KAF8300 based Standard Grade Camera Photon Transfer Performance Brief: Apogee U8300, FLI ML8300, QSI583

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12 January 2012

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Scope of Work

- A standard grade Apogee U8300*, FLI ML8300 and QSI 583 were characterized to quantify their performance in several areas
  - Specific parameters measured included:
    - Read noise
    - Full well capacity
    - PhotoResponse NonUniformity (Pn or PRNU)
    - DarkSignal NonUniformity (Dn or DSNU)
    - Camera Gain
    - Camera Gain Linearity
- Photon Transfer** methods were used for the analysis

*Firmware revision: release 35, driver set: release 3.1.13.1

**click:
http://www.narrowbandimaging.com/ptc_method_wsp2009_page.htm

Summary of Measured Results

Parameter	Measured value
Read Noise	10.0 (e-) @ 1MHz (U8300) 11.5 (e-) @ 8MHz (ML8300) 10.3 (e-) @ 500KHz (QSI583)
Full Well Onset	33,995(e-) (U8300) 28,875(e-) (ML8300) 30,421 (e-) (QSI583)
PRNU	0.345% (U8300) 0.37% (ML8300) 0.37% (QSI583)
DSNU	333% (U8300) 90.1% (ML8300) 90.1% (QSI583)
Camera Gain	0.60 e-/DN- (U8300) 0.45 e-/DN (ML8300) 0.5e-/DN (QSI583)
Cooling	57.8C delta from ambient (27.2C ambient, -30.6C ultimate temperature (U8300) 65C delta from ambient (27.2C ambient, -37.8C ultimate temperature) (ML8300) 33C delta from ambient (20C ambient, -13C ultimate temperature) (QSI583)
Readout time	~9 seconds, 1MHz, 16 bit (U8300) ~2 seconds, 8MHz, 16 bit (ML8300 ~21 seconds, 500KHz, 16 bit (QSI583)

Temperature slewing times

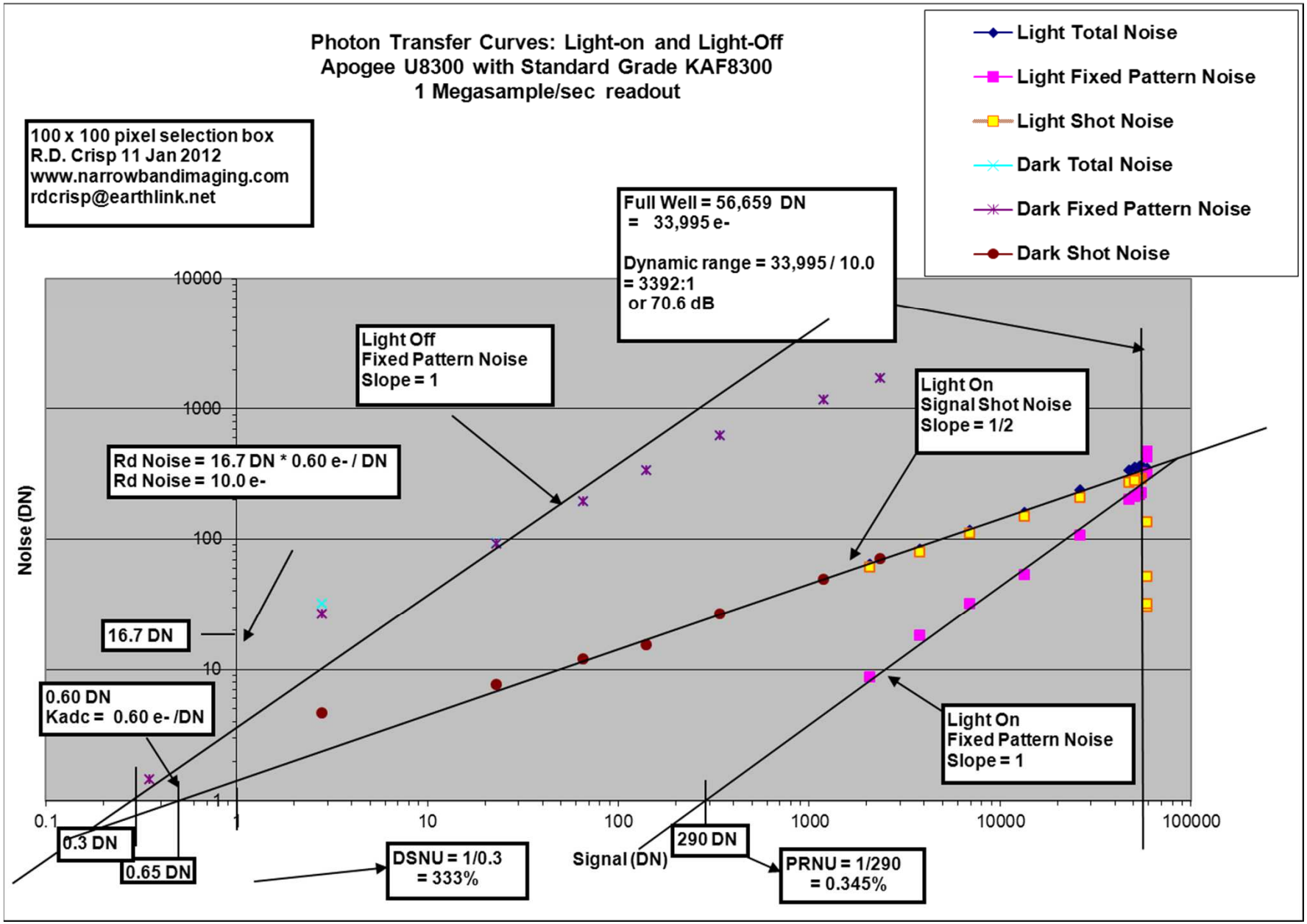
Starting temperature	Ending temperature	Time (U8300)	Time (ML8300)
+15C	0C	20 minutes	3 minutes
0C	-25C	27 minutes	4 minutes
-25C	-20C	11 minutes	3 minutes
+17.4C	-25C	30 minutes	5 minutes

Due to limited cooling of QSI583 this thermal slew timing was not included: the temperature range could not be supported: @24C ambient, ultimate temp was limited to –13C. It reached the ultimate cooling level in approx 5 minutes.

Details of Characterization

Photon Transfer Procedure

- For tests, standard photon transfer measurements of flat fields were performed
  - Using ambient lighting, pairs of identical exposures were made beginning with minimum exposures and ending with full well: all light-on tests were made at –25C (except for QSI583 which would not cool that cold, and was tested at –10C)
    - All exposures were made using overscan to precisely determine the offset value (bias frames aren't good enough)
    - A specific selection box location containing 10,000 pixels was used for all measurements (light on, dark)
  - Dark measurements were made at +15C using pairs of identical darks starting with minimum exposures to a maximum of two hours at +15C. Minimum signal dark tests were made at –15C to reduce amount of charge collected to minimal values
  - Standard Photon transfer data reduction methods were used


Photon Transfer Curves: Light-on and Light-Off
Apogee U8300 with Standard Grade KAF8300
1 Megasample/sec readout
100 x 100 pixel selection box
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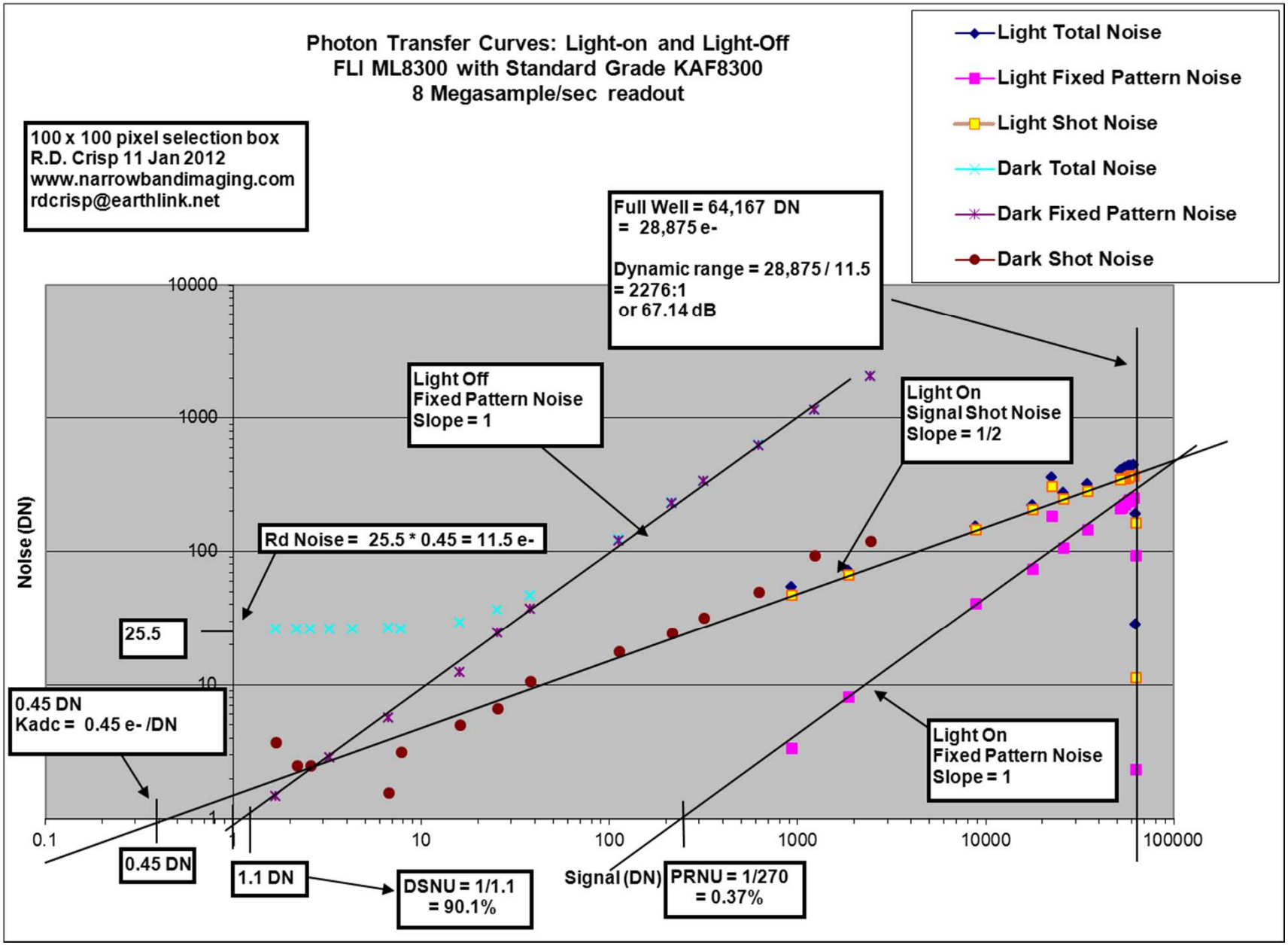
Light Total Noise
Light Fixed Pattern Noise
Light Shot Noise
Dark Total Noise
Dark Fixed Pattern Noise
Dark Shot Noise
Full Well = 56,659 DN
= 33,995 e-
Dynamic range = 33,995 / 10.0
= 3392:1
or 70.6 dB
Light Off
Fixed Pattern Noise
Slope = 1
Light On
Signal Shot Noise
Slope = 1/2
Rd Noise = 16.7 DN * 0.60 e- / DN
Rd Noise = 10.0 e-
16.7 DN
0.60 DN
Kadc = 0.60 e- /DN
Light On
Fixed Pattern Noise
Slope = 1
0.3 DN
0.65 DN
DSNU = 1/0.3
= 333%
290 DN
PRNU = 1/290
= 0.345%
Noise (DN)
Signal (DN)
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000


Photon Transfer Curves: Light-on and Light-Off
FLI ML8300 with Standard Grade KAF8300
8 Megasample/sec readout
100 x 100 pixel selection box
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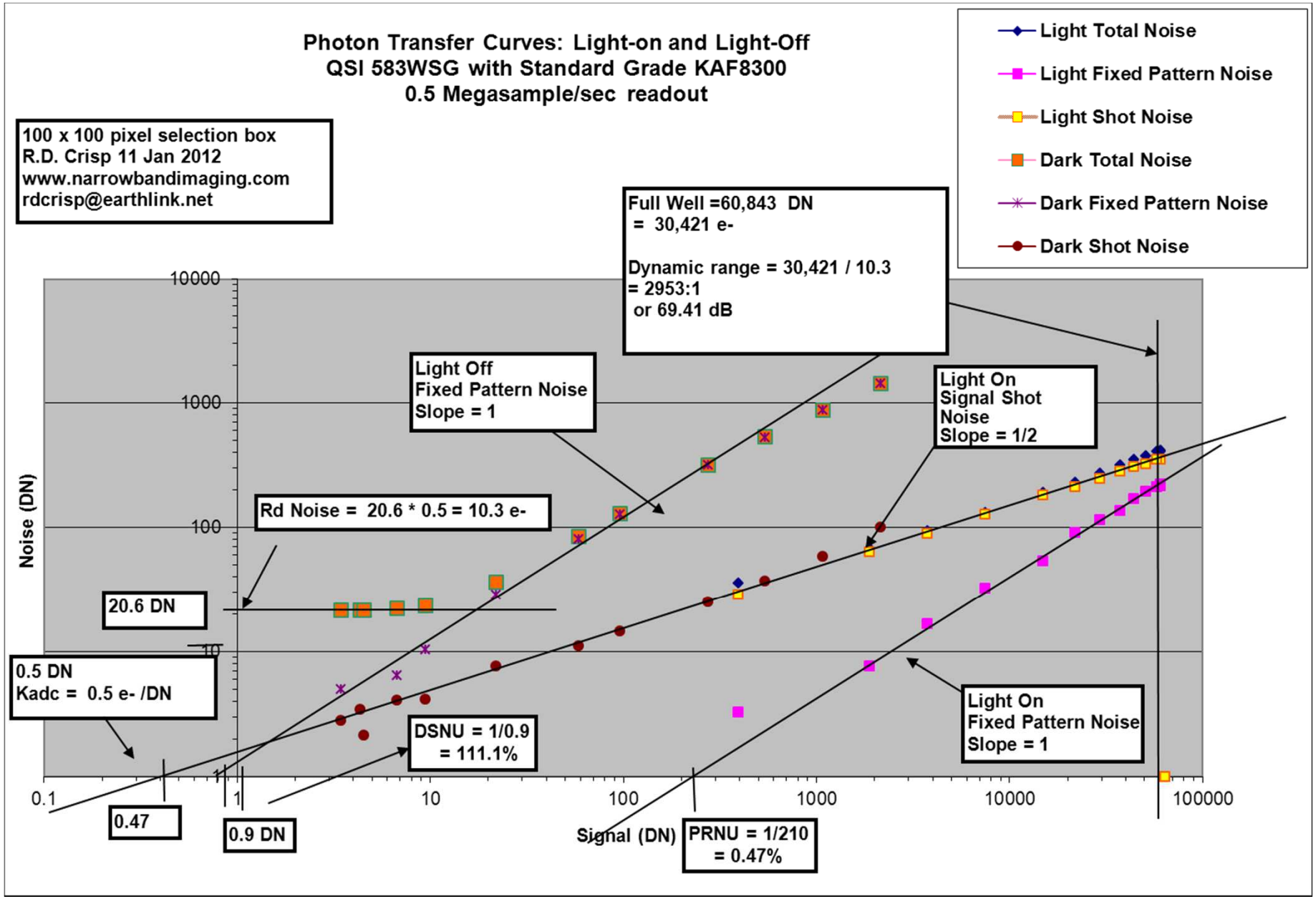
Light Total Noise
Light Fixed Pattern Noise
Light Shot Noise
Dark Total Noise
Dark Fixed Pattern Noise
Dark Shot Noise
Full Well = 64,167 DN
= 28,875 e-
Dynamic range = 28,875 / 11.5
= 2276:1
or 67.14 dB
Light Off
Fixed Pattern Noise
Slope = 1
Light On
Signal Shot Noise
Slope = 1/2
Rd Noise = 25.5 * 0.45 = 11.5 e-
25.5
0.45 DN
Kadc = 0.45 e- /DN
Light On
Fixed Pattern Noise
Slope = 1
Noise (DN)
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000
0.45 DN
1.1 DN
DSNU = 1/1.1
= 90.1%
Signal (DN)
PRNU = 1/270
= 0.37%


Photon Transfer Curves: Light-on and Light-Off
QSI 583WSG with Standard Grade KAF8300
0.5 Megasample/sec readout
100 x 100 pixel selection box
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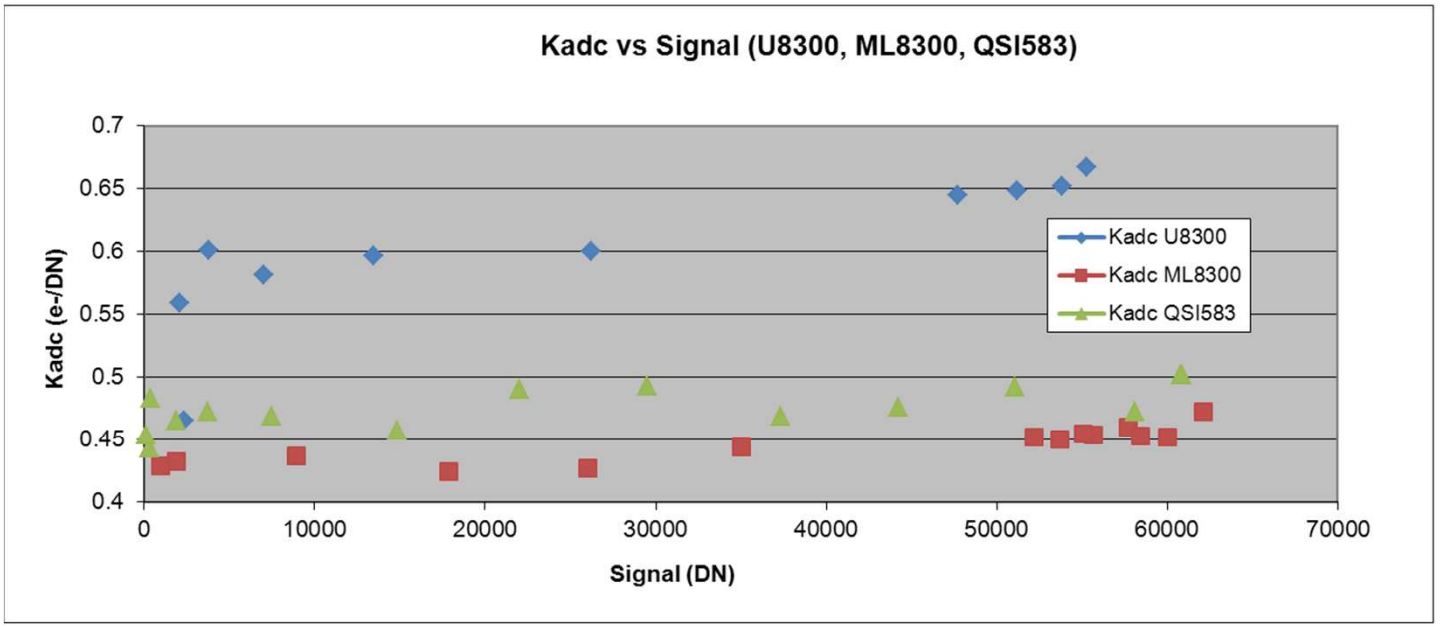
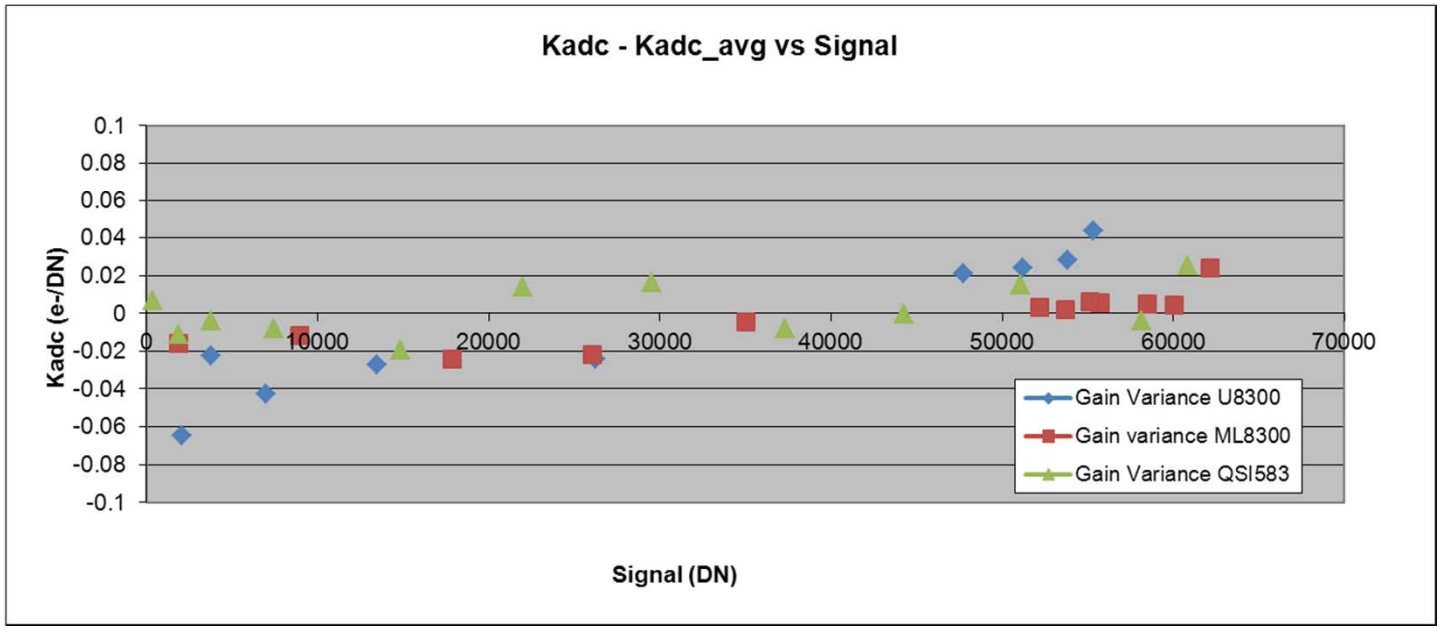
Light Total Noise
Light Fixed Pattern Noise
Light Shot Noise
Dark Total Noise
Dark Fixed Pattern Noise
Dark Shot Noise
Full Well =60,843 DN
= 30,421 e-
Dynamic range = 30,421 / 10.3
= 2953:1
or 69.41 dB
Light Off
Fixed Pattern Noise
Slope = 1
Light On
Signal Shot
Noise
Slope = 1/2
Rd Noise = 20.6 * 0.5 = 10.3 e-
20.6 DN
0.5 DN
Kadc = 0.5 e- /DN
DSNU = 1/0.9
= 111.1%
Light On
Fixed Pattern Noise
Slope = 1
0.47
0.9 DN
PRNU = 1/210
= 0.47%
Noise (DN)
Signal (DN)
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000

Linearity


Kadc vs Signal (U8300, ML8300, QSI583)
Kadc (e-/DN)
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0
10000
20000
30000
40000
50000
60000
70000
Signal (DN)
Kadc U8300
Kadc ML8300
Kadc QSI583


Kadc - Kadc_avg vs Signal
Kadc (e-/DN)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0
10000
20000
30000
40000
50000
60000
70000
Signal (DN)
Gain Variance U8300
Gain variance ML8300
Gain Variance QSI583