Adi Bornheim, July 15 2015

See also Alex` twiki : https://twiki.cern.ch/twiki/bin/viewauth/CMS/ShashlikLaserTests

SH matrix tests :
Test 1 :

3 : MCP1, four fibers, low gain, 0.4 V @ 2900 V with laser at H4, run 36

6 : MCP2, three fibers, high gain, 0.25 V @ 2600 V with laser at H4, run 37

8 : small SiPM, one fiber, with cookie, 60 mV, run 38

7 : large SiPM, one fiber, run 40

Photek test : Photek and Hamamatsu with direct laser, run 41

Test 2 :

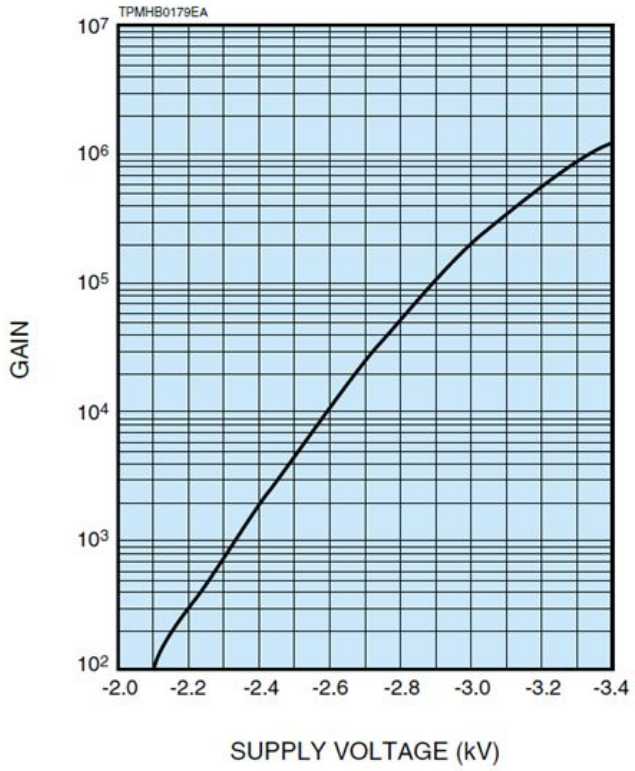
3: cell6, MCP1, four fibers, run 42, 2nd laser connector, 300 mv @ 2900 V, HV CH0

6 : cell 3, MCP2, four fibers, run 41, top laser connector, @ 2600 V, HV CH1

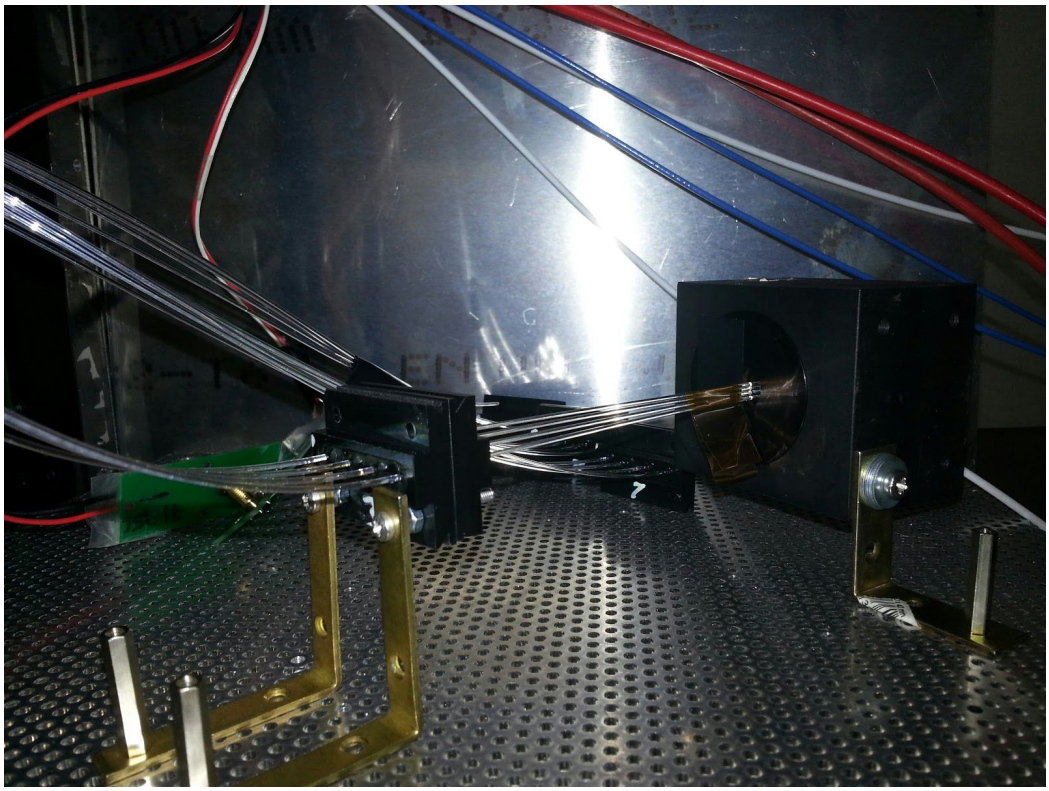
7: cell 7, large SiPM, CH4, run43, 3rd laser connector, 69.1 V, 75 mv

8 : cell8, small SiPM, CH3, run44, used 1st laser connector, 200 mv, 4 fibers

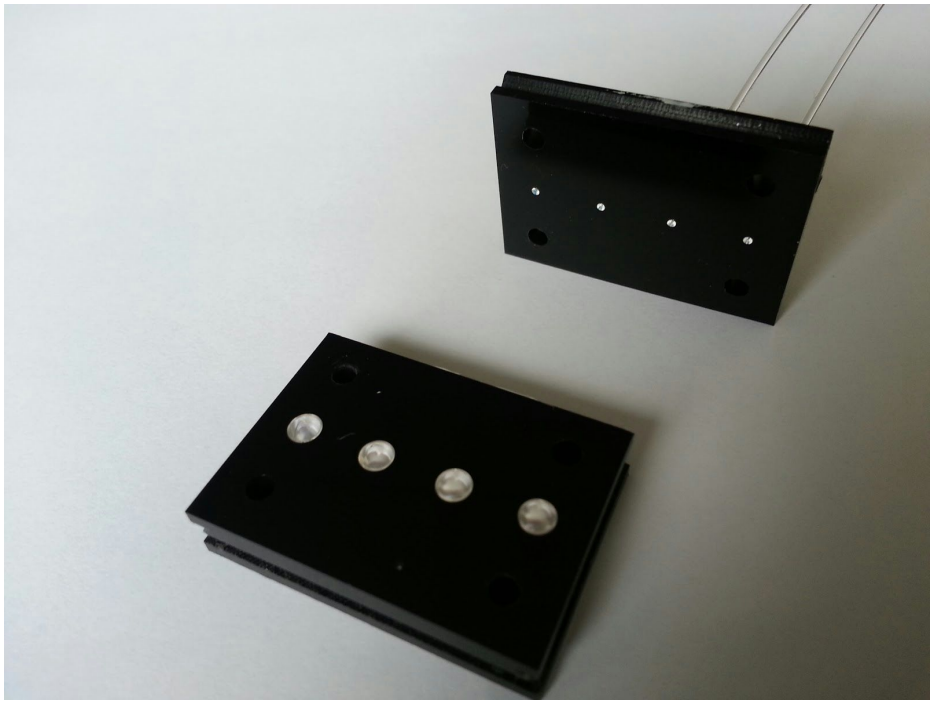
Gain curve for the Hamamatsu MCP :



Optical connection of the clear fiber from SH matrix to the clear fiber merging onto MCP (fiber connector in the foreground, MCP with four fibers merged onto window in the back):



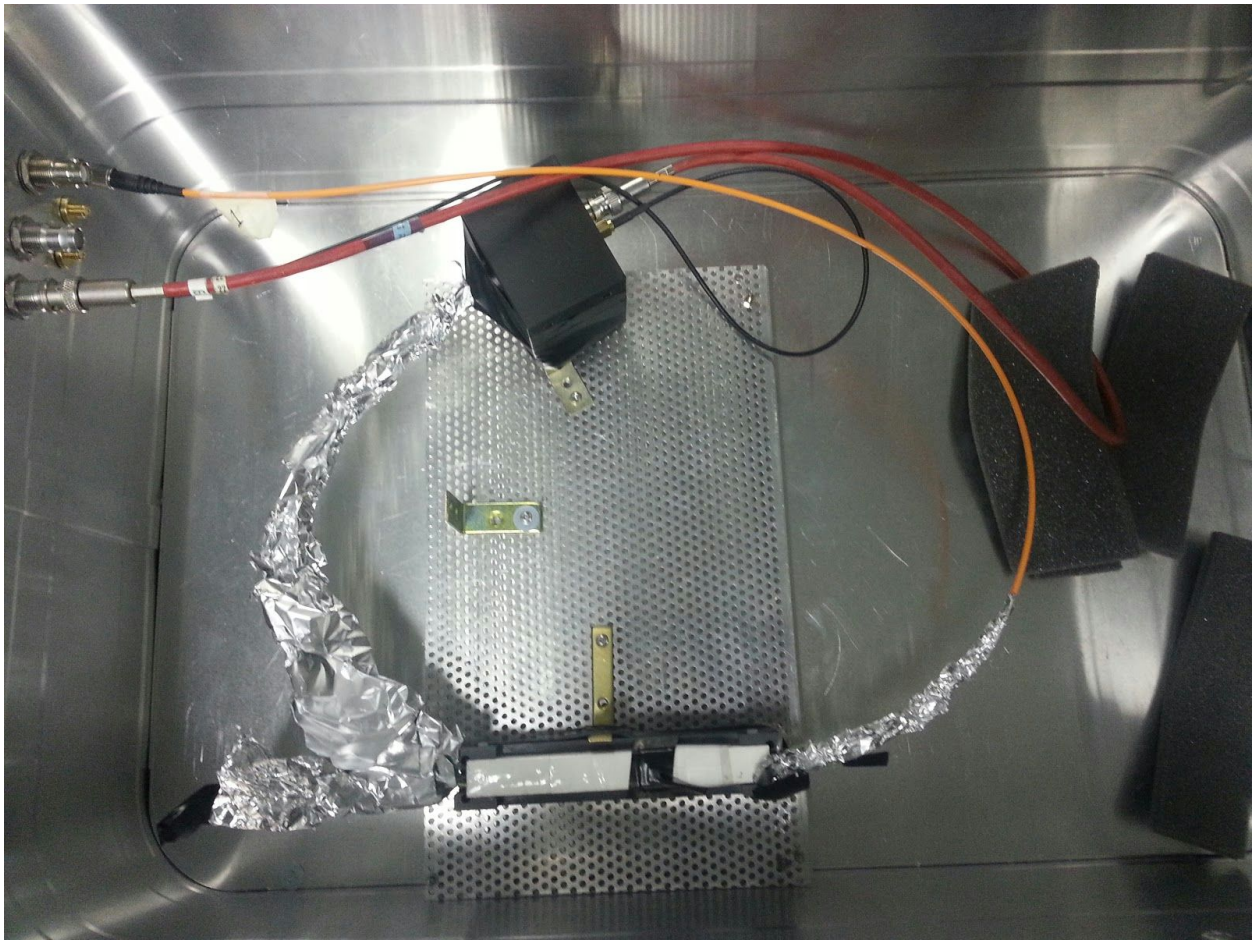
Fiber connector (top right, with two fibers going in from the back. Bottom left : Diffuser for SiPM coupling in the default SH matrix setup - not used by us for now.) :



SH cell test summer 2015

run 134 (CERN_July2015_beam_laser_SH_134.root) : first test with laser injected into single SH cell - MCP2 @ ~2.5 kV, 20 dB on DRS4 2422
signal ~300 mV

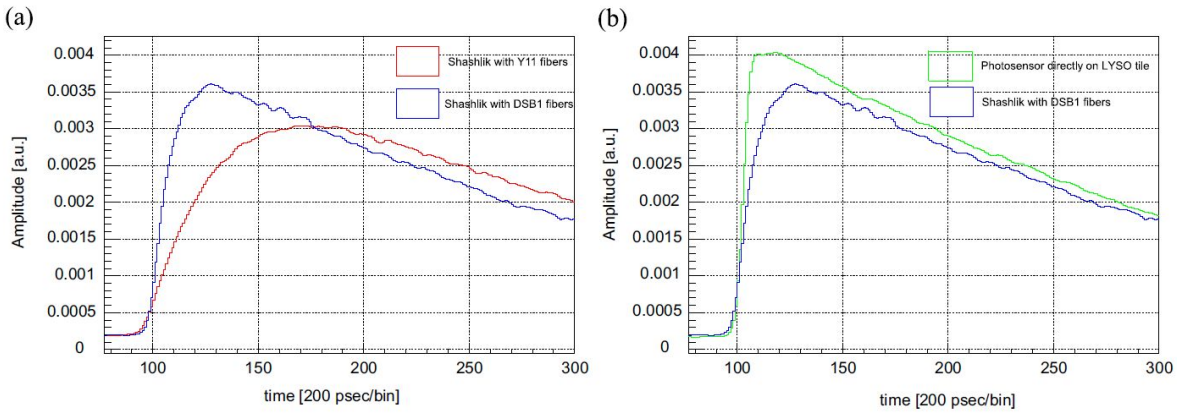
laser signal leaking out of injection fiber outside cell, pick up from WLS fibers and leaking into MCP window directly ?
cover all with tin foil



test (no file recorded ??) : 300 mV@2.8 kV, 20 dB attenuation on DRS4 ???

previously I had noted : run 135 (CERN_July2015_beam_laser_SH_135.root) : 300 mV@2.8 kV, 20 dB attenuation on DRS4 ????
=> need to properly shield the fibers against cross talk.

Pulse shapes of LYSO scintillation seen by MCP and DRS4 with Y11, DSB shifters and without wavelength shifter (from NIMA
doi:10.1016/j.nima.2015.04.013
http://www.sciencedirect.com/science/article/pii/S0168900215004829#) :



To cross check laser pulse shape, check run
CERN_July2015_laser_test_SH_41.root (in Adis CERN public dir).
It has laser direct onto MCP and a different type of MCP (Photek 240).

August 5, 2015 :

Repeat previous setting :
run 135 (CERN_July2015_beam_laser_SH_135.root) : 200 mV@2.8 kV (amplitude a bit lower now ?), 20 dB attenuation on DRS4

Laser pulse energy stability spec : <4%

Increase laser pulse rate (now ~15 Hz) :
run 136 (CERN_July2015_beam_laser_SH_136.root) : 200 mV@2.8 kV (amplitude even lower now ?), 20 dB attenuation on DRS4

changed laser fiber shielding :
run 137 (CERN_July2015_beam_laser_SH_137.root) : 100 mV@2.8 kV, 20 dB attenuation on DRS4

WLS fiber disconnected at the MCP window, MCP window left open .
run 138 (CERN_July2015_beam_laser_SH_138.root) : 150 mV@2.8 kV, 20 dB attenuation on DRS4
large pulse, shape different …

covering laser fiber with tin foil and turning MCP away from cell fixes that.

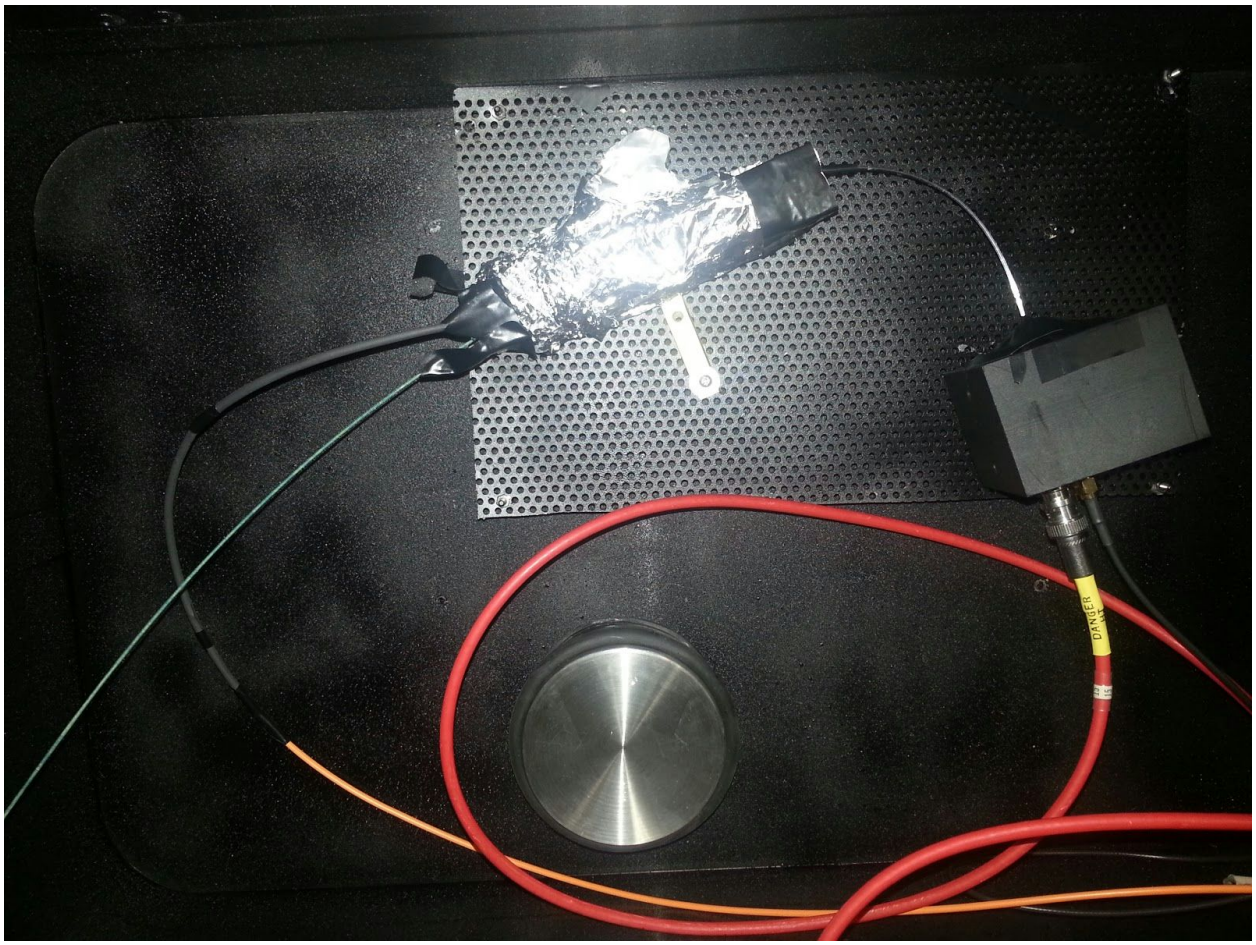
August 7, 2015 :
box has been painted black inside.
exchanged leaky fibers against another one.
had observed that visually there is a lot of leakage at the end of the fiber and no visual leakage along the fiber on the previous one.
new one might be slightly better.
sealing end of the fiber since leakage through the end stop.
run 139, MCP with fibers, 2.5 kV, 20 dB, 200mv, MCP placed sideways away from the SH cell

run 140, MCP with fibers, 2.5 kV, 20 dB, 250 mv, MCP placed close to the SH cell

further shielding of the SH cell, fibers and MCP window connector.

At this point, I decided to do this differently :-) :

Single clear fiber connection between MCP and one fiber/capillary in the cell.



run 142, MCP with single capillary S084, 2.5 kV, 0 dB, 150 mV,

run 143, MCP with DSB fiber, 2.5 kV, 0 dB, 450 mV,

August 10, 2015 :

run 144, MCP with DSB fiber, 2.5 kV, 6 dB, 400 mV

run 145, MCP with single capillary S084, 6 dB, 150 mV

Following runs have much higher amplitude, possibly due to reseating the clear fiber.

run 146, MCP with single capillary S091, 10 dB, 300 mV, 312.1 mV offline 0.68
run 147, MCP with single capillary S085, 10 dB, 400 mV, 368.3 mV 0.96

run 148, MCP with single capillary S086, 10 dB, 400 mV, 334.4 mV 0.87
run 149, MCP with single capillary S087, 10 dB, 300 mV, 232.4 mV offline 0.98
run 150, MCP with single capillary S084, 10 dB, 300 mV, 234.3 mV offline 0.85
run 151, MCP with DSB fiber, 10 db, 400 mV, 297.1 mV

S091 0.68
S084 0.85
S085 0.96
S086 0.87
S087 0.98

August, 13, 2015 :

run 152, MCP with DSB fiber, 10 db, 200 mV
amplitude lower than previously, possibly some further reduction during the recording of 5k events.
setup may need to settle in after switching everything on

run 153, MCP with S087 capillary, 10 dB, 300 mV

run 154, MCP with S087 capillary, 10 dB, ??, repeat to check drift of amplitude over time

pulling out laser fiber a bit increases amplitude hugely - most of the light seems to exit
at the end of the fiber.
move laser fiber further into Shashlik up to the orange coating.

run 155, MCP with DSB fiber, 10 dB, 3 kV, 250 mV

run 156, MCP without DSB fiber, 10 dB, 3 kV,

August, 18, 2015 :

run 157, MCP without DSB fiber, 10 dB, 3 kV, 200 mv

run 158, MCP without DSB fiber, hole blocked with steel needle, 10 dB, 3 kV, 100 mV

remove clear fiber a bit, no only a few mm sticking into the SH cell.
no signal with steel needle,

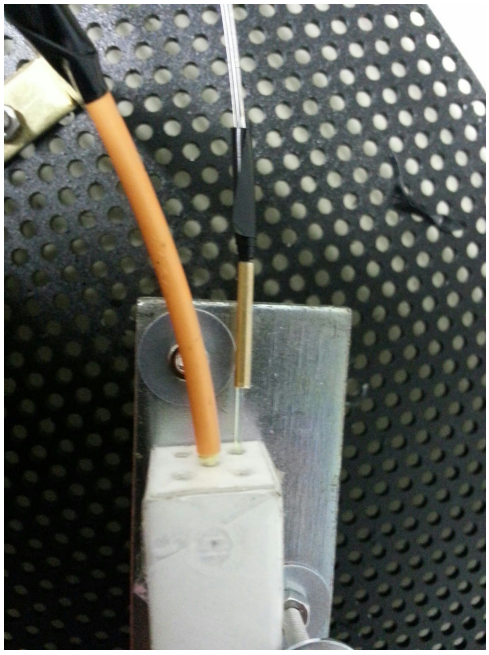
run 159, MCP with DSB, 10 dB, 300 mV

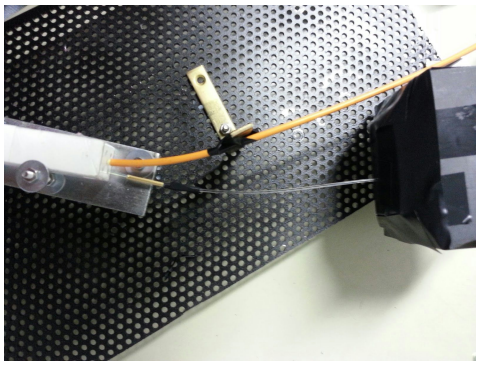
run 160, MCP without fiber, 10 dB, 200 mV

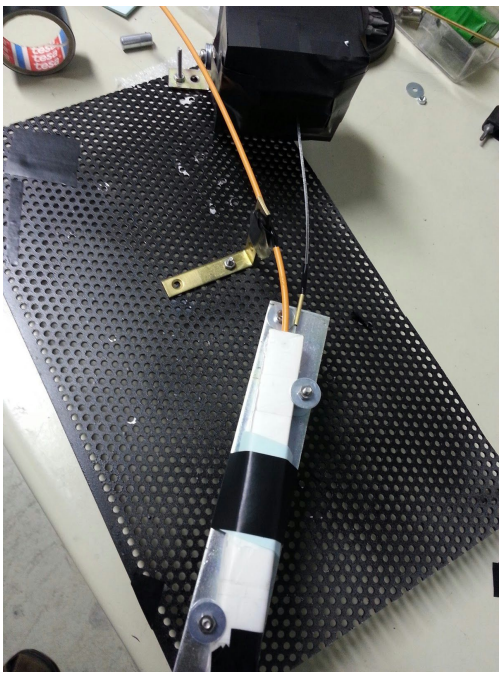
run 161, MCP with DSB fiber, connection to clear fiber outside the SH cell, 10 dB

August 19, 2015 :

Make DSB to clear fiber connection outside SH cell with brass tube







run 162 : SH cell with DSB fiber, 10 dB, 300 mV

run 163 : SH cell with capillary S087, 10 dB, 50 mV

run 164 : SH cell with capillary S084, 10 dB, 50 mV

run 165 : SH cell with capillary S091, 10 dB, 50 mV

run 166 : SH cell with capillary S085, 10 dB, 50 mV

run 167 : SH cell with capillary S086, 10 dB, 50 mV

run 168 : SH cell with capillary S086, 0 dB,

run 169 : SH cell with capillary S085, 0 dB

run 170 : SH cell with capillary S085, 0 dB, 0.6 MS/S

run 171 : SH cell with capillary S085, 0 dB, 2.0 MS/S

August 21, 2015 :

run 172 : SH cell with capillary S087, 0 dB
run 173 : SH cell with capillary S091, 0 dB
run 174 : SH cell with capillary S084, 0 dB
run 175 : SH cell with capillary S085, 0 dB

run 176 : SH cell with capillary S086, 0 dB
run 177 : SH cell with capillary S086, 0 dB - remeasure after capillary fixture came loose

run 178 : SH cell with DSB fiber, 16 dB - huge amplitude difference
run 178 : SH cell with DSB fiber, 16 dB - just remeasure without touching
run 179 : SH cell with DSB fiber, 16 dB - cycle HV
run 180 : SH cell with DSB fiber, 16 dB - connect/disconnect
run 181 : SH cell with DSB fiber, 16 dB - connect/disconnect
run 182 : SH cell with DSB fiber, 16 dB - long run with low rate
run 183 : SH cell with DSB fiber, 16 dB - reconnect, laser high rate again
run 184 : SH cell with DSB fiber, 16 dB - reconnect
run 185 : SH cell with DSB fiber, 16 dB - reconnect
all runs up to here in the bottom right from back (looking towards the MCP on the other side. cover of the machete hole towards the back)

run 186 : SH cell with DSB fiber, 16 dB- reconnect in different hole : top right seen from readout side
run 187 : connect/disconnect same hole
run 188 : top left hole
run 189 : bottom left
run 190 : back to bottom right hole

connect four clear fibers to MCP
run 191 : bottom right, DSB fiber still, lower amplitude, 10 dB
run 192 : same, 0 dB - large drop in intensity

run 193 : same hole, capillary S087
run 194 : top right, capillary S087
run 195 : bottom left, capillary S087
run 196 : top left, capillary S087
run 197 : back to bottom right, capillary S087

S87 bottom right, S91 top right, S085 top left, S86 bottom left
run 198 with the above 4 capillaries
run 199 repeat same run without touching
run 200 repeat
run 201 disconnect/connect - repeat
run 202 disconnect/connect - repeat

with this arrangement put glue on clear fibers

August 24, 2015 :

run 203 run long run of 20k as found this morning with four capillaries, tape securing capillaries was off
run 204 fix tape and foam securing of capillaries - repeat

August 26, 2015 :

- powercut in the barracks due to electrical work in GIF area, fixed.

Changed laser fiber connector on the box
New capillary holder on the bulb end

Orientation of the Shashlik stack has changed.

206 S087 in bottom right hole, 0 dB
207 same, move counter weight on mounting plate
208 dismount/mount S087, repeat
209 tighten screw with spring for S087, this turns the capillary a bit.
210 remove some foam holding the SH stack tightly
211 remove foam holding brass tube connector
212 put back foam holding brass tube connector
213
214 test new single fiber connector
215 dismount/mount capillary, repeat
216 repeat

August 27, 2015 :

217 S087 in bottom right
218 remove and reinsert capillary. HV and laser cycled. Laser turned off @ event 228
219 remove and reinsert capillary. HV and laser cycled
220 remove and reinsert capillary. HV and laser cycled
221 remove and reinsert capillary. HV and laser cycled

222 replaced with S084
223 remove and reinsert capillary. HV and laser cycled
224 remove and reinsert capillary. HV and laser cycled
225 remove and reinsert capillary. HV and laser cycled

August 31, 2015 :

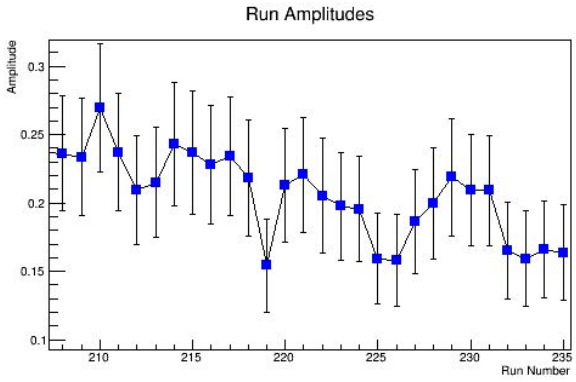
226 S087 in bottom right - repeat to compare to the other day
227 S087 in bottom right - repeat again to compare to the other day

Note: the previous two runs (226, 227) were done without the weight in place, meaning pressure was not applied between the capillary and output fiber

228 replaced with S085
229 remove and reinsert capillary. HV and laser cycled
230 remove and reinsert capillary. HV and laser cycled
231 remove and reinsert capillary. HV and laser cycled

232 replaced with S086
233 remove and reinsert capillary. HV and laser cycled

234 remove and reinsert capillary. HV and laser cycled
235 remove and reinsert capillary. HV and laser cycled



September 2, 2015 :

The setup was changed slightly, possible that springs and such were not as well aligned, leading to the systematic drop in amplitude we see

236 replaced with S091
237 remove and reinsert capillary. HV and laser cycled
238 remove and reinsert capillary. HV and laser cycled
239 remove and reinsert capillary. HV and laser cycled

240 replaced with S084
241 remove and reinsert capillary. HV and laser cycled
242 remove and reinsert capillary. HV and laser cycled
243 remove and reinsert capillary. HV and laser cycled

244 replaced with S085
245 remove and reinsert capillary. HV and laser cycled
246 remove and reinsert capillary. HV and laser cycled
247 remove and reinsert capillary. HV and laser cycled

248 replaced with S086
249 remove and reinsert capillary. HV and laser cycled
250 remove and reinsert capillary. HV and laser cycled
251 remove and reinsert capillary. HV and laser cycled

252 replaced with S087
253 remove and reinsert capillary. HV and laser cycled
254 remove and reinsert capillary. HV and laser cycled
255 remove and reinsert capillary. HV and laser cycled

256 replaced with S091
257 remove and reinsert capillary. HV and laser cycled

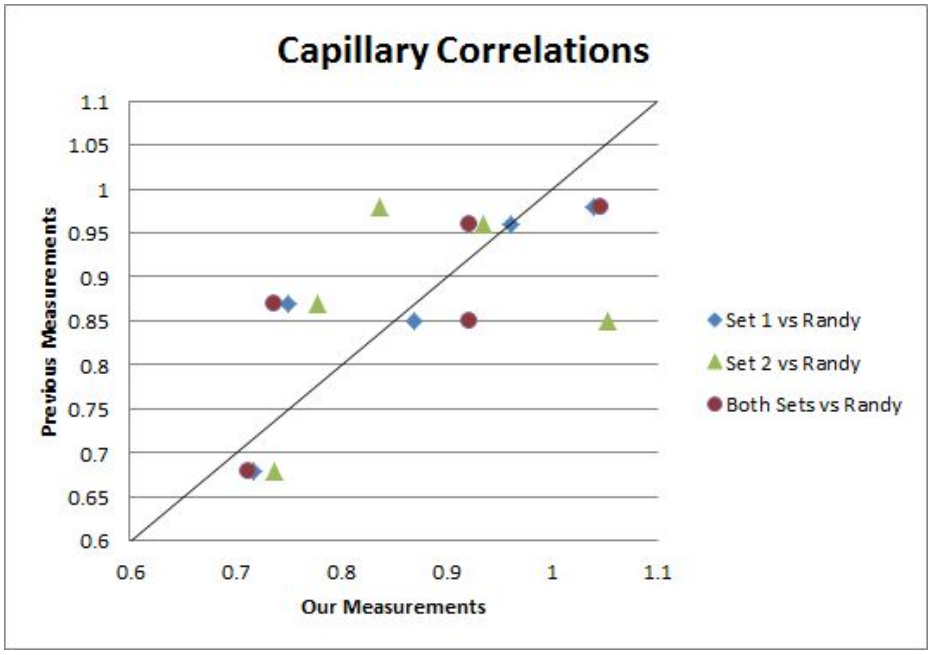
- amplitude seemed very low, probably something not settled in right

258 HV and laser cycled. Capillary NOT touched
259 HV and laser cycled. Capillary moved slightly, I think more pressure is now being applied to the end of it.
260 remove and reinsert capillary. HV and laser cycled

261 setup with MCP and both SiPMs reading out, using DSB fibers

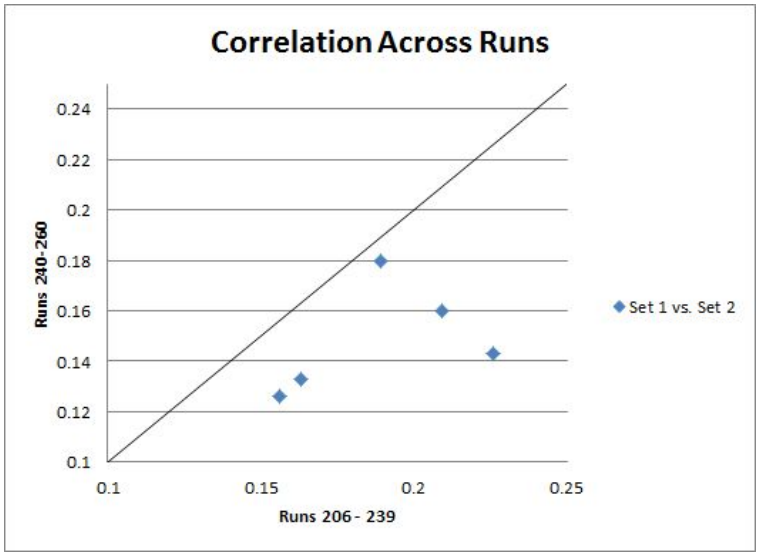
Observed Capillary Amplitudes

Capillary	Randy	Adi & Alex (set 1)	Set 1 - normalized	Adi & Alex (set 2)	Set 2 - normalized	Adi & Alex (both sets)	Both Sets - normalized
S084	**0.85**	0.189	0.87	0.18	1.053	0.185	0.922
S085	**0.96**	0.209	0.962	0.16	0.936	0.185	0.922
S086	**0.87**	0.163	0.75	0.133	0.778	0.148	0.737
S087	**0.98**	0.226	1.04	0.143	0.836	0.21	1.046
S091	**0.68**	0.156	0.718	0.126	0.737	0.143	0.713
Mean:	**0.868**	**0.1886**	**0.868**	**0.1484**	**0.868**	**0.1742**	**0.868**



Notes:

- Set 1 refers to runs 206-239 and Set 2 refers to runs 240-260
- Each data set on the graph was normalized separately so it would have the same mean as Randy's original measurements



Notes:

- Raw numbers from all runs, not very good correlation, everything is lower in the second set of runs. This may be because the set-up was not exactly the same, it was my (Alex's) best recreation of the spring setup Adi originally put together for the matrix.
- What's interesting is that everything in the first graph correlates alright with Randy's original measurements when normalized separately. However in this second graph we see a weak correlation between the two sets of runs we did, this may indicate that there is some systematic error bringing down everything for Set 2.

262 setup with both MCP and both SiPMs reading out, using DSB fibers

September 14, 2015 :

Now using the slightly different setup for all 4 readouts. Inserting only one capillary at a time (bottom right). HV at 3000. Redoing tests of all the capillaries to see if the results are still consistent and if S084 and S087 were indeed mistakenly switched in the previous set of runs.

265 S084 - Amplitude seems overall much lower than previously, not triggering as often either. Data may not be good
266 remove and reinsert capillary. HV and laser cycled

Stopped taking data with the capillaries. Signal too small to be useful

267 All 4 DSBs re-inserted:

CH1:	Large SiPM
CH2:	Small SiPM
CH3:	Main MCP
CH4:	Other MCP (no signal appears to be getting read out)

268 Everything cycled (HV, LV, Laser) and DSBs rotated/moved slightly. Also re-scaling on the axis to see it affects readout.

269 (clean) Everything cycled. All DSBs removed and reinserted, maintaining which DSB is in which hole
270 (chipped) Everything cycled. All DSBs removed and reinserted, the ones going to the SiPMs were reversed
271 (clean) Same procedure as above
272 (chipped) Same procedure as above

Note: the DSB fiber going to the SiPMs appear both cracked on one end, which would explain why the amplitudes are different, the runs are now denoted chipped or clean to indicate which end interfaced with the SiPMs

273 (clean) Same procedure as above

16.09.2015 :

Rearrange four sensor assembly to get straighter clear fiber connector.
Now use tube guide for spring support
Two capillaries and two DSB fibers.
S087 on lower right, connected to MCP
S085 on upper left, connected to large SiPM.

CH1: Large SiPM
CH2: Small SiPM
CH3: Main MCP - MCP2
CH4: Other MCP - MCP1

Run 274 : MCP 1&2 : 3 kV, SiPM : 69.9, no attenuators,

rearrange sensors to accommodate 25 cm clear connectors
CH1: Large SiPM
CH2: Small SiPM
CH3: Main MCP - MCP2
CH4: Other MCP - MCP1

Run 275 : MCP 1&2 : 3 kV, SiPM : 69.9, no attenuators, all clear connectors with DSB fibers

swapp clear fibers on the detector sides - huge difference in signal
size

Run 276 : MCP 1&2 : 3 kV, SiPM : 69.9, no attenuators, all clear connectors with DSB fibers, SiPMs side clear fiber swapped one vs other, MCP side clear fiber swapped one vs other

Run 277 :
Run 278 : insert capillary S087 into top, left hole, connected to SiPM CH1

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30.09.2015, Adi :

Test for PbWO ultimate timing tests.

Run 279 :
Long LYSO xtal, fiber straight into xtal with 16 fold attenuation, MCP1 connected without cookie.
2.3 kV, amplitude 200 mV

Run 280
with cookie and grease

Run 281
with double fiber connector, 3.0 kv, amplitude 150 mV, gain ratio 700 / 200000, 0.0035

Run 282
repeat

Run283
reflective tube at an angle, 2 kV

Run 284
directly on xtal, no cookie, 10 dB

Run 285
reflective tube, no cookie, 10 dB, 100 mV

Run 286 *[This file possibly doesn't exist, the existing 286 file refers to data taken in October]*
no tube, no cookie, 10 dB, 300 mV

02.10.2015 :

<u>Run 286</u>
All four sensors hooked up via DSB. To test whether the saved graphs are scaled to the actual mV, or just the fraction of 0.5 (saturation point) that is literally displayed on the oscilloscope.
HV @ 2850 V
Scale for different channels:
Ch1: 50 mV Ch2: 20 mV Ch3: 50 mV Ch4: 200 mV
Naively looking at the readout, Channels 1 and 2 appear to have approximately the same amp, while ch3 is about half and ch4 is about two thirds the amplitude.

<u>Run 287</u>
Additional run to determine above goal
Ch1: DSB 50mVCh2: DSB 20 mV Ch3 Nothing Ch4: S087 200 mV
Based on scope, ch4 looks imporperly connected, but the only important data is from ch1 for this test

<u>Run 288</u>
Additional run to determine above goal
Ch1: DSB 100mV Ch2: DSB 20 mV Ch3 Nothing Ch4: S087 200 mV

Conclusion: The readout reads the true voltage, perhaps in volts, and not just the raw number displayed. Take this result with a grain of salt, I think it is worth double checking.

Run 289-292
S087 connected to MCP and into ch1 only. Runs to determine if S087 and S084 were mistakenly swapped earlier. Capillary removed and reinserted between runs. 100mV, 0dB, HV @ 3kV

Run 293-296
S084 connected to MCP and into ch1 only. Runs to determine if S087 and S084 were mistakenly swapped earlier. Capillary removed and reinserted between runs. 100mV, 0dB, HV @ 3kV