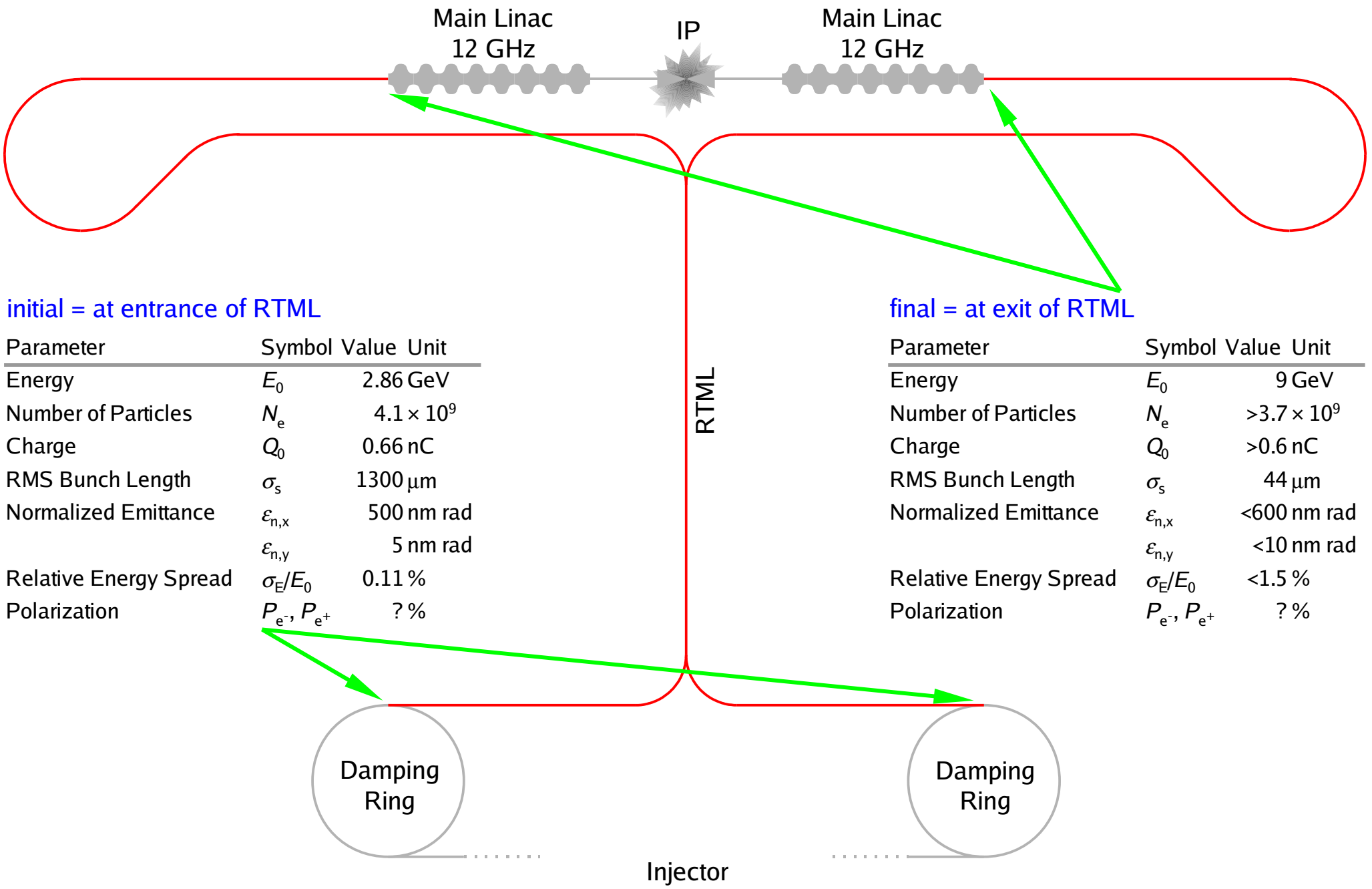
Beam Instrumentation in the RTML

=> Overview

=> Challenges

=> Beam Instrumentation

Definition



initial = at entrance of RTML

Parameter	Symbol	Value	Unit
Energy	E_0	2.86	GeV
Number of Particles	N_e	4.1×10^9	
Charge	Q_0	0.66	nC
RMS Bunch Length	σ_s	1300	μm
Normalized Emittance	$\varepsilon_{n,x}$	500	nm rad
	$\varepsilon_{n,y}$	5	nm rad
Relative Energy Spread	σ_E/E_0	0.11	%
Polarization	P_{e^-}, P_{e^+}	?	%

final = at exit of RTML

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:

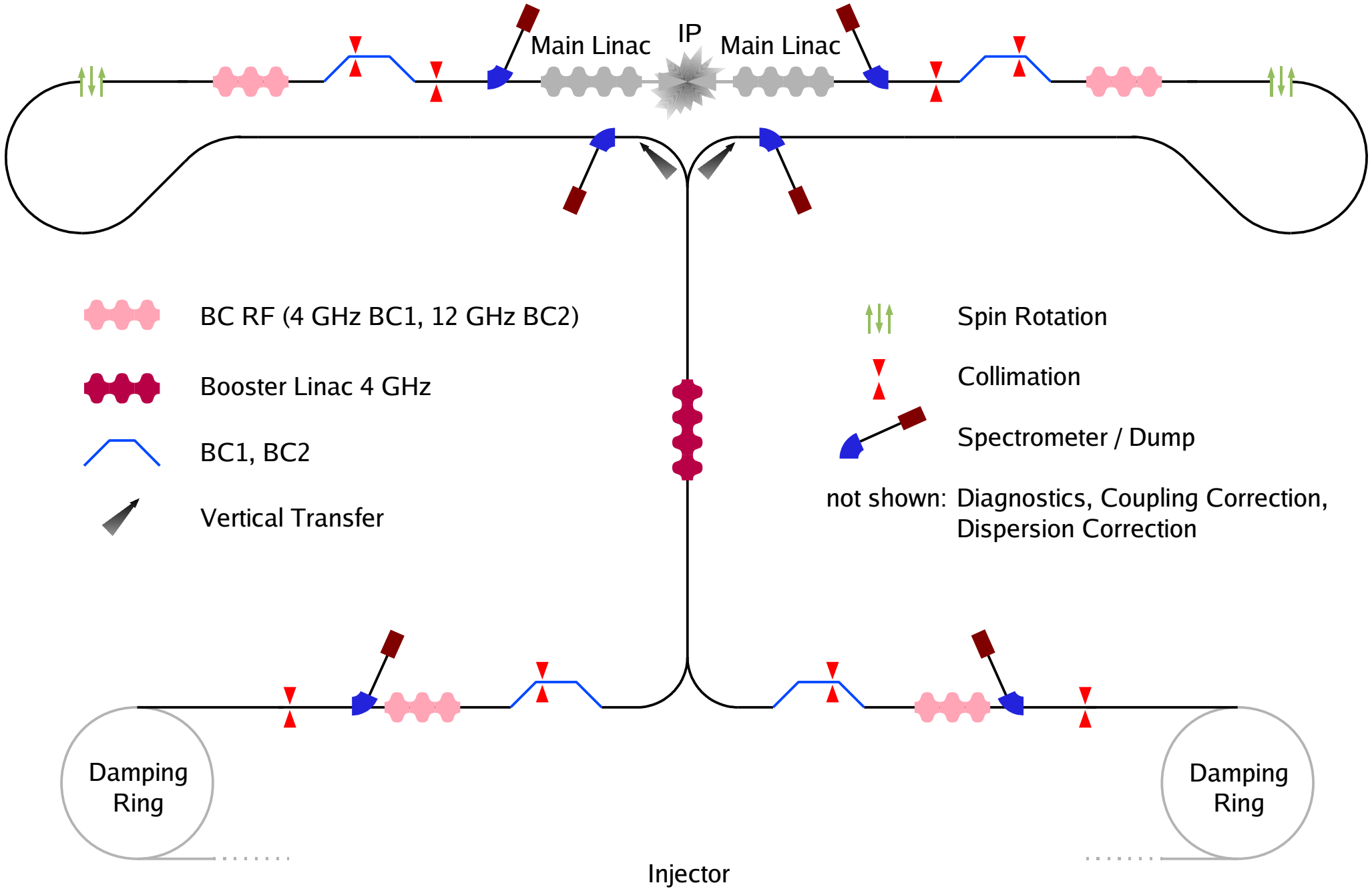
Parameter	Symbol	Value	Unit	Jitter Tolerance
Energy	E_0	9	GeV	± ? %
Number of Particles	N_e	>3.7 × 10^9		± 0.1 %
Charge	Q_0	>0.6	nC	± 0.1 %
RMS Bunch Length	σ_s	44	µm	± 0.5 %
Normalized Emittance	$\varepsilon_{n,x}$	<600	nm rad	± ? %
	$\varepsilon_{n,y}$	<10	nm rad	± ? %
Relative Energy Spread	σ_E/E_0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

=> The RTML is not a passive beam transport but an active beam tuning element.
The particles bunches are not only transported but also shaped, tuned and

characterized

Functional Layout (Draft)



Beam Instrumentation Requirements

Since the beams have to be accurately characterized,
we need to measure quite many different things:
(assuming specs for electrons and positrons are the same, except for polarization)

-> Beam position (accuracy 100 μm, resolution 10 μm)

-> Charge (accuracy 10 pC, resolution 0.6 pC)

-> Transverse profile (resolution 0.1 μm)

-> Emittance (horizontally: accuracy 10 nm rad, resolution 10 nm rad,
vertically: accuracy <1 nm rad, resolution <1 nm rad)

-> Longitudinal profile (accuracy >10 μm, resolution >10 μm in front of BC1,
accuracy 10 μm, resolution 10 μm along the RTML,
accuracy 1 μm, resolution 1 μm behind BC2)

-> Energy (accuracy 1 MeV, resolution 1 MeV)

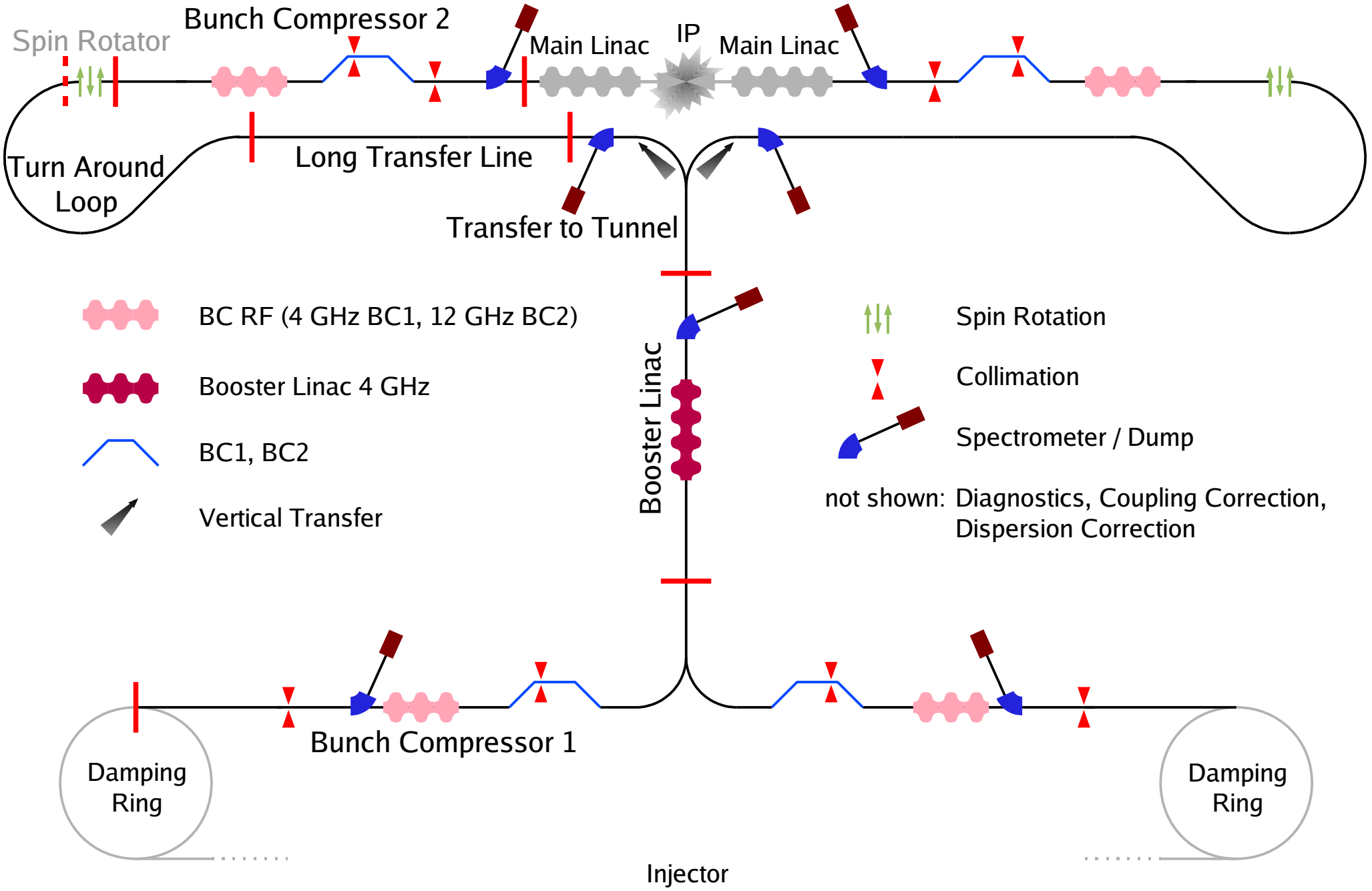
-> Energy profile (resolution 0.2 MeV)

-> Phase (accuracy 0.1 deg @ 12 GHz, resolution 0.1 deg @ 12 GHz)

-> Polarization (accuracy 1 % (?), resolution 1 % (?))

If we need the values bunch by bunch or pulse by pulse needs to be evaluated.
Currently, measuring a pulse seems to be o.k. (except for longitudinal bunch profile ;-)).
In any case, measuring each bunch would be preferable!

Functional Layout (Draft)



Beam Instrumentation Requirements

Quantities are counted per beam (electrons or positrons).

Bunch Compressor 1:
- Position
- Charge
- Transverse Profiles
- 2× Emittances
- 2× Longitudinal Profile
- 2× Energy
- 2× Energy Spread
- 1× Phase
- 1× Polarization
- (Synchrotron Radiation)

Booster Linac:
- Position
- Charge
- Transverse Profiles
- 1× Energy
- 1× Energy Spread

Transfer to Tunnel:
- Position
- Charge
- Transverse Profiles
- 1× Emittances
- (1× Energy)
- (1× Energy Spread)
- 2× Polarization

Long Transfer Line:
- Position
- Charge
- Transverse Profiles

Turn Around Loop:
- Position
- Charge
- Transverse Profiles
- 1× Emittances
- 1× Longitudinal Profile
- 1× Polarization

Spin Rotator:
- Position
- Charge
- Transverse Profiles
- 1× Polarization

Bunch Compressor 2:
- Position
- Charge
- Transverse Profiles
- 2× Emittances
- 2× Longitudinal Profile
- 2× Energy
- 2× Energy Spread
- 1× Phase
- 1× Polarization
- (Synchrotron Radiation)

Summary

- The RTML is a collective of different beam lines
- Each beam line serves a distinct function
- And has its own beam instrumentation requirements
- Several diagnostics systems are similar across beam lines
- Partially the requirements are comparable to existing or planned accelerators
- Some systems are challenging, e.g. bunch length