3. Injector Complex

3.1 Layout Philosophy

Low emittance storage rings have the inherent problem that the lifetime of the circulating beam can be reduced to a few hours due to intrabeam scattering. It is thus mandatory to have an efficient injection scheme with **fast refilling** of the ring . In addition the attractive possibility for a **continuous topping up** of the beam intensity should be left open. Injection at the top energy of the ring without ramping is thus mandatory.

The two standard solutions for the injector are:

1. Full energy Linac
2. Booster Synchrotron with Preinjector (Linac or Microtron)

A full energy Linac has some attractive side effects like the potential to produce very short pulses for possible FEL applications in a stand alone configuration. The price tag for such a solution is however relatively high, with an estimate of about 25 MCHF. for the whole linac complex. In addition the running costs are higher for a linac than for a booster. For this reason we have chosen for SLS the more economic booster variant.

The **traditional approach** for a compact booster synchrotron is to build a compact lattice with separated function magnets (ALS, SPEAR, ESRF, BESSY etc.). This requires a circumference of typically 50 m/GeV or about 120 m in our case. The booster would be located either in a separate building or in the center of a circular hall.

For the **SLS booster** we have a chosen a different philosophy: to stretch the circumference, till the booster fits into the **same tunnel as the storage ring**. This saves building space and shielding costs. With the generous space available for the lattice one can now adopt the idea, originally proposed for storage rings [Ref. 1] , to distribute the bending over **many small combined function magnets**.

This booster design offers a striking number of **advantages**, which are summarized below:

- substantial saving of building space
- reduced shielding costs
- economic magnets with small aperture
- flexible repetition rates and ramping profiles
- low power consumption (<200kW), making continuous top-up injection „affordable”
- low emittance beam (9nm at 2.4GeV)
- efficient and fast injection into the storage ring
- easy transfer line between booster and ring
- relaxed parameters for the injection and extraction kickers
- simple vacuum chamber

The choice of the **repetition rate** for the booster is governed by the following issues:

1. A high repetiton rate leads to:
   a) strong eddy currents, which in turn affect the chromaticity correction with sextupoles. To minimize this effect a thin vacuum chamber is required.
   b) high induced voltages on the magnet coils.

1. A slow repetition rate leads to long filling times

Our choice of **3Hz** is a good compromise:

- filling of the storage ring is reasonably fast (in the order of 2-5 minutes)
- construction of the vacuum chamber is relatively simple: a round stainless steel tube, 0.7 mm thick, is deformed into an elliptical cross-section of $30 \cdot 20 mm^2$, requiring no reinforcement ribs.
- The maximum induced voltage on any magnet is less than 500V versus ground
- the beam has enough time to damp down to the equilibrium value for the emittance.

There are however some **disadvantages** of this layout:

- the large booster circumference requires a correspondingly long vacuum system.
- The ramping of the booster magnets produces time varying strayfields which require a distance of more than about 2m between the two machines.
- there is no separate access to the storage ring during booster test runs.

To have easy access to the storage ring and the booster one could place the booster high up under the roof of the tunnel. However we have chosen to place the booster directly at the inner wall of the tunnel, at the same height as the storage ring (see Fig. f31_a). Access to the ring tunnel will occur from the technical area. through five openings in the inner wall. However one has to duck under the vacuum chamber of the booster, placed 1.4m above the floor.

As a pre-injector for the booster synchrotron we have chosen a **3GHz Linac** with a minimum energy of 100MeV. This complex is described in chapter 3.3.

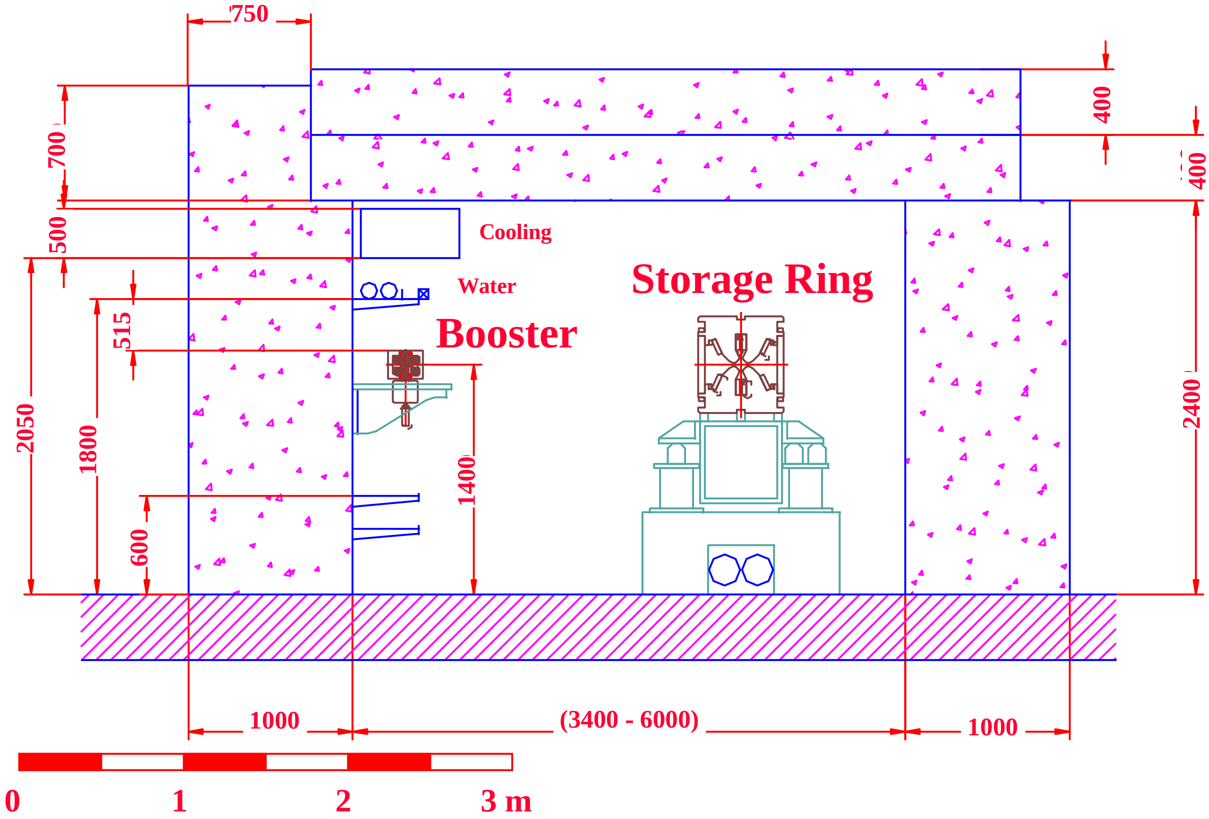
The reference energy for the booster is 2.4GeV. A summary of the relevant booster parameters is given in table t31_a

References:

A novel low emittance lattice for high brilliance electron beams
W.D. Klotz, G. Mülhaupt, Another Lattice Model for High Brightness Synchrotron Radiation Sources ESRF-LAT-88-07, 1988

Reference energy	GeV	2.4		
Circumference	m	270		
Lattice		FODO with 3 straights of 8.68 m		
Harmonic number		$450 = 15 \cdot 30$		
RF frequency	MHz	500		
maximum current	mA	12		
Maximum rep. rate	Hz	3		
Tunes Qx , Qy		12.41	8.38	
Chromaticities (*x*,*y*)		-15	-12	
Momentum compaction factor		0.005		
Equilibrium values at 2.4 GeV:				
Emittance	nm·rad	9		
Radiation loss	keV/turn	233		
Energy spread, r.m.s.		0.075%		
Partition numbers J (x,y,E)		1.7	1	1.3
Damping times (*x*,*y*,*E*)	ms	11	19	14

Table t31_a: Booster parameters



f31_a: Cross-section of the accelerator tunnel. On the left side we see a compact dipole magnet of the booster synchrotron and on the right side a quadrupole of the storage ring.