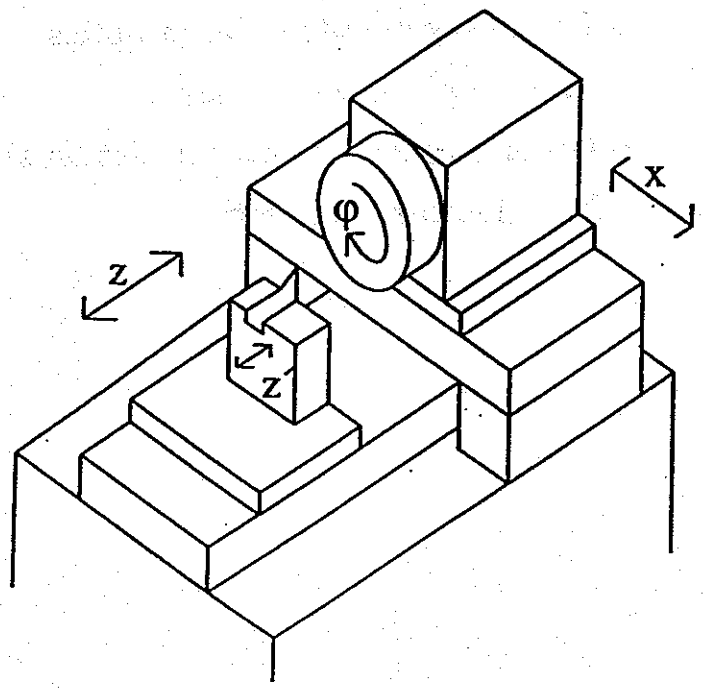
MACHINING NON-AXISYMMETRIC OPTICS

Senior Development Engineer

Rank Taylor Hobson Inc.
Keene, New Hampshire

Optics MODIL Sixth Industrial Briefing
West Palm Beach, Florida, March, 15–16, 1990

Four-Axis SPDT Machine Tool Motions



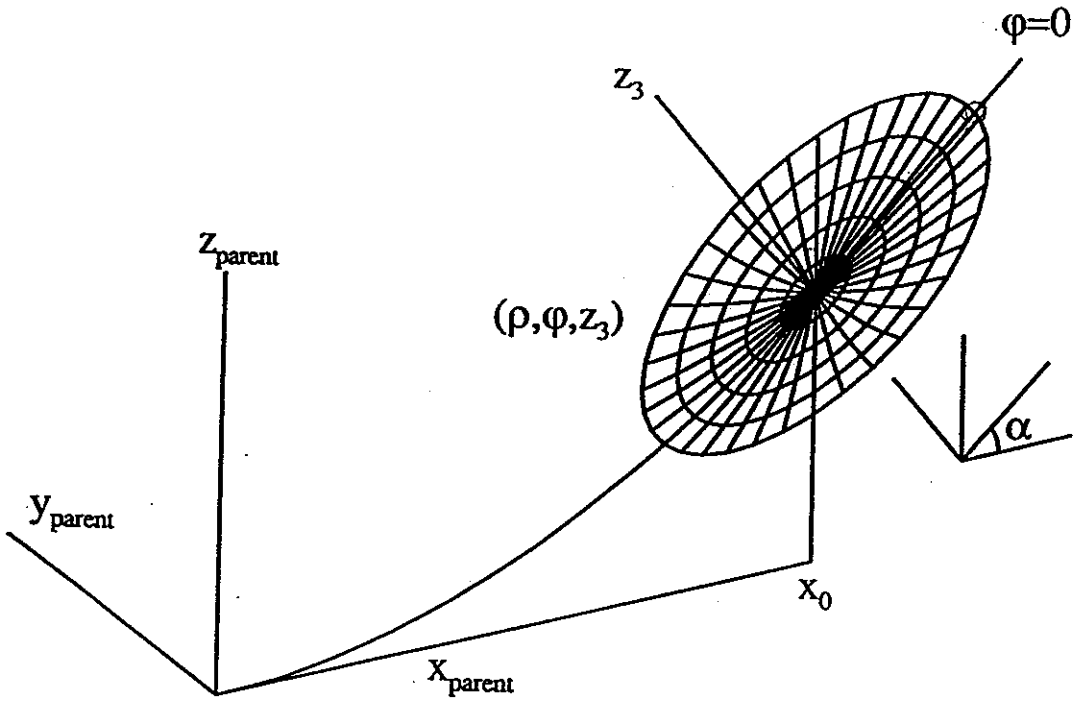
Overview

- Applications for Non-Axisymmetric Turning
- Off-Axis Segments of Large Optic
- Example Mirror
- Machining Setup
- Recent Results

Applications

- Off-axis segments of large optics
- Large optic corrector plates
- Other unknown (e.g., contact lens)
- Machine error correction

Off-Axis Geometry

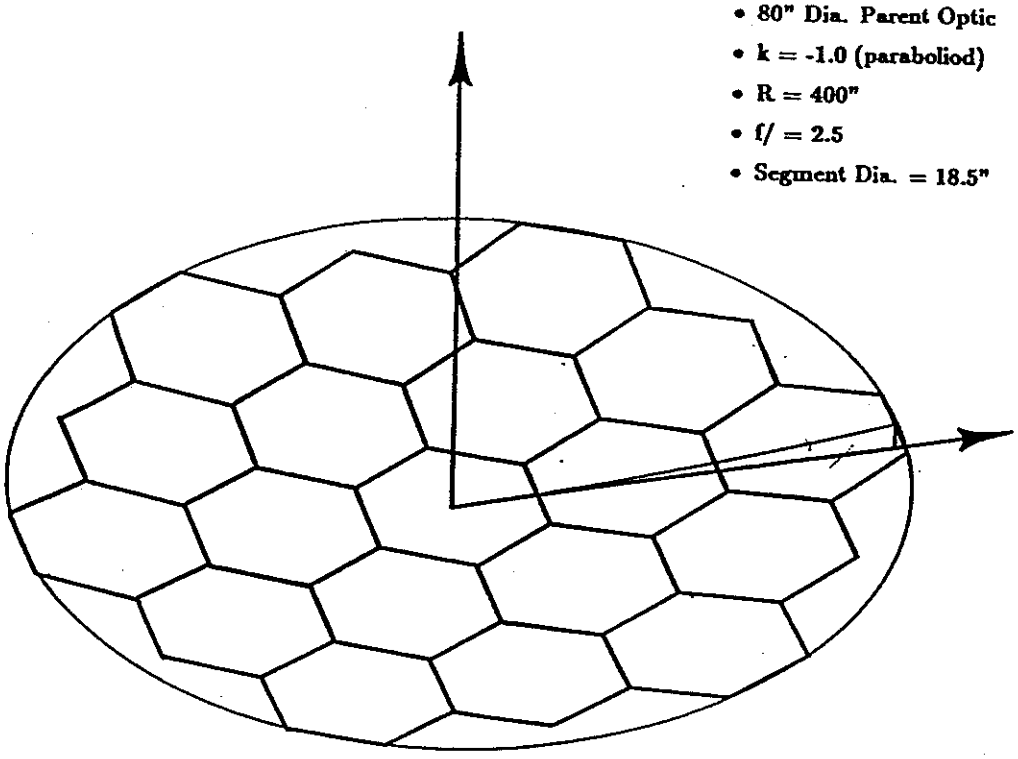


Off-Axis Conic Surface Equations

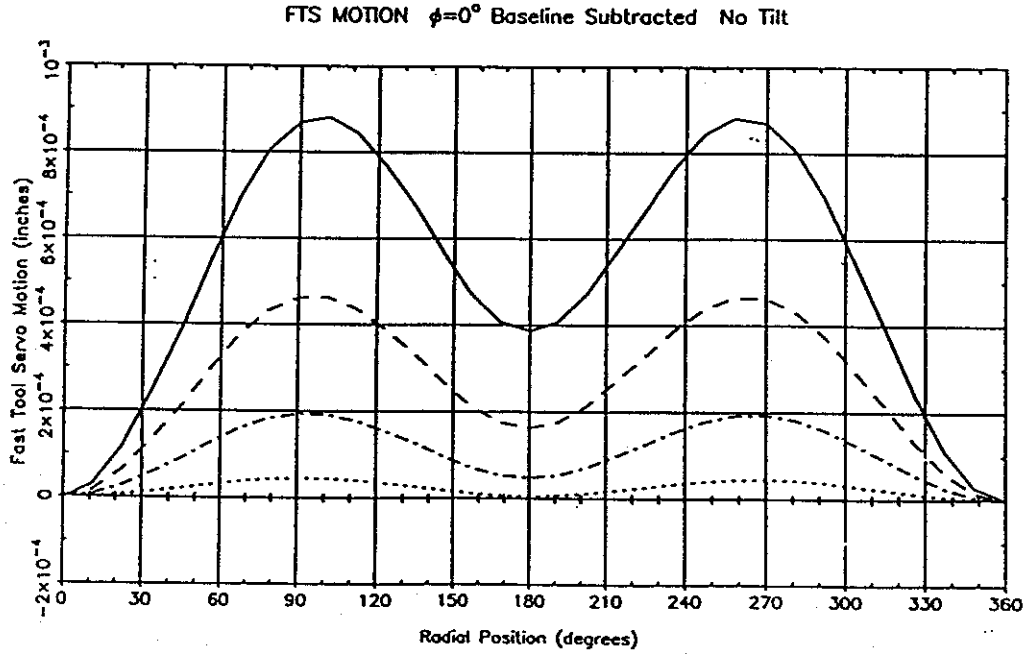
$$z_3 = d_1 + d_2\rho\cos(\varphi) \mp \sqrt{d_3 + d_4\rho\cos(\varphi) + d_5\rho^2 + d_6\rho^2\cos^2(\varphi)}$$

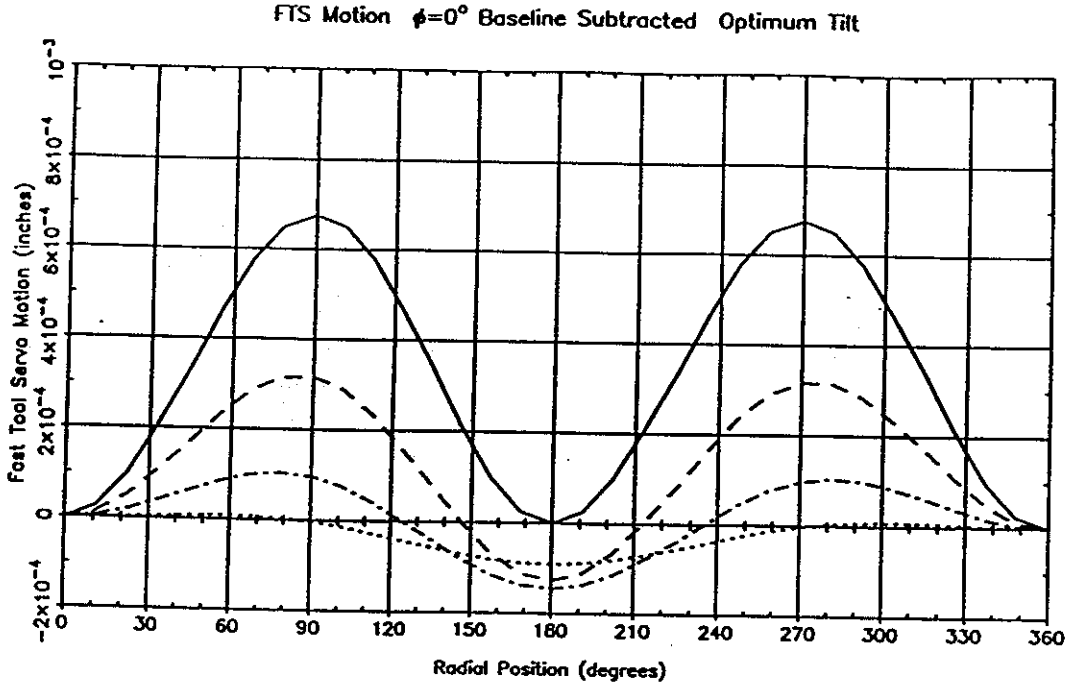
$$d_i = d_i(x_0, z_0, r, k, \alpha)$$

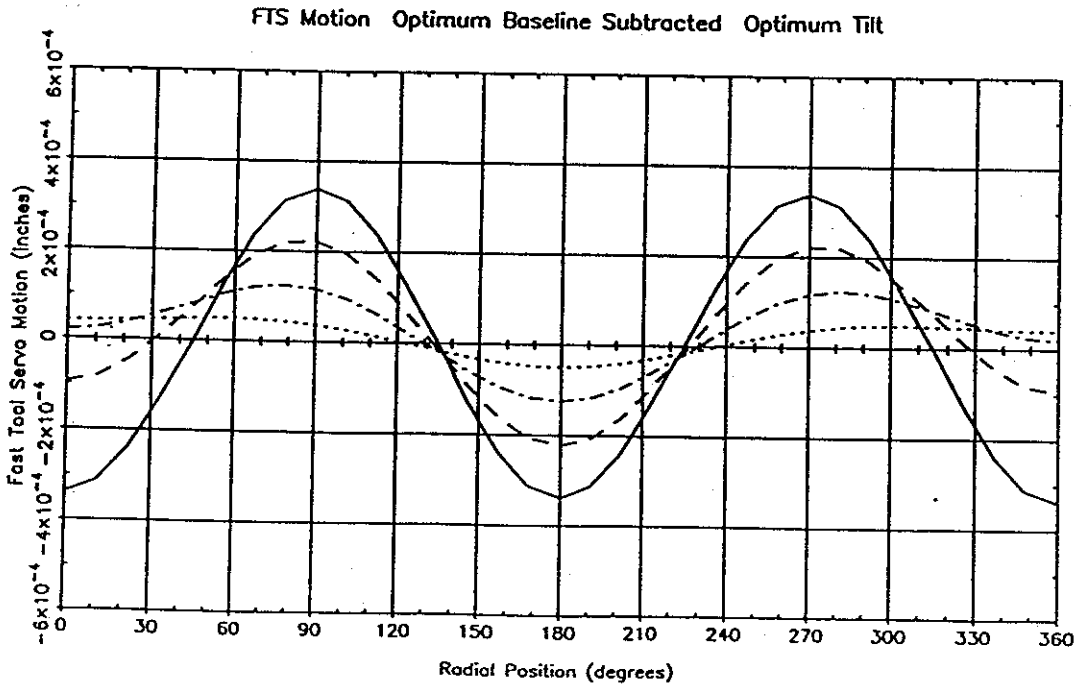
- 80" Dia. Parent Optic
- k = -1.0 (paraboliod)
- R = 400"
- f/ = 2.5
- Segment Dia. = 18.5"



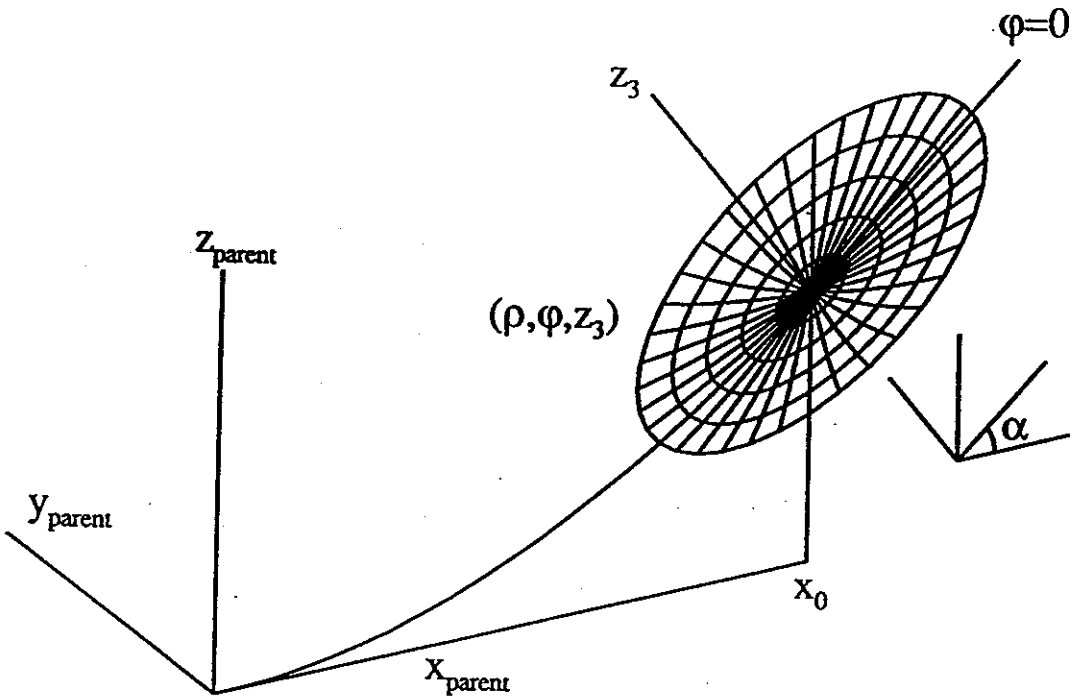
Example Mirror




FTS Motion ϕ=0° Baseline Subtracted Optimum Tilt
Fast Tool Servo Motion (inches)
10^{-3}
8×10^{-4}
6×10^{-4}
4×10^{-4}
2×10^{-4}
0
-2×10^{-4}
0
30
60
90
120
150
180
210
240
270
300
330
360
Radial Position (degrees)


FTS Motion Optimum Baseline Subtracted Optimum Tilt
Fast Tool Servo Motion (inches)
6×10^{-4}
4×10^{-4}
2×10^{-4}
0
-2×10^{-4}
-4×10^{-4}
-6×10^{-4}
0
30
60
90
120
150
180
210
240
270
300
330
360
Radial Position (degrees)

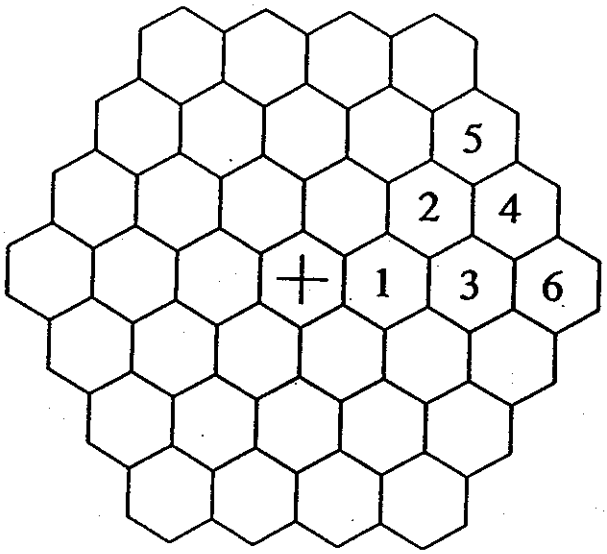
Off-Axis Geometry



Factors Influencing Z´ Tool Motion

- Optimized Tilt Angle - α
  - Controlled by ρ_{max}
  - $z_3(\rho_{max},\varphi_0)=z_3(\rho_{max},\varphi_{180})$
- Optimized Baseline Subtraction
  - $z'(\rho,\varphi)=z_3(\rho,\varphi)-[z_{3max}(\rho)+z_{3min}(\rho)]/2$

Keck† Primary Mirror Tesselation



Mirror Design
radius: 34.974 m
conic constant: -1.003683
hexagonal edge: 0.90 m
primary f/: 1.6
Ritchey-Chrétien

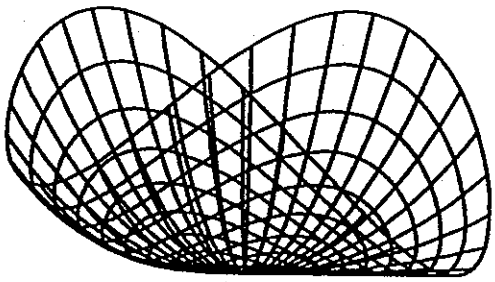
† The Keck Telescope is a joint project of the University of California and the California Institute of Technology.

Keck Primary Mirror Data

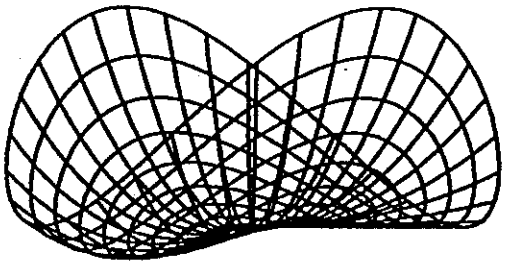
row	center position x_0 (mm)	tilt correction $\delta\alpha$ (arc sec)	tool motion z' (mm)
1	1558.8	-3.10	0.0235
2	2700.0	-5.31	0.0701
3	3117.7	-6.10	0.0932
4	4124.3	-7.93	0.1617
5	4124.3	-7.93	0.1617
6	4676.5	-8.88	0.2067

Z´ Tool Motion - Outside Keck Segment

($\varphi=0^0$ Baseline Subtracted)



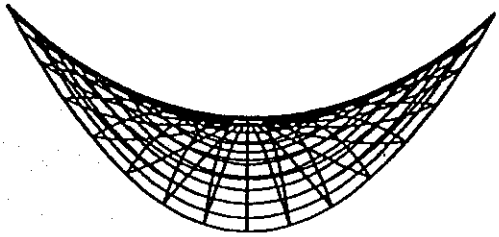
Slope of Parent Conic x_0



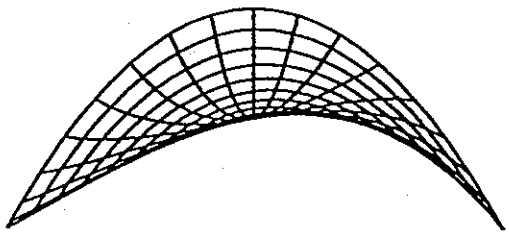
Optimized Choice of α

Z´ Tool Motion

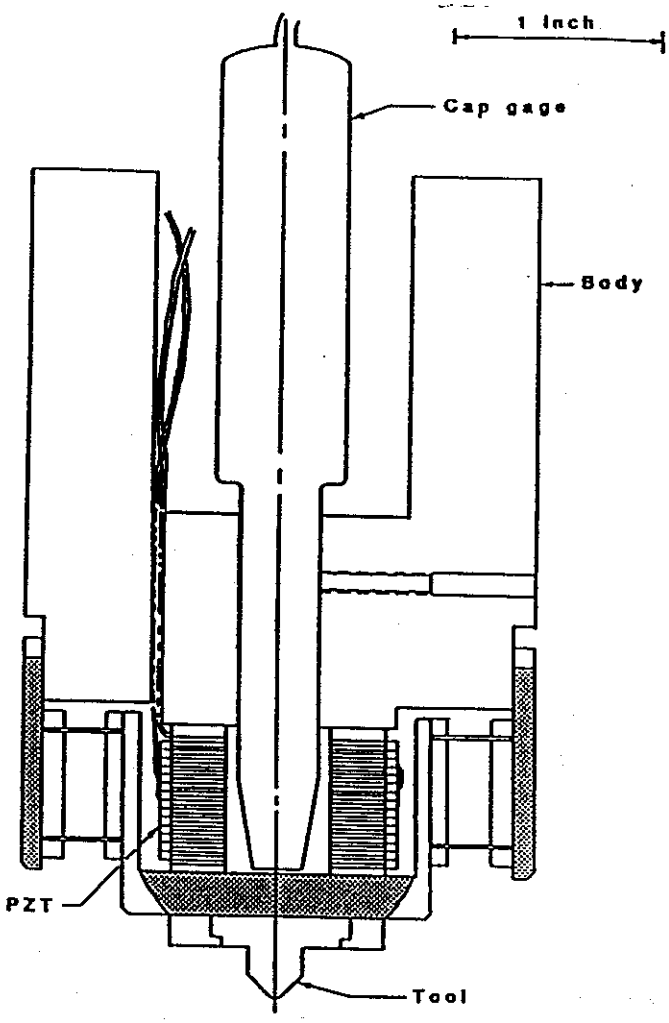
(Optimized Baseline Subtracted)



$\varphi=90^0$ $\varphi=270^0$



$\varphi=180^0$ $\varphi=0^0$



Fast Tool Servo Cross-Section

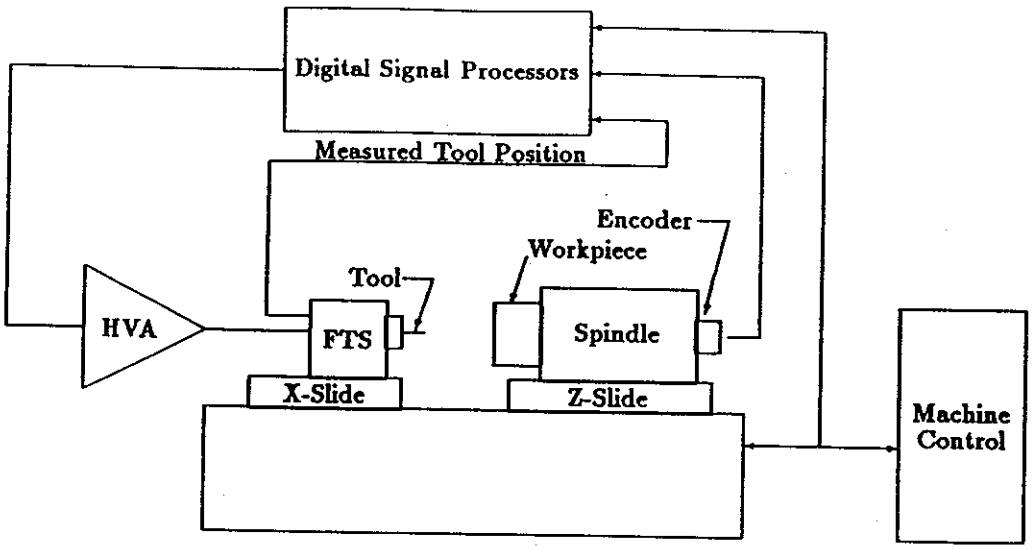


Diagram of Experimental Setup