HAWC Calibration: Near Term Goals

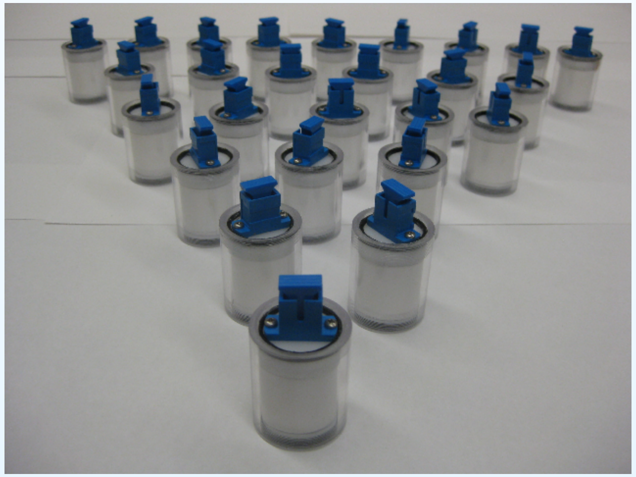
John A.J. Matthews

johnm@phys.unm.edu

University of New Mexico

Albuquerque, NM 87131

Calibration system: *Recent Progress (I)*

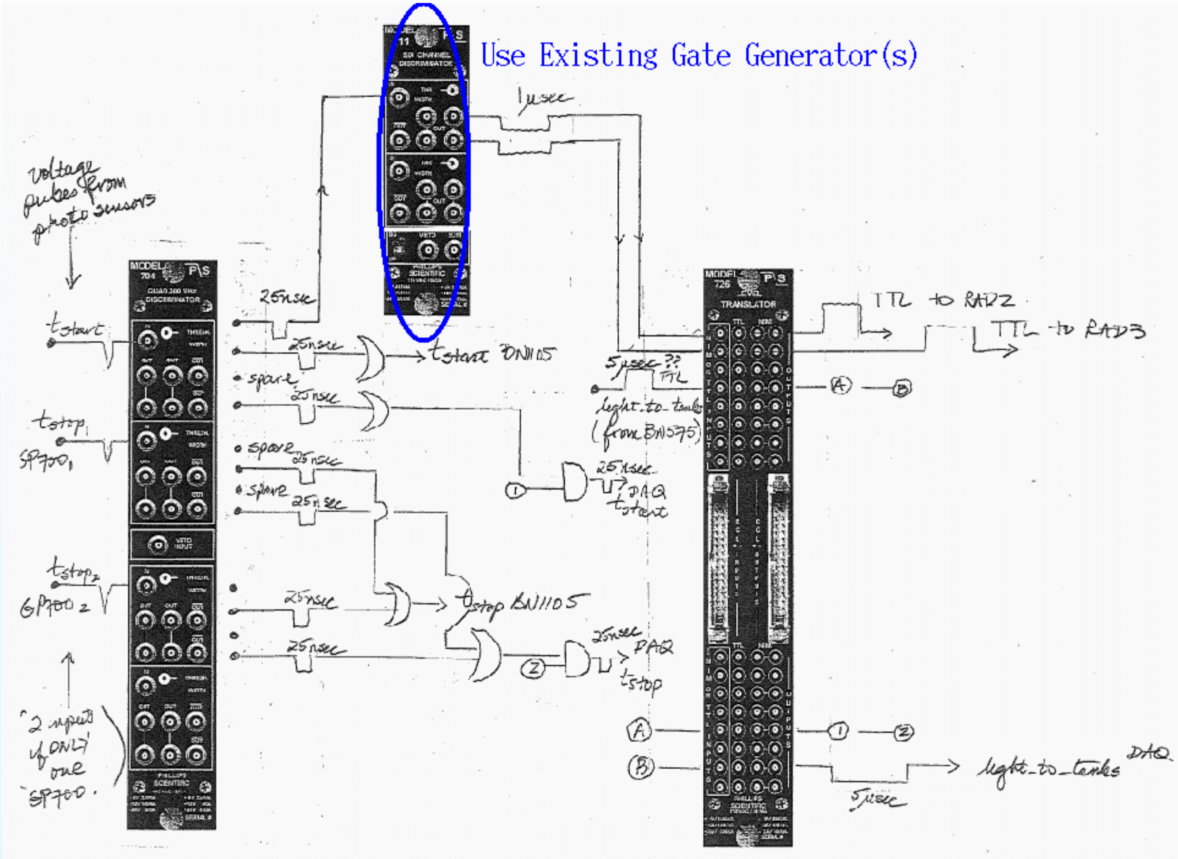


The near term goals from the Madison meeting included:

- Upgrade the calibration systems at CSU and at MTU:
  1. to incorporate minor design changes based on CSU/MTU studies
  2. to have two *identical* systems: one of which will be shipped to the HAWC site
- Address outstanding issues:
  1. length, and fiber count, for the long (~ 550') *distribution* fibers
  2. excess fiber storage (for the long *distribution* fibers)
- Order, and/or fabricate, parts for HAWC30
- Upgrade the CSU control system: computer and software to match what will be at the HAWC site
- *Then continue calibration control software development and tank calibration studies at CSU ...*

This list is essentially done!

Calibration system: *Recent Progress (II)*



- Select NIM logic modules for t^{DAQ}_{start}, t^{DAQ}_{stop} and $light - to - tanks^{DAQ}$ signals:
  1. Use modern (Phillips Scientific) discriminator (704) and level conversion (726) modules.
  2. Start with existing *AND*, *OR* and gate generators for other functions ...

The University of New Mexico

Calibration system: *Near Term Studies (I)*

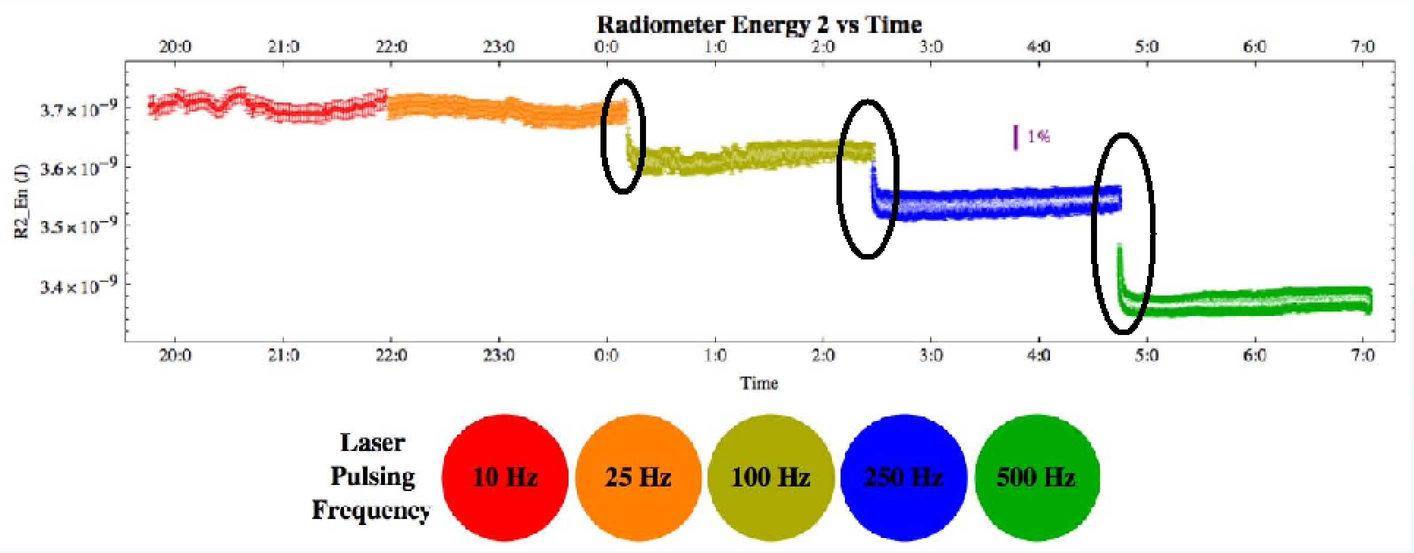
SPECIFICATIONS

Spectral response (see curve)	180 - 1100 nm
Maximum total energy	250 nJ
Maximum energy density	1.25 μJ/cm²
Max. peak pulse power density *(30 ns pulse)*	100 mW/cm²
Max. average power density	5.0 mW/cm²
Minimum detectable energy	500 fJ
Maximum pulse rep rate	500 Hz (2 kHz available)
Maximum pulse width	50 μsec
Calibration accuracy	±5%
Linearity	±0.5%
Detector active area dimensions	10 x 10 mm (1.0 cm²)
Full scale ranges	6; 3 pJ - 300 nJ
Head dimensions (dia x depth)	6.0 cm x 4.6 cm (2.4" x 1.8")
Preamplifier dimensions (l x w x h)	11.5 cm x 7.7 cm x 5.1 cm (4.5" x 3.0" x 2.0")
Probe weight (head and preamp)	0.5 kg (1.0 lb)

- The $ToT \rightarrow n_{PE}$ calibration needs a reliable measurement of the light intensity to the tanks.
- The HAWC calibration system uses commercial (Laser Probe) radiometers and RjP-765 silicon light sensors.
- For various reasons: ultra-short laser light pulses and large dynamic range ($\lesssim 0.1$PE to $\sim 10^4$PE), we are stretching the nominal specifications of the RjP-765 silicon light sensor.
- Thus studies are needed to confirm (and possible to calibrate) the radiometer over the parameter space for HAWC.

Calibration system: *Near Term Studies (II)*

The University of New Mexico



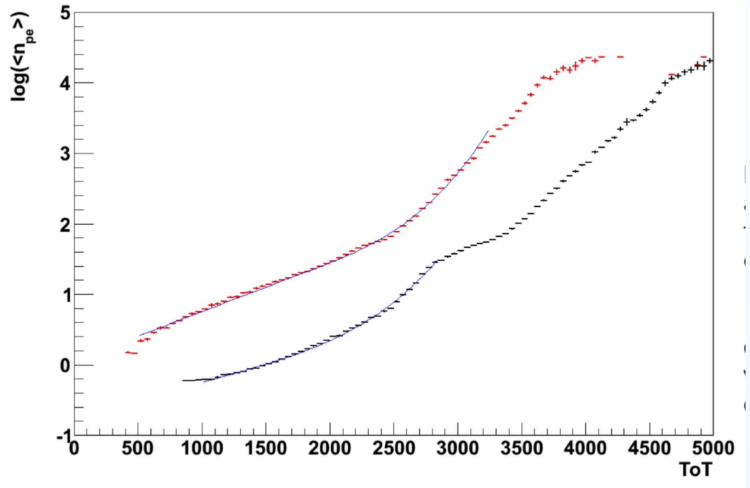
- Optimize the PMT calibration:
  1. Which filter wheel (FW) settings: *e.g.* for $ToT \rightarrow n_{PE}$ are 10 measurements per decade in $\log_{10}(n_{PE})$ sufficient, *e.g.* for time slewing is one measurement per 10 nsec in ToT sufficient and over what range of ToT, *e.g.* do we double this for different light levels at A,B,D PMTs *vs* the central C PMT?
  2. Number of light pulses *vs* FW setting ... likely not a constant value.
  3. Light pulses/radiometer readout (to follow the time dependence of the laser intensity ... see figure above).

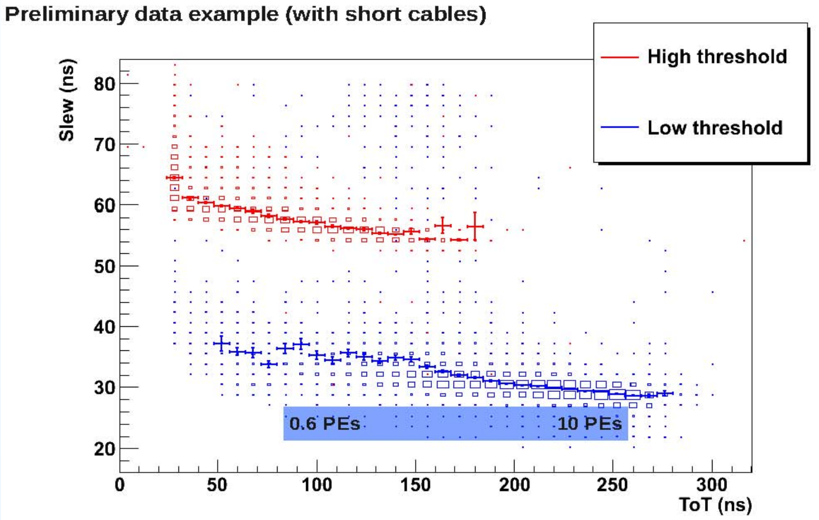
Calibration system: *Near Term Studies (III)*

The University of New Mexico

- Optimize the *round trip timing* calibration:
  1. Recall that each light path to the tanks includes 2 additional fibers to allow us to monitor the light transit times
  2. The *round trip time* is the difference between the t_{stop} and t_{start} (NIM level) signals
  3. This is digitized by a dedicated BN1105 *universal frequency counter* and by the HAWC DAQ
  4. It is now time to integrate this measurement into the (default) calibration control software and to compare: $t_{stop} - t_{start}$ with $t^{DAQ}_{stop} - t^{DAQ}_{start}$

HAWC calibration: *Intermediate Term (I)*



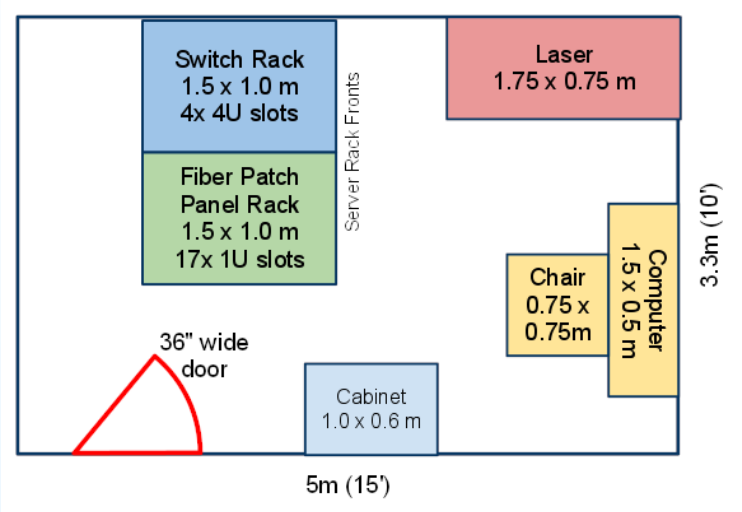


Stabilize the calibration analysis software using the CSU data:

- The calibration *deliverables* include:
  1. (Top Left) Relation between what HAWC measures: PMT ToT and the PMT signal in PEs (n_{PE}).
  2. (Top Right) Time slewing correction (nsec) *vs* the measured PMT signal in ToT. Should we also record the RMS width of this correction *vs* ToT?

Prepare figures and tables for a *NIM* paper.

HAWC calibration: *Intermediate Term (II)*



Begin installation at the HAWC site:

- The calibration room:
  1. The calibration room is much smaller than in our original plan ...
  2. There are many components: will they all get to the site when needed ...
- Fiber routing to the HAWC tanks:
  1. The fiber cable routing needs to be *mouse proof* ...
  2. Details for routing the ~ 550' distribution cables into the calibration room need to be finalized ...