

## **EHT Metadata for 2021 campaign**

### **Supporting Documentation for Tsys Tables from PV30M**

1) The tables provide Tsys\*, understood as the Tsys including the impact of the airmass on the line-of-sight.

2) The 30M telescope measures Tsys\* with an observation on an ambient load and on sky (it also includes an observation on a cold load to derive the receiver temperature). Such observations are done in which is called a “calibration scan”. The calibration scans are usually done during the gaps between VLBI scans, if the time gap permits. For the IRAM30m, no measurement of Tsys can be done during a VLBI scan. Tsys\* is calculated within the MIRA calibration software that performs online data calibration for continuum observations at the IRAM 30m telescope.

3) Because of 2), the provided Tsys\* table follows the following methodology to assign calibration metadata to a VLBI scan:

3.a) If a VLBI scan on a given source has one or more calibration scans on the same source within 10 minutes of the VLBI scan start time\*, we select the calibration metadata from the nearest-in-time calibration scan and assign it to the VLBI scan.

\* the exact time difference between the selected calibration scan and the VLBI scan start time is provided in column “Delta\_t” of the Tsys\* table. The limit time of 10 minutes is chosen from our experience at the 30m; we consider such separation in time between a calibration and a science scan valid. The interval can be changed if desired.

3b) If 3.a) is not fulfilled and a VLBI scan on a given source does NOT have a calibration scan on the same source within 10 minutes (or whatever Delta\_t is chosen), a linear interpolation between the closest-in-time calibration scans on the same source before and after the VLBI scan start time is performed, and calibration metadata at the start time of the VLBI scan are derived from the linear interpolation. The derived metadata from the interpolation at the start time of the VLBI scan is assigned to the VLBI scan in the Tsys\* tables. Note that all values are interpolated: azimuth, elevation, all the Tsys\* for each band/pol., Tamb, and Tatm. In this case, the column “Delta\_t” of the Tsys\* table indicates “Interp”.

Note: in the rare cases where a VLBI scan does not have a calibration scan within Delta\_t, and there are also no two calibration scans on the same source surrounding the VLBI scan to enable an interpolation, we choose the calibration metadata from the nearest-in-time calibration on the same source, even if it has a Delta\_t larger than defined (usually 10 minutes). This case is uncommon and might occur perhaps at the very beginning or end of a track.

Note\_2: In rare cases, a source might not have any calibration scan done on the source position. In such cases, NA is provided in the tables. In such cases, the best would be to calculate a new Tsys\* from a nearby scan, adapting from the closest Tau\_z.

4) Note: The Tsys\* provided is measured using an independent continuum backend called the Narrow-band Continuum Backend (NBC) operating with a bandwidth of 1

GHz within the telescope subbands, which do not correspond exactly to the center of the EHT backend subbands defined as b1, b2, b3 and b4. In summary, the Tsys\* data assigned to b1 and b2 is obtained by a continuum measurement on 1 GHz of bandwidth centered ~6.0 GHz below the local oscillator frequency, and for b3 and b4 is obtained by a continuum on 1 GHz of bandwidth centered 6.0 GHz above the local oscillator frequency. These frequencies at which the Tsys\* are measured are indicated in the header of the Tsys\* tables.

5) The Tau\_zenith is calculated by the telescope calibration software MIRA from the measurements during the calibration scans (see point 1). Tau\_z is calculated for the central observing frequencies of the NBC backend (indicated at the header of the Tsys\* table, see point 4). Knowing the values like the physical temperature of the ambient and cold load, the forward efficiency of the antenna, the atmospheric properties from a meteorological station (pressure, humidity) and using the ATM model (Cernicharo 1985, Pardo et al. 2001) to derive the Tatm, etc., the tau\_z is calculated. All the process is done during the online calibration using MIRA that the IRAM30m telescope runs during the observations.

6) Also attached in the Tsys\_tables/supporting/ subdirectory are the WX tables, and an extra table per track containing all the calibration scans done during that track ("track\_CALs\_Pv.txt"). See also the README file inside the folder.

For more detailed information on the calibration procedures at the IRAM 30m telescope the reader is referred to:

- Kramer, C., 1997, Calibration of spectral line data at the IRAM 30m radio telescope, [https://www.iram.es/IRAMES/otherDocuments/manuals/Report/cali\\_rep\\_ddo970205.ps](https://www.iram.es/IRAMES/otherDocuments/manuals/Report/cali_rep_ddo970205.ps)
  - Pety, J. Bardeau S., Reynier E., 2009, Comparison of ATM versions: Impact of calibration of IRAM instruments, <https://www.iram-institute.org/medias/uploads/atm-comparison.pdf>
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