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SOLAR THERMAL ENERGY RESEARCH GROUP

A novel procedure to reduce ray tracing simulation times by predicting the number of rays

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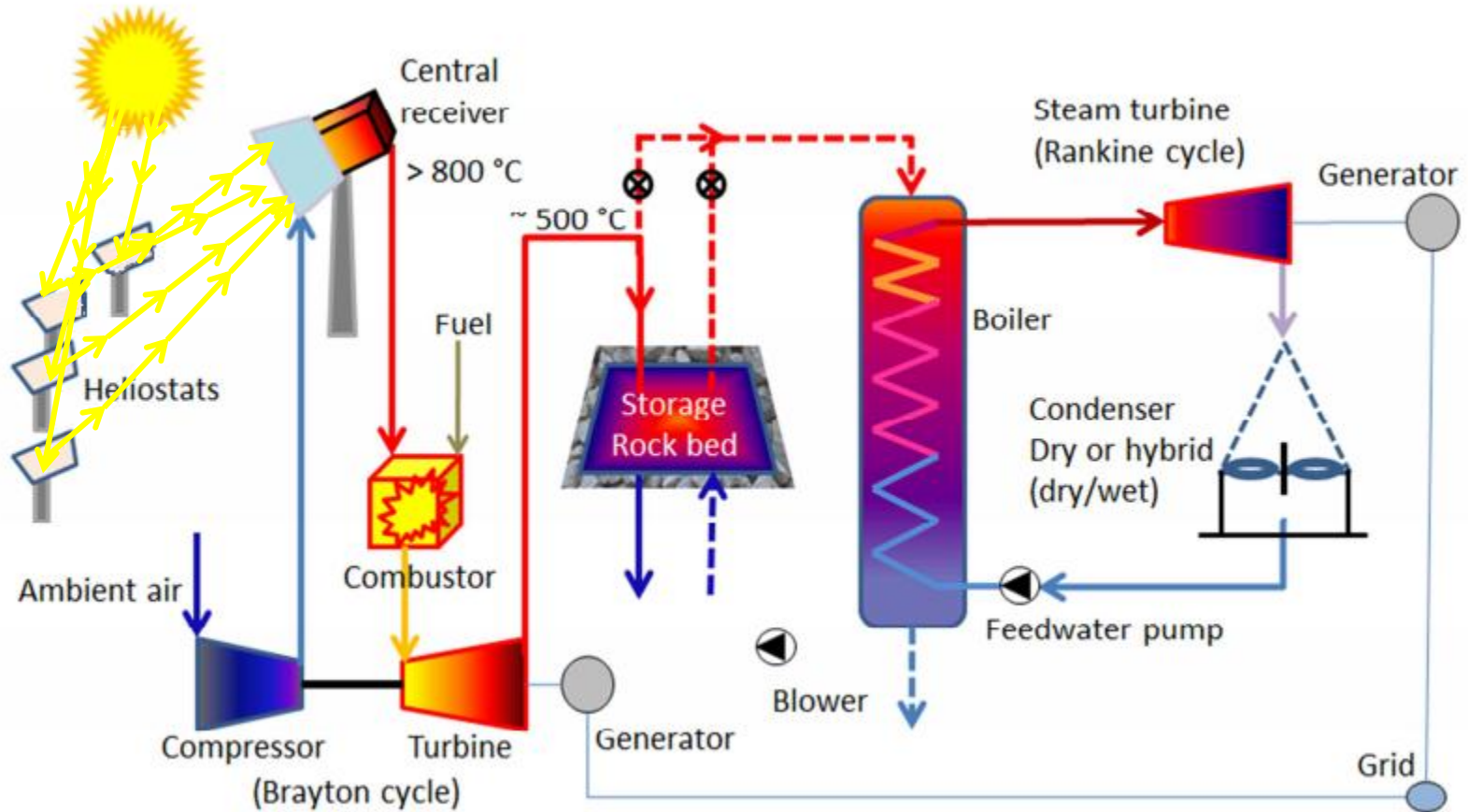
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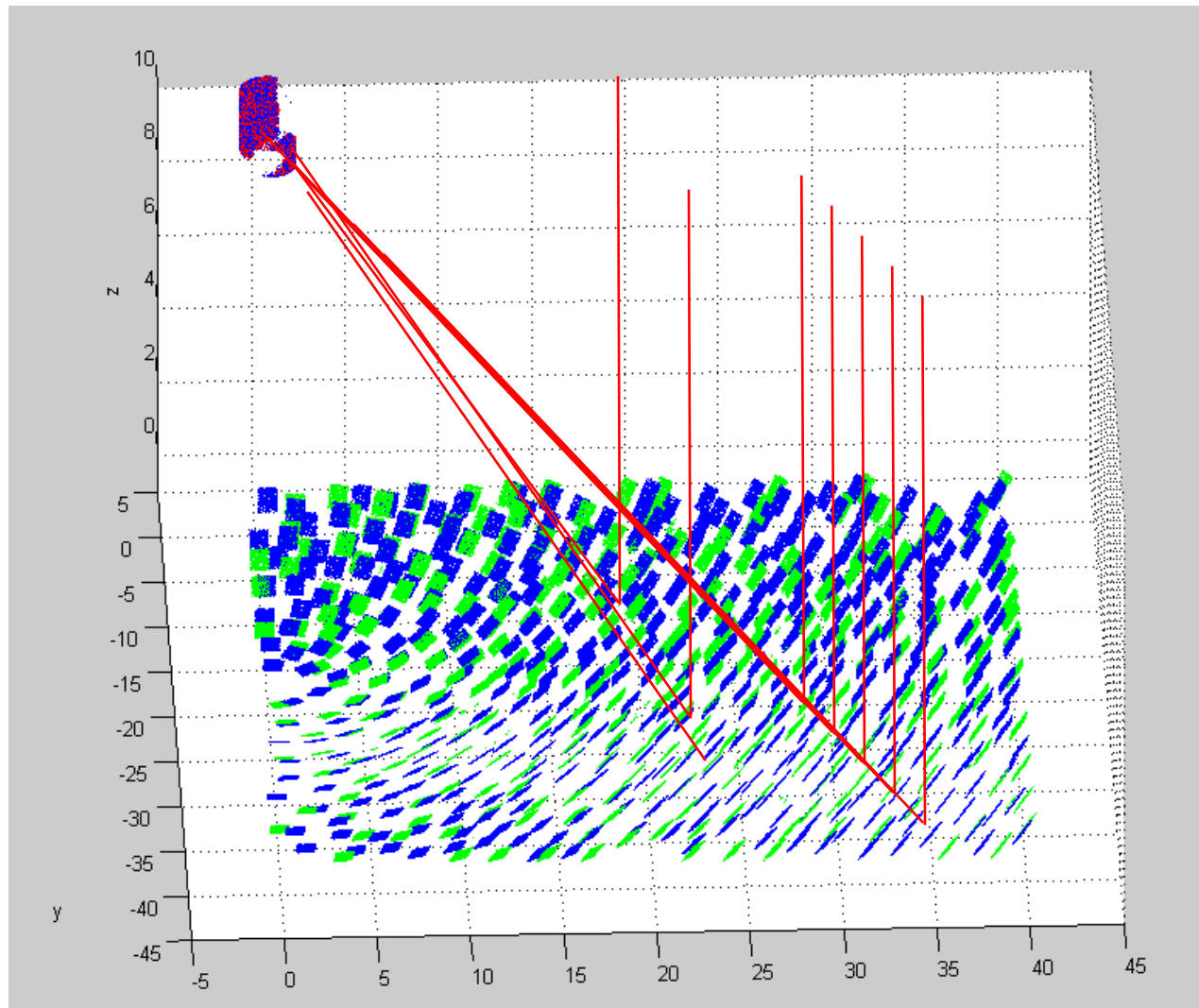


Introduction to ray tracing



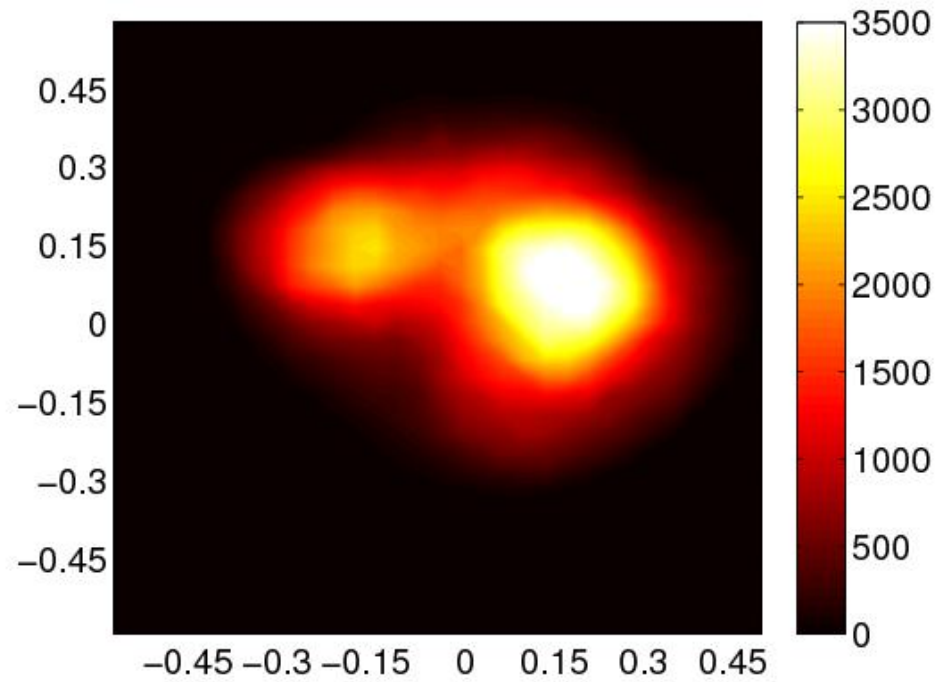
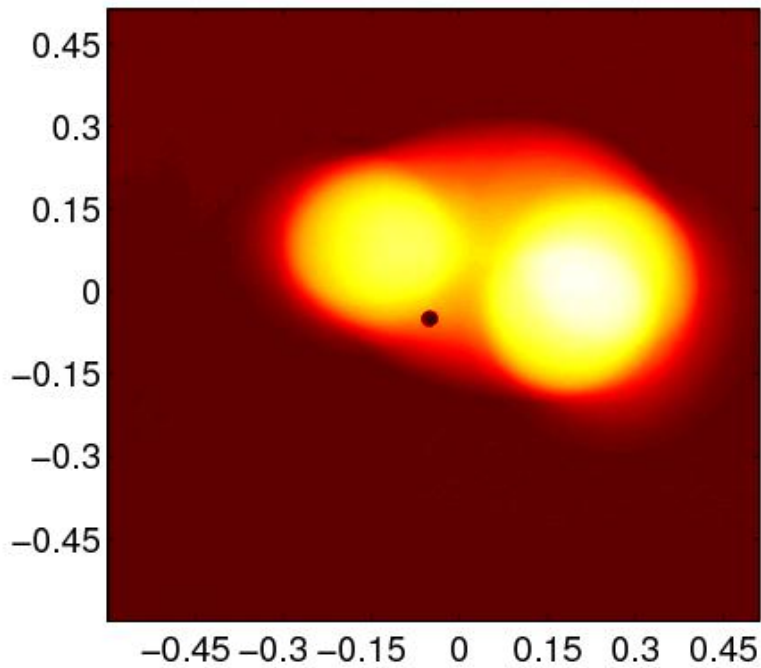


Optimized field layout



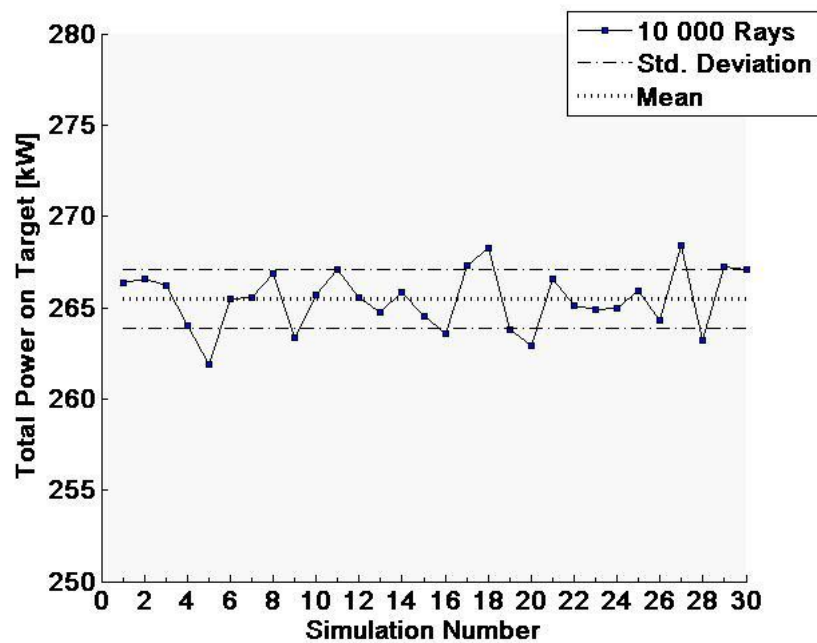
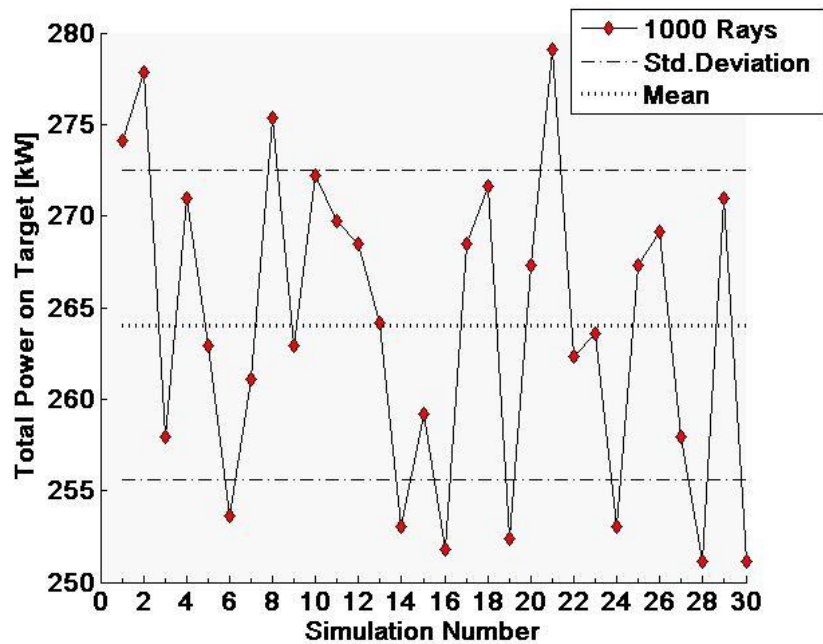


Ray Tracing



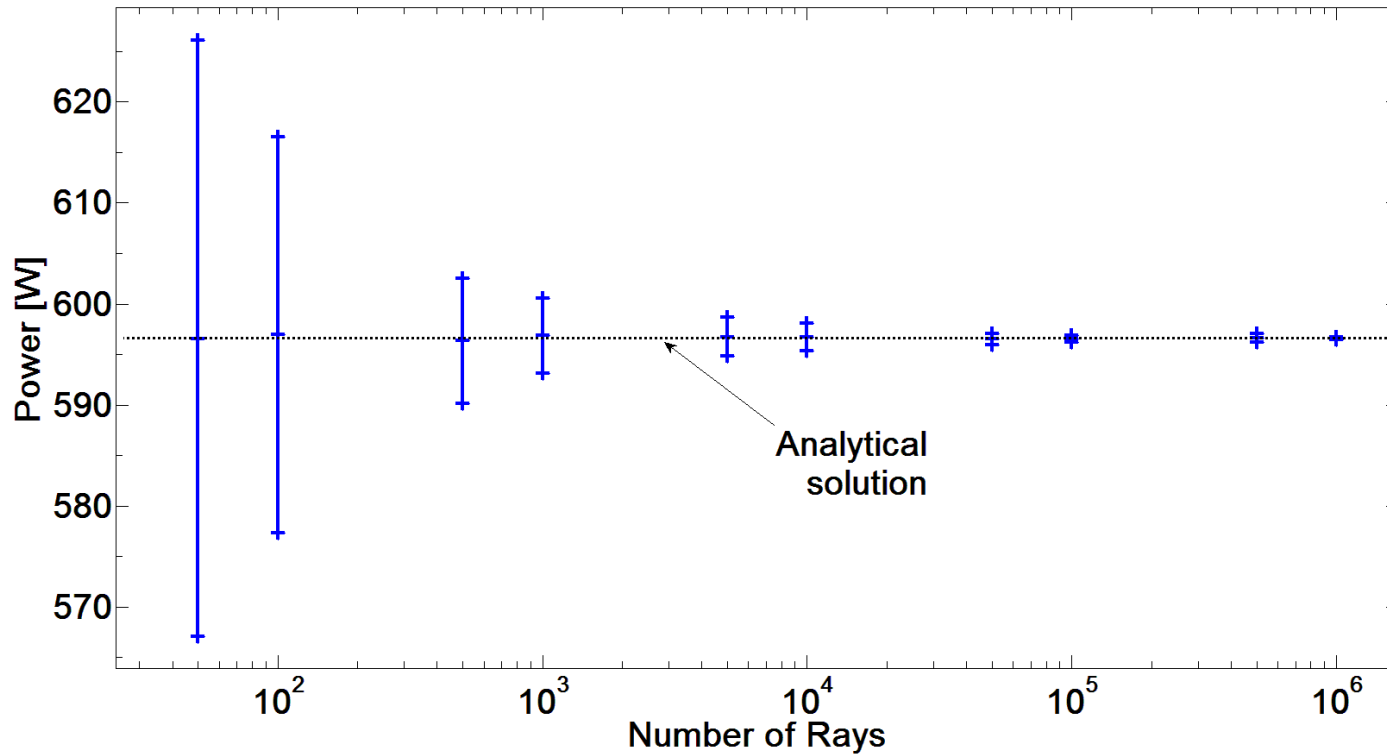


Shot Noise





Variance





Mean and Standard Deviation



$$\bar{y}_n = \frac{1}{n} \sum_{i=1}^n y_i$$

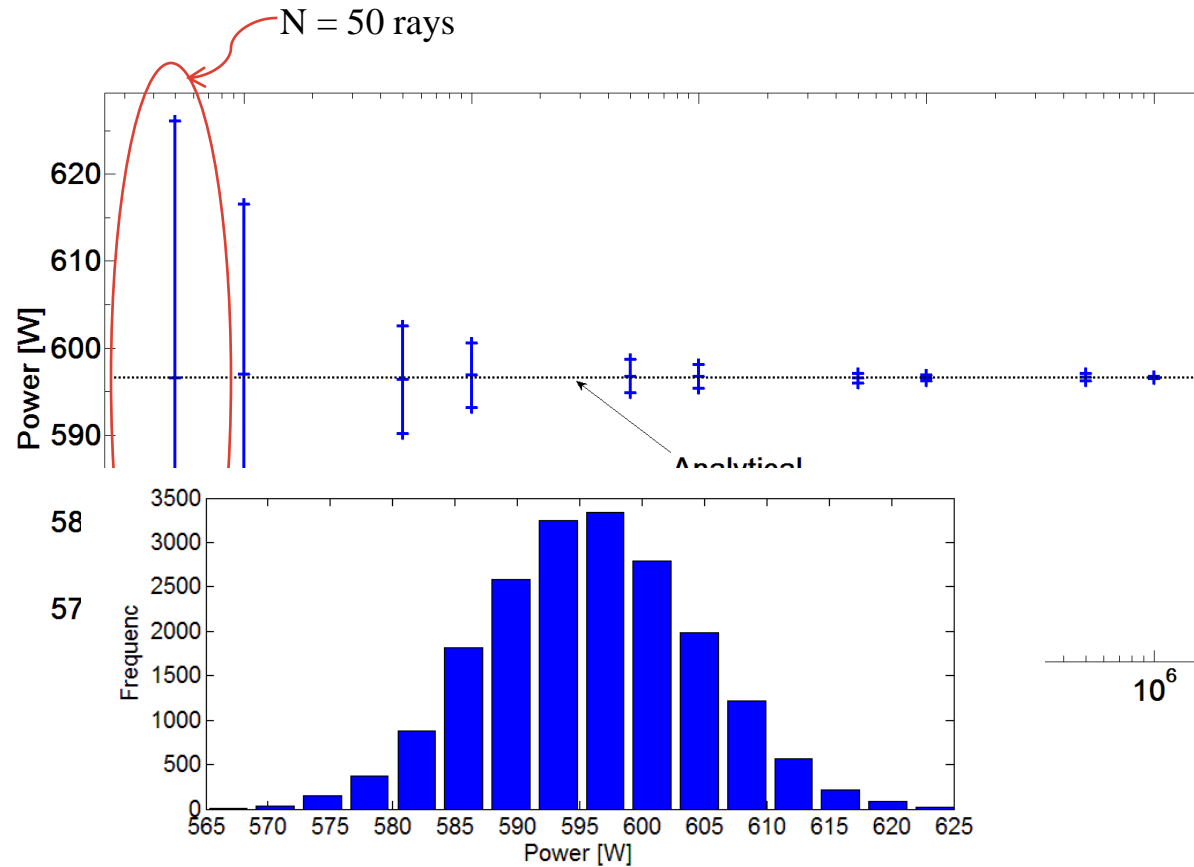
Mean

$$s_n = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n y_i^2 - \frac{(\sum_{i=1}^n y_i)^2}{n} \right]}$$

Standard Deviation

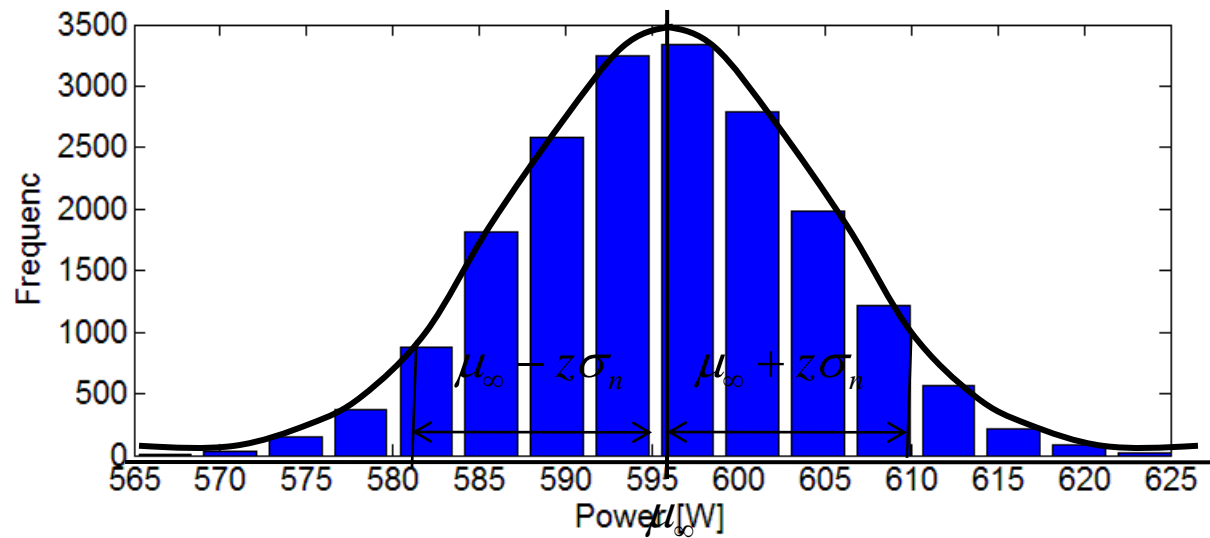


Variance Limit Theorem



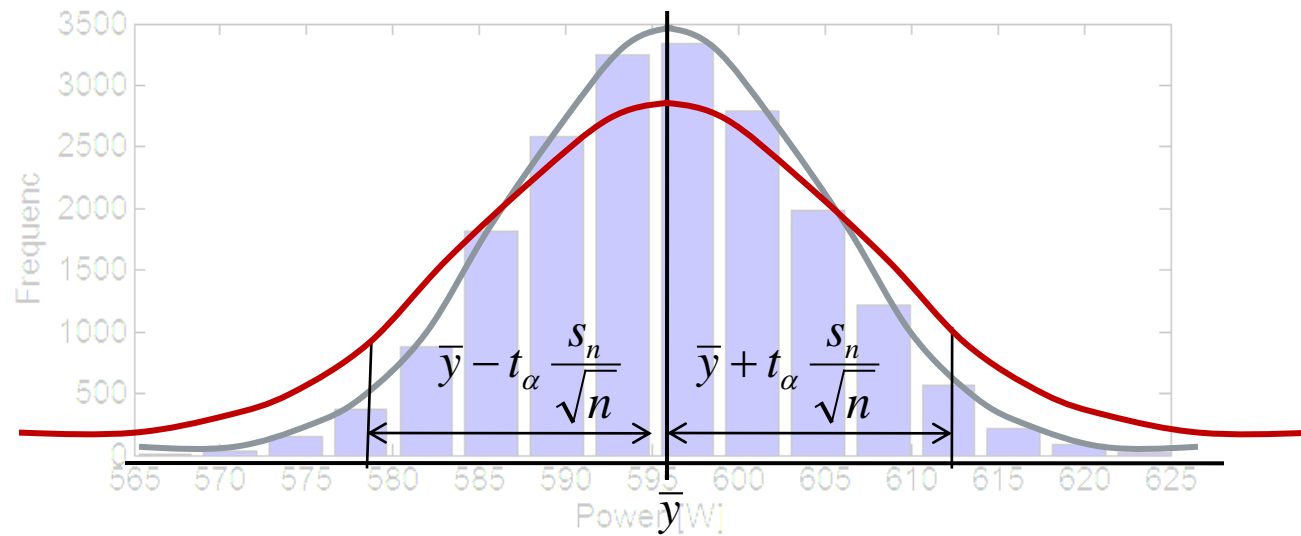


Central Limit Theorem



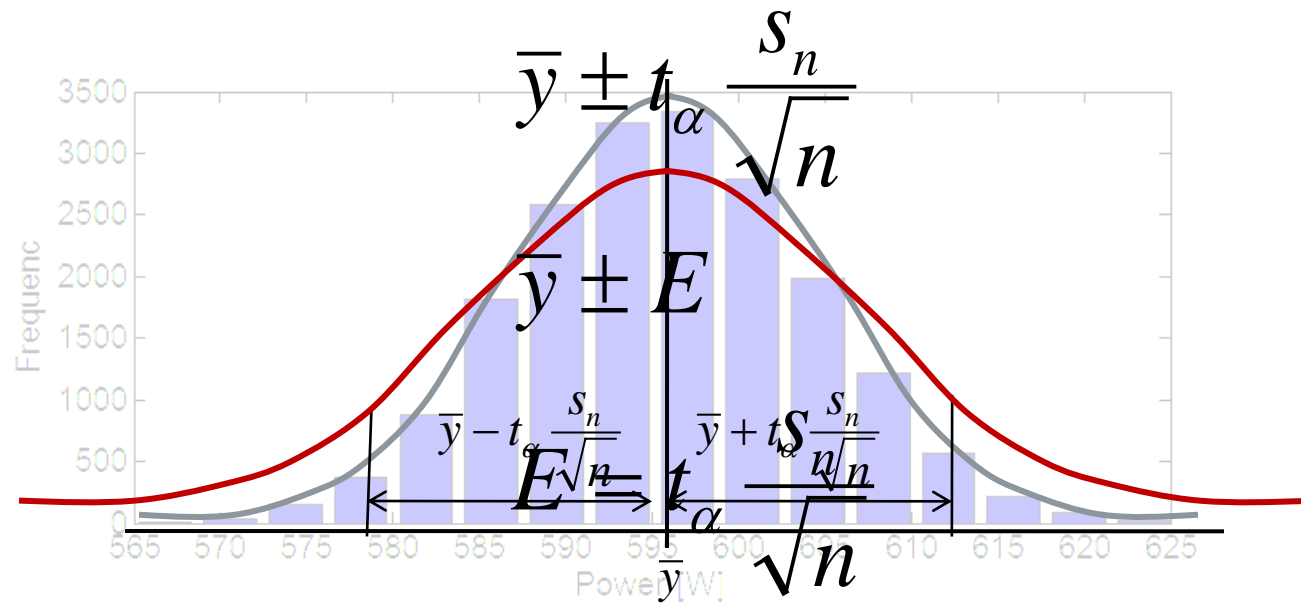


t-Distribution



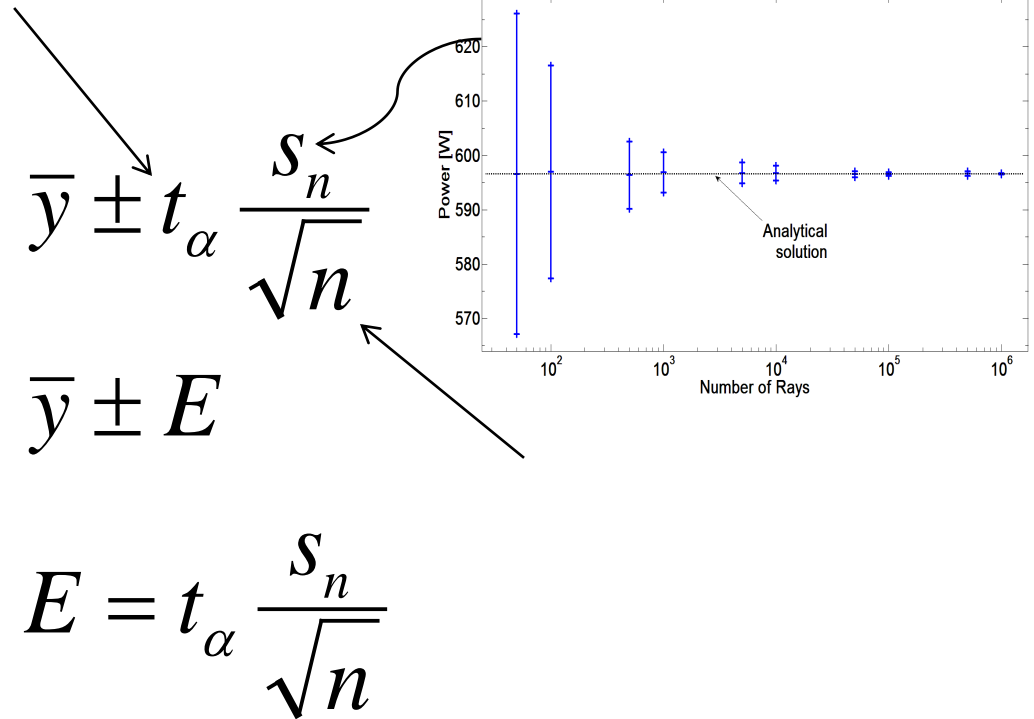


Exponential Error





Expanded Error





Number of simulations required



$$m = \frac{t_{\alpha}^2 S_n^2}{E^2}$$





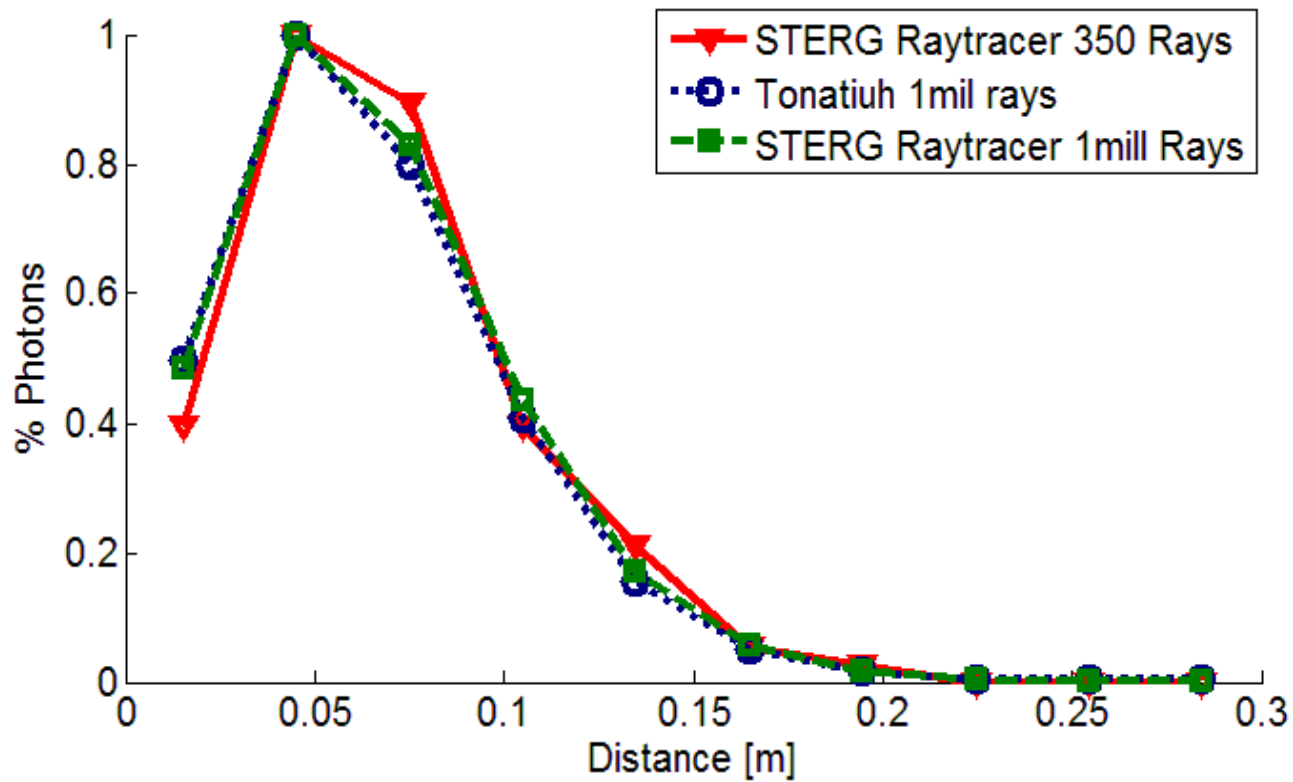
1. **Set Tolerable Error and Confidence;**
2. Run simulations with $N = \max(\text{Number of objects, Spatial Resolution})$;
3. Calculate the Error using $E = t_\alpha \frac{s_n}{\sqrt{n}}$
4. **If**
 - a. Stop;
5. **Else**
 - a. Calculate the required number of simulations $m = t_\alpha^2 s_n^2 E^{-2}$
 - b. Run one simulation using m rays;



Results: Eurodish

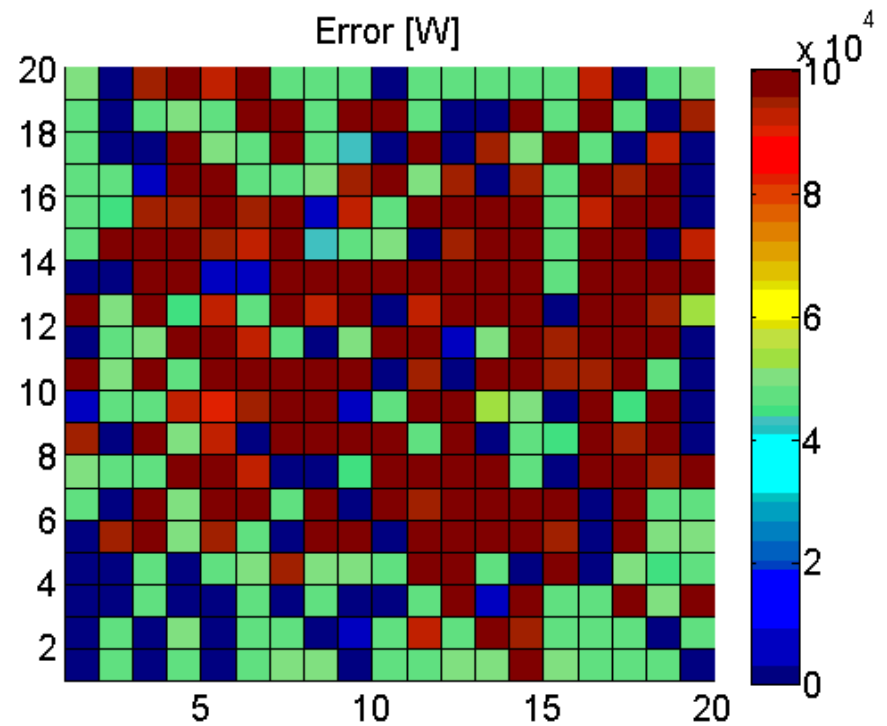
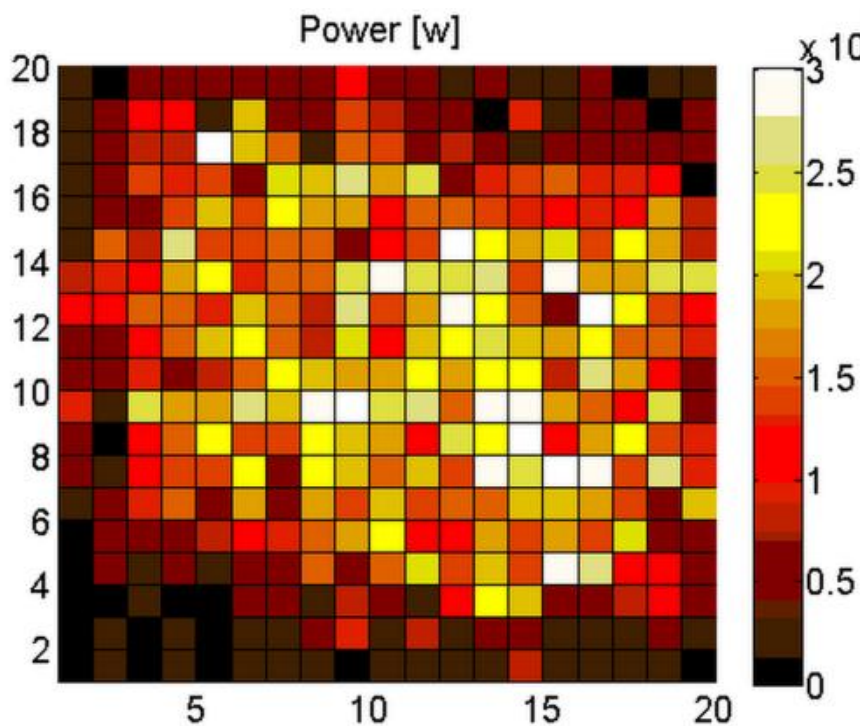


Power Run 1	Power Run 2	Mean	Std. deviation	Error
57.126 kW	55.596 kW	56.361 kW	1.082 kW	3.118 kW



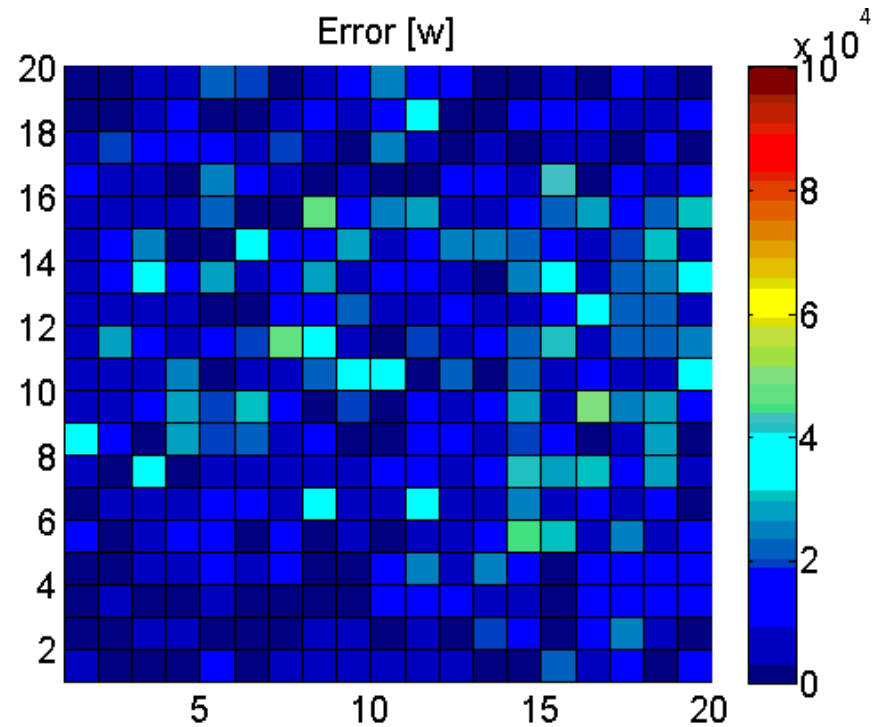
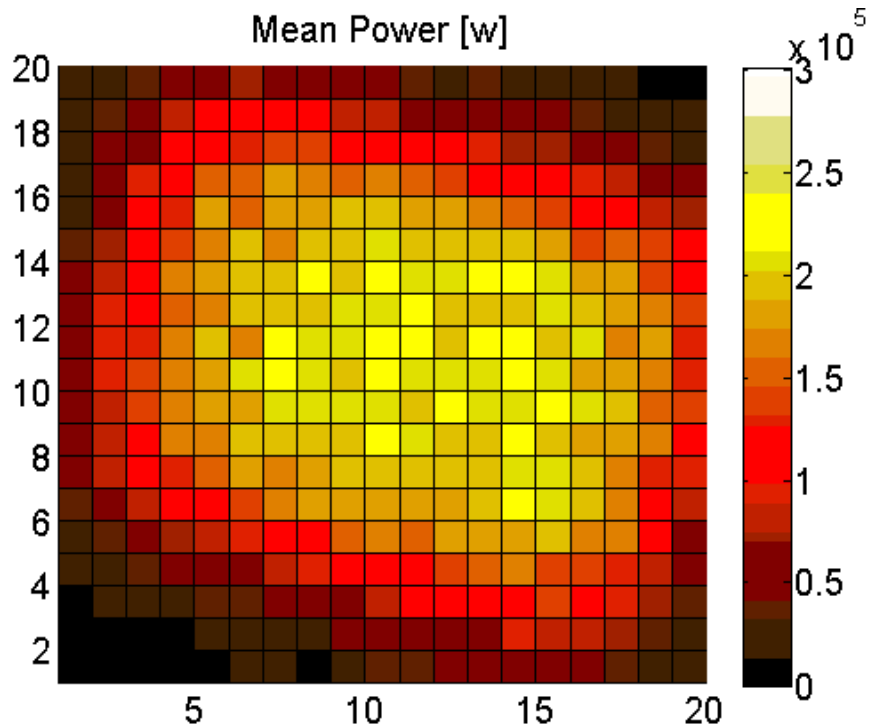


Results: Optimized PS-10 plant





Results: Optimized PS-10 plant





Questions?

