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An outlook to the development of cryogenic CMOS electronics for particle physics

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The growing interest on the use of CMOS circuitry for quantum computing and sensing is increasing the momentum of the R&D on cryogenic CMOS, unmistakably demonstrated by an almost tenfold increase on the number of related yearly publications since 2017, and creating new collaborative efforts between academia and industry partners on the optimisation of semiconductor technology and CMOS processes and modelling for operation at cryogenic temperatures.

On the one hand, the availability of enabling infrastructures and key capabilities for the development of cryogenic mixed-signal integrated electronics operating below 4K and down to the mK will finally solve the long standing wiring bottleneck of the quantum computers, paving the way for scalability into the million qubit realm.

On the other hand, the excellent performance of CMOS at the mild cryogenic temperature range opens interesting opportunities on the development of innovative readout concepts for rare-event searches on neutrino physics and direct dark matter detection using noble liquid targets. Single and dual-phase detectors employing (solid-state) photon sensors require front-end readout electronics operating at 165K (LXe) or 88K (LAr), as future large-scale experiments will call for innovative cold integrated readout electronics implementing digital signal processing embedded in the photodetection module.

In both cases, reliable cold CMOS Process Design Kits are fundamental for the development of complex mixed-signal ASICs allowing for innovative detector architectures and concepts, data transfer, readout and control. While MOSFET device models on both VDSM bulk and FD-SOI technologies seem to scale relatively well down to 77K, CMOS PDKs are typically qualified down to 233K. Silicon foundries, CAD software houses and fabless IP providers are now ramping up the development of CMOS processes, cold IPs and PDKs qualified for very low temperatures.

We will discuss the outlook for the design of system-capable "cold"ASICs in astroparticle and high-energy physics, discussing ongoing efforts and options in academia and industry for the creation of infrastructures for the development of CMOS electronics for cryogenic environments.

BIOGRAPHY:
Manuel Rolo received his Electronics Engineering degree from University of Aveiro and holds a PhD in Physics from the University of Turin. His previous experience in the semiconductor manufacturing industry (Qimonda AG), with European microelectronics service providers (CMP, Grenoble) and as a Senior Manager for Microelectronics at PETsys Electronics is now complemented with over 10 years at INFN developing and coordinating R&D on ASIC design for particle, astroparticle, nuclear physics and industrial applications. He is author or co-author in over 400 journal papers and several international patents in the field of radiation sensors and integrated electronics.

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