



UNIVERSITY OF
BIRMINGHAM



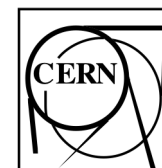
making physics matter



Science & Technology
Facilities Council

THE WORLD OF PARTICLES and their interactions

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University of Birmingham UK, and CERN



The idea of the Workshop

- Children develop awareness and attitudes towards science and careers at an early age
- children hear in the news about CERN and the discoveries of new particles and ask questions
- particle families and interactions can be understood at a basic level due to their similarity to human family dynamics
- Primary schools should engage with modern physics – it aids motivation in addressing the perceived difficulty of the subject
- **Developed in co-creation with Odgen Trust local teacher and University of Birmingham**
- Creative approach to inclusive learning is a powerful tool to enthuse children towards science/physics



Learning through playing

- Use of toys to relate with idea of particles
- Card games to familiarise with particles and their interactions, and consolidate concepts and knowledge
- Freedom of choice of creative ways to express ideas

- **Proper science ideas delivered:**
- Structure of matter
- Particle accelerators
- Particle collisions
- Particle families
- Particle interactions

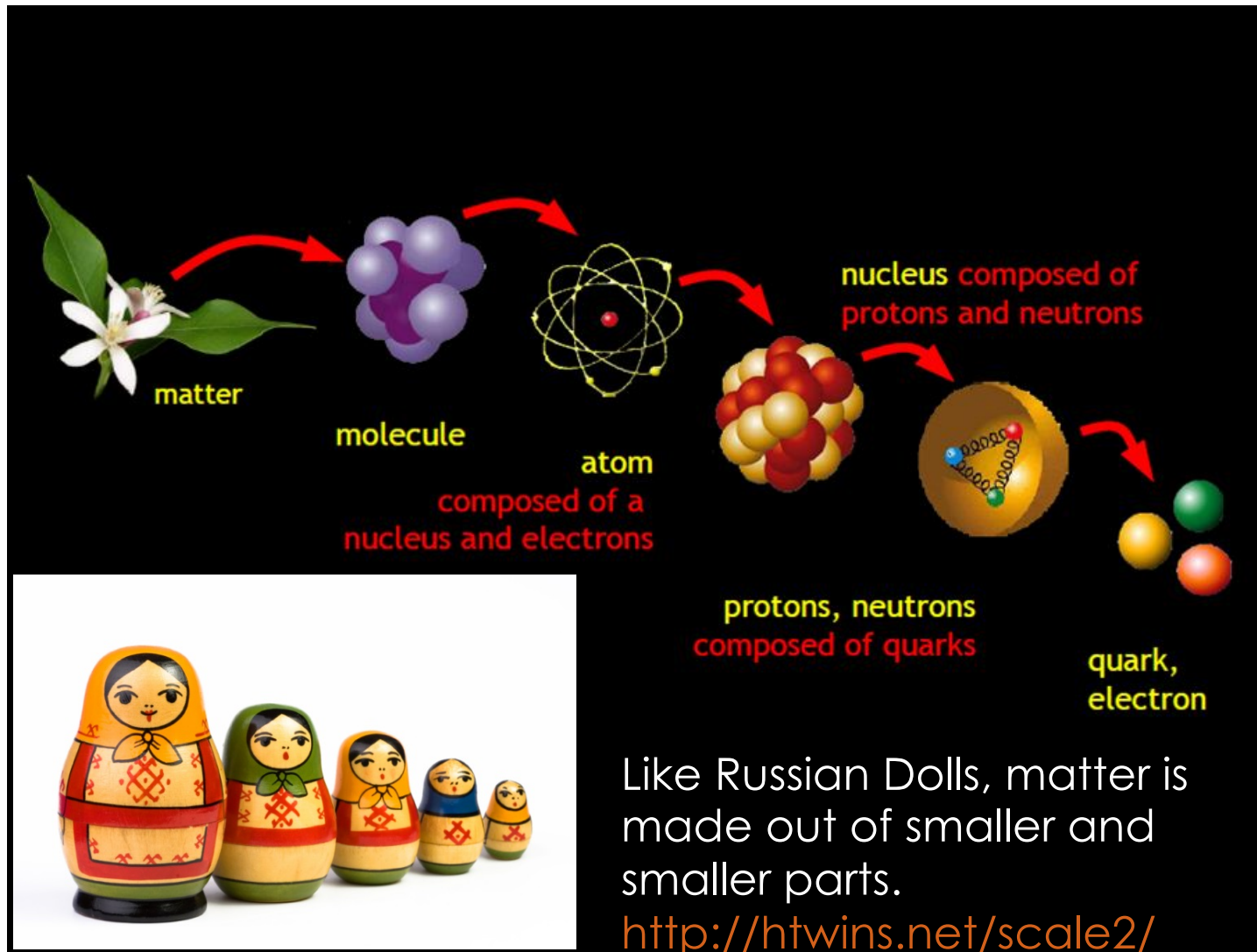


The structure of the Workshop

- Introductory talk
- Happy Family card game to learn particle families
- Particle model making
- Snap card game to learn particle interactions as “likes” and “dislikes”
- Creative writing/playing to show examples of particle interactions

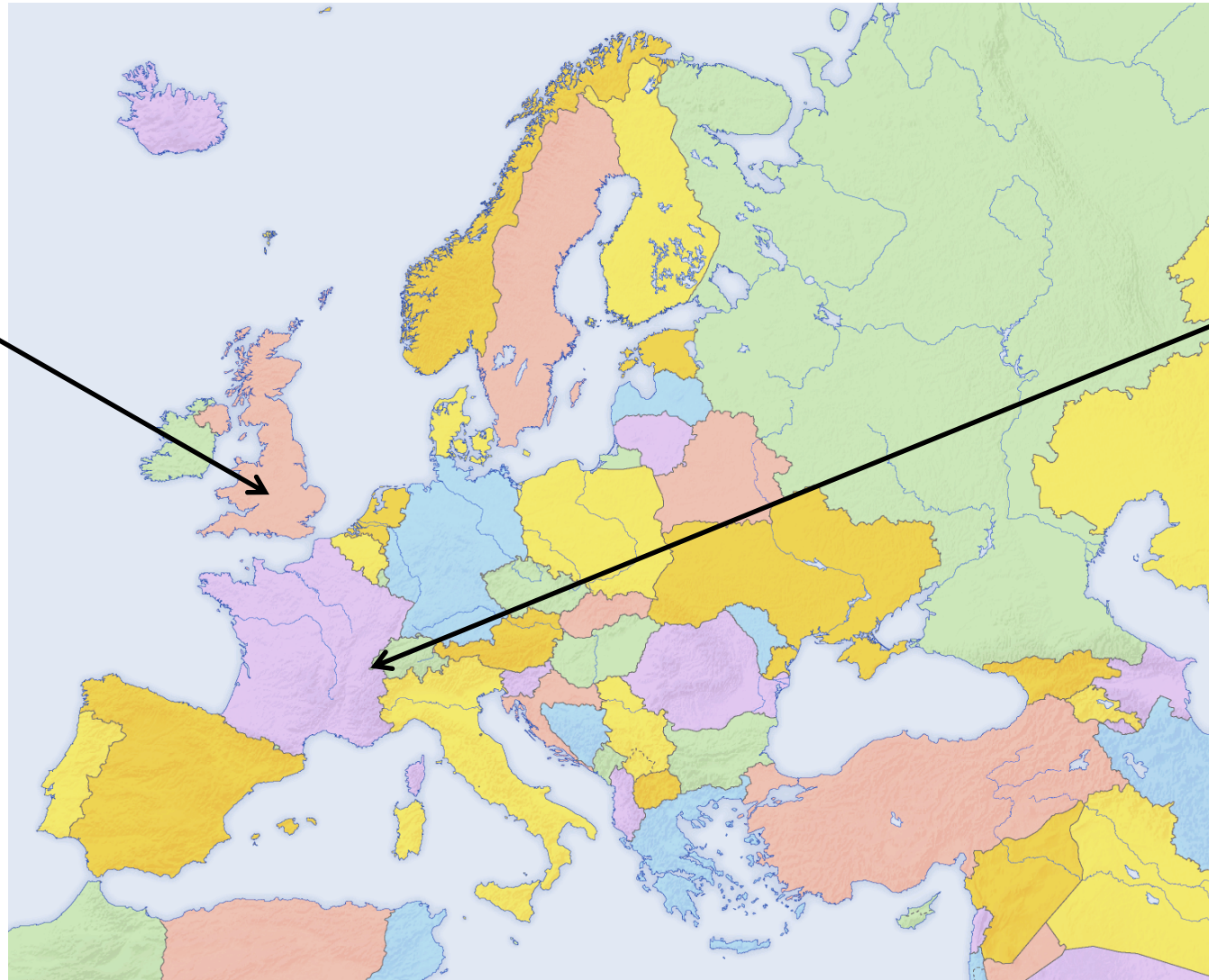


What are the building blocks of materials?



Where is CERN?

you are here

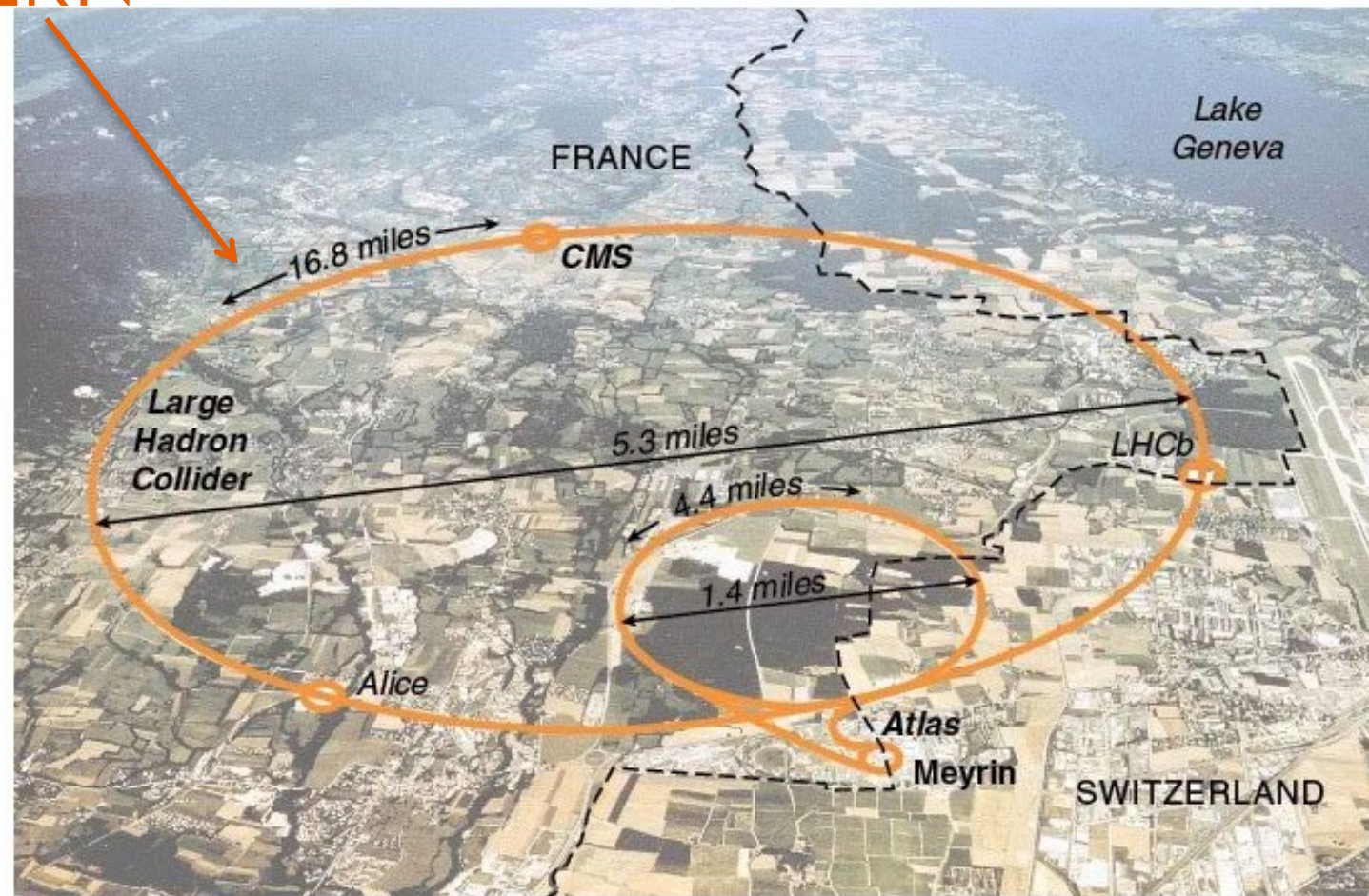


CERN



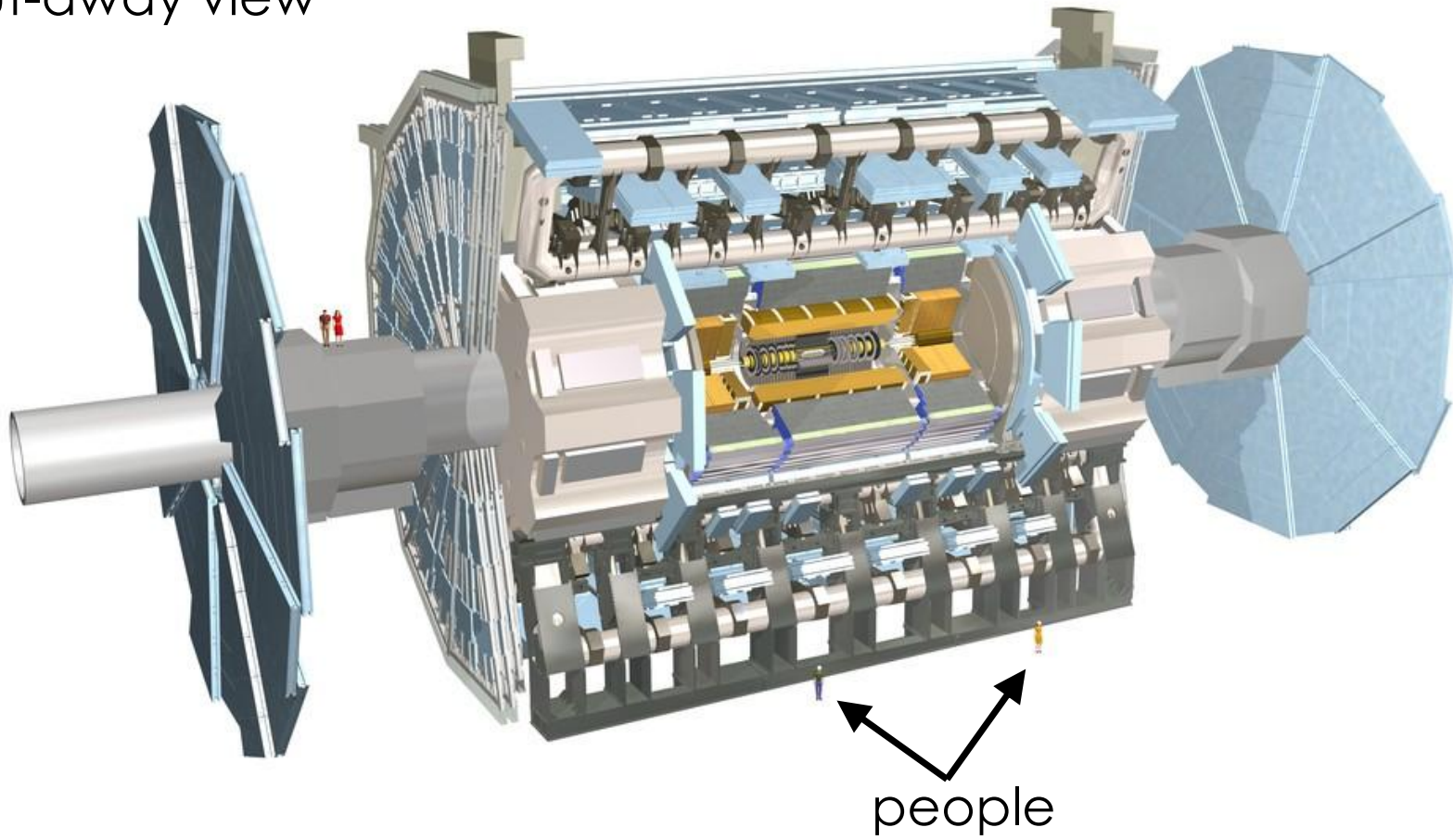
The Large Hadron Collider at CERN

CERN



What is ATLAS?

cut-away view



The particle zoo: the Quark family



Name: Up
Surname: Quark



Name: Charm
Surname: Quark



Name: Top
Surname: Quark



Name: Down
Surname: Quark



Name: Strange
Surname: Quark



Name: Beauty
Surname: Quark

The particle zoo: the Lepton family



Name: Electron
Surname: Lepton



Name: Muon
Surname: Lepton



Name: Tau
Surname: Lepton



Name: Electron
Neutrino
Surname: Lepton



Name: Muon
Neutrino
Surname: Lepton



Name: Tau Neutrino
Surname: Lepton



The particle zoo: the Boson family



Name: Gluon
Surname: Boson



Name: Photon
Surname: Boson



Name: Z
Surname: Boson



Name: W Plus
Surname: Boson



Name: W Minus
Surname: Boson



Name: Higgs
Surname: Boson

Matter and Anti-matter



Matter: with one white feature e.g. white hat



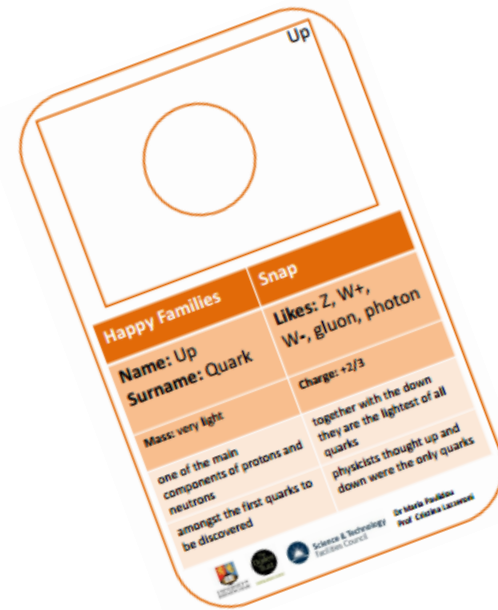
Anti-matter: with the same feature in black e.g. black hat



Task 1: Happy Families game

Your aim is to collect all six members of any of the families:

- ❑ Quarks
- ❑ Anti-quarks
- ❑ Leptons
- ❑ Anti-leptons
- ❑ Bosons



The player who collects the most families is the winner.



Rules of the Happy Families game

- The aim of the game is to collect as many families (groups of 6 cards that belong to the same family) as possible.
- Deal out all the cards so that every player gets an almost equal number of cards; this will depend on the number of players.
- The dealer starts by asking another player for a card needed to complete a family.
- If the other player has the card, they must give it to this player.
- The player may continue asking for cards until they make a mistake.
- When a mistake is made the player who was asked for their card takes their turn to request cards.
- During the game, players can request and retake the cards taken from them in previous rounds.
- When a player gathers a family they must put the 6 cards face down on the table in front of them.
- The player who collects the most families is the winner.



Task 2: Make your own particle !



- ❑ Read the trump card of your particle
- ❑ Design your particle and draw your design on the trump card
- ❑ Give mass to your particle by adding plasticine
- ❑ Make your particle using the resources



Task 3: Snap game

Your aim is to collect as many cards as you can from the families of quarks, leptons, bosons.

The player who collects the most cards is the winner.

Shout



when particles **LIKE** each other!



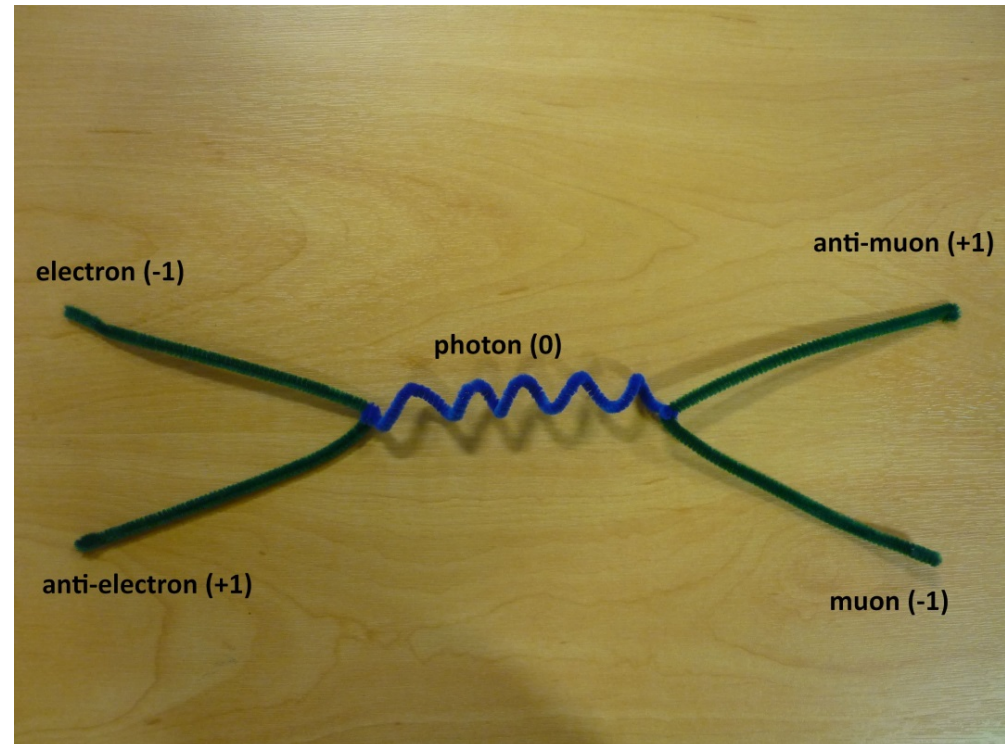
Rules of the Snap game

- Anyone may deal. The cards are shuffled and dealt out to the players as equally as possible. Players do not look at their cards but keep them in a face down stack in front of them.
- The player to dealer's left begins and the turn to play passes clockwise.
- At your turn you simply turn the top card of your face-down pile and place it face-up alongside. In this way each player forms a pile of face-up cards beside their face-down pile.
- If at any moment two of the face-up piles have particles that **like each other** at the top (for example electron and Z), anyone who notices this shouts "snap!".
- The first person who shouted "snap!" takes both matching face-up piles and adds them face-down to the bottom of their face-down pile.
- The game then continues as before, beginning with the player to the left of the last one who turned a card.
- If you have no face-down cards left when it comes to your turn, you simply turn over your face-up pile to make a new face-down pile and turn over the top card as before.
- If you have no cards left at all, you are out of the game. The last player in is the winner (or alternatively, the player with the largest number of cards).



Task 4: Write your own particle story

- ❑ Particles meet with each other
- ❑ Particles can turn into other particles and then to new particles
- ❑ Particle meetings follow the rules of likes and dislikes



Build your own story using pipe cleaners and following one of the examples given.



Example of a story

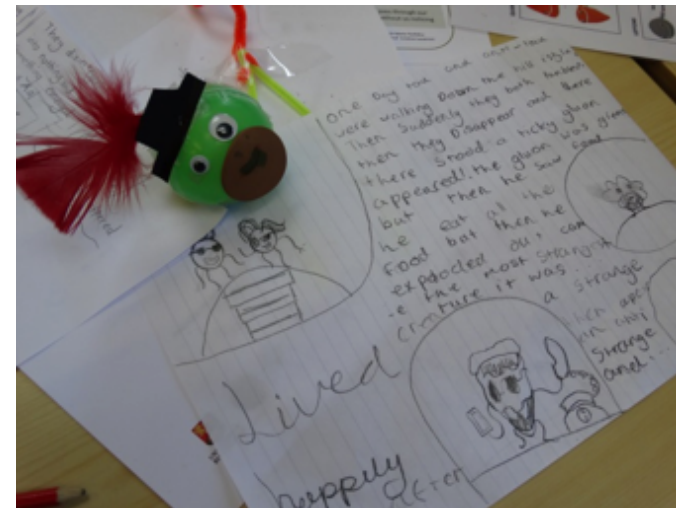
One sunny day Jimmy the **electron** and Molly the **anti-electron** were playing in their garden eating cookies and drinking orange juice. Jimmy started feeling really hot from the sun. Molly said “oh poor you...”. She took his hand to comfort him but suddenly...they both disappeared!

In their place a very greedy **photon** appeared who started eating all the cookies. The cookies were many and the photon got bigger and bigger until... it exploded with a big “splat” sound!

Left behind were two chatty **muons** who immediately started to discuss the wonders of this world and how too many cookies in one go are bad for you...



Output: particles



Output: stories

THE PARTICLE SONG BY N RUKANDEMA AND A MOODY, (SING TO THE TUNE: "I WILL SURVIVE")

One day a little muon
Walked out his door
He had opened up his curtains
And swept the floor

But after getting up
And recovering from his dream
He opened up
And this is what he's seen

It was a muon
Muon neutrino
He was walking down the
street
Drinking vino

And once their eyes met
For the first time muon
thought
He found love
And wasn't scared at all

And poof like that
They disappeared
They ran away inside
Could not be heard

And in their place
Was a W-minus
It just appeared
No reason to be feared

It ran outside
Onto the street
Until it bumped into a lamppost
And fell onto its feet

But coming in the distance
Could be seen an anti-charm
What was this?
A beauty on its arm

Another pair
With loving hearts
They rode off into the sunset
Arm in arm

And here is the end
Of our classic tale of chance
We say goodbye
Goodbye from us!

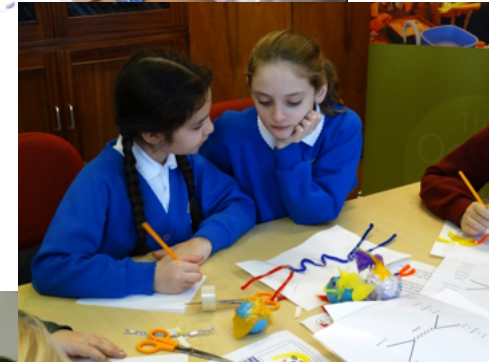


Output: sharing concepts, and changes

93% explained what they learnt to family and friends



“I did this because gluons are “sticky” and this is why all the feathers are stuck!”



“When I grow up I want to be a particle physicist and find more particles!”



100% describe new acquired knowledge after 1 month
93% say they are more interested in science



Feynman Diagrams:

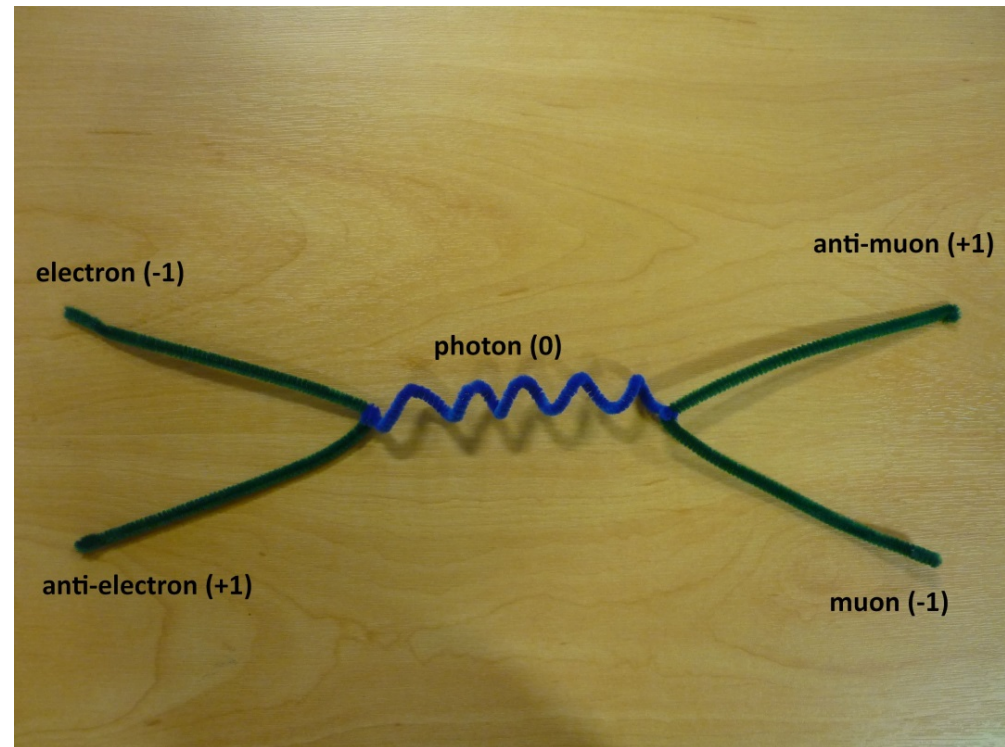
Additional Material:

For longer workshops,
or for High School Students



Particles write stories: Feynman diagrams show these stories

- Particles interact with each other
- Particles can turn into other particles and then to new particles
- All particles have charge (positive, negative or zero)
- During their interactions, the total charge stays the same
- Interactions follow the rules of likes and dislikes



Credits

- Europe map from http://commons.wikimedia.org/wiki/Atlas_of_Europe
- map of LHC from <http://imgarcade.com/1/lhc-map/>
- ATLAS from <http://atlas.ch/>
- building blocks of matter from <http://rooksheathscience.com/2014/06/>, Russian dolls from <http://www.kzero.co.uk/>
- The particle zoo from <http://www.particlezoo.net/>
- snap image from <http://www.milwaukeeemarketingresults.com/Snap-/13194572?pid=283521>
- cartoon 1 from <http://www.picturesof.net/> cartoon 2 from <https://chefpeterpang.wordpress.com/> and cartoon 3 from <https://www.colourbox.com>



References

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[1] van Tuijl, C. & van der Molen, J.H.W. *Study choice and career development in STEM fields: an overview and integration of the research*, *Int J Technol Des Educ* (2016) 26: 159. doi:10.1007/s10798-015-9308-1

[2] Honey, M. & Kanter, D. E. *Design, Make, Play: Growing the Next Generation of STEM Innovators*, 1st ed. New York [u.a.]: Routledge, 2013. Print.

[3] Root-Bernstein, *Arts and crafts as adjuncts to STEM education to foster creativity in gifted and talented students*, *R. Asia Pacific Educ. Rev.* (2015) 16: 203. doi:10.1007/s12564-015-9362-0

