PROTON SOURCE OJT

This OJT provides you with a checklist, guideline, and record of your Operator II Proton Source training, and introduces you to regular operational procedures as well as physical locations of equipment. **It is very important that you do not lose this document.** If you lose this document, the training you have completed will have to be redone.

This training list has been successfully completed.

Department Head (Signature/Date)_____

Contents

PROTON SOURCE TRAINING

Part 1: MCR

1.1 Pre-Accelerator

Trainer Date

1. Ion Source

Draw a simplified version of the ion source. Explain the method of extracting beam from the source, and the function of the following components:

____ Anode

____ Cathode

____ Racetrack

____ Hydrogen inlet

____ Cesium inlet

____ Magnet

____ Extractor cone

Trainer Date

2. Source Operation

Know the methods for monitoring the source devices and know their nominal operating values.

____ Be able to adjust common source parameters and be aware of their effects

- ____ Source changes can take up to several hours to take full effect
- ____ Be aware of the gas pressure regulation and cesium boiler regulation control loops

____ Be aware of the importance of the cathode temperature and the effect it has on the cesium layer

____ Identify the traces on the following oscilloscopes

- ____ Source arc
- ____ Source extractor

____ Be aware of the hydrogen gas alarm system and its purpose

Trainer Date

3. Source Cabinet Access

____ Be able to access a source cabinet following the procedure in ADDP-PR-1034

_____
Trainer Date

4. RFQ Injection Line (RIL)

Know the parameters and typical operating values for the devices that make up the following areas:

_____ Low Energy Beam Transport (LEBT)

_____ RFQ amplification chain

_____ Medium Energy Beam Transport (MEBT)

_____ Low energy buncher

_____ Vacuum equipment

____ Understand the concept of gas neutralization with respect to source output

_____ Laser notcher

_____ Know how to launch the RFQ Injection Linac synoptic display

_____
Trainer Date

5. Pre-Acc Pulse Shifter and Beam Enable Chassis

Know how the beam enable chassis and pulse shifter work together to enable beam.

_____ Know the function of the pulse shifter and beam enable chassis

_____ Know the different types of pulses the chassis generates

_____ Know what the inputs for beam permits are

____ Which inputs come from the beam switch sum box (BSSB)

1.2 Linac Safety

Trainer Date

1. Critical Devices

Know how the Linac critical devices protect personnel.

____ Know the critical devices for Linac, the laser notcher, and NIF.

____ Know the failure mode critical devices for Linac and NIF

Trainer Date

2. Turning Linac Off and On

Know how to turn Linac off and on before and after an access.

____ Know the appropriate CDCs to manipulate

____ Know how to turn off the Marx modulator LRF stations

____ Know how to turn off the klystrons

- ____ Turn off the software charge switch
- ____ Turn off the modulator reference voltage
- ____ Open the 480 V contactor

____ Know which 400 MeV devices to turn off and on

- ____ Reset the elements' fields when turning on

Trainer Date

3. Linac Access Hazards

Be aware of the Linac access hazards and how to identify the warning signs.

____ Know the hazards that may exist in supervised and controlled accesses

Trainer Date

4. Linac Configuration Control Lockout

Know how to perform a configuration control lockout of Linac power supplies in preparation for a supervised access, which includes proper use of the Configuration Control Lockout Form.

1.3 Linac Tuning and Operation

Trainer Date

1. Tuning

Have a general understanding of how to tune Pre-Acc and Linac.

____ Know how to perform a D1 save

____ Know the basics of tuning RIL

____ Know which loss monitors to use while tuning

____ Know how to use the velocity oscilloscope

____ Normal trace

____ Know how to monitor the bunch length in the 400 MeV Line

Trainer Date

2. 400 MeV Autosteer Program

____ Understand the purpose and importance of the 400MeV Autosteer program

____ Know where it runs and how we interact with it

____ Be able to determine which devices it controls

____ Know how to tell, and what to do, if it is not working correctly

____ Understand that if the Autosteer program reads beam too far off position, a Linac 400MeV Steer (L32) may be necessary

____ Understand that this requires Linac Studies pulses

Trainer Date

3. Drift Tube Linac RF Station Control

Know the ACNET programs commonly used to interface with the Drift Tube Linac RF (LRF) systems.

____ Know how to control the Marx modulator LRF stations (L28)

____ Determine trip status

____ Use a parameter page to check station readbacks

____ Know why certain trips cannot be reset from the MCR

Trainer Date

4. Side-Coupled Linac RF Station Control

Know the ACNET programs commonly used to interface with the Side-Coupled Klystron Linac RF (KRF) systems.

____ Know how to control the KRF stations

- ____ Determine trip status
- ____ Reset a tripped station
- ____ Turn a station off or on
- ____ Check gradient and phase values

____ Use a parameter page to check the status of KRF stations

- ____ Check station parameters
- ____ Check gradient or phase set points
- ____ Control software charging switches

Trainer Date

5. Linac Diagnostics

Know what diagnostics are available in Linac, and how to use them in the MCR to monitor and tune the beam, including:

____ Toroid and BLM plots

____ 400 MeV BLM and BPM plots – Java or ACNET

____ Know how to access Linac oscilloscopes locally and remotely

- ____ A and B source oscilloscopes
- ____ Linac RF station oscilloscopes
- ____ Velocity meter
- ____ Bunch length

Trainer Date

6. Beam Switch Sum Box (BSSB)

Know how to control beam to the Proton Source accelerators using the BSSB. Know how disabling a master switch affects the following:

____ High energy physics (HEP) and studies beam requests

____ NIF beam

Trainer Date

7. Activate Linac Studies Pulses

Know the purpose of Linac studies pulses.

____ Know how to generate and regulate Linac studies pulses

Trainer Date

8. Normal Beam Conditions

Know the nominal values for the following:

____ Source output

____ Linac output

____ Linac efficiencies

____ Dump toroids

1.4 Drift Tube Linac RF

Trainer Date

1. Drift Tube Cavity Components

Draw a simple cross-sectional view of a DTL RF cavity including the following:

____ Drift tubes

____ Quadrupole magnets

____ Tuning slug

____ Bulk tuner

____ Post coupler

____ Stem and stem box cover

____ Vacuum port

Trainer Date

2. DTL RF Components

Draw a DTL RF block diagram including the following components, and know their functions:

____ Master oscillator and reference line

____ Operating frequency

____ LLRF VXI crate

____ Amplifier, driver, and PA

____ Know what power each operates at

____ Transmission line

____ Trombone

____ Gas barrier

____ Cavity

____ Marx modulator

____ 480V AC disconnect & transformer

____ Driver anode supply

____ Power amplifier (PA) filament supply

____ Inductrol voltage regulator

____ Programmable logic controller (PLC)

Trainer Date

3. Marx Modulator

Know the function of the following basic components of the Marx modulator:

____ Charging supply

____ Marx cells

____ Local modulator controls

Trainer Date

4. Linac Marx Modulator Inhibits

Know how the following Marx modulator inhibits occur and understand the difference between them. Additionally, know the procedure for resetting a station after a trip.

____ Over voltage

____ Over current

____ Spark trip

____ Cell trip summation

____ ZOV driver/voltage

1.5 Side Coupled Cavity Linac (SCL) RF

Trainer Date

1. SCL Cavity Components

Draw a simple diagram of an SCL RF cavity including the following:

____ Accelerating cell

____ Coupling cell

____ Bridge coupler

____ Quad

____ Vacuum manifold

Trainer Date

2. SCL RF Components

Know the function and draw an SCL RF block diagram of the following:

____ 9 kV charging supply (CS)

____ 18 kV pulse forming network (PFN)

____ 12 MW klystron

- ____ 180 kV transformer
- ____ Electron gun
- ____ Tube
- ____ Collector
- ____ Waveguide

____ Side coupled cavity

1.6 NIF

Trainer Date

1. NIF Operation

Be familiar with the requirement for NIF operations.

____ Requirements for NIF beam

- ____ Permit
- ____ Keys
- ____ Critical devices

____ Linac stations used in NIF acceleration

____ Linac quads used for NIF beam

Trainer Date

2. Beamline Layout

Draw the general layout of the NIF beamline and its relationship to Linac. Your diagram should include:

____ 58° magnet

- ____ Understand the purpose of the NIF 58° magnet gauss probe, L:CGAUSS

____ 32° magnet

____ Toroids

____ Target

____ Collimators

____ Irradiation area

Trainer Date

3. Linac's Role

Have a general understanding of the role of Linac in providing beam to NIF. Your knowledge should include the following:

____ TCLK events associated with NIF

____ Parameters for Einzel lens NIF chop times

____ How to control the LE buncher for both NIF and HEP beam

____ Which RF cavities are involved in accelerating NIF beam

____ The approximate energy of the beam sent to the NIF target

____ LRF4 pulse shift for NIF

____ How the NIF beamline vacuum is maintained, and its relation to Linac vacuum

Trainer Date

4. Operations Department's Role

Understand the role of the AD Operations Department in providing beam to NIF. Have a discussion with your trainer about the separation of responsibilities between AD/Ops and NIF personnel, emphasizing that some equipment and procedures are operated by NIF personnel only.

Trainer Date

5. NIF Beam Priority

Understand the concept of priority beam for NIF, including the following information:

____ What priority beam requests mean for HEP beam pulses

____ The circumstances in which NIF may request priority beam

____ How to adjust NIF priority

- ____ What is meant by "DC beam" in the context of NIF priority, and how to achieve it

____ How to disable beam to NIF

1.7 400 MeV Area

_____	
Trainer	Date

1. Linac Beam Dumps

Understand the function of each of the Linac beam dumps. Know what determines which beam dump is currently being used, and which beam dump is used during normal HEP operation.

____ Straight-ahead dump

____ Momentum dump

____ Understand the purpose for the Linac spectrometer magnet and gauss probe, L:SPEC

_____	
Trainer	Date

2. Booster Injection Systems

Draw a diagram and know the function of the Booster injection systems including the following:

____ 400 MeV chopper

____ Booster Lambertson

____ MH1

____ MV1

____ MV2

____ Debuncher

____ MH2

____ Orbump

____ Stripping foil

1.8 Booster Safety

Trainer Date

1. Critical Devices

Understand how the Booster critical devices protect personnel.

____ The critical devices and failure mode critical devices that protect the Booster enclosure

____ MI vs. dump mode

____ Identify the current mode

____ How to change modes

Trainer Date

2. Booster Configuration Control Lockout

Know how to do a configuration control lockout in preparation for a supervised access. This includes proper use of the Configuration Control Lockout Form.

Trainer Date

3. Turning Booster Off and On

Understand how to turn Booster off and on before and after an access. Your knowledge should include:

____ What devices are turned off or on via the sequencer

____ The appropriate CDC to manipulate

____ How to properly switch off or on the 13.8 kV Brentford disconnects using Booster Gradient Magnet Power Supply Bus System Lockout/Tagout Procedure ADSP-05-1212

____ How to become qualified to perform this procedure

Trainer Date

4. Booster Access Hazards

Be aware of the Booster access hazards and how to identify the warning signs:

____ Hazards that may exist in supervised and controlled accesses

1.9 Booster Tuning and Operation

Trainer Date

1. Tunnel Layout

____ Know the type of lattice for the Booster

- ____ Know which locations have focusing and defocusing gradient magnets
- ____ Know which locations are more effective at moving the beam horizontally and vertically

____ Know where the injection and extraction elements are and which plane they bend the beam

- ____ Know the location of the Booster dump

____ Know the locations of the Booster collimators and notch absorber

____ Know where the RF cavities are located

Trainer Date

2. Injection Tuning

Know how to do a Booster injection tune including the following tasks:

____ Make a D1 save

____ Adjust injection bend field

____ Tune main 400 MeV devices and trims

____ Close the injection orbit

Trainer Date

3. RF Capture Tuning

Know how to tune Booster beam capture, including:

____ Adjust Linac velocity

____ Perform a 400 MeV steer

____ Adjust LLRF parameters

- ____ Paraphasing offset
- ____ Paraphasing delay
- ____ A and B pots
- ____ Injection frequency
- ____ Frequency curve delays

____ Debuncher gradient and phase tuning

____ Check injection bend field

Trainer Date

4. Correction Elements

Know how to tune the Booster correction elements. Additionally, know the following:

____ Correction element packages contain:

- ____ Horizontal and vertical dipoles
- ____ Quads and skew quads
- ____ Sextupoles and skew sextupoles
- ____ Understand that each element of the corrector package has its own regulator

____ Parameters for individual correctors

____ Perform 3-bumps using dipole correctors (B82 and B111)

- ____ Understand why horizontal shorts and vertical longs are more sensitive

____ Tune on ramps for higher order elements (B15)

- ____ Save and restore ramps
- ____ Check which ramp file to tune on (B37)

____ Tune the DC offsets for quads and sextupoles (B111)

- ____ DC offset mults
- ____ Quad 3-bump mults

Trainer Date

5. Booster Beam Cycle

Understand the chronology of a typical beam cycle including:

____ Electron stripping

____ Paraphasing

____ Notching

____ Acceleration

____ Cogging

____ Bunch rotation

____ Phase locking

Trainer Date

6. Diagnostics

Know what diagnostics are available in Booster to tune or monitor beam.

____ Snapshot BLMs

- ____ Understand the difference between the B:BLMxxx and B:IRMxxx parameters

____ Booster beam loss plots

- ____ Be familiar with a typical loss profile

____ BLM cycle plot (B136)

____ BPM plots

- ____ 400 MeV Line (B32 or B33)
- ____ Booster Orbit (B40)
- ____ Booster Turn-By-Turn BPM (B38)

____ Proton Torpedo

- ____ Be familiar with what a good batch profile looks like

____ Multiwire display for both 400 MeV and 8 GeV Lines

Trainer Date

7. Booster Status

Using Booster status page (B21), know how to monitor or control the following:

____ GMPS control and status

____ GMPS load status

____ Major devices in:

- ____ Booster
- ____ 400 MeV Line
- ____ 8 GeV Line

____ Extraction kickers control and status

____ Vacuum readbacks and control

____ Magnet and ion pump temperature readbacks

____ Linac and MTA vacuum readbacks

Trainer Date

8. Normal Beam Conditions

Be familiar with nominal values for the following:

____ Beam intensity profile

____ Extracted beam intensity per event

____ Beam efficiency per event

____ Beam loss profile

Trainer Date

9. Oscilloscope Usage

Know how to perform common tuning and monitoring tasks with the patch panels and oscilloscope located near Console 2, including:

____ View the appropriate signals on the Booster oscilloscopes

- ____ Phase drive
- ____ RPOS
- ____ Fast phase error
- ____ RF sum
- ____ Wall current monitor
- ____ Booster to Main Injector phase lock

Trainer Date

10. Beam Turns Page Usage

Know how to perform common tasks on the beam turns control page (B4), including:

____ Changing the number of turns on a specific event

____ Changing the number of bunches delivered on a specific event

- ____ Know that partial batching can be disabled per event

____ Displaying the kicker times

1.10 Booster Gradient Magnets

Trainer Date

1. Gradient Magnet Diagram

Be able to draw a simple cross-sectional view of a Booster gradient magnet including the following:

____ Magnet pole faces

____ Electrical conductors

____ Magnetic field lines

____ Compare the gradient magnet cross section to that of a typical dipole magnet such as those in Main Injector

Trainer Date

2. Magnet Girder Components

Draw a diagram showing all of the components of a Booster girder.

____ Magnets

____ Capacitor bank

____ Ion pump

____ Choke

____ Know that the components on the girder form a resonant circuit

Trainer Date

3. GMPS

Be familiar with the layout of GMPS including:

____ GMPS control and status

____ Parameters for voltages and currents

____ GMPS components

- ____ Disconnect and transformer
- ____ Power supply
- ____ Purpose of choke

____ Purpose of reference magnet

1.11 Booster RF

Trainer Date

1. Low Level RF

Be aware of the basic block diagram for Booster LLRF. Understand the role of:

____ LLRF curves

- ____ Frequency
- ____ Paraphase
- ____ Bias program
- ____ Know how to restore the curves (B26 or B30)
- ____ Be able to verify that the frequency and bias curves are playing out

____ RF ramps

- ____ Radial offset (ROF)
- ____ Radial gain (RAG)
- ____ Anode program (APG)
- ____ Know how to adjust and restore the ramps (B29)

____ The A and B ENI amplifiers

____ RPOS and phase detectors

- ____ Know where these devices are in the tunnel

____ Cogging module

____ Phase lock and bucket-to-bucket transfer

____ Bunch rotation

Trainer Date

2. High Level RF Components

Understand the function of the HLRF components including:

____ Anode supply

____ Modulator

____ Solid state driver

____ RF cavity

- ____ Ferrite tuners
- ____ Power Amplifier

____ Bias supply

____ Know how and when to bypass an RF Station from the Anode Supply

Trainer Date

3. High Level RF Control and Operation

Be able to monitor and diagnose the trip status of Booster RF components.

____ Plot station parameters, such as gap envelope or modulator voltage

____ Respond to various watchdog trips

____ Respond to various modulator, bias supply, and anode supply trips

____ Know how to tell if a station is mod blocking

____ Know how to bypass an RF station's alarms

____ Know how to disconnect a station from the anode supply

____ Modulator External Interlock Unit (MEIU)

- ____ Power Amp Air Flow
- ____ Repeated RFGE Faults
- ____ Power Amp LCW Leak
- ____ Vacuum Pressure High

____ Display diagnostic trip logs

____ Be able to reset a Booster RF station

Trainer Date

4. Longitudinal Damper System

Know that the Booster longitudinal damper system is a beam feedback system. Your knowledge also should include:

____ Basic damper system theory

____ The different longitudinal damper modes

____ How to save, restore and adjust damper phase and magnitude curves

____ How to enable and disable damper modes for an event

____ How to view damper error signals

1.12 8 GeV Line Extraction and Dump

Trainer Date

1. Notching

Understand the reason for notching in Booster, as well as the roles of the Linac laser notcher and NOKD. This should include:

____ Linac laser notcher operation

____ NOKD operation

- ____ Where the notched beam is deposited in Booster
- ____ Nominal oscilloscope trace for the kicker
- ____ Timing parameters for the notch

Trainer Date

2. Booster Extraction Systems

Draw a diagram of the Booster extraction systems including the elements listed below. Know the function of the following:

____ DOGL3

____ BEX bump

____ Extraction kickers at L2 and L12

- ____ Normal oscilloscope traces for these kickers
- ____ Know how to adjust the timing of the extraction kickers

____ MP02

____ VBC1

____ MI8BND

____ Dump kickers

- ____ Know how to adjust the timing of the dump kickers

____ V803

____ MP03

____ Understand the difference between dump mode and MI mode

- ____ Configuration of B:V803 and B:BS809

1.13 Utilities

Trainer Date

1. Linac 55° LCW

____ Know that the supply pressure and temperature are regulated by CUB

____ System is cooled by process chilled water

____ Know that this system provides cooling and make up for:

____ DTL cavity and RF cooling skids

____ Pre-Acc cooling skid

____ NIF cooling skid

____ 400 MeV/Waveguide cooling skid

____ Debuncher RF cooling skid

____ Test stand cooling skid

____ Be able to monitor this system through ACNET

____ Supply pressure

____ Return pressure

____ Temperature

____ Leak alarms

Trainer Date

2. Klystron Chilled Water

____ Know that the supply pressure and temperature are regulated by CUB

____ System is cooled by process chilled water

____ Know which systems the klystron chilled water provides cooling for

____ Klystron RF power supplies

____ Klystron solenoid magnets and power supplies

____ Klystron electron beam collector

____ Klystron body cooling

Trainer Date

3. Klystron Cavity Water

____ Know what the Klystron Cavity Water system cools

____ Understand that the Distribution Skid provides LCW for the Buncher, Vernier, and KRF1 through KRF7

Trainer Date

4. Booster 95° LCW

____ Know that the supply pressure and temperature are regulated by CUB

____ System is cooled by process chilled water

____ Know which systems the Booster 95° LCW provides cooling for

____ Booster RF

____ Booster magnets

____ Booster power supplies

____ Know which systems make up water from Booster 95° LCW

____ Klystron RF cooling skids

____ Klystron cavity distribution skid

____ Be able to monitor this system through ACNET

____ Supply pressure

____ Return pressure

____ Temperature

____ Leak alarms

Trainer Date

5. Linac and Booster Vacuum Systems

Know how to use console applications to help diagnose vacuum problems including:

____ Check gauge and valve statuses

____ Check vacuum readings

____ Plotting or listing vacuum readings

____ Use the Booster ion pump temperature plot

____ Know how to monitor and control the ion pump power supplies remotely (L55 and B21) and locally

1.14 Theory

Trainer Date

1. Proton Source Timing

____ Understand a Linac station's timing and the chronology of a typical beam pulse

- ____ Source timing
- ____ PreAcc RF timing
- ____ LRF station timing
- ____ Quad timing

____ Know which timings are shifted by the pulse shifter to inhibit or permit beam from being accelerated

Trainer Date

2. Transition

Understand the concept of transition, including:

____ The time and energy of transition in Booster

____ The RF phase jump performed to keep beam stable through transition

Trainer Date

3. Basic Machine Parameters

Understand basic machine parameters and how they are calculated, including:

____ Orbit times at injection and extraction

____ Harmonic number

- ____ Know how this can be calculated from the RF frequency and the beam revolution period

____ Length of Booster beam cycle

____ Bunches

____ Buckets

____ Turns

____ Batches

Trainer Date

4. Cogging

Understand how Booster utilizes cogging in the extraction process.

____ The purpose of cogging

____ How cogging is completed

____ Which events are cogged

Trainer	Date

5. Bunch Rotation

Understand how Booster utilizes bunch rotation in the extraction process.

____ The purpose of bunch rotation

____ How and when bunch rotation is completed

____ Parameters for tuning bunch rotation

Part 2: Walkaround

2.1 Pre-Accelerator

Trainer	Date

1. Pre-Acc Area

____ Source cubes
- ____ Source body
- ____ Extractor cone
- ____ Cesium boiler, valve, and tube
- ____ Hydrogen gas bottle
- ____ Vacuum pumps

____ LEBT
- ____ Solenoid magnets
- ____ Trim magnets
- ____ Vacuum valves
- ____ Toroid
- ____ Vacuum pumps

____ Einzel lens chopper
- ____ Einzel lens
- ____ Chopper controller
- ____ Chopper HV power supply
- ____ Chopper on and off switches (IGBTs)

____ RFQ
- ____ Tuning slug
- ____ Vacuum pumps
- ____ Transmission line

____ MEBT
- ____ Laser notcher
- ____ Quad doublets
- ____ Buncher

____ Source HV racks
- ____ HRM
- ____ Arc oscilloscope
- ____ Arc supply modulator and pulser
- ____ Heater power supplies
- ____ Umbilical cord

____ Power supplies
- ____ Extractor and pulser
- ____ Trims
- ____ Solenoids
- ____ Quad doublets

____ RFQ driver cabinet
- ____ Oscilloscope

____ Pre-Acc LCW skid

_____ Trainer Date

2. Pre-Acc Control Room

____ Extractor oscilloscopes

____ Beam enable and pulse shifter chassis

____ Vacuum equipment
- ____ Turbo pump power supplies
- ____ Vacuum readbacks

____ Linac CDC chassis

____ Laser notcher CDC chassis

____ Linac & Source control nodes

____ RFQ tuner motor controller

____ RFQ driver anode power supply

2.2 Linac Galleries

_____
Trainer Date

1. DTL Stations – Linac Upper Gallery

____ Marx modulator

- ____ Charging supply
- ____ Marx cells
- ____ Marx modulator 480V AC disconnect

____ Marx modulator control rack

- ____ FPGA
- ____ PLC controller
- ____ Local/Remote switch
- ____ FPGA power supply fuses
- ____ Emergency switch

____ Driver cabinet

- ____ Tomco solid state amplifier
- ____ Driver cavity (4616)
- ____ Interlock and status monitor
- ____ Panel breakers

____ Driver anode power supply

____ Power amplifier (7835)

- ____ Transmission line
- ____ Main 480V breaker

____ Proper response to a Linac 55° LCW failure, in the following order, while in contact with a Linac expert:

- ____ Shut off all QPSs
- ____ Turn off LRF station HV
- ____ Shut off PA filament power, control power, and main breaker
- ____ Turn off the pumps for the RF and cavity water systems

- ____ Station control A5 racks
  - ____ Overload indicators
  - ____ Oscilloscope signals
  - ____ Driver and PA interlocks
  - ____ Station console and keyboard
  - ____ LLRF VXI crate
  - ____ PA filament PLC
  - ____ Stepper motor controller for the tuning slug
- ____ RF water system control panel A7 racks
  - ____ Interlocks
  - ____ Pressure gauges and conductivity meter
  - ____ Supply and return valves
  - ____ Supply and return header
- ____ Quad power supplies (QPSs)
  - ____ Troubleshooting procedure
  - ____ Spare cards for QPSs
  - ____ Wall breakers for groups of quads
- ____ Vacuum pump supplies
  - ____ Know the procedure for resetting a tripped supply
- ____ Vacuum valve controller
  - ____ Know how to open a vacuum valve
  - ____ Know how the vacuum valves are interlocked
- ____ Linac data server (node 600) and Linac timing (node 601)
  - ____ Smart rack monitor (SRM)
- ____ Buncher
  - ____ Control station/rack
  - ____ Tomco solid state amplifier
  - ____ SRM
- ____ Linac spare module cabinet
- ____ DTL steering magnet power supplies

Trainer Date

2. DTL Utilities – Linac Lower Gallery

____ Penetrations

- ____ Interlock box for penetrations

____ Typical Linac RF and cavity water station

- ____ Procedure for making up water or head pressure for either RF or cavity systems
- ____ Cavity and RF temperature regulation

____ PA filament power supply

____ Inductrol voltage regulator

____ Transmission line

____ Trombone

____ LRF4 QPSs

____ Linac 55° LCW temperature sensor

Trainer Date

3. NIF – MCR

____ Keys

- ____ BSSB NIF Enable key
- ____ NIF Beam Enable key
- ____ NIF Reset & Enable key

____ Remote interlock status module

Trainer Date

4. NIF – Upper Linac Gallery

____ LE buncher racks

____ NIF/HEP buncher phase switch module

____ LRF3 racks

____ LRF3 NIF interface module

____ LRF4 racks

____ NIF ion gauge controller

____ NIF ion pump and turbo

____ NIF vacuum valve controller

____ LRF4 pulse shifter

____ LRF4 NIF interface module

____ Irradiation area

____ Control room

____ Remote interlock status module

____ CDC chassis

Trainer Date

5. NIF – Lower Linac Gallery

____ Controls rack

____ NIF cage

____ NIF LCW system

____ NIF QPSs

____ Critical device power supplies

Trainer Date

6. Klystron Stations – Linac Upper Gallery

____ Transition section
- ____ 200 kW klystrons
- ____ Charging supply and controller
- ____ PFN and controller
- ____ 500 kW modulator contactor controller
- ____ Location and function of the Linac master oscillator

____ Klystron stations
- ____ Charging supply
- ____ PFN
- ____ Step-up transformer
- ____ Klystron
- ____ Waveguide

Trainer Date

7. Klystron Control Racks – Linac Upper Gallery

____ Station status and interlock module
- ____ Charge switch

____ Emergency off button

____ 24 MW modulator safety interlocks

____ Control crates and associated SRM modules
- ____ VME station control
- ____ VME modulator control
- ____ VXI LLRF control

____ PFN master reset

____ Phase controller and master reset

____ Oscilloscope signals

____ Klystron filament power supply
- ____ What is the operational heat mode

____ Solenoid power supplies for klystron

____ Upstream and downstream QPSs racks
- ____ Bulk supplies and pulsers
- ____ Control cards

____ Steering trim magnet power supplies

Trainer Date

8. Klystron Utilities – Linac Upper Gallery

____ Klystron RF LCW water skids

- ____ Which system is used for make-up
- ____ Which system is used for heat-exchange
- ____ Number of skids operational at one time
- ____ Know how to reset a tripped skid

____ Vacuum racks for side coupled cavities

- ____ Ion pumps
- ____ Vacuum valve controllers

____ Klystron 480 V distribution panel

Trainer Date

9. Klystron Utilities – Linac Lower Gallery

____ Cavity distribution water skid

- ____ Which system is used for make-up
- ____ Which system is used for heat-exchange

____ Klystron chilled water head pressure pumps (booster pumps)

____ Station cavity and transition cavity cooling skids

- ____ How these skids regulate water temperature

____ 400 MeV and waveguide water skid

____ Klystron waveguide air compressors

2.3 Booster Galleries

Trainer	Date

1. 400 MeV Line Components

____ 400 MeV chopper
- ____ Controller
- ____ Thyratron cabinets
- ____ HV supply
- ____ Oscilloscope signals

____ Vacuum controller and gauges

____ B:LAM power supply

____ Linac dump components
- ____ L:SPEC
- ____ Trim supplies
- ____ Multiwire electronics
- ____ Toroid electronics
- ____ Quad supplies and controllers

____ Booster CDC chassis
- ____ MI inputs into Booster CDC

____ MTA CDC chassis

____ Major bend power supplies
- ____ B:MV0
- ____ B:MH1
- ____ B:MV1
- ____ B:MV2
- ____ B:MH2

____ Quad power supplies
- ____ Controller
- ____ Disconnects

____ Multiwire motor controller

____ BPMs

____ Debuncher cavity and RF cooling systems

____ Debuncher station

____ Booster 400 MeV Line trim supplies

____ Orbump power supply

Trainer Date

2. Booster RF Station Components

____ RF modulator
- ____ Power supply disconnect
- ____ Modulator control unit
- ____ Station LCW supply and return valves

____ Bias supply
- ____ Power supply disconnect
- ____ Contactor control unit
- ____ Station LCW supply and return valves

____ Solid state driver rack
- ____ Controller
- ____ Interlocks

____ RMU rack
- ____ Oscilloscope signals
- ____ IRM and PLC interface panel
- ____ MEIU control
- ____ Jumper out an individual watchdog input

Trainer Date

3. RCC Racks

____ Watchdog modules

____ Anode power supply control unit

Trainer Date

4. Correction Element Power Supply Racks

____ Bulk power supply and controller

____ Individual corrector power supplies

____ Corrector power supply breakers

____ Control power supplies

____ C473 ramp cards

Trainer Date

5. GMPS Power Supplies

____ Knife switch cabinet

____ SCR module

____ Choke cabinet

____ Local PLC controller

Trainer Date

6. Vacuum Racks

____ Manipulating vacuum valves

____ Reading vacuum gauges

____ Nominal vacuum values

____ Know how to properly turn on and off ion pump power supplies

____ Understand the ion pump troubleshooting procedure

____ Ion pump temperature sensors

____ Roughing station

____ Local PLC controller

Trainer Date

7. Instrumentation

____ BPMs

____ Associated VMEs

____ BLMs

____ Associated IRMs

Trainer Date

8. Booster West Gallery

____ Vacuum racks

____ GMPS control racks

- ____ GMPS control cards
- ____ Various current and voltage meters
- ____ Jumpering out a girder's interlocks
- ____ GMPS load status monitor
- ____ Booster hipotter

____ B:WGNBS (West Gallery North Bulk Supply) for correctors in periods 20, 21, 22 and 23

____ Reference magnet

- ____ What signal comes from the reference magnet

____ RCC rack with anode power supply control unit

____ B:WGCBS (West Gallery Center Bulk Supply) for correctors in periods 24, 1, 2 and 3

____ VBC1, DOGL3, and VBC0

- ____ Power supply disconnects

____ SEXTL power supplies

____ Fan Room

- ____ Vacuum racks
- ____ Fan controls

____ Extraction kickers

- ____ Power supply controllers
- ____ PFNs and thyratrons
- ____ Power supply disconnect

____ 8 GeV Line power supplies

- ____ MI8BND
- ____ Q800-Q803

____ GMPS 1 and 2

- ____ Local PLC controller

____ MP02 power supply and disconnect

Trainer Date

9. West Utility Yard

____ Anode supply

____ Glycol skid status and pump control

____ Brentford disconnect switches

____ GMPS transformers 1 and 2

Trainer Date

10. Booster West Tower

____ MP03 power supply and disconnect

____ B:BTWBS (Booster Tower West Bulk Supply) for correctors in periods 4, 5, 6, and 7

____ Booster dump and 8 GeV Line

____ V803 controller

____ Dump line corrector power supplies

____ BCOLL collimator VME

____ 8 GeV Line ion pumps

____ Dump and partial batch kickers

____ HV power supplies and controllers

____ PFNs and thyratrons

____ Power supply disconnects

Trainer Date

11. Booster Low Level RF (LLRF) Room

____ A and B station ENIs

____ LLRF VXI crate

____ LLRF DDS VME

____ Vacuum racks

____ Understand that the equipment is temperature sensitive

Trainer Date

12. Booster East Gallery

____ B:EGNBS (East Gallery North Bulk Supply) for correctors in periods 16, 17, 18 and 19

____ RCC rack with anode power supply controller

____ B:EGCBS (East Gallery Center Bulk Supply) for correctors in periods 12, 13, 14 and 15

____ L12 extraction kicker

- ____ HV power supply and controller
- ____ PFN and thyratron
- ____ Power supply disconnect

____ NOKD

- ____ HV power supply and controller
- ____ PFN and thyratron
- ____ Power supply disconnect

____ B:EGSBS (East Gallery South Bulk Supply) for correctors in periods 8, 9, 10 and 11

____ Booster longitudinal dampers

- ____ Amplifiers
- ____ Oscilloscope

____ GMPS 3 and 4

- ____ Local PLC controller

____ Vacuum racks

Trainer Date

13. East Utility Yard

____ Anode supply

- ____ Glycol skid status and pump control

____ Brentford disconnect switches

____ GMPS transformers 3 and 4

Trainer	Date

14. A0 Nitrogen Dewars

____ Know which critical systems use nitrogen from these dewars

- ____ Linac and Booster vacuum valves
- ____ Linac PA coaxial transmission lines
- ____ CUB LCW valves
- ____ CUB head pressure (all systems)

____ Know the locations of the dewars and how to read the nitrogen pressure locally

____ Know who is responsible for the A0 nitrogen dewars

____ Know how to find nitrogen delivery contact information and confirm delivery