

# The polarized Galaxy at 43 and 95 GHz as seen by *QUIET*

XXIX IAU General Assembly FM5: *The legacy of Planck*  
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Tone Melvær Ruud for the *QUIET* collaboration

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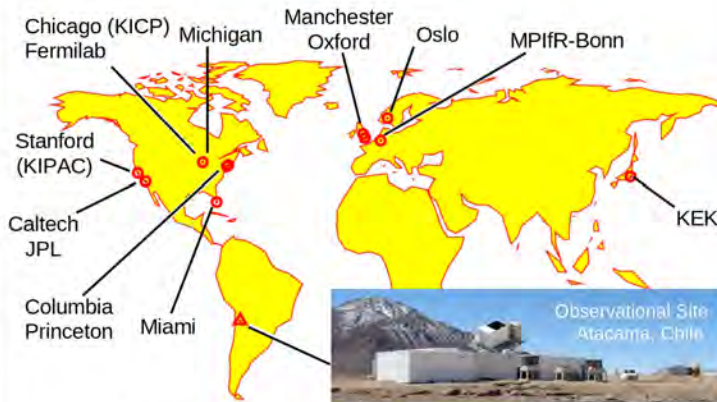
## *Q/U Imaging Experiment*

- ▶ Ground-based polarimeter experiment (Stokes Q,U)
  - ▶ 19-element Q-band (43 GHz) array (2008 Oct - 2009 Jun)
  - ▶ 90-element W-band (95 GHz) array (2009 Aug - 2010 Dec)
- ▶ Main goals:
  - ▶ Detect polarized CMB; probe for B-modes
  - ▶ Demonstrate capabilities of MMIC detectors ("radiometer on a chip")
- ▶ Chajnantor Plateau, Atacama Desert, Chile (5080 m.a.s.l.)
  - ▶ Large accessible sky fraction, easy access, low PWV
  - ▶ Natural sky rotation suppresses systematic errors





## QUIET collaboration

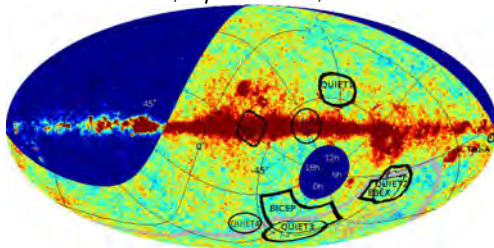


5 countries, 14 institutes, ~40 people

## Analyses so far

10 000 hrs of observation, 4 CMB fields, 2 foreground fields

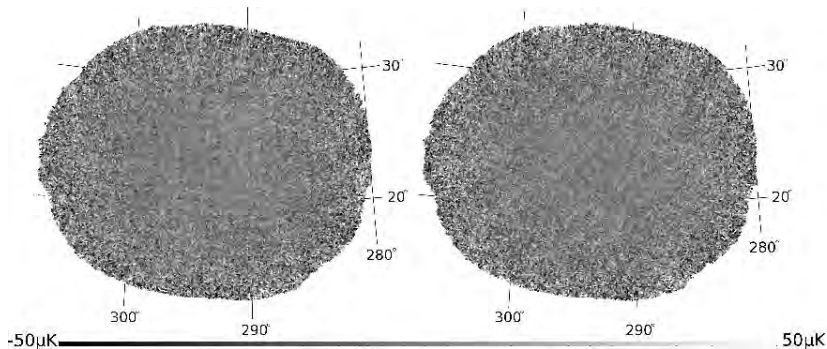
- First Season QUIET Observations: Measurements of CMB Polarization Power Spectra at 43 GHz in the Multipole Range  $25 \leq \ell \leq 475$ , *ApJ* 741:111, 2011
- Second Season QUIET Observations: Measurements of CMB Polarization Power Spectrum at 95 GHz, *ApJ* 760:145, 2012
- The QUIET Instrument: *ApJ* 768:9, 2012
- The Q/U Imaging ExperimenT: Polarization Measurements of Radio Sources at 43 and 95 GHz, *ApJ* 806:112, 2015



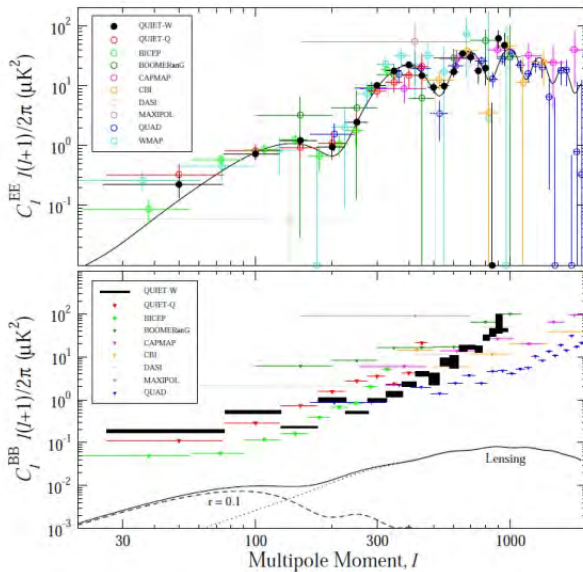
# QUIET W-band Maximum-Likelihood CMB map (2012)

Stokes Q

Stokes U

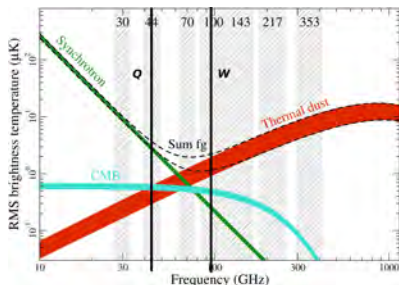


# Polarization power spectra 2012

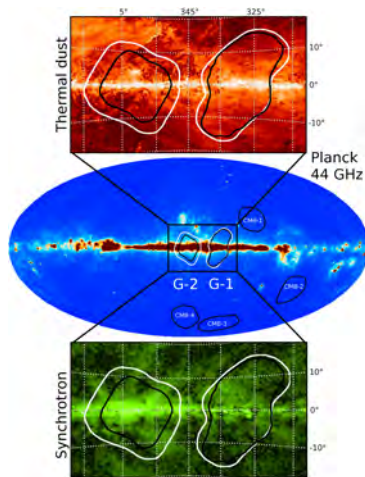


# QUIET foreground analysis (2015)

- ▶ *The Q/U Imaging Experiment: Polarization measurements of the galactic plane at 43 and 95 GHz: In press; <http://arxiv.org/abs/1508.02778>*
- ▶ QUIET has the highest reported Q-band sensitivity in the literature

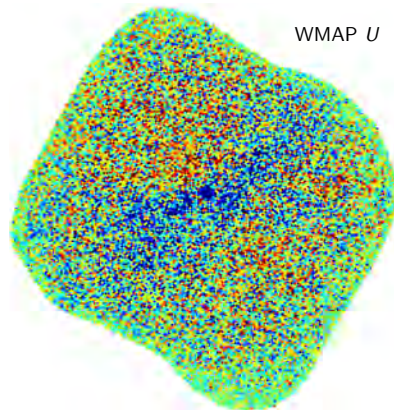
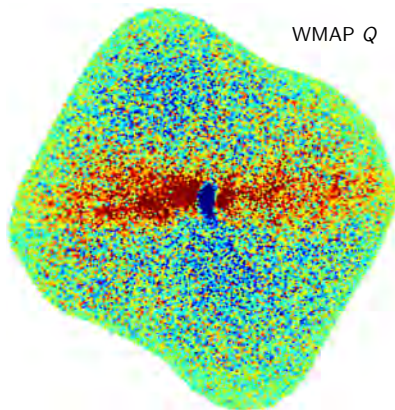


*Planck Collaboration X (2015)*



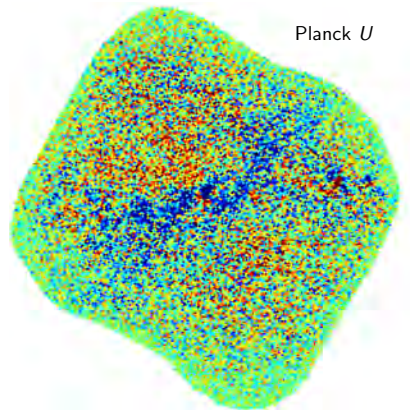
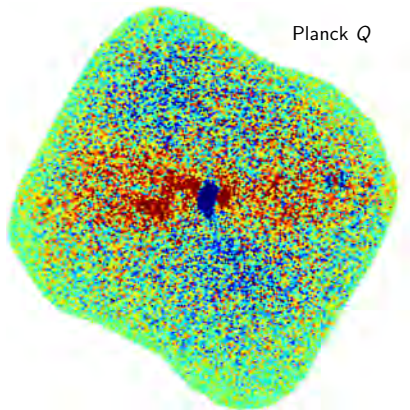


## Q-band Galactic Center maps



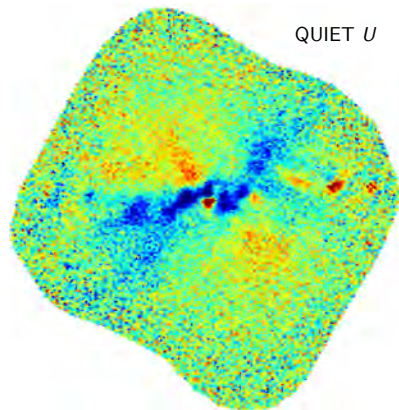
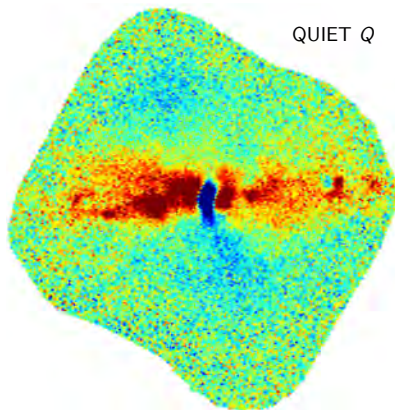
- ▶ The deepest large-area Galactic polarization maps published to date at these frequencies
  - ▶ 2.3-6 times deeper than WMAP and *Planck* in terms of instrumental noise, depending on frequency and field

## Q-band Galactic Center maps



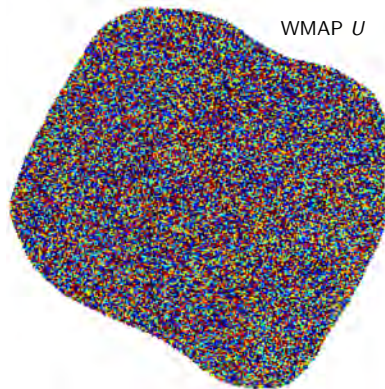
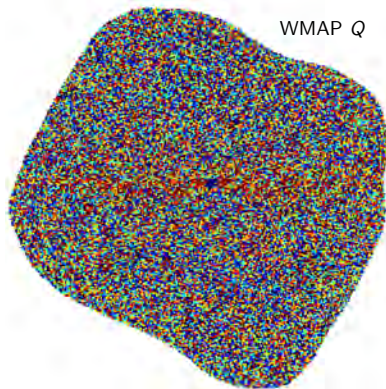
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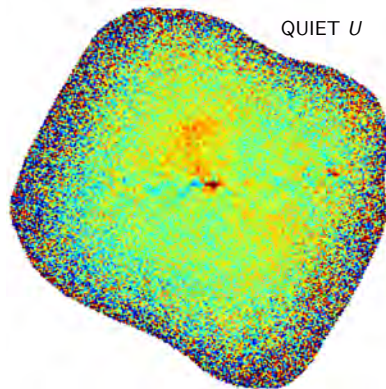
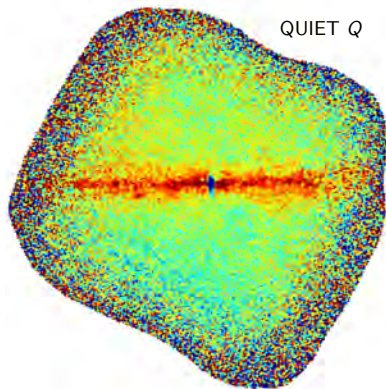
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## W-band Galactic Center maps



- ▶ Excellent agreement between QUIET and WMAP in all maps
  - ▶ No indication of significant residual systematic errors in either experiment

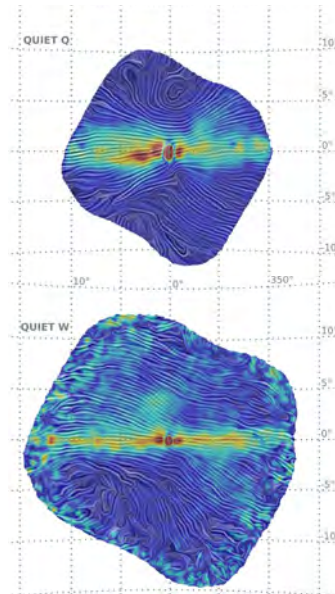
## W-band Galactic Center maps



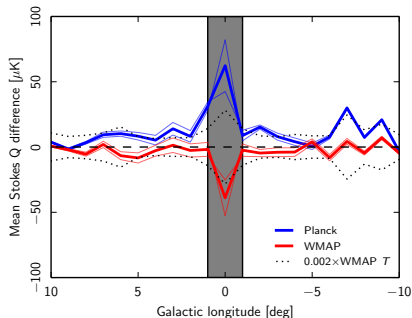
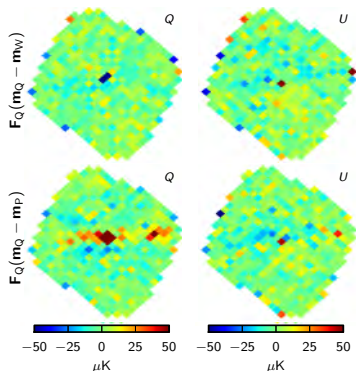
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## Co-added QUIET+WMAP maps

- ▶ Given the good agreement, we combine our maps with WMAP by inverse-variance-weighting to produce optimal all-scale maps for further analysis
  - ▶ Full-field polarized synchrotron spectral index of  $-3.01 \pm 0.01$  (G-2) and  $-2.91 \pm 0.01$  (G-1)
  - ▶ Robust detection of polarized synchrotron spectral index steepening of  $\simeq 0.2$  off- vs. on-plane
  - ▶ Detection of Faraday rotation at Galactic center
- ▶ All quantities consistent with earlier measurements



## Comparison of Q-band Galactic Center maps



- *Planck* 44 GHz data deviates from QUIET and WMAP in the Galactic Plane
  - Spatial profile suggests residual temperature-to-polarization leakage at 0.2% level, consistent with reported uncertainties for this channel
  - The new QUIET maps provide unique opportunity to improve understanding of *Planck* data



## Summary

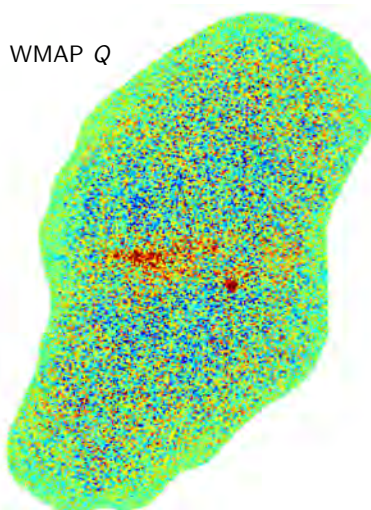
- ▶ QUIET has published the deepest large-area Galactic polarization maps to date at Q- and W-band  
<http://arxiv.org/abs/1508.02778>
- ▶ Comparison to *Planck* 44 GHz map indicates residual *Planck* systematic errors consistent with reported values
  - ▶ New QUIET maps can improve this situation
- ▶ Raw QUIET and co-added QUIET+WMAP maps are publicly available at Lambda together with all necessary ancillary information, including full pixel-pixel covariance matrices  
[http://lambda.gsfc.nasa.gov/product/suborbit/quiet\\_prod\\_table.cfm](http://lambda.gsfc.nasa.gov/product/suborbit/quiet_prod_table.cfm)

*Thank you for your attention!*

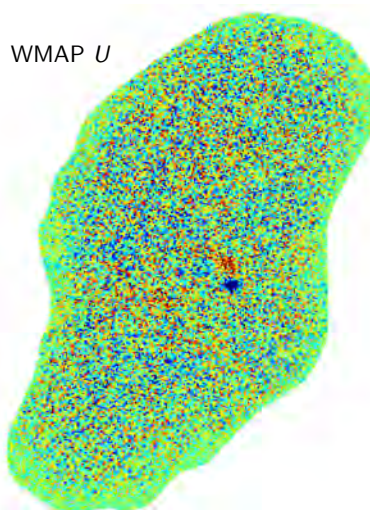


## Q-band Galactic field G-1 maps

WMAP  $Q$

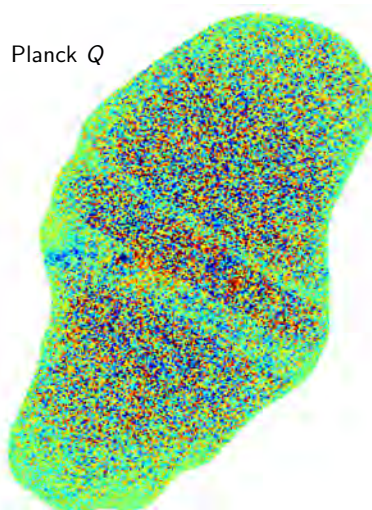


WMAP  $U$

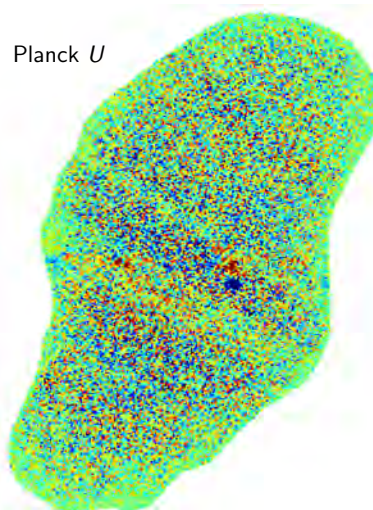


## Q-band Galactic field G-1 maps

Planck  $Q$

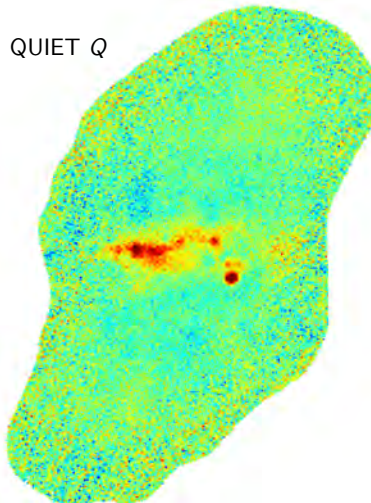


Planck  $U$

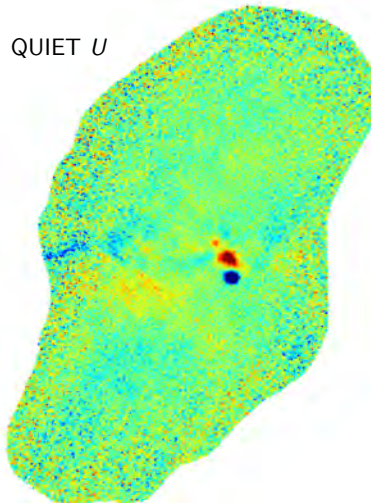


## Q-band Galactic field G-1 maps

QUIET Q

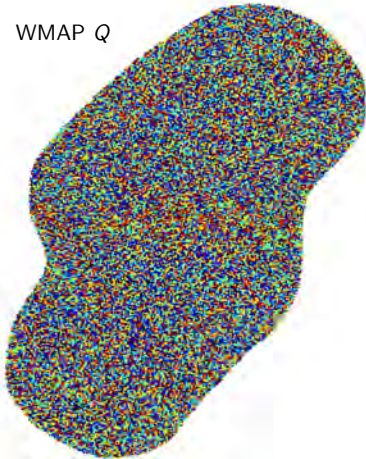


QUIET U

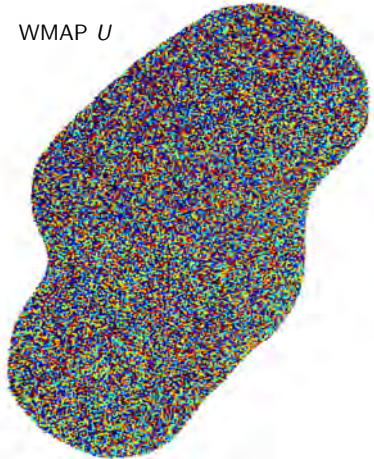


## W-band Galactic field G-1 maps

WMAP  $Q$

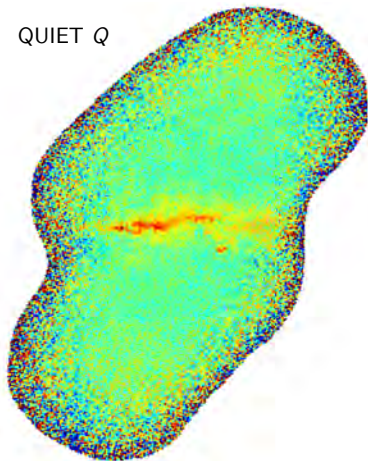


WMAP  $U$



## W-band Galactic field G-1 maps

QUIET Q



QUIET U

