PS1 Facility design and construction

The Pan-STARRS telescopes are located at Haleakala Observatories on the island of Maui. The first telescope built, the Pan-STARRS1 Telescope (PS1), is an alt-az telescope with an 1.8m diameter mirror. With a field-of-view diameter of 3 degrees, it can observe a 7 square degree are on the sky with every exposure. The PS1 GPC1 camera is mounted in the focal plane.

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The starting point for the PS1 data archive is at Pan-STARRS1 data archive home page.

The Pan-STARRS site

The Pan-STARRS telescopes are located at Haleakala Observatories on the island of Maui on the site of the Lunar Ranging Experiment (LURE) Carter & Williams 1973. DIMM measurements show the site has a median image quality of 0.83 arcseconds (the mode is 0.66 arcseconds). On average 35% of the nights on Haleakala are photometric, with an additional 30% useable with very low extinction or more than 60% of the sky clear of clouds. The wind is predominately trade winds from the east-northeast, with occasional ”Kona” winds from west-southwest. Pan-STARRS is in the wake of the flow from the trades into the crater wall. Detailed metrics of the site characteristics will be published elsewhere (Chambers in prep).

More recently the Daniel K. Inouye Solar Telescope has been erected to the south-south west of Pan-STARRS, the impact of DKIST operations is not yet known, but the plan is to manufacture ice at night, with the subsequent dissipation of heat, that is used to cool DKIST for daytime operations.

The International Astronomical Union has determined that the acceptable level of Radio Frequency Interference outside an observatory doing optical and infrared observations should be less than 2W/m2 in tegrated over the radio spectrum. This is exceeded at Haleakala and at the start of the PS1 Mission, radio frequency interference from various Federal and commercial transmission sites near the summit was an issue, but with the relocation of TV broadcasters to the Ulukalapua site, this problem has been mitigated and we see no evidence of RFI in GPC1. However cellphone transmission, wifi transmission, and microwave ovens have a noticeable effect and are not allowed at the Observatory.

Telescope, optics, and control system

The Pan-STARRS1 Telescope (PS1) is an alt-az telescope with an instrument rotator built by EOST with an enclosure by EOS. The PS1 Dome motion closely follows the telescope through a featherweight direct coupling. The dome has four independently commandable vents for air flow through the dome. The dome slit is covered by two independently com- mandable shutters that can be deployed over the top on to the back side of the dome. When the moon is up the dome slit shutters are used to mitigate scattered light from the moon.

The Pan-STARRS1 optical design (Hodapp et al. 2004, Hodapp et al. 2004, Morgan & Kaiser 2008) has a wide field Richey-Chretien configuration with a 1.8 meter diameter f/4.44 primary mirror, and 0.9 m secondary. The table below has a summary of Pan-STARRS1 Characteristics.

Characteristic	Description
telescope focal length	8000 mm
plate scale	38.8 mm/radian 25.75 arcsec/mm
field of view diameter	3.0 degrees
field of view area	7.068 square degrees
primary mirror diameter	1800 mm
primary mirror coating	protected aluminum
secondary mirror diameter	947 mm
secondary mirror coating	protected silver

focal ratio	4.44
effective aperture (includes diffraction and obscuration)	17,284 cm^2
rotator range	179 degrees
telescope/dome range	420 degrees
detector pixel size	10 µm = 0.258 arcsec
camera fill factor (10% gaps/no pixels, 14% masked pixel defects)	76%

The resulting converging beam then passes through two refractive correctors, one of six possible interference filters with a clear aperture diameter of 496 mm, and a final refractive corrector that is the cryostat window. See Figure 2.

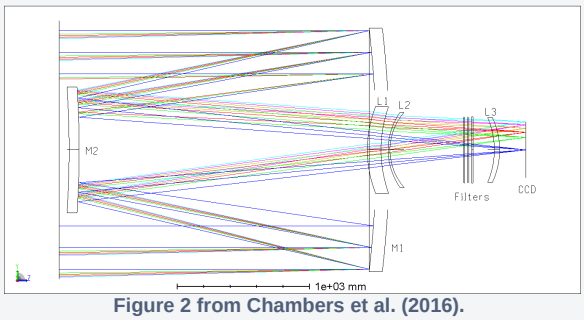

Figure 2 from Chambers et al. (2016).

Figure 2 from Chambers et al. (2016)

Pan-STARRS optical design (Morgan & Kaiser 2008). The implemented version was NOADC-M-3.0 shown here.

The optical design has 4 aspheric surfaces; one each on the primary and secondary mirrors, one on the first corrector lens, L1, and a final aspheric on L3, the last corrector lens in the optical path and which also serves as the cryostat window. The secondary mirror has a conic constant of -20.43 and a 6th order aspheric term of 4.5×10^{19} - which made it a challenge to fabricate (Morgan & Kaiser 2008).

The Secondary Mirror is mounted on a hexapod and can be moved in five axes: x,y,z,tip, tilt. The Primary Mirror is on a pneumatic support system and can be commanded y,z, tip, and tilt. The Primary Mirror can be moved in the x direction as well, but this is not on a powered actuator, but must be done manually. Furthermore the Primary Mirror has a 12 point astigmatic correction system. Thus there are 22 independent mirror actuators that can be use to bring the optics into proper collimation, alignment with the optical axis as defined by the axis of the instrument rotator, and in addition allow for modest amounts of Primary mirror deformation to remove trefoil, coma, and astimagtism Wave front sensing is required to bring the telescope into proper focus, alignment, collimation, and these higher order optical corrections. The procedure for collimation and alignment is discussed in Morgan & Kaiser 2008.

The telescope illuminates a diameter of 3.3 degrees, with low distortion, with some vignetting at the edges of this illuminated region. The field of view is approximately 7 square degrees. The 8 meter focal lenght at f/4.4 gives an approximate 10 micron pixel scale of 0.258 arcsec/pixel.