Measuring Planets Fluxes with Planck/LFI

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On the Behalf of Planck Collaboration

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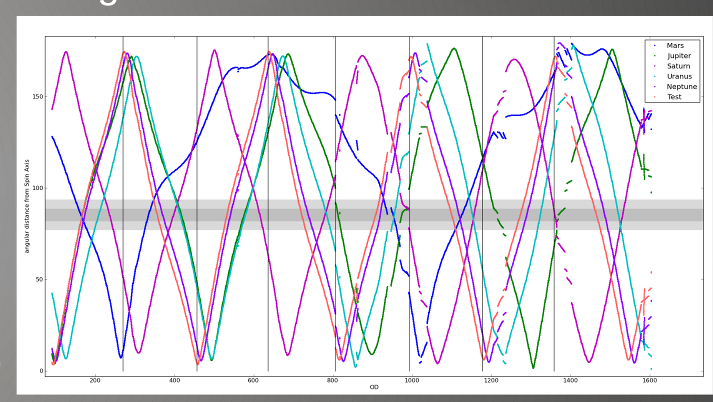
Abstract

The spectral energy distribution of planets is an important benchmark to inter-calibrate different CMB experiments. In particular Jupiter allows accurate comparison due to its high S/N ratio (1). Since planets are moving objects, the measure must account for their proper motion as well as a number of second order effects (2). Here we present the results of accurate measurements of brightness temperature T_b of Jupiter, and we compare them Jupiter with WMAP. A more complete table with the measurement of Mars, Saturn, Uranus is in preparation to be released in the forthcoming issue of Planck papers.

1. Planets transits

the Planck focal plane, when their angular distance from the Planck spin axis is about 85 deg. The plot shows this angle as a function of the Operative Day. Planck surveys are delimited by black lines. A planet crosses one or more horns when the corresponding line falls inside the dark gray band. Corresponding samples from calibrated timelines are extracted and processes. To asses better background removal, a larger acceptance (5 deg radius) is considered, shown in light gray. A typical transit lasts for 7-10 days, but each horn observes a planet for no more than a day. The number of transits is 8 for Saturn, Uranus and Neptune, 7 for Jupiter, 3 for Mars.



2. Raw T_{ant}, planet antenna temperatures, for each

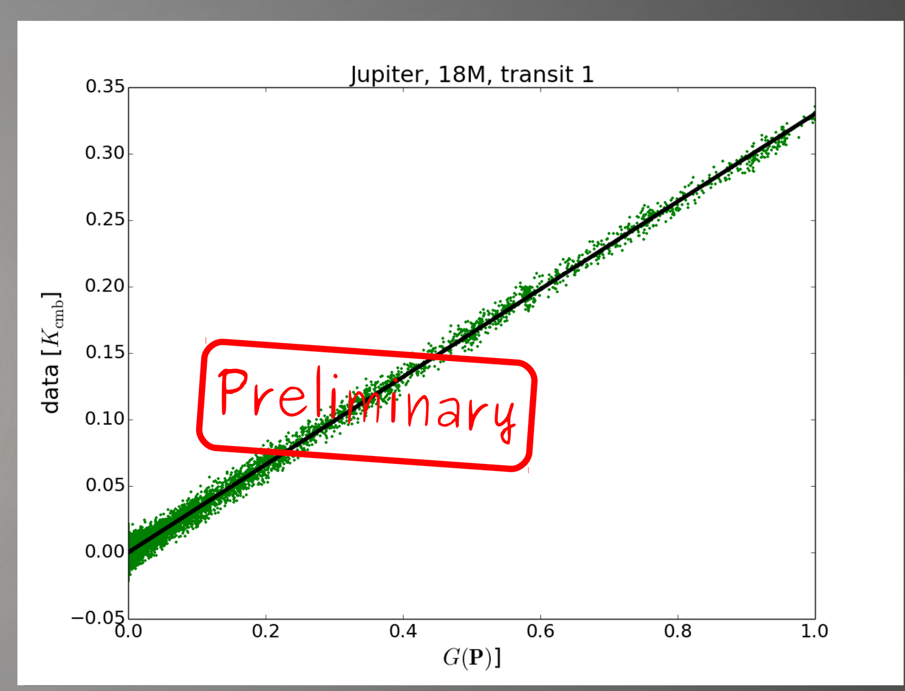
individual radiometer and transit are recovered from calibrated timelines for a known beam response. This is equivalent to apply a linear regression (1)

(1) $T_t = T_{ant}\,G(\mathbf{P}_t) + T_{background}$,

where t is the sample time, T_t is the sample value, $\mathbf{P}_t$ the planet position in the beam reference frame.

We assumed a gaussian elliptical beam pattern $G(\mathbf{P})$ [a] with parameters either provided by the collaboration or fitted on the timelines themself.

[a] $G(\mathbf{P})$ is normalized to have $G(\mathbf{0}) = 1$.



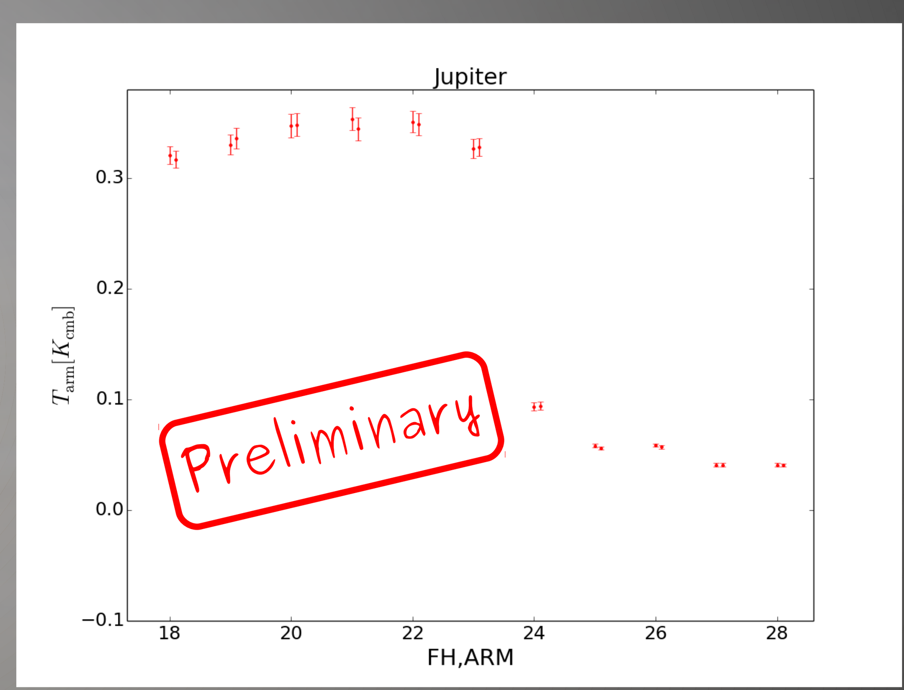
3. T_b the planet brightness temperature

(1,2) per radiometer and transit is derived from raw T_{ant}

(2) $T_b = B^{-1}(T_{ant}\, f_{sl}\, \Omega_{beam} / \Omega_{planet}\, ((\partial B/\partial T)_{cmb}))$

where $B^{-1}(x)$ the inverse blackbody function and $(\partial B/\partial T)_{cmb}$ the CMB spectrum derivative in T are both computed at each radiometer central frequency F_{cent}. Eq.(2) corrects for beam efficiency f_{sl}, planet and beam solid angles, Ω_{planet} and Ω_{beam}.

The figure shows for each radiometer the raw Tant for Jupiter.

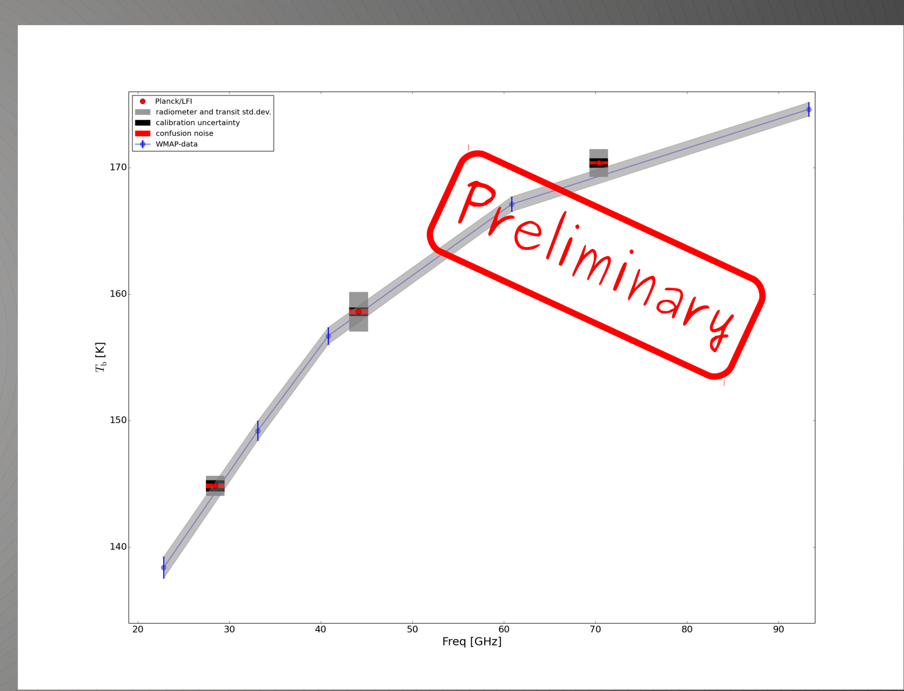


4. T_b of Jupiter for LFI and WMAP

are compared in the plot and show in a good agreement.
The red points are averages for each frequency channel taken over the whole set of transits and radiometers. The bars represents uncertanities: confusion noise, calibration uncertainty and residual scattering of data.

WMAP data (5) are shown as blue points, their error bars accounts just for calibration and Ω_{beam} uncertainties.

Confusion noise accounts for 0.06 – 0.01 % uncertainty, the remaining comes from instrumental effects. Eq.(2) reduces the time dependence in the Jupiter data from 4% down to a 0.2%. A residual variability within radiometers of the same frequency channel, respectively of 0.2%, 0.6%, 0.3% at 30, 44 and 70 GHz. The cause of this effect is still under analysis despite it is likely due to small uncertainties in F_{cent}.



5. Forthcoming work

This work was devoted to the analysis of Jupiter data for all of the Planck/LFI transits. We obtained a good agreement with WMAP measures, but we evidenced again some residual systematic below 0.2%, which needs to be removed. This will be the scope of a more detailed work, together with the production of an improved table of planet brightness temperatures for (4) as the one reported in (1) for the 2013 issue of Planck/LFI data.

References

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