From:	Laycock, Paul
To:	Capasso, Frances
Cc:	Ma, Hong; Torre Wenaus; Kolja Kauder; Pleier, Marc-Andre; Laycock, Paul
Subject:	Intent to submit an LDRD-A proposal
Date:	Friday, May 27, 2022 1:08:08 PM

Dear Fran,
Please find the details of an LDRD-A proposal that we intend to submit.

Best regards, and have a nice holiday weekend everyone!

Paul

P.S. The list of PIs assumes that this proposal is in a “general" category and not in direct competition with experiment-specific proposals, I first proposed this idea in discussions for the FCC-ee LDRD-A proposal. If that is not the case then we would like to adjust the PI list accordingly, and we assume this can be discussed if necessary next week.

Title: Differentiable Design Optimization

Abstract: Artificial Intelligence and Machine Learning have exploded in the last decade and it is difficult to overstate their impact in science and society. AI/ML applications began by addressing isolated problems, e.g. classification problems, and finding an optimized solution. Modern applications are more sophisticated and use combinations of individual ML models to find better solutions, a good example is the Generative Adversarial Network which combines a generator and a discriminator to produce simulators with impressive performance. The core mathematical operation behind the optimization is calculation of differentials, which then minimize a loss function via gradient descent. Deep-learning has motivated industry to produce powerful tools to automatically compute differentials. Recently the neos project [1] showed that it is possible to make an entire HEP analysis pipeline differentiable and thus use deep-learning to optimize the full analysis chain.

We propose to take the approach of differentiable computing to its ultimate limit and use it to optimize the entire experimental physics process, from detector design through to final analysis results. Starting with ATLAS, we will first reproduce the work done in [1] and demonstrate analysis optimization using differentiable programming, producing the minimal deliverable of this work. The next step will extend the scope of optimization to include the detector. Using the EIC detector, DUNE far detector modules, and a potential FCC-ee detector as test cases, we will establish the validity of this application in time to provide crucial input to the EIC and DUNE detector design processes. In so doing, we will place Brookhaven National Laboratory as the world-leading institute for designing experimental science.

List of PIs: Paul Laycock, Torre Wenaus, Kolja Kauder, Marc-André Pleier

Other BNL Organizations:

References:

1. End-to-end-optimised summary statistics for High Energy Physics
https://arxiv.org/pdf/2203.05570.pdf