Progress Report
on

Dualband QWIPs Development for DITP

to

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by

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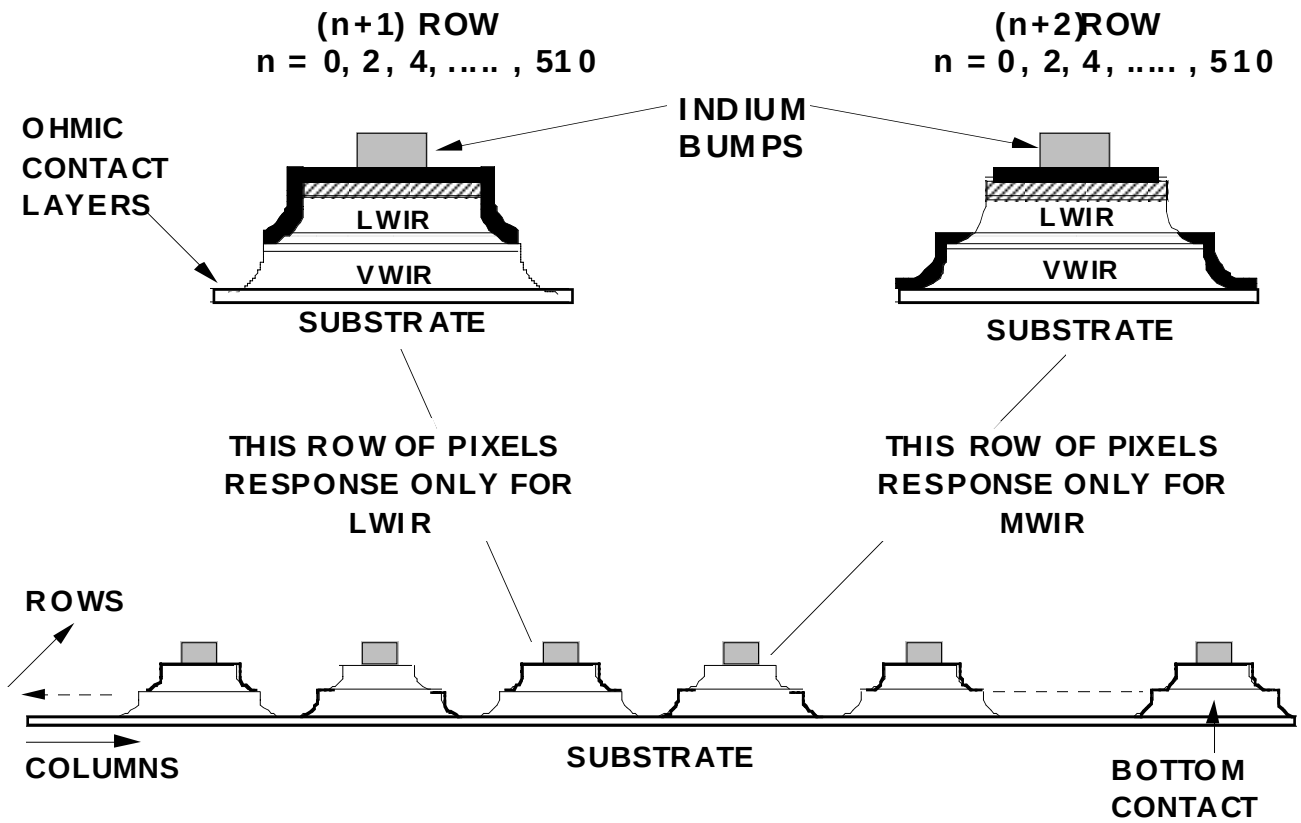
Jet Propulsion Laboratory
California Institute of Technology
July 23, 1998

OUTLINE

- STATUS OF DUALBAND (LW, VLW) QWIP CAMERA
- PROGRESS OF 10 μm CUTOFF QWIP RESEARCH FOR LOW BACKGROUND STRATEGIC APPLICATION
- SIGNIFICANT ACHIEVEMENTS/CY'98 PLANS

CONCEPT 3

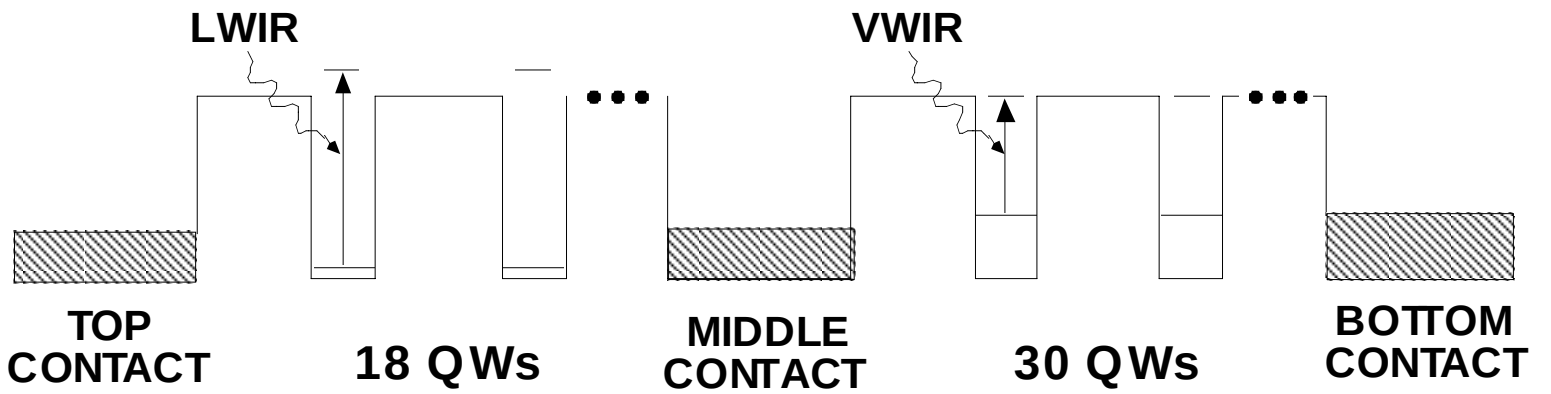
INTERLACE TWO COLOR QWIP FPA



PROS:
- SIMULTANEOUS READOUT
- MULTIPLEXER AVAILABLE
- ONE SIZE INDIUM BUMPS

CONS:
- 50% SPATIAL RESOLUTION
- DIFFICULT FABRICATION PROCE

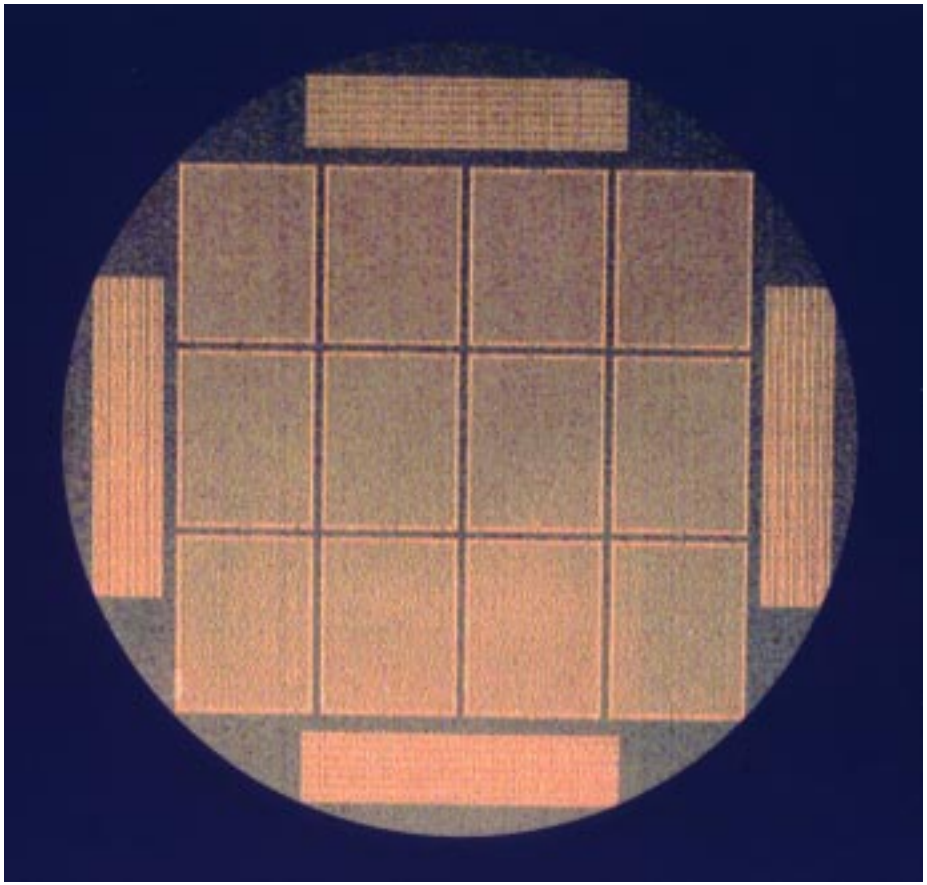
DUALBAND QWIP DEVICE STRUCTURE



BOUND-TO-CONTINUUM

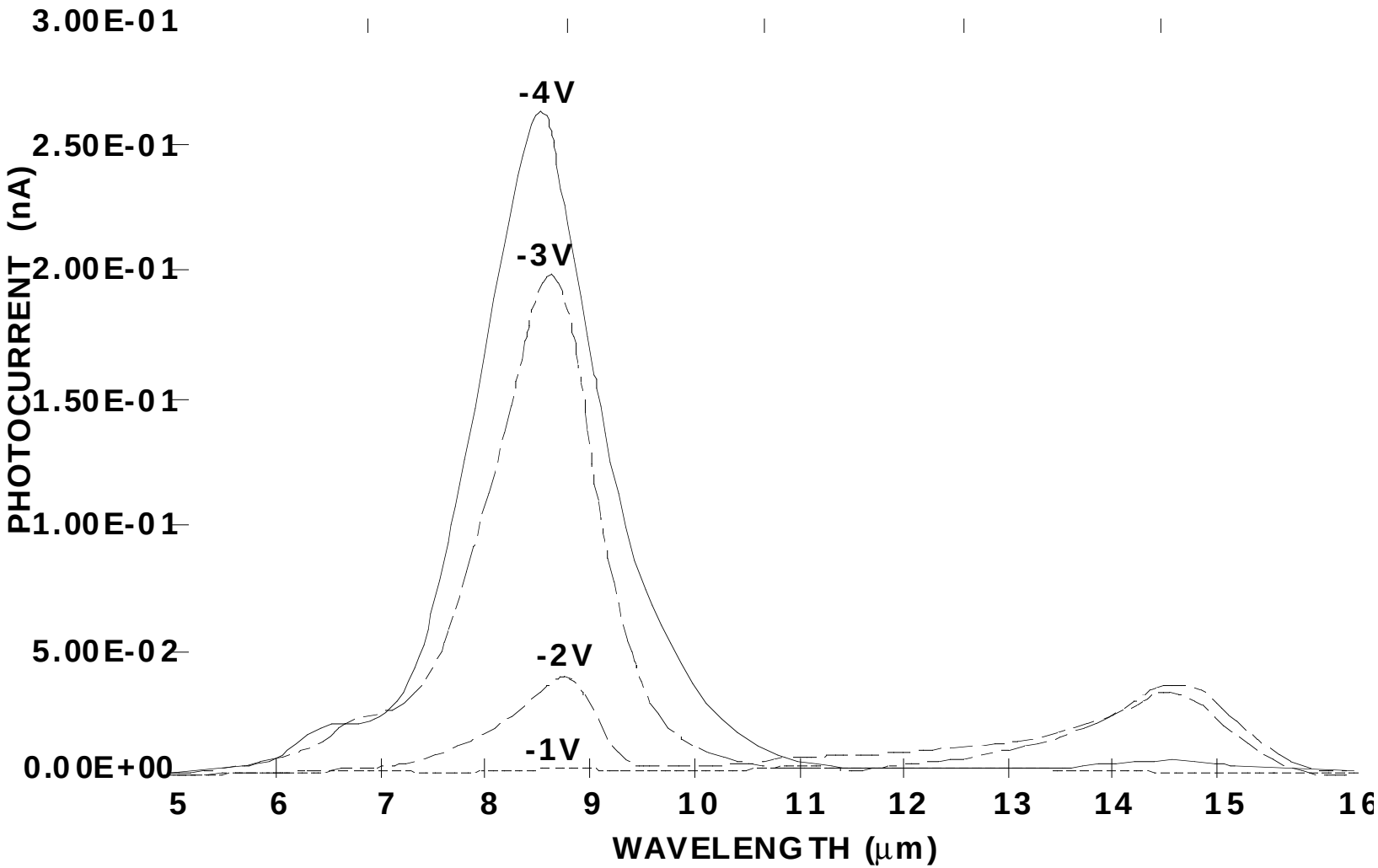
BOUND-TO-QUASIBOUN

TWELVE 640 X 486 QWIP FOCAL PLANE ARRAYS

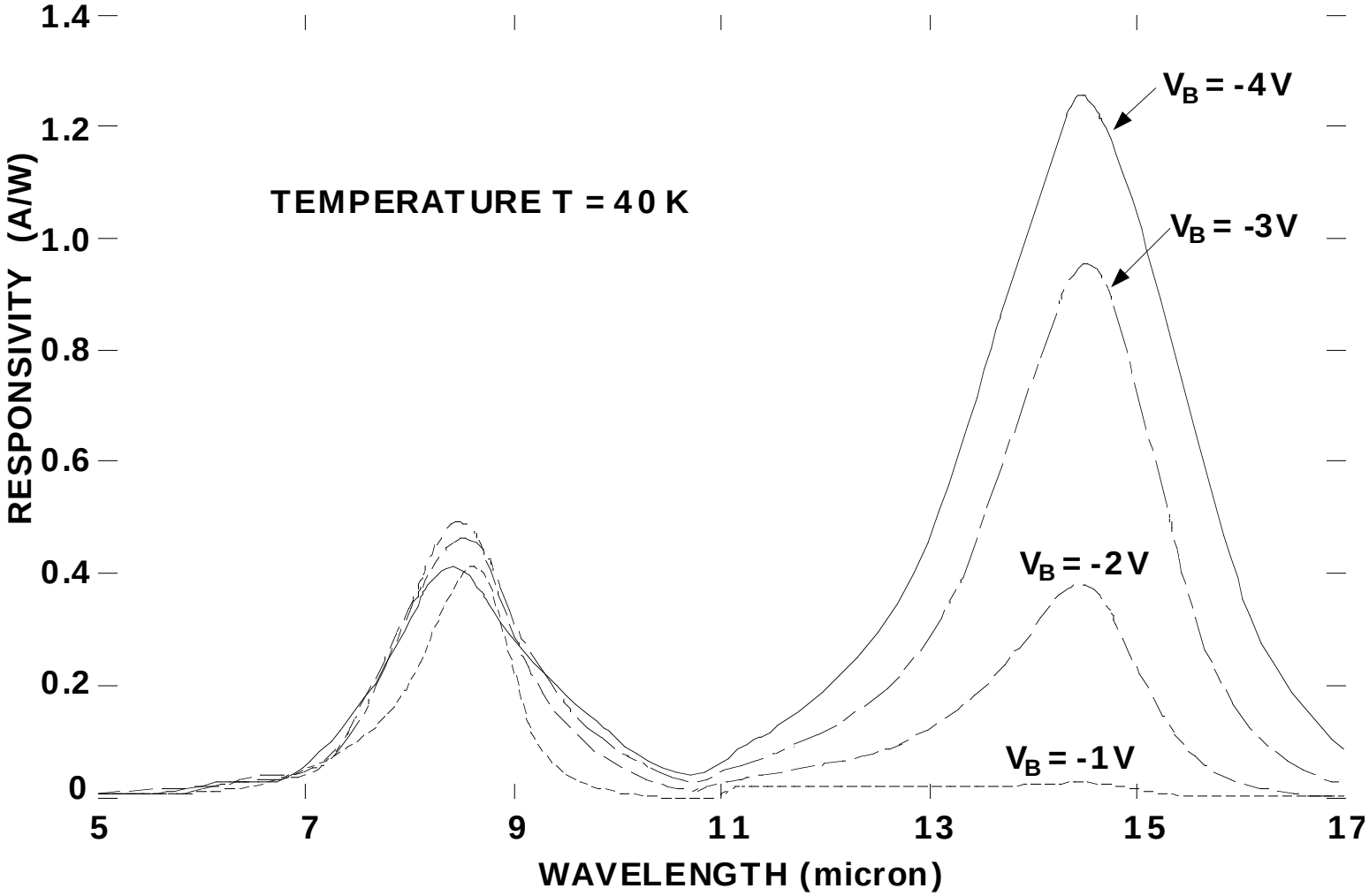


- LOW COST
- HIGHER YIELD
- AVAILABILITY

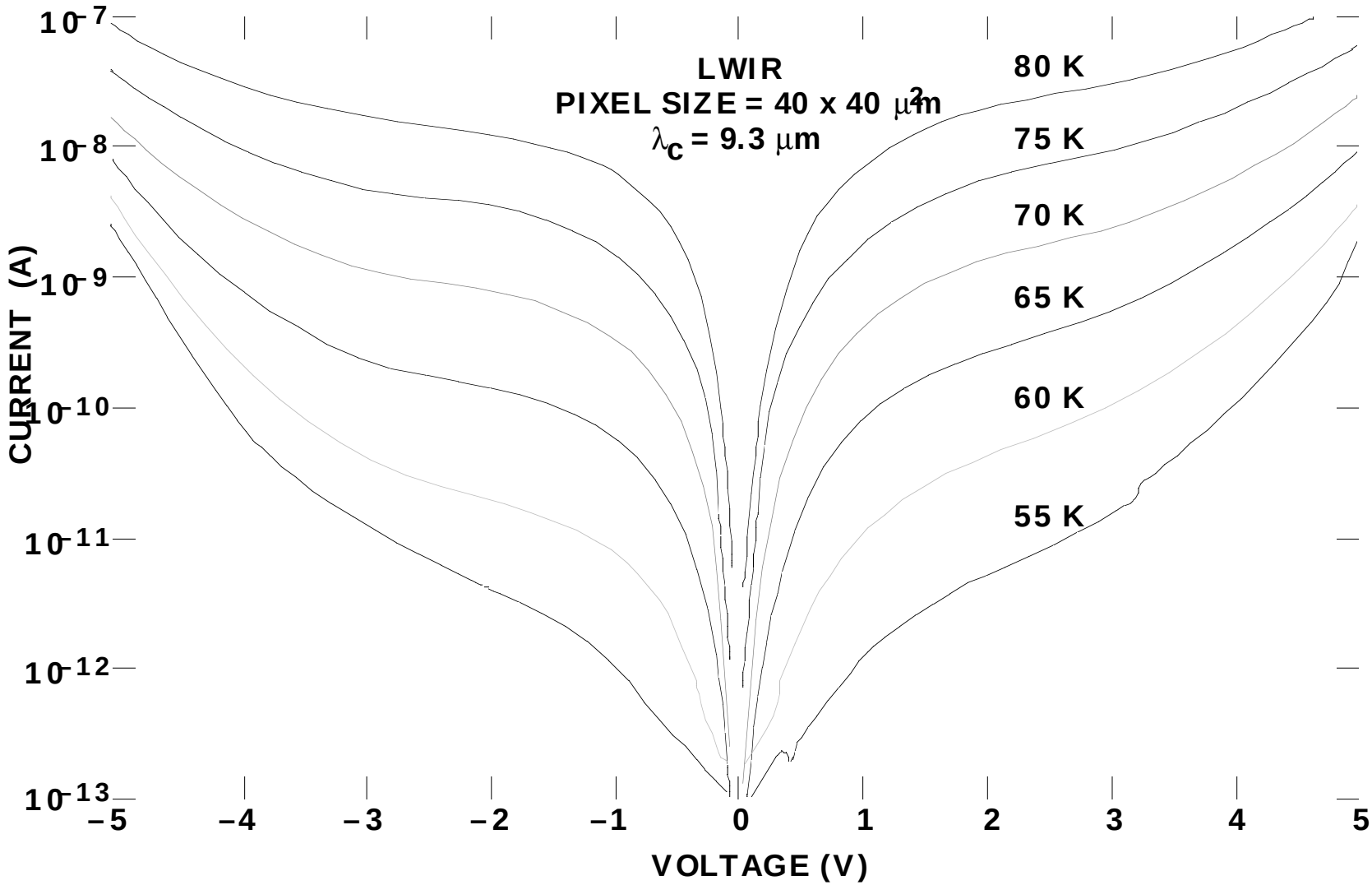
PHOTOCURRENT 500 K BLACKBODY



SIMULTANEOUS SPECTRAL RESPONSIVITY OF DUALBAND FOCAL PLANE ARRAY

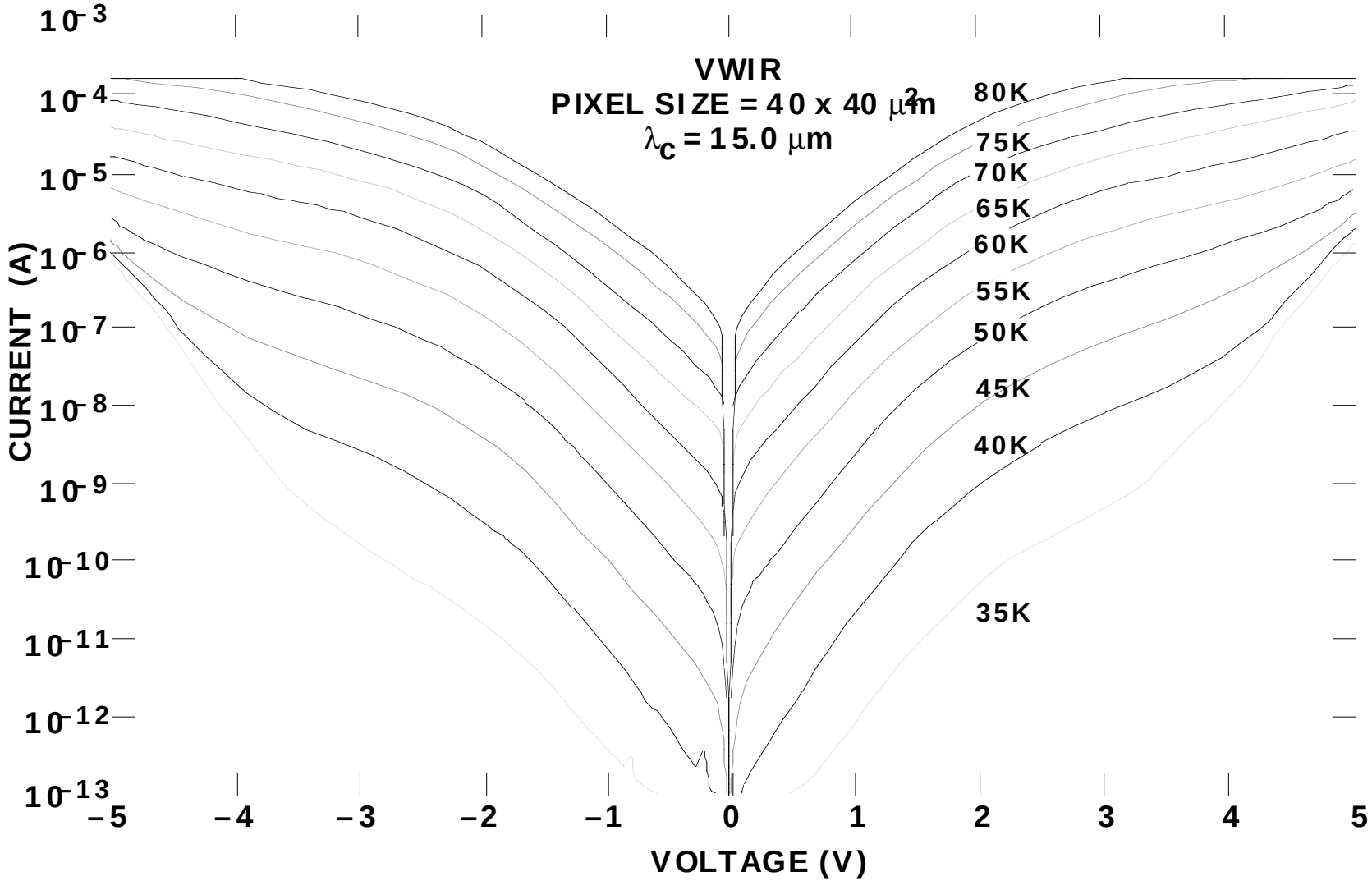


DARK CURR ENT vs. BIAS VOLTAGE



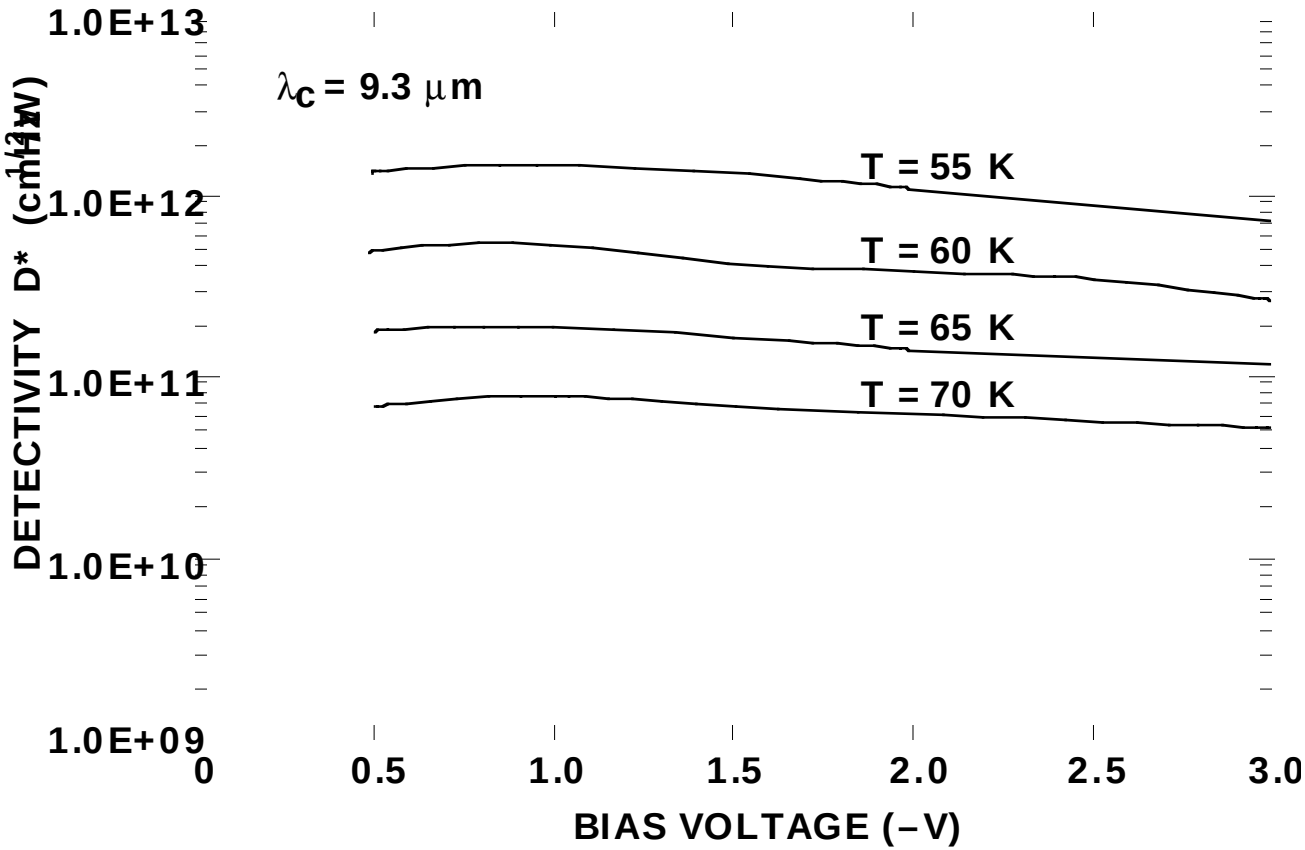
DEMONSTRATES LOW DARK CURRENT

DARK CURRENT vs. BIAS VOLTAGE

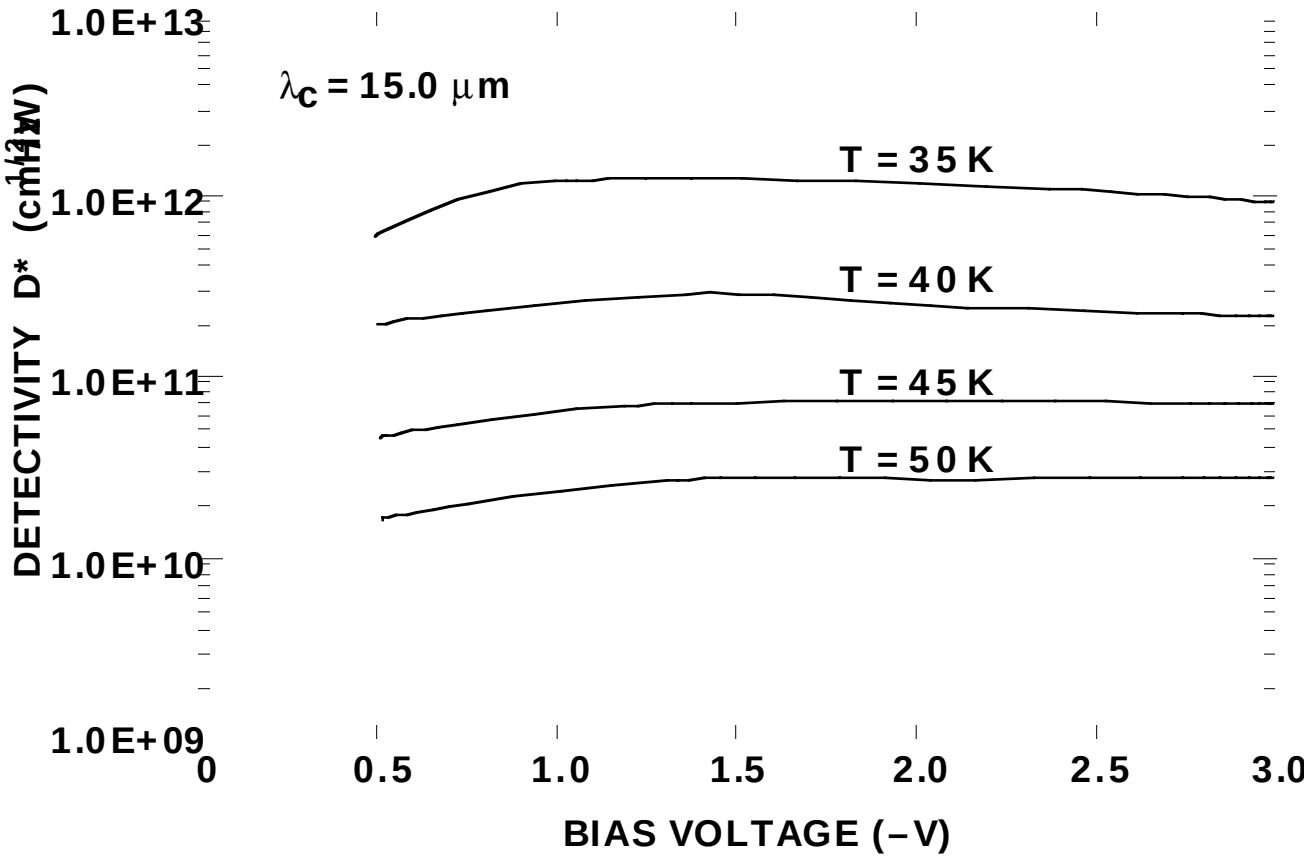


DEMONSTRATES LOW DARK CURRENT

DETECTIVITY vs. BIAS VOLTAGE OF LWIR DETECTORS



DETECTIVITY vs. BIAS VOLTAGE OF VWIR DETECTORS



BMDO DITP REQUIREMENTS FOR DUALBAND QWIP CAMERA
(THROUGH AFRL)

- **ONE MICRON BAND PASS IN**
  - 8-9 μm SPECTRAL REGION (LWIR)
  - 14-15 μm SPECTRAL REGION (VLWIR)

- **NEAR BACKGROUND LIMITED PERFORMANCE (BLIP)**
  - LOW BACKGROUNDS
    - » 6×10^{13} photons sec^{-1}/cm^{2} (LWIR)
    - » 6×10^{13} photons sec^{-1}/cm^{2} (VLWIR)

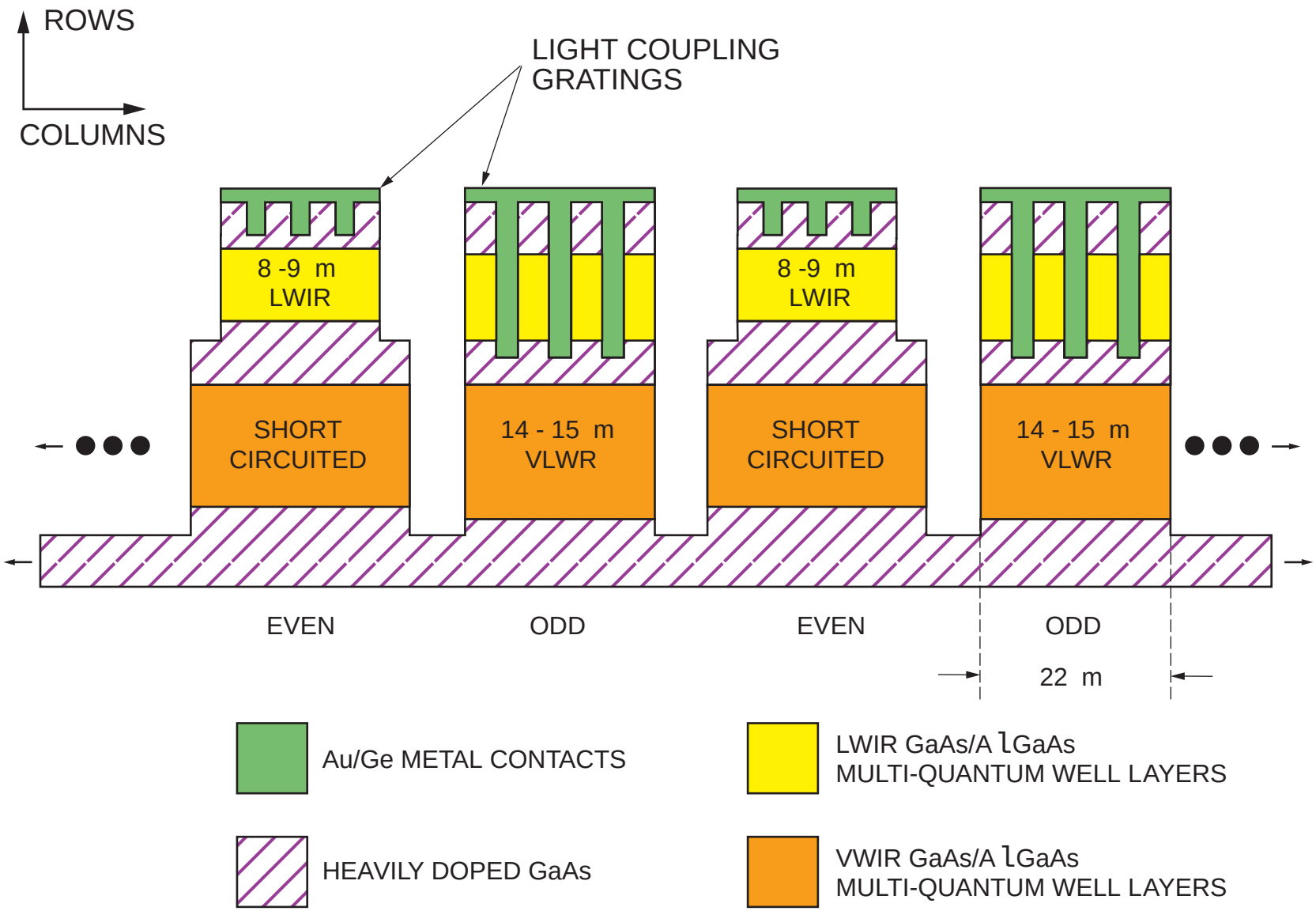
PIXEL SIZE = $40 \times 40\ \mu m^{2}$

ANALYSIS OF LWIR & VLWIR QWIP DETECTORS FOR BMDO REQUIRMENTS

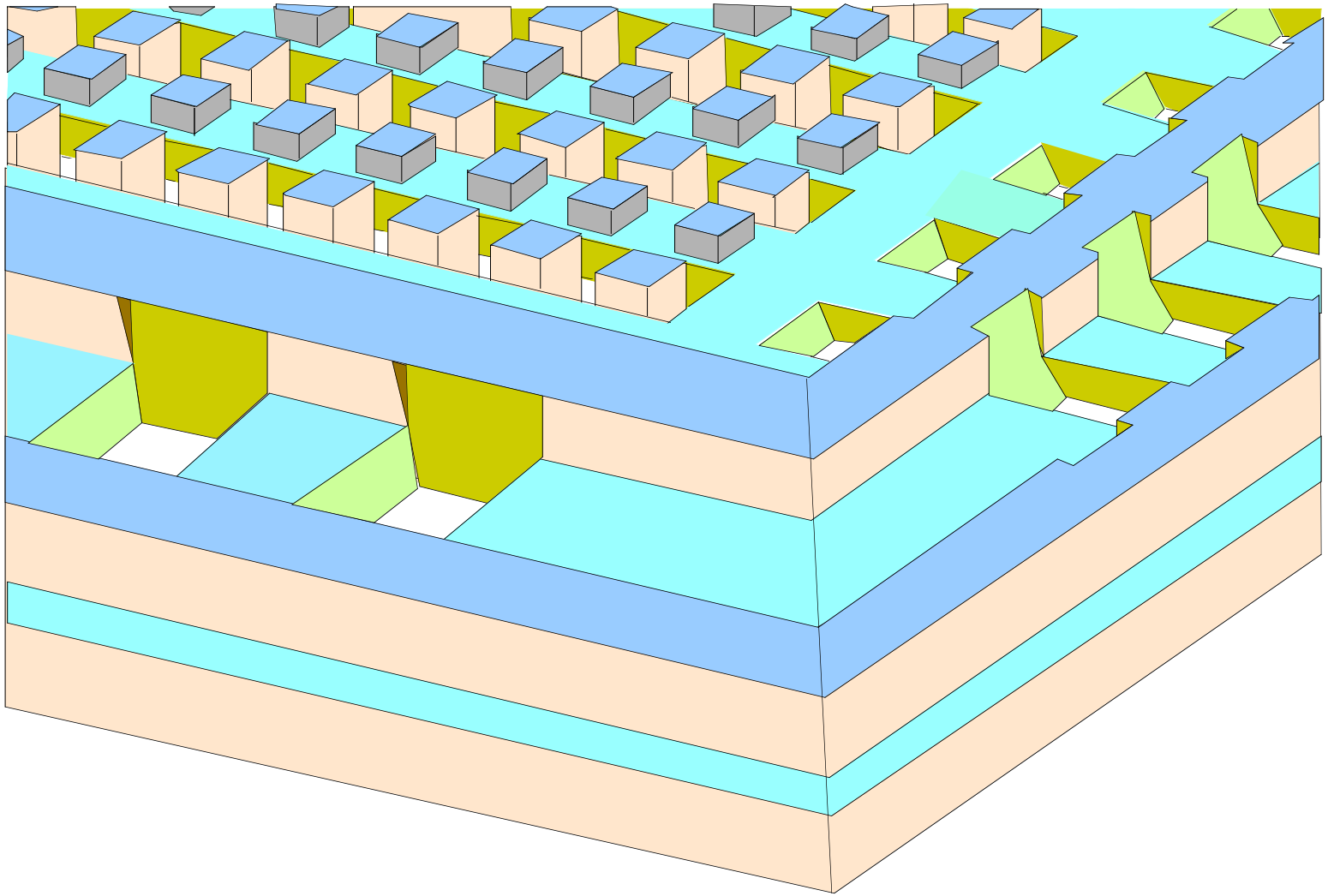
- **LWIR BACKGROUND**
  (OPERATING AT 60 Hz FRAME RATE)
  PHOTO CURRENT = PHOTON INTENSITY x Q.E. x GAIN/FRAME RATE
  - **PHOTO CURRENT ~592,000 electrons**
  - **BACKGROUND LIMITED PERFORMANCE AT TEMPERATURE ~**

- **VLWIR BACKGROUND**
  - **PHOTO CURRENT ~464,000 electrons**
  - **BACKGROUND LIMITED PERFORMANCE AT TEMPERATURE ~**

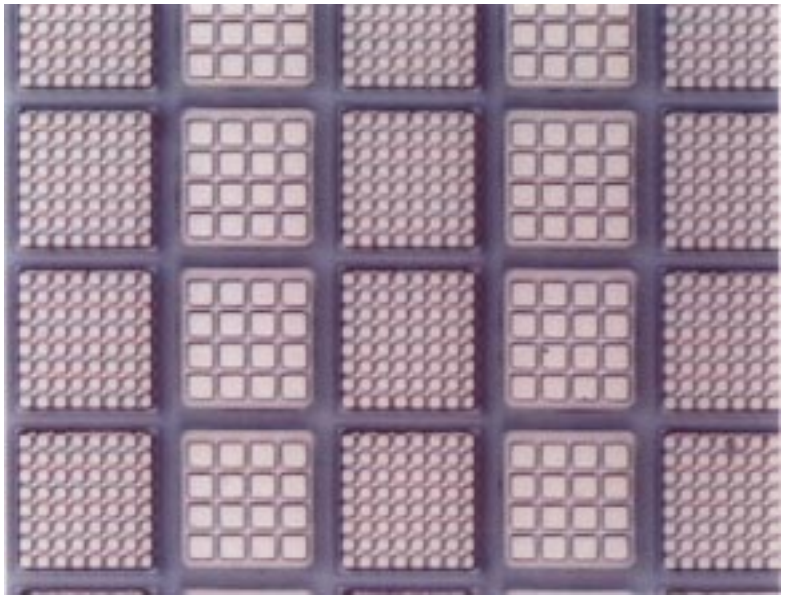
640 x 486 DUALBAND QWIP FOCAL PLANE ARRAY

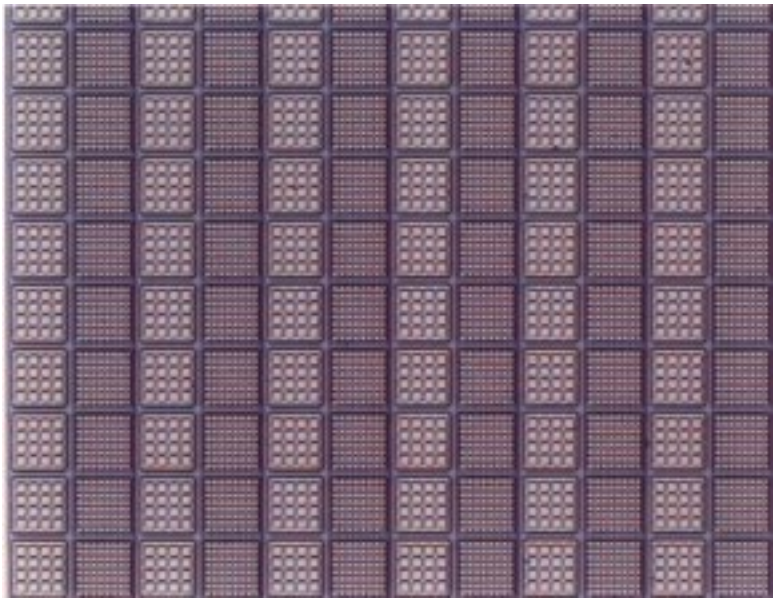


8-9 μm and 14-15 μm TWO COLOR QWIP FOCAL PLANE ARRAY



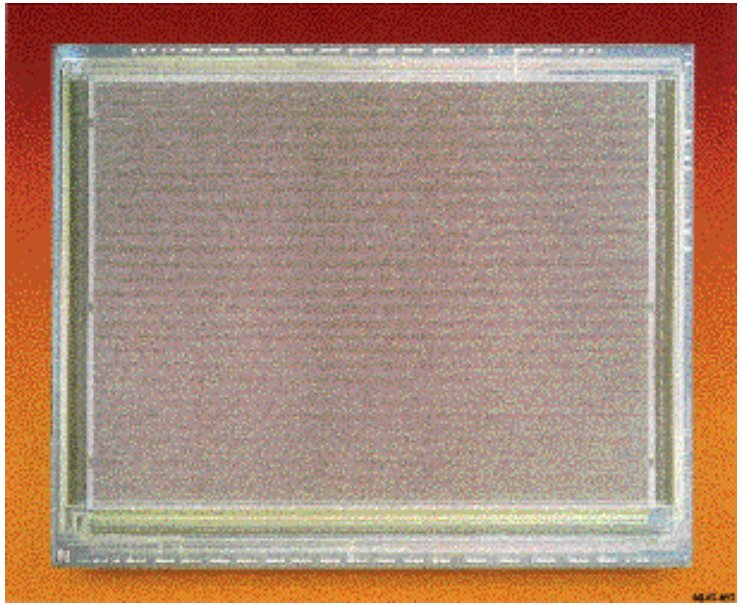
8-9 μm and 14-15 μm TWO COLOR QWIP FOCAL PLANE ARRAY



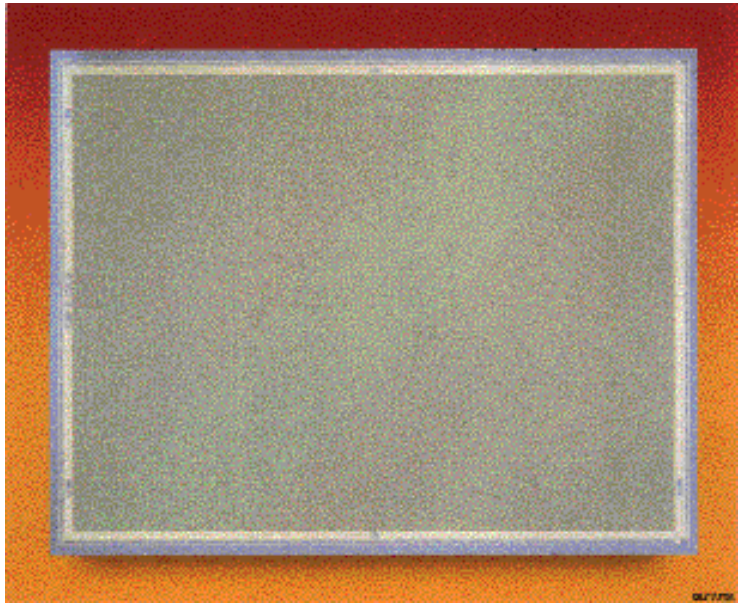


PARAMETERS OF RAYTHEON 640 x 486 READOUT MULTIPLEXER

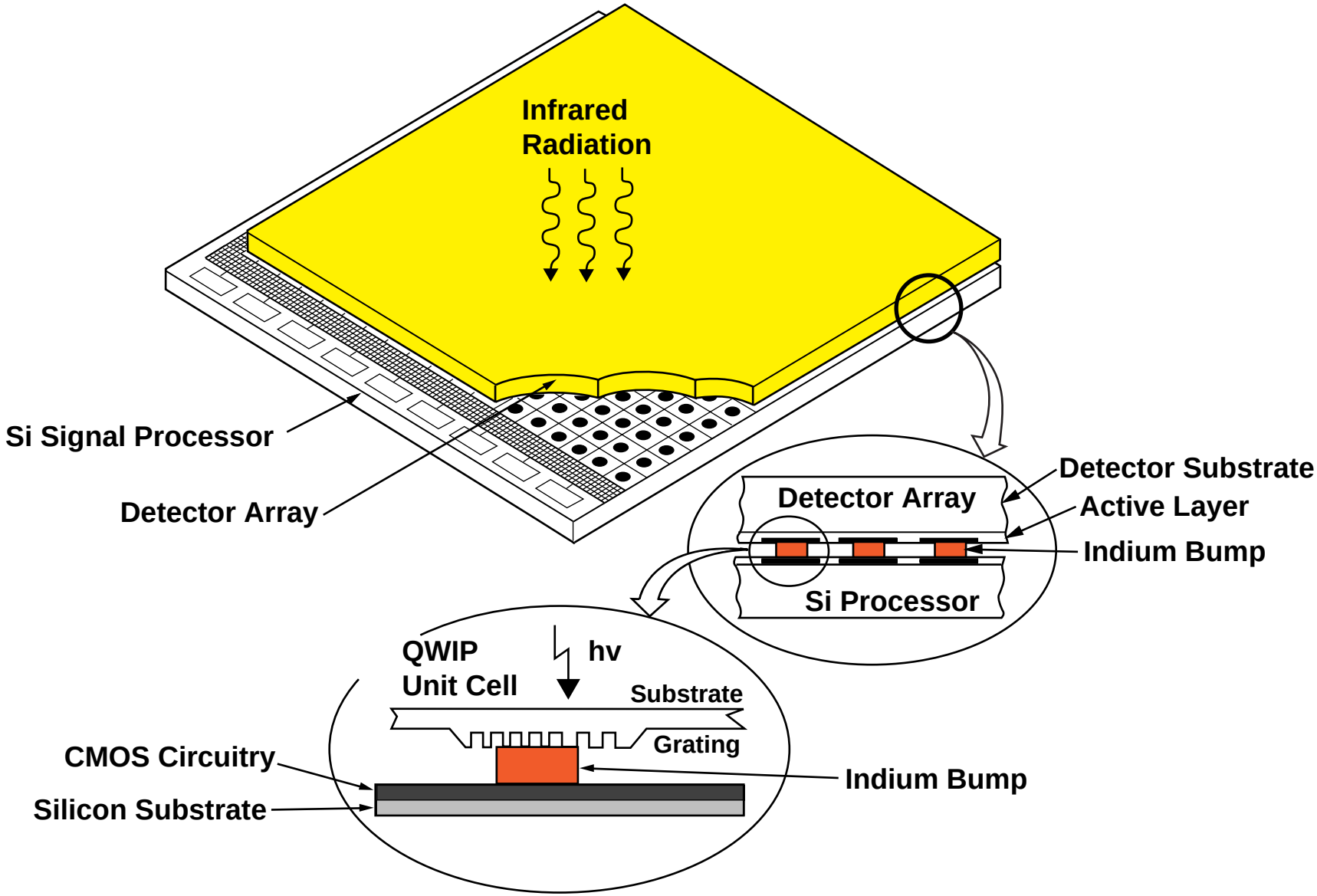
PARAMETER	AE181
ARRAY FORMAT	640 x 486
INTEGRATION MODE	SNAPSHOT
INTERLACED INTEGRATION	YES
PIXEL PITCH	25 μm
READOUT SIZE	0.73" x 0.60"
WELL CAPACITY e-	11,000,000
NOISE e- (READOUT)	450
NUMBER OF OUTPUTS	4
READOUT FORMAT	ROW BY ROW (INTERLACED OR NON-INTERLACED)
T_{INT} (% T_{FRAME})	68 μS-50%
WINDOWING	NO
FRAME RATE (FULL FRAME)	60Hz
POWER DISSIPATION	110mW
NUMBER OF CLOCKS	4
CMOS PROCESS	1.0 μm



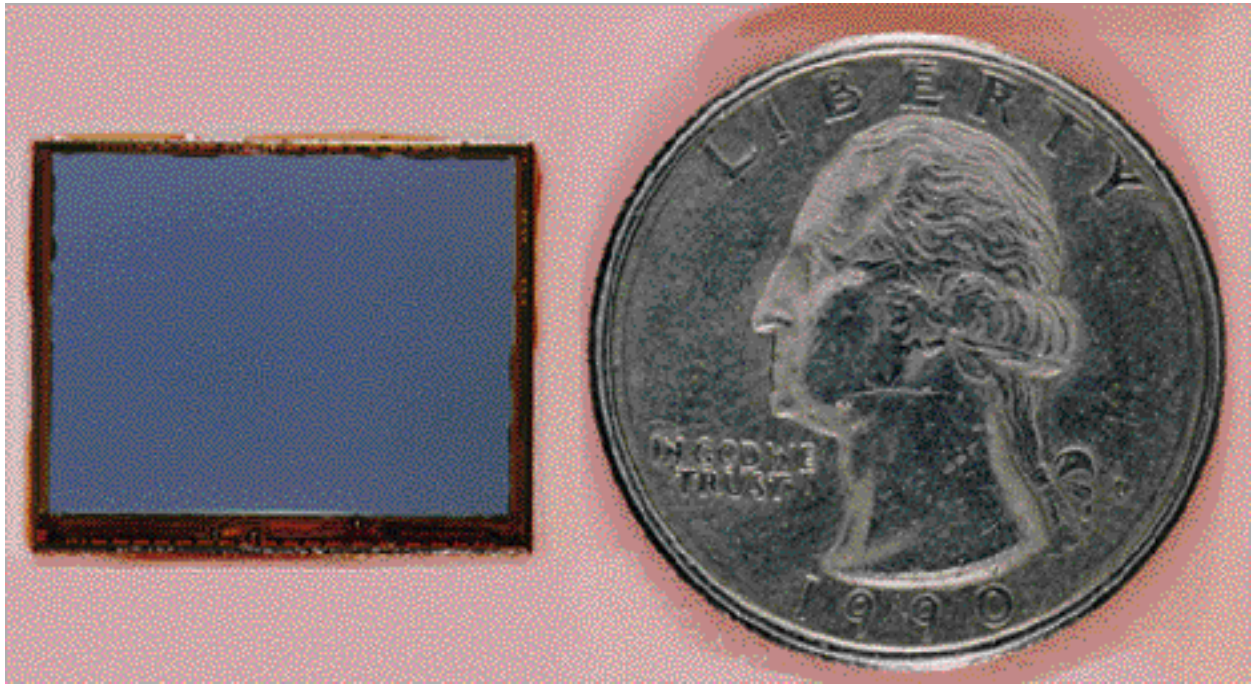
640 x 486 READOUT MULTIPLEXER



640 x 486 DUALBAND QWIP FOCAL PLANE ARRAY


Infrared
Radiation
Si Signal Processor
Detector Array
Detector Substrate
Active Layer
Indium Bump
Detector Array
Si Processor
QWIP
Unit Cell
hv
Substrate
Grating
CMOS Circuitry
Silicon Substrate
Indium Bump

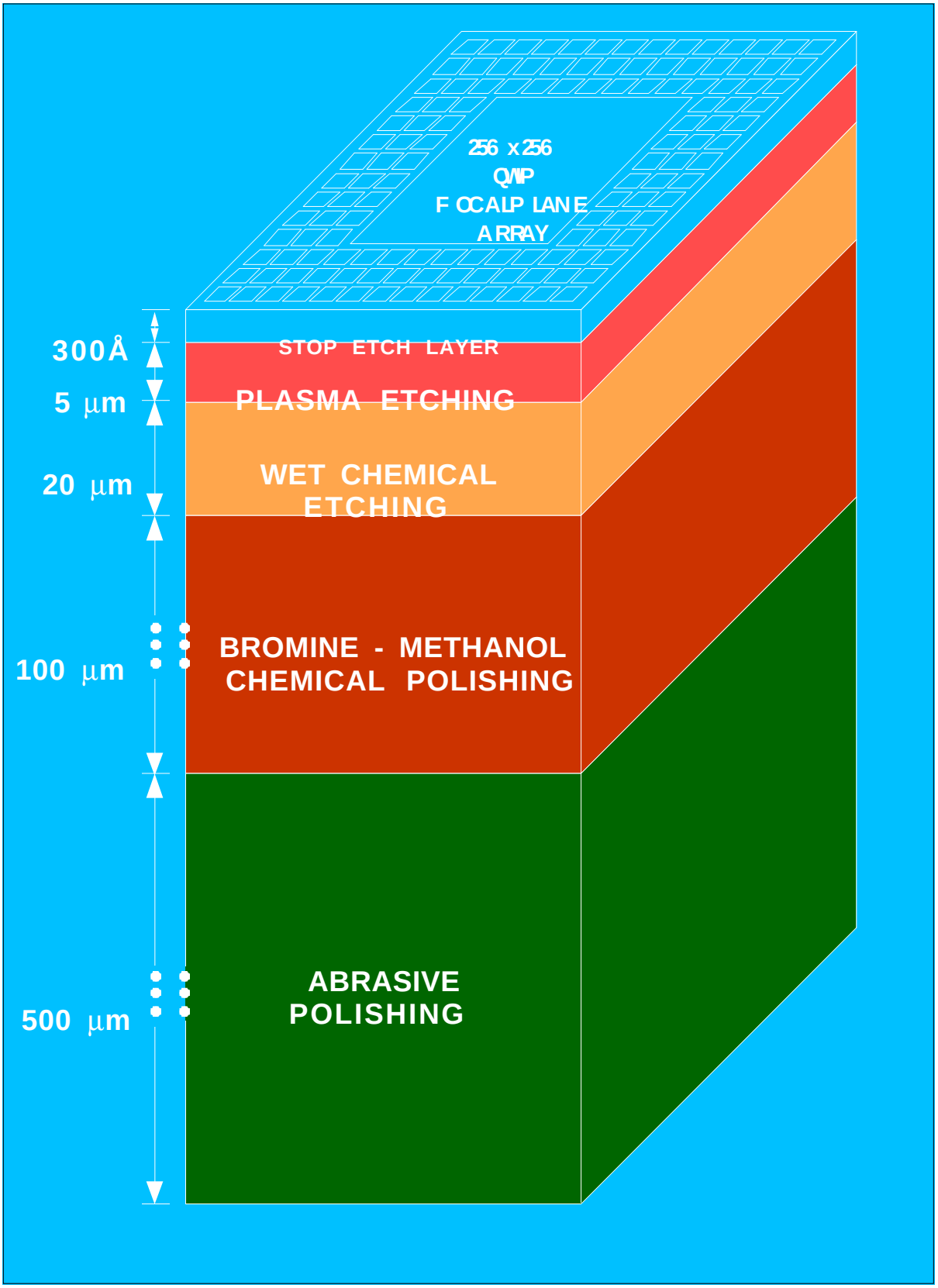
A SIZE COMPARISON OF THE 640 x 486 LONG-WAVELENGTH QWIP FPA TO A QUARTER



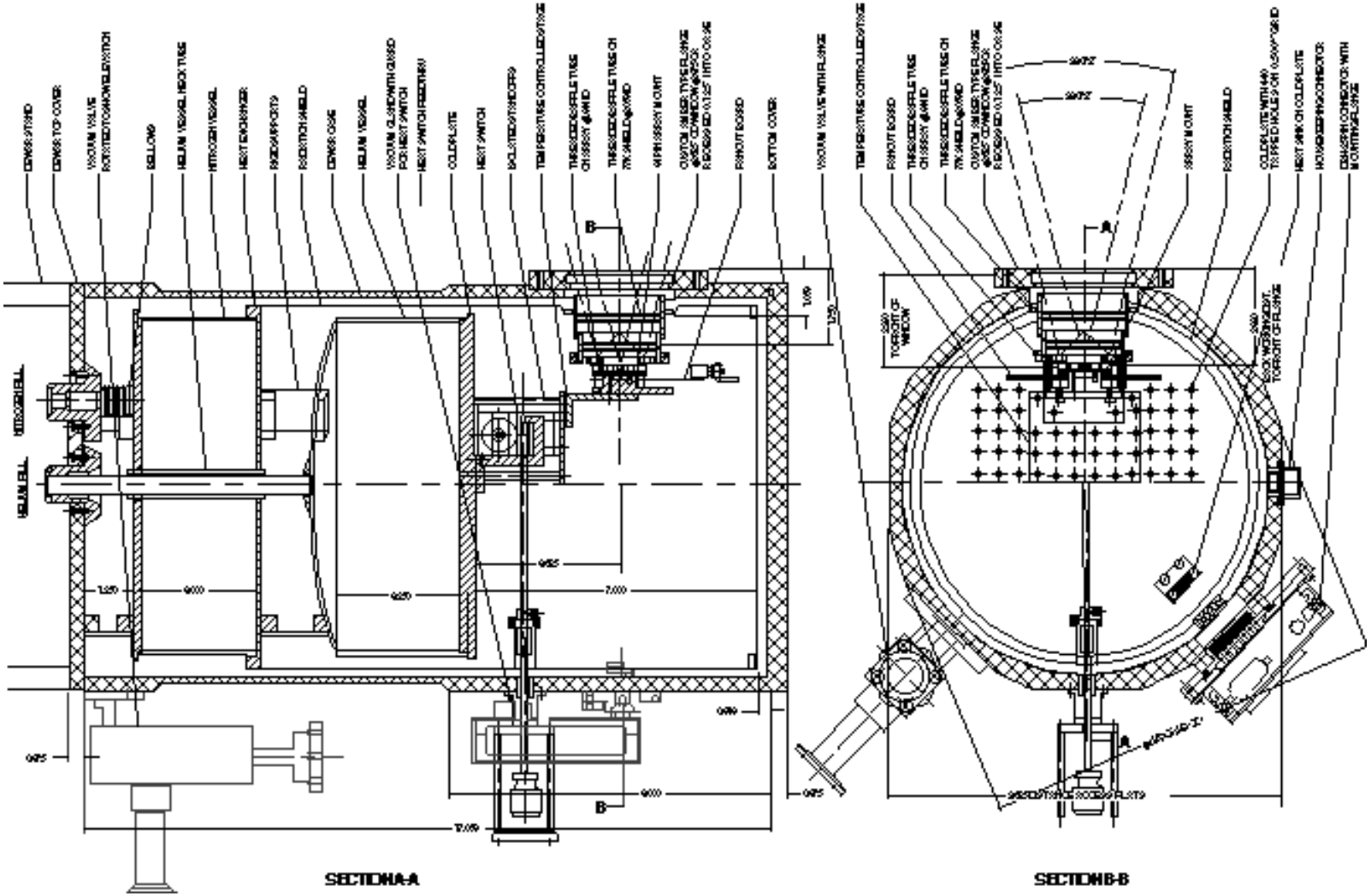
Advantages of Thinning

- Enhance light coupling
- Eliminate thermal mis-match
- Eliminate pixel-to-pixel cross-ta

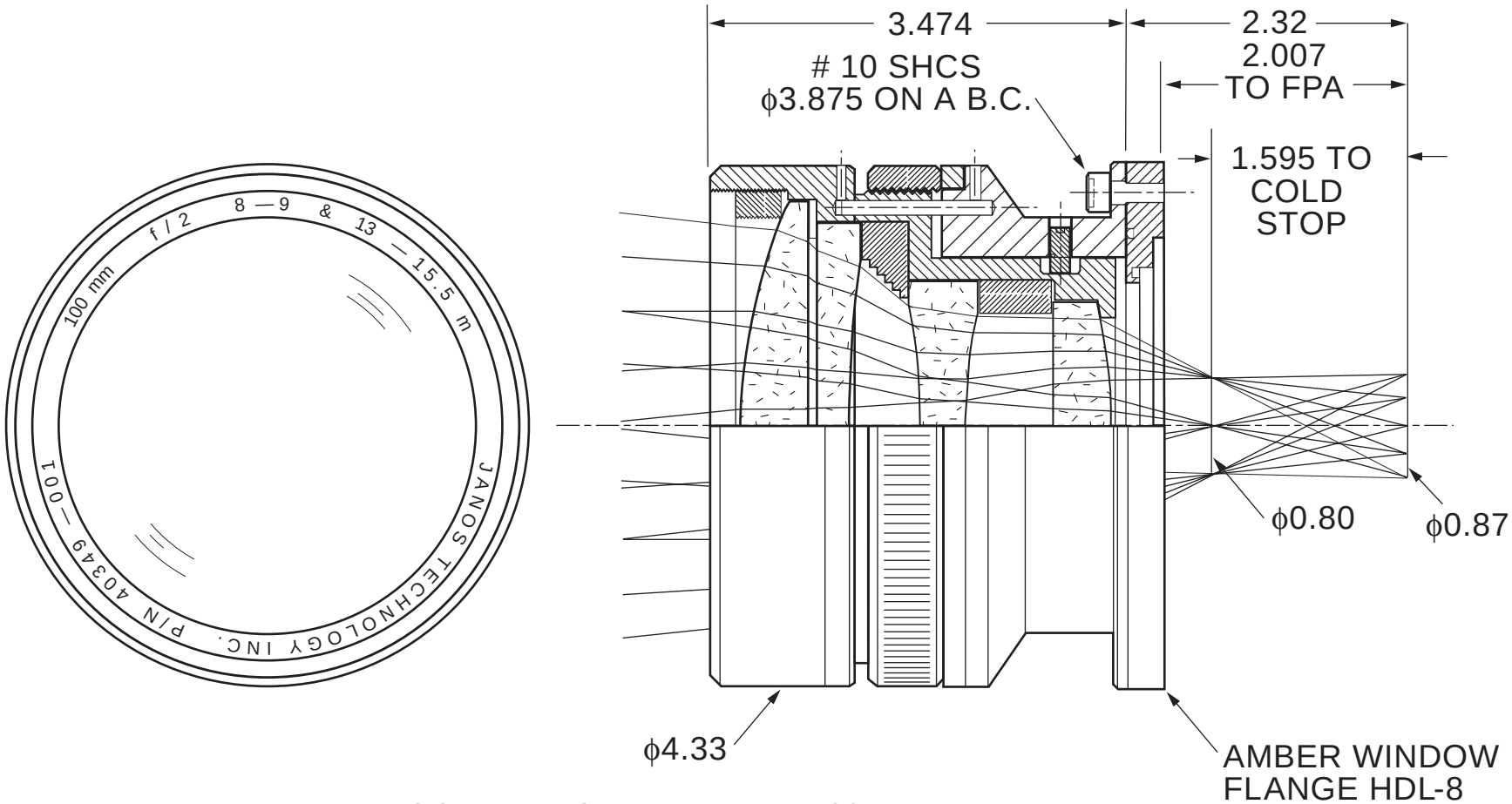
FOCAL PLANE ARRAY THINNING PROCESS



SCHEMATIC DIAGRAM OF TWO-STAGE DEWAR ASSEMBLY FOR 640 x 486 DUALBAND QWIP CAMERA



SCHEMATIC DIAGRAM OF DUALBAND LENS ASSEMBLY

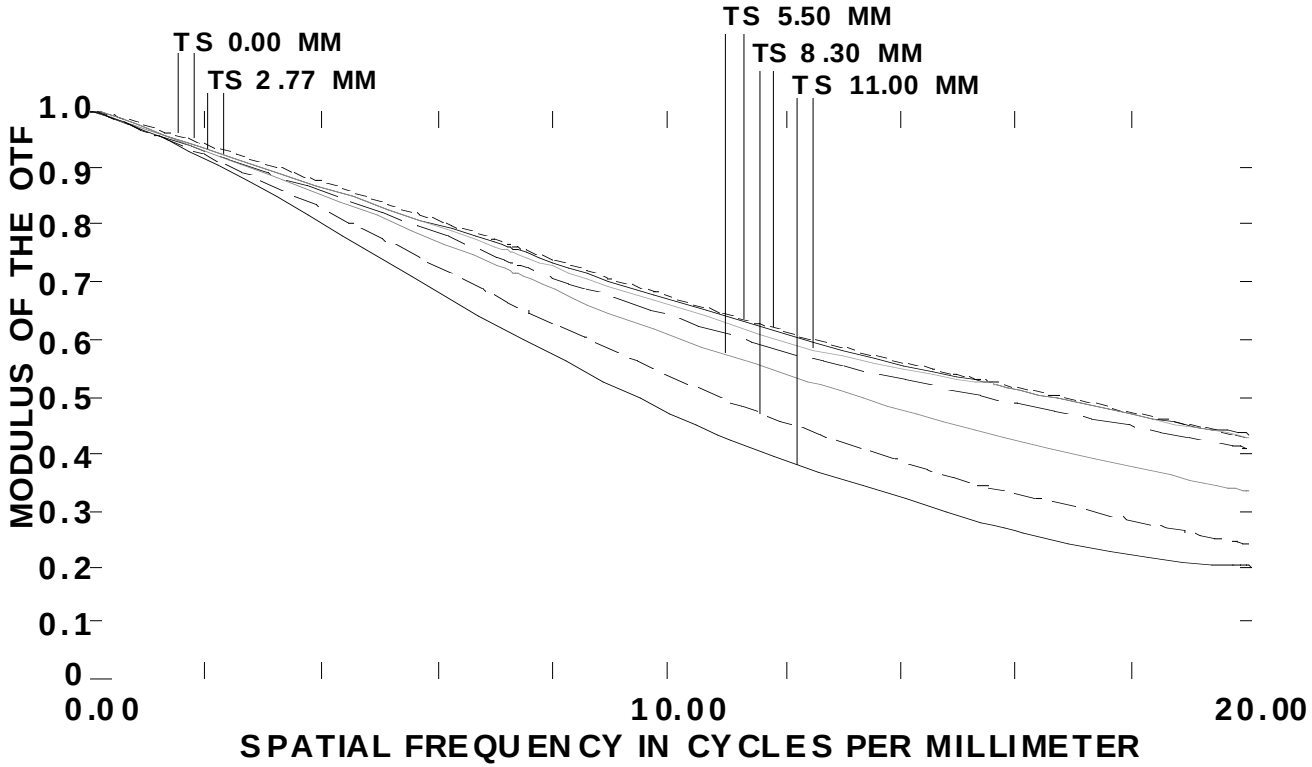


FOCAL LENGTH = 100mm

SPECTRAL BAND PASS = 8-9 m AND 13.5 — 15.0 m

f NUMBER = 2

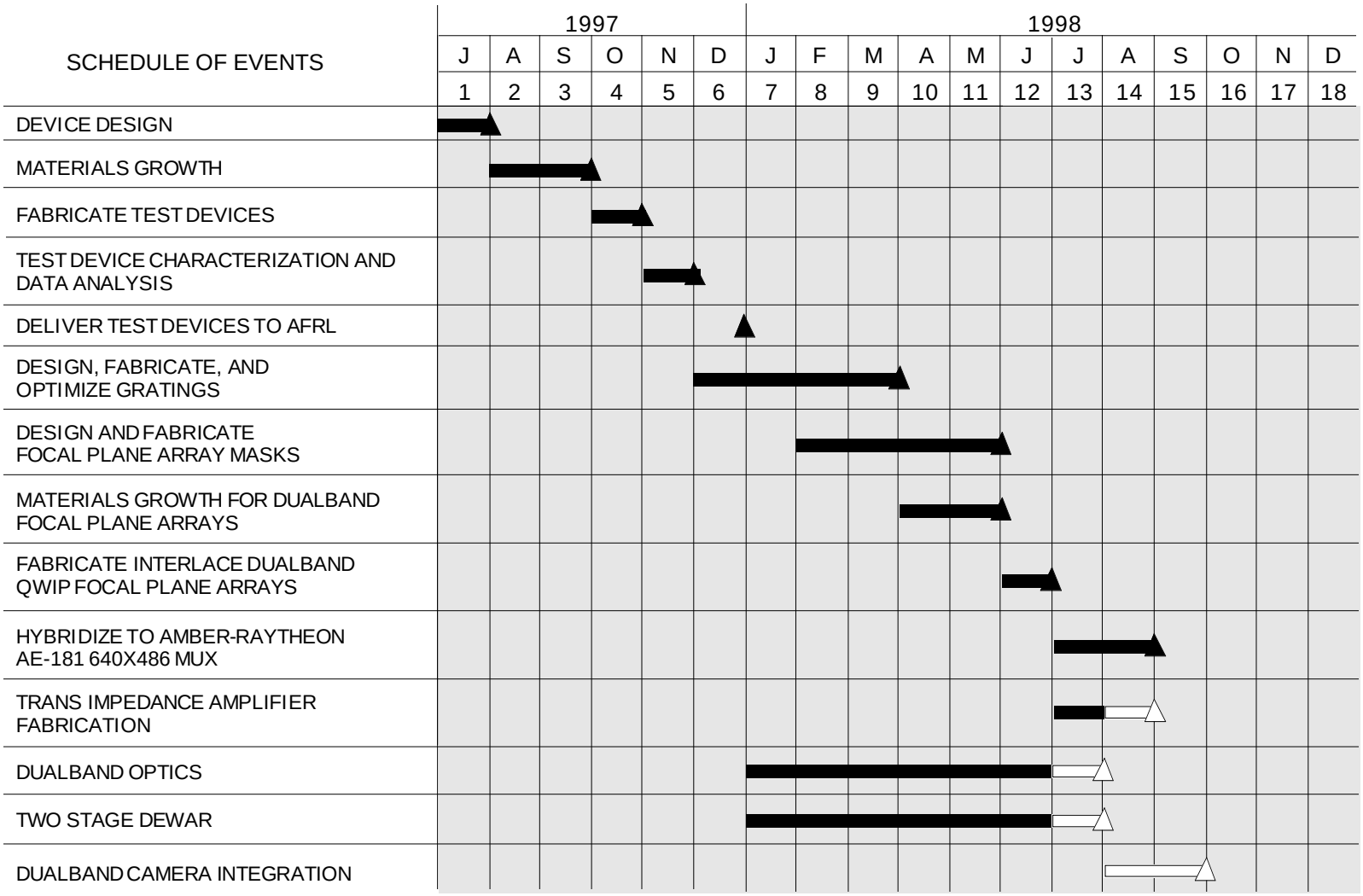
F/2.0 100 mm 8.0 and 15.5 micron LWIR OBJECTIVE
FULL FIELD MTF PREDICTION



POLYCHROMATIC DIFFRACTION MODULATION TRANSFER FUNCTION

JPL 100MM F/2 8/15.5U OBJECTIVE
WED FEB 4 1998
DATA FOR 8.0000 TO 15.5000 MICRONS

CURRENT STATUS OF 8-9 AND 13.5-15 MICRON DUALBAND QWIP CAMERA DEMONSTRATION



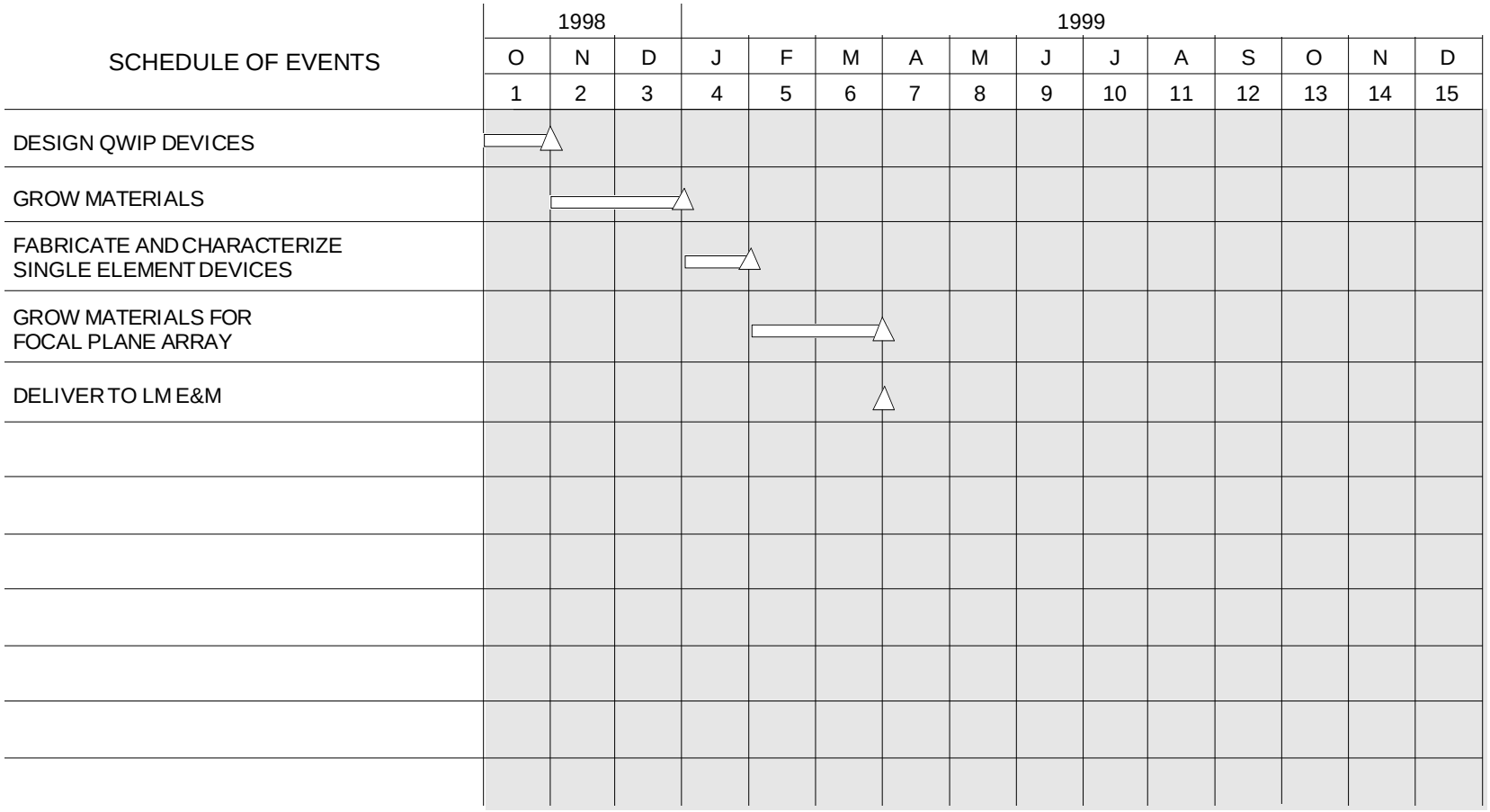
INDUSTRIAL PARTNER: AMBER, RAYTHEON COMPANY

DUALBAND CAMERA CHARACTERIZATION

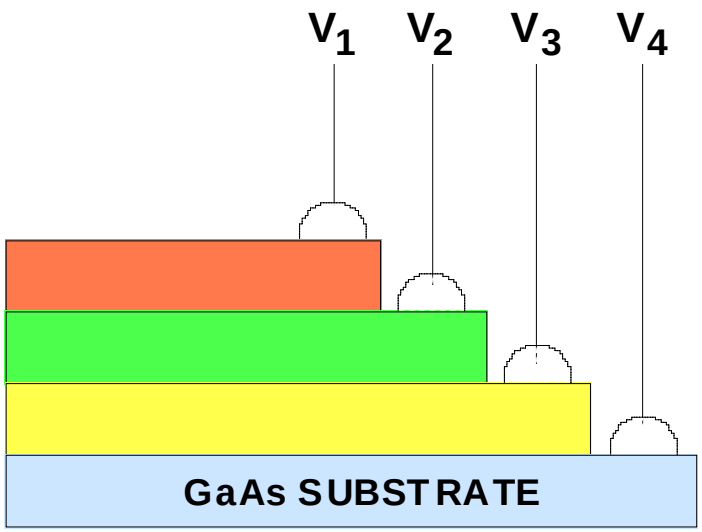
- DARK CURRENT
- QUANTUM EFFICIENCY
- DETECTIVITY
- NOISE EQUIVALENT TEMPERATURE DIFFERENCE (NE_T)
- UNIFORMITY (DARK CURRENT, Q.E., DETECTIVITY, NE_T)
- STABILITY (UNIFORMITY AS A FUNCTION OF TIME)
- REPEATABILITY (COMPARE UNIFORMITY OF DATA SETS)

PLANS FOR FY’99

DESIGN, GROW AND DELIVER DUALBAND (8-9 & 13.5-15 μm) QWIP FOCAL PLANE ARRAY MATERIALS



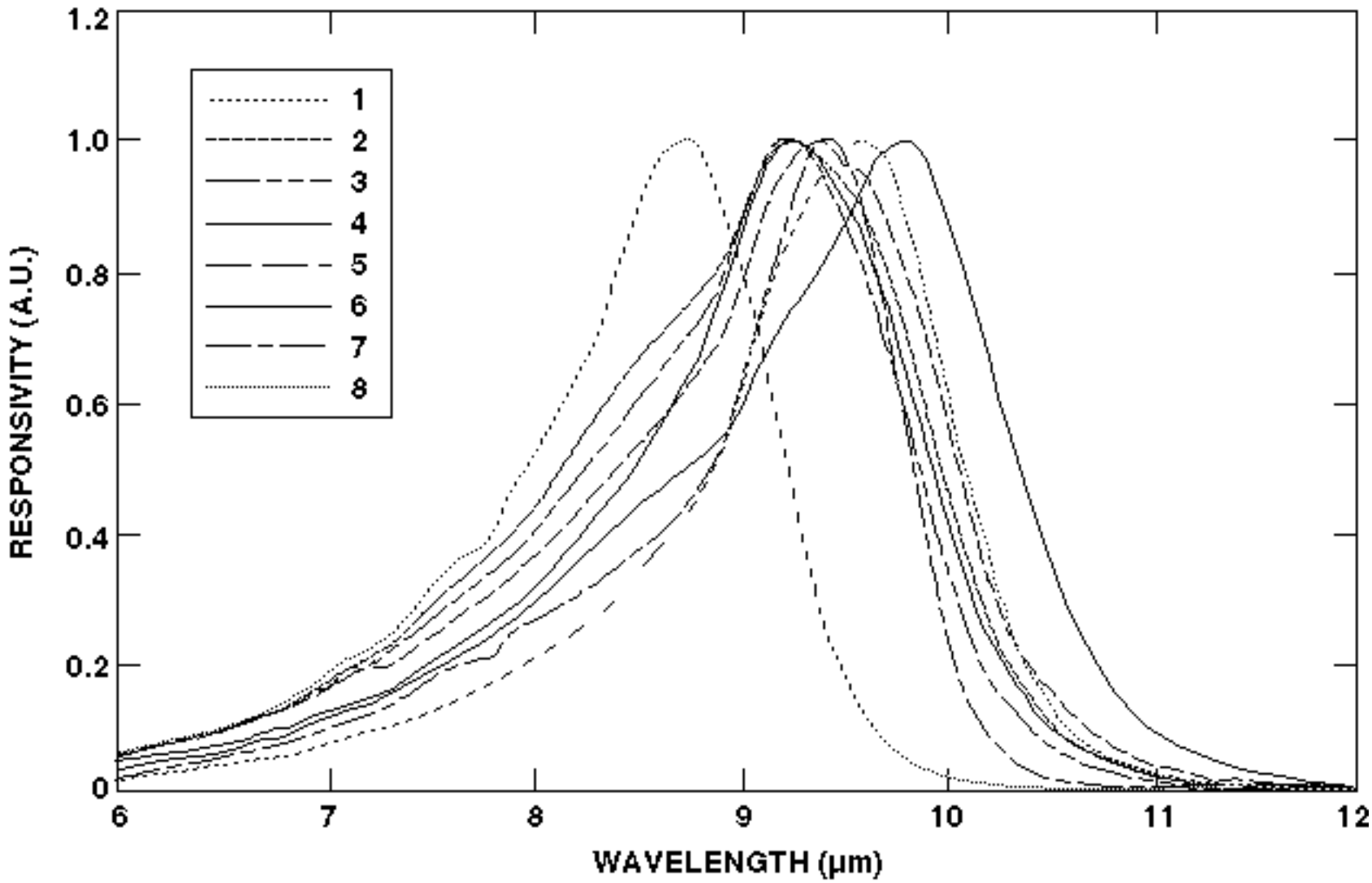
INDUSTRIAL PARTNER: LOCKHEED MARTIN ELECTRONICS AND MISSILES



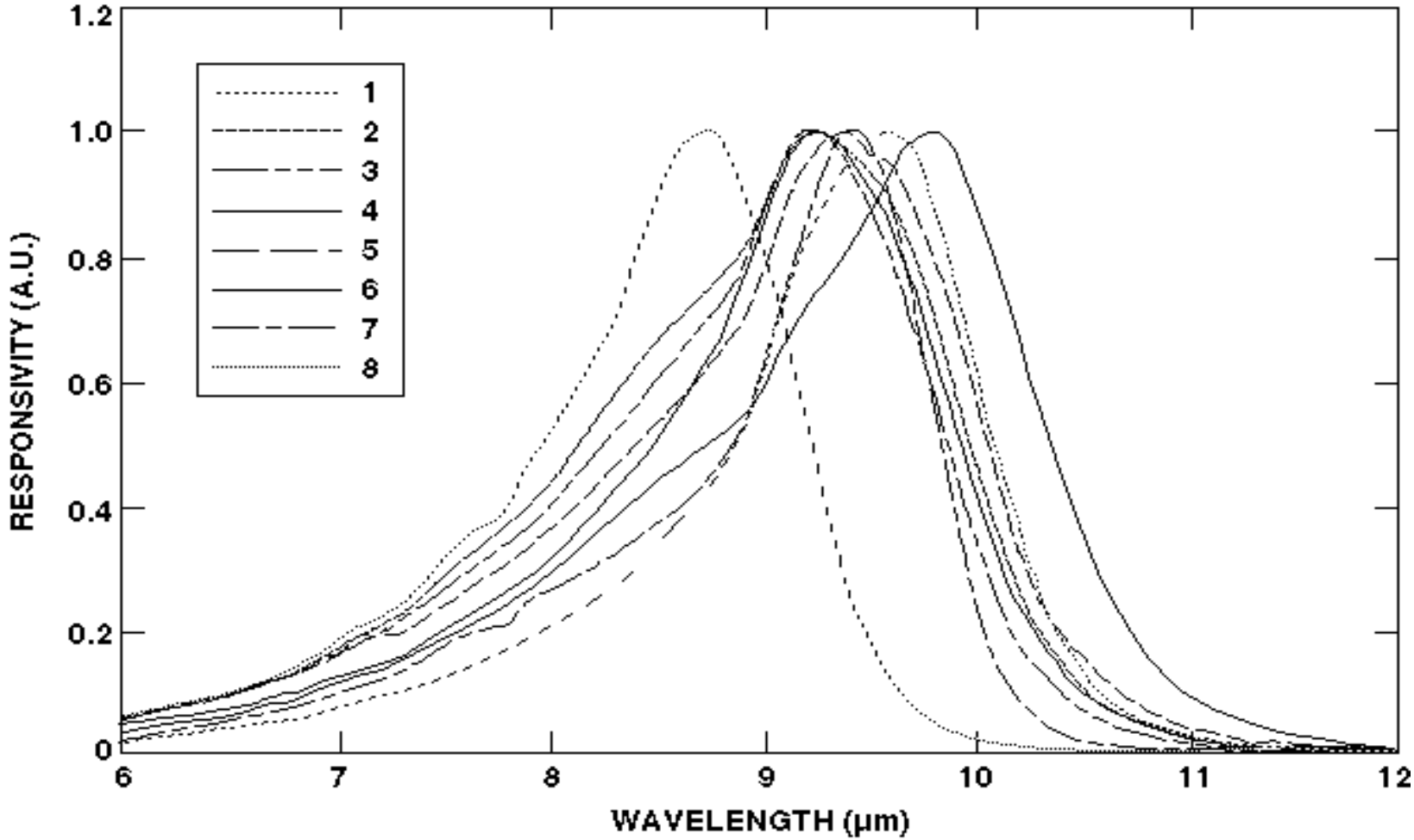
- DESIGN AND FABRICATE 3-COLOR QWIP DETECTOR
- DESIGN NEW LIGHT COUPLING SCHEME

10 MICRON CUTOFF HIGH QUANTUM EFFICIENCY QWIPs FOR LOW BACKGROUND APPLICATION

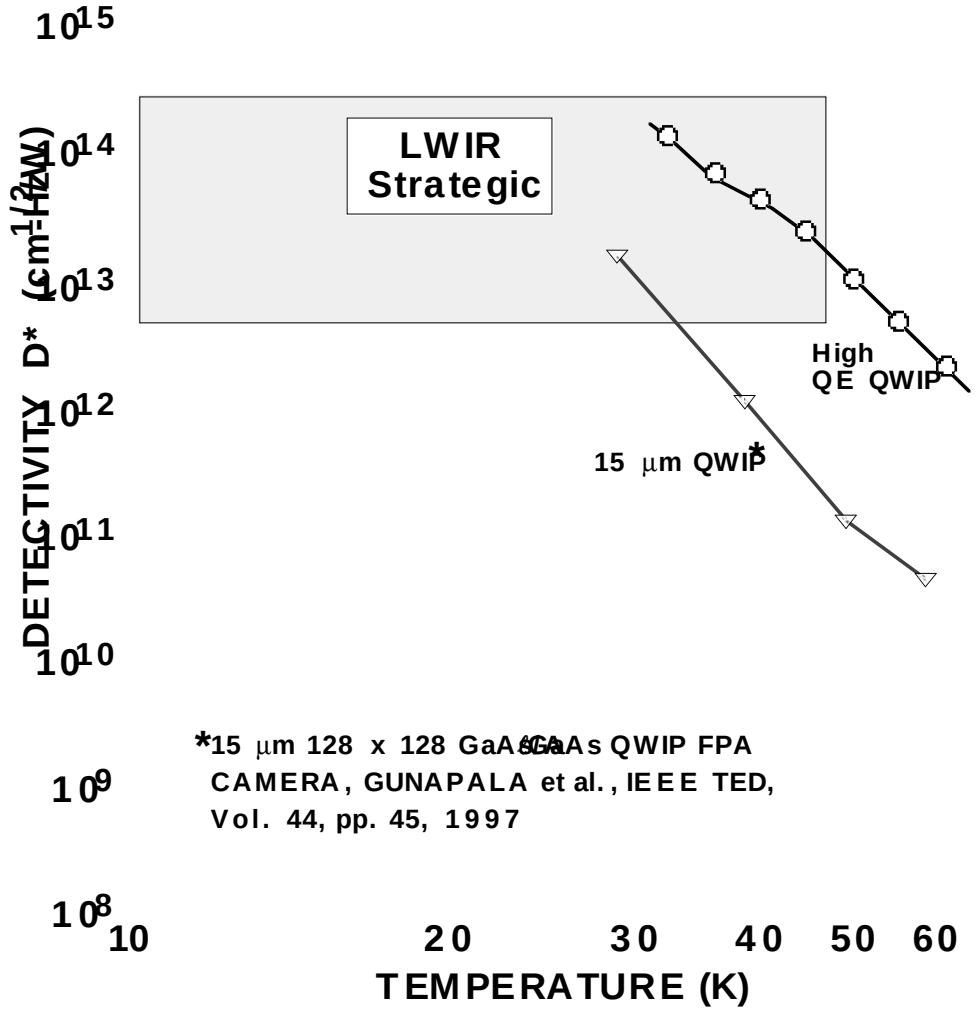
QWIP NORMALIZED RESPONSIVITY

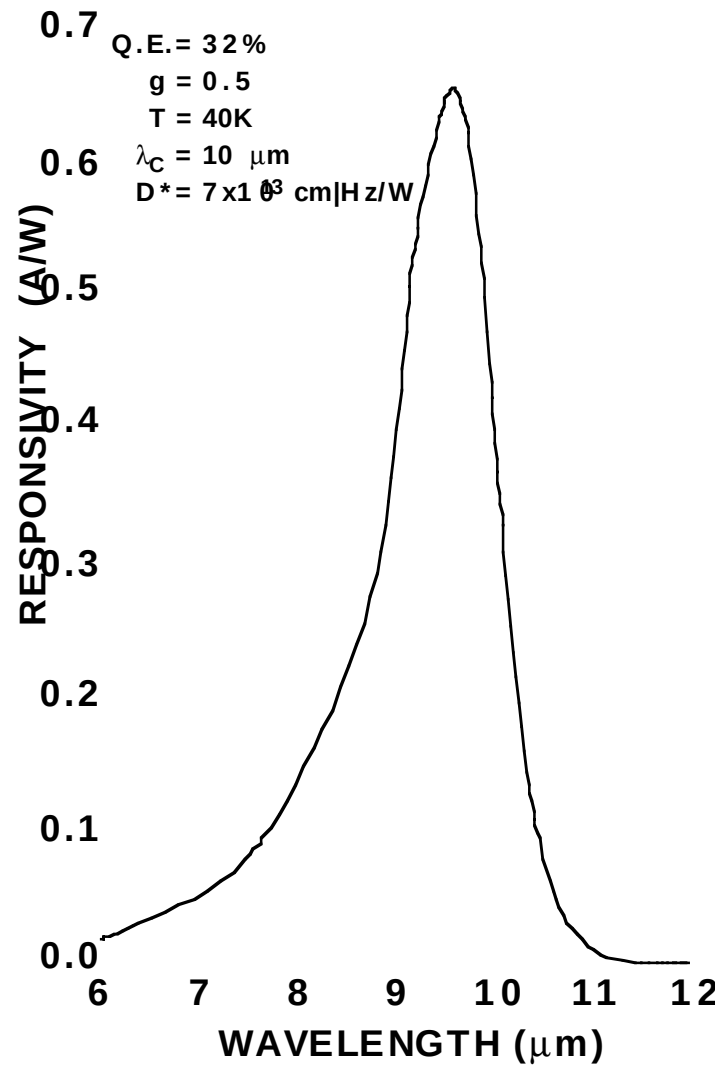


PERFORMANCE ANALYSIS



HIGH QUANTUM EFFICIENCY 10 MICRON CUTOFF QWIPs





REFERENCES