HAWC Optical Calibration: $900 \longrightarrow 300$ Tanks

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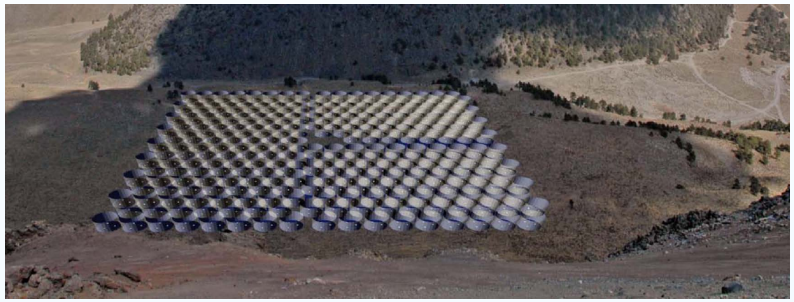
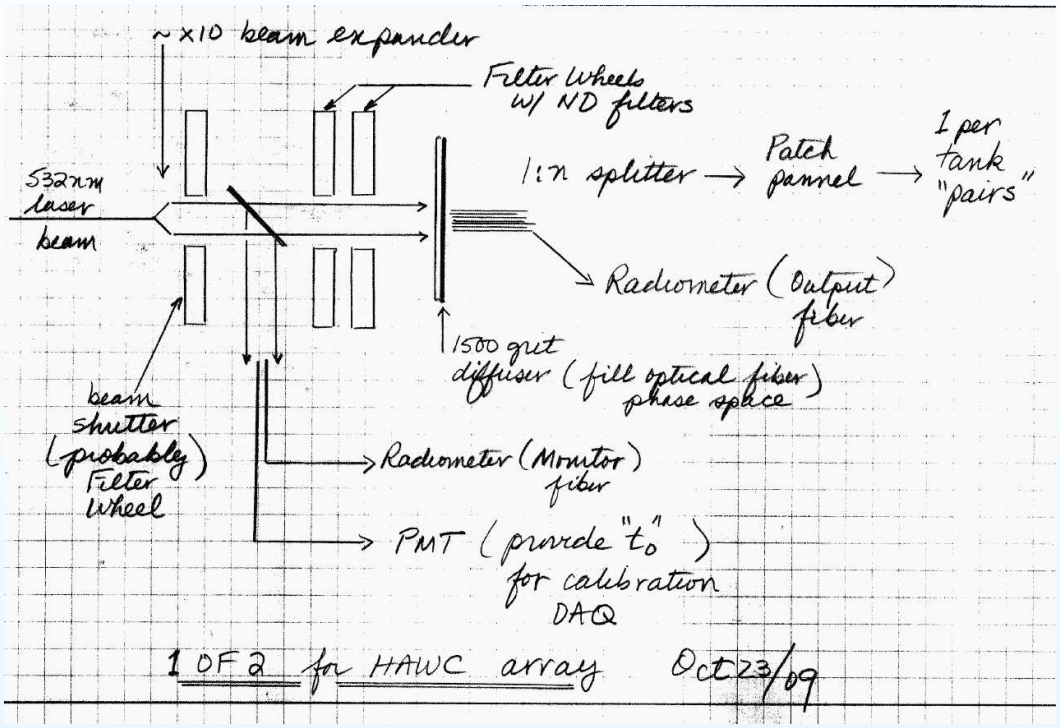
Calibration system: *baseline design*



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

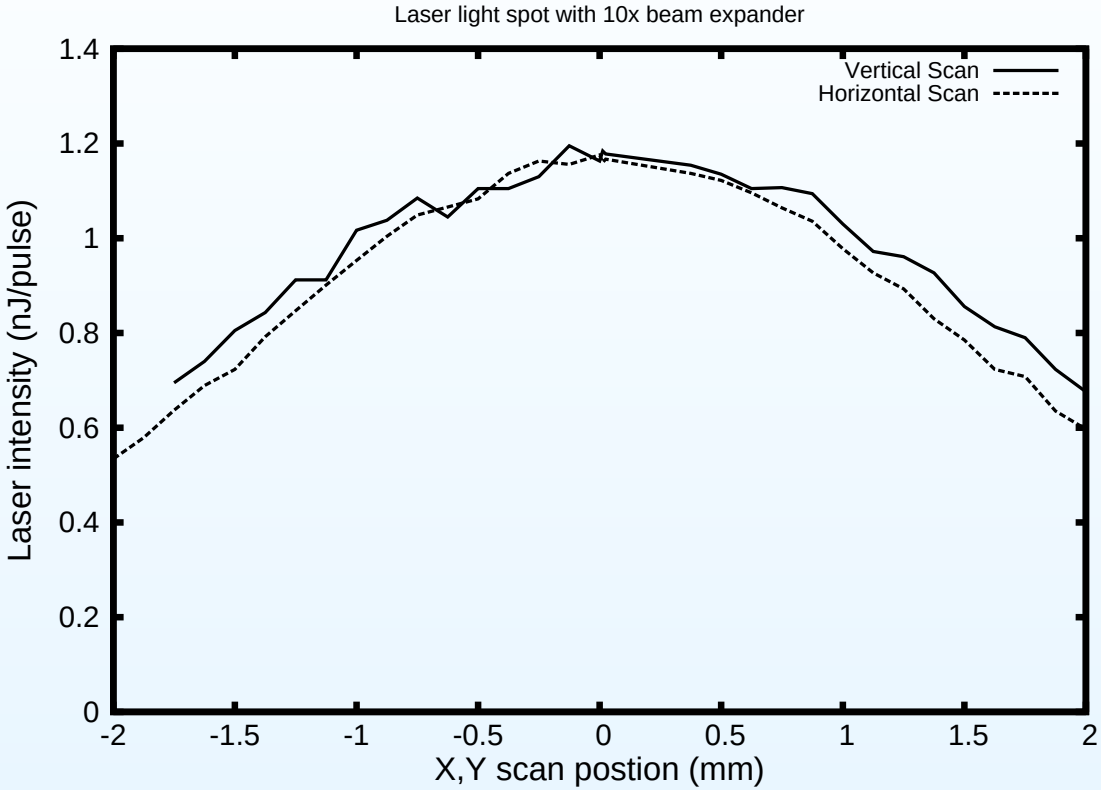
- As before we propose:
  1. two, identical laser sources: each source calibrates $\sim 1/2$ tanks
  2. lasers are coupled to optical fibers w/ beam expanders and 1:n fiber splitters
- What has changed is:
  1. one duplex optical fiber now goes to each tank-pair providing the calibration light to those 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, ~ 15m long, optical fibers go from the 1:7 splitters to a *diffuser* near each PMT.

Calibration system: *laser source (I)*



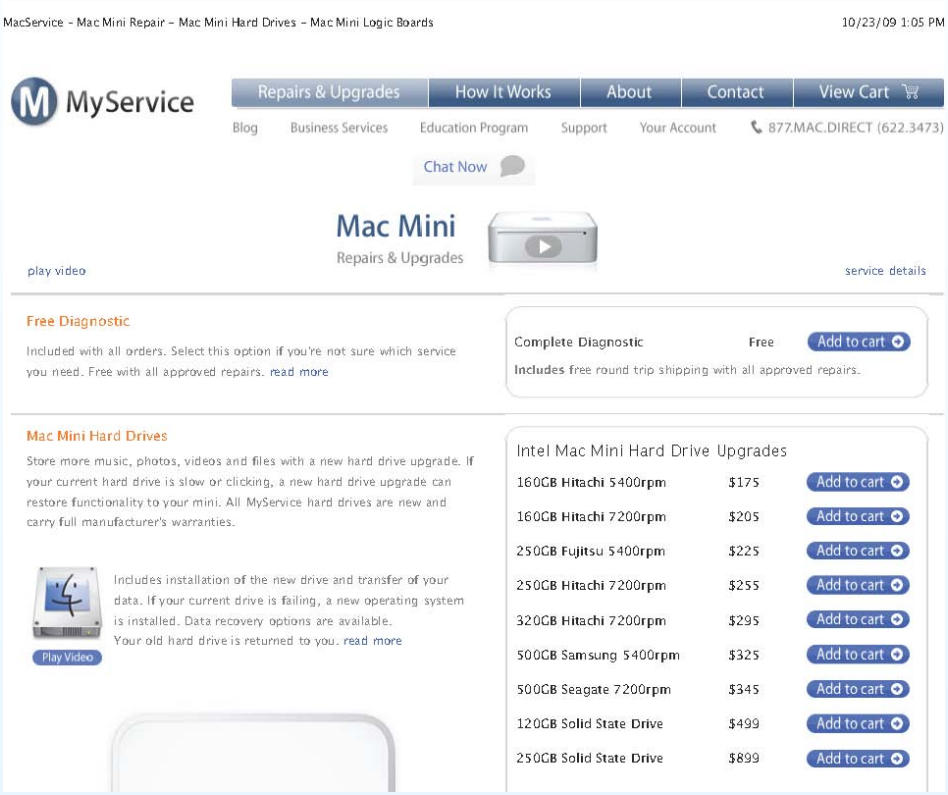
- What has changed is:
  1. time synchronization between the two (independent) laser sources now uses a PMT to define a t_0 ... that must be input to the HAWC DAQ.
  2. a beam shutter (in each laser source) ensures that calibration light comes from only one of the lasers (at any given time).
  3. a 1500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

Calibration system: *laser source (II)*



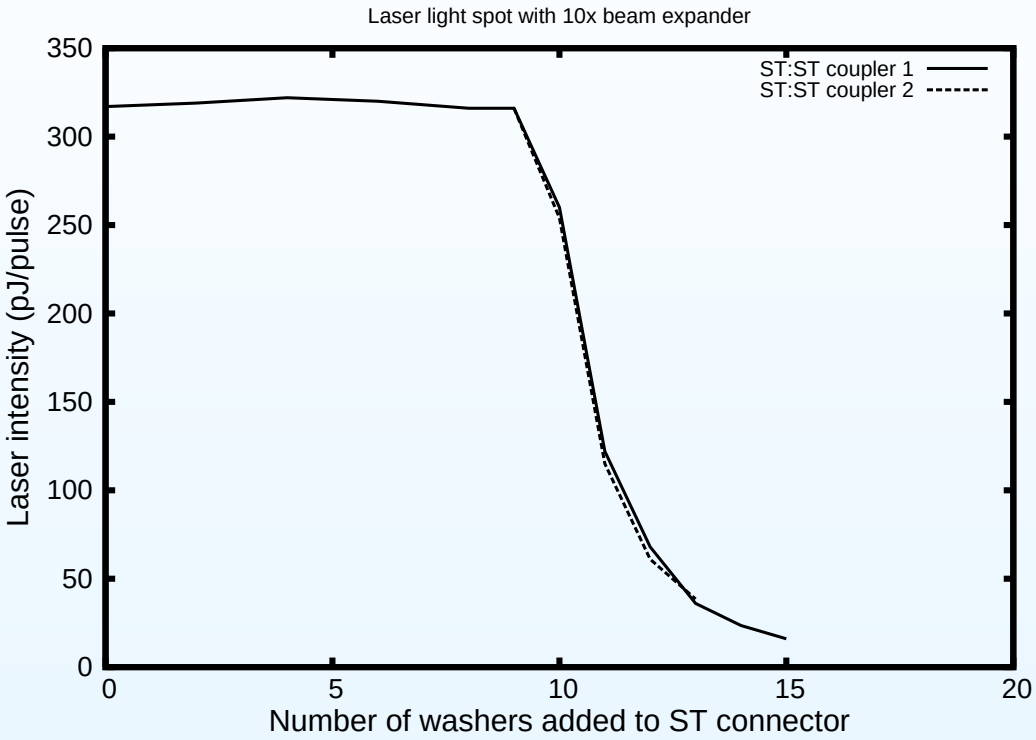
- Laser beam profile with 10x beam expander:
  1. a 1:91 optical fiber splitter (with 62.5μ/125μ optical fibers) occupies $\sim \pm 0.75$mm
  2. thus most (outgoing) signals should be within $\sim \pm 10\%$ in intensity.

Calibration system: *laser source (III)*



- 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.

Calibration system: *other studies*



- 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*

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- What is the fi ber to fi ber uniformity and fi ber (output) light intensity for fi eld distribution options:
  - 1:7 optical fiber splitters, 62.5μm 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, 200μm 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 signifi cant ($>> 2\times$) increase in intensity with a different laser?

Calibration system: *summary/conclusions*

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- Continuing progress ...
- Nevertheless several ongoing studies ...
- Focus on few-tank prototype array is critical to help resolve the next set of issues ...