VLBI phase-referencing experiments for deep space probes*

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Introduction

In addition to the regular VLBI tracking sessions by obtaining differential group delay observables in ChangE lunar project, we carried out a few phase-referencing experiments using the Chinese VLBI network to validate its ability of positioning for deep space probes. The traditional method to calculate uvw of a quasar is not suitable for a deep space probe in the near-field, so we developed a new method to calculate UVW for near-field target. In the special same-beam observation condition of ChangE-3 lunar surface working stage, we performed the phase-referencing imaging from the software correlator and got the angular position by Difmap, then changed it into Rover relative position of Lander on the lunar surface. We also tried another method to solve directly relative angular position between ChangE-3 Lander and Rove. The results agree well with those from imaging method. Compared with the visual localization results, the accuracy of Rover relative position of Lander obtained by the phase-referencing method can be confirmed at the level of 1 meter. Phase-referencing positioning experiments of MEX (Mars Express) spacecraft and ChangE 5-T1 (precursor of Chinese ChangE 5

Phase-referencing experimental results

1. In-beam phase-referencing Imaging results of CE-3 two-probes

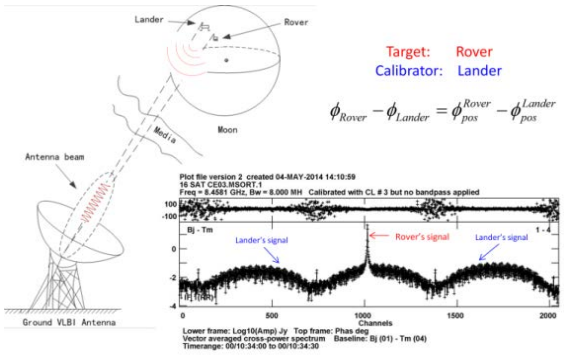

Figure 1: CE-3 two-probes Signal received within the same antenna beam and the same IF.

Table 1: Visual results and in-beam phase-referencing results, unit: meter

Site		Visual results	Imaging results	Differences
A	North	9.030	9.194	-0.164
	East	1.550	1.341	0.209
B	North	5.000	5.252	-0.252
	East	8.900	9.207	-0.307
C	North	-5.650	-5.245	-0.405
	East	8.360	8.812	-0.452
D	North	-9.750	-9.728	-0.022
	East	0.270	0.599	-0.329
E	North	-19.770	-19.533	-0.237
	East	-0.200	-0.159	-0.041

2. Dirty images of CE5T1 and MEX that related to the extragalactic radio source

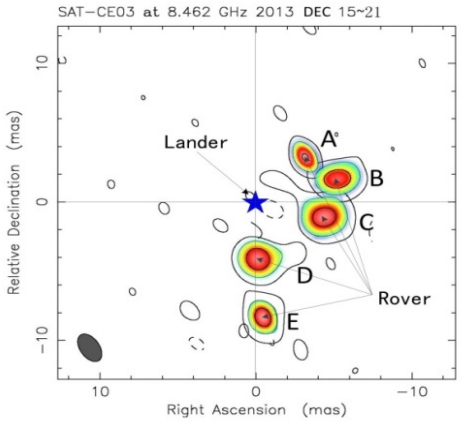

Figure 2: Phase-referencing Imaging (PR-I) results of CE3's probe

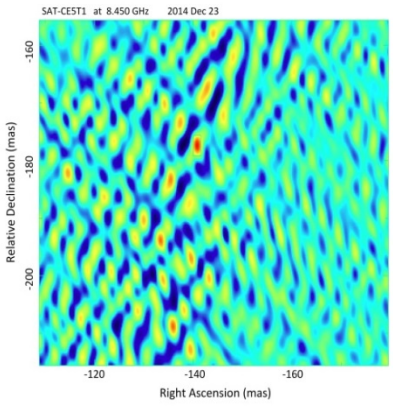

Figure 3: Dirty image of CE5T1 which at Earth-Moon Lagrangian point is made by 4 hours observations of Shanghai, Beijing, Kunming, Urumqi VLBI stations. The brightest peak position is the angle offset of CE5T1. The angle accuracy of the dirty image is consistent with that of CE5T1 orbit determination.

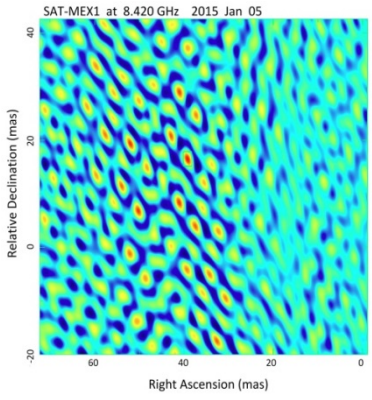

Figure 4: Dirty image of MEX is made by 1.5 hours observations of Shanghai, Beijing, Kunming, Urumqi, Bardary stations. There're many side lobes, and the brightest peak position is the angle offset of MEX. There is an systematic offset (tens-mas) in the image which is maybe caused by the MEX delay prediction error.

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