

Neutron Optics for focussing and imaging

WP 5, DK-CH

(work in progress since September)

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NEXMAP

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SPALLATION
SOURCE



DANCHIP

Background: X-rays

X-rays: A. Snigirev *et al.* CRL for X-rays: *Nature* **384**, 49 - 51 (1996).

Status:

Synchrotrons: Most used optics for ESRF !
Transmission X-ray Microscopy

Advantages:

- Cheap
- Very adaptable: wide energy range and wide range of focal spots
- Highly reproducible: Can be inserted and removed rapidly
- Supports various types of microscopy

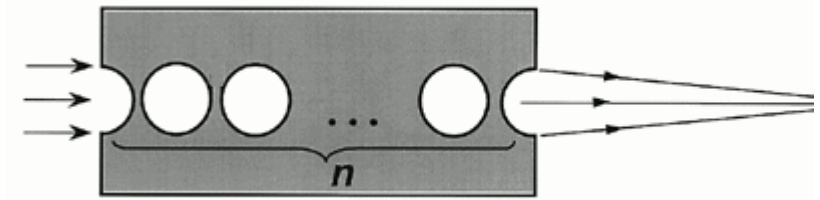
Neutrons: M.R. Eskildsen *et al.* CRL for neutrons: *Nature* **391**, 563-566 (1998)

Disadvantages

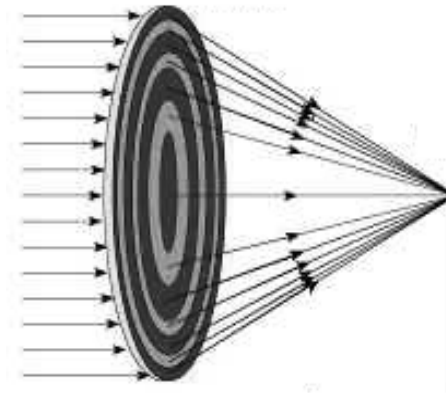
- Less efficient
- Compatibility with time-of-flight?

Existing lens technology

1. Refractive lenses
Compound refractive lens



2. Diffractive lenses
(Fresnel) zone plate



3. Reflective lenses
Bent supermirror lens

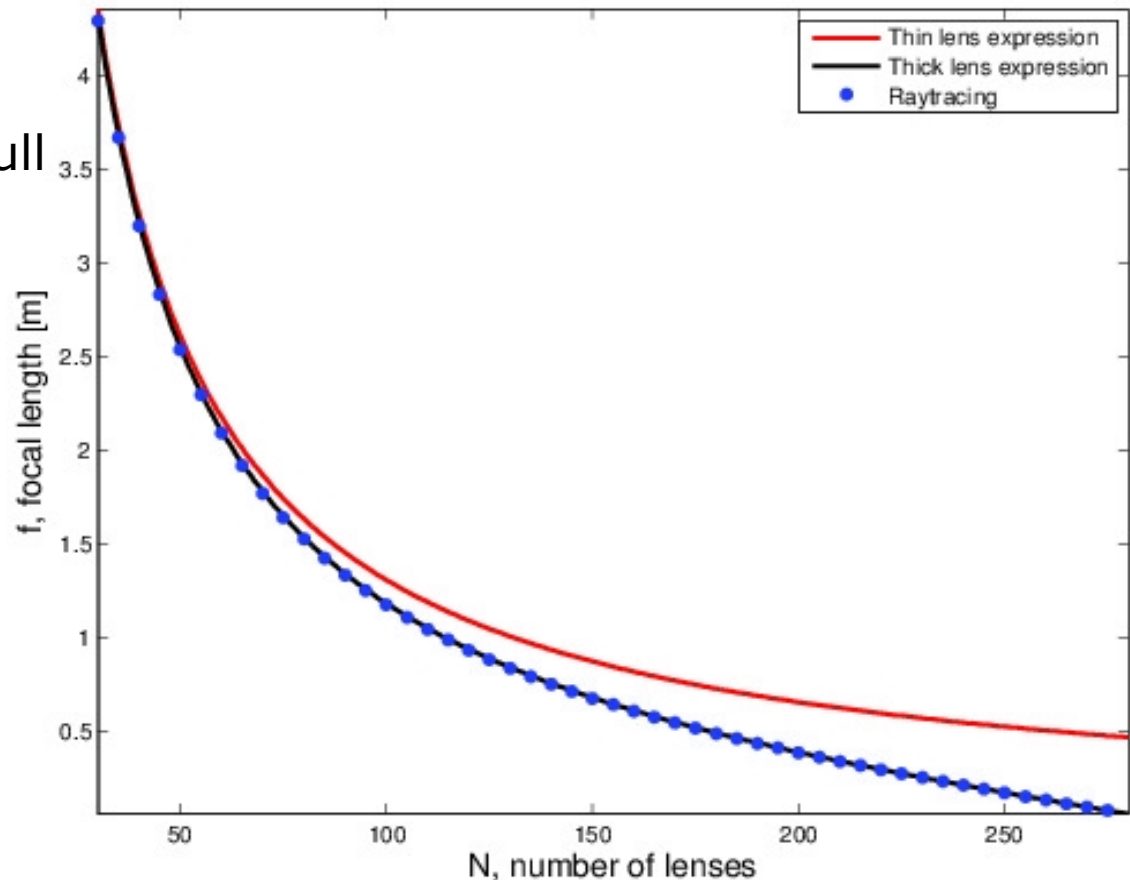
Compound refractive lenses

Is a thin lens + a thin lens + ... = a thin lens?

Analytical work is built on a full raytracing description:

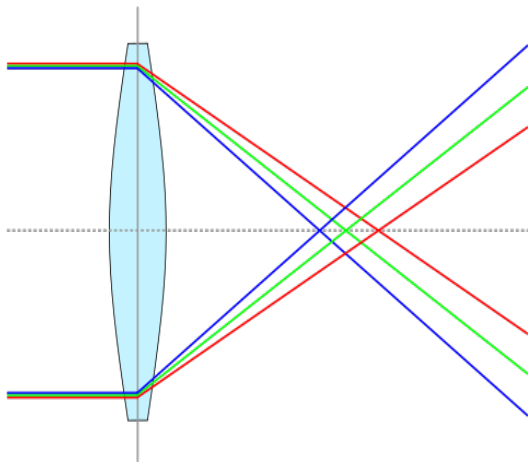
- 1) Iterative/ODE
- 2) Closed form, ray transfer

Red: thin lens description
 Blue: full raytracing
 Black: ray transfer
 (iterative/ODE not shown)



Extension to TOF, pink beam, white beam:

Chromatic aberration:

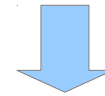


$$\text{CRL: } \Delta f / f = -2 \Delta \lambda / \lambda$$

$$\text{ZP: } \Delta f / f = -\Delta \lambda / \lambda$$

Mono. synchrotron X-rays: $\Delta \lambda / \lambda \approx 0.001$

Mono. (e.g. SANS) neutrons: $\Delta \lambda / \lambda \approx 0.1$



Variations of order $\Delta \lambda / \lambda$

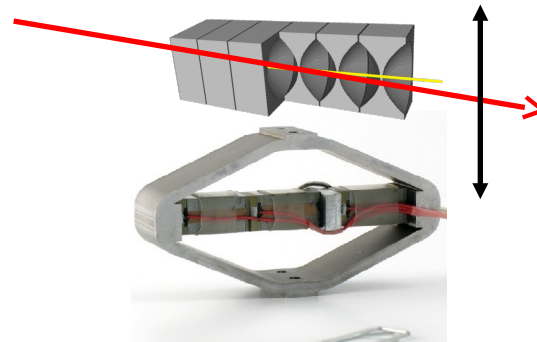
Visible light: Materials with different dispersion are combined

Not possible for neutrons!

Extension to TOF, pink beam, white beam:

Three solutions investigated:

1. Mechanical translocator



Piezo: CEDRAT Tech.
Range: ~1 mm
Time: ~2 ms

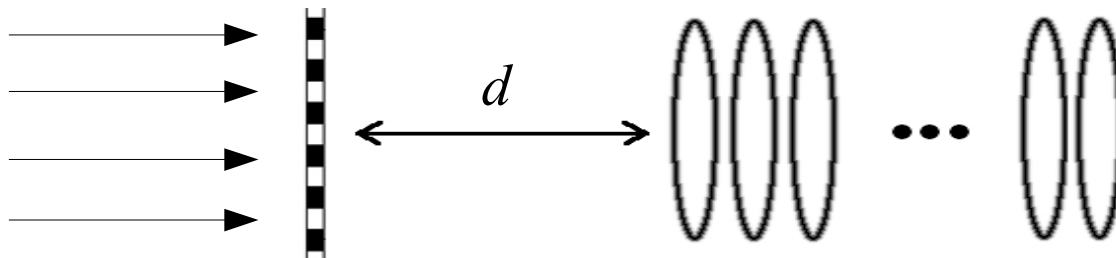
2. Magnetic translocator

Make lenses of ferrite: material for fast switching

➡ Polarization at the same time*

Extension to TOF, pink beam, white beam:

3. (Passive) combination of ZP and CRL:



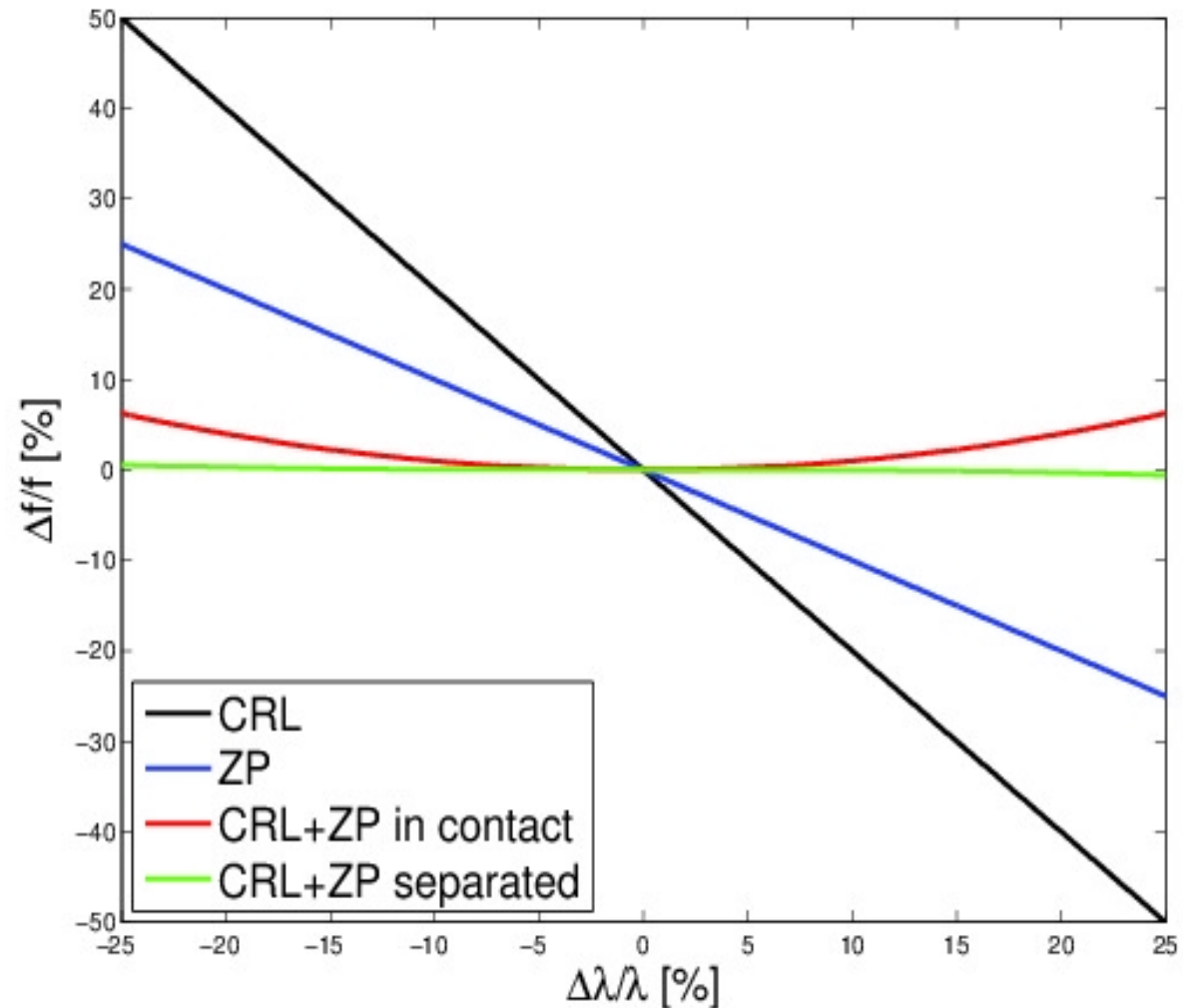
ZP focusses, CRL defocusses

$$d=0 \quad \rightarrow \quad \frac{\Delta f}{f} = \left(\frac{\Delta \lambda}{\lambda} \right)^2$$

$$d>0 \quad \rightarrow \quad \frac{\Delta f}{f} = \frac{-3}{8} \left(\frac{\Delta \lambda}{\lambda} \right)^3$$

Extension to TOF, pink beam, white beam:

- Chromatic spread for CRL and ZP is substantial
- A CRL and ZP in contact is much better
- A CRL and a ZP distanced is even better



Experimental investigation of CRL + ZP combination:

is being pursued (at BOA beamline at SINQ)

Production/purchase of CRL:

Table 1 Candidate elements for CRLs

Element/isotope	b_c/σ_a (fm^{-1})
O	310
C	19
• Be†	10
Pb*	8.0
• F†	5.8
Zr*	5.3
Pb*	3.1
Bi†	2.5
H*†	2.1
Zr*	1.6
• Mg†	0.86
Mo*	0.85
Mo*	0.68
Sr*	0.43
N*†	0.34
Tl*†	0.24

Be:

- Used for X-rays
- A. Snigirev?

MgF2:

- Used for light
- Commercially available

Production of ZP:

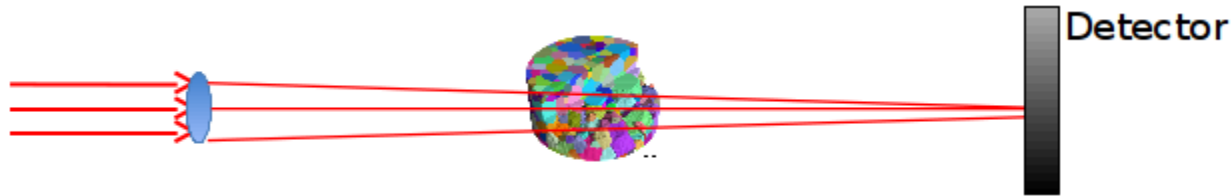
- Lithographic process
- Ni on Si is excellent
- In talks with DANCHIP



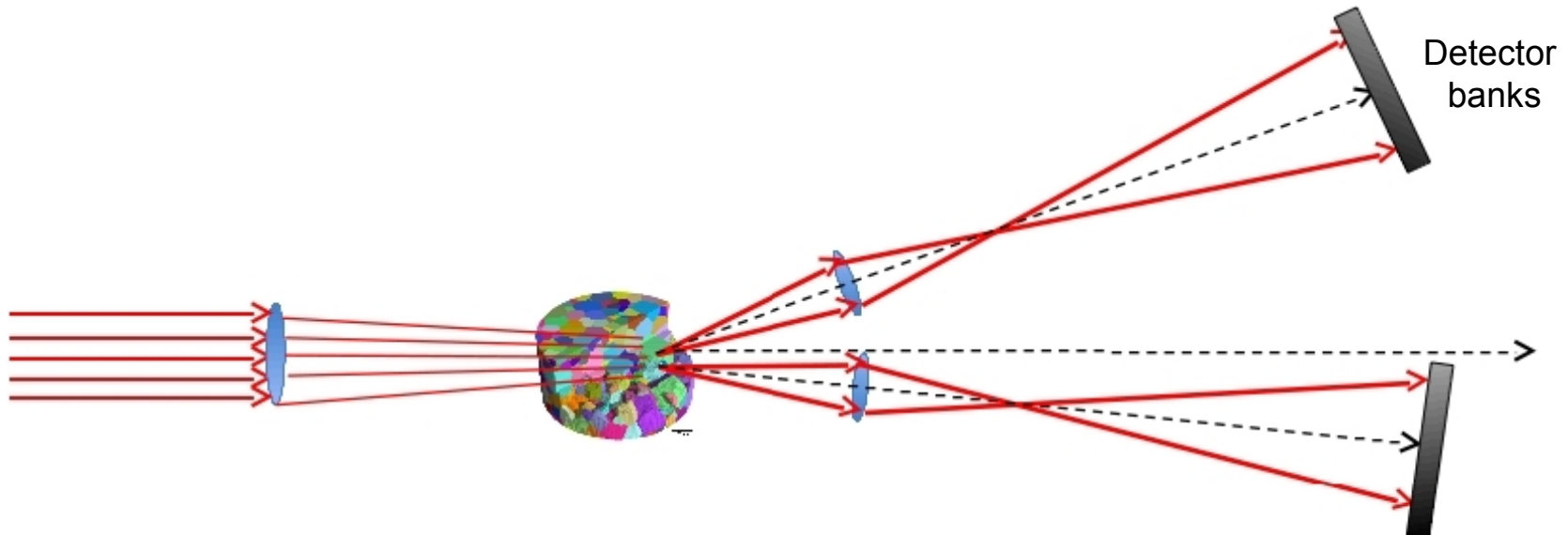
Modified from M.R. Eskildsen *et al.*
Nature **391**, 563-566 (1998)

Case for use with SANS

High resolution SANS*



SANS microscopy



3D SANS maps at all Q 's