# HIFI beams and efficiency parameters

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### **Observations on Mars**

- → Maps of Mars with 7x7 fast dbs raster during 2 runs:
- OD330-331 (8.5") and OD390-414 (5"), in Apr. and Jun/Jul 2010
- $\rightarrow$  SAA: -14 and SAA = +17/27

#### Mars Maps



### Mars' Model

Brightness temperature map at first frequency



Right ascension(arcsec)

http://www.lesia.obspm.fr/perso/emmanuel-lellouch/mars/

Because of Mars convolution at High frequencies, the Tb used is the mean brightness temperature/beam

## Beam : data analysis

Fit of a 2D Gaussian (see Michael Olberg report)
→ Amplitude, FWHM

Numerical convolution with mars model maps to retrieve the HPBW (PSF)

HPBW numerical deconvolution fits the analytic relation between FWHM and planet diameter ( $\theta$ s) HPBW = sqrt[FWHM<sup>2</sup>-(ln2/2\* $\theta$ s)<sup>2</sup>]

Theoretically for tha HIFI antenna:

HPBW =  $2/pi^{1.6} + 0.021 * \text{Te} (dB)^{3}/D$ 

With Te, the edge taper

### **HPBW**



Difference of the fitted Te between run 1 and 2 →Translate a variation of the HPBW measurements (pointing quality due to SAA ?). But Mostly at low frequencies

### Possible explication :Random effect

Simulation of low sampling(7x7) maps convolved with Mars + SNR=50  $\rightarrow$  relative error larger at low V than at high V ( $\rightarrow$  point-like at low V but not at high V )



Random effect  $\rightarrow$  we can simply fit both run 1/2

#### HPBW : H almost equal V



### HPBW- All data



Fit the derived HPBW over all the bands  $\rightarrow$  Te=8.01 ± 0.41 dB

#### HPBW residuals- All data



HPBW residuals (arcsec)

# Beam effiency: Beff

 The antenna temperature Ta measured on a planet depend of the beam convolution, between a Gaussian beam and a disk, with the so-called Geometrical dilution factor (Fd):

 $Fd=1/(1-2^{-(\Theta s/\Theta t)^2})$ 

- With θs and θt the angular diameter of the source and of the telescope beam (HPBW), respectively
- Ta = Tmb\*Beff/Feff and Tmb=Trj/Fd
- With Ta the antenna temperature measured, Trj the Rayleigh-Jeans temperature of the planet, and with Beff and Feff the beam and forward efficiencies. Feff =0.96.
- In practice the Beff is computed by the following equation :
   Beff = Ta/Tmb\*Feff

### Beam and Aperture efficiency

The aperture efficiency (ηa) depends of the antenna surface accuracy (σ) and wavelength (λ):

Ruze formula:

 $\eta a = \eta a 0 \exp(-(4pi\sigma/\lambda)^2) = Ageo/Aeff$ 

and for HIFI

Beff = 1.015  $\eta_{a}$ 

2D calculation of the illumination pattern taking into account the full blockage by Urs Graf (Kosma)



Good reproducibility between run 1 and 2 ( $\pm$  1 $\sigma$ ) Very good fit : Beff accuracy  $\pm$  2.3 % But for some bands (4,5,7) can be up to 4%

### Beff: V



but for some bands (1,4,6,7) can be up to 10%

### Beff: H+V



Beff accuracy ± 4 %

### **Point source sensitivity: χ**<sub>pss</sub>

From C. Kramer report :

Xpss=Sv/Ta = 2k/Ageo Feff/ ηa

Compute Sv from Mars model and HPBW. fit the measured Sv/Ta on Mars with Xpss taking the derived  $\eta a0$  and  $\lambda$  with Beff

+ scaling factor K0.

### Xpss:H



Very good fit : Xpss accuracy ± 2.3 % - K0=1.125

### Xpss:V



Xpss accuracy ± 5.5 %

#### Xpss:H+V



Xpss accuracy ± 4.5 %

# H/V imbalance

Imbalance possible reasons between H and V polarization:

- •H/V Beff
- •H/V Relative pointing (known) + APE
- •H/V HPBW (should be OK, same FIT)
- •H/V sideband ratio (for lines)

•Convolution with source brightness distribution (point-like, extended)



H/V Bands 1-6 < 5-7%  $\pm 2\% \rightarrow$  measurable H/V Band 7: up to 10% but linear and reproducible

#### **Comparison with Mars S.Scan**



S. Scan : Band 1-3 : weak slopes measured → Instrumental origin ?
S. Scan : Band 4,5 : shows large difference (continuum unstability ?)
S. Scan : Band 6,7 : Too noisy

## Summary

- Mapping of Mars with all bands and polarizations have allowed
- HPBW retrieved with an averaged fit rms of ± 0.75"
- Beff and Xpss retrieved H  $\pm 2\%$  V  $\pm 5\%$  HV  $\pm 4\%$
- $\rightarrow$  H is much better than V
- Mars model initially ± 5% in absolute (now with WMAP ± 1%?)
- Beff and Xpss H/V ratio retrieved 5-7% up to 10% for band 7
- It would be useful to have more measurements on Mars to improve the statistics and check the long term reproducibility