Apogee U8300 and FLI ML8300 Standard Grade Camera Preliminary Characterization Report: Photon/Dark Transfer Curve Analysis

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Scope of Work

- A standard grade Apogee U8300* and FLI ML8300 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
    - Cooling
- 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	8.9 (e-) @ 1MHz (U8300) 7.59 (e-) @ 8MHz (ML8300)
Full Well Onset	28,329 (e-) (U8300) 25,667 (e-) (ML8300)
PRNU	0.345% (U8300) 0.37% (ML8300)
DSNU	125% (U8300) 90.1% (ML8300)
Camera Gain	0.5DN/e- (U8300) 0.4 e-/DN (ML8300)
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)
Readout time	~9 seconds, 1MHz, 16 bit (U8300) ~2 seconds, 8MHz, 16 bit (ML8300

Temperature slewing times

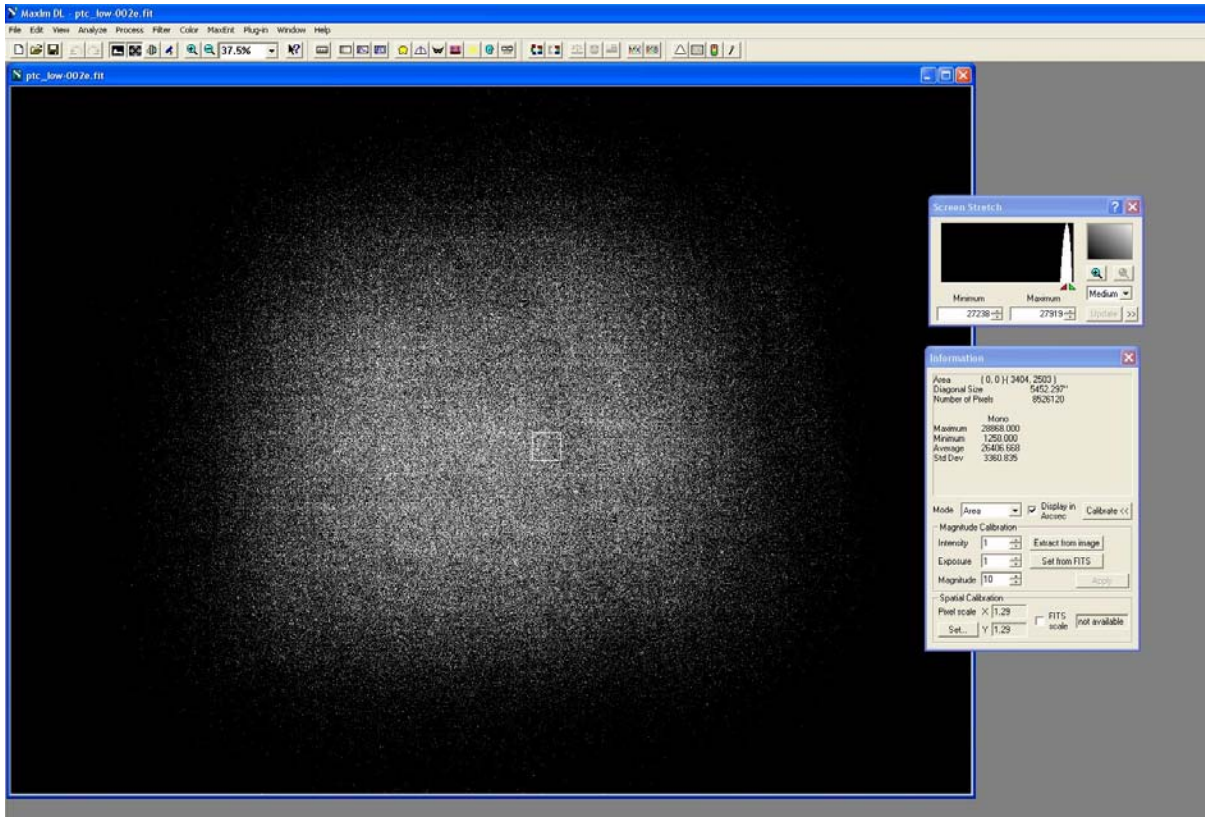
Starting temperature	Ending temperature	Time (U8300)	Time (ML8300)
+15C	0C	20 minutes	3 minutes
0C	-25C	27 minutes	4 minutes
-25C	-20C	11 minutes	3 minutes
+17.4C	-25C	30 minutes	5 minutes

Details of Characterization

Photon Transfer Procedure

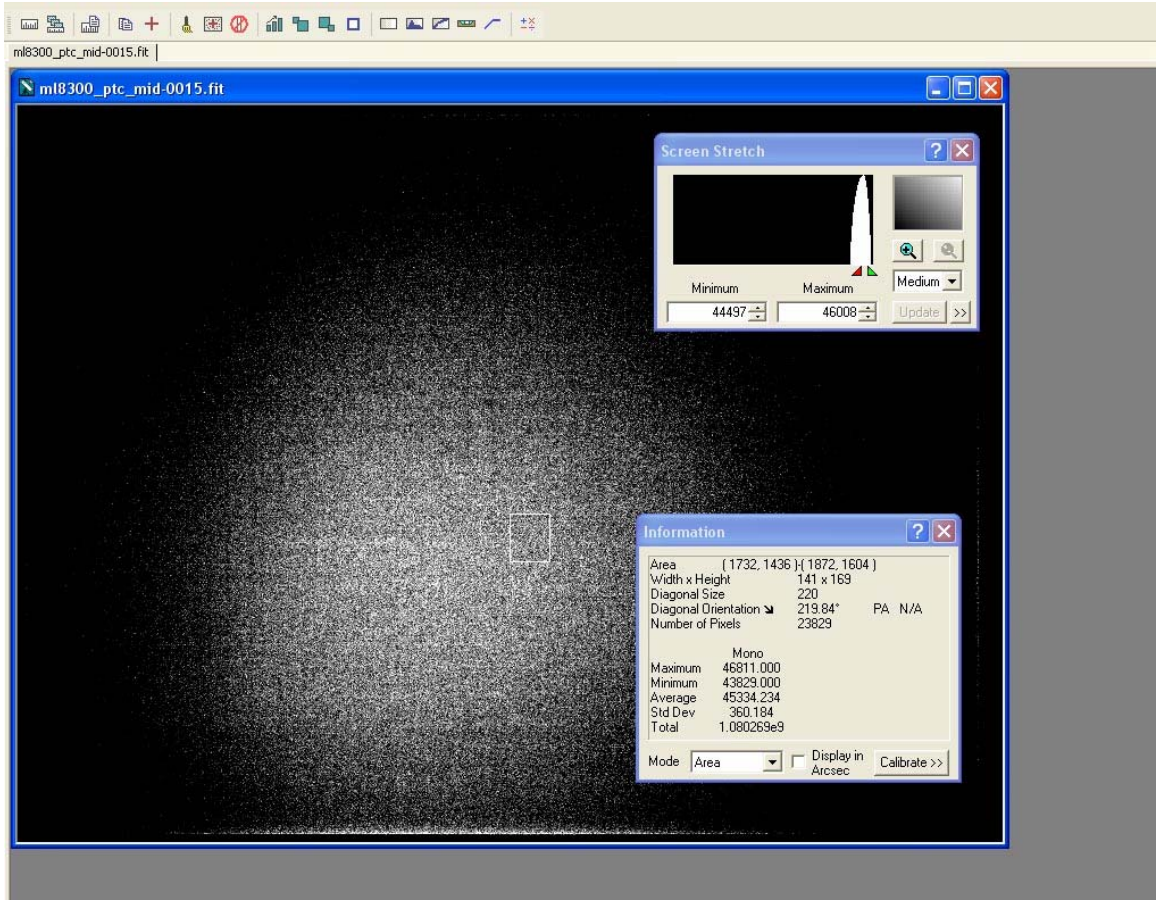
- For tests, standard photon transfer measurements of flat fields were performed
  - Using ambient lighting, pairs of identical exposures were made beginning with minimum exposures and ending with full well: all light-on tests were made at –25C
    - All exposures were made using overscan to precisely 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
  - The read noise value was measured in the overscan region and was used for the Y axis intercept for the PTC/DTC since near zero valued signal counts are difficult to obtain.

Typical Flat Field Frame used for PTC (U8300)



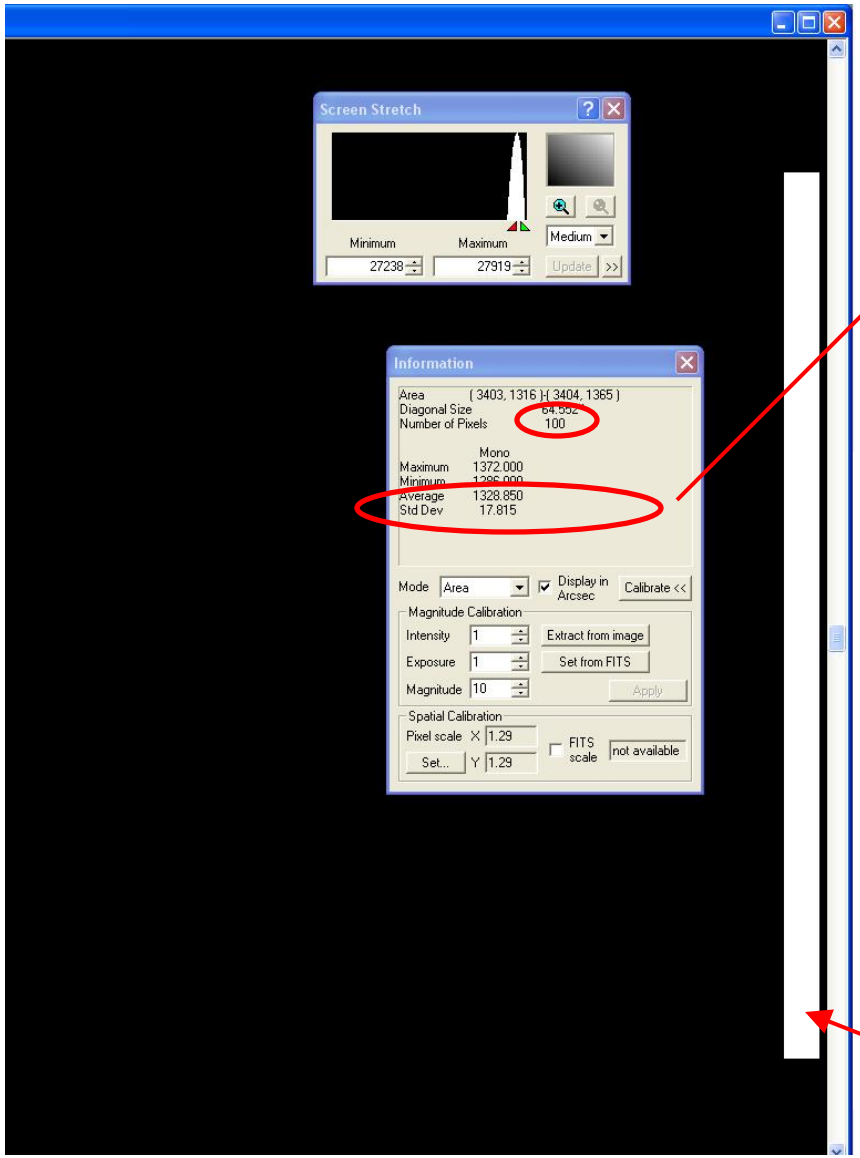
- Selection box is 100 x 100 pixels
- X-offset: 1850
- Y-offset: 1325
- Location selected for nominal pixel behavior: no “junk” pixels, and measurement convenience while avoiding gradients
- Used 2 hour +15C dark to pick location for analysis
- Same identical pixels used for all tests

Typical Flat Field Frame used for PTC (ML8300)

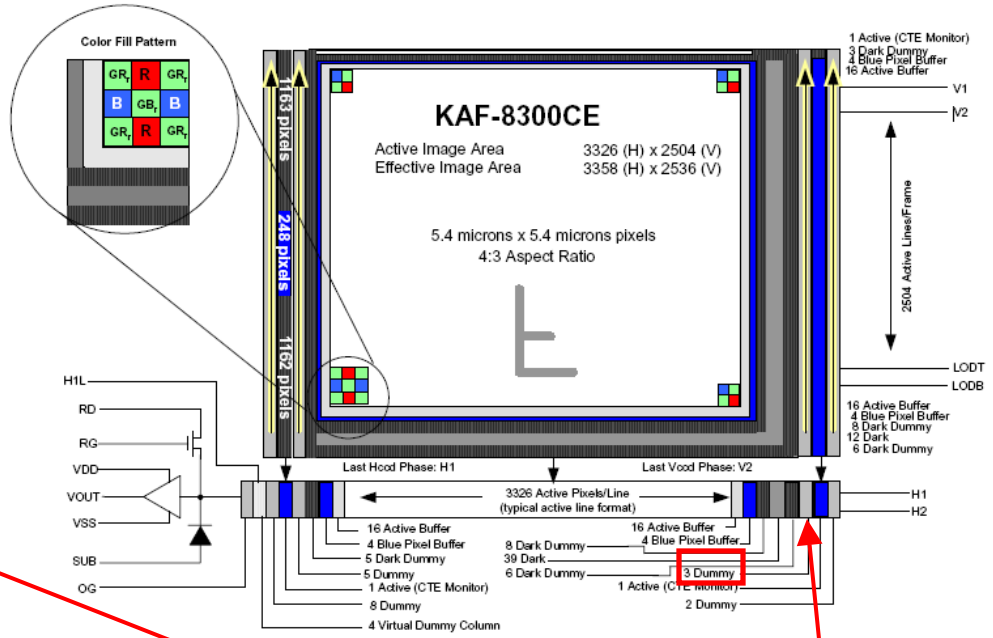


- Selection box is 100 x 100 pixels
- X-offset: 1750
- Y-offset: 1275
- Location selected for nominal pixel behavior: no “junk” pixels, and measurement convenience while avoiding gradients
- Used 2 hour +15C dark to pick location for analysis
- Same identical pixels used for all tests

Read noise determination from overscan region (U8300)

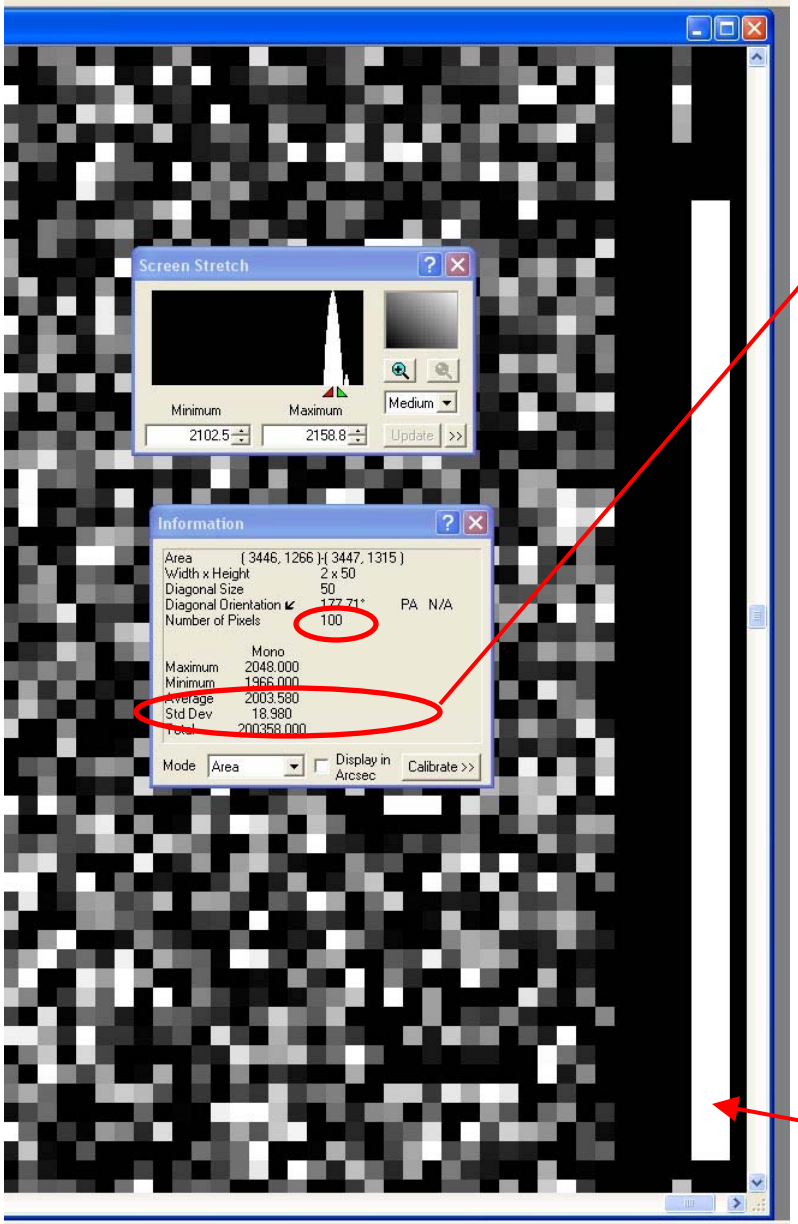


Overscan region:
Std deviation = 17.815 DN
Kadc: 0.5e-/DN
Read Noise: =17.815 * 0.5 = 8.9 e-

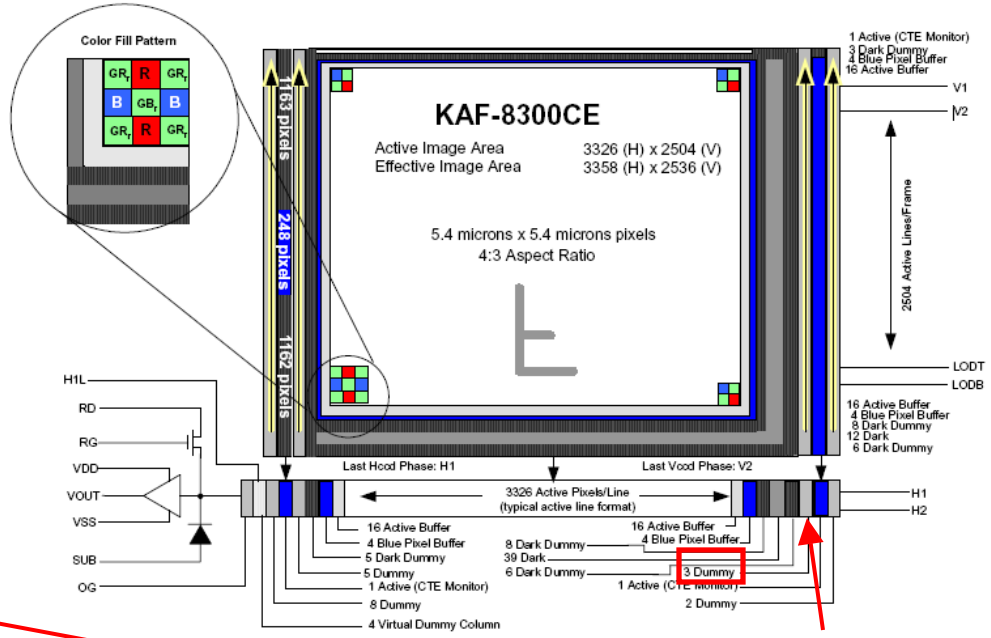


Read noise measured using
STD Deviation of these pixels

Read noise determination from overscan region (ML8300)



Overscan region:
Std deviation = 18.98DN
Kadc: 0.4e-/DN
Read Noise: =18.98 * 0.4
= 7.59 e-



Read noise measured using
STD Deviation of these pixels

Full well determination from spreadsheet (U8300)

	offset	signal	stdev	delta std	
	1333	60612	471.05		
4	1333	60612	470.8	49.741	
	1317.6	60615	469		
4	1317.6	60609	469.5	49.32	
	1335.6	60612	467.512		
8	1335.6	60612	467.3	49.2	
	1322	60590	460.3		
2	1322	60591	459.9	51.046	
	1354.2	60499	427.4		
8	1354.2	60500	427.2	76.4	
	1323.8	60146	349.5		
5	1323.8	60135	348.4	192	
	1343	56658	366.5		
8	1343	56659	366.5	407.8	Full Well Onset
	1328	55169	364.1		
8	1328	55153	359.3	407	
	1344	49068	337.5		
3	1344	49115	340.3	385.5	
	1324	52556	351.1		
2	1324	52526	353.6	398.2	
	1334	27603	235.8		
7	1334	27563	234.9	296.7	
	1341	14792.5	160.9		
4	1341	14817	159.7	213.7	
	1321	8313.7	114.8		
5	1321	8323.9	116	156.9	
	1325.3	5055.5	82.23		
5	1329.4	5177	84	114.7	
	1320.7	3393.6	63.9		
8	1320.7	3395.1	63.6	89.3	

increasing signal

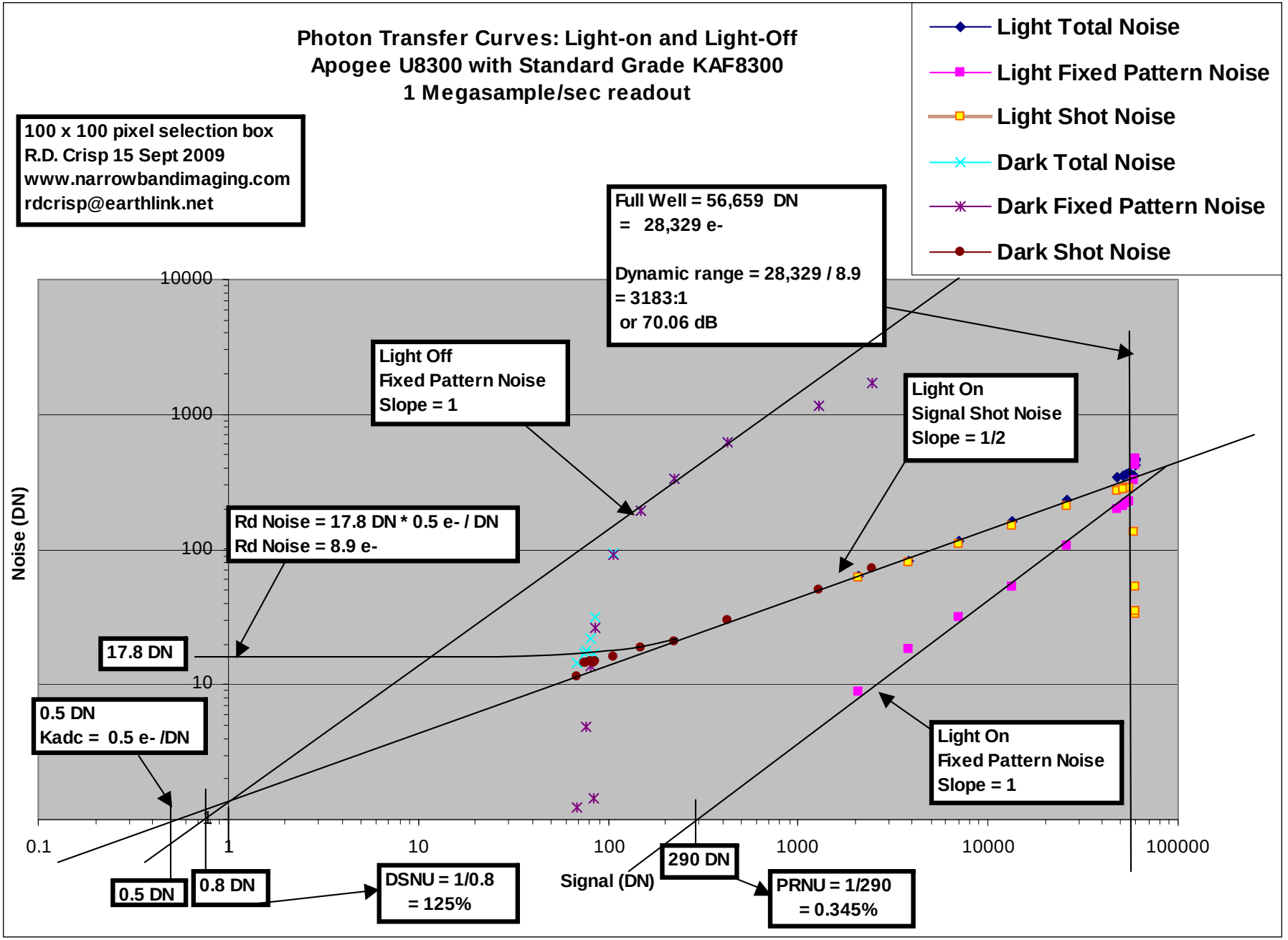
Full well onset is indicated when the delta standard deviation begins to drop off with increasing signal

Full well determination from spreadsheet (ML8300)

signal	stdev	delta std	
65533.2	21.614		
65530.4	34.328	39.421	
60111.9	427.7		
59567.6	422.5	502.3	
64422.9	437.6		
64167.3	444.5	514.4	Full Well Onset
62175.9	436.8		
62204.6	430.5	516.6	
60311.1	428.7		
60851.2	436.6	509.3	
57533.1	416.7		
58150.3	415	496.8	
57170.3	413.9		
57339.8	412.5	493.8	
55599.3	406.4		
56068.7	405.8	489.8	
65447.2	183.6		
65440.3	191.6	231.5	
54776.3	398.8		
53914	399.2	482.2	
45325.3	355.5		
4520.9	356.7	433.8	
36784.1	313.3		
37477.4	319.2	398.8	
28189.6	270.9		
28124.2	268.8	351.2	

increasing signal

Full well onset is indicated when the delta standard deviation begins to drop off with increasing signal


Photon Transfer Curves: Light-on and Light-Off
Apogee U8300 with Standard Grade KAF8300
1 Megasample/sec readout
100 x 100 pixel selection box
R.D. Crisp 15 Sept 2009
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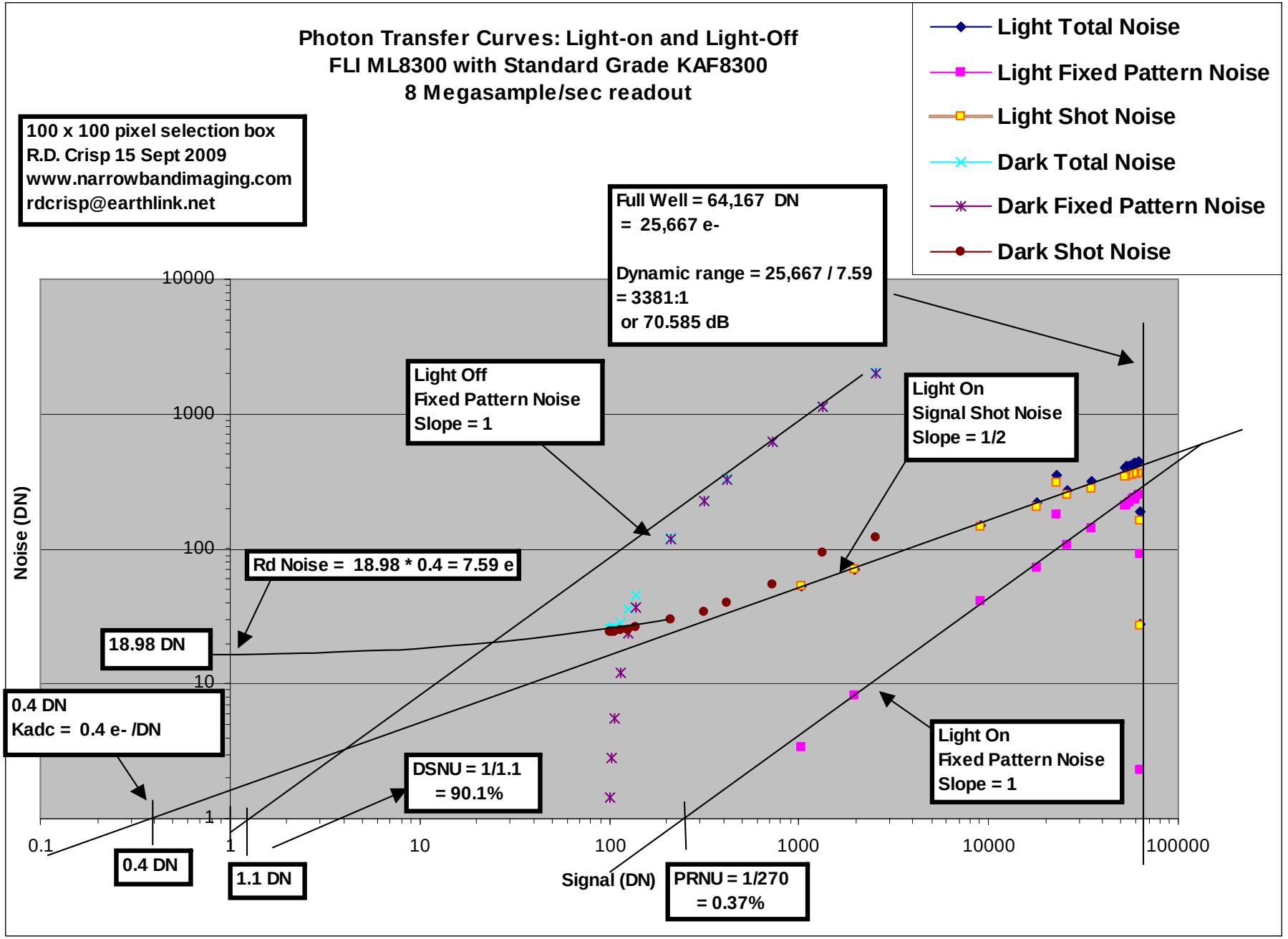
Light Total Noise
Light Fixed Pattern Noise
Light Shot Noise
Dark Total Noise
Dark Fixed Pattern Noise
Dark Shot Noise
Full Well = 56,659 DN
= 28,329 e-
Dynamic range = 28,329 / 8.9
= 3183:1
or 70.06 dB
Light Off
Fixed Pattern Noise
Slope = 1
Light On
Signal Shot Noise
Slope = 1/2
Rd Noise = 17.8 DN * 0.5 e- / DN
Rd Noise = 8.9 e-
17.8 DN
0.5 DN
Kadc = 0.5 e- /DN
Light On
Fixed Pattern Noise
Slope = 1
0.5 DN
0.8 DN
DSNU = 1/0.8
= 125%
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
R.D. Crisp 15 Sept 2009
www.narrowbandimaging.com
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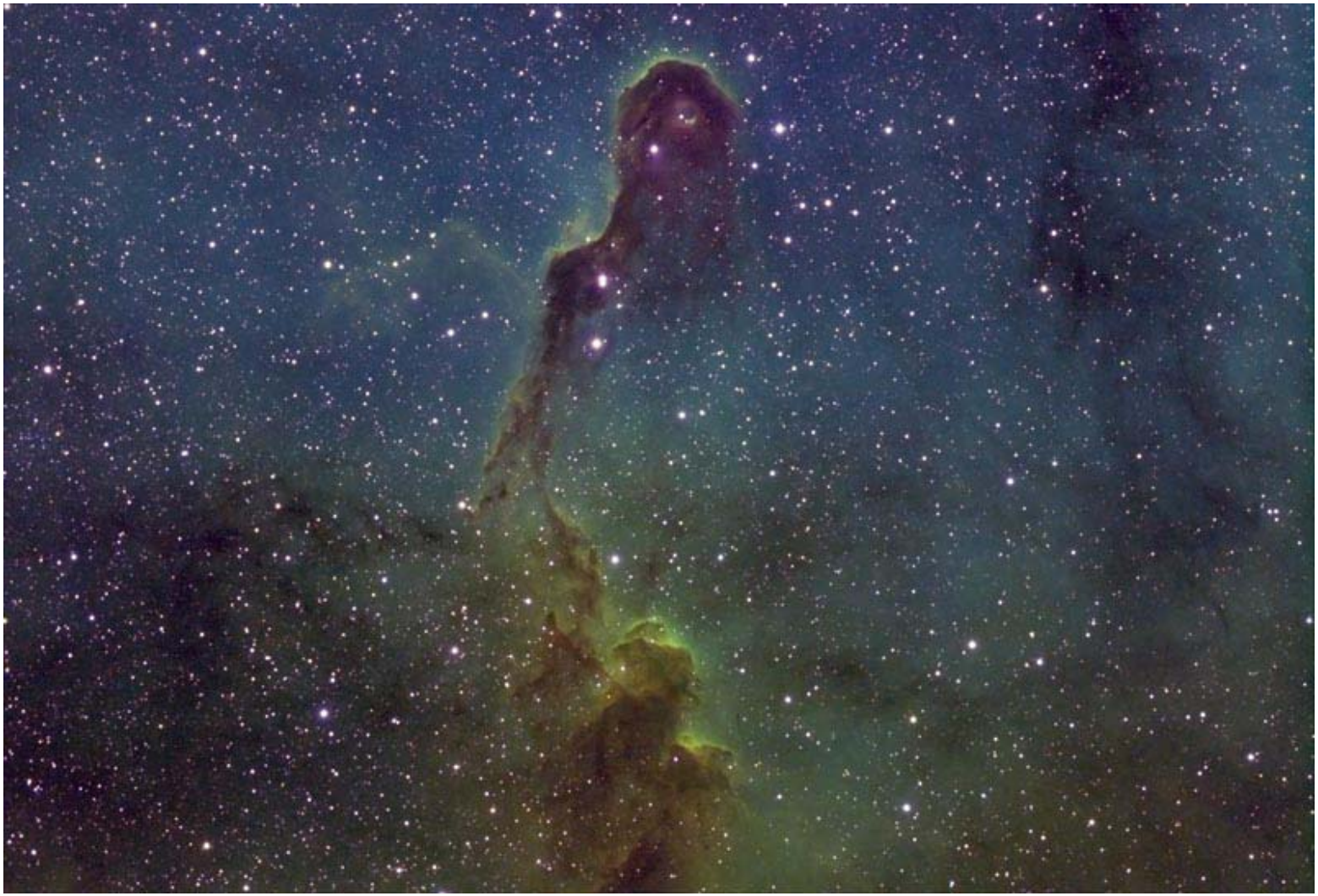
Light Total Noise
Light Fixed Pattern Noise
Light Shot Noise
Dark Total Noise
Dark Fixed Pattern Noise
Dark Shot Noise
Full Well = 64,167 DN
= 25,667 e-
Dynamic range = 25,667 / 7.59
= 3381:1
or 70.585 dB
Light Off
Fixed Pattern Noise
Slope = 1
Light On
Signal Shot Noise
Slope = 1/2
Rd Noise = 18.98 * 0.4 = 7.59 e
18.98 DN
0.4 DN
Kadc = 0.4 e- /DN
DSNU = 1/1.1
= 90.1%
Light On
Fixed Pattern Noise
Slope = 1
0.4 DN
1.1 DN
PRNU = 1/270
= 0.37%
Noise (DN)
Signal (DN)
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000

Images from ML8300



ML8300
12 hours total exposure time:
AP155EDF f/7 with 100mm field flattener
FLI Research Grade
[SII], Halpha and [OIII] filters

Image Link:

http://www.narrowbandimaging.com/ic1396_ap155_ml8300_s2hao3_page.htm

ML8300
5 hours total exposure time:
AP155EDF f/7 with 100mm field flattener
no filter

Image Link:

http://www.narrowbandimaging.com/m33_ap155edf_f7_ml8300_nofilter_page.htm

ML8300
45 minutes total exposure time:
AP155EDF f/7 with 100mm field flattener
FLI Research Grade Halpha Filter

Image Link:

http://www.narrowbandimaging.com/ic434_ap155edf_f7_ml8300_fli_ha_page.htm