QCD and PRECISION PHYSICS

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The community of theorists working on precision calculations (QCD and Electroweak) in the US is directly addressing some of the major science drivers of the last P5 report, from the exploration of new physics through in-depth studies of the Standard Model (SM) and its quantum-field-theory (QFT) properties, to the development of more and more sophisticated techniques to extract direct and indirect evidence of new physics from existing and future experimental facilities.

Results from precision calculations to which the US theory community has directly contributed have had a major impact on all LHC searches and measurements so far, notably in pushing the reach of the Higgs-physics program beyond what had been originally envisioned for Run 2. Precision calculations will become even more crucial in the LHC high-luminosity phase (HL-LHC).

New ideas are emerging to exploit synergies, such as between the HL-LHC and the Electron-Ion-Collider (EIC) physics programs in the next decade. For example, a precision DIS experiment at the EIC will open a unique window to independently constrain the combination of parton distributions relevant for Higgs physics and high-mass resonance searches at the HL-LHC. At the same time, techniques developed to precisely predict hadronic jet properties and find rare events at the HL-LHC will also be of high value for the EIC community.

The search for physics beyond the SM will have its best prospects for success when being carried out in parallel with a renewed commitment to SM physics. We may be at an interesting historical juncture. Data sets being analyzed and those anticipated in the near future could offer the opportunity for a breakthrough precisely in our understanding of QFT. If the human mind can understand how quarks and gluons smoothly evolve into hadrons, an *exemplary* problem in QFT, now is our chance, and the QCD theory community in the US could play a leading role in this, given the existing expertise and the constant outcome of groundbreaking ideas over the past several decades.
This is very crucial to the physics of the LHC, and is indeed where another important component, the study of Monte Carlo event generators and how they act as mediators of perturbative and non-perturbative aspects of QCD comes into play.

Precision calculation [QCD, EW, even lattice for (g-2)] are crucial to the interpretation of future data. Given the broad impact, depth, and synergy of the precision physics program, it is crucial to maintain the strength necessary to support it. We have in the US a small but vibrant community, with strong expertise in both foundational and cutting-edge areas of precision physics, but we are lacking the critical mass of people working on it, if we compare with competing programs e.g. in Europe. Precision physics calculation are optimally done with teams, and the US support of such efforts is insufficient. We have very good people, but lack what one would call the ***theoretical infrastructure***, particularly in crucial areas like Monte Carlo event generators, multi loop calculations for collider physics, and determination of PDFs at a corresponding accuracy.

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To continue being competitive in the field of precision physics for the next decade of LHC physics, especially in higher-order calculations and Monte Carlo development, an investment in manpower is needed. One area of weakness is the inadequate funding of postdoc positions in our community, especially when compared to peer groups in Europe. For a relatively modest increase in funding we would be able to increase the postdoctoral numbers, and as a result increase the scientific output significantly. Students interest is high, but it is worrisome to see that most if not all students in precision physics move to Europe for post-graduate research positions. Increased funding for postdocs would also help to retain our own talent.

A major goal of the Snowmass process is the development of a detailed white paper on these issues.