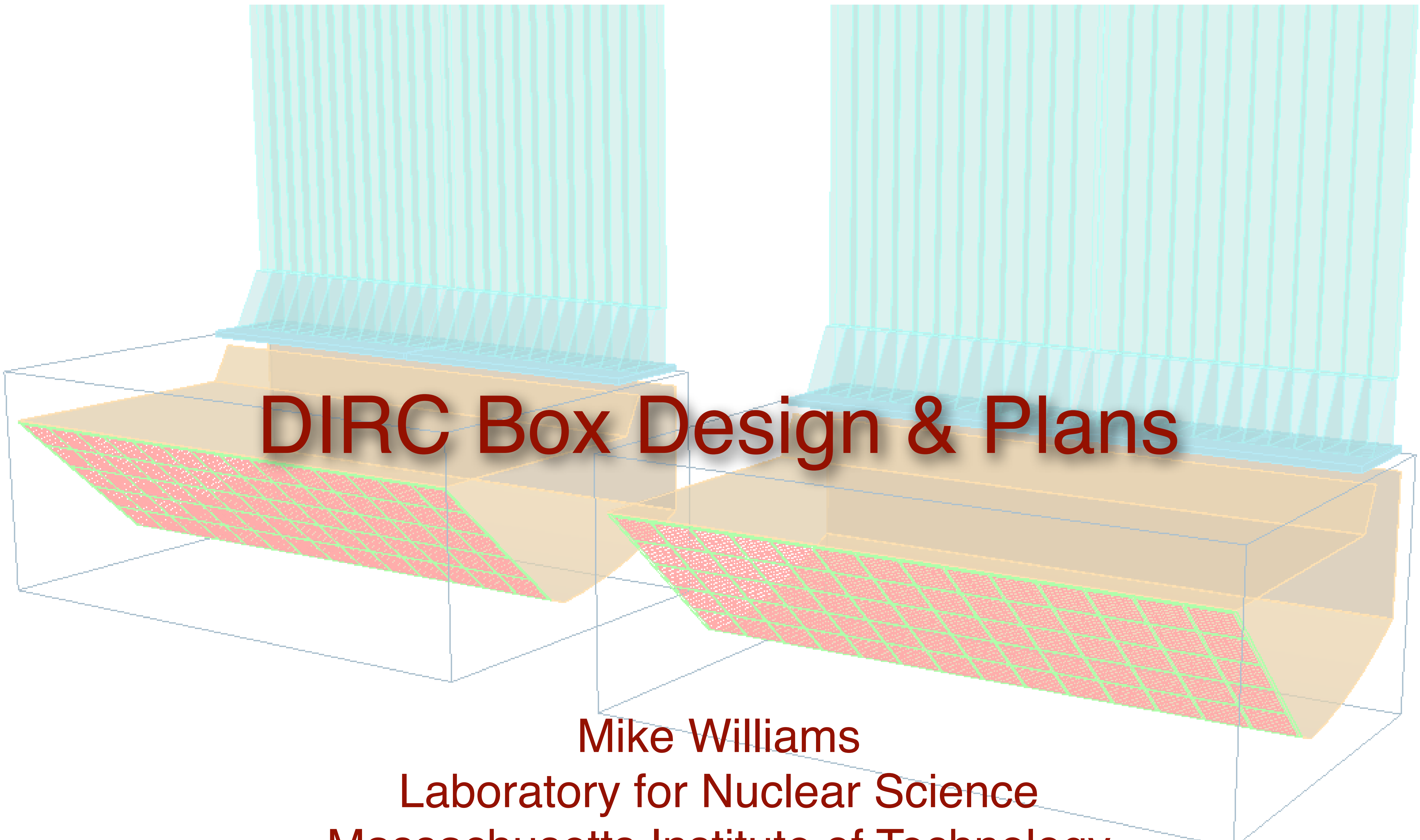

DIRC Box Design & Plans

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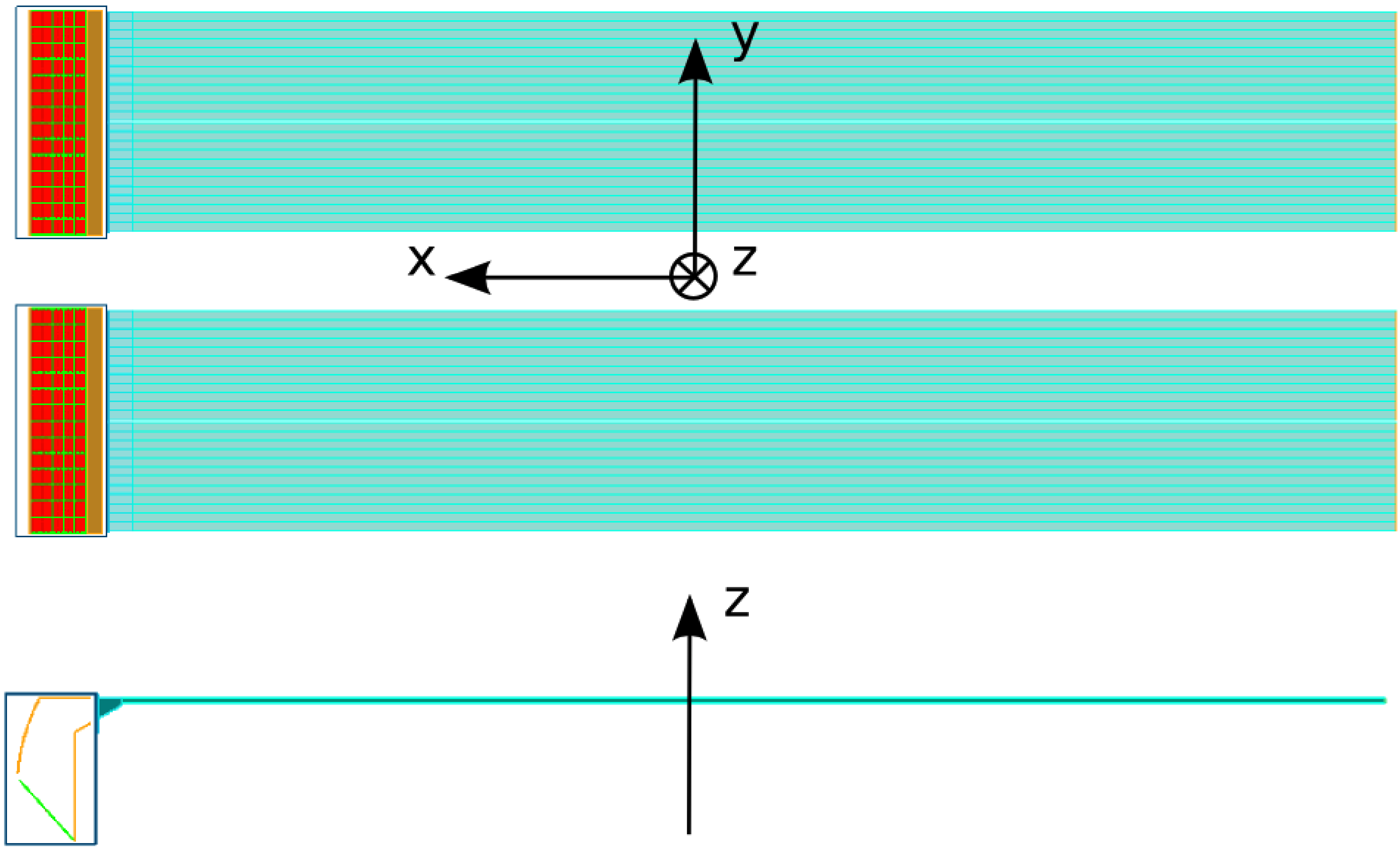
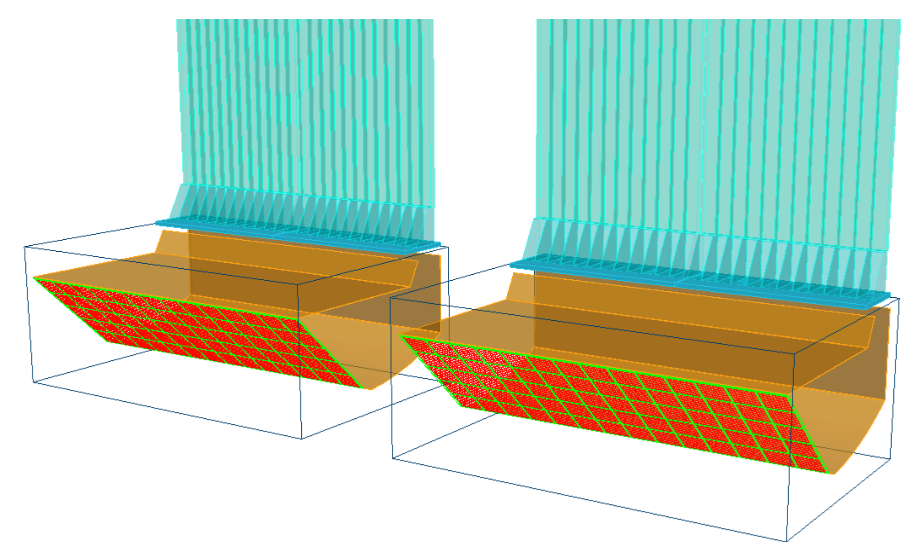
Overview

The bars will be aligned in a wall orthogonal to the beam direction:



All tracks will enter at near-perp angles w.r.t. the bars ($\theta \lesssim 11^{o}$).

Nominal design calls for two expansion boxes filled with distilled water.



Box

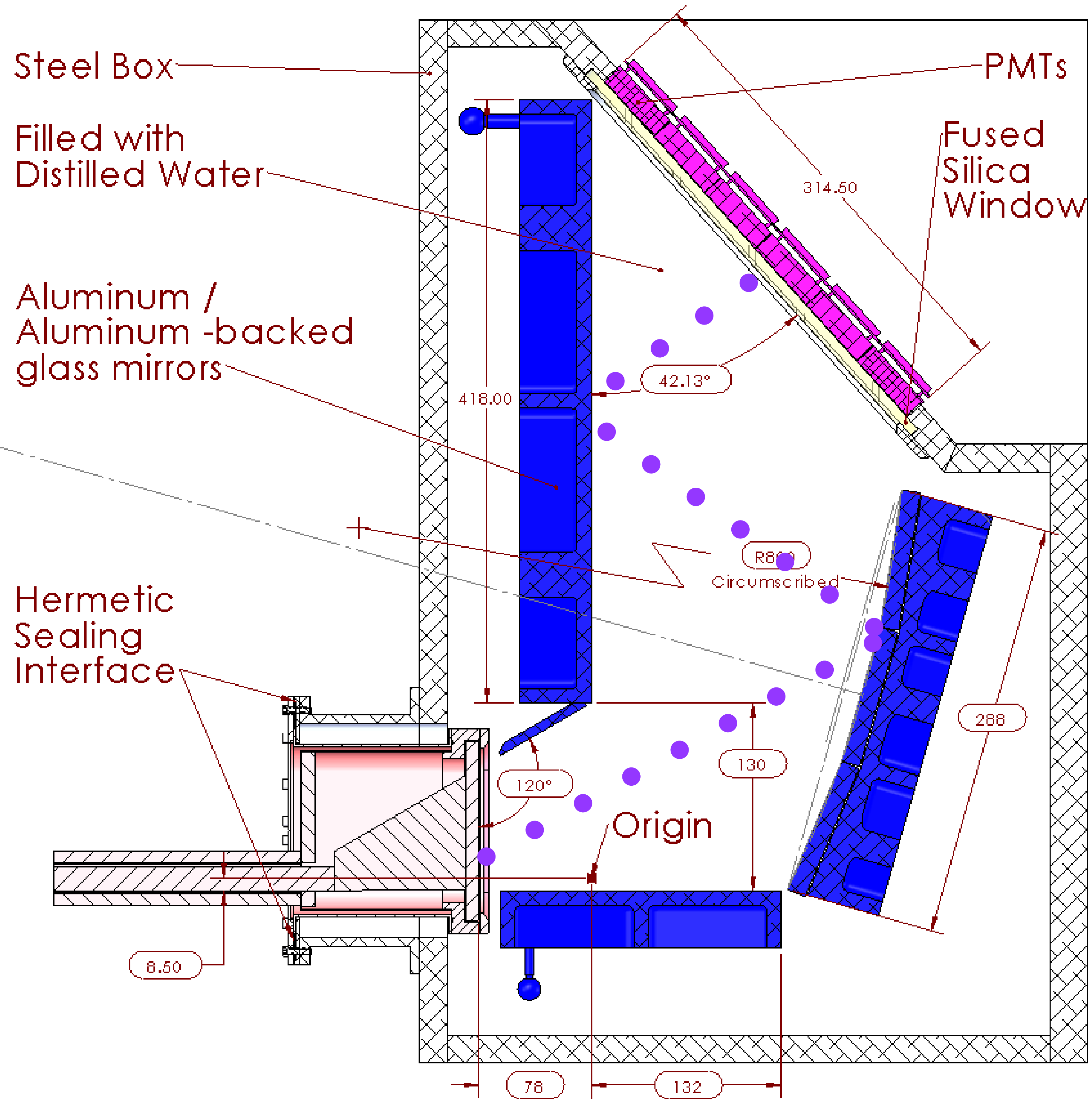
Goal of the box design is to minimize the PMT area covered to reduce the cost.

Our design is based on the SLAC SuperB prototype with the following changes:

❖Quartz medium is replaced by distilled H_20.

❖Cylindrical mirror replaced by a 3-segment flat mirror.

❖"Focusing" box interfaces with 2 bar boxes.



DIRC Simulation

To determine the expected performance, we built a fast simulation:

❖Charged particles propagated thru a bar where multiple scattering is included by treating the bar as a large number of thin segments.

❖Cherenkov photons emitted randomly along the path thru the bar.

❖Wavelength spectrum generated accounts for production and detection efficiency.

❖Each photon is analytically traced to the PMT plane. Upon exiting the bars, they are smeared by 3mrad to account for transport along the bar.

❖The mirrors are assumed to contribute negligible distortion (<0.5mrad).

❖The PMT pixel size and timing resolution is used for the H12700.

❖Photon yield normalized by comparing to SLAC FDIRC.

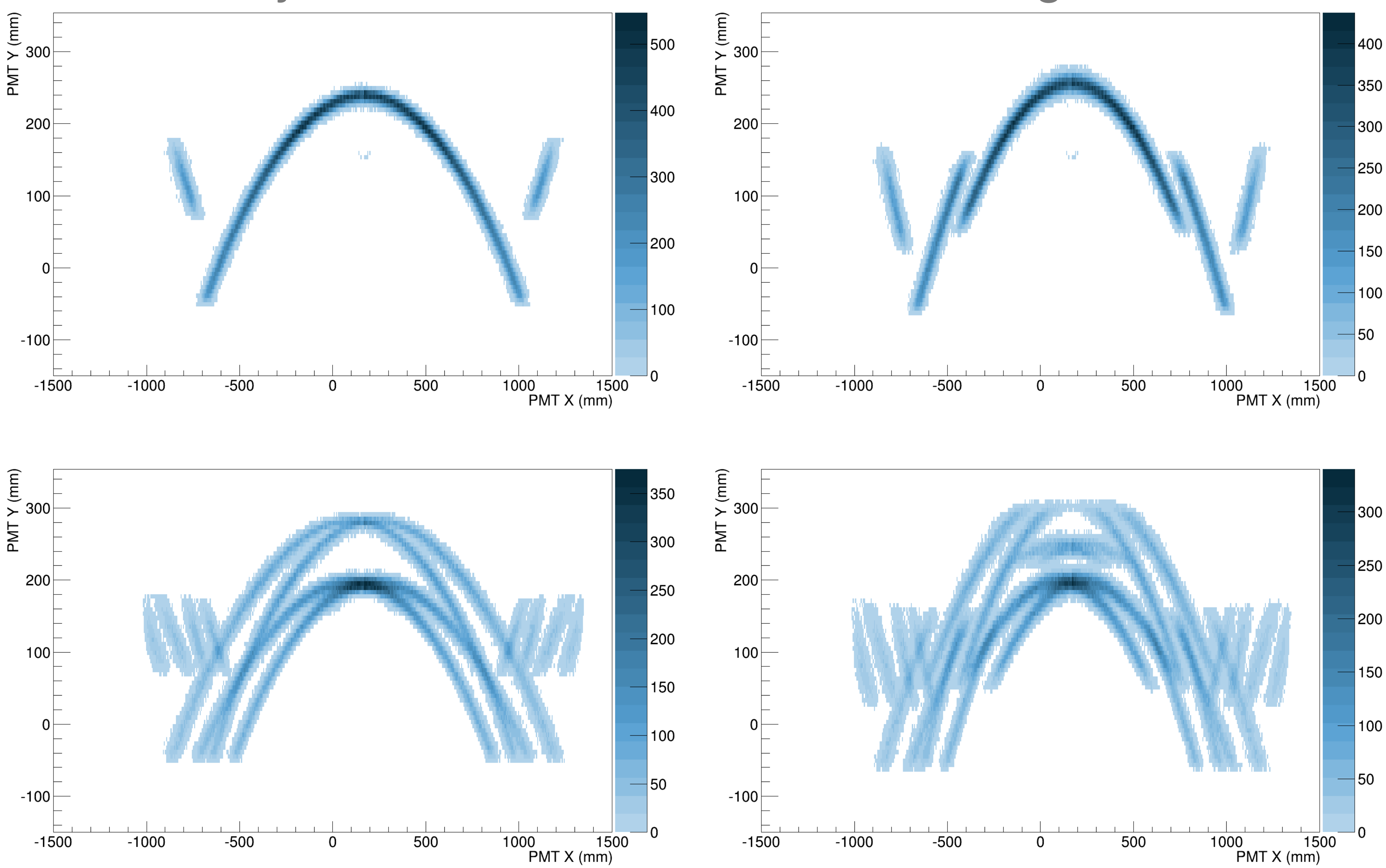
❖Events reconstructed using a likelihood and a 3D (x,y,t) kernel PDF.

3-Segment Mirror

Cylindrical mirrors are non-trivial (and expensive) to build, what if we replace it with a 3-segment flat mirror approximation?

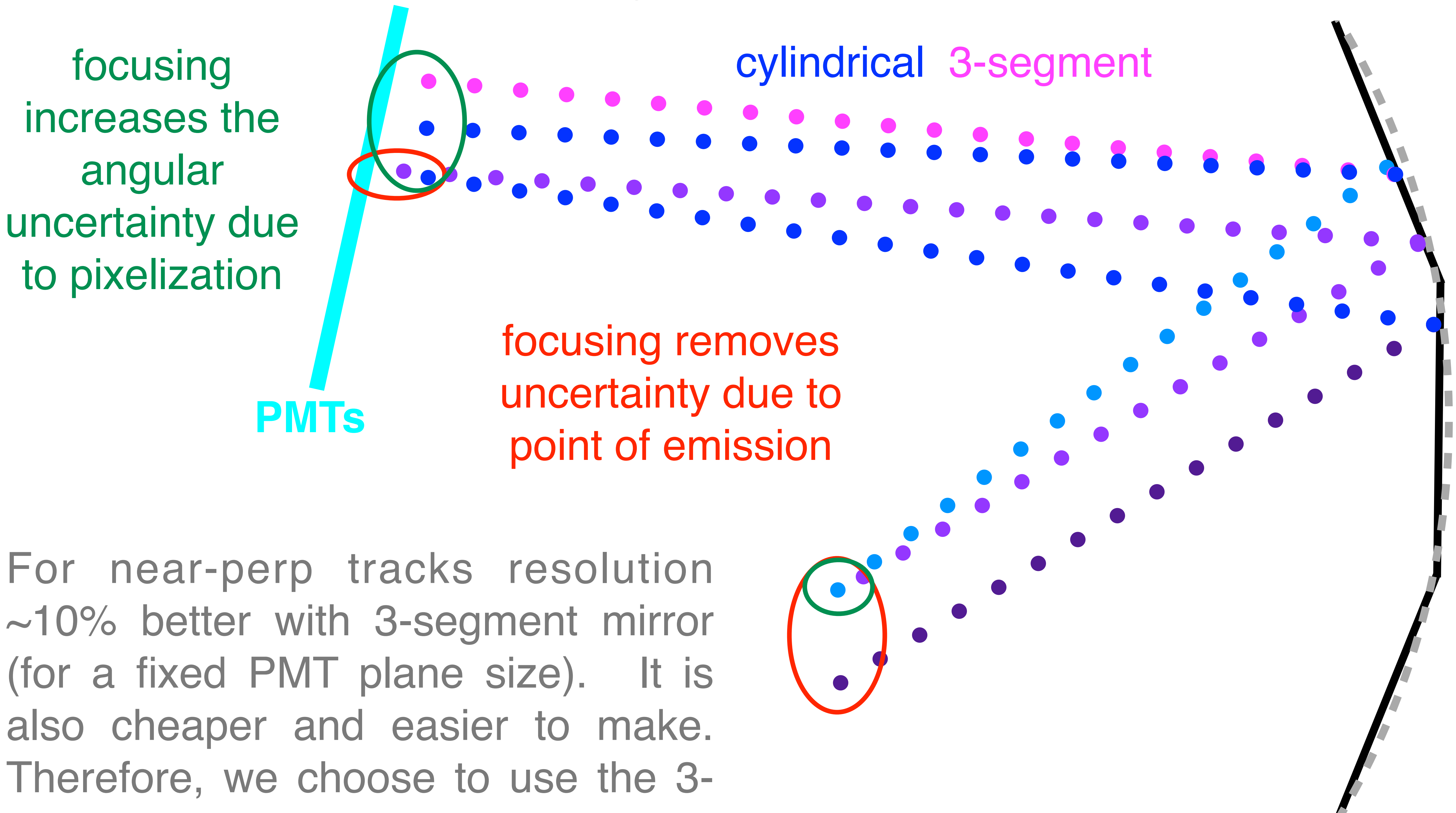
cylindrical

3-segment



3-Segment Mirror

The cylindrical mirror focuses away the thickness of the bar, but it amplifies the pixelation error in the focusing direction.



For near-perp tracks resolution ~10% better with 3-segment mirror (for a fixed PMT plane size). It is also cheaper and easier to make. Therefore, we choose to use the 3-segment mirror in our design.

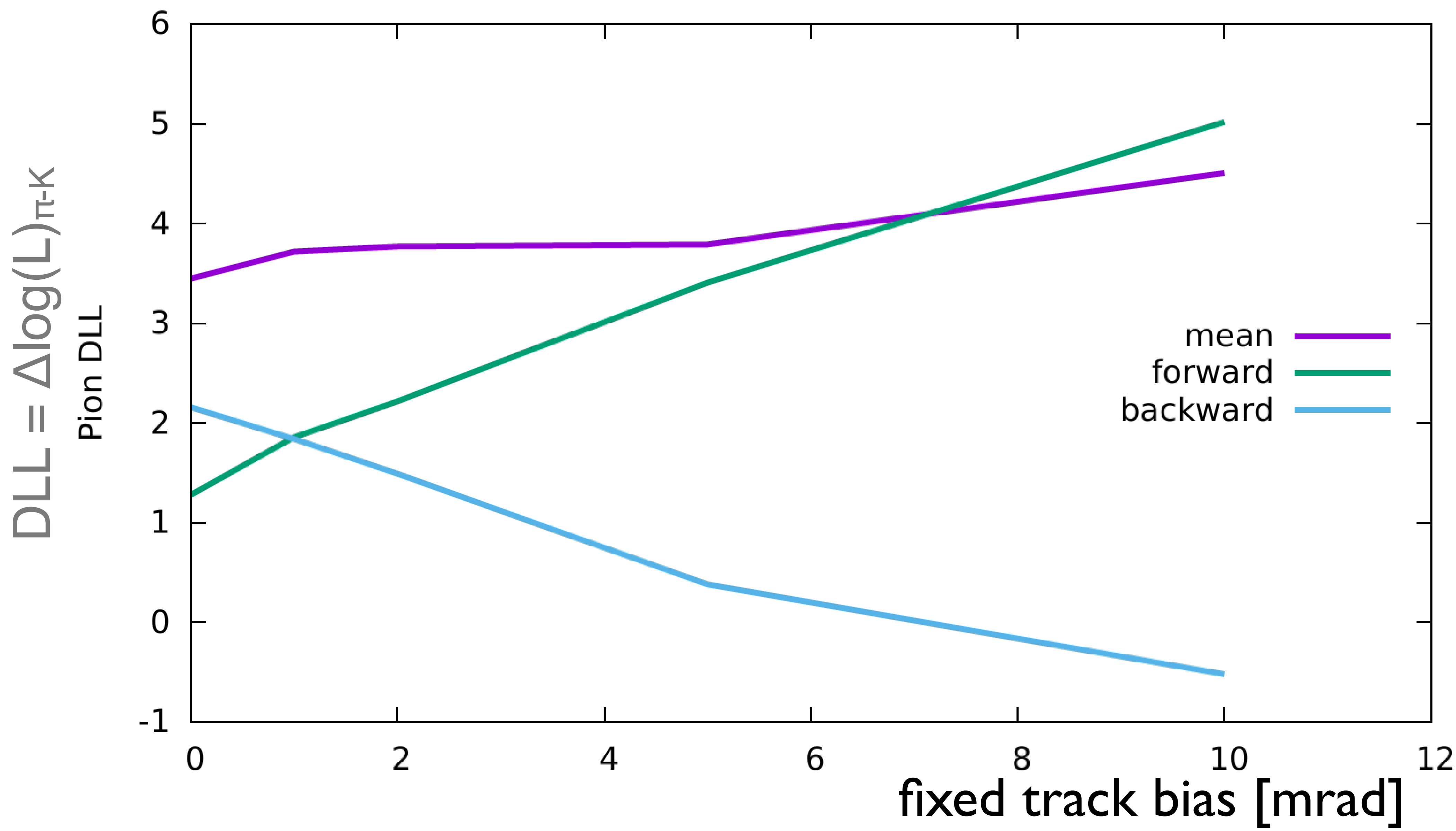
Fill it!

We plan to fill the box with distilled water. The path length in water is not big enough to warrant using DI water (expected attenuation ~5%; this is roughly canceled out in overall performance by gain due to magnification effect).

We plan to design and build a water-filtering system that will: circulate the distilled water; monitor its pH; kill biologicals using UV; etc.

Correlated Uncertainties

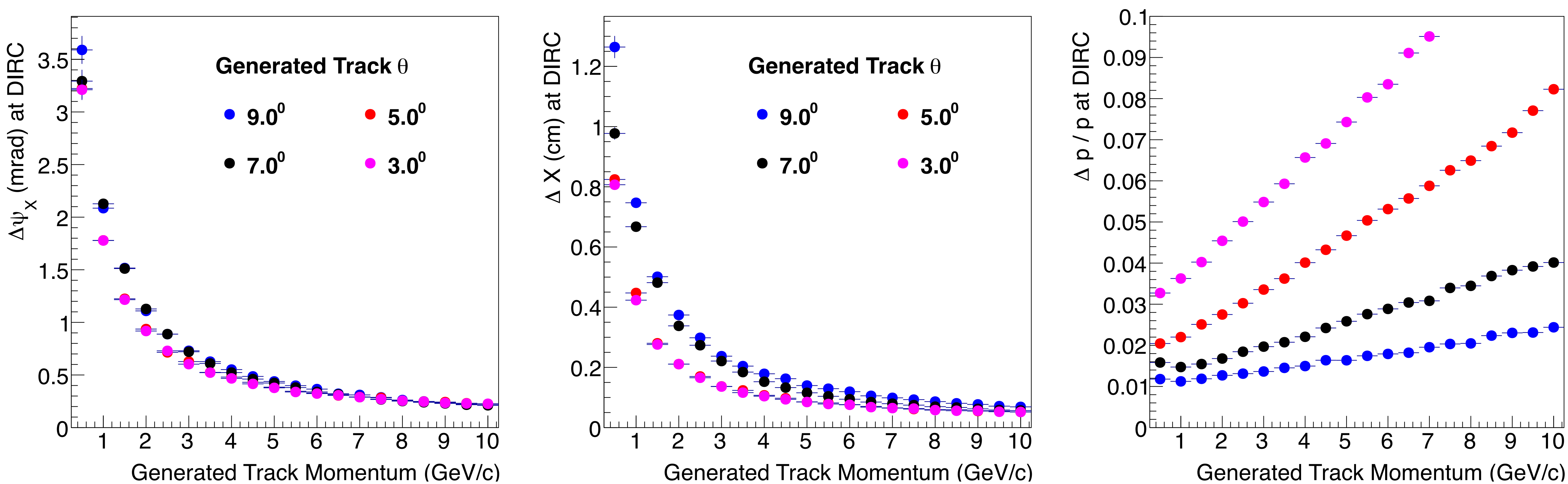
As all tracks in GlueX are near-perp, we get both “forward” and “backward” photons. These are affected in opposing ways by correlated errors.



Artificially biasing the track angle “one way” such that forward(backward) photons look more pion(kaon) like cancels to LO in the full likelihood.

Tracking & Multiple Scattering

Tracking uncertainties from the GlueX GEANT-based simulation:



Multiple scattering effect is small due to short path length thru the bars for near-perp tracks, and aforementioned cancelation effect. For a perp track, the correlated error for p=4GeV/c is about 0.7mrad.

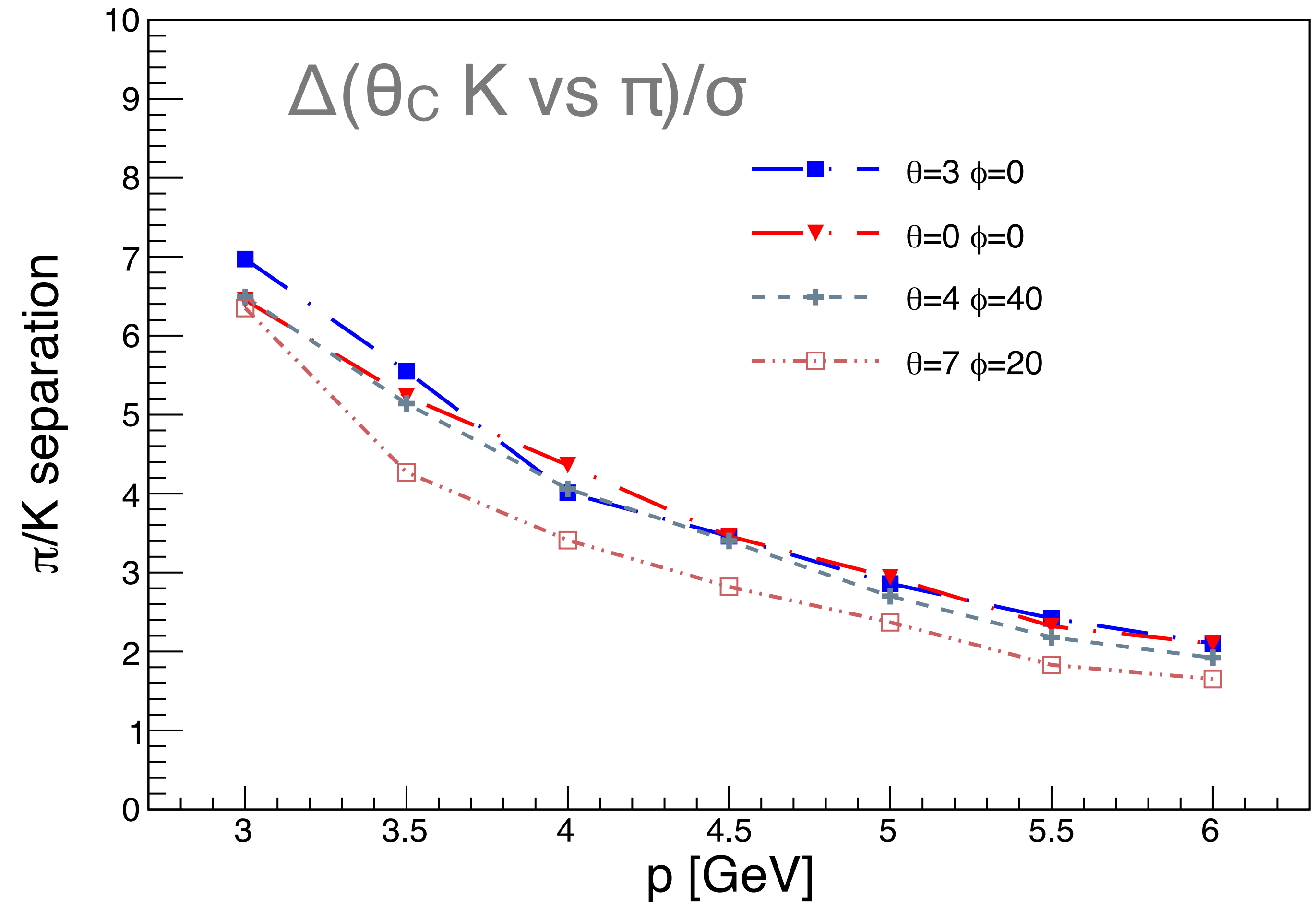
Performance

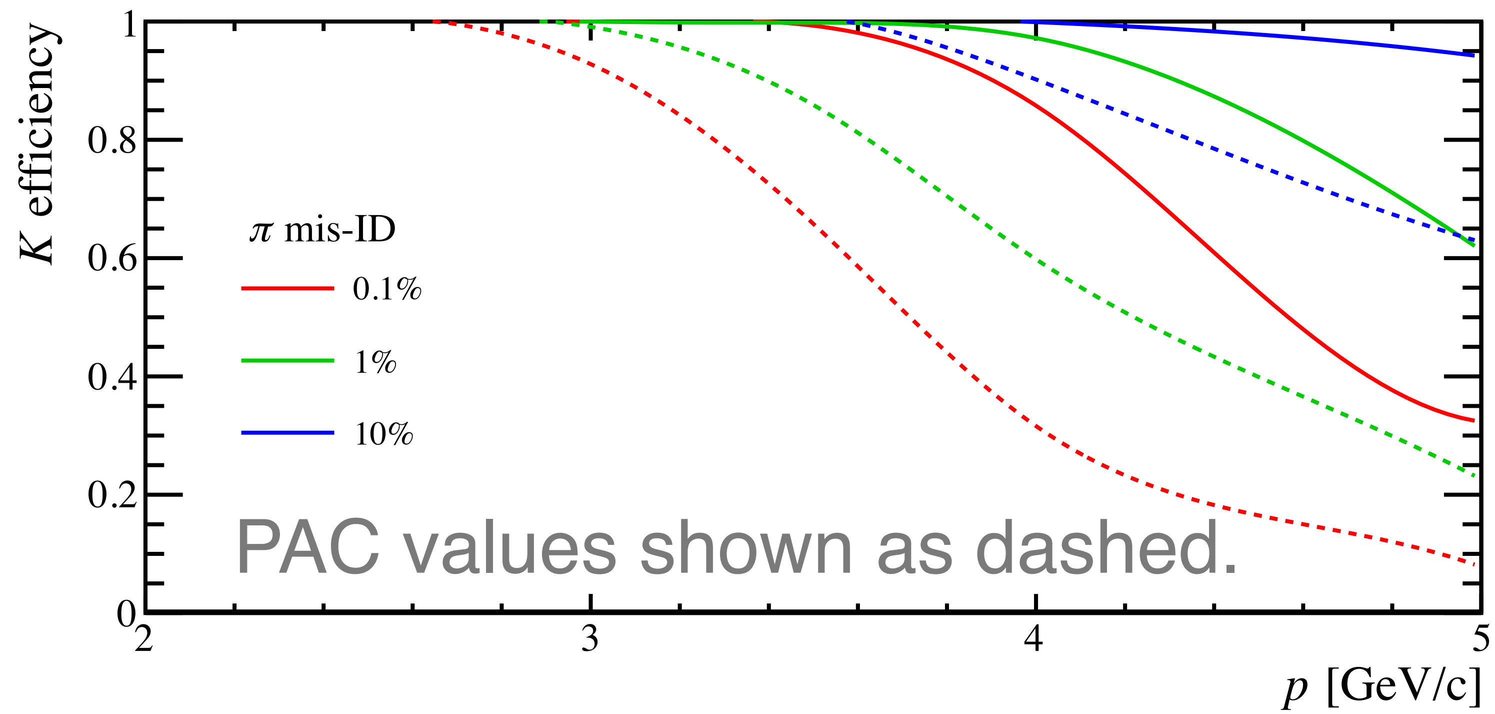
K-π separation better than used in PAC study which assumed σ=2.5mrad (it was intentionally conservative). Major differences:

❖Correlated term was taken to be 1.5mrad in the PAC study.

❖H12700 PMTs increase the photon yield.

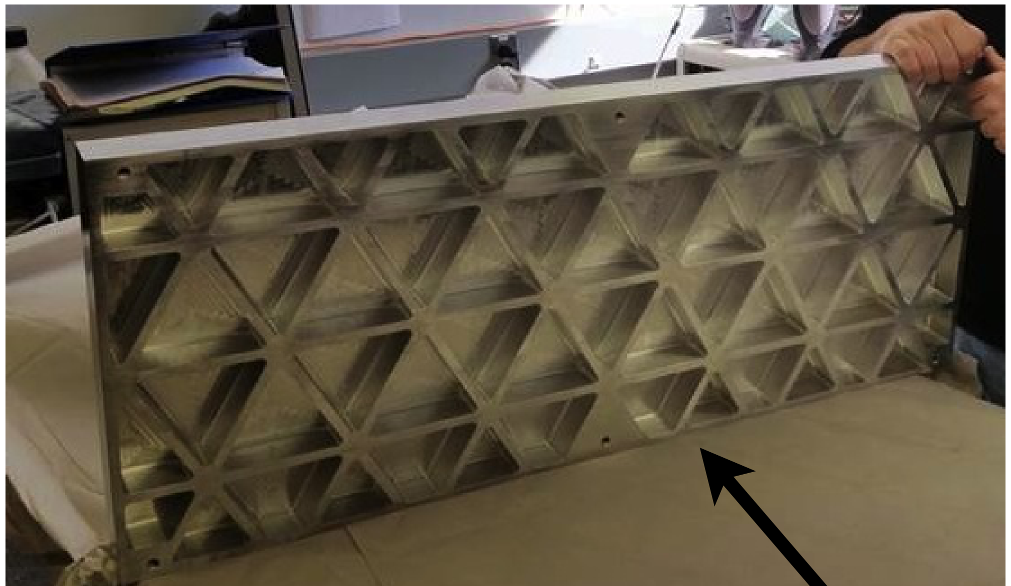
❖The 3-segment mirror improves the per-photon resolution by 10%.

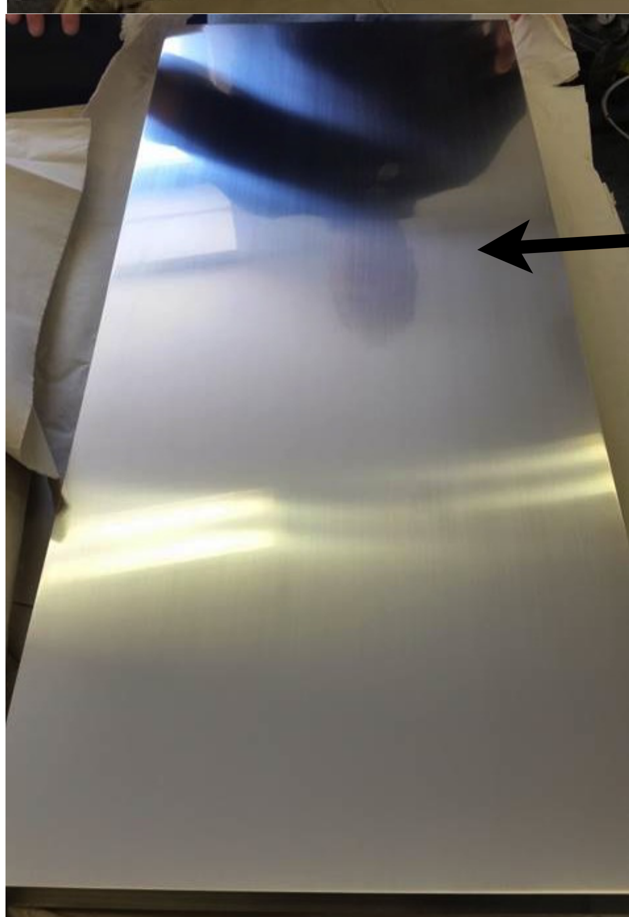




Mirrors

Considering 2 options: front-surface glass on Al strongback and polished Al.



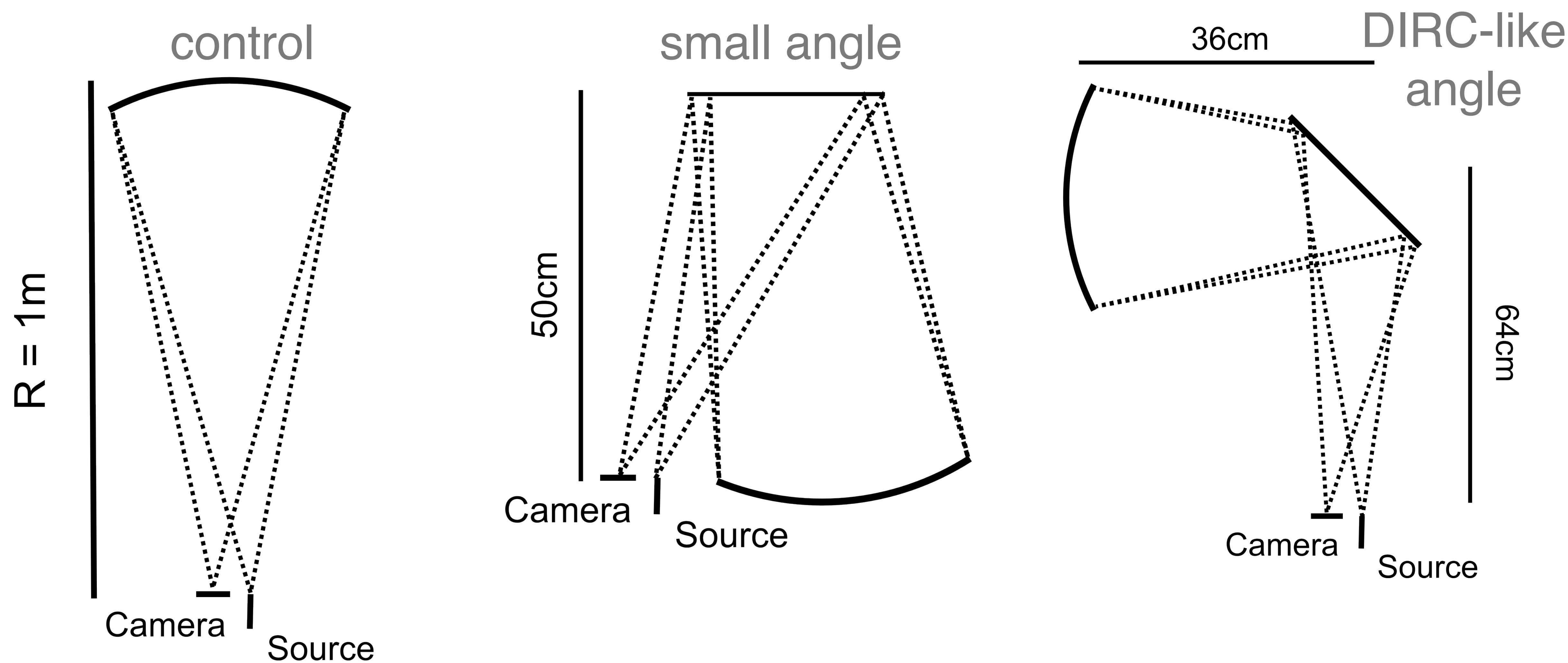


Al strongback
(will be used for either option)

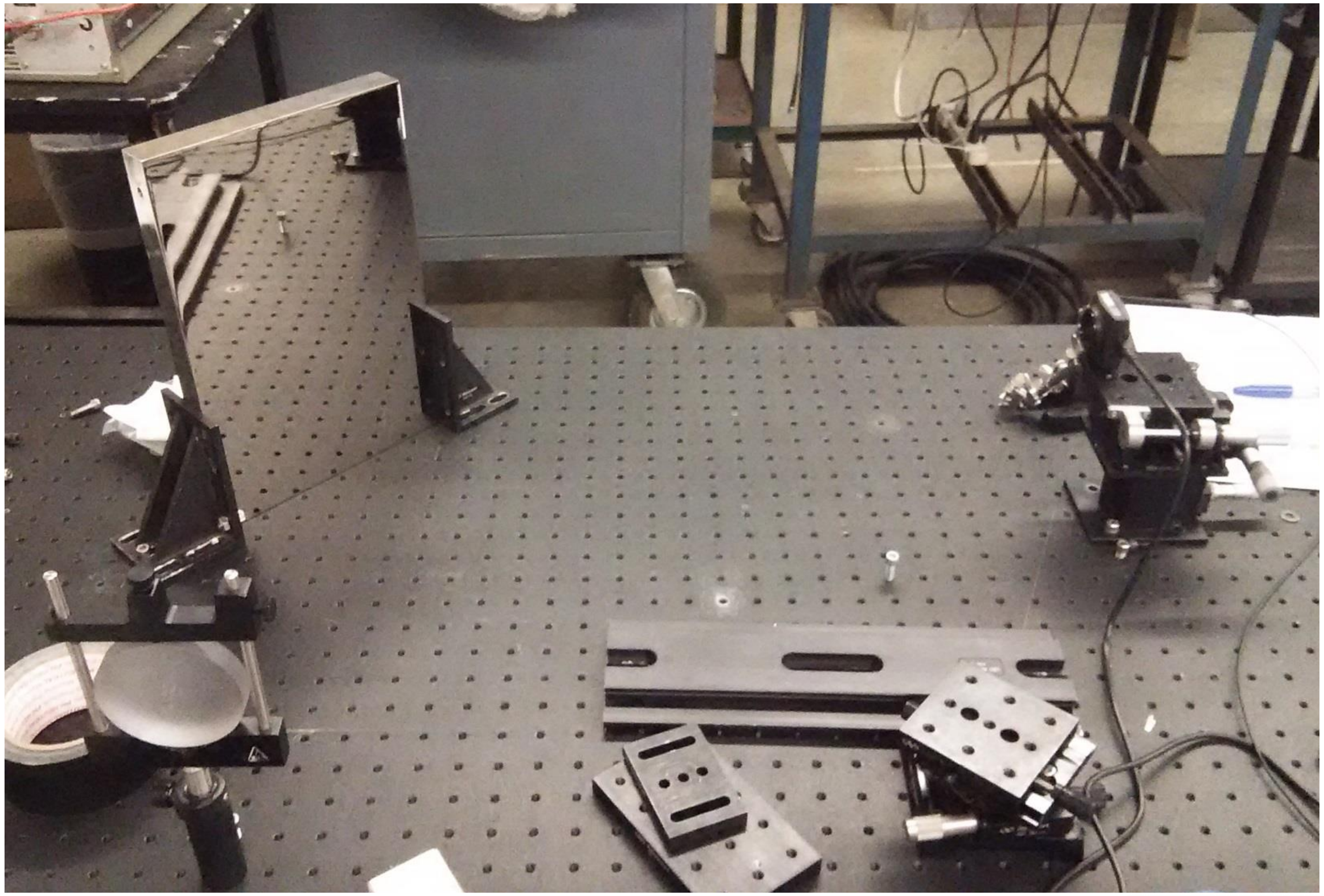
The glass option is cheaper, but both are cost-effective.

Mirror Testing

We have a test setup at MIT to characterize the mirrors:



Mirror Testing



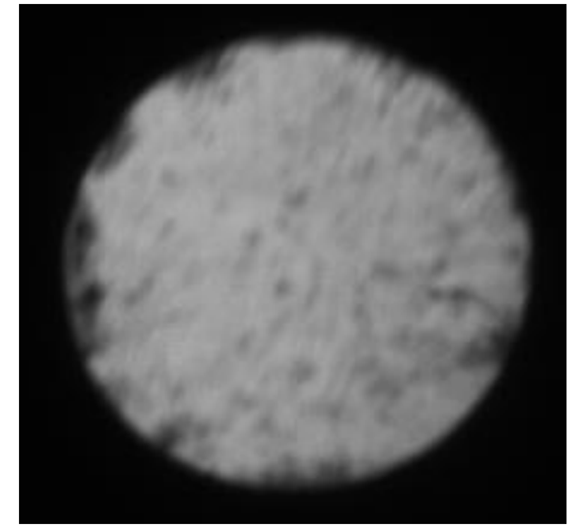
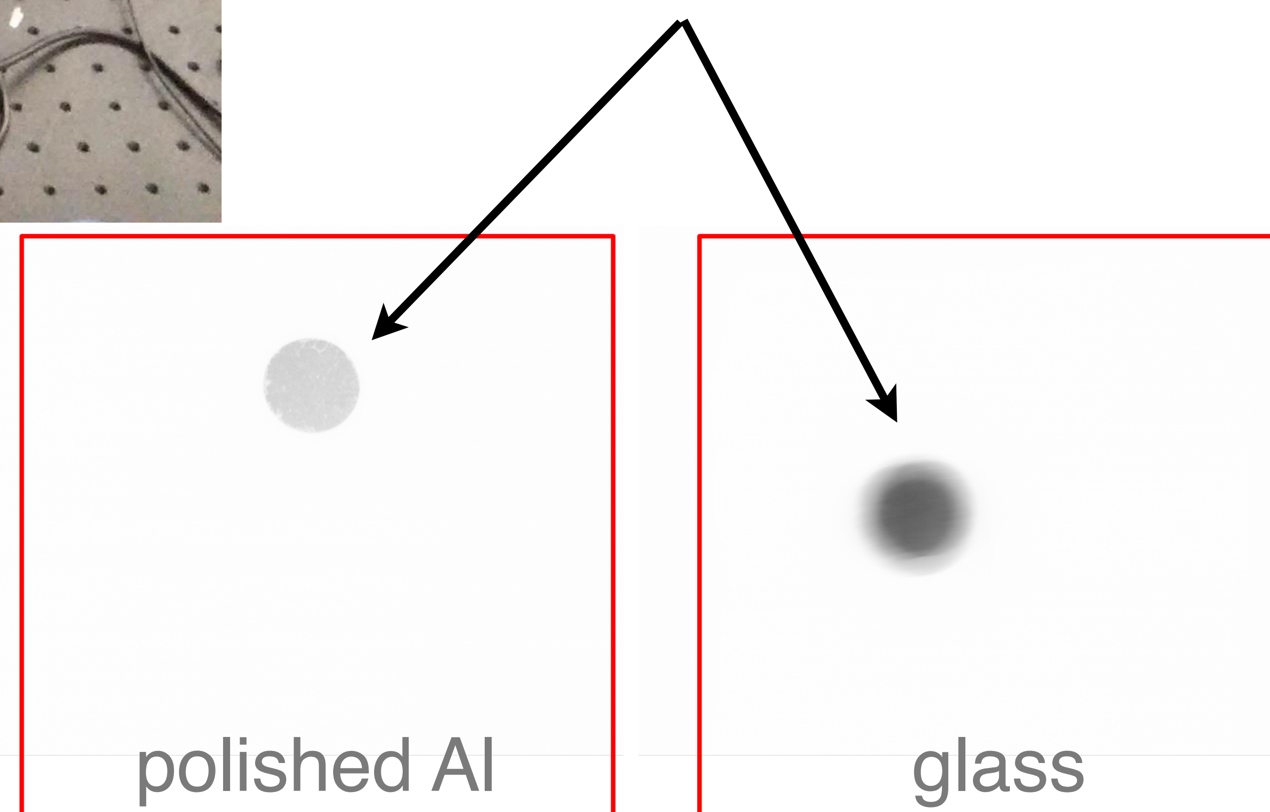


image from 1mm unpolished fiber

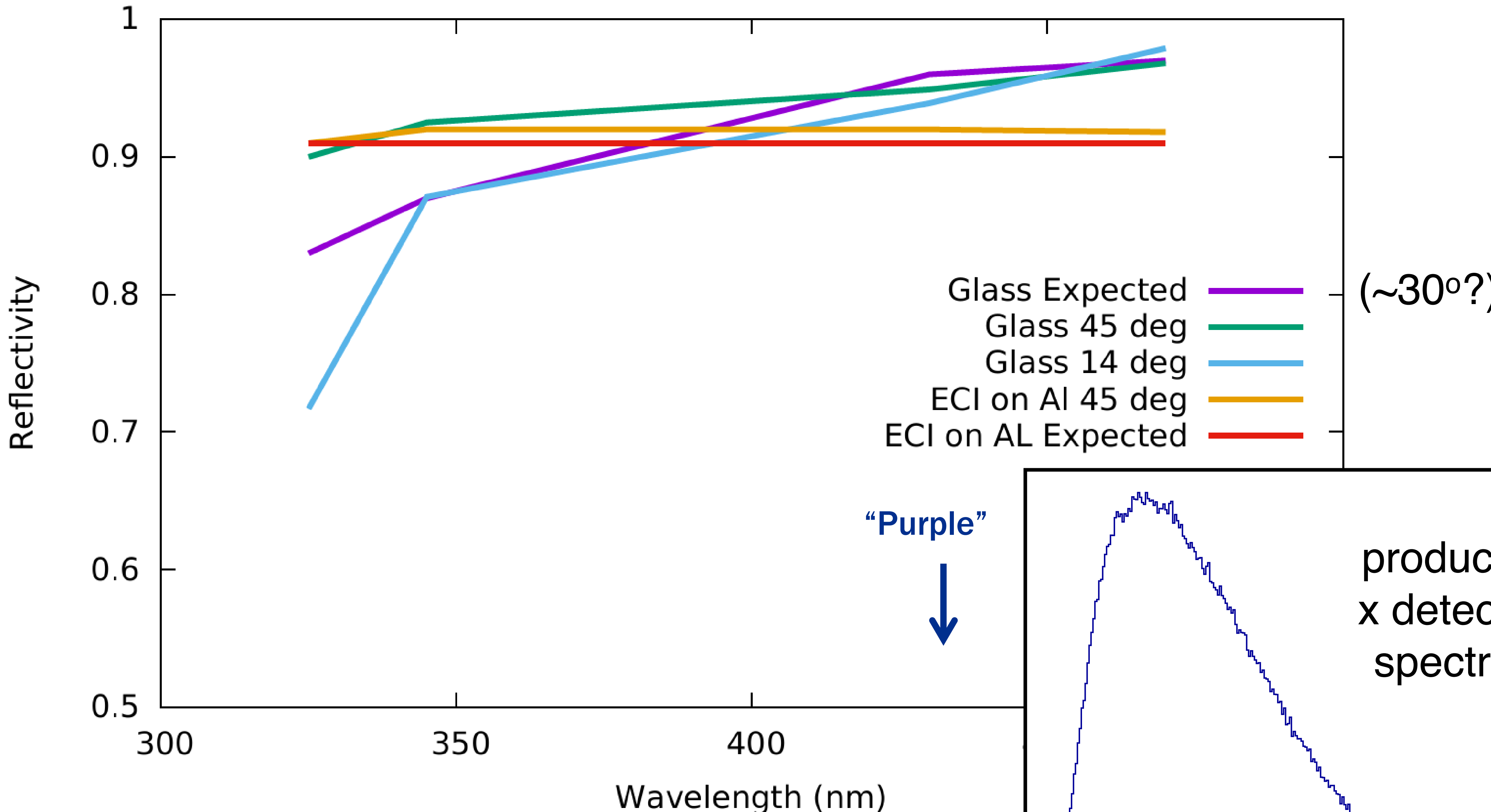


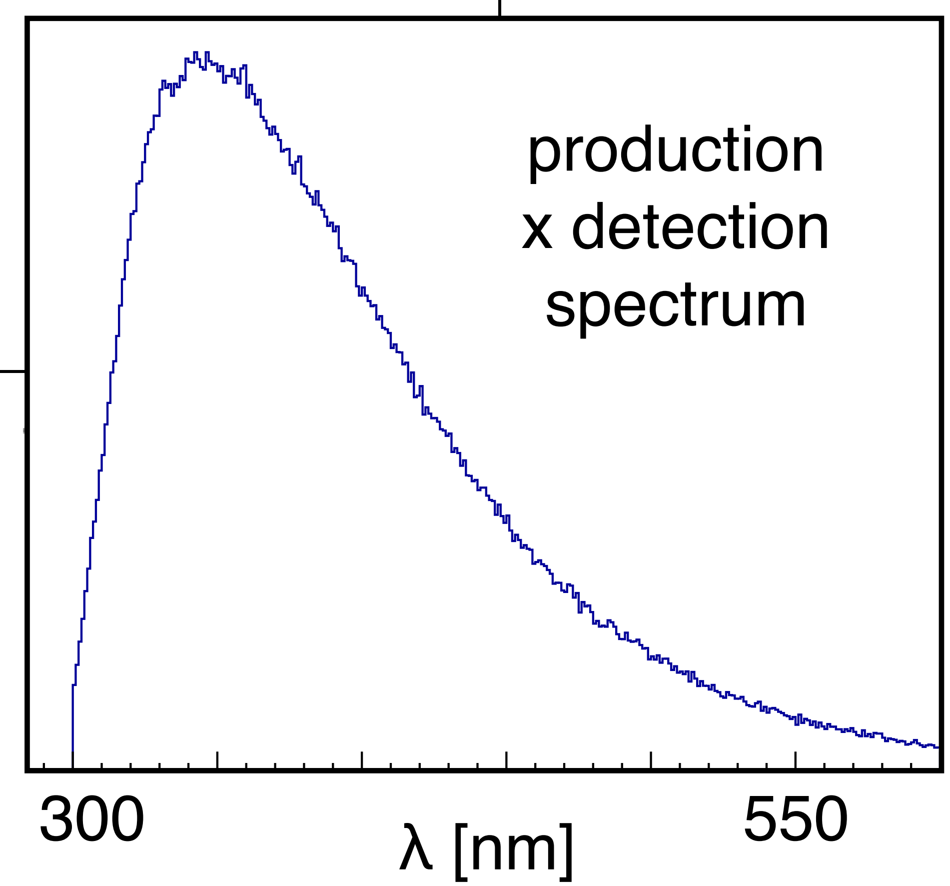
Distortion from glass < 0.2mrad, from polished Al it’s too small to measure; both are acceptable.

red line = DIRC PMT pixel size

Mirror Testing

Results of our measurements on the test samples:





Both are acceptable. We also see no effect of the glass being submerged in distilled water for 7 weeks (will continue to study this).

Box

Key elements of the box design:

❖Filled with distilled water.

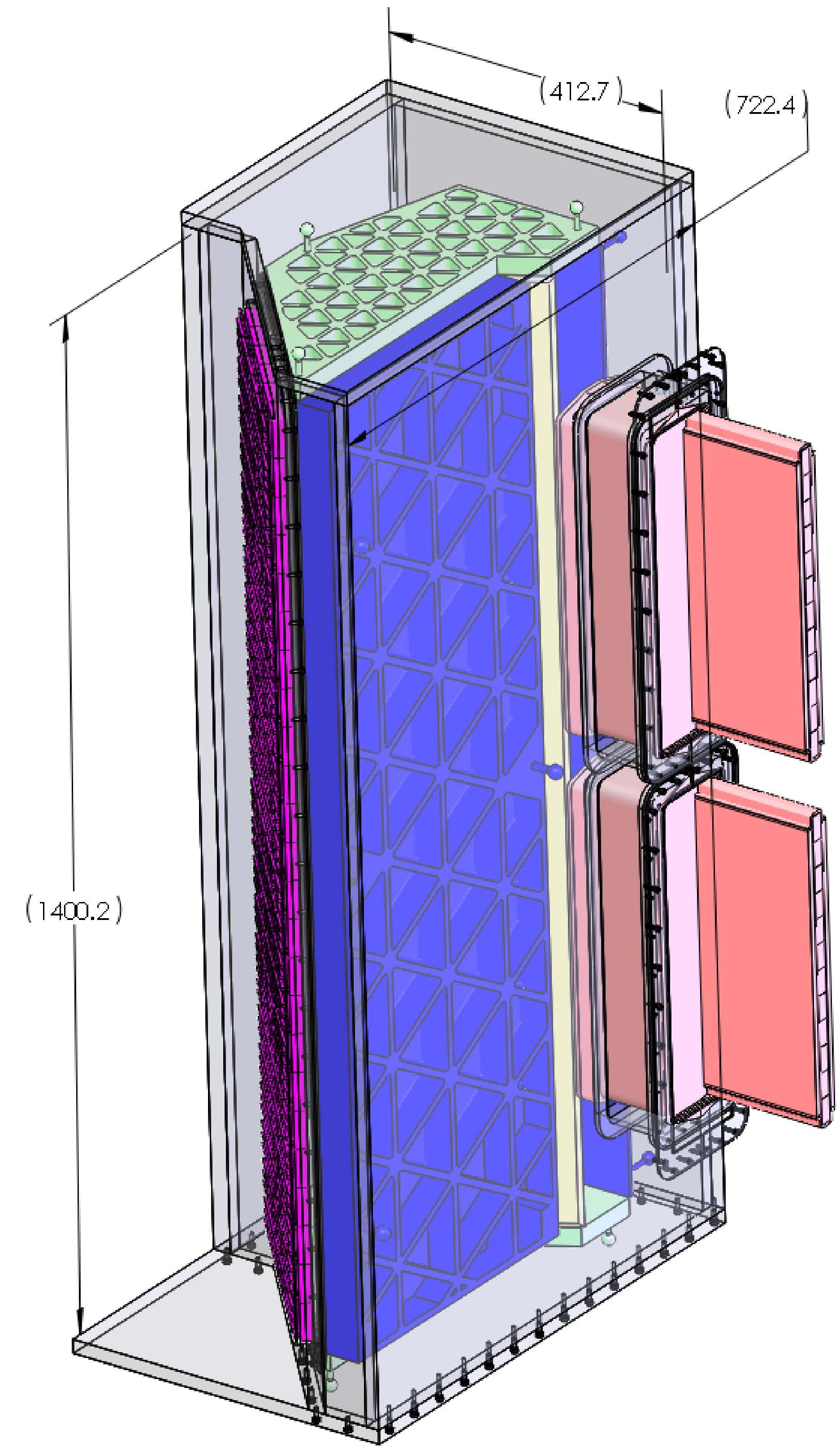
❖Quartz window separating water/PMTs.

❖Mirrors mounted quasi-kinematically.

❖Hermetically sealed.

❖Mounted vertically.

Work ongoing to finalize the design.



Staged Production Plans

Our plan is to build a first box (Box1), with the intention of using this in the final DIRC:

❖Build Box1 and perform all basic testing prior to moving it to Hall D.

❖Ship bar boxes to JLab, build the support structure.

❖Install the bar boxes at GlueX and connect them to Box1.

❖Determine the photon yield and alignment/resolution in situ using GlueX data.

❖Consider whether or not to make any modifications/changes to the design of Box2, and whether to modify Box1.

Summary

❖We have developed a conceptual design for a DIRC detector for GlueX and studied it in detail in simulation. The design is based on the prototype for the SuperB experiment, with some modifications that take advantage of the limited range of track entrance angles to the bars in GlueX.

❖Our conceptual design achieves the physics goals of GlueX. The resolution is much better than assumed in the PAC study, mostly due to the correlated term being about half as large as assumed.

❖Two options have been studied for the mirrors. Both are cost-effective, provide acceptable distortion and reflectivity. We are continuing to study the mirrors (e.g., alternative coating for the glass), and plan to make a final decision on technology by the end of the year.

❖We are ready to move towards finalizing the design, and then starting fabrication and assembly.