

# PI-MTE3

## LARGE-FORMAT, IN-VACUUM CAMERAS

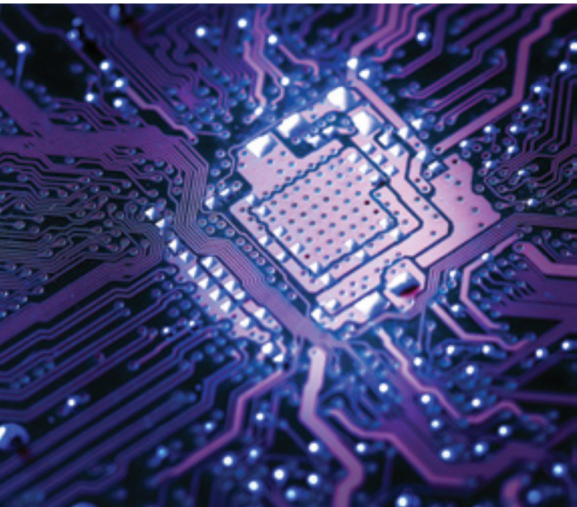
- True In-Vacuum Cameras
- Direct Detection of Soft X-Rays
- Up to 4k x 4k Sensor Formats



# Connected Teledyne – Helping Drive Your Results

## Teledyne Portfolio

Teledyne Imaging provides a collective of expertise across the spectrum. Individually, each division offers best-in-class solutions. Together, they leverage their combined strengths to provide the deepest technology portfolio in the world. From nano scales in the world of electron microscopy to space based astronomical imaging, Teledyne Imaging brings scale to the world’s most difficult and demanding applications.



## Working For You

Teledyne is committed to operational excellence at each step with involvement at every level of the supply chain – from pixel and sensor design to fabrication, systems and analysis, reducing our customer’s exposure. By leveraging a continuous link to a network of engineers, we grant our customers full access to our proprietary technologies and developments, providing an optimal solution that surpasses any multi-component integration.

## Partnerships

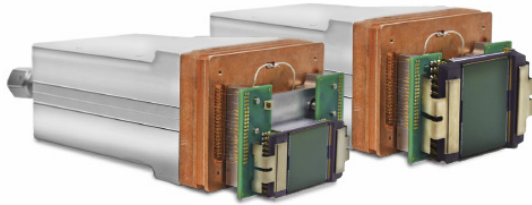
Teledyne Imaging has supported customer innovation needs for decades. Our partners are matched to a dedicated team of experts that ensure quick integration with software, optical, electrical, and mechanical elements. Additionally, the Teledyne team is in full consultation with their partners, supporting projects from start to end, with supply guarantees.



# Highlights

## Breakthrough In-Vacuum Performance

PI-MTE3 in-vacuum CCD cameras are engineered for direct detection in VUV, EUV, and x-ray imaging applications from ~10 eV to 30 keV.



The back-illuminated CCDs (large 2k x 2k or 4k x 4k formats) utilized by the PI-MTE3 platform offer >95% peak quantum efficiency. Efficient liquid cooling results in low dark current, facilitating long integration times.

Due to their four-port readout architecture, these low-noise, 16 or 18-bit cameras provide frame rates up to 7x to 10x higher than previous-generation two-port cameras.

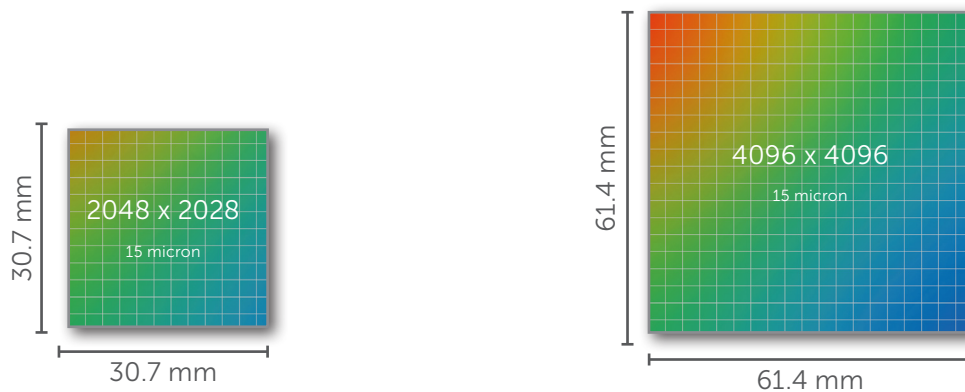
Applications include: EUV | VUV | Soft X-Ray | High-Harmonic Generation (HHG)

## Applications

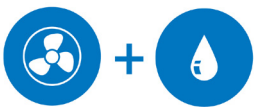
- XUV imaging
- SAXS/GISAXS
- Semiconductor metrology
- Grazing-incidence imaging/
- Spectroscopy
- X-ray diffraction
- X-ray phase contrast imaging
- X-ray spectroscopy
- X-ray microscopy

# Key Camera Features

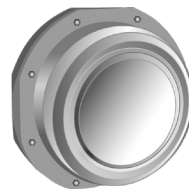
- High frame rates (~3 full fps @ 2k x 2k resolution)
- Low-noise multi-port, 16 MHz effective readout
- 24/7 in-vacuum operation: 10<sup>-9</sup> Torr
- Edge-mounted sensor: the first row of the sensor is close to the camera edge
- CCD cooled to < -55°C using +10°C liquid
- All liquid connectors meet latest synchrotron guidelines
- Design allows mounting of filter and Be window
- Intuitive LightField® software for real-time flatfield and background correction
- Compatibility with Python™, Linux®, MATLAB™, (MathWorks), and LabVIEW® (National Instruments)
- Integration with EPICS software
- Low-outgassing electronics



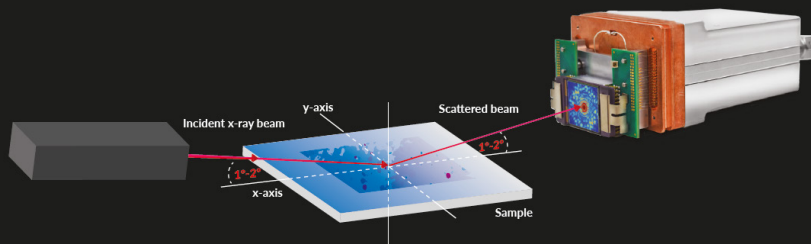
Large-format, back-illuminated 2048 x 2048 and 4096 x 4096 resolution CCD sensors with >95% peak quantum efficiency in the 10 eV to 30 keV range



Deep cooled to reduce thermally generated noise



100% in-vacuum testing, including cables and cooling tubes



# Imaging Software Flexibility

Most imaging experiments need flexibility - and the PI-MTE3 is a perfect fit:

- Microsoft® Windows® 10 or Linux® 64-bit operating system support
- Seamless integration of controls and data acquisition into MATLAB™ (MathWorks), LabVIEW® (National Instruments), ASCOM®, Maxim DL™ (Cyanogen Imaging), and Python®
- SDK / API compatible with Microsoft Windows and Linux

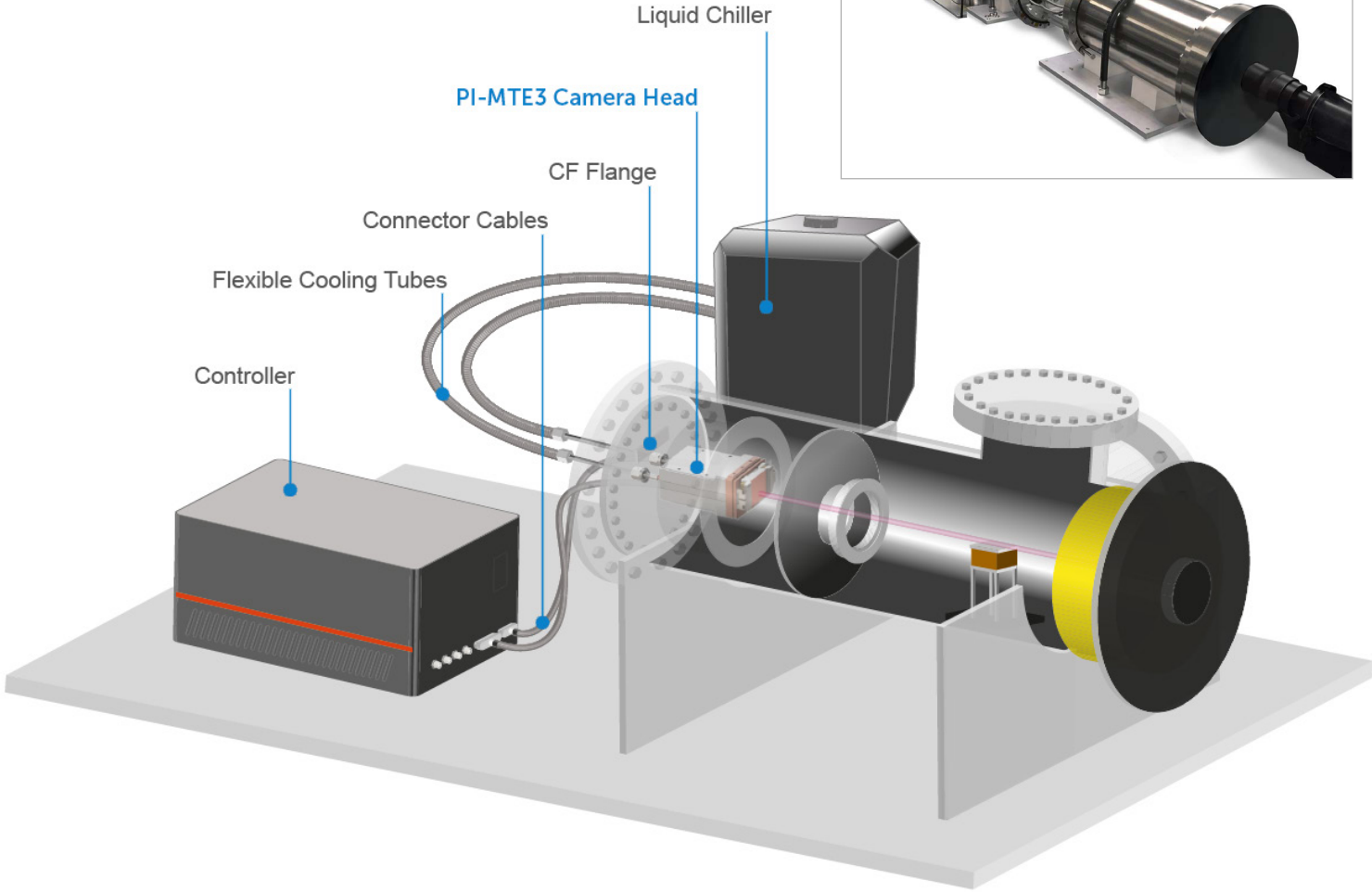


# Exceptional Reliability

Princeton Instruments has been designing x-ray cameras for more than three decades. As of today, hundreds of these low-noise cameras are being used at leading laboratories and facilities around the world! The exceptional reliability of our high-performance cameras is attributable to no-compromise engineering design and production techniques.

## 100% Tested In-Vacuum

Every PI-MTE3 camera is tested in-vacuum as a complete system... including all cooling and electrical cables.

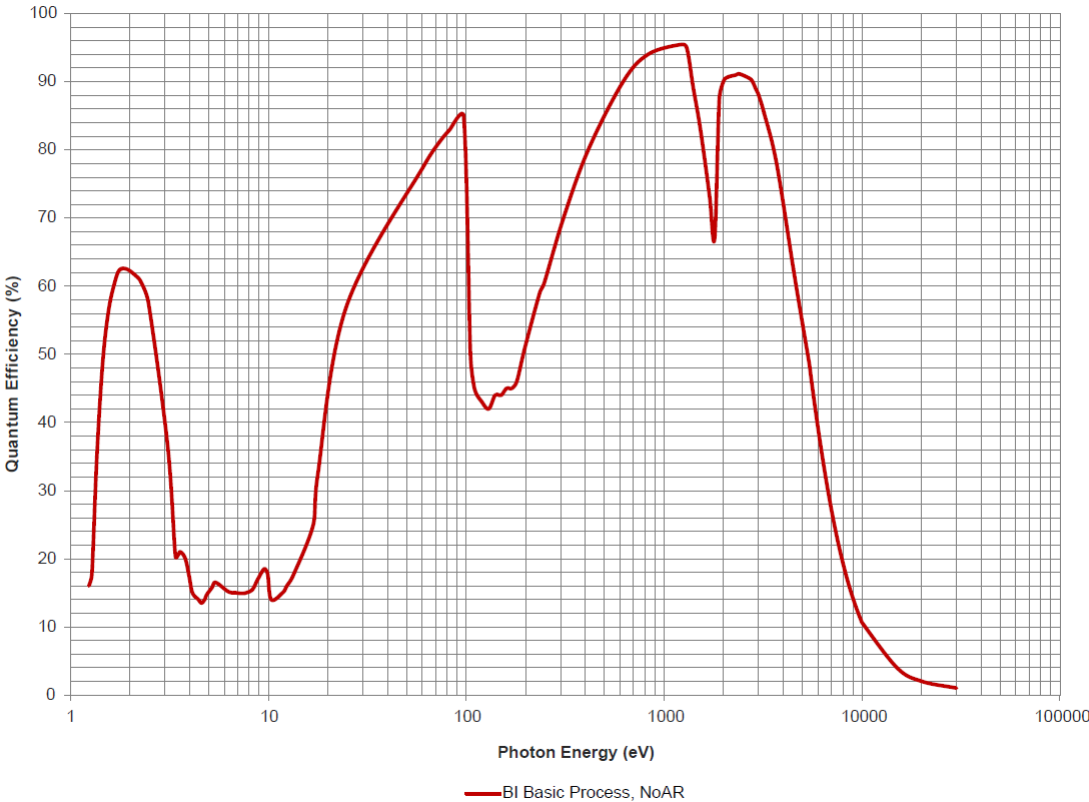


# PI-MTE3 Specifications

Feature	PI-MTE3 2048B	PI-MTE3 4096B
CCD image sensor	e2v CCD230-42; scientific grade 1; MPP; back illuminated; no AR coating	e2v CCD231-84 or 230-84; scientific grade 1; MPP; back illuminated; no AR coating
CCD format	2048 x 2048 imaging pixels; 15.0 x 15.0 $\mu\text{m}$ pixels; 100% fill factor	4096 x 4096 imaging pixels; 15.0 x 15.0 $\mu\text{m}$ pixels; 100% fill factor
Imaging area	30.7 x 30.7 mm	61.4 x 61.4 mm
Deepest cooling temperature (@ +20°C)	-55°C (typical) with liquid chiller	-50°C (typical) with liquid chiller
Thermostating precision	$\pm 0.1^\circ\text{C}$	
Dark current (e <sup>-</sup> /pixel/sec)	0.0015	230-84: 0.0015 231-84: 8.0
Cooling method	Liquid cooling	
Full well, single pixel (typical)	150 ke <sup>-</sup>	230-84: 150 ke <sup>-</sup> , 231-84: 300 ke <sup>-</sup>
ADC speed	16 MHz (4 MHz x 4 ports); 4 MHz (1 MHz x 4 ports); 400 kHz (100 kHz x 4 ports)	12 MHz (3 MHz x 4 ports); 4 MHz (1 MHz x 4 ports); 400 kHz (100 kHz x 4 ports)
ADC bits		
System read noise @100 kHz per Port (e <sup>-</sup> rms)	6.5	230-84: 6.0 231-84: 3.4
Readout modes	4-port, 2-port, or 1-port readout; Kinetics; External Sync	
Nonlinearity	<2% @ 100 kHz	
Software-selectable gains	1, 2, 4 e <sup>-</sup> /ADU	0.2, 1.1 e <sup>-</sup> /ADU
Host interface	USB 3.0	
I/O signals (TTL)	Trigger In, Expose Out, Shutter Out/In, Readout, Ready	
Software (optional)	LightField for Microsoft Windows 10 (64 bits); PICam SDK for Microsoft Windows and Linux; EPICS support via automation	
Bake-out temperature	50°C (maximum)	
Vacuum compatibility	10 <sup>-9</sup> Torr	
Certification	CE	
Operating environment	+5°C to +30°C non-condensing	
Feedthrough	DN100 or 6" industry-standard CF flange	
Camera weight	2.31 kg (5.10 lbs)	2.7 kg (5.9 lbs)
Camera head dimensions (L x W x H)	217.6 mm (8.56") x 102.3 mm (4.03") x 73.9 mm (2.91")	220.4 mm (8.68") x 102.3 mm (4.03") x 75.6 mm (2.98")

Specifications are subject to change

# Quantum Efficiency Curves



# Frame Rates (frames/sec)

## PI-MTE3 2048B

Binning	16 MHz	4 MHz	400 kHz
1 x 1	3.2	0.9	0.09
2 x 2	7.4	2.9	0.33
4 x 4	14.3	7.7	1.05
8 x 8	22.2	15.4	2.9

## PI-MTE3 4096B

Binning	12 MHz	4 MHz	400 kHz
1 x 1	0.56	0.21	0.024
2 x 2	1.36	0.70	0.081
4 x 4	2.80	1.81	0.253
8 x 8	4.68	3.66	0.680

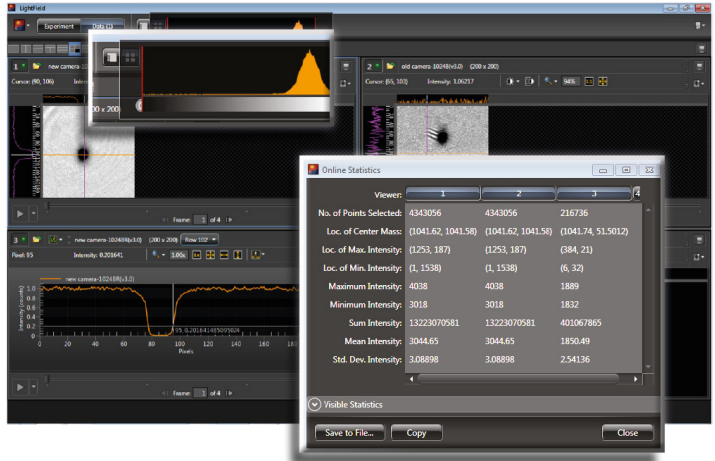


# LightField<sup>®</sup> Software

## The Future of Scientific Imaging and Spectroscopy Software

The combination of LightField and PI-MTE3 cameras provides researchers with the most advanced and reliable toolset for experimental setup, data acquisition, and post processing:

- Powerful 64-bit software package includes Microsoft Windows 10 support
- Complete control of Teledyne Princeton Instruments cameras and spectrometers
- Dependable data integrity via automatic saving to disk, time stamping, and retention of both raw and corrected data
- Full experimental details and system settings are archived and can be reloaded for future experiments ensuring maximum reproducibility
- For light-sensitive experiments, the user interface offers “low light” and “no light” modes during data acquisition
- LightField works seamlessly in multi-user facilities, remembering each user’s hardware and software configurations
- Simple math functions and complex transforms can be applied to live or stored data, with an included easy-to-use editor to create your own formulas
- Integrated LabVIEW<sup>®</sup>, MATLAB<sup>™</sup>, Python<sup>™</sup>, ASCOM<sup>®</sup> and Maxim DL<sup>™</sup>
- Exports to your favorite file formats, including TIFF, FITS, ASCII, AVI, IGOR, and Origin
- Demo camera mode allows the user to view all of the settings and parameters associated with any camera without physically connecting the camera
- Live data processing operations provide real-time evaluation of incoming data to optimize experimental parameters



# System Components

The PI-MTE3 can be provided in custom configurations to suit your experiment. Please contact your local Teledyne Princeton Instruments representative. The most common configurations are listed below.

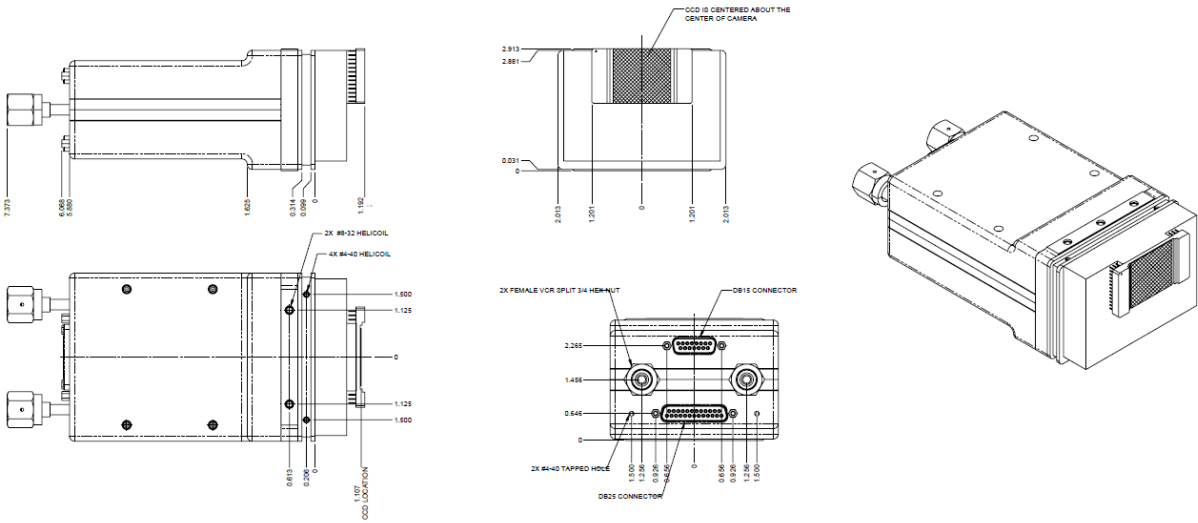
Since the PI-MTE3 is highly sensitive to the effects of shipping and handling as well as debris, we have designed a special, robust shipping container that protects the camera and reduces contamination.



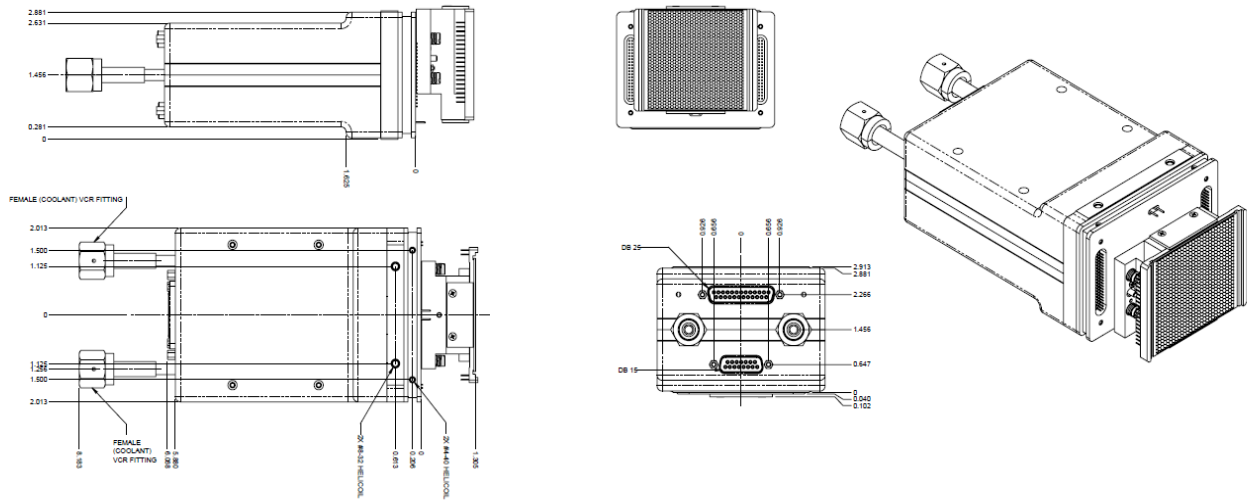
### Optional accessories and customization:

- LightField software
- PICam SDK/API for Linux and Microsoft Windows (provided for free)
- Customized coatings and filters from UV to NIR
- Custom optical assemblies

# PI-MTE3 2048B

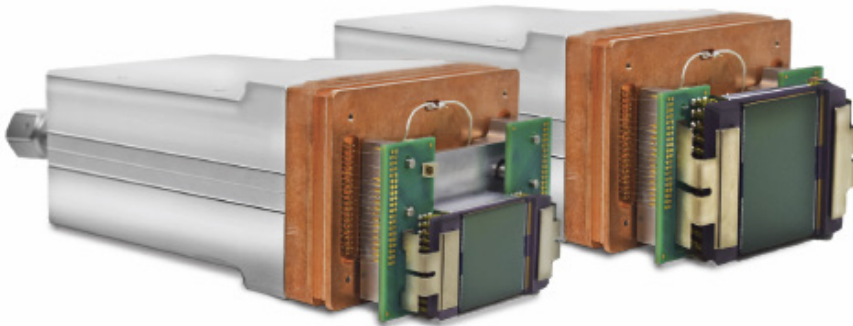


# PI-MTE3 4096B



# PI-MTE3

## LARGE-FORMAT, IN-VACUUM CAMERAS



Contact your local Teledyne Princeton Instruments representative for additional information.

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