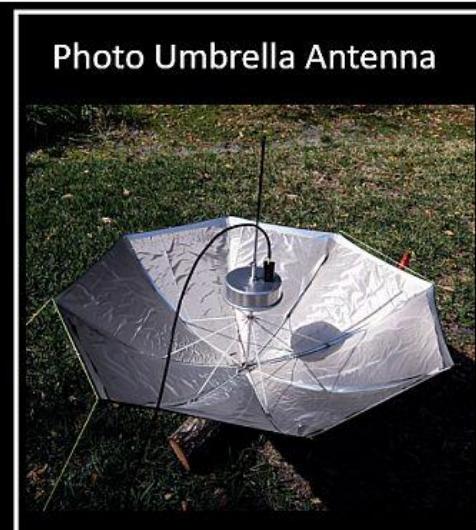
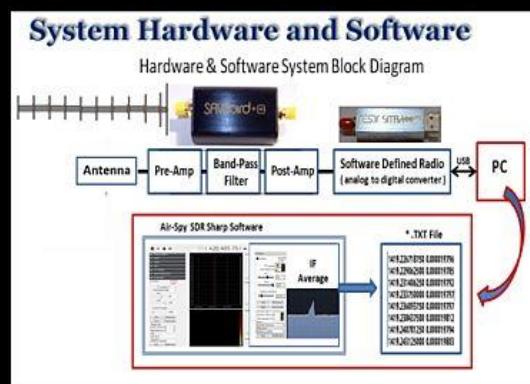
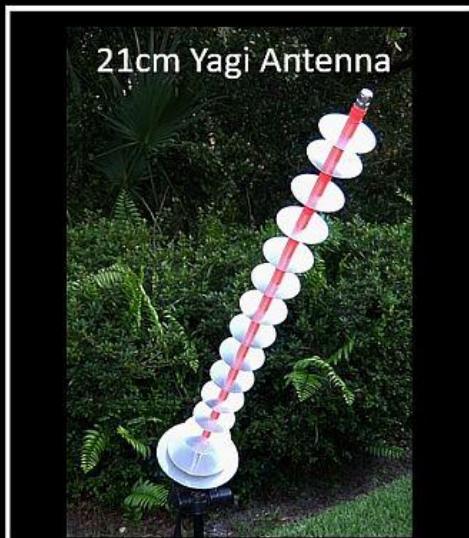
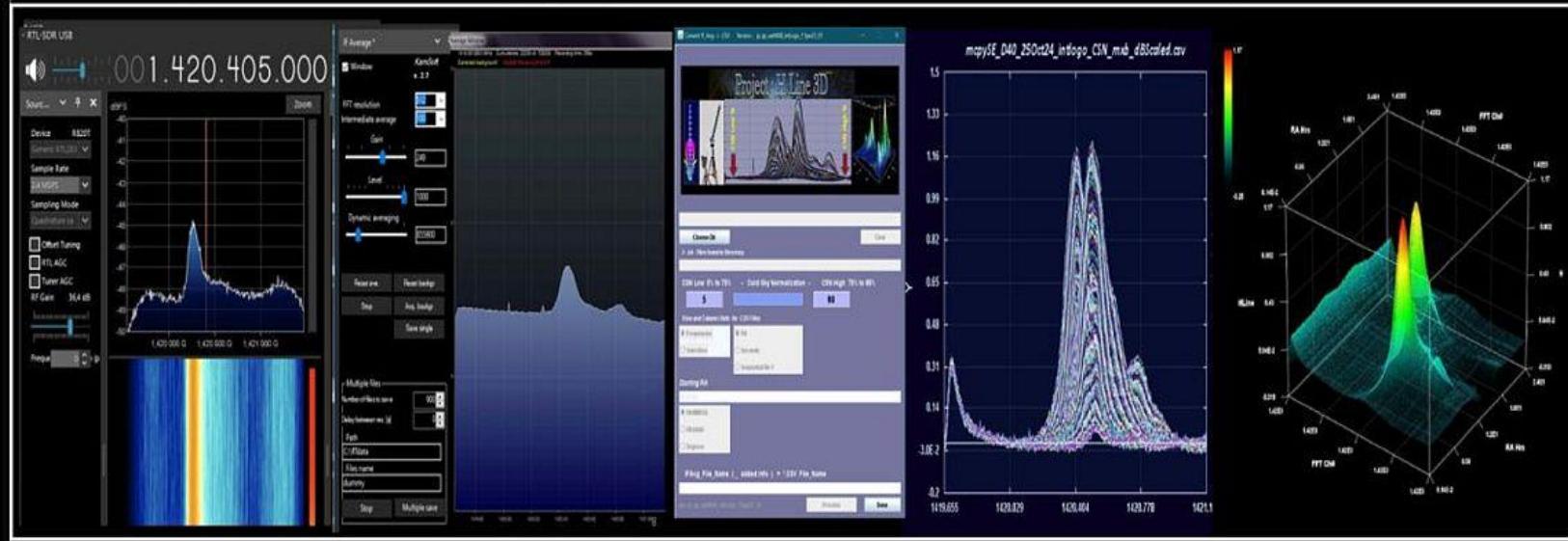


Project : H Line 3D



AirSpy SDR# > Kaminski IF_avg Plugin > HLine3D > Rinearn Graphics



Project : H Line 3D

21cm Yagi / Umbrella Antenna & Processing / Graphic Software PROJECT

A Beginner's Guide to Antenna Fabrication, Reception, Recording, Software Processing Graphic Display

of the 21 cm Wavelength Microwave Electro-Magnetic Emission Spectrum
from Neutral Hydrogen (Inter-Stellar Mass.) Clouds within our Galaxy

The Goal :

To Provide a beginner (high school or undergrad college student)
the Information required to fabricate an
Operational Astronomical H-Line Radio Telescope System
with easy to comprehend **Acquisition and Processing Software**
& **2D system evaluation and 3D drift scan data set Graphics**

- All in One Repository -



Hardware :

- 1) *Patch_Feed Disk_Director Yagi Antenna Fabrication*
a) *NEC Modeling : Yagi Antenna Development*
- 2) *Photo Umbrella Antenna*

Software :

- 1) *AirSpy SDR# Studio*
- 2) *Kaminski IF_Average*
- 3) *HLine3D Processing*
- 4) *Rinearn 2D 3D Graphics*

Hardware :

- 1) *Patch_Feed Disk_Director Yagi Antenna*
- 2) *Photo Umbrella Antenna*



Photo Umbrella Antenna



21cm Wavelength Circular_Patch_Feed Disk Director Yagi Antenna

*An
Efficient Low_Noise
Portable Economical
21cm Neutral Hydrogen
Radio Telescope
Antenna*

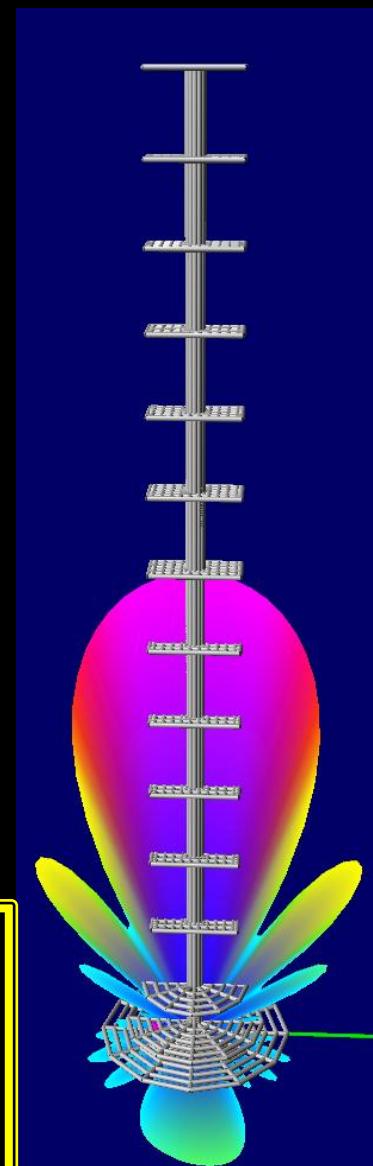
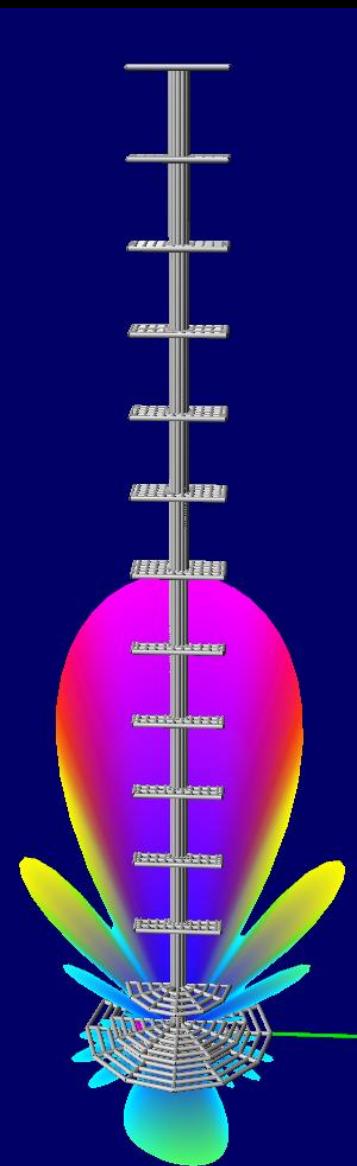
STUDENT EDITION

*If built carefully to correct dimensions
This antenna will have similar
performance to the original
&
It is light enough to be mounted on a
low cost photo tripod*

Derived from the work of

Prof Matjaz Vidmar, Ph.D.

<https://lea.hamradio.si/~s53mv/cigar/design.html>



21cm Student Edition PEX Yagi Fabrication Tools

cutting PEX tube to length

SharkBite 1/4-in to 1-in Pex Cutter

Item #2590607 | Model #U701

[Shop SharkBite](#)

[Shop the Collection](#)



\$9.55



cutting Aluminum (PEX) tube to length



Olson Saw 35-241 Fine Kerf Saw 35-550 42 tpi with Aluminum Thin Slot Miter Box, Slot Size .014-Inch, Slot Angles 45, 60, 90, Cutting Depth 7/8-Inch, Pack of 1

Brand: ZONA
4.3 ★★★★☆ 1,806 ratings
200+ bought in past month

-10% \$21.62



cutting aluminum sheet into disks



Sponsored ⓘ

10" Left Cut Aviation Snip - Left Cut Offset Stainless Steel Cutting Shears with Forged Blade & Power Comfort Grips Aviation...

★★★★★ 10

\$9.99

21cm Student Edition PEX Yagi

Antenna Components *Using 0.020" & 0.030" Aluminum Sheet*

REMOVE BLUE FILM



2Pack 6061 T651 Aluminum Sheet Metal 6 x 6 x 1/32 (0.0315") Inch Flat Plain Aluminum Plate Covered with Protective Film, Heat Treatable Rectangle Aluminum Metal Plate for Crafting, DIY, 0.8mm Thick

Brand: Lswteiz

4.7 ★★★★★ 231 ratings | Search this page

\$7⁹⁹ (\$4.00 / Item)

SharkBite

1/2-in x 5-ft White PEX-B Pipe

\$3.28



2 Pieces 6061 T651 Aluminum Sheet Metal 6X 6x0.02(24Gauge) Inch Rectangle Metal Plate, 0.5mm Aluminum Sheet, Plate for Crafting, Industry

Brand: iteshuai

4.7 ★★★★★ 112 ratings | Search this page

Amazon's Choice

in Aluminum Sheets & Plates by iteshuai

200+ bought in past month

\$5⁹⁹ (\$3.00 / Item)

Roll over image to zoom in



K & S Precision Metals 83035 Round Aluminum Tube, 1/2" OD x 0.035" Wall Thickness x 12" Length, 0.5 in OD, 1 pc, made in USA

Visit the K&S Store

4.5 ★★★★★ 239 ratings

\$6⁹⁹

✓prime Two-Day

Electronic Components

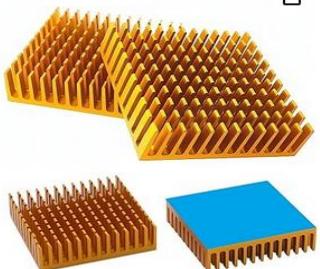


Nooelec SAWbird+ H1 - Premium Saw Filter & Cascaded Ultra-Low Noise Amplifier (LNA) Module for Hydrogen Line (21cm) Applications. 1420MHz Center Frequency. Designed for Software Defined Radio (SDR)

Visit the NooElec Store

4.4 ★★★★☆ 62 ratings | Search this page

\$44⁹⁵ (\$89.90 /100 g)



WWZMDIB 4Pcs 40mm Heatsink Back Side Thermal Conductive Tape 40mm x 40mm x 11mm Heat Sink

Visit the WWZMDIB Store

4.7 ★★★★☆ 11 ratings | Search this page

\$5⁹⁹ (\$1.50 / Item)

✓prime

FREE Returns

Did you know? There's no annual fee for Prime Visa. Get a \$100 Amazon Gift Card instantly upon approval. Learn more

Brand

WWZMDIB



USB 3.0 Extension Cable 1 ft, Yeung Qee High Speed USB 3.0 A Male to A Female Extension Cord for Data Transfer USB Flash Drive, Keyboard, Mouse, Playstation, Xbox, Card Reader, Printer etc (1ft/0.3M)

Brand: Yeung Qee

4.5 ★★★★☆ 113 ratings | Search this page

\$5⁷⁹



DHT Electronics RF coaxial connector adapter SMA male coaxial Termination Loads 1W DC- 3.0GHz 50 ohm Pack of 2

Brand: DHT Electronics
4.4 ★★★★☆ 215 ratings | Search this page

50+ bought in past month

\$5⁵⁰ (\$2.75 / Count)

✓prime
FREE Returns
30-day refund/replacement

Specific personal



NooElec NESDR Smart XTR SDR - Premium RTL-SDR w/Extended Tuning Range, Aluminum Enclosure, 0.5PPM TCXO, SMA Input. RTL2832U & E4000-Based Software Defined Radio

Visit the NooElec Store

4.3 ★★★★☆ 189 ratings | Search this page

\$43⁹⁵

✓prime Two-Day
Foto Return



SMA Male to SMA Male Coaxial Cable 50 ohm KMR240 Coax Cable Ultra Low Loss Antenna Extension Cable with SMA Connector for 3G/4G/5G/LTE Network Equipment, GPS, RF Radio to Antenna (25FT)

Visit the MOOKEERF Store

4.5 ★★★★☆ 77 ratings | Search this page

\$23⁹⁹ (\$0.96 / Foot)

✓prime One-Day



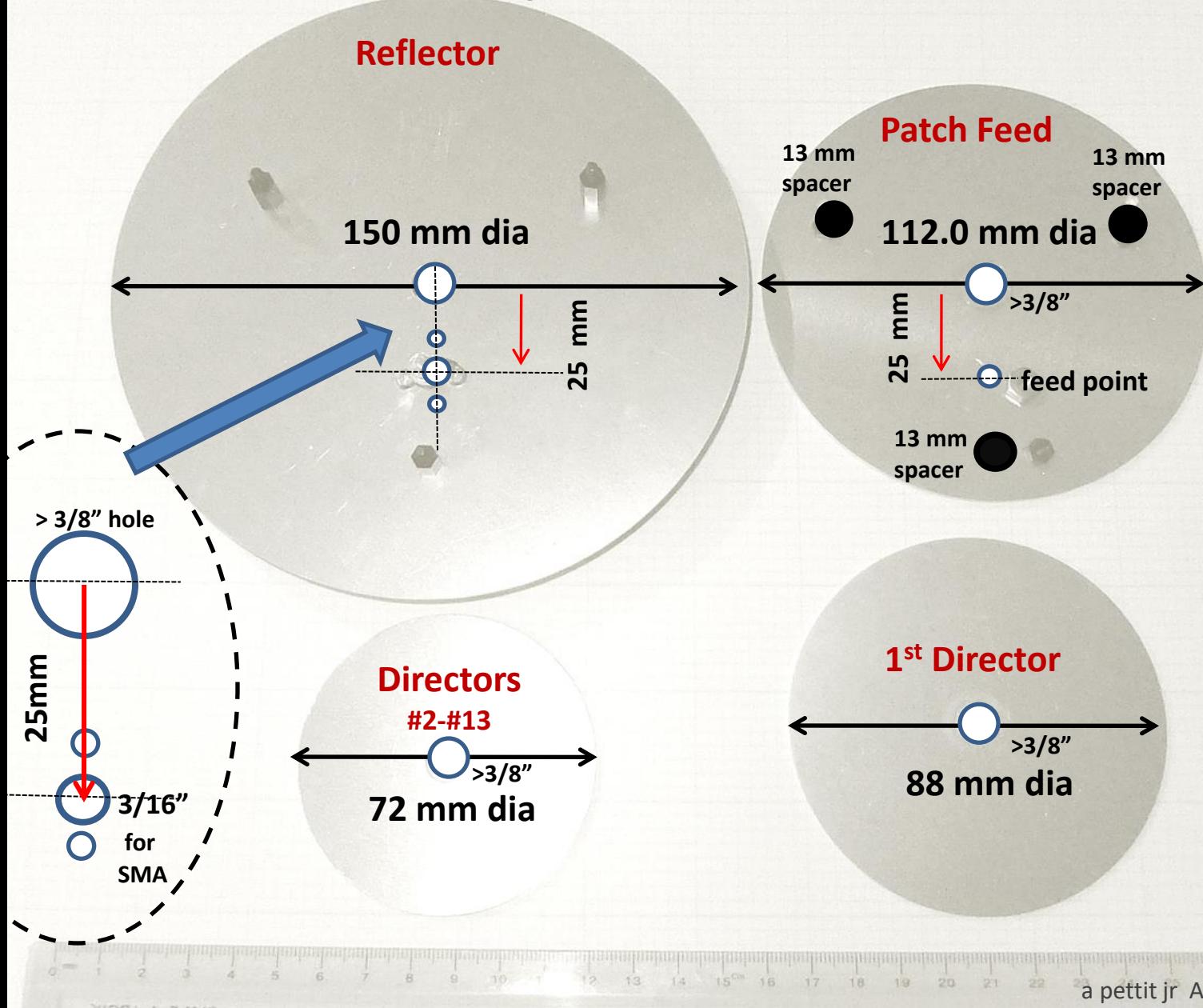
onelinkmore SMA Panel Mount Connector SMA Male 2-Hole Panel Chassis Mount Flange Solder Post Plug Connector Mounting Panel Post Straight Insulator PCB Coaxial Converter Pack of 5

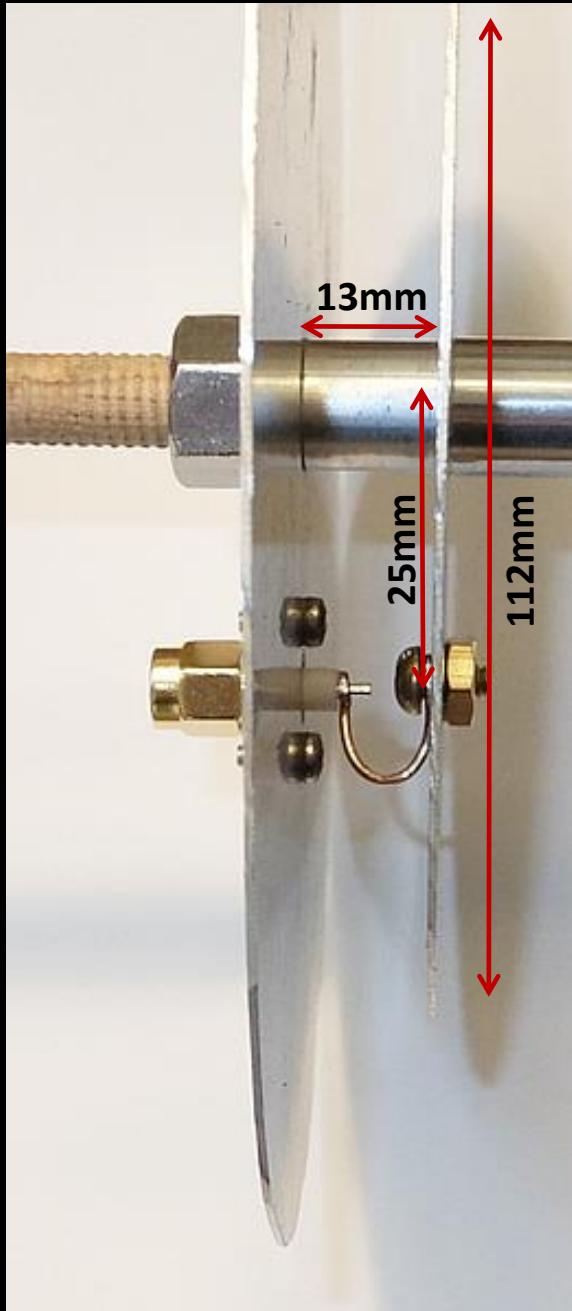
Visit the onelinkmore Store

5.0 ★★★★★ 3 ratings | Search this page

\$6⁹⁸ (\$1.40 / Count)

Cir Patch Feed Plate Yagi Component Dimensions





Patch Feed Construction Details

>> Most Critical Dimensions <<

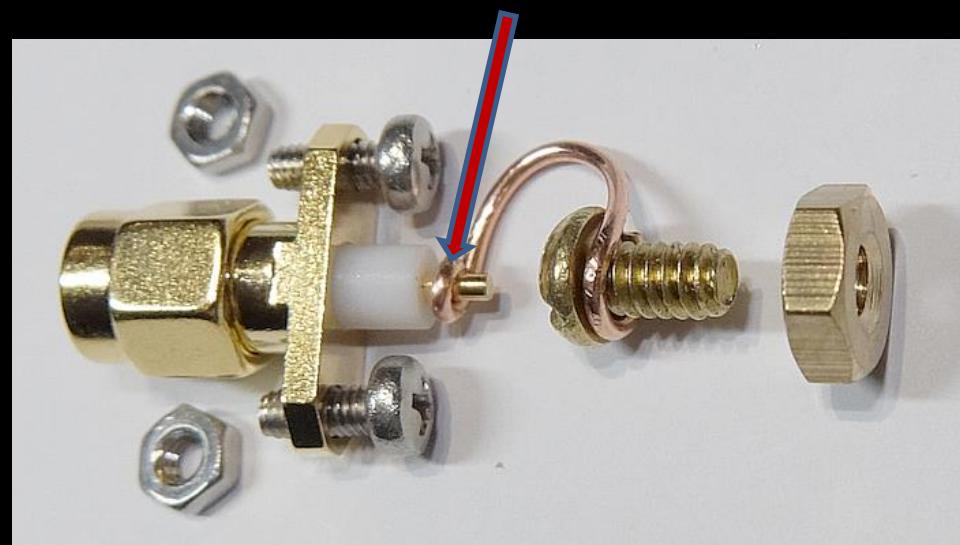
112 mm Diameter of the patch feed

13 mm spacer Thickness reflector<>patch feed

25 mm Radius of the Feed Point

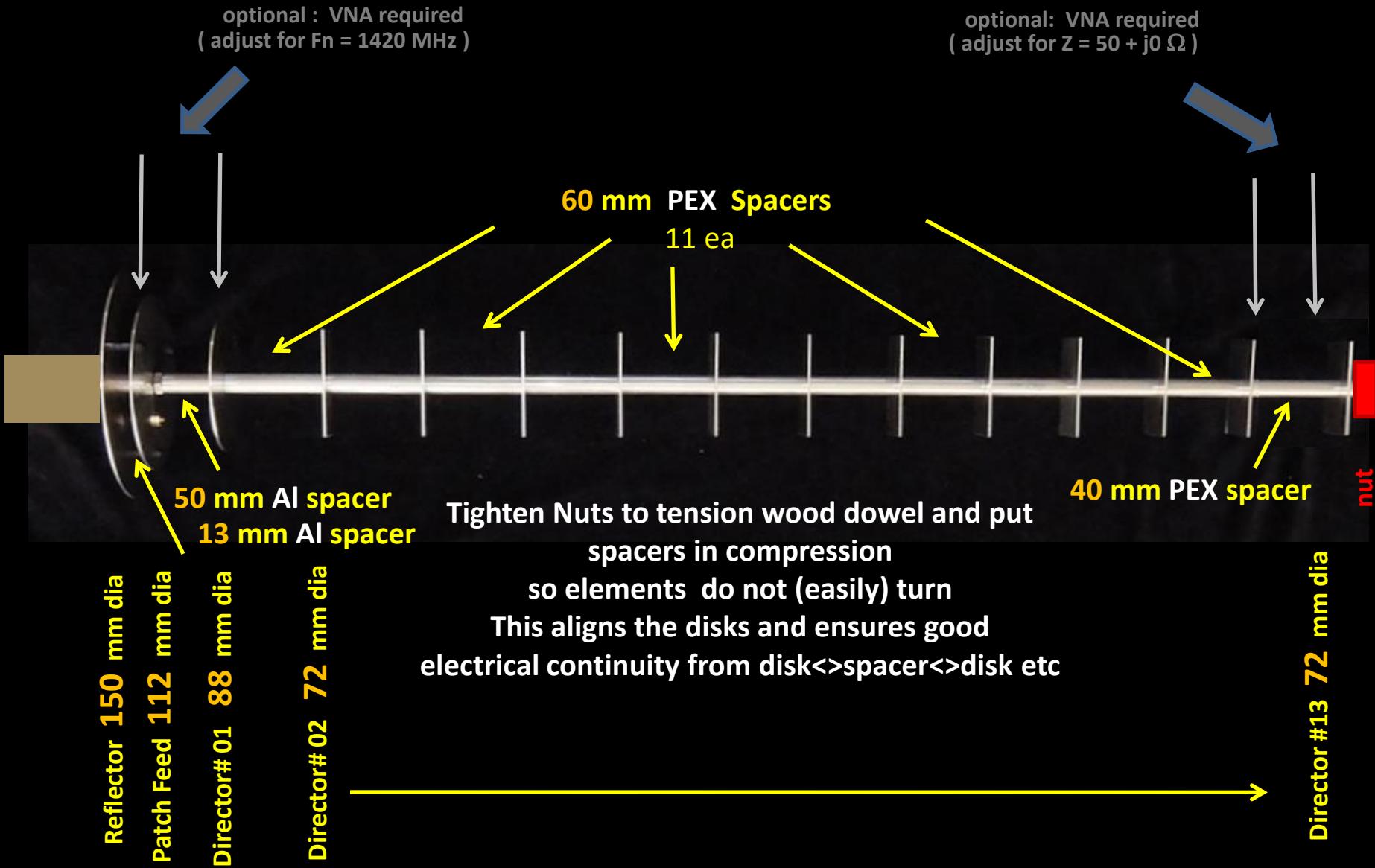
(optional plastic spacers not installed)

(copper wire loop on the SMA center conductor pin
Should Be Soldered
after SMA connector is installed on Reflector Disk)



>> Clean Parts for good Electrical Contact <<

Cir Patch Feed Disk Yagi Dimensions for PEX Student Edition



Interface Ideas

low cost lightweight Tripod



Roll over image to zoom in

JOILCAN Tripod for Camera, Camera Tripod 67" Heavy Duty Tripod, Phone Tripod for Video Recording Photo Vlog, Aluminum Camera Tripods with Holder & Travel Bag for Camera DSLR

[iPhone Projector Laser](#)

Visit the JOILCAN Store

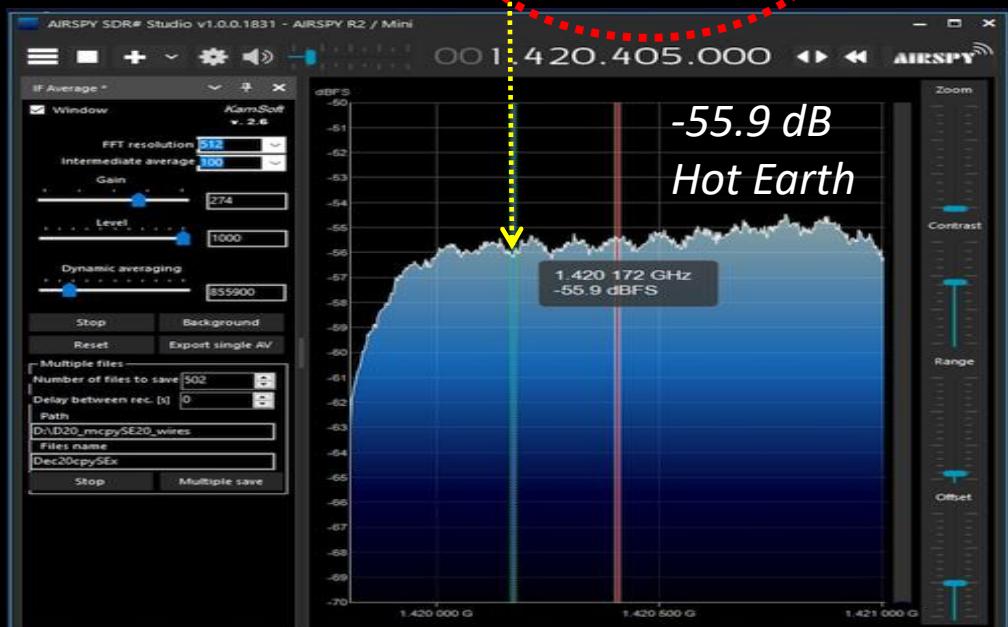
4.5 ★★★★★ 1,580 ratings

| [Search this page](#)

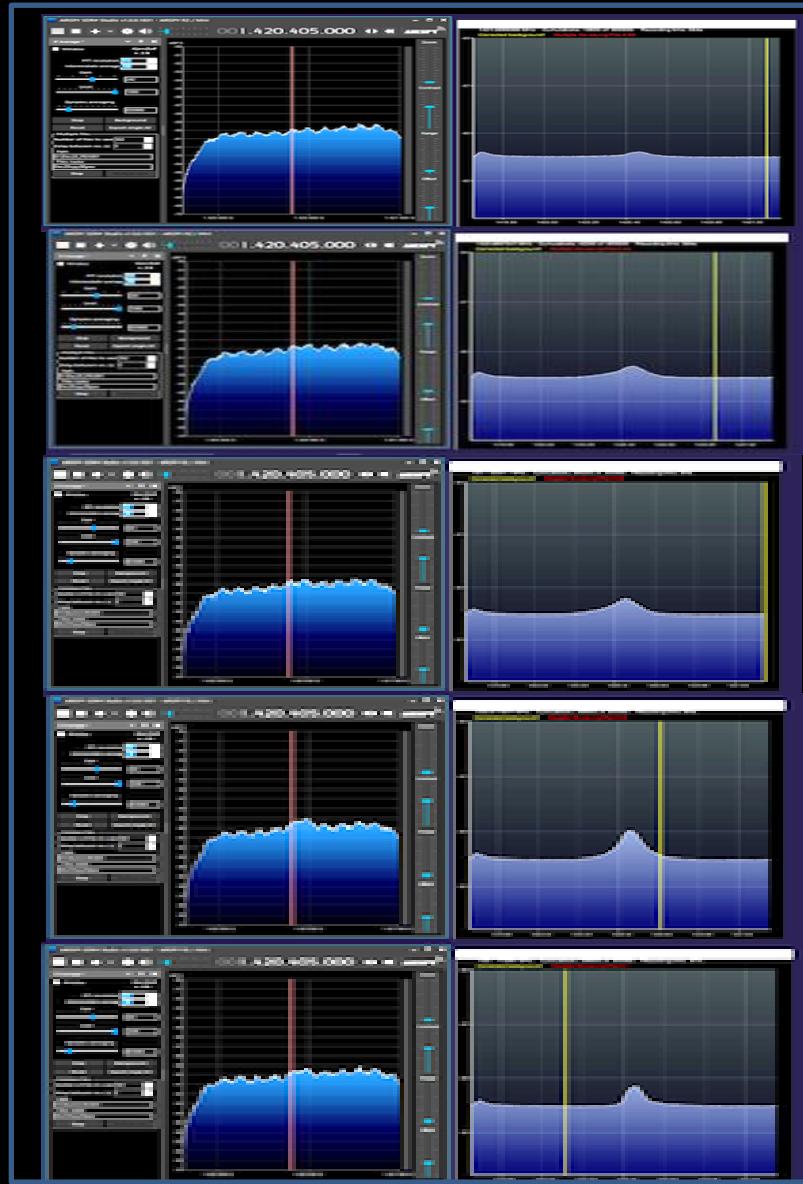
300+ bought in past month

-24% \$27⁹⁹

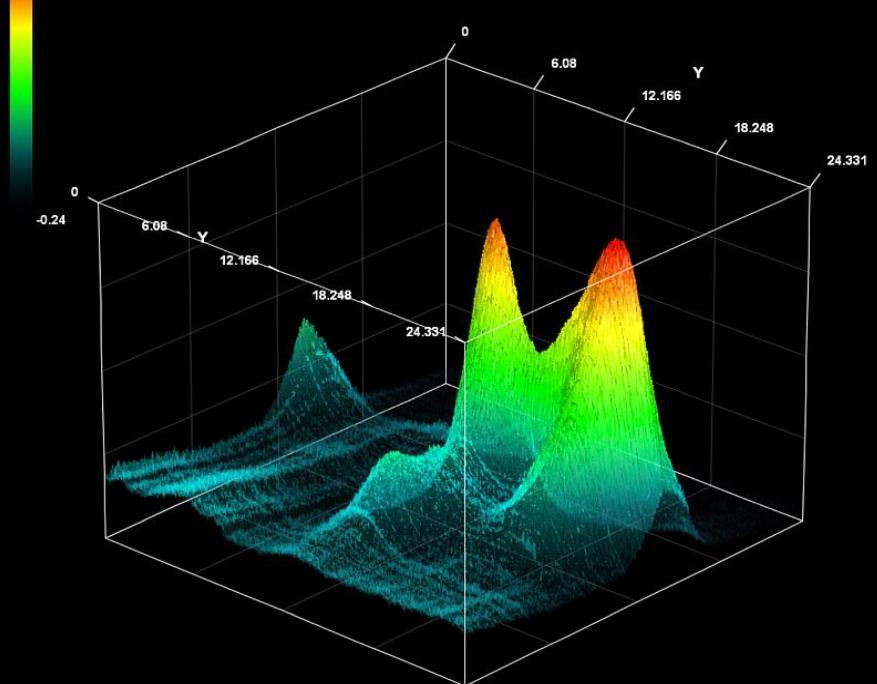
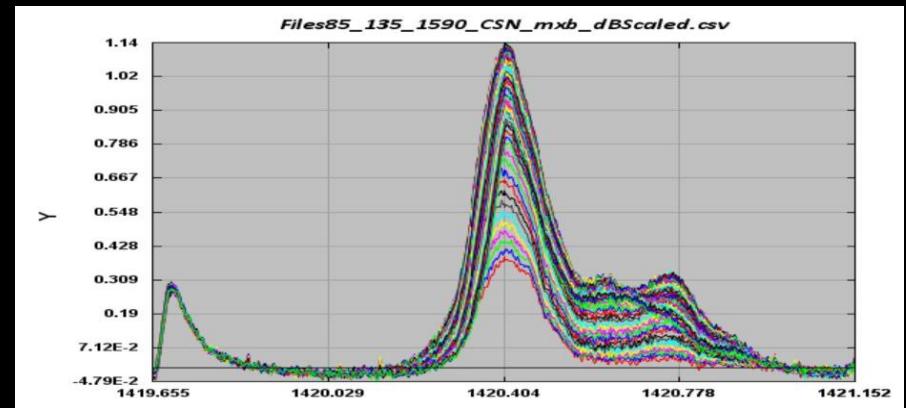
System Operational Verification Hot_Earth vs Cold_Sky



Drift Scan SDR# & IF_Avg Spectral Display



*Student Editon Patch_Feed Disk_Director
Yagi Antenna Performance examples*

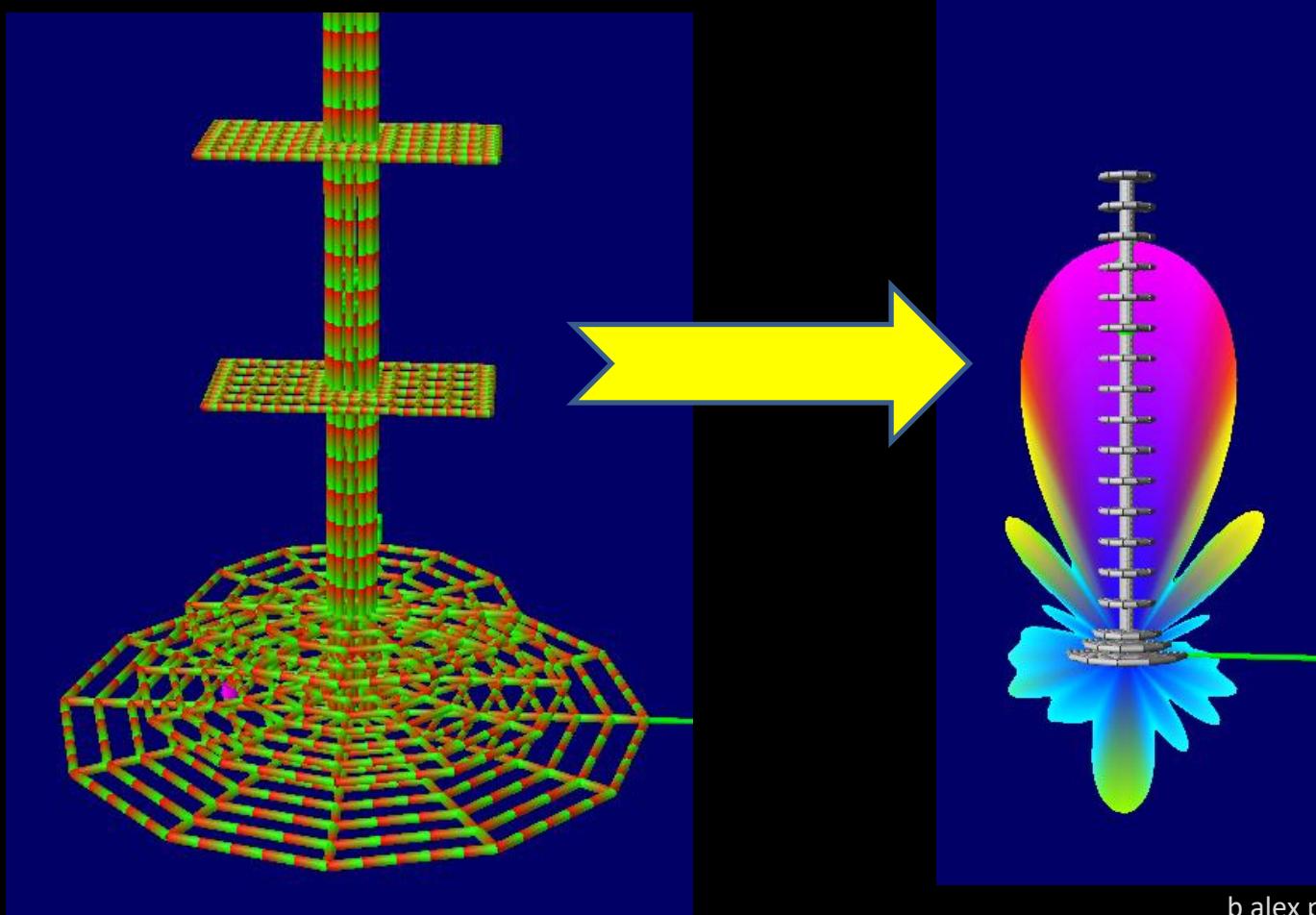


Numerical Electromagnetics Code

*Numerical Analysis
of the
Electromagnetic Properties
of
Antenna Structures*

Numerical Electromagnetics Code

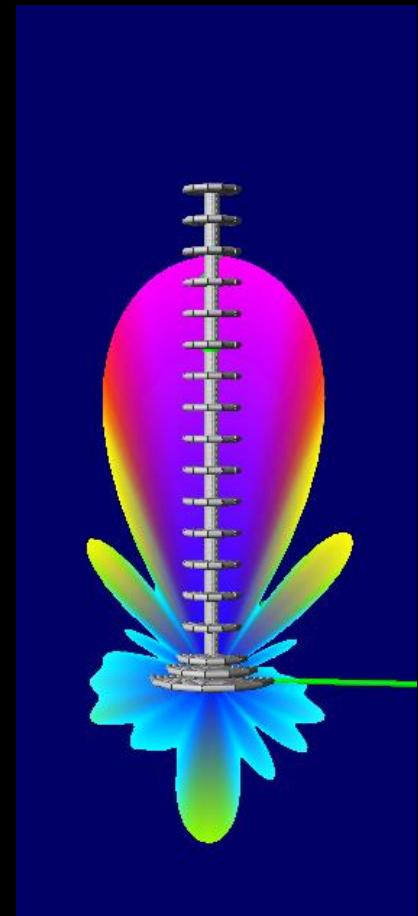
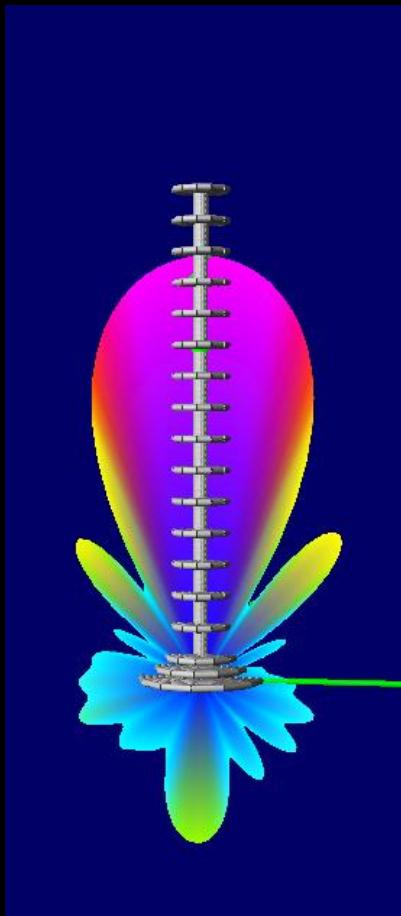
SEGMENTATION : each of these small elements are analyzed



Numerical Electromagnetics Code Analytical Models

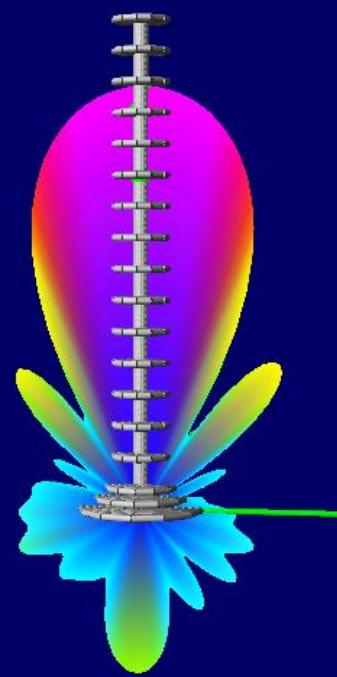
*A Typical
Analytical Model
is just an
Interesting*

*Academic
Exercise*



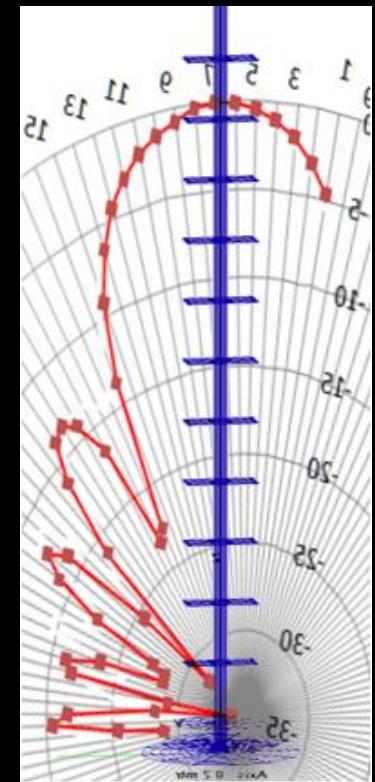
Numerical Electromagnetics Code Model Validation

NEC Model

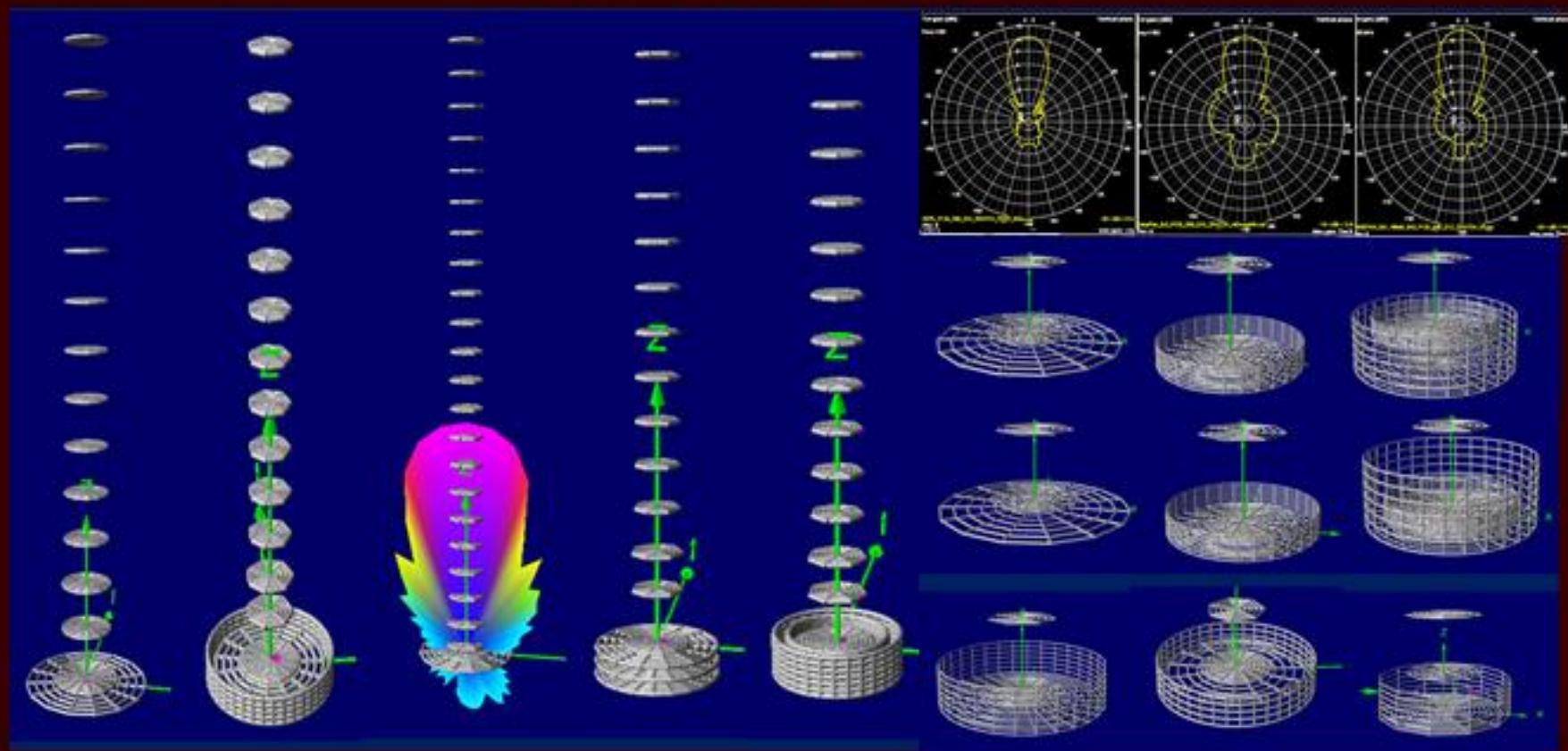


***However : When
Validated by Testing
an
Analytical Model Becomes
the Basis for Correct
Performance
Predictions
for
Changes / Modifications***

Test Data



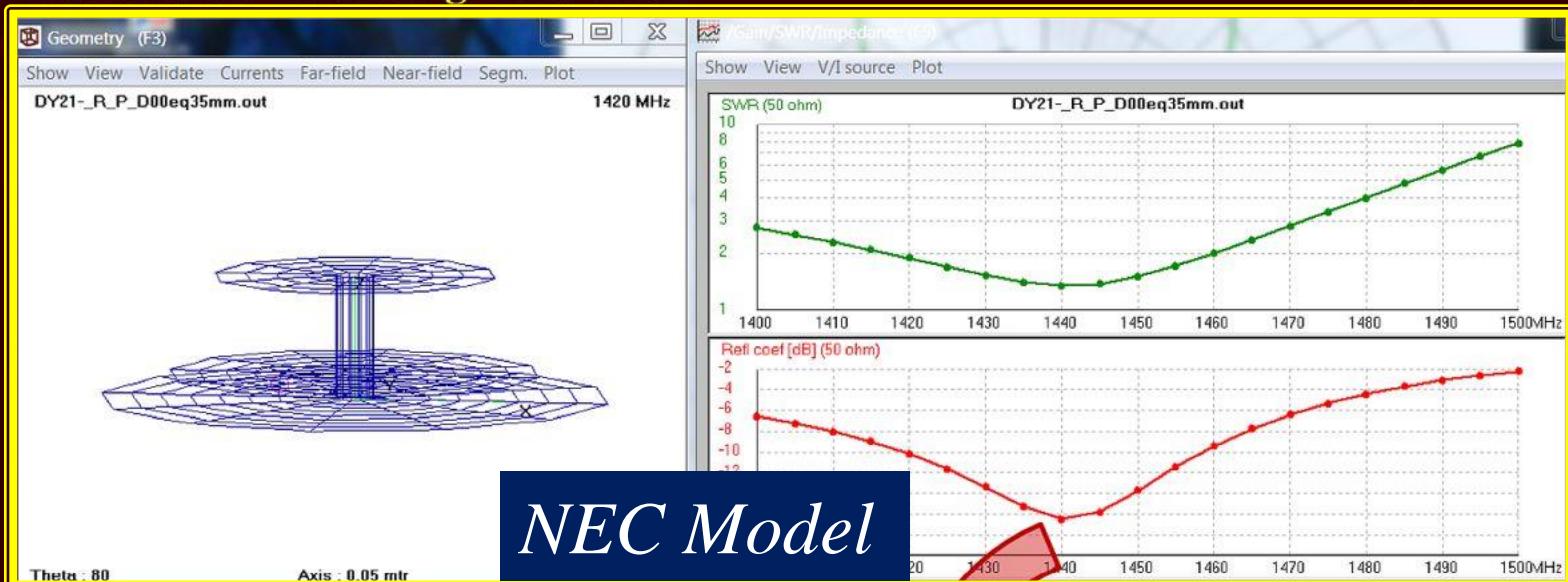
Numerical Electromagnetics Code Overview



Examples of the 130+ NEC model variations analyzed

Numerical Electromagnetics Code

Model Data vs VNA Analysis



NEC Model



Virtually IDENTICAL Results

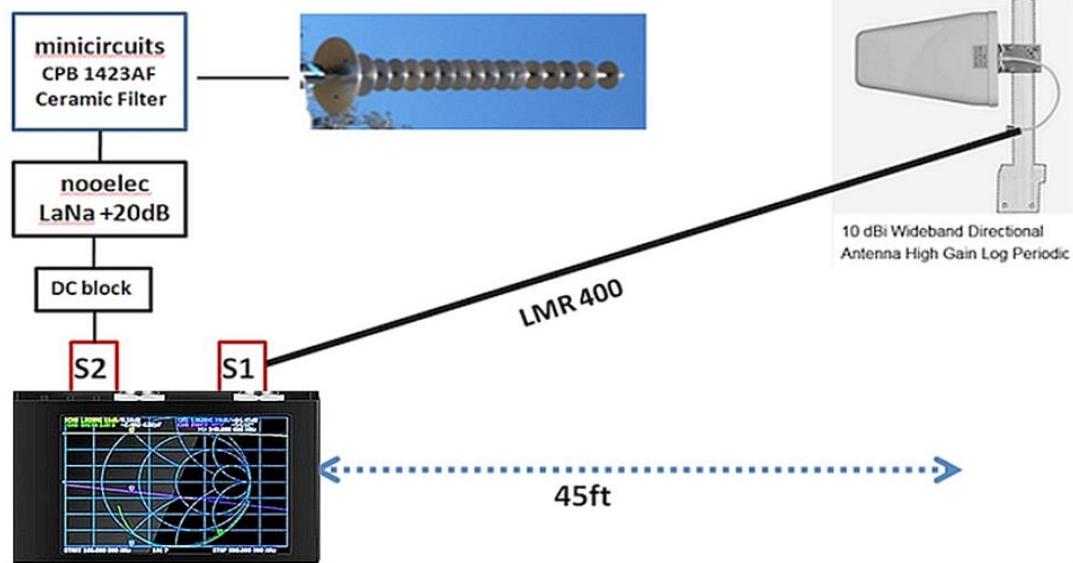


Test Data

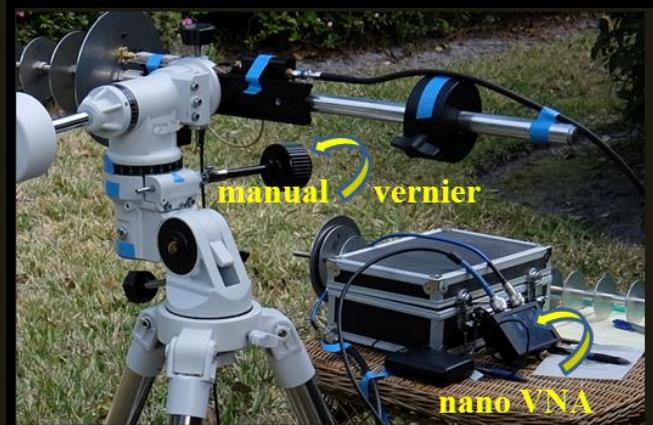
Antenna Beam Pattern Characterization Tests

Test setup : using a nanoVNA

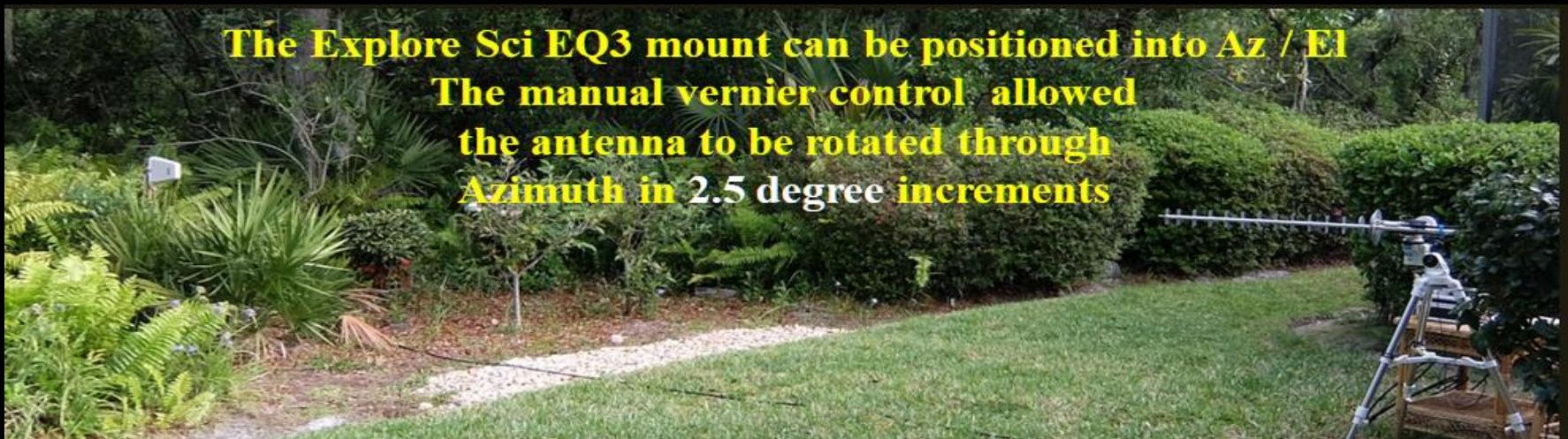
Antenna Beam Characterization Test Range



A Test Range was designed based on a nanoVNA to characterize the antenna's BEAM PATTERN

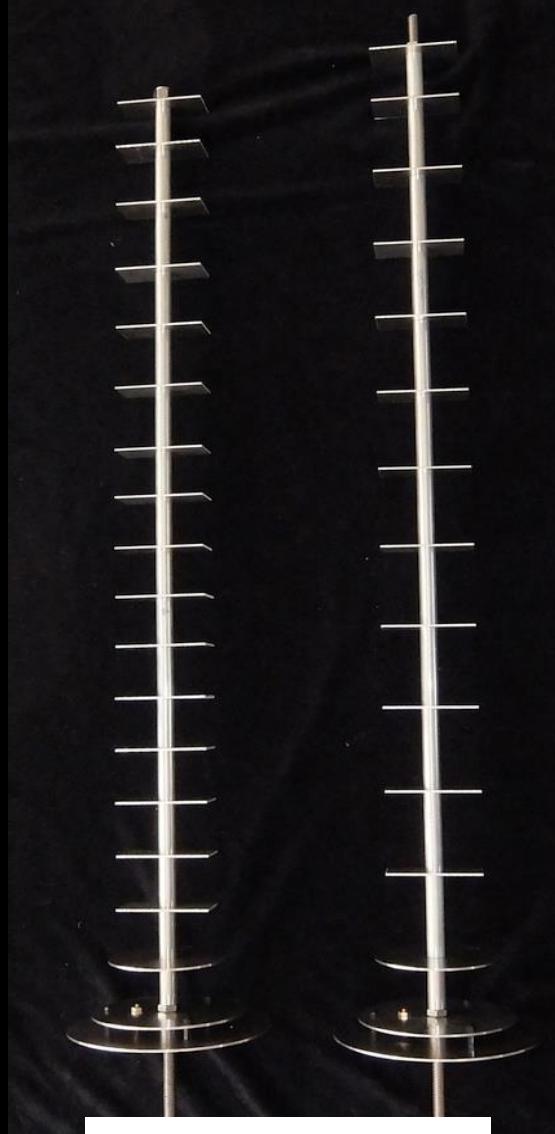


The Explore Sci EQ3 mount can be positioned into Az / El
The manual vernier control allowed
the antenna to be rotated through
Azimuth in 2.5 degree increments

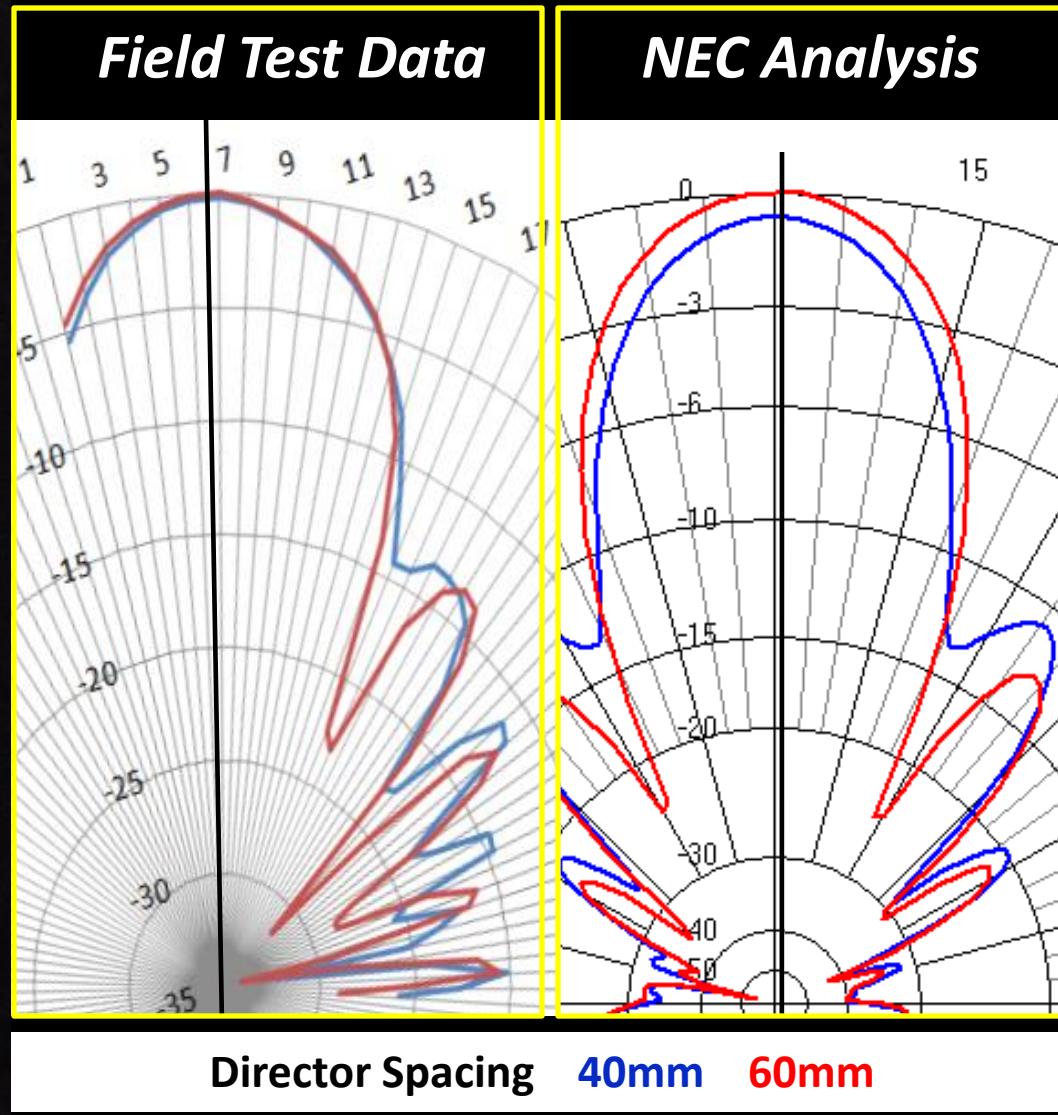


Cir Patch Feed Plate Yagi 0.75m long

Beam Pattern Field Testing vs Numerical Electromagnetics Code



40mm 60mm
Director Spacing



Hardware :

- 1) *Patch_Feed Disk_Director Yagi Antenna*
- 2) ***Photo Umbrella Antenna***



Photo Umbrella Antenna



*21cm Hydrogen
1 meter
Umbrella Radio Telescope*

*Design Goal:
balance*

*Cost Complexity Portability
Performance*

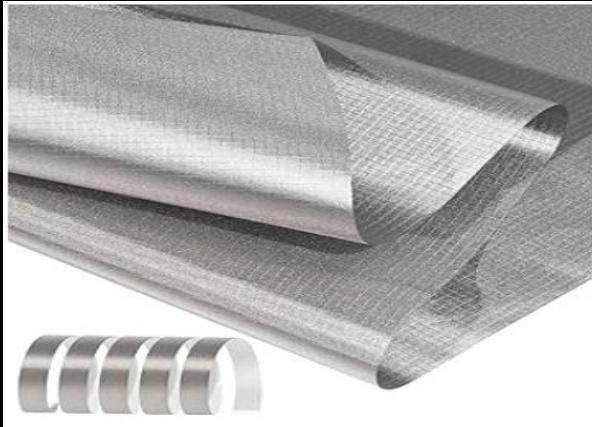


<https://www.youtube.com/watch?v=ymclkNnCeCc>

(unlined) White Satin Photo Umbrella



Nickel Copper Faraday Fabric



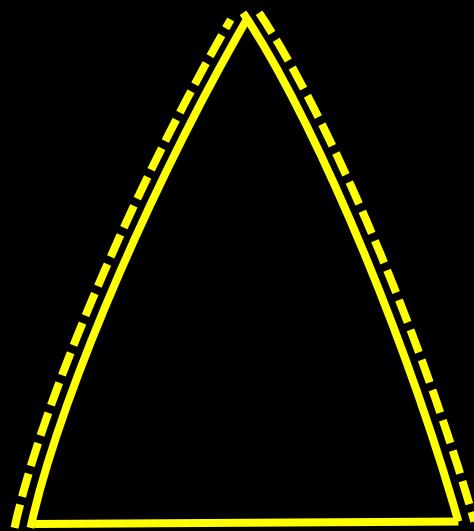
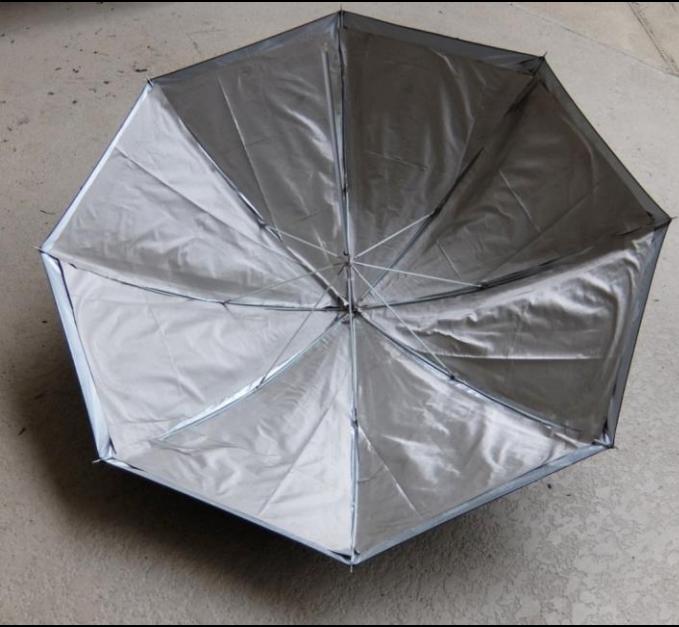
Brand: Dingbaayee

\$23⁹⁸

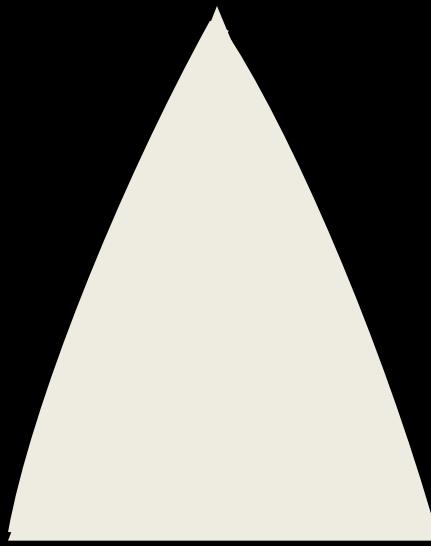
Faraday Fabric, Faraday Cloth 43"x118" with Faraday Tape Military Grade Protection Nickel Copper Faraday Cloth for WiFi, GPS

Brand: Dingbaayee

Photo Umbrella Antenna

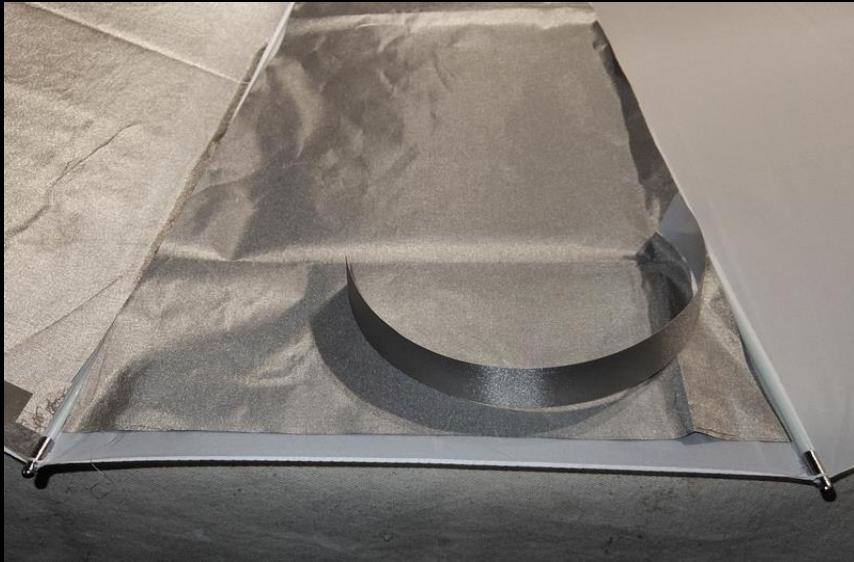


**Cut width 1/4" - 3/8" oversized to
Extend Under Ribs**



**Make a Cardboard or Foam Core Board
Template**

Align panel with ribs and attach with 1" tape at outer edge **Spray umbrella then segment with contact cement**
Make small cutouts for rib <> umbrella tie strings **Protect previously installed panels**



Use dry brush to install
Push edges of panel segment under ribs to overlap



Photo Umbrella Antenna *Loop Feed Components*



Parrish's Magic Line Round Cake Pan, 6 x 2

Brand: Parrish Magic Line
★★★★★ 243 ratings

\$9.99

✓prime One-Day
FREE Returns

Get a \$100 Gift Card: Pay \$0.00 \$9.99 upon approval for the Amazon Prime No annual fee.

Size: 6 x 2 Inch

6 x 1 Inch	6 x 2 Inch \$9.99 ✓prime	8 x 1 Inch
--	--	--



Boobrie SMA Coaxial Cable Connector SMA to F Coax Connector F Female to SMA Male Adapter for LAN / LMR Wireless Antenna Devices / RF Coaxial Cable / WiFi Radios External Antenna Pack of 2

Visit the Boobrie Store
★★★★★ 106 ratings

\$6.19 (\$3.10 / Count)

✓prime One-Day
FREE Returns

With Amazon Business, you would have saved \$156.94 in the last year. Create a free account and save up to 5% today.

Compatible Devices Scanner
Connector Type Coaxial
Connector Gender SMA Male, Male-to-Female, F type Female
Brand Boobrie
Number of Ports 1

Electronic Components

LNA (Low Noise Amplifier)

Nooelec SAWbird+ H1 - Premium Saw Filter & Cascaded Ultra-Low Noise Amplifier (LNA) Module for Hydrogen Line (21cm) Applications. 1420MHz Center Frequency. Designed for Software Defined Radio (SDR)

Visit the NooElec Store

4.4 ★★★★★ 62 ratings | Search this page

\$44.95 (\$89.90 /100 g)

SDR (Software Defined Radio)

NooElec NESDR Smart XTR SDR - Premium RTL-SDR w/Extended Tuning Range, Aluminum Enclosure, 0.5PPM TCXO, SMA Input. RTL2832U & E4000-Based Software Defined Radio

Visit the NooElec Store
4.3 ★★★★★ 189 ratings | Search this page

\$43.95

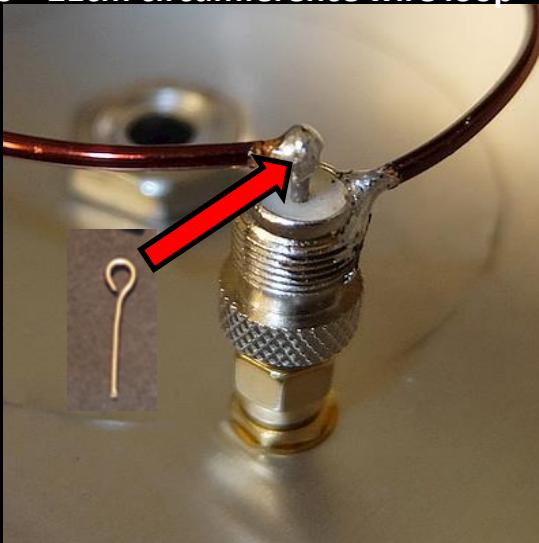
✓prime Two-Day
FREE Returns

1.42 GHz Loop Feed Antenna Fabrication

adapted from OM6AA

http://om6aa.eu/Loop_Feed_with_enhanced_performance.pdf

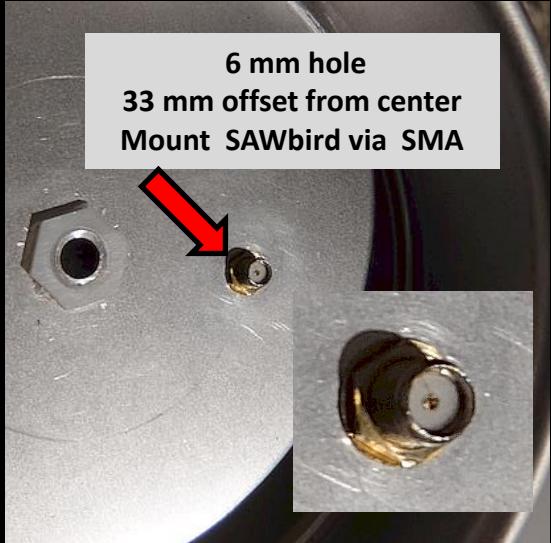
F-type <> SMA Adapter soldered to 21cm circumference wire loop



Completed Loop



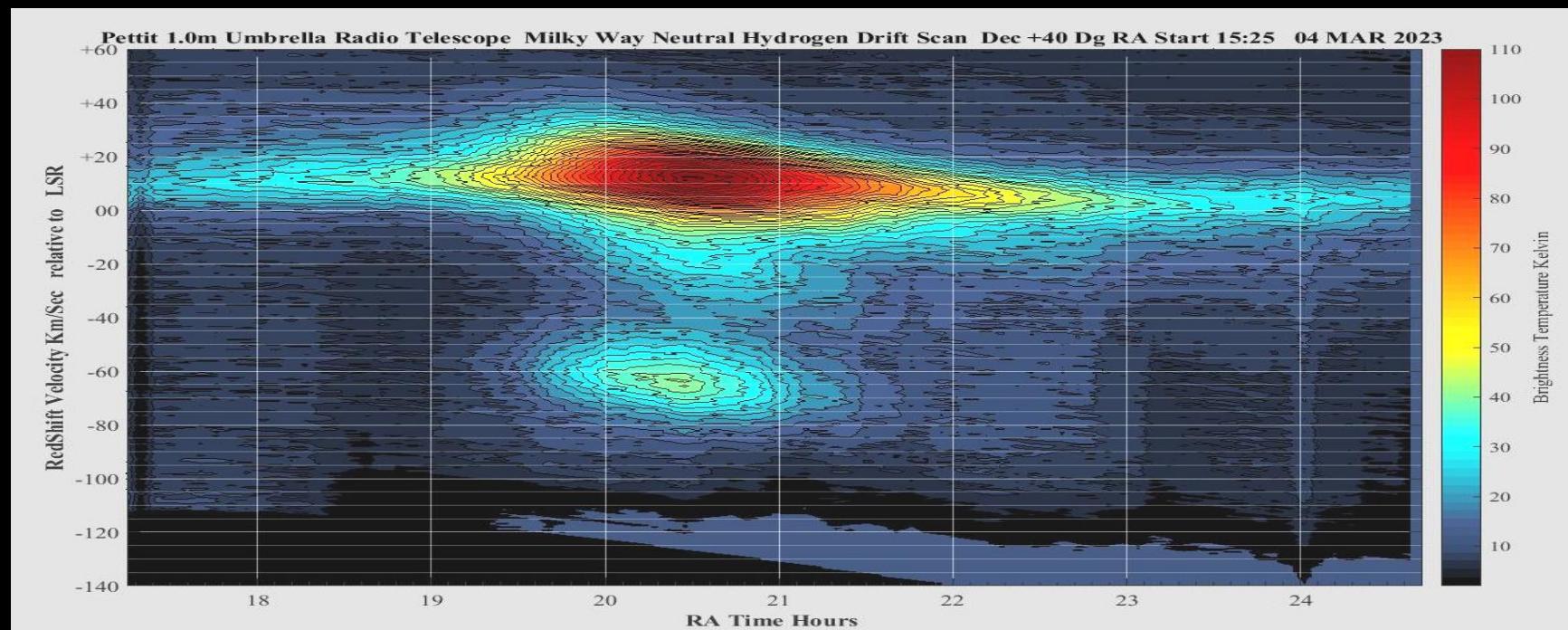
nooelec SAWbird H1 SMA attached to 6" dia x 2" deep Cake Pan



Complete Loop Feed Assembly

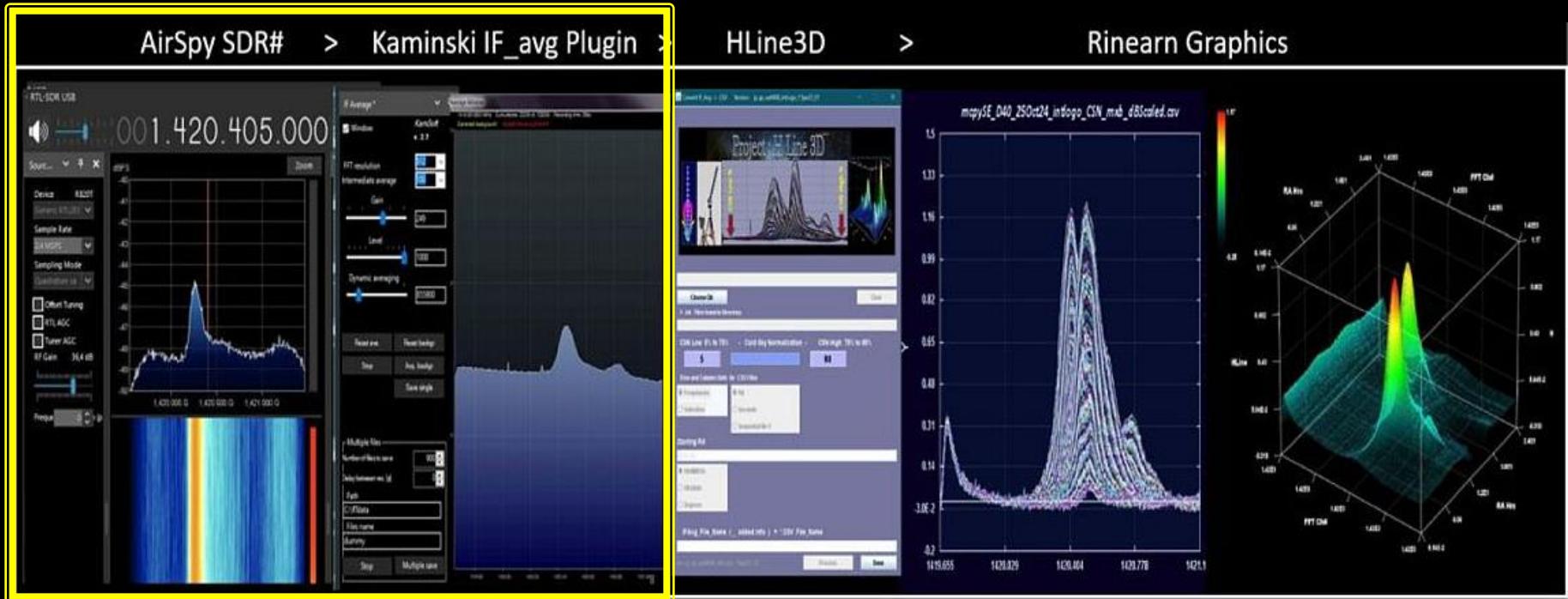


Declination + 40 Deg RA 20:30 Hrs



Software :

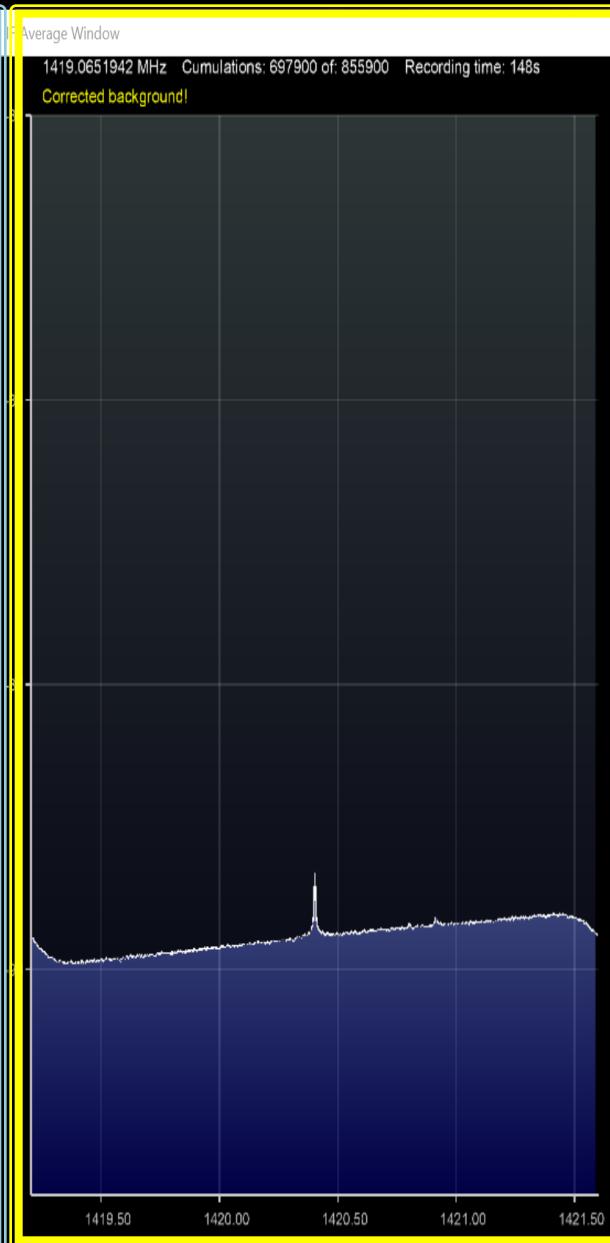
- 1) *AirSpy SDR# Studio***
- 2) *Kaminski IF_Average***
- 3) *HLine3D Processing***
- 4) *Rinearn 2D 3D Graphics***



Air-Spy SDR Sharp Software

AirSpy SDR# Studio

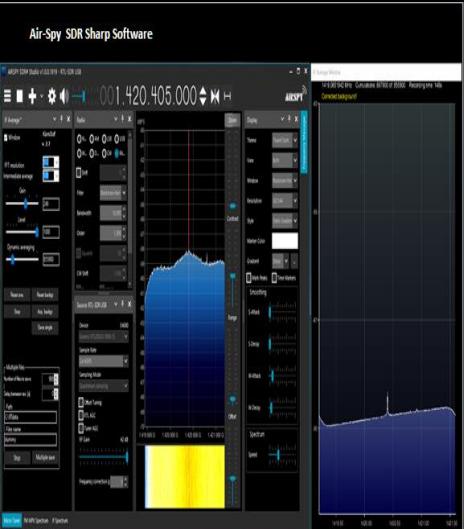
& IF Average



Air-Spy SDR Sharp Software

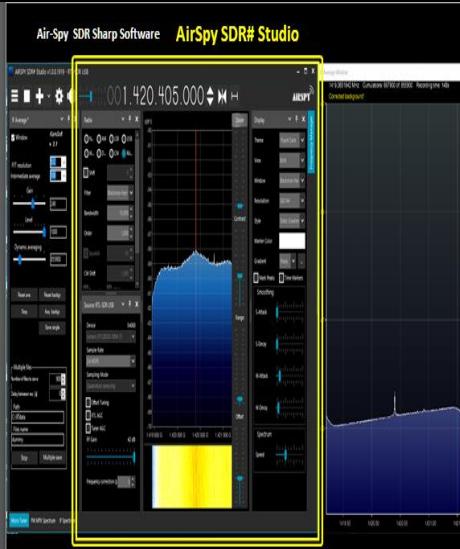
Details : AirSpy SDR# Studio & IF Average

Air-Spy SDR Sharp Software



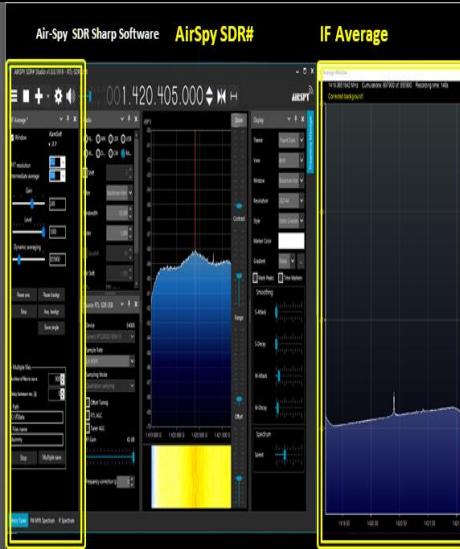
33

Air-Spy SDR Sharp Software AirSpy SDR# Studio



34

Air Spy SDR Sharp Software AirSpy SDR#



35

IF Average



36

Sample Rate 2.4 MSPS
RF Gain max 42 dB



37

Sets Audio Only



38

Set S-Attack / S-Decay @
min = best display
smoothing



39

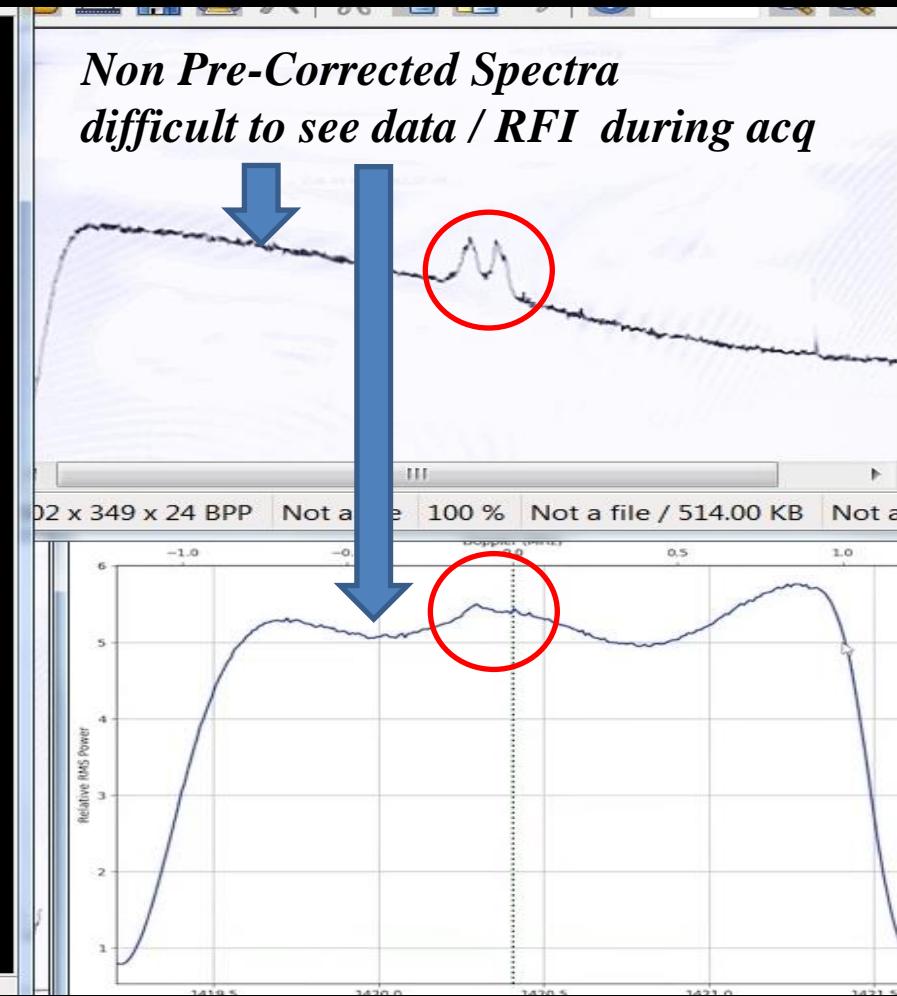
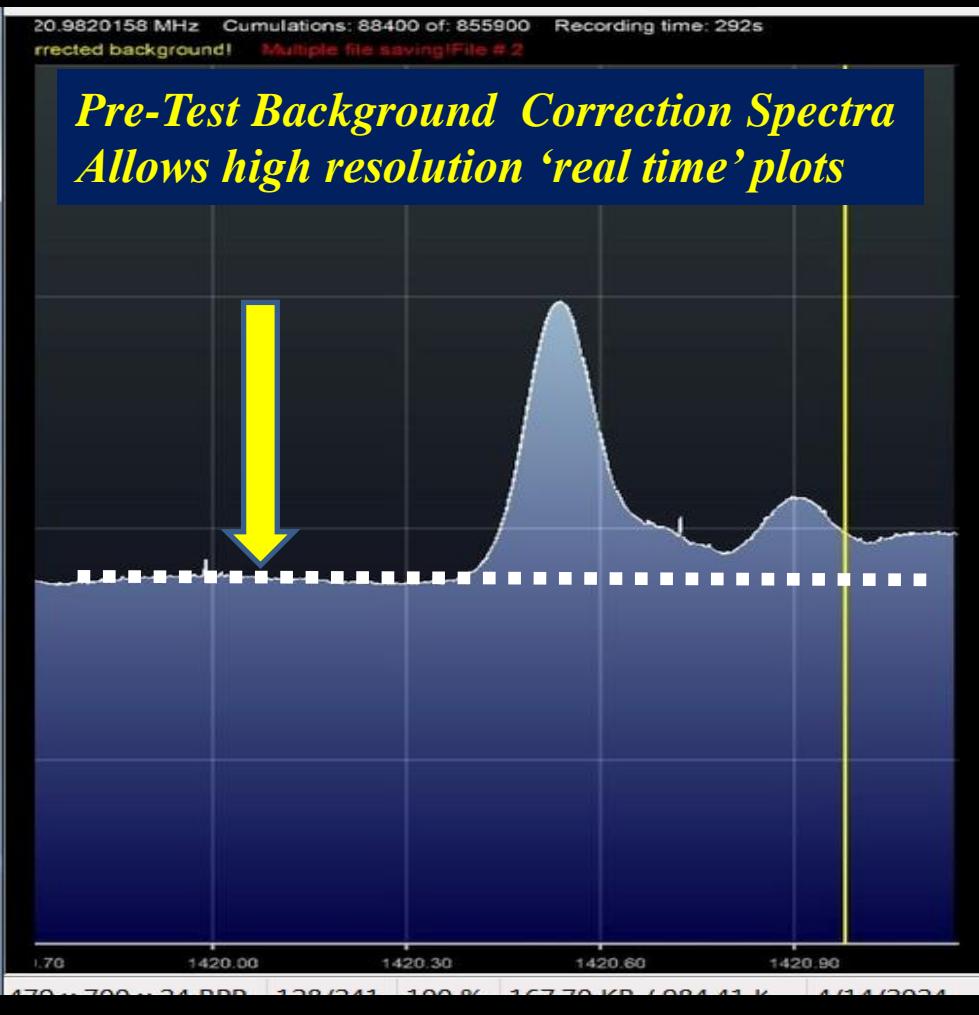
IF Avg Control Window &
Spectral Display



40

*The advantage of SDR# & IF_Avg over the alternates is that a pre-test **Background Correction** can be performed to remove the M curve or Large Shifts so the Actual Spectral Data can be seen during acquisition*

It is Widely Used and Proven to Work



Software / Hardware

Linearity and Eng_Units Calibration have been Validated

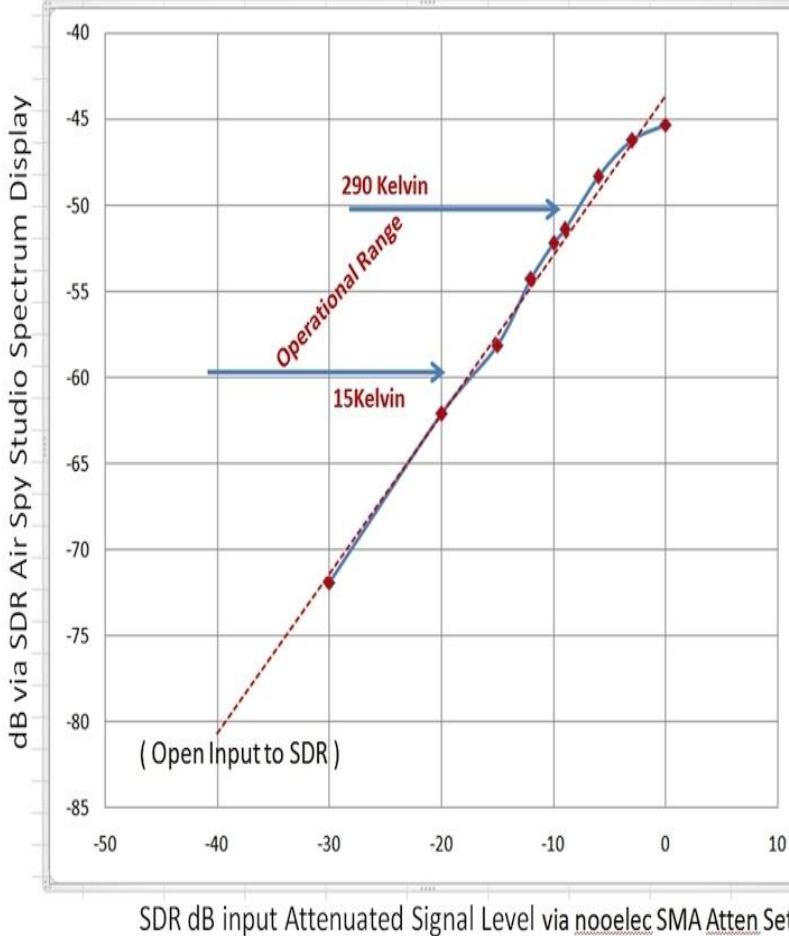
SDR# Studio

&

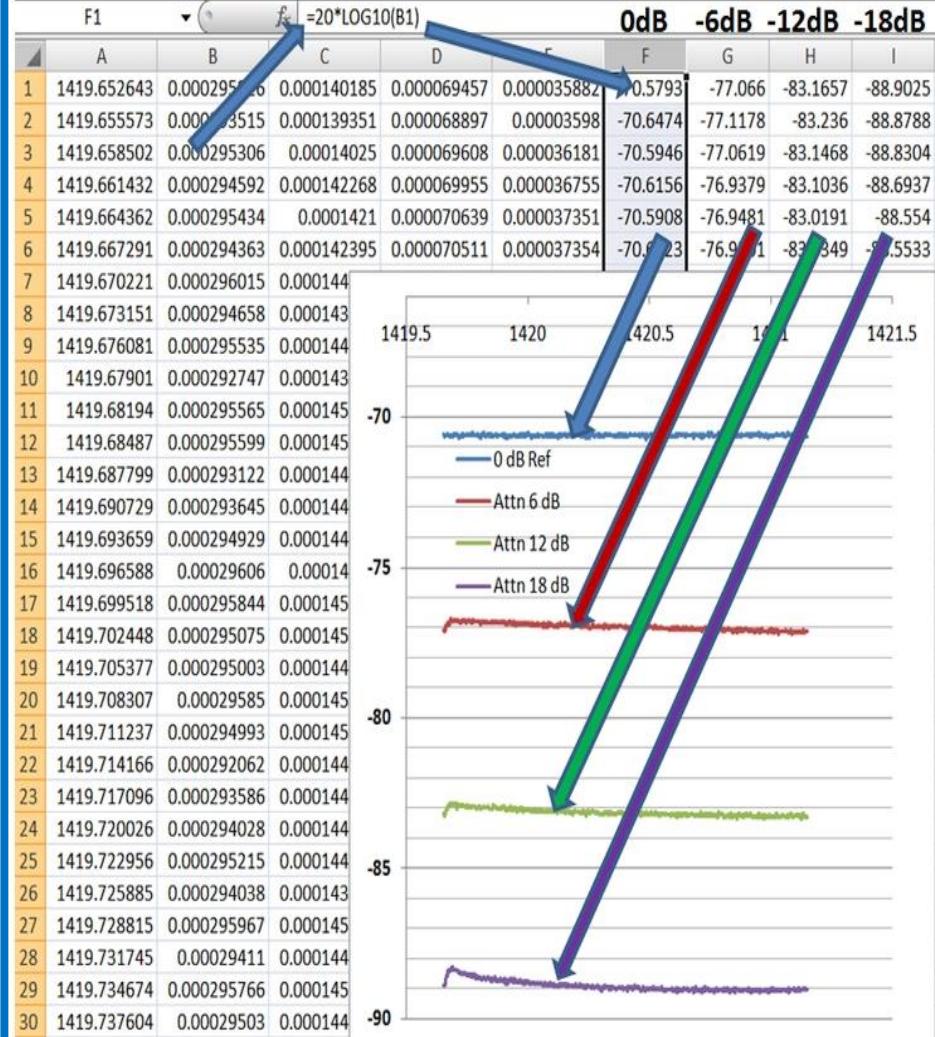
IF_average

Pettit Radio Telescope System Electronics Linearity Test 08 Feb 2023

RF Noise Generator set @ '-45dB' level w/ no attenuators (saturation @ -44 dB)

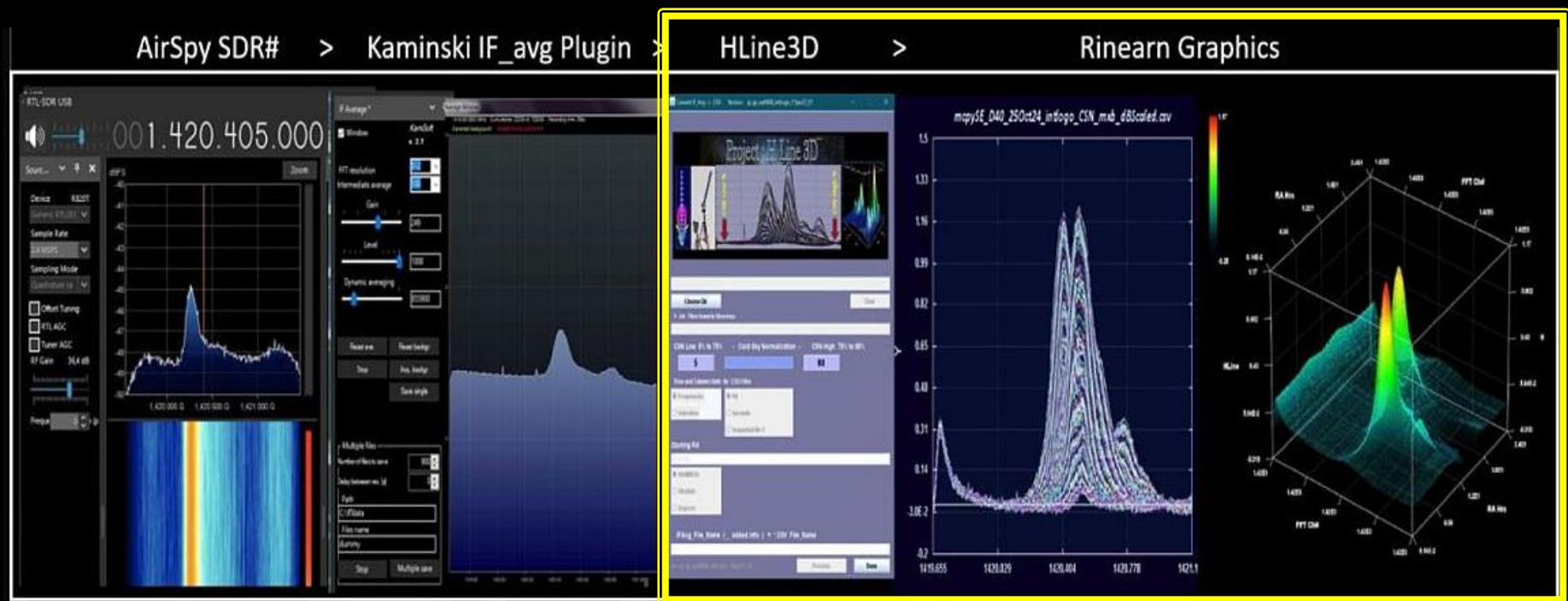


IF Average Plug_In Text File Amplitude Calibration



Software :

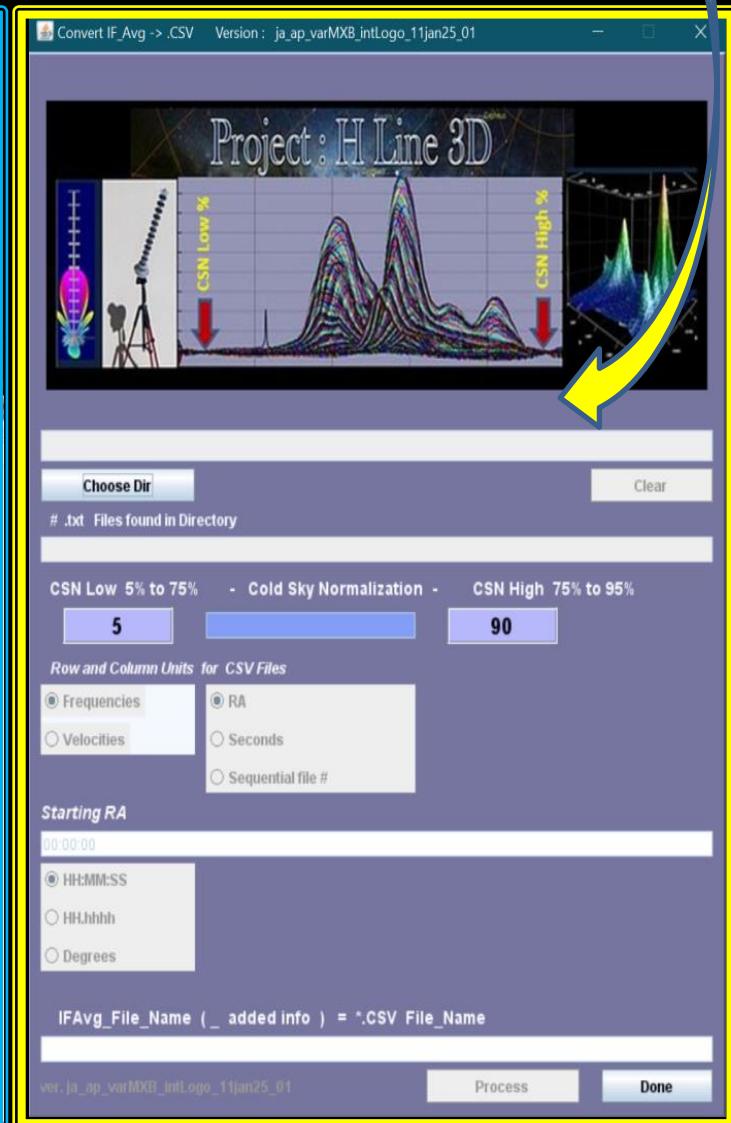
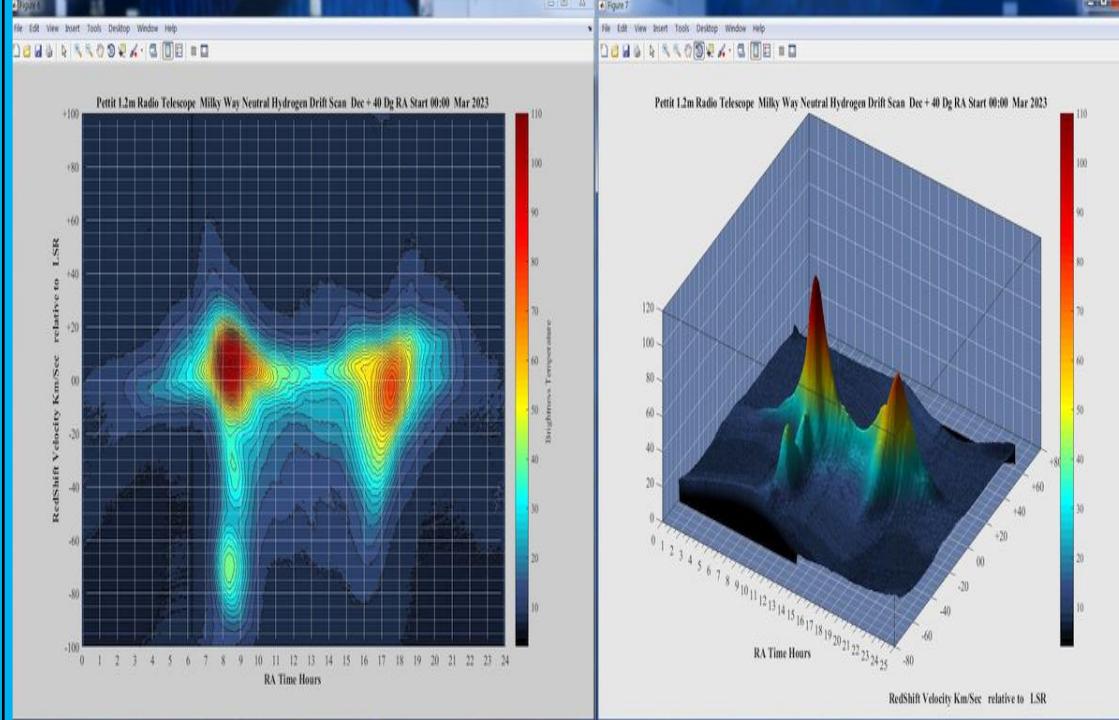
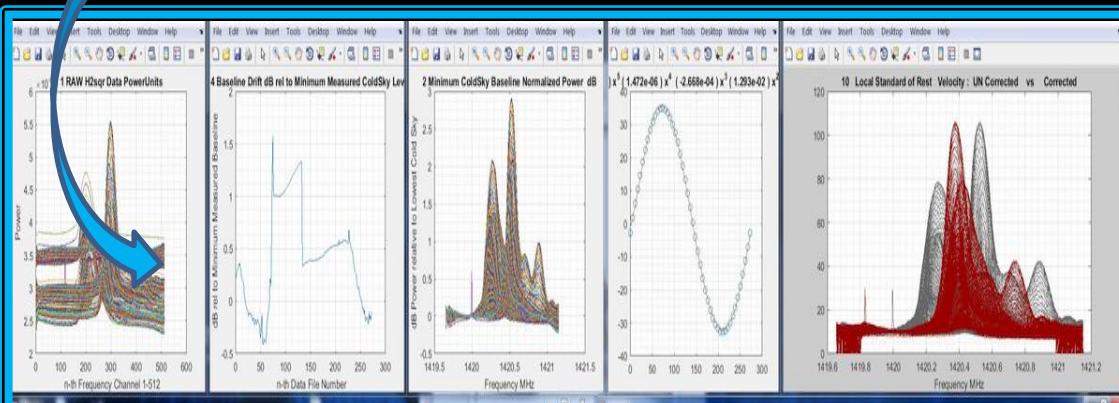
- 1) *AirSpy SDR# Studio*
- 2) *Kaminski IF_Average*
- 3) ***HLine3D Processing***
- 4) ***Rinearn 2D 3D Graphics***



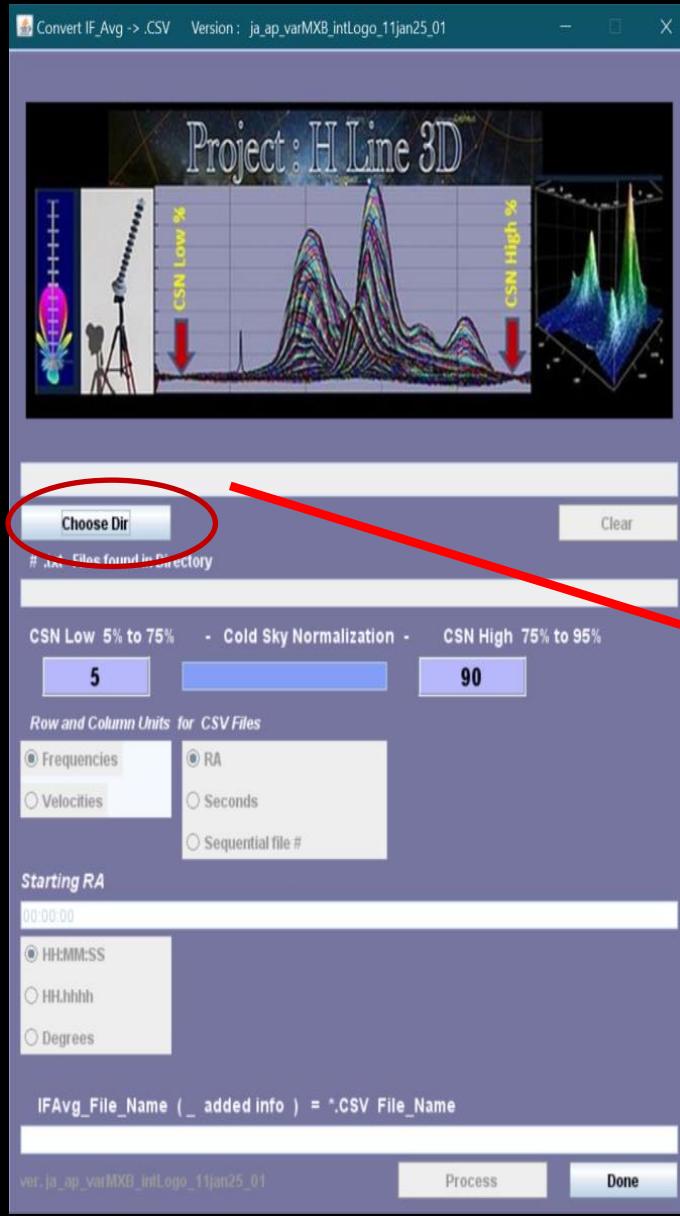
Software :

*for Spectral Processing & File Conversion based on
Matlab Code developed ~ 5 years ago*

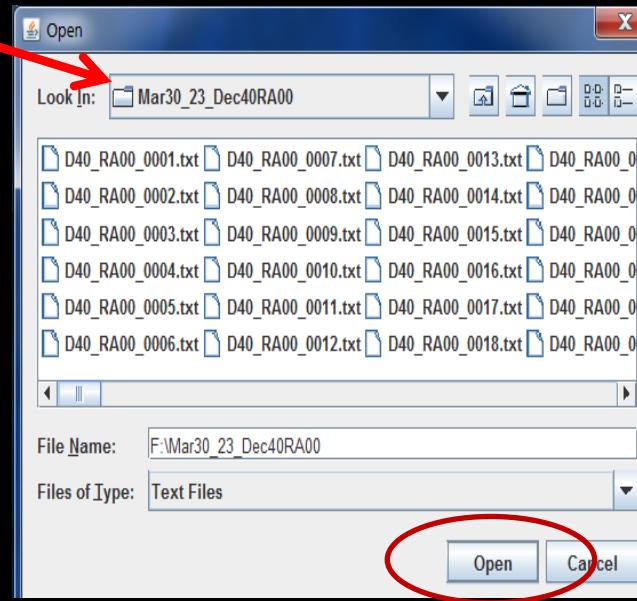
HLine3D JAVA executable



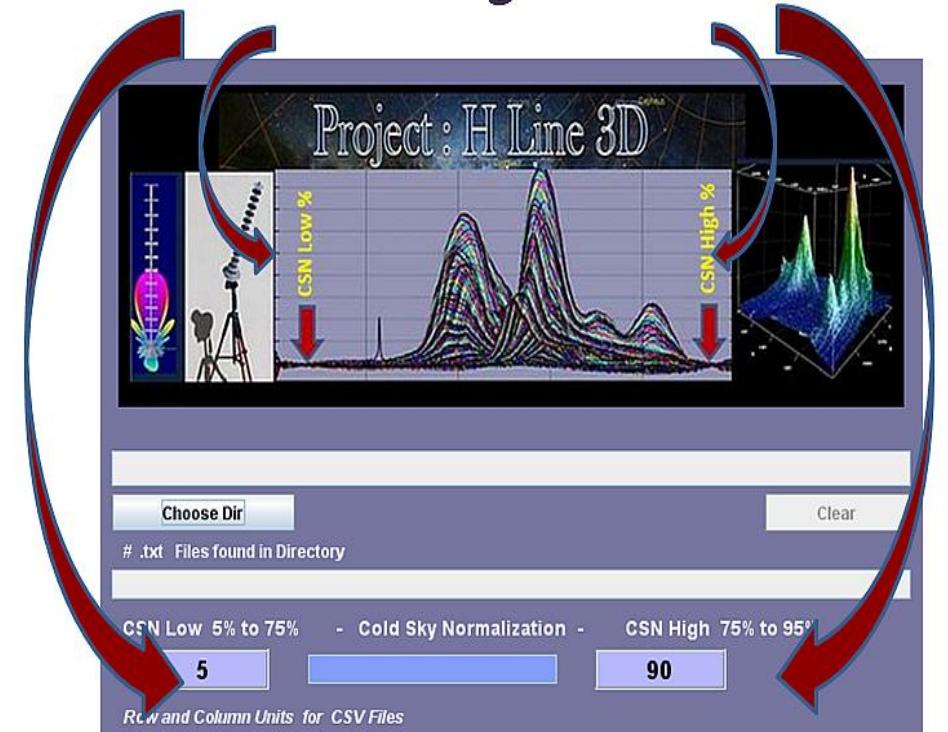
JA_IFAvg2CSV.jar Processing Software Guide



1) Select 'Choose Dir', Fileset and 'Open'

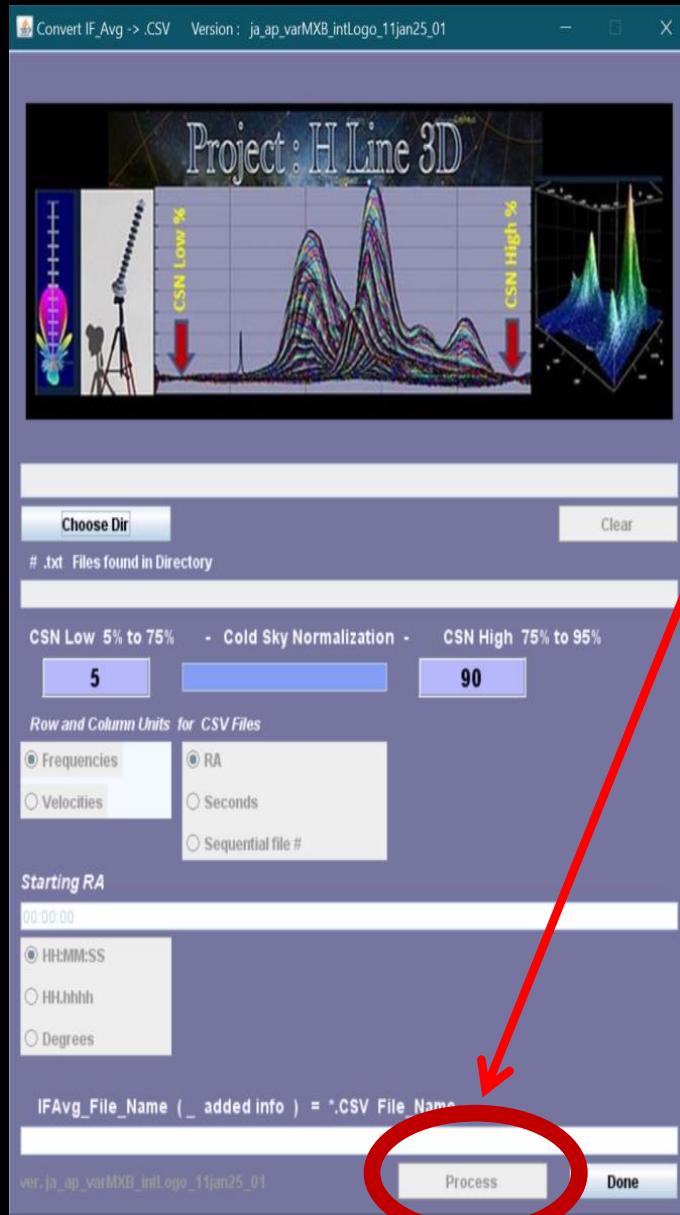


*2 point Cold Sky Normalization
 $mx + b$ 2 pt dataset correction
set low and high % values*



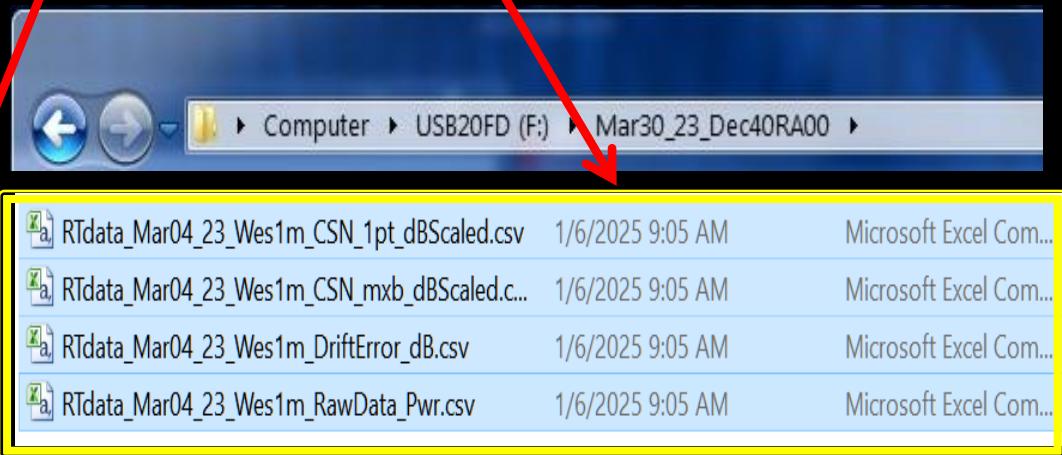
**2) Enter %Low and %High Frequencies
for
Cold_Sky_Normalization (CSN)**

JA_IFAvg2CSV.jar Processing Software Guide



3) Press PROCESS

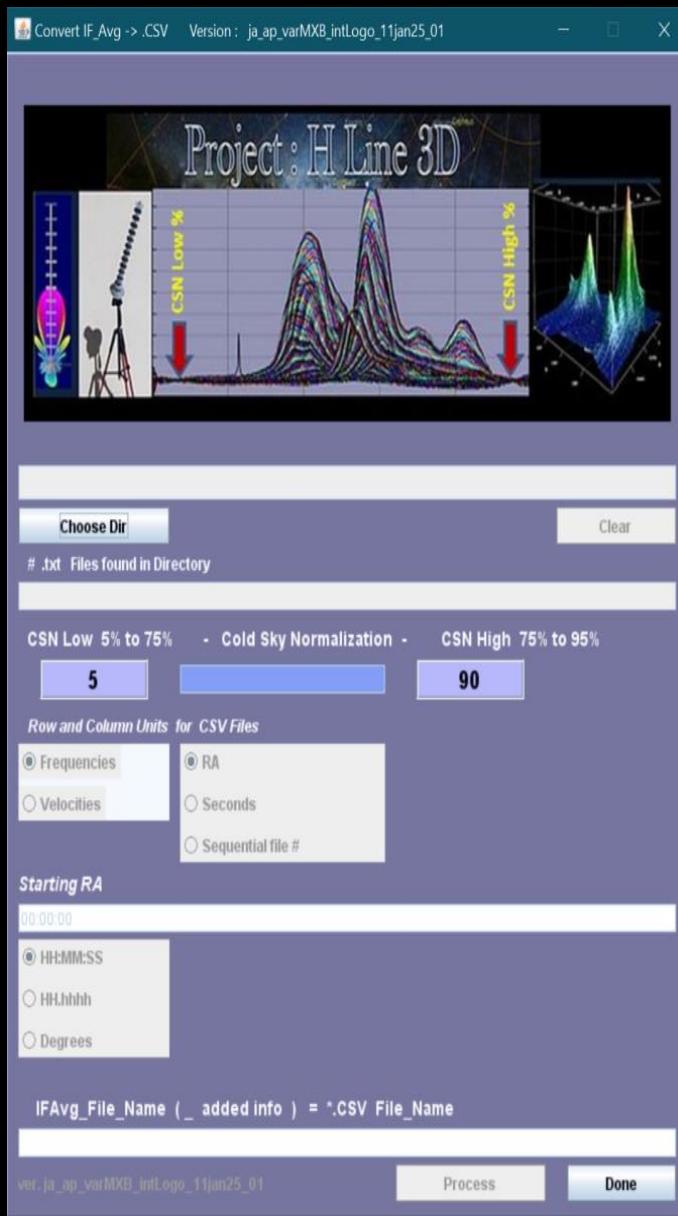
*.CSV files written to original Fileset Directory



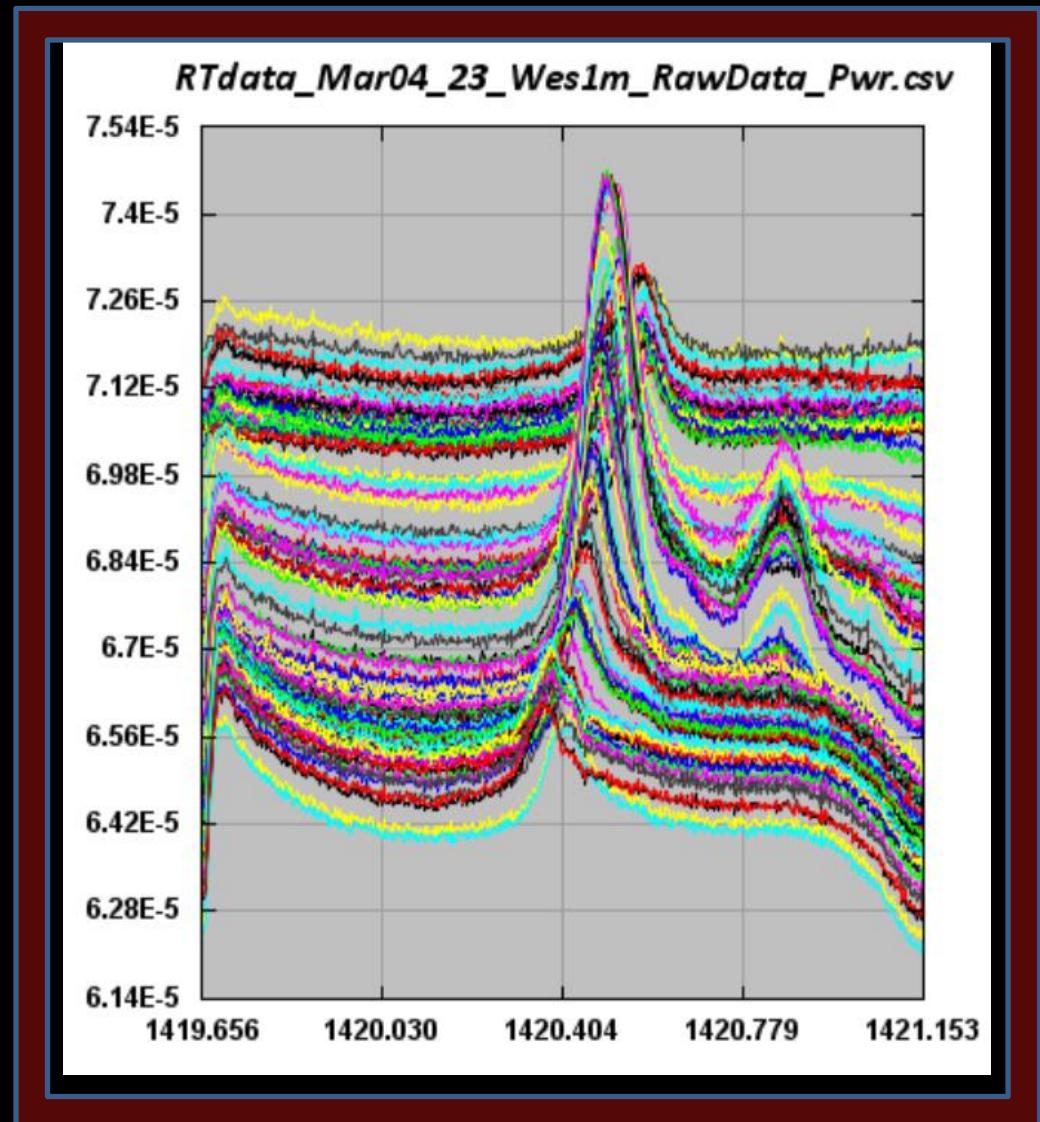
Task Completion Verification



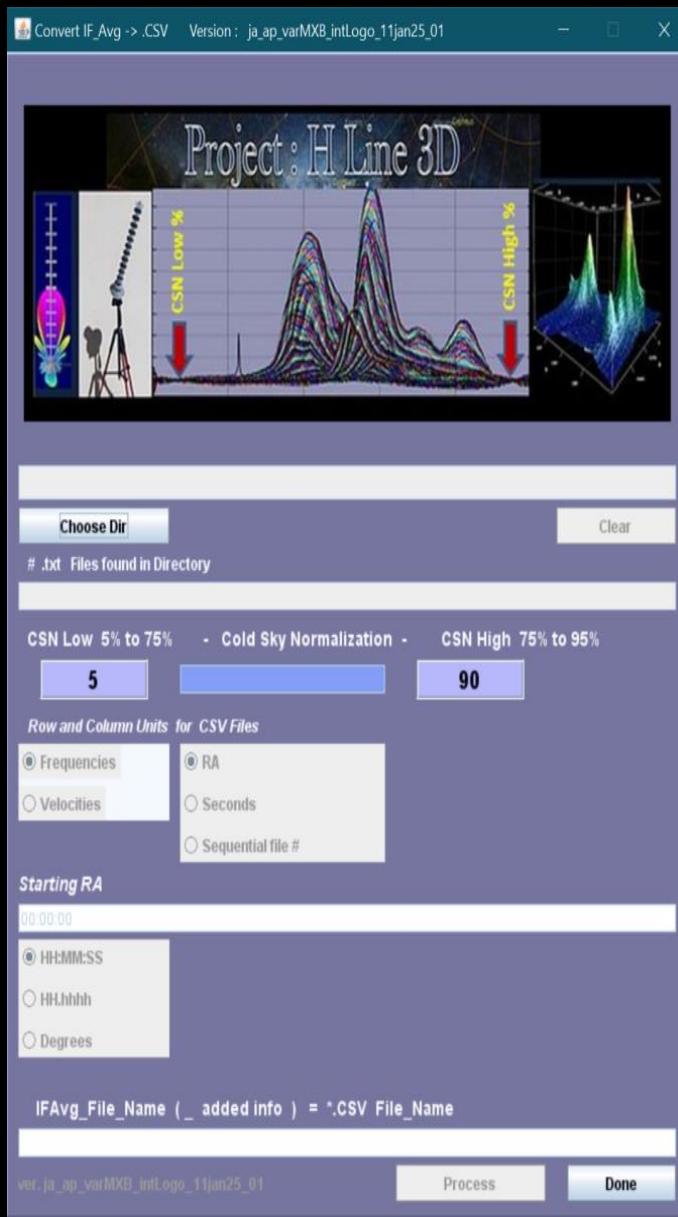
JA_IFAvg2CSV.jar Processing Software Guide



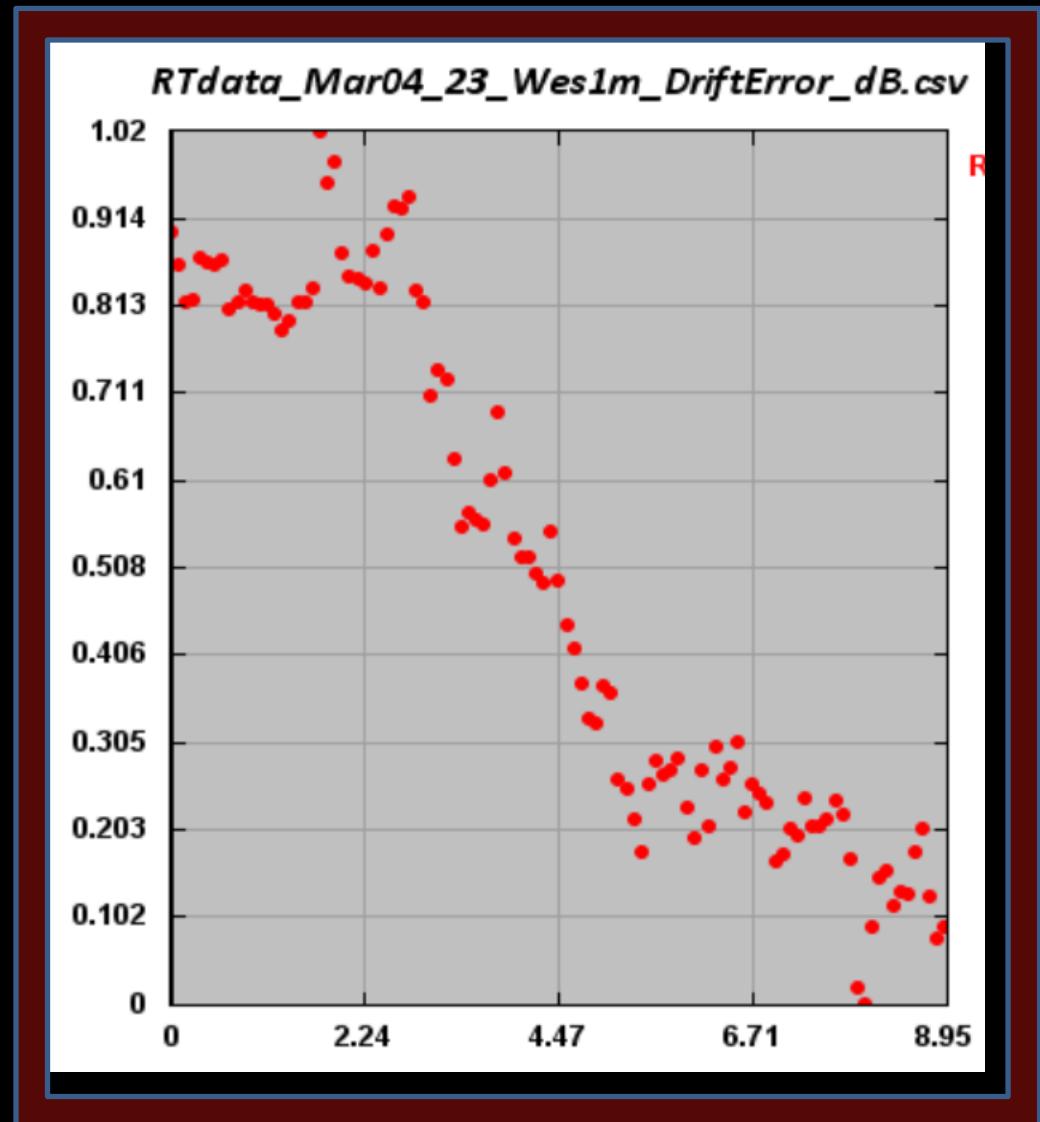
1) Raw Uncorrected Data containing frame to frame drift



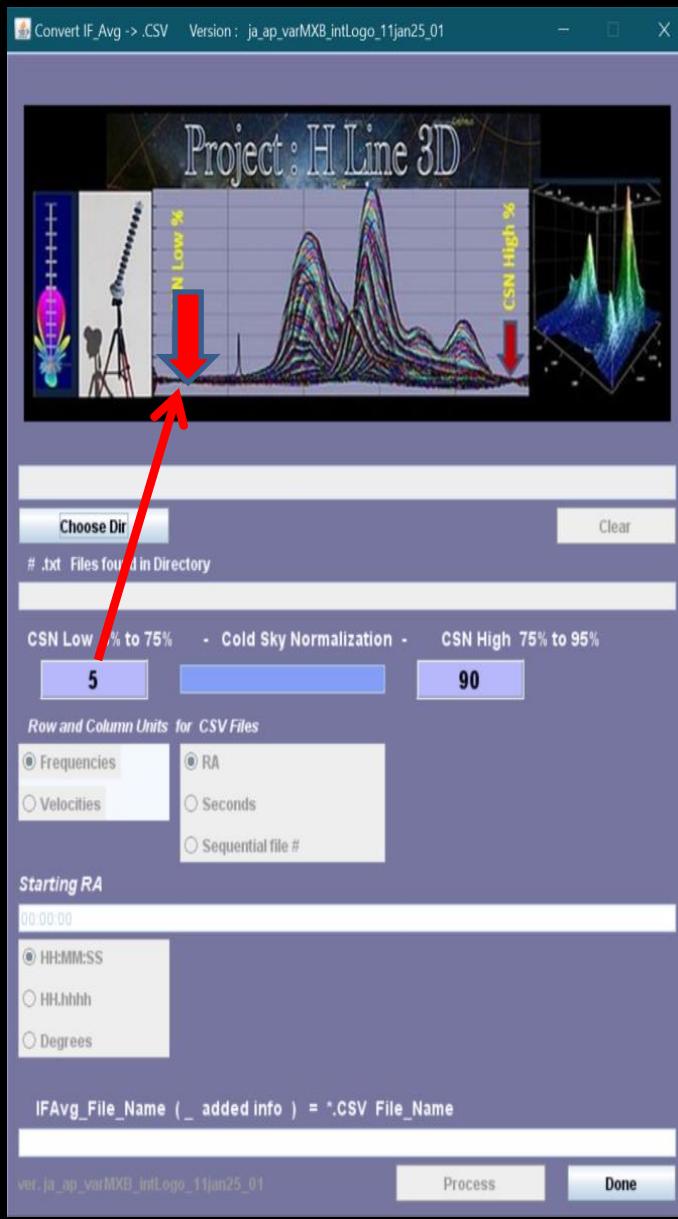
JA_IFAvg2CSV.jar Processing Software Guide



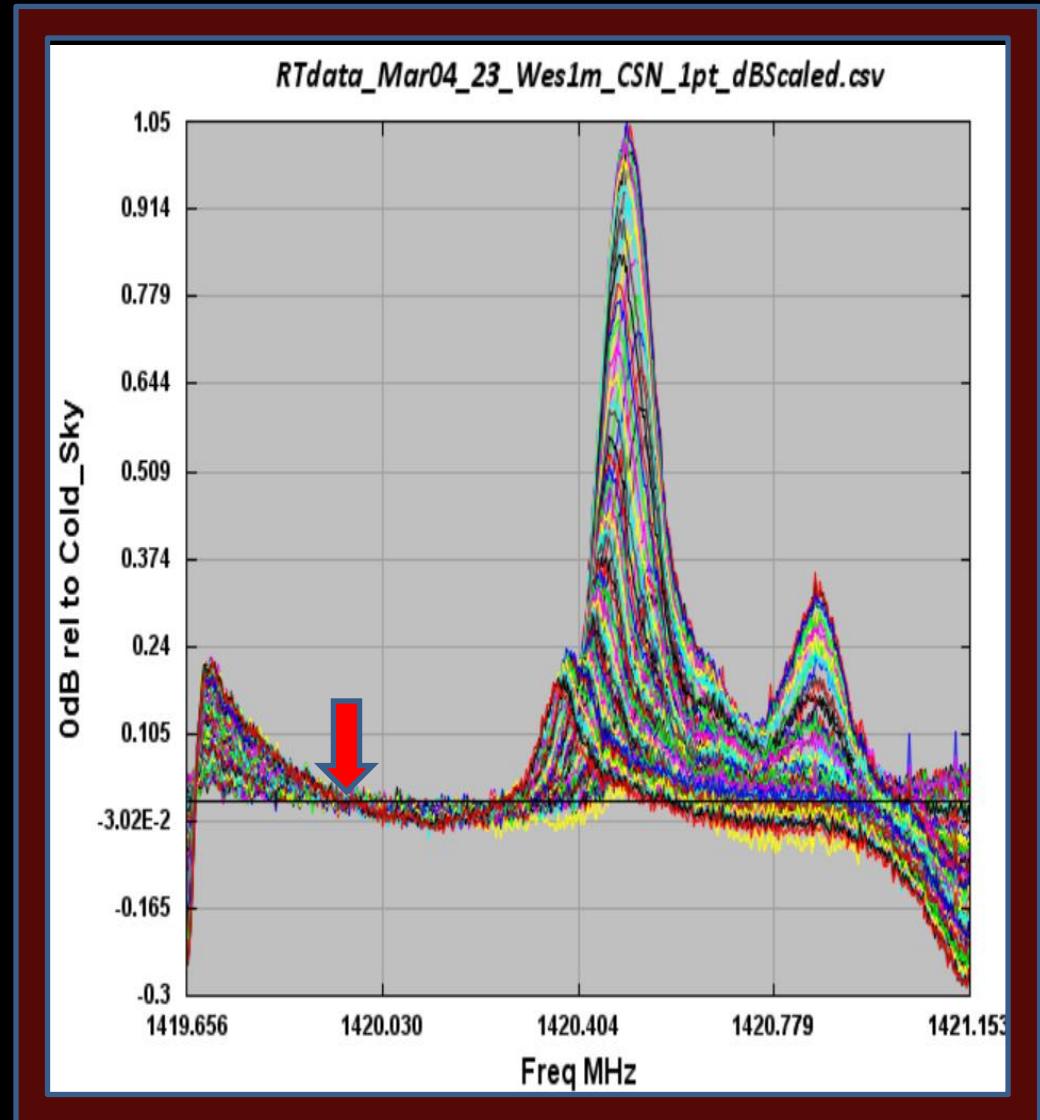
2) Frame to Frame Drift X axis = Hours of Time



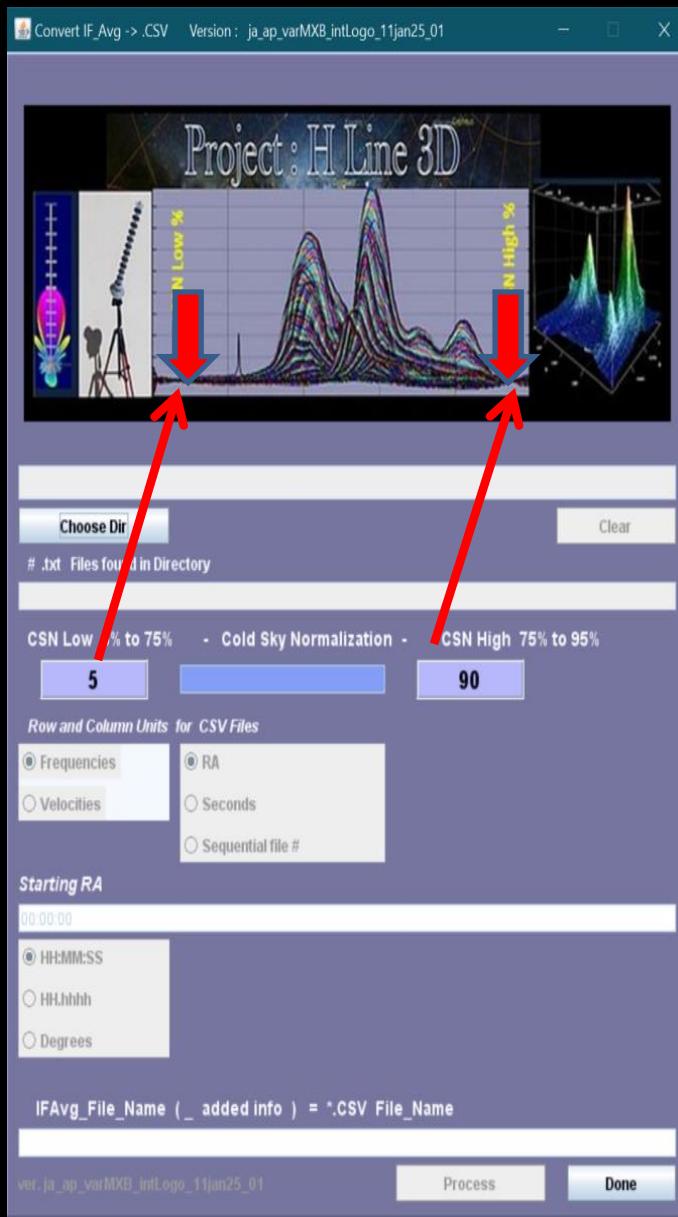
JA_IFAvg2CSV.jar Processing Software Guide



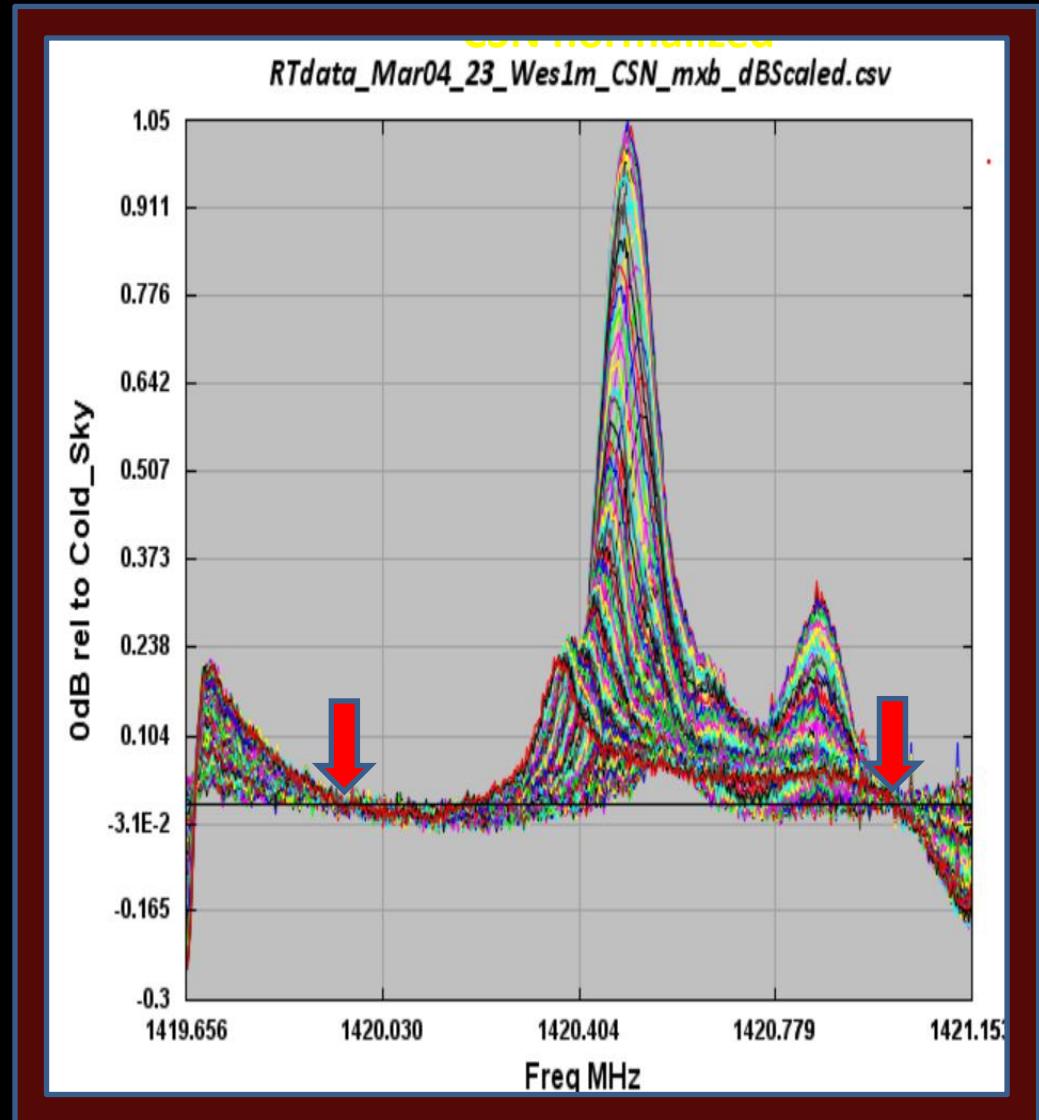
3) 1pt %Low Single CSN normalized



JA_IFAvg2CSV.jar Processing Software Guide



4) 2 pt %Low and %High
mx+b



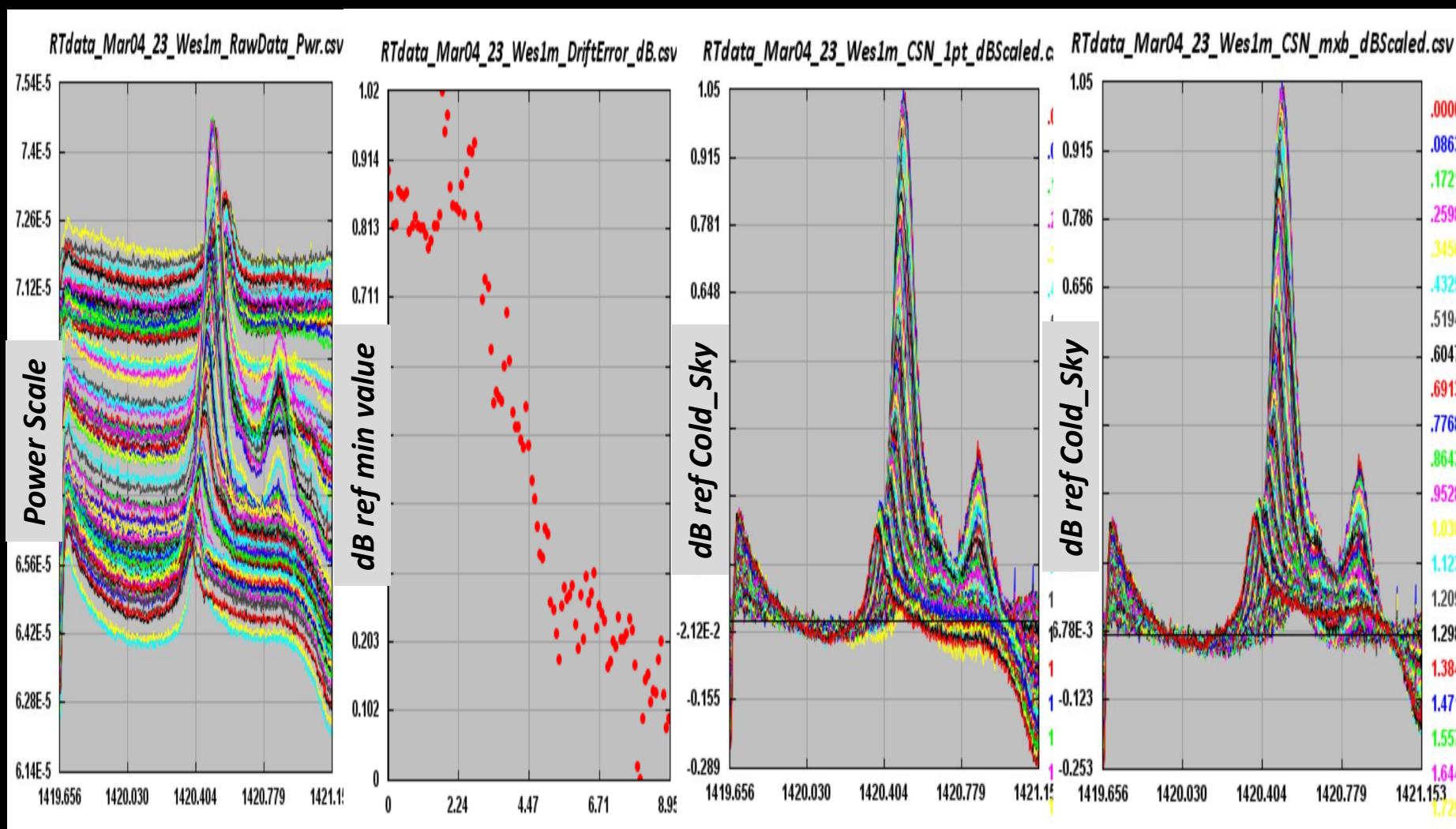
JA_IFAvg2CSV.jar Processing Workflow

1) Raw Data containing frame to frame drift

2) Frame to Frame drift
X axis Hours of Time

3) %Low 1pt
CSN normalized

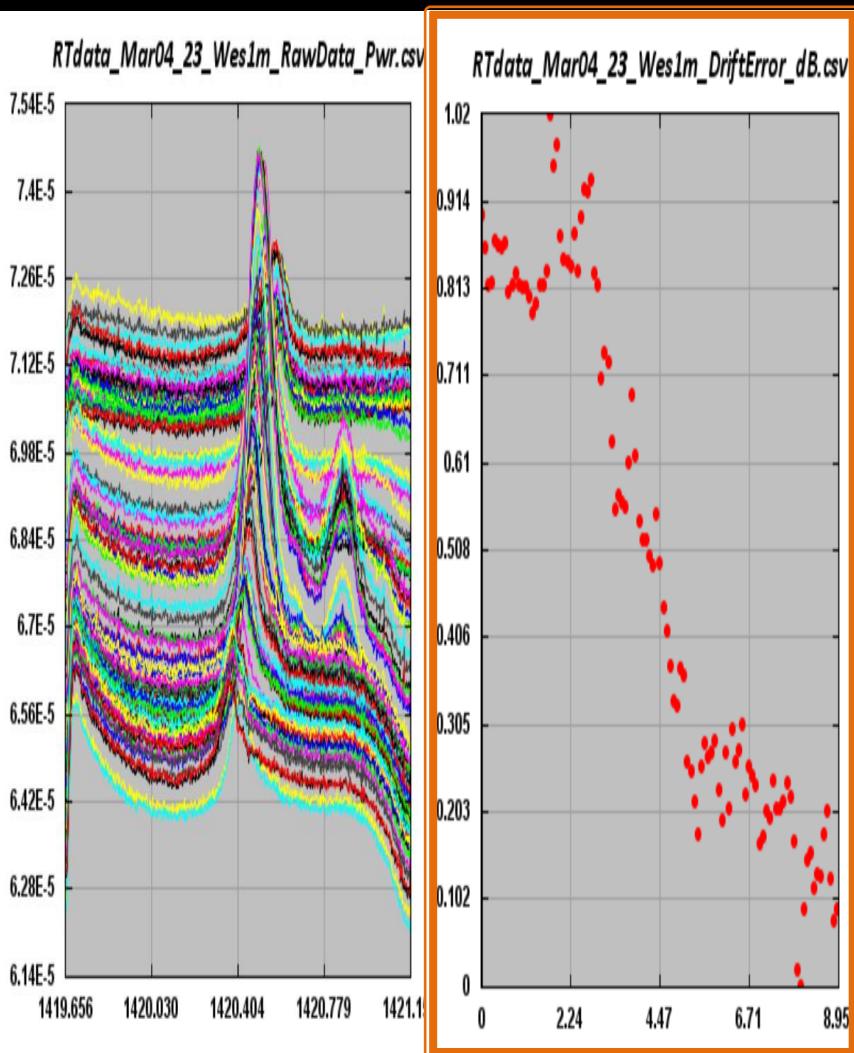
4) %Low and %High 2pt mx+b
CSN normalized



JA_IFAvg2CSV.jar Processing Workflow

Measuring / Quantifying Drift Changes / Shifts in Data

During the time period in which spectral data is being acquired,
many factors may cause an overall background level shift ...

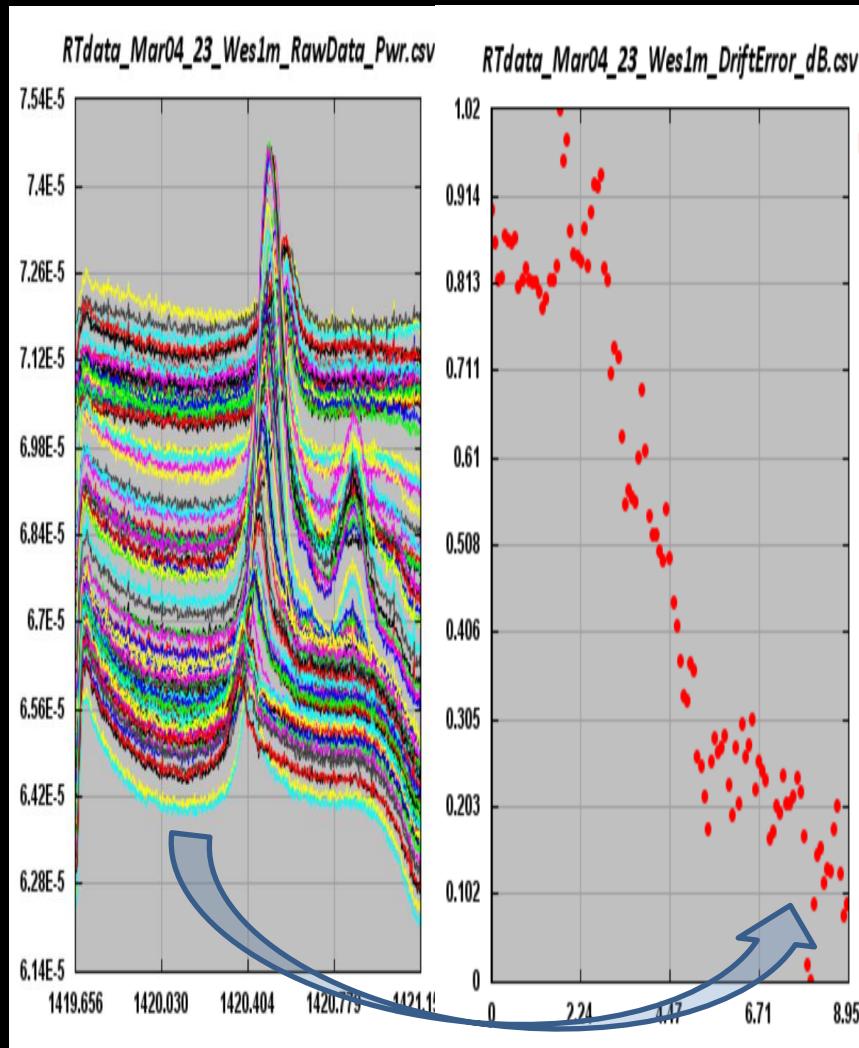


- 1) **Atmospheric Transparency**
- 2) **Sunlight Spillover** (gradual change)
being received in the antenna's beam side-lobe patterns or being reflected off nearby vegetation (trees, buildings, bushes)
- 3) **Temperature Changes** (gradual change)
in the surrounding environment or heating of the antenna and electrical components
- 4) **LNA Gain Changes** (gradual change)
The nooelec SAWBird H1 LNA has a thermal amp gain drift of only -0.1 dB / +10 dgC
- 5) **Attenuation Loss Shifts** (fast steps)
due to oxidized or loose connections changing conductivity with time / temperature

The corrections are considered changes in noise level and the drift is **subtracted from** the data referenced to the lowest value rather than **divided by** as would be done for correcting amplifier gain change.

JA_IFAvg2CSV.jar Processing Workflow

“Cold Sky Normalization” 1 pt Background Drift Correction



The Background Drift can be measured and plotted.

Step #1 Specify a small frequency range lower than any Hydrogen Line data with which to ‘Normalize’ the Drift
This can be considered the “Cold Sky” Background

Step #2 Find the spectrum with the Lowest Amplitude at that range and use it as the Drift Correction Reference.

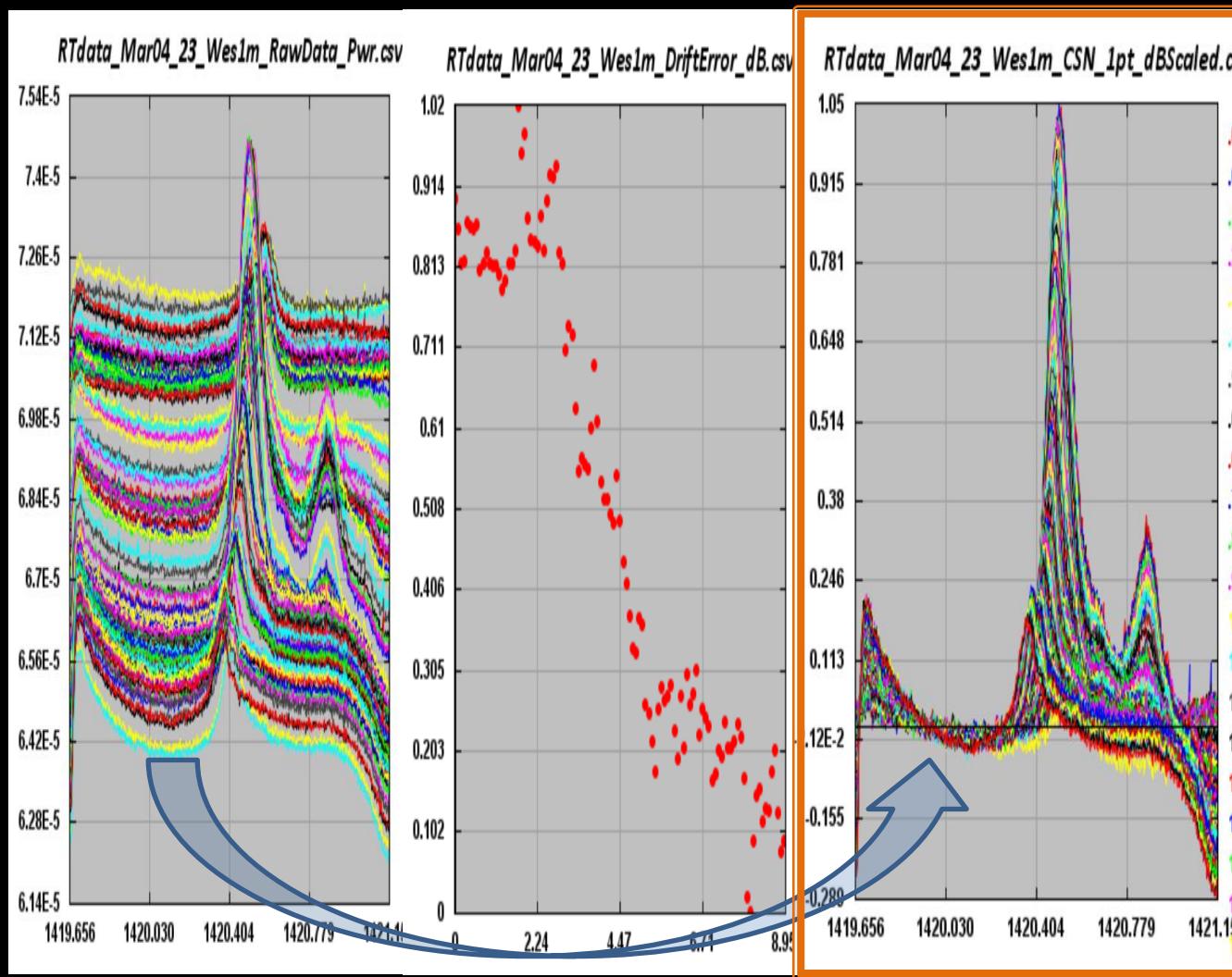
Step#3 For each spectra, calculate the difference in amplitude between its average value over the drift correction frequency range and the Reference, and subtract that from all values in that spectrum

Step#4 Repeat that for each of the spectra.

Lowest Amplitude = Drift Correction Reference

JA_IFAvg2CSV.jar Processing Workflow

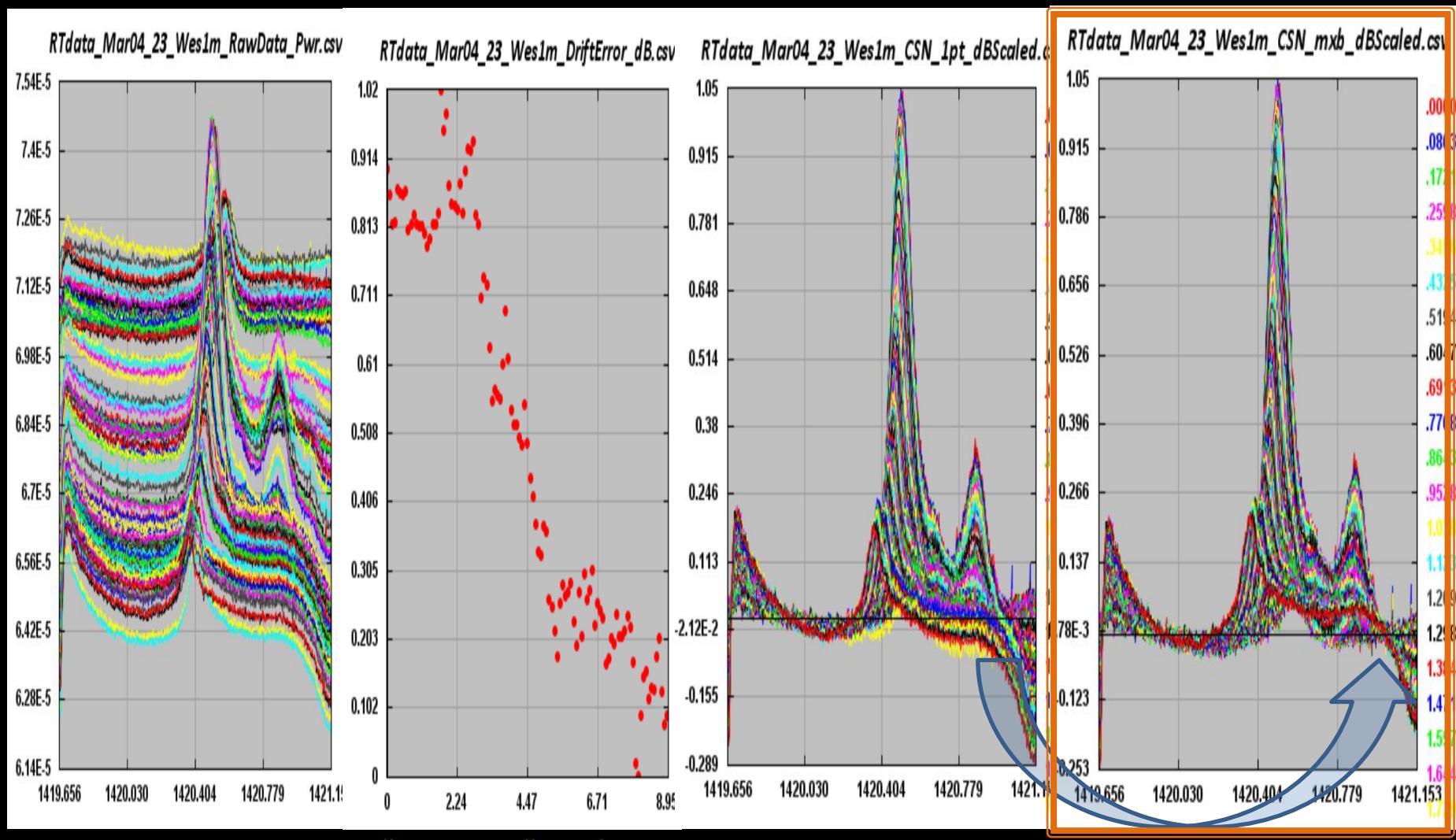
“Cold Sky Normalization” 1 pt Background Drift Correction



“Cold-Sky” Drift Corrected Spectrum Set

JA_IFAvg2CSV.jar Processing Workflow

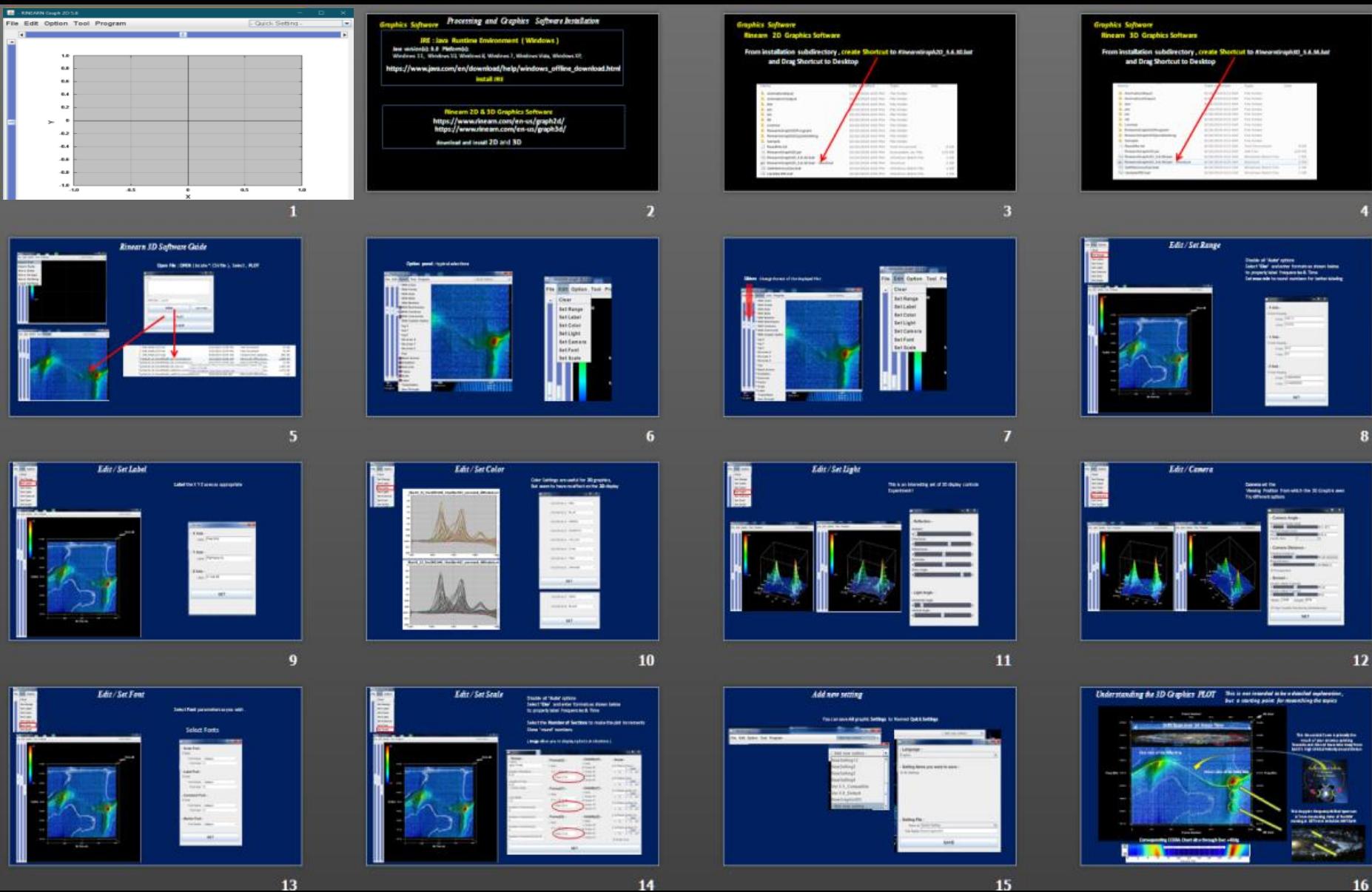
“Cold Sky Normalization” 2 pt mx+b Background Drift Correction



“Cold-Sky” Drift Corrected Spectrum Set

Rinearn (2D) & 3D Graphics Software Guide

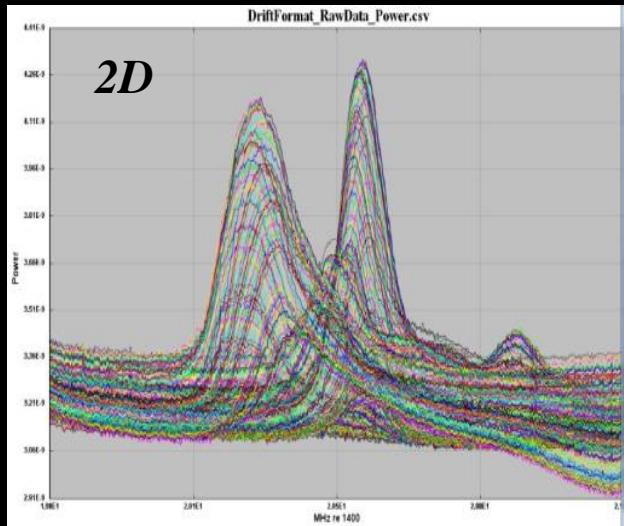
Rinearn Graphics step-by-step menu Processing Workflow



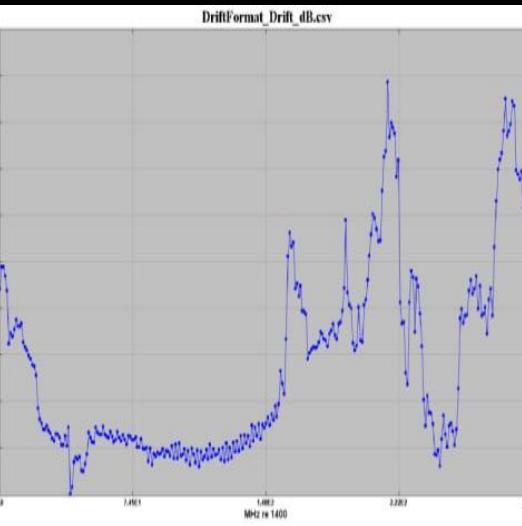
Rinearn 2D & 3D Graphics Software Guide

2D

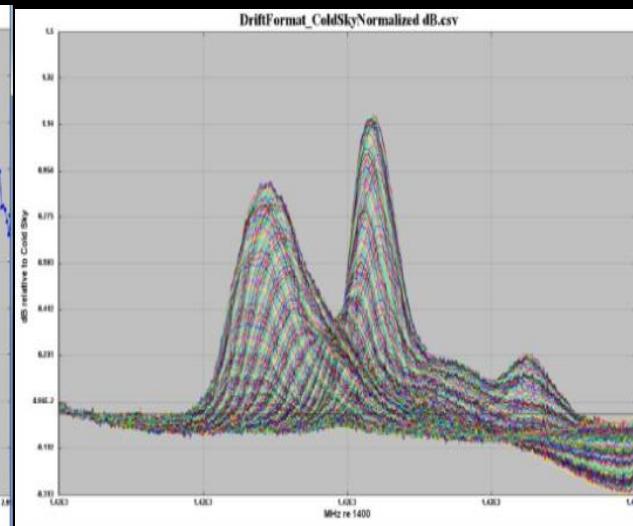
Raw Data Spectrum Set



Background Drift

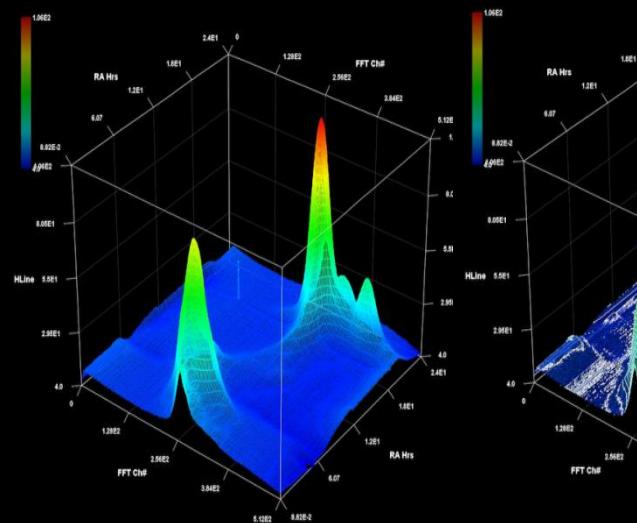


Corrected Data Normalized to Cold Sky in dB

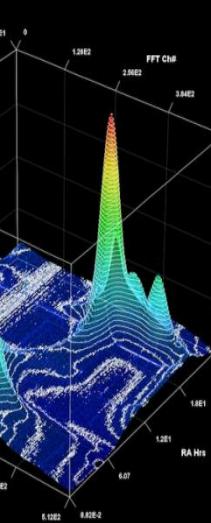


3D

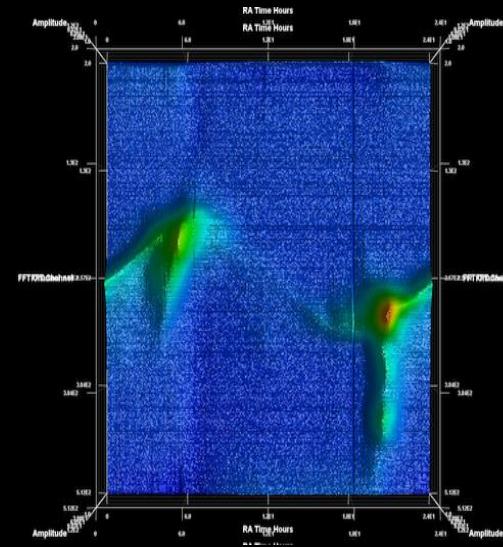
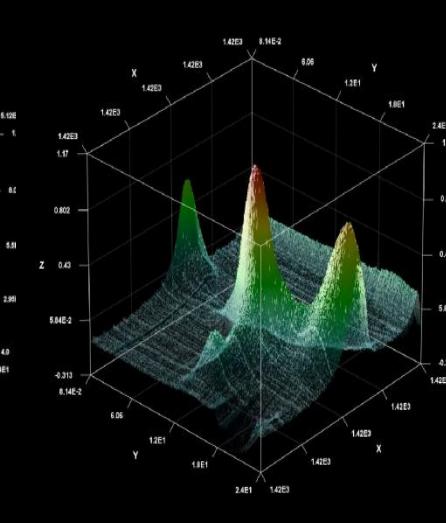
H_Line Data Set



24 Hour Drift Scan

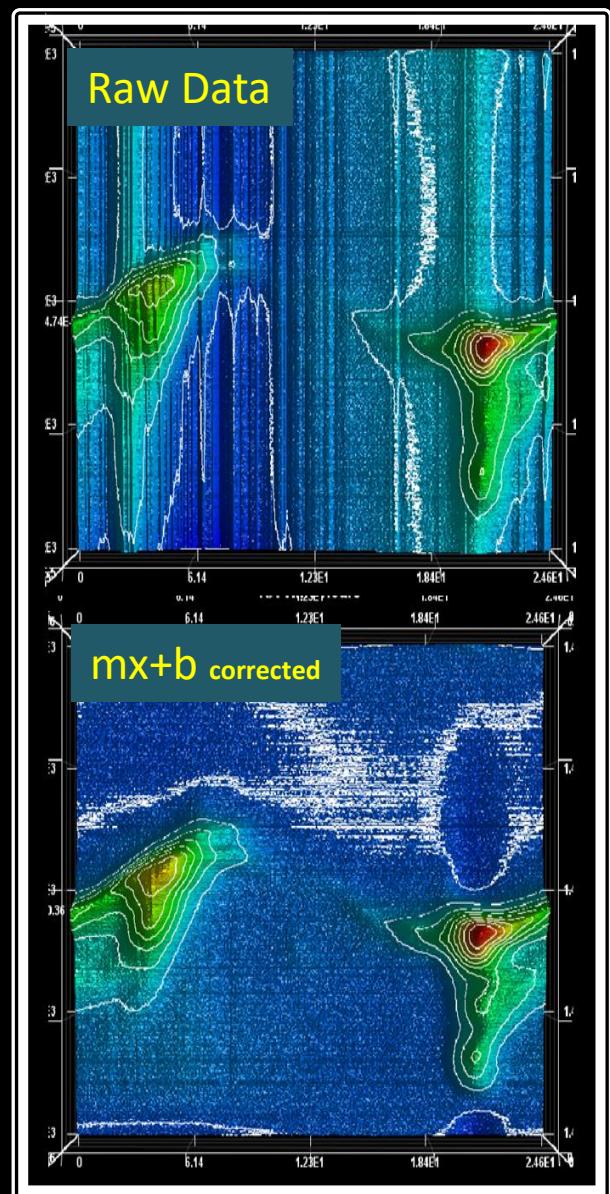


@ Declination + 40°

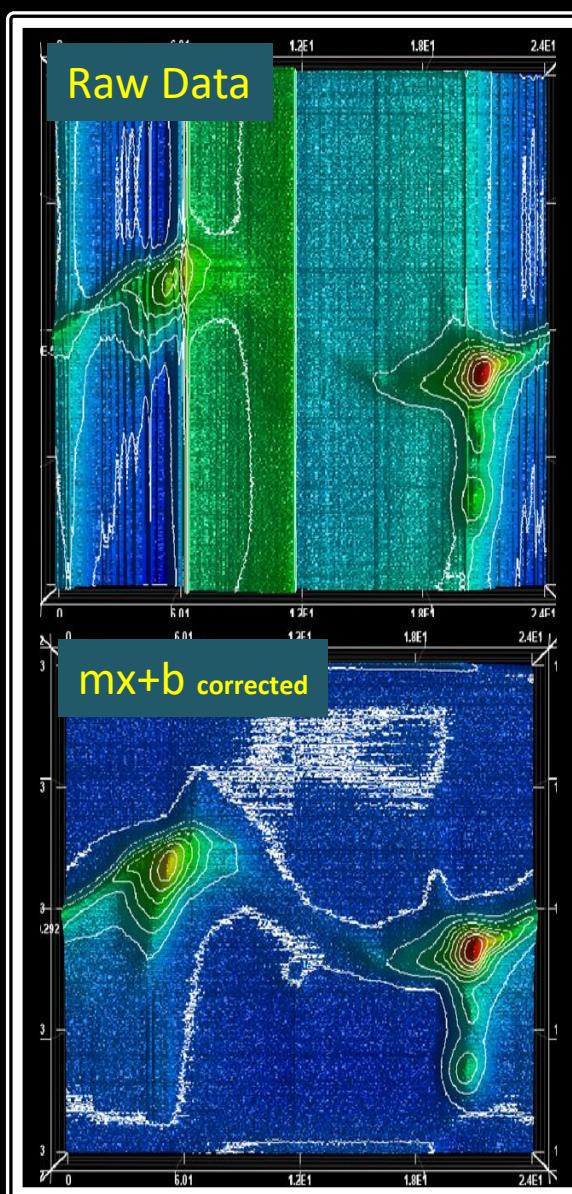


Examples : *Raw* & *2 pt mx+b Cold_Sky_Normalization Corrected*

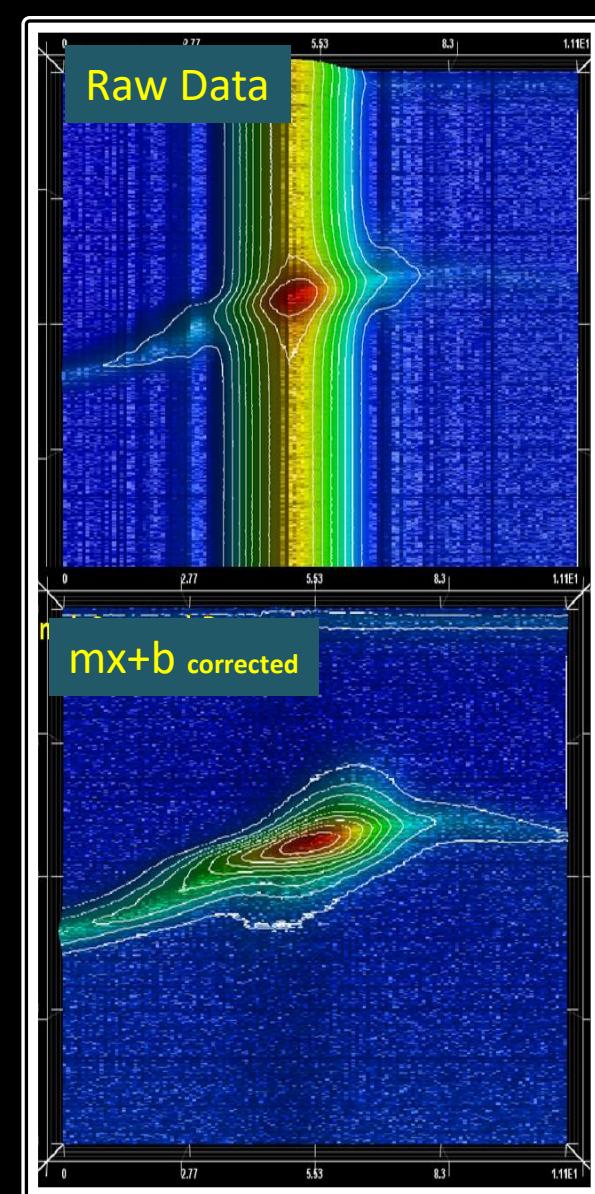
PRT 1.2m Dish “~ normal data”



PRT 1.2m Dish added plastic sheet dew shield @ 5-10 hrs

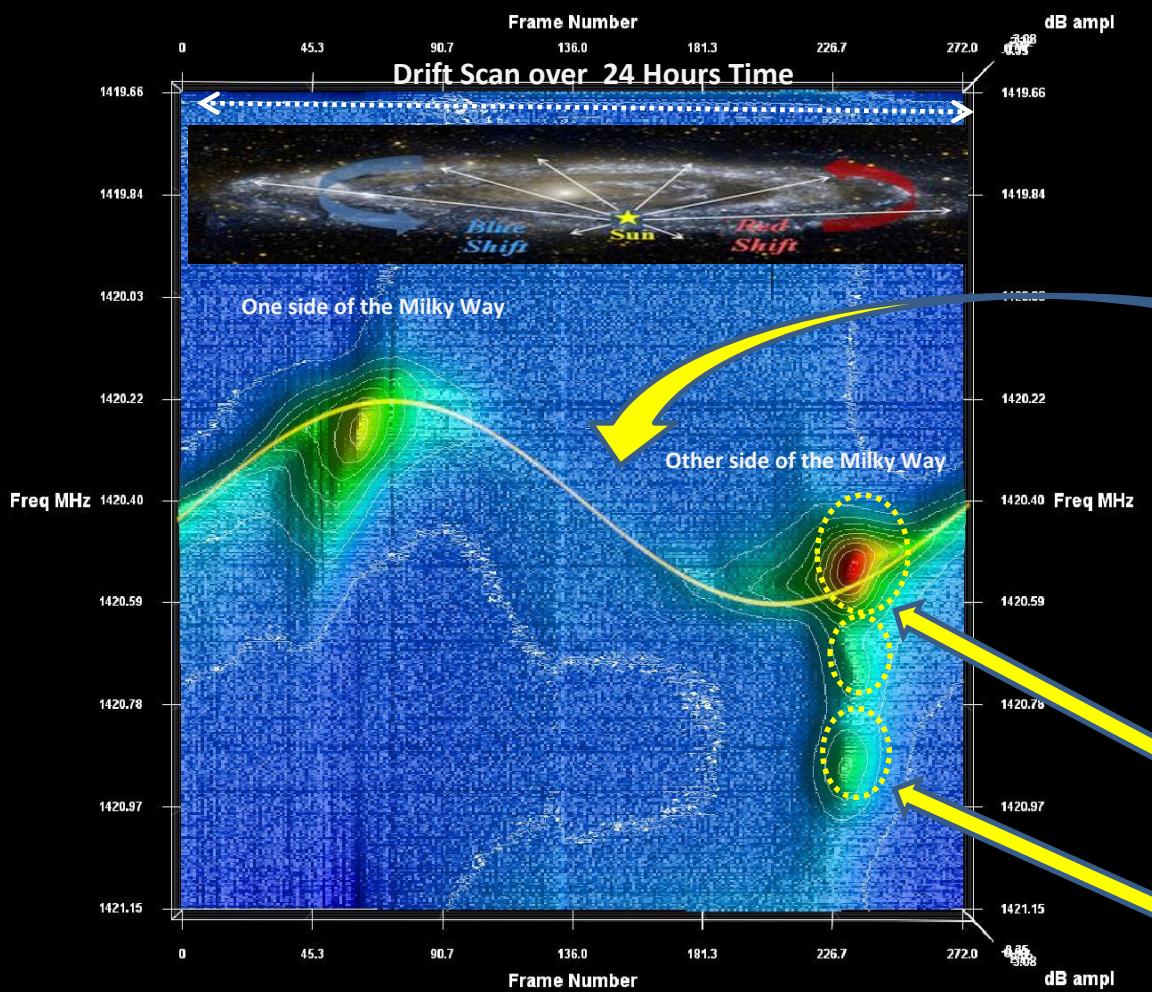


0.75m Disk Yagi high Sun noise bleedover into side lobe



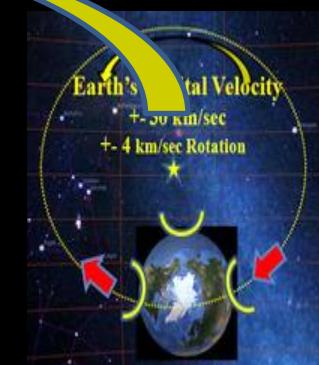
Understanding the 3D Graphics PLOT

This is not intended to be a detailed explanation, but a starting point for researching the topics



This Sinusoidal Curve is primarily the result of your antenna pointing

Towards and then 12 hours later Away From Earth's high Orbital Velocity around the Sun (~ 40 km/sec)



This Doppler Frequency Shifted Spectrum is from measuring Arms of the MW moving at Different Velocities WRT Earth



Project : H Line 3D

