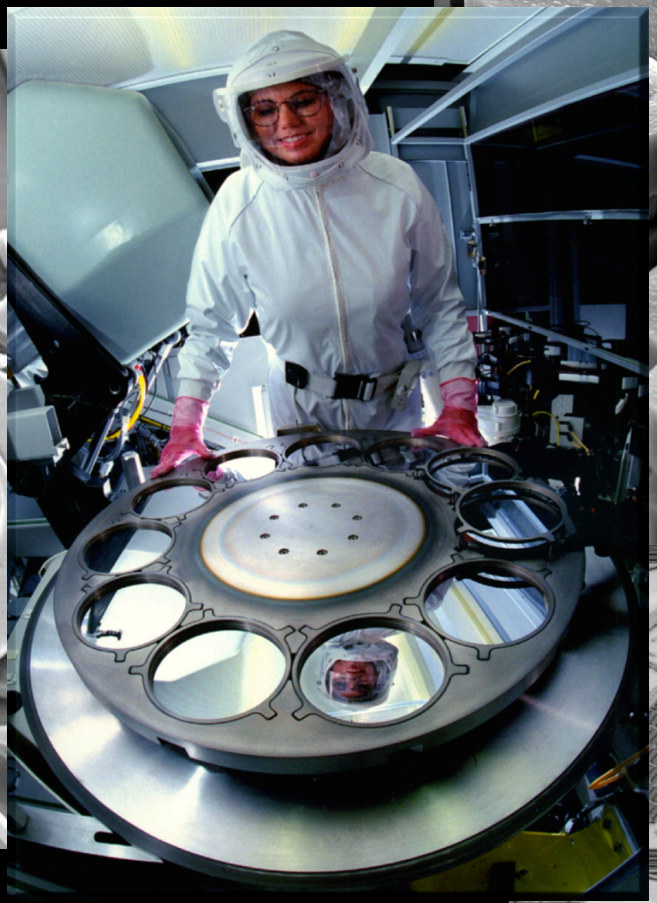
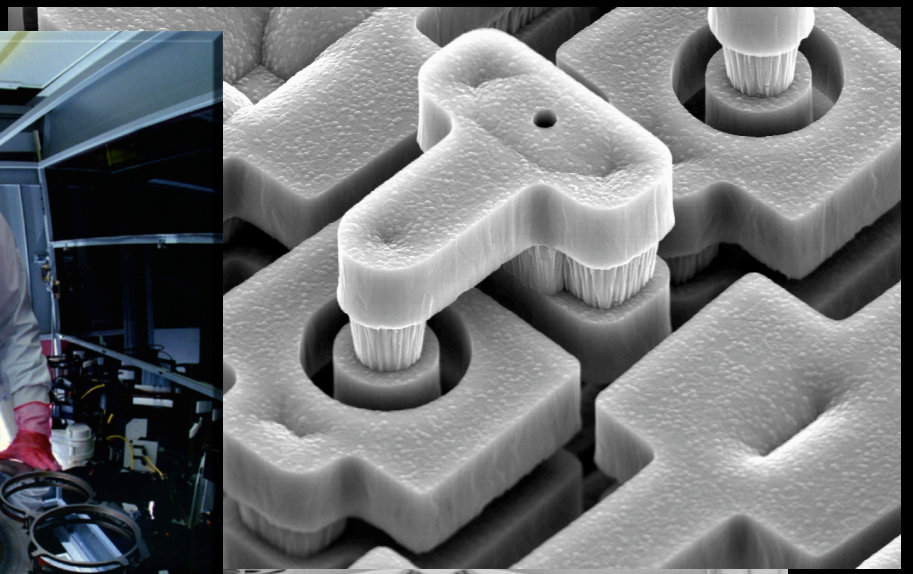
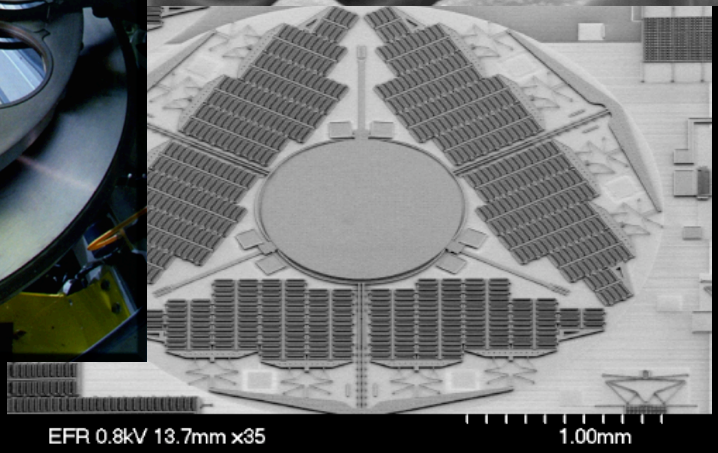
Introduction to MEMX







MEMX Background

MEMX's founding team includes Paul McWhorter, Sam Miller, Jeff Sniegowski, and Steve Rodgers

- Formed in October, 2000 as a spin-off from Sandia National Laboratories
- MEMX will commercialize Sandia's revolutionary SUMMiT V MEMS technology
- MEMX technical team includes the key SUMMiT V inventors, developers and designers
- MEMX benefits from the $100 Million investment Sandia has made in developing SUMMiT V over the last ten years
- Top notch investor backing: Sequoia Capital, Austin Ventures, Agilent

MEMX Mission and Status

Translate the world's best MEMS technology into significantly successful commercial products.

MEMX will focus on excellence in engineering and product development and will partner with established companies to provide sales and marketing expertise.

MEMX has active programs in: RF MEMS, adaptive optics, optical telecom, national security, and medical devices

Programs funded via NRE (5 corporate partners) and/or government grants ($1.2M to date from NASA, NSF, NIH)

CfAO TMT Discussion

08/19/04

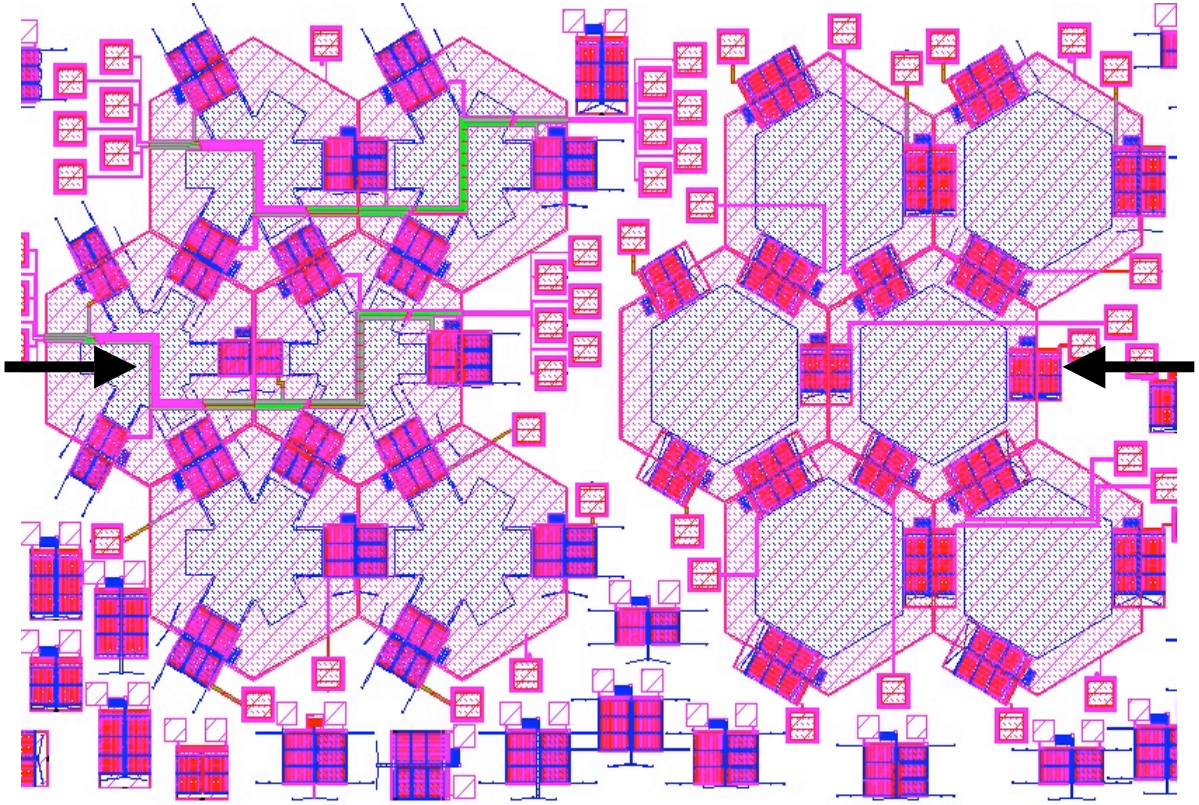
MEMX AO Program

NSF SBIR Funding

- Phase 1: July-December 2003; $100K
- Phase 1 focused on fundamental buried actuator design and fabrication; mini-arrays of hex pixels
- Phase II: August 2004 through July 2006
- Phase II focuses on:
  - Mirror flatness via improved mechanical design
  - Blanket metallization techniques
  - Full-size array design and fabrication
  - Additional optical modeling

Mini-Array CAD Drawings

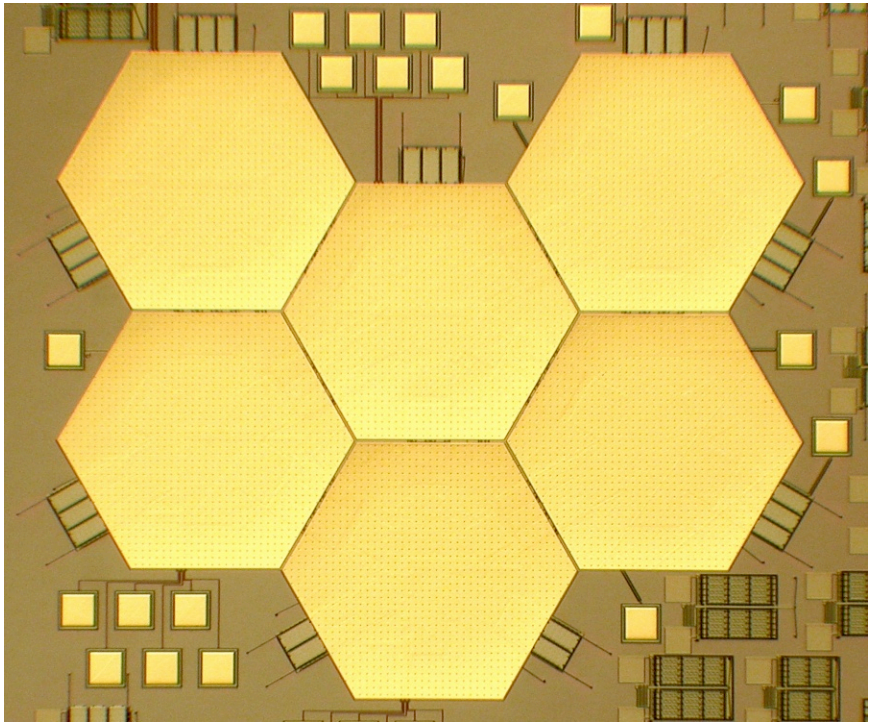
6 Element Mini-Array with Baseline Actuators



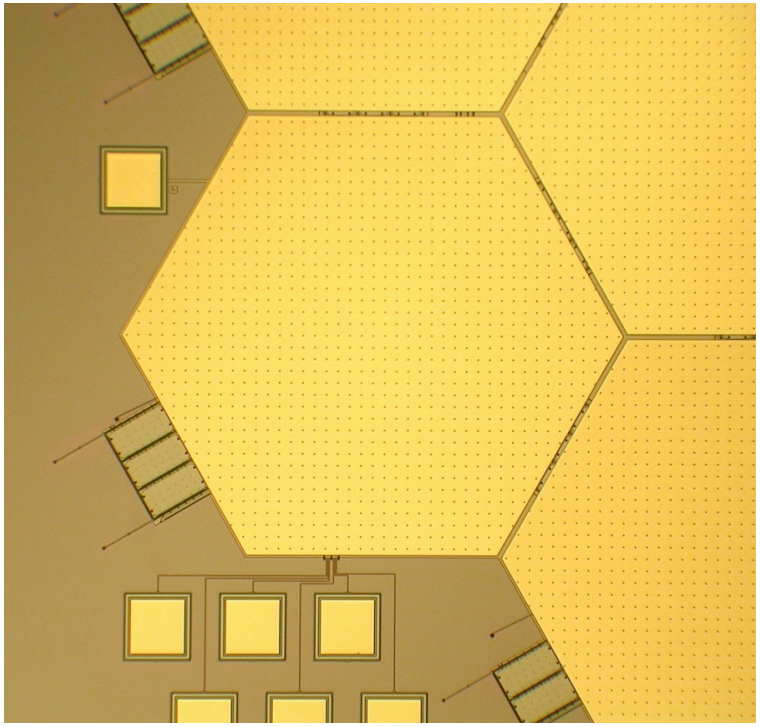
6 Element Mini-Array with Compact Actuators

Gold-Coated Mini-Array Photos

Gold-coated Mini-Array

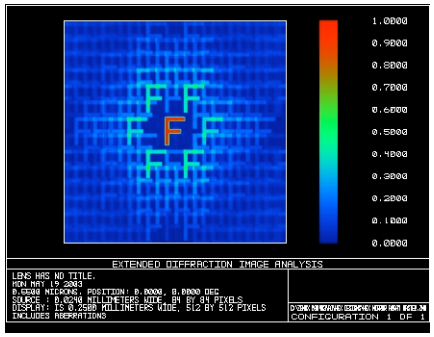


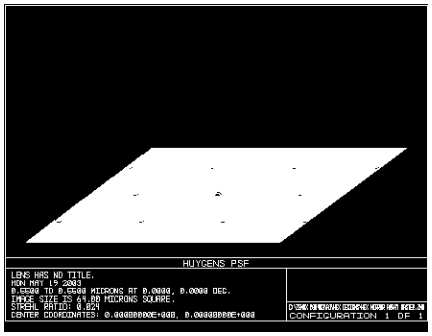
Hexagonal Mirror Close-Up



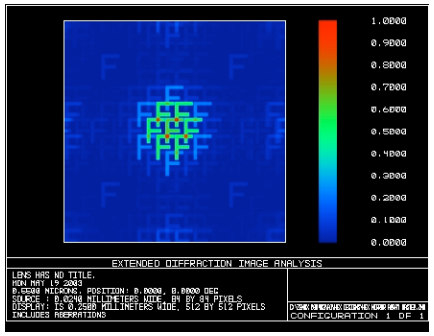
Impact of Mirror ROC on Strehl

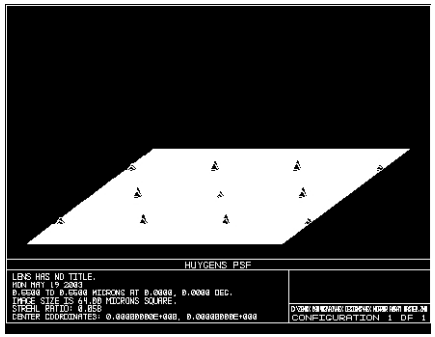
500micron, 100mm ROC Hex Pixel



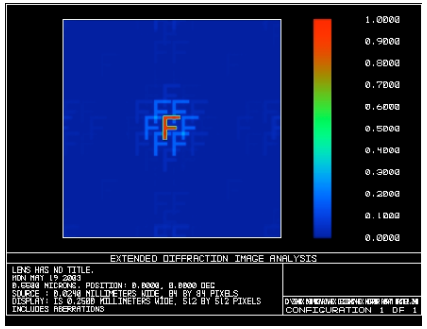


500micron, 175mm ROC Hex Pixel



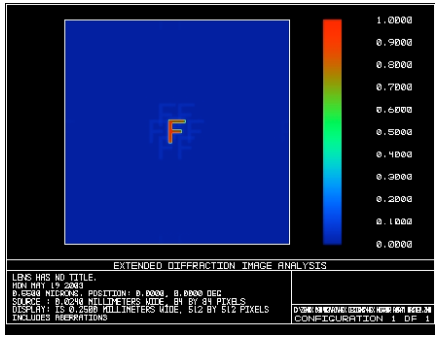


500micron, 250mm ROC Hex Pixel

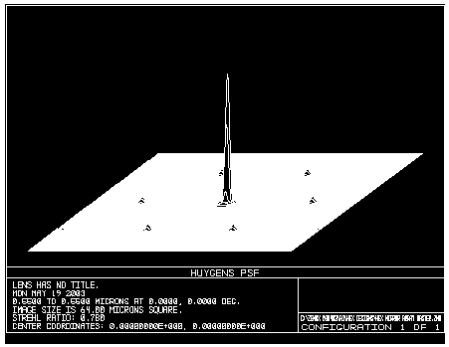


Strehl = 0.30

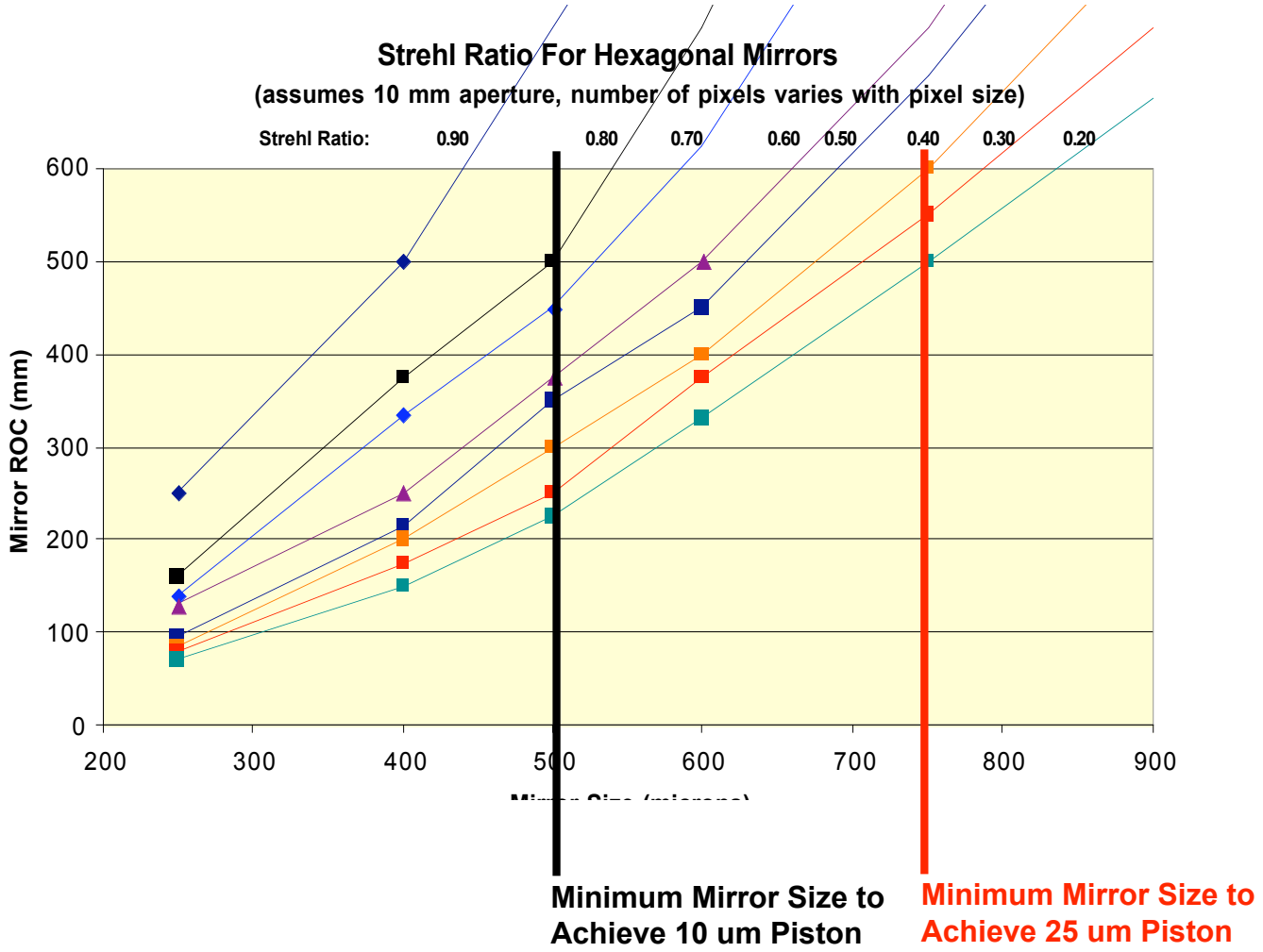
500micron, 500mm ROC Hex Pixel



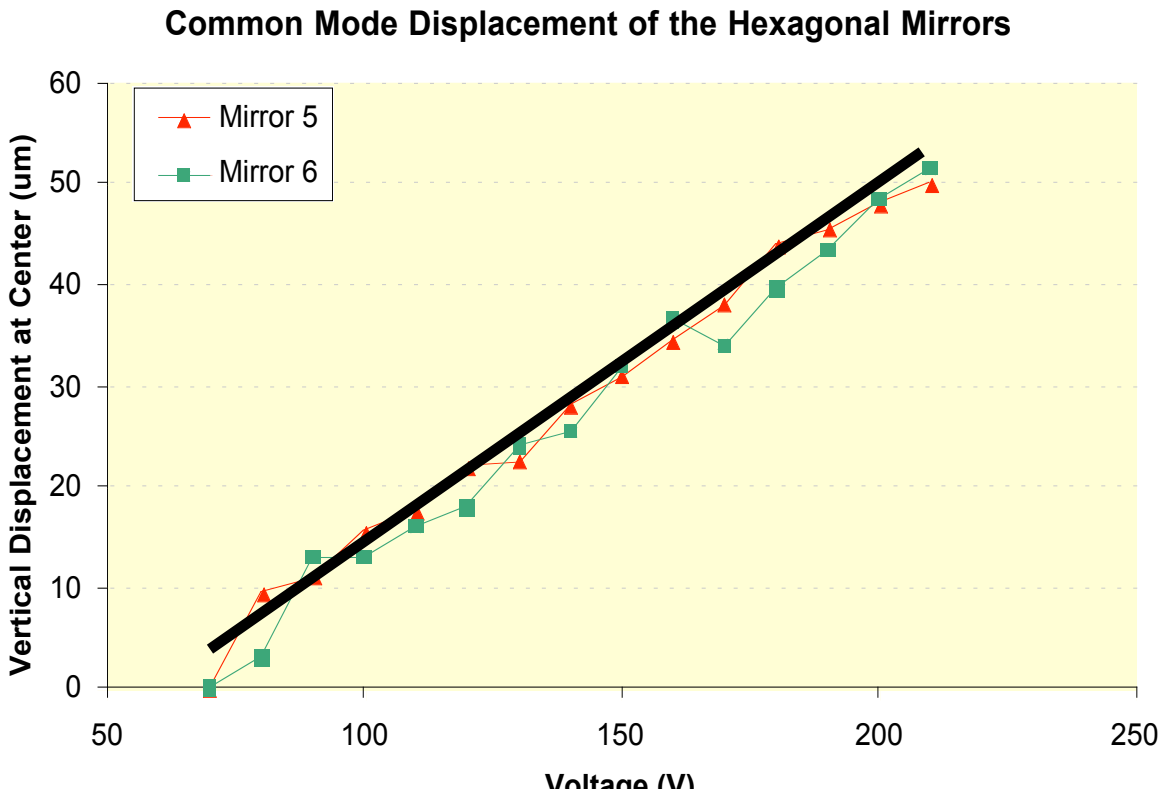
Strehl = 0.78



Strehl as f(Mirror Size, ROC)



Vertical Stroke vs. Voltage



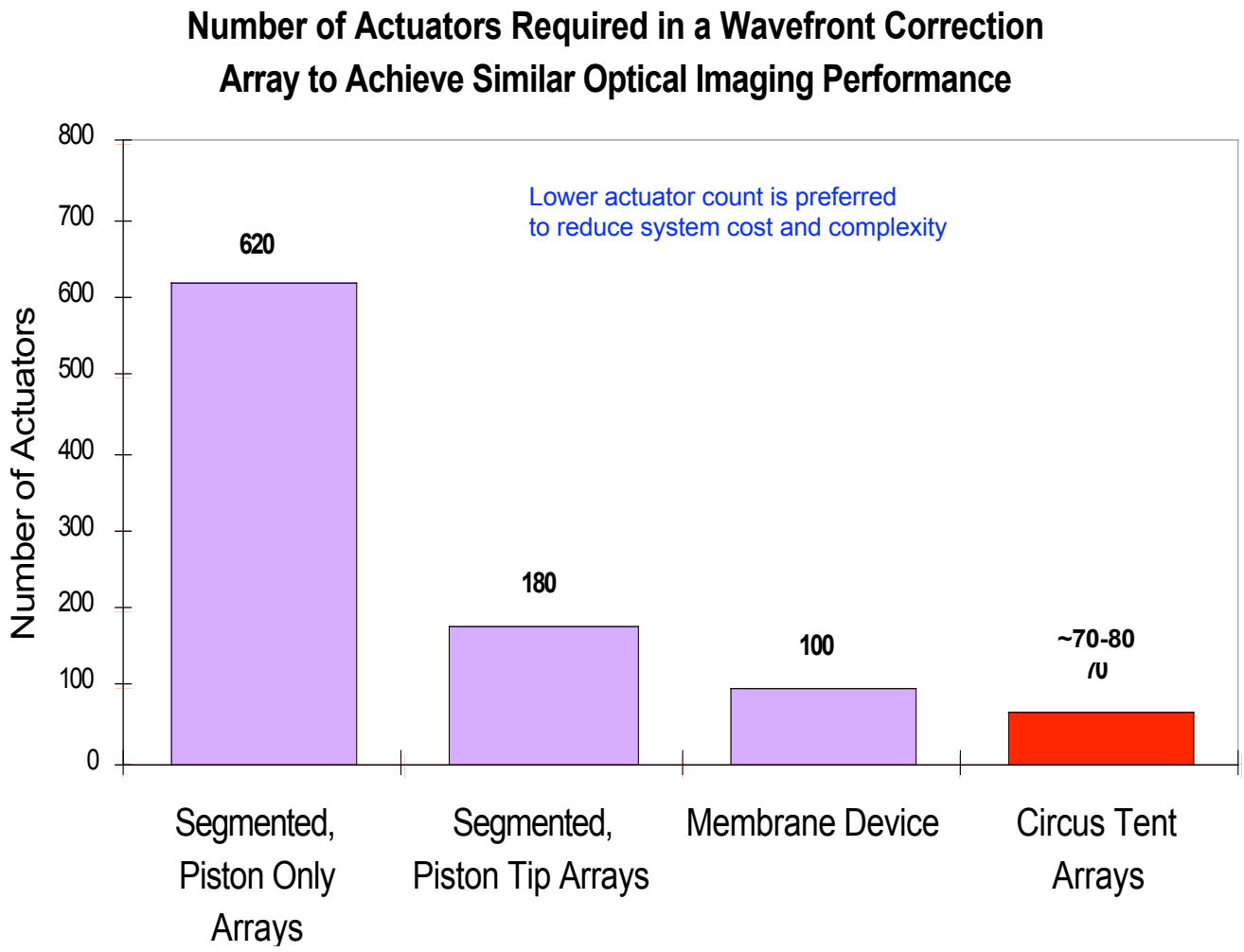
- Data appears noisy due to measurement technique used
- Actual curve is smooth and linear

MEMX AO Program

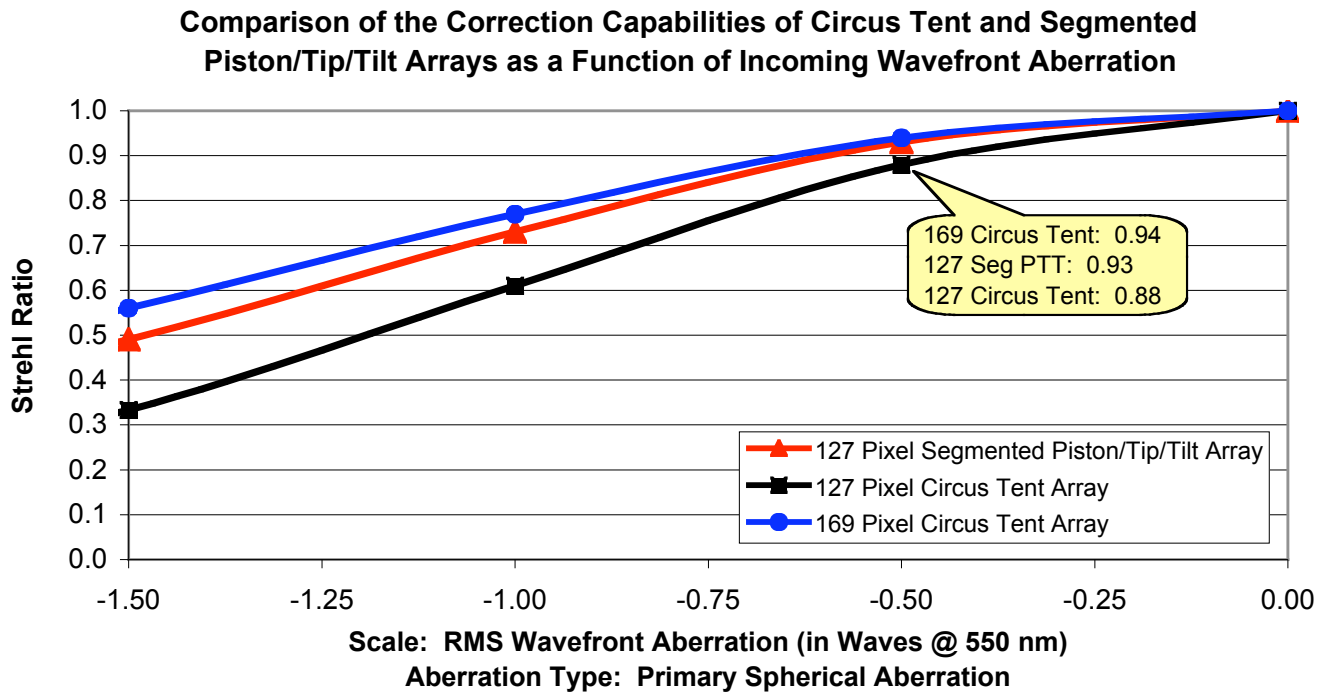
NIH SBIR Funding

- Phase 1: Jan – Jun 2004; $100K
- Phase 1 focused on an innovative approach which should reduce actuator count by factor of 3 and provide similar imaging quality
- Phase II: Proposal submitted August 2004
- Phase II focuses on:
  - Mirror flatness via improved mechanical design
  - Blanket metallization techniques
  - Full-size array design and fabrication
  - Additional optical modeling

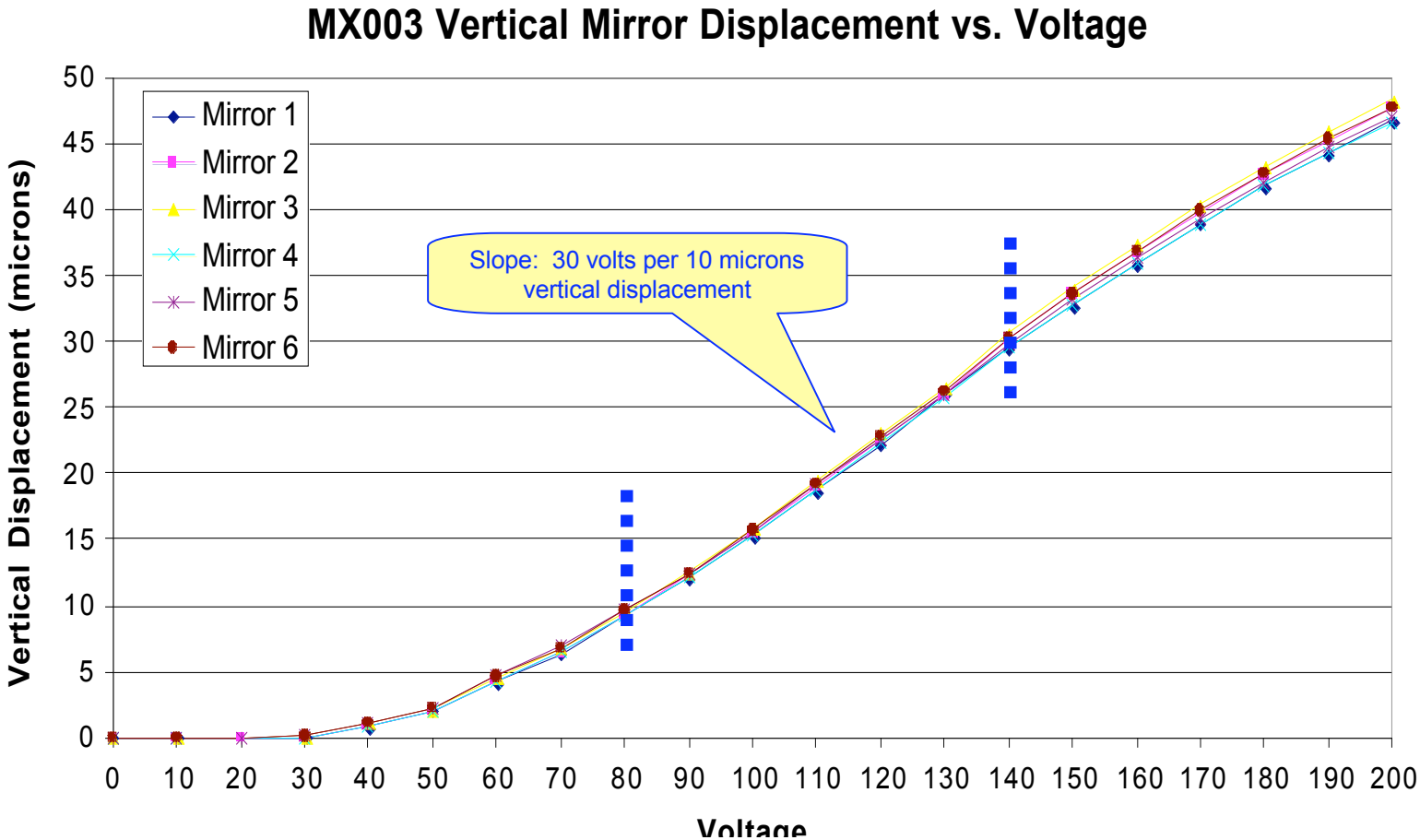
The Value of the Circus Tent Approach



Analytical Modeling of Circus Tent and Standard Mirror Arrays



Measured Vertical Stroke vs. Voltage (Circus Tent)



MEMX AO Program

CfAO Funding

- June - November 2004; $50K
- Designed to improve MEMX's "baseline" metallization processes
  - Optimize chip packaging process (epoxy, temp)
  - Improve deposition process (sputtered Au)
  - Improve deposition process (evaporated Au)

MEMX AO Program

TMT Concept (?)

- Nanolaminate material with MEMS actuator array underneath
- MEMX can build arrays of high force actuators
  - 10s mN force over 10 μm horizontal stroke
  - 100s μN force over 10 μm vertical stroke
- Issues
  - Wire bond not possible. Through wafer vias are required (we think)
  - Actuator attachment to reflective material
  - Array tiling approach – how to tile small arrays to get full-scale array