Future Particle Accelerators




Curriculum & Classroom Connections

Skit is an example of a "high energy" classroom activity based on SHARK TANK.

- **Pitching new (future) ideas for particle accelerators**
- **Research (fundamental physics, benefits and challenges, etc.)**
- **Understanding constraints**
- **Using imagination and creativity**
- **Developing social and other soft skills (compromise, teamwork)**
- **Simulates "real world" grant process**
- **Requires collaboration and presentation skills**

Welcome to the SHARK TANK

We are here to present 5 proposals on:

FUTURE PARTICLE ACCELERATORS

to move forward the

EUROPEAN STRATEGY FOR

PARTICLE PHYSICS

What you will hear about today:

Supercompact Wakefield Accelerators for Medical Applications

High Intensity Linear Accelerator

Moon-based SuperHighEnergy (large circumference) Beam Colliders (CCM)

Super Large Electron Positron Collider Toroidal (SLEPT)

Muon Collider

Super Large Electron Positron Collider Toroidal (SLEPT)

We are stuck?

On July 2012, mass of Higgs = 125 GeV/c2.

It is the heart of the Standard Model (SM) and other mysteries.

The SM doesn’t answer the origin of matter-antimatter asymmetry, dark matter and dark energy.

How do we move forward?

SLEPT will pave the way! The collider is designed to accelerate positron and electron to reach a center of mass of energy = 240 GeV!

Super Large Electron Positron Collider Toroidal (SLEPT)

How does it work?

- Linear accelerator
- Booster ring
- Main collider ring (100 km in circumference) to 99.999999% speed of light
- Detectors will discover particles (maybe new particles), mass and interaction strength of Higgs, validate theoretical model and potentially discover new aspects of universe

What is the cost?

6 billion Euro

BUT collaboration with different countries:

3 billion Euro (LHC cost 9 billion USD)

Advantages:

Large number of Higgs is produced.

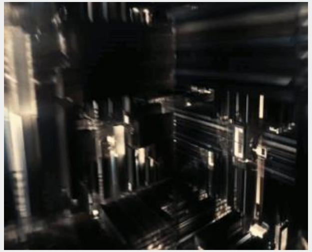
Upgrade to Super Proton Proton Collider (SPPC)

Economic and job creation

Challenges:

Detectors are still in research stage but models are currently designed in respected university. We will solve it!

LUMINA COLLİDER : Coming from the future



CLIC Summary

1. Structure

- **Geometric Design**: A folded and twisted modern linear collider.
- **Holographic Coating**: Transparent surfa  ergy flows and particle beams.

2. Energy and Technology

- **Quantum Energy**: Advanced quantum technologies providing limitless energy.
- **Plasma Magnets**: Plasma magnets and superconductors are used control the energy flow.

3. Collision and Data

- **Transparent Collision Zones**: Dynamic and holographic collision points.
- **VR Analysis**: Data inspection and simulations in virtual reality environments.

Circular Collider on the Moon (CCM)

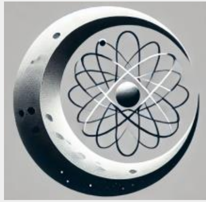
Advantages:

- the vacuum is free
- radiation and safety considerations: NOT A PROBLEM
- land acquisition: PIECE OF CAKE
- Circumference can be UP TO the circumference of the moon
- Can leverage deep cold of lunar night
- Surface and subsurface options available
- Will drive NEW technologies and science
- Promotes and supports International collaboration

Challenges:

- Requires robust space and lunar infrastructure
- Difficult engineering optimization for many construction options (tunnels, trench and cover, surface)
- May be several decades or centuries in the future

Moon based particle accelerators



The construction of a very large hadron collider around the ~11 000 km circumference of a great circle of the Moon—a circular collider on the Moon (CCM)—is an attractive prospect for the (next-to-) next-to- next-generation of particle physics project, a potential successor to the proposed FCC at CERN, SPPC in China, or CitS in the Gulf of Mexico.

The CCM could achieve an unprecedented center-of-mass proton–proton collision energy of:

14 PeV

a thousand times more energetic than the LHC

This slide from:
A very high energy hadron collider on the Moon by
James Beacham and Frank Zimmermann

Many of the raw materials required to construct the machine, injector complex, detectors, and facilities of the CCM can potentially be sourced directly on the Moon.

Of the various scenarios for CCM construction ... the most compelling... involves drilling shafts and excavating a nearly 11 000 km tunnel—along with additional tunneling for the injector complex and auxiliary tunnels—a few dozen to a few hundred meters under the lunar surface to avoid lunary day–night temperature variations, cosmic radiation damage, and meteoroid strikes.

TOTAL COST: "Priceless"

A muon collider

Muons never been used in a particle collider.

A muon collider could be explore high-energy physics frontiers with a relatively small environmental footprint.

The more massive a particle, the less energy it loses through synchrotron radiation. Being 200 times heavier than electrons, muons emit about two billion times less synchrotron radiation.

A muon collider could therefore run using less energy, for example a 10 TeV muon collider could be competitive with a 100 TeV proton collider.

Dealing with short lifetime of muons requires developing innovative concepts and demanding technologies and collaboration in the coming years to fully demonstrate its feasibility.

While other accelerators also aim to explore new physics, the combination of high energy and clean collisions in a muon collider gives it a unique edge in discovering subtle or rare phenomena.

Wakefield acceleration to battle cancerous growth

My pitch is about how we can use very small particle accelerators that are only 1 cm long to battle cancer growth from inside the body. The idea is built off of wakefield particle accelerators. These accelerators are now still in an experimental phase, but studies done at CERN by the team of which Marlene Turner is a part of are showing promising results of particle acceleration to extremely high energy levels within just small distances.

If we can stabilise the wakefield particle accelerator and cramp it into only a 1 cm long capsule we are able to fight cancer growth with radiation therapy from within the body. This would reduce a lot of tissue damage being made by existing radiation therapies. This would be revolutionary!

So committee please choose to spend as much money as you can to accelerate (pun intended) studies such as Marlene’s at CERN so we can help out millions of people rather sooner than later.

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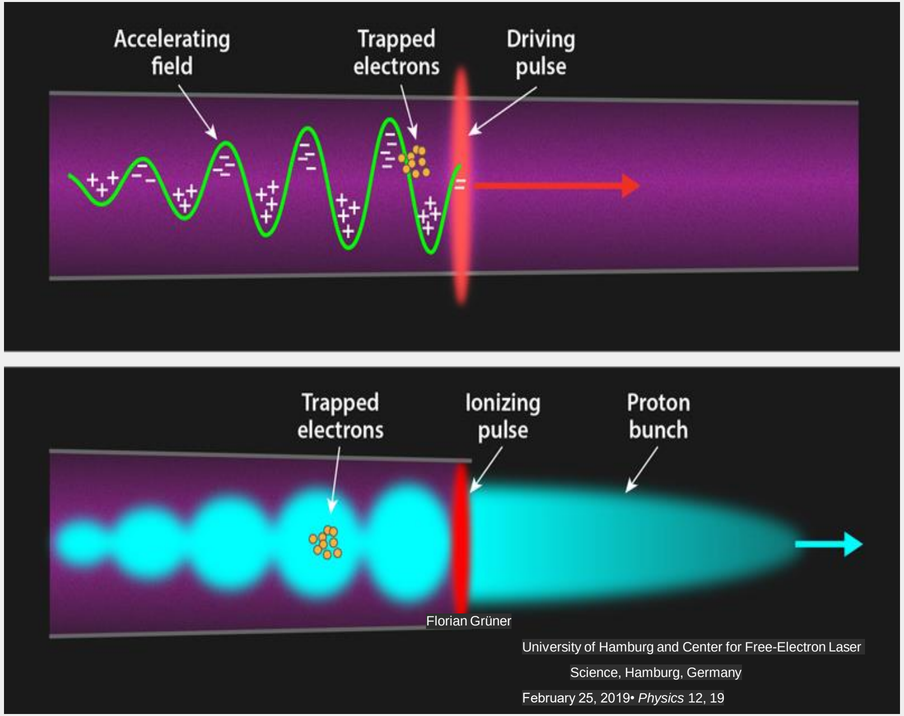

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Judges: Which technology do you choose?

LUMINA
CCM
SLEPT
WAKEFIELD
MUON

Debrief

For Judges:

- **What was it like to have to pick ONE proposal for future funding?**

- **How can governments and organizations decide which proposals to support?**

For Presenters:

- **What were the challenges in researching future technologies?**

- **what was it like to create a pitch?**

- **How can governments and organizations decide which proposals to support?**

Useful Material & Resources

Reference any material that you find useful for your students and/or your colleagues

FCC: https://home.cern/science/accelerators/future-circular-collider

CEPC:

https://cerncourier.com/a/chinas-designs-for-a-future-circular-collider/

HL-LHC

https://home.cern/science/accelerators/high-luminosity-lhc

ILC: https://linearcollider.org/

CLC: https://home.cern/science/accelerators/compact-linear-collider

MC: https://home.cern/science/accelerators/muon-collider

CCM (Moon-based particle Accelerator):

https://iopscience.iop.org/article/10.1088/1367-2630/ac4921#njpac4921s10

- **Wakefield acceleration and the possibilities for medical applications.**

ITW2024 Study Group 7

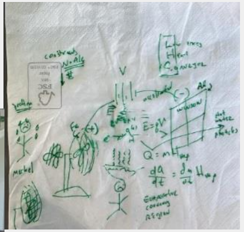
One way in which our thinking has changed…

We are all thinking about the idea of starting atomic theory with the Standard Model and then introducing all the other atomic models (Bohr, Rutherford, Thomson, Dalton, Ancient Greeks) by asking "why is this model not sufficient for understanding what we observe"

Highlights, snapshots, final words

Wonderful

Amazing



Collaboration

Diversity