NAPP Photon Beam Entrance Alignment

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1. Introduction

1.1 ALBA Synchrotron Light facility

- ALBA is a 3rd generation Synchrotron Light facility located in Cerdanyola del Vallès, (Barcelona).
- The whole installation was finished in 2009.
- In 2010 the facility was inaugurated.
- Since early 2012 ALBA has been hosting official users.
1. Introduction
1.1 ALBA Synchrotron Light facility

The ALBA Synchrotron light source is a 3GeV storage ring able to work in top up mode which delivers X-Ray beams to seven beamlines, already in operation.
2. BL 24 – CIRCE Photoemission Spectroscopy and Microscopy

CIRCE: Soft X-Ray beamline that counts with two different end stations, Photoemission Electron Microscopy (PEEM) and Near Ambient Pressure Photoemission (NAPP).

<table>
<thead>
<tr>
<th>TECHNICAL SPECIFICATIONS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Photon energy:</td>
<td>100 - 2000 eV</td>
</tr>
<tr>
<td>Polarization:</td>
<td>Variable</td>
</tr>
<tr>
<td>Energy resolution:</td>
<td>~ 8000</td>
</tr>
<tr>
<td>Photon flux</td>
<td>~ 10^{13} ph/s</td>
</tr>
<tr>
<td>Beam spot size at PEEM position (VxH) (FWHM):</td>
<td>variable, min 3.2 x 36 um²</td>
</tr>
<tr>
<td>Beam spot size at NAPP position (VxH) (FWHM):</td>
<td>~ 20 x 100 um²</td>
</tr>
</tbody>
</table>
The Near Ambient Pressure Photoemission (NAPP) is an Ultra High Vacuum setup equipped with a hemispherical electron energy analyzer.

- Can operate from UHV up to 25 mbar.
- Includes a differential pumping system.
- Sample spot smaller than 100µm.
- Allows to get information during some reactions (catalysis, fuel cells, batteries, corrosion...).
2. BL 24 – CIRCE Photoemission Spectroscopy and Microscopy

2.2 Photon Beam Entrance.

- Compactness and pumping efficiency.
- Apertures positions adjustable from the outside.
- Pressure difference (analysis chamber - beamline) 9 orders of magnitude.

OUR GOAL: Align the apertures within the ±0.1mm!!

<table>
<thead>
<tr>
<th>Location</th>
<th>Aperture size (mm)</th>
<th>P (mbar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis chamber</td>
<td>-</td>
<td>2.5 x 10+1</td>
</tr>
<tr>
<td>1</td>
<td>0.3</td>
<td>4.1 x 10−3</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>1.7 x 10−5</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1.2 x 10−7</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>1.6 x 10−9</td>
</tr>
</tbody>
</table>
3. ALBA Survey and Alignment

3.1 Instrumentation.

- **Laser tracker:** for network measurement, fiducialization, installation, alignment…
  
  Reproducibility of a 3D coordinate (2σ)
  0 – 2.5m : 12μm

- **Theodolite:** for the PBE apertures alignment (optically), fiducialization.
  
  Angular measurement:
  Standard deviation 1σ:
  +0.5°

- **Optical Level:** help to check the apertures position and measure the holes diameter.
  
  Standard deviation
  (1km two way levelling) : ±0.2mm
3. ALBA Survey and Alignment

3.2 Software.

- Spatial Analyzer
- For connect the instrumentation.
- For monitoring measurements.
- For calculate geometries (cylinders…) or lines (axis).
**4. PBE Fiducialization**

The object is to put in relation the PBE beam axis with the exterior reference points to make easier the later component alignment. In addition, the apertures will be aligned before the component is positioned in its final location to allow a light beam pass through it.

1. **PBE supported in such a way that the mechanical axis is horizontal with respect to the local gravity.**

2. **The mechanical centerline will be defined by the end flanges scanned by the Laser Tracker and symbolized by two references.**

3. **The theodolite is put above the line and its telescope aligned in horizontal and vertical planes with respect to the PBE system datum.**

4. **A lantern is placed in the opposite side to symbolize the light beam passing through the apertures.**

5. **Focusing and observing the apertures, we adjust the vertical and horizontal micrometers until the hole is centered in the theodolite axis.**

6. **The WILD Precision Level will help us to check the apertures position optically.**

7. **The micrometers values are taken and the capillary and the fiducial marks measured with Laser Tracker.**

Fiducialization setup top view
5. PBE Alignment

A specific NAPP mirrors configuration, allow to work in order zero beam (white beam):

- The white beam is materialized by two spherical optical targets.
- This will be our destination axis.
- Is needed to establish a destination coordinate system.
- Taking as common point, between the source and destination point group, the capillary aperture and its coordinate system.

Distance M4d to focusing point (DM4-f): **1750mm**

Distance focusing point to capillary aperture: **15mm**
5. PBE Alignment

The measured set of fiducial marks is used to align the PBE with respect to the capillary coordinate system.

Error estimation, 1 sigma:

<table>
<thead>
<tr>
<th>FARO Laser Tracker &lt; 2.5m</th>
<th>±15μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBE fiducials reproducibility</td>
<td>±15μm</td>
</tr>
<tr>
<td>LEICA TM5100A</td>
<td>±35μm</td>
</tr>
<tr>
<td>(Network best fit (10-15m)</td>
<td>±30μm</td>
</tr>
<tr>
<td>Total</td>
<td>±40μm (50 μm)</td>
</tr>
</tbody>
</table>

### Results (using capillary coord. Syst)

<table>
<thead>
<tr>
<th></th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source positions x</td>
<td>-866.24</td>
<td>x-789.05</td>
<td>x-633.17</td>
<td>x-501.39</td>
<td>x-313.86</td>
</tr>
<tr>
<td>y</td>
<td>0.22</td>
<td>y-92.64</td>
<td>y-91.52</td>
<td>y-17.22</td>
<td>y-0.72</td>
</tr>
<tr>
<td>z</td>
<td>60.35</td>
<td>z-60.26</td>
<td>z-60.69</td>
<td>z-241.53</td>
<td>z-146.08</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th></th>
<th>F1</th>
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<th>F3</th>
<th>F4</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final positions (after PBE alignment) x</td>
<td>-866.19</td>
<td>x-789.01</td>
<td>x-633.15</td>
<td>x-501.36</td>
<td>x-313.81</td>
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<tr>
<td>y</td>
<td>0.26</td>
<td>y-92.66</td>
<td>y-91.53</td>
<td>y-17.23</td>
<td>y-0.78</td>
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<tr>
<td>z</td>
<td>60.31</td>
<td>z-60.21</td>
<td>z-60.63</td>
<td>z-241.51</td>
<td>z-146.04</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Δ</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
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<tbody>
<tr>
<td>x</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>y</td>
<td>-0.04</td>
<td>-0.02</td>
<td>-0.01</td>
</tr>
<tr>
<td>z</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Requested accuracy: Better that ±0.1mm
5. PBE Alignment

Beam entrance stage mounted to analysis chamber with frame
6. Final results

December 2012

- Photon Beam Entrance final alignment.

End 2013

- NAPP is opened to hosting official users.
- About 7 groups of researchers.
- A total amount of 9 experiments:

ESR – Ethanol Steam Reforming

\[ \text{C}_2\text{H}_5\text{OH} + 3 \text{H}_2\text{O} \rightarrow 6 \text{H}_2 + 2 \text{CO}_2 \]

Breathing chemistry

- Submitted for best experiment of 2013 @ ALBA

...
7. Summary

- NAPP beamline branch needs a differential pumping system.

- The End station PBE has four adjustable apertures which should be aligned in a fiducialization process.

- A special instruments setup allow us to align the apertures and define the main axis. In addition, a set of fiducial marks is measured.

- The PBE alignment is carried by defining the destination axis thanks to the order zero beam.

- Since end 2013, NAPP branch hosts official users and near 10 experiments have been developed.
8. Acknowledgments

- Jon Ladrera, ALBA Survey and Alignment group member.
- Carles Colldelram, ALBA Engineering Transversal section head.
- Fabien Rey, Former head of ALBA Survey and Alignment group, and current ESS Survey and Alignment group leader
- Virginia Pérez, CIRCE - NAPP scientist.
- Carlos Escudero, CIRCE - NAPP scientist.
Thank you for your attention!