



Simulation of JUNO experiment: challenges, description and comparison with data

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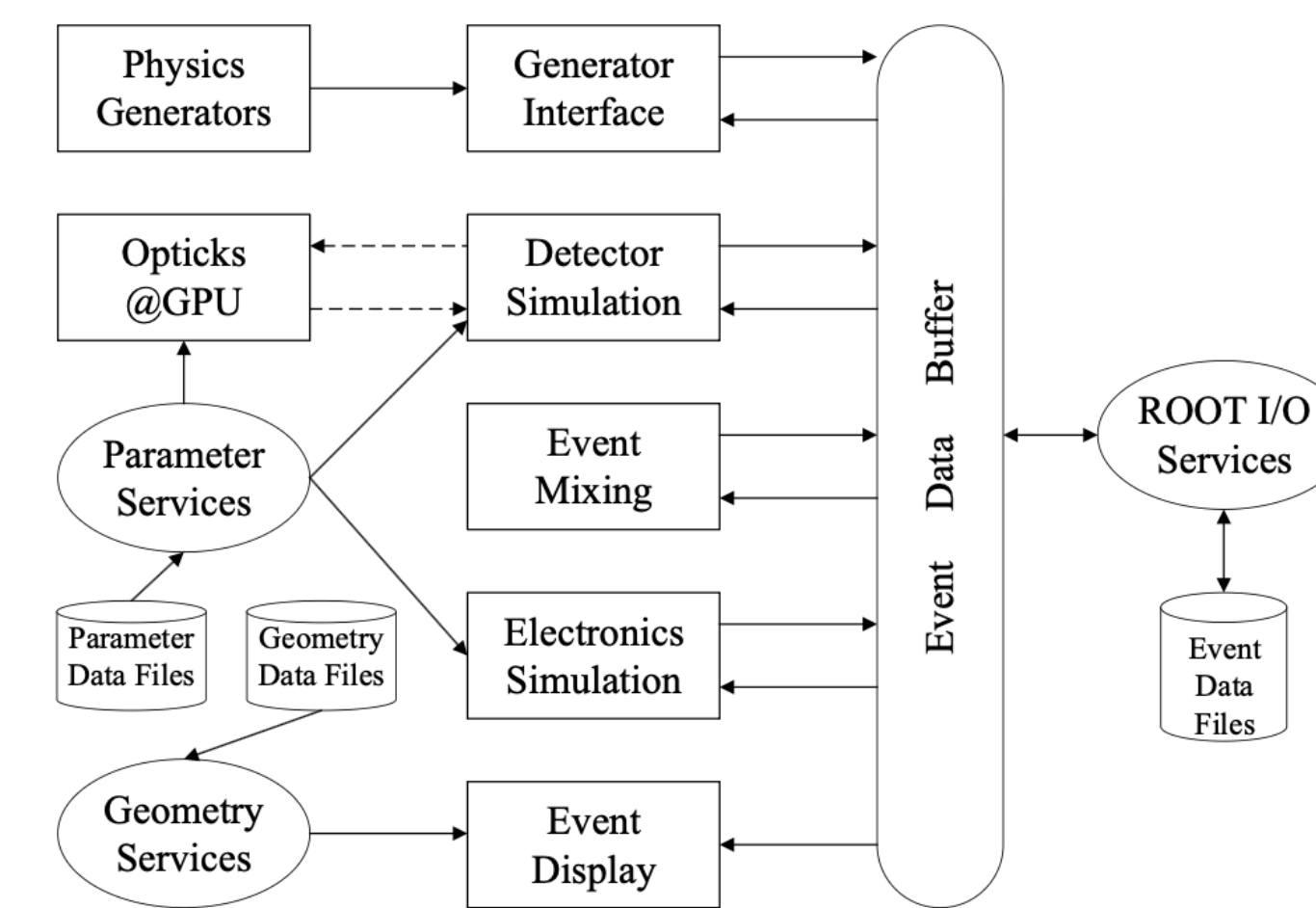


Requirements & Challenges

- Rich physics program: large number of event generators.
- Big size detector: large number of input parameters for detector geometry, LS models, PMTs and electronics.
- Various sources of signal: development of mixing simulation.
- Background from cosmic muons and atmospheric neutrinos: handle of optical photons at large scale.

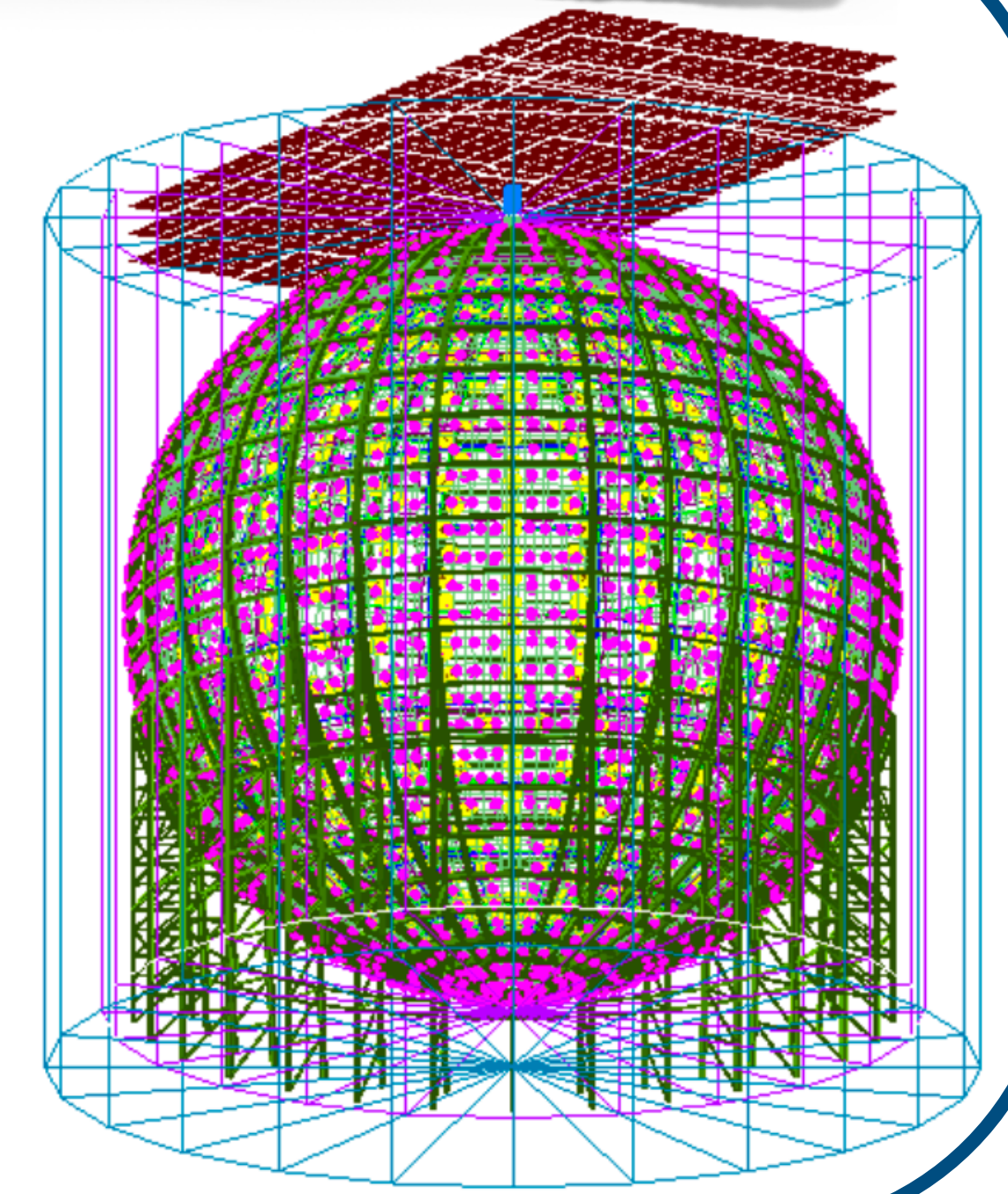
Simulation framework

- JUNO simulation software^[1] on SNI^{PER}^[2]+Geant4.
- Generator → Detsim → ElecSim chain



Detector and electronic simulation

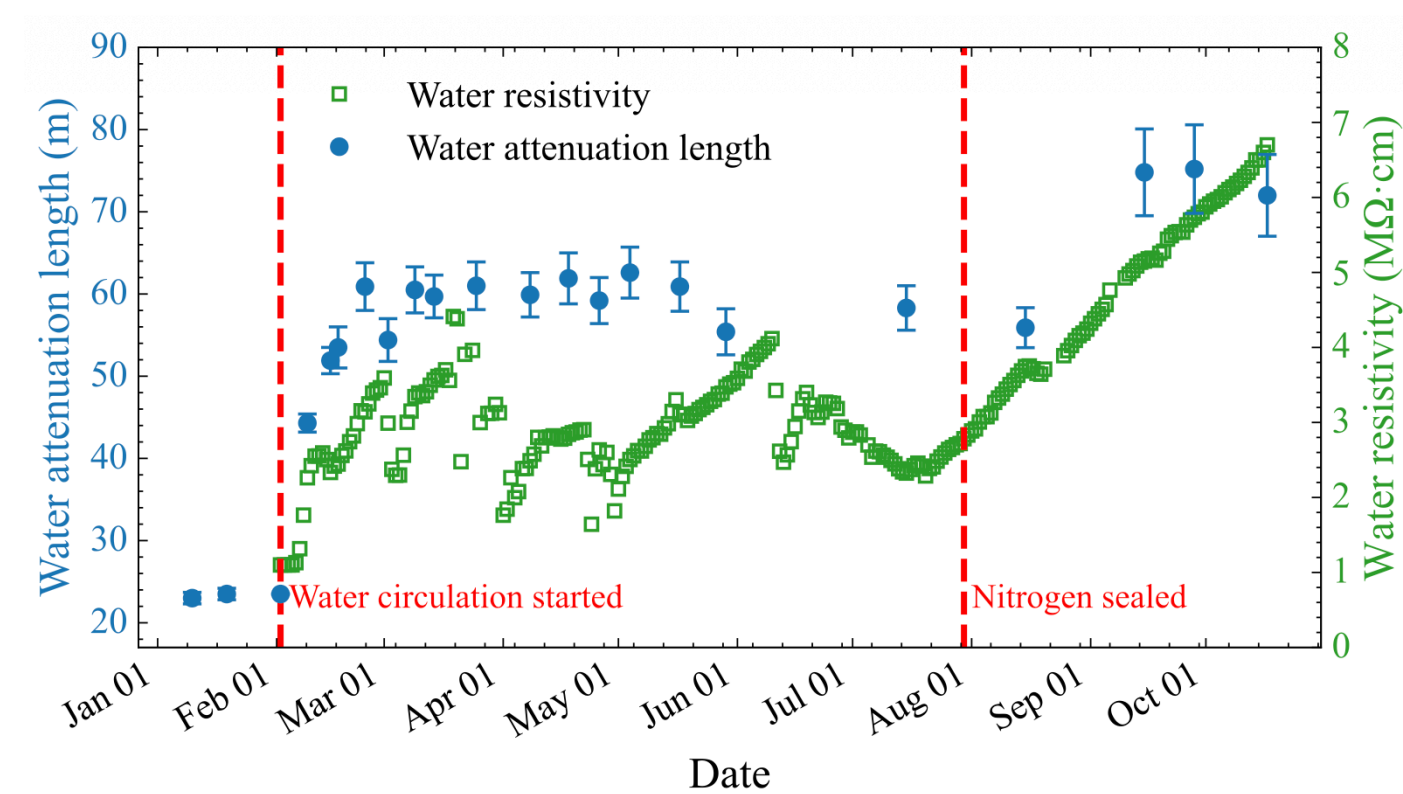
- Updated as-built geometry with detailed PMT models (4 different types for CD and WP).
- First principles: LS quenching, absorption/re-emission optical transport, PMT optical model & response^[3].
- Modeling of PMT, electronics and trigger responses.



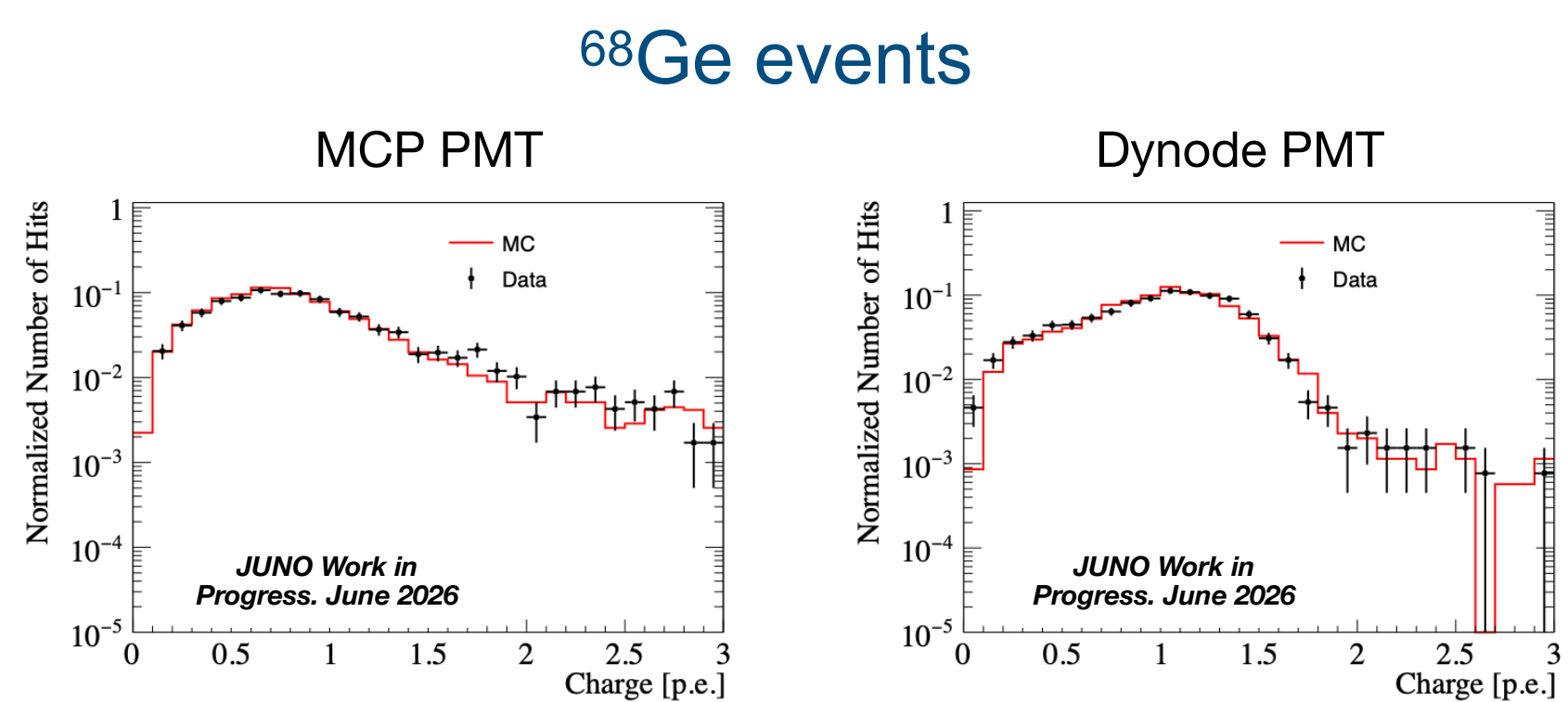
MC Tuning

- Systematic iterative tuning of simulation parameters.
- Tuned categories: geometry, LS optics, PMT response, water properties, electronics response^[4].

Update of material parameters: water and LS attenuation length

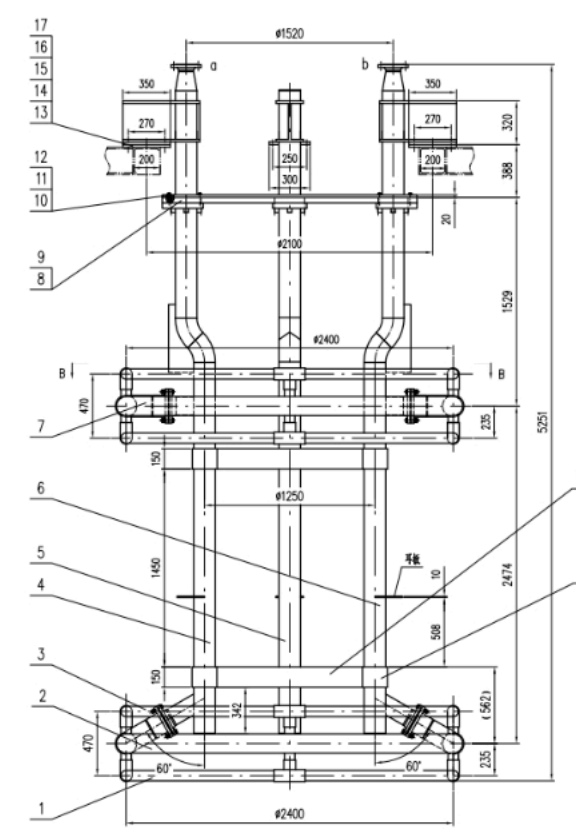


Modeling of PMTs charge

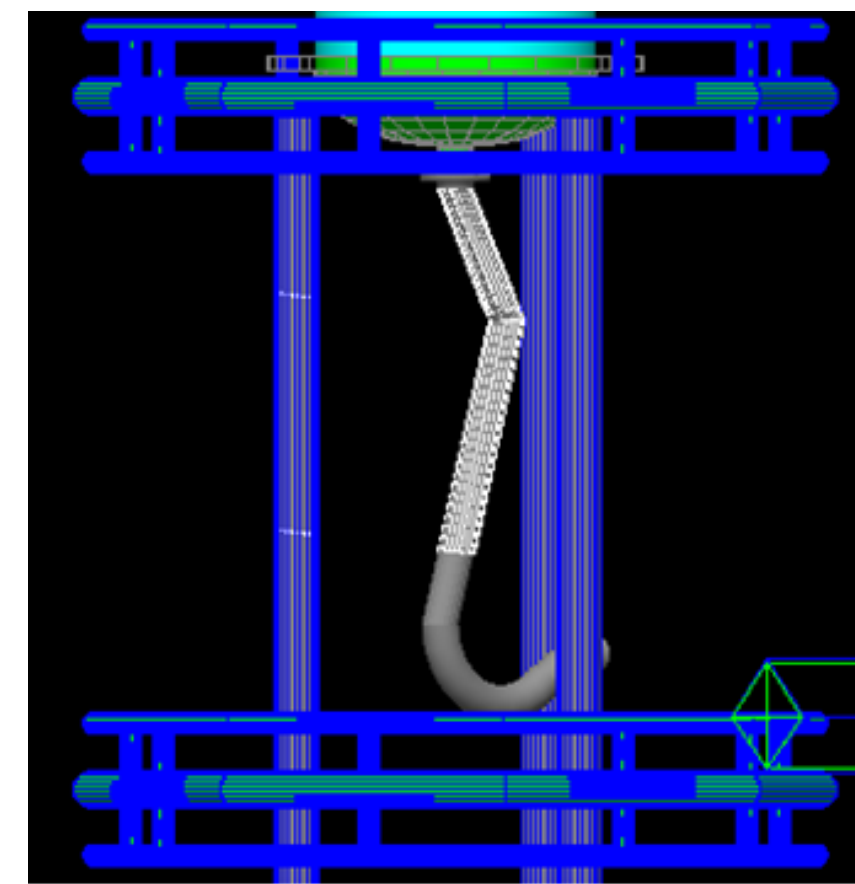


Implementation of complex geometry

Top chimney

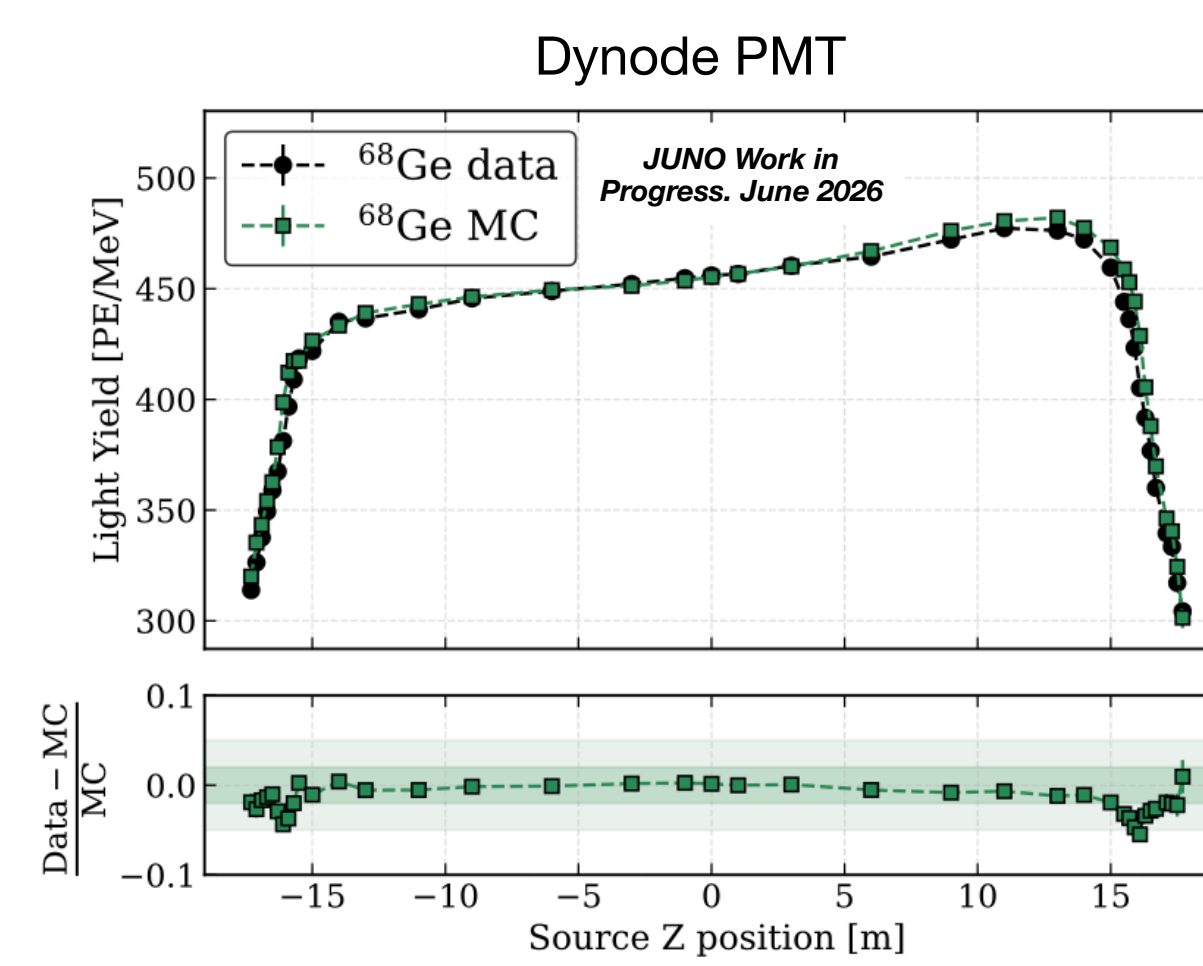
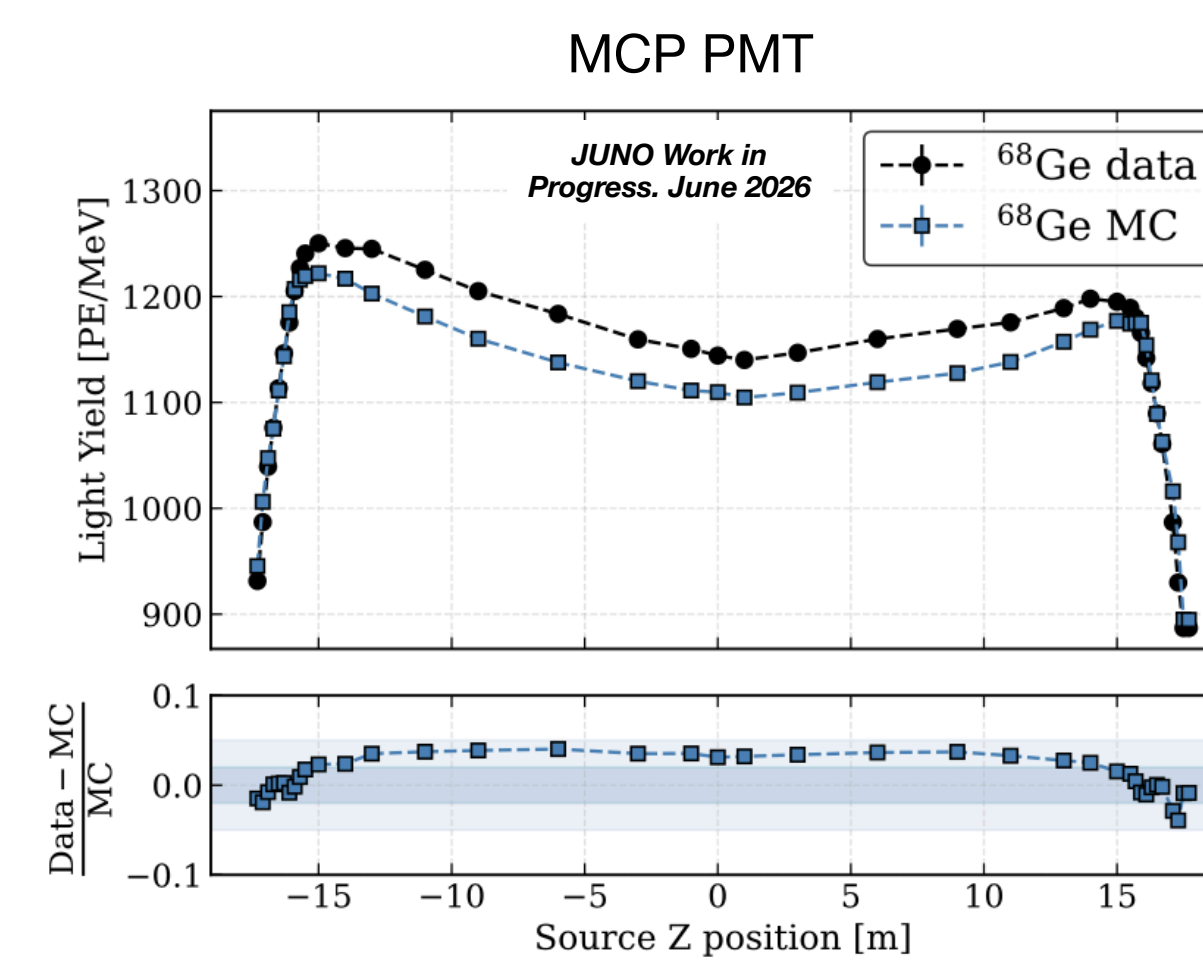


Bottom chimney and Water distribution

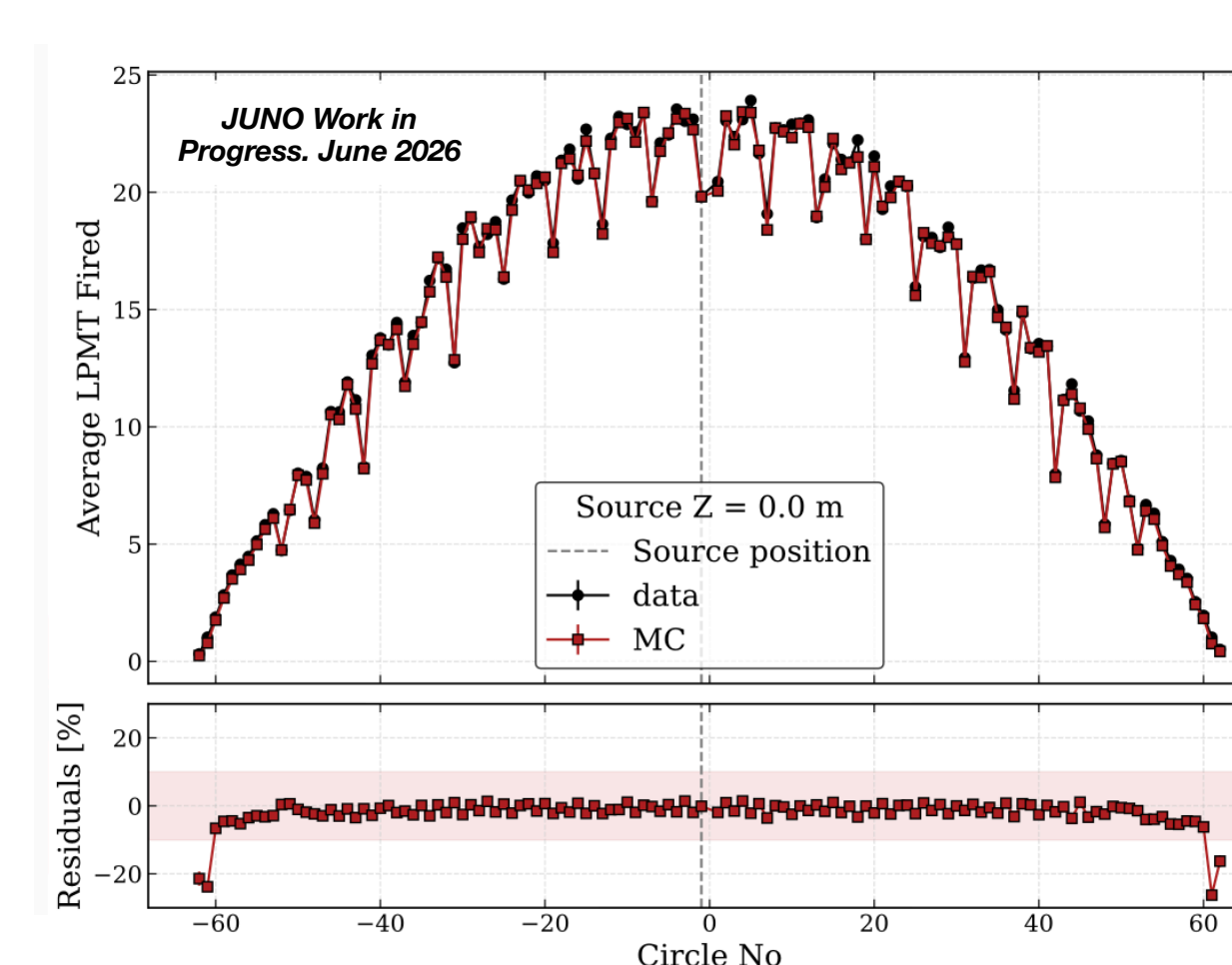
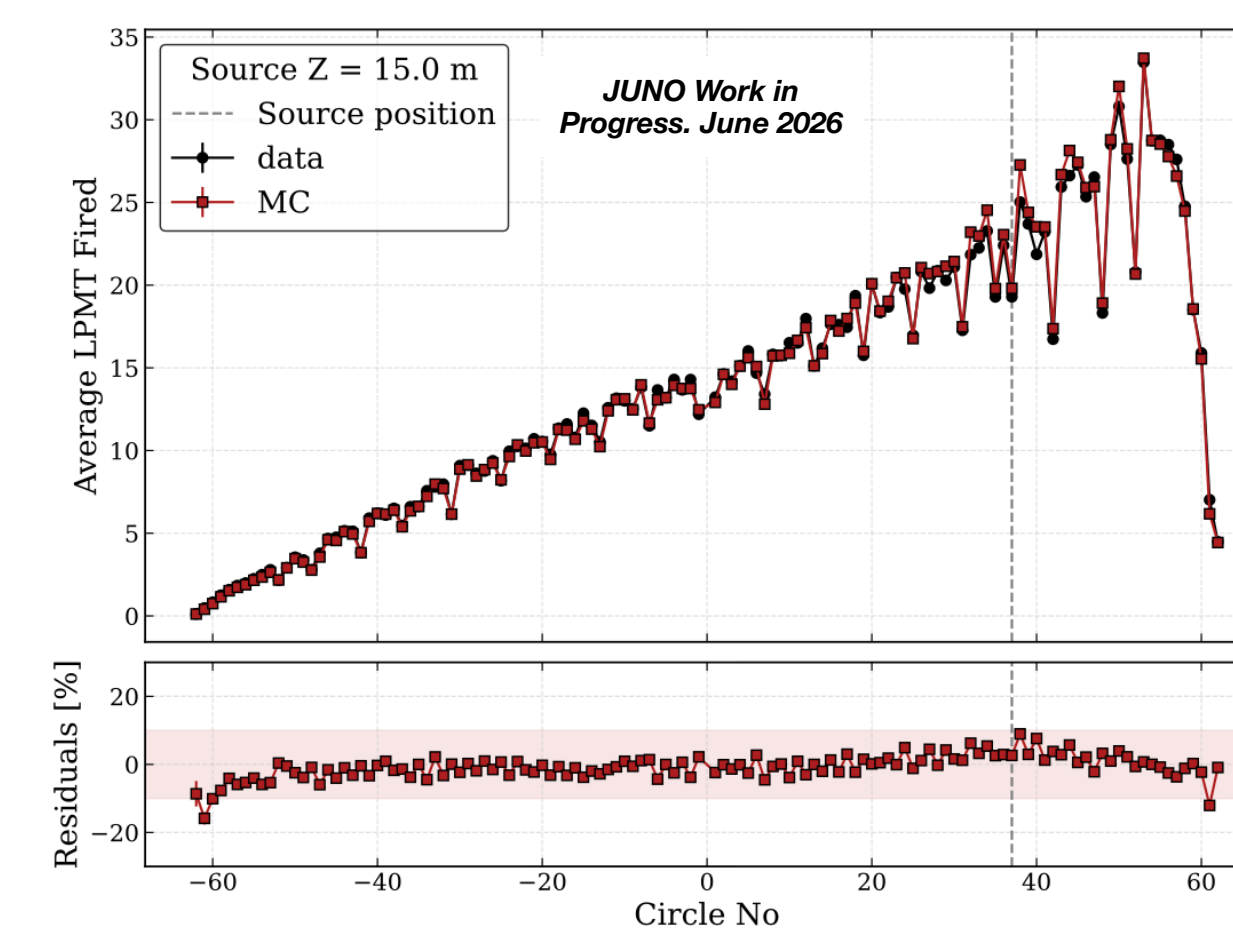


MC Performances

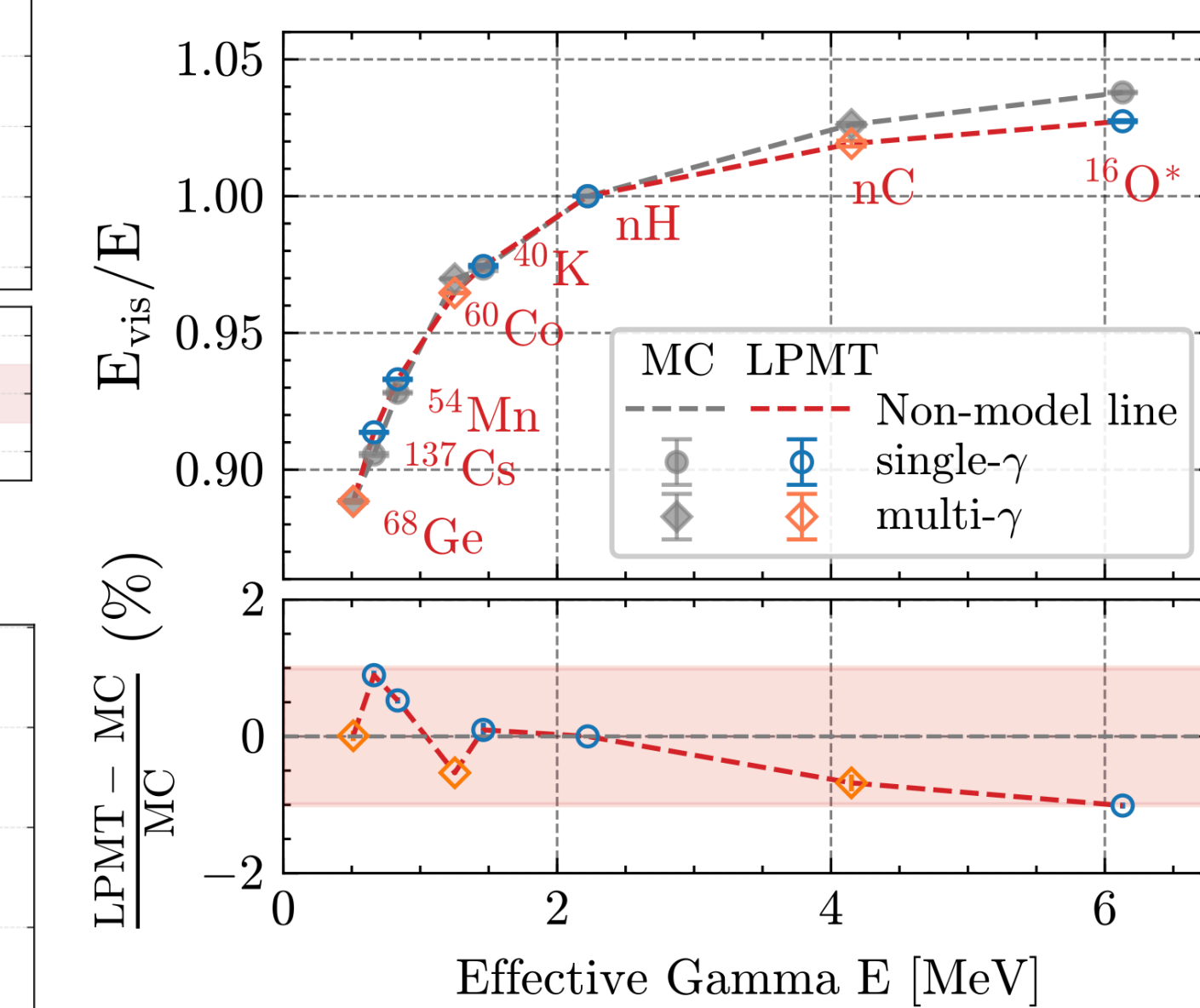
Light yield at different source positions



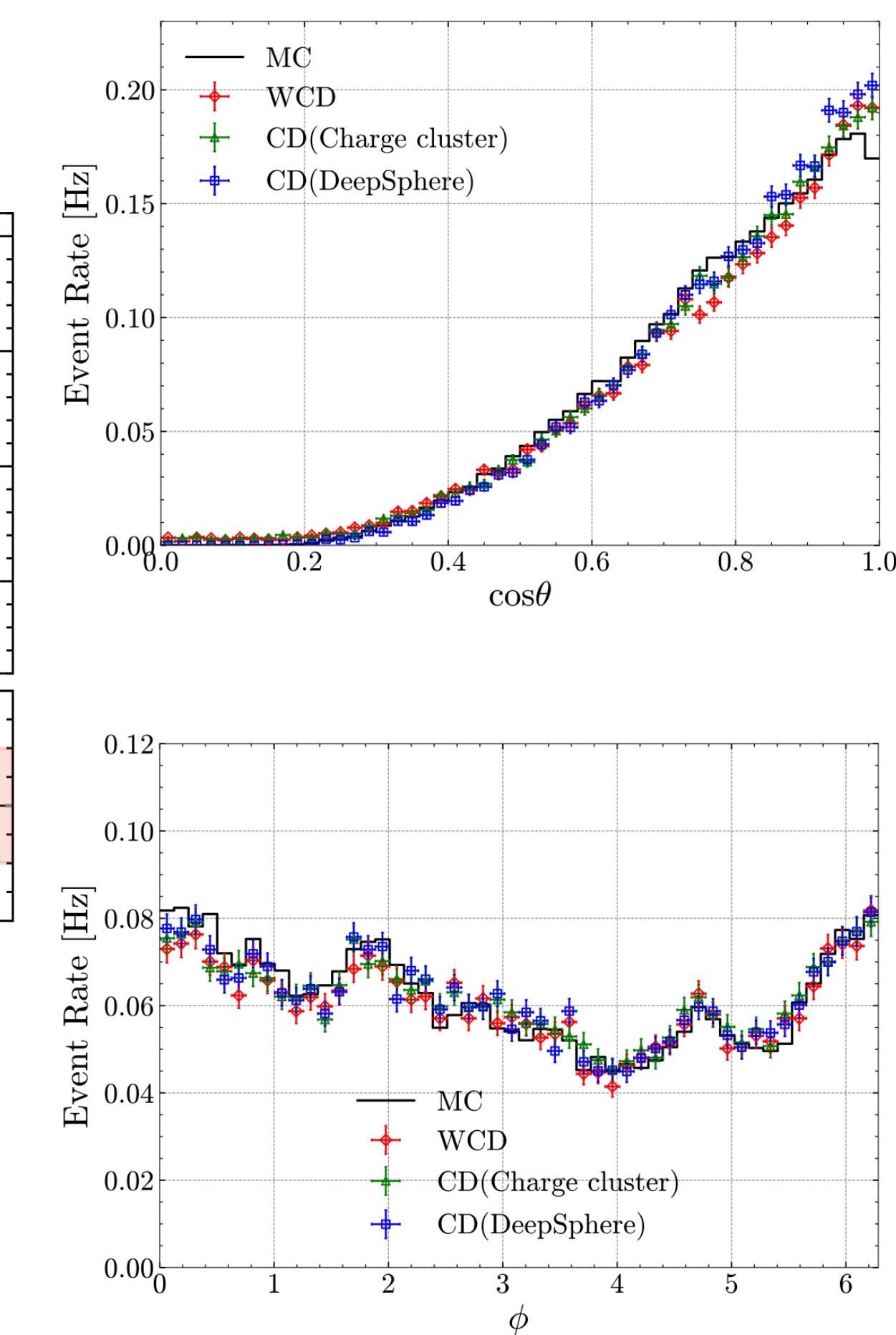
Comparison for each layer of PMTs and for different source position



LS non linearity



Muon angular distribution



- Light yield and PMT response agreement better than 5%.
- LS non linearity consistency is better than $\pm 1\%$.

[1] T. Lin et al., Simulation software of the JUNO experiment, *Eur. Phys. J. C* 83, 382 (2023).

[2] J.H. Zou et al., SNI^{PER}: an offline software framework for non-collider physics experiments, *J. Phys.:Conf. Ser* 664, 072053 (2015).

[3] Y.Wang et al., A new optical model for photomultiplier tubes, *Eur.Phys.J.C* 82, 329 (2022).

[4] A. Abusleme et al. [JUNO collaboration], Initial performance results of the JUNO detector, *Chinese Physics C* 50 (4), 043001 (2026).