Experimental Set-up of FSO-Fiber converged communication system

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Objective

01. Measurement of received power at different locations of receiver,
02. BER measurement at different location for different received powers.
03. BER measurement with different atmospheric conditions.
04. Measurement of the turbulence strength parameter.

Hardware Set-up

Experiment Video

Recorded Data

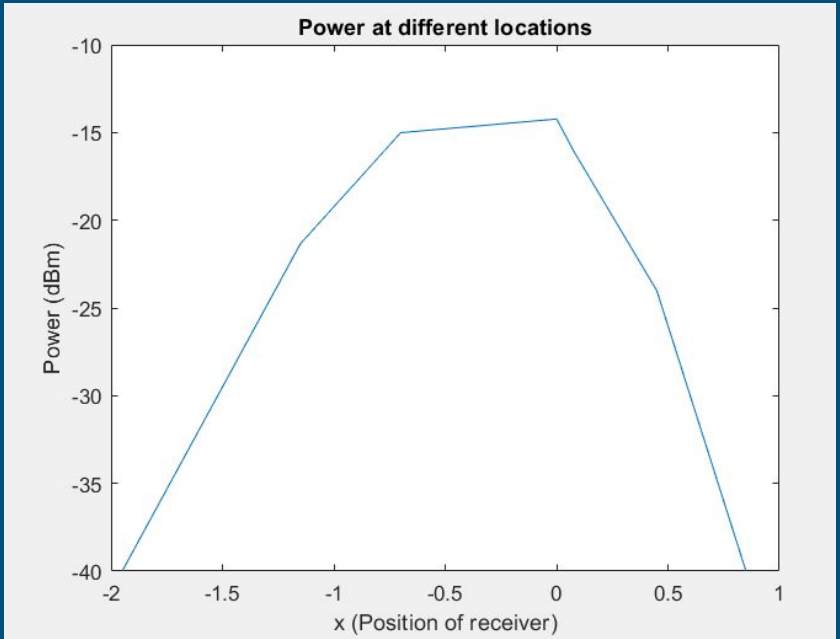
Readings

Theory

- Free space optical communication is a wireless communication in which optical beam is used to transmit data.
- Performance of this communication technique is affected by different factors like atmosphere condition, temperature, turbulence.
- Atmospheric turbulence is the change of refractive index of the free medium causes by different temperatures at different atmospheric levels, Wind speed.
- Increase in turbulence reduces performance and reduces received power.
- Path loss is caused by fog, snow, rain, dust etc.

Power at different locations

- (X, Y, Z) = (0, 0, 0) -> Point where maximum power is obtained
- -ve represent left side of maximum point whereas +ve represent ride side of maximum point

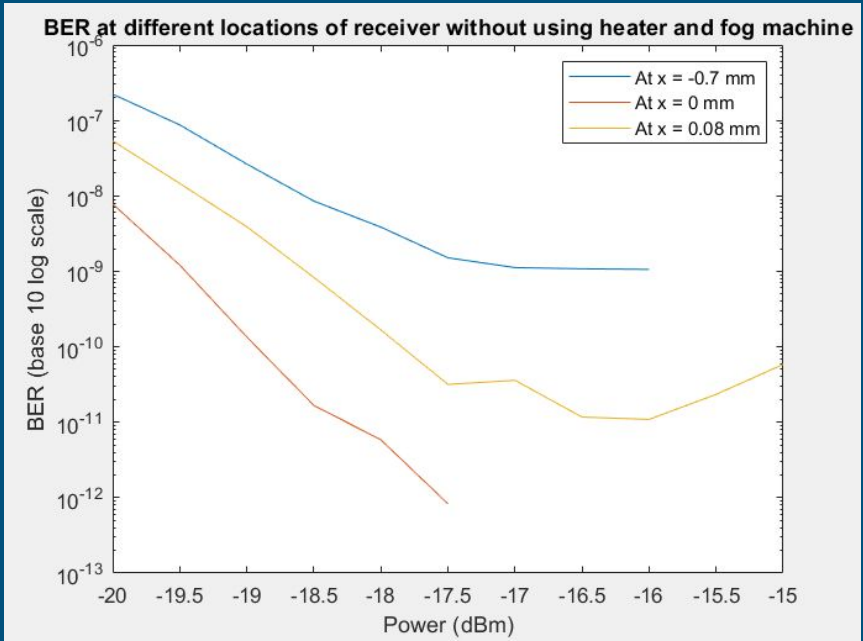


X (mm)	Power (dBm)
-1.95	-40
-1.15	-21.34
-0.7	-15.01
25.15	-14.23
0.08	-16.13
0.45	-24.02
0.85	-40

Conclusion

1. Power received, first increases and then decreases as we start from extreme point.
2. For multiple receivers, receivers should be placed as close as possible to each other.

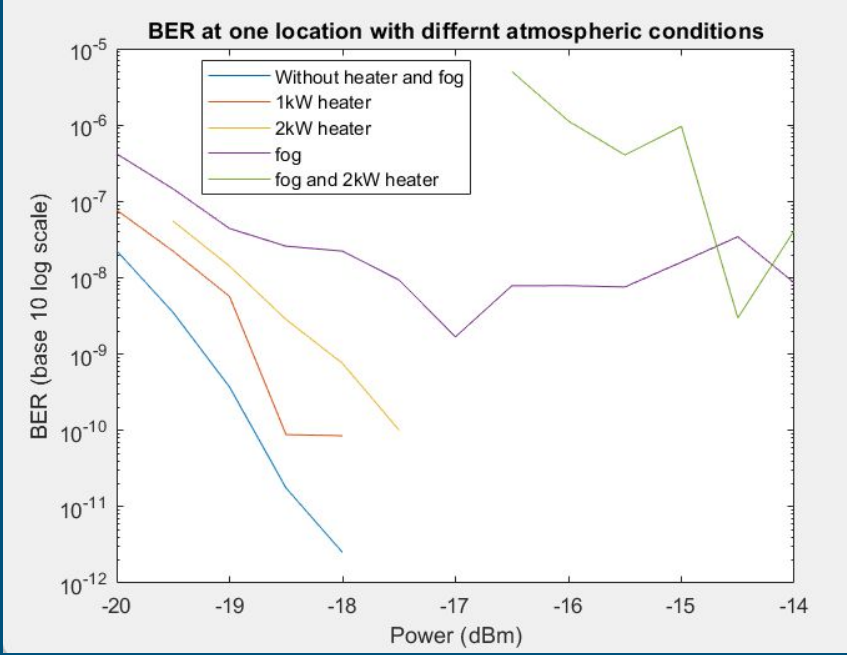
BER at different location with different attenuation for unframed data without using fog and heater



- BER increases with increase in attenuation.
- BER is minimum at middle position of receiver and increases on moving in either direction.

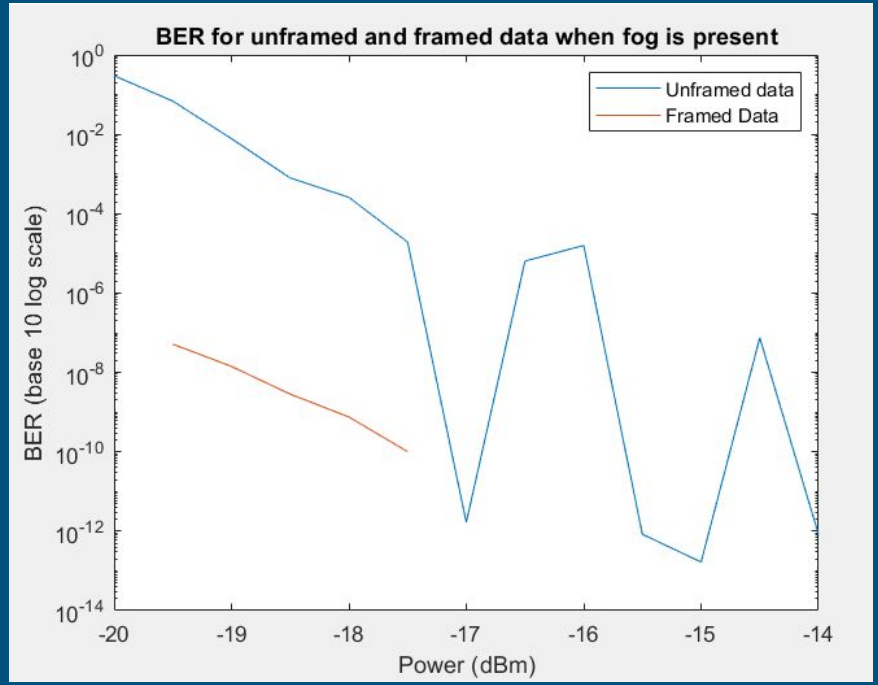
BER measurement for different conditions with different attenuation

For Framed data



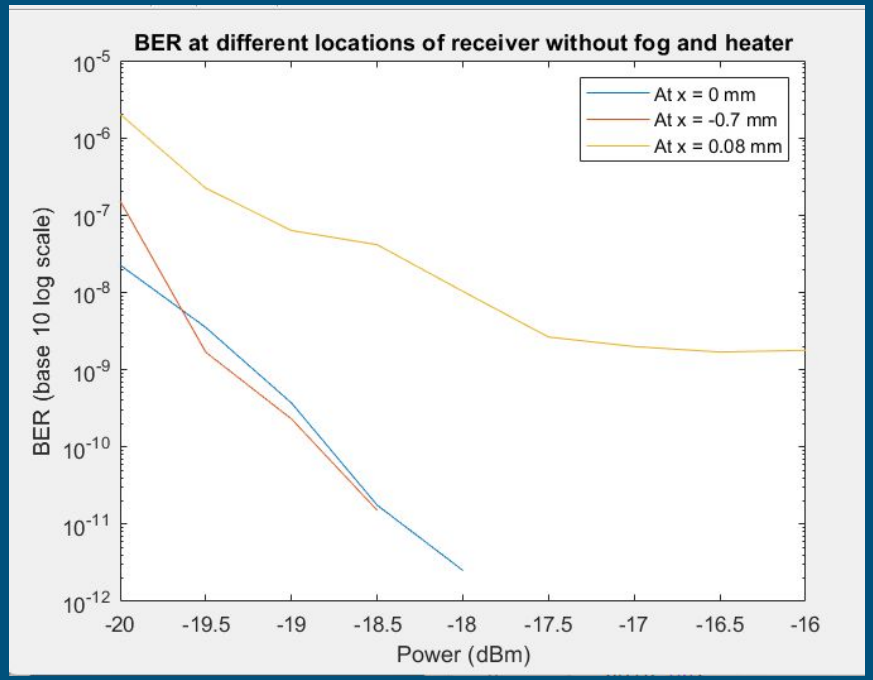
- BER increases as turbulence increases.
- At high turbulence BER is significant even at higher powers.
- Fluctuations in BER increases with increase in turbulence.

BER measurement for framed and unframed data with different attenuation when fog is present



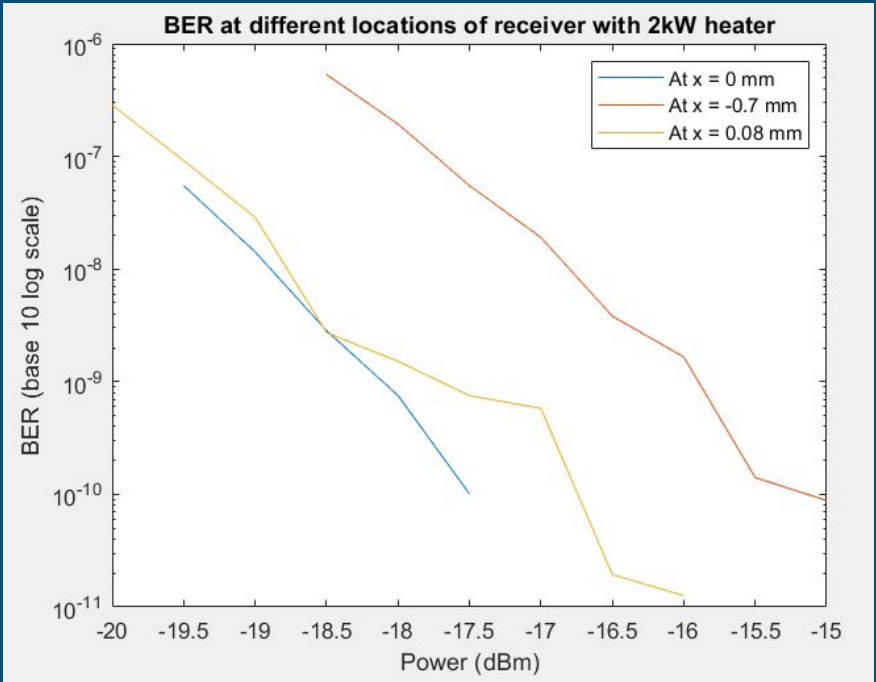
- BER for framed data is very less than BER for unframed data at same attenuation.
- Due to fog, fluctuations in BER increases.

BER at different location with different attenuation for framed data without fog machine and heater



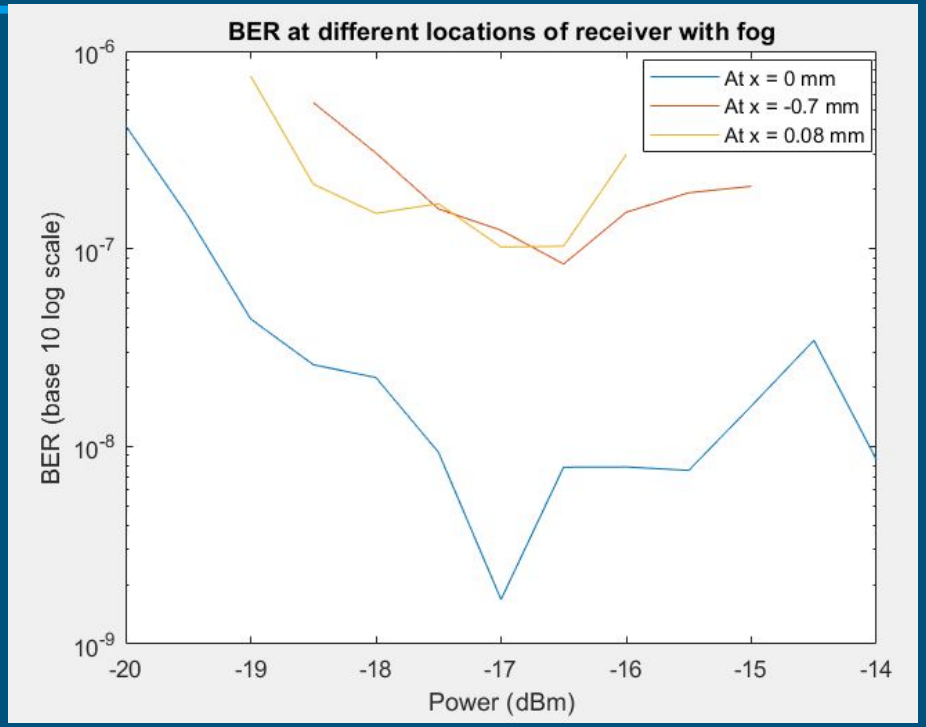
- BER increases with increase in attenuations.
- BER is minimum at x = 0 mm (Position corresponding to maximum power)

BER at different locations with different attenuation for framed data with 2kW heater



- BER is minimum at (0, 0, 0) (Position corresponding to maximum power)

BER at different location with different attenuation for framed data with fog



- BER is minimum at x = 0 mm, y = 0 mm and z = 0mm.
- Fluctuations in BER value because of fog for different attenuation.

Turbulence strength parameter (Cn^2) calculation

$$r_k = h_k x_k + n_k,$$

r_k = Received signal power
x_k = Transmitted signal power
h_k = Channel gain
n_k = Noise

$$\sigma_I^2 = \frac{E[h^2] - E[h]^2}{E[h]^2}$$

σ_I^2 = Scintillation Index (S.I.) (The normalized variance of the channel gain)

$$\sigma_I^2 = 1.23 C_n^2 k^{7/6} L^{11/6}$$

k = wave number for lambda = 1550 nm (k = 4.0537E+06)
L = Length of link in meter (L = 6.4)

Calculation

When fog machine and 2kW heater are used

- S.I. by formula is variance/mean^2

S.I. = (1.298/6.0633)^2

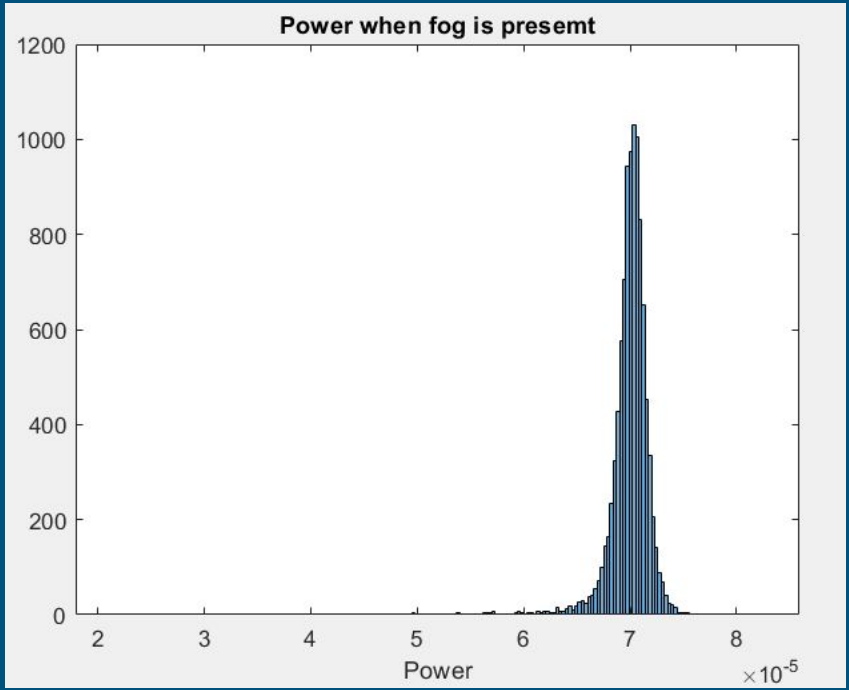
Cn^2 = 0.0459/((1.23)*((6.4)^11/6)*(4.0537E+06^(7/6)))

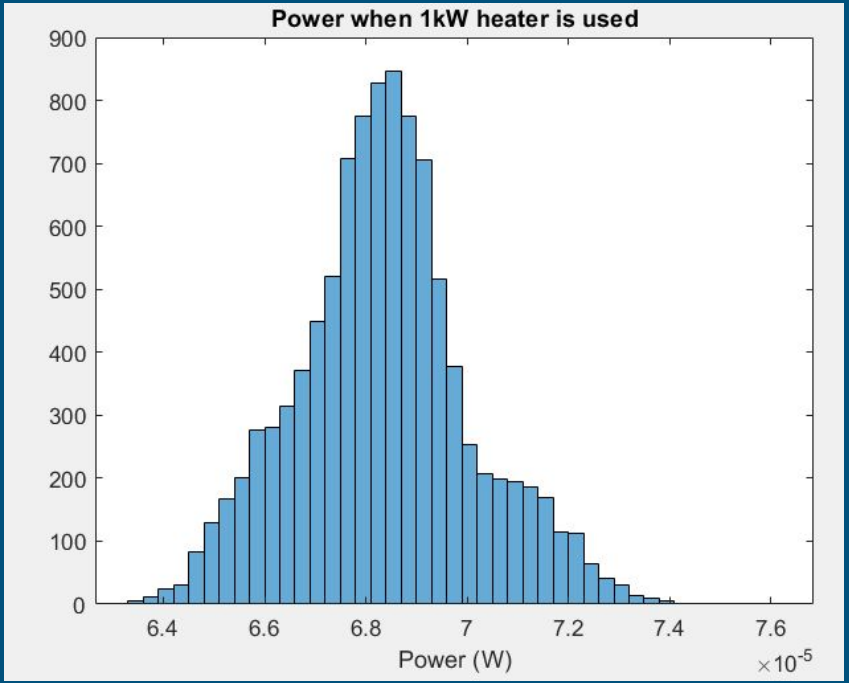
Cn^2 = 2.4237E-11

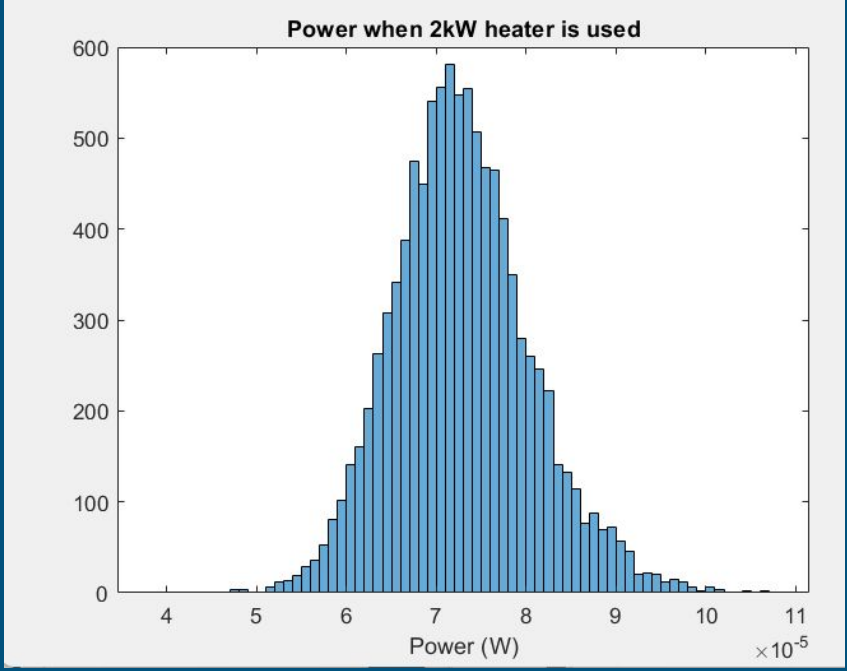
Calculated values of Cn^2

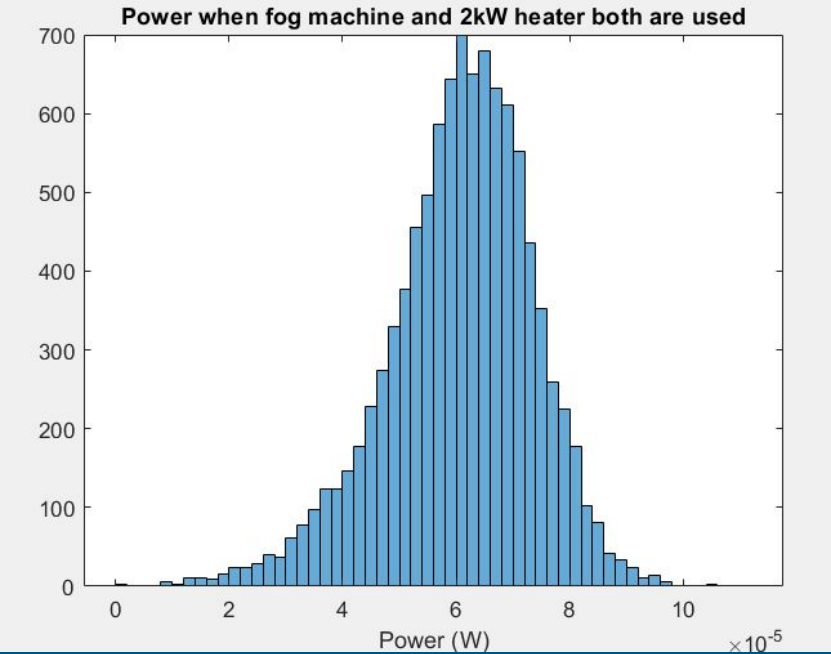
Conditions	Cn^2	Strength of turbulence
1 kW heater is used	3.3685E-13	Weak turbulence
Fog machine is used	4.5238E-13	Weak turbulence
2 kW heater is used	5.8387E-12	Medium turbulence
When both fog machine and 2 kW heater both are used	2.4237E-11	Medium turbulence

- Based on the Cn^2 values : Turbulence strength when fog is used is weak, Turbulence strength when 1 kW heater is used is weak, Turbulence strength when 2 kW heater is used is medium, Turbulence strength when fog machine and 2 kW heater both are used is medium,


Power when fog is presemt
1200
1000
800
600
400
200
0
2
3
4
5
6
7
8
Power
×10^-5


Power when 1kW heater is used
900
800
700
600
500
400
300
200
100
0
6.4
6.6
6.8
7
7.2
7.4
7.6
Power (W)
×10^-5





- Standard deviation increases as turbulence strength increases.

Conclusion

- Power received is maximum at middle position.
- BER increases as strength of turbulence increases.
- BER is less at middle position (0, 0, 0) then at side positions ((-0.7, 0,0) and (0.08, 0, 0)).
- Deviation in power increases as strength of turbulence increases.
- Order of Cn^2 is:

  1 kW heater< Fog < 2kW heater < Fog and 2kW heater.

Thank you