

# EMVA 1288 Report Summary Cover Page

Package includes all associated EMVA Report Summaries valid for the following Phantom camera models

## S991 Color

Refer to the report corresponding with your camera configuration:

- Color - Global Shutter PDF pages 2-5
- Color - Rolling Shutter PDF pages 6-9

Each report summary was generated by Vision Research in accordance with the EMVA 1288 3.1 standard.

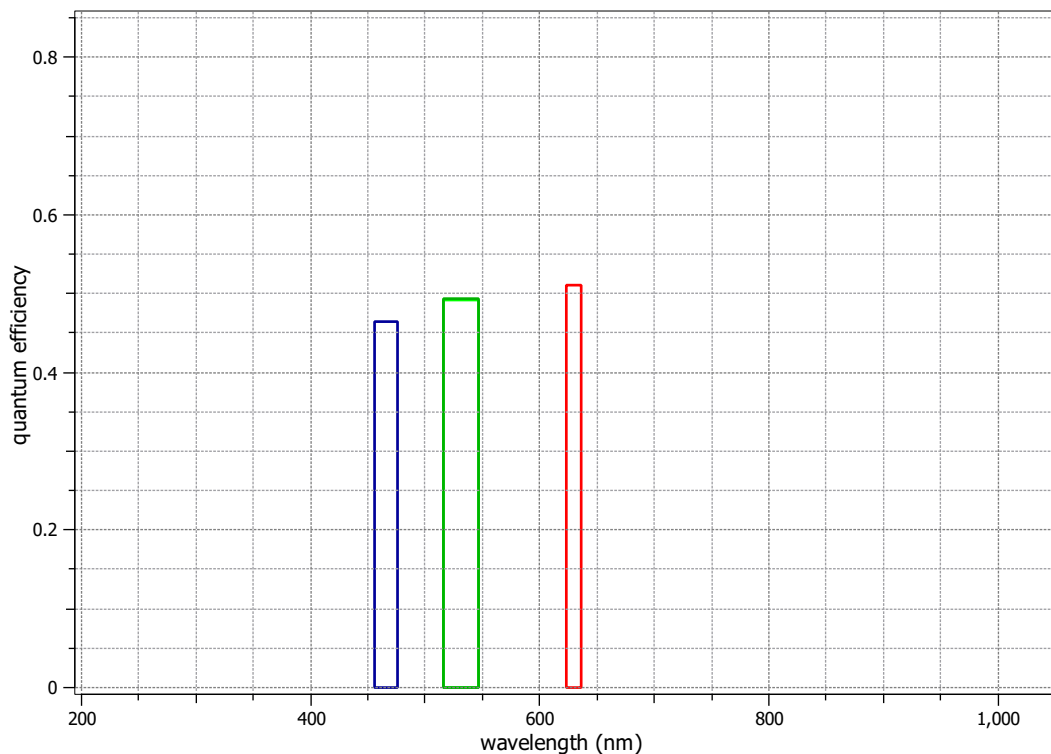
For more information on EMVA 1288 image measurements visit:  
[www.phantomhighspeed.com/emva](http://www.phantomhighspeed.com/emva)

## EMVA 1288 Data Sheet m0313

This datasheet describes the specification according to the standard 1288 release 3.1 for "Characterization and Presentation of Specification Data for Image Sensors and Cameras" issued on December 30, 2016 by the European Machine Vision Association (EMVA), published at [www.standard1288.org](http://www.standard1288.org) and the *zenodo EMVA 1288 community* with proprietary extensions from AEON. The measurements were performed with the AEON ACC2b RGB-IR, Release 9, 30.07.2018, SN 0032(AMETEK).

Measurements were performed by Vision Research. Measurements are on raw sensor data.

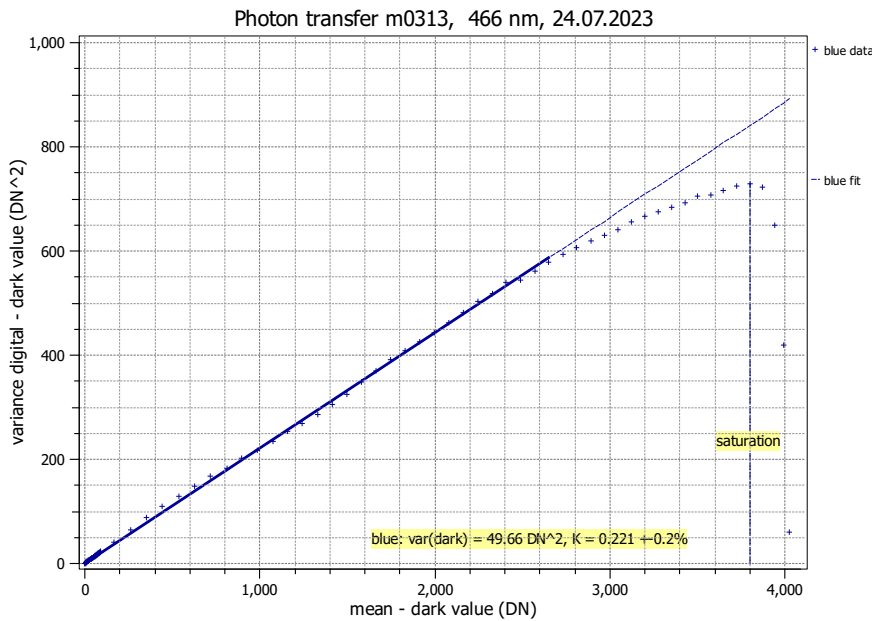
Vendor	Vision Research	Type of data presented	Single
Model	Phantom S991	<b>Operation point 1</b>	
Serial number	99102	Wavelength centroid	466.2 nm
Sensor diagonal	31.72 mm	Wavelength FWHM	20.3 nm
Lens category	F-Mount	Gain, black-level	1 / 0
Resolution	4096 × 2304, 12 bit	<b>Operation point 2</b>	
Pixel size (h×v)	6.75 μm × 6.75 μm	Wavelength centroid	531.5 nm
Sensor	Vision Research Proprietary	Wavelength FWHM	31.2 nm
Sensor type	CMOS	Gain, black-level	1 / 0
Shutter type	Global	<b>Operation point 3</b>	
Overlap cap.	Overlapping	Wavelength centroid	629.4 nm
Max. frame rate	938.0 Hz	Wavelength FWHM	13.3 nm
Interface type	CoaXPress 2.0	Gain, black-level	1 / 0
		<b>Optional data measured</b>	
		None	



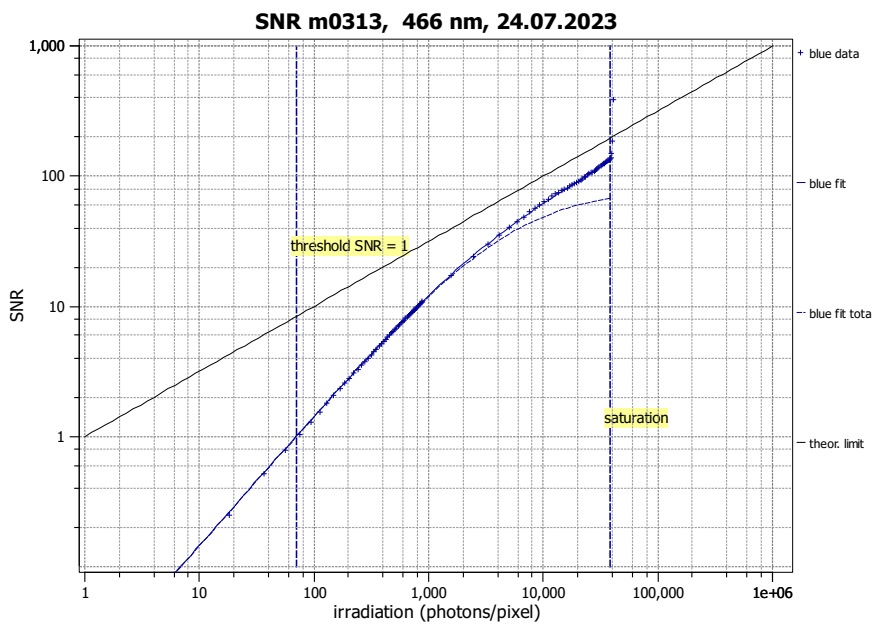
## Summary Sheet for Operation Point 1 at a Wavelength of 466 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	24.2°C
Exposure time	500.00 $\mu$ s	Camera body temperature	32.0°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	466 nm, 20.3 nm

### Photon Transfer



### Signal-to-Noise Ratio



#### Quantum efficiency

$\eta$  46.4%

#### Overall system gain

$K$  0.221 DN/e<sup>-</sup>

1/ $K$  4.517 e<sup>-</sup>/DN

#### Temporal dark noise

$\sigma_d$  31.80 e<sup>-</sup>

$\sigma_{y,\text{dark}}$  7.05 DN

#### Signal-to-noise ratio

SNR<sub>max</sub> 133

42.5 dB

7.1 bit

1/SNR<sub>max</sub> 0.75 %

#### Absolute sensitivity threshold

$\mu_{p,\text{min}}$  69.7 p

$\mu_{p,\text{min,area}}$  1.53 p/ $\mu$ m<sup>2</sup>

$\mu_{e,\text{min}}$  32.3 e<sup>-</sup>

$\mu_{e,\text{min,area}}$  0.71 e<sup>-</sup>/ $\mu$ m<sup>2</sup>

#### Saturation capacity

$\mu_{p,\text{sat}}$  38001 p

$\mu_{p,\text{sat,area}}$  834 p/ $\mu$ m<sup>2</sup>

$\mu_{e,\text{sat}}$  17638 e<sup>-</sup>

$\mu_{e,\text{sat,area}}$  387 e<sup>-</sup>/ $\mu$ m<sup>2</sup>

#### Dynamic range

DR 545

54.7 dB

9.1 bit

#### Spatial nonuniformities

DSNU<sub>1288</sub> 3.71 e<sup>-</sup>

0.82 DN

PRNU<sub>1288</sub> 1.26 %

#### Linearity error

LE<sub>min</sub> -3.63%

LE<sub>max</sub> 2.53%

#### Dark current

$\mu_{c,\text{mean}}$  4541  $\pm$  962 e<sup>-</sup>/s

1005.3 DN/s

$\mu_{c,\text{var}}$  2340  $\pm$  118 e<sup>-</sup>/s

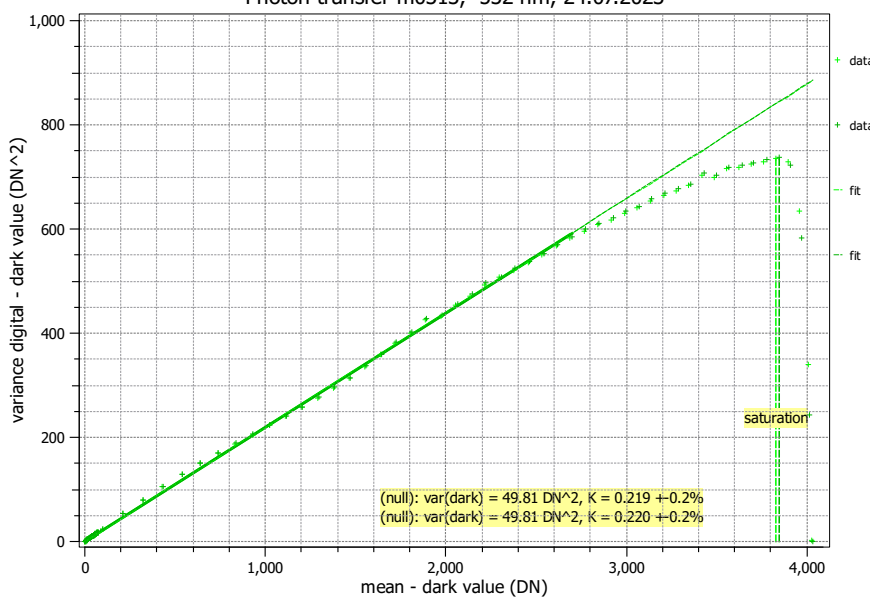
$T_d$  — °C

## Summary Sheet for Operation Point 2 at a Wavelength of 532 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	24.2°C
Exposure time	500.00 $\mu$ s	Camera body temperature	32.3°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	532 nm, 31.2 nm

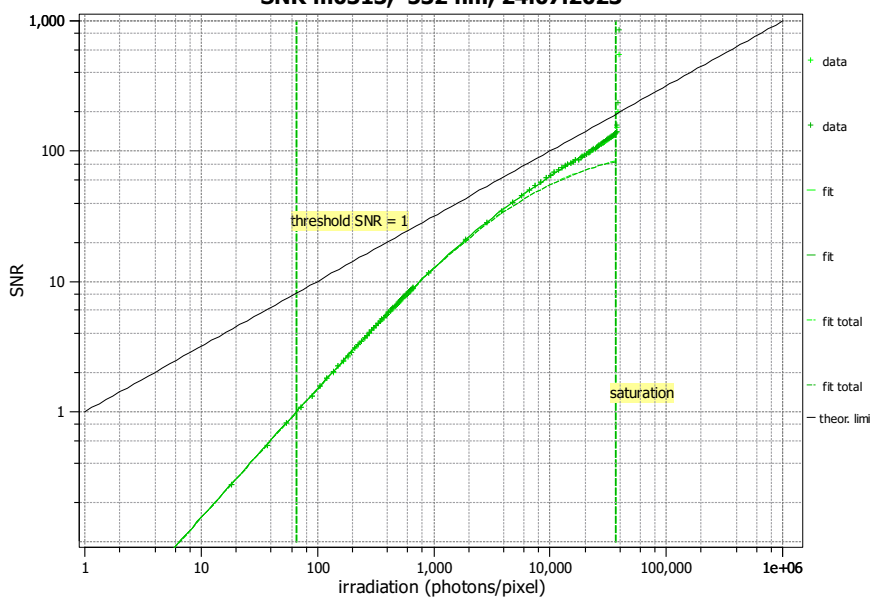
### Photon Transfer

Photon transfer m0313, 532 nm, 24.07.2023



### Signal-to-Noise Ratio

SNR m0313, 532 nm, 24.07.2023



#### Quantum efficiency

$\eta$  49.2%

#### Overall system gain

$K$  0.219 DN/e<sup>-</sup>

1/ $K$  4.559 e<sup>-</sup>/DN

#### Temporal dark noise

$\sigma_d$  32.15 e<sup>-</sup>

$\sigma_{y,\text{dark}}$  7.06 DN

#### Signal-to-noise ratio

SNR<sub>max</sub> 134

42.5 dB

7.1 bit

1/SNR<sub>max</sub> 0.75 %

#### Absolute sensitivity threshold

$\mu_{p,\text{min}}$  66.4 p

$\mu_{p,\text{min},\text{area}}$  1.46 p/ $\mu$ m<sup>2</sup>

$\mu_{e,\text{min}}$  32.7 e<sup>-</sup>

$\mu_{e,\text{min},\text{area}}$  0.72 e<sup>-</sup>/ $\mu$ m<sup>2</sup>

#### Saturation capacity

$\mu_{p,\text{sat}}$  36513 p

$\mu_{p,\text{sat},\text{area}}$  801 p/ $\mu$ m<sup>2</sup>

$\mu_{e,\text{sat}}$  17960 e<sup>-</sup>

$\mu_{e,\text{sat},\text{area}}$  394 e<sup>-</sup>/ $\mu$ m<sup>2</sup>

#### Dynamic range

DR 550

54.8 dB

9.1 bit

#### Spatial nonuniformities

DSNU<sub>1288</sub> 4.07 e<sup>-</sup>

0.89 DN

PRNU<sub>1288</sub> 0.91 %

#### Linearity error

LE<sub>min</sub> -3.71%

LE<sub>max</sub> 2.50%

#### Dark current

$\mu_{c,\text{mean}}$  4559  $\pm$  965 e<sup>-</sup>/s

1000.0 DN/s

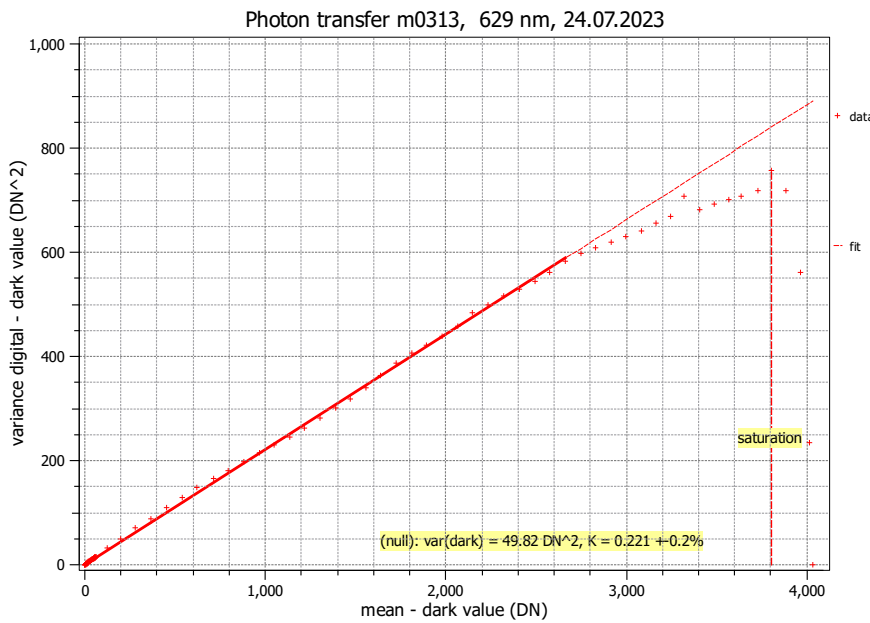
$\mu_{c,\text{var}}$  2453  $\pm$  99 e<sup>-</sup>/s

$T_D$  — °C

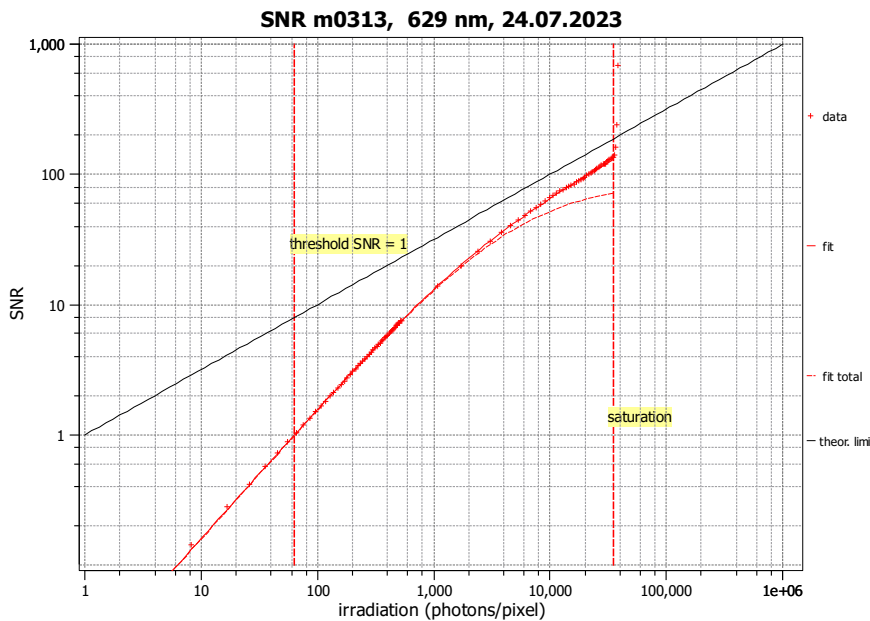
## Summary Sheet for Operation Point 3 at a Wavelength of 629 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	24.3°C
Exposure time	500.00 $\mu$ s	Camera body temperature	32.5°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	629 nm, 13.3 nm

### Photon Transfer



### Signal-to-Noise Ratio



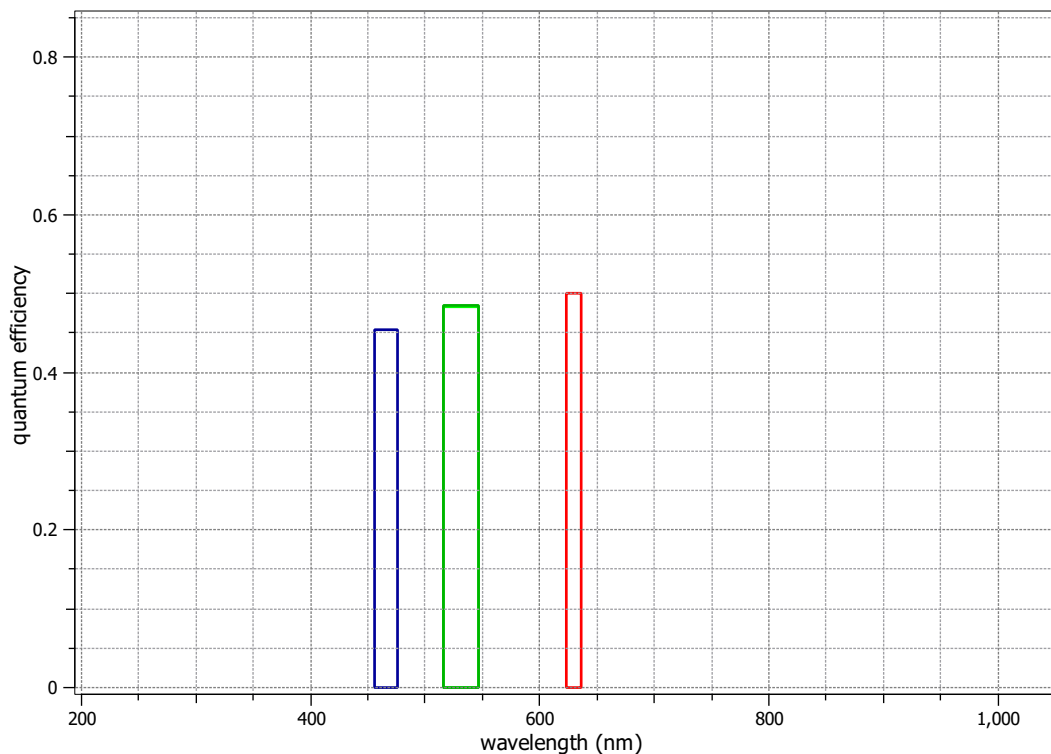
<b>Quantum efficiency</b>	
$\eta$	51.0%
<b>Overall system gain</b>	
$K$	0.221 DN/e <sup>-</sup>
$1/K$	4.525 e <sup>-</sup> /DN
<b>Temporal dark noise</b>	
$\sigma_d$	31.91 e <sup>-</sup>
$\sigma_{y.dark}$	7.06 DN
<b>Signal-to-noise ratio</b>	
SNR <sub>max</sub>	133
	42.5 dB
	7.1 bit
$1/\text{SNR}_{max}$	0.75 %
<b>Absolute sensitivity threshold</b>	
$\mu_{p.min}$	63.6 p
$\mu_{p.min.area}$	1.40 p/ $\mu$ m <sup>2</sup>
$\mu_{e.min}$	32.4 e <sup>-</sup>
$\mu_{e.min.area}$	0.71 e <sup>-</sup> / $\mu$ m <sup>2</sup>
<b>Saturation capacity</b>	
$\mu_{p.sat}$	34910 p
$\mu_{p.sat.area}$	766 p/ $\mu$ m <sup>2</sup>
$\mu_{e.sat}$	17803 e <sup>-</sup>
$\mu_{e.sat.area}$	391 e <sup>-</sup> / $\mu$ m <sup>2</sup>
<b>Dynamic range</b>	
DR	549
	54.8 dB
	9.1 bit
<b>Spatial nonuniformities</b>	
DSNU <sub>1288</sub>	4.28 e <sup>-</sup>
	0.95 DN
PRNU <sub>1288</sub>	1.16 %
<b>Linearity error</b>	
LE <sub>min</sub>	-4.11%
LE <sub>max</sub>	2.54%
<b>Dark current</b>	
$\mu_{c.mean}$	4563 $\pm$ 965 e <sup>-</sup> /s
	1001.9 DN/s
$\mu_{c.var}$	2586 $\pm$ 160 e <sup>-</sup> /s
$T_d$	— °C

## EMVA 1288 Data Sheet m0314

This datasheet describes the specification according to the standard 1288 release 3.1 for "Characterization and Presentation of Specification Data for Image Sensors and Cameras" issued on December 30, 2016 by the European Machine Vision Association (EMVA), published at [www.standard1288.org](http://www.standard1288.org) and the *zenodo EMVA 1288 community* with proprietary extensions from AEON. The measurements were performed with the AEON ACC2b RGB-IR, Release 9, 30.07.2018, SN 0032(AMETEK).

Measurements were performed by Vision Research. Measurements are on raw sensor data.

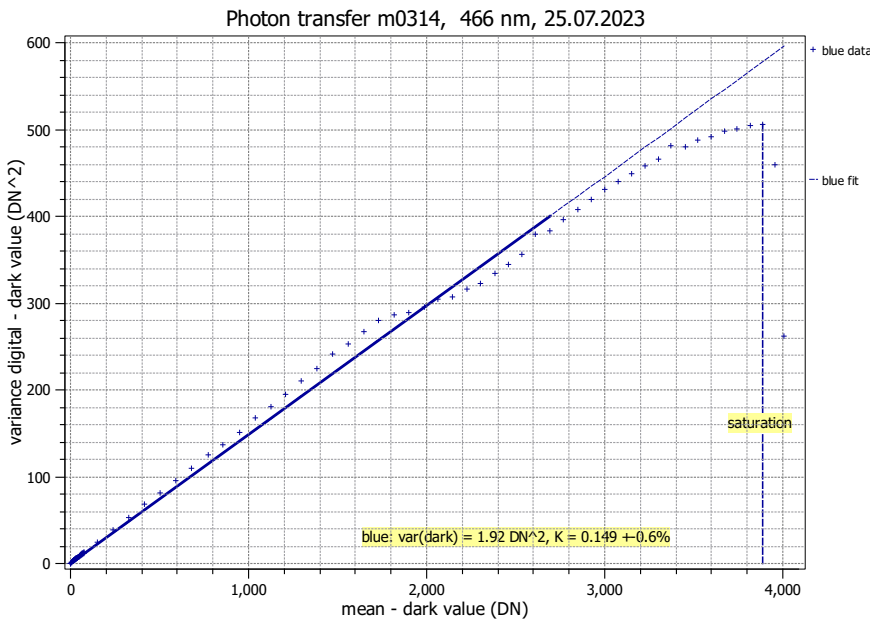
Vendor	Vision Research	Type of data presented	Single
Model	Phantom S991	<b>Operation point 1</b>	
Serial number	99102	Wavelength centroid	466.2 nm
Sensor diagonal	31.72 mm	Wavelength FWHM	20.3 nm
Lens category	F-Mount	Gain, black-level	1 / 0
Resolution	4096 × 2304, 12 bit	<b>Operation point 2</b>	
Pixel size (h×v)	6.75 μm × 6.75 μm	Wavelength centroid	531.5 nm
Sensor	Vision Research Proprietary	Wavelength FWHM	31.2 nm
Sensor type	CMOS	Gain, black-level	1 / 0
Shutter type	Rolling	<b>Operation point 3</b>	
Overlap cap.	Overlapping	Wavelength centroid	629.4 nm
Max. frame rate	938.0 Hz	Wavelength FWHM	13.3 nm
Interface type	CoaXPress 2.0	Gain, black-level	1 / 0
		<b>Optional data measured</b>	
		None	



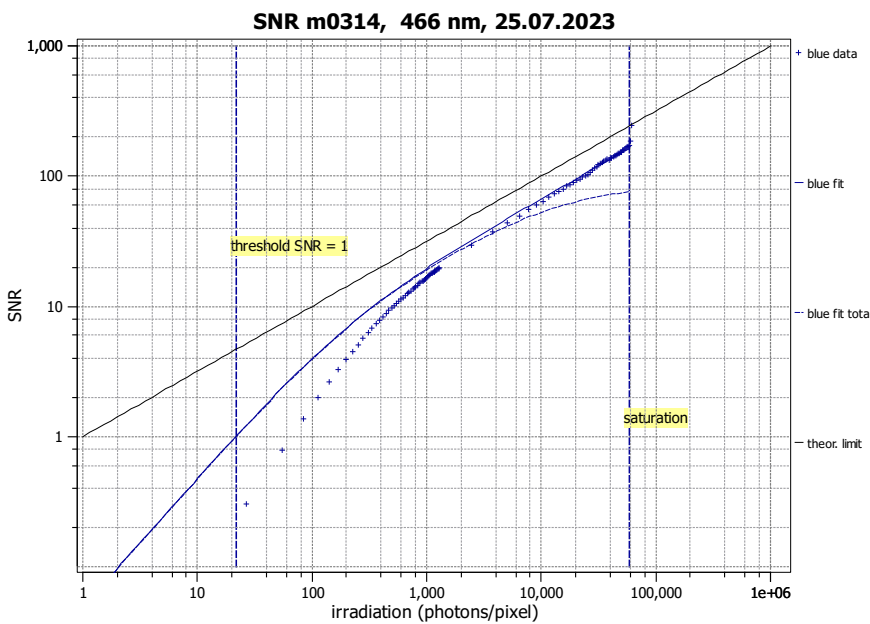
## Summary Sheet for Operation Point 1 at a Wavelength of 466 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	23.8°C
Exposure time	500.00 μs	Camera body temperature	31.3°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	466 nm, 20.3 nm

### Photon Transfer



### Signal-to-Noise Ratio



<b>Quantum efficiency</b>	
$\eta$	45.5%
<b>Overall system gain</b>	
$K$	0.149 DN/e <sup>-</sup>
$1/K$	6.728 e <sup>-</sup> /DN
<b>Temporal dark noise</b>	
$\sigma_d$	9.13 e <sup>-</sup>
$\sigma_{y,\text{dark}}$	1.39 DN
<b>Signal-to-noise ratio</b>	
$\text{SNR}_{\text{max}}$	163
	44.3 dB
	7.4 bit
$1/\text{SNR}_{\text{max}}$	0.61 %
<b>Absolute sensitivity threshold</b>	
$\mu_{p,\text{min}}$	21.65 p
$\mu_{p,\text{min},\text{area}}$	0.475 p/μm <sup>2</sup>
$\mu_{e,\text{min}}$	9.84 e <sup>-</sup>
$\mu_{e,\text{min},\text{area}}$	0.216 e <sup>-</sup> /μm <sup>2</sup>
<b>Saturation capacity</b>	
$\mu_{p,\text{sat}}$	58612 p
$\mu_{p,\text{sat},\text{area}}$	1286 p/μm <sup>2</sup>
$\mu_{e,\text{sat}}$	26645 e <sup>-</sup>
$\mu_{e,\text{sat},\text{area}}$	585 e <sup>-</sup> /μm <sup>2</sup>
<b>Dynamic range</b>	
DR	2707
	68.6 dB
	11.4 bit
<b>Spatial nonuniformities</b>	
DSNU <sub>1288</sub>	1.33 e <sup>-</sup>
	0.20 DN
PRNU <sub>1288</sub>	1.17 %
<b>Linearity error</b>	
LE <sub>min</sub>	-1.35%
LE <sub>max</sub>	1.23%
<b>Dark current</b>	
$\mu_{c,\text{mean}}$	469 ± 23 e <sup>-</sup> /s
	69.7 DN/s
$\mu_{c,\text{var}}$	531 ± 37 e <sup>-</sup> /s
$T_d$	— °C

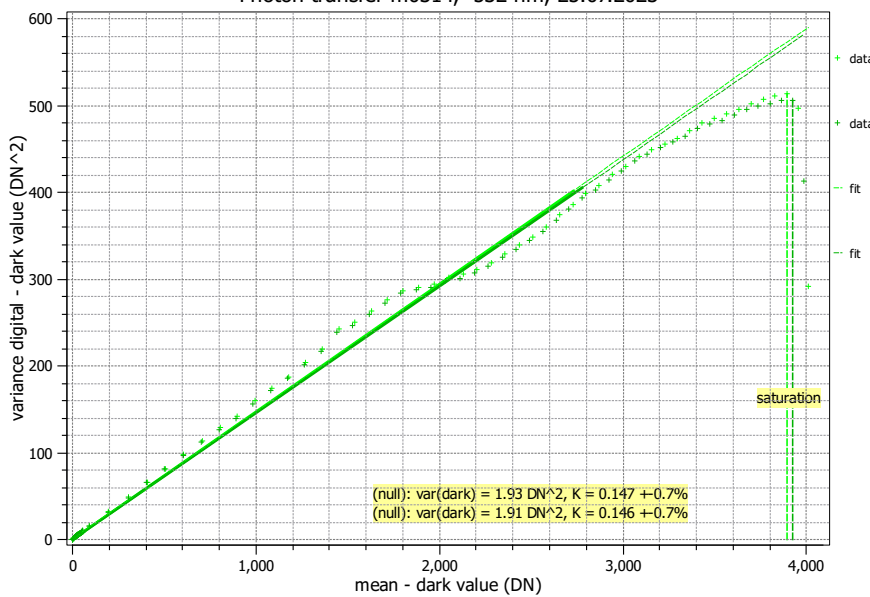


## Summary Sheet for Operation Point 2 at a Wavelength of 532 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	23.7°C
Exposure time	500.00 $\mu$ s	Camera body temperature	31.0°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	532 nm, 31.2 nm

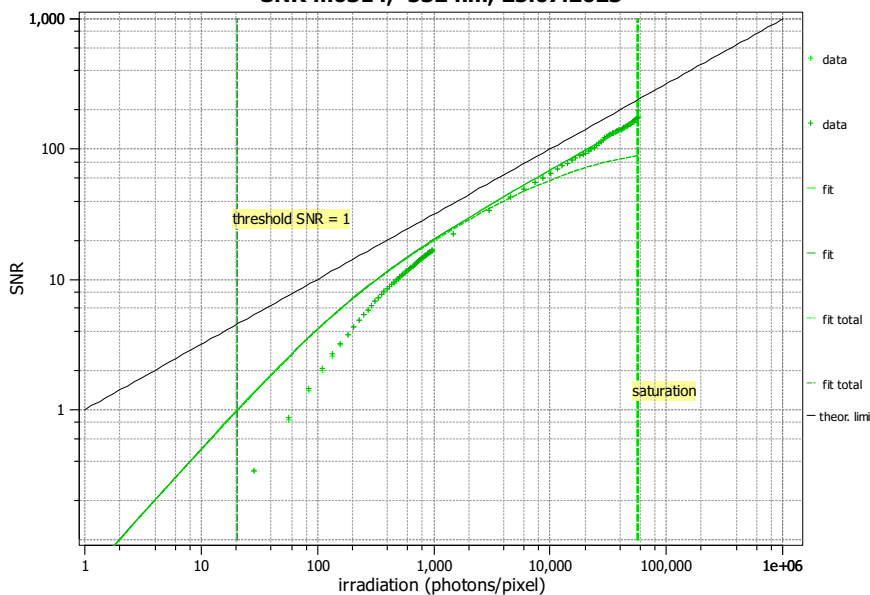
### Photon Transfer

Photon transfer m0314, 532 nm, 25.07.2023



### Signal-to-Noise Ratio

SNR m0314, 532 nm, 25.07.2023



#### Quantum efficiency

$\eta$  48.3%

#### Overall system gain

$K$  0.147 DN/e<sup>-</sup>

$1/K$  6.791 e<sup>-</sup>/DN

#### Temporal dark noise

$\sigma_d$  9.23 e<sup>-</sup>

$\sigma_{y,\text{dark}}$  1.39 DN

#### Signal-to-noise ratio

SNR<sub>max</sub> 164

44.3 dB

7.4 bit

$1/\text{SNR}_{\text{max}}$  0.61 %

#### Absolute sensitivity threshold

$\mu_{p,\text{min}}$  20.58 p

$\mu_{p,\text{min,area}}$  0.452 p/ $\mu\text{m}^2$

$\mu_{e,\text{min}}$  9.95 e<sup>-</sup>

$\mu_{e,\text{min,area}}$  0.218 e<sup>-</sup>/ $\mu\text{m}^2$

#### Saturation capacity

$\mu_{p,\text{sat}}$  55831 p

$\mu_{p,\text{sat,area}}$  1225 p/ $\mu\text{m}^2$

$\mu_{e,\text{sat}}$  26985 e<sup>-</sup>

$\mu_{e,\text{sat,area}}$  592 e<sup>-</sup>/ $\mu\text{m}^2$

#### Dynamic range

DR 2713

68.7 dB

11.4 bit

#### Spatial nonuniformities

DSNU<sub>1288</sub> 1.38 e<sup>-</sup>

0.20 DN

PRNU<sub>1288</sub> 0.94 %

#### Linearity error

LE<sub>min</sub> -1.58%

LE<sub>max</sub> 1.38%

#### Dark current

$\mu_{c,\text{mean}}$  469 ± 23 e<sup>-</sup>/s

69.0 DN/s

$\mu_{c,\text{var}}$  554 ± 33 e<sup>-</sup>/s

$T_d$  — °C

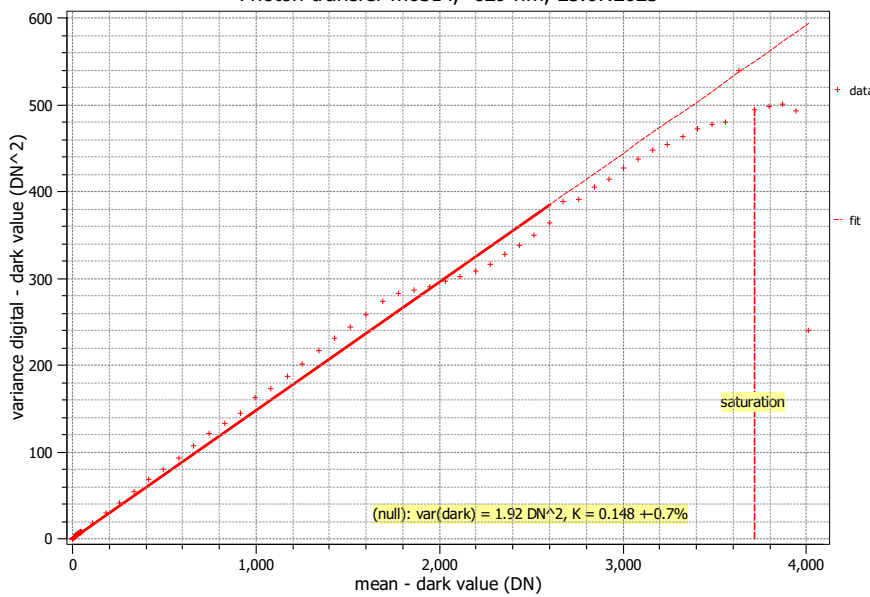


## Summary Sheet for Operation Point 3 at a Wavelength of 629 nm

Type of data	Single	Gain, black-level	1 / 0
Exposure control	By irradiance	Environmental temperature	23.7°C
Exposure time	500.00 $\mu$ s	Camera body temperature	30.8°C
Frame rate	100.0 Hz	Internal temperature(s)	—
Data transfer mode	Bayer GB12	Wavelength, centr., FWHM	629 nm, 13.3 nm

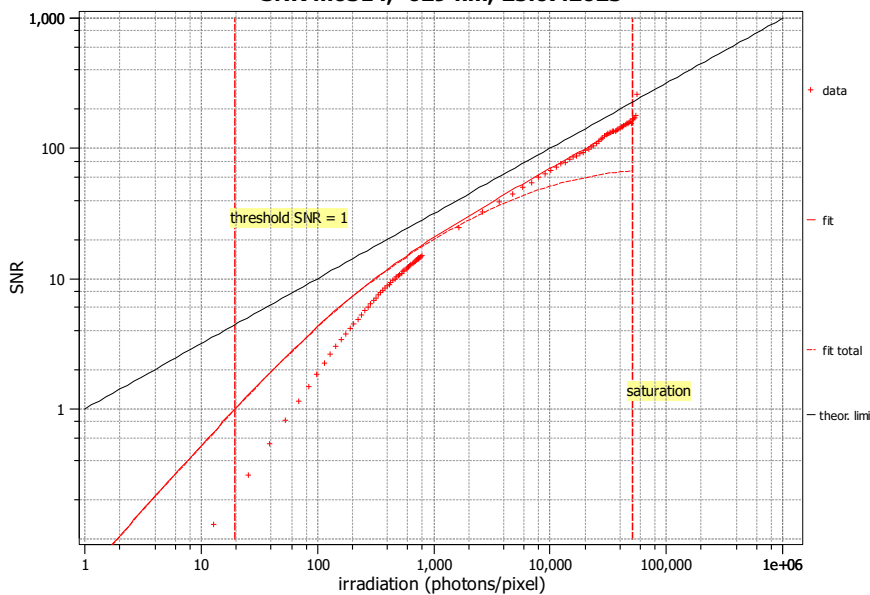
### Photon Transfer

Photon transfer m0314, 629 nm, 25.07.2023



### Signal-to-Noise Ratio

SNR m0314, 629 nm, 25.07.2023



#### Quantum efficiency

$\eta$  50.1%

#### Overall system gain

$K$  0.148 DN/ $e^-$

$1/K$  6.757  $e^-$ /DN

#### Temporal dark noise

$\sigma_d$  9.15  $e^-$

$\sigma_{y,\text{dark}}$  1.38 DN

#### Signal-to-noise ratio

$\text{SNR}_{\text{max}}$  160

44.1 dB

7.3 bit

$1/\text{SNR}_{\text{max}}$  0.62 %

#### Absolute sensitivity threshold

$\mu_{p,\text{min}}$  19.70 p

$\mu_{p,\text{min,area}}$  0.432 p/ $\mu\text{m}^2$

$\mu_{e,\text{min}}$  9.86  $e^-$

$\mu_{e,\text{min,area}}$  0.217  $e^-$ / $\mu\text{m}^2$

#### Saturation capacity

$\mu_{p,\text{sat}}$  51257 p

$\mu_{p,\text{sat,area}}$  1125 p/ $\mu\text{m}^2$

$\mu_{e,\text{sat}}$  25666  $e^-$

$\mu_{e,\text{sat,area}}$  563  $e^-$ / $\mu\text{m}^2$

#### Dynamic range

DR 2602

68.3 dB

11.3 bit

#### Spatial nonuniformities

$\text{DSNU}_{1288}$  1.41  $e^-$

0.21 DN

$\text{PRNU}_{1288}$  1.34 %

#### Linearity error

$\text{LE}_{\text{min}}$  -1.64%

$\text{LE}_{\text{max}}$  1.26%

#### Dark current

$\mu_{c,\text{mean}}$  479  $\pm$  20  $e^-$ /s

69.9 DN/s

$\mu_{c,\text{var}}$  560  $\pm$  39  $e^-$ /s

$T_d$  — °C