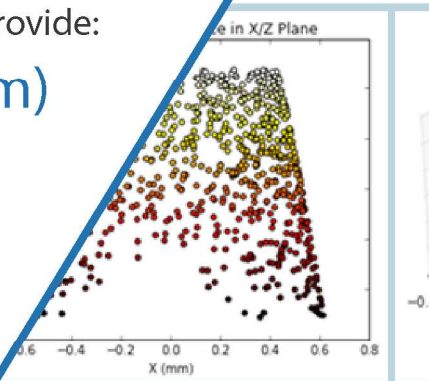
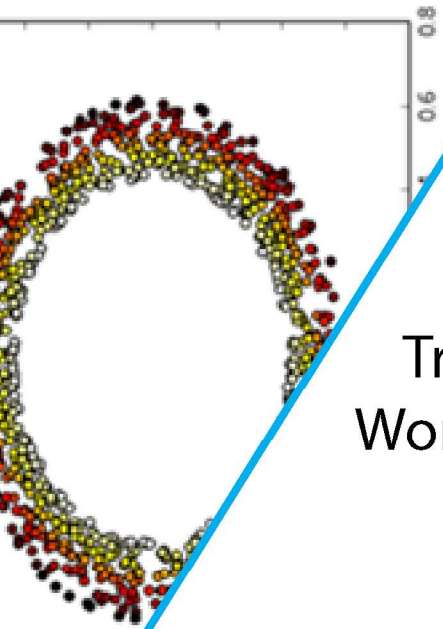




# Axially Symmetric Synchrotron Optics

COHERENCE-PRESERVING, HIGH RESOLUTION  
FOCUSING AND COLLIMATING X-RAY OPTICS

Sigray, Inc.  
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Sigray's axially symmetric mirror lenses provide:

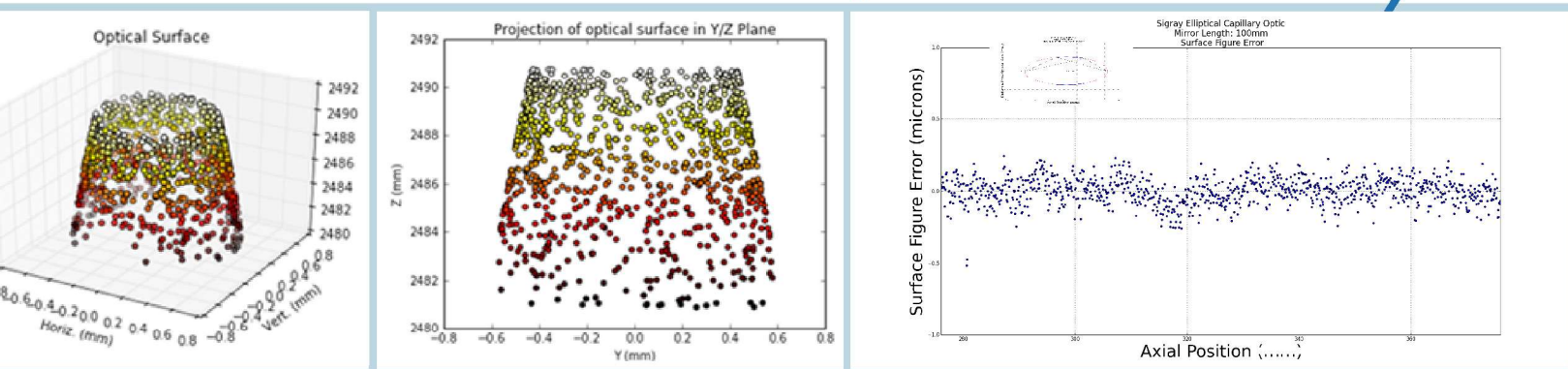
- High Resolution (0.2 - 2  $\mu\text{m}$ )**
- Large NA for Higher Flux**
- Energies from 0.1 to 60 keV**
- Transmission Efficiency >80%**
- Working Distance 1-100 mm**

Designed to replace KB Mirrors, ZPs, and Polycapillaries for Microfocus Beamlines

## How will Sigray Improve Your Beamline Performance?

Energy	Applications	Sigray Advantage over Other Approaches
<3 keV	Ptychography (0.2 - 3 keV) ARPES (0.5 - 2 keV) PEEM (0.1 - 3 keV)	High NA & efficiency for soft x-rays, larger working distance than zoneplates, and achromatic
<20 keV	TXM (0.3 - 20 keV)	Customer-specific design Achromatic, high efficiency
2 - 60 keV	$\mu\text{XRF}$ (2 - 30 keV) $\mu\text{XRD}$ (5 - 60 keV) XAFS (2 - 20 keV) Super Confocal **	High flux, high efficiency, and shorter working distances than KB mirrors Double paraboloidal design  ** Super confocal options available upon request for <5 $\mu\text{m}$ (configuration uses a twin paraboloidal lens scheme with multiple advantages over polycapillary optics)

Examples of surface profiles and surface errors: Three-dimensional ray tracing of example optical surface profile of an ellipsoidal optic (three figures on the left). Rightmost figure is an example of the minimal (far submicron) surface figure error achieved by Sigray (errors are shown for the ellipsoidal design inset).



# Superior Performance for Your Beamline

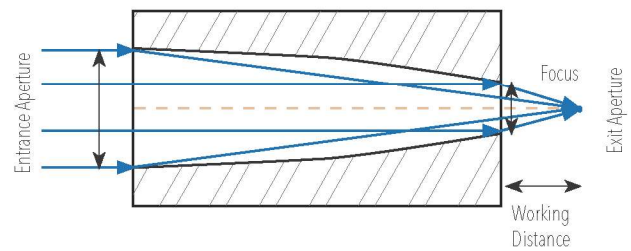
## Axial Symmetry and Advanced, Customized Manufacturing

### Optimized Designs for Your Needs

Sigray offers paraboloidal (right), ellipsoidal, and toroidal optics for high resolution focusing or low divergence collimation. The parameters and shape of the axially symmetric mirror lens can be customized upon request.

Example specifications of a focusing paraboloidal mirror lens optimized for 9 keV are shown below. Note that optics are available for 0.1 to 60 keV, with parameters dependent on energy of interest.

Paraboloidal Mirror Lens Configured to Focus X-rays



Parameter	Specification
Critical Energy at Max Convergence Angle	9 keV (up to 15 keV x-rays can be focused with lower efficiency)
Minimum Focus	0.8 $\mu\text{m}$
Reflecting Surface	Coated with Platinum (other materials available upon request)
Working Distance (mm)	20 mm
Convergence Angle (2X Numerical Aperture)	35 mrad
Entrance Aperture (ID)   Exit Aperture (OD)	1.4 mm   0.7 mm
Strehl Ratio	75% (larger value can be achieved upon request)
Transmission Efficiency	~90%

### Focal Size and Working Distance

The focus size is dependent on working distance (optic to sample). Currently achievable spot sizes are down to 0.2  $\mu\text{m}$  (see table on right), and continuous improvements in reducing focus size are ongoing.

### Focus (FWHM) as a Function of Working Distance

*As of September 2016*

Working Distance (mm)	2	5	10	20	30
Focus ( $\mu\text{m}$ )	0.2	0.4	0.6	0.8	1.5

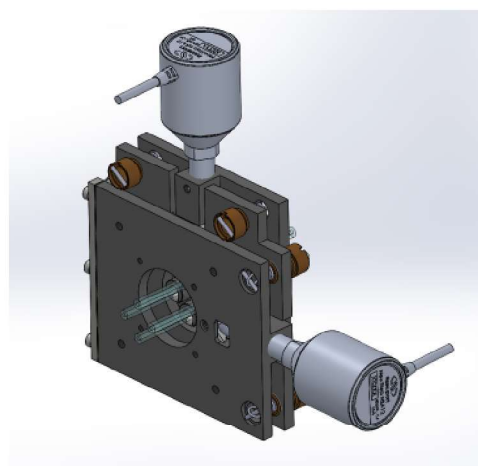


# Breakthrough X-ray Optic Advantages

The choice of x-ray optics for high resolution, microns-scale imaging has typically been limited to Kirkpatrick-Baez (KB) mirrors or zoneplates (ZP).

## Advantages over KB Mirrors

Advantage	Technical Parameters and Details
Higher Numerical Aperture and Flux	>2X the numerical aperture for <b>&gt;4-7X the flux of a KB mirror</b>
Improved Beamline Design	Short working distances for large demagnification of the source (allows shorter, more cost-effective beamline development) and no off-axis beam deflection  Allows multiple lenses within a single beamline (see right)
Soft X-ray Capabilities	Single reflection provides superior performance for low energy x-rays
Coherence Preservation	Preserves coherence for FELs
Flexible Experimental Design	Compact and lightweight form factor enables scanning of the x-ray optic (instead of the sample) and easier alignment



Multiple mirror lenses can be used in a single beamline to optimize for different applications. Shown is an optional tip-tilt stage available for purchase, with each optic designed with different parameters (e.g. energy, convergence angle, spot size, working distance, etc)

## Advantages over Zoneplates

Advantage	Technical Parameters and Details
Substantially Larger Numerical Aperture	Equivalent to a 4 nm zoneplate
Achromatic	Simplifies many microbeam applications and is essential for spectroscopy
Higher Flux & Efficiency	>100X Flux due to high efficiency & larger numerical aperture

Interested? Go to [www.sigray.com/optics-proposal-request](http://www.sigray.com/optics-proposal-request) to enter your beamline details and we will design a custom solution.