4.6 Astrometric Beam Combiner

The compressed starlight wavefronts propagating through the system pass from the ODLs into the astrometric beam combiner (ABC). Within the ABC the starlight input is split into two paths to perform angle and fringe tracking functions. The ABC also houses the internal metrology assembly and the internal calibration optics.

There are a total of four ABCs in SIM, two serving the guide interferometers and two serving the science interferometers; a single design meeting the more stringent science interferometer requirements is being used for all four ABCs. This results in the ABCs being somewhat "over-qualified" for the guide interferometers, but a net savings should be realized in design, development, fabrication, assembly, and test costs by approaching the design in this way.

The layout of the ABC is illustrated to scale in figure x. The enclosing red box indicates the volume allocated within the overall SIM instrument for the ABC. The design to date has primarily considered the first order optical requirements; that the light is collimated for a majority of the path provides some amount of flexibility in the exact placement of many of the ABC elements, so some additional space can be provided in specific areas if it becomes necessary once the detailed mechanical and thermal design is explored.

Sources in the ABC

The light generating sources are located in the instrument backpack, and their outputs carried to the ABCs by fiber optic cables. The fiber outputs are collected and collimated in two places: the internal metrology assembly, and the self-check and calibration source. The internal metrology beam is introduced into the system via a through hole in a fold mirror. It is split into a core beam and an annular beam in the compensated combiner; each beam then propagates out through the system to a Compressor CCR fiducial, which returns it back to the ABC. When activated, the self-check and calibration beam is injected via a non-polarizing 90/10 beamsplitter; it then propagates to the compensated combiner where it is split into two beams. Depending on the exact arrangement of retro shutters, starlight shutters, siderostat and FSM orientations, these beams are used to verify the internal operation of the ABC, alignment of the starlight paths, and to support diffraction calibration of the system.

Initial Beamsplitter Pair

The light in each arm entering the ABC first encounters separate non-polarizing 50/50 beamsplitters, splitting the light in to angle tracking and fringe tracking paths (via transmission and reflection, respectively).

Angle Tracker

The angle tracker camera consists of four opto-mechanical paths, forming four distinct, non-overlapping spots on two array detectors (a CCD for the 0.4-0.9 μm starlight, and an IR array for the internal metrology light) mounted to a common interface. By determining the centroid of the starlight spots with respect to the internal metrology spots, information about the angle of the light paths within the SIM instrument can be inferred, and used to control tip/tilt commandable elements at other locations within the optical paths.

Compensated Combiner

The fringe path contains the compensated combiner, which consists of three plane-parallel refractive plates to compensate for first order misalignment and chromatic effects, and the combining beamsplitter. A pattern of masks and coatings on the combining surface serves to interfere the starlight beams (forming two outputs) and to handle the splitting of the internal metrology beam (and the self-check and calibration beam when activated).

Fringe Tracker

The internal metrology light propagates back into the internal metrology assembly for heterodyne detection. The two interfered starlight combiner outputs propagate to a 10x confocal parabola compressor with a 2 arcsec (as measured on the sky) field stop. The light is then dispersed and focused onto a CCD detector, with a slight offset in one of the paths to create two distinct fringe spectra on the CCD.

ABC Self-Check Elements

When the self-check mode is in effect, the various shutters are opened and closed to selectively illuminate the CCRs and all or part of the optical paths of the ABC, and thereby verify the aliveness of the detectors and associated electronics.

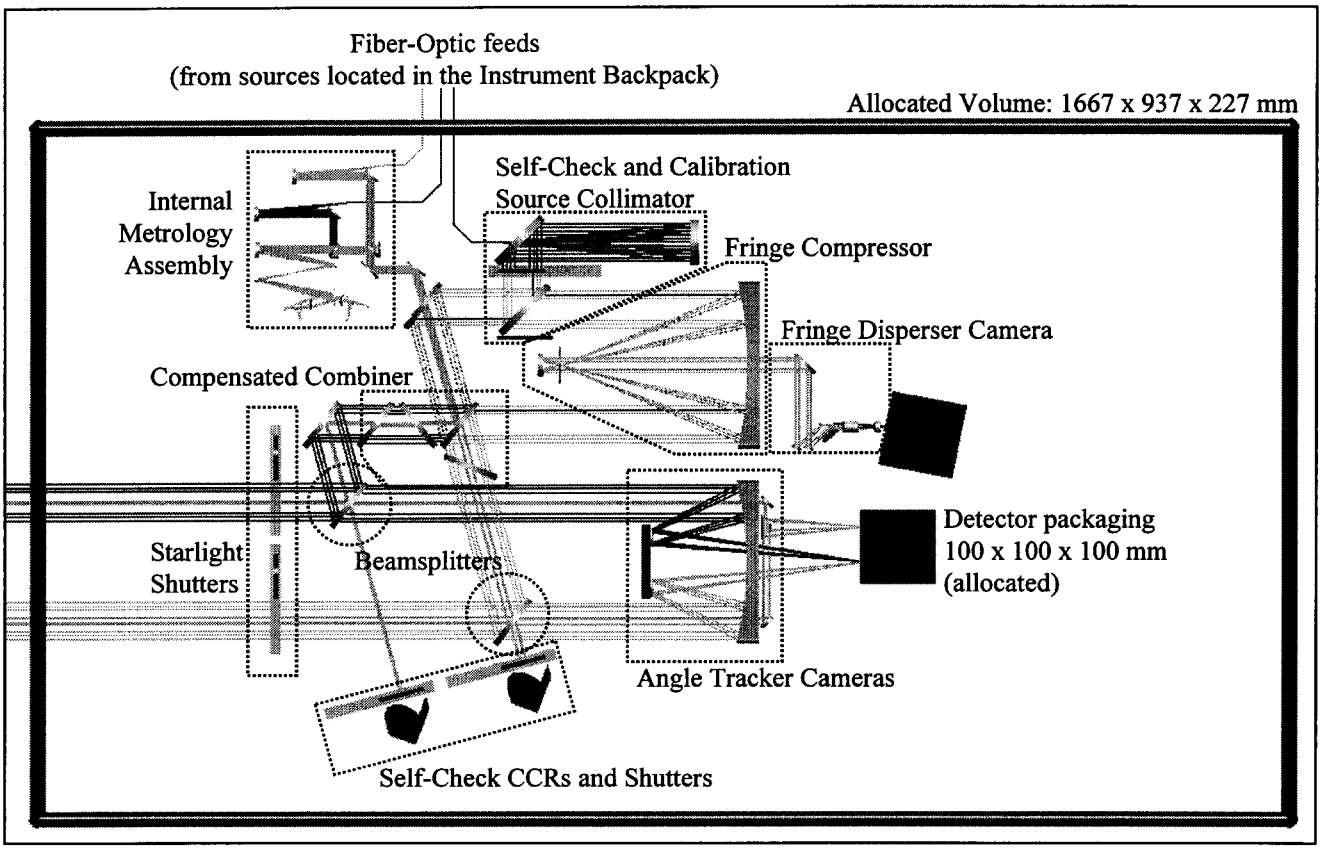

Figure x. Astrometric Beam Combiner Layout.