# HFI maps : what's new wrt 2013

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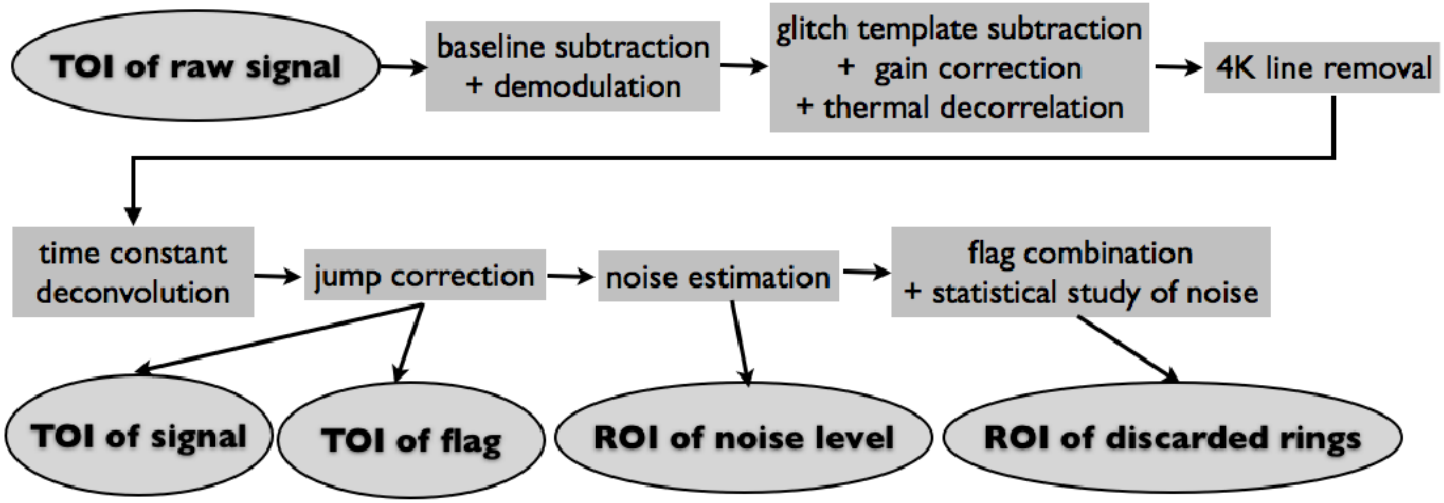
planck


Ferrara 2014

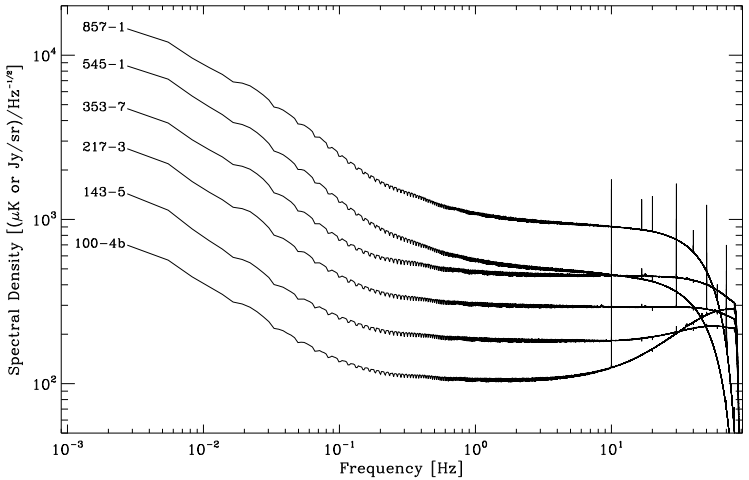
# Overview

- TOI processing
- calibration strategy
- accuracy & stability
- Solar dipole measurement
- map characteristics
- outlook

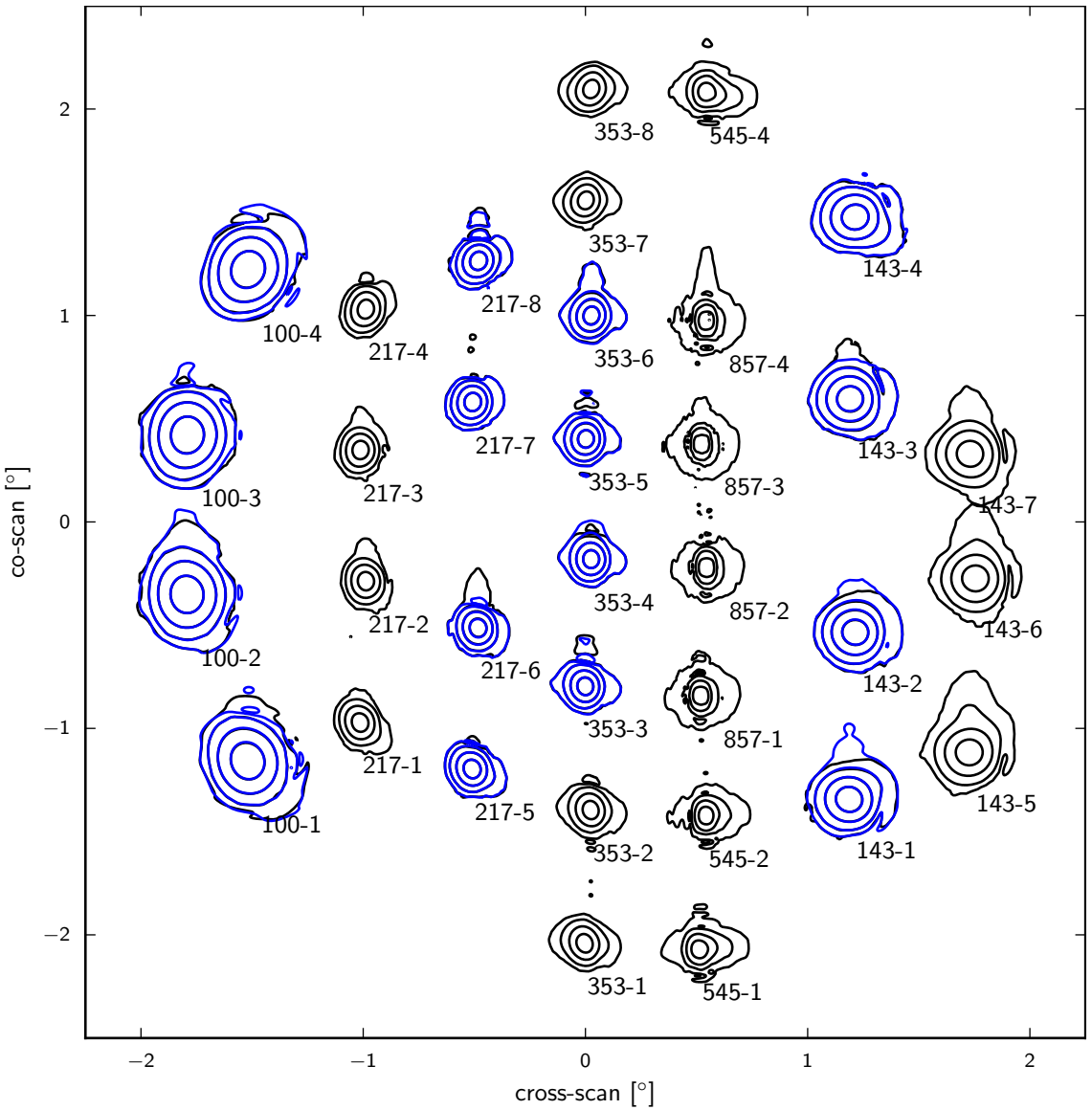
# TOI processing overview

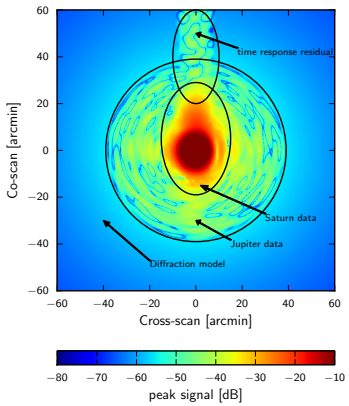



- very efficient TOI processing pipeline
  - deglitching ($\sim$ 15% data lost)
  - improved 4K lines removal & flagging
  - O(20%) stable data rejected (CR, 4K,...)
  - $\sim 1/f$ noise ($f_{knee} \sim 0.1$ Hz)
- $\Rightarrow$ destriping approach: noise = offsets + white noise
- use stable pointing period ($\sim$ 40mins) as baseline for offsets



# HFI detector scanning beams PRELIMINARY




| Freq. (GHz) | FWHM (arcmin) |
|---|---|
| 100 | 9.69 |
| 143 | 7.30 |
| 217 | 5.02 |
| 353 | 4.94 |
| 545 | 4.83 |
| 857 | 4.64 |

$B_\ell$ uncertainties at $\ell = 1000$ :

(100, 143, 217 GHz)

$(2.2, 0.84, 0.81)10^{-4}$

( 2013 : $(61, 23, 20)10^{-4}$ )

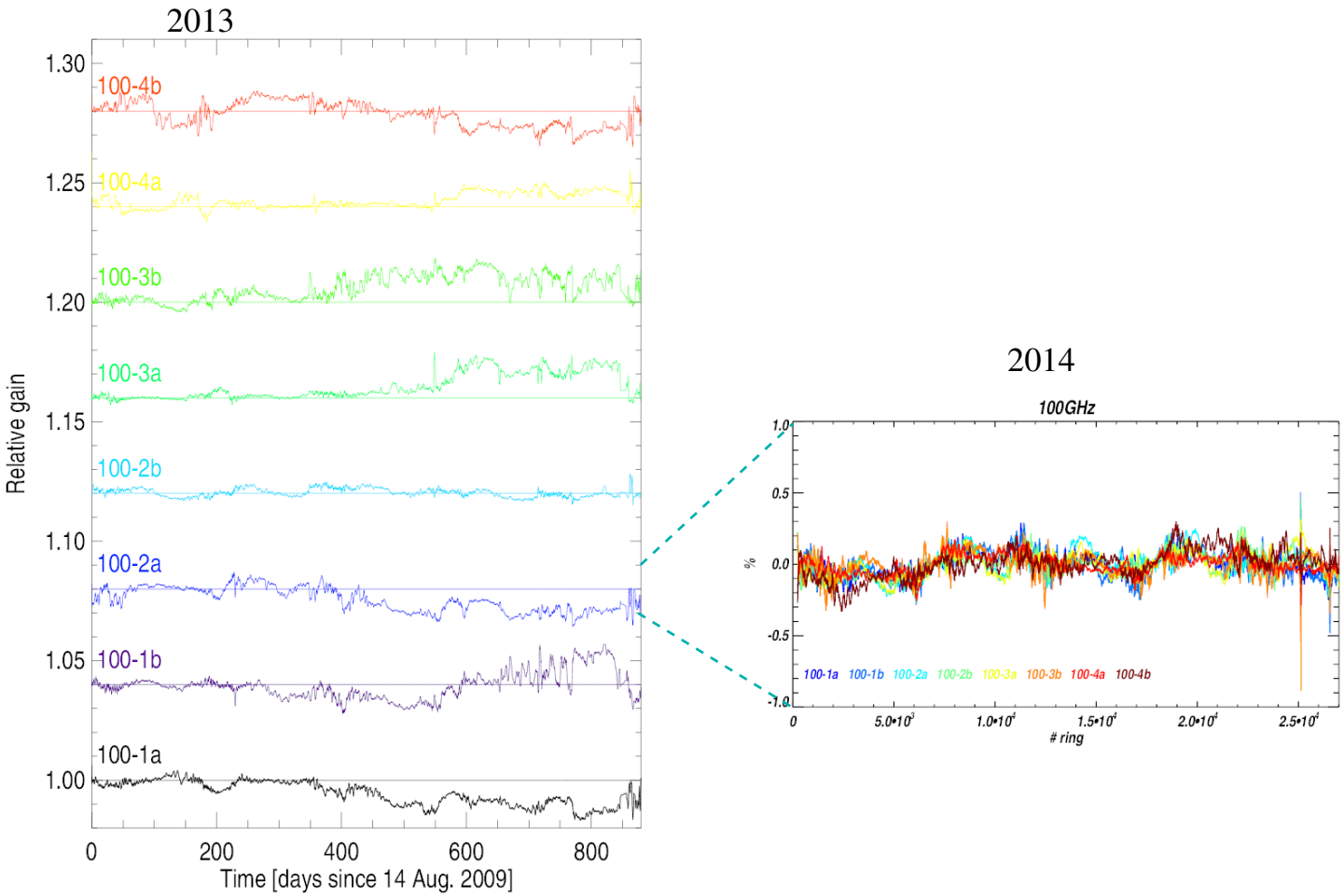
# 2013 calibration overview

- Calibrator = Solar dipole WMAP measurement
- Apparent gain variations caused by ADC non-linearities corrected a posteriori
- O(0.3%) remaining time (in)stability (100-217 GHz) - not enough for orbital dipole
- O(0.3%) detector-to-detector relative accuracy (100-217 GHz)
- 545 & 857 GHz calibrated with planet flux measurements (Uranus & Neptune)

# 2014 calibration

- orbital dipole calibration operational after :
  - ADC non-linearities measured in-flight (warm data campaign)
  - Correction implemented at TOI level
  - A new systematic showed up : time response with O(1-2s) time constant
  - $\Rightarrow$ time transfer function extended
  - $+$ residuals accounted for in calibration
  - $\Rightarrow$ Better time stability
- Solar dipole parameter measurements with HFI

# Calibration time stability PRELIMINARY



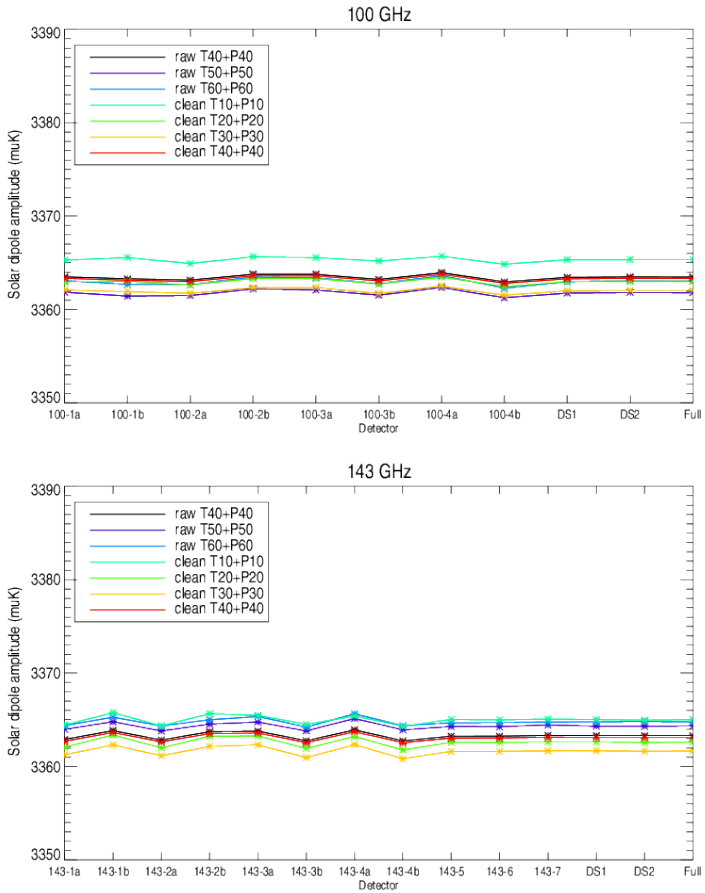
# Orbital dipole calibration PRELIMINARY

- orbital dipole $\leftrightarrow$ Doppler effect due to spacecraft orbital (Solar system) motion
- $\pm 300 \mu K$, $\sim 12$ months period
- for better accuracy and robustness, multi-bolometer calibration :
  - solve $m = g.(S + T) + o + noise$
  - unknowns : $g$ (gain), $S$ (sky signal - I,Q and U per pixel) and $o$ (destriping offset)
  - $\Rightarrow$ iterative linearized procedure
- bolometer-to-bolometer relative accuracies (percent)

| | 100 GHz | 143 GHz | 217 GHz | 353 GHz |
|---|---|---|---|---|
| 2014 | 0.09 | 0.07 | 0.16 | 0.78 |
| 2013 | 0.39 | 0.28 | 0.21 | 1.35 |

# Solar dipole parameters from HFI PRELIMINARY

- compared dipole fits on several data-sets :
- final value derived from ILC :
  $d = 3364.09 \pm 0.02(stat) \pm 2.0(syst)\mu\mathrm{K}$
  $(l, b)[degrees] = (263.96[.03], 48.23[0.10])$
- WMAP measurement : $3355 \pm 8\mu K$
  $(l, b) = (263.99 \pm 0.14, 48.26 \pm 0.03)$
- Systematic errors estimated from max. difference between datasets (FG, polar)
- consistency check with updated dust model

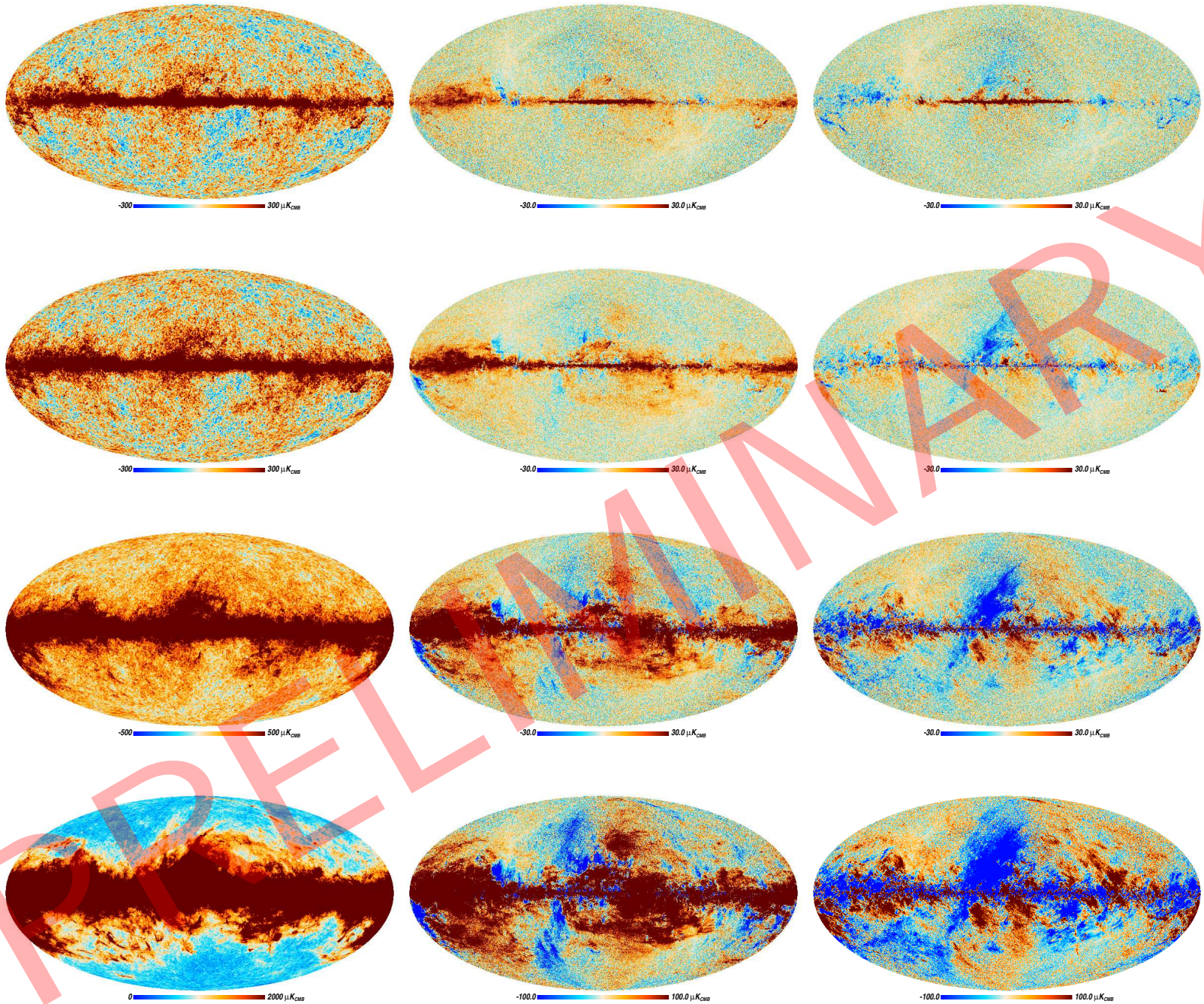


# Inter-frequency calibration accuracy (HFI) PRELIMINARY

- intercalibration on CMB anisotropies with SMICA :

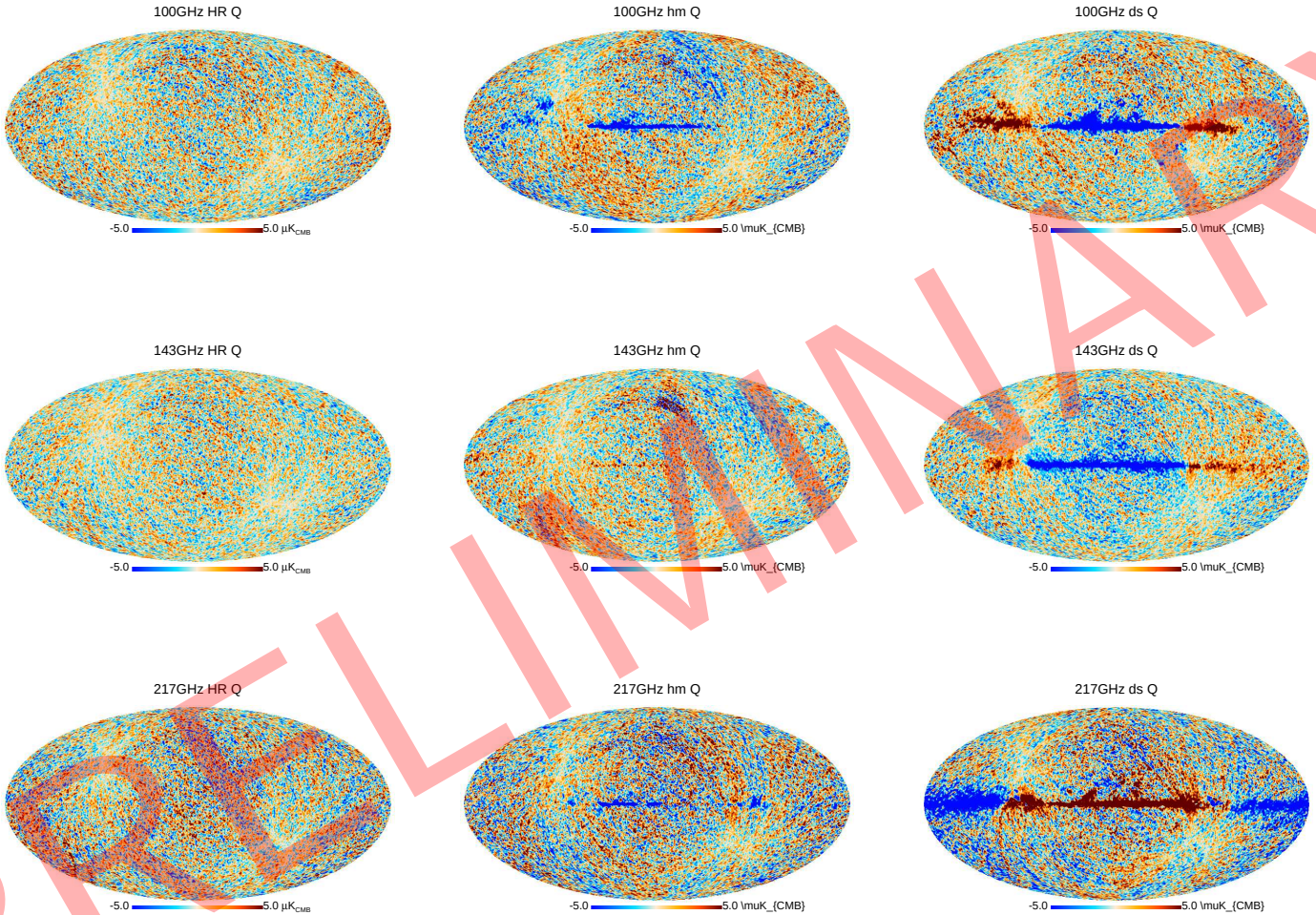
| Frequency (GHz) | 100 | 143 | 217 | 353 | 545 |
|---|---|---|---|---|---|
| relative calibration | $1.0008 \pm 0.0002$ | 1.0 (ref.) | $1.0029 \pm 0.0003$ | $1.008 \pm 0.002$ | $1.02 \pm 0.02$ |

- calibration difference wrt WMAP at map level $\sim 1.2\%$ in 2013
- in 2014 :
  - found Solar dipole amplitude O(0.3%) larger than WMAP
  - + better intermediate beam description
  - + slow time response accounting
- $\Rightarrow$ HFI and WMAP now agree within 0.2% !



# Null tests(Q maps)

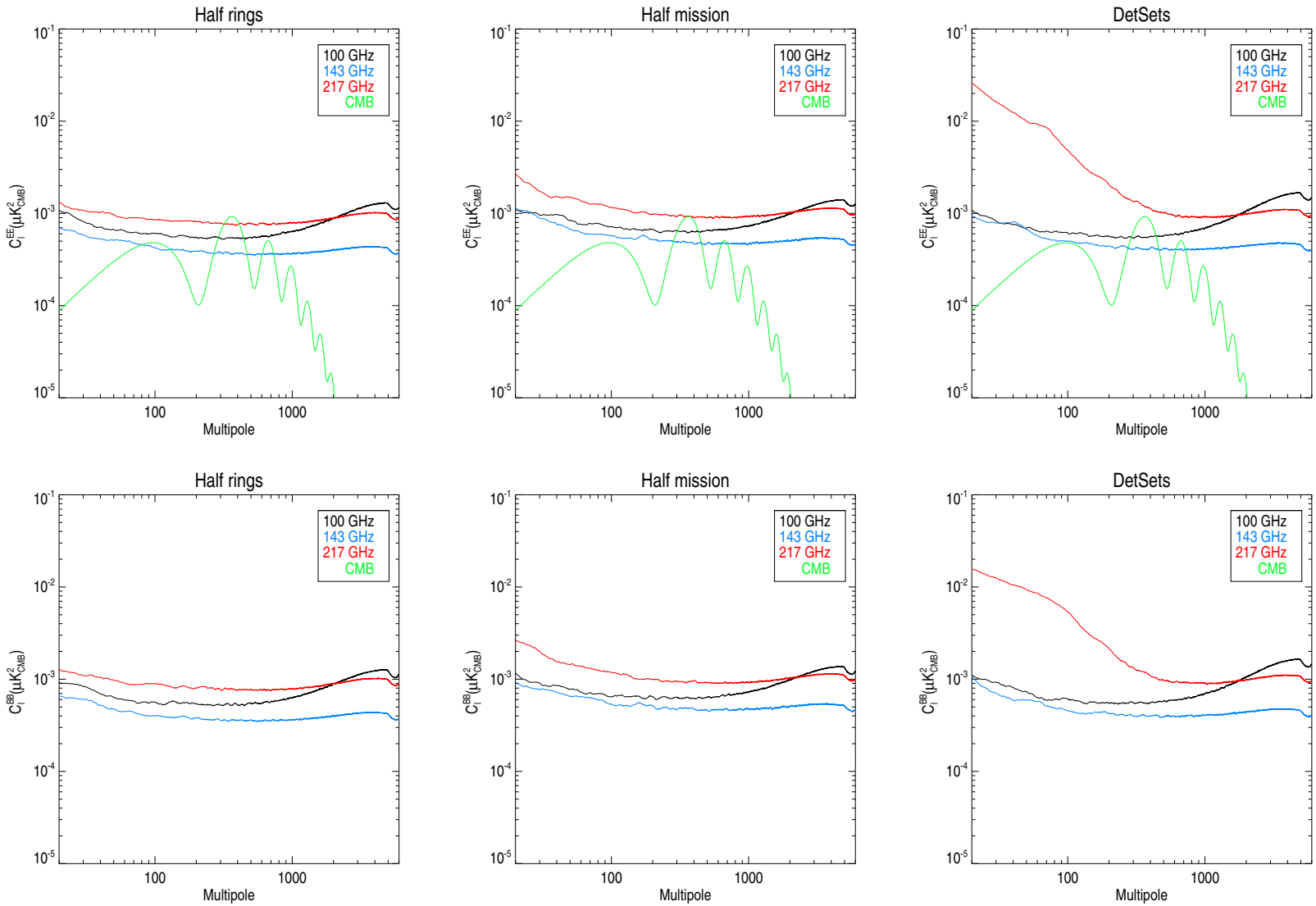
Half ring | Half mission | detector sets






half mission and detector set differences reveal remaining systematics

# Null tests(EE spectra) PRELIMINARY




pseudo-spectra with galactic mask (70% of the sky) normalized with fsky

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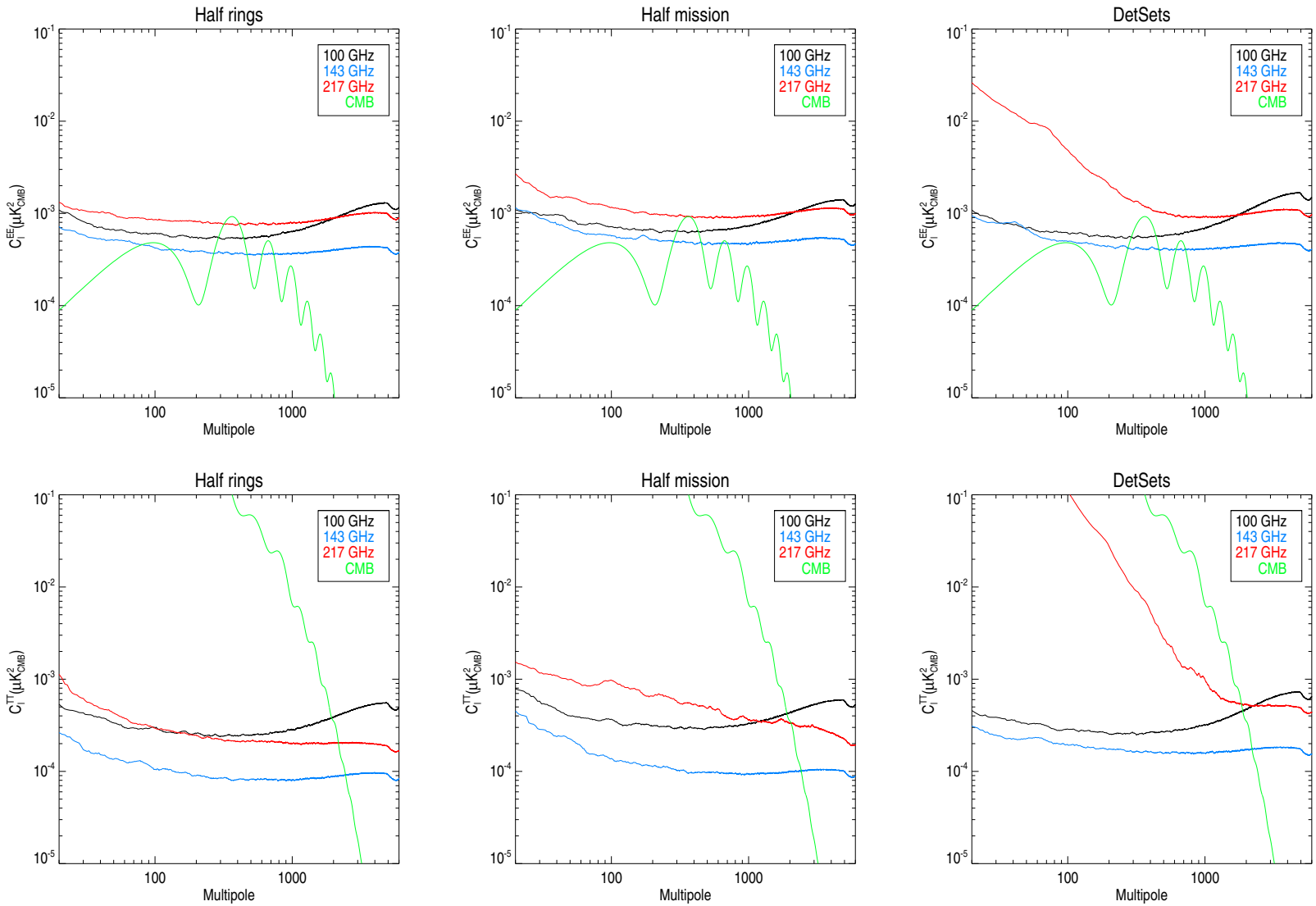


pseudo-spectra with galactic mask (70% of the sky) normalized with fsky

# Sensitivities and systematics

Overall sensitivities from HR estimation :

| Frequency (GHz) | 100 | 143 | 217 | 353 | 545 | 857 |
|---|---|---|---|---|---|---|
| per beam solid angle ($\mu K_{CMB}$) | 7.5 | 4.3 | 8.7 | 29.7 | | |
| (kJy sr$^{-1}$) | | | | | 9.1 | 8.8 |
| Temperature ($\mu K_{CMB}$ deg) | 1.29 | 0.55 | 0.78 | 2.56 | | |
| (kJy sr$^{-1}$ deg) | | | | | 0.78 | 0.72 |
| Polarization ($\mu K_{CMB}$ deg) | 1.96 | 1.17 | 1.75 | 7.31 | | |

However :

- to recover polarization in Planck one needs to combine data from several detectors
- any mismatch between them $\Rightarrow$ $T \rightarrow P$ leakage
- Main sources :
  - calibration (gain, monopole) : T dipole $\rightarrow$ P
  - band-passes : Dust signal $\rightarrow$ P
  - beam mismatch
- work on-going on these topics...

# Conclusions and prospects

- significant reduction of ADC-induced systematics
- more complete time response accounted for
- 2014 data calibrated on orbital dipole
- Solar dipole measured independently from WMAP
- better than ever Temperature maps
- low $\ell$ polarisation maps still dominated by $T \rightarrow P$ leakages (calibration, band-pass) $\Rightarrow$ polar. not released yet for 100-217 GHz
- on-going work to reduce and/or a posteriori correct for these systematics under way

**The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 scientific institutes in Europe, the USA and Canada.**

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Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.