Photons, Not Electrons: Why Xanadu Sees Light as the Path to Utility-Scale Quantum Computing

Published November 3, 2026

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Key Takeaways

- Xanadu's photonic architecture encodes quantum information in light and uses modular design to connect processors across chips, racks or data centers.
- Photon loss is the central engineering challenge in Xanadu's approach, giving the company a focused target for improving system performance.
- Xanadu's photonic components overlap with AI data center supply chains, including silicon photonics, telecom materials and advanced interconnects.

Takeaways from Our Conversation with Xanadu COO Rafal Janik on Photonic Quantum Computing

Most quantum computing companies are, at root, trying to control electrons. Photonic quantum computing takes a different route. It encodes information in light itself. In a recent episode of The Next Big Thing, we spoke with Rafal Janik, Chief Operating Officer of Xanadu, about what that choice means for performance, manufacturing and the path to a useful machine. Here are the ideas that stood out.

The full conversation is available here.

As of October 14, 2026, the WisdomTree Quantum Computing Fund (WQTM) had a 1.53% weight in Xanadu. Holdings are subject to change.

From MRI Physics to Quantum Photonics

Rafal is a physicist by training. After his graduate work, he took a research role at a hospital because the physics of MRI is close to the physics of quantum computing. In fact, some of the first quantum computers ever demonstrated used nuclear magnetic resonance, the same principle behind MRI. He later left a PhD course of study to found a computer vision company building self-driving systems for construction and agricultural equipment, then joined Xanadu to build its internal machine learning effort. He moved to head

of product and eventually to COO. That mix of deep physics and applied engineering shapes how he talks about the technology. It's less about elegance, more about what can actually be built and sold.

A Decade of Building toward Utility

Xanadu marked its tenth anniversary in September 2026. Its stated mission is to build quantum computers that are useful and available to people everywhere, and Rafal stressed that "useful" carries most of the weight. The company put its first machines online in 2019 and, in 2022, announced its Borealis system, which it said performed a calculation in two minutes that would have taken the largest supercomputer of the time millions of years.[1] Rafal was candid that this was an esoteric mathematical task that nobody cares about commercially. The real goal has always been fault-tolerant, utility-scale machines rather than today's noisy intermediate-scale devices.

Xanadu is also not a university spinout. Its architecture and intellectual property were developed in-house, built on founder Christian Weedbrook's research. A key design choice is how it encodes qubits. Rather than single photons, as most photonic efforts do, Xanadu uses many photons per qubit. That decision drives most of what follows.

A Quantum Computer Native to Modularity

In most quantum architectures, the qubits sit still on a chip and are manipulated by laser or microwave pulses, much like in-memory computing. A photonic quantum computer is closer to a conventional computer. The qubits travel as pulses of light, and structures on the chip apply the gates, just as electrical pulses representing ones and zeros move through the gates of a classical processor.

The biggest consequence is modularity. Because photons are already moving, connecting them across chips, racks or data centers is natural. In February 2025, Xanadu published a Nature paper demonstrating what it described as a true modular quantum computer, its Aurora system.[2] Rafal's punchline is that in a modular architecture, the question of how many qubits you have becomes less relevant. A million-qubit machine, he argued, is largely a matter of manufacturing more modules and linking them with fiber-optic cable. What stands in the way is not scale-out engineering but loss.

He also offered a provocative view on competitors.

He said that "secretly everybody's building a photonic quantum computer."

Any company that wants to link many small processors will need low-loss photonic interconnects, and some, such as trapped-ion players working in visible and ultraviolet wavelengths, will also need to convert signals to the infrared wavelengths used in fiber networks. Xanadu, in his telling, is already solving those problems.

One Enemy: Photon Loss

Critics often call photon loss the Achilles' heel of photonic quantum computing. As light moves through chips and fiber, imperfections in materials and structures can absorb or scatter it, and eventually the quantum information is gone. Rafal reframed this as an opportunity. In superconducting systems, engineers

juggle many separate error sources, such as coherence time, crosstalk between qubits, readout errors and data loading. In Xanadu's approach, the dominant imperfections all reduce to a single number: how much light is lost. Improve any component and the whole system benefits, which gives the engineering team a focused target for getting below the error-correction threshold.

Why Clock Speed Matters

Rafal also made a point that is easy to overlook: speed. If a quantum algorithm needs billions of operations, a slow clock rate turns a computation into months. Few customers can use a machine that completes one application every six weeks, and the data may be stale by the time the answer arrives. Photonics has a very high ceiling here. Aurora operated at a megahertz clock rate, limited by the classical control electronics (FPGAs) rather than by the light itself. Other modalities, he noted, face speed limits set by the underlying physics of their qubits.

Riding the AI Data Center Supply Chain

Perhaps the most relevant point for those following the investment landscape is where photonic quantum computing overlaps with today's AI buildout. Xanadu builds on standard materials from the telecom and datacom world. Some examples include:

- Semiconductors used in lasers and photodiodes
- Silicon nitride from silicon photonics
- Thin-film lithium niobate for active switching

That lets the company work with volume foundries, including GlobalFoundries, UMC, IMEC and Tower Semiconductor, without waiting for new facilities or new materials.

Rafal described a striking dynamic. Some of those suppliers have order backlogs for photodiodes stretching years because of AI demand, yet still take calls from a 350-person quantum company. One reason is optionality. AI demand could change, while quantum is a potential future market. The other is that Xanadu has been a pathfinder. When the company first asked foundries for lower-loss photonic circuits, he said, the response was that nobody cared, because you could simply turn up the laser. Then data centers began running short of energy, and energy per bit transferred became a priority. Lower-loss circuits allow lower-power lasers, so work done for quantum suddenly mattered for datacom. He described a similar pattern with Corning on custom fiber bundles. What Xanadu needs today, Corning expects data center customers to need in a year or two.

It was a useful reminder that frontier technologies rarely develop in isolation. The components that quantum photonics pushes forward overlap heavily with the silicon photonics and advanced interconnect supply chains that already serve AI infrastructure.

Cryogenics, Power and What Really Matters

Photonics is often described as a room-temperature modality, but Rafal added nuance. Approaches based on single photons rely on probabilistic entangling gates and therefore need single-photon detectors, which

require cryogenic temperatures. Some peers plan to place their whole system at around four kelvin. Xanadu's multi-photon approach uses deterministic gates, so computation can occur at room temperature. Cryogenics is needed only to count photons when validating the initial qubits, a small part of the system. That is where its collaboration with Bluefors, a leading maker of cryogenic systems, comes in.

His broader view was that cryogenics matters less for operations than for research and development. Xanadu manufactures hundreds of thousands of chips per quarter and tests them with automated robotic fleets, generating terabytes of data. A cryogenic chip, by contrast, needs half a day or more to cool, test and warm up, which slows the learning cycle considerably.

On energy, he was blunt.

A utility-scale quantum computer that can replace enormous amounts of classical compute makes the power comparison secondary.

The first questions are whether a modality can hit its technical milestones and then its manufacturing milestones. Only after that do density and power optimization take center stage.

Software, Algorithms and the CUDA Playbook

Xanadu is equally known for PennyLane, an open-source quantum programming platform embedded in some 150 universities worldwide. The company's QHack hackathon, running at the time of our conversation, had around 2,500 participants. Rafal was refreshingly direct about why this matters. Quantum computing, he said, has "dirty secrets."

For instance, it has been 10 years away for 25 years, and the community understands very few algorithms that deliver clear benefits.

Breaking encryption may be the best known.

Even promising applications are hard to validate. When Xanadu presented ideas to partners such as Mitsubishi Chemical and Rolls-Royce, he said, the response was that the problem could already be solved classically, with decades-old software, at acceptable precision. Finding algorithms that address a genuine computational choke point is difficult, and the proof of advantage has to be rigorous, since there is no quantum computer yet on which to simply run empirical tests. Software tooling, and projects such as Backline, which aims to integrate quantum computers with FPGAs, GPUs, CPUs and ASICs, are how the company is trying to close that gap.

There is a strategic angle as well. Rafal pointed to NVIDIA's CUDA as a model: an open software platform that builds a community of developers who are ready to use the hardware when it arrives. He also noted that as compute commoditizes, value tends to migrate from hardware to software and applications, which positions Xanadu to participate on both sides.

What to Watch

Rafal's conversation suggests a few questions worth following as the industry moves toward the end of the decade.

- Can photon loss continue to fall?
- Can photonic components be manufactured at volume, with the throughput and packaging that modular systems demand?
- Will credible, verifiable applications emerge before large-scale hardware exists?
- How much will the quantum and AI infrastructure supply chains continue to reinforce each other?

None of these has a settled answer, and each modality faces its own version of them. What photonics offers is a distinctive combination: an architecture that looks more like a data center than a laboratory, built on components the world already knows how to manufacture.

1 Source: Lars S. Madsen et al., "Quantum Computational Advantage with a Programmable Photonic Processor," *Nature* 606, no. 7912 (2022): 75–81.

2 Source: H. Aghaee Rad et al., "Scaling and Networking a Modular Photonic Quantum Computer," *Nature* 638 (2025): 912–19.

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