Overall, the study is technically sound and addresses an important gap in the metrological characterization of CRNS detectors. The work is novel because it provides one of the first systematic evaluations of commercial CRNS instruments in traceable neutron reference fields. However, several weaknesses limit the scientific impact and broader relevance of the paper. The research addresses the tirst systematic characterization of commercial CRNS detectors in traceable neutron reference fields, strong collaboration between PTB and CIEMAT, comprehensive use of MCNP simulations, and valuable benchmark dataset for future CRNS metrology efforts.

Following are the review comments:
1. Limited Connection to Soil Moisture Applications: The manuscript is motivated by soil moisture monitoring, yet the study remains entirely focused on detector physics and neutron metrology. There is no quantitative demonstration of how the reported calibration factors (S = 0.79–1.34) influence soil moisture retrieval uncertainty, CRNS footprint estimation, or field-scale hydrological applications. The practical implications for CRNS users are therefore unclear.
2. Calibration Reduced to Empirical Scaling Factors: The methodology relies heavily on applying a single global correction factor (S) to force agreement between simulations and observations. While this improves consistency, it does not identify the physical reasons for the discrepancies. The paper does not determine whether the bias originates from detector geometry simplifications, material properties, cross-section libraries, electronics, or environmental scattering.
3. Lack of Independent Outdoor Validation: The validation is performed exclusively in laboratory reference fields. Since CRNS detectors operate in complex outdoor neutron environments, the manuscript does not demonstrate whether the corrected response functions remain valid under realistic field conditions involving vegetation, snow, atmospheric humidity, topography, or heterogeneous soils.
4. Insufficient Description of Detector Models: A significant limitation is the lack of detailed detector geometry and electronics information due to manufacturer confidentiality. This prevents reproducibility and independent verification of the MCNP simulations. Readers cannot assess model completeness or replicate the study.
5. Weak Validation Energy Range for CRNS Applications: The monoenergetic validation extends only from 24 keV to 5 MeV. However, cosmic-ray neutron spectra span a much broader energy range, extending into tens or hundreds of MeV. The manuscript does not sufficiently justify why validation in this restricted energy interval is adequate for environmental neutron sensing.
6. Large Background Contributions Reduce Confidence: The study reports that room-scattered neutrons contribute:

- 90–99% of counts for bare detectors,
- 50–70% for moderated detectors,
- ~20% for the S1 detector.

These very high background fractions indicate that the measured signal is dominated by scattered neutrons rather than direct beam neutrons, raising concerns about the robustness of the validation results.
7. Uncertainty Analysis is Incomplete: The uncertainty treatment focuses mainly on counting statistics and source strength uncertainties. The manuscript lacks a comprehensive uncertainty budget that includes:

- detector positioning errors,
- geometry simplifications,
- nuclear data uncertainties,
- room-return corrections,
- shadow-cone corrections,
- electronics dead-time effects.

Such uncertainties could significantly affect the reported agreement.

8. Limited Scientific Advancement Beyond Calibration: The study mainly demonstrates that measured detector responses can be matched to simulations within 10–12%. While useful from a metrology perspective, the broader scientific advance is modest. The paper does not generate new physical insights into CRNS response mechanisms or improve existing soil moisture retrieval frameworks.

9. Environmental Sensitivity Not Quantified: The authors repeatedly state that the validated models can be used to study environmental influences such as:

- buildings,
- snow,
- water bodies,
- vegetation.

However, no sensitivity experiments are actually presented. Including a few representative simulations would significantly strengthen the manuscript and demonstrate the utility of the validated models.

10. Conclusions Overstate Readiness for Calibration Frameworks: The manuscript concludes that the work is a key step toward SI-traceable calibration frameworks. However, the study itself identifies several unresolved limitations:

- large room-return contributions,
- inability to characterize bare detectors in monoenergetic fields,
- dependence on empirical correction factors,
- lack of dedicated CRNS calibration facilities.

Therefore, the conclusions should be more cautious and emphasize that this work is a preliminary validation rather than a complete calibration framework.

Thus, the major concerns

1. Weak linkage to soil moisture science.
2. Heavy dependence on empirical scaling factors.
3. Lack of outdoor/field validation.
4. Incomplete uncertainty analysis.
5. Excessive influence of room-scattered neutrons.
6. Limited reproducibility due to proprietary detector information.

Major Revision

The paper has merit and is likely publishable after revision, but the authors should strengthen the physical interpretation, provide a more rigorous uncertainty analysis, clarify the implications for CRNS soil moisture retrievals, and better justify the applicability of the laboratory-derived calibrations to real-world environmental monitoring.