COMPUTING IN PARTICLE PHYSICS

The coexistence of particle physics and computing.

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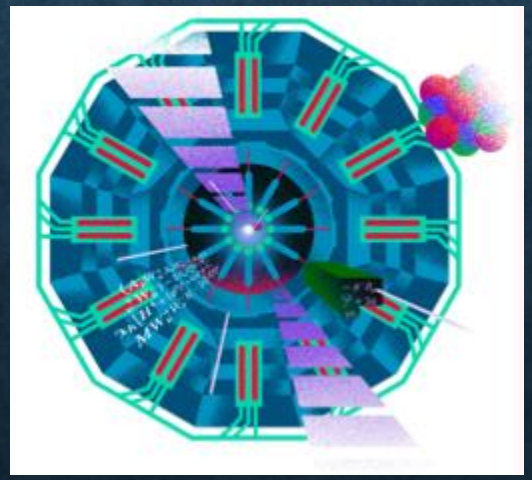
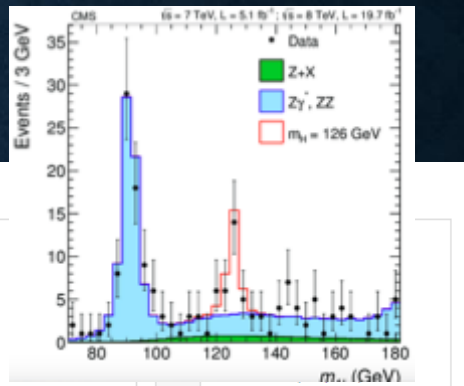
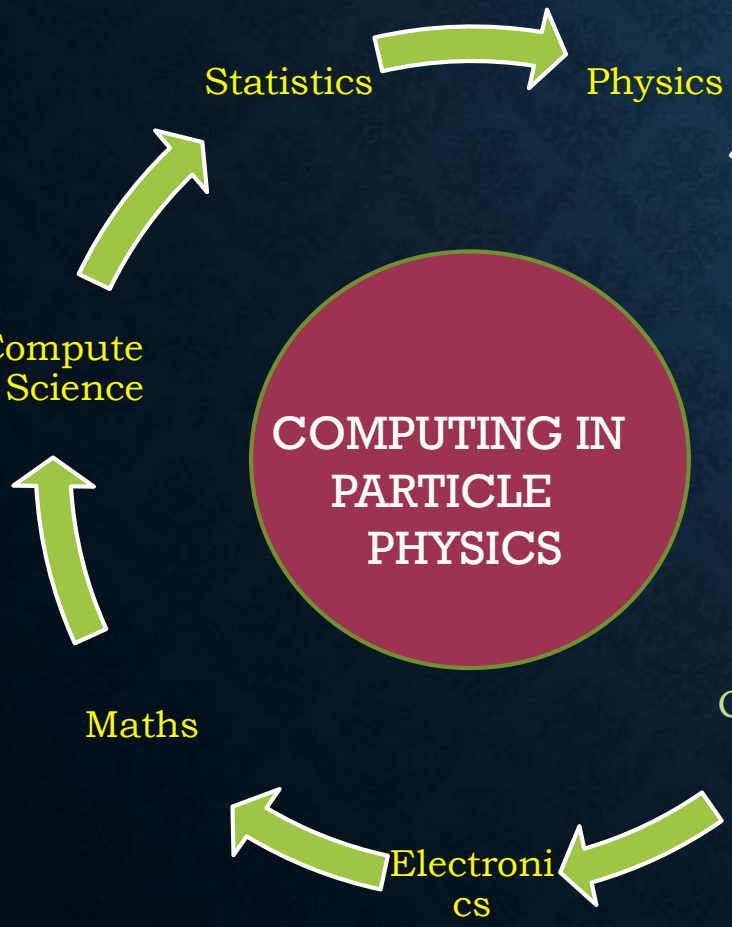


CURRICULUM & CLASSROOM CONNECTIONS





Measurements & errors
Particles & radiation
Mechanics & materials
Electricity
Fields & their consequences
Nuclear physics
Engineering physics
Electronics, Optics

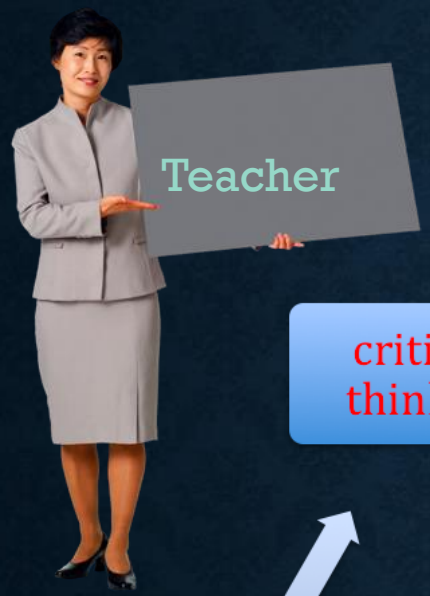
Algebra
Logarithmic & exponential functions
Trigonometry
Differentiation & integration
Differential equations
Complex numbers
Representation of data
Probability
Discrete random variables

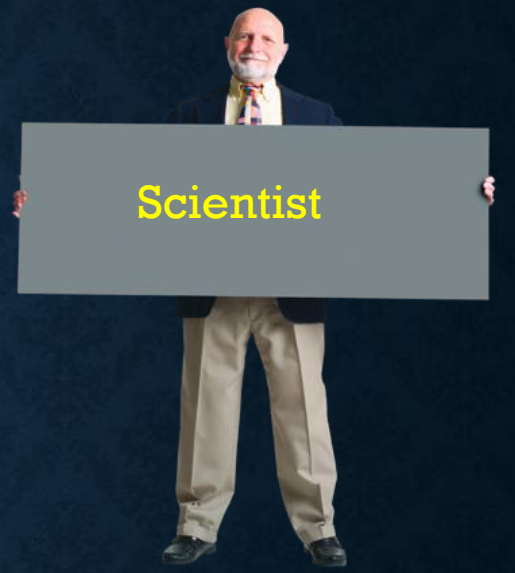
Data representation
Communication & internet technologies
Hardware
System software
Security
Monitoring & control systems

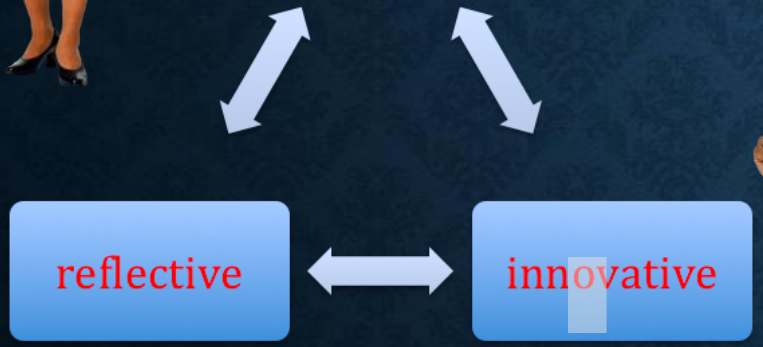
Basic circuits theory
Electronics devices & circuits
Power supplies
Data convertors

Materials structures
Metals, polymers ceramics
Advanced chemistry
Transformation of materials
Advanced materials

CURRICULUM & CLASSROOM CONNECTIONS-

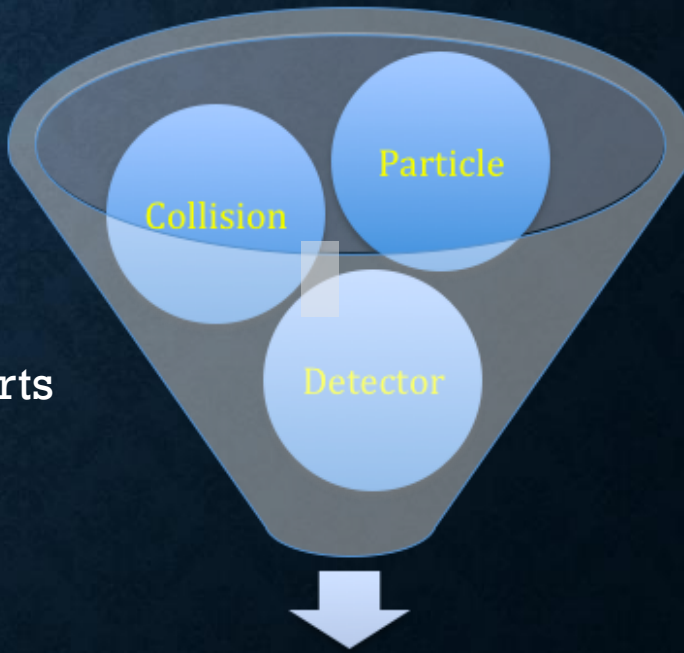




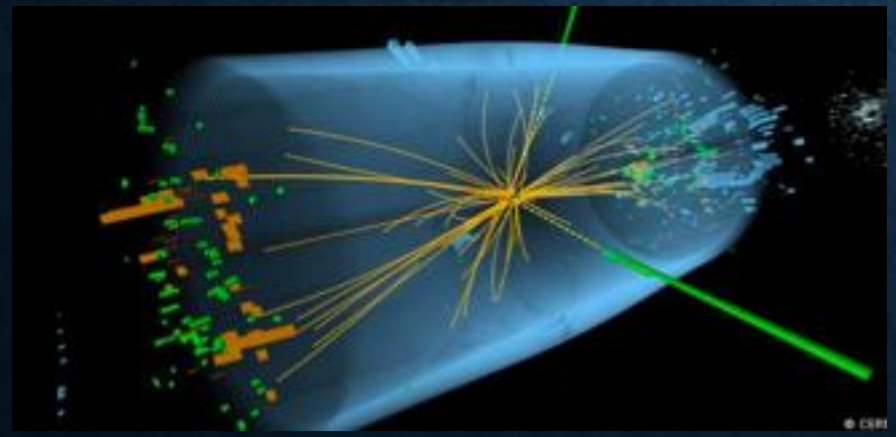


What skills does student need to have?

-domain knowledge
-problem solving
-data preparation
-data analysis & exploration
-creating dashboards & reports
-communication skills



DATA



KEY IDEAS – LHC CONTROL SYSTEMS

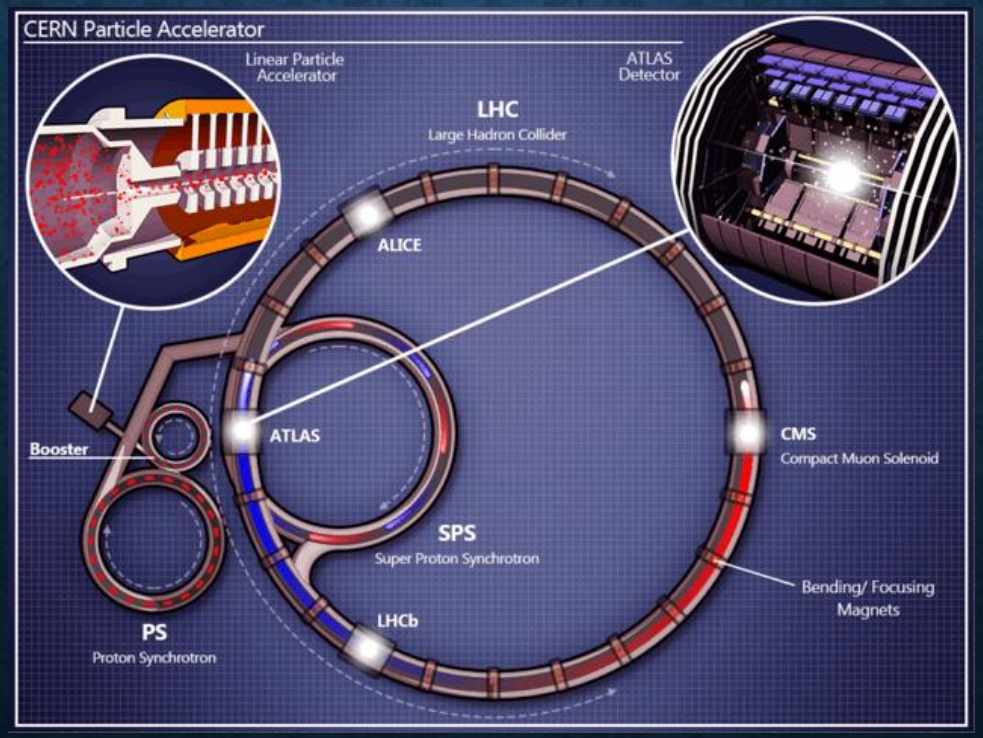
- Beam Injection
- Control
- Monitoring
- Feedback

LHC Beam Control

Collision Data Acquisition

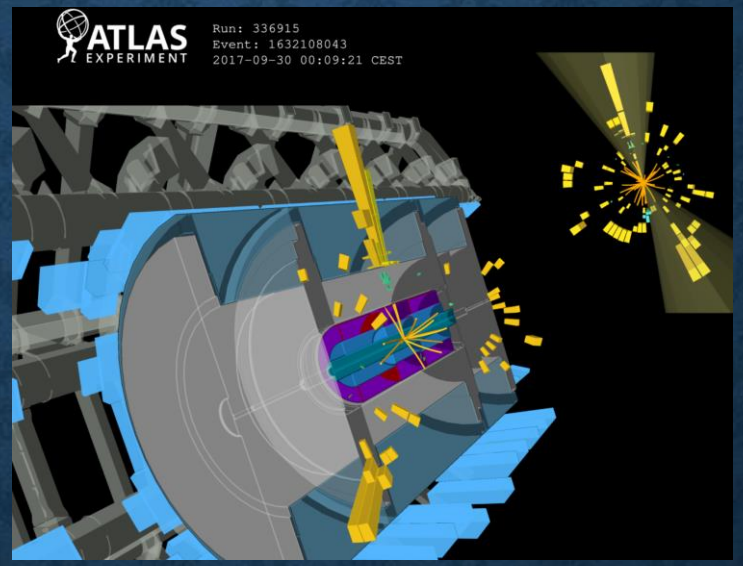
Simulation

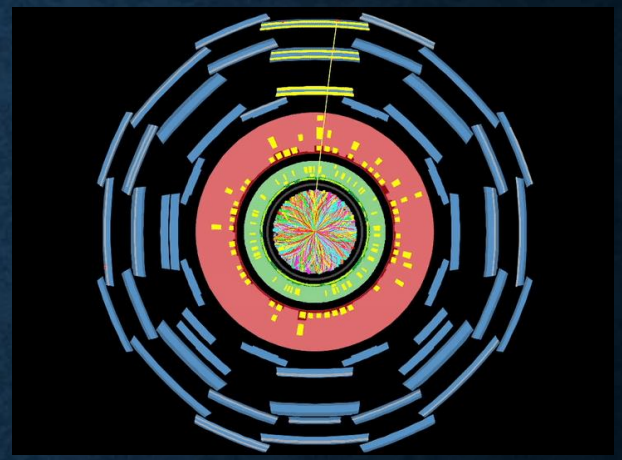
Data Processing & Storage

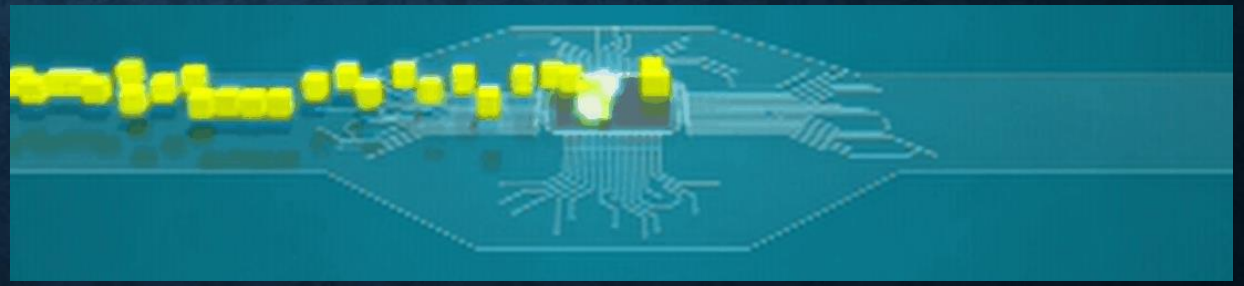


KEY IDEAS – SIMULATION AND DATA SELECTION

- Simulation (Monte Carlo data)
  - Event generation
  - Detector simulation
  - Digitisation
  - Reconstruction
- Data Selection
  - Triggering
  - "From hit to bit"
- The Future
  - Programmable FPGAs
  - Quantum Computing (?)
  - AI for data selection (the future)





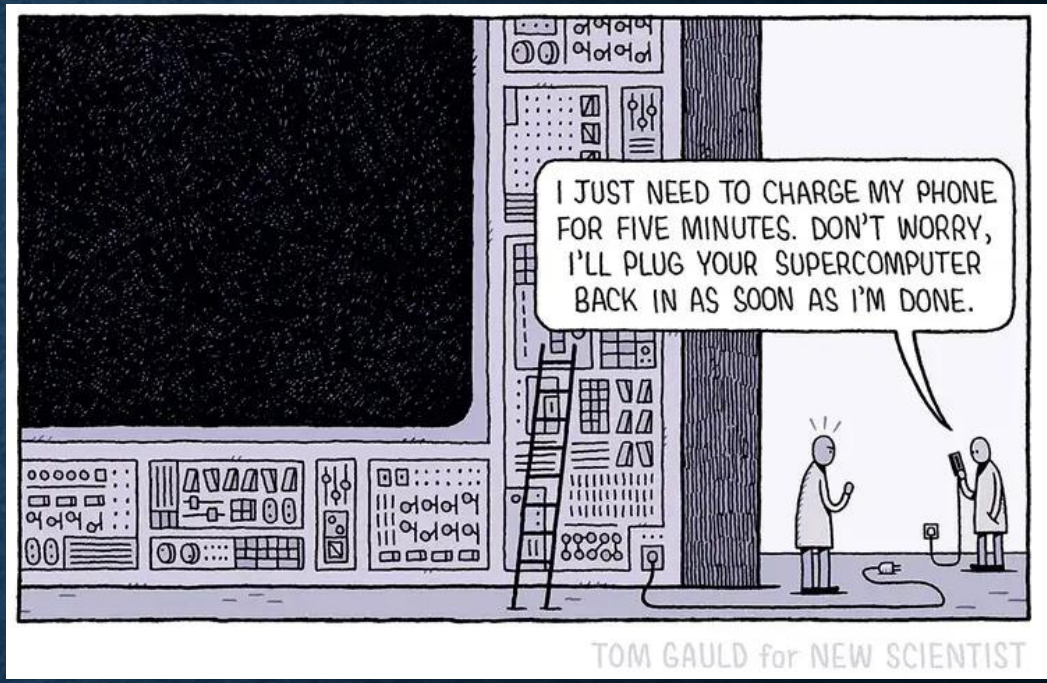


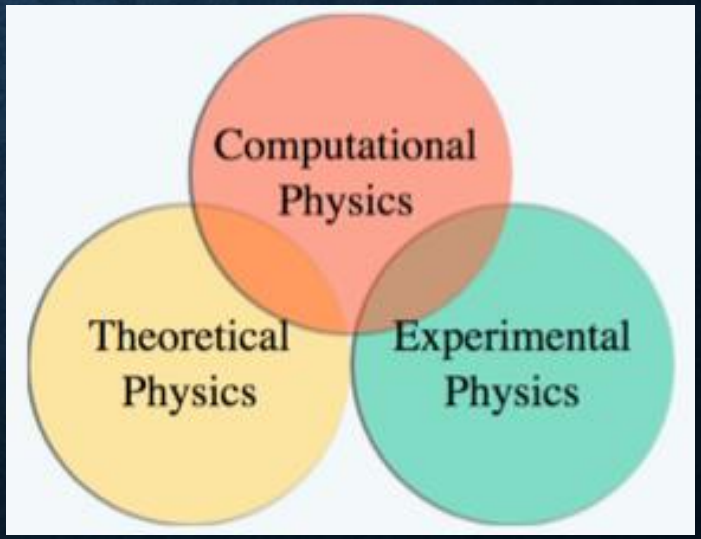
KEY IDEAS - DATA PROCESSING AND STORAGE

- History (creation of WWW)
- Funnelling to data centre (10Gb/s)
- Data storage
- Data Grid Processing
- Future
  - Bandwidth Solutions
  - Storage Solutions

POTENTIAL STUDENTS' CONCEPTIONS

- CERN needs supercomputers
- Have to be **really** good at physics, mathematics and/or programming to work in data analysis for CERN --> motivated though! :-)
- Only for boys
- Too complicated for regular students
- It has no relevance to our daily lives
- Difficult to deal with the errors
- Possibly not an engaging topic for some





POTENTIAL CHALLENGES

- Learning specific mathematical, physics, and/or computational skills
- Doing a Citizen Science type project
- Building a supercomputer with video processing chips from game computers

But…

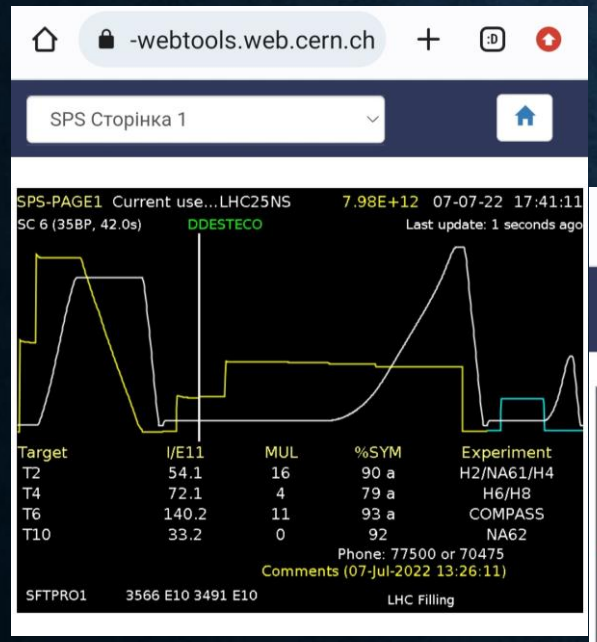
…you could start with some easy calculations, so they get a feel for the amount of data produced at CERN!

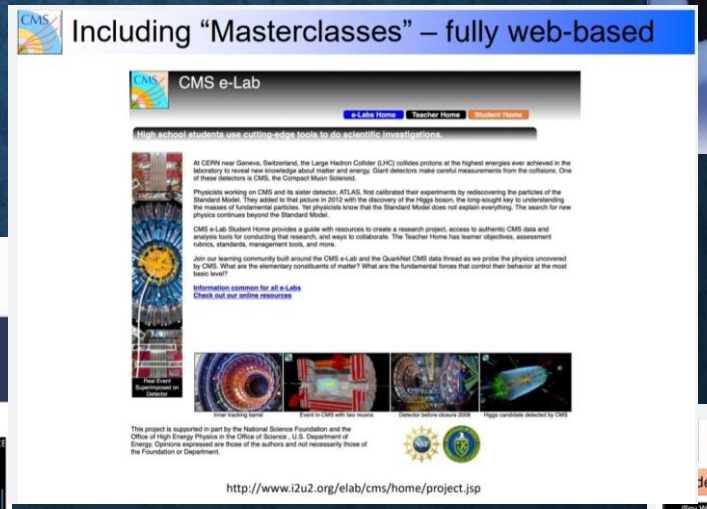
Just for position data with one detector you get: ~100 M channels: 27+ bits, every particle hits ~15 channels, ~500 particles per collision, and with 40 M collisions per second we get ***~8,100,000 Mbps****!*

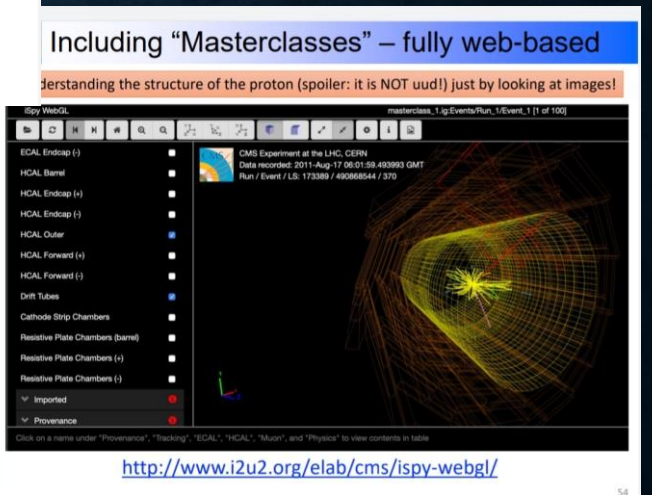
100 out of 40 M collisions, four detectors, ~300 days of operation per year: ***300 Tb****!*

HELPFUL MATERIAL AND RESOURCES

- https://op-webtools.web.cern.ch/vistar/vistars.php?usr=LIN
- https://scoollab.web.cern.ch/sites/default/files/Particle_v2/index.html







HELPFUL MATERIAL AND RESOURCES

- http://opendata.cern.ch
- https://opendata-education.github.