

## FY2024 NPP LDRD Type B Pre-Proposal

# Noble-liquid calorimetry for future colliders

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@BrookhavenLab

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Proposal title: Noble-liquid calorimetry for future colliders

Primary Investigator: Scott Snyder

Other Investigators:

Indicate if this is a cross-directorate proposal. Yes \_\_\_\_ No x\_\_

If yes, identify other directorates/organizations:

Proposal Term:                      From: Oct 2023                      To: Sep 2025



# FY2024 NPP LDRD Type B Pre-Proposal

Proposal title and brief abstract: Noble-liquid calorimetry for future colliders

Improve simulation and reconstruction and detector optimization for the noble-liquid detector concept being developed for future lepton colliders.

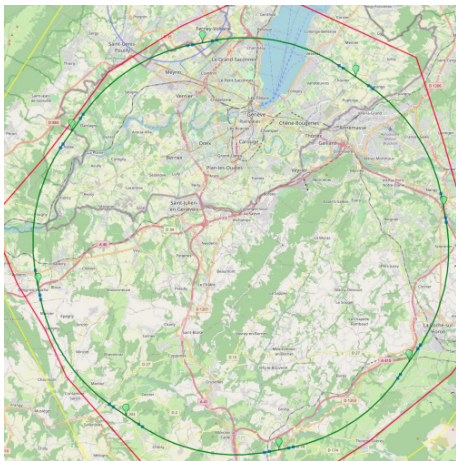
Program: **HEP**

Return on Investment: Support for detector development work for a future collider is likely to increase after the P5 report. Getting involved early in R&D increases the chances of capturing that funding. The ultimate goal is to establish BNL as the US host laboratory for one detector for a future collider.

Broader impact on the activities at the laboratory: Builds on BNL's long involvement with LAr calorimetry. BNL interest in the readout electronics and trigger systems, featuring low noise front-end electronics for cryogenic operation. Possible interest for EIC community detector?

Total planned funding per year in FY24 and FY25: 100-125k/year (to be finalized)

One future collider concept is the FCCee/FCChh, being developed at CERN as a possible follow-on to the LHC as part of the European Strategy for Particle Physics

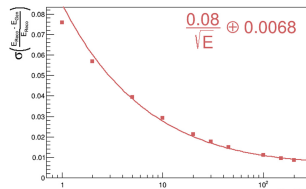
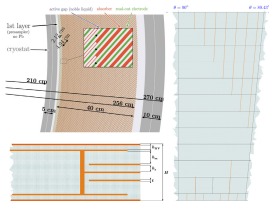


## Detector concepts

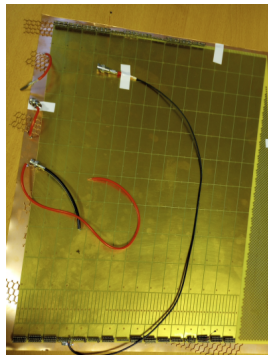
- CLD: Evolution of designs from ILC and CLIC.
- IDEA: Less mature but still with a long history.
- Noble liquid ECAL: New concept being developed over the past few years.



- Detector concept originally developed for FCChh, where radiation hardness is a key requirement.
- Being also evaluated for FCCee (or other lepton collider).
  - ▶ Excellent stability, uniformity, and linearity beneficial for systematics-limited analyses.
  - ▶ May cost considerably less than other alternatives.
- Evolution of ATLAS calorimeter with much finer granularity for particle-flow reconstruction:  $\Delta\theta, \Delta\phi = 10, 8$  mrad, 12 longitudinal layers.
- Straight absorbers and multilayer signal boards at a constant angle to the interaction point.
- Minimize upstream material for sensitivity down to 300 MeV.
  - ▶ Calorimeter inside central solenoid and lightweight cryostat.
- Either warm or cold electronics.
- Preliminary simulations show excellent resolution.
  - ▶ Expect to use particle-flow and machine learning techniques for ultimate resolution.



- Current design work being done at CERN, leading towards a prototype.
- Transitioning to ECFA Detector R&D project.
- Young project, few people.
  - ▶ Good opportunity for newcomers to get involved and make an impact.
- Simulation and reconstruction software still rudimentary.
- Many choices/optimizations still open.



- Proposal: Support 1/2 postdoc for 2 years to work on improving simulation/reconstruction software and detector optimization, leading towards testing of a prototype.
- In collaboration with S. Snyder and the noble liquid group at CERN (M. Aleksa, et al.).
- Deliverables include the improved software and likely a paper on the design optimization and performance studies.

# Summary

- A new detector concept is being developed for a future lepton collider centered on a noble-liquid EM calorimeter with fine granularity.
- BNL has extensive experience with LAr calorimetry.
- Propose to support a postdoc at half-time to improve simulation and reconstruction software and work on detector optimization, in collaboration with CERN and other institutes to build and test a prototype.
- Budget: 1/2 postdoc for 2 years ( $=\$176k?$ ) +  $\approx 10\%$  PI plus incidentals (travel, etc.).
- Ultimate goal: establish BNL as US host laboratory for one of the detectors for a future collider.
- Other possible synergies:
  - ▶ Of interest for EIC community detector?
  - ▶ BNL interest in the readout electronics and trigger systems, featuring low noise front-end electronics for cryogenic operation.