HAWC Optical Calibration: 900 → 300 Tanks

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Calibration system: baseline design

The HAWC array is now composed of 150 tank-pairs:

- As before we propose:
  1. two, identical laser sources: each source calibrates $\sim 1/2$ tanks
  2. lasers are coupled to optical fibers w/ beam expanders and 1:n fiber splitters

- What has changed is:
  1. one duplex optical fiber now goes to each tank-pair providing the calibration light to those tanks and 2-times the light path to monitor the end-to-end propagation time.
  2. at each tank-pair light is now split (only) 7-ways: 3 fibers to each tank and 1 fiber to provide the end-to-end time monitor.
  3. much shorter, $\sim 15$m long, optical fibers go from the 1:7 splitters to a diffuser near each PMT.
Calibration system: laser source (I)

- What has changed is:
  1. time synchronization between the two (independent) laser sources now uses a PMT to define a $t_0$ ... that must be input to the HAWC DAQ.
  2. a beam shutter (in each laser source) ensures that calibration light comes from only one of the lasers (at any given time).
  3. a 1500 grit diffuser results in a more-uniform speckle pattern
Laser beam profile with 10x beam expander:

1. a 1:91 optical fiber splitter (with 62.5\(\mu\)/125\(\mu\) optical fibers) occupies \(\sim \pm 0.75\)mm

2. thus most (outgoing) signals should be within \(\sim \pm 10\%\) in intensity.
• Possible calibration control computer:
  1. the Mac Mini can now be obtained with solid state disk drive
  2. a conventional Mac Mini computer (running UNIX) has been used to control one of the Auger FD relative calibration systems for ~18 months without problems.
Mechanical adjustment of fiber intensity (or coupling into 1:n splitters):

1. it is desirable for the return (end-to-end timing) signals to be relatively similar in amplitude.

2. while fine control is difficult, mechanical separation of the fibers at a ST:ST coupler allows the transmitted intensity to be varied by $\sim 10 \times$ per fiber ...
Calibration system: continuing issues

- What is the fiber to fiber uniformity and fiber (output) light intensity for field distribution options:
  - 1:7 optical fiber splitters, 62.5 μm fibers, and one diffuser per PMT
    1. advantage is that the diffuser can be as close as needed to the PMT; the design goal is a maximum signal of $\sim 10^4$ PEs
    2. a possible dis-advantage is that there is one fiber per PMT VS one fiber per tank
  - 1:3 optical fiber splitters, 200 μm fibers, and one diffuser per tank
    1. an advantage is that the larger fibers have smaller fiber to intensity variations
    2. the dis-advantage is that the diffuser must be $\gtrsim 2$ m from the PMTs; thus the PMT solid angle at the diffuser is small!
    3. it is unclear whether one diffuser/tank is a plus or minus in regards placement and tethering issues ...

- Or can we gain a significant ($>> 2 \times$) increase in intensity with a different laser?
Calibration system: summary/conclusions

- Continuing progress ...

- Nevertheless several ongoing studies ...

- Focus on few-tank prototype array is critical to help resolve the next set of issues ...