3   Layout of a synchrotron light source

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The main components of a synchrotron light source are (see Fig. 3.1): linac as pre-accelerator, linac-to-booster transfer line, booster synchrotron, booster-to-storage ring transfer line, storage ring, front ends, beam lines, and end stations [3.1,3.2]. The main functions of the components are described in the following.
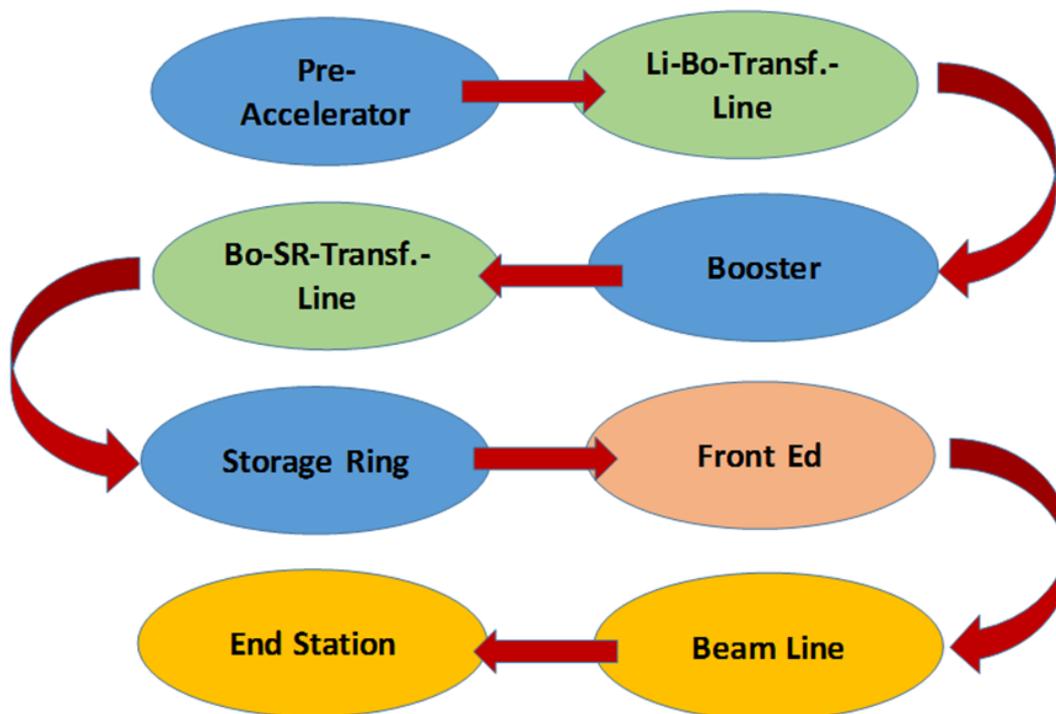

Fig. 3.1: The main sections of a synchrotron light source

–   **Pre-accelerator:** In most cases the pre-accelerator is a linac that produces a current of 4–10 mA with an energy of at least 100 MeV. The duration of the electron pulse should be a few µsec, and the duration of the pulse itself should be 1–2 nsec with a frequency of 500 MHz. It is described in more detail in section 14.2.

–   **Linac-to-booster transfer line (LTB):** This transfers the beam from the linac to the booster with high efficiency. The final energy of the linac should be in the range of 100–150 MeV (see section 14.3).

–   **Booster synchrotron:** This accelerates the beam from the pre-accelerator up to the operation energy of the storage ring (2.5–3 GeV). To reach a high injection efficiency, the emittance of the booster synchrotron should be 10 nmrad or less. The repetition rate of the booster should be in the range of 1–5 Hz (see section 14.1).

–   **Booster-to-storage ring transfer line (BTS):** This transfers the beam from the booster to the storage ring with high efficiency (see section 14.4).

–   **Storage ring:** This accumulates the beam injected from the synchrotron and stores it at currents up to 400 mA. The stability of the stored beam has to be in the sub-micrometre region. According to the requirements of users, the emittance should be small and the number and length of straight sections should be high. All of these factors are determined by the lattice of the machine. As an example, the lattice for the SRL ALBA [3.2] is presented in Fig. 3.2.
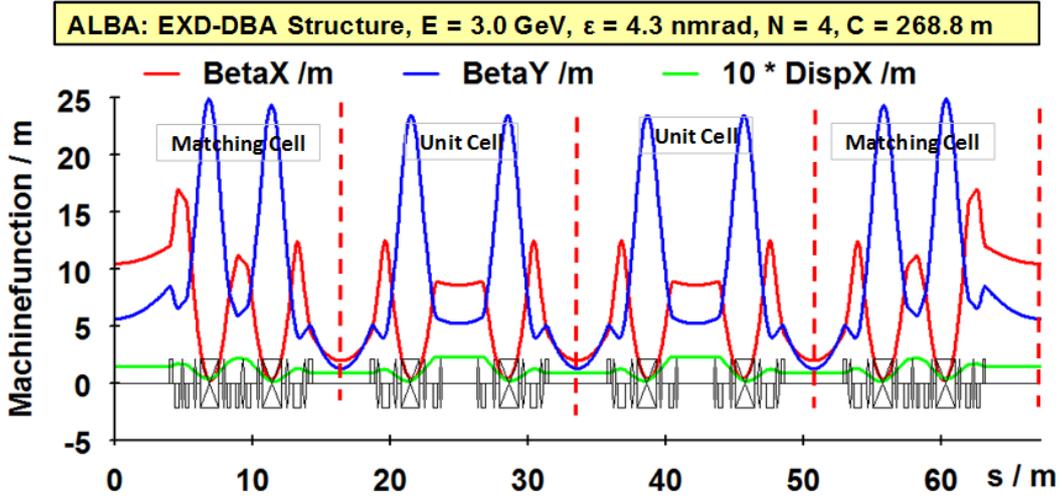
Fig. 3.2: The machine function in an achromat of ALBA

The lattice of the storage ring in ALBA consists of four achromats, leading to 24 straight sections overall. The machine functions $\beta_x(s)$ (in red), $\beta_y(s)$ (in blue), and $\eta_x(s)$ (in green) of an achromat of the ALBA lattice are shown in Fig. 3.2. The values of $\beta_x(s)$ and $\beta_y(s)$ determine the envelopes $E_x(s)$ and $E_y(s)$ according to Eqs. (3.1) and (3,2), as well the divergences $E'_x(s)$ and $E'_y(s)$ of the beam in the machine for the nominal energy E_0:

$$E_x(s) = \sqrt{A_x\,\beta_x(s)}, \quad E_y(s) = \sqrt{A_y\,\beta_y(s)}, \tag{3.1}$$

$$E'_x(s) = \sqrt{A_x\,/\,\beta_x(s)}, \quad E'_y(s) = \sqrt{A_y\,/\,\beta_y(s)}, \tag{3.2}$$

The values of A_x and A_y define the acceptances of the machine in the horizontal and vertical directions [3.3]. For a stored beam envelopes A_x and A_y are the emittances ε_x and ε_y.

The closed orbit for energy deviations ΔE is given by the dispersion function $\eta_x(s)$ according to

$$D_x(s) = \eta_x(s)\left(\frac{\Delta E}{E}\right) \tag{3.3}$$

– **Front ends:** Over the front ends (see Figs. 3.3 and 3.4), coupled with the vacuum system of the storage ring, the photo beam coming from the bending magnets or insertion devices of the circulating electron beam in the storage ring will be passed to the beam lines in the experimental hall.

– **Beam lines:** Through the beam lines the photon beam will pass to the end station. Each beam line has a special layout, depending on the experiment. The arrangements of the beam lines in the case of ALBA are shown in Figs. 3.7 and 3.8

– **End station:** Within the end station are the samples exposed, and the corresponding detectors measure the stray light from the sample.

The layout of the accelerator complex is presented in Fig. 3.5. The booster synchrotron and the storage ring are mounted in the same machine tunnel. Adjacent to the machine tunnel is the so-called linac bunker. At the centre of the building is the service area for the equipment (radio-frequency system,

diagnostics, power supplies, vacuum, etc.) needed for operation of the linac, booster synchrotron, and storage ring. Not all of the space at the centre of the building is needed for the service area, and a free area is available, which is called the courtyard. For the Swiss light source this area is used for offices and laboratories. The arrangement of the booster and storage ring in the same tunnel (for ALBA) is shown in Fig. 3.6 [3.2]. The storage ring is on the left side and the booster is on the right. The space between the two, needed for installation and maintenance, is between 0.8 and 1.5 m wide.
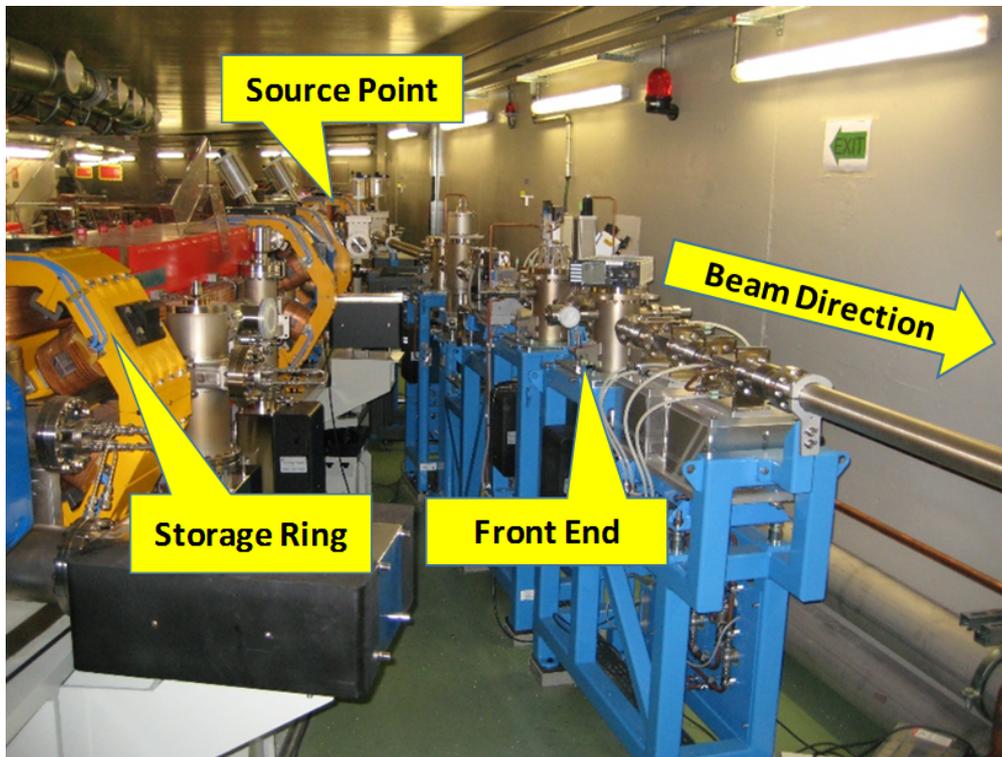

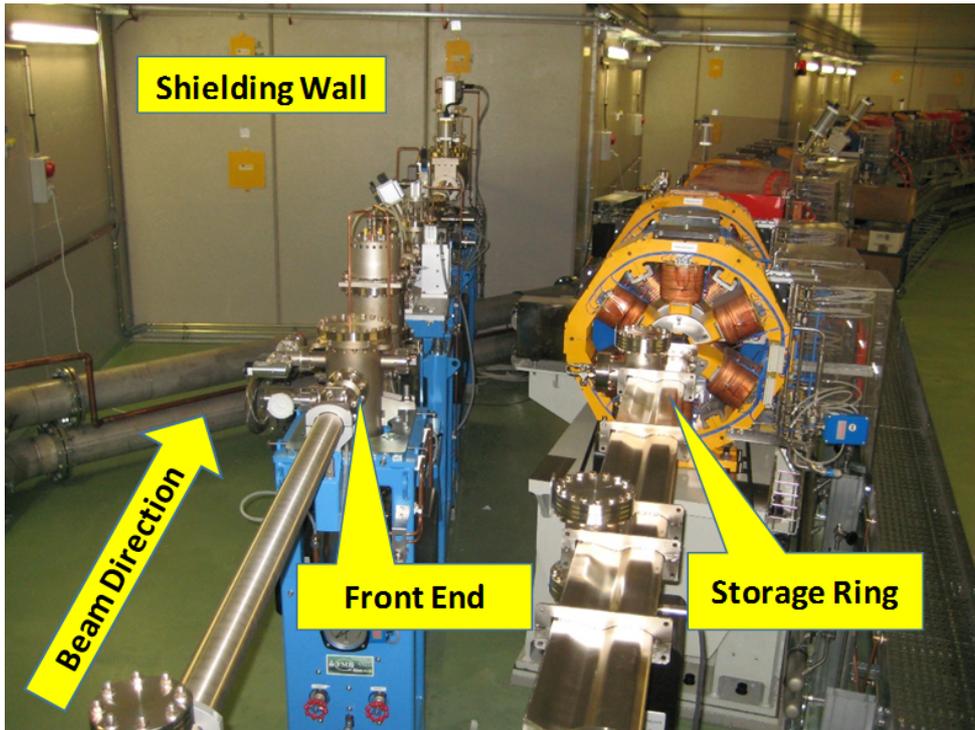**Fig. 3.3:** The first part of the front end, which comes from the source point

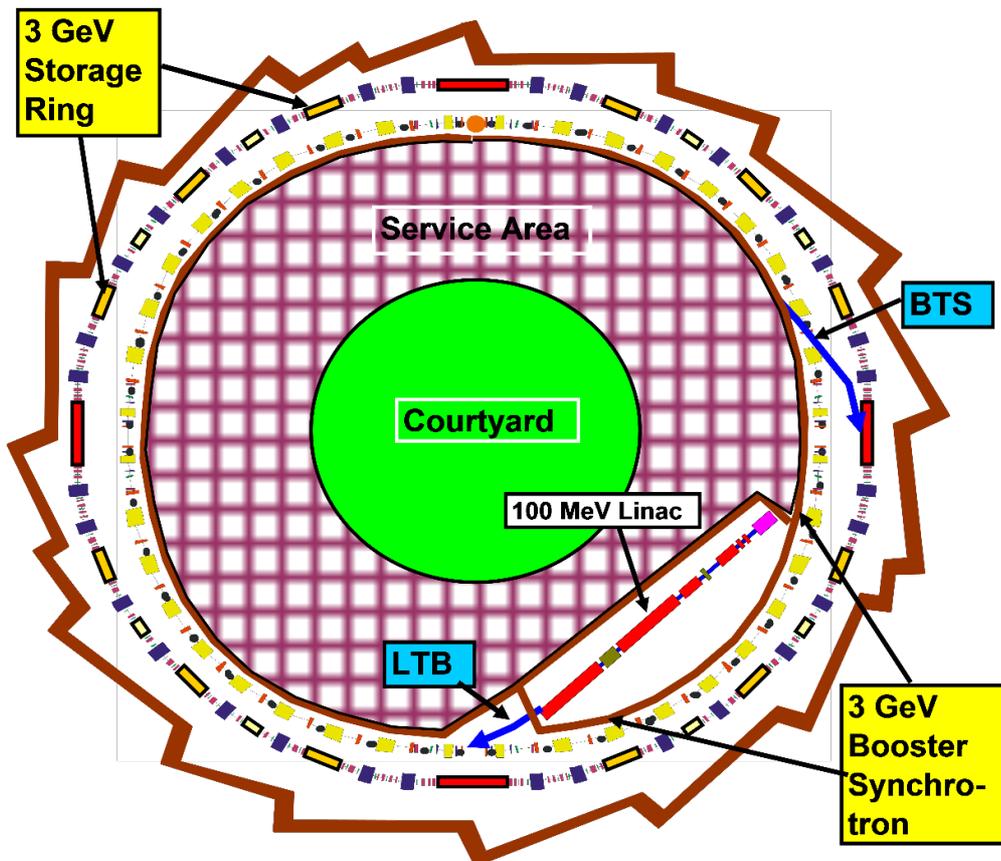**Fig. 3.4:** The second part of the front end, which goes to the shielding wall

Fig. 3.5: The layout of the accelerator complex
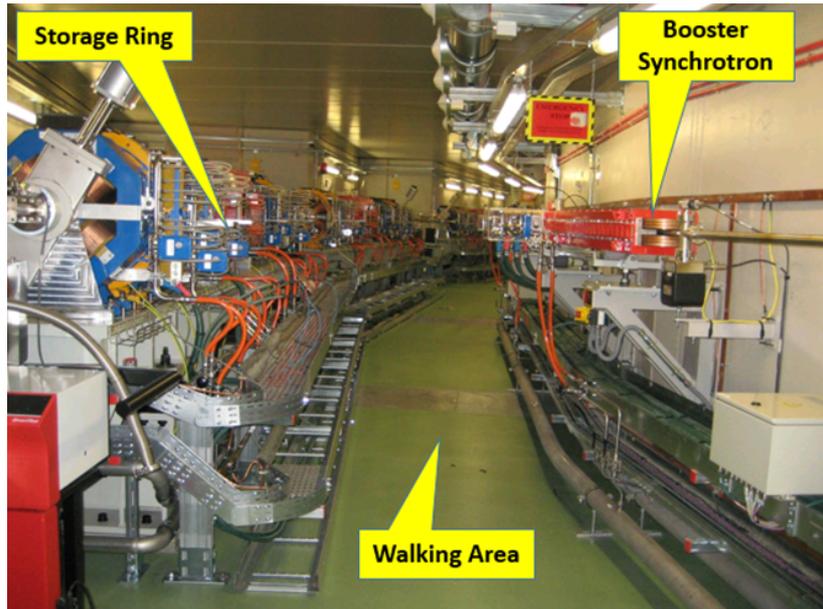
Fig. 3.6: The machine tunnel with the storage ring on the left-hand side and the booster synchrotron on the right-hand side.
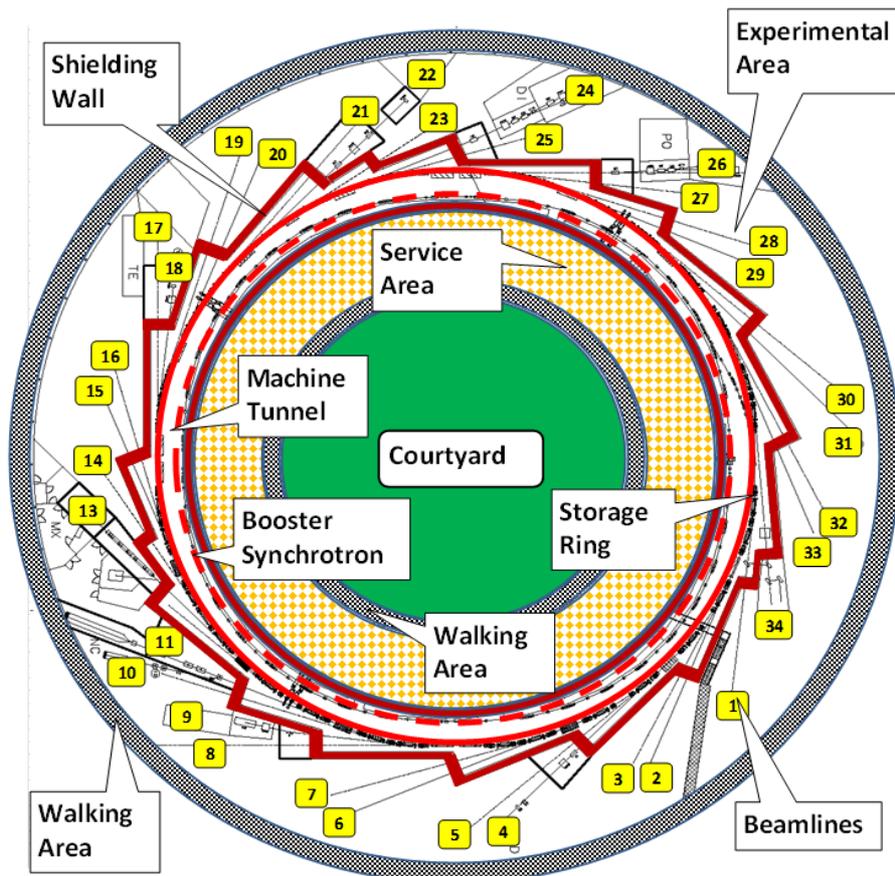

Fig. 3.7: Arrangement of the possible beam lines in the experimental area of ALBA

The arrangement of the beam lines in the experimental hall of ALBA [3.4] is presented in Fig. 3.7, and Fig. 3.8 is a photograph of the ALBA experimental hall. Around the machine tunnel is a 1.5 m-thick shielding wall. The front ends are located between the storage ring and the shielding wall.

Right after the shielding wall are the beam lines with the corresponding safety hutches and the end station (see Fig. 3.8). The experimental hall at ALBA has space for 34 beam lines coming from the insertion devices and from the bending magnets. At present there are seven beam lines at ALBA.

Fig. 3.8: Beam lines in the experimental hall of ALBA

References

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