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Efficacy of a portable, moderate-resolution, fast-scanning differential mobility analyzer for ambient aerosol size distribution measurements

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S1. Finite element modeling

S1.1. *Spider DMA geometry and boundary conditions*

Figure S1 shows the geometry and boundary conditions employed in the Spider DMA finite element modeling. A 2D axisymmetric model was considered to reduce computational complexity. In the radial geometry of the Spider DMA, a 0.9 L/min sheath flow (Q_{sh}) and a 0.3 L/min polydisperse aerosol flow (Q_{a}) enter the classifier at a large radius (∼42 mm) and exit at a small radius near the center of the geometry as excess (Q_{ex}) and classified aerosol (Q_{c}) flows. The area shown with light blue color corresponds to the modeling flow domain. Electrode voltage was varied exponentially between 5–5000 V in 30 s scans. Both upscans and downscans were simulated.

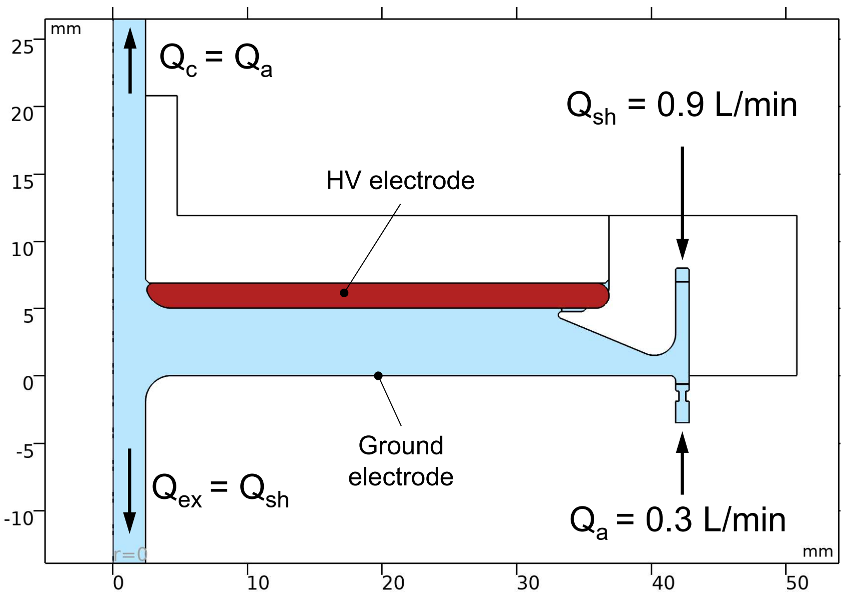

Figure S1. Geometry of the Spider DMA used in the 2D finite element modeling. Light-blue shaded area corresponds to the modeled flow domain. Flow conditions: 0.9 L/min sheath (Q_{sh}) and excess flows (Q_{ex}); 0.3 L/min sample (Q_{a}) and classified (Q_{c}) aerosol flows.

S1.2. *Particle trajectories*

Figure S2 demonstrates the trajectories of 200 nm particles in the Spider DMA over a 30 s upscan. Charged particles entering the classifier migrate across the ground and high-voltage electrodes as a result of the electrostatic force induced by the electric field formed between the electrodes. The example shown is an excerpt of the scan at an instant where the majority of the incoming particles reach the classifier exit flow (i.e., near the peak transmission of the scanning transfer function). Short particle injection intervals allow for a quasi-continuous flux of particles over the scan. Owing to the radial DMA geometry, particle velocity is low at the entrance of the DMA, and progressively increases as particles move toward the center of the classifier.

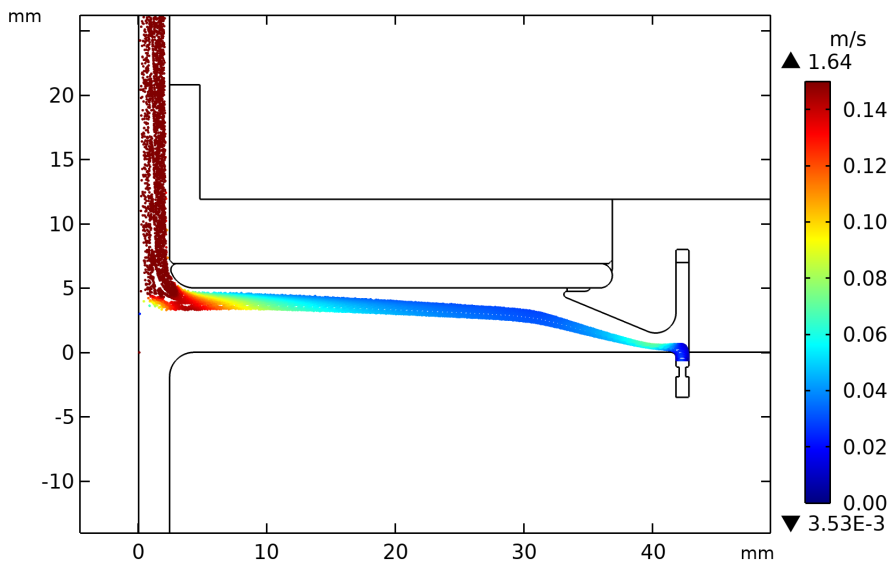

Figure S2. Finite element modeling of particle trajectories in the Spider DMA over a 30 s upscan. 200 nm particles are released in the inlet of the classifier (large radius) and exit at the center. This example is a snapshot of the voltage ramp at which the majority of incoming particles reach the classifier exit. Color indicates particle velocity.

S1.3. *Transfer function parameters - upscans vs. downscans*

The scanning transfer function of the Spider DMA was evaluated with finite element modeling, and those results where subsequently fitted to Gaussian functions as shown in Figure 2 in the main manuscript. Figure S3 demonstrates a comparison between the parameters of those fitted curves for upscan and downscan transfer functions. Peak height ($\Omega_{\max}$) over downscans is consistently higher than upscans, by a factor of about 1.26 across the operating voltage range of the instrument; downscan peaks width (σ) is narrower than upscans, by a factor of about 0.82. Since the area below the transfer function is proportional to the product of peak height ($\Omega_{\max}$) and width (σ), the resulting difference in the transfer function area, to a large extent, cancels out. Note that the area is proportional to the total transmission efficiency of the transfer function. On average, the area of the Gaussian peaks used to fit the modeling data for downscans is 3.5% larger than upscans.

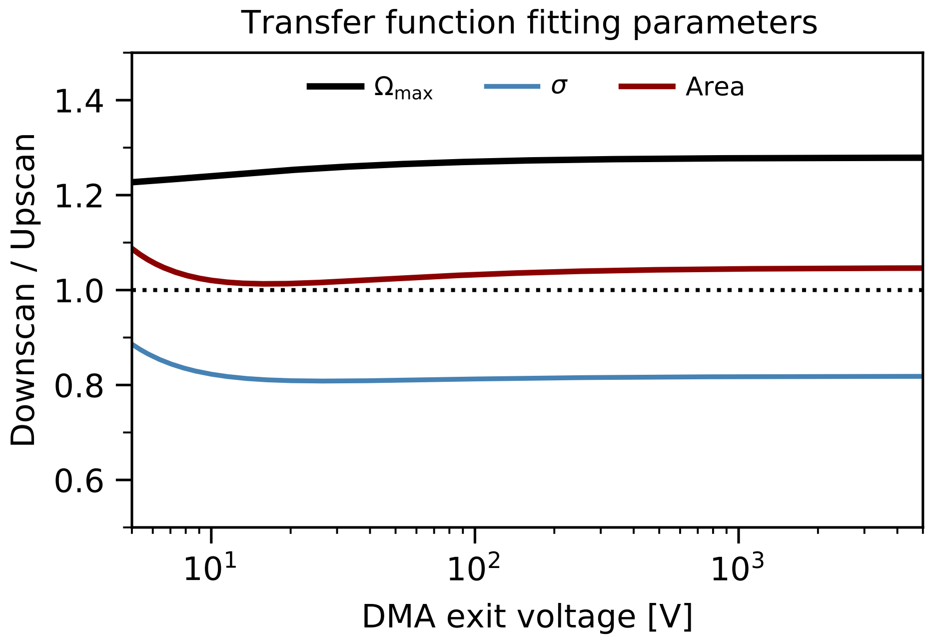

Figure S3. Ratio of downscan over upscan transfer function peak height ($\Omega_{\max}$), width (σ), and Area, as a function of the Spider DMA scanning voltage. The comparison refers to the parameters of the Gaussian functions employed to fit the Spider DMA finite element modeling data.