RDC #3
Solid State Tracking
LGADs planning

Introduction

Sally and Tony

Goals for today

- We are very excited to see everyone (as usual)
- At the CPAD workshop, it is obvious there is an enthusiastic group of researchers working on LGADs for future HEP experiments
- At workshop, we were encouraged to promote:
  - Blue Skies proposals
  - Teams working together more: as in ~1-2 options of common submission to foundries for LGADs, more common submissions in LGADs and electronics for it
  - Holistic (non-silo'd) design and development
- We wanted to take the next steps to see if we can organize common work packages toward generic and blue skies R&D for LGADs
  - Time scales of 10-30 years: i.e. Higgs factories and beyond in collider physics
- RDC3 should be community driven; we want to be facilitators working towards common projects and goals
  - Asked for a paragraph of text with respect to this + a list for the staff needs per year (for the next 1-3 years), equipment required, submissions,... to be a rough estimate of cost

Investigation of low gain avalanche detectors exposed to proton fluences beyond $10^{15}\;n_{eq}cm^{-2}$	*Jiahe Si*	
53/1-1350-A - Trinity-A, SLAC		16:00 - 16:15
First survey of centimeter-scale AC-LGAD strip sensors with a 120 GeV proton beam	*Artur Apresyan et al.*	
53/1-1350-A - Trinity-A, SLAC		16:15 - 16:30
Development of AC-LGADs for near-future Higgs factories and nuclear physics experiments	*Jennifer Ott*	
53/1-1350-A - Trinity-A, SLAC		16:30 - 16:45
A high-granularity timing active target for the PIONEER experiment	*Adam Molnar*	
53/1-1350-A - Trinity-A, SLAC		16:45 - 17:00
InAs/GaAs Quantum Dot Scintillator for 4D Tracking Applications	*Tushar Mahajan*	
53/1-1350-A - Trinity-A, SLAC		17:00 - 17:15
Investigating the impact of 4D tracking in ATLAS beyond Run 4	*Ariel Schwartzman*	
53/1-1350-A - Trinity-A, SLAC		17:15 - 17:30
The Development of Silicon Carbide Low Gain Avalanche Detector	*Tao Yang*	
53/1-1350-A - Trinity-A, SLAC		17:30 - 17:45
Discussion of Commonalities (Timing)	*Anthony Affolder et al.*	
53/1-1350-A - Trinity-A, SLAC		17:45 - 18:00

FOA DE-FOA-0003177

- **FOA DE-FOA-0003177, section 5f is the only FOA Helmut has indicated where proposals will be possible for the next ~2 years.**
- **Due date is September, 2024.**
- **It is university-lead:** No threshold for individual universities, but all universities together should be (significantly) more than 50%. Can include submission costs to the university fractions.
  - The narrative should describe the full scope of work for ALL participants, including for the budget. The reviewers need to be able to evaluate the WHOLE effort, not just the university part.
- **Duration of ½ to 3 years:** Been suggested to propose from 2-3 year to cover gap under new R&D funding line come to be.
- **Proposal size: 5k to 5M a year has been funded.** Suggested to propose a ramping profile as new funds will ramp up over years. Need to be less than 1 M in the first year. Most likely much less.
- **It strongly encourages multi-institutionial proposals.** We should lean into this for CPAD-based submission.
- **Funding has to be something not already supported by DOE (no double dipping)-** when new R&D funding line come to be, this one may be switched over to it
  - Need to understand constraints from this.

Next Steps:

- For **FOA DE-FOA-0003177,** we need to figure out if we can have a viable university lead.
  - If we do, we need to start organizing the proposal, figure out what we want and allow for enough time for all the bureaucracy to complete for a mult-institutional submission with sub-contractors to complete. Need to start detailed budgets,.. by June/July.
- If we can't have an university-lead project, we should still understand if we have a common direction(s) the US wants to take in LGADs.
  - We would be able to indicate the goals of the research, breadth of the activity, scale/profile of funding required. We would inform CPAD and DOE of these needs in order to be in the planning for the new R&D that will come available.
    - Develop common work packages with DRC4 and DRC11
  - It would also be useful for discussion with ECFA DRD3, other funding proposal, etc.
  - It is going to be necessary to work together to get to these bigger goals
    - And it is nice to work together ☺
- There is a meeting for RDC3 conveners on Feb. 14th where we will be more information setting scale of expectations submitting funding requests

Examples of goals from DRD3, BRNs,…

PRD	Thrust
PRD 18: Develop high spatial resolution pixel detectors with precise per-pixel time resolution to resolve individual interactions in high-collision-density environments	Thrust 1: Lepton colliders, requiring timing on the order of 10 ps; pixel pitch on the order of 10 microns Thrust 2: Hadron colliders, requiring timing resolution down to 1 ps to achieve HL-LHC-like pileup, in a high radiation environment (up to fluences in the order of $10^{18} n_{eq}/cm^2$)

2	2.1	MS2.1	Reduction of the pixel cell size for 3D sensors		x			
2	2.1	MS2.2	Combination of a temporal resolution of about 50 ps and a pixel size of about 50 × 50 μ^2 in 3D sensors			x		
2	2.1	MS2.3	Improve 3D temporal resolution to 10 ps				x	
2	2.2	MS2.4	Improve position resolution in LGAD toward about 10 micron maintaining a 30 ps temporal resolution		x			
2	2.2	MS2.5	Improve LGAD radiation resistance up to $5{\cdot}10^{15}$ n_{eq}/cm^2			x		
2	2.2	MS2.6	Improve LGAD temporal resolution to 10 ps				x	
2	2.2	MS2.7	Improve LGAD radiation resistance up to $1{\cdot}10^{16}$ n_{eq}/cm^2				x	

2	2.1	4D tracking: 3D sensors
2	2.2	4D tracking: LGAD

2	2.1	D2.1	Production of 3D sensors with reduced pixel size		x			
2	2.1	D2.2	Large matrix of 3D sensors with reduced pixel size to be coupled to read-out ASIC				x	
2	2.2	D2.3	Production of LGAD sensors with enhanced position resolution		x			
2	2.2, 3.3	D2.4	Production of LGAD with radiation resistance up to $1{\cdot}10^{16}$ n_{eq}/cm^2				x	

- These are all in line with presentations from CPAD meeting and the concerns we discussed: Spatial and timing precision, radiation tolerance, …

Backup

Longer Term R&D Priorities

- Directions encompassed in BRN and Snowmass Reports
- Areas of R&D Priorities
  - Topic Area #1: Adapting non-silicon and novel-configuration sensors
    - Improved costs, area, radiation tolerance, performance
  - Topic Area #2: Scalable, low-mass detector systems
    - MAPs based tracking
  - Topic Area #3: Trackers for Lepton Colliders
    - Similar requirements for timing and spatial resolution
  - Topic Area #4: Trackers for Hadronic Colliders
    - Extreme radiation with fine timing and spatial resolution
  - Topic Area #5: Advanced modeling

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PRD 18: Develop high spatial resolution pixel detectors with precise per-pixel time resolution to resolve individual interactions in high-collision-density environments	Thrust 1: Lepton colliders, requiring timing on the order of 10 ps; pixel pitch on the order of 10 microns Thrust 2: Hadron colliders, requiring timing resolution down to 1 ps to achieve HL-LHC-like pileup, in a high radiation environment (up to fluences in the order of $10^{18} n_{eq}/cm^2$)
PRD 19: Adapt new materials and fabrication/integration techniques for particle tracking	Thrust 1: Adapting non-silicon and novel-configuration sensors (diamond, large-bandgap semiconductors, thin film materials, nanotechnology, 3D sensors, new emerging materials) with new industrial partnerships Thrust 2: Development of readout electronics matched to new sensor characteristics, including new processing such as 3D-integration
PRD 20: Realize scalable, irreducible-mass trackers	Thrust 1: Highly integrated monolithic, active sensors Thrust 2: Scaling of low-mass detector system Thrust 3: Systems for special applications: space-based tracking detectors, and dedicated searches for rare processes and dark matter

Table 20 of BRN

IF03-1 Develop high spatial resolution pixel detectors with precise per-pixel time resolution to resolve individual interactions in high-collision-density environments

IF03-2 Adapt new materials and fabrication/integration techniques for particle tracking in harsh environments, including sensors, support structures and cooling

IF03-3 Realize scalable, irreducible-mass trackers in extreme conditions

IF03-4 Push advanced modeling for simulation tools, developing required extensions for new devices, to drive device design.

IF03-5 Provide training and retain expert workforce to enable future tracking systems to be designed, developed, constructed and simulated.

IF03-6 Nurture collaborative networks, provide technology benchmarks and roadmaps and funding in order to develop required technologies on necessary time scales, costs and scope.

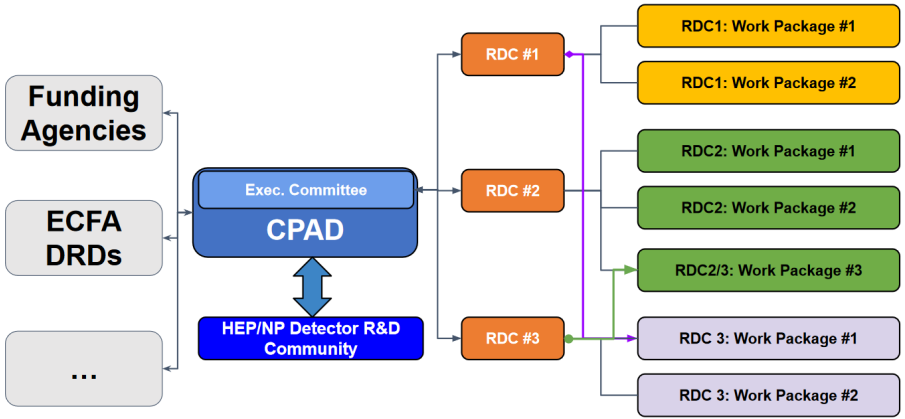
Key Points from IF03 in Snowmass Instrumentation Report

Meetings

- We had an RDC3 Introductory Meeting on Oct. 4th: https://indico.fnal.gov/event/61509/
- At it, there was a series of 2-3 page flash-talks where groups got to introduce themselves, what they are doing presently, and their future interests.
  - If you didn't present, please send us a few slides and we will add it to the agenda to collect everyone's interests in one place
    - We are still looking for a good method to gather all our material.
- We plan to have regular ~quarterly meetings of RDC3 in order to keep in touch, communicate new information, discuss how we are interacting with DRD3,….
  - We may have ad-hoc meetings when necessary for grant planning,….

Our vision of the scope of RDC3

- Future systems will be very challenging and require co-design at the early stages to reach the targets our physics goals demand
  - Silo'd designs which worked for the LHC and HL-LHC upgrades cannot work in our opinion
- In the long term, we would like to target larger work packages which will study the topic areas on the previous slide
  - Requires working closely with other RDCs and DRDs at the beginning
    - DRC4 (Readout and ASICs), DRC10 (Detector Mechanics), DRC11 (Fast Timing), ECFA DRD3 (Solid State), ECFA DRD7 (Electronics), ECFA DRD8 (Integration)
      - How we work with the ECFA DRDs is not clear but such collaboration is welcomed on both sides
  - In addition to the sensor elements themselves, we need to make sure we can read them out, support and service the full system.



RDC 3: Solid State Tracking

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