



Biomedical Engineering 生醫工程

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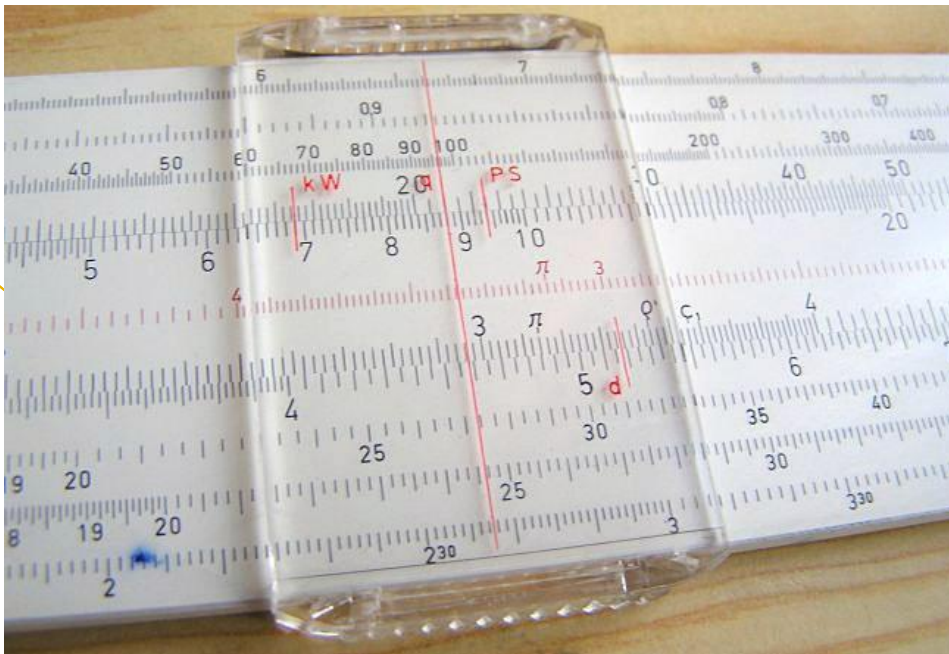
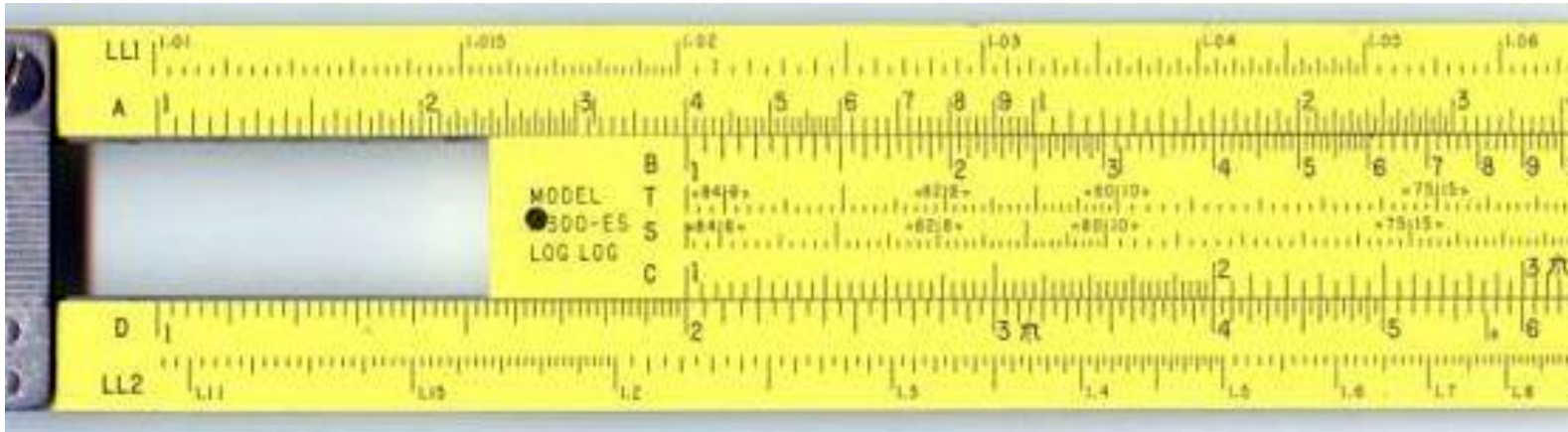
Spring 2024

Measurements & Statistical Error Bars

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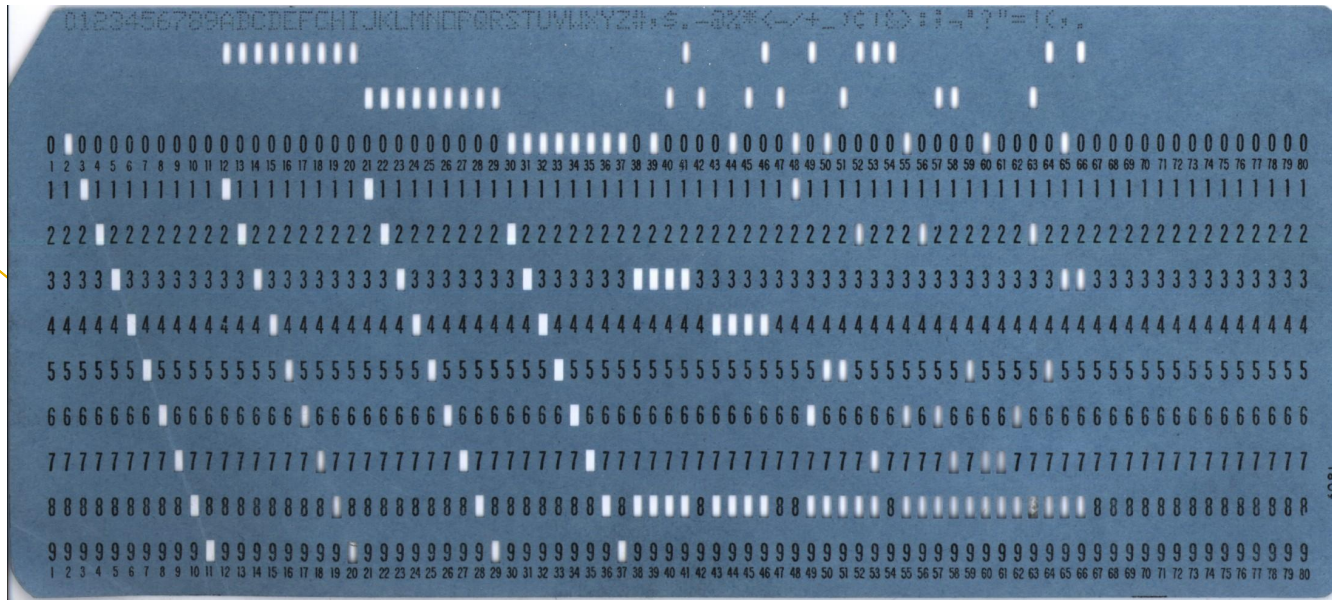


History of Computation: Slide rules



In use from 1950-75.

History of Computation: Punch cards and paper tape



History of Computation: Programmable Pocket Calculators

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In use from 1980-95.

In use from 1970-85.

History of Computation:

Home computers around 1984



In use from 1982-95.

320 or 640 pixels.

4-8k pixels.

128 kilobytes of RAM

16 GB of RAM

1-2 MHz processor

3.5 GHz

Floppy disk drive 300 kB

internet

No harddrive

1 TB SSD

Languages BASIC, Pascal

Many to choose

Oh! An unwelcome visitor!



Walk to

Push

Pull

Give

silver

paint

Open

Close

Read

key

brush

Walk to

Pick up

What is

Unlock

New kid

Use

flashlight

manuscript

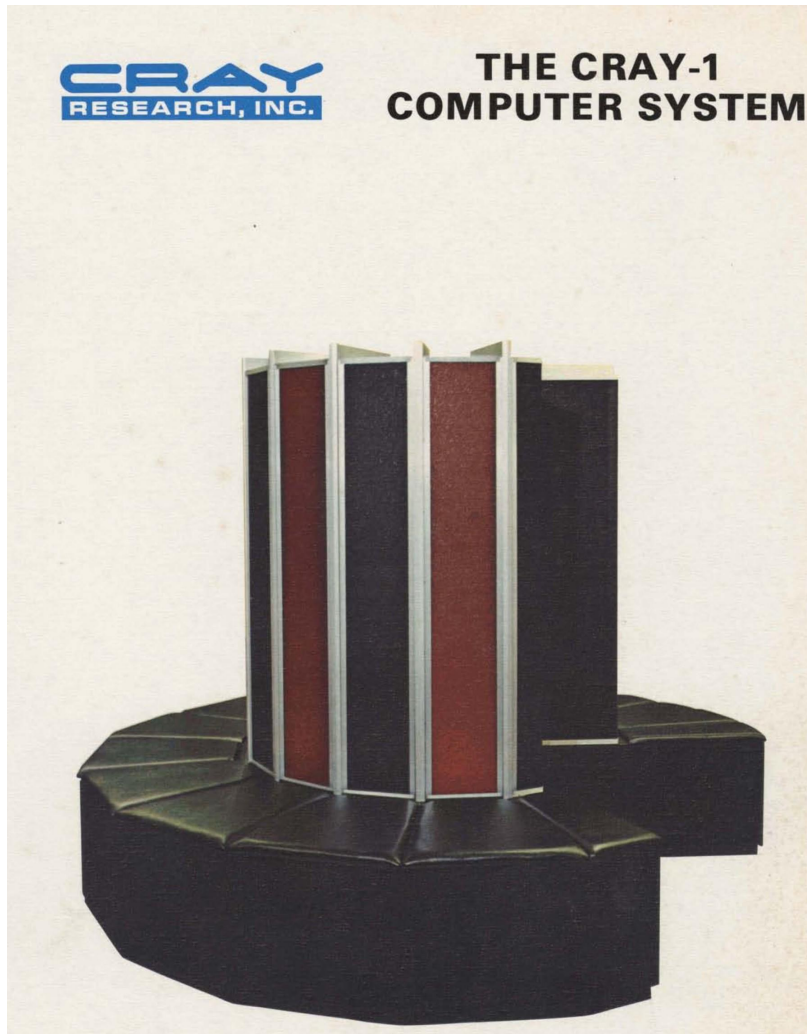
Turn on

Turn off

Fix

History of Computation: Ancient super computers

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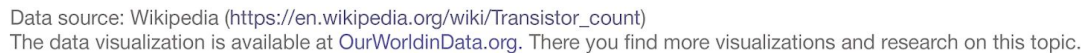
The size of a large room.
A powerful as today's
iPhone

History of Computation: Personal computers



Our World
in Data

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Moore's law, the Exponential Increase of Computing Power **may be Ending**

End of Scaling

- **Energy consumption** has become more important to users
 - For mobile, IoT, and for large clouds
- Processors have reached their power limit
 - Thermal dissipation is maxed out (**chips** turn off to avoid **overheating!**)
 - Even with better packaging: heat and battery are limits.
- Architectural advances must increase energy efficiency
 - Reduce power or improve performance for same power
- The dominant architectural techniques have reached limits in energy efficiency!
 - 1982-2005: Instruction-level parallelism
 - Compiler and processor find parallelism
 - 2005-2017: **Multicore**
 - Programmer identifies parallelism
 - **Caches**: diminishing returns (small incremental improvements).

CERN - European Organization for Nuclear Research

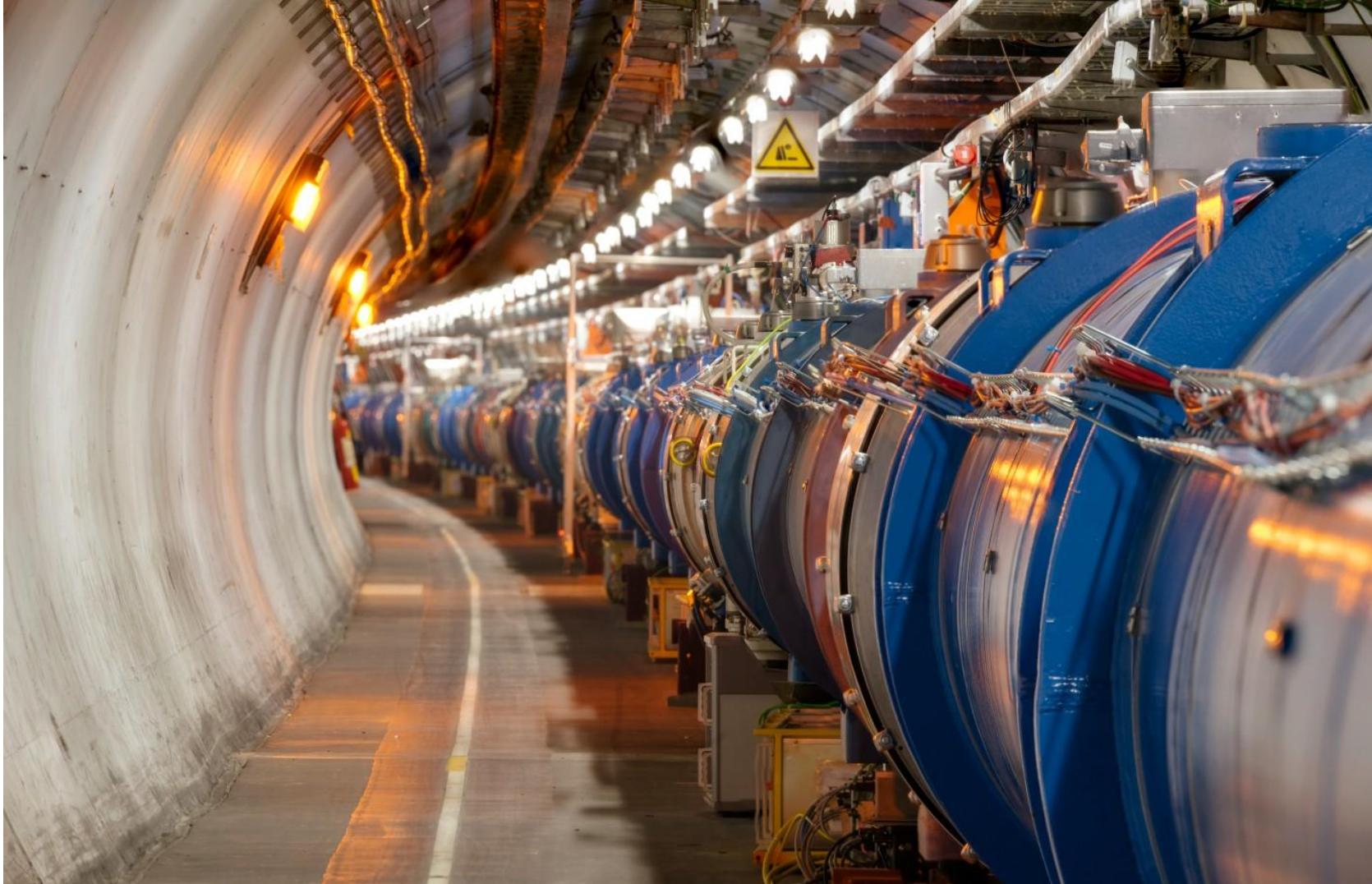
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CERN/Science Source/Photo Researchers, Inc.

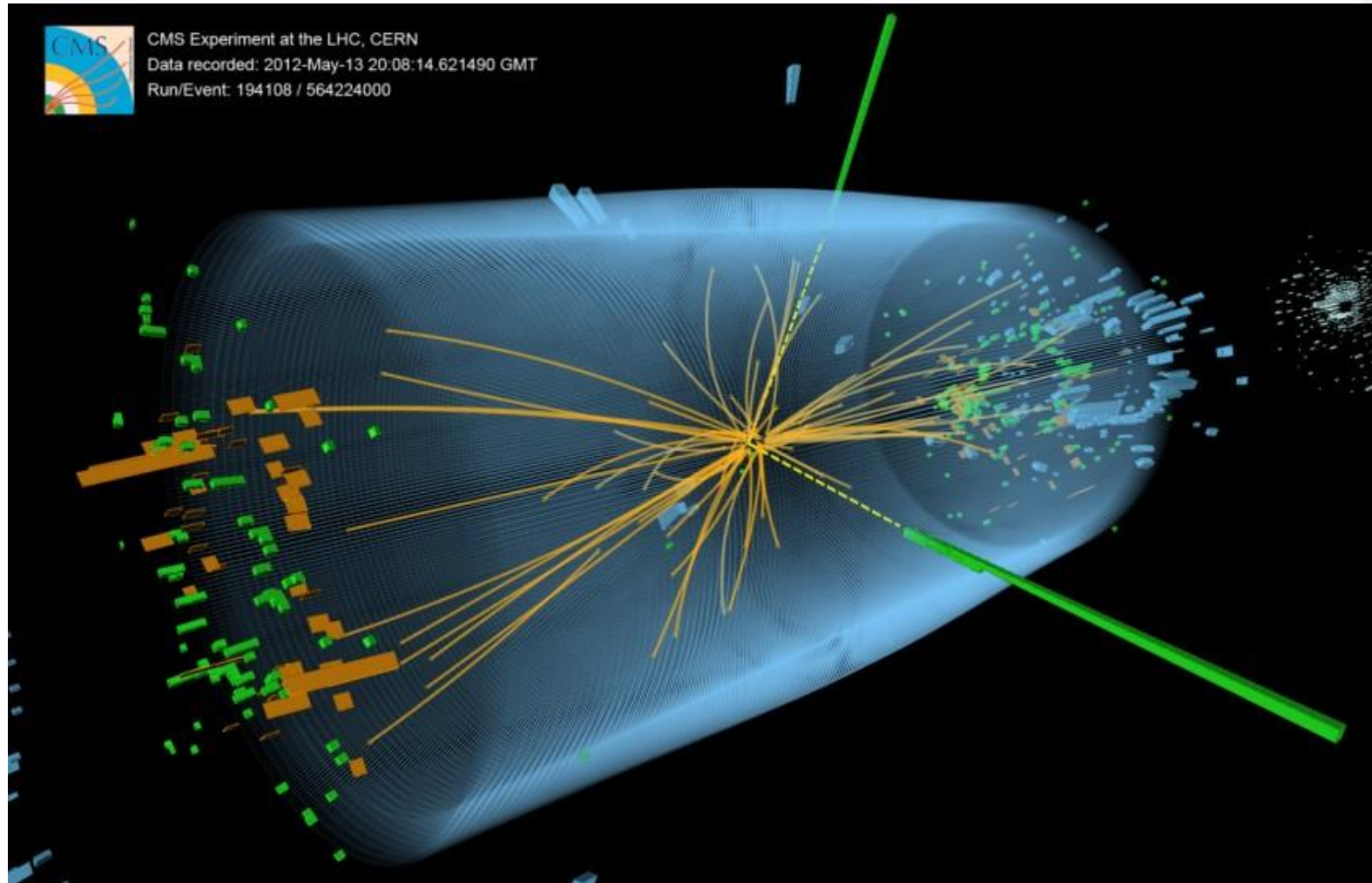
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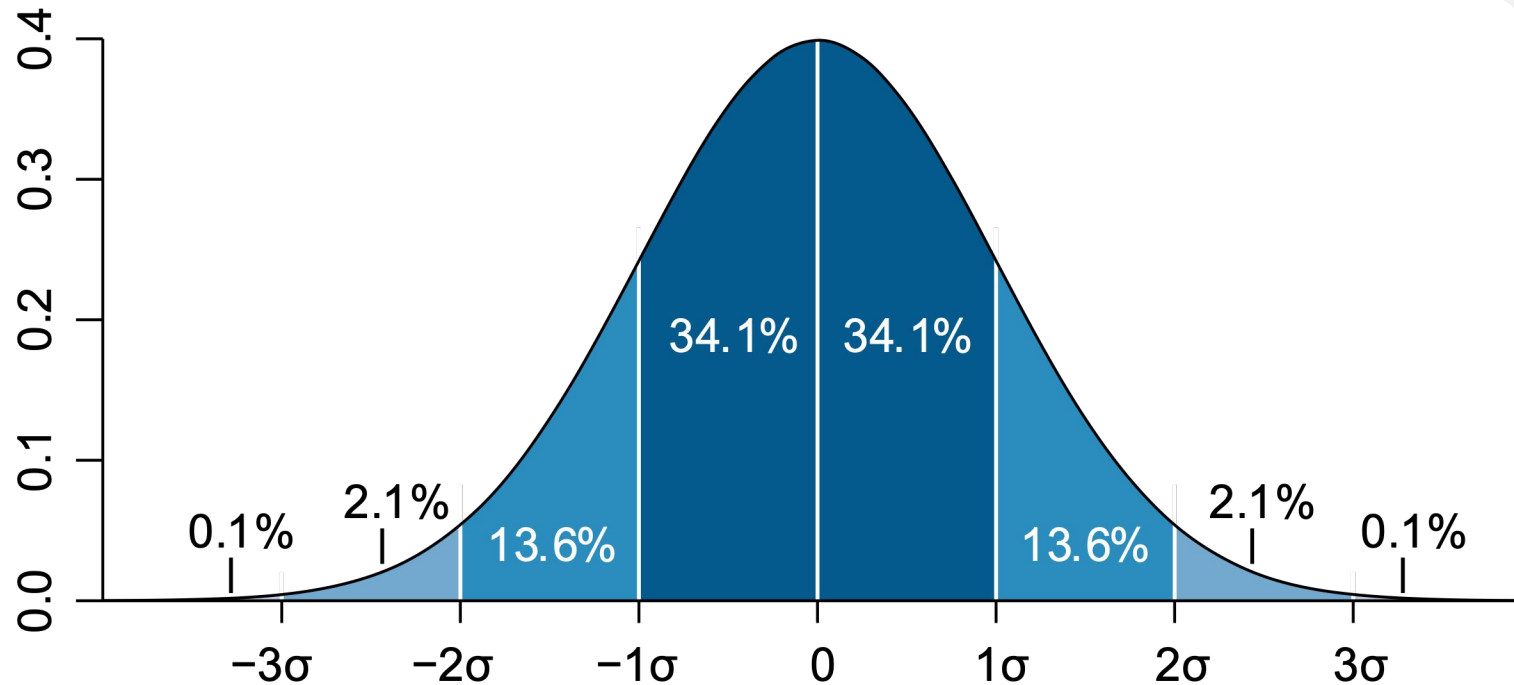


Discovery of the Higgs Boson

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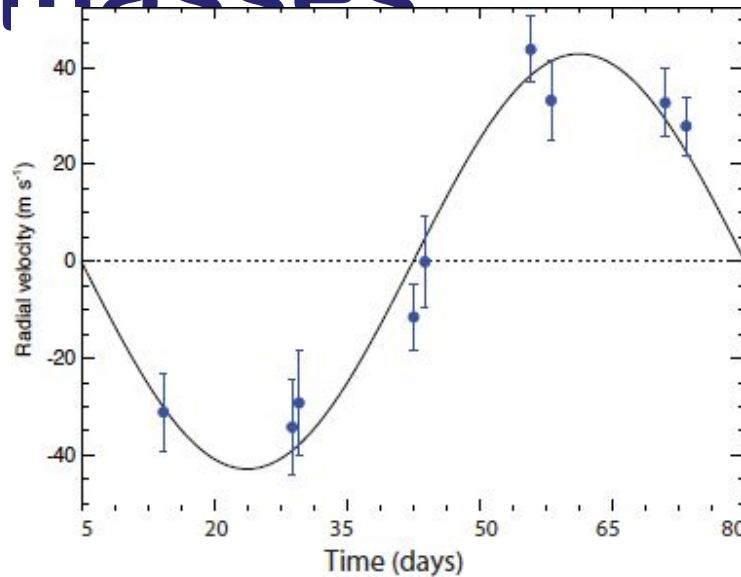


Probability Density Function



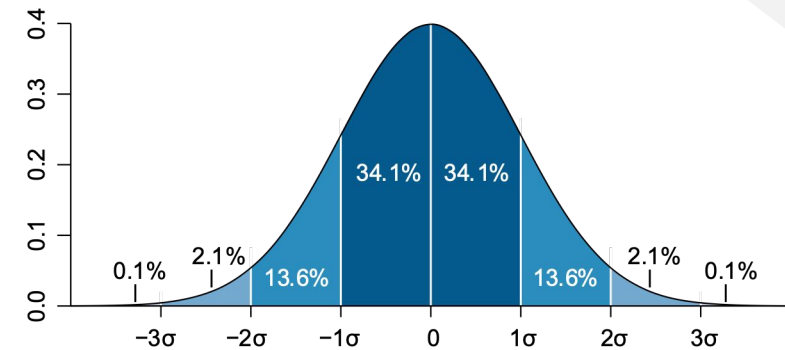
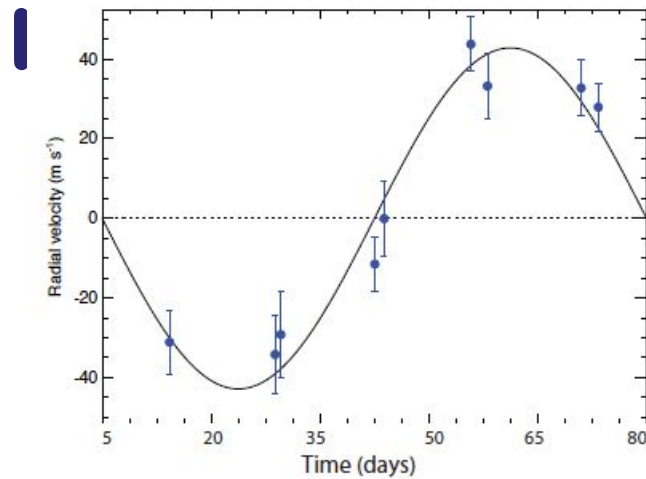
$$f(x \mid \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Hurray, we discovered a Exoplanet with 12 Earth masses



$$M = 12 M_E$$

Hurray, we discovered a Exoplanet with 12 Earth



$$M = (12 \pm 6) M_E$$

Is there convincing evidence for the planet to real exist?