



# National Geodetic Survey Absolute Antenna Calibrations

CORS User Forum

Andria Bilich & Gerald Mader

NGS Geosciences Research Division

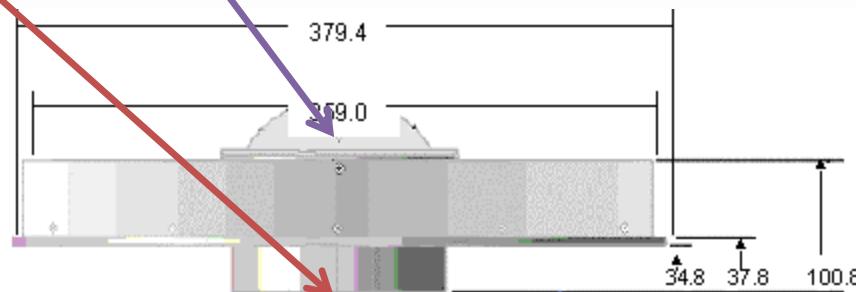
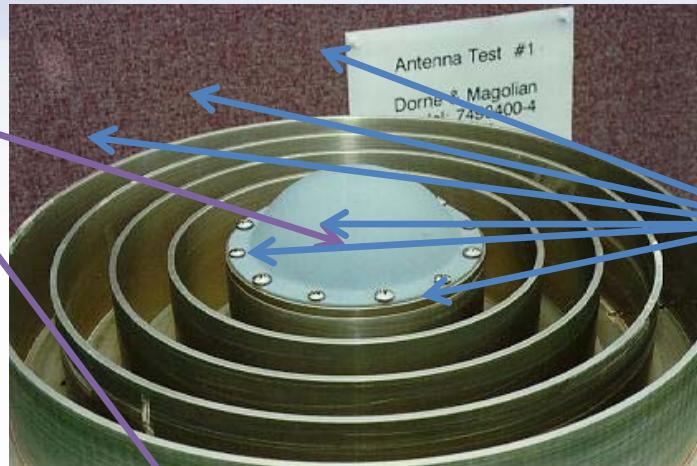
# Outline

- Absolute antenna calibrations
  - What are they?
  - How are they different from relative calibrations?
  - What do they look like?
  - What impact do they have on positions?
- NGS Calibration Services
  - How do I get my antenna calibrated?
  - Where are the values published?

# Where do I receive the signal?

Antenna  
element

Antenna  
reference  
point  
(ARP)



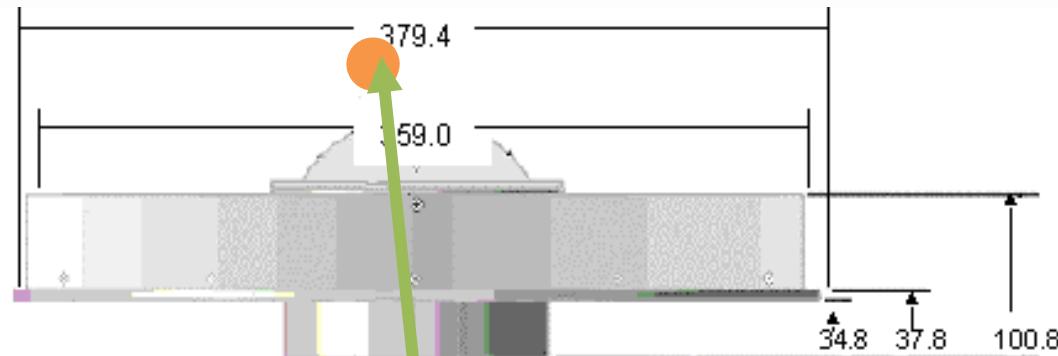
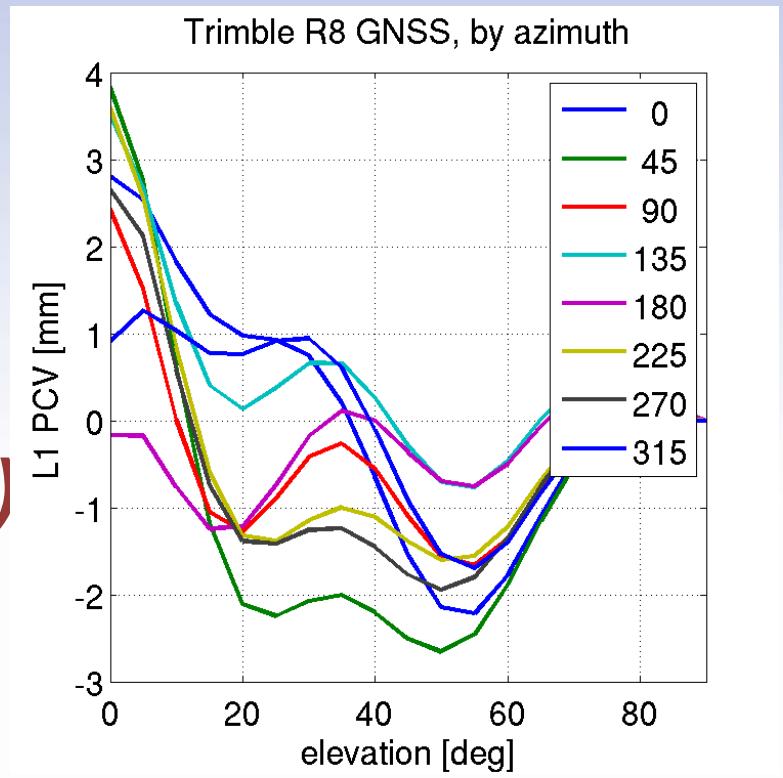
Nonphysical  
and  
inconstant  
point floating  
in space

# What is GNSS Antenna Calibration?

*Create a “map”  
of antenna  
characteristics*

- Mean point  
being positioned  
**(PC0)**
- Spatial variations  
**(PCV)**

**PCV**  
**(el)**  
**PCV**  
**(az,el)**



# Equipment and Environment Effects on PCV

Ashtech  
choker ring  
(700936D\_M)



with  
SCIS  
radome

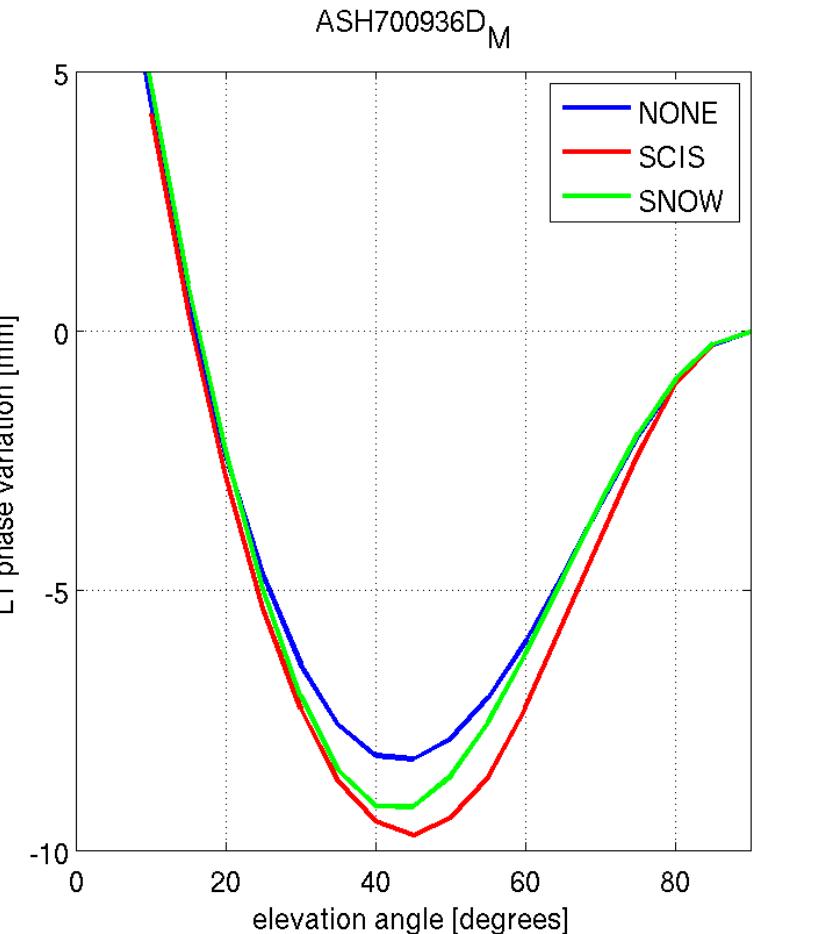


with  
SNOW  
radome



9/23/2010

ION GNSS 2010



# What Is The Effect of PCO/PCV?

Antenna element introduces elevation- (and azimuth-) dependent advance/delay to the carrier phase observation = PCO + PCV

- Effect on heights (wrt elevation cutoff)
- Alias into troposphere estimate
- <= 10cm height errors on mixed-antenna baselines

**Mixed-antenna and longer baselines  
demand good antenna calibrations**

**Published values are idealized (environment-free)**

# Relative vs. Absolute

Short baseline, differential solution

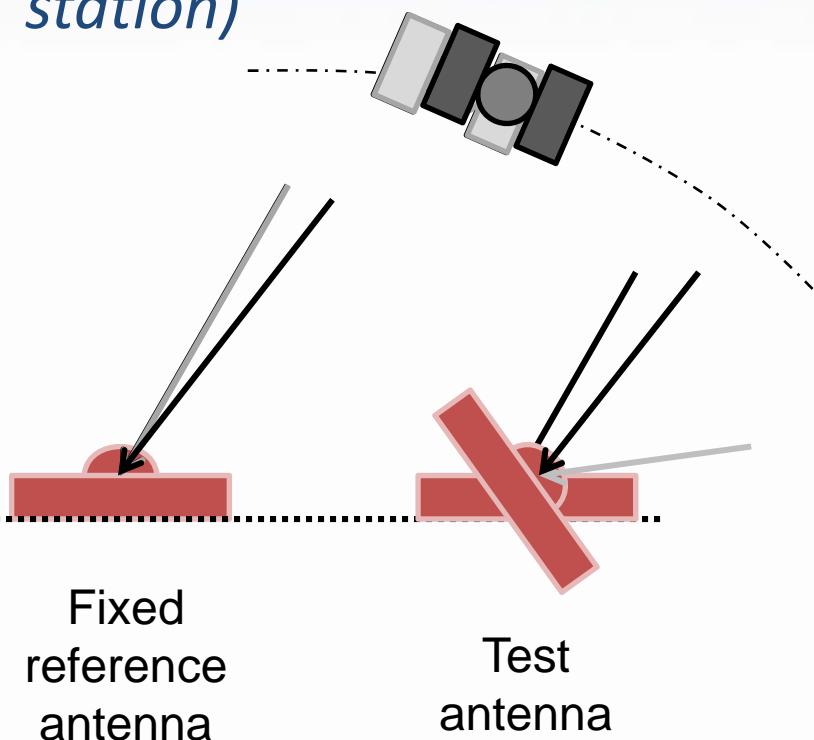
Relative:

- 2 fixed antennas
- Can only determine PCV/PC0 *relative to reference antenna*

Absolute:

- 1 fixed (ref), 1 moving (test) antenna
- Observable combination removes reference antenna effects

*IGS switch to absolute created ~ 1 ppb scale change (on average, 0.5 cm per station)*



# NGS Absolute Calibrations

## Motivations and Goals

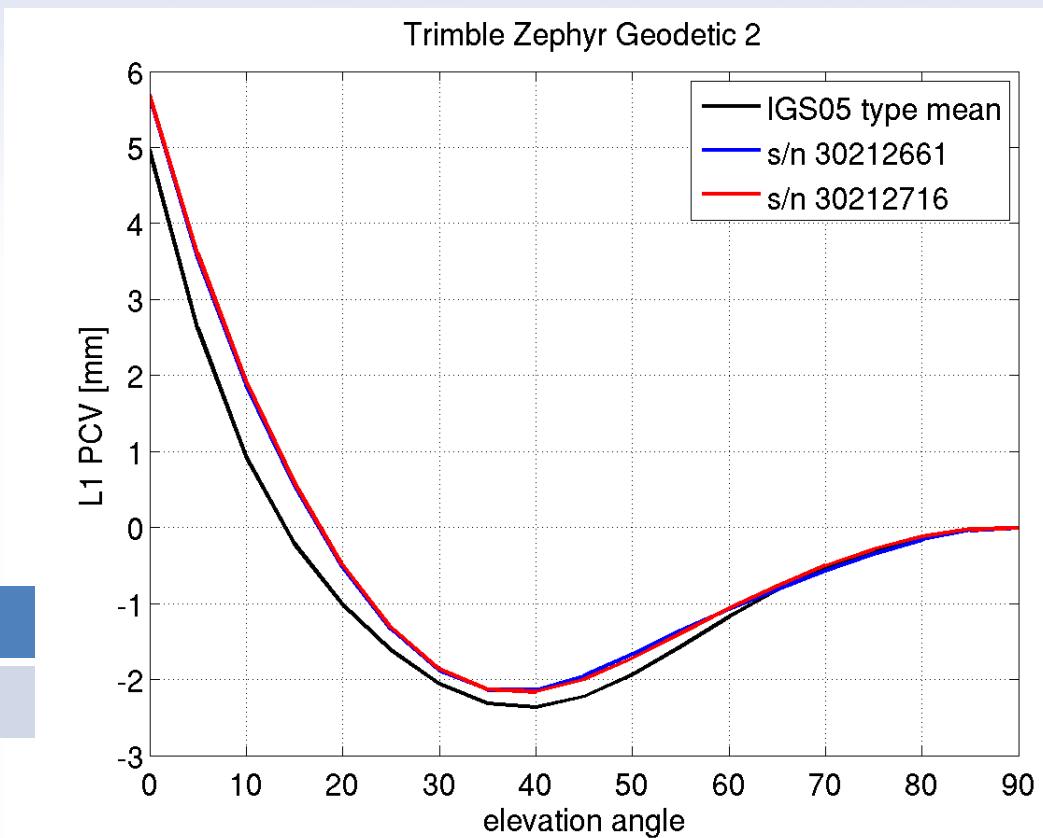
**Serve high precision needs of U.S. surveying  
and geodesy communities**

- Simultaneous multi-freq, multi-GNSS calibrations
- Absolute (phase out relative)
- 2-D (elevation, azimuth) phase center patterns
- Free calibration service
- Calibration values publicly distributed via Internet

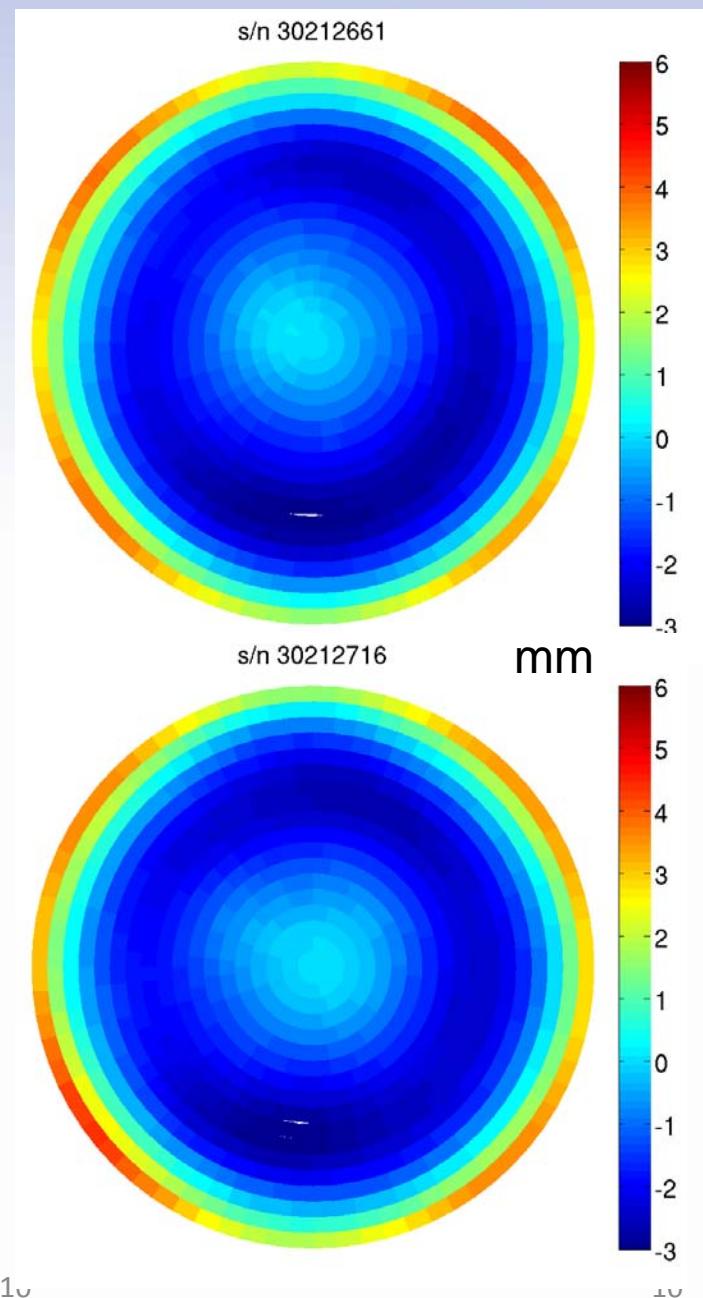
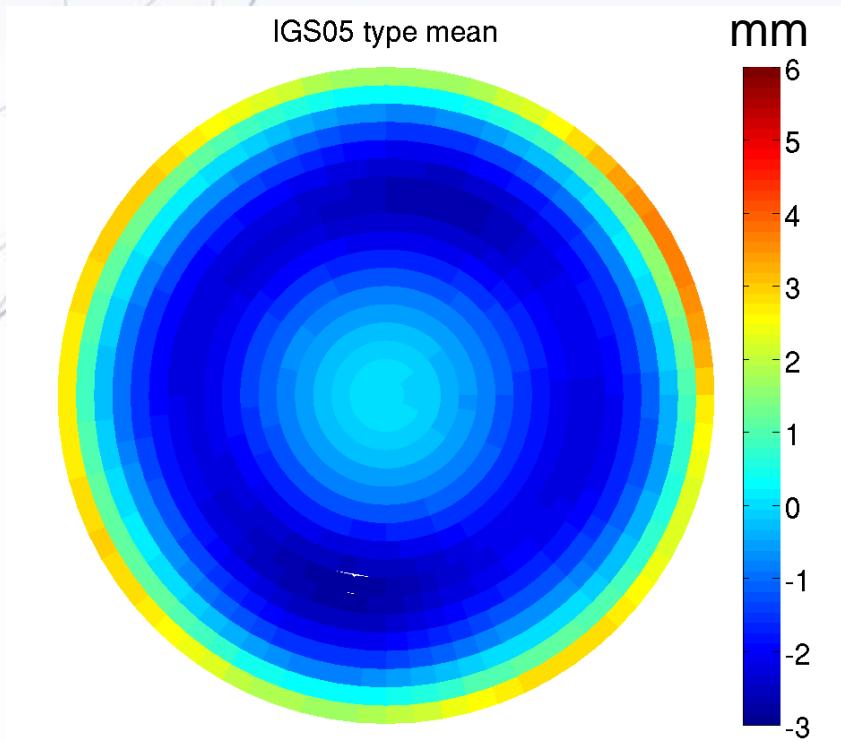
# Trimble Zephyr Geodetic 2 (TRM55971.00)



(mm)	North	East	Up
<b>IGS05</b>	1.07	-0.19	67.17



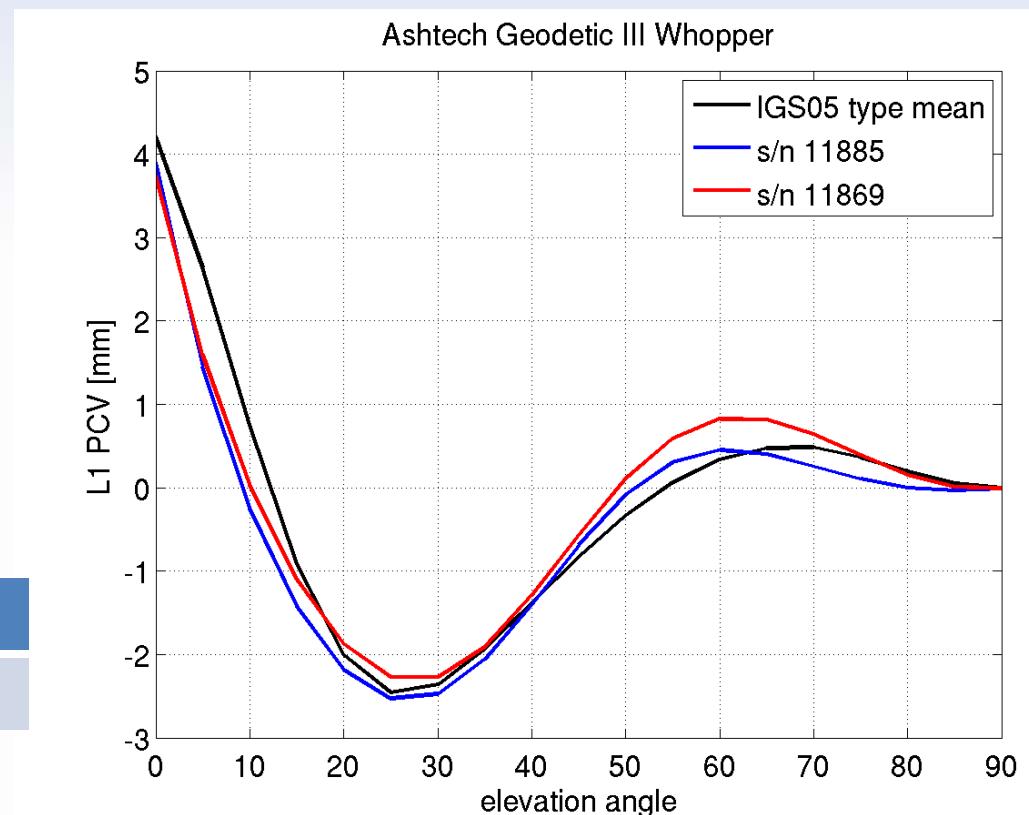
# TRM55971.00 phase center pattern



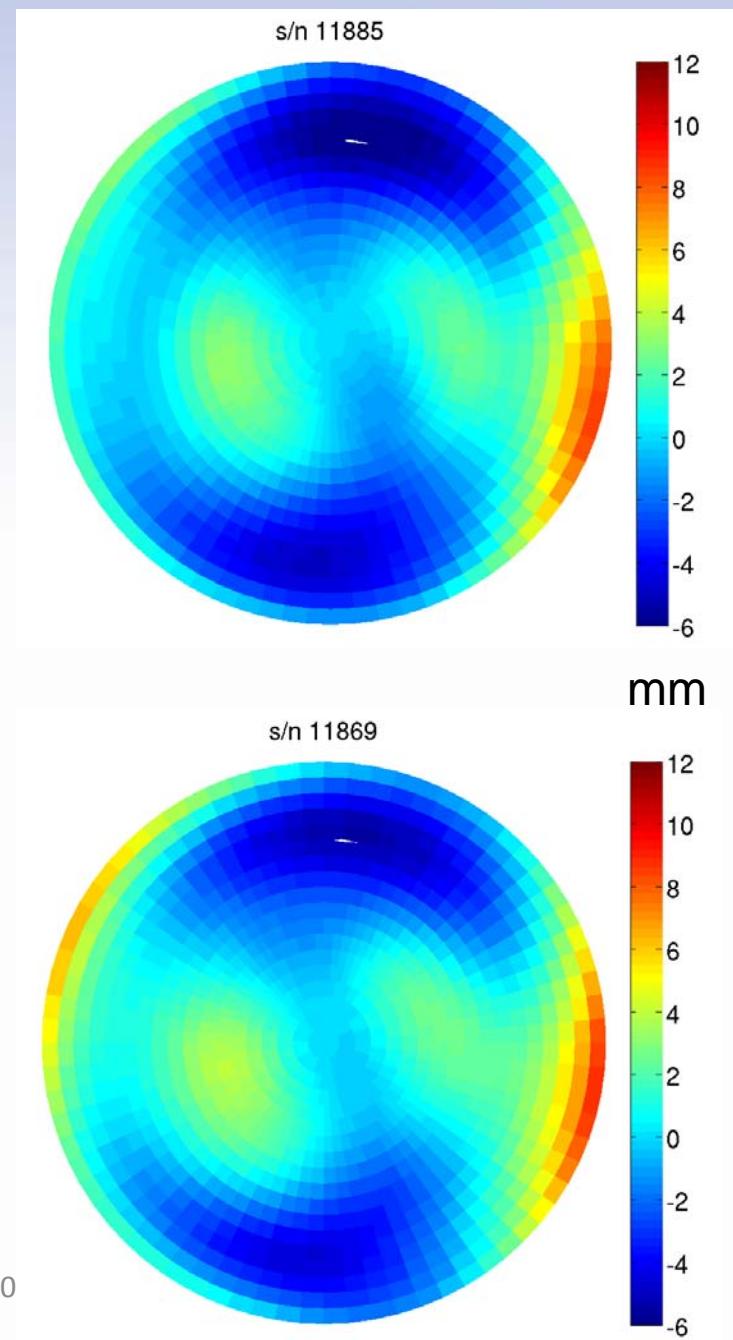
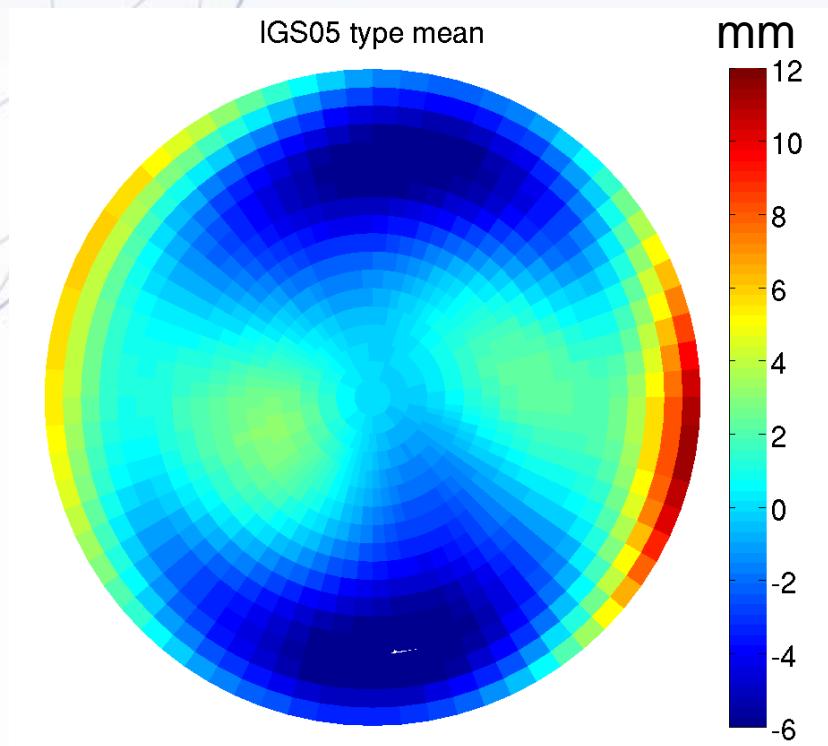
# Ashtech Geodetic III 'Whopper' (ASH700718B)



(mm)	North	East	Up
IGS05	-1.67	-0.47	69.48



# ASH700718B phase center pattern



Global Positioning System (GPS) Ant...

GPS Antenna Calibration

Calibrated Antennas:

- [Antcom Corporation \(ACC\)](#)
- [AeroAntenna \(AER\)](#)
- [Allen Osborne Associates \(AOA, NGS, JPL\)](#)
- [ALTUS Positioning Systems \(APS\)](#)
- [Ashtech \(ASH, THA\)](#)
- [DataGrid International \(DGR\)](#)
- [Gutec AB \(GUT\)](#)
- [Hemisphere GPS \(HEM\)](#)
- [Javad \(JAV, JNS, IPS\)](#)
- [Leica \(LEI\)](#)
- [Macrometer \(MAC\)](#)
- [Magellan Professional \(MAG\)](#)
- [Micro Pulse \(MPL\)](#)
- [NavCom \(NAV\)](#)
- [NovAtel \(NOV\)](#)
- [Sensor Systems \(SEN\)](#)
- [Septentrio Satellite Navigation \(SEP\)](#)
- [Sokkia \(SOK\)](#)
- [Spectra Precision \(SPP\)](#)
- [Thales Navigation \(ASH, THA\)](#)
- [Topcon \(TOP, TPS\)](#)
- [Trimble \(TRM\)](#)



Antenna testing facility in Corbin, VA

## NGS Calibration Services

# PCO/PCV Distribution

- Freely available
- Distribution via website:  
<http://www.ngs.noaa.gov/ANTCAL>
- Data formats for different software:
  - NGS format (relative and absolute)

&lt;ant\_info.003&gt;

ANTENNA ID	DESCRIPTION			DATA SOURCE (# OF TESTS)			YR/MO/DY	END OF ANTENNA		
[north] [east] [up]										
[90] [85] [80] [75]	[70]	ASH701945C_M	PFAN							
[40] [35] [30] [25]	[20]	ROBOT	Geo++ GmbH							
[north] [east] [up]		5.0								
[90] [85] [80] [75]	[70]	0.0 90.0 5.0								
[40] [35] [30] [25]	[20]	2								
IGS05_1597										
G01										
	0.25	-0.55	85.58							
NOAZI	0.00	-0.23	-0.90	-1.90	-3.12	-4.44	-5.75	-6.94	-7.88	-6
	0.0	0.00	-0.34	-1.10	-2.17	-3.41	-4.67	-5.88	-6.95	-7.79
	5.0	0.00	-0.34	-1.12	-2.19	-3.40	-4.65	-5.83	-6.89	-7.73
	10.0	0.00	-0.35	-1.13	-2.19	-3.39	-4.61	-5.77	-6.81	-7.66
	15.0	0.00	-0.36	-1.14	-2.19	-3.37	-4.56	-5.70	-6.74	-7.59
	20.0	0.00	-0.36	-1.14	-2.19	-3.37	-4.56	-5.70	-6.74	-7.59

&lt;KKC-10/08/23=310&gt; (absolute)

# NGS Calibration Services

- Formal policy document
  - Calibration process and stages
  - Eligibility for calibration
  - Rights and responsibilities
- Request calibration via web form
- Tracking system with automated customer notification emails

The screenshot shows a web browser window titled "Absolute Antenna Calibration - Mozilla Firefox". The page is titled "Absolute Antenna Calibration" and features a "National Geodetic Survey" logo. A navigation bar includes links for "NGS Home", "About NGS", "Data & Imagery", "Tools", "Surveys", and "Science & Education". Below the navigation bar is a sub-header: "NGS Absolute Antenna Calibrations Tracking System". A section titled "Antenna Calibration Request" contains fields for "Returning Antenna Provider" (mandatory) and "Email" (joe.smith@antenna.com). A "New Customer? Please Register" link is also present. The main form area is titled "Antenna Information (to be calibrated)" and asks to select an antenna brand from a dropdown menu. The dropdown menu is open, showing a list of brands including Antcom Corporation (ACC), AeroAntenna (AER), Allen Osborne Associates (AOA, NGS, JPL), ALTUS Positioning Systems (APS), Ashtech (ASH, THA), DataGrid International (DGR), Gutec AB (GUT), Hemisphere GPS (HEM), Javad (JAV, JNS, JPS), Leica (LEI), Macrometer (MAC), Magellan Professional (MAG), Micro Pulse (MPL), NavCom (NAV), NovAtel (NOV), Sensor Systems (SEN), Septentrio Satellite Navigation (SEP), Sokkia (SOK), and Spectra Precision (SPP). Other options are available for non-existing brands. Other form fields include "Antenna Type", "IGS Antenna Type Code", "Model Name", "Part #", "Primary DOF (Directional Orientation Feature)", "RF Connector Type", "Calibration Information" (Note: Type Mean (3 - 5 antenna samples). \* (Special circumstances only)), "Requested Calibration Method" (Calibration Method dropdown), and "Explain if 'Relative'" (text input field). A "Done" button is at the bottom.

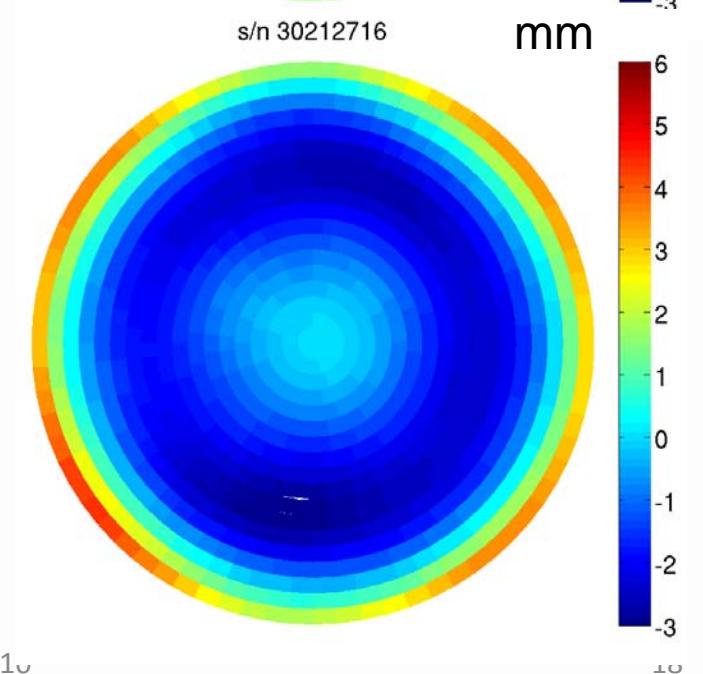
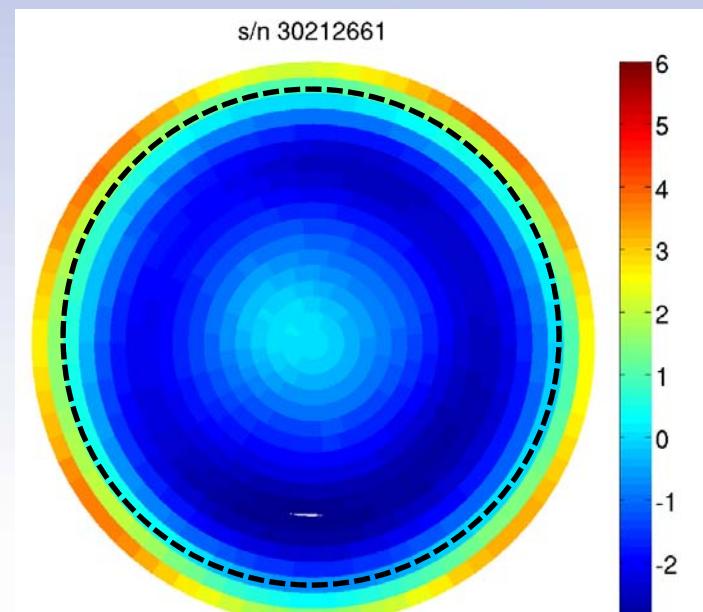
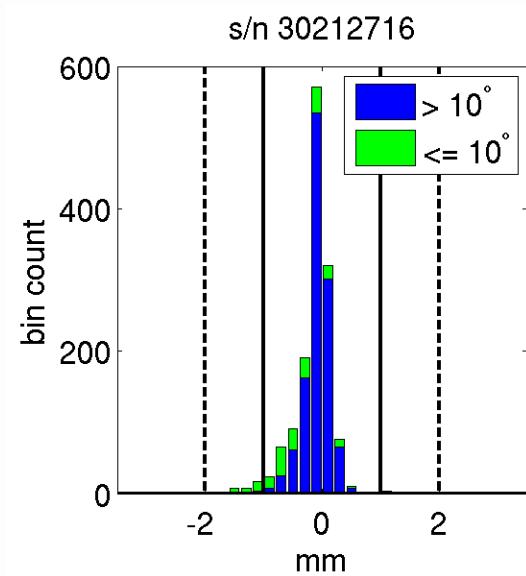
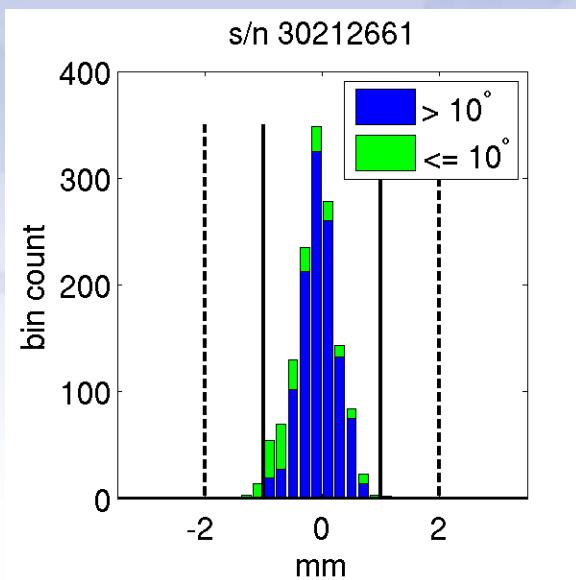
# For more information...

- Website: <http://www.ngs.noaa.gov/ANTCAL>
- Email NGS Calibrations staff at  
[NGS.AbsAntCal@noaa.gov](mailto:NGS.AbsAntCal@noaa.gov)

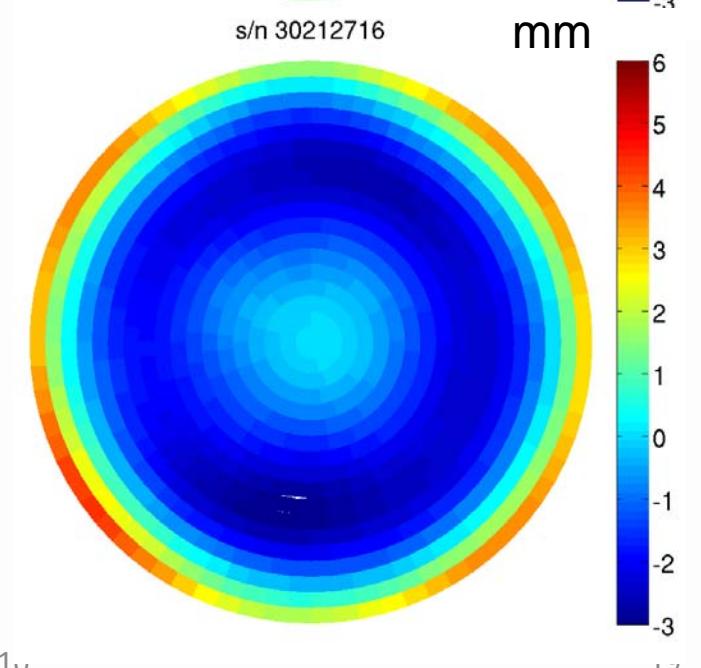
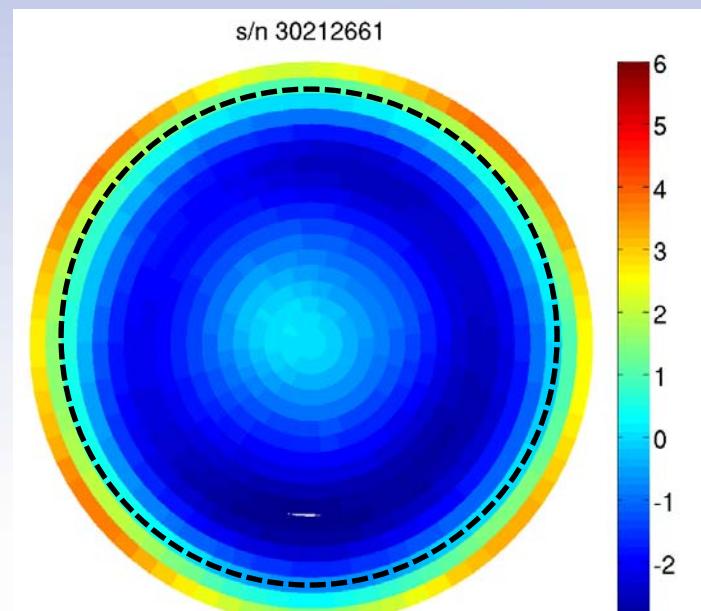
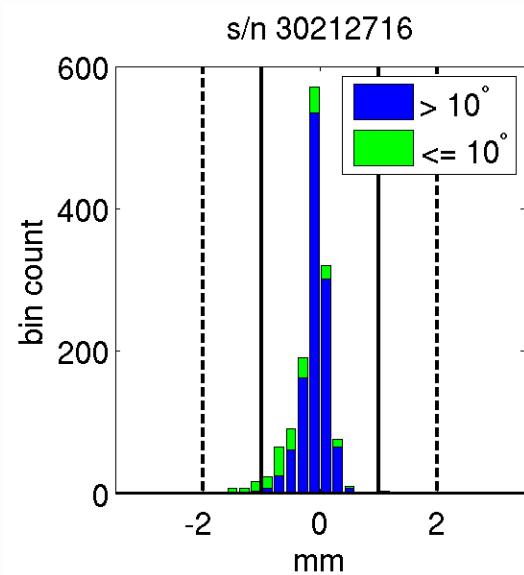
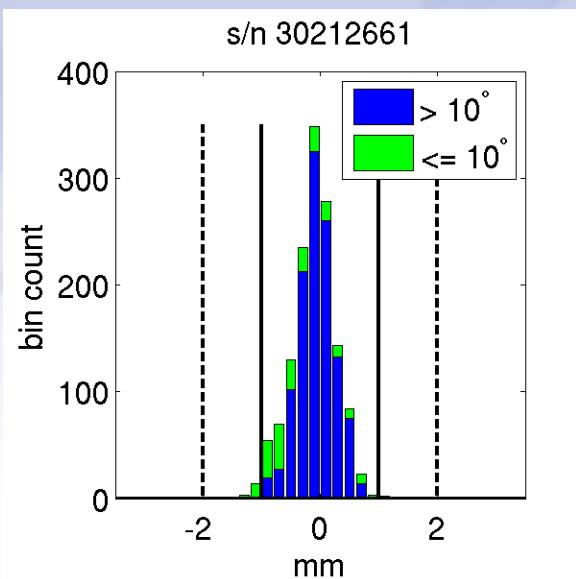
Thank you for your attention!



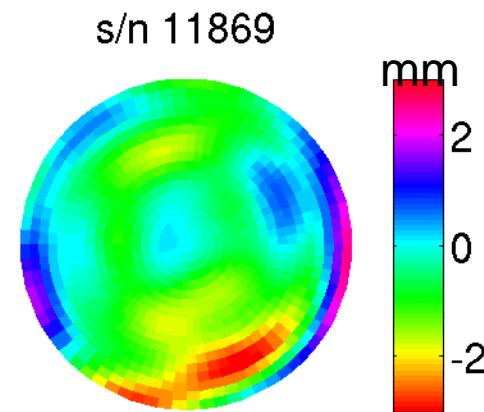
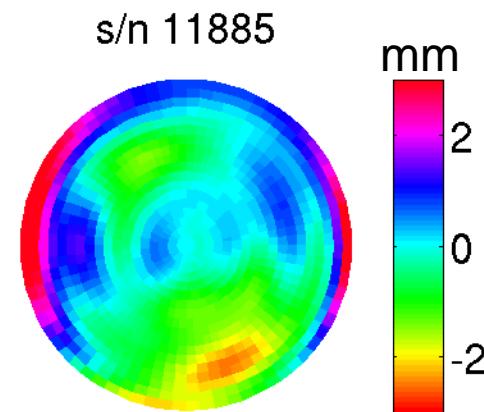
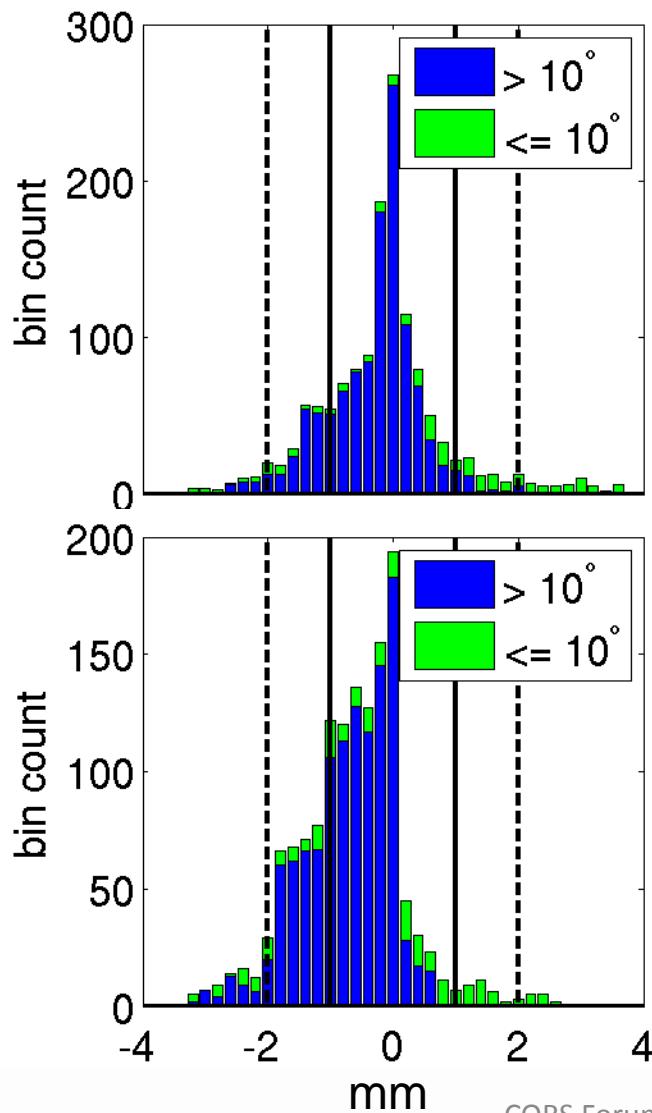
# Deviation from IGS type mean



# Deviation from IGS type mean



# Deviation from IGS type mean



# Calibration Setup

- *Single differences*
- Short baseline (5 m)
- Simplified multipath environment
- Common clock (heading receiver)
- Remaining factors = phase centers (ref, test), differential multipath, hardware bias

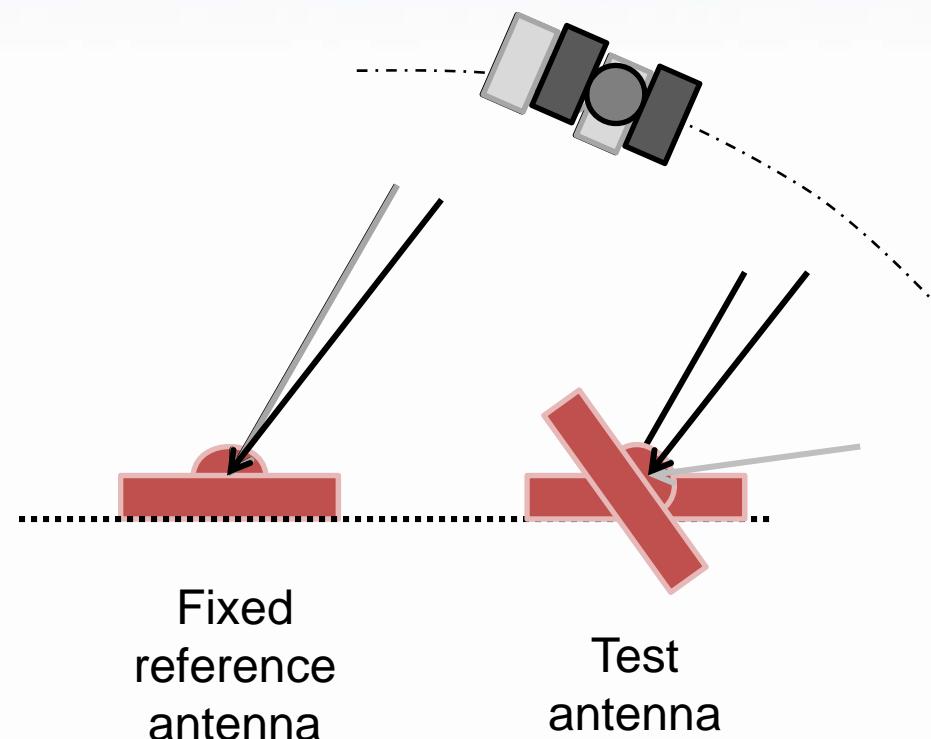


# Time Difference of Single Differences

Closely spaced time pairs

+ robot motion =

- PC0/PCV at reference antenna removed
- slowly varying biases (differential MP, hardware bias) minimized

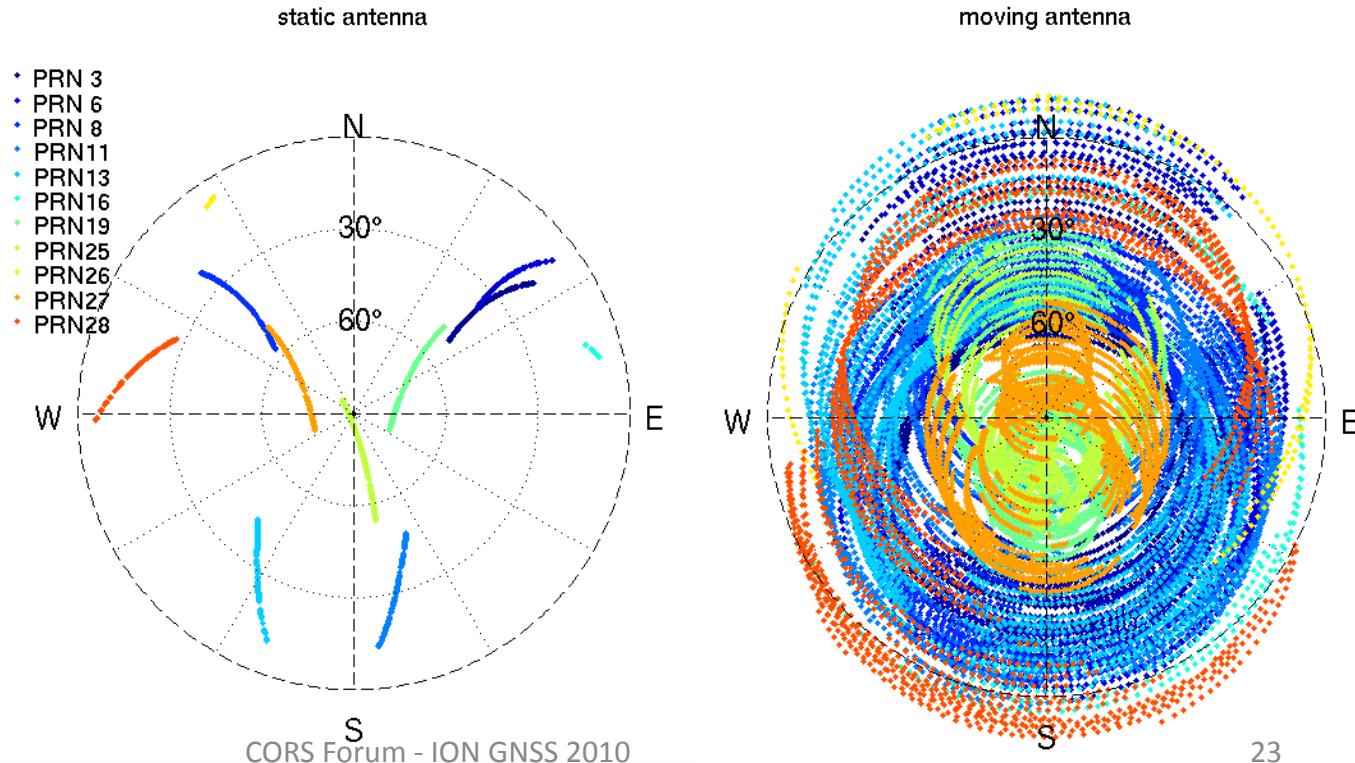




# Why Robot?

- Introduce angle changes for TDSD

- Better spatial coverage



# Modelled Factors

- *A priori* position
- Frame rotation(s) between robot and local frame
- Rotation arm length
- Phase windup (antenna motion)

**PCV (az,el)**

**PCO [ENU]**

