



Optique Peter

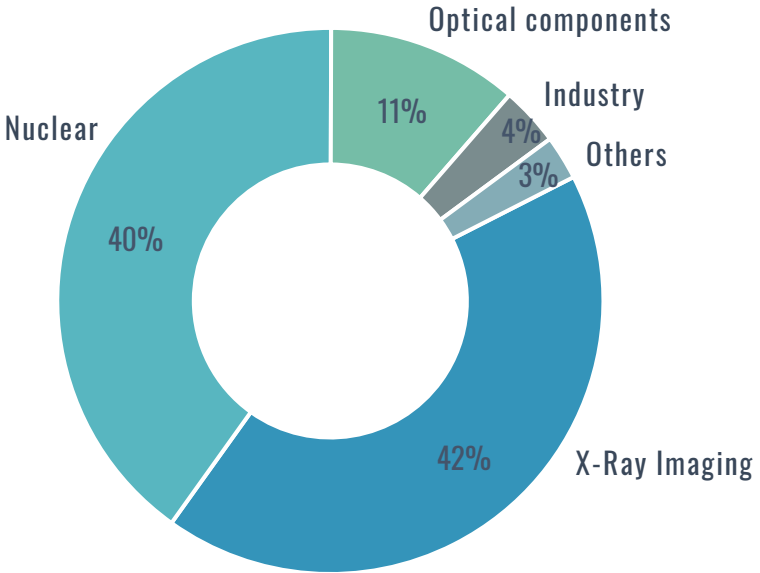
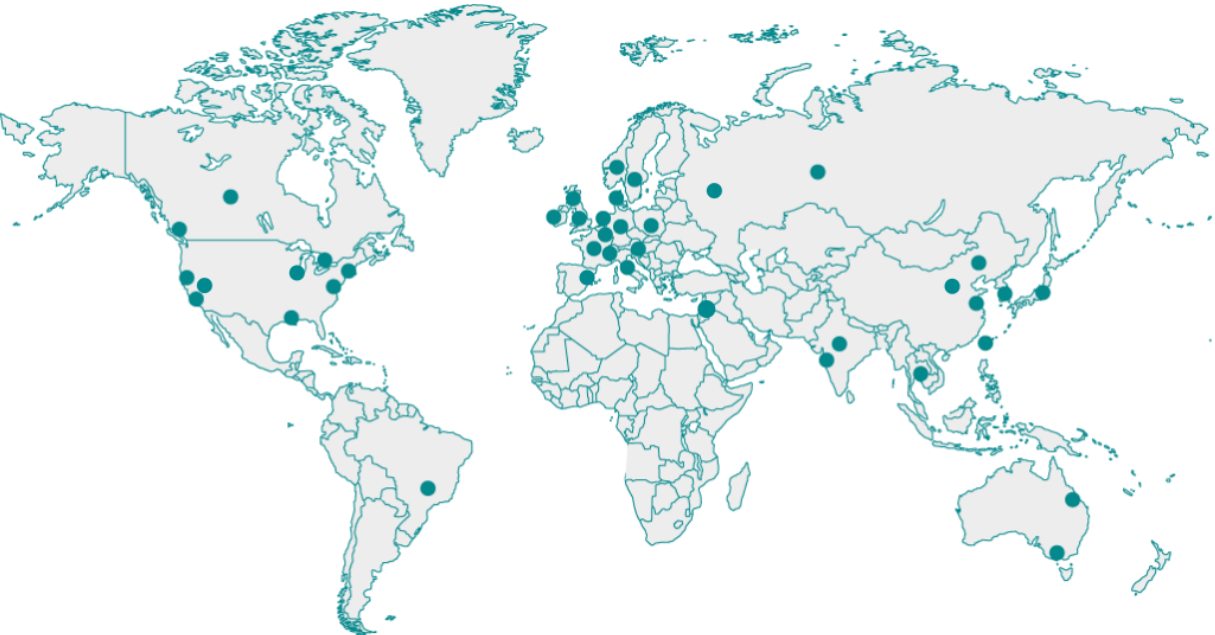
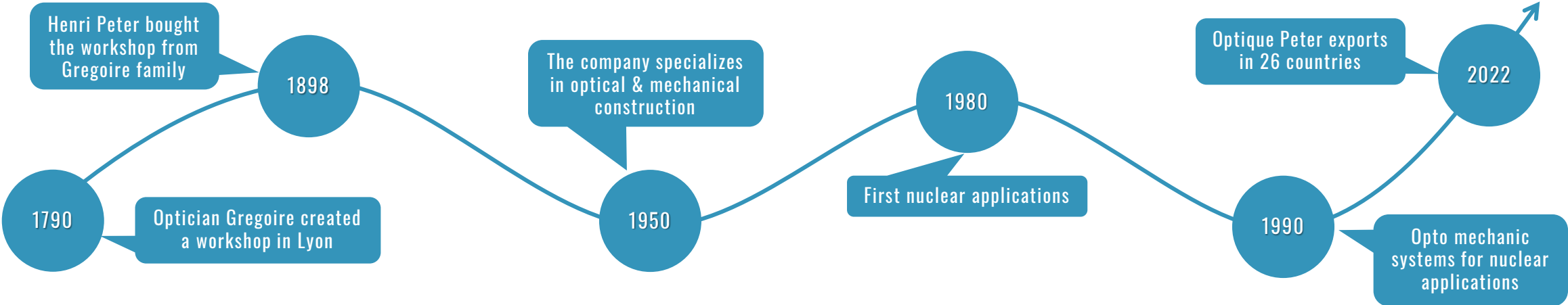
OPTICAL & MECHANICAL ENGINEERING

SRI2021

X-Ray Imaging and Optical Equipment for Synchrotrons



232 years of history



Our References in X-Ray and Neutron Imaging Applications



First Monochromatic Beam microscope delivered to ESRF / ID22 in 1997



First White Beam macroscope delivered to SLS in 2002



First White Beam microscope developed for Scintax project in 2008

101 X-Ray imaging microscopes and macroscopes delivered to 36 research institutes and synchrotrons:



X-Ray Imaging Instruments for Synchrotrons applications

Monochromatic

White Beam

Multiresolution

Zoom Macroscope

Macroscope

Scintillators

Objectives

Video microscope

Spectroscopy



Monochromatic Beam



White Beam

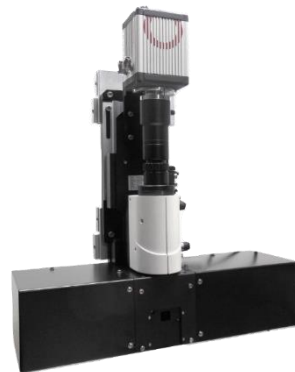
Microscopes



Macroscopes



Low/medium magnification



High magnification



Multi Resolution

Zoom macroscopes

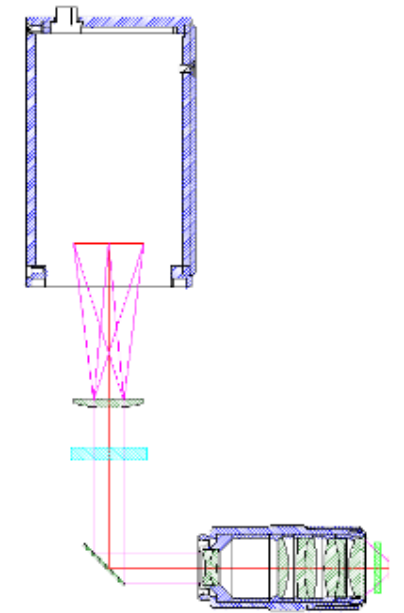


X-Ray imaging optics

X-Ray Imaging Microscopes Monochromatic and White Beam configurations

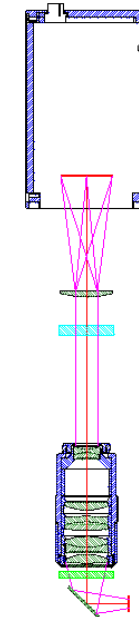
“Monochromatic” configuration

- Objective in line with the X-Ray beam
- High NA/Short working distance objective : Better light collection and better resolution
- BUT : Objectives may brown under high flux / high energy beam
(Some objectives allow the mounting of a lead glass protective window)
- Recommended for low flux/low energies and high resolution experiments



“White beam” configuration

- Objective out of the X-Ray beam (mirror between scintillator and objective)
- Long working distance objective : only backscattered light may brown the objective
- A glass protective window protects the objective against backscattered radiations
- Long working distance objectives have lower NA, thus lower light collection and lower resolution
- Recommended for high flux / high energies experiments



Monochromatic X-Ray Imaging Microscopes



Single objective
Single scintillator



3 objectives / 3 scintillators
Direct imaging



3 objectives / 3 scintillators
Single eyepiece



3 objectives / 3 scintillators
Quadruple eyepieces

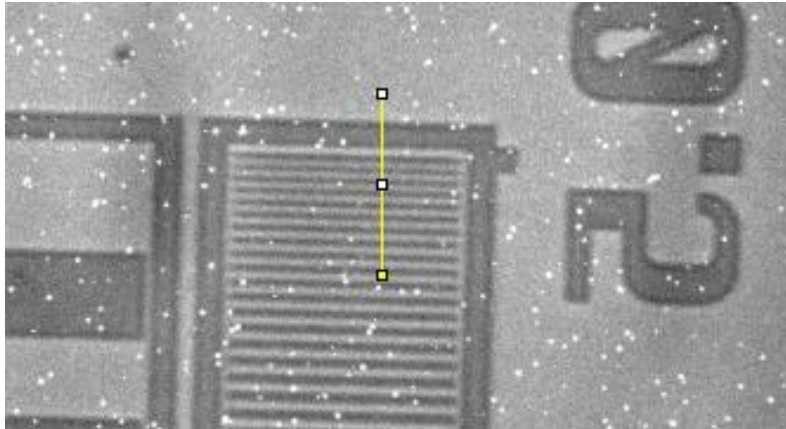


Triple tiltable scintillator support



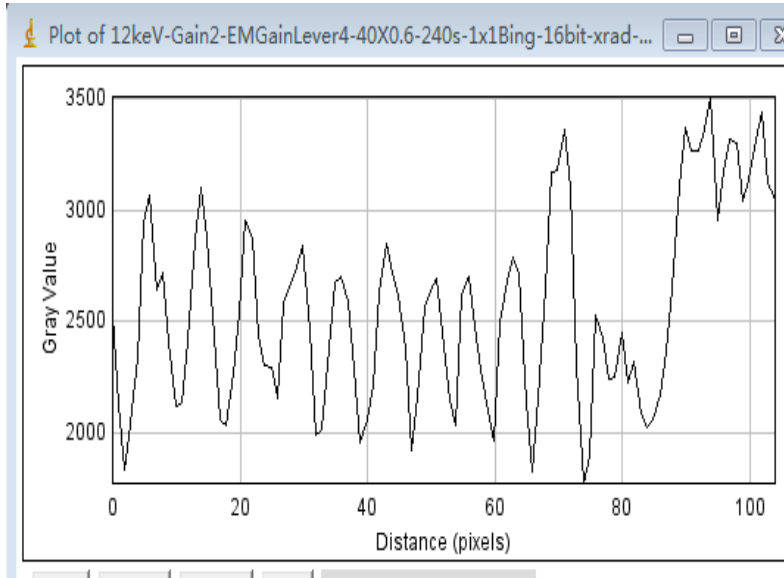
Single tiltable scintillator support

High resolution Monochromatic X-Ray imaging microscopes resolution test



Energy=12KeV 40X NA=0.6

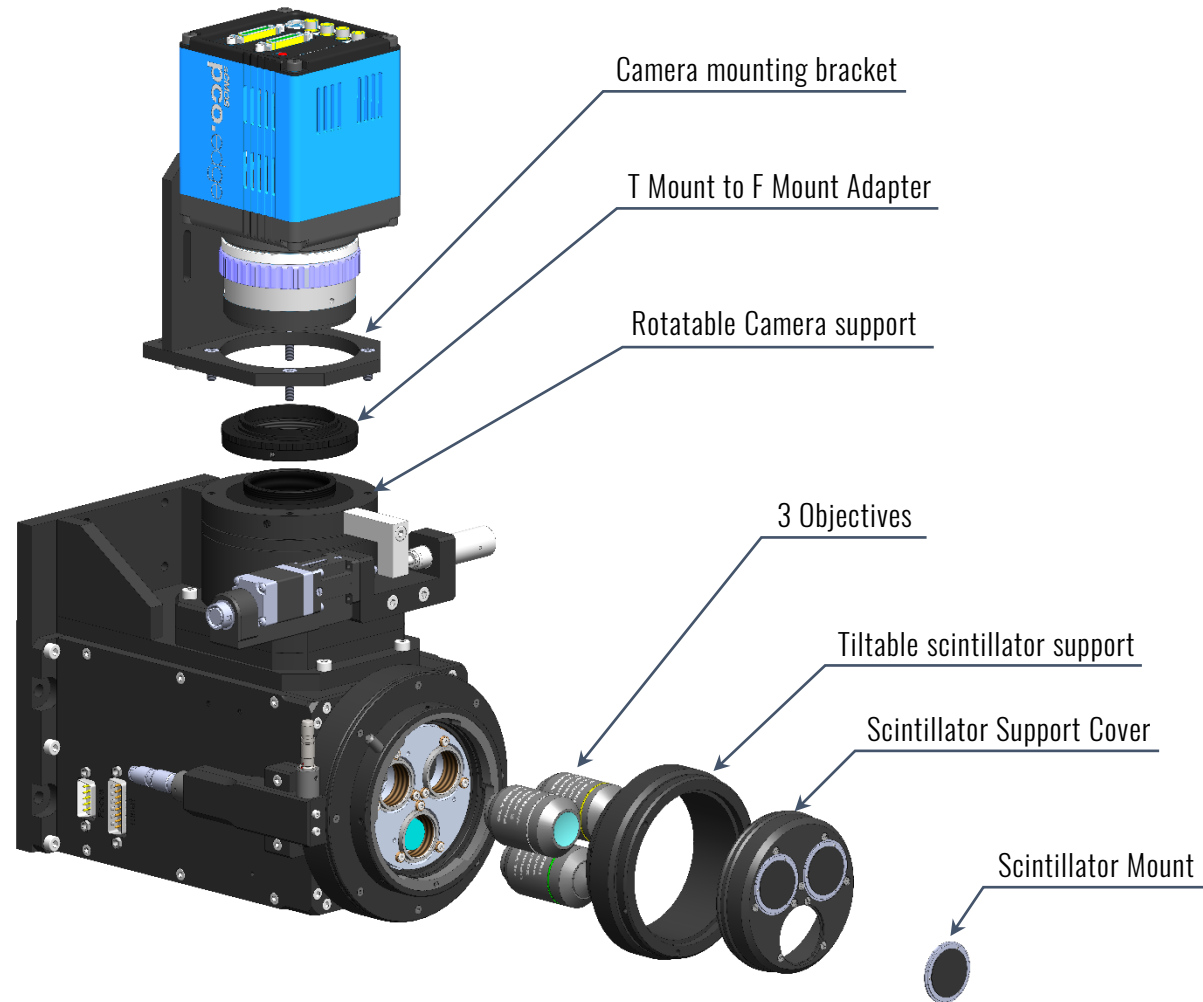
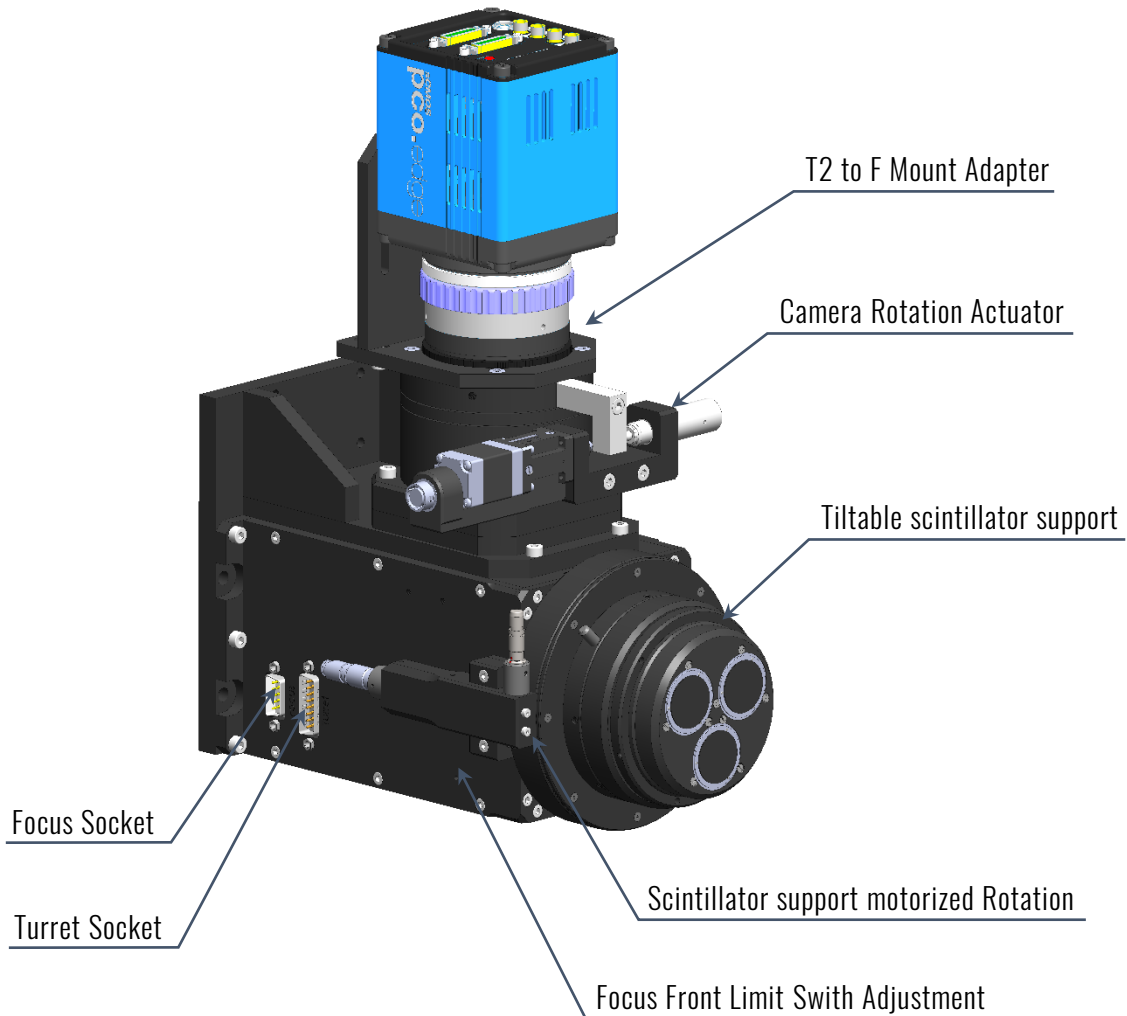
MTF=0.103/0.271=0.380



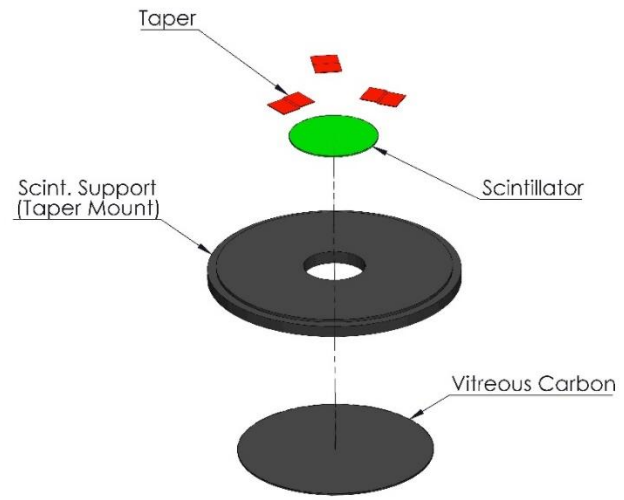
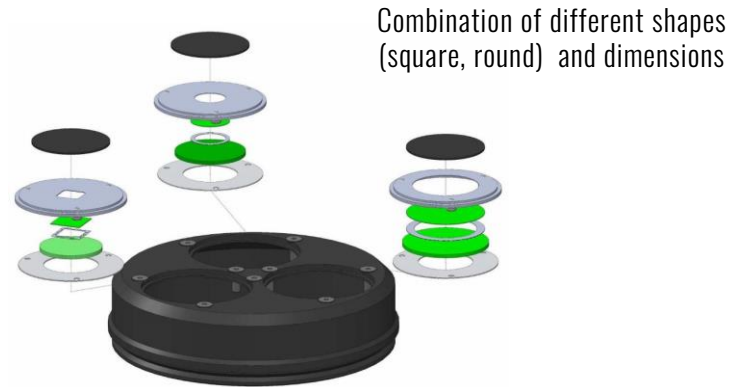
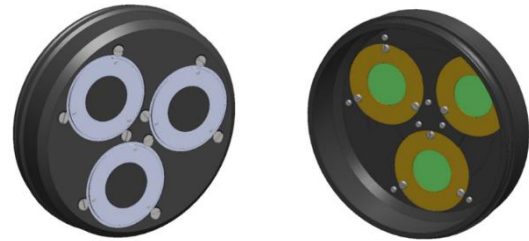
Courtesy IHEP - BSRF
Prof. Li Gang

MONOCHROMATIC X-RAY IMAGING MICROSCOPE

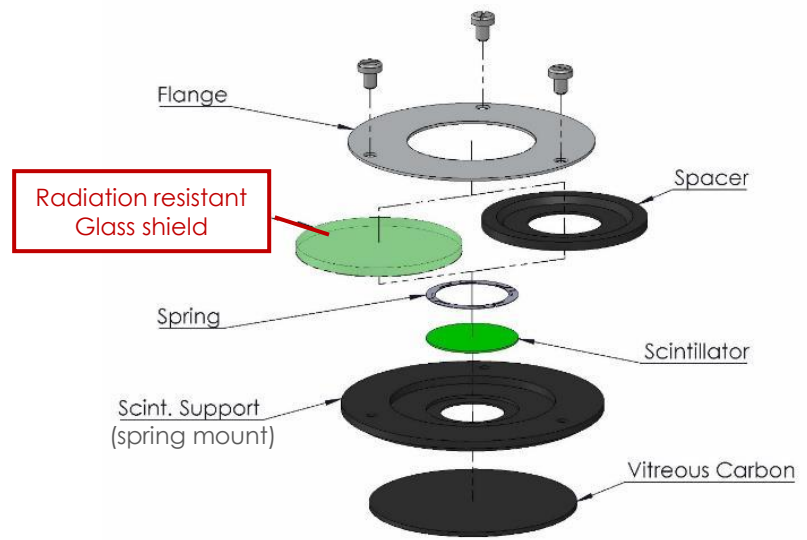
Triple objective – triple scintillator support



Scintillators Supports for Monochromatic Microscopes



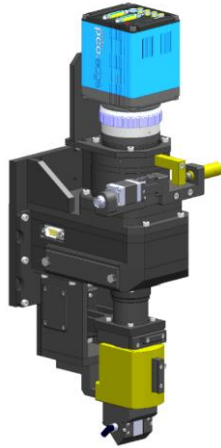
Scintillator taper mounting



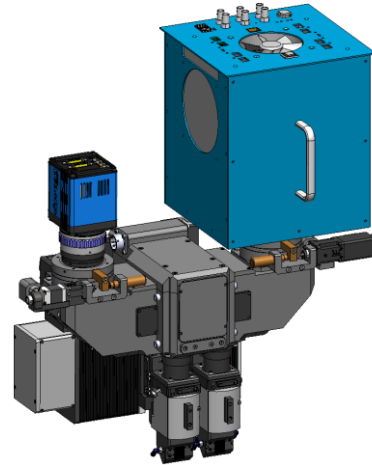
Scintillator spring mounting
With 1 mm thick radiation resistant front glass shield

WHITE BEAM X-RAY IMAGING MICROSCOPES

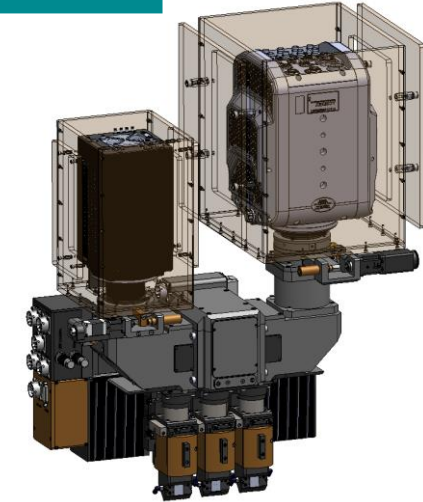
White Beam



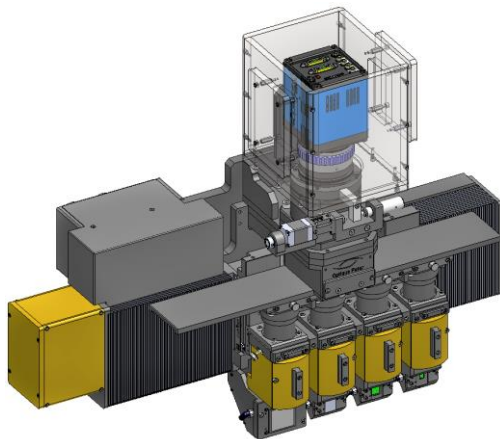
Single objective microscope
With Single Camera



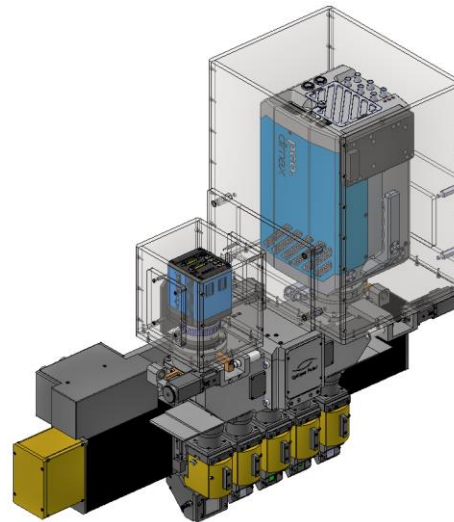
Double objective microscope
With Dual Camera Port



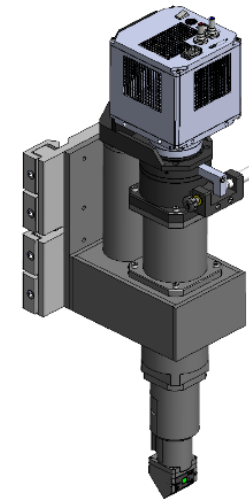
Triple objective microscope
With Dual Camera Port



Quadruple objective microscope
With Single camera



Quintuple objective microscope
With Dual Camera Port

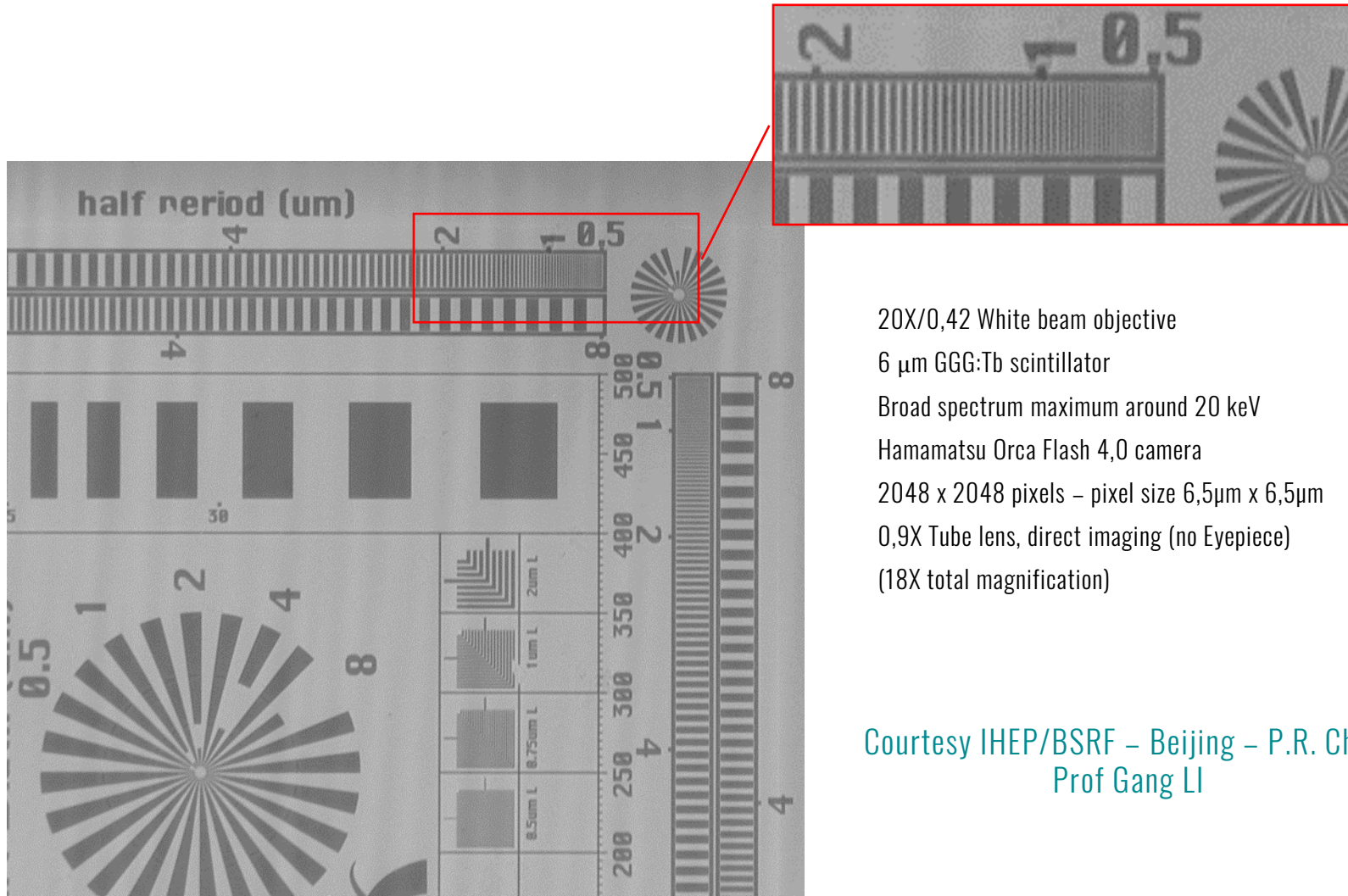


Near Field microscope

High resolution WB X-Ray imaging microscopes

Resolution test for White Beam microscope 20X/0.42 Objective

White Beam

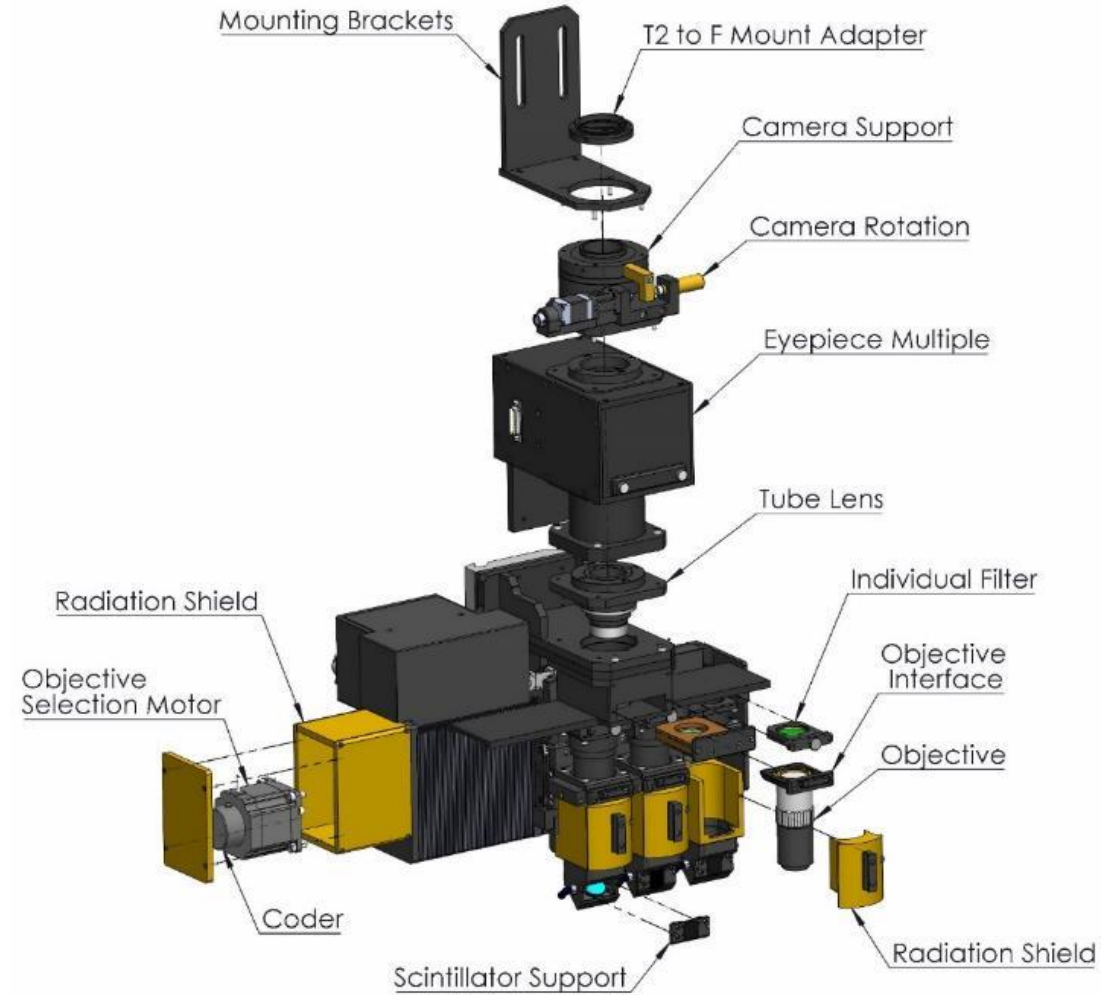
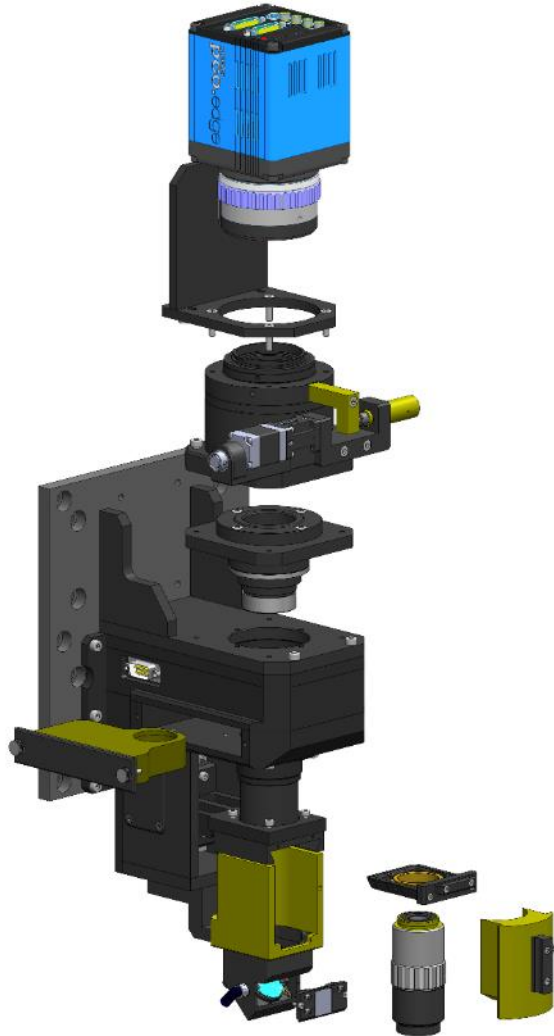


20X/0,42 White beam objective
6 μm GGG:Tb scintillator
Broad spectrum maximum around 20 keV
Hamamatsu Orca Flash 4,0 camera
2048 x 2048 pixels – pixel size 6,5 μm x 6,5 μm
0,9X Tube lens, direct imaging (no Eyepiece)
(18X total magnification)

Courtesy IHEP/BSRF – Beijing – P.R. China
Prof Gang LI

WHITE BEAM X-RAY IMAGING MICROSCOPES

White Beam



WHITE BEAM X-RAY IMAGING MICROSCOPES

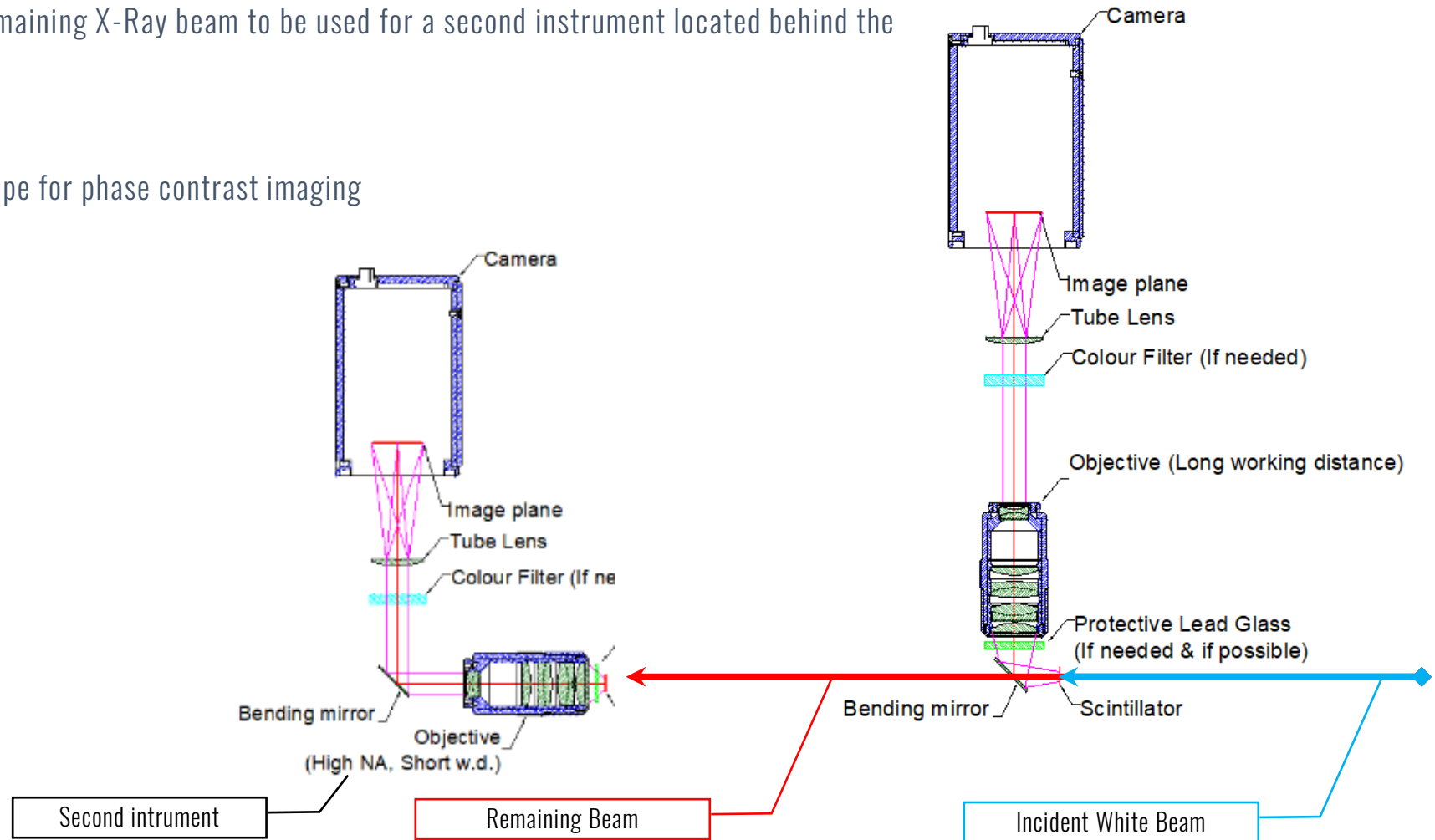
Combined X-Ray imaging with a second instrument

White Beam

The bending mirror between the scintillator and the objective can be made of low Z material (Such as Glassy Carbon)

This allows the remaining X-Ray beam to be used for a second instrument located behind the microscope :

- Diffractometer
- Second microscope for phase contrast imaging
- ...

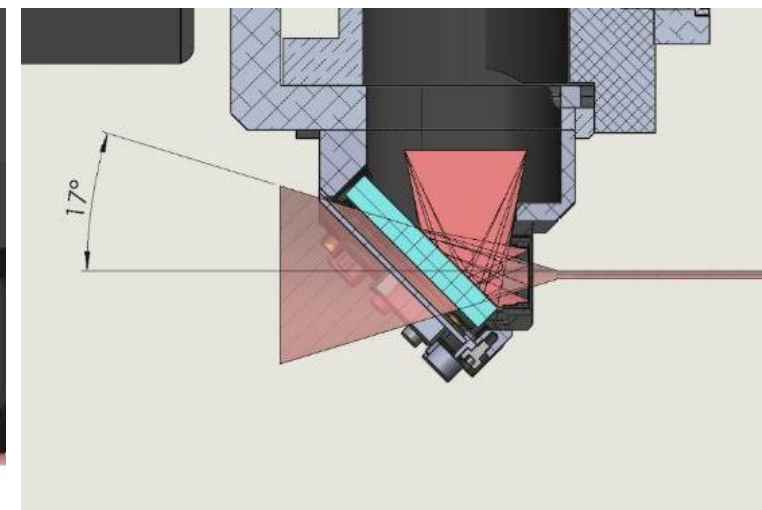
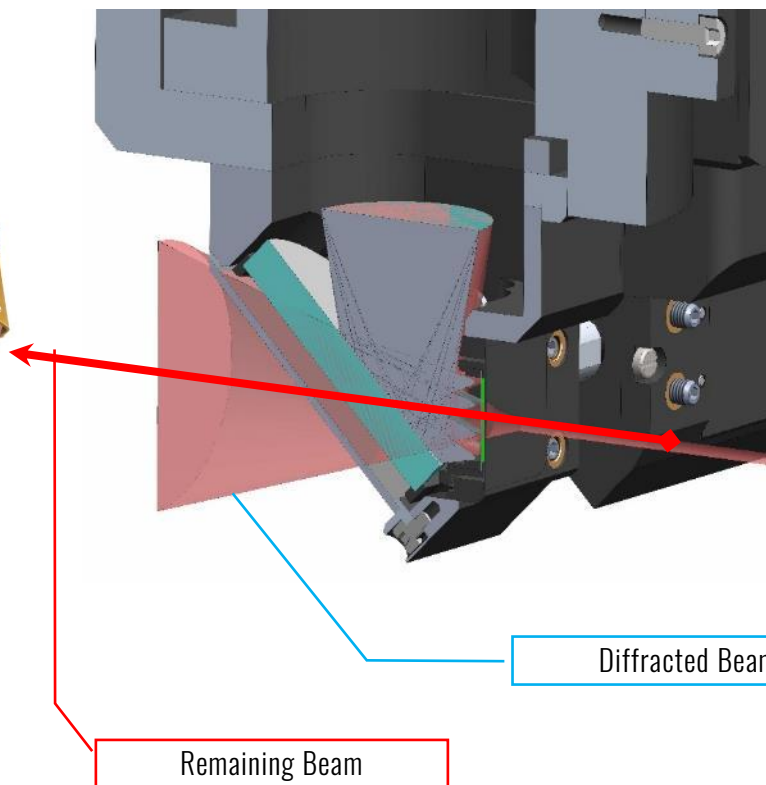
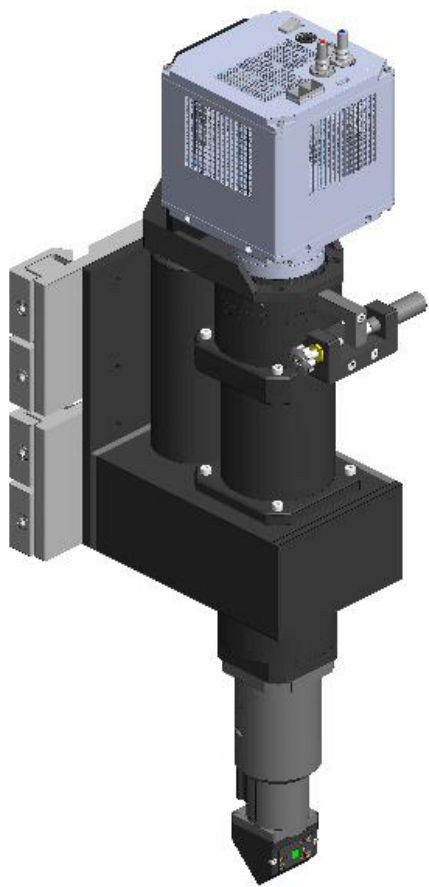


NEAR FIELD WHITE BEAM X-RAY IMAGING MICROSCOPES

White Beam

Near Field White Beam X-Ray imaging microscope :

- Special microscope for 5X/0,14 – HR5X/0,21 – 7,5X/0,21 and 10X/0,28 objectives
- X-Ray semi transparent mirror



Compact scintillator head with X-Ray semi transparent mirror

WHITE BEAM X-RAY IMAGING MICROSCOPES

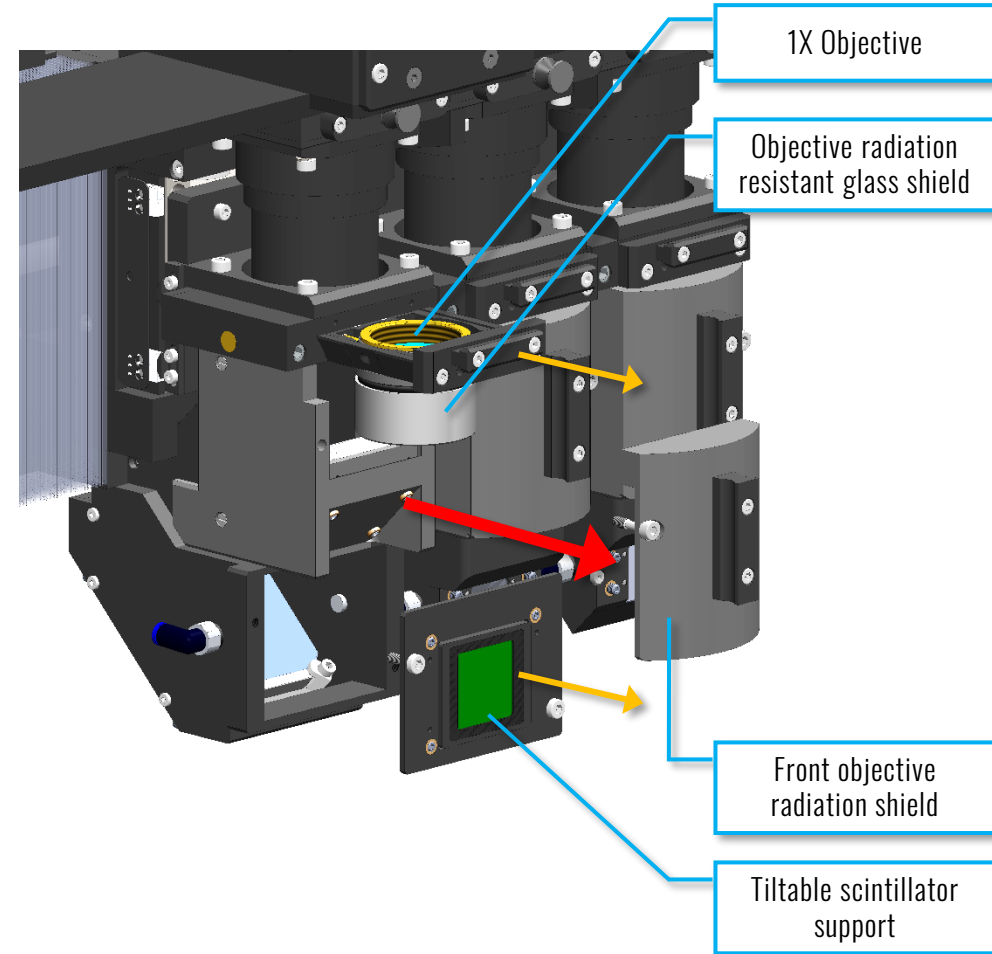
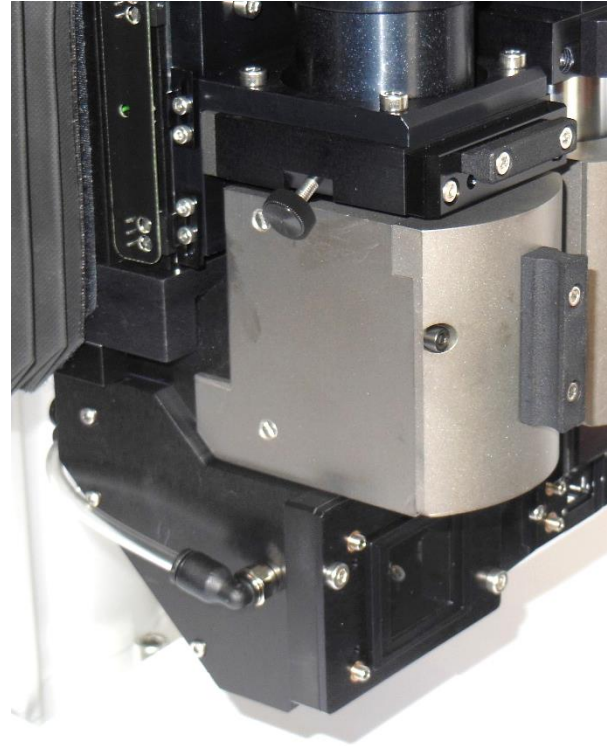
Radiation resistant objectives

White Beam



WHITE BEAM X-RAY IMAGING MICROSCOPES

Very low magnification head



White beam microscope Very low magnification head

- 1X magnification with a F180 mm tube lens
- 1,11X magnification with a F200 mm tube lens
- 1,5X magnification with a F270 mm tube lens

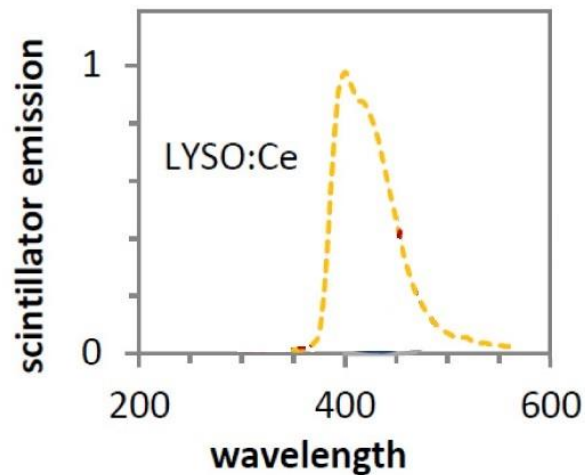
Tiltable scintillator supports

Scintillator size up to H 30 mm x V 27 mm

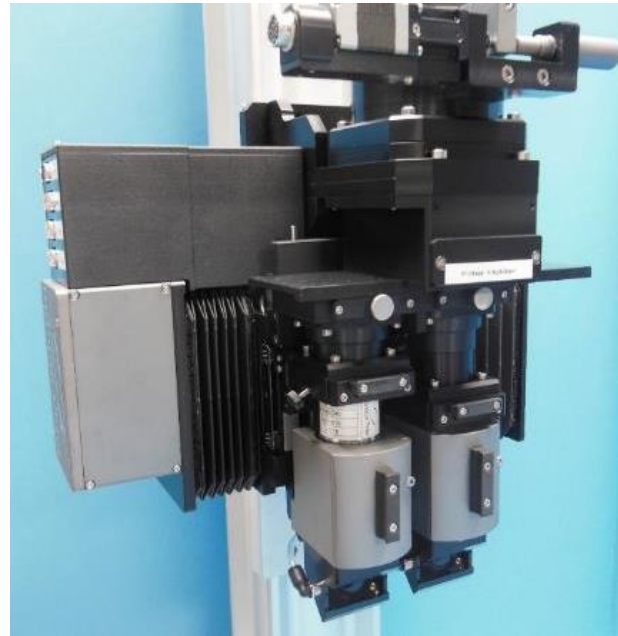
WHITE BEAM MICROSCOPE WITH NEAR UV OPTICS FOR FAST IMAGING

Near ultraviolet (NUV) emitting scintillators spectrum allow very fast X-Ray imaging Push the resolution limit of White beam microscope with NUV optics has been recently manufactured :

- New radiation hardened 10X/0,28 NUV Objective
- New NUV Tube Lens adapted to fast imaging large detector (up to 39 mm detector diagonal)
- One million images/s reached at ESRF – ID19



NUV emitting LYSO:Ce scintillator
Short decay time
Limited afterglow



NUV White Beam
Double objective microscope

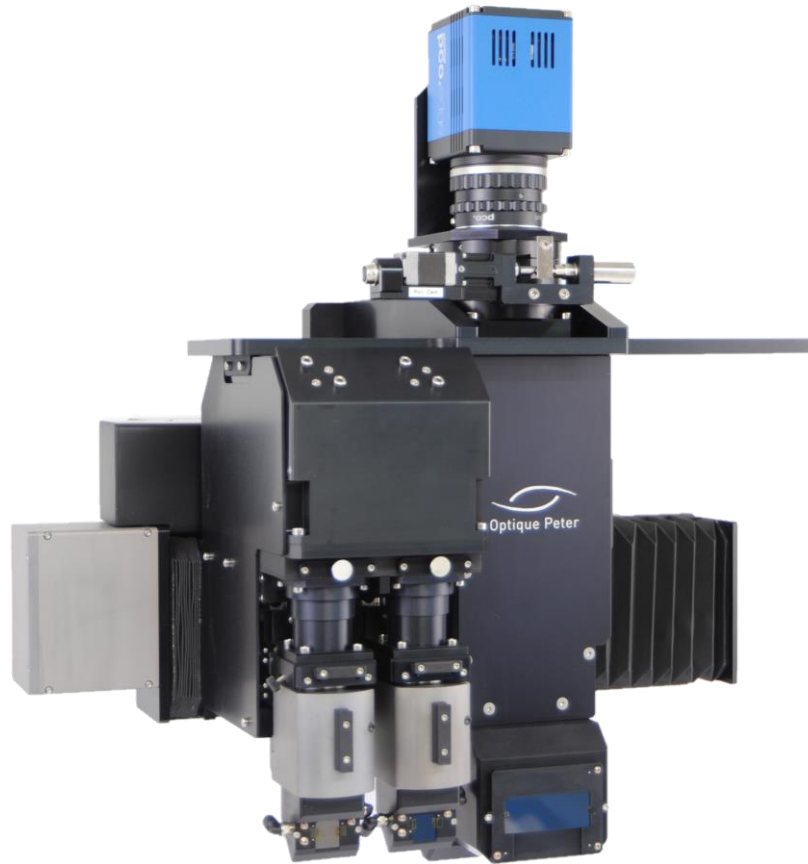


NUV White Beam
Single objective microscope
1 Million i/s with Shimadzu HPV-X camera
ESRF-ID19

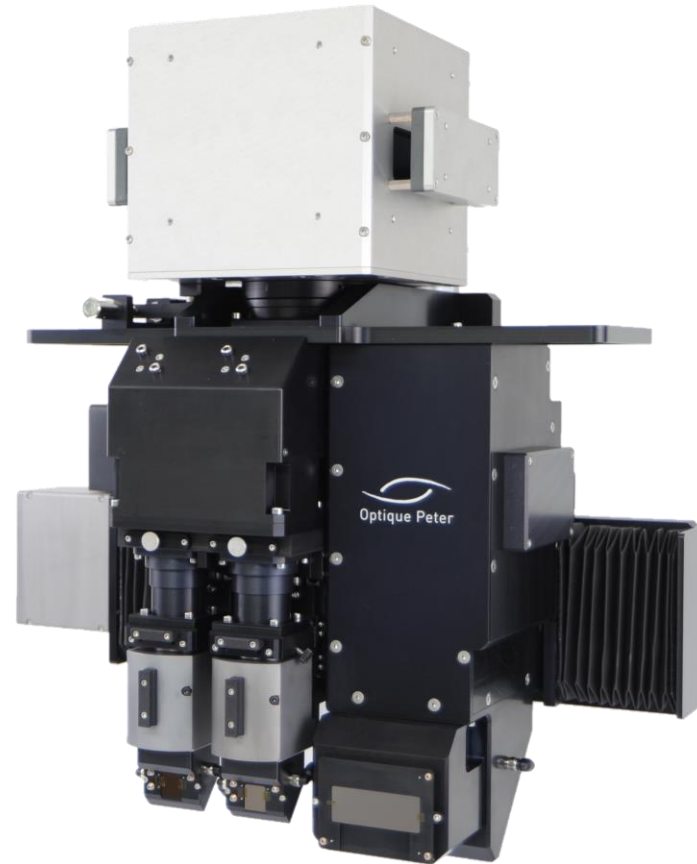
Courtesy Dr. Alexander Rack

X-Ray imaging Multiresolution Zoom/Microscope

Multiresolution



Two microscope heads
For White beam Objectives
2X to 40X magnification
Motorized focus



Zoom macroscope
Magnification range from 0,285X to 1,8X
up to 50 mm x 50 mm Filed of view
Motorized zoom & focus

Camera interface with
motorized rotation
Camera X-Ray shielded box

X-Ray imaging Zoom Macroscopes

Zoom Macroscope



Zoom macroscope
With double camera stage



Zoom macroscopes
Quadruple scintillator support
For 0,5x – 0,8x and 1x objectives



Zoom macroscopes
Quadruple scintillator support
For 2x objective

X-Ray imaging Macroscopes



Low magnification macroscopes

For large format cameras
Up to 250 mm field of view
Motorised focus & magnification



4X/0.35 very high resolution microscope

For large format camera (44 mm detector)
Motorised focus & diaphragm
Detector up to 44mm



High resolution macroscopes

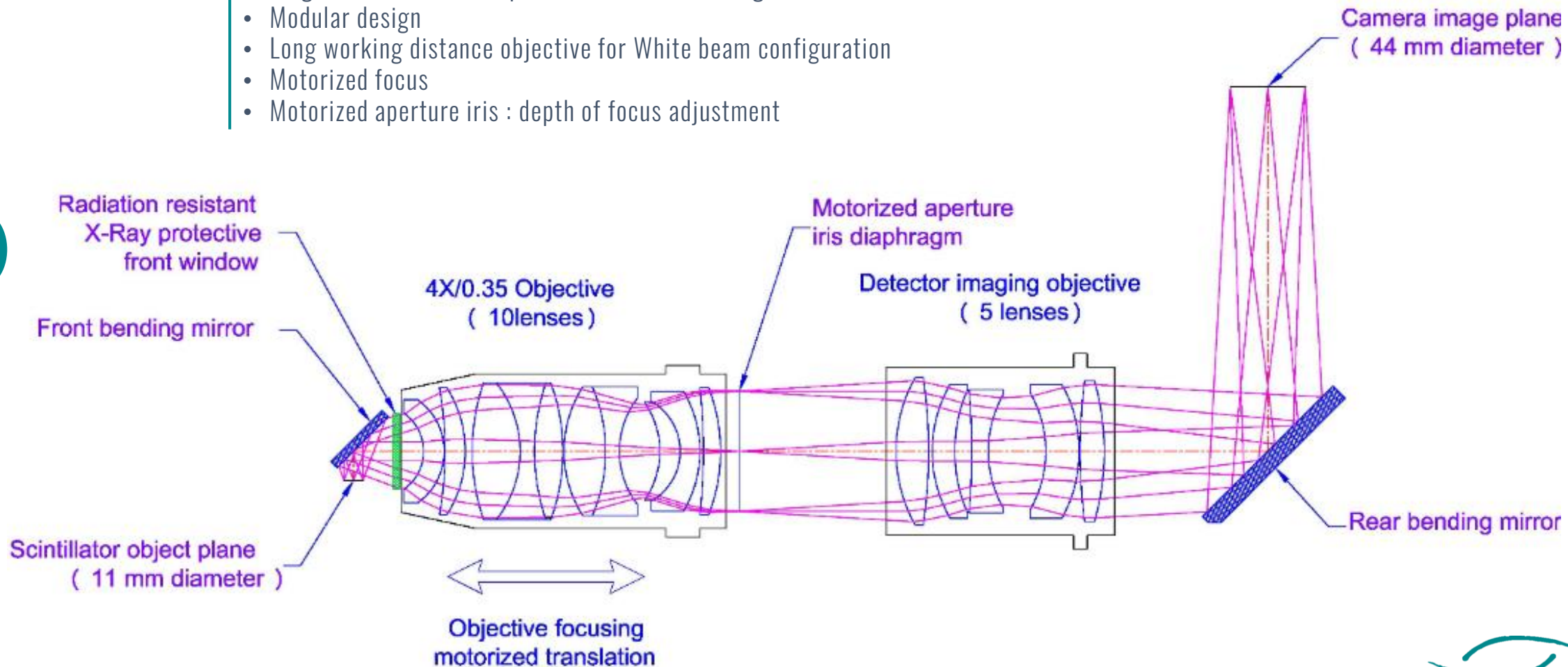
For large detector camera
(up to 89 mm detector diagonal)
Motorised focus/camera rotation

Macroscope

WHITE BEAM X-RAY IMAGING MACROSCOPE 4X/0.35 - Very high resolution - Very high NA

Pushing the performances to the limit

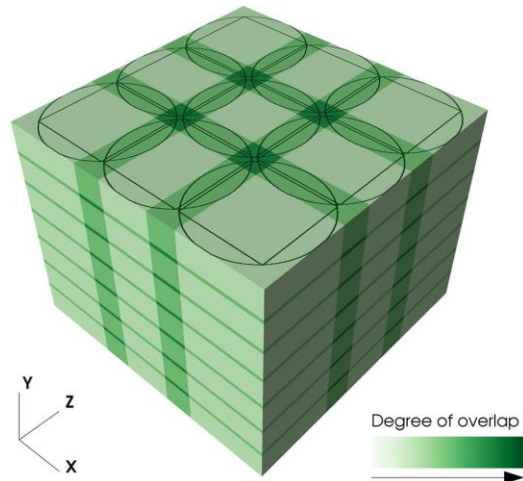
- Higher NA : 0,35
- Large camera format : up to 44 mm detector diagonal
- Modular design
- Long working distance objective for White beam configuration
- Motorized focus
- Motorized aperture iris : depth of focus adjustment



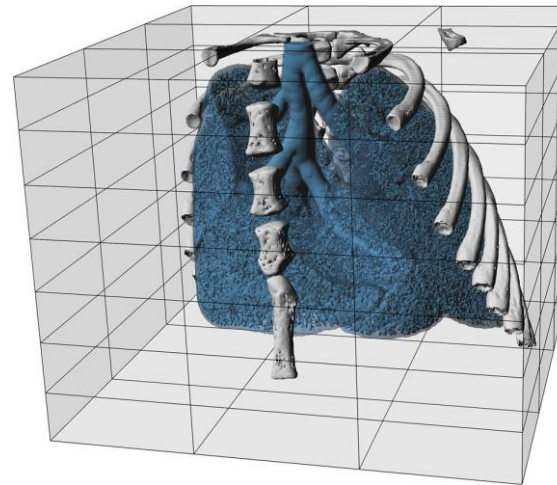
WHITE BEAM X-RAY IMAGING MACROSCOPE

Micrometer-resolution X-ray tomographic full-volume reconstruction of an intact post-mortem juvenile rat lung

Borisova et al - Histochemistry and Cell Biology - <https://doi.org/10.1007/s00418-020-01868-8>

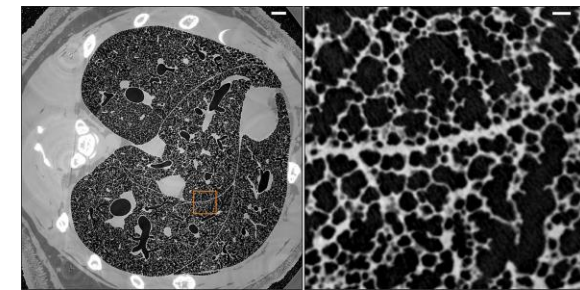


Data acquisition
3x3x7 tiles



Volume view of the full data set
 $9095 \times 9106 \times 7084$ voxels
 $25.0 \times 25.0 \times 19.5$ mm³.

horizontal slice through the final stitched dataset



18.9 x 18.9 mm²

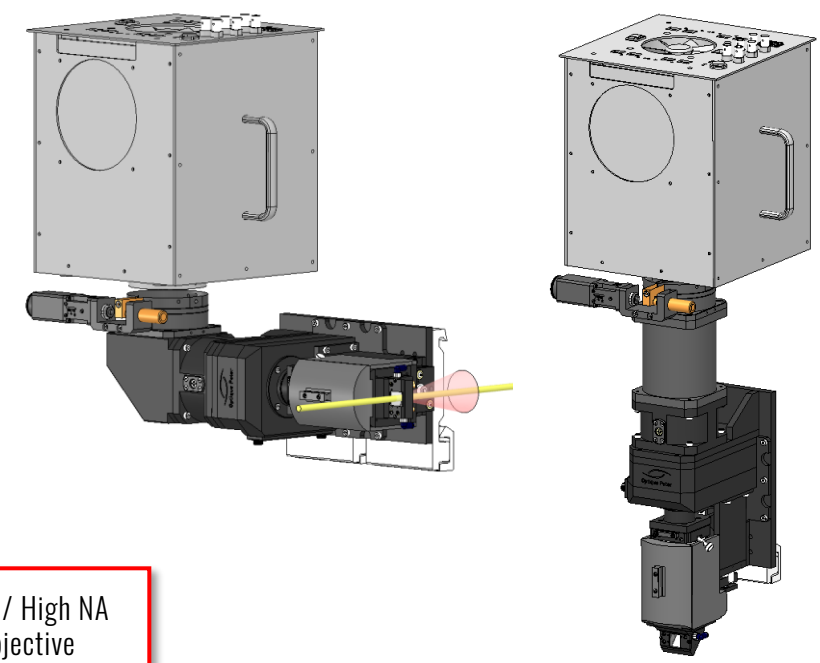
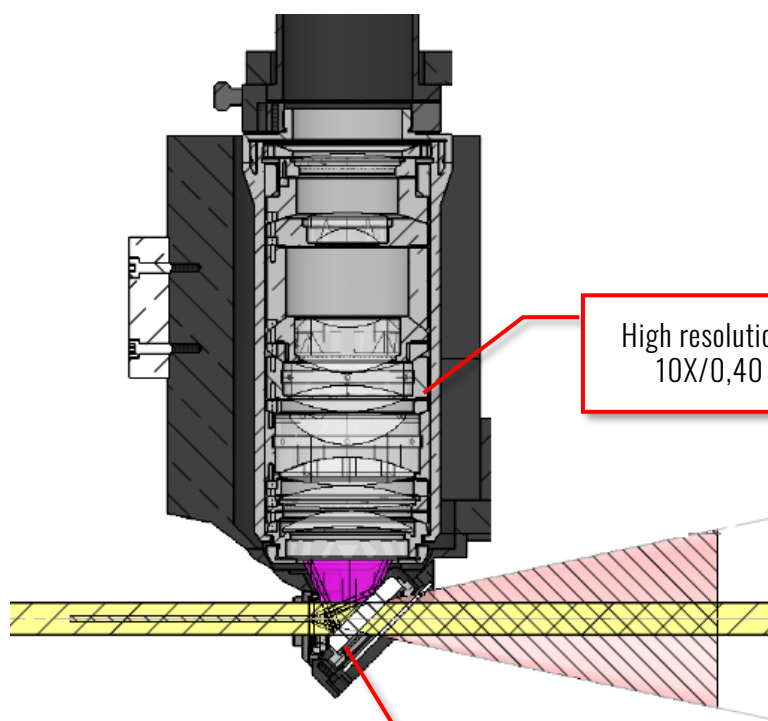
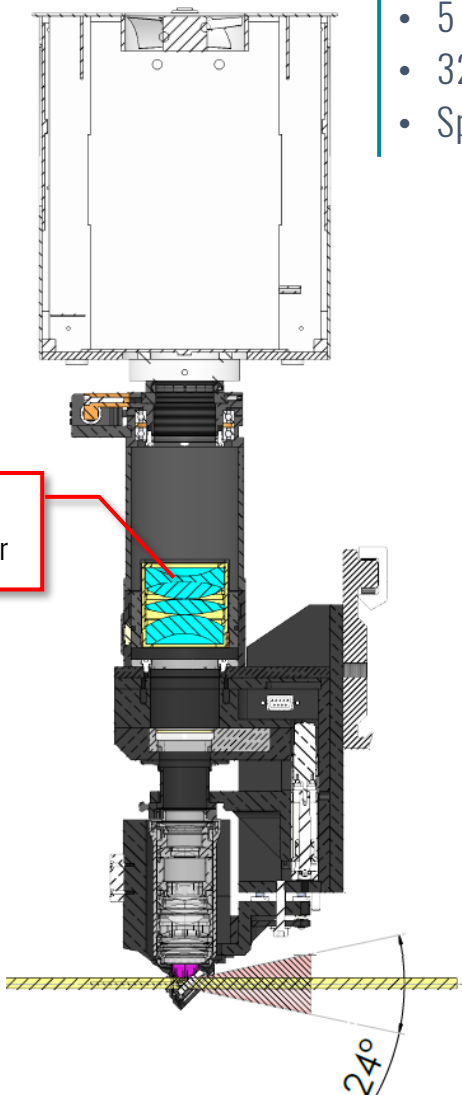
1.5 x 1.5 mm²

- Tomography carried out at the TOMCAT beamline X02DA of the Swiss Light Source (SLS) facility
- 150 μ m thick LuAG:Ce scintillator
 - 4X/0.35 X-Ray imaging microscope from Optique Peter
 - GigaFRoST High speed imaging and readout system

High-resolution tomographic data acquisition was completed in under 22 min, which was within the 20-30 min time limit to image soft tissue before structural degrading started to take place

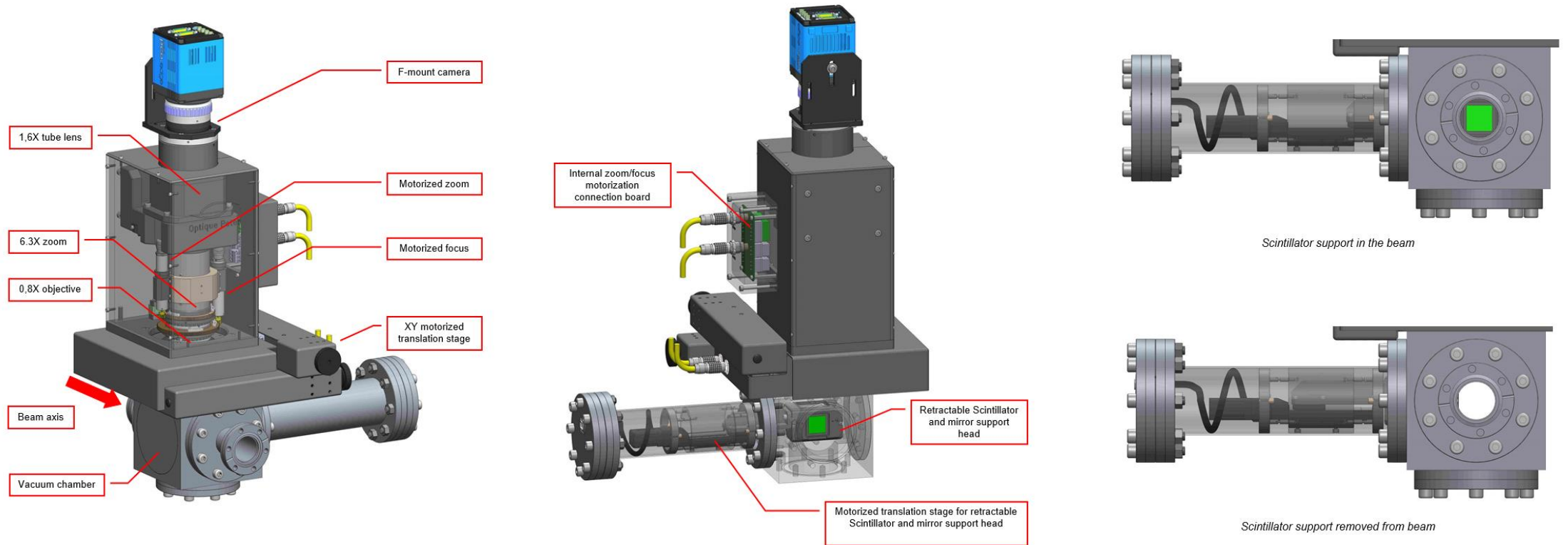
NEW ! 10X/0,40 objective for WHITE BEAM X-RAY IMAGING MICROSCOPES

- High resolution / High NA 10X/0,40 objective
- 5 mm front radiation resistant glass protection
- 32 mm image diameter
- Special head for single or multiple objective WB microscope

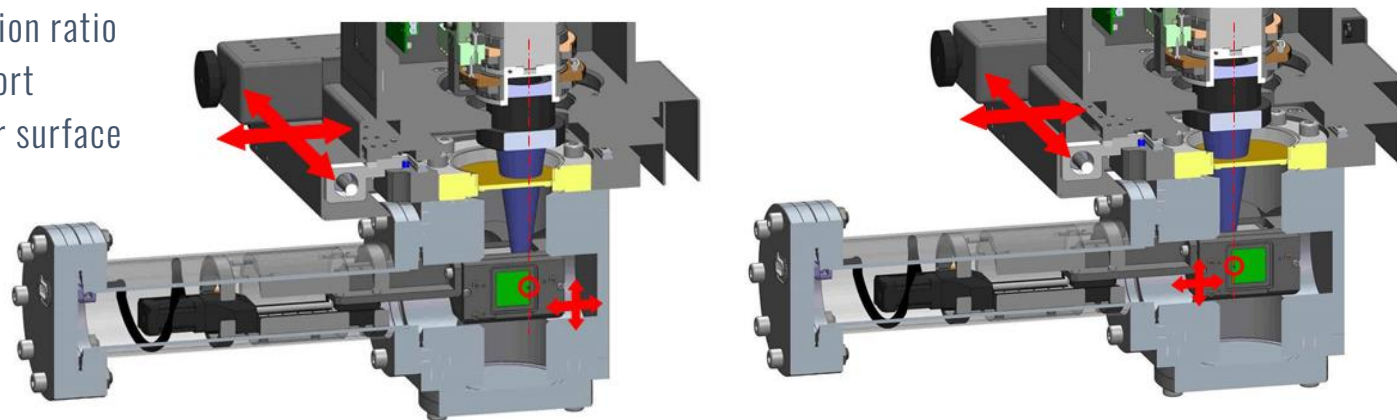


NEW ! in Vacuum X-Ray imaging zoom

Zoom Macroscope



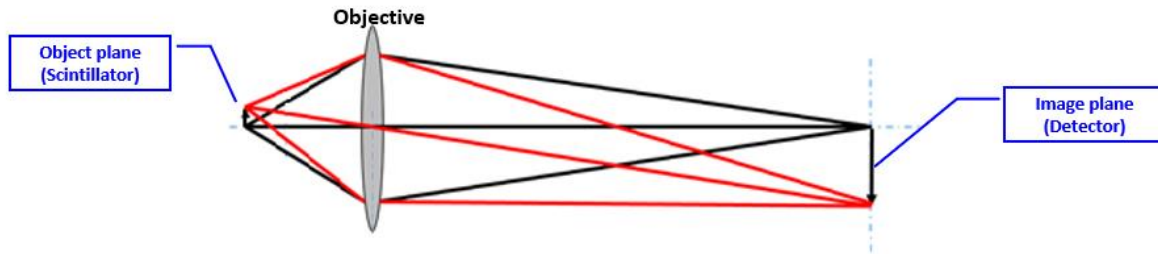
- 6,3x or 16x motorized zoom magnification ratio
- In vacuum retractable scintillator support
- Zoom on XY stage for Whole scintillator surface imaging at any magnification



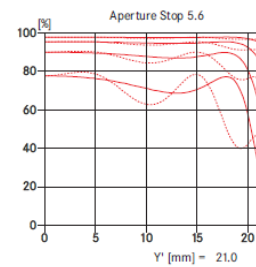
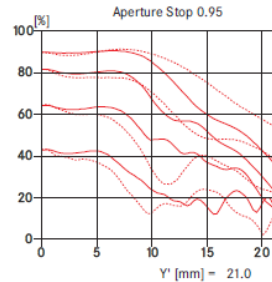
NEW ! HIGH RESOLUTION / HIGH NA TANDEM MACROSCOPES

- Different choices for Macroscopic optic design

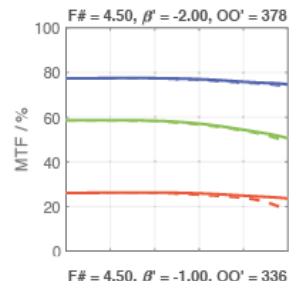
Single lens system : finite corrected optics



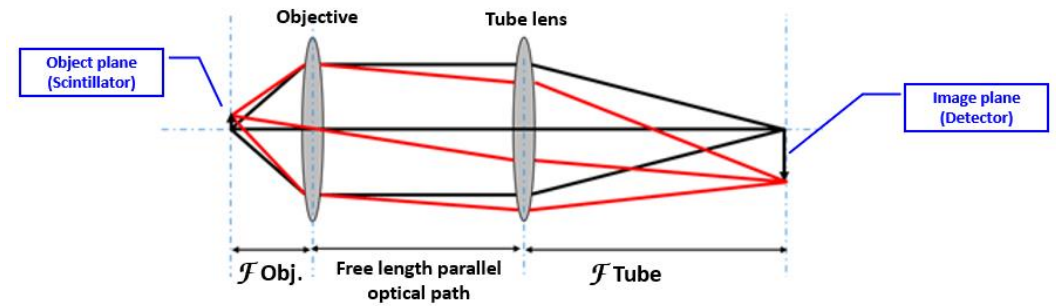
- Single lens macro system with standard optics, Designer have to choose between :
 - High NA but limited image quality at full aperture – Example F50mm f/0,95



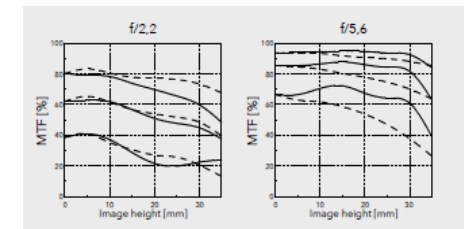
- High image quality but limited NA : – Example F85mm f/4,5



Tandem lens system : infinite corrected optics

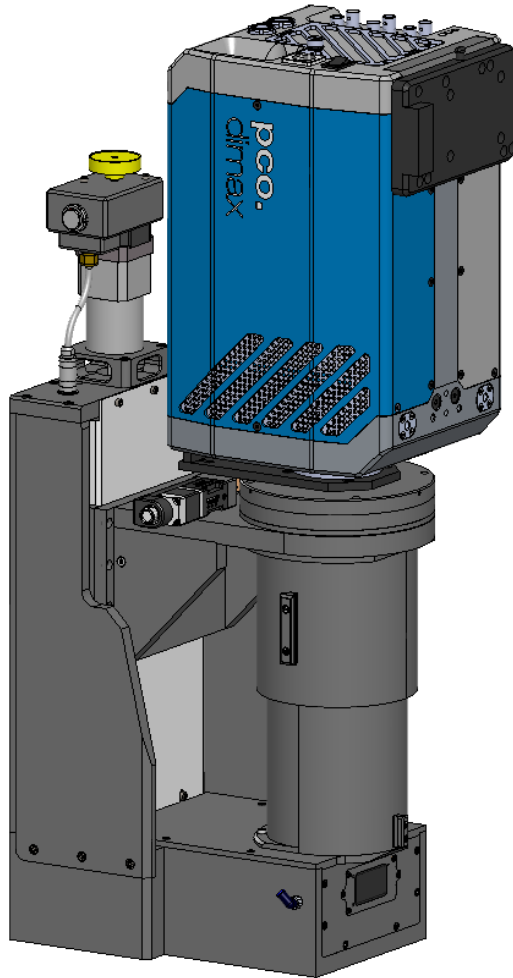


- Tandem lens macro system with standard optics :
 - Better NA
 - Standard optics have good but limited resolution at full aperture when tandem mounted

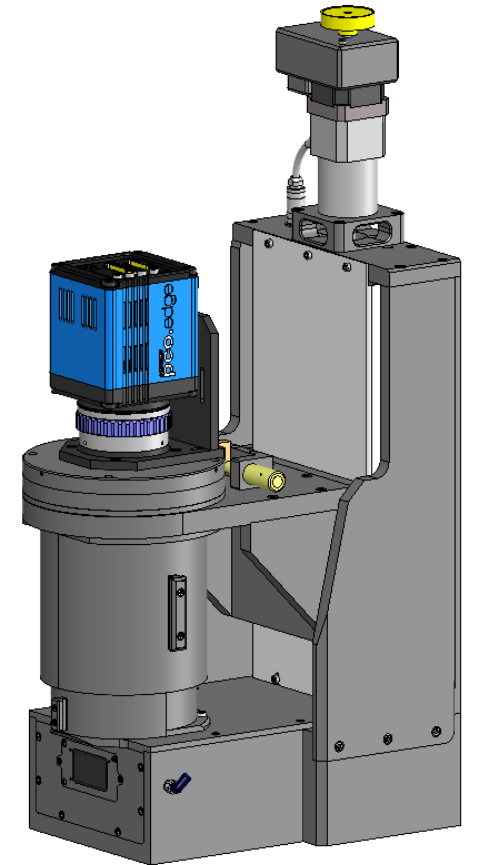


NEW ! HIGH RESOLUTION / HIGH NA TANDEM MACROSCOPES

Macroscope



- Flexible design with either :
 - Tandem configuration of standard optics
 - Tandem configuration with specially designed high resolution / High NA tandem optics
- 5 mm front radiation resistant glass protection
- 0,5X to 2X magnifications
- Easy objective changing
- Camera detector diagonal from 22 mm to 44 mm
- Scintillator field of view diagonal from 22 mm to 44 mm
 - 3 possible combinations with 3 different standard objectives (F100 / F150 / F210 mm)
 - 16 possible combinations with 4 different special high NA objectives



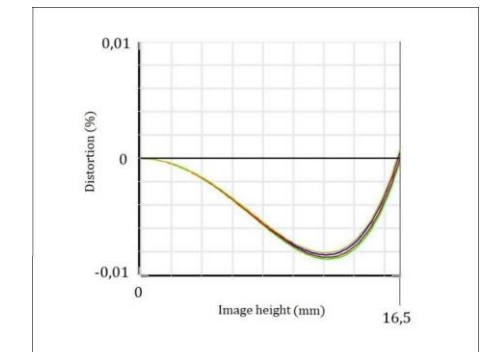
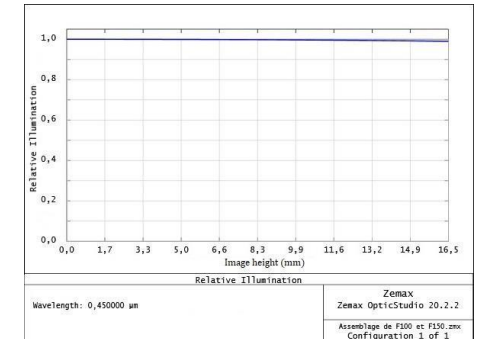
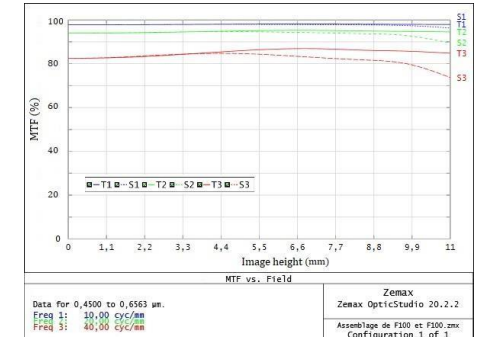
NEW ! HIGH RESOLUTION / HIGH NA TANDEM MACROSCOPES

16 possible tandem combinations with 4 specially designed high resolution objectives :

- F100 mm / 0,27NA
- F133 mm / 0,20 NA
- F150 mm / 0,18 NA
- F200 mm / 0,135 NA

Macroscope

				Objective on the camera side			
Type	Focal (mm)	NA	Ø object (mm)	Type 1 100 mm 0.268 22 mm	Type 2 133 mm 0.196 29.3 mm	Type 3 150 mm 0.178 33 mm	Type 4 200 mm 0.135 44 mm
Type 1	100	0.27	22	G = 1.0 X NA = 0.27 Ø object = 22 mm Ø Image = 22 mm	G = 1.33 X NA = 0.27 Ø object = 22 mm Ø Image = 29.3 mm	G = 1.5 X NA = 0.27 Ø object = 22 mm Ø Image = 33 mm	G = 2.0 X NA = 0.27 Ø object = 22 mm Ø Image = 44 mm
<i>Typical camera pixel size : 4.5 µm to 6.5 µm</i>							
Type 2	133	0.20	29.3	G = 0.75 X NA = 0.20 Ø object = 29 mm Ø Image = 22 mm	G = 1.0 X NA = 0.20 Ø object = 29.3 mm Ø Image = 29.3 mm	G = 1.128 X NA = 0.20 Ø object = 29.3 mm Ø Image = 33 mm	G = 1.5 X NA = 0.20 Ø object = 29 mm Ø Image = 44 mm
<i>Typical camera pixel size : 5.5 µm to 6.5 µm</i>							
Type 3	150	0.18	33	G = 0.67 X NA = 0.18 Ø object = 33 mm Ø Image = 22 mm	G = 0.89 X NA = 0.18 Ø object = 33 mm Ø Image = 29.3 mm	G = 1.0 X NA = 0.18 Ø object = 33 mm Ø Image = 33 mm	G = 1.33 X NA = 0.18 Ø object = 33 mm Ø Image = 44 mm
<i>Typical camera pixel size : 9 µm to 11 µm</i>							
Type 4	200	0.135	44	G = 0.5 X NA = 0.135 Ø object = 44 mm Ø Image = 22 mm	G = 0.67 X NA = 0.135 Ø object = 44 mm Ø Image = 29.3 mm	G = 0.75 X NA = 0.135 Ø object = 44 mm Ø Image = 33 mm	G = 1.0 X NA = 0.135 Ø object = 44 mm Ø Image = 44 mm
<i>Typical camera pixel size : 9 µm to 14 µm</i>							



F 100 mm + F 100 mm Tandem : 1X / 0,27 NA



Optique Peter

OPTICAL & MECHANICAL ENGINEERING

SRI2021

Thank you for your attention !

Visit our website: www.optiquepeter.com

Find us on LinkedIn 