

Keynote: Perovskite Single-Crystal X-ray Detectors: From Low-Dose Single-Photon Sensitivity to High-Flux Operation and Radiovoltaic Power Sources.

Friday, 16 January 2026 09:00 (1 hour)

Hybrid lead-halide perovskites have recently emerged as a promising new class of high-Z semiconductors for direct X-ray detection, combining strong X-ray absorption, effective ambipolar charge transport with solution-processable single-crystal growth. Over the past few years, perovskite-based detectors have demonstrated rapid progress, achieving performance metrics that approach or rival established materials such as CdTe, while offering fundamentally different pathways for materials synthesis and device integration.

This keynote reviews the physical principles, materials science, and device architectures underlying perovskite single-crystal X-ray detectors with a particular focus on operation at high photon fluxes relevant to modern light sources. The X-ray photovoltaic (XPV) detection concept is introduced, in which thick perovskite single crystals operate at zero external bias and rely solely on built-in electric fields for charge separation and collection. This low-field operation effectively mitigates ion-migration-induced instabilities that have historically limited perovskite detectors, enabling long-term stable performance together with single-photon sensitivity, near-unity detection efficiency, and high spatial resolution.

Key materials and device parameters governing detector performance are discussed, including crystal thickness, carrier mobility–lifetime product, diffusion length, recombination dynamics, and interface engineering. Recent advances in mixed-cation perovskite single crystals enabling millimetre-thick absorbers are highlighted, demonstrating efficient charge extraction across the full medical X-ray energy range and providing a framework for extending operation toward higher energies and higher photon fluxes.

The interplay between intrinsic material properties and detector architecture is examined to identify performance bottlenecks and design rules for high-rate, high-dynamic-range and high flux operation.

Radiovoltaic power sources based on high-Z perovskite semiconductors enable self-powered radiation systems in which the incident X-ray field serves simultaneously as signal and energy source. Such devices open routes toward autonomous detector modules and radiation-hard sensors for beamline diagnostics, space instrumentation, nuclear environments, and long-lived medical applications. When combined with ultra-low-power electronics, radiovoltaic elements may enable adaptive detectors that dynamically respond to local photon flux without external power.

The talk concludes with an outlook on remaining challenges and opportunities for deploying perovskite X-ray detectors at light sources, including scalable array integration, readout-chip compatibility, count-rate capability, and long-term materials robustness. Owing to their openness to novel detector concepts and tolerance for early-stage technologies, synchrotron and FEL user communities are uniquely positioned to play a pivotal role in advancing perovskite-based X-ray sensors toward next-generation high-Z detection platforms.

References:

Sakhatskiy, B. Turedi, et al. *Nature Photonics* 17, 510–517 (2023)

B. Turedi, Sakhatskiy, et al., submitted.

Sakhatskiy, B. Turedi, et al., submitted.

Author: Dr YAKUNIN, Sergii (ETH Zurich)

Presenter: Dr YAKUNIN, Sergii (ETH Zurich)

Session Classification: HiZPAD - Perovskites