

## Workshop Protocol: Refurbishing the Effelsberg Timing System

<b>Datum &amp; Zeit</b>	Thursday, Juli 5 2018	12:00 – 17:30 at the Radio Observatory Effelsberg (Lecture room)
<b>Teilnehmer</b>	Extern R. Holzwarth (MenloSystems), W. Schäfer (TimeTech) MPIfR: A. Kraus, G. Wieching, R. Keller, U. Bach, A. Roy, E. Barr, D. Champion, R. Karuppusamy, H. Hafok, J. McKee, Z. Kidane, D. Dillbohner.	

### Agenda:

**12:00 Welcome and Introduction to the Topic** (A. Kraus / R. Keller)

**12:45 Lunch Snack**

**13:15 Tour through the observatory**

**14:00 Timing for ESA** (R. Holzwarth)

Presentation and short discussion

**14:20 Boundary conditions of the Pulsar Group** (N. Wex, tbc)

Presentation and short discussion

**14:40 Boundary conditions of the VLBI Group** (U. Bach)

Presentation and short discussion

**15:00 Coffee break**

**15:30 Discussion and Decision finding** (All)

checking all boundary conditions of the groups, discussion of solutions and defining a concept to be realized.

Topics to be discussed:

1. Minimum required time resolution?
2. Should the maser be synchronized to GPS or not?
3. How to handle redundancy; automatic fallback or manual switch over?
4. aob

**17:00 Conclusion** (R. Keller)

## Presentations and Discussions:

R. Holzwarth gave an overview of what Menlo Systems is doing and what could be relevant for our timing problem. I.e. he introduced a closed loop roundtrip phase compensated optical link for precision frequency distribution and a system for transmitting optical pulses via stabilized fiber links providing  $<2\text{fsec}$  jitter over 10sec. He strongly recommends a direct link to PTB in Braunschweig to get high precision UTC. He also offered to have a look on the possibility to establish a fibre link from Bonn to Braunschweig (Contact person at MPIfR: A. Oberreuter [ao@mpifr.de](mailto:ao@mpifr.de)).

David Champion gave a short introduction into pulsar observations with their timing needs. Most critical are gravitational waves measurements where pulse timing measurements are made over 10 years with a 1PPS uncertainty of  $<10\text{ns}$  whereas the absolute UTC information is taken from NTP within msec. Important here is the logging of the difference Maser to UTC, measured via 1PPS. These values should be recorded very seriously and kept over years. He suggest to have one file per UTC source (which are our GPS-RX) to have redundancy. This difference has to be not too big and without steps, so any change of cables or Maser adjustments are severe. At least these changes have to be protocolled carefully. There were remarks from R. Holzwarth to try to lock to PTB RB-fountain clock which provides best UTC with  $<<1\text{nsec}$  jitter according W. Schäfer.

Uwe Bach presented the needs of VLBI which have less needs for long time stability. The IVS recommendations suggest time uncertainty of  $<100\text{usec}$  during  $<<1\text{day}$  and no steps in the clock time. He presented a comparison of UTC from GPS integrated over 1h and 1day showing clearly the short time variation of this system.

Wolfgang Schäfer presented some ideas for the Effelsberg timing system. He also suggests to connect to PTB-UTC with the best RB-fountain clock #7 providing best UTC possible. UTC is more stable than any maser after 5 days. Best protocol is integerPPP in receivers "geodetic grade". He suggests to harmonize with people in Wettzell who have experience in this. There are GNSS receivers and calibration methods to secondary labs at the level of 1.5 ns calibration uncertainty, which could guide the activities in Effelsberg. Effelsberg is NOT a secondary lab in the metrological sense, but the methods and error models could be used. Receivers should be calibrated regularly, best 4/year based on PTB's travelling receiver (contact Andreas Bauch).

In the general discussion David Champion pointed out that logging the time difference is sufficient and no locking of the maser to UTC is needed. Reinhard Keller stressed his motivation to minimize errors by introducing automatic adjustment. But Wolfgang Schäfer did not recommend this due to unknown effects; "you never know what happens". Gundolf Wieching suggest that

this has to be investigated further. Ramesh Karuppusami suggested to check the 1PPS signal of the Meinberg receivers which have  $\pm 50\text{ns}$  jitter unless the low phase noise option was ordered.

## Conclusions:

- Time uncertainty of the 1PPS timing signal: <10nsec in 10years.
- Don't synchronize the Maser to UTC unless the mechanism is known to uncritical wrt. Time steps and phase jumps.
- Continue Maser – UTC time difference logging, extend it to all existing UTC sources for redundancy.
- Switch manually between masers and UTC clocks: it's unlikely and observations are spoiled anyway.
- Document any system changes; cables, distributors, other equipment.

## To do List

To do	responsible	date
Check 1PPS phase noise option of the Meinberg receivers	R. Keller	7/2018
Install frequency and phase difference measurement of masers	Z. Kidane	7/2018
Pre install and document the new timing installation before switch-over to the new maser and location.	System Group	8/2018
Renew $\Delta t$ logging software and extend it to 4 UTC sources	Z. Kidane, R. Keller	8/2018

This document and some of the presentations can be found on our Wiki pages:

[https://eff100mwiki.mpifr-](https://eff100mwiki.mpifr-bonn.mpg.de/doku.php?id=information_for_astronomers:information_of_the_receiver_division:index)

[bonn.mpg.de/doku.php?id=information\\_for\\_astronomers:information\\_of\\_the\\_receiver\\_division:index](https://eff100mwiki.mpifr-bonn.mpg.de/doku.php?id=information_for_astronomers:information_of_the_receiver_division:index)

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