**X-Ray Fluorescence Imaging (XFI)**

**Medical imaging techniques**

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<thead>
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<tbody>
<tr>
<td>Temporal resolution</td>
<td>poor</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>poor (4.5mm)</td>
<td>high (1mm)</td>
<td>high (1mm)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>high</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Dose exposure</td>
<td>moderate to high</td>
<td>high</td>
<td>none</td>
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**Unique advantages of XFI for medical imaging**

- Low resorption in tissue due to high working point of ~70 keV
- High sensitivity
- No gold in the human body – no false detection
- GNP's can be attached to several peptides and antibodies
- GNP's are stable: enabling the possibility for pharmacokinetics
- Spatial resolution only limited by x-ray beam diameter

**Stable electron beams**

Stable ionisation injection beams from 1 % N₂ dopant

**First XFI measurements**

Fluorescence signal from Au and Gd measured

**Thomson Scattering**

Energy of Thomson scattered X-Ray is given by:

$$\omega_L = \frac{2\gamma^2}{1 + \alpha^2 / 2 + \gamma^2 \alpha^2}$$

**XFI with GNP's requires source with:**

- Low bandwidth (<15%) [5]: $\Delta \omega_x \simeq 2 \nu_0$ [6]
- Small source size and divergence: $\Delta E \simeq \gamma^{-1} - 1$
- Large flux and rep. rate: $N_X \propto Q N_{	ext{rep}} g_{	ext{eff}} (\text{atoms})$
- Compactness and low cost
- X-Ray energy $h \nu > 90$ keV $\rightarrow \gamma > 120$

While X-Ray tubes are cheap & compact and synchrotrons have desirable beam parameters, all-optical Thomson sources fulfill all criteria!

**Experimental setup**

Flexible setup to develop and demonstrate all-optical XFI X-Ray source

**Active plasma lenses**

Compact, aberration-free, high gradient e-beam optics [7, 8, 9]

**Differential pumping**

Enclosed differential pumping allows 10 Hz repetition rate

**Summary and future**

Experimental campaign underway towards proof-of-principle XFI experiments

**Milestones reached**

- Differential pumping setup for 10 Hz gas-jet operation
- Stable, reliable electron beam source commissioned
- First XFI signal from all-optical X-Ray source measured
- Plasma lenses relax requirement on electron beam energy spread for XFI

**Next steps**

- Installing and commissioning APL into Thomson source
- Demonstrate X-Ray spectrum filtering with APL
- Pushing for system-wide 10 Hz operation
- XFI measurements of medical samples

**References**


**PLASMED-X project**

www.desy.de/projects/plasmed-x

**Research for grand challenges**

Helmholtz-Zentrum München
Deutsches Forschungszentrum für Gesundheit und Umwelt