



First atmospheric neutrino signal in JUNO



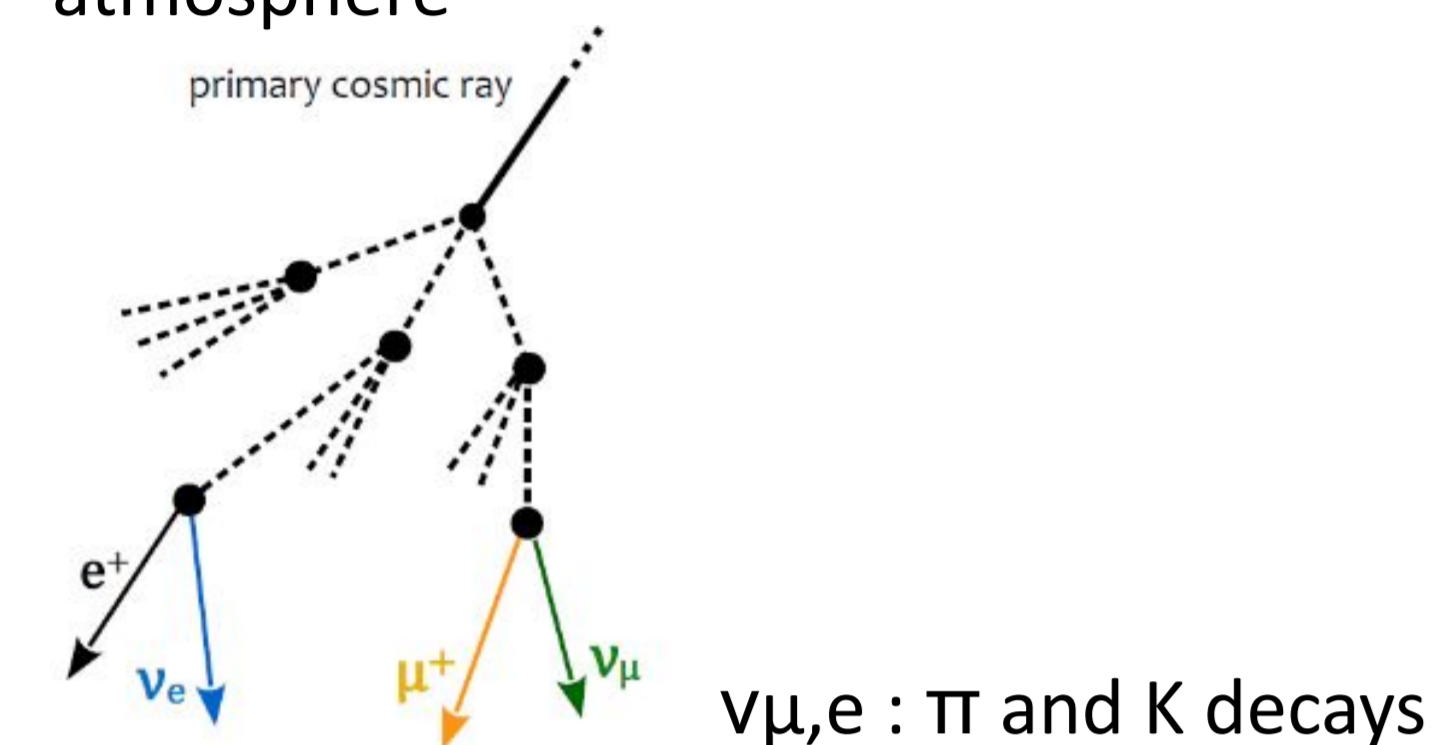
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Atmospheric Neutrinos and the JUNO experiment

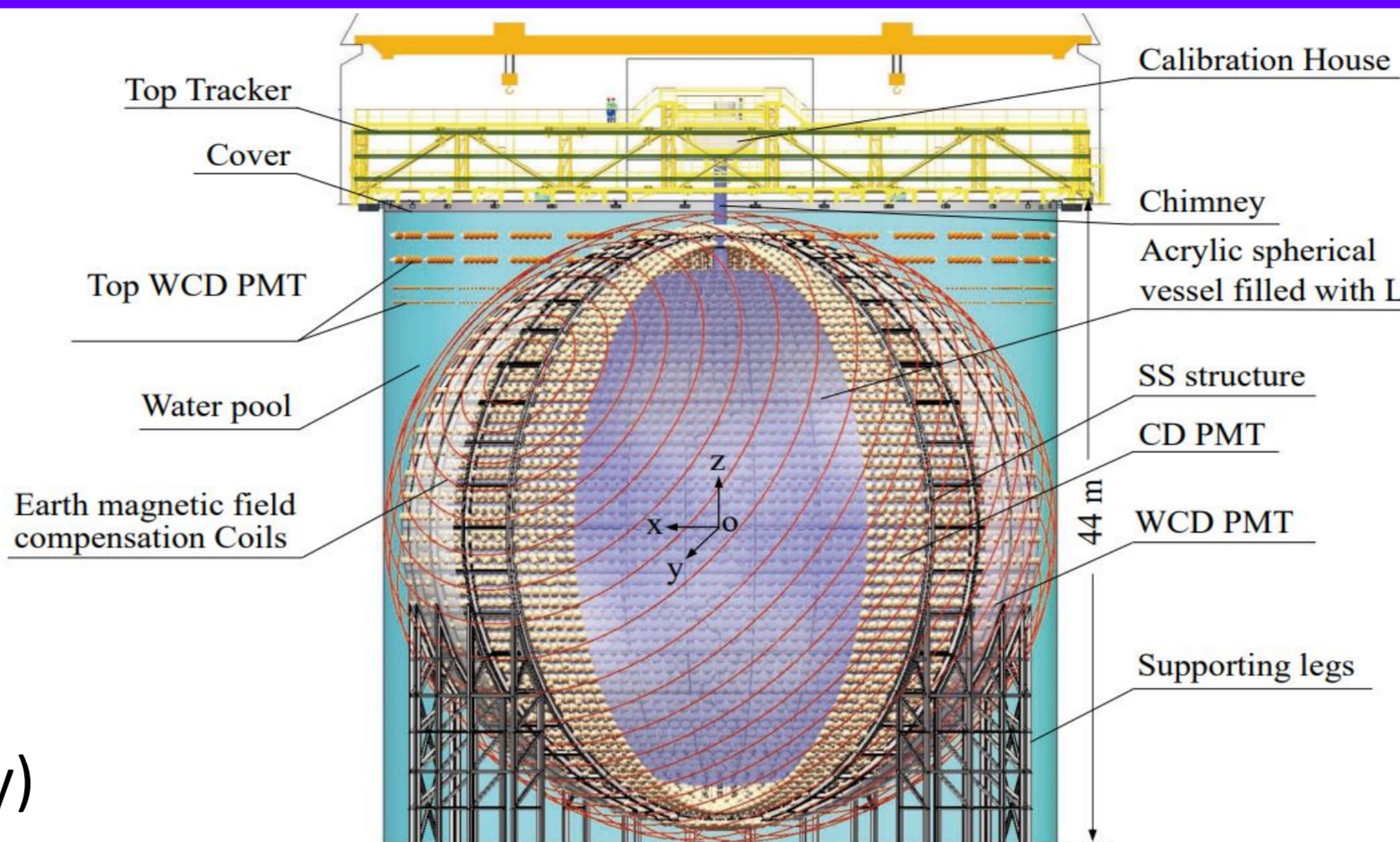
Source:

Initiated by primary cosmic rays hitting the atmosphere



JUNO:

- Larger liquid scintillator (LS) experiment (20 kton)
- CD: Central Detector, with ~20,000 large PMTs
- Between steel structure (SS) and acrylic vessel:
 - CD buffer (5 kton water)
- Two veto systems:
 - Water Pool (WCD) and Top Tracker (TT)
 - For cosmic muon tagging: efficiency > 99.97% (inefficiency for muons coming through top chimney)

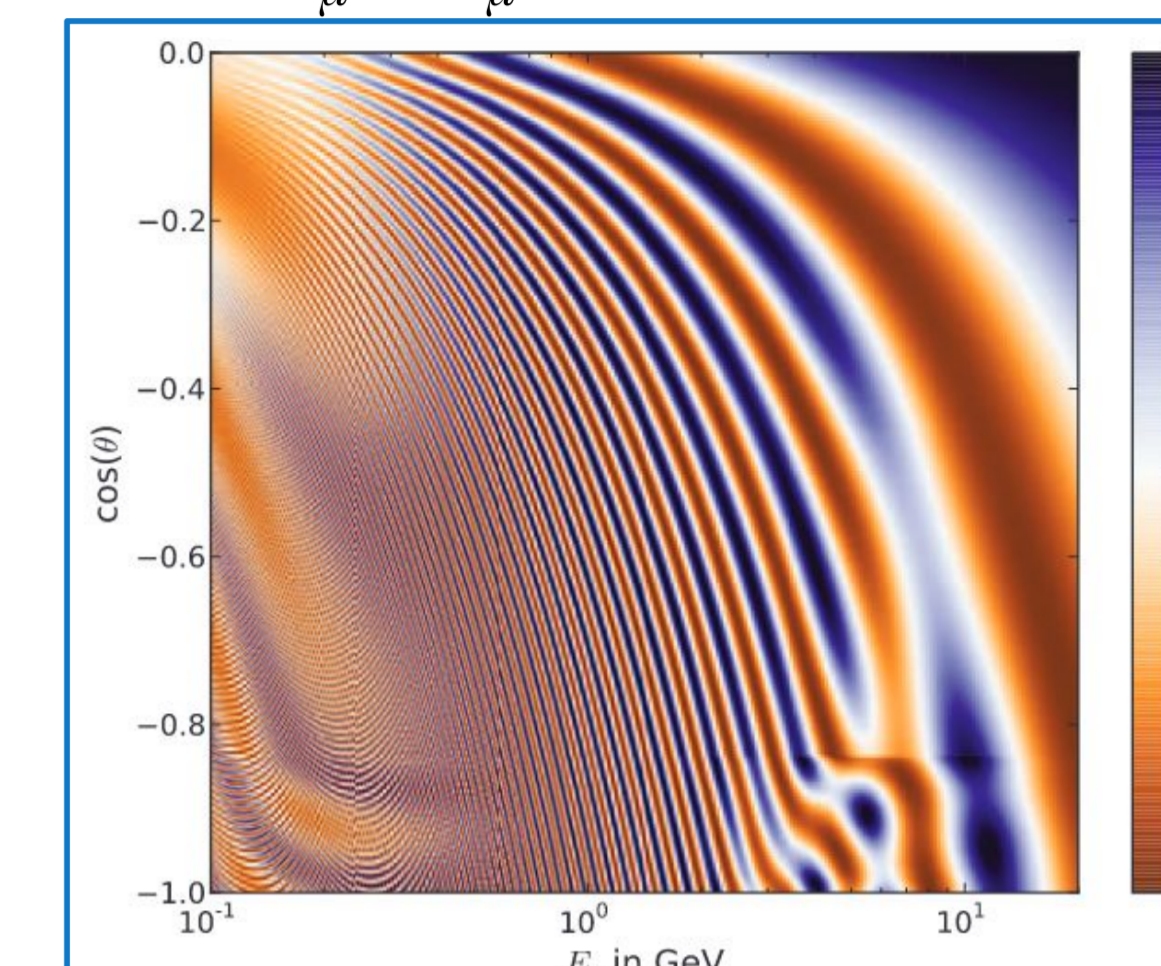


Multi-purpose: sub-MeV to multi-GeV neutrinos

Atmospheric neutrinos provide a complementary channel to reactor neutrinos for oscillation studies in JUNO

This work: focus on selection of a first clean signal sample

$p(\nu_\mu \rightarrow \nu_\mu)$ (normal ordering)



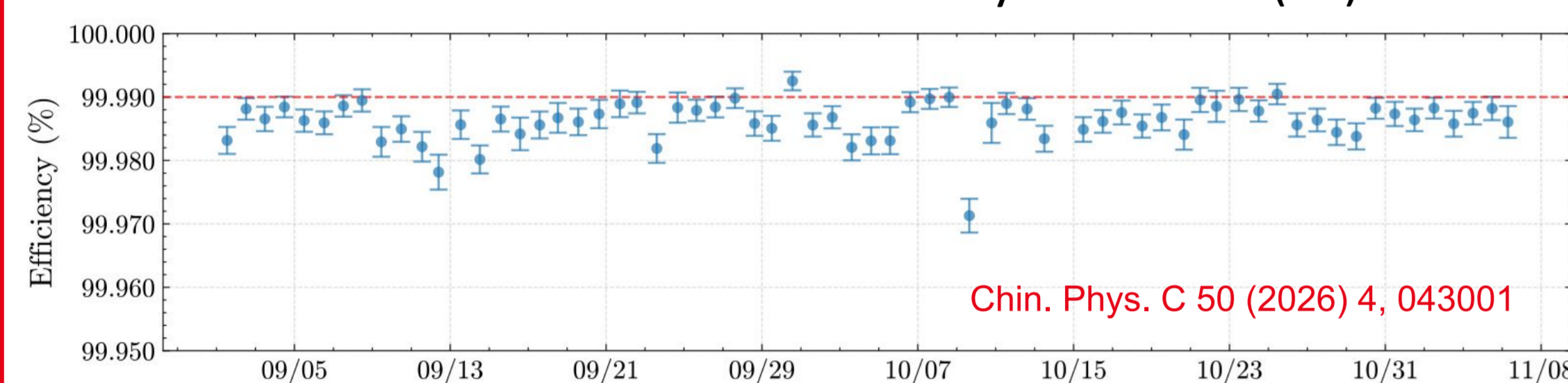
Event selection

1. Selection of CD primaries

→ Removal of afterpulses and secondary triggers

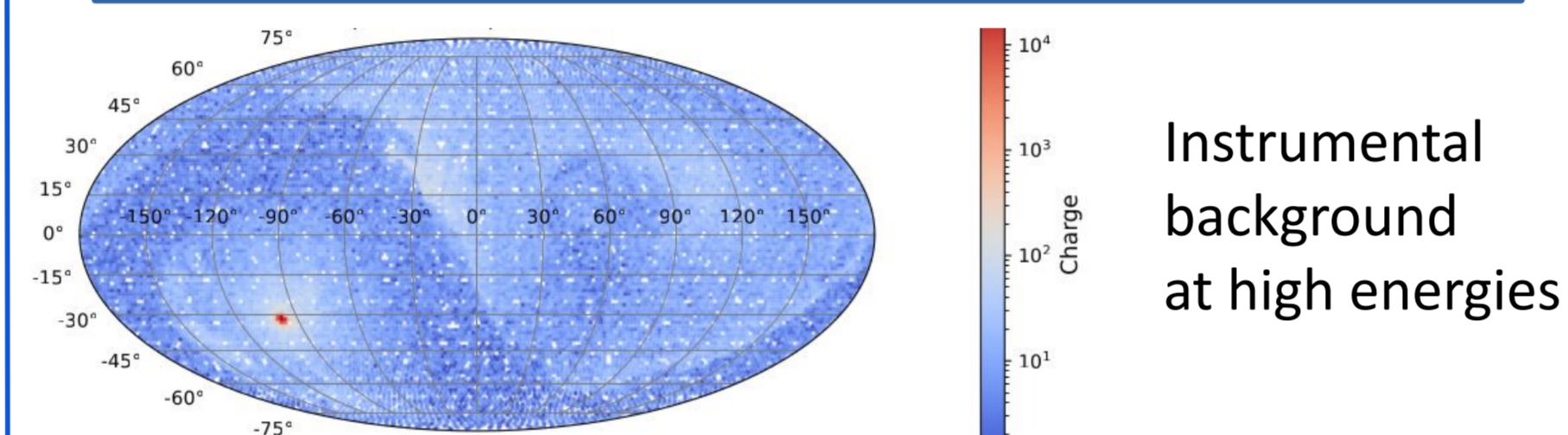
2. Selection of CD-only events

→ Removal of cosmic muons: select fully contained (FC) events

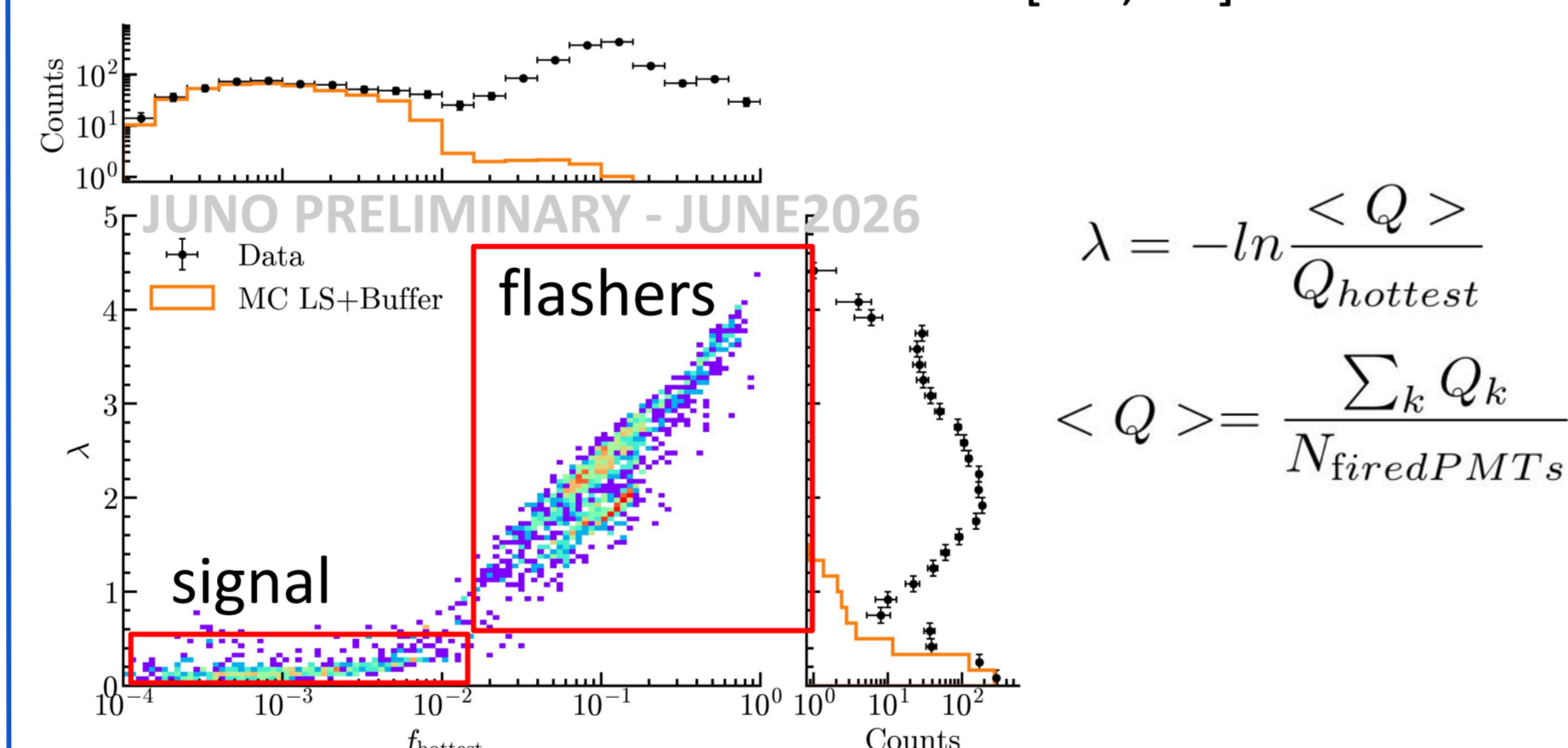


	Method 1	Method 2	Method 3
CD Primaries			
NPE threshold	4×10^4	None	2×10^5
$\Delta T_{\text{current-previous}}$ (Afterpulse removal)	$> 40 \mu\text{s}$ & $\Delta T_{\text{to last muon}} > 400 \mu\text{s}$	$> 40 \mu\text{s}$ or $> 10 \mu\text{s}$ & $\frac{Q_{\text{curr}}}{Q_{\text{prev}}} > 100$	$> 20 \mu\text{s}$
CD-only			
NPE threshold	4×10^4	4×10^4	2×10^5
$ \Delta T $ CD-WCD	$> 3 \mu\text{s}$ if $\text{CD}_{\text{NPE}} > 2 \times 10^5$	$> 3 \mu\text{s}$	$> 3 \mu\text{s}$
ΔT CD-TT	$[-750, 0]$ ns	None	None

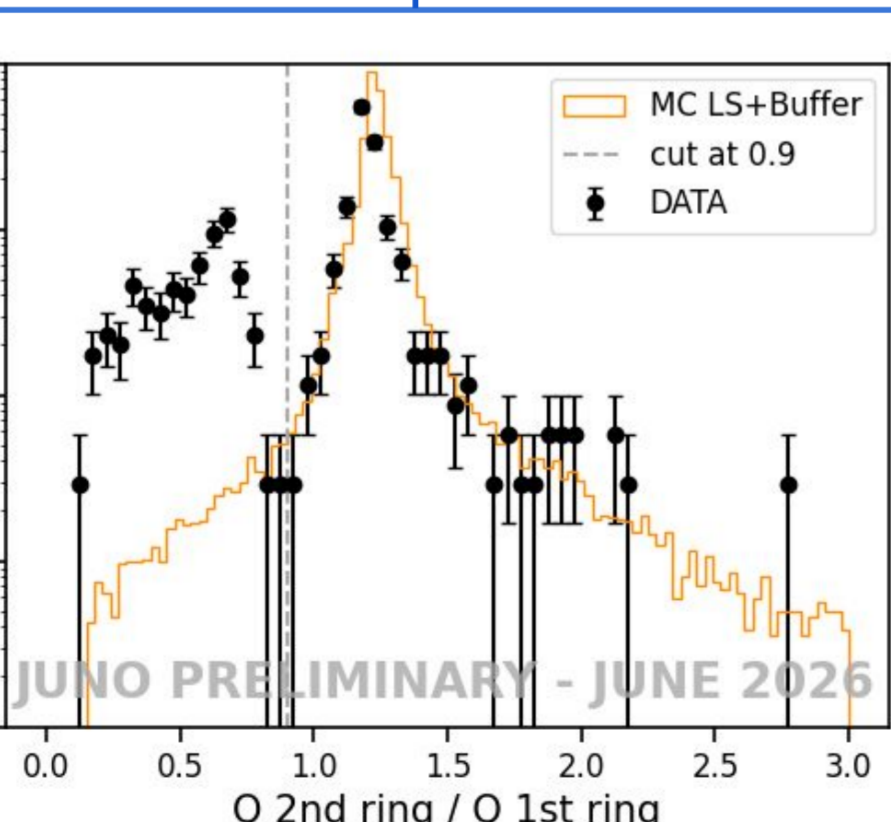
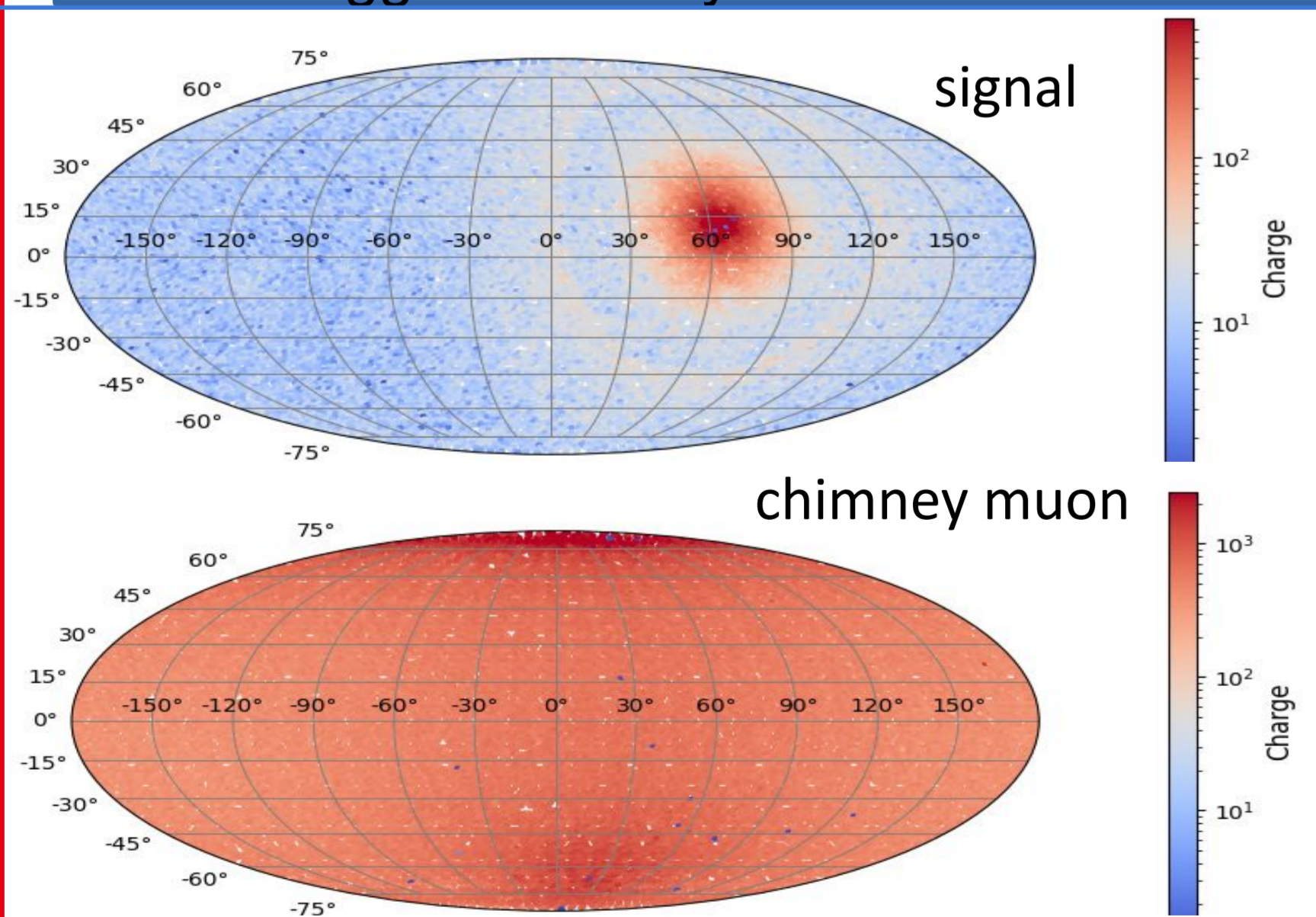
3. PMT flasher removal



$f_{\text{hottest}} = Q_{\text{hottest}} / Q_{\text{total}}$: region of highest charge density
 $\lambda = \text{charge density from the hottest PMTs}$
 $k = \text{PMTs with } R^2 \text{ to hottest PMT } [1.5, 2.5] \text{m}^2$

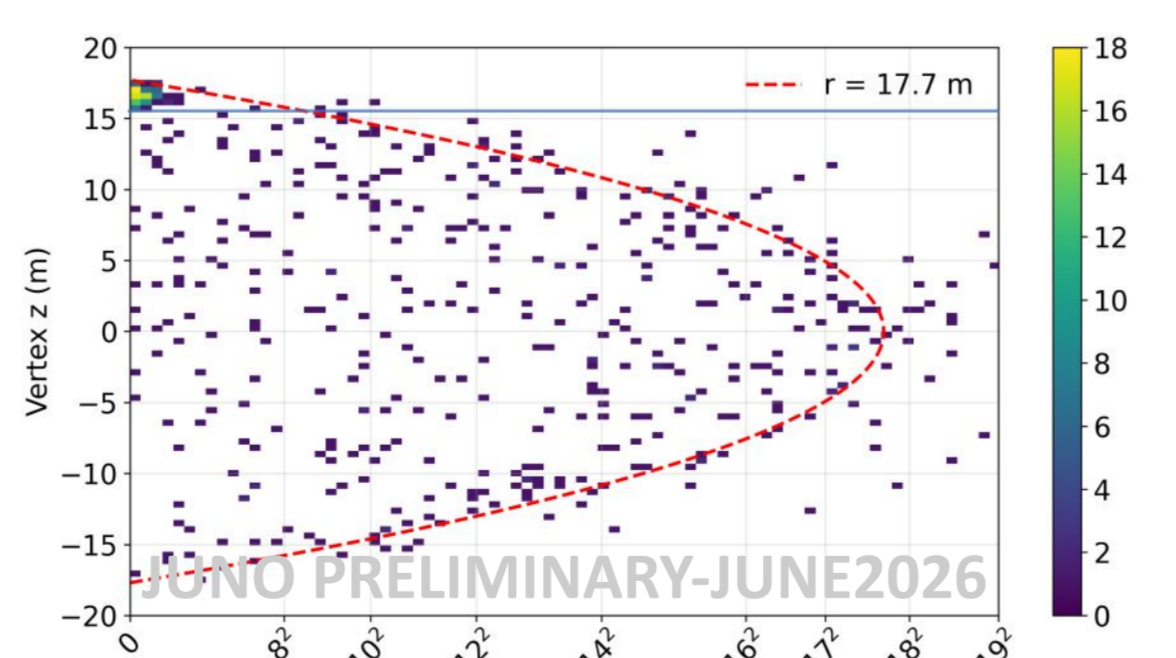


4. Untagged chimney muon removal



→ Strategy 2: use the reconstructed vertex (see Poster ID432 for details)

→ Strategy 1: charge ratio between 2nd and 1st (upper) PMT rings (chimney = more charge in 1st ring)

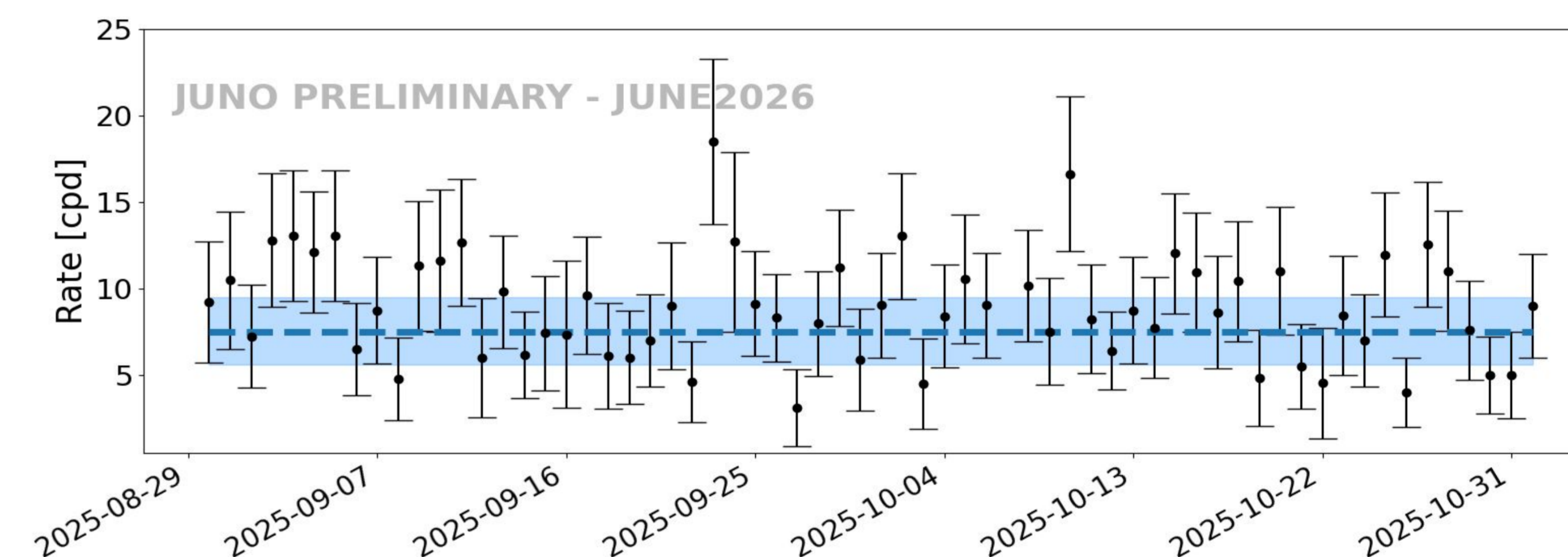
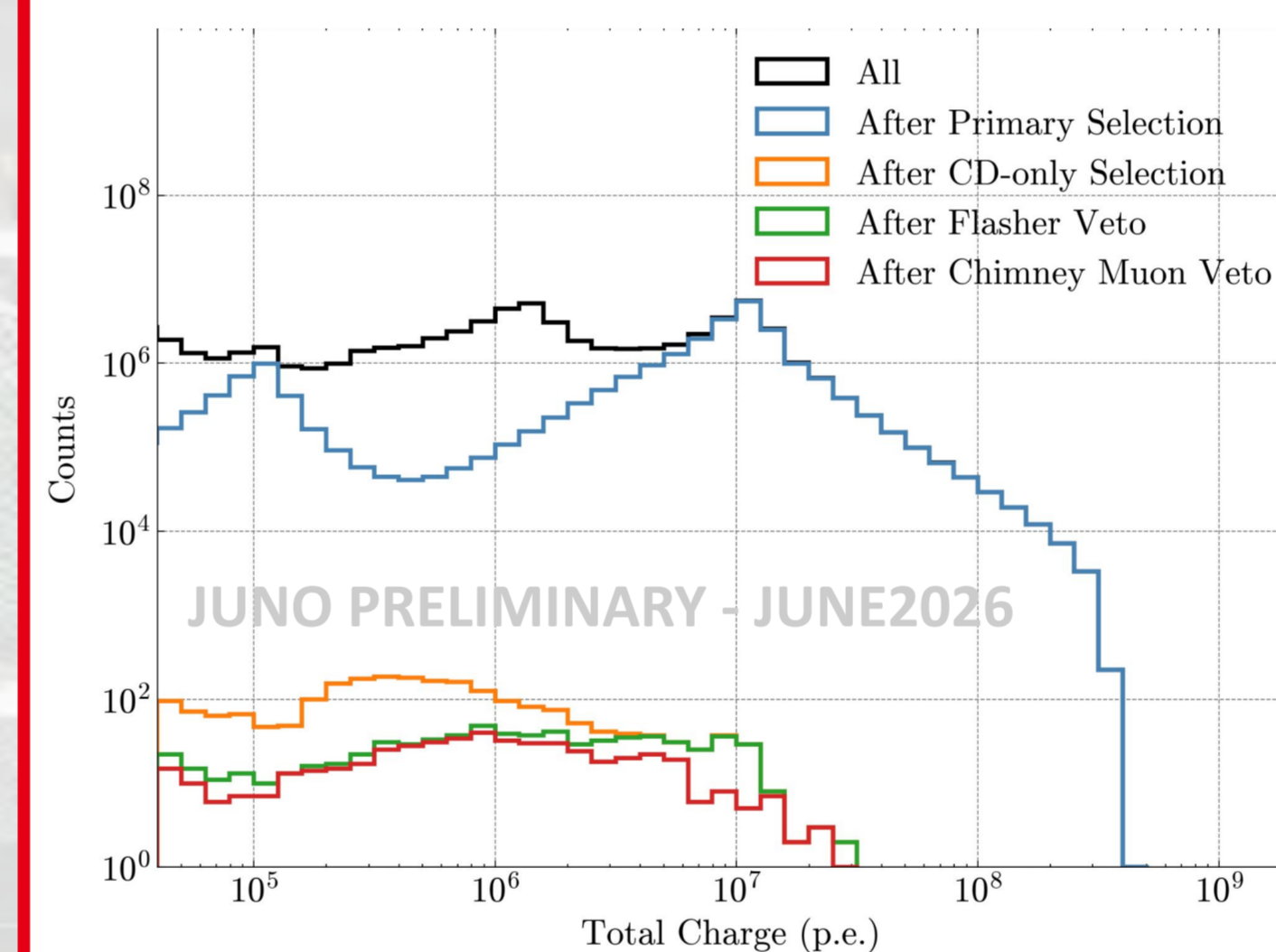


Results with first JUNO data

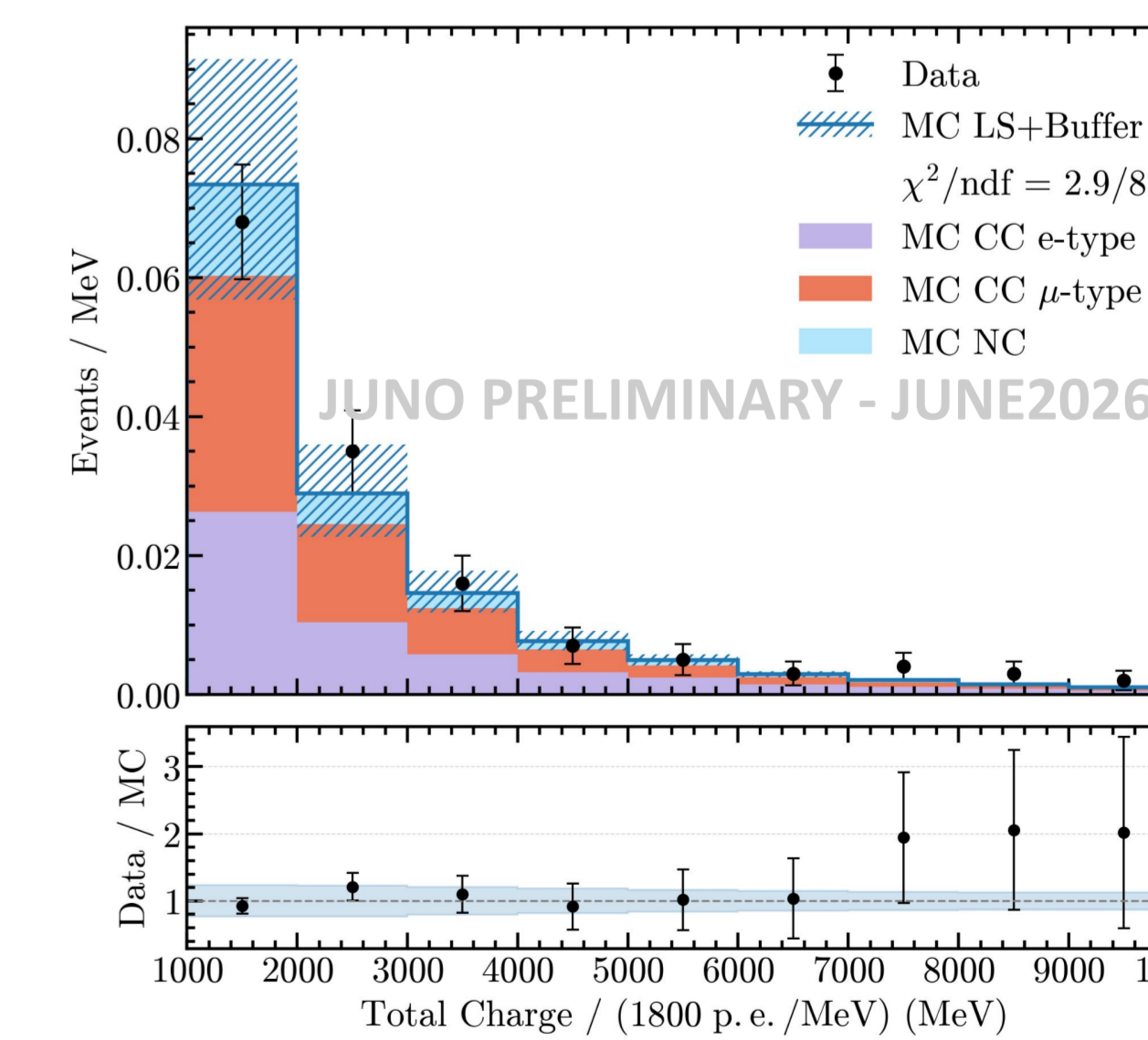
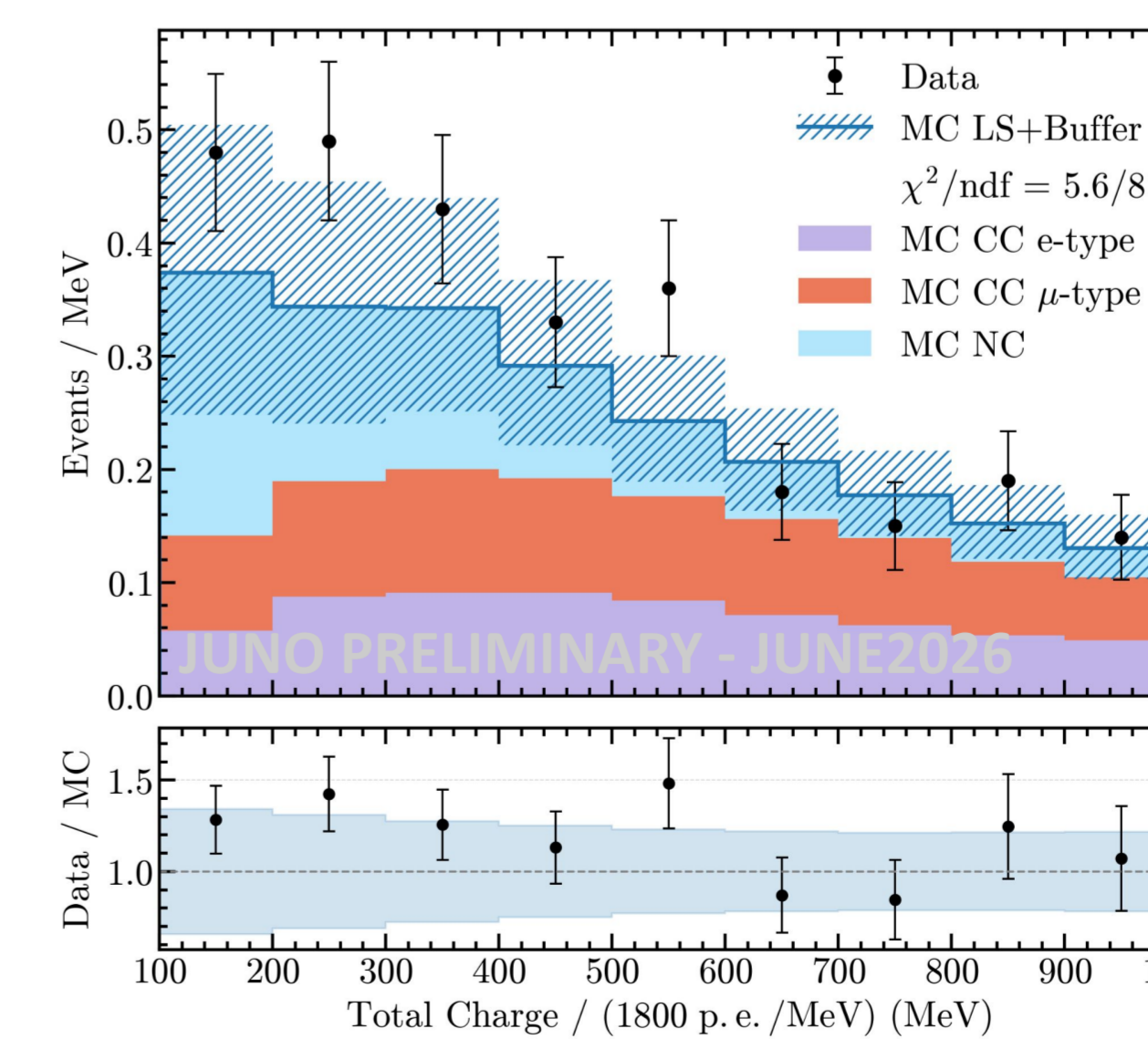
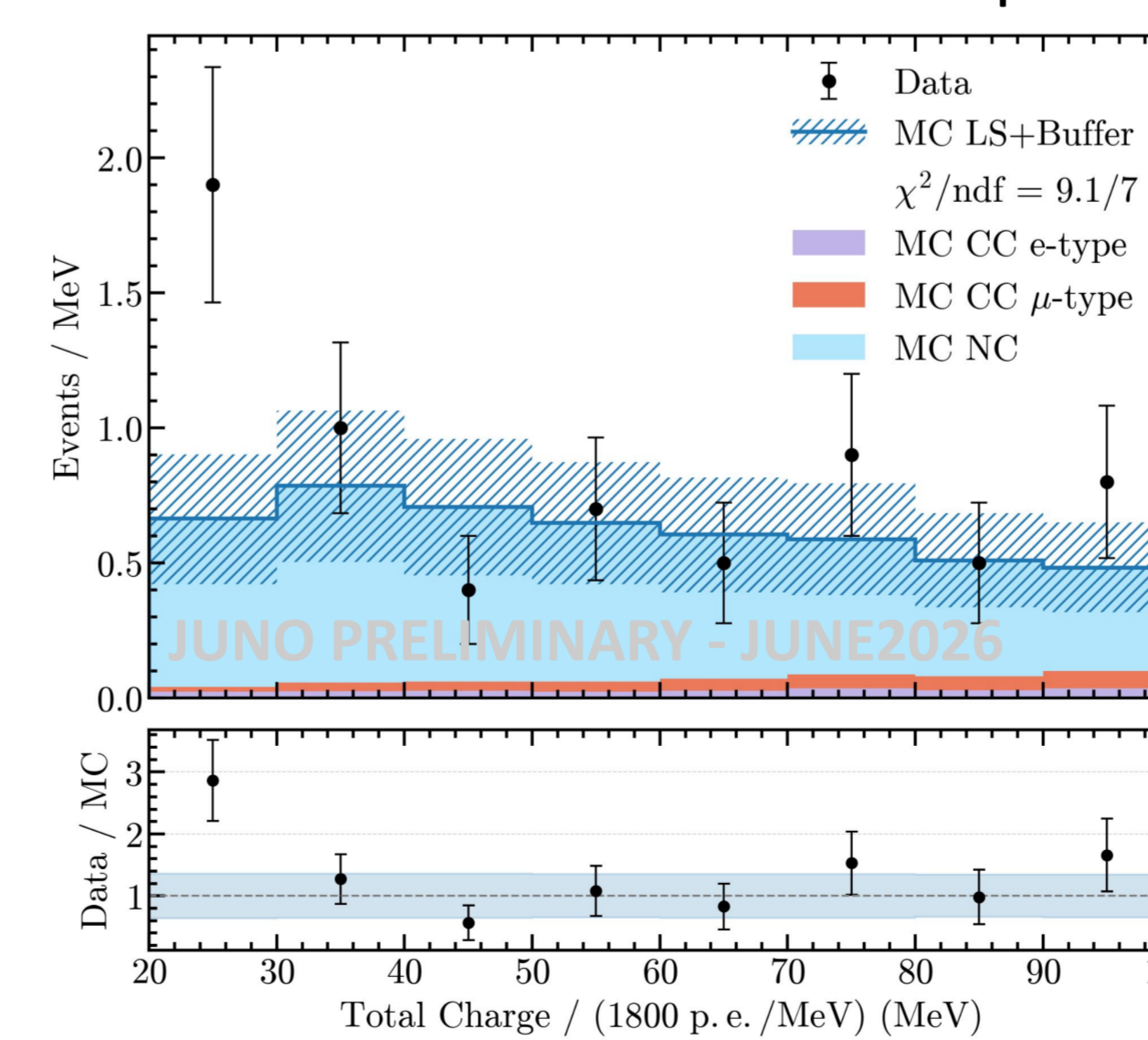
- First JUNO atmospheric neutrino FC sample:
 - 485 candidates in 55 days
- Consistency between different methods
- Energy range (visible): 20 MeV to 10 GeV

- Detector and selection stability > 20 MeV during data taking
 - rate consistent with expectation, stable over ~2 months

Expected rate (MC LS+Buffer): $7.5^{+2.0}_{-1.9}$ cpd Data: $8.8^{+0.4}_{-0.4}$ cpd



- MC prediction: HONDA flux, GENIE v3.04.02 with G18 10a 02 11b tune, oscillated using PDG2025 (NO)
- Visible energy spectra of atmospheric neutrinos across three energy ranges:
 - NPE to energy conversion based on approximation: 1 MeV = 1800 NPE (light-yield, Ch. Phys. C 50 (2026) 4, 0430)
- Data consistent with the prediction within uncertainties



Summary and Outlook

Established a first clean atmospheric neutrino sample, proving the detector response stability >20 MeV in JUNO → First atmospheric neutrino observation with a liquid scintillator detector →

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Stay tuned for first oscillation results and sub-GeV NC interaction modeling