For Draft List of Standard Errors

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Beam Dynamics, Simulations Group

(Summarized by Kiyoshi Kubo)

Items and persons to do

- Check BDS Quad-BPM mechanical alignemnt tolerance: K. Kubo → Done
- Calculate tolerance of magnet vibrations (pulse to pulse, random change): J. Lopez
- Check magnet strength stability requirement in ML (quad and corrector): K .Kubo → Done, from old study. May need to do for the new lattice. (?)
- Review transverse orbit jitter due to cavity tilt: D. Schulte
- Check fixed magnet strength error (now 1E-4 is used) in BDS: K. Kubo will ask G. White
- For BPM: (No assignment to items with "?", will take time)
  - Give a template of BPM error parameters: D. Schulte
  - Study on scale error tolerance (now 2%, which is too tight ?): ?
  - Give numbers to both single bunch and multi-bunch.:?
  - Need beam offset wrt BPM after corrections. (required range) : ?
  - Tolerable number of failed BMP: ?
- Estimate required accuracy of beam energy in ML.: Daniel try to find a person. (May take time.)
- Survey Line Error will be discussed on Wedesday.
- **Look if we forgot anything important.**

“Standard” Local Alignment Error in RTML and ML
(RMS, if not specified otherwise.)

Error	Cold Sections	RTML Warm	BDS Warm
Quad Offset	300 μm	150 μm	200 μm
Quad roll	300 μrad	300 μrad	300 μrad
RF Cavity Offset	300 μm	---	---
RF Cavity Pitch	200 μrad	---	---
BPM Offset (initial)	300 μm	200 μm	**30 μm* Max. 100 μm***
Cryomoduloe Offset	200 μm	---	---
Cryomodule Pitch	20 μrad	---	---
Bend offset	---	300 μm	200 μm
Bend Roll	---	300 μrad	300 μrad

***Spec of Quad- BPM max. misalignment is 100 um in ATF2.**
So RMS 30 um and max. 100 um looks fine. (?)

Mechanical fast movement (vibration)

	Cold Sections	RTML Warm	BDS Warm
Quad, Sext.	100 nm	30 nm ?	30 nm ?

Tolerance will be determined by orbit change at IP.
Also should be looked:
RTML: emittance dilution in the turn-around (note that it is before the feed-forward)
ML: Orbit change at linac end (assuming post linac orbit feedback or not ?)
BDS: ???

Need to calculate again. Javier will.

“Standard” Magnet Strength Stability Requirement
Magnet to magnet independent, random

	Cold Sections	RTML Warm	BDS Warm
Quad	**3E-5**	1E-5	1E-5
Bend Strength	---	1E-5	1E-5
Corrector	**3E-5**	1E-3	1E-3
Sext.	---	---	1E-5
Oct.	---	---	1E-5

Tolerance will be determined by orbit change at IP.
Also should be looked:
RTML: emittance dilution in the turn-around (note that it is before the feed-forward)
ML: Orbit change at linac end (assuming post linac orbit feedback or not ?). From RDR, jitter < 0.5 sigma.

Numbers fir the cold section should be checked: Kiyoshi will check.
Old study is found, ILC-Asia Note, ILC-Aisa2005-25: 6E-5 → 0.5 sigma_y jitter
I (K.K.) divided by 2, since there are other jitter sources.

“Standard” RF dynamic errors

	Amplitude	Phase
BC Correlated	0.5%	0.24 deg.
Uncorrelated	1.6%	0.48 deg.
ML Correlated	0.07%	0.35 deg
Uncorrelated	1.05%	5.6 deg
Crab e+e- Relative		0.015 deg

from RDR

Correlated :same for all klystrons
Uncorrelated : klystron to klystron independent, random

What determines the tolerance?
BC: Timing at IP
ML: Energy jitter at the end.
Crab: Horizontal offset at IP

Transverse orbit jitter due to cavity tilt should reviewed. Daniel will.

“Standard” Magnet Strength fixed Error

	Cold Sections	RTML Warm	BDS
Quad	0.25%	0.25%	1 E-4
Bend Strength	---	0.25%	1E-4
Corrector	?	?	?
Sext.	---	---	1E-4
Oct.	---	---	1E-4

It is not clear what determines these tolerances.

1E-4 is too small? Need to revised. Ask Glen.

“Standard” error of beam monitors

	Cold Sections	RTML Warm	BDS
BPM Resolution depend on dynamic error	1 µm +?*range	1 µm +?*range	0.1 µm +?*range
BPM Scale error	2%	2% ?	2% ?
Beam size monitor resolution	1 µm (working assumption for now)		
Luminosity monitor (single pulse)	---		1%

For BPM,

Daniel will give a template (from CLIC)
2% scale error is too tight (Manfred)
Give numbers to both single bunch and multibunch.
Need beam offset wrt BPM after corrections.
Tolerable number of failed BMP?

Beam energy error in Main Linac

What determines the energy error?

A) Calculate energy from cavity voltages?

→ RF cavity voltage error

B) Measure energy using dipole correctors and BPM?

→ Strength error of corrector magnet and BPM scale error

What is affected by the energy error?

- Response to correctors can be calibrated.
  - Ratio, corrector strength / beam energy is relevant ?

Required accuracy should be estimated.
Daniel will try to find a person to do.

“Standard” Survey Line Error

Error	Step length = L1	Step length = L2	
Random angle / step			
Random offset / step			
Systematic angle (common for all steps)			
Systematic offset (common for all steps)			
Initial angle			
Offset of Primary References			

Will be discussed on Wednesday.
May be too early to fill numbers now ???

Anything else to be listed?

Following slides show comments and references.

What is “standard” errors and for what?

Standard error should be:

- Tolerable, from beam dynamics
- Reasonable, from engineering

Let us (beam dynamics group) make draft list first.

- – Tolerance, if we estimated.
- – Assumed (commonly used) errors in simulations.
- – Assign a people to each of to do item.

- “Publish” the list and ask feasibility and make it official.

Reference for BDS

Error set in BDS simulatio, By Glen White, LET WS at SLAC, 2007

Quad, Sext, Oct x/y transverse alignment	200 um
Quad, Sext, Oct x/y roll alignment	300 urad
Initial BPM-magnet field center alignment	30 um
dB/B for Quad, Sext, Octs	1e-4
Mover resolution (x & y)	50 nm
BPM resolutions (Quads)	1 um
BPM resolutions (Sexts, Octs)	100 nm
Power supply resolution	14 - bit
FCMS (Final CryoModule System): Assembly alignment	200 um / 300urad
FCMS: Relative internal magnet alignment	10um / 100 urad
FCMS: BPM-magnet initial alignment (i.e. BPM-FCMS Sext field centers)	30 um
FCMS: Oct – Sext co-wound field center relative offsets and rotations	10um / 100urad
Corrector magnet field stability (x & y)	0.1 %
Luminosity (pairs measurement or x/y IP sigma measurements)	1%

Reference for Main Linac:
e.g. by R.Ranjan, report in GDE meeting Vancouver, 2006

Nominal Misalignment tolerances

Tolerance	Vertical (y) plane
BPM Offset w.r.t. Cryomodule	300 μm
Quad offset w.r.t. Cryomodule	300 μm
Quad Rotation w.r.t. Cryomodule	300 μrad
Cavity Offset w.r.t. Cryomodule	300 μm
Cryostat Offset w.r.t. Survey Line	200 μm
Cavity Pitch w.r.t. Cryomodule	300 μrad
Cryostat Pitch w.r.t. Survey Line	20 μrad
BPM Resolution	1.0 μm

Reference for RTML
by J. Smith, report in LET Workshop at SLAC, 2007

Survey Alignment

Our old canonical set, should consider more realistic misalignments...
Survey people would prefer we use cold specs for all components.

Error	Cold Sections	Warm Sections	With Respect To...
Quad Offset	300 μm	150 μm	Cryostat
Quad Tilt	300 μrad	300 μrad	Cryostat
Quad strength	0.25%	0.25%	Design Value
BPM Offset BPM-Quad Shunting	300 μm 20 μm?	200 μm 7 μm	Cryostat/Survey Quadrupole
BPM Resolution	1 μm	1 μm	True Orbit
Bend tilt	300 μm	300 μm	Survey Line
Bend Strength	0.5%	0.5%	
RF Cavity Offset	300 μm	n/a	Cryostat
RF Cavity Pitch	200 μrad	n/a	Cryostat
Cryostat Offset	200 μm	n/a	Survey Line
Cryostatic Pitch	20 μrad	n/a	Survey Line

Refence for RF error: RDR

TABLE 3.9-1
Summary of tolerances for phase and amplitude control. These tolerances limit the average luminosity loss to <2% and limit the increase in RMS center-of-mass energy spread to <10% of the nominal energy spread.

Location	Phase (degree)		Amplitude (%)		limitation
	correlated	uncorr.	correlated	uncorr.	
Bunch Compressor	0.24	0.48	0.5	1.6	timing stability at IP (luminosity)
Main Linac	0.35	5.6	0.07	1.05	energy stability $\leq$0.1%

of the vector sum must be calibrated to an accuracy on the order of 1% for amplitude and 1.0° for phase. The phases of crab cavities in the beam delivery system must be stabilized to better than 0.015°. Table 3.9-1 gives an overview of the regulation requirements of the Main Linac and RTML bunch compressor.

Reference for BDS: RDR

TABLE 2.7-1
Key parameters of the BDS. The range of L^*, the distance from the final quadrupole to the IP, corresponds to values considered for the existing detector concepts.

Parameter	Units	Value
Length (linac exit to IP distance)/side	m	2226
Length of main (tune-up) extraction line	m	300 (467)
Max Energy/beam (with more magnets)	GeV	250 (500)
Distance from IP to first quad, L^*	m	3.5-(4.5)
Crossing angle at the IP	mrad	14
Nominal beam size at IP, σ^*, x/y	nm	639/5.7
Nominal beam divergence at IP, θ^*, x/y	μrad	32/14
Nominal beta-function at IP, β^*, x/y	mm	20/0.4
Nominal bunch length, σ_z	μm	300
Nominal disruption parameters, x/y		0.17/19.4
Nominal bunch population, N		2×10^{10}
Beam power in each beam	MW	10.8
Preferred entrance train to train jitter	σ_y	< 0.5
Preferred entrance bunch to bunch jitter	σ_y	< 0.1
Typical nominal collimation aperture, x/y		8–10/60
Vacuum pressure level, near/far from IP	nTorr	1/50