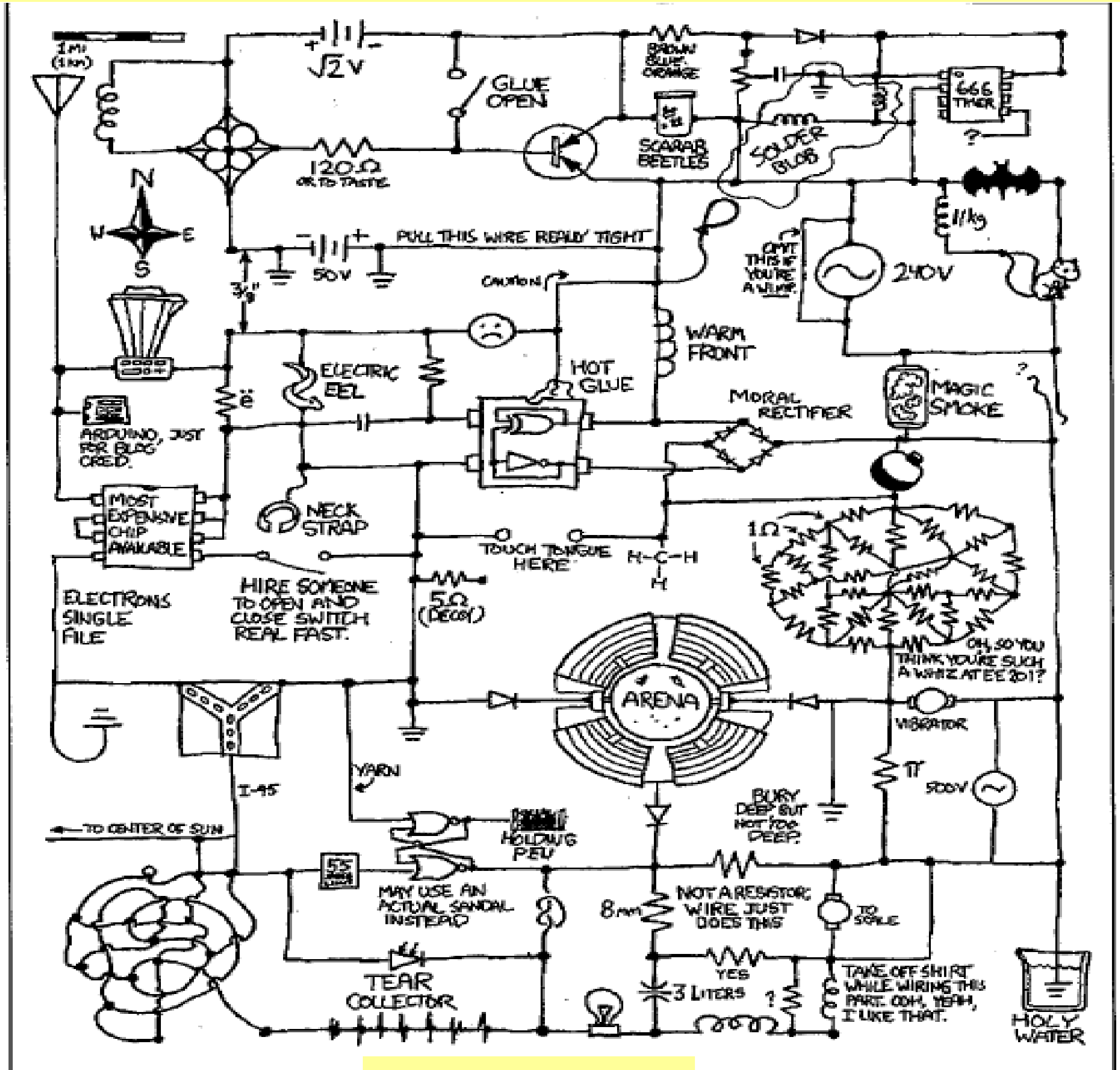
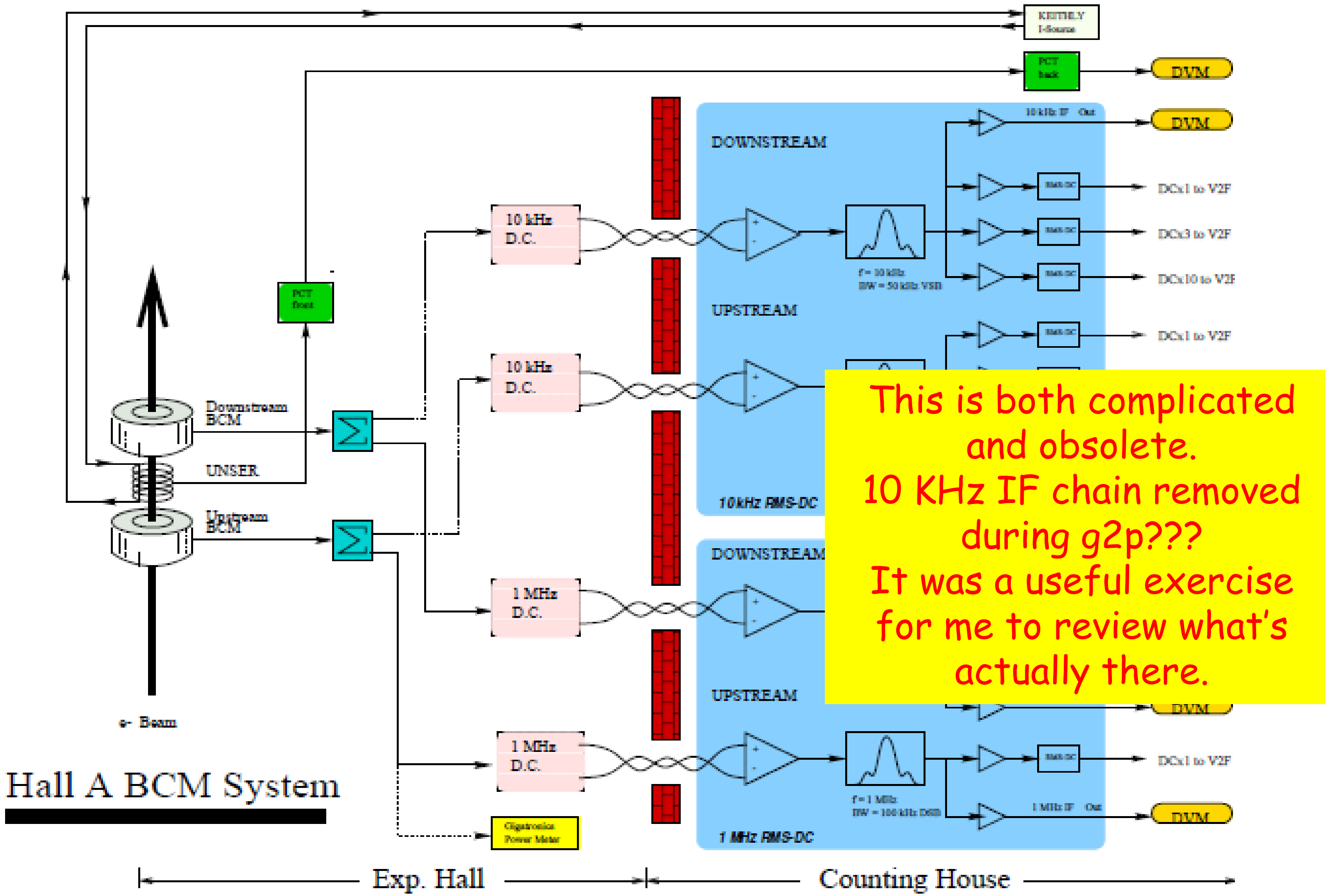
Hall A Beam Current Monitoring Infrastructure



Dave Mack

July 21, 2015

Hallaweb.jlab.org/github/halla-osp/version/Standard-Equipment-Manual.pdf



This is both complicated and obsolete.
10 KHz IF chain removed during g2p???
It was a useful exercise for me to review what's actually there.

Figure 3.1: Schematic of the Hall A beam current measurement system.

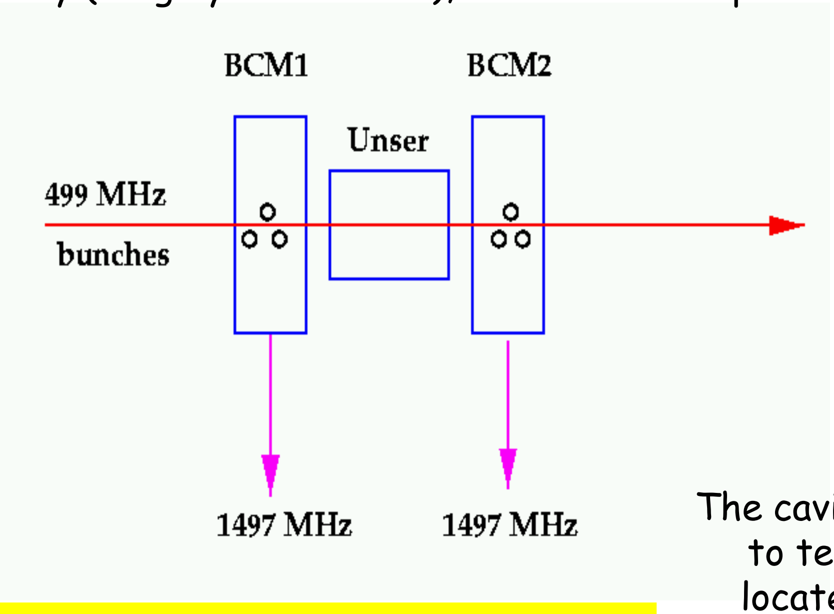
System Overview

Two key types of non-intercepting transducers:

1. Resonant cavity monitors (pill-box, $TM_{010,}$ Q value ~ 1500??) –
   very high S/N,
   but unfeasible to dead-reckon an accurate calibration with RF at 1497 MHz

2. Unser monitor (Parametric Current Transformer) –
   extremely stable gain,
   but relatively noisy (roughly 1 muA/√Hz), and offset has poor long term stability

Fast Raster



Target

The cavities and Unser are sensitive to temperature change, so are located inside an insulating box regulated at 110F.

With beam threading both cavities and Unser, absolute current knowledge can be transferred from the Unser to the cavities.

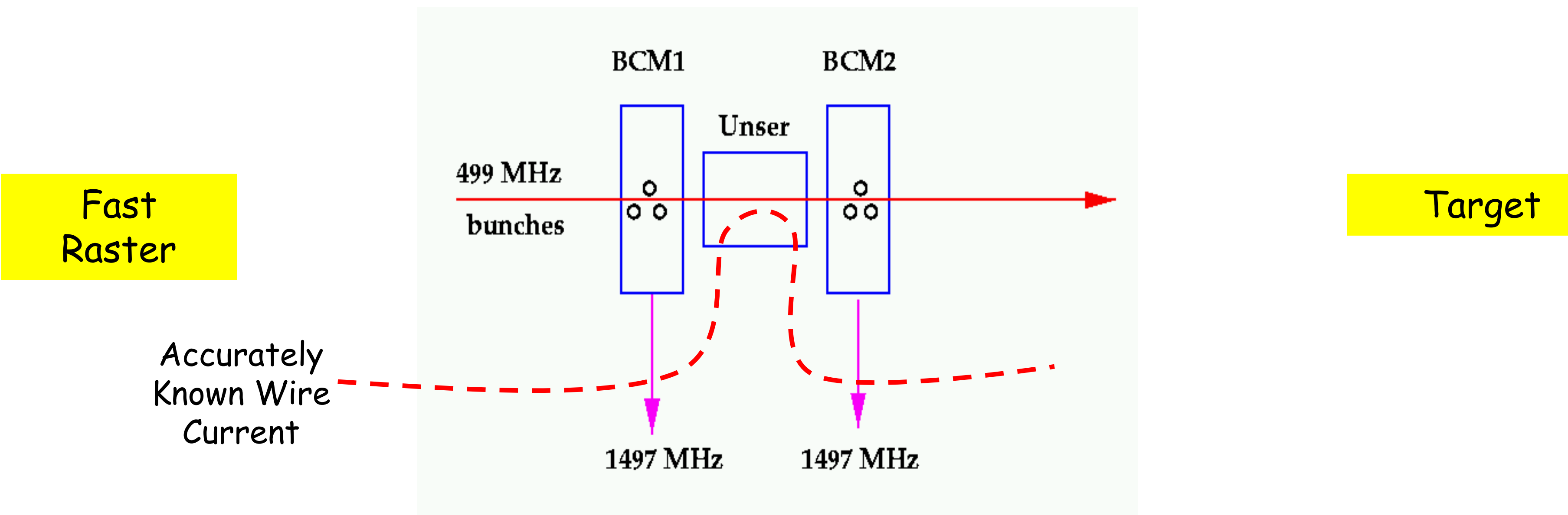
Unser

Determines absolute effective Unser for calibration of cavities.

(The relatively noisy Unser signal is then generally ignored until the next calibration.)

We measure the gain of the entire electronics chain (Unser+V/F+gated scalers) in a so-called "Unser wire calibration" by passing an accurately known current thru a wire.

The Unser gain is stable and accurate to 0.1% (4 mV/muA), but it's the entire chain that matters.



The **Keithley 224 programmable** current reference was checked against two precision meters. We concluded the set current of 30 muA is probably systematically higher than truth by ~0.1% .

(See halog https://logbooks.jlab.org/entry/3306990 .)

This is within specification, ~20 years after purchase, and can be incorporated into the calibration.

Cavity Monitors

The cavity 1497 MHz signals are split and processed in 3 completely separate electronics:

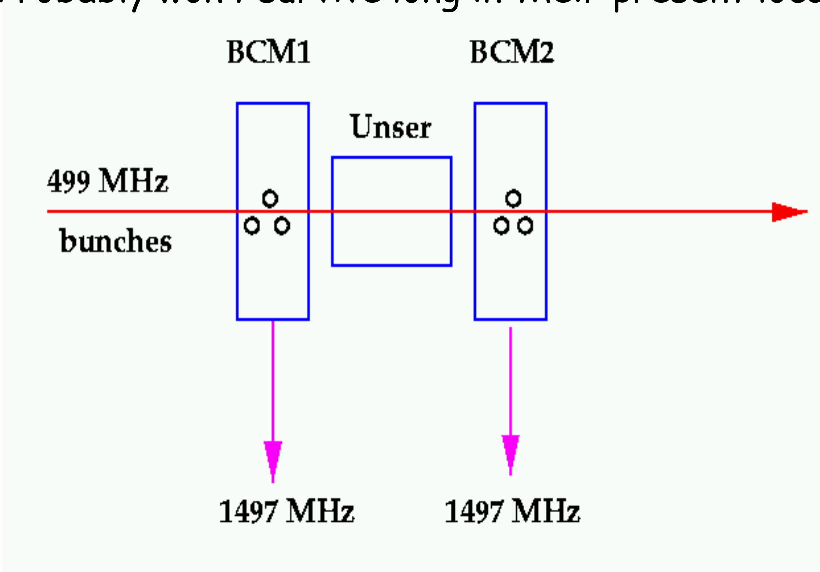
1 MHz IF analog receivers (default Current Monitor for Fall '14-Spring '15):

1) Copies of the up and down-stream IF signals goes to HP3458 digital voltmeters for EPICS.
2) Three separate gain settings are needed to cover a wide dynamic range with high linearity.

3) Digital receivers Luke/Musson R&D (appeared to be working well in Spring '15):

When set up right, can cover a wide dynamic range with high linearity.
Probably won't survive long in their present location.

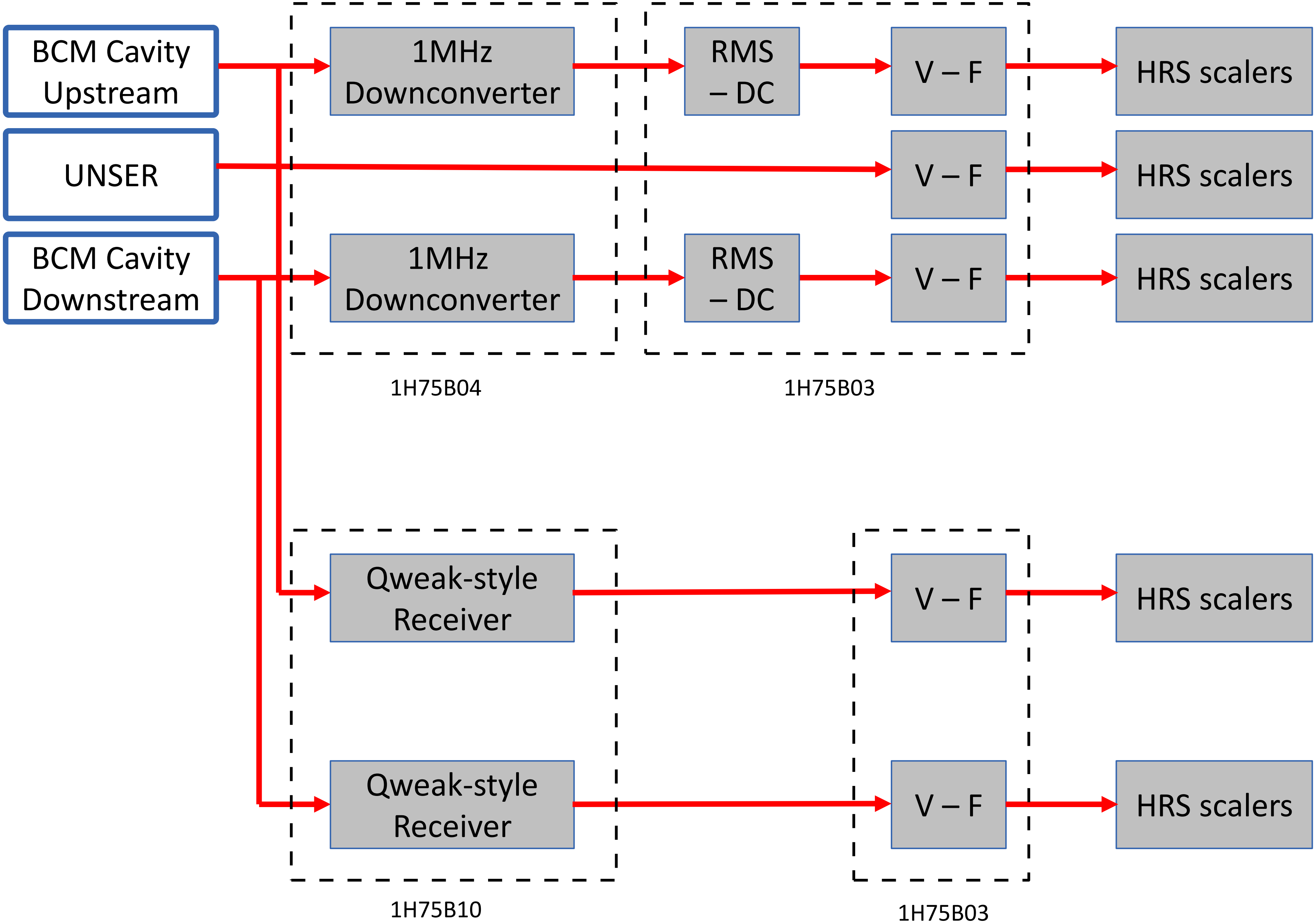
Fast Raster



Target

I'm surprised to find we're using 1 MHz receivers and have dropped the 10 KHz receivers. The analog receivers are linear over a larger dynamic range at lower frequencies, so long ago I switched Hall C to 100 KHz IF, and Denard provided Hall A with 10 KHz IF capability.

However, now that accelerator plays with the MO frequency, a 10 KHz system might be problematic if it is 5 KHz one week, and 15 KHz the next. This is a headache.


BCM Cavity Upstream
UNSER
BCM Cavity Downstream
1MHz Downconverter
1MHz Downconverter
1H75B04
RMS – DC
RMS – DC
V – F
V – F
V – F
1H75B03
HRS scalers
HRS scalers
HRS scalers
Qweak-style Receiver
Qweak-style Receiver
1H75B10
V – F
V – F
1H75B03
HRS scalers
HRS scalers

Thanks, Luke!

Hall A System Improvements

- Put Unser on a UPS so offset doesn't change after small power bumps.
- Get the current source recalibrated?
- Cavity stability factors:

  i. Are the cavities well-tuned? Looks good so far.

  ii. What Q value do the cavities have? How large are residual temperature variations inside insulated box?

- Keep testing the digital receiver system (move rad-soft components to labyrinth?)
- Improve cavity signal splitting hygiene:

  i. any change to digital receiver path (installing an attenuator, tightening a connector, etc) can change both bcm calibrations at % level due to reflections. Install isolators?

  ii. The analog receiver DC output x1 signals are split with a "T" and sent to parity daq.

Hall C System Improvements

- Put BCM1,2 in a well insulated box?

  Hall C was first hall online, so got the beta version.
  The "sweaters" never fit right and are falling apart.

- Buy a current source

  Our "Meekins" current reference vanished during the first year of digital receiver commissioning in Qweak

Acknowledgements

Luke, Thir, Eric, Alexander …

Extras

Charge

We normalize to charge, not current. We must integrate the current to get charge.

A beautiful solution: Signal Voltage → Frequency → Scalers

With scalers gated by run DAQ, there's minimal ambiguity in when to cut off the integral $Q = \int I \, dt$.

We don't even need to know scaler gate width if there's a clock going into the same scaler bank. Hall A uses a WTF reference frequency of 103.8 KHz.

The true gate width is

Gate width (sec) = clock counts/103,800

Thus

BCM scaler rate (Hz) = BCM counts/Gate Width(sec)