



Particle Physics Experiment



Experimental Collaborations

Future Collider Studies

The future starts in the 2040s or beyond





DEEP UNDERGROUND



LHC Experiments LHC Run3 started Summer 2022 LHC Run4 continues into 2030s

supe



collaboration





Neutrino Experiments

DUNE will operate in 2030s Lots of smaller-scale experiments in the meantime





From the large LHC experiments...









THE UNIVERSITY of EDINBURGH



LHCb Experiment at CERN







THE UNIVERSITY of EDINBURGH



Questions you might answer

- What are the properties of the **Higgs boson**? (symmetry properties, couplings to different particles, ...)
- Is there only one type of Higgs boson?
- Are there **new particles and interactions** at high energy scales?
- What causes our universe to be made of matter? (Matter-antimatter oscillations, and CP violation)
- Do the observed hadrons match expectations from QCD? (searching for new excited states and measuring their properties)
 + are there new types of matter? (pentaquarks, tetraquarks, ...)
- What is dark matter?





To next generation neutrino experiments...





MicroBooNE & SBND













proton

30 cm

RUN 14445, EVENT 120 July 04, 2024 - 20:40:22 UTC

SBND Data



THE UNIVERSITY of EDINBURGH



 v_{μ} CC candidate

muon

Questions you might answer

- How do neutrinos interact with matter?
- What is the neutrino mass hierarchy?
- How do neutrinos **oscillate**? (on short and long distance scales)
- Do neutrinos and antineutrinos violate **CP symmetry**?
- Are neutrinos their **own antiparticles**?
- How can we best detect astrophysical neutrinos, and what can they tell us about the universe?
- Are there **new neutrino families** beyond the known three?
- What is the nature of **dark matter**?







To dedicated dark matter experiments...

DarkSide-20k













THE UNIVERSITY of EDINBURGH



Questions you might answer

- Is the dark matter hypothesis correct?
- What is the **nature** of dark matter? WIMP? Axion? Hidden photon?
- Are there non-standard neutrino magnetic moments?
- Are there changes in energy spectra and rates? What does this tell us about **astrophysics**?





To designing, building, running experiments



Construction and R&D for the LHCb 'RICH' (Cherenkov detector)



Cryogenic wavelength-shifting photodetectors (UV \rightarrow blue) for neutrino experiments









To Applications in Medical Physics

- Development of a full-body PET scanner
- Geant4 simulation studies
- Study of innovative scintillators









Skills & Outcomes

- Gain experience in cutting edge technologies, data analysis tools, machine learning techniques & software development
- Improve communication skills (presentations, writing, public engagement)
- Become an expert in **data intensive science** (big very big data!)
- Collaborate with people from all over the world
- **Travel** opportunities, including an extended placement at a major facility (e.g., CERN, Fermilab)
 - o Extra funding to cover the costs associated with living abroad
- Our students go on to work in many different areas highly sought skill set
 - o Academia (postdocs, fellows, academics)
 - o Finance, engineering, tech firms





Who are we?

- 16 academic staff, 1 senior researcher, 25 postdocs, 33 PhD students (+ MPhys + MSc students and dedicated engineers)
- Projects offered
 - $\circ~$ Physics of the Higgs boson and search for new particles at <code>ATLAS</code>
 - CP violation and flavour physics with LHCb
 - Dark matter/axion searches with LUX/LZ and DarkSide
 - Neutrino physics with **DUNE / SBND / MicroBooNE** and **SuperNEMO**
 - Research and design of future particle detectors
 - o Development of full-body PET scanner (medical physics)
- All projects have opportunities for hardware R&D and software development





