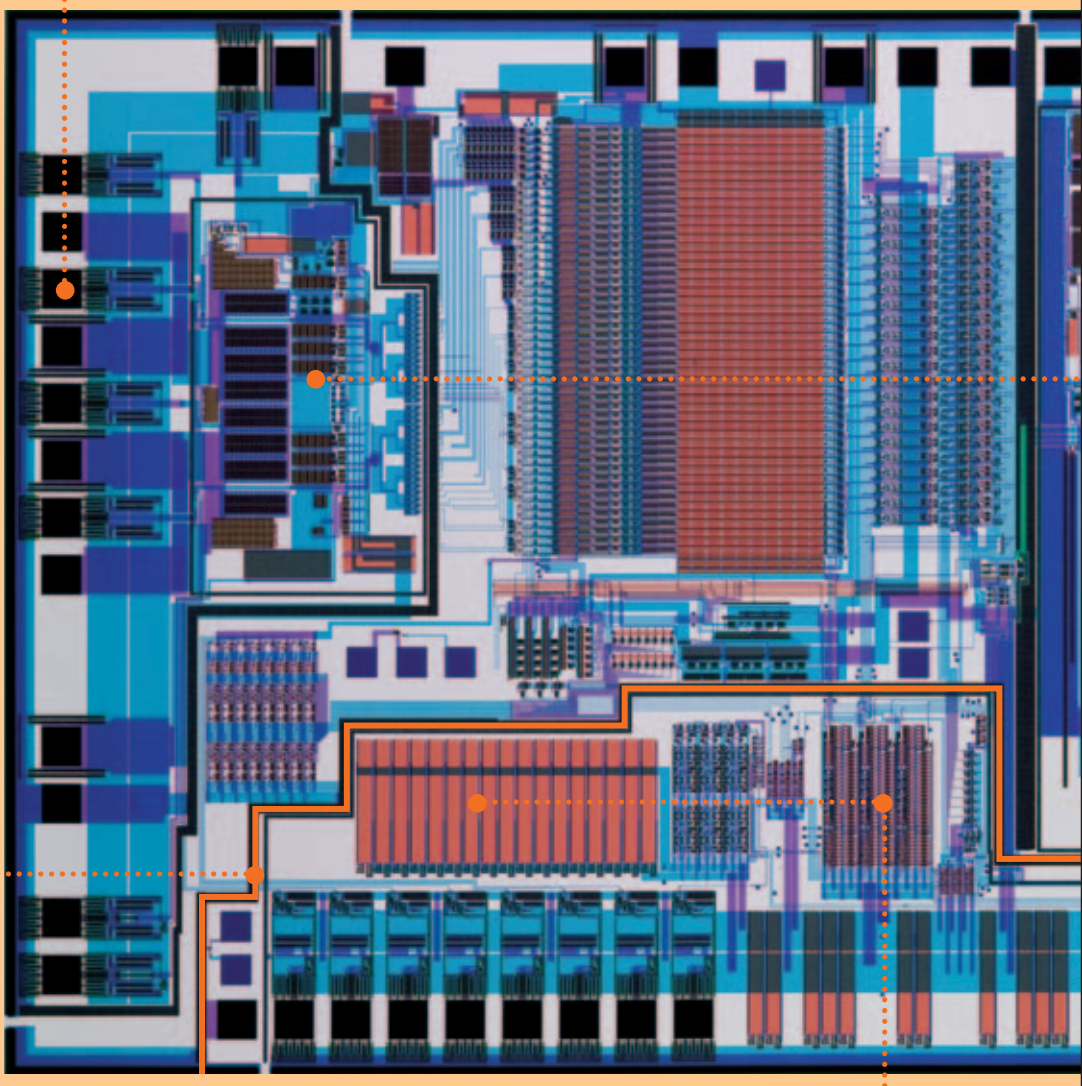
deconstruction: microchip

Custom designed microchips have become essential in processing signals from modern physics experiments that generate lots of data. This chip, the QIE9, designed by Fermilab engineers, is just one example of the many Application Specific Integrated Circuits (ASICs) used in such experiments. The chip converts raw analog signals to the digital format required for data analysis.

From 1 to 64,000
Photomultiplier tubes convert light from particle interactions to electrical signals. Tiny wires, about half the width of a human hair, transport the signals to the connection pads of the QIE9 chip. The wide range of input signals, with the largest 64,000 times stronger than the smallest, presented a challenge to the Fermilab chip designers. The answer: a custom-designed multi-range chip with a built-in Analog-to-Digital Converter (ADC).

Input



Keep it quiet!
Combining several functions on the same chip increases the reliability of signal processing. However, "noisy" digital circuits can interfere with noise-sensitive analog circuits. To solve this problem, Fermilab engineers placed several noise isolation barriers on the QIE9. One barrier divides the chip into an analog (left) and a digital section.

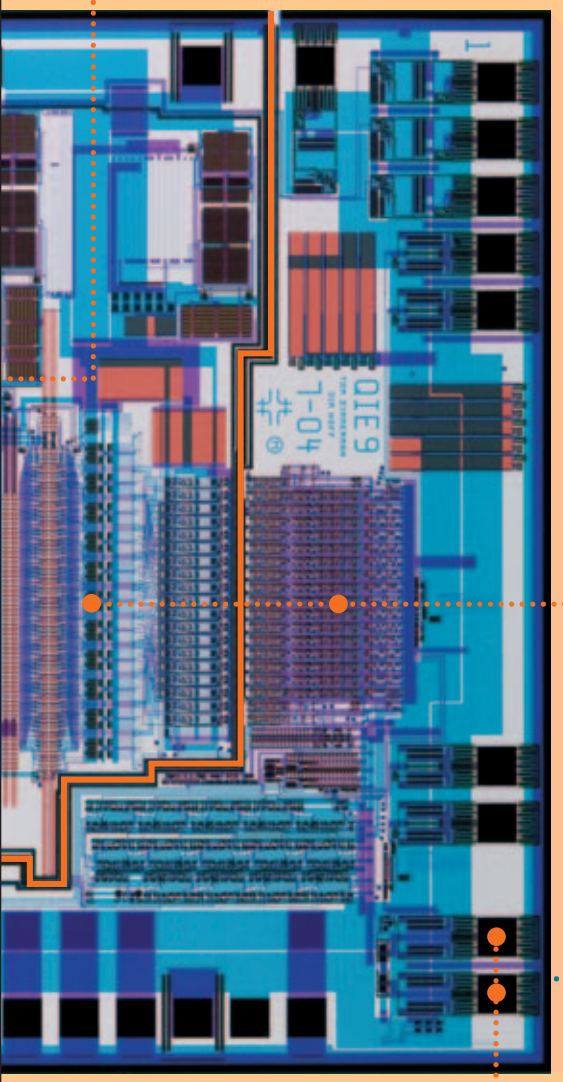
The heart of the chip
This control section contains the digital clock of the QIE9. Seven million times per second it emits a "heart beat," which synchronizes the operation of all QIE9 components. The beat matches the expected rate of input signals from the photomultiplier tubes

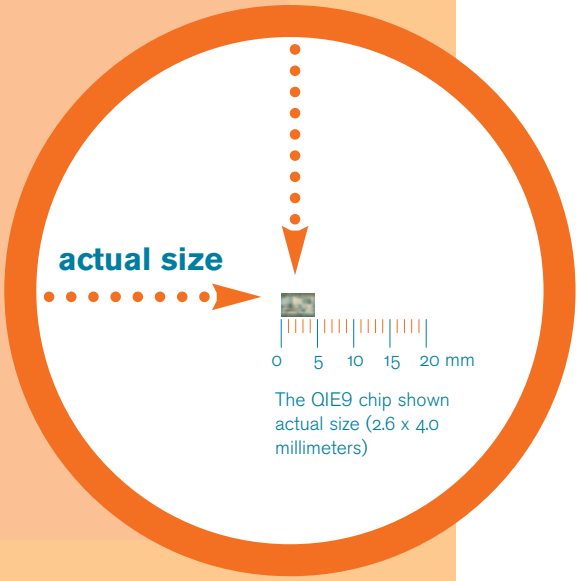
Octaves of a piano
Fermilab engineers designed all sections of the QIE9 from the ground up to provide optimal performance and to occupy a minimum amount of space. For example, engineers designed a high-speed current splitter, which can handle the wide range of incoming signals. It divides an input signal into eight ranges, which can be thought of as the octaves of a piano.

Which note is it?
In previous circuit designs, Fermilab engineers often used a separate, commercial chip to digitize signals. To increase performance and to save cost and space, engineers outfitted the QIE9 with a built-in Analog-to-Digital Converter. The ADC determines the strength of the signal within a range, similar to identifying the note within an octave, and reports the result in digital format.

Chip design:
Tom Zimmerman and
Jim Hoff, Fermilab

Text:
Ray Yarema and
Tom Zimmerman, Fermilab





The QIE9 chip shown actual size (2.6 x 4.0 millimeters)

A discovery to be made
Two pads deliver the digitized signal for transmission to the data acquisition system of the experiment. Computers combine the QIE9 output with the output of other particle detection systems. Physicists use the full data set to search for rare particle interactions.