The ESA spacecraft Smart 1 was observed by EVN stations Medicina (IT), Metsähovi (FI), and Westerbork (NL) on May 25 2006 at S-band as a practice run in a frame work of EH019 project in preparation for other interesting events.

I'm happy to present here a First Preview of some preliminary results of Smt25 VLBI test run.

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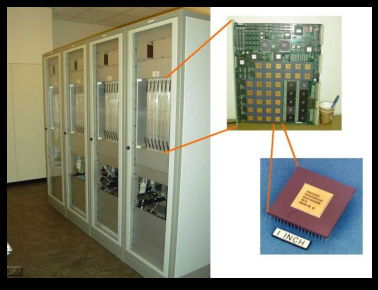
First Results of the First EVN VLBI Practice Run on the Smart One

Presentation at Cassini PSG meeting, 21-23 June 2006, Nantes, France

Medicina 32-m VLBI antenna

Metsähovi 14-m VLBI antenna

Westerbork synthesis radio telescope, single 25-m antenna is used for tracking experiments

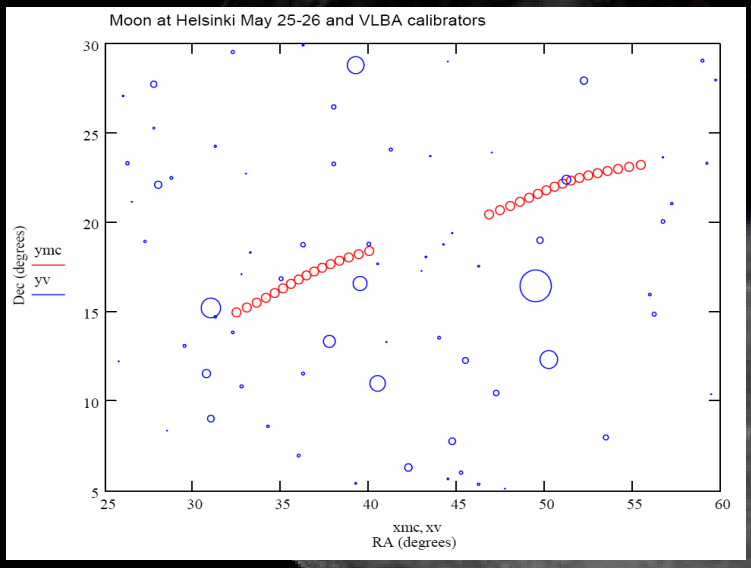


Computational core, Board and chip of the 50 Tflops EVN Mk5 Correlator at JIVE

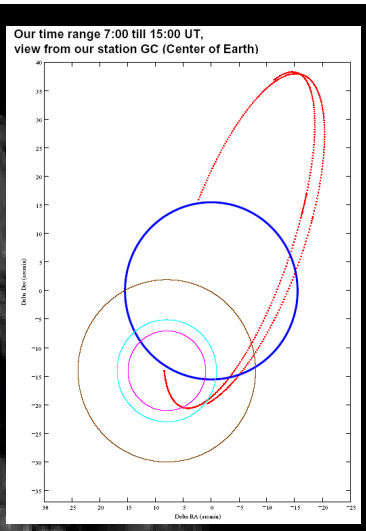
"Old" hardware setup on which JIVE/Huygens software correlator was developed

"New" hardware setup; it's also a development platform for a general purpose broad band EVN Software Correlator at JIVE

The Smart 1 was observed by EVN stations Medicina, Metsähovi, and Westerbork. Medicina and Westerbork used Mk5 VLBI data recorders and Metsähovi used PCEVN VLBI data recorder in parallel with Mk5. Metsähovi S/X band receiver was kindly provided by the Finnish Geodetic Institute (FGI). Electronic transfer of Mk5 data from Medicina to JIVE was exercised using GEANT and SURFNET fiber optics infrastructure. PCEVN data from Metsähovi was sent via public network.



Moon as seen from Helsinki (red) on May 25-26 traveling over the VLBA calibrators data base sky (blue, size coded for spectral flux density)

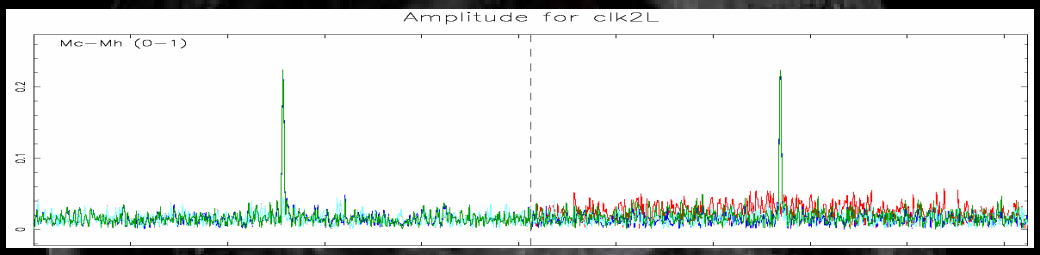


Moon, spacecraft trajectory and telescopes' beams. We tracked it for 8 hours, a lot of interesting data to mine, but here we will concentrate mainly on one particular minute – S/C egress from an occultation.

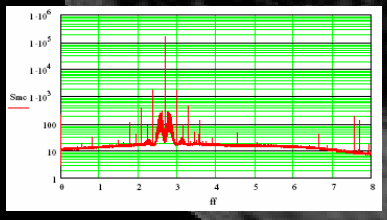
Spacecraft trajectory predictions were provided by ESA/Smart1 team

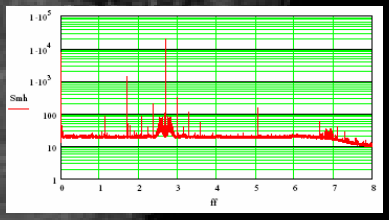
The spacecraft signal was processed at JIVE using Ultra High Spectral Resolution Software correlator developed at JIVE under contract 17002/02/NL/LvH/bj with ESA for VLBI tracking of the Huygens probe.

Broad band signals from calibrator source J0242+1101 for clock search were processed on EVN Mk5 correlator at JIVE.

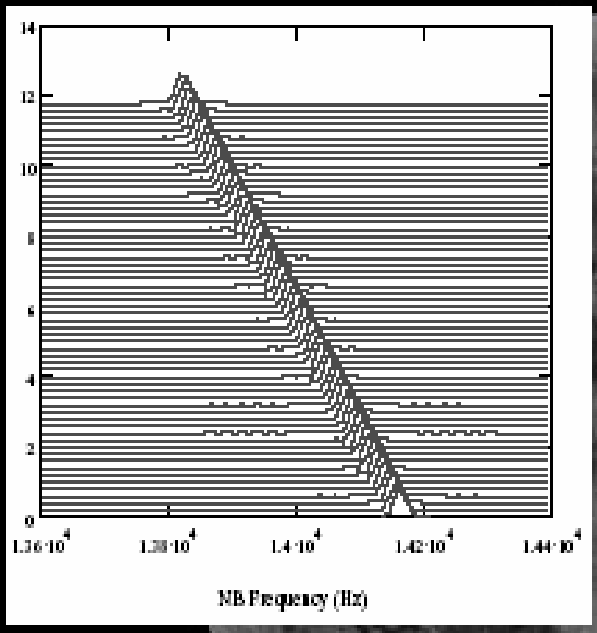


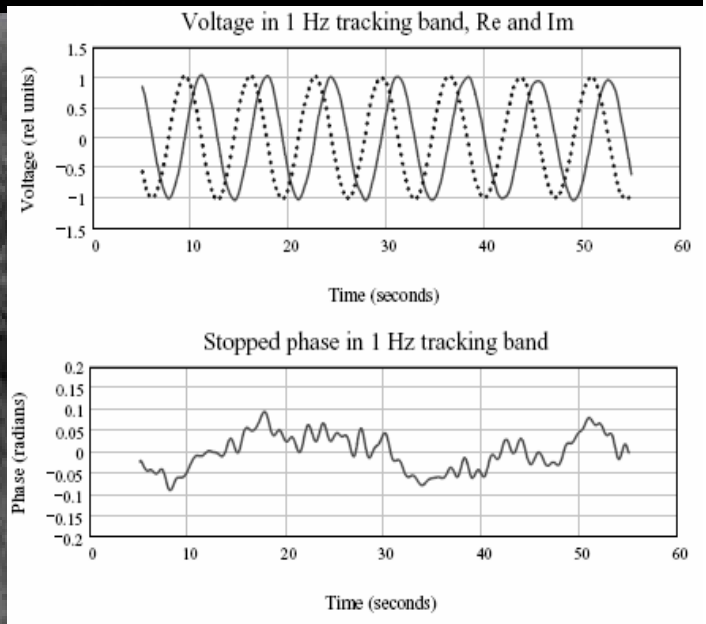
Fringe finder fringes from EVN Mk5 Correlator on Mc-Mh baseline. This signal allowed us to reduce clock uncertainty on a baseline from ~ microsecond to ~ nanosecond level.





Singe dish spectra (64001 spectral channels, 125 Hz resolution) of Smart1 signal over 8 MHz video band, for stations Medicina (left) and Metsähovi (right).



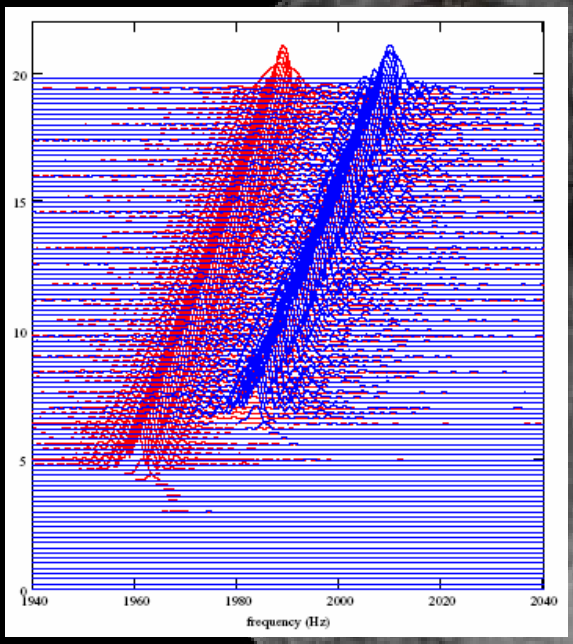


Scan 0001 Smart1 TX carrier line detected by Medicina telescope at 2.235 GHz (Frequency resolution 24 Hz)

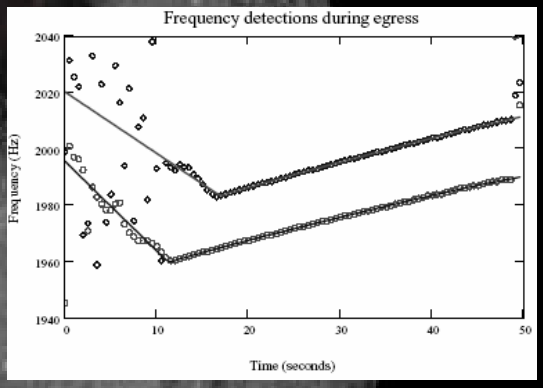
End result of phase tracking
Frequency residual < 1 mHz
Velocity residual < 0.1 mm/s
Of course, this is just instrumental accuracy, results are masked by propagation effects and S/C LO variance

Well.. It's easy to track a spacecraft when you can see it.. But if not?

Scan 0028 dynamic spectra of S/C signal as observed by Medicina (left) and Metsähovi (right) stations during the spacecraft's egress from an occultation



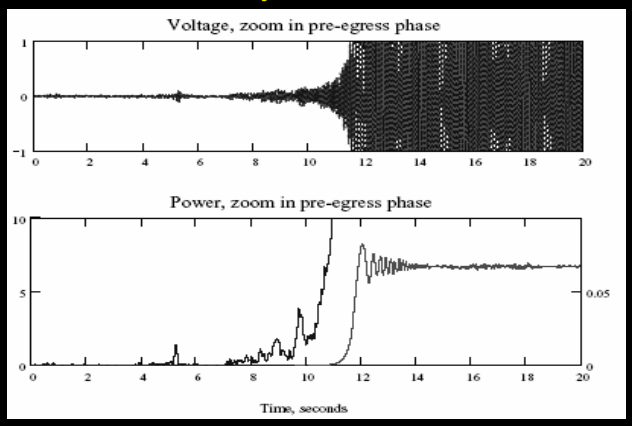
Frequency detections:
Medicina – circles, Metsähovi - diamonds



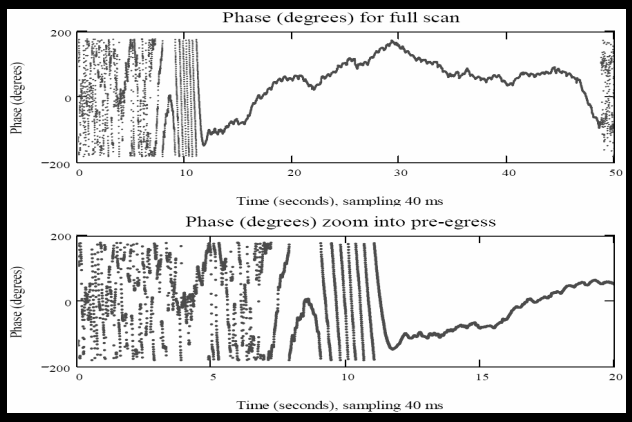
Frequency scales for both stations are cross-calibrated to sub-milliHz level with "clock-search" data on calibrator source

Check these "mouse tails" at the bottom of the main detections.. It's a diffracted signal which appears many seconds before the direct signal beams into receiving antennas.

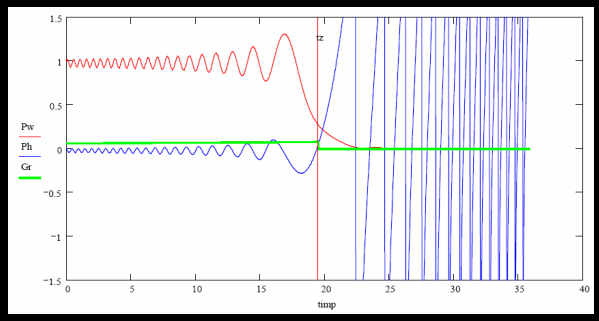
Carrier wave voltage, power and phase as detected by Medicina station



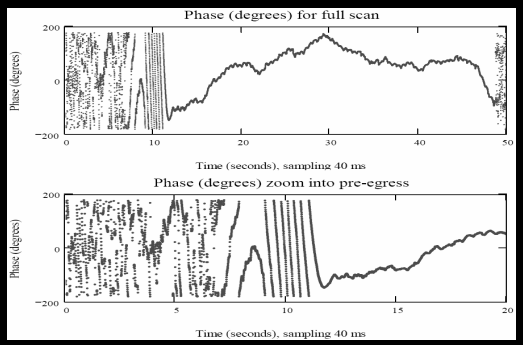
Post-egress “classical” diffraction pattern and zoom on pre-egress high beamed features, like these seen around seconds 5 and 8-10

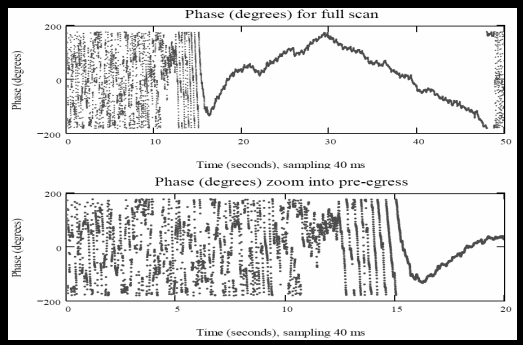


For comparison: power (red) and phase (blue) patterns for diffraction on a flat circular screen



Phase tracks for Medicina (left) and Metsähovi (right) VLBI stations. Geometrical egress occurred at second 11 of this scan for Medicina and at second 16 for Metsähovi. Note, that power level at the beginning of the scan is many orders of magnitude weaker than at post-egress times.

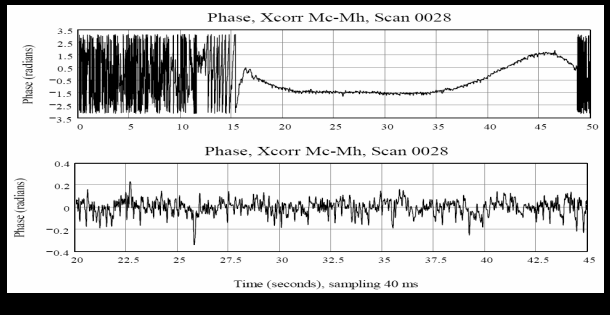




Differential phase on baseline Mc-Mh. Slow variation represents propagation effects. Phase variance of S/C LO is (almost) canceled by cross-correlation. Short-time spikes on differential phase could be ether instrumental impurity either reflections from Moon’s surface

Short term phase noise 65 milliradian (or 4.6 ps) rms at 40 ms sampling,

Initial phase ambiguity ~ several cycles



Involving more stations and more frequency tones will resolve ambiguities and correct for ionospheric propagation effects