Muon Collider Projects

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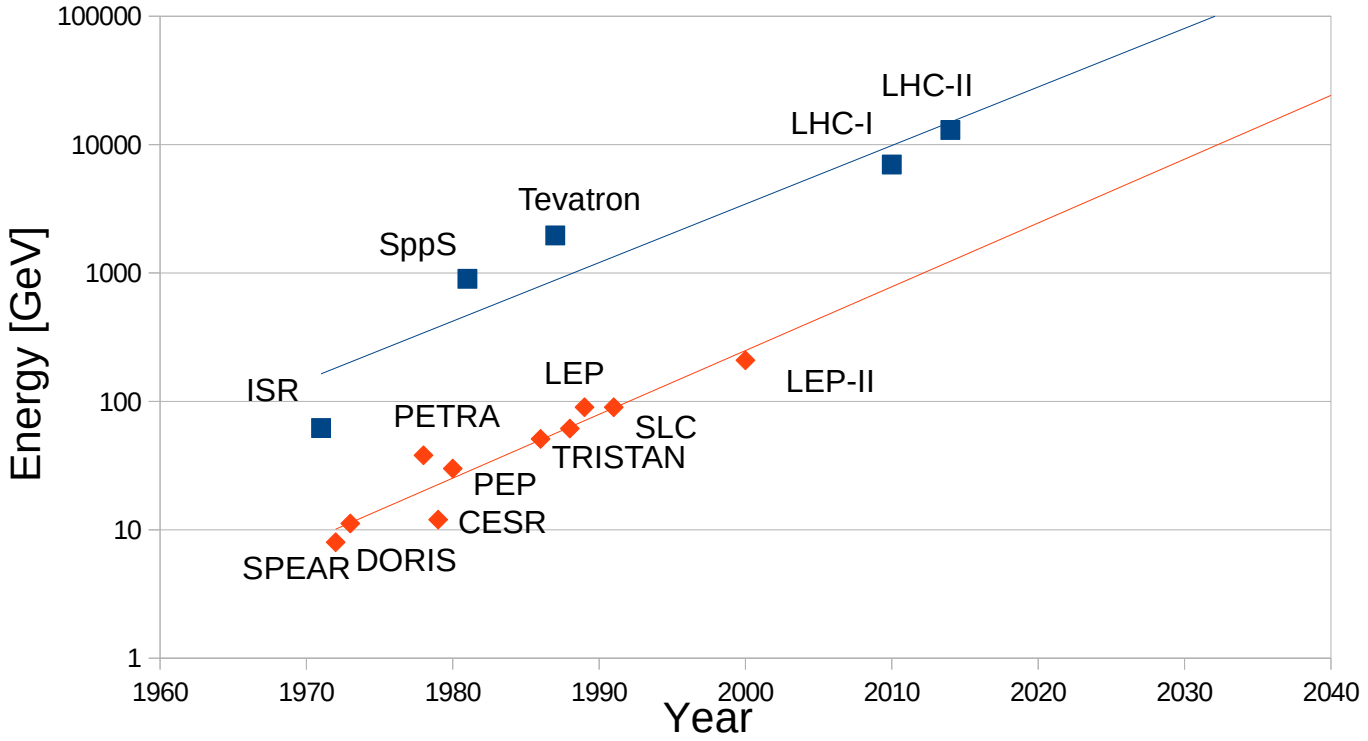
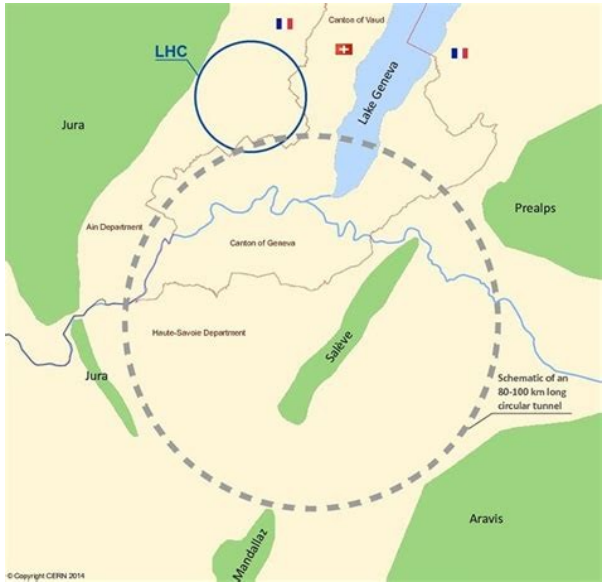
The Future of Particle Physics

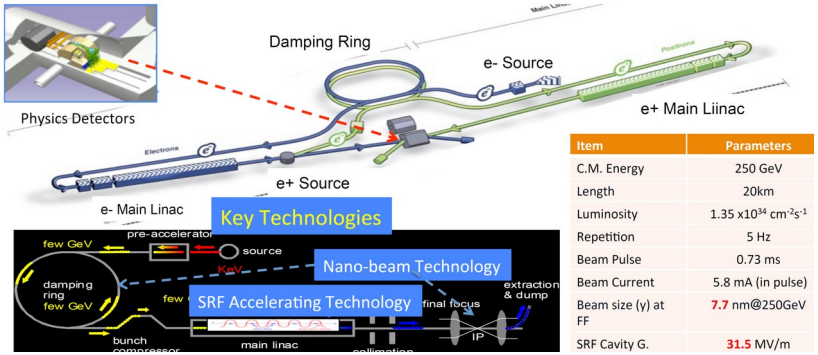


- Effort to explore phenomena at higher and higher energies
- Corresponds to smaller scales
- Higher energy → bigger, more expensive, more power hungry
  - Electricity cost is limiting LHC performance *right now*
- What should come next?

What next?

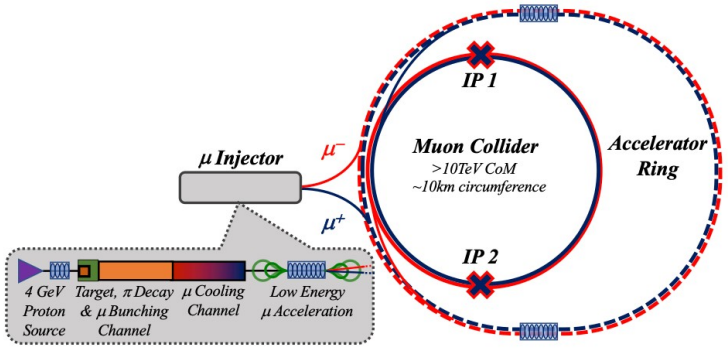


Protons?



Item	Parameters
C.M. Energy	250 GeV
Length	20km
Luminosity	1.35 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	7.7 nm@250GeV
SRF Cavity G.	31.5 MV/m

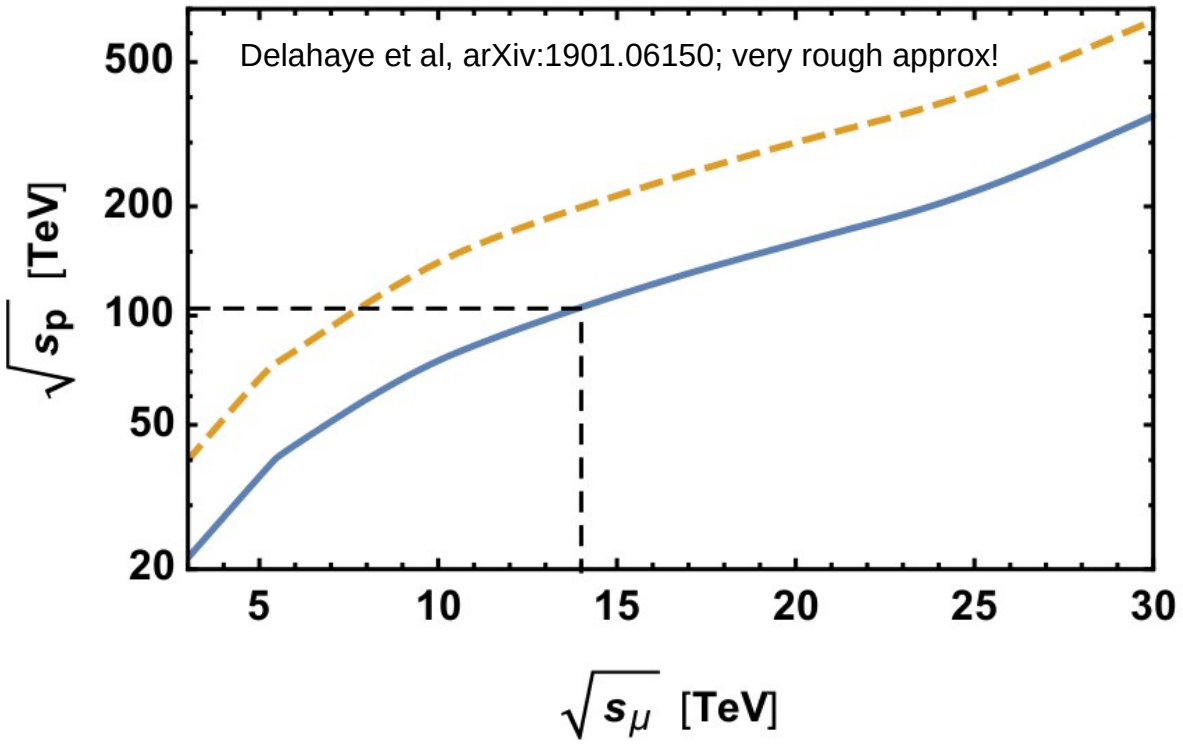
Electrons?



Muons?

Science & Technology Facilities Council
ISIS

Physics potential of muons



Energy at which cross-section is equal

Assuming equal Feynman amplitude (EW)

Assuming factor 10 enhancement in pp (EW+QCD)

- Proton collision energy is shared between quarks
  - Effective energy significantly reduced
- Seek a particle which
  - Is not so low mass as an electron
  - Is a fundamental particle
- **Muons!**

Science & Technology Facilities Council ISIS

Muons

- Muon
  - Half-life 2.2 μs
  - Mass 105.658 MeV/c
  - 207 times electron mass
- What would a muon collider look like?

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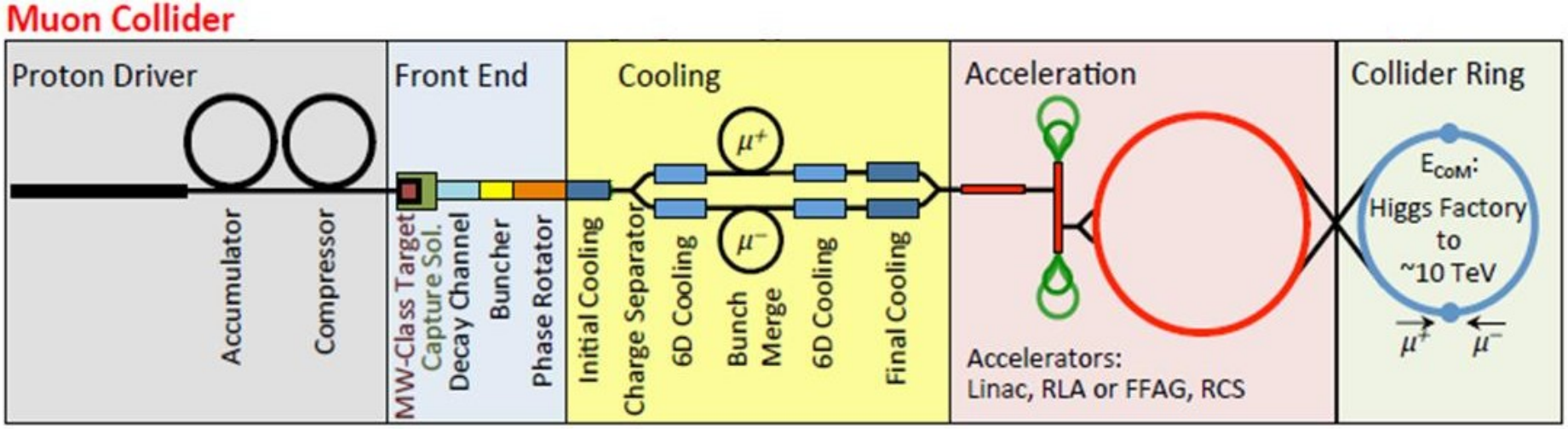
Muons – Disruptive Technology



- MW-class proton driver → target
- Pions produced; decay to muons
- Muon capture and cooling
- Acceleration to TeV & Collisions
- Critical Challenges:
  - Can we make a high intensity muon beam?
    - Target
  - Can we cope with muon decay products?
    - Collider

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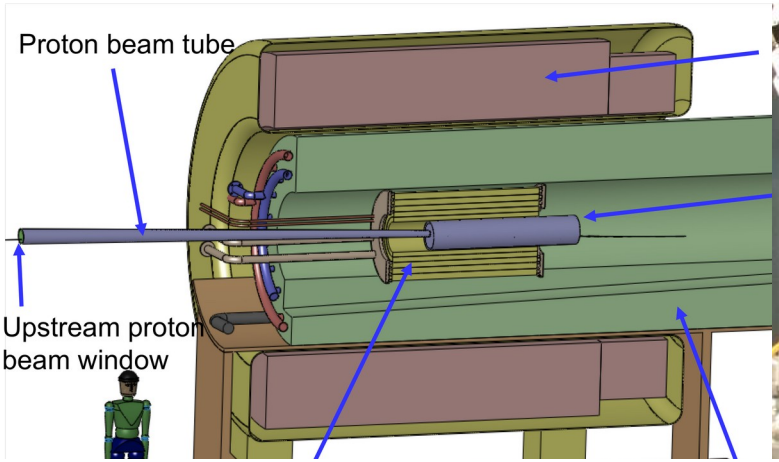
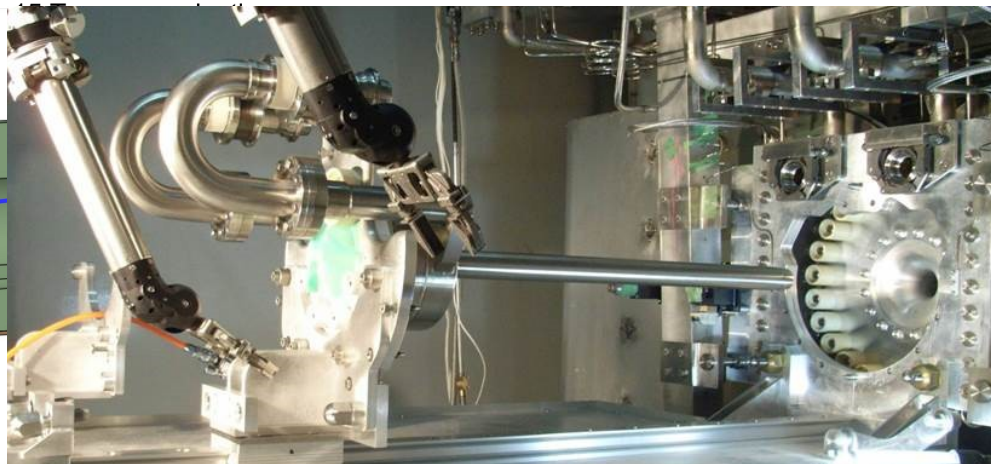
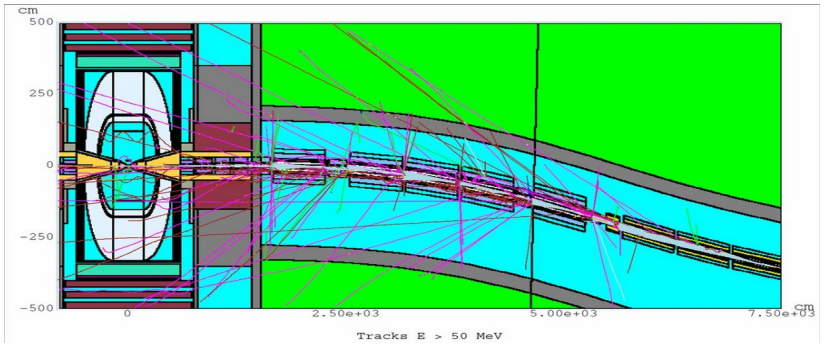
Muon Collider Target

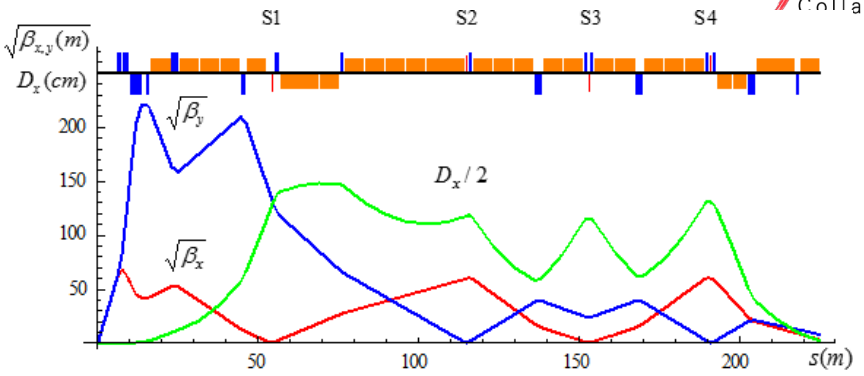




- Protons on target → pions → muons
  - Heavily shielded, very high field solenoid captures π^+ and π^-
- Challenge:
  - Heating and forces acting on the target
  - Radiation environment
  - Maintaining good pion production
- Fluidised powder target strong option

Machine Detector Interface





- Muon collider requires extremely strong focusing
  - Strong focusing → dense beams → more collision products
  - Beam is ~ microns in size
- Elaborate system of focusing near the interaction point
- Complicated shielding to protect detector from muon decay products

Muon Collider Target Ph.D.

- Can we achieve the parameters required for the muon collider?
  - Can the target survive the heating?
  - What is the radiation environment like?
  - Do we make enough pions?
- Development of novel targets
  - Bottle neck for many proton accelerators
- Collaborate with world's leading pion production target team
  - RAL technology and Warwick University
  - Developing targets for T2HK and DUNE
- Work closely with CERN and other target development groups worldwide

Muon Collider MDI D.Phil.

- Study on the Machine Detector Interface of the muon collider
  - Can we achieve the required beam quality?
  - How can we make these tiny beams?
  - What are the technologies required to get the beams to line up?
  - How do we protect the detector and other equipment from muon decays?
    - Neutrino radiation is an issue!
- Collaborate with Oxford University's John Adams Institute
  - Experts on Machine Detector Interface
- Vital to determine physics performance of the facility
  - MDI determines the detector design → physics reach

What's in it for You?

- Accelerator physicists are highly employable!
  - Many (permanent) lab staff positions
  - Very high demand
    - ESS (Copenhagen)
    - ISIS2 (Oxford)
    - HL-LHC (Geneva)
    - PIP2/3 (Chicago)
    - Many more
- High prestige roles
  - Involved in a major international collaboration
  - Very externally facing
  - Lots of opportunities to travel and meet community members
- Fun
  - Super interesting work
  - Novel! Chance to invent cool stuff
  - You can determine what will be the next collider in Europe

Final Word

- Collider to follow LHC will be decided in next few years
  - Will determine future of particle physics for next 50 – 100 years
  - These studentships mean that you will contribute to this decision
- The muon collider has the potential to explore physics reach at the highest energies
  - Fraction of the footprint of comparable facilities
  - Expectation of much lower power requirements
  - Advance particle physics by ~ decades
- Many technical challenges
  - All are manageable with current or near-to-current technologies
- The next machine will be **your** accelerator
  - The technology is for you to invent
  - The technology is for you to demonstrate
  - The collider will be a defining technology for **your** generation