

# RadioAstron Navigation

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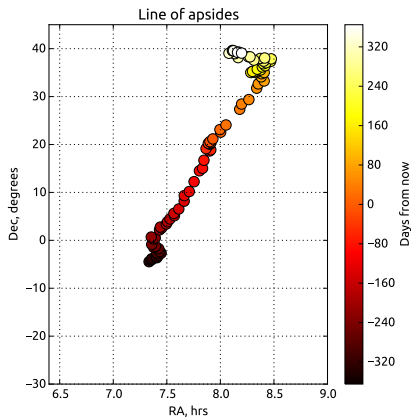
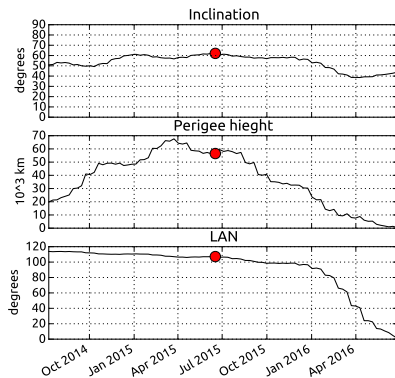
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15–16 June 2015

# Orbital evolution overview

July 2014 – July 2016



## RadioAstron Navigation: Tracking

- Ussuriysk and Bear Lakes range and range rate observations
- Laser tracking
- Optical angular observations
- Puschino and Green Bank Doppler data

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## RA Radio tracking: July 2014 – June 2015

Ussuriysk and Bear Lakes ranges and range rates at C-band, Bear Lakes one-way Doppler at X-band.

### **Ussuriysk C-band:**

46 passes with 73k pairs of range and range rate data points. A posteriori estimate of range rate noise  $\approx 4.15$  mm/s, range biases are within 20 m.

### **Bear Lakes C-band:**

93 passes with 6k range and 135k range rate data points. A posteriori estimate of range rate noise  $\approx 1.01$  mm/s, range biases are within 30 m.

### **Bear Lakes X-band:**

75 passes, 393k one-way Doppler observations (1 second sampling). A posteriori noise estimate  $\approx 0.323$  mm/s.

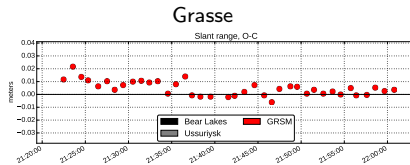
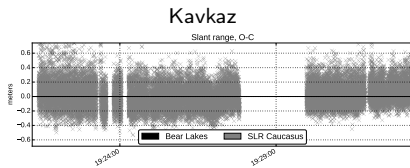
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# Laser tracking

Total 60 passes were scheduled, 11 ended up with received echoes.

Month	Passes sched.	Passes \w echoes
2014, July	1	1
2014, August	1	0
2014, September	1	1
2014, October	4	1
2014, November	6	1
2014, December	10	2
2015, January	6	3
2015, February	9	1
2015, March	10	0
2015, April	8	1
2015, May	4	0
2015, June	1	?



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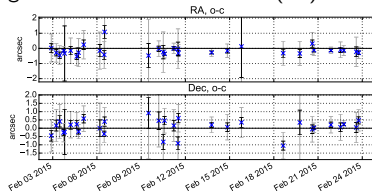
# Optical angular observations

Observations from July 2014 to June 2015

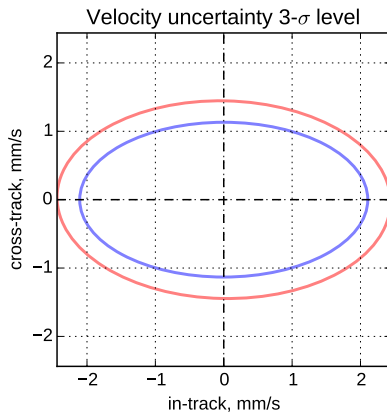
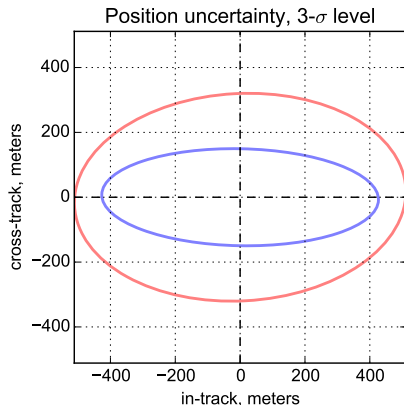
Observatory	Nights	Meas.	Obs. time, h
Kitab	43	589	10.78
Mayhill(H06)	34	424	25.03
Mondy	30	648	5.50
Mayhill(H15)	6	23	0.67
Kourovskaya	11	288	15.10
Krasnodar	47	530	103.68
Sid. spring	33	505	37.03
Kislovodsk	56	464	48.65
CrAO	19	549	4.70
Abastumani	3	14	0.28
Total	282	4034	251.42

Additional support with observations from ISON, MASTER-Kislovodsk and Kourovskya observatories.

Most observations have noise not greater than 0.5 arcseconds ( $1\sigma$ ).



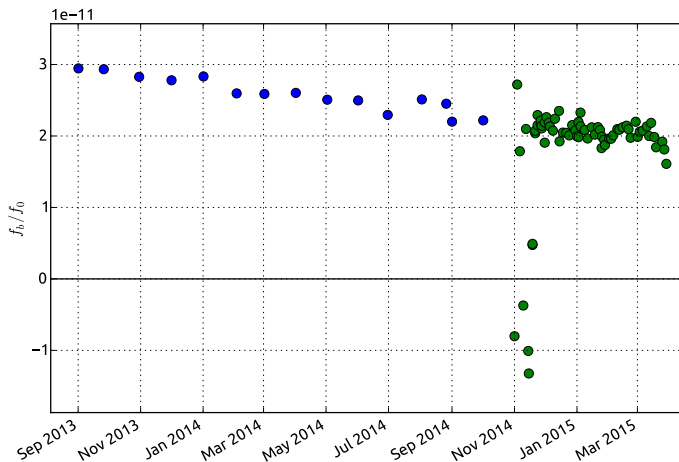
# Optical angles affecting accuracy



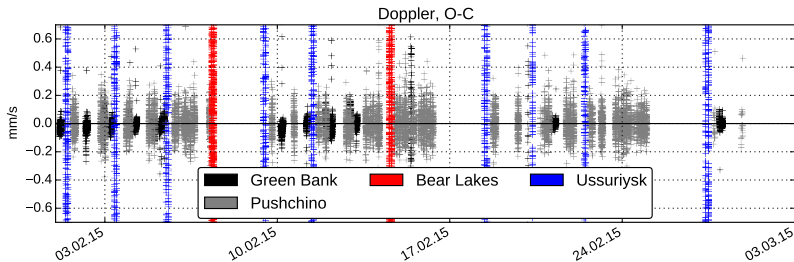
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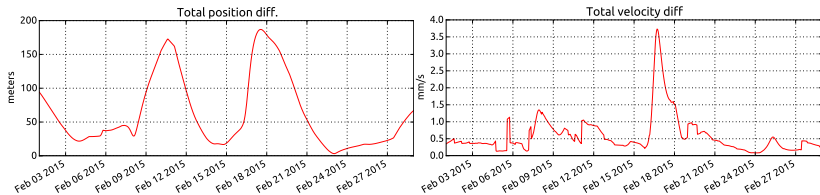
# On-board frequency bias



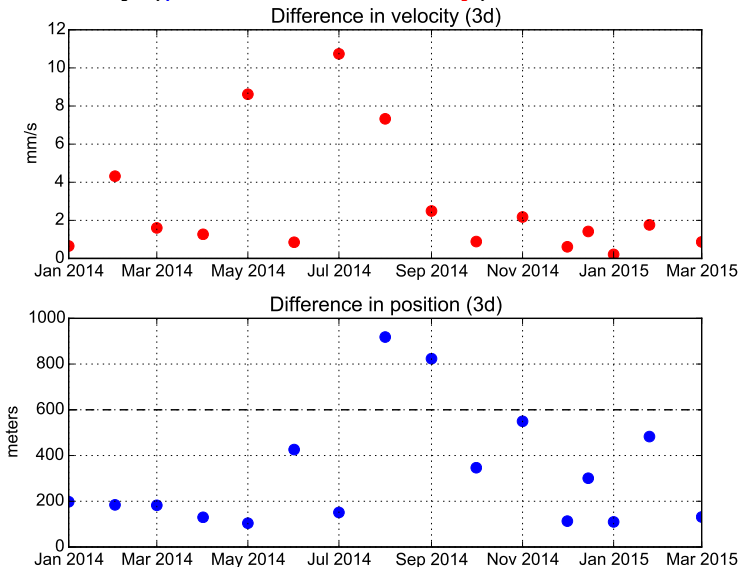
# Pushchino and Green Bank Doppler



- 1 One consider parameter over the whole OD interval ( $\sim 30$  days)
- 2 Different consider parameter for every command session ( $\sim 2 - 4$  days)



# Orbit accuracy (position and velocity)



## Conclusion

- Tracking and routine ballistic and navigation tasks are performed without problems
- OD uncertainty generally stays within acceptable level (problems during summer months)
- The approach to deal with one-way Doppler bias affects accuracy (two-way Doppler analysis in process)

Thank you for your attention!