

# LA-UR-23-20779

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**Title:** LANL Letter of Intent to join the ECFA DRD3 working group

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**Intended for:** Letter of Intent

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DRD3 Workshop on 22-23 March 2023

## Expression of Interest for participation in DRD3 – R&D on Solid State Detectors

Background information: <https://indico.cern.ch/event/1214410/>

Instructions ([Replace or delete the blue example text!](#))

Fill only one form per institution.

**Name of the institution, full address:**

**Country:**

USA

**Contact person(s)** (full name and email):

- *Xuan Li, [xuanli@lanl.gov](mailto:xuanli@lanl.gov)*

**CERN and other experiments** (participation in running experiments & projects)

- *LHCb, sPHENIX, E1039, Electron-Ion Collider (EIC)*

**Size of the group interested in the DRD3 activities**

(approx. FTE of participation in DRD3):

- *0.25 FTE (permanent staff)*
- *0.25 FTE (temporary staff, postdocs, students)*

**List of participants** (already contracted personnel, as to appear on the proposal):

- *Xuan Li, [xuanli@lanl.gov](mailto:xuanli@lanl.gov)*
- *Cesar da Silva, [cesar\\_luiz@lanl.gov](mailto:cesar_luiz@lanl.gov)*
- *Matt Durham, [durham@lanl.gov](mailto:durham@lanl.gov)*
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- [Krista Smith, kristas@lanl.gov](mailto:kristas@lanl.gov)
- ....

## Technological area(s) of interest within the DRD3 collaboration

*In the following, we ask you to fill two tables on resources and free text fields to outline your research interest and the infrastructure/equipment/facilities available at your institution. Based on the ECFA roadmap and community discussions, we have pre-defined seven technological areas. In case you do not find your planned R&D activity reflected in the proposed technological areas, feel free to add a further line in the tables and comment on them in the free text field.*

*Note that we are asking you to estimate resources, not to commit to resources. The estimates on financial and personnel resources of individual institutes given in the two tables below will be treated confidentially. Information on research interests, available equipment, and the list of participants will, however, be shared with the (to be formed) DRD3 collaboration.*

### A. Technological area(s) of interest within the DRD3 collaboration (FTE Table)

*Please mark your interest with the approximate personnel power in FTE/year. In case you foresee a budget profiling over the years, please indicate this accordingly. Split the personnel into permanent (experienced researchers and technical staff) and temporary (students, postdocs, and researchers with limited-duration contracts). Indicate additional personnel you plan to request to the new strategic funding programs with an asterisk \**

Technological area	Resources (FTE per year) (split into permanent and temporary personnel) [2024 to 2028]	
	Permanent [FTE/year]	Temporary [FTE/year]
<b>Monolithic CMOS sensors</b>  [ASIC design, TCAD, testing, off-chip electronics (PCB, FPGA), modeling, ...]	2024-2028: TBD	2024-2028: TBD

<b>Sensors for tracking and calorimetry with space, time and/or energy resolution</b> [4D, 3D, trench detectors, modeling, simulation, ...]	24-28: TBD	24-28: TBD
<b>Radiation damage &amp; ultrahigh fluences</b> [Defect characterization, TCAD and other damage simulations, irradiation tests, ...]	24-28: 0.1	24-28: 0.1
<b>New characterization techniques and facilities of common interest</b> [Irradiation and test beam facilities, IBIC, laser testing, ..]		
<b>Non-silicon semiconductor and other material studies</b> [Diamond, SiC, GaN, WBG, ..]		
<b>Interconnect and device fabrication technologies</b> [3D integration, TSV, reduction of pitches, wafer bonding technologies,..]		
<b>Dissemination and outreach</b> [Mobility programs, publications, conferences, training, links to other research fields and industry, IP, website, collaboration admin, ...]		

## B. Technological area(s) of interest within the DRD3 collaboration (Financial Table)

*Please mark your interest with the approximate financial resources/year. In case you foresee a budget profiling over the years, please indicate this accordingly. Split the finances into operations budget (consumables, investment into sensor production, operation of equipment, ...) and capital investments (new infrastructure and equipment, ...). Do not include the personnel given in the previous table. Please estimate in kCHF or clearly indicate the currency used. Place new strategic funding you plan to request into separate lines and mark them with an asterisk \**

<b>Technological area</b>	<b>Resources (financial resources per year)</b> <i>(split into operations budget and capital investment)</i> <b>[2024 to 2028]</b>	
	<i>Operations budget</i> <i>[kCHF/year]</i>	<i>Capital investment</i> <i>[kCHF/year]</i>
<b>Monolithic CMOS sensors</b>  [ASIC design, TCAD, testing, off-chip electronics (PCB, FPGA), modeling, ...]		
<b>Sensors for tracking and calorimetry with space, time and/or energy resolution</b> [4D, 3D, trench detectors, modeling, simulation, ...]		
<b>Radiation damage &amp; ultrahigh fluences</b> [Defect characterization, TCAD and other damage simulations, irradiation tests, ...]		
<b>New characterization techniques and facilities of common interest</b> [Irradiation and test beam facilities, IBIC, laser testing, ..]		
<b>Non-silicon semiconductor and other material studies</b> [Diamond, SiC, GaN, WBG, ..]		
<b>Interconnect and device fabrication technologies</b> [3D integration, TSV, reduction of pitches, wafer bonding technologies,..]		
<b>Dissemination and outreach</b> [Mobility programs, publications, conferences, training, links to other research fields and industry, IP, website, collaboration admin, ...]		

## Technological area(s) of interest within the DRD3 collaboration (Free text: Research)

*Outline your research interest and your main goals in bulleted format. Indicate planned new strategic RD activities with an asterisk. Do not write more than one page.*

### CMOS

*Dense tracking environments in experiments at HL-LHC experiments call for an increased use of timing information in addition to the position measurement of pixel detectors in order to mitigate the effects of pile-up. This research aims to combine the typical detector pitch (e.g. 50x50  $\mu\text{m}^2$ ) with the timing information enough to contribute to jet-substructure (e.g. <100 ps), using reasonably accessible technologies (imaging CMOS 150nm to 180nm) with small collection electrode size (< 3  $\mu\text{m}$ ) which are radiation hard to >2e15 n/cm<sup>2</sup> NIEL and >150 Mrad TID, in order to provide a detector prototype for the outer layers of the HL-LHC experiments and future experiments (for example, the project detector at the future Electron-Ion Collider). A special research focus will be on the development of signal amplification in small pixel CMOS sensors to enable future tracking detector with time-resolution in view of 4D detectors. The option to achieve sensor for very high radiation tolerance will be investigated with silicon carbide sensors. Important is the investigation of their functionality as HEP detectors and possible design modification to achieve high radiation hardness. Moreover, the characterization methods are foreseen to be developed further.*

#### *1. Monolithic CMOS sensors*

*1.1 Merging gain amplification techniques with custom rad hard Pixel designs (e.g. low gain layer amplification and/or optimized SPAD)*

*Goal: Test structures for fast charge collection that can lead to 4D tracking*

*1.2 Integration into existing and future detectors*

*Goal: Implementation of large surface detector*

#### *2. Sensors for tracking and calorimetry with space, time and/or energy resolution*

*2.1 Improve sensor designs to reduce charge collection time*

*Goal: Validation of sensor design with in-lab bench tests and potentially beam tests at the test-beam facilities.*

#### *3. Radiation damage & ultrahigh fluences*

*3.1 Understand the effects of NIEL and TID in the custom structures for novel materials (e.g. Silicon carbide)*

*Goal: Irradiation with Neutrons, study of charge collection. Our group would be interested to help setup the irradiation tests at the LANL LANSCE facility.*

## Technological area(s) of interest within the DRD3 collaboration (Free text: Tools)

*Outline the equipment available at your institution (split into existing and planned). Indicate planned R&D equipment funded via new strategic R&D programs with an asterisk.*

*Existing tools:*

- Irradiation facility: 500-800 MeV protons*

- *Laser based characterization tools (TCT standard)*
- *Environment Chamber for low temperature (down to -20C) silicon sensor characterization*
- *Established MAPS and AC-LGAD test benches, related low- high-power supplied, and associated readout modules.*
- *....*

*Planned tools:*

- *Fast ASIC or FPGA module for CMOS development*

**Technological area(s) of interest within the DRD3 collaboration (Free text: Industry)**

*Outline relationships with industry.*

- *We are working closely with CERN on the CMOS sensors.*

***Any further comment(s):***

- *The above given budget estimates and workforce were not discussed with my funding agency yet; we will provide updates as soon as possible regarding the numbers.*
- *...*