MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886
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Telephone: 508-692-4764
Fax: 617-981-0590

To: Millimeter-wave VLBI Group

From: Alan E.E. Rogers AEER

Subject: Burst mode sampling

Introduction

In the discussions of mm VLBI the question of burst mode sampling might be raised. The Canadians are considering the use of a NRO burst mode sampler at the JCMT. The idea of burst mode sampling is not new and was discussed back in 1970 in the early bandwidth synthesis papers but was never considered being competitive with bandwidth synthesis. With the advent of mm VLBI the Japanese have reactivated the idea and are building a burst mode sampler. Is this a good idea? How much can be gained?

Detection threshold improvement

For simplicity, assume that we have at most only one burst of rate B for time d per coherence time t and that each coherence interval has to be incoherently averaged with other bursts. In this case, for a fixed integration time T, the number of segments without burst mode is T/t while the number of bursts is $TR/(Bd)$ where R is the average sustainable data or recording rate. The detection threshold in flux density is inversely proportional to the square root of the number of bits in each segment and inversely proportional to the fourth root of the number of segments. Thus the detection threshold of the burst mode relative to the continuous mode with the same record rate is

$$\left(Bd/(Rt)\right)^{-1/2}\left(TRt/(TBd)\right)^{-1/4} = (B/R)^{-1/4}\,(d/t)^{-1/4}$$

(B/R) is the ratio of burst rate to record rate and (d/t) is the ratio of memory size S times burst rate the record rate times the coherence time. Substituting the following parameters (from Kawaguchi's article in Frontiers of VLBI):

B	=	*4 Gb/s*
R	=	*256 Mb/s*
S	=	*8 Gb = 1 GB*
t	=	*10 seconds* (typical for poor conditions at 3mm)

The burst rate improves the threshold by a factor of 1.99 while the lack of memory needed to reach the 10 second coherence time degrades the threshold by 1.5 so that the net improvement is only about 33%. For burst mode to be effective with R = *256 Mb/s*, more memory is required and the situation with MkIV at a sustained rate of *1 Gb/s* and *K4* with a sustained rate of 256 MHz would only just break even with 5 GB of burst memory needed to make the burst last for the coherence time. Burst mode could be advantageous when used with MKIII, VLBA or S2 at R=128 Mb/s, but needs about 2.5 GB of memory to gain a factor of 2 in sensitivity.