# Operationalism in Model-Independent Searches

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## Current situation

- Wealth of expected upcoming data at high energy frontiers (HL-LHC, FCC, ILC)
- Targets: Increase understanding, detect new particles, improve sensitivity and precision etc.
- Many models beyond the Standard Model (BSM), no evidence yet, direct testing needs many resources

*"The trick will be to learn how to navigate the vessel in the uncharted, higher-energy waters, where no-one knows if – or where – new physics might be. And this trick has a name: "model independence"* [Massimi 2019]

Examples: Simplified models, effective field theories, data-driven machine learning etc.

## Operationalism 2.0 [Chang 2009][Chang 2017]

- Meaning and Meaningfulness
  "Meaning as use" [Wittgenstein 1953]
  *"To know the meaning of a term used by me it is evident […] that I must know the conditions under which I would use the term"* [Bridgman 1938, p.116]
  Example: Diameter of electron – concept of length incorporates E.M theory

- Interpretation of Bridgman's (later) work
  Instead of complaints about meaninglessness, meaning can be extended to new regimes
- Conceptual structure has joints at which operational meaning change
- Can only theories bridge discontinuous parts? → Operations can provide a continuity of meaning against which metrological validity can be judged (Example: Wedgwood scale)
- Start: **1)** Concept with secure net of uses (stable meaning in a restricted domain), **2)** Try and establish another secure net of uses (in adjacent domain), **3)** Establish a credible link between the two domains

## Meaning and Model Independence

- How to establish meaning when it comes to new hypothetical entities?
- How can new insights meaningfully connect to existing knowledge?

**Idea**: Revive **operationalism** as a philosophy of extension – translating existing concepts into new regimes, operationally define a relation between new concepts and existing concepts

**Practical approach**: Use operational entities (operationally described processes, particles and states) to extend meaning to model-independent searches for new physics

## Operationalism – Original conception [Bridgman 1927]

- We do not know the **meaning of a concept** unless we have a **method of measurement** for it
- Concept is (synonymous with) corresponding set of operations
- Operational analysis of many physical concepts shows: not homogenous; Different regimes → different measurement methods.
- Example: **length** (ruler, light waves) → Do different operations measure the same or do we have more than one concept?

**Criticism: 1)** Naïve and unsystematic, **2.)** Neglects a simple, systematically unified explanation of empirical phenomena [Hempel 1966], **3.)** operational definition does not exhaust meaning, **4)** operational definitions are not required for all concepts. **5)** What are operations? (According to Bridgman not only laboratory measurements but mental and "pen-and-pencil" operations etc)

## Operational entities in model-independent searches

- Define hypothetical new entities, which can be processes, states or particles operationally (e.g instrumental, mental or paper-pencil type) → this can start a skeleton in the new domain, which can be linked to existing concepts
- Example: **1)** Formulate measurement operations in the detector (tracking chamber, calorimeter) to form a skeleton of a signature – operationalize existing particle signatures (black-boxed [Mättig & Stöltzner] and guarantee an extension of meaning by overlapping operation
  **2)** Connect EFT by operations and extend meaning by it?

**References:** Bridgman, P.W. , 1927. *The Logic of Modern Physics*, New York: Macmillan, Bridgman, P. 1938. "Operational Analysis", *Philosophy of Science*, 5: 114–131; reprinted in Bridgman 1955, pp. 1–26, Chang, H., 2009, Operationalism, *The Stanford Encyclopedia of Philosophy* (Fall 2021 Edition), Chang. H., 2017. *Operationalism: Old Lessons and new challenges* in Reasoning in measurement (Mößner & Nordmann) 2018, Routledge, Hempel, Carl G., 1966. *Philosophy of Natural Science*, Englewood Cliffs, N.J.: Prentice-Hall., Massimi, M. 2019 Model Independence Phys. World 32 (9) 40, Mättig, P. & Stöltzner, M. 2019 Studies In History and Philosophy of Science Part B, Wittgenstein, L. 1953. Philosophical Investigations. trans. by G. E. M. Anscombe.