Dual Calorimetry at JUNO

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On behalf of the JUNO collaboration

XIX International Workshop on Neutrino Telescopes

*left APC/IJCLab, moving to SYSU

2 sets of PMTs & electronics

JUNO Liquid Scintillator (LS)

Large PMT system (LPMT):

20" PMT + Charge integration based electronics

Main calorimetry

for 3% energy resolution@1MeV

Small PMT system (SPMT):

3" PMT + Photoelectron counting based electronics

Second calorimetry

to form Dual Calorimetry for

helping detector systematics control

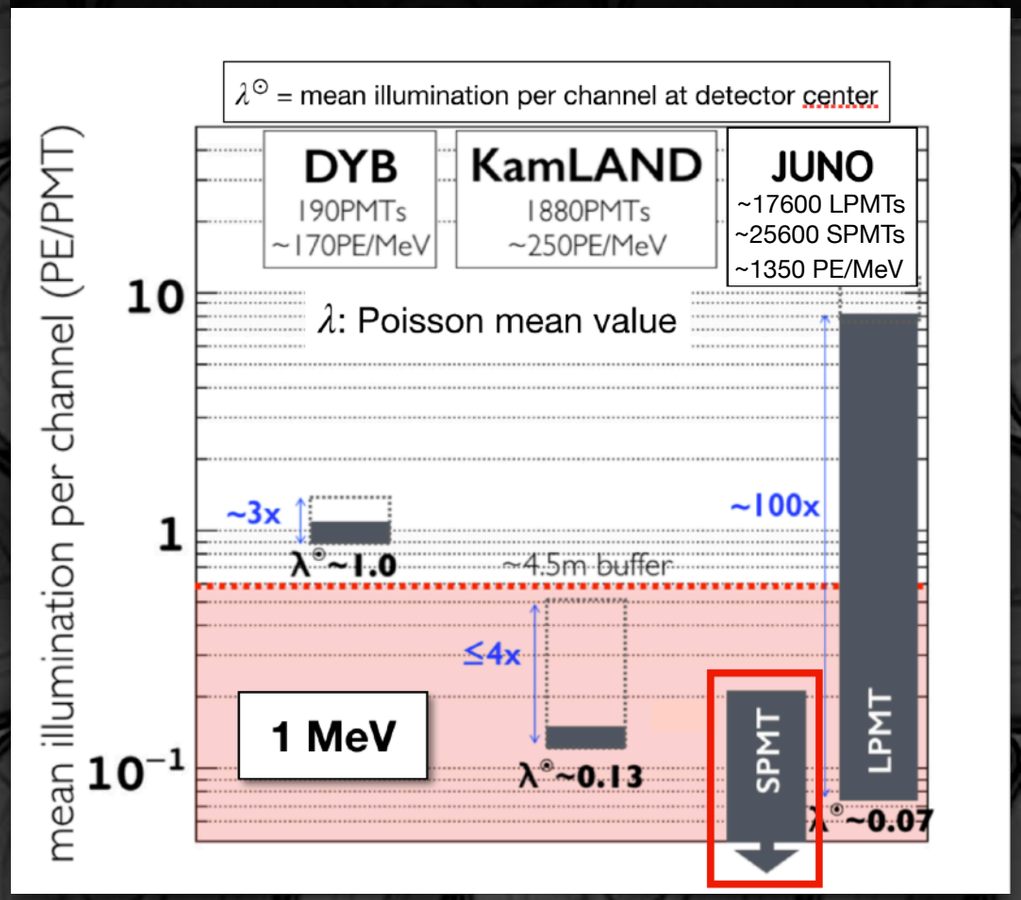
JUNO: sub-percent energy detection systematics control

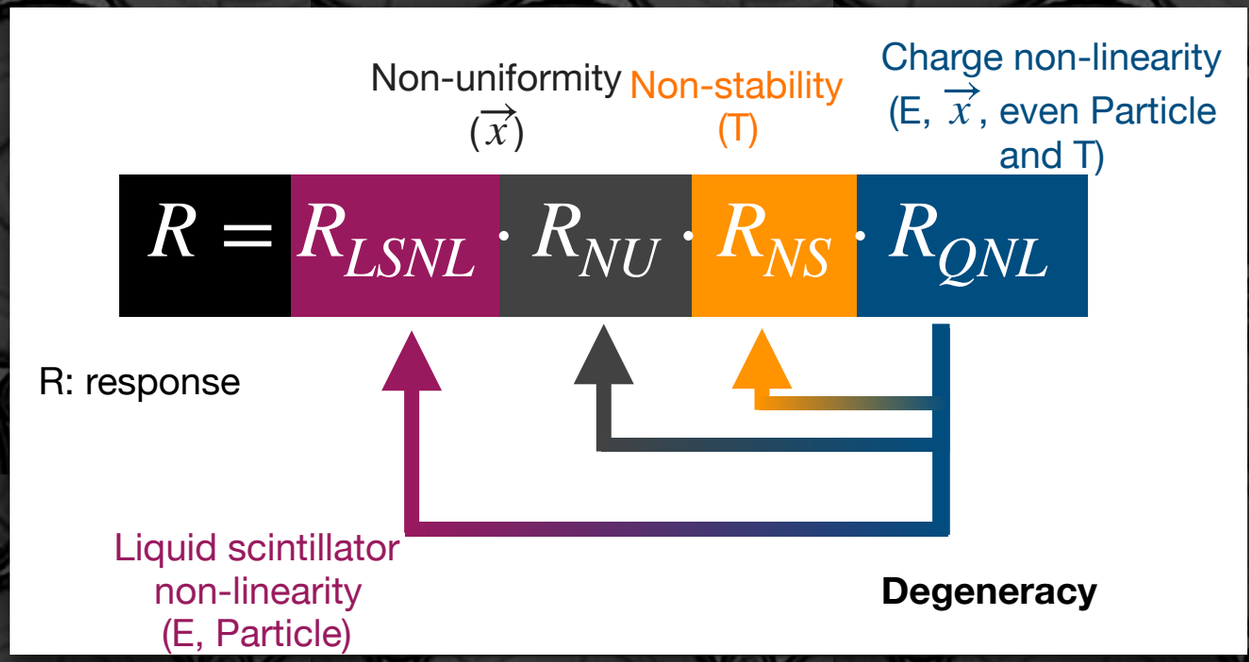
Why Dual Calorimetry (SPMT)?

LPMT Calorimetry

Largest charge dynamic range

Detector response degeneracy
(through readout charge response)





*QNL is also called electronics/instrumental non-linearity

Single photoelectron (PE) dominant

Digital PE counting

~"Zero" Charge Non-Linearity (QNL)

~"Zero" degeneracy

SPMT Calorimetry

Principle

Calorimetry response comparison between LPMT and SPMT

Correlated (fully or partially) | Uncorrelated

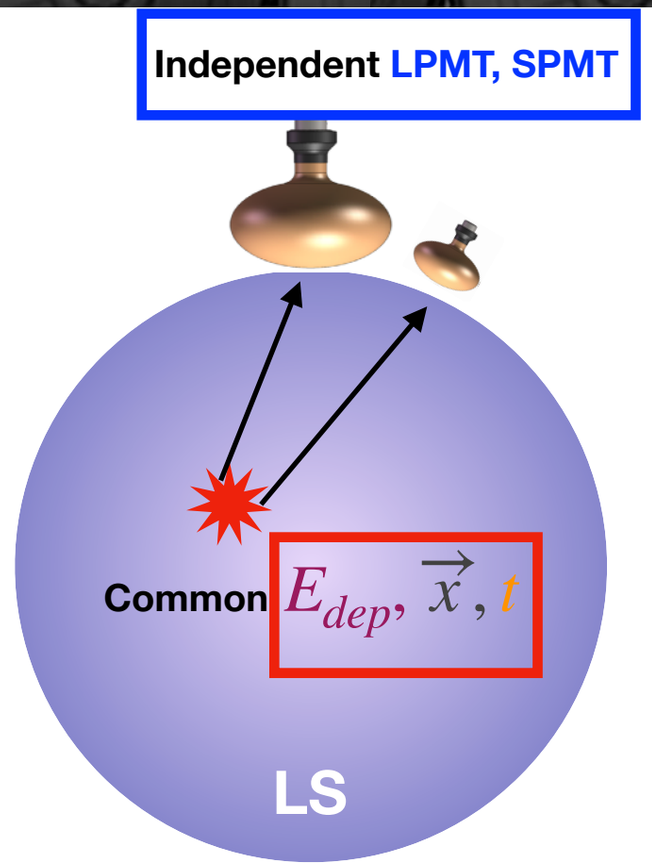
$$R^L = R_{LSNL} \cdot R^L_{NU} \cdot R^L_{NS} \cdot R^L_{QNL}$$

Cancellation | Isolation

$$R^S = R_{LSNL} \cdot R^S_{NU} \cdot R^S_{NS} \cdot R^S_{QNL}$$

Always same energy deposition | Upon detector running

Common event vertex, Independent PMT geometry

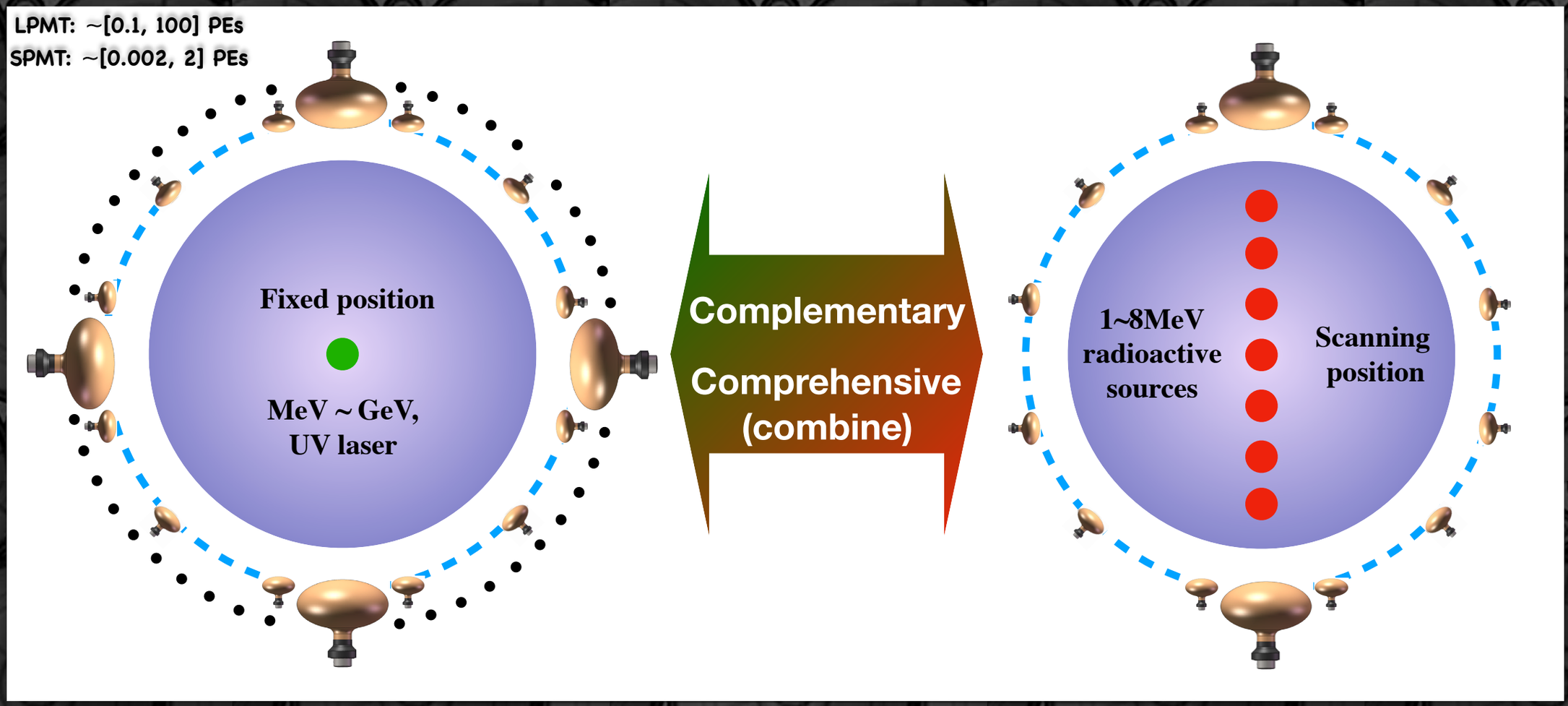


Direct charge response comparison:

$$R^L_{QNL} : R^S_{QNL}$$

Linear charge reference

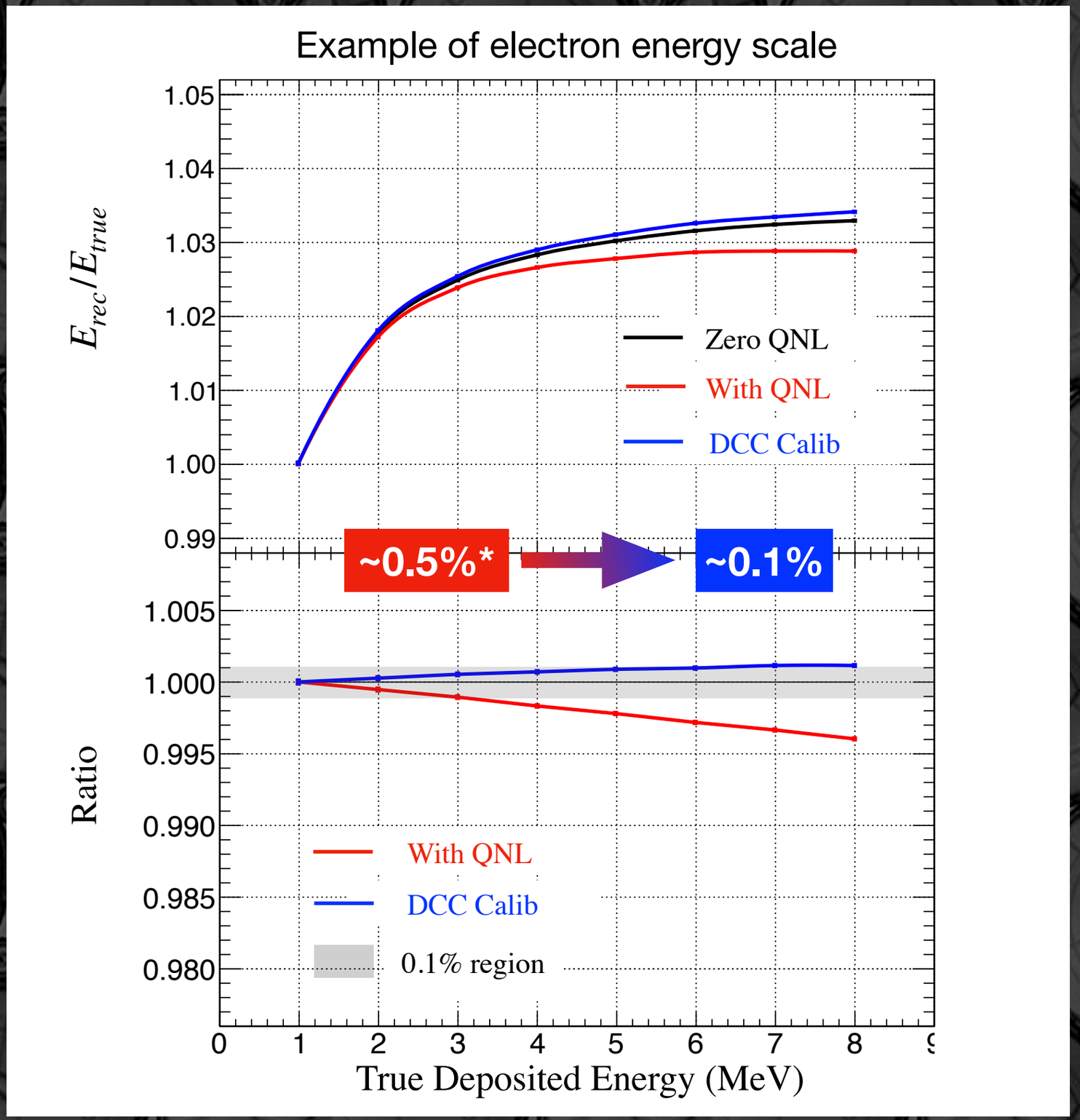
Novel calibration method: Dual Calorimetry calibration (DCC)



Direct calibration of potential QNL of LPMT at every single channel level for JUNO reactor neutrino physics

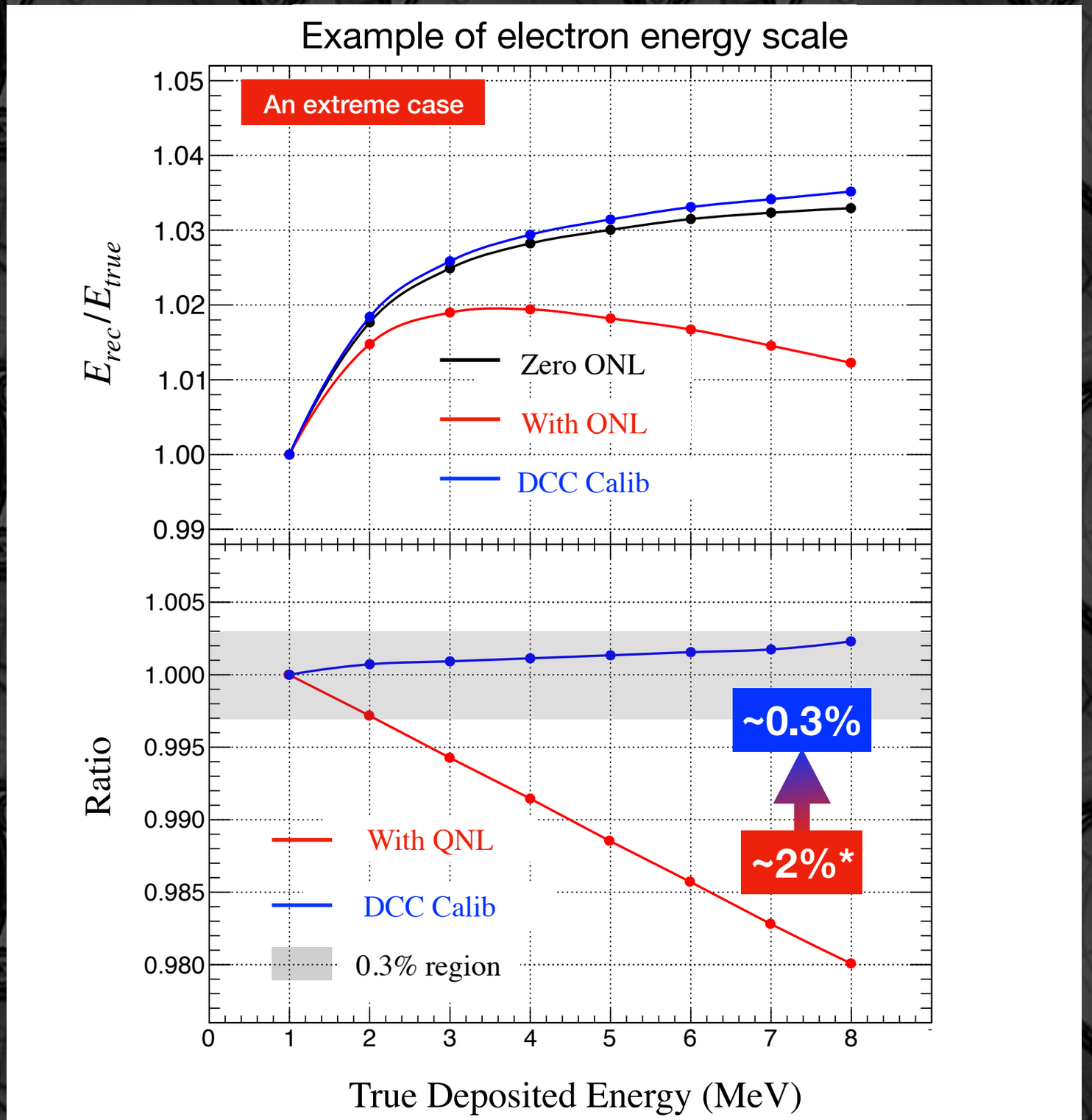
Included in the "Calibration Strategy of the JUNO experiment" paper
arXiv:2011.06405

Potential performance — energy scale control



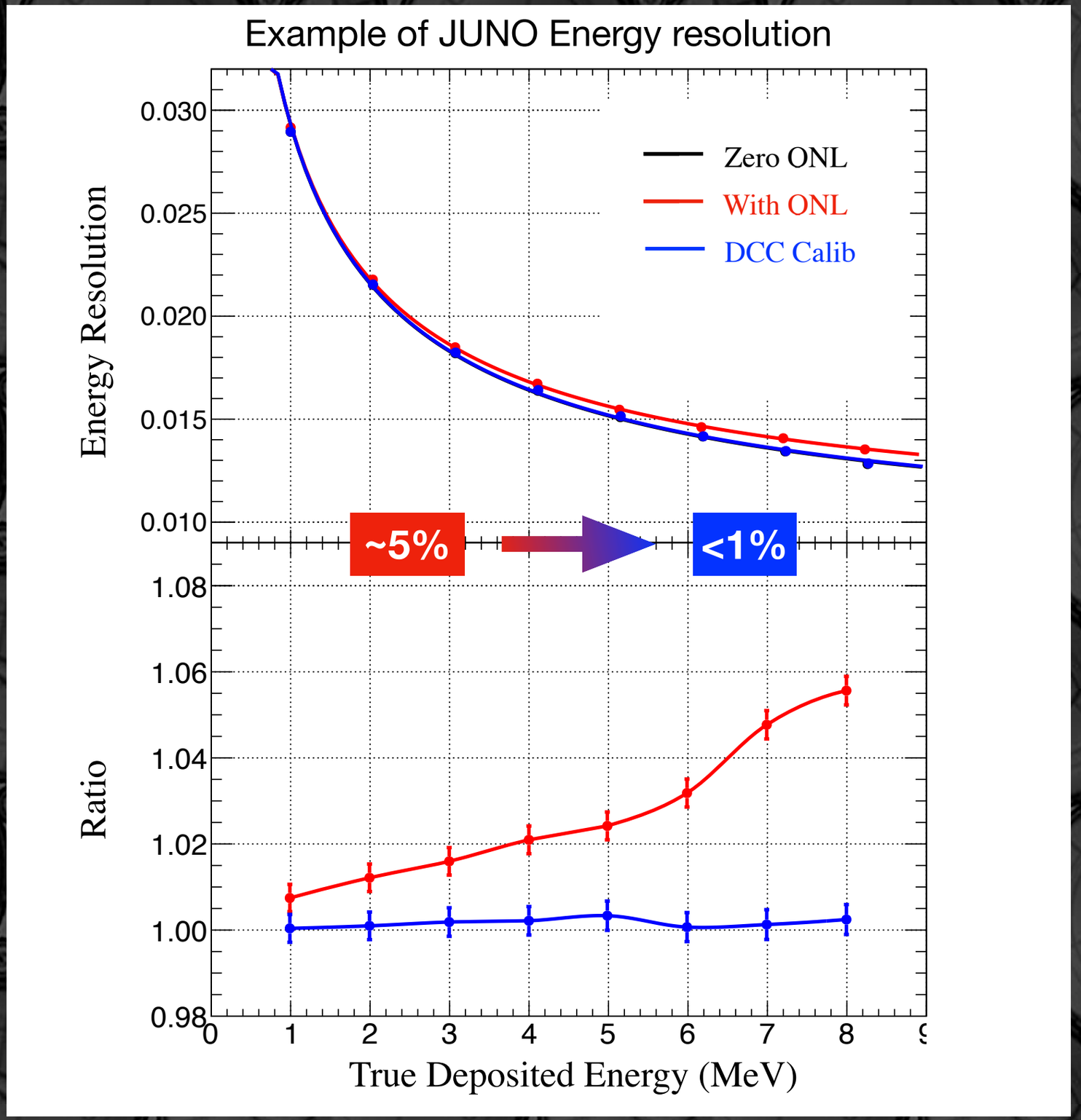
*assumed QNL effect in energy scale

Potential performance — energy scale control (extreme case)



*assumed QNL effect in energy scale

Potential performance — energy resolution control



*assumed QNL effect in energy resolution

Dual Calorimetry:

Novel calibration method

Improving the control of JUNO energy detection systematics

(sub-percent level)

through LPMT QNL calibration

Further Dual Calorimetry implementation to be developed