

Actuation Force Study of Next Generation Micro Shutter Array for More Reliable Actuation

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INTRODUCTION: Micro shutter array (MSA) is a programmable optical spatial filtering device fabricated by MEMS technology, which was originally developed for James Webb Space Telescope to enable multi-object spectroscopy. Next Generation Micro Shutter Array (NGMSA) is an effort to improve JWST MSA by eliminating macroscopic actuation magnet and using electrostatic force to achieve simple and reliable instrument that can support NASA's multiple future missions. We have been fabricating NGMSA with design inherited from JWST, however the legacy design is not friendly for electrostatic actuation because applied force direction on the moving shutter blade is different. We use COMSOL AC/DC module's electrostatics feature to understand electrostatic force applied on an individual shutter within a range of motion and study new candidate designs. Also, structural mechanics module is used to study torsion bar's restoration force.

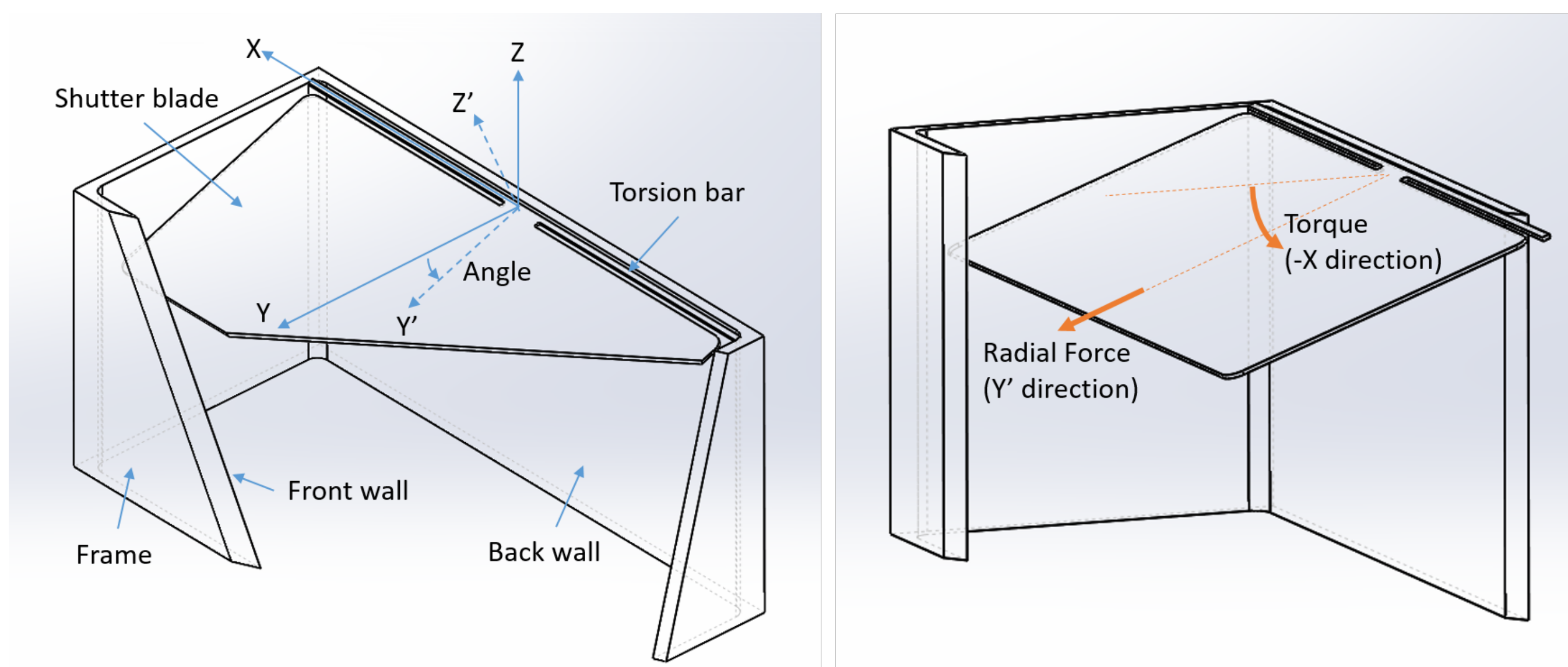


Figure 1. Description of unit micro shutter (left) and analyzed force components (right)

COMPUTATIONAL METHODS: Electrostatic model – half of a unit shutter with a range of shutter positions are used as computation geometry. Solid mechanics model – one side of a symmetrical torsion bar is used for computation geometry

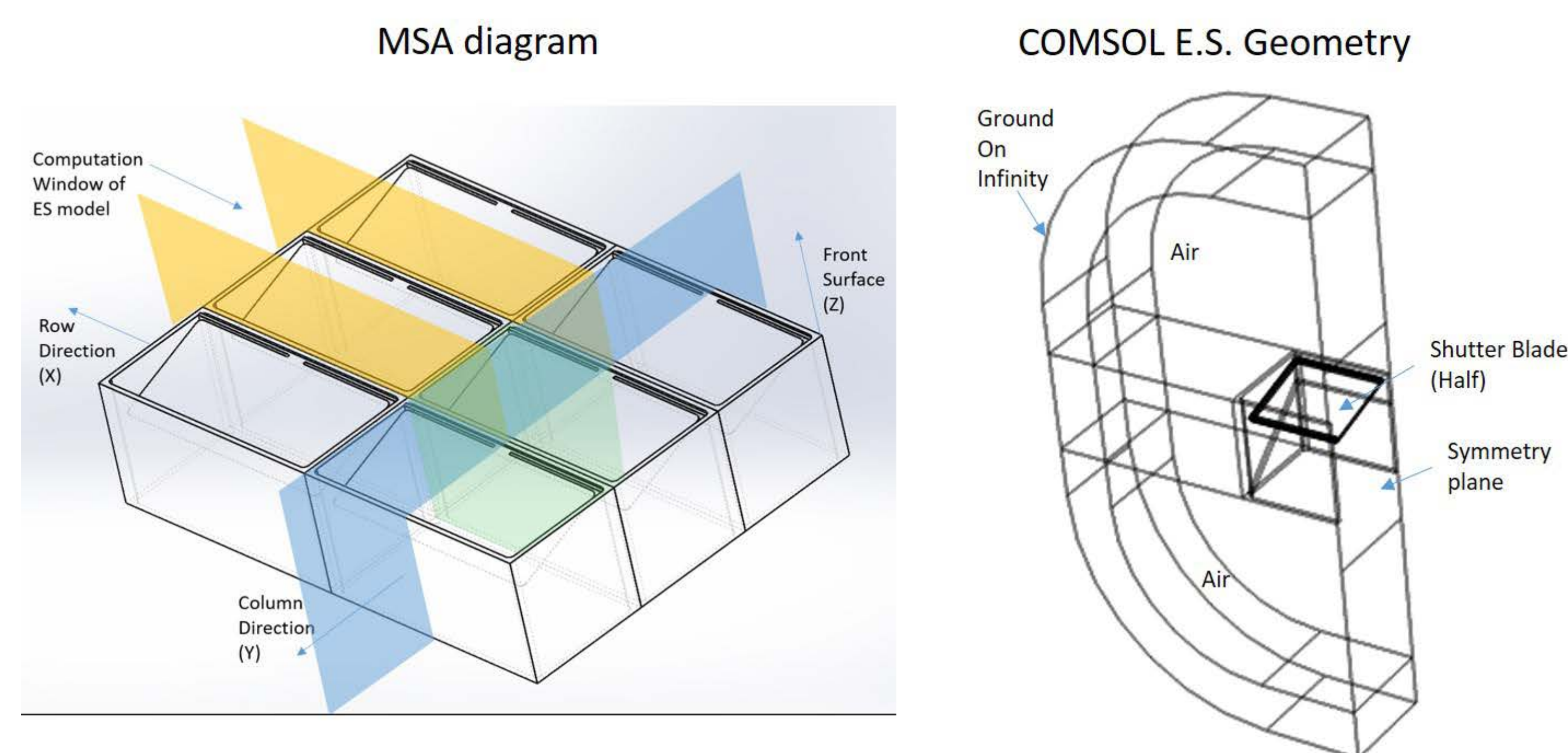


Figure 2. Parts of MSA used for electrostatic computation geometry (left) and a sample COMSOL geometry (right)

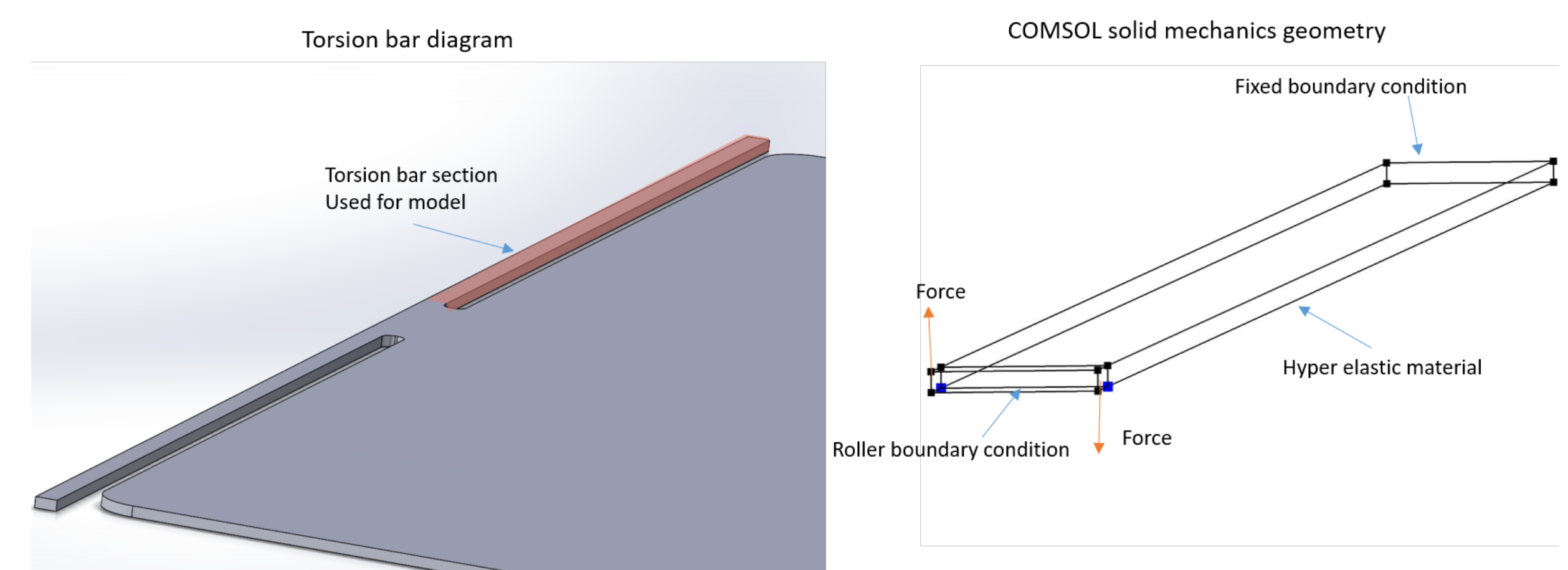


Figure 3. Parts of MSA used for solid mechanics computation geometry (left) and a sample COMSOL geometry (right)

RESULTS: Electrostatic torque and radial force are calculated from electrostatic model and restoration torque by torsion bar is calculated from solid mechanics model.

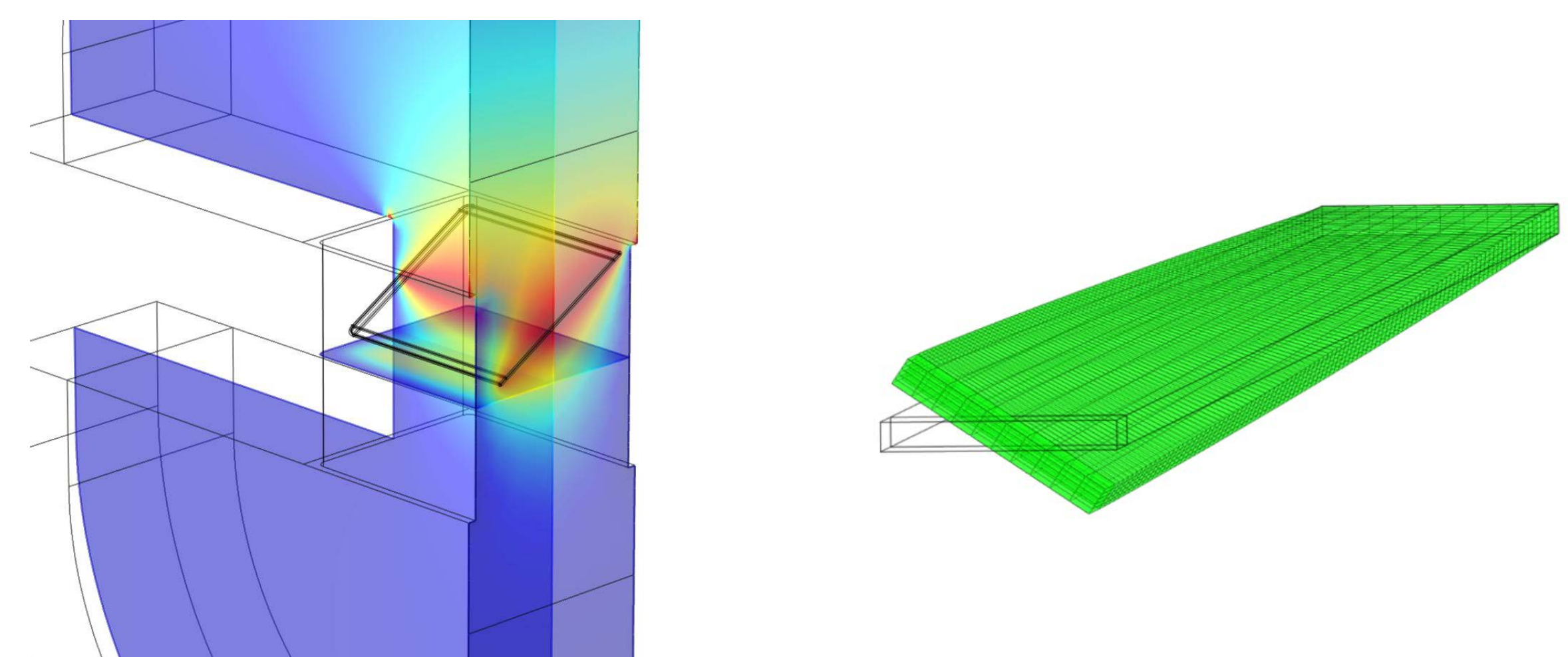


Figure 3. Electrostatic model (left) and solid mechanics model (right)

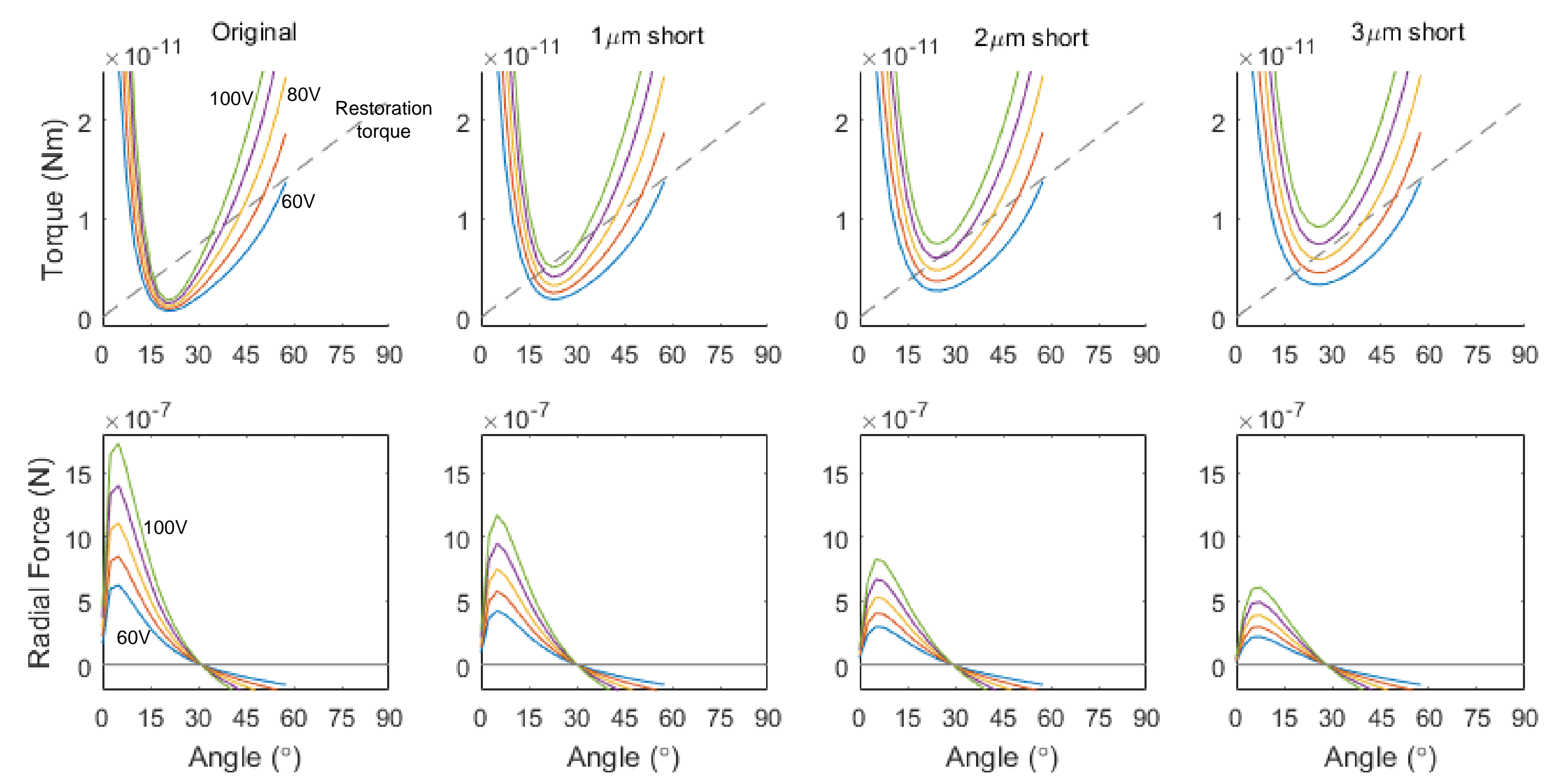


Figure 4. Electrostatic torque and radial force calculation result with varying shutter blade length. Shorter blade length increase mid-range torque and minimize radial force, hence makes electrostatic actuation easier than original shutter blade design.

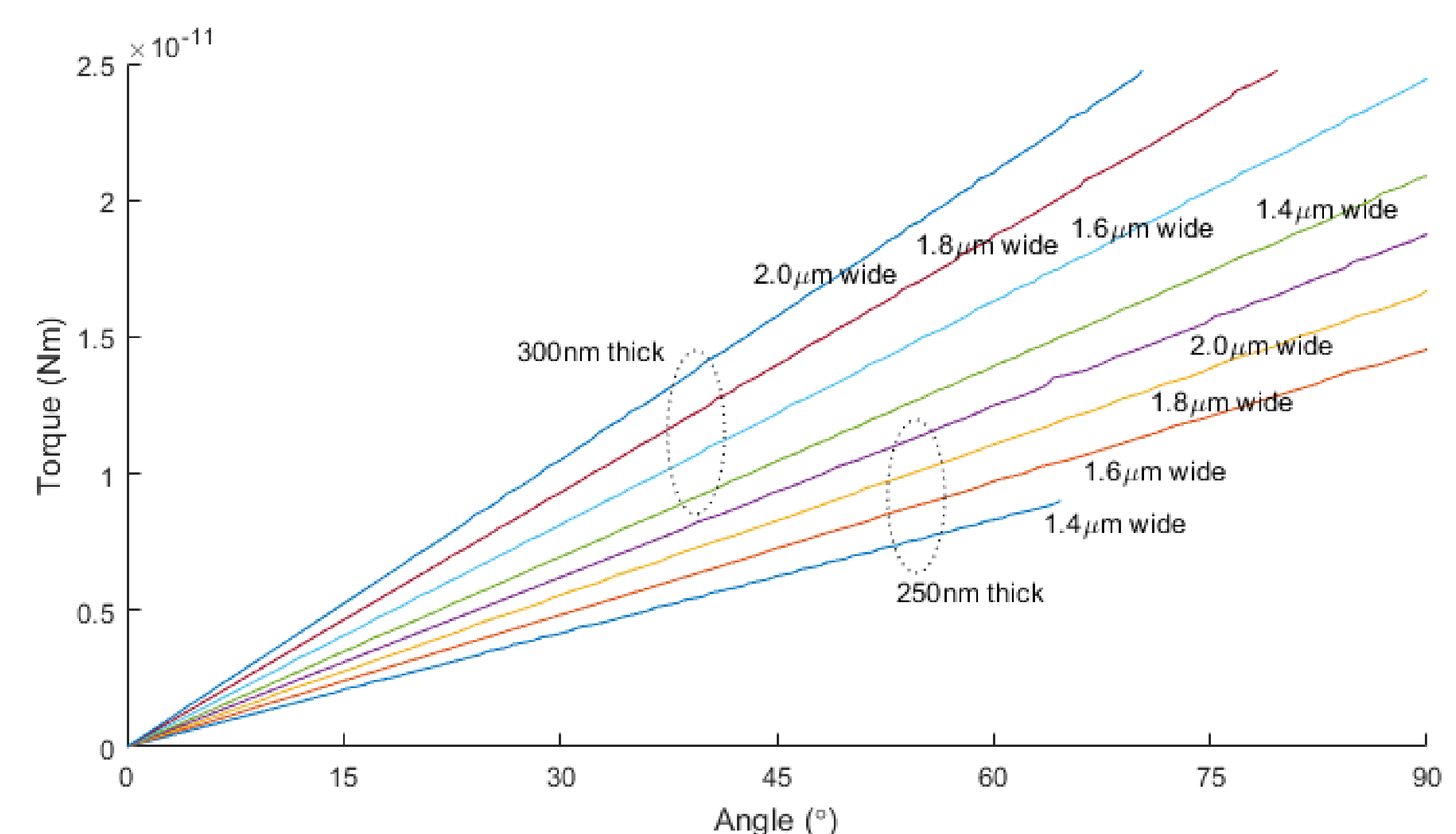


Figure 5. Restoration force calculated by solid mechanics model variation of torsion bar dimension results in different restoration force (torsional stiffness)

CONCLUSIONS: How electrostatic force is applied on a shutter blade is studied. Also, mechanical restoration force is studied for comparison. Original design suffers from reverse net torque regime which makes electrostatic actuation difficult. Result from modified design show better torque profile for easier actuation.