Optimisation of Optical Design in Grazing Incidence Collector for EUV Lithography DPP Sources

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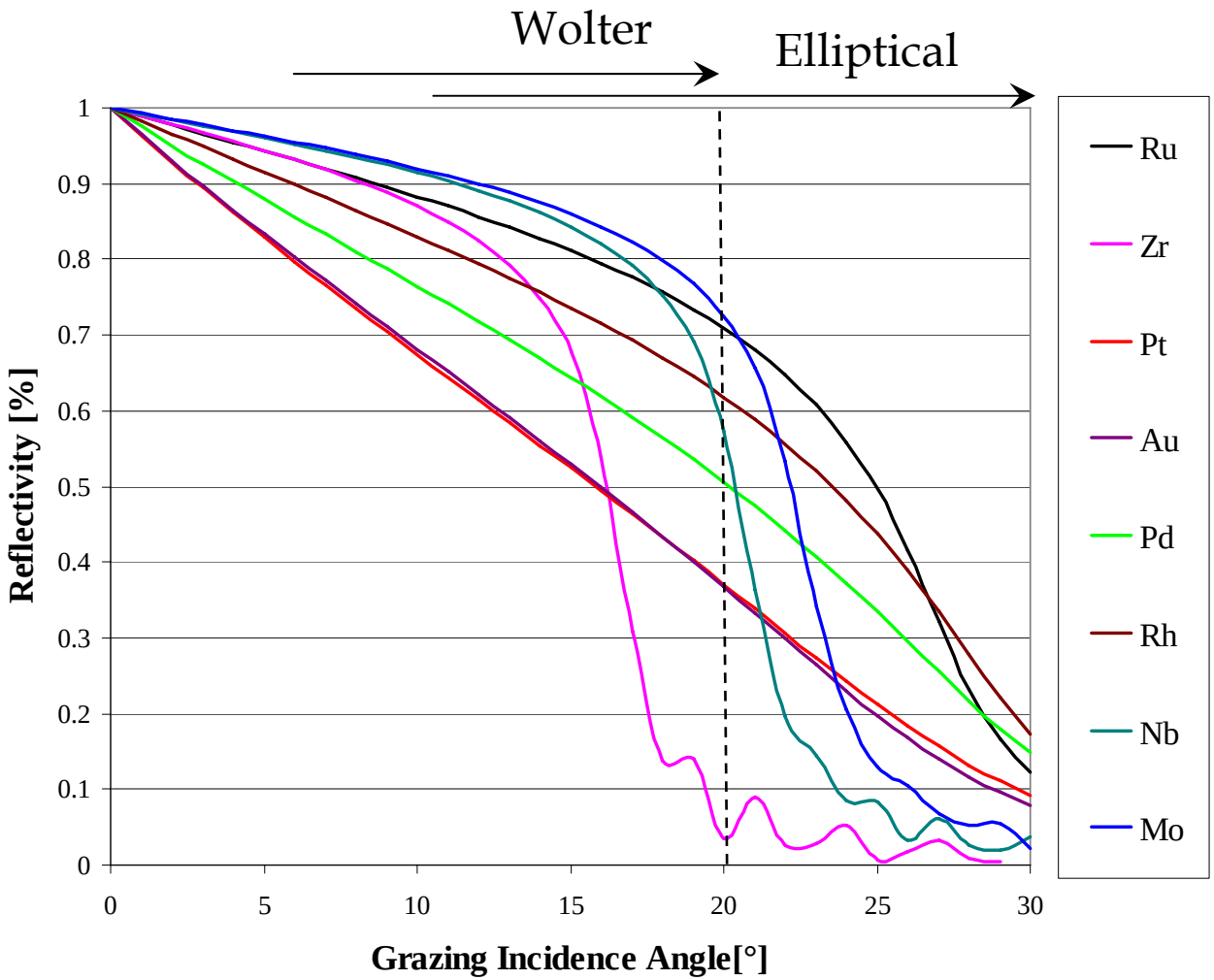
Optical Requirements

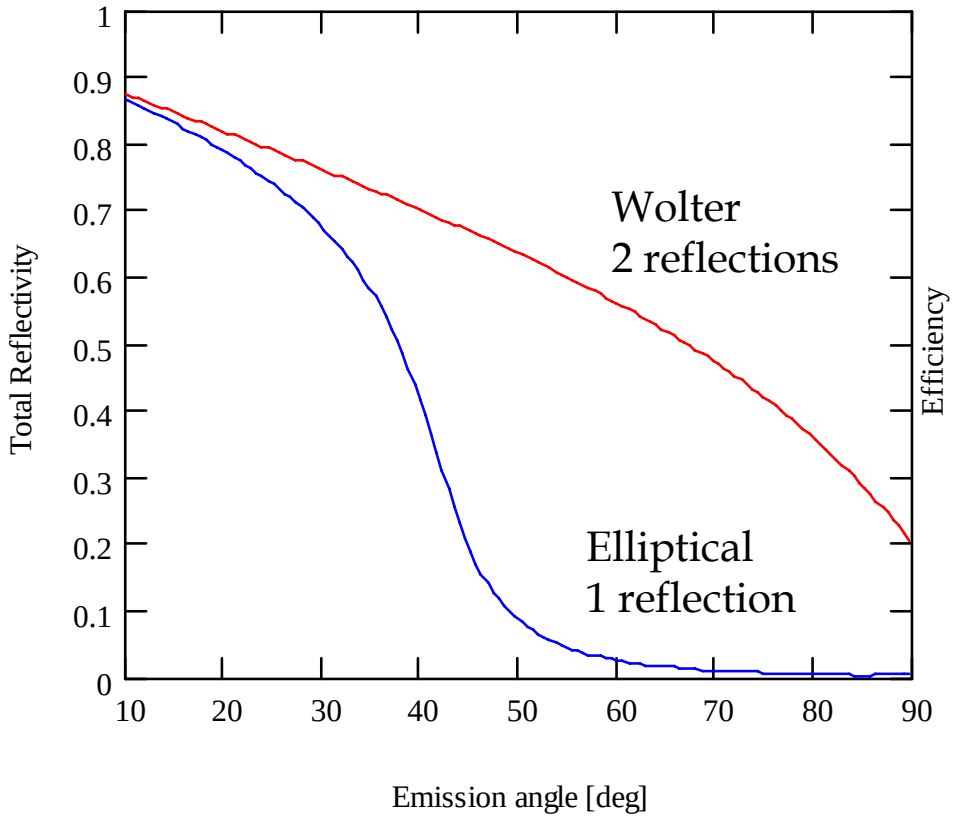
Parameter	Requirement	Comment
Focal length	1500 – 2000 mm	For Wolter design
Output NA	0.1 – 0.25	Illuminator dependent
Output etendue	3 – 6 $mm^2 \cdot sr$	POB / Illuminator dependent
Source-Collector distance	> 100 mm	Constrained by DMT and optical design
Collectable angles	< 60°	Constrained by source and optics design
Alignment accuracy	< 100 µm / 1 mrad	Requires precision alignment of shells to optical axis
Collector transmission including obscurations	30 - 60%	Optical design and EUV reflective material dependent

Theoretical Reflectivity of Selected Materials

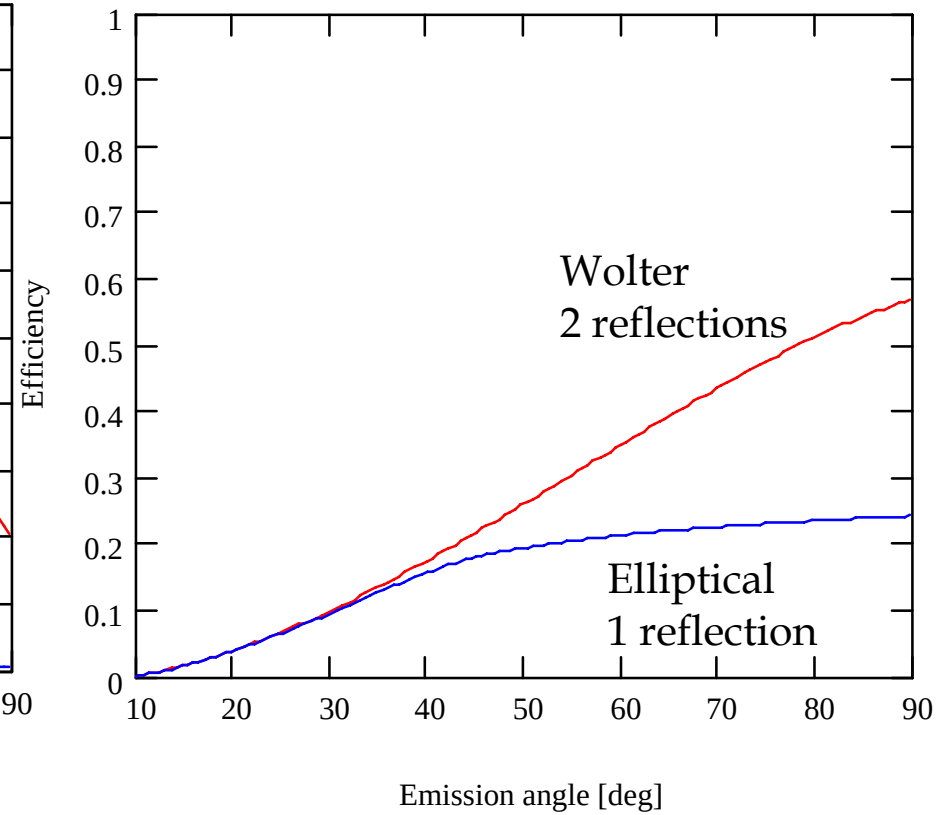


Wolter vs. Elliptical Design
Maximum Theoretical Efficiency with Ruthenium

Total reflectivity vs. emission angle



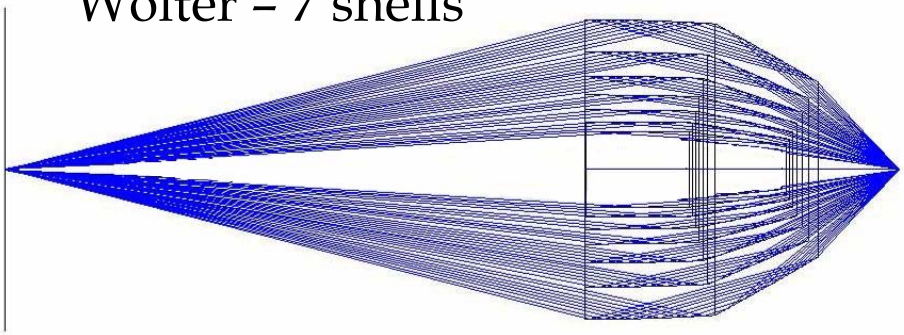
Efficiency vs. emission angle

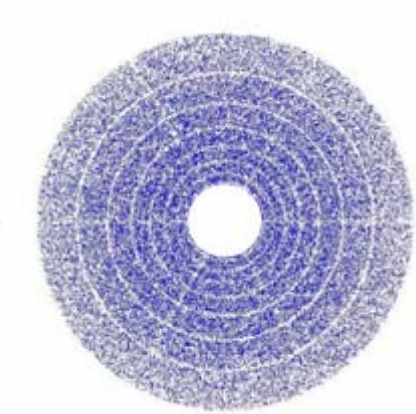


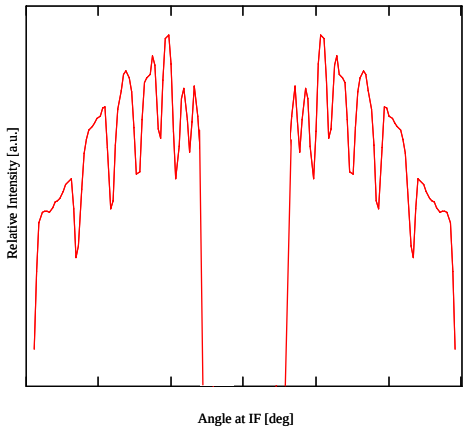
Output NA = 0.2

Wolter vs. Elliptical Design
Far Field Distribution

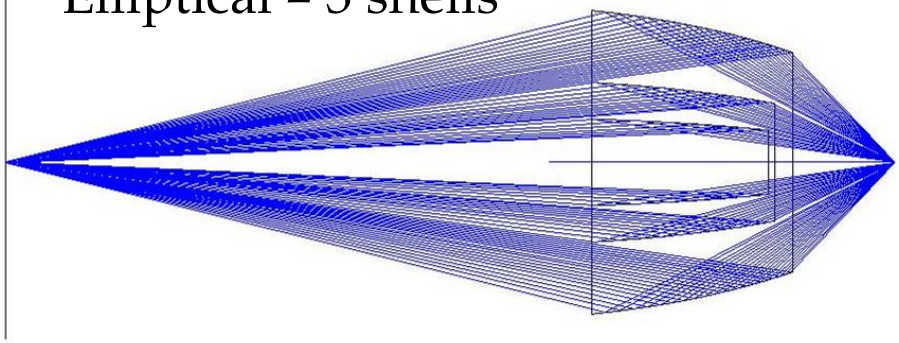
Wolter – 7 shells

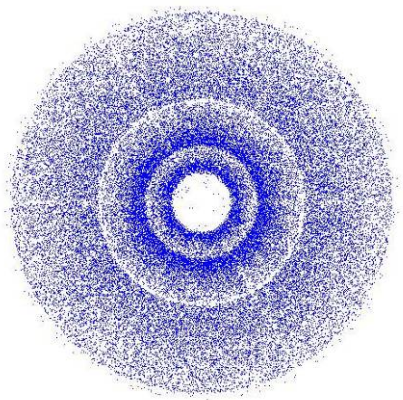


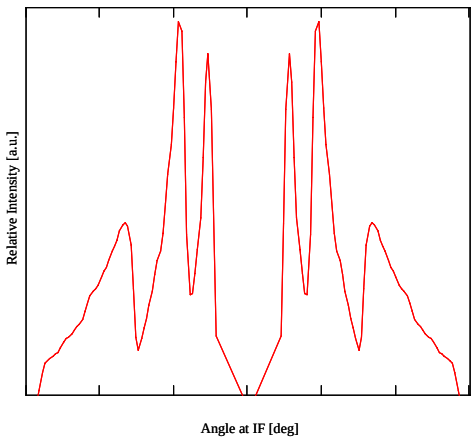




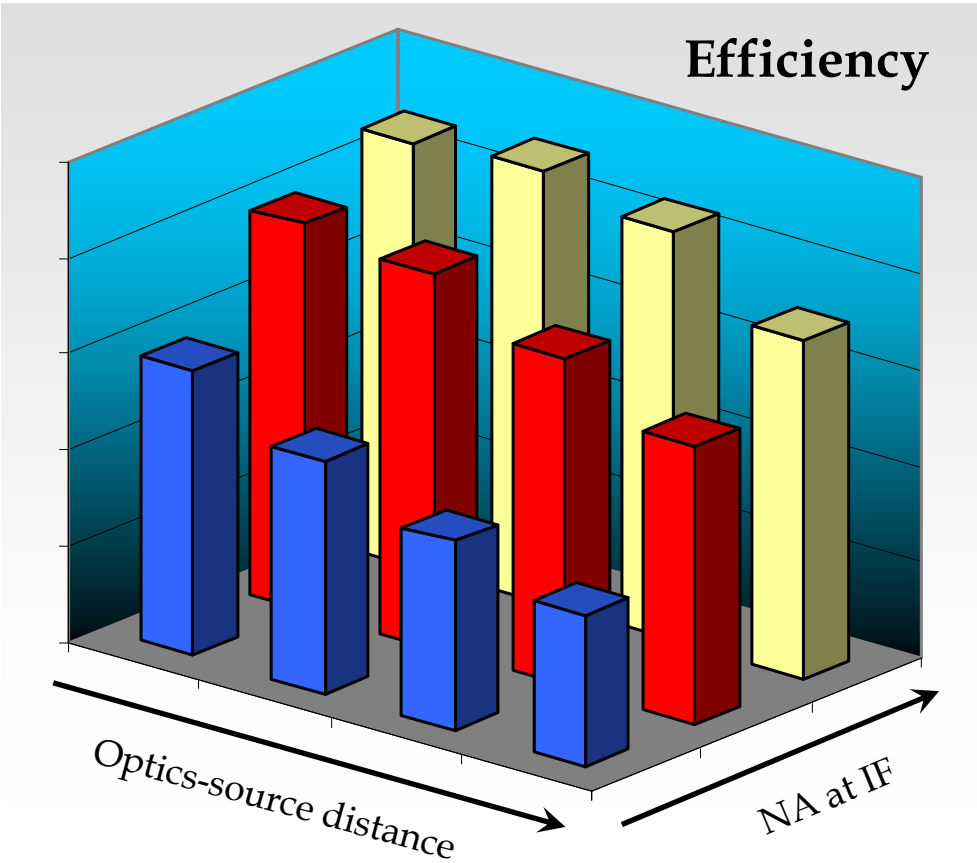
Elliptical – 3 shells

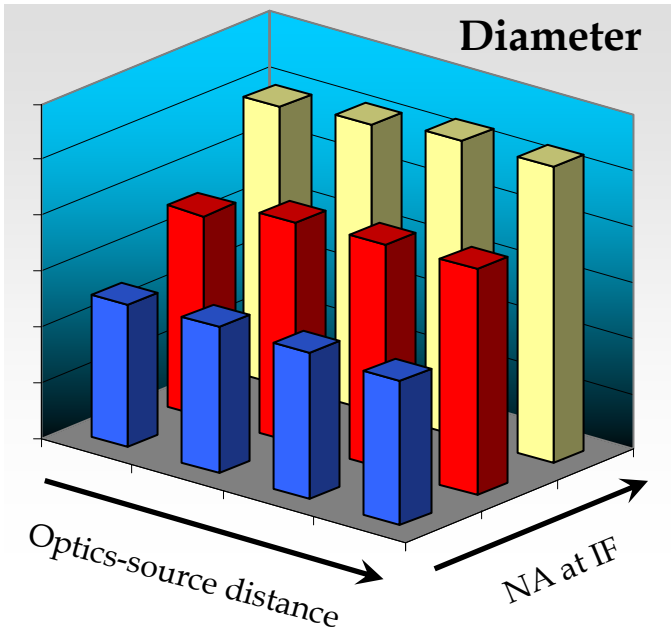






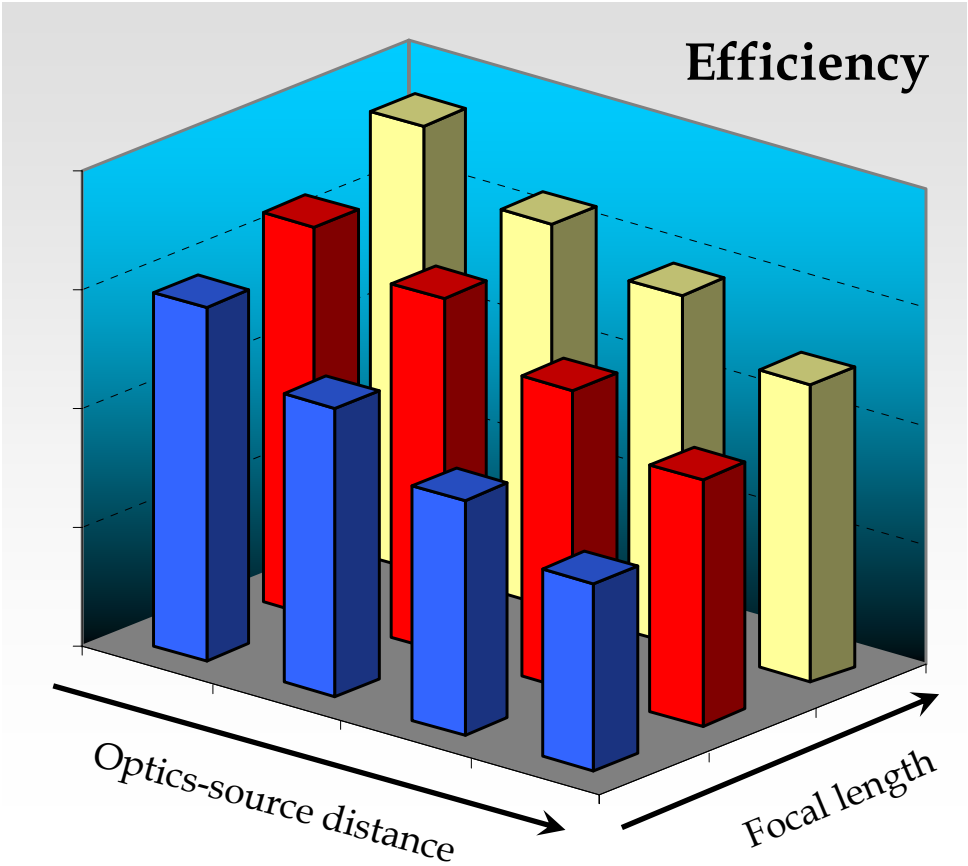
Efficiency Trend vs. Source-optics Distance and Output NA

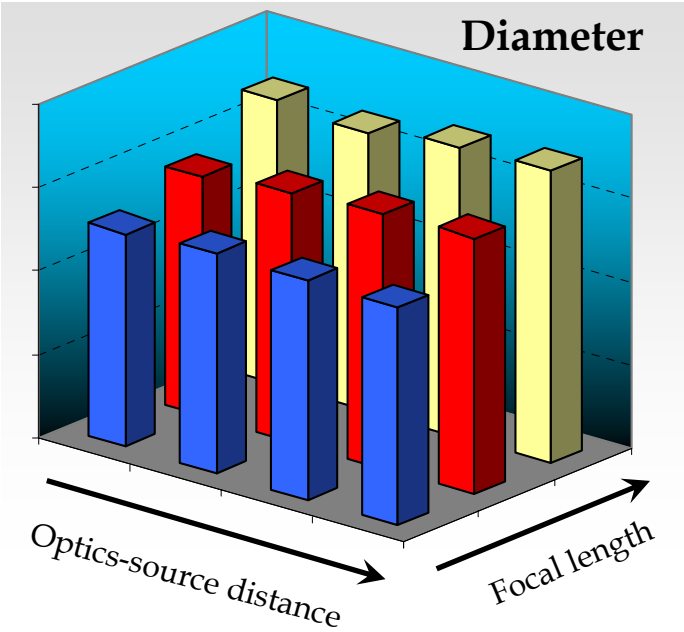




Fixed focal length

Efficiency Trend vs. Source-optics Distance and Focal Length





Fixed NA at IF

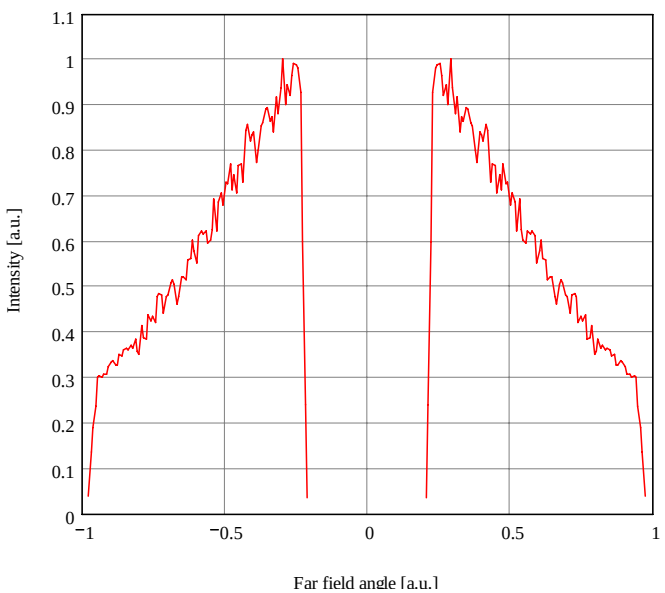
Design Criteria

- The collector is a bridge between the source and the illuminator and must be designed in close co-operation among source, collector and illuminator suppliers.
- Examples of key factors optimising collector design, requiring inclusion from the beginning not only of optical specifications but also of
  - shell thickness
  - manufacturing requirements
  - debris mitigation tool
  - coating reflectivity vs. incident angle
  - source model (size, shape, angular distribution)

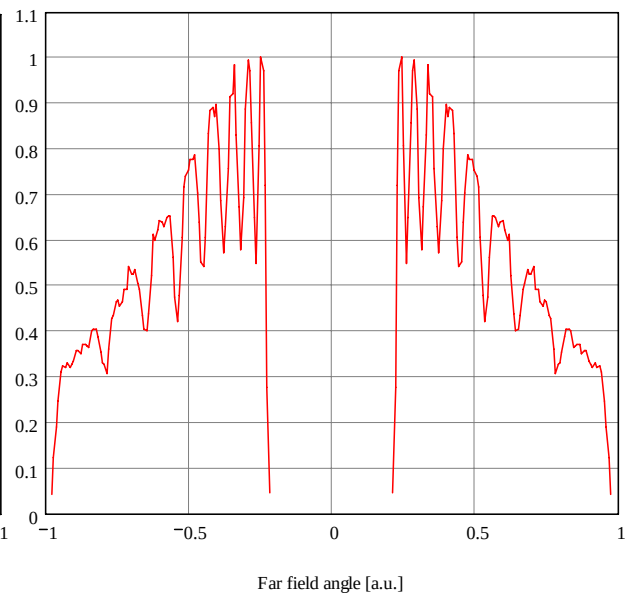
Example: Shell Thickness and Far Field Optimisation

- If shell thickness is not included in the optical design process from the beginning, non-optimum far field intensity distribution is obtained

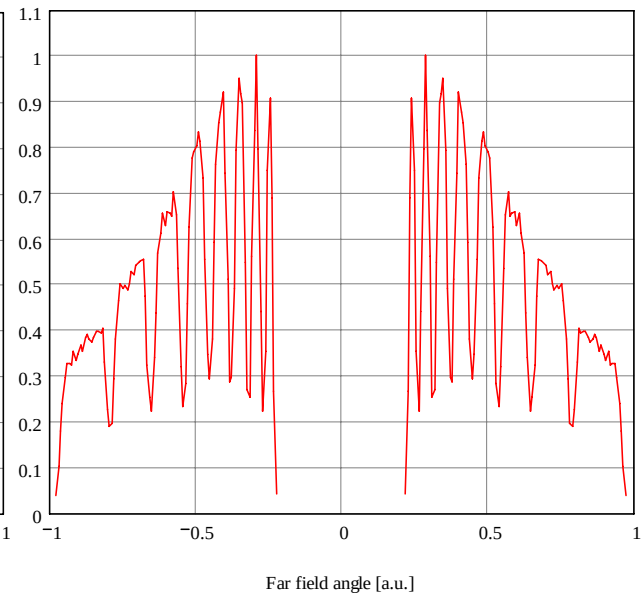
Thickness: 0 mm



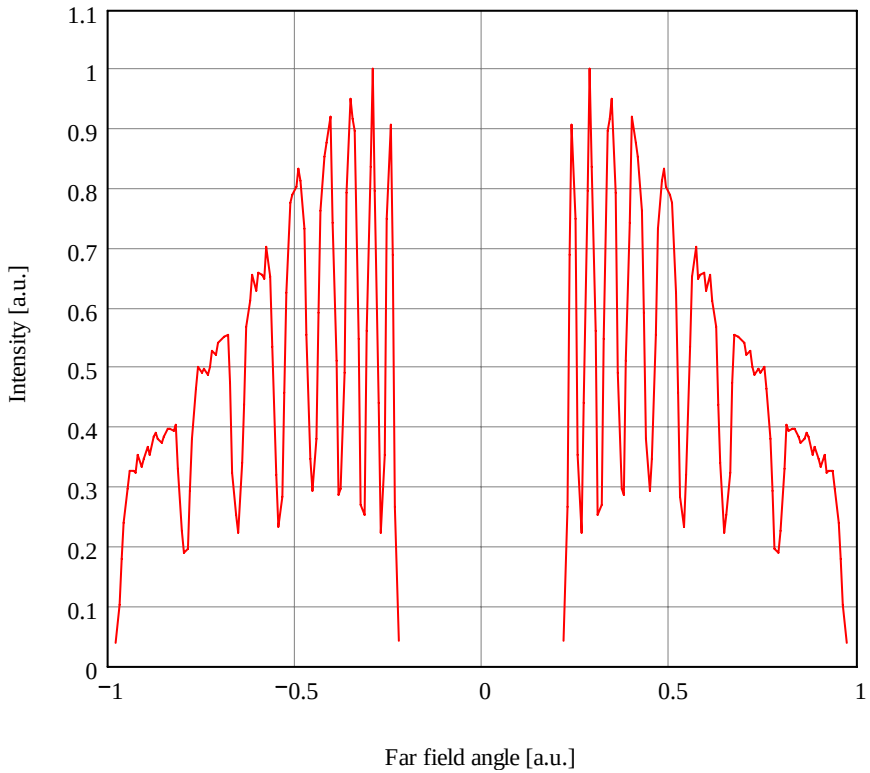
Thickness A



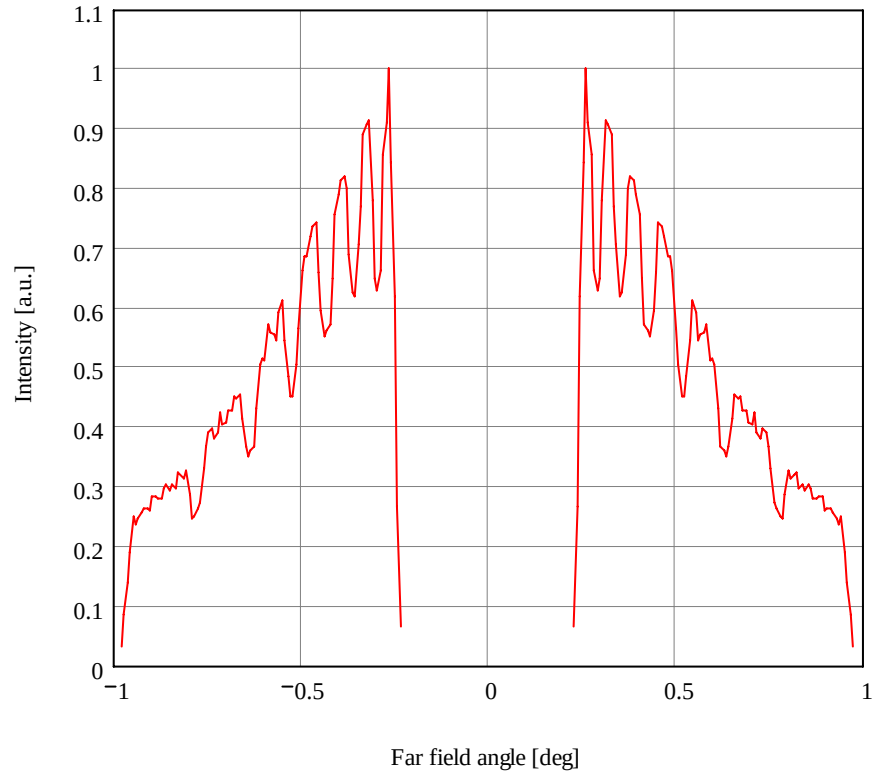
Thickness B > A



Thickness B
Non-optimum design



Thickness B
Optimised design

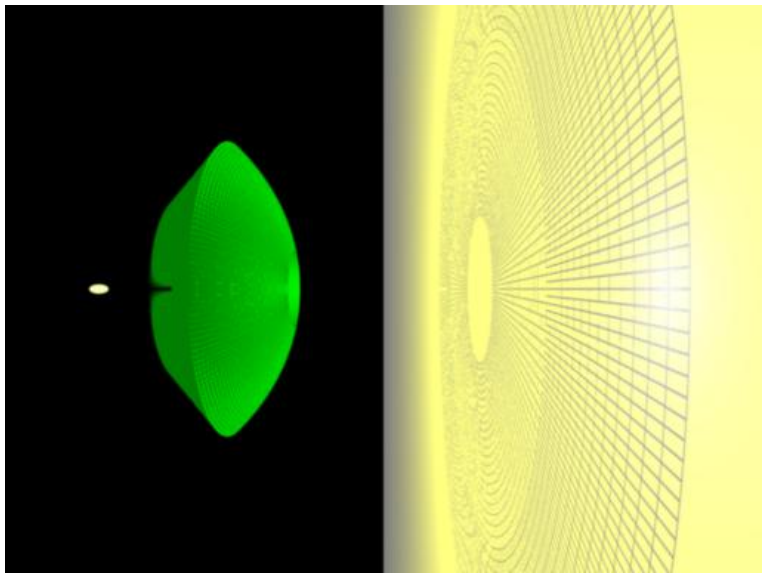


- Shell thickness is selected as trade-off between optical performance and thermal, mechanical and manufacturing requirements.

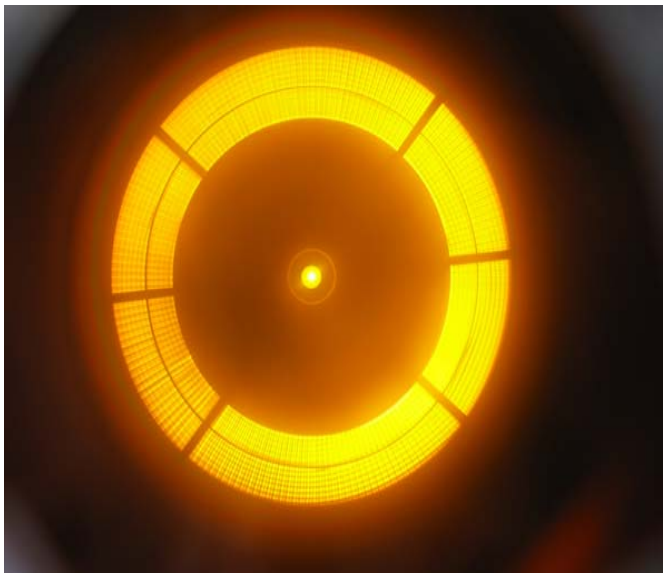
Example: Debris Mitigation Tool

Matching of collector design and Debris Mitigation Tool (DMT) design is required for optimum performance. In particular:

- dimensions of DMT and collector have large impact on their performance
- proper dimensioning of position and thickness of support spokes avoids additional obscuration
- easy alignment to same optical reference is a key factor to fast replacement

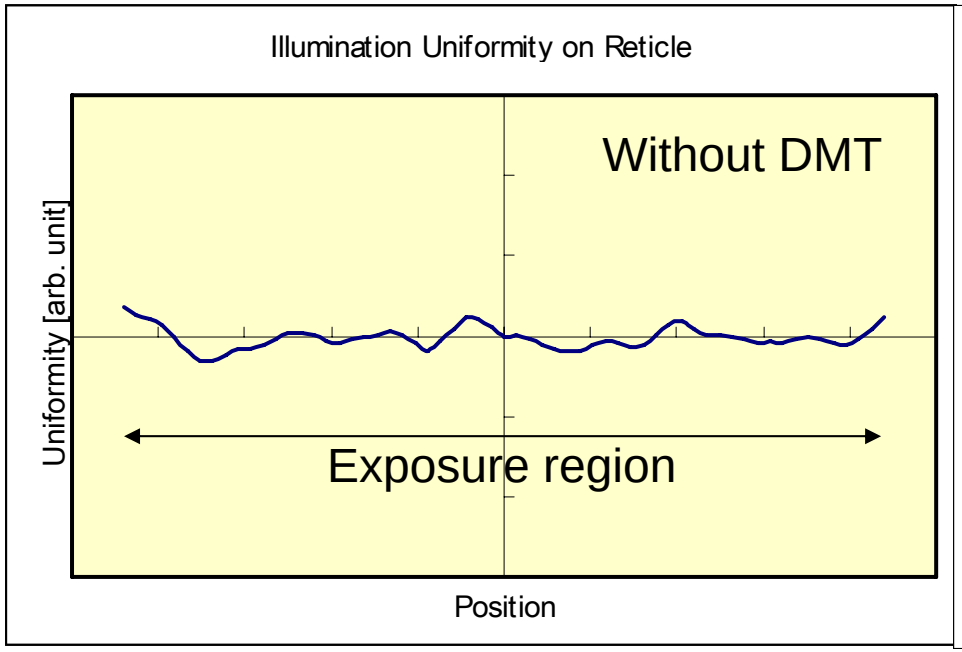


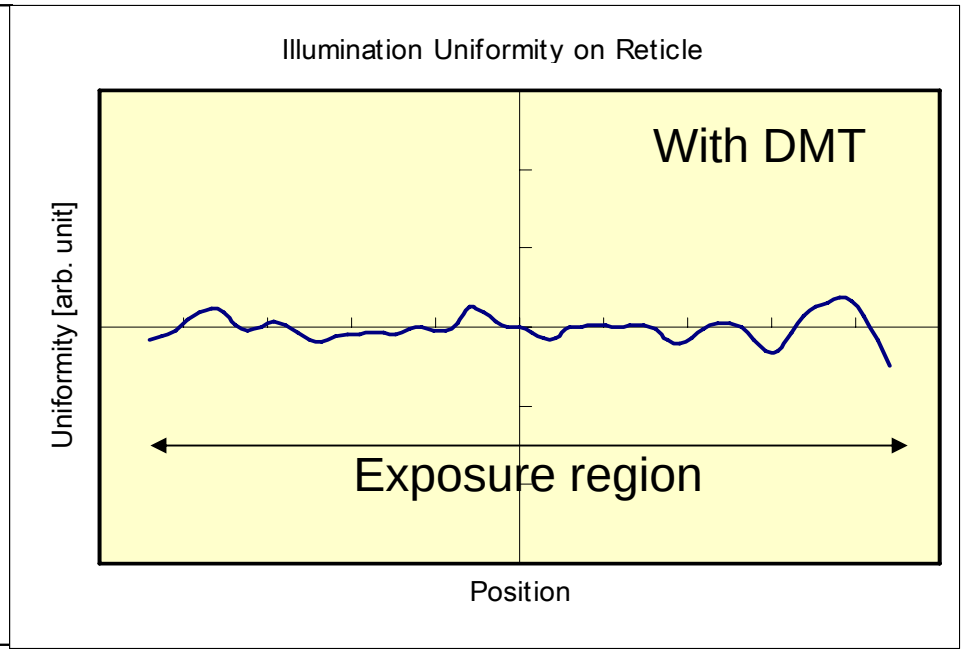
DMT pictorial view



DMT illumination

Illumination uniformity on reticle obtained by ray tracing
Influence of DMT structure on illumination uniformity

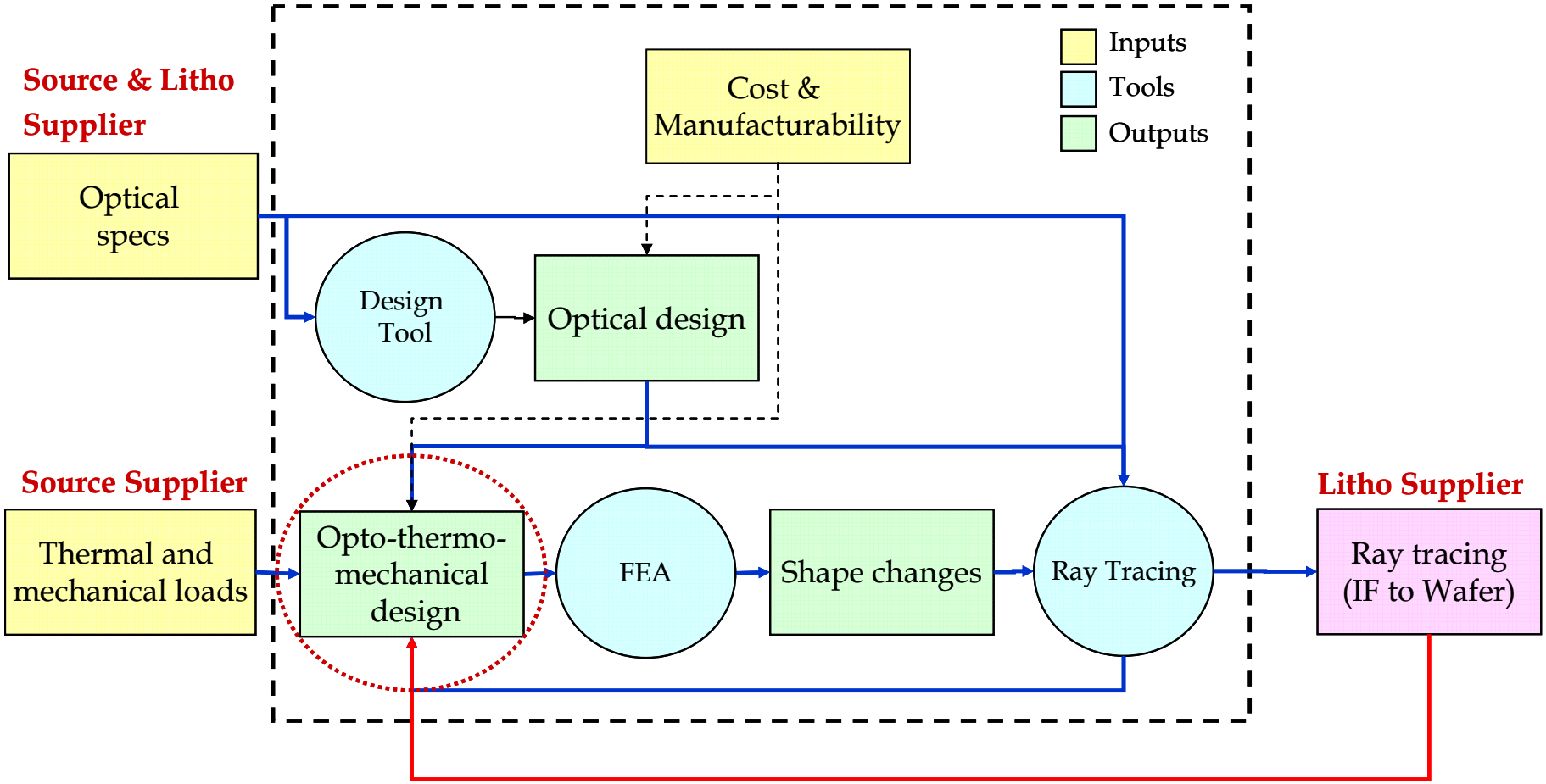




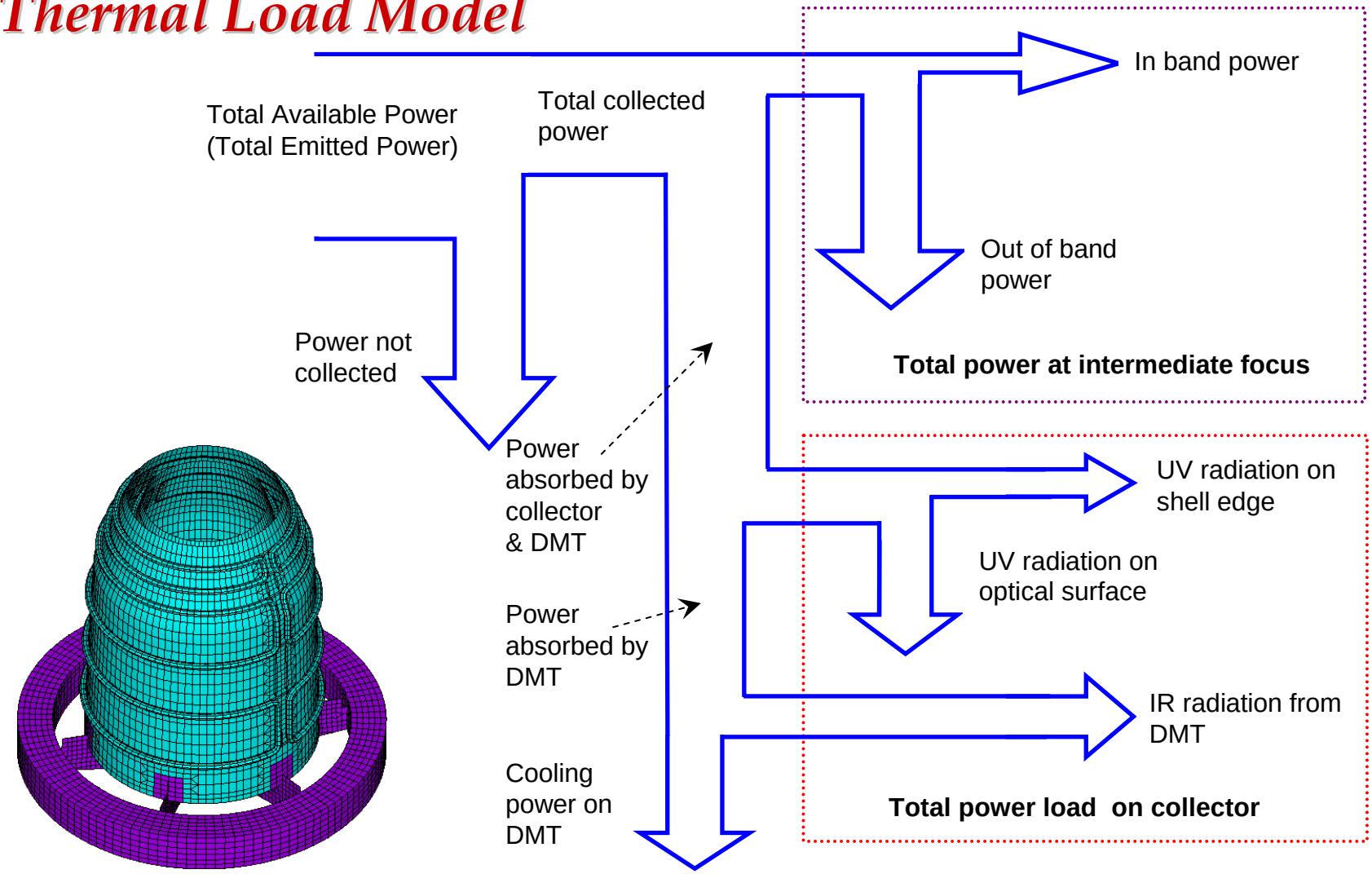
Illumination uniformity on reticle with and without DMT. The scales in both graphs are same. Influence of DMT can be minimized.

The undulation seen in both graphs will be caused by insufficient number of rays.

Flow Chart of Thermo-Optical Design Process

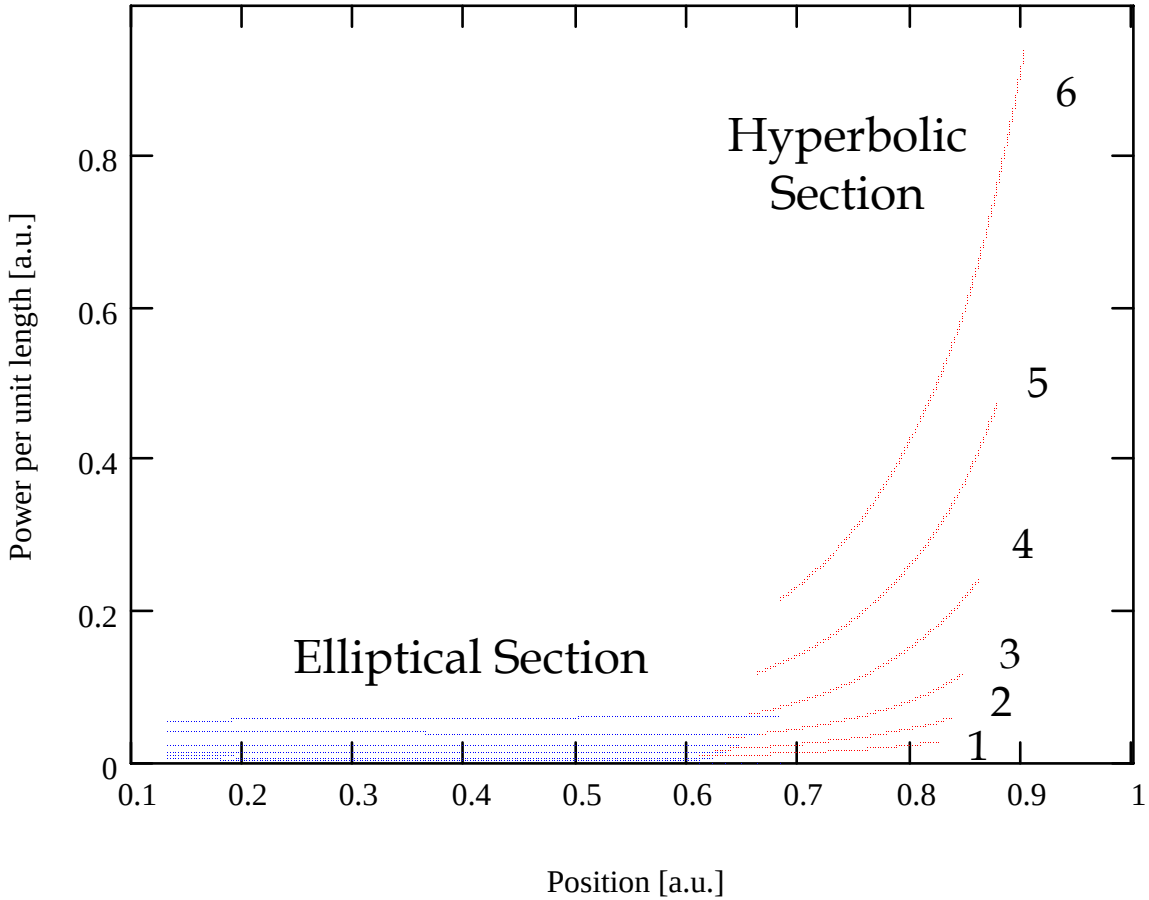


Thermal Load Model

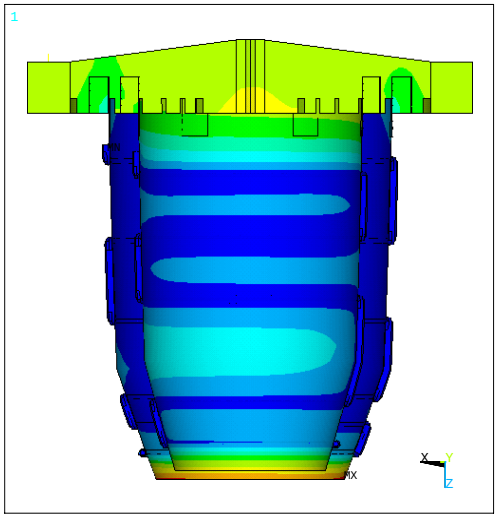


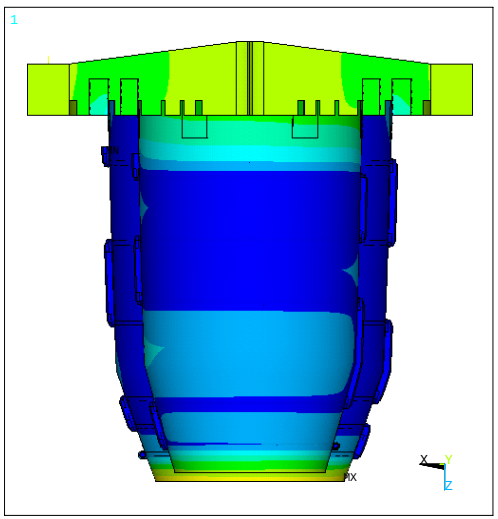
Example: Thermal Load from Source Radiation

Power load per unit length

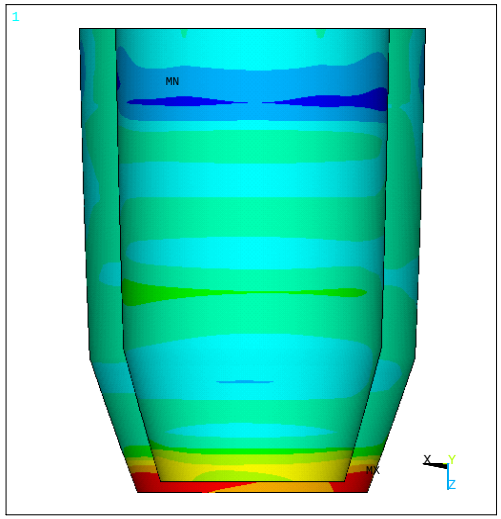


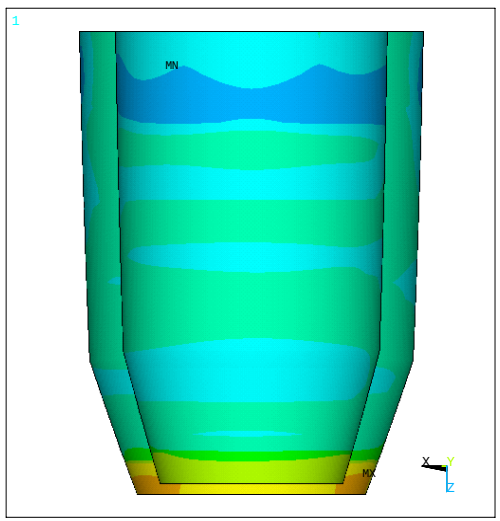
Temperature field



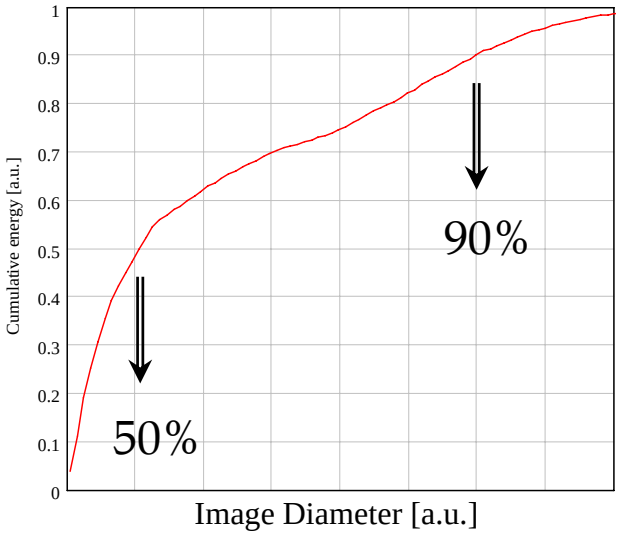


Slope error

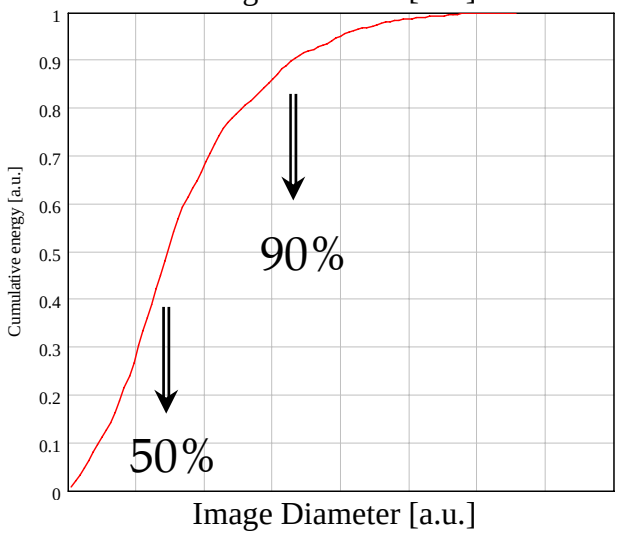




Cumulative energy at IF



Shell Thickness A



Shell Thickness B > A

Conclusions

- EUV collector module is evolving, but still a customized product.
- Collector optics optimization demands close working co-operation between source, collector and litho suppliers.
- HVM EUV collector optics, under evolutionary and revolutionary development, has much focus on:
  - increased collection efficiencies
  - high thermal load management
  - IF and far field stability
  - lifetime

Thank you for your attention