



## **RA-Dec Correlations Significantly Alter Rotational Alignment**

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# CRF alignment to ICRF2 needs full Covariance



**Data:** S/X October 1978 – September 2009

5.3 Million delays from 1709 sources

**Rotations with respect to 267 ICRF2 definings:**

No Net Rot. constraint:  $\sum s_x ds = 0$

**Estimated using full RA-Dec covariance:**

X-axis = 1.4 +- 5.4  $\mu\text{as}$

Y-axis = 2.4 +- 5.6  $\mu\text{as}$

Z-axis = 2.0 +- 4.4  $\mu\text{as}$

**Estimated using only diagonal covariance:**

X-axis = -25.8 +- 4.9  $\mu\text{as}$

Y-axis = 9.4 +- 4.9  $\mu\text{as}$

Z-axis = -1.6 +- 4.3  $\mu\text{as}$



# K-band alignment to ICRF2 needs full Covariance



**Data:** K-band sessions #1-12: 2002–2009  
0.1 Million delays from 275 sources

**Rotations with respect to 125 ICRF2 defining:**

**Estimated using full RA-Dec covariance:**

$$\begin{aligned} \text{X-axis} &= 0.1 \pm 6.8 \text{ } \mu\text{as} \\ \text{Y-axis} &= 1.2 \pm 7.4 \text{ } \mu\text{as} \\ \text{Z-axis} &= -0.1 \pm 5.2 \text{ } \mu\text{as} \end{aligned}$$

**Estimated using only diagonal covariance:**

$$\begin{aligned} \text{X-axis} &= -20.5 \pm 11.5 \text{ } \mu\text{as} \\ \text{Y-axis} &= -17.7 \pm 11.9 \text{ } \mu\text{as} \\ \text{Z-axis} &= -8.2 \pm 7.9 \text{ } \mu\text{as} \end{aligned}$$



# X/Ka-band alignment needs full Covariance



**Data: X/Ka-band: 2005–2009**

0.01 Million delays from 387 sources

**Rotations with respect to 153 ICRF2 defining:**

**Estimated using full RA-Dec covariance:**

X-axis = -0.3 +- 6.3  $\mu\text{as}$

Y-axis = 2.9 +- 6.6  $\mu\text{as}$

Z-axis = -0.1 +- 4.9  $\mu\text{as}$

**Estimated using only diagonal covariance:**

X-axis = -35.1 +- 17.9  $\mu\text{as}$

Y-axis = -31.1 +- 18.3  $\mu\text{as}$

Z-axis = 38.6 +- 11.2  $\mu\text{as}$



## Conclusions:

The No-Net-Rotational constraint:

$$\sum s_x ds = 0$$

shapes the RA-Dec full covariance produced by the solution.

The correlations contain significant information needed to correctly estimate 3-D rotations and their sigmas and thus must be accounted for.

*Note: the rotations in this paper have changed slightly since the workshop due to the post-workshop correction of a small bug in our NNR code. The conclusion that correlations are important at the level of 10s of  $\mu$ as remains unchanged.*

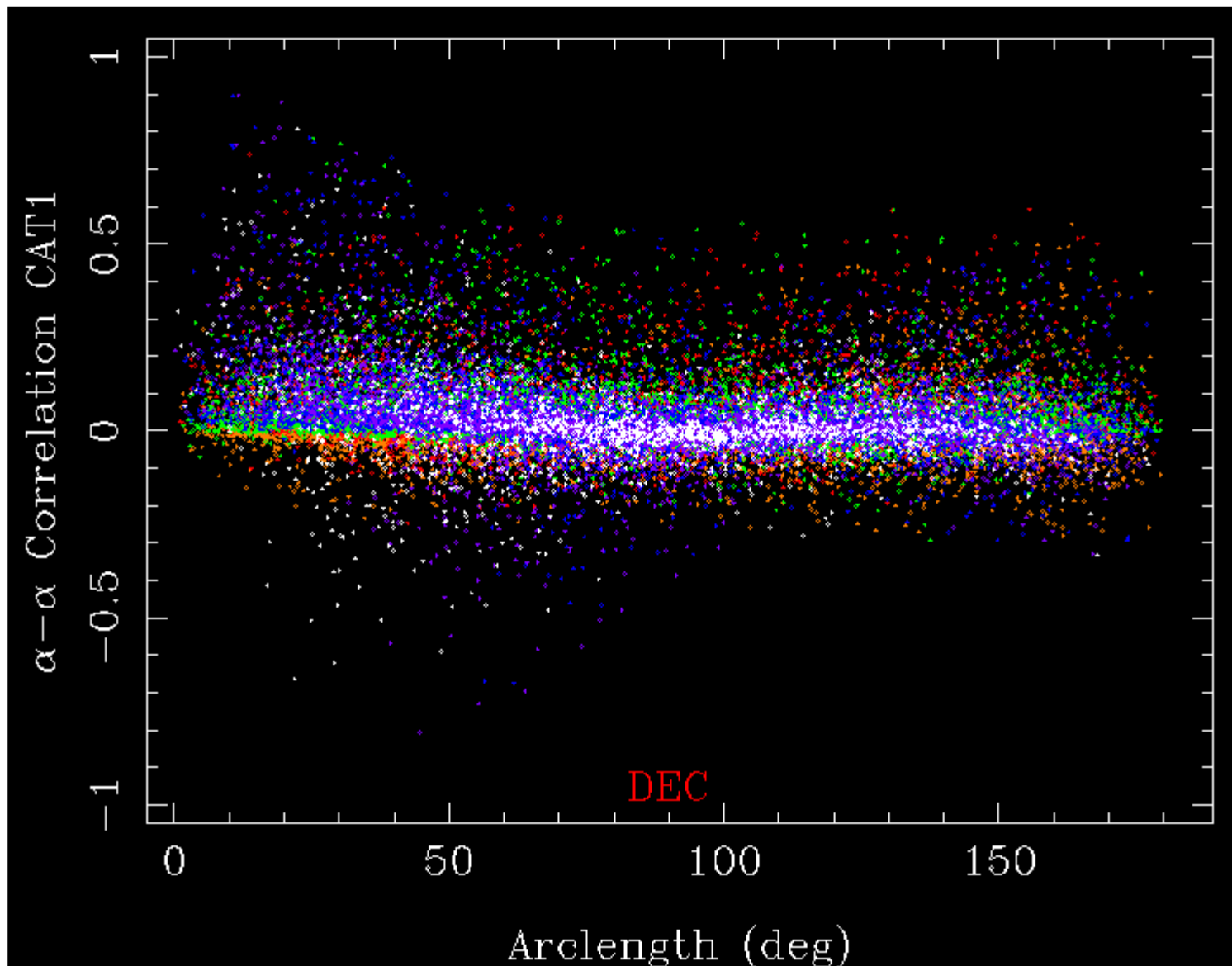


# **Backup slides**

Showing distribution  
of RA-Dec correlations



# S/X Global CRF Correlations of RA-RA





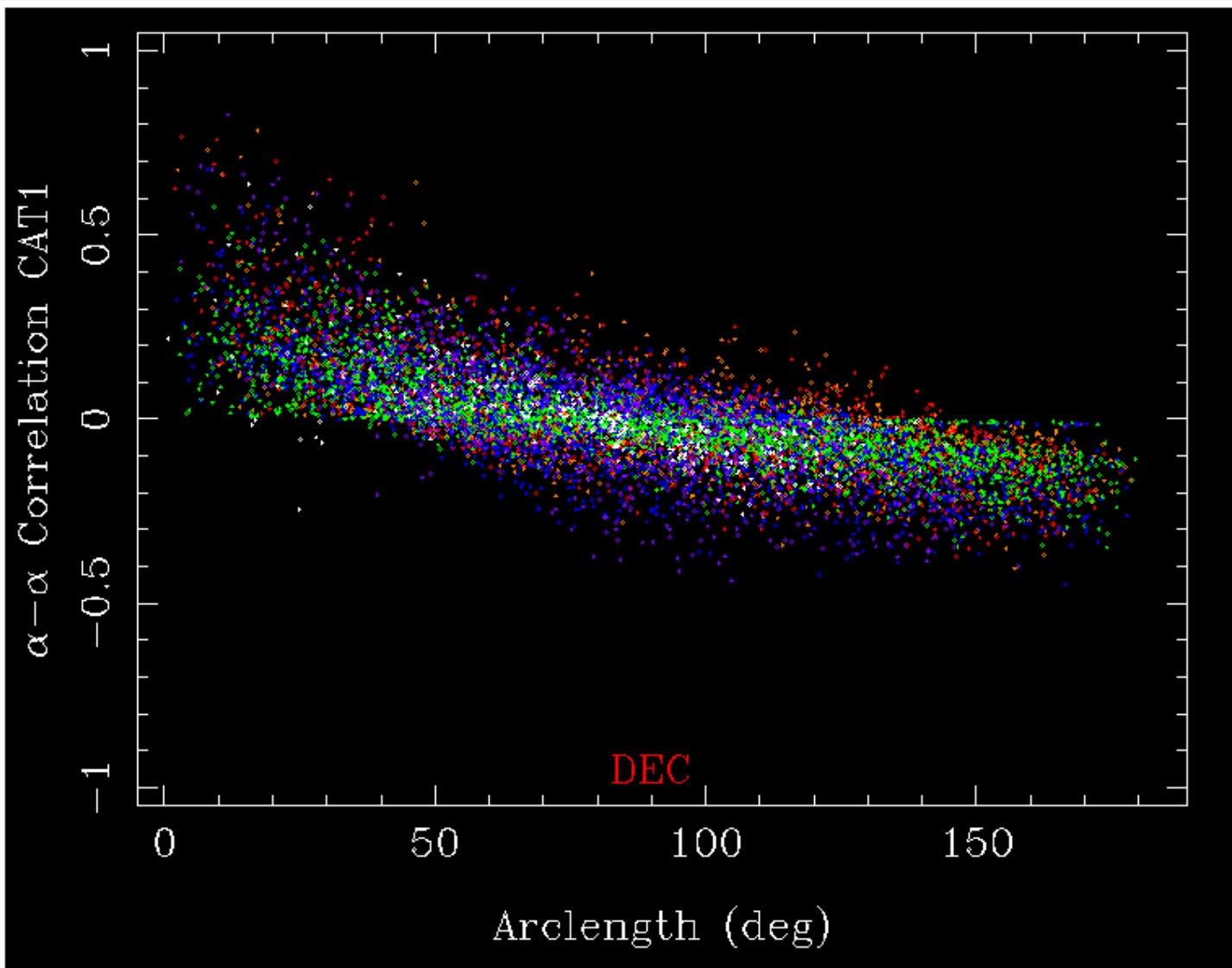
# K-band Global CRF Correlations of RA-RA



Note trend of  
positive correlations  
at short arcs

changing to

negative correlations  
at long arcs







# X/Ka-band Global CRF Correlations of Dec-Dec



Note that almost all Dec-Dec correlations are positive.

Thus differences are better determined than the absolute Declinations.

This creates a tendency for zonal errors.

