

# Improving neutrino detection with double calorimetry in LArTPCs - Approval for LIDINE 2024 Conference

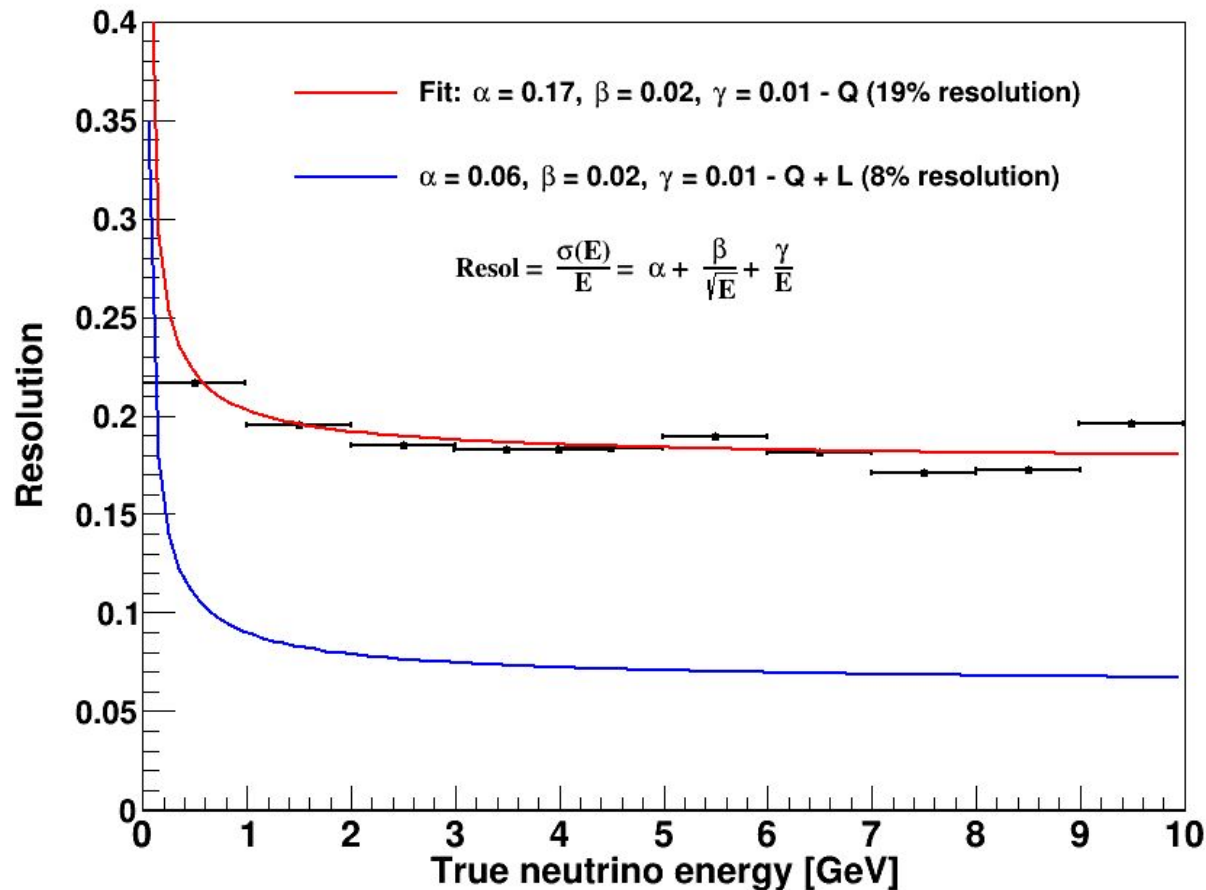
**Luis Gustavo, Ettore Segreto and Laura Paulucci**  
UNICAMP and UFABC

# Energy Resolution Function

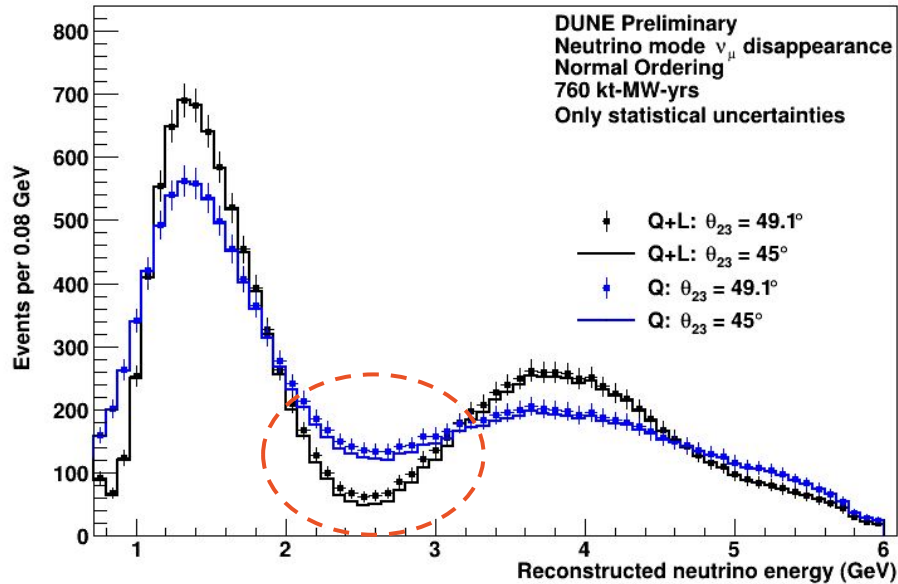
- **Charge energy resolution:** Numu CC events - 19% resolution
  - Neutrino energy reconstruction in the Vertical Drift (Wenjie Wu) - CM 13 Sep, 2022 - > <https://indico.fnal.gov/event/53964/contributions/250282/>
- **Charge + Light energy resolution:** Numu CC events - 8% resolution
  - Charge and Light analysis in DUNE Far Detector HD (Marta Torti and Giulia Brunetti) - CM 25 May, 2023 - > <https://indico.fnal.gov/event/57487/contributions/267200/>
    - Preliminary results on simulated beam events CC Numu contained on Total Deposited Energy.

# Energy Resolution Function

- Fit the MC charge resolution with a proper function;
- Modify one of the parameters to reproduce the expected Q + L resolution.

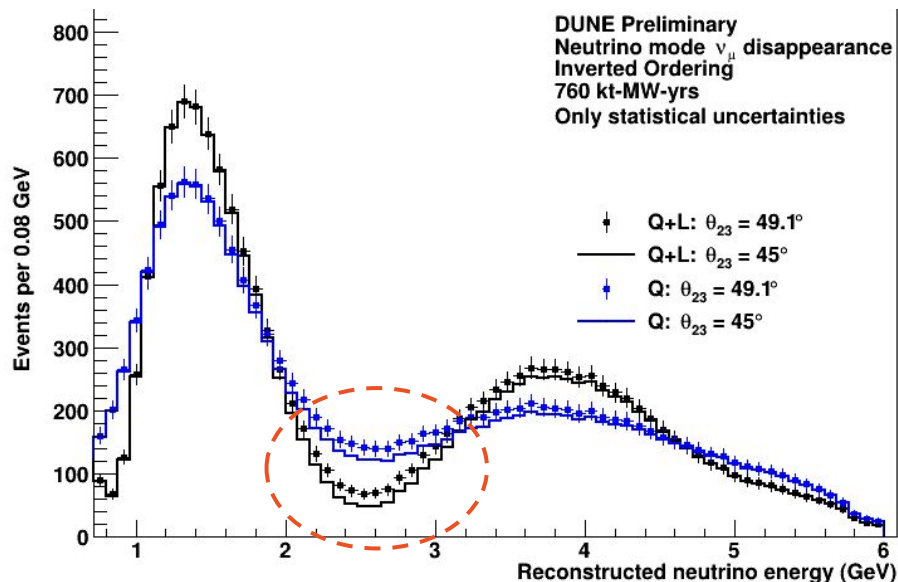


# Plots for approval

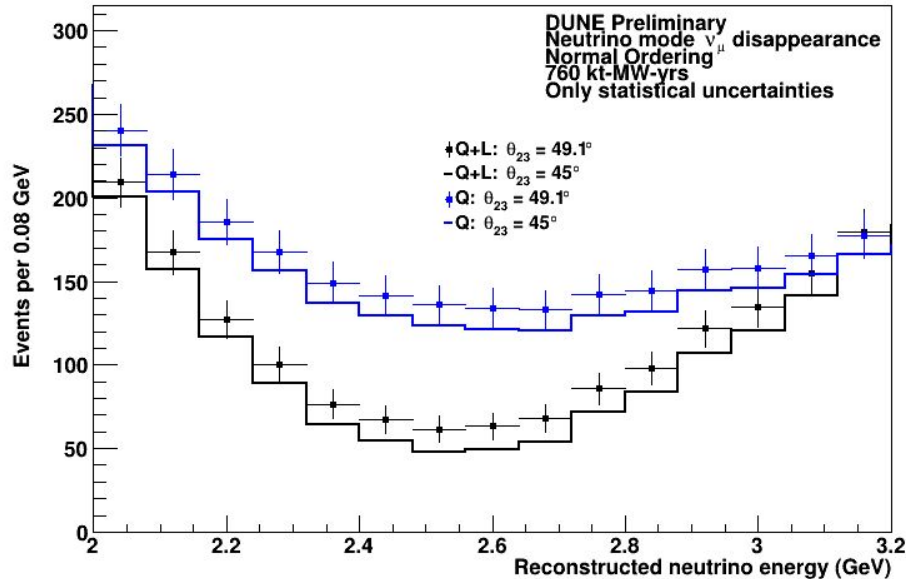


- **GLOBES software:** Ancillary files from: <https://arxiv.org/src/2103.04797v2/anc>
- **Improved identification of events (both mass orderings)** - could improve the determination of the octant of the oscillation parameter  $\theta_{23}$ .

Numu CC events	Energy Resolution	
	Q resolution	Q+L resolution
	19%	8%

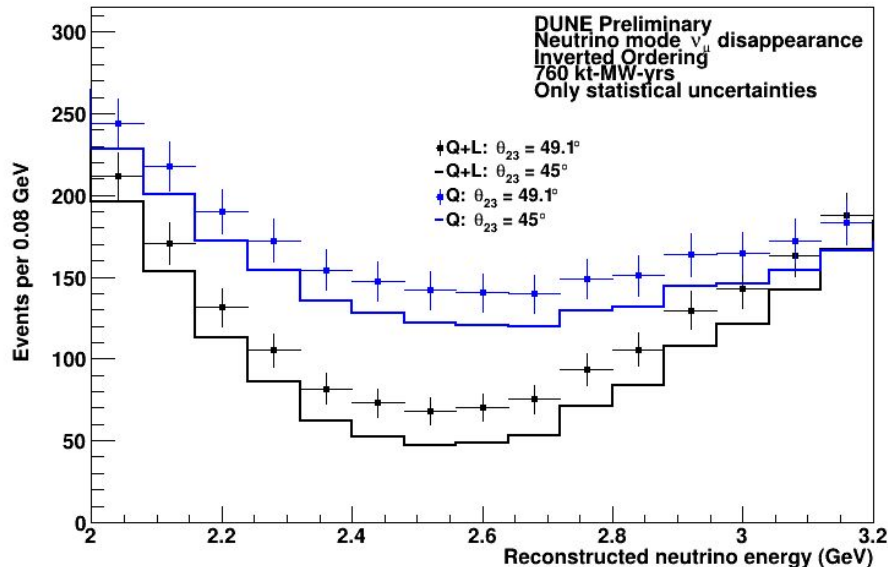


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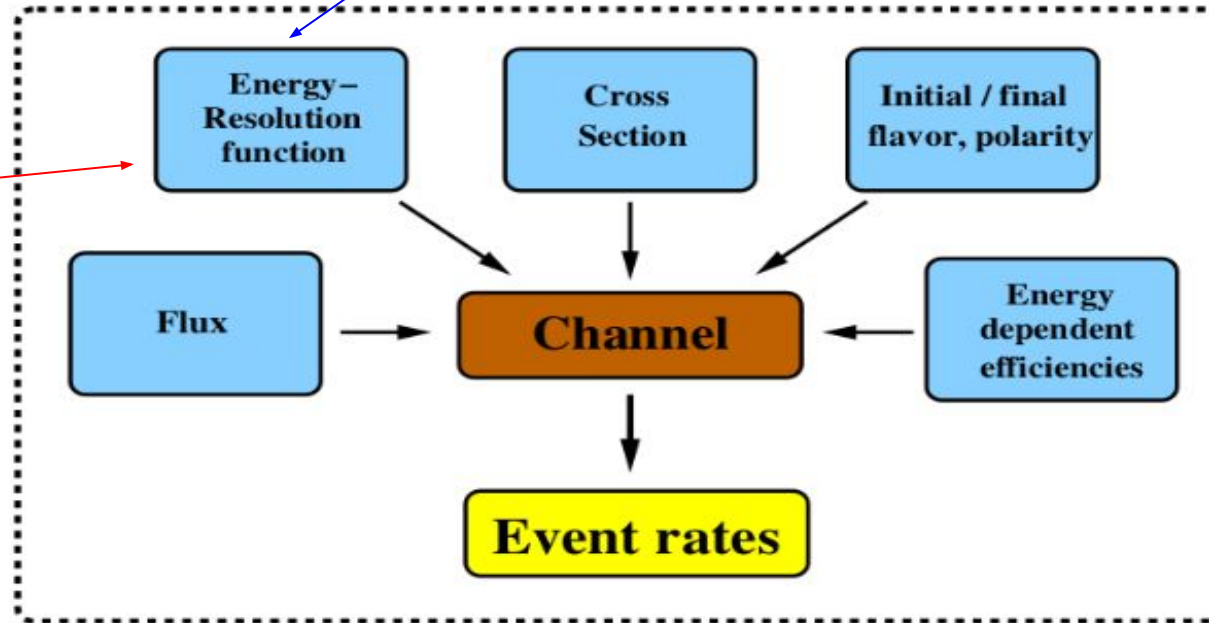
Numu CC events	Energy Resolution	
	Q resolution	Q+L resolution
	19%	8%



# Back up

# Event rates

Updated data: Charge and Light signal - Gaussian function



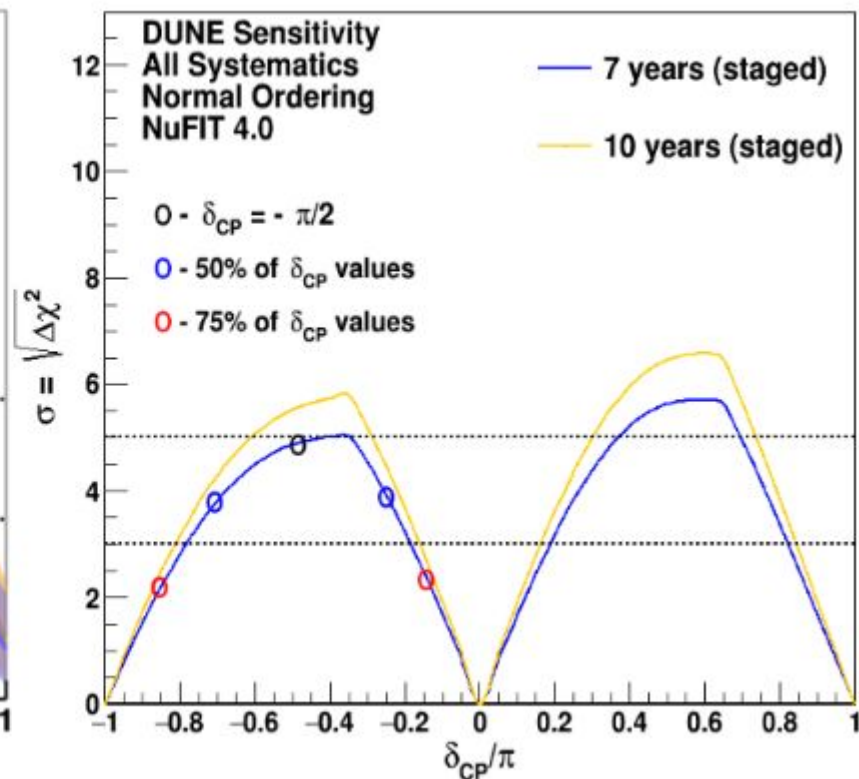
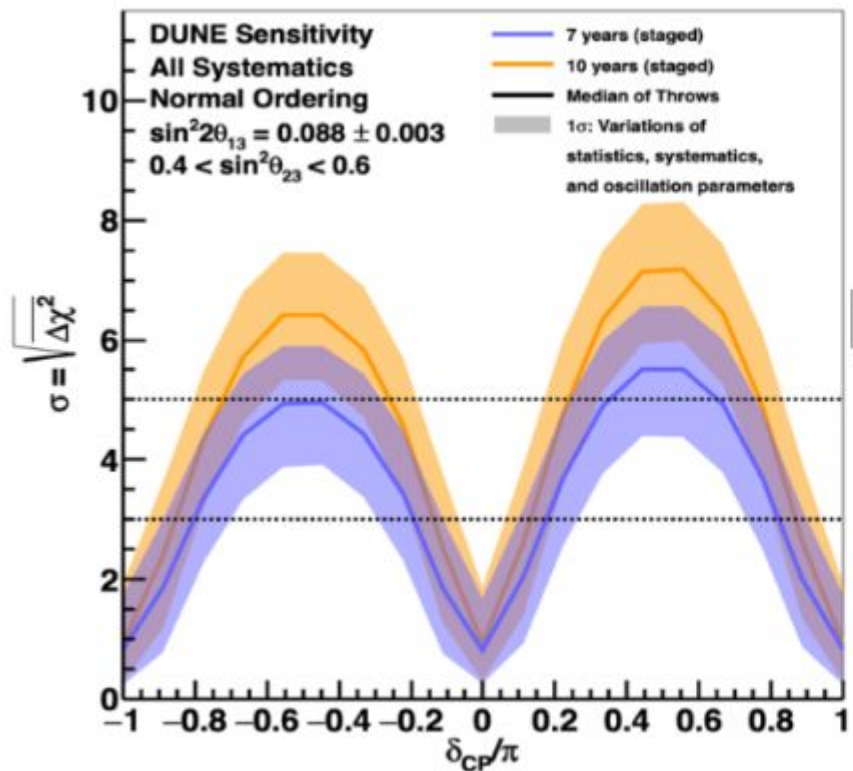
TDR only Charge signal - smearing matrices

$$n_i^c = N/L^2 \int_{E_i - \Delta E_i/2}^{E_i + \Delta E_i/2} dE' \int_0^\infty \phi^c(E) P^c(E) \sigma^c(E) R^c(E, E') \epsilon^c(E').$$

Channel's values in GLOBES

# Back up

- Sensitivity CPV

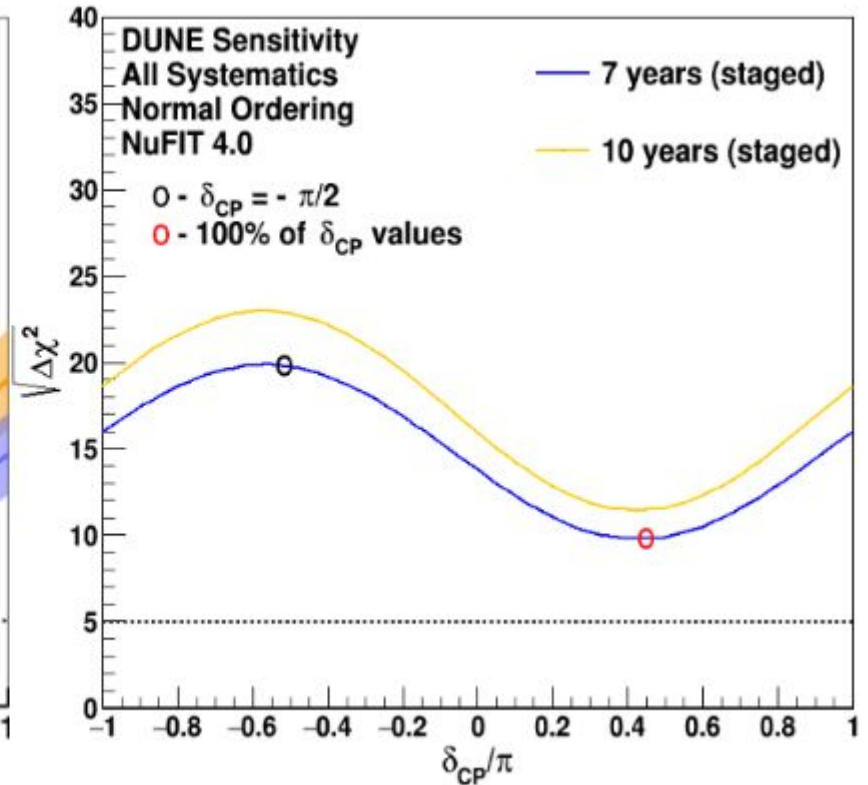
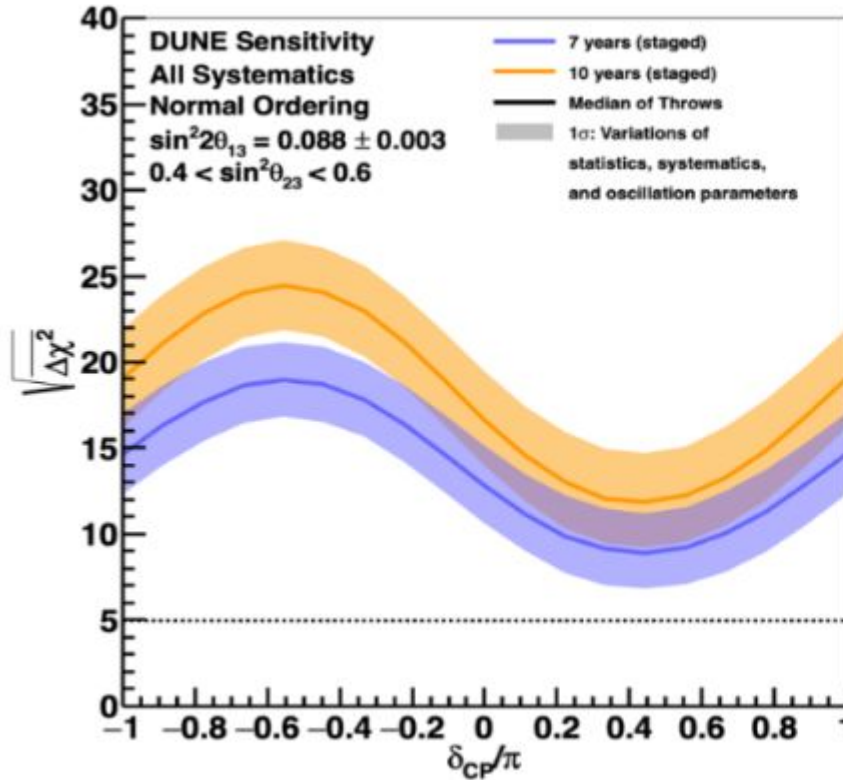


$$\Delta\chi_{CPV}^2 = \text{Min}[\Delta\chi_{CP}^2(\delta_{CP}^{test} = 0), \Delta\chi_{CP}^2(\delta_{CP}^{test} = \pi)]$$



# Back up

## • Sensitivity Mass Ordering



$$\Delta\chi_{\text{ordering}}^2 = \chi_{\text{opposite}}^2 - \chi_{\text{true}}^2$$

# Back up

- **Energy Resolution Function:**

- Charge signal - > Results from Wenjie Wu Presentation.

Resolution	3view_30deg	3view_30deg (anti-nu)	HD (tech-note)
Numu CC events (contained)	20.3%	17.2%	18%
Numu CC events (exiting)	18.3%	17.8%	20%
Nue CC events	14.1%	12.0%	13%

<https://indico.fnal.gov/event/53964/contributions/250282/>

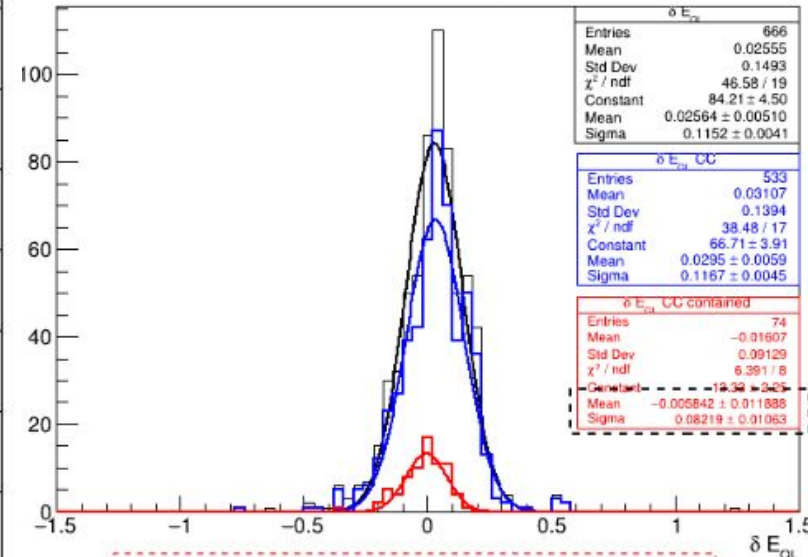
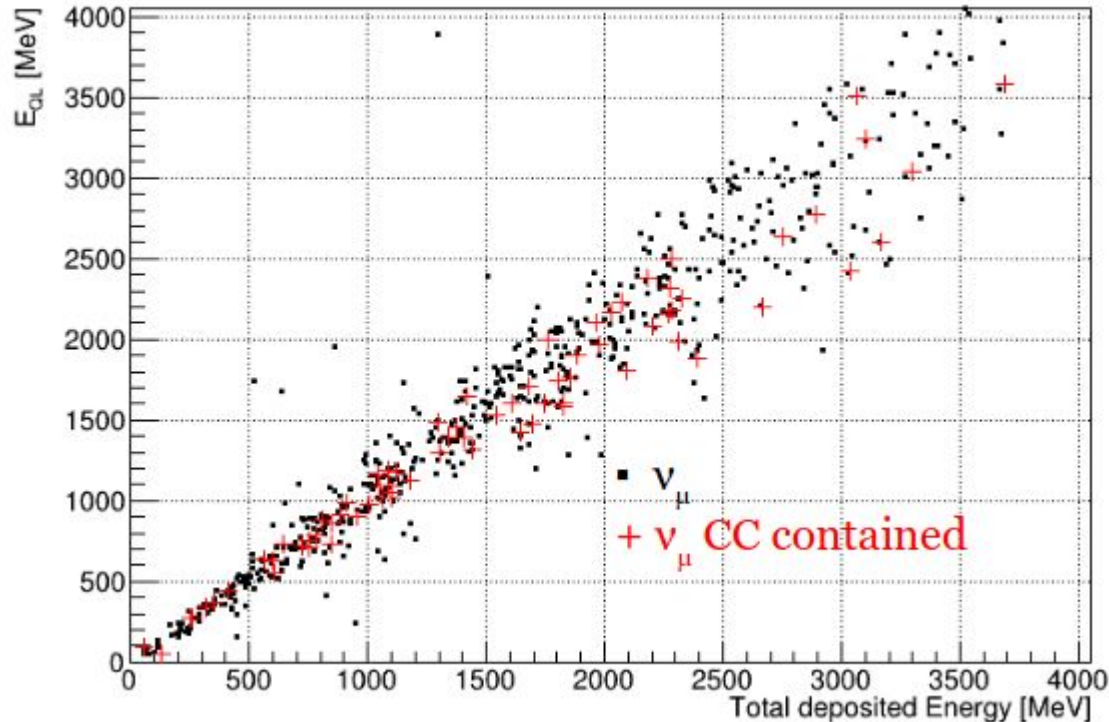
# Back up

- **Energy Resolution Function:**

- Charge and Light signal for muon neutrino CC contained - > Results from Giulia Brunetti/Marta Torti Presentation.

EQL vs Total Edep

$$\delta E_{QL} = \frac{E_{QL} - E_{dep}}{E_{dep}}$$



For CC contained events  
Mean : -0.006  
Sigma: 0.082

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