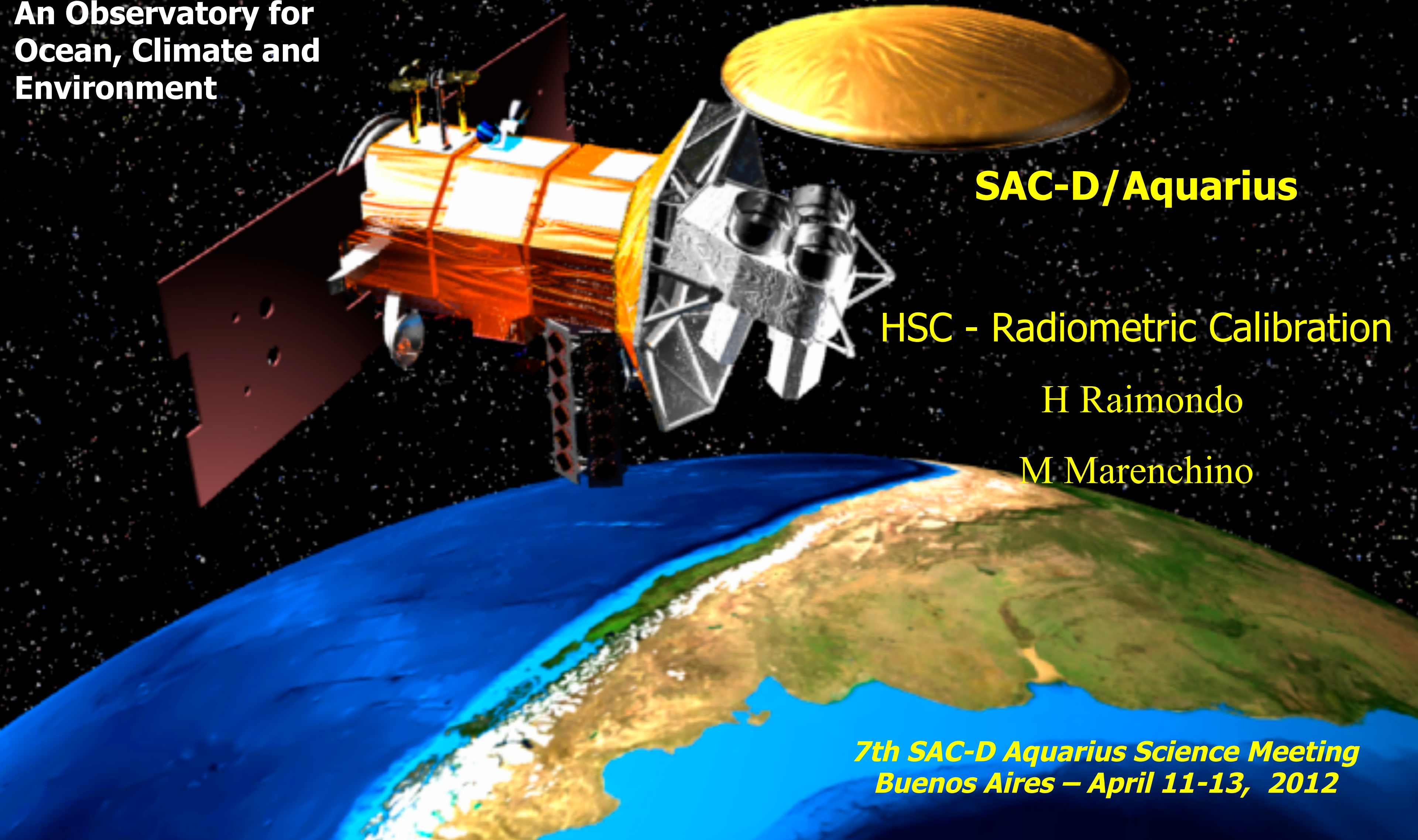
SAC-D/Aquarius

An Observatory for Ocean, Climate and Environment



SAC-D/Aquarius

HSC - Radiometric Calibration

H Raimondo

M Marenchino

7th SAC-D Aquarius Science Meeting
Buenos Aires – April 11-13, 2012

HSC - Switchable ranges

➢ **HSC is a versatile instrument. Besides setting the different operating modes and submodes, the following parameters can be set by command:**

- ✓ **Number of Stages (6, 12, 24, 48 or 96)/(x1, x2, x4, x8 or x16)**
- ✓ **Integration Time (23 to 44.966 msec)**
- ✓ **Gain (4.5 to 34.5 dB)**
- ✓ **Offset (0 to 1023) which must be coherent respect the first three parameters.**

➢ **The HSC Instrument has switchable ranges giving the capability of Full Scale Radiance adjustment for different light conditions during the orbit.**

➢ **All the needed information so as to know the operating mode/submode, and other parameters that define the state and characteristics of HSC are present in the HK.**

➢ **An appropiate IT must be calculated taking into account SAC-D orbit: the altitude and speed of the spacecraft, together with the IT, determine the pixel resolution along track.**

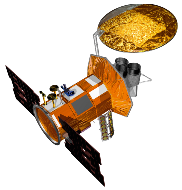
➢ **Also present in the HK is the temperature of the CCD. The radiometric correction coefficients depend on this temperature.**

Radiometric Corrections

Spectral and Radiometric Characterization

- HSC has two optical systems and each one of them has two Signal Processing Chains (SPC). Each of the optical system with each of the two SPCs was spectral and radiometrically characterized.
- The measurements were made at temperatures in the operating range of the optical system (Range: –5°C to –15°C). Two temperatures were used:
  - one in the range –6.1°C to –7.4°C
  - the other in the range –12.3°C to –13.5°C.
- Each optical system was illuminated using an integrating sphere, spectral and radiometrically calibrated. Two reference points were determined:
  - One with the optic covered (Ls=0). Changes were made in the offset to obtain ~8 DN in Pix 1028. (dark image / fondo)
  - The other changing Ls, without changing the offset, in order to obtain almost saturation (~1010 DN in Pix 1028). (illuminated image / ilum)
- The measurement covered all the FOV (Field of View) of the optical system. As the integrating sphere doesn't cover all the FOV, the characterization was made in two stages.

Radiometric Calibration



CALIBRACIÓN RADIOMÉTRICA HSTC2K

Tabla T-R5

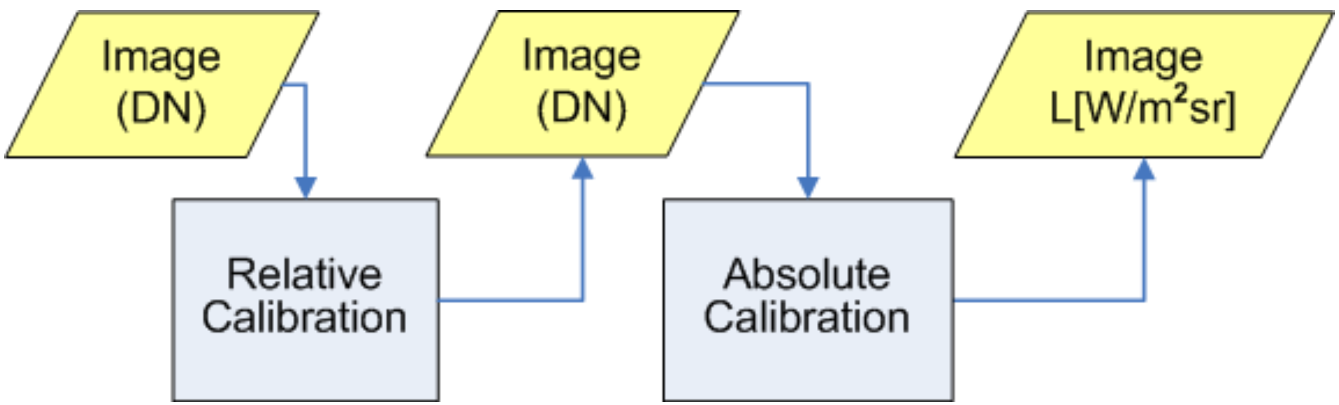
CAMARA 2 RANGO –10°C -15°C

Lado Píxeles Menores

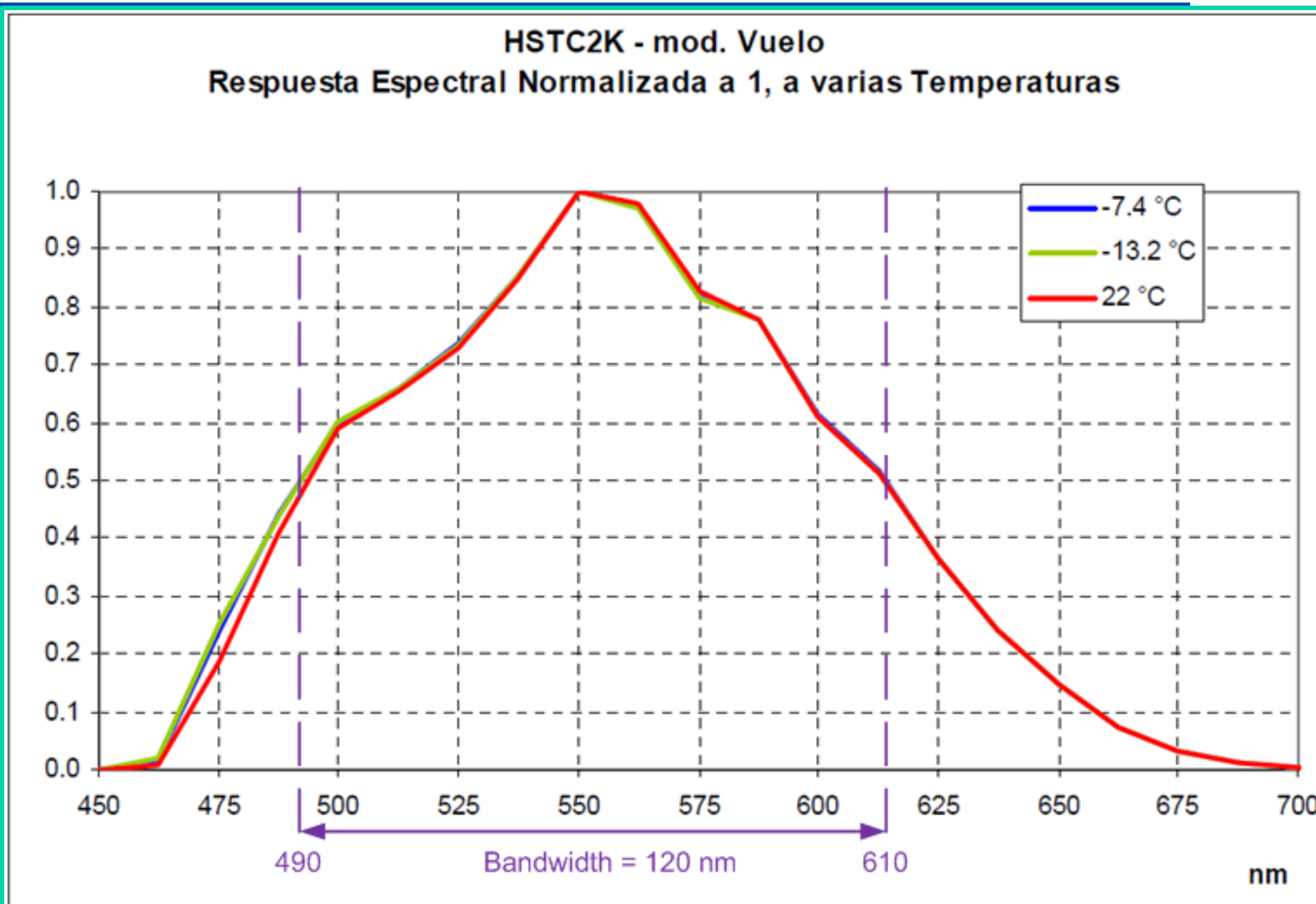
CAMARA 2		SPC X		Fecha: 24NOV05			Hora: 15:35
Temp °C	Gan	Offset	Nro Eta.	Ilum.	Rad. [A]	DN P1028	Archivos (*.txt)
-13.2	201	480	24	fondo	0	6	T-Rc2xn13f24-1
-13.2	201	470	48	fondo	0	7	T-Rc2xn13f48-1
-13.2	201	450	96	fondo	0	9	T-Rc2xn13f96-1
-13.3	201	450	96	Ilum	2.39E-9	996	T-Rc2xn13i24-1
-13.3	201	470	48	Ilum	4.75E-9	998	T-Rc2xn13i48-1
-13.3	201	480	24	Ilum	9.41E-9	999	T-Rc2xn3i96-1

Lado Píxeles Mayores

CAMARA 2		SPC X		Fecha: 25NOV05			Hora: 13:50
Temp °C	Gan	Offset	Nro Eta.	Ilum.	Rad. [A]	DN P1028	Archivos (*.txt)
-13.5	201	480	24	fondo	0	6	T-Rc2xn13f24-2
-13.5	201	470	48	fondo	0	7	T-Rc2xn13f48-2
-13.5	201	452	96	fondo	0	10	T-Rc2xn13f96-2
-13.5	201	452	96	Ilum	2.40E-9	1008	T-Rc2xn13i24-2
-13.5	201	470	48	Ilum	4.73E-9	992	T-Rc2xn13i48-2
-13.5	201	480	24	Ilum	9.43E-9	1002	T-Rc2xn13i96-2



Spectral Response



The bandwidth at 50% is 490nm-610nm.

Radiometric characterization

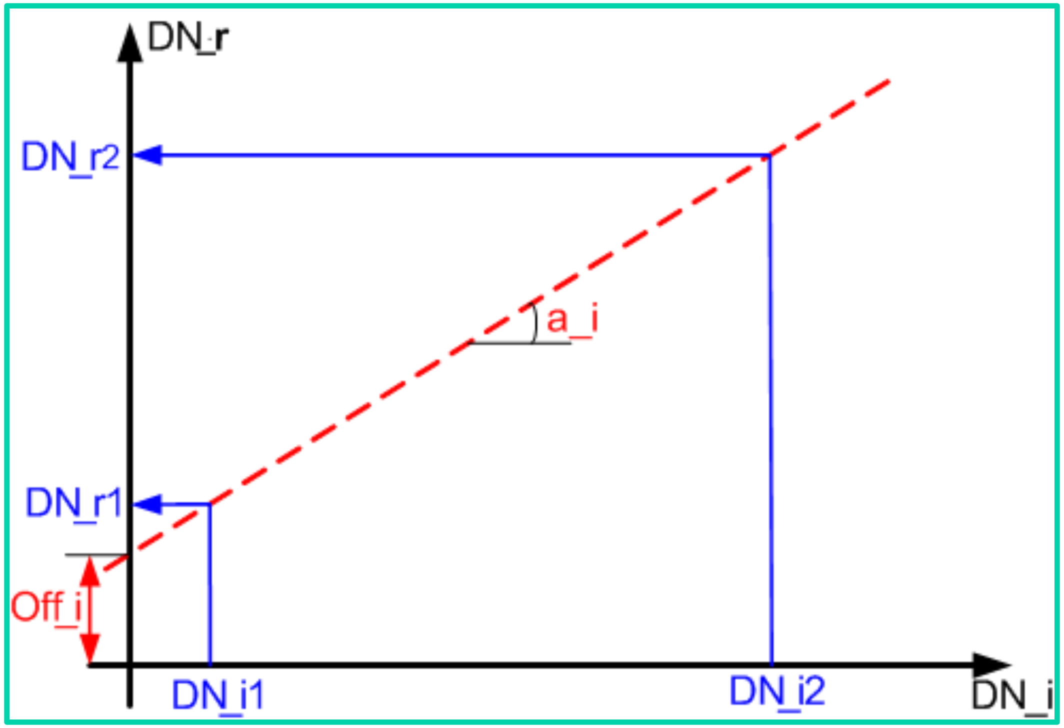
"Flat" spectral radiance of near saturation for different number of stages:

Gain	Stages	Rad Spectral µW/cm2.sr.nm	Banwith nm	Radiancia µW/cm2.sr
201	6	2.18E-02	120	2.62E+00
201	12	1.06E-02	120	1.27E+00
201	24	4.85E-03	120	5.82E-01
201	48	2.42E-03	120	2.90E-01
201	96	1.23E-03	120	1.48E-01

Average of 3 (of the 2056) pixels characterized by Camara2:

Camar2 - SPCX - Temp: -10 ºC to -15 ºC									
Temp ºC	Gain	Offset	Stages Number	Ilum	Rad [A]	Rad µW/cm2.sr	DNprom P1028	DNprom P500	DNprom P751
-13.3	201	480	24	fondo	0	0	**6.71**	7.41	6.45
-13.3	201	470	48	fondo	0	0	**7.08**	8.35	7.18
-13.3	201	450	96	fondo	0	0	**8.98**	11.42	9.87
-13.3	201	480	24	Ilum	9.41E-09	0.5820	**998.59**	892.57	939.95
-13.3	201	470	48	Ilum	4.75E-09	0.2904	**994.55**	890.73	938.03
-13.3	201	450	96	Ilum	2.39E-09	0.1476	**1001.91**	901.79	946.91

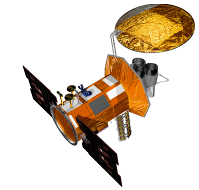
Relative Calibration

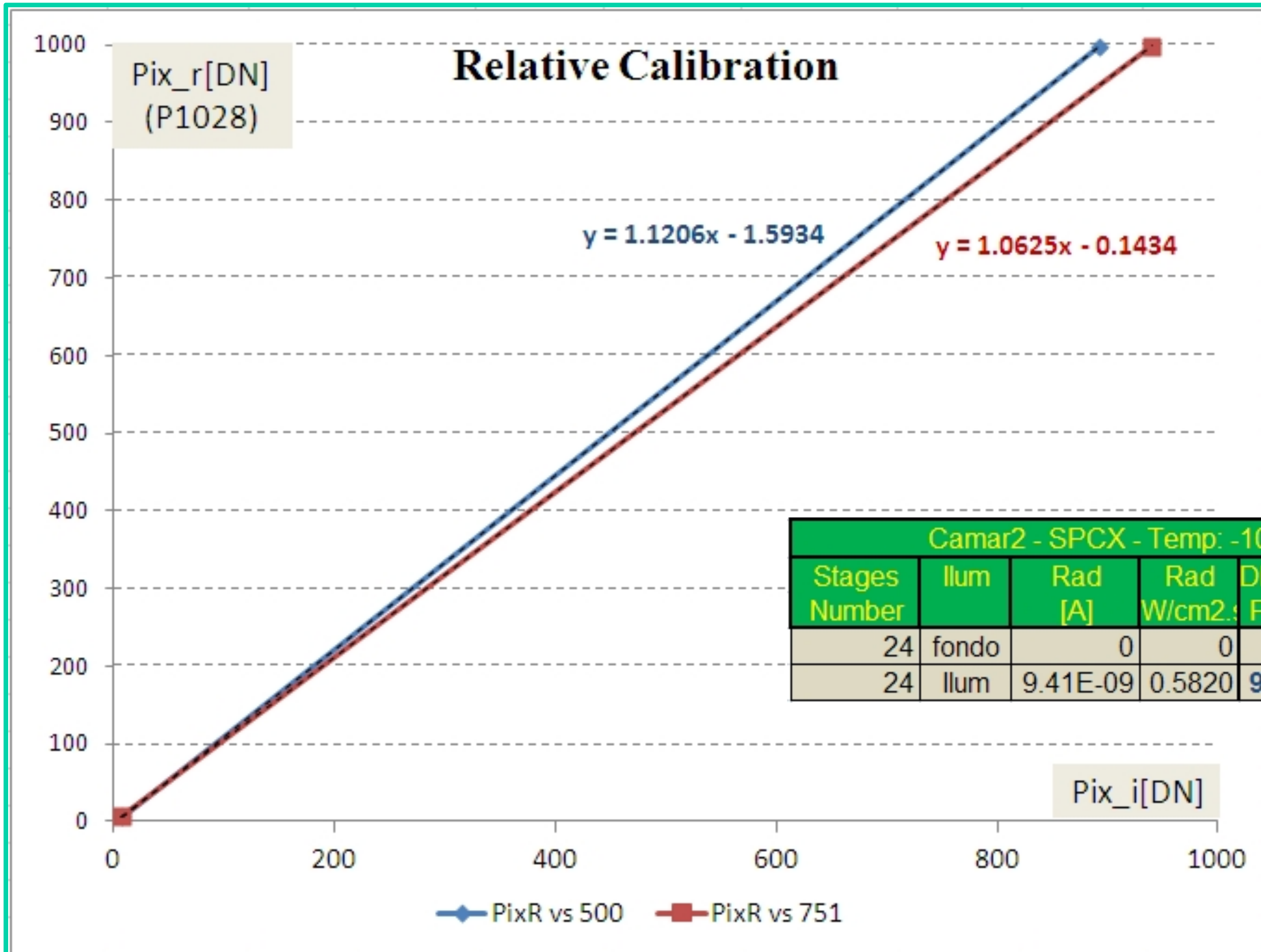


DN_i1: DN of the pixel “i” in the dark(fondo) image.
DN_r1: DN of the reference pixel in the same dark image.
DN_i2: DN of the pixel “i” in the illuminated image.
DN_r2: DN of the reference pixel in the same illuminated image.

SAC-D/AQUARIUS

Relative Calibration

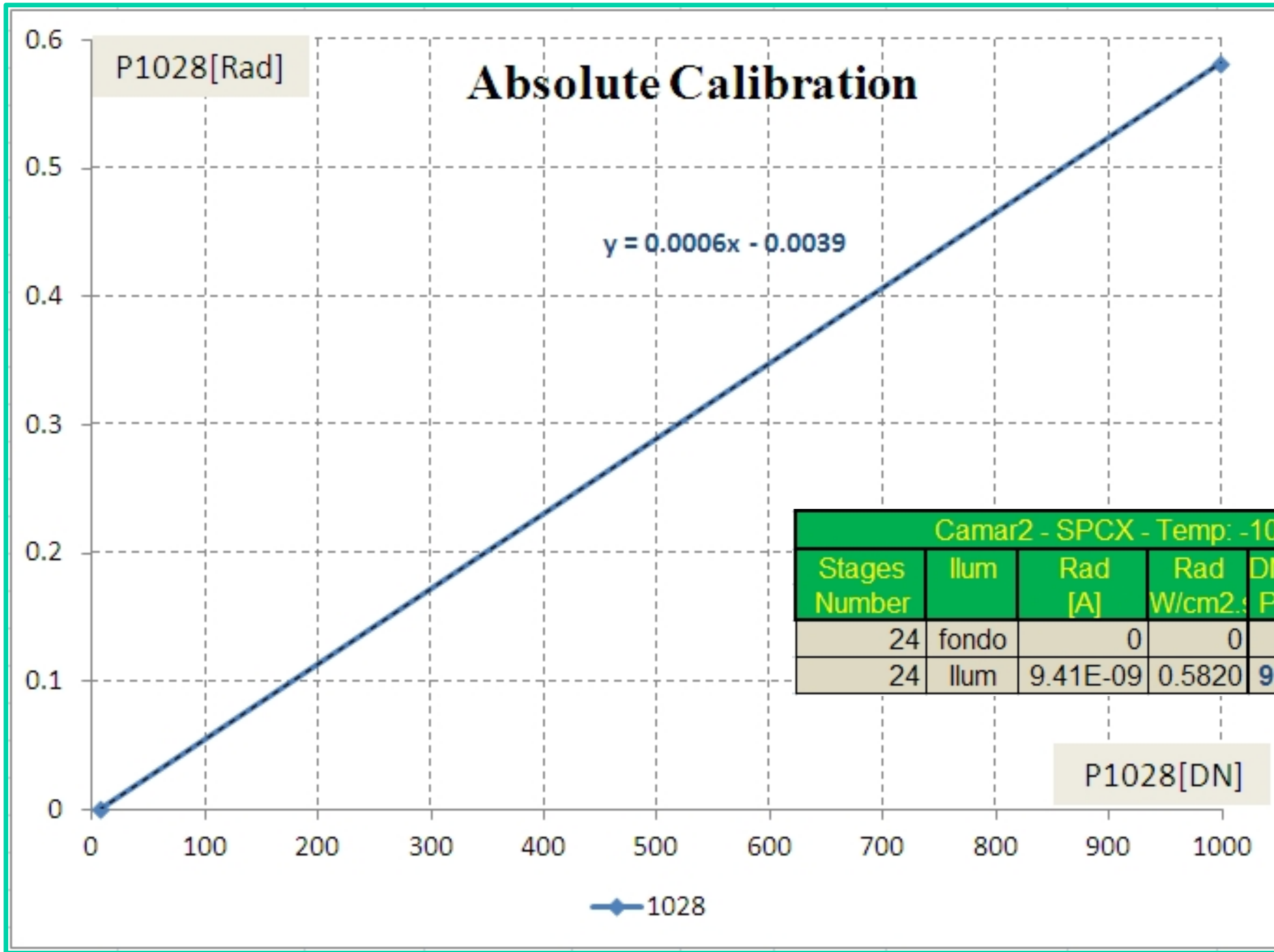




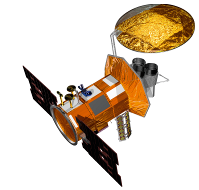
Camar2 - SPCX - Temp: -10 ºC to -15 ºC						
Stages Number	Ilum	Rad [A]	Rad W/cm2.s	DNprom P1028	DNprom P500	DNprom P751
24	fondo	0	0	**6.71**	7.41	6.45
24	Ilum	9.41E-09	0.5820	**998.59**	892.57	939.95

SAC-D / AQUARIUS

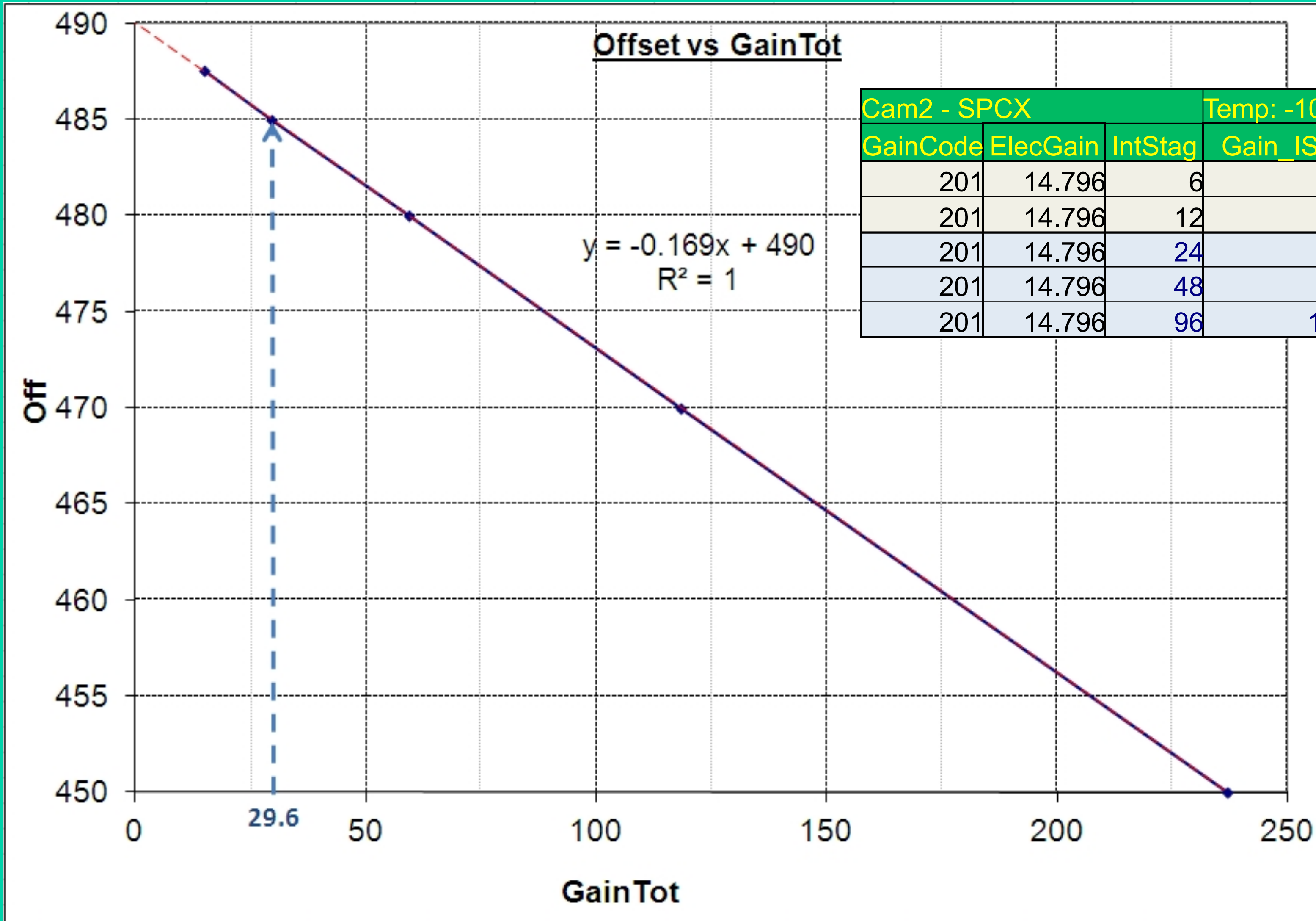
Absolute calibration



Camar2 - SPCX - Temp: -10 ºC to -15 ºC						
Stages Number	Ilum	Rad [A]	Rad W/cm2.	DNprom P1028	DNprom P500	DNprom P751
24	fondo	0	0	**6.71**	7.41	6.45
24	Ilum	9.41E-09	0.5820	**998.59**	892.57	939.95

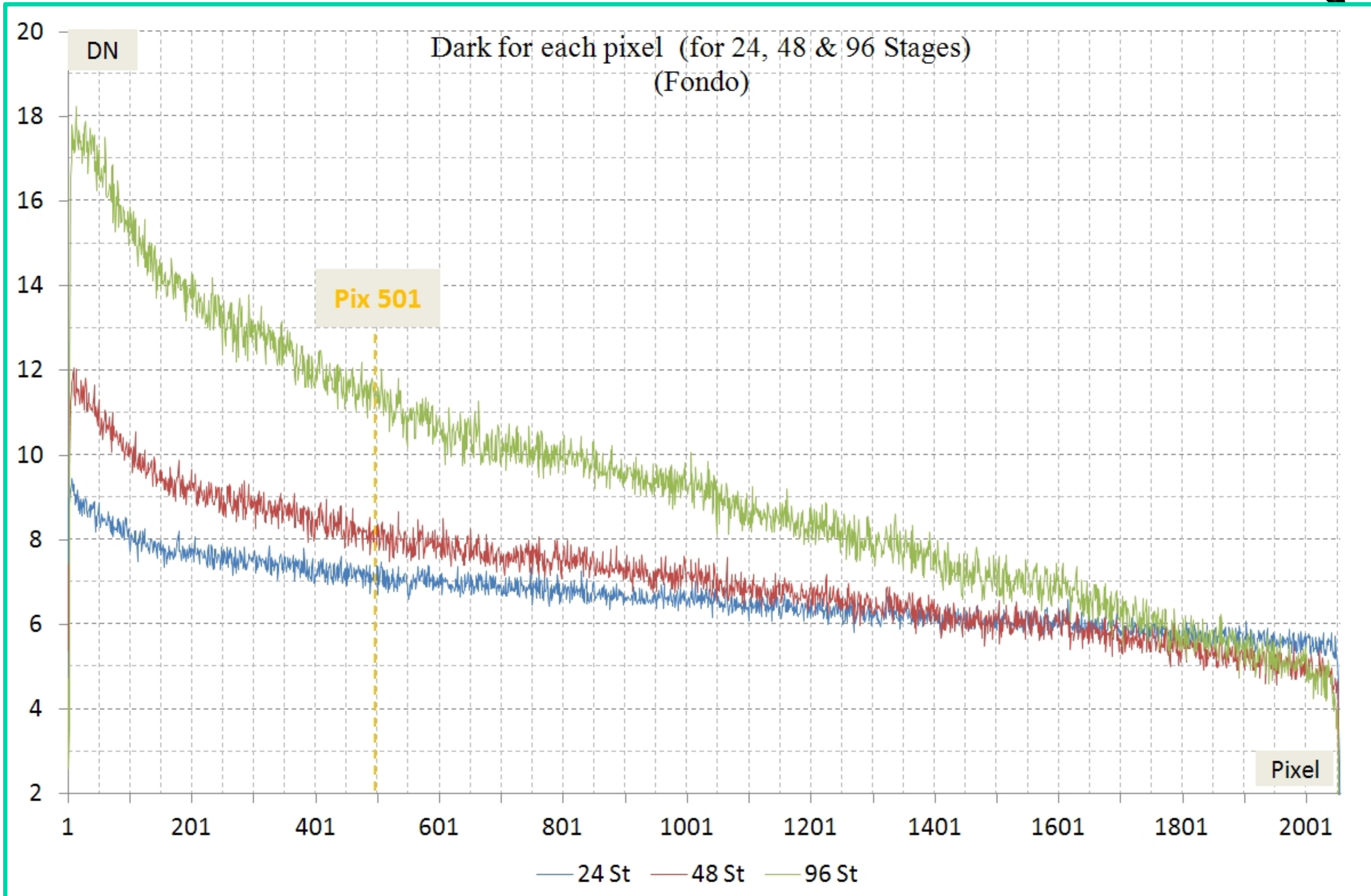


Offset estimation



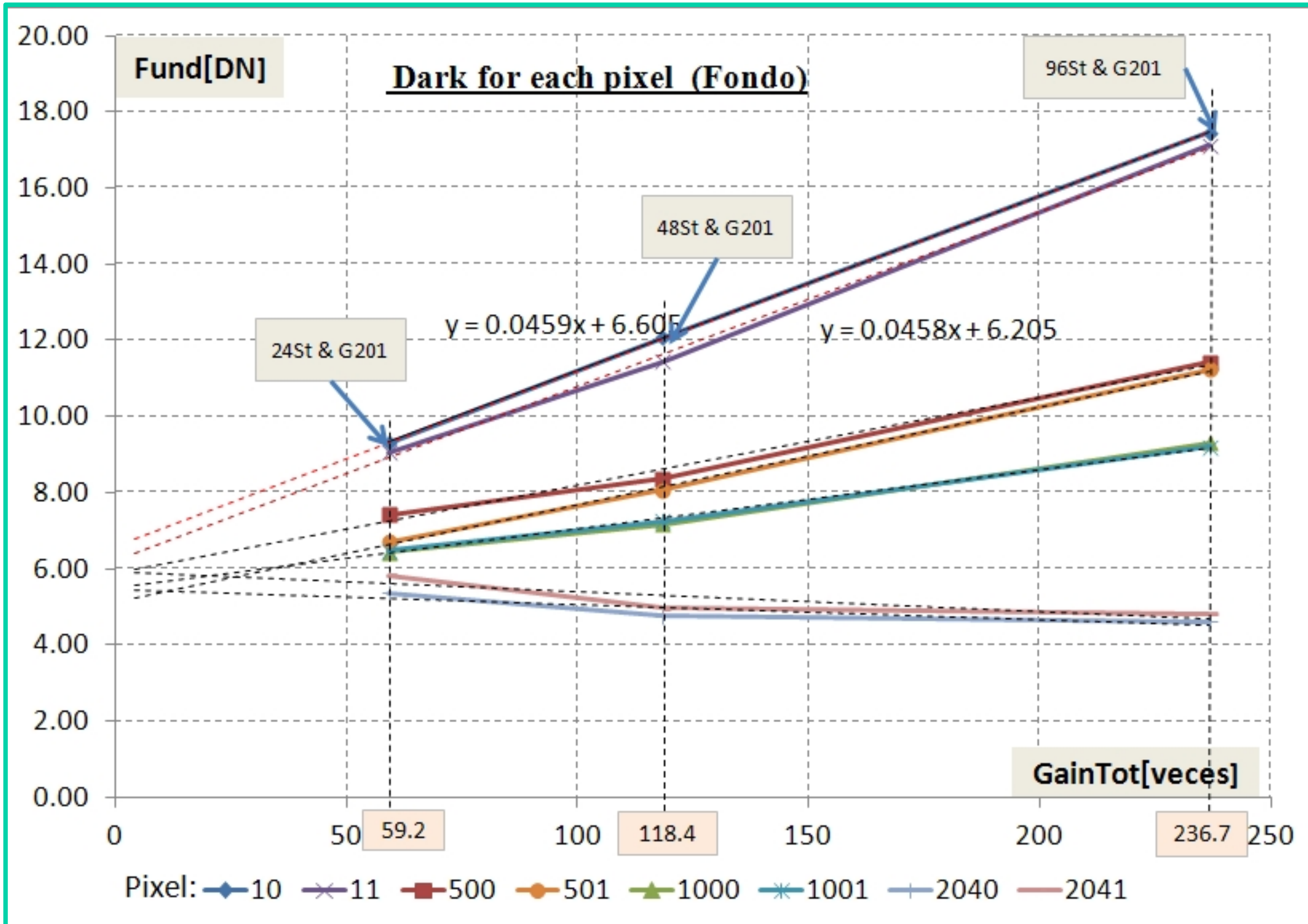
Cam2 - SPCX			Temp: -10 ºC to -15 ºC		
GainCode	ElecGain	IntStag	Gain_IS	**GainTot**	Off_Dec
201	14.796	6	1	**14.796**	487.5
201	14.796	12	2	**29.592**	485.0
201	14.796	24	4	**59.184**	480.0
201	14.796	48	8	**118.367**	470.0
201	14.796	96	16	**236.734**	450.0

Dark – 24, 48 & 96 Stages



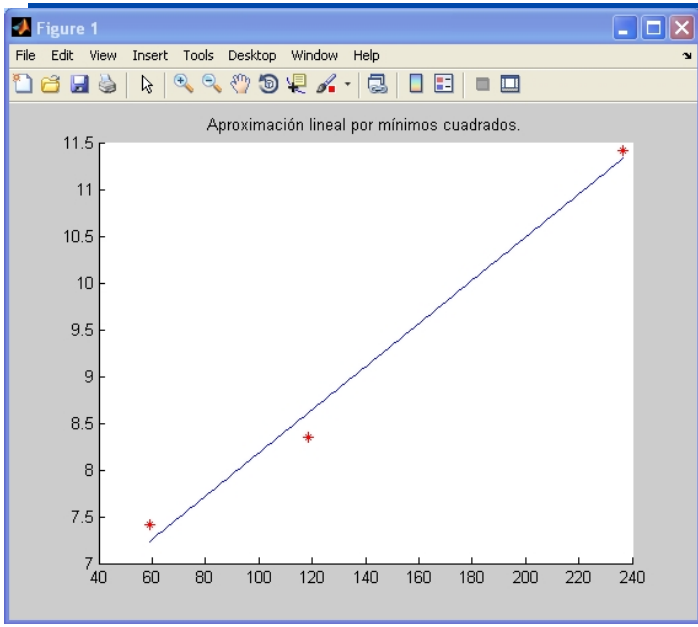
SAC-D/AQUARIUS

Dark[DN] estimation

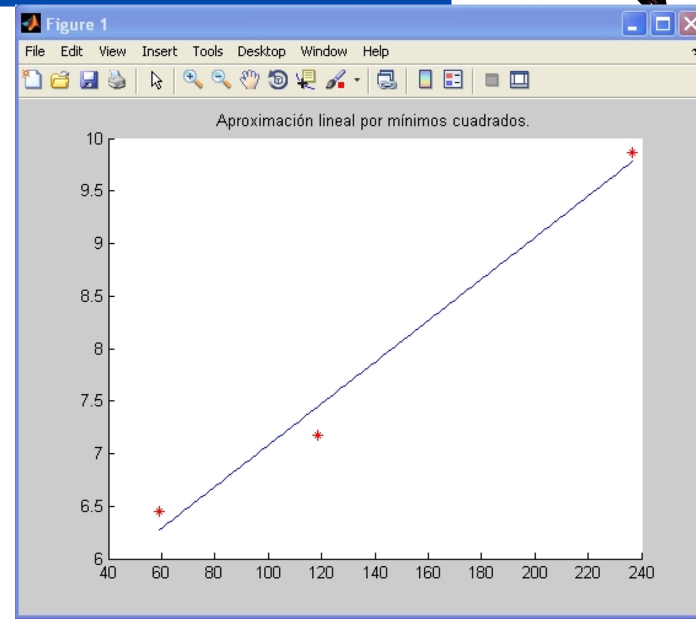


Fund[DN] estimation - Backup

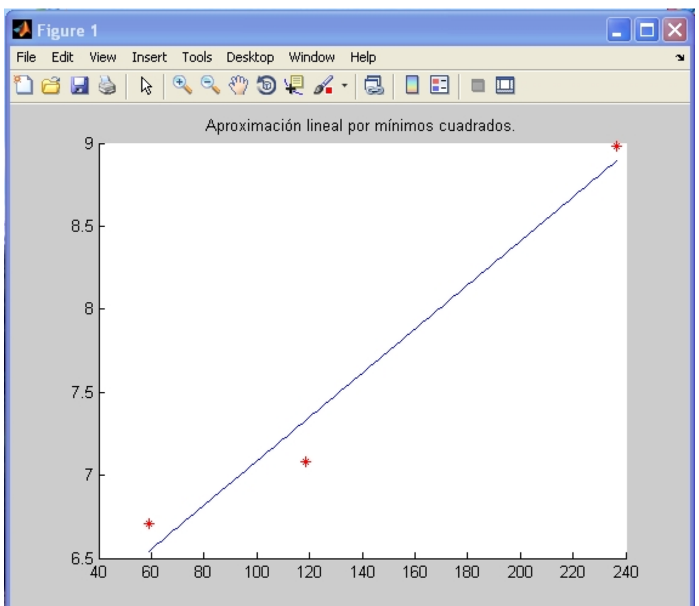
P500



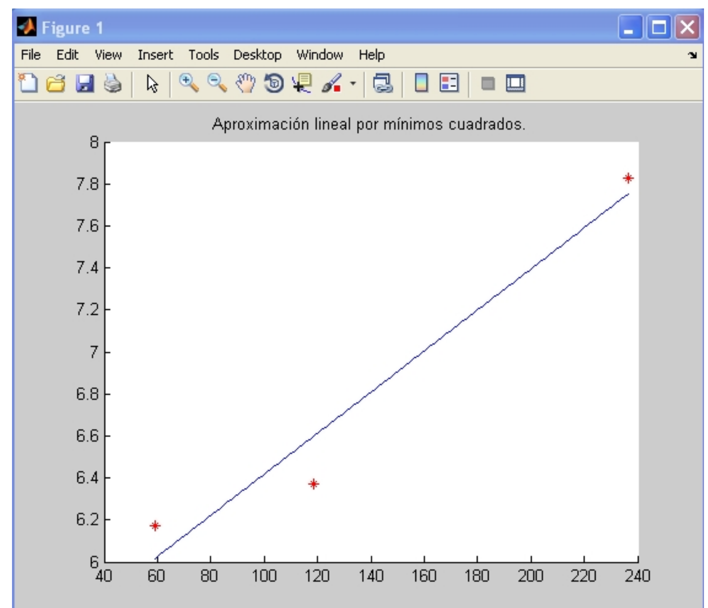
P750



P1028



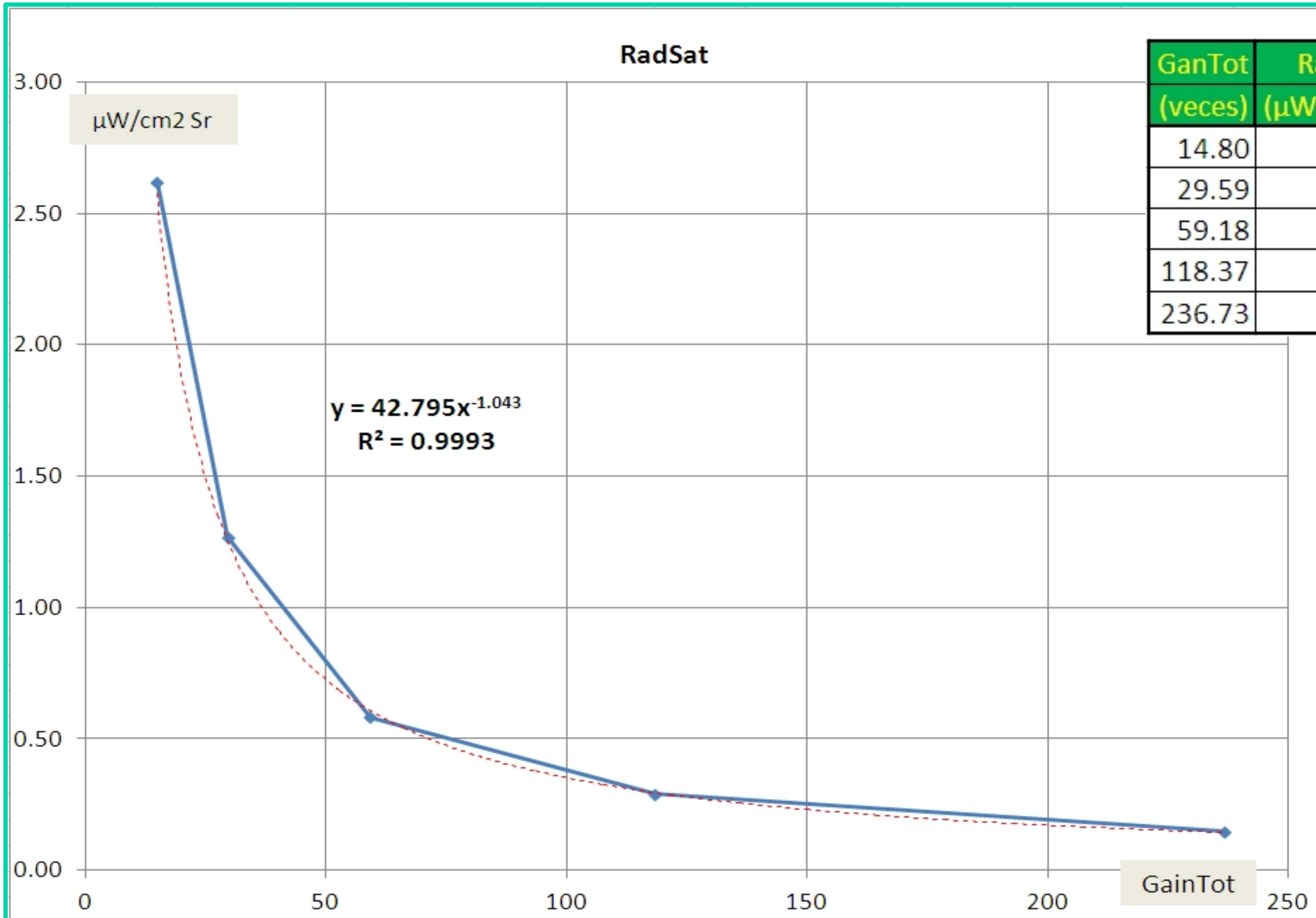
P1357



H Raimondo M Marenchino

Illuminated[DN] estimation

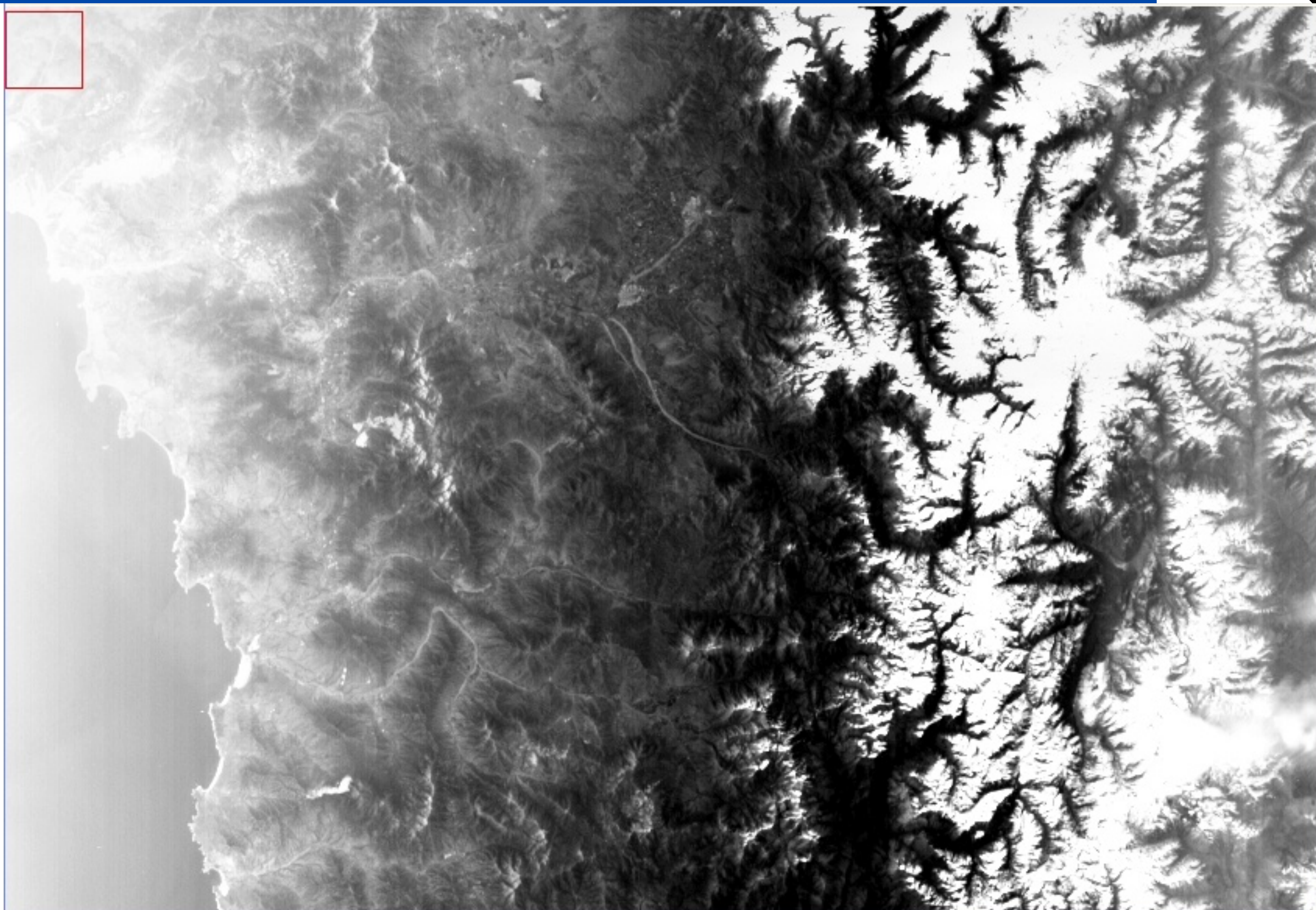
Radiance estimation



GanTot (veces)	Rad Sat (µW/cm2 Sr)
14.80	2.620
29.59	1.268
59.18	0.582
118.37	0.290
236.73	0.148

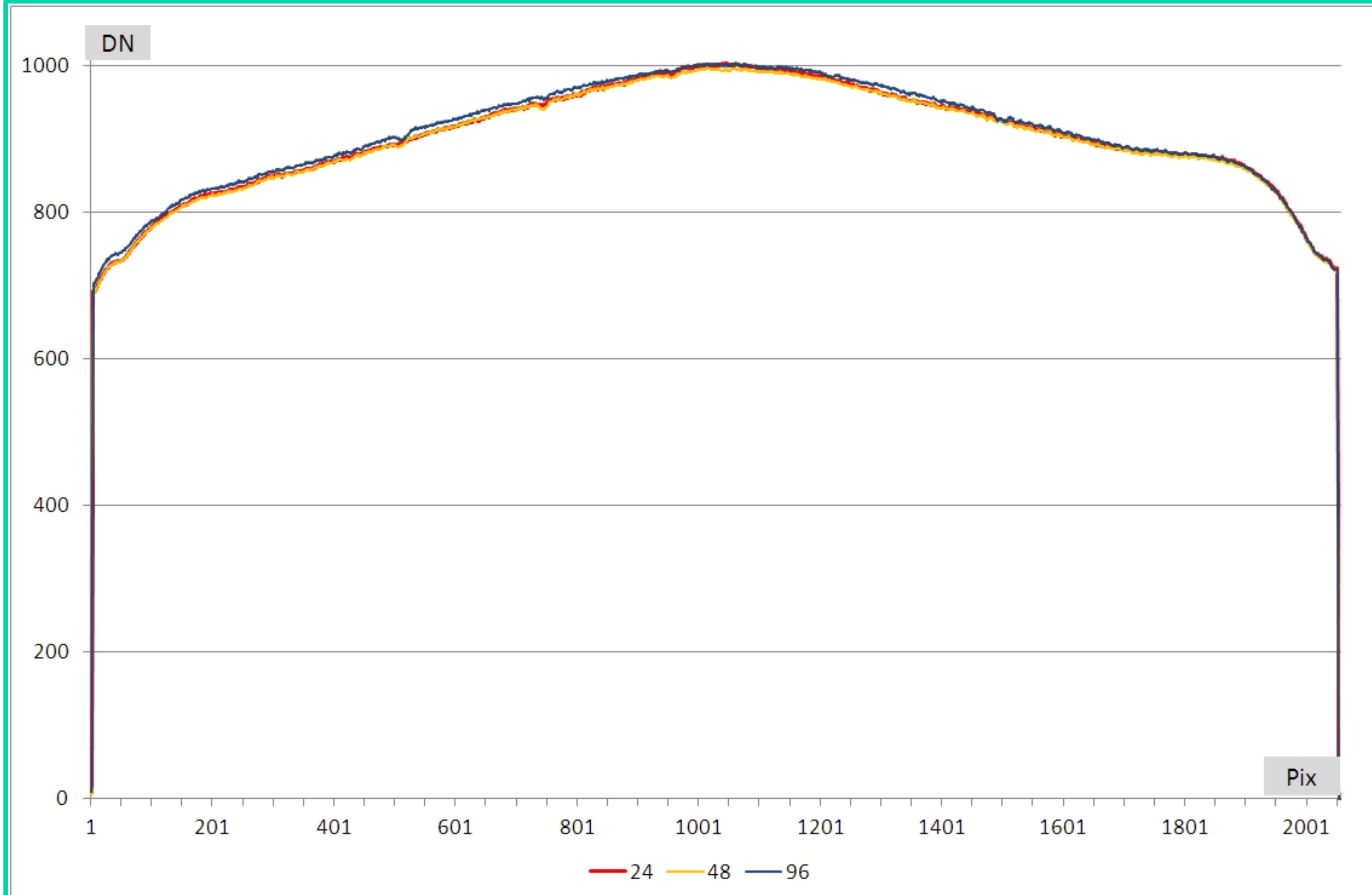
SAC-D/AQUARIUS

Raw HSC subset- Cam:2, Stag: 6, SPCX, Gain: x0A , Off: x1F4



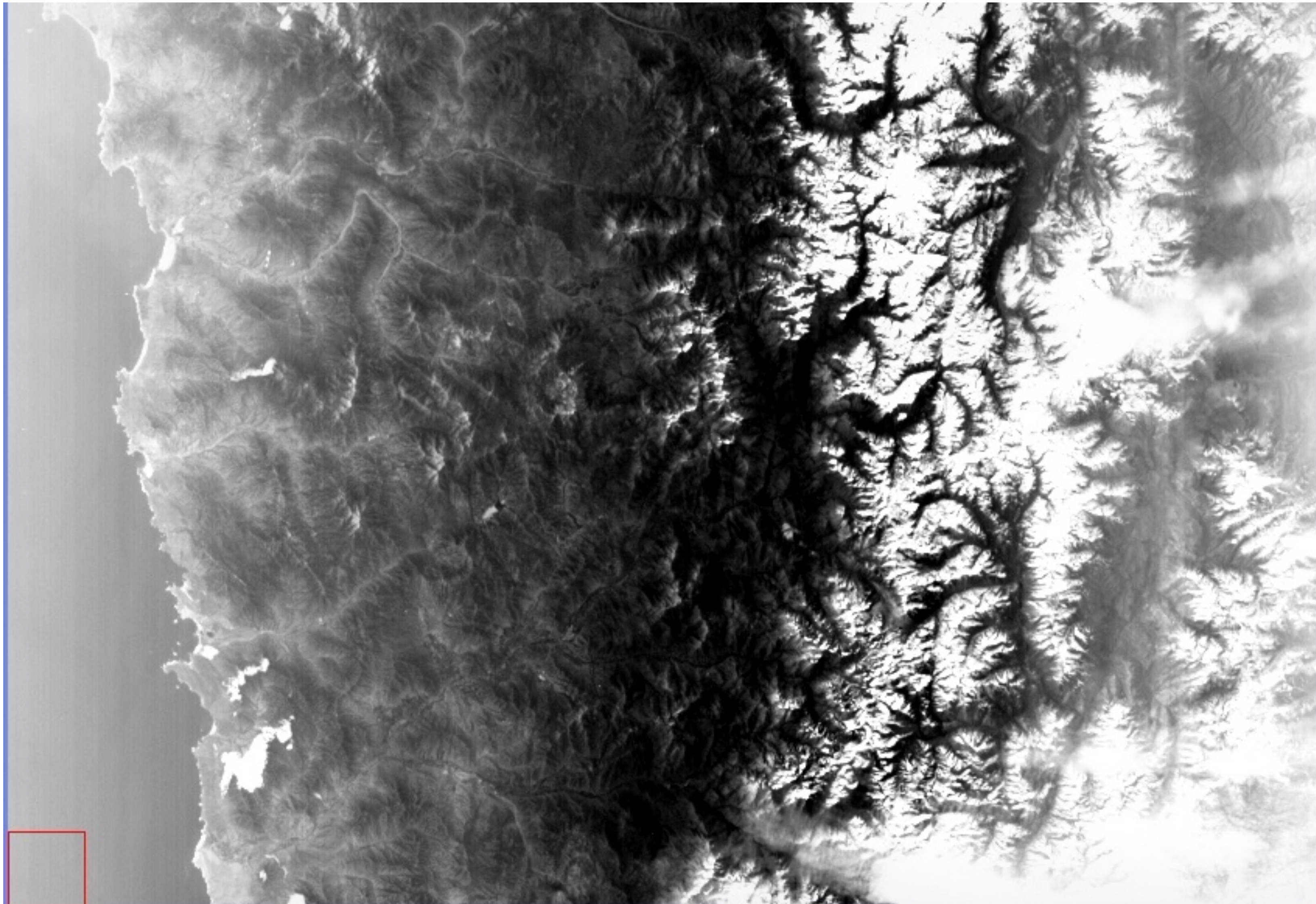
E N D

Illuminated (iluminada)



HSC - Example

HSC - Example



Instrument Presentation

❖The High Sensitivity Camera (HSC) is an instrument based on TDI CCD technology. The HSC instrument measures the Top of Atmosphere Radiance in the visible range of the spectrum (490-610 nm).

❖Data collection is performed over the dark side of the sun terminator to avoid sensor saturation due to sun light reflection and atmospheric scattering effects.

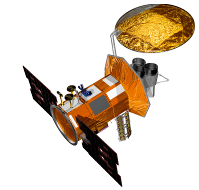
❖The HSC Instrument shall operate in Real Time Mode over Argentina and in Stored Mode over other opportunity targets around the world.

❖The HSC contains two (2) cameras, that is two (2) independent Optical Systems associated with their respective TDI CCD sensors and spectral filters. 2 x TDI with 96 stages (6, 12, 24, 48 or 96) of 2048 elements each.

❖ Each Optical System has 36.25º FOV and the angle between the optical axes of each system is 35º. The total resulting FOV is 71.3º with a little overlap of 1.2º in the center.

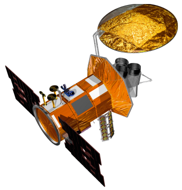
❖The center of the total FOV (boresight direction) is pointing 25º away from NADIR.

Main Characteristics of the Instrument



	Value	Units
Spectral Range:	490-610	nm
Ground Pixel Size @ nadir :	≅ 213	m
Field of View FOV1= FOV2 : Total FOV :	36.25 71.3	degrees degrees
FOV Overlap :	1. 2	degrees
Swath Width :	1614	km
Full Scale Radiance:	0.15	$\mu W / cm^2 sr$
Switchable Ranges of Full Scale Radiance:	x2, x4, x8, x16	
Radiometric Error :	< 20	%
SNR :	> 200	
Quantization :	10	bits
Mass Memory Size :	96	MBytes
Maximum Length of Stored Image :	3500	km
Required Time to fill Mass Memory :	≅ 9	minutes

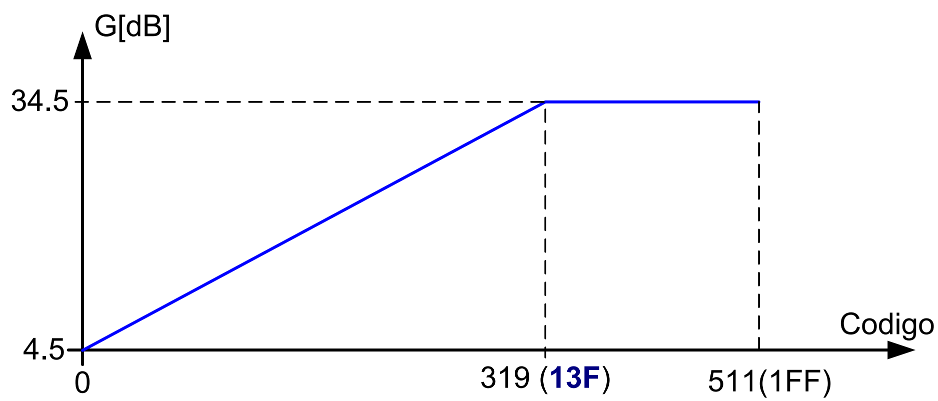
SAC-D/AQUARIUS Stages, Integration time, Gain and Offset



Stages	6	12	24	48	96
Code	0xE (14)	0xD (13)	0xB (11)	0x7 (7)	0xF (15)
Gain X	x1	x2	x4	x8	x16

Integration time: Is programmable between 23 and 44.966ms, with 256 programming steps and a resolution, per step of 0,08614ms.

The gain varies linearly between 4.5 and 34.5 dB in steps of 0.1 dB. The gain codes varies from 0 to 319, for any code over 13F the gain is 34.5 dB.



Tiempo de Integracion		
TI - hex	TI - dec	TI - ms
0	0	23.0000
A	10	23.8614
14	20	24.7228
1E	30	25.5842
28	40	26.4456
32	50	27.3071
3C	60	28.1685
46	70	29.0299
50	80	29.8913
5A	90	30.7527
64	100	31.6141
6E	110	32.4755
78	120	33.3369
82	130	34.1984
8C	140	35.0598
96	150	35.9212
A0	160	36.7826
AA	170	37.6440
B4	180	38.5054
BE	190	39.3668
C8	200	40.2282
D2	210	41.0896
DC	220	41.9511
E6	230	42.8125
F0	240	43.6739
FA	250	44.5353
FF	255	44.9660

The offset is a lineal function of the "offset codes" that varies from 0 to 1023.