Do we need better synchrotrons?

A. Magerl

Kristallographie und Strukturphysik

(Crystallography and Structural Physics)

Naturwissenschaftliche Fakultät I

Friedrich-Alexander-Universität Erlangen-Nürnberg

Overview

- **today‘s synchrotron light sources**

- **a few examples on science**

  sound-excited crystals

  shock waves

  Si 888 in backreflection, an 8-beam case

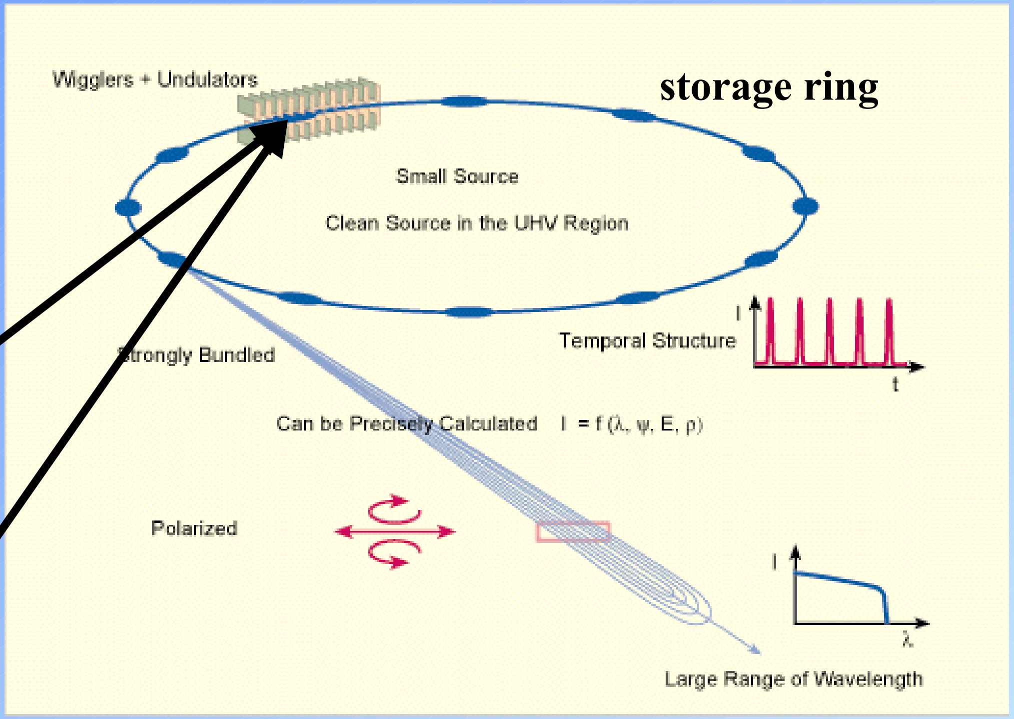
  photon storage

- **the concept of ERLSYN**

  stage 1: storage ring

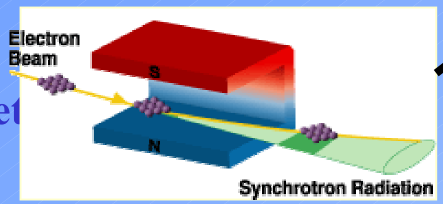
  stage 2: the ERL upgrade

synchrotron radiation:

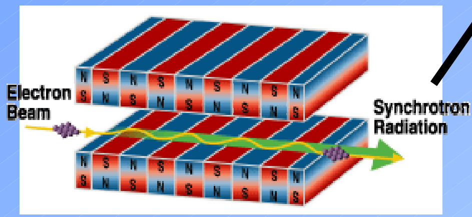


insertion devices

bending magnet



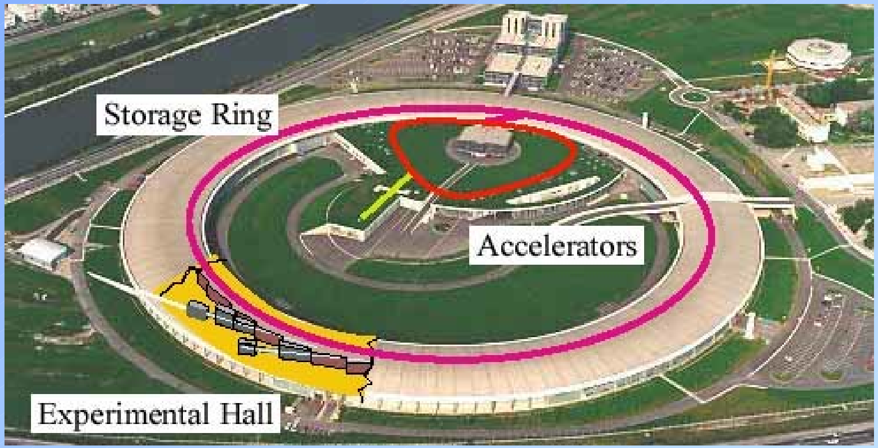
wiggler,
undulator



- **extreme brilliance by small emittance and modern insertion devices**
  ($\sim 10^{19}$ photonen s^{-1} mm^{-2} $mrad^{-2}$ 0.1%bandwidth)
- **small source size (anisotropic, horizontal ~100 μm, vertical ~10 μm)**
- **partially coherent (0.1 %, phase contrast techniques)**
- **pulsed (length of the electron bunches, 50 ps)**
- **polychromatic (from infra red (cm) to hard x-rays (0,01 Å))**
- **polarized (linearly or circularly, magnetism)**

synchrotron ligth sources

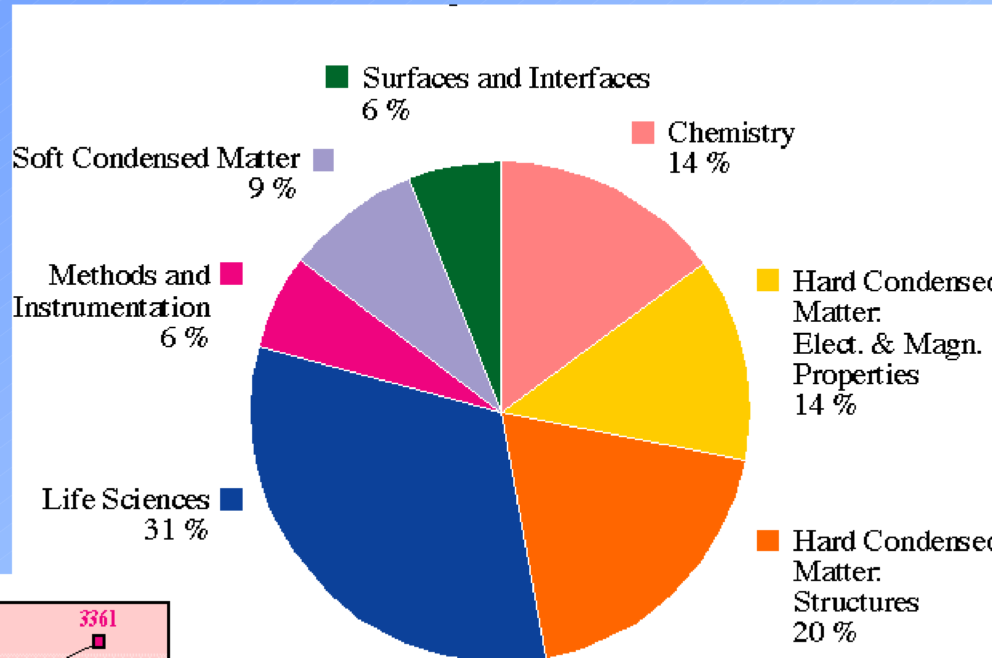
European Synchrotron Radiation Facility ESRF, Grenoble (1994), energy 6 GeV, circumference 844 m

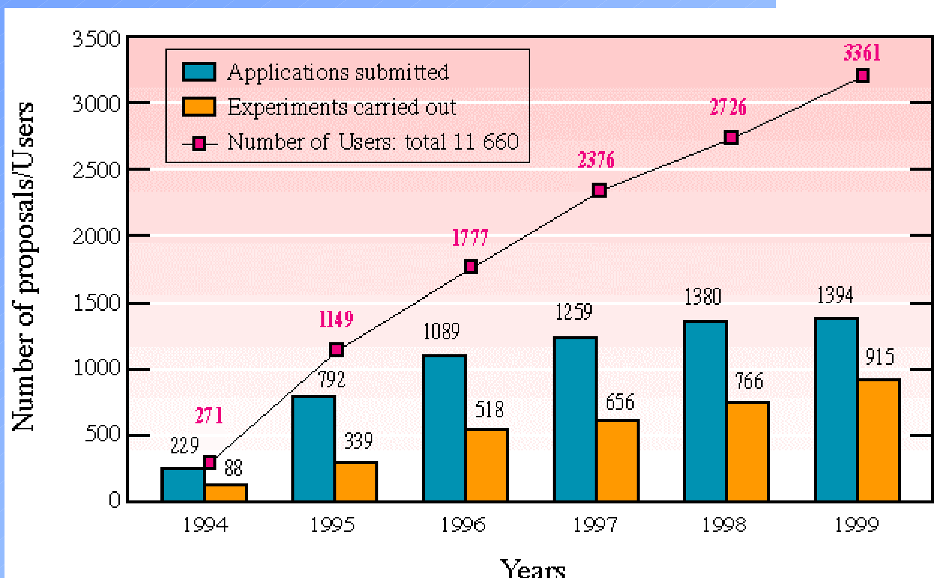


Swiss Light Source SLS, Villingen
Energy 2,4 GeV, circumference 288 m

SPring8 (1997), Japan
Energy 8 GeV, circumference 1436 m

Users at the ESRF



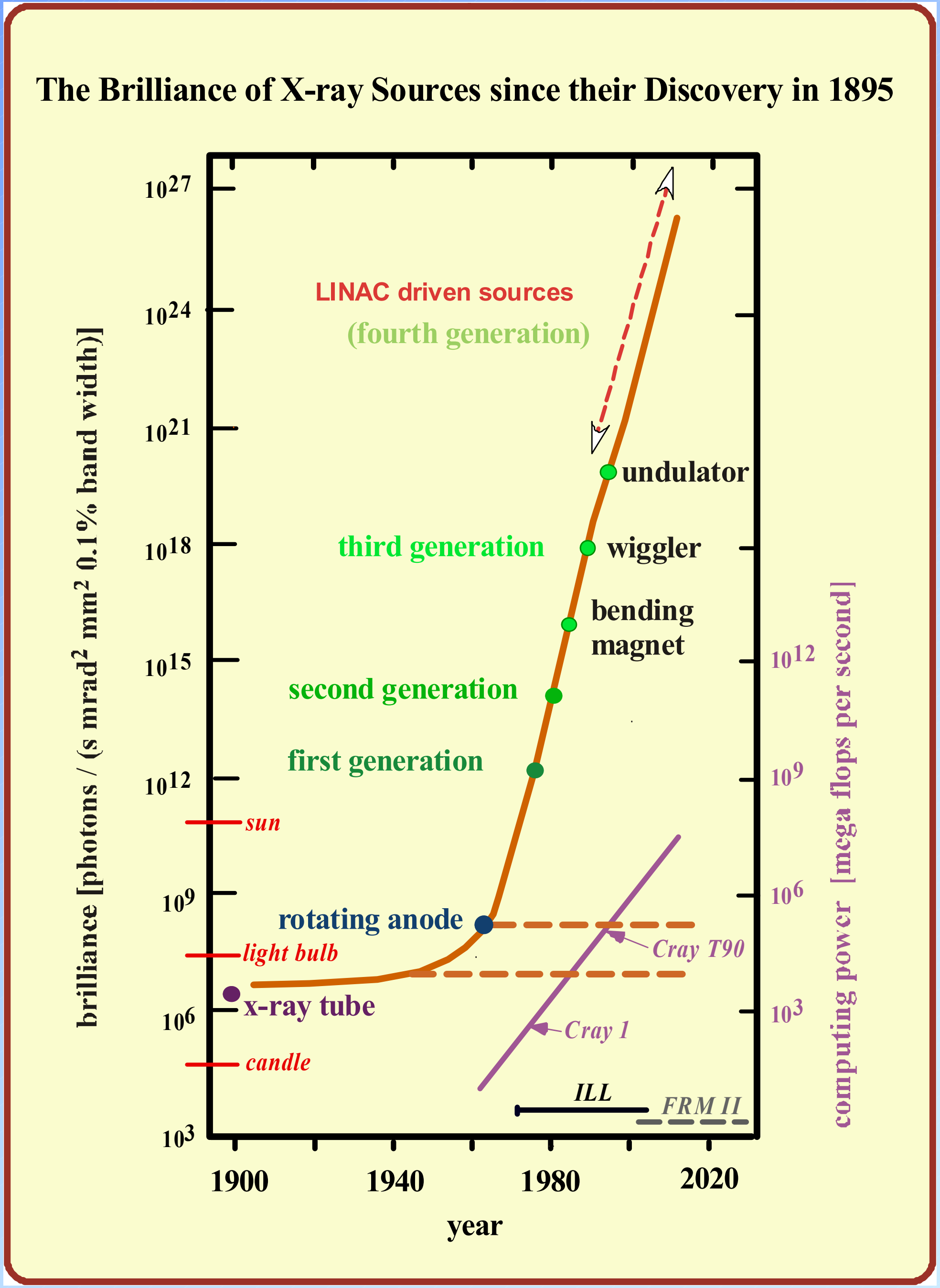


A SLS is a central facility offering unique experimental conditions for a large number of users from many different fields

extreme intensity & quality of the x-ray beam

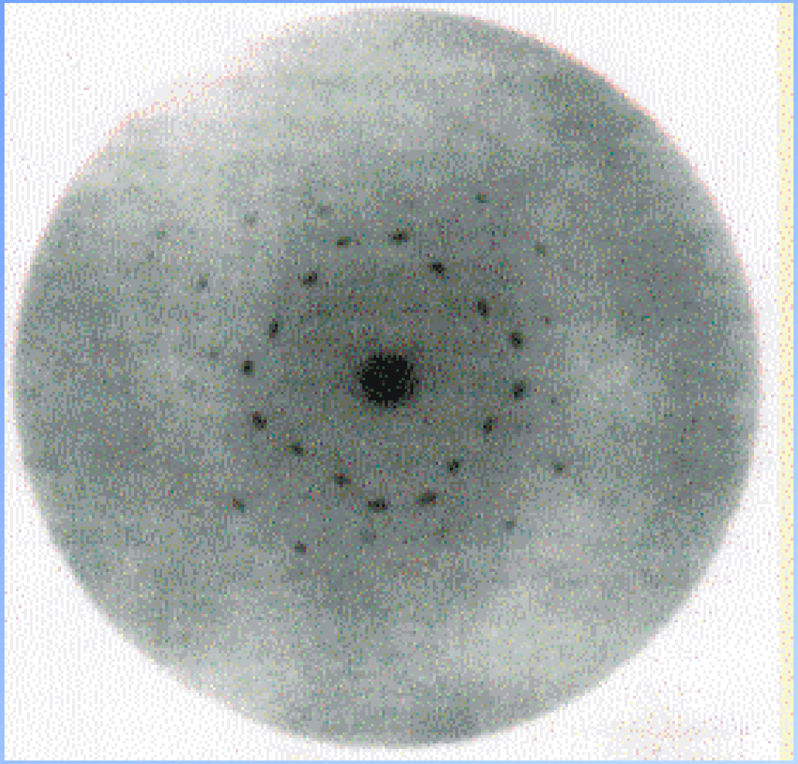
brilliance:

- complex problems
- fast throughput
- small samples
- diluted samples (surfaces)
- high quality
- high precision
- inelastic scattering
- magnetism



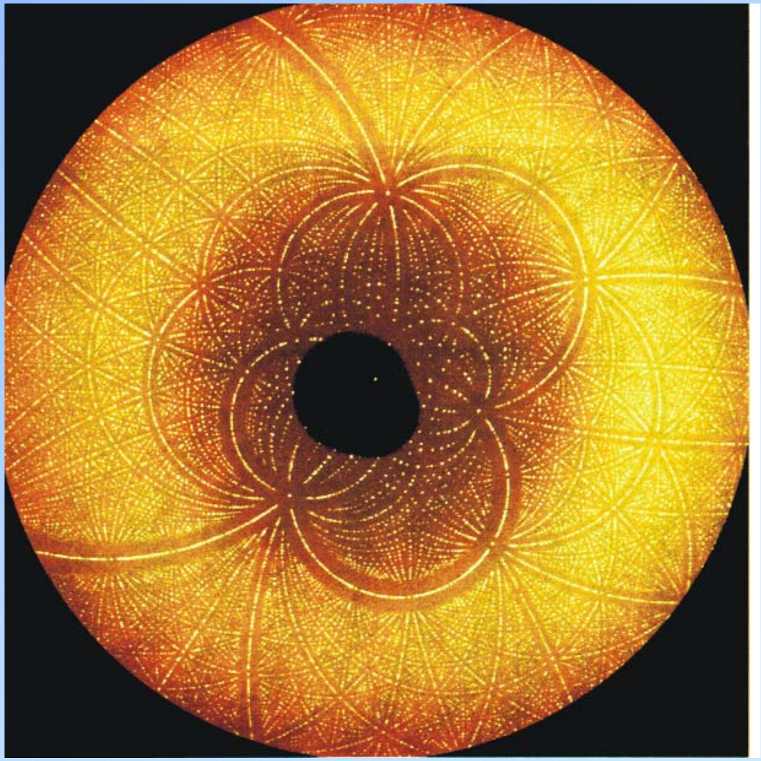
The Laue diagram number 5 (1912)

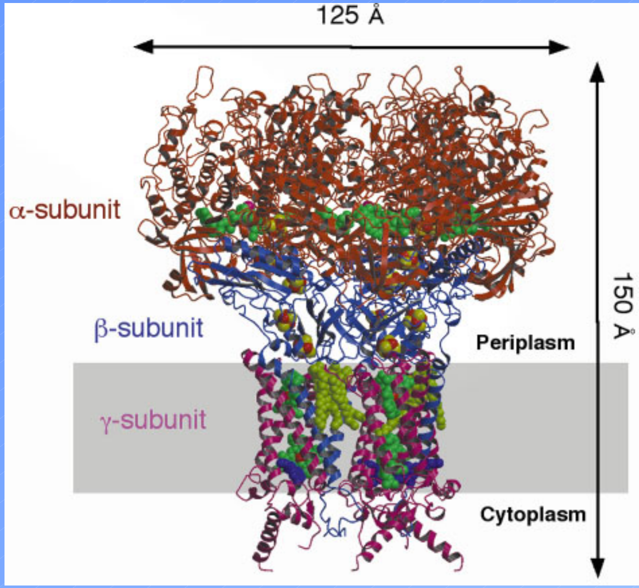
exposure time 30 min



A Laue diagram at SLS

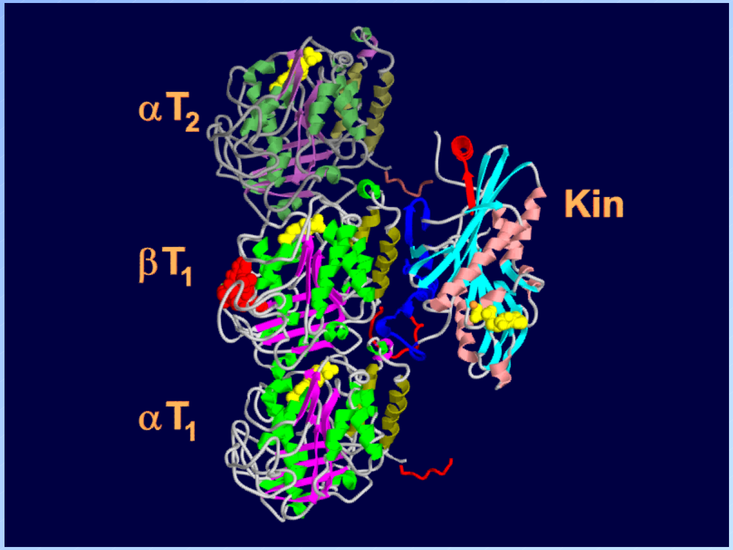
exposure time 10^{-10} s

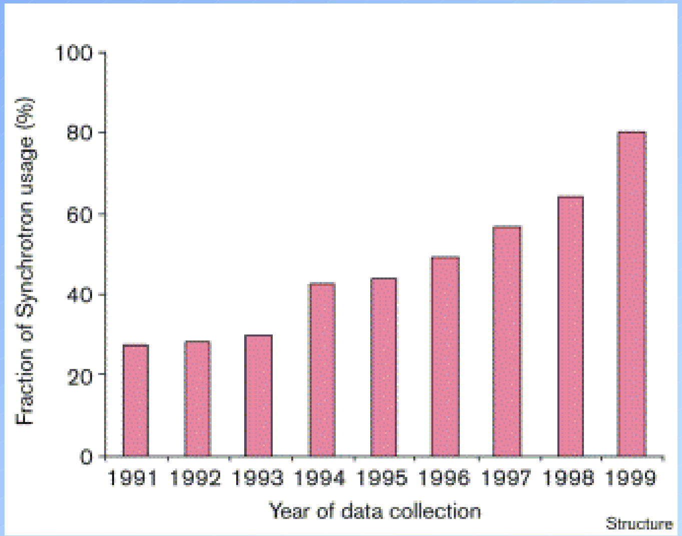




Structure of a membrane protein complex:
Formate Dehydrogenase-N at 1.6 Å (ESRF Highlights 2001)

Catalytic α-subunit is shown in orange, ß-subunit in blue and g-subunit in pink.





Entries in the Protein Data Bank, Brookhaven, USA, of structures measured with synchrotron radiation
W. Minor et al., Structure, 8, R105-R110 (2000)

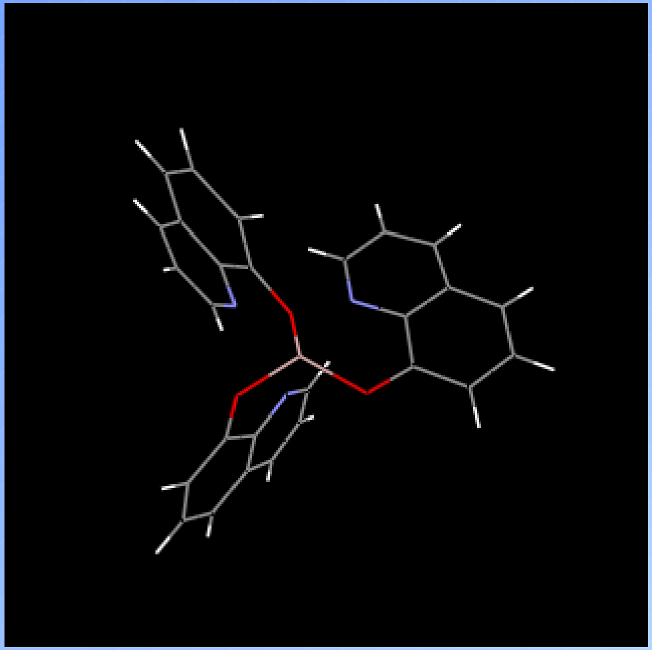
High beam quality

Michael Cölle, Robert E. Dinnebier and Wolfgang Brütting, 2002, Chem. Comm. 23, 2908-2909

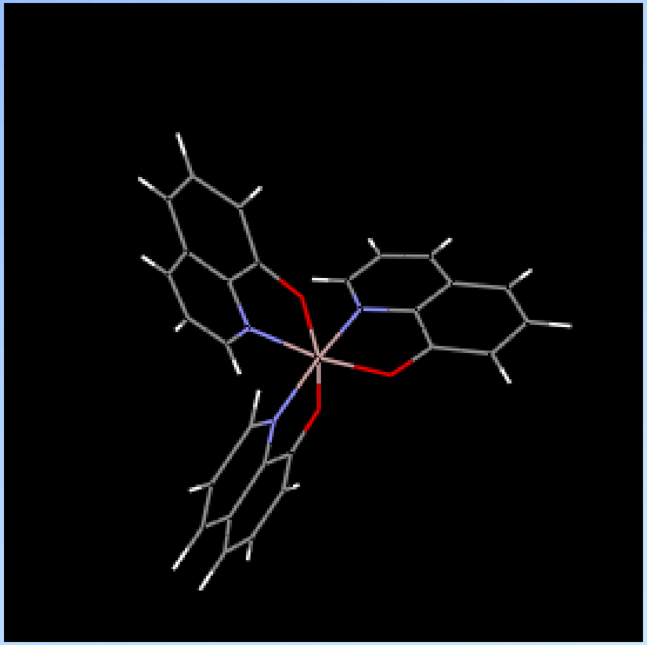
precise informationen: structure refinement from powder diagrams

Evidence for the facial isomer in the blue luminescent δ-phase of tris(8-hydroxyquinoline)aluminum(III) (Alq_3)

Isomere in δ-Alq_3

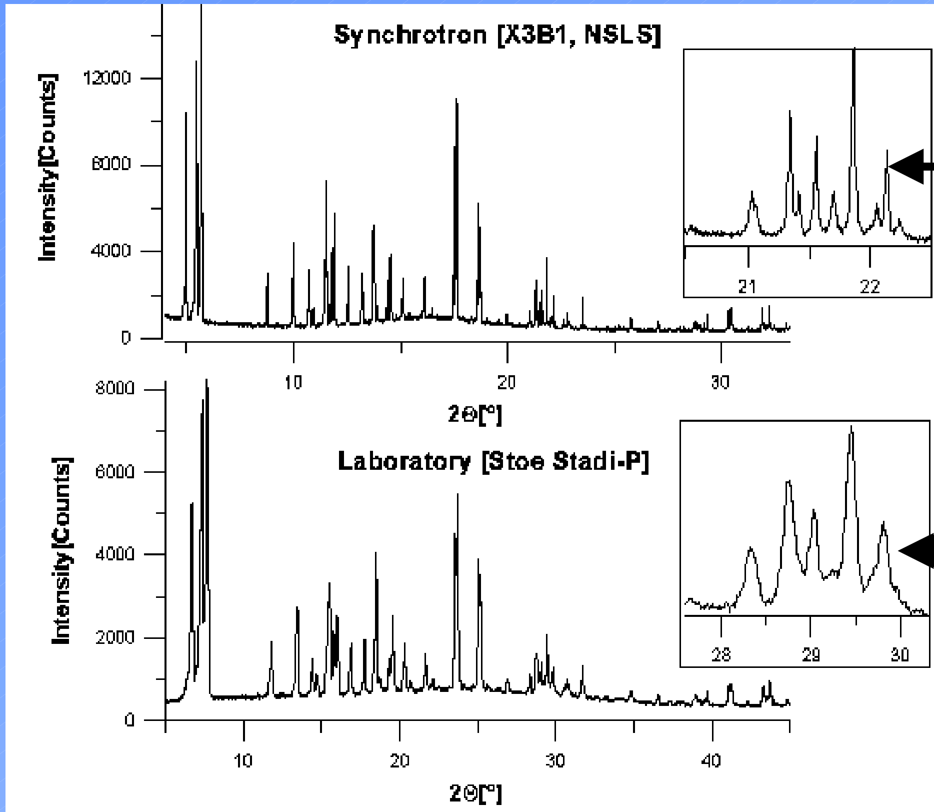


facial



meridonal

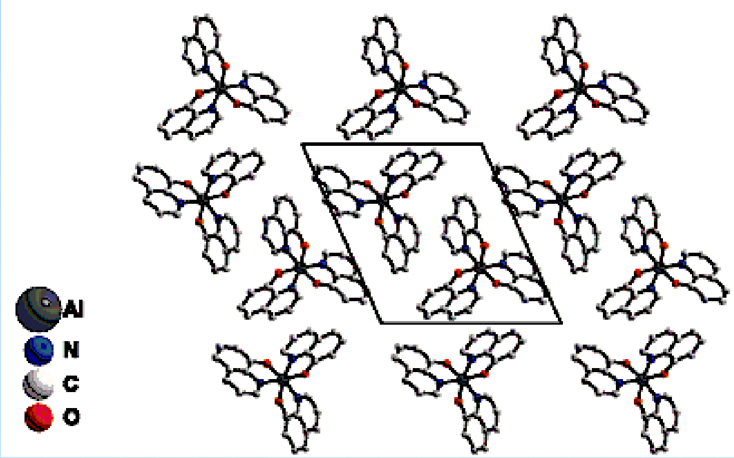
Different degrees of overlap of the π-orbitals of hydroxyquinoline ligands belonging to neighboring Alq_3 molecules are likely to be the origin of the significantly different electro-optical properties. Two isomers in the blue luminescent δ-phase of Alq_3 are possible



synchrotron source

laboratory source

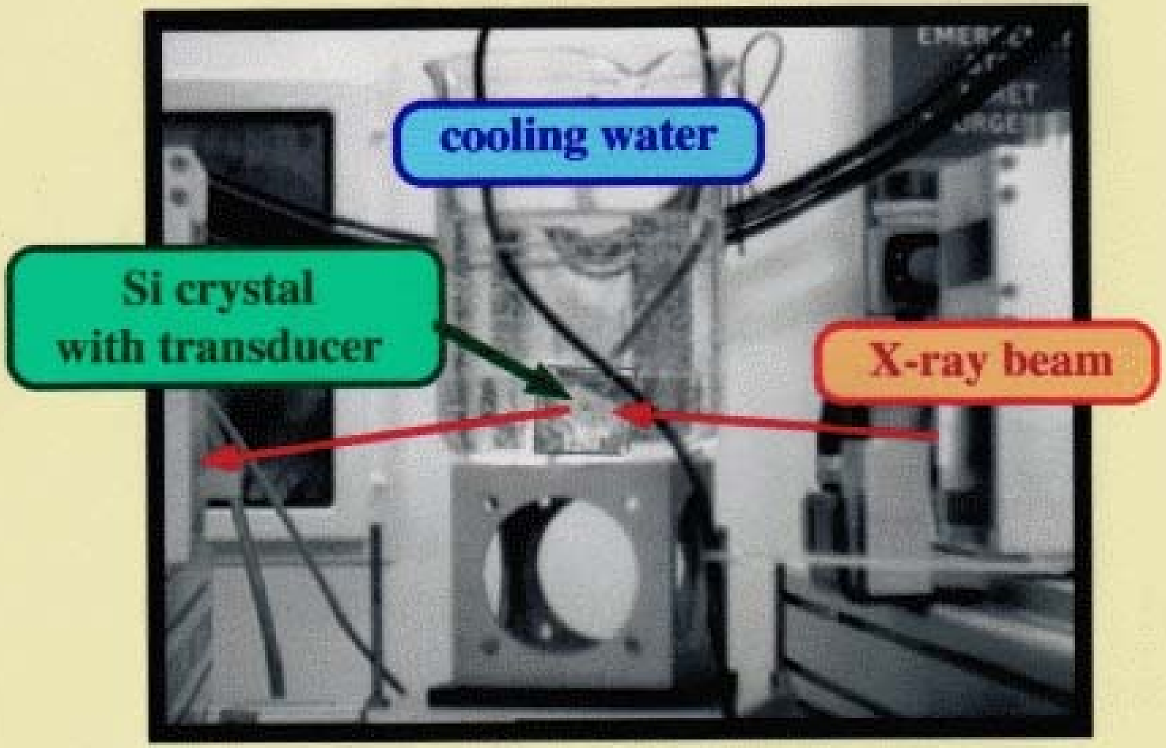
Crystal structure of δ-Alq_3 in a projection along the *c*-axis.



The two structures can only be distinguished with a resolution as offered on synchrotron beams

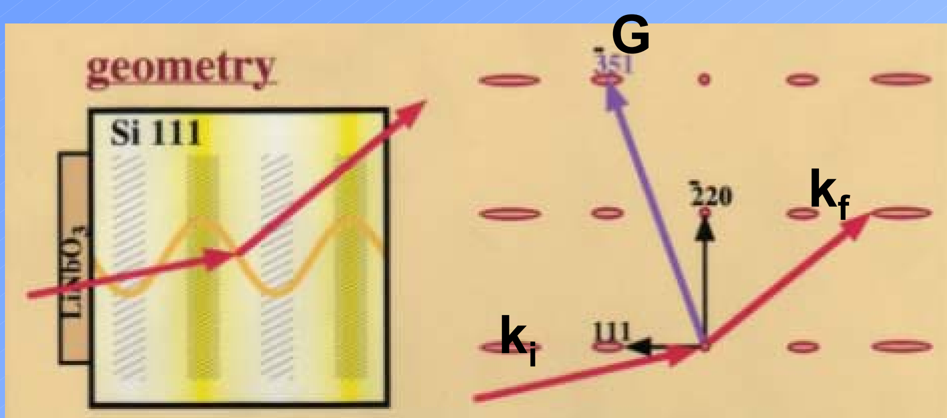
a few examples: sound-excited crystals

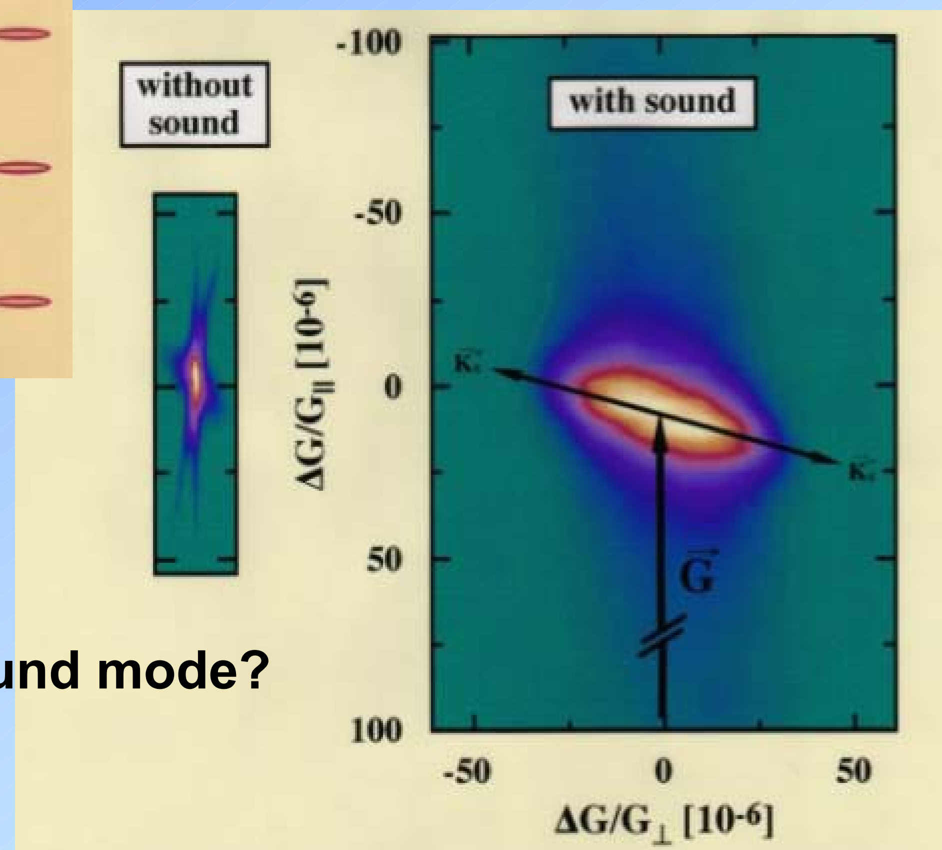
triple axis diffraction at the high energy beam line (>100keV) ID15 at the ESRF



The strain field of a sound wave may enlarge a Bragg peak and hence increase the reflected x-ray intensity: tunable optical element.

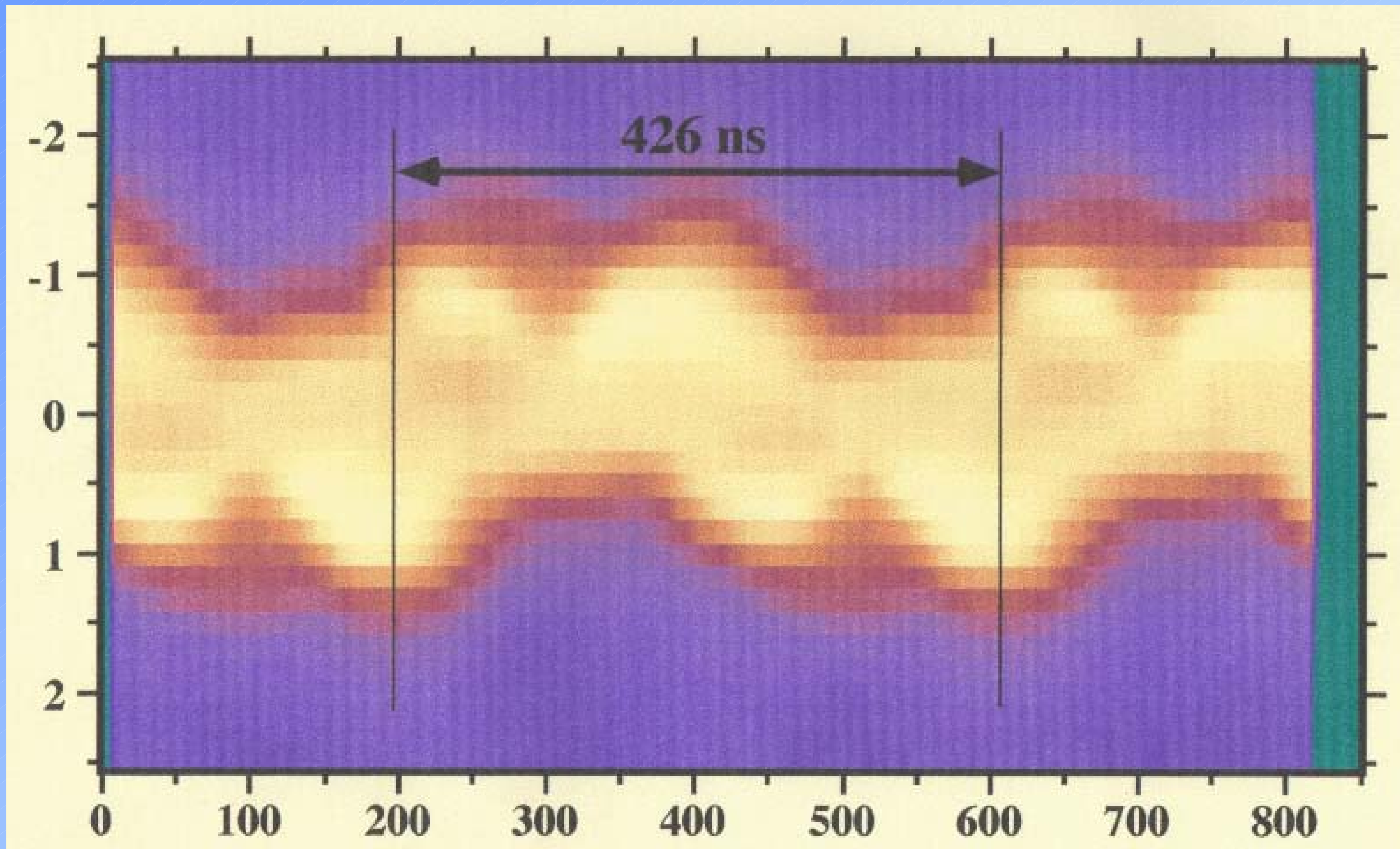
A longitudinal strain field maintains the beam divergence and provides better characteristics than a transversal distorsion (mosaicity).





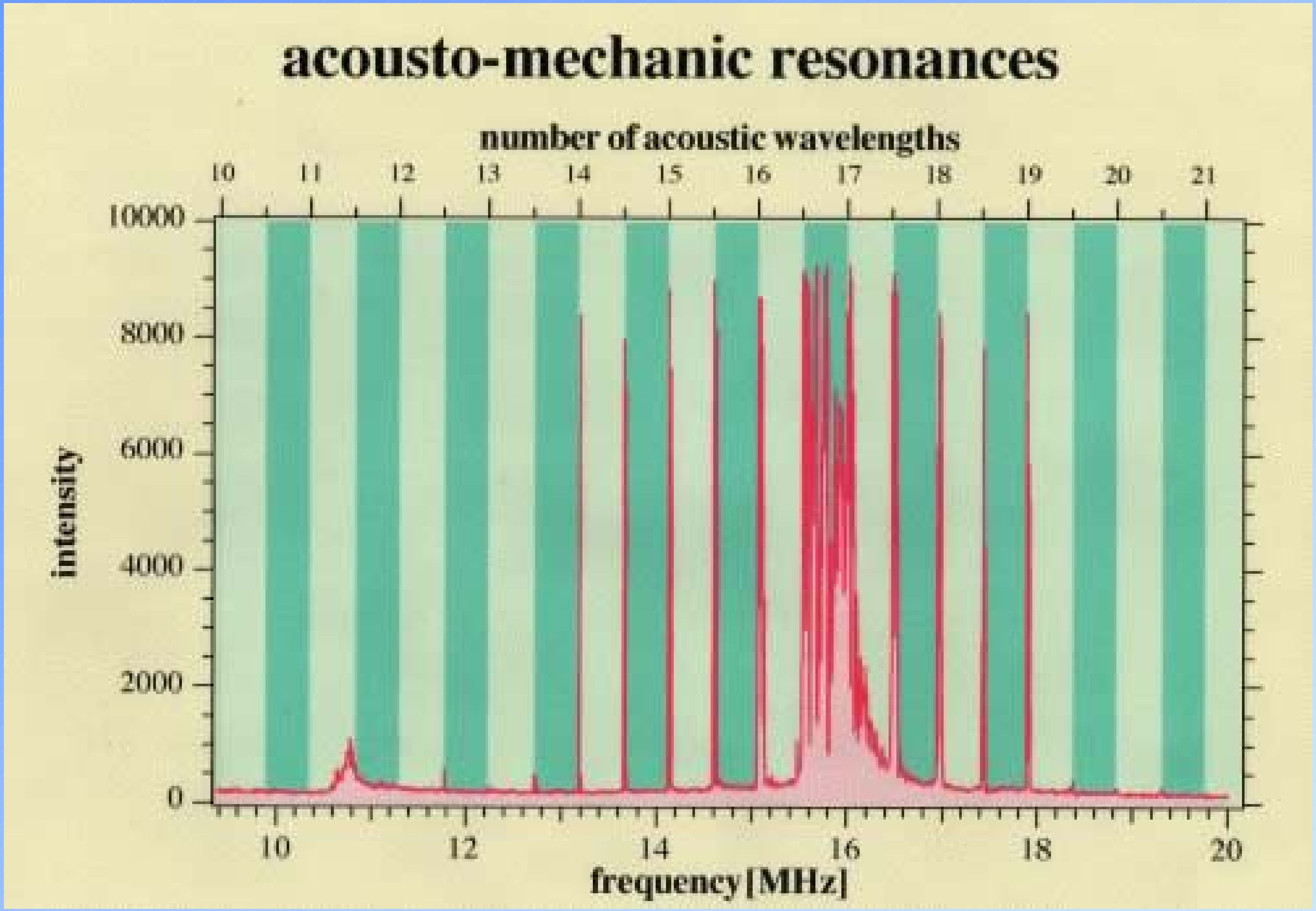
A pure longitudinal sound mode?

time dependent rocking curves at 2.35 MHz sound frequency



rocking angle [´´]

time [ns]



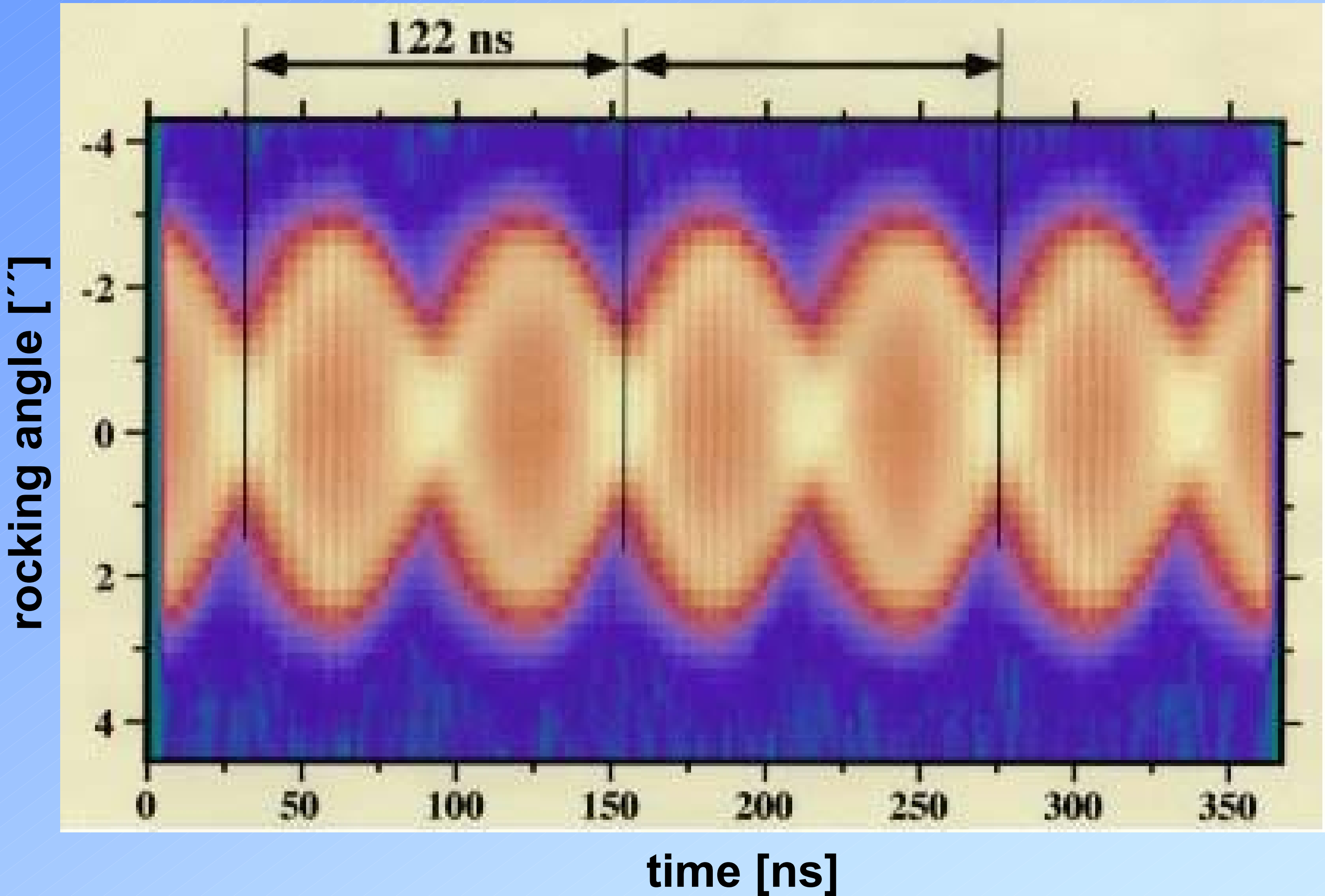
<u>**conditions:**</u>

even harmonic mode of the transducer (5 MHz)

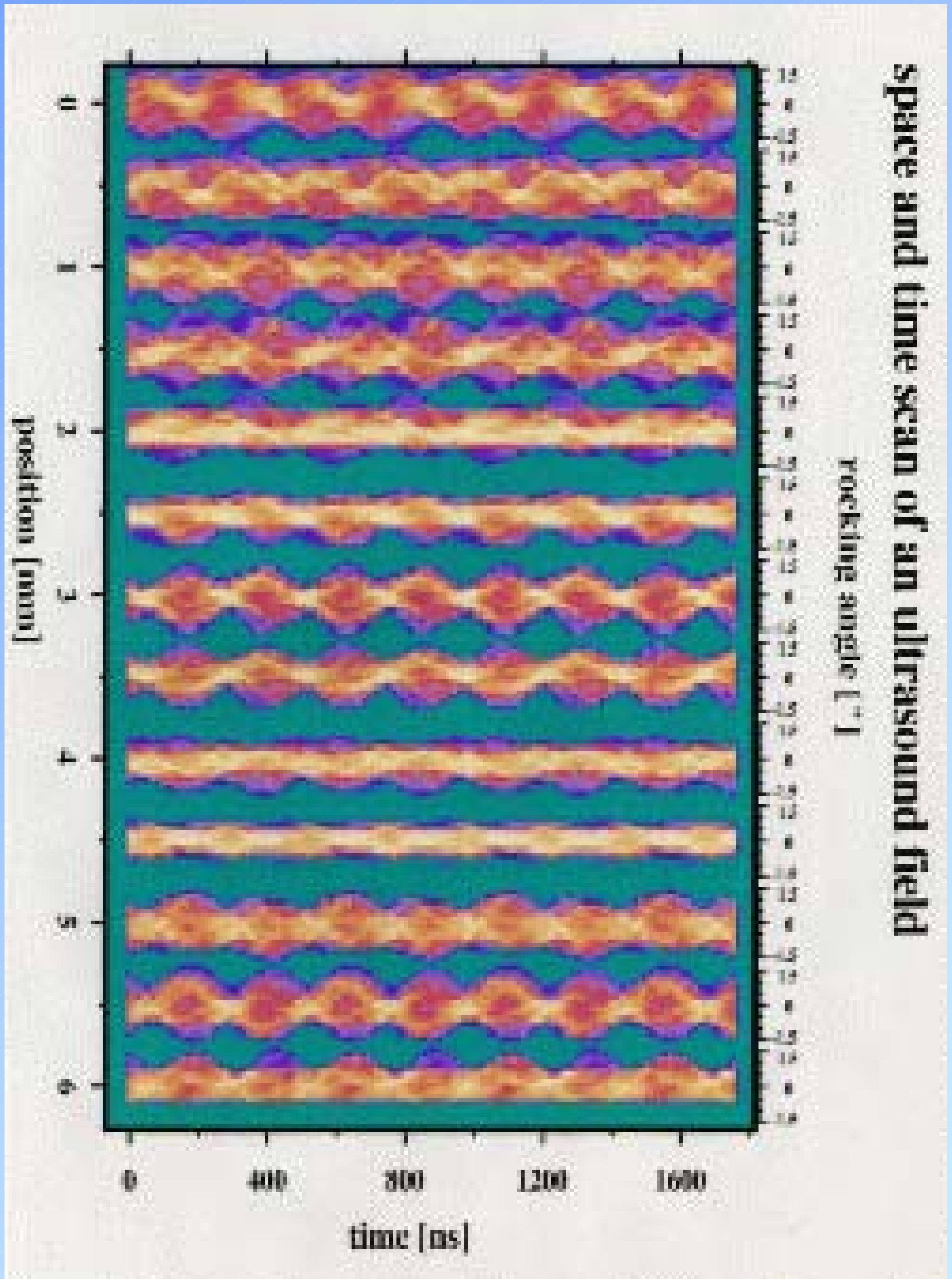
wave must have a knot at the ends of crystal

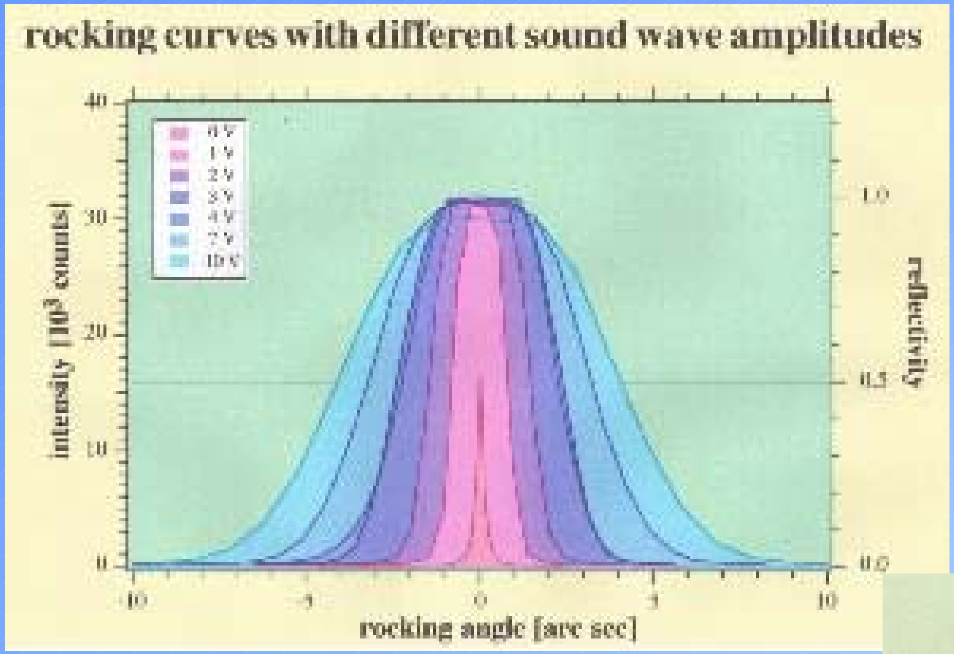
time dependent rocking curves

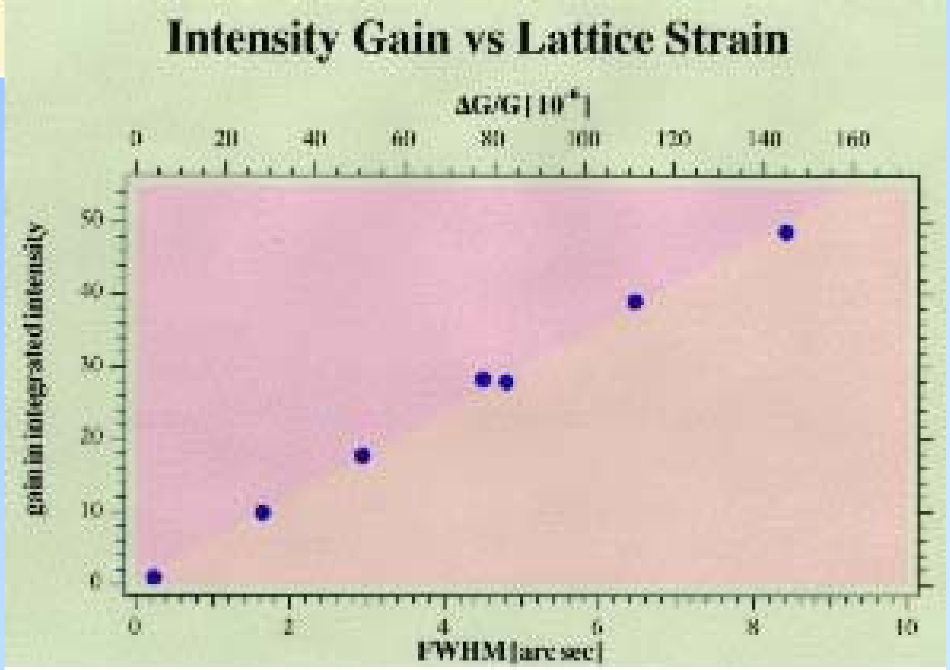
at 8,18 MHz at a crystal resonance



time and space dependent rocking curves at 2 MHz at a crystal resonance





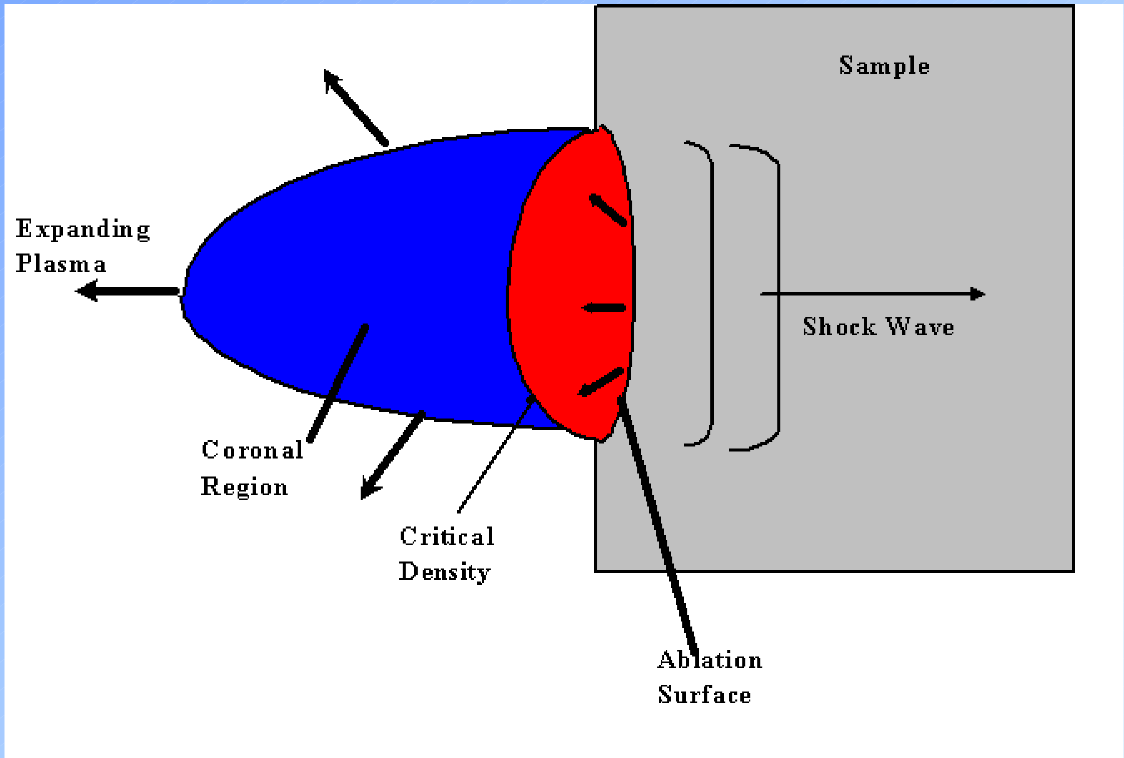


The x-ray intensity can be tuned over a wide range by pure longitudinal sound waves

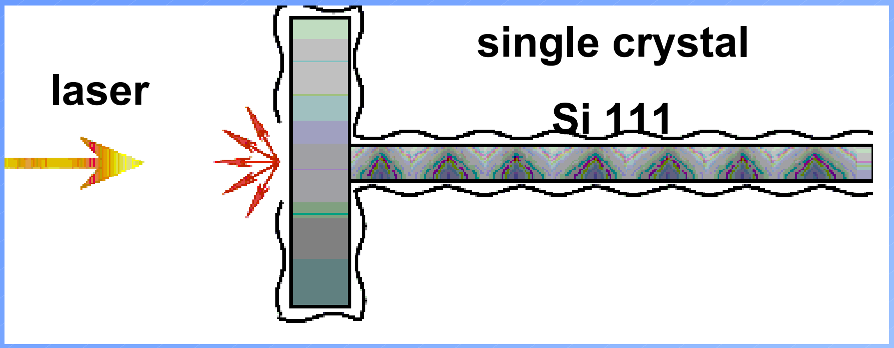
Shock waves by laser illumination K. D. Liss et al.

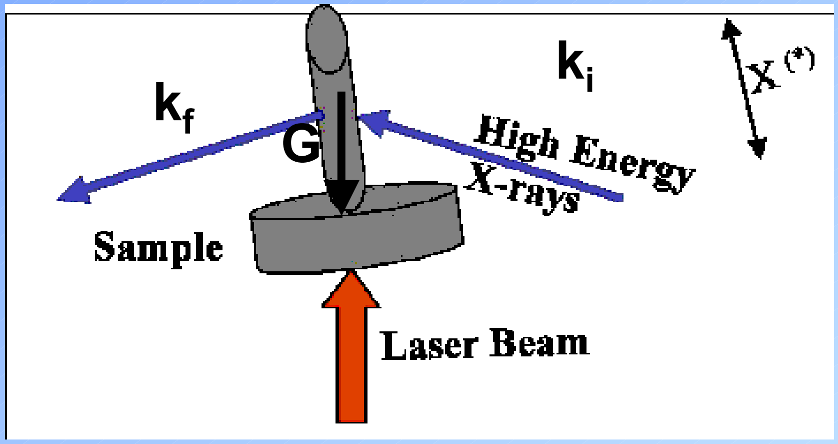
laser light causes several processes to occur:

- thermal shock wave
- ablation
- melting and re-crystalisation

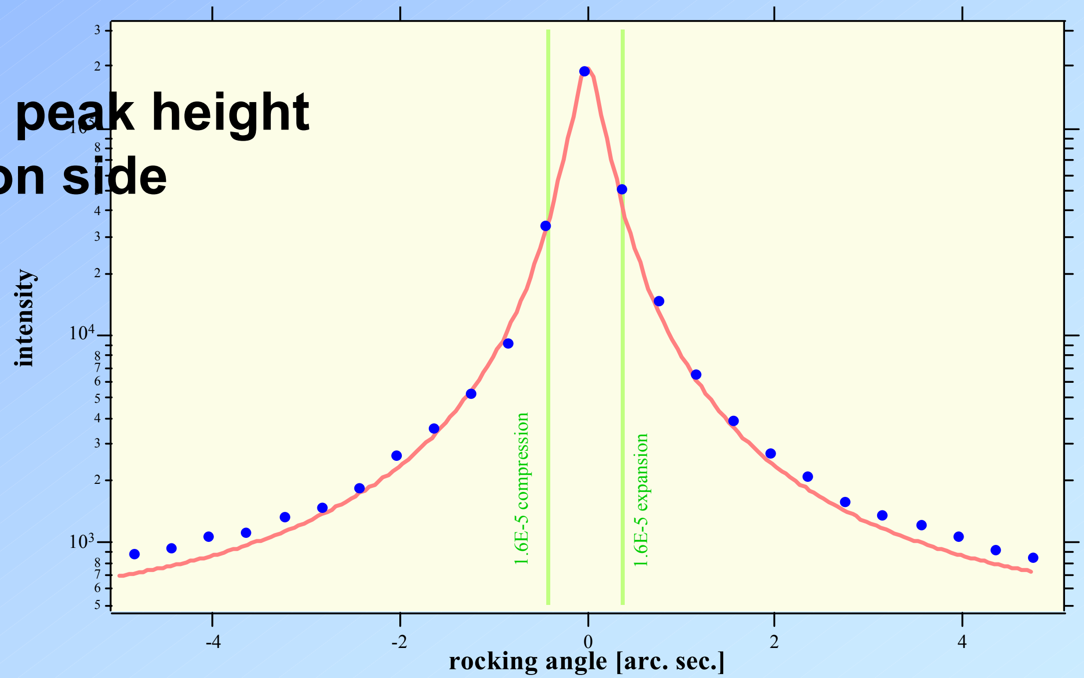


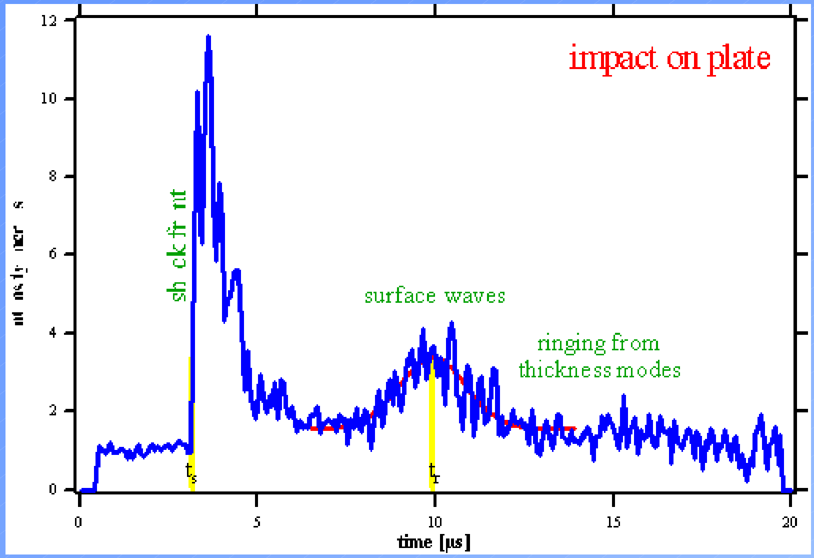
geometry and measurement principle:

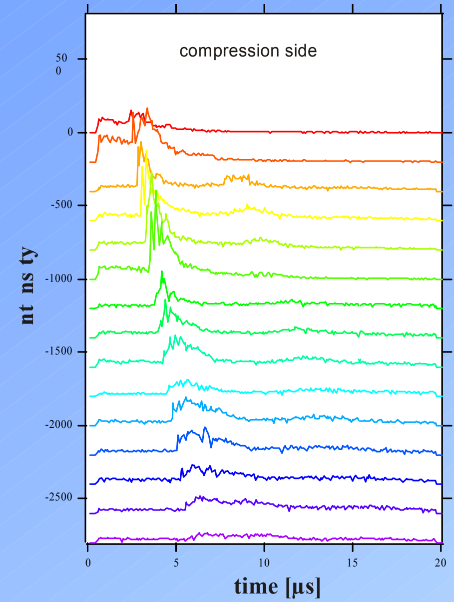


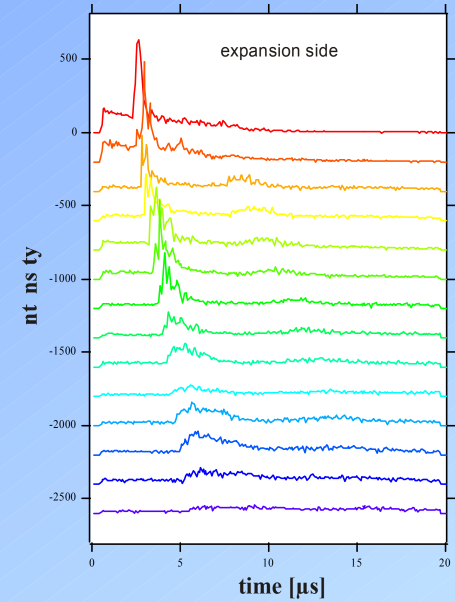


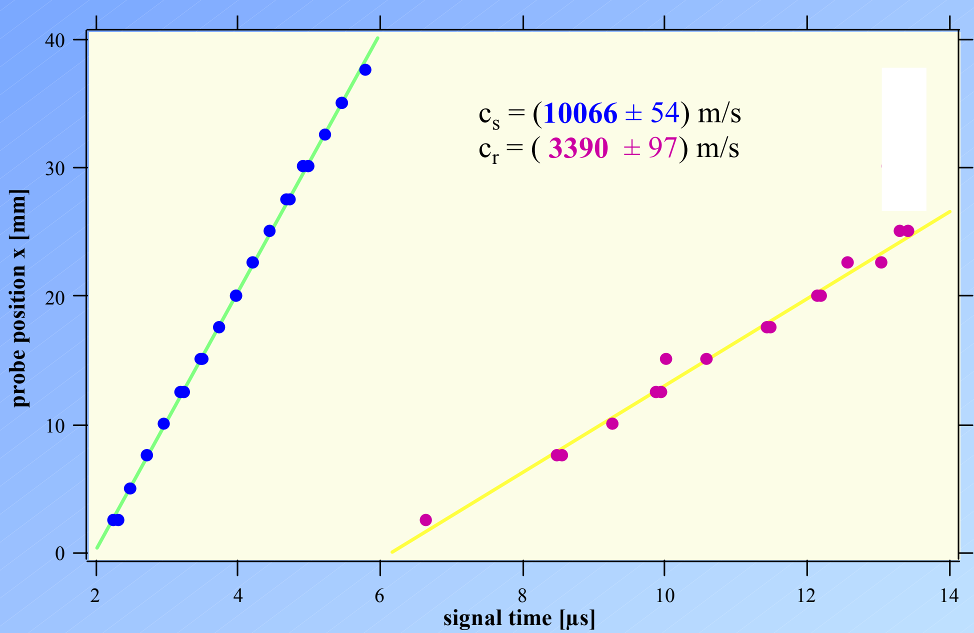
rocking curves at half the peak height
compression and dilatation side











The propagation velocity of c_s = 10066 m/s is higher than the sound velocity for Si along [111] of c = 9640 m/s. The surface wave has a velocity of c_s = 3390 m/s.

The individual shock wave components are not resolved with present time resolution.