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会議報告

Italian SuperB General Meeting Report

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Abstract

A workshop was held in Perugia, Italy, from June 16th to the 19th on the design of a Super B factory, which is proposed to be built in Italy. This machine, called "SuperB," would re-use many components of the PEP-II accelerator, while the detector would re-use components from the Babar detector. The design luminosity of the machine, however, would be much higher than that of PEP-II: 10^{36} cm^{-2}s^{-1} at the Y(4s) resonance. In addition, the machine is also planned to be run as a τ-charm factory with a luminosity of 10^{35} cm^{-2}s^{-1} at a $\sim$4 GeV center-of-mass energy. The machine design also features polarized electrons. The challenges presented by these requirements and the evolving design of the accelerator part of the project (including siting issues) are discussed.

1. INTRODUCTION

The SuperB project is a proposal to build a high-luminosity B factory and detector in Italy. The project would make use of some accelerator and detector components from PEP-II and Babar, but would be built at or near the Laboratori Nazionale di Frascati (LNF) in Frascati, Italy. The physics goals of the machine are to deliver electron-positron collisions at center-of-mass energies ranging from the the τ-charm threshold at 3.55 GeV up to the Y(4s) resonance at 10.58 GeV. A feature which makes it unique compared to previous or planned similar factories (PEP-II, KEKB, Super-KEKB) is the ability to collide polarized electrons for τ physics.

The General Meeting for the SuperB collaboration was held at the Hotel Gio in Perugia, Italy, from the 16th to the 19th of June, 2009, followed by an executive session on the 20th of June. The morning of the 16th was devoted to introductory plenary sessions, with the remainder of the meeting taking place in parallel sessions and workgroups, with summary sessions held on Friday. The author attended to present an update on the design of SuperKEKB, and attended the accelerator parallel sessions, leaving to return to Japan during the Friday morning summary sessions. Accordingly, the focus of this report will be on the issues discussed during the accelerator sessions.

The slides shown at the workshop are available online at the workshop homepage: http://www.pg.infn.it/superb/workshop2009/.

2. ACCELERATOR DESIGN ISSUES

A few of the major SuperB design features are given here, with a focus on those which were primary topics of discussion at the workshop: site, polarization, and beam energies.

2.1 Crab Waist

The design of SuperB depends for its high luminosity on the use of very low emittance beams ($\varepsilon_x = 2.8$ nm in the LER, 1.6 nm in the HER, with $\varepsilon_y = 7$ pm in the LER, 4 pm in the HER) at a large crossing angle (30 mrad half-angle), and the novel crab waist (or sextupole waist) scheme which was proposed by P. Raimondi, and has been demonstrated in use at DAØNE. The crab waist scheme uses sextupoles around the IP to tilt the waist of each bunch to align with the longitudinal axis of the opposite bunch, minimizing the hourglass effect. With such a tightly focused beam ($\sigma_y = 38$ nm at the IP), it is possible to achieve a luminosity of 10^{36} cm^{-2}s^{-1} using relatively modest beam currents ($\sim$2–3 A in each ring) and without requiring extremely high beam-beam parameters ($\xi_x = 0.004$, $\xi_y = 0.095$). The trade-off is that the the beams must be controlled very precisely with fast orbit feedback operating at tens or hundreds of Hz. Such fast feedbacks

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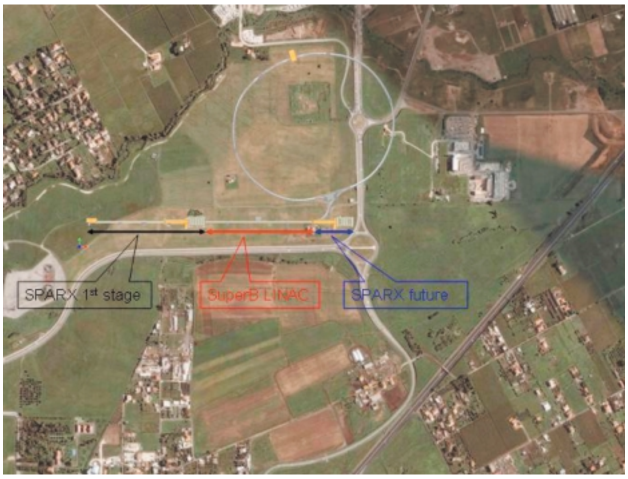

Fig. 1 Originally proposed Tor Vergata site.

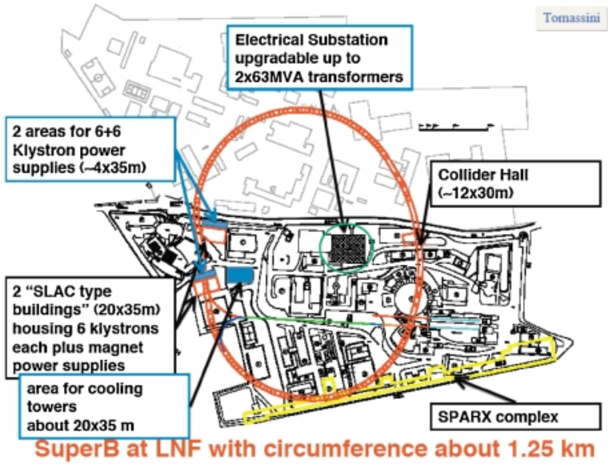

Fig. 2 Currently proposed LNF site.

have been achieved at some light sources; as John Seeman remarked, "What we need to do is make two light sources–and then collide them." M. Esposito *et al.* are carrying out ground vibration measurements to determine the level and correlation length of ground motion that can be expected. A new arc cell has been designed by P. Raimondi and M. Biagini, with phase advances of $0.75*2\pi$ per cell in the horizontal plane and $0.25*2\pi$ in the vertical, which is more compact, has better acceptance and gives lower emittances than the previous one being considered.

2.2 Site

As of January 2009, the main site being considered was the Tor Vergata site, near the Frascati laboratory. This site has the advantage of being relatively large, permitting a ring circumference of ~1800 m, though without having any pre-existing infrastructure. A picture of this site is shown in **Fig. 1**. For various practical and political reasons, attention at the Perugia meeting started to focus more on the possibility of locating the SuperB accelerator underneath the current LNF campus in Frascati. As seen in **Fig. 2**, a ~1400 m ring would fit partially under the LNF site, with a bit less than half of it extending under the site of the ENEA (Italian National Agency for New Technologies, Energy and the Environment) laboratory across the road. All major structures (collider hall, klystron galleries, power supplies, etc.) would be built on the LNF side, to minimize traffic to the ENEA side.

The evolving parameters for SuperB are shown in **Fig. 3**. Note that the parameters for March 2009 and

LER/HER	Unit	June 2008	Jan. 2009	March 2009	LNF site
E+/E-	GeV	4/7	4/7	4/7	4/7
L	cm^{-2} s^{-1}	$1x10^{36}$	$1x10^{36}$	$1x10^{36}$	$1x10^{36}$
I^+/I^-	Amp	1.85 /1.85	2.00/2.00	2.80/2.80	2.70/2.70
N_{part}	$x10^{10}$	5.55 /5.55	6/6	4.37/4.37	4.53/4.53
N_{bun}		1250	1250	2400	1740
I_{bunch}	mA	1.48	1.6	1.17	1.6
θ/2	mrad	25	30	30	30
β_x^*	mm	35/20	35/20	35/20	35/20
β_y^*	mm	0.22 /0.39	0.21 /0.37	0.21 /0.37	0.21 /0.37
ε_x	nm	2.8/1.6	2.8/1.6	2.8/1.6	2.8/1.6
ε_y	pm	7/4	7/4	7/4	7/4
σ_x	μm	9.9/5.7	9.9/5.7	9.9/5.7	9.9/5.7
σ_y	nm	39/39	38/38	38/38	38/38
σ_z	mm	5/5	5/5	5/5	5/5
ξ_x	X tune shift	0.007/0.002	0.005/0.0017	0.004/0.0013	0.004/0.0013
ξ_y	Y tune shift	0.14 /0.14	0.125/0.126	0.091/0.092	0.094/0.095
RF stations	LER/HER	5/6	5/6	5/8	6/9
RF wall plug power	MW	16.2	18	25.5	30.
Circumference	m	1800	1800	1800	1400

Fig. 3 Evolution of SuperB parameters to present.

earlier assume the Tor Vergata site. Parameters for the LNF site assume energies in the LER and HER of 4 GeV and 7 GeV, respectively. As mentioned below, these values are likely to change as a result of the workshop.

2.3 Polarization

The requirement for a polarized beam introduces certain design constraints, as showed by U. Wienands. Polarization build-up times due to Sokolov-Ternov radiative spin-flip polarization were calculated for the HER at the Tor Vergata site, and for the LER at the LNF site. The polarization build-up times were 5–6 hours in the former case, and 8–10 hours in the latter case, and are much longer than the expected beam lifetimes (tens of minutes). As a result, it is necessary to continuously inject polarized electrons. The steady-state degree of polarization then depends on the polarization lifetime due to radiative depolarization (spin diffusion), and the lifetime of the beam itself. In this case, a shorter beam lifetime actually improves the steady-state degree of polarization in the beam.

The stored beam is vertically polarized in the arcs, and the axis of spin must be rotated to the longitudinal direction when passing through the Interaction Region. The longest depolarization time is achieved with anti-symmetric spin rotators on either side of the ring, in which case the steady-state polarization is above 80% due to the cancellation of precession effects on spin-axis deviations between one arc of the ring and the other. However, to implement these, a large amount of space is needed; a ring layout featuring anti-symmetric spin rotators is shown in **Fig. 4**. The centers of the two arc sections are offset from each other by pairs of spin rotators in the arc sections.

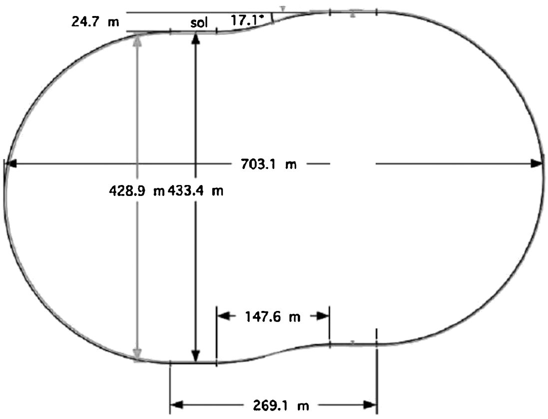

Fig. 4 Ring layout with anti-symmetric spin rotators for Tor Vergata site. (U. Wienands)

Unfortunately, at the LNF site there is no room for anti-symmetric spin rotators, so symmetric spin rotators must be used around the IP. In this case the polarization lifetime is greatly reduced. A plot of the polarization lifetime versus γG (where $G = (g-1)/2$) is shown in **Fig. 5**. As can be seen, the maximum polarization lifetime at the resonance peaks is only about 45 minutes–which would allow ~78% polarization at a beam lifetime is 3.5 minutes.

2.4 Energy

To accommodate polarization at the LNF site, it is necessary to run the LER at an energy corresponding to one of the peaks in the plot, which correspond to 3.75 GeV and 4.2 GeV. The higher energy is preferred by the accelerator group, to minimize the effects of intra-beam scattering on the emittance of the LER. (The detector group would naturally prefer a lower LER energy and higher HER energy for greater boost.) A smaller energy spread between the LER and the HER also reduces the RF power requirements. For now, the accelerator group is using 4.2 GeV × 6.7 GeV

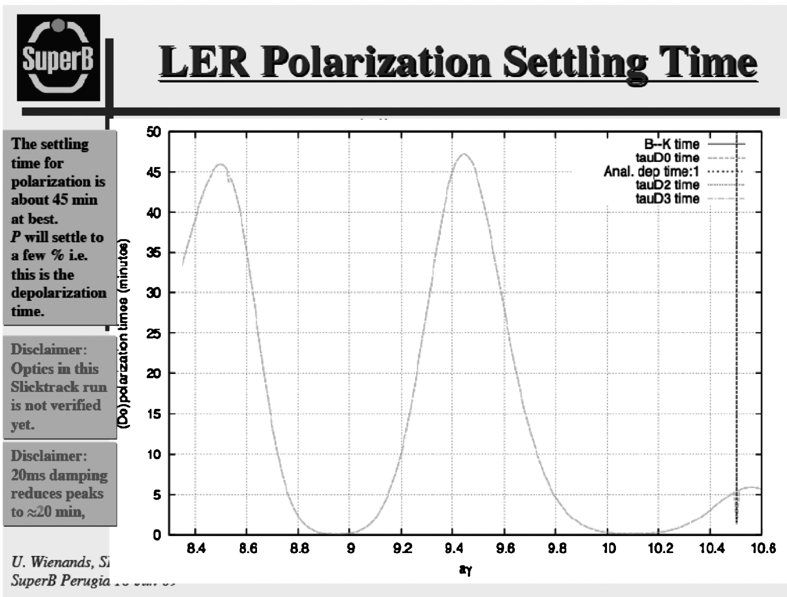

Fig. 5 Polarization settling time at LNF site site. The horizontal axis is in units of γG, where $G = (g-2)/2$. (U. Wienands)

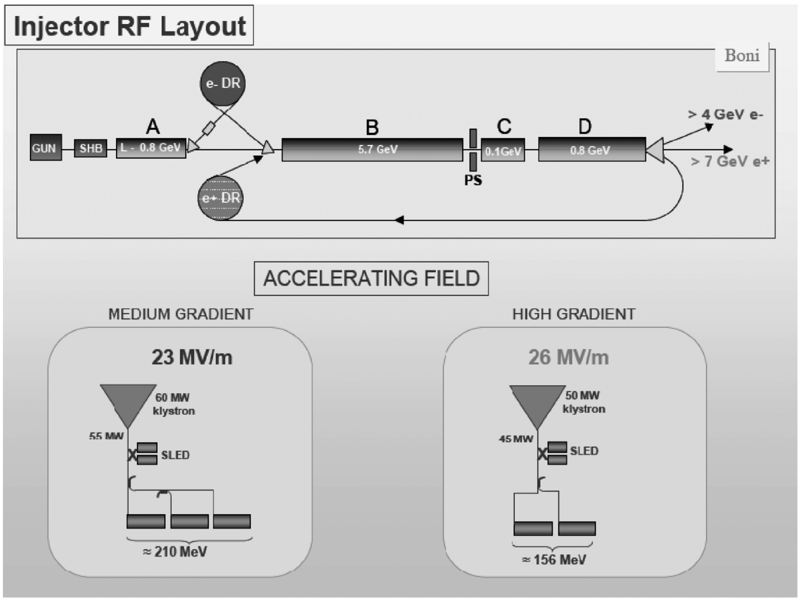

Fig. 6 Injector RF layout (R. Boni)

as a baseline for design.

2.5 Injector

The layout of the injector system is shown in **Fig. 6**. The e^- damping ring has a spin-rotator in front for converting the spin axes of the polarized electrons to vertical for damping and injecting into the ring. Positrons would be accelerated through the downstream section twice, passing through a positron damping ring after the first pass. At the LNF site, the linac currently being used for DAϕNE can be re-used at the initial stage, to the left.

3. SUMMARY

The SuperB General Meeting seemed to be a very productive one, with significant progress made in the evolution of the SuperB design. Many other design issues, not touched on in this report, were also covered and the transparencies can be viewed at the workshop website[1]. The next general meeting will be held in October, 2009 in the US at SLAC.

REFERENCES

1) All illustrations come from presentations which can be found at the website of the SuperB General Meeting in Perugia: http://www.pg.infn.it/superb/workshop2009/