Measuring Light Distribution of LED Sources for HyperK

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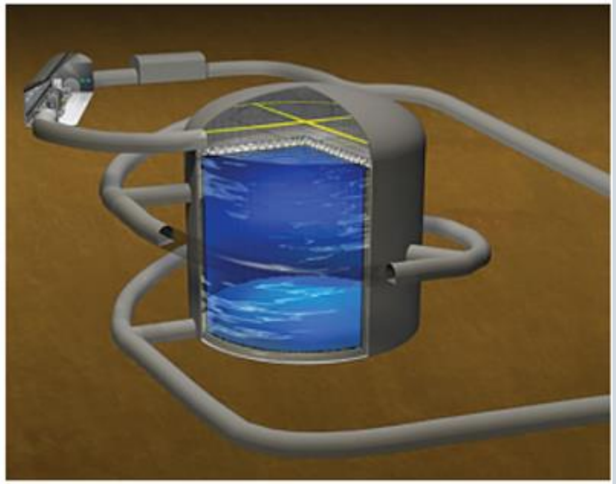
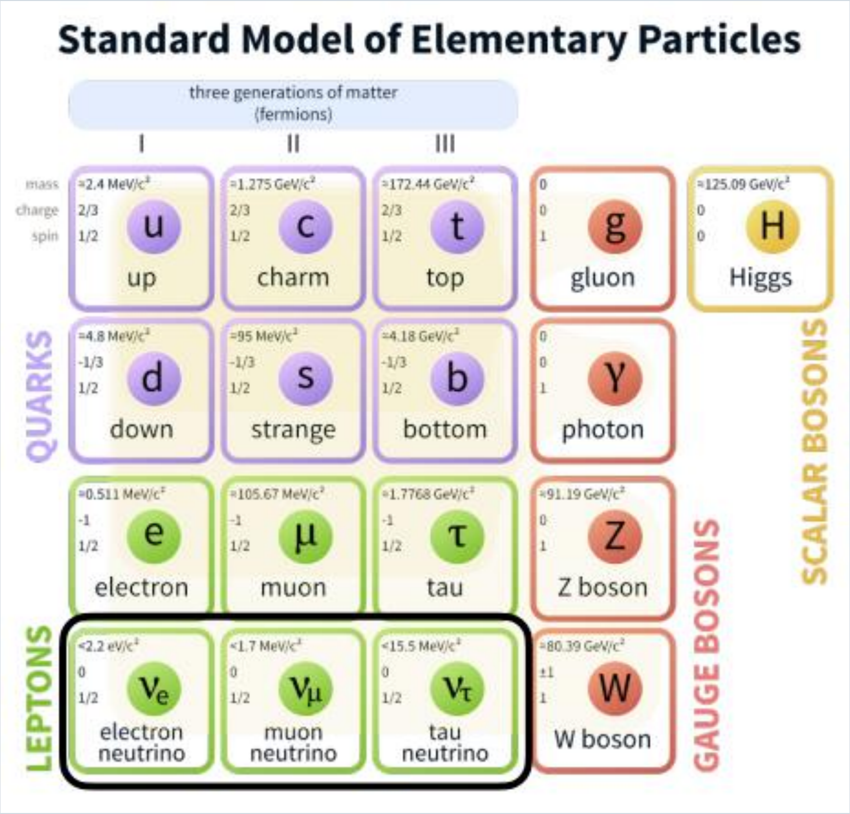
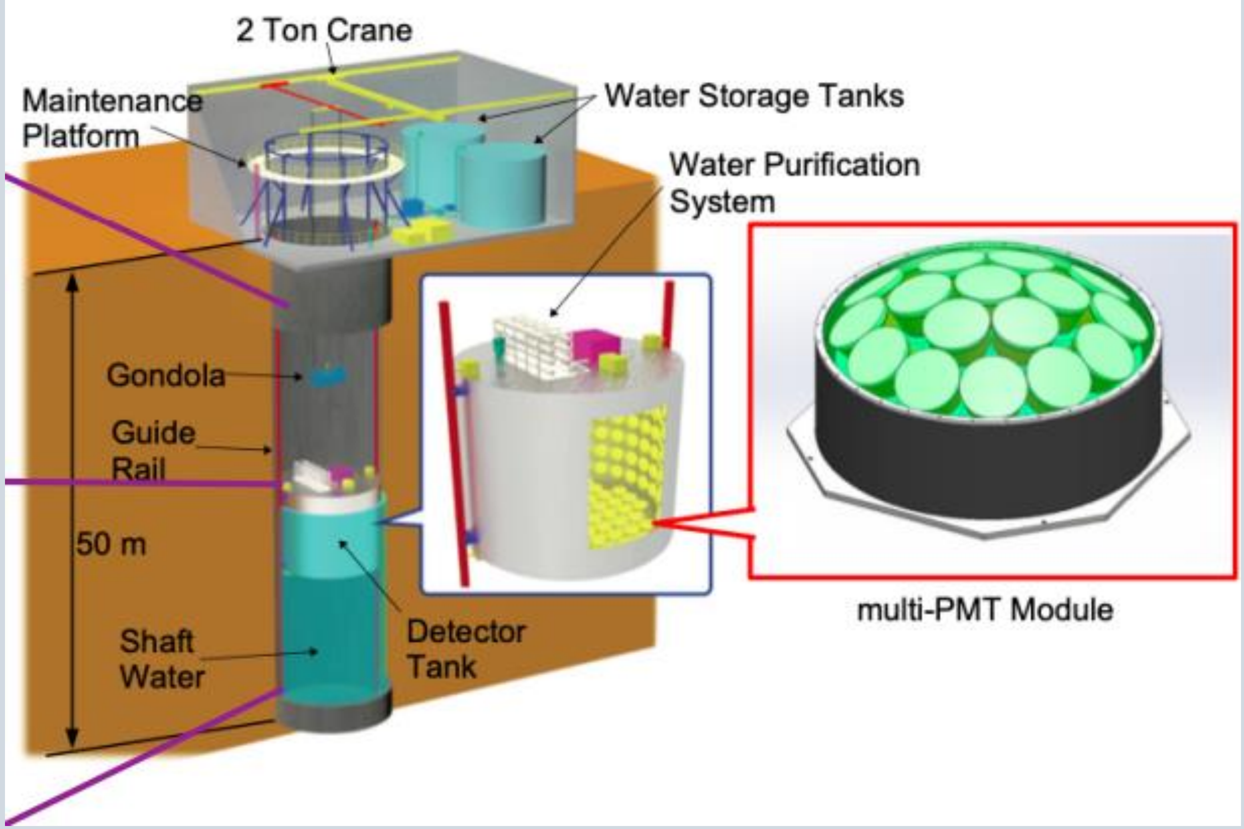
Neutrinos and Hyper-Kamiokande

- Neutrinos only interact through the weak force
- There are multiple potential flavour and mass states, and a neutrino particle can oscillate between the various states.
- The Hyper-Kamiokande (HyperK) experiment employs water-Cherenkov detectors to study this phenomenon.



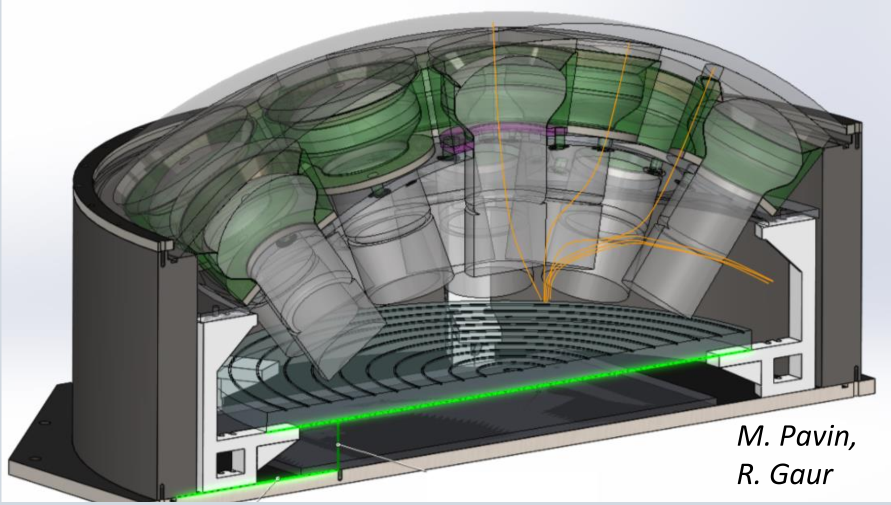


HyperK’s Intermediate Detector



- The Intermediate Water-Cherenkov Detector (IWCD) is a close-to-source detector of much smaller volume than the main HyperK tank.
- Will be lined with mPMTs that will reconstruct the interaction vertex and other properties of events
- Due to small size, high timing precision and photogrammetry are necessary for vertex reconstruction

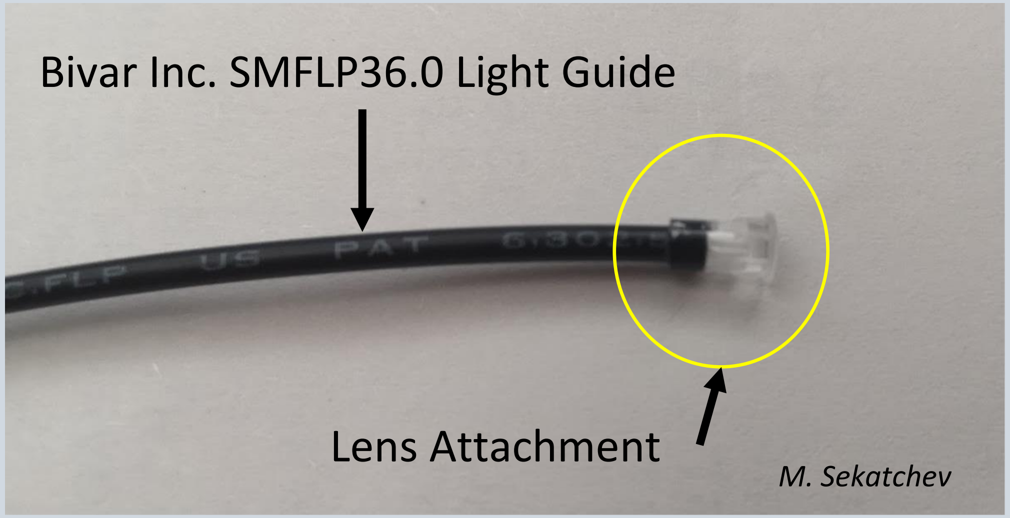
Purpose - LEDs for Calibration



- 13 calibration LEDs beneath sealed dome; powered and controlled by interior electronics
- 12 directional LEDs for photogrammetry
- 1 pulsed LED for timing calibration

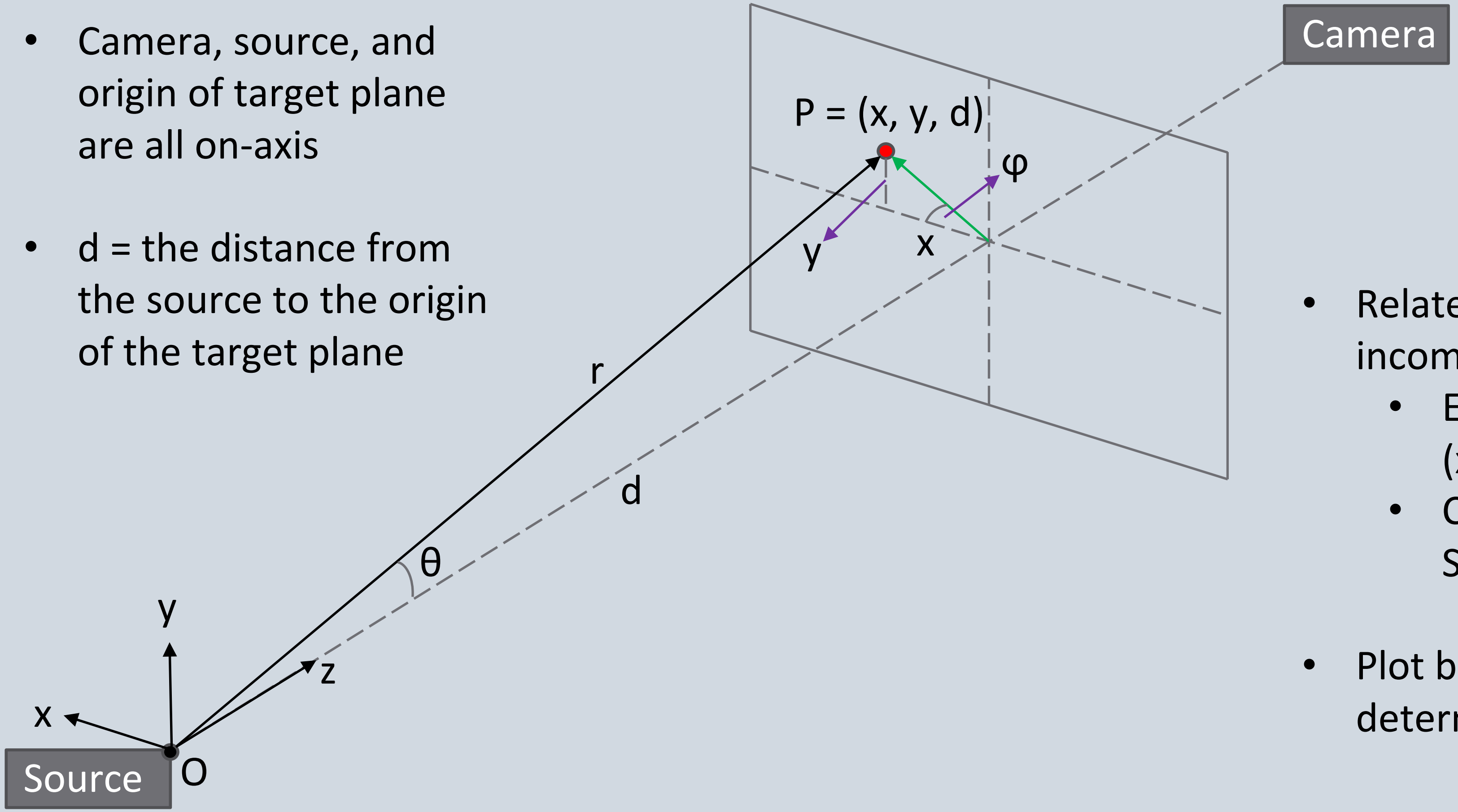
Purpose - LEDs for Calibration

- Light transported from LEDs below PMTs to surface of dome by light guides and emitted through attached lens
- Must fully quantify the affect of lens and light guide on calibration light



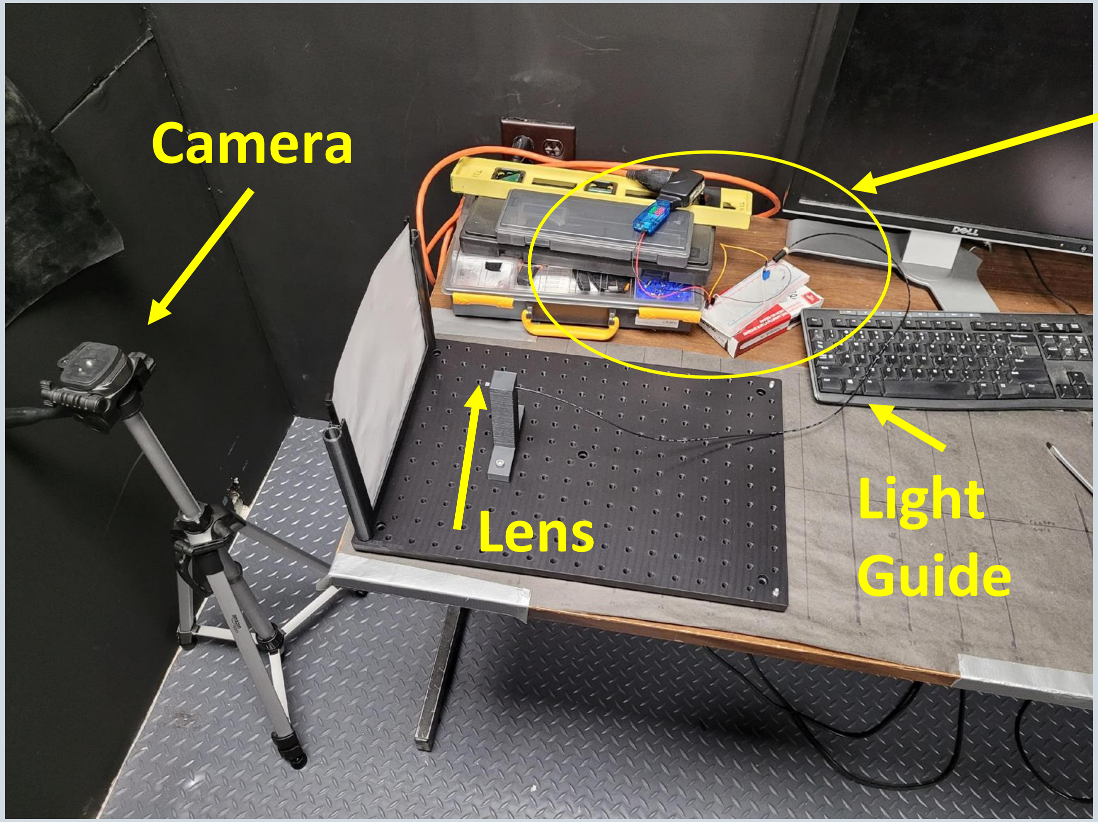
Theory – Brightness from 2D image

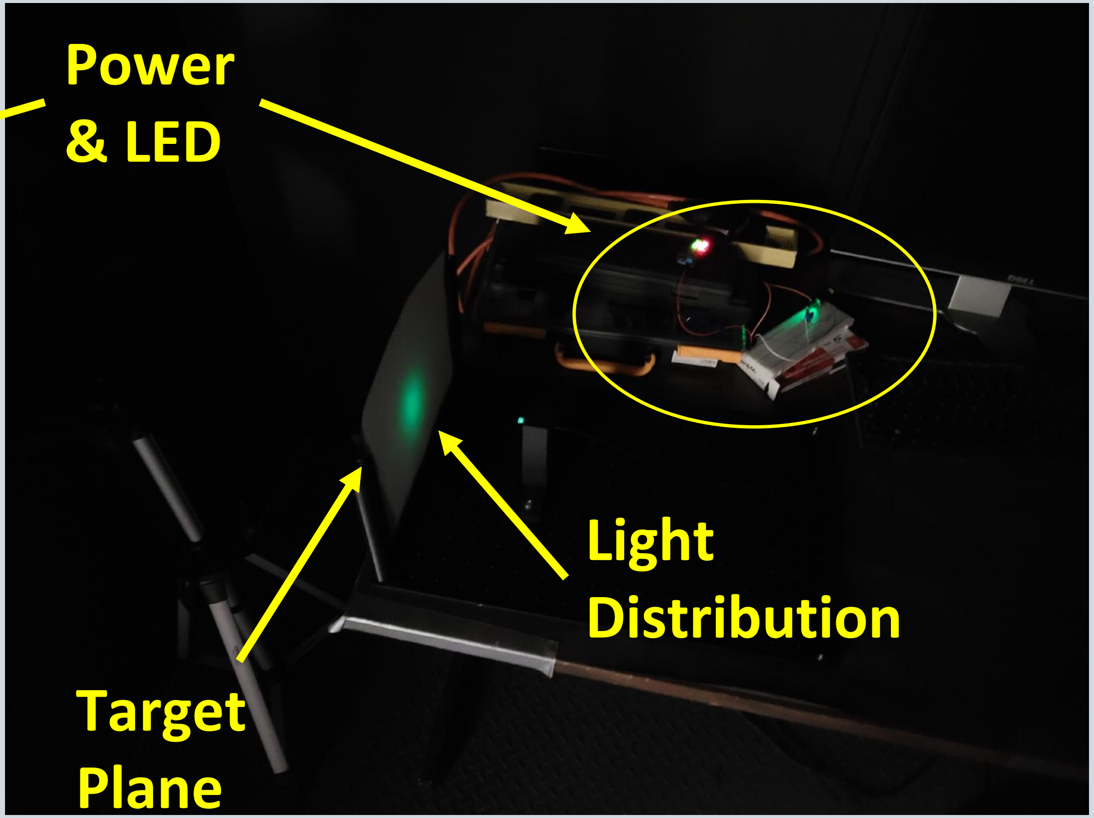
- Camera, source, and origin of target plane are all on-axis
- d = the distance from the source to the origin of the target plane



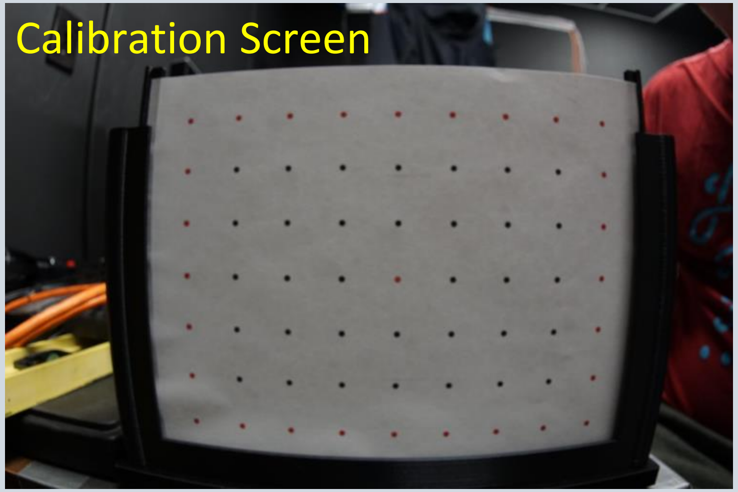
- Relate pixel brightness to incoming polar angle θ
  - Each pixel has corresponding (x, y) coordinates
  - Convert from Cartesian to Spherical to determine θ
- Plot brightness vs polar angle to determine distribution

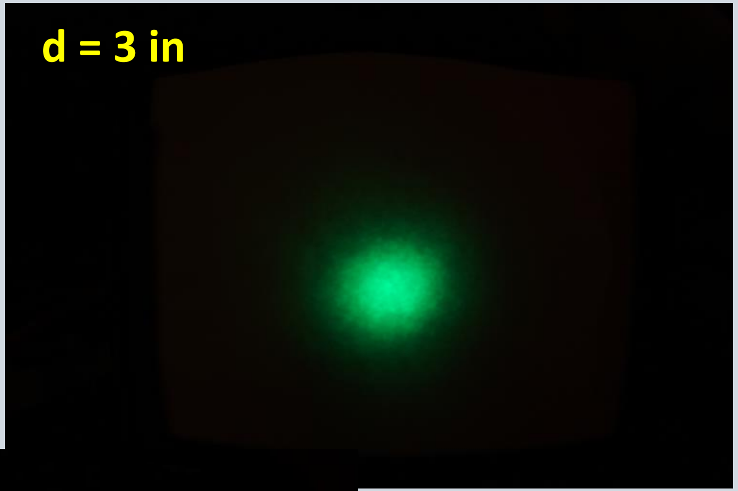
Experimental Set-up

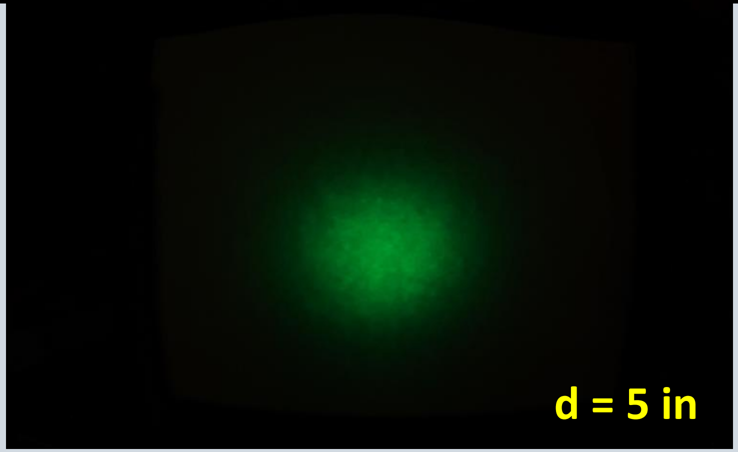




Data Collection







- The LED source is moved further away from target plane for each trial. Angular distribution should be constant as the physical source is not changing.

- Each set of trials requires a calibration photograph with known cartesian coordinates to convert to and from pixel coordinates.

Calibration Technique

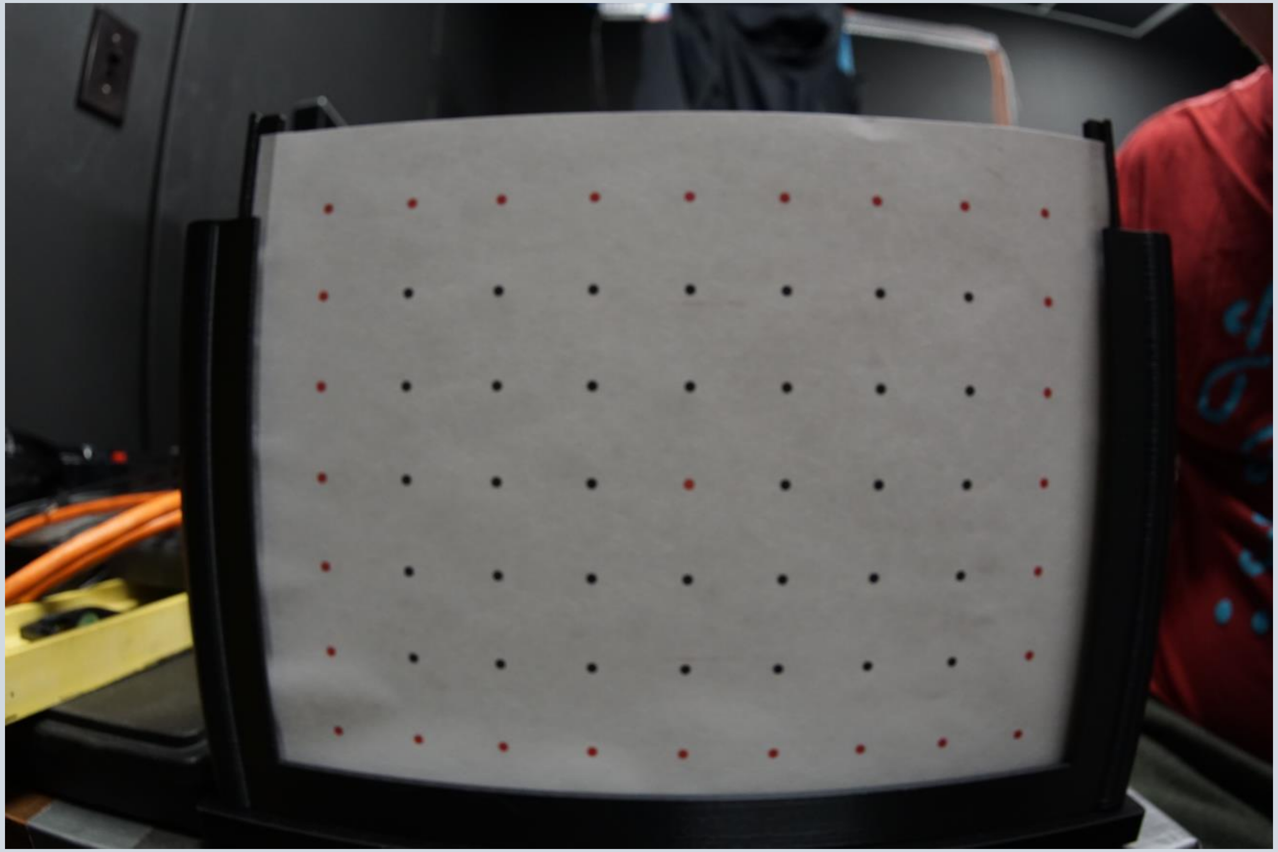
Step 1 – Locate all circles
- Uses Hough Circles

Step 2 – Define Corners
- Rough pixel location found via Paint

Step 3 – Define Known Circles

Step 4 – Interpolate between Knowns
- Uses LinearNDInterpolater

Step 5 – Convert Pixel to True Coordinates



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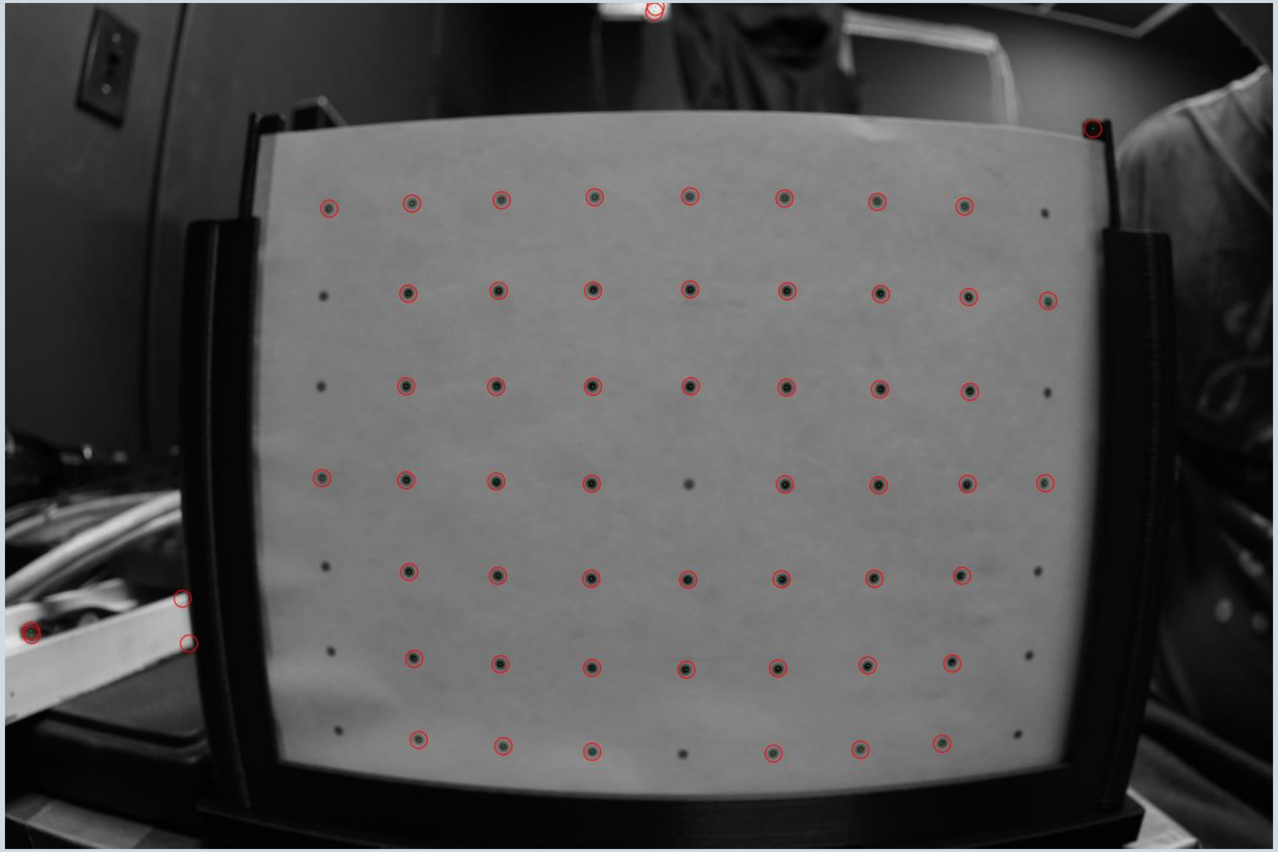

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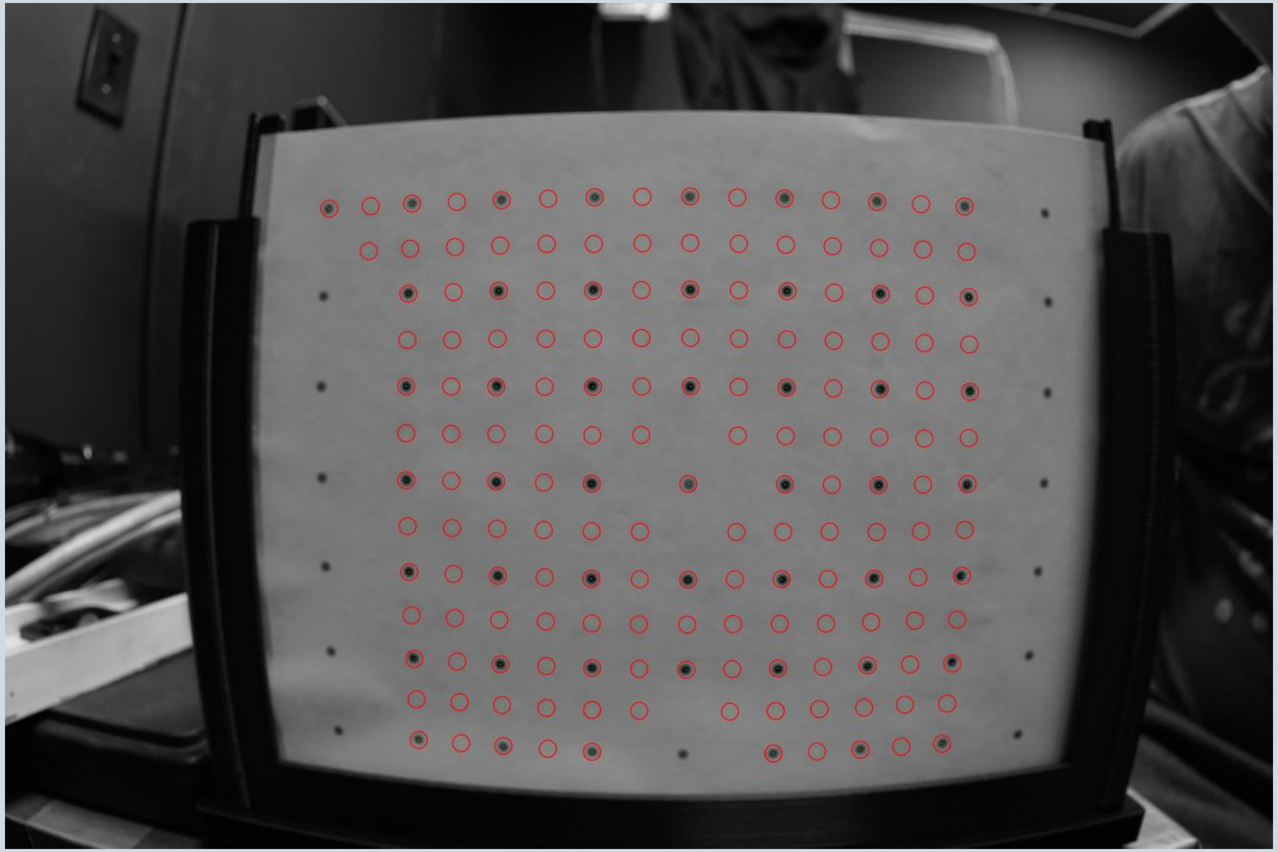
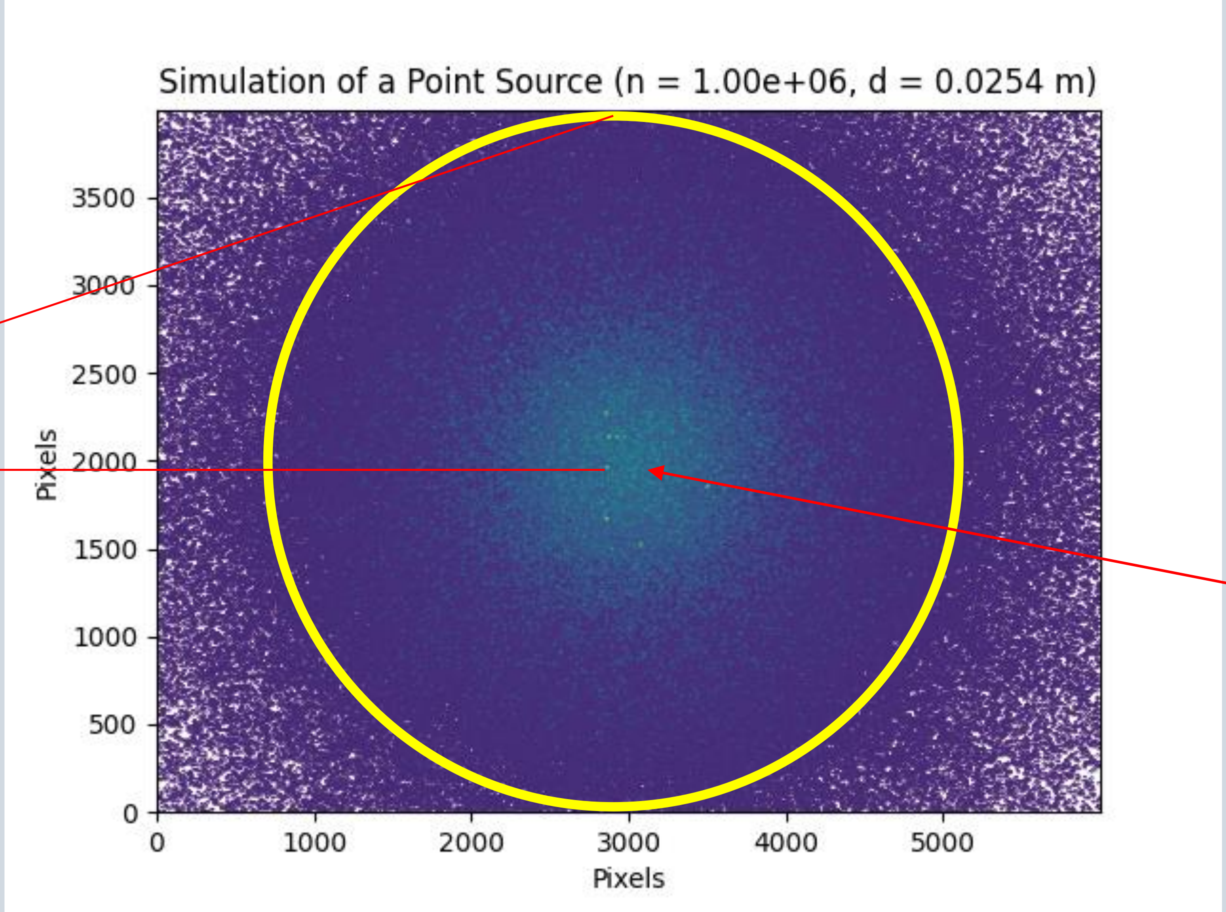


Analysis Technique

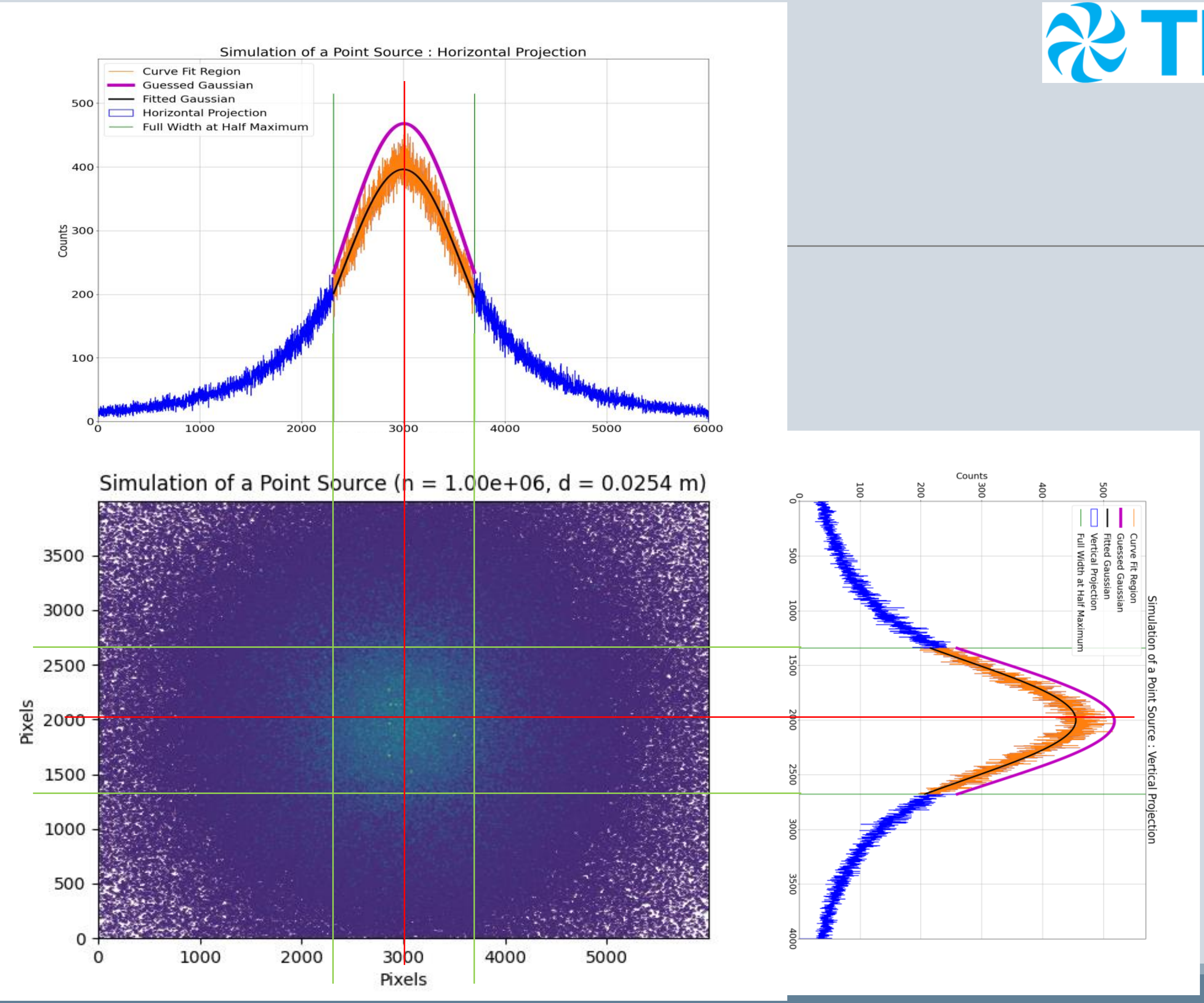


cos(theta) limit

Point Source –

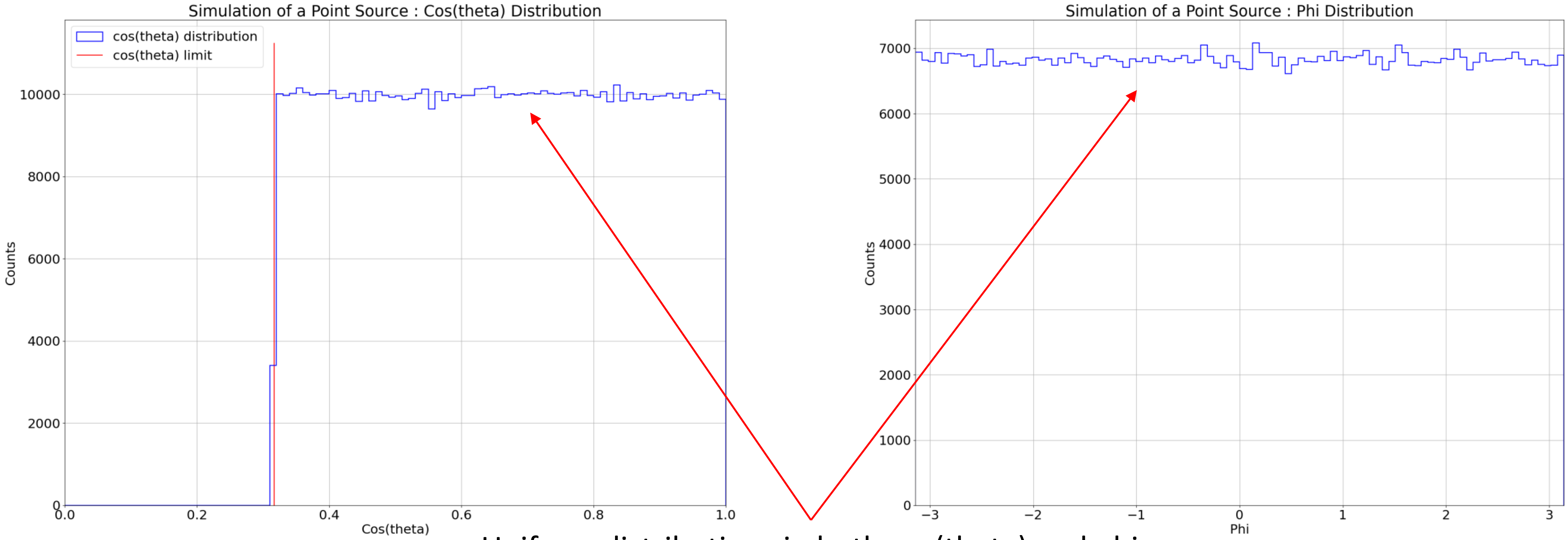
Uniform distribution in both cos(theta) and phi

Determine centre of maximum possible circle

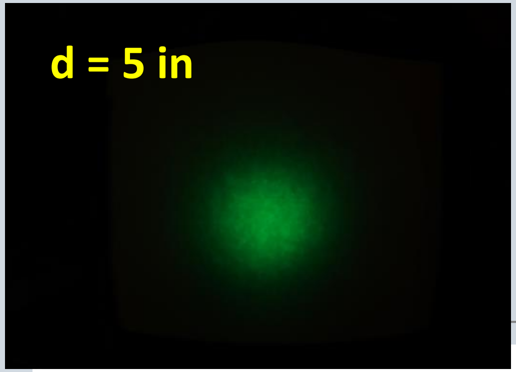


- Isolate Full Width at Half Maximum
- Approximate isolated data as Gaussian
- Fit Gaussians to each data set
- Extract centres of Gaussian as the pixel coordinates of the centre of the light distribution

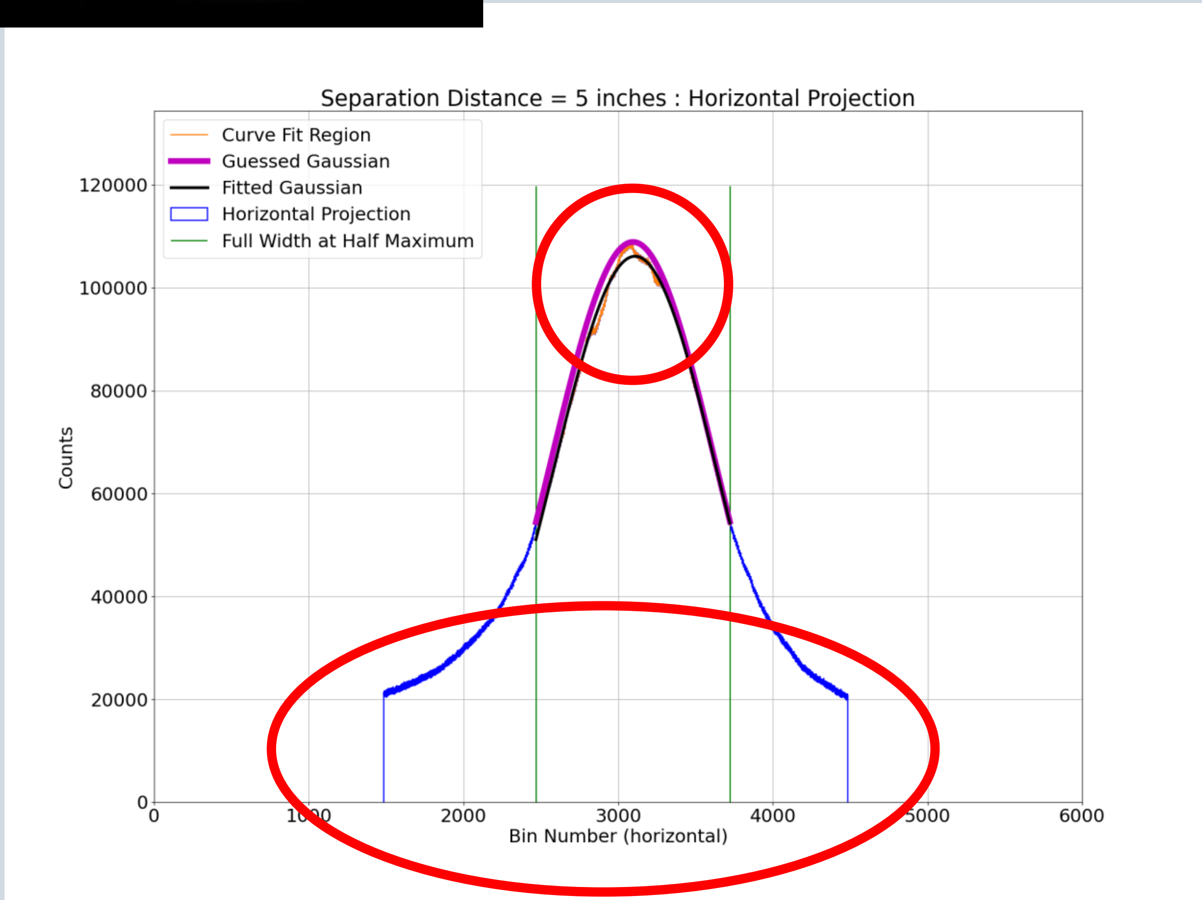
Simulation Results

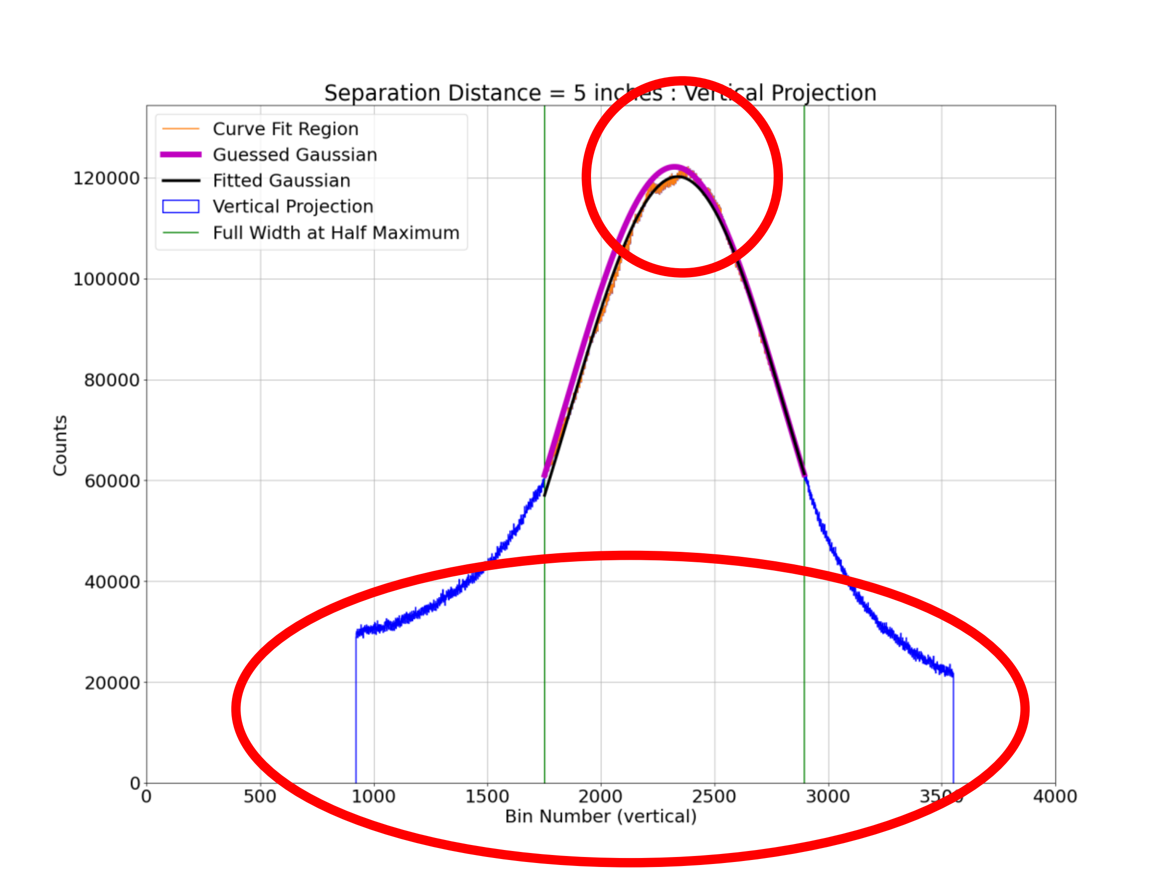


Uniform distributions in both cos(theta) and phi



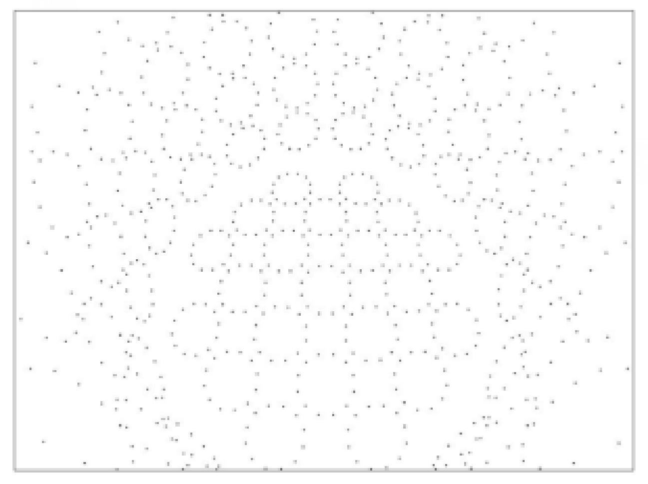
Example Test Results : d = 5 in





Looking Forward

- Create more stable lens stand
- Remove background light contribution
- Model angular distribution in both cos(theta) and phi
- Pass information to full simulation of IWCD tank



Questions?

Thank you!

Merci!