

SHiP physics software and computing

Oliver Lantwin

[oliver.lantwin@cern.ch]

Spain@SHiP — 2026-05-05

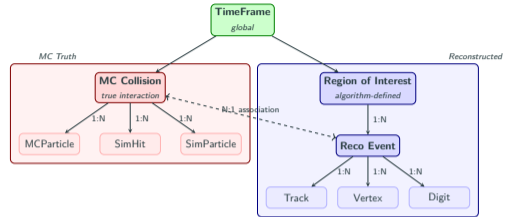


- › SHiP: a newly approved experiment with a new framework — rare opportunity to build software right from the start
- › Unique challenges at the intensity frontier: no trigger, continuous readout, 10^7 spills to simulate
- › Complementary to HL-LHC, DUNE; designed to operate beyond HL-LHC



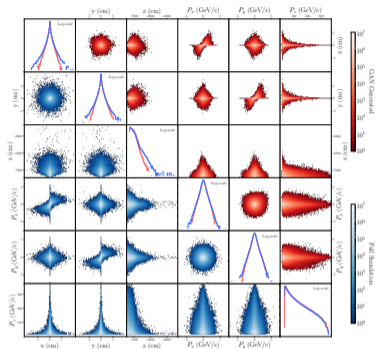
Challenge: 4D events

- › No trigger, continuous readout
- › Reconstruction with maximum fidelity
 - › Data rates not limiting
 - › Redundant background rejection requires careful tagging of activity and potential links to signal candidates
 - › GNNs and anomaly-detection algorithms are being explored for tagging

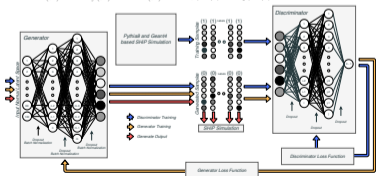


- › **Eventless software framework:** redefine “events” on the fly
 - › For simulation, reconstruction, analysis — zoom in and out on demand
 - › A paradigm shift from traditional HEP frameworks, collaborating with DUNE’s framework R&D

Challenge: Simulation at the intensity frontier



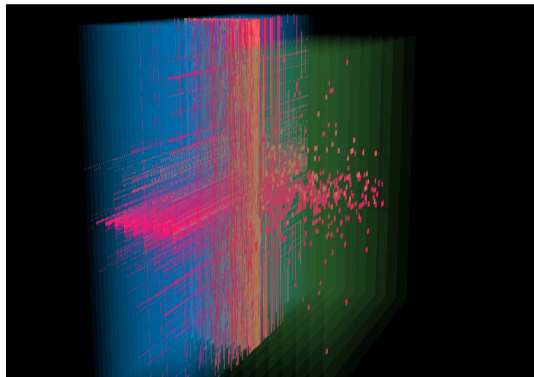
- › Full simulation infeasible beyond $\mathcal{O}(1 \text{ spill})$ — but we run for $\mathcal{O}(10^7 \text{ spills})$: a **7 orders of magnitude gap**
- › Fast simulation, ML and statistical methods will have to fill the gap
- › Rarest events must be considered to reach the required background level with safety margin
- › Reliable simulation foundational for detector design and optimisation
 - › Validation with published data and dedicated measurements



Challenge: A story of two detectors



- › Two very different detectors with different physics and reconstruction
- › Decay spectrometer: classic magnetic spectrometer with tracking upstream and downstream of the magnet
- › Tracking calorimeters of SiW and MTC require precise tracking and vertexing despite high multiplicity and material budget for neutrino physics and light dark matter





- › **No legacy code** — rewriting from scratch for the TDR (by Q1 2028)
 - › Size of collaboration perfect for framework R&D: can move fast on RNTuple, bits, Phlex etc.
- › Joint online and offline framework
- › Learn from LHC, HL-LHC and DUNE to build a framework for the next three decades
- › ML integrated at all stages
 - › Simulation, reconstruction, analysis, detector optimisation, specification-driven development



- › Common Physics Software project with logical sub-projects
 - › Simulation
 - › Reconstruction
 - › Geometry
 - › Digitisation
 - › ...
- › Led by Universität Siegen and Imperial College, with contributions from German and Swiss groups
 - › Subsystem liaisons ensure information flow
 - › Leadership positions available in many sub-projects
 - › Opportunities for all levels of experience and all sizes



- › Physics software foundational for all TDR studies
- › Re-architecting our framework now to serve for the lifetime of the experiment
- › **Perfect time to get involved** — leadership positions open, contributions welcome at all levels
 - › Talk to me, we're here to discuss!