PHY315/CEB558
Session 3

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Fall 2007

Experimental Errors

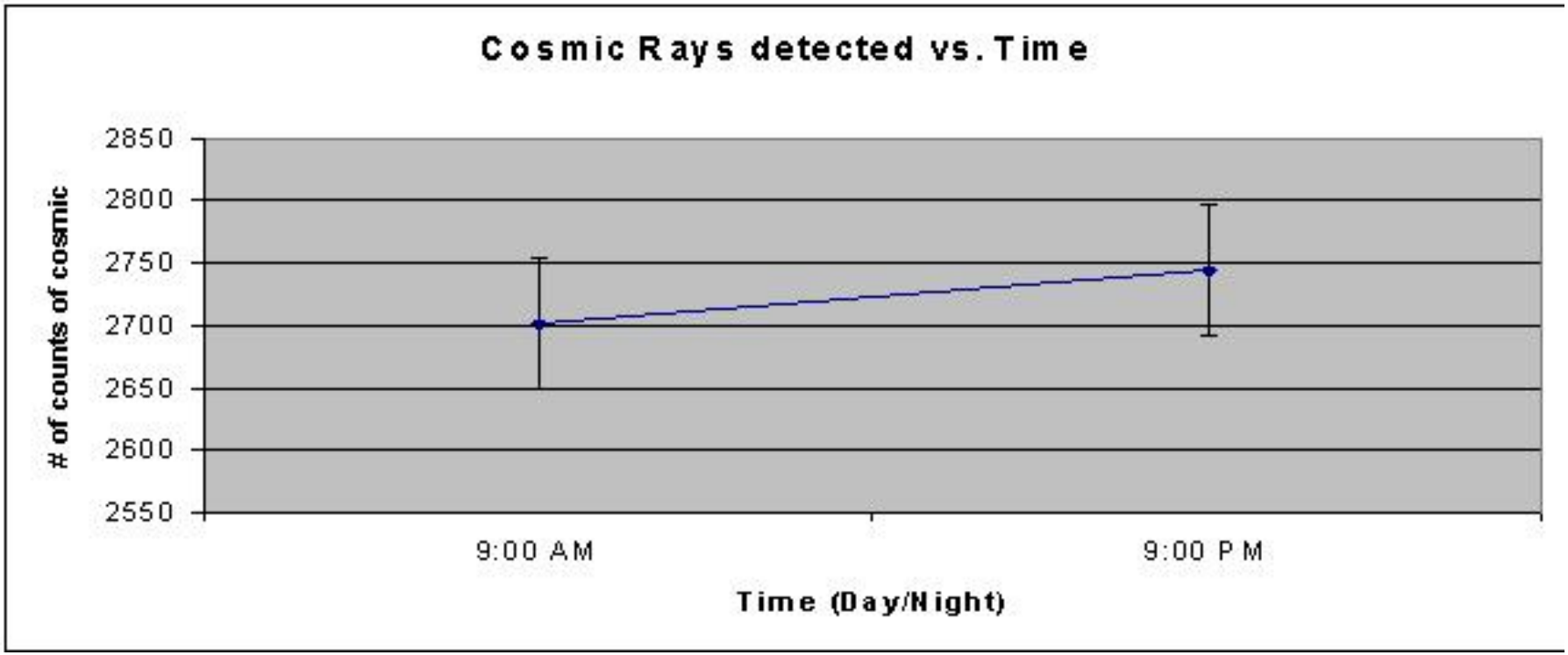
- No measurement is perfect so we need a way to discuss how close it is to the “truth”
- There are 4 concepts we need:
  - Accuracy – how close the measurement is to the truth (the answer)
  - Precision – how repeatable the measurement is
  - Systematic errors – in the measurement technique, don’t improve unless identified
  - Random errors – average to zero so we can get improvement with repeated measurement
- Examples – darts, (90%) meter stick

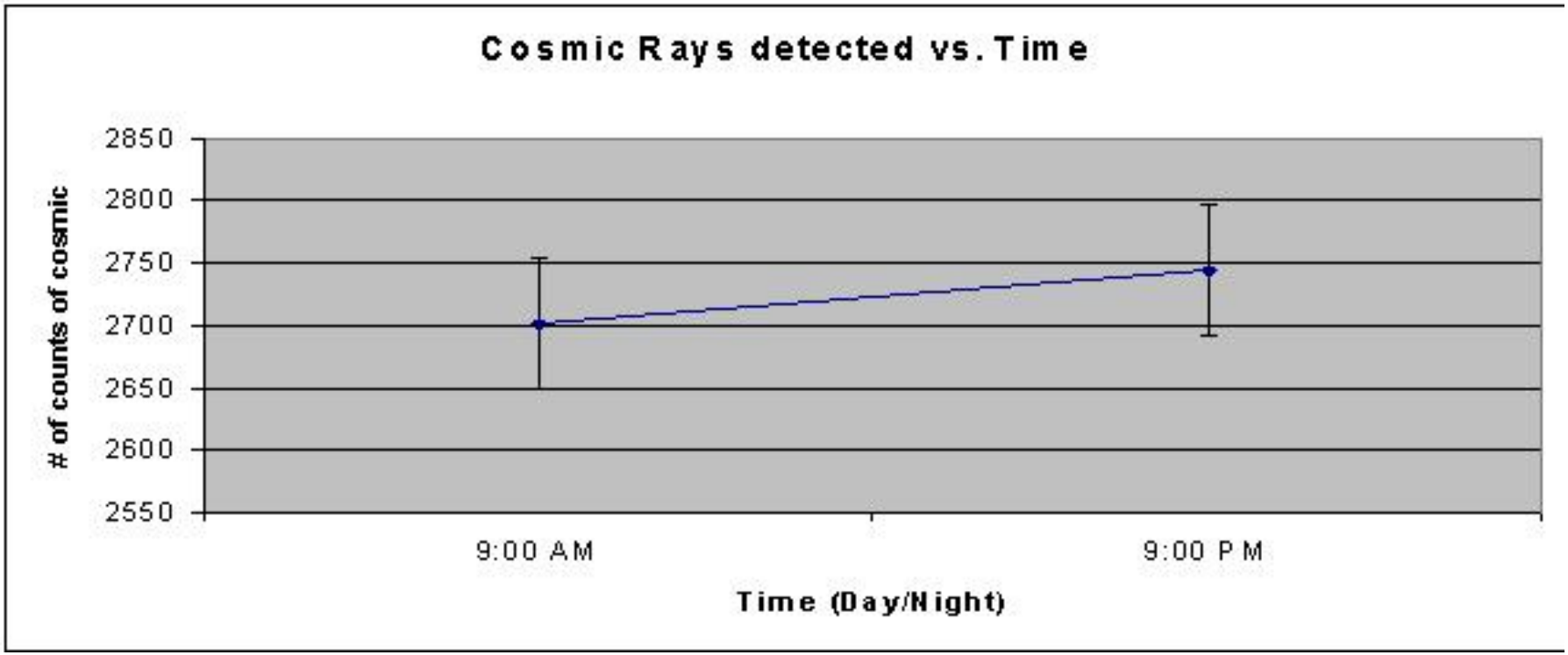
Looking at Statistical Data

- For things that are counted the statistical error is estimated by the square root of the number of counts.
  - N = 9 dN = 3 dN/N = 1/3 (33%)
  - N = 25 dN = 5 dN/N = 1/5 (20%)
  - N = 100 dN = 10 dN/N = 1/10 (10%)
  - N = 10,000 dN = 100 dN/N = 1/100 (1%)
- The error grows, but the relative error (the precision) is improving
- If we are calculating the rate (counts per unit time)
  - R = N/t then dR/R = dN/N (usually error on t is small)

An Example

- Let’s look at a site that collects similar cosmic ray data:
  - http://www2.slac.stanford.edu/vvc/cosmicrays/crdatacenter.html

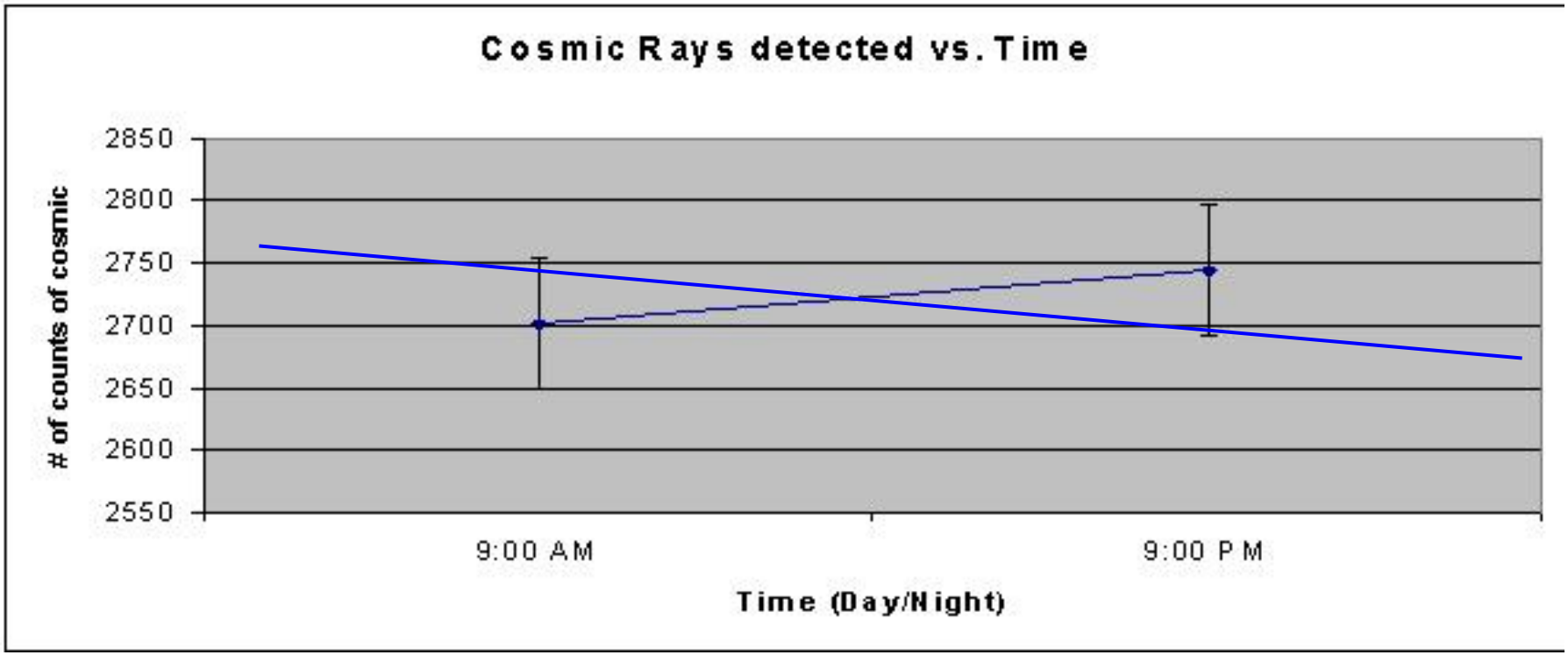

Cosmic Rays detected vs. Time
# of counts of cosmic
2850
2800
2750
2700
2650
2600
2550
9:00 AM
9:00 PM
Time (Day/Night)



2/3 of the time “true answer” is within the error bars

Difference of 43 between points is less than the error bar (+/- 52)

The only conclusion that can be made is that we need more data!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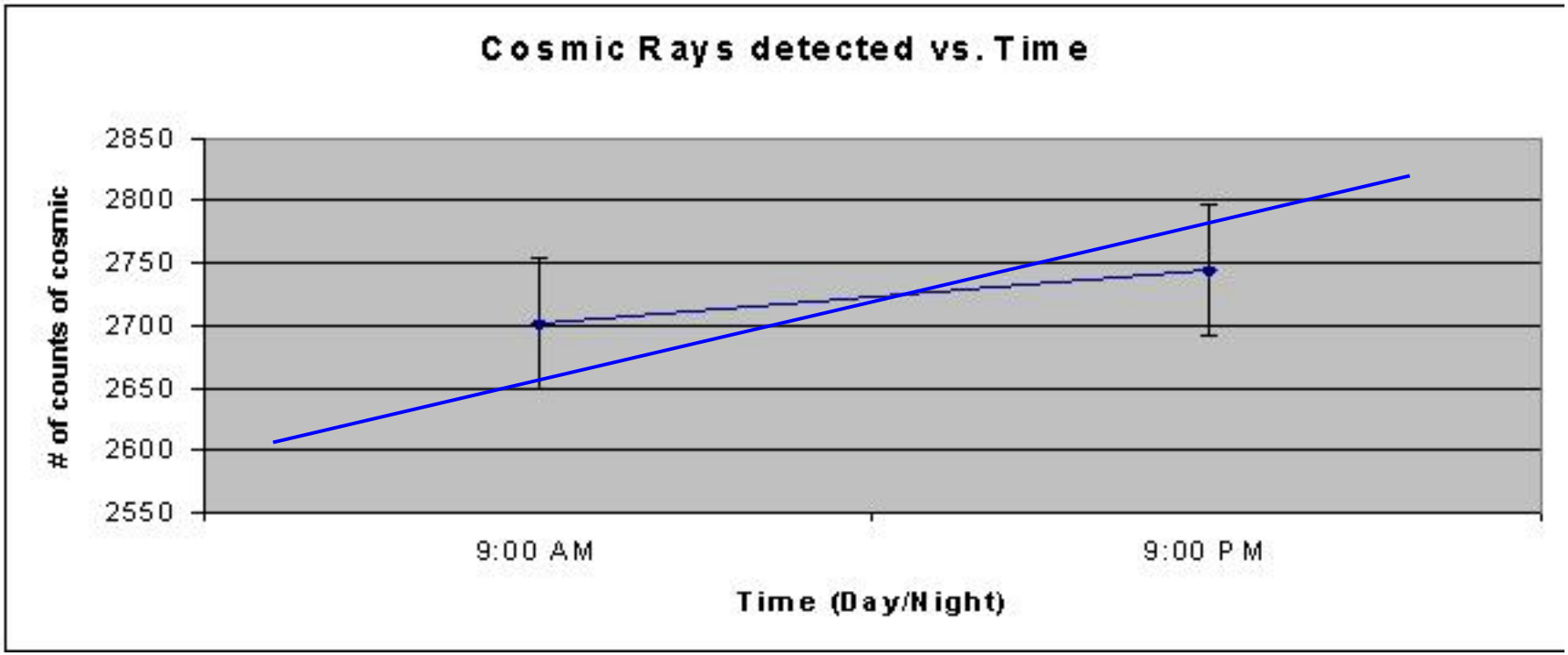
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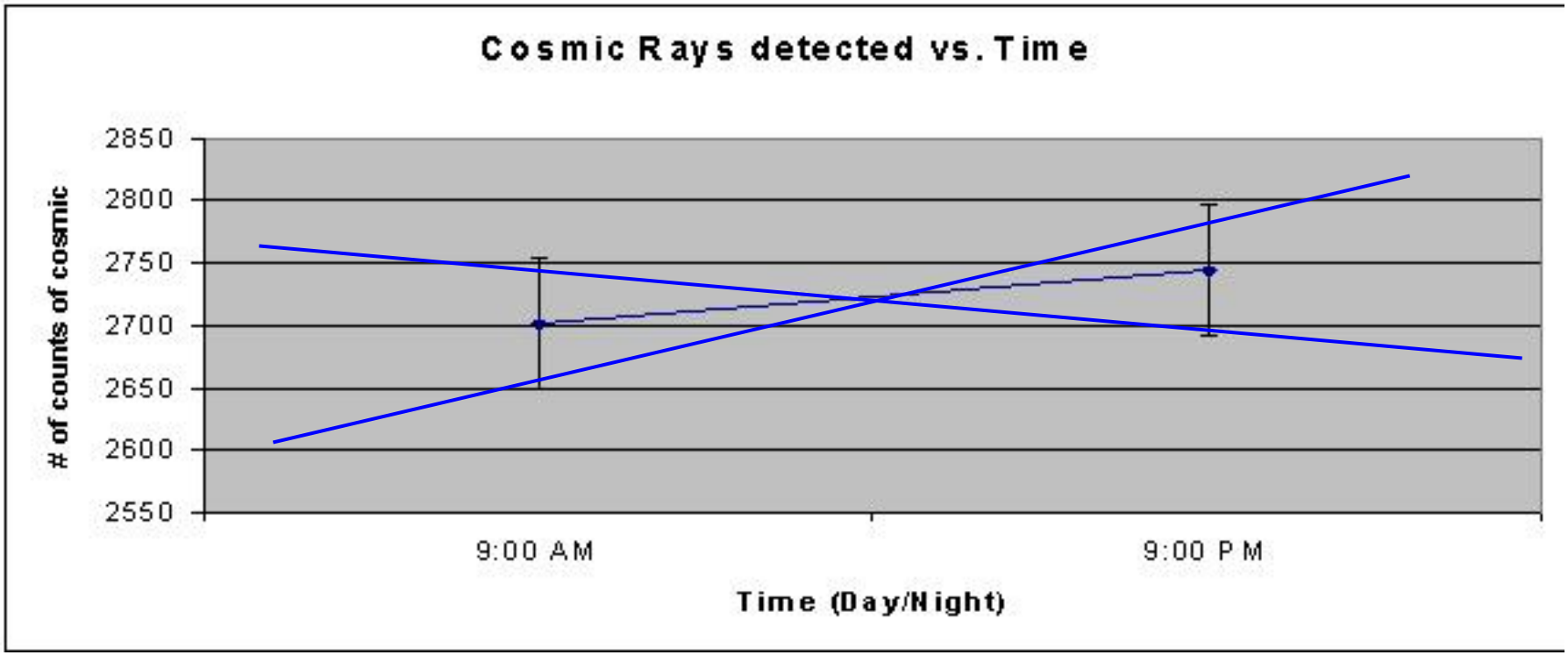
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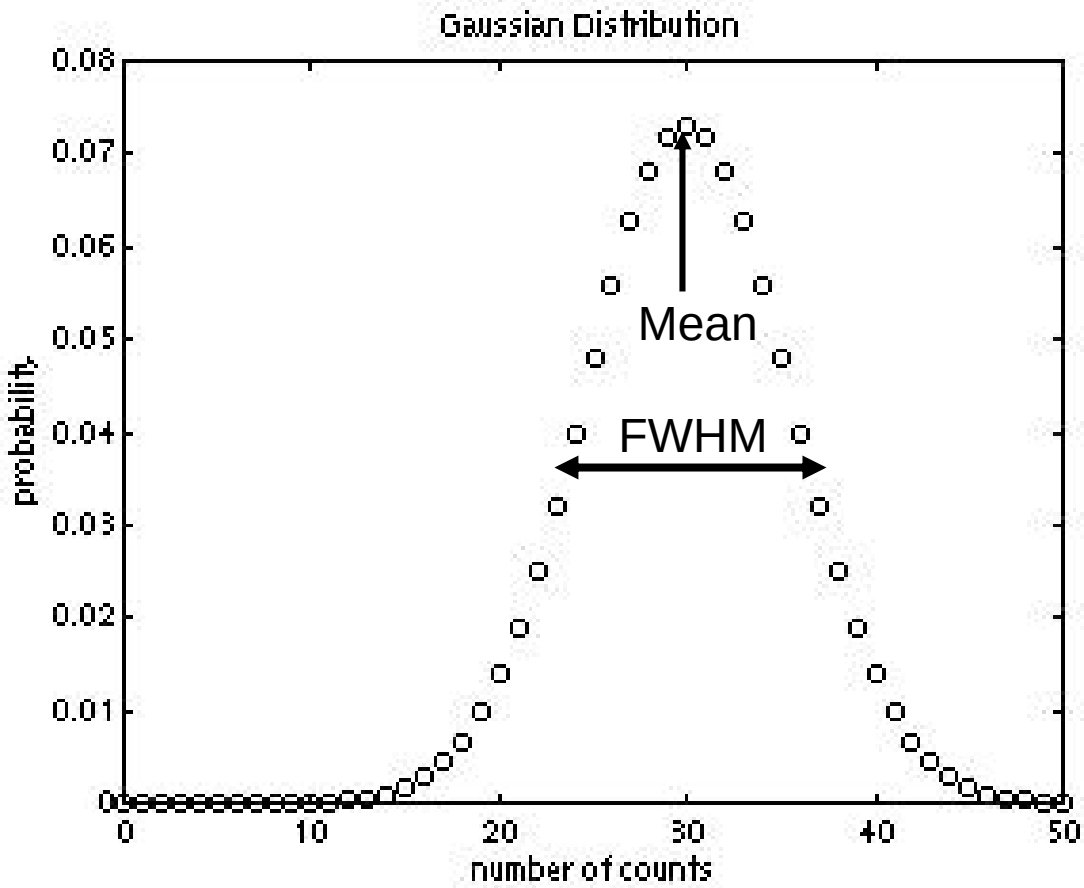
Normal (Gaussian)

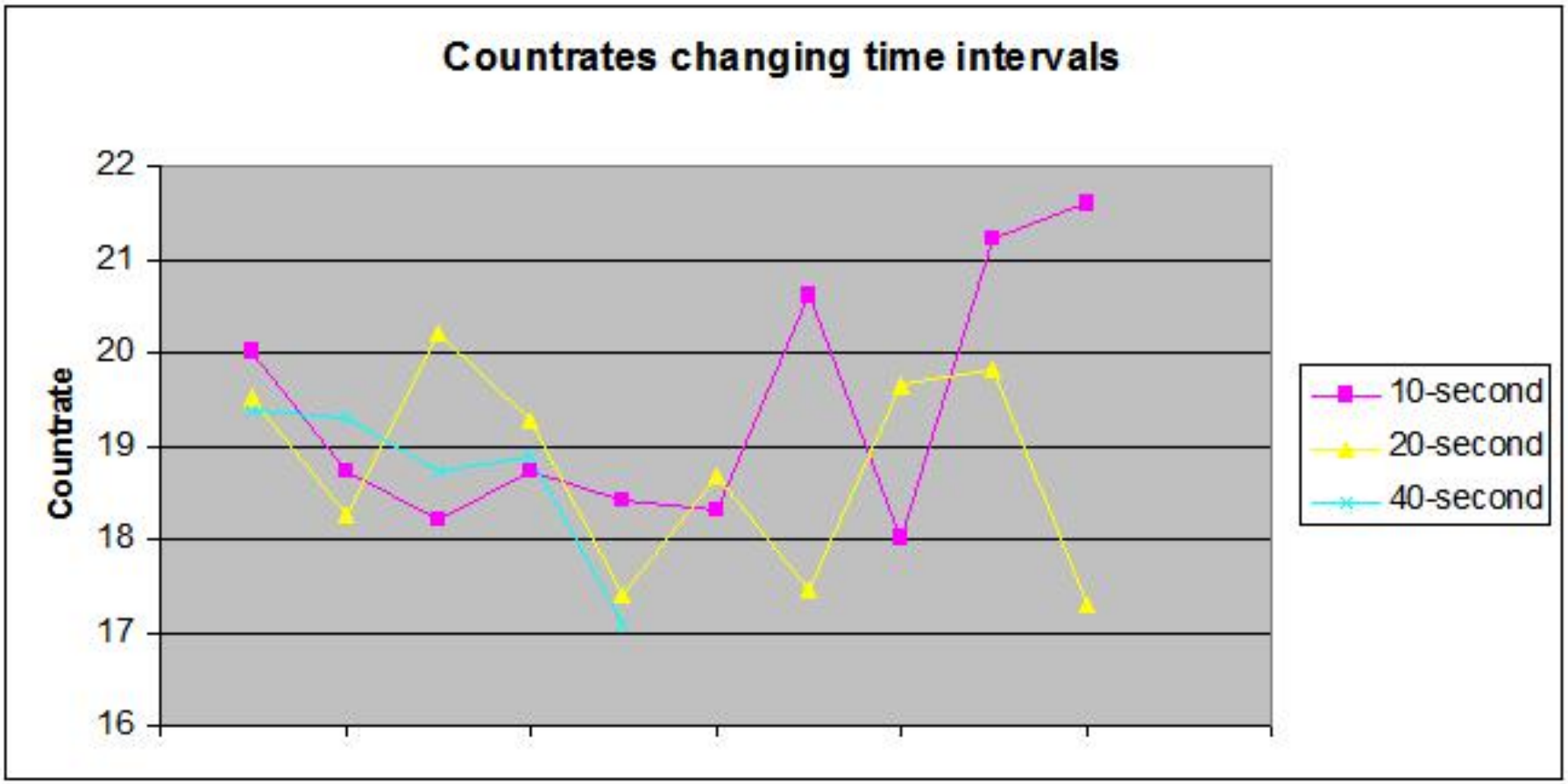


68% of all measurements will fall within the FWHM

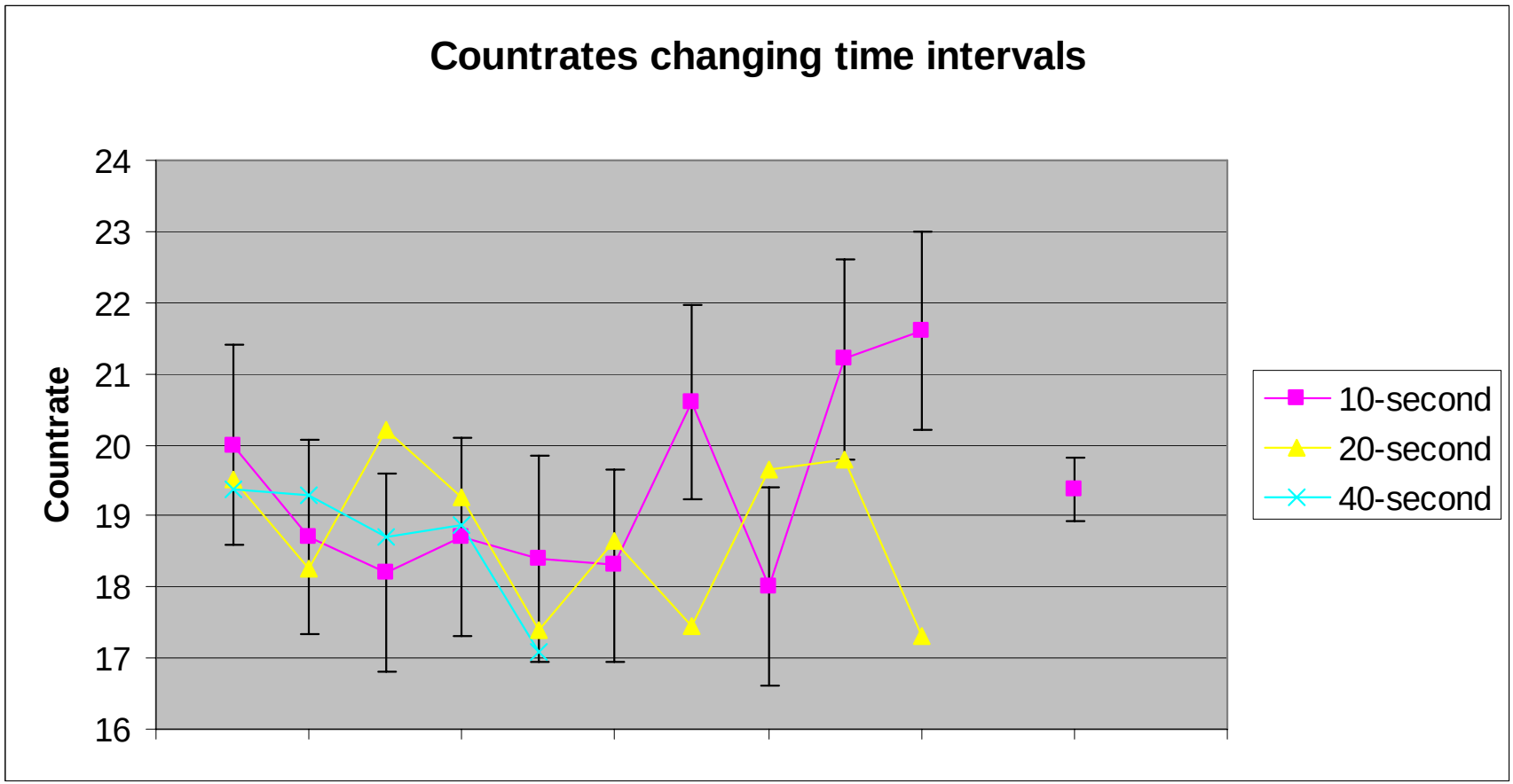
32% of measurements will be beyond FWHM,

only 4.6% will be beyond 2 x FWHM

Gillian's Data



Gillian's Data with Errors

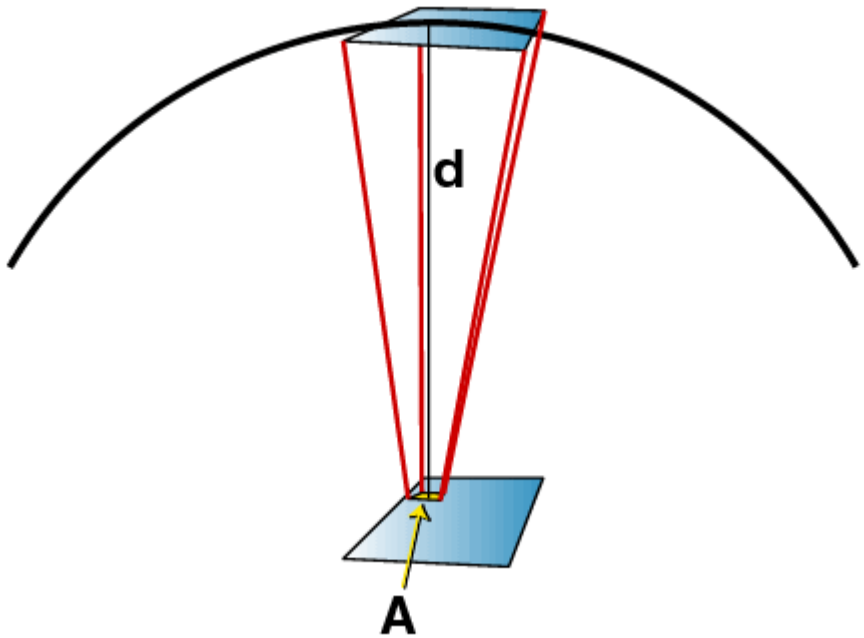


What we measure

- Our detectors and DAQ “count” particles
  - The number of counts depends on how long we count, so
- We convert that into a “rate” (counts per time) through our detectors
  - The rate depends on the size of our counters and if we use more than one (always!) it depends on the geometry of the counters, so

Flux

Independent of the size of the detectors that measure it



$$\textbf{Flux} = \frac{(\text{count rate})\, d^2}{(\text{area of top panel})\ (\text{area of bottom panel})}$$

Units = rate of muons per unit area per unit of solid angle (number/area)