We are deeply grateful to Reviewer #1 for their careful review and perceptive comments on our work. The initial draft contained several areas that lacked sufficient rigor and clarity, and the reviewer's valuable suggestions were instrumental in helping us correct these errors and strengthen our discussion. We appreciate the effort put into guiding our revisions. Below, we provide a point-by-point response to all comments, with our responses shown in blue and Reviewer #1's comments in **bold**.

I have gone through the manuscript "**Enhancing the Temporal Resolution and Sensitivity of Beta Attenuation Monitors via Concentrated Particle Deposition and Multi-Sensor Ensemble Averaging".**

The authors aimed to improve the performance of a **Beta Attenuation Monitor** for real-time monitoring of low concentrations of particulate matter ($PM_{2.5}$). They investigated three optimization strategies: reducing the particle deposition area (from **2.0 to 0.4 cm²**), simulating a **six-unit BAM array** through ensemble averaging, and optimizing the smoothing time. The optimized configuration (0.4 cm² deposition area, six-unit averaging, and a 30-minute smoothing window) reduced the instrument response time from **60 minutes to 22 minutes** while maintaining a standard deviation of **2.67 µg m⁻³** and achieving an LOD of **7.75 µg m⁻³.** These findings demonstrate that combining hardware optimization with statistical averaging enables faster, more sensitive, and more reliable real-time ambient air quality monitoring. **The manuscript is well written.**

Here are a few comments that need to be addressed before the manuscript is accepted for publication.

1. **The abstract is too long. Please include only the best outcomes.**

   We thank the reviewer for this helpful suggestion. We have revised and streamlined the Abstract to make it more concise (~265 words) while preserving all essential quantitative findings. Redundant methodology descriptions were eliminated.

2. **There is no justification provided for the selection of deposition area 2.0, 1.0, 0.6 and 0.4 cm^2. Please explain why the specific range has been considered.**

   We thank the reviewer for this constructive question. The selection of the specific deposition areas (2.0, 1.0, 0.6, and 0.4 cm^2) was designed to establish a systematic geometric gradient to characterize the trade-off between signal amplification and counting noise, while operating within the physical boundaries of the instrument:

(1) Baseline Control (2.0 cm^2): This represents the standard, unmodified opening of the commercial BAM, serving as our reference baseline to evaluate all performance improvements.

(2) Intermediate Steps (1.0 cm^2 and 0.6 cm^2): These apertures establish a systematic geometric gradient (representing area reductions of 50% and 70% relative to the baseline). These intermediate steps allow us to model the non-linear relationship of concentrated areal mass loading and evaluate detector shielding effects under steady-state conditions.

(3) Physical Lower Boundary (0.4 cm^2): This area represents the absolute operational limit of the filter tape mechanical strength and vacuum pump capacity. At a standard sampling flow rate of 16.67 L min_{-1}, reducing the deposition area to 0.4 cm^2 increases the filter face velocity to 6.9 m s^{-1} and initial pressure drop from 58 mmHg to 118 mmHg. Reducing the area further (below 0.4 cm^2) leads to filter media deformation, tape tearing, and severe volumetric flow rate decay.

(4) Beta Counting Statistics Limit: In addition to pressure constraints, reducing the aperture below 0.4 cm^2 results in excessive detector shielding, dropping the initial beta intensity I_0 below 3,168 cps. This elevates the relative statistical noise (CV) past 2.01%, which would trigger a performance reversal and degrade the overall (LOD).

We have updated Materials and Methods (Lines 132–134) of the revised manuscript to explicitly state this selection rationale.

3. **The quality and presentation of the figures require improvement. In particular, the description provided for Figure 3 appears inconsistent with the graphical representation, suggesting that the explanation may have been reversed. The authors are advised to carefully verify the figure, labels, and corresponding discussion.**

We thank the reviewer for this careful check. We have thoroughly re-examined Figure 3, its axis labels, legend, caption, and the corresponding discussion in the text.

We recognize that the inverse relationships between deposition area, beta intensity, and coefficient of variation (CV) can easily lead to potential misinterpretation. To ensure absolute clarity for readers, we have revised the text in Results and Discussion of the manuscript to provide an explicit, step-by-step description of Figure 3.

We have also audited all figure labels and captions to ensure this physical relationship is unmistakably clear.

4. **Every figure and table should be cited in the manuscript. There is no citation of Figure 4. The figure caption format should be same in manuscript. For example on page no 7 Figure 3 is written Fig. 3 and Figure 5 is written as Figure 5.**

   We apologize for the oversights regarding figure citations and formatting inconsistencies in our previous draft. We have audited the entire revised manuscript to ensure that all figures are cited in numerical order and that their formatting strictly adheres to the Atmospheric Measurement Techniques (AMT) house style:

   Explicit Citation of Figure 4: Figure 4 is now explicitly cited and discussed in Page 9 (Line 200) where the relationship between temporal smoothing windows and instrument response time is established

   Standardization of Figure References: All in-text figure citations have been audited and standardized to match AMT style rules:

   - Mid-sentence references consistently use the abbreviated form “Fig.” or “Figs.” (e.g., Fig. 3, Fig. 4, Fig. 5).
   - References at the beginning of a sentence consistently use the spelled-out word “Figure” (e.g., “Figure 6 illustrates...”).

5. **On Page 17, the manuscript refers to Equation (3); however, the equation itself is not presented. The authors should include the complete equation together with its appropriate citation and ensure that all mathematical expressions are correctly numbered and referenced.**

   We thank the reviewer for this observation, which helped us identify and resolve a source of potential reader confusion. We have verified the manuscript and would like to clarify that Equation (3) is indeed presented in the Introduction (Page 3, Line 73):

   $$C_{ml} = -\ln(1 - \frac{1}{\sqrt{N_0 t}})K$$

   It is properly cited as being derived from Wedding and Weigand (1993).

   The confusion arose because on Page 17 of the initial draft, we referred to this formula as *their "Eq. (3)"* (with quotation marks) to denote its historical origin. This phrasing inadvertently suggested that the equation was missing from our text or belonged to an unpresented external reference.

To ensure that all mathematical expressions are transparently referenced and easy to follow, we have revised the phrasing on **Page 18 (Line 305)** to explicitly guide the reader back to the earlier section.

6. **Provide a comparative table for proposed method with other recently reported BAM optimization techniques.**

We thank the reviewer for this excellent recommendation. We agree that presenting a systematic comparison with historical and modern beta gauge developments highlights our work's positioning and practical utility.
To address this, we have added a dedicated comparative table (Table 4) to the revised manuscript in Page 22. This table contrasts our proposed unified framework against classic hardware optimizations (geometry, source isotope, flat-flux alignment) and modern hybrid/mechanical designs, highlighting how our synergy overcomes the traditional limitations of single-detector beta gauges.

Table 4. Comparison of the proposed framework with key BAM optimization and hybrid methods.

Reference	Primary Optimization Mechanism	Key Metrological Focus
Dakubu (1978)	Modeling absorber geometric positioning between source and detector.	Minimizes measurement errors from filter position shifts
Jaklevic et al. (1981)	Beta source isotope selection (^{14}C vs. ^{147} Pm)	Achieved high precision (±5 μg cm^{-2}) for thin-film standards.
Klein et al. (1984)	Flux homogeneity via flat sources and wide detectors.	Eliminated errors from surface heterogeneities.
Park et al. (2001)	Mechanical automatic filter cassette exchange mechanism utilizing discrete Teflon filters.	Drastically minimized sampling dead-time loss and long-term ambient drift via rapid, automated calibration standards.
Huang et al. (2022)	Hybrid light-scattering coupled with beta attenuation.	Fast optical response times to interpolate PM mass.
This Study (2026)	Synergistic concentrated deposition + multi-sensor ensemble averaging.	Simultaneously minimizes LOD and response time.