SYQD 1: Precise Quantum Detectors in Space, Time and Energy – Semi- and Superconductors in Particle and Condensed Matter Physics

Time: Thursday 10:45–12:40 Location: ZHG104

Invited Talk SYQD 1.1 Thu 10:45 ZHG104
Symposium introduction: semiconductor quantum sensors/detectors in particle physics - a success story — •Norbert Wermes — Phys. Inst, Bonn University, Bonn, Germany

Introduction to the symposium

Invited Talk SYQD 1.2 Thu 11:00 ZHG104
Precision Timing with Silicon Detectors — •Nicolo Cartiglia — Via Pietro Giuria 1, 10123, Italia

At the core of nearly every current or planned particle detector lies a silicon-based tracking system capable of reconstructing the momenta of particles produced in high-energy collisions.

The continuous advancement of tracking systems, from a few electronic channels three decades ago to the many millions in today's detectors, has been a key enabler of our current understanding of nature. This evolution now faces its greatest challenge, as future high-energy physics experiments impose stringent requirements on spatial and temporal resolution, detector dimensions, and power consumption.

Over the past 15 years, silicon detectors have undergone rapid development, establishing themselves as the technology of choice not only for precision tracking but also for accurate timing measurements. This transformation has been driven by several design innovations, such as Low-Gain Avalanche Diodes (LGADs) and Resistive Silicon Detectors (RSDs), as well as improvements in techniques like Monolithic Active Pixel Sensors (MAPS) and Silicon-Germanium-based readout electronics.

In this contribution, I will review the recent evolution of silicon detector technologies and discuss how the integration of precise timing capabilities is redefining the way experiments are designed.

Invited Talk SYQD 1.3 Thu 11:25 ZHG104
Quantum sensor systems for enhanced precision particle detection — •Michael Doser — CERN EP, 1211 Geneva 23, Switzerland

In the context of the requirements of future particle physics experiments, quantum sensors look likely to play a central role. Among the wide range of possible quantum sensors, five technological axes (Quantum systems in traps and beams; Low-dimensional quantum materials; Superconducting quantum devices; Macroscopic scaled-up quantum systems; Quantum techniques for sensing) look particularly well suited to particle physics. This presentation will give an overview with examples of the range of applications and will highlight their relevance to, and potential impact on, both low and high energy particle physics.

Invited Talk SYQD 1.4 Thu 11:50 ZHG104
High-performance superconducting nanowire single photon detectors — •Val Zwiller — Single Quantum, Delft, Netherlands — Quantum Scopes, Stockholm, Sweden — Royal Institute of Technology, Stockholm, Sweden

The ability to detect single photons is crucial for quantum optics as well as for a wide number of applications. Several technologies have been developed for efficient single photon detection in the visible and near infrared. The invention of the superconducting nanowire single photon detector in 2001 enabled the development of a new class of detectors that can operate close to physical limits. Different aspects will be discussed including wavelength detection range, time resolution, dark counts, saturation rates and photon number resolution along with various applications such as Lidar, quantum communication, deep space communication, microscopy and bio-medical measurements.

Multipixel single photon detectors based on superconducting nanowires will also be discussed, including a quantum spectrometer that is based on an array of high-performance single photon By time stamping single photon detection events at the output of a spectrometer we generate data that can yield spectra as well as photon correlations such as g(2), g(3) to g (n) as well as cross correlations among different spectral lines, under pulsed excitation, transition lifetimes can also be extracted. This instrument therefore replaces a spectrometer, a streak camera, a Hanbury-Brown Twiss interferometer and operates with far higher signal to noise ratio than is possible with existing detectors that are commonly used in the infrared.

Invited Talk SYQD 1.5 Thu 12:15 ZHG104
ALICE ITS3 – the ultimate paper wrap pixel detector — •Magnus Mager — CERN, Geneva, Switzerland

Over the last decade, Monolithic Active Pixel Sensors (MAPS), fabricated in commercial CMOS Imaging technologies, have made their way into several high-energy physics applications, where low material budgets and high resolution are crucial. With its current, record-holding $10\,\mathrm{m}^2$, 12.5 GPixel Inner Tracking System, ITS2, ALICE currently showcases this technology and harvests physics data of unprecedented resolution.

To further improve the experiment, ALICE is upgrading the innermost three tracking layers in the next Long Shutdown of LHC (LS3, 2026–2030) with a novel detector, the ITS3. This detector will be based on truly cylindrical, bent (down to radii of 19 mm), wafer-scale (up to $10{\times}27\,\mathrm{cm}$) MAPS. The sensors are thinned down to $50\,\mu$m, and are wrapped around the beam pipe, held in place by carbon foam spacers.

During the R&D phase (2019–2024), a number of novel developments have been demonstrated, notably including the qualification of 65nm MAPS, the demonstration of wafer-scale stitched MAPS, and the demonstration of bent MAPS.

In this talk, the detector concept will be introduced, key R&D results presented, and the path towards detector installation in 2028 given.