Study of turbulence and transport in mirror geometries in the LAPD

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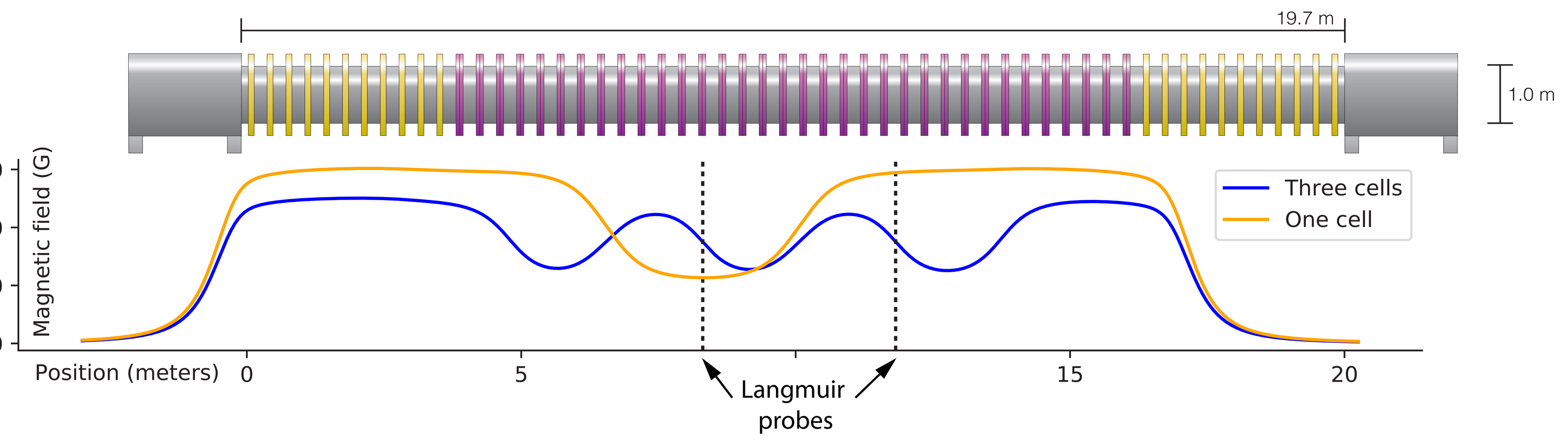
Motivation and results

- Does adding magnetic curvature drive change turbulence? **There are hints that it does**
- **Increasing mirror ratio results in decreased density and magnetic fluctuation amplitudes, but floating potential remains approximately flat**
- Radial particle flux decreases with increased mirror ratio

LAPD and discharge specifications

- Plasma length: 19.7 meters
- Inner diameter: 1.0 meter
- Discharge period: 12 ms
- Density: ~10^{12} particles / cm^3
- Ion cyclotron frequency: 383.6 kHz



Diagnostics

- 4-tip Langmuir probes for floating potential (x2) and ion saturation current
- Magnetic field fluctuations (bdot)
- 6.25 MHz effective sampling rate (16-sample average)
- 0.5 cm spatial resolution

Analysis methods

- Analysis is over the approximately quiescent period (4.8 ms to 11.2 ms)
- Fluctuations calculated by de-trending profiles
- Summed fluctuation power, particle flux, and cross-phases calculated from fluctuation DFTs
- Fluctuations between 1 kHz and 200 kHz were analyzed
- Phase reference was a 4-tip Langmuir at r=27 cm and outside of the mirror

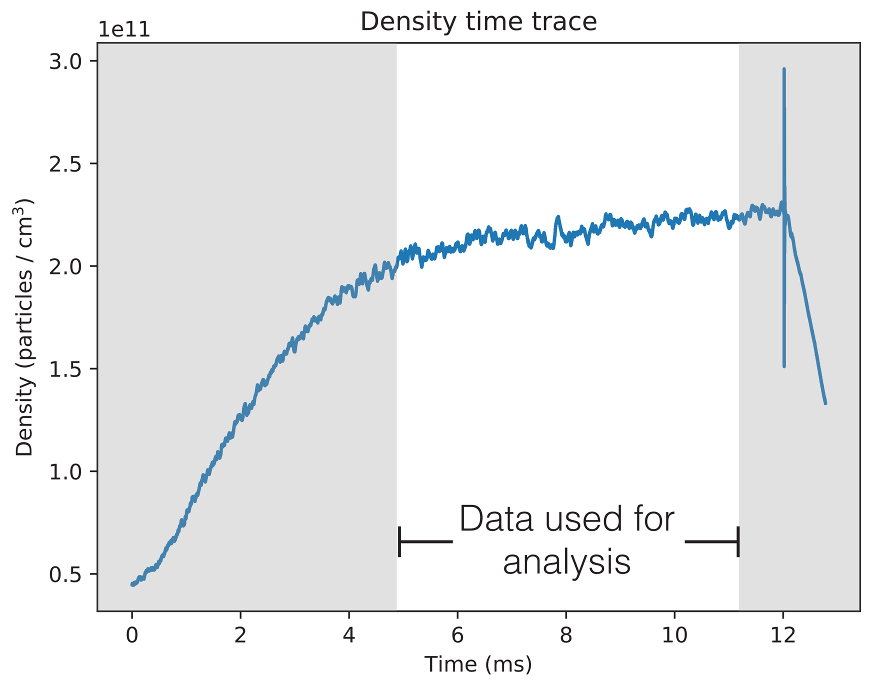
Magnetic field configurations

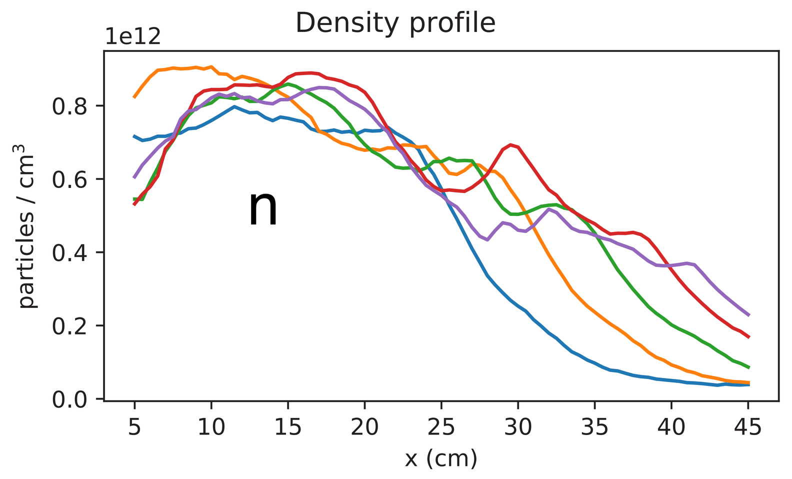
Single mirror cell

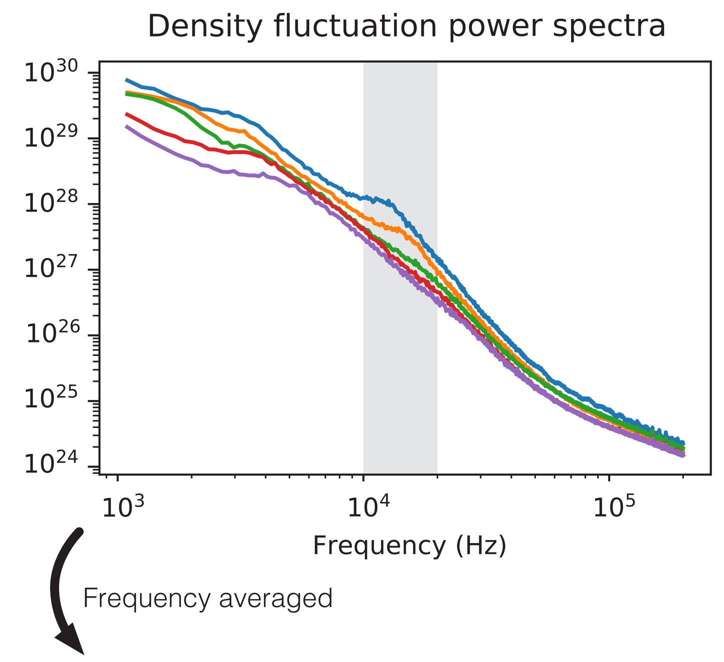
- Constant 500G at center of machine
- Flat magnetic field for reference
- **Mirror ratios: 1.5, 2.0, 2.5, 3.0**

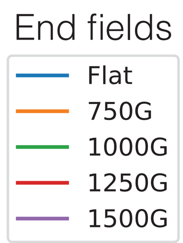
Three mirror cells

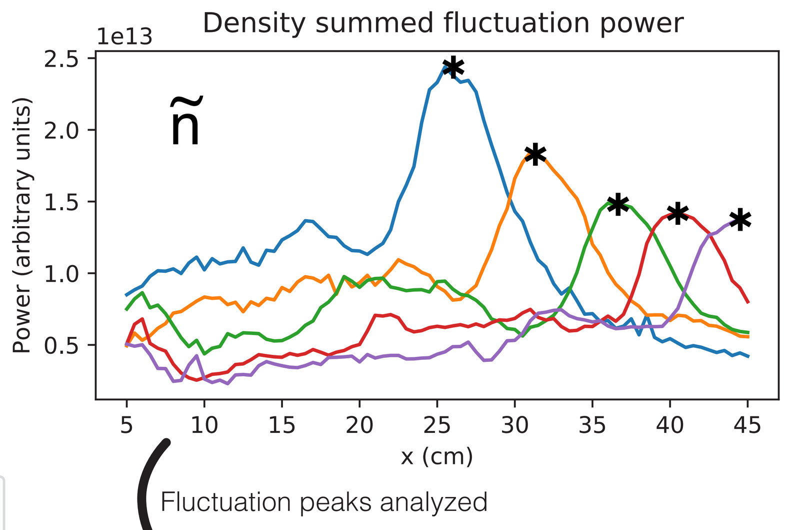
- Flat magnetic field for reference
- **Mirror ratios: 1.5, 1.9**

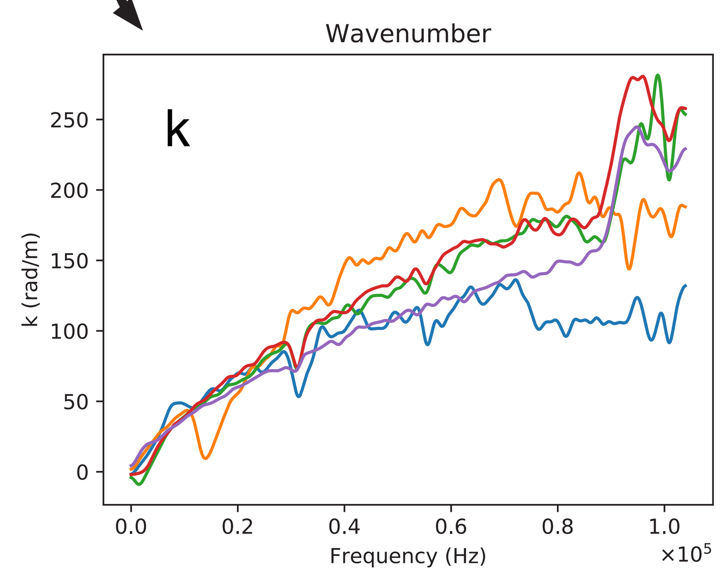


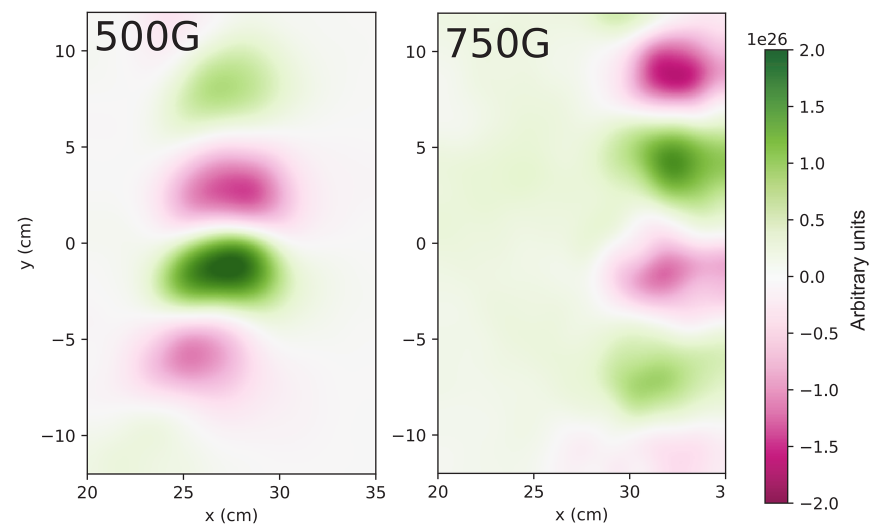


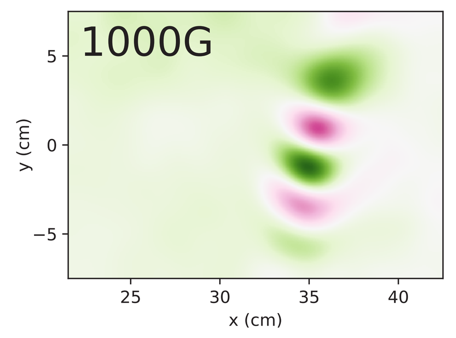






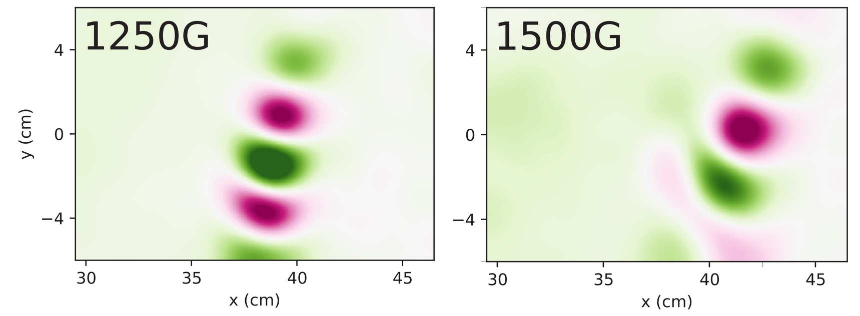


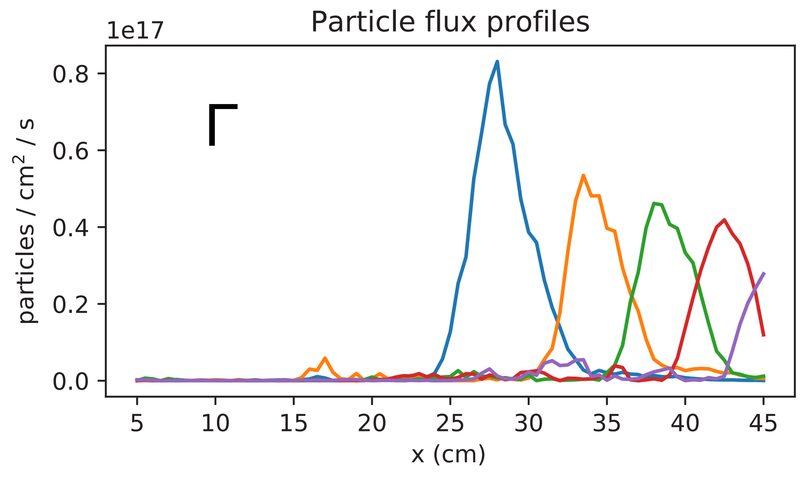


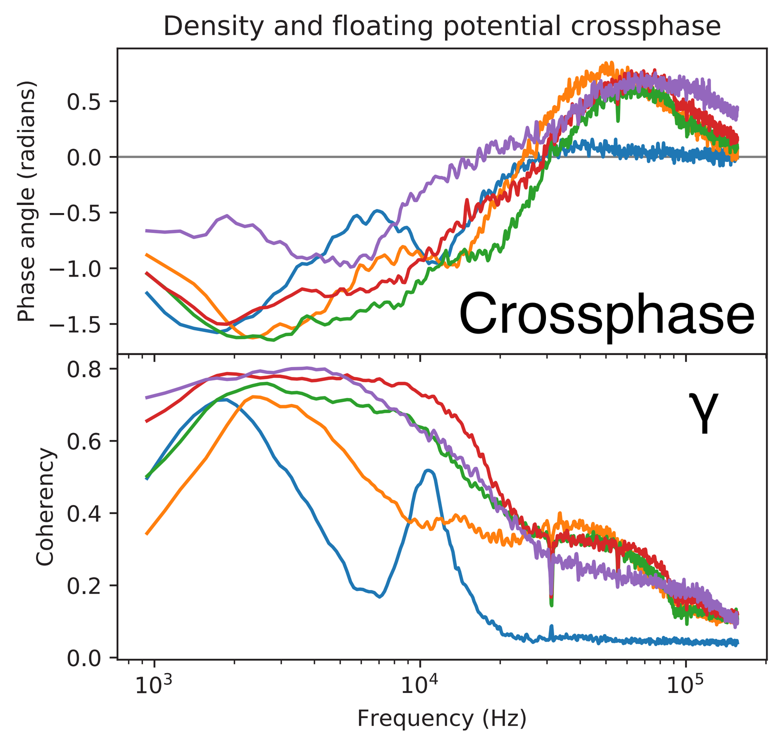


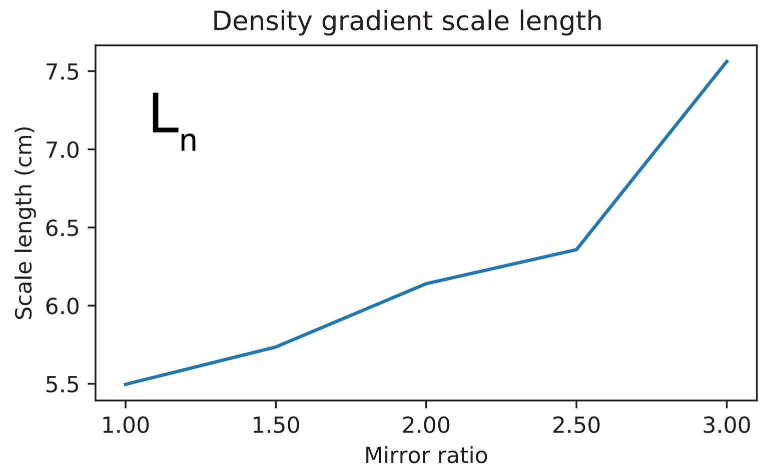
Density-reference cross-spectrum

- Averaged from 10-20 kHz
- Gaussian smoothing (σ = 0.75 cm)





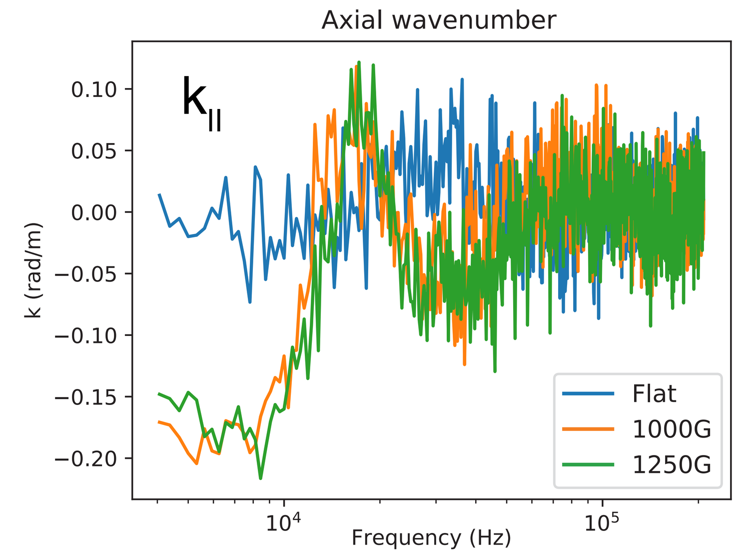


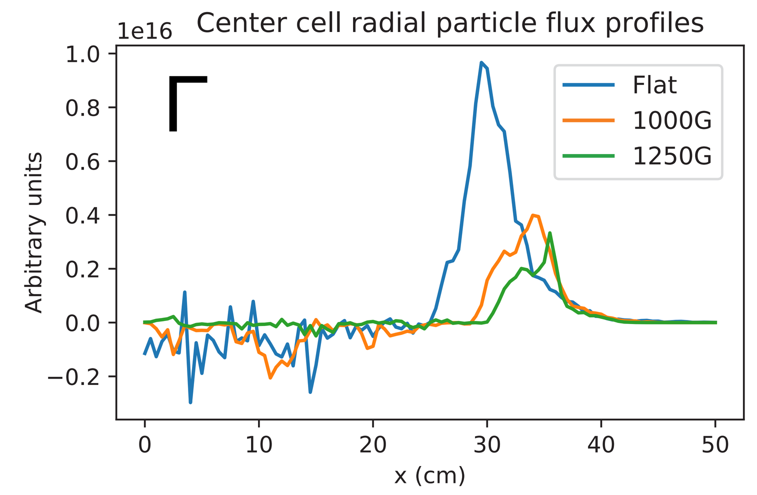


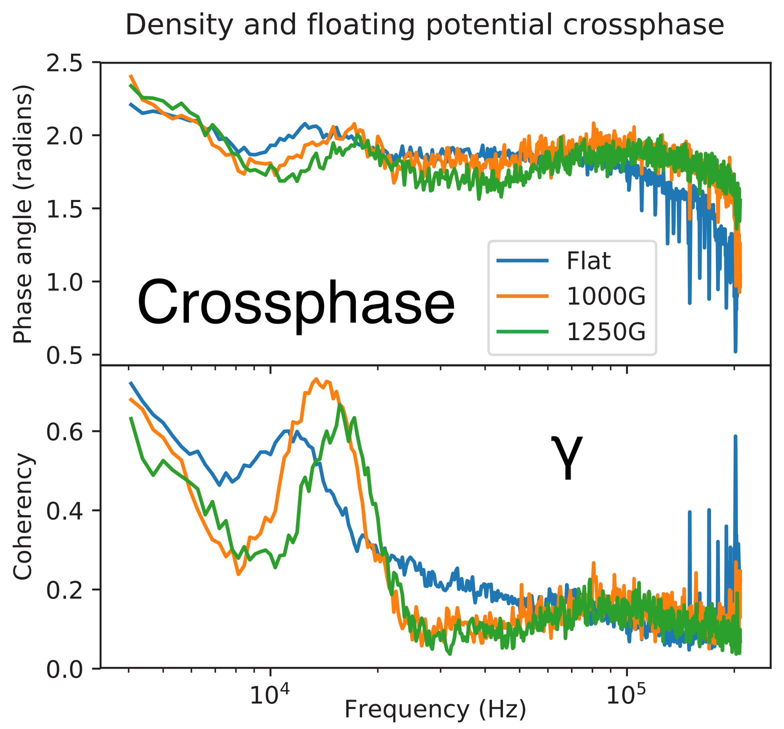
With increasing mirror ratio:

- density and floating potential profiles shift radially outward because of the magnetic field flare
- floating potential decreases
- **density fluctuation amplitudes decrease**
- floating potential fluctuation amplitudes remain constant

3 cell mirror







Summary of results

Single mirror

- **There are hints of changes in turbulence with the addition of magnetic curvature**
- Increasing mirror ratio does not appreciably change the floating potential fluctuation power, but density and $B_\perp$ fluctuations decrease
- Radial particle flux decreases with increased mirror ratio
- Particle flux and density gradient length scale results are counterintuitive
- Phase velocity is in the same direction and comparable to diamagnetic phase velocity
- **Particle flux decreases with increased mirror ratio, but the profiles relax**
- Changes in crossphase of density and floating potential fluctuations give evidence of new instabilities

3-cell mirror

- Profiles are similar to single-celled case
- Changes in axial (parallel) wavenumber suggests shifts in the underlying instabilities
- Particle flux decreases with introduction of mirror cells, but increased end field may have little effect
- Decrease in crossphase in 3-cell mirrors also indicates changes in underlying instabilities

Future work

- Measurement and analysis of 3-celled mirror structure
- Comparison of gradient-free and high-field-gradient positions
- Comparison with existing literature

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