

# **CCD-11000XR/ COOL-11000XR**

**Extremely high resolution x-ray detector**

**Manual**

**Version: V 1.10**

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## 1 Introduction

### Features:

- 4024 (H) x 2680 (V) pixels, 3 fps or  
2012 (H) x 1340 (V) pixels, 6 fps (2 x 2 Binning)
- Resolution: > 25 lp/mm
- Energy range: 20 ... 150 keV
- X-ray protection of the sensor by integrated fibre optics
- Detector area: 36 (H) x 24 (V) mm
- No distortion, no shading
- No mechanical shutter
- Option: Peltier cooled for longer exposure times (COOL-11000XR)

With the **CCD-11000XR** VDS Vosskühler presents for the first time a very high resolution x-ray detector with 11 MPixels.

The image resolution takes place at 4024 (H) x 2680 (V) pixels with up to 3 fps or within 2 x 2 Binning-Mode at 2012 (H) x 1340 (V) pixels with up to 6 fps.

The detector achieves a resolution of higher than 25 lp/mm at an active sensor area of 36 (H) x 24 (V) mm.

By means of the integrated fibre optics an x-ray protection exists for the sensitive CCD-sensor. Therefore the detector can be employed in an energy range of 20 – 150 keV. On the contrary to x-ray area detectors the life time within permanent operation is considerably higher due to the fibre optics.

Because of the high resolution of the **CCD-11000XR** camera, less expensive x-ray sources with essential bigger spot size can be used for the same system resolution.

Owing to the interline transfer sensor no mechanical shutter is necessary. For this reason the camera can also be employed at continuous x-ray sources.

The detector achieves a dynamics of higher than 60 dB at a read-out noise of less than 60 e. For the 12bit digital data the following Interfaces are available: RS644, Camera-Link or Gigabit Ethernet.

By means of the optional peltier cooling (**COOL-11000XR**) the sensor is cooled to 5 °C fix, enabling to achieve clearly longer exposure times.

### Applications:

- X-ray microscopy
- Micro Tomography
- Printed Circuit Board Inspection
- Semiconductor Inspection
- Spot size inspection of  
x-ray tubes
- X-ray Diffractometry

## 2 Technical Data

### Technical Data:

- 4024 (H) x 2680 (V) pixels at 3 fps or 2012 (H) x 1340 (V) (2x2 Binning) at 6 fps
- Resolution: > 25 lp/mm
- Energy range: 20 – 150 keV
- Active area: 36.18 (H) x 24.12 (V) mm
- Pixel size: 9  $\mu\text{m}$  x 9  $\mu\text{m}$
- Scintillator: Gd<sub>2</sub>O<sub>2</sub>S, 30 $\mu\text{m}$
- Interline transfer sensor (no. mechanical shutter)
- Image on demand
- Effective dynamics:  $\geq 1:1000$  ( $\geq 60$  dB)
- Sensor saturation:  $\geq 60000$  e  
Binning:  $\geq 120,000$  e
- Read out noise: < 60 e
- Anti-blooming circuit
- Exposure time up to approx. 2 sec. (non-cooled), longer than 10 sec. (cooled)
- Digital output: 12-bit, RS-644 (LVDS), CL, GigE
- Pixel clock: 40 MHz
- Video gain: 1 or 2 (+ 6 dB)
- Power supply: + 12 V (SELV), approx. 0.6 A (cooled maximum 2.7 A)
- Ambient air temperature: 0° to 40 ° C
- CE standard
- Made in Germany

### Please note:

The right polarisation of the 12 V supply voltage has to be taken into consideration.

The warranty becomes void in case of unauthorized tampering or any manipulations not approved by the manufacturer.

### 3 Camera Construction

#### 3.1 Mechanical Dimensions: CCD-11000XR

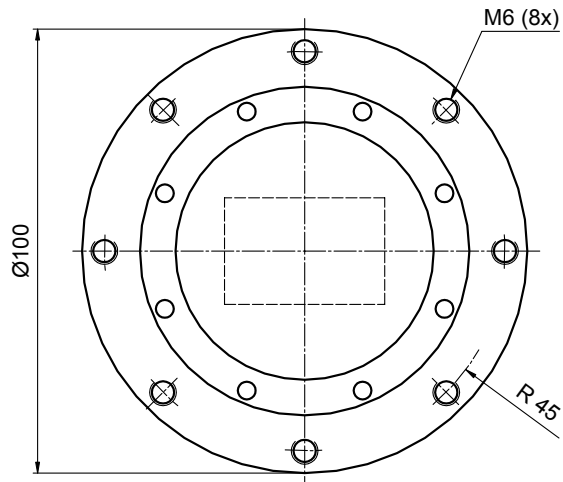


Image 1: Front view

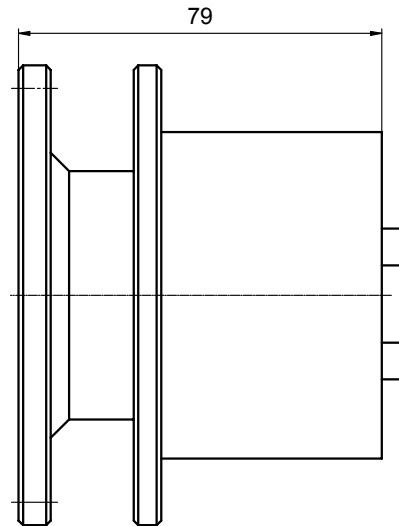


Image 2: Side view

#### 3.2 Mechanical Dimensions: COOL-11000XR

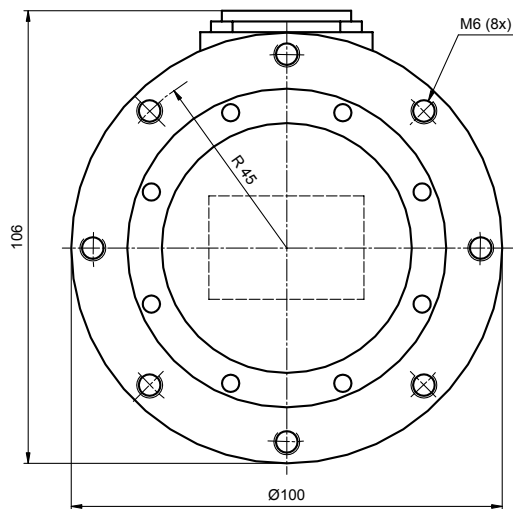


Image 3: Front view

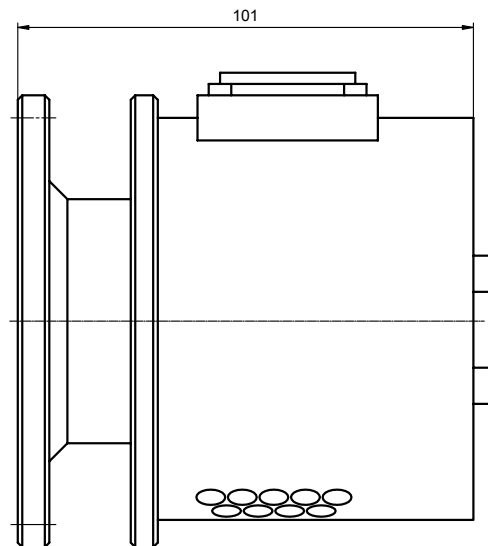


Image 4: Side view

## 4 Control Junction

### 4.1 Pin Connection of the Control Junction (15-pin D-SUB Jack)

This jack is intended for the power supply as well as for controlling the camera by the user.

Pin	Function
1	] + 12 V DC
2	
3	] GND
4	
5	test output (reserved)
6	-
7	-
8	(reserved)
9	Mode: (open) $\Rightarrow$ continuous operation (GND) $\Rightarrow$ image on demand
10	- ] trigger input (optocoupler)
11	
12	- ] exposure output (optocoupler)
13	
14	Line-sync-output (active low)
15	Frame-sync-output (active low)

### 4.2 Power Supply

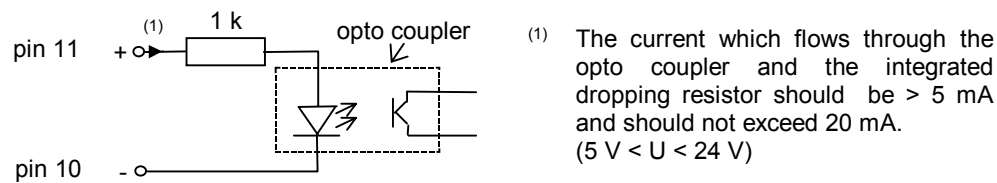
The camera requires 12 V +5 % at a current capacity of maximum 620 mA or rather 2.7 A in case of the COOL-11000XR camera.

### 4.3 Mode Input (Image on Demand)

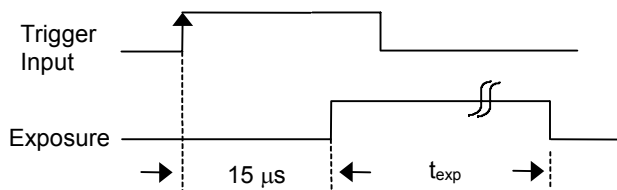
The mode input serves for the switch between the continuous operation with 333 ms exposure time and the shutter- and image-on-demand operation and it is shown by the LED IOD on the backside of the camera. After switching to image on demand operation before the first image indentation a break of minimum 333 ms has to be kept.

Input pin 9      open -> continuous operation  
                   GND -> image on demand

### 4.4 Trigger Input



The image record is started with  $15 \mu\text{s}$  delay due to the rising pulse edge at the trigger input.

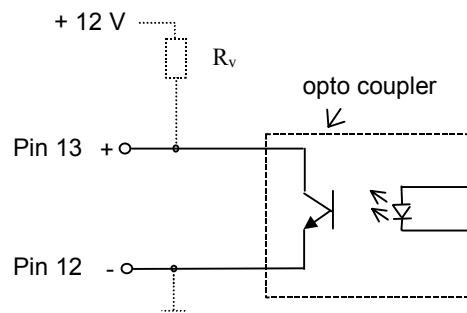


The shutter time  $t_{\text{exp}}$  can be regulated between  $122 \mu\text{s}$  and  $5 \text{ ms}$ , in steps of  $122 \mu\text{s}$ , via trimmer ST at the back of the camera. For the control an oscilloscope should be connected at the exposure output (wiring with a resistor on the supply voltage).

If the trigger input is longer active than the adjusted shutter time  $t_{\text{exp}}$ , the shutter time  $t_{\text{exp}}$  automatically extends to the active time at the trigger input and is rounded to a multiple of the line time from  $122 \mu\text{s}$ . With this, also exposure times to the second area are possible.

As a further trigger- and exposure control input the /TRES input is available at the 37-pin digital output (see page 11).

#### 4.5 Exposure Output

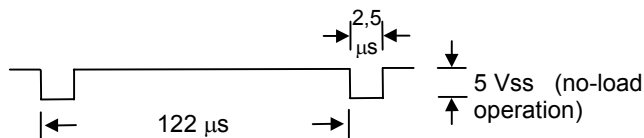


The current which flows through the opto coupler should not exceed 20 mA (at 12 V  $R_v \geq 600 \Omega$ ).

The exposure output indicates the active exposure time of the sensor in the image on demand operation. At the end of the exposure this output stays active 122  $\mu\text{s}$  (1 line) longer than the real exposure. The active exposure is also indicated by the LED Exp. on the backside of the camera. For using the exposure output externally a resistor  $R_v$  according to the drawing has to be applied.

After the image record the 2680 active lines of the image are output at the digital output. This image output is shown by LED Fout on the backside of the camera.

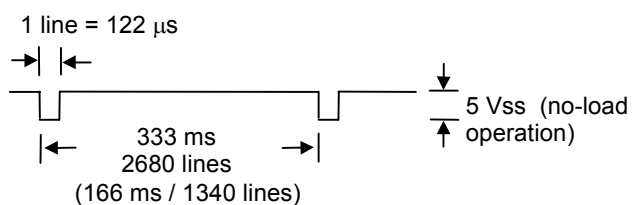
#### 4.6 Line-Sync-Output



The line-sync-output (active low) supplies approx. 1200 mV at the termination with 75 ohms.

#### 4.7 Frame-Sync-Output

The frame-sync-output is only active in continuous operation.



The frame-sync-output (active-low) supplies approx. 1200 mV at the termination with 75 ohms.



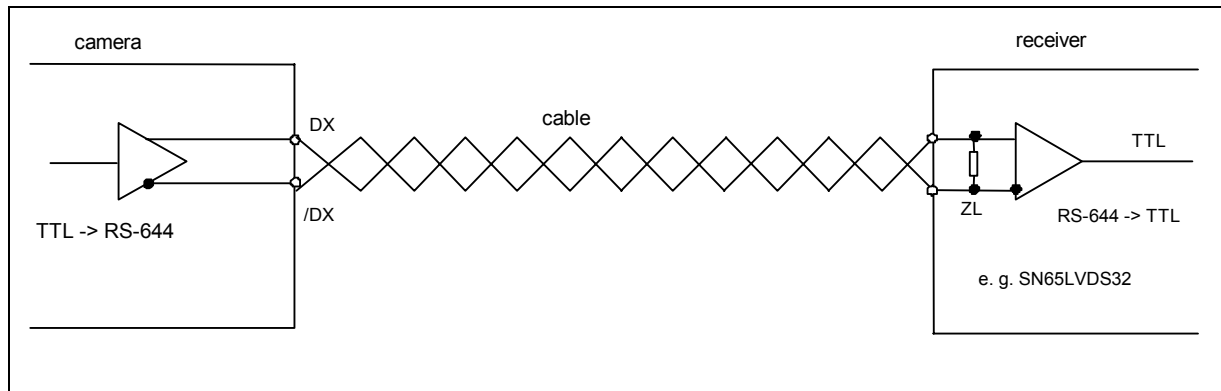
## 5 Digital Data Output

### 5.1 RS-644 Pin Connection of the Digital Output (37-pin D-SUB Jack)

Pin	Function	Pin	Function
1	PCLK	20	/CLK
2	LEN	21	/LEN
3	FEN	22	/FEN
4	D0 (LSB)	23	/D0
5	D1	24	/D1
6	D2	25	/D2
7	D3	26	/D3
8	D4	27	/D4
9	D5	28	/D5
10	D6	29	/D6
11	D7	30	/D7
12	D8	31	/D8
13	D9	32	/D9
14	D10	33	/D10
15	D11 (MSB)	34	/D11
16	GND	35	GND
Control Input 17	/TRES (RS-422A) (trigger input; active low)	Control Input 36	TRES (RS-422A) (trigger input)
Control Input 18	/SV2 (gain * 2; active low)	Control Input 37	Mode high $\Rightarrow$ continuous low $\Rightarrow$ image on demand
Control Input 19	/BIN (binning active low)		

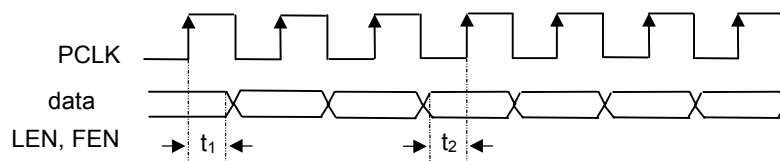
## 5.2 Digital Output

The digital output supplies digital image data with 40 Mpixels/sec. at a word width of 12-bit. The output has available differential RS-644 signals which can be passed on by twisted wire pair.



The terminating resistance ZL has to be adapted corresponding to the wave resistance of the line (usual size 100 ohms).

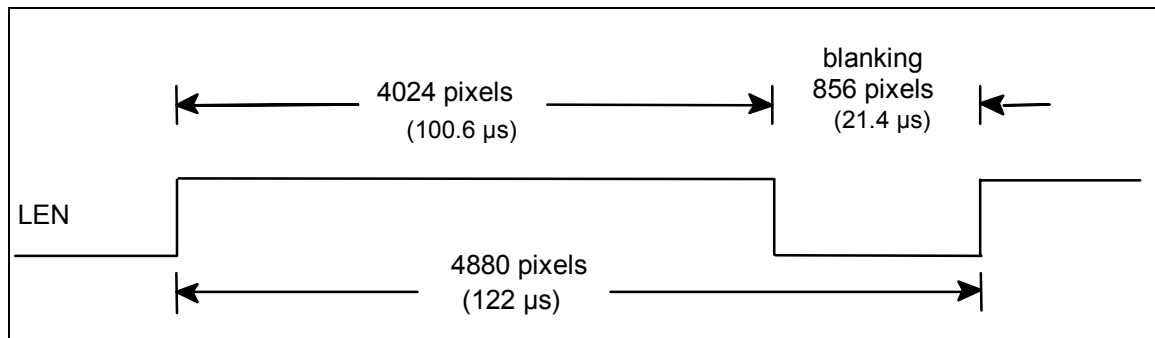
Timing:



1. data:  $t_1 \geq 6 \text{ ns}$      $t_2 \geq 10 \text{ ns}$
2. LEN:  $t_1 \geq 6 \text{ ns}$      $t_2 \geq 10 \text{ ns}$
3. FEN:  $t_1 \geq 6 \text{ ns}$      $t_2 \geq 10 \text{ ns}$

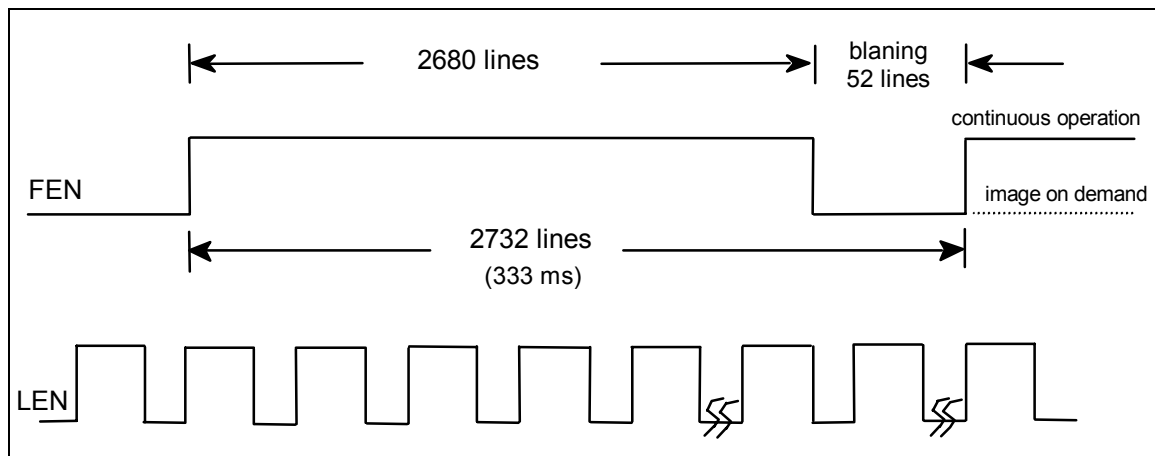
### 5.3 Line Enable

The line-enable becomes active at each line of an image (active high).

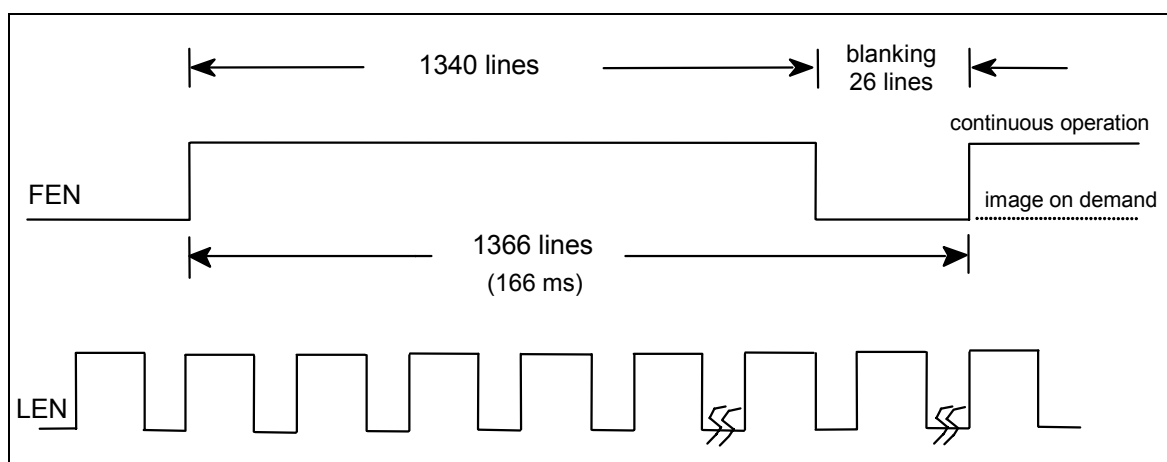


### 5.4 Frame-Enable (Resolution 4024 x 2680)

The frame-enable is active for 2680 lines (active high).



### 5.5 Frame-Enable (Binning 4024(H) x 1340(V))

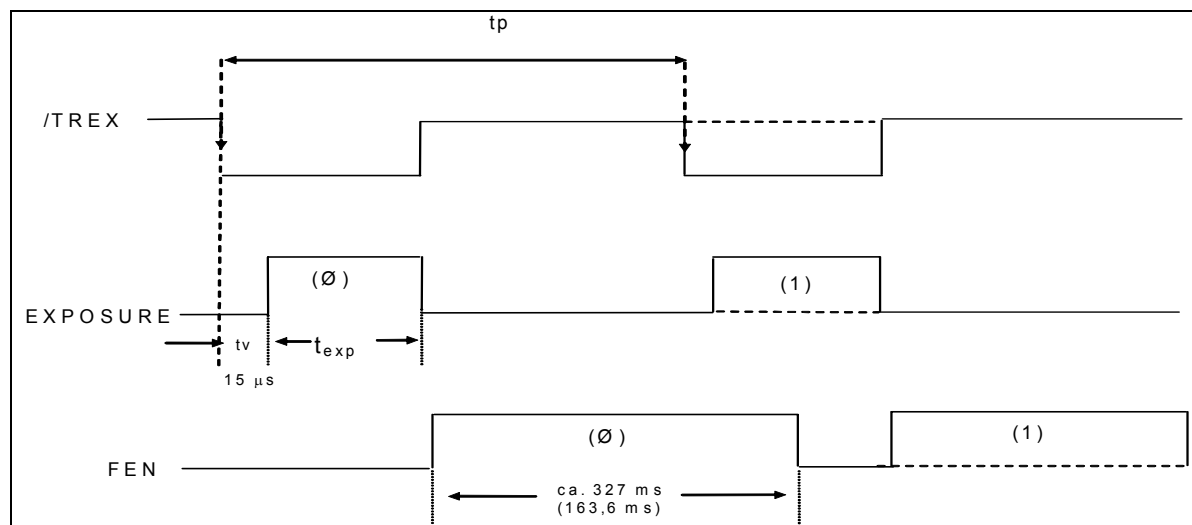


## 5.6 Trigger Input /TREX

Via trigger input TREX also the shutter time of the camera at the image on demand operation can be fixed. The input can be used either as RS-422A input (TREX and /TREX) or only as /TREX active-low input. For the RS-422A operation a termination resistance of 100 ohms can be connected internally in the camera.

Activating the TREX input, the active exposure of the sensor starts with 15  $\mu\text{s}$  delay and stays active as long as the TREX input is active. The preset exposure time is always rounded to a multiple of the line time from 122  $\mu\text{s}$  and so the exposure time can be indicated spaciouly by the user.

The camera can be single triggered or periodically ( $t_p$ ) up to the maximum image frequency of 3 Hz ( 6 Hz binning). One should note that at the periodically triggering with 3 Hz the exposure delay  $t_v$  can reach up to 137  $\mu\text{s}$  (jitter max. 1 line).



$$t_F = 333,3 \text{ ms} \quad (166.6 \text{ ms at binning})$$

$$t_p \geq t_F \quad (\text{The period duration } t_p \text{ must be at least as long as the image time } t_F)$$

$$t_p - t_{exp} > 3 \text{ ms} \quad (\text{must be kept!})$$

## 5.7 Increasing of the Video Gain

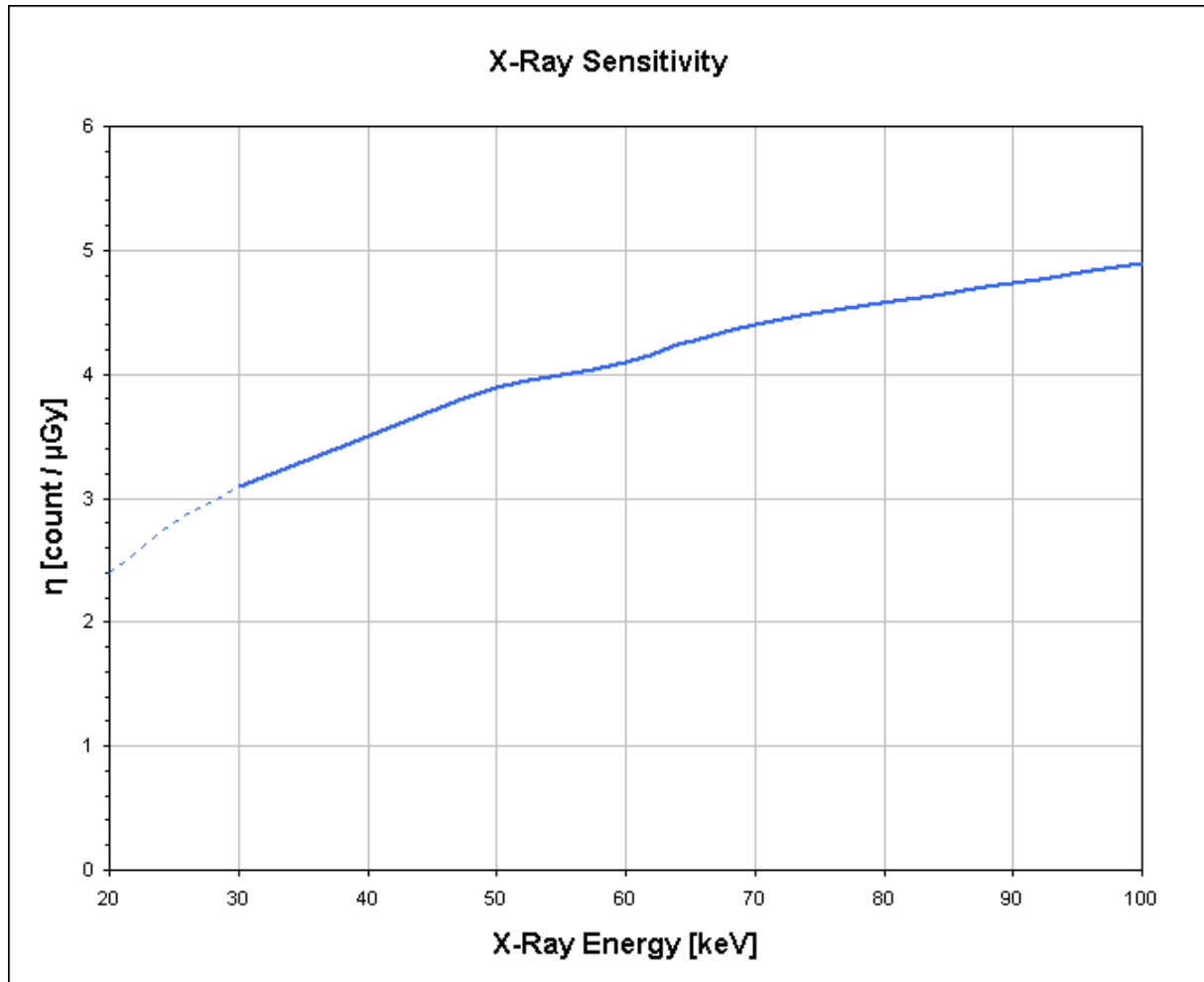
The analogue video gain of the camera can be increased by factor 2 (+ 6 dB) via input /SV 2 (active low). This is especially advantageous at very short shutter times or bad lighting conditions. The input is TTL - compatible (high > 2V, low < 0.8 V).

## 5.8 Switching to 6 Images/Sec. (Binning)

With the trigger input /BIN (active low) it is possible to switch up to 6 images/sec. at 4024 (H) x 1340 (V) pixels. At an open input it is possible to give out 3 images/sec. at full resolution. The input is TTL - compatible (high > 2V, low < 0.8 V).

## 5.9 X-Ray sensitivity of the CCD-11000XR

### X-Ray sensitivity of the CCD-11000XR



Measured with full resolution. With 2x2 binning the values are 4 times higher.

$$\frac{\text{count}}{\text{mR}} = 8.73 * \frac{\text{count}}{\mu\text{Gy}}$$