TLEP News

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Editors:
the TLEP Steering group
Online version:
http://tlep.web.cern.ch

Editorial: Happy days

The past month witnessed great progress on the TLEP design: Optics "version -1", multi-turn strong-strong beam-beam simulations including beamstrahlung, a 100-km tunnel alternative, revised TLEP parameters, a draft structure for the design study, the TLEP documentation database, and an International Advisory Committee figure among the most recent achievements. Some of these points are detailed further below. The TLEP concept also drew great attention with audiences in Japan, Switzerland, France and the US. By 15 July 2013 the TLEP Design Study had attracted 280 physicists from 21 different countries and CERN, which is, as everyone knows, a "country" of its own.

It's Official!

The TLEP design study is part of the CERN Medium Term Plan (MTP) approved by the CERN Council. Here, among 14 appearances of the acronym TLEP in the MTP, is a direct quote:

> - studies for high-energy proton-proton and electron-positron colliders in a new 80-100 km circular tunnel have already started. The aim is to have available Conceptual Design Reports by the time of the next update of the European Strategy for Particle Physics.

Now we have got our work cut out!

0.2 nm?

Who said getting an emittance lower than LEP2's at much higher beam energy was difficult? A first arc optics design by Bernhard Holzer delivers a horizontal emittance 100 times smaller than the original TLEP design goal (0.2 versus 20 nm)! Figure 1 compares the optical functions over an arc cell with those for LEP2. This arc optics can now be relaxed, through longer cells, e.g. to achieve a horizontal emittance around 2 nm.

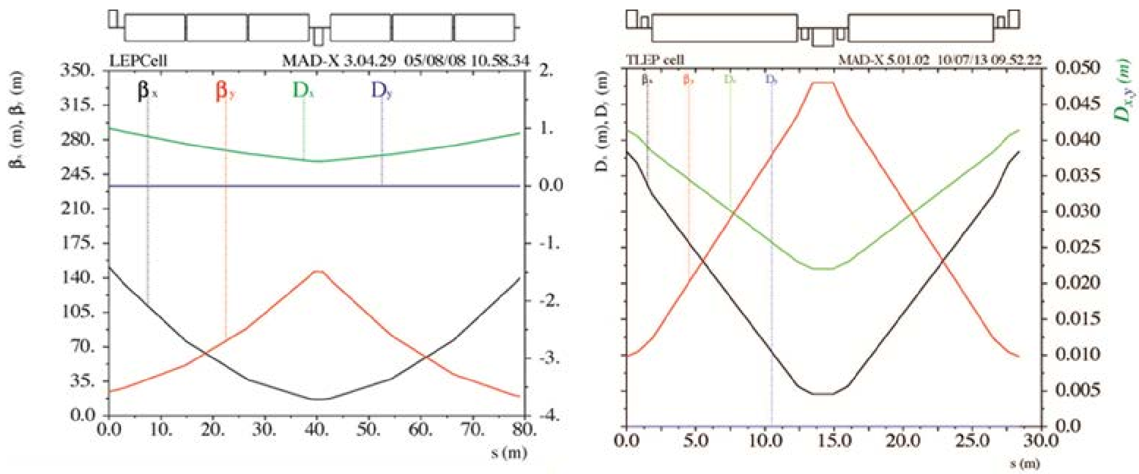

Figure 1: Arc optics for LEP2 (left) compared with TLEP version "-1" (right). Shown are the horizontal and vertical beta functions (black and red) and the dispersion (green and blue [=zero]) over one arc cell. Going from LEP2 to TLEP, here the bending radius increases from 3100 to 9100 m, and the cell length decreases from 79 to 28 m. As a result of these changes, the horizontal emittance shrinks from 48 nm at 104.5 GeV in LEP to 0.2 nm at 175 GeV in TLEP (Helmut Burkhardt, Yunhai Cai, Bernhard Holzer).

Self-consistent luminosity simulations

Last week Kazuhito Ohmi performed the world's first ever strong-strong multi-turn beam-beam simulations including beamstrahlung! Results shown below, in Fig. 2, appear consistent with an analytical estimate of the self-consistent bunch length in the presence of beamstrahlung. Without beamstrahlung the bunch length is constant. In a weak-strong model, where the "strong" bunch is unaltered during the simulation, the weak bunch lengthens up to 12 mm. In the more realistic strong-strong simulation both colliding bunches change their distribution with time, getting longer. For the parameters of Fig. 2 the steady-state bunch length is 4.3 mm, in good agreement with an independent analytical estimate. The luminosity then falls ~30% short of the design value. Recently the TLEP parameters have been revised taking into account these new findings. They now include the bunch lengthening due to beamstrahlung, an effect first pointed out by Kaoru Yokoya in early 2012.

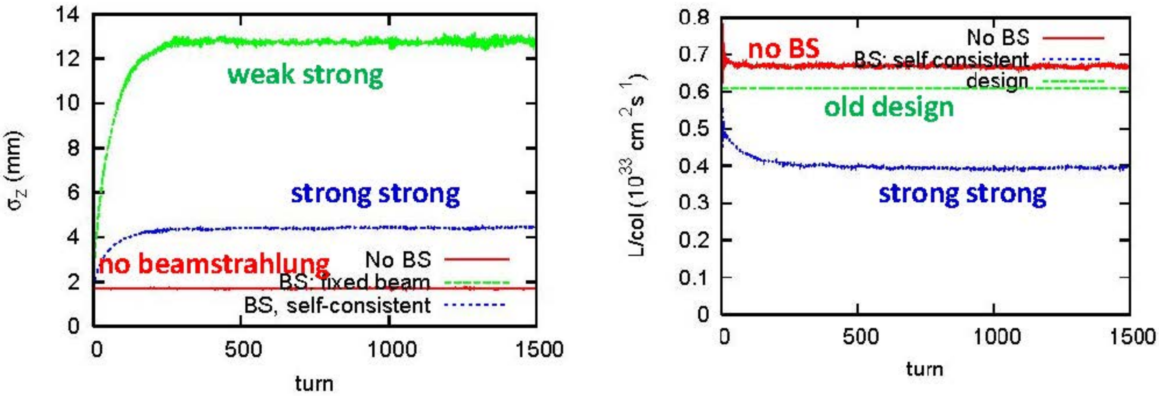

Figure 2: Strong-strong and weak-strong simulation results including beamstrahlung for old TLEP parameters at 240 GeV c.m. (Kazuhito Ohmi). Shown are the rms bunch length [left] and the bunch luminosity [right] until the simulation reaches a steady state, under various approximations. The final bunch length of 4.3 mm agrees with an analytical calculation, for the parameters considered in this example.

Great strides in parameter space

The search for optimum TLEP parameters is progressing! Inspired by optics version "-1" (an optics with 12 straights but no low-beta insertions yet) for TLEP-t the transverse emittances and momentum compaction can be reduced. At lower beam energies the arc cells then need to be lengthened by integer factors in order for the emittances not to become too small. Also, self-consistent values are now being computed for the bunch length including the effect of beamstrahlung. In addition the RF frequency was raised from 700 to 800 MHz, and a circumference of 100 km, instead of 80 km, is also tentatively considered. Updated parameters at four different beam energies are proposed in Table 1. The first of two options for TLEP-t features more bunches, smaller emittance, and smaller vertical IP beam size; the second an 8 times larger emittance (2x the arc cell length), fewer bunches of higher charge, larger IP beam size, and lower beamstrahlung lifetime. The parameters of Table 1 will be presented during the 5th TLEP workshop at FNAL. If approved by the Steering group they may later become the 'official' parameter set.

Table 1: Proposed updated TLEP parameters, considering a circumference of 100 km, 11 km bending radius, 50 MW SR power per beam, and 4 interaction points. Listed are the beam energies for 4 different running modes, the beam current, the number of electrons or positrons per bunch, the transverse emittances, the beta functions at the collision point(s), the rms bunch length including the additional energy spread due to beamstrahlung, the energy loss per turn due to synchrotron radiation, the beam-beam tune shift (chosen as equal to, or lower than the maximum values inferred from LEP2 experience), the luminosity per interaction point (taking into account the hourglass effect), the unavoidable beam lifetime due to radiative Bhabha scattering, and the additional beam lifetime contribution from beamstrahlung assuming a momentum acceptance η of 2% (the total beam lifetime being obtained from the inverse sum of these two contributions).

	TLEP-Z	TLEP-W	TLEP-H	TLEP-t	
E_{beam} [GeV]	45	80	120	175	
beam current [mA]	1440	154	29.8	6.7	
$\#e-$/bunch [10^{11}]	4.0	1.0	3.7	0.88	7.0
horiz.,vert. emit. [nm]	29.2, 0.06	3.3, 0.017	7.5, 0.015	2.0, 0.002	16.0, 0.016
$\beta^*_{x,y}$ [mm]	500, 1	200, 1	500, 1	1000, 1	
$\sigma^{tot}_{z,rms}$ [mm]	2.93	1.98	2.11	0.77	1.95
E^{SR}_{loss}/turn [GeV]	0.03	0.3	1.7	7.5	
$\xi_{x,y}$/IP	0.068	0.086	0.094	0.057	
$\mathcal{L}$ /IP[10^{32}cm^{-2}s^{-1}]	5860	1640	508	132	104
beam lifetime [min] (rad. Bhabha)	99	38	24	21	26
beam lifetime [min] (beamstrahlung, using Telnov formula with η=2%)	$>10^{25}$	$>10^{6}$	38	14	2 [12 w η=2.5%]

TLEP machine detector interface

About 10 colleagues participated in first discussions on the TLEP machine detector interface (Fig. 3). Initially the main focus of attention will be particle losses due to radiative Bhabha scattering and beamstrahlung. The TLEP MDI team would welcome an "optics version 0" – including interaction regions – as a great gift for the summer!

Figure 3: Participants are all smiles at the first meeting of the TLEP Accelerator Working Group "Machine Detector Interface, Collimation & Masking" convened by Manuela Boscolo and Helmut Burkhardt on 10 July 2013 (photo Giovanni Rumolo).

TLEP documents

A TLEP documentation database has been created. It is hosted under the ESGARD website at Saclay: http://esgard.extra.cea.fr/database/index.php . From this matrix, one can access the various documents by clicking either on the type (report, conf…) or on the category (Gen, Th, ACC, EXP) or on the numbers in the table.

Sleepless in Seattle

The normal adjective for Seattle would be "wet". This year it was "hot" as in 'heat wave', 'High Energy Frontier' or 'TLEP'. At the "Snowmass" High Energy Frontier Workshop in the State of Washington (USA) two TLEP contributions, presenting the description and the expected physics goals of TLEP, were much appreciated by the conveners, and discussed by everyone – the final versions will appear very soon on the TLEP web site. In most of the summary reports, TLEP appeared as new and 'starting' … but in good place.

HL-TLEP? First thoughts on the TLEP luminosity upgrade

While the TLEP baseline design parameters are barely established with an impressive value for the total (4-IP) luminosity at 240 GeV c.m. of 2×10^{35} $cm^{-2}s^{-1}$, a few experts around the world are already exploring options that could raise the TLEP luminosity by another one or two orders of magnitude. Prominent among the contemplated upgrade schemes towards "HL-TLEP", are 4-beam charge compensation coupled with crab-waist collisions, by Valery Telnov and Mike Koratzinos, and much faster top-up injection cycles, for which a powerful injector ring pulsed at 60 Hz instead of 0.1 Hz was proposed by John Seeman in late 2012. (In Europe it would be 50 Hz, of course).

Upcoming events

Summer events with presentations and discussions on TLEP include the EPS-HEP Conference in Stockholm, the final US "Snowmass" community study meeting, as well as the International Symposium on Higgs Physics in Beijing.

If you are aware of an event where a presentation by TLEP would be welcome, why don't you let us know or even volunteer by sending message to the TLEP SG?

The web site of the **TLEP @ FNAL workshop** on 25-26 July 2013 was changed to: https://indico.fnal.gov/conferenceDisplay.py?confId=6983.

As mentioned in the last issue, the **6th TLEP workshop** will be held at CERN 16-18 October 2013, followed by a **joint VHE-LHC/TLEP design study kick off** meeting in February 2014.