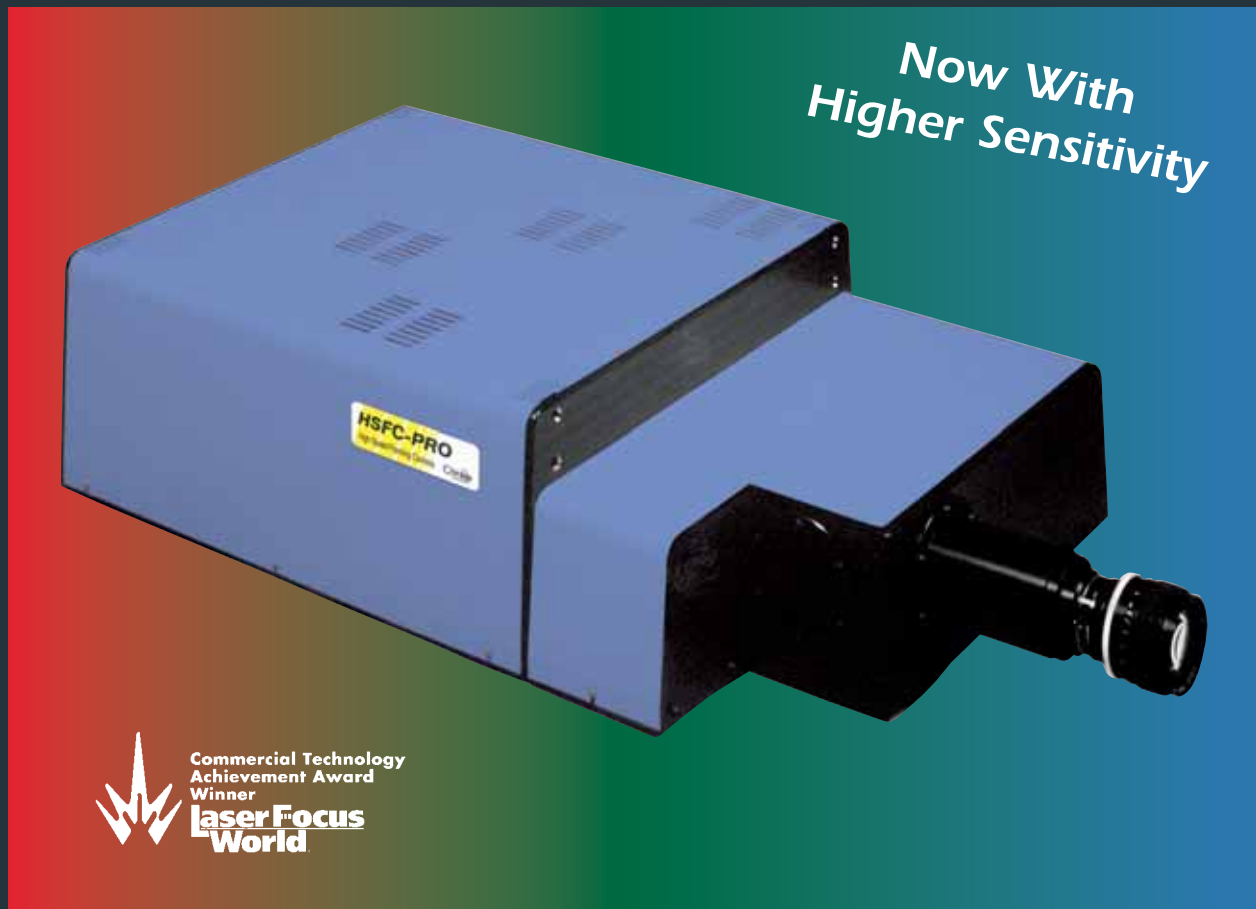


# HSFC-PRO

Ultra-High Speed Framing Camera



Imaging Rate  
333 Million  
Frames Per Second

the  
**cooke**  
corporation

# HSFC-PRO

The HSFC-PRO consists of a single optical input, an image splitter to four imaging modules with gateable MCP image intensifiers, and high resolution CCD imaging sensors yielding 8 images at full CCD resolution in Double Exposure modes.

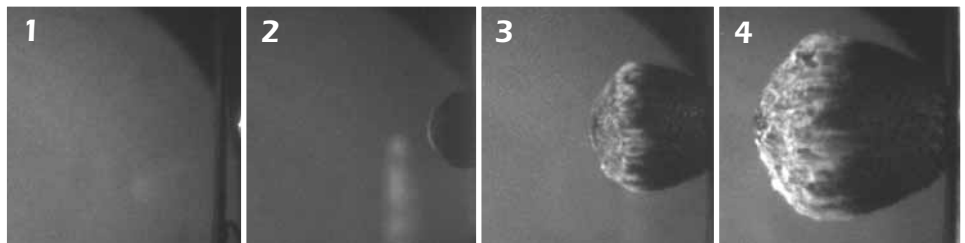
## Features

- 2 - 4 imaging modules
- Gen2 or enhanced Gen3 photocathodes available
- 12-bit dynamic range per image
- Ultra Fast Shutter down to 3ns (1.5 ns optional)
- High sensitivity (>100 counts / photoelectron with P43 phosphor)
- Spectral sensitivity near UV to near IR
- Quiet Correlated Double Sampling (QCDS) for low electronic noise
- Horizontal and vertical binning to increase SNR
- 2-stage peltier cooler (-12°C) for negligible dark noise
- Optical or electrical triggering with extremely short jitter time
- Double-Shot or multiple exposure capability on each module
- High speed serial data transfer via fiber optic link (FOL)

## Applications

- Hypervelocity Impact Studies
- Ultrasonic Flame Propagation
- Combustion Studies using LIF
- Ballistics/Detonics
- Sparks in Electronic Studies
- Spray and Particle Analysis
- DPIV
- Laser Ablation
- Kinetics of Ferro-Electric materials

## Hypervelocity Impact

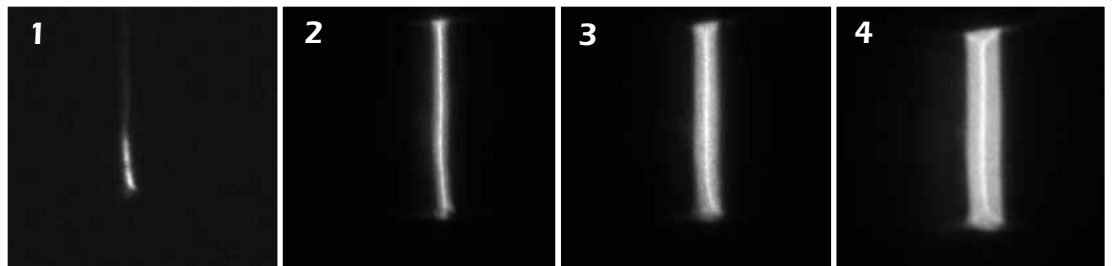


Aluminum ball (few mm's size) penetrates a thick steel plate.

### Timing Details

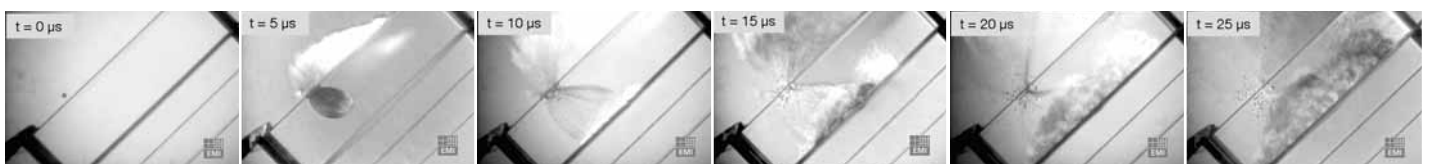
	Image 1	Image 2	Image 3	Image 4
Delay	0	5 ns	10 ns	15 ns
Exposure	20 ns	20 ns	20 ns	20 ns

## Spark Gap



Spark gap taken with the HSFC-PRO High Speed Framing Camera.  
Spark Gap Width: 8mm taken 20 ns apart @ 3 ns each.

## Impact Of Space Debris



Images courtesy of the Fraunhofer-Institut für Kurzzeitdynamik ^  
Ernst-Mach-Institute, [www.emi.fhg.de](http://www.emi.fhg.de)

## System Specifications

OPTICAL INPUT	<ul style="list-style-type: none"> <li>▪ Accepts standard Nikon (F-Mount) photo camera lens (others on request)</li> </ul>
	<ul style="list-style-type: none"> <li>▪ Lens input can be mounted from different angles (see cover image)</li> </ul>
IMAGE SPLITTER	<ul style="list-style-type: none"> <li>▪ 4 channels, diverting about 22% of total incoming light to each imaging module.</li> <li>▪ User can exchange beam splitter parts and mirrors to configure 1, 2, 3 or 4 channel systems.</li> <li>▪ Beam splitter cubes are placed in the infinite ray path between the collimator lenses.</li> <li>▪ Mirrors are mounted on strong spring loaded holders to absorb external shocks.</li> <li>▪ Individual filters can be inserted in filter holders on each module for spectrally resolved imaging.</li> </ul>
IMAGE INTENSIFIER	<ul style="list-style-type: none"> <li>▪ Proximity focused MCP (single stage) - 2<sup>nd</sup> generation</li> <li>▪ 6<math>\mu</math>m high resolution MCP</li> <li>▪ Diameter 25mm</li> <li>▪ Input Window Glass or Quartz</li> <li>▪ Output Window Glass</li> <li>▪ Photocathode S20, GaAs, GaAsP, (filmless with extended lifetime), others on request</li> <li>▪ Phosphor Screen P43 or P46</li> </ul>
OPTICAL COUPLING	<p><b>Coupling between image intensifier and CCD:</b></p> <ul style="list-style-type: none"> <li>▪ MCP to CCD via "Ultra Speed Tandem Lens"</li> <li>▪ Collimator lens F2.5/100mm and output lens F1.4/46 mm</li> <li>▪ Transmission efficiency &gt; 20%</li> <li>▪ Vignetting &lt; 3%</li> <li>▪ Resolution &gt; 60 lp/mm, distortion free</li> </ul>
TRIGGERING	<ul style="list-style-type: none"> <li>▪ By electrical signal (TTL level, BNC connector) or by optical signal (SC connector).</li> </ul>
TRIGGER MODES	<p><b>Auto:</b> internal via software</p> <p><b>Single:</b> internal/external</p> <p><b>Continuous:</b> internal/external</p>
SHUTTER DISABLE	<ul style="list-style-type: none"> <li>▪ High speed TTL inputs for disabling shutters (photocathodes) of each module, BNC connectors.</li> </ul>

GATING MODES	
<b>Ultra Fast Gating</b>	Exposure time: 3, 10, 20, 25, 30nsec, 30 - 100nsec in 10 nsec steps, 100nsec - 1000msec in 20 nsec steps, 1000msec - 1000sec in 1 microsecond steps.  Delay time: 0 - 50nsec in 1nsec steps, 50 - 100nsec in 5nsec steps, 100nsec - 1000msec in 20nsec steps, 1000ms - 1000sec in 1 microsecond steps.  Maximum pulsing frequency 3.3 KHz.
<b>High Rate Gating</b>	Exposure time: 20nsec - 1000msec in 20nsec steps. Delay time: 20nsec - 1000msec in 20nsec steps. Maximum pulsing frequency 2 MHz.
SENSITIVITY	>100 counts / photo electron with P43 phosphor. >20 counts / photo electron with P46 phosphor.
EXPOSURE MODES	Single exposure or multiple exposure (Max. 5) for ultra fast gating cycle or high rate gating.  Double exposure for two full resolution images on each module for High Rate Gating Mode.  Time between two images on the same module depends on phosphor decay time, the minimum delay time is 500nsec.
CCD INTEGRATION TIME	1 ms...1000s, selectable for adjustment to phosphor decay integration. Starts automatically, triggered by gate unit.
MAXIMUM IMAGING FREQUENCY	Full resolution images: 4 images: 333 Mega fps (non-overlapping, 3ns exposure time). 8 images: 8 Mega fps (non-overlapping, Double exposure mode).
JITTER	< 0.5ns: At exposure and delay times < 100ns. < 5ns: At exposure and delay times > 100ns.
COOLING	2-stage peltier with forced air cooling, regulated to -12°C.
CAMERA INTERFACE	Data Transfer via Fiber Optic Link (FOL). 4x double SC connector, cable length 10m (standard) 1500m (optional).
PCI INTERFACE BOARD	Four PCI Interface Boards, compatible to PCI Local Bus, Rev. 2.1, burst rate 132 MByte/s.
COMPUTER HARDWARE	Pentium based computer with up to 4 PCI boards operating under Windows OS.
POWER SUPPLY	Input 90...260V/150W.
SOFTWARE	CamWare Software compatible with Windows OS for camera control, image acquisition/enhancement and archiving in various file formats. Custom software development capabilities available.
GENERAL INFORMATION	Dimensions: 87 (L) x 52 (W) x 28 (H) cm approximately (without lens mount) With the lens add 17 cm to the length or width.  Weight: 80 kg approximately.  Certification: CE-certified.

## CCD Sensor Specifications

SVGA CCD Sensor	CCD-Interline Progressive Scan with "Lens-onChip"
NUMBER OF PIXELS	1280 (H) x 1024 (V)
PIXEL SIZE	6.7 $\mu$ m x 6.7 $\mu$ m
SENSOR FORMAT	2/3"
SCAN AREA	8.6mm x 6.9mm
FULL WELL CAPACITY	25,000 electrons
SMEAR	< 0.005%
ANTI-BLOOMING	> 1000
CCD QUALITY	grade 0
QUANTUM EFFICIENCY @ 500nm	typ. 40%
SPECTRAL RESPONSE	matching MCP-Phosphor peak emission
DYNAMIC RANGE	12 bit
SCAN RATE	12.5 MHz
READOUT NOISE @ 12.5 MHz	7 to 8 electrons
A/D CONVERSION FACTOR	5 electrons/count
DARK CURRENT	0.1 electrons/pixel/sec
EXTINCTION RATIO	1:2000
NON-LINEARITY	< 1%
BINNING HORIZONTAL	1 to 8
BINNING VERTICAL	1 to 32
REGION OF INTEREST (ROI)	Rectangular with minimum 32 x 32 pixel, free selection of horizontal and vertical resolution

Other optional accessories such as lighting, lenses and triggering systems are also available.

## High Intensity Lighting Sources



**PALFLASH**  
Sub- $\mu$ sec Flash Duration

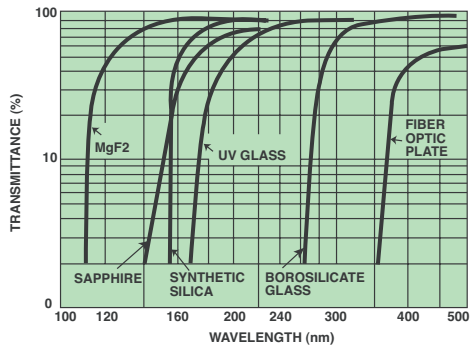


**SENSIFLASH**  
1500 Joules over 8 msec



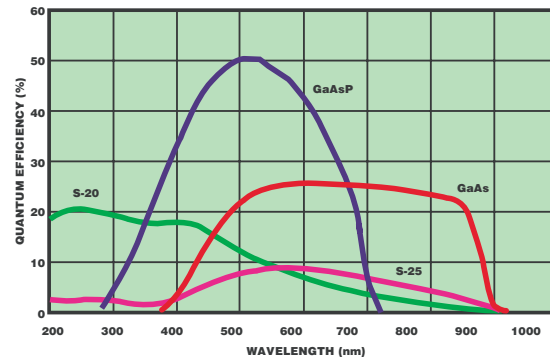
**PALLITE**  
Continuous High Illuminance

## Image Intensifier



### Input Window

The material of the input window limits the lower range of the spectral response.

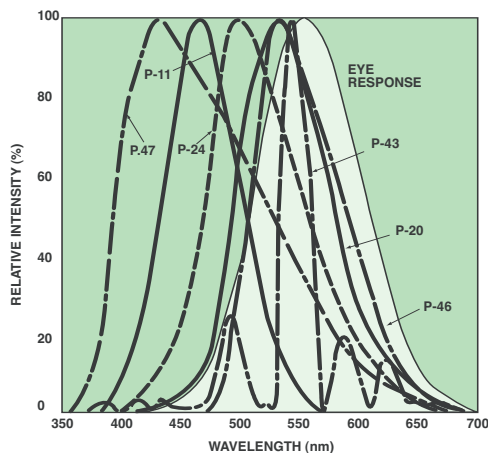


### Photocathode

The photocathode materials are fast gateable or high efficiency slow gateable.

Photocathode Material	Peak Wavelength (nm)	Quantum Efficiency at peak wavelength (%)	Equivalent background input (EBI) ( $\text{W}/\text{cm}^2$ )	Dark Counts ( $\text{S}^{-1}/\text{cm}^2$ )
S20 (multialkali)	430	14-18	$3 \cdot 10^{-14}$	1500
S25 (multialkali)	600	8.3-9.3	$2 \cdot 10^{-14}$	10,000
Enhanced Gen 3 (GaAs)	830	23	$4 \cdot 10^{-14}$	30,000
Enhanced Gen 3 (GaAsP, filmless)	500	50	$2 \cdot 10^{-14}$	10,000

### Phosphor Response Curve



### Phosphor Specifications

Phosphor	Phosphor Decay (Typical)		Typical Efficiency
	10%	1%	
P43	1 ms	4 ms	100%
P46	0.2 - 0.4 $\mu\text{s}$	2 ms	30%