Some Timing Aspects at TESLA and ILC

Heiko Ehrlichmann,
DESY

Snowmass ILC Workshop 2005

Motivation

ensure some flexibility in bunch filling patters

-> restrictions for damping ring parameters

(some restrictions only essential for positron DR, but electron DR should be symmetric)

-> restrictions for path length, depending on the positron generation scheme

-> restrictions for future length upgrades

-> problems with a second IP

DR Frequency

- LINAC RF frequency is fixed: 1300MHz
- RF frequency relation to LINAC should be as easy as possible

  -> determines the smallest possible bunch distance unit

f (DR)	
1:1 -> 1300MHz	optimal
1:2 -> 650MHz	very good
1:3 -> 433MHz	reasonable
2:5 -> 520MHz	possible
5:13 -> 500MHz	possible

DR Harmonic Number

- the choice of the harmonic number h (= number of RF buckets) determines possible bunch patterns
- for high flexibility h should be highly divisible

  (divider: 2, 3, 5, 7, 11,13 …)
- the damping ring circumference U is given by $U = h * \lambda_{(RF)}$

  -> the DR circumference is not a free parameter

DR Compression Factor

- in the DR the bunch distance must be reduced = compressed to get a “short” DR
  - minimal DR circumference = bunch train length / compression factor
- to get equidistant bunches at the IP within one train the “compression factor” must be a prime number

  (…11, 13, 17, 19, 23, 29 … TESLA: 17)

=> *not necessary, but highly reasonable*

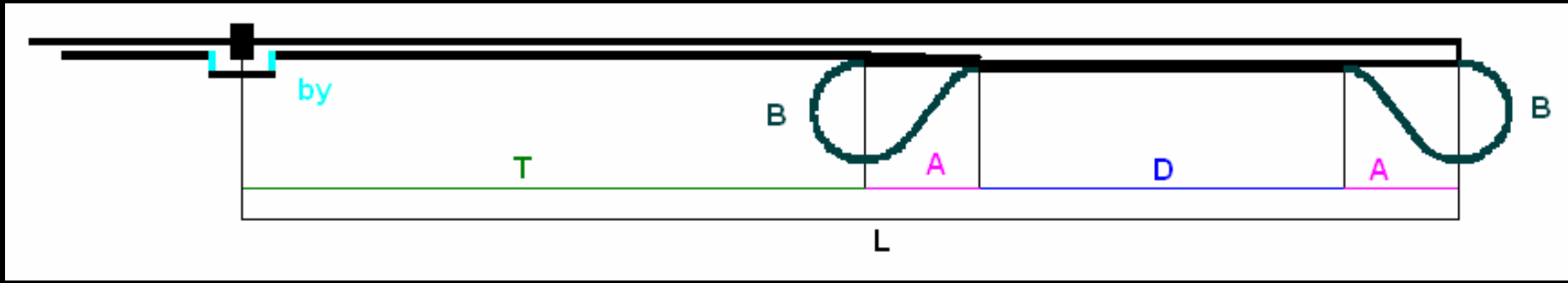
Positron Generation

TESLA scheme

- e+ generation using the colliding e- beam creates strong restrictions for path length
- LINAC length and DR circumference are no longer free parameter

- for highest flexibility in bunch filling patters an ejected DR bucket should be refilled by its partner e- bunch

Pass Length Considerations



TESLA case, using the DR arc for 180° turn of positrons

L = LINAC, distance IP to end of DR bending section
T = e+ transport, distance IP to end of DR bending section, parallel to the LINAC
A = DR, strait section within the dog bone arc, parallel to the LINAC
B = length of the DR arc section between the bends
D = length of the DR strait section, parallel to the LINAC
by =*additional* pass length for the IP bypass

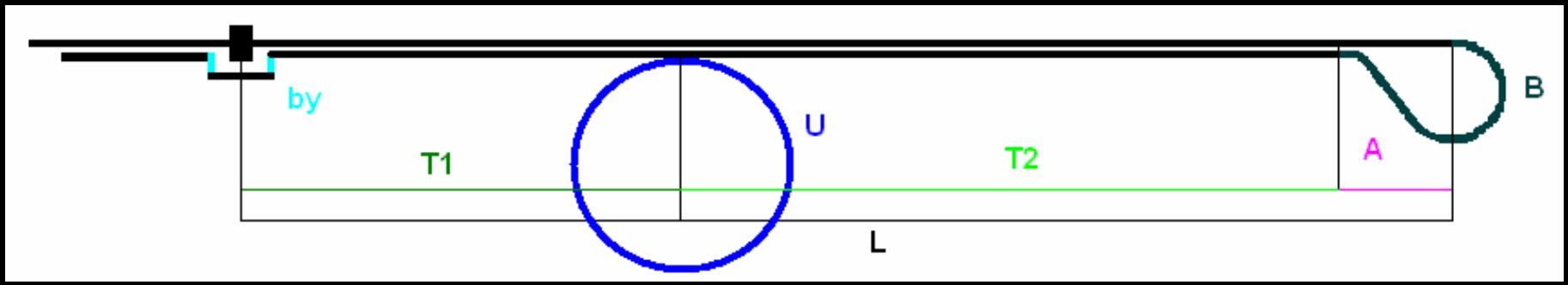
U = 2(A + B + D)
L + by + T + A = A + D + A + B + n U

L = T + D +2A

=> 2L = A – B + (n + 1)U - by // TESLA: n=1

=> L = U + (A - B)/2 - by

Arbitrary DR Position and Geometry



L = LINAC, distance IP to end of return arc bending section
T1 = e+ transport from IP to the DR, parallel to the LINAC
T2 = e+ transport from the DR to the return arc, parallel to the LINAC
A = “strait section” of the return arc
B = length of the return arc
by =additional pass length for the bypass

$T2 + B + L + by + T1 = n\,U$ $\qquad$ $L = T1 + T2 + A$

$$\Rightarrow n\,U = 2L - A + B + by$$

=> no restriction for DR geometry or position along the LINAC
=> TESLA choice is only a special case

Consequences

- *the length of the straight LINAC tunnel and the DR circumference are linked*
  - *-> number of cryomodules -> E_{cms} is affected*
- *the geometry of the180° return arc has an influence*
- *the damping ring geometry or position is a free parameter*
- the IP bypass could be used for fine tuning
  - -> to compensate tolerances of building positions

Second IP

- *no further complication, if the IP's are at the same longitudinal position*
- *with longitudinal offset Δ:*
  - *without further effort the IP's will be not symmetric*

    -> n U = 2L – A + B + by for the first IP position

    -> *position of the second IP at a "parasitic" bunch crossing position*

    -> longitudinal IP distance must be a multiple of the desired bunch crossing

    -> bunch distances are fixed, flexibility is reduced to changes by factors of two
  - *possible solution: path length compensation with an additional "loop" with l = 2 Δ*

Length Upgrade

- restrictions will remain unchanged

new LINAC length

⇒ new DR with new circumference or

⇒ usage of the existing DR

⇒ **length upgrade in units of about U/2**

(geometry of the new 180° arc for fine tuning)

RF Phase

- closed circular system in case of e+ generation via colliding e- beam

  phase (e+ DR) fixed

  -> phase (e+ LINAC) determined

  -> phase (e- LINAC) determined

  -> phase (e+ booster) determined

  => no RF knob for e+ DR injection phase

⇒ path length adjustment section unavoidable

  also important for vertex shifts

  order of magnitude: at least one LINAC bucket

  -> 23cm