**Snowmass2021 Letter of Interest: Operational definition of quantum sensors for HEP**

*M. Garcia-Sciveres*
*Lawrence Berkeley National Lab*

**Thematic Areas:** *IF1: Quantum Sensors*
*CF1. Dark Matter: Particle-like*
*CF2. Dark Matter: Wave-like*
*RF3: Fundamental Physics in Small Experiments*

**Contact Information:** *mgs@lbl.gov*

A crisp definition of what is a quantum sensor and what is not has proven elusive since the kick-off of the DOE QuantISED program in 2018. This is not merely of academic interest, but has very real implications for how R&D is reviewed and funded. DOE program officers had an initial concept that "a quantum sensor is a device that uses Entanglement, Superposition and/or Squeezing"[1] (let's call it ESS). This was relaxed and not strictly applied for the 2018 awards, but is now being revived, and DOE seems to be headed towards a strict application of ESS as a litmus test. There are many problems with both ESS and its strict application as a litmus test (sections of white paper will present these). Snowmass, being a community process, provides an opportunity to correct this problem and allow scientists to develop a definition that is optimal for science. The purpose of this white paper is to develop an operational definition of quantum sensors for HEP. Interested co-authors are welcome.

The main HEP need is measurement of rare physical phenomena, or not so rare but with ultimate precision. In both cases the point is to achieve sensitivity to the smallest possible signal (eventually one quantum of whatever it is) with the smallest possible noise, often characterized as some fraction of the "standard quantum limit" yardstick for continuous measurements, or by dark counts above some threshold for discrete ones (where we ultimately want single quantum detection with zero dark counts). The point of this white paper is to flesh out this reasoning, reconcile it with actual HEP applications, and arrive at a concise definition more appropriate than ESS that the community can get behind.

PS: A different, futuristic angle (not yet of practical interest), is that a quantum sensor is an input device for a quantum computer, which acquires an amplitude or phase (not a physical observable!) and sets up a state in the quantum computer that can be processed (interfere with others, etc) in order to generate observables. Probably not something for this white paper.

[1] This languange is taken from https://science.osti.gov/-/media/sc-2/pdf/presentations/2017/DOE-Office_of_Science_Dear_Colleague_Letter_on_QIS.pdf and
testimony to congress also in 2017 https://science.house.gov/imo/media/doc/Binkley%20Testimony.pdf