



Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)

Project Title	Design and development of highly sensitive particle radiation detection sensor and systems
Project Summary	The design and development of highly sensitive X-ray radiation detection sensors and systems is a multidisciplinary effort that integrates materials science, electronics, optics, and computational imaging. X-ray detection is fundamental to medical diagnostics, industrial inspection, defense surveillance, and scientific research, where the demand for higher resolution, lower dose exposure, and faster acquisition speeds continues to grow. Modern detectors are designed to convert high-energy photon interactions into measurable electrical signals with maximum efficiency and minimal noise. Architectures typically fall into two categories: indirect detection, where scintillators convert X-rays into visible light captured by CMOS sensors, and direct detection, where semiconductor materials such as cadmium telluride or amorphous selenium absorb X-rays directly to generate electron-hole pairs. Direct detection offers superior efficiency and precision, while indirect detection remains widely used for its versatility and cost-effectiveness. Sensitivity is the defining characteristic of these systems, determined by quantum efficiency, dark current suppression, and the performance of readout electronics. Advanced designs employ low-noise amplifiers, correlated double sampling, and optimized ADCs to preserve signal integrity. Temporal resolution is equally critical, especially for dynamic imaging, requiring fast response times and pixel architectures capable of capturing rapid sequences without motion blur. Integration into complete systems involves mechanical design for shielding and stability, FPGA or ASIC-based signal processing for real-time image reconstruction, and high-speed data interfaces such as PCIe or GigE Vision for seamless communication. Calibration and linearity testing ensure diagnostic accuracy across varying X-ray intensities. Applications of these systems are diverse. In medicine, they enable digital radiography, CT scans, and dental imaging with reduced patient dose and sharper images. In industry, they support non-destructive testing of welds, composites, and semiconductor wafers. Defense and security sectors rely on ruggedized detectors for cargo scanning and radiation monitoring, while scientific research at synchrotron facilities and particle physics experiments demands single-photon resolution and high temporal precision. Development challenges include material limitations, power management, environmental durability, and regulatory compliance, all of which require careful engineering solutions. Emerging innovations are reshaping the field. Single Photon Avalanche Diode (SPAD) arrays allow detection of individual X-ray photons with picosecond timing accuracy, enabling time-resolved imaging. Quantum-enhanced detection methods promise sensitivity beyond classical limits, while AI-driven image reconstruction reduces noise and automates diagnostics. Flexible electronics are opening possibilities for portable or wearable X-ray systems. The roadmap for development involves material research, prototype fabrication, system integration, validation trials, and scaling for manufacturing, ensuring cost-effectiveness and reliability. In conclusion, highly sensitive X-ray radiation detection sensors and systems represent a transformative leap in imaging technology. By advancing sensor architectures, minimizing noise, and integrating intelligent processing, these systems deliver unprecedented diagnostic accuracy, industrial reliability, and defense capability. With innovations such as SPAD arrays and AI-enhanced reconstruction, the future of X-ray detection promises safer, faster, and more insightful imaging across diverse domains, bridging laboratory research with real-world impact.

Ph.D. Supervisors⁺

(Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)				
Role	Name of Faculty	Date of Superannuation ^{\$} (DD/MM/YYYY)	Academic Unit in IITD/Institute/University	Email ID (Official) & Contact Number
Supervisor 1*	Jolly Xavier P	31/05/2040	SeNSE	jxavier@sense.iitd.ac.in
Supervisor 2	Mukul Sarkar	31/10/2045	EE	msarkar@ee.iitd.ac.in ,

*Supervisor 1 must be from IIT, Delhi.
 +All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.
 \$The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc) *The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)
M.Tech. with Electronics and Instrumentation Technology background.

Source of fellowship/funding and project number (CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)
FITT project: FT/2023/11/15

Role of Faculty Members involved:	
Supervisor-1	Will guide the student on sensor design, architecture and characterization.
Supervisor-2	Will guide the student on sensor and system readout and its application.

- Note :-**
- Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SIRe.
 - Declaration:- Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SIRe student.
 - PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.
 - If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.
 - A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.
 - The third supervisor’s name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.
 - If institute fellowship is being sought then the DRC approval of the parent departments of both supervisors is required at the time of selection.