(Very) Brief Report on Best Observed Qweak BCM (Beam Charge Monitor) Resolution

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- Over the course of its two year run, Qweak ran with up to six total BCMs; two hooked up to "all-analog" electronics and four hooked up to digital electronics. Both sets of electronics underwent some changes during the run.

- A more full "lessons-learned" report on the Qweak BCM experience will be prepared in the future to help MOLLER BCM R&D planning

- This brief report only reports on the "best-observed" BCM resolution during Qweak and compares it to the MOLLER goal for BCM resolution.

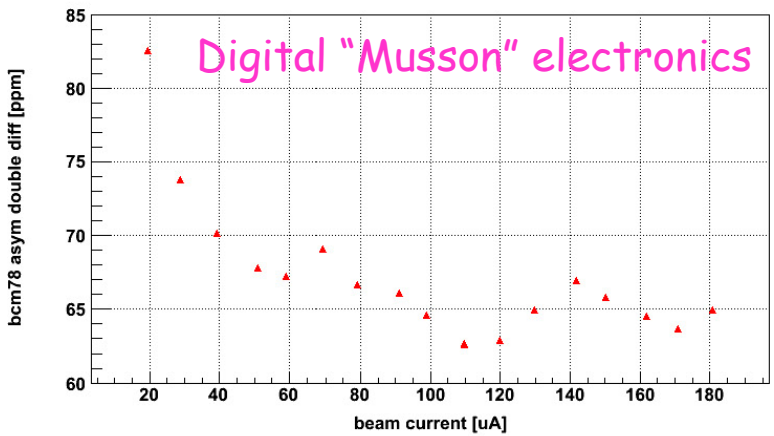
Update on July 26, 2012: Next three slides are same as June followed by new measurement Ramesh Subedi did to determine where "noise floor" is and whether further bench studies with RF signal sources are worth pursuing.

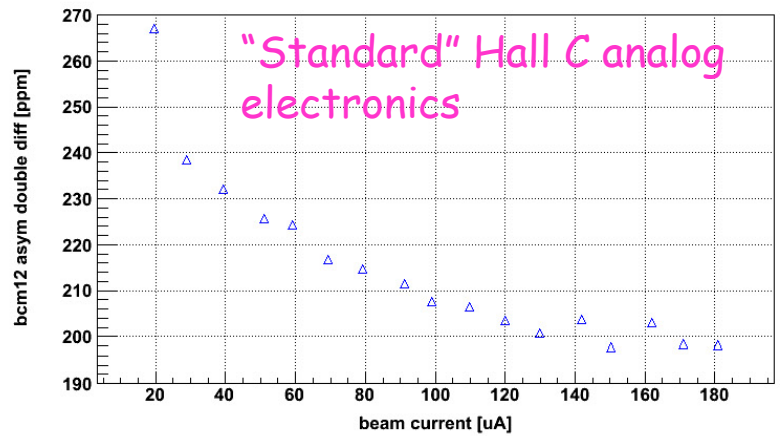
Qweak – BCM "double differences" versus beam current

Charge asymmetry $A_Q = (Q_+ - Q_-)/(Q_+ + Q_-)$:actually data below is for quartets

Monitor resolution is determined by comparing the charge asymmetry from nearby monitors with a "double difference" ($A_{Q1} - A_{Q2}$) plot – gives the uncorrelated noise.

BCM double-differences versus beam current at standard Qweak data-taking rate (960 Hz data samples; 240 Hz quartets)





plots courtesy of Ramesh Subedi

→ Best performance ~ 65 ppm, independent of beam current from ~ 80 – 180 μA

Other conclusions:

- the digital electronics performed better
- both sets of electronics seems to hit a "noise floor" that was independent of beam current at >~ 80 μA

Comparison of Best Case Qweak BCM Resolution to MOLLER Goal

For a single BCM, resolution (@ 250 Hz quartets):
$\sigma(A_{Q1})$ *or* $\sigma(A_{Q2})$
$= \sigma(A_{Q1} - A_{Q2})/\sqrt{2} =$ 65 ppm/ $\sqrt{2}$ ~ 46 ppm

Assume worst case "white noise" estimate to extrapolate to 1 kHz pairs:

46 ppm x $\sqrt{2}$ ~ 65 ppm

MOLLER goal is ~ 10 ppm to keep the contribution small compared to the MOLLER expected statistical width of ~ 83 ppm/pair for 1 kHz pairs

Possible Near Term R&D Program

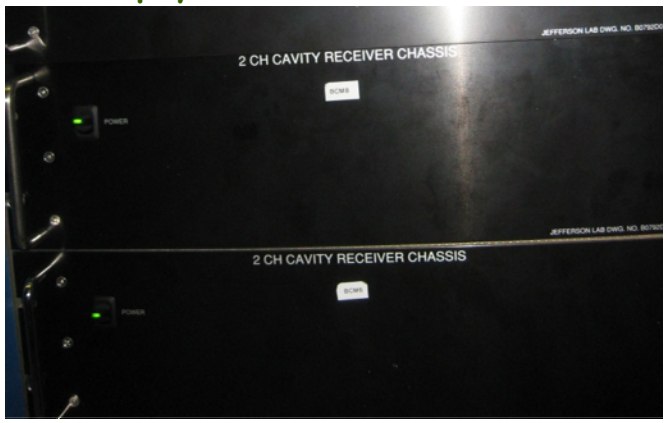
- The insensitivity of the best observed BCM double difference to beam current indicates that attempts to boost the signal (ie. like upgraded copper cavities) seem unlikely to overcome the apparent noise floor.

- In the near-term, we can do studies to see if the apparent 65 ppm "noise floor" is intrinsic to the cavity receiver electronics

Update on July 26, 2012: next slide shows new measurement with update on this

- Possible plan:
  - Move two of the cavity receiver electronics units to the intended Qweak "simple" DAQ test stand (one 8 channel Triumf ADC) in EEL
  - Use the existing 1497 MHz rf signal source with splitter to drive the electronics and look at double differences versus signal level and sampling frequency

(Note: Each cavity receiver has its own local oscillator, so perhaps some of what we are seeing is simply local oscillator noise).

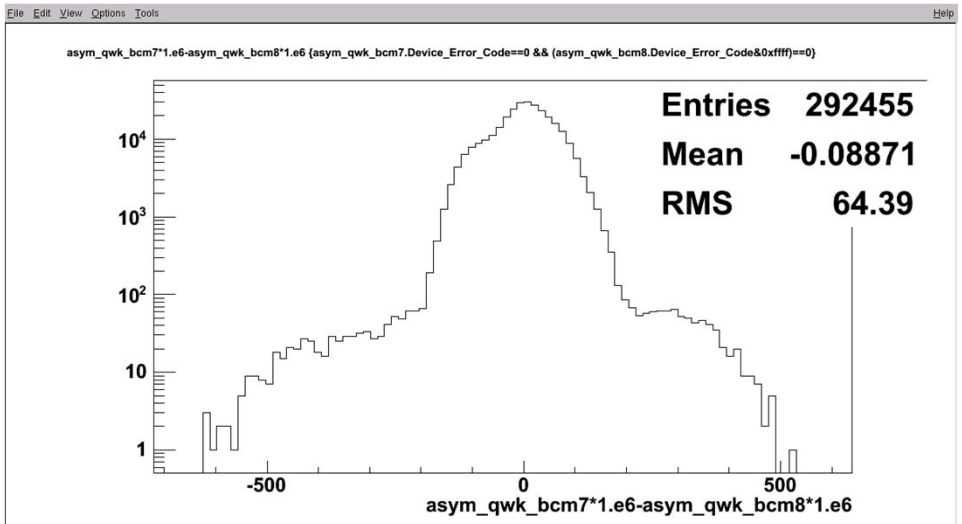


"Noise Floor" of Digital BCM Electronics with RF source

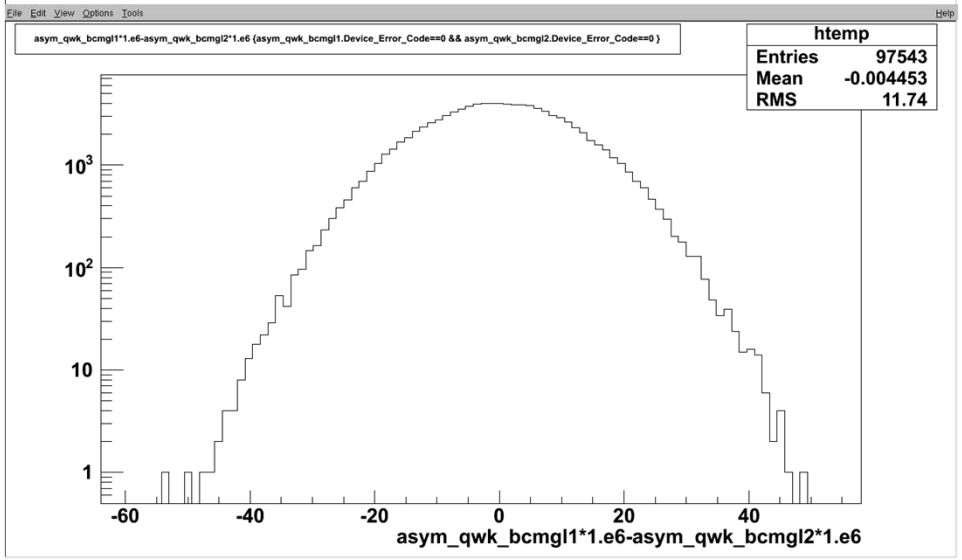
After our last meeting, Ramesh Subedi did measurements with

- 1497 MHz RF source directly in our "usual configuration" (1 signal per box; ie. different local oscillator in each case)
- 1497 MHz RF source into two separate channels of 1 box (ie. local oscillator is common to each)

Double difference for "usual" configuration with RF source:
~ 64 ppm → same as we observe with beam; ie. this noise floor appears not to be coming from the BCM physical hardware or signal delivery cables



Double difference for "special" configuration with RF source into two channels of single box:
~ 12 ppm → consistent with "local oscillator noise" dominating the "usual" measurement



Update (July 2012) on BCM R&D Plans

Basic conclusion of Ramesh's short measurement is that we can reproduce the BCM double difference observed with beam by using an RF signal source

So there is a credible R&D program that can be pursued with just an RF source to understand what limits the resolution and what electronics configuration minimizes it.

The BCM digital receiver modules (and associated cabling and RF signal source) have been moved from the Hall C counting house – about to undergo renovations – to the EEL building where Qweak will have a small DAQ teststand with one 8 channel Qweak-style ADC and appropriate helicity triggering.