

# re-discover radio







# ▪ SDR Advances and the Future of SDR



April 18, 2015  
Phil Theis, K3TUF

▪ Engineering, PennSun Solar



# SDR Advances

## Agenda

- ▶ What is an SDR?
- ▶ New Technologies in SDR
  - ▶ Direct Sampling
- ▶ SmartSDR Architecture
  - ▶ Networking
  - ▶ CESSB
- ▶ Wide and Narrow simultaneously



# Is this radio an SDR?

- ▶ Modulation: FM Only
- ▶ Change Controls? No
- ▶ Change Functions? Yes
- ▶ User programmable? Yes
- ▶ Software controlled? Yes





# Is this radio an SDR?

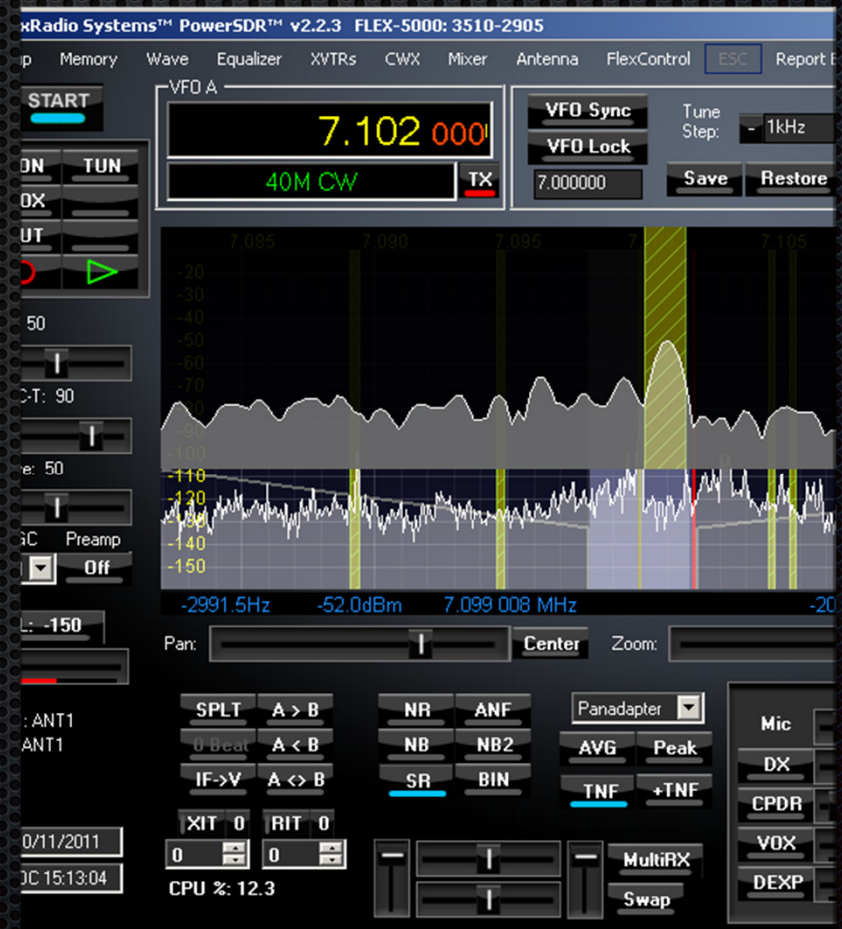
- ▶ Modulation: Fixed set
- ▶ Change Controls? No
- ▶ Change Features?  
Theoretically...
- ▶ User programmable? No
- ▶ Software controlled? Yes





# Is this radio an SDR?

- ▶ Modulation: expandable
- ▶ Change Controls? Yes
- ▶ Change Features? Yes
- ▶ User programmable? Yes
- ▶ Software controlled? Yes





# What is *Software Defined*?

- ▶ Modulation using software, changeable YES
- ▶ Digital Signal Processing in software YES
- ▶ Control Surface Reconfigurable YES
- ▶ Can add new feature with new control YES
- ▶ Radio controlled by software YES



# Yes, yes, but: BENEFIT?

- ▶ What has SDR done for you lately?
  - ▶ New mode?
  - ▶ New feature?
  - ▶ New controls?
  - ▶ New capabilities?
- ▶ If not, who cares if it's called SDR?





# RF Tracking Notch Filter™



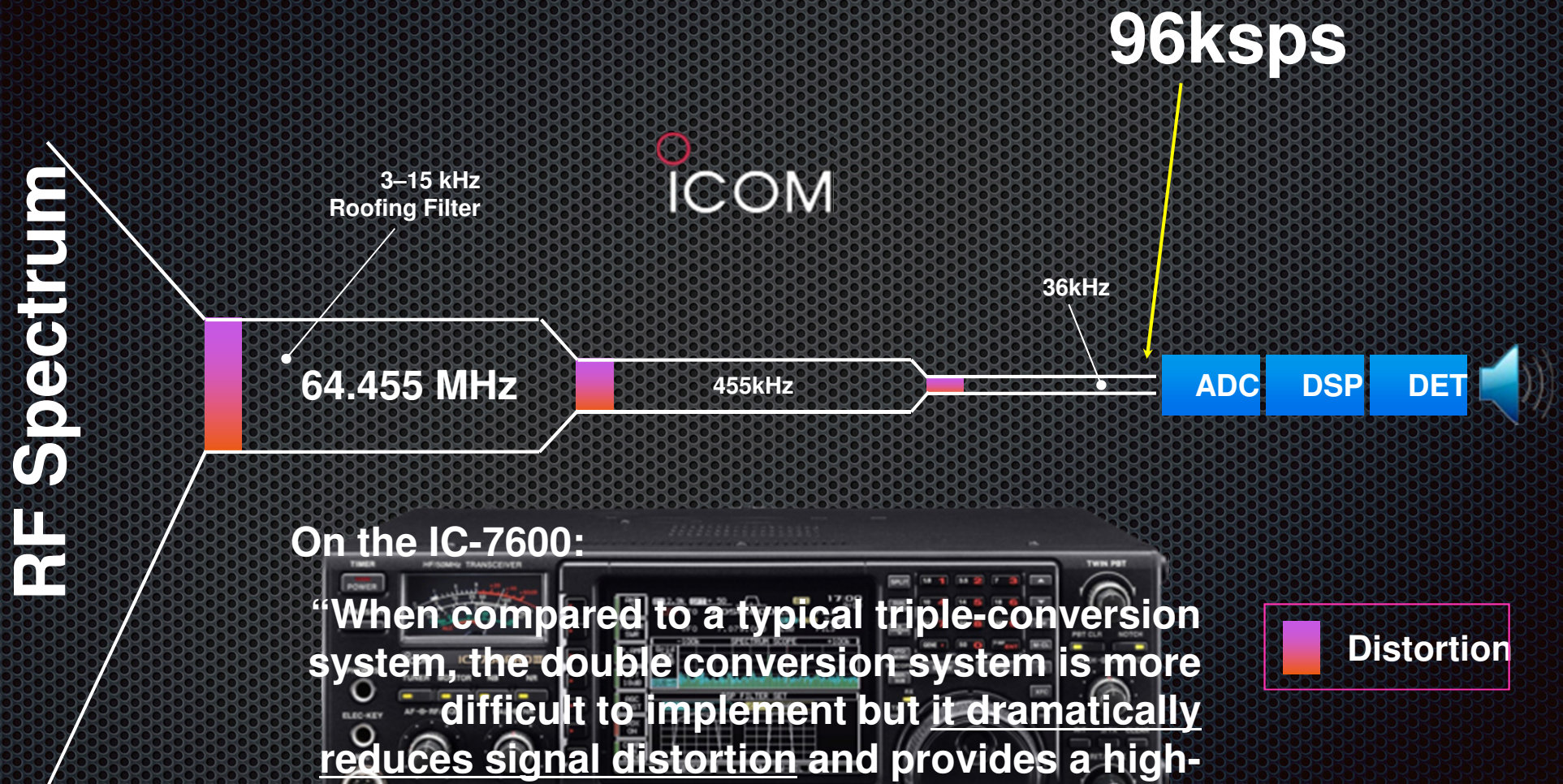


# Radio RF/IF Architectures

- ▶ Multi-conversion a.k.a. superheterodyne
  - ▶ Your car radio, your TV, any older scanner you have
  - ▶ Most every Kenwood, Icom, Ten-Tec, Elecraft and Yaesu on the market today
- ▶ Direct Conversion
  - ▶ FLEX-5000, FLEX-3000, FLEX1500, Elecraft KX3
- ▶ Direct Sampling a.k.a wideband
  - ▶ FLEX-6000, HPSPDR



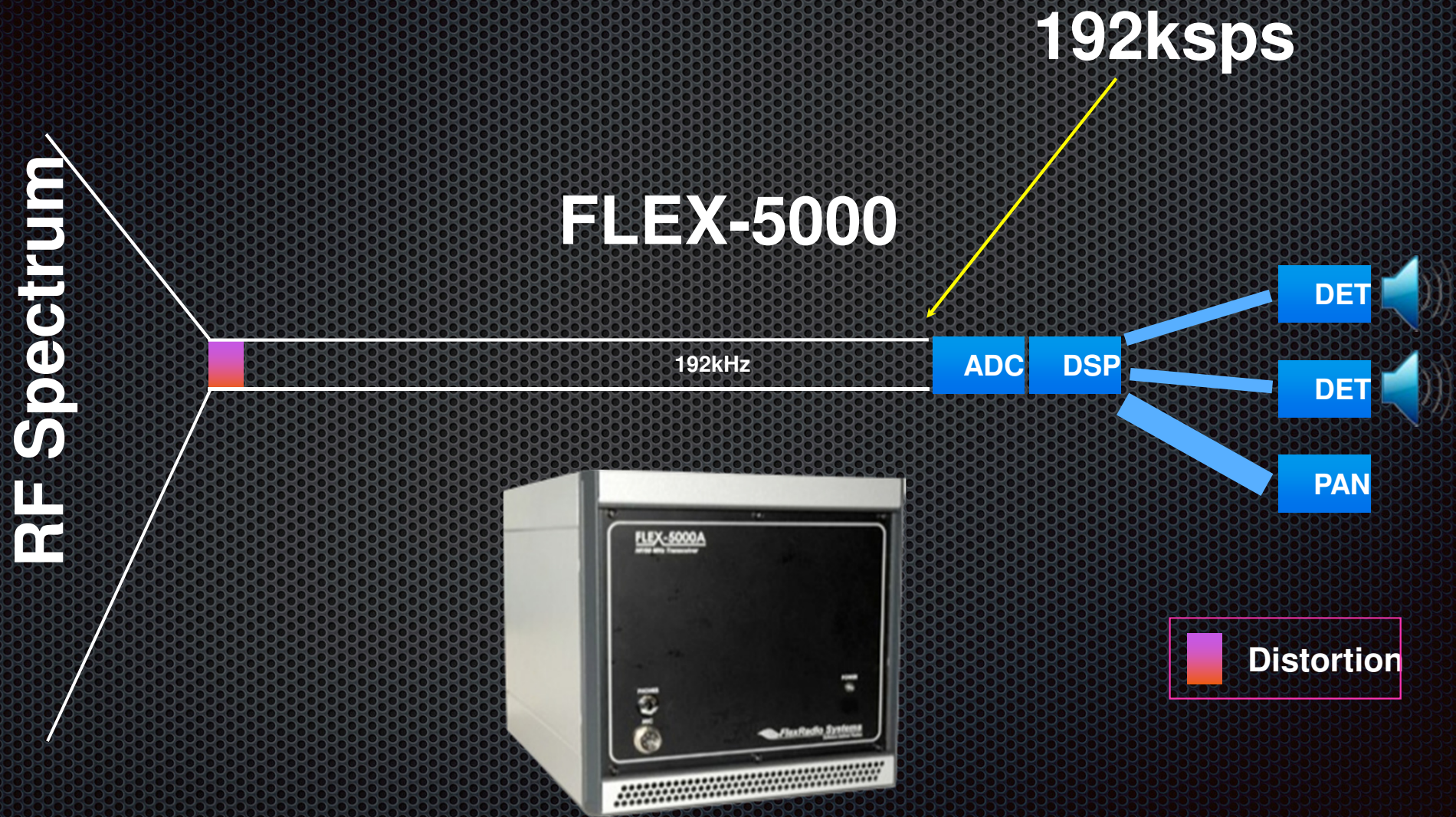
# Multi-Conversion



— Icom America website



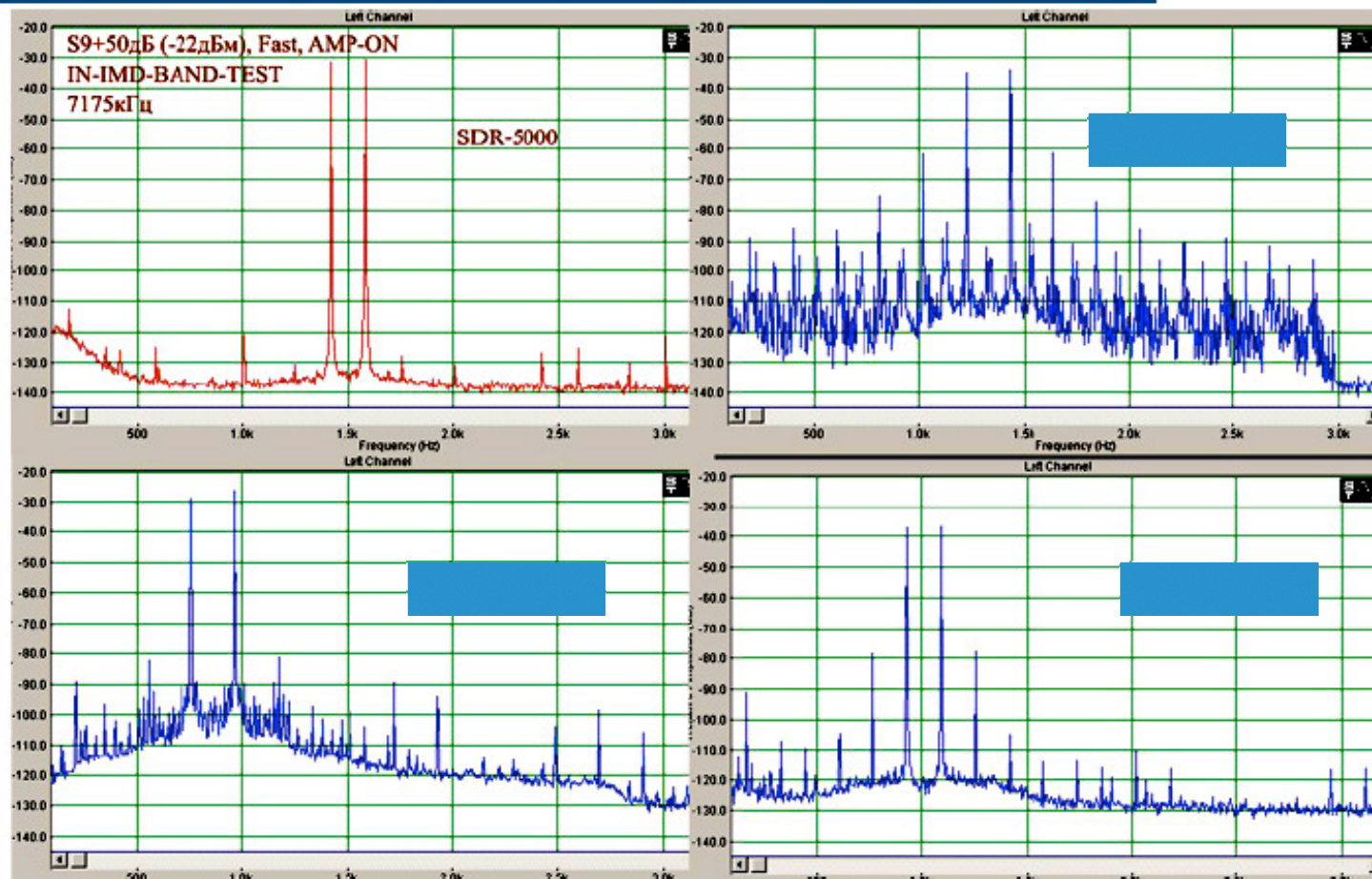
# Direct Conversion





# Sherwood Engineering

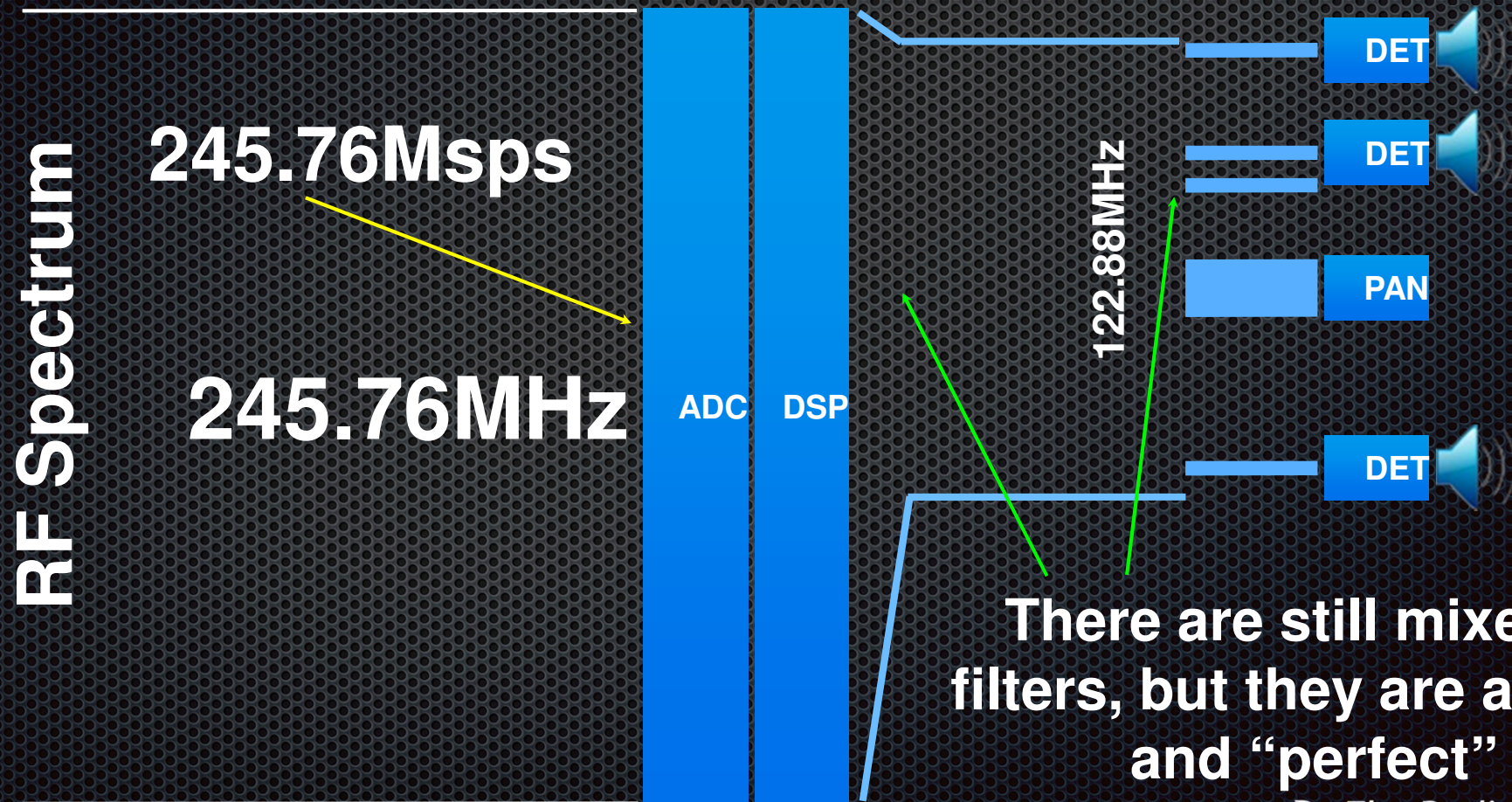
## Data from UR5LAM on 4 Transceivers





# Direct Sampling

## FLEX-6000





# Direct Sampling Benefits

- + Distortion minimized (ADC @ antenna): best signal clarity
- + n-Receivers, n-Panadapters and varying widths see more bands, more receivers
- + Extremely high dynamic range: operate in worst conditions
- + Extreme flexibility through reprogrammability (*ultimate* SDR): future benefits
  - Technically challenging to design



**We are called to be  
the architects of the future,  
not it's victims**

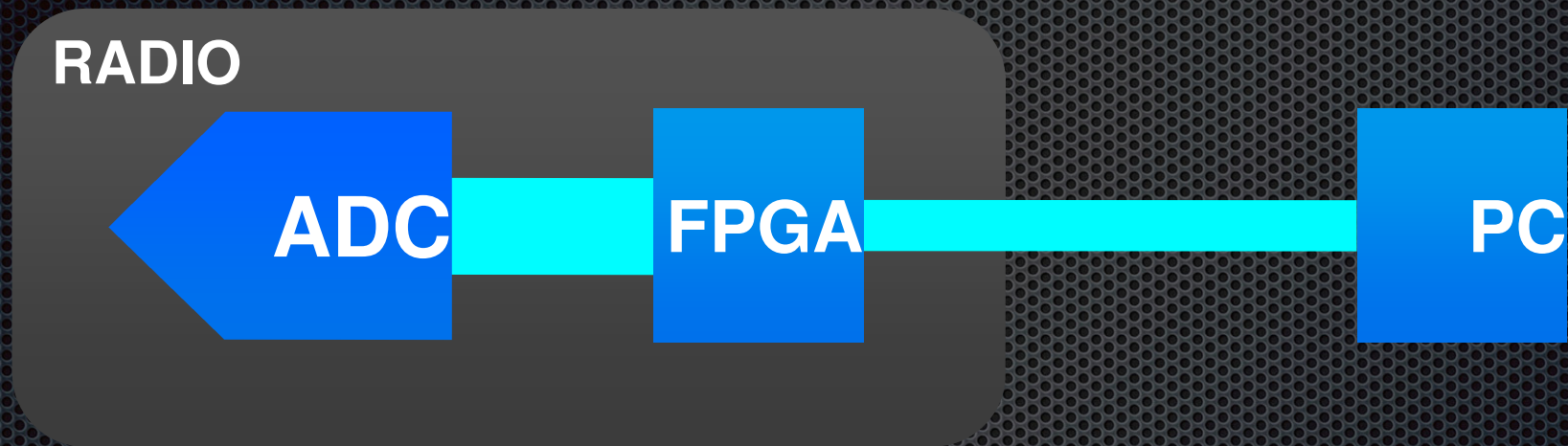


**—R. Buckminster  
Fuller**



# Design Options:

## #1: ADC and a hose



- ▶ Radio is ADC  $\Rightarrow$  FPGA  $\Rightarrow$  Ethernet
- ▶ Leverage PowerSDR; minimal SW investment



# ADC and a hose: CDRX-3200



- ▶ CDRX-3200, C
- ▶ 32 Synchronous, Coherent ADCs + FPGA
  - ▶ 440Mbps bandwidth
- ▶ Our customers have trouble absorbing the bandwidth



# ADC and a hose: LBRX-24

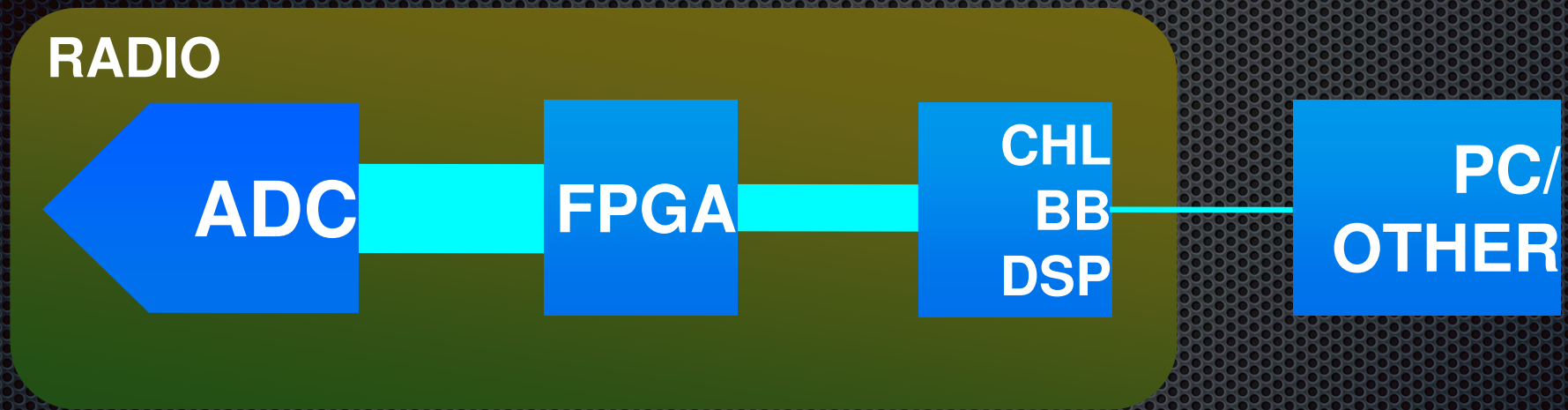


- ▶ LBRX-24, circa 2010
- ▶ 24 Microwave ADCs + 2 FPGAs
- ▶ 40Gbps bandwidth, yes Gigabit, 4x10Gb SFP+
- ▶ Our customers' PCs have memory in the 100s of GB



# Design Options:

## #2: ADC + FPGA + DSP/uP



- ▶ Radio reduces bandwidth to minimum before Ethernet
- ▶ Oh gosh: start over with SW: big investment!



# IN or OUT of the box?

## ▶ OUT OF THE BOX (DSP in external PC)

- + Simpler, cheaper radio design: apparent cost benefit
  - + Radio designer can shed software costs: “not my problem --- check with the community”
- Long term maintenance?: will volunteers maintain?
  - Must buy a PC: Loss of some cost benefit
- Interoperability issues (PC - radio): computer knowledge important
- Architectural: Built only for local LAN / fast computer



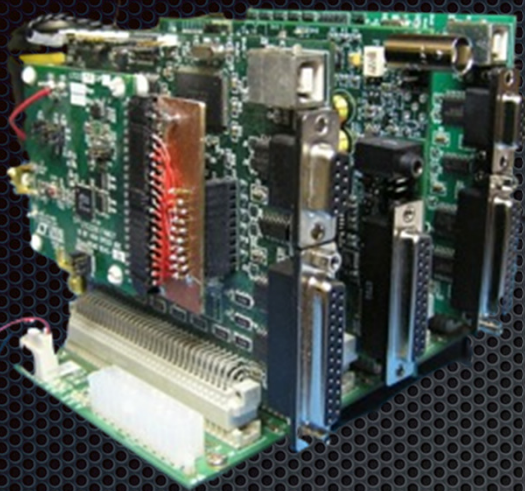
# IN or OUT of the box?

## ► IN THE BOX (DSP in radio)

- Complex design: time to market / cost disadvantage
- Processing Fixed: can't just add new computer
- + Completely integrated: Radio vendor controls and can fix all issues
- + Architecture: Huge bandwidth advantage (think remote)
  - + Porting easy: Run on many platforms quickly
  - + Flexibility: Doesn't preclude external DSP
  - + Simplicity: Plug in, turn on and go



# Direct Sampling Radios



**HPSDR**



**Hermes**



**ANAN-100D**

**HPSDR**

**RF DSP**

**DSP CTRL**



# Direct Sampling Radios



**FLEX-6000**

**RF DSP**

**CTRL**



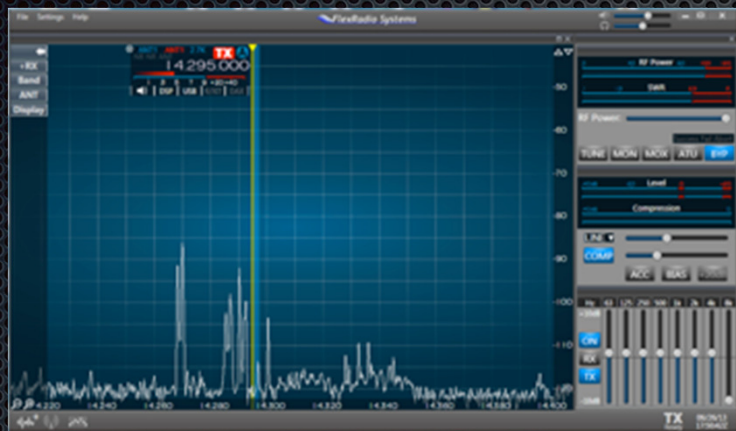
# Integrating the Baseband Processor

## Key Benefits

- ▶ Consistent performance independent of PC
- ▶ Minimized network bandwidth (think remote)
  - ▶ Minimization of “system” problems
  - ▶ Self-contained, rapid startup platform
- ▶ Spectrum displays (panadapter) independent of available network bandwidth
  - ▶ Network optimized



# Spectrum Display BW



**1MHz**  
**<500kbps**



**10MHz**  
**770Mbps**

**1500:1**  
**Bandwidth**  
**Difference**



# Long Ago, People Danced @ Concerts, Now They Video / Click / Share / Tweet...

1990s



2010s





# Media + Data Uploading + Sharing from Mobiles = Ramping Fast & Still Early Stage

First



PHOTOS

**Explosive  
Growth, But  
Still Early  
Stage**

Now



VIDEO

**Ramping  
Very Fast**

Next



SOUND

**Emerging**

Next

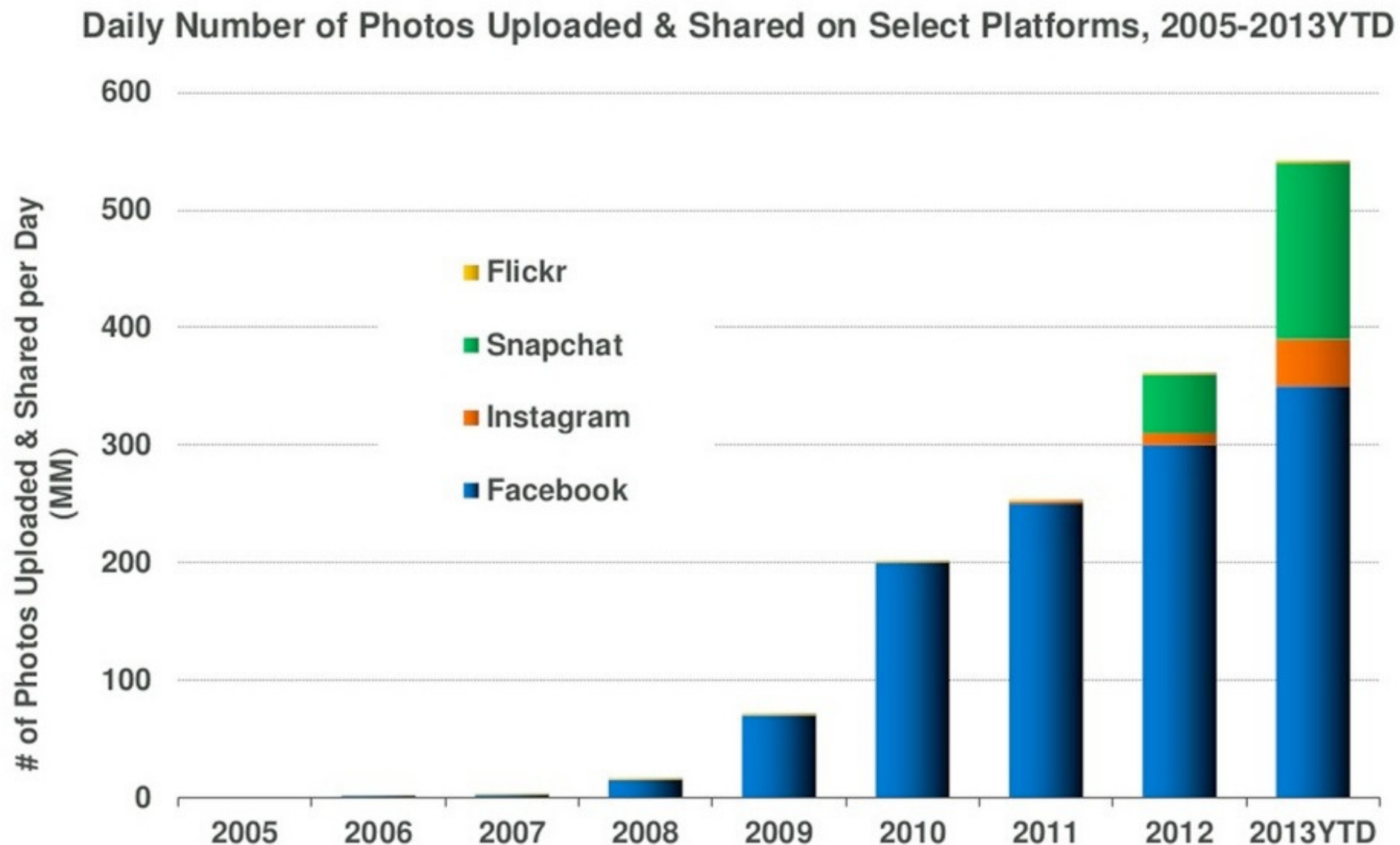


DATA

**Emerging**

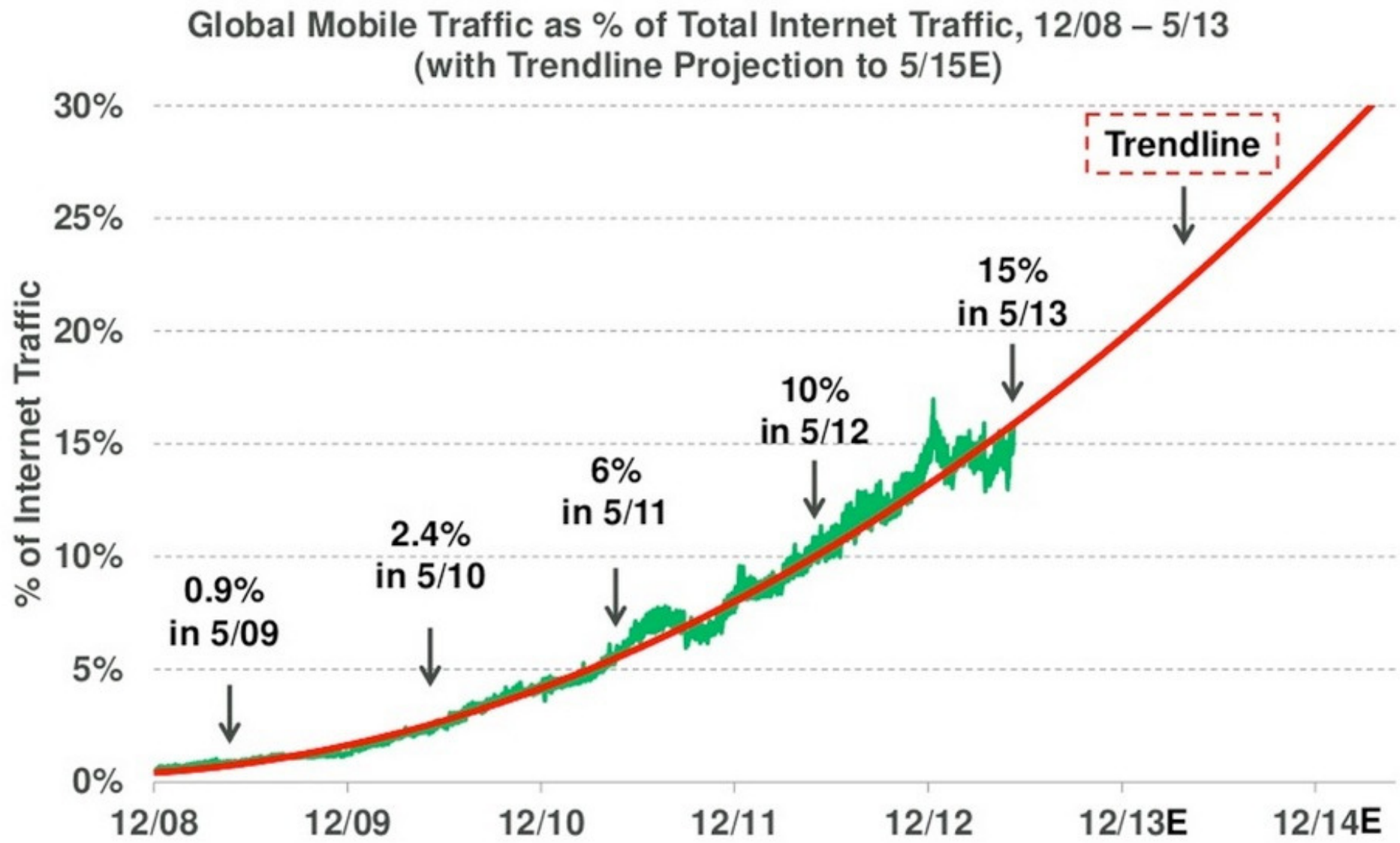


# Photos = 500MM+ Uploaded & Shared Per Day, Growth Accelerating, on Trend to Rise 2x Y/Y...





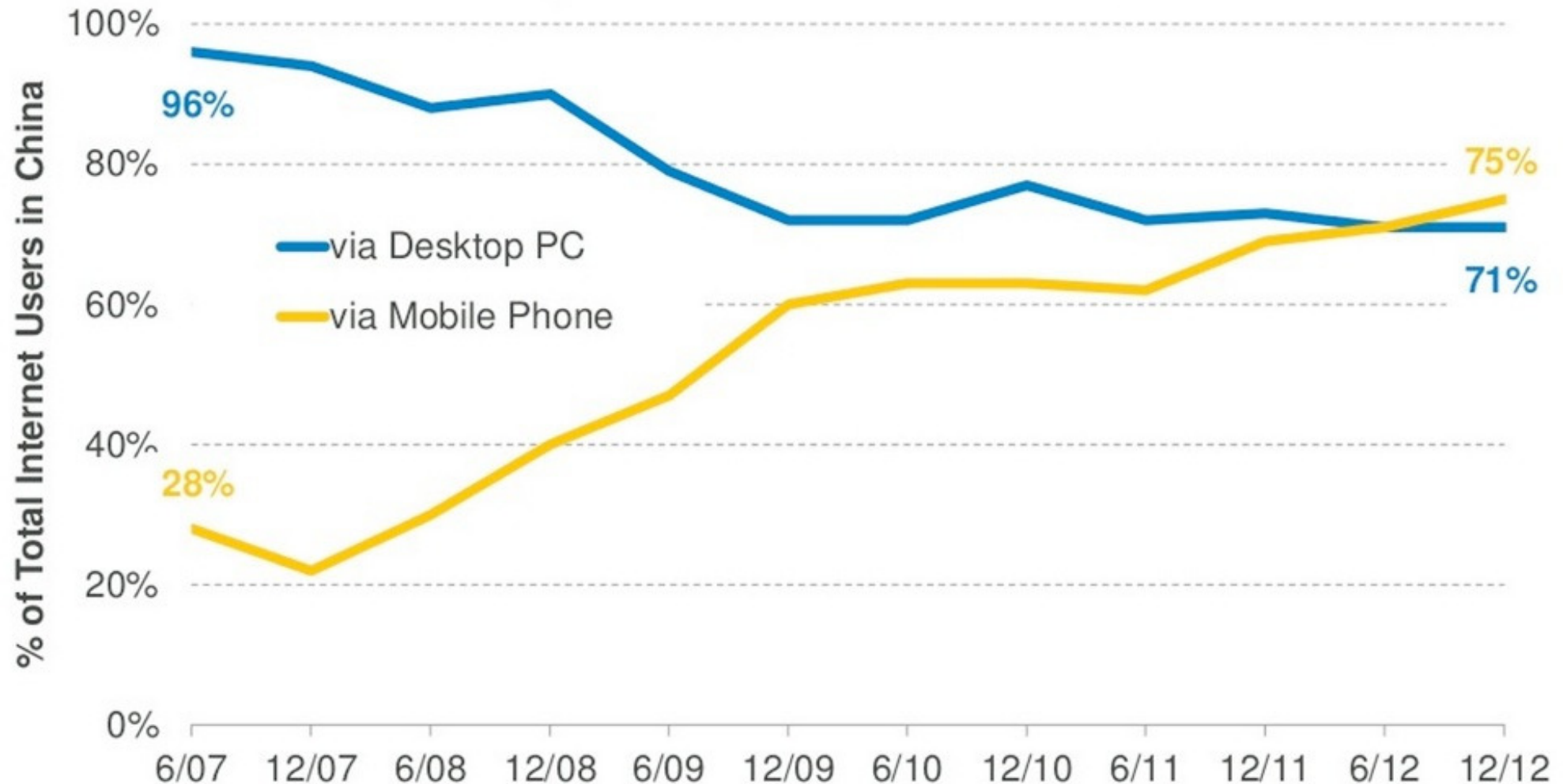
# Mobile Traffic as % of Global Internet Traffic = Growing 1.5x per Year & Likely to Maintain Trajectory or Accelerate





# China – Mobile Internet Access Surpassed PC, Q2:12

% of Chinese Internet Users Accessing the Web  
via Desktop PCs vs. via Mobile Phones, 6/07 – 12/12





# A Car or a Computer on Four Wheels?





# Networking

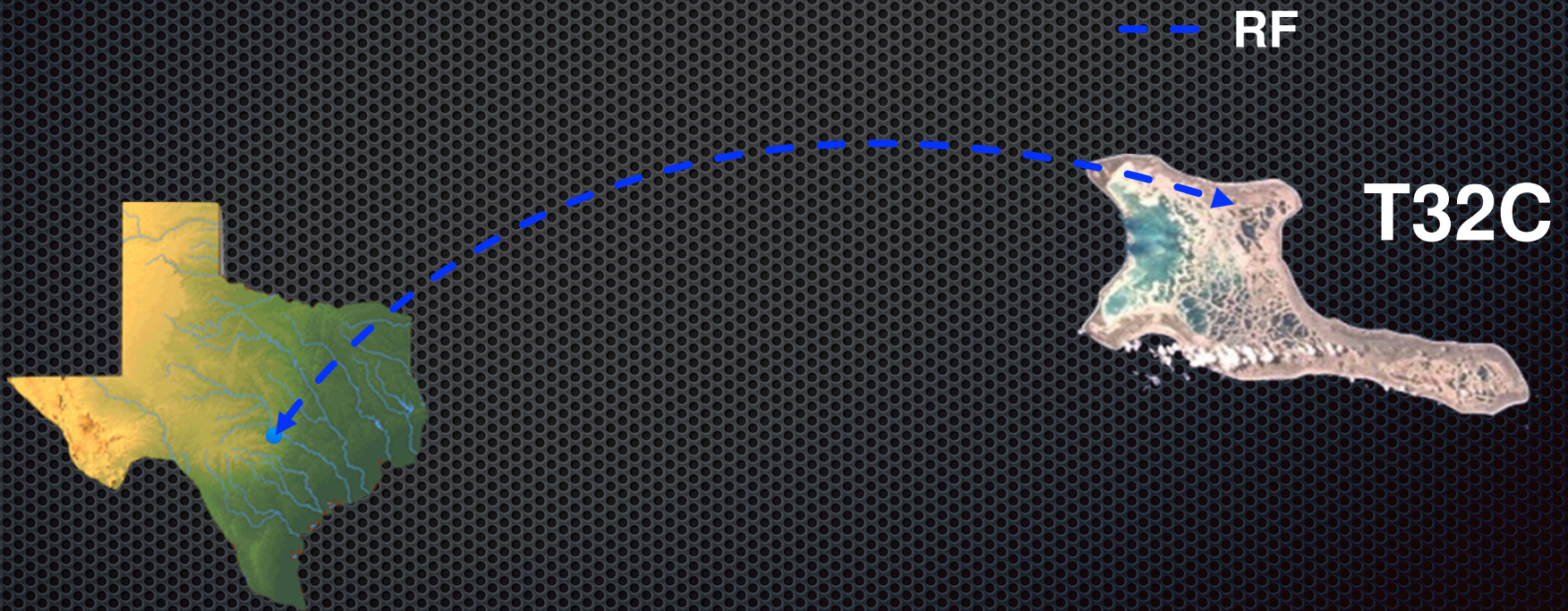
EVERYTHING is moving to the network.

You can TAKE YOUR FUN WITH YOU



# What is a contact?

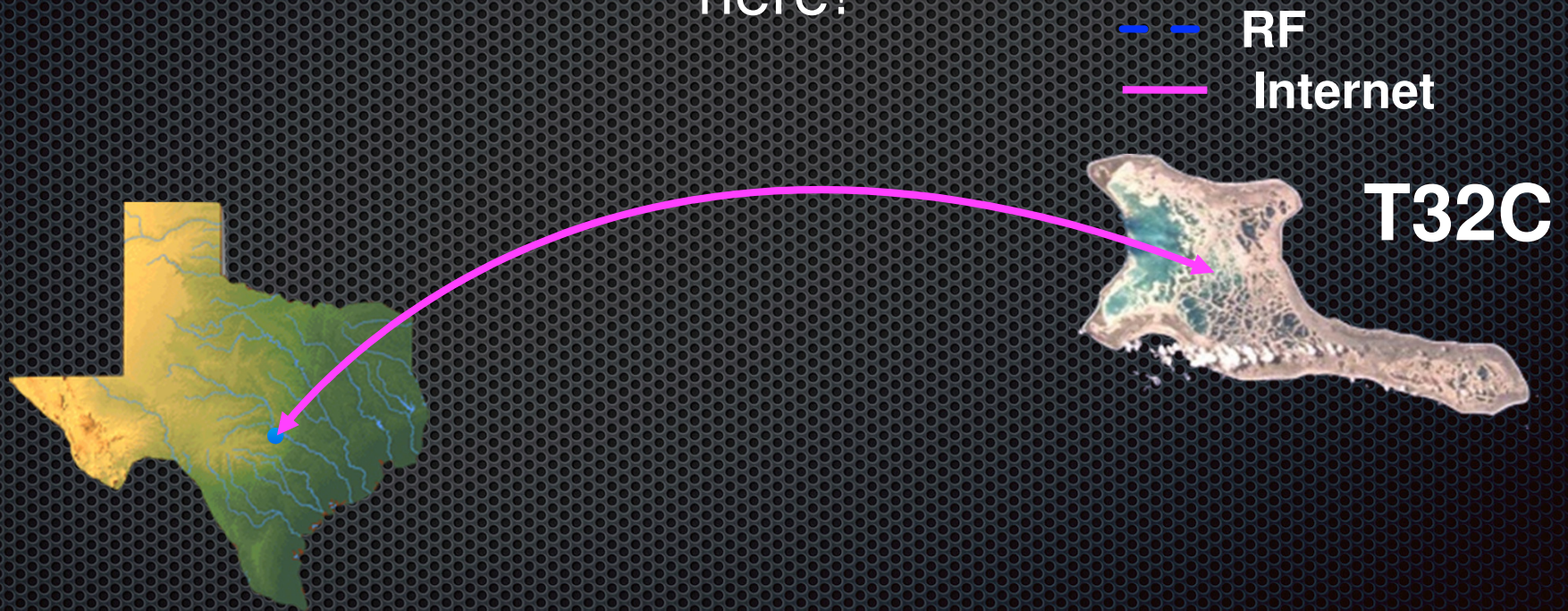
- ▶ You're at your QTH and you work Christmas Island





# What is a contact?

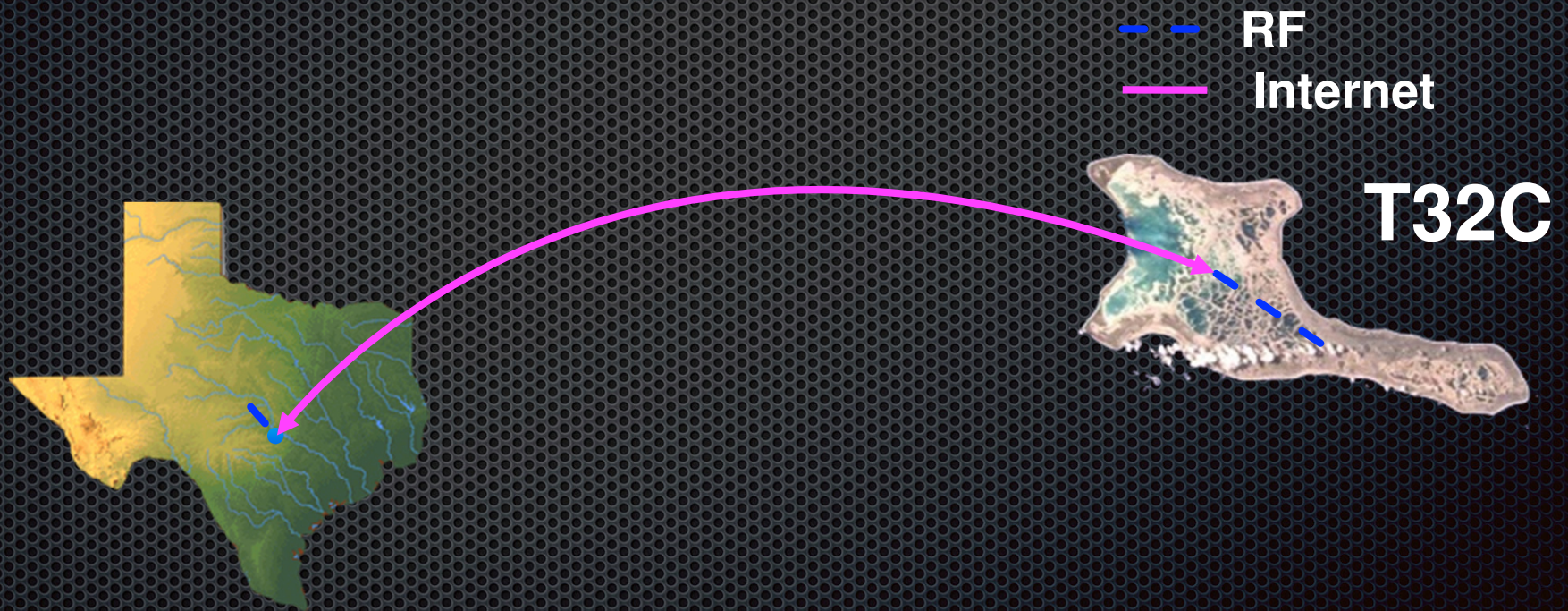
- ▶ You're trade emails with the operator of T32C on Christmas Island. His email says "You are 599 here!"





# What is a contact?

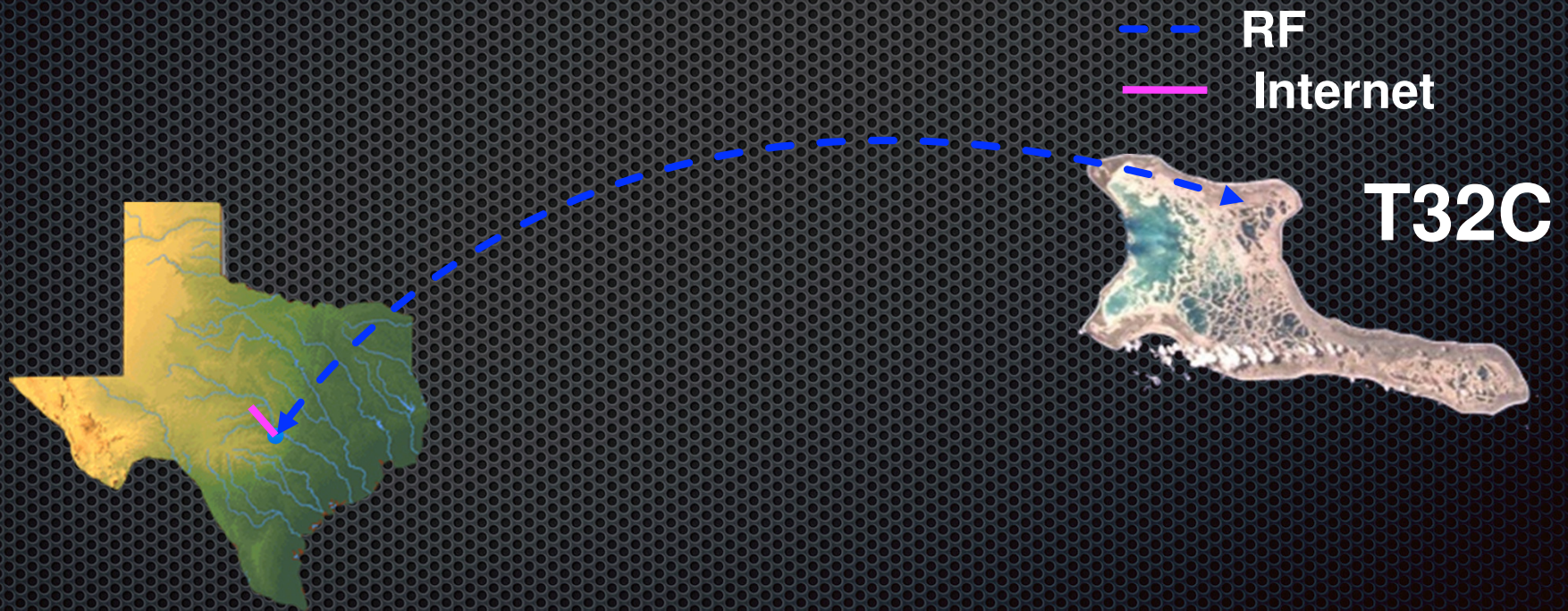
- ▶ You talk to Christmas Island using your local 2m repeater and EchoLink





# What is a contact?

- ▶ You're at the store and you remote control your home station to work Christmas Island





# Does your radio need THIS?





# Does your radio run HERE?





# T/F: Rare DX is convenient

## Where's your operating position?





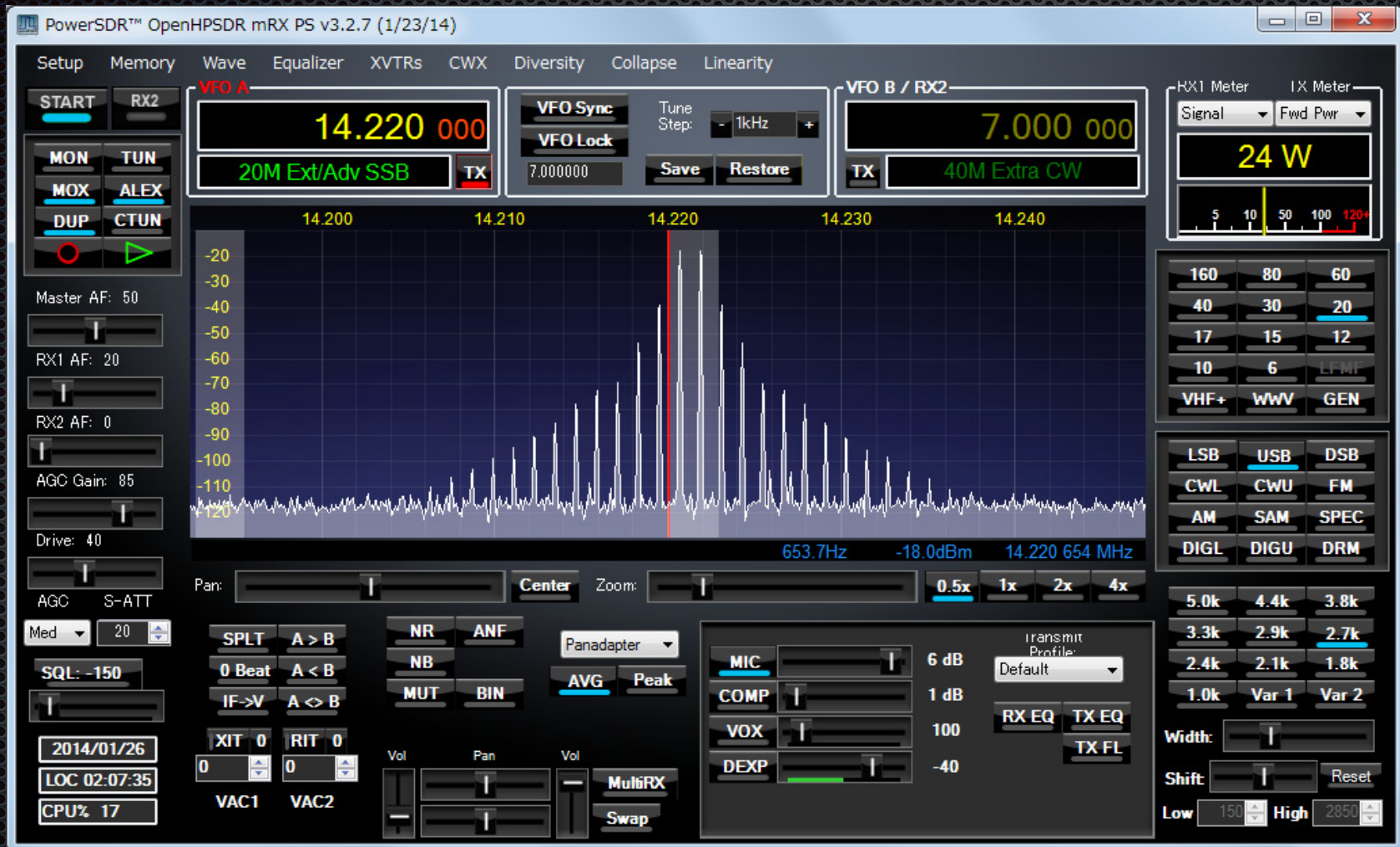
# Adaptive Predistortion

- ▶ Power Amplifiers: Nonlinearities
  - ▶ Designs have improved
- ▶ What if we knew in advance of the PA?
  - ▶ Could we correct?
- ▶ HPSSDR: Pure Signal



# Predistortion

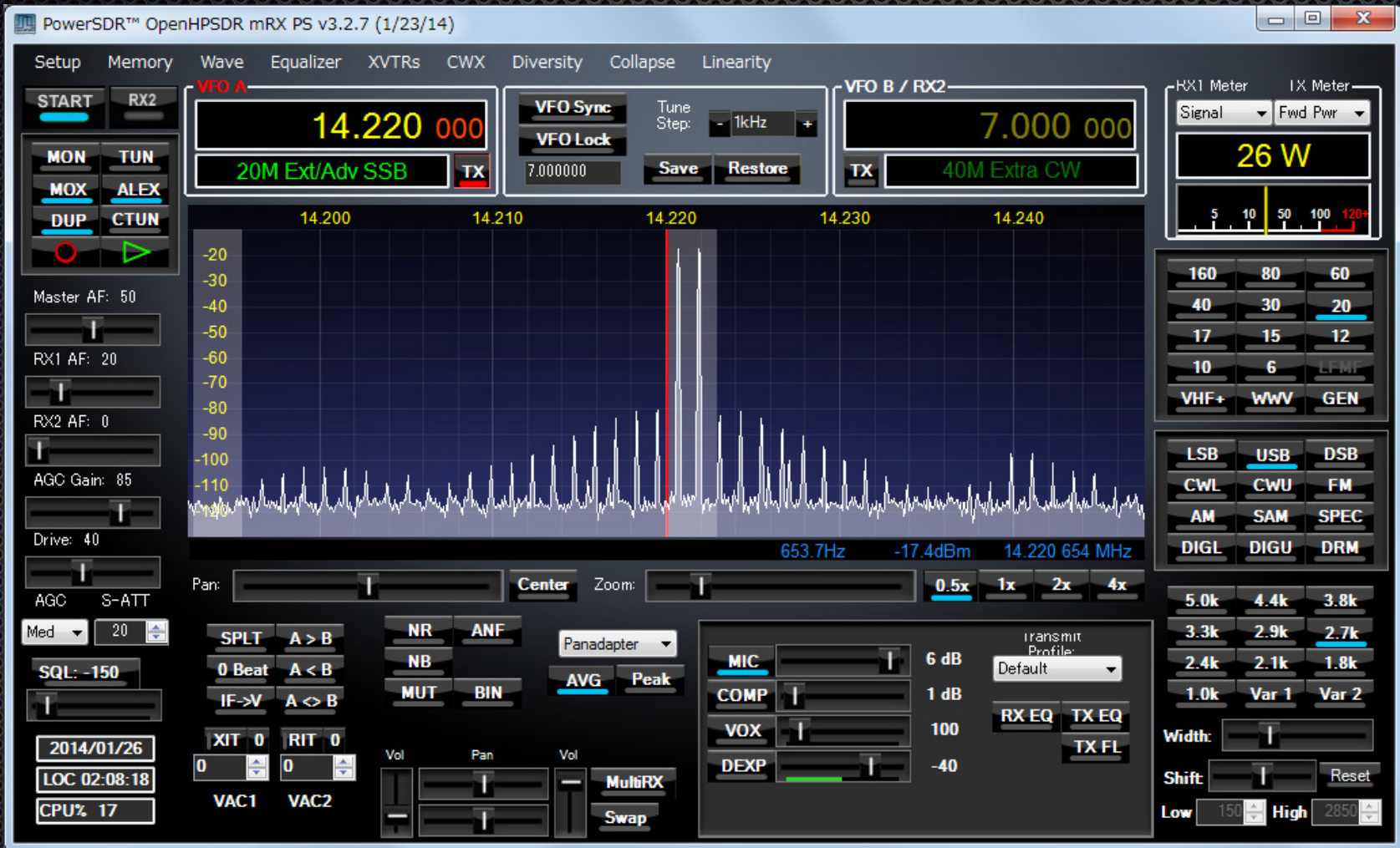
## Before





# Predistortion

## After





# Phase Noise

- ▶ Affects both RX and TX interference capabilities
- ▶ Oscillator phase noise getting better every year
  - ▶ Direct Sampling radios demanding
- ▶ Take a look at the all FLEX-6000 Thunderbird FD



# Low Phase Noise

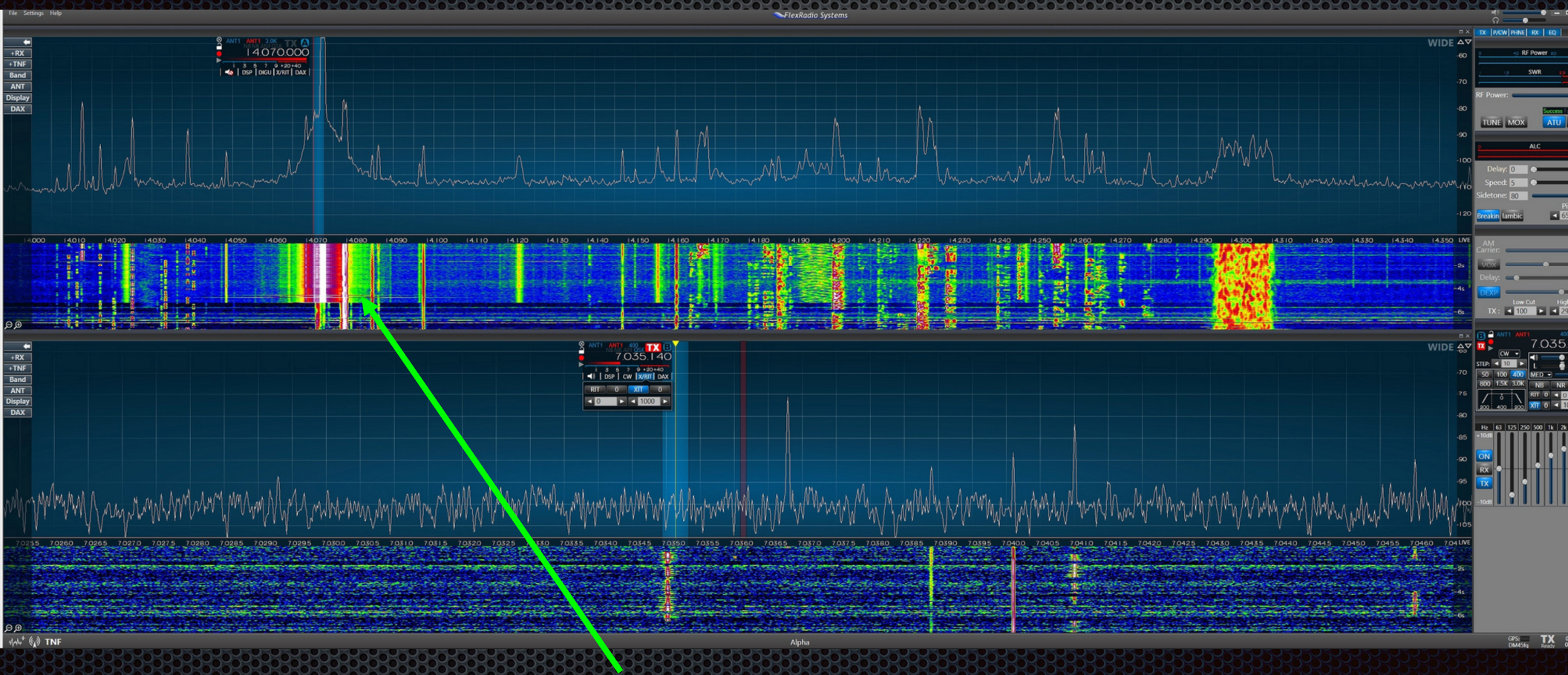
## Field Day





# Low Phase Noise

## Field Day



100W PSK31

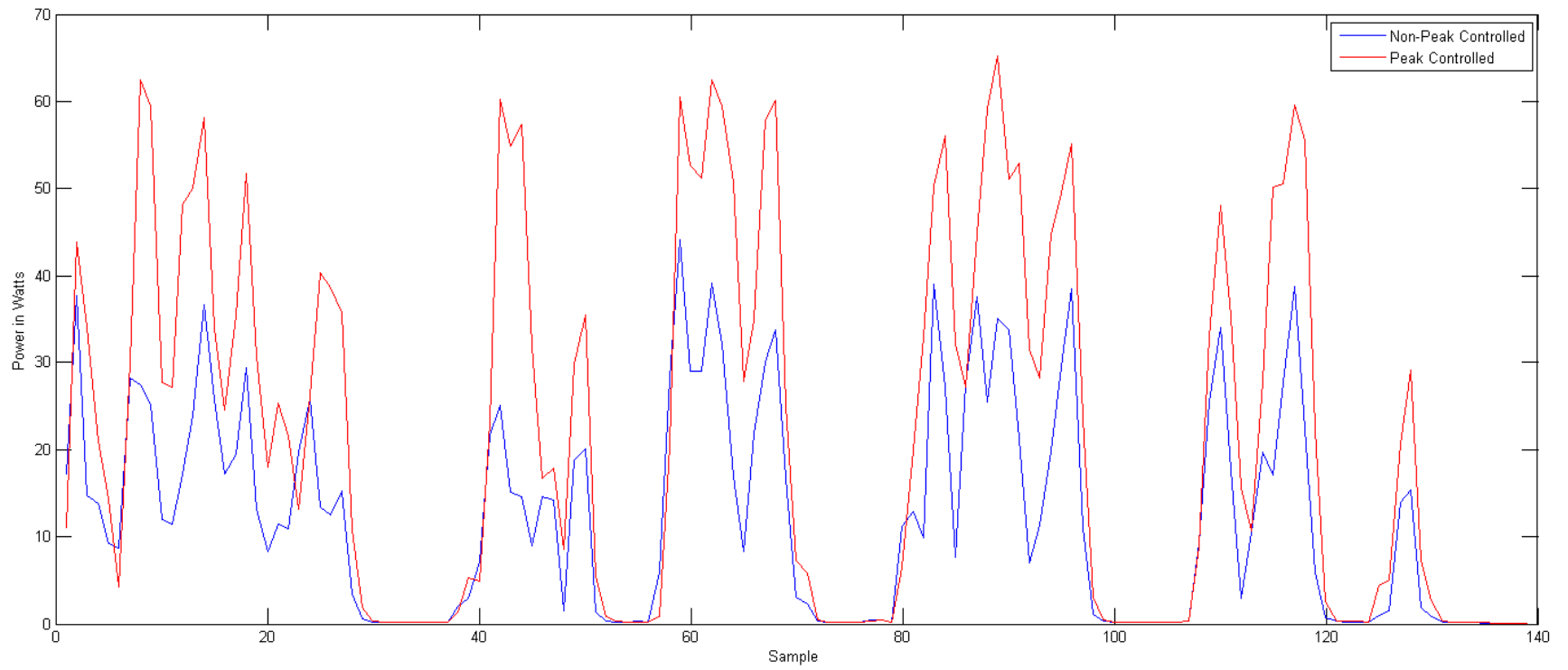


# Speech Processor (CESSB)

- ▶ David Hershberger, W9GR, approached us at Dayton 2013
- ▶ Algorithm implemented in SmartSDR + on-air testing
- ▶ Excellent speech and a ~2.5dB power improvement
- ▶ Results and algorithm to be published in QEX later this year







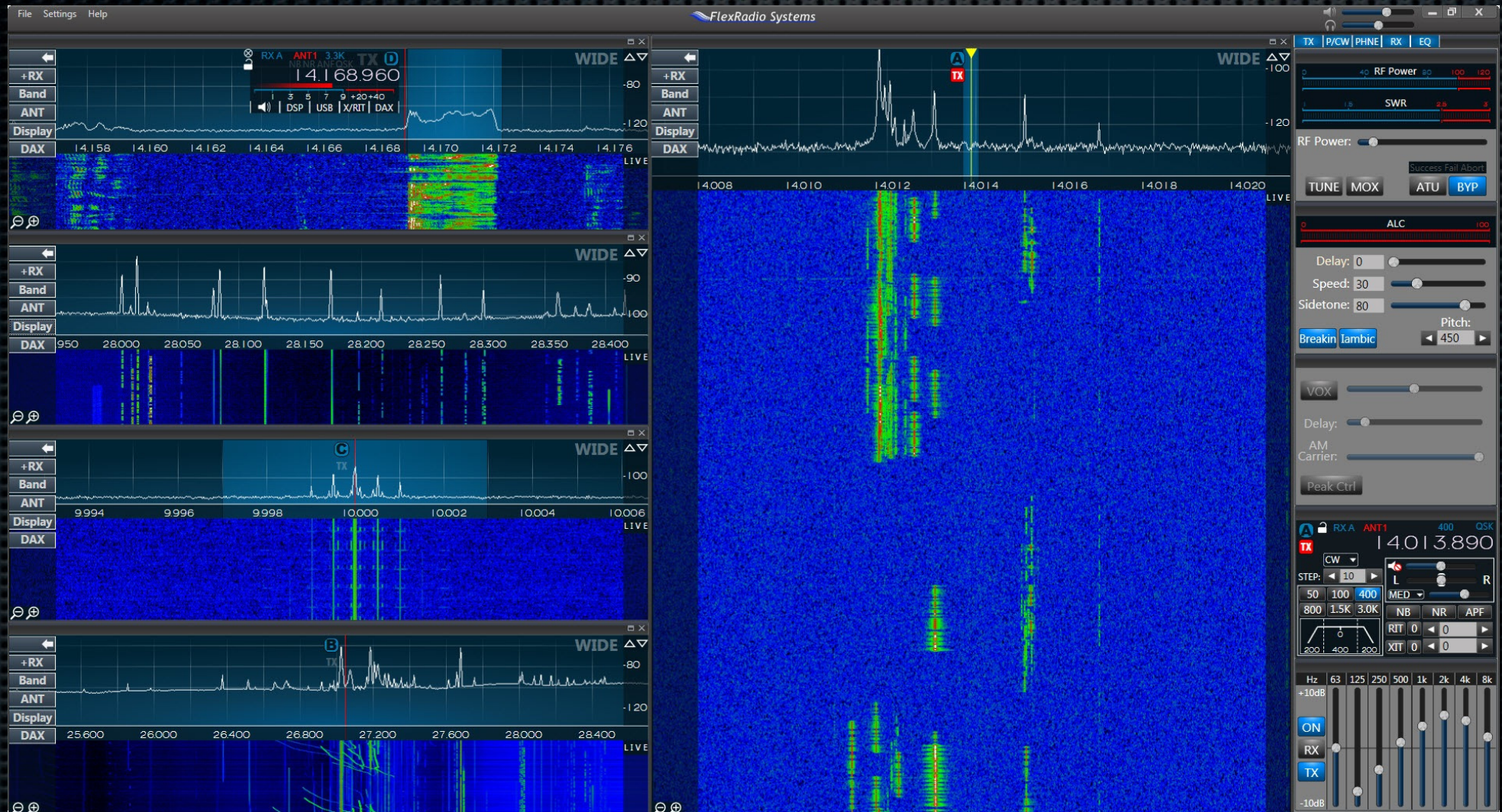


# Many data streams at once

- ▶ FLEX-6700
  - ▶ 8 narrow-band 24kHz receivers
    - ▶ 8 panadapters
- ▶ 4 wide-band (192kHz) I/Q streams for skimming

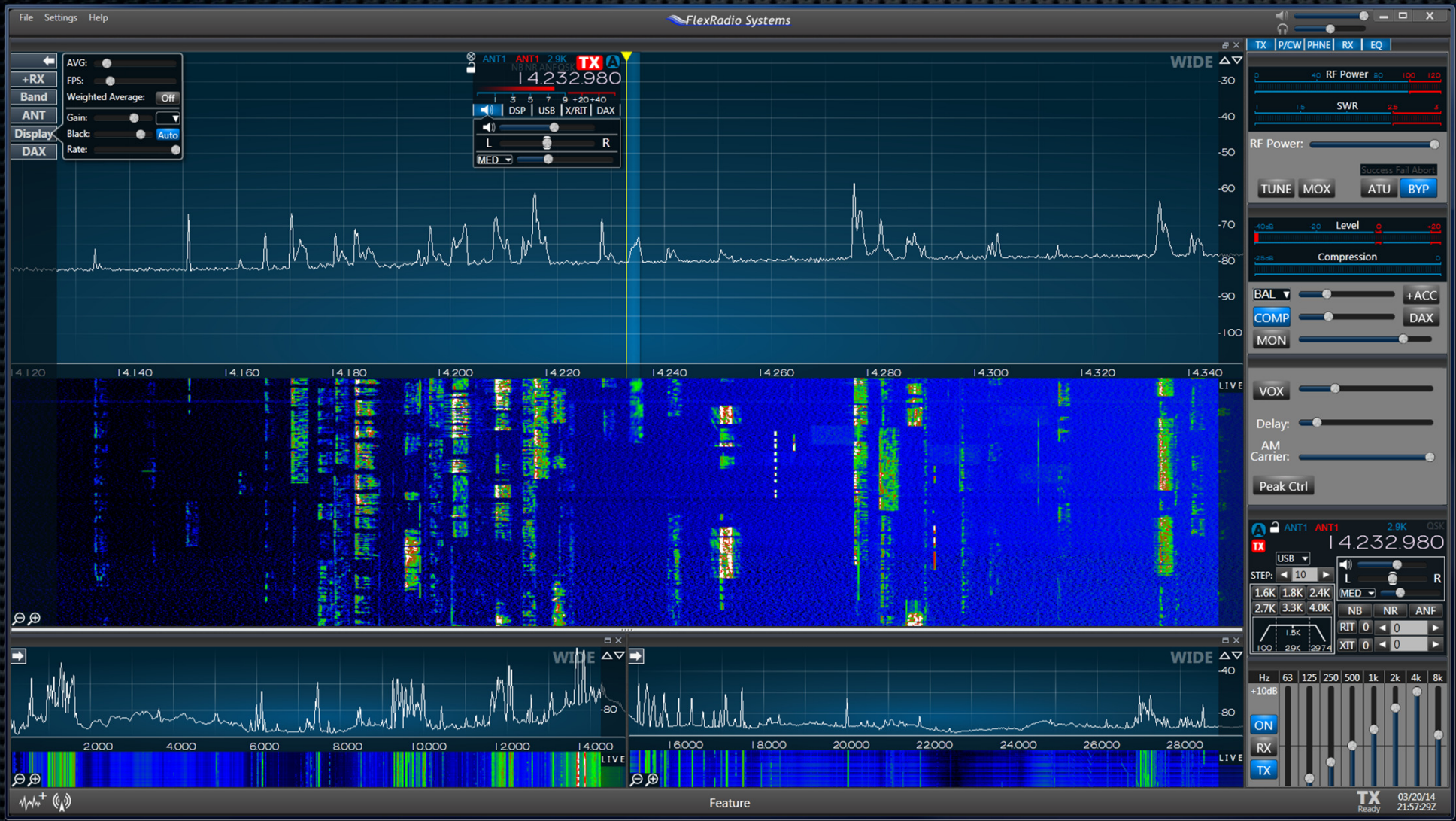


# Multi-mode Waterfall



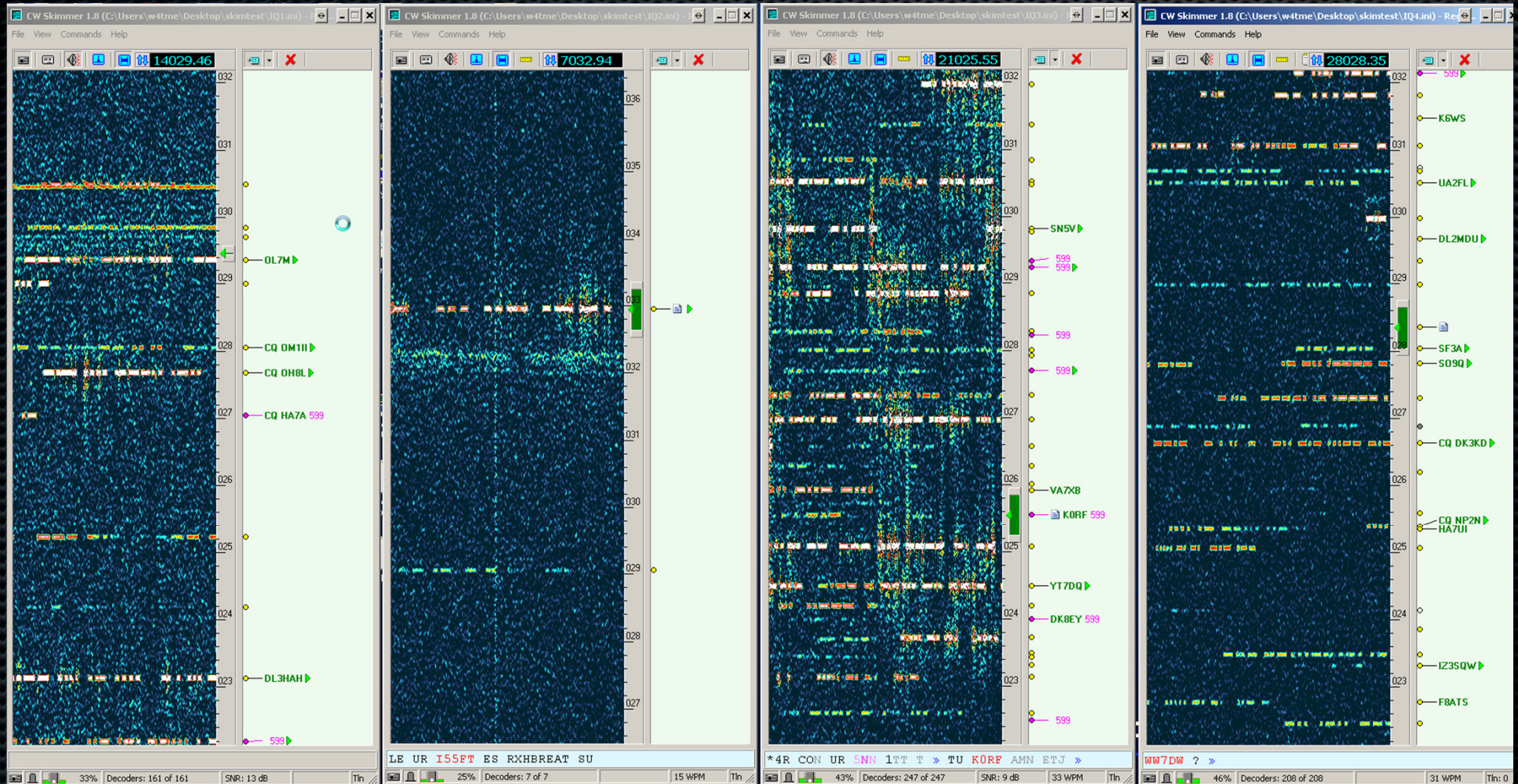


# Waterfall plus Bandscope



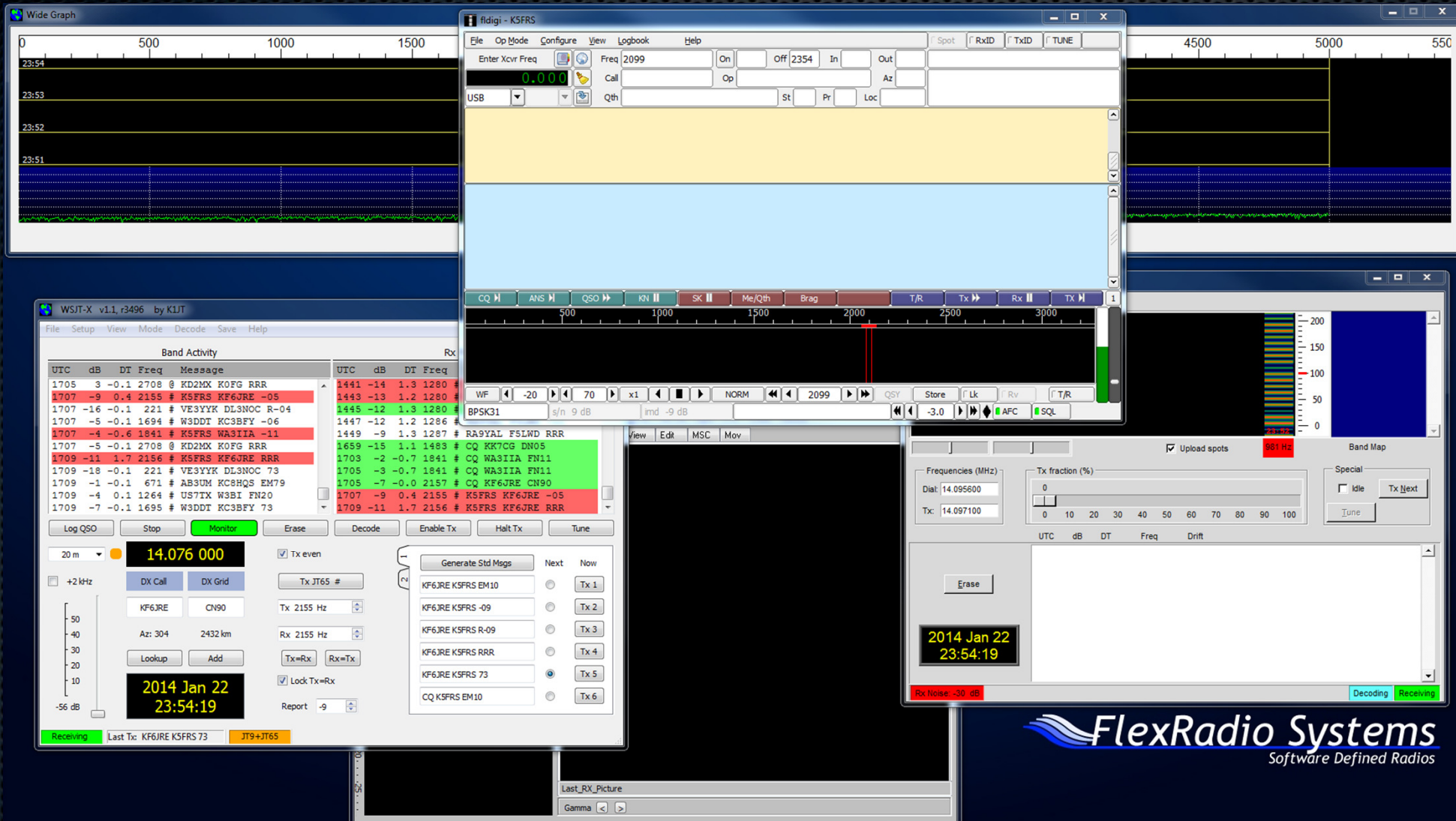


# CW Skimmer x4





# Digital Modes



**FlexRadio Systems**  
Software Defined Radios

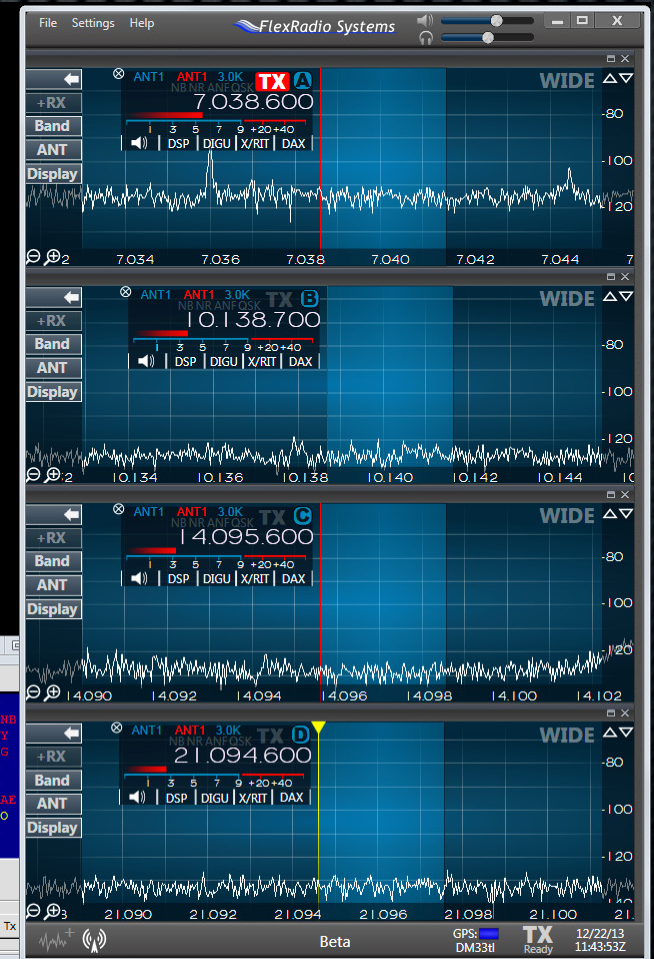
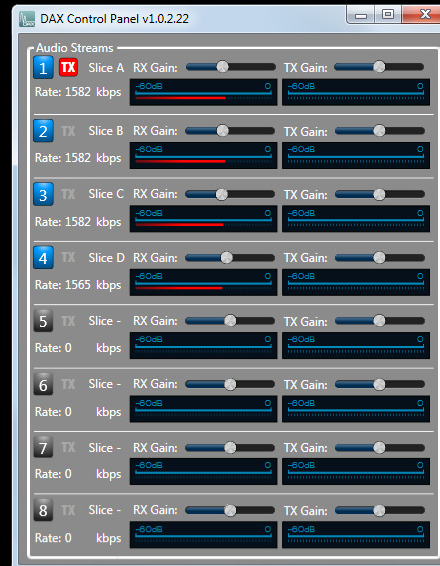
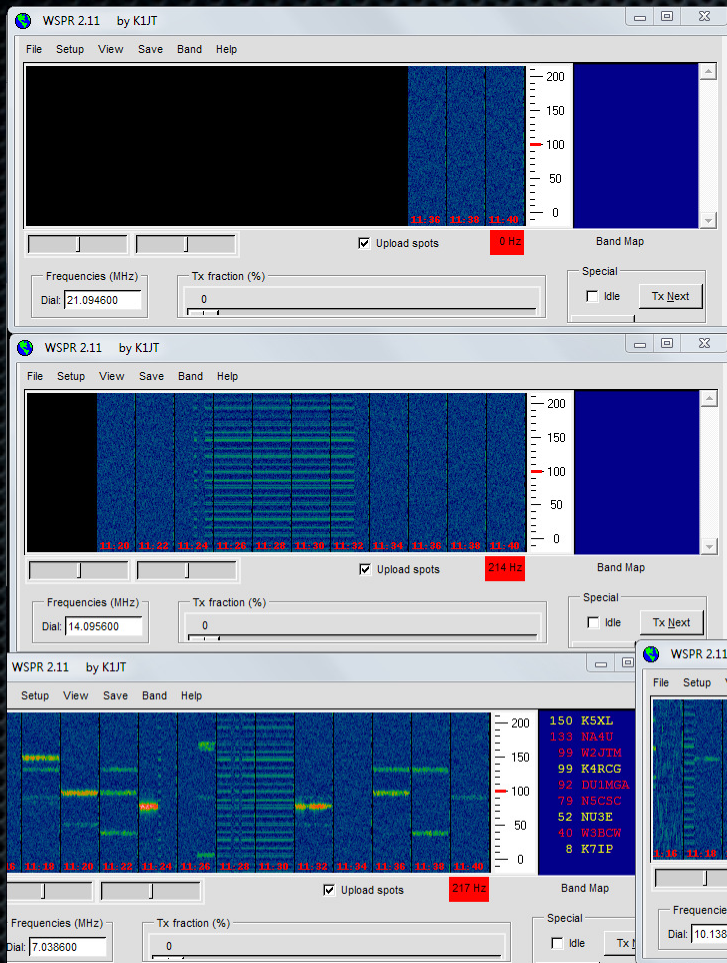
**FlexRadio Systems**  
Software Defined Radios





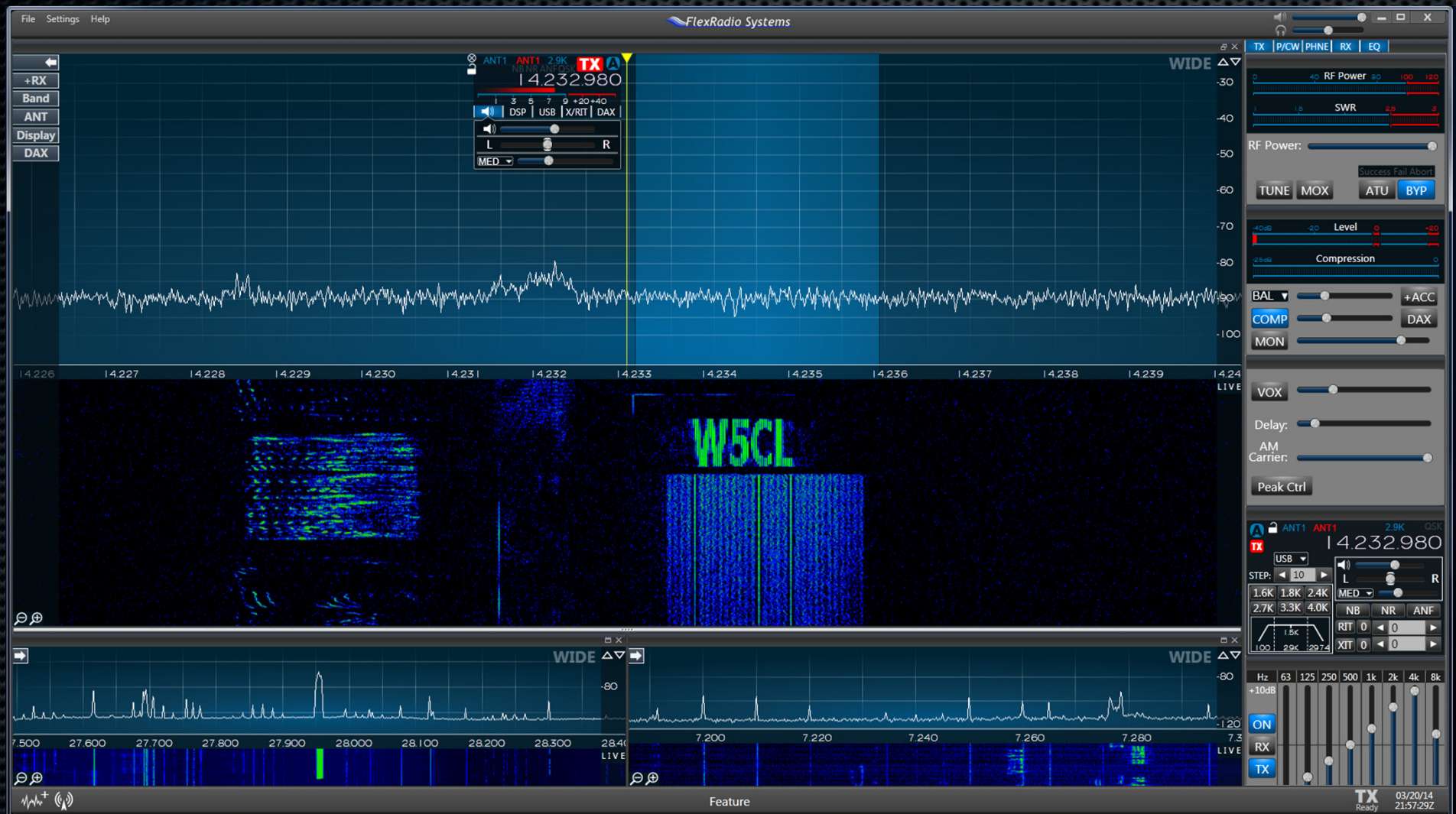


# WSPR times 4!



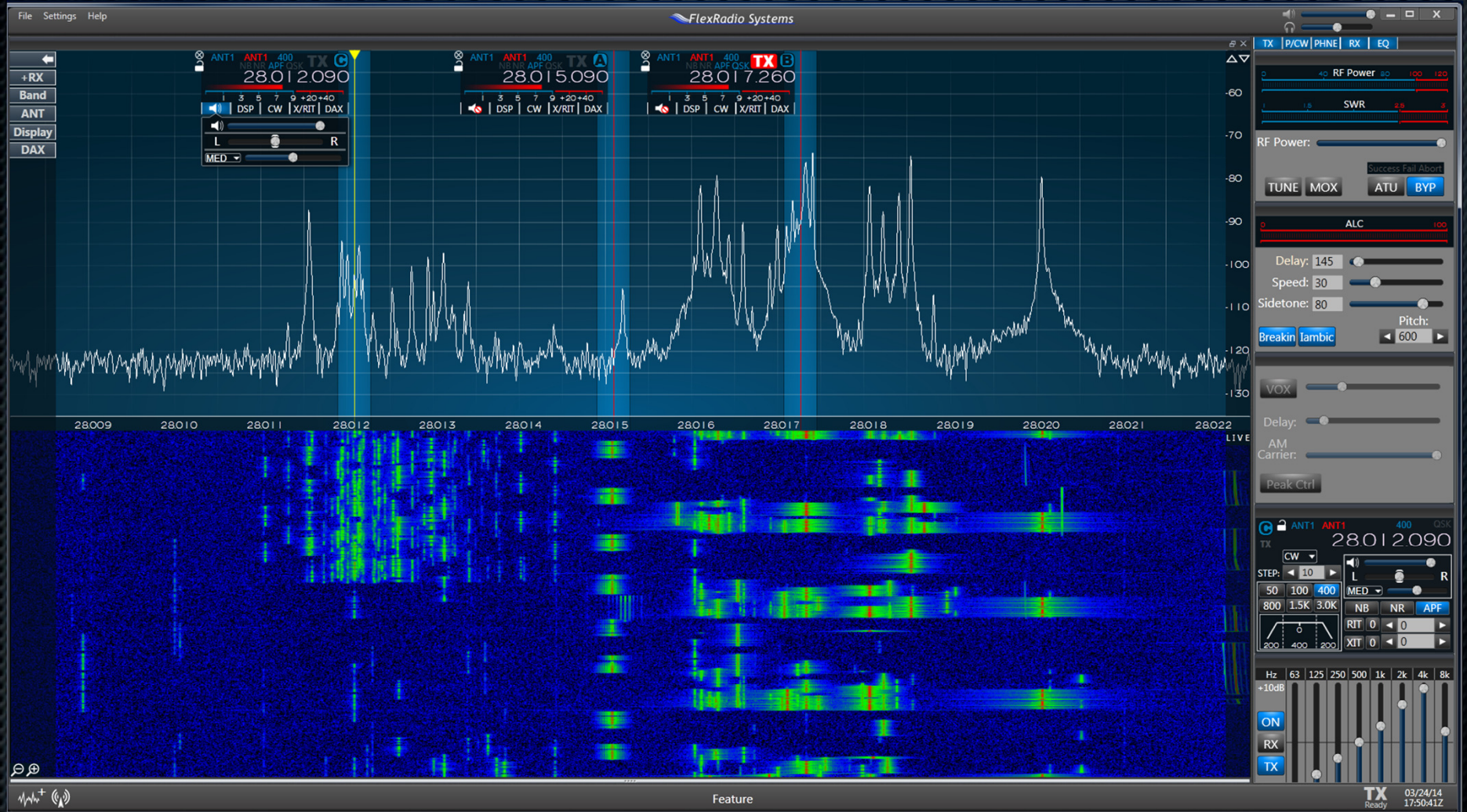


# EasyPAL





# TX6G: A Picture is worth 1,000 words





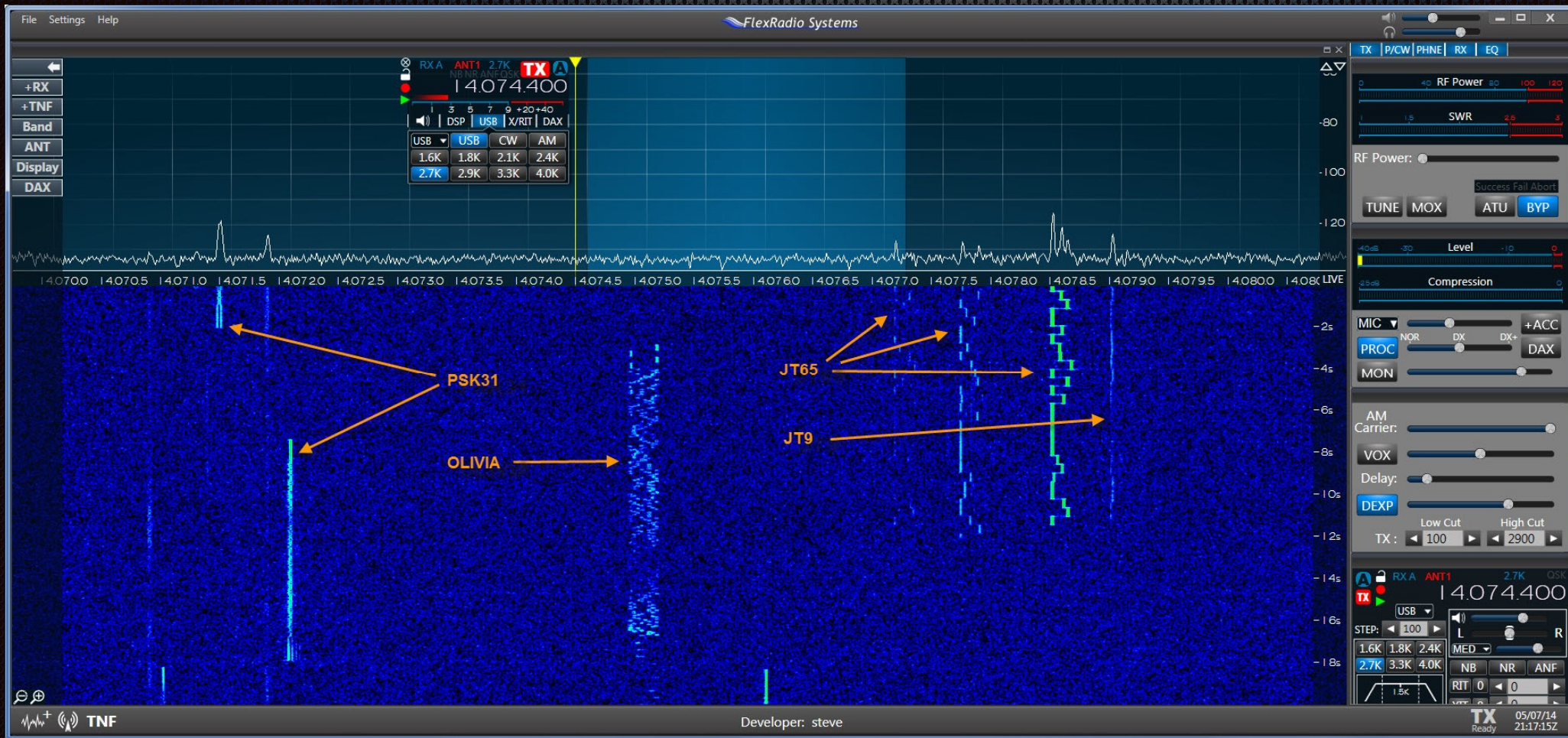
# The Future:

## Decoding

- ▶ Today: CW, PSK, RTTY
- ▶ Tomorrow: Everything Digital and voice
- ▶ Digital is fully integrated ... no cables



# The Future: Decoding





# The Future: Remote

- ▶ Today: Mostly hacked together and inconvenient
- ▶ Tomorrow: Easy remote, tablets everywhere





# The Future: Integration

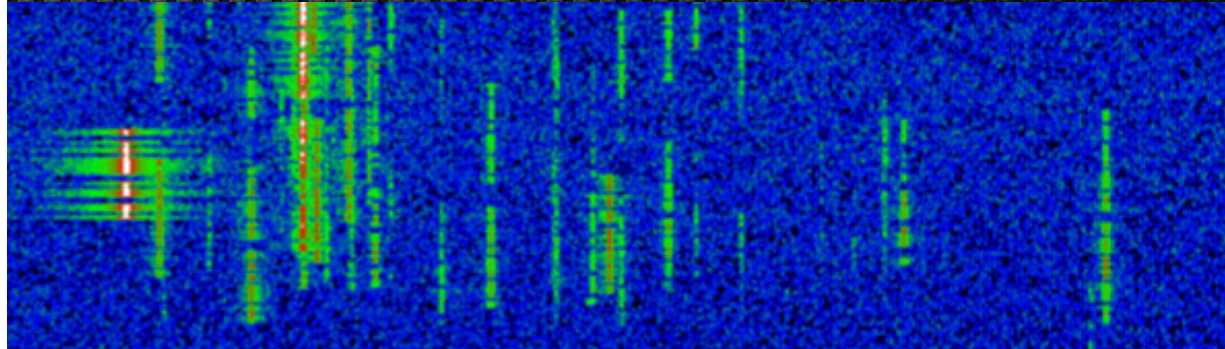
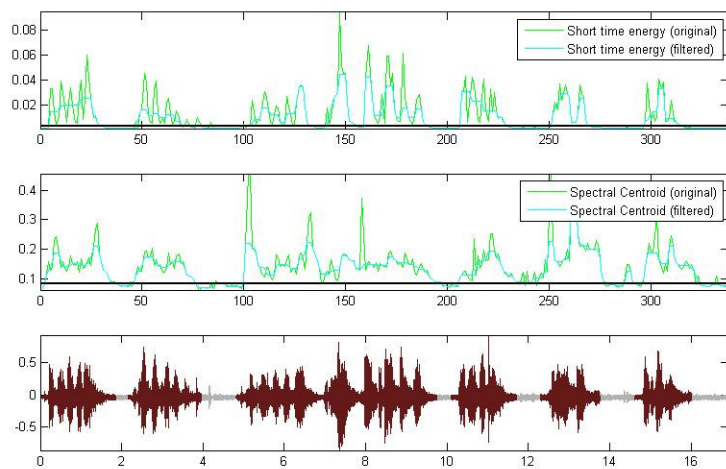
- ▶ Today: On premise integration driven by contesters
- ▶ Tomorrow: Integration driven by plethora of remote solutions and the need to drive other hardware





# The Future: Signal Classification

- ▶ Today: Virtually none
- ▶ Tomorrow: Radios will find and classify signals (determine mode)





# The Future:

## Steering and MIMO

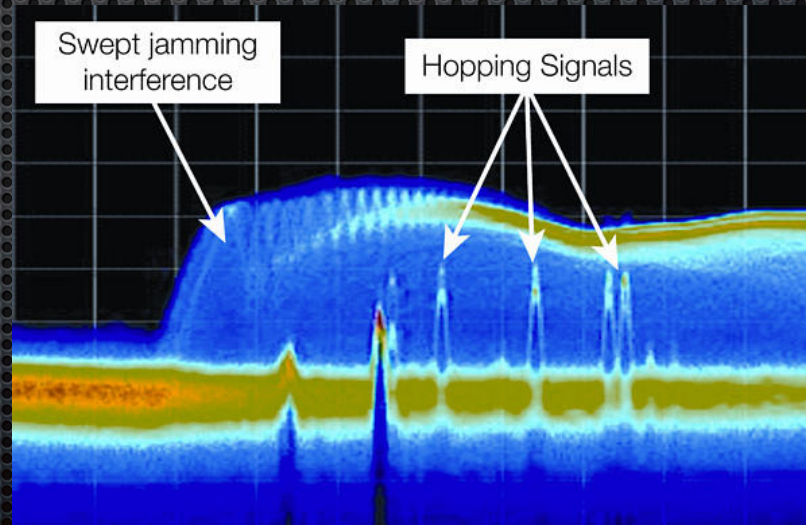
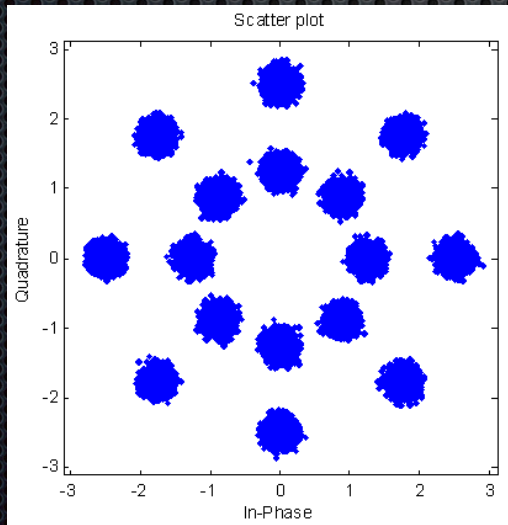
- ▶ Today: Phased receive arrays, few TX arrays
- ▶ Tomorrow: Every antenna will have an SCU and for operators with multiple antennas, instant arbitrary, rotation will be possible





# The Future: Visualization

- ▶ Today: Panadapters, Waterfalls and the occasional scope
- ▶ Tomorrow: New displays that show perspectives of data not previously seen. Operational advantage will drive innovation





# The Future:

## Noise Reduction

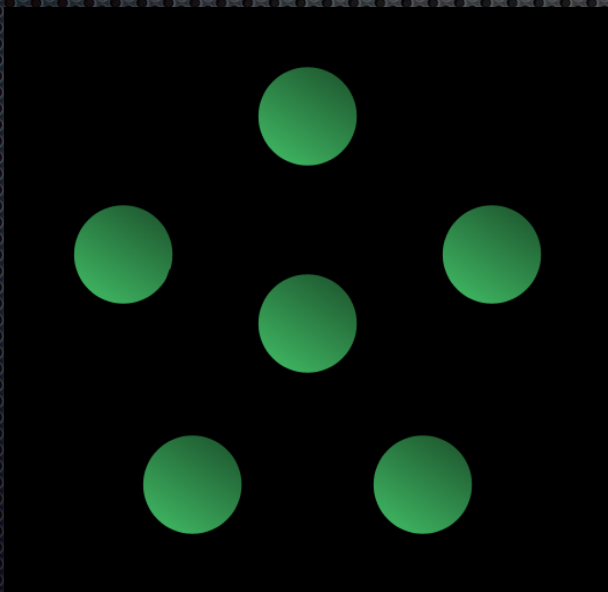
- ▶ Today: Advanced NB, NR techniques in many radios
- ▶ Tomorrow: Dedicated noise receivers will be used to eliminate noise more effectively, optimal combining across multiple antennas will emerge





# The Future: Networking

- ▶ Today: Occasional Remote-to-base operation
- ▶ Tomorrow: Remote assets will be combined inside of a single program to enhance operational capabilities. Remotes may be used in combining, DFing or other applications





# re-discover radio

