Title: Smash, Bang, Boom: Fundamental Physics at the LHC

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Abstract: The world's most ambitious scientific experiment is buried 100 meters underground, straddling Switzerland and France. A billion times every minute, the Large Hadron Collider (LHC) slams together protons, while four giant detectors watch closely.

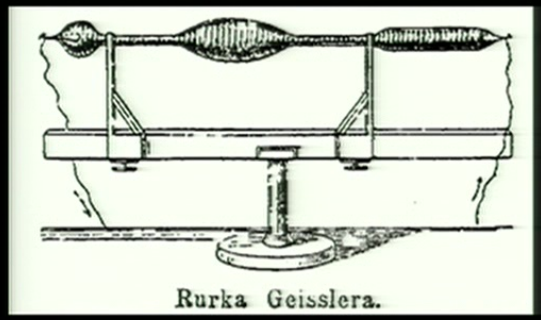
- So how does the Large Hadron Collider work?
- Why can slamming tiny particles into each other provide clues about the nature of all space and time?
- What mysteries are physicists trying to solve with data from the LHC?
- How does the cutting edge of particle physics relate to the world around us, from the patterns of stars in the sky to the fact that they shine at all?

Natalia Toro, PI Faculty, works at the intersection of theories and hard data. She will explain how complex collision data from the LHC is being digested and examined right now, and how it may set the course for the science of the future.

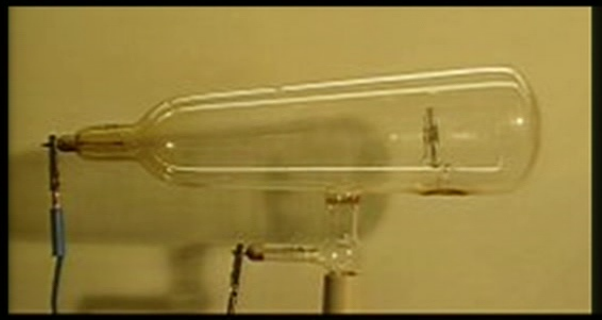
Pre-History of Particle Physics

Faraday, 1838

Geissler, 1857



Crookes 1869-75



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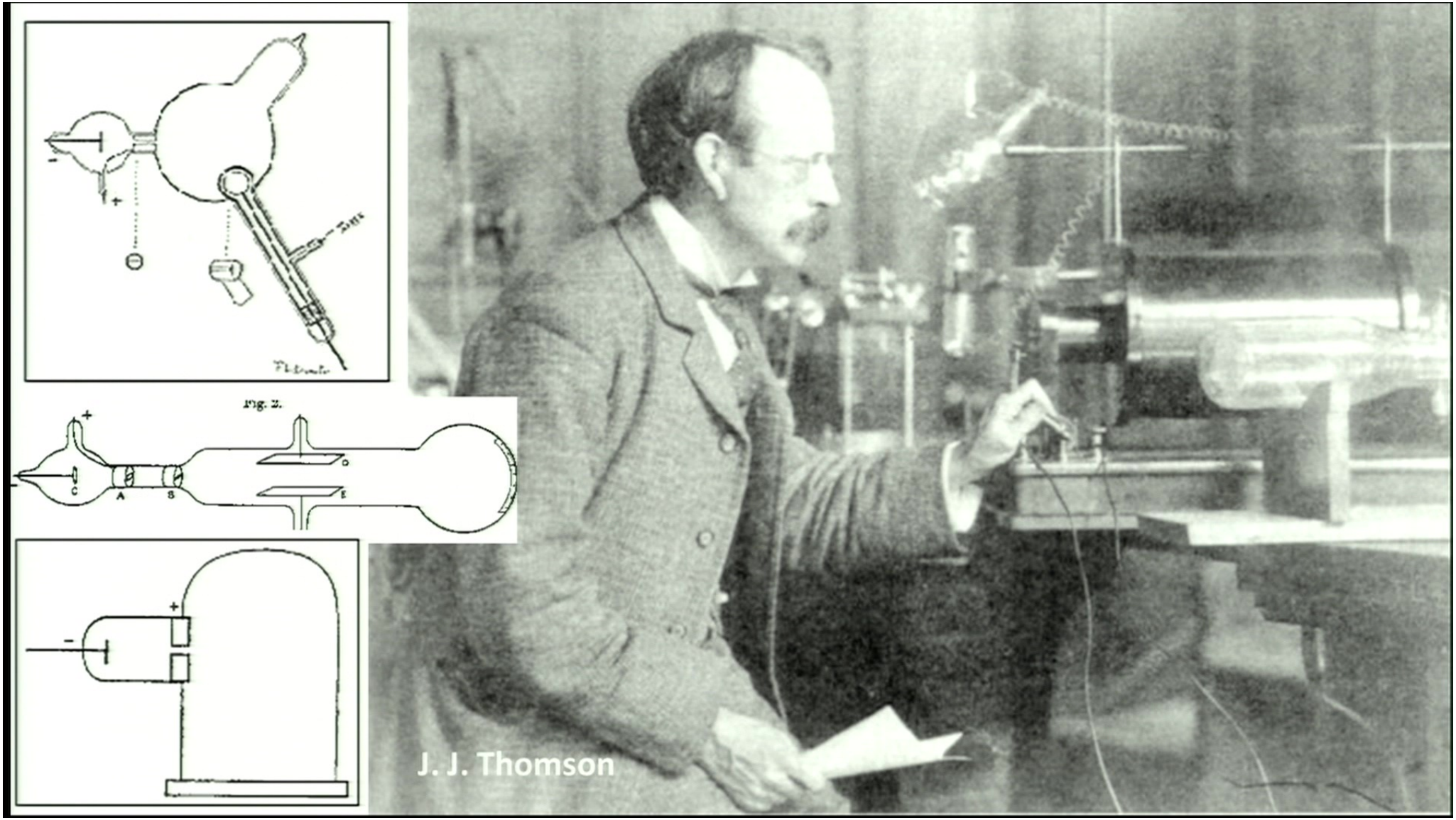
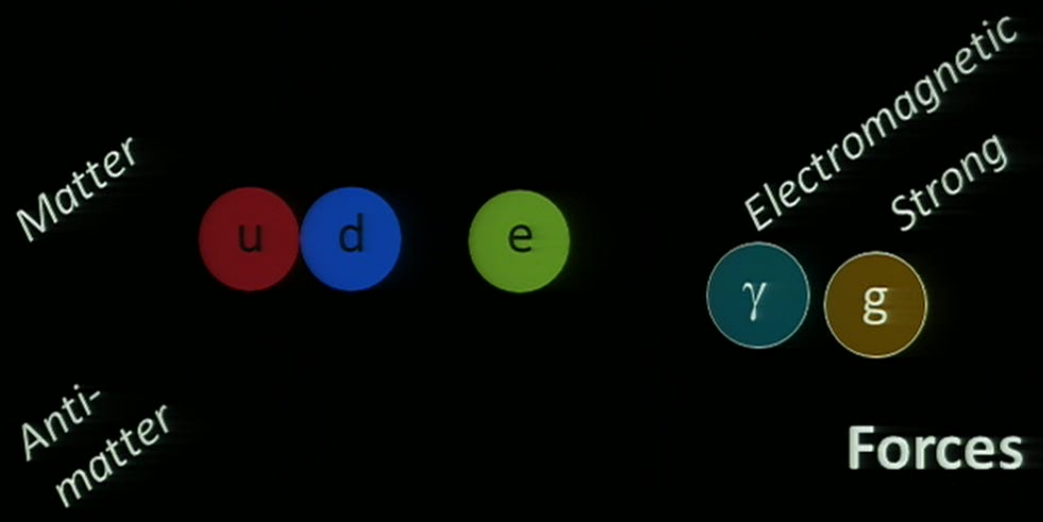

J. J. Thomson

The Standard Model: A New Periodic Table



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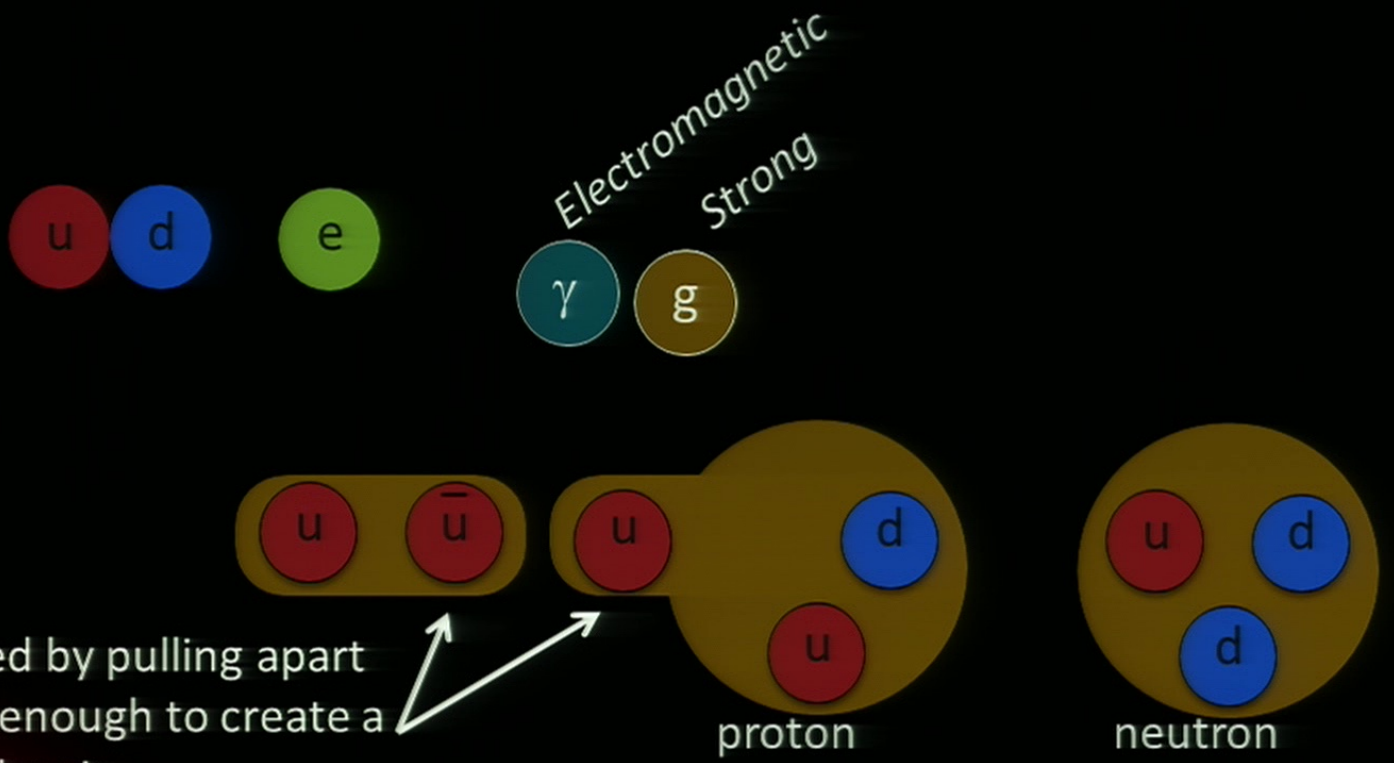
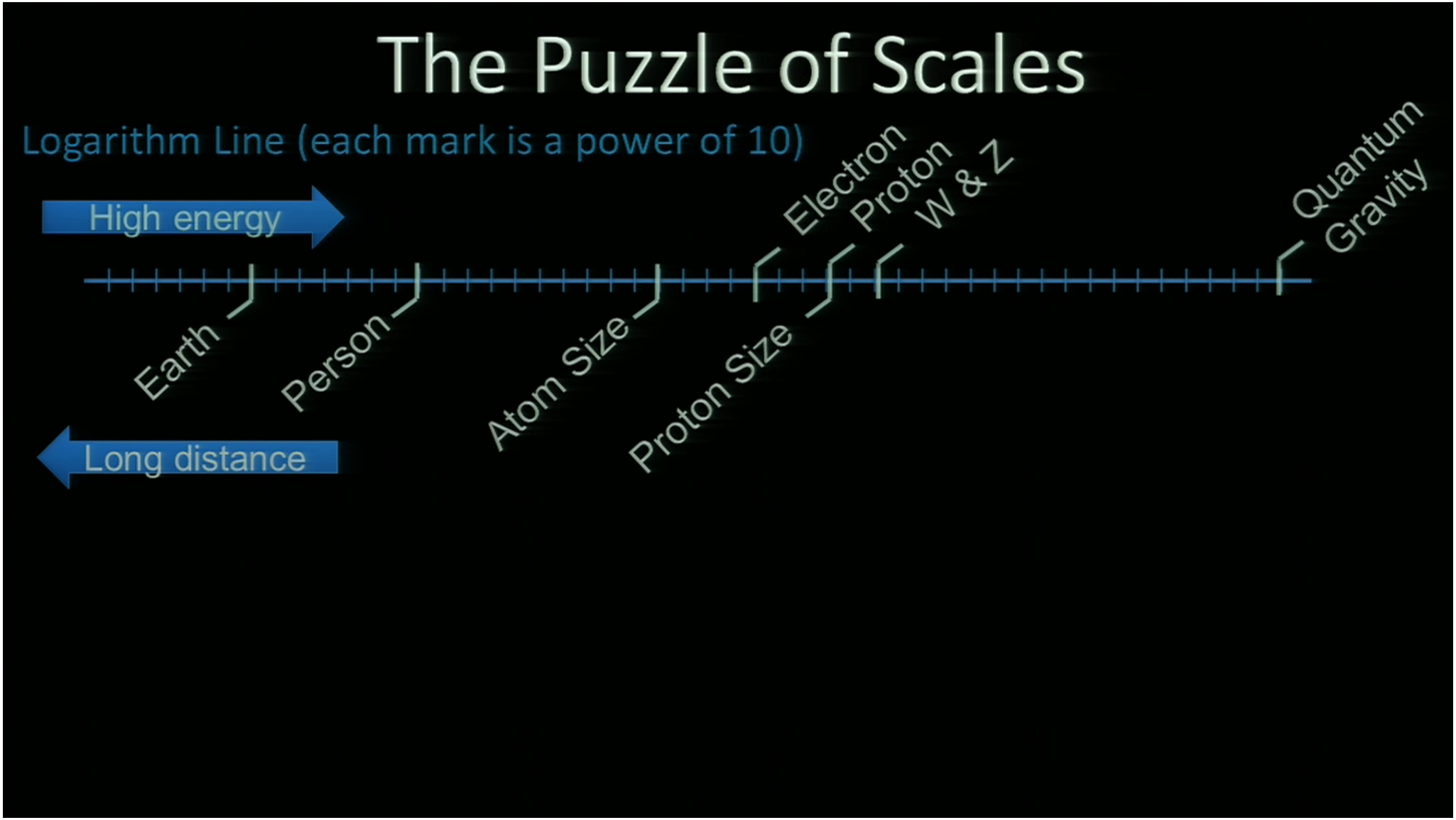
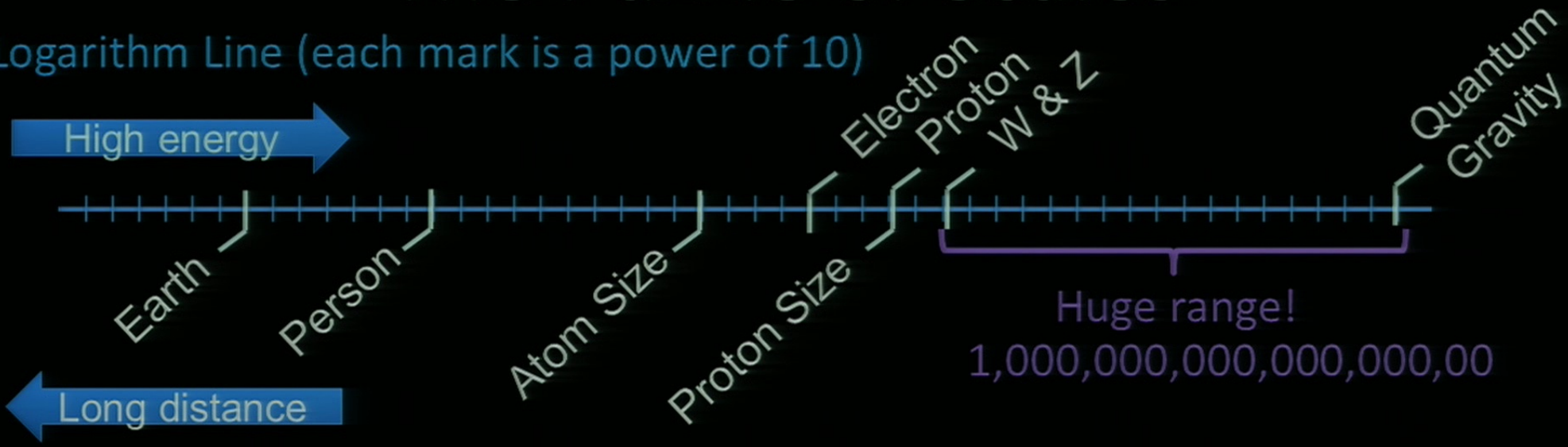
Building Blocks of the Elements




The Puzzle of Scales
Logarithm Line (each mark is a power of 10)
High energy
Long distance
Earth
Person
Atom Size
Proton Size
Electron
Proton
W & Z
Quantum Gravity

The Puzzle of Scales

Logarithm Line (each mark is a power of 10)



Quantum mechanics corrects the W mass:

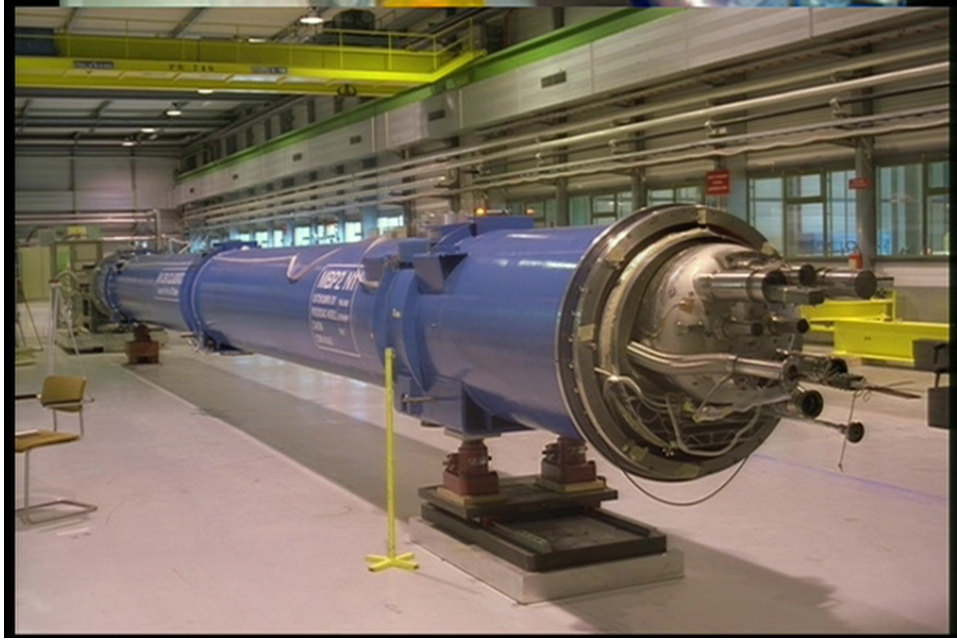
$$M = M_{classical} + M_{quantum} \quad \text{and} \quad M_{quantum} = \# \times M_{largest}$$

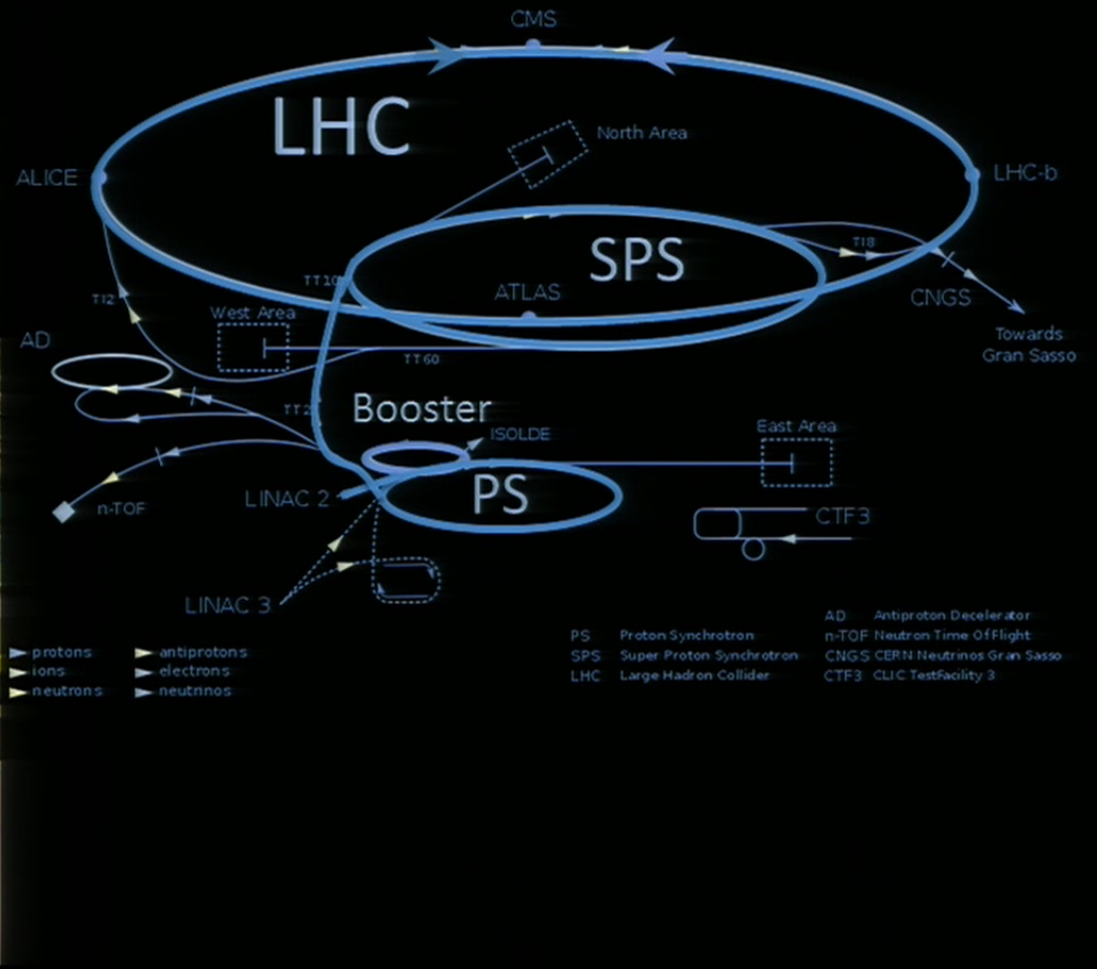
$M_{classical} = 1{,}280{,}236{,}158{,}903{,}735{,}48$

$M_{quantum} = -1{,}280{,}236{,}158{,}903{,}735{,}47$

OR

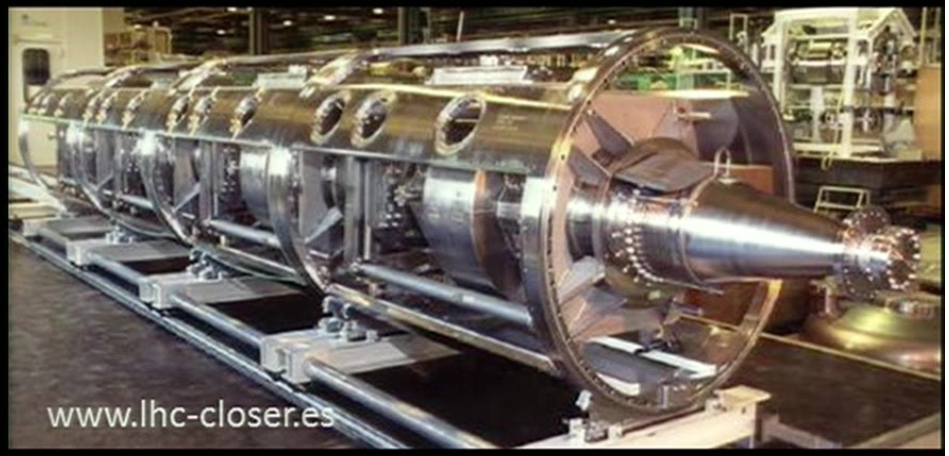
is very small
(very special theory)




CMS
LHC
North Area
ALICE
LHC-b
SPS
ATLAS
CNGS
Towards
Gran Sasso
West Area
AD
Booster
ISOLDE
East Area
n-TOF
LINAC 2
PS
CTF3
LINAC 3
protons
ions
neutrons
antiprotons
electrons
neutrinos
PS Proton Synchrotron
SPS Super Proton Synchrotron
LHC Large Hadron Collider
AD Antiproton Decelerator
n-TOF Neutron Time Of Flight
CNGS CERN Neutrinos Gran Sasso
CTF3 CLIC TestFacility 3

Accelerating the Protons

Same principle as the cathode ray tube, on a much larger scale



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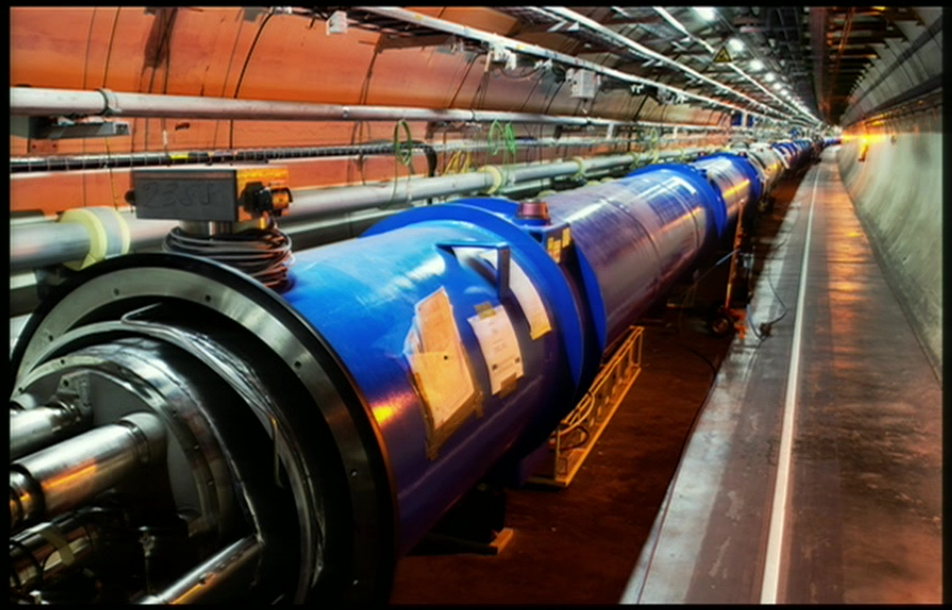
Why is the LHC so large?

Highest energy proton beams (by 4–7x)

At this energy, each magnet can only bend the protons by 7 cm

The LHC is as small as it can possibly be, with protons closing the circle.



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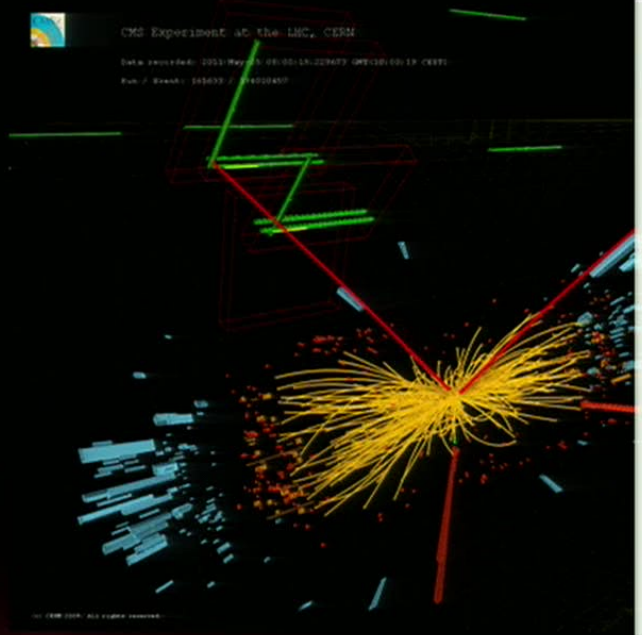
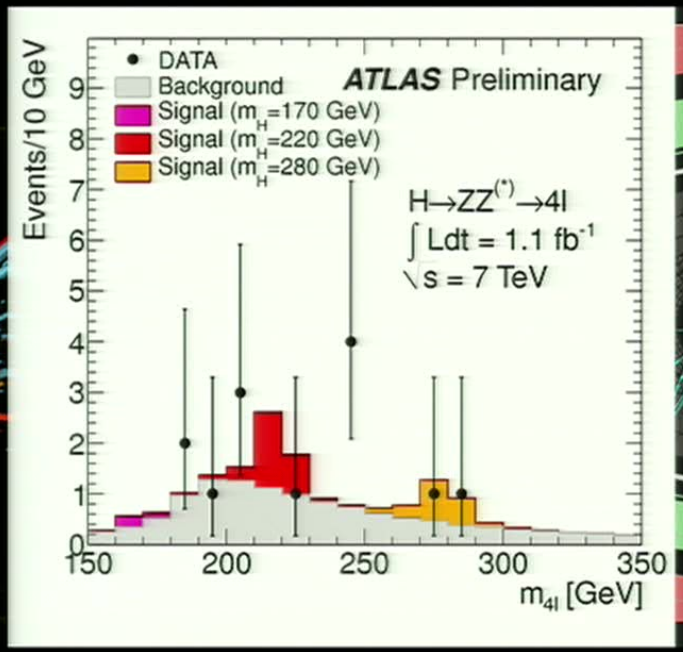
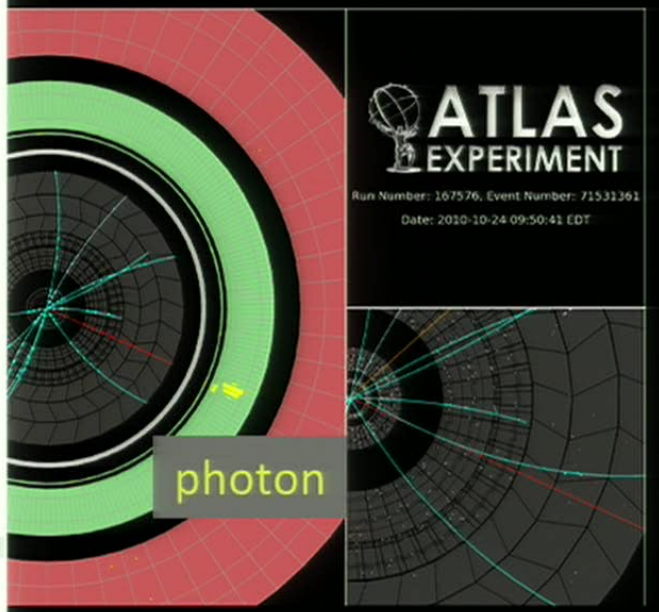
What would a Higgs look like?







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...if it's heavier

...if it's lighter