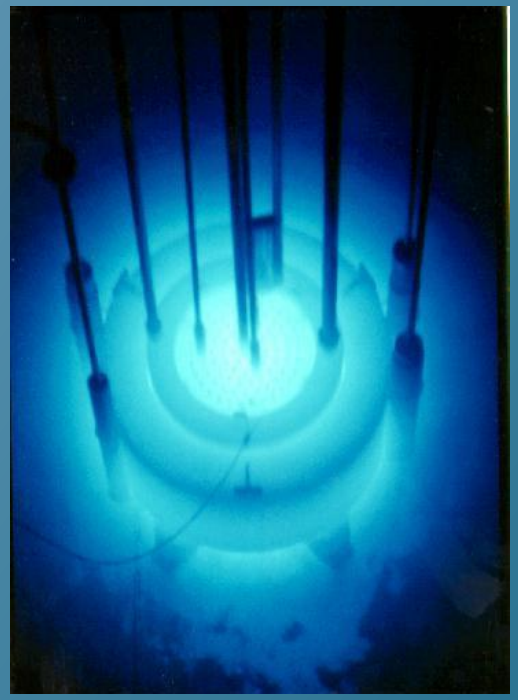
Reed Research Reactor
reactor.reed.edu/pictures.html



Moriah Tobin
Advisor: Mike Albrow
August 12. 2010

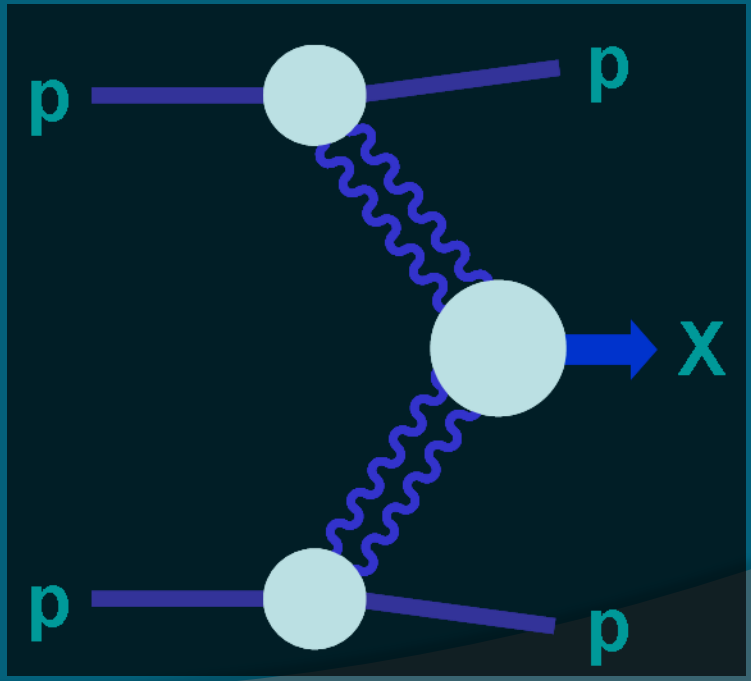
Modeling Fast Timing Quartz Cherenkov Detectors

Outline

- Why do we need fast timing?
- Why Cherenkov?
- Simulation Setup
- Photo-Detectors
- Timing Process
- Timing Resolutions
- Further Studies

Why Fast Timing?

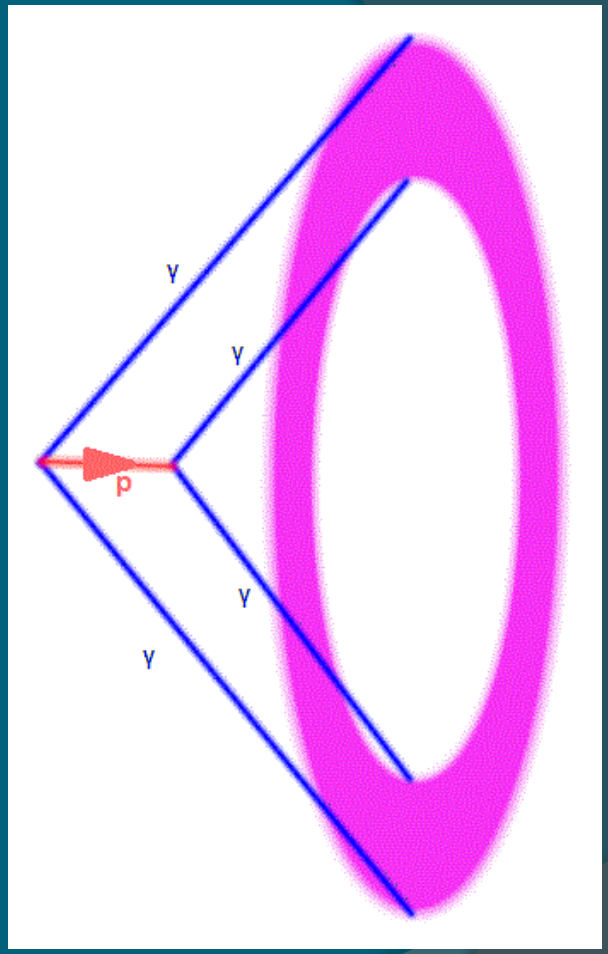
- Many application
- Vertex Measurements of Proton Collisions to 2mm



http://www.hep.phy.cam.ac.uk/theory/research/cep.html

Why Cherenkov Lignt?

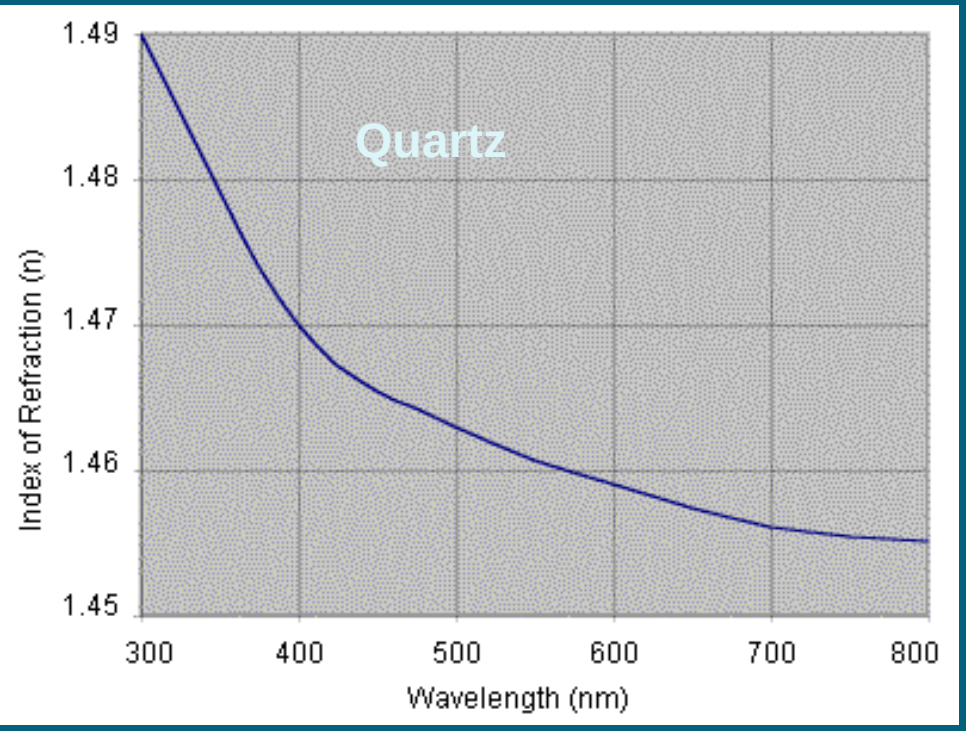
- More Prompt than Scintillation
- Cherenkov Angle: $\cos\theta = \frac{1}{n\beta}$



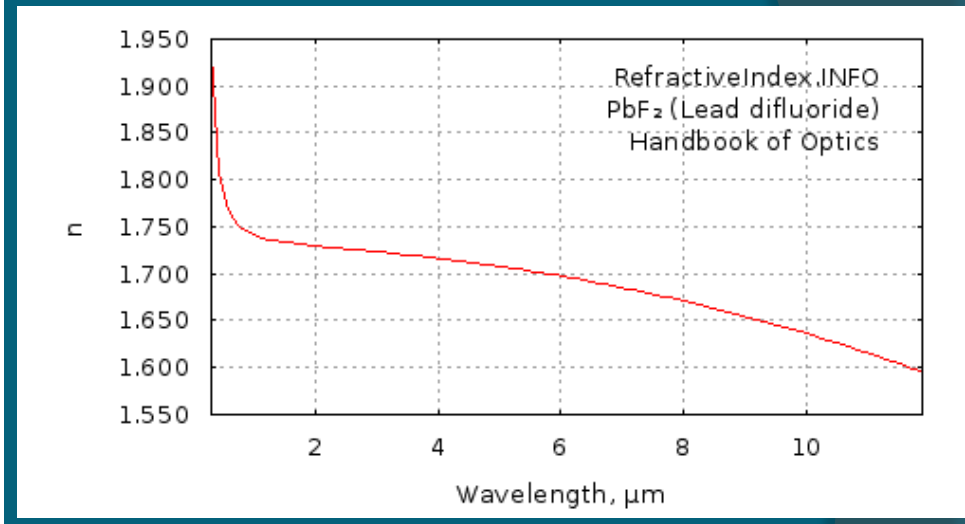
http://www.ps.uci.edu/~superk/superk_detector.html

http://apod.nasa.gov/apod/ap010221.html

Quartz and PbF2 Refractive Index

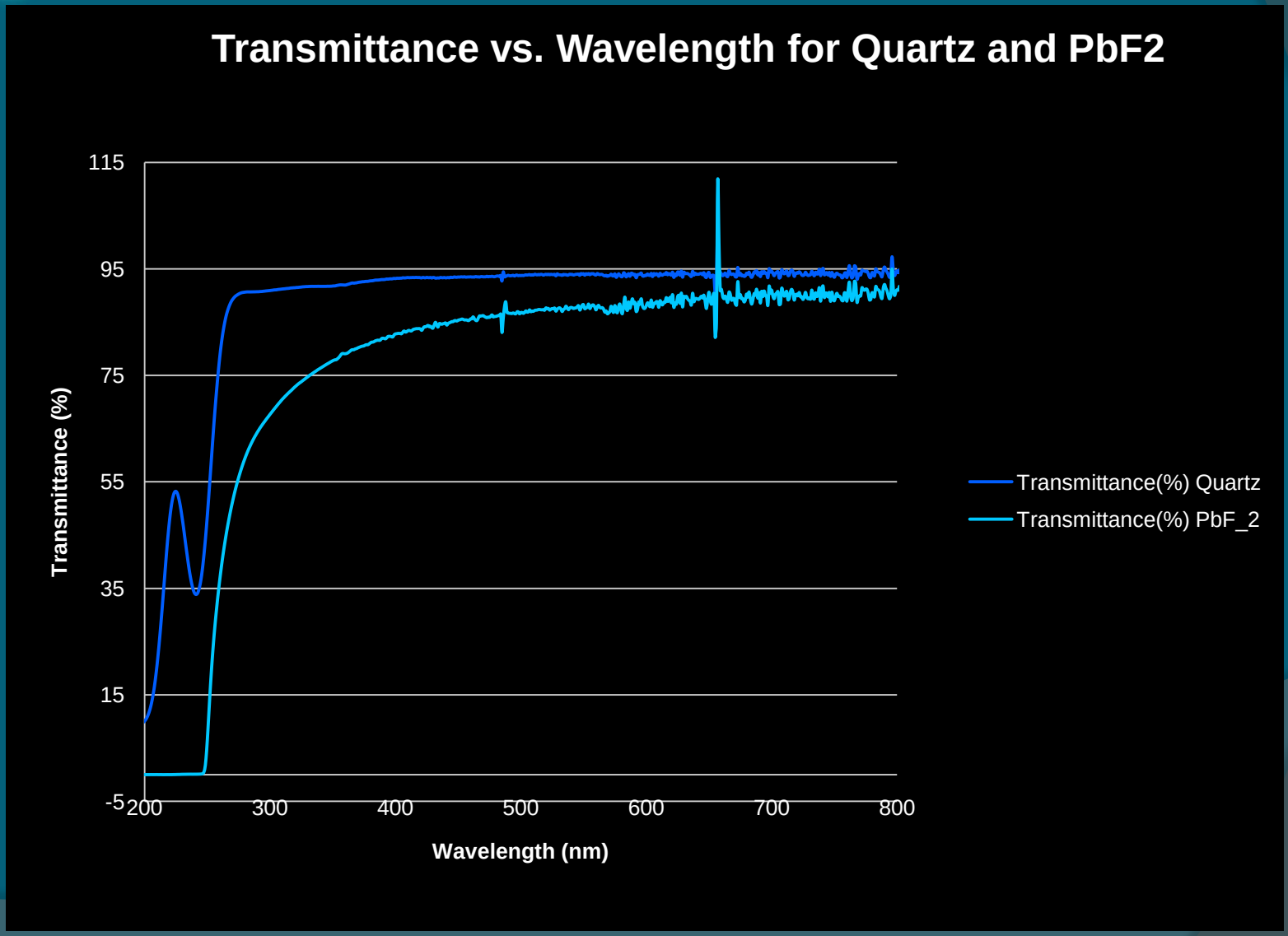


http://www.instant-analysis.com/Principles/spectra.htm



http://refractiveindex.info/?group=CRYSTALS&material=PbF2

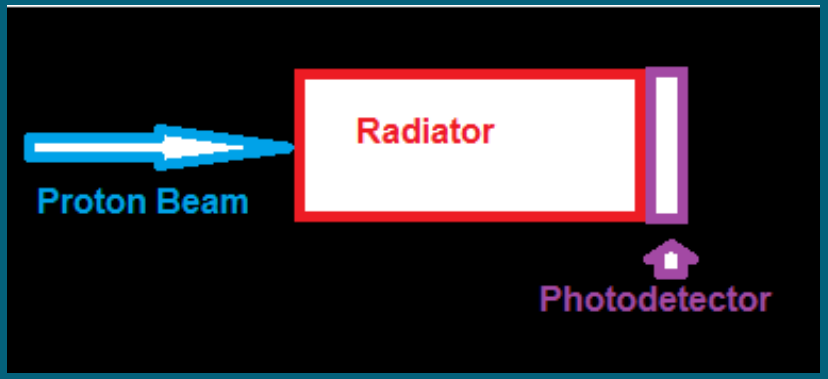
Quartz and PbF2

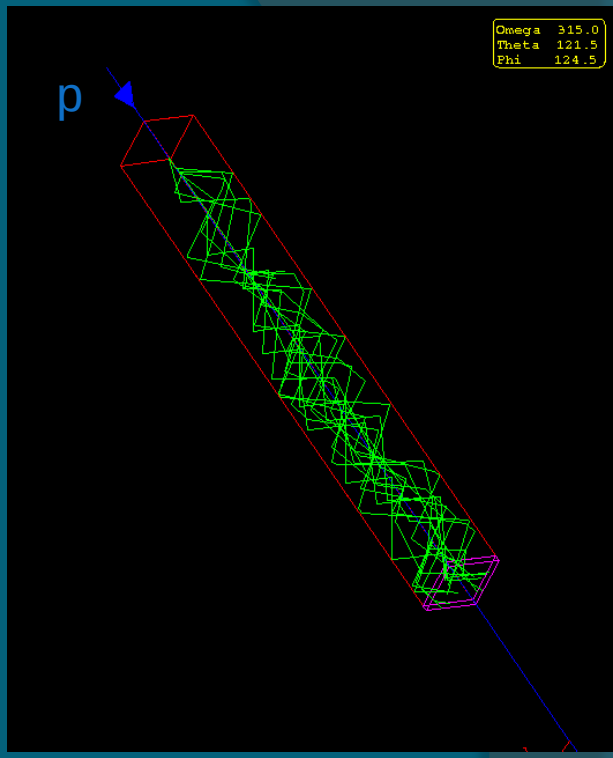


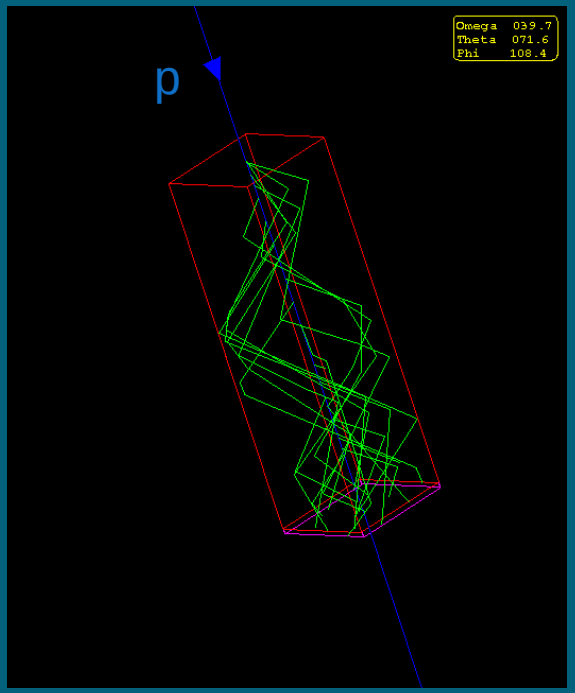
Simulation Tools

- Geant4: A C++ based Monte Carlo simulation program.
- ROOT: A C++ based analysis program
- Interactions in Geant4
- Analysis and photo-detector in ROOT

SiPM Setup


Radiator
Proton Beam
Photodetector


Omega 315.0
Theta 121.5
Phi 124.5
p


Omega 039.7
Theta 071.6
Phi 108.4
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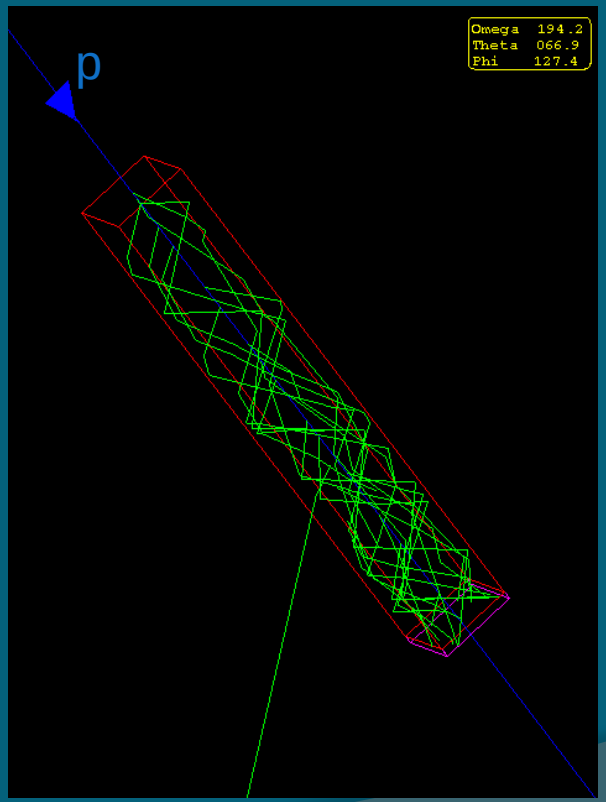
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Theta 066.9
Phi 127.4
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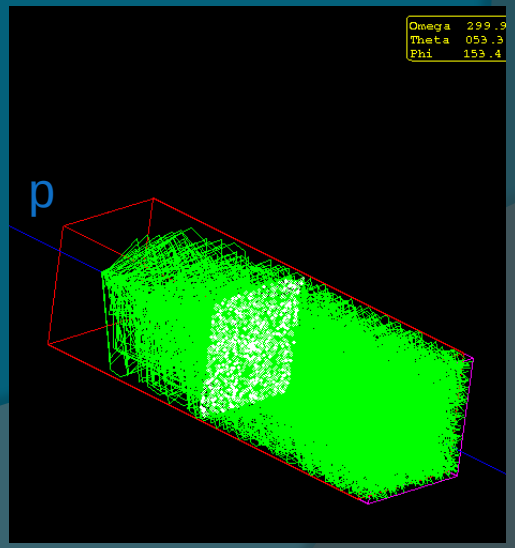
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Phi 153.4
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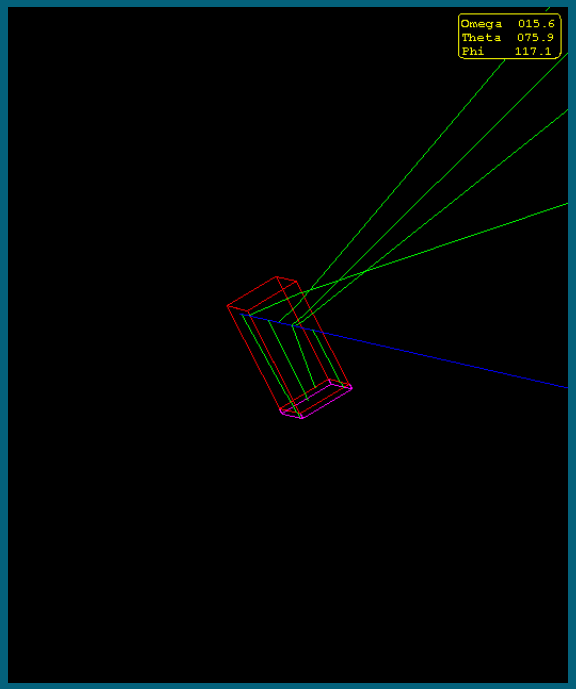
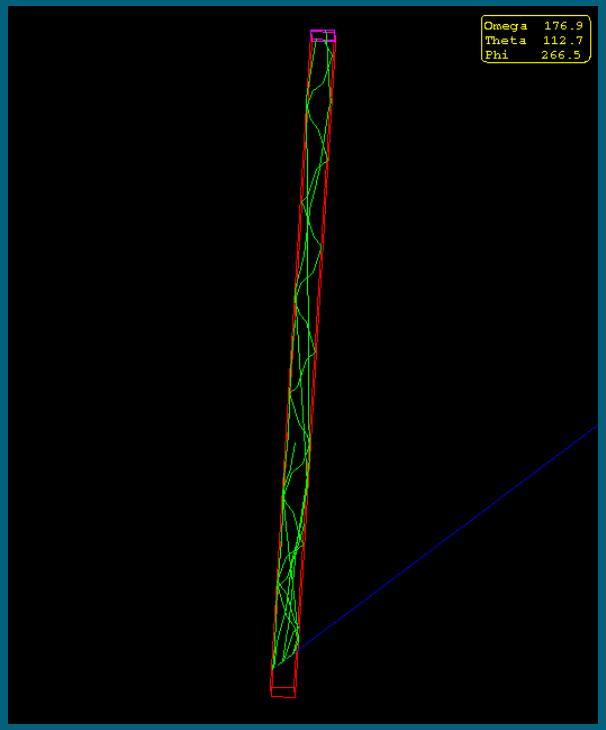
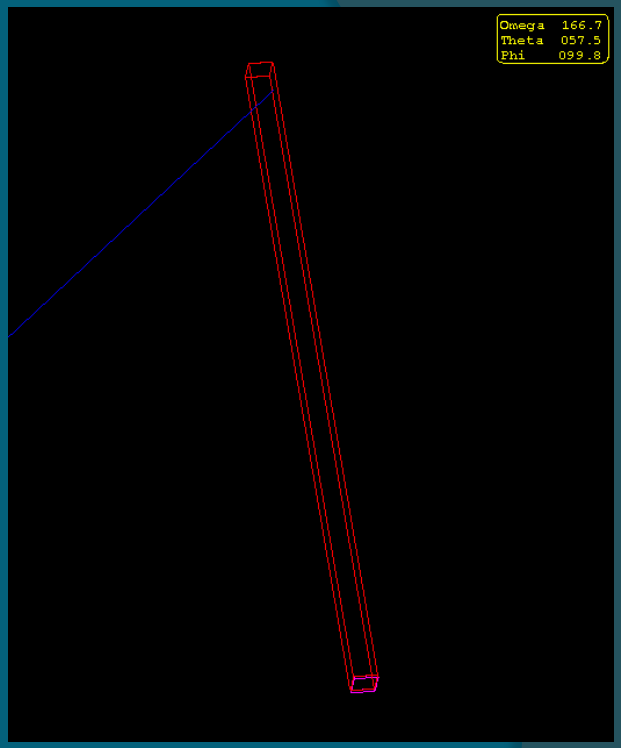
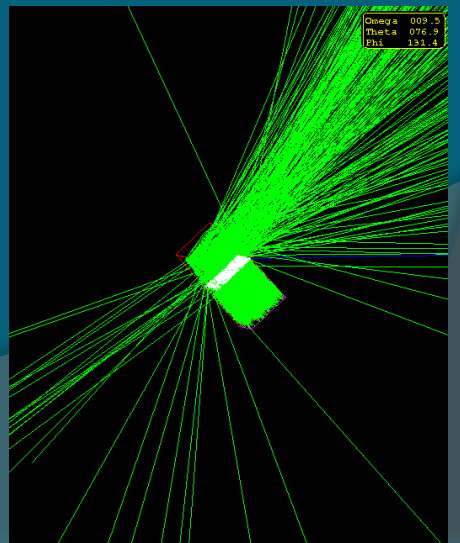
QUARTIC Setup



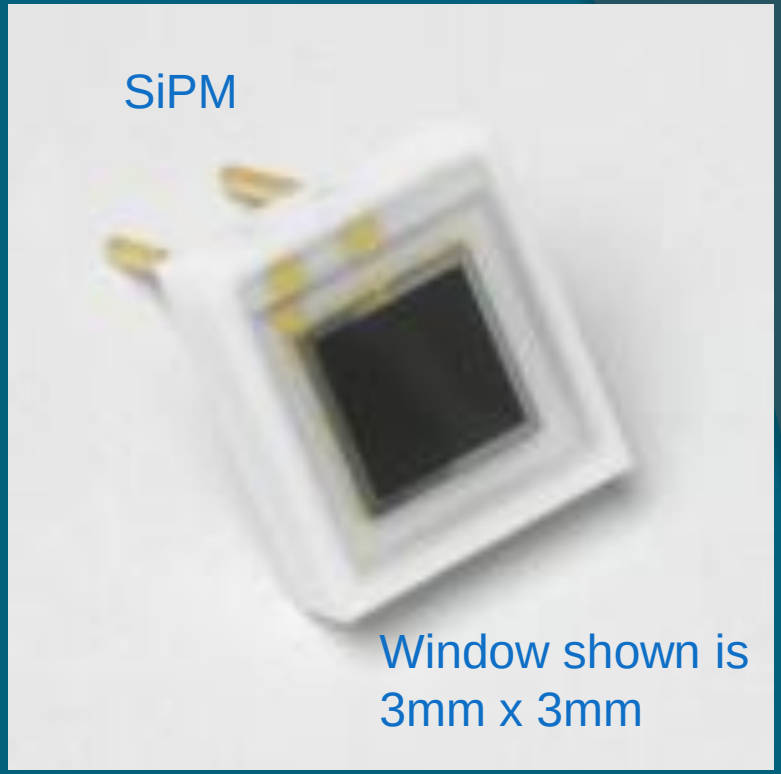




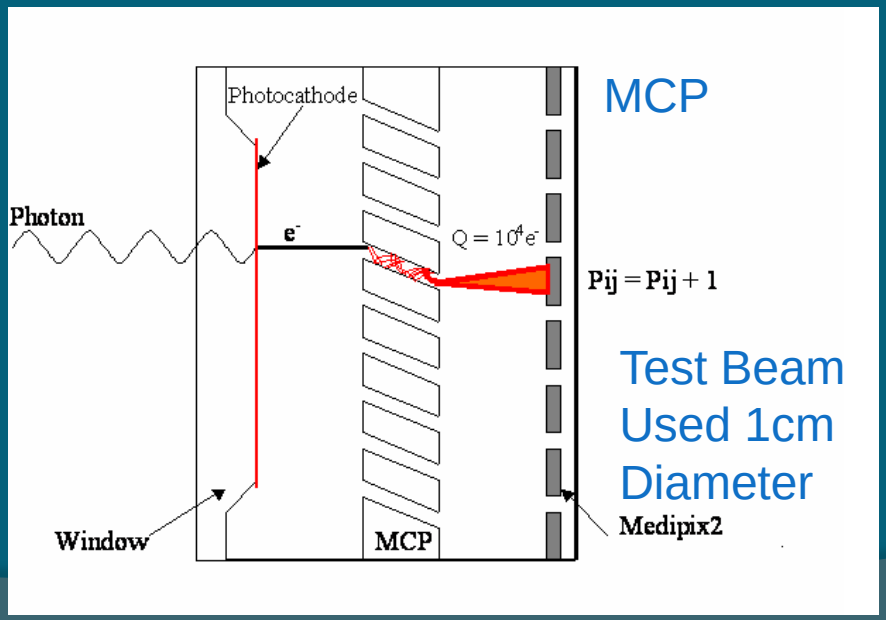


Photodetectors

- Silicon Photo-Multiplier (SiPM)
- Micro-Channel Plate (MCP)

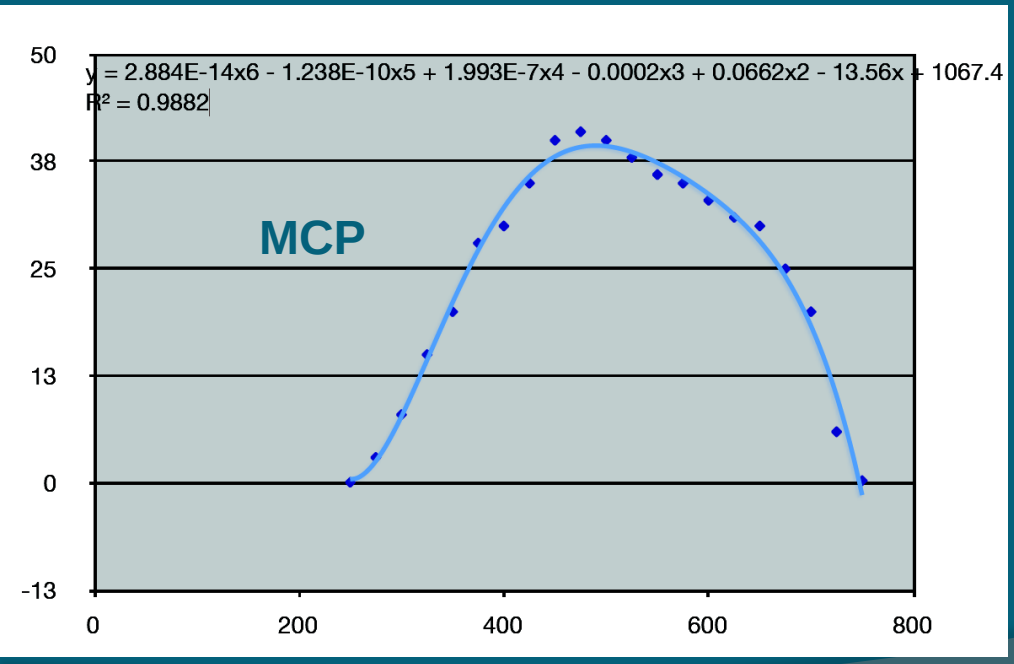


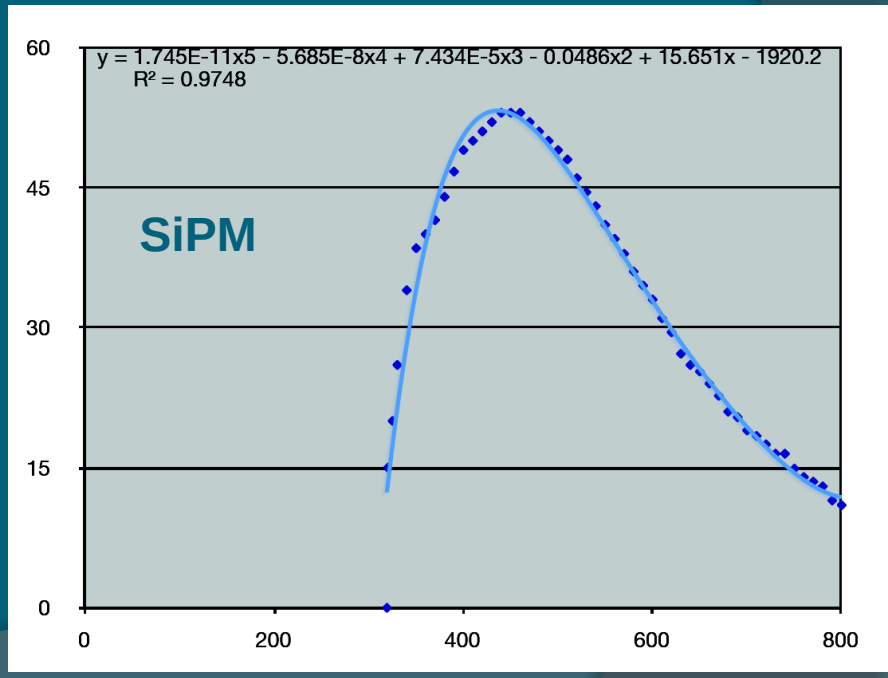
http://jp.hamamatsu.com/products/sensor-ssd/4010/4025/S10362-33-050C/index_en.html



Detector Efficiency

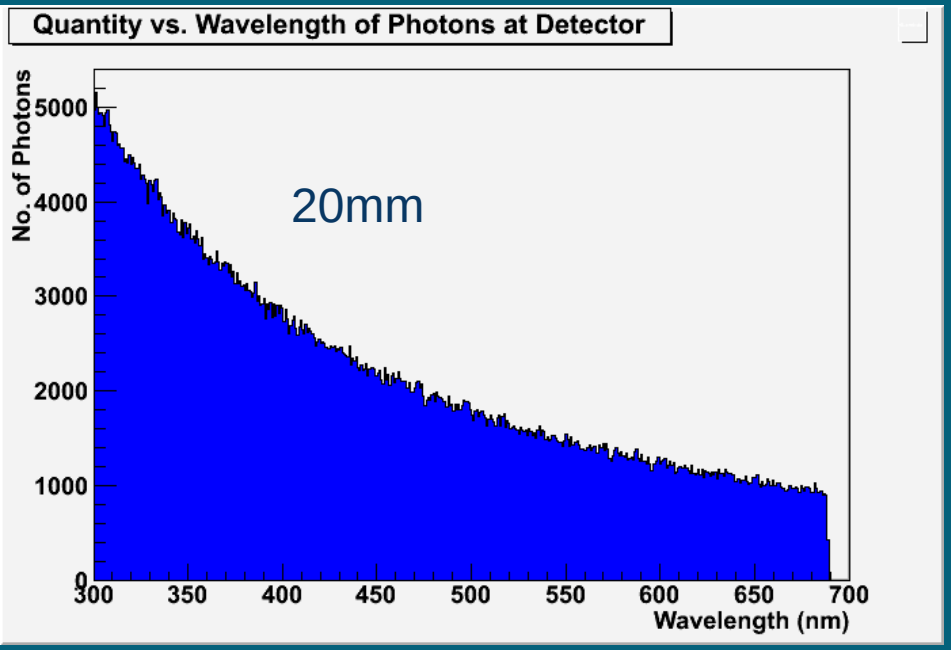
- Probability that an incident photon will produce a photoelectron for SiPM and MCP below

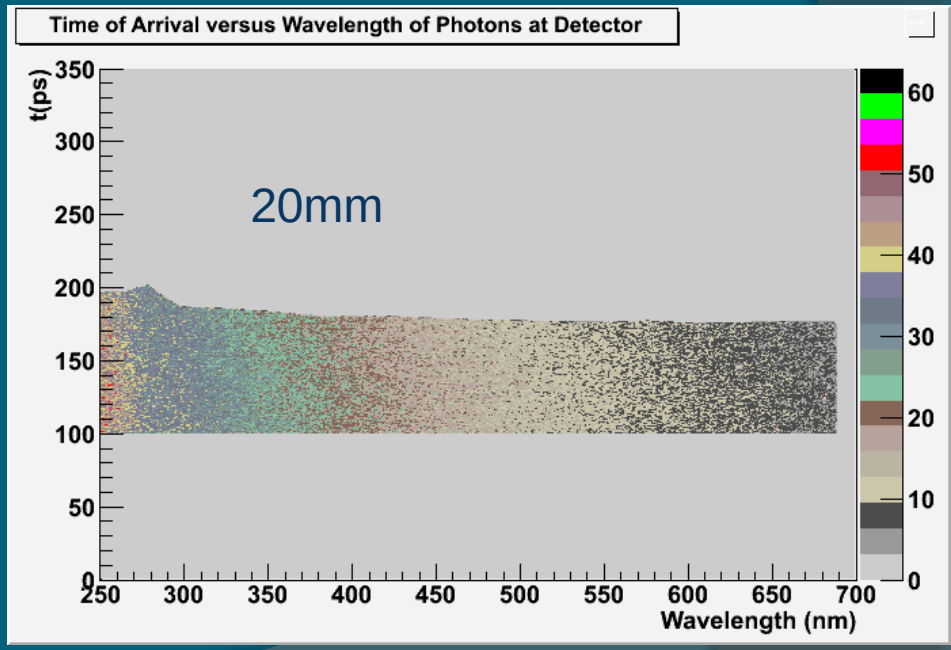




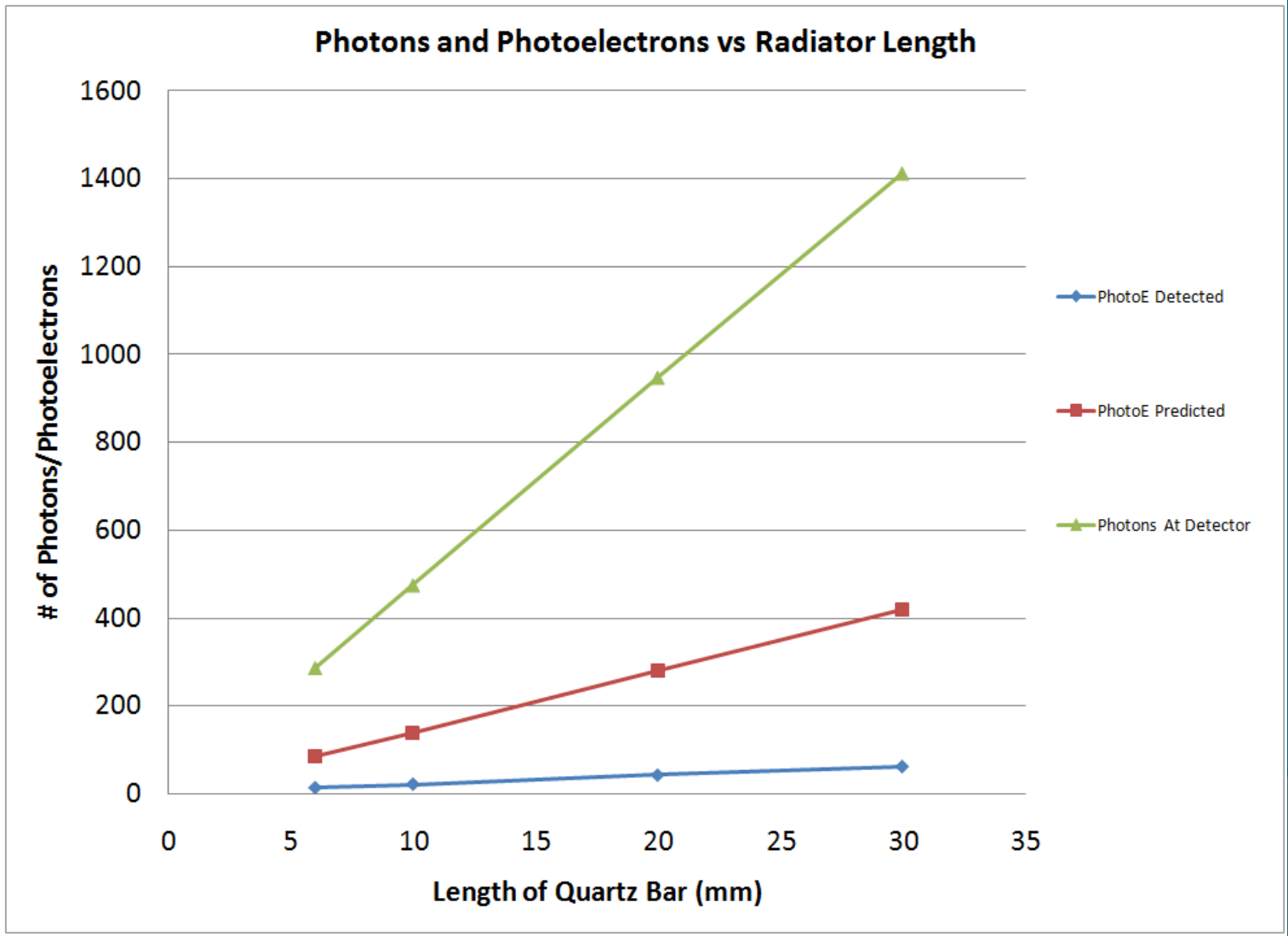
Photons At Detector vs. λ

- Photons reaching detector
- Geant4 modeling process well

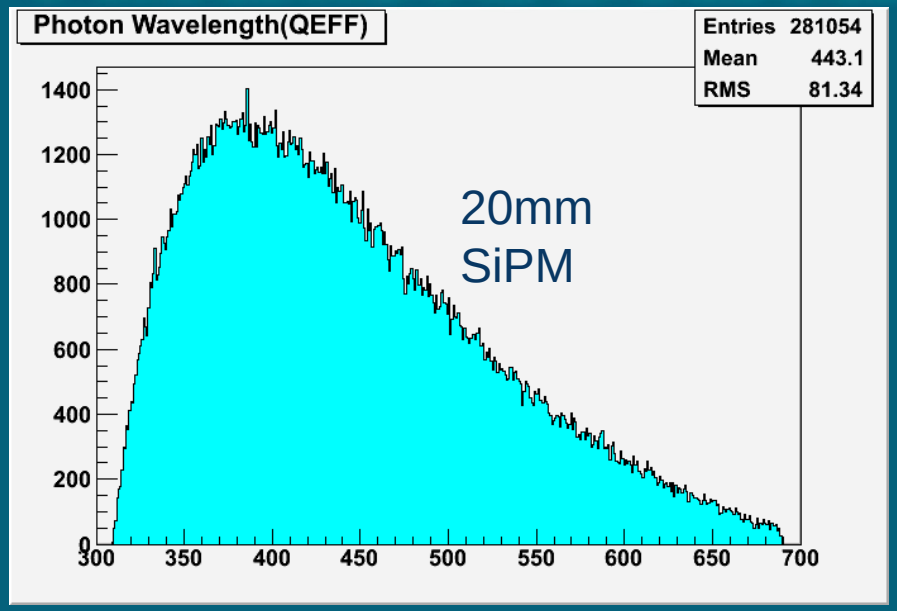


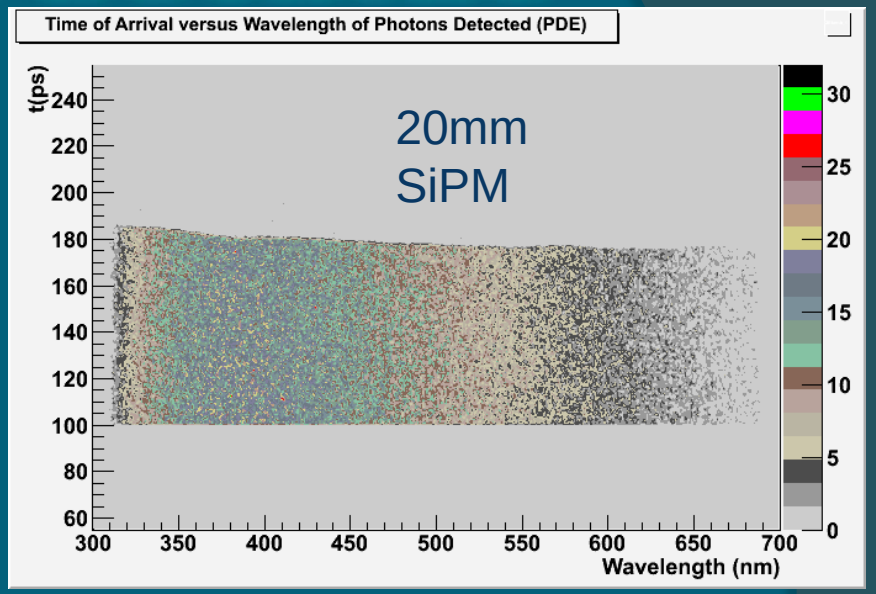


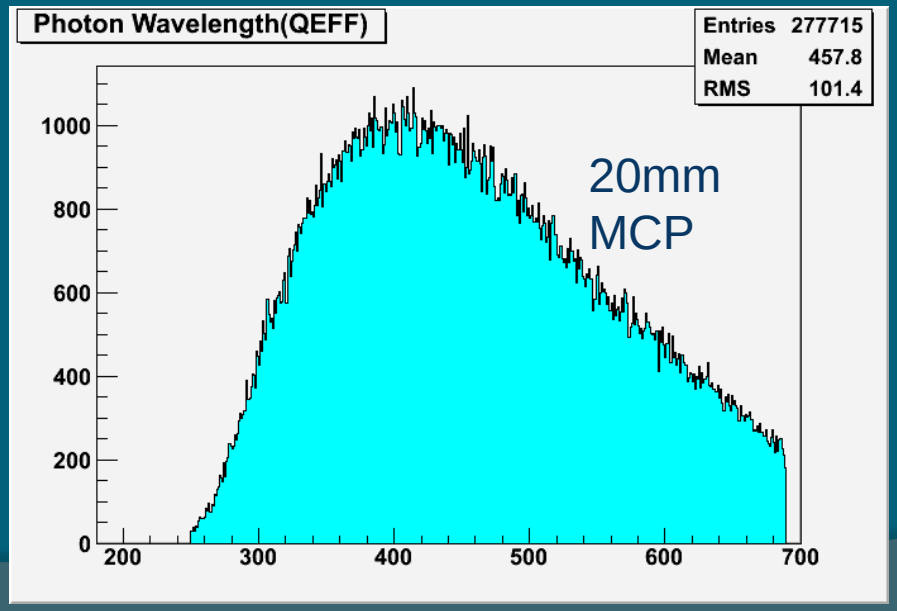
No. of Photons At Detector

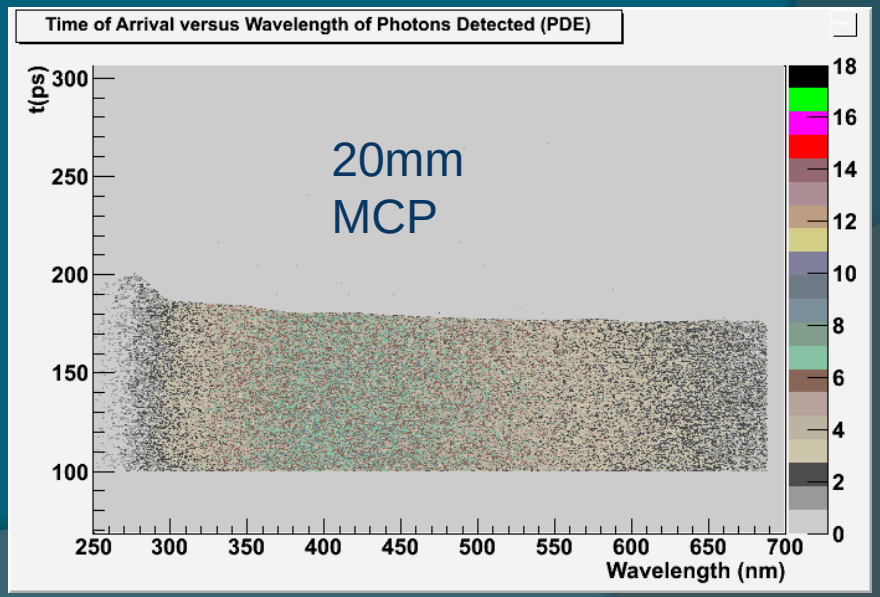


Photons At Detector & Detected



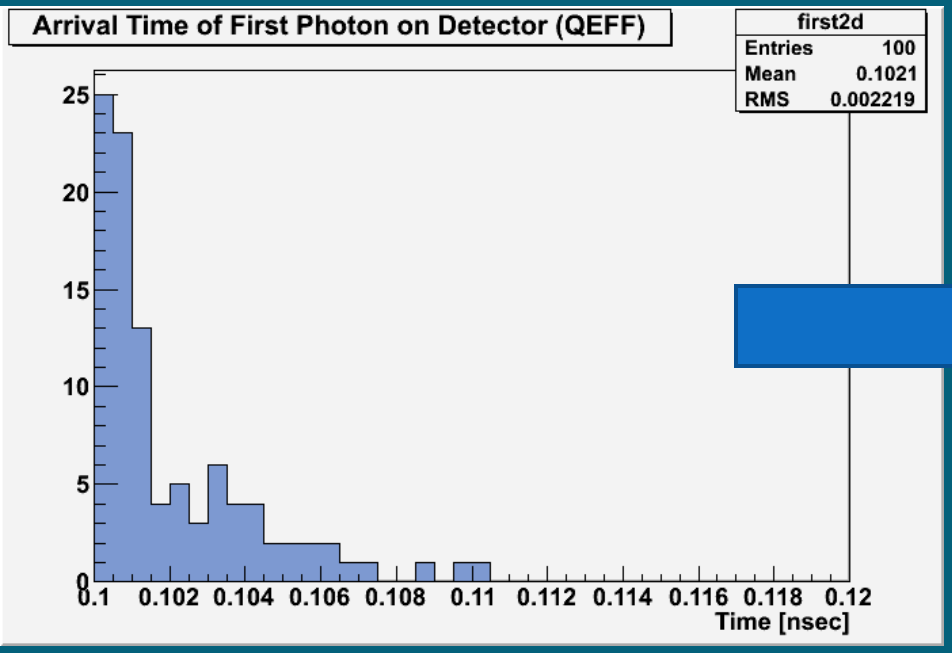


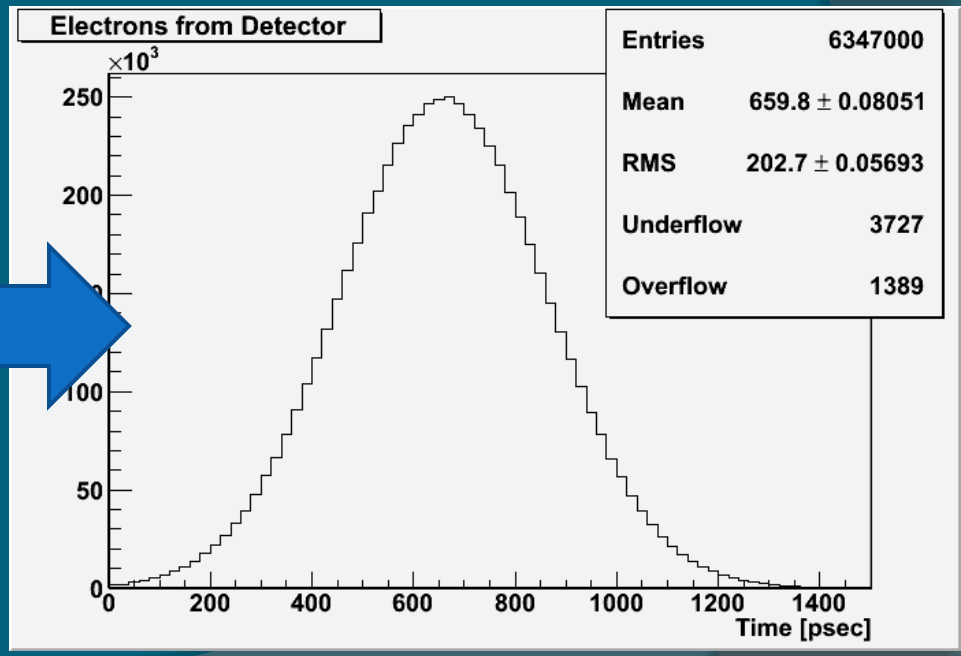




Jitter and Time Transit Spread (TTS)

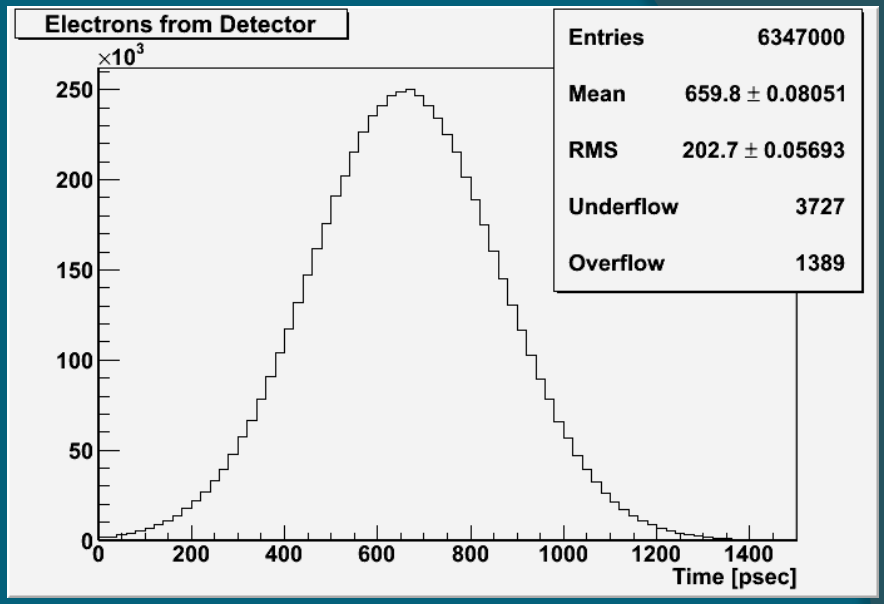
- Jitter: Effect of electronics displaces whole signal
- TTS: Effect of electron travel “smears” pulse

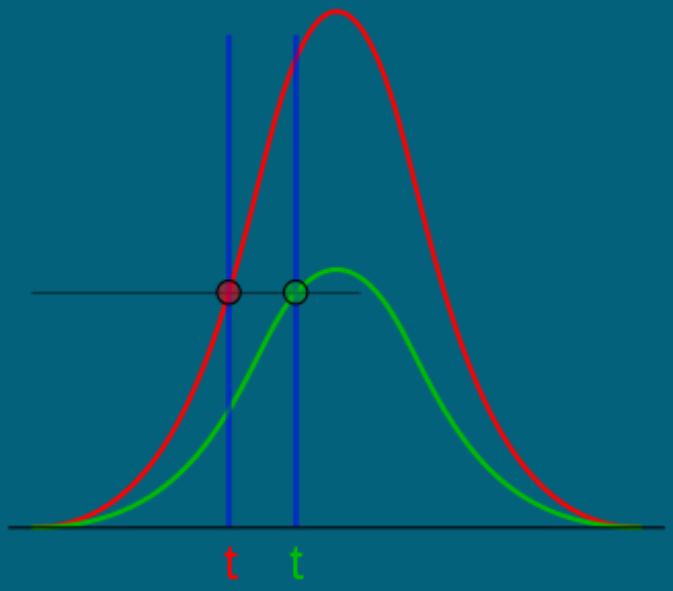


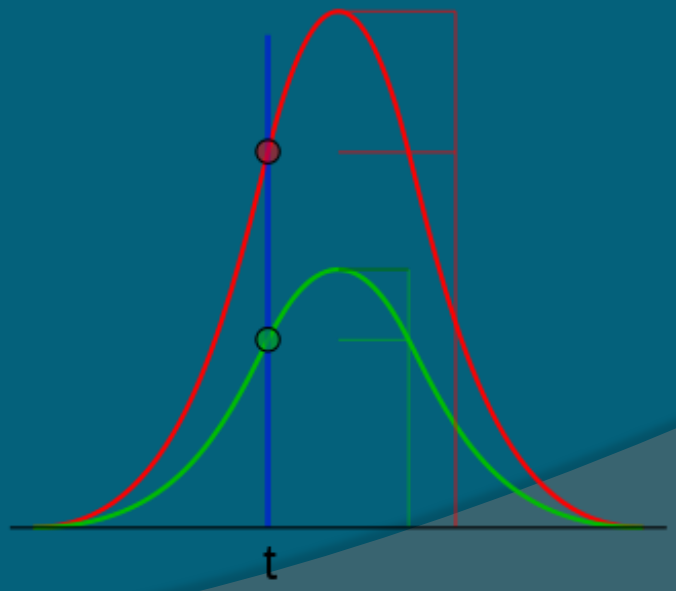


CFD Timing

- Jittered, Spread Pulse



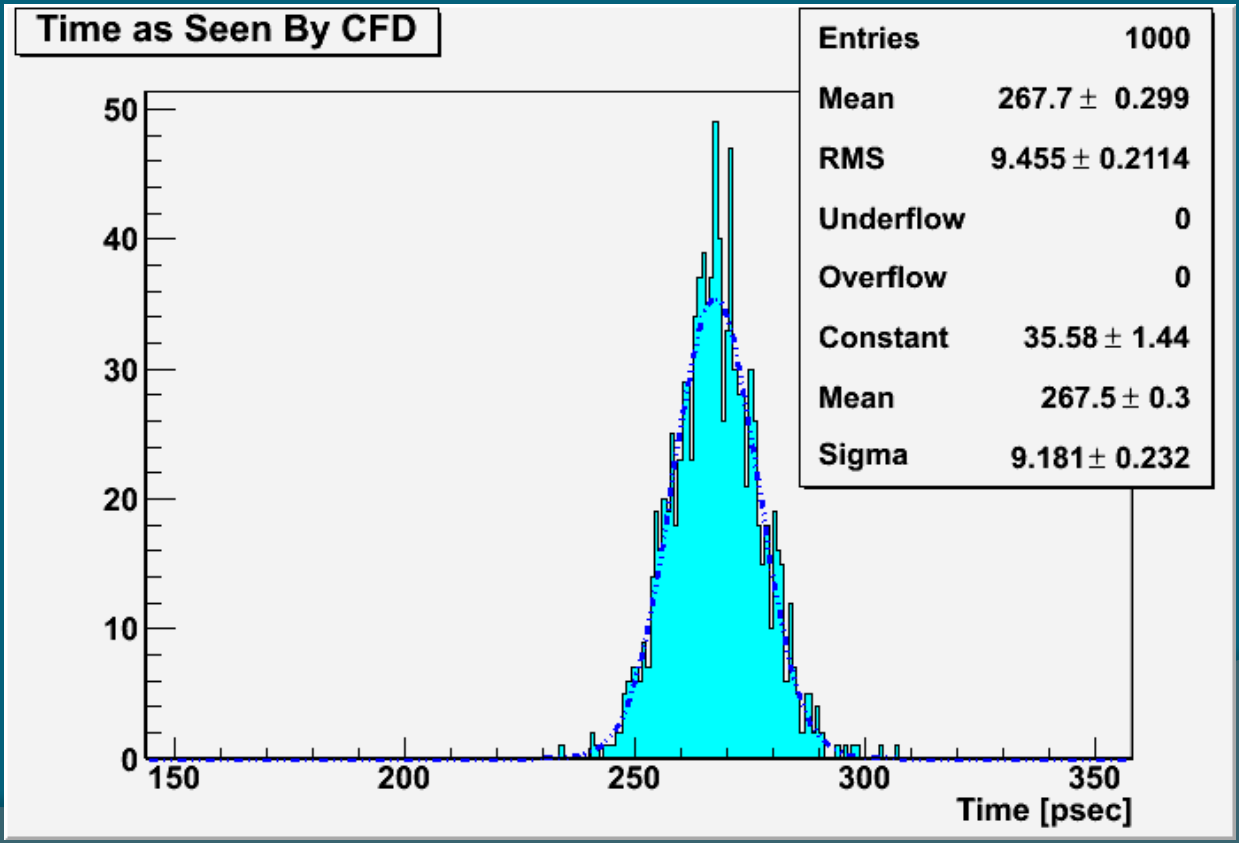




http://en.wikipedia.org/wiki/File:Constant_fraction_1.svg

Timing Resolution

- Fit CFD times of 1000 protons with Gaussian, find st. deviation



Further Studies

- Look at Timing Resolution with Signal Correction
- Look at Lead Fluoride as a Possible Radiator.
- Simulate Blue & Red Filters
- Do more QUARTIC setups
- Find the Factor of 2
- Figure Out Source of Photoelectron Loss

Mike Albrow

Hans Wenzel

Earle Wilson

Anatoly Ronzhin

Thank You

Additional thanks to Roger Dixon, Erik Ramberg, Carol Angarola for their work to make this internship possible, and the DOE Office of Science SULI project.