

Future Particle Accelerators

HST2025 Study Group 8

“Prediction is very difficult, especially about the future.”

-Niels Bohr



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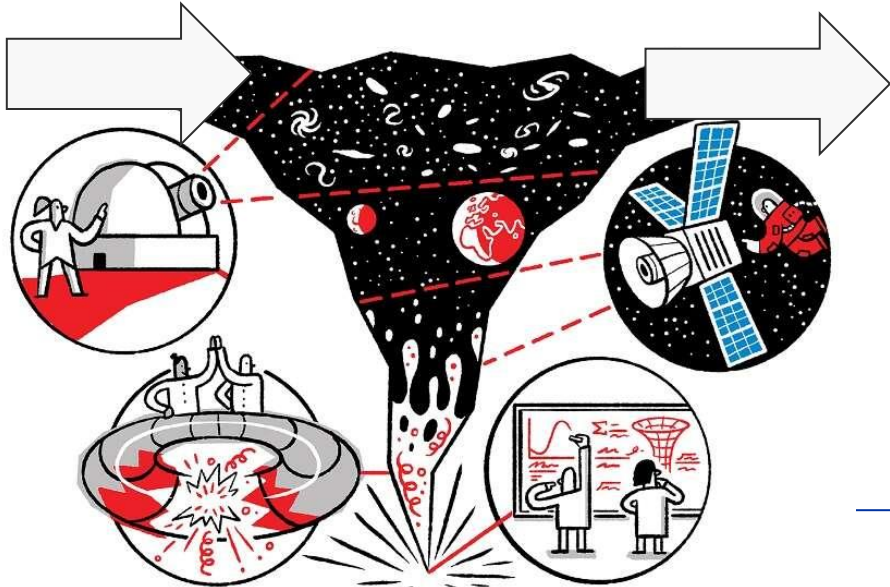
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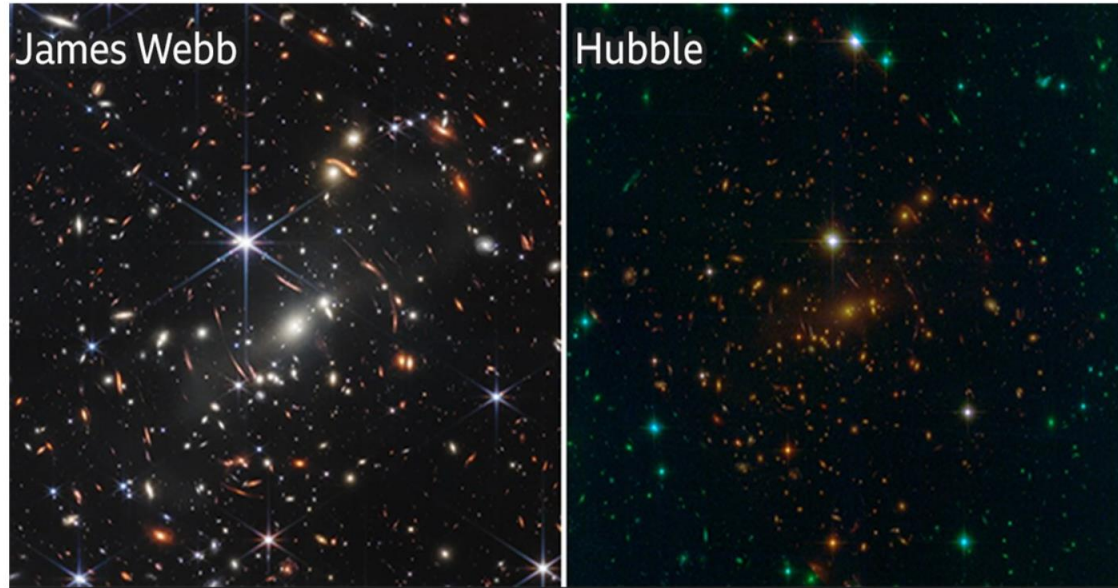
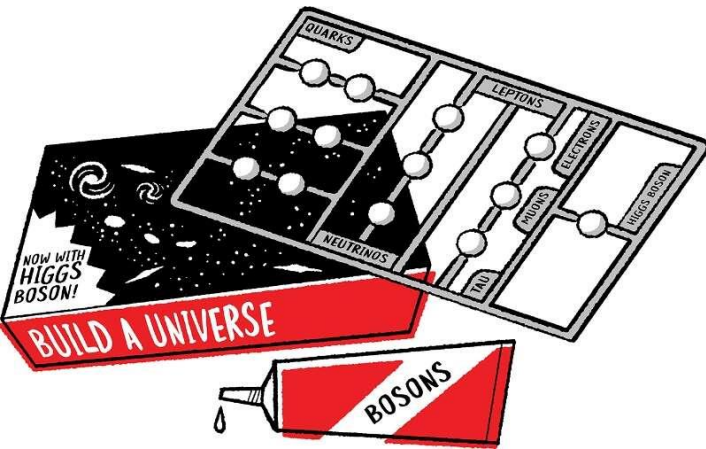
Key Ideas

- *Scientific technologies are continuously evolving*
- *Long term planning and investments must be made with room for adaptability*
 - *Need a wide selection of proposals → diversity of thought*
- ***We need more people to invest in science! (and become scientist)*** 😊



Curriculum & Classroom Connections

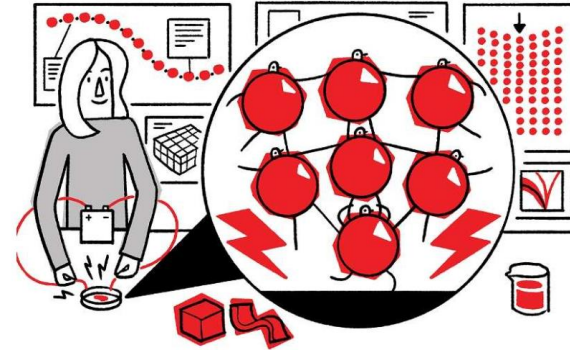
- *Nature of Science*
- *Experimental observations vs. predictions*
- *Higher resolutions with more advanced techniques*



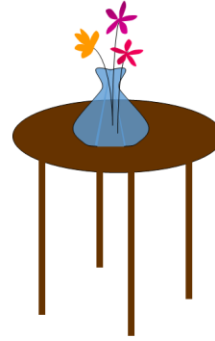
Source: Nasa/Esa/CSA/STScI



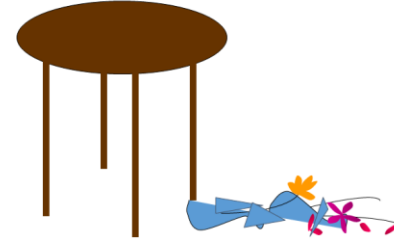
Potential Students' Conceptions & Challenges



Natural

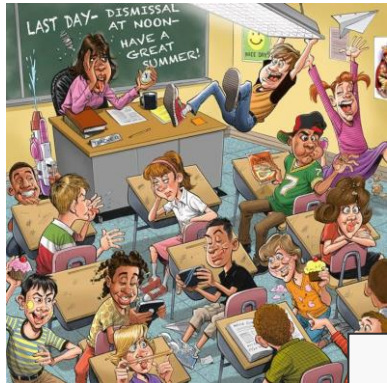
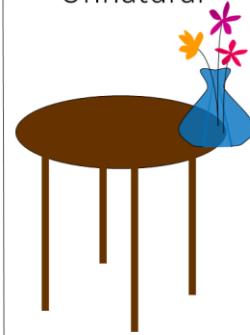


Natural



M. Strassler 2013

Highly Unnatural



- *Additional factors: social approval, economic investment, sustainability.*
- *Learner Profile: Open-Minded, Inquirers, Knowledgeable, Communicators, Thinkers.*
- *There are **STILL** unknown things in this universe → how can we motivate the **pursuit** of knowledge?*

Best Practice Example

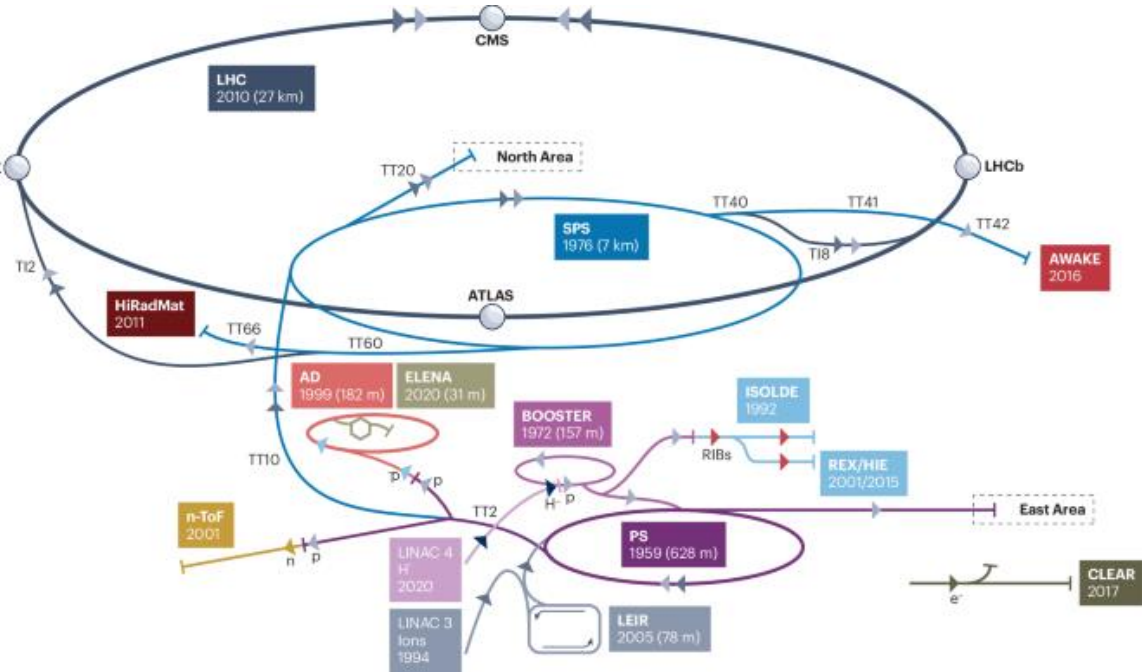
Why do we need future accelerators?

In this activity, students will...

- Analyze patterns between CERN accelerator dimensions and energy :sort particles based on discovery date and properties.
- Infer limitations to the Standard Model
- Predict future accelerators size and potential new particles existence.

Materials

- CERN accelerator complex map with timelines
- Standard Model particles cards with date of detection and energy
- Composition of the Universe
- Activity worksheet



Trivia Time!

An example from the Activity Worksheet

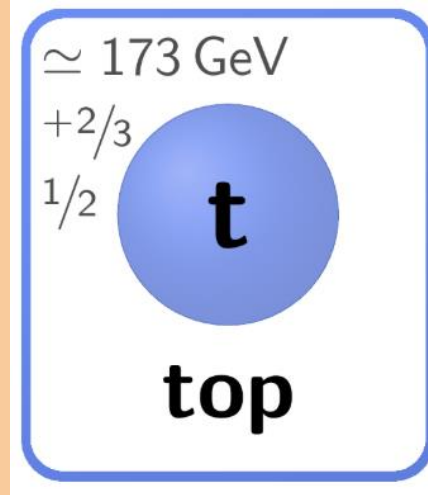
	Accelerator	Launch year	Radius (km)	Kinetic energy of a proton (GeV)
A	LINAC 4	2020	-	0.16
B	PS	1959	0.072	25
C	SPS	1976	1.1450	900
D	LHC	2010	4.28	7000
E	All of the above			

Which CERN accelerator is capable of creating a top quark, the most massive of fundamental particles?

mass

charge

spin



Discovered 1995 by Fermilab

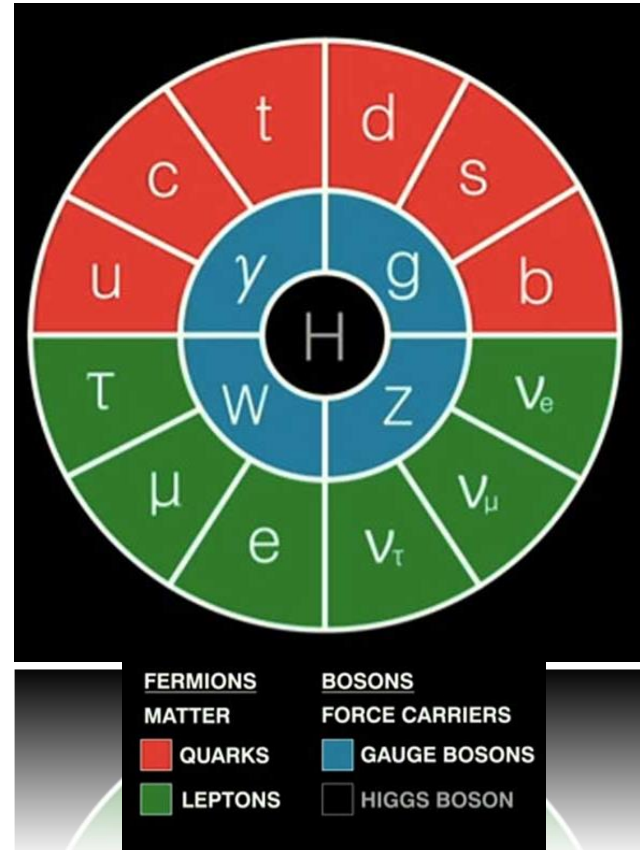


Best Practice Example

Why do we need future accelerators?

DISCUSSION & REFLECTION QUESTIONS

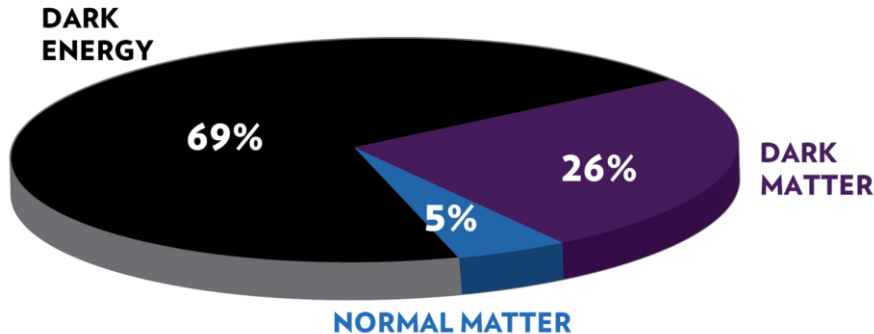
1. How do the accelerator sizes compare to the fundamental particle properties that can be discovered or detected by them?
2. Why is the Standard Model not enough to describe the entire universe?
3. What would scientists need to create to discover or detect unknown particles?
 - a. Using what you know about particle physics, could there be other ways to detect unknown particles?
4. What limitations or challenges might future accelerator projects have?



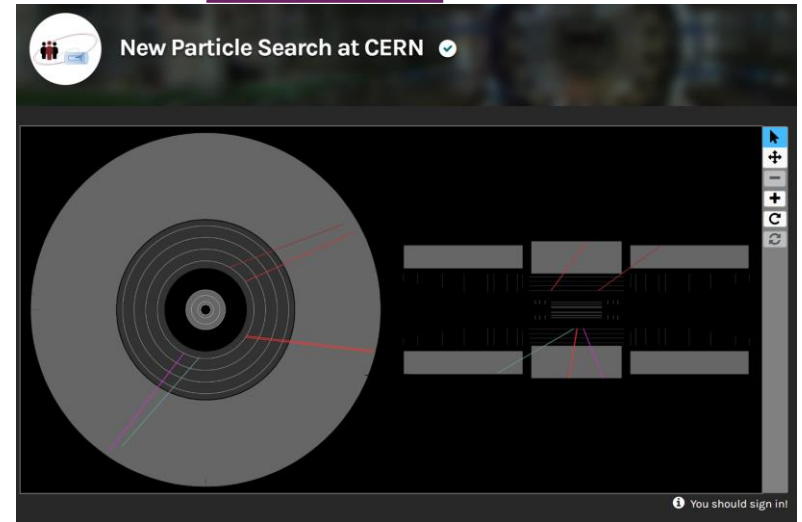
Useful Material & Resources

- *European and U.S. Particle Physics Proposals - future projects for accelerators*
- *Composition of the Universe*

ENERGY DISTRIBUTION
OF THE UNIVERSE



- *Zooniverse*



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One way in which our thinking has changed...

Although particle physics might not be well represented in our curriculums, we can still integrate the concepts into other physics topics such as:

- SCALE
- Linear and Circular Motion
- Acceleration and Free Fall
- Energy & Momentum (conservation)
- Fields (electric & magnetic)
- Thermal

Highlights,
snapshots,
farewell
messages...



SCIENCE FOR PEACE



FCC ?

LCF ?

CLIC ?

*“The **n**ext **g**ener**a**tion of **s**cience is **c**urrently being decided by **p**eople who **w**ill not be **a**live to see its **c**omple**t**ion, and **b**uilt by **p**eople who **a**re not yet **b**orn.”*

Isabel Bejar Alonso

c o l l a b o r a t i o n

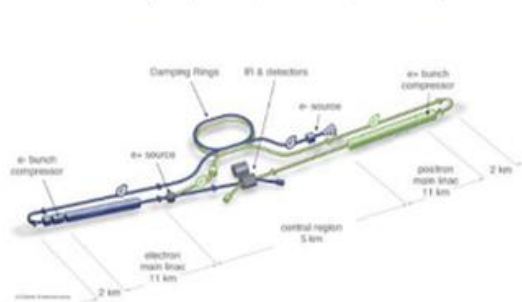
Proposed large-scale projects at CERN, ~ 2045

e^+e^- colliders
("Higgs factories")

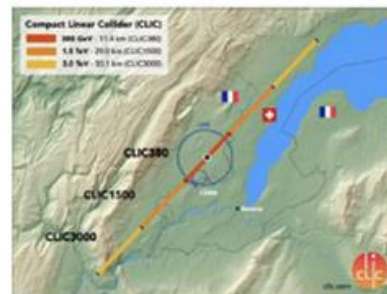
FCC-ee (e^+e^- , circular, 91 – 365 GeV)



LCF (e^+e^- , linear, 91 – 240, 550 GeV)



CLIC (e^+e^- , linear, 380 GeV, 1.5 TeV)



Intermediate projects

(Leave room (time, budget, resources) for further development of THE machine that can probe directly the energy frontier at the 10 TeV parton scale)

LEP3 (e^+e^- , circular, 91 – 230 GeV)



LHeC (ep, circular, electron ERL, 50 GeV e^- , > 1 TeV ep collisions)

