Small Hydrogen Line Radio Telescope Background Drift/Shift

Potential Small Radio Telescope Background Drift/Shift Sources

Ground Noise Spillover
Outside Temperature Variation
Sky Transparency Changes
Sun Blackbody Radiation in Antenna Beam Pattern
Sun reflection off roofs / buildings / trees
Radio Frequency Interference (LAN Blocking)
RF Connection Thermal Expansion Ohmic Changes
Thermal LNA Gain Changes
Thermal SDR Filter Shape Changes
Sunlight Refraction off Clouds

Small Hydrogen Line Drift/Shift Correction Techniques

1) Dicke-Switch to Temp Reference Load
2) Frequency Band Shift to Non H Line
3) In-Band Cold Sky Normalization

Small Hydrogen Line Radio Telescope Background Drift/Shift Correction Techniques

1) Dicke-Switch Temp Ref / Frequency Band Shift / In-Band Cold Sky Normalization

(an optical imaging analogy of the 3 techniques)

The **Dicke-Switch** Technique works by switching the input of the radio-telescope LNA between the Antenna and a Temperature Reference Load. Gain variations can have their effects corrected by measuring the difference in signals between the Antenna Signal and the Noise Level of the Temperature Reference Resistor. The Gain Correction Process should be implemented by **Division.** *It requires added components in front of the LNA (coax switch or internal switch) which degrades the system noise figure .* ***Only Gain Variations can be detected / corrected by this technique.***

1) LNA input via a **Dicke-Switch** alternately switches between the antenna and a Resistive Load = Optical Dark Frame equivalent

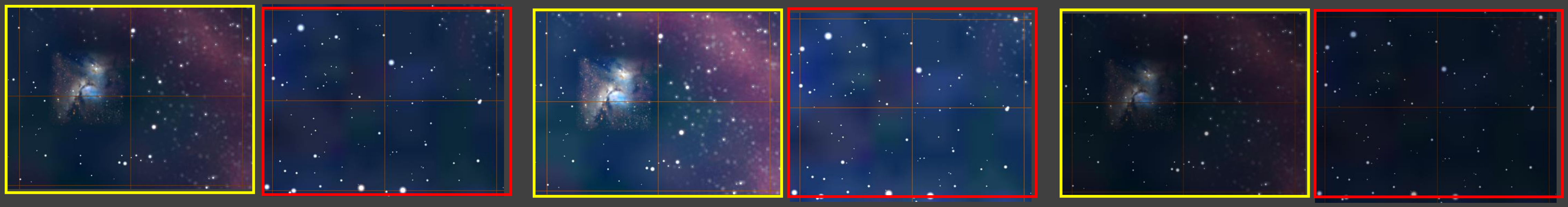
Small Hydrogen Line Radio Telescope Background Drift/Shift Correction Techniques

2) Dicke-Switch Temp Ref / Frequency Band Shift / In-Band Cold Sky Normalization
(an optical imaging analogy of the 3 techniques)

1423 MHz Frequency Band-Switching probably dates from the Spectra-Cyber Era when stepped frequency analysis was the norm such that a 256 point freq spectrum might have required 256 seconds, but it had poor S/N as each frequency was measured for only one Second. As a sample at 1423 MHz 'would be beyond the H Line ' another one second made little difference to the total acquisition time. However, when used with an SDR, this consumes 50% of the acquisition time. Since the variations are primarily background noise level shifts, the process should be implemented by **Subtraction** . ***This technique will allow correction for All Variations in Background Shift (drift)***

2) Optical Image Shifting away from primary target equates to the **Frequency Band-Switching** technique

Data Drift Data Drift Data Drift



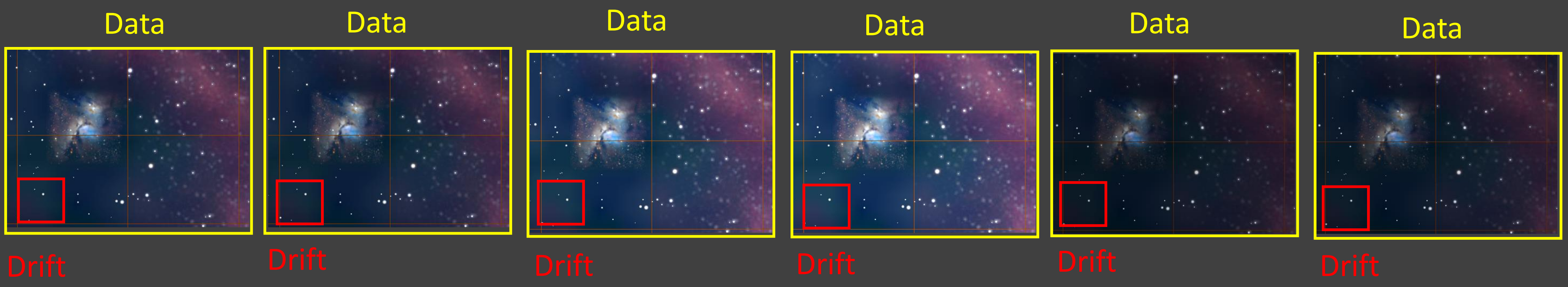
Small Hydrogen Line Radio Telescope Background Drift/Shift Correction Techniques

3) Dicke-Switch Temp Ref / Frequency Band Shift / In-Band Cold Sky Normalization

(an optical imaging analogy of the 3 techniques)

In-Band Cold Sky Normalization can be obtained by selecting a small spectral region Not influenced by Hydrogen emission spectra. That value can be obtained from within normal Non Frequency Shifted spectral data samples. It consumes no additional acquisition time. Since the variations are primarily background noise level shifts, the process should be implemented by **Subtraction** . This would typically be a Post-Acquisition Process in order that the lowest noise frame be determined and used for data set normalization.
This technique will allow correction for All Variations in Background Shift (drift).

3) A Portion of the **In-Band H Line Spectrum** not influenced by the H Line Data can be used to correct each Data Frame

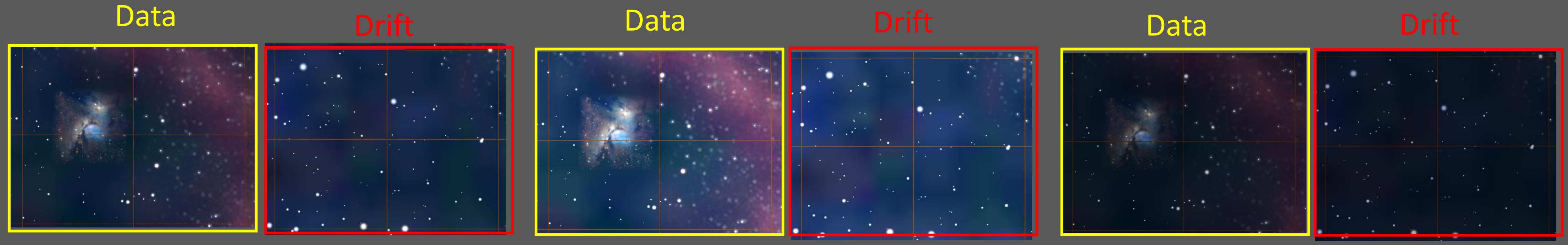


Dicke Temp Ref Switch / Frequency Band Shift / In-Band Cold_Sky_Normalization for Data Drift Correction

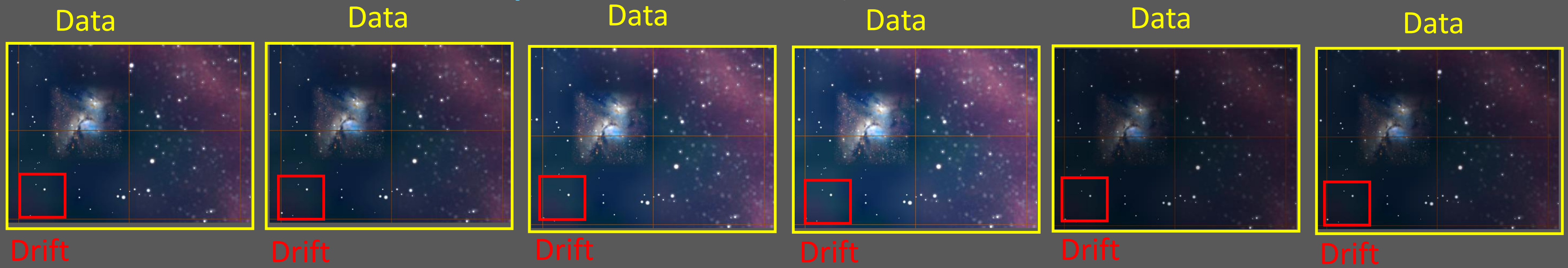
(an optical imaging analogy of the 3 techniques)

1) LNA input via a **Dicke-Switch** alternately switches between the antenna and a Resistive Load = Optical Dark Frame equivalent

2) Optical Image Shifting equates to the **1423 MHz Frequency Band-Switching** technique



3) A Portion of the **In-Band H Line Spectrum** not influenced by the H Line Data can be used to correct each Data Frame



Post Test In-Band Cold Sky Normalization Process

1) Scan through the data set at the pre-specified Low freq or % of range and find the lowest in the spectrum set using an average of a range +- 10 freqs around the specified freq (%) (using Power values)

2) Find the delta between that and each spectra and subtract that from the entire range ..
Don't make it = 0 as that deletes the 10K sky and is not valid

3) Convert to dB referenced to the selected low freq CSN value

4) Find the differential dB at the high CNN value mx+b range from '0 dB' for each file , and create a linear slope of values from the Low to High cold sky normalization (CSN) values and correct each spectrum

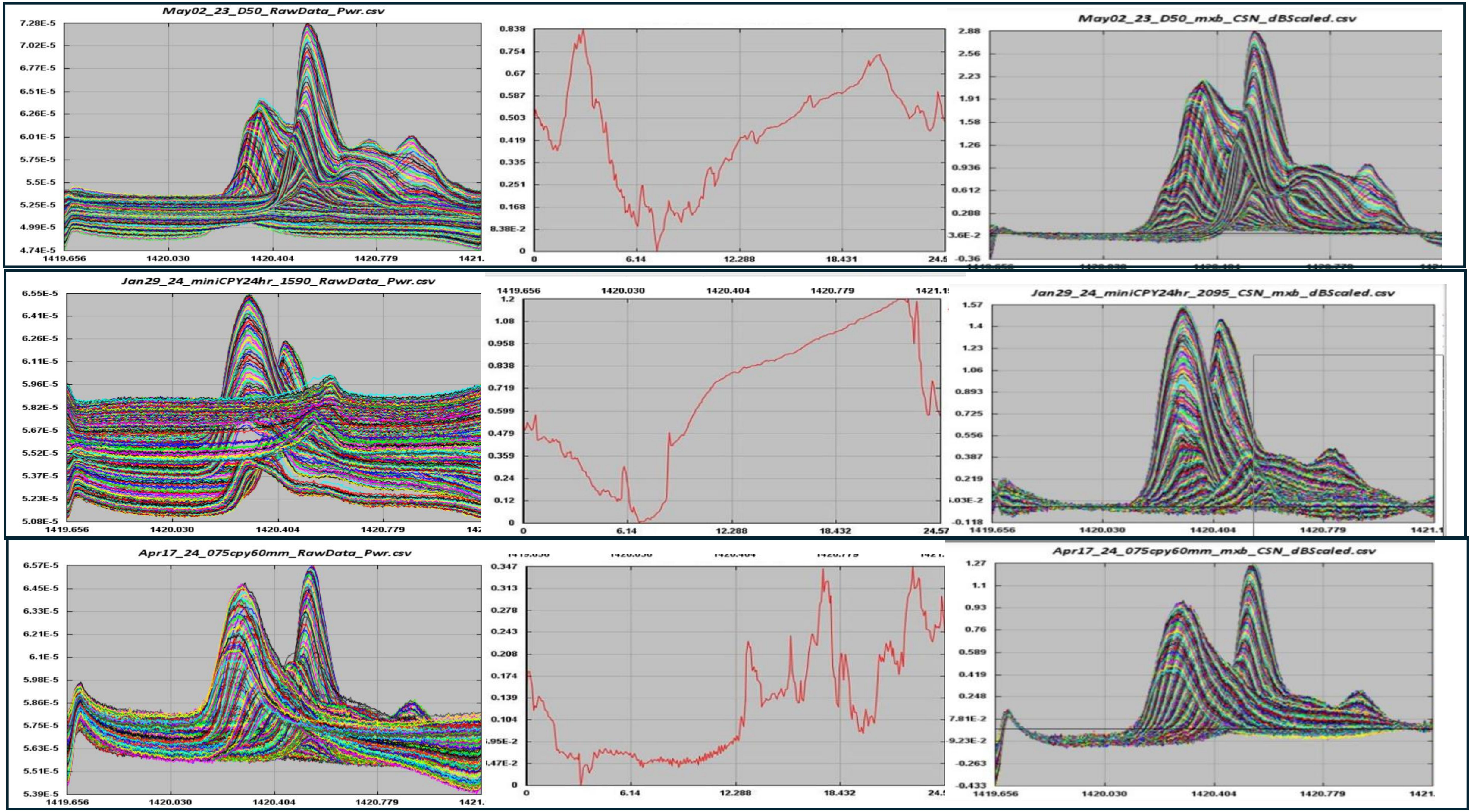
an overview https://github.com/AP-HLine-3D/HLine3D/blob/main/21cm_Step3A_HL3D_Processing_mx%2Bb_Rev013.pdf

Pre-Test Background Correction Reference Spectrum Technique

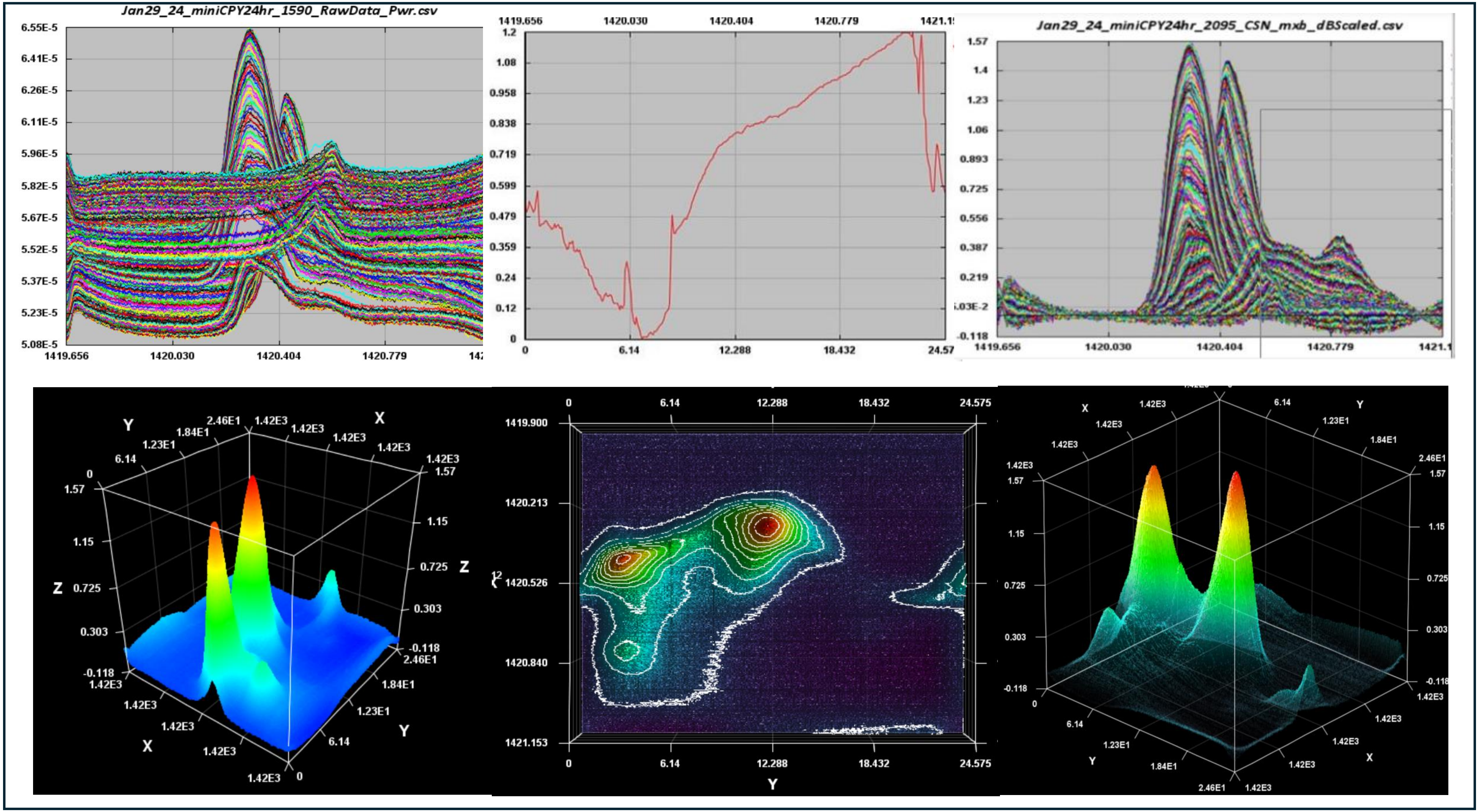
Some good guesses as to how IFavg creates a *Pre-Test Background Correction Reference Spectrum.*
The typical M curve shown in many data acq plots represents **Gain Variations** over the band.

The pre-test calibration Power spectra obtained by using a Pre-LNA Resistor or Earth Sim Cover over the feed needs to be normalized to 1 (~ center band) . (use the same acq avg time as the data spectra for this)
These values are then to be used as the denominator to divide each spectra to flatten the M shaped Gain curve. (created an excel sheet to demo this)

Post Test In-Band Cold Sky Normalization examples ***2D format***



Post Test In-Band Cold Sky Normalization   *3D format of mx+b Corrected Data*



The original cold sky drift normalization was written (by me) in Mathworks Matlab

MatlabProcessing07_forPDF.pdf