

赤外・テラヘルツ検出器の現状

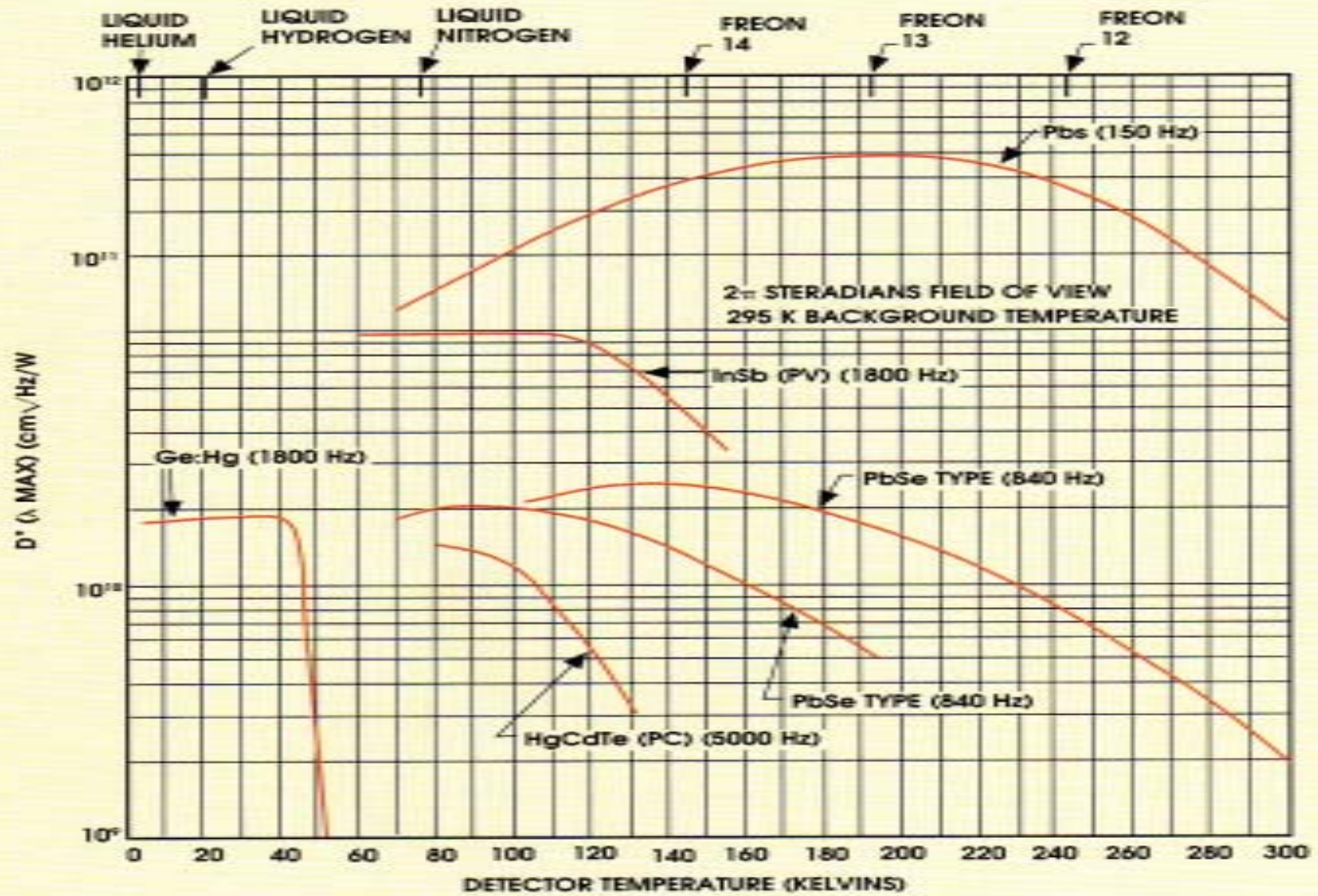
赤外・遠赤外線検出器

- 遠赤外線検出器の種類と感度
- HgCdTeとInSb検出器
- 増幅器と校正
- THz検出器

PERFORMANCE AND OPERATION PARAMETERS OF SOME INTRINSIC QUANTUM DETECTORS

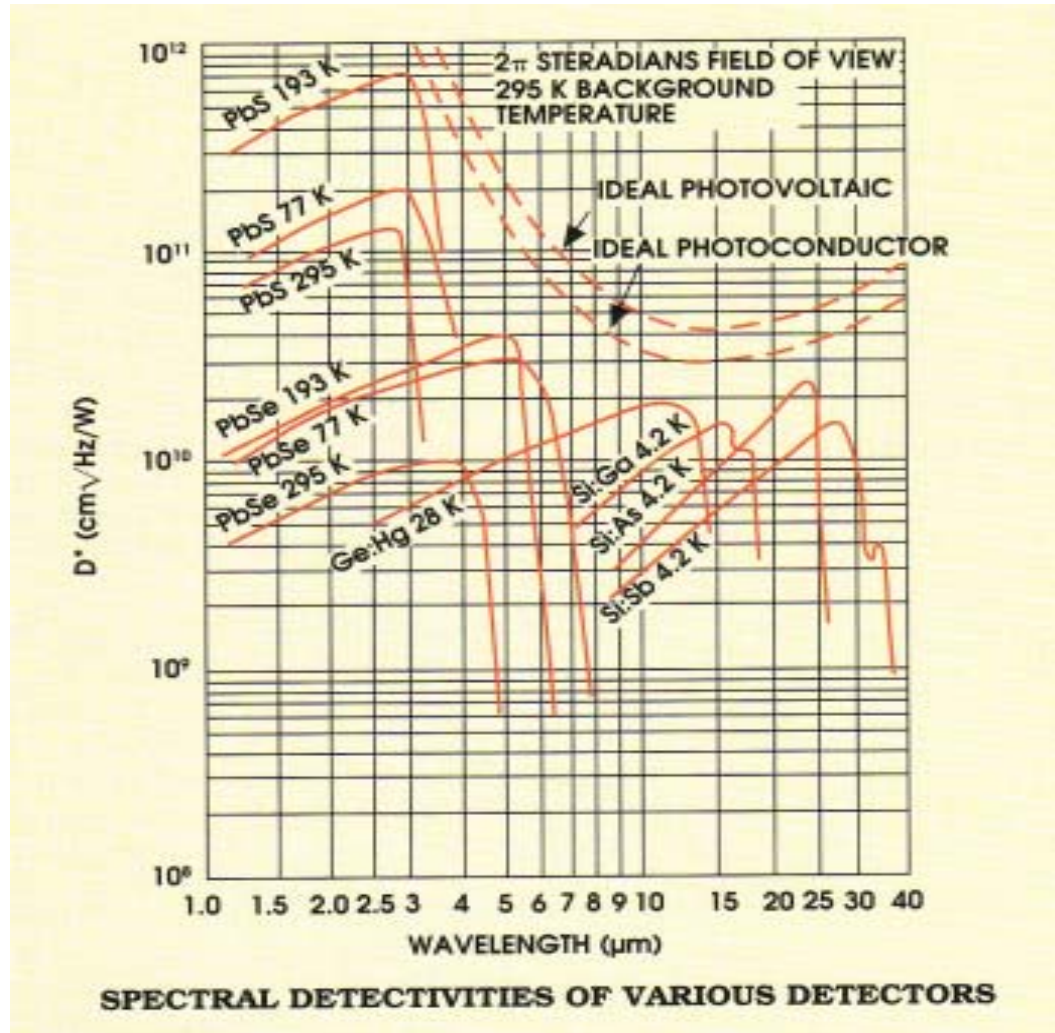
DETECTOR MATERIAL	OPERATION MODE	OPERATION TEMPERATURE (K)	TIME CONSTANT (μs)	PEAK WAVELENGTH (μm)	USABLE WAVELENGTH (μm)	$D^*(500 \text{ K})$ ($\text{cm Hz}^{1/2}\text{W}^{-1}$)
Si	PV	300	10^{-2}	0.9	0.6-1.1	$\sim 10^7$
Si	Avalanche	300	$\sim 10^{-5}$	0.9	0.6 - 1.1	$> 2 \cdot 10^7$
Ge	PV	300	$\sim 10^{-5}$	1.5	0.9 - 1.9	$5 \cdot 10^9$
PbS	PC	300	> 100	2.4	1.1 - 3.5	$1.5 \cdot 10^9$
InAs	PV	77	0.5	3.1	1.8 - 3.8	$2 \cdot 10^{10}$
PtSi	Schottky-Barrier	< 90	$\sim 10^3$	0.9	0.8 - 5.0	$2 \cdot 10^9$
PbSe	PC	300	1 - 5	3.9	1 - 5.0	$2 \cdot 10^8$
InSb	PV	77	0.1 - 2	4.9	2 - 5.5	$5 \cdot 10^{10}$
CdHgTe	PV	195	~ 2	4.5	1 - 5.5	$4 \cdot 10^{10}$
CdHgTe	PC	77	0.1 - 2	10.5	8 - 14	$2.5 \cdot 10^{10}$
CdHgTe	PV	77	0.5 - 2	10.5	8 - 11.5	$2 \cdot 10^{10}$
PbSnTe	PV	77	~ 0.5	11	8 - 11.5	$2 \cdot 10^{10}$

検出器温度と感度



DEPENDENCE OF DETECTIVITY ON OPERATING TEMPERATURE FOR TYPICAL DETECTORS

遠赤外線検出器の感度及び波長領域



遠赤外線検出器

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HgCdTeとInSb検出器

HgCdTe

検出器サイズ: 0.025 ~ 2.0mm

使用温度: 常温 (300K)、TE (210, 240K)、LN2 (77K)

検出感度 (D^*) : $> 5E9 \sim > 1E11$

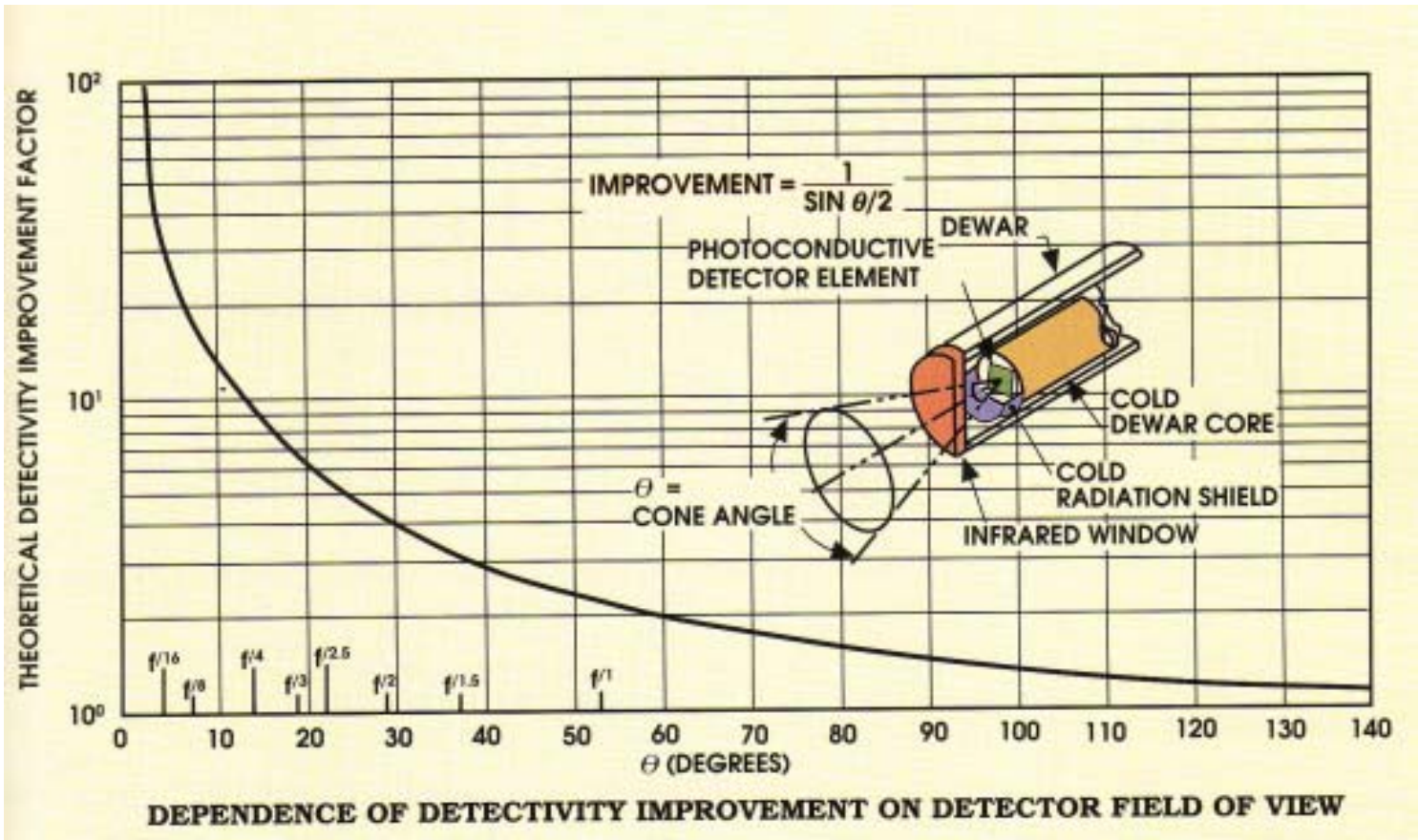
InSb

検出器サイズ: 0.1 ~ 2.0mm

使用温度: LN2 (77K)、SN2 (54K)

検出感度 (D^*) : $> 1E11$

開口角と検出感度



HCT InSb検出器

検出器型式	検出素子サイズ	開口角	感度 (V/W)	感度 (A/W)	雑音(V) @10kHz	D* @10kHz
• MCT-12-0.05-10	50um	10	98832		2.54E-09	2.04E+11
• MCT-12-0.05-10	50um	10	104380		2.59E-09	2.01E+11
• MCT-12-0.05-10	50um	10	110144		2.82E-09	2.05E+11
• InSb-0.1-10	100um	10		3.65	1.23E-07	2.53E+11
• InSb-0.1-10	100um	10		3.73	1.44E-07	2.29E+11
• InSb-0.1-10	100um	10		4.16	2.22E-07	1.65E+11

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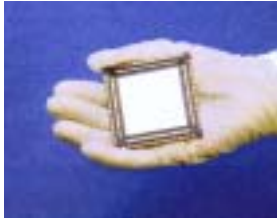
アレー検出器

IRCCD-DETECTORS FOR MID- AND LONG-WAVELENGTH IR

DETECTOR MATERIAL	SPECTRAL BAND (μm)	OPERATION TEMPERATURE (K)	ELEMENT NUMBER	PIXEL SIZE (μm^2)	FILLING FACTOR (PER-CENT)
InSb	3 - 5	70-85	256 x 256	50 x 50	>85
			512 x 512	25 x 25	>80
			1024 x 1		100
CdHgTe	3 - 5	195	256 x 256	40 x 40	>60
			512 x 512	27 x 27	>65
			(under development)		
Pt Si-Schottky Barrier	3 - 7	40 - 90	512 x 512	32 x 25	66
			640 x 480	20 x 20	80
			1040 x 1040	17 x 17	71
Si:In	3 - 7	<50	128 x 128	50 x 50	>90
GaAs/AlGaAs Quantum-well	7 - 11	77	256 x 256	50 x 50	>65
CdHgTe	8 - 12	77	256 x 256	40 x 40	>75
			640 x 480	27 x 27	>70
Si:Ga	8 - 17	<30	128 x 128	75 x 75	>90
Si:Sb	12-36	<30	128 x 128	25 x 35	>90
Pyroelectric Lithium tantalate	1 - 30	~300	192 x 128	35 x 35	>65

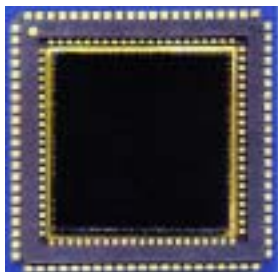
高感度アレー検出素子

0.85-2.5um



Parameter	Measured Performance	Units
Detector Interface circuit	SFD	
Cell Pitch	18.5	μm
Die Size	1600	mm^2
Integration Capacity	1.0×10^5	carriers
Integration Capacitance	18-35	fF
Signal Conversion Gain	3.0 -6.0	$\mu\text{V}/\text{e}^-$
Output Signal Excursion	0.4-1.0	V
Maximum Data Rate	>1	MHz
Maximum Slew Rate	400	nsec
Minimum Read Noise (CDS)	<10	e^-
Minimum Read Noise (Fowler Sampling)	<3	e^-
Quantum Efficiency	>60	%
Spectral Response	0.85-2.5	μm
Dark Current @ 78K	<0.03	e^-/sec
Power Dissipation	<2	mW

0.9-5.0um



Parameter	Goals	Units
Detector Interface circuit	SFD	
Cell Pitch	18.5	μm
Die Size	<400	mm^2
Integration Capacity	2.5×10^5	carriers
Integration Capacitance	80-100	fF
Signal Conversion Gain	1.6-2.0	$\mu\text{V}/\text{e}^-$
Output Signal Excursion	0.4-0.5	V
Maximum Data Rate	>1	MHz
Minimum Read Noise (CDS)	<10	e^-
Minimum Read Noise (Fowler Sampling)	<3	e^-
Quantum Efficiency	>60	%
Spectral Response	0.9-5.0	μm
Dark Current @ 60K	<0.1	e^-/sec
Power Dissipation	<1	mW

リニアアレーセンサー

• MUXを使用

- 信号が安定している
- データ取得システムが容易
- 配線が少ない
- コネクタが小さい
- 冷凍器の保持時間が短い
- 読出し時間が長い(Video rate)
- 早い現象に向かない

• MUXを不使用

- 信号が外部の影響を受ける
- データ取得システムが大きい
- 配線数が多い
- コネクタが大きい
- 冷凍器の保持時間が短い
- 読出し時間が短い((読込時間)
- 早い現象に向いている

Discrete Linear Array Detector

検出素子数	16	32	64	96	128
波長領域	2 - 13ミクロン				
最小素子サイズ	20 - 25ミクロン				
最小素子間隔	10ミクロン				
開口角	60度				
1基盤最大長	16mm				
基盤材料	サファイア				

width	length	#elements	spacing
0.2	0.4	64	0.012
0.1	1	64	0.05
0.5	0.5	32,64,128	0.1
0.5	2	32,64	0.05

64ch MCTArray Detector & AMP



IR-6416 FPAS System

Femto-Second Laser Pulse Spectroscopy System



- Φ 64 Element HgCdTe Detector Array
- Φ Ultra-Low Noise Preamplifiers
- Φ High Speed Integrators
- Φ Adjustable Delay and Gate Times
- Φ 16 Bit A/D Converters
- Φ 10 Mhz Data Transfer to PC
- Φ > 2 Khz Laser Repetition Rate
- Φ Completely Isolated Channels

IR-6416 Specifications

SPECIFICATIONS:

Laser Pulse Repetition Rate.....0 to 2Khz.

Integration Time.....Adjustable in 10 ns steps between 54 to 2600 ns.

Integration Delay.....Adjustable in 2 ns steps between 30 to 520 ns.

Integrator Type.....Boxcar, Simultaneous acquisition of 16 to 128 Channels.Using multiple units in parallel provides more than 1024 Channels.

Detector Interface.....Photoconductive:HgCdTe (MCT) - Low Noise Amplifier with Bias.

Photovoltaic.....InSb - Low Noise FET Amplifier with Zero Volt Bias. HgCdTe (MCT) - Low Noise Amplifier with Zero Volt Bias.

A/D Conversion.....16 Bit, +10V to -10V input Multiplexed 16 channels per A/D converter

Maximum Number of samples.....1 Million complete scans of all channels

FIFO Memory.....1024 x 16 FIFO Memory

Data Communications.....FIFO Memory is read out by a 10 Mhz digital communications port. Requires PC Plug-in Card.

Signal.....Approximately 7 Volts from 80 femtosecond laser at 7 um

Noise.....Less than 2 nv/Hz^{1/2} at Input.

System Signal to Noise.....80 db (10,000:1) at 1000 scans

Digital Noise.....+/- 1/2 LSB

Typical System Noise.....+/- 2 LSB rms (1000 Scans @ 2Khz Laser Rep Rate)

Digital Dynamic Range.....-32767 to + 32767 = 65535 (16Bits)

Analog Dynamic Range.....-10 V to +10 V

16ch AMP Board



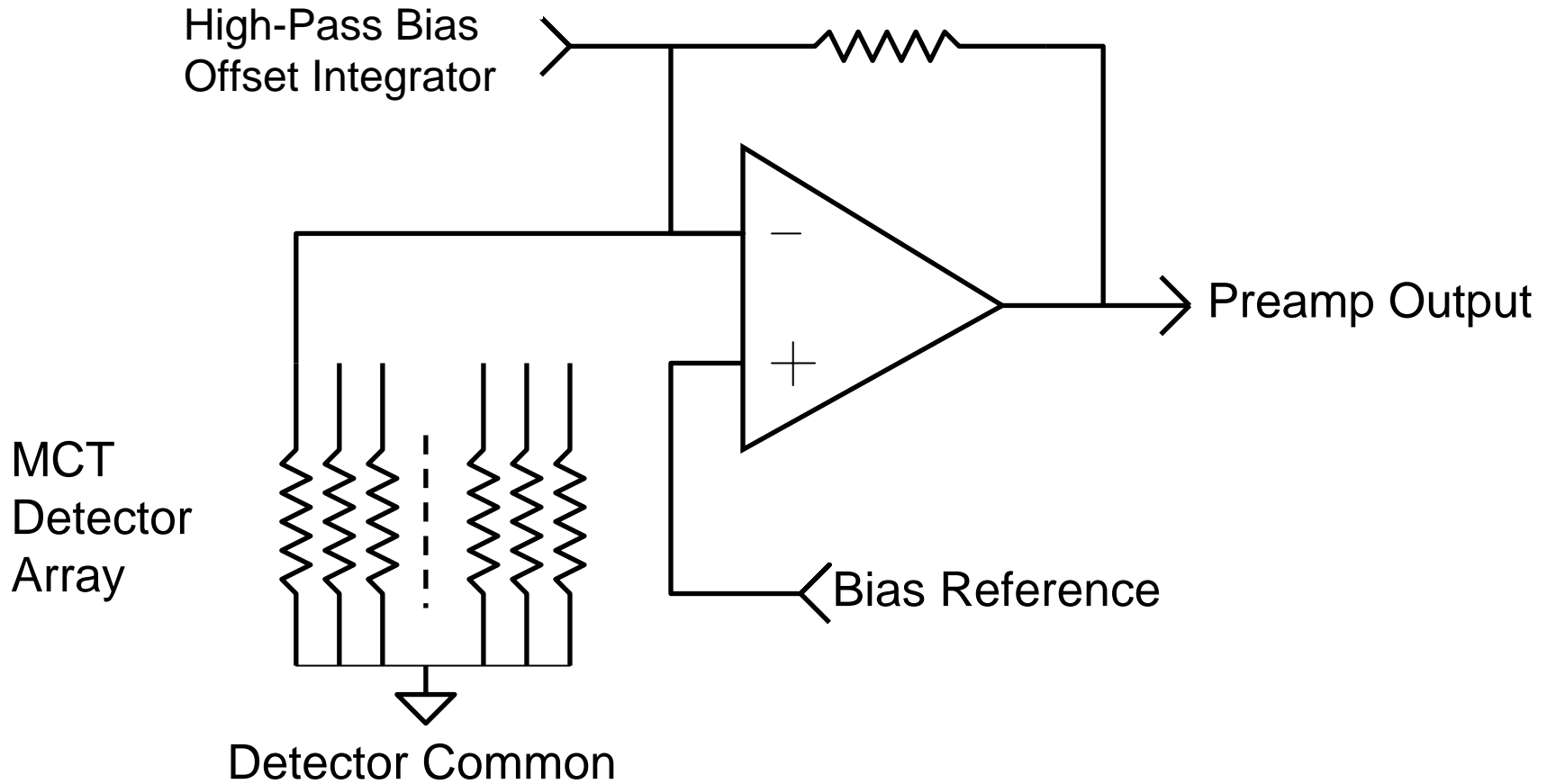
IR-6416 Design Parameters

- Φ 16 Isolated Channels on each PCB
- Φ PCB's Expand for up to 2048 Channels
- Φ 16 Bit A/D on each PCB
- Φ Jitter-Free Integration Gate (less noise)
- Φ Low-Noise Current Steering Circuitry
- Φ Preamp, Bias, Sync, Integrator, A/D, and MUX on each PCB

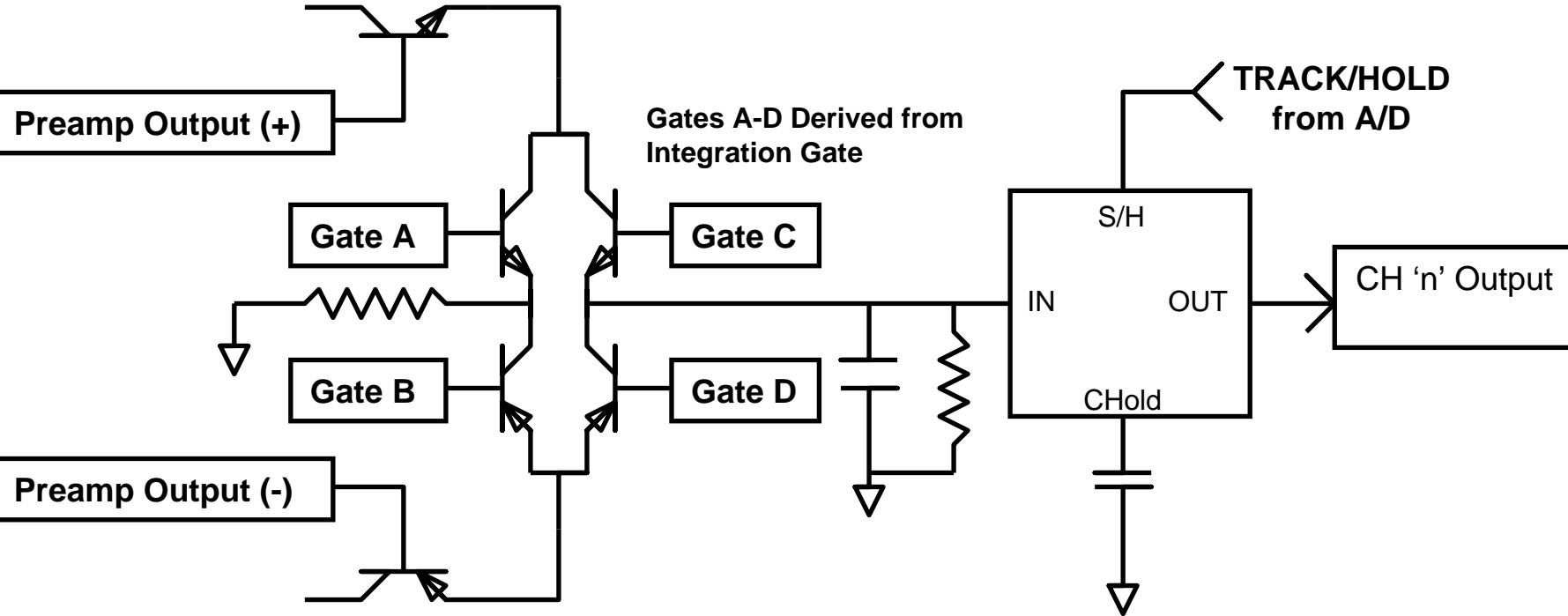


IR-6416 PCB Rack

IR-6416 Detector and Preamplifier



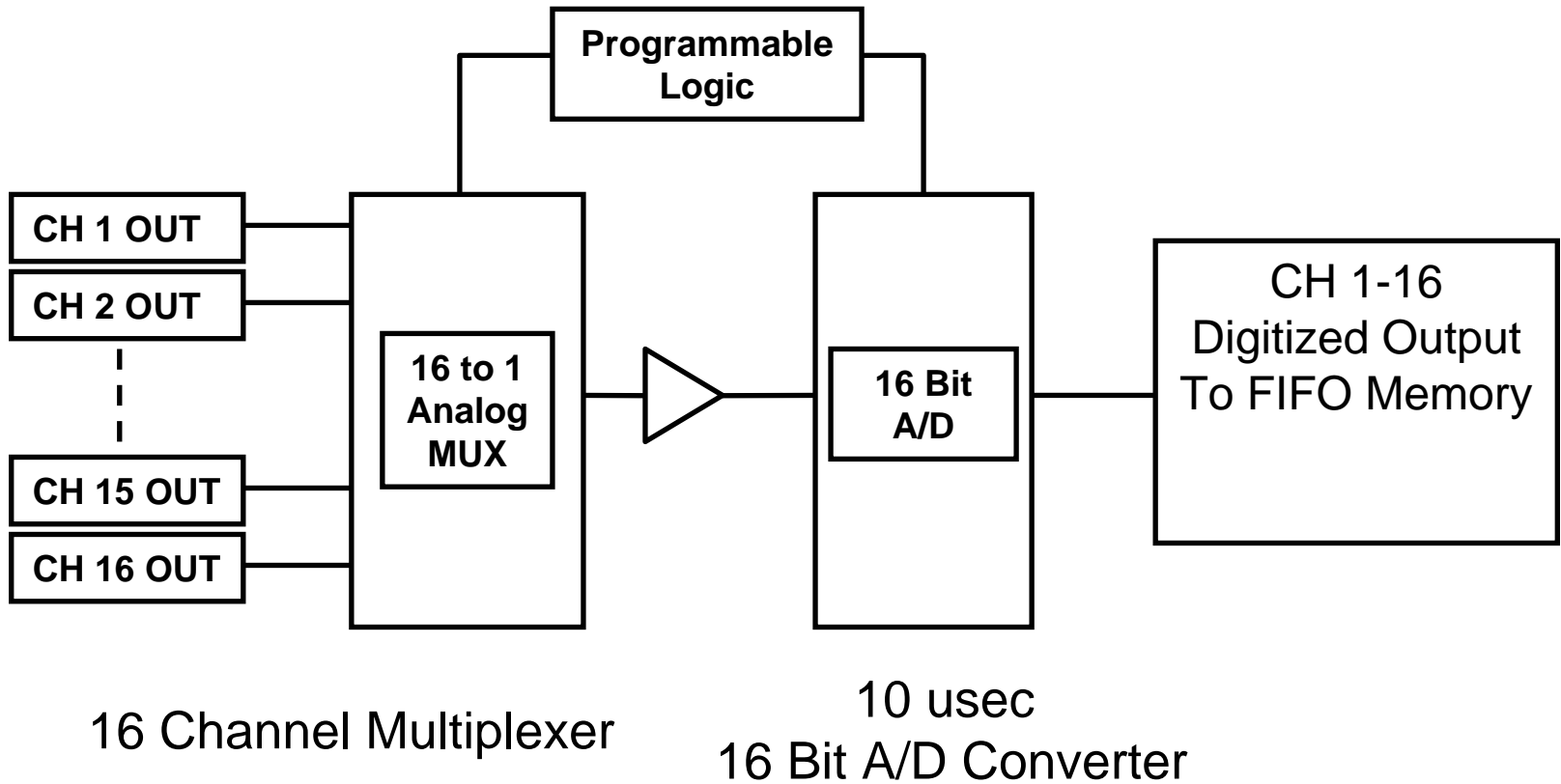
IR-6416 Integrator and Sample/Hold



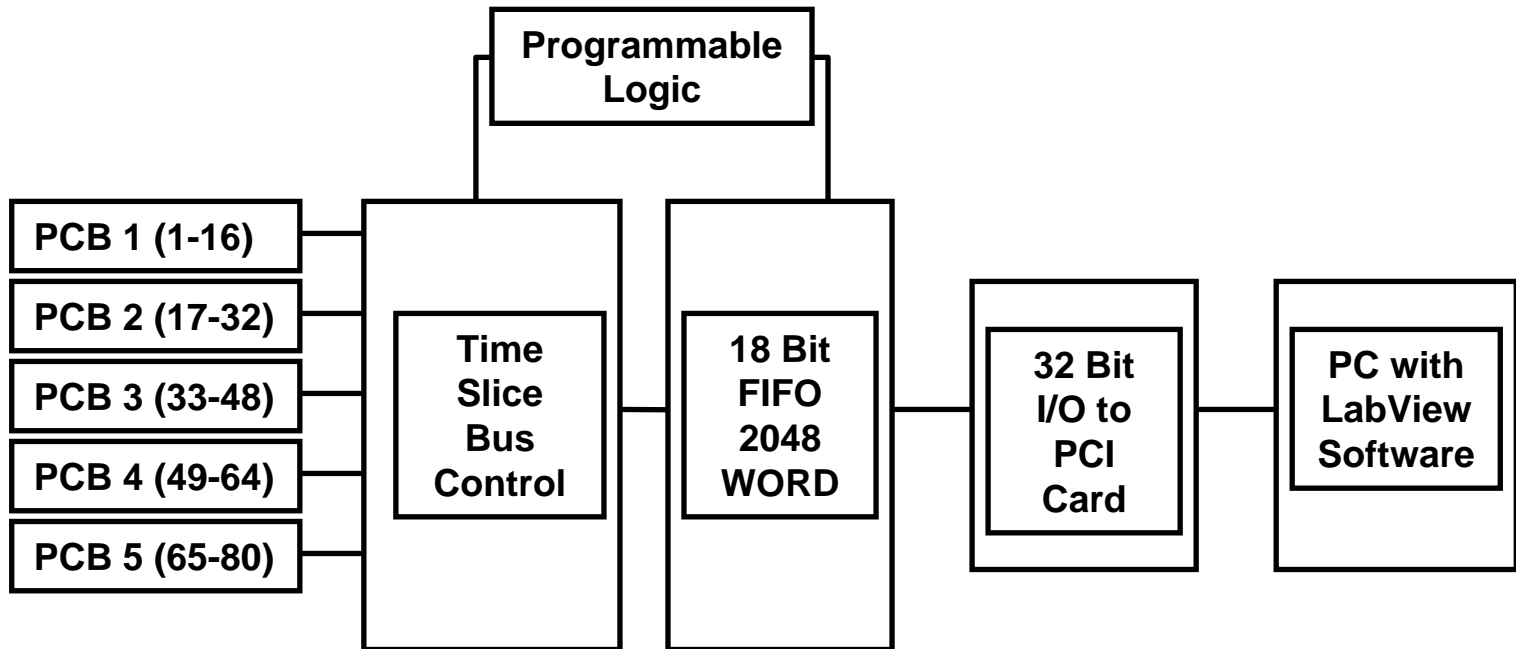
High Speed, Low Noise
Current Steering Integrator
(Boxcar Type)

Sample & Hold

IR-6416 Mux and A/D Conversion



IR-6416 10 Mhz Data Transfer



Interlaced Data
from PCB's
2Khz Rep Rate

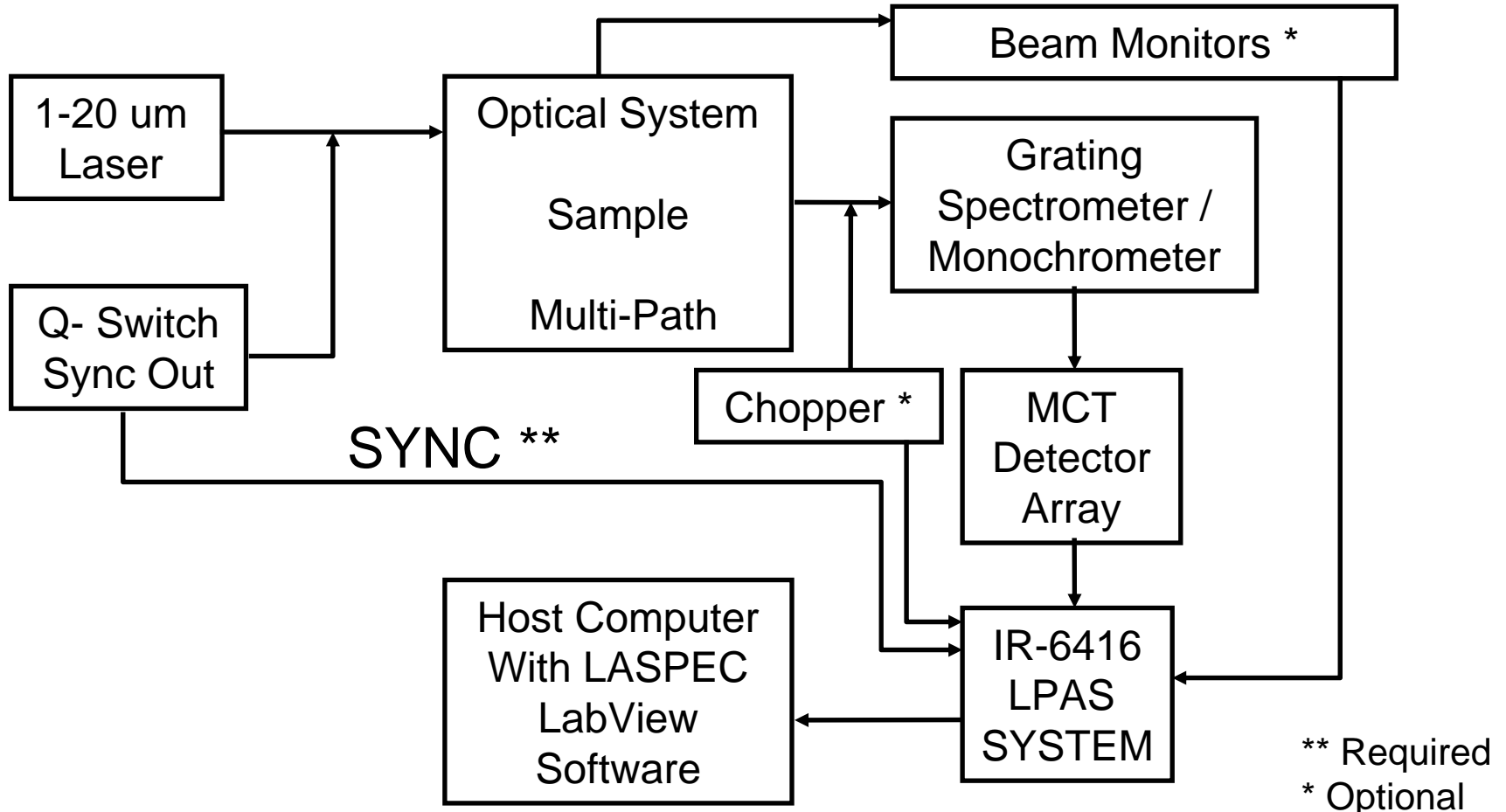
Time Slice
Sequencer

FIFO
Memory

10 Mhz
Data I/O

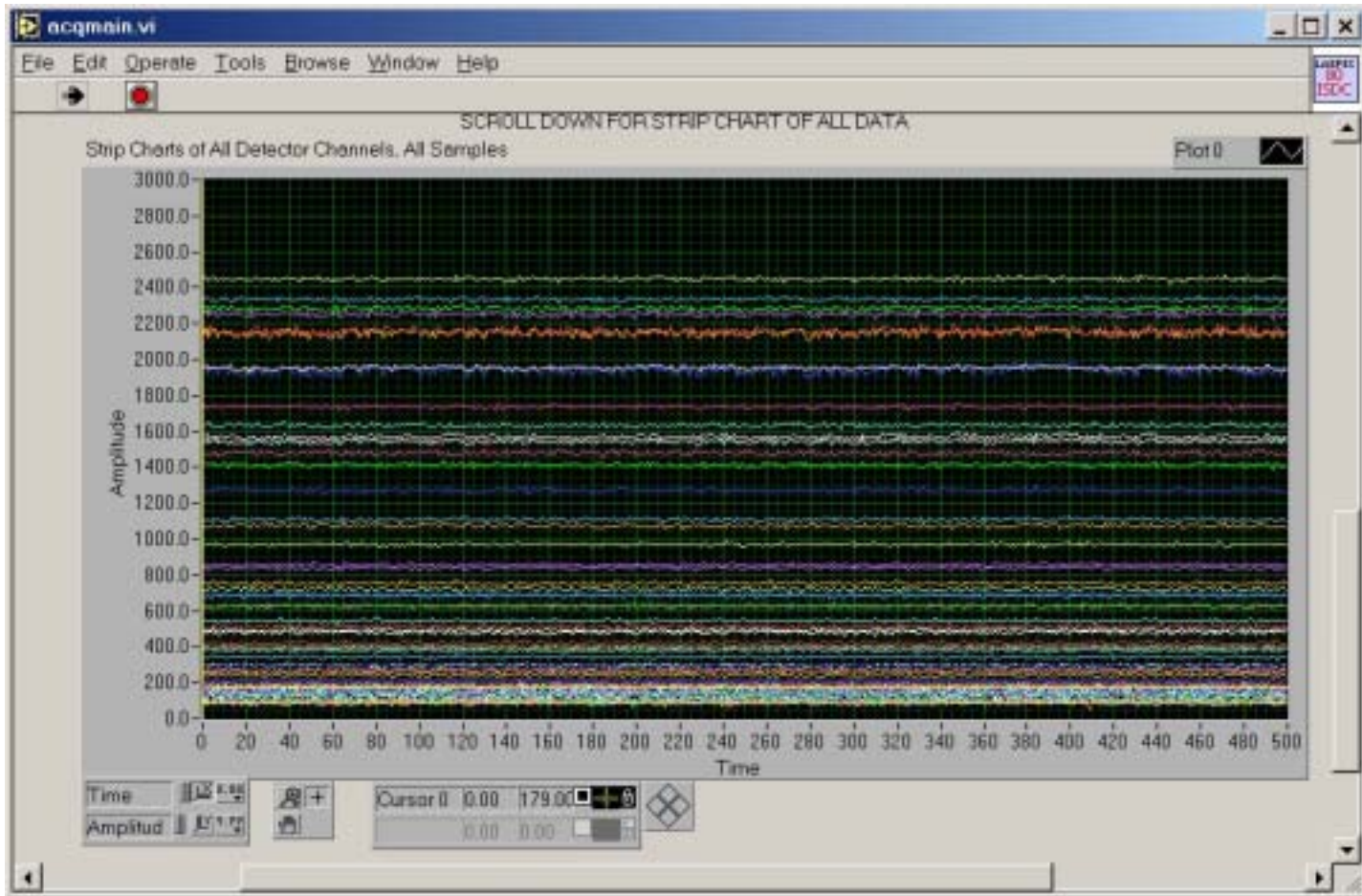
Data
Analysis

IR-6416 System Application



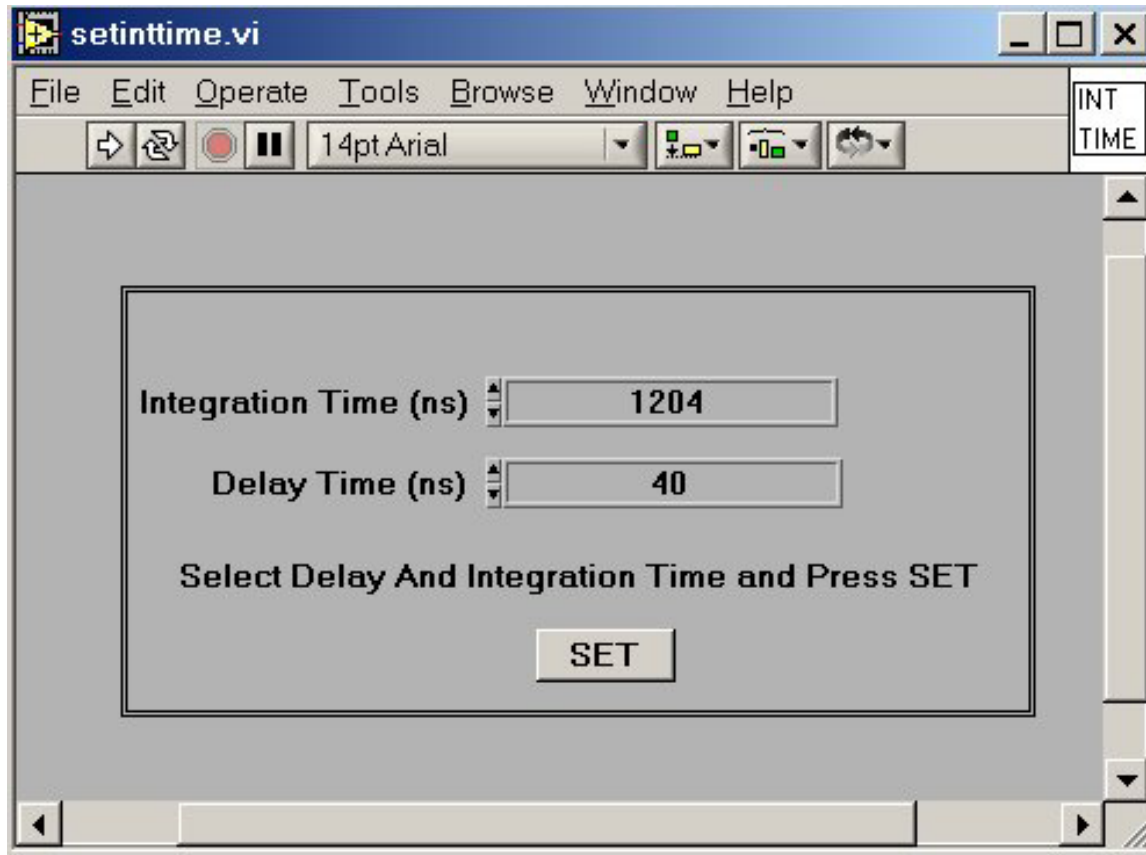
Typical 2D Vibrational Spectroscopy Setup

IR-6416 LASPEC Control Software



LASPEC Channel Vs. Sample Number

IR-6416 LASPEC Control Software



LASPEC Integration Gate Setup

IR-6416 SYSTEM with MCT Detector



IR-6416 Laser Pulse Integrator System

IR-6416 with Detector Complete System

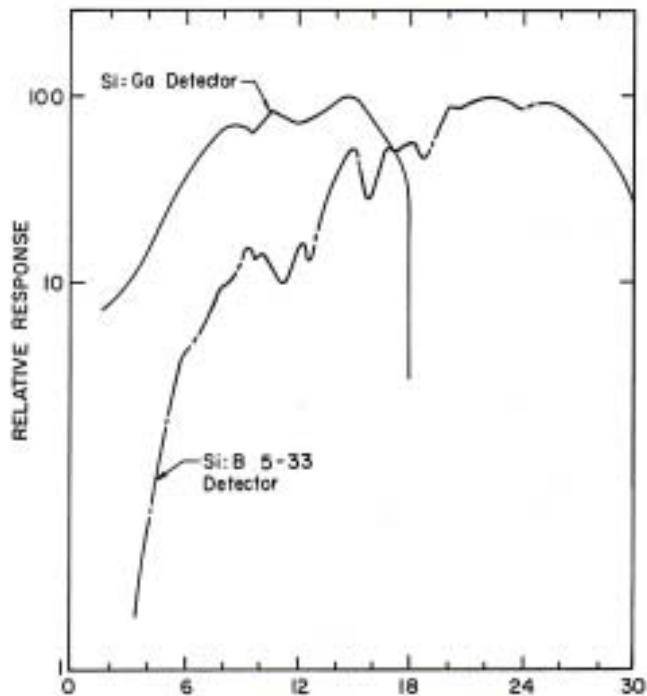
- 64 Element MCT Detector Array
- 80 Channel IR-6416 System (16 Ext Ch's)
- PCI DIO Card
- Host Computer System
- Interconnect Cables
- Power Supply
- LASPEC Control Software
- LabView™ Source code and VI's



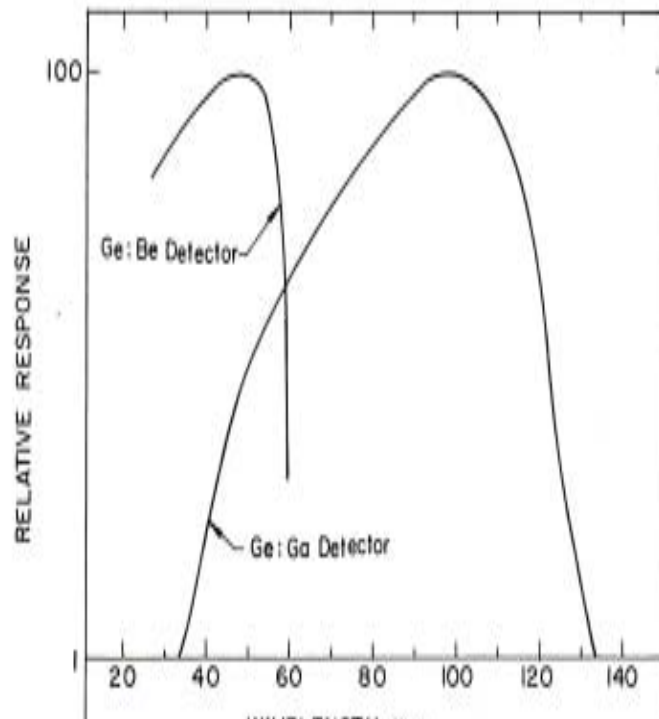
遠赤外線検出器

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- THz検出器等

Si:Ga, B Ge:Be, Ga 検出器



	WAVELENGTH μm	
Type	Si:Ga Detector	Si:B Detector
Spectral Response	Extrinsic	Extrinsic
Operating To: (Low Background)	5-18 Microns	5-33 Microns
Chopping Frequency (Typical)	4K	4K
Standard Element Size	DC-1000Hz (Low Background)	DC-9KHz
	0.5 mm, 1.0 mm, 2.0 mm	0.5 mm, 1.0 mm, 2.0 mm



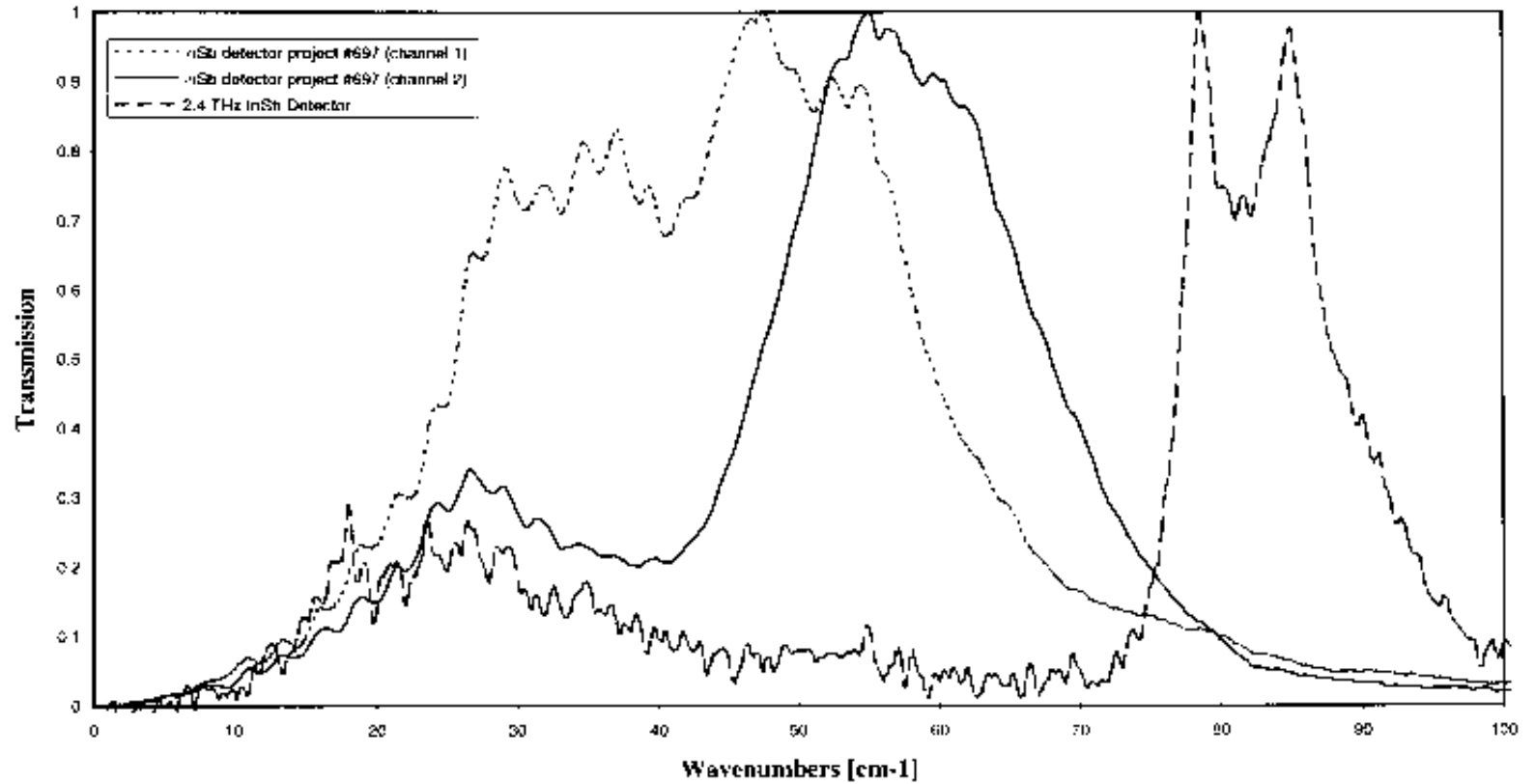
	Ge:Be Detector	Ge:Ga Detector
Type	Extrinsic	Extrinsic
Spectral Response	30-52 Microns	30-130 Microns
Operating To: (Low Background)	4K	<3K
Chopping Frequency (Typical)	10-5KHz	10-100 Hz
Standard Element Size	1.0 mm	0.5 mm, 1.0 mm, 2.0 mm

THz帯検出器の種類と波長域

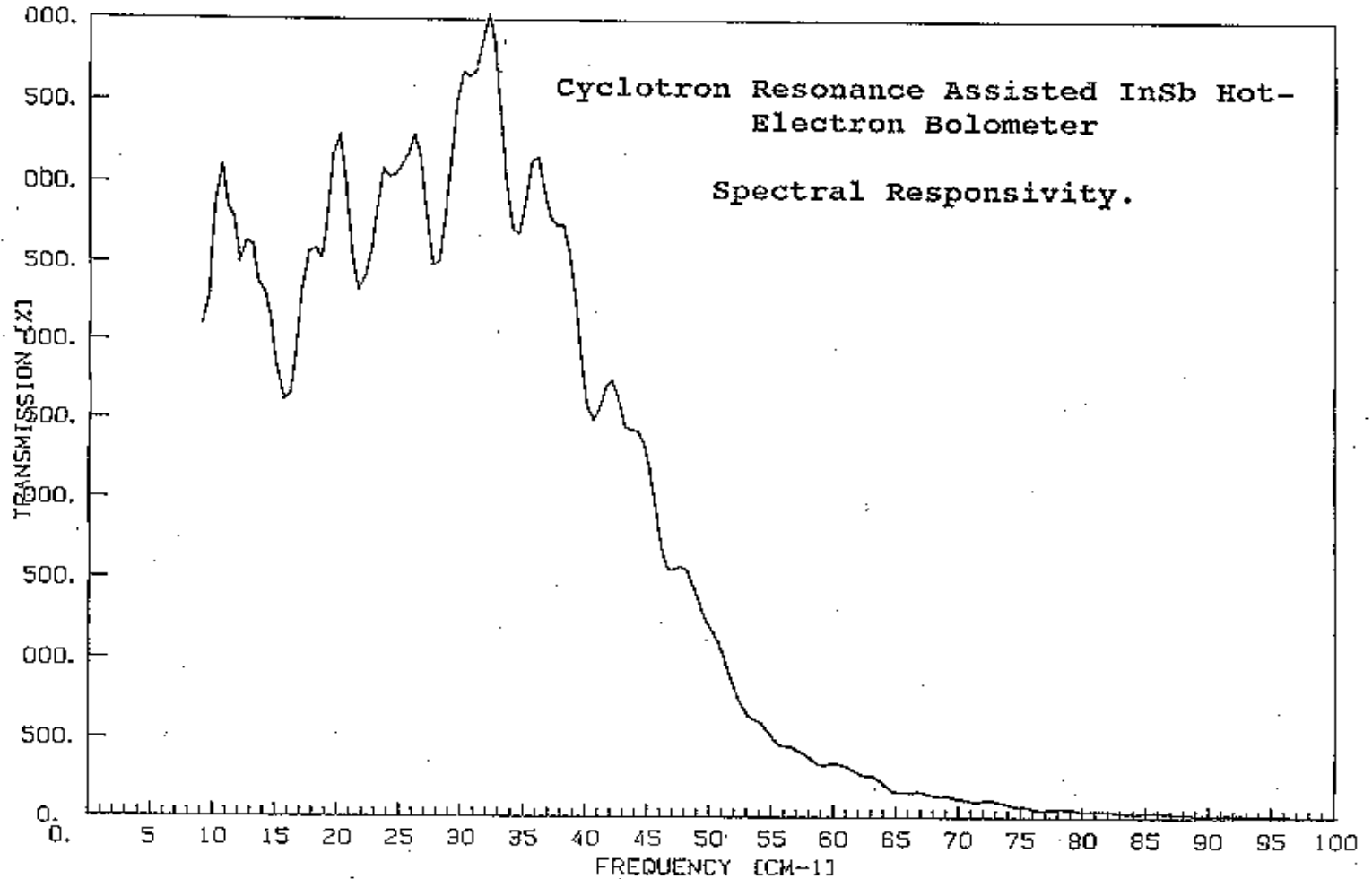
Si:Ga	: 5-18	@4K
Si:B	: 5-33	@4K
Ge:Be	: 30-50	@4K
Ge:Ga	: 40-130	@4K
Ge:Ga(圧縮型)	: 80-180	@4K
Si Bolometer	: 0.1-1000	@4K
	0.1-5000	@300mk-1.6K
Ge Bolometer	: 0.1-5000	@300mk-1.6K
Hot e- InSb	: 150-200 450-5000	@4K 磁場調整型
	200-5000	@4K 不均一磁場
	450-5000	@4K
Nb超伝導ボロメータ	: 1-1000	@1.6-4K

InSb検出感度

InSb detectors (Project #697)



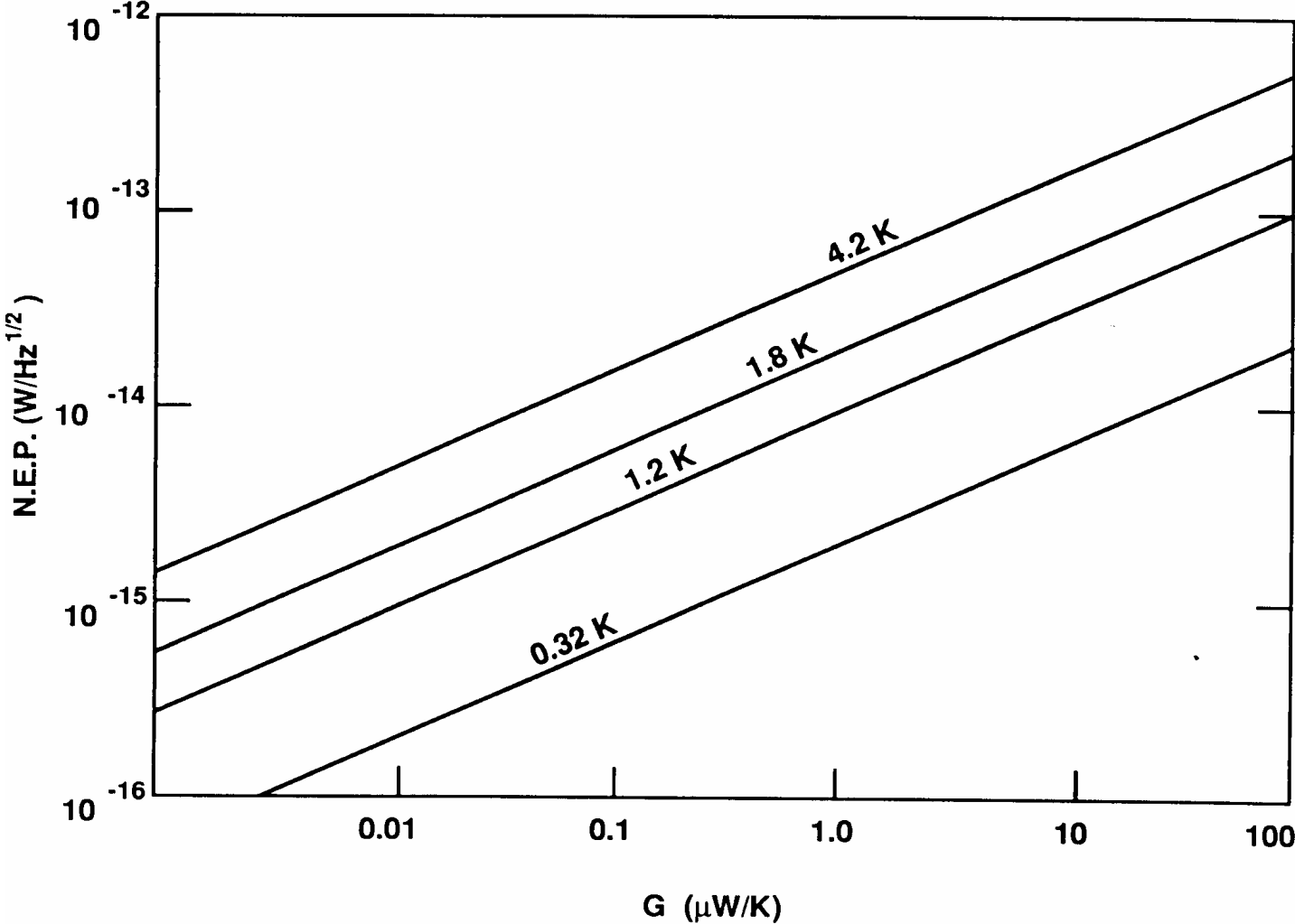
InSb 検出器 波長感度曲線



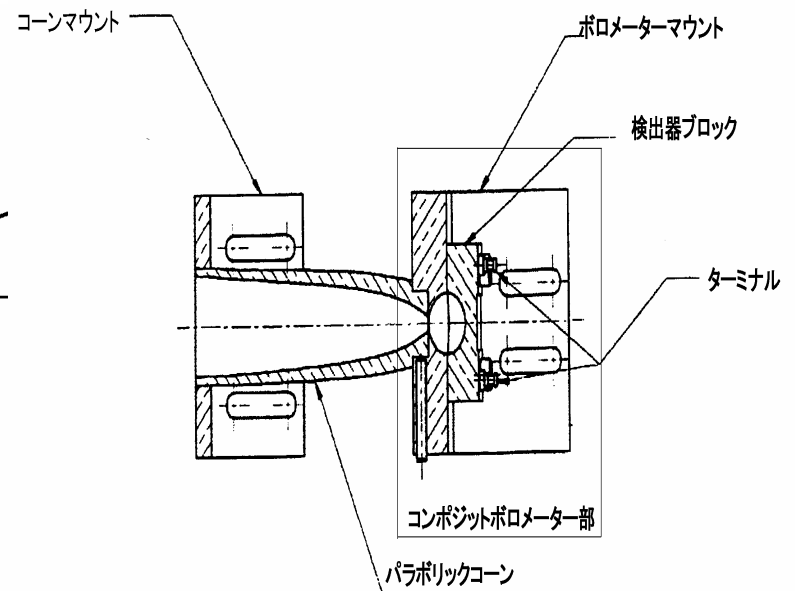
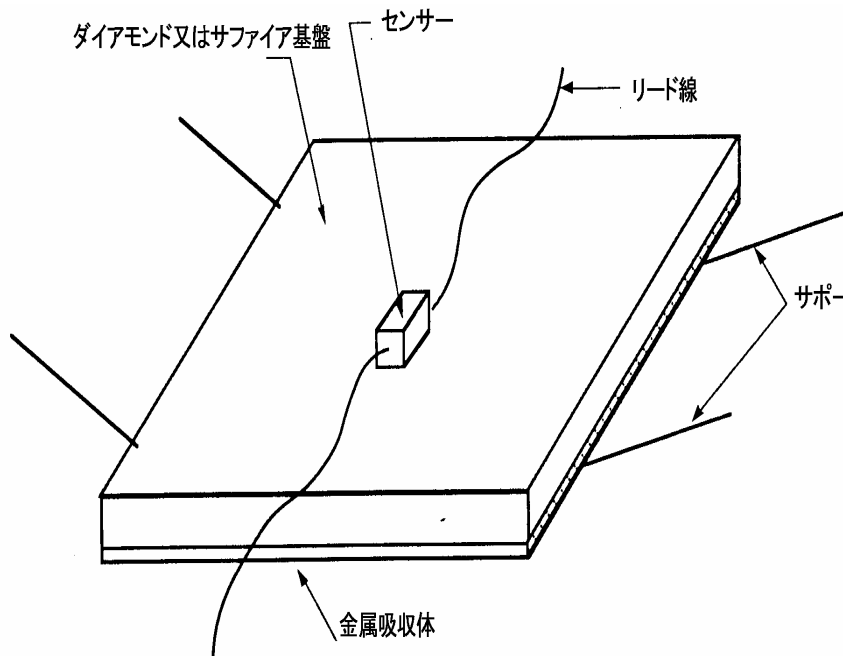
液体ヘリウム冷凍器



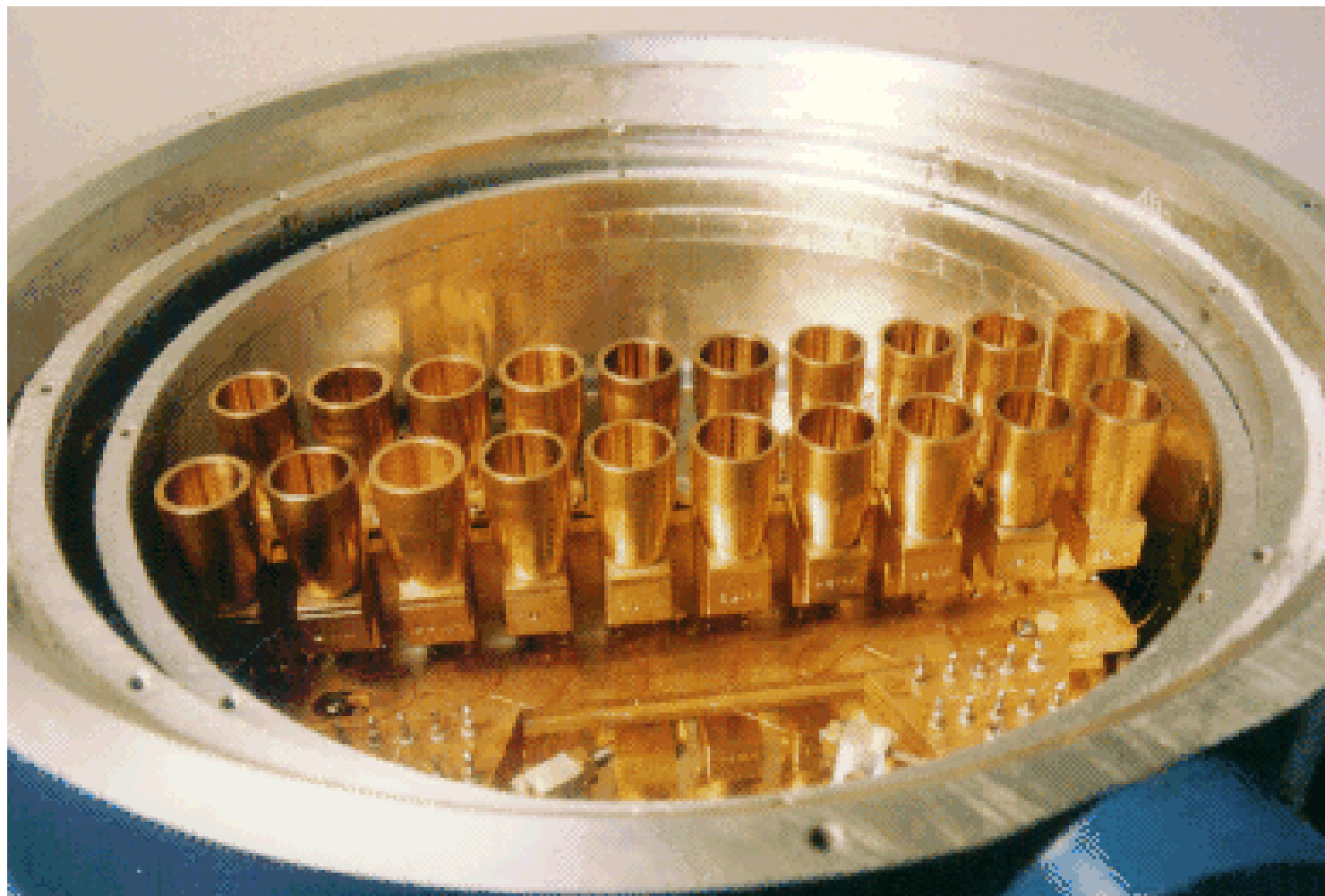
Si bolometer NEP



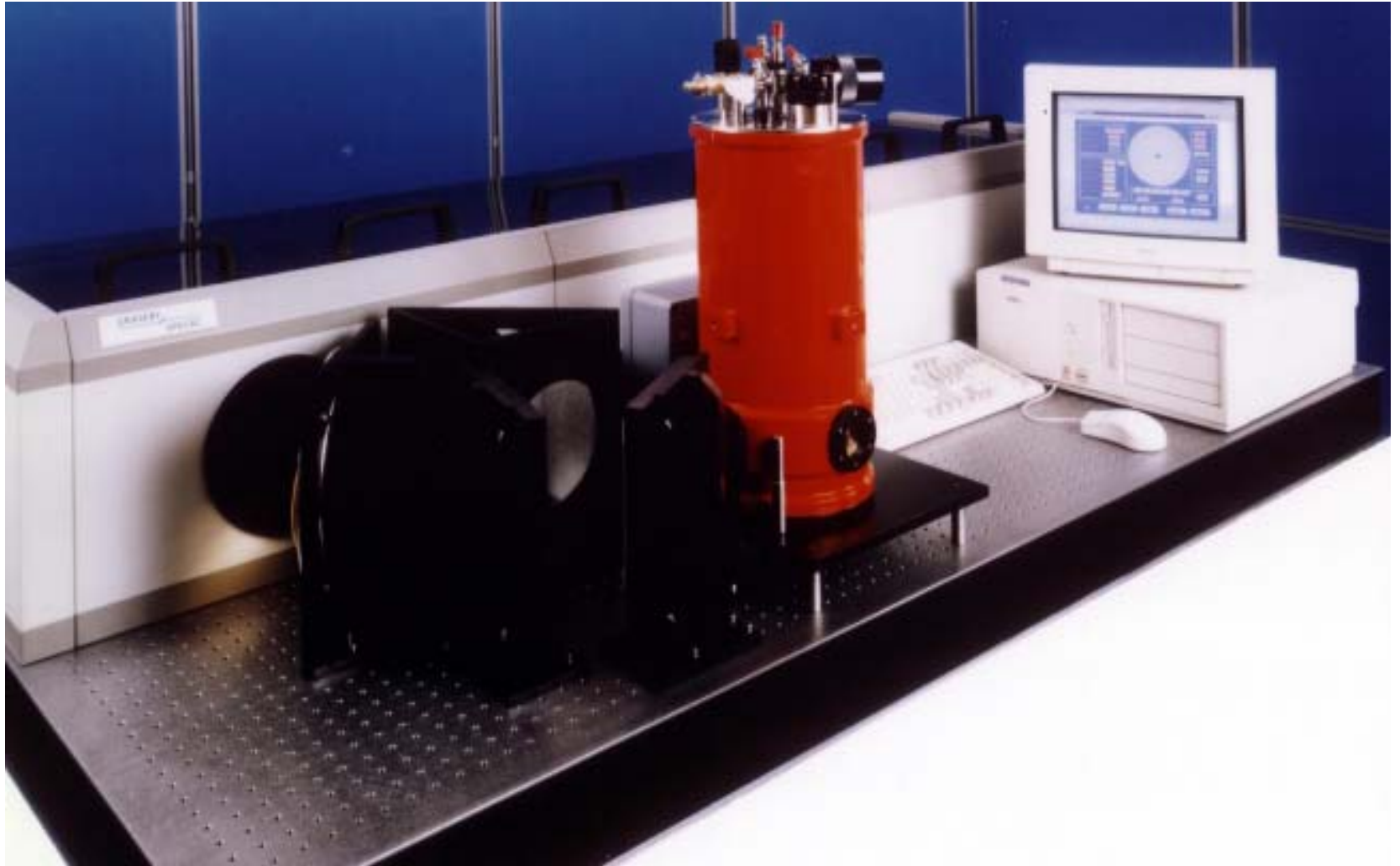
Si bolometer の形状



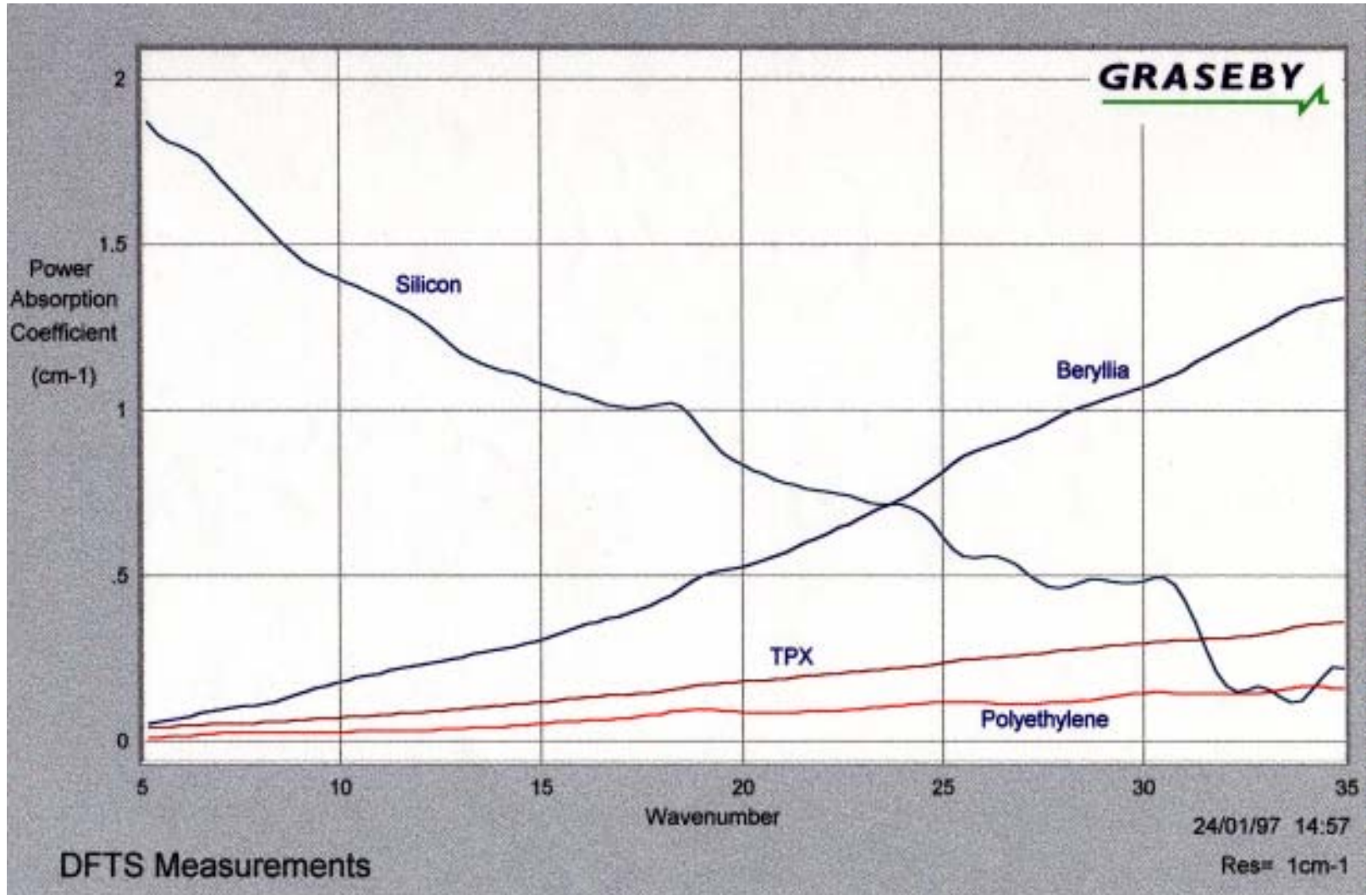
遠赤外線領域アレー検出器



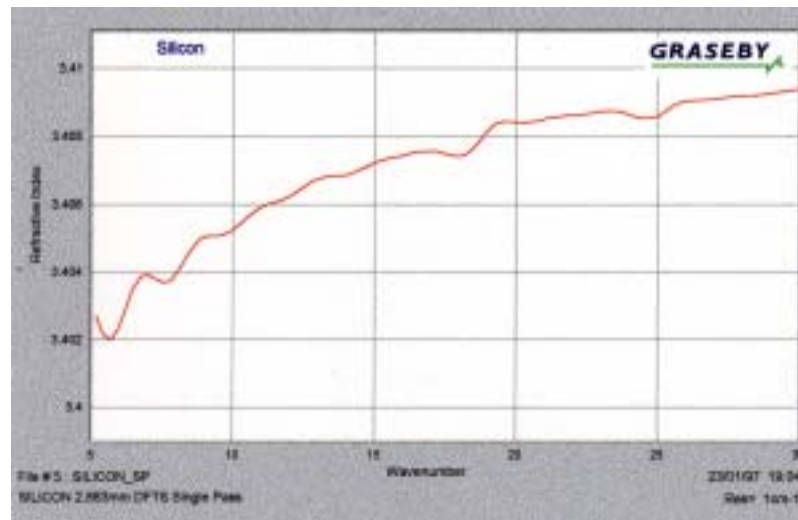
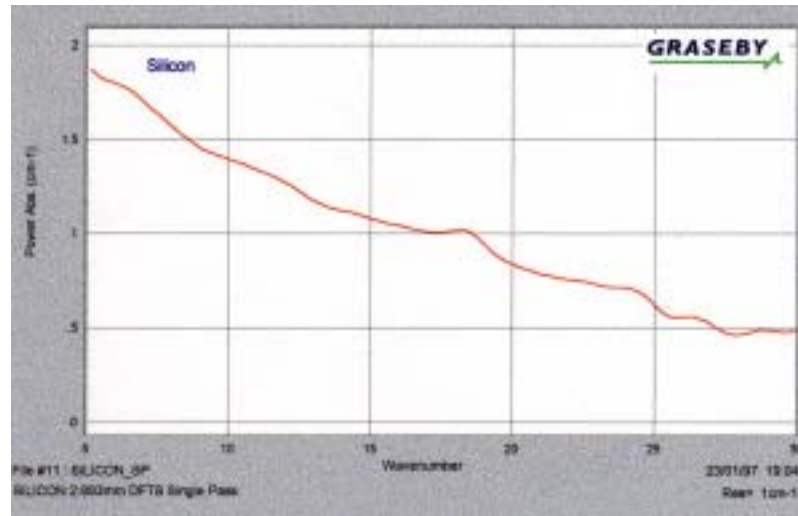
ボロメーターの応用



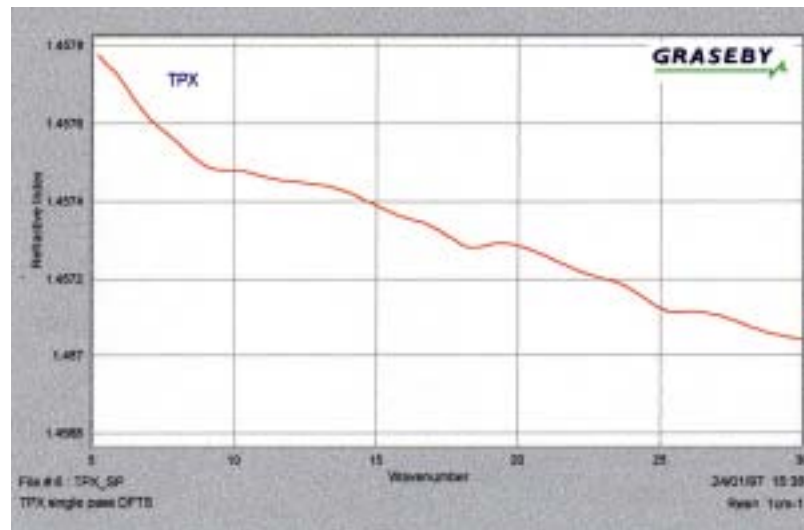
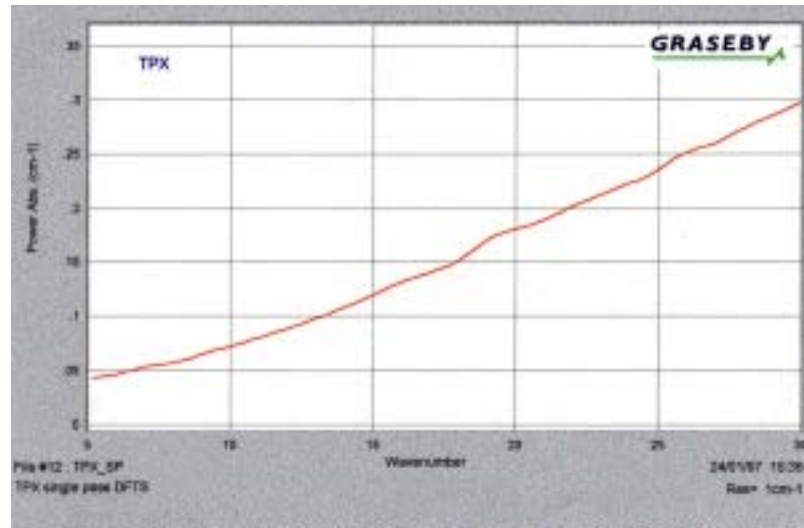
THz領域における材料評価



遠赤外線領域におけるSi



遠赤外線領域におけるTPX



遠赤外線領域におけるPolyethylene

