CABER
LIMA- PERÚ 2017

100 años PUCP

Simulation and characterization of a photovoltaic system at working conditions

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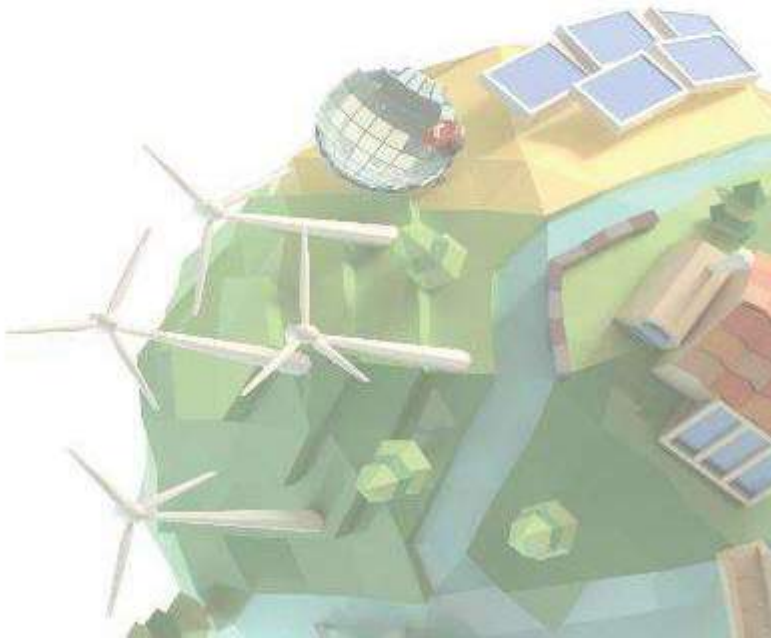


PRIMER CONGRESO DE ENERGÍAS RENOVABLES Y ARQUITECTURA BIOCLIMÁTICA **I CABER 2017**

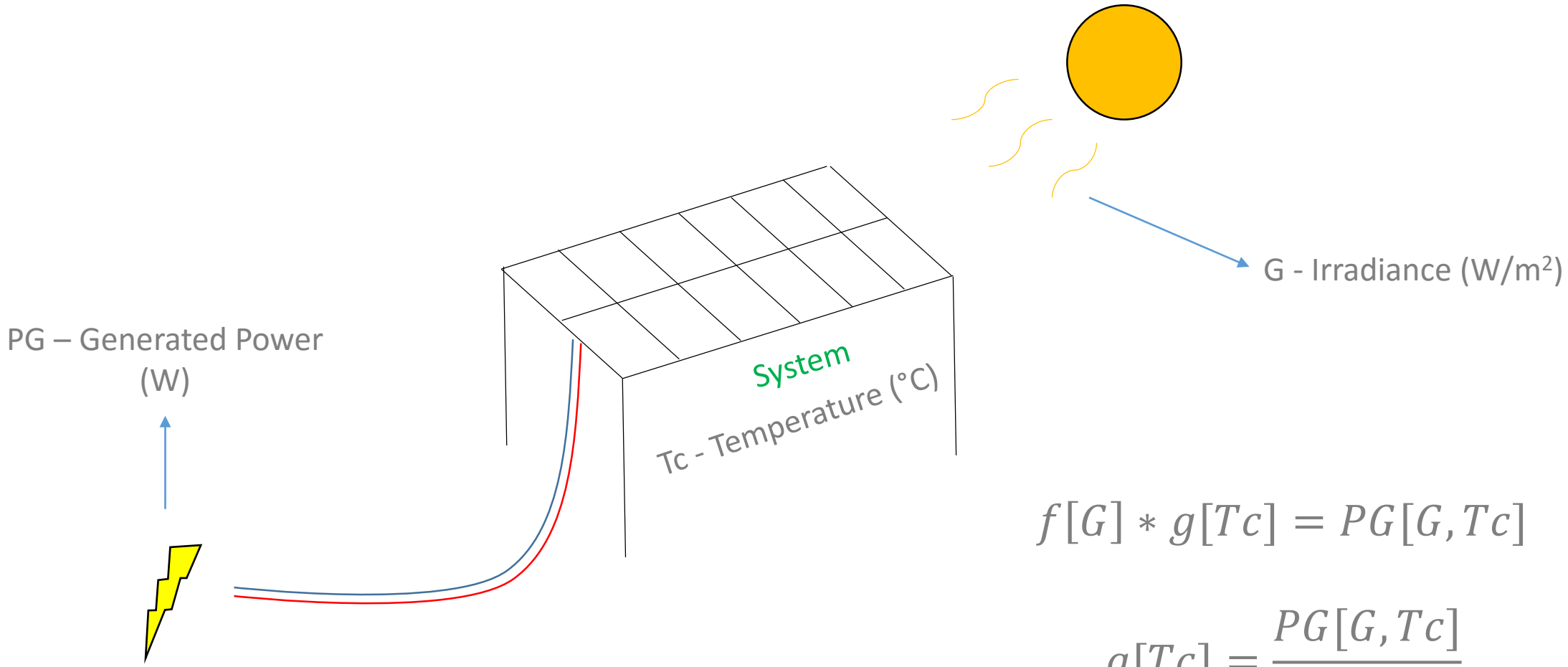
“Reconstruyendo el Perú Sosteniblemente”

Objective

Develop a method to find the practical Power(PP):

- ✓It give us information about the presence of intrinsic losses in a photovoltaic system while it is preforming.
- ✓Help to decreases the deviation in prediction of energy produced.
- ✓Reduce the time of study.
- ✓The method is invariant for external losses.

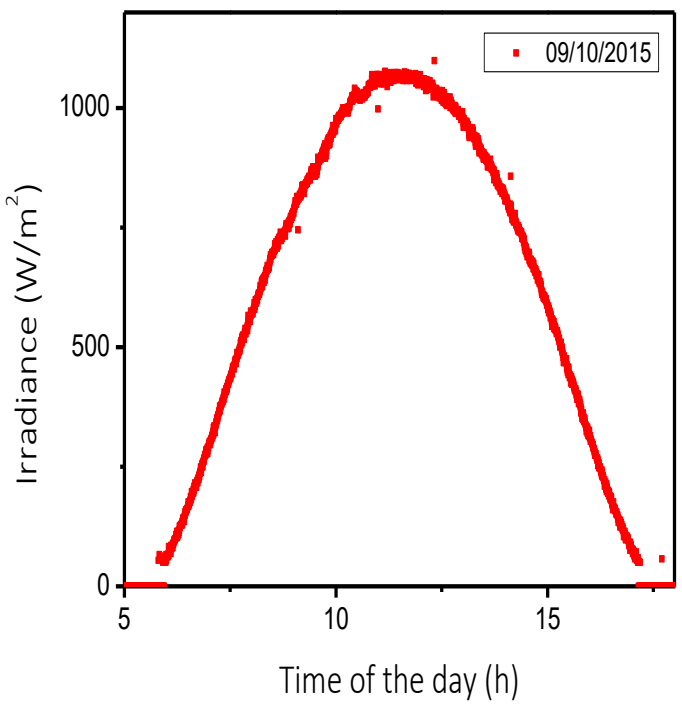
Simple scheme of a PV system



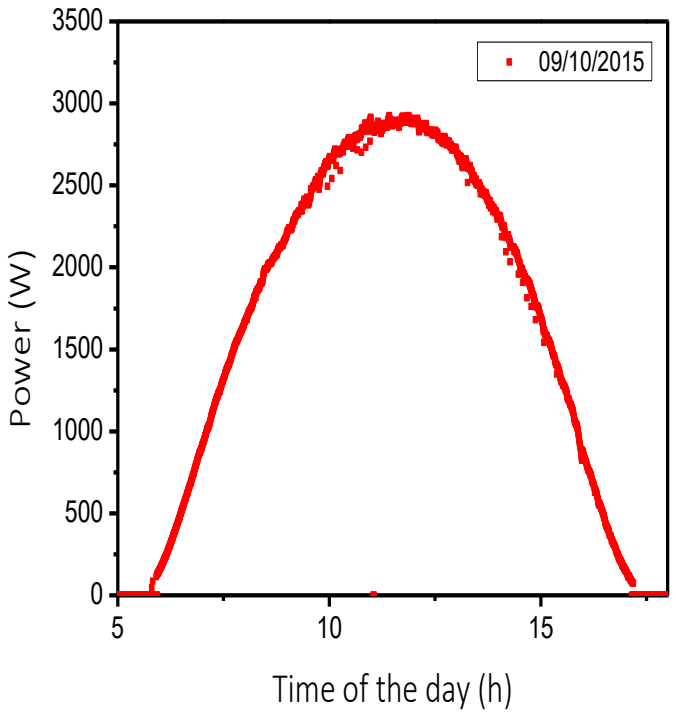
$$f[G] * g[Tc] = PG[G, Tc]$$

$$g[Tc] = \frac{PG[G, Tc]}{f[G]}$$

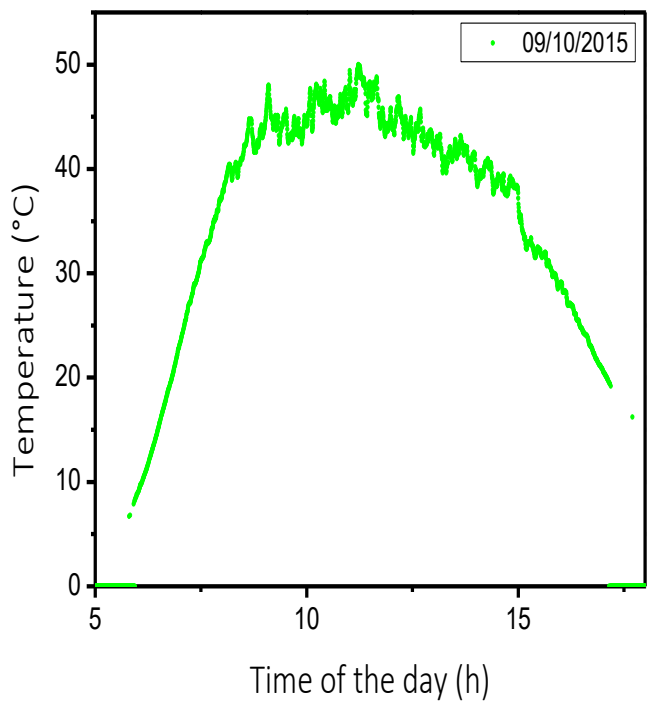
Irradiance



Generated Power



Cell Temperature



3.3 kW Photovoltaic System grid-connected

Solar Array Properties

Pstc or NP

Maximum Power	3300 W
Short-circuit current	28.74A
Open-circuit Voltage	472.8 V
Maximum Power Point Current	26.82 A
Maximum Power Point Voltage	382.8 V
Thermal losses coefficient of Power (γ)	-0.041%

Pstc : Power at standar conditions (1000 W/m2, 1.5 Air Mass and 25°C)

Osterwald's Model*

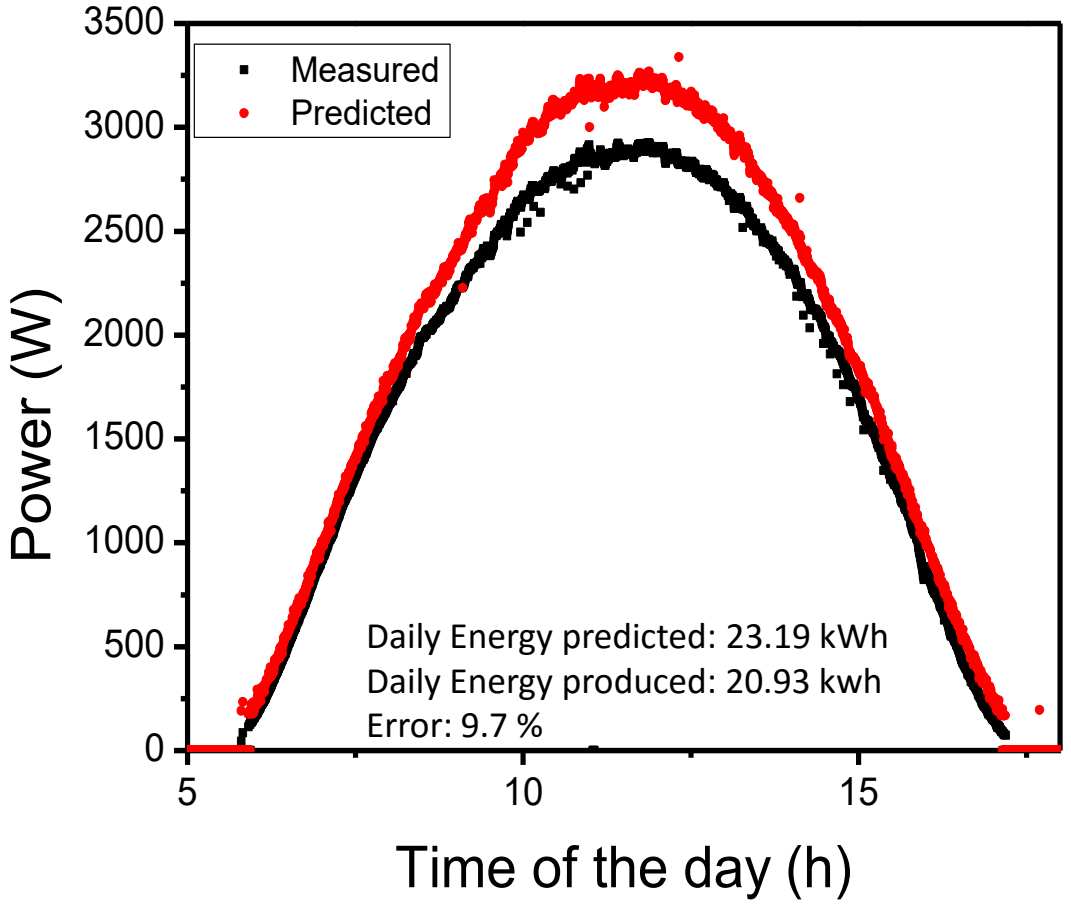
$$P_{Osterwald}[G, Tc] = \frac{G}{1000} * NP * (1 + \gamma(Tc - 25))$$

$PG[G, Tc]$ $f[G]$ $g[Tc]$

Osterwald model is used for photovoltaic cells, modules and big arrays.

(*) 1986 – C R Osterwald . Translation of device performance measurements to reference conditions. Solar Cells, 18 , 3-4 Pages 269-279.

Prediction using Osterwald's Model



Osterwald's Method to improve the accuracy

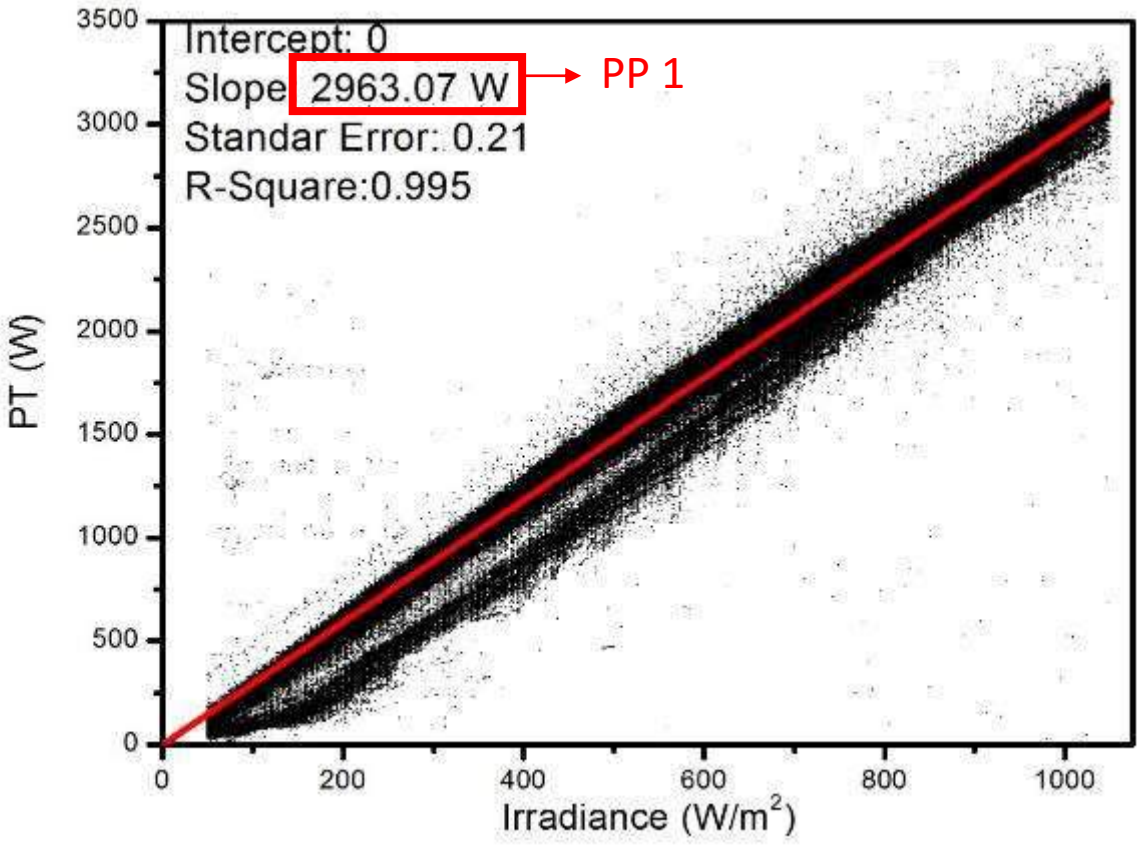
Osterwald's Model

$$P_{\mathrm{produced}} = \frac{G}{1000} * \mathrm{NP} * \left(1 + \gamma(\mathrm{Tc} - 25)\right)$$

Equation form is changed:

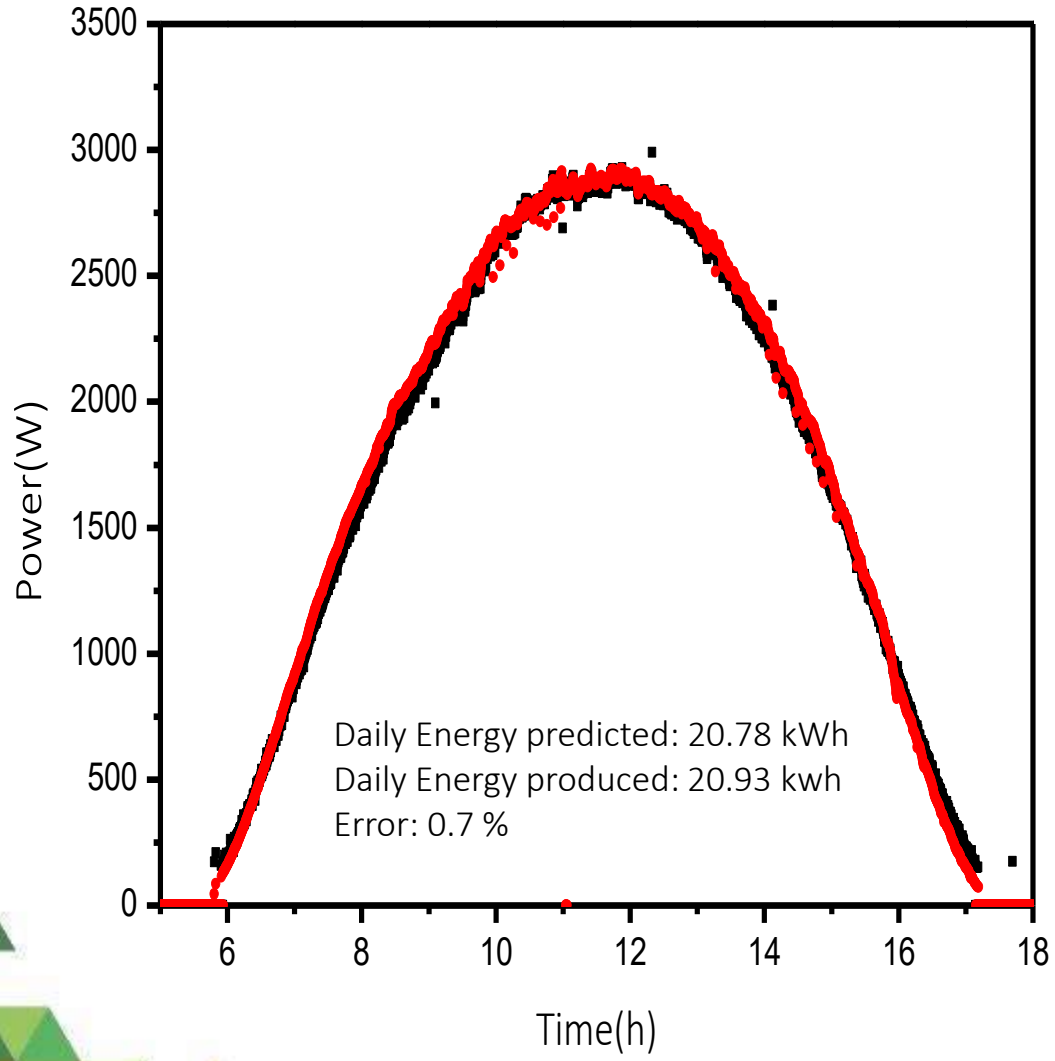
$$\frac{P_{\mathrm{produced}}}{\left(1 + \gamma(\mathrm{Tc} - 25)\right)} = P_{\mathrm{stc}} * \frac{G}{1000} = PT$$

$$y = \quad m \quad * \quad x$$

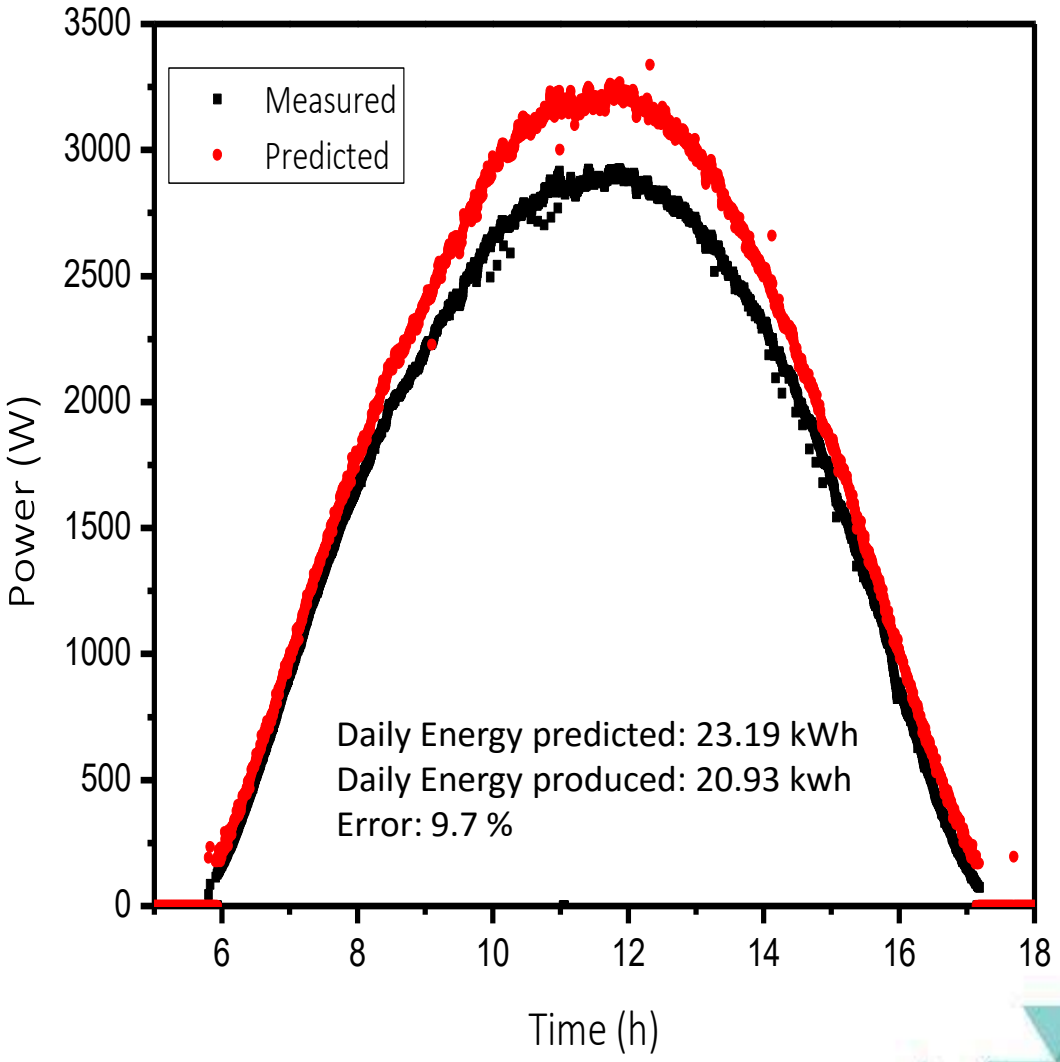


From the graphic, it is possible to obtain the slope, our new Pstc

Prediction with Osterwald's Method of correction

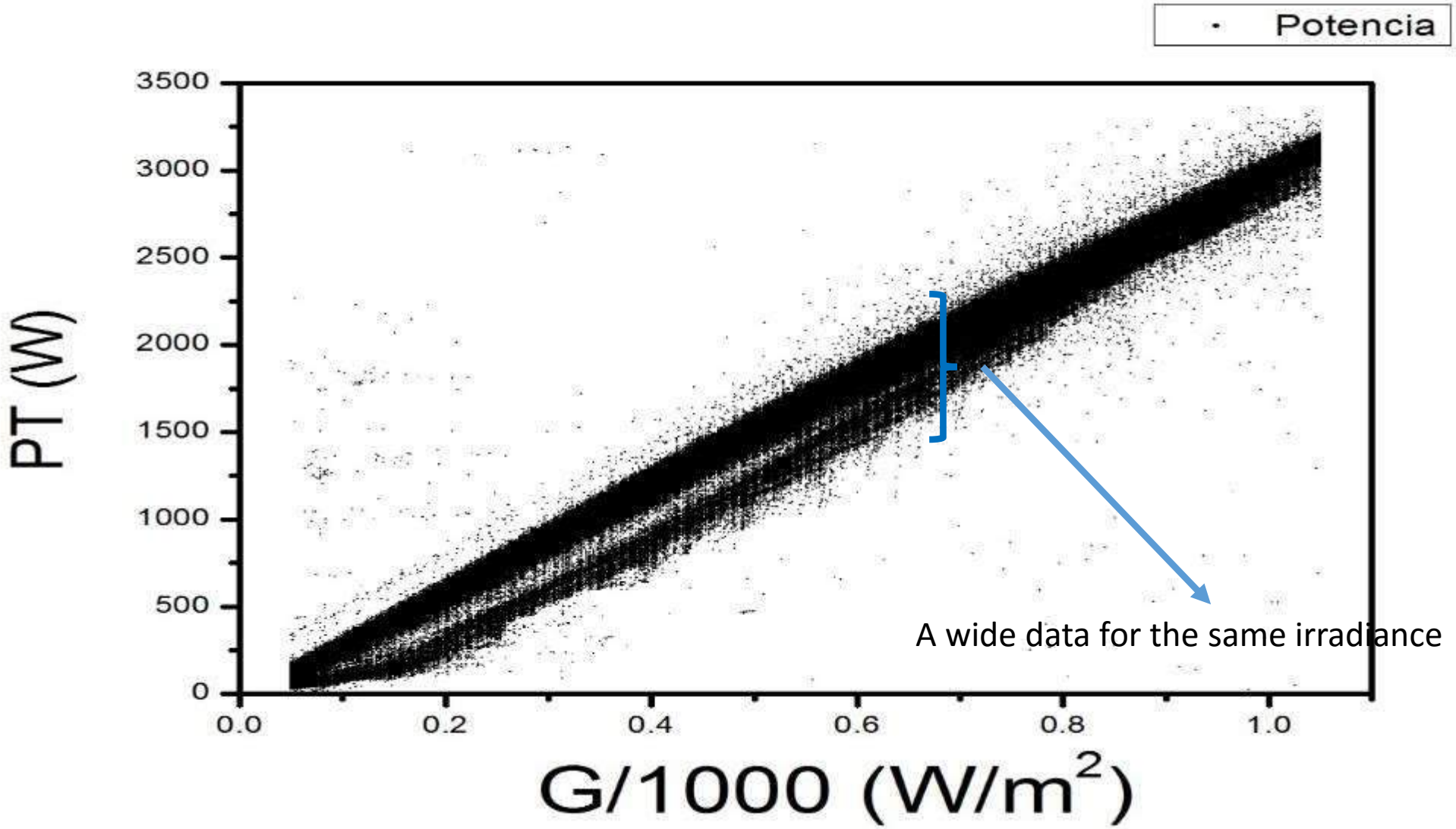


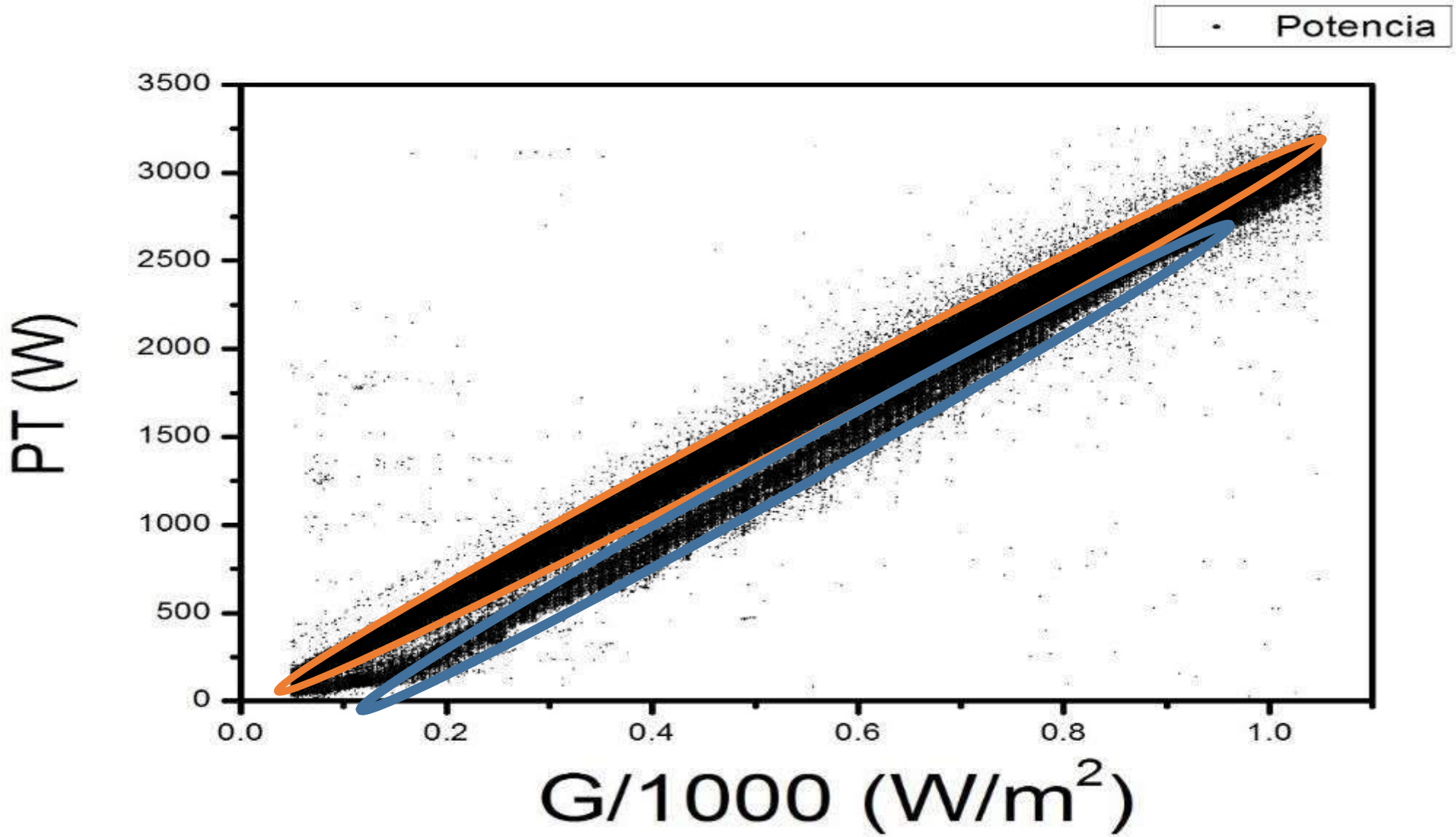
Prediction with Osterwald's Model



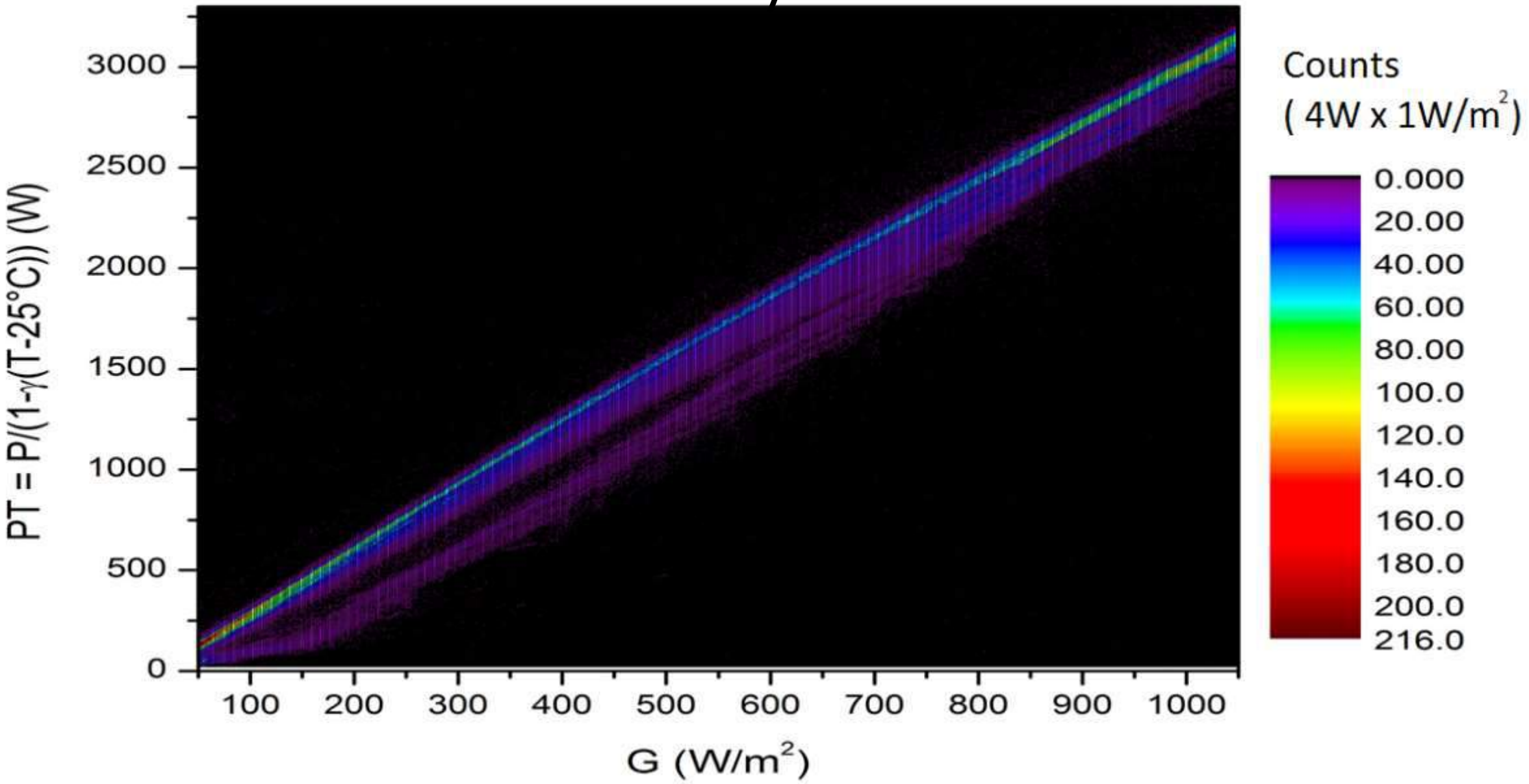
Comparison of Predictions

		Study time: 6 months		Study time: 12 months	
Power (W)	Method	Value of Pstc (W)	MBE (%)	Value of Pstc (W)	MBE (%)
NP	Osterwald Model	Pstc=3300.0	9.88	Pstc=3300.0	9.047
PP 1	Osterwald Method	Pstc=2940.69	-2.826	Pstc= 2963.07	-2.086

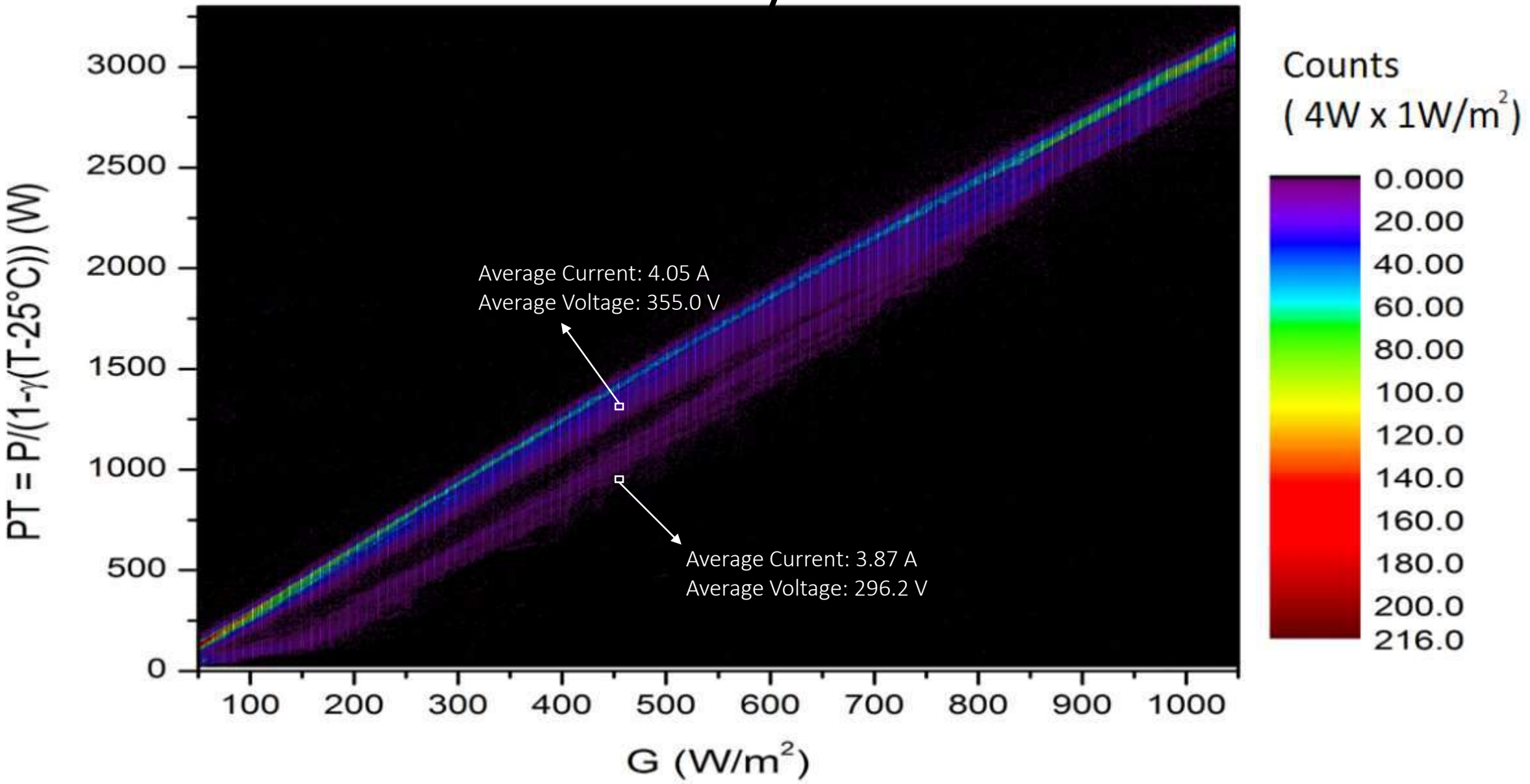

Potencia
PT (W)
3500
3000
2500
2000
1500
1000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
G/1000 (W/m²)
A wide data for the same irradiance


Potencia
PT (W)
3500
3000
2500
2000
1500
1000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
G/1000 (W/m²)

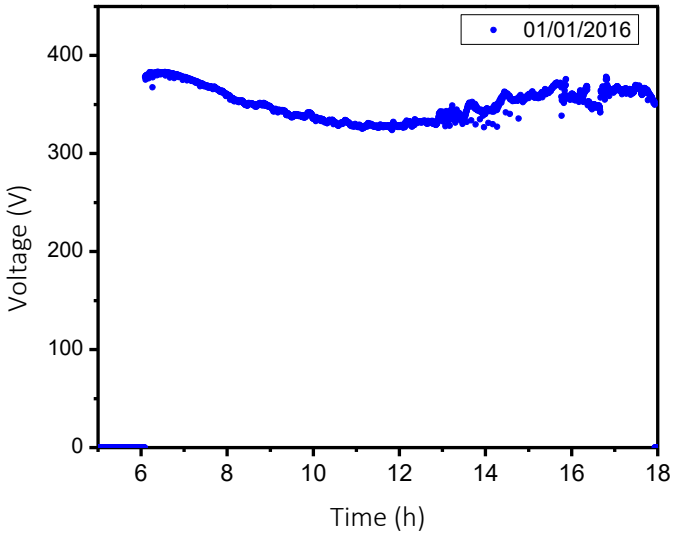
Density Plot

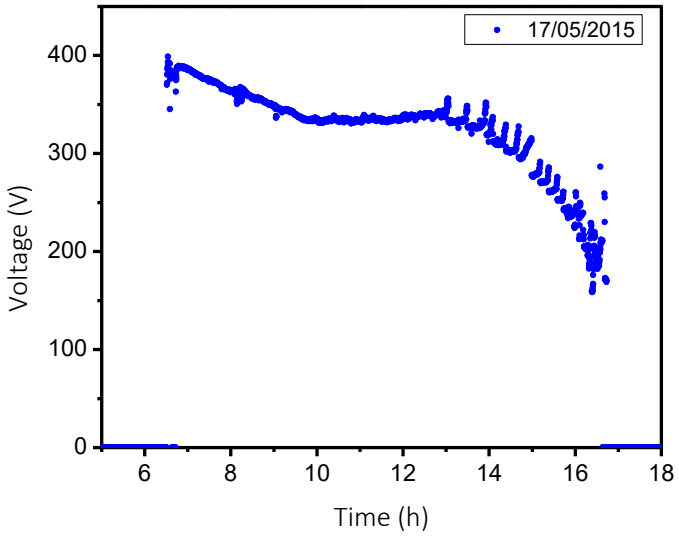


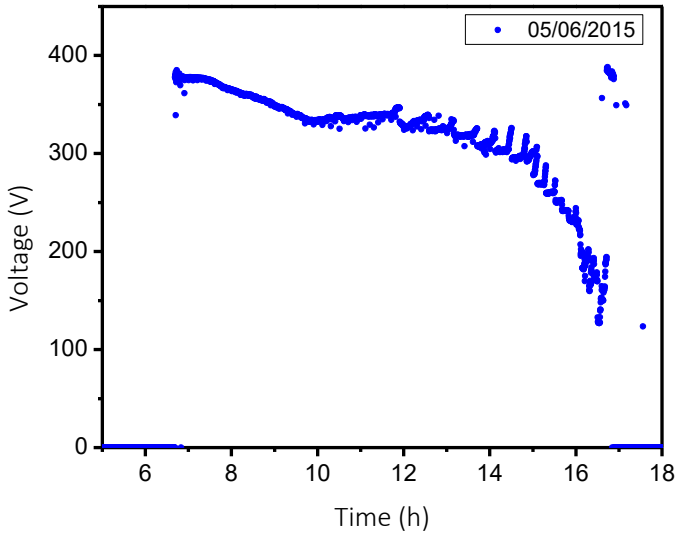
Density Plot

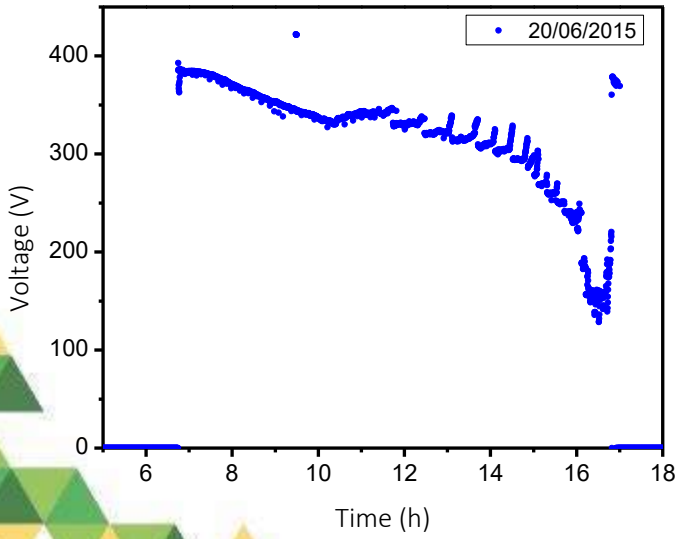


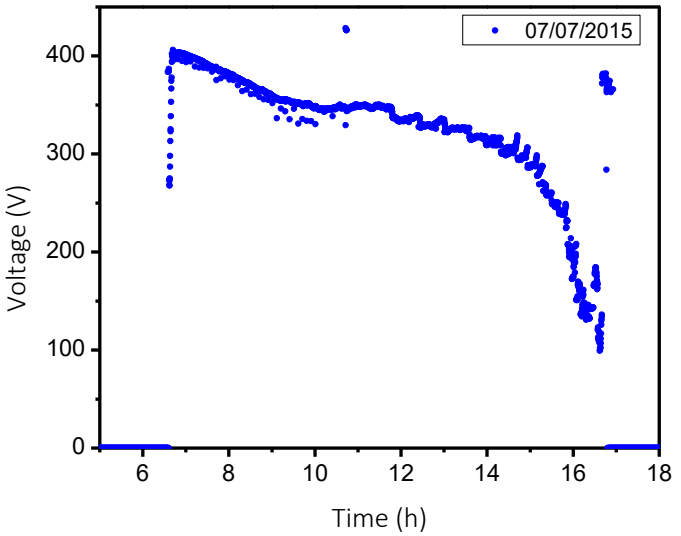
Drop of Voltage (3 May to 25 July)

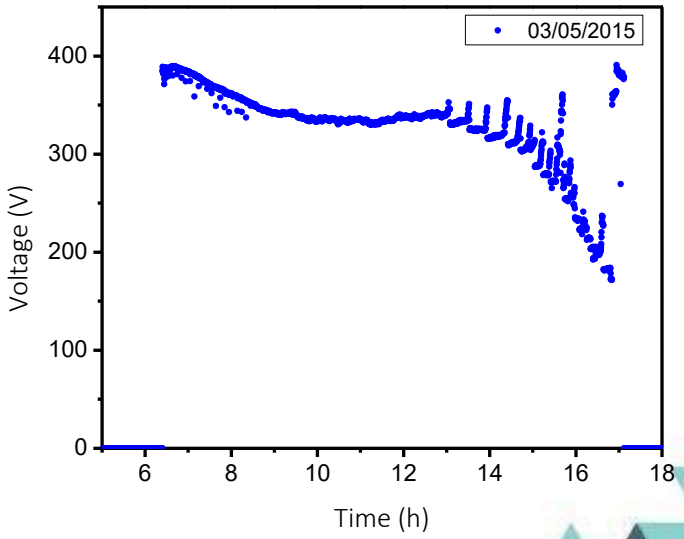




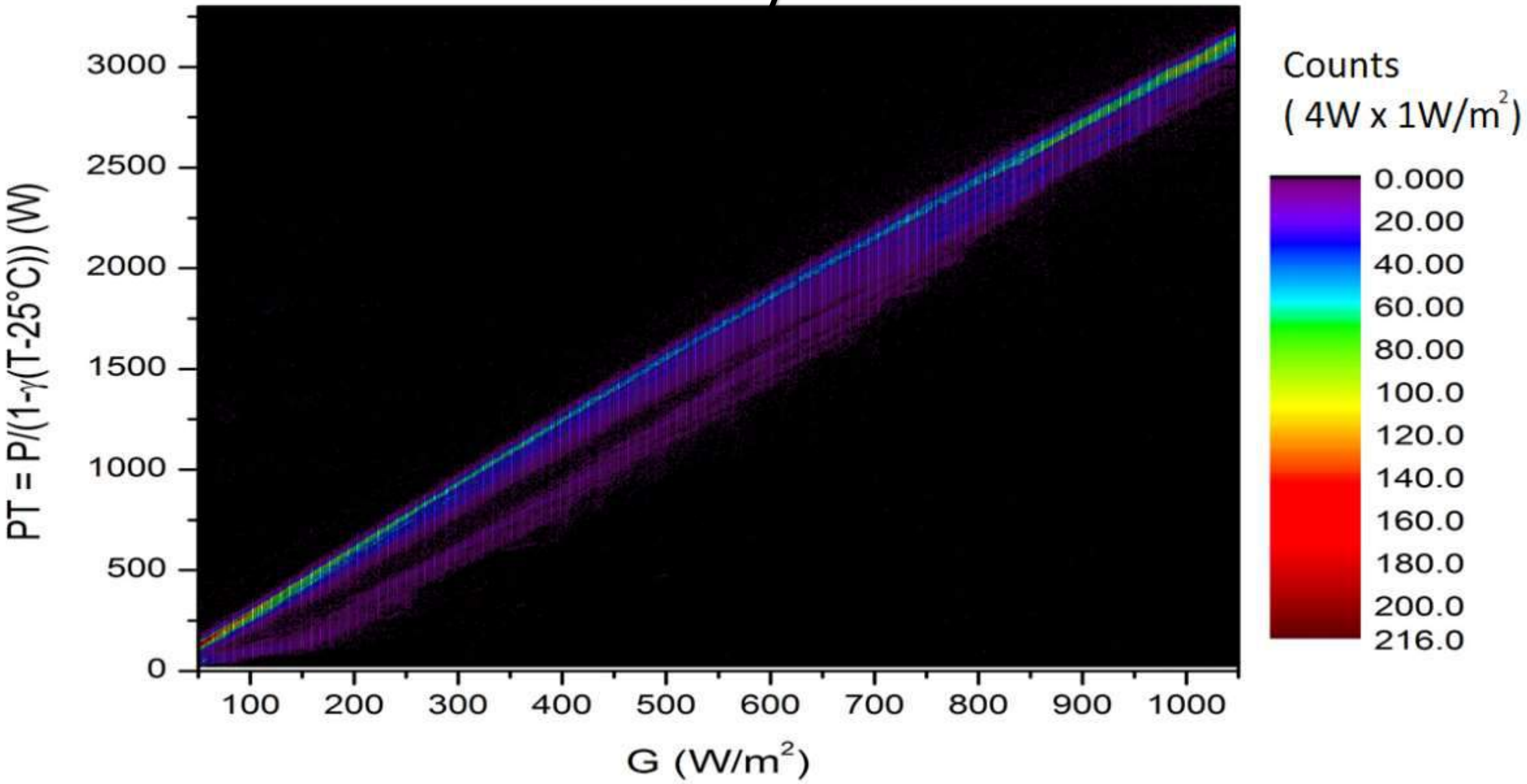




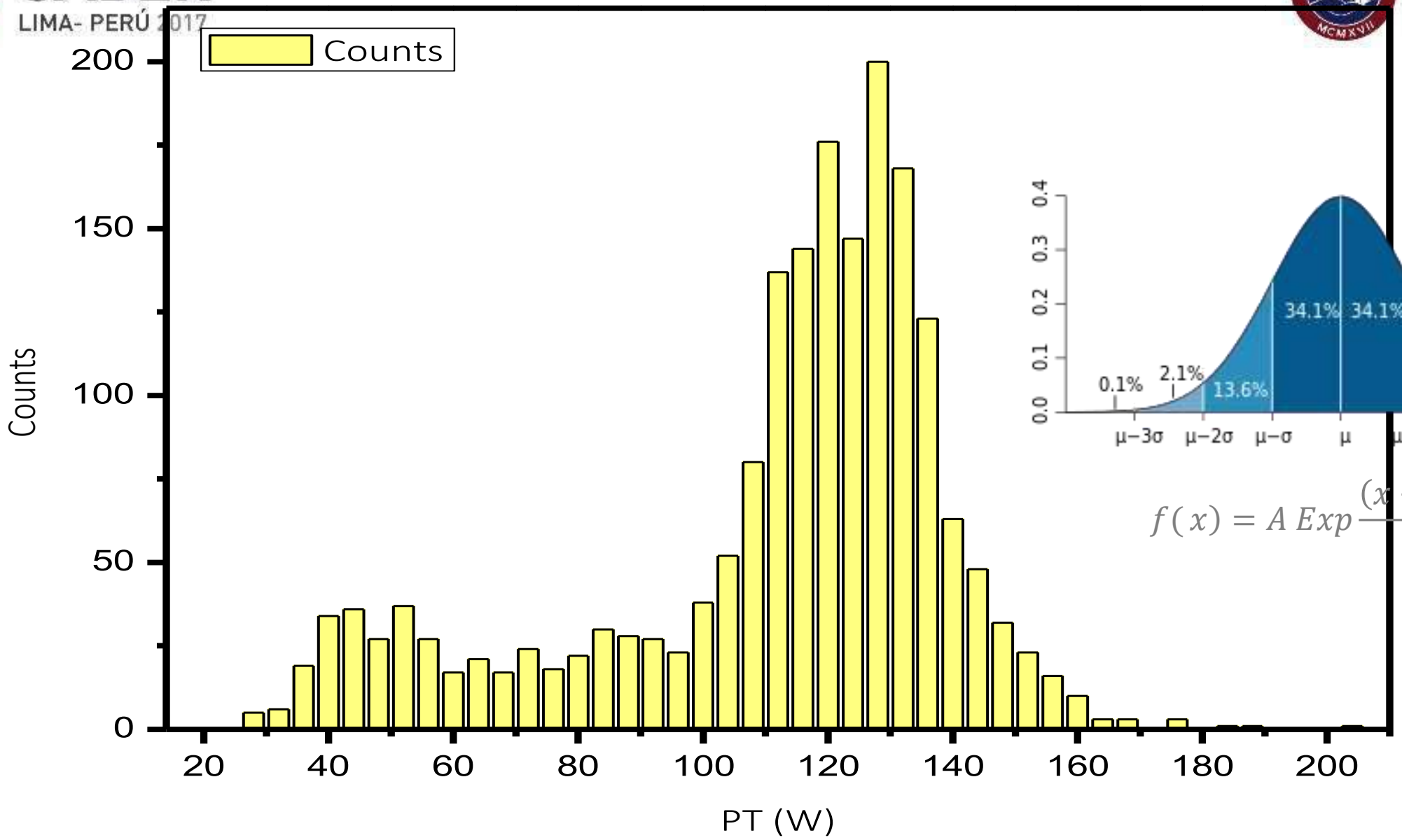




Density Plot

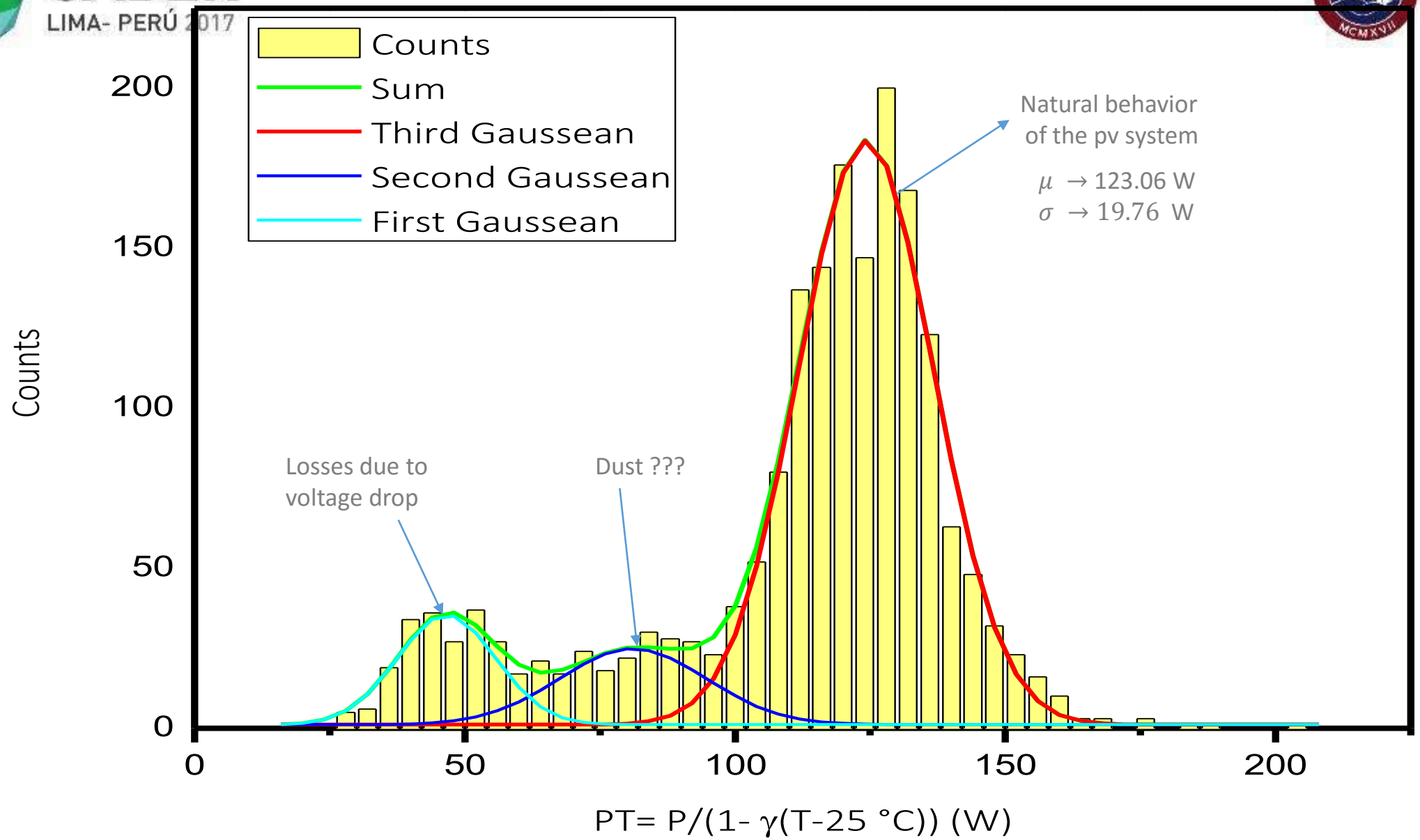


G = 51 W/m^2

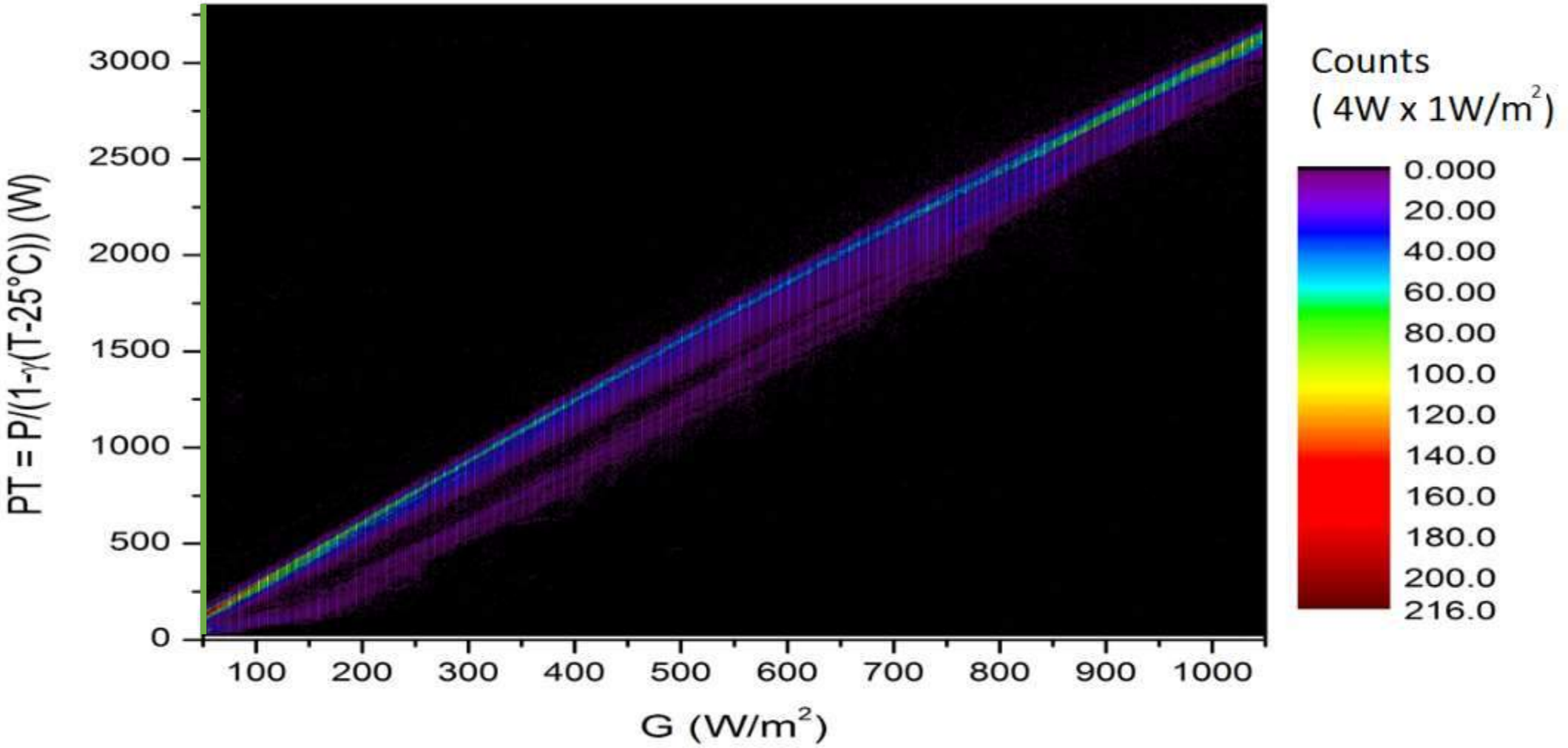


$$f(x) = A\,Exp\frac{(x-\mu)^2}{\sigma^2}$$

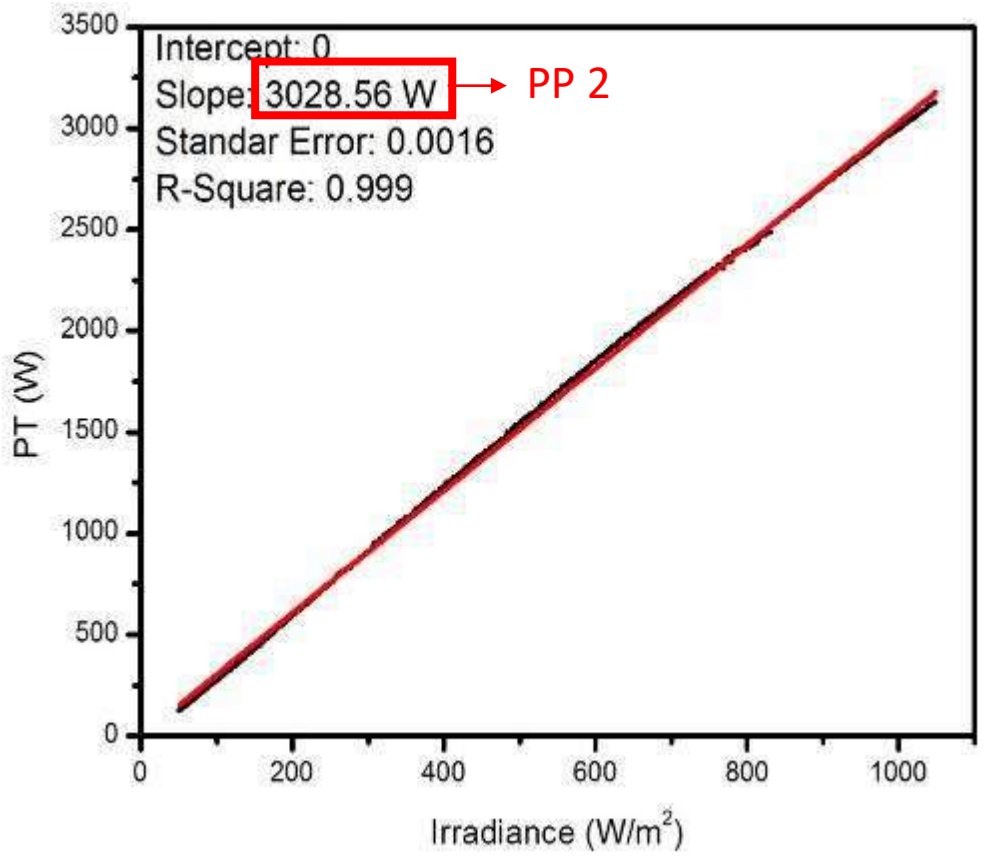
G = 51 W/m^2


Counts
Sum
Third Gaussean
Second Gaussean
First Gaussean
Natural behavior of the pv system
$\mu \rightarrow 123.06$ W
$\sigma \rightarrow 19.76$ W
Losses due to voltage drop
Dust ???
Counts
0
50
100
150
200
PT= P/(1- γ(T-25 °C)) (W)

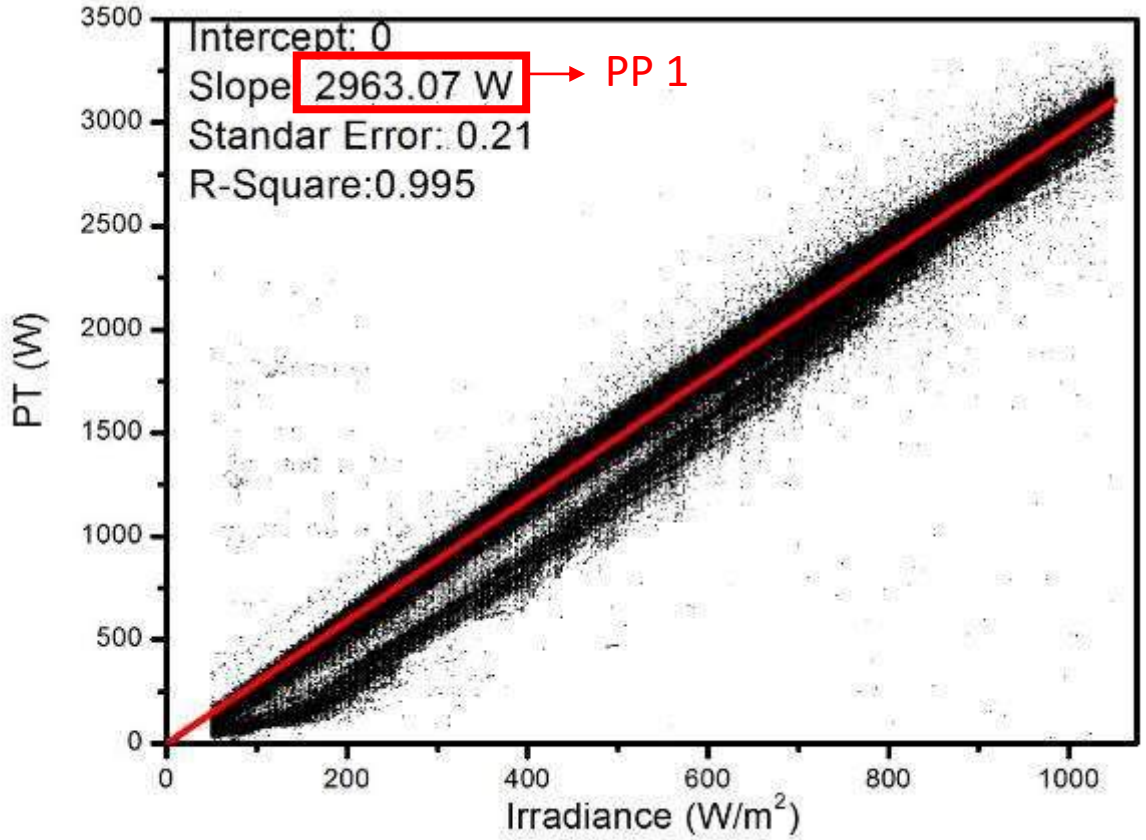
Histogram 3D o Contour Plot



Osterwald Gaussean Filter



Osterwald's fit method



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PP 1	Osterwald Method	Pstc=2940.69	-2.826	Pstc= 2963.07	-2.086
PP 2	Osterwald gaussian filter	Pstc=3030.2	0.208	Pstc= 3028.56	0.154

Conclusions

- Our method presents a slightly improvement in the 2.6 % of MBE against the common Osterwald method.
- Our method decreases time of study to the half. It does not have a notable improve if the method is applied to more time of study.
- The method is non-sensible to the shadows on the array (external losses). In other words, the presence of shadows do not have influence in the prediction.
- The method give us a notion for intrinsic losses, around 8 % in this case.