Overview: mPMT & ν_e CC1π Studies

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UofT Neutrino/DM Meeting

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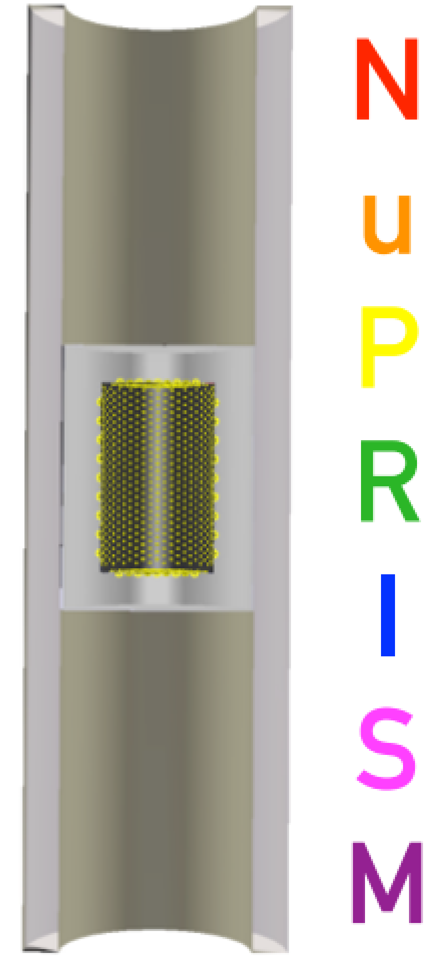
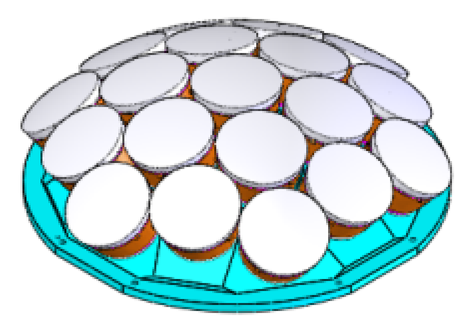
NuPRISM mPMT Studies

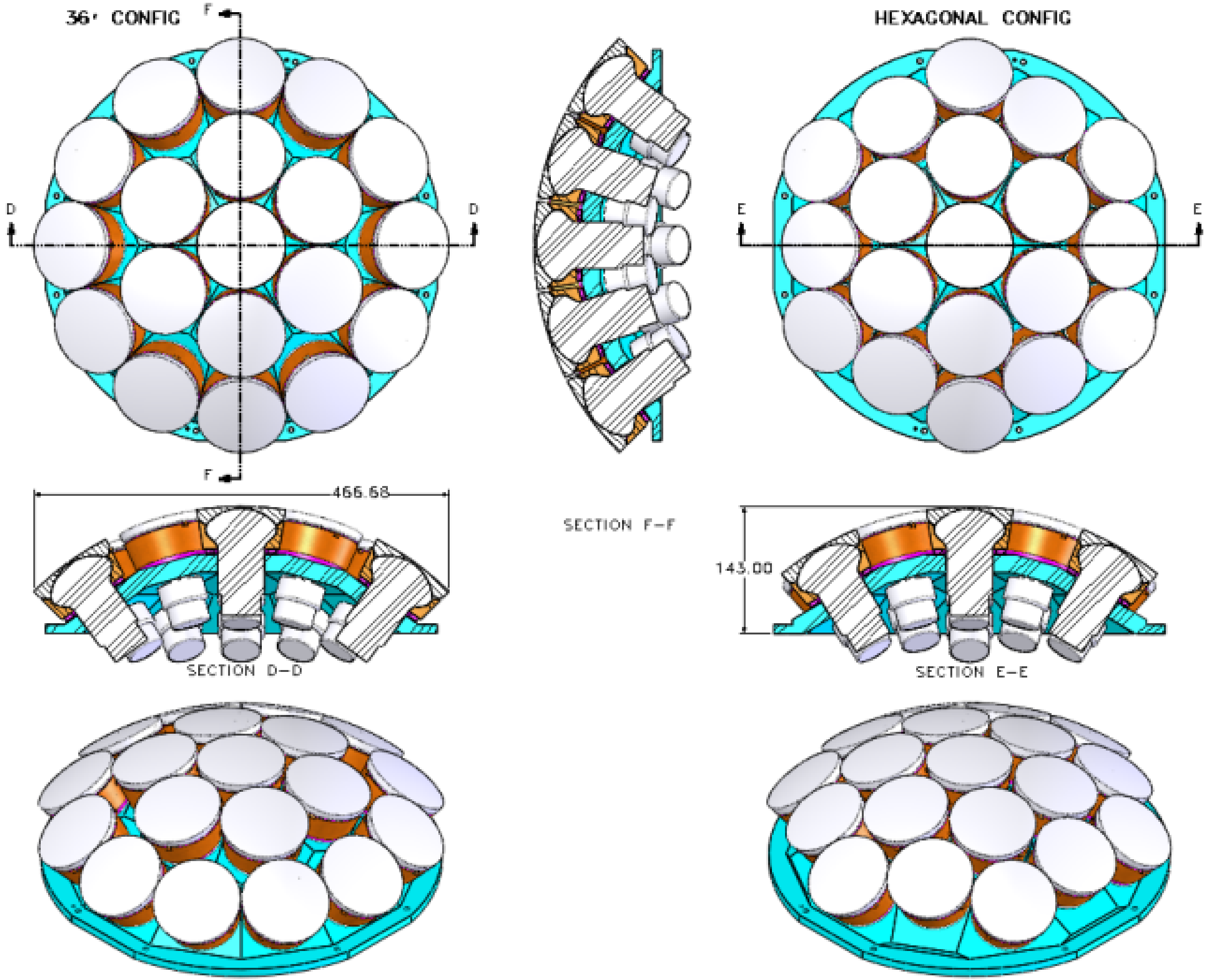


- Water Cherenkov detector
  - 1 km downstream of JPARC neutrino beam
  - Spans 1°-4° off-axis range
  - Taller than Super-K, but with smaller diameter
- Reduce systematic errors for future beam experiments
- Study prospect of using multi-PMT (mPMT) modules rather than traditional PMT configuration
  - Modules comprised of small (3-inch) PMTs
  - Study angular acceptance of these modules



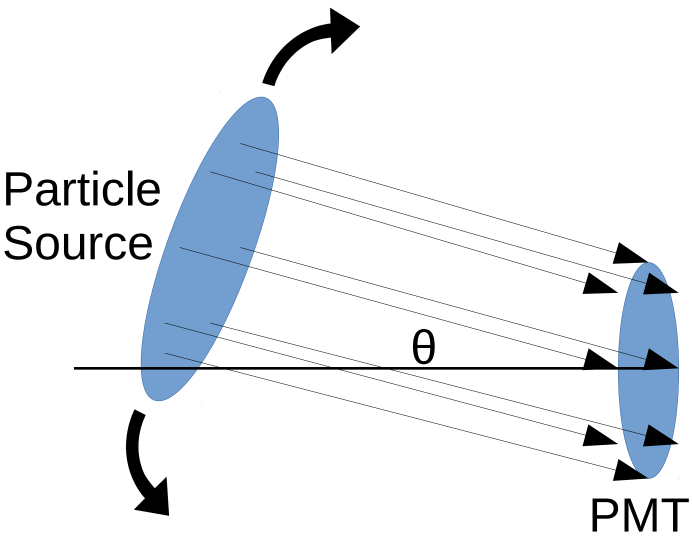
3-ring configuration
- less efficient packing
- longer reflectors

hexagonal configuration
- more efficient packing
- shorter reflectors



Simulations in WCSim

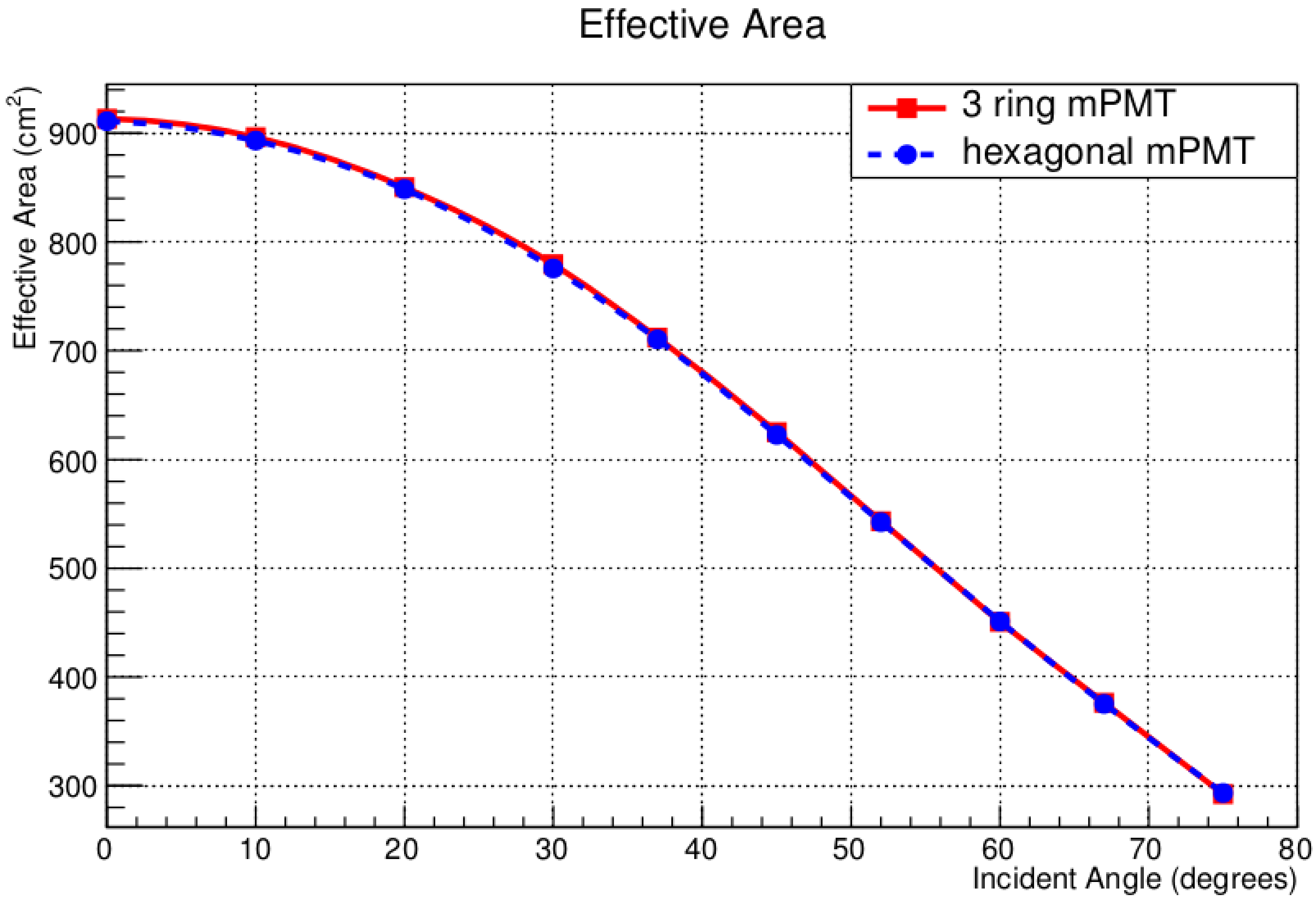
- Quantum and collection efficiencies turned off
- Dark noise turned off
- Circular source of optical photons
  - 400 nm wavelength
  - 1 meter from (m)PMT
  - 1,000,000 events
- 10 angles simulated beteween 0° and 75°



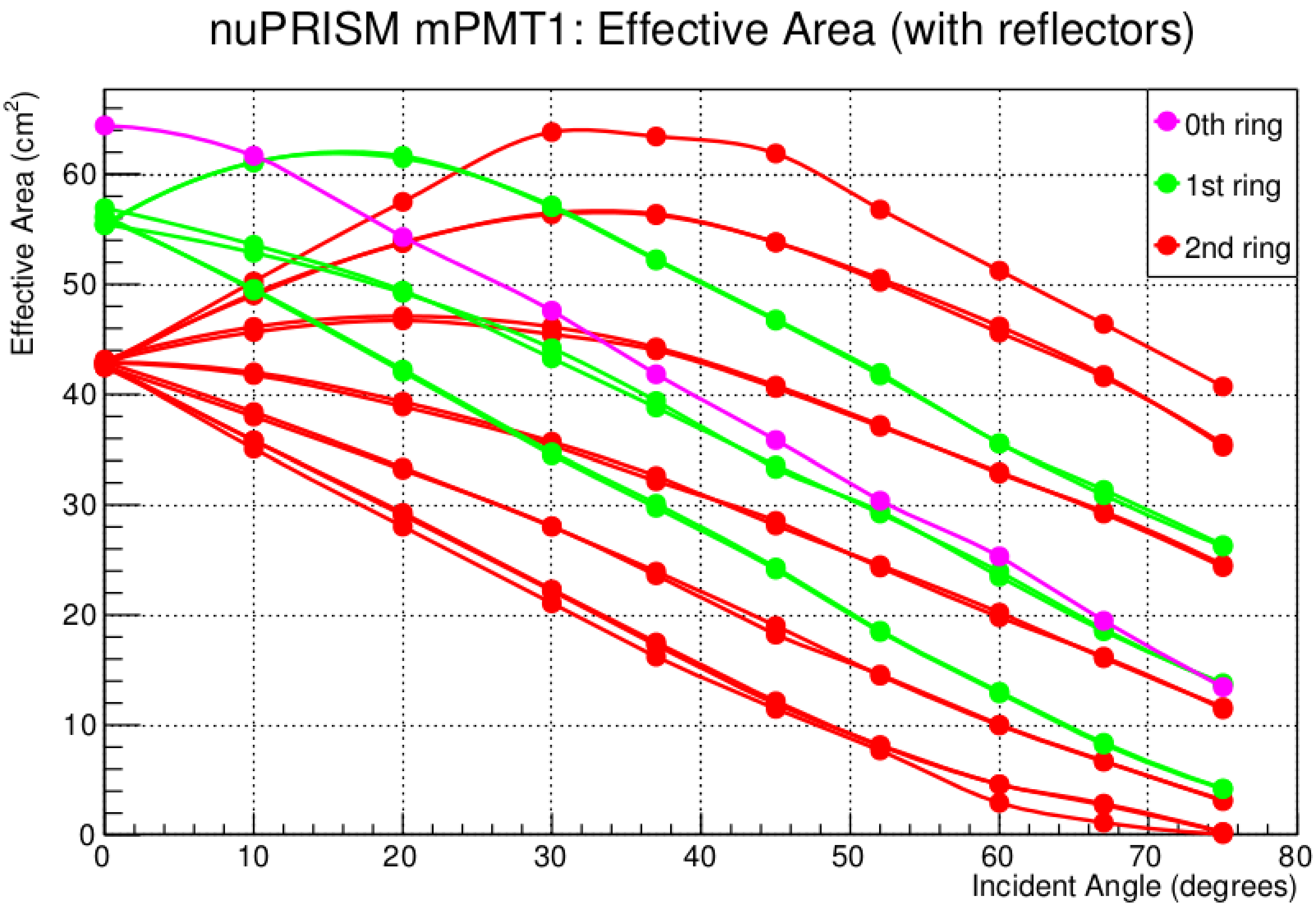
$$\text{Effective Area} = \frac{NHits}{NEvents} \times \pi r^2$$

where r is the radius of the photon source

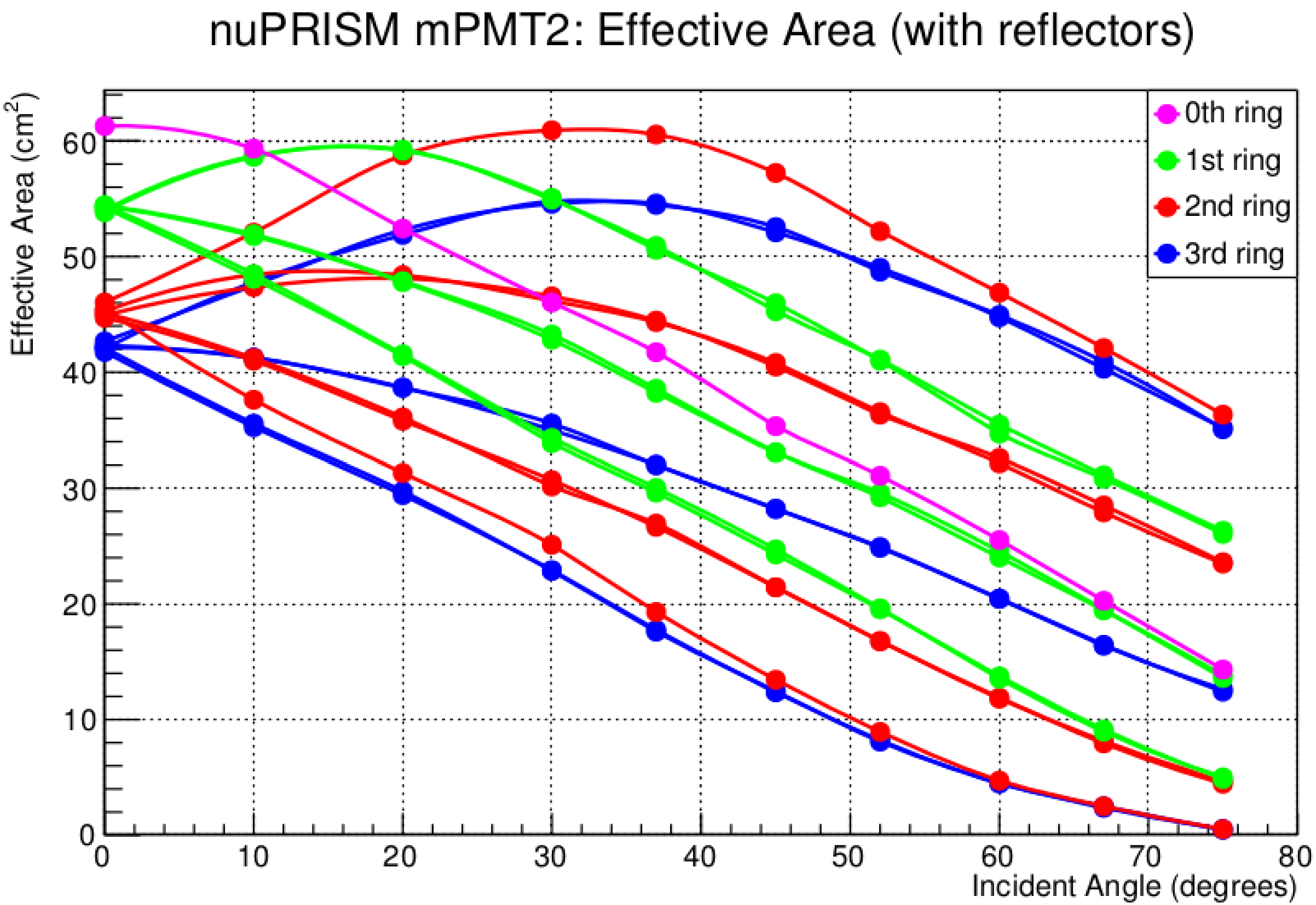
Direct Comparison (with reflectors)



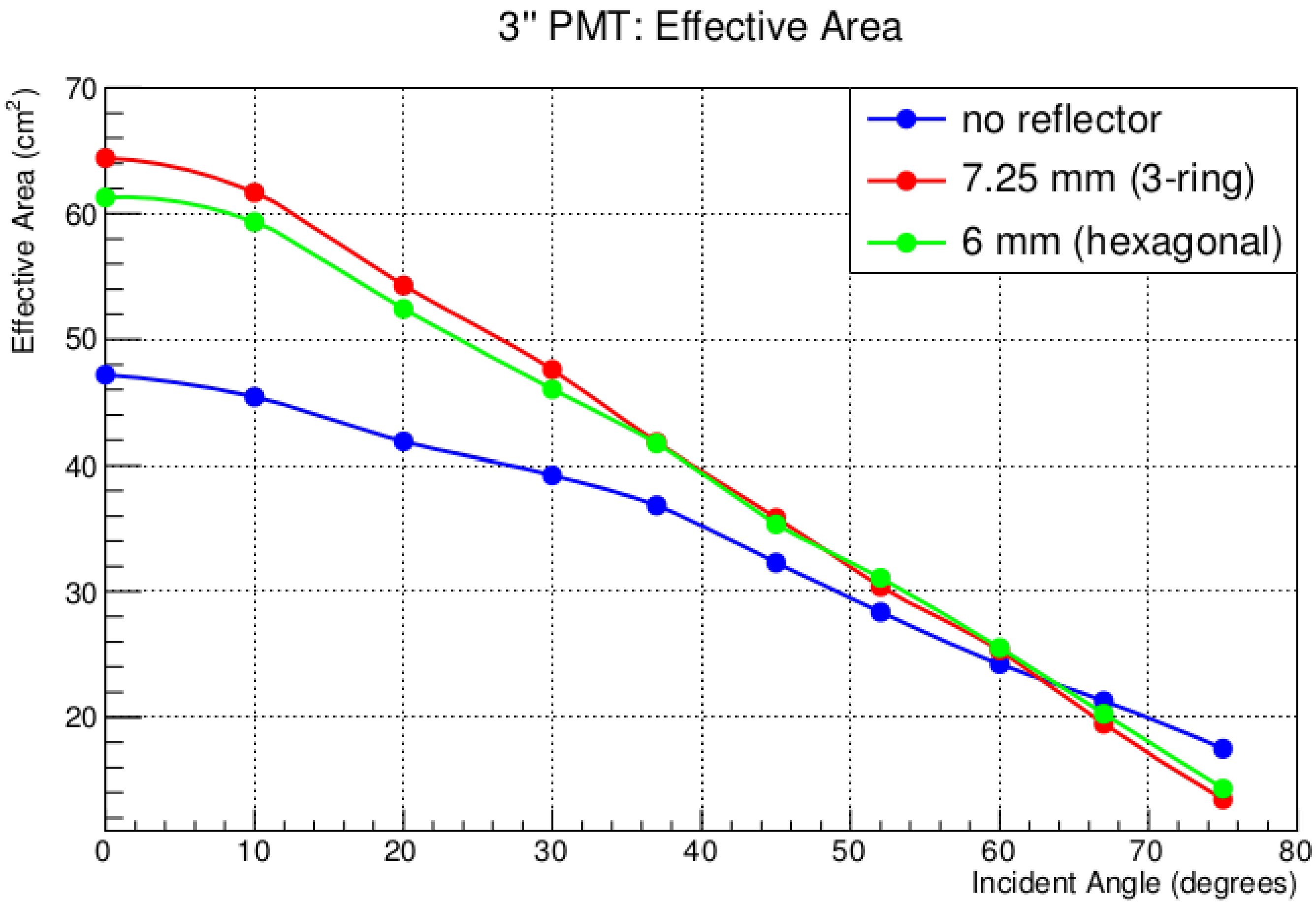
3-ring mPMT: Individual PMTs



Hexagonal mPMT: Individual PMTs



3" PMT Comparison



Now working on macro for θ-φ simulations with updated version of WCSim

ν_e CC1π^+ Studies

$$\nu_e + p/n \rightarrow e^- + \pi^+ + p/n$$

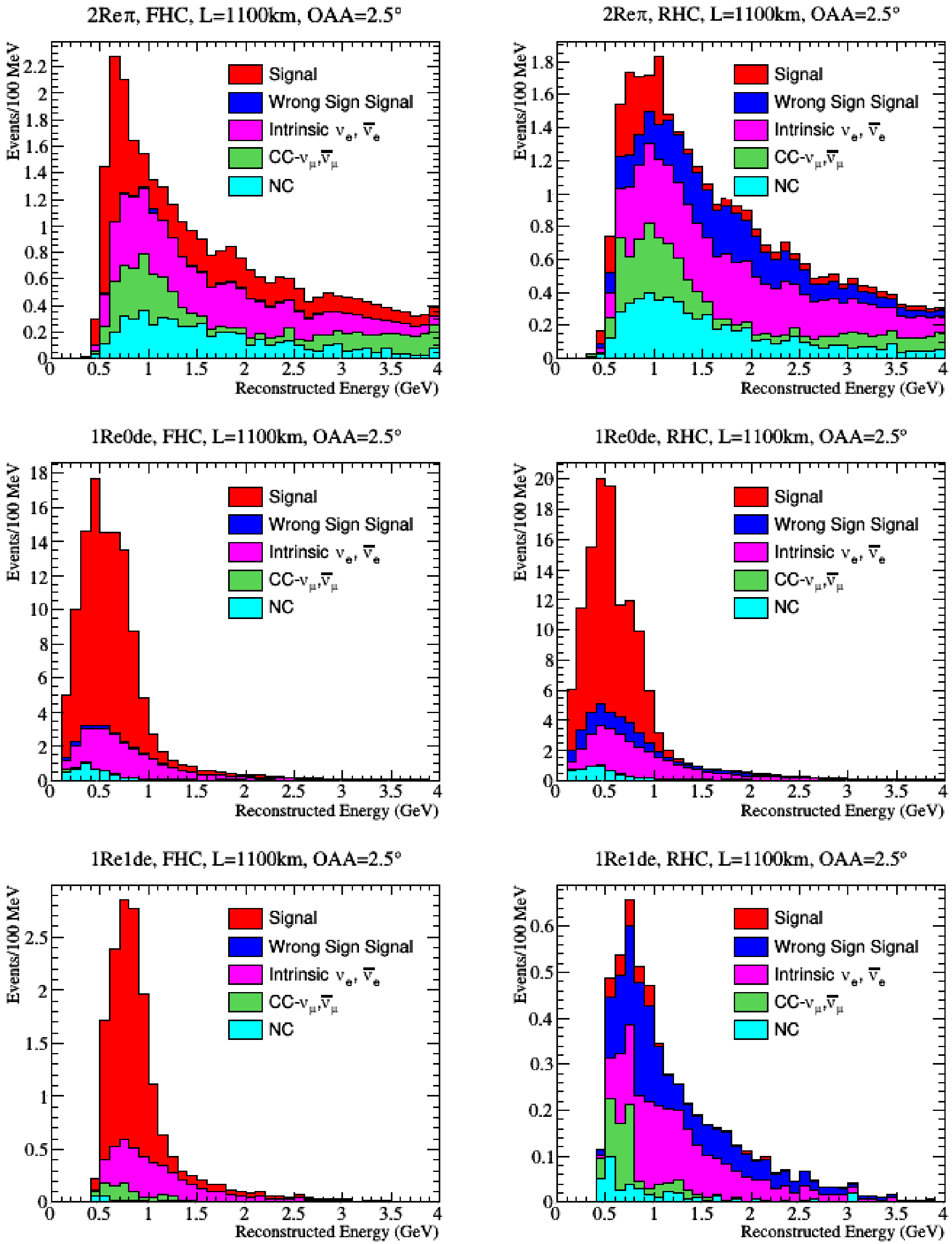
- Current T2K analysis uses only 1-ring samples
- Expand sample by including multi-ring events
- Use fiTQun to make cuts separating ν_e CC1π^+ events
- Study was done to estimate expected number of events and performance of selection for Korean detector (T2HKK) with:
  - 1100 km baseline
  - 187 kton fiducial volume
  - 1.5º, 2.0º, and 2.5º off-axis
  - FHC and RHC
  - $\delta_{CP} = 0, \pi/2, \pi, 3\pi/2$
  - NH and IH
- Currently working to translate studies to T2K

Event Selection

$\nu_e + p/n \rightarrow e^-$	1Re, 0 decay e*	(1R0de)
$\rightarrow e^- + \pi^+\ below\ CT$ ** $\rightarrow \mu \rightarrow e$	1Re, 1 decay e	(1R1de)
$\rightarrow e^- + \pi^+\ above\ CT$	2Reπ, 0 decay e	(2R0de)
$\rightarrow e^- + \pi^+\ above\ CT$ $\rightarrow \mu \rightarrow e$	2Reπ, 1 decay e	(2R1de)

*decay electrons determined by number of sub-events
1[st] sub-event corresponds to the primary neutrino interaction
Decay electrons will produce additional sub-events

** CT = Cherenkov Threshold



- predicted event candidates for 2R, 1R0de and 1R1de
- both FHC (left) and RHC (right) shown
- all for OAA of 2.5°
- normal mass hierarchy assumed

Future Work

- Use machine learning techniques for multi-ring event identification
  - working towards expanding sample to include multi-ring events