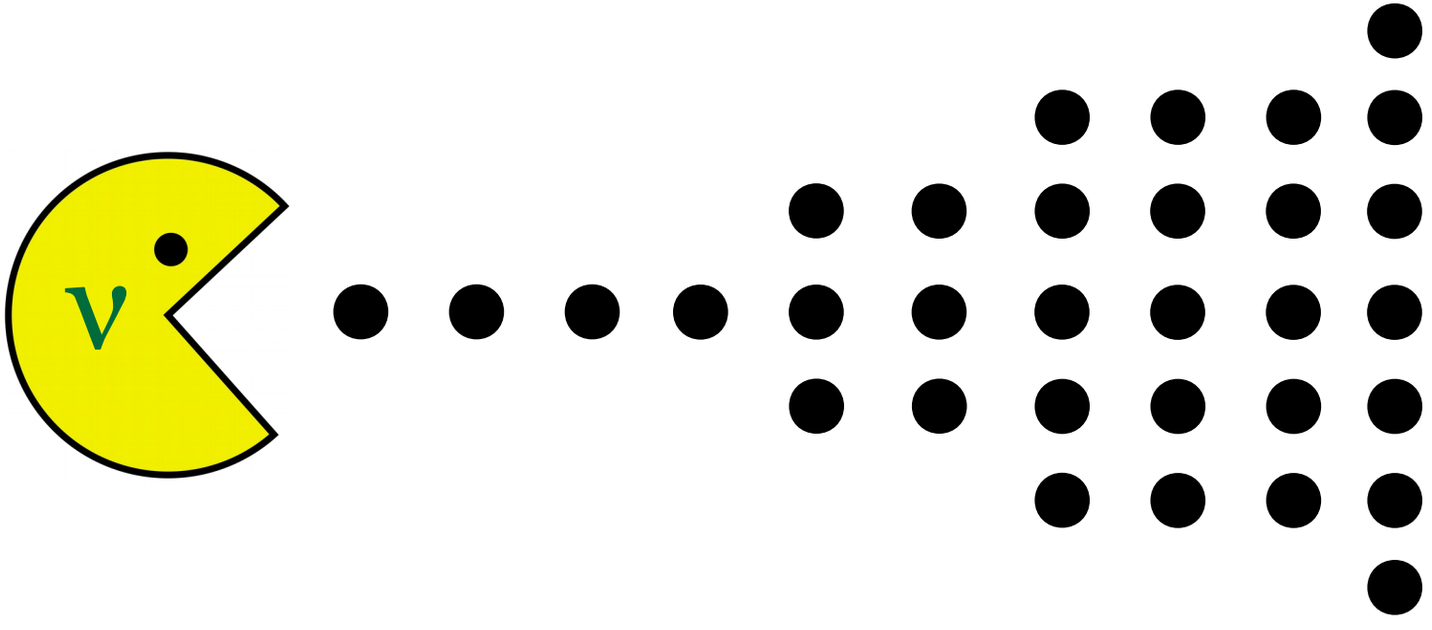
LArCADe: lowering thresholds in LArTPC detectors

FNAL snowmass planning – May 8th 2020



Fermilab

David Caratelli & Angela Fava

LArCADe: **L**iquid **Ar**gon **C**harge **A**mplification **De**vices

David Caratelli, FNAL snowmass planning, 05/08/20

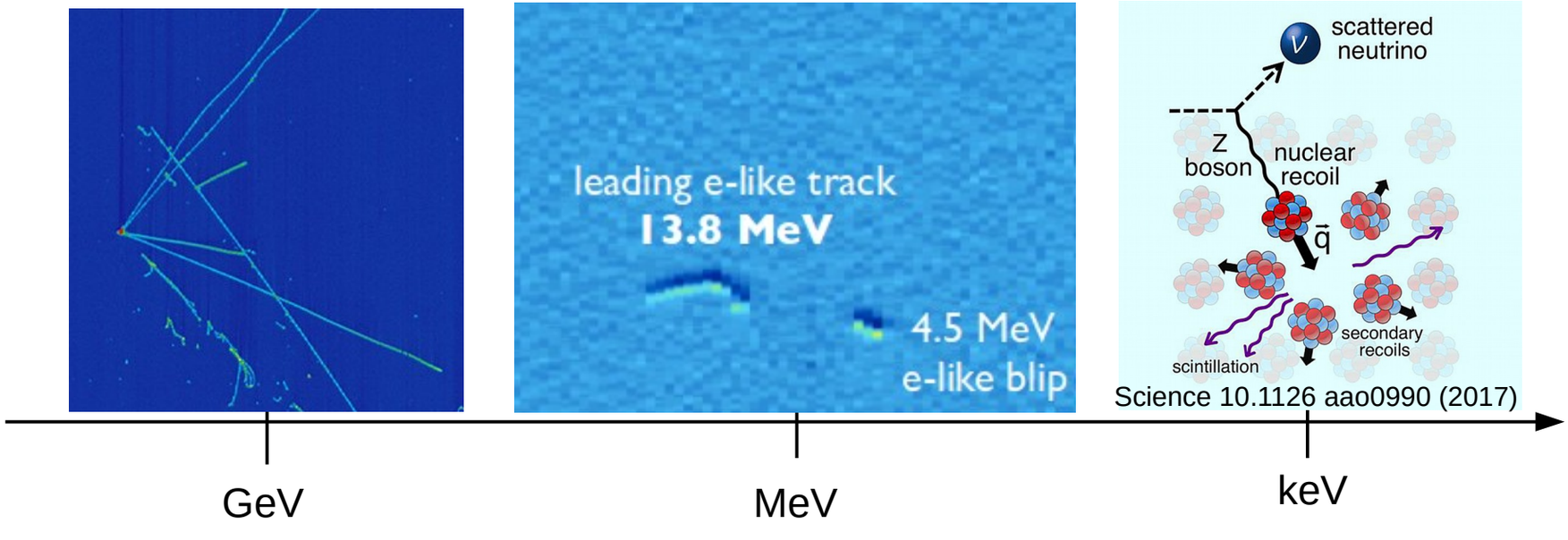
LDRD project @ Fermilab started in spring ‘18

Investigate feasibility of obtaining stable e^- charge amplification in LAr.

→ past attempts, non-conclusive.

With the goal of trying to further expand the physics reach of large-scale LArTPCs

Single-phase LArTPCs



LArCADe: **L**iquid **Ar**gon **C**harge **A**mplification **De**vices

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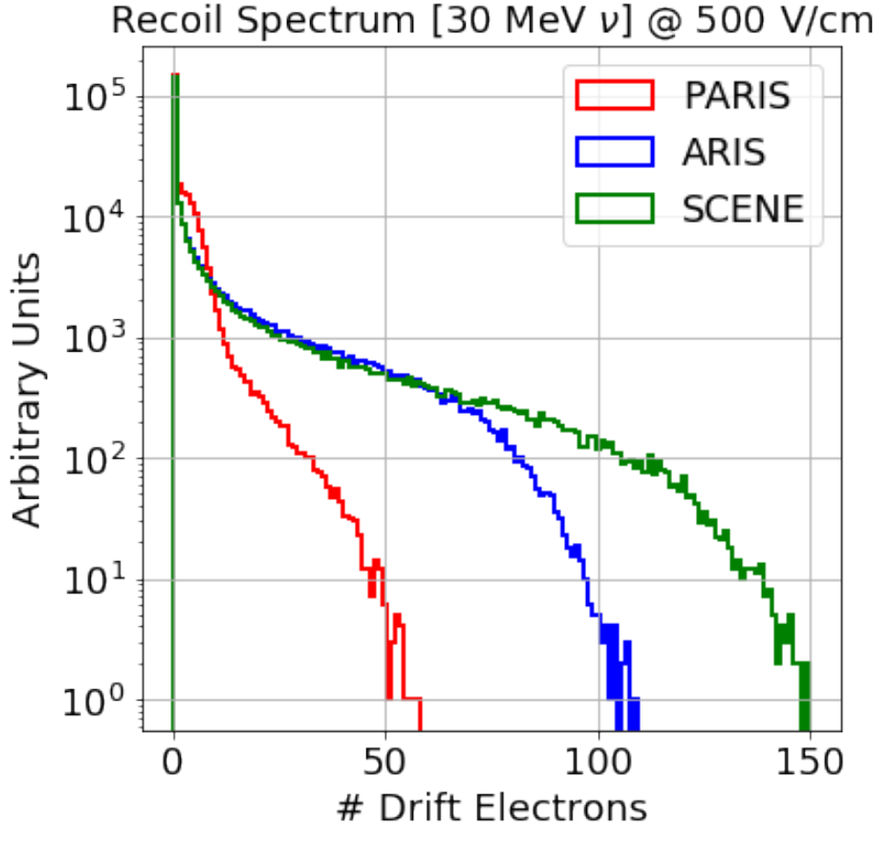
Physics motivation: expand reach of large-scale single-phase LArTPCs to be sensitive to nuclear reoil ionization signatures.

These signatures produce O(10s-100) – at most! – free electrons in LAr.

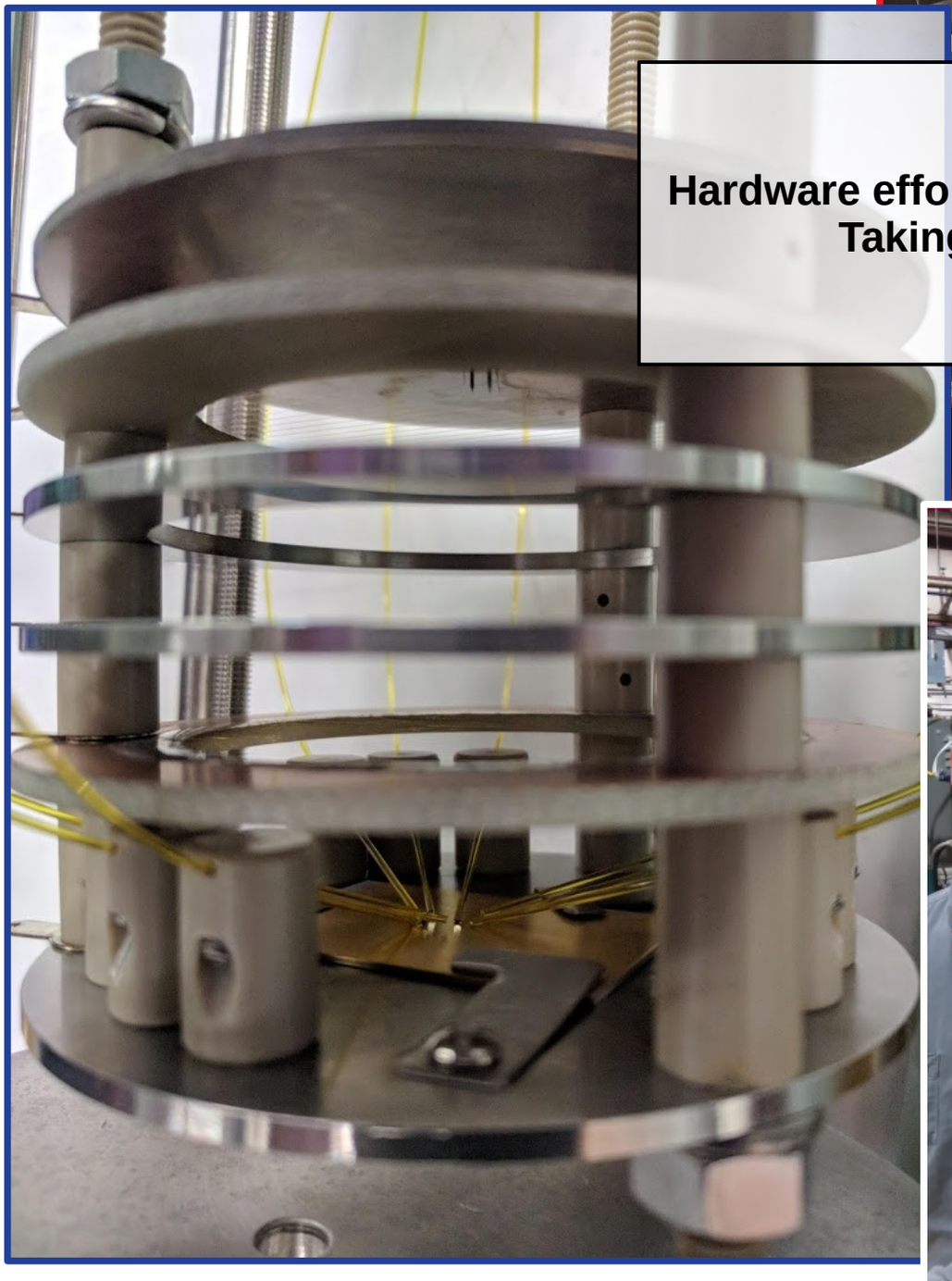
Current ν - LArTPCs subject to O(100s-1k) equivalent noise charge (ENC) noise levels.

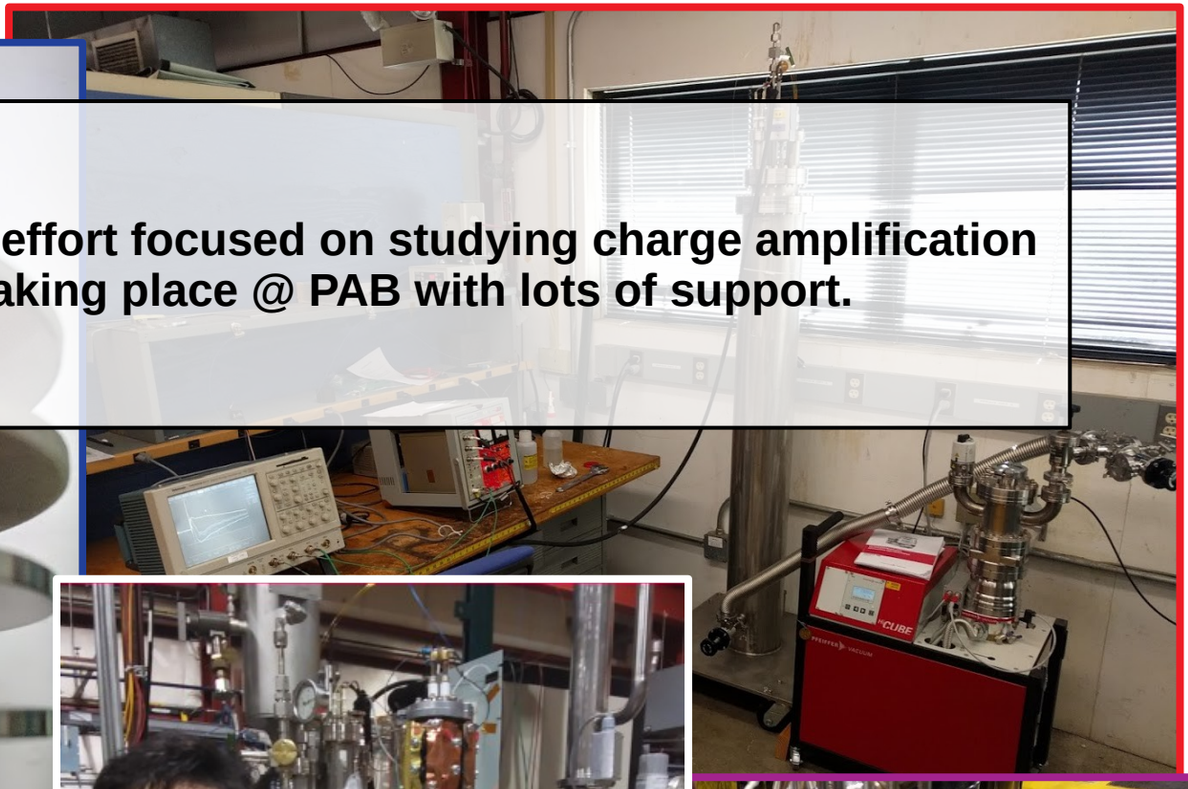
Expanding interest to R&D on feasibility of sensitivity to recoil directionality in GAr.



Spectrum of expected recoil electrons after quenching for CEνNS interaction from 30 MeV neutrino.

LArCADe Project





Hardware effort focused on studying charge amplification
Taking place @ PAB with lots of support.

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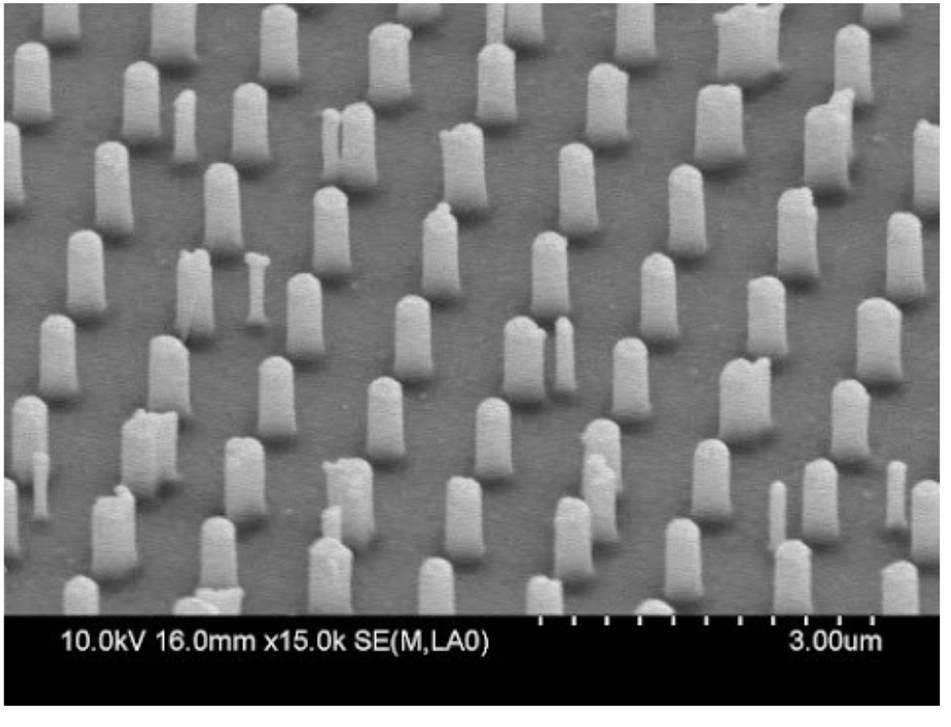
Center for Functional NanoMateirals @ BNL

Started partnering in 2019 with the Center for Functional nanomaterials at BNL:

Producing tip-arrays reaching O(10) nm apex radius to enhance potential for amplification over broader area.

tip-array with sub μm apex produced @ BNL



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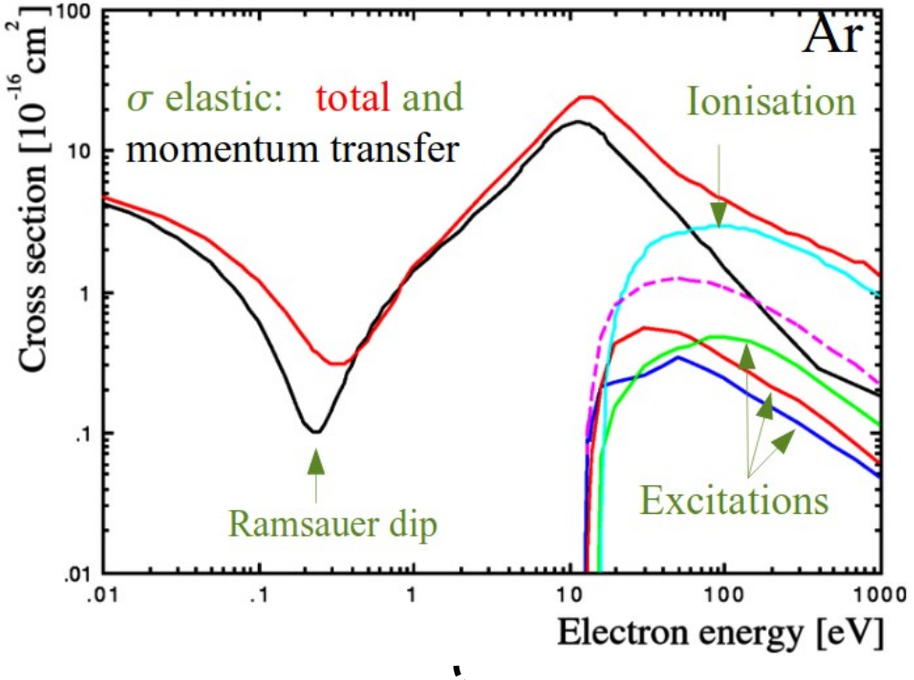
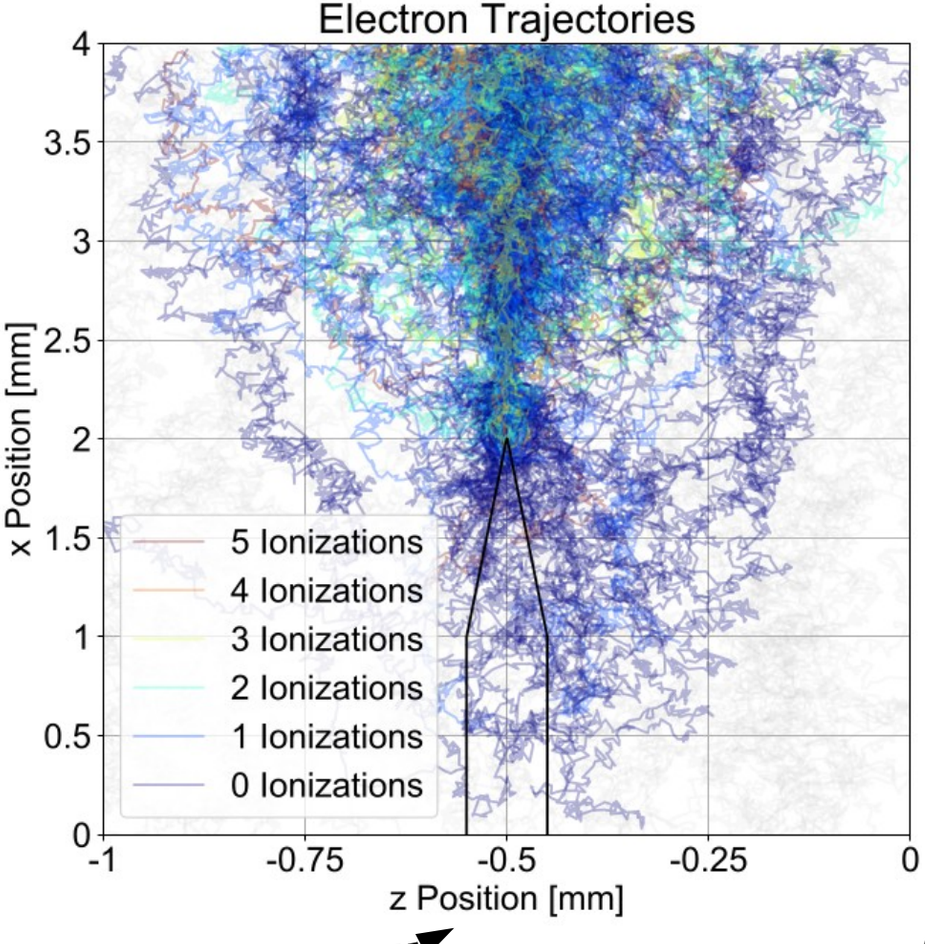
Center for Functional NanoMateirals @ BNL

This has led to a broader effort in modeling electron drift and scattering in high-field and complex geometries. An important component of the broader effort.

Developing micro-physics e- propagation and interaction simulation





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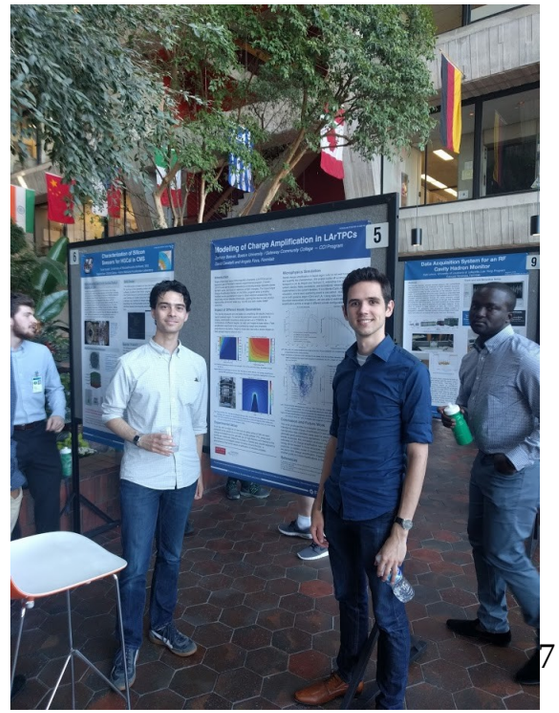
Where we stand: in the process of analyzing data taken at PAB, planning future runs and developing simulation to check data and better inform setup requirements.

Moving forward: pursue R&D developments on detector configuration informed by what learned in first part of the project, and broaden effort to R&D on feasibility of nuclear recoil directionality measurements.

Context: Low-threshold physics in noble element detectors is a strong and vibrant branch of the HEP and nuclear physics communities. Interested in contributing to the broader R&D effort that can enable next generation of measurements in this area, and doing so in the context of the upcoming snowmass process.

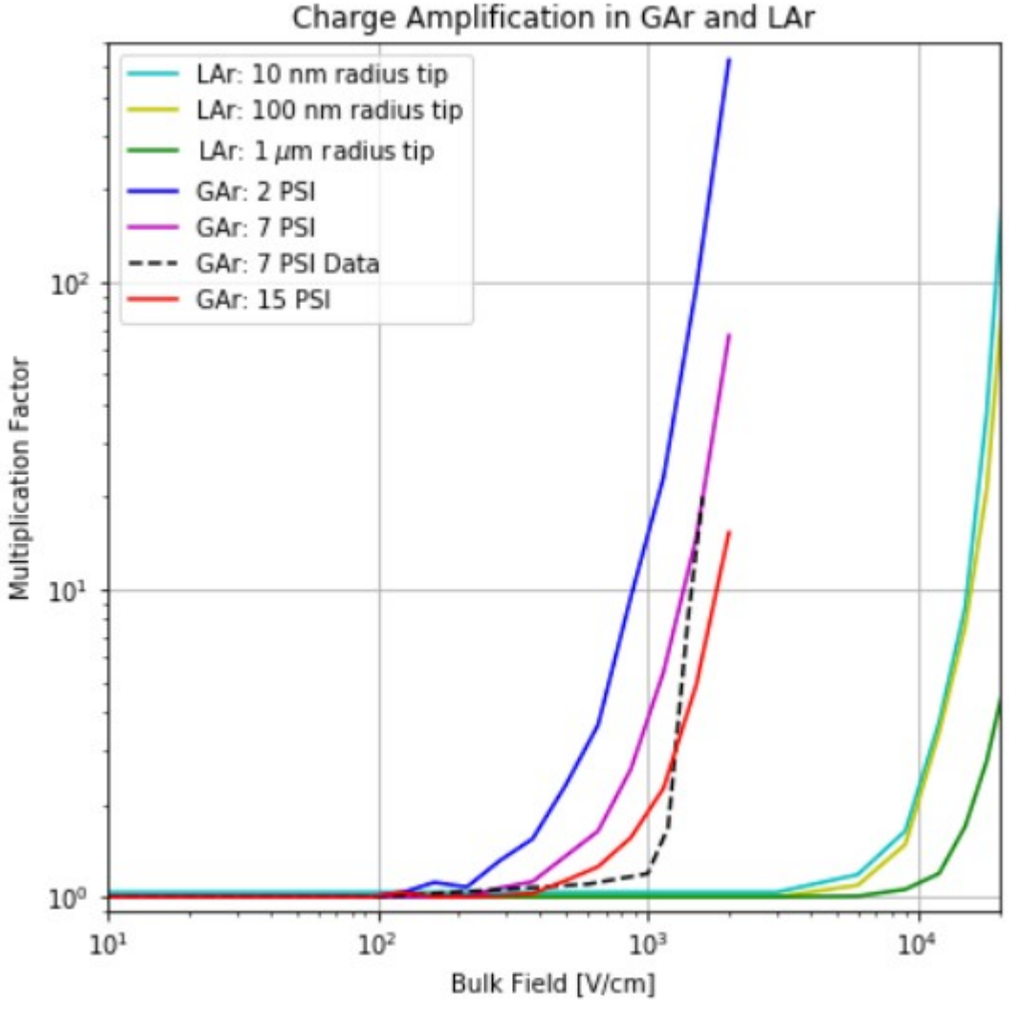
Contacts: Angela Fava, David Caratelli

Thank you



Backup

Backup


Charge Amplification in GAr and LAr
LAr: 10 nm radius tip
LAr: 100 nm radius tip
LAr: 1 μm radius tip
GAr: 2 PSI
GAr: 7 PSI
GAr: 7 PSI Data
GAr: 15 PSI
Multiplication Factor
Bulk Field [V/cm]
10^0
10^1
10^2
10^1
10^2
10^3
10^4