ULTRA PRECISE VLBI TRACKING OF FUTURE PROBES TO EUROPA AND JUPITER SYSTEM

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SYMPOSIUM Nationaal Platform voor Planeetonderzoek,
25-26 april 2006, Koningshof, Veldhoven, Nederland

website: www.planeetonderzoek.nl

Abstract : We present our results of estimated accuracy and possible application of ultra precise VLBI tracking of future probes to Jupiter and Saturn satellite systems

This presentation is an updated version of what was presented at
Workshop on a Future Mission to Europa and the Jupiter System
December 12-13, 2005, Centre National d'Etudes Spatiales, Paris.

website: http://jupiter-europa.cesr.fr

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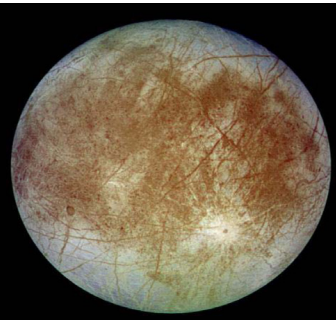
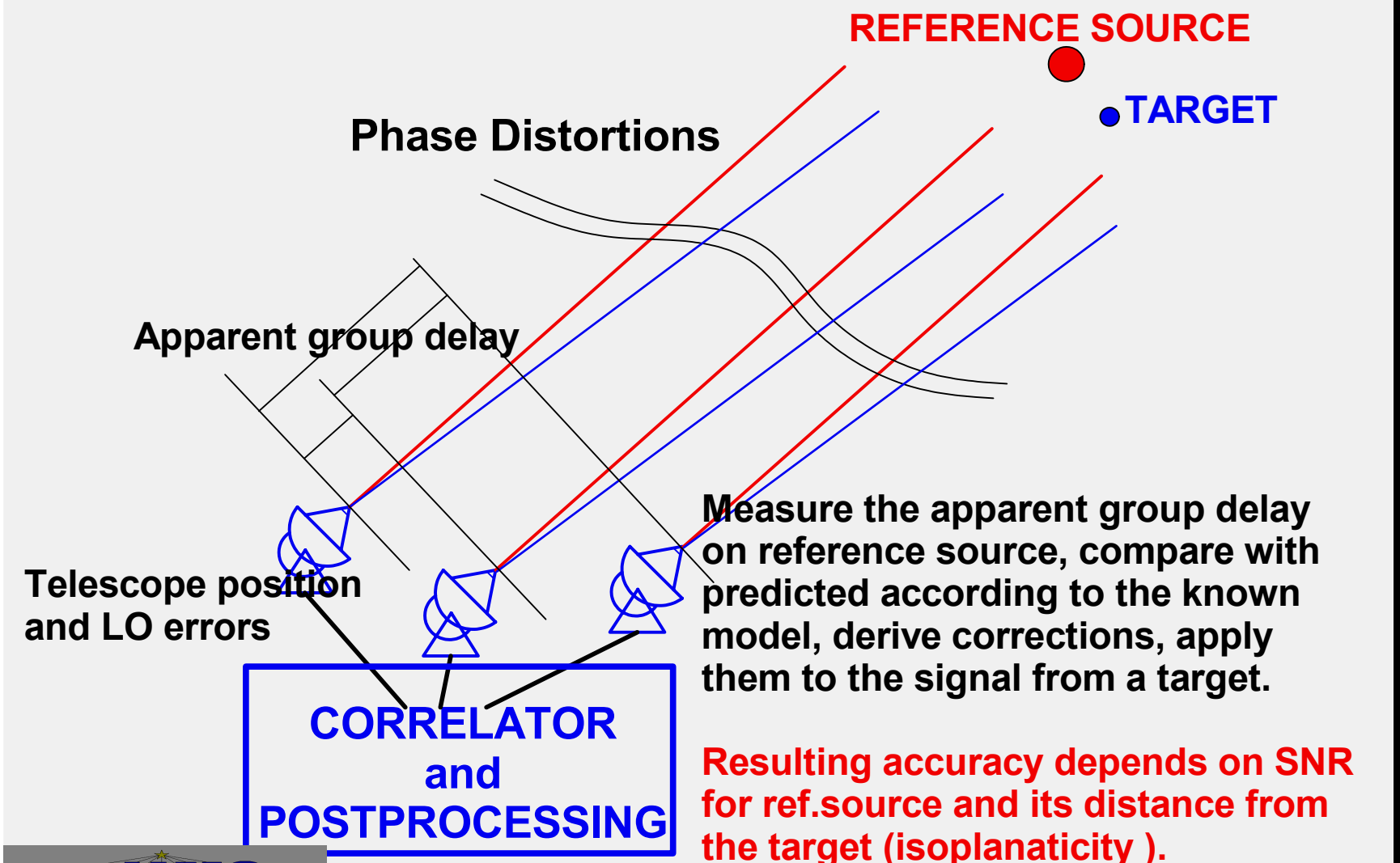
Basics of phase-referencing VLBI





Measure the apparent group delay on reference source, compare with predicted according to the known model, derive corrections, apply them to the signal from a target.

Resulting accuracy depends on SNR for ref.source and its distance from the target (isoplanaticity).

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JIVE / ESA Huygens VLBI team

Ref: VLBI TRACKING OF THE HUYGENS PROBE IN THE ATMOSPHERE OF TITAN.
S. V. Pogrebenko, L. I. Gurvits, R. M. Campbell, I. M. Avruch, J.-P. Lebreton, C. G. M. van't Klooster,
(ESA SP-544, February 2004).

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JIVE experience with Huygens probe's signal detection using Global VLBI Network

3.5 W power in carrier line at 2 GHz

3.5 dBi TX antenna gain,

<10^{-11} probe's Rb oscillator stability

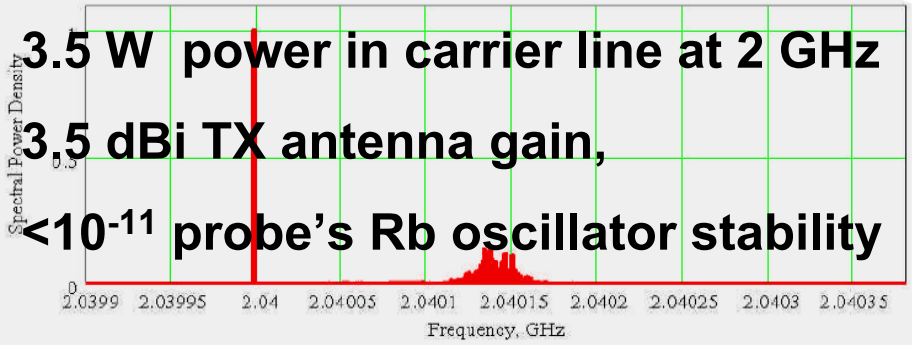
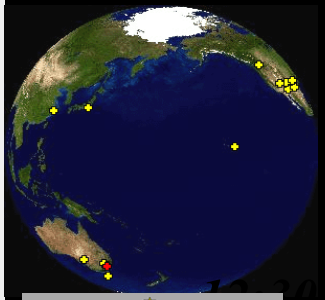
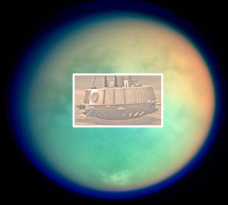


Fig. 4-1. Typical spectrum of BPSK modulated signal





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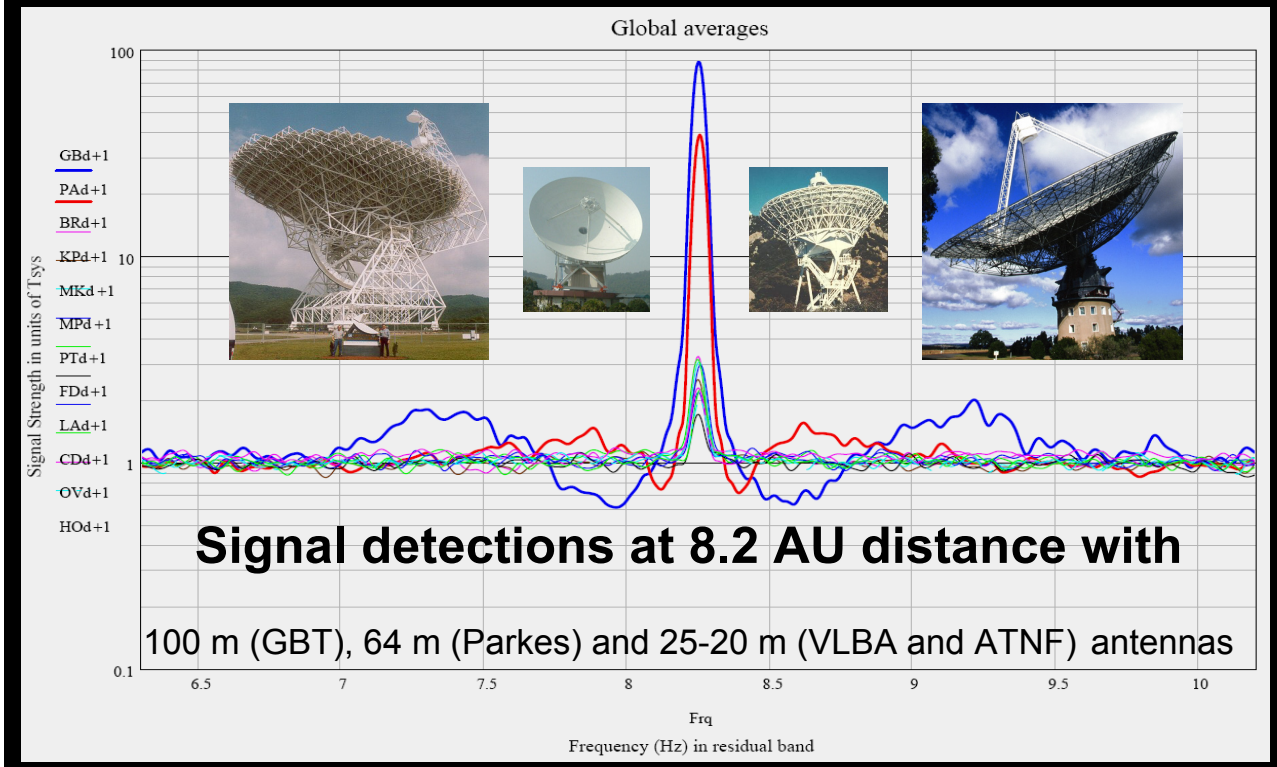
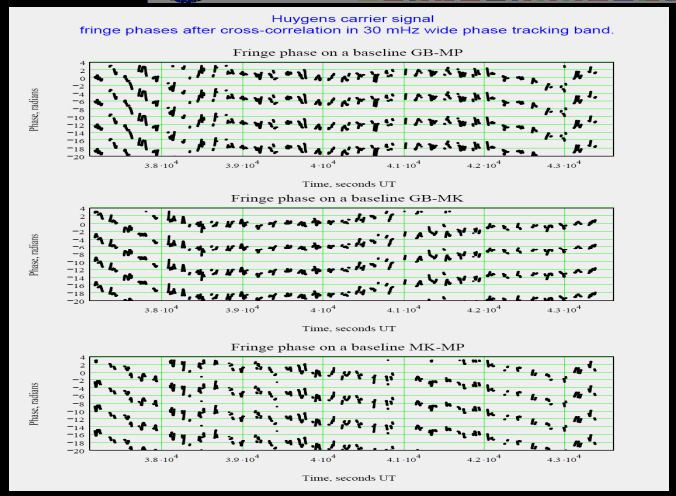


Signal detections at 8.2 AU distance with

100 m (GBT), 64 m (Parkes) and 25-20 m (VLBA and ATNF) antennas



Differential phases on triangle

GBT - Mauna Kea - Mopra

Phase noise ~0.5 radian for 10s integration

translates into ~1 km spatial accuracy at Titan distance

Projections for VLBI spatial accuracy at S, X and Ka bands for Saturnian and Jovian systems

Signal strength at Earth (W/m^2)
for TX power P_{TX}, antenna gain G_{TX} and distance R

$$P_s = \frac{G_{TX} P_{TX}}{4\pi R^2}$$

SNR for radio telescope with
diameter D, efficiency A_{eff}, system temperature T_{sys}
and spectral resolution dF, ($dF = 1 / t_{int}$)

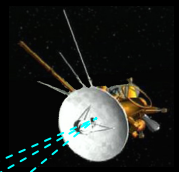
$$SNR = A_{eff} \frac{\pi D^2}{4} \frac{P_s}{k T_{sys}} \frac{1}{\delta F}$$

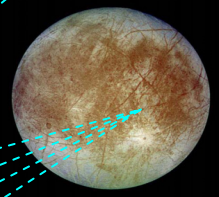
SNR for a baseline between stations 1 and 2

$$SNR_{12} = \sqrt{SNR_1 SNR_2}$$

Differential phase accuracy (radians)

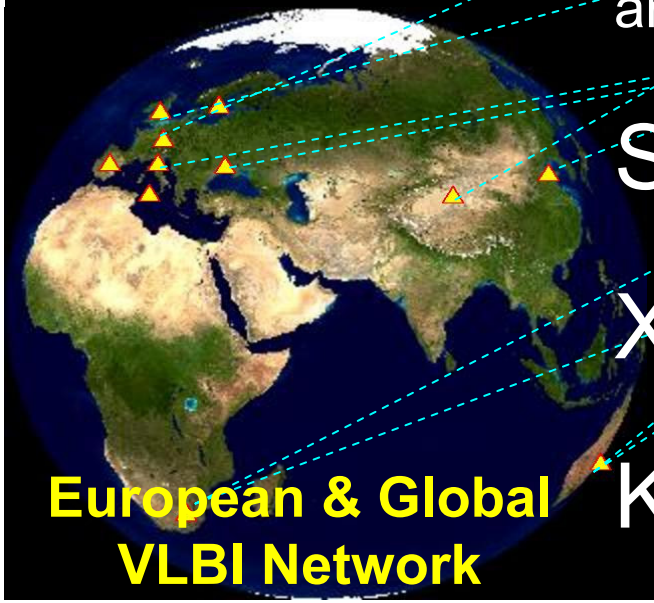
$$\Delta\varphi_{12} = 1 / SNR_{12}$$





Potential spatial accuracy (meters)

In 1 hour semi-coherent integration time,
1-3 W semi-isotropic TX power
and adequate TX LO stability:



European & Global VLBI Network

S-band (2 GHz) – 100 meters

X-band (8 GHz) – 10 meters

Ka-band (30 GHz) – 1 meter

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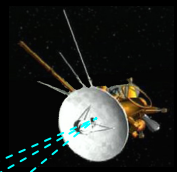
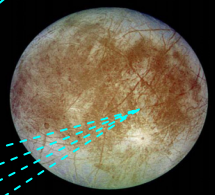
Potential projects



More than an order of magnitude improvement of the Jovian system celestial mechanics model



Multiple landers + orbiter:
plate tectonics of geologically active bodies in Jovian system,
Tidal deformation and inner ocean circulation of Jovian satellites

European & Global VLBI Network

Multiple landers + orbiters:
Tomography of electron content of near-Jupiter plasma

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