Fine-mesh PMT Measurements at UVA

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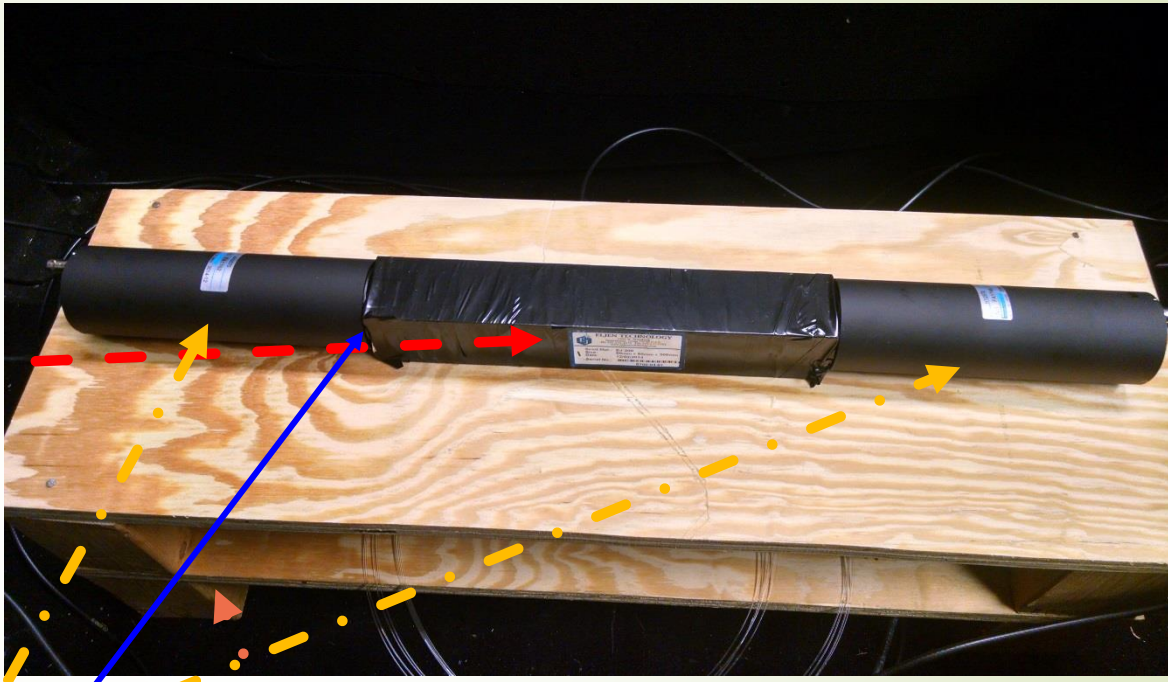
2” Fine-mesh PMT Measurements

- Single photoelectron measurements with low light accomplished using a preshower tile with maximum possible of 100 photoelectrons.
- Timing resolution measurements using the three-bar method from USC

DAQ Trigger

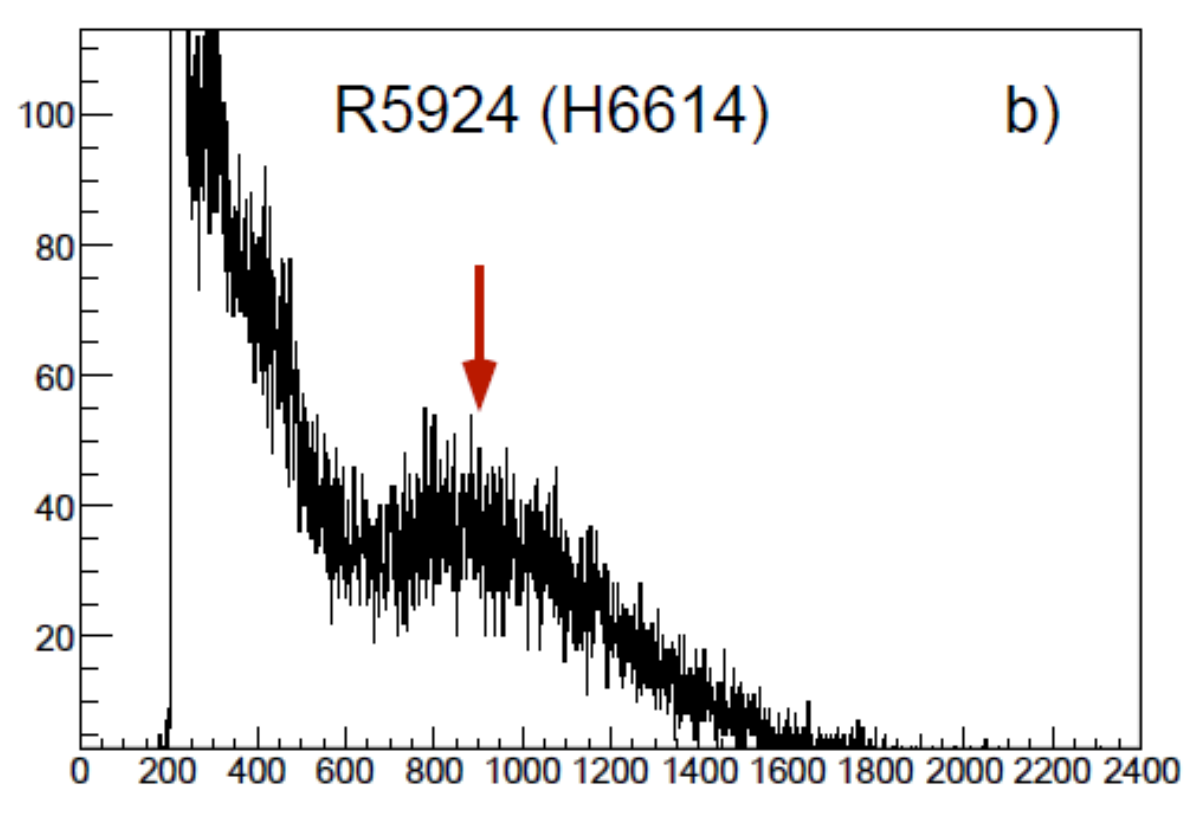
- The test material is placed approximately equal distant in the vertical direction between two **scintillator bars** (EJ-200 from Eljen Technology) 5 cm x 5 cm x 30 cm.
- The light from the scintillators are collected by two **Hamamatsu R9779 PMTs**, which are coupled to the ends of the scintillators with **optical grease**.



The figure shows the top trigger bar. Below the **lower platform** is a second identical scintillator bar. Either a preshower tile or a third scintillator bar resides in between the two platforms.

Location of Single P.E.

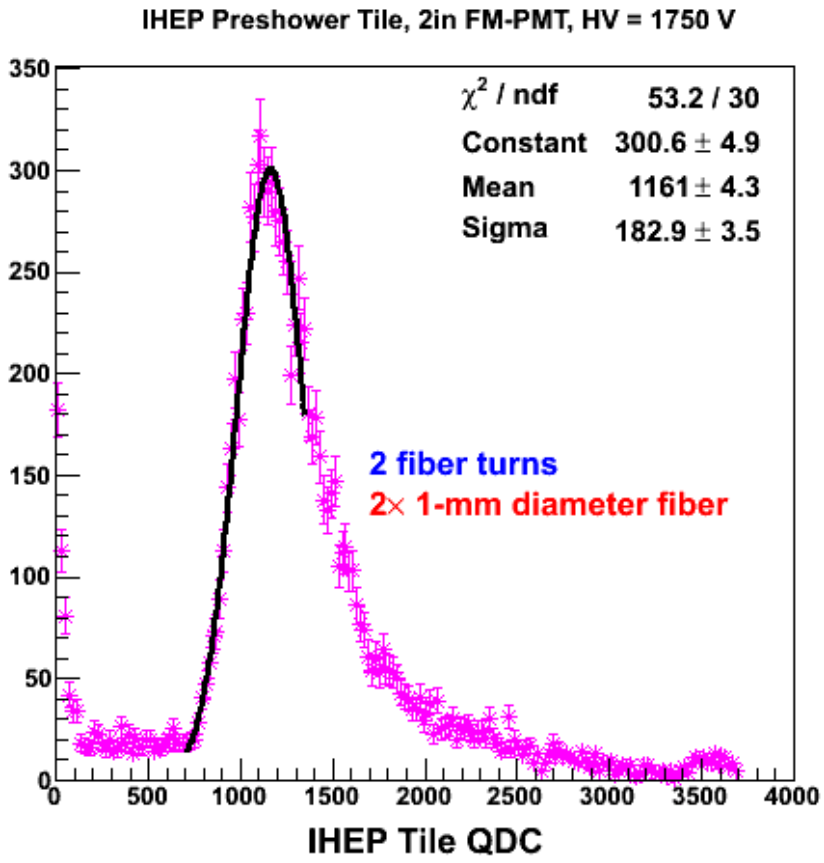
- Isolating the SPE from the fine-mesh PMTs is difficult, but can be done with a low intensity LED. Image from FIU measurements.

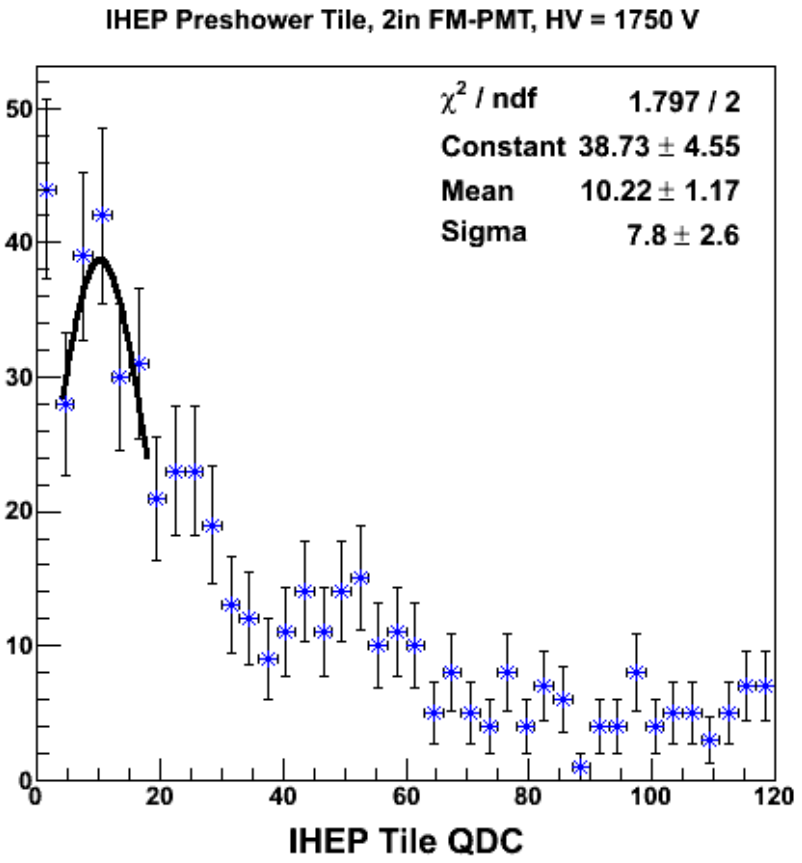


Location of Single P.E.

- At UVA isolation of the SPE was attempted by using a well calibrated preshower Tile with 2x 1-mm WLS fibers.
- Goal was to keep the HV at 2.0 kV to cross calibrate with the JLab High B field measurements.
- Controlling the number of photoelectrons with this system was not easy to produce a few p.e.

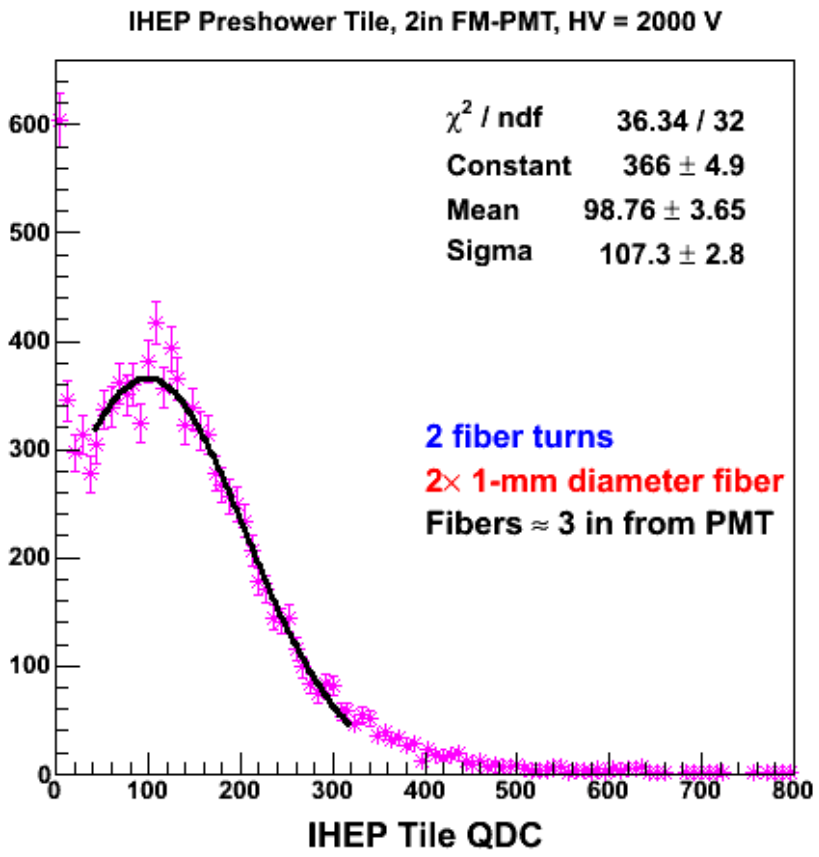
QDC Spectrum at 1.75 kV

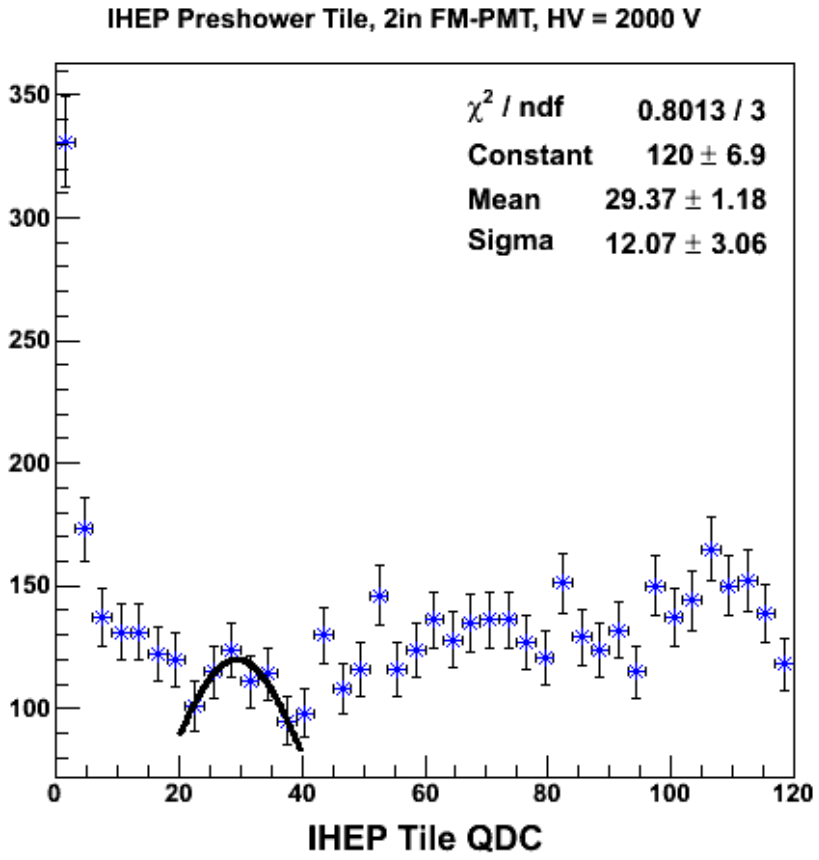




QDC Spectrum at 2.0 kV

<SPE> = 28.5 ± 1.0





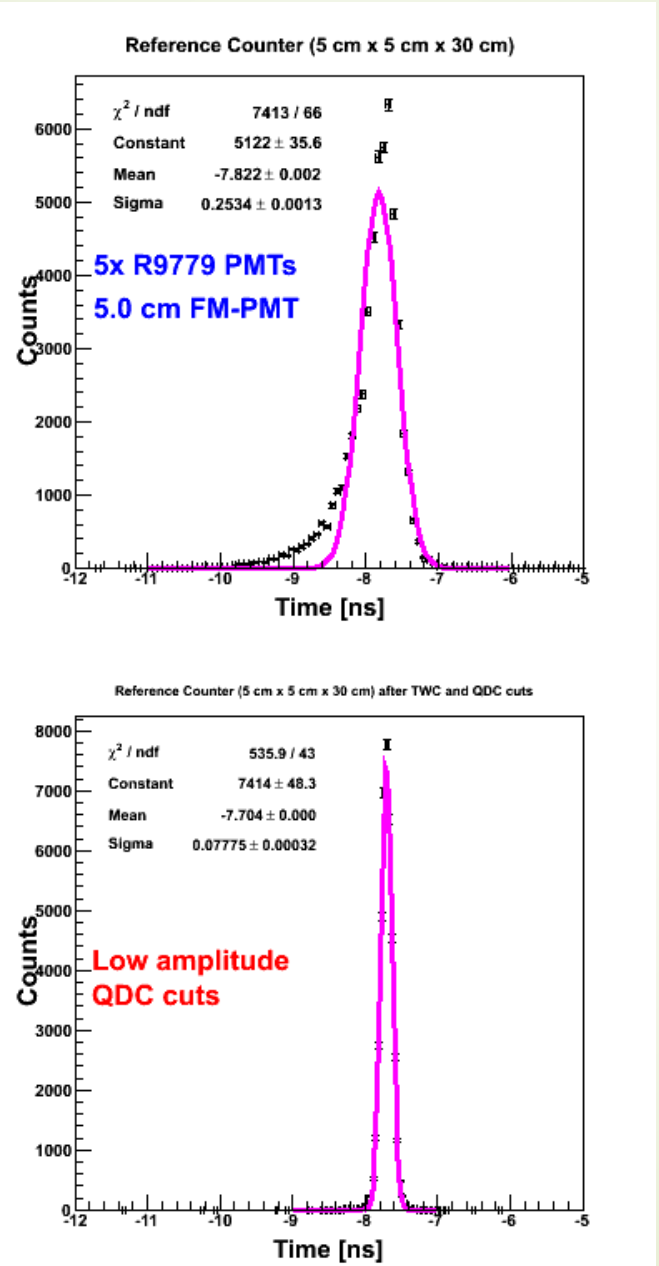
Three Bar Time Resolution Measurements

- In January, 3 identical scintillator bars from Eljen with 6 R9779 PMTs were used to determine the timing resolution of the trigger bars.
- In this configuration, $\sigma_{ref} = \sqrt{\frac{2}{3}}\sigma_T$ with σ_T the measured time resolution.
- Click here for details.
- The reference bar resolution is σ_{ref} = 58 ps after applying time-walk corrections.
- $\sigma_{PMT} = \sqrt{2}\sigma_{ref} = 82$ ps

Three Bar Time Resolution Measurements with 2” Fine-mesh PMT

- In this measurement, one of the middle scintillator PMTs was replaced with the 2” FM-PMT to determine the timing resolution achievable with this PMT.
- In this configuration, $\sigma_{mid} = \sqrt{\left(\sigma_T^2 - 0.5\sigma_{ref}^2\right)}$ with σ_{mid} the measured time resolution of the middle bar.
- Click here for details.
- The achieved middle bar resolution with the FM-PMT is σ_{mid} = 64 ps after applying time-walk corrections.
- Resulting in $\sigma_{FM-PMT} = 98$ ps

Time Resolution with 2” Fine-mesh PMT



Time Response of Hamamatsu PMTs

PMT	Rise Time [ns]	Transit Time [ns]	TTS [ns]
R9779	1.8	20	0.25
H6614-70	2.5	9.5	0.44

Estimated Number of Photoelectrons

- The time resolution for a PMT can be expressed as $\sigma_T = \sqrt{\frac{1}{NPE}(\sigma_{TTS}^2 + \tau_{sct}^2)}$ with $\tau_{sct} = 2.1$ ns the light decay constant of the scintillator.
- Using the values from page 11 for the TTS for each PMT and the measured timing results:
  - NPE = 460 for 2” FM-PMT
  - NPE = 660 for R9779 PMTs
- The main difference is $\Delta\sigma_T$ = 6 ps (58 ps versus 64 ps), which is sensitive to how well the time-walk effect is corrected.