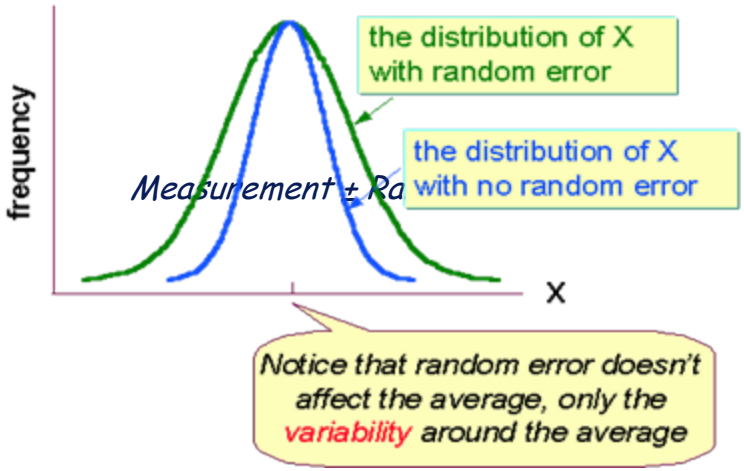
Random Errors

- ALWAYS **present.**

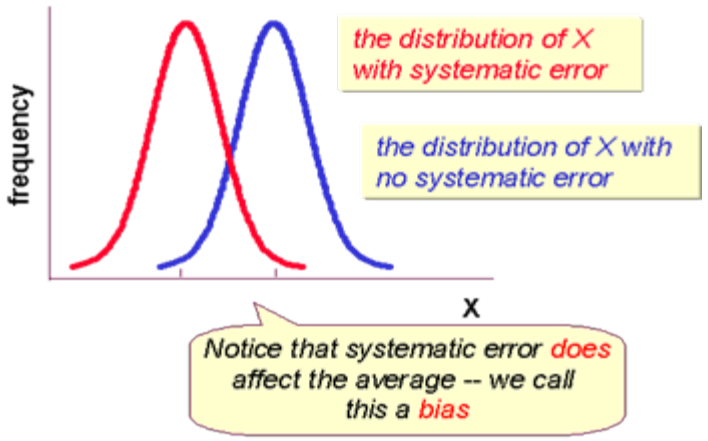


- Sources:
  - **Random operator errors**
  - **Random changes in experimental conditions**
  - **Noise in apparatus**
  - **Noise in Nature**

- How to minimize them?
  - **Take repeated measurements and calculate their average.**

Systematic Errors

- **Are** TYPICALLY **present.**

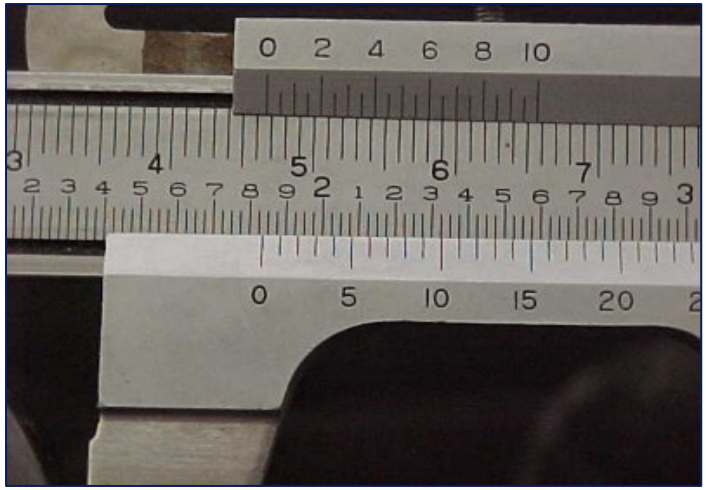


- Sources:
  - **Instrumental, physical and human limitations.**
    - » **Example: Device is out-of calibration.**
- How to minimize them?
  - **Careful calibration.**
  - **Best possible techniques.**
  - **Discover and control them.**

Precision and Accuracy in Measurements

- Precision

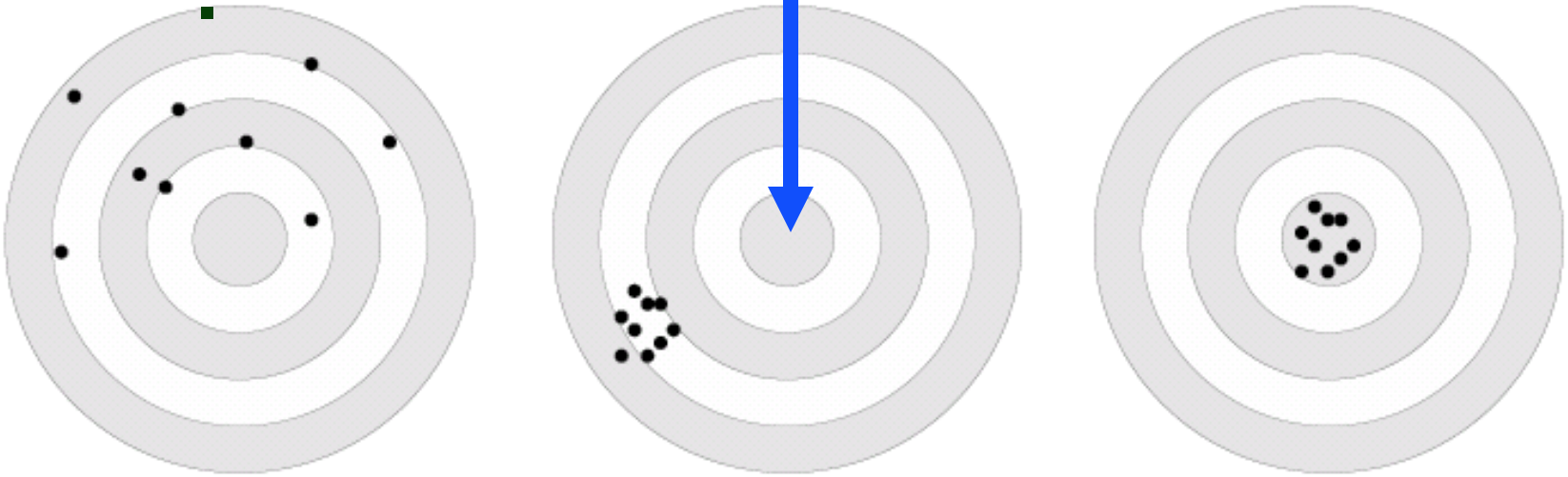
  How reproducible are measurements?



- Accuracy

  How close are the measurements to the true value.

accuracy and precision



not precise and not accurate

large random and *systematic* errors

precise but not accurate

small random error, large *systematic* error

precise and accurate

small random error, small *systematic* error

Some common mistakes

Poor experiment design

Not testing for systematics (control)

Ignoring sample selection effects (bias)

Bad statistics: assume wrong distribution (tails!)

Failure to repeat the experiment using different sample with same physics

Quoting errors

Fourth Test of General Relativity: New Radar Result

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New radar observations yield a more stringent test of the predicted relativistic increase in echo times of radio signals sent from Earth and reflected from Mercury and Venus. These "extra" delays may be characterized by a parameter λ which is unity according to general relativity and 0.93 according to recent predictions based on a scalar-tensor theory of gravitation. We find that $\lambda = 1.02$. The formal standard error is 0.02, but because of the possible presence of systematic errors we consider 0.05 to be a more reliable estimate of the uncertainty in the result.