Acrylic Attenuation Length Simulations, Continued

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Acrylic Vessel Simulations Recap

- Acrylic Optical Modeling:
  - We will use one index of refraction model for all different types of acrylic:
    - Established by measuring IOR in two different ways, see DocDB 3941, version 2.
  - Have done simulations of varying acrylic attenuation length
    - Results presented ~1 month ago.
  - Now presenting the rest of that data, with similar conclusions reached, but extended.

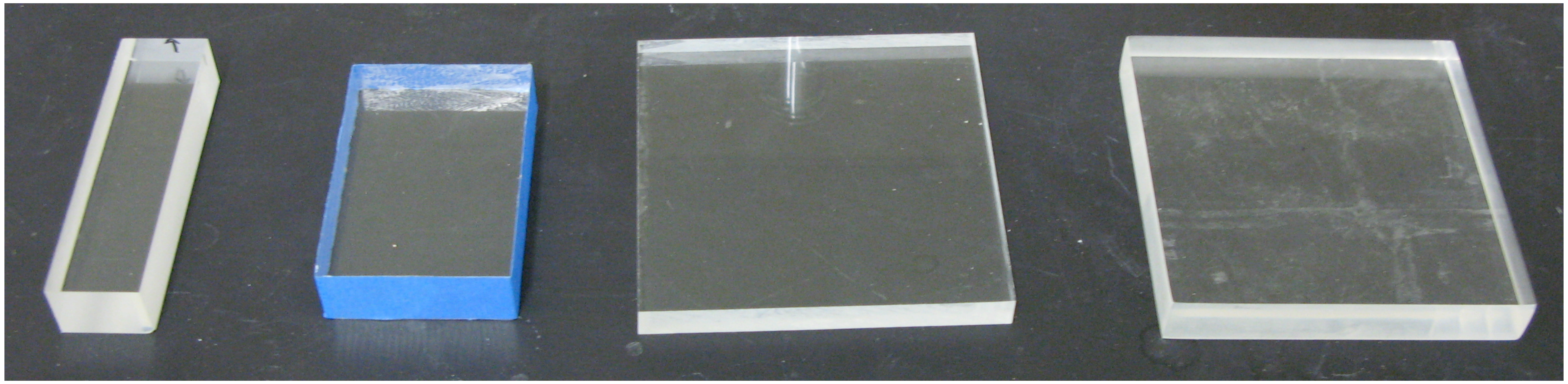
AV Attenuation Length: Methods Recap

- Measure best-and worst-case attenuation length spectrum for each material:

Measured Transmittance → $$T^* = \frac{(1-R)^2 T}{1 - R^2 T^2}$$ → Loss due to attenuation

→ Loss due to surface reflection

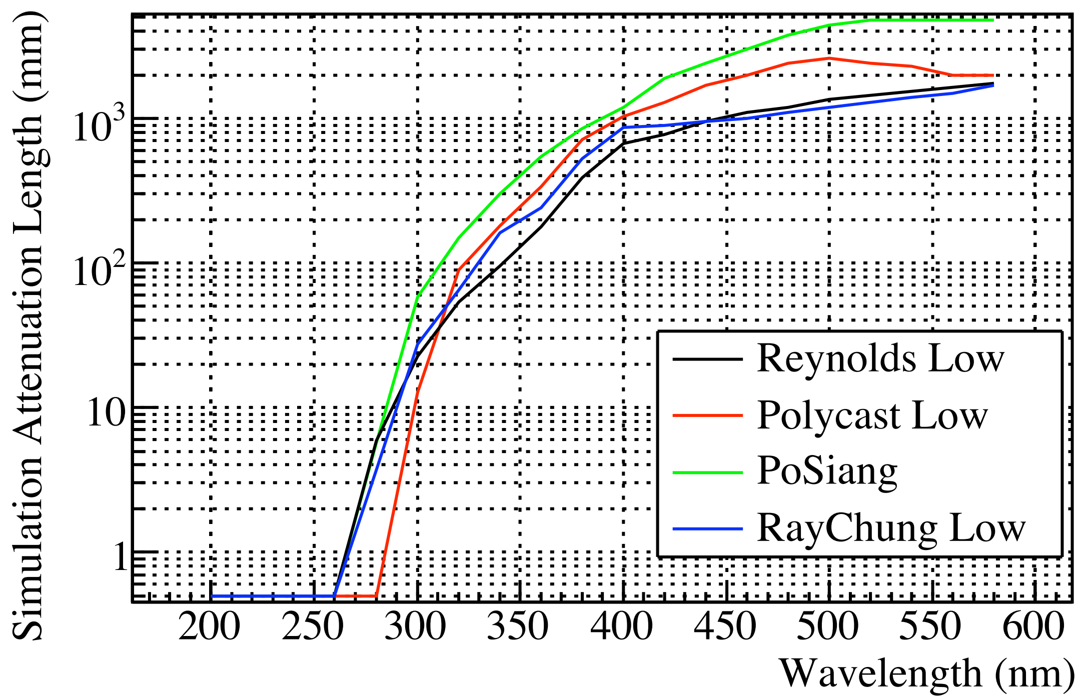
- Four acrylics: Raychung (Reflector), PoSiang (IAV), Reynolds, and Polycast (OAV).
- For each material:
  - Make measurements of many samples
  - At one wavelength, take the highest T* and solve for T (given known R), then attenuation length
  - Do this for 20 different wavelengths to get best-case attenuation length for each material.
  - Repeat process for lowest T* to get worst-case attenuation length

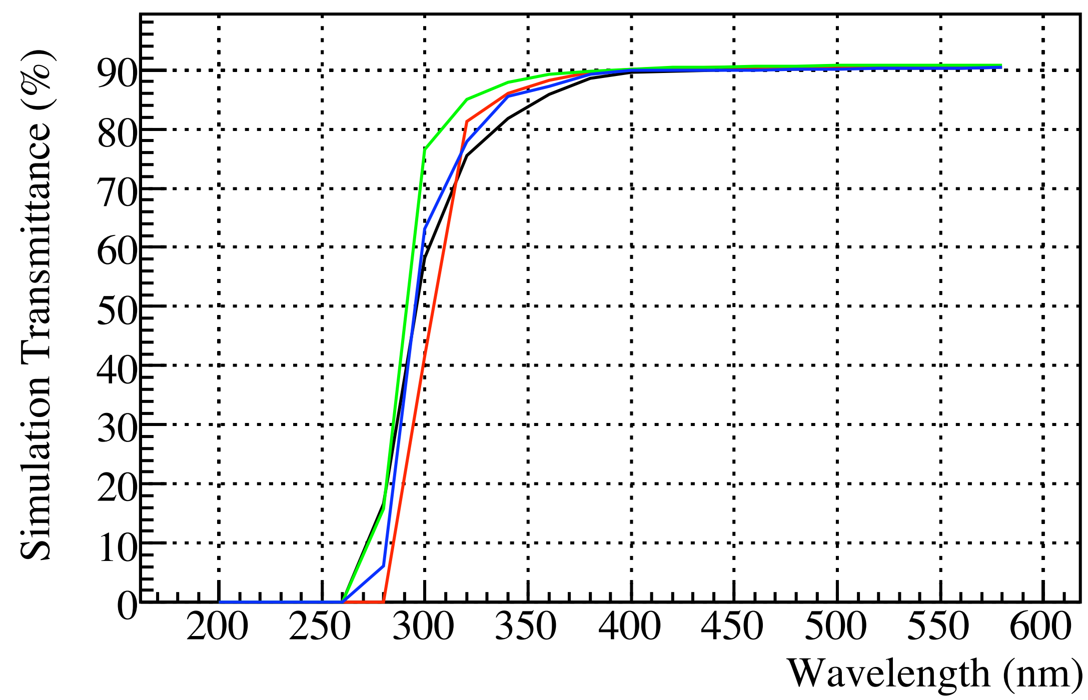


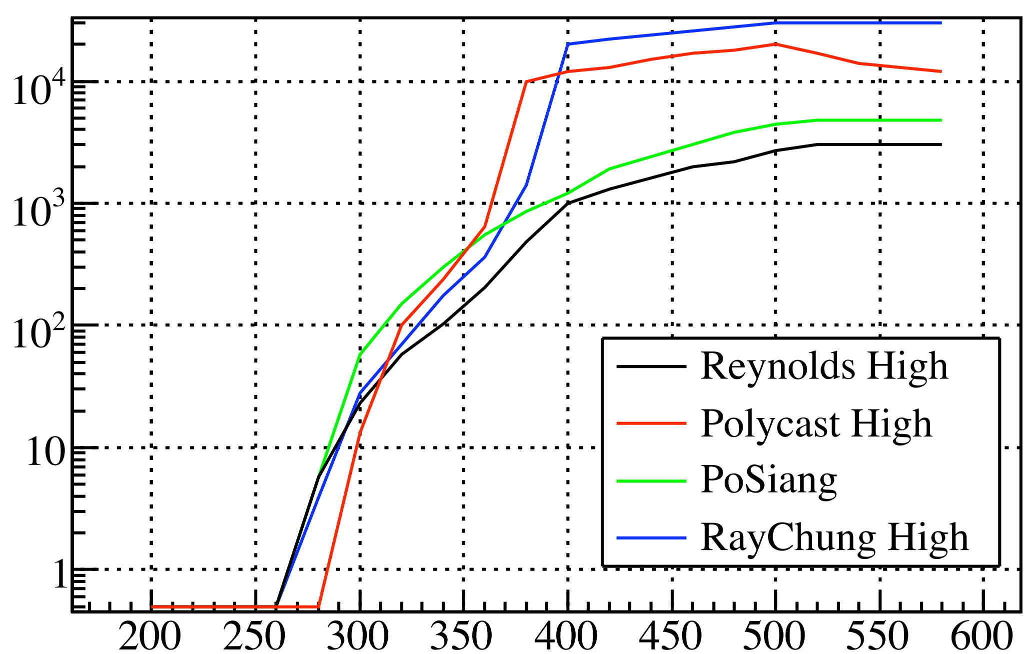
Acrylic Attenuation Lengths

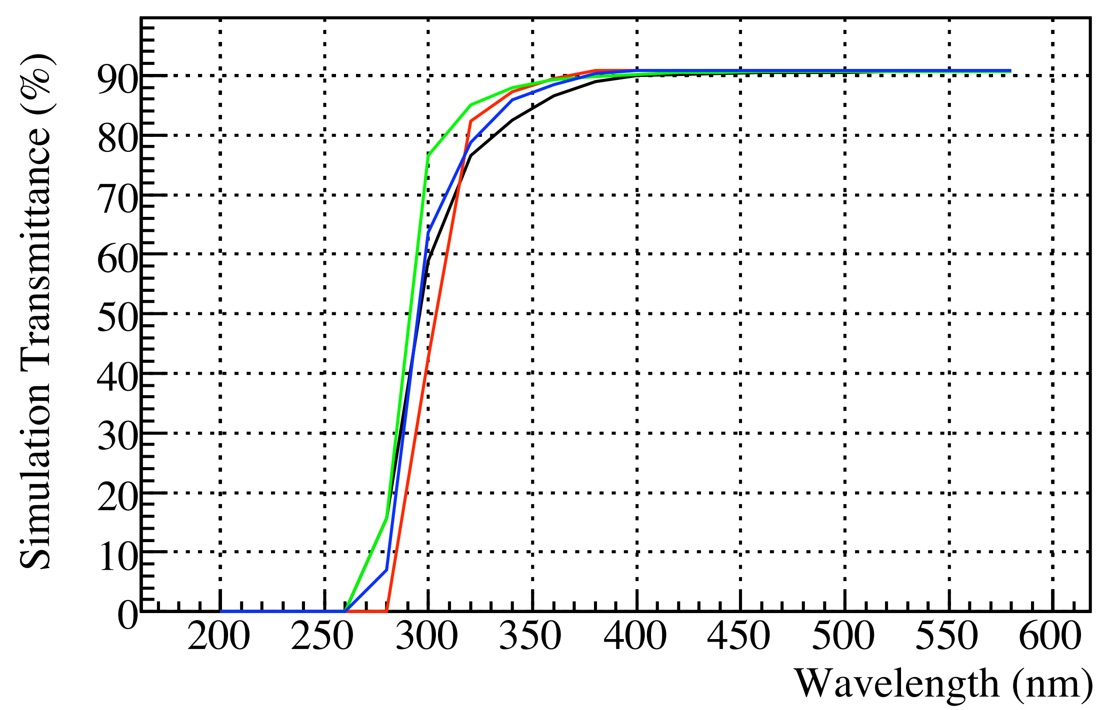
- Best- and worst- case models for each acrylic type:
  - See DocDB 3777 for details on measurement method, uncertainties

Attenuation Lengths







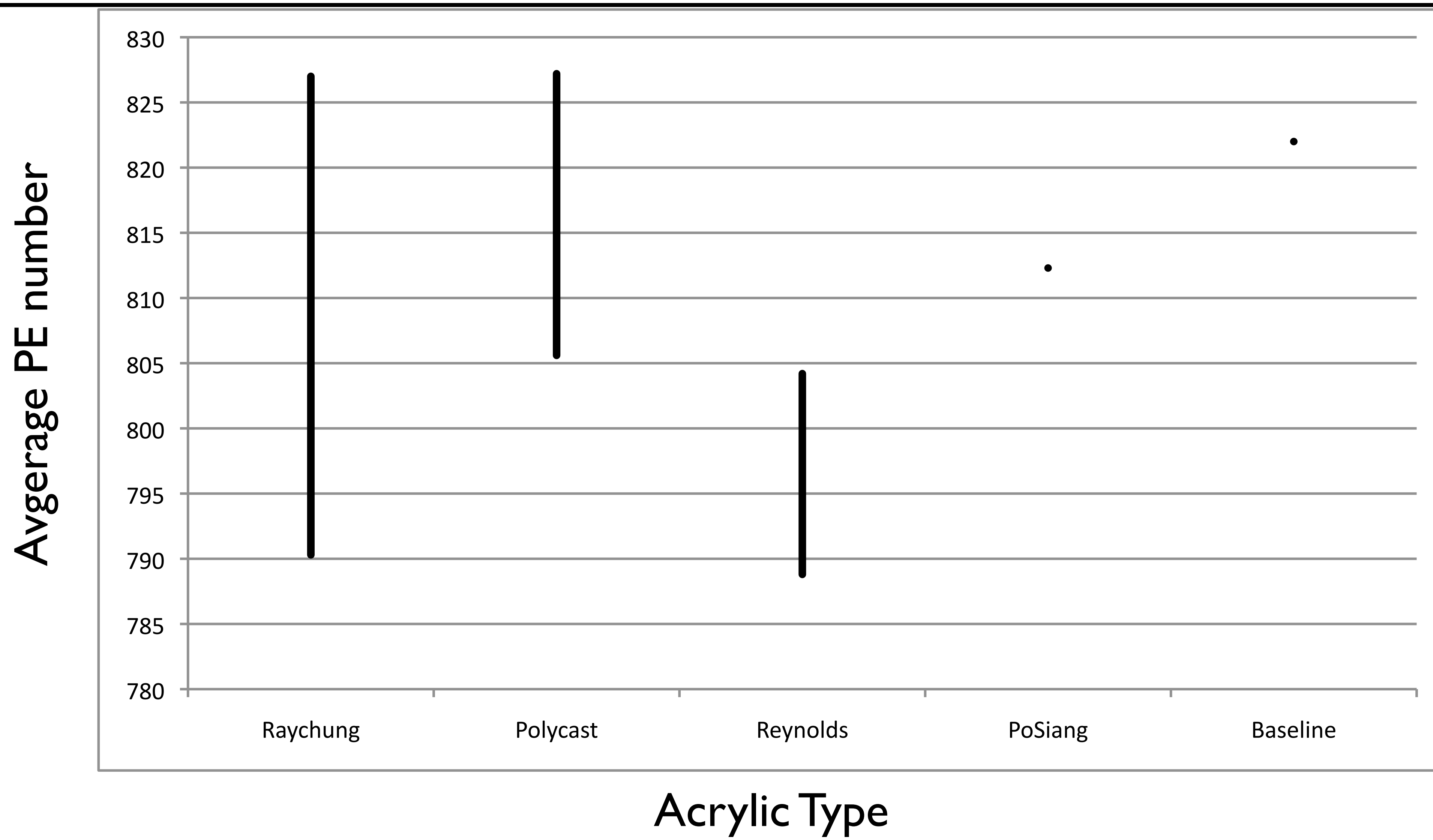


Resultant transmittance spectra: 1 cm pathlength

Simulation

- Use NuWa to simulate detector:
  - Default MDC09a detector model, including Qing's geometry fix
  - Exception: OAV acrylic material is adjusted to these 7 different models
- Commands:
  - nuwa.py -n xxxx -R xxxx -m "MDC09a.runGamma -k 6" -o xxxx.root
    - Generated 10k 6MeV gammas at the center of the GdLS
    - Fit PE spectrum with a gaussian to find 6MeV cut
  - nuwa.py -n xxxx -R xxxx -m "MDC09a.runIBD" -o xxxx.root
    - Modified to generate only IBD neutrons throughout GdLS
    - Mistake in generation: no generated events in GdLS above 2.5 m from bottom
- 120k IBD neutrons for each type of acrylic.
  - PDSF, COOP, WISC using Spade to organize and catalog raw data

Results: Calibration Data



- Raychung showed largest light yield variability at ~4.4%
- Baseline is on the higher end of these light yield values
- Statistical uncertainty from 10k events: 1%
- Since light yield shows non-negligible changes, changes in other metrics are possible.

Results: IBD Neutrons

Sample	Neutron Detection Efficiency (%)	Neutron Efficiency Statistical Uncertainty (%)	Neutron Efficiency Systematic Uncertainty (%)	events in +/-1% uncertainty bin
RayChung Best	92.00	0.085	0.227	464 (.01%)
RayChung Worst	91.89	0.085	0.220	449 (.01%)
Polycast Best	92.09	0.084	0.216	443 (.01%)
Polycast Worst	91.97	0.085	0.220	451 (.01%)
Reynolds Best	91.96	0.089	0.226	425(.01%)
Reynolds Worst	91.98	0.084	0.210	431 (.01%)
Baseline Acrylic	91.97	0.085	0.221	451 (.01%)
PoSiang	91.95	0.085	0.221	452 (.01%)

- Changes in response due to different OAV acrylics are small:
  - Differences in neutron detection efficiency are 0.2% or less.
    - Difference between best and worst case efficiency for any material is never greater than .12%
  - Differences in systematic uncertainty from the 6MeV cut are 0.017%.
    - Same size as statistical uncertainty on this value, 0.011%
    - Difference between best and worst case systematic uncertainty for any material never greater than 0.016%
    - Any changes are not statistically significant.

Results: Change ALL acrylics:

- Switching ALL acrylic in AD:
  - Any effects of switching would be largest if ALL acrylics were changed.
  - Calibration changed: 6MeV gammas throughout ENTIRE target volume.

Sample	Neutron Detection Efficiency (%)	Neutron Efficiency Statistical Uncertainty (%)	Neutron Efficiency Systematic Uncertainty (%)	events in +/-1% uncertainty bin
All Acrylic Polycast Best	91.1	0.090	0.265	542(.011%)
All Acrylic Reynolds Low	90.8	0.090	0.270	553 (.011%)

- Efficiency changes a stat. significant but small amount
- 6MeV cut systematic uncertainty: not a statistically significant change.

Conclusions

- Knowing this, we can now avoid implementing more complicated NuWa optical models:
  - We don't have to input different optical properties for each acrylic sheet of each reflector, OAV, and IAV!
  - We don't need to input different acrylic optical properties for every AD!
    - All ADs can be sufficiently described using identical acrylic optical models
  - We can treat ALL acrylics with one optical model, if we are willing to accept inaccuracies of <.3% in neutron detection efficiency.
- Actions:
  - Should I implement an acrylic optical model with one type of acrylic, or should I include different models for each component (i.e., IAV, OAV barrel, OAV caps, Reflector)?
- Next (last?) step:
  - Do electronics, trigger and readout simulation, map reconstructed energy vs. position, see if there are any changes when acrylic is swapped.