

Modeling the pyramidal wavefront sensor in ZEMAX™ by a suitable user defined surface



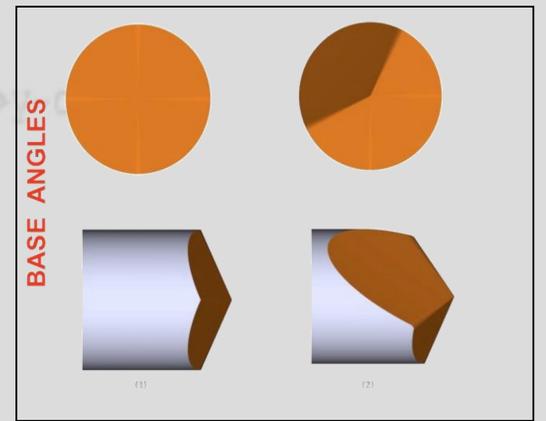
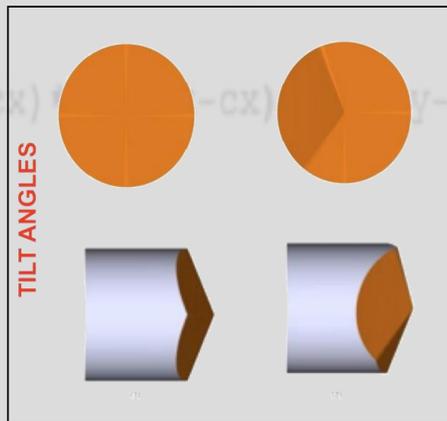
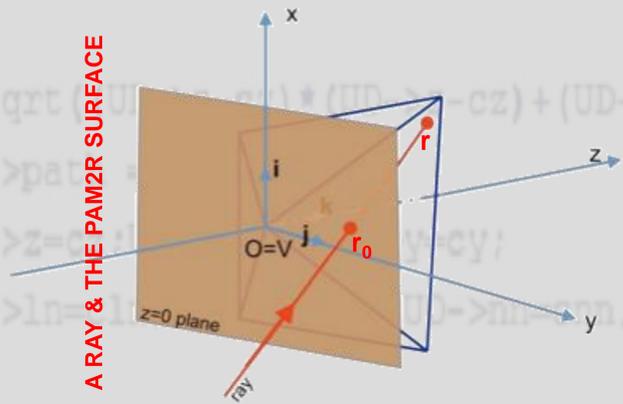
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Introduction

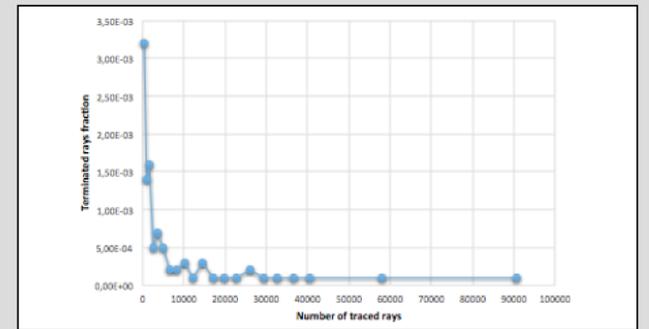
After 20 years of wavefront sensors based on pyramid (PWFS), there are no straightforward ways to model such device in standard sequential ray-tracing software: modeling strategies tend to be oriented to the needs of the single user only and, in general, are unsatisfactory due to lack of flexibility. To overcome this problem, we have exploited the possibility of ZEMAX™ to develop a user defined surface (UDS), whose properties are described in a dynamic link library (DLL) written in C language. The pyramid UDS approach greatly improves the versatility during the design and simplifies both quality and tolerance analysis. We highlight here the main characteristics of the PAM2R surface, showing results we obtained on two case studies of PWFS in operation at LBT: the SCAO system (FLAO) & the GLAO system within the LINC-NIRVANA instrument. The aim of this study is to share and broadcast a common PWFS design tool in the AO community for ZEMAX™ users.

A common tool for the Pyramid WFS design is now established: PAM2R UDS-DLL



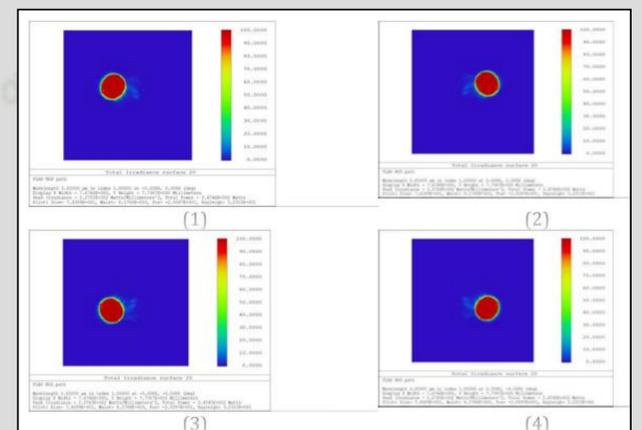
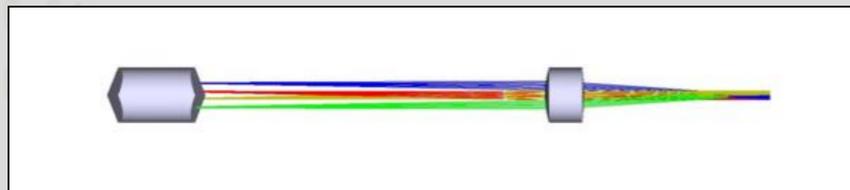
PAM2R is implemented in ZEMAX™ as a UDS through a DLL written in C, encoding the ray-trace prescription of any input ray with direction cosines and position of the vector r_0 (i.e. intersection with the plane containing the pyramid vertex V). Output ray direction cosines and position are given on the surface after the UDS. The applied ray-tracing through the pyramid automatically takes into account which face the ray passes through. Moreover, the pyramid UDS is parametrized with 4 base angles and 4 tilt angles, and, together with pyramid thickness and glass type (mirror has already been implemented), providing a ZEMAX™ Sequential Surface with 10 degrees of freedom → Sensitivity/Tolerance analysis of a PWFS by ray-tracing analysis is finally feasible with standard method.

PAM2R makes easy also the treatment of the ray-tracing through the pyramid vertex & faces edge: if a ray passes close to one of these points (closer than the floating precision given by the machine running ZEMAX™) such ray is perturbed in its initial position r_0 and traced again. This procedure is quickly convergent. → Vignetting and incorrect propagation due to the non-application of the Snell law at the pyramid vertex & faces edge are excluded by design.



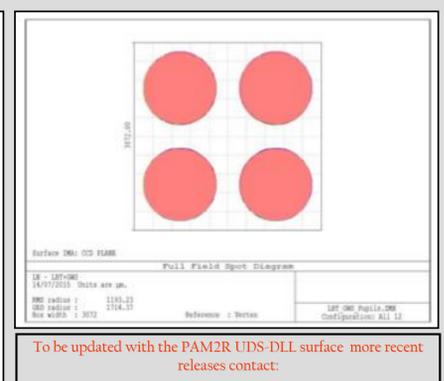
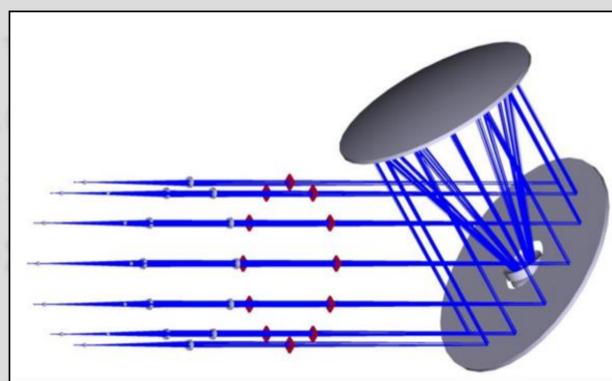
The LBT SCAO system (FLAO) with PAM2R

PAM2R allows the design of the FLAO system with its achromatic double-pyramid. The image below renders the FLAO design from the pyramid Vertex up to the 4 pupils image-plane (covered diagonal FOV is 2.5 arcsec with a F/45 beam). The image on the right shows the Physical Optical Propagation obtained with the ZEMAX™, considering the entire propagation through the optical system (LBT + FLAO) of a flat wavefront. Possible pyramid vertex & faces edge chamfers are not considered by PAM2R. The residual diffraction effects are due to the finite sizing of the pyramid faces.



The LBT GLAO system of LINC-NIRVANA with PAM2R

PAM2R allows the design of the GLAO system of LINC-NIRVANA exploiting the multi-configurations tool of ZEMAX™. In this case the pyramidal optics are single pyramid (red in the layout figure). They may patrol a FOV up to 6 arcminutes diameter wide to catch the light of up to 12 natural guide stars. The light coming from the 12 reference stars is superimposed into 4 pupils, by a common re-imaging camera on the detector



To be updated with the PAM2R UDS-DLL surface more recent releases contact:
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