3 Questions with Dr. Giacomo Vacca, Kinetic River Corp.

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As founder and president of Kinetic River, Dr. Giacomo Vacca develops and produces biophotonic innovations while helping others bring their own products to life. His San Jose, Calif.-based biophotonic design, consulting and product development company aims to create tools for innovative and disruptive life science research and biomedical diagnostics.

After receiving his bachelor's and master's degrees in physics from Harvard University, Vacca earned his doctorate in applied physics from Stanford University. Under the guidance of Nobel Prize-winner Dr. Robert B. Laughlin, his dissertation introduced a new ultrafast optical technique for investigating microscopic fluid phenomena. Vacca is a senior member of The Optical Society as well as a research fellow of Abbott Laboratories' Volwiler Scientific Society. He has received a Top Research Platinum Award for Laser Rastering and a Silver Award for Outstanding Technical Leadership.

BioPhotonics recently asked Vacca three questions about his work with cellular analysis, fluorescence lifetime imaging microscopy (FLIM) and the business of biophotonic design.

Q: What are you working on right now?

Vacca: Four years ago, I founded Kinetic River because I wanted to break new ground with biophotonic innovations that would support cutting-edge biomedical research and in vitro clinical diagnostics. Two recent milestones on this path are the Danube flow cytometer and the BeamWise design automation software tool.

In 2013, we introduced the Danube, a fluorescence lifetime flow cytometer. We are now releasing the second generation of this instrument, which is designed to increase the throughput of FLIM by more than a thousandfold, enabling the analysis of entire populations of thousands of cells in the same time it would normally take to analyze a handful. Our collaborator, professor Jessica Houston [of] New Mexico State University, is using the Danube to reinvent several classes of fluorescence lifetime assays. For applications that do not require subcellular localization information, the Danube provides high-throughput population analysis on an instrument that's robust and easy to use. One particularly exciting prospect is the label-free metabolic differentiation of normal and cancer cells.

At [the Biomedical Optics Conference at] Photonics West this past February, we launched BeamWise, the result of a joint partnership announced in 2013 to develop and market a set of software tools and related services for streamlining the design of biophotonic systems. BeamWise automates the generation of CAD models and drawings of complex optical instrumentation, and greatly reduces the burden of design change management. As an example, we are currently working with professor John Nolan, president of the International Society for Advancement of Cytometry, and his group at La Jolla Bioengineering Institute on a novel flow cytometer design.

Q: What are the implications of that work?

Vacca: Historically, fluorescence lifetime assays have been performed on small numbers of cells at a time due to the complexity and time-consuming nature of FLIM measurements. The Danube makes it possible for lifetime measurements to be integrated into standard flow-based protocols. One of the main benefits of fluorescence lifetime is its intrinsic immunity from calibration errors – of great importance in Förster resonance energy transfer assays. Another key benefit is the ability to probe protein-protein interactions

and the cellular microenvironment. Whether for high-throughput screening or for metabolic state cell identification, our instrument opens the door to a much wider adoption of fluorescence lifetime as a standard tool in flow-based cell assays.

The BeamWise design tool puts a virtual optics bench in the hands of system developers. The initial rough layout, refinements and even major changes to the design of biophotonic instrumentation are now straightforward, fast, intuitive and easily documented. Rather than wasting significant engineering time and resources reworking physical prototypes, BeamWise allows designers, developers and reviewers to quickly explore the consequences of design choices and catch problems before they become very expensive to fix. Down the line, we see the emergence of parametric design approaches like BeamWise as the new norm in biophotonic system design.

Q: What's the next step?

Vacca: We will continue to consult for clients on biophotonic design and technology assessment projects. One of our primary goals for this year is to form additional partnerships with academic and industry research groups to expand the application of our tools. We are now looking for other groups interested in running FLIM on entire cell populations. We are always interested in conversations with investigators focused on original research and groundbreaking analysis and screening methods. We are also in conversation with a number of teams designing complex optical equipment about adopting BeamWise to explore design options and cut their time to market.

We have a rich product pipeline under development that focuses on cell analysis applications. There are many boundaries of the current state of the art that I believe are ready to be pushed. In my previous work on cell analysis throughput, I showed that one could wildly exceed what were formerly thought to be hard performance ceilings. At Kinetic River, we are very focused on eliminating technical bottlenecks to the introduction and wide adoption of novel, life-saving cell analysis modalities. We want to enable analyses that today are cumbersome, costly or, frankly, even impossible. Some of the areas that we have our attention on are label-free interrogation of cells, the detection of very small particles [like] exosomes and microvesicles, and what one might call hypermultiplexing flow cytometry. It's an exciting time to be in this line of work!