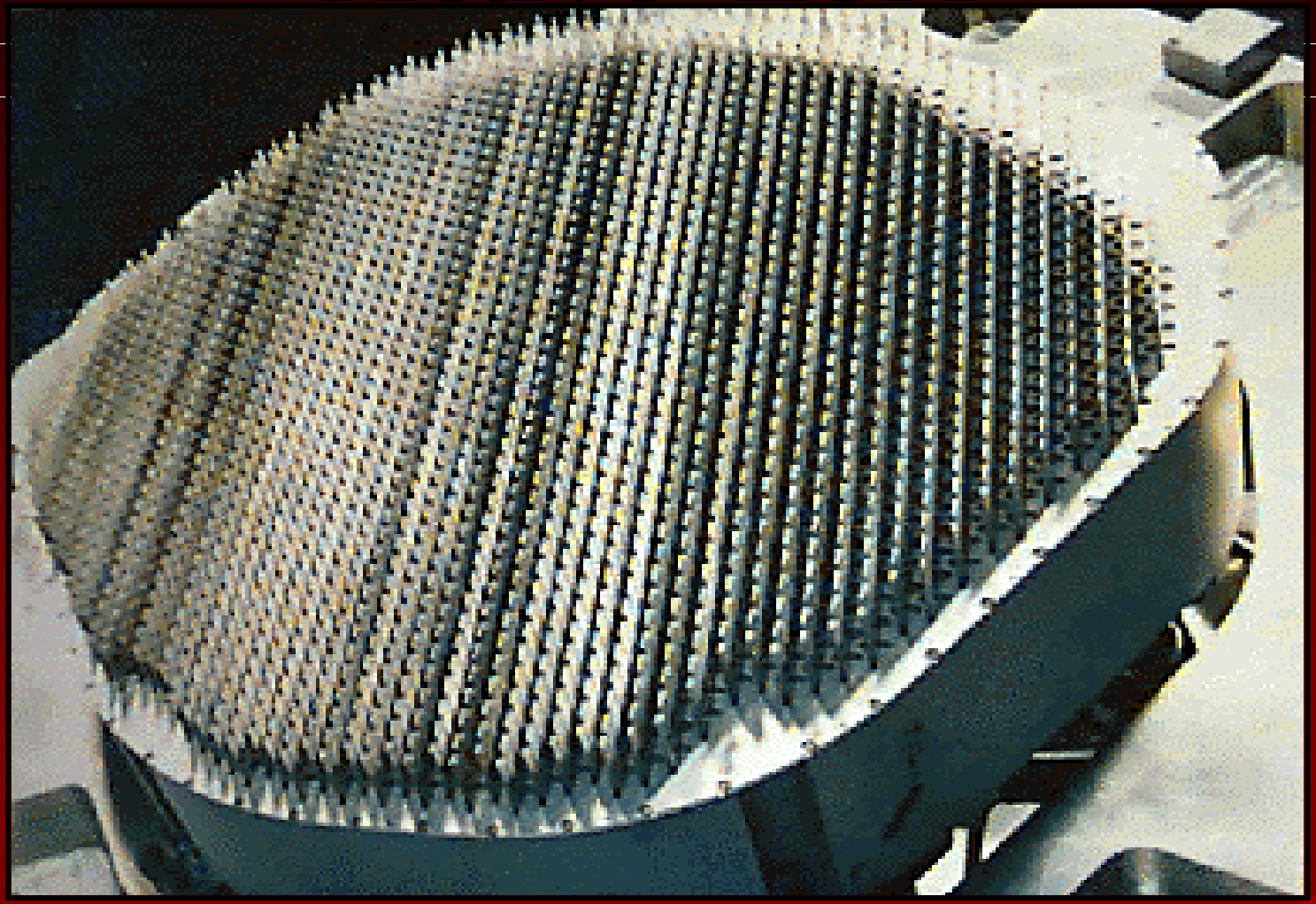
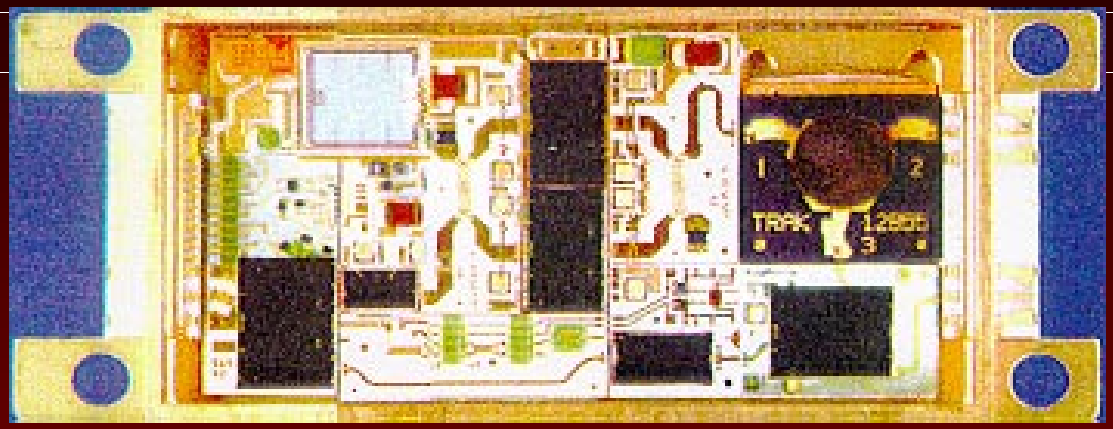
MEMS And Advanced Radar

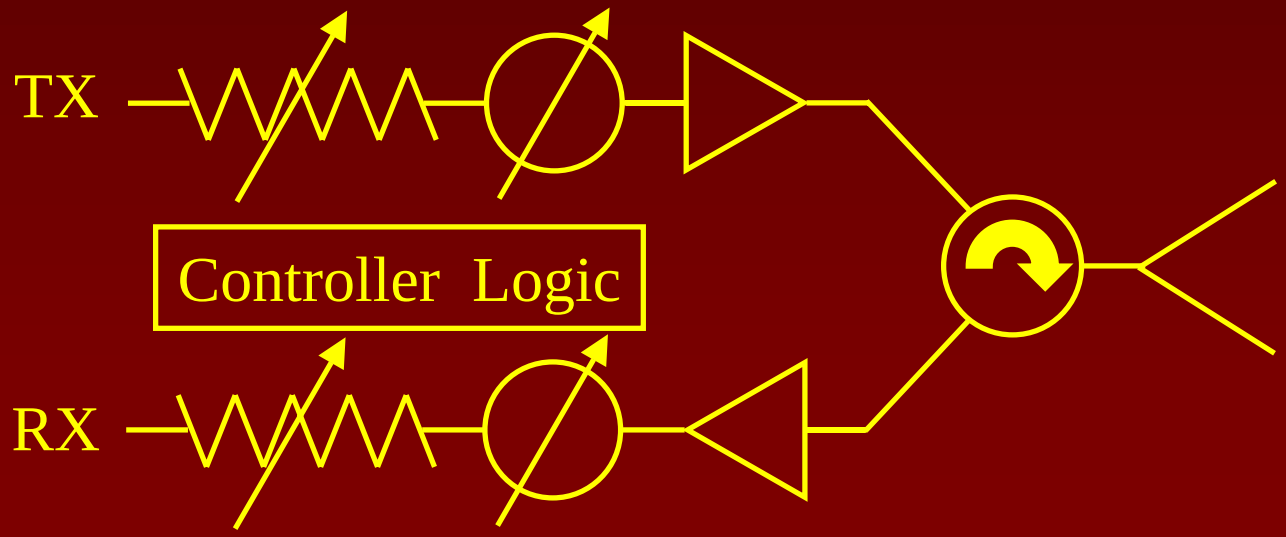
Dr. John K. Smith

Active ESA



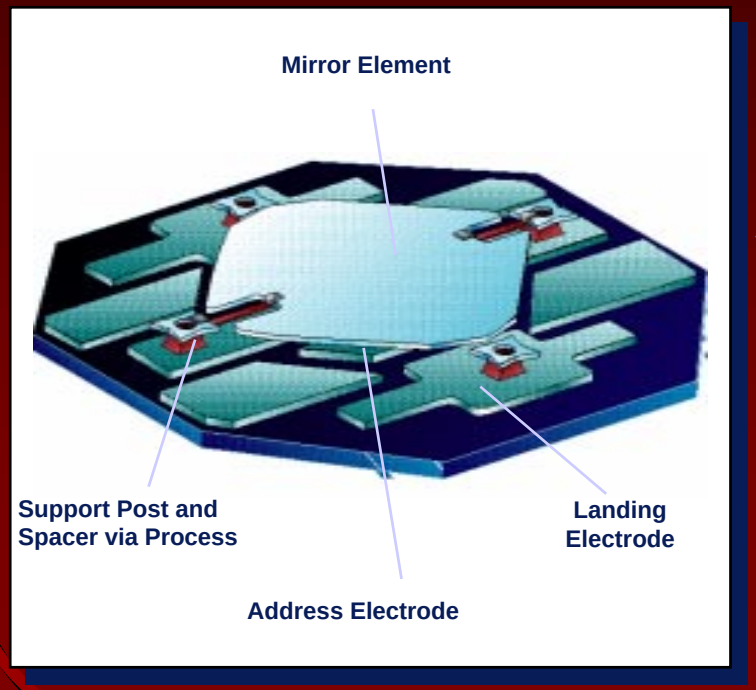
T / R Module



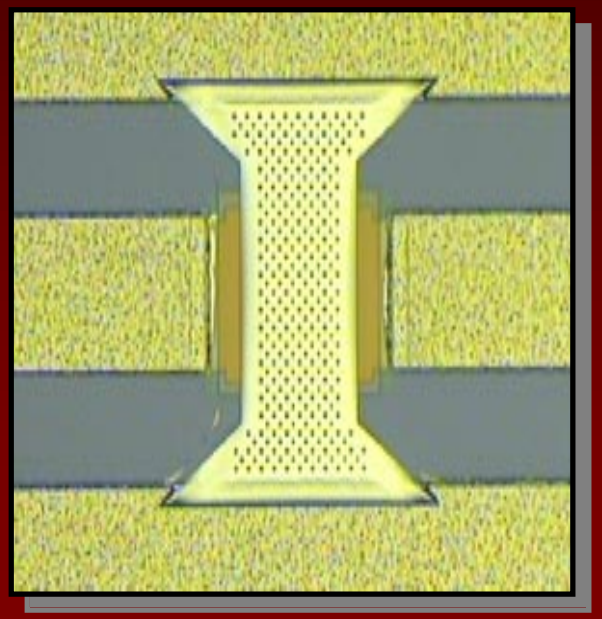


MEM RF Switch

Digital Mirror Device



Shunt Bowtie Switch



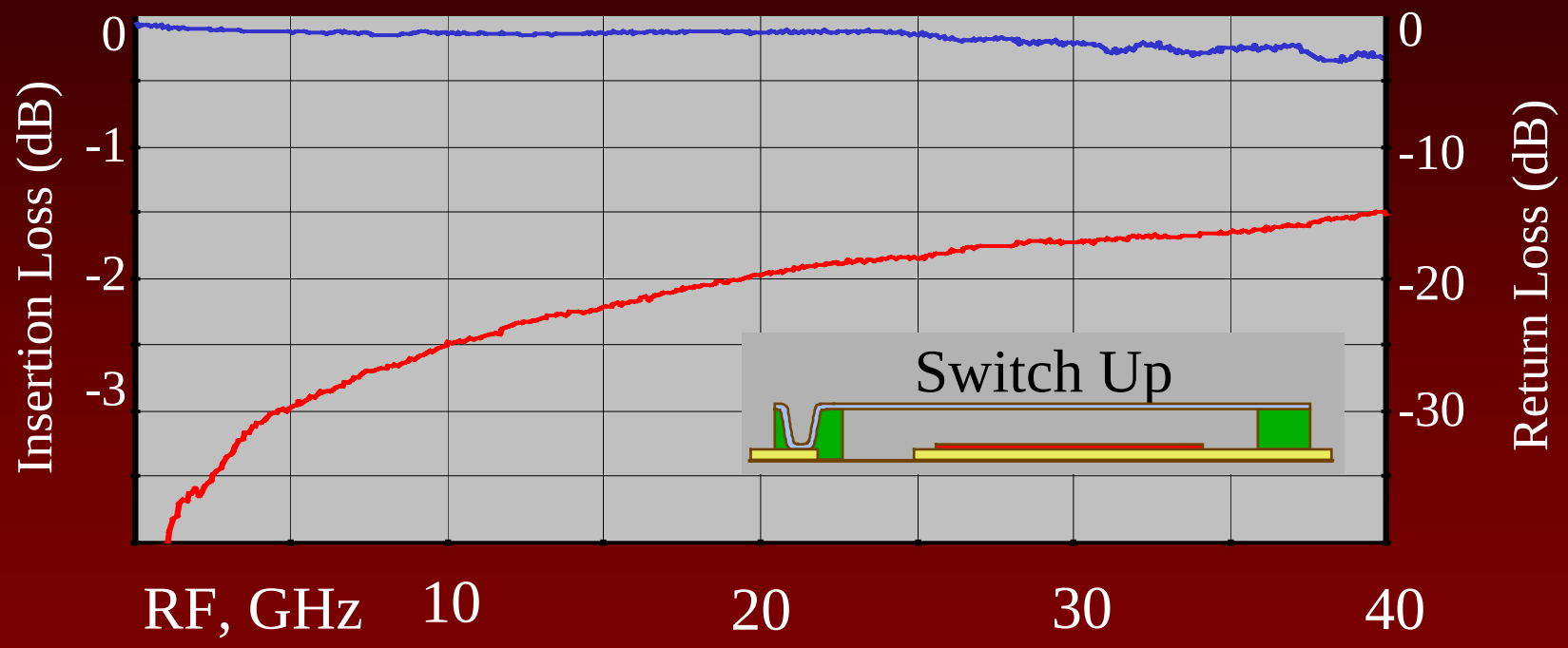
MEM Switch

- Controlled By Static DC Voltage
- Acts As RF Switch Or Capacitor

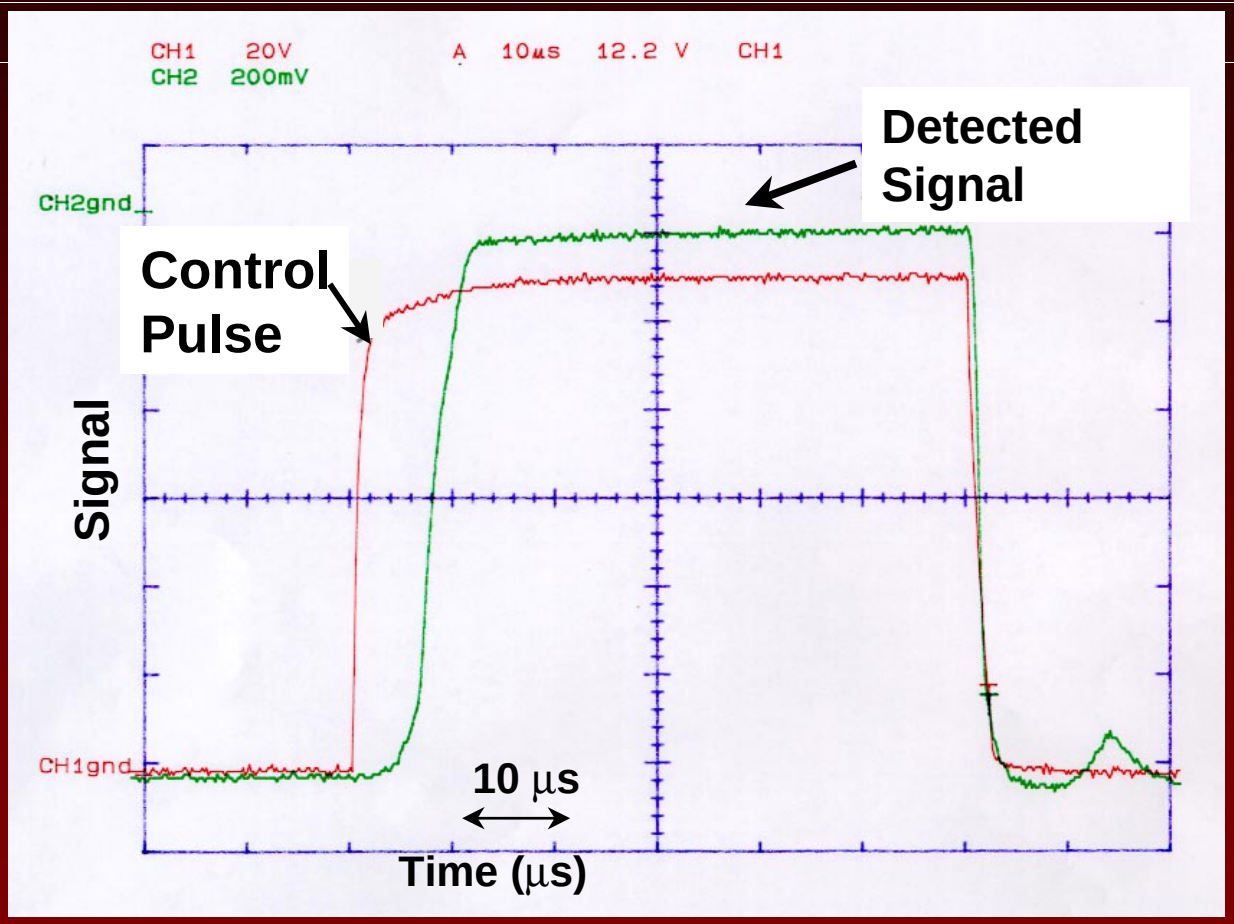
Open Circuit / Low Capacitance

Closed Circuit / High Capacitance

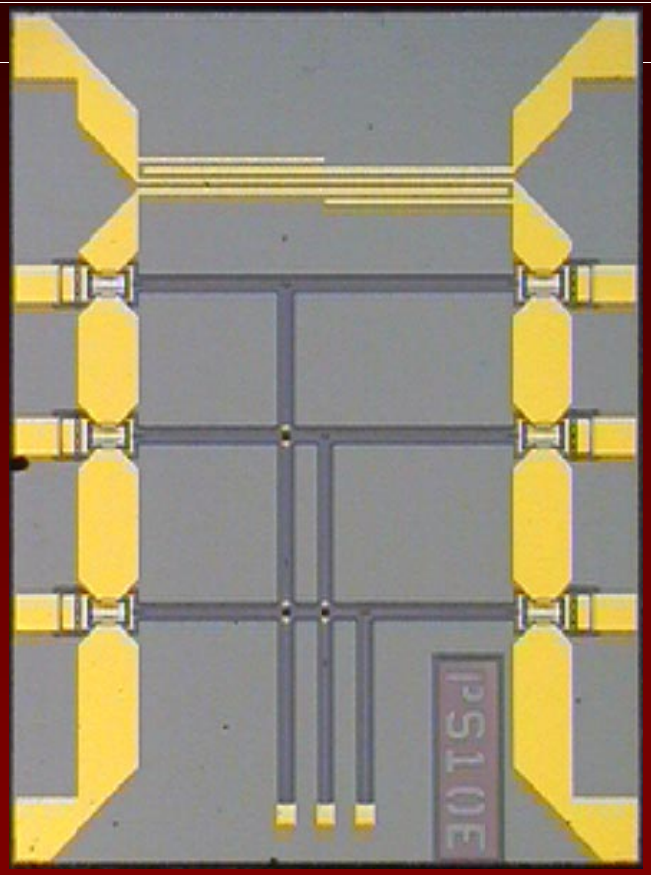
RF Performance



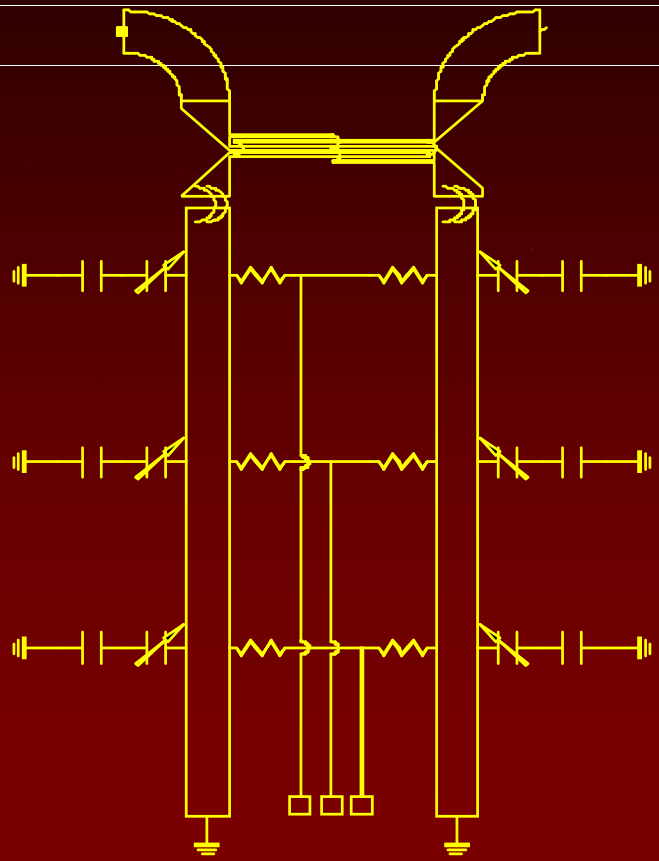
Switching Time



X-Band Phase Shifter



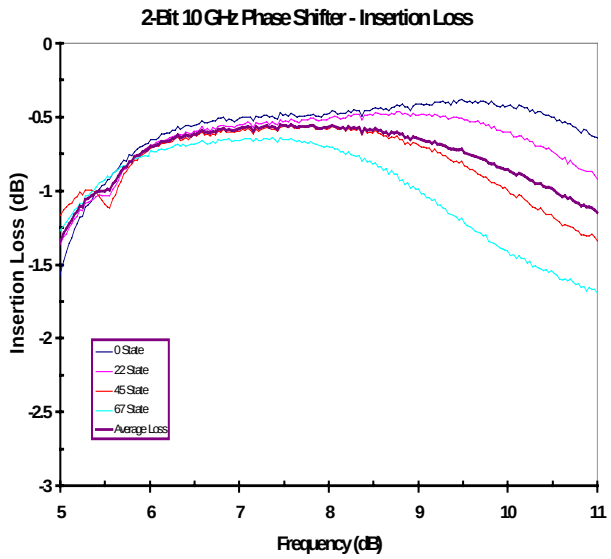
Photograph

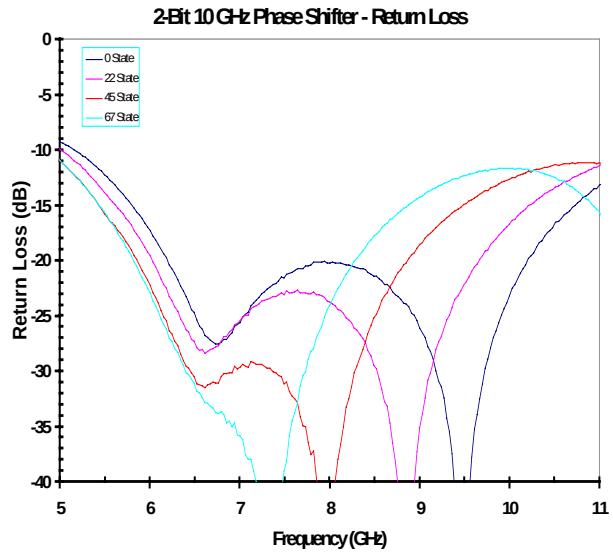


Schematic

Measured Characteristics

10 GHz 2-Bit (Small) PS Performance





6.0 - 10.0 GHz
- Average insertion loss 0.55-0.9 dB (Arithmetic average of all 4 states)

5.5 - 11.0 GHz
- Return loss > 11 dB

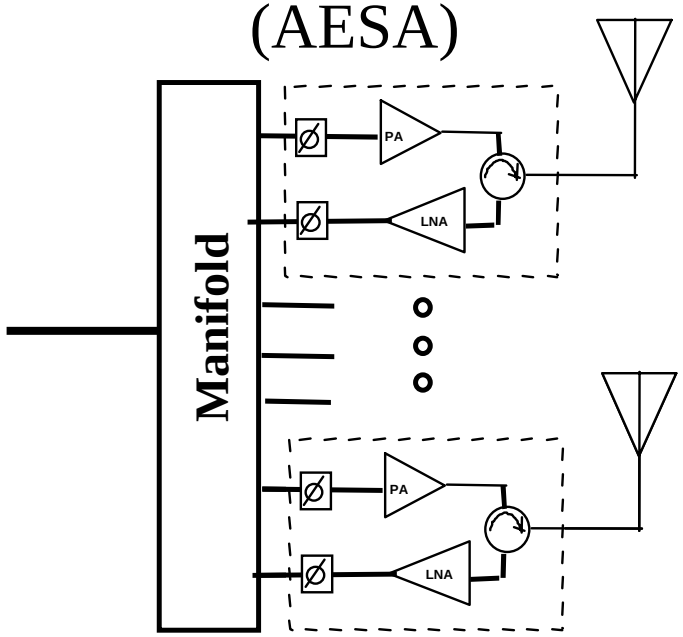
Phase Shifter Technologies

Typical 4 Bit X-Band

Technology	Unit Cost	Power	Loss
MEMS	$10	1 mw	1.5 dB
GaAs MMIC	$40	20 mw	6-8 dB
Ferrite	$100	400 mw	1.2 dB
Diode	$20	200 mw	2.0 dB

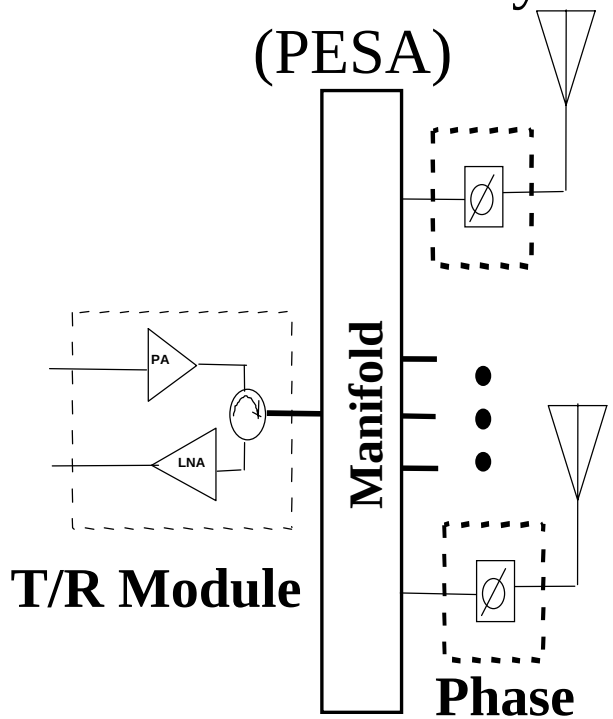
AESAs And PESAs

Active Electronically Scanned Array (AESA)



T/R Module

Passive Electronically Scanned Array (PESA)



T/R Module

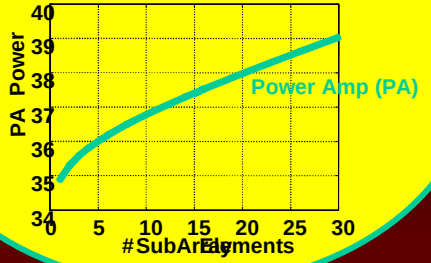
Phase Shifter

Transmitter Power Trades

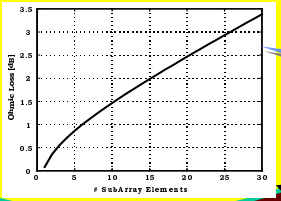
FIXED RF LOSSES

EQUAL PERFORMANCE

REQUIRED PWR$_{PA}$

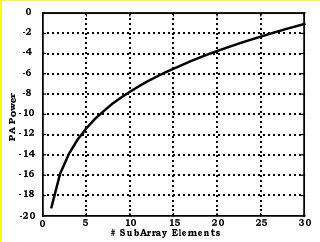


PESA MANIFOLD LOSS

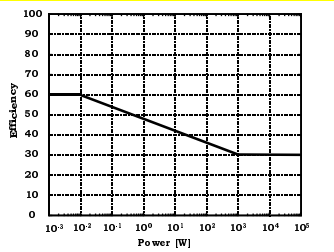


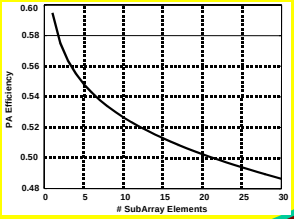
 # ELEMENTS IN SUB-ARRAY (PARAMETRIC)

PWRGEN BY EACH PA

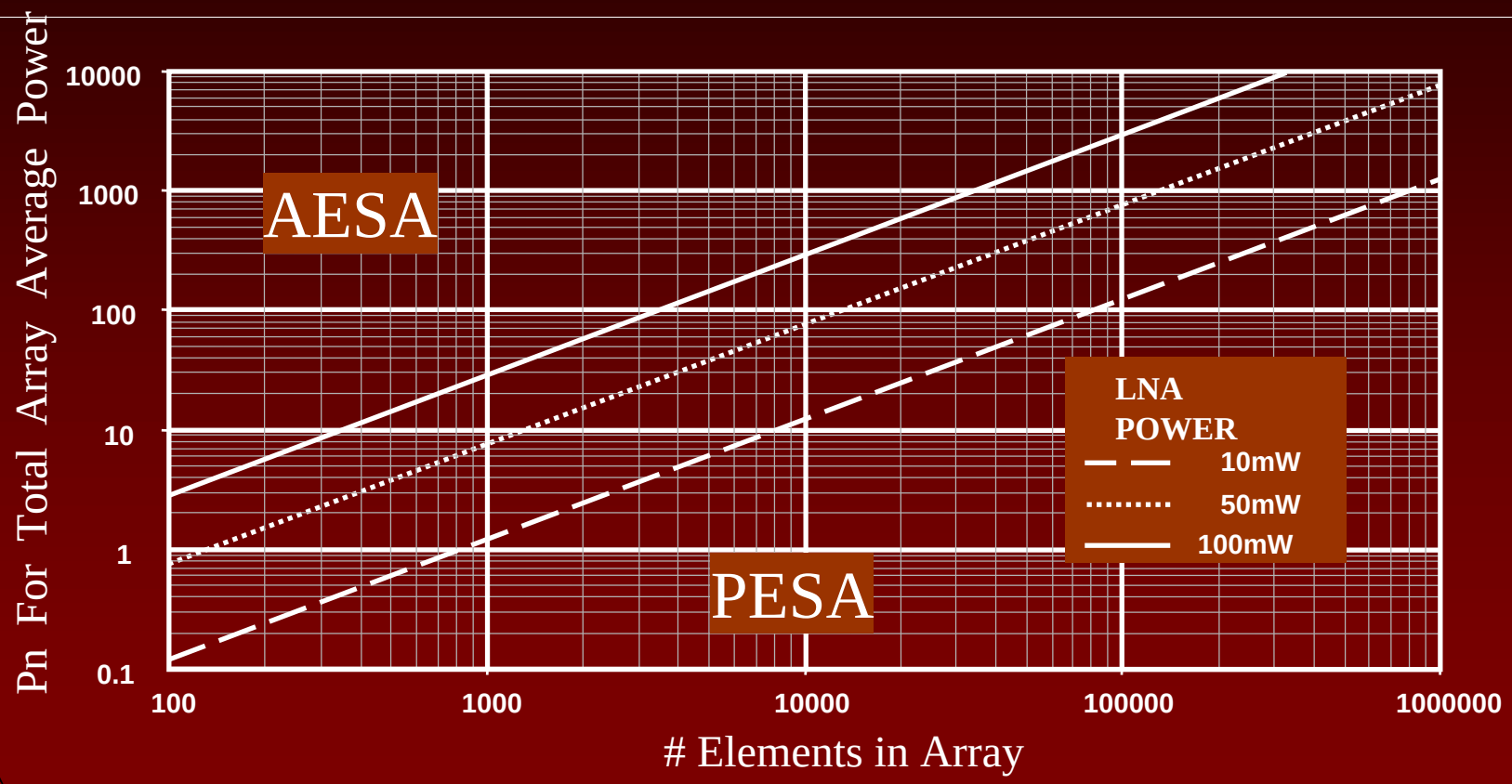


PA EFFICENCY (Eff $_{PA}$)



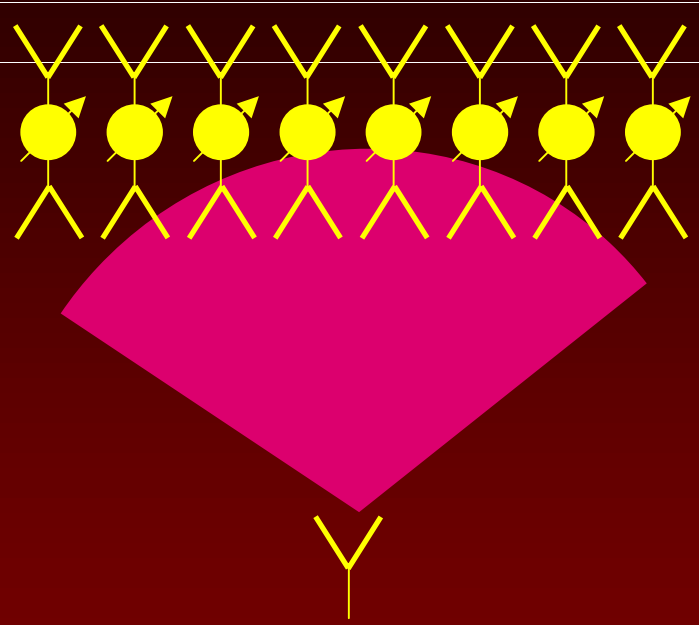


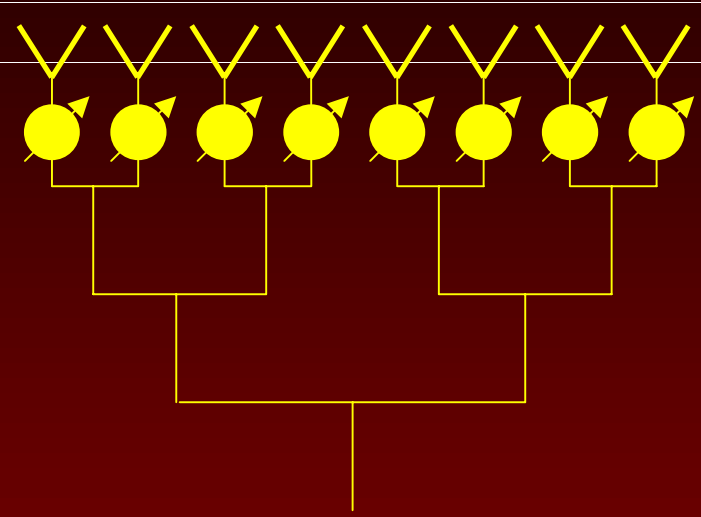
Array Size And MEM's Advantage



MISSILES AI AIRBORNE SURVEILLANCE AERO STAT SBR

Space Fed Lens Vs. Constrained Feed





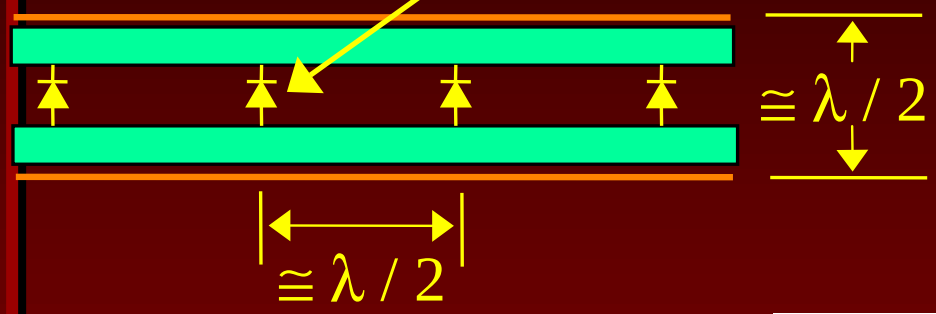
	Space	Constrained
Cost	Low	High
Weight	Low / Med	Med / High
Bandwidth	Low	Med / High

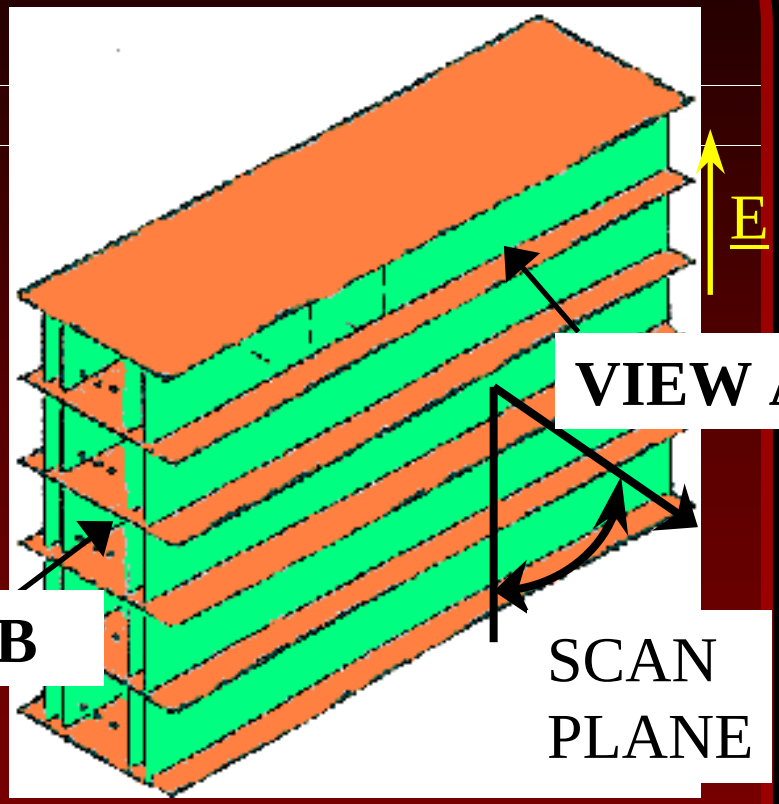
Space - Fed Lens Applications

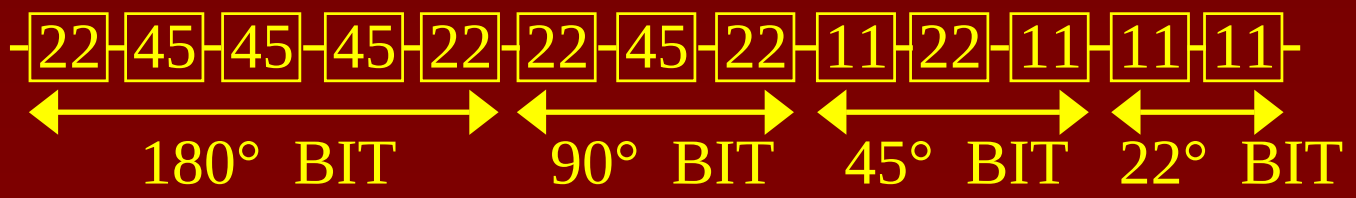
- Aerostat

- Ship

Radant™ Lens


VIEW A
PIN DIODE SWITCH
≅ λ / 2
≅ λ / 2


E
VIEW A
VIEW B
SCAN
PLANE

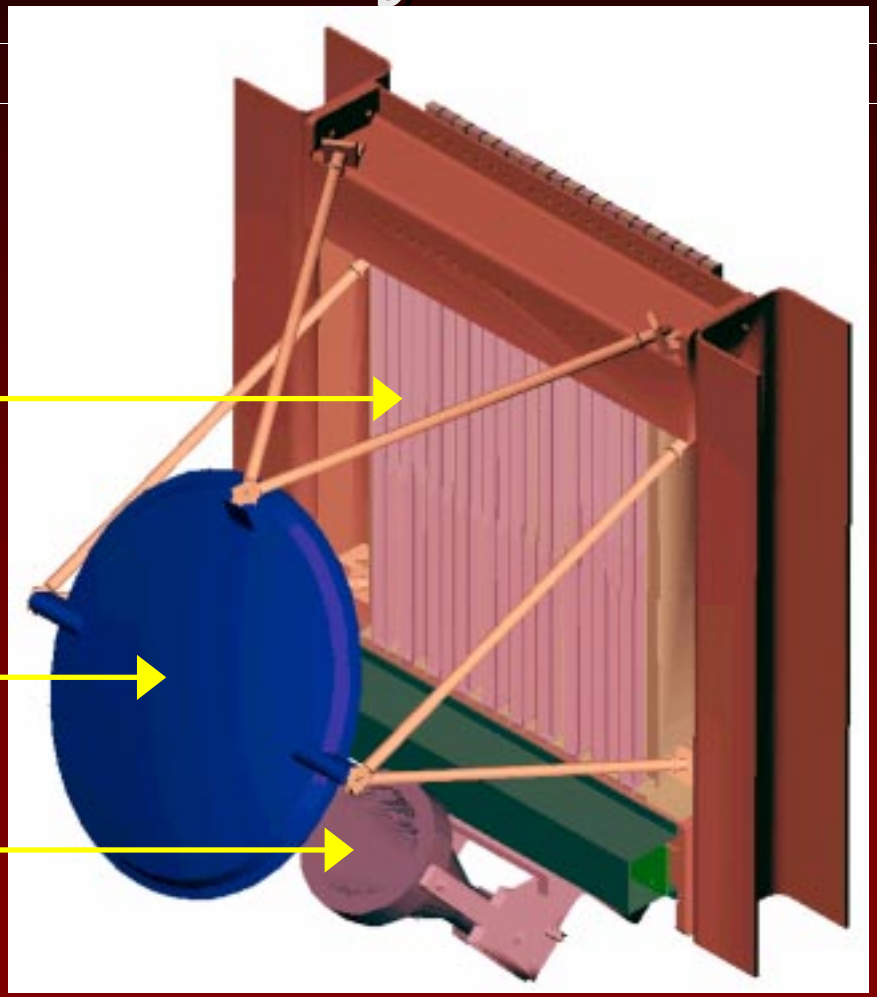

VIEW B
22 45 45 45 22 22 45 22 11 22 11 11 11
180° BIT
90° BIT
45° BIT
22° BIT

Experimental System

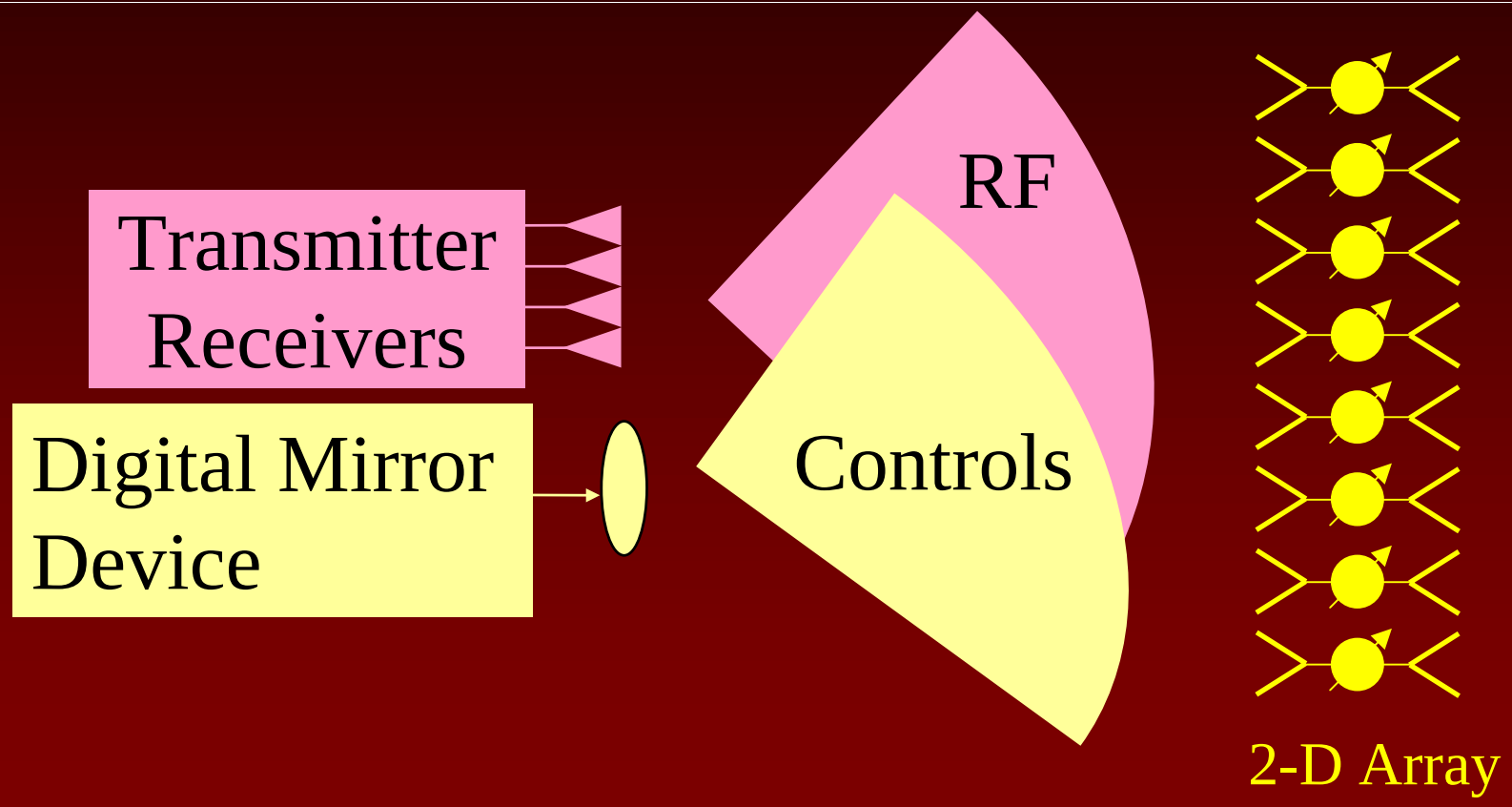
Radant™ Lens

Reflector

Feed



MEM-Tenna


Transmitter
Receivers
Digital Mirror
Device
RF
Controls
2-D Array

Digital Mirror Device

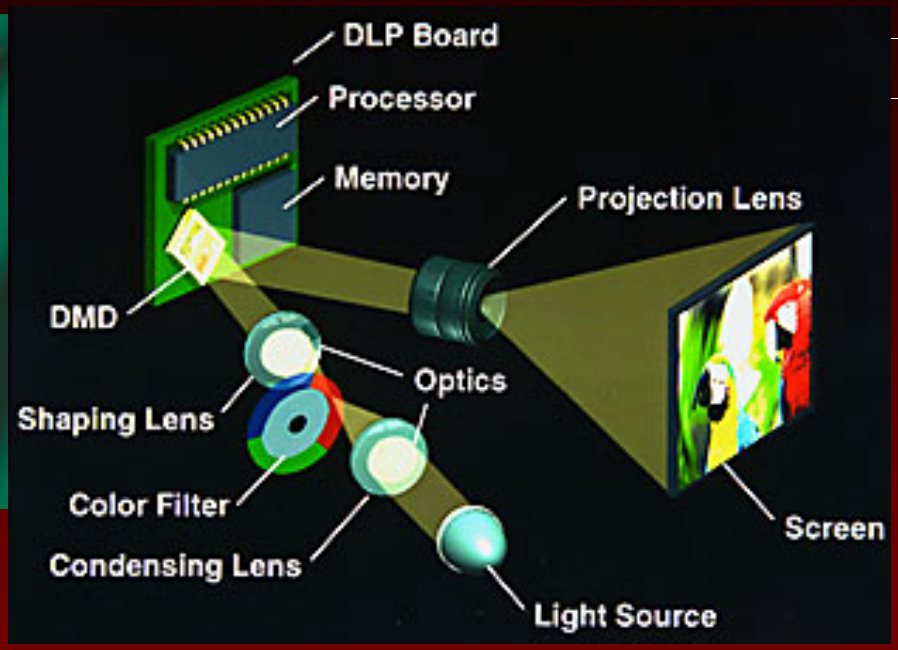
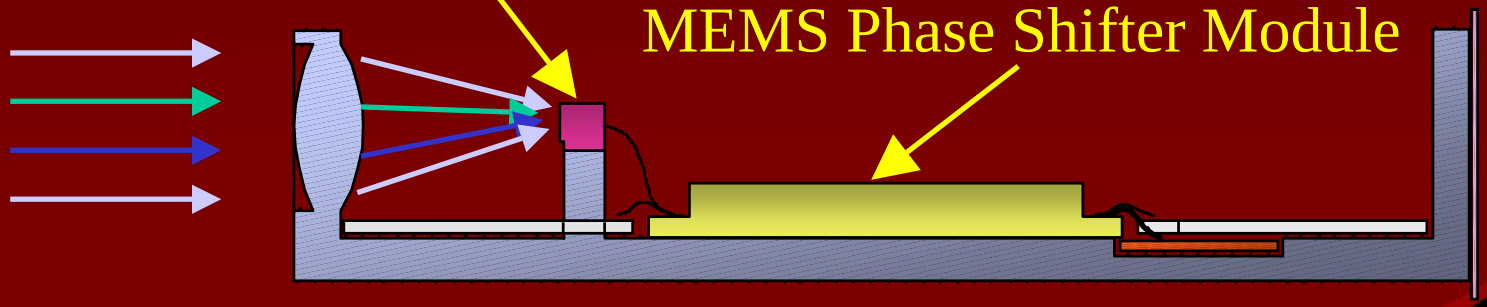


Photo Detector Diode

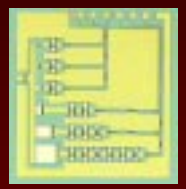
MEMS Phase Shifter Module



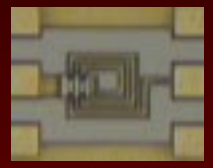
MEM Tunable Filter

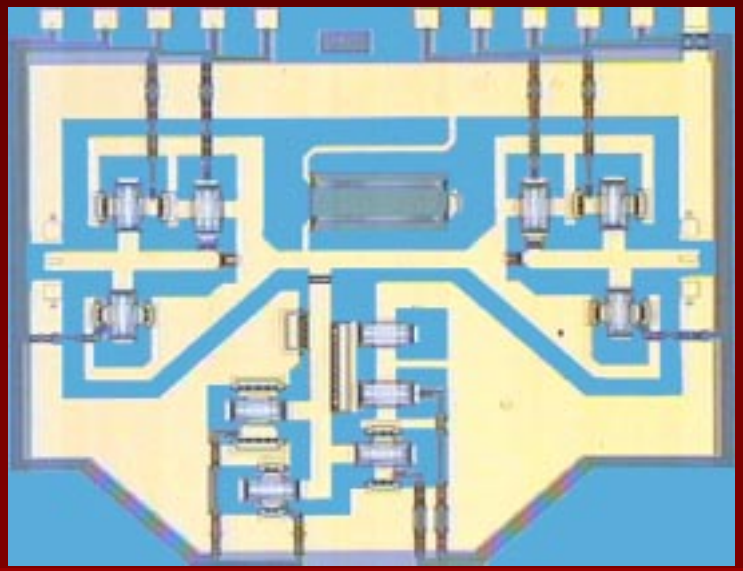
Capacitive MEM Switch

Variable Capacitor

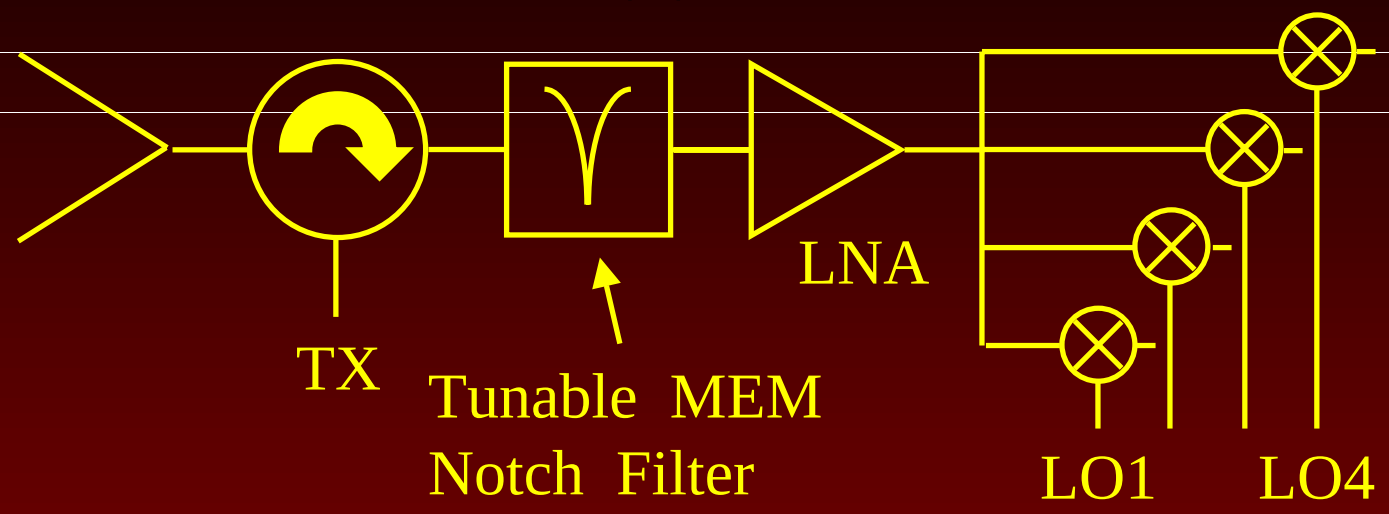


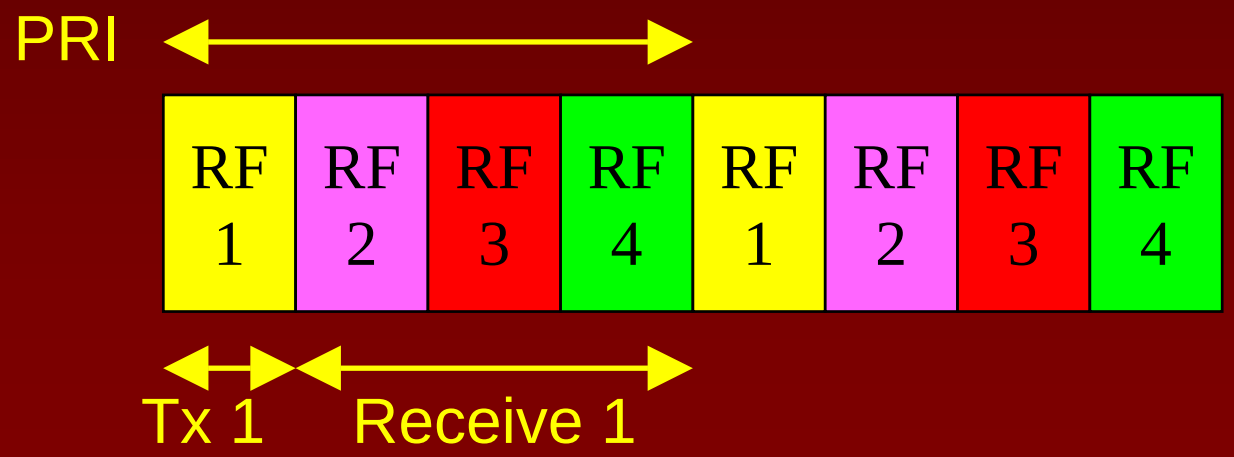
High-Q Inductors





STAR Waveform





STAR and Radar

- Range And Velocity Eclipsing Reduction
- Frequency Diversity
- Interleaved Waveforms: SAR/GMTI
- Multiple Beams
- Data Links In Common Aperture
- A/G And A/A Mode Interleaving

Conclusions

- MEMs Phase shifters and filters revolutionize radar antennas
  - Space feeds: MEM-Tenna
  - STAR Waveforms
- Order of magnitude reduction in cost and weight is possible