MLA Boresite Alignment Results

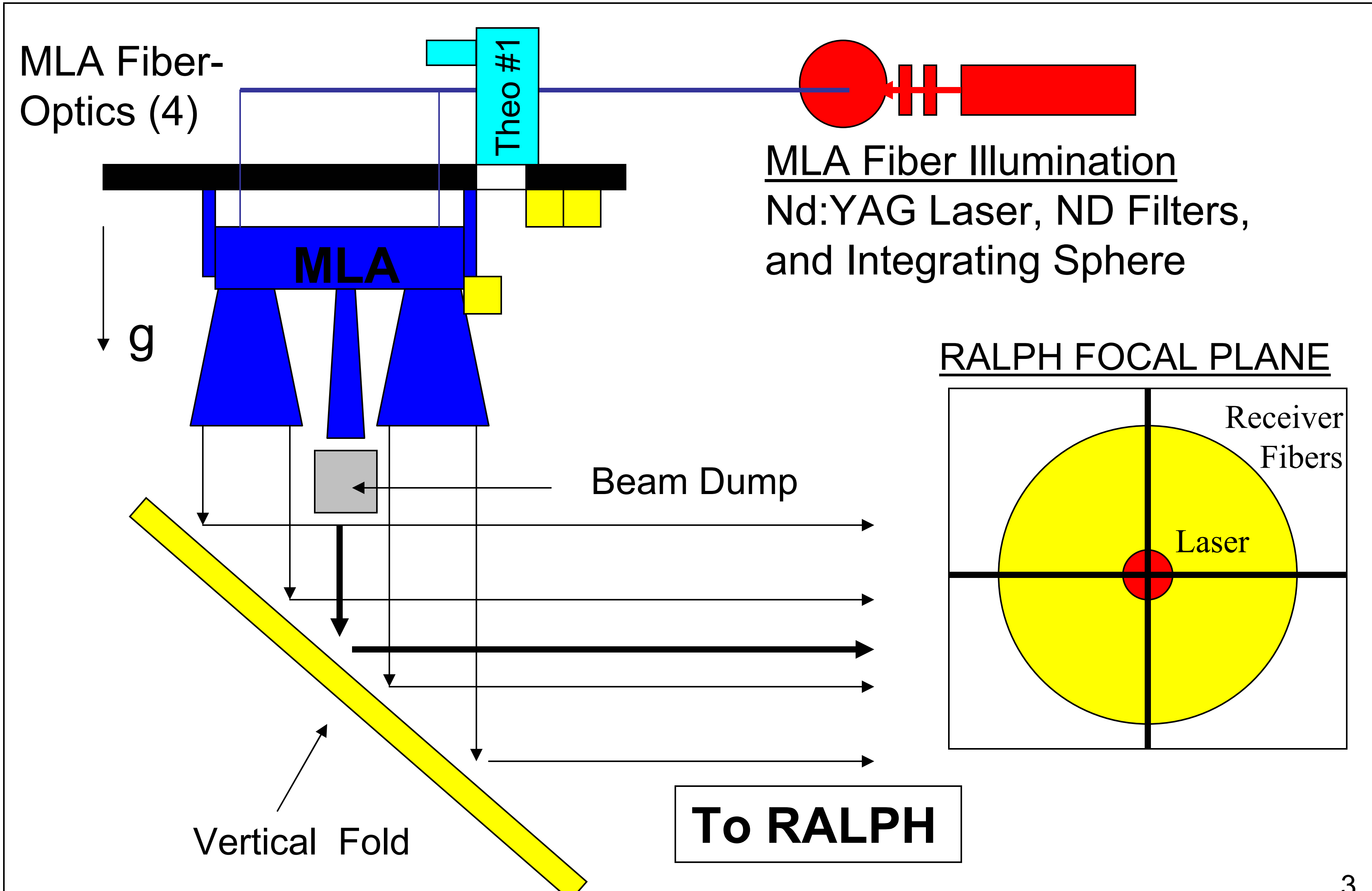
Luis Ramos-Izquierdo, John Cavanaugh, Stan Scott
NASA/GSFC Code 924, April 14, 2004

- Instrument Delivery Alignment, 6/25/03
  - NASA/GSFC Bldg. 33/Rm F303 Clean Room
  - MLA mounted on Alignment Plate GSE
  - RALPH Optical Test System
- Post S/C Vibe and Acoustics Alignment, 1/2/04
  - NASA/GSFC Bldg. 7 Acoustic Test Chamber
  - MLA/MESSENGER installed on Elephant Stand
  - Risley/LTR Target Assembly with short tube
- Post S/C TVAC and Ship Alignment, 3/15/04
  - Astrotech Clean Room, Cape Kennedy, FL.
  - MLA/MESSENGER installed on Turnover Fixture
  - Risley/LTR Target Assembly with extended tube

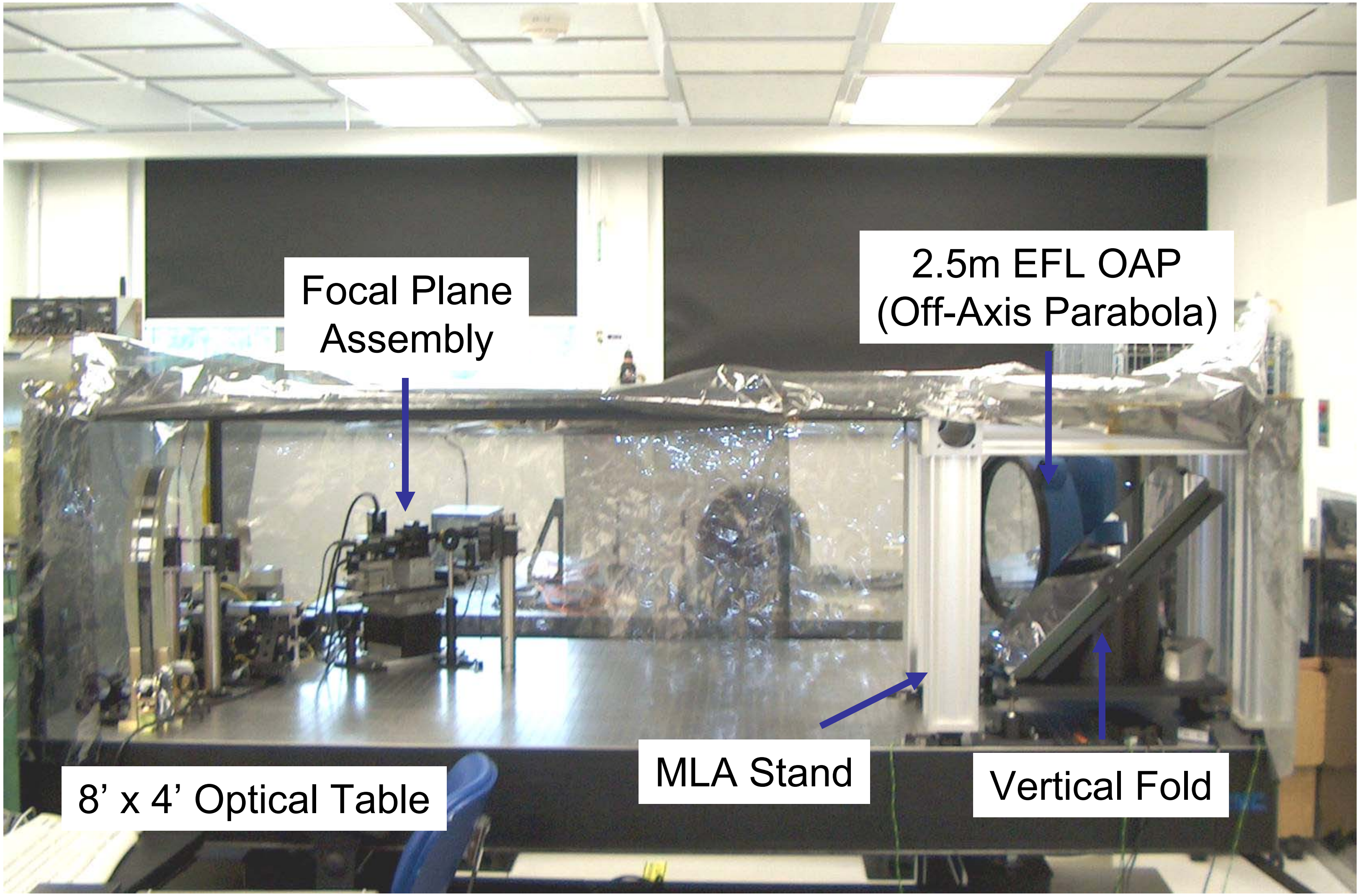
Instrument Delivery Alignment

- Performed using RALPH Optical Test System
  - MLA Laser is attenuated with Laser Beam Dump and pointed at center of RALPH focal plane reticule
  - Fiber source coincident with the RALPH reticule is scanned in X and Y axes to map out receiver FOV
- Receiver And Laser Profiling Hardware (RALPH)
  - Well developed and documented optical test system
  - Used with EM and Flight hardware: MLA initial alignment, MLA pre- & post-vibe testing, MLA pre- & post-TVAC testing, MLA final alignment verification
  - RALPH beam fully illuminates receiver tube apertures
  - Best & most accurate MLA boresite alignment data
  - ~+/- 25urad uncertainty on measured FOV’s

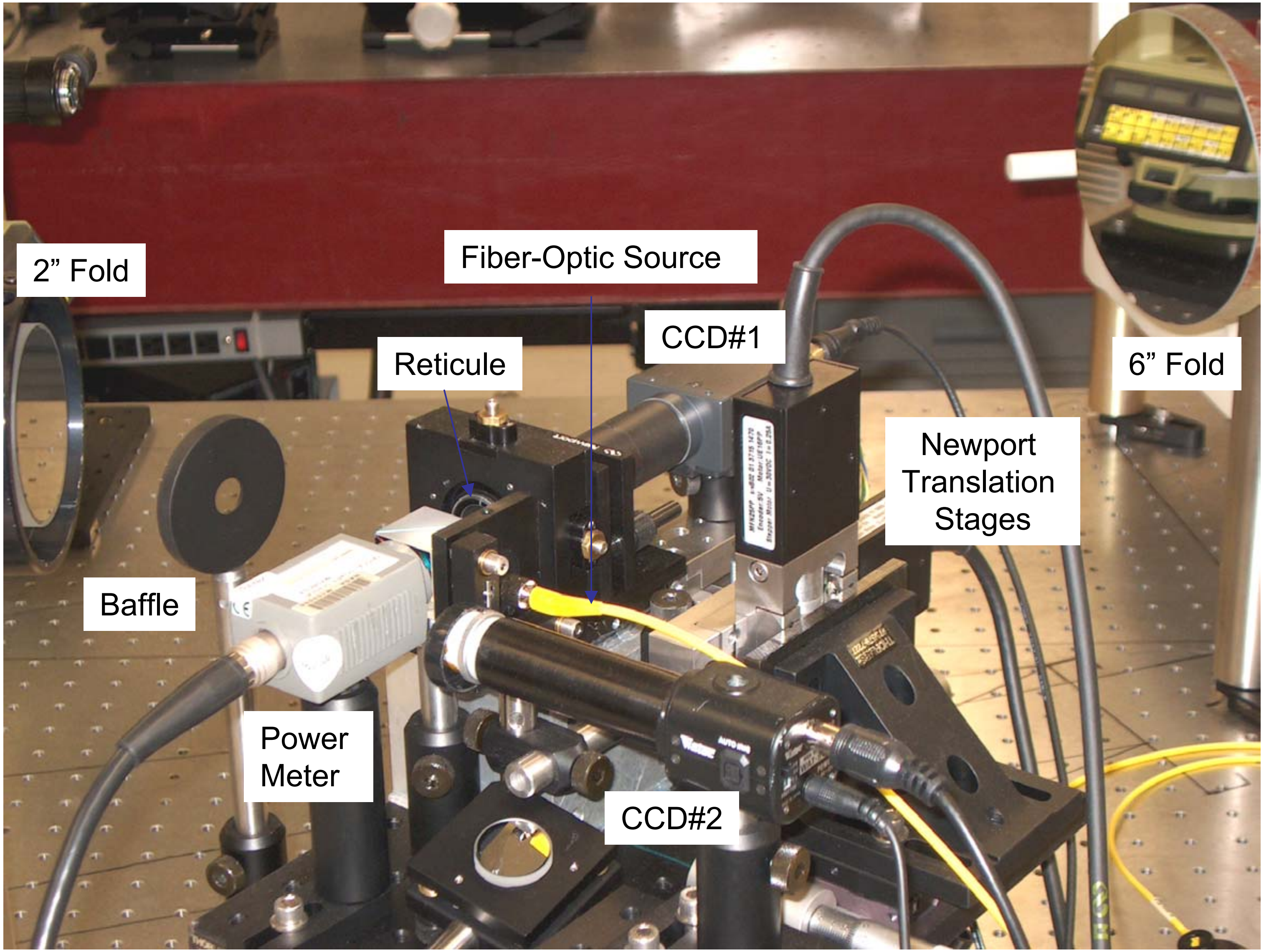
MLA Boresite Alignment Set-Up



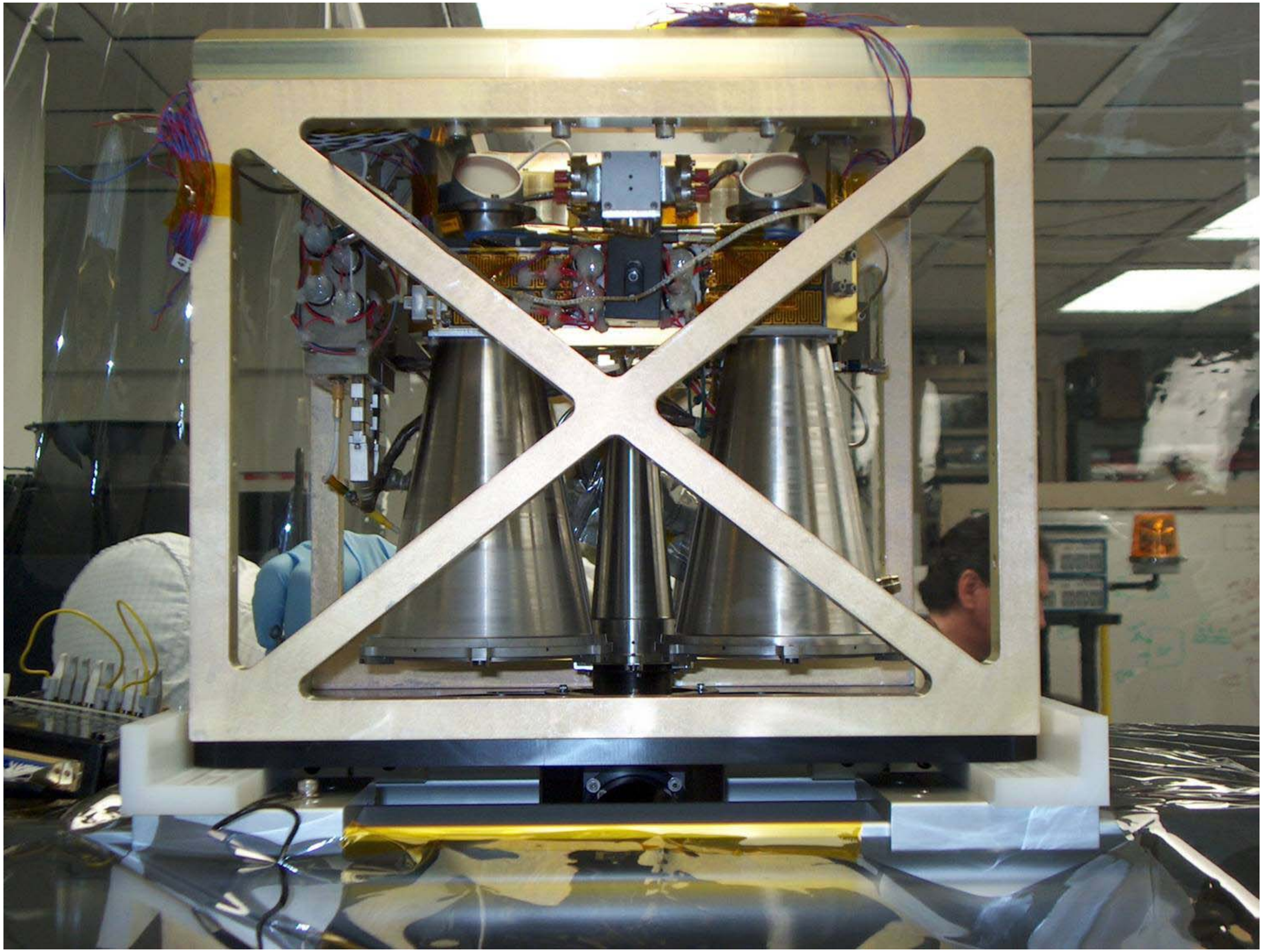
MLA RALPH Optical Test System

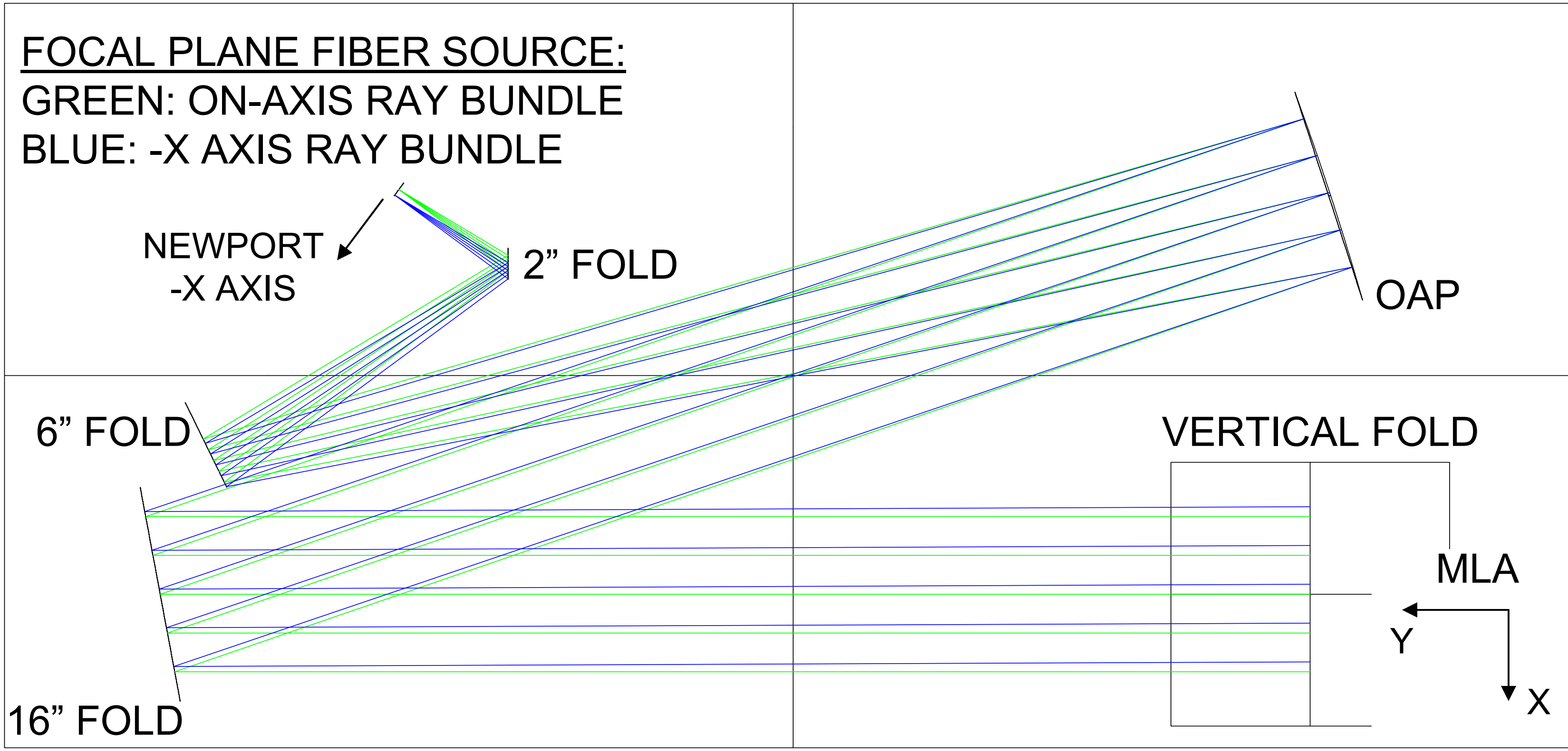


RALPH Focal Plane Assembly



MLA installed on RALPH





4’ X 8’ OPTICAL TABLE

3D LAYOUT

SORL OAP 100-02-14Q (14" DIA., 100" EFL)
WED APR 14 2004
SCALE: 0.1000

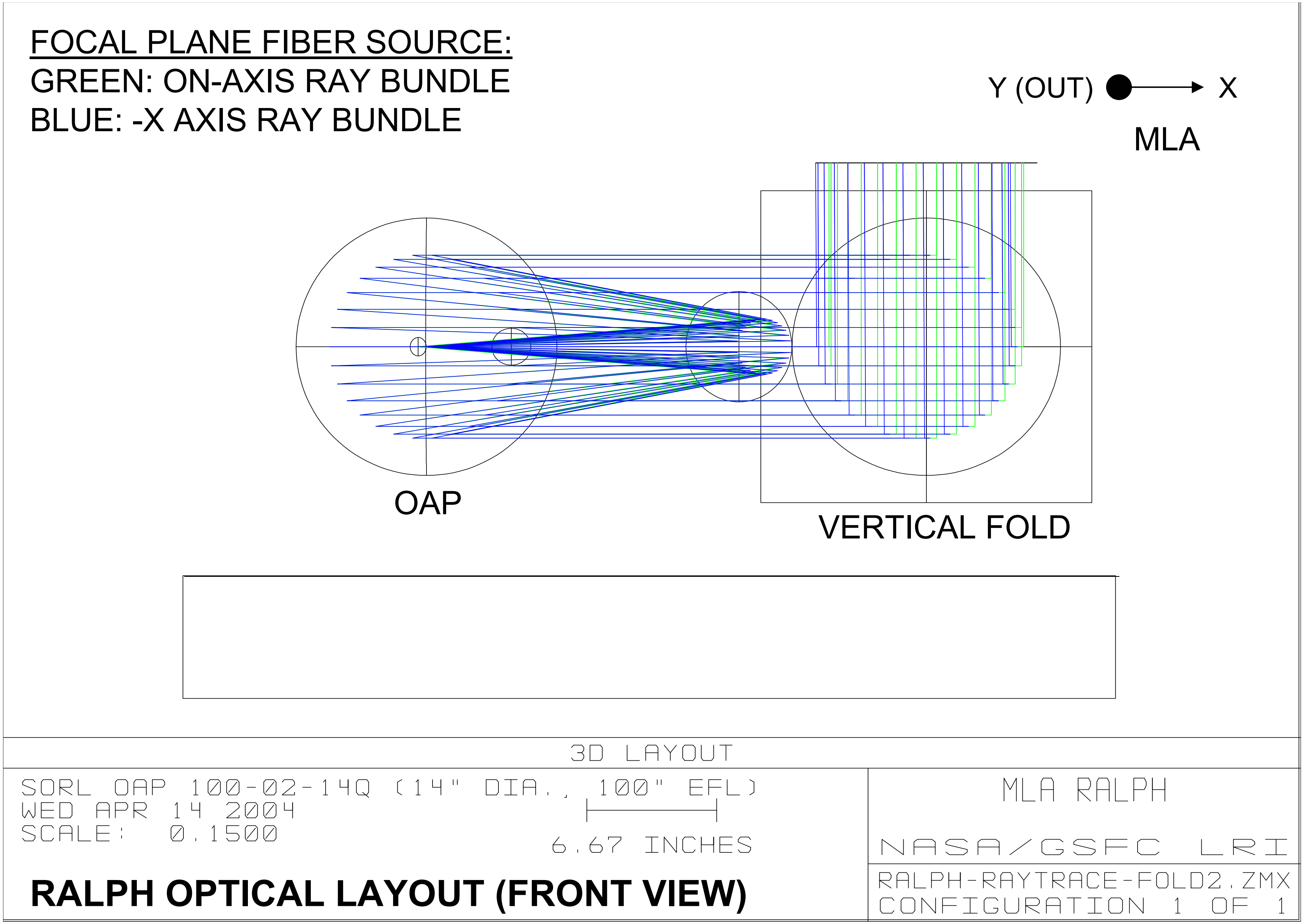
10.00 INCHES

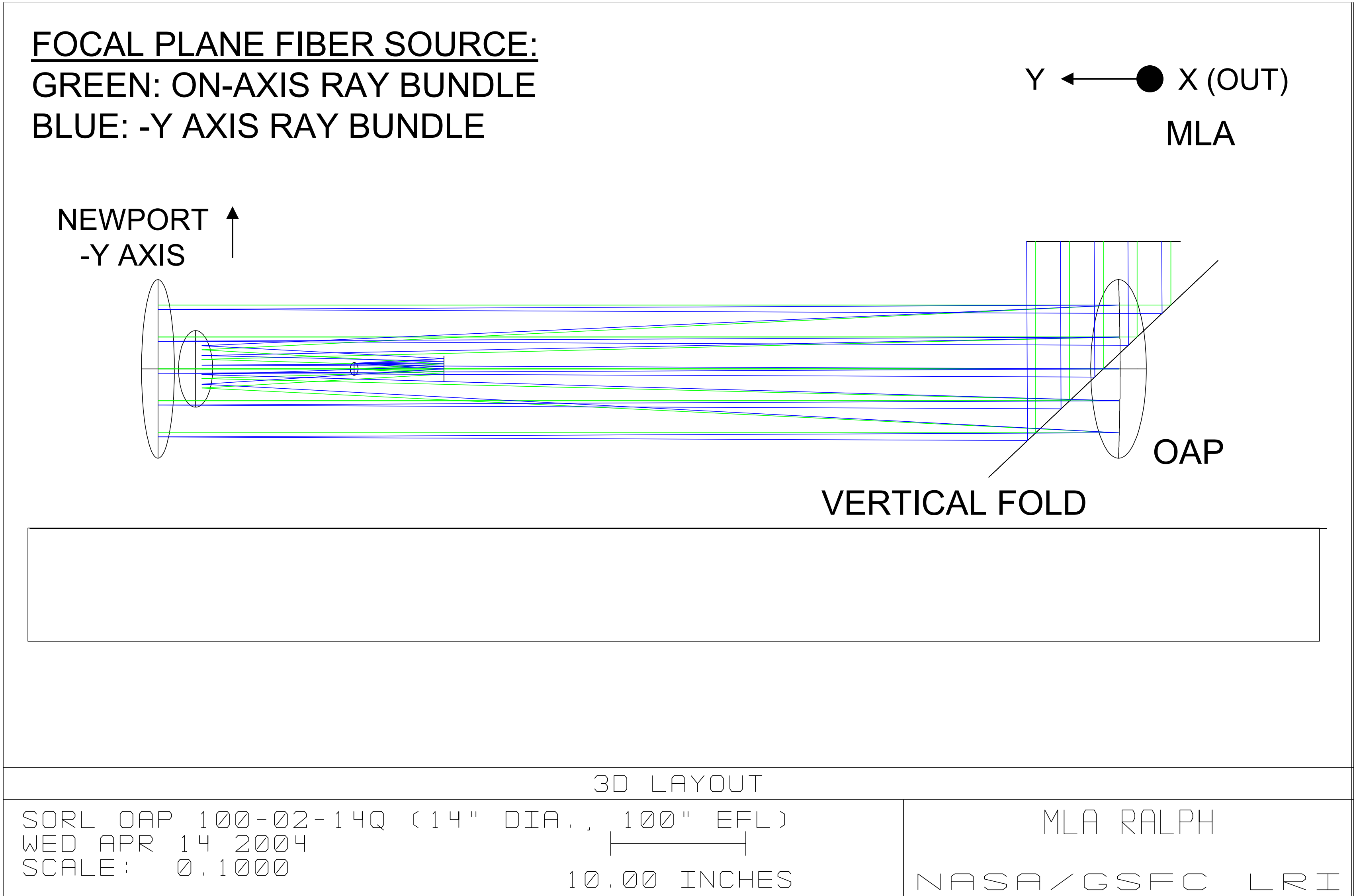
MLA RALPH

NASA/GSFC LRI

RALPH-RAYTRACE-FOLD2.ZMX
CONFIGURATION 1 OF 1

RALPH OPTICAL LAYOUT (TOP VIEW)


FOCAL PLANE FIBER SOURCE:
GREEN: ON-AXIS RAY BUNDLE
BLUE: -X AXIS RAY BUNDLE
Y (OUT)
X
MLA
OAP
VERTICAL FOLD
3D LAYOUT
SORL OAP 100-02-14Q (14" DIA., 100" EFL)
WED APR 14 2004
SCALE: 0.1500
6.67 INCHES
MLA RALPH
NASA/GSFC LRI
RALPH-RAYTRACE-FOLD2.ZMX
CONFIGURATION 1 OF 1
RALPH OPTICAL LAYOUT (FRONT VIEW)

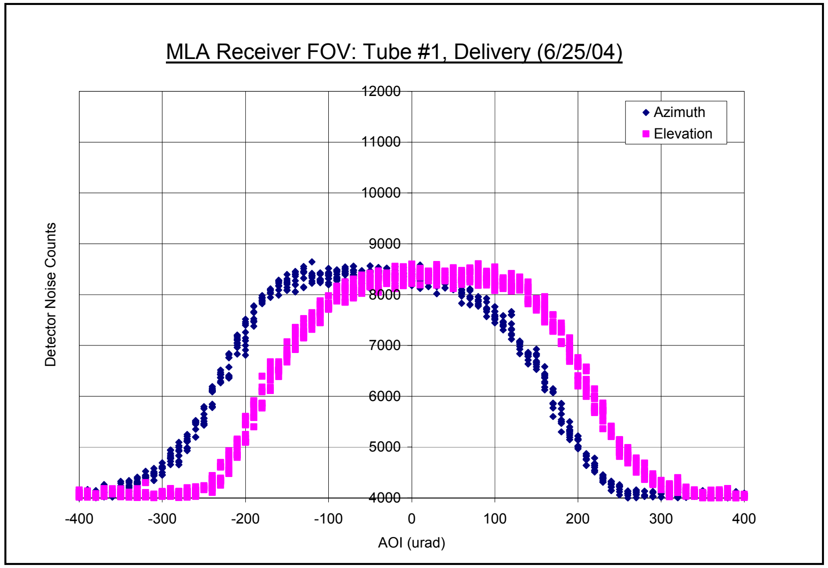


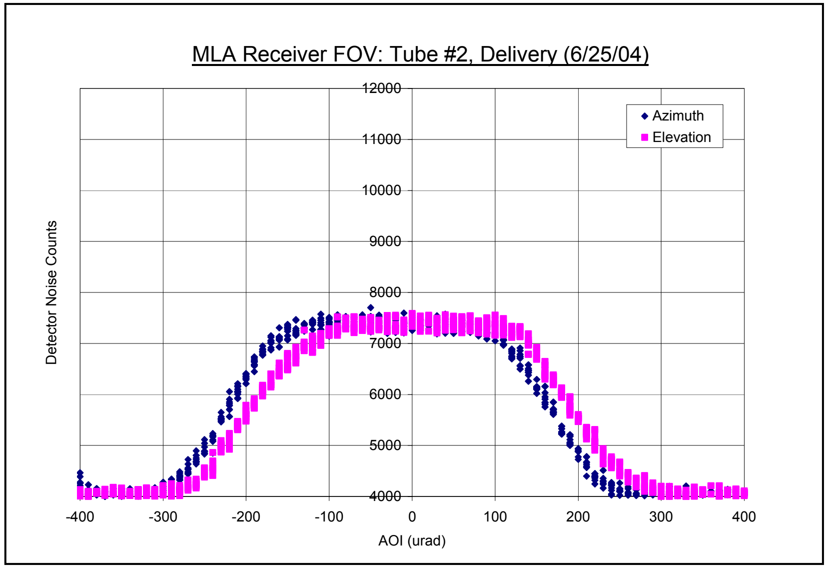
RALPH OPTICAL LAYOUT (SIDE VIEW)

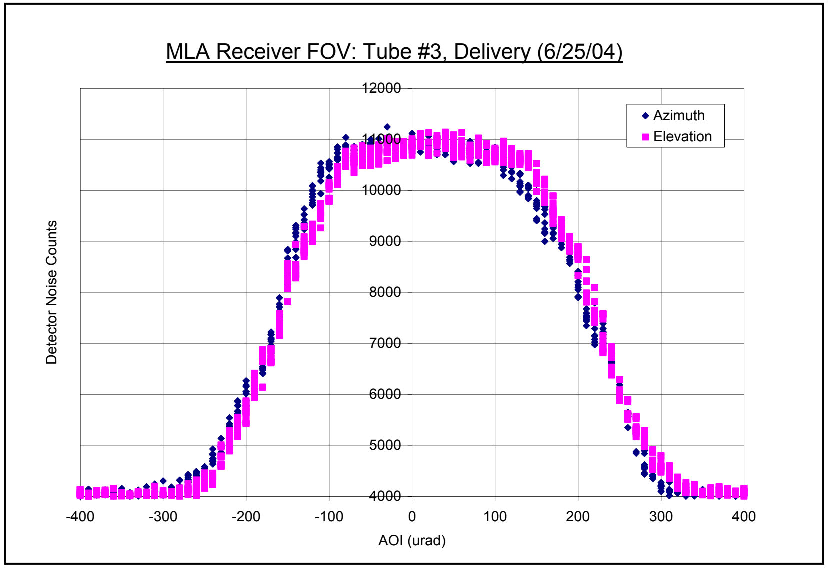
RALPH v. MLA Coordinates

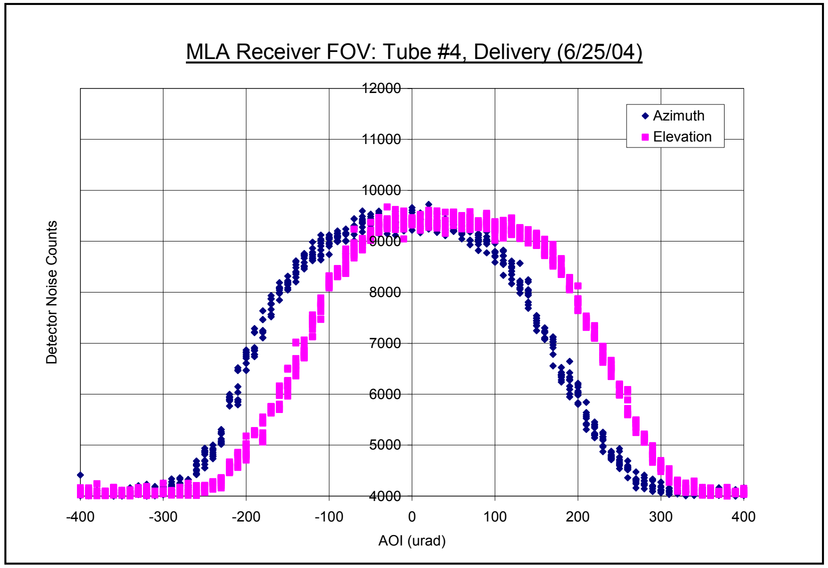
- RALPH source moves to Newport -X direction
  - RALPH beam goes to MLA –X axis
  - For a FOV plot centered on the RALPH –X axis:
    - Receiver tube points towards MLA +X (+Ry MLA)
    - MLA Laser is on –X side relative to receiver C/L
- RALPH source moves to Newport -Y direction
  - RALPH beam goes to MLA +Y axis
  - For a FOV plot centered on the RALPH –Y axis:
    - Receiver tube points towards MLA -Y (+Rx MLA)
    - MLA Laser is on +Y side relative to receiver C/L
  - Multiply FOV plot Y-axis centroid coordinate by -1 to plot MLA Laser location relative to MLA receiver FOV

MLA Receiver FOV: Instrument Delivery (6/25/03)









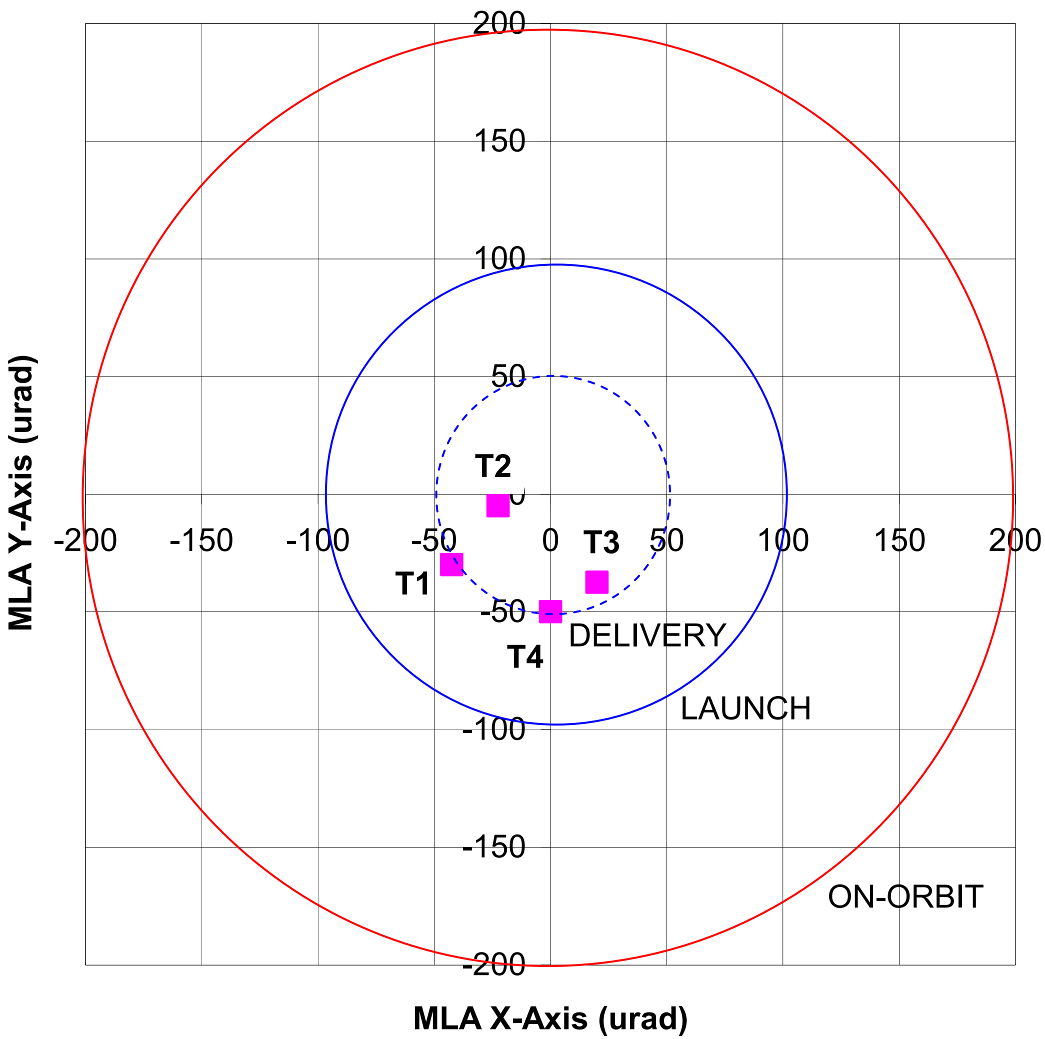
MLA Boresite Alignment at Instrument Delivery (6/25/03)

	RECEIVER FOV CENTROID		MLA LASER CENTROID		
	RALPH AZ	RALPH EL	MLA X	MLA Y	R
Tube 1	-43	30	-43	-30	52
Tube 2	-23	5	-23	-5	23
Tube 3	20	38	20	-38	43
Tube 4	0	50	0	-50	50

All units in micro-radians

- MLA Receiver FOV plots are as expected for 1ATM testing, FWHM and FOV centroid numbers are still valid
- MLA Laser centroid coordinates are specified relative to the particular MLA receiver tube optical axis
- X and Y axes are per the MLA Coordinate System
- MLA Boresite Alignment Requirements:
  - MLA Instrument Delivery < +/-50μrad
  - MESSENGER Launch < +/-100μrad
  - MESSENGER On-Orbit < +/-200μrad (MLA Receiver FOV)

MLA Boresite Alignment: Instrument Delivery (6/25/03)



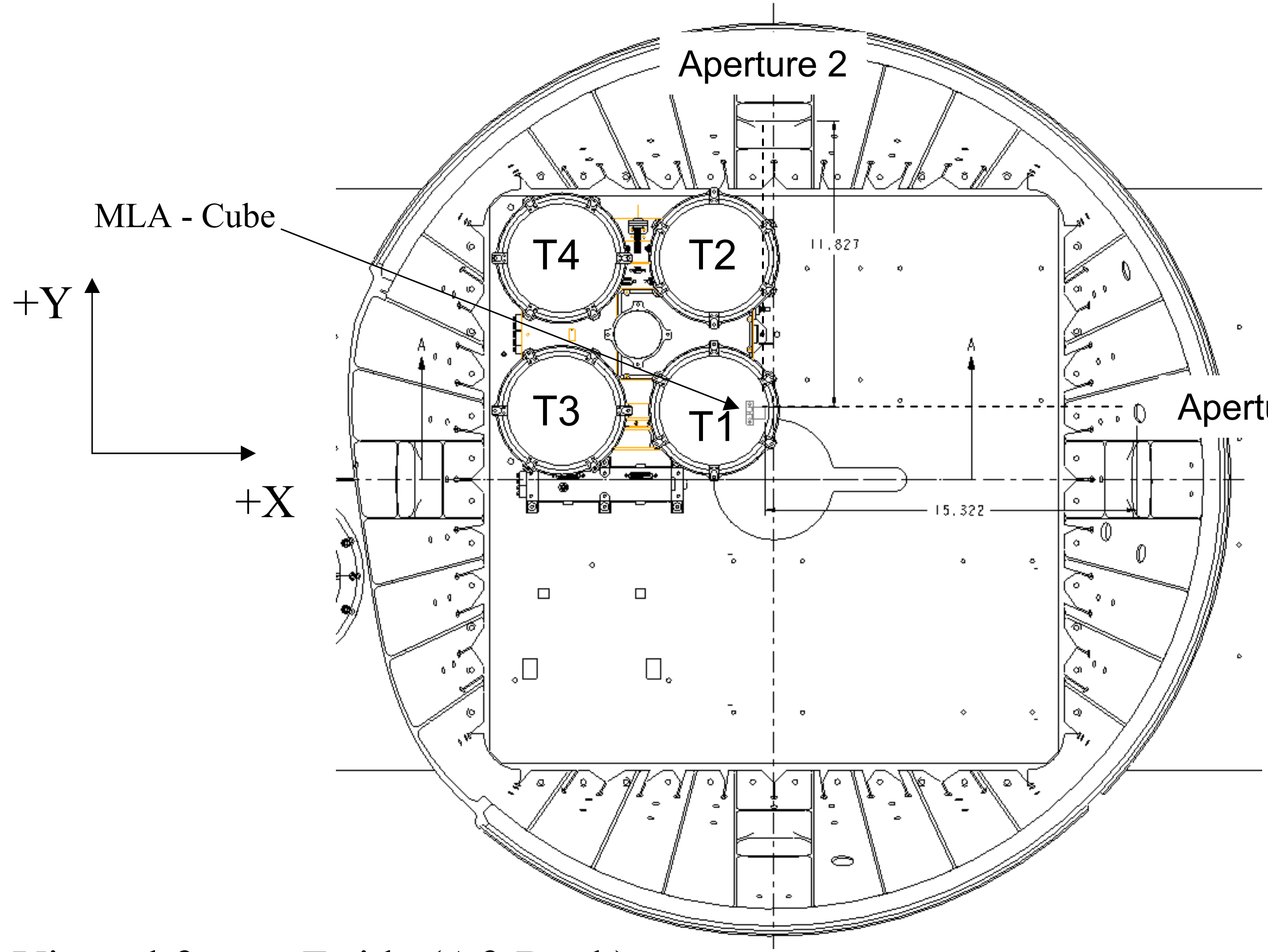
Data points are MLA Laser boresite alignment relative to each MLA Receiver FOV.

Circles indicate boresite alignment requirements for instrument delivery, launch, and on-orbit operation.

MLA S/C Level Boresite Alignment

- Performed using Risley/LTR Target Assembly
  - MLA Laser beam is enclosed by a tube and attenuated by the Laser Beam Dump, the beam is then flipped 180deg. by an LTR and scanned with computer controlled Risley prisms in two orthogonal axes
  - Each receiver tube is scanned sequentially and the detector output (pulse width) v. Risley deviation angle is plotted to map out the receiver FOV and boresite
  - MLA S/C level boresite alignment was measured only once per test due to MESSENGER time constraints
- Post S/C Vibe and Acoustics
  - MESSENGER on Elephant Stand $\Rightarrow$ short tube baffle
- Post S/C TVAV and Ship
  - MESSENGER on Turnover Fixture $\Rightarrow$ extended tube

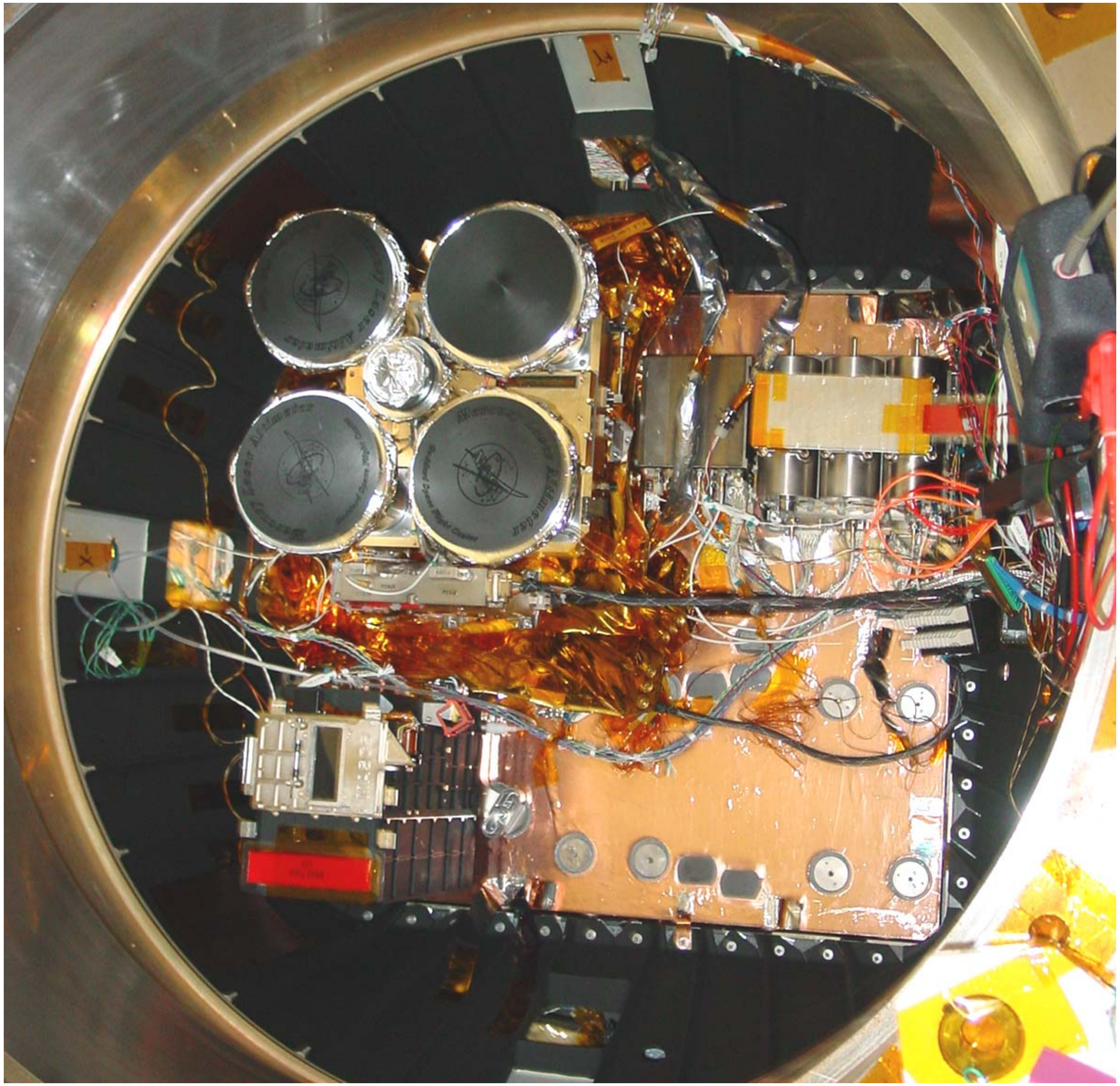
MLA location on MESSENGER Deck



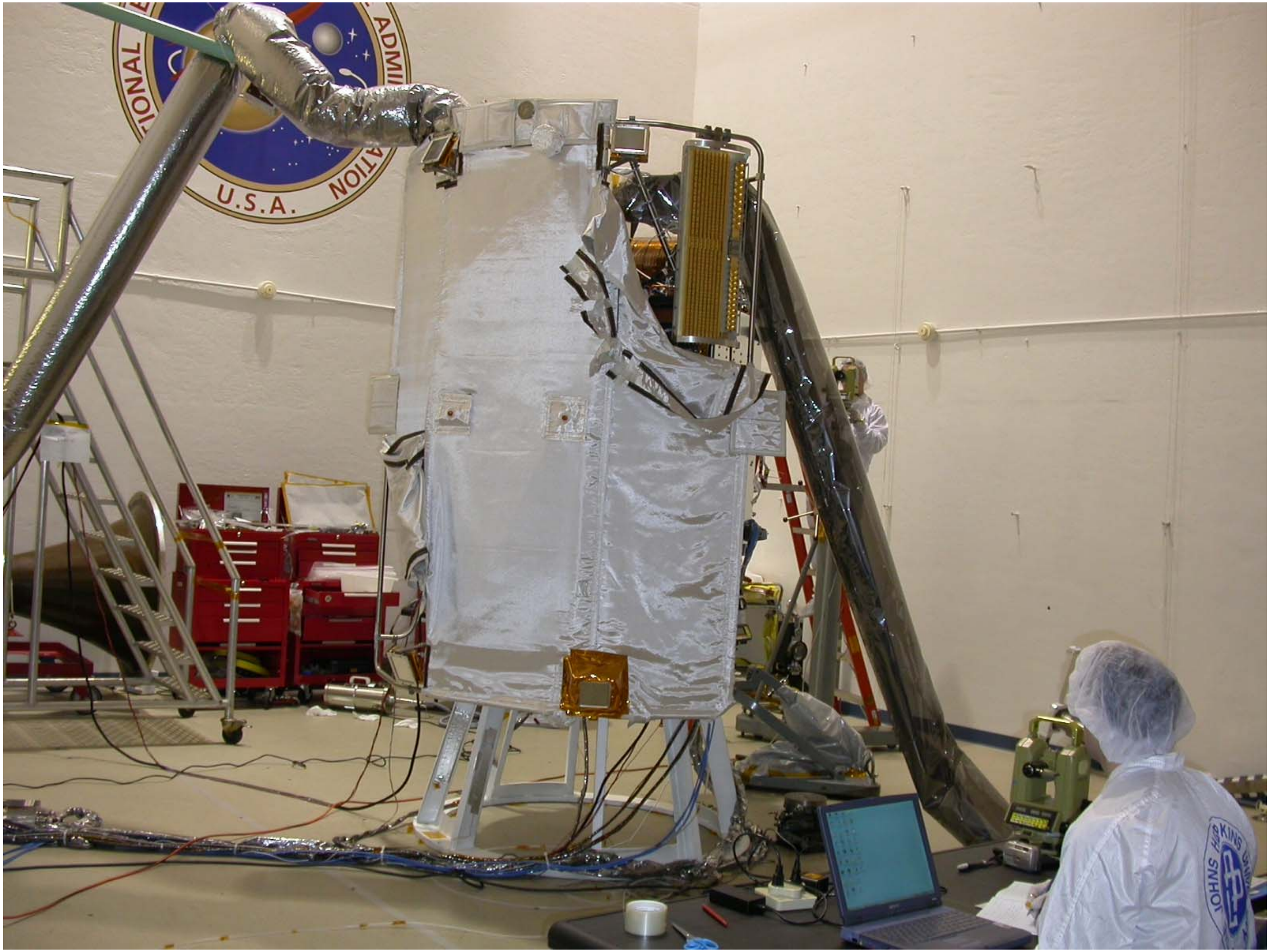
Viewed from +Z side (Aft Deck)
(Dimensions in inches)

Location of MLA Cube
09-18-02

MLA installed on MESSENGER Deck



MESSENGER installed on Elephant Stand



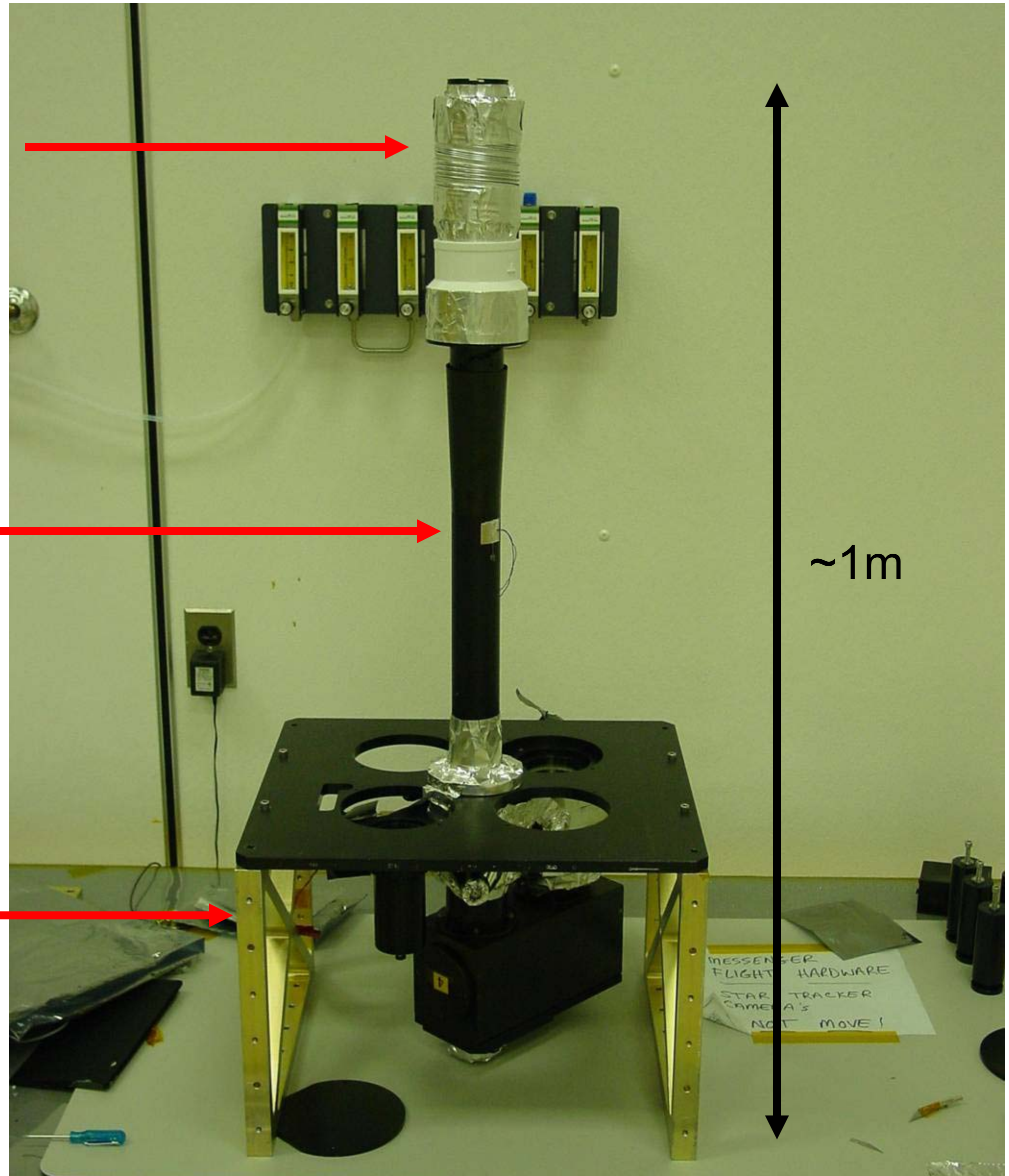
MESSENGER installed on Turnover Fixture

MLA Risley/LTR Target Assembly (Short Tube)

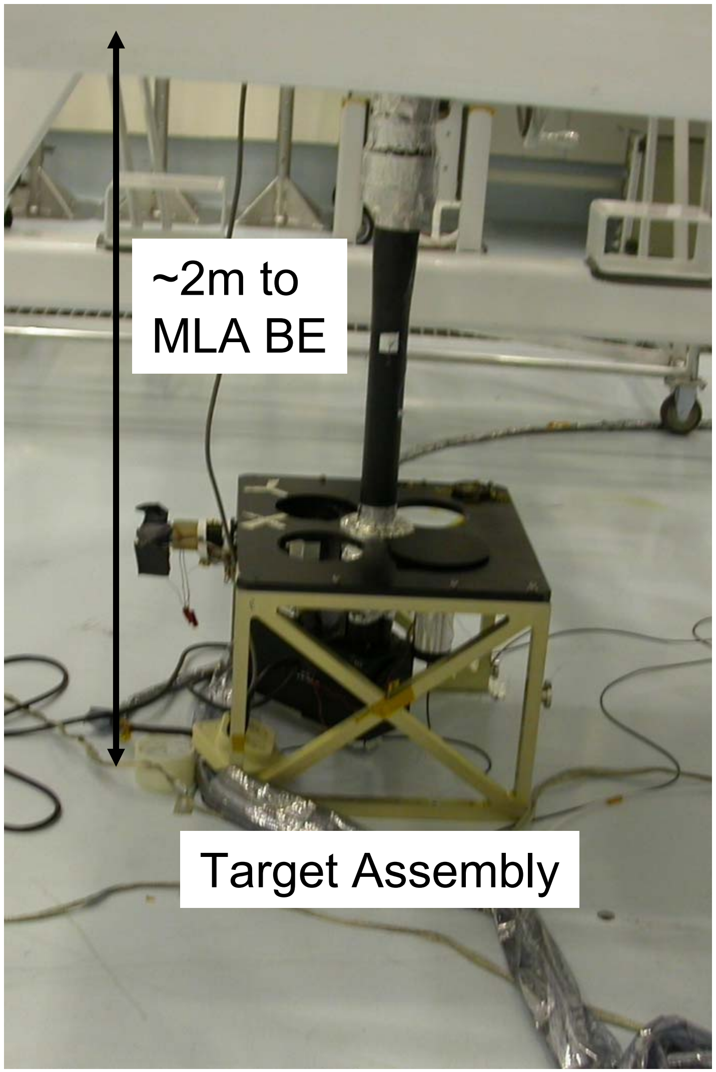
MLA BE Coupling
(flexible but stiff)

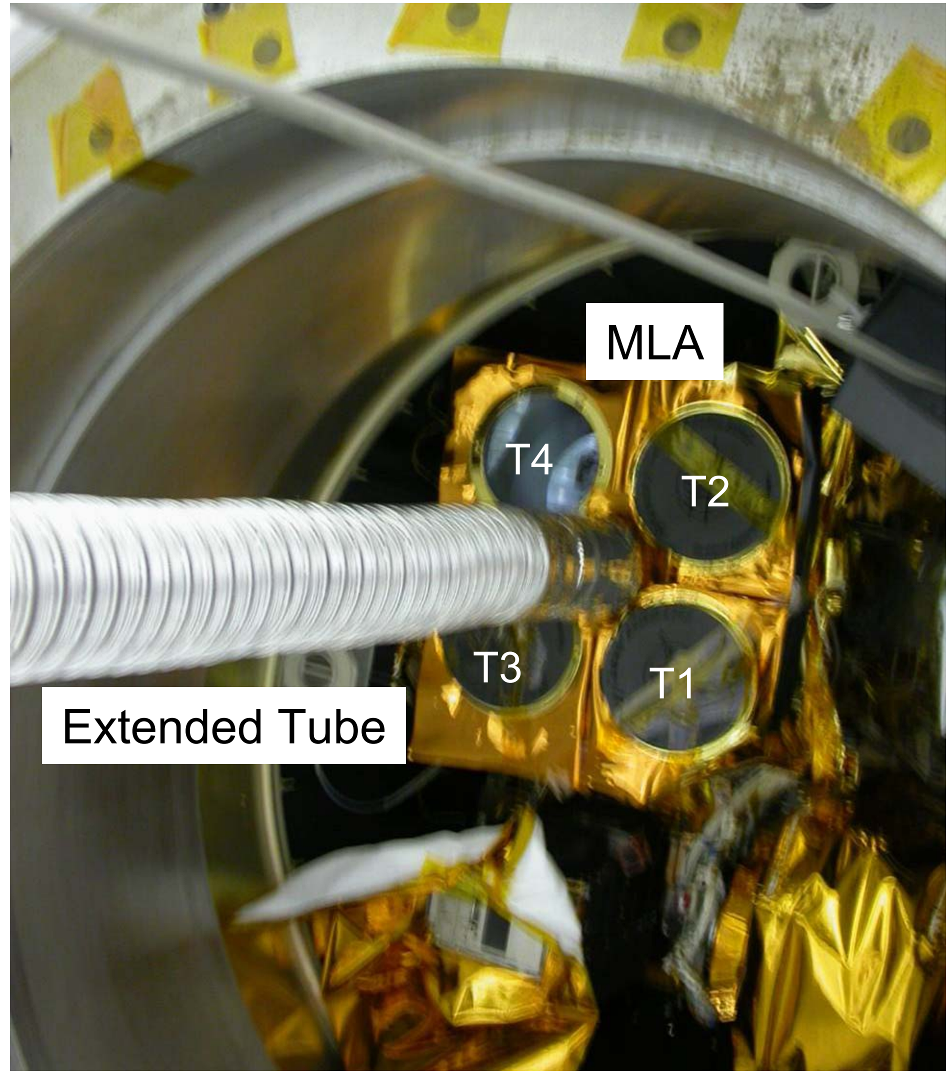
Short Tube
(aluminum)

LTR/Risley
Target
Assembly

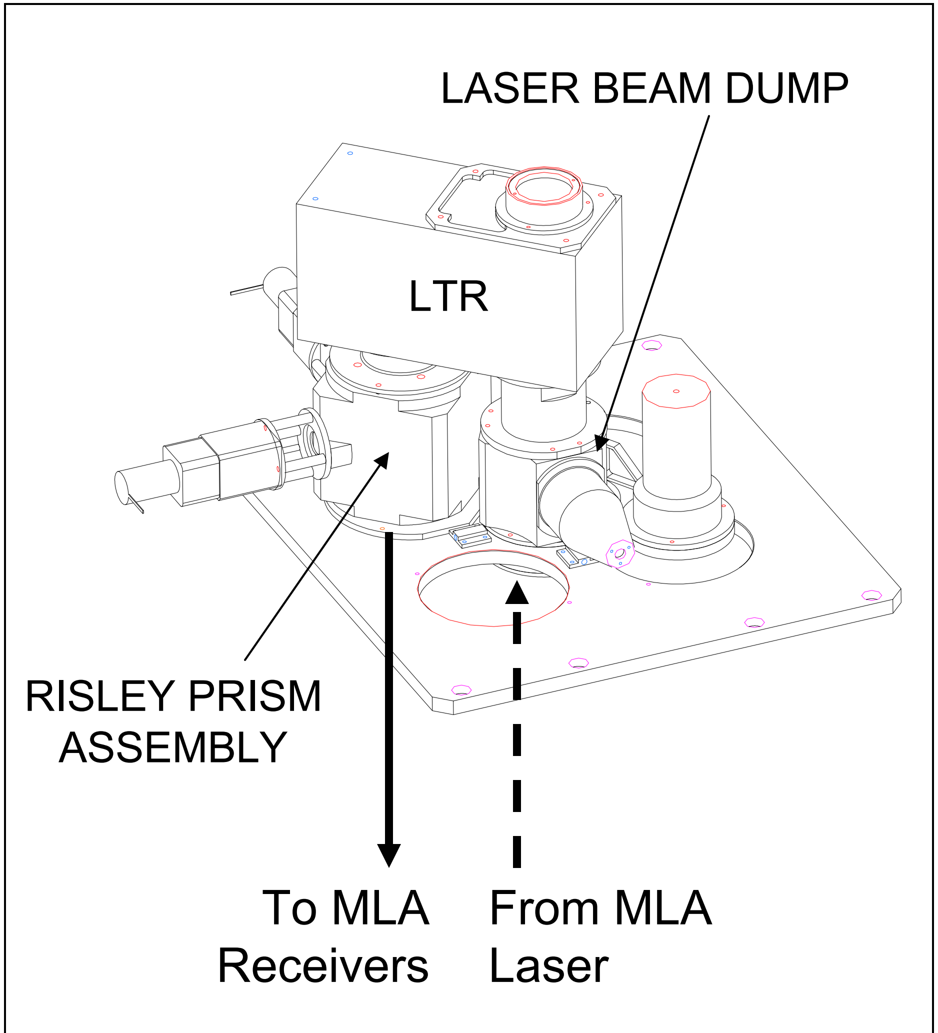


MLA Risley/LTR Target Assembly (Extended Tube)



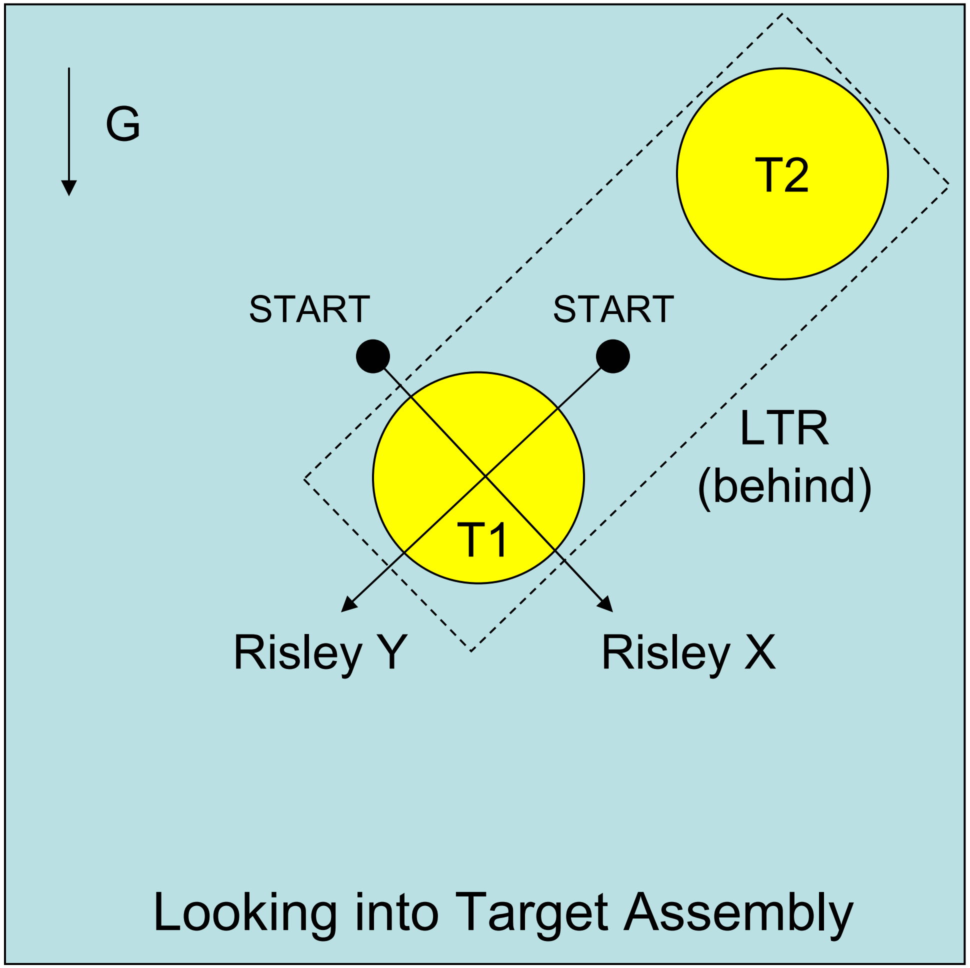


MLA RISLEY/LTR TARGET ASSEMBLY



- Put together using GLAS and VCL BCE hardware
- Target used for the 1st time during MLA TVAC
- Partial receiver aperture illumination by MLA Laser
- Risley "null setting" can change over time
  - S/C Vibe: 20μrad error
  - S/C TVAC: 40μrad error
  - Null errors not corrected
  - In the future should re-null Risley's before each test
- Manual data analysis

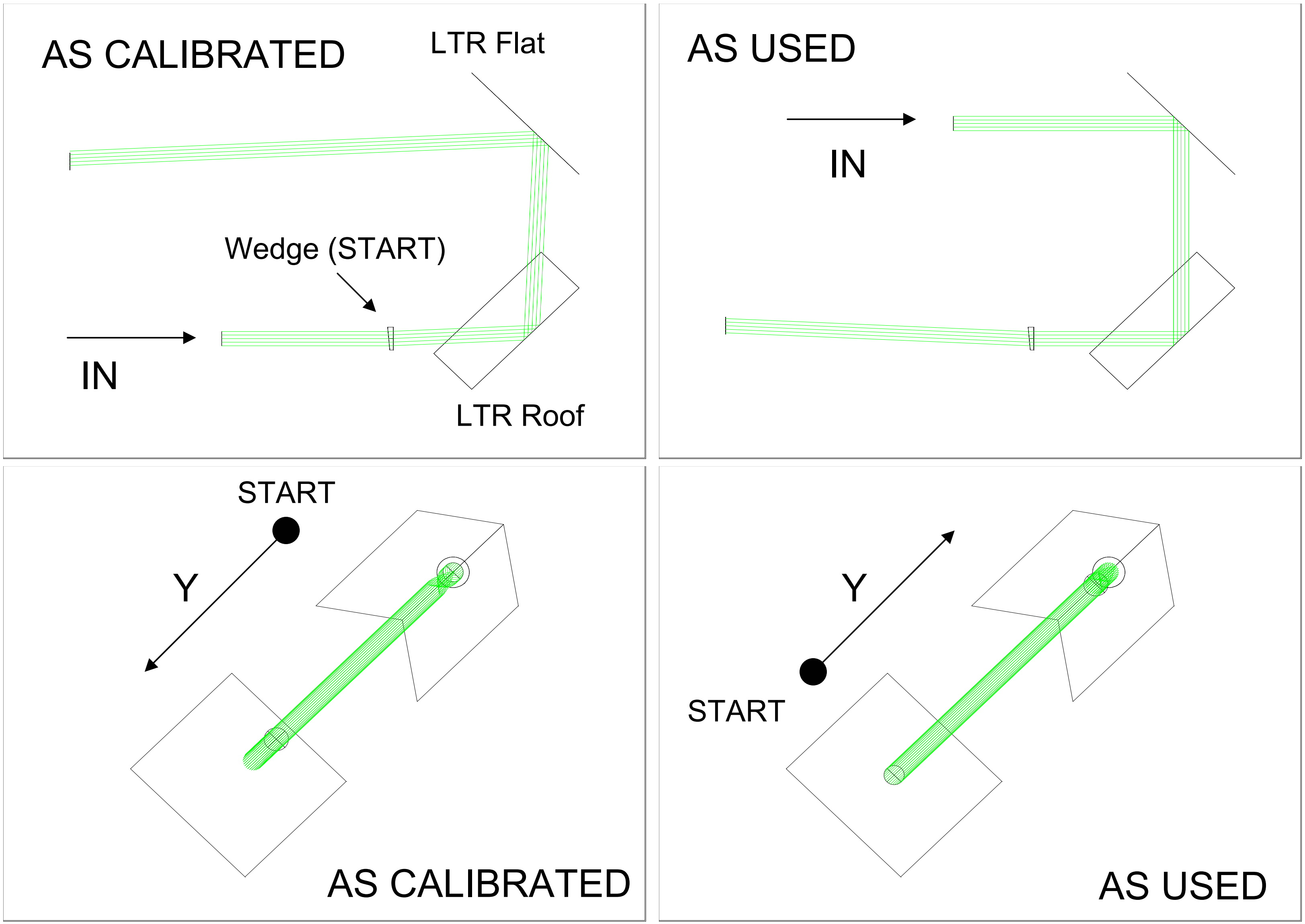
LTR/Risley Target Angular Calibration



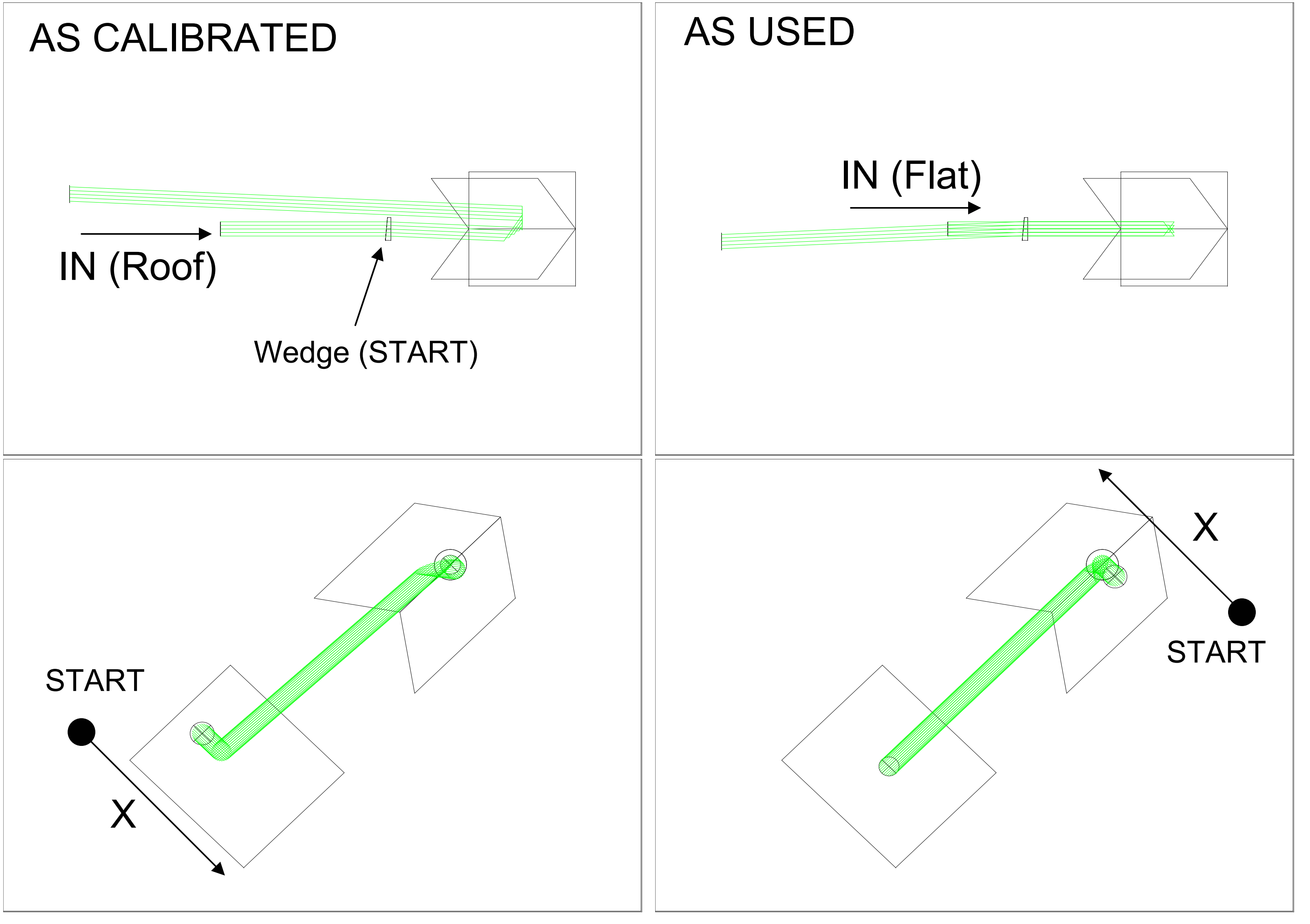
- T2 and T1 are theodolites
- T2 and T1 are aligned parallel to one another
- T1 measures the T2 beam deviation as the Risley's are scanned
- Target assembly was calibrated backwards
  - Center hole is MLA Laser input aperture
- Target assembly not currently available to repeat calibration
- Will model and raytrace to understand behavior when used as intended

S. Scott 3/15/04

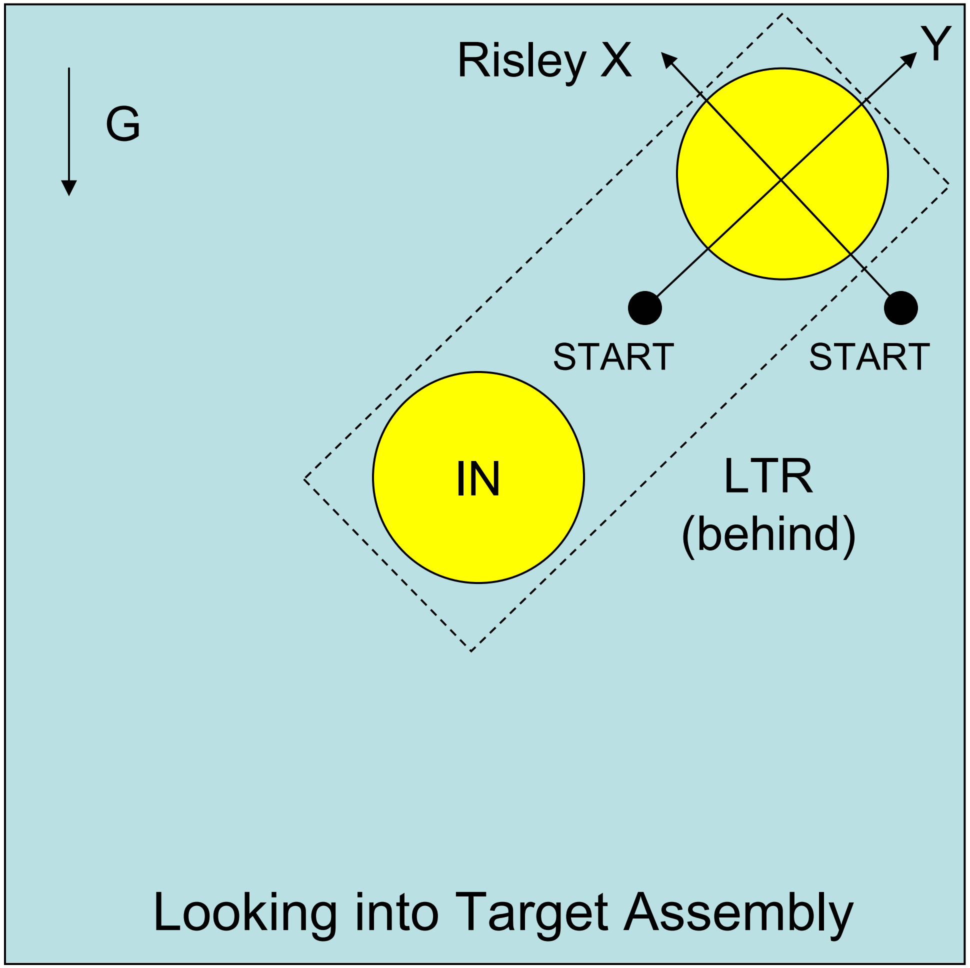
LTR with Y-Axis Wedge



LTR with X-Axis Wedge

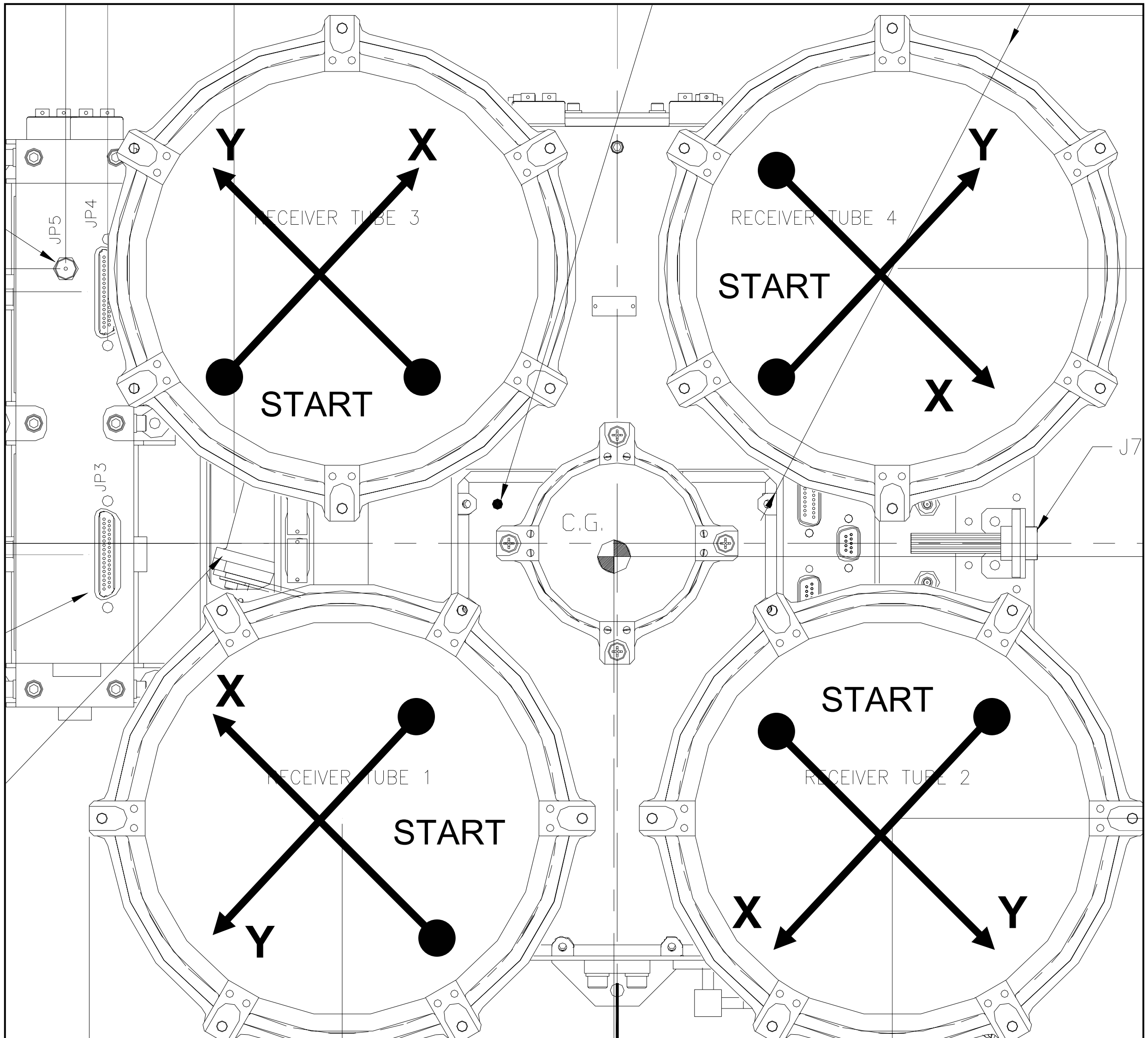


LTR/Risley Target Beam Deviation



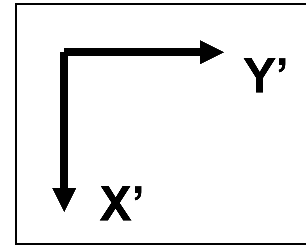
- Reversing input port flips directions of beam scan
- Risley X-axis scan starts at negative μradians while Y-axis scan starts at positive μradians
- Superimpose Risley scan axes directions on MLA Receiver apertures
- Need to convert Risley coordinate system to MLA coordinate system in order to compare to RALPH data (Instrument Delivery)

MLA Laser Scan Axes Relative to MLA Receiver Tubes



Looking into MLA Apertures

MLA

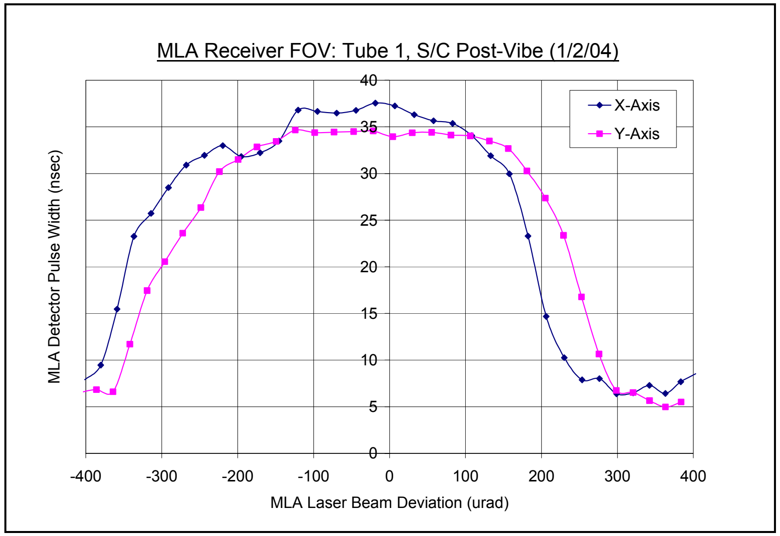


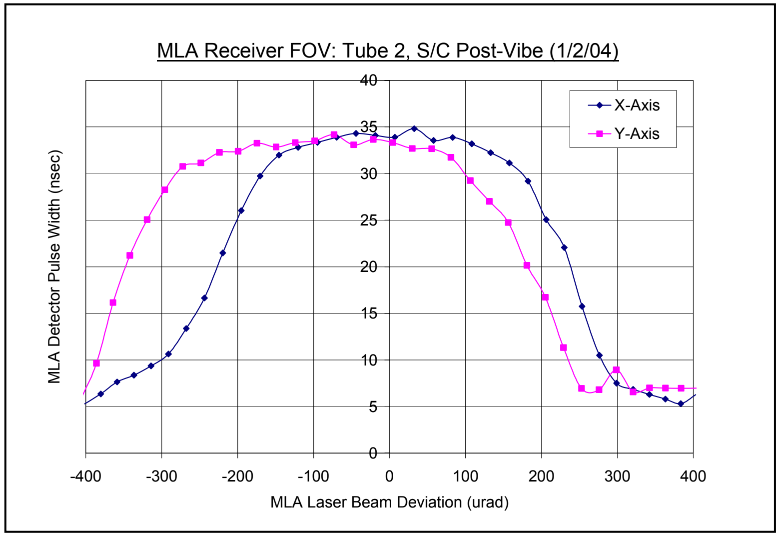
Coordinate System Conversion

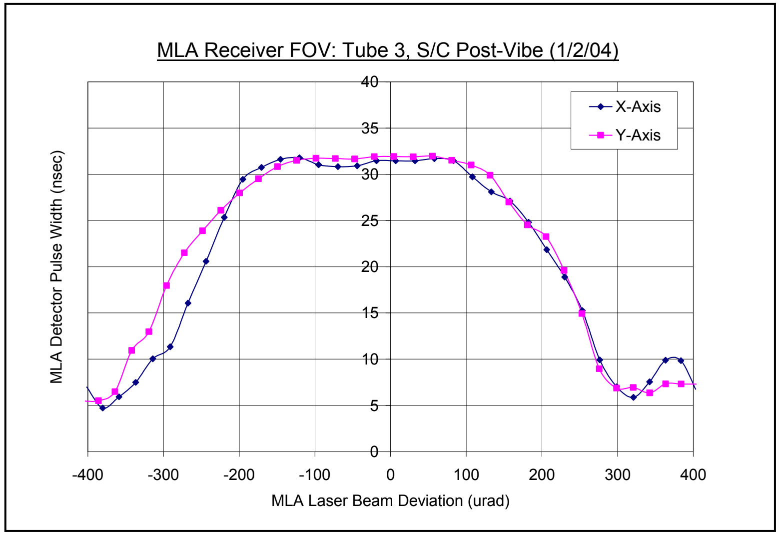
	X'
TUBE 1	= -(0.707)X + (0.707)Y
TUBE 2	= +(0.707)X + (0.707)Y
TUBE 3	= -(0.707)X - (0.707)Y
TUBE 4	= +(0.707)X - (0.707)Y

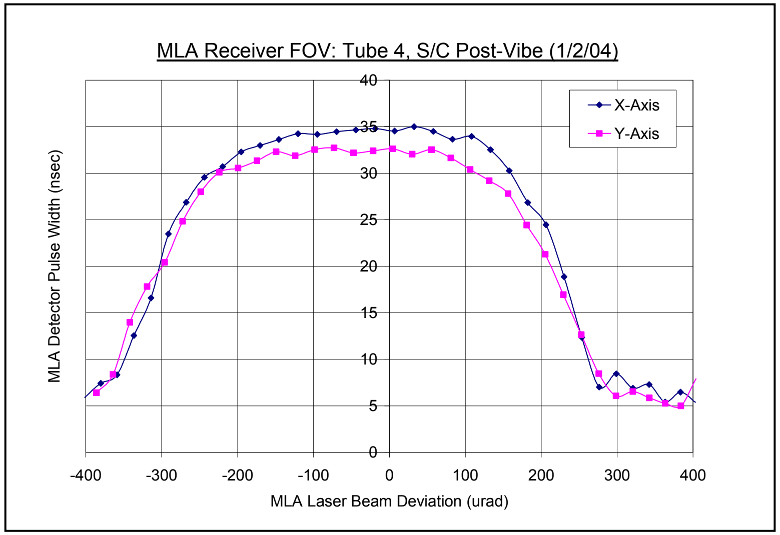
	Y'
TUBE 1	= -(0.707)X - (0.707)Y
TUBE 2	= -(0.707)X + (0.707)Y
TUBE 3	= +(0.707)X - (0.707)Y
TUBE 4	= +(0.707)X + (0.707)Y

MLA Receiver FOV: S/C Post-Vibe (1/2/04)









MLA Post-S/C Vibe/Acoustics Test FOV Sweep Summary (1/2/04)

	Risley X-AXIS						Risley Y-AXIS					
	50%	90%	90%	50%	FWHM	CENTER	50%	90%	90%	50%	FWHM	CENTER
TUBE 1	-340	-138	101	186	526	-48	-302	-196	167	242	544	-22
TUBE 2	-227	-147	141	238	465	1	-348	-244	85	183	531	-81
TUBE 3	-256	-197	117	234	490	-26	-291	-178	136	234	525	-25
TUBE 4	-302	-199	139	225	527	-34	-310	-226	115	219	529	-51

Units urad

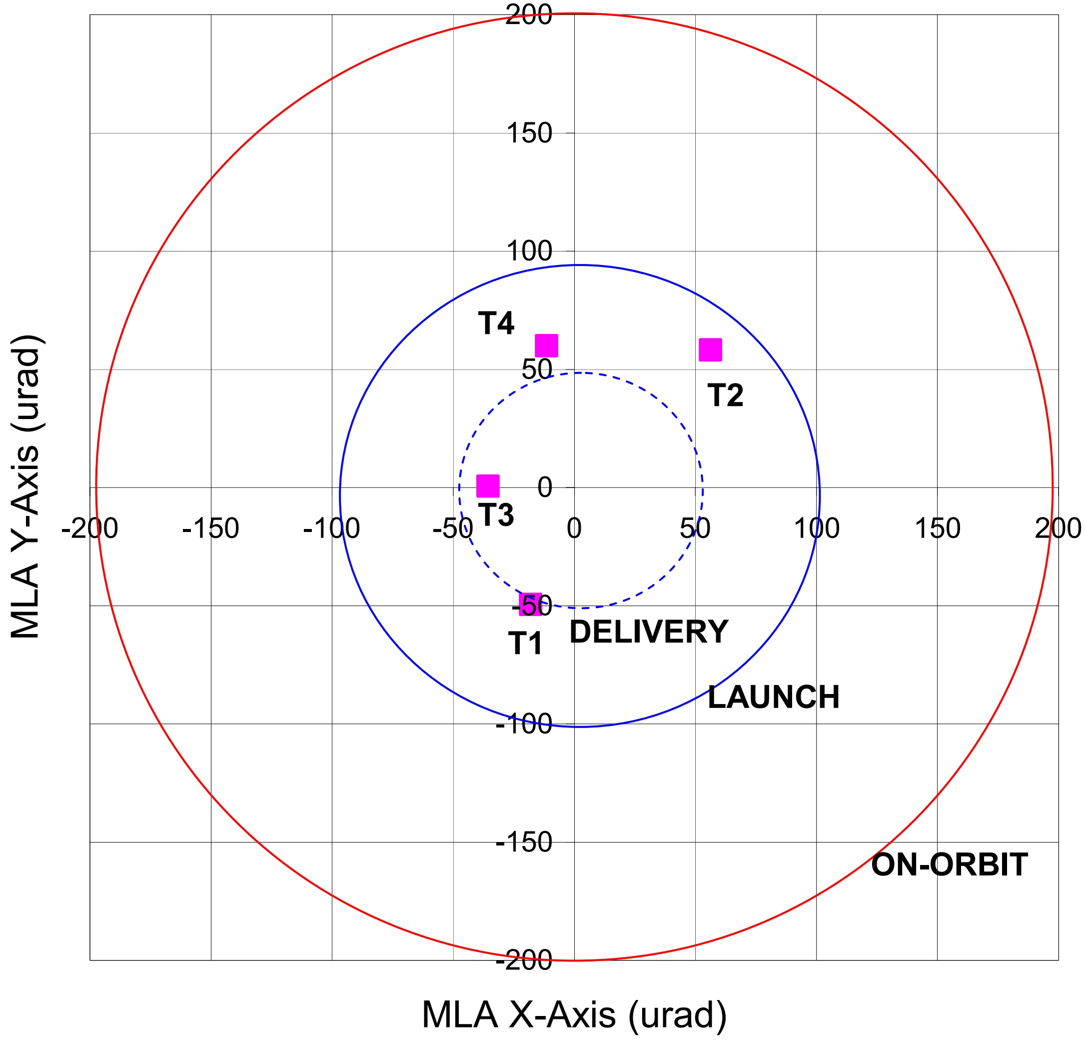
	FOV Risley Coordinates			FOV MLA Coordinates			Laser MLA Coordinates		
	X	Y	R	X'	Y'	R	X'	Y'	R
TUBE 1	-48	-22	53	18	49	53	-18	-49	53
TUBE 2	1	-81	81	-56	-58	81	56	58	81
TUBE 3	-26	-25	36	36	-1	36	-36	1	36
TUBE 4	-34	-51	61	11	-60	61	-11	60	61

Units urad

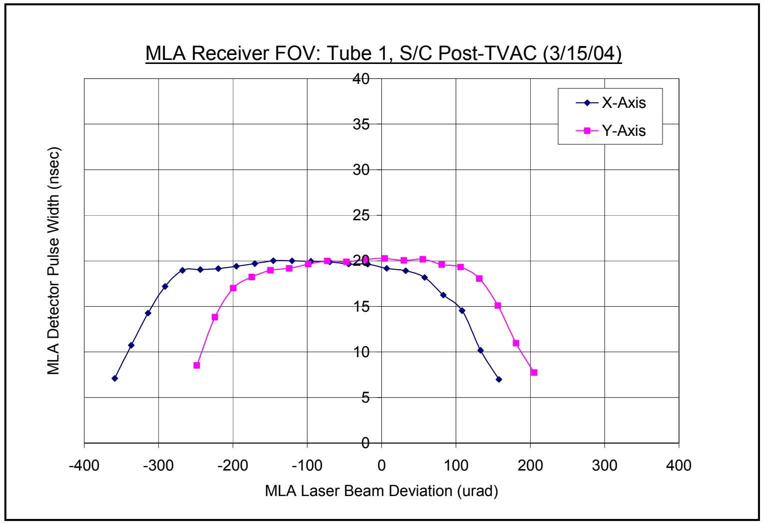
Data Analysis Procedure

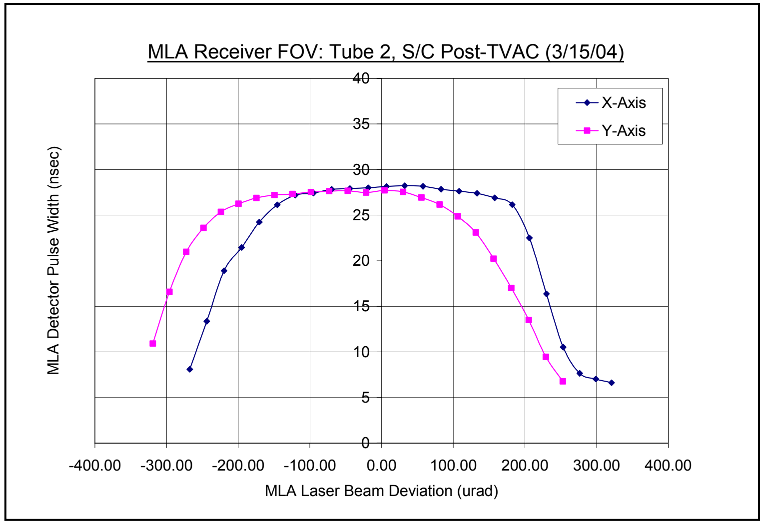
1. Substract background and normalize Receiver FOV X-axis and Y-axis cross-sectional plots
2. Calculate locations (in urad's) of 50% and 90% level FOV crossing points
3. Calculate Receiver FOV 50% and 90% level FOV centers and average to determine Receiver FOV center
4. Convert Receiver FOV center coordinates from Risley coordinate system to MLA coordinate system
5. Multiply Receiver FOV center coordinates by -1 to obtain MLA Laser center relative to MLA Receiver FOV
7. Plot MLA Laser center coordinates for each Receiver Telescope

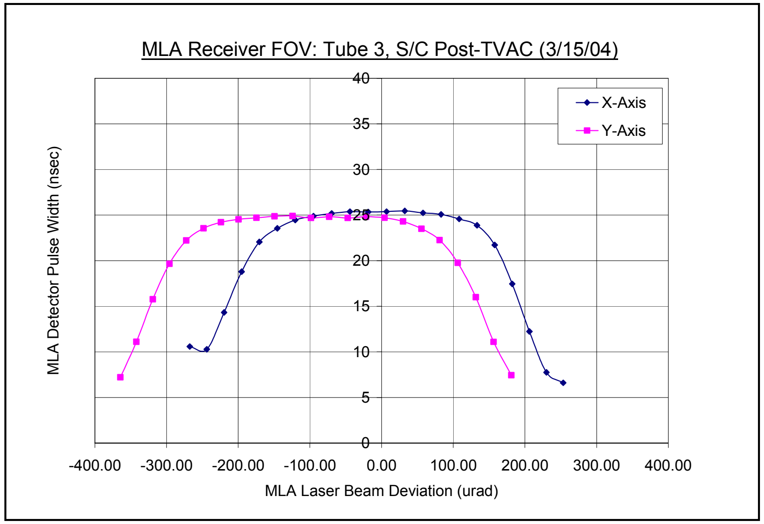
MLA Boresight Alignment: Post S/C Vibe & Acoustics

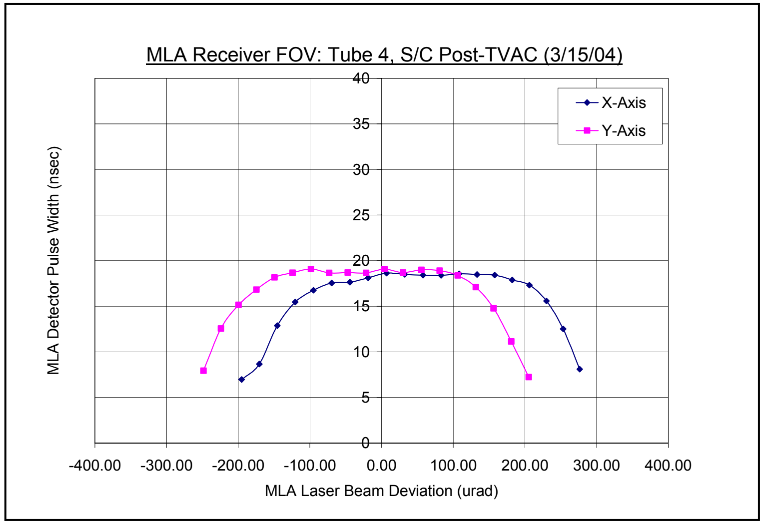


MLA Receiver FOV: S/C Post-TVAC (3/15/04)









Post S/C TVAC/Ship FOV Sweep Summary (3/15/04)

	X-AXIS						Y-AXIS					
	50%	90%	90%	50%	FWHM	CENTER	50%	90%	90%	50%	FWHM	CENTER
TUBE 1	-319	-271	39	114	433	-109	-223	-148	112	163	386	-24
TUBE 2	-226	-146	183	226	452	9	-293	-217	92	179	472	-60
TUBE 3	-210	-145	137	189	399	-7	-317	-255	62	130	447	-95
TUBE 4	-146	72	200	251	397	94	-218	-154	116	167	385	-22

Units urad

	FOV Risley Coordinates			FOV MLA Coordinates			Laser MLA Coordinates		
	X	Y	R	X'	Y'	R	X'	Y'	R
TUBE 1	-109	-24	112	60	94	112	-60	-94	112
TUBE 2	9	-60	60	-36	-49	60	36	49	60
TUBE 3	-7	-95	95	72	62	95	-72	-62	95
TUBE 4	94	-22	97	82	51	97	-82	-51	97

Units urad

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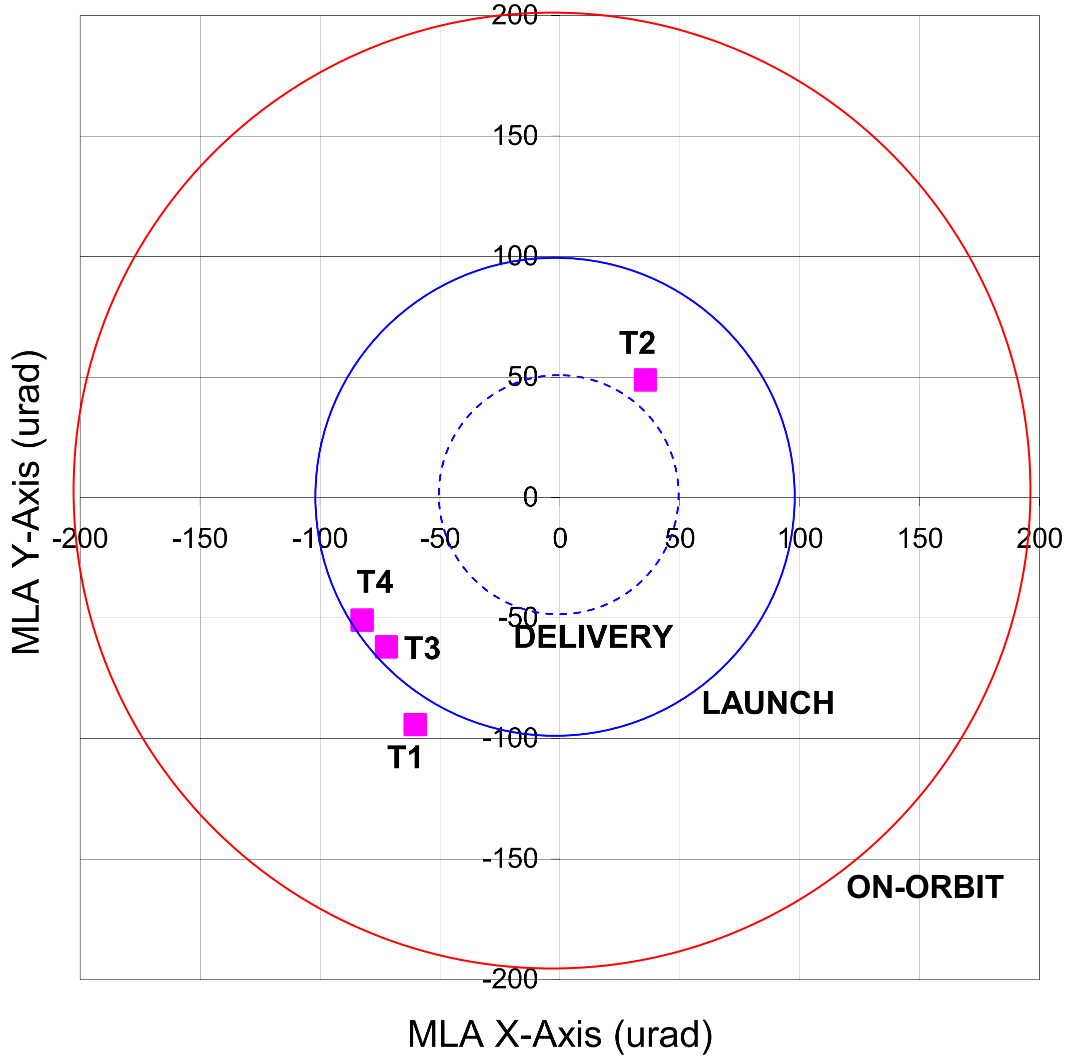
7. Plot MLA Laser center coordinates for each Receiver Telescope

MLA Boresight Alignment: Post S/C TVAC and Ship



MLA Boresite Summary

- Instrument was delivered with boresite "in spec"
- S/C Vibe and Acoustics test results met allocation
- S/C TVAC and Shipping test results exceeded boresite error allocation on Receiver Telescope S/N 1
  - Requirement is <100 μrad, actual is 112 μrad
  - Test set-up/data is suspect
    - Data analysis did not account for Risley null offset
    - MLA Laser beam was clipped by Target extended tube:
      Low Beam Dump energy monitor reading & low receiver telescope signals (~20-25nsec v. 35-40nsec peak typical)
    - Target extended tube is fairly stiff and could be imparting a sideways force on MLA Beam Expander and affecting MLA boresite alignment results
    - Recommend test is repeated before MESSENGER launch
    - Should consider jacking up Target Assembly in lieu of using extended tube and nulling Risley's prior to test