# HAWC Optical Calibration: ... getting serious!

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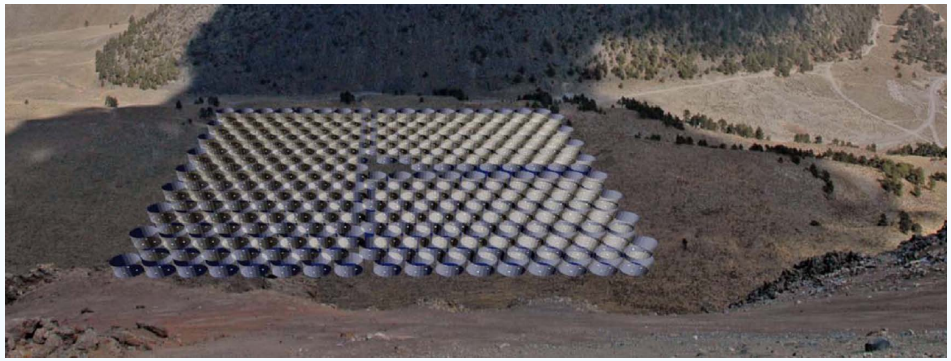
# Calibration system: *baseline design*



The HAWC array is composed of 150 tank-pairs:

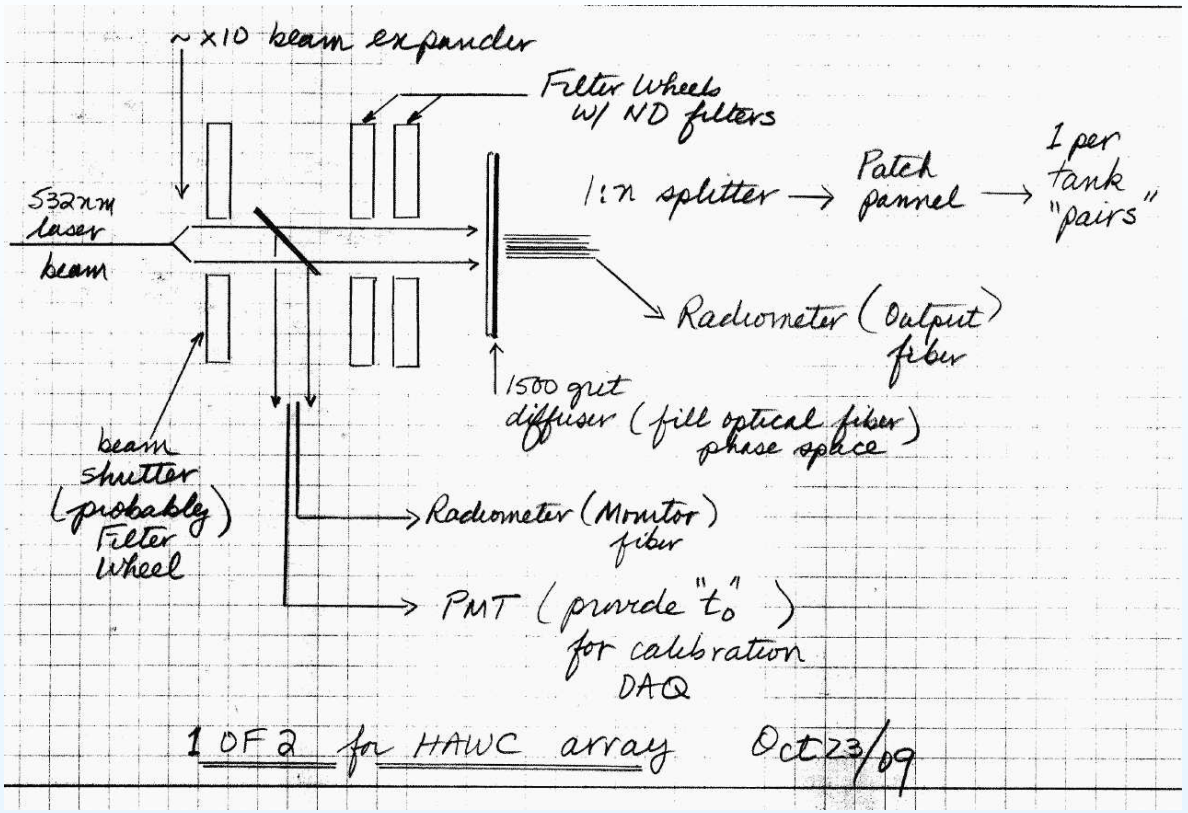
- We had proposed:
  1. two, identical laser sources: each source calibrates $\sim 1/2$ tanks
  2. lasers are coupled to optical fibers w/ beam expanders and passive 1:n fiber splitters
- What has changed is:
  1. Brenda had concerns with pulsing half of the 900 PMTs (with any given calibration pulse) particularly at the highest light levels: $\sim 10^4$ PE/PMT
  2. Milagro used optical switches: could HAWC benefit from this technology?
  3. twenty 1:10 *high efficiency* splitters are available (from Milagro)

# Calibration system: *revised design*

Proposed *new* design:

1. use only one (not two) lasers ... saving ∼$25k
2. use DiCon 532nm, MEMS, optical switches:
   - three 1:4 switches fit into a (1-wide) module ... [in GP750 crates]
   - couple three switch outputs to 1:10 splitters and one is blank (off)
   - then 150 outputs require: 150/(10 x 3 x 3) = 1 2/3 switch modules
   - DiCon GP750 crate plus 2 modules ∼$22k ... a wash!
3. (with at least one switch on) we can pulse from 1/15 to 1/3 of the array (on any given laser pulse) ... but light intensities not yet measured!

# Calibration system: *laser source*

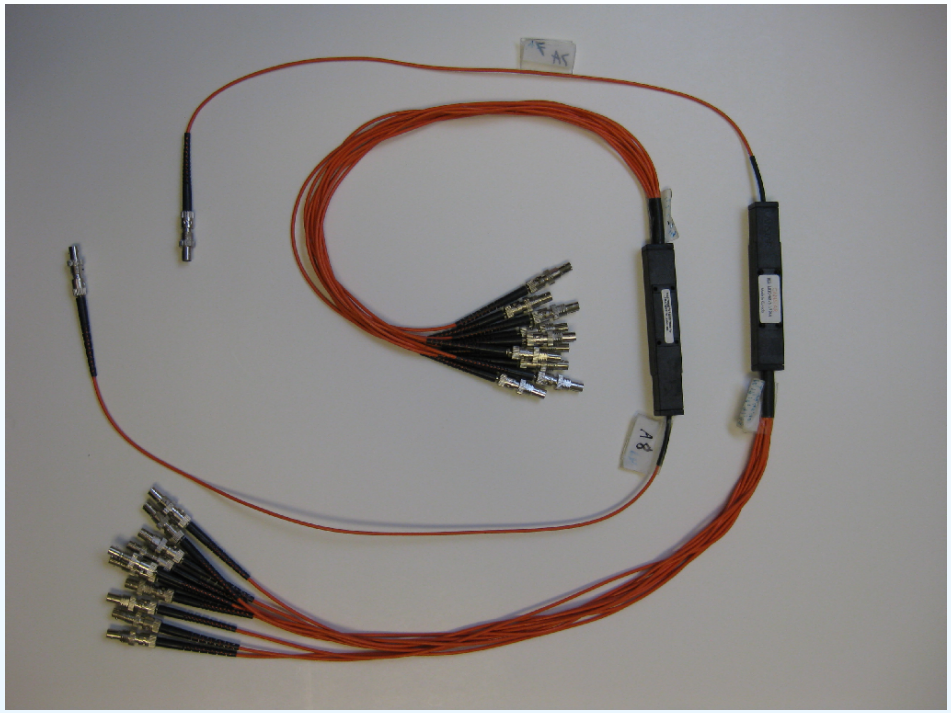



- Most of this figure is unchanged but:
  1. now only one source ... so sketch is 1 of 1
  2. 1:n splitter is now a much simpler (and smaller) 1:7 splitter; so probably change to $\times 3$ beam expander
  3. two filter wheels with $\sim 4$ intensities/decade and $\sim 5$ decades of intensity

# Calibration system: *fiber time stability*

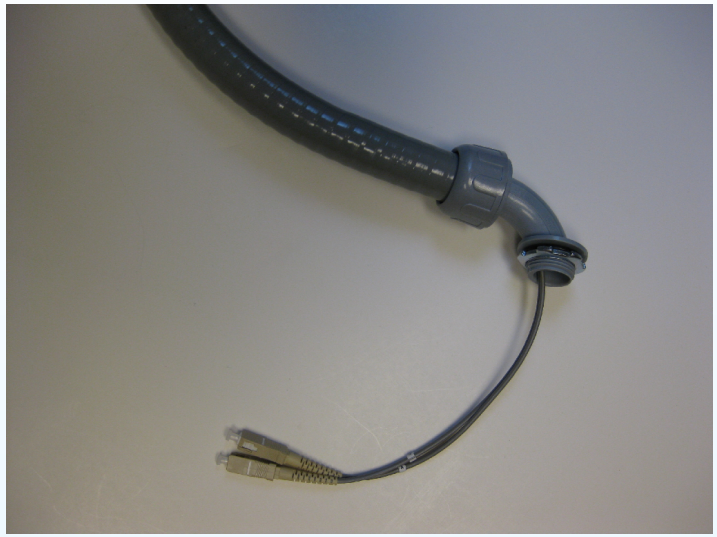

- Use round trip time to monitor time stability of light pulses
- Our initial plan was to divide the array into quarters and add fiber delays to multiplex the (then) $\sim$ 15 fibers/quarter of array ... so 4-FADC channels needed!
- But now there are 150 fibers to monitor!
- We have one DiCon GP700 crate with 1:64 optical switches from Milagro
- Three such switches would allow all 150 fibers to be monitored using 1-FADC!
- DiCon GP700 programmable switches are available on eBay!

# Calibration system: *technical issues (I)*



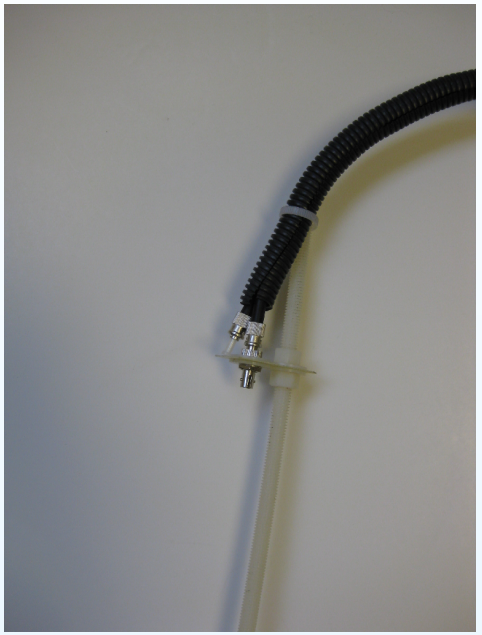
- Milagro 1:10 splitters:
  1. 20 splitters exist ... we need 15!
  2. 2 have been characterized recently:
     - very uniform fiber:fiber illumination
     - typical coupling 5% of light into each fiber (ideal would be 10%)

# Calibration system: *technical issues (II)*



- fiber tank penetrations:
  1. Liquid-TUFF flexible conduit:
     - easy to assemble
     - resistant to rodents and UV light
  2. (photo above) 3/4” ID conduit will “just” pass one duplex SC fiber ... thus probably 1” ID is needed
  3. right angle coupling a problem with screw-on hatch cover
  4. what similar products are available in Mexico?

# Calibration system: *technical issues (III)*



- fiber support at PMT:
  1. need rigid support for fiber $\sim 45$ cm above the PMT
  2. two problems with my toy design:
     - avoid nylon (Michael Schneider) *e.g.* use (thin) stainless steel rod(s)
     - avoid standard metal ST couplings ... they rust!
  3. hold the fiber using a (plastic) SC:SC union (just plug-in the SC connector!)

# **Calibration system:** *summary/conclusions*

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- Several proposed changes:
  - address concerns
  - but (temporarily) more uncertainty in (maximum) light intensity

- Petra has prepared a *draft* calibration document ... it needs to be updated with the latest design

- Focus on few-tank prototype array is already helping resolve the next set of issues ...