Development of a highly efficient and tunable fluorescence detector with an energy resolution of about 1eV

Klaus Attenkofer[*], Bernhard Adams[#], Marco Wiedenhoeft[*]

*:XFD/Sector 11 #:XFD/Sector7

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

An EXAFS-Detector for Time Dependent Spectroscopy: The Requir

High Effic

- •High Detection Efficiency
- •Large Solid Angle (2p)

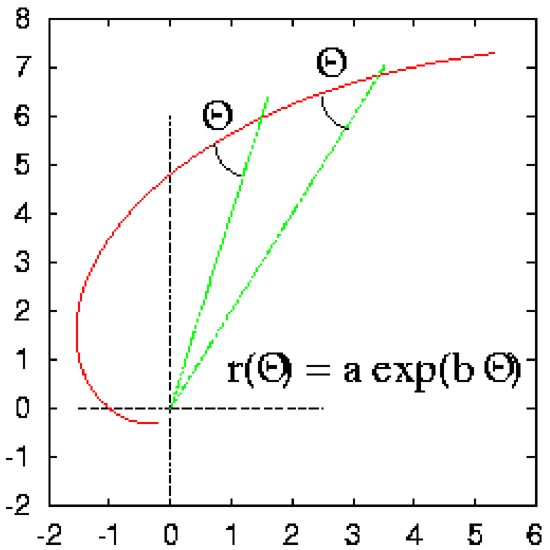
Fast Time Response:

- •Processing Time (< 10ns/count)
- •Option of Multi Photon-Counting per X-ray Pulse

- •Tunable in Energy
- •Tunable Energy Resolution (20-0.5eV)
- •Imaging / Energy Resolution
- •Easy to use (Computer Control)
- •Option of Multi-Element-System

Crystal Optics with Variable Crystal-Shape

What are the Basics of a Crystal Optics

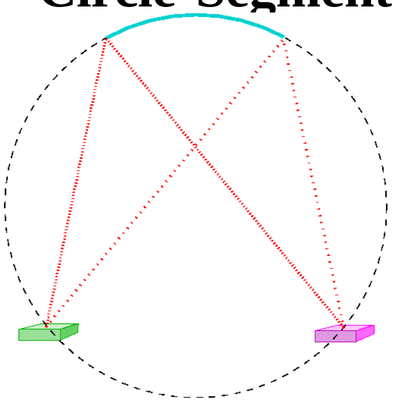


Basic Principle:

The shape, which is defined by a **constant angle q** is called **logarithm spiral**

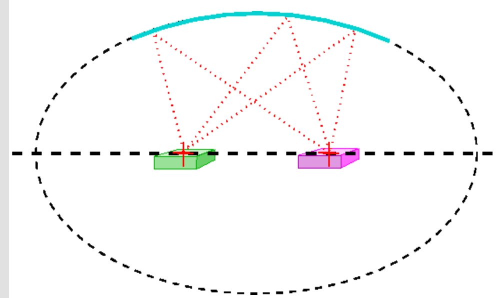
Approximations:

Circle-Segment:



- Good approximation for back-reflection
- Small angle acceptance

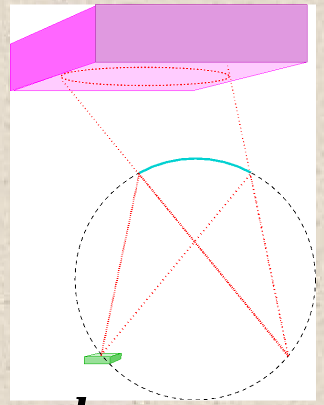
Ellipse-Segment:



- Better approximation of the logarithm spiral
- Image of the source

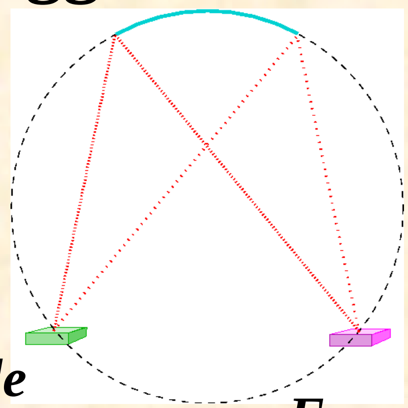
Laue Versus Bragg Geometry

Laue



- Large Detector (time response!)
- Thin crystal for low energies
- Back-side of the crystal has to be open

Bragg

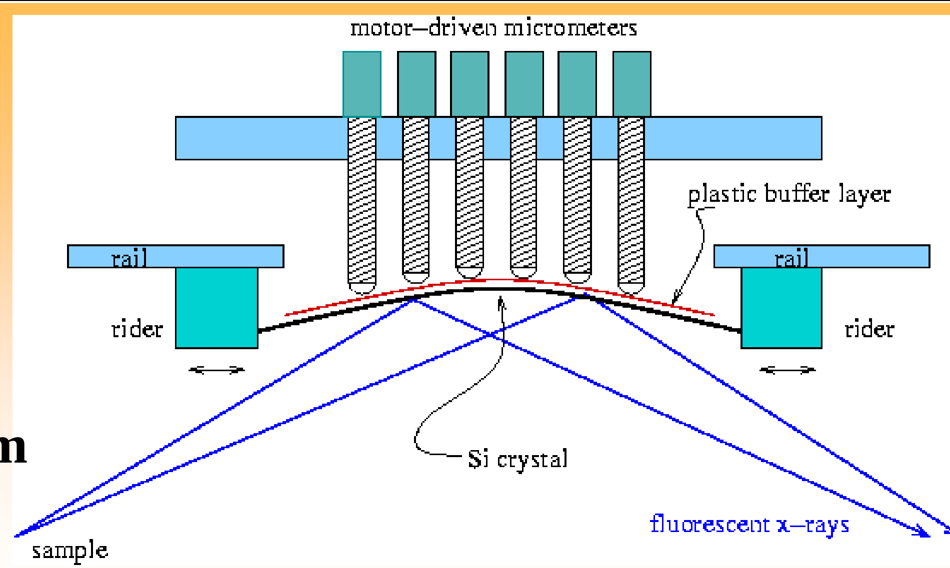


- Small Detector/Focus
- Crystal thickness is defined by the maximal strain
- Mechanical support on the back

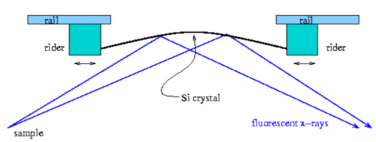
The Bending Concept

The Bender:

- Typical Si 100
- Size: ~140x20mm^2
- Thickness:150mm-480mm
- Sample-Crystal distance: ~35-40cm
- Solid angle: 5x10^{-4} (depending on crystal and bending radius)

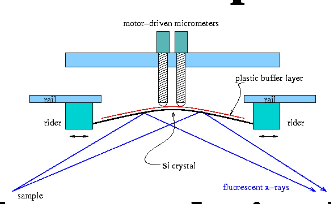


First Step:



Shape: ~Sinus

Second Step:

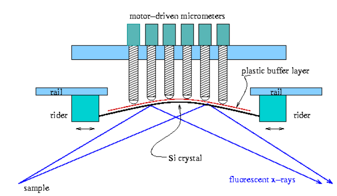


Shape: closer to desired shape

Iterations….

• • • •

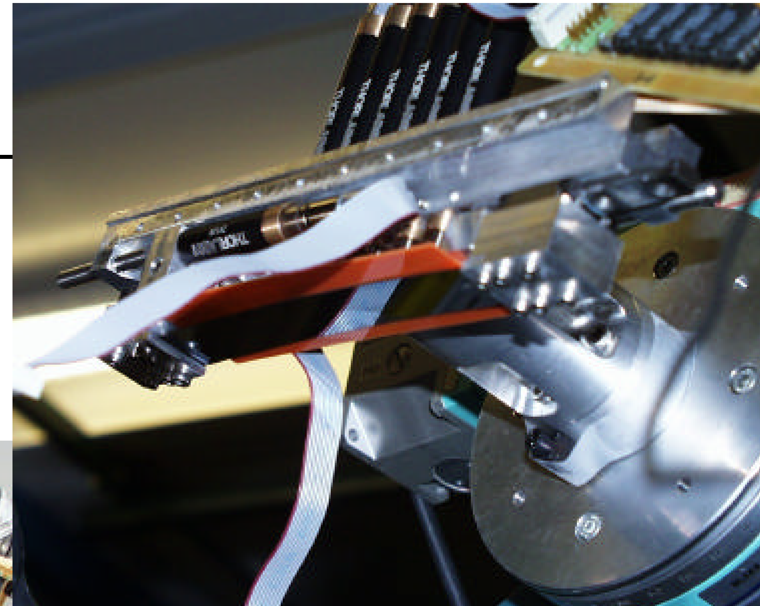
Final

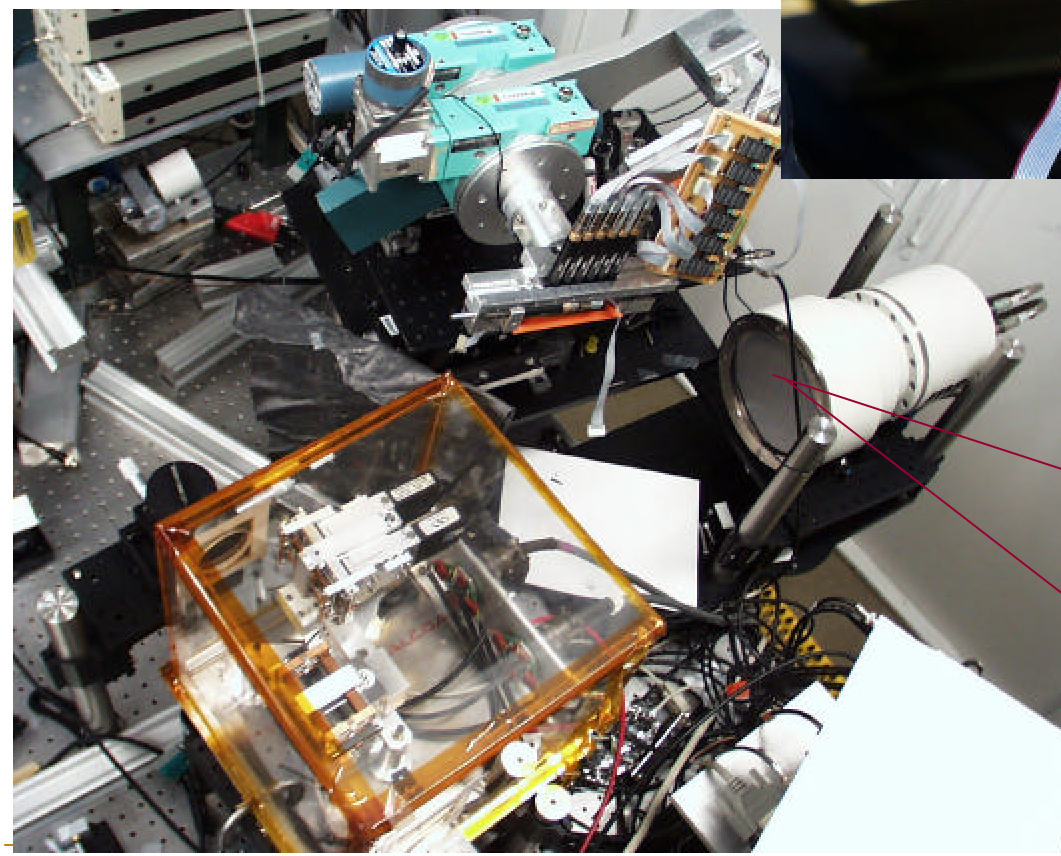


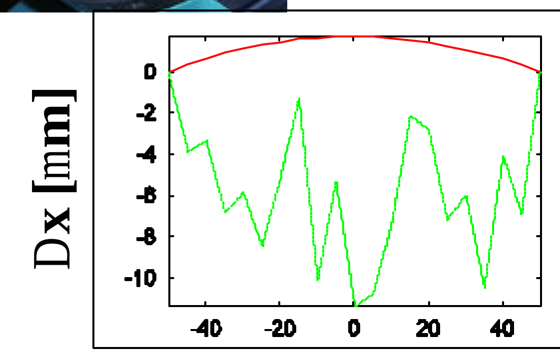
Shape: desired shape

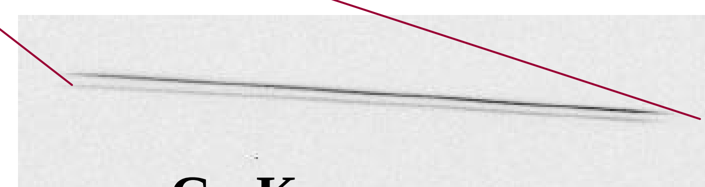
Correction based on shape measurements and optical image!

The Test-Device









$Ga\text{-}K_{a\,1/2}$

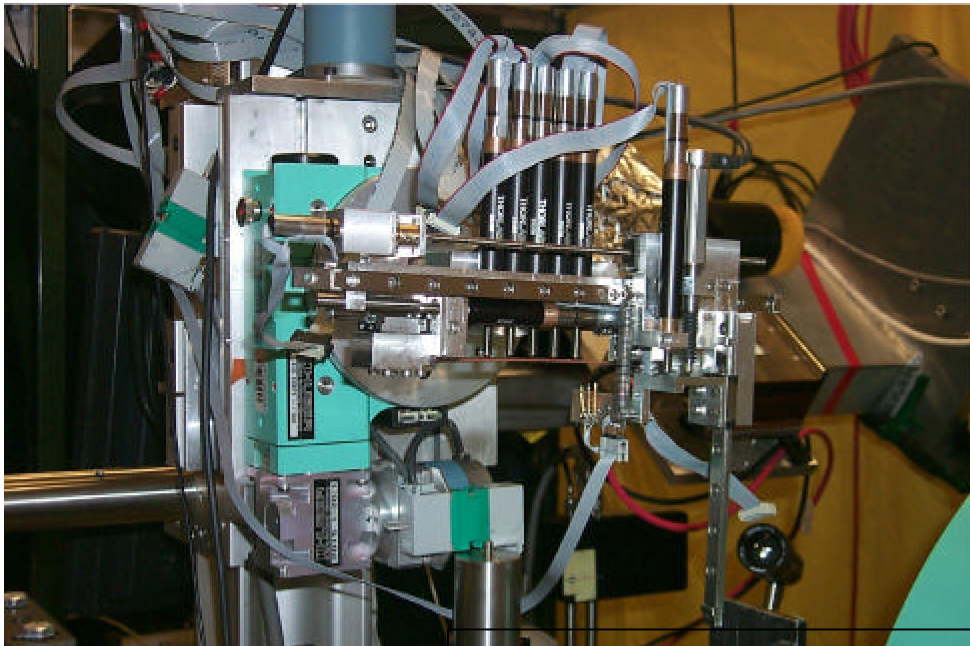
Detector Options & Electronics

	APD	Plastic Scintillator	Andor CCD (with MCP amplifier)	Mar CCD (165)
Size:	<2mm^2	1-10cm^2	Depending on demagnification	Diameter 165mm
Time Resolution	<100ps	1-30ns	<150ns	none
Available	Yes/No (Array)	Yes (new detectors are in development)	No	Yes

Electronics:

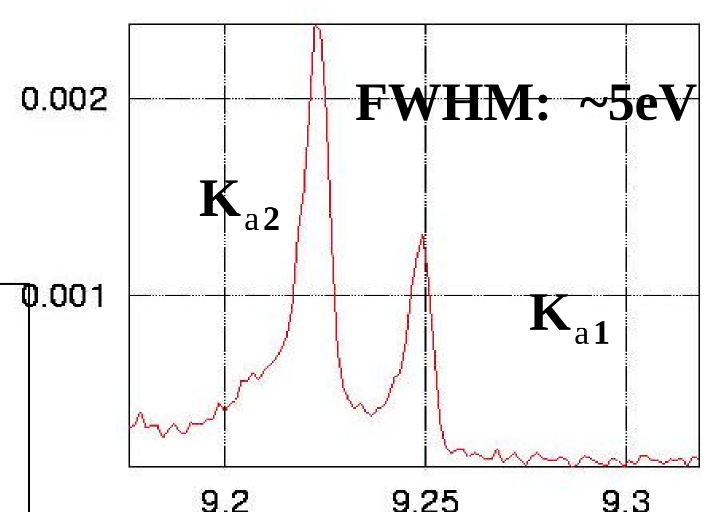
Two different systems are available, which allow to record the intensity of each individual x-ray bunch (up to a ms -> Laser-repetition rate)

First Results:



Energy Scan:

Large area detector without slit
(x-ray beam: 50mm x 20mm)
~50% efficiency

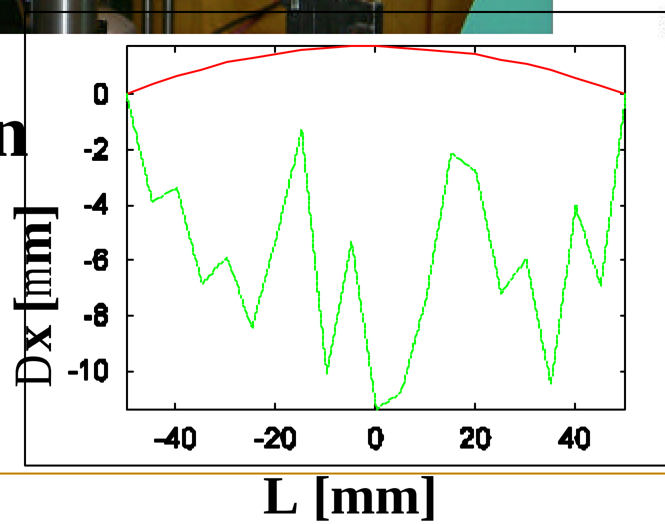


Ka1: 9251.74 eV

Ka2: 9224.82 eV

Profile Scan

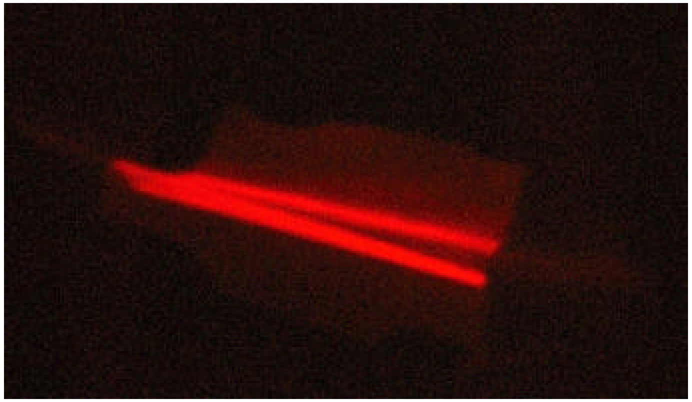
Deviations about 5-10mm



Future & Conclusions

Future:

- Improvement of mechanics (increasing of degrees of freedom)
- Improvement of profile-meter
- Optimization algorithm -> Computer control
- Miniaturization of mechanics
- Resources for multi-element system



Conclusion:

•Successful prove of principle

•Working prototype with 5eV resolution at 50% efficiency

•Computer control on all important motions (for energy and shape change)

•Unit price ~$15000-$20000