SNS Linac
Beam Diagnostics and Commissioning Overview

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Outline

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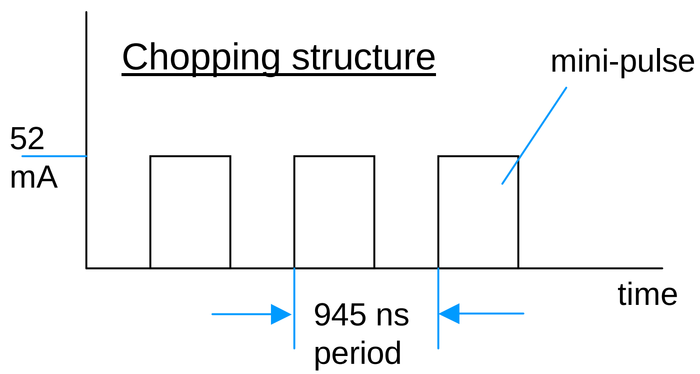
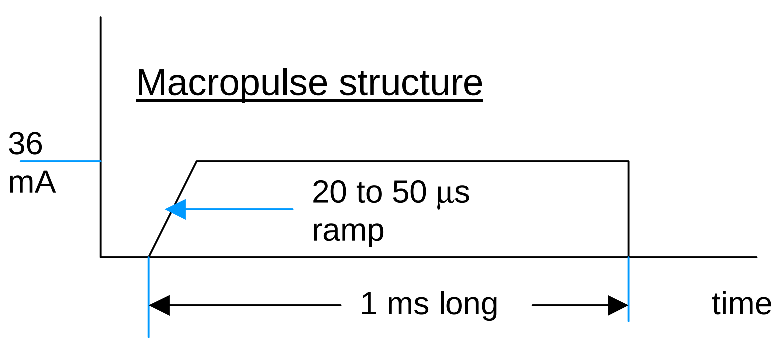
Linac Operating Modes

Normal operation

52-mA (peak) H- beam current
402.5 MHz microstructure
36-mA macropulse average current w/ chopping
1 ms macropulse length
60 Hz pulse rate





Commissioning beams

Beam for commissioning linac

36 mA, 30- 50 µs, 1 to 10 Hz,
Limited by activation and
Beam heating of interceptive
devices.

Beam for commissioning ring

52 mA, 600 ns long (single mini-pulse)
For single-turn injection into ring.

Notes
Chopper is not a subharmonic of RF frequency.
RF is pulsed at 60 Hz..

Purpose of Beam Diagnostics

The linac beam diagnostics will be designed for the following uses:

- Initial turn-on and commissioning of linac and ring.
- Normal facility operation (non-interceptive diagnostics).
- Detection of off-normal operation.
- Recovery from off-normal operation.
- Linac development and upgrade.

Diagnostics AP Performance Requirements

Beam position monitors	Dynamic range	<15 mA to 60 mA; > 300 ns pulse length reduced performance 1 mA to 15 mA
	Position meas.	
	Accuracy	± 1% of aperture
	Resolution	±0.1% of aperture
	Phase meas.	At 402.5 and 805 MHz
	Accuracy	± 2 degrees
	Resolution	± 0.2 degrees
	Energy meas.	Time of flight
	Accuracy	± .02 MeV @ 7.5 MeV to .8 MeV @ 1 GeV
	Resolution	± .002 MeV .08 MeV
Beam current Toroids	Dynamic range	<15 mA to 60 mA (full performance range) reduced performance 1 mA to 15 mA
	Accuracy	± 1%
	Resolution	±0.1%
	Droop	< 1% per ms (with baseline restoration)
Beam loss monitors	Beam loss	<1 watt per meter. Loss primarily from H- stripping in residual gas.
Wire scanners	Beam profiles	Resolution ± 0.2 mm

Initial Turn-on and Commissioning Measurements

<u>Aperture scans (x, x’, y, y’)</u>

Faraday cup with energy degrader

<u>Transmission efficiency</u>

Differential current measurements (toroids)
Faraday cup with energy degrader
Beam loss measurements (Ion chamber)

<u>Beam size (transverse matching)</u>

Wire scanners

<u>Phase, energy and amplitude scans</u>

Beam synchronous phase
Beam energy (time of flight)
Delta-E delta-t measurements

Commissioning the DTL

Commissioning the DTL requires making measurements of the output beam synchronous phase and energy, while varying the input beam synchronous phase and the RF amplitude.

The RF static amplitude and phase must be set to about ±2% and ±2 degrees respectively.

Time-of-flight energy measurement accuracy using two BPMs separated by a distance *L* is given by

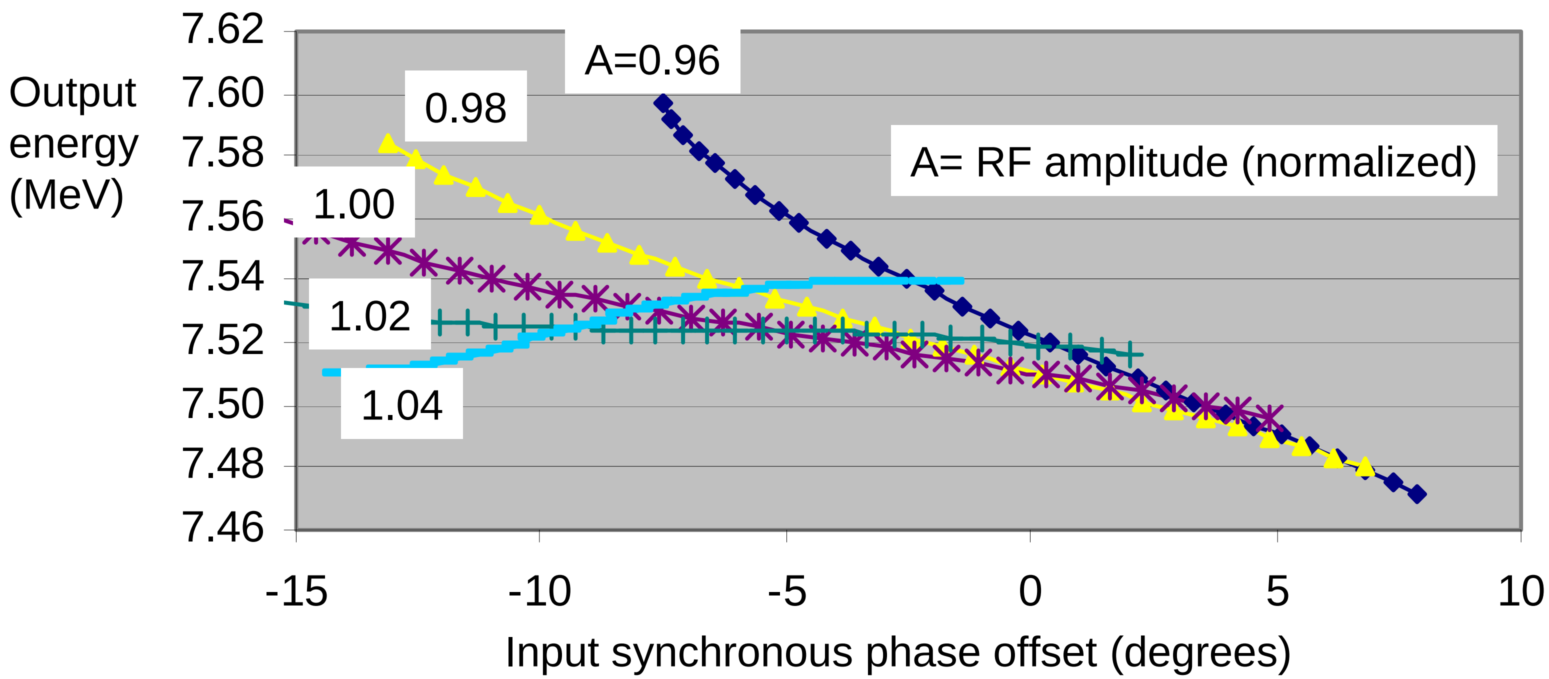
$$dE = Mc^2 \cdot (\beta\gamma)^3 \cdot \frac{c \cdot dt}{L}$$

Where Mc^2 = H^- rest mass, $\beta\gamma$ are Lorentz parameters, *c*=speed of light, and *dt* is the time-of-flight delay measurement accuracy.

For *E*=7.5 MeV, *L*=1 meter, and *dt*=2 degrees (at 805 MHz), the expected energy measurement accuracy is about 0.004 MeV.

DTL Amplitude-Phase Scan Simulation

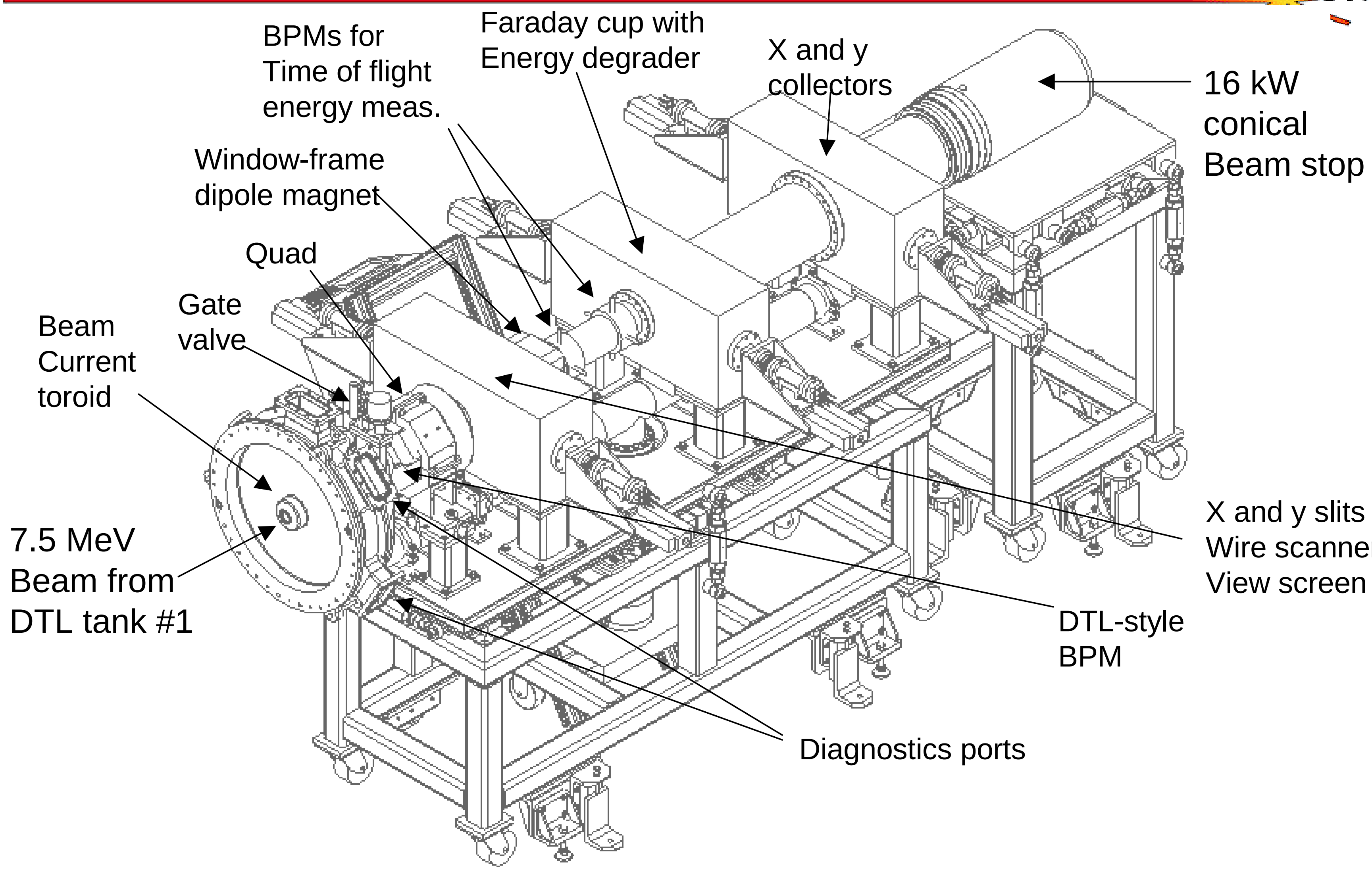
Simulation of RF amplitude-phase scan of DTL tank #1 (7.5 MeV).



The expected time-of-flight (TOF) energy measurement accuracy at 7.5 MeV is about 0.02 MeV (L=20 cm).

The expected TOF energy resolution is about 0.002 MeV.

Diagnostics Plate Instrumentation



7.5-MeV Diagnostic Plate Measurements

Measurement	Diagnostic used
Beam profiles	wire scanners
Beam current	DTL-type toroid Faraday cup, with energy degrader foil.
Beam synchronous phase	DTL- type drift tube BPM
Beam energy	BPM time of flight (20 cm flight path)
Emittance	slits and collectors
Beam image	view screen
Halo	Segmented halo scraper (fixed aperture)
Beam stop	36 mA, 7.5 MeV,1 ms, 60 Hz (16 kW) Conical nickel beam stop (low activation)

Beam Stops for Linac Commissioning

•The 16-kW beam stop on the Diagnostics Plate is the only beam stop capable of running at the full beam current (36 mA, 1 ms, 60 Hz) prior to commissioning both the ring and the spallation neutron target.

•The Diagnostics Plate will be used for injector (ion source, RFQ, MEBT) and DTL tank #1 commissioning and development whenever DTL tank #2 is not installed.

•The 1-GeV linac 0° beam stop is rated at about 7 kW (36 mA, 100 μs, 2 Hz).

•Intermediate beam stops (Faraday cups), at 86 and 185 MeV, are rated only at 100 to 300 watts (limited by activation).

Collaboration with other Labs on diagnostics

BNL is building the BLM system for the linac, LRBT, ring, and RTBT.

BNL is designing the wire scanner actuators for MEBT, linac, LRBT, ring & RTBT.

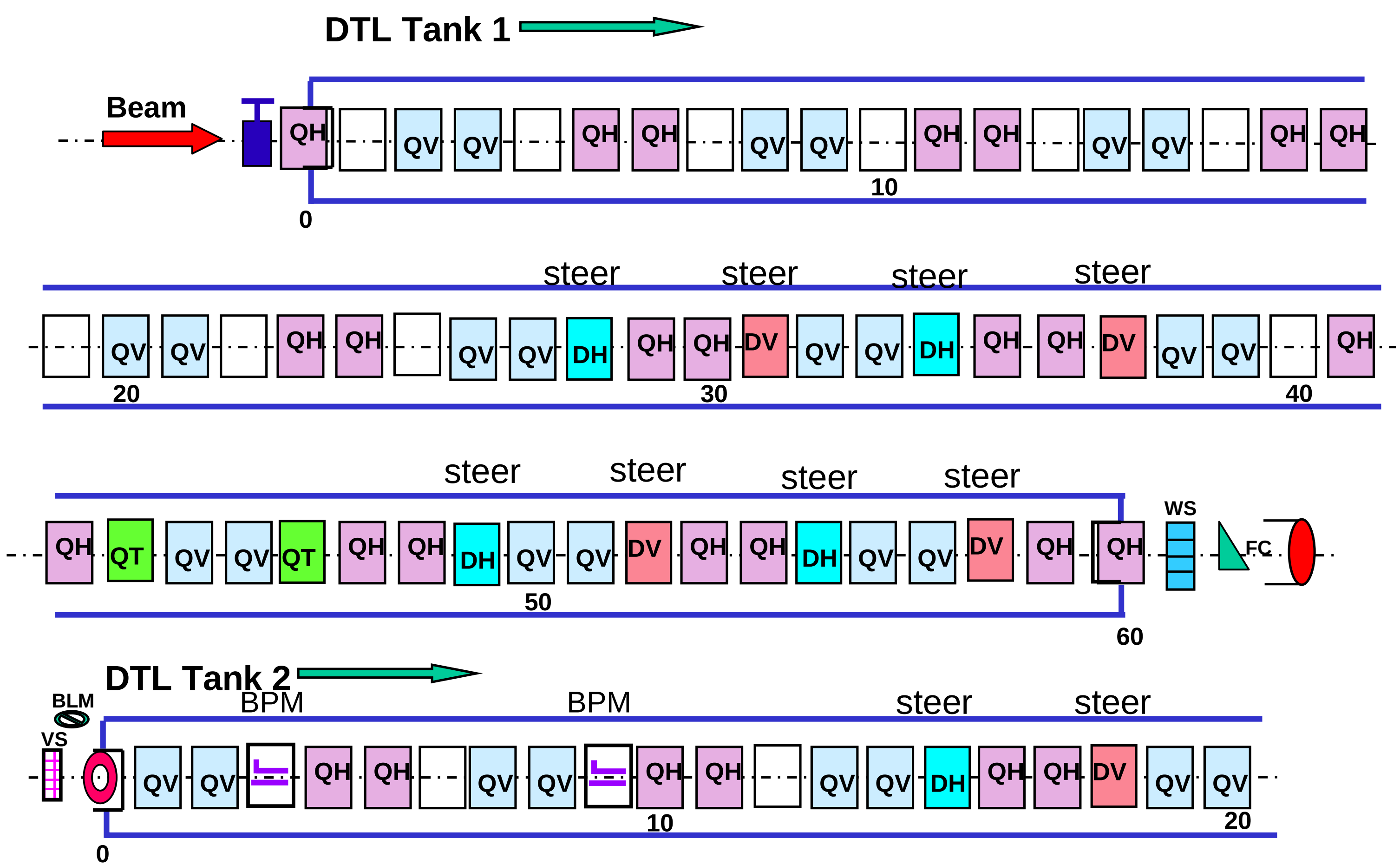
LANL is designing & building the BPM position/phase electronics for MEBT, linac, and LRBT.

LANL is designing the wire scanner electronics for MEBT, linac, and LRBT.

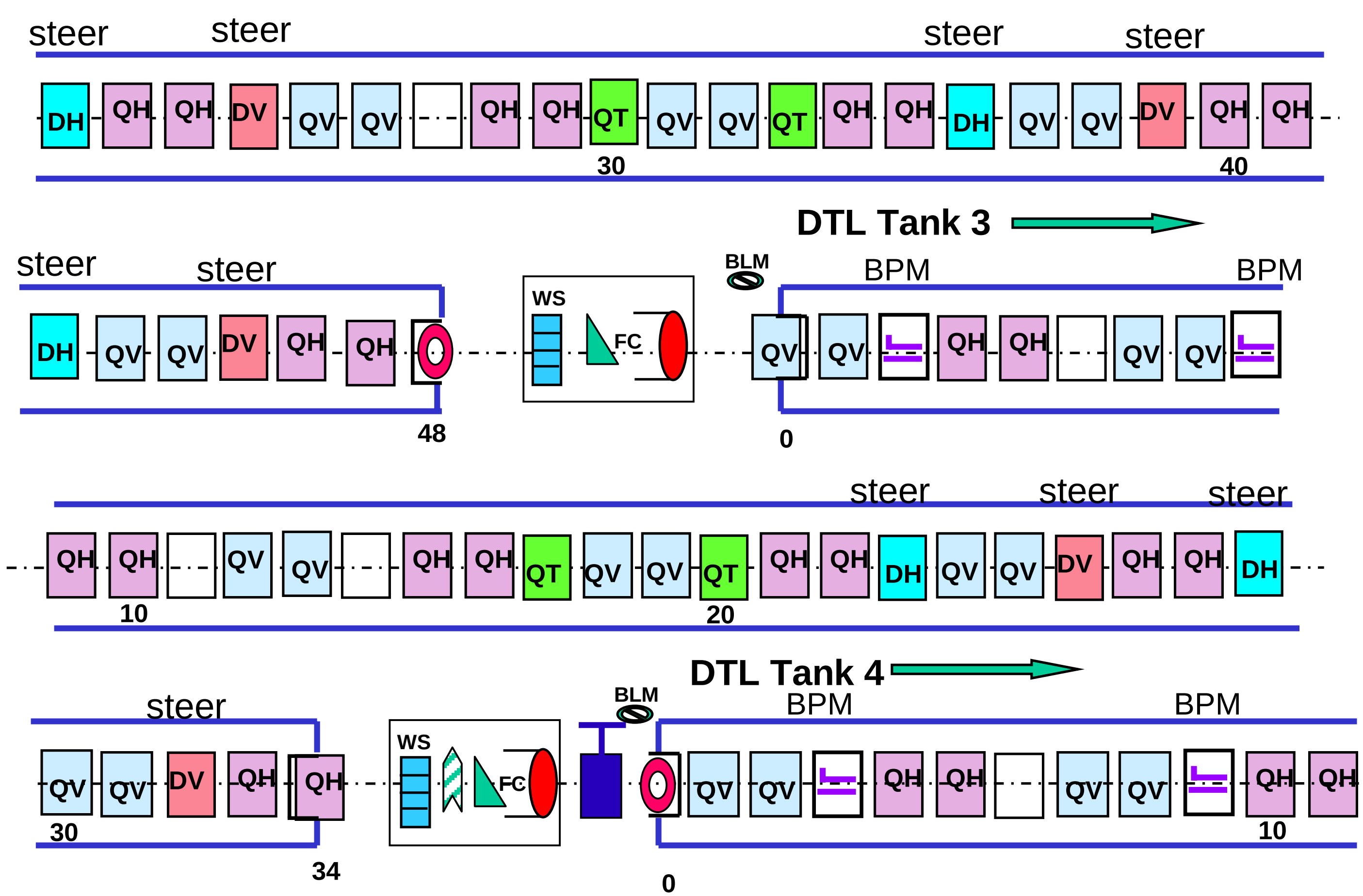
LANL is designing the harp pickups & electronics for linac, ring, and neutron target.

MEBT = medium energy (2.5-MeV) beam transport
LRBT = linac to ring beam transport (also called HEBT)
RTBT = ring to target beam transport

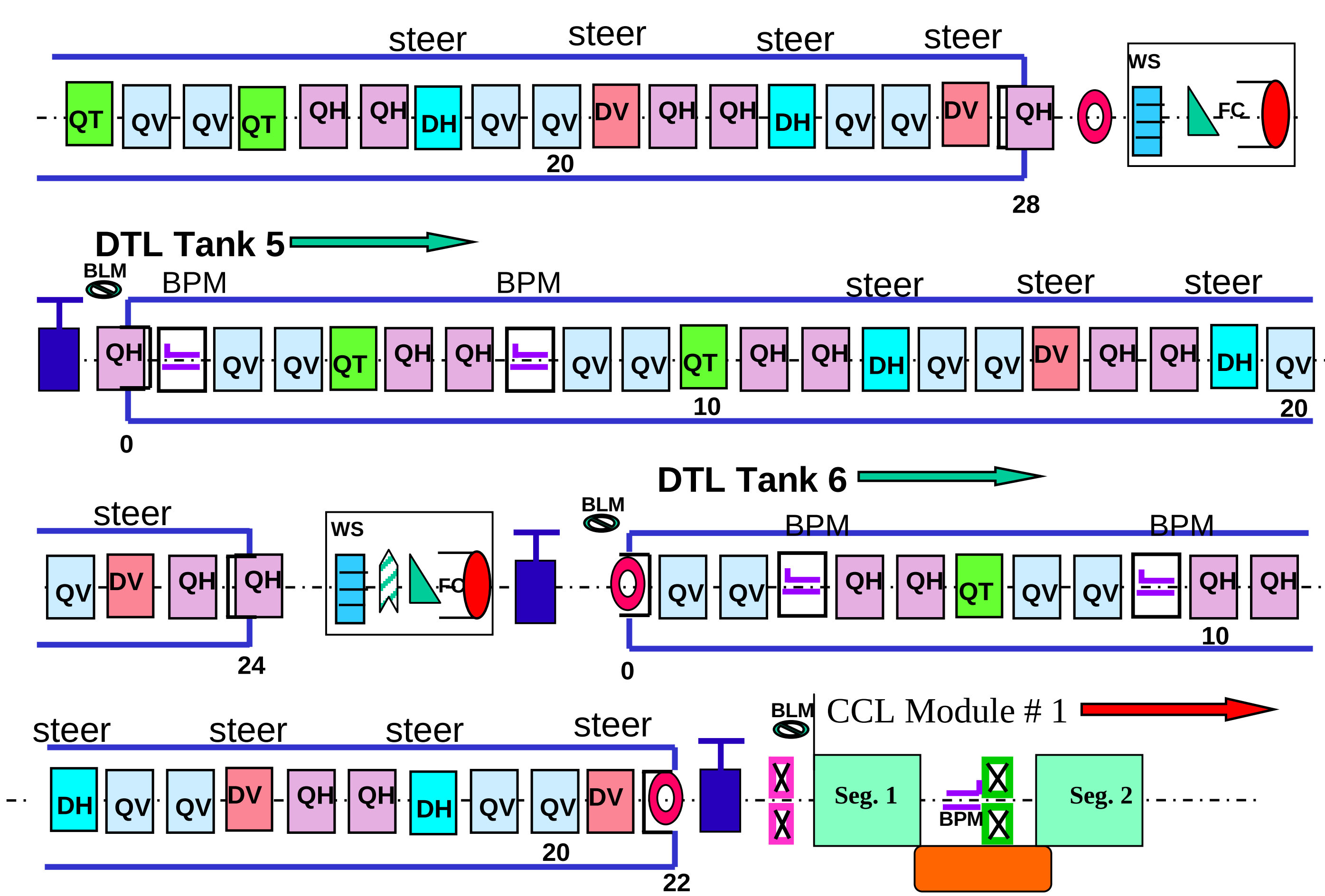
DTL Beam Diagnostics Layout



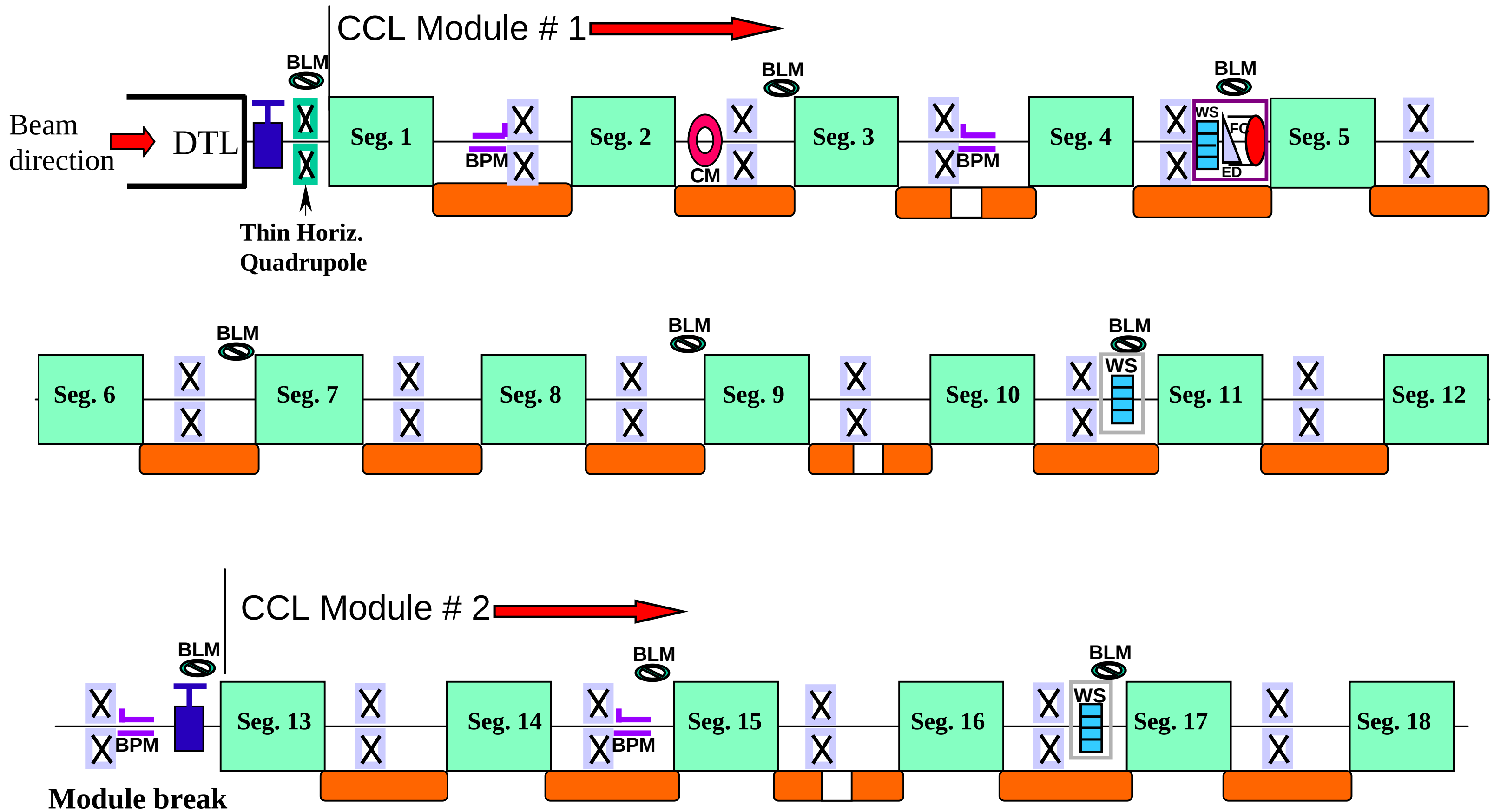
DTL Beam Diagnostics Layout (cont)



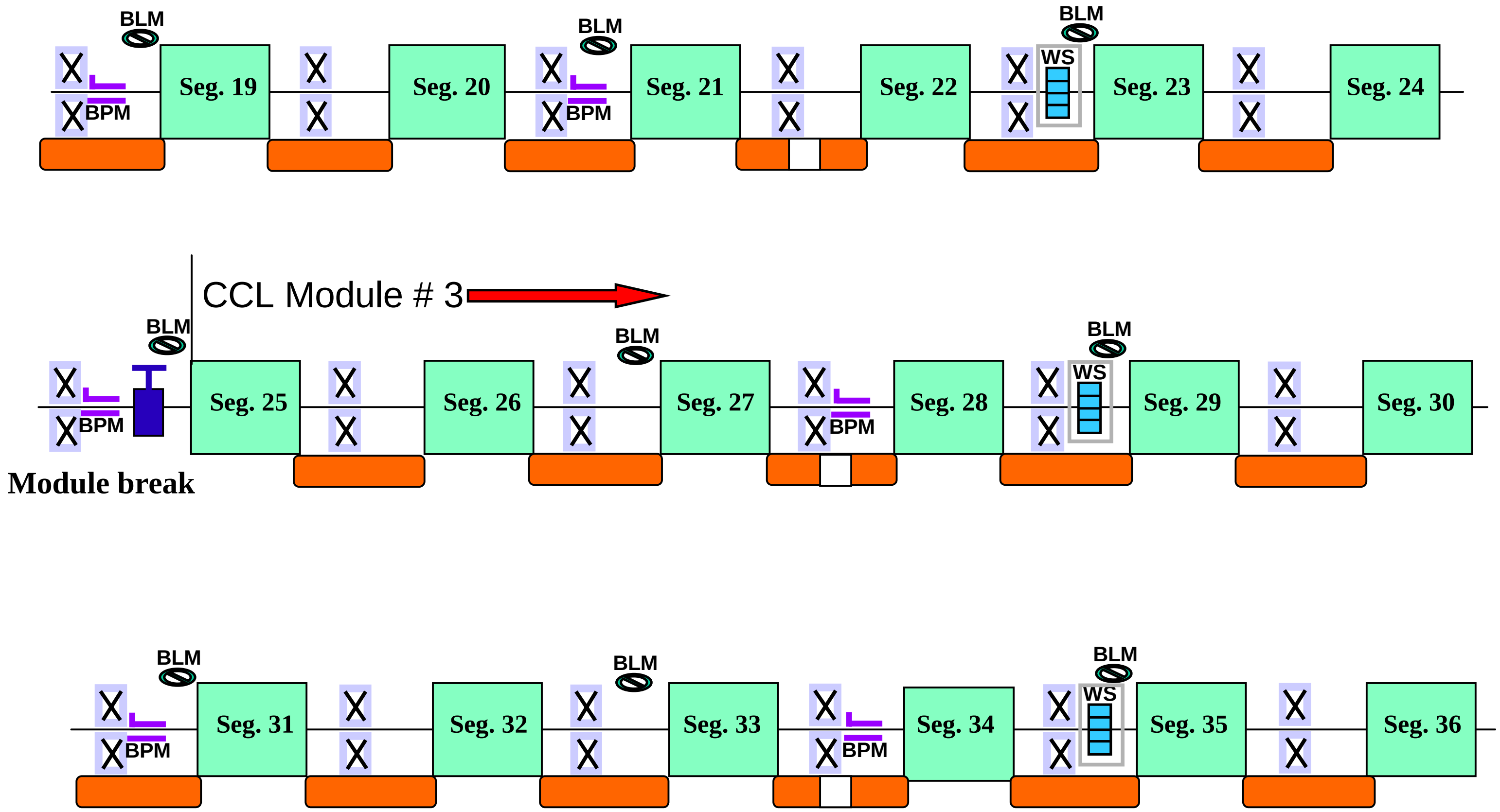
DTL Beam Diagnostics Layout (cont)



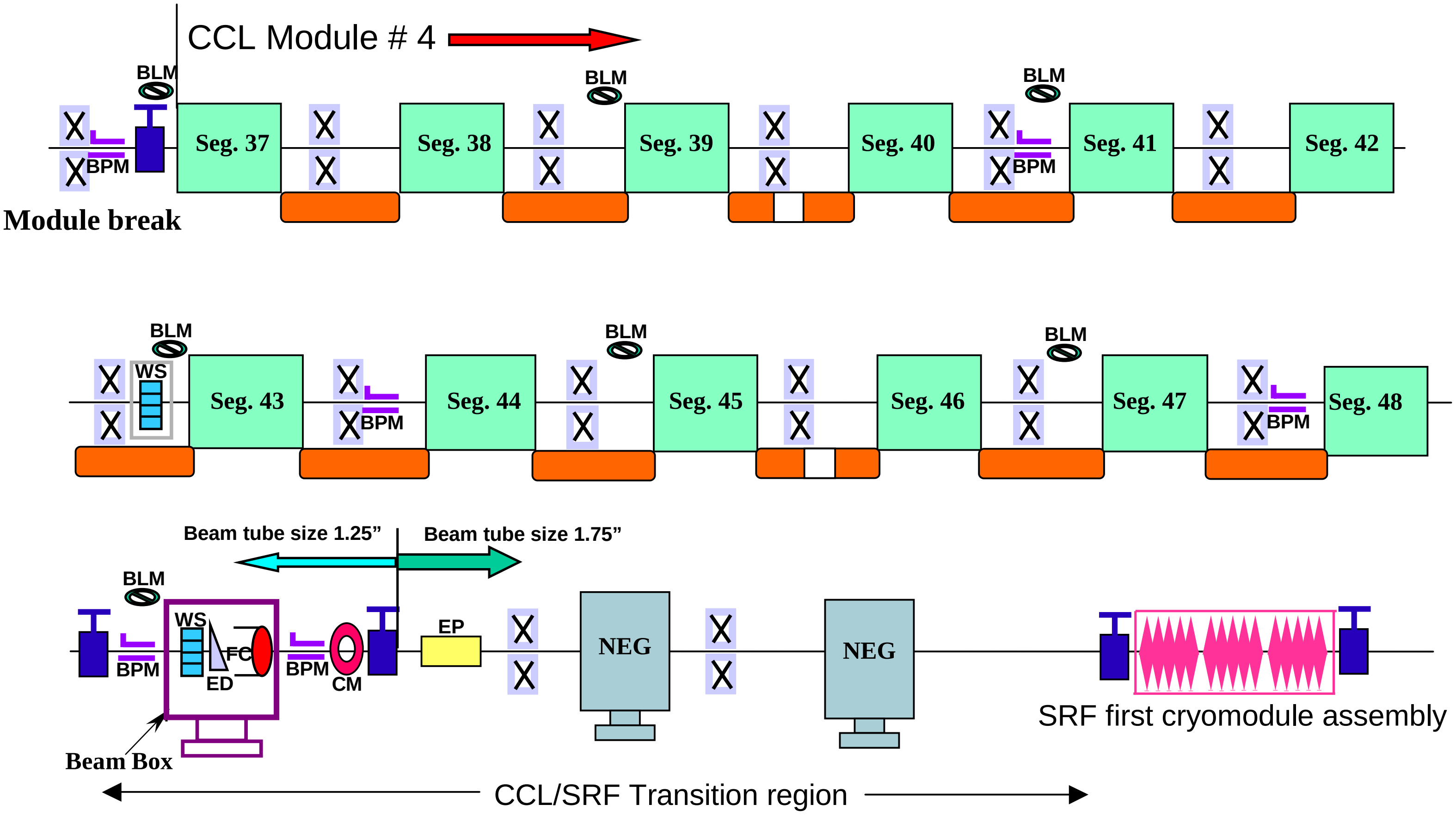
CCL Beam Diagnostics Layout



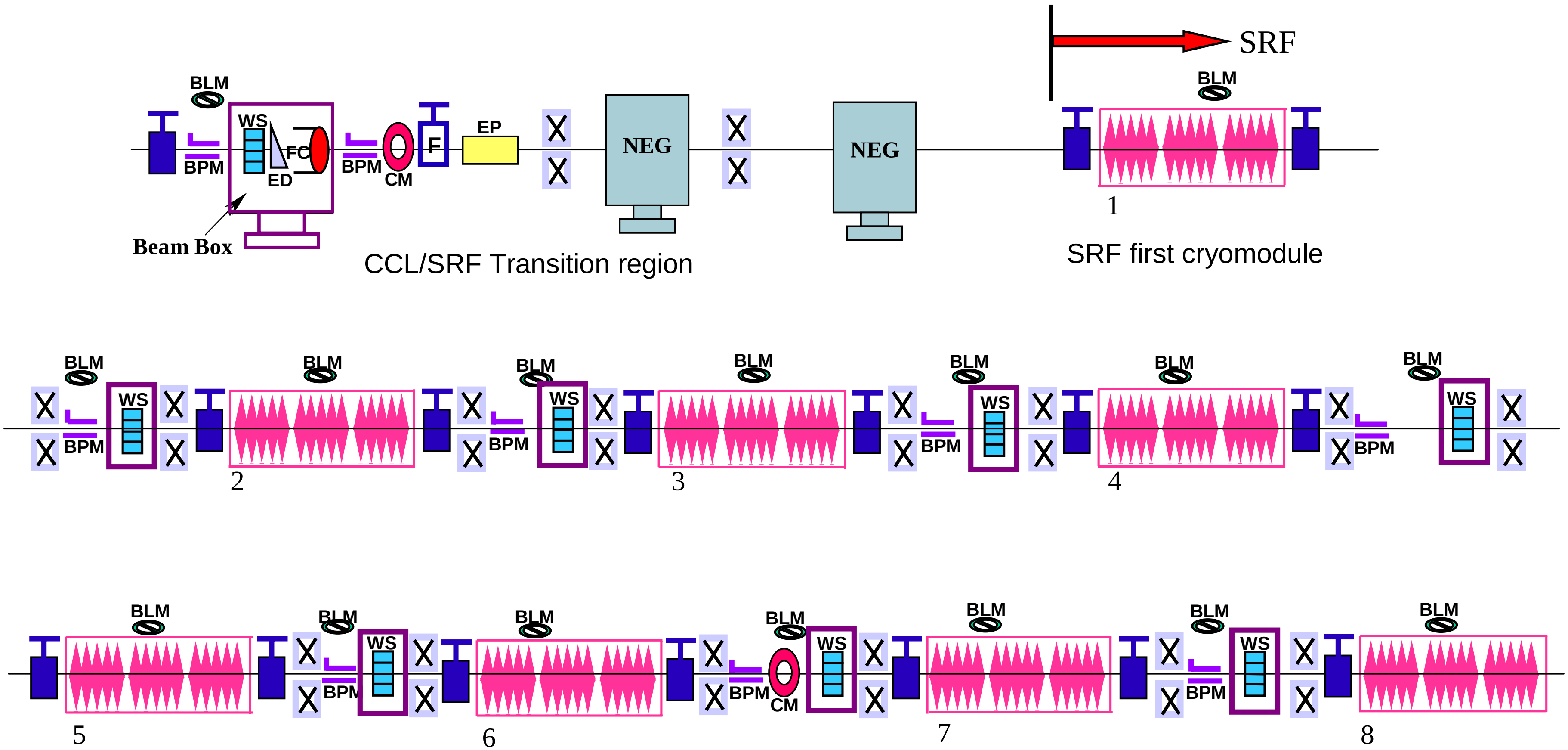
CCL Beam Diagnostics Layout (cont)



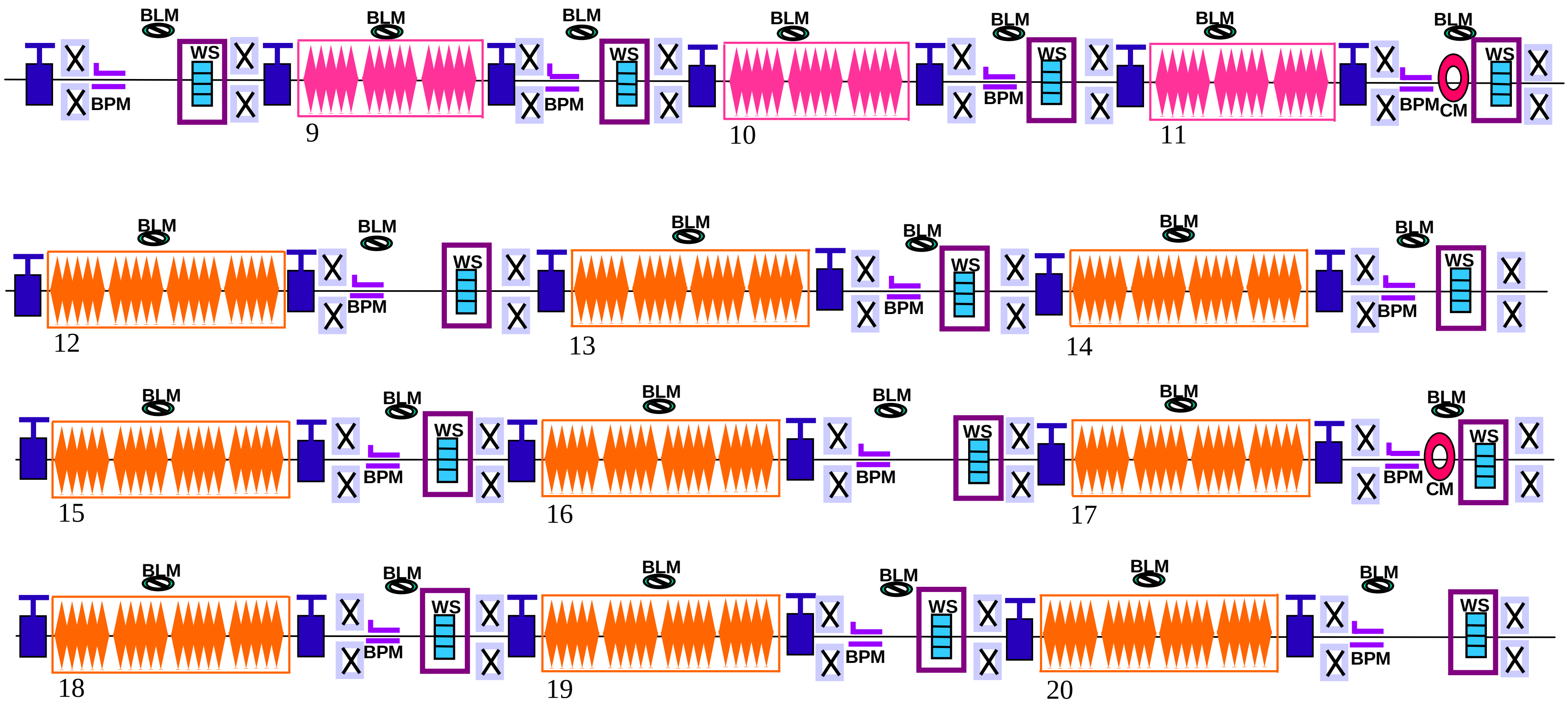
CCL Beam Diagnostics Layout (cont)



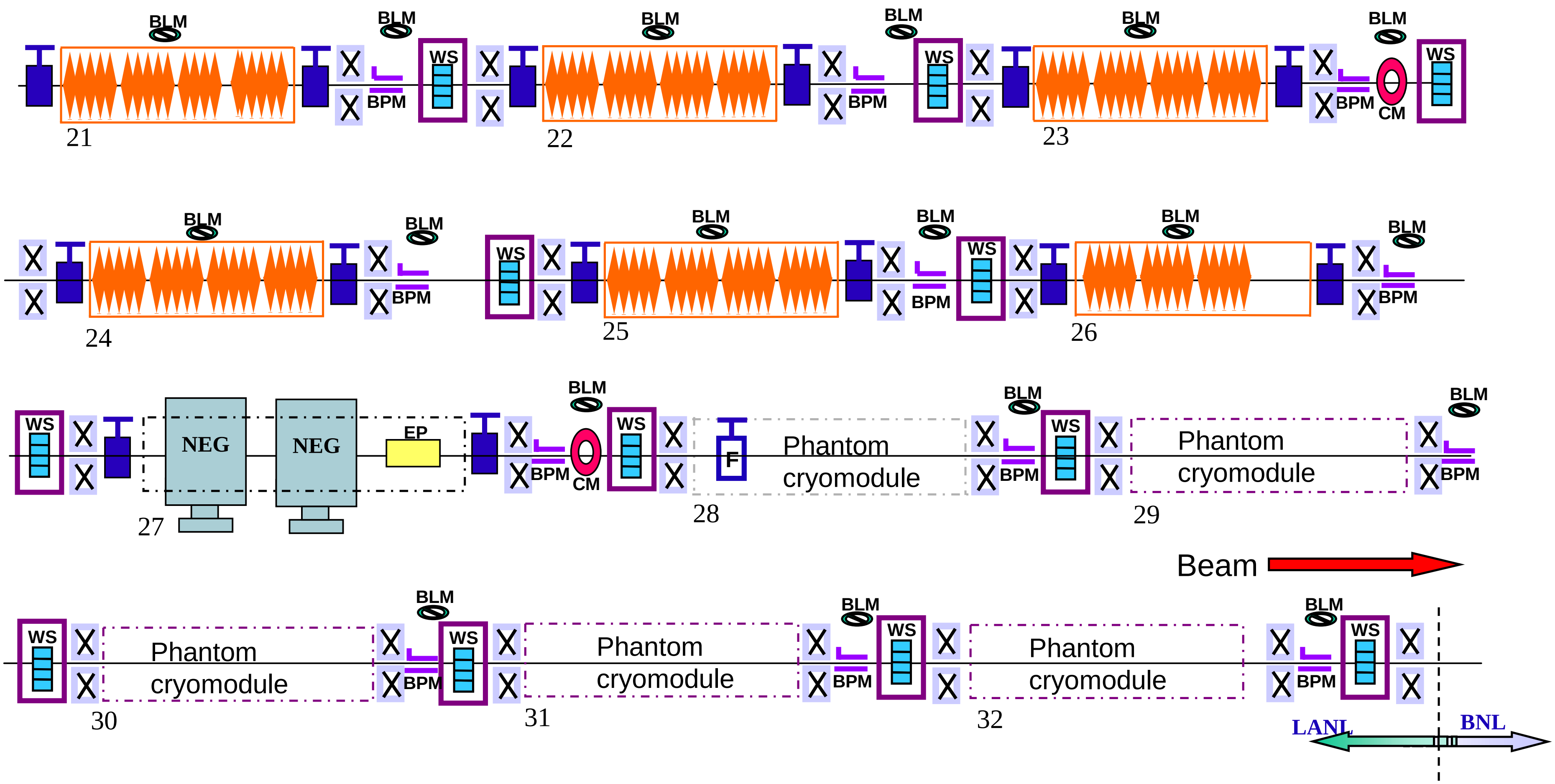
SRF Beam Diagnostics Layout



SRF Beam Diagnostics Layout (cont)



SRF Beam Diagnostics Layout (cont)



FY 2001 Milestones

BPM phase & position electronics PDR	02/01
BPM phase & position electronics FDR	06/01
BPM phase & position electronics begin procurement	06/01
BPM pickup design PDR	01/01
DTL BPM pickup FDR	06/01
DTL BPM pickup begin procurement	06/01
DTL & CCL current monitor pickups FDR	04/01
DTL & CCL current monitor pickups begin procurement	04/01
Wire scanner electronics PDR	05/01
DTL Wire scanner actuator PDR	02/01
DTL wire scanner actuator begin procurement	05/01
Harp electronics PDR	07/01
Harp mech. Design PDR	07/01
Harp mech design FDR	08/01
Diagnostics Plate development PDR	05/01
Begin Diagnostic Plate procurement	05/01
Beam-in-Gap (laser neutralization) PDR	05/01

Summary and Conclusions

•BPM phase and energy measurement accuracy requirements are
•challenging but achievable.

•There is very limited space for beam diagnostics.

•There are no show-stoppers.

•LANL is collaborating with BNL and LBL on diagnostics development.