Full Disk Patrol



1. Overview

At the time of this review, the FDP is the least developed of the SOLIS instruments. This was a deliberate choice resulting from difficulty in doing design studies on three instruments at once. The FDP was also judged to be the least unique of the SOLIS instruments and the one with the longest heritage and, therefore, possessing relatively low risk.

1.1 Basic Capabilities and Science Goals

The FDP will produce monochromatic images of the full disk of the sun. The spectral resolution will be approximately 25,000 and the spatial sampling will be nominally one arc second. Photometric precision in a single exposure will be of the order of one part in 300. These capabilities will allow observation and measurement of the intensity and Doppler shift of the photosphere and selected chromospheric lines. The scientific intent is to study specific solar activity such as sunspots, plages, filaments, prominences, flares, and signatures of coronal mass ejections. An additional observational goal is large-scale patterns of mass motions as manifest by both the Doppler shift and local proper motions. In order to make these observations, a capability for a relatively rapid repeat time is required, nominally once per minute. At a single wavelength, a rate of one frame per second could be sustained.

A basic synoptic observation program has been defined. It consists of H-alpha core, red and blue wing, and 1083 nm pseudo equivalent width and Doppler images once per minute. Once per ten minutes, a continuum image will be recorded. Once per three hours, Ca II K3 and K2 violet and red images, and finally, once per day, a sequence of photospheric Doppler images will be recorded from which the p-mode oscillations may be filtered to a small amplitude. The core observing program is designed to allow special purpose user and campaign observations to be interleaved without interruption.

The FDP is intended to replace the H-alpha flare patrols at Kitt Peak and Sac Peak, the High-Degree Helioseismometer at Kitt Peak and the daily programs of H-alpha and K spectroheliograms at Sac Peak. It will complement data from ISOON, PSPT, and GONG. Table 1 summarizes the FDP specifications.

Parameter	Goal	Rationale
Angular		
element	1 arc second	match average daytime seeing
coverage	full disk	observe features anywhere on the disk
format	2000 x 2000	single exposure for full disk

geometrical accuracy	<0.5 arc second rms	proper motion studies and accurate co-alignment w/other data
instrumental MTF	<0.1 at f $\geq f_{Nyquist}$	avoid excessive angular aliasing
Temporal		
accuracy	1 s	correlate with other data
one-wavelength cycle time	<2 s	study rapid phenomena
reconfigure time	<10 s	compare observations at different wavelengths
Spectral		
resolution	25,000	gross properties of spectral lines
range	380-1083 nm	cover wide range of heights and phenomena
simultaneity	two wavelengths	avoid seeing noise
core synoptic wavelengths	393, 656, 1083, continuum, photospheric Doppler	extend past records

Table 1. Top-level specifications for the FDP

1.2 Basic Plan as Proposed and Subsequent Changes

The original plan was based on the Precision Solar Photometric Telescope (PSPT) and liquidcrystal tunable filter projects at NSO/SP. The PSPT instruments are interference filter full-disk imagers using 2k by 2k CCD cameras and were designed for high photometric precision. The filter project was not completed.

The proposal envisaged covering the entire wavelength range from 380 to 1100 nm using a single tunable birefringent (Lyot) filter. This plan counted on the existence of a broad-band polymer polarizer that was efficient over the entire wavelength range. A future upgrade to make magnetograms was proposed. A nominal spectral resolution at H-alpha of 50,000 was originally proposed.

It turned out that the proposed polarizer had a published transmission curve that was incorrectly labeled. Subsequent searching did not turn up a suitable replacement, although there is some interesting laboratory work. The result is that a filter tunable over the entire wavelength range would not be easy to build. The revised plan uses two Lyot filters: one tunable unit that covers 380 to 670 nm and a fixed filter for 1083 nm. The spectral resolution was reduced to 25,000 when a strong scientific case for twice the resolution could not be supported.

The future magnetogram upgrade was deleted when studies showed that, because of seeing, the noise level would be high when using four-frame-per-second CCDs and sequential polarization modulation. A beam splitter mode that would allow simultaneous orthogonal polarization state

imaging of half the solar disk was deemed to be too expensive. In any event, the state-of-the-art magnetic capabilities of the VSM make the filter magnetograph unnecessary.

A high-magnification full-disk mode was deleted when it became clear that 4k by 4k format cameras are not ready for use in our application and because of the impossibility of squeezing a full-disk image through a Lyot filter with the required high angular resolution.

1.3 Heritage

Regular recording of the full solar disk in monochromatic light began at Meudon and Mt. Wilson observatories nearly one hundred years ago. The monochromators were spectroheliographs. Lyot filters became popular in the 1950s, albeit almost exclusively for the Ha line. At NSO/SP, photographic records are made once daily at Sacramento Peak using a spectroheliograph for Ha and K, and more frequently using a Halle filter for H α . At NSO/KP, the spectromagnetograph is used to produce once-daily helium images. A High-Degree Helioseismometer has been operated occasionally for several years after it was retired from use at the South Pole. In addition, NSO built and maintains the Precision Solar Photometric Telescopes which are used to produce regular, high precision monochromatic images of the sun from several sites around the world. The NSO is also involved in the ISOON project to provide H-alpha and magnetogram data regularly from the USAF network around the world. The FDP was originally proposed by the NSO staff at Sac Peak to replace the antiquated present equipment in a way to continue the past record while complementing the PSPT and ISOON capabilities. There are many filter-based fulldisk imagers around the world. They are gradually being converted from film to modern CCD detectors. The FDP is able to take advantage of many of the design features of these instruments. The NSO is fortunate to have inherited the CSIRO 1/8 Å filter built nearly forty years ago. This filter has large (35 mm aperture) calcite elements that would be virtually impossible to replace today. NASA and NSO built a 1083 nm filter a few years ago for use in flare studies. It was little used because of faulty commercial data collection electronics and is available for this project. NSO has in recent years built ten Lyot filters for the GONG project using all new components. NSO also constructed the 1083 nm filter using parts from an old Zeiss filter. These filters have all been successful. NSO has experience with large-format CCD cameras. The PSPT and ISOON projects use 2k x 2k format and the GONG project recently acquired eight high-speed 1k x 1k cameras.