

# The State of the art in X-ray optics — the FOX family of ellipsoidal single reflection optics

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## XENOCS supplies :


- innovative X-ray multilayer optics
- X-ray beam delivery solutions



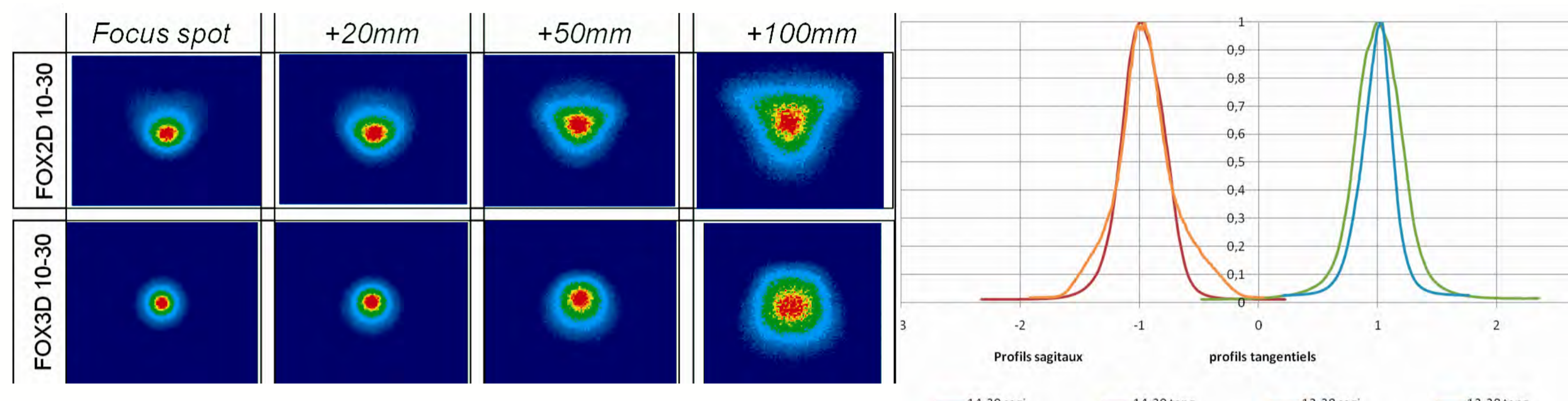
## Applications presently covered :

- Protein Crystallography
- Small Molecule
- SAXS
- High Resolution
- High pressure diffraction
- Powder diffraction
- And many others ...

## FOX3D product range

	Applications	Typical Flux [photons/sec]	Focal Spot Size FWHM [μm <sup>2</sup> ]	Divergence	Brightness 10 <sup>6</sup> [mrad <sup>-2</sup> mm <sup>-2</sup> sec <sup>-1</sup> ]
<b>FOX3D CU 14_39P optic</b> (on a 1,2KW/70 μm source)	Proteomics	> 4.5 10 <sup>9</sup>	230 x 230	5.4 x 5.4 mrad <sup>2</sup>	3000 
<b>FOX3D CU 21_21HC optic</b> (on a 50W/50 μm source)	XRR Microdiffraction	> 440 10 <sup>6</sup>	80 x 80	4 x 0.5 deg	113
<b>GeniX CU VHF</b>	Proteomics	> 300 10 <sup>6</sup>	200 x 200	5.4 x 5.4 mrad <sup>2</sup>	257
<b>GeniX CU Low Divergence</b>	SAXS, WAXS	> 150 10 <sup>6</sup>	NA	0.8 X 0.8 mrad <sup>2</sup>	105

## Superior focussing properties of 3D optics



Comparison of the beam profile at different points along beam path for FOX3D and FOX2D optics (simulation)

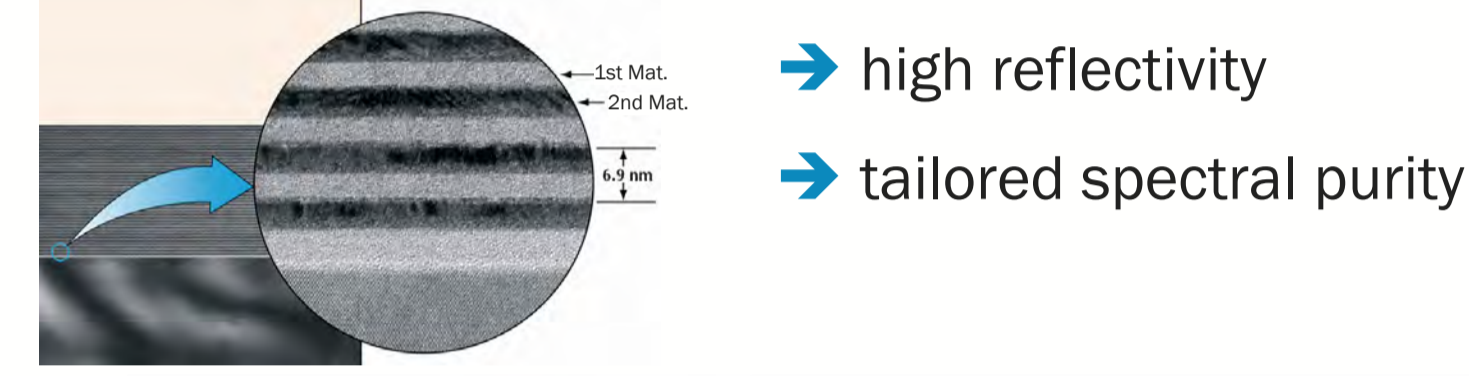
Intensity profiles FOX3D vs FOX2D

### Benefits:

- smaller spot size for equivalent magnification
- higher flux density
- shaper beam profile (background reduction)

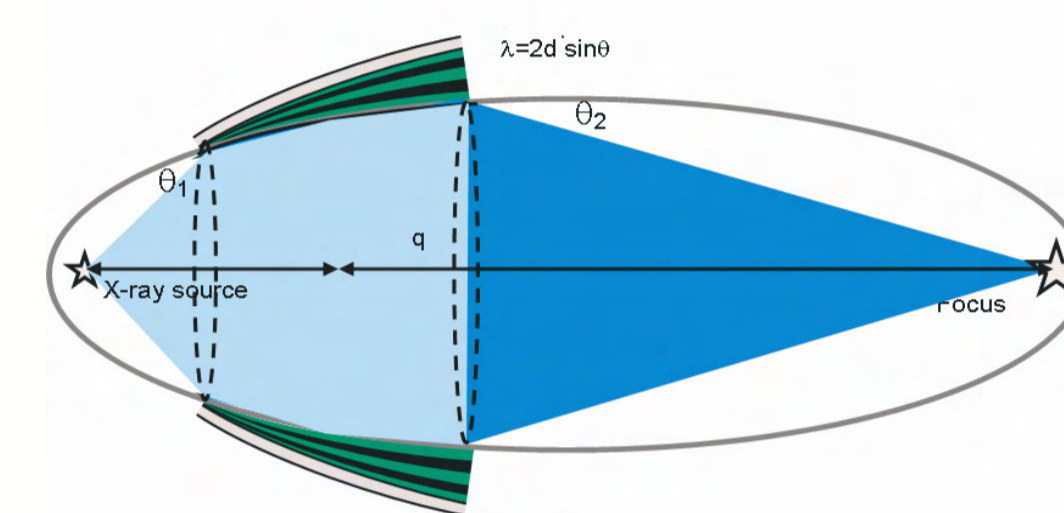
## Increased collecting power

### X-ray multilayer coatings

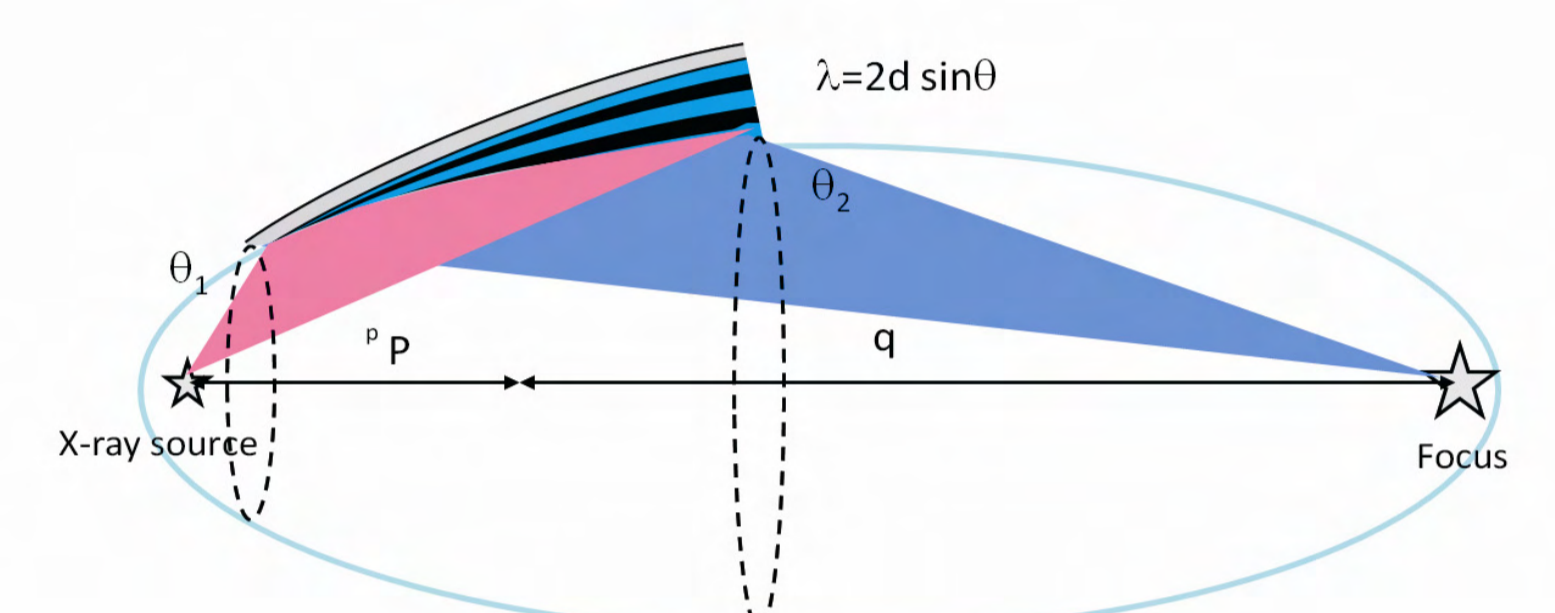


### X-ray multilayer coatings

- ➔ larger collection angles
- ➔ single reflection optics

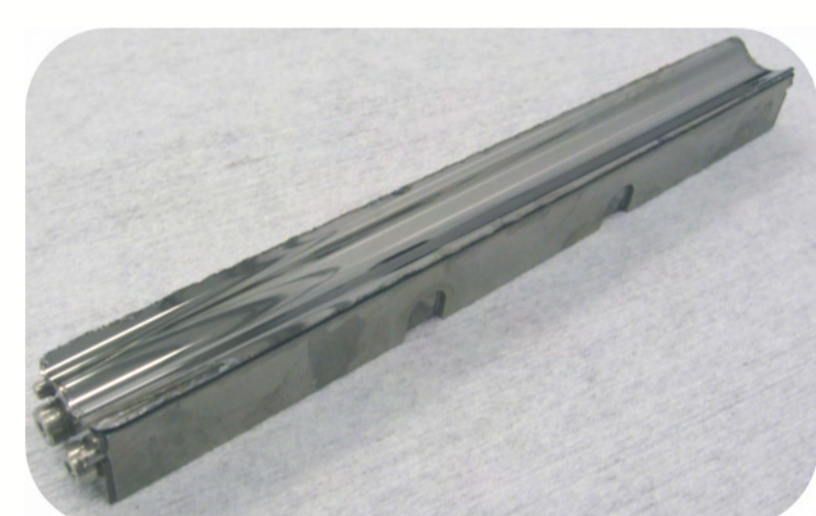


Increased collection angle in saggital plane



Increased collection angle in meridional plane

## FOX3D Optics in Single Crystal



- Flux Improvement : ➔ 1.5x - 2.5x / 2D 12-38 depending on sample size
- Shape Improvement

Data courtesy of Magali Mathieu and Valérie Steier, Sanofi Aventis, Vitry France

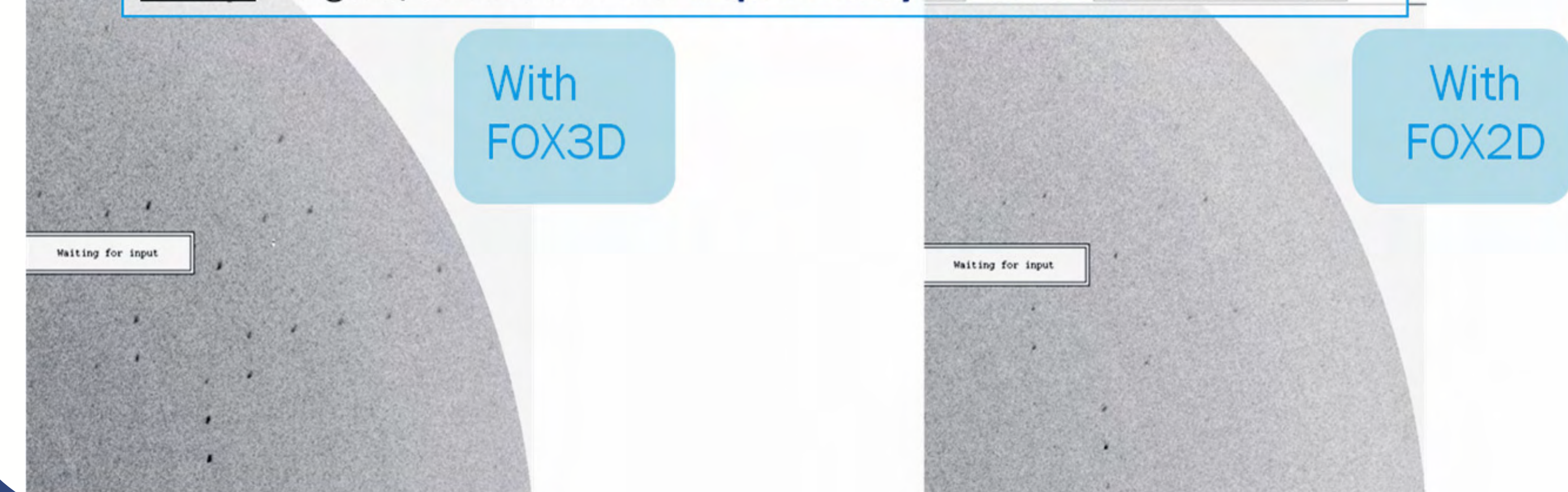


Crystal B: 300*60*5μm <sup>3</sup>	FOX2D CU 12_38P			FOX3D CU 14_39P		
	Overall	InnerShell	OuterShell	Overall	InnerShell	OuterShell
Low resolution limit	42.41	42.41	3.27	24.49	24.49	3.27
High resolution limit	3.10	9.80	3.10	3.10	9.80	3.10
Rmerge	0.215	0.044	0.770	0.147	0.033	0.446
Rmeas (within I+/-)	0.251	0.051	0.899	0.174	0.039	0.525
Rmeas (all I+ & I-)	0.251	0.051	0.899	0.174	0.039	0.525
Rpim (within I+/-)	0.130	0.027	0.461	0.092	0.021	0.274
Rpim (all I+ & I-)	0.130	0.027	0.461	0.092	0.021	0.274
Fractional partial bias	-0.031	-0.007	-0.056	-0.038	-0.014	-0.023
Total no. of observations	35098	1254	4222	32835	1025	3958
Total number unique	10121	348	1322	9800	320	1250
Mean(I/σd(I))	8.3	51.8	1.7	13.9	78.4	2.4
Completeness	92.9	95.5	83.1	90.9	89.2	80.1
Multiplicity	3.5	3.6	3.2	3.4	3.2	3.2

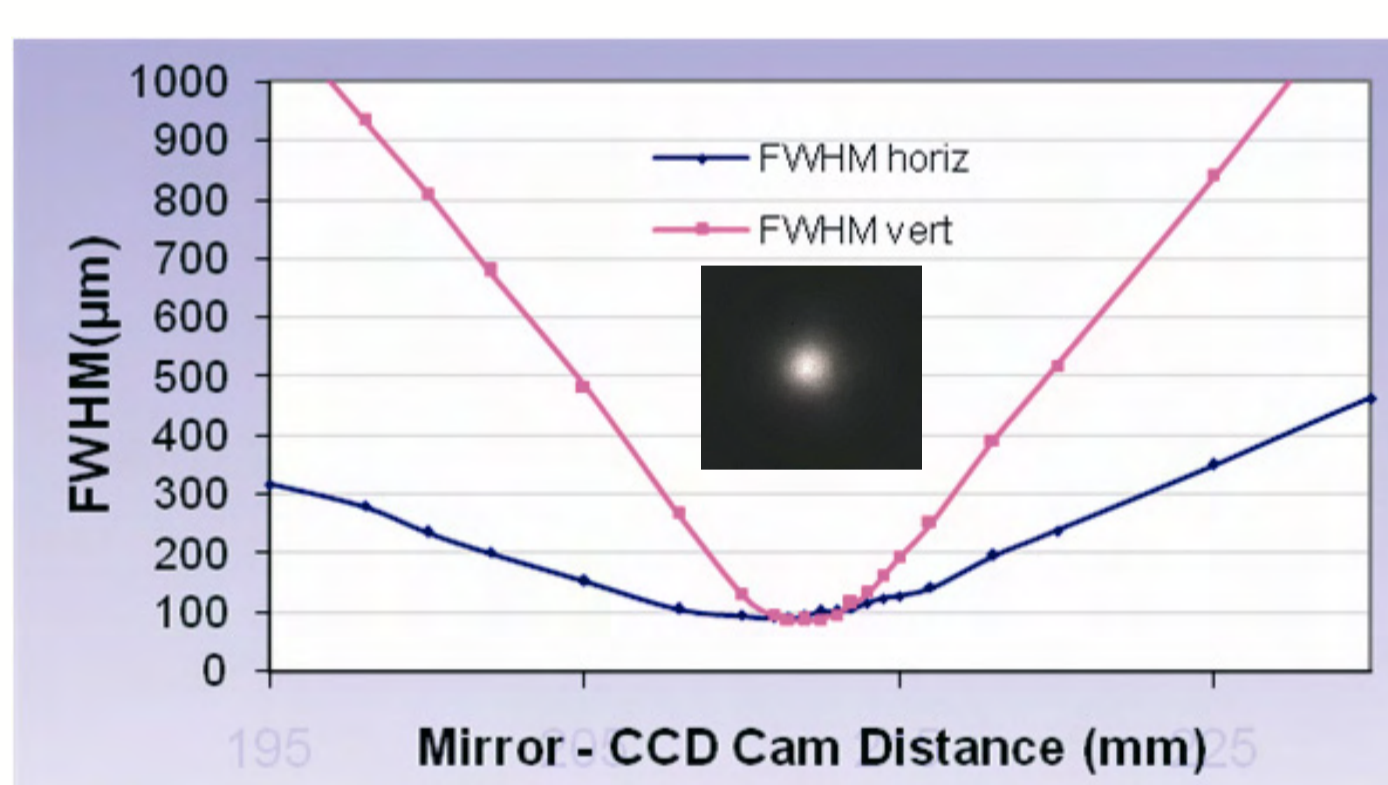
Data is significantly better on the FOX3DCU 14\_39P. Signal/noise ratio has improved 40 to 67% depending on the resolution shell. Data usable to about 3.2Å

Signal/noise ratio has improved by 75 to 130% with FOX3DCU 14\_39P Data usable to about 2.15Å

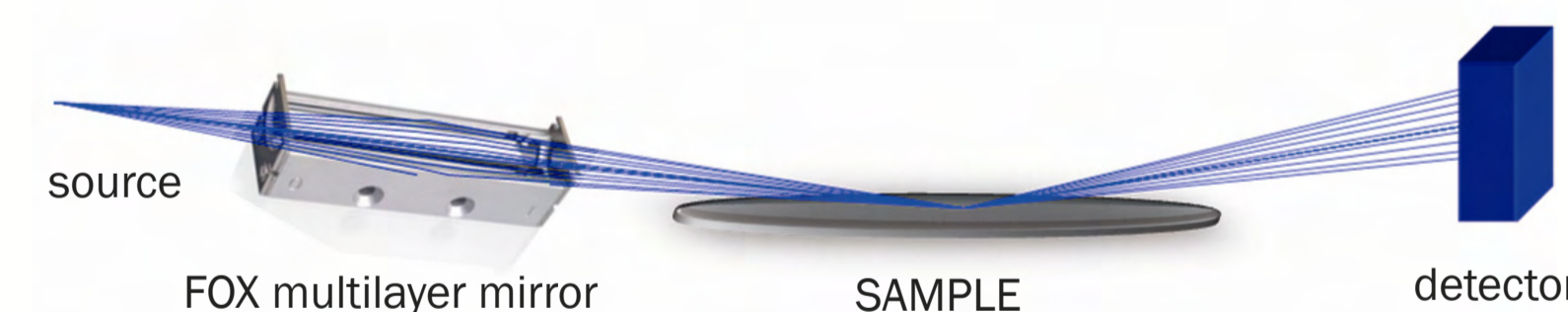
Sanofi: 'Signal/noise ratio has improved by 75 to 130% with FOX3D'



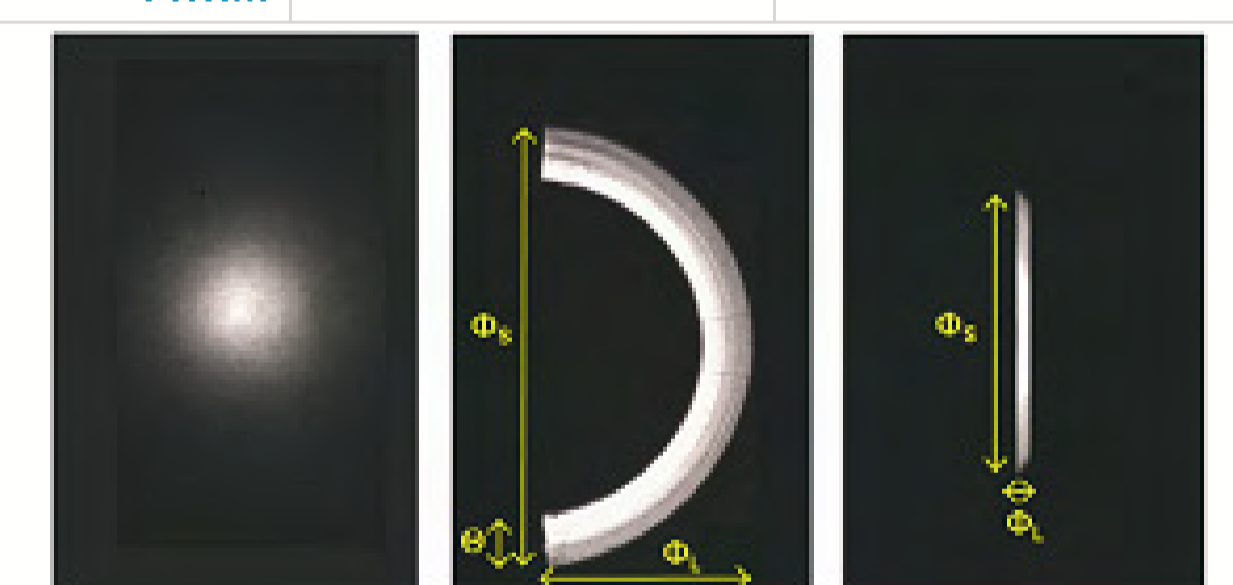
## High Convergence FOX3D (XRR, microdiffraction)



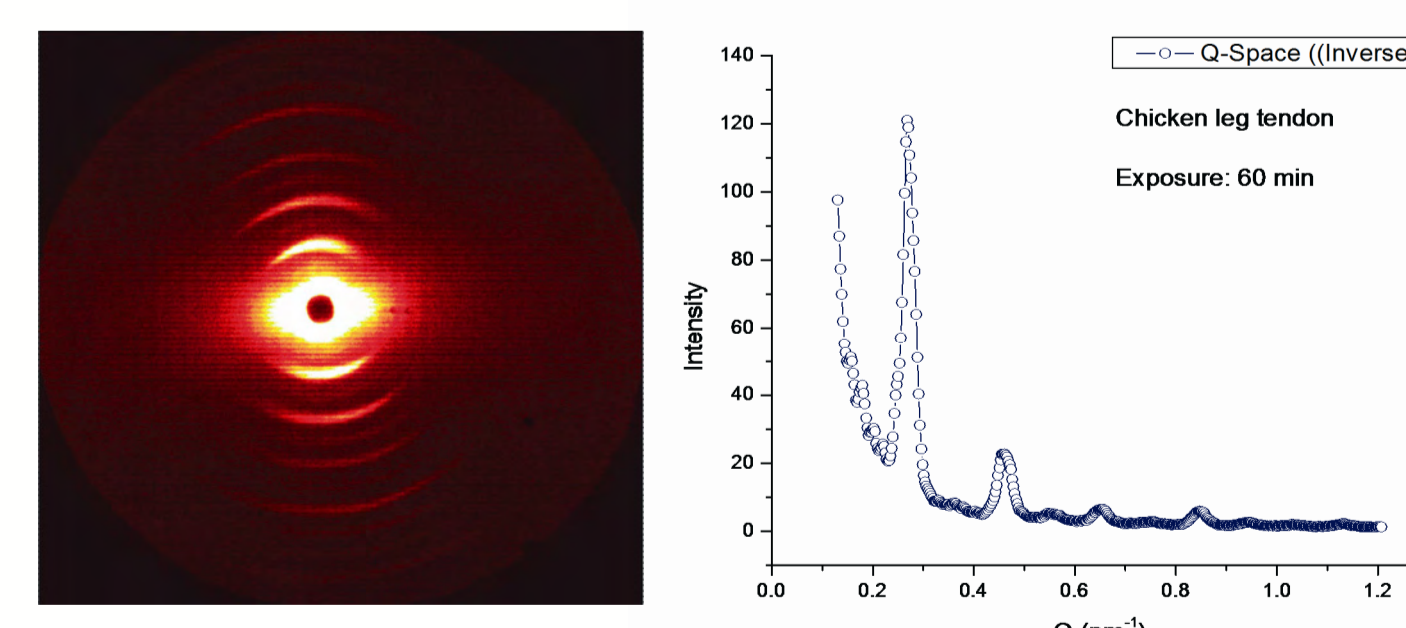
Focusing curves & CCD image of beam profile at focus (inset)



Beam configuration	Full Beam	Slit-limited Beam (customizable)
Typical flux	> 440 x 10 <sup>6</sup> ph/s	> 26 x 10 <sup>6</sup> ph/s
Beam convergence	ΦS ≥ 4 deg ΦL ≥ 2 deg θ = 0.54 deg	ΦS = 2.6 deg ΦL = 0.05 deg
Spot size at focus FWHM	~80 μm	~80 μm



## SAXS: microfocus source + FOX2D optic



SAXS data collected with GeniX-powered SAXS system from a hydrated chicken leg tendon sample.

Key parameters of SAXS setup with GeniX  
Data courtesy of Dr. Youli Li, Univ. of California, Santa Barbara, USA.

Source-to-Sample Distance	1.8 meters
Sample-to-Detector Distance	1.7 meters
Detector	Bruker HI-STAR multiwire
Beam Collimation	3 sets of motorized slits
Qmin*	1.0x10 <sup>-2</sup> Å <sup>-1</sup>
Beam Flux at sample*	1.4 x 10 <sup>7</sup> ph/s

\* Note that a lower Qmin and higher flux can be obtained with further system optimisation.



- FOX3D solutions enable larger collection angles : up to 4 degrees
- FOX3D solutions deliver improved spot and beam shapes
- FOX3D solutions preserve source brightness through its single reflection design

FOX3D optics combined with micro-focus sources deliver a higher flux and flux density onto your samples resulting in greatly improved signal to noise compared to traditional optics.

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