xd2b681_Xb99d.ms
          - working
        - calibration
        - log
        - product
        - qa
        - script
        - member.uid___A001_X133d_X2c8b.README.txt


GZ
2018.1.01201.S.PLtutorial.tar.gz
2018.1.01201.S
science_goal.uid___A001_X133d_X2c85
group.uid___A001_X133d_X2c86
member.uid___A001_X133d_X2c8b
calibrated
calibration
log
product
qa
script
TXT
products
rawdata
uid___A002_Xd2
b681_Xa1c2.ms
uid___A002_Xd2
b681_Xb99d.ms
working
We will work in this folder

In a terminal, move to the *working* directory:

dtafoya — -zsh — 143×53

```
% cd YOUR_OWN_PATH/2018.1.01201.S/science_goal.uid___A001_X133d_X2c85/
group.uid___A001_X133d_X2c86/member.uid___A001_X133d_X2c8b/calibrated/
working
```

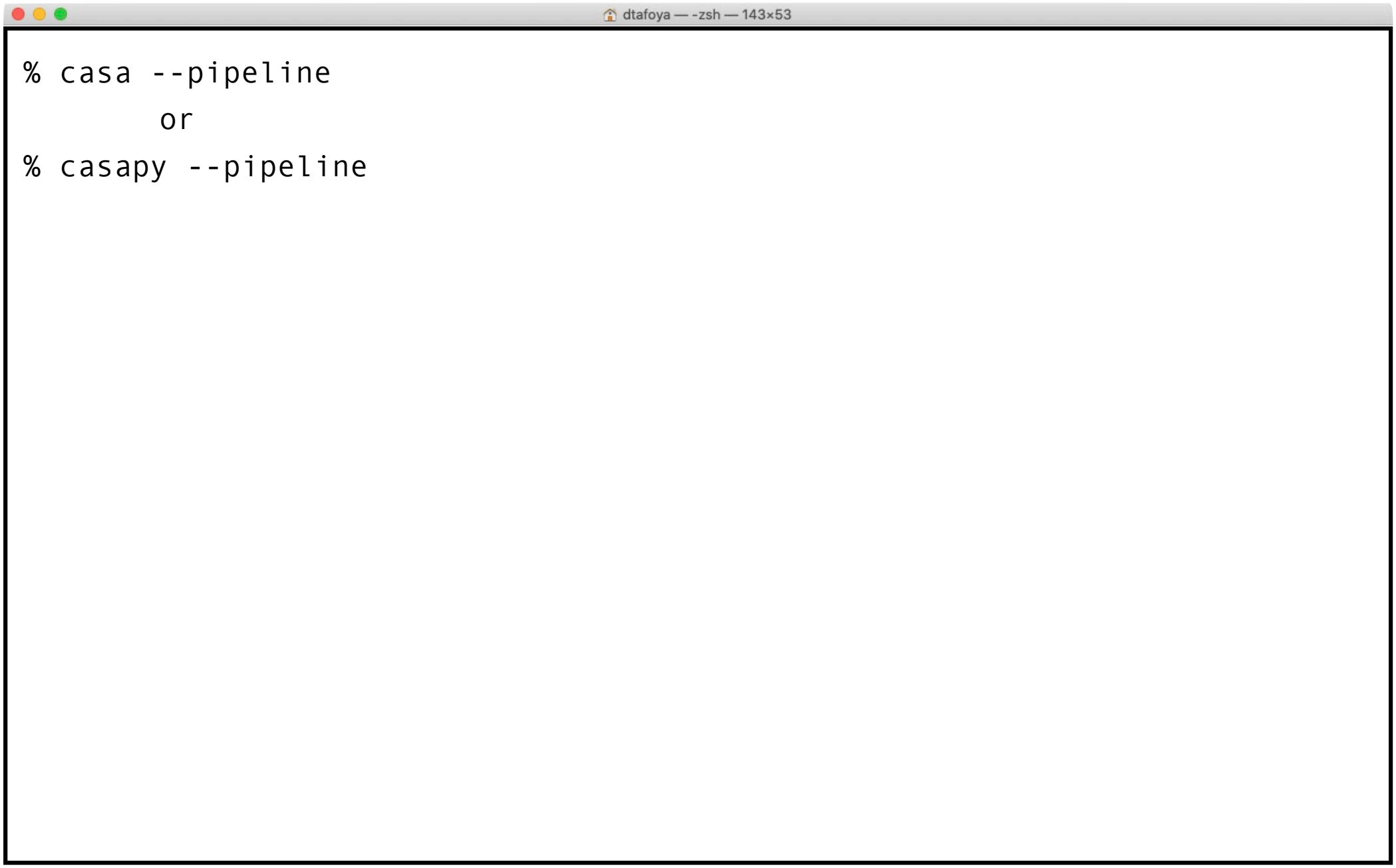
Then, check the content of the *working* directory:

dtafoya — -zsh — 143×53

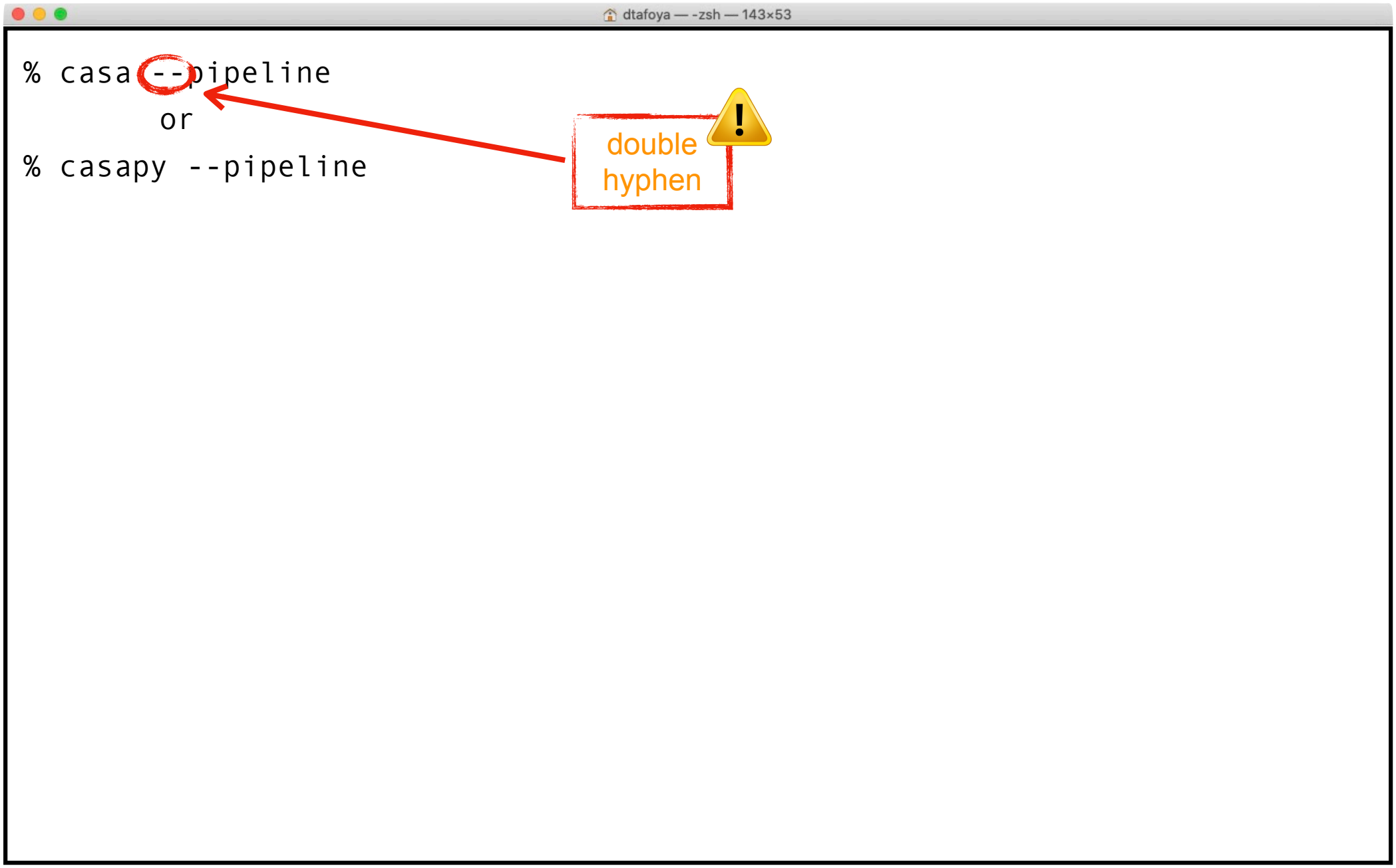
```
% cd YOUR_OWN_PATH/2018.1.01201.S/science_goal.uid___A001_X133d_X2c85/
group.uid___A001_X133d_X2c86/member.uid___A001_X133d_X2c8b/calibrated/
working

working% ls
flagmanager.last
flux.csv
h_init.last
h_save.last
hifa_restoredata.last
importasdm.last
listobs.last
pipeline-20201105T143636
pipeline-20201105T143636.context
uid___A002_Xd2b681_Xa1c2.ms
uid___A002_Xd2b681_Xa1c2.ms.flagversions
uid___A002_Xd2b681_Xa1c2.ms.h_tsyscal.s6_1.tsyscal.tbl
uid___A002_Xd2b681_Xa1c2.ms.hifa_bandpassflag.s12_7.spw16_18_20_22_24_26.channel.solintinf.bcal.final.tbl
uid___A002_Xd2b681_Xa1c2.ms.hifa_spwphaseup.s13_3.spw16_18_20_22_24_26.solintinf.gpcal.tbl
uid___A002_Xd2b681_Xa1c2.ms.hifa_timegaincal.s16_3.spw16_18_20_22_24_26.solintinf.gpcal.tbl
uid___A002_Xd2b681_Xa1c2.ms.hifa_timegaincal.s16_4.spw16_18_20_22_24_26.solintint.gpcal.tbl
uid___A002_Xd2b681_Xa1c2.ms.hifa_timegaincal.s16_6.spw16_18_20_22_24_26.solintinf.gacal.tbl
uid___A002_Xd2b681_Xb99d.ms
uid___A002_Xd2b681_Xb99d.ms.flagversions
uid___A002_Xd2b681_Xb99d.ms.h_tsyscal.s6_2.tsyscal.tbl
uid___A002_Xd2b681_Xb99d.ms.hifa_bandpassflag.s12_8.spw16_18_20_22_24_26.channel.solintinf.bcal.final.tbl
uid___A002_Xd2b681_Xb99d.ms.hifa_spwphaseup.s13_4.spw16_18_20_22_24_26.solintinf.gpcal.tbl
uid___A002_Xd2b681_Xb99d.ms.hifa_timegaincal.s16_4.spw16_18_20_22_24_26.solintinf.gpcal.tbl
uid___A002_Xd2b681_Xb99d.ms.hifa_timegaincal.s16_5.spw16_18_20_22_24_26.solintint.gpcal.tbl
uid___A002_Xd2b681_Xb99d.ms.hifa_timegaincal.s16_7.spw16_18_20_22_24_26.solintinf.gacal.tbl
```

In a terminal, run CASA with the pipeline:



In a terminal, run CASA with the pipeline:



In a terminal, run CASA with the pipeline:

dtafoya — -zsh — 143×53

```
% casa --pipeline
        or
% casapy --pipeline

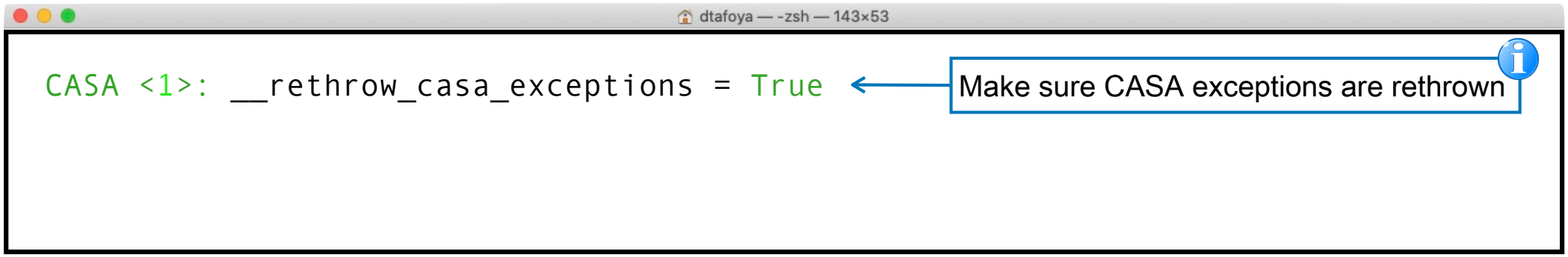

IPython 5.4.0 -- An enhanced Interactive Python.

PIPELINE CASA 5.6.1-8   -- Common Astronomy Software Applications

Found an existing telemetry logfile: /Users/dtafoya/.casa/casastats-561-8-21c3d94ba1ca45a13d-20201116-201536-
PIPELINE.log
Telemetry initialized. Telemetry will send anonymized usage statistics to NRAO.
You can disable telemetry by adding the following line to your ~/.casarc file:
EnableTelemetry: False
2020-11-17 21:51:55 INFO: Environment is not MPI enabled. Pipeline operating in single host mode
2020-11-17 21:51:57 INFO: Environment variable FLUX_SERVICE_URL not defined.  Switching to backup url.
2020-11-17 21:51:57 INFO: Environment variable FLUX_SERVICE_URL_BACKUP not defined.
2020-11-17 21:51:58 INFO: Pipeline version 42866 (Pipeline-CASA56-P1-B) running on Daniel-no-MacBook-Pro.local
2020-11-17 21:51:58 INFO: Host environment: 16.0 GB memory, 4 x Intel(R) Core(TM) i5-7360U CPU @ 2.30GHz running MacOS
10.15.7
2020-11-17 21:51:58 INFO: Initializing cli...
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: h
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: hif
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: hifa
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: hifv
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: hsd
2020-11-17 21:51:58 INFO: Loaded CASA tasks from package: hsdn


CASA <1>:
```

Create the pipeline context:

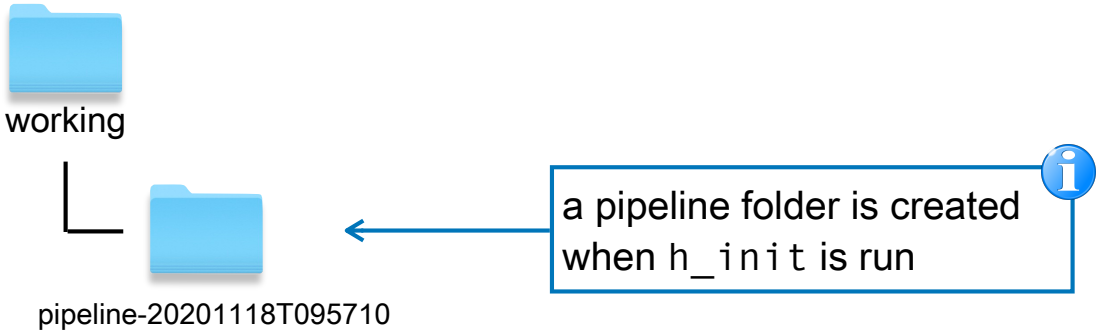


Create the pipeline context:

dtafoya — -zsh — 143×53

```
CASA <1>: __rethrow_casa_exceptions = True
CASA <2>: h_init()
Out[2]: <Context(name='pipeline-20201118T095710')>
```

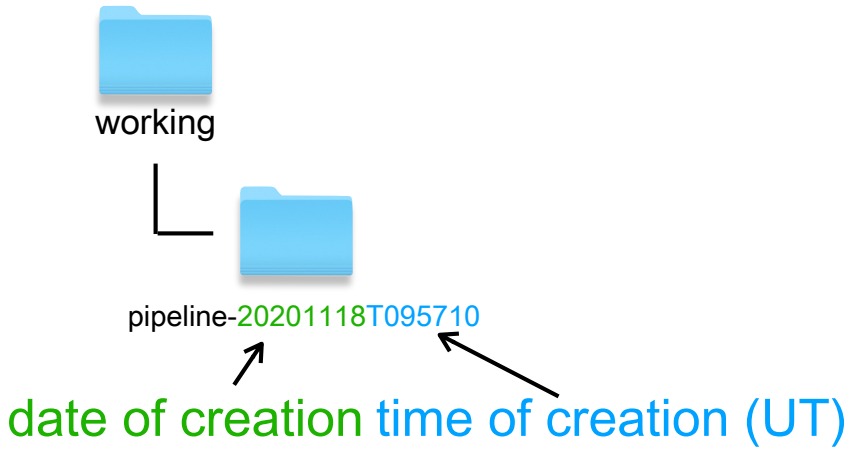
Initiates the context



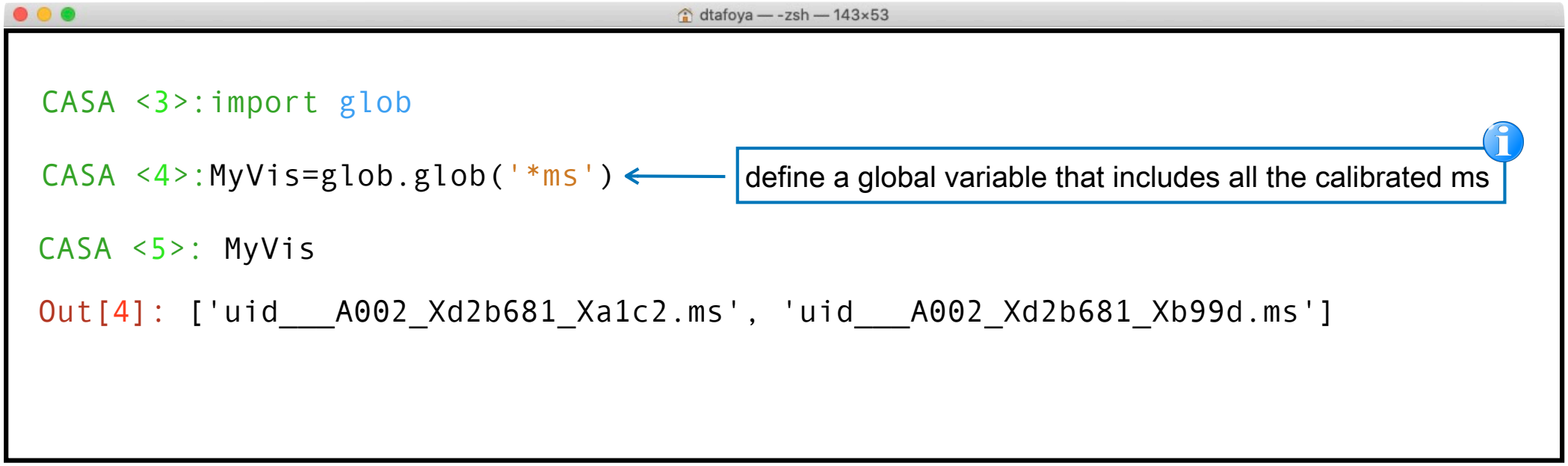
Create the pipeline context:

dtafoya — -zsh — 143×53

```
CASA <1>: __rethrow_casa_exceptions = True
CASA <2>: h_init()
Out[2]: <Context(name='pipeline-20201118T095710')>
```



Define global variable for the measurement sets:



Steps of this tutorial:

```
 1 hifa_importdata(vis=MyVis,dbservice=False)
 2 hif_mstransform(pipelinemode="automatic")
 3 hifa_flagtargets(pipelinemode="automatic")
 4 hifa_imageprecheck(pipelinemode="automatic")
 5 hif_makeimlist(specmode='mfs')
 6 hif_findcont(pipelinemode="automatic")
 7 hif_uvcontfit(pipelinemode="automatic")
 8 hif_uvcontsub(pipelinemode="automatic")
 9 hif_makeimages(pipelinemode="automatic")
10 hif_makeimlist(specmode='cont')
11 hif_makeimages(pipelinemode="automatic")
12 hif_makeimlist(specmode='cube')
13 hif_makeimages(pipelinemode="automatic")
14 hifa_exportdata(imaging_products_only=True)
```

Steps of this tutorial:

```
 1 hifa_importdata(vis=MyVis,dbservice=False)
 2 hif_mstransform(pipelinemode="automatic")
 3 hifa_flagtargets(pipelinemode="automatic")
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 9 hif_makeimages(pipelinemode="automatic")
10 hif_makeimlist(specmode='cont')
11 hif_makeimages(pipelinemode="automatic")
12 hif_makeimlist(specmode='cube')
13 hif_makeimages(pipelinemode="automatic")
14 hifa_exportdata(imaging_products_only=True)
```

import and prepare the data

find and subtract the continuum

make images and cubes

exports to fits files

Steps of this tutorial:

```
 1 hifa_importdata(vis=MyVis,dbservice=False)
 2 hif_mstransform(pipelinemode="automatic")
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 9 hif_makeimages(pipelinemode="automatic")
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11 hif_makeimages(pipelinemode="automatic")
12 hif_makeimlist(specmode='cube')
13 hif_makeimages(pipelinemode="automatic")
14 hifa_exportdata(imaging_products_only=True)
```

Getting started: Import the data

dtafoya — -zsh — 143×53

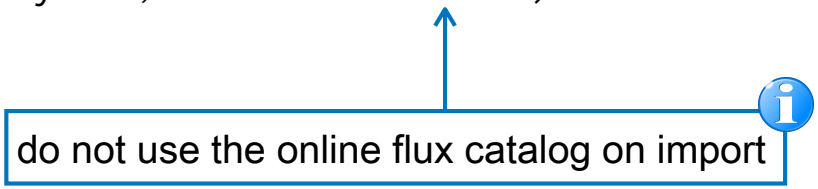
```
CASA <6>: hifa_importdata(vis=MyVis,dbservice=False)
```

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

Getting started: Import the data

dtafoya — -zsh — 143×53

```
CASA <6>: hifa_importdata(vis=MyVis,dbservice=False)
```




```
 1 hifa_importdata
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```

Getting started: Import the data

```
1 hifa_importdata
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10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

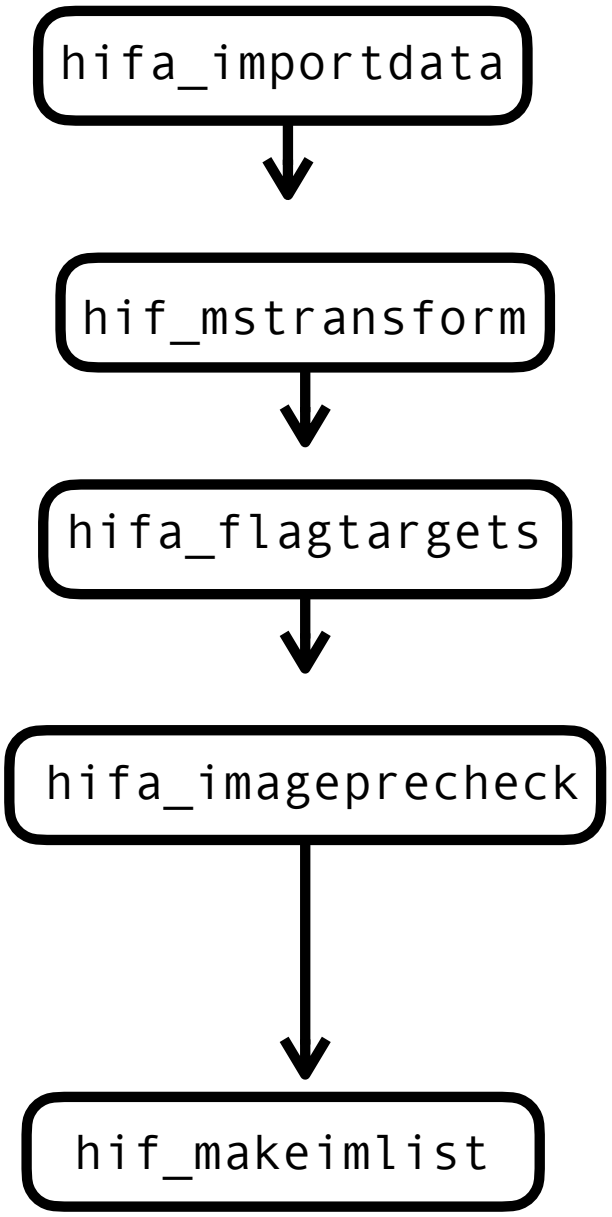
dtafoya — -zsh — 143×53

```
CASA <6>: hifa_importdata(vis=MyVis,dbservice=False)
```

do not use the online flux catalog on import

- Several messages will appear in the terminal and logger.
- It may take around 10 min to finish.

Steps before continuum subtraction:



will apply Binary Data Flags, and will calculate some properties of the MSs.

will create the measurement sets of the target for imaging.

will create flags for the science target data.

will use the representative source and spw containing the representative frequency selected by the PI in the OT to calculate the synthesized beam and to make sensitivity estimates for the aggregate bandwidth and representative bandwidth for three values of the robust parameter.

will determine image parameters (image size, cell size, etc) to be used in the subsequent `hif_makeimages` stage.

While waiting for `hifa_importdata` to finish, a few comments on the pipeline tasks:

– *What does* `hifa` *and* `hif` *stand for?*

- `hif`: interferometry (ALMA & VLA)
- `hifa`: interferometry (ALMA-only)
- `hifv`: interferometry (VLA-only)
- `hsd`: single-dish

A complete list of tasks used by the ALMA (and VLA) pipeline may be found by typing `tasklist` at the CASA prompt and looking under the "User defined tasks" for all of the `hifv_*`, `hifa_*`, `hsd_*`, `hif_*`, and `h_*` tasks

The lists of tasks can also be put in a python script:

example.py

```
import glob
import os

__rethrow_casa_exceptions = True
context = h_init()

os.system('rm -rf uid*_target.ms')
os.system('rm -rf uid*_target.ms.flagversions')

MyVis=glob.glob('*ms')

try:
    hifa_importdata(vis=MyVis,dbservice=False)
    hif_mstransform(pipelinemode="automatic")
    hifa_flagtargets(pipelinemode="automatic")
    hifa_imageprecheck(pipelinemode="automatic")
    hif_makeimlist(specmode='mfs')
    hif_findcont(pipelinemode="automatic")
    hif_uvcontfit(pipelinemode="automatic")
    hif_uvcontsub(pipelinemode="automatic")
    hif_makeimages(pipelinemode="automatic")
    hif_makeimlist(specmode='cont')
    hif_makeimages(pipelinemode="automatic")
    hif_makeimlist(specmode='cube')
    hif_makeimages(pipelinemode="automatic")
    hifa_exportdata(imaging_products_only=True)
finally:
    h_save()
```

U:**- example.py   All L5   (Python ElDoc)

The pipeline script is executed in the same way as other python scripts:

dtafoya — -zsh — 143×53

```
CASA <7>: execfile('my_pipeline_script.py')
```

example.py

```
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import os

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context = h_init()

os.system('rm -rf uid*_target.ms')
os.system('rm -rf uid*_target.ms.flagversions')

MyVis=glob.glob('*ms')

try:
     hifa_importdata(vis=MyVis,dbservice=False)
     hif_mstransform(pipelinemode="automatic")
     hifa_flagtargets(pipelinemode="automatic")
     hifa_imageprecheck(pipelinemode="automatic")
     hif_makeimlist(specmode='mfs')
     hif_findcont(pipelinemode="automatic")
     hif_uvcontfit(pipelinemode="automatic")
     hif_uvcontsub(pipelinemode="automatic")
     hif_makeimages(pipelinemode="automatic")
     hif_makeimlist(specmode='cont')
     hif_makeimages(pipelinemode="automatic")
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     hif_makeimages(pipelinemode="automatic")
     hifa_exportdata(imaging_products_only=True)
finally:
     h_save()
```

U:**- example.py   All L5   (Python ElDoc)

Handling the pipeline **context**:

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Handling the context:

- The pipeline always runs with a context:
  `h_init()`
- To resume at any specific stage, save context before closing CASA:
  `h_save('my_context.context')`
- To resume from a specific task:
  `h_resume('my_context.context')`

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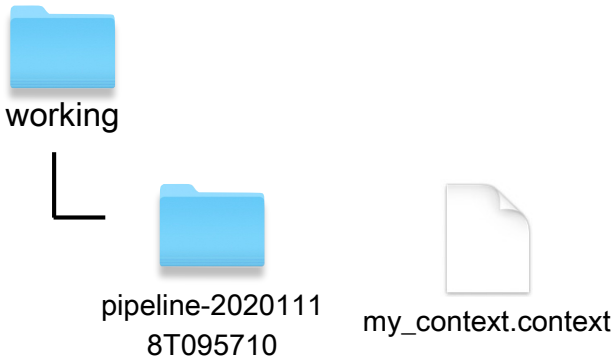
dtafoya — -zsh — 143×53

```
CASA <7>: h_save('my_context.context')
```



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dtafoya — -zsh — 143×53

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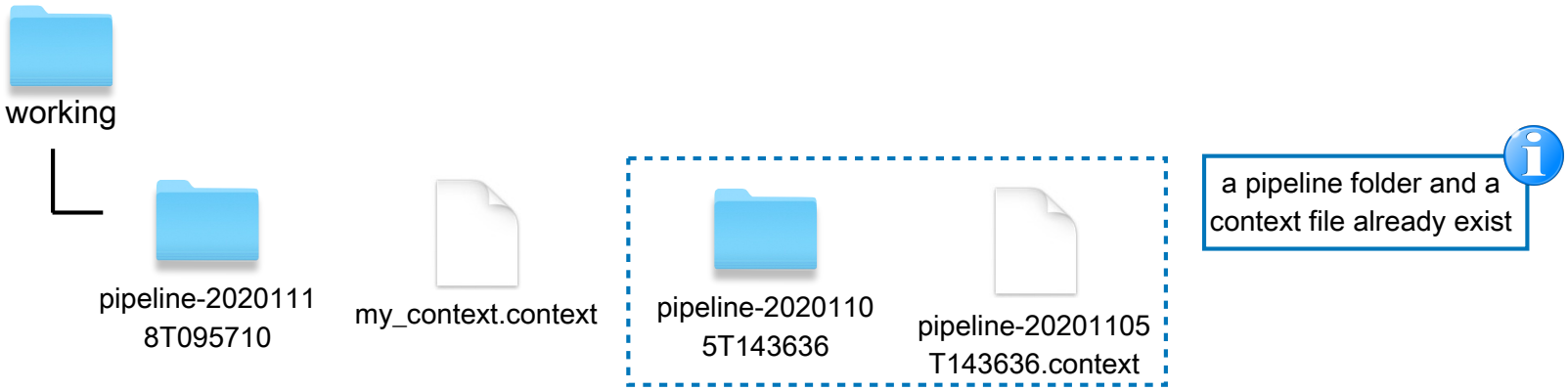
```



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dtafoya — -zsh — 143×53

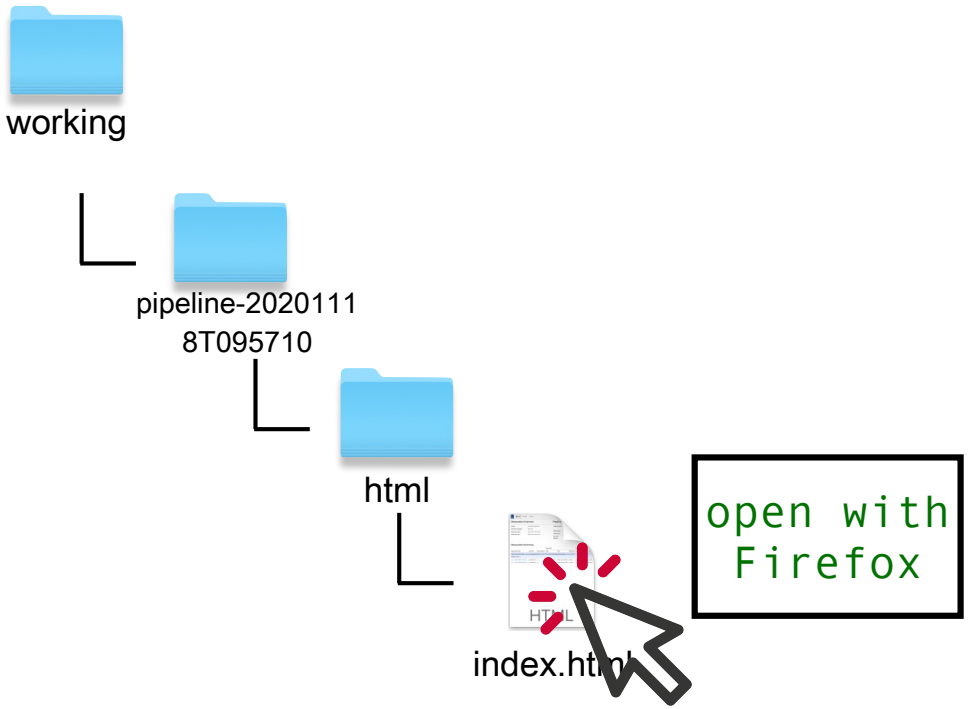
```
CASA <7>: h_save('my_context.context')
```

The pipeline weblog:

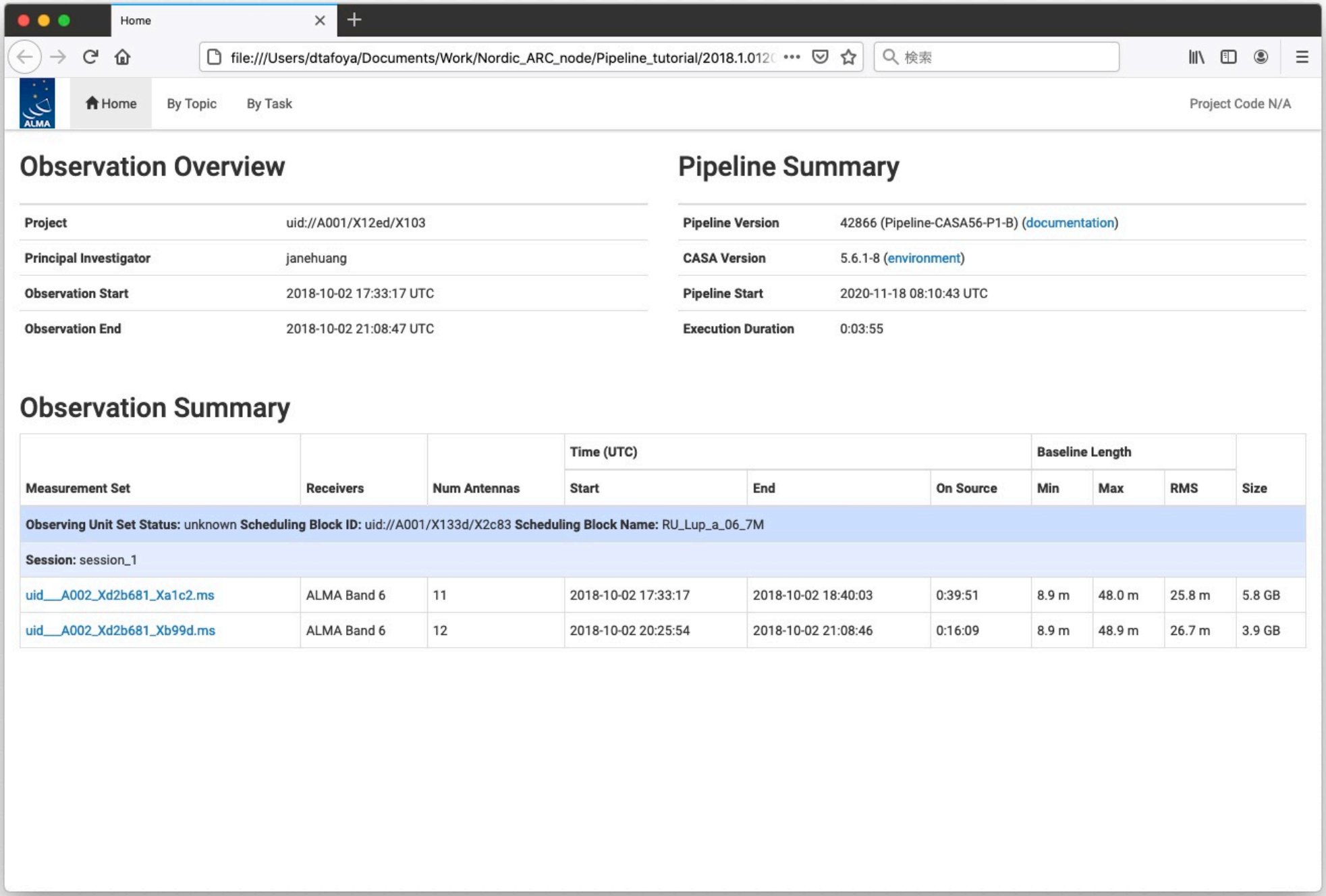
The pipeline weblog:

-Where is my weblog?

- A html weblog will be created in the working folder:



In Firefox:



Observation Overview

Project	uid://A001/X12ed/X103
Principal Investigator	janehuang
Observation Start	2018-10-02 17:33:17 UTC
Observation End	2018-10-02 21:08:47 UTC

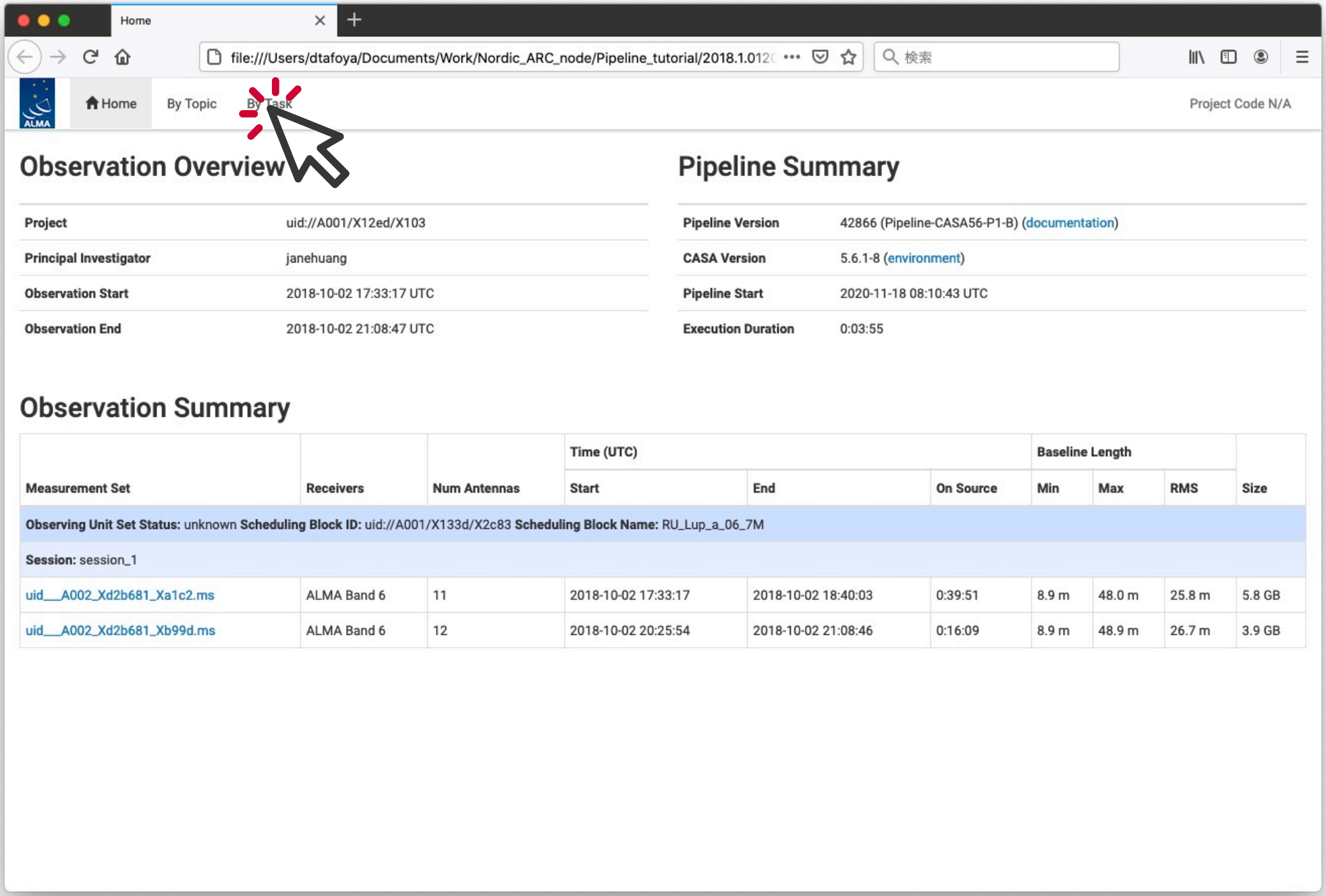
Pipeline Summary

Pipeline Version	42866 (Pipeline-CASA56-P1-B) (documentation)
CASA Version	5.6.1-8 (environment)
Pipeline Start	2020-11-18 08:10:43 UTC
Execution Duration	0:03:55

Observation Summary

Measurement Set	Receivers	Num Antennas	Time (UTC)			Baseline Length			Size
			Start	End	On Source	Min	Max	RMS	
Observing Unit Set Status: unknown **Scheduling Block ID:** uid://A001/X133d/X2c83 **Scheduling Block Name:** RU_Lup_a_06_7M									
Session: session_1									
uid___A002_Xd2b681_Xa1c2.ms	ALMA Band 6	11	2018-10-02 17:33:17	2018-10-02 18:40:03	0:39:51	8.9 m	48.0 m	25.8 m	5.8 GB
uid___A002_Xd2b681_Xb99d.ms	ALMA Band 6	12	2018-10-02 20:25:54	2018-10-02 21:08:46	0:16:09	8.9 m	48.9 m	26.7 m	3.9 GB

In Firefox:



Observation Overview

Project	uid://A001/X12ed/X103
Principal Investigator	janehuang
Observation Start	2018-10-02 17:33:17 UTC
Observation End	2018-10-02 21:08:47 UTC

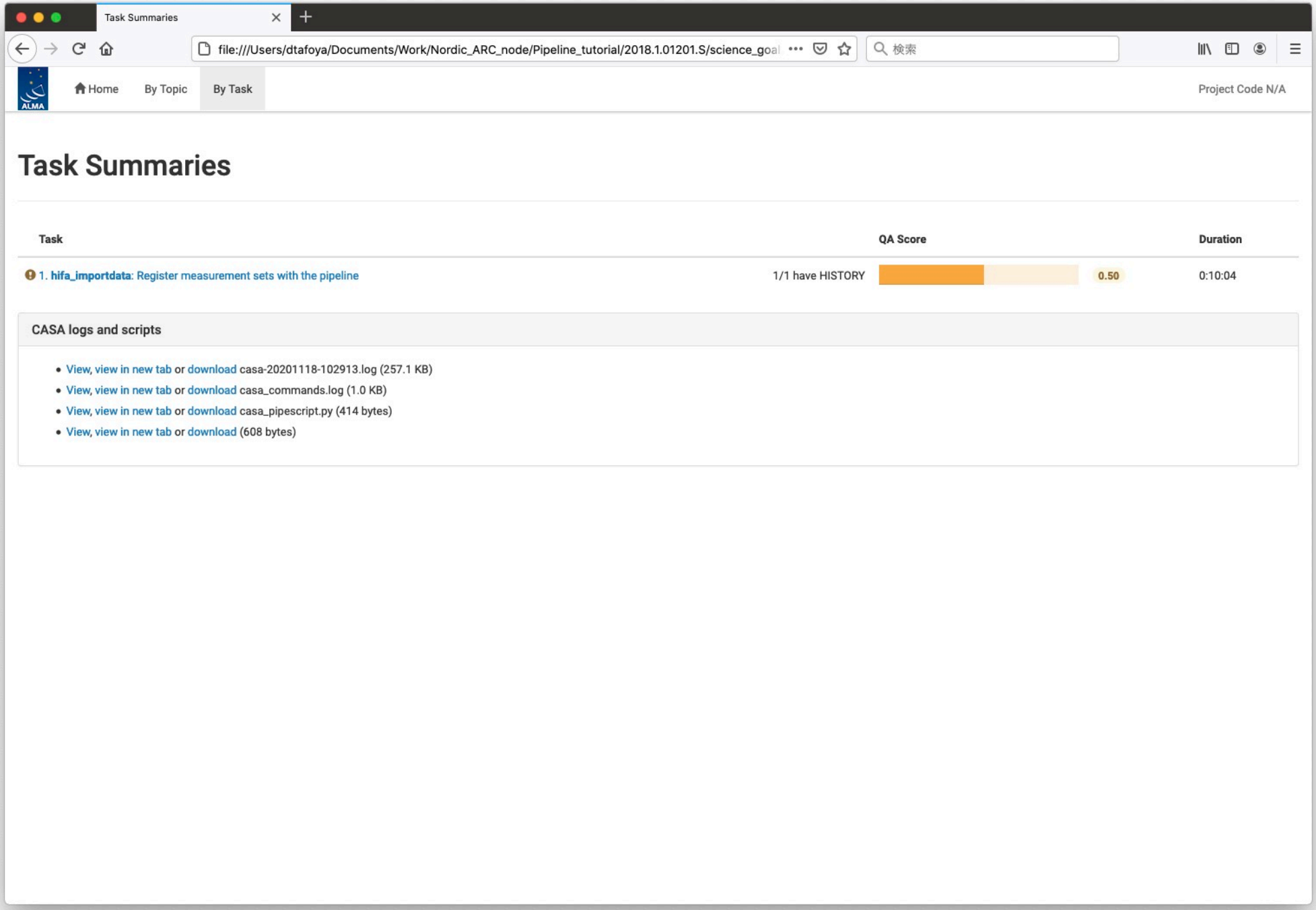
Pipeline Summary

Pipeline Version	42866 (Pipeline-CASA56-P1-B) (documentation)
CASA Version	5.6.1-8 (environment)
Pipeline Start	2020-11-18 08:10:43 UTC
Execution Duration	0:03:55

Observation Summary

Measurement Set	Receivers	Num Antennas	Time (UTC)			Baseline Length			Size
			Start	End	On Source	Min	Max	RMS	
Observing Unit Set Status: unknown **Scheduling Block ID:** uid://A001/X133d/X2c83 **Scheduling Block Name:** RU_Lup_a_06_7M									
Session: session_1									
uid___A002_Xd2b681_Xa1c2.ms	ALMA Band 6	11	2018-10-02 17:33:17	2018-10-02 18:40:03	0:39:51	8.9 m	48.0 m	25.8 m	5.8 GB
uid___A002_Xd2b681_Xb99d.ms	ALMA Band 6	12	2018-10-02 20:25:54	2018-10-02 21:08:46	0:16:09	8.9 m	48.9 m	26.7 m	3.9 GB

In Firefox:


Task Summaries
file:///Users/dtafoya/Documents/Work/Nordic_ARC_node/Pipeline_tutorial/2018.1.01201.S/science_goal
検索
Home
By Topic
By Task
Project Code N/A
Task Summaries
Task
QA Score
Duration
1. hifa_importdata: Register measurement sets with the pipeline
1/1 have HISTORY
0.50
0:10:04
CASA logs and scripts
View, view in new tab or download casa-20201118-102913.log (257.1 KB)
View, view in new tab or download casa_commands.log (1.0 KB)
View, view in new tab or download casa_pipescript.py (414 bytes)
View, view in new tab or download (608 bytes)

back to CASA…

Next step is running `mstransform`:

```
1 hifa_importdata
2 hif_mstransform
3 hifa_flagtargets
4 hifa_imageprecheck
5 hif_makeimlist
6 hif_findcont
7 hif_uvcontfit
8 hif_uvcontsub
9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <8>: hif_mstransform(pipelinemode="automatic")
```

- It may take around 1.5 min to finish.

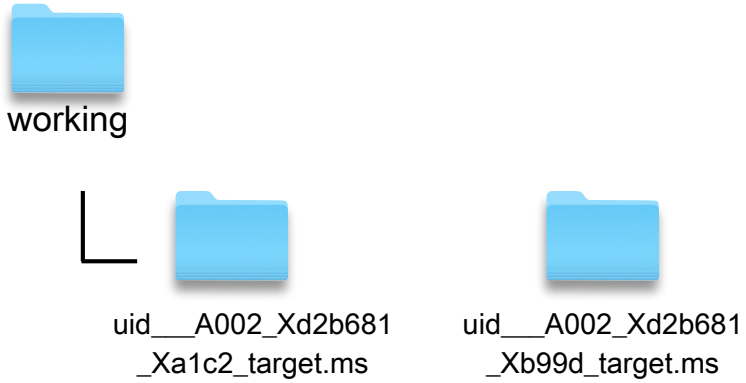
Next step is running `mstransform`:

```
1 hifa_importdata
2 hif_mstransform
3 hifa_flagtargets
4 hifa_imageprecheck
5 hif_makeimlist
6 hif_findcont
7 hif_uvcontfit
8 hif_uvcontsub
9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <8>: hif_mstransform(pipelinemode="automatic")
```

- It may take around 1.5 min to finish.
- `mstransform` will create target measurement sets for imaging.



Flagging data of the targets:

dtafoya — -zsh — 143×53

```
CASA <9>: hifa_flagtargets(pipelinemode="automatic")
```

- It may take around 1.5 min to finish.
- Usually no flags for the target unless problematic data - you can re-run this stage and input values in the flag templates if you want.

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

Flagging data of the targets:

```
1 hifa_importdata
2 hif_mstransform
3 hifa_flagtargets
4 hifa_imageprecheck
5 hif_makeimlist
6 hif_findcont
7 hif_uvcontfit
8 hif_uvcontsub
9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <9>: hifa_flagtargets(pipelinemode="automatic")
```

- It may take around 1.5 min to finish.
- Usually no flags for the target unless problematic data - you can re-run this stage and input values in the flag templates if you want.
- Flagging commands can be added to the *uid*flagtargetstemplate.txt* files that are provided with the archived pipeline products. There should be one file for every MS that needs additional flagging, with a name matching the MS uid.
- If these files are found in the directory where the pipeline is run (*working*), they will be picked up by the `hifa_flagtargets` task and applied to the data before science target imaging.

Pre-check the imaging parameters:

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <10>: hifa_imageprecheck(pipelinemode="automatic")
```

- It may take around 7 min to finish.
- Useful if you want pipeline to figure out the best image parameters for you in order to match the resolution of the original science goal.
- if you don’t run this, the default robust is 0.5.

Pre-check the imaging parameters:

```
1 hifa_importdata
2 hif_mstransform
3 hifa_flagtargets
4 hifa_imageprecheck
5 hif_makeimlist
6 hif_findcont
7 hif_uvcontfit
8 hif_uvcontsub
9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

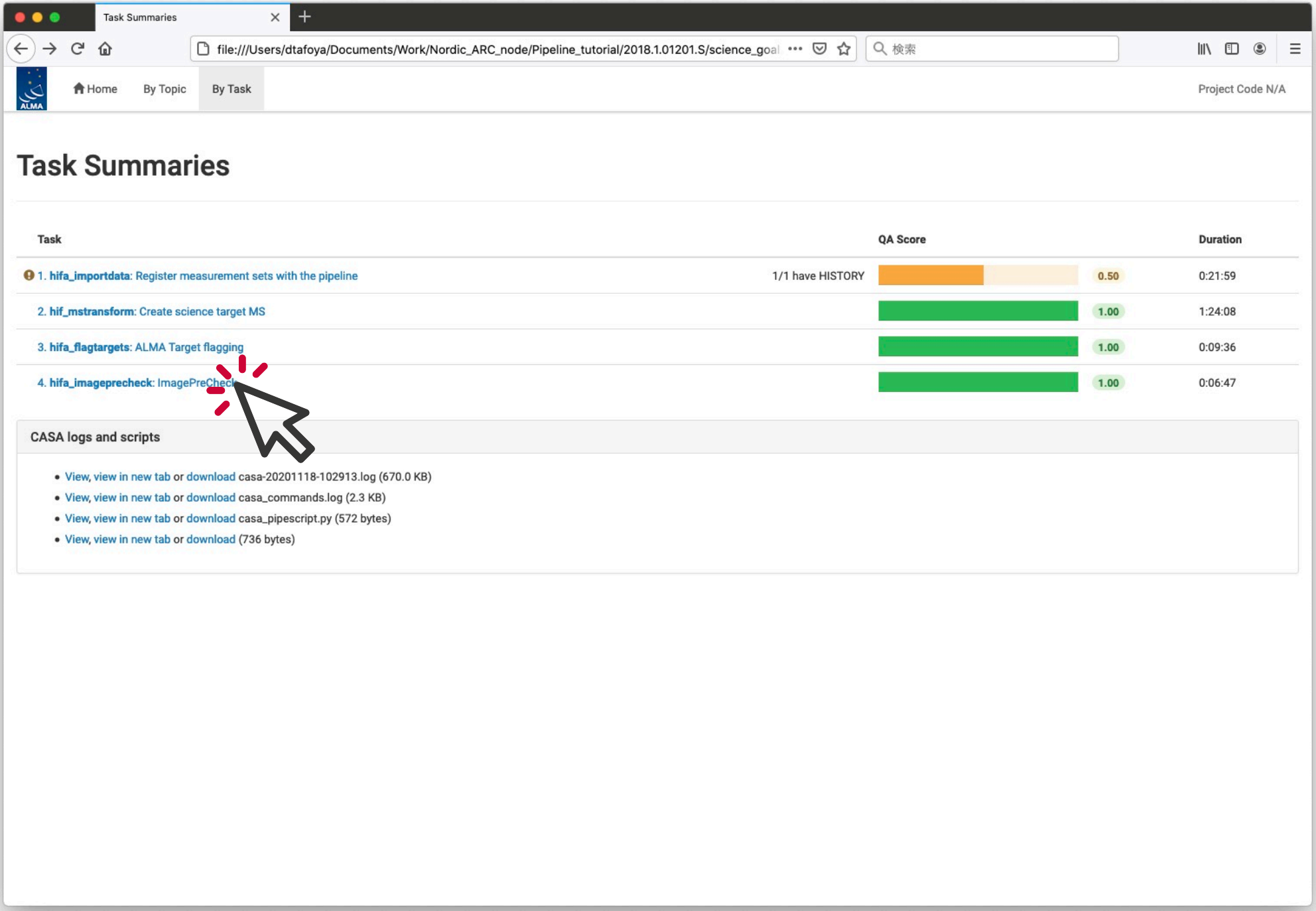
```
CASA <10>: hifa_imageprecheck(pipelinemode="automatic")
```

- It may take around 7 min to finish.
- Useful if you want pipeline to figure out the best image parameters for you in order to match the resolution of the original science goal.
- if you don't run this, the default robust is 0.5.

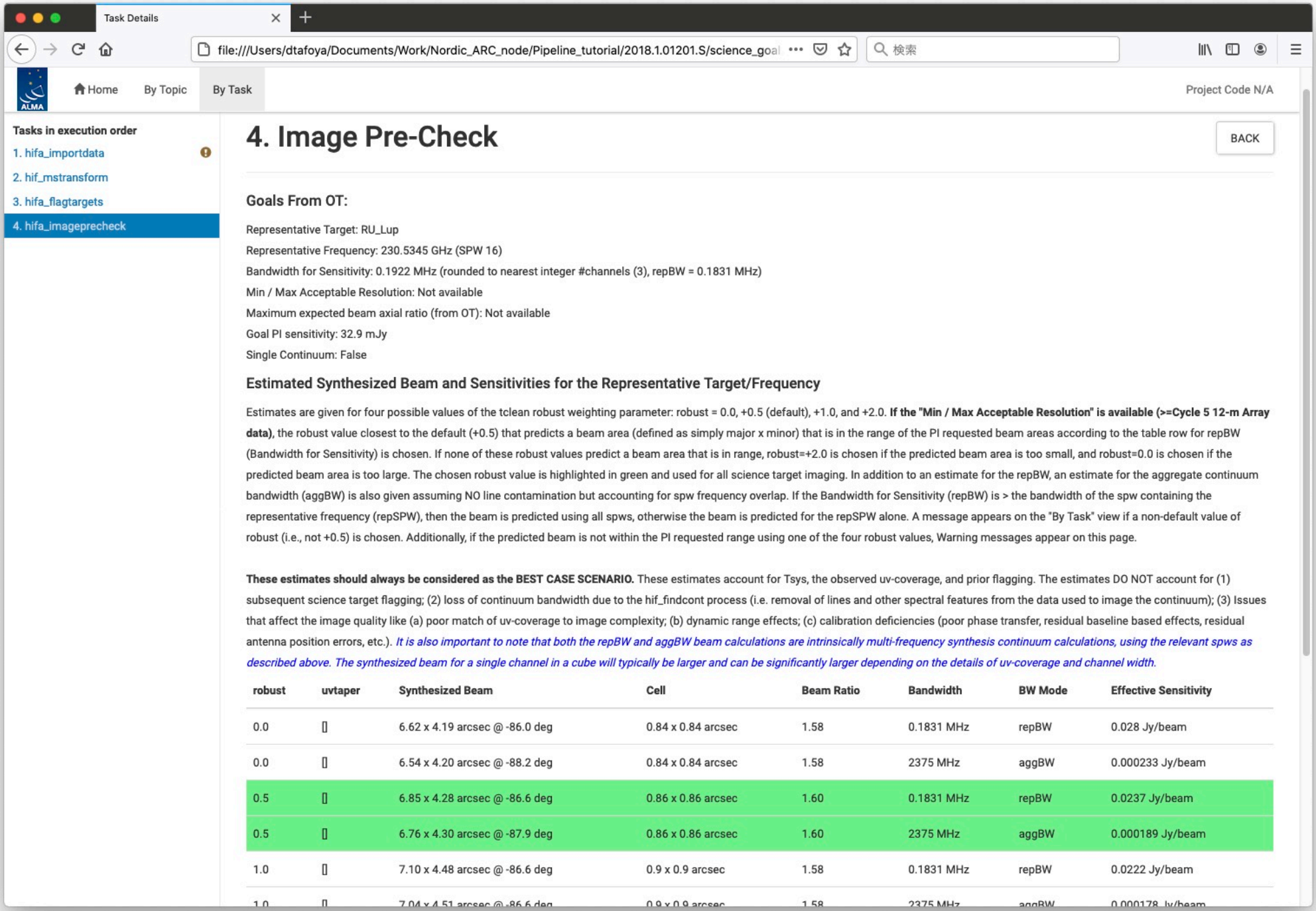
Remember

- keep checking your weblog
- refresh and see the steps appear
- run `h_save('my_context.context')` regularly

In the weblog:



In the weblog:



Task Details

file:///Users/dtafoya/Documents/Work/Nordic_ARC_node/Pipeline_tutorial/2018.1.01201.S/science_goal

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Tasks in execution order

1. hifa_importdata
2. hif_mstransform
3. hifa_flagtargets
4. hifa_imageprecheck

4. Image Pre-Check

BACK

Goals From OT:

Representative Target: RU_Lup
Representative Frequency: 230.5345 GHz (SPW 16)
Bandwidth for Sensitivity: 0.1922 MHz (rounded to nearest integer #channels (3), repBW = 0.1831 MHz)
Min / Max Acceptable Resolution: Not available
Maximum expected beam axial ratio (from OT): Not available
Goal PI sensitivity: 32.9 mJy
Single Continuum: False

Estimated Synthesized Beam and Sensitivities for the Representative Target/Frequency

Estimates are given for four possible values of the tclean robust weighting parameter: robust = 0.0, +0.5 (default), +1.0, and +2.0. **If the "Min / Max Acceptable Resolution" is available (>=Cycle 5 12-m Array data)**, the robust value closest to the default (+0.5) that predicts a beam area (defined as simply major x minor) that is in the range of the PI requested beam areas according to the table row for repBW (Bandwidth for Sensitivity) is chosen. If none of these robust values predict a beam area that is in range, robust=+2.0 is chosen if the predicted beam area is too small, and robust=0.0 is chosen if the predicted beam area is too large. The chosen robust value is highlighted in green and used for all science target imaging. In addition to an estimate for the repBW, an estimate for the aggregate continuum bandwidth (aggBW) is also given assuming NO line contamination but accounting for spw frequency overlap. If the Bandwidth for Sensitivity (repBW) is > the bandwidth of the spw containing the representative frequency (repSPW), then the beam is predicted using all spws, otherwise the beam is predicted for the repSPW alone. A message appears on the "By Task" view if a non-default value of robust (i.e., not +0.5) is chosen. Additionally, if the predicted beam is not within the PI requested range using one of the four robust values, Warning messages appear on this page.

These estimates should always be considered as the BEST CASE SCENARIO. These estimates account for Tsys, the observed uv-coverage, and prior flagging. The estimates DO NOT account for (1) subsequent science target flagging; (2) loss of continuum bandwidth due to the hif_findcont process (i.e. removal of lines and other spectral features from the data used to image the continuum); (3) Issues that affect the image quality like (a) poor match of uv-coverage to image complexity; (b) dynamic range effects; (c) calibration deficiencies (poor phase transfer, residual baseline based effects, residual antenna position errors, etc.). *It is also important to note that both the repBW and aggBW beam calculations are intrinsically multi-frequency synthesis continuum calculations, using the relevant spws as described above. The synthesized beam for a single channel in a cube will typically be larger and can be significantly larger depending on the details of uv-coverage and channel width.*

robust	uvtaper	Synthesized Beam	Cell	Beam Ratio	Bandwidth	BW Mode	Effective Sensitivity
0.0	[]	6.62 x 4.19 arcsec @ -86.0 deg	0.84 x 0.84 arcsec	1.58	0.1831 MHz	repBW	0.028 Jy/beam
0.0	[]	6.54 x 4.20 arcsec @ -88.2 deg	0.84 x 0.84 arcsec	1.58	2375 MHz	aggBW	0.000233 Jy/beam
0.5	[]	6.85 x 4.28 arcsec @ -86.6 deg	0.86 x 0.86 arcsec	1.60	0.1831 MHz	repBW	0.0237 Jy/beam
0.5	[]	6.76 x 4.30 arcsec @ -87.9 deg	0.86 x 0.86 arcsec	1.60	2375 MHz	aggBW	0.000189 Jy/beam
1.0	[]	7.10 x 4.48 arcsec @ -86.6 deg	0.9 x 0.9 arcsec	1.58	0.1831 MHz	repBW	0.0222 Jy/beam
1.0	[]	7.04 x 4.51 arcsec @ -86.6 deg	0.9 x 0.9 arcsec	1.58	2375 MHz	aggBW	0.000178 Jy/beam

open a Firefox browser
and do a demonstration

Set the imaging parameters:

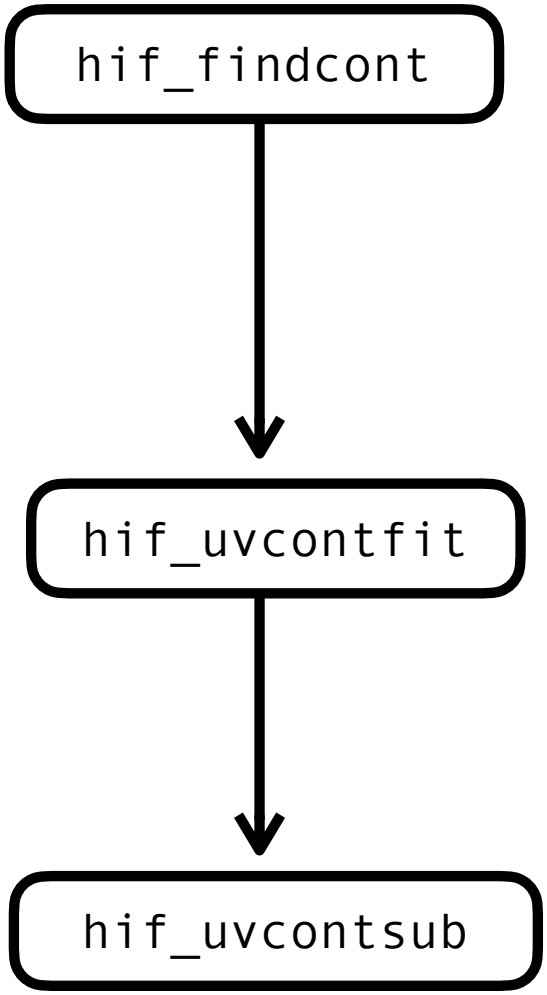
dtafoya — -zsh — 143×53

```
CASA <11>: hif_makeimlist(specmode='mfs')
```

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

- this will create all image parameters; `specmode ='mfs'` will do aggregated continuum for each SPW.
- the parameters defined here will be used when making images in step 9.

Finding and subtracting the continuum



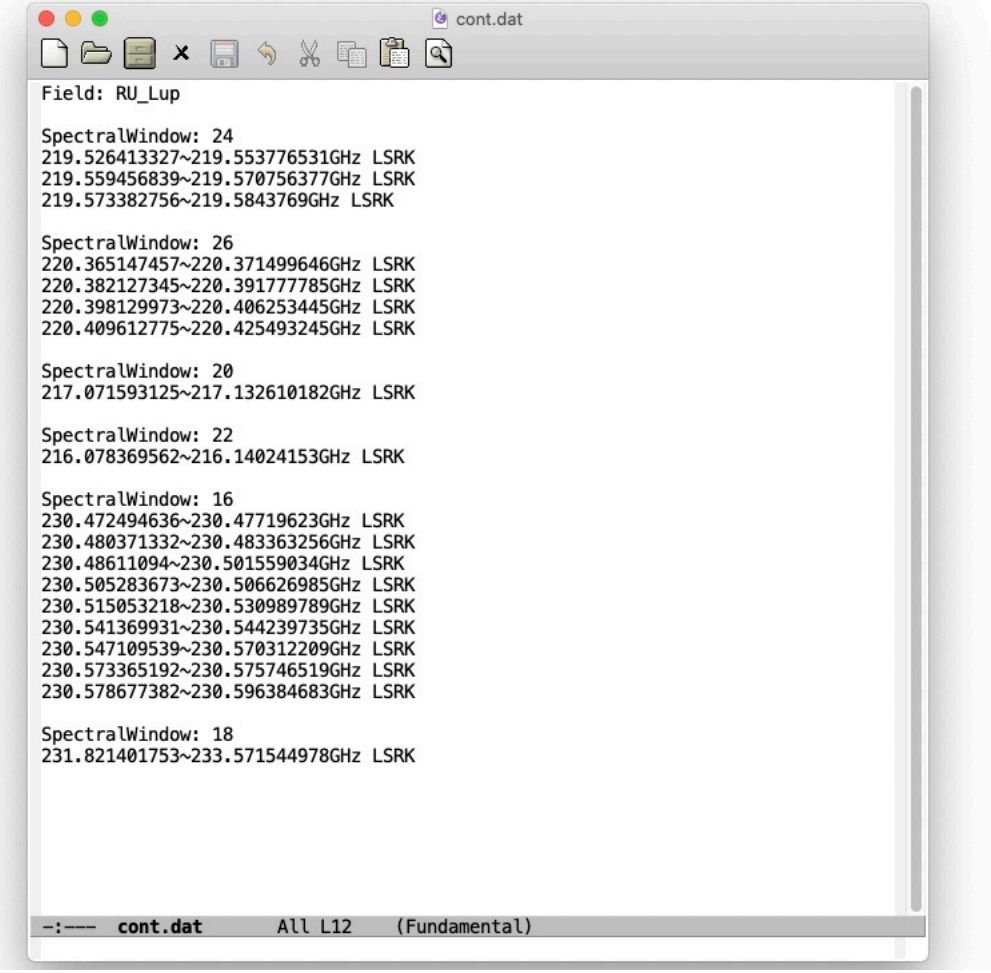
will make dirty image cubes for each spectral window of each science target. It will generate and evaluate the mean spectrum of a masked region of the dirty line+cont image constructed from *moment0* and *moment8* (peak) images. It will calculate frequency ranges that are the least likely to contain any line emission or absorption.

This task will use these frequency ranges to fit and subtract the continuum. Subsequent continuum images will include only these frequency ranges, and the line cubes will be made from the continuum subtracted data.

The `hif_uvcontfit` calibration table is applied to the data. After this step, the original continuum + line emission is contained in the **DATA** column of the MS, while the continuum subtracted data are written to the **CORRECTED** column.

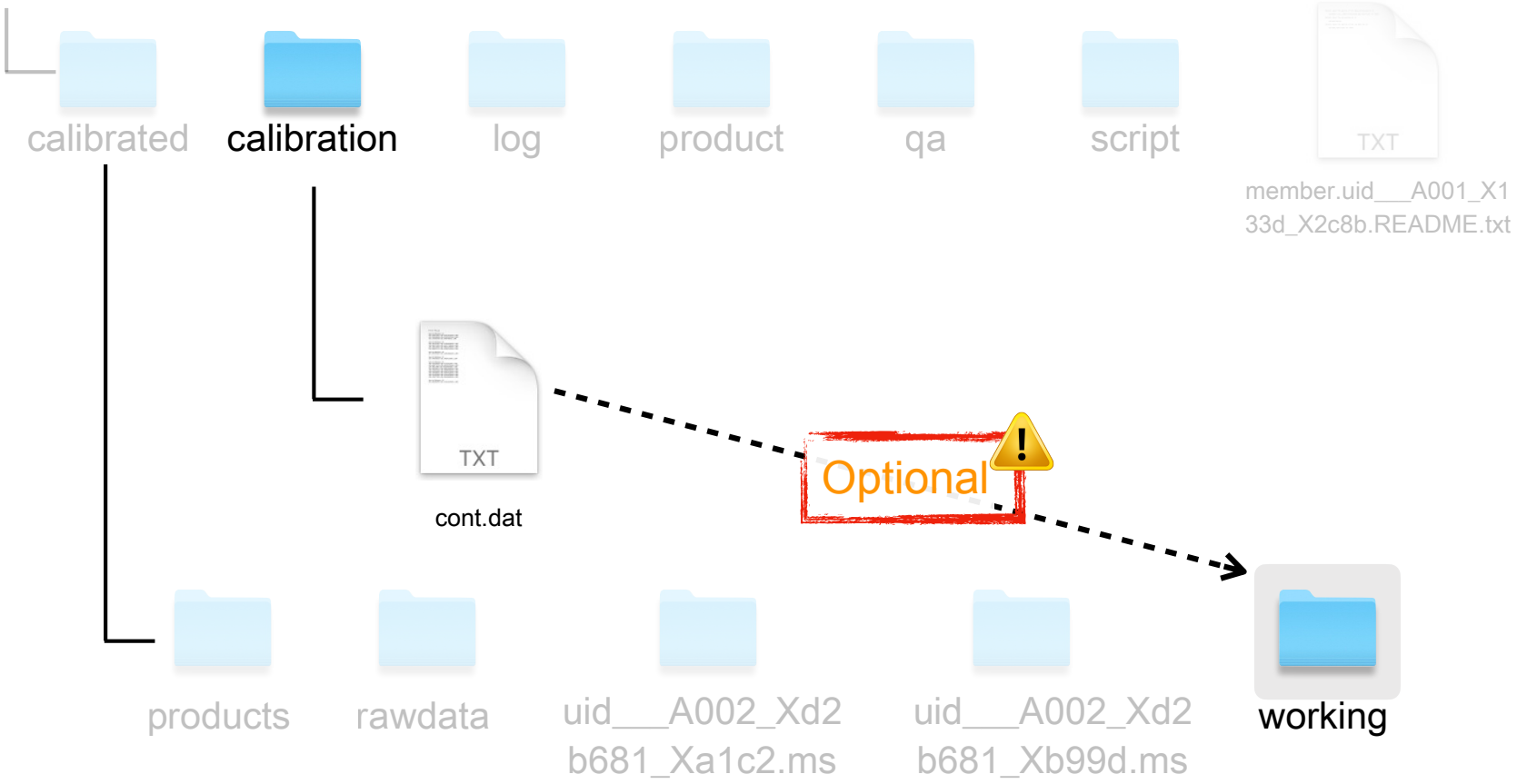
The *cont.dat* file:

- A file named *cont.dat* is delivered with the pipeline products.
- It lists the LSRK frequency ranges that are used to make the per-spw and aggregate continuum images, and for fitting and subtracting the continuum for the image cubes.



The *cont.dat* file:

- A file named *cont.dat* is delivered with the pipeline products.
- It lists the LSRK frequency ranges that are used to make the per-spw and aggregate continuum images, and for fitting and subtracting the continuum for the image cubes.



Find the continuum channels:

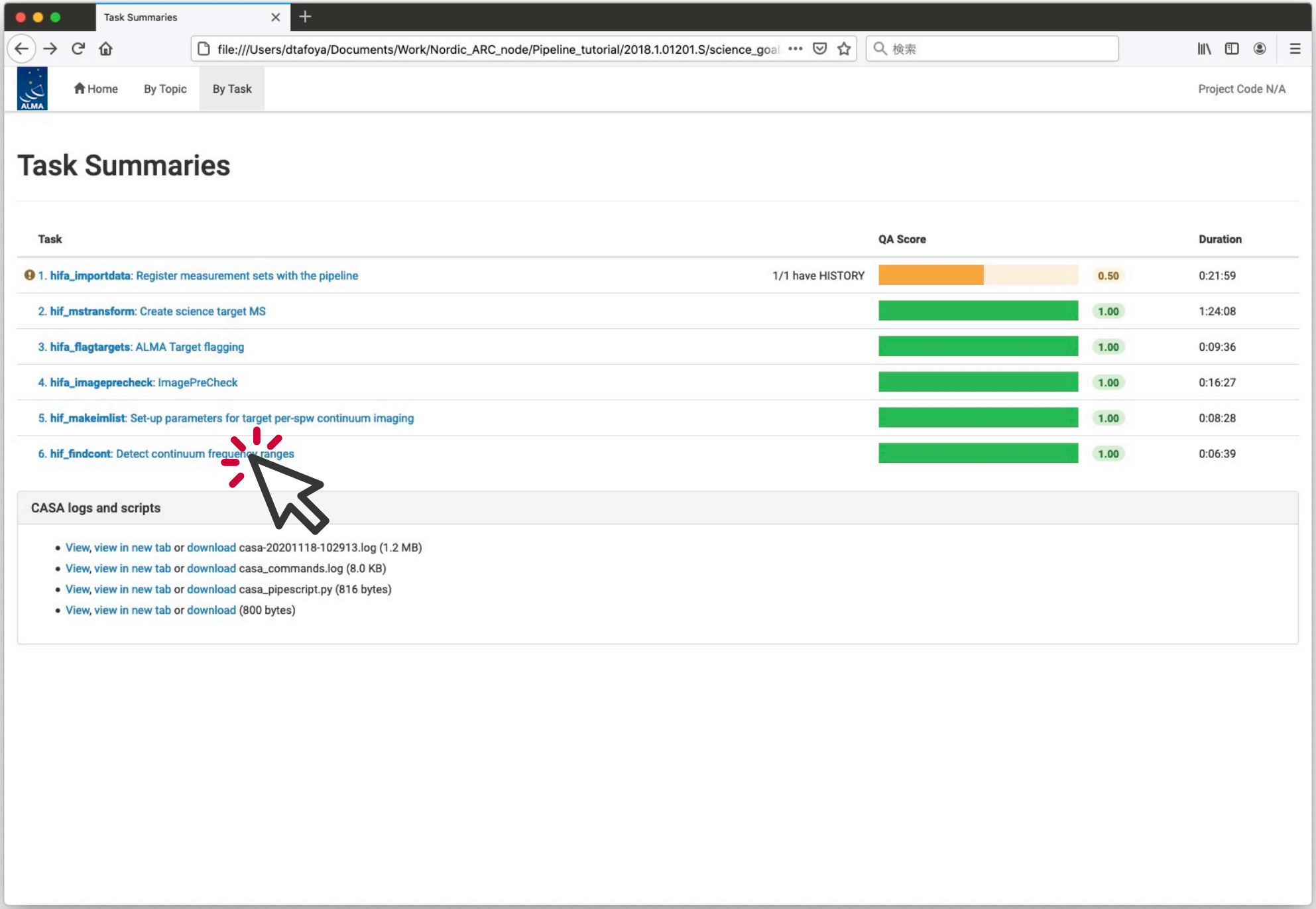
dtafoya — -zsh — 143×53

```
CASA <12>: hif_findcont(pipelinemode="automatic")
```

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

- this will take around 7 min for the ACA data - as it makes some cubes and will show a spectrum in your weblog.
- if the pre-existing *cont.dat* file is used, the information in the weblog will be shown, but no spectrum will be shown.

In the weblog (if `hif_findcont` was run without *cont.dat*):



In the weblog (if `hif_findcont` was run without *cont.dat*):

Task Details

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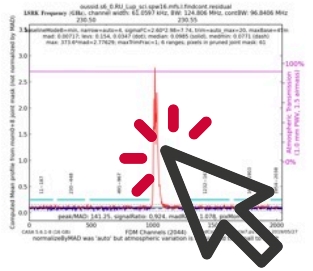
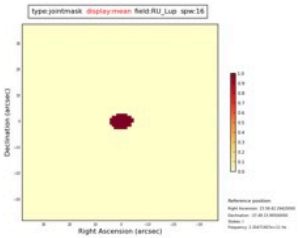
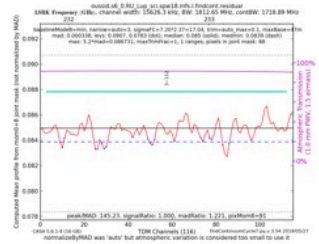
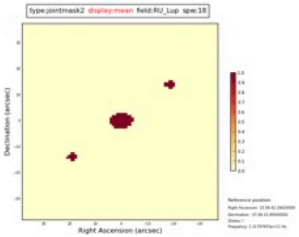
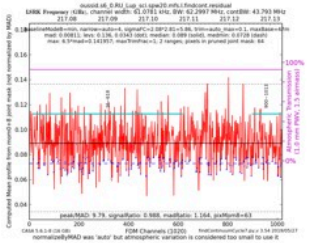
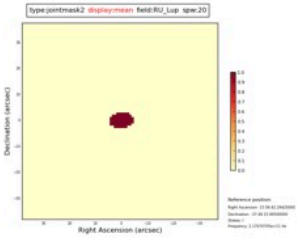
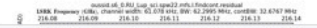
Tasks in execution order

1. hifa_importdata
2. hif_mstransform
3. hifa_flagtargets
4. hifa_imageprecheck
5. hif_makeimlist (mfs)
6. hif_findcont

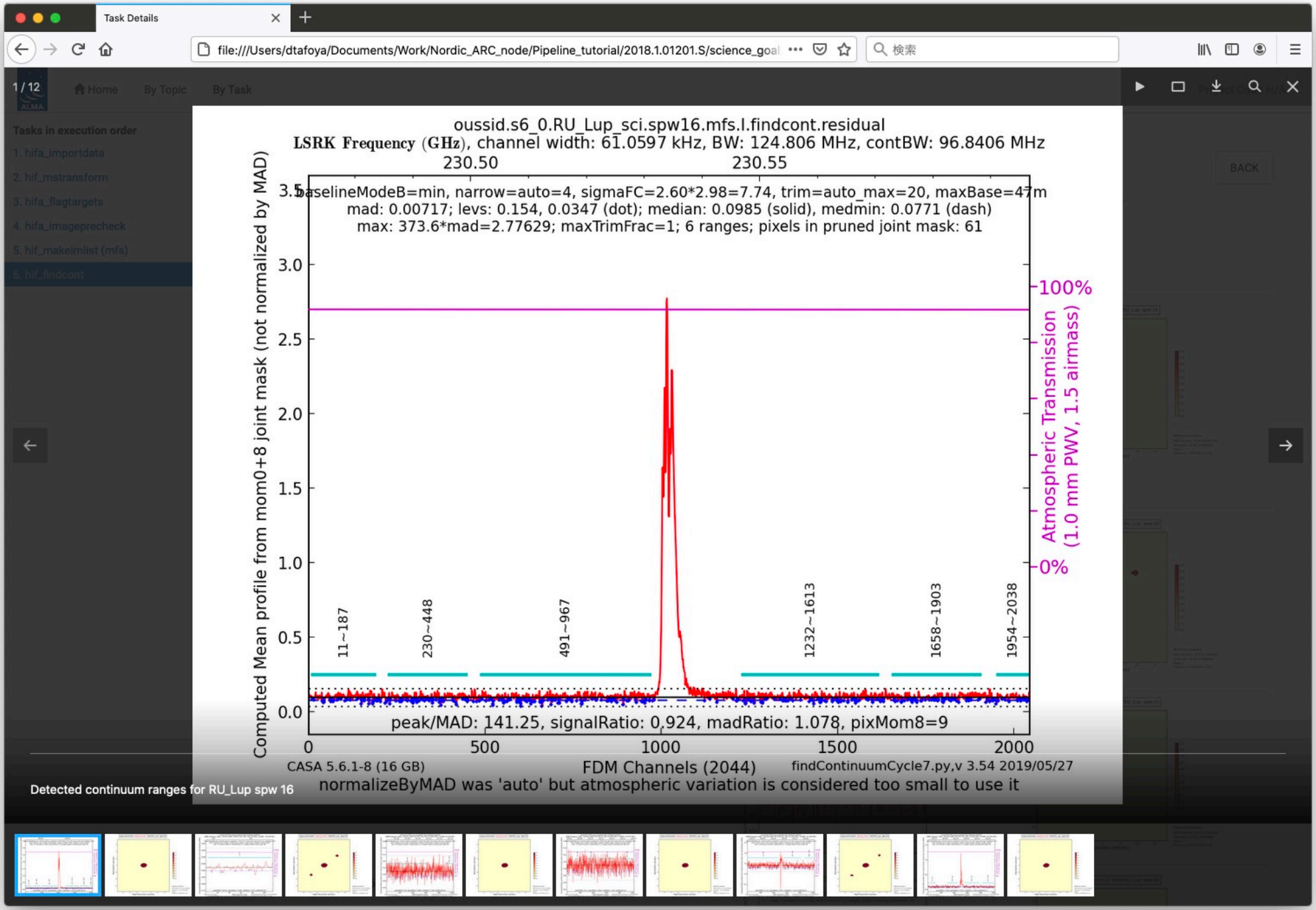
6. Find Continuum

BACK

		Continuum Frequency Range					
Field	**Spw**	**Start**	**End**	**Frame**	**Status**	**Average spectrum**	**Joint mask**
RU_Lup	16	230.47255 GHz	230.48336 GHz	LSRK	NEW		
		230.48592 GHz	230.49929 GHz				
		230.50186 GHz	230.53098 GHz				
		230.54710 GHz	230.57043 GHz				
		230.57311 GHz	230.58813 GHz				
		230.59119 GHz	230.59638 GHz				
	18	231.83702 GHz	233.55591 GHz		NEW , All cont.		
	20	217.07165 GHz	217.10848 GHz		NEW		
		217.12565 GHz	217.13261 GHz				
	22	216.08631 GHz	216.08961 GHz				

file:///Users/dtafoya/Documents/Work/Nordic_ARC_node/Pipeline_tutorial/2018.1.01201.S/science_goal.uid___A001_X133d_X2c85/group.ui..._sci.spw16.mfs.I.findcont.residual.meanSpectrum.mom0mom8jointMask.min.min.2.6sigma.narrowauto=4.trimauto_max=20.overwriteTrue.png

In the weblog (if `hif_findcont` was run without *cont.dat*):



Fitting the continuum:

dtafoya — -zsh — 143×53

```
CASA <13>: hif_uvcontfit(pipelinemode="automatic")
```

- This will take around 6 min.

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

Subtracting the continuum:

dtafoya — -zsh — 143×53

```
CASA <14>: hif_uvcontsub(pipelinemode="automatic")
```

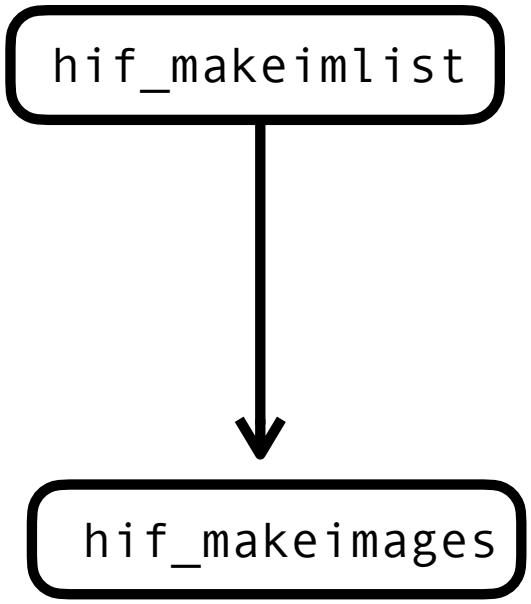
```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

- The original continuum + line emission is contained in the DATA column of the MS, while the continuum subtracted data are written to the CORRECTED column.

Remember

- keep checking your weblog.
- refresh and see the steps appear.
- run `h_save('my_context.context')` regularly.

now we can actually make images:



This stage determines image parameters (image size, cell size, etc) to be used in the subsequent `hif_makeimages` stage.

Cleaned images are created for each spectral window using the parameters defined in `hif_makeimlist`.

First, make image of the aggregated continuum:

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

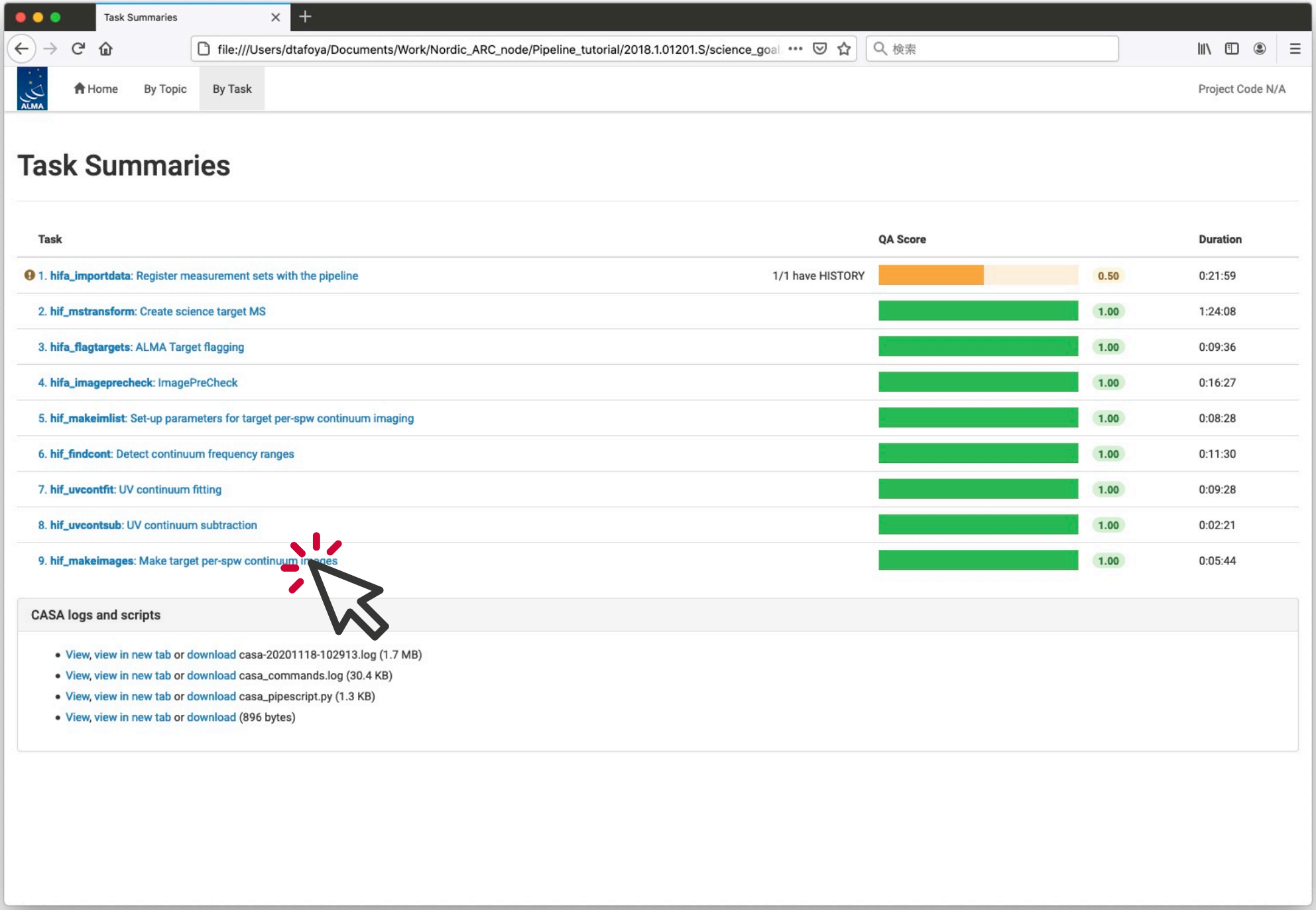
In step 5 `hif_makeimlist(specmode='mfs')` was run.

dtafoya — -zsh — 143×53

```
CASA <15>: hif_makeimages(pipelinemode="automatic")
```

- This will take around 6 min.
- This will create the images based on the previous `hif_makeimlist` (step 5).

In the weblog:



In the weblog:

Task Details

file:///Users/dtafoya/Documents/Work/Nordic_ARC_node/Pipeline_tutorial/2018.1.01201.S/science_goal

Home | By Topic | By Task | Project Code N/A

Tasks in execution order

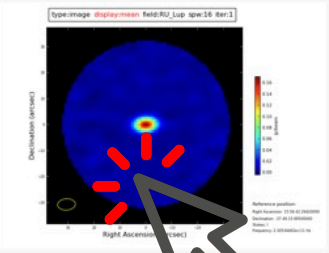
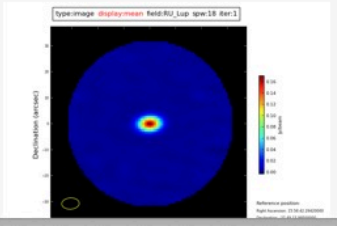
1. hifa_importdata
2. hif_mstransform
3. hifa_flagtargets
4. hifa_imageprecheck
5. hif_makeimlist (mfs)
6. hif_findcont
7. hif_uvcontfit
8. hif_uvcontsub
9. hif_makeimages (mfs)

9. Tclean/MakeImages

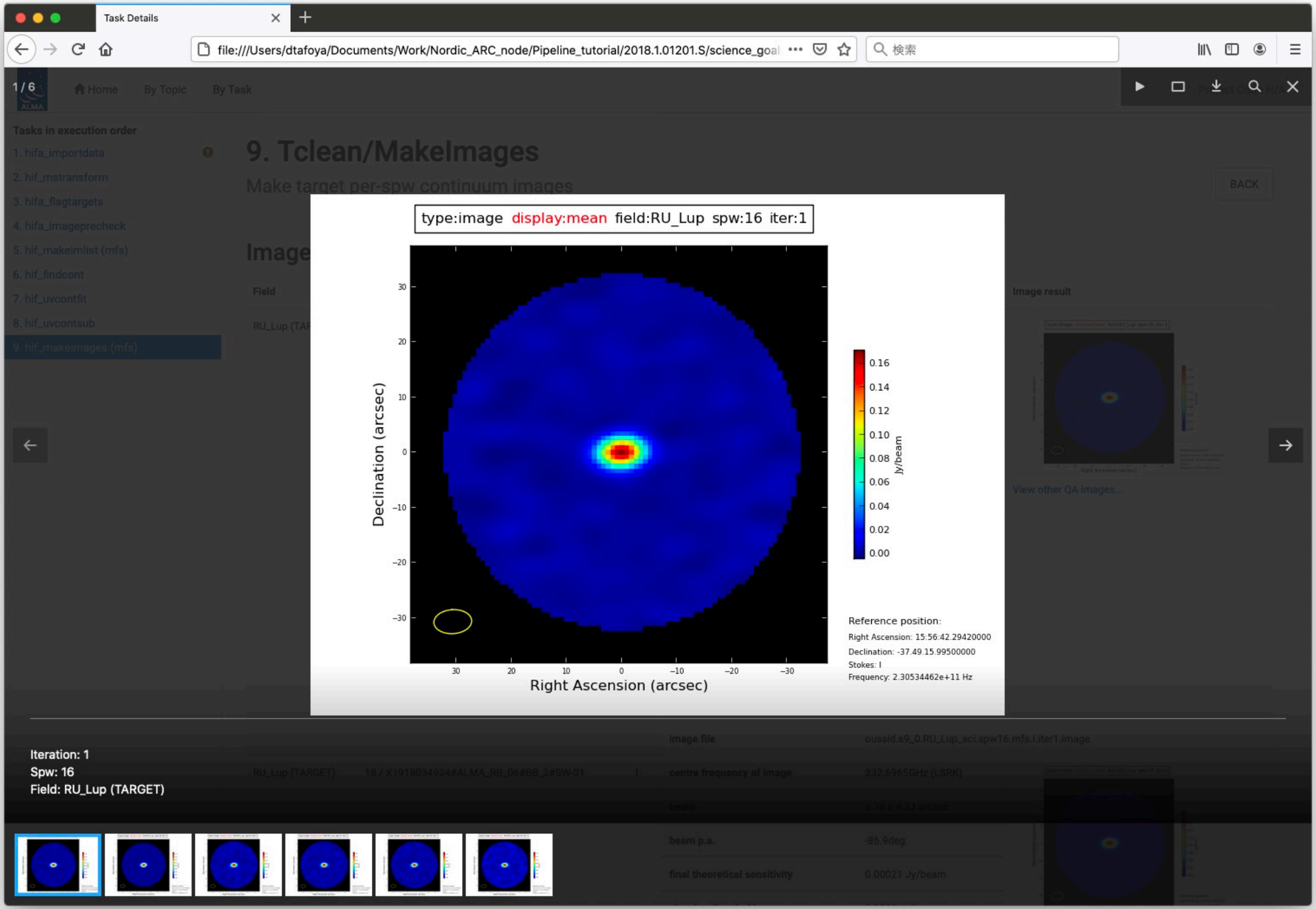
Make target per-spw continuum images

BACK

Image Details

Field	Spw	Pol	Image details		Image result
RU_Lup (TARGET)	16 / X1918034924#ALMA_RB_06#BB_1#SW-01	I	centre frequency of image	230.5345GHz (LSRK)	 View other QA images...
			beam	6.88 x 4.36 arcsec	
			beam p.a.	-86.4deg	
			final theoretical sensitivity	0.0011 Jy/beam	
			cleaning threshold	0.0078 Jy/beam Dirty DR: 1.5e+02 DR correction: 3.5	
			clean residual peak / scaled MAD	4.79	
			non-pbcor image RMS	0.0018 Jy/beam	
			pbcor image max / min	0.171 / -0.0135 Jy/beam	
			fractional bandwidth / nterms	0.054% / 1	
			aggregate bandwidth	0.0968 GHz (LSRK)	
			score	1.00	
			image file	oussid.s9_0.RU_Lup_sci.spw16.mfs.I.iter1.image	
RU_Lup (TARGET)	18 / X1918034924#ALMA_RB_06#BB_2#SW-01	I	centre frequency of image	232.6965GHz (LSRK)	
			beam	6.78 x 4.33 arcsec	
			beam p.a.	-86.9deg	
			final theoretical sensitivity	0.00021 Jy/beam	

In the weblog:



In the weblog:

Task Details

file:///Users/dtafoya/Documents/Work/Nordic_ARC_node/Pipeline_tutorial/2018.1.01201.S/science_goal

Home | By Topic | By Task | Project Code N/A

Tasks in execution order

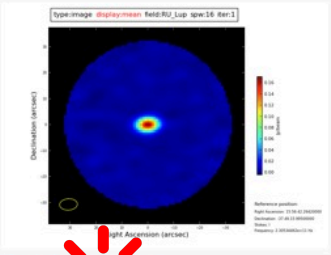
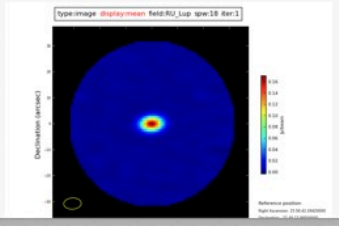
1. hifa_importdata
2. hif_mstransform
3. hifa_flagtargets
4. hifa_imageprecheck
5. hif_makeimlist (mfs)
6. hif_findcont
7. hif_uvcontfit
8. hif_uvcontsub
9. hif_makeimages (mfs)

9. Tclean/MakeImages

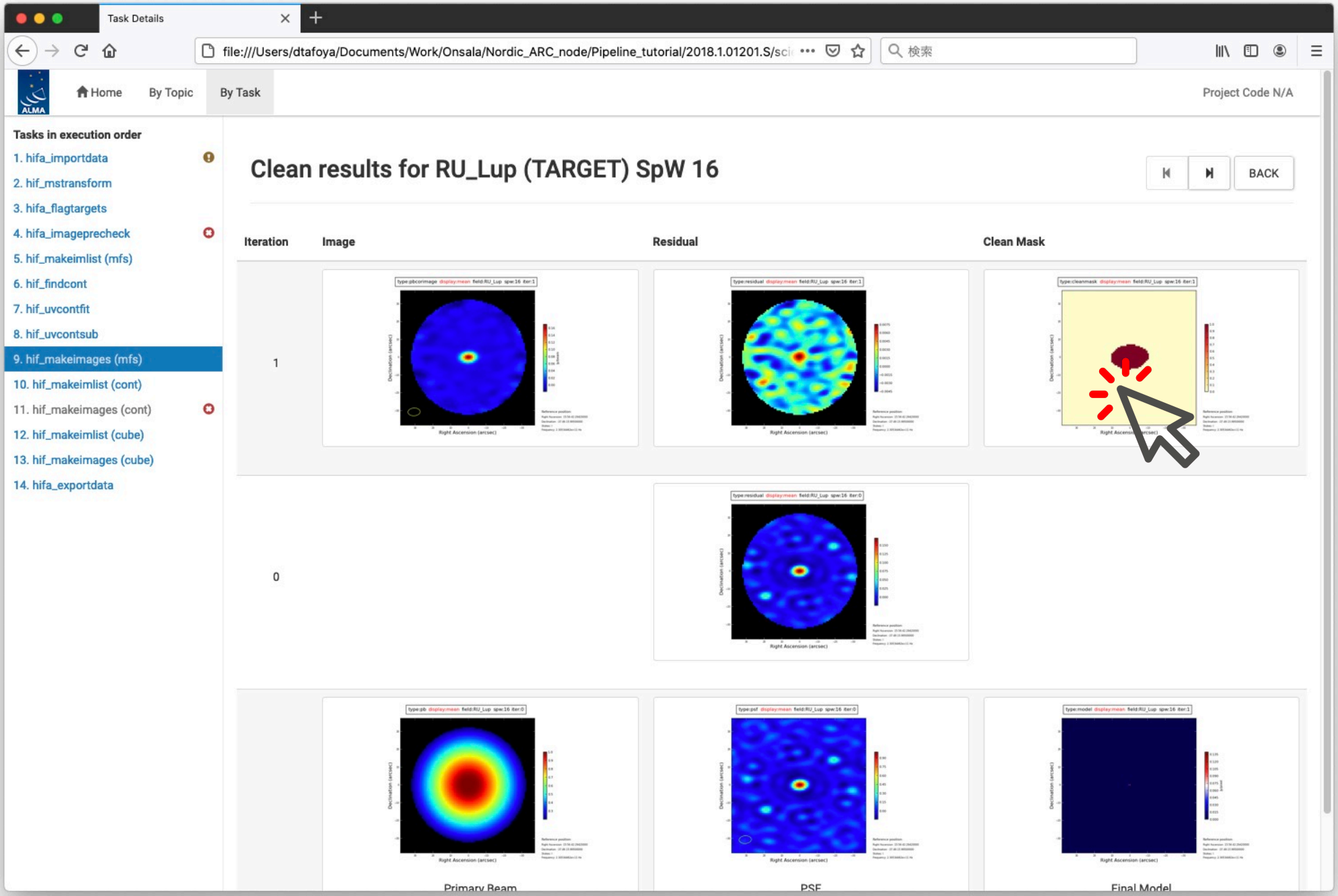
Make target per-spw continuum images

BACK

Image Details

Field	Spw	Pol	Image details		Image result
RU_Lup (TARGET)	16 / X1918034924#ALMA_RB_06#BB_1#SW-01	I	centre frequency of image	230.5345GHz (LSRK)	 View other QA images...
			beam	6.88 x 4.36 arcsec	
			beam p.a.	-86.4deg	
			final theoretical sensitivity	0.0011 Jy/beam	
			cleaning threshold	0.0078 Jy/beam Dirty DR: 1.5e+02 DR correction: 3.5	
			clean residual peak / scaled MAD	4.79	
			non-pbcor image RMS	0.0018 Jy/beam	
			pbcor image max / min	0.171 / -0.0135 Jy/beam	
			fractional bandwidth / nterms	0.054% / 1	
			aggregate bandwidth	0.0968 GHz (LSRK)	
			score	1.00	
			image file	oussid.s9_0.RU_Lup_sci.spw16.mfs.I.iter1.image	
RU_Lup (TARGET)	18 / X1918034924#ALMA_RB_06#BB_2#SW-01	I	centre frequency of image	232.6965GHz (LSRK)	
			beam	6.78 x 4.33 arcsec	
			beam p.a.	-86.9deg	
			final theoretical sensitivity	0.00021 Jy/beam	

In the weblog: The cleaning masks (auto masking)

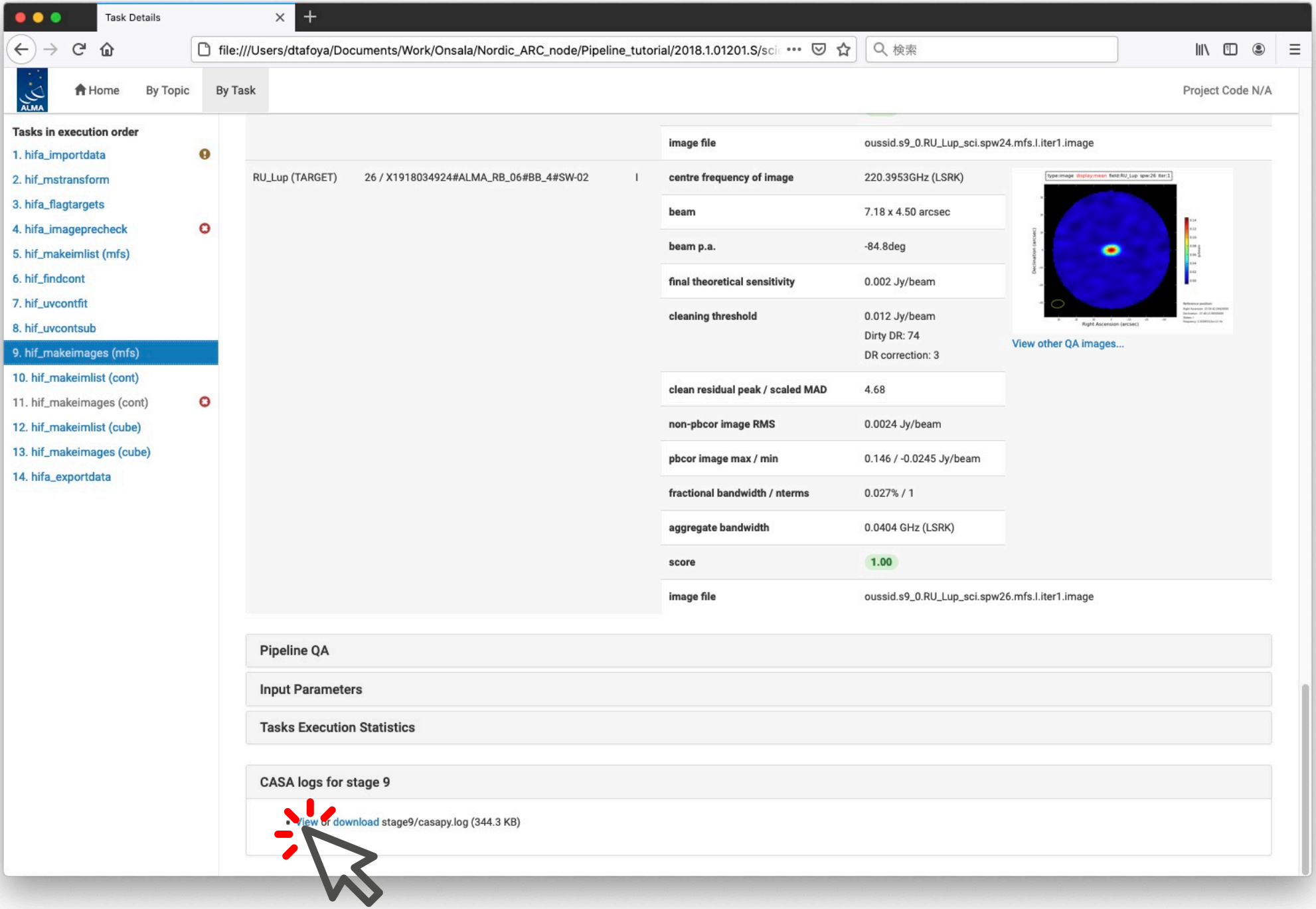


The parameters of automasking

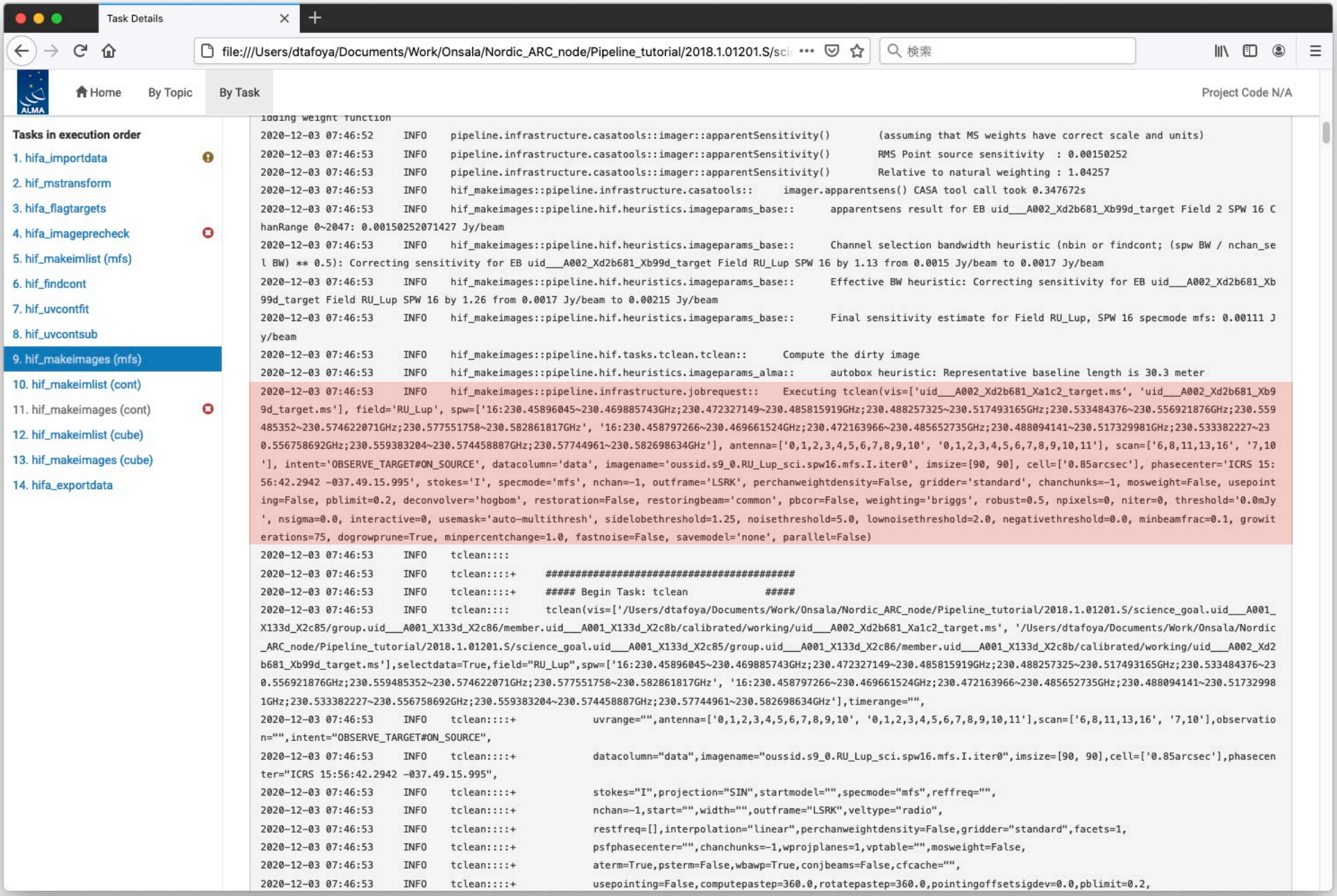
The values presented in this table are the standard values that the pipeline uses when it performs automasking and have been extensively tested.

Array	*sidelobethreshold*	*noisethreshold*	*minbeamfrac*	*lownoisethreshold*	*negativethreshold*
12m (short) b75<300m	**2.0**	**4.25**	**0.3**	**1.5**	**0.0 (continuum)** **15.0 (line)**
12m (long) b75>300m	**3.0**	**5.0**	**0.3**	**1.5**	**0.0 (continuum)** **7.0 (line)**
7m (continnum/line)	**1.25**	**5.0**	**0.1**	**2.0**	**0.0**
12m + 7m combined **TENTATIVE**	**2.0**	**4.25**	**0.3**	**1.5**	**0.0**

check the CASA log to see the parameters used by the pipeline:



scroll down to find the parameters used for `tclean`:



move on to continuum images:

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <16>: hif_makeimlist(specmode='cont')
```

- continuum using the channels found by `hif_findcont`.
- previous images are not deleted, each image is named representative of the stage number.

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```
CASA <17>: hif_makeimages(pipelinemode="automatic")
```

now the spectral cubes:

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```
CASA <18>: hif_makeimlist(specmode='cube')
```

- will image the spectral cubes for all the spws, but imaging can be controlled by defining input parameters (see next slides).

dtafoya — -zsh — 143×53

```
CASA <19>: hif_makeimages(pipelinemode="automatic")
```

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

Change the imaging parameters:

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```
CASA <20>: hif_makeimlist(specmode='mfs',robust=-0.5,spw='24',hm_imsize=60)
```

- only image spw 24 with robust parameter set to -0.5 and image size = 60pixels.

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```
CASA <21>: hif_makeimages(pipelinemode="automatic")
```

Change the imaging parameters:

dtafoya — -zsh — 143×53

```
CASA <22>: hif_makeimlist(specmode='cube',spw='24',nchan=200,start='219.553GHz')
```

- makes a cube of 200 channels of the spw 24, starting ar freq=219.553GHz.

dtafoya — -zsh — 143×53

```
CASA <23>: hif_makeimages(pipelinemode="automatic")
```

Use `help(hif_makeimlist)` to see more options:

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```
CASA <24>: help(hif_makeimlist)

 Help on instance of hif_makeimlist_cli_ in module hif_makeimlist_cli:

 hif_makeimlist = class hif_makeimlist_cli_
  |  Methods defined here:
  |
  |  __call__(self, vis=None, imagename=None, intent=None, field=None,
 spw=None, contfile=None, linesfile=None, uvrange=None, specmode=None,
 outframe=None, hm_imsize=None, hm_cell=None, calmaxpix=None,
 phasecenter=None, nchan=None, start=None, width=None, nbins=None,
 robust=None, uvtaper=None, clearlist=None, per_eb=None, calcsb=None,
 parallel=None, pipelinemode=None, dryrun=None, acceptresults=None)
  |      Compute list of clean images to be produced
  |
  |              Detailed Description:
  |
  |      Create a a list of images to be cleaned.
  |
  |              Arguments :
  |                      vis: List of input MeasurementSets
  |                         Default Value:
```

Finally, export new images to fits format, if desired:

```
 1 hifa_importdata
 2 hif_mstransform
 3 hifa_flagtargets
 4 hifa_imageprecheck
 5 hif_makeimlist
 6 hif_findcont
 7 hif_uvcontfit
 8 hif_uvcontsub
 9 hif_makeimages
10 hif_makeimlist
11 hif_makeimages
12 hif_makeimlist
13 hif_makeimages
14 hifa_exportdata
```

dtafoya — -zsh — 143×53

```
CASA <25>: hifa_exportdata(imaging_products_only=True)
```

- Export the images to fits files.

A few final notes

- Once the continuum subtraction stages are done, its basically `hif_makeimlist` and `hif_makeimages` loops
- You should always have the weblog open to view in real-time
- If you made a mistake, don't worry, the stage just will fail and report an error but you can still continue
- If you want to change an image parameter before running `hif_makeimages`, run `hif_makeimlist` again, check the weblog to make sure of the parameters
- In imaging cubes, do each SPW separately, so you have full fine-tuning available
- Do `h_save()` regularly, if your CASA crashes the weblog and pipeline context are not saved correctly - you must restart
- For more examples, visit the ALMA Imaging Pipeline Reprocessing webpage:

  https://casaguides.nrao.edu/index.php/ALMA_Imaging_Pipeline_Reprocessing

End of tutorial