Contents

1 Summary

This document presents a summary and update on the IP measured from skydips. It follows the methods in the original IPT document closely, except the fixed IP angle is allowed to vary across the focal plane and offset parameters have been added to the Q and U data. The 2015 skydips taken with the dome closed are used to measure the fixed IP. Then, skydips with the dome open are used to measure the remaining IPT parameters. The model is fit to each detector to account for variations across the focal plane.

There is general agreement between the IPT parameters across the 2015 commissioning run. However, a few channels that are grouped together in the s8c array significantly, and consistently, deviate from the IPT model.

The IPT parameters are also fit to the pre-2015 skydip data using the 2015 fixed component. There is tension between the offset parameters in the pre-2015 data, and disagreement between the 2015 and pre-2015 C_o parameter.

2 Brief review: The IPT model

The IPT model accounts for a fixed IP in the optics, and an elevation dependent IP due to absorption of the sky signal by the wind screen and an emission signal from the wind screen (Q_f, Q_a, and Q_e respectively).

The parameters are the percentages of sky signal that becomes polarized p_f and p_s, the angle of the fixed IP θ_{ip}, and an offset between this angle and the polarized signal from the wind screen C_o. Constant offsets are also fit to the Q and U signal for each skydip.

$Q_f = p_f * N_s(1 - \exp^{-\tau AM}) \cos(2\theta_{ip})$
$Q_a = p_s * N_s(1 - \exp^{-\tau AM}) \cos(2(\theta_{ip} + el + C_o))$
$Q_e = p_s * N_s \cos(2(\theta_{ip} + el + C_o + 90))$

$IPT_Q = Q_f + Q_a + Q_e + Offset_Q$ (replace cos with sin and $Offset_Q$ with $Offset_U$ to get IPT_U)

3 Skydips with Dome Closed

3.1 Dome Brightness and Calibrator Angle

With the dome closed and the calibrator in, the dome brightness and calibrator angle are measured (N_D,θ_c). This is used to measure the fixed IP polarization angle (θ_{ip}). Figure 1 shows an example of Q, U, and θ_C from a single channel.

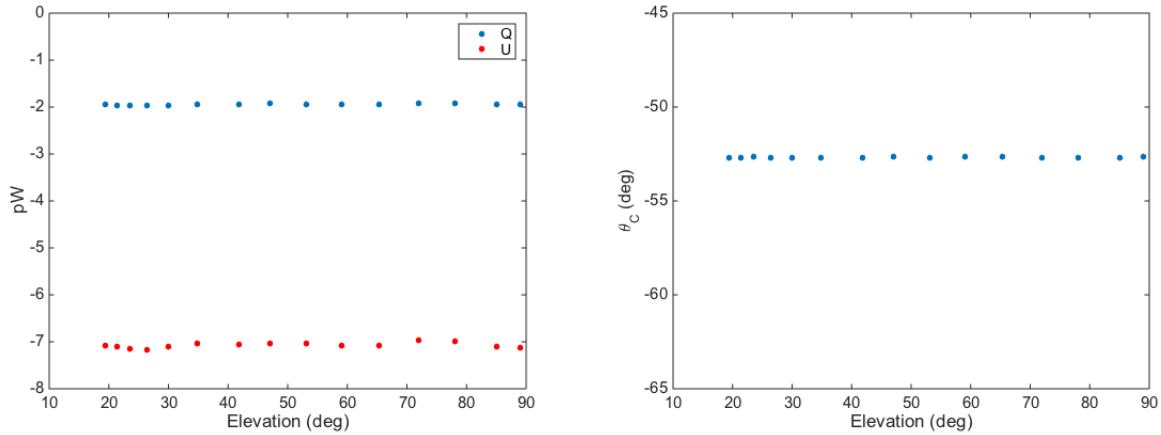

Figure 1 **Left:** The Q and U signal from a signal channel. **Right:** The polarized angle. As expected, the polarized angle is flat across all elevations when the calibrator is in the beam.

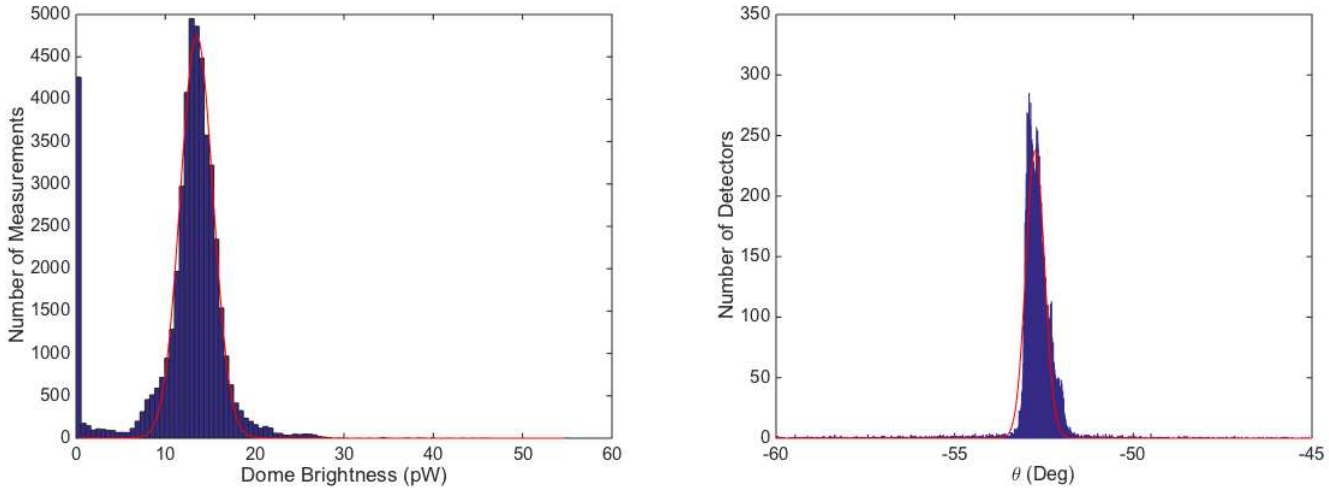

Figure 2 Histograms of the dome brightness (left) and polarized angle (right) measured from each channel. The histogram of dome brightness shows the measurement for each channel at each elevation. For clarity, the polarized angle shows measurements at a single elevation.

The dome brightness is (14 ± 2) pW.

3.2 Percent and Angle of fixed Instrumental Polarization (p_f, θ_{IP}).

With the calibrator out of the beam, the fixed polarization is measured (p_f and θ_{ip}). Figure 3 shows an example of Q,U, and θ_{ip} from a single channel. As was seen in the 2012 data, the polarization angle is roughly constant for all elevations indicating that the absorption and emission from the wind screen cancel and we are left measuring the fixed IP component.

The measurements from all channels are shown in figure 4.

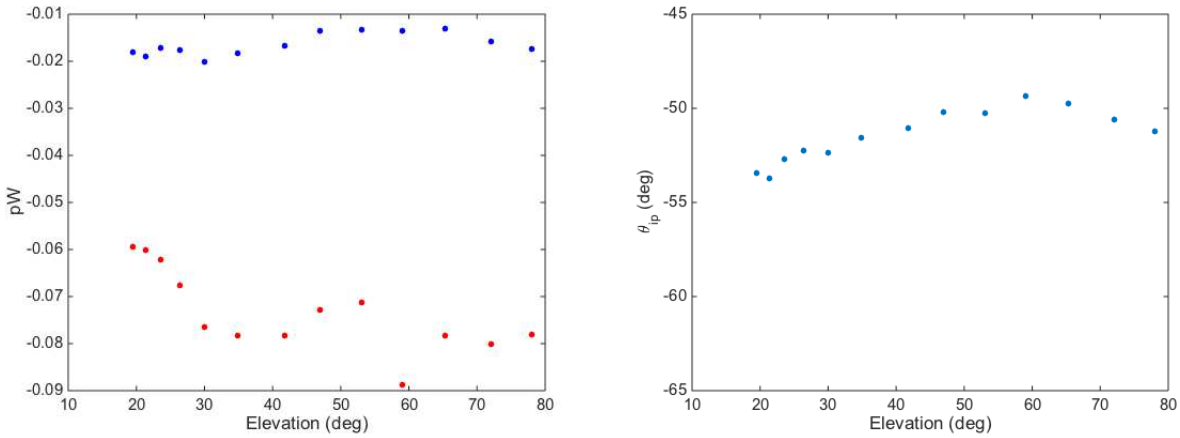

Figure 3 **Left:** The Q and U signal from a signal channel. **Right:** The polarized angle from a single channel. It is roughly flat across the elevation range (it varies by $\sim 4°$).

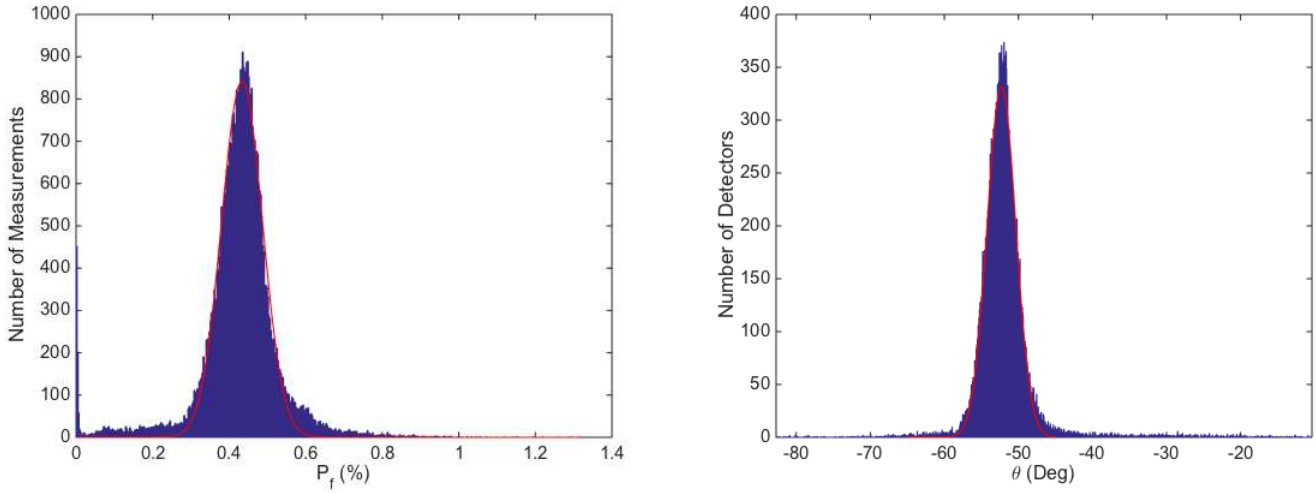

Figure 4 A histogram of the fixed IP percentage (left) and polarized angle (right). The fixed IP is similar to the calibrator angle, but has a larger spread in values around the mean.

The angle of the fixed IP varies across the focal plane. The average and standard deviation of θ_{IP} for each detector is shown in figure 5. The gradient of $\sim 5°$ across the focal plane is larger than the standard deviation of most channels.

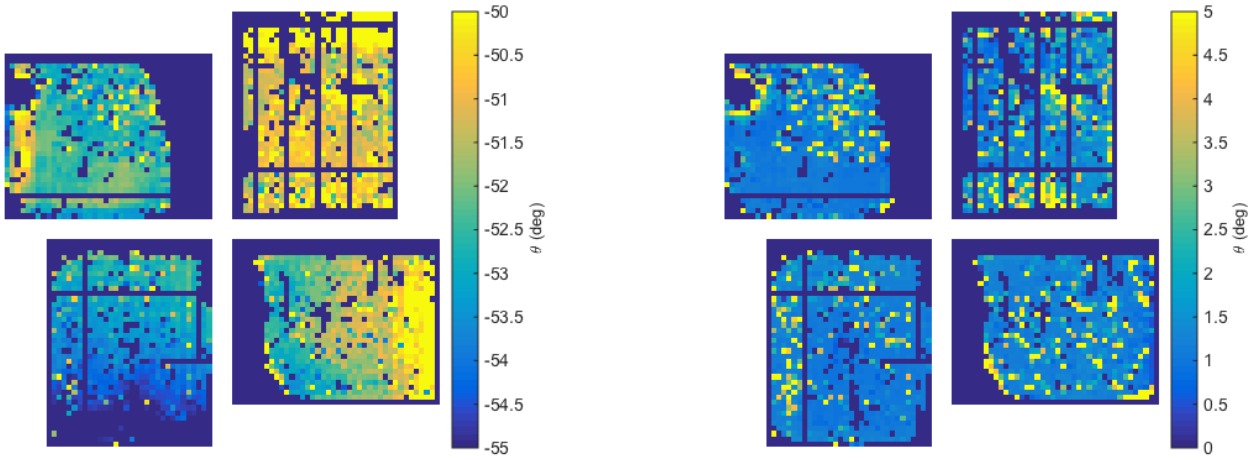

Figure 5 **Left:** The average fixed IP angle across the focal plane. **Right:** The standard deviation of θ_{ip}.

4 Skydips with Dome Open

4.1 Sky Brightness (N_s) and Calibrator Angle

The normalization of the sky brightness was previously measured (*see:* May_12_2015.pdf). It is briefly reviewed here. Figure 7 shows the skydip data with a calibrator from a single channel. The normalization of the sky brightness and offsets are measured to be 20.1 pW, 0.5 pW, and 2 pW for N_s, $Offset_Q$, and $Offset_U$ respectively. The sky brightness is fixed for all remaining IPT fits.

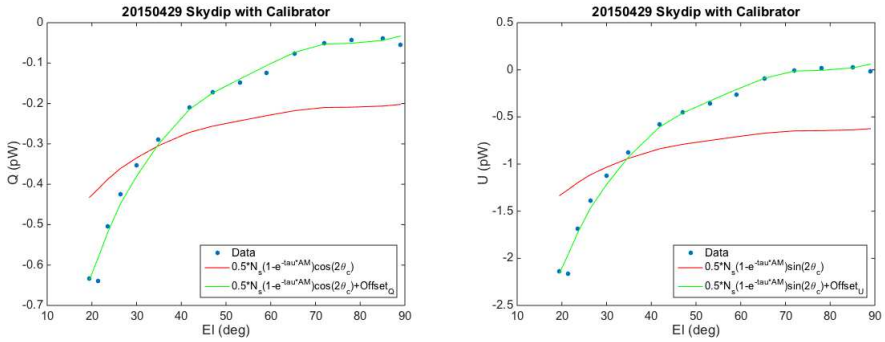

Figure 6 The Q and U signals from a single channel (left and right respectively).

4.2 IPT parameters (p_s, C_o, $Offset_Q$, $Offset_U$)

Using the above results, the p_s, C_o, Q-offset, and U-offset parameters are measured for all the skydip data. Figure 7 shows the distribution of model parameters for each 2015 skydip across the focal plane. There is good agreement between the parameters across all skydips. The pre-2015 data is shown in figure 8 and has a single outlier in the C_o parameter (from the 20121017 skydip) and general tension in the offset parameters. Also note that the bulk of the C_o values disagree with the 2015 results. These discrepancies are currently being investigated. Note: Figures 7 and 8 show the distribution across the focal plane for each skydip. To do: Look at the distribution for *each channel* across the skydips.

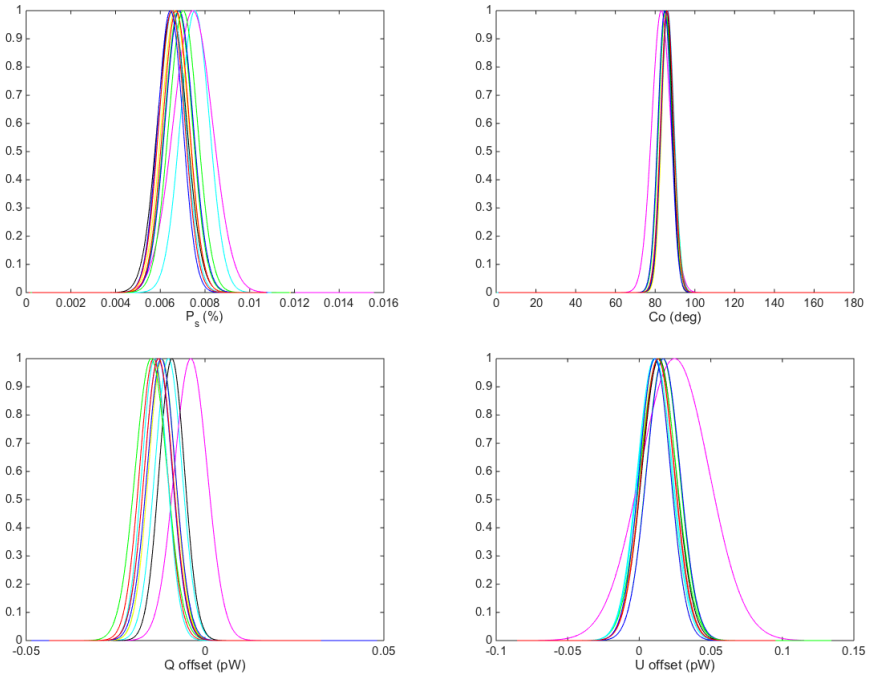

Figure 7 IPT model Fits to the 2015 skydip data. Each colour represents a unique skydip. There are 13 skydips in total. **Top:** The polarization percentage and offset from θ_{ip} due to the wind screen. **Bottom:** The Q and U offsets.

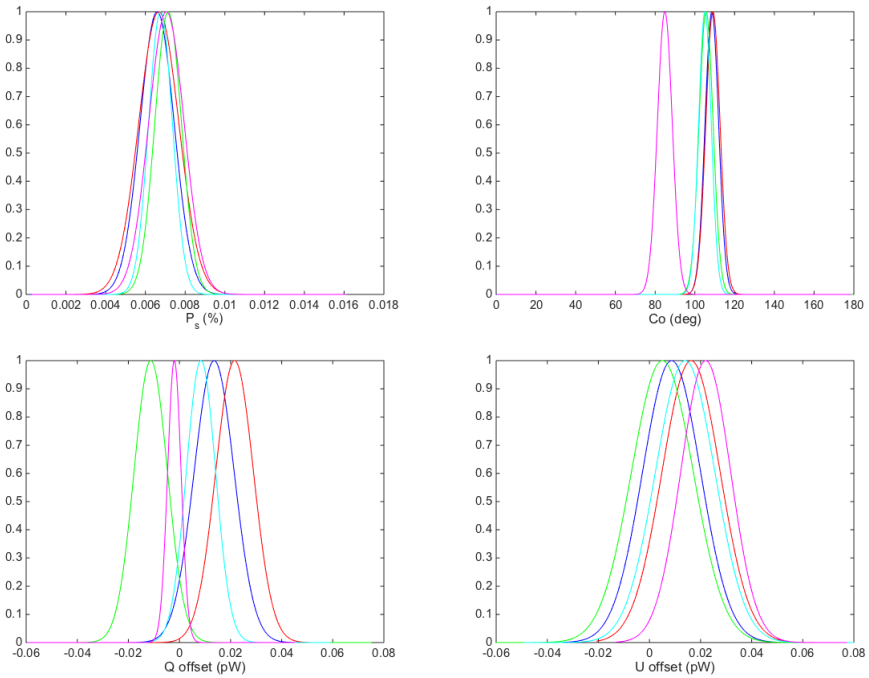

Figure 8 IPT model Fits to the pre-2015 skydip data. There are five skydips in total. **Top:** The polarization percentage and offset from θ_{ip} due to the wind screen. **Bottom:** The Q and U offsets. *Note:* The same sky brightness, P_f, and θ_{IP} values are used for the 2015 and pre-2015 data.

5 Poorly Fit Regions

As has been seen before, some detectors are a poor fit to the IPT model. Figure 9, shows the χ^2 values across the focal plane for a single skydip. A group of these channels, located in the s8c array, systematically deviate from the IPT model at intermediate elevations. An example of a consistently well fit channel and a badly fit channel over the 2015 commissioning run are shown in figure 10.

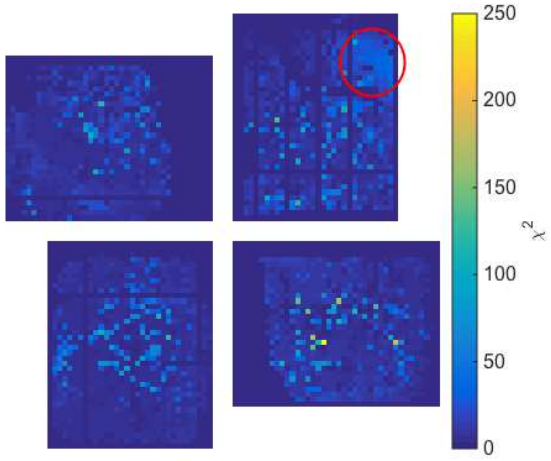

Figure 9 The χ^2 values across the focal plane for the 20150427 skydip. A region of detectors which systematically deviate from the IPT model is identified in the red circle.

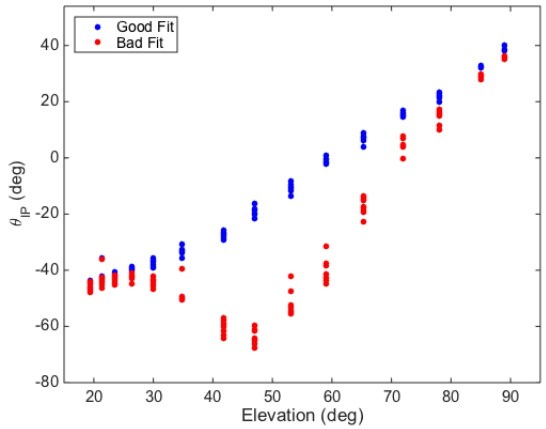

Figure 10 The polarization angle for a well-fit channel and a badly-fit channel. The data from each skydip in 2015 is plotted to show the day-to-day deviation in the data.