

# Noise biases exciton transport measurements in nanocrystal solids

## CNR-calibrated correction restores accuracy

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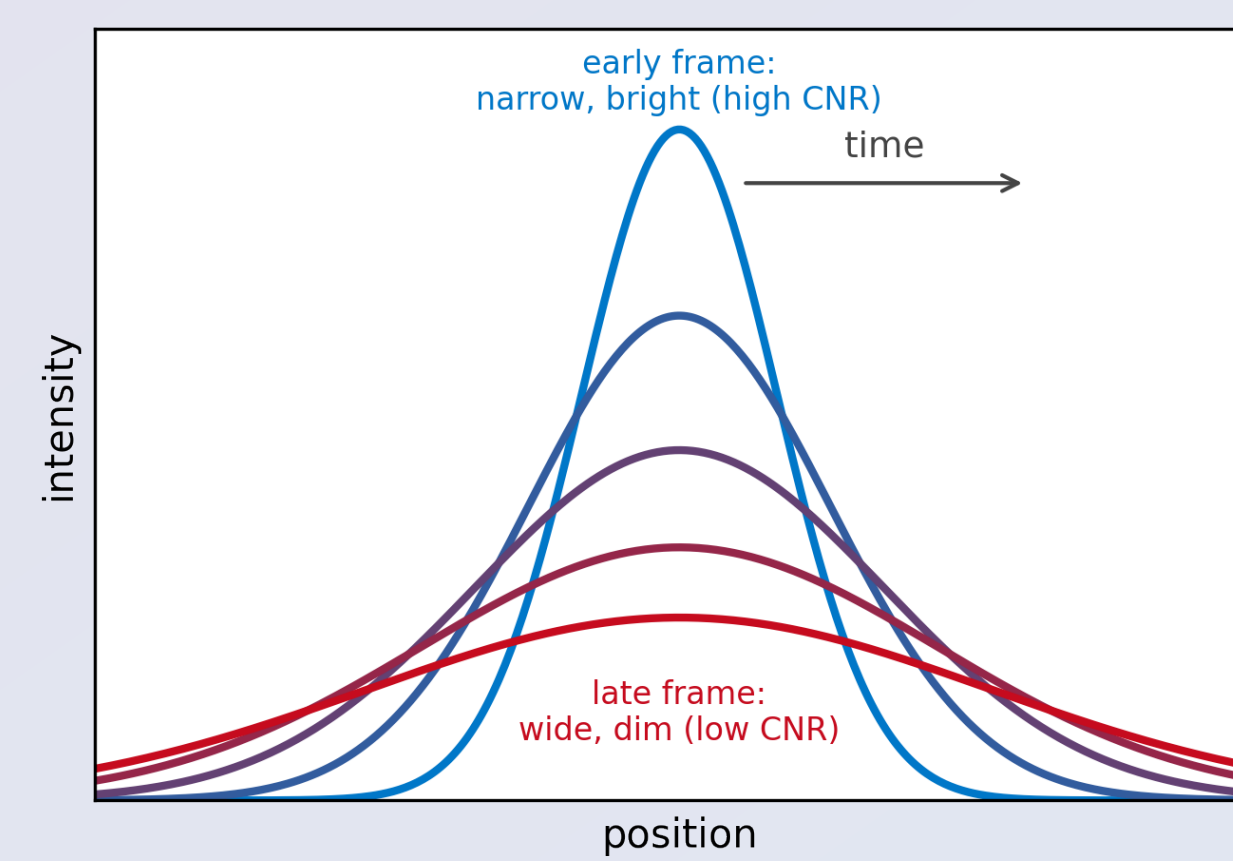


for:    ...averaging won't save you

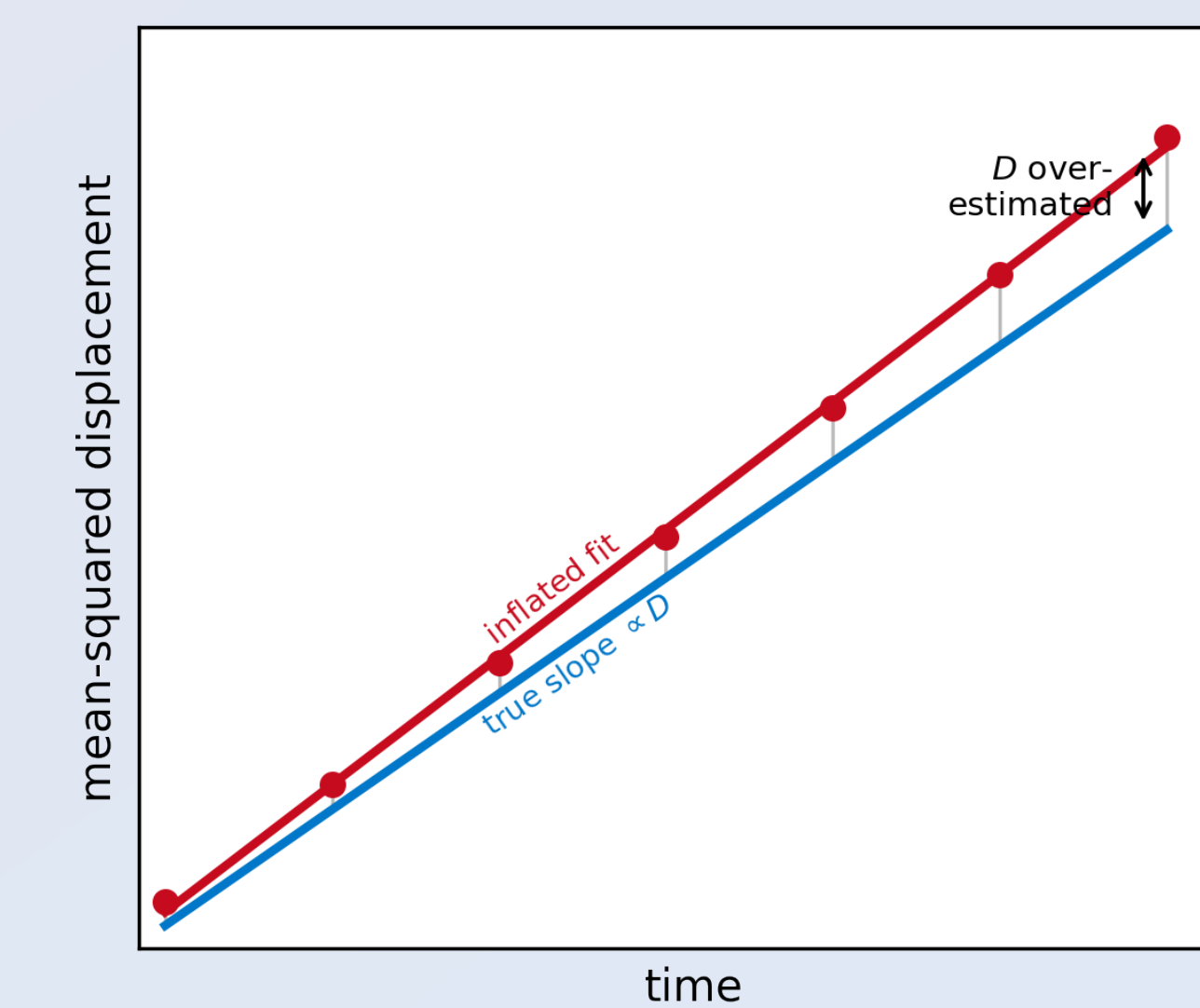
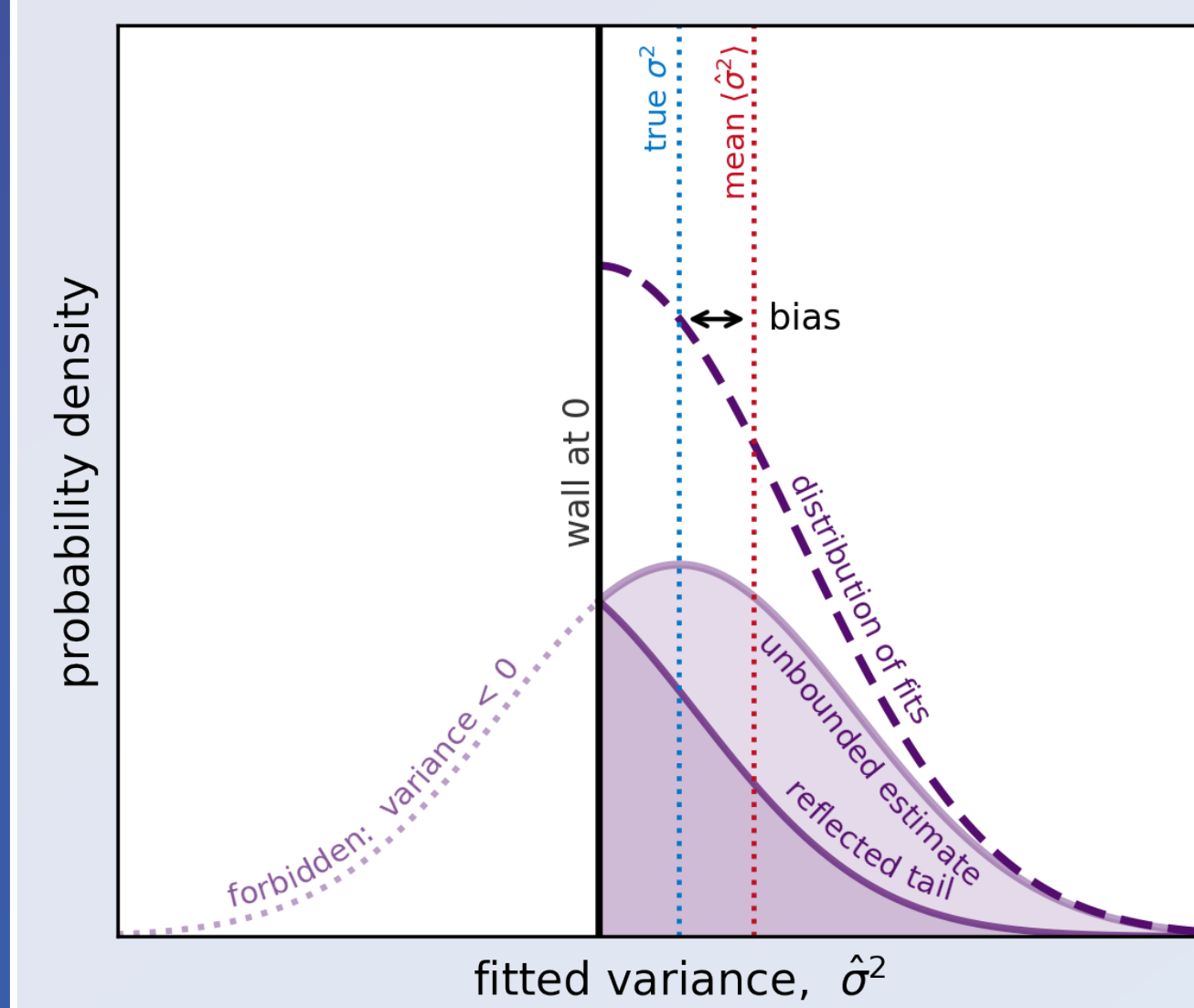
### Highlights

- A profile-width ( $\sigma^2$ ) fit cannot go negative, so when contrast falls, low-*CNR* fits skew high. This inflates *D* (by up to an order of magnitude) and pushes the subdiffusive exponent  $\alpha$  toward the ballistic limit.
- It is a **bias, not mere imprecision**: averaging the fitted values across repeated measurements does not remove it. Only higher per-frame contrast does.
- A calibration keyed on per-frame *CNR* **subtracts the bias** from each frame, independent of the *D* or  $\alpha$  being measured. The only data input is *CNR*, from the open-source **fft-cnr** package. Validated across Gaussian, Voigt, and generalized-Gaussian profiles.

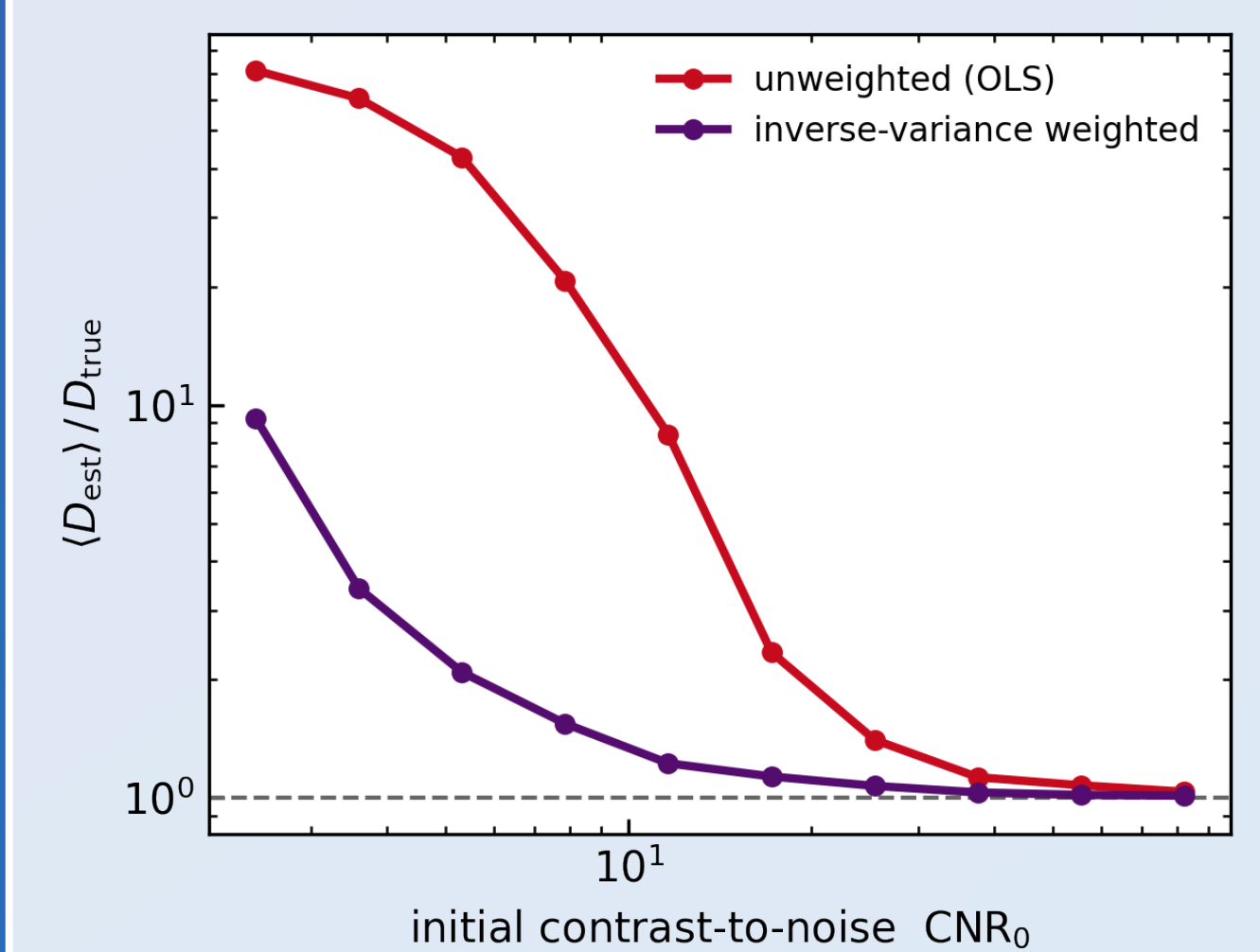
### Every frame is wider, dimmer, noisier



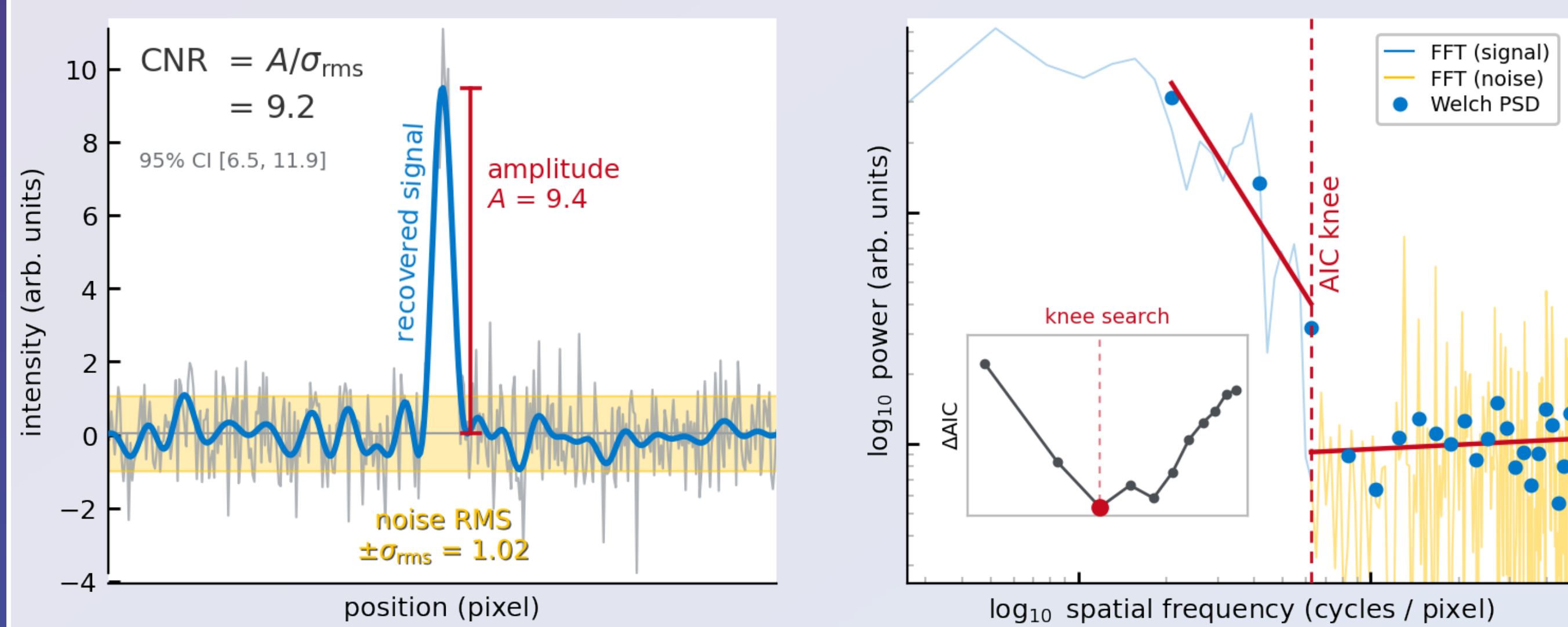
### A width can't go negative, so noise only inflates it



### Weighting doesn't fix it

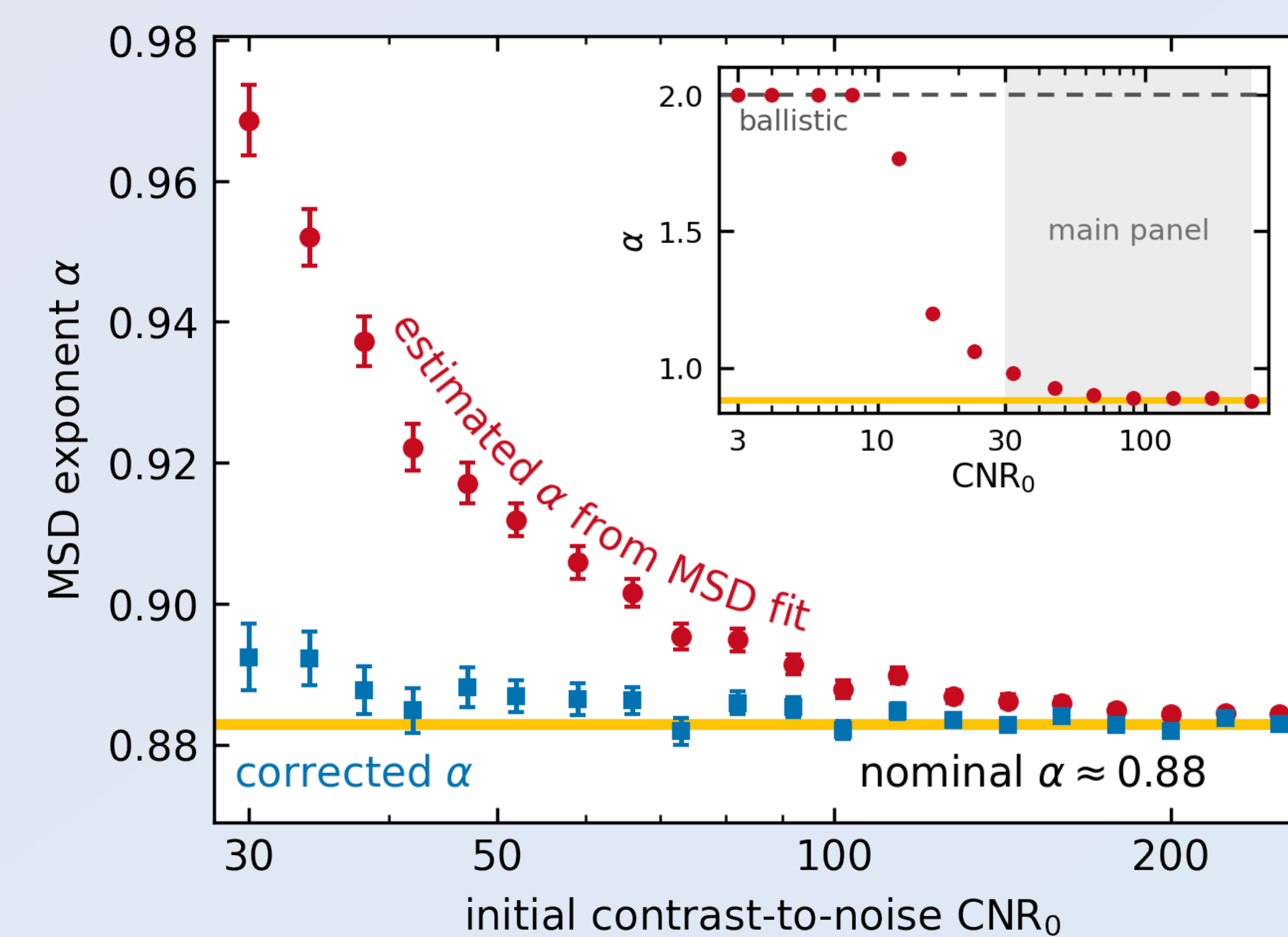


### You can measure the CNR



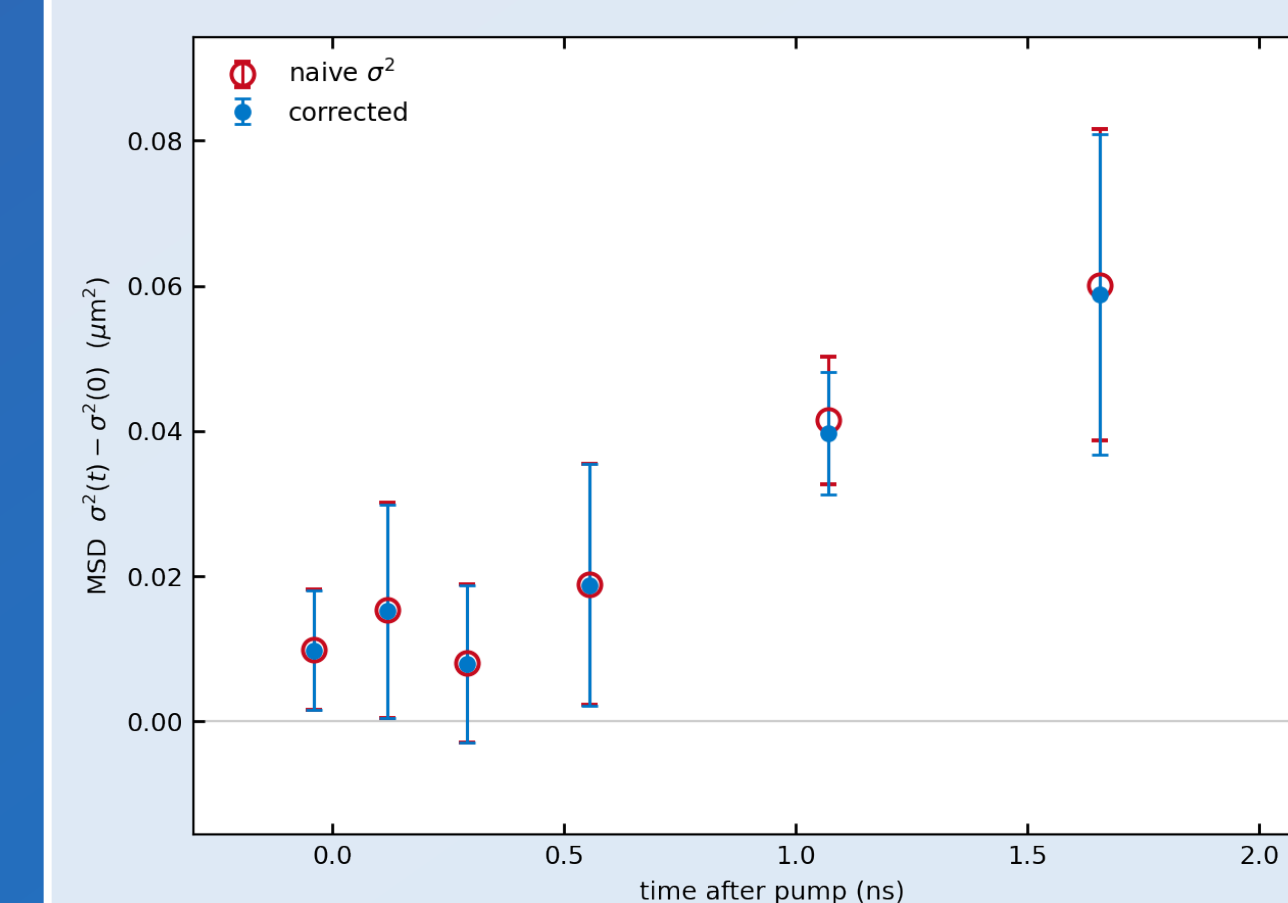
**fft-cnr** [1] reads the per-frame contrast-to-noise straight from one intensity profile. Left: a noisy profile (gray) with the recovered signal (blue); the contrast-to-noise ratio is the peak amplitude over the noise RMS. Here  $CNR = 9.2$ , with a 95% confidence interval of 6.5 to 11.9. Right: the estimate is spectral. Low-frequency signal power (blue) stands above a flat high-frequency noise floor (yellow); an Akaike-information-criterion knee (red) locates the frequency where signal gives way to noise, and the floor fixes the noise RMS. The open-source **fft-cnr** package returns the *CNR* and its confidence interval for every frame.

### The subdiffusive exponent is biased and recoverable



Apparent MSD exponent  $\alpha$  against  $CNR_0$  for a realistic-width bed built from an exciton-hopping map from [2] with nominal  $\alpha = 0.883$ , gold line. The inset extends to low contrast, where the naive exponent saturates at the ballistic ceiling ( $\alpha = 2$ ). White measurement noise is scaled to each  $CNR_0$ , and  $\alpha$  is read from the MSD averaged over 64,000 independent noise realisations. Bed:  $250 \times 250$  spatial bins, 20 frames, exciton lifetime  $\tau = 7$  ns.

### Correcting bias on real stroboSCAT data



Binned MSD ( $\mu\text{m}^2$ ) versus time for a MoSse alloy: naive fitted  $\sigma^2$  (red) and folded-normal-corrected  $\sigma^2$  (blue). Binning removes the per-frame scatter, but the systematic bias survives averaging, so the correction shows on every binned point.

Monte Carlo on reference:

- $\sigma_0 = 1, \tau = 1$ ,
  - $D = 0.02 \sigma_0^2 / \tau$ ;
  - 12 frames from 0 to  $t_{\text{final}} = 3\tau$ ;
  - 241 pixels over  $\pm 6\sigma_0$ .
- Points are decile averages of a dense  $CNR_0$  sweep.

### References

- Thiebes, J. J. (2026). *fft-cnr*. Zenodo. <https://doi.org/10.5281/zenodo.20691435>
- Solari et al., *Exciton Transport in Disordered Perovskite Nanocrystal Solids*, 2026 (in revision).

More info:

