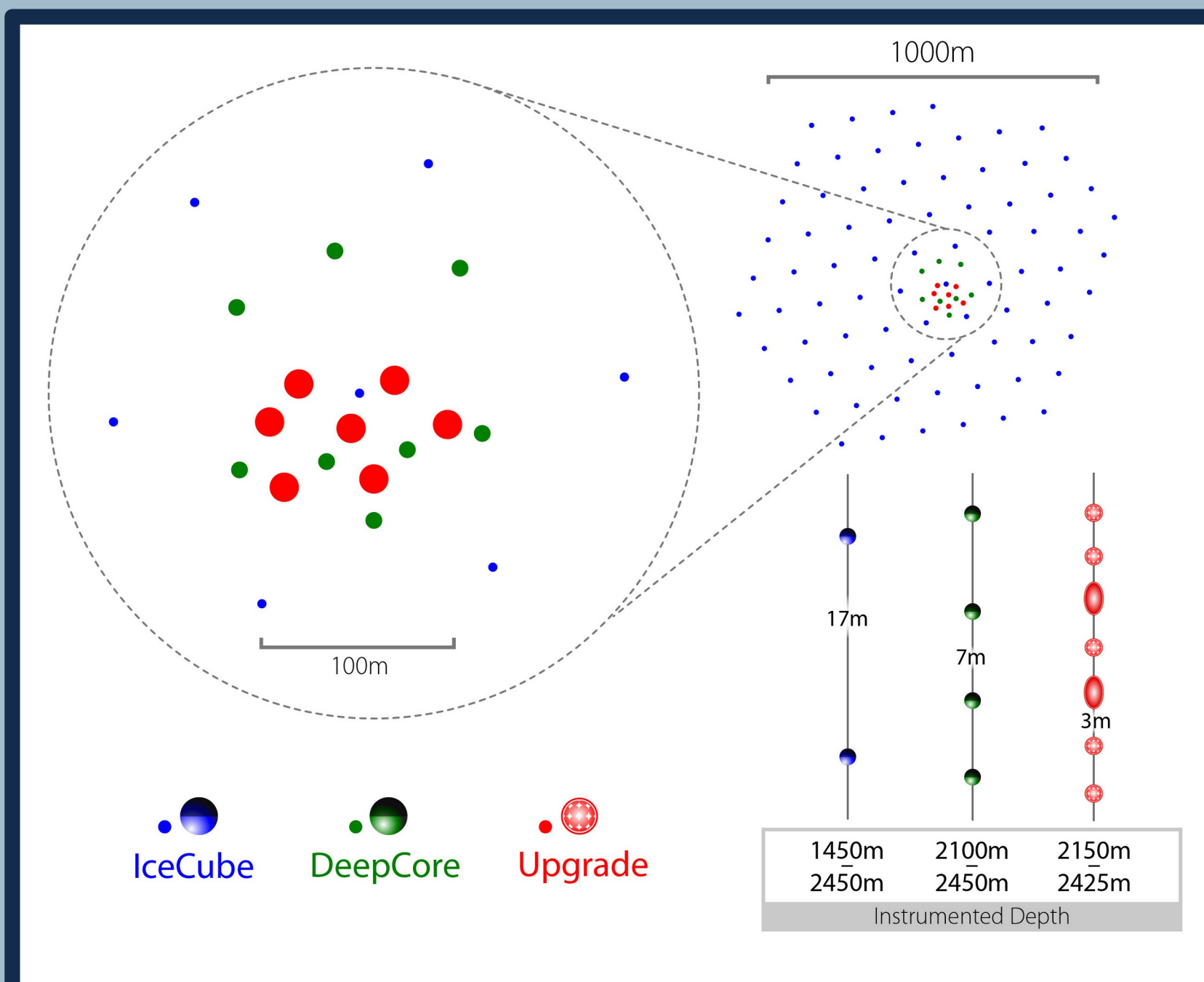


# The Effective Area of the IceCube Upgrade D-Egg Module

Ramy Hmaid

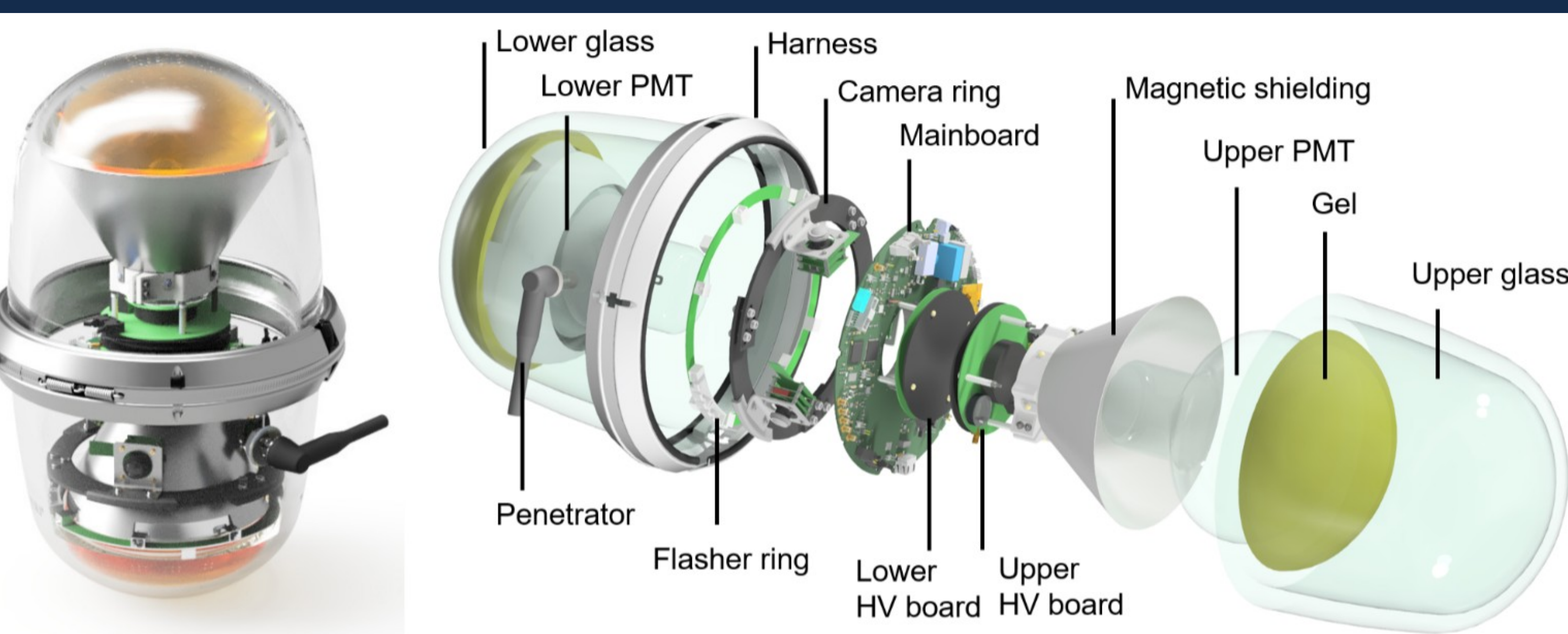
## The IceCube Upgrade



- 700 modules along 7 new strings will be installed in the next two months
  - c. 280 D-Egg modules
  - c. 300 mDOM modules
- Goals of the Upgrade
  - 1) Calibrate IceCube:
    - Many sensors will be installed (LED lights, cameras, acoustic modules, etc.)
  - 2) Higher sensitivity to lower neutrino energies (below 100 GeV)
    - More PMTs per module
    - Lower noise rate
    - Closer module spacing

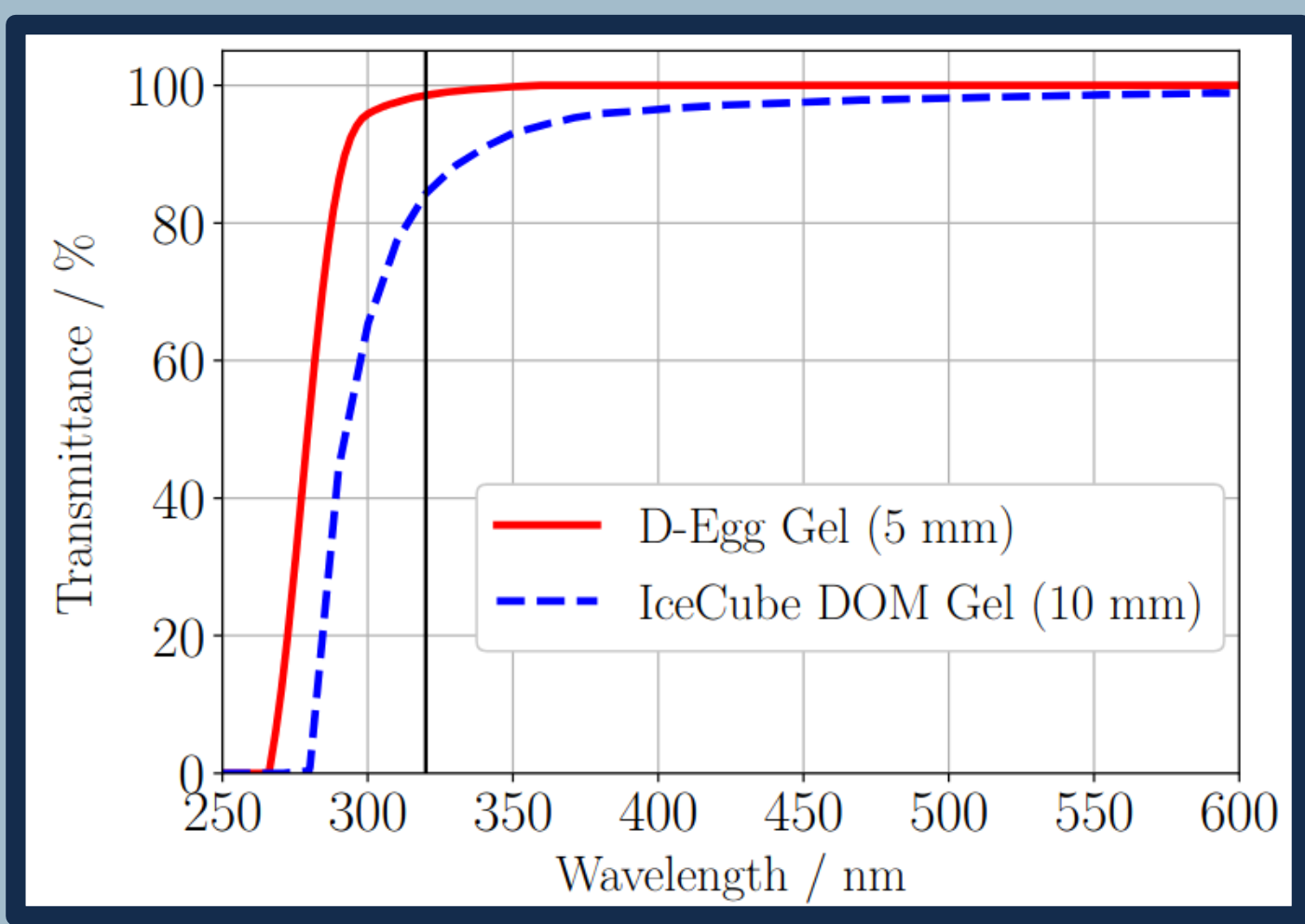
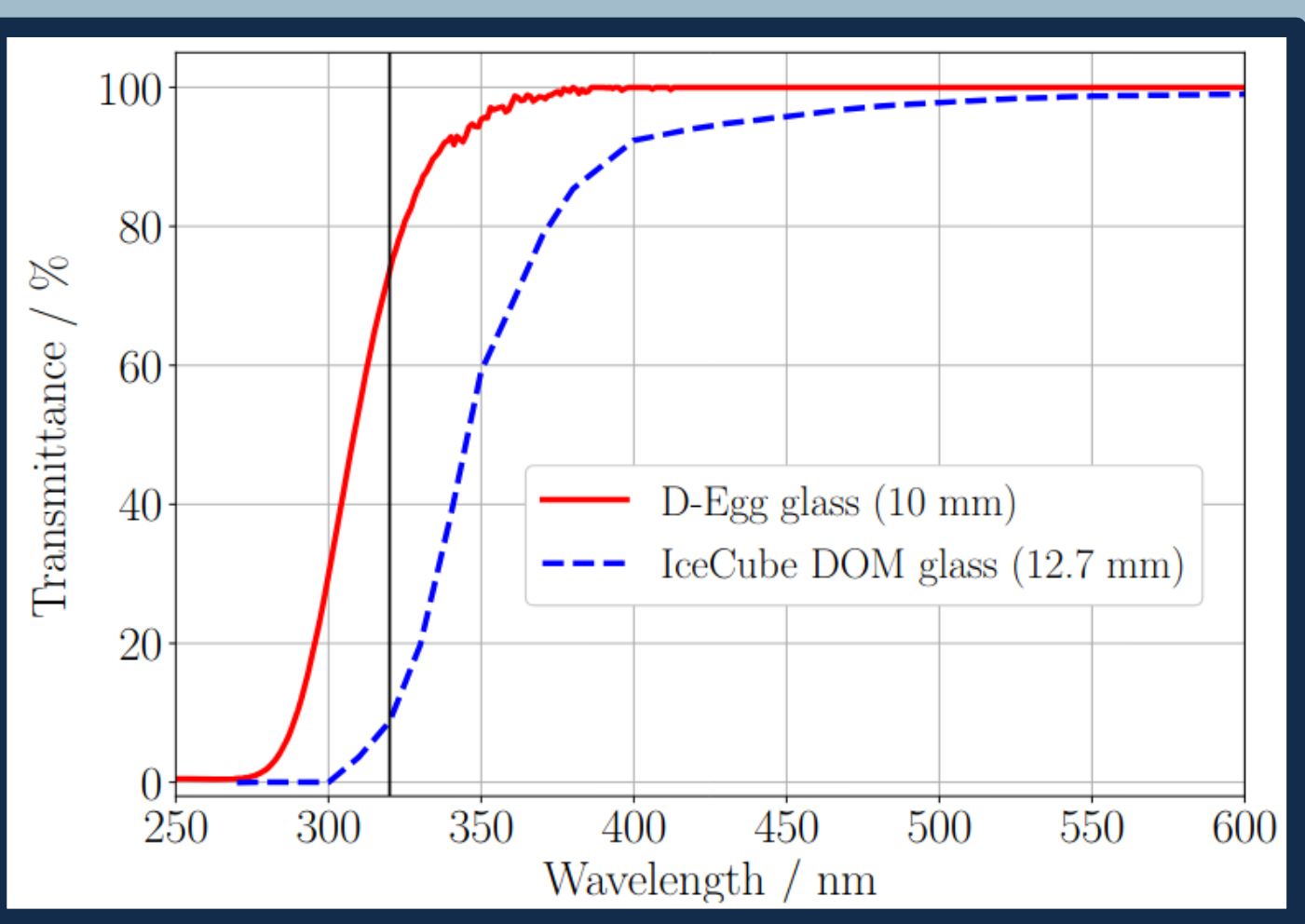
Module density		
Distance	IceCube Gen1	Upgrade
Along string:	17m	3m
Between strings:	~100m	~20m

## The D-Egg Upgrade Module

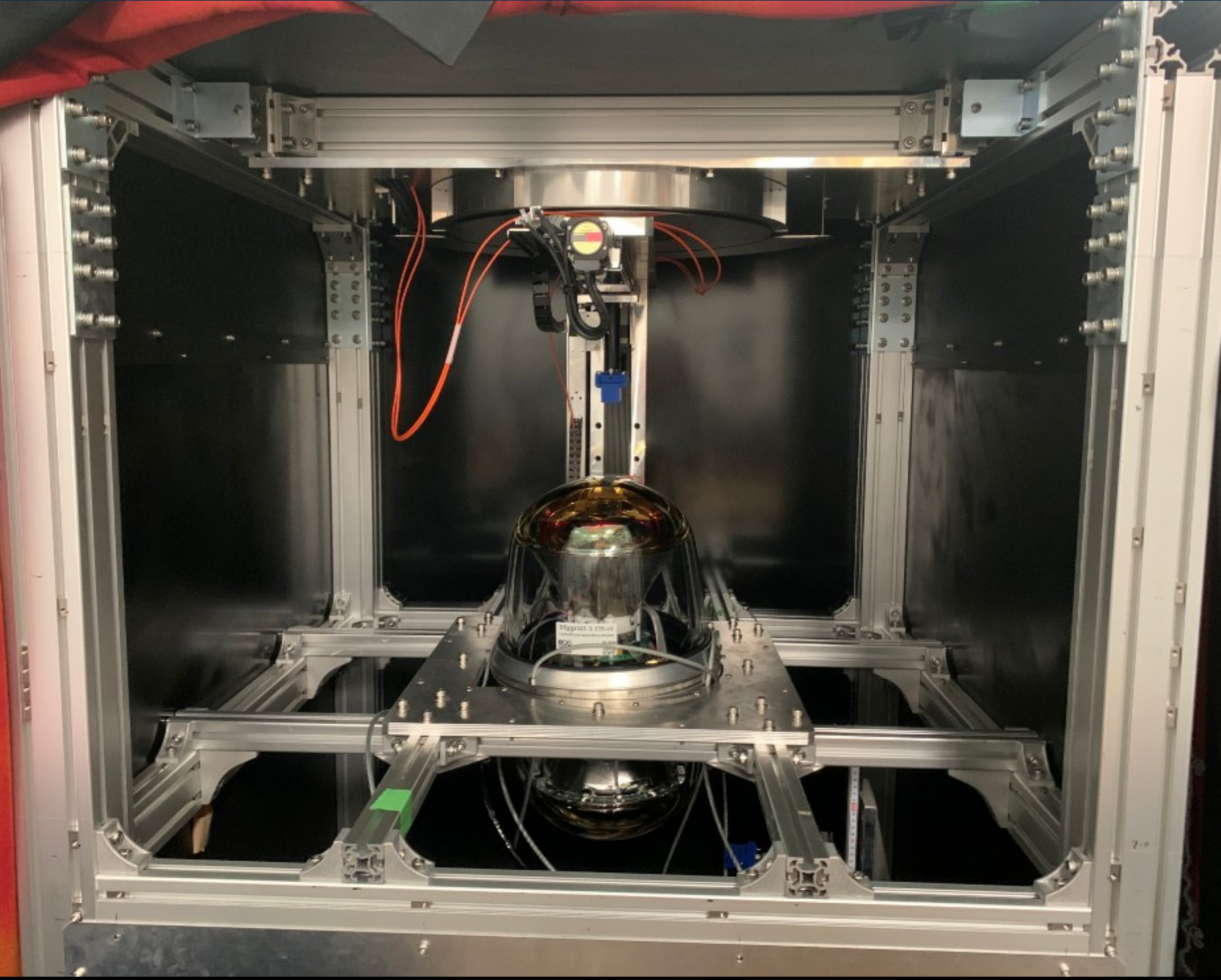


- 2 PMTs
  - Directional reconstruction
  - Noise filtering through coincidence triggers
- UV transparent borosilicate glass and optical gel
- Reduced radioactive  $^{40}\text{K}$  component

8 inch Hamamatsu R5912-100

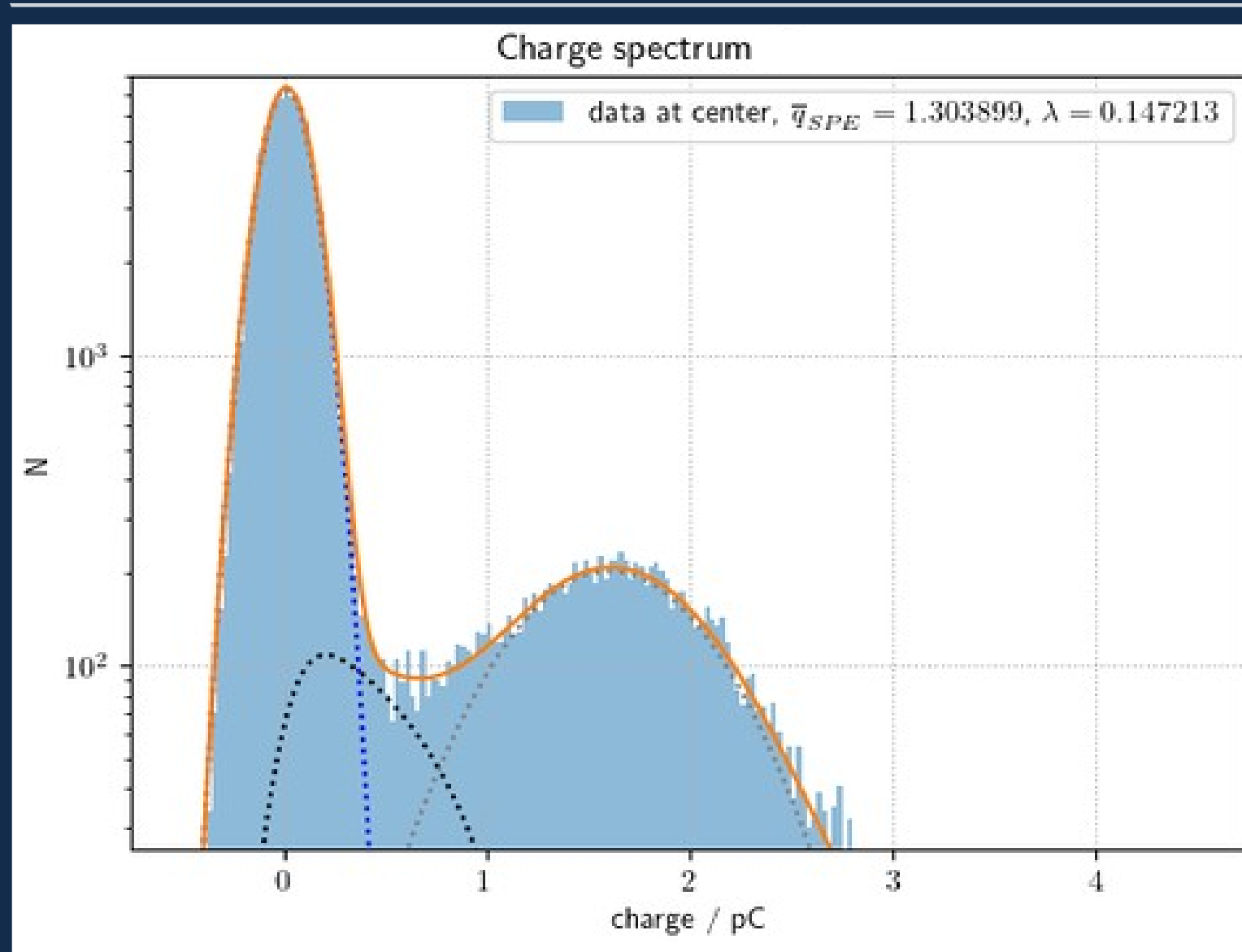
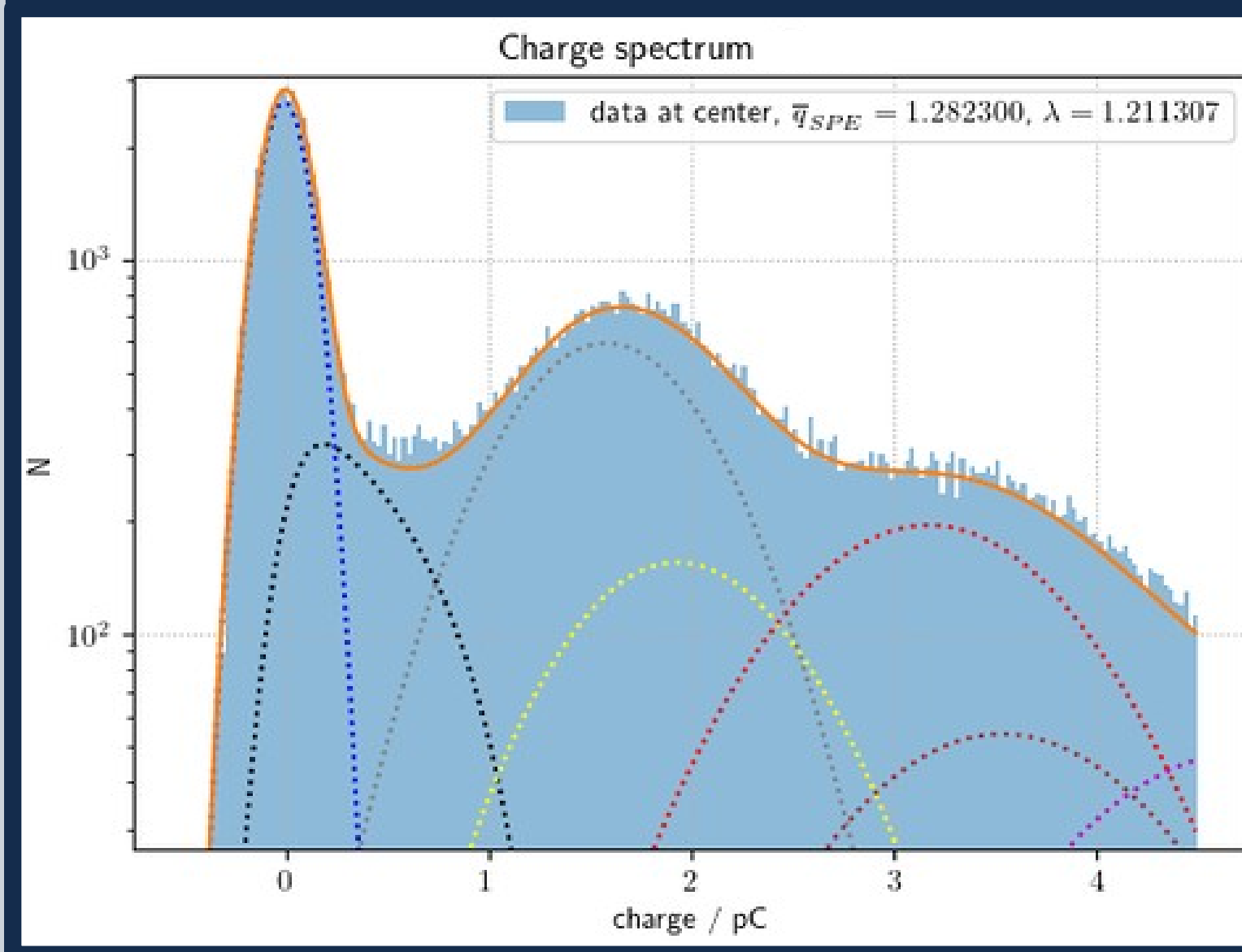


## Photon Response Measurement Setup

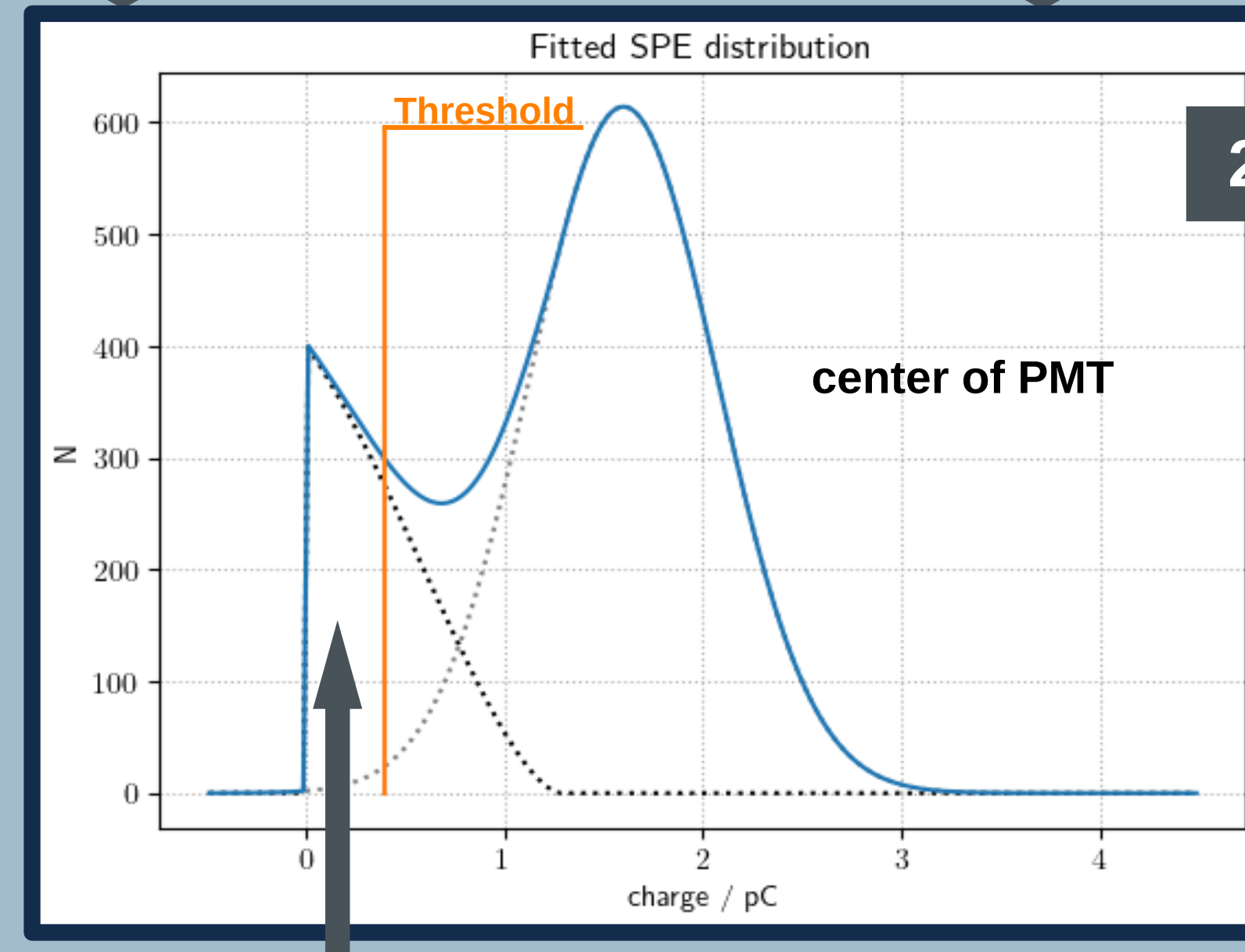


- 6 motors
  - rotation
  - translation
- 405 nm laser
- 4 movable arms
  - guide laser from
    - 1) top
    - 2) side
    - 3) below
- Focusing lens

## D-Egg Single-Photon Response

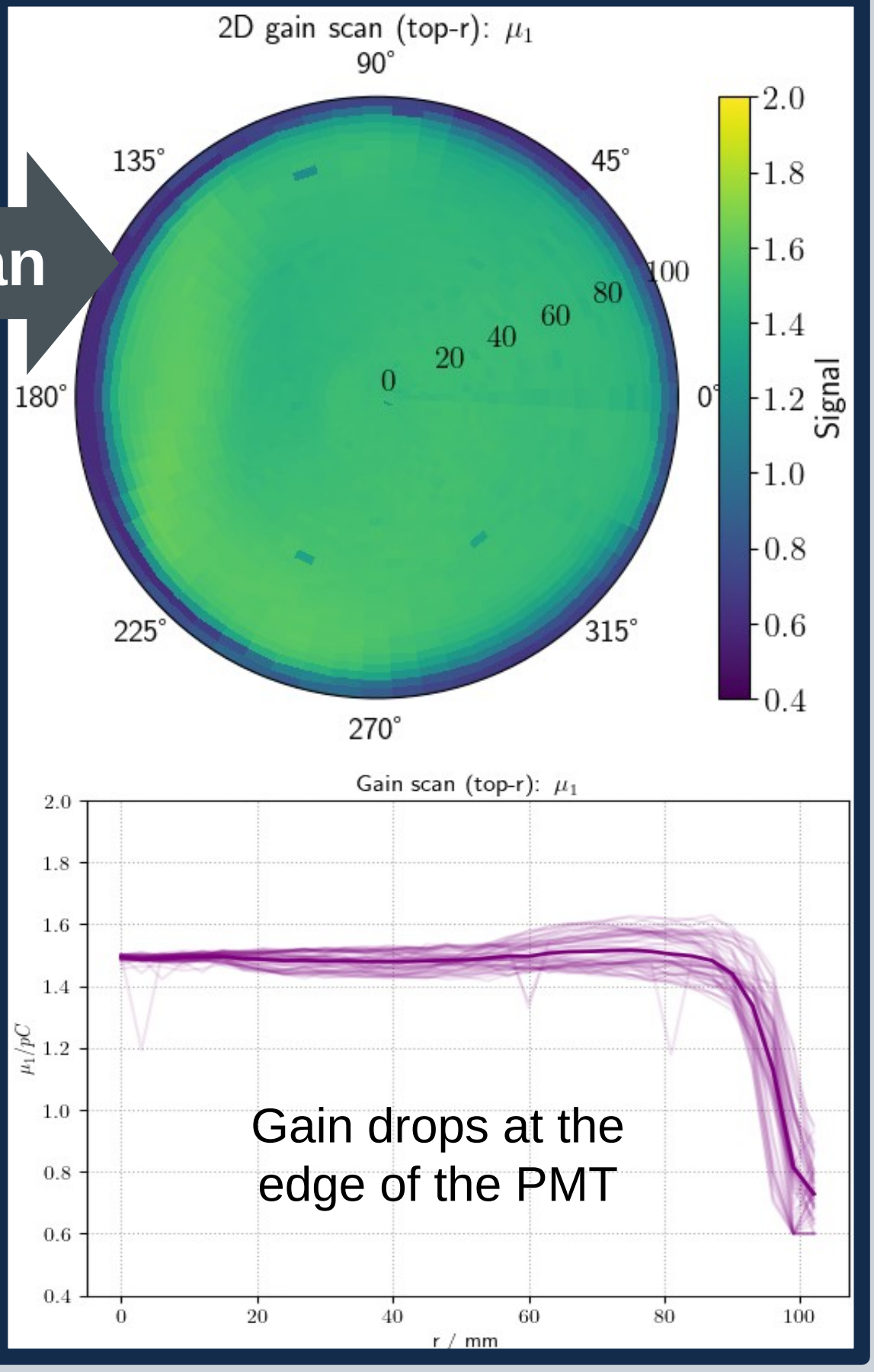


Extract single-photon spectrum

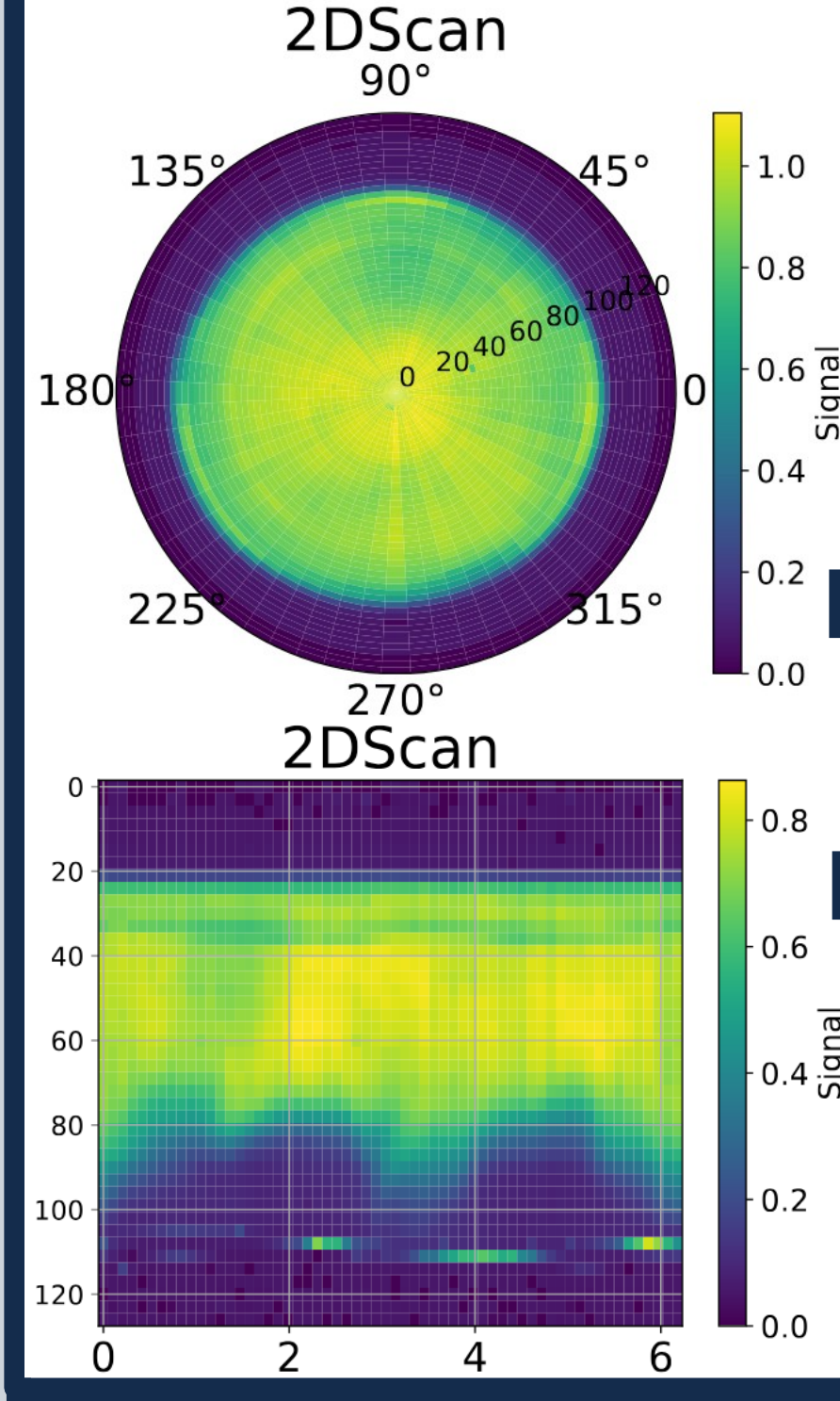


- Tail distribution from inelastic scattering off the first anode
- About 15% of photoelectrons do not pass the threshold for detection

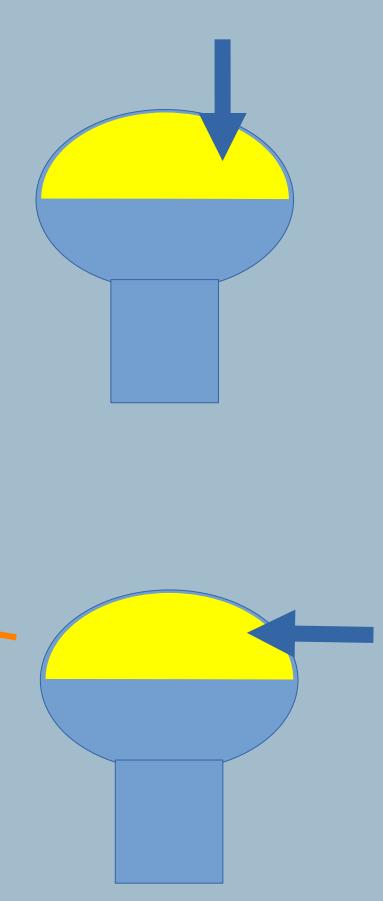
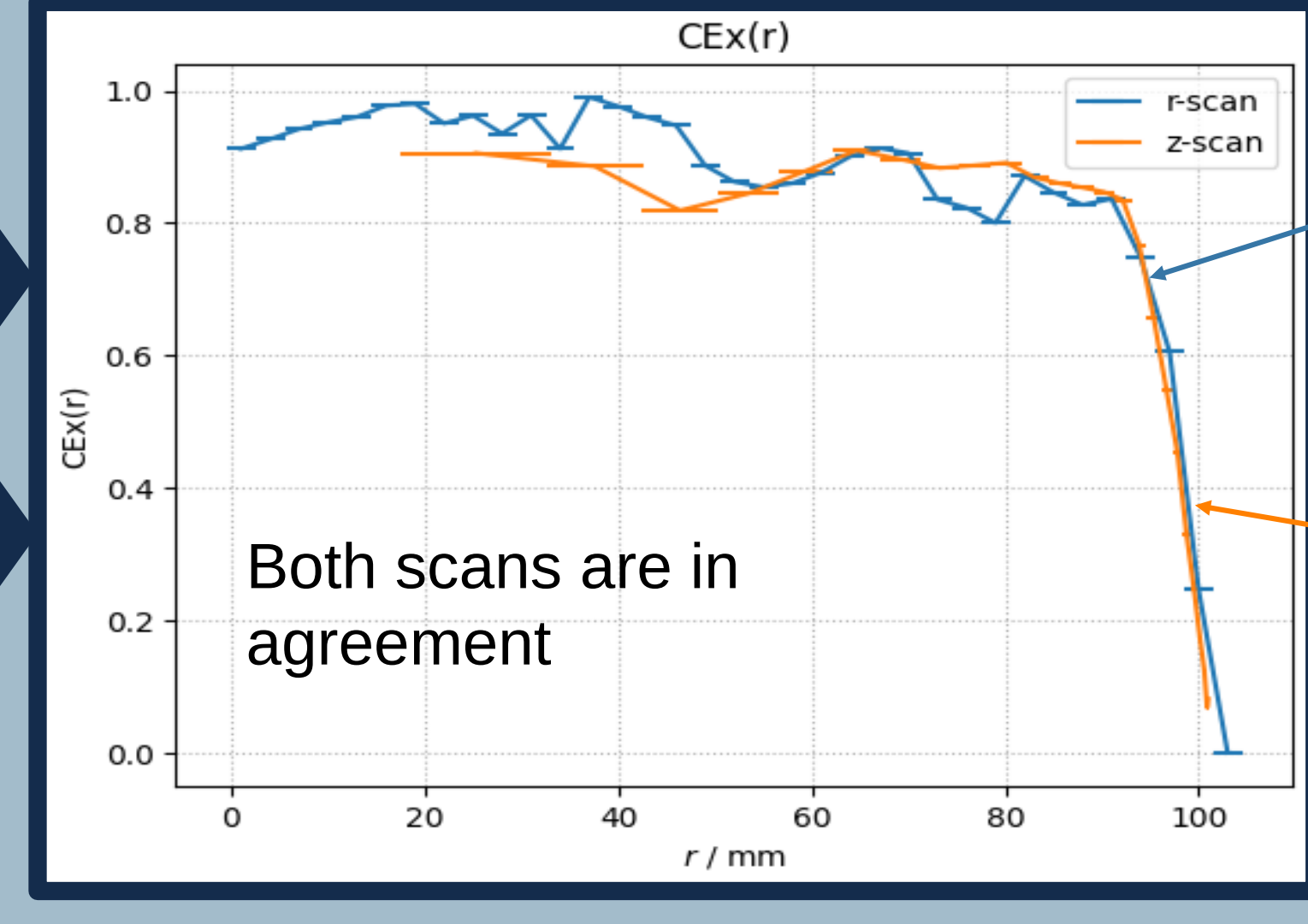
2D Scan



## D-Egg Multi-Photon Response

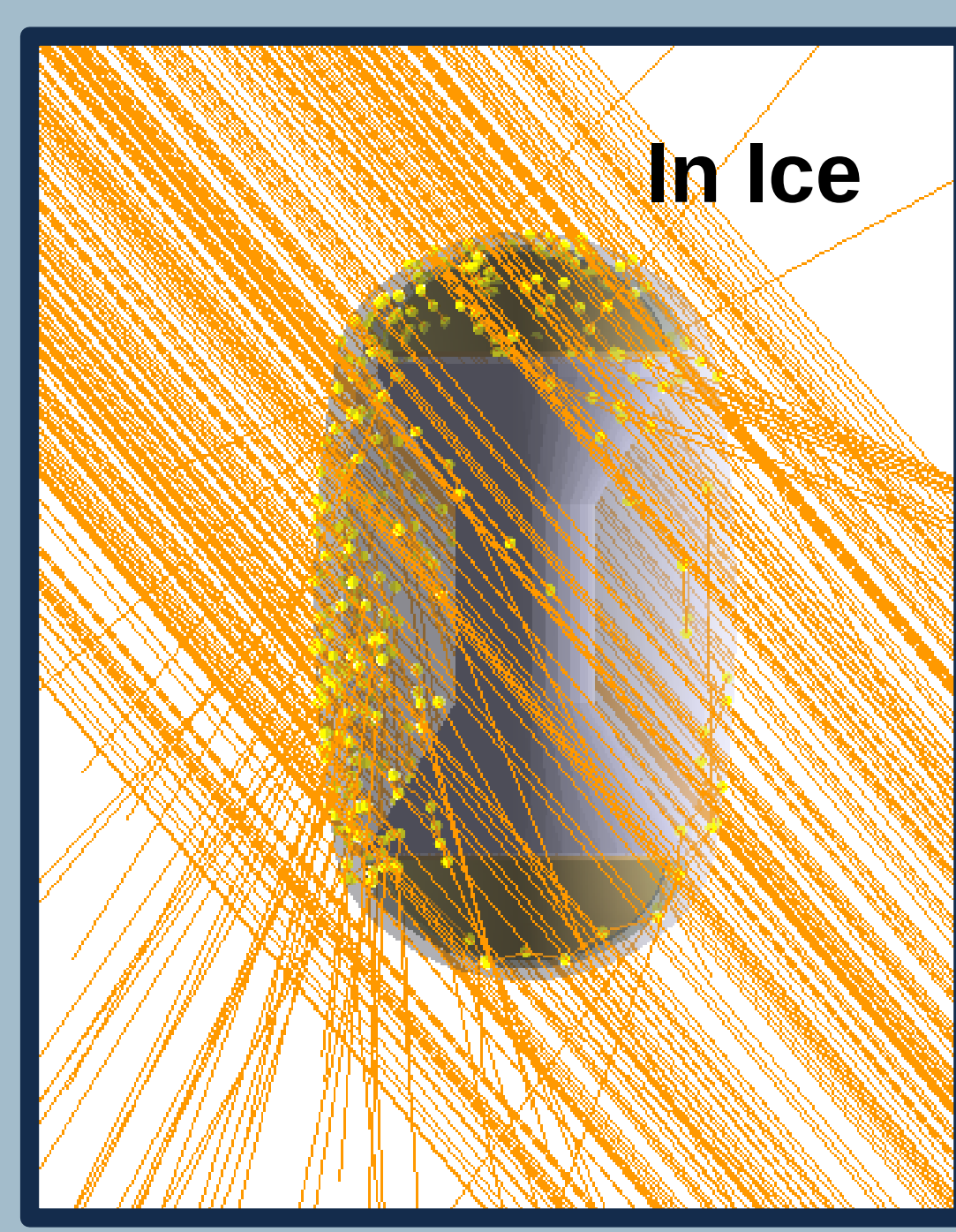


r-scan: Laser shooting down onto PMT  
z-scan: Laser shooting sideways onto PMT



## Geant4 Simulation

Implement single- and multi-photon response into the detector simulation to get the Effective Area of the D-Egg:



D-Egg effective area at 405 nm: 93 cm<sup>2</sup>

