necessary for nulling. The advantage over prior art is that an entire subsystem, the field-flipping optics, can be eliminated.

For ultimate simplicity in the flight instrument, one might fabricate coatings to very high tolerances and dispense with the adaptive nullers altogether, with all their moving parts, along with the field flipper subsystem. A single adaptive nuller upstream of the beam combiner may be required to correct beam train errors (systematic noise), but in some circumstances phase chopping reduces these errors substantially, and there may be ways to further reduce the chop residuals. Though such coatings are beyond the current state of the art, the mechanical simplicity and robustness of a flight system without field flipper or adaptive nullers would perhaps justify considerable effort on coating fabrication.

This work was done by Eric E. Bloemhof of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47027

Portable Dew Point Mass Spectrometry System for Real-Time Gas and Moisture Analysis

This system has applications in semiconductor fabrication, industrial gas production, and natural gas refineries.

John F. Kennedy Space Center, Florida

A portable instrument incorporates both mass spectrometry and dew point measurement to provide real-time, quantitative gas measurements of helium, nitrogen, oxygen, argon, and carbon dioxide, along with real-time, quantitative moisture analysis.

The Portable Dew Point Mass Spectrometry (PDP-MS) system comprises a single quadrupole mass spectrometer and a high vacuum system consisting of a turbopump and a diaphragm-backing pump. A capacitive membrane dew point sensor was placed upstream of the MS, but still within the pressure-flow control pneumatic region. Pressure-flow control was achieved with an upstream precision metering valve, a capacitance diaphragm gauge, and a downstream mass flow controller. User configurable LabVIEW software was developed to provide real-time concentration data for the MS, dew point monitor, and sample delivery system pressure control, pressure and flow monitoring, and recording. The system has been designed to include *in situ*, NIST-traceable calibration.

Certain sample tubing retains sufficient water that even if the sample is dry, the sample tube will desorb water to an amount resulting in moisture concentration errors up to 500 ppm for as long as 10 minutes. It was determined that Bev-A-Line IV was the best sample line to use. As a result of this issue, it is prudent to add a high-level humidity sensor to PDP-MS so such events can be prevented in the future.

This work was done by C. Arkin, Stacey Gillespie, and Christopher Ratzel of ASRC Aerospace Corporation and Mary Whitten of the University of Central Florida for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13316

Maximum Likelihood Time-of-Arrival Estimation of Optical Pulses via Photon-Counting Photodetectors

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Many optical imaging, ranging, and communications systems rely on the estimation of the arrival time of an optical pulse. Recently, such systems have been increasingly employing photon-counting photodetector technology, which changes the statistics of the observed photocurrent. This requires time-of-arrival estimators to be developed and their performances characterized.

The statistics of the output of an ideal photodetector, which are well modeled as a Poisson point process, were considered. An analytical model was developed for the mean-square error of the maximum likelihood (ML) estimator, demonstrating two phenomena that cause deviations from the minimum achievable error at low signal power. An approximation was derived to the threshold at which the ML estimator essentially fails to provide better than a random guess of the pulse arrival time. Comparing the analytic model performance predictions to those obtained via simulations, it was verified that the model accurately predicts the ML performance over all regimes considered.

There is little prior art that attempts to understand the fundamental limitations to time-of-arrival estimation from Poisson statistics. This work establishes both a simple mathematical description of the error behavior, and the associated physical processes that