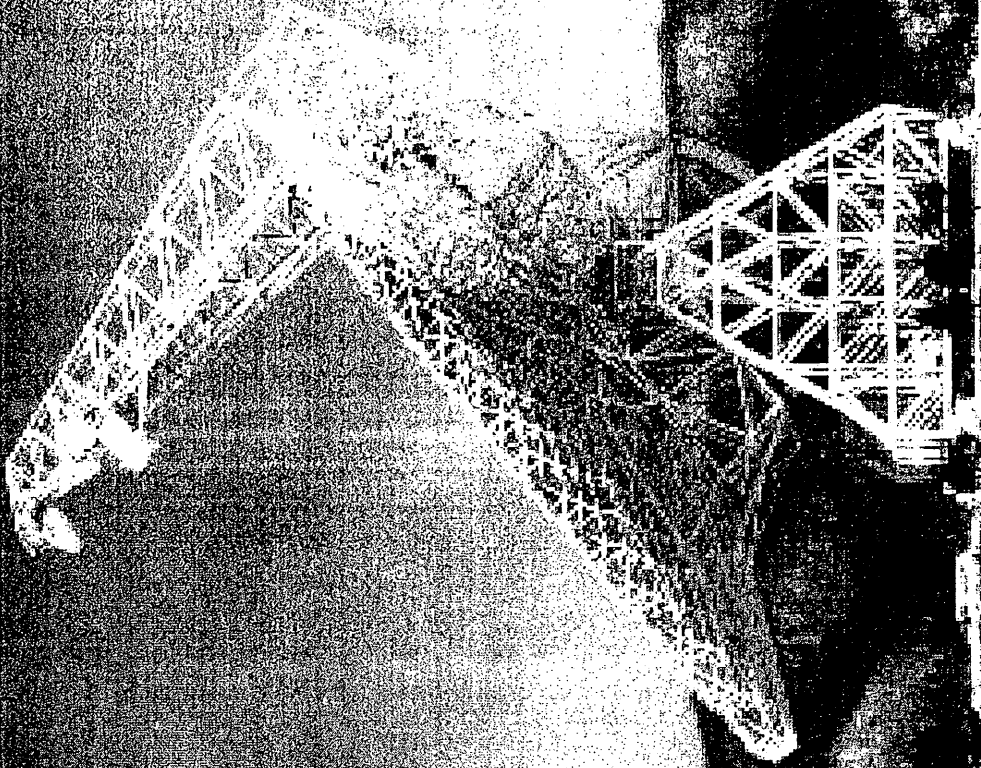


# Instrumentation

K. Constantines



010





# New PTCS Instruments

<b>Instrument</b>	<b>Purpose</b>	<b>Status</b>	<b>Initial Capability</b>	<b>Priority</b>
Structural temp	Correct thermal deformation	Designed Parts ordered	June 2003	High
Quadrant Detector	Dedicated Feed Arm Position	Retrofit	June 2003	Medium
Accelerometers	Structural health Inclinometers	On hold	No date set	Low
Vertical air temp	LRF group index prediction	On hold	No date set	Low
FA Tip Barometer	LRF group index prediction	On hold	No date set	Low
Hot-wire anemometers	Wind deformation	On hold	No date set	Low





## Structural Temperature

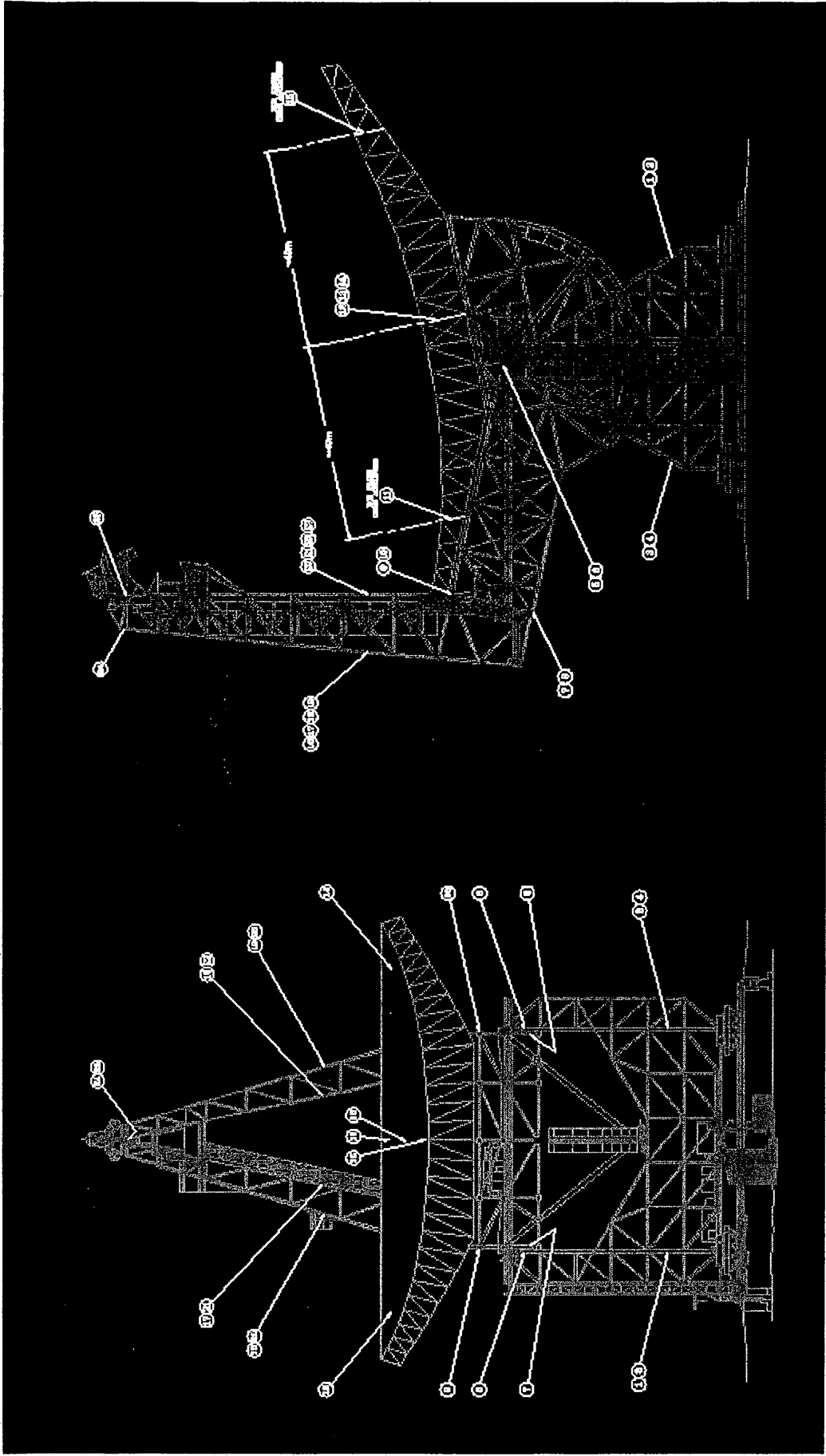
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- ~ 30 locations, 0.2C interchangeable accuracy, 0.01C resolution, 1Hz. COTS solution.
- Estimate gradients in alidade, horizontal and vertical FA, primary.
- RSI predicted 19" pointing error for 5C (uniform) gradient w/ 270 solar azimuth.
- Uses:
  - Temp dependent optical alignment model (focus tracking)
  - Temp dependent primary model
  - Temp dependent pointing model
- Implementation order
  - Vertical FA
  - Alidade
  - Encoder
  - Primary
  - Horizontal FA





# Temperature Sensor Locations









# Pointing Accuracy, 5° C Gradient, 95° EI

Loral Tech Memo 52 Table 2-19 EI=95,  $\Delta T=5, V_w=0, \text{Sun Az}=270$

Error Sources	EI Errors (arcsec)		X-EI Errors (arcsec)	
	Repeatable	Nonrepeatable	Repeatable	Nonrepeatable
<b>Mechanical Alignments</b>				
RF/EI Axes Orthogonality	0.0		0.0	
EI/Az Axes Orthogonality	0.0		59.8	
Az Axis Verticality	5.0		5.0	
<b>Structural Deformations</b>				
Reflector				
Wind				
Thermal Gradient		0.0		16.3
Alidade				
Wind				
Thermal Gradient				2.4
<b>Servo and Drive</b>			0.9	0.3
<b>Miscellaneous</b>				
EI Bearing Wobble	1.0		0.4	0.4
Az Bearing Wobble	1.0		0.4	0.4
Encoder Accuracy			1.2	1.2
Encoder Coupling			1.8	0.2
Encoder Referencing	10.0			0.9
<b>RSS Subtotals</b>	11.3	2.4	60.0	18.8





# Pointing Accuracy, 5° C Gradient, 5° EI

Loral Tech Memo 52 Table 2-19		EI=5, ΔT=5, V <sub>w</sub> =0, Sun Az=180		
Error Sources	EI Errors (arcsec)		X-EI Errors (arcsec)	
	Repeatable	Nonrepeatable	Repeatable	Nonrepeatable
<b>Mechanical Alignments</b>				
RF/EI Axes Orthogonality	0.0		0.0	
EI/Az Axes Orthogonality	0.0		5.2	
Az Axis Verticality	5.0		0.4	
<b>Structural Deformations</b>				
Reflector				
Wind				
Thermal Gradient		0.3		
Alidade				
Wind				
Thermal Gradient		11.5		
<b>Servo and Drive</b>			0.9	0.3
<b>Miscellaneous</b>				
EI Bearing Wobble	1.0		0.4	0.1
Az Bearing Wobble	1.0		0.4	0.1
Encoder Accuracy			1.2	1.2
Encoder Coupling			1.8	2.1
Encoder Referencing	10.0			10.0
<b>RSS Subtotals</b>	11.3		12.1	2.4





# Tipping Structure Contributions, 5C in X direction

Local Tech Memo 52	X-Dir Thermal, 5C Gradient		X-EI Error		
Error Sources	P/E Coeff Rad/M, Rad/Rad	Deflection Rad, in	Rad, mm	EI Error Arcsec	X-EI Error Arcsec
Parabola +X	0.0130	-2.2100E-01	-5.613		-15.20
Parabola +Y	-0.0091	4.8530E-05	0.001	0.00	
Parabola +Z	-0.0092	1.1050E-06	0.000	0.00	
Parabola X Rot	1.5490	1.0500E-08	1.050E-08	0.00	
Parabola Y Rot	1.7710	2.2910E-05	2.291E-05		8.45
S/R + X Shift	-0.0183	-3.9947E-01	-10.147		38.68
S/R + Y Shift	0.0141	0.0000E+00	0.000		0.00
S/R + Z Shift	0.0103	0.0000E+00	0.000		0.00
S/R X Rotation	0.1504	0.0000E+00	0.000E+00	0.00	
S/R Y Rotation	0.1336	-3.5594E-04	-3.559E-04		-9.91
Feed +X Shift	0.0051	-2.2899E-01	-5.816		-6.18
Feed +Y Shift	-0.0051	0.0000E+00	0.000	0.00	
Feed +Z Shift	-0.0012	0.0000E+00	0.000	0.00	
Focal Length Change	-0.0092	2.0200E-05	0.001	0.00	
<b>Total (arcsec)</b>				0.00	15.85
<b>Assumed Gradient Accuracy, C</b>	0.2000				0.63





# Tiping Structure Contributions, 5C in Y direction

Local Tech Memo 52	Y-Dir Thermal, 5C Gradient		Y-Dir Thermal, 5C Gradient
Error Sources	P/E Coeff	Deflection	EI Error
	Rad/M, Rad/Rad	Rad, in	Arcsec
Parabola +Y	-0.0091	-8.0570E-01	-20.465
Parabola +Z	-0.0092	-6.5660E-02	-1.668
Parabola X Rot	1.5490	-1.3730E-04	-1.373E-04
S/R + Y Shift	0.0141	-1.4796E-01	-3.758
S/R + X Shift	0.0103	-3.5434E-02	-0.900
S/R X Rot	0.1504	4.8383E-05	4.838E-05
Feed + Y Shift	-0.0051	-1.2145E-01	-3.085
Feed + Z Shift	-0.0012	-3.3417E-02	-0.849
Focal Length Change	-0.0092	-2.1830E-01	-5.545
<b>Total (arcsec)</b>			<b>0.35</b>
<b>Assumed Gradient Accuracy, C</b>	<b>0.2000</b>		<b>0.01</b>





# Tippling Structure Contributions, 5C in Z direction



Local Tech Memo 52	Z-Dir Thermal, 5C Gradient		EI Error	
Error Sources	P/E Coeff	Deflection	Rad, mm	Arcsec
	Rad/M, Rad/Rad	Rad, in		
Parabola +Y	-0.0091	-7.3760E-01	-18.735	35.52
Parabola +Z	-0.0092	-5.2980E-02	-1.346	2.58
Parabola X Rot	1.5490	-1.0530E-04	-1.053E-04	-33.98
S/R +Y Shift	0.0141	-1.4378E-01	-3.652	-10.73
S/R +X Shift	0.0103	6.2052E-02	1.576	3.38
S/R X Rot	0.1504	1.9781E-05	1.978E-05	0.62
Feed +Y Shift	-0.0051	-1.2061E-01	-3.063	3.25
Feed +Z Shift	-0.0012	3.7947E-02	0.964	-0.24
Focal Length Change	-0.0092	6.6250E-02	1.683	-3.23
<b>Total (arcsec)</b>				<b>-2.82</b>
<b>Assumed Gradient Accuracy, C</b>	0.2000			<b>-0.11</b>





## Quadrant Detector

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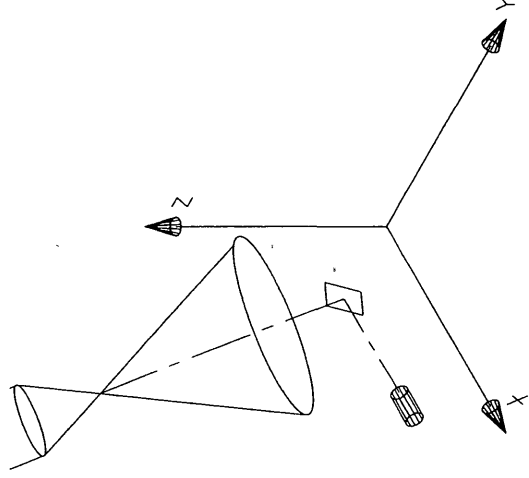
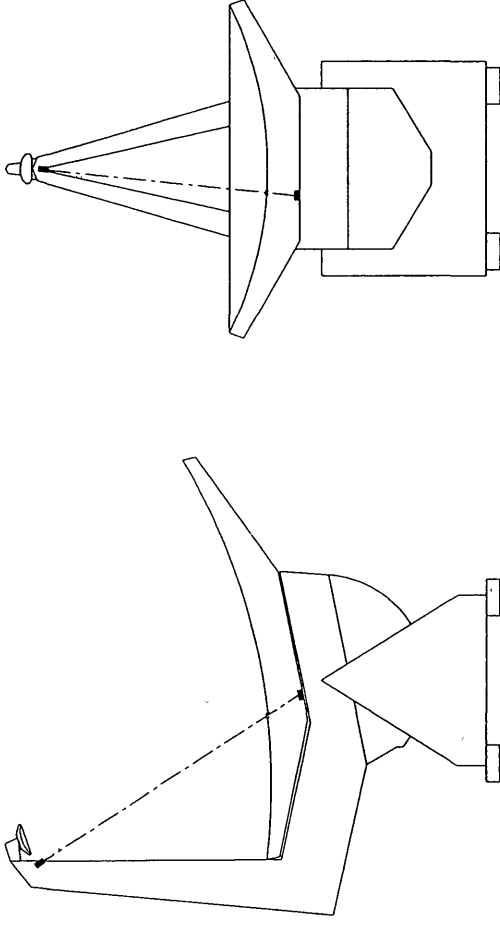
- Measures FA tip displacement in plane ~ normal to principle ray of GBT
- 10 Hz, ~12 $\mu$ m resolution. FS Nonlinearity < 5mm. Noise strongly dependent on atmosphere, ~<300 $\mu$ m.
- Tested summer '02. Upgrades in temp stability, control, monitoring, and calibration in progress
- Uses:
  - Short-term SR control signals (may use accelerometers and dynamical model)
  - Assist in FA LRF position estimation





# Quadrant Detector

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## QD Performance Prediction

Short-Term Effect	Current	Notes	Improvements
Quantize	12 $\mu$ m	15 bits	
Path	<500 $\mu$ m	Anecdotal 5 $\mu$ rad path bending	
PSD Nonlinearity	4000 $\mu$ m	Exceeds detector spec by 3-4	< 1000 $\mu$ m
Path and Elex Noise	<230 $\mu$ m	Measured in lab 20m path	
<u>RSS Noise effects</u>	<550 $\mu$ m		
<b>Long-Term Effect</b>			
Mechanical/Thermal Drift	$\pm$ 3500 $\mu$ m	Guess	
Electronic Thermal	400 $\mu$ m	10 $^{\circ}$ C	<100 $\mu$ m







## Accelerometers

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- 10 Hz 3-axis seismic MEMS accelerometers,  
~2 $\mu$ G/root-Hz
- Locations: FA tip, left and right EI bearings
- Uses:
  - Rate assist QD
  - Structural vibration mode shape and frequency
  - Inclinometers





## **Vertical Air Temperature**

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- ~ 13 locations on alidade and vertical FA, 0.2°C accuracy, 0.01°C resolution, 1 Hz.
- $\Delta Ng/\Delta T \sim -9 \text{ ppm}/^\circ\text{C}$  : Need path average  $< 0.4 \text{ ppm}$
- Expect to use same COTS solution as structural temp



## FA Tip Barometer

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- LRF  $\Delta Ng/\Delta P \sim 0.3\text{ppm/mbar}$ : Need path average Hg < 0.4 ppm.
- Path barometric pressure thought to be more predictable than temperature.
- Use ADC and control in QD laser assembly





## Hot-Wire Anemometers

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- Possible locations on FA tip, primary rim, alidade.
- 0.1m/s accuracy, 0.05 resolution, 10 Hz rate, 0-25 m/s
- Uses:
  - Correlation and correction of wind loading pointing effects





## **Existing PTCS Instruments**

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- Az/EI encoders
- SR link encoders
- Active surface panel encoders
- Holography
- Weather stations (3)
- 2-axis FA tip accelerometer
- LVDT primary temperature sensors

