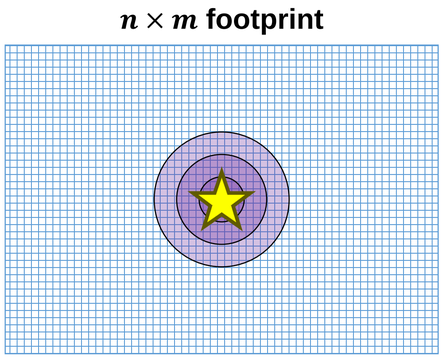
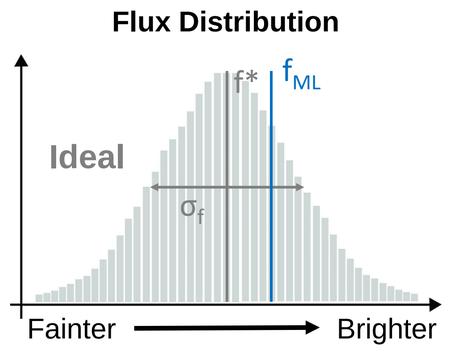
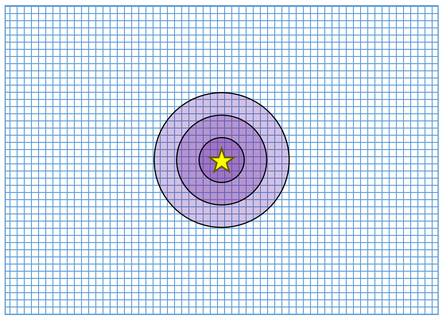
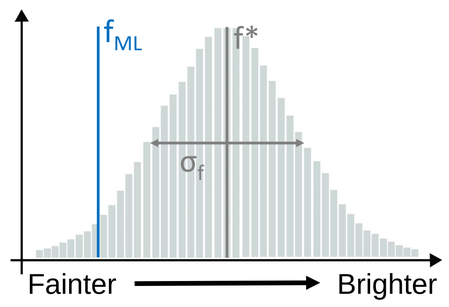
Position Known



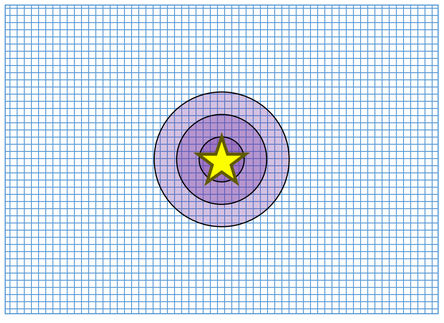


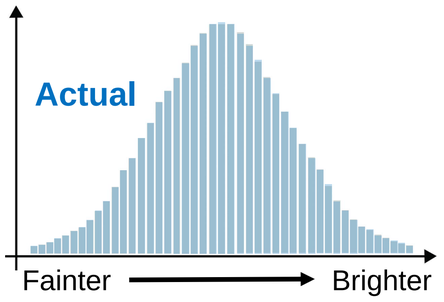
Random noise sometimes leads to high fluctuations.





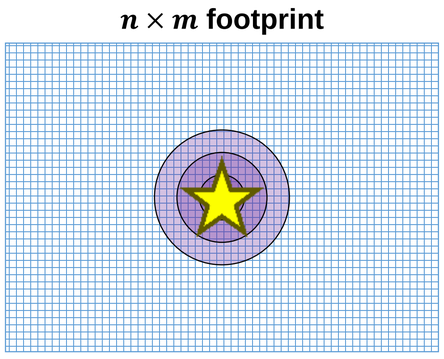
It also leads to low fluctuations with equal probability.

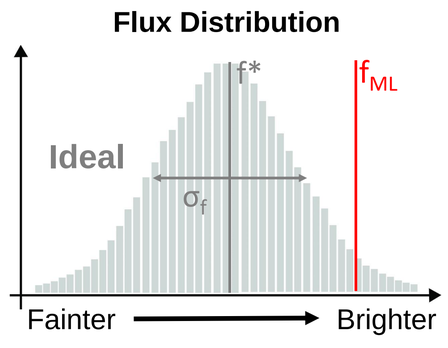




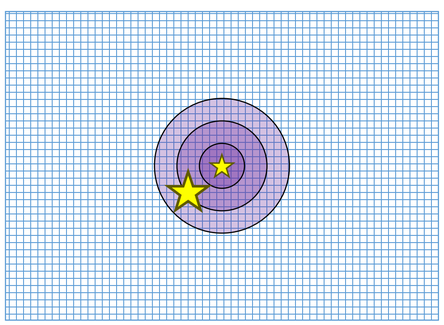
Because fluctuations are symmetric,
the maximum-likelihood estimate is unbiased.

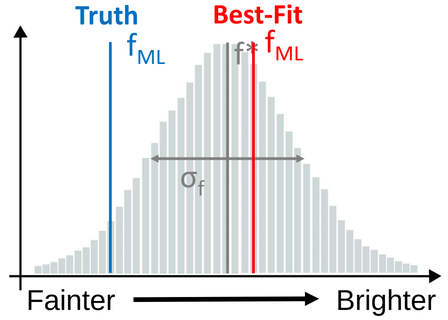
Position Unknown



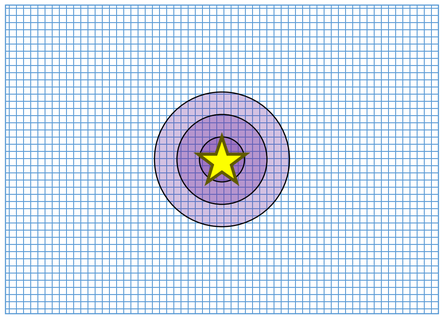


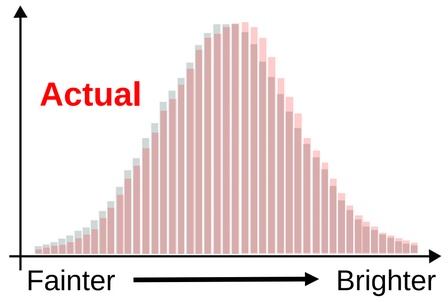
The position is centered at the true position when random noise generates high fluctuations…





But when there are low fluctuations at the true position, a better fit can be achieved at a different position.





Because fluctuations are asymmetric,
the maximum-likelihood estimate is biased.