requirements, ideas and questions for LHeC e+ source

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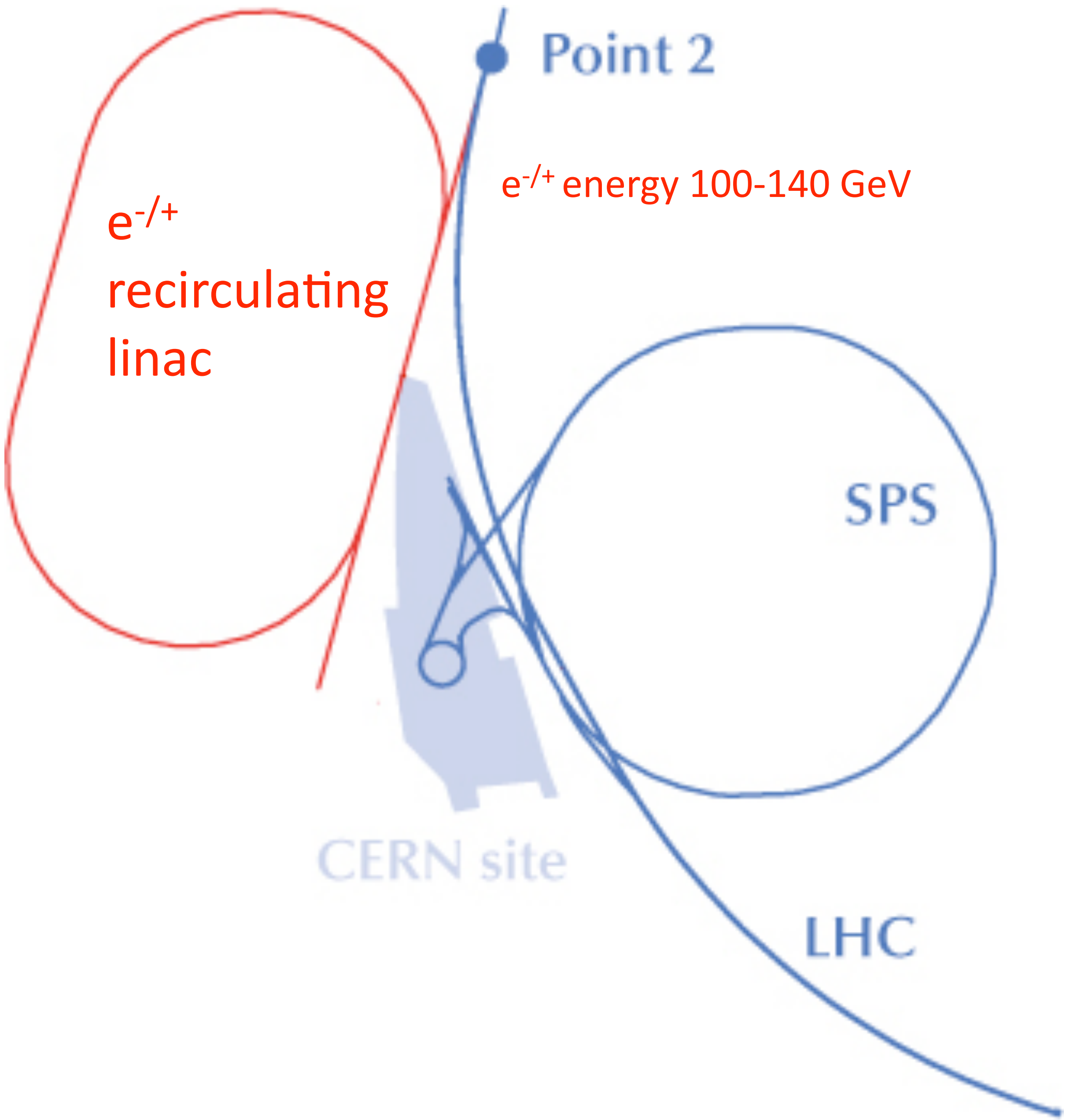
LHeC linac-ring $e^{+/-}$-p collider



beam parameters for LHeC ring-linac collider compared with other projects

	CLIC (1)	ILC (2)	XFEL	HP- SPL (p)	LHeC ERL (cw)	LHeC (50 ns)	LHeC (250 ns)	Unit
Energy at IP	1500	250	20	5	60	100	100	GeV
Luminosity				N/A	10 (1)	1	1	$\times 10^{32}$ $cm^{-2}s^{-1}$
Bunch population	0.372*	2*	0.6	0.07	**0.14 (0.01)**	**0.3**	**1.5**	$\times 10^{10}$
Bunch length		300*	24	57	300	300	300	μm
Bunch interval	0.5*	369*	200*	2.8	50	50	250	ns
Normalized horiz. emittance	0.6 (at inj.)* 0.381 (in DR*	10 (at IP)*	1.4*	0.35	50	50	50	μm ·rad
Normalized vert. emittance	1.0 (at inj.)* 0.0041 (in DR)*	0.04 (at IP)*	1.4*	0.35	50	50	50	μm ·rad
Average current		0.04	0.03	1-2	**5 (0.5)**	**0.5**	**0.5**	mA
Repetition rate	50 or 150	5*	10*	50	CW	10 (?) (5% d.f.)	10 (?) (5% d.f.)	Hz
Bunches per pulse	312*	2625*	3250	422400	N/A	71430	14286	
Pulse current		9*	25	20/40	**5 (0.5)**	**10**	**10**	mA
Beam pulse length	0.000156	1*	0.65*	0.4-1.2	N/A	5	5	ms

(1) CLIC parameterlist for 3 TeV. http://clic-meeting.web.cern.ch/clic-meeting/clictable2007.html

(2) Nominal and design range of beam parameters at the IP. From the ILC Technical Design Report 2007 Volume 3, Table 1.3-1 page 9, Table 2.1-2 page 29.

parameters for pulsed-linac versions:

pulse current similar to ILC,

but average current ~10 times higher

(pulse length x 5; repetition rate x 2)

- *we can trade repetition rate against pulse length*
- *can spent e- beam drive undulator e+ source?*
- *do we need a damping ring?*

parameters for cw-ERL version:

average current ~100 times ILC

but instantaneous current ~1/2 ILC

- *can e+'s be recycled together with their energy?*
- *is Compton scheme an option?*

comments from Omori san 30.12.2008 – cw scheme

Here, I think only Compton schemes because the Compton scheme is familiar to me.
Maybe conventional sources and undulators will give another solution...

(1) cw linac, 1e8 e+/bunch, 50 ns spacing, continuous operation

I think that a ERL Compton scheme will meet this.
An example of the required **ERL parameter**.

E= 1.8 GeV
frequency = 20 MHz (bunch spacing 50 ns)
I = 49 mA
Ne/bunch = 1.5x10^{10} (2.4 nC/bunch)
operation: CW

This is a difficult ERL. ***However, I think that this is NOT an impossible ERL.***
This ERL with 5 optical cavities (600 mJ in each) will generate
1.2x10^{10} gamma/bunch. Then those gammas create 1x10^8 e+/bunch.

No e+ stacking is assumed.
Anyway, I think that we need a damping ring.

However, if CW operation is required, it is very hard to find a time which can be used for damping.

comments from Omori san 30.12.2008 – pulsed scheme

(2) pulsed linac 5% duty factor (50 Hz trains/second, 0.6 ms pulse
length = 12000 bunches/train), 3e9 e+/bunch, 50 ns spacing during
Pulse

I think that a linac Compton scheme will meet this.
We will use a linac of 4-6 GeV beam energy and CO2 lasers with non-stacking optical cavities.
In the view point of linac Compton scheme, **many requirements of LHeC seems easier than those of ILC.**
The bunch charge, 3e9 e+/bunch, is three times smaller than the required value in ILC. The ILC requirement is 1x10^{10} e+/bunch [?].
So, we can reduce the bunch charge of the Compton linac.
The large bunch charge of the Compton linac is one of big issues for ILC.

The 50 ns spacing is also easier than the ILC requirement.
In the ILC linac Compton scheme, bunch spacing is 6.15 ns.
50 Hz repetition is also easier than the linac scheme of ILC.
In the ILC linac Compton scheme, repetition is 150 Hz.
On the other hand, the pulse length, 0.6 ms [now 1-5 ms],
is much longer than that of the ILC linac Compton scheme.
…

comments from Omori san 30.12.2008 – pulsed scheme cont'd

…
In ILC linac Compton scheme, we assume about 600 ns pulse length (6.15 ns x 100 bunches, for example),
then we assume to use a normal conducting linac for Compton.
In LHeC, I think that we need a **super conducting linac operating in 50 [or 10] Hz for Compton**. …
The long pulse length, 0.6 m sec [now 1-5 ms], is maybe hard requirement for the CO2 lasers.
We need information from Vitaly-san.

Anyway, I think that linac Compton scheme is a potential solution, but we need check.

Again, I think that we need a damping ring.
In 50 Hz scheme, we have about 20 m seconds for damping. Is this enough time?

comments from Vivoli san 29.03.2009 – ultimate target limit

The Peak Energy Deposition Density for Tungsten target is 35J/g. So this is the limit that should not be exceeded for pulse. I also checked the energy deposited by the photons in the target in my EGS simulations for ILC and I found that for a photon beam of mean energy = 27.7 MeV each photon deposits around 0.83 MeV of energy, in a volume of about 0.032 cm^3. Since the density of Tungsten is 19.25 g/cm3 we get roughly a PEDD = 2.2e-13 J/g for photon. So, we can have a **maximum of 1.6e14 photons per pulse**, impinging the target. If we assume a Yield e+/gamma = 2%, we get a **maximum number of captured e+ = 3e12 per pulse**. The **normalized emittance of the positrons captured for the ILC was about 6500 micron transversal.** You can scale the emittance and the Yield almost proportionally, since the transversal distribution [***in which space or phase space?]*** of the positrons in the solenoid is roughly uniform.

my question:

if we ask for 50 μm transverse emittances in x & y can we have 3e10 or 3e8 e+ / pulse?

options we could study:

- ERL Compton scheme for cw operation (Omori san?)
- undulator scheme using spent beam for pulsed operation (Ian Bailey san?)
- linac-Compton scheme for pulsed operation (Vitaly san?)