LGAD Consortium for EIC and beyond

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LGAD Consortium Meeting
November 1, 2021

Landscape

- There have been tremendous interests in **ultra fast silicon detector and LGADs** in recent years
  - LGADs will be used at the HL-LHC for pileup mitigation (ATLAS and CMS), TOF-PID (CMS heavy ion), and have been used for forward physics at TOTEM
- Several variants to LGADs have been proposed and some are already quite advanced in their design, e.g. AC-LGADs
- Several ideas and proposals have been put forward for detectors that use LGAD-based technologies
  - ToF/4D-tracker, Roman Pots, B0 subsystems at EIC
  - LHCb Upgrade II, ALICE 3 Timing Layer, ATLAS Roman Pots for HL-LHC (ARP)
  - NA62, PIENUX
  - Space applications, e.g. particle spectroscopy
  - Future projects, e.g. FCC, Muon Colliders etc.
  - See the *CERN Experimental Physics R&D day* will have a joint session related to the synergy in R&D between CERN EP and EIC, on November 12th (https://indico.cern.ch/event/1063927/).
- **LGAD-based technologies are relatively new and need a collaborative effort to make them ready for use at EIC and other applications in a short time scale**
  - There is a broad spectrum of expertise in HEP, high-and medium energy NP!

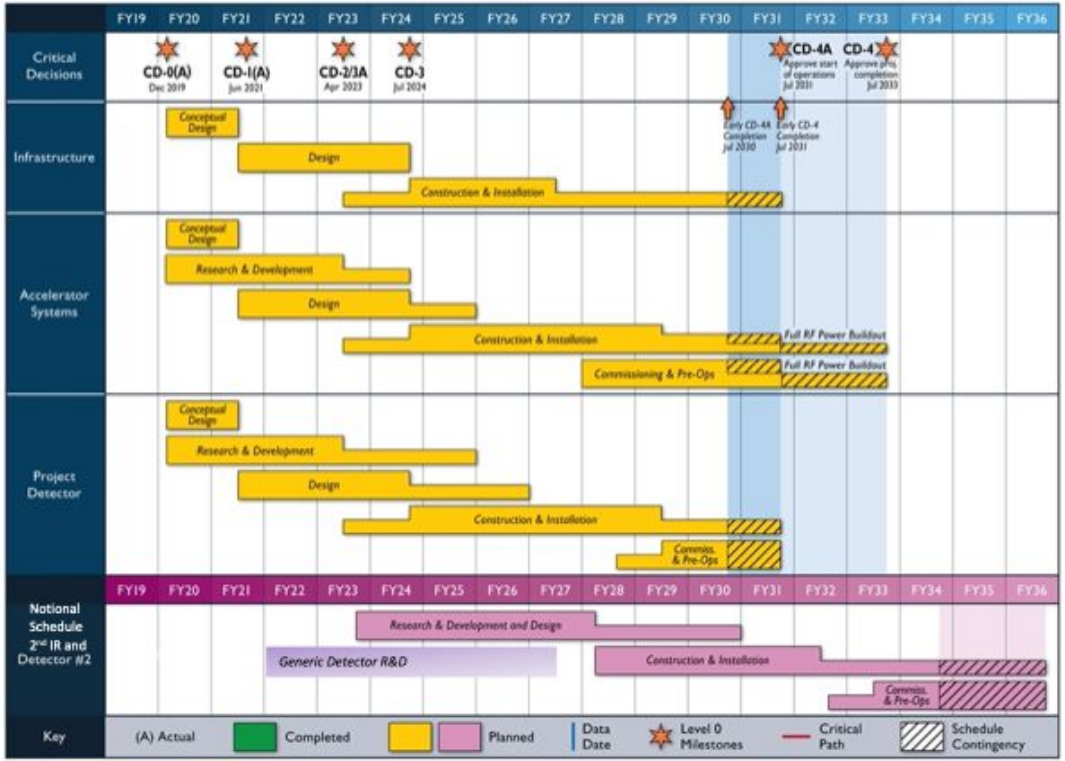
The LGAD Consortium Goals

- **Create a collaborative effort to develop EIC detector technologies based on the LGAD technology**
  - Bring together people with common interest in LGAD-based detectors in HEP, NP and other communities
  - Share expertise on the common aspects of the underlying technology that transcend any specific detector realisation
  - NB: the consortium does not intend to replace the collaborative effort of a detector project, but supplement it, in order to study common challenges and possibly develop common solutions across different detector projects
- **On a longer term this consortium will be a stepping stone for other applications of LGADs**

EIC Timeline Overview

- The EIC is capable of supporting a science program that includes two detectors and two interaction regions (IR), but Project has only funding for one full IR and one detector. A second IR and detector within the same timeline is desirable
- Three collaborations have been formed (ECCE, ATHENA, CORE) all of them are considering LGADs
- **Timeline** (driven by US DOE Critical Decisions - CD - schedule)
  - **CD-0 - Dec 2019:** conceptual planning and design used to develop alternative concepts and requirements
  - **CD-1 - June 2021:** conceptual design, begin the project execution phase
  - **Mid-2022**: Selection of detector(s)
  - **CD-2 - Jan 2023:** decision on baseline technologies
  - **CD-3 - March 2024**: release funds for construction
  - **CD-4 - 2031-2033**: detector constructed

EIC Timeline Overview



R&D Effort for LGADs at EIC

- EIC community has recognised that a coherent effort is needed in the R&D to develop LGAD technologies for EIC applications
  ⇒ eRD112 was created in summer 2021 as an R&D project to support LGAD developments for EIC TOF and Roman Pots (2021 to 2026 time span of R&D)
  - This effort is embedded in the wider-scope LGAD consortium
    - Participating Institutes are a subset of the LGAD consortium
    - Discussions of general interest will take place in the LGAD consortium meeting and mailing list
  - Tight schedule of deliverables to meet the stringent EIC deadlines
    - Definition of detector specifications and layouts
    - Sensor prototyping and testing (several submissions to BNL and HPK foundries)
    - Electronics development (ASICs and flexes)
    - Prototyping of mechanical supports and cooling system
  - *See Zhenyu Ye presentation today for more details*

Commonalities with other Projects

- Common developments for future LGAD-based detectors can minimise cost and effort
  - E.g. for EIC we try and see if a common (or similar) detector layout(s) or architecture can work for TOF and Roman Pots (sensor and electronics)
- Several developments can be common with other applications beyond EIC, e.g. ALICE, LHCb, NA62 etc.
  - **Sensor R&D**, e.g. sharing of design, wafer submissions to foundries and testing
    - LGADs development has been driven by ATLAS and CMS timing detector and is now well established
    - AC-LGAD development is advanced, supported by a strong community of LGAD experts
  - **Electronics development**: we use ATLAS HGTD and CMS ETL as stepping stones
    - On-going ASIC design for EIC RPs, more institutes are expected/welcome to join to expand scope to include electronics for the TOF detector
    - Different conditions between EIC and LHC (e.g. radiation levels, hit occupancy and triggers) entail implementation of different technical solutions, but sharing of information, expertise and designs can be beneficial to both communities
  - Strategies for **Cooling and Mechanical supports** can be shared
- Good match between EIC schedule and schedules for LHC upgrades that can be exploited

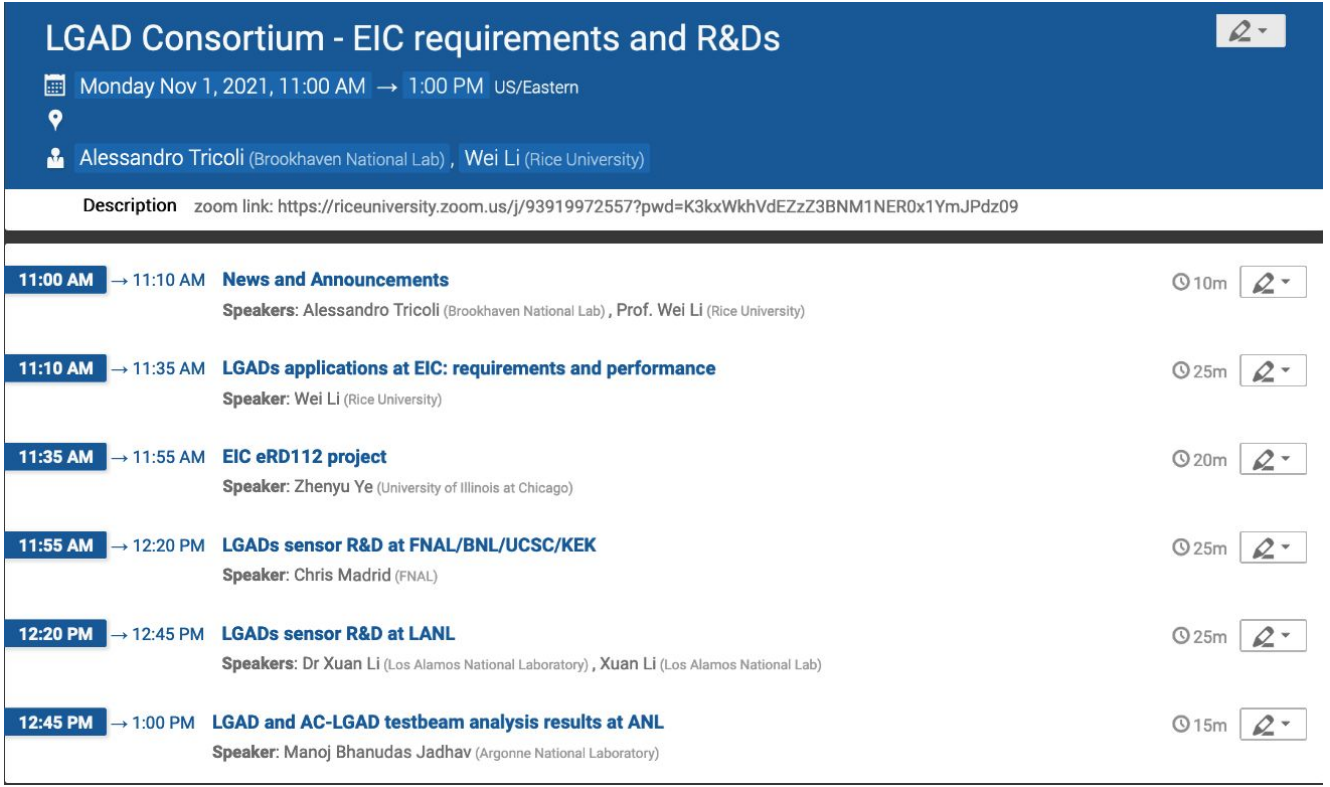
Summary

- Fast-timing has become essential in several scientific applications
- LGADs are now an established technology considered by all LHC experiments for ~30 ps timing
  - Ongoing studies hint that ≤20 ps is achievable with thinner LGADs
- **Standard LGADs can be further developed to also include accurate space resolution for 4D detectors**
- **EIC is considering the use of AC-LGADs for TOF/4D-tracker and Roman Pots subsystems and an R&D program is established (eRD112)**
- **The LGAD Consortium was created to support LGAD-based technology development for EIC and other applications**
  - Sensors, electronics, cooling, mechanics
- **We welcome collaborations with other experiments to exploit common interests on such R&D**
  - **Get in touch if you want to collaborate and share expertise!**

Useful Links

- **LGAD Consortium mailing list:** lgads-eic@mailman.rice.edu
  - To subscribe, send an email to *A. Tricoli* (alessandro.tricoli@cern.ch) , *W. Li* (wl33@rice.edu) or do it yourself through web interface https://mailman.rice.edu/mailman/listinfo/lgads-eic
- **EIC LGAD Consortium Indico pages:** https://indico.bnl.gov/category/323/
  - General interest meetings:
    - Electronics - https://indico.bnl.gov/event/11717/
    - Expressions of Interests - https://indico.bnl.gov/event/10704/
    - Kick-off - https://indico.bnl.gov/event/9693/

This meeting



LGAD Consortium - EIC requirements and R&Ds

Monday Nov 1, 2021, 11:00 AM → 1:00 PM US/Eastern

Alessandro Tricoli (Brookhaven National Lab), Wei Li (Rice University)

Description zoom link: https://riceuniversity.zoom.us/j/93919972557?pwd=K3kxWkhVdEZzZ3BNM1NER0x1YmJPdz09

11:00 AM → 11:10 AM	**News and Announcements** **Speakers**: Alessandro Tricoli (Brookhaven National Lab), Prof. Wei Li (Rice University)	10m
11:10 AM → 11:35 AM	**LGADs applications at EIC: requirements and performance** **Speaker**: Wei Li (Rice University)	25m
11:35 AM → 11:55 AM	**EIC eRD112 project** **Speaker**: Zhenyu Ye (University of Illinois at Chicago)	20m
11:55 AM → 12:20 PM	**LGADs sensor R&D at FNAL/BNL/UCSC/KEK** **Speaker**: Chris Madrid (FNAL)	25m
12:20 PM → 12:45 PM	**LGADs sensor R&D at LANL** **Speakers**: Dr Xuan Li (Los Alamos National Laboratory), Xuan Li (Los Alamos National Lab)	25m
12:45 PM → 1:00 PM	**LGAD and AC-LGAD testbeam analysis results at ANL** **Speaker**: Manoj Bhanudas Jadhav (Argonne National Laboratory)	15m