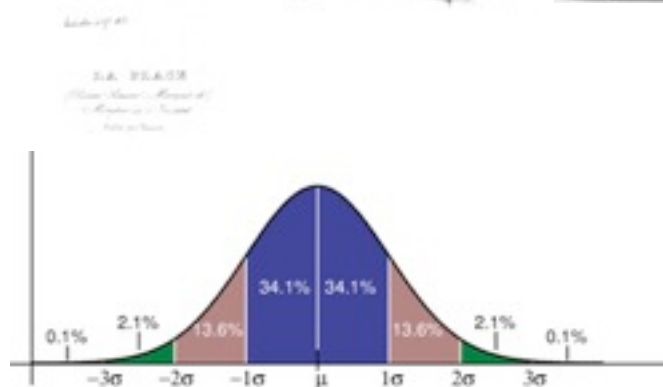


# Applied Statistics

Troels C. Petersen (NBI)



*"Statistics is merely a quantization of common sense"*

# Anvendt Statistik

Troels C. Petersen (NBI)

*“Statistics is merely a quantisation of common sense”*

## Introduction:

- The role of statistics and uncertainties.
- The basic axioms of statistics.
- The Central Limit Theorem.
- A little experiment.
- Probability and Statistics.
- The basis of exact sciences, yet not exact.

## Technicals:

- Rooms and hours.
- Computers and software.
- Curriculum and exam.

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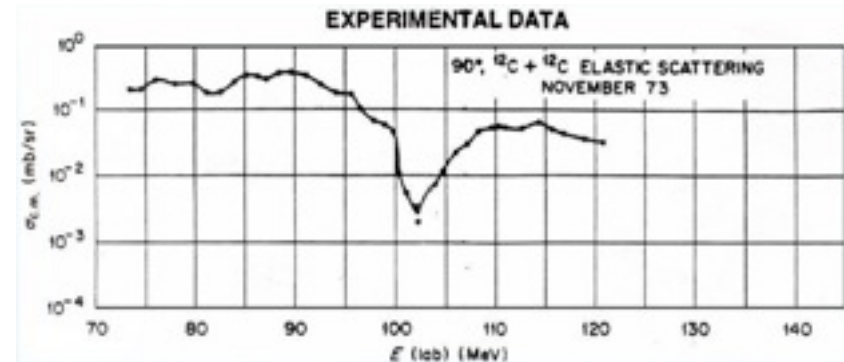
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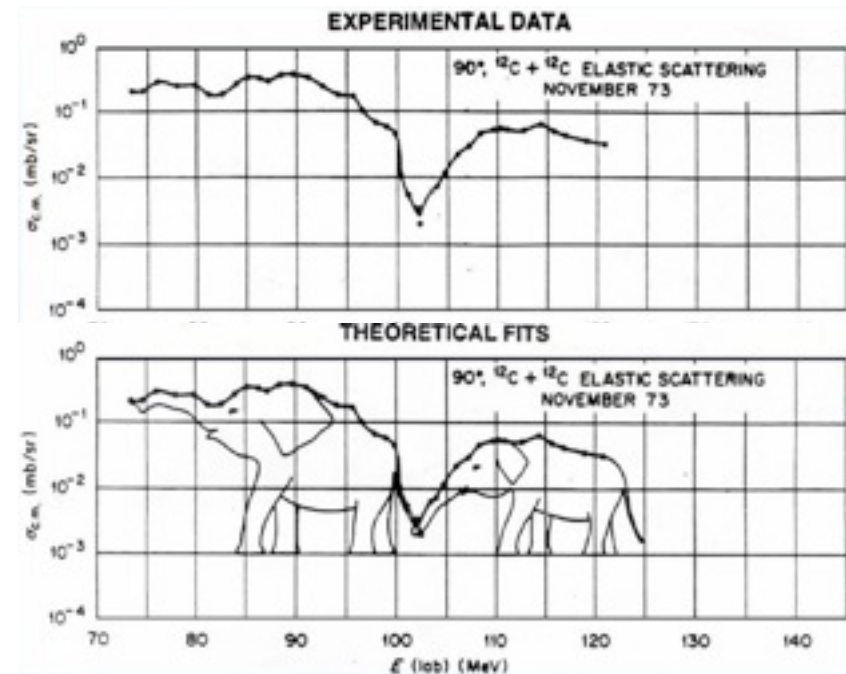
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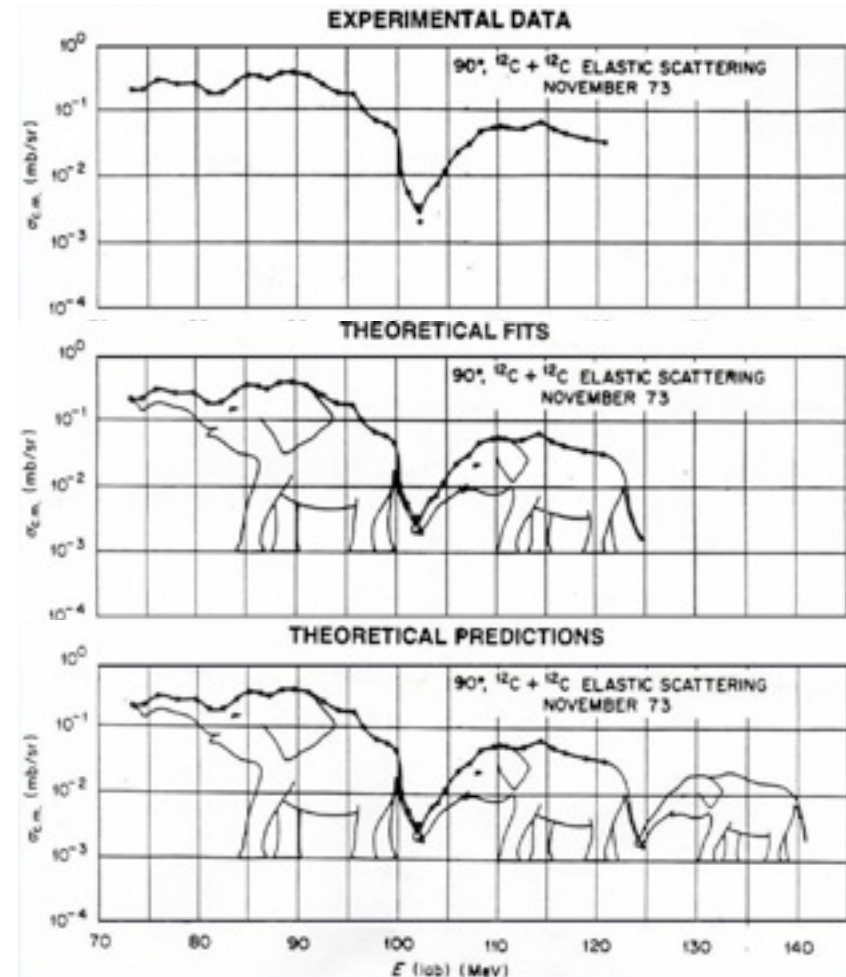
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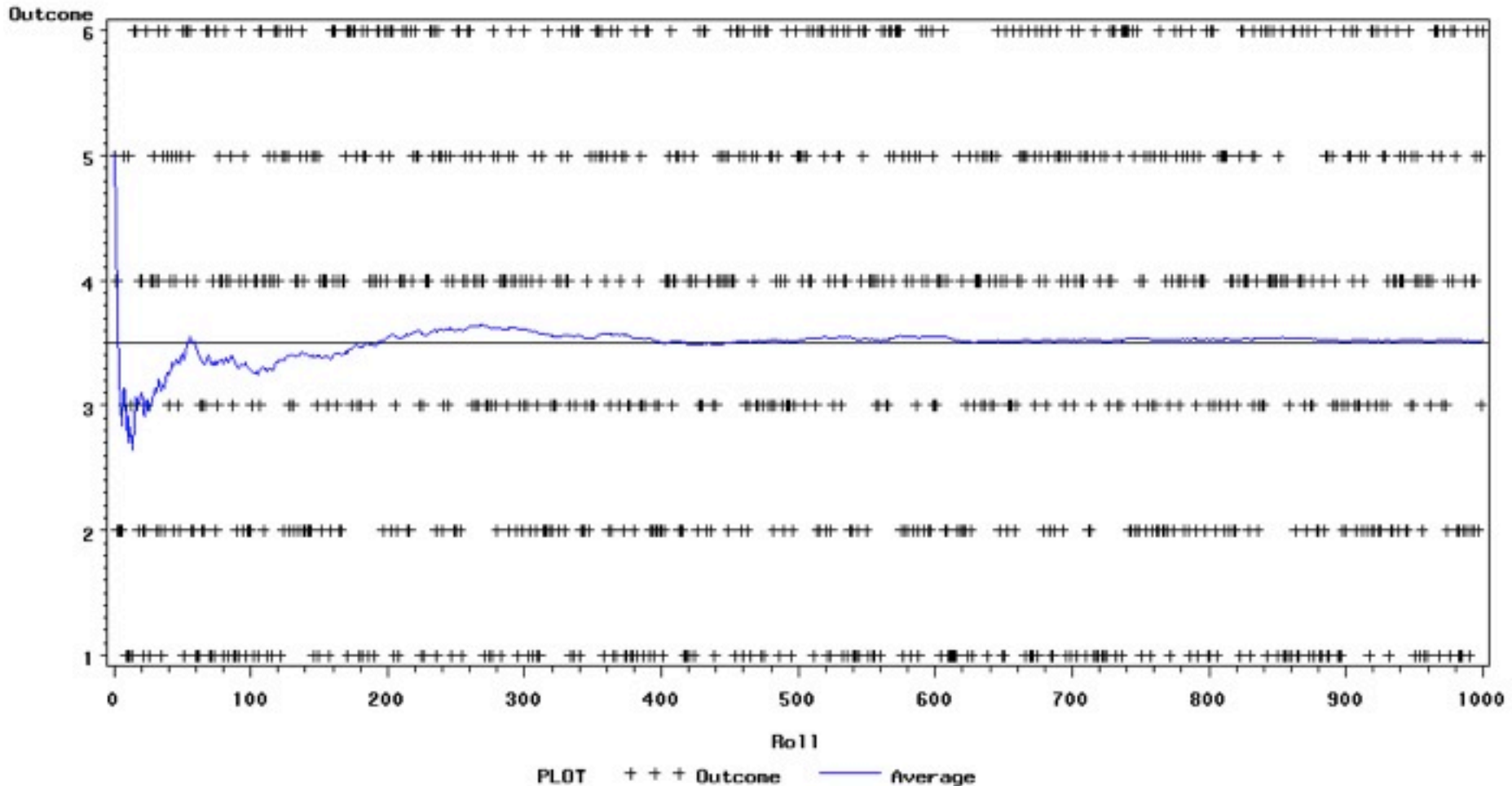
“Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.”

[H. G. Wells]

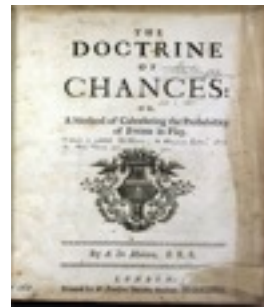
# Law of large numbers

## LAW OF LARGE NUMBERS IN AVERAGE OF DIE ROLLS

AVERAGE CONVERGES TO EXPECTED VALUE OF 3.5



# Central Limit Theorem

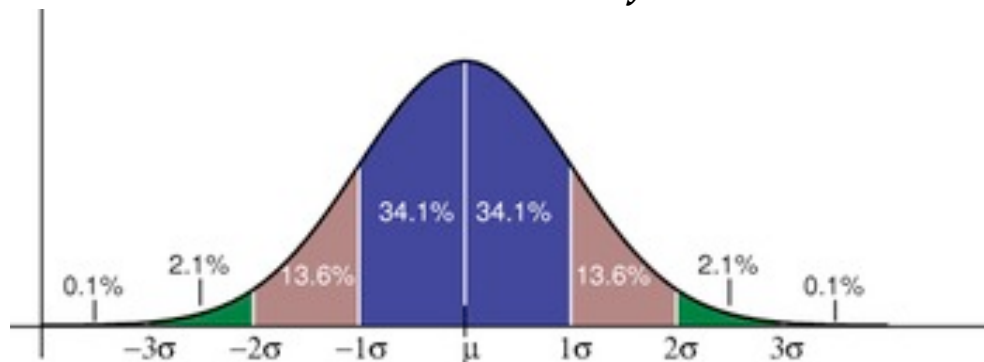


## Central Limit Theorem:

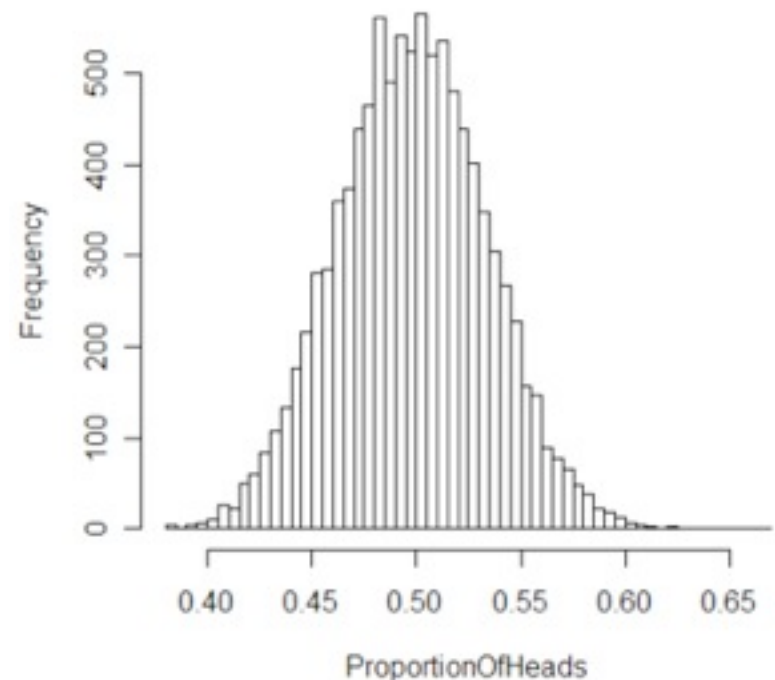
The sum of  $N$  *independent* continuous random variables  $x_i$  with means  $\mu_i$  and variances  $\sigma_i^2$  becomes a Gaussian random variable with mean  $\mu = \sum_i \mu_i$  and variance  $\sigma^2 = \sum_i \sigma_i^2$  in the limit that  $N$  approaches infinity.

This holds under fairly general conditions, which means that the Gaussian distribution takes a central role in statistics.

*The Gaussian is "the unit" of distributions!*



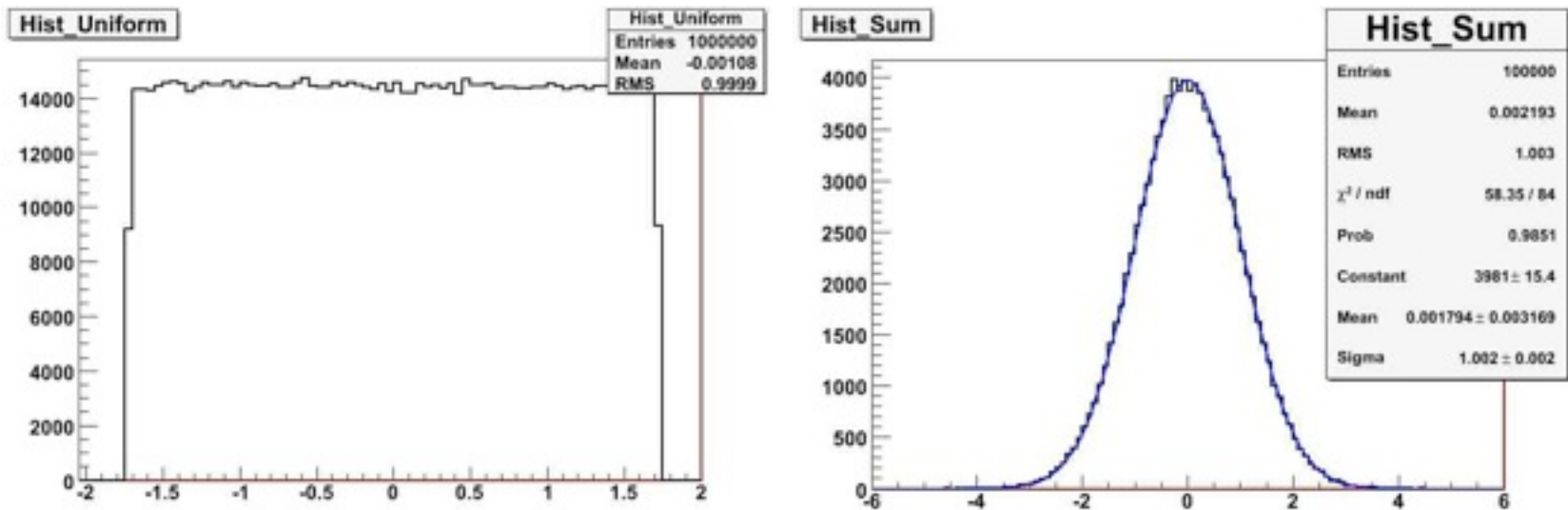
Histogram of ProportionOfHeads





# Example of Central Limit Theorem

Take the sum of 100 uniform numbers! Repeat 100000 times to see what distribution the sum has...

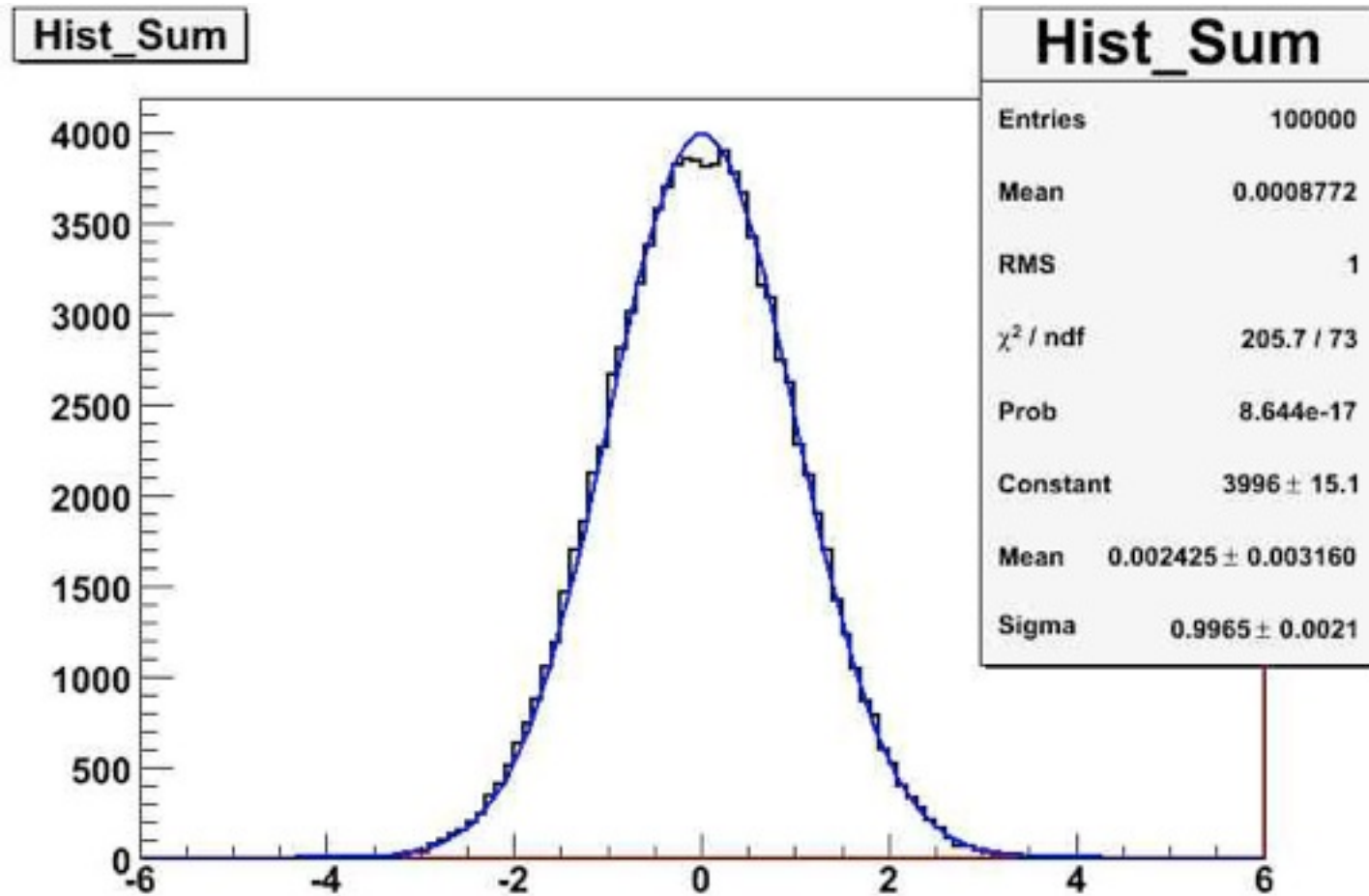


The result is a bell shaped curve – a so-called **normal** or **Gaussian** distribution.

*It turns out, that this is very general!!!*

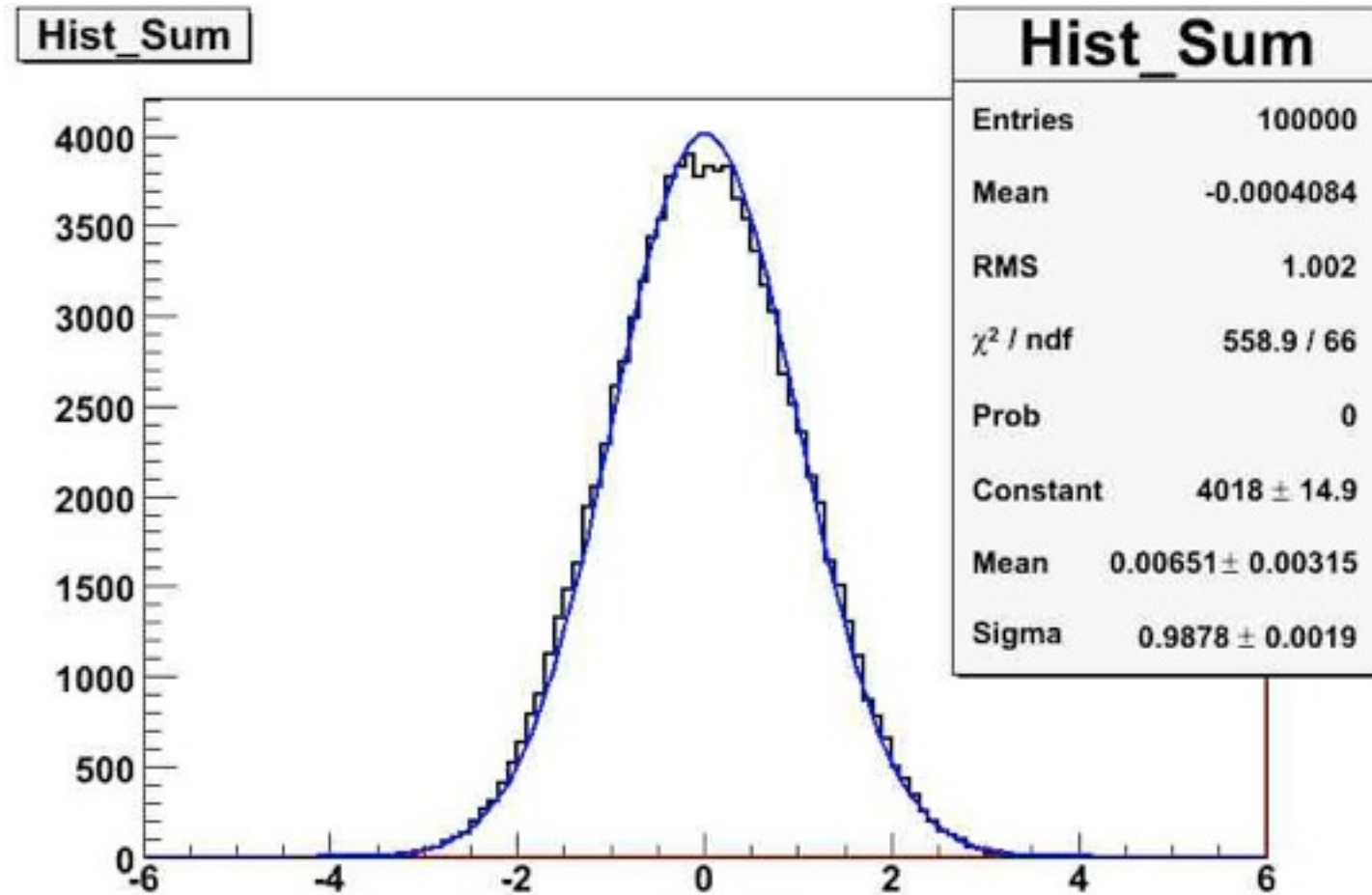
# Example of Central Limit Theorem

Now take the sum of just **10** uniform numbers!



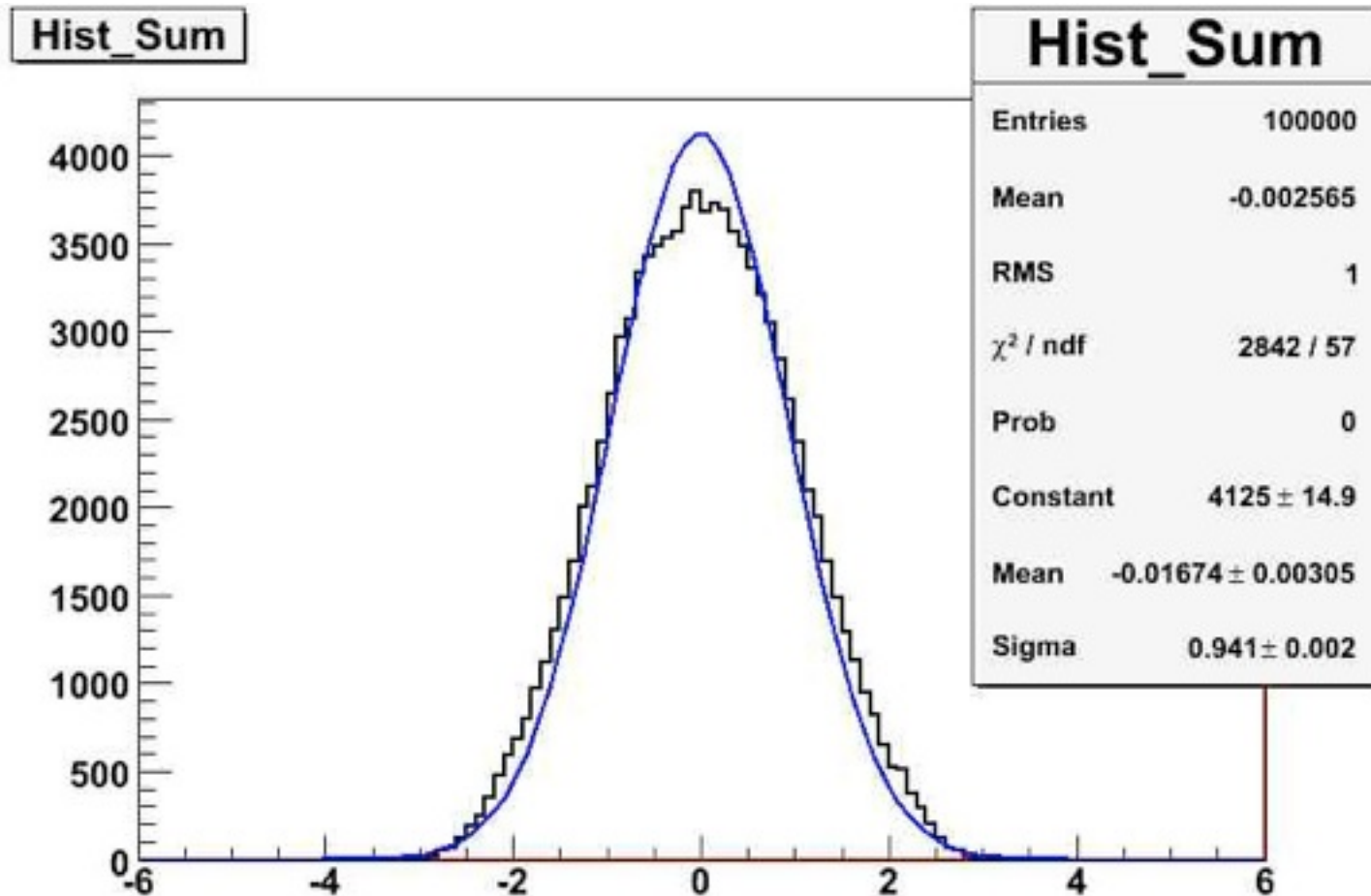
# Example of Central Limit Theorem

Now take the sum of just **5** uniform numbers!



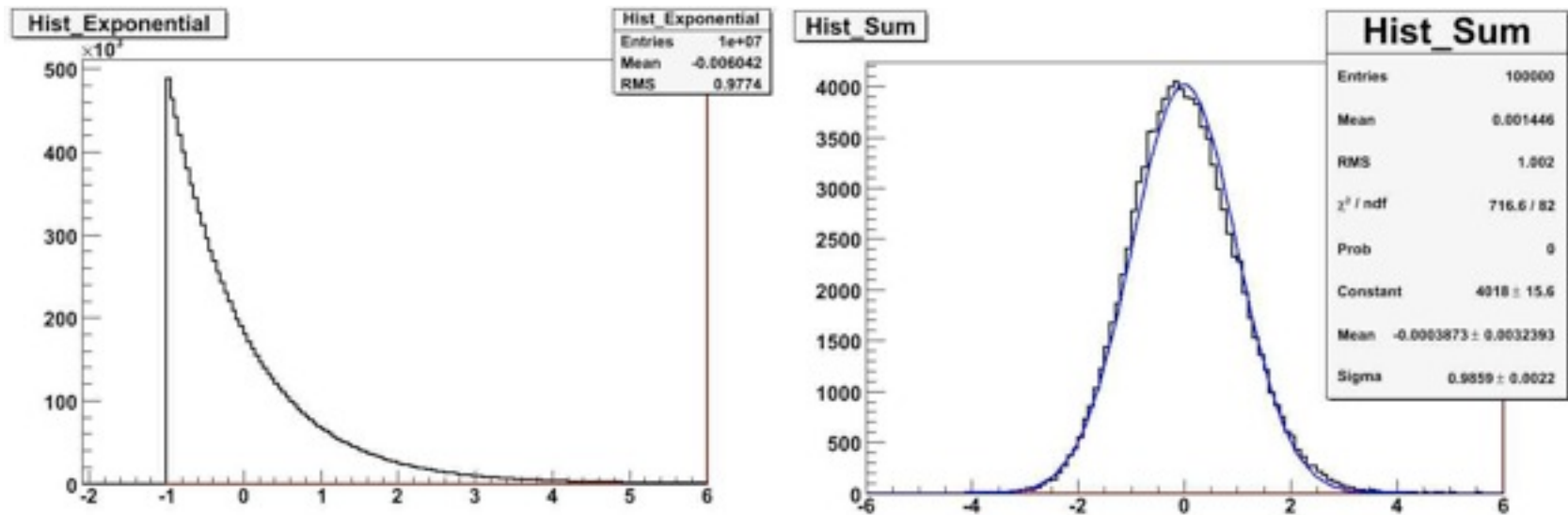
# Example of Central Limit Theorem

Now take the sum of just **3** uniform numbers!



# Example of Central Limit Theorem

This time we will try with a much more “nasty” function. Take the sum of 100 *exponential* numbers! Repeat 100000 times to see the sum’s distribution...



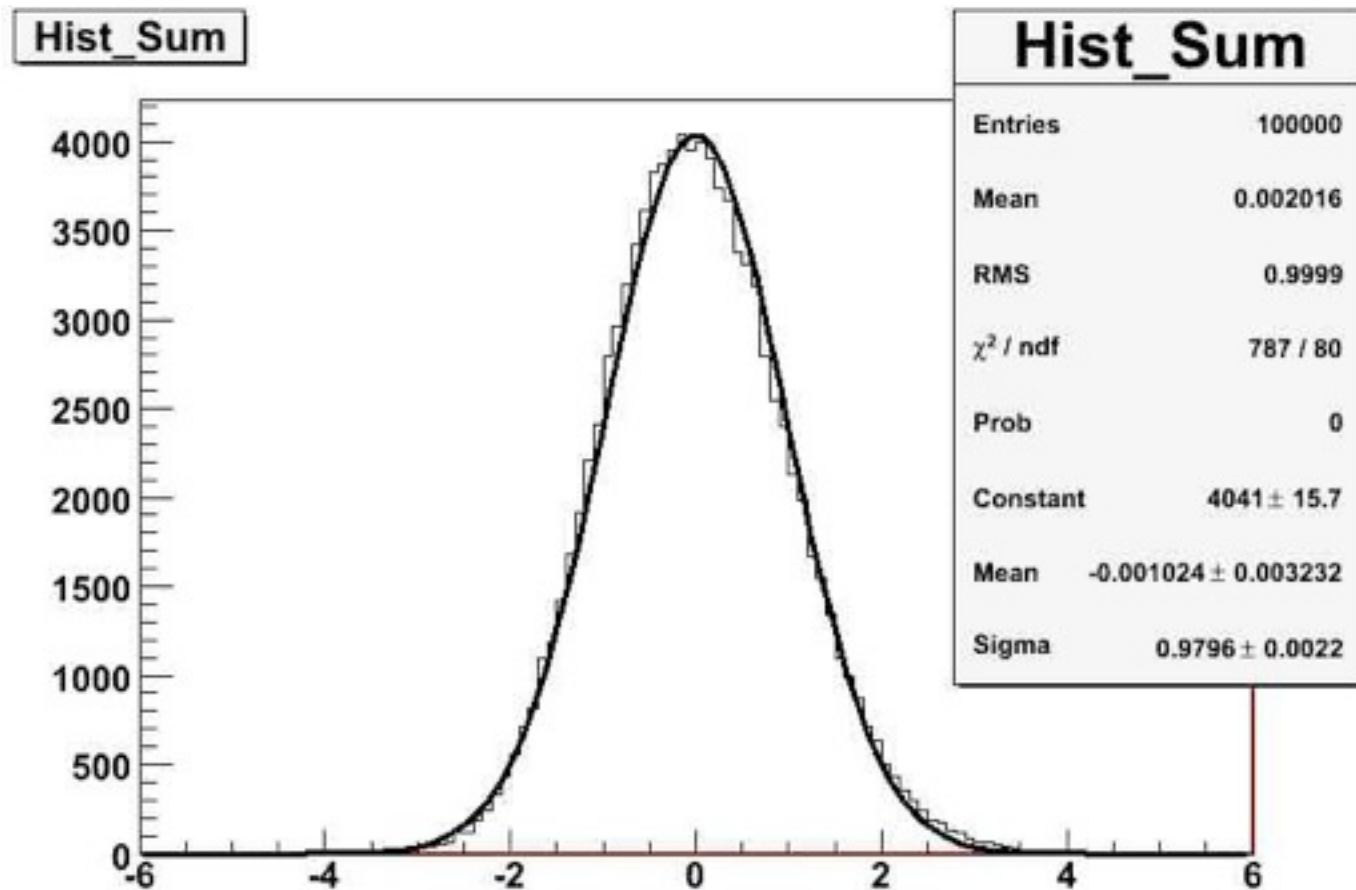
Even with such a non-Gaussian skewed distribution, the sum quickly becomes

*Gaussian!!!*

It turns out, that this fact saves us from much trouble: Makes statistics “easy”!

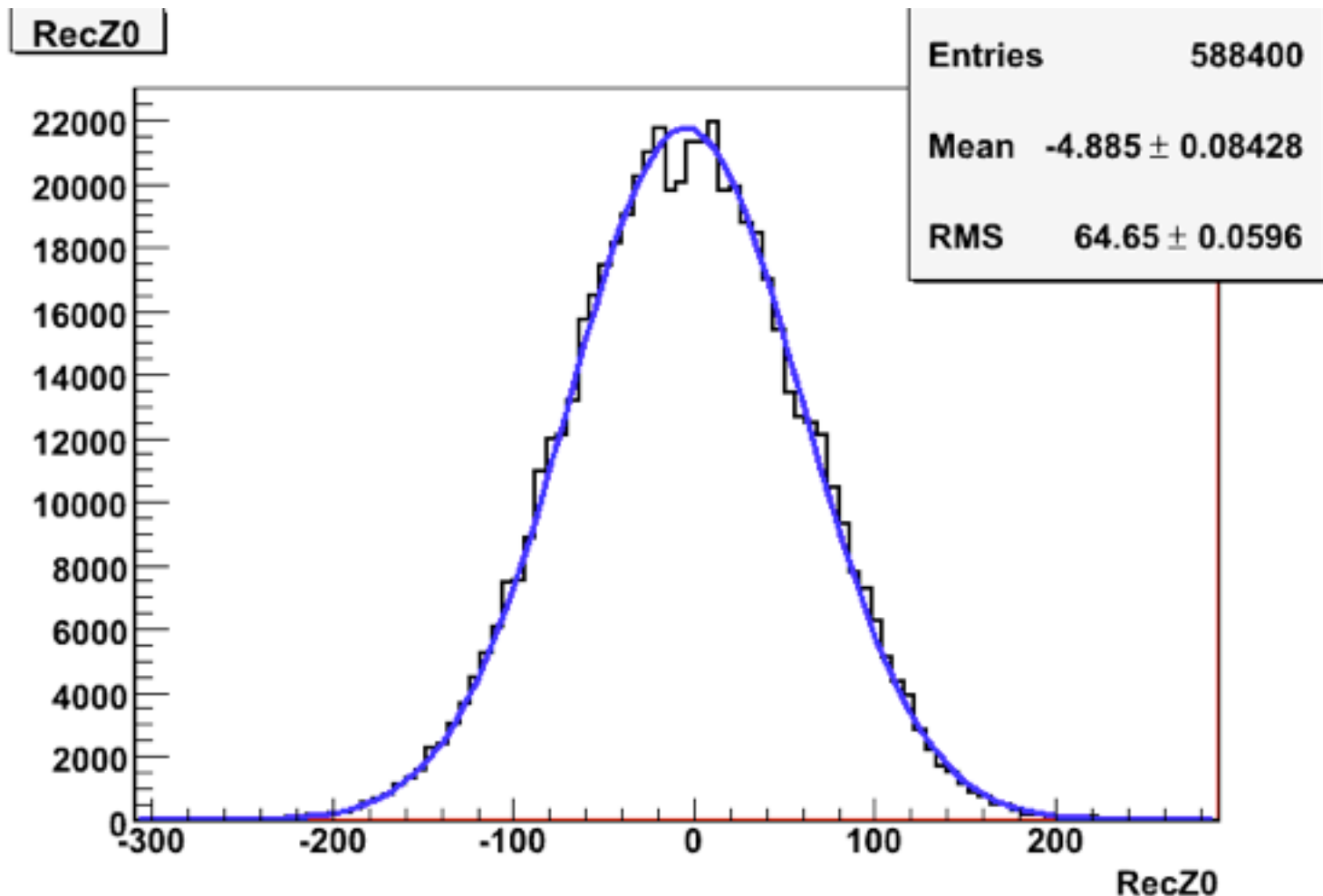
# Example of Central Limit Theorem

Generally, measurements are the result of many different influences from various distributions! Here **10** uniform numbers and **10** exponential numbers:

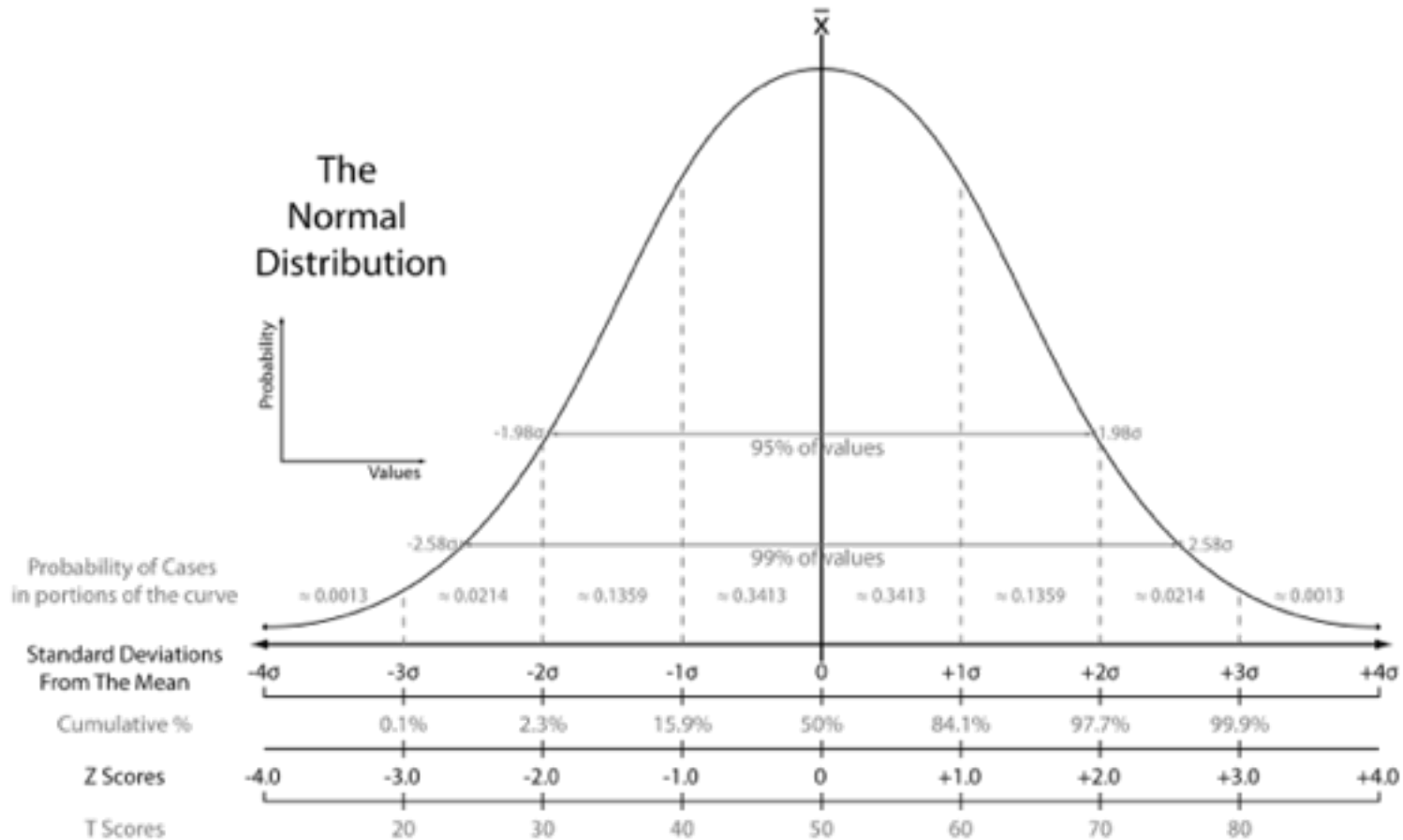


# Example of Central Limit Theorem

Looking at z-coordinate of tracks at vertex from proton collisions in CERNs LHC accelerator by the ATLAS detector, this is what you get:



# Central Limit Theorem





# Central Limit Theorem

