Scientific Measurement

PHY-103

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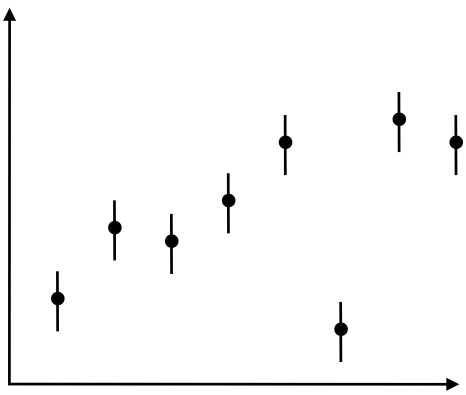
Lecture 2 - Graph Plotting

Queen Mary University of London

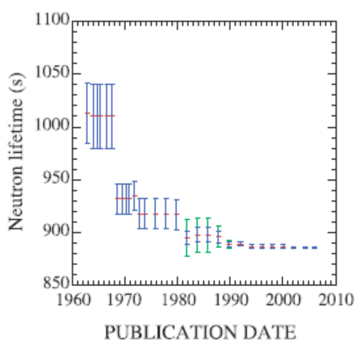
Graph Plotting

Graph plotting is important to experimental practice:

- allows you to spot mistakes

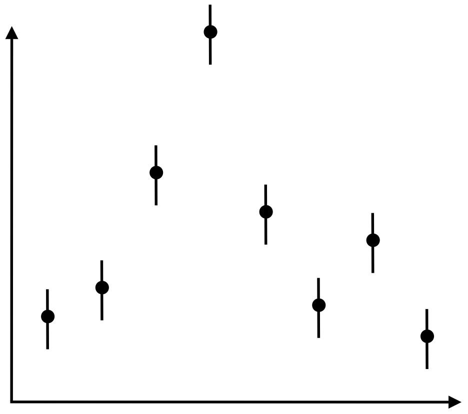


One point is anomalous
Consider remeasuring point
Check equipment
Measure close to/around anomaly
Do not discard data unless you are convinced
it really is experimental problem
- it could be real physics!



Real example of bias

Graph Plotting

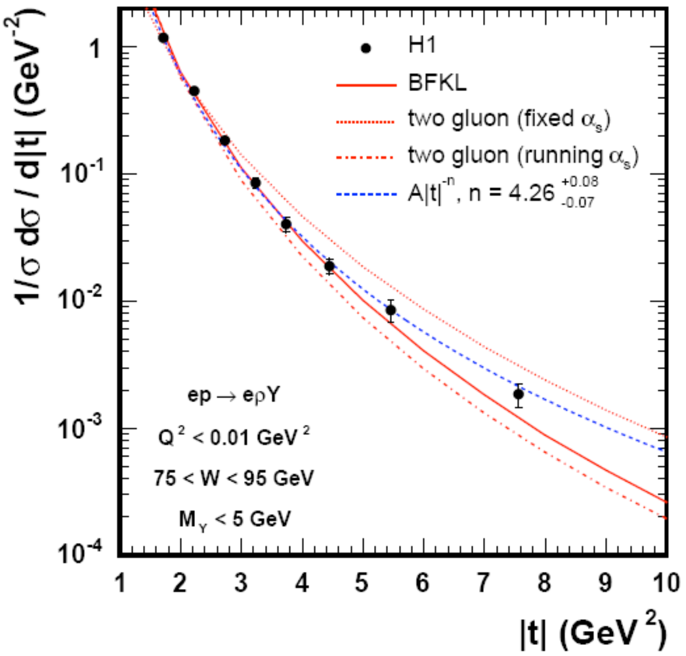


plotting helps identify 'features'
choose to take more data around peak
this helps determine peak position better

identify relationships eg: linear behaviour, exponential, quadratic etc

Graph Plotting

plots allow comparison with theory
can perhaps refute one theory
only data can do this!



red dashed & dotted cures are incompatible with the data
full red curve in agreement with data
blue curve fitted to data

Graph Plotting

Rules of Graph Plotting

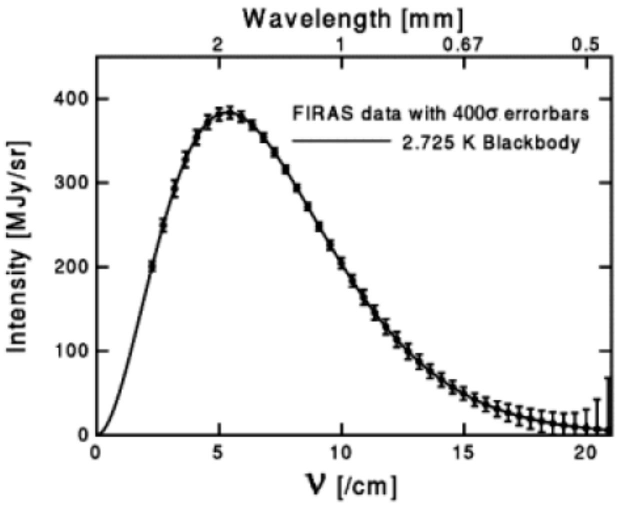
Always plot uncertainty on your measurement! ALWAYS!

Preference: use a solid circle ● to mark data point

can use o ∗ ■ + but easy to confuse error bars

If value is 13.6 ± 0.2 then draw point at 13.6 and vertical line from 13.4-13.8

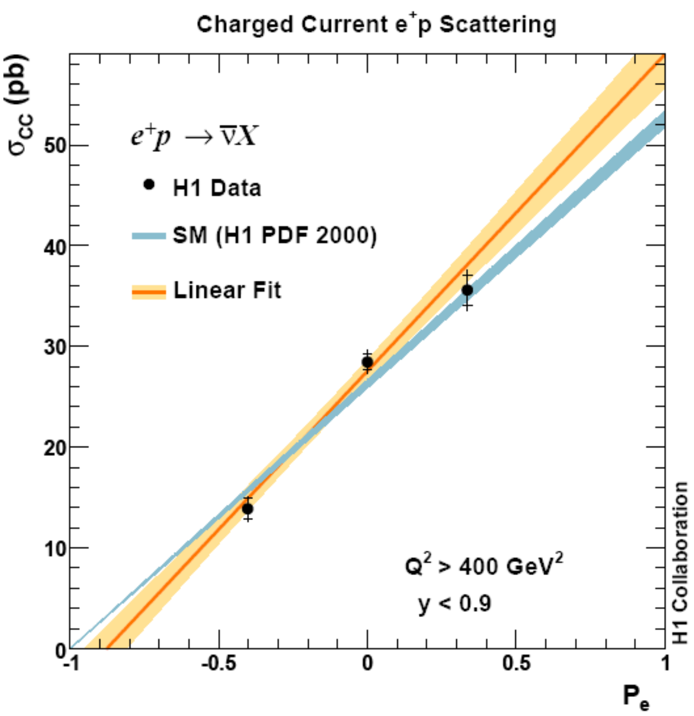
Errors can be asymmetric eg: 13.6 + 0.2 - 0.8 i.e. draw line 12.8-13.2



errors often on ordinate and abcissa - not always

If errors too small to draw you could multiply by 2 or 10 for presentation

Graph Plotting



Title

axis labels

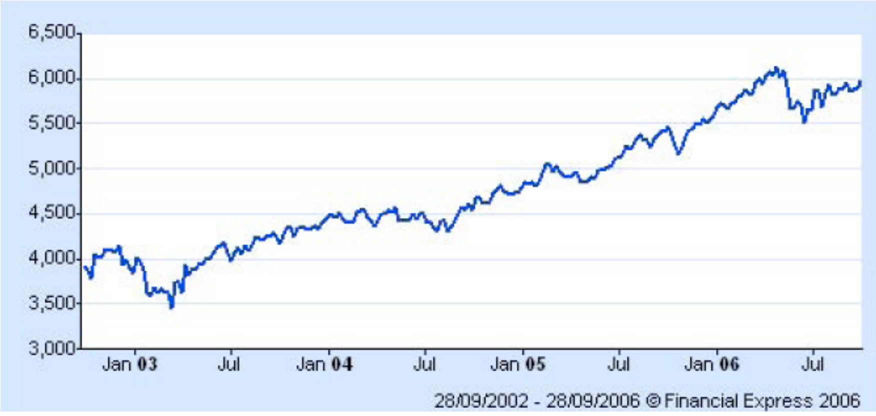
units

legend

axis values

Forget these at your peril!

You will lose marks



Sometimes suppress the zero

- Makes details more visible
- Be aware that it can overemphasise dips and troughs
- FTSE 100 3 year history has 30% gain, not 300% above!

Try to define linear variables - easier to spot linear behaviour e.g:

For pendulum:

$$T = 2\pi\sqrt{\frac{L}{g}}$$ then plot $$T^2 = 4\pi^2\frac{L}{g}$$

for refractive index:

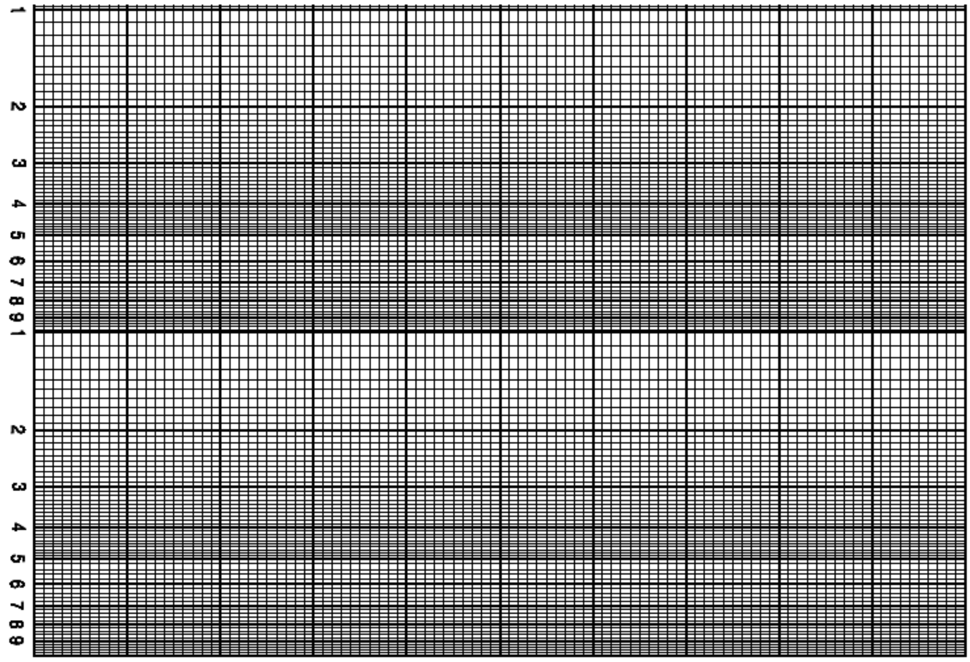
$$n = A + \frac{B}{\lambda^2}$$ plot n vs $$\frac{1}{\lambda^2}$$

For exponential relationships e.g. radioactive decay rate:

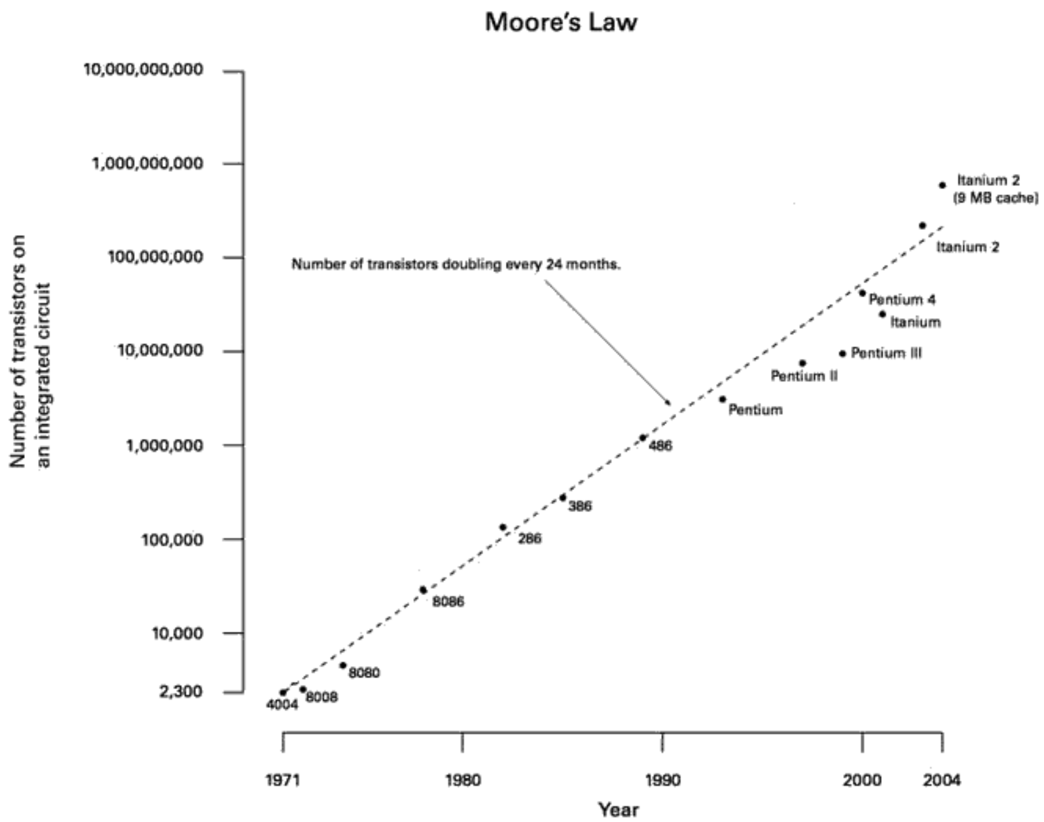
$$N = N_0 e^{-t/\lambda}$$

linearise by taking logarithms: $\log_{10} N = \log_{10} N_0 - \frac{t}{\lambda} \log_{10} e$

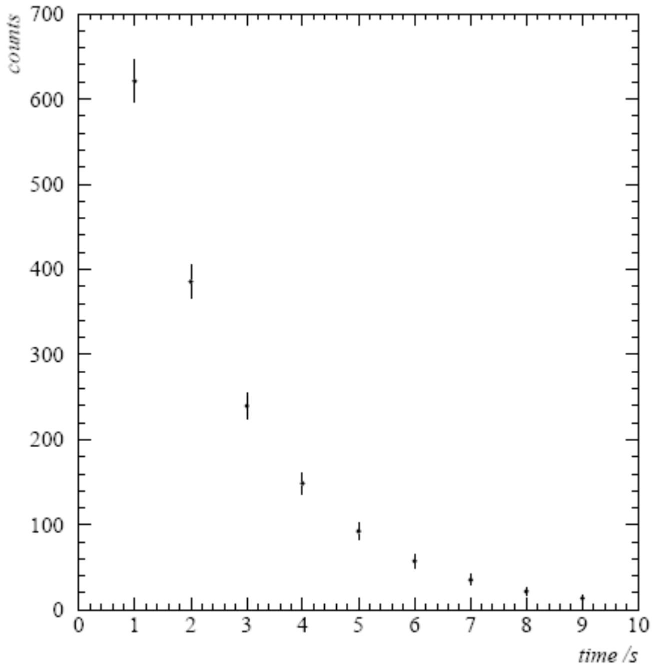
$\log_{10} e = 0.4343$

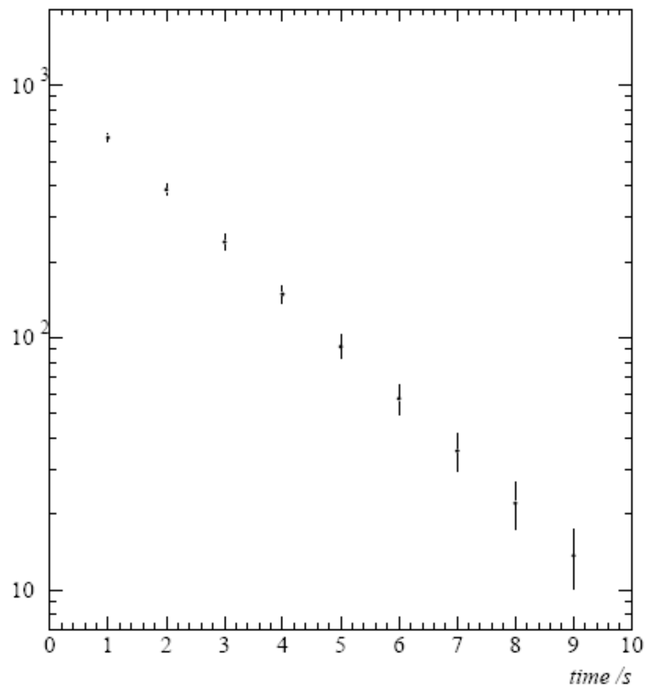


plot on log-lin paper
factors are constant
not differences!
label each decade



Graph Plotting





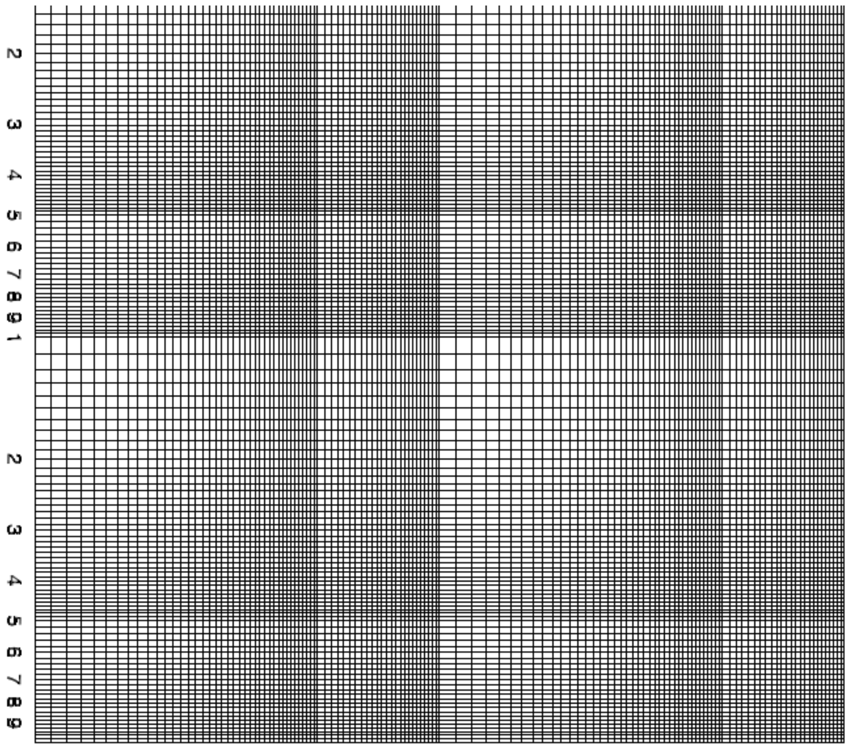
Same data shown on logarithmic and linear scales - data are same in both plots!
Notice error bars look different in both plots
In fact they are the same in both!

Graph Plotting

For power laws e.g: $V = kI^{\frac{3}{2}}$

taking logarithms: $\log_{10} V = \log_{10} k + \frac{3}{2} \log_{10} I$

plot on log-log paper:



Nowadays use computers to plot
They switch lin/log axes simply!
PhysPlot will do this too