



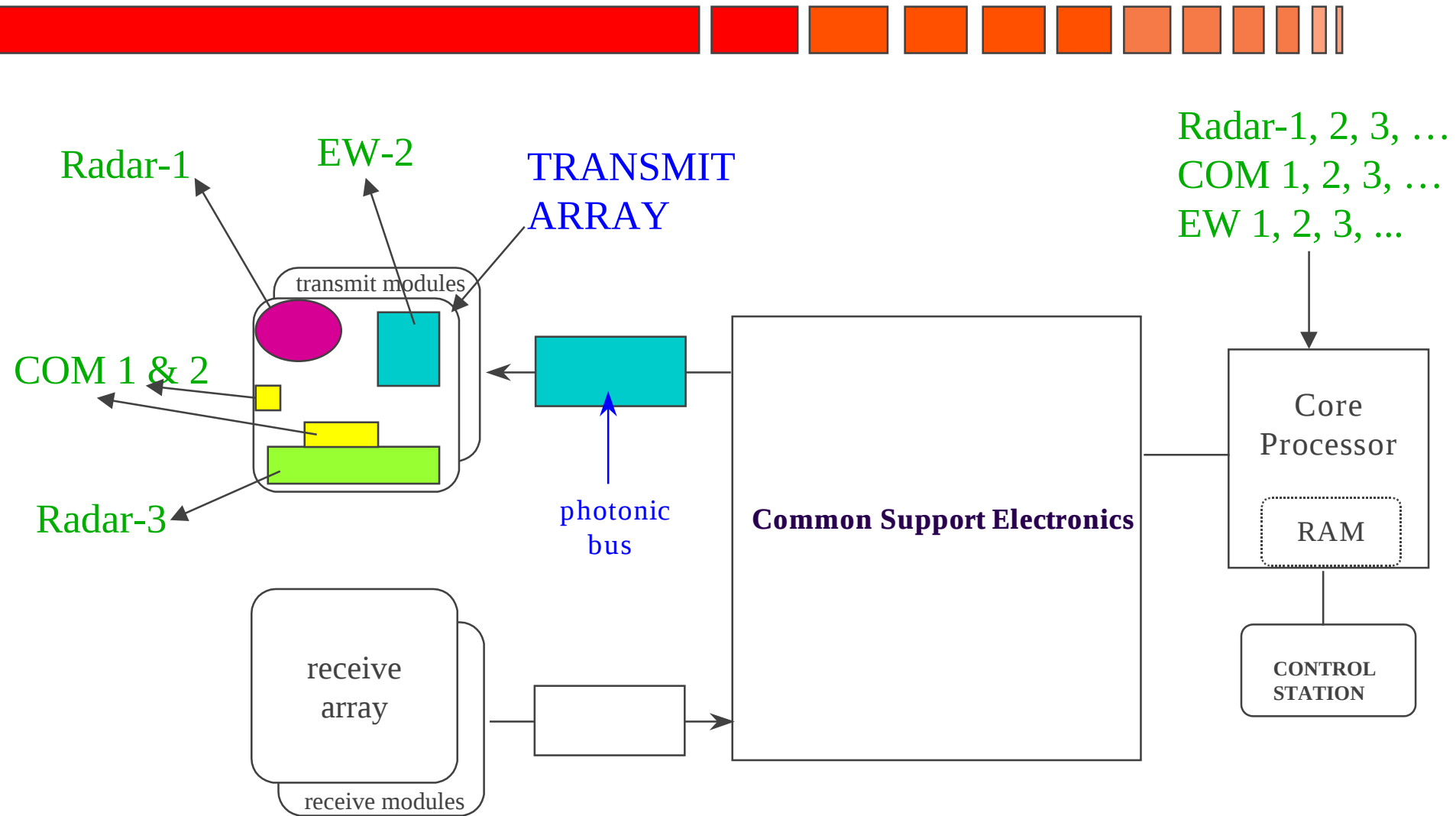
Proposed WDM-Based Wideband Photonic RF Bus For The Navy's AMRFS Architecture

DARPA WDM WORKSHOP
April 18, 2000

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Photonic RF Bus & the AMRFS Architecture



The need for a photonic RF Bus



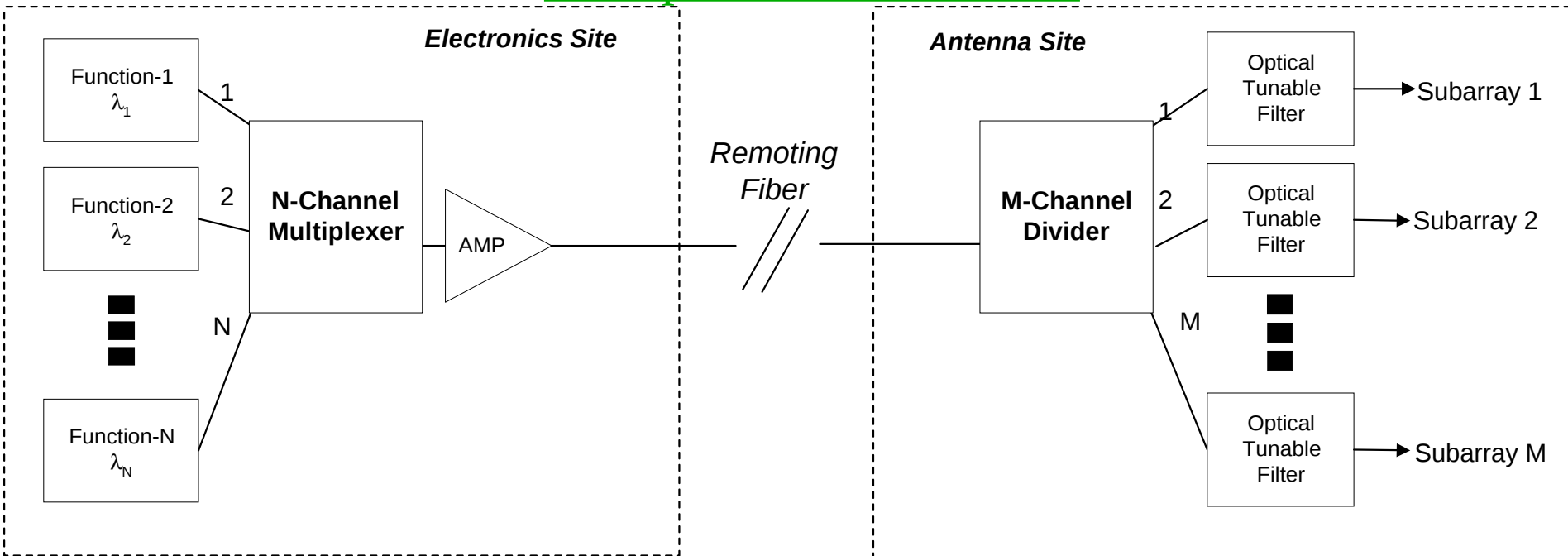
Effective dynamic allocation of wideband multifunction apertures and transmit/receive resources requires an advanced RF interconnection network, with programmable *broadcast*, *multicast*, and *narrowcast* capability.

Coaxial interconnections are point-to-point with little reconfiguration capability (large number of lines and switches required), are lossy and heavy.

The WDM RF photonic bus offers a wideband, lightweight, fully programmable solution

WDM RF Bus: Architecture

Multiplex and Broadcast



PROPERTIES

- (+) Single fiber to the antennasite
 - (+) Single optical amplifier
 - (+) Expandability is relatively easy
 - (+) Loss grows slow with M plus fixed MUX loss
- $$L \text{ (dB)} = -10 \log M - L_M$$

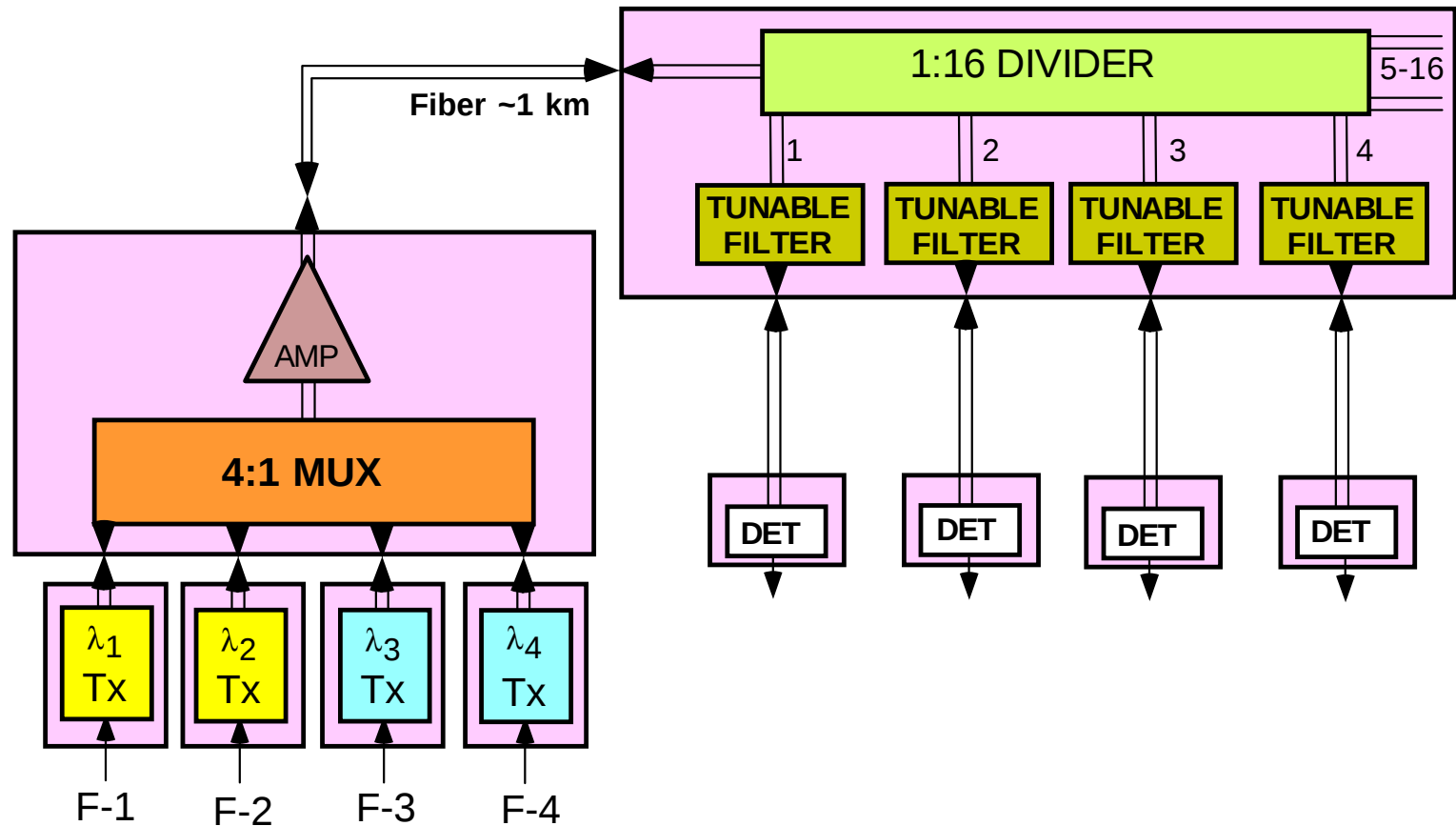
Prototype WDM RF Bus Objectives (1998/1999)



Development and demonstration of a WDM-based photonic RF bus for interconnecting and dynamically allocating multiple subarrays to multiple RF functions.

Prototype bus specs: *4 RF functions, 16 subarrays, operation over 1-5 GHz, SNR > 150 dB/Hz, SFDR > 110 dB-Hz^{2/3}*

Photonic RF Bus: *Prototype Block Diagram*



Wavelengths (from ITU grid): 1542.14 nm, 1546.12 nm, 1550.12 nm, 1554.13 nm

Estimated RF Isolation: > 90 dB

Photonic RF Bus: *Prototype*



4:1 MUX

Optical Amp

Direct Link

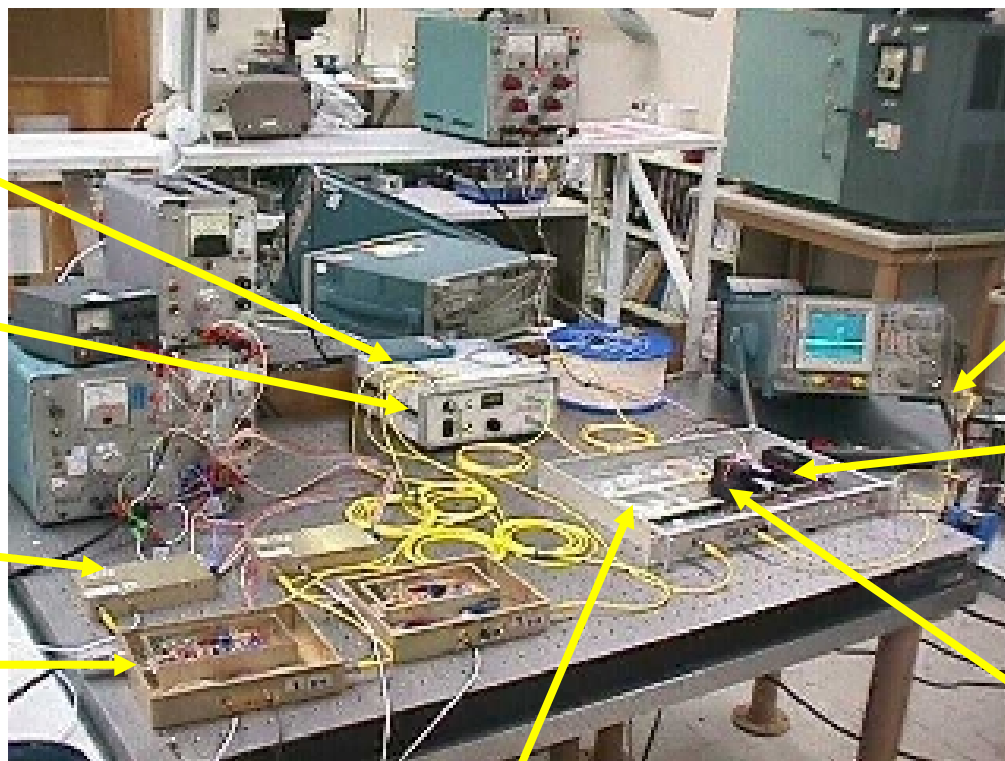
External Link

Receiver

Manual Filter

Electronic Filter

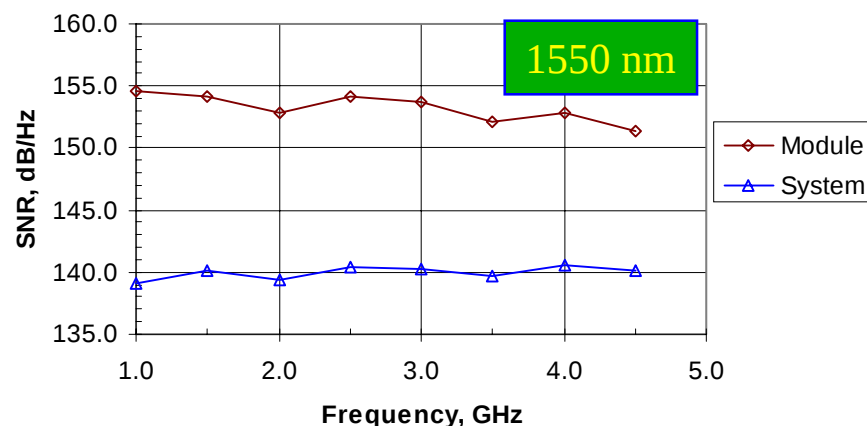
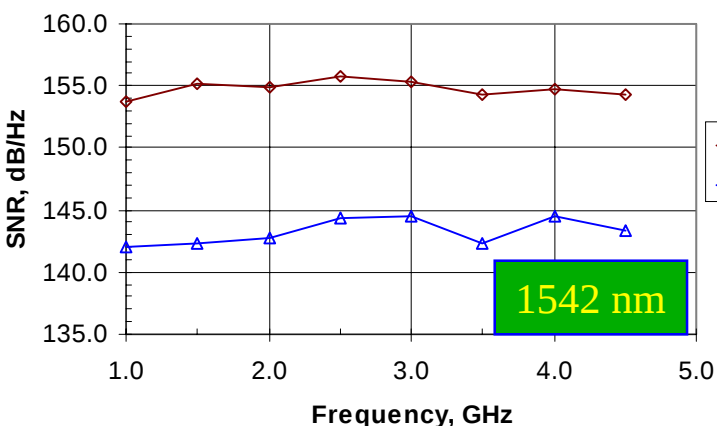
1x16 Splitter



Photonic RF Bus: *Measured SNR of the Prototype Bus*

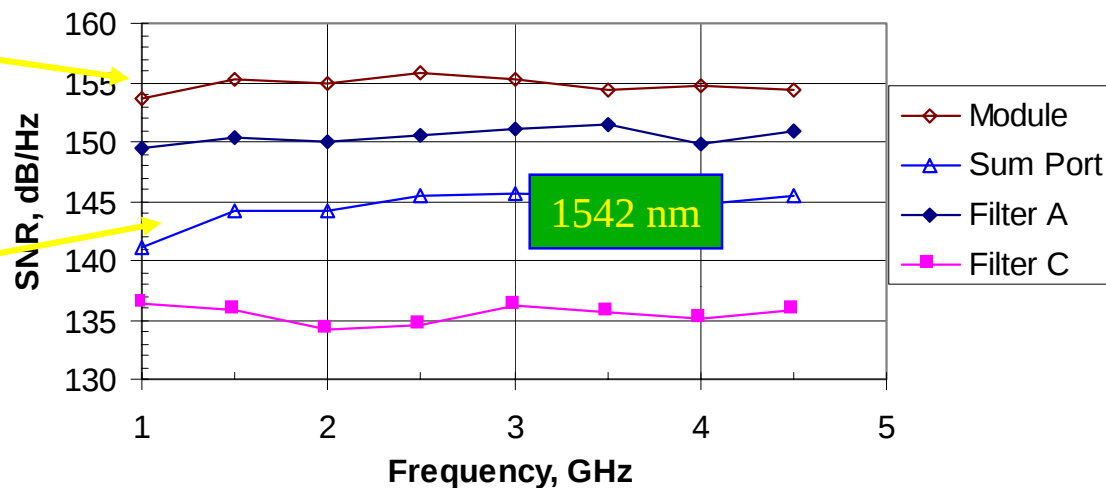


Predicted Average SNR: 141 dB/Hz



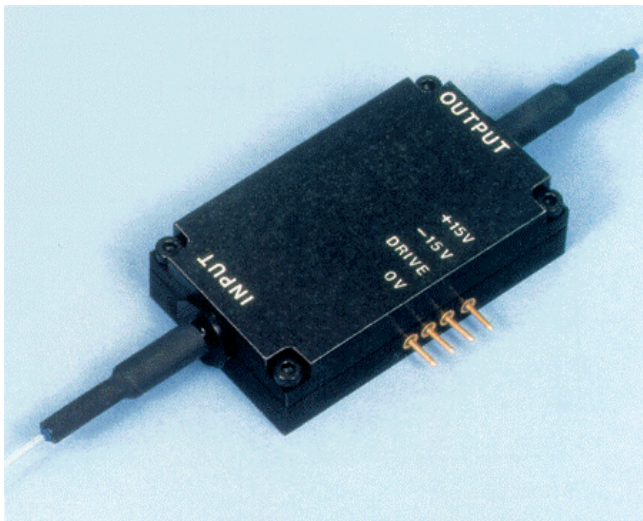
O.A. to 1542 nm only

O.A. to all wavelengths



Photonic RF Bus: COTS Optical Tunable Filters

QUEENSGATE (\$ 5.5 k)



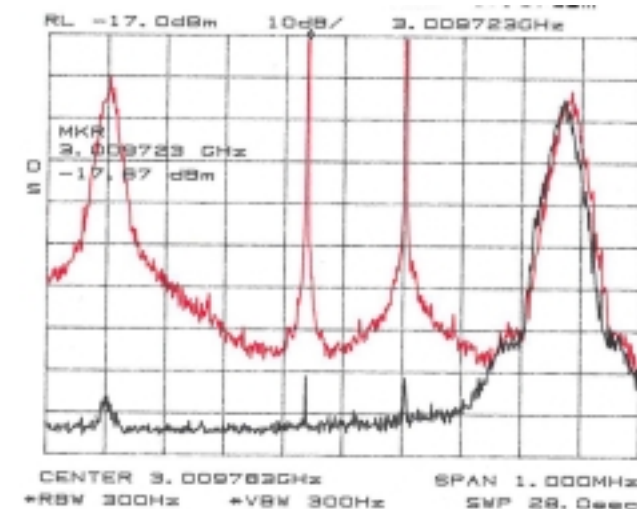
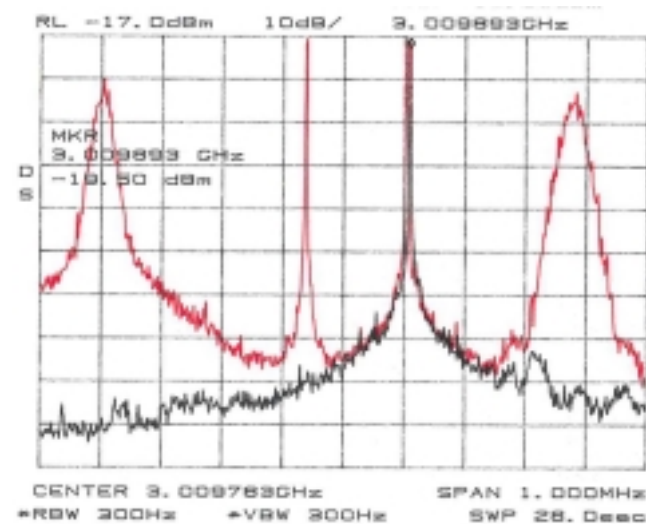
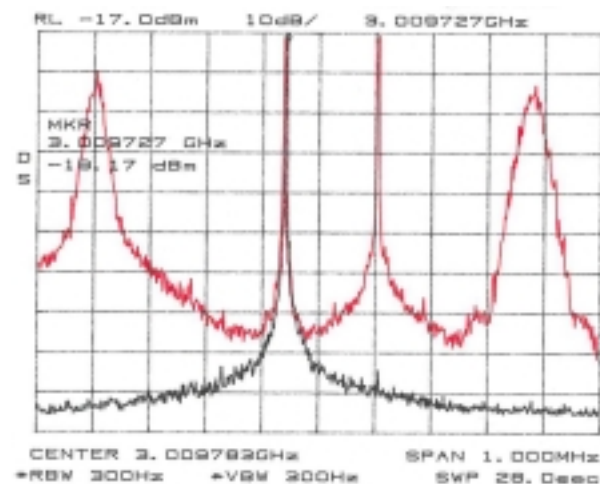
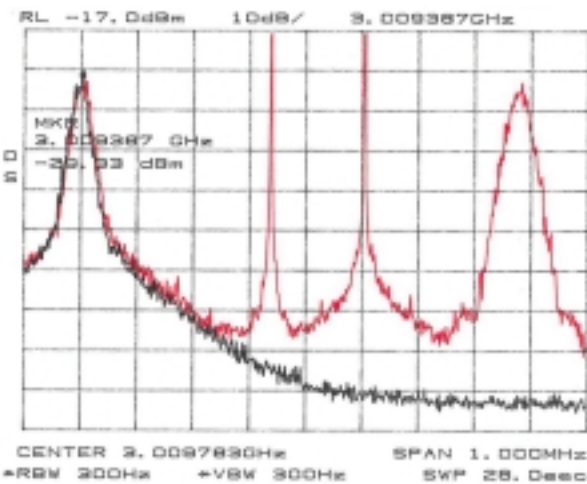
BW: 29.6 nm (vs 14 nm of bus)
 3 dB Op. BW: 0.15 nm (18.75 GHz)
 IL: 3.0 dB
 Speed: 50 nm/ms
 Voltage: 0-20 V

DICON (\$ 2.0 k)



BW: 30 nm (vs 14 nm of bus)
 0.5 dB Op. BW: 0.6 nm (75 GHz)
 IL: 1.0 dB
 Speed: Manual

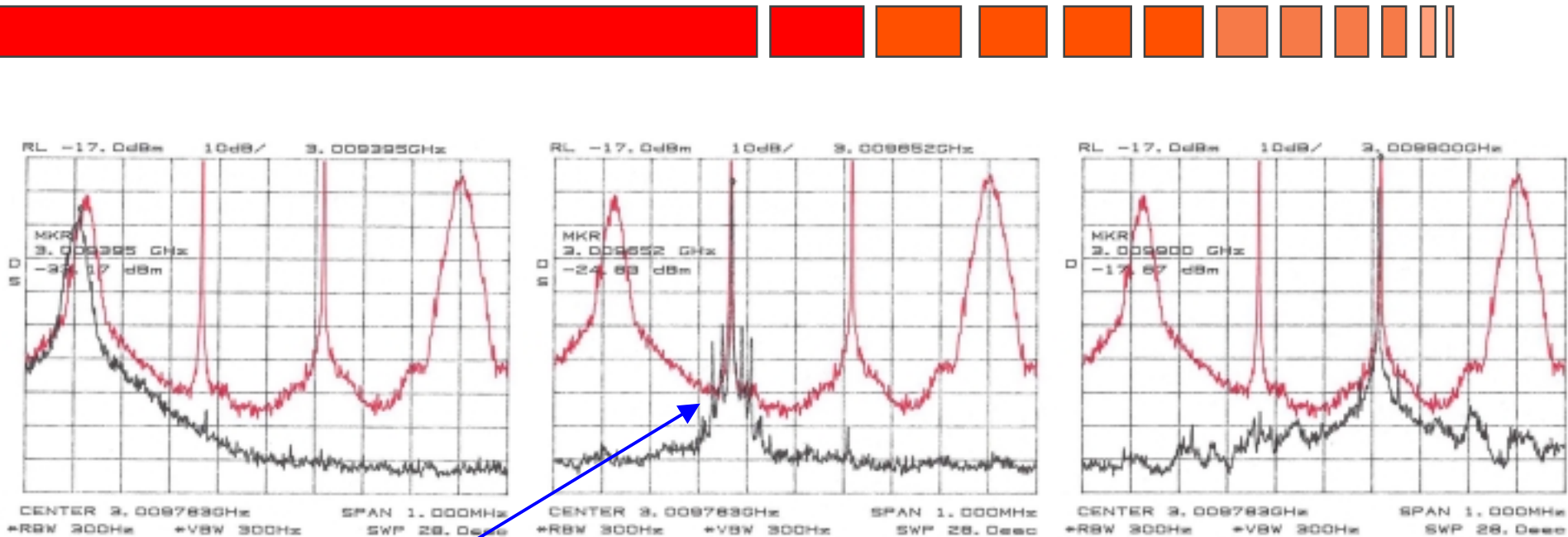
Photonic RF Bus: *Channel Isolation (Manual Filter)*



Manual Filters (Dicon)

- EMI limited measurements
- Excellent reproducibility

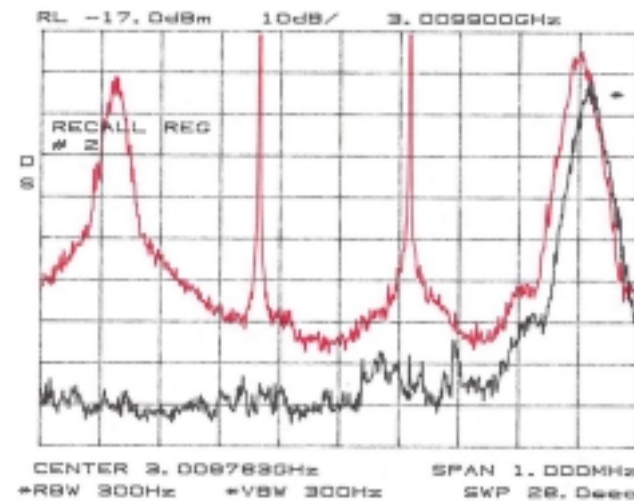
Photonic RF Bus: *Channel Isolation (Electronic Filter)*



Optical reflections ?
Random generator noise ?

Electronic Filters (Queensgate)

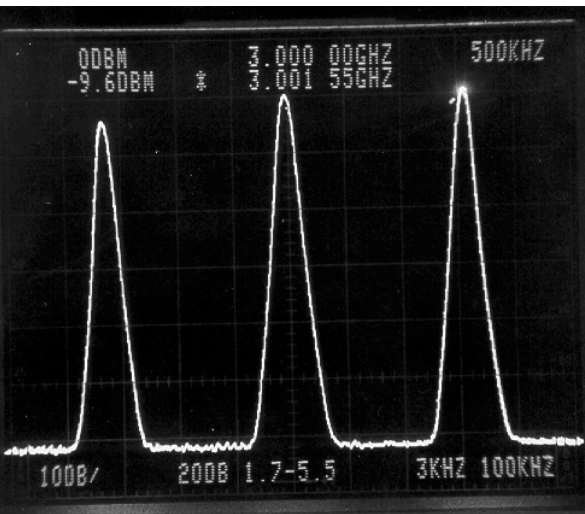
- EMI limited measurements
- Lossier than Dicon's (by 2 dB)
- Strange "spikes"



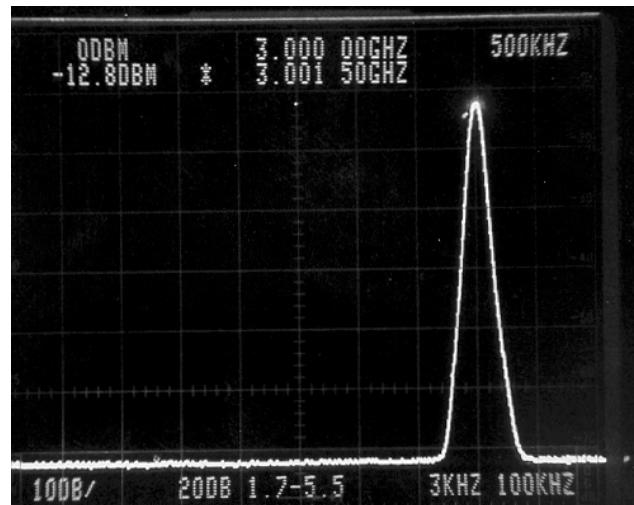
Photonic RF Bus: *Channel Isolation (EMI Isolated)*



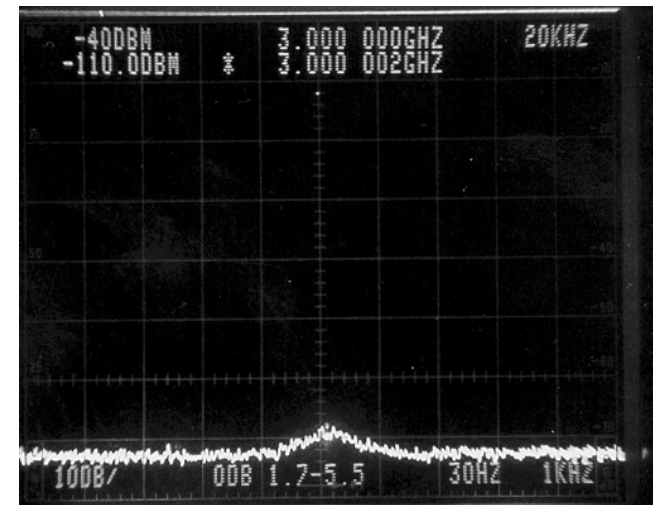
No Filter



Selected Signal



Blocked Signal



Output signal (no filter) = -9 dBm

Selected signal (with filter) = -12.8 dBm

Blocked signal = <-110 dBm

Isolation is better than 97.2 dB

Photonic RF Bus Prototype: *CONCLUSIONS*

- 
- COTS-based Photonic RF Bus was designed, fabricated and tested. It performed as expected: **NO SURPRISES**
 - Low cost directly modulated links, moderate cost externally modulated links and low cost receivers were developed and performed very well over the 1-5 GHz band
 - Need to know what "type" of link is appropriate for what "type" of function
 - Further improvements possible by matching the link and function RF responses
 - COTS passive optical components and COTS optical amplifiers have good performance. No need for custom devices

Photonic RF Bus Prototype: *CONCLUSIONS*



- The optical tunable filters are the key component of the bus.
- The COTS manual tunable optical filters we used performed very well, but are not practical ...
- The electronic tunable filters we used did not perform as well: they were drifting, were lossy, and affected the system Phase Noise

The Photonic RF Bus needs tunable optical filters ...



Desired Optical Tunable Filter Specs

- (1) Speed: < 1 msec
- (2) Loss: 1-2 dB (Optical)
- (3) 0.5 dB Optical BW: 0.6-0.5 nm
- (4) Optical Isolation: 50 dB (optical) @ 4 nm from center
- (5) Size: not critical (2-3 in³ is OK)
- (6) Cost: $\sim \$ 1$ k
- (7) Control: analog or digital is OK
- (8) No dithering plates please ... they kill the system phase noise.