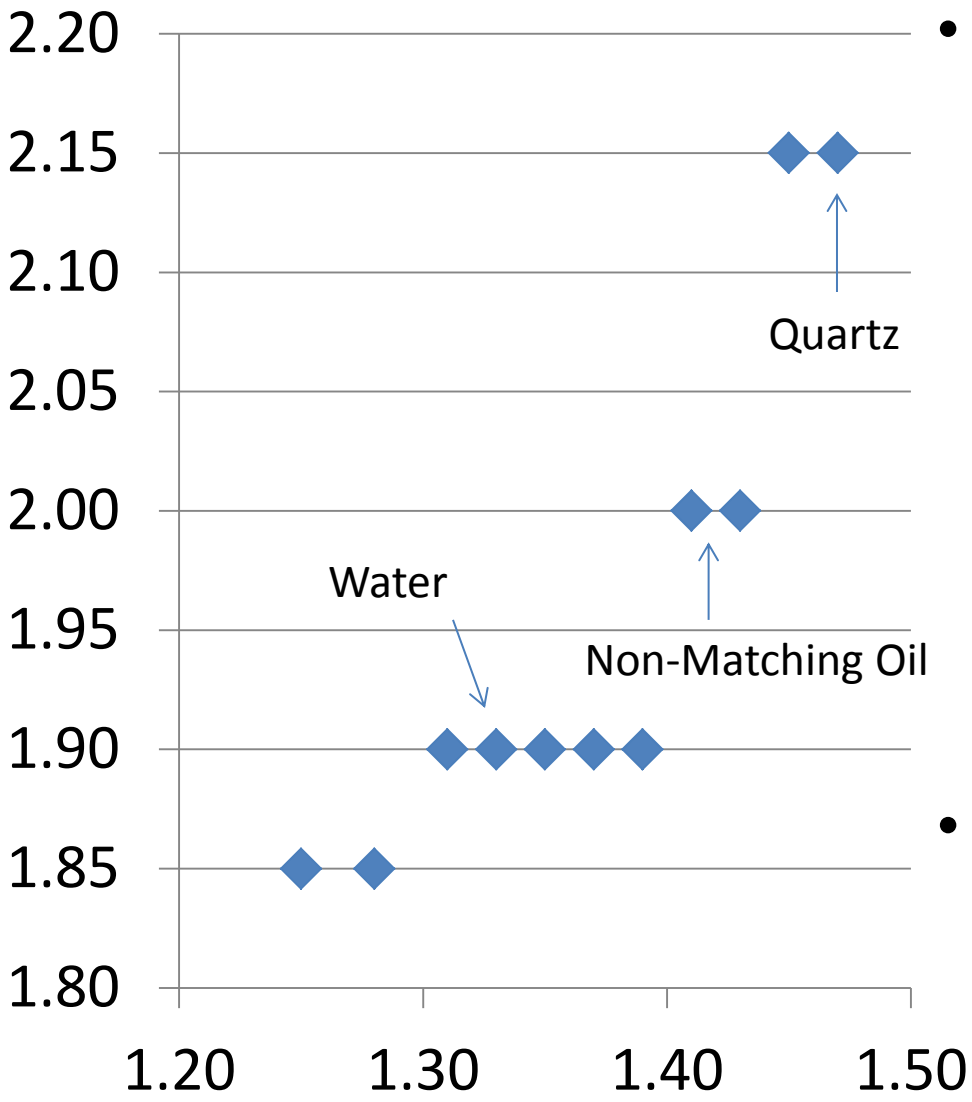
Readout Mirror Box Design

Changes Since Last Time

- Lowered the initial spreading, as optical aberration is accounted for geometrically
  - I had been double counting it by adding the spread
  - Improved resolution all around
- Examine how moving the PMT plane closer and further affects resolution
- Looking at a third type of mirror: a three segment mirror

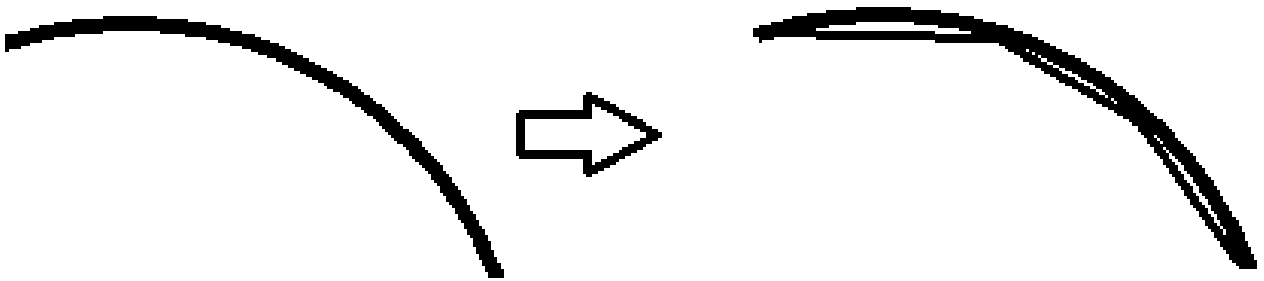
Pi/K Separation (mrad) versus Liquid Index of Refraction



- This plot assumes 100% transmission for the liquid (not true in oil)
  - Uses a focusing mirror
- Surprisingly, the separation improves as the index gets further from that of quartz
  - Apparently due to the separation increase being larger than the spreading increase
  - Would also be strongly impacted by the fact that oil loses 20-30% of the photons – the separation scales with inverse sqrt(n) as expected
    - Instead of 2.15 mrad, matching oil is at 2.45 mrad
- Conclusion: Water is cheaper and has better performance

Segmented Mirror

- The cylindrical mirror may be hard (and/or expensive) to manufacture and calibrate
  - Also worse separation than a flat mirror
- Therefore, compromise with multiple segments (per Mike)



Examining patterns

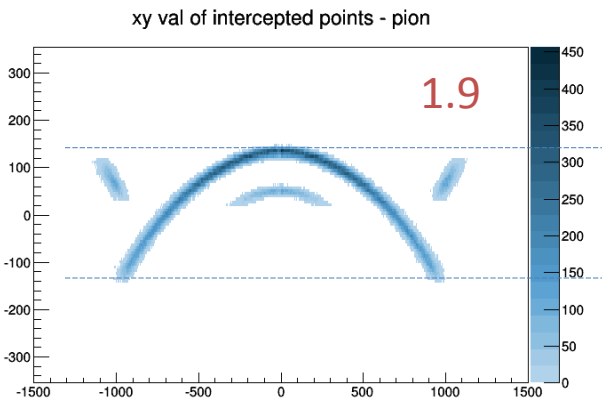
- For reference, a pion at 4.5 Gev and several angles were thrown
  - Perpendicular
  - Theta = 7 degrees phi = 0 degrees
  - Theta = 4 degrees phi = 40 degrees
- Distributions on the following slide
  - Overlaid with the separation power at these angles

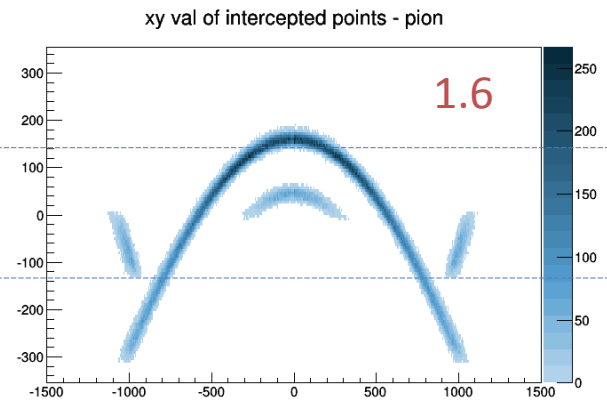
Focusing Mirror

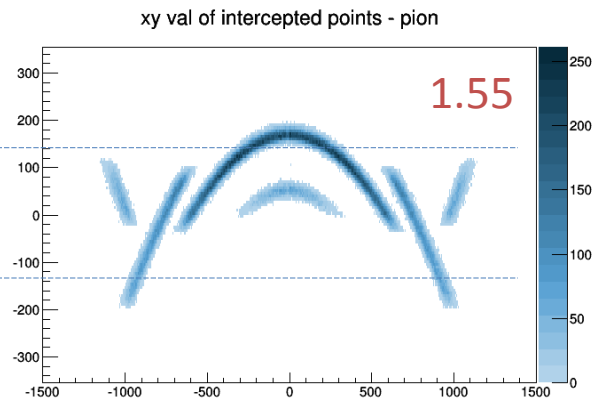
Flat Mirror

3 Segment Mirror

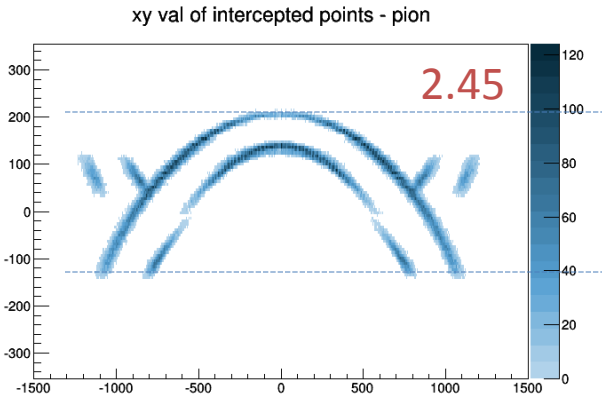
Perpendicular

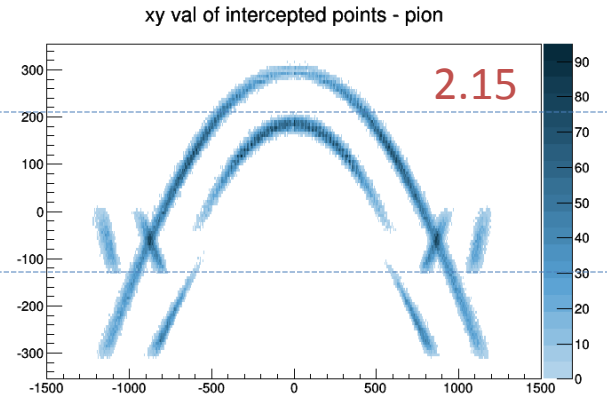


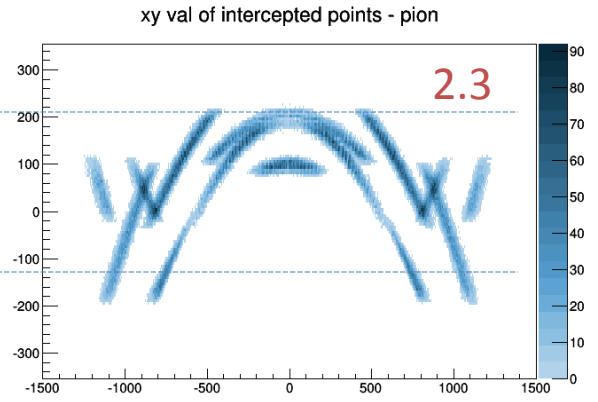




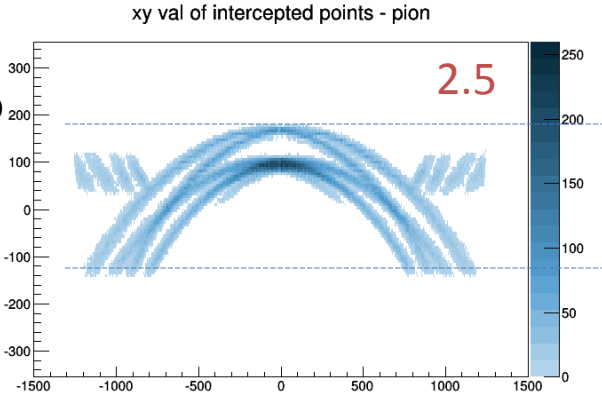
Theta = 7 deg

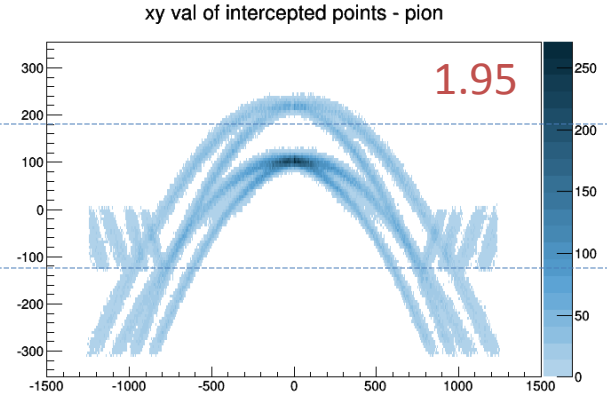


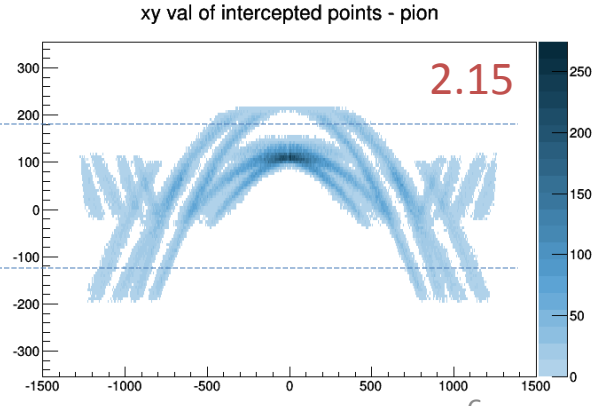




Theta = 4 deg
Phi= 40 deg

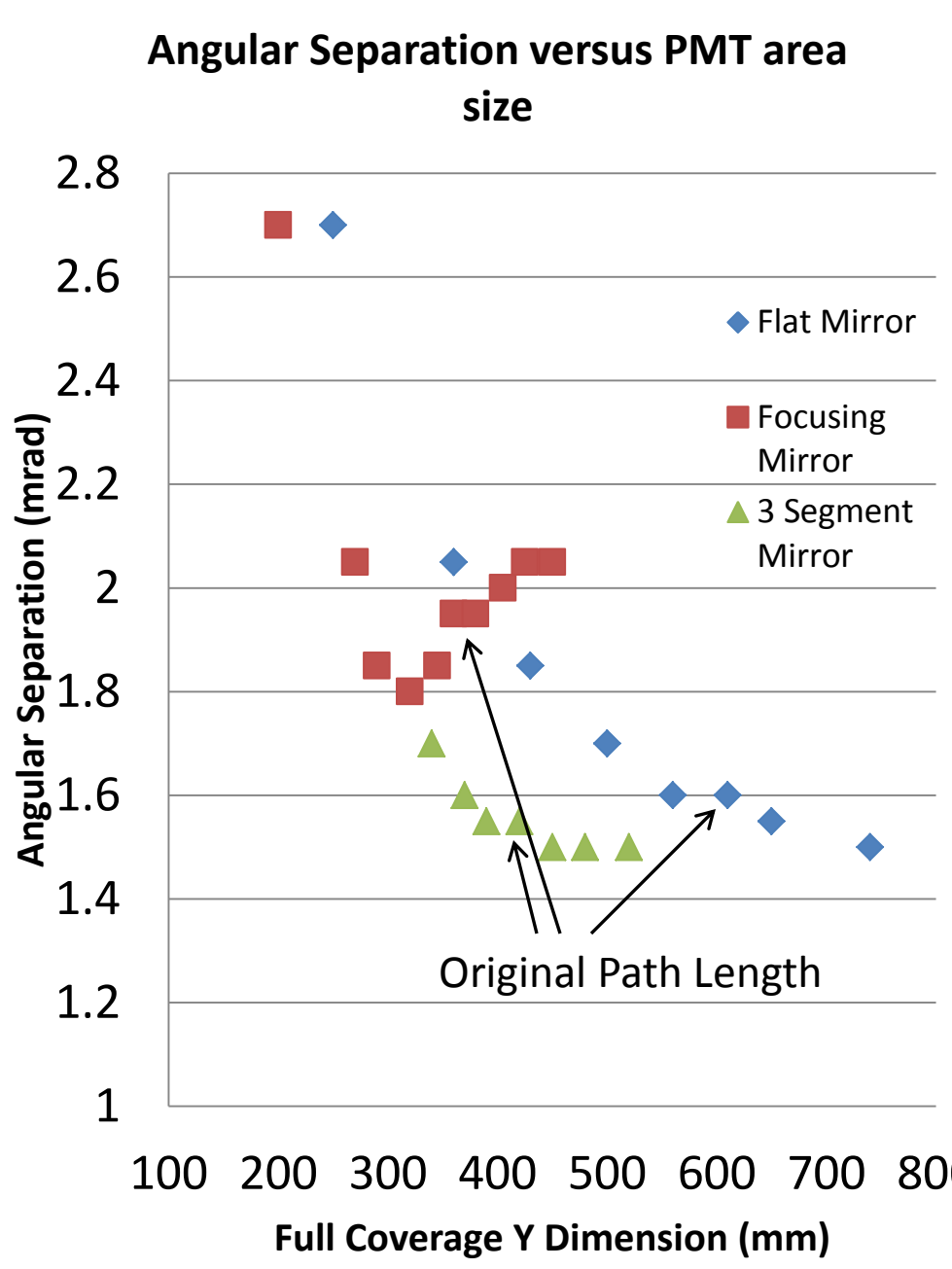


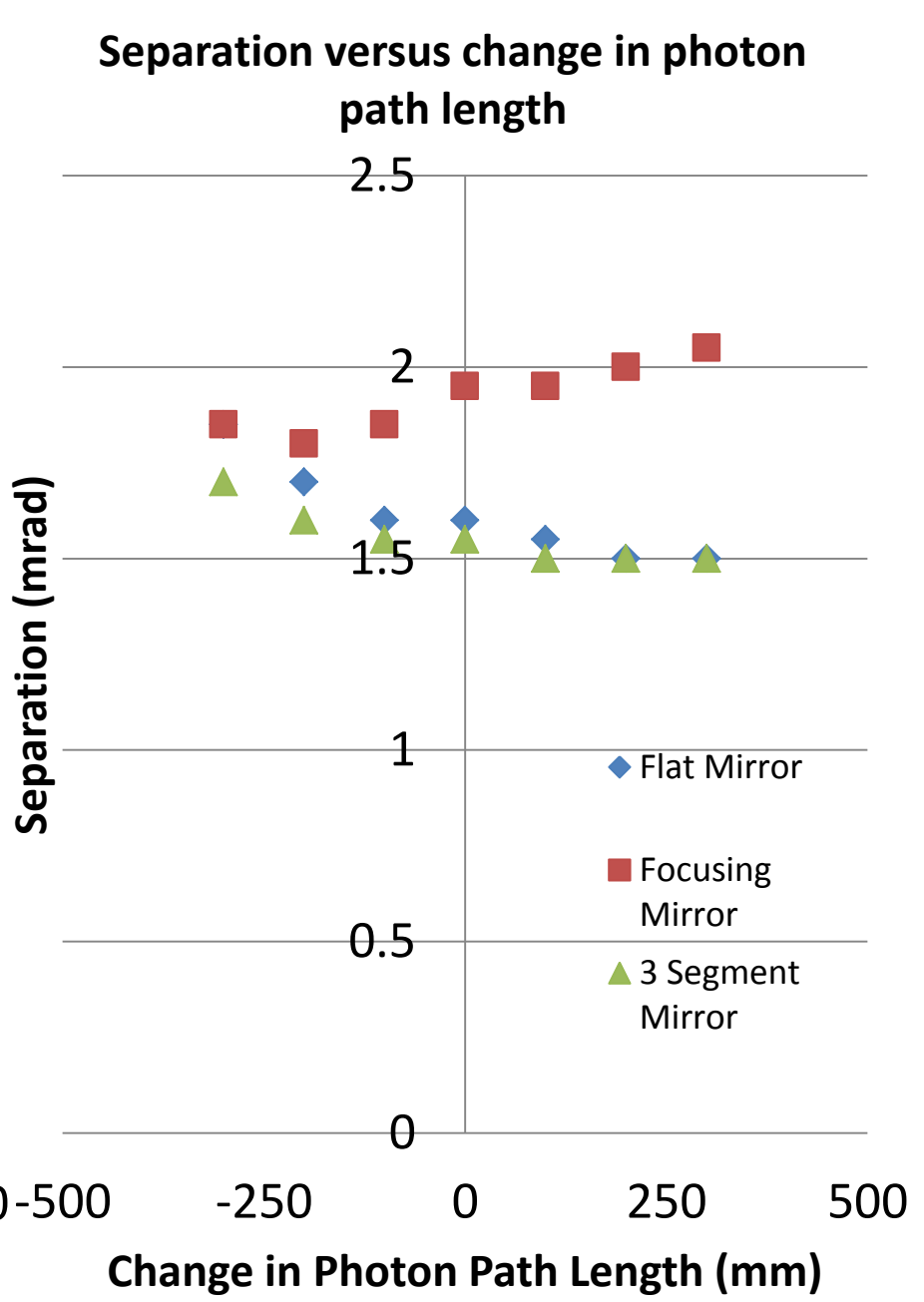




Path Length Considerations

- The flat mirror achieves a separation of 1.6 mrad to the focusing mirrors 1.9, but at a cost of ~70% more PMT area
- Therefore, try moving the PMT plane closer and further to see the effect on both separation and PMT coverage
  - PMT coverage is reported as mm of completely covering y height – for reference, the original design with 300mm of PMTs has a value of 360mm in this variable
  - Test with perpendicular tracks

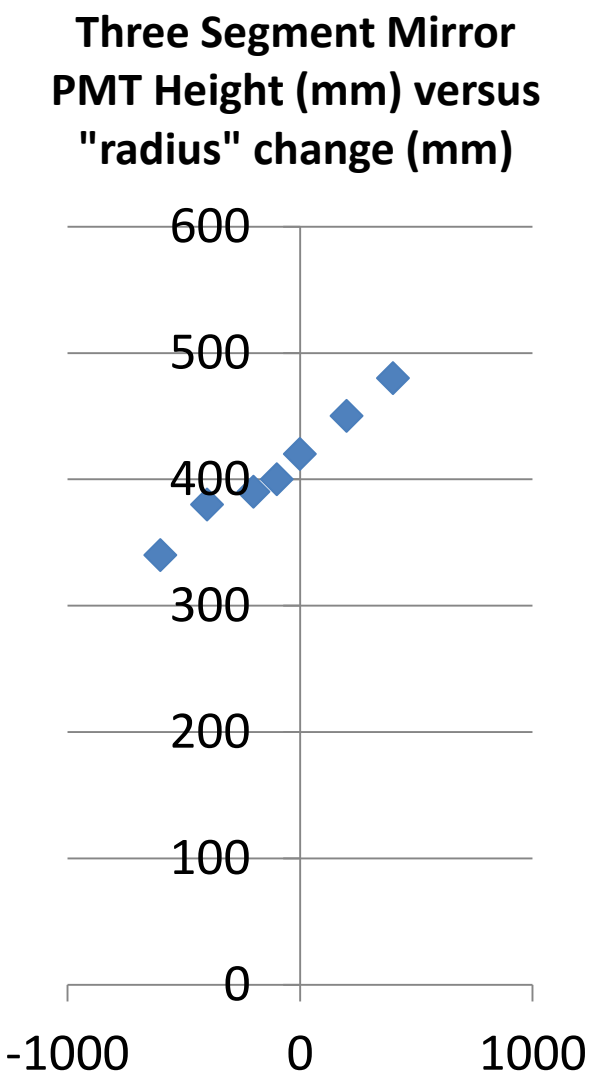

Angular Separation versus PMT area size
Angular Separation (mrad)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
100
200
300
400
500
600
700
800
Full Coverage Y Dimension (mm)
Flat Mirror
Focusing Mirror
3 Segment Mirror
Original Path Length

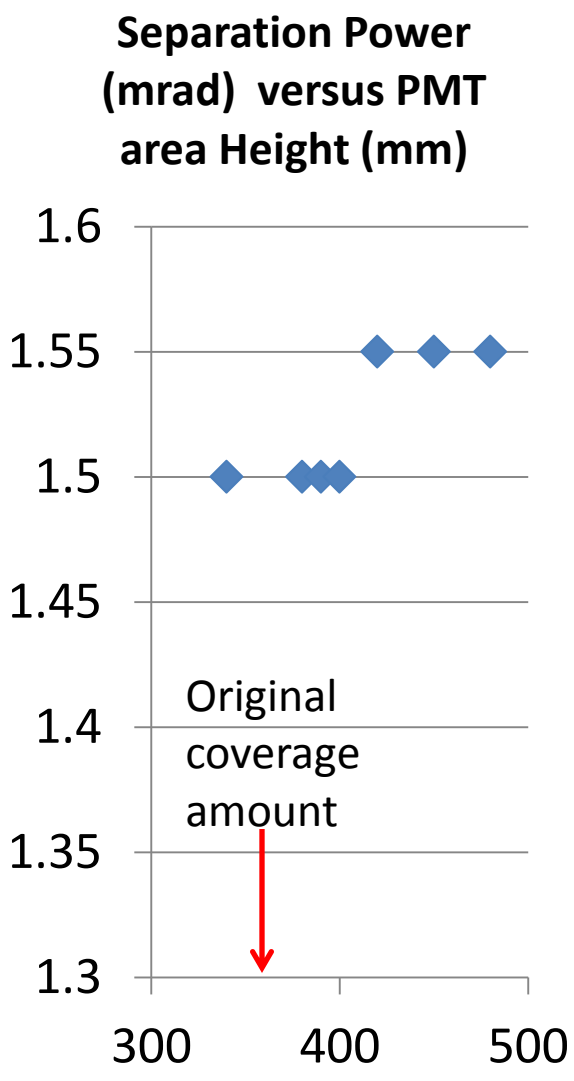

Separation versus change in photon path length
Separation (mrad)
2.5
2
1.5
1
0.5
0
-500
-250
0
250
500
Change in Photon Path Length (mm)
Flat Mirror
Focusing Mirror
3 Segment Mirror

Path Length Conclusion

- For a given PMT area size, the 3 segment mirror provides a better angular separation than either the flat mirror or the focusing mirror
  - Best of both worlds (in the perpendicular case)
  - Should also be easier to manufacture/calibrate
- Try other “curvatures” of the 3 segment mirror to improve

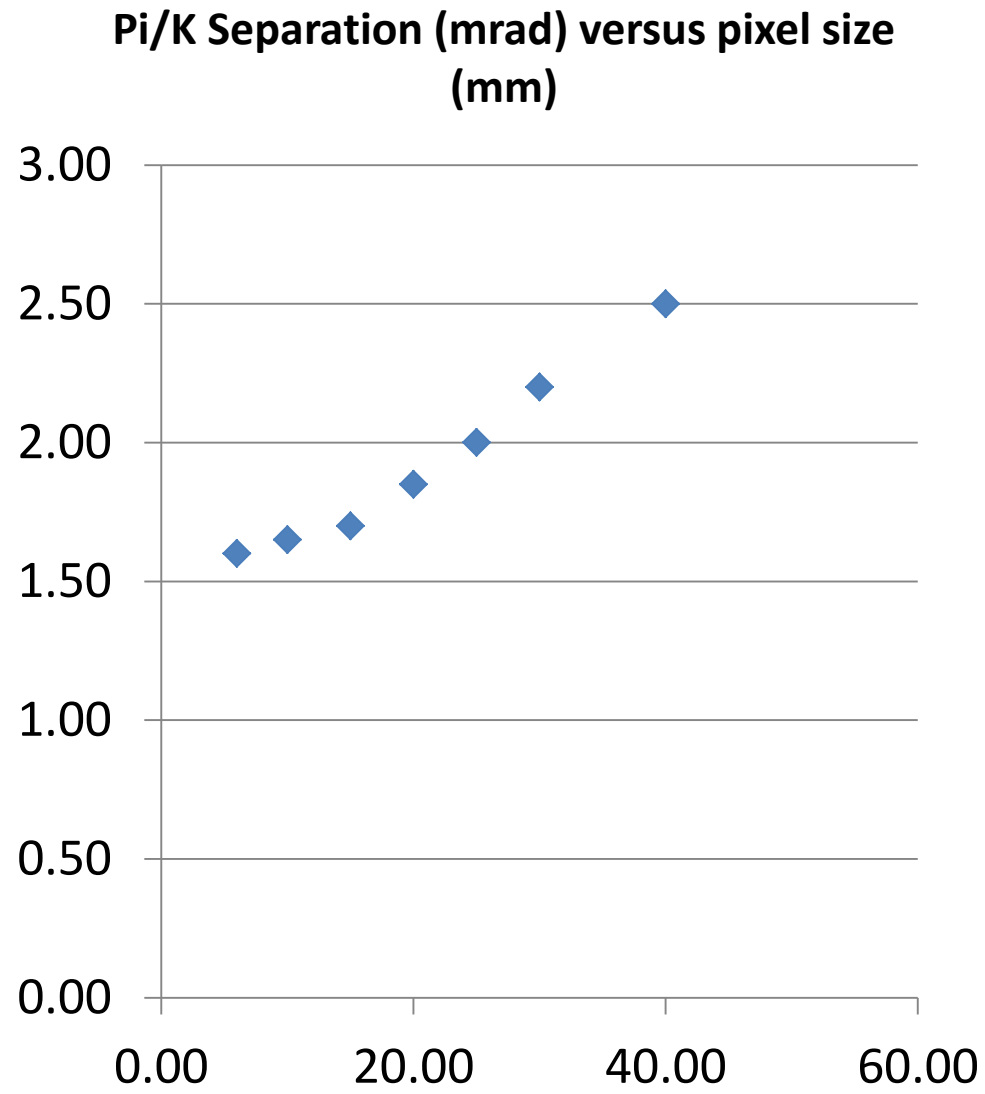
Three Segment Curvature Studies





- For a perpendicular track, increasing the curvature into which the 3 segments are inscribed has no effect on the separation, but reduces the required PMT area significantly
- Have not run this for off angle tracks – likely that they will see some negative effect, as they have more over lap
- Marked the amount of area needed by focusing PMTs

Effect of the PMT resolution



- Plot to the left is for a flat mirror with perpendicular tracks
- Minimal effects on resolution up to 10-15mm
- Will run for the 3 segment mirror soon