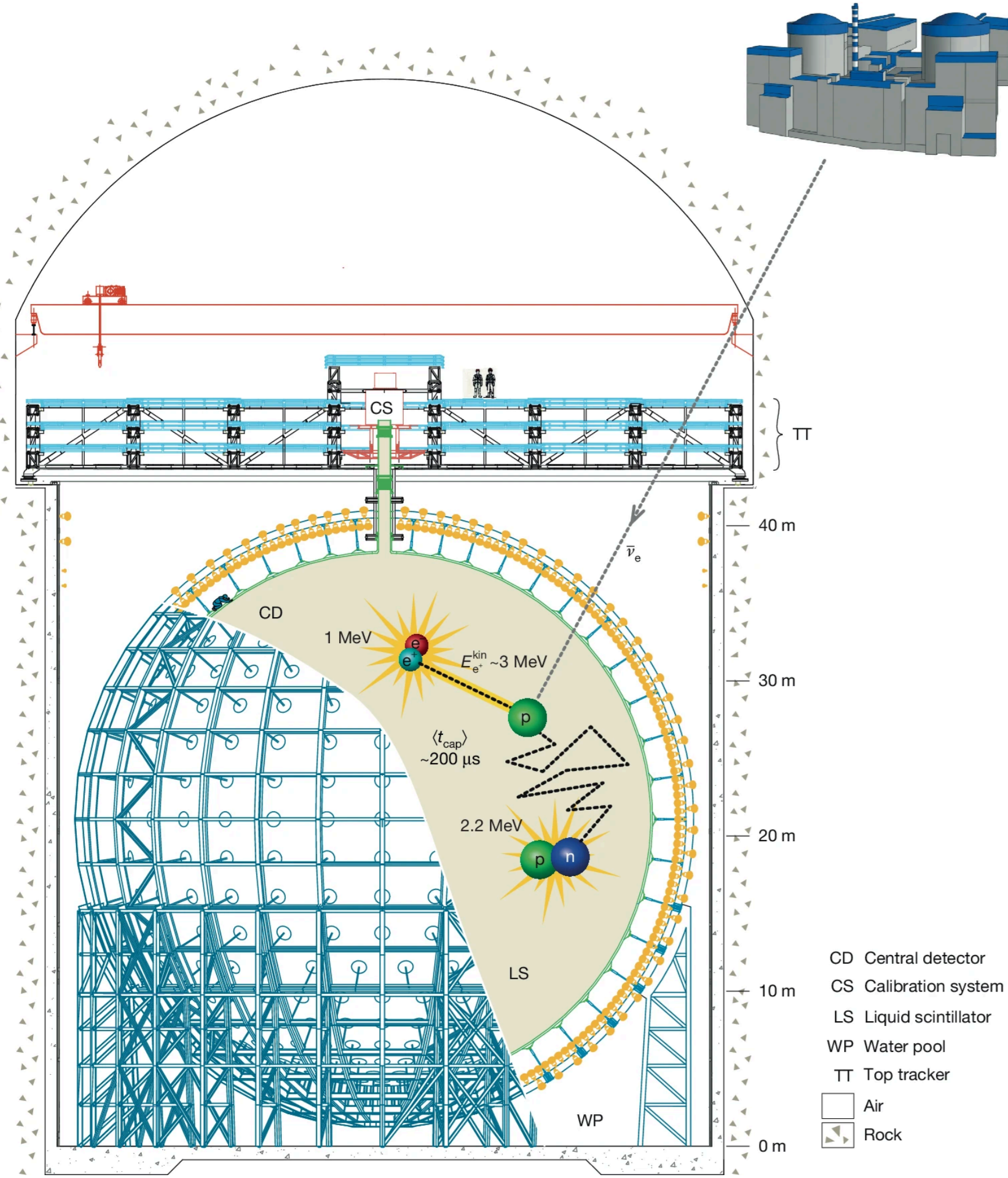


## JUNO detector and event selection



### JUNO at a glance

- 20-ktonne liquid scintillator (LS) detector
- 52.5 km from the Yangjiang and Taishan reactor cores
- About 700 m underground
- 17,596 20-inch and 25,587 3-inch PMTs; 78% geometrical coverage

### Physics goals

- Determine the neutrino mass ordering
- Sub-percent precision on oscillation parameters
- Supernova burst, DSNB, geo-, atmospheric and solar neutrinos
- Beyond-Standard-Model searches, including proton decay

## Inverse beta decay (IBD)

Candidates are selected by the prompt-delayed coincidence of a positron signal and neutron capture on hydrogen.



## Candidate summary and selection efficiencies

Final dataset: 2,379 identified antineutrino candidates in 59.1 days.

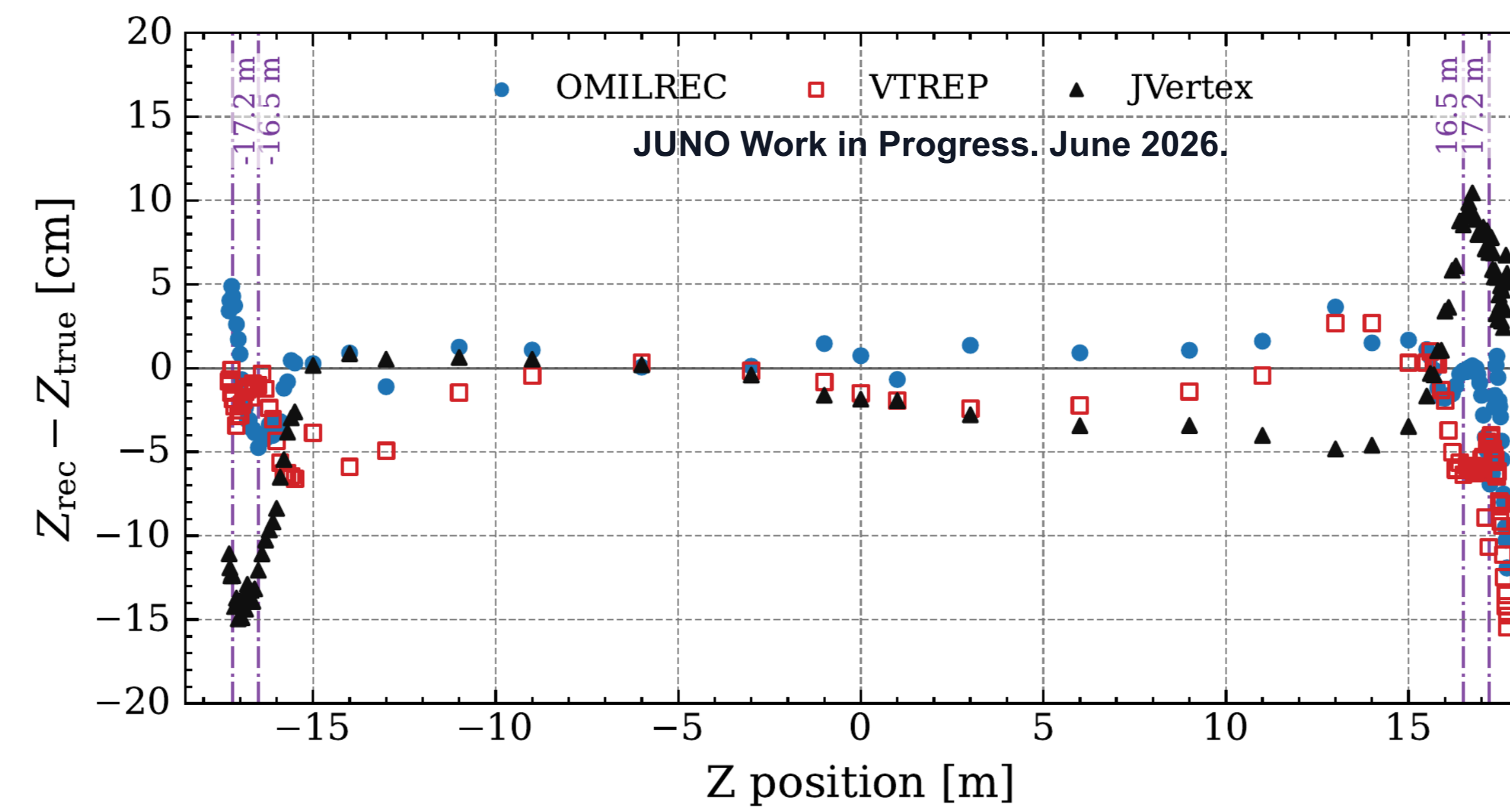
### Antineutrinos ( $\bar{\nu}_e$ ) candidates summary

DAQ live time (days)	59.1	
$\bar{\nu}_e$ Candidates	2,379	
<b>Selection efficiencies (%)</b>	$\epsilon$	$\sigma_{rel}$
<b>Fiducial volume</b>	80.6	1.6
PMT flasher rejection	>99.9	Negligible
$\mu$ Veto	93.6	Negligible
Multiplicity	97.4	Negligible
Prompt-delayed coincidence	95.1	0.13
<b>Total efficiency (<math>\epsilon_{tot}</math>)</b>	69.9	1.6
$\bar{\nu}_e$ signal (cpd <sup>3</sup> )		
Without $\epsilon_{tot}$ corrected	33.5 ± 1.7	
With $\epsilon_{tot}$ corrected	47.9 ± 2.6	
Non-oscillated $\bar{\nu}_e$	150.9 ± 2.7	

Table 1 lists IBD-selection efficiencies and uncertainties only; target-proton normalization is a separate rate factor.

## FV efficiency and vertex reconstruction

A  $^{68}\text{Ge}$  calibration source deployed with the Automatic Calibration Unit (ACU) along the z-axis is used to evaluate the reconstructed-vertex bias at different z positions.



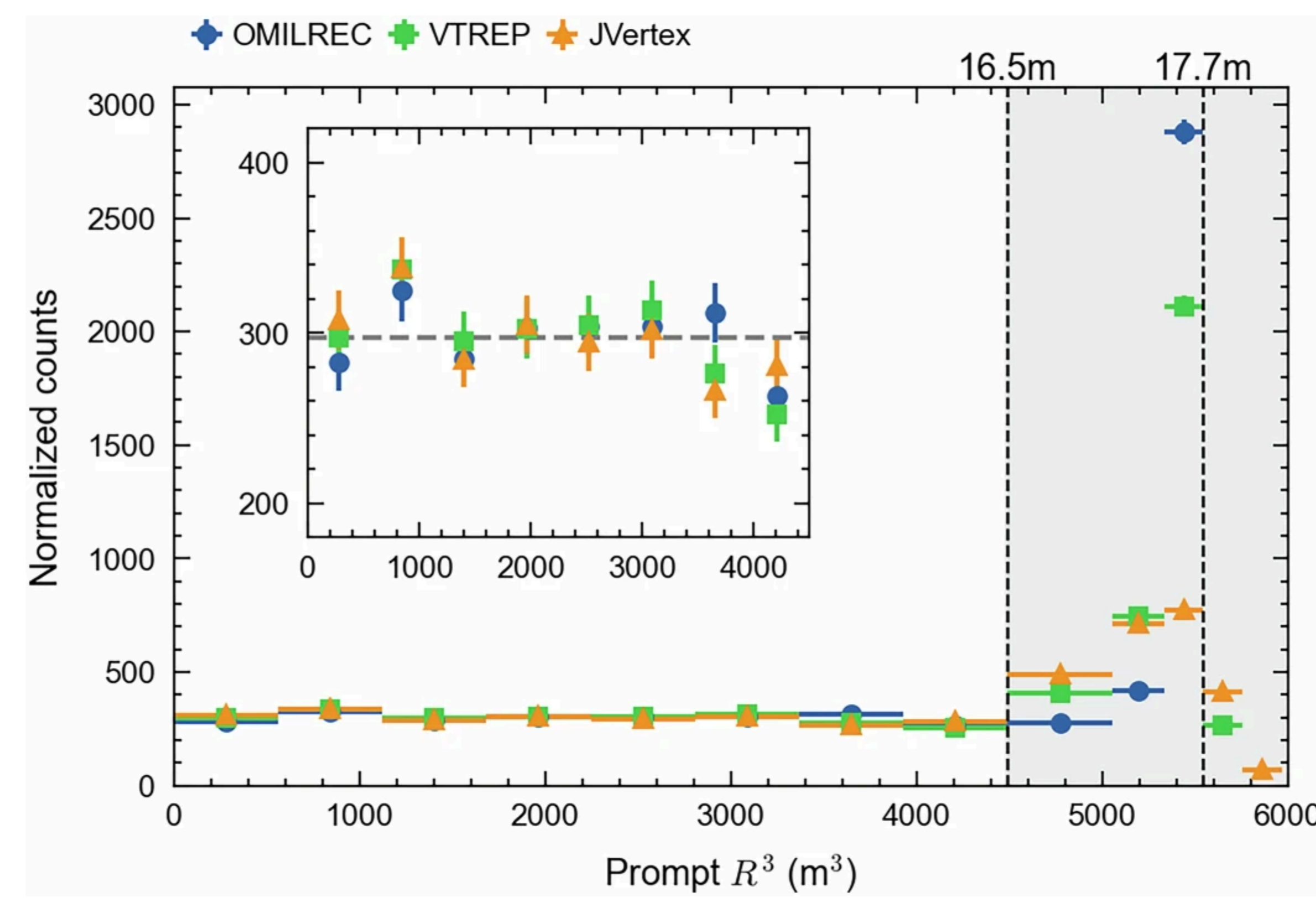
Reconstructed-z bias from ACU source deployments.

### Independent vertex-searching algorithms:

- OMILREC**: the combined time and charge likelihood functions are maximized
- VTREP**: finds the point with the sharpest residual-time distribution
- JVertex**: employs a maximum-likelihood estimation method constructed from first hit times after time-of-flight subtraction

The vertex bias for all three methods remains within 10 cm across almost the entire detector.

## Spatial distribution and FV efficiency



Prompt-event density versus reconstructed  $R^3$  for the three algorithms.

- Efficiency**: geometrical volume fraction accepted in the selection, 80.6%, assuming a uniform IBD distribution within the FV.
- Validation**: cosmogenic  $^{12}\text{B}$  and high-energy ( $>3.5$  MeV) IBD samples use the reconstructed-in-FV fraction relative to the total.
- FV uncertainty**: the spread among reconstruction algorithms near the fiducial boundary gives a 1.6% relative uncertainty.
- ACU cross-check**: the measured about 10 cm vertex-reconstruction bias at the FV boundary gives a comparable  $\sim 1.8\%$  relative uncertainty.

## Reactor-antineutrino rate inputs

Predicted events in prompt-energy bin  $i$ :

$$N_i = C \times \int_{E_i^{rec}}^{E_{i+1}^{rec}} dE_{\bar{\nu}_e}^{rec} \int_{-1}^1 d\cos\theta \times \sum_r \frac{\mathcal{P}_{ee}(E_{\bar{\nu}_e}, L_r)}{4\pi L_r^2} S_r(E_{\bar{\nu}_e}) \times \frac{d\sigma}{d\cos\theta}(E_{\bar{\nu}_e}, \cos\theta) R(E_{\bar{\nu}_e}^{rec}|E_{\bar{\nu}_e}),$$

$C$  includes target protons  $N_p$ , live time  $T_{live}$  and IBD selection efficiency  $\epsilon_{IBD}$   
 $N_i$  events in bin  $i$        $P_{ee}$  survival probability  
 $S_r$  emitted spectrum       $L_r$  baseline  
 $d\sigma/d\cos\theta$  IBD cross-section  
 $R(E_{\bar{\nu}_e}^{rec}|E_{\bar{\nu}_e})$  detector response

## Target protons

### Number of free target protons

$N_p = (1.442 \pm 0.014) \times 10^{33}$   
Determined from LS volume, density and hydrogen mass fraction.

### $N_p$ calculation

$$N_p = V_{LS} \times \rho_{LS} \times f_H / M_H \times N_A$$

$V_{LS}$ : LS volume

$M_H$ : molar mass of H

$\rho_{LS}$ : LS density

$N_A$ : Avogadro constant

$f_H$ : hydrogen mass fraction

### Input uncertainty

$V_{LS}$ : geometric survey of the acrylic vessel, flow monitoring during filling.

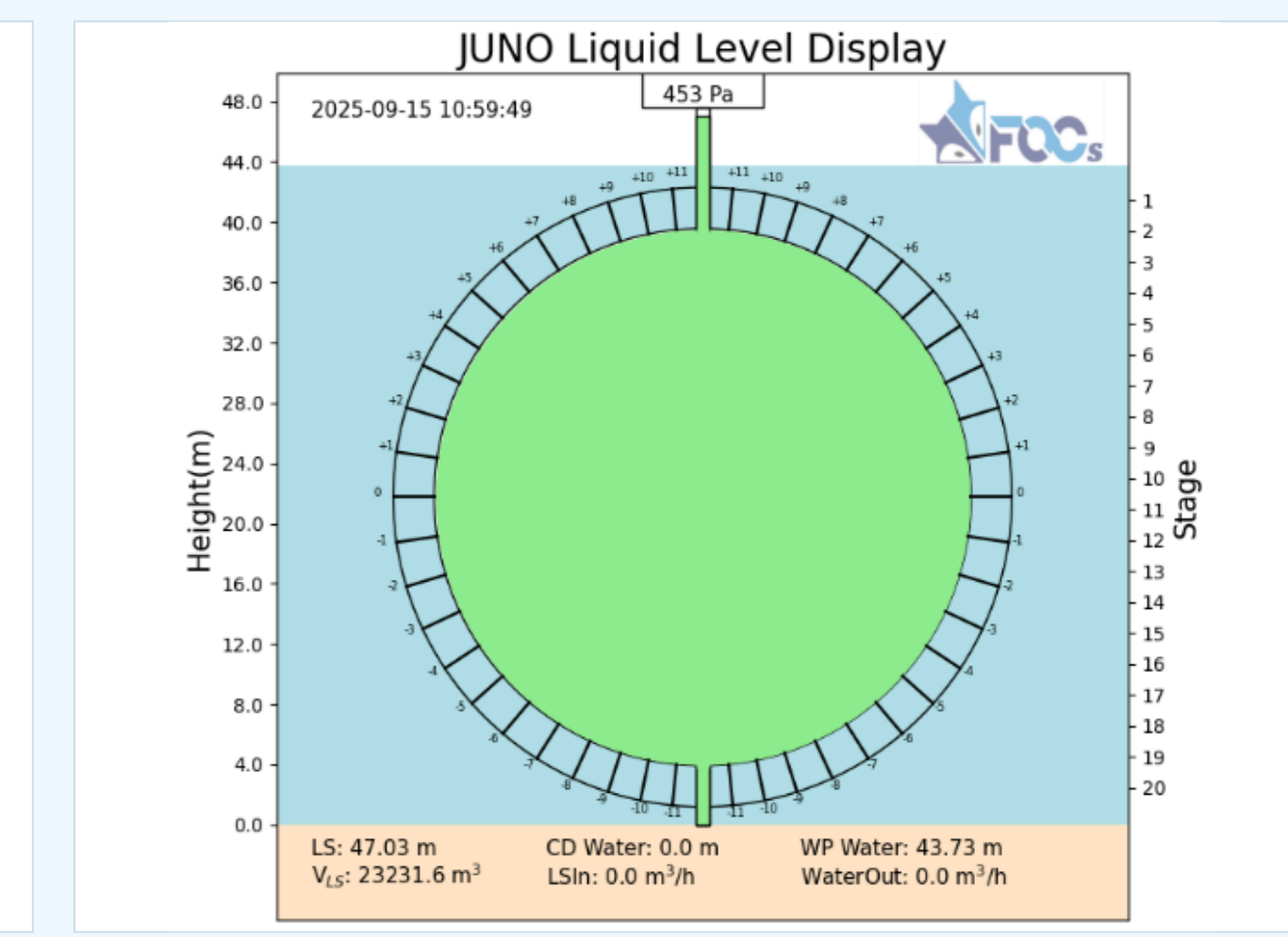
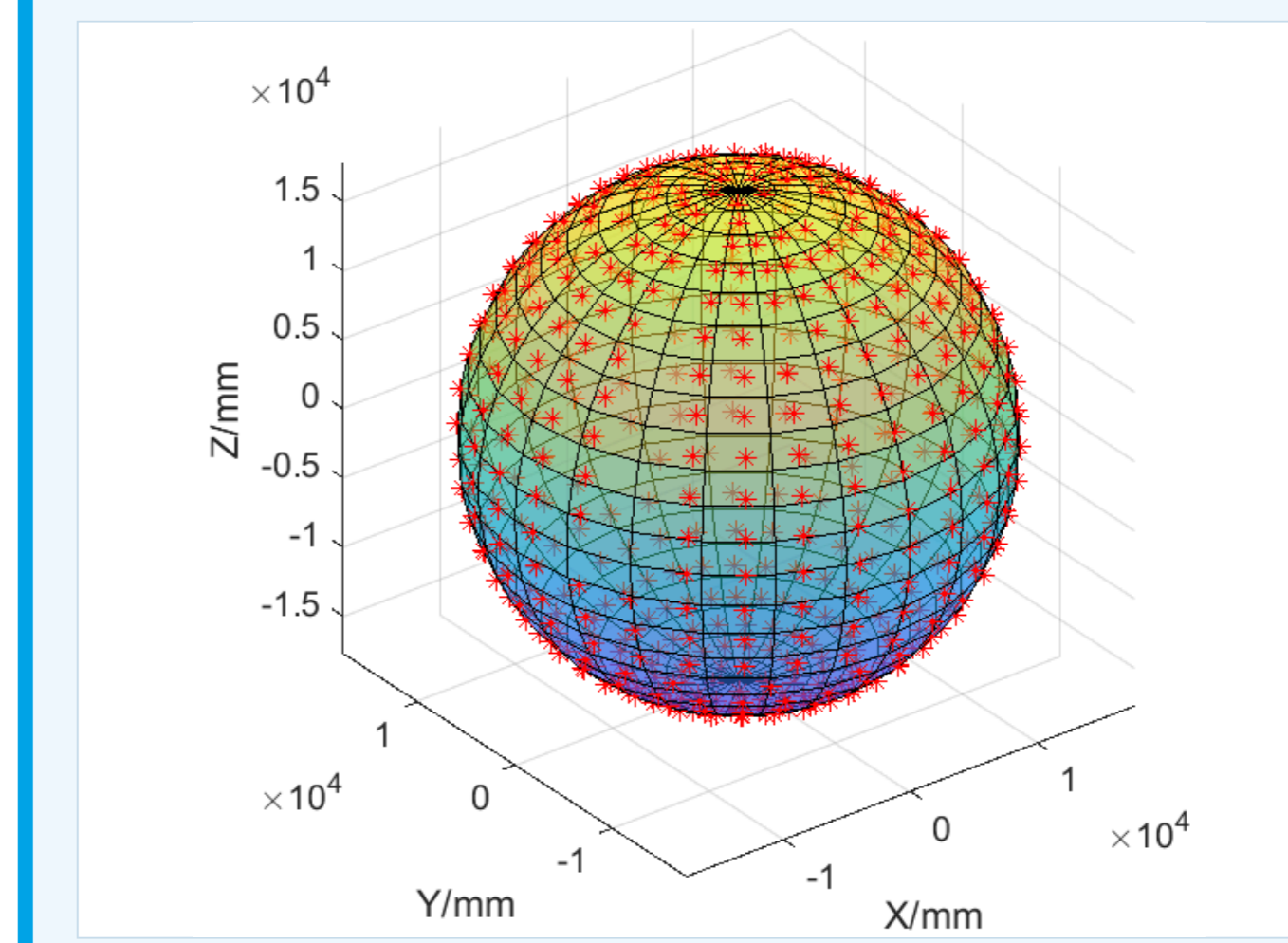
$f_H$ : elemental analyses of LS samples.

$\rho_{LS}$ : uncertainty negligible.

Comparing independent estimates of  $V_{LS}$  and  $f_H$  gives a **1.0% target-proton normalization uncertainty.**

## LS volume methods

Method 1: acrylic-vessel survey      Method 2: filling-volume record



## Uncertainty summary

Input	Rel. unc.	Main source
<b>FV-selection eff.</b>	1.6%	vertex reconstruction near FV boundary
<b>Target-proton norm.</b>	1.0%	LS volume; hydrogen fraction

### References:

- [1] JUNO Collaboration, Nature 654, 343-352 (2026).
- [2] JUNO Collaboration, Chin. Phys. C 50, 043001 (2026).