

Communicating Dark Matter

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Goals:

Create strategies for the communication of physics topics that are related with searches for dark matter in the LHC.

Produce a series of informative elements about searches for dark matter in the LHC.

Talk about the paper “Vector Boson Fusion Topology and Simplified Models for Dark Matter searches at Colliders”.

Socialize the informative elements in places like high schools, colleges, and interactive museums.



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Target Audience and Strategy

The target audience are people over 12 years old.

We made a series of infographics about:

- Standard Model.
- Dark Matter.
- Particle Accelerators.
- Searches for Dark Matter in Particle Accelerators.



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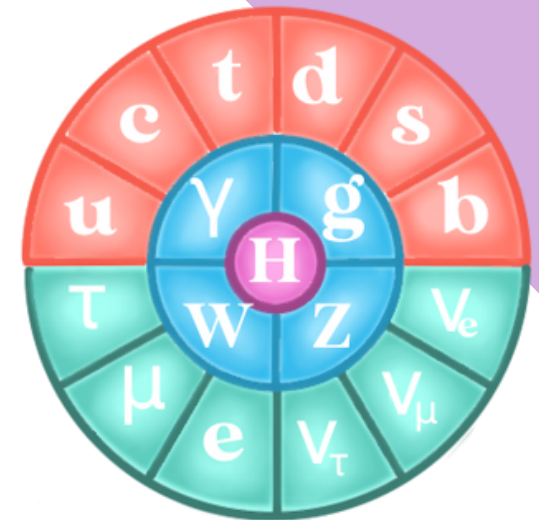
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What are we made of?

To know about simplified models, particle collisions and particle accelerators we must first know about particle physics.

In this infographic we talk about:

- Fundamental particles and fundamental forces.
- The gravity problem.
- Higgs Boson.
- Physics beyond the standard model.



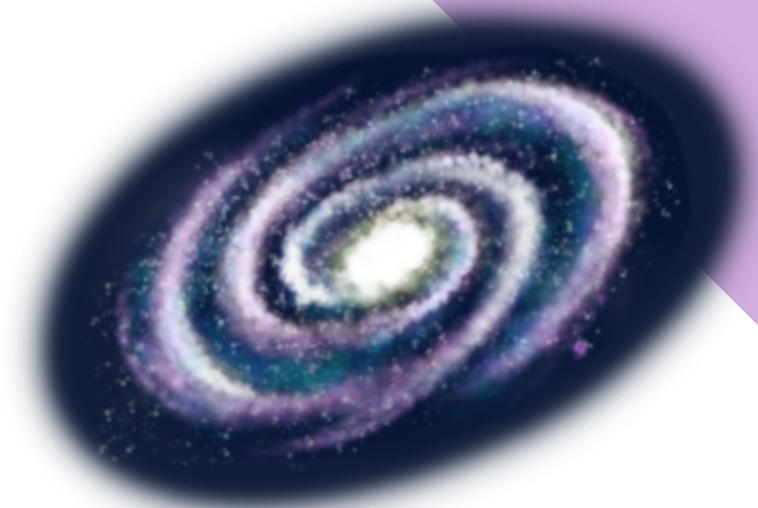
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Dark Matter

In this infographic we explore the generalities of dark matter. We talk about:

- DM abundance in universe.
- How it was discovered.
- DM characteristics.
- Why is so hard to detect it.
- Candidates for DM.
- DM detection methods.



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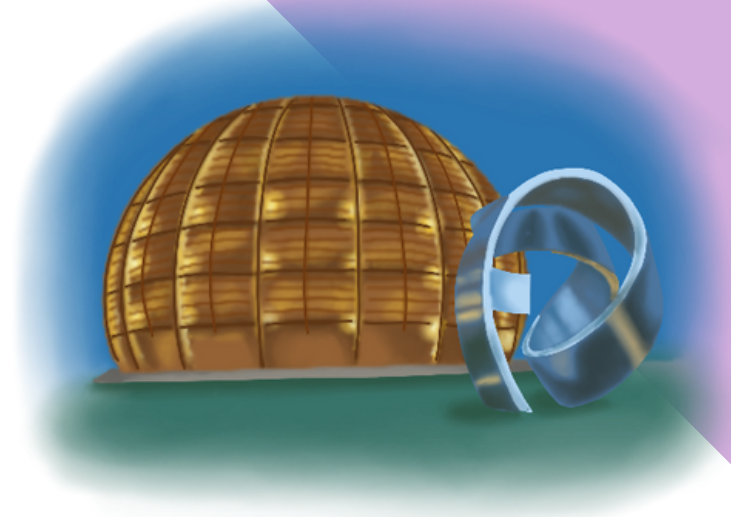
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Particle Accelerators

Once we know about standard model and dark matter, we can talk about particle accelerators.

In this infographic we talk about:

- What is a particle accelerator?
- Its uses in industry and research.
- CERN
- LHC, its functions, characteristics and experiments
- CMS, its parts, functions and purposes.



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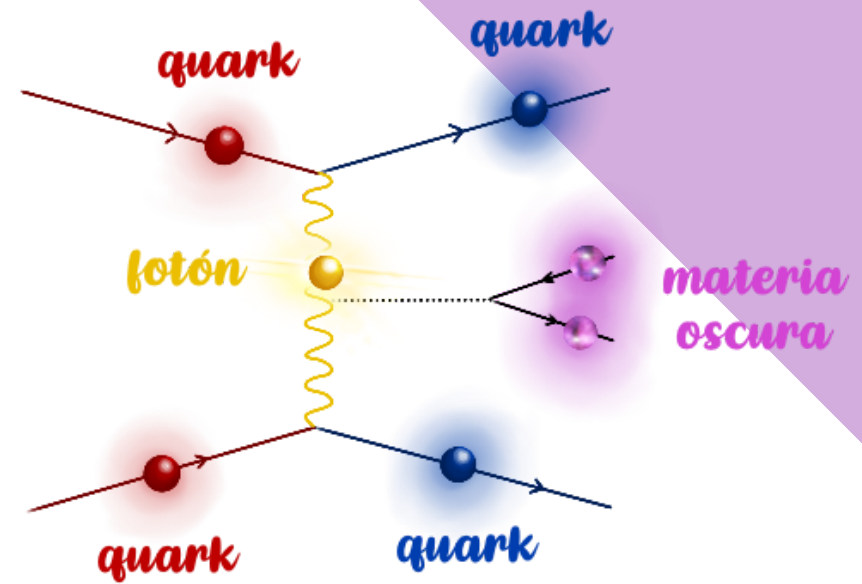
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Dark Matter and Particle Accelerators

Now we're ready to talk about the paper.

In this infographic we talk about:

- Searches for DM in the LHC.
- Theoretical models and Simplified Models.
- VBF.
- Computational simulations.
- Signal and background.
- Results.



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References

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- Duque-Escobar, S., Ocampo-Henao, D., & Ruiz-Álvarez, J. D. (2021). Vector boson fusion topology and simplified models for dark matter searches at colliders. arXiv preprint arXiv:2111.13082.
- Garrett, K., & Duda, G. (2011). Dark matter: A primer. *Advances in Astronomy*, 2011.



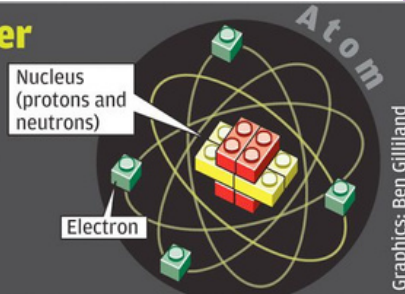
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References

Small stuff: The building blocks of matter

According to the **standard model** of particle physics, atoms are made of particles, which, in turn, are made of elementary particles. These come in two families – quarks and leptons. All matter is made up of a combination of two quarks ('up' and 'down') and the lepton called the electron. The rest are usually only 'seen' in high-energy particle accelerator collisions or in the moments after the big bang



Graphics: Ben Gilliland

The elementary forces

Strong

The **strong nuclear force** is responsible for holding quarks together to form protons and neutrons. It behaves like elastic – the further apart you pull two quarks, the stronger the force gets between them. Its 'force carrier' is called a **gluon**

Gluon

Weak

The **weak nuclear force** is responsible for radioactive decay. It allows an atom to change into a different type of atom by taking on or losing particles. Its force carrier is the '**W**' (or '**Z**') **boson**

W and Z bosons

Electromagnetic

The **electromagnetic force** affects any fundamental particle that carries a charge (that's all the particles right, except neutrinos). Its force carrier is the **photon**

Photon

...and gravity

The elementary particles

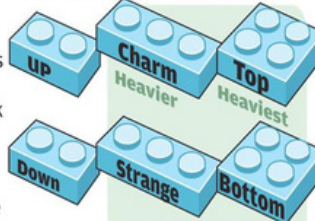
Quarks

All of the matter in the universe is made of a combination of 'up' and 'down' quarks

All combinations are called hadrons (Greek for heavy)

Each of the six 'flavours' of quark can have one of three different 'colours' (different properties)

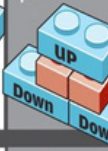
Quarks come in six 'flavours':



These two columns have to be made in a particle accelerator

Protons and neutrons are made up of three quarks bound together by gluons

Proton: Two 'up', one 'down' quark



Neutron: One 'up', two 'down' quarks



An 'up' quark can emit a 'W' boson to become a 'down' quark (and vice versa)

Neutrinos can change from one flavour to another on the fly – a trick called oscillation

Leptons

The most familiar lepton is the electron

Leptons are not made up of quarks (or indeed of anything smaller). The muon and tau are heavy electrons

Another lepton is the neutrino. These ghostly particles barely possess any mass and hardly interact with matter

An electron can lose energy by emitting photons and gain energy by absorbing them

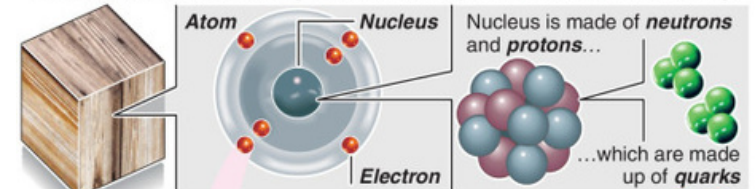


Antimatter:

All of the elementary particles (except the photon) have an opposing anti-particle. The antimatter version of a neutrino is an antineutrino

Standard model – structure of the universe

Particle physicists believe that matter – everything created in the universe by the Big Bang about 14 billion years ago – is made up of 12 types of fundamental particle and six force carriers. These building blocks, which cannot be broken down any further, make up the **Standard Model** theory



Fundamental particles and forces (year of discovery)

LEPTONS

These particles exist on their own

Electron 1897
neutrino 1956

QUARKS

Up 1994
Down 1977

Quarks only exist bound together

Strange 1947
Charm 1973
Bottom 1977
Top 1994



FORCE CARRIERS

Most matter on earth is made from these four particles

Muon 1937
neutrino 1962
Tau 1975

Tau neutrino 1975

Photon 1900
Z boson 1983
W+ boson 1983
W- boson 1983

Gluon 1979

These eight particles came into existence in moments after Big Bang. Found in cosmic rays

Higgs boson To be discovered

Source: Particle Physics and Astronomy Research Council

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Thank you.



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