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Experiment as Theseus's Ship: Which Experiments Preserve Diachronic Identity?

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Introduction

In view of the fact that modern experiments in high-energy physics have been going on for decades—updating, reassembling, and remodeling instruments, teams, scientific programs, and methods of processing and accumulating data—attention is drawn to the question of
(a) what should be considered a single discrete experiment and
(b) when one experiment in a series should be considered complete and the next begun.

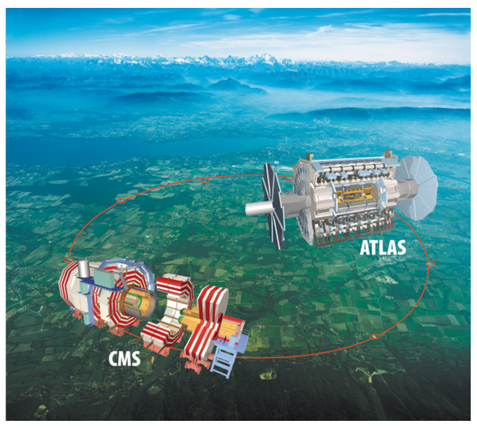
For the purpose of distinguishing among separate experiments in a scientific program, we propose to rely on the parallel discussion of relative and temporary identity—in particular, the example of the ship of Theseus paradox. In relation to Theseus's ship, the problem is: If, over time, the planks of the ship (akin to units of an experimental apparatus) are gradually replaced by new ones, and, at some point, all the planks are replaced, then the question arises of whether the replacement ship (or experiment) shares its identity with the original ship. In another caveat, if the original ship is disassembled and then assembled again from the same planks, will this reassembled ship be the same as the one remodeled from other planks?

Placing the theory-ladenness of the experiment at the center of our consideration, we propose to distinguish, first of all, the series of experiments in which the theory of the phenomenon does not change diachronically (e.g., neutral current experiments or Higgs boson experiments), and, second, series of experiments over which, although theories of the phenomenon change, their signatures (qualitative attributes sought in data) remain invariant. We call such series model-driven and signature-driven, respectively.

Theory-driven experiments:
The Higgs theory

Upper: D0/CDF (Fermilab), till 2011

Lower: ATLAS/CMS (CERN), 2012



Discussion

Notably, signature-driven experiments are also theory-laden; however, the same signatures are inherited by theories positing different ontologies that allow them to inherit empirical data despite conceptual differences. Examples of the latter experimental series are charged-lepton flavor violation experiments (e.g., MEG, Mu2e, COMET). I argue that, as far as the analogy with ship identity goes, the model-driven series of experiments reveals more similarities to the reassembled ship, while signature-driven ones can be likened to the remodeled one.

Although we concede that in both kinds of experimental series, the constituents of apparatus are replaced by others, I suggest that the most constitutive element of the experiment is its phenomenal theory, which is also the primary determinant of its identity. Therefore, I relate the experiment's identity essentially to whether its original theory persists or only hands its signature over to another theory. Such a position invites an appeal to Leibniz's Law, which, to ensure identity, requires each qualitative attribute of the first experiment to be identical to each qualitative attribute of the second, maintaining this requirement only for attributes that stem from phenomenal theory.

I examine the arguments for replacement experiments, reassembly experiments, or both to be deemed identical to the original experiment by drawing on conceptual frameworks Lewis's four-dimensionalism and staged approach. We discuss arguments in favor of the position that staged view is the more appropriate conceptual scheme when considering signature-driven experiments, whereas four-dimensionalist arguments have more relevance to model-driven ones.

Steinberger and Wolfe, 1955
Theory: symmetry with known reactions

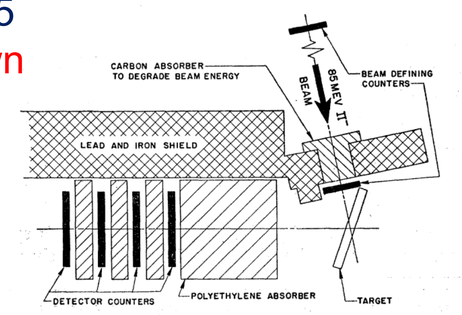
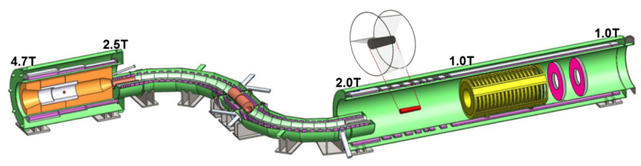
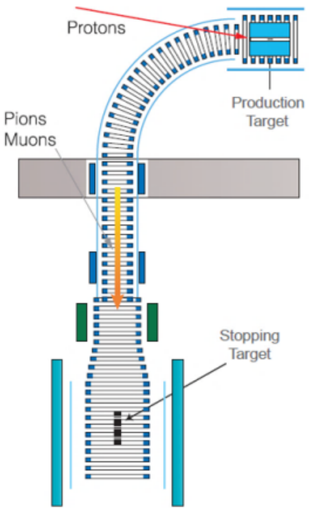


FIG. 1. Experimental arrangement.

Common signature: conversion of a muon to an electron without emission of other particles





Mu2e (left) and COMET (right), 2020s
Theories: Beyond the Standard Model

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