Workshop IGLEX “Andromède & ThomX”

23 June 2016, LAL Orsay

The X-line of ThomX

jerome.lacipiere@neel.cnrs.fr
mjacquet@lal.in2p3.fr
Brightness panorama of X-ray (10-100 keV) sources

**Synchrotron**: not very practical, limited access time
High power, monochromaticity, coherence.

**X-ray tube**: lab sources
Lack of power, monochromaticity, coherence.
Brightness panorama of X-ray (10-100 keV) sources

**CCS** (X-ray flux $> 10^{12} - 10^{14}$ ph/sec)

**CCS principle**

- **e\(^{-}\) beam (MeV)**
- **20-75 MeV**
- **30-100 keV**
- **X ray beam**
- **power laser**

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Brightness panorama of X-ray (10-100 keV) sources

CCS (X-ray flux > $10^{12} - 10^{14}$ ph/sec)

- Compactness (surface $\sim 100$ m$^2$)
- High intensity ($10^{12} - 10^{14}$ ph/sec)
- Energy tunable beam and High X-ray energy
- High quality beam (brightness $10^{11} - 10^{15}$)

Some powerful analyzes currently realized at synchrotrons and requiring a high brightness beam could be largely developed in a lab size environment (hospitals, labs, museums).

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Brightness panorama of X-ray (10-100 keV) sources

**Next future** (supra machines)

**Near future** ("hot" machines)

<table>
<thead>
<tr>
<th>Flux</th>
<th>$10^{13}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brighness</td>
<td>$5 \times 10^{11}$</td>
</tr>
<tr>
<td>Transv. source size</td>
<td>40-100 μm</td>
</tr>
<tr>
<td>$E_X$ on-axis</td>
<td>30-90 keV</td>
</tr>
</tbody>
</table>

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The Compton beam

\[ E_X \sim \frac{4 \gamma^2 E_{ph}}{1 + (\gamma \theta)^2} \]

Univocal relation between energy \( E_X \) and diffusion angle \( \theta \)

Conical beam

\[ E_X : E_e = 50 \text{ MeV} \]

\[ \theta \sim 10 \text{ mrad} \rightarrow 22 \text{ keV} \]

\[ \text{On axis X-rays} \rightarrow 45 \text{ keV} \]
2 ways to use a Compton beam

1. Using the 2D divergent beam

- Pink beam (1% - 30% bw)
- Flux $\sim 10^{11} - 10^{13}$ ph/s
- Several cm diameter beam

→ Measure large sample with no more need to move it (patient, animals, material …)

2. Using the central part of the beam after focusing

Focus device (Refractive lenses (CRL), Capillary optics …)

- Quasi-monochromatic beam ($\sim 0.1\% - 0.01\%$ bw)
- Flux $\sim 10^8 - 10^{10}$ ph/s
- $< $ mm diameter beam

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TABLE 1
Beam monitoring & focusing

Connection pipe + radiation protection

“TABLE 2”
X-Ray experiments
X-RAY OBTURATOR

Valve system

Purpose
• Cutting the beam for all downstream devices
• Measuring the background noise

Design
• Sliding tungsten shutter + electrical actuator
• 2 external end-switches
• Beryllium window + nitrogen flange
**SLIT SYSTEM**

Alignment device + Beam shape

**Purpose**
- Beam selection
- With slit system #2, alignment of X-line

**Design**
- Standard JJ X-Ray slit system design
- Customized stainless steel body
  - (vacuum tightness)
- Linear encoders on all movements

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FLUORESCENT SCREEN

Beam detection

Purpose

• Detecting the presence of the beam

Design

• Retractable fluorescent screen
• CCD camera
• Si diode (redundant information)
**DIODES DETECTOR**

*Intensity variation measurement*

**Purpose**
- Measuring beam intensity variations

**Design**
- 2 Si photodiodes with symmetric translation movement
- 2 possible positions for the whole detector
**Thom X – X Line –** **Table 1**

**BEAM PROFILER**

*Absolute position measurement*

**Purpose**

- Measuring beam absolute position

**Design**

- Translation of a caliper holding 2 tungsten wires inside the beam, along 1 direction
- 2 possible positions for the whole detector
- End of the line: Beryllium window + nitrogen flange

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Thom X – X Line – Table 1

TRANSFCATOR

*Beam collimation & focus*

**Purpose**
- Collimating / focusing the beam core for experiments on table 2

**Design**
- Translation of beryllium lenses inside the beam, aligned to the beam axis
- Independent positioning system
- Helium or nitrogen flush
**TRANSFOCATOR HOLDER**  
*Alignment of the Transfocator*

**Purpose**  
- Independent alignment of the transfocator

**Design**  
- Motorized manipulator with 4 independent movements  
- 2 translations / 2 rotations  
- High accuracy / repeatability
Thom X – X Line – **Table 1**

**GRANIT TABLE**

*Support of the TABLE 1*

**Purpose**

- Alignment of the whole line of detectors on table1

**Design**

- Motorized assembly with 4 independent movements, 5 granite tables
- High range translation: extracting the whole table.
- High accuracy / repeatability
Thom X – X Line – **Table 1**

**STATUS OF TABLE 1**

**Manufacturing & assembly**
- All detectors, but transfocator
- Transfocator holder: assembly in progress

**Tests**
- Table 1: movements are OK, accuracy & repeatability to be checked
- All detectors: to be tested at ESRF FAME beamline in September
RADIATION PROTECTION
*Beam Shutter + Lead Shield*

**Purpose**
- Safety element: protection of people inside the X-hutch

**Design**
- Beam shutter is connected to the lead shield
- Lead shield is adjusted to the connection pipe

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Thom X – X Line – **Connection pipe**

- Decoupled of the X-Hutch elements
- Minimizing air switches

**Primary vacuum chain :** $10^{-3}$ mbar
**Thom X – X Line – **Table 2

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### "TABLE 2" EQUIPMENT

**Purpose**: X-ray experiments

**Status**
- Still under definition – no CAD design yet
- Highly versatile equipment

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Thom X – X Line – **Table 2**

**CONNECTION PIPE HOLDER**

**Design**
- Adjustable holder refurbished from ESRF
- 2 degrees of freedom
Thom X – X Line – **Table 2**

### SLIT SYSTEM #2

**Purpose**
- Beam selection
- With slit system #1, alignment of X-line

**Design**
- Custom JJ X-Ray slits, aperture 150×150mm

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Table 2

GRANIT TABLE

- On the ground
- Reference horizontal surface for all devices
- Allowing horizontal movements with rails or air cushion
Thom X – X Line – **Table 2**

**MONOCHROMATOR**

**Purpose**
- Beam wavelength selection

**Design**
- Hexapod will allow 3 rotations around « Monochromator IP »
- Manual translation along X axis (insertion / extraction)
**Thom X – X Line – Table 2**

**SLIT SYSTEM #3**

**Purpose**
- Cleaning the beam, limiting diffusion

**Design**
- Under definition, aperture 30×30mm
- 300mm translation along beam axis
Thom X – X Line – Table 2

GONIOMETER

- Moving plate + embedded systems

2 movements

- Rotation around vertical axis, centered on monochromator IP
- Translation along beam axis to put sample origin on monochromator IP
SAMPLE HOLDER

**Purpose**: Sample positioning and orienting

**Design**
- Hexapod allowing 6 degrees of freedom (orbital movement + 3 translations), working volume 300×300×300mm
- Turntable allowing 360° rotation around axis perpendicular to hexapod table
Thom X – X Line – **Table 2**

**DETECTOR HOLDER**

2 primary movements
- Rotation around vertical axis crossing sample origin
- Horizontal translation

2 secondary movements
- 2 concurrent rotations for Soller slit system

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Thom X – X Line – Table 2

STATUS OF “TABLE 2”

Work in progress…
Beam monitoring

Highly versatile equipment
Outlook coming next ...

Dosimetry - Beam characterisation (Johann Plagnard)
Outlook coming next ...

Beam monitoring

→ Dosimetry - Beam characterisation  (Johann Plagnard)

→ Imaging - Therapy  (Alberto Bravin)
Outlook coming next ...

→ Dosimetry - Beam characterisation
→ Imaging - Therapy
→ Fluorescence - Diffraction

Thank you