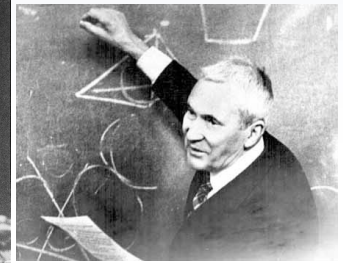
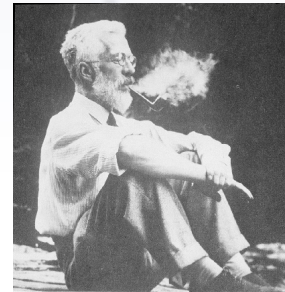
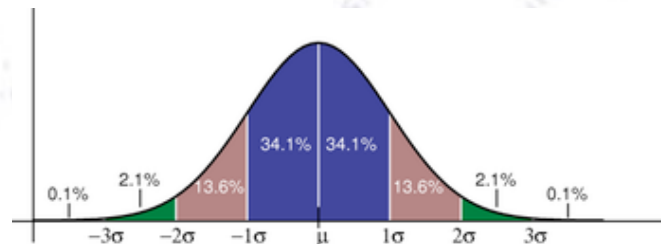


Applied Statistics

Why statistics?



Troels C. Petersen (NBI)



"Statistics is merely a quantisation of common sense"



Why uncertainties?

Errors/Uncertainties

In physics there are various elements of uncertainty:

- **Theory is not deterministic**
Examples: Quantum effects & chaos
- **Random measurement errors**
Fluctuations are present even without quantum effects!
- **Things we could know in principle but don't...**
e.g. from limitations in cost, time, etc.



We can quantify the uncertainty using **PROBABILITY**

Armed with the realisation of limitations, we can make better calculations/experiments and informed conclusions.

Example: Speed of Gravity

Imagine that you measured the speed of gravity, and got the following result:

$$v_{\text{gravity}} = 2.89 \times 10^8 \text{ m/s}$$

That would tell you...

Example: Speed of Gravity

Imagine that you measured the speed of gravity, and got the following result:

$$v_{\text{gravity}} = 2.89 \times 10^8 \text{ m/s}$$

That would tell you...

Nothing!!!

Because you have no idea of the uncertainty.

Example: Speed of Gravity

Imagine that you measured the speed of gravity, and got the following result:

$$v_{\text{gravity}} = 2.89 \times 10^8 \text{ m/s}$$

Depending on the uncertainty, you might foresee three very different conclusions:

$v_{\text{gravity}} = (2.89 \pm 9.21) \times 10^8 \text{ m/s}$	Could be anything, even negative!
$v_{\text{gravity}} = (2.89 \pm 0.09) \times 10^8 \text{ m/s}$	Consistent with c, and not much else!
$v_{\text{gravity}} = (2.89 \pm 0.01) \times 10^8 \text{ m/s}$	Inconsistent with c: New Discovery!!!

(extreme) Conclusion:

Numbers without stated uncertainties are meaningless!



Why statistics?!?

Why statistics in physics?

Experimental measurements are only **SAMPLES** of the reality, they can never represent the entire set of possibilities, so

- they are affected by uncertainties
- results can be expressed as probabilities

Theoretical calculations are mostly **APPROXIMATIONS** limited by finite resources to do the calculations or by imprecise input parameters, so

- they are also affected by uncertainties
- predictions can also be expressed in terms of probability

Statistics gives the understanding of **uncertainty** and **probability** in relating data and theory!!!

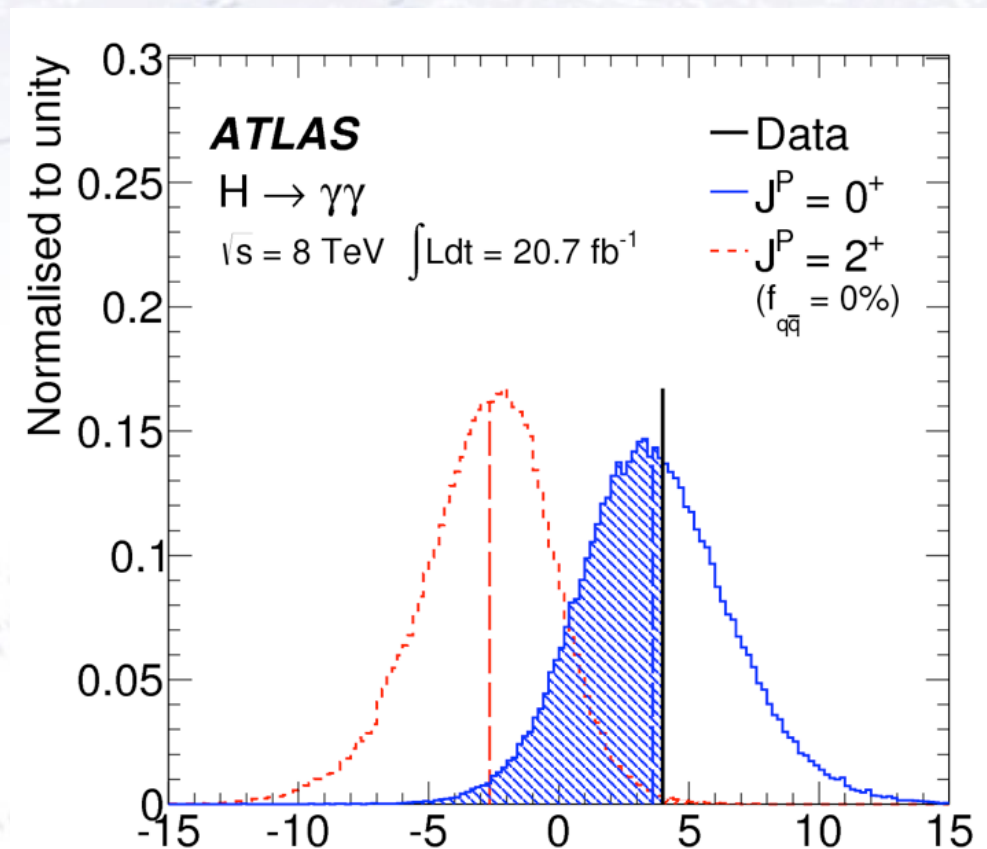
Why statistics in physics?

Statistics is about **hypothesis testing**, quantifying the answer to the question
“**which theory matches the data best?**”

Statistics is about collecting data and logically analysing it, not being fooled by coincidences and chance observations.

Statistics is about fitting trends in data, allowing for projections and predictions.

Statistics is about understanding data, and extracting the essential information from it in the most powerful way.



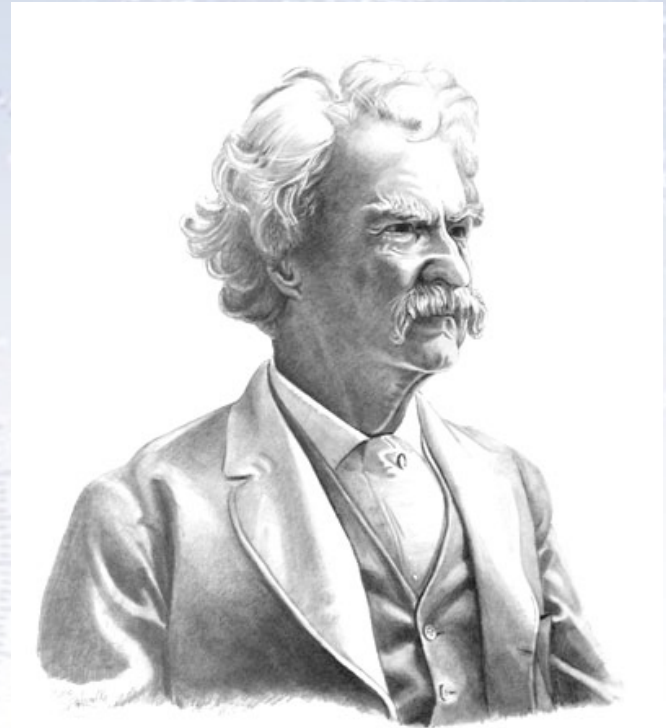
Is the Higgs a spin 0 or spin 2 particle?

Mark Twain:

*"There are three kinds of lies:
lies, damned lies, and statistics."*

My opinion:

*"The only way to convey accurate
information is by statistics."*



THE WALL STREET JOURNAL.

Big Data's High-Priests of Algorithms

'Data Scientists' Meld Statistics and Software for Find Lucrative High-Tech Jobs

8th of August 2014

While a six-figure starting salary might be common for someone coming straight out of a doctoral program, data scientists with just two years' experience can earn between \$200,000 and \$300,000 a year, according to recruiters.