Overview of Main Beam RTML

adopted from ILC: Damping Ring To Main Linac Transport = RTML

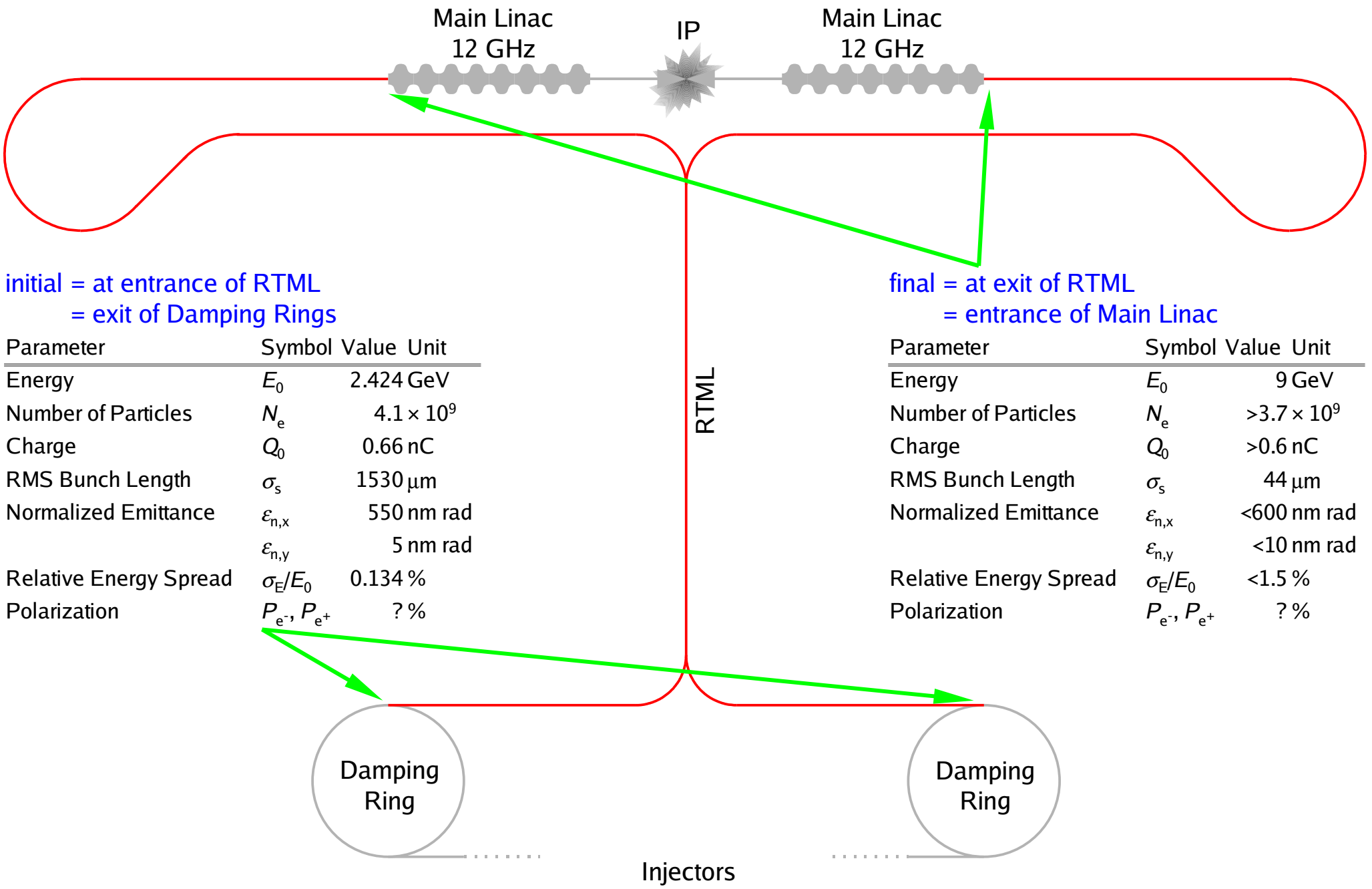
=> Functions

=> Challenges

=> Status

=> Outlook

Definition



initial = at entrance of RTML
= exit of Damping Rings

Parameter	Symbol	Value	Unit
Energy	E_0	2.424	GeV
Number of Particles	N_e	4.1×10^9	
Charge	Q_0	0.66	nC
RMS Bunch Length	σ_s	1530	μm
Normalized Emittance	$\varepsilon_{n,x}$	550	nm rad
	$\varepsilon_{n,y}$	5	nm rad
Relative Energy Spread	σ_E/E_0	0.134	%
Polarization	P_{e^-}, P_{e^+}	?	%

final = at exit of RTML
= entrance of Main Linac

Parameter	Symbol	Value	Unit
Energy	E_0	9	GeV
Number of Particles	N_e	$>3.7 \times 10^9$	
Charge	Q_0	>0.6	nC
RMS Bunch Length	σ_s	44	μm
Normalized Emittance	$\varepsilon_{n,x}$	<600	nm rad
	$\varepsilon_{n,y}$	<10	nm rad
Relative Energy Spread	σ_E/E_0	<1.5	%
Polarization	P_{e^-}, P_{e^+}	?	%

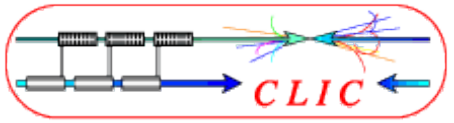
Requirements

At the entrance of the Main Linac the beams have to meet tight tolerances to ensure proper beam transport to the IP and good luminosity:

Parameter	Symbol	Value	Unit	Jitter Tolerance
Energy	E_0	9	GeV	± 0.1 %
Number of Particles	N_e	>3.7 × 10^9		± 0.1 %
Charge	Q_0	>0.6	nC	± 0.1 %
RMS Bunch Length	σ_s	44	μm	± 0.5 %
Normalized Emittance	$\varepsilon_{n,x}$	<600	nm rad	± ? %
	$\varepsilon_{n,y}$	<10	nm rad	± ? %
Relative Energy Spread	σ_E/E_0	<1.5	%	± ? %
Polarization	P_{e^-}, P_{e^+}	?	%	± ? %
Phase Offset	$\Delta\phi$	0	deg	± 0.1 deg

The RTML must ensure that these requirements are fulfilled, even if beam properties at the exit of the damping rings do not meet them (...within certain boundaries...).

=> The RTML is not a passive beam transport but an active beam tuning element.



Functions

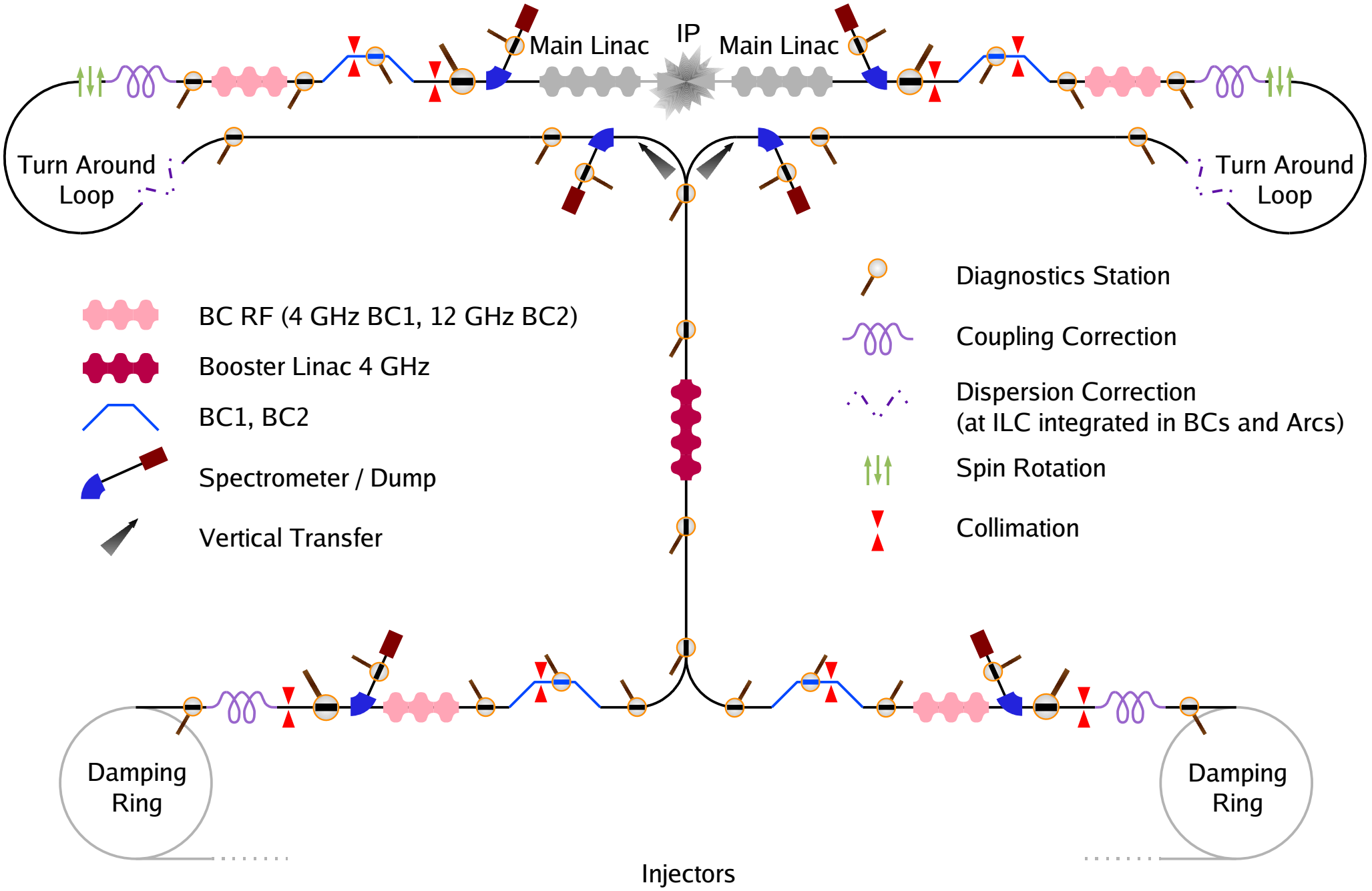
- Transport => Transport Lines, Turn Around Loops, Arcs
- 6D Phase Space Shaping / Matching
  - longitudinal => Bunch Compressors incl. RF for Energy Chirp, Collimators
  - transverse => Optics, Collimators
- Acceleration => Booster Linac
- Re-Orientation of Polarizationvector => Spin Rotator
- Characterization
  - => Diagnostics (Position, RMS Length, longitudinal and transverse Profiles, Energy, Energy Spread, Emittance, Charge, Phase, Polarization,...)
- Correction / Tuning
  - => Dispersion Correction (at ILC: normal and skew quads integrated in BCs, Loop, Arcs), Coupling Correction, Phase Correction / Synchronization, Feedback, Feedforward
- Others => Intermediate Beam Dumps, Spectrometer Beam Lines...

= ILC RTML, but beam parameters are different (e.g. beam energy, emittance)

=> beam dynamics challenges are different

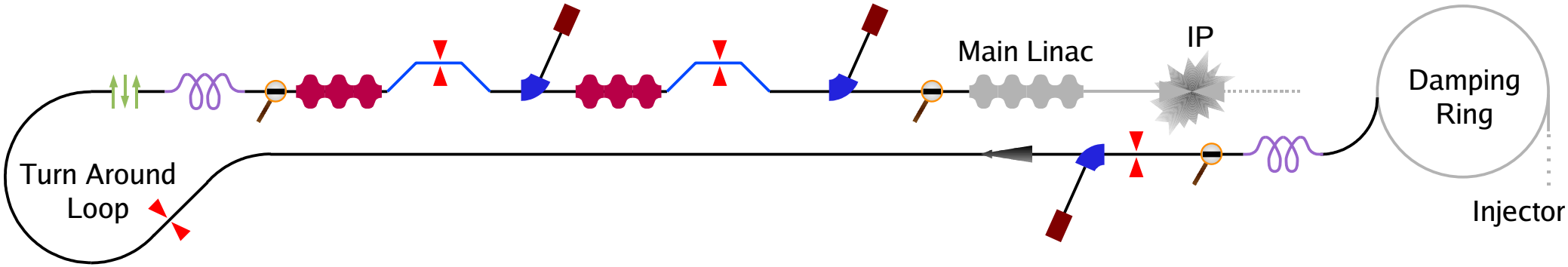
=> layout is different

Functional Layout (Draft)



Functional Layout ILC RTML

as described in ILC RDR



BC RF

BC1, BC2

Emittance Measurement

Spectrometer / Dump

Vertical Transfer

Coupling Correction

Dispersion Correction (integrated in BCs and Arcs)

Spin Rotation

Collimation

Sources of Beam Quality Degradation

RTML ≈ ILC RTML

- Misalignment
  - static and dynamic, e.g. ground motion, vibration,...
  - => all components incl. beam pipes
- Magnetic Field Errors
  - magnet strength / power supply ripple, residual field components, stray fields, earth field
  - => along entire RTML
- RF Voltage and Phase => booster linac and bunch compressor RF
- Wake Fields
  - geometry, resistivity, surface roughness,...
  - => cavities, collimators, beam pipes
- Space Charge Fields => transfer lines
- Synchrotron Radiation
  - => ISR in turn around loops and arcs
  - => CSR in bunch compressors
- Beam-Gas Interaction / Beam-Photon Scattering
  - => Fast Beam-Ion Instability in transfer lines

Damping Rings

- Jitter of incoming Beam Parameters
  - phase, energy, charge, length,...

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Damping Rings

- Jitter of incoming Beam Parameters
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RTML can cope with this via feedback and feedforward... ...within certain limits

Status

- Conceptual Design of Bunch Compressor Chicanes BC1 and BC2
  => layout existing

- RF for Bunch Compressors
  => layout existing, revisions required, wake fields to be studied

- Conceptual Design of 9 GeV Turn Around Loop
  => preliminary layout existing, revisions required

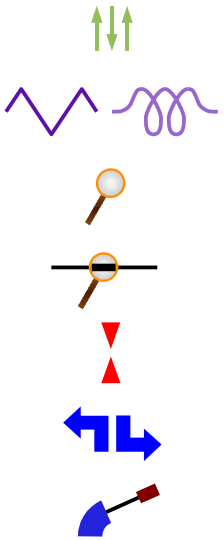
- Booster Linac
  => layout existing, wake fields to be studied

- Transfer Line
  => draft layout and alignment studies existing, revisions required

- Arcs at 9 GeV (might include vertical transfer from ground level (injector) to tunnel level (main linac))
  => may be possible to be extracted from loop, but not yet studied

- Arcs at 2.4 GeV
  => can be extracted from loop, but not yet done

Status



- Spin Rotator => not yet studied
- Dispersion and Coupling Correction Sections => not yet studied
- Diagnostics Systems => work in progress
- Diagnostics Beam Lines => not yet studied
- Collimation => not yet studied
- Feedback / Feedforward => not yet studied
- Intermediate Dumps, Spectrometer Beam Lines => not yet studied

Current and upcoming work

We try to fix initial and final parameters, as well as the remaining free parameters, which are not given by initial and final specifications:

i.e. energy after Booster Linac (and intermediate bunch length), this implies work on BC2 RF, Turn Around Loop (and BCs)

Once this is done, we can

- review existing lattices for Transfer Line and Turn Around Loop
- study beam dynamics in Booster Linac and BC RF
- create missing beam lines to compile a preliminary RTML for start-to-end simulations
- create Spin Rotator lattice
- elaborate diagnostics and tuning requirements
- ...

Current and upcoming work

At the same time we have to compile tables of beam parameters and tolerance along the entire RTML to track beam evolution:

- entrance of BC1 RF
- entrance of BC1
- entrance of Booster Linac
- entrance of Turn Around Loop
- entrance of BC2 RF
- entrance of BC2
- exit of BC1 RF
- exit of BC1
- exit of Booster Linac
- exit of Turn Around Loop
- exit of BC2 RF
- exit of BC2

Actually, we started doing this as input for beam instrumentation.
Many values are already known, but, e.g., tolerances still need to be elaborated!

On going effort:

- compilation of functions, requirements, constraints, issues, challenges, ...

Please contribute!