

# MUON CAMPUS OJT

This OJT provides you with a checklist, guideline, and record of your Operator II Muon Campus training, and also 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)\_\_\_\_\_

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# MUON TRAINING

## Part 1: MCR

### 1.1 Introduction

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#### 1. Beamlines

Be able to construct a basic outline of the beam path from the Recycler to the Muon Campus experiments including the following beamlines:

- \_\_\_ RR to P1 Line
- \_\_\_ P1 & P2 Lines
- \_\_\_ M1 Line
- \_\_\_ M2 & M3 Lines
- \_\_\_ Delivery Ring
- \_\_\_ Abort Line
- \_\_\_ M4 & M5 Lines
- \_\_\_ g-2 Ring

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#### 2. Tunnel Layout

\_\_\_ Be familiar with the naming and numbering convention of the following beamlines:

- \_\_\_ M1 Line
- \_\_\_ M2 Line
- \_\_\_ M3 Line
- \_\_\_ M4 Line
- \_\_\_ M5 Line
- \_\_\_ Delivery Ring Abort Line

\_\_\_ Be familiar with the naming and numbering convention of the Delivery Ring

- \_\_\_ Understand the difference between the ACNET device name and the magnet name
- \_\_\_ Know where the enclosure entrances are

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### 3. AP0 Vault Layout

- \_\_\_\_\_ Draw a diagram of the AP0 Target Vault
  - \_\_\_\_\_ Target
  - \_\_\_\_\_ Collimator
  - \_\_\_\_\_ Lens
  - \_\_\_\_\_ Pulsed Magnet
  - \_\_\_\_\_ Beam Dump

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### 4. Intensities & Efficiencies

Know the intensity and efficiency parameters for the Muon Campus in the following areas:

- \_\_\_\_\_ Recycler efficiency
- \_\_\_\_\_ RR to P1 Line intensity
- \_\_\_\_\_ P2 Line intensity
- \_\_\_\_\_ M1 Line intensity
- \_\_\_\_\_ Target intensity
- \_\_\_\_\_ M2 Line intensity
- \_\_\_\_\_ M3 Line intensity
- \_\_\_\_\_ M4 Line intensity
- \_\_\_\_\_ M5 Line intensity
- \_\_\_\_\_ Delivery Ring Abort intensity
- \_\_\_\_\_ g-2 Detector intensity
  - \_\_\_\_\_ Understand that there is a significant delay in this readback
- \_\_\_\_\_ g-2 decay rate
  - \_\_\_\_\_ Understand that there is a significant delay in this readback

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### 5. Re-bunching & Extraction

- \_\_\_\_\_ Know how the beam is re-bunched in Recycler for Muon Campus
- \_\_\_\_\_ Know how the re-bunched beam is extracted from Recycler to the Muon Campus
  - \_\_\_\_\_ Know how long of a delay there is between extractions
  - \_\_\_\_\_ Understand why there is a delay between extractions

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## 6. Running Modes

- \_\_\_\_\_ Know the differences between the Muon Campus modes of running
  - \_\_\_\_\_ g-2 Mode
  - \_\_\_\_\_ Mu2e Mode
- \_\_\_\_\_ Know how to change the number of 2.5 MHz bunches delivered to the Muon Campus
  - \_\_\_\_\_ Understand that the number of Booster Batches will need to be changed
- \_\_\_\_\_ Know the TCLK events associated with the modes of running
  - \_\_\_\_\_ Recycler events
  - \_\_\_\_\_ Muon reset events
  - \_\_\_\_\_ Muon transfer events
- \_\_\_\_\_ Understand the importance of placing the Muon reset events correctly in the timeline
- \_\_\_\_\_ Understand the reason for removing the events from the timeline when beam is not in use by the experiment
- \_\_\_\_\_ Understand the reason for ramping P1 & P2 beamlines following an access to Main Injector/F-Sector
- \_\_\_\_\_ Understand the reason for the delay before sending beam to Muon Campus following a Switchyard cycle

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## 7. Momentum Selection

- \_\_\_\_\_ Understand the importance of 3.1 GeV/c for the g-2 experiment
- \_\_\_\_\_ Know how the muon beam is separated from the protons before extraction to g-2

## 1.2 Muon Campus Safety

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### 1. Electrical Safety System (ESS)

- \_\_\_\_\_ Identify the inputs to the ESS
- \_\_\_\_\_ Know which devices are interlocked to the ESS

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## 2. Critical Devices

- \_\_\_ Know what CDCs protect the Pre-Target enclosure
  - \_\_\_ Identify the critical devices interlocked to this CDC
- \_\_\_ Know what CDC protects the Pre-Vault enclosure
  - \_\_\_ Identify the critical devices interlocked to this CDC
- \_\_\_ Know what CDC protects the Transport US/DS & Mid enclosures
  - \_\_\_ Identify the critical devices interlocked to this CDC
  - \_\_\_ Understand the implications of a Transport Mid access during normal operation
- \_\_\_ Know what CDC protects the Delivery Ring enclosure
  - \_\_\_ Identify the critical devices for g-2 mode
  - \_\_\_ Identify the critical devices for Mu2e mode
- \_\_\_ Know what CDC protects the Extraction enclosure
  - \_\_\_ Identify the critical devices interlocked to this CDC
  - \_\_\_ Understand that the MC1 CDC must be enabled before the Extraction CDC can be enabled
- \_\_\_ Know what CDC protects the MC1 enclosure
  - \_\_\_ Identify the critical devices interlocked to this CDC
- \_\_\_ Know what CDC protects the M4 Beamline enclosure
  - \_\_\_ Identify the critical devices interlocked to this CDC

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## 3. Muon Campus Access Hazards

- \_\_\_ Hazards that may exist in supervised and controlled accesses
  - \_\_\_ Understand the radiation hazards near the wall of the Target Vault in the Pre-Vault and Transport US enclosures
  - \_\_\_ Understand the magnetic field hazard of the g-2 ring when accessing MC1 and the precautions that are required when working near the ring

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## 4. Vault Access

- \_\_\_ Understand that ES&H is responsible for all Vault accesses

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## 5. AP0 Airborne Radiation Monitoring

- \_\_\_\_\_ Understand the reason for airborne radiation monitoring at AP0
  - \_\_\_\_\_ Know how the air circulation system works
  - \_\_\_\_\_ Know that the target air is sampled in AP0, as the air enters Pre-Vault, and before the air exits Pre-Target
  - \_\_\_\_\_ Know what parameters are useful for monitoring the target air monitoring system
  - \_\_\_\_\_ How to respond to an AP0 airborne radiation FIRUS alarm following ADDP-OP-0001

## 1.3 Power Supplies

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### 1. Muon Campus Turn Off and On

- \_\_\_\_\_ Know which devices are turned off or on via the sequencer
  - \_\_\_\_\_ Understand that some devices must be ramped down before being turned off
- \_\_\_\_\_ Know the appropriate CDCs to manipulate
- \_\_\_\_\_ Know how to turn off or on the beamline enclosures before and after an access using the following procedures:
  - \_\_\_\_\_ Pre-Target & Pre-Vault 480V LOTO Procedure [ADSP-05-1218](#)
  - \_\_\_\_\_ Transport 480V LOTO Procedure [ADSP-05-1219](#)
  - \_\_\_\_\_ Delivery Ring 13.8kV and 480V LOTO Procedure [ADSP-05-1220](#)
  - \_\_\_\_\_ Extraction Enclosure Including the Extraction Stub 480V LOTO Procedure [ADSP-05-1221](#)
  - \_\_\_\_\_ M4 Enclosure 480V LOTO Procedure [ADSP-05-1222](#)
  - \_\_\_\_\_ Know how to become qualified for these procedures
- \_\_\_\_\_ Know how to prepare the MC1 enclosure for access

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### 2. Power Distribution

- \_\_\_\_\_ Know which MOS at Kautz Rd. Substation supplies power for the M1 Beamline power supplies
  - \_\_\_\_\_ Know that I:F17B3 must be switched off for F-Sector access.
- \_\_\_\_\_ Understand that the D:IB powers multiple power supplies around the Delivery Ring
  - \_\_\_\_\_ Know which power supplies D:IB powers

## 1.4 Beamlines

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### 1. M1 Line

- \_\_\_ Be familiar with the purpose and layout of the M1 Line
- \_\_\_ Be able to identify major bending elements in the line

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### 2. M2 Line

- \_\_\_ Be familiar with the purpose and layout of the M2 Line
- \_\_\_ Be able to identify major bending elements in the line

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### 3. M3 Line

- \_\_\_ Be familiar with the purpose and layout of the M3 Line
- \_\_\_ Be able to identify major bending elements in the line

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### 4. M4 Line

- \_\_\_ Be familiar with the purpose and layout of the M4 Line
- \_\_\_ Be able to identify major bending elements in the line
- \_\_\_ Be able to identify where the beamline split occurs

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### 5. M5 Line

- \_\_\_ Be familiar with the purpose and layout of the M5 Line
- \_\_\_ Be able to identify major bending elements in the line
- \_\_\_ Be able to identify which devices are in the Extraction Stub enclosure

## 1.5 LCW Systems

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### 1. Muon Campus LCW

- \_\_\_\_\_ Know which LCW systems are used, what they cool, what they heat exchange with, and where they make up from
  - \_\_\_\_\_ Remnant LCW system
  - \_\_\_\_\_ Muon LCW system
  - \_\_\_\_\_ F27 Closed Loop LCW system
- \_\_\_\_\_ Know what parameters are used to monitor makeup flow for the Muon LCW system
- \_\_\_\_\_ Know how many LCW pumps are used in normal operation

## 1.6 Vacuum

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### 1. Vacuum

- \_\_\_\_\_ Be able to use the Muon vacuum applications to check vacuum levels, turn on and off ion pumps, and manipulate vacuum valves
  - \_\_\_\_\_ Know the nominal vacuum levels for the Muon Campus
  - \_\_\_\_\_ Know the Target Vault is at atmosphere

## 1.7 Instrumentation

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### 1. BPMs

- \_\_\_\_\_ Understand how to acquire beamline orbit data
- \_\_\_\_\_ Understand how to acquire Delivery Ring orbit data
  - \_\_\_\_\_ Know that the Delivery Ring BPM system will not work for g-2 running
- \_\_\_\_\_ Be able to reboot the BPMs

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### 2. BLMs

- \_\_\_\_\_ Be able to plot individual BLMs

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### 3. SEMs & PWCs

- \_\_\_ Know the function of the secondary emission monitors and proportional wire chambers in the Muon Campus
  - \_\_\_ Know how to view the wire profile data and observe beam in the Muon Campus
  - \_\_\_ Understand the difference between the two styles of monitors and where they are used
  - \_\_\_ Know that not all devices are left in the beam
  - \_\_\_ Understand why it is important to keep the instrumentation out of the beam when not in use
- \_\_\_ Know where the ArCO<sub>2</sub> systems are located

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### 4. Intensity Monitoring

- \_\_\_ Know the types of intensity monitors used in the Muon Campus
- \_\_\_ Understand why ion chambers must be used downstream of the target

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### 5. Wall Current Monitor

- \_\_\_ Understand the purpose of the wall current monitor in the M1 Beamline
- \_\_\_ Know how to view the wall current monitor data
  - \_\_\_ Understand the program is single user

## 1.8 Target Systems

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### 1. Target

- \_\_\_ Know what the target is composed of
- \_\_\_ Understand the purpose of target rotation
  - \_\_\_ Understand how the target is cooled

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### 2. Lithium Lens

- \_\_\_ Understand the purpose of the lithium lens
- \_\_\_ Understand why lithium is used
- \_\_\_ Understand how the lithium lens is cooled
  - \_\_\_ Be aware of how a lithium breach is detected

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### 3. Pulsed Magnet

- \_\_\_ Understand the purpose of the pulsed magnet
  - \_\_\_ Understand where beam goes if the pulsed magnet does not ramp
- \_\_\_ Understand how the pulsed magnet is cooled

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### 4. External Interlock Trips

- \_\_\_ Know how to respond to external interlock trips for the power supplies and devices
  - \_\_\_ Pulsed magnet
  - \_\_\_ Dump
  - \_\_\_ Target
  - \_\_\_ Lithium lens

## 1.9 Tuning

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### 1. P1 & P2 Beamline Tuning

- \_\_\_ Adjust P1 and P2 Line power supplies with I68
  - \_\_\_ Understand that I68 does not change the 8GeV ramp value for the other events that use the P1 and P2 Lines
- \_\_\_ Monitor P1, P2, and M1 Beamline losses for the Muon events with S42

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### 2. Target Tuning

- \_\_\_ Adjust the angle and position of beam on the target
  - \_\_\_ Know what devices to monitor while tuning
  - \_\_\_ Know what devices are used to adjust the beam angle and position

## Part 2: Walkaround

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### 1. AP0 Service Building

- \_\_\_ Enclosure entrances
  - \_\_\_ Pre-Vault
  - \_\_\_ Transport US
- \_\_\_ M1 CDC chassis
- \_\_\_ Delivery Ring CDC chassis
- \_\_\_ Pre-Vault TLM chassis
  - \_\_\_ TLM gas bottles
  - \_\_\_ TLM gas flow meter
- \_\_\_ M1 toroid hardware
- \_\_\_ M1 vacuum systems
  - \_\_\_ Ion pump power supplies
  - \_\_\_ CIA crate
- \_\_\_ M1 final focus quad power supplies
- \_\_\_ D:H700 power supply
- \_\_\_ AP0 Water Cage
  - \_\_\_ Lens water system
  - \_\_\_ PMAG water system
  - \_\_\_ Dump water system
  - \_\_\_ Lithium storage
- \_\_\_ Vault air sampling station
- \_\_\_ Target air blower disconnect
  - \_\_\_ D:TARFDP meter
- \_\_\_ LOTO disconnect
- \_\_\_ Backup generator load transfer switch
- \_\_\_ Class D fire extinguisher
- \_\_\_ Target rotation controller and hardware
- \_\_\_ Target SEM hardware
- \_\_\_ Target station interlock chassis
- \_\_\_ Vault key tree

- \_\_\_ Magnet drops
  - \_\_\_ Pre-Vault
  - \_\_\_ Transport US
- \_\_\_ Airborne contamination monitor
  - \_\_\_ Know how radon can affect the monitor
- \_\_\_ D:PMAG power supply
  - \_\_\_ 480V disconnect
- \_\_\_ D:LENS power supply
  - \_\_\_ 480V disconnect
- \_\_\_ Lens and PMAG power supply controller
  - \_\_\_ Lens charging power supply racks
  - \_\_\_ PMAG charging power supply rack
- \_\_\_ Vault entrance
- \_\_\_ Lens test stand
- \_\_\_ M2 & M3 SEM electronics
- \_\_\_ M2 & M3 toroid electronics
- \_\_\_ Air circulation systems
- \_\_\_ M2 & M3 line power supplies
- \_\_\_ D:H812 power supply

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## 2. AP10 Service Building

- \_\_\_ Emergency access key
- \_\_\_ BPM electronics
- \_\_\_ BLM electronics
- \_\_\_ SEM & ion chamber electronics
- \_\_\_ D:QD, D:QF & D:QSS power supplies
  - \_\_\_ Control panel
  - \_\_\_ Power supply interlock module
  - \_\_\_ Magnet klaxon interlock module
  - \_\_\_ Hi-pot controller
- \_\_\_ Correction dipole power supplies and spares
- \_\_\_ Delivery Ring vacuum systems
- \_\_\_ Delivery Ring coasting beam valve chassis
- \_\_\_ LOTO disconnect

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### 3. AP30 Service Building

- \_\_\_ SEM & PWC electronics
- \_\_\_ M3 & M4 Line power supplies
- \_\_\_ Delivery Ring correction dipole power supplies
- \_\_\_ D:KPS3I & D:KPS3E
  - \_\_\_ Controls & kicker scope
  - \_\_\_ Power supply
  - \_\_\_ Resonant charge transformer
  - \_\_\_ Thyatron
  - \_\_\_ PFL
  - \_\_\_ Fluornert skid
- \_\_\_ D:ISEP
  - \_\_\_ Pulse forming network
  - \_\_\_ Power supply
  - \_\_\_ Controls
- \_\_\_ D:ELAM power supply
- \_\_\_ D:V901 power supply
- \_\_\_ Vacuum systems
  - \_\_\_ Delivery Ring
  - \_\_\_ Abort
  - \_\_\_ M2 Beamline
  - \_\_\_ M3 Beamline
  - \_\_\_ M4 Beamline
  - \_\_\_ M5 Beamline
- \_\_\_ Extraction CDC chassis
- \_\_\_ M4 CDC chassis
- \_\_\_ Correction dipole supplies and spares
- \_\_\_ Emergency access key
- \_\_\_ LOTO disconnects

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#### 4. AP50 Service Building

- \_\_\_ SEM electronics
- \_\_\_ LOTO disconnect
- \_\_\_ Magnet klixon interlock module
- \_\_\_ Delivery Ring correction dipole supplies
- \_\_\_ M3 beamline power supplies
- \_\_\_ Abort line power supplies
- \_\_\_ D:IB power supply
  - \_\_\_ Digital volt meter
  - \_\_\_ Control panel
  - \_\_\_ LCW flow meter
  - \_\_\_ 13.8 kV disconnect
- \_\_\_ Delivery Ring sextupole power supplies
- \_\_\_ Delivery Ring 2.5MHz RF
  - \_\_\_ Amplifiers
  - \_\_\_ LCW cooling skid
- \_\_\_ D:KPS5A
  - \_\_\_ Controls & kicker scope
  - \_\_\_ Power supply
  - \_\_\_ Resonant charge transformer
  - \_\_\_ Thyatron
  - \_\_\_ PFL
- \_\_\_ D:ASEP
  - \_\_\_ Controls & interlock chassis
  - \_\_\_ Power supply
  - \_\_\_ Pulse forming network
- \_\_\_ Utility yard
  - \_\_\_ D:IB 13.8kV disconnect
  - \_\_\_ Emergency backup generator
- \_\_\_ ArCO<sub>2</sub> system gas bottle storage

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**5. MC-1**

- \_\_\_\_\_ g-2 experiment control room
- \_\_\_\_\_ MC-1 key tree
- \_\_\_\_\_ Enclosure entrance
- \_\_\_\_\_ g-2 status display
- \_\_\_\_\_ MC-1 Fridge Room
- \_\_\_\_\_ Know which group is responsible for the cryogenic system

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**6. MC-1 Power Supply Room**

- \_\_\_\_\_ MC-1 CDC chassis
- \_\_\_\_\_ PWC hardware
- \_\_\_\_\_ Abort patch panel
- \_\_\_\_\_ Quad power supplies
- \_\_\_\_\_ D:H005 power supply
- \_\_\_\_\_ D:V003 power supply
- \_\_\_\_\_ Extraction Enclosure LOTO disconnect
- \_\_\_\_\_ M4 Beamline LOTO disconnect

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**7. F2 Service Building**

- \_\_\_\_\_ I:F17B3 power supply
  - \_\_\_\_\_ PRAC
  - \_\_\_\_\_ LOTO disconnect

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## 8. F23 Service Building

- \_\_\_\_\_ M1 line power supplies
  - \_\_\_\_\_ M:HV100
  - \_\_\_\_\_ M:HV102
  - \_\_\_\_\_ M:V105
  - \_\_\_\_\_ Quad power supplies
  - \_\_\_\_\_ Correction trim regulators and bulk supply
  - \_\_\_\_\_ Ramp cards for M1
- \_\_\_\_\_ BPM electronics
- \_\_\_\_\_ BLM electronics
- \_\_\_\_\_ SEM electronics
- \_\_\_\_\_ Breaker panels
- \_\_\_\_\_ LOTO disconnect

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## 9. F27 Service Building

- \_\_\_\_\_ M2 & M3 beamline power supplies
- \_\_\_\_\_ Correction dipole supplies and spares
- \_\_\_\_\_ BPM electronics
- \_\_\_\_\_ SEM electronics
- \_\_\_\_\_ Closed loop LCW system
- \_\_\_\_\_ LOTO disconnect