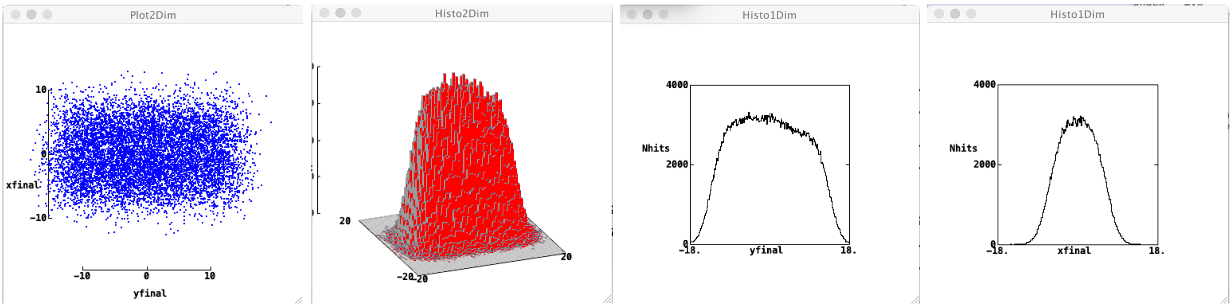
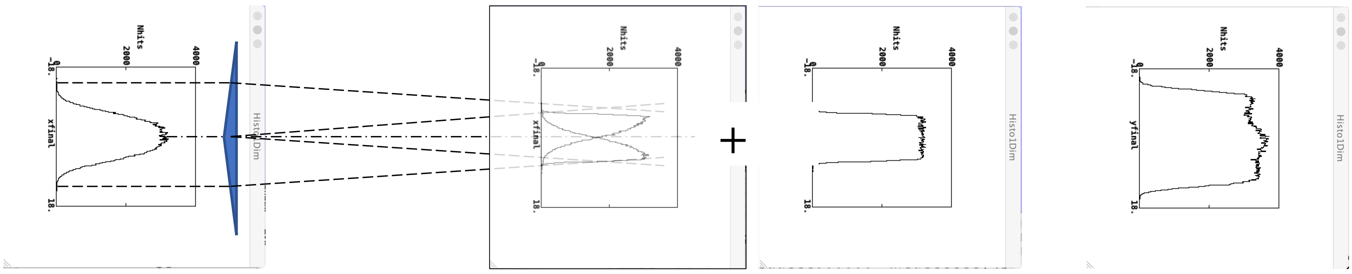
Wedges & Lenses for Excimer Laser Beam Shaping

An excimer beam is large & highly multimodal, very far away from the TEM_{00} beam associated with many other lasers, and is normally used to illuminate a mask whose demagnified image is then projected onto the part. **Ideally, illumination would be of uniform intensity** over the mask area, whereas the typical beam spot & profiles in long & short axes are more typically as below. Short axis is a kind of flattened quasi-gaussian, long axis has a flattish top, but often with some asymmetry,- rather exaggerated here. There are two paths to obtaining a more uniform intensity beam spot, beam **Homogenization** and **Beam Shaping**, each with their characteristics, pros & cons; this note deals with beam shaping.

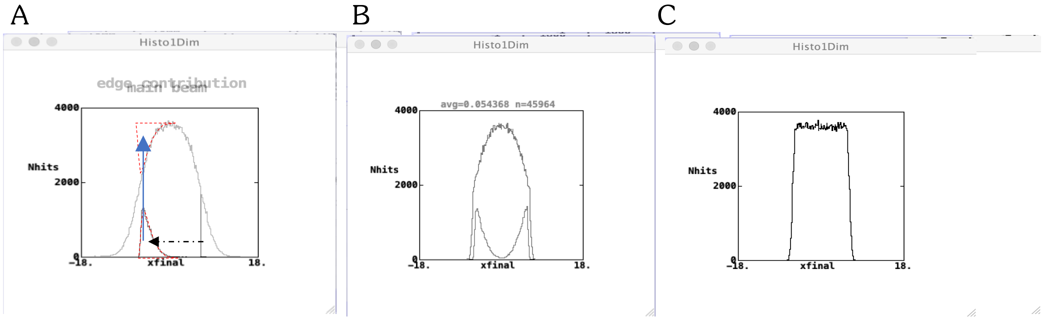


An early trick in excimer processing was to pass the beam through a weak **biprism**, cutting the beam in two & by refraction ensuring that the two halves converge & overlap on a downstream plane, here for the short axis. The match can be good enough to produce the desired **top-hat profile**:- N.B. This works less well for the long axis (right).



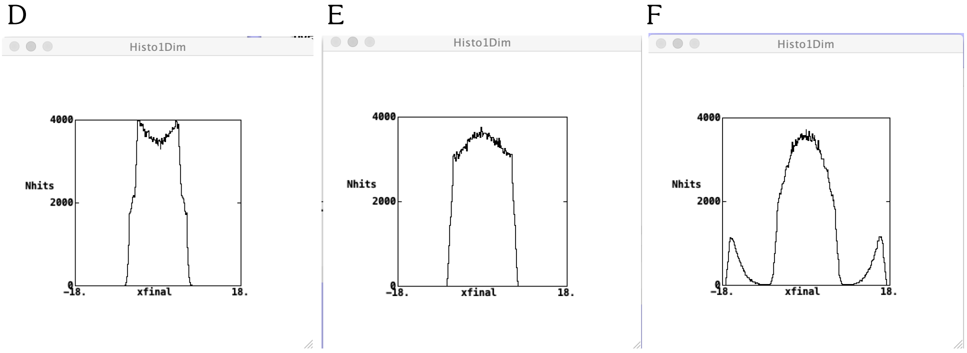
An alternative approach is to introduce a **prismatic wedge** into the edge of the beam, roughly up to the half power point; so that only the flank of the beam is deviated, and on some downstream plane is in a position to complement the fall-off in beam intensity on the opposite side of the beam from centre to the left, (A) so that if one does this with 2 identical wedges on either side of the beam (B) these two edge contributions can then be added to the main beam to again generate a top hat shape (C).

A B C



As before, the top hat profile is limited to one target plane, D & E shows profiles at distances 10% up & downstream, whilst the different contributions continue to propagate separately and become distinct for e.g. on a plane yet further downstream (F). If that uniform intensity distribution in the mask plane (C) is to be useful in forming an image of the mask, the projection lens located at plane (F) or further downstream must have a large enough aperture and moreover be capable of combining those contributions correctly in the target plane.

D E F

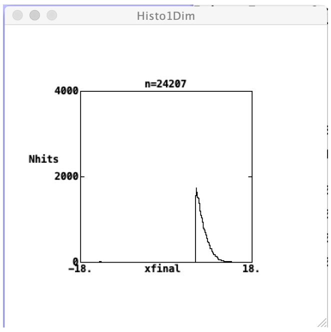


However, this is not the best way to reshape the beam; the idea of using specially cut **cylindrical lens segments** in place of wedges inserted into the flanks of the beam was pioneered by Optec in 1990! & offers several advantages.

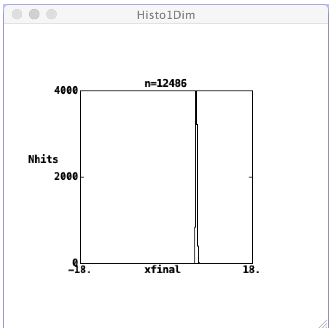
The flank of the beam passing through the lens (G) is not simply displaced as one proceeds downstream but instead brought to a line focus (H), inverted (I) & (J), and then added to the main beam on the SAME side of the beam rather than crossing over. The fact that the profile of that edge contribution evolves as it propagates means that **finer control** can be used and resulting overall profile in the mask plane (K) is improved, particularly in the long axis (L):-

However the real advantage of lenses over wedges is that since there is significantly less lateral displacement of the flank contributions, the profile at the plane the same distance **downstream** from the mask is much **more compact** (M&N),- the former to compare directly with (F). This is particularly important when such beam shaping is used in the long axis of the beam, where in the **wedge-based** version the edge contribution has to cross right over to the other side of the beam, introducing a huge amount of **unwanted divergence.**

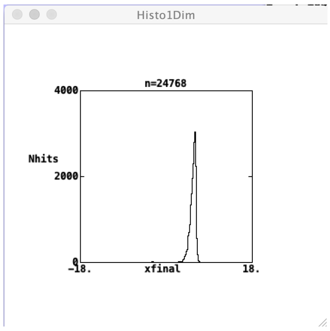
G



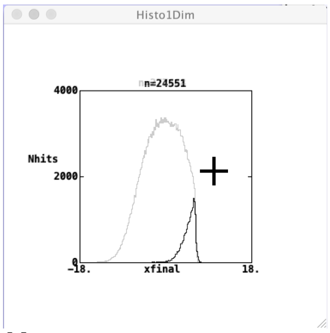
H



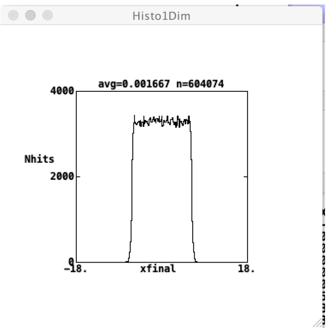
I



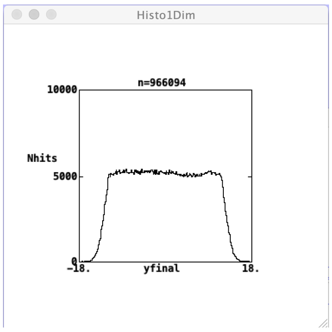
J



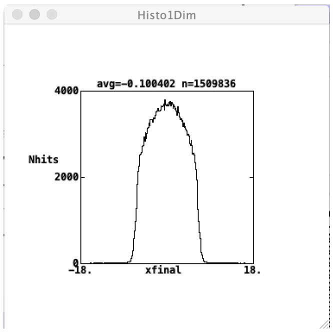
K



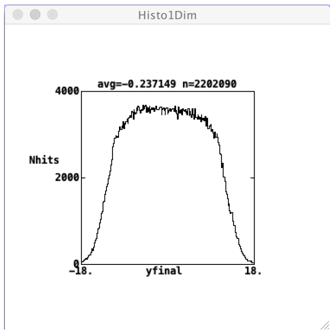
L



M

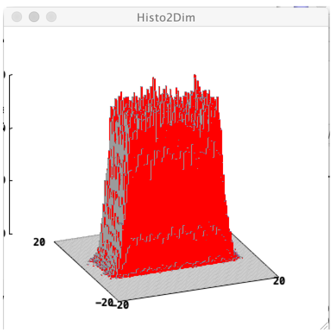


N

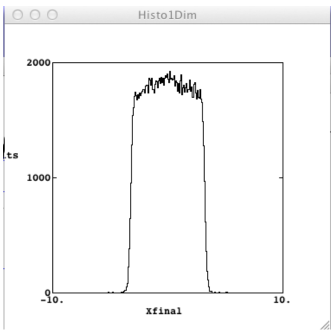


With judicious control over the degree of insertion of the lens elements, and exact distance of the working plane, one can trim the final profile very finely, and cater for a very wide variety of beam shapes, including quite highly asymmetric, generating a **uniform intensity rectangular beam spot** (O). It is also possible to generate **specific beam profiles** P,Q,R) which can be useful in specific processing applications:-

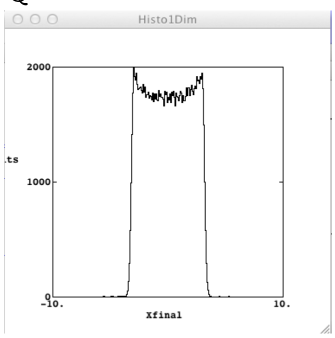
O



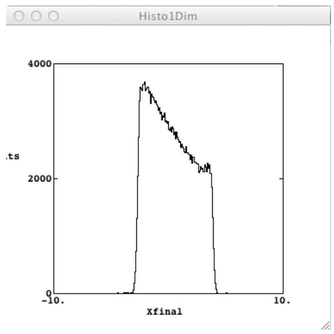
P

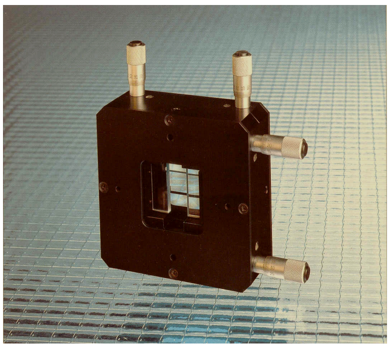


Q



R





Optec **HY Beam Shaping modules** (one for each axis) can be used alone, or combined to make a 2-axis beam shaper HY120, where lens insertion is controlled individually for each beam edge with a micrometer. Modules are available with different working distance to suit individual applications. HY modules are suitable for all excimer wavelengths, and are **highly efficient**, since most of the beam passes through no optics whatsoever. They do not suffer from diffraction or any of the unwanted side effects of, for e.g., array type homogenizers. Hundreds of these modules are used around the world, & regularly featured on Optec systems, vastly **improving the efficiency** of excimer laser systems & helping to **prolong the useful life** of an excimer laser as profile degrades due to normal wear on the electrodes.