Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

FY2026 NPP LDRD Type B Pre-Proposal

Development of a Generic 4D Telescope Platform

Principal investigator:
Gabriele D'Amen [Physics Department]
Shaochun Tang [Physics Department]

FY2025 NPP LDRD Type B Pre-Proposal

Proposal title:

Development of a Generic 4D Telescope Platform

Primary Investigator:

Gabriele D'Amen (PD)
Shaochun Tang (PD)

Indicate if this is a cross-directorate proposal: Yes ___ No _X_

If yes, identify other directorates/organizations:

Proposal Term:

From: 10/1/2025 To: 9/30/2027 (2 yrs)

FY2025 NPP LDRD Type B Pre-Proposal

Proposal title and brief abstract: *Development of a Generic 4D Telescope Platform*

We will develop a platform for readout of 4D sensors (Scintillator detectors/AC-LGAD) based on CaRIBOu technology (modular readout). This system can be used as a **powerful, portable, and affordable general purpose telescope** able to provide high time- and space- resolution particle detection in laboratory and at test beams. By adapting the capabilities of CaRIBOu software and firmware environment, this platform will provide **a plug-and-play way to add 4D tracking capabilities** to a wide range of experiments and applications

Program: **HEP**

Return on investment:

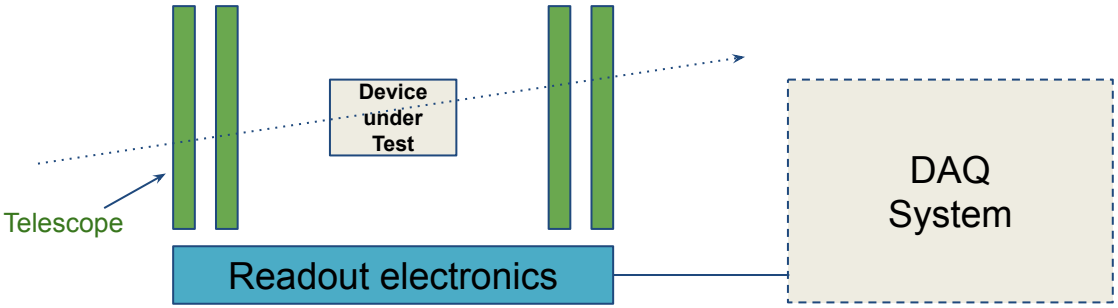
- Potential for BNL to produce the device (think of FELIX…)
- Saves resources O(10^4-10^5 USD)/time/personpower for projects requiring precise 4D tracking (HEP, NP, Medical…)
- Leads to new collaborations within RDC3/RDC5 (US) and DRD3/DRD7 (EU)
- Strengthen BNL position as one of the leaders of both fast-timing silicon technology and readout electronics for HEP/NP applications
- PI is eligible for Early Career Award

Broader impact on the activities at the laboratory:

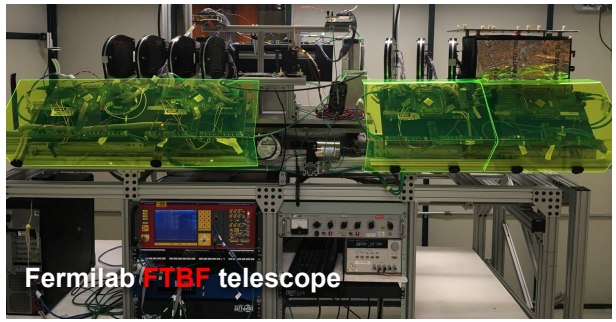
- **within our group:** BNL aims to take a leadership role in future HEP colliders (see past awarded LDRDs)
- **within our department:** Huge impact on our EIC-oriented silicon development

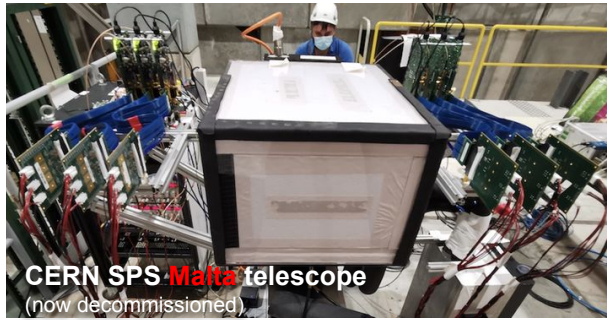
Total planned funding per year in FY26 and FY27: 250k USD/yr (500k in total)

Motivation



- Characterization of components and devices in lab and at testbeams often limited by the availability and cost of particle detectors
- All projects involving any measurement of **particle Position and/or Time-of-Arrival** require a dedicated **Telescope setup**
  - *Resources, time and personpower spent on 4D reconstruction*
- Telescope systems are sometimes installed **permanently or semi-permanently at beam facilities** (cost in the order of M$)
  - *Often based on old (obsolete?) technologies (leftover from CERN experiments…)*
  - *Wide heterogeneity of capabilities, costs, availability, interfaces with user…*
  - *Limits already scarce choice in feasible testbeam facilities*
- We want to make a **Powerful** (50 ps time resolution/<10um space resolution), **Affordable** (<20k USD/telescope layer), **Standardized**, **Portable** system for us and external collaborators to use





Technological concept

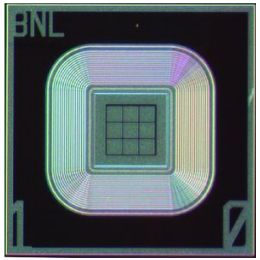
Goal

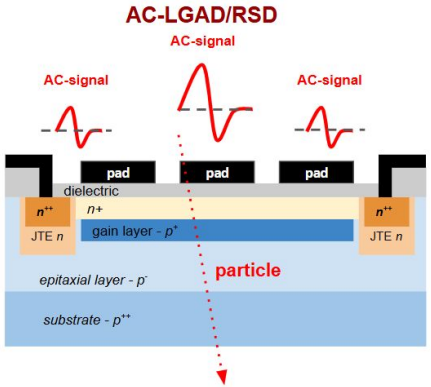
Design a powerful, portable, and affordable general purpose telescope able to provide high time- and space- resolution particle detection in laboratory and at test beams

AC-LGAD sensors are one of the candidates to achieve excellent 4D performances

- Sensors and expertise **already available at BNL**
- **Time resolution**: ~30ps
- **Space resolution**: < 10um

Due to the peculiar nature of **signal formation and sharing** in AC-LGADs, **new readout electronics is needed** with high speed and high resolution ADCs and FPGA resources





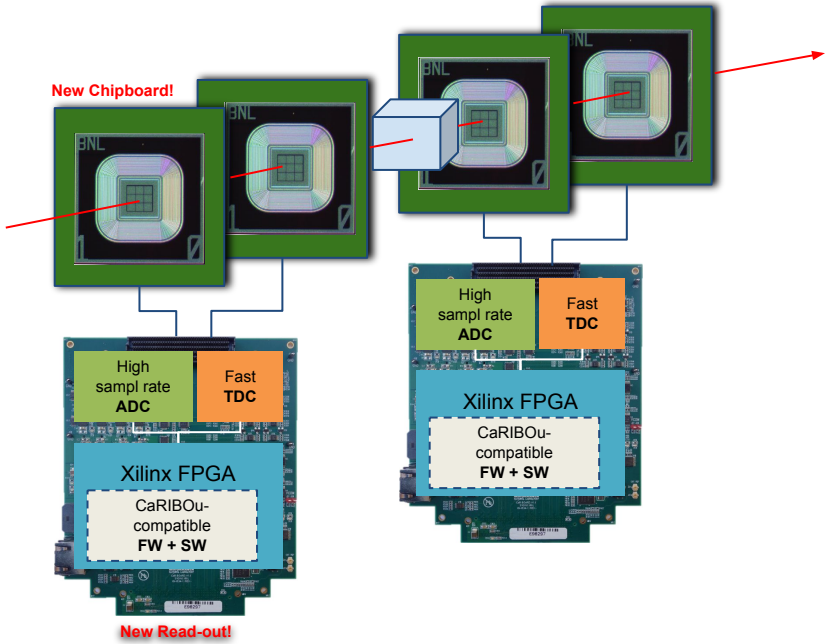
Technological concept

Deliverable

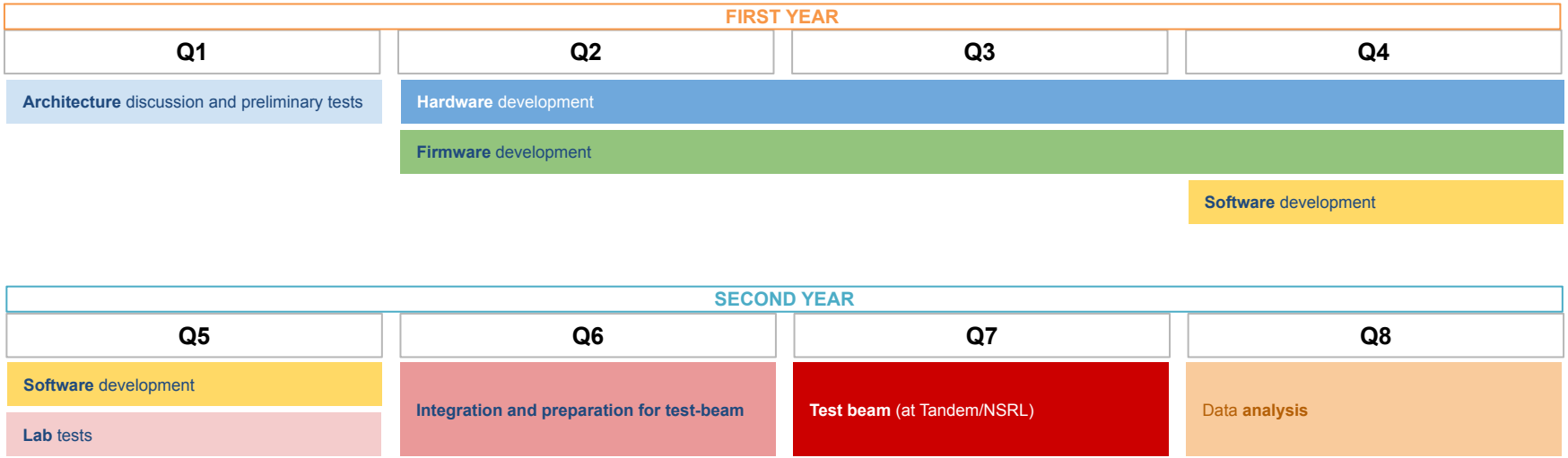
We will design and develop a new hardware platform (**chipboard + readout**) for readout of Ultra-fast 4D sensors compatible with CaRIBOu software and firmware

Readout system

- **CaRIBOu**: modular readout for R&D (developed at BNL)
- By adapting the capabilities of **CaRIBOu software and firmware environment**, this platform will provide a **plug-and-play** way to add 4D tracking capabilities to a wide range of experiments and applications
- System equipped with **Xilinx FPGA**, high sampling rate (~ 10 GS/s) channels of **8 bit/12 bit ADC** to sample the amplitude of AC-LGAD signals and **fast TDC** for particle time-of-arrival measurement
- Board will use **off-the shelf components** and provide **robust data acquisition** capabilities running on a dedicated SoC



Research milestones



Personnel

- *Shaochun Tang*
  - Hardware & Firmware design
- *Gabriele D'Amen*
  - Software development & Characterization in lab
- *PostDoc*
  - Firmware, Software development and system integration
- *Technician*
  - Sensor characterization

Procurements

- *Xilinx FPGA*
- *ADCs*
- *PCBs*

Summary Slide

Motivation

- Widespread need (especially looking towards EIC/FCC/Muon Collider) for reliable, powerful, user-friendly **4D tracking system**
- 4D tracking at test-beams and lab expensive and time-consuming (We don't want to **re-invent the wheel** every time)
- Existing setups based on **older technologies**

Return-on-Investment

- Saves resources/time/personpower
- Leads to new collaborations within RDC (US) and DRD (EU)
- Strengthen BNL position as leader of fast-timing detectors & readout electronics
- Potential for BNL to produce the device (think of FELIX…)
- PI is eligible for Early Career Award

Deliverables

The blueprint for a plug-and-play 4D telescope, including:

- PCB/hardware design
- Firmware
- Data Acquisition software

Present the work at international conferences