

Calibration in CASA



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ALMA Data workshop

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Atacama Large Millimeter/submillimeter Array

Expanded Very Large Array

Robert C. Byrd Green Bank Telescope

Very Long Baseline Array



Outline

- **The Flow of Calibration**
- Key CASA tasks for data reduction/calibration
- Flagging

Measurement Set

- CASA stores u-v data in directories called “Measurement Sets”
TO DELETE THEM USE `rmtables(“my_data.ms”)`
- These data sets store two copies of the data (called “columns”):

<p>“Data” Column</p> <p>Contains the raw, unprocessed measurements.</p>	<p>“Corrected” Column</p> <p>Usually created by applying one or more calibration terms to the data.</p>
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- Additionally a “model” may be stored separately.
THIS IS USED TO CALCULATE WHAT THE TELESCOPE SHOULD HAVE OBSERVED.
- Each data point may also be “flagged,” i.e., marked bad.
IN THIS CASE IT IS IGNORED (TREATED AS MISSING) BY CASA OPERATIONS.

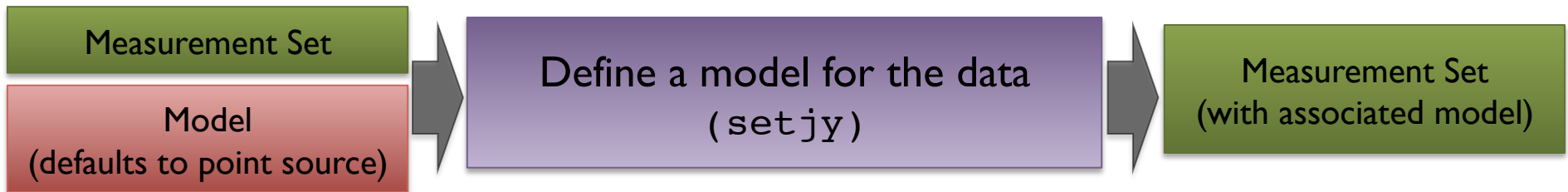
Calibration Tables

- Calibration yields estimates of phase and amplitude corrections.
E.G., AS A FUNCTION OF TELESCOPE, TIME, FREQUENCY, POLARIZATION.
- CASA stores these corrections in directories called “calibration tables.”
TO DELETE THEM USE `rmtables("my_data.ms")`
- These are created by calibration tasks:
E.G., `gaincal`, `bandpass`, `gencal`
- Applied via “`applycal`” to the data column and saved as corrected.



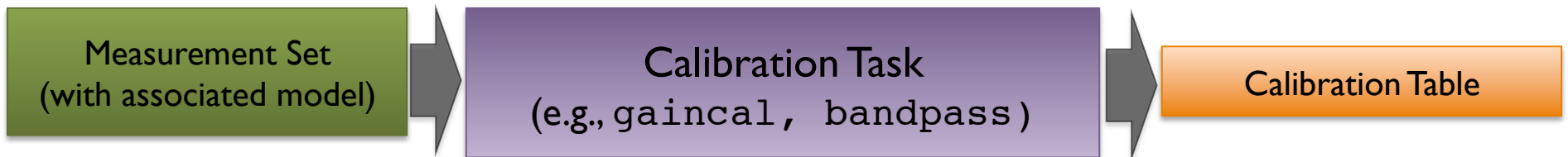
Basic Calibration Flow

Define what the telescope SHOULD have seen.



Basic Calibration Flow

Derive the corrections needed to make the data match the model.



Basic Calibration Flow

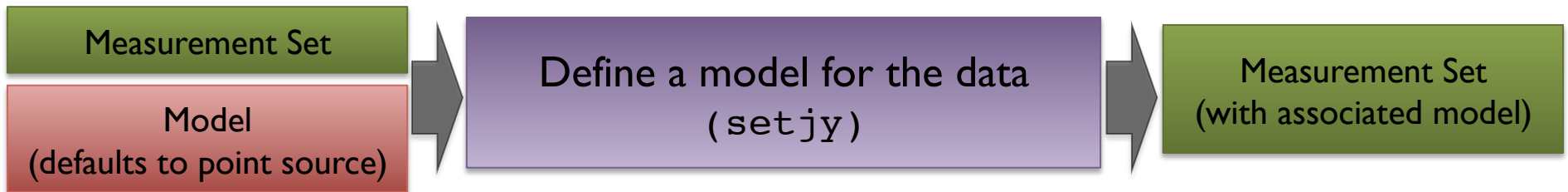


Apply these corrections to derive the corrected (calibrated) data.

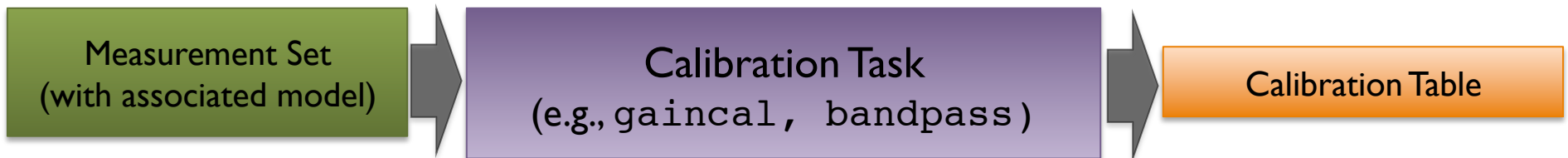


Basic Calibration Flow

Define what the telescope SHOULD have seen.



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Possible Flagging and Calibration Recipe

- (Apply online calibrations for water vapor and Tsys)
 - EXAMINE bandpass/flux calibrator(s)
 - FLAG bandpass/flux calibrators
 - APPLY bandpass/flux calibration to itself
 - APPLY bandpass/flux cal to gain cal sources
 - EXAMINE gain calibration sources
 - FLAG gain calibration sources
 - APPLY gain calibration to itself
 - APPLY bandpass/flux/gain cal to targets
 - EXAMINE targets
 - FLAG targets
- Iterate*
- Iterate*
- Repeat as necessary*



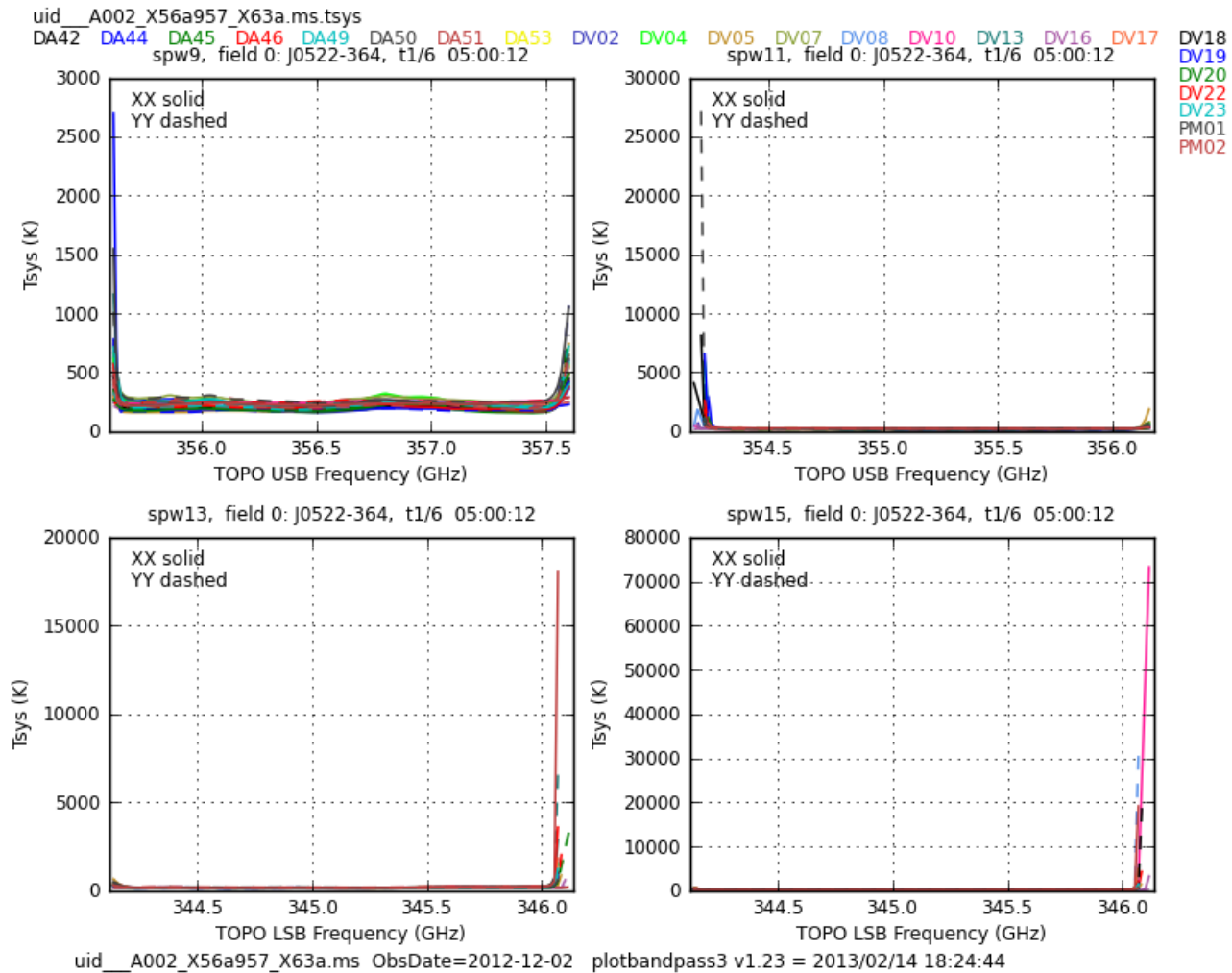
ALMA Online Calibration

- **System Temperature (T_{sys})** – atmospheric emission/opacity
 - Key to gain transfer across elevation
 - Amplitude calibration, variable with frequency (observed in “TDM”)
 - System temperatures of order ~ 100 K at Band 3 to ~ 1000 K at Band 9
- **Water Vapor Radiometer (WVR)** – phase delay due to atmosphere
 - Key to correct short-timescale phase variations
 - Phase calibration, variable with time

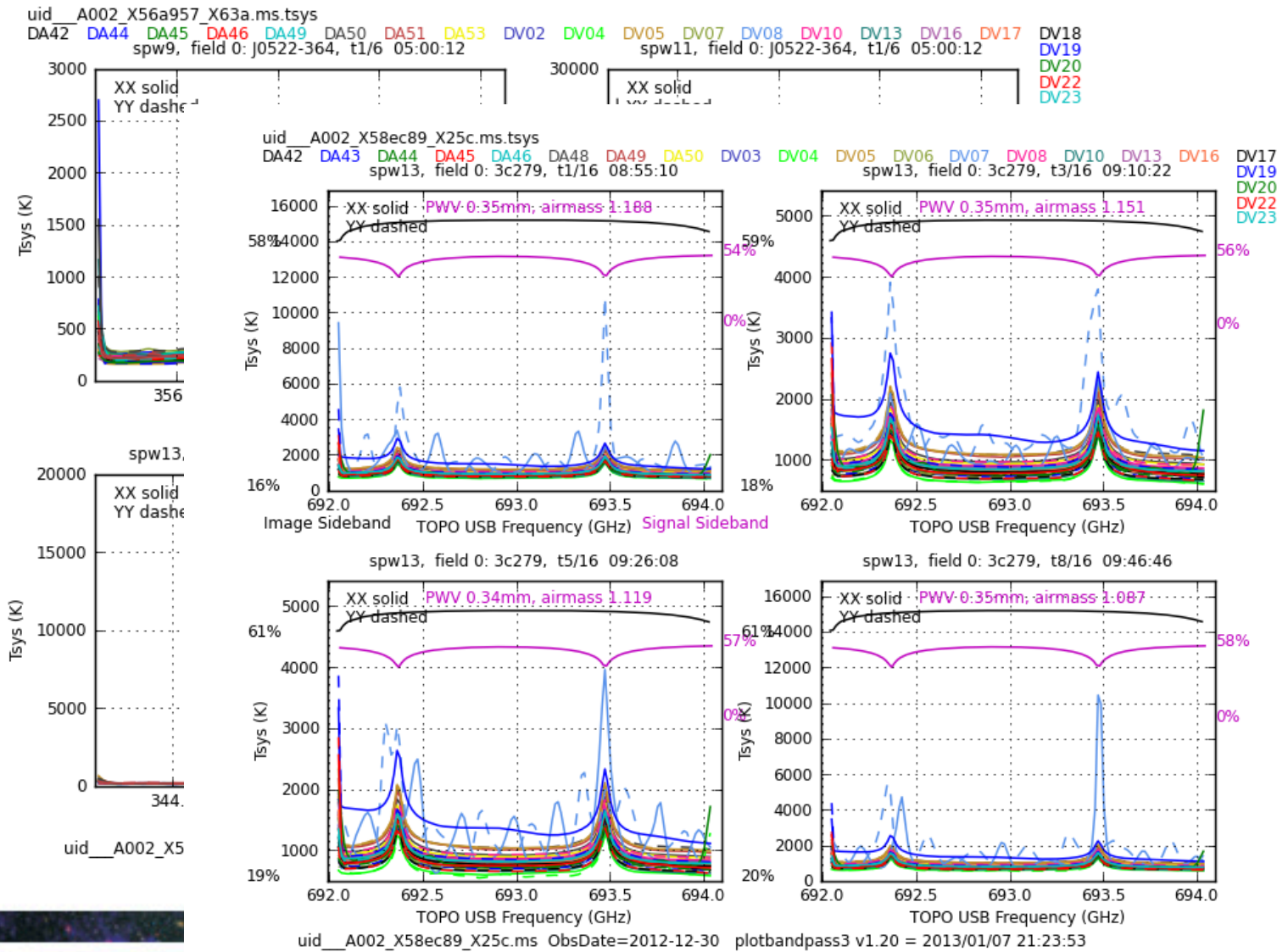
These are provided by the observatory (eventually applied online).

- Apply them as first step (or start with provided pre-applied versions)
- In either case, inspect these tables to learn about data quality
- *Hands-on data sets already have these corrections applied*

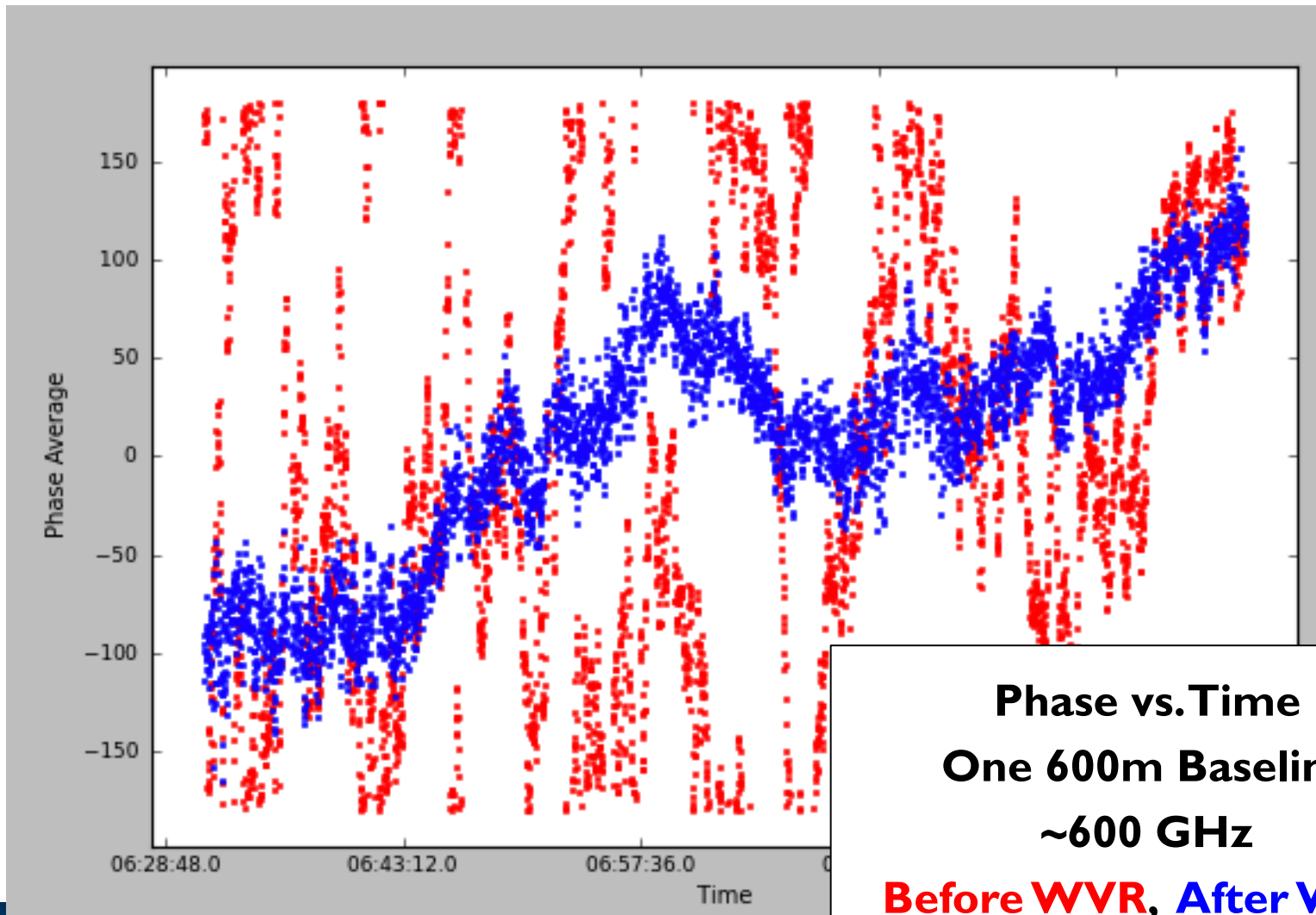
ALMA Online Calibration



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Key Tasks for Calibration

Derive Calibration Tables

- `setjy`: set “model” (correct) visibilities using known model for a calibrator
- `bandpass`: calculate bandpass calibration table (amp/phase vs frequency)
- `gaincal`: calculate temporal gain calibration table (amp/phase vs time)
- `fluxscale`: apply absolute flux scaling to calibration table from known source

Manipulate Your Measurement Set

- `flagdata/flagcmd/flagmanager`: flag (remove) bad data
- `applycal`: apply calibration table(s) from previous steps
- `split`: split off calibrated data from your ms

Inspect Your Data and Results

- `plotms`: inspect your data interactively
- `plotcal`: examine a calibration table

Schematic Calibration

Calibrate the Amplitude and Phase vs. Frequency of Each Antenna
ASSUME TIME & FREQUENCY RESPONSE SEPARABLE, REMOVE TIME VARIABILITY



Calibrate the Amplitude and Phase vs. Time of Each Antenna
ASSUME TIME & FREQUENCY RESPONSE SEPARABLE, REMOVE FREQ. VARIABILITY

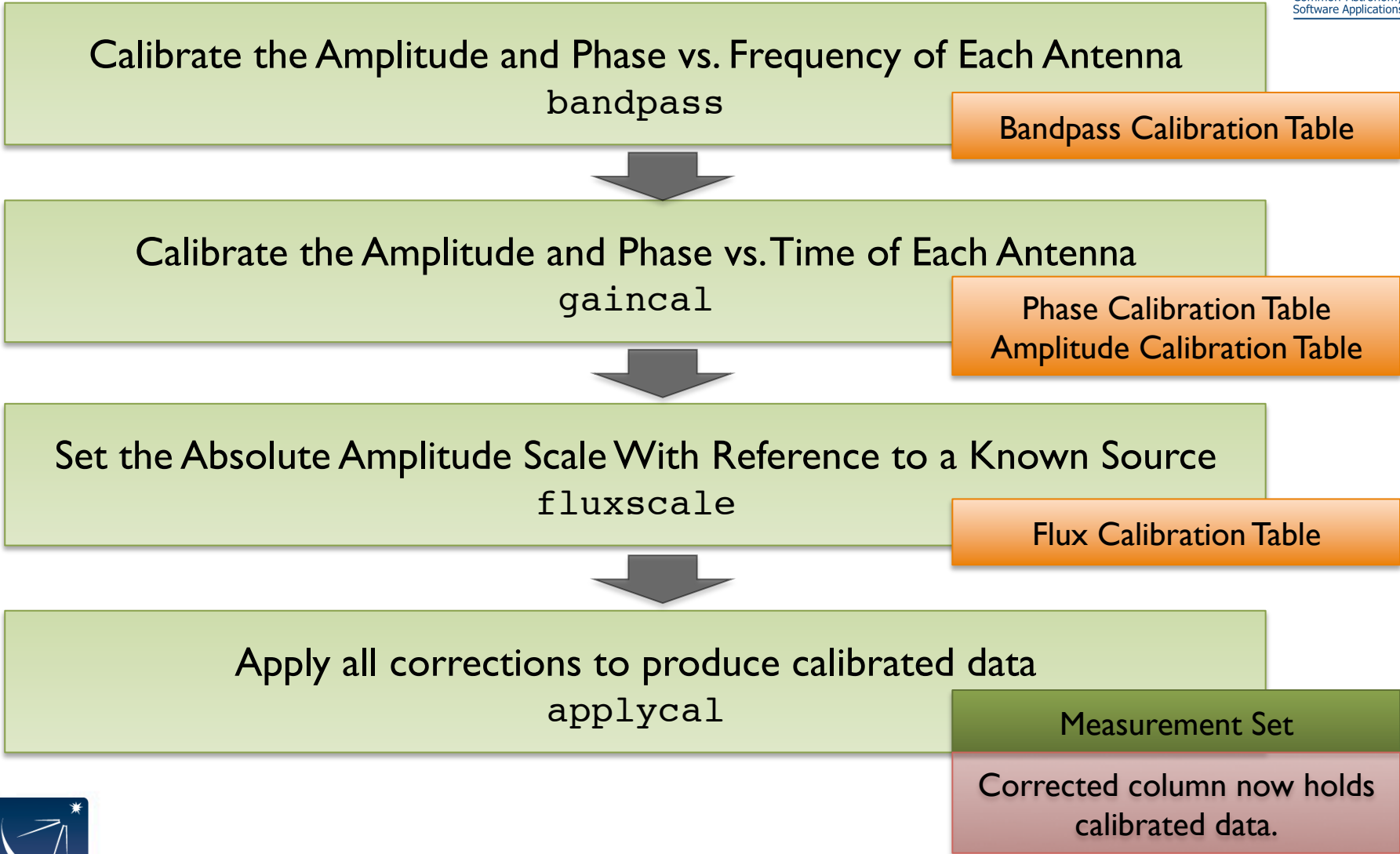


Set the Absolute Amplitude Scale With Reference to a Known Source
PLANET (MODELED), MONITORED QUASAR, ETC.



Apply all corrections to produce calibrated data

Schematic Calibration



Outline

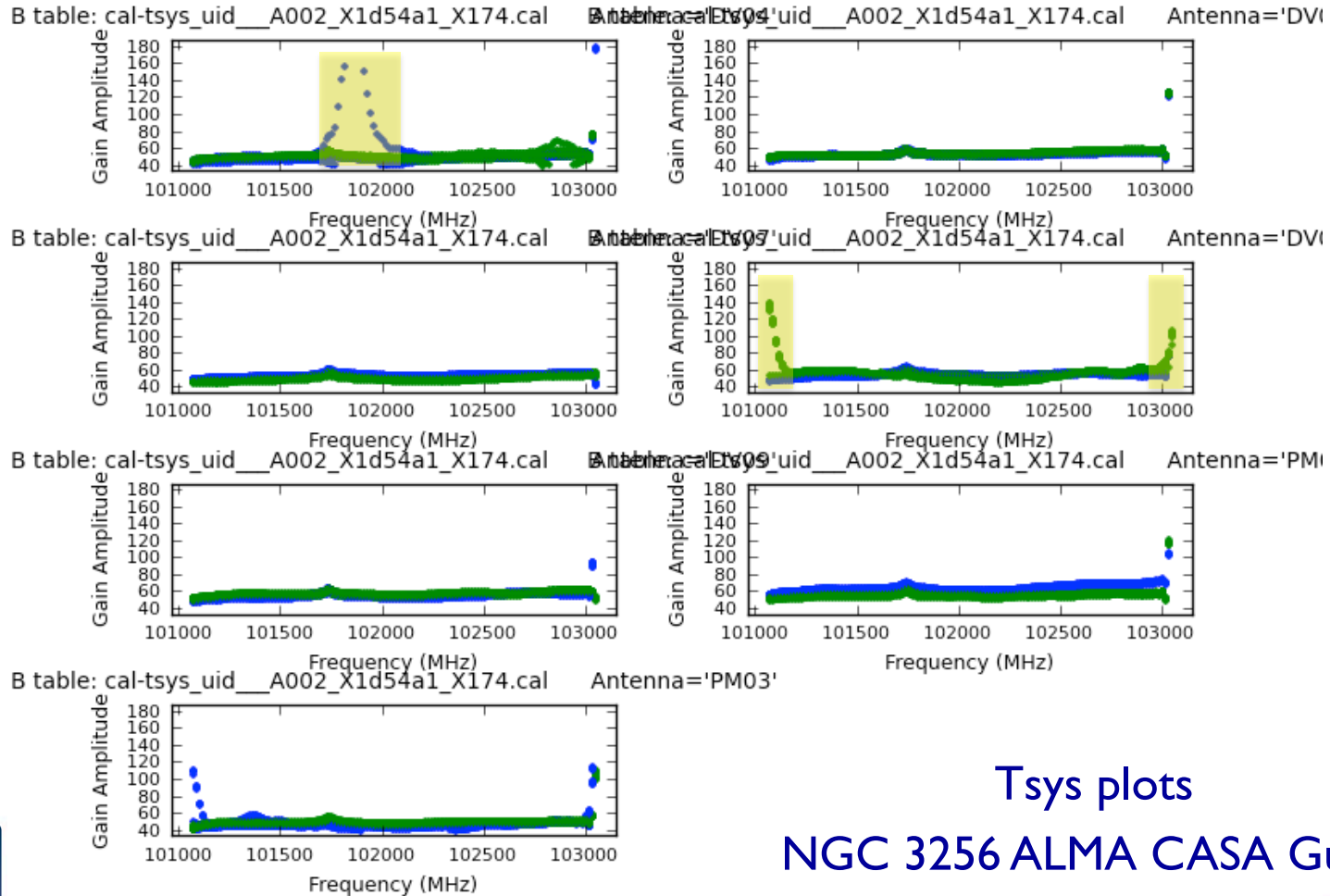
- The Flow of Calibration
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- **Flagging**

Flagging: Initial Flagging

- Shadowing
 - Issue at low elevations
 - Issue for compact arrays
 - In CASA: *flagdata(vis='my_data.ms', mode='shadow')*
- Observing Log
 - Many observatories will note weather or hardware problems that affect the data.
- Other obvious errors



Flagging: Initial Flagging



Flagging: What to Look For

- Plots of amplitude and phase vs. time and frequency
- Iterate over
 - Antenna
 - Spectral window
 - Source
- Make plots of calibrators first
 - Easier to find problems in observations of bright point source
 - Harder to find problems in observations of a faint and extended source



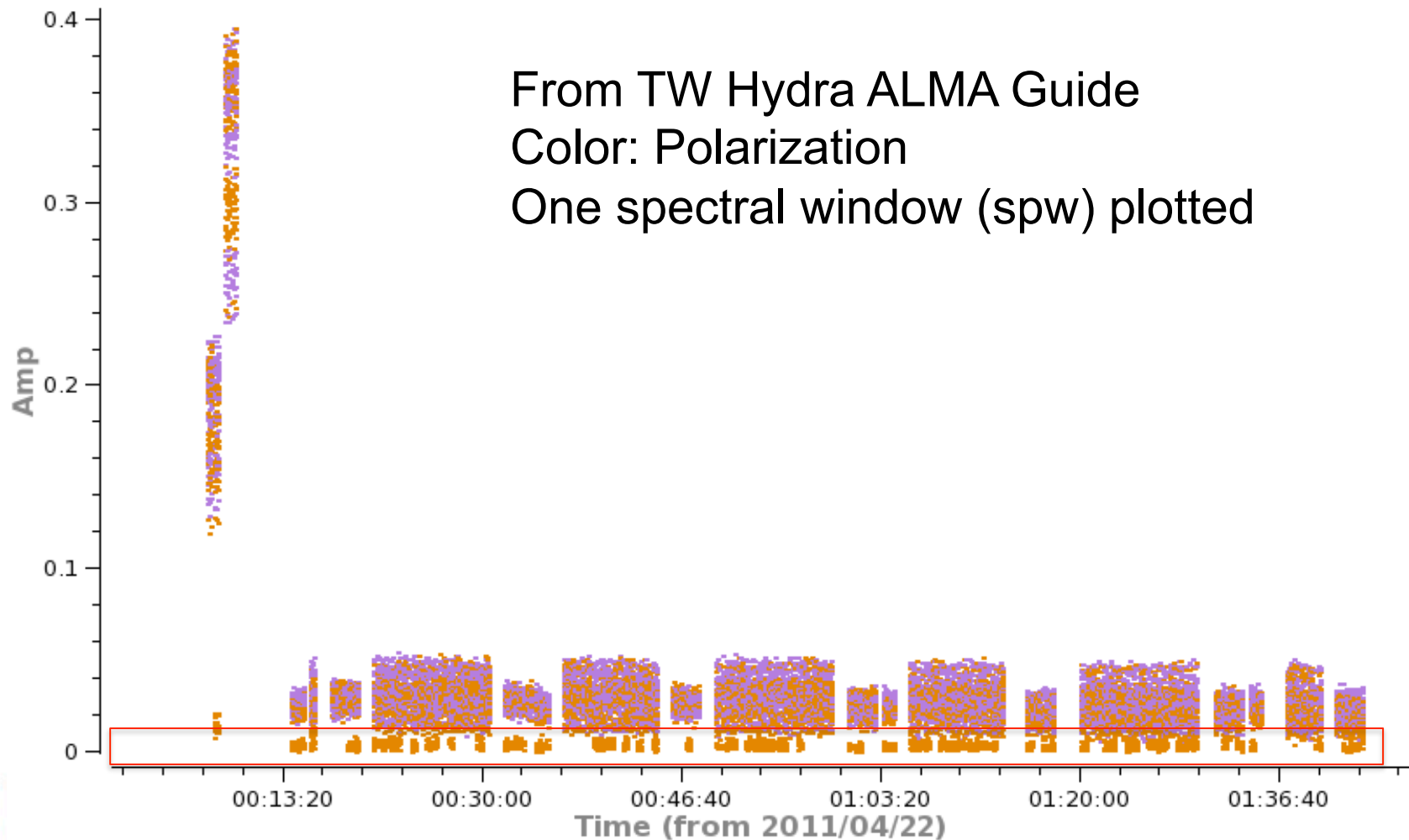
Flagging: What to Look For

- Smoothly varying phases and amplitudes can be calibrated
- Discontinuities can not be calibrated
- Features in the calibrators that may not be in the target data can cause problems



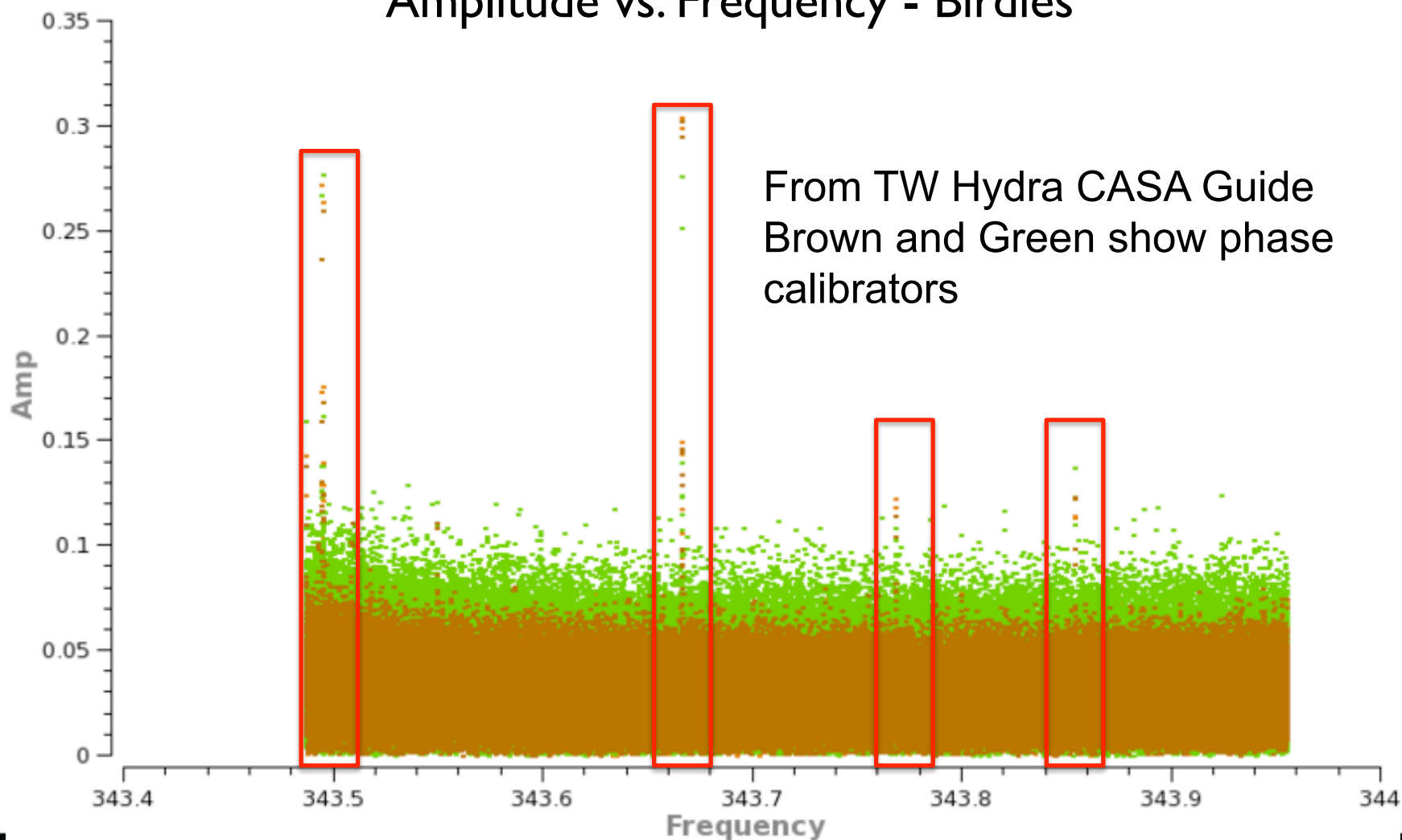
Flagging: What to Look For

Amp vs. Time



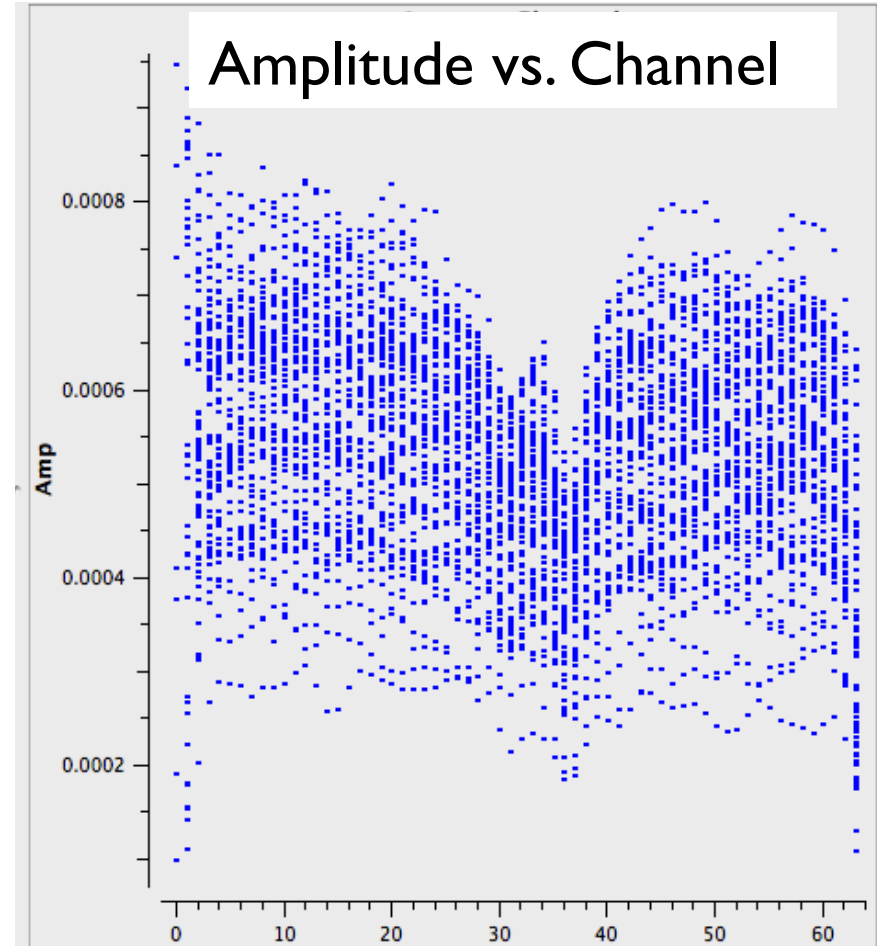
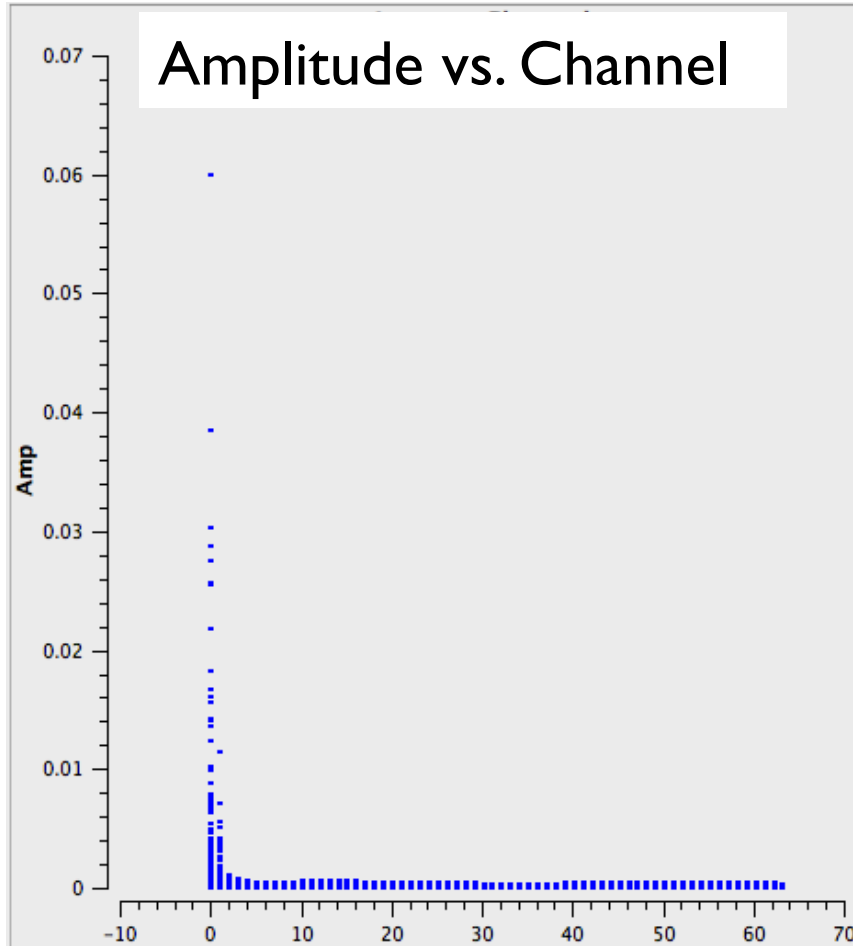
Flagging: What to Look For

Amplitude vs. Frequency - Birdies

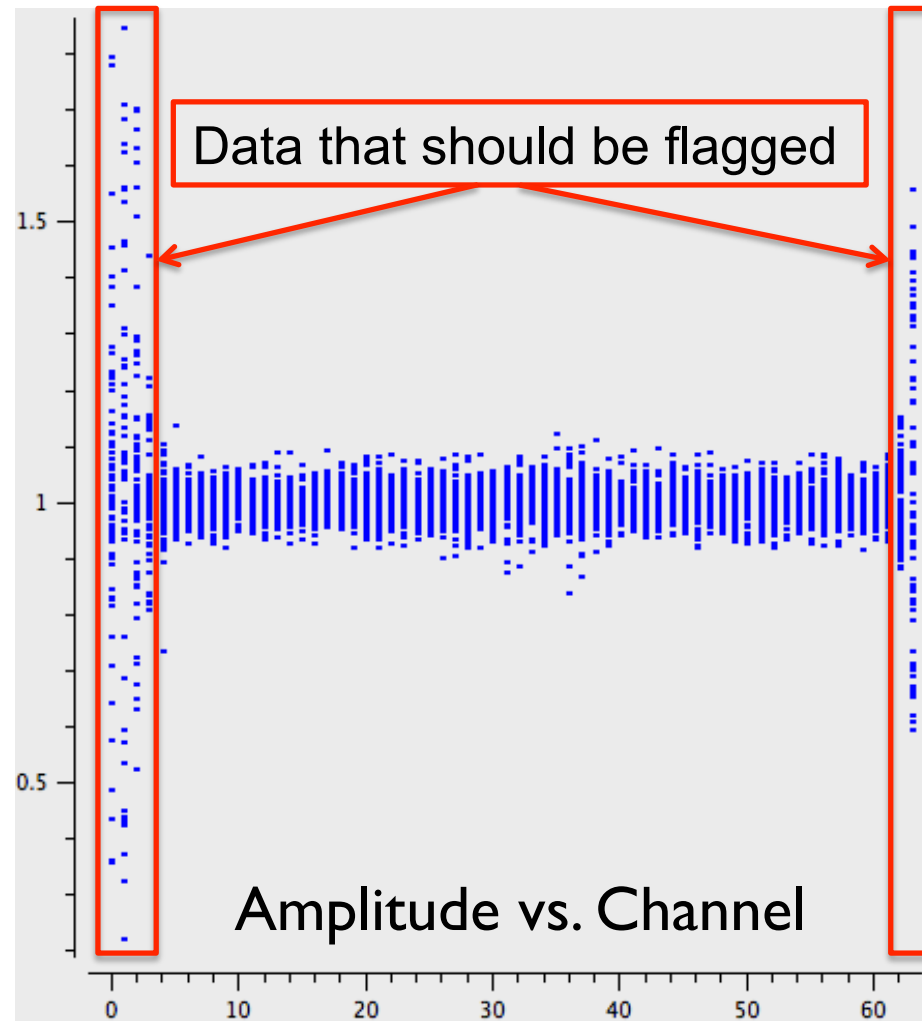


Flagging: What to Look For

Edge Channels

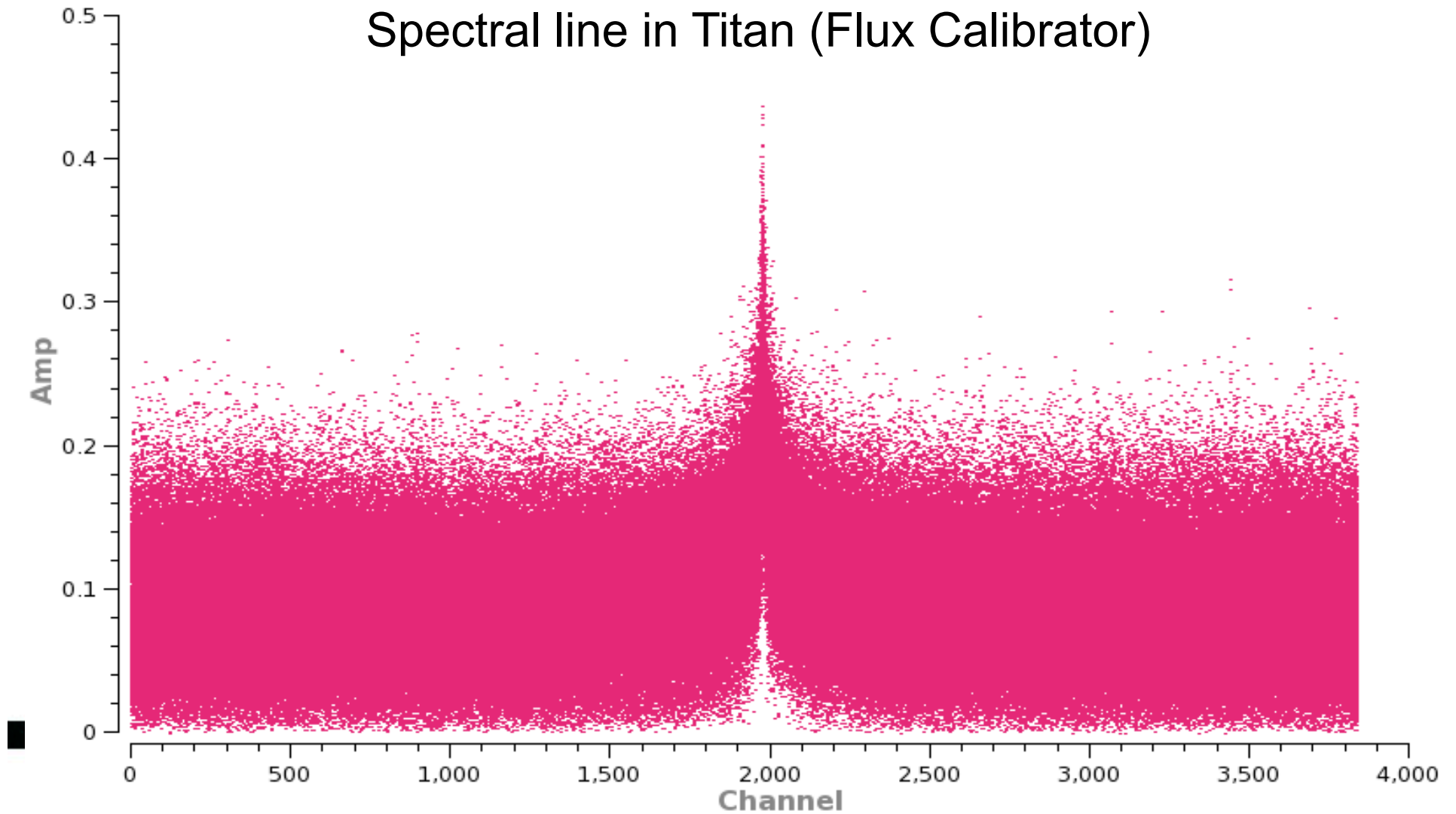


Flagging: What to Look For



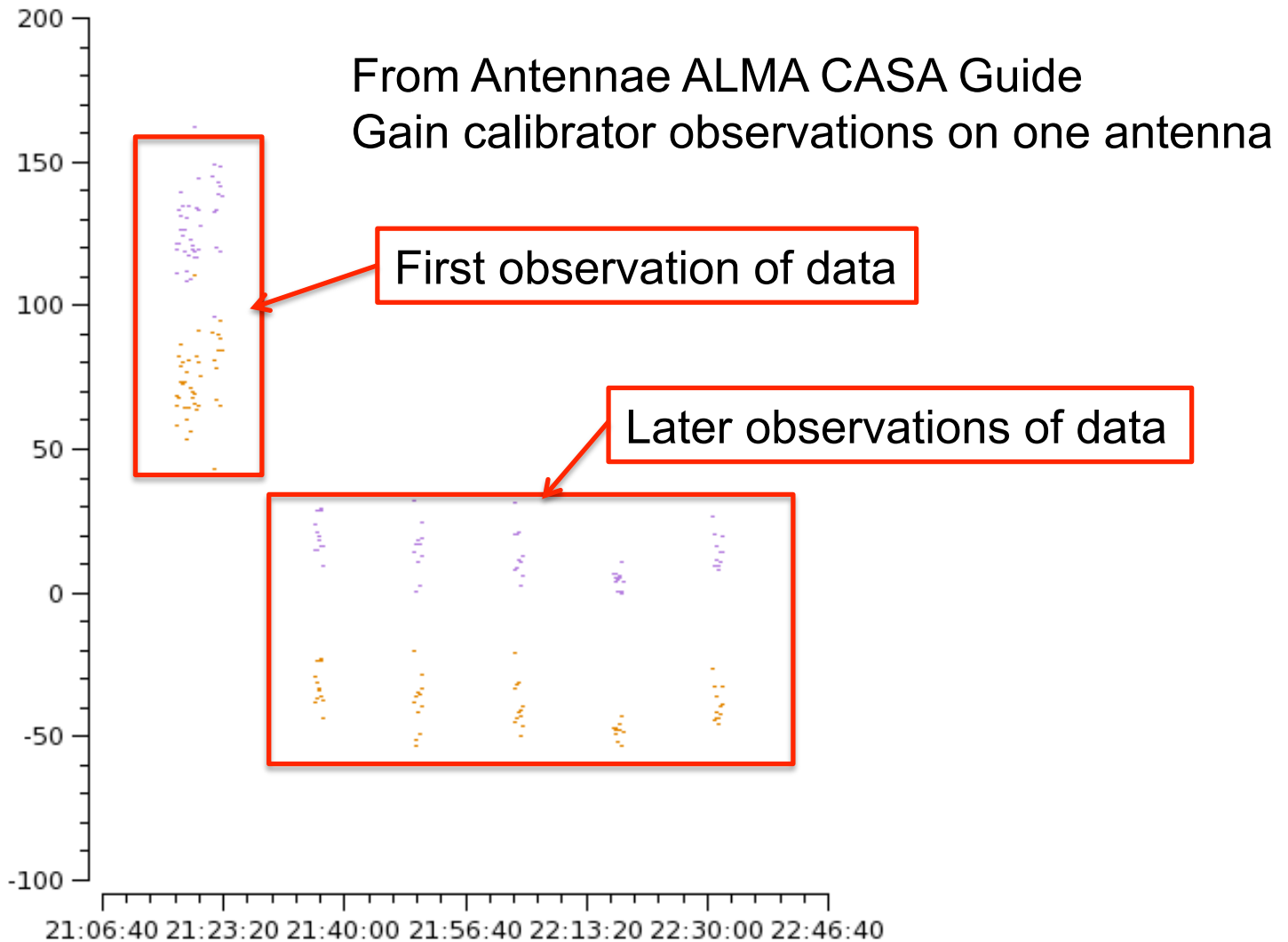
Flagging: What to Look For

From TW Hydra Band 7 Guide
Spectral line in Titan (Flux Calibrator)



Flagging: What to Look For

Phase vs. Time on Gain Calibrator



Sage Advice

From Rick Perley to a young Scott Schnee:
“When in doubt, throw it out.”