



QIEs for MICE?

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MICE front-end DAQ need:

- Digitize $\lesssim 300$ phototube signals...
 - ...at instantaneous event rate up to ≈ 1 MHz...
 - ...with low deadtime...
 - ...during beam spills up to ≈ 1 ms in length occurring at ≈ 1 Hz
- Over last ≈ 15 years, Fermilab has developed a series of ASICs to solve this problem:

QIE

(Charge Integrator and Encoder)

- Integrates input current on multiple ranges and digitizes the one range that's on-scale
 \Rightarrow "Floating-point" ADC: maximizes dynamic range for given resolution

Available QIE versions:

Version	User	Design Bucket Rate	Quantity Available	Comment
QIE5	KTeV	53 MHz	oodles	Off-chip ADC, complex control, 32-event buffer
QIE6	CDF	7.6 MHz	hardly any	Off-chip ADC, charge loss for pulses straddling bucket boundary
QIE7	MINOS	53 MHz	hardly any	Off-chip ADC, awkward operating voltages
QIE8	CMS	40 MHz	some	Could make more (\approx \$50k/run)
QIE9	“BTeV”	7.6 MHz	some	Could make more (\approx \$50k/run)

Example:

- CMS QIE outputs 7 bits per time 25-ns slice (2 bits range, 5 bits mantissa) with piecewise-linear ADC characteristic giving (high-range) quantization error < 2%

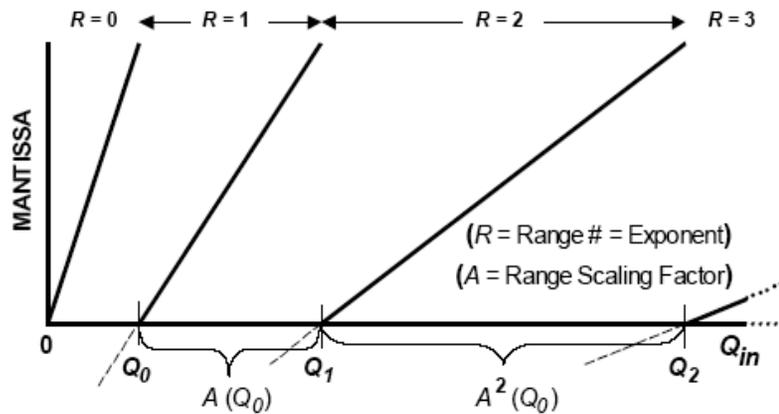


Fig. 2. QIE modified floating point charge transfer characteristic.

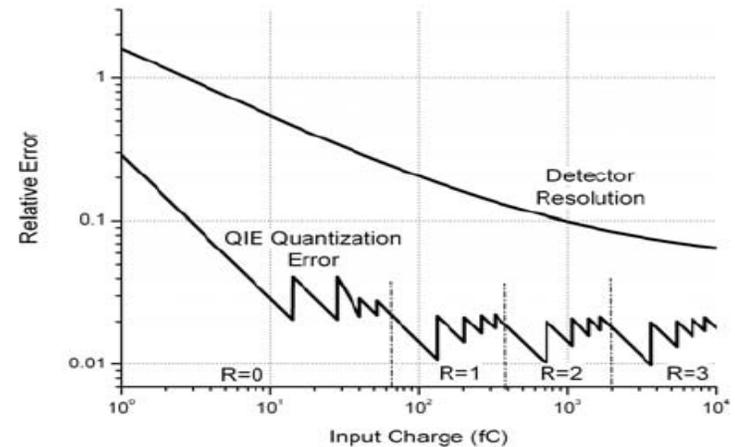


Fig. 5. Detector resolution and QIE chip quantization error

- Least count 2.6 fC, max charge 26 pC \Rightarrow dynamic range 10,000:1 (\approx 13-bits equiv.)
- If zero-suppress, need additional \approx 8 bits to indicate PMT #
- Could buffer 1000 slices using e.g. Cypress CY7C4221V 1k x 9 15-ns FIFO or CY7C4231V 2k x 9 15-ns FIFO ($< \approx$ \$15 ea in 100s)

Some References:

CMS QIE website: http://www-ppd.fnal.gov/tshaw.myweb/CMS_ASIC_new.htm

T. Zimmerman & J. R. Hoff, “The design of a charge integrating, modified floating point ADC chip,” FERMILAB-PUB-03-210, IEEE J. Solid State Circuits **39**, 895-905 (2004); avail. from <http://www-spires.fnal.gov/spires/find/hep?key=5646448>

R. J. Yarema *et al.*, “A high speed, wide dynamic range digitizer circuit for photomultiplier tubes,” FERMILAB-TM-1895, Nucl. Instrum. Meth. A **360**, 150-152 (1995).