DCU

FRONTIERS

FRONTIERS

Bringing Nobel Prize Physics in the Classroom

THE ELEMENTARY PARTICLES

STEAM

INTO VERTICAL CURRICULUM OF SECONDARY SCHOOL

DCU

ELLINOGERMANIKI AGOGI

NUCLIO

EGO EUROPEAN GRAVITATIONAL OBSERVATORY

IASA

Paris Centre for Cosmological Physics

Co-funded by the Erasmus+ Programme of the European Union

léargas

FRONTIERS

Daniela Ambrosi

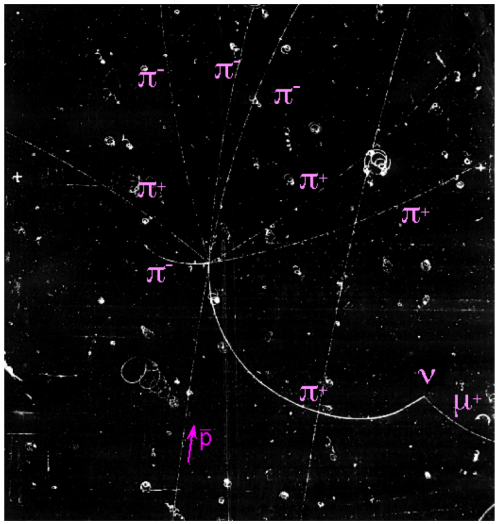
Maria Barouta

work group

Sevi Malamou

Macrocosmo,

Giotto, ? - 1337



Microcosmo

Daniela Ambrosi

I'm a teacher of Science (Biology, Chemistry, Astronomy, Earth Science) in high school "Galileo Galilei" of Perugia. I have been teaching since 1988 and I have been studing all my life. I graduated in Biology, in Natural Science, in Modern Literature with PhD in Geology and STEM with PBL Problem Based Learning.

I had been attended in ITP Italian Teacher Program of CERN, 2016, 2017, 2019; in Bruxelles, SCIENTIX Congress on 2011, 2014, 2018;, in Florence Involen Congress 2015; in Berlin the 2nd Profiles Congress 2014 and other.

SUBJECTS

Astrophysic
- Standard Model
- contamination
- explorations
- Cosmic rays

Astronomy
- Universe
- Atmosphere
- Astronomical measurement

Technology
- technologically advanced instruments
- for high-energy research

Topic

elementary particles, interaction light and matter, Muoni, Cosmic Ray, Cloud Chamber

Aim

Learning about Standard Model, cloud chamber, scattering, decay protons to muoni, may be relativistic time

This activity can be done in the framework of the astronomy lesson that is available in Italian schools both for primary and for secondary schools. In astronomy lesson, the teacher has freedom to do activities with their students .Even though there is no much time in Italian curriculum, if teachers collaborate (Physics, Math, Computer Science, Art) they can do interdisciplinary lesson that works.

Overview of this lesson pack:

Name of the activity	**The masquerade dance of the particles**
Topics introduced	elementary particles, interaction light and matter, Muoni, Cosmic Ray
Curriculum Connection	GREECE: secondary (5th grade) ITALY: **Topic**: elementary particles, interaction light and matter, Muoni, Cosmic Ray, Cloud Chamber **Aim**: Learning about Standard Model, cloud chamber, scattering, decay protons to muoni. **Connection with the curriculum**: This activity can be done in the framework of the astronomy lesson that is available in Italian schools both for primary and for secondary schools. In astronomy lesson, the teacher has freedom to do activities with their students.Even though there is no much time in Italian curriculum, if teachers collaborate (Physics, Math, Computer Science, Art) they can do interdisciplinary lesson that works.
Reference Demonstrator	Build your own cloud chamber (http://inspiringscience.rdea.gr/delivery/view/index.html?id=d9d4548e86fc449699bbd42ada36377f&t=p)
Age of students	from 13 to 18
Duration	10 hours from a) to c) 2-3 hours - d) 4 hours - e) 2 hours for the realization, 1 hour of play

Overview of this lesson pack:

Type of activity	**The masquerade dance of the particles**
Description of activity	**Teacher activities:** **a) The Scale of Universe** **b) The world of particles** **c) Standard Model** **d) Cloud-chamber** **e) Game** **Student activities:** **a) make a padlet** **b) write schedules of the elementary particles** **c) write schedules of of the Standard Model** **d) identify particles from the traces in the cloud chamber** **e) make mask for each particles, write schedules for game, play game**
Equipment requirements	Computer, a transparent box (a fish-tank for example), a cold plate on bottom of the box, a hot water container, dry ice to keep the one metal plate cold, glue, a felt, a Isopropyl alcohol with more than 90%vol alcohol, a flashlight. Papers , scissors, colored brushes, balls
Prior knowledge for students	force, atomic structure, electric charge, supersaturated gases

Overview of this lesson pack:

Type of activity	**a) How big is the known universe?**
Description of activity	Teacher activities: Gathering the previous knowledge of student with brainstorming after they watched movie. movie https://youtu.be/m2YJ7aR25P0 https://youtu.be/rP7fco81s4M Student activities: *use https://scaleofuniverse.com/* making a padlet, What are the smaller particles of matter? What is the smaller and the bigger length build reports with length scales Students learn about measure, multiples and submultiples; aware of the order of magnitude of the macro and micro cosmos
Equipment requirements	Computer, smartphone, papers , scissors, colored brushes,
Prior knowledge for students	measurement, physical quantities, basic powers ten

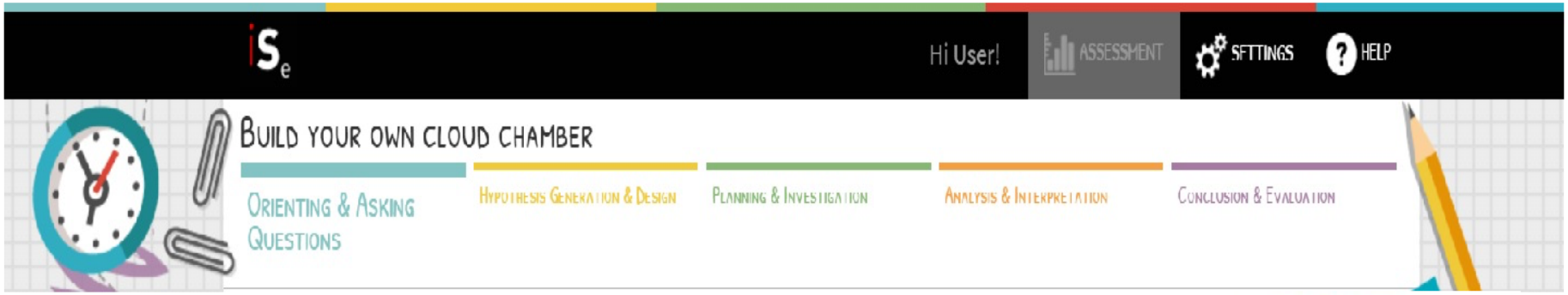
Overview of this lesson pack:

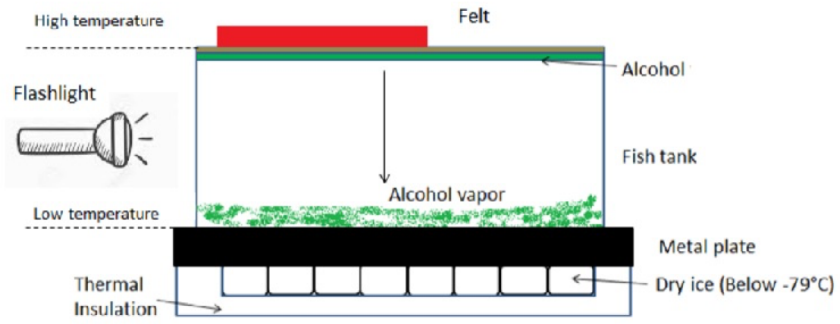
Type of activity	**b) & c) The world of particles**
Description of activity	Teacher activities: Introduce this topic by movie, short lesson and after asks questions and prompts student to make a game - https://www.particlezoo.net/ - https://youtu.be/XYcw8nV_GTs - https://youtu.be/72pprrSSDK0 - https://youtu.be/AU_O9yrgwhk for equation theory energy equal mass https://www.britannica.com/video/185388/equation-theory-energy-relativity-mc Student activities: students observing images and short videos, make schedules with the principal properties about elementary particles, they draw and construct the masks of the particles
Equipment requirements	Computer, paper, scissor, colours
Prior knowledge for students	physical quantities, electric charge, force

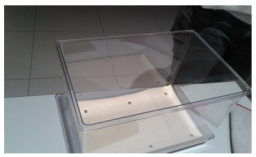
Overview of this lesson pack:

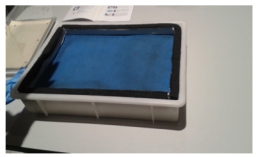
Type of activity	**d) BUILT CLOUD CHAMBER**
Description of activity	Teacher activities: Introduce this topic by movie, after asks questions and prompts student to express hypotheses about tracks that they can see into cloud chamber. http://inspiringscience.rdea.gr/delivery/view/index.htmlid=d9d4548e86fc449699bbd42ada36377f&t=p lesson about decay of some kind of particles https://feynman.aivazis.com/ (17-18 age) http://www.infn.it/multimedia/particle/paitaliano/all_decay.html (14-16 age) Student activities: students observing images and short videos of cloud chamber, What is its shape? It looks like...? How is possible identify them? What is muon? Where came from the muon? What is Cosmic ray? Why atoms and particles decay?
Equipment requirements	Computer, a transparent box (a fish-tank for example), a cold plate on bottom of the box, a hot water container, dry ice to keep the one metal plate cold, glue, a felt, a Isopropyl alcohol with more than 90%vol alcohol, a flashlight
Prior knowledge for students	atomic structure, electric charge, supersaturated gases

How we can see the elementary particle? Cloud Chamber









Who?
What?
When?
How?
Why?

IBSE PBL CBL

http://inspiringscience.rdea.gr/delivery/view/index.html?id=d9d4548e86fc449699bbd42ada36377f&t=p

Overview of this lesson pack:

Type of activity	**e) game**
Description of activity	Teacher activities: First level teach the name and properties about elementary particles Second level teach Standard Model, in particular the interactions that can occur between particles and which are the mediating particles, and Colours charge. Third level teach the scattering with corresponding Feynman's diagrams Student activities: draws and builds the mask for each particle, write schedule, with property of elementary particles, colours charge, Feynman's diagrams, write cards with questions and answers about them.
Equipment requirements	Computer, smartphone, papers , scissors, colored brushes, ball
Prior knowledge for students	Standard Model and some Feynman's diagrams

Main Target

Students

- use an engaging teaching in order to let students be main actors of the learning process ***learn by doing*** *and use* ***ITC***
- **use gammification** the application of typical elements of game playing to other areas of activity, typically as an online marketing technique to encourage engagement
- show the relationship between teaching and learning as a part of **PBL** (project based learning) methodology.

Teachers

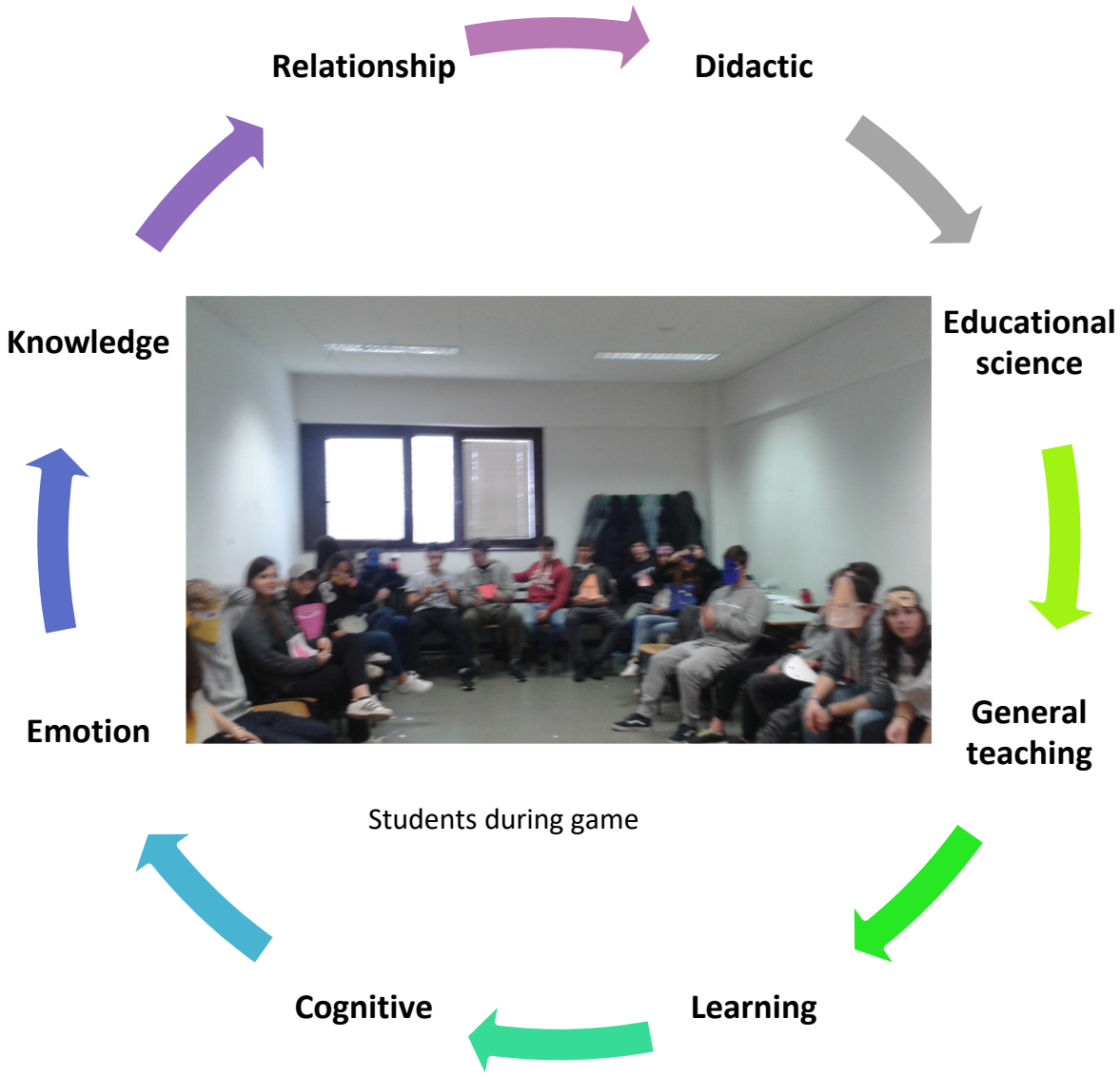
- transform research and place ***Astrophysics*** at the center of STEAM use ITC http://inspiringscience.gr http://www.frontiers-project.eu
- encourage integration of Art & Design in K–20 education with the creation of masks, graphics for cards and playing cards
- realize an vertical interdisciplinary curriculum, Physics, Math, Computer Science, Art

The **Curiosity** marks the beginning of learning
How big is the known universe?
What are we made of?
How can we see elementary particles?

The **pleasure** of discovering and building a *cloud chamber*
This demonstrator introduces students to cloud chambers, the first experimental apparatus that enabled scientists to visualize elementary particles coming from the cosmos. Students learn about the principles of operation of a diffusion cloud chamber, and with the help of their teacher they construct a simple diffusion cloud chamber in order to observe cosmic ray particle tracks in it.
What is particle's shape? It looks like...?
How is possible identify them? What is muon? Where came from the muon?
What is Cosmic ray?

The **passion** for both the topic and the competition. Students learn by making cards with question and answer. They enter into the heart of the challenge and thus carry out an in-depth study of particle physics

FRONTIERS AREA



Students during game

Thanks to ICT we have taken several photos and we have made some short movies, we have used virtual labs, graphics cards.

They were able to see and hear Nobel laureates and researchers

We have given to students another point of view to analyze real data.

We have tried to apply *Morin's "tetralogical ring"* in the relationship student-teacher-learning.

The masquerade dance of the particles

First level (age 13-15) Know the name and properties about elementary particles

Students make schedules with the principal properties about elementary particles

Each student interprets a particle and wear own mask

One of them is the Higgs Boson, he said the name of a particle

The student with this mask name, stand up and tell his history (note of schedule)

After roll two dice, and count the number that came out going clockwise

Now the player chooses a number that corresponds to a question concerning the card read

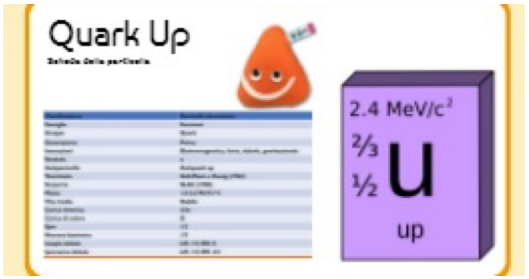
If he answers well, he buys 3 points and can roll the dice, but if he answers wrong, he loses 1 point and stands still.

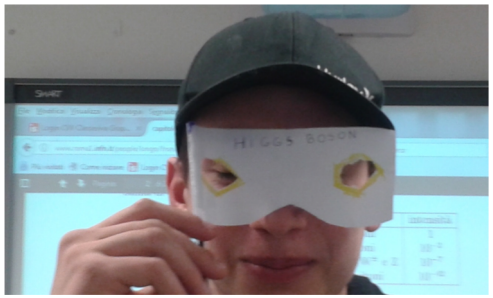
The student (point 4) roll two dice, and count the number that came out going clockwise, starting with the last player who answered

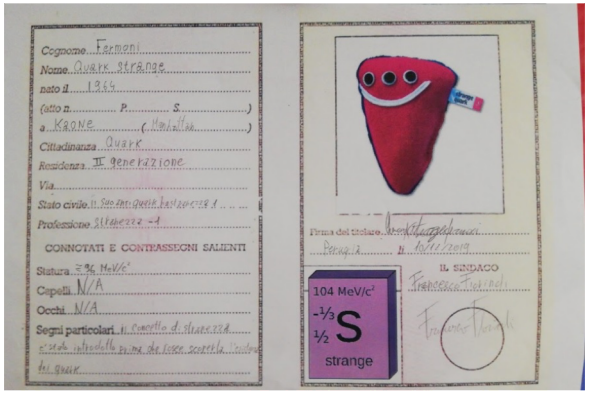
Whoever reaches the score of 50 first wins

STUDENT ACTIVITY

1. study the properties of elementary particles in the standard model
2. draw the particle mask
3. write cards with the properties of the particles card history
4. write the cards with some questions about the same particle and the correct answers
5. play







The masquerade dance of the particles

Second level (age 14-15) Know the interactions that can occur between particles and which are the mediating particles

Each student interprets a particle - antiparticle and wear its own mask with color charge about quarks, (ex. we have up blue, green, red; antiup yellow, magenta, ciano)

the students are divided into two teams
one team is particles quarks
the other antiquarks

the big red ball is Strong Nuclear force gluons
the medium blue ball is Weak nuclear force boson W+W- Z° the small yellow ball is light photon

the player chooses a card without reading and places it on the other team

the team's leader reads the name of the Handron particles

the first team arranges the boys with the masks corresponding to the particle and throws the ball that corresponds to the interaction related to the question

If he answers well, he buys 3 points and can roll the dice, but if he answers wrong, he loses 1 point and stands still.

The student (point 10) roll two dice, and count the number that came out going clockwise, starting with the last player who answered

Whoever reaches the score of 30 first wins

Colour charge

Un quark
porta un colore

Un antiquark
porta un
anti-colore

Un gluone
porta un colore
e un anti-colore

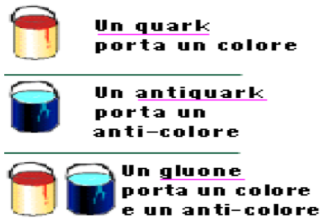
Chagall, Marc, 1887-1985

Van Gogh Vincent, 1853-1890

STUDENT ACTIVITY

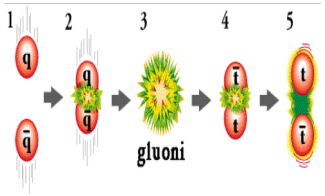
1. study the properties of elementary particles in the standard model
2. study quarks and gluons are color-charged particles
3. draw the mask of quarks, a particle - antiparticle with color charge about quarks, (ex. we have up green, blue, red; antiup ciano, magenta, yellow
4. write cards with the properties of the particles card history
5. write the cards with some questions about the same particle and the correct answers
6. play
7. quarks and gluons are color-charged particles

sample questions



What are the color-charged ?
Quarks and gluons are *color-charged particles.* If electrically charged particles interact by exchanging photons, color charged particles also exchange gluons in *strong interactions*. In doing so, the color-charged particles "stick" together - and gluon comes from the English "glue", which means "glue".

What is the difference between gluons and photons ?
The main difference between the strong interaction and the electromagnetic one is that the mediators of the strong interaction (the gluons) themselves have a *color charge*; those of the electromagnetic interaction (photons), on the other hand, have no electric charge.



What is "color force field" ?
Two or more quarks close to each other incessantly exchange gluons, creating a very strong "color force field" that binds them. There are three color fillers, and three corresponding complementary (anti-color) color fillers. A quark continuously changes its color charge as it exchanges gluons with other quarks.

The masquerade dance of the particles

Third level (age 16-18) know the scattering with corresponding Feynman's diagrams

Each student interprets a particle - antiparticle and wear its own mask with color charge about quarks, (ex. we have up blue, green, red; antiup yellow, magenta, ciano)

the students are divided into two teams
one team is particles quarks
the other antiquarks

the big red ball is Strong Nuclear force gluons
the medium blue ball is Weak nuclear force boson W+W- Z° the small yellow ball is light photon

students wright schedule about some kind of decay (n°, p+, π..)
the player chooses a card without reading and places it on the other team

the team leader reads the name of the particle's decay , the first team arranges the boys with the masks corresponding to the particle's decay

the first team arranges the boys with the masks corresponding to the particle's decay

If he answers well, he buys 3 points and can roll the dice, but if he answers wrong, he loses 1 point and stands still.

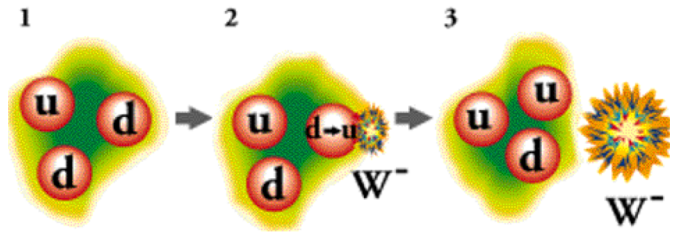
The student (point 9) roll two dice, and count the number that came out going clockwise, starting with the last player who answered

Whoever reaches the score of 30 first wins

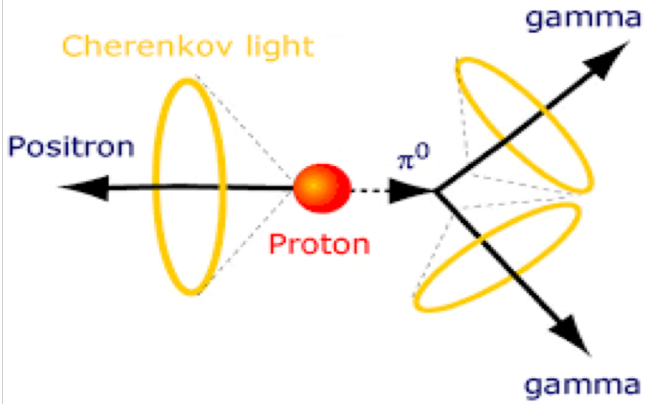
STUDENT ACTIVITY

1. study the properties of elementary particles in the standard model
2. study quarks and gluons are color-charged particles
3. draw the mask of quarks, a particle - antiparticle with color charge about quarks, (ex. we have up green, blue, red; antiup ciano, magenta, yellow
4. write cards about decay of some particles
5. write the cards with some questions about them and the correct answers
6. play

sample questions



How does a neutron decay?
A neutron (udd) decays into a proton (uud), an electron, and an antineutrino. This process is called neutron beta decay. Why "beta"? Because the electrons produced in nuclear decays were called beta rays, before they were discovered to be electrons. The process must be mediated by a virtual W- particle, which takes away a charge of -1.



How does a proton decay?
In particle physics, proton decay is a hypothetical form of particle decay in which the proton decays into lighter subatomic particles, such as a neutral pion and a positron.

Who was the first to formulate the hypothesis of the proton decay?
The proton decay hypothesis was first formulated by Andrei Sakharov in 1967.
Despite significant experimental effort, proton decay has never been observed. If it does decay via a positron, the proton's half-life is constrained to

From teacher to teacher:

Topic: elementary particles, interaction light and matter, Muoni, Cosmic Ray, Cloud Chamber
Aim: Learning about Standard Model, cloud chamber, scattering, decay protons to muoni, may be relativistic time

(a) **How big is the known Universe**? *https://scaleofuniverse.com/*

(b) **What are elementary particles?** https://www.particlezoo.net/

(c) **Standard Model** https://youtu.be/XYcw8nV_GTs

https://youtu.be/72pprrSSDK0

https://www.britannica.com/video/185388/equation-theory-energy-relativity-mc

https://youtu.be/AU_O9yrgwhk

(d) **How we can see the elementary particle? Cloud Chamber**

http://www.frontiers-project.eu/demonstrators/cloud-chamber/

http://inspiringscience.rdea.gr/delivery/view/index.htmlid=d9d4548e86fc449699bbd42ada36377f&t=p

(e) **Game** *"The masquerade dance of the particles"* https://youtu.be/zBr9YiSwdzM

https://youtu.be/9DR0aP497Z https://youtu.be/PCL7VmKAwwI

https://docs.google.com/document/d/1scASt9N1KH-NoMfeInFC70PDXn7WyHhmI-J5o96MU24/edit?usp=sharing

THANKS FOR YOUR ATTENTION