PARTICLE PHYSICS

HST2026 Study Group 7

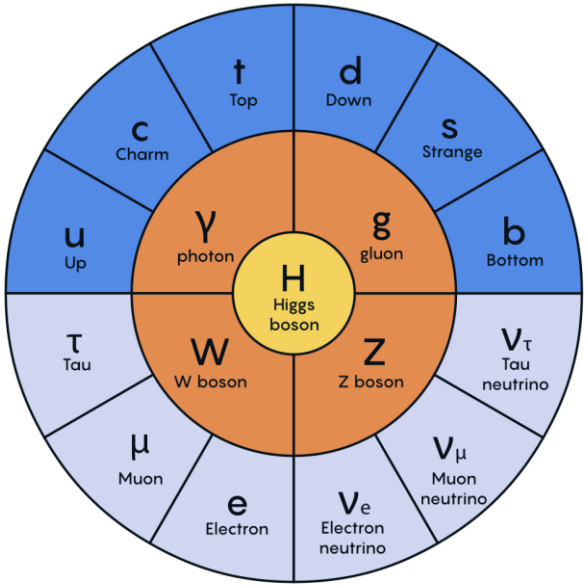
Key Ideas in Particle Physics

What?

Why?

How?

The catalog of known particles & forces is the Standard Model (SM)



Curriculum & Classroom Connections

Radioactivity

Alpha, Beta and Gamma decays is an opportunity to connect with particle physics :

- Conservation of Energy and charge
- The difference between subatomic and elementary particles

The properties of matter

The definition of Matter as anything that has a mass and a volume.

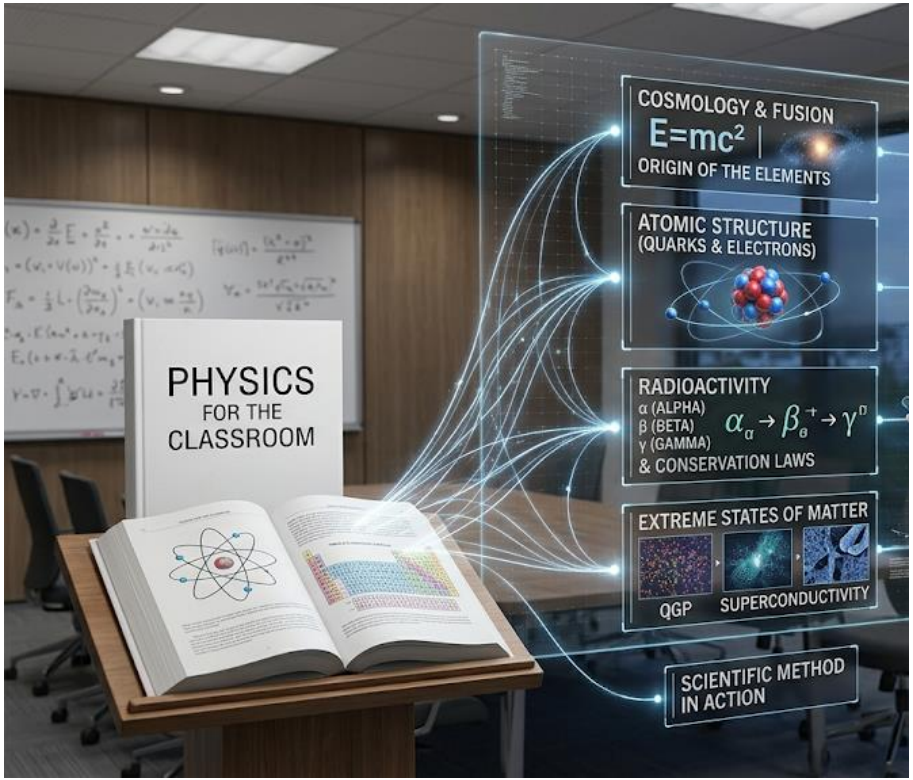
The quantum properties of some materials in extreme temperature conditions (superconductivity, QGP)

The atomic structure

The difference between subatomic particles and elementary particles, the origin of the elements through the Big Bang ($E=mc^2$) and fusion in the stars.

The scientific research in general

Particle physics is a great example of application of the scientific method



Potential Students' Conceptions & Challenges

Lots of new terms

Students can be discouraged by the amount of new vocabulary

Scale visualization

Students might be confused by what is smaller than what.
Cells - Molecules - Atoms - Subatomic particles - Elementary particles

In conflict with their prior knowledge

It is very different from classical physics. Some definitions have to change. The wave-particle duality can be counter intuitive

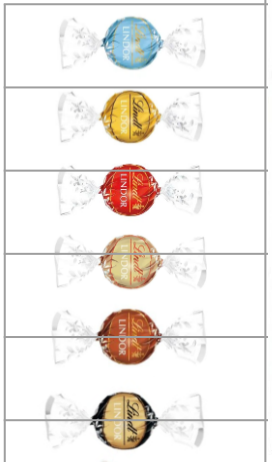
Extreme abstraction

- There is almost no direct hands-on experiment to do in class.
- Analogies can be useful but sometimes misleading.
- The ball misconception of the particle and the outdated planetary models of the atom

Best Practice Example

Students play a game that connect particle physics with the structure of a subatomic particle

They have to build a particle with quarks depending on a certain budget of charge and properties they receive. These could be represented with 6 flavors of chocolates that have different properties (Baryon number and Charge) on their nutrition facts. Their mission would be to create a specific Baryon. Our mystery particle has a total charge of +1, baryon number of 1 and strangeness of -1.



Quark	Symbol	Charge	Baryon Number	Strangeness
up	u	$+\frac{2}{3}$	$\frac{1}{3}$	0
down	d	$-\frac{1}{3}$	$\frac{1}{3}$	0
charm	c	$+\frac{2}{3}$	$\frac{1}{3}$	0
strange	s	$-\frac{1}{3}$	$\frac{1}{3}$	-1
top	t	$+\frac{2}{3}$	$\frac{1}{3}$	0
bottom	b	$-\frac{1}{3}$	$\frac{1}{3}$	0

Useful Material & Resources

CERN

- CERN Educational resources
- The mystery box experiment Lego OR 3D print Link
- The personality quiz
- DIY cloud chamber + video
- DIY Particle Detector (advanced material required)
- Particle Builder board game
- Particle Twister
- Quark Puzzle 3D print
- cernland.net

Other resources

- PhET simulations
- Einstein-First
- Quantum Girls
- QuarkNet
- ParticleAdventure
- Glow in the dark
- Flame colors
- Photoelectric effect
- Plasma ball

PERIMETER INSTITUTE

- The wooden block
  to introduce the concept of scientific modelling
- The two slits experiment & Sand in a cup
  to investigate the nature of the electron and the particle-wave duality
- Beyond the atom
  - Taming the particle zoo to sort cards to find patterns
  - Bubble chamber detective to use their knowledge of magnetic fields and forces, conservation of momentum, and conservation of charge to infer.
  - Feynman diagram cards to study and manipulate

YouTube CH

- CERN for an immersion to the greatest experiments
- ScienceClic for great overviews, all levels
- Kurzgesagt to spark curiosity and wonder
- Veritasium for clear demonstrations
- ATLAS Experiment & CMS Experiment
  For short interviews with familiar faces

HST2026 Study Group 7

Marianne (Norway), Maria (Greece), Abdulrahman (Lebanon), Gloria (Italy), Saf (Belgium)

One way in which our thinking has changed…

*We never imagined before **how research at CERN pushes the boundaries of technology**. The innovations developed for particle physics have found applications far beyond CERN, from medical imaging and cancer treatment to computing and space research.*

*This experience has shown us that **publicly funded projects can achieve extraordinary results** when they are supported by strong governance, a clear vision, and a culture of excellence.*

Highlights, snapshots, farewell messages…

We feel extremely lucky to have participated in this program and look forward to bringing CERN's messages into our classroom and inspire the next generation of researchers

Thank you Anja, Milena and all the lecturers for making this HST 2026 experience so enriching !!