CCP-TEPP

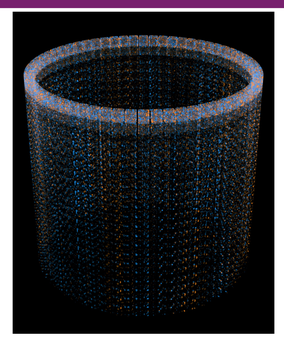
Towards a Collaborative Computational Project in Theoretical and Experimental Particle Physics

https://ccp-tepp.github.io

What computation is done in particle physics?

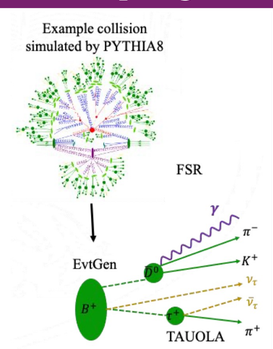
Lattice Quantum Field Theory

The equations describing the fundamental forces of nature are discretised and solved using Monte Carlo methods. Heavy use of GPU compute; strong scaling problem.



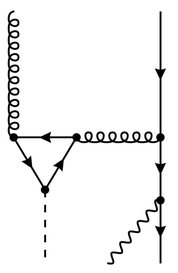
Event generation

Approximate rules derived from lattice and perturbative calculations used to derive statistics for expected observations in experiment. GPU-enabled; not strong scaling.



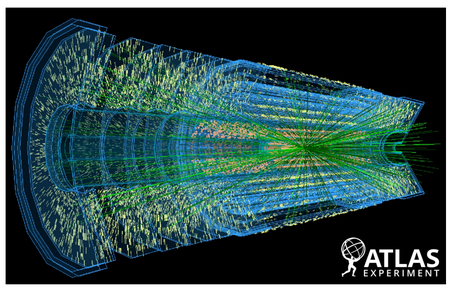
Event reconstruction

Where data have been observed in experiments, reverse engineer the observations to understand what physics occurred to create them. Requires grid-scale high-throughput compute. Increasing use of GPU/Machine Learning.



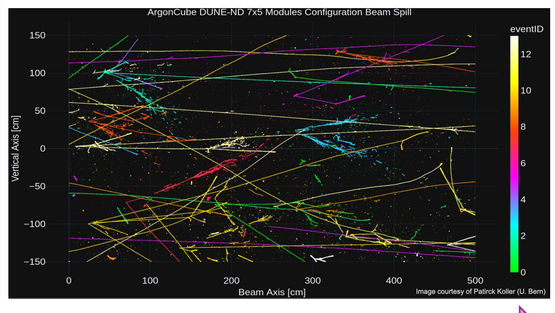
Many-loop amplitudes

Advanced computer algebra methods are used to provide perturbative estimates of interactions observed in experiment. Memory and CPU-intensive.



Detector Simulation

Model interactions of high-energy particles with detector materials for optimizing design and operation. CPU intensive, R&D on enabling GPU.



Theoretical particle physics ⟷ **Experimental particle physics**

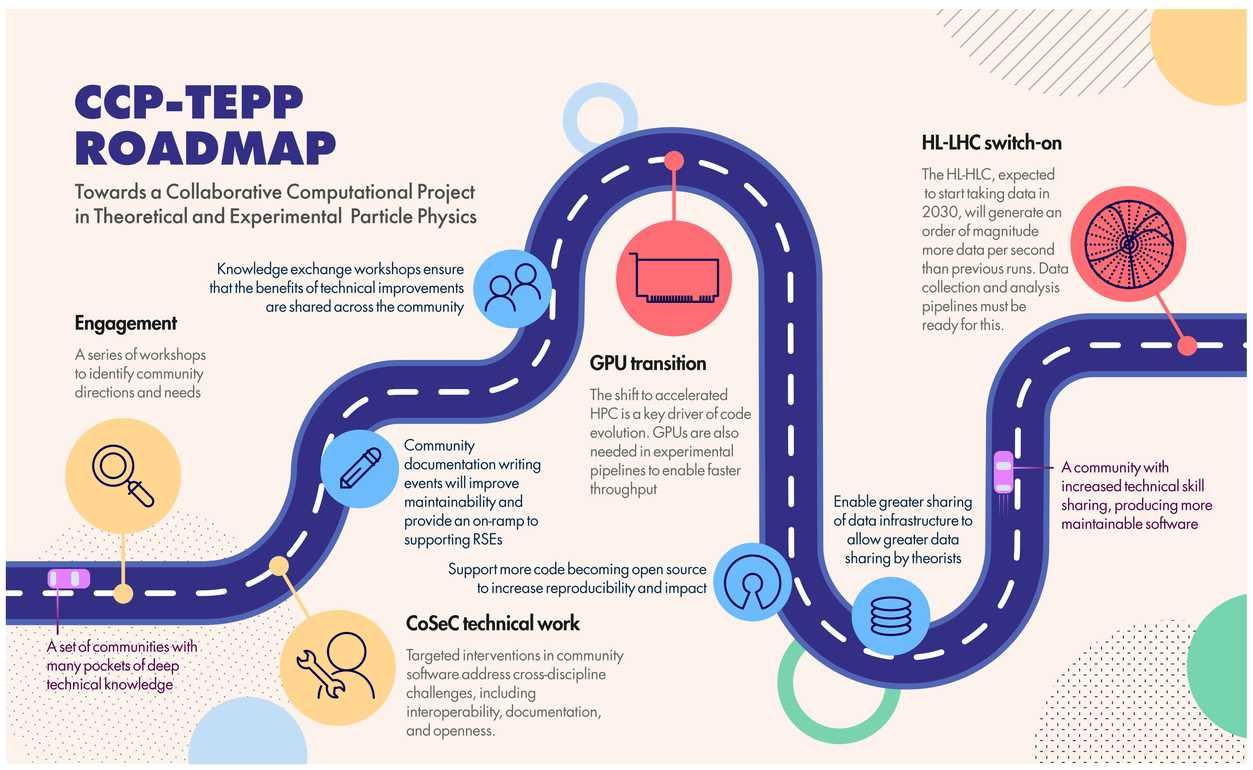
What is CCP-TEPP doing to support this?

Community Engagement

Roadmapping

In 2025 CCP-TEPP facilitated a series of workshops to identify computational challenges common across theory and experiment. These included

- Supporting transition to GPU-enabled software where it already exists
- Maintenance of older software where original authors have retired
- Documentation of software, including improving readability and comprehensibility of implementations as well as ease of onboarding for new users
- Sharing of knowledge between different parts of the community—access to HPC for those experienced with HTC; access to data curation resources for areas where this has historically been deprioritized
- Data sharing between different collaborations is hampered by poor support for common standardized file formats



Knowledge Exchange

In September 2025 we organized a knowledge exchange workshop at Daresbury Labs. Over 30 researchers from across computational particle physics assembled, with talks from theory, experiment, and industry contexts on many common cross-community challenges.

Docathon

In March 2026 teams from theory and experiment spent 2.5 days in Warwick on a focused documentation effort, leading to documentation improvements in many commonly-used community codes.

Hadrons hackathon

Hadrons is a UK-developed tool for a broad class of computations in lattice quantum field theory. Most collaborations have their own implementations of these, but many are unmaintained and do not support GPUs. Representatives from most UK LFT collaborations spent two days working with Hadrons developers on porting and testing their workflows.

Summer School

It isn't sustainable to make short interventions to improve areas identified as needing work; we also need to build the skills in these areas within the research community so that they become embedded in the wider research culture. Later this month we will host a one-week summer school for particle physics researchers in Swansea to do just this.

Technical Work

Grid I/O support

Grid is the most commonly-used lattice library in the UK. While it partially supports the standard International Lattice Data Grid format, this support is technically non-compliant, and is missing features from the latest version that enable up to 50% storage savings. Work at Swansea has enabled this support to be overhauled, and is ongoing to integrate these changes into downstream libraries such as Hadrons, to allow easier migration between software stacks.

API Documentation

Geant4 is a major community code in the experiment subcommunity, with significant use outside TEPP in domains such as medical, space, and nuclear engineering. The roadmap identified improving API documentation as a specific need for widely used community codes. Work at Warwick has provided the foundations for creating and deploying Doxygen API documentation creation within Geant4. This work has been integrated into Geant4 recently.

CoSeC Computational Science Centre for Research Communities

Swansea University Prifysgol Abertawe

WARWICK THE UNIVERSITY OF WARWICK

UKRI Science and Technology Facilities Council