

The Earth's nutation

VLBI vs. IAU 2000A

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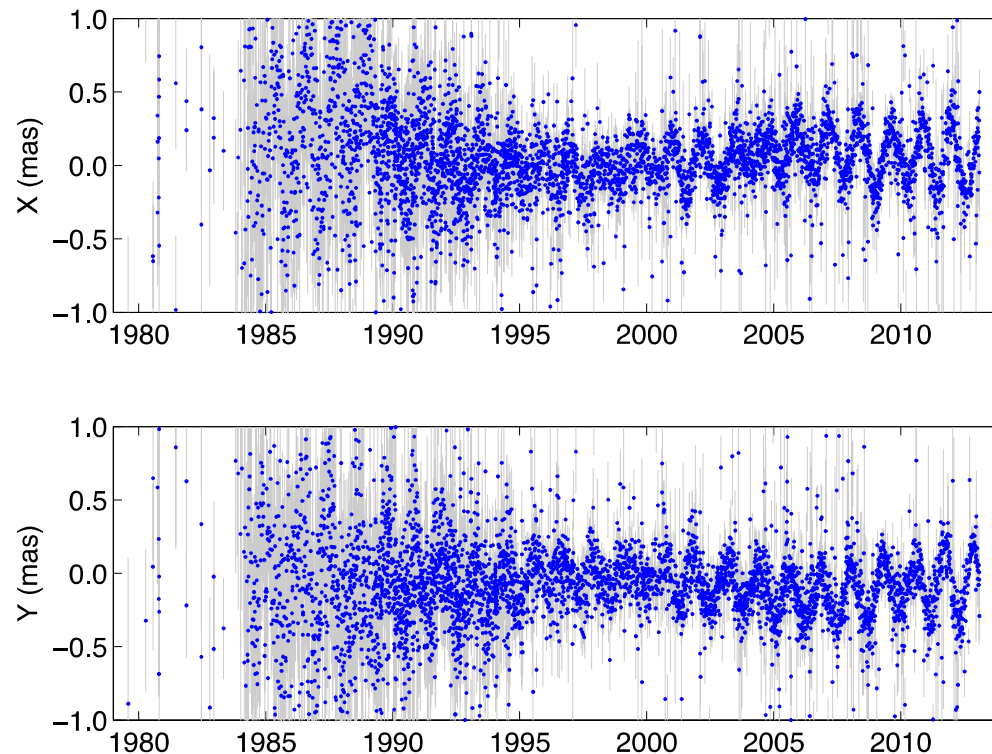
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The IAU 2000A nutation

- Nonrigid = Rigid $\times$ F(geophys. parameters)
 - Mathews, Herring, & Buffett (2002) work:
 - establish the form of F for an inelastic Earth w/ liquid core, solid inner core, oceans, and EMC
 - fit geophys. parameters to 21 amplitudes of VLBI/REN 2000 (Souchay et al. 1999)
- IAU 2000A tables

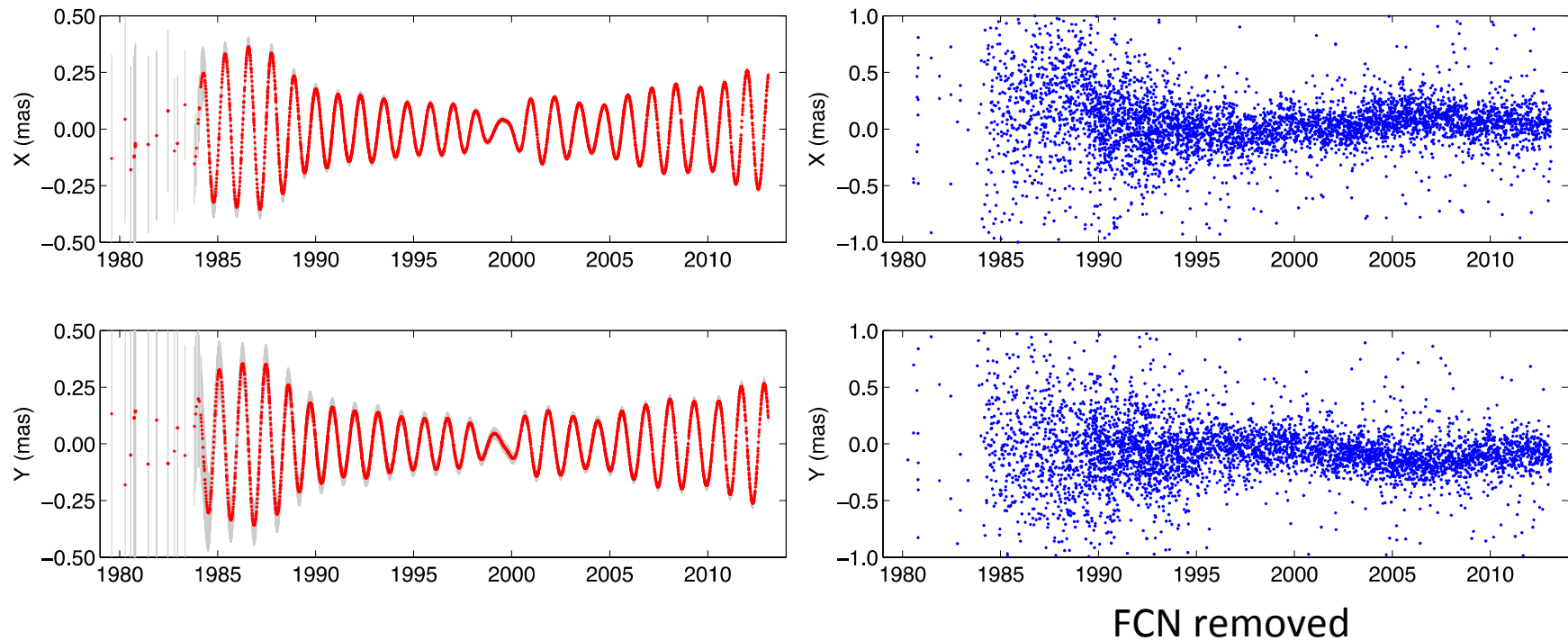
VLBI against IAU 2000A

- 0.2 mas in rms
- Significant patterns: free core nutation, 18.6yr



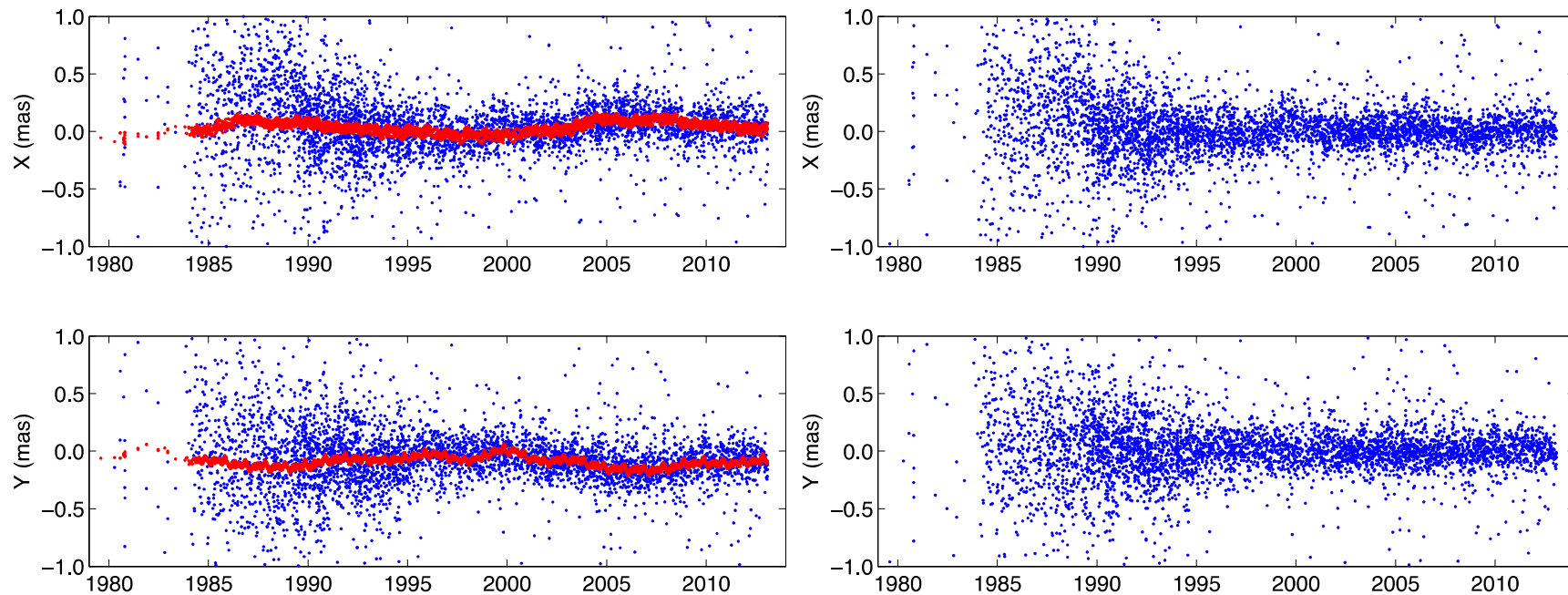
Explore the residuals

- FCN modeled by, e.g., least-squares



Explore the residuals

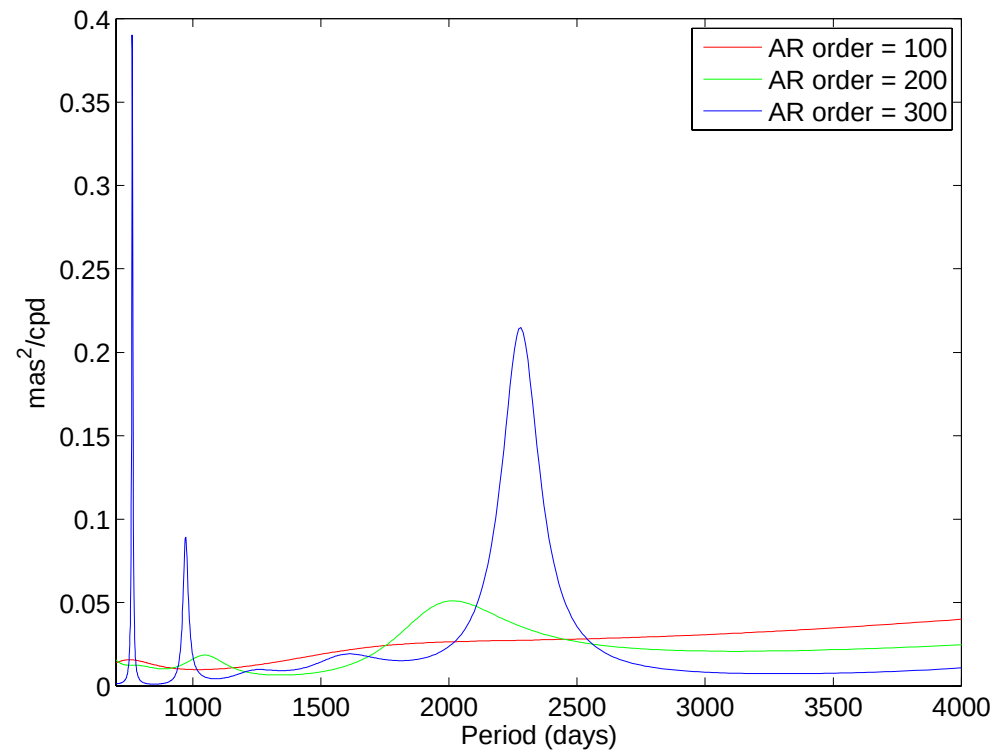
- Estimate additional corrections to 18.6yr, 9.3yr, 1yr, 0.5yr, 28d, 14d



Residuals: remaining patterns!

Identify remaining terms

- MEM spectrum of the X-component: $\sim 700\text{d}$, $\sim 1000\text{d}$, $\sim 2300\text{d}$



Identify remaining terms

- Detect spectral lines in dX
 - After 1990
 - Using, e.g., F. Mignard's FAMOUS

Period (days)	±	Amplitude (μ as)	±	Phase (°)	±
FAMOUS					
2210	57	17	3	−93	11
764	9	13	4	−129	17
978	24	8	3	−173	24
MIMOSA					
2222	378	16	3	−104	14
766	34	13	4	−121	19
962	65	8	4	173	20

Identify remaining terms

Period (days)	±	Amplitude (μ as)	±	Phase (°)	±
FAMOUS					
2210	57	17	3	-93	11
764	9	13	4	-129	17
978	24	8	3	-173	24

X MHB

I	I'	F	D	Ω	Ve	Ea	Ma	Ju	Pa	Period (days)	Phase (°)	Amplitude (μ as)
0	0	0	0	0	0	0	0	2	2	2165.2980	68.7030	46.4
1	0	-1	0	0	0	0	0	0	0	-2190.3501	41.6913	13.1
0	0	0	0	0	0	0	0	2	1	2165.7962	68.7030	11.0
0	0	1	-1	1	0	-1	0	2	0	2165.7962	-111.2970	5.8
0	0	2	-2	1	-3	3	0	0	0	2060.8595	-168.6517	4.7
1	1	-2	1	-1	0	0	0	0	0	-2189.7228	118.7539	2.7
0	0	0	0	0	0	0	0	2	0	2166.2947	68.7030	1.3
2	-2	0	-2	-1	0	0	0	0	0	-2120.6518	-85.8764	1.5
0	0	0	0	3	0	0	0	0	0	-2266.1279	15.1337	1.0

Identify remaining terms

Period (days)	±	Amplitude (μ s)	±	Phase (°)	±
FAMOUS					
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0	0	0	0	0	0	0	0	2	1	2165.7962	68.7030	11.0
0	0	1	-1	1	0	-1	0	2	0	2165.7962	-111.2970	5.8
0	0	2	2	1	0	0	0	0	0	2000.0595	100.0517	4.7
1	1	-2	1	-1	0	0	0	0	0	-2189.7228	118.7539	2.7
0	0	0	0	0	0	0	0	2	0	2166.2947	68.7030	1.3
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0	0	0	0	3	0	0	0	0	0	-2266.1279	15.1337	1.0

$$F - D + \Omega - Ea + 2Ju ?$$

Identify remaining terms

Period (days)	±	Amplitude (μs)	±	Phase ($^{\circ}$)	±
FAMOUS					
2210	57	17	3	-93	11
764	9	13	4	-129	17
978	24	8	3	-173	24

X MHB

I	I'	F	D	Ω	Ve	Ea	Ma	Ju	Pa	Period (days)	Phase ($^{\circ}$)	Amplitude (μs)
0	0	0	0	0	4	-6	0	0	-2	727.5803	125.1206	19.5
0	0	0	0	0	4	-6	0	0	-1	727.5241	125.1206	4.3
0	0	0	0	0	4	-7	0	0	-2	-733.4689	24.6541	2.6
0	0	0	0	0	4	-6	0	0	0	727.4679	125.1206	1.9
0	0	1	-1	1	-4	5	0	0	0	-727.5241	54.8795	1.1
0	0	2	-2	1	-4	4	0	0	0	-814.7802	109.8349	1.1

Identify remaining terms

Period (days)	±	Amplitude (μ s)	±	Phase (°)	±
FAMOUS					
2210	57	17	3	-93	11
764	9	13	4	-129	17
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0	0	0	0	0	4	-6	0	0	-2	727.5803	125.1206	19.5
0	0	0	0	0	4	-6	0	0	-1	727.5241	125.1206	4.3
0	0	0	0	0	4	-6	0	0	-2	727.4689	125.1206	2.6
0	0	0	0	0	4	-6	0	0	0	727.4679	125.1206	1.9
0	0	1	1	1	4	5	0	0	0	727.5241	54.8795	1.1
0	0	2	-2	1	-4	4	0	0	0	-814.7802	109.8349	1.1

$$4Ve - 6Ea (-2Pa ?) ?$$

Identify remaining terms

Period (days)	$\pm$	Amplitude (μs)	$\pm$	Phase ($^\circ$)	$\pm$
FAMOUS					
2210	57	17	3	-93	11
764	9	13	4	-129	17
978	24	8	3	-173	24

X MHB

I	I'	F	D	Ω	Ve	Ea	Ma	Ju	Pa	Period (days)	Phase ($^\circ$)	Amplitude (μs)
2	0	-2	0	1	0	0	0	0	0	-943.2273	-151.5728	28.5
0	0	0	0	0	1	-2	0	0	0	-975.3778	-18.9531	3.6
0	0	0	0	0	0	2	-3	0	0	901.9850	-145.3661	3.1

Identify remaining terms

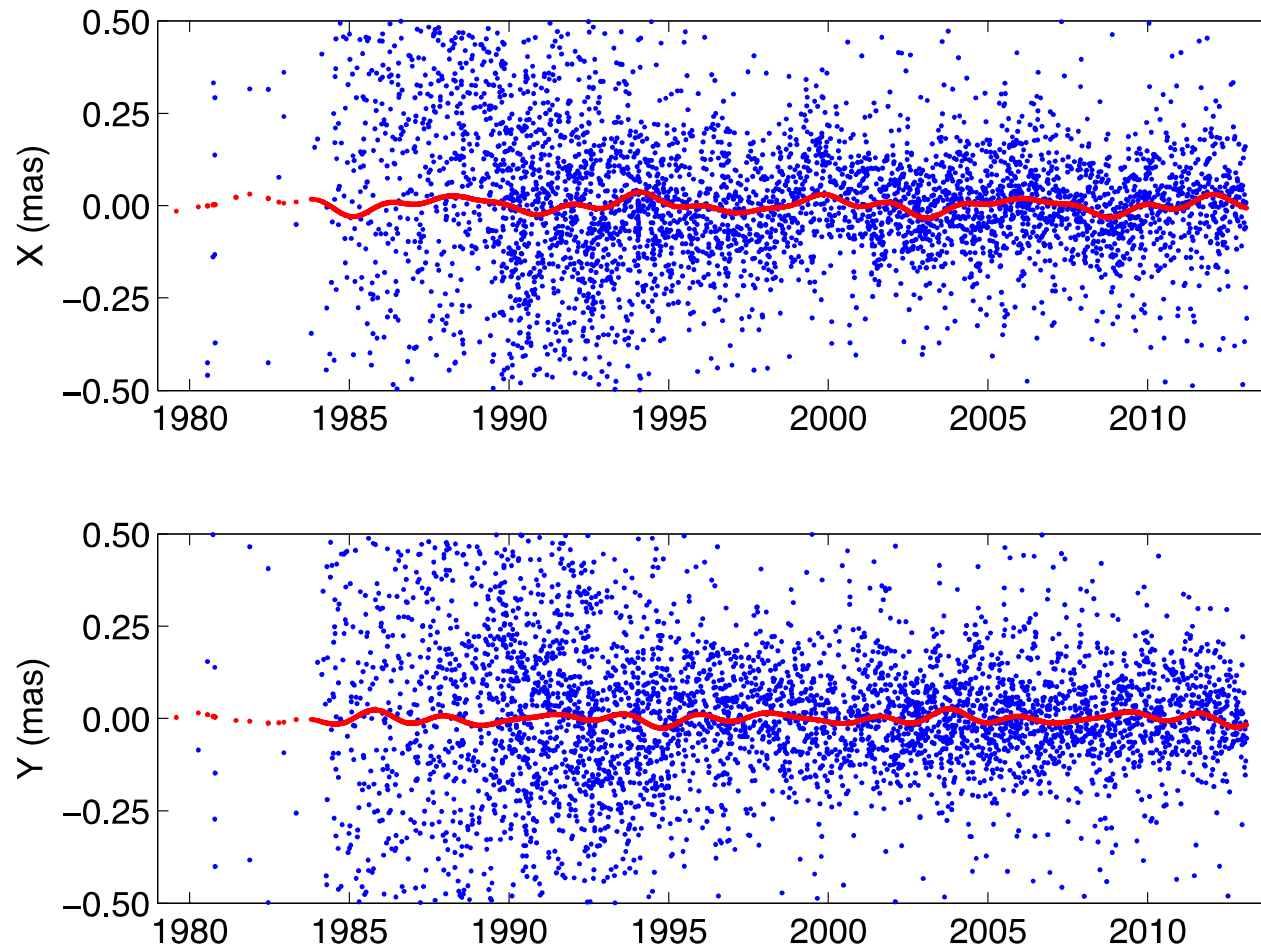
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FAMOUS					
2210	57	17	3	-93	11
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X MHB

I	I'	F	D	Ω	Ve	Ea	Ma	Ju	Pa	Period (days)	Phase ($^\circ$)	Amplitude (μs)
2	0	-2	0	1	0	0	0	0	0	-943.2273	-151.5728	28.5
0	0	0	0	0	1	2	0	0	0	975.3778	18.9531	3.0
0	0	0	0	0	0	2	-3	0	0	901.9850	-145.3661	3.1

2I - 2F ?

How does it fit?



$$\mathbf{F - D + \Omega - Ea + 2Ju, 4Ve - 6Ea - 2Pa, 2I - 2F}$$

How does it fit?

- MHB amplitudes (μas)

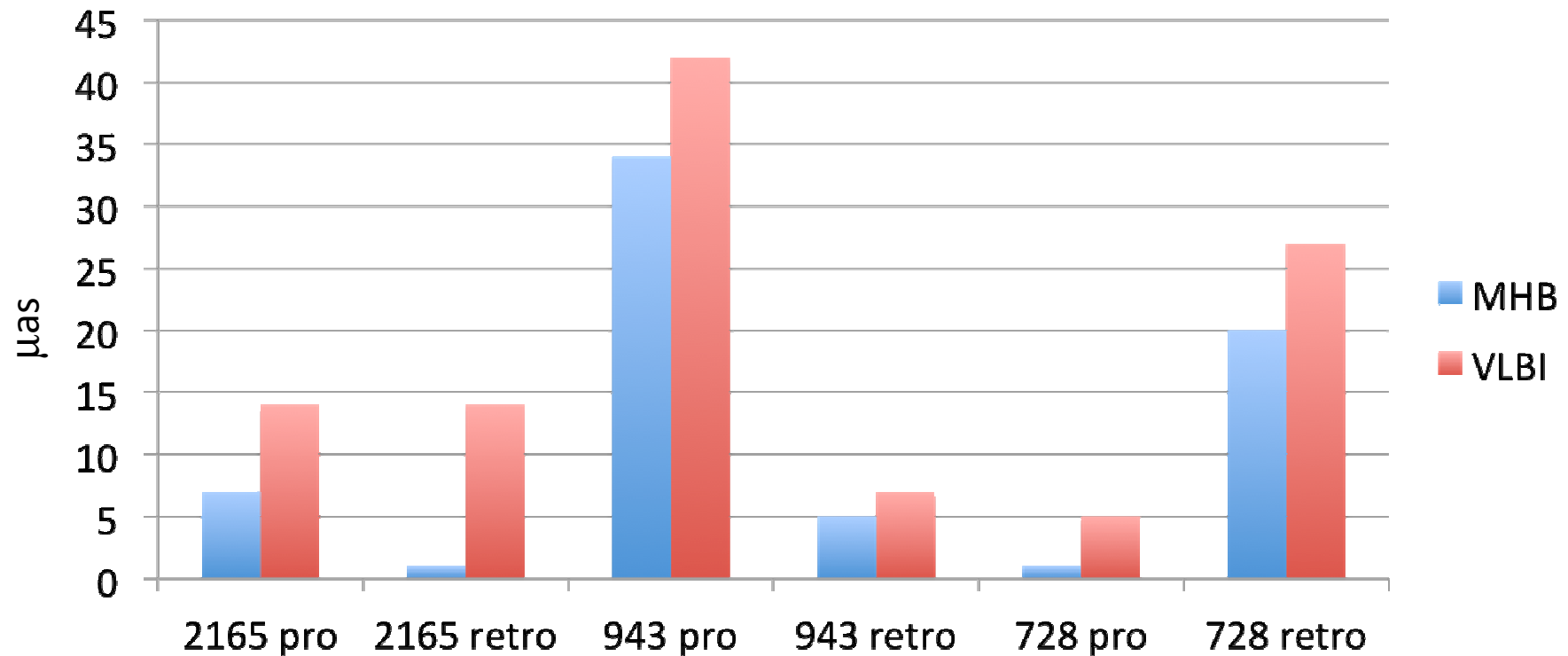
	Period	Pro		Retro	
2F-D+W-Ea+2Ju	2165.80	6.8		1.0	
2I-2F+W	-943.23	33.7		5.2	
4Ve-6Ea-2Pa	727.58	0.9		20.4	

- VLBI corrections (μas)

	Period	Pro	$\pm$	Retro	$\pm$
2F-D+W-Ea+2Ju	2165.80	7.0	1.9	13.1	2.3
2I-2F+W	-943.23	8.4	2.3	1.5	1.9
4Ve-6Ea-2Pa	727.58	3.5	2.2	7.0	2.3

Concluding remarks

- VLBI detects some corrections to small nutation terms, including planetary nutations



Concluding remarks

- Why?
 - Rigid Earth nutation underestimated these terms?
 - Transfer function?

