Proposal to Install Four Lightguide Detectors in μBooNE

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3/13/13

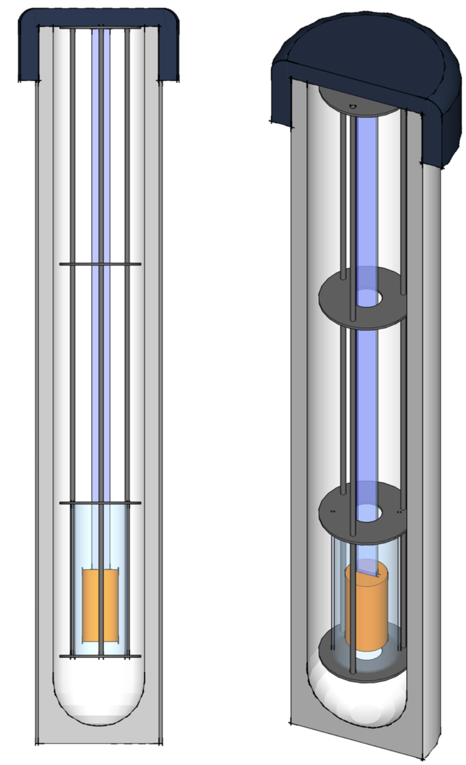
Motivation

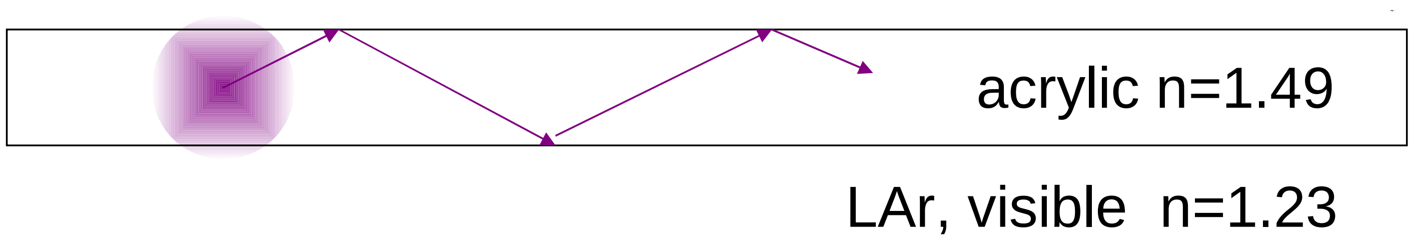
- Next generation of multi-kton LArTPC detectors present a challenge for light collection system
- MIT group proposed using a lightguide detector for scintillation light collection in large LArTPCs
- LBNE has adopted this idea (with modifications) for its light collection system
  - Performance estimates based only on lab measurements (e.g. NIMA 640, 69-75 (2011), arXiv:1210.3793)

➢ Need to test physics capabilities of lightguide detectors in an actual LArTPC experiment

What Are the Lab Measurements of LAr Lightguide Detectors?

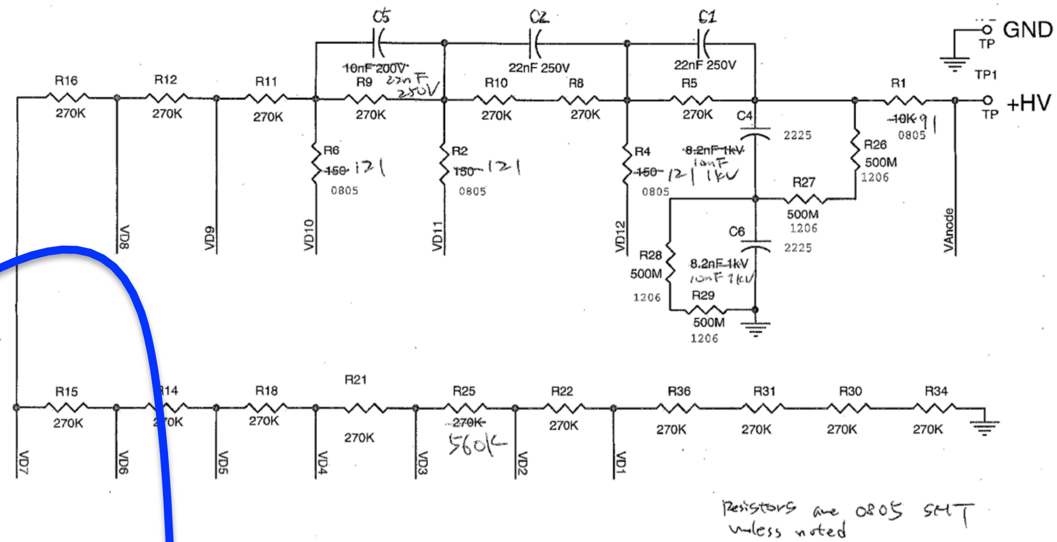
- LAr scintillation light is produced at 128 nm and must be wavelength-shifted (WLS) to the visible to be detected by PMTs
- Tests of various lightguide materials and WLS coatings were performed at MIT
- Used ^{210}Po alpha source (5.3 MeV) to excite LAr scintillation light
- Light WLS by a coating on an acrylic bar may be trapped and transported by total Internal reflection to the PMT.



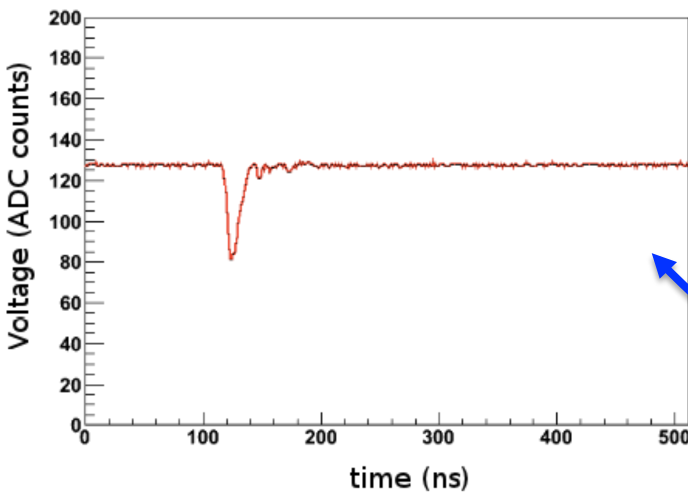


Electronics and Readout Chain

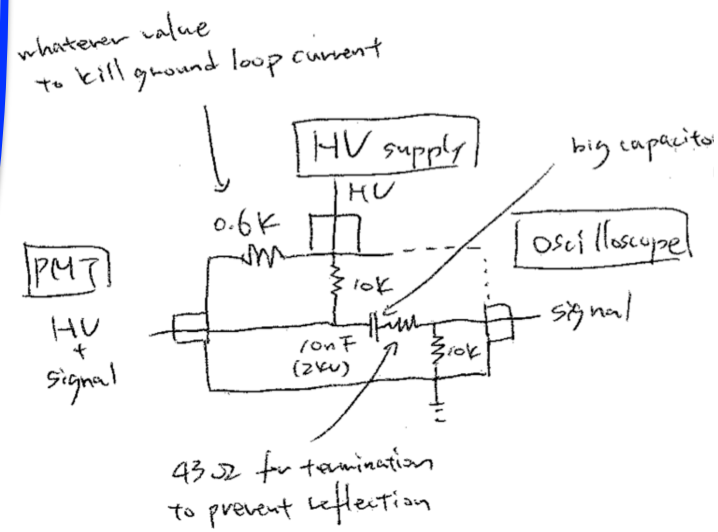
2" Pt-coated cryogenic PMT
(Hamamatsu R7725mod)



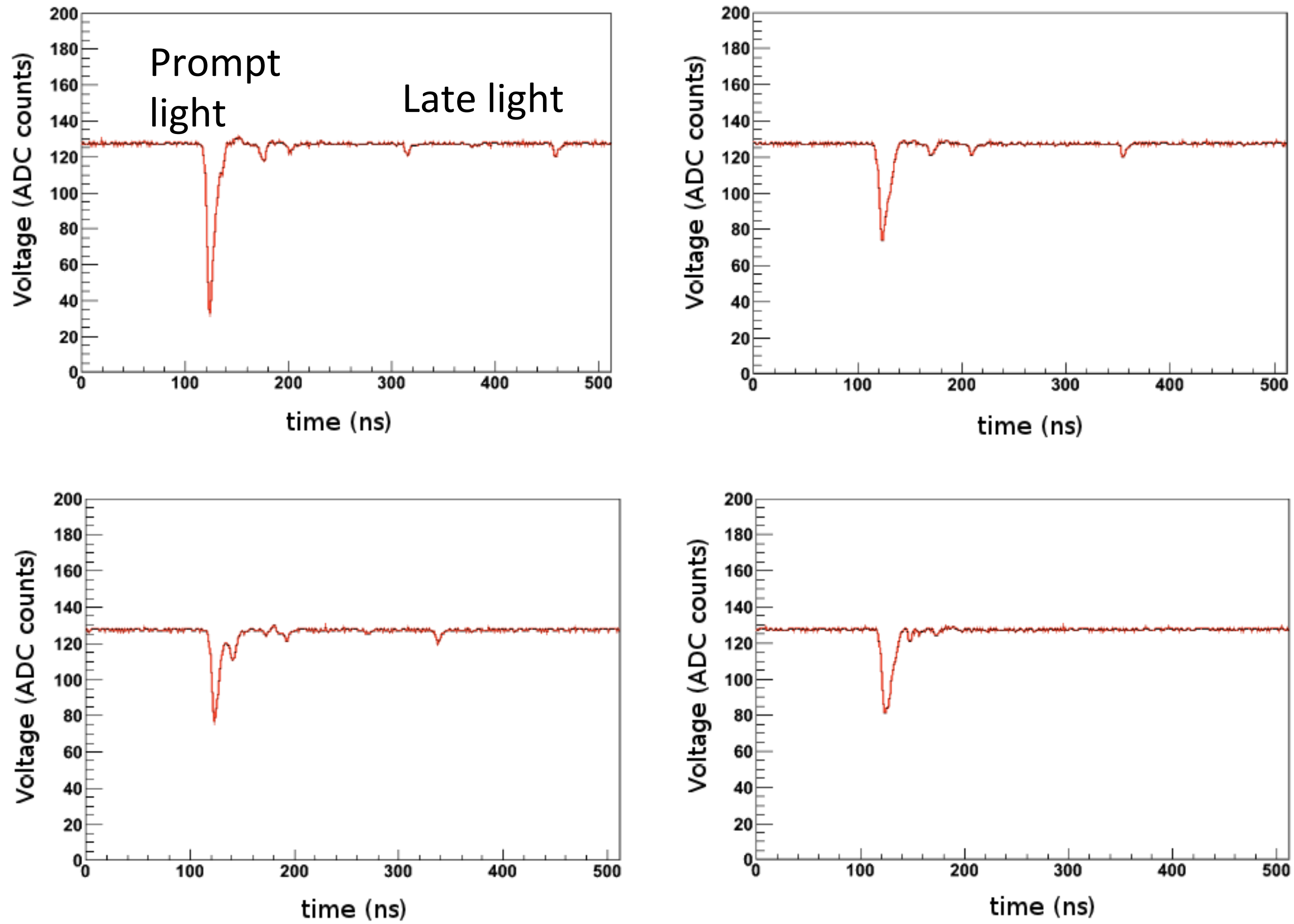
PMT base and HV splitter
designed by Teppei Katori



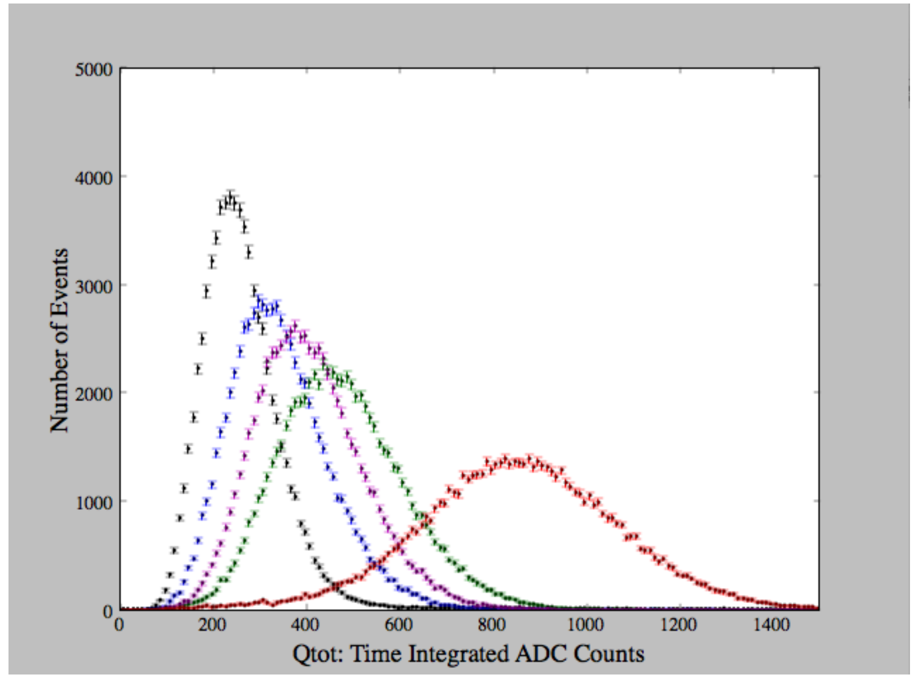
Pulses read out by 8-bit Alazar Tech ATS9870 digitizer at 1GS/s



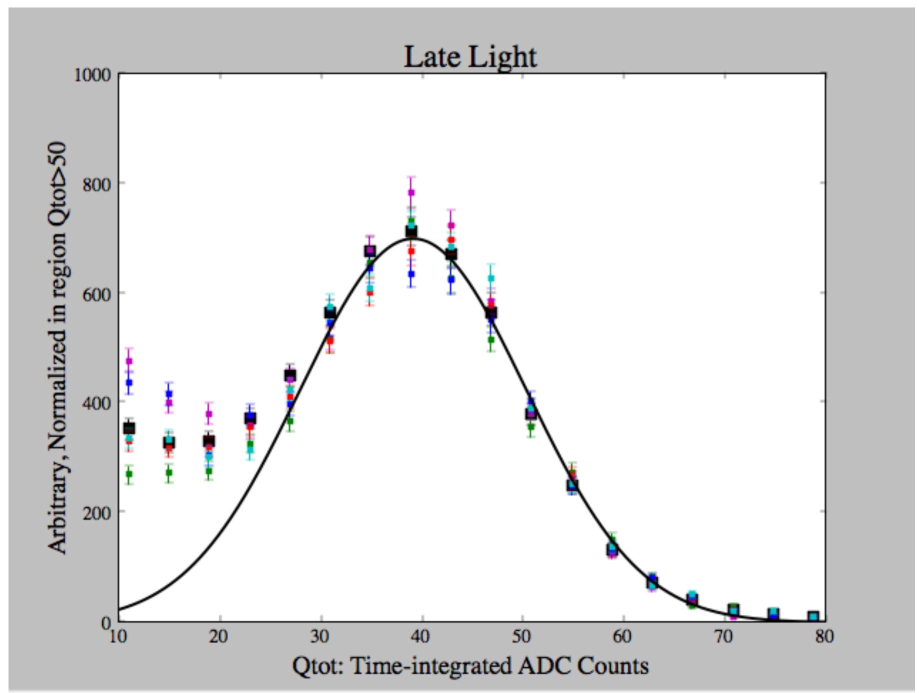
LAr Scintillation Light: Fast and Slow components



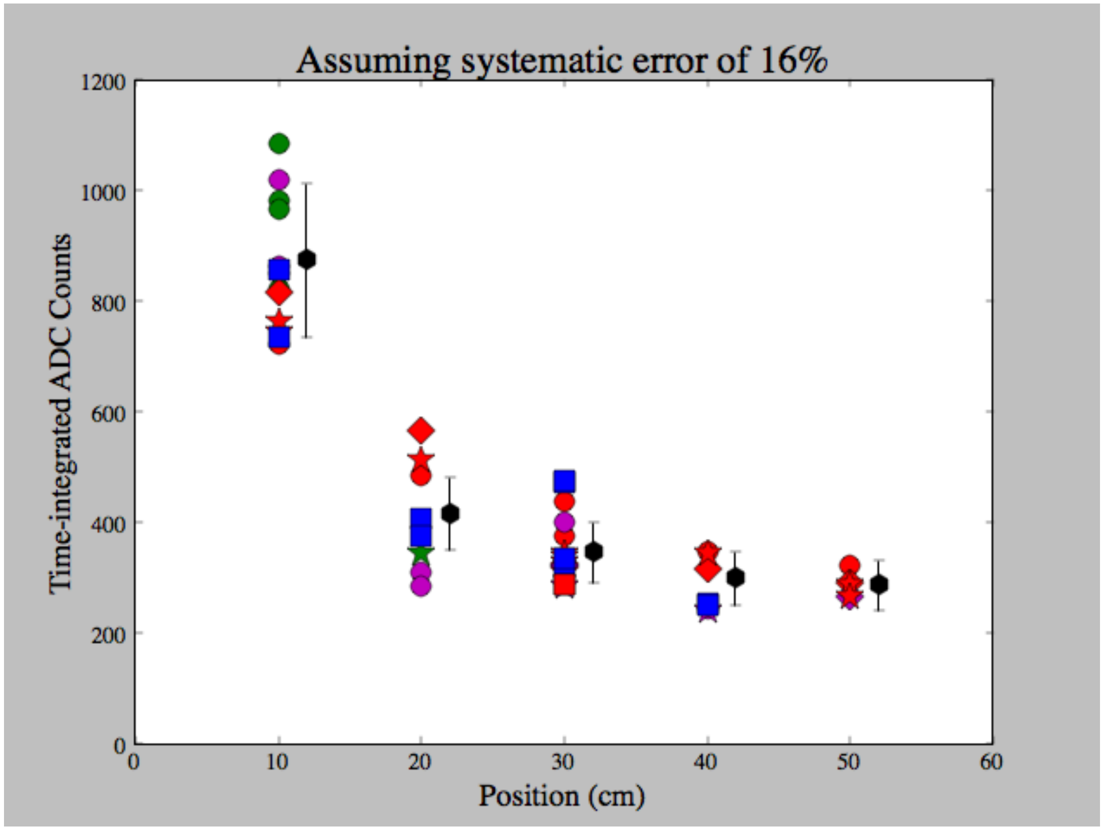
- Prompt light used to measure alpha peak at several distances along lightguide



- Late light (at the SPE level) used to measure PMT gain



Attenuation Along Lightguide



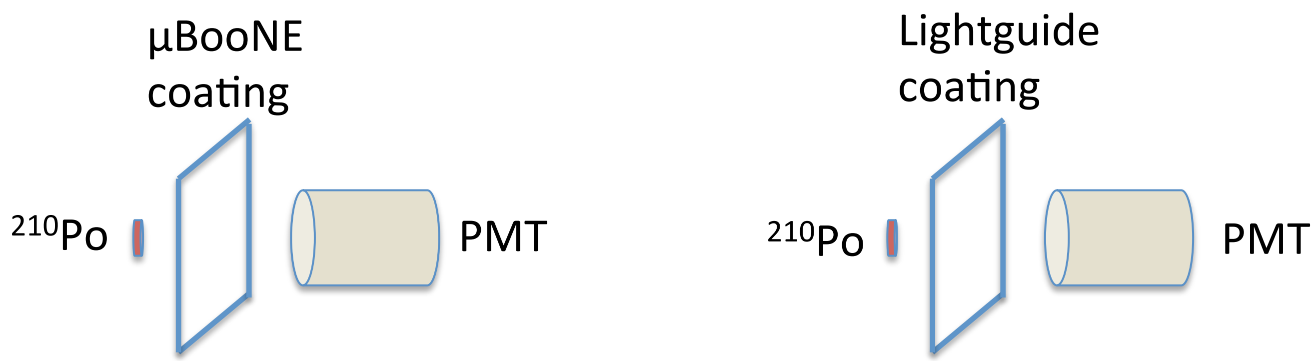
Exponential fit* to all data: λ = 44 cm
Exponential fit* excluding first point: : λ = 79 cm

*Note: Naïve exponential fit neglects wavelength-dependent effects, surface roughness, etc.

Lightguide Vs. Acrylic Plate WLS Coatings

- μBooNE acrylic plate WLS coatings differ from lightguide WLS coatings
  - Lightguide properties lost if TPB falls out of solution

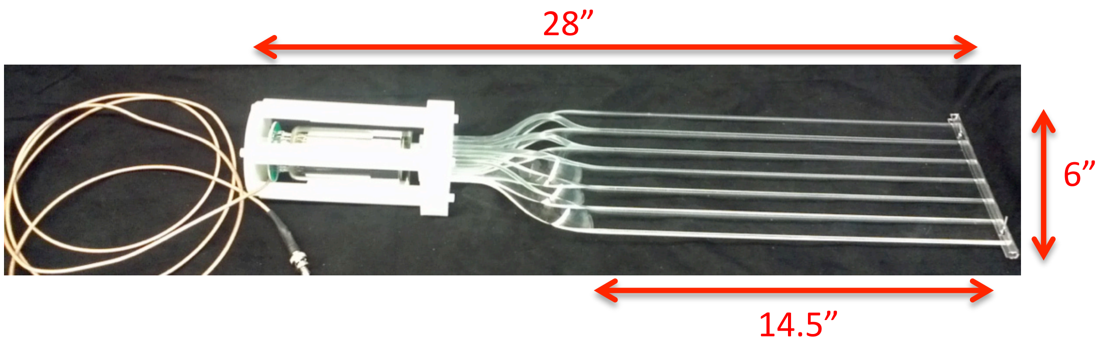
- We are studying the relative quantum efficiencies of the two coatings in LAr at MIT using an ^{210}Po alpha source

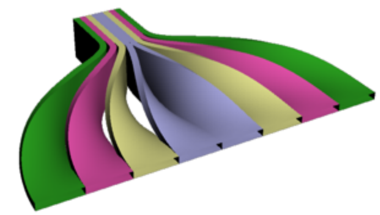


- Based on preliminary results, expect ~order of magnitude less light

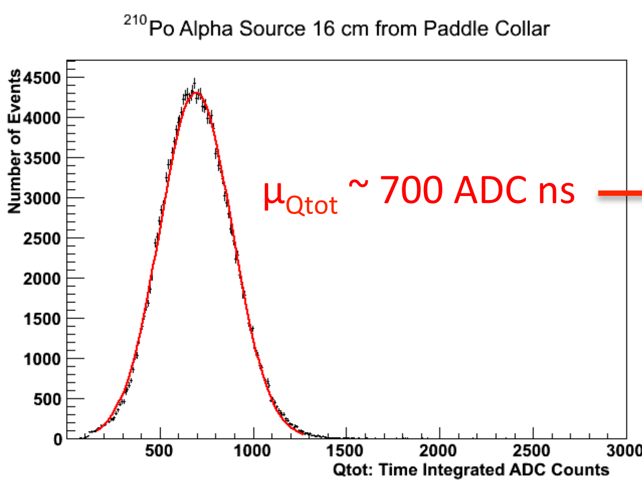
From Bars to Paddles

- An adiabatic lightguide (“paddle”) can be built out of many bars and read out by a single 2” PMT



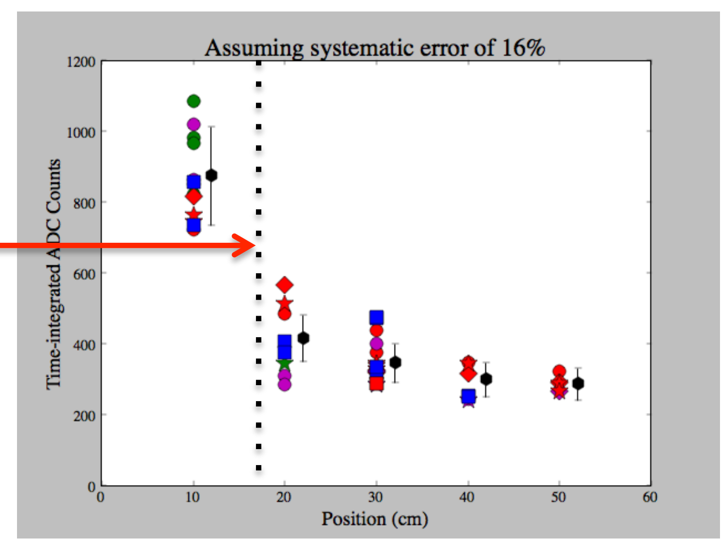


- We compared the light output for a ^{210}Po source clipped to the paddle ~16-18 cm from the PMT

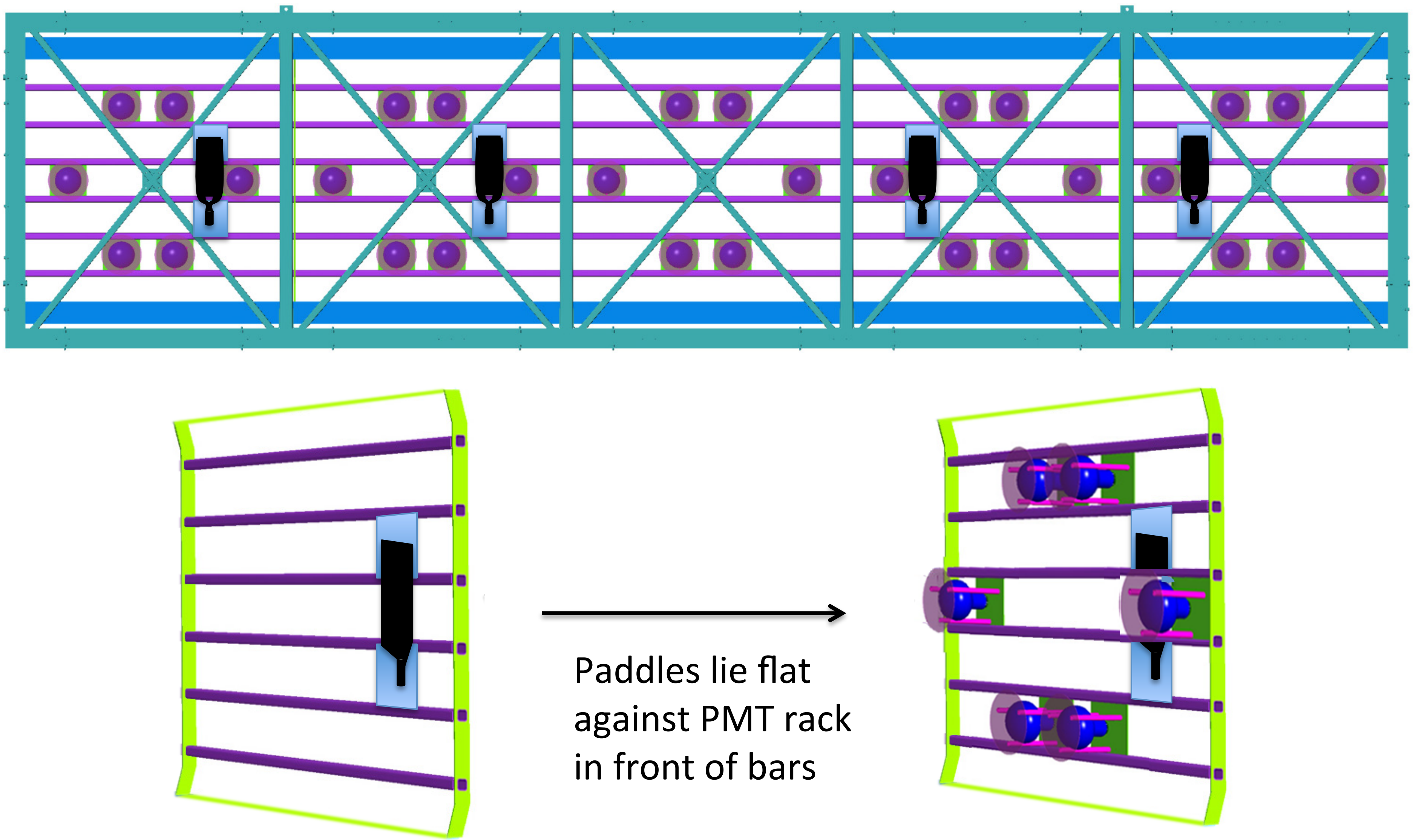


μ_{Qtot} ~ 700 ADC ns

Matches expectations



Where Would the Paddles Fit in μBooNE?

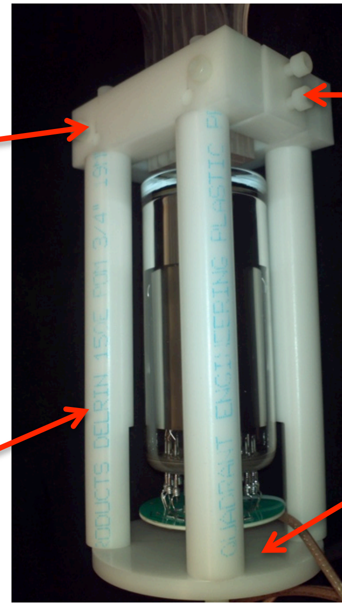


Paddles lie flat against PMT rack in front of bars

How Will They Be Mounted in µBooNE?

Delrin collar pinches paddle neck on top and bottom

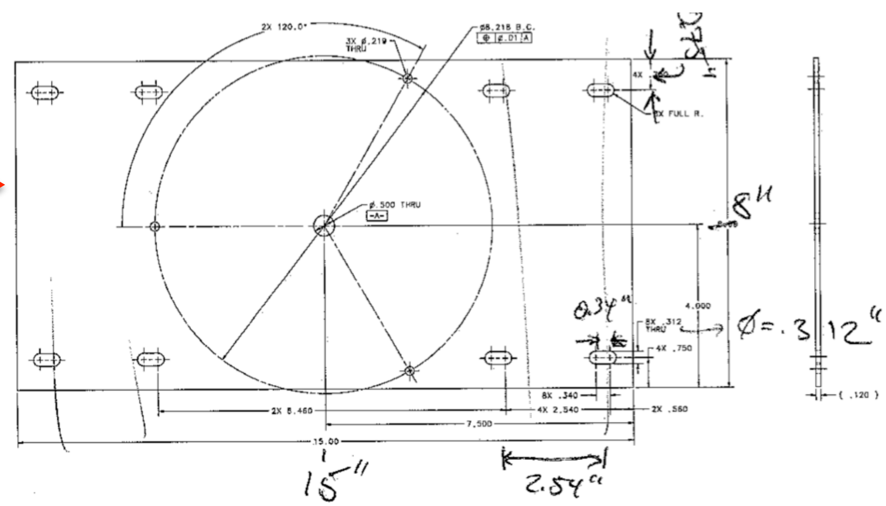
Nylon screws pinch paddle neck from the side



Four Delrin posts loosely confine PMT underneath paddle

Bottom Delrin plate will be made rectangular (circular plate shown)

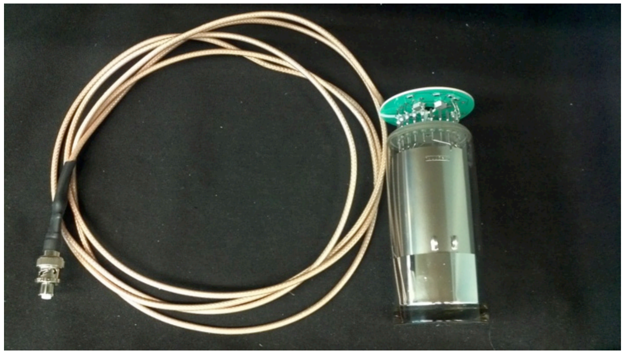
Delrin collar and bottom plate screwed into same back plate used for µBooNE PMT mount

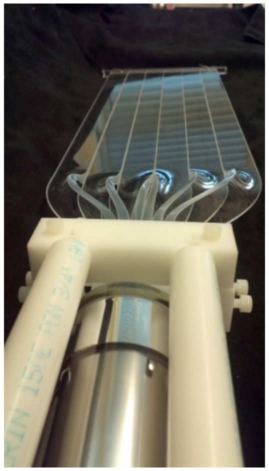


⟶ Replace Delrin with stainless steel?

Paddle Integration and Readiness

- µBooNE light collection system has been designed for 40 channels
  - Including PMT feed-through, splitter, HV, and readout electronics
- Only 30 of these channels will be instrumented with 8” PMTs
  - Opportunity to make use of spare channels to do interesting physics / R&D
- Adiabatic lightguides, 2” PMTs, and PMT bases are all in hand
  - Short lead time required to build paddle mounts and coat paddles (~1 month)





Conclusions

- Lightguide detectors are a promising new way to collect scintillation light in a LArTPC
  - Especially relevant for large detectors such as LBNE
- μBooNE has an opportunity to be the first experiment to demonstrate this technology
- We propose to install 4 lightguide detectors in μBooNE
  - PMT paddle integration seems to be easily accommodated by current μBooNE design

μBooNE and lightguides are a perfect match!

Thank you!