

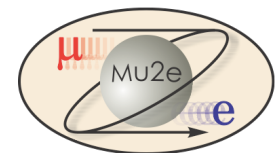


U.S. DEPARTMENT OF  
**ENERGY** Office of  
Science

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# Mu2e CD-2 Review ES&H

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ES&H Coordinator  
7/8/2014



# Outline

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- Mu2e Integrated Safety Management (ISM) Plan
- Project ES&H Support
- ES&H Standards and Codes
- TDR ES&H Design Criteria
- Hazard Analysis Report
- Radiation Shielding
- Fire and Life Safety Assessment
- NEPA Status
- Security Vulnerability Assessment Report
- Conclusions

# Mu2e Integrated ES&H Plan

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- The Mu2e ISM Plan has been completed.
- Defines Mu2e's Environmental, Safety and Health Policy
  - *A strong Environment, Safety, and Health (ES&H) program is essential to the successful completion of the Mu2e project at Fermi National Accelerator Laboratory (FNAL). We are committed to ensuring a safe work environment for Mu2e workers, at all participating universities, National Laboratories, and other participating institutions and to protect the public from hazards associated with construction and operation of Mu2e. In addition, all work related to Mu2e will be performed in a manner that preserves the quality of the environment and prevents property damage.*

# Mu2e Integrated ES&H Plan

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- Line managers, supported by the Mu2e collaborating institutions', laboratories' and universities' ES&H organizations, will provide consistent guidance and enforcement of the ES&H program that governs the activities of workers.
- The Mu2e Integrated Safety Management Plan defines competency with the
  - Integrated Safety Management System
    - Principles of Integrated Safety Management
      - Worker & line management responsibility for safety
      - Clear roles & responsibilities
      - Personnel experience, knowledge, and skill
        - Appropriate training
      - Balanced priorities
      - Safety standards & requirements
      - Hazard controls tailored to work being performed

# Mu2e Integrated ES&H Plan

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- Core Functions of an Integrated Safety Management System
  - Define the scope of the work
  - Identify & analysis of hazards associated with the work
  - Develop and implement hazard controls
  - Confirm readiness and perform work within controls
  - Provide feedback & seek continuous improvement
- Roles and Responsibilities for ISM Implementation
  - Senior Management
  - Line Managers
  - ES&H Coordinator
  - Technical and Scientific Staff
  - Contractors & subcontractors
- DocDB-785

# Examples

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- Radiation Work Permits (RWP) – written and implemented for tests involving sources
  - Sr 90
  - Neutron sources
- Operations Readiness Clearance (ORC) for CHL cryostat
  - Included 5032 Cryo Review
- Fermilab Safety Subcommittees aware of future needs of Mu2e
  - Radiation Safety Subcommittee
  - Cryo Subcommittee
  - Electrical Subcommittee

# Mu2e Integrated ES&H Plan

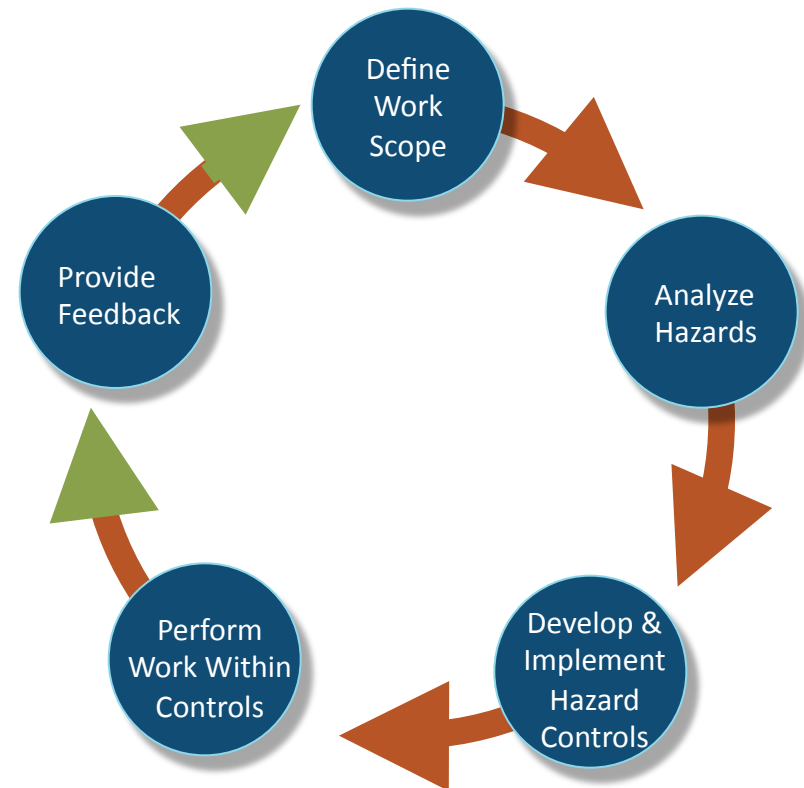
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- ES&H Program Elements
  - Program Expectations
  - Safety Assessments for Hazard Identification and Control
    - Preliminary Hazard Analysis Report - complete
    - Final Hazard Analysis Report – complete, ready for signatures
    - Safety Assessment Documentation
    - Beneficial Occupancy
    - Commissioning & Accelerator Readiness Reviews
    - Work performed during construction, R&D, and commissioning activities
  - NEPA Compliance
  - Leadership in Energy and Environmental Design (LEED)

# Integrated Safety Management

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- Encompasses safety, environment, security, quality, cyber security
- Makes ES&H and quality intrinsic to every job and project
- NEPA process for Mu2e addresses potential impacts of project execution and subsequent operation
- Hazard Analysis Report catalogues potential hazards in all phases of project, and provides a solid basis for project design, planning, and execution





# Mu2e ES&H Support Personnel

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- Dee Hahn– Mu2e ES&H Coordinator
- Teri Dykhuis – FNAL NEPA Program Manager
- Tony Leveling, Wayne Schmitt – Radiation Safety Shielding
- Gary Lauten – Radiation Safety Operations
- John Anderson – Safety Interlocks Systems
- Jim Priest – Life Safety/Fire Protection
- Jim Niehoff – Fire Protection Engineer
- Kurt Krempetz, Tom Page – Cryogenic Engineers
- Bill Soyars– Chair, Cryogenic Safety Sub-Committee
- Dave Mertz – Electrical Safety
- John Cassidy - Construction Field Oversight at FNAL

## ES&H Coordinator's Integration into Mu2e

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- ES&H Safety Coordinator on project management team
- ES&H responsibilities defined within project documentation
  - Project Management Plan
- Participates in weekly project management meetings
- Participates in subgroup meetings

# ES&H Regulations, Standards and Codes

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- FNAL Necessary & Sufficient Standards (Partial List)
  - Fermilab Environmental Safety & Health Manual (FESHM)
  - Fermilab Radiological Control Manual (FRCM)
  - 10 CFR 835 Occupational Radiation Protection
  - 10 CFR 851 Worker Safety & Health Program
  - OSHA 1926 & 1910 (Occupational Safety & Health)
  - NFPA (Fire & Life Safety)
  - International Building Code (IBC)
  - ASME (Vessels/Piping), ANSI, ASHRAE
  - DOE 450.4 Integrated Safety Management (ISM)
  - DOE 420.2B Safety of Accelerator Facilities
  - 10CFR/40 CFR (Environmental)
  - DOE 451.1B NEPA Compliance Program
    - Categorical Exclusion
    - Environmental Assessment (EA)
    - Environmental Impact Statement (EIS)

• More complete list available in TDR and HAR

# TDR ES&H Design Criteria Development

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- Life Safety & Fire Protection
  - Fire & Life Safety Assessment completed for FNAL
  - Occupancy, Ventilation, Emergency Power (Lighting, Ventilation, Elevators, Cranes)
    - Emergency Egress, Ventilation
    - Fire Protection Systems (Pre-Activation, VESDA, Smoke Detectors, etc.)
- Cryogenic Safety
  - Preliminary Cryogenic Safety & ODH Analysis
    - Oxygen Levels, Ventilation, Secondary Containment, Etc.
- Environmental
  - Categorical Exclusion granted
- Radiation Safety
  - Shielding Requirements
    - Surface and Underground
    - Air Emissions (Decay Time)
    - Surface and Ground Water
- Security Vulnerability

# Hazard Analysis

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- The goal of the HAR is to identify hazards & mitigations associated with Mu2e throughout its life cycle
  - Project phase (current through CD-4)
    - Construction
  - Operations phase
  - Decommissioning
- The Safety Assessment Document (SAD) will build on information from the HAR
- DocDB 675

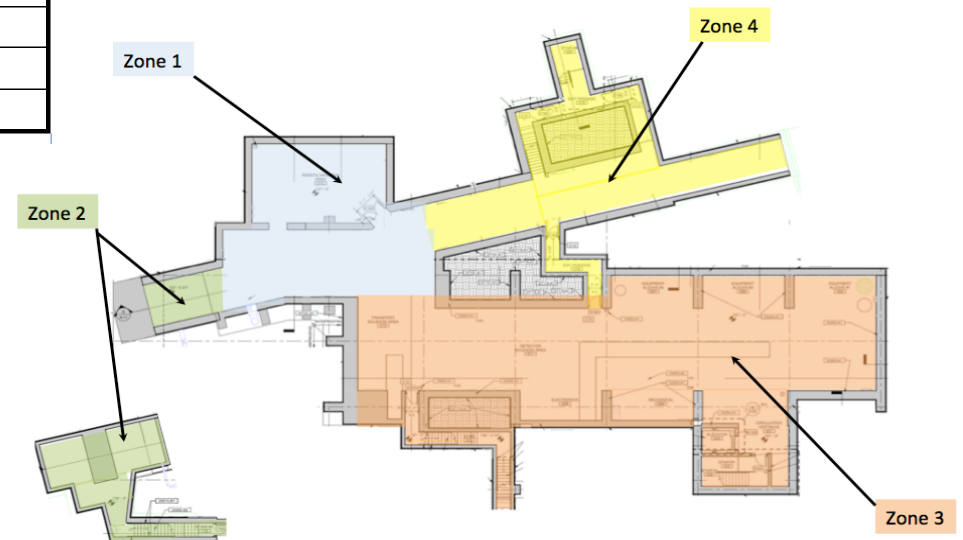
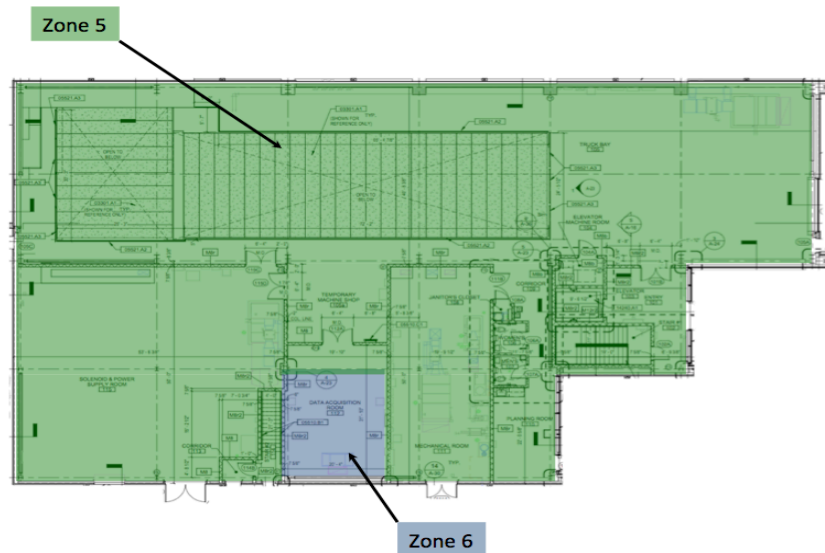
# Hazard Analysis

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- To ensure that all potential hazards are identified during the technical design phase, a Hazard Analysis (HA) has been performed.
- Project divided into 8 zones
- A Baseline Hazards List was developed for each of these zones
- Preliminary (pre-mitigation) risk assessment was completed for hazards present in each zone.
- A list of design strategies were developed for each hazard in each zone and the risk was re-analyzed taking into consideration passive design mitigations.
- Operational mitigations will further reduce risks.

# Zones

Zone No.	Principal Occupancies
1	Production Solenoid and remote handling area.
2	Proton beam absorber and extinction monitor area.
3	Detector Enclosure
4	External <u>Beamline</u>
5	Mu2e Surface Building
6	Mu2e Electronics Room
7	Recycler Ring and connecting <u>beamlines</u>
8	Delivery Ring



# Hazards

Hazard List	Applicable Regulations and Standards	Hazard List	Applicable Regulations and Standards
<b>Mechanical Hazards</b> Moving large, heavy equipment Overhead cranes/hoists Vacuum pumps Power tools and equipment Motor generator equipment Compressed gases Vacuum/pressure vessels Open hatches Fall hazard Burn hazard Trip Hazard	ANSI/ASME Standard B30.20 Overhead Cranes FESHM 5120,5021,5023,5024, 5025,5031,5033,5034,5066 OSHA 29 CFR 1910.22 Walking & Working Surfaces	<b>Oxygen Deficiency Hazards</b> Cryogenic spill Cryogen leak Ventilation failure Sensor failure Confined space	29CFR1910.134, OSHA Respiratory Standard, FESHM 5103 FESHM 5064,5032
<b>Flammable Gas Hazards</b> Flammable gas for welding	FESHM 6020.3	<b>Cryogenic Hazards</b> Oxygen deficiency Cryogenic distribution system Thermal Pressure	FESHM 5031, 5031.1, 5032 FESHM 5064
<b>Electrical Hazards</b> Stored energy exposure High voltage exposure Low voltage, high current exposure Electrical faults Battery bank and UPS equipment Arc flash Cable tray overloading/mixed utilities	NFPA 70 National Electrical Code NFPA 70 E Standard for Electrical Safety in the Workplace NFPA 70 B recommended Practice for Electrical Equipment Maintenance FESHM 5040,5041,5042,5043,5044, 5046	<b>Laser Hazards</b> Lasers	ANSI Z136.1-2000 Safe Use of Lasers FESHM 5062.1
<b>Fire Hazards</b> Flammable/combustible materials Wire and cable insulation Electrical Lighting	NFPA 101 Life Safety Code FESHM 6010, 6020.1,6020.2 6040.1, 6040.2, 6040.3	<b>Radiation Hazards</b> Calibration source exposure Prompt radiation from beamline Indirect radiation from beamline Radioactive contamination Activation Creation of mixed waste RF & microwave Magnetic fields	FESHM 10010 FRCM
<b>Toxic Material Hazards</b> Chemical agents Lead and other heavy metals	FESHM 5052,8040	<b>Environmental Hazards</b> Construction impacts Storm water discharge Soil activation Air activation Cooling water activation Discharge/emission points	40CFR61 Subpart A, National Emissions Standards for Hazardous Air Pollutants (NESHAPS) 6 NYCRR 200-234-NYSDEC Prevention and Control of Air contamination and Air Pollution FESHM 8000's
<b>Construction Hazards</b> Site clearing Excavation Work at elevations Material handling Utility interfaces	29CFR1926, Safety and Health Regulations for Construction FESHM 5066 FESHM 7010,7030, 7040 FESHM 8012	<b>Natural Phenomena Hazards</b> High Wind Snow/ice Flood due to rain Lightening Earthquakes	FESHM 2040



# Hazards in Each Zone

Zone Number	Zone Description	Mechanical Hazard	Flammable Gas Hazards	Electrical Hazards	Fire Hazards	Oxygen Deficiency Hazards	Cryogenic Hazards	Laser Hazards	Radiation Hazards	Toxic Material Hazards	Environmental Hazards
1	Production Solenoid and remote handling area.	X	X	X	X	X	X	X	X	X	X
2	Proton beam absorber and extinction monitor area.	X	X	X	X	X		X	X		X
3	Detector Enclosure	X	X	X	X	X	X	X	X	X	X
4	External Beamline	X	X	X	X			X	X		X
5	Mu2e Surface Building	X	X	X	X	X	X		X	X	X
6	Mu2e Electronics Room	X	X	X	X				X	X	X
7	Recycler Ring & connecting beamlines	X	X	X	X			X	X		X
8	Delivery Ring	X	X	X	X			X	X		X

# Mu2e Hazard Analysis

		ZONE									
		Risk	1	2	3	4	5	6	7	8	Total
Before Mitigation	High	7	4	7	6	7	5	5	5	46	
	Moderate	3	3	3	1	1	3	1	1	16	
	Low	2	1	2	2	2	1	2	2	14	
	Minimal	0	0	0	0	0	0	0	0	0	
	Total	12	8	12	9	10	9	8	8	76	
After Mitigation	High	0	0	0	0	0	0	0	0	0	
	Moderate	6	4	7	6	6	4	5	5	43	
	Low	2	3	3	1	1	3	1	1	15	
	Minimal	4	1	2	2	3	2	2	2	18	
	Total	12	8	12	9	10	9	8	8	76	

# Example

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## Mu2e HAZARD ANALYSIS

**ZONE:** 1-8

**HAZARD:** Flammable gas – cutting and welding equipment.

**HAZARD INITIATOR:** Careless handling, equipment failure, flammable residue on process items, **heat, pressure, static electricity, mechanical shock,**

**HAZARD CONSEQUENCE:** Personnel injury, fatality, equipment damage, program delay.

**COMMENTS:** Welding are common activities in construction zones.

### RISK ASSESSMENT PRIOR TO MITIGATION

**CONSEQUENCE**  High  Moderate  Low  Minimal

**PROBABILITY**  Likely  Occasional  
 Probable  Remote

**RISK**  Critical  High  Moderate  Low  Minimal

# Example

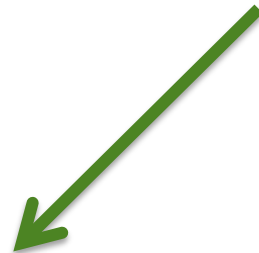
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- **MITIGATING FACTORS (DESIGN)**
- Equipment design (e.g. check valves)
- Segregated storage of acetylene and oxygen canisters.
- Adequate ventilation. Subcontractor documents, Exhibit A requires Burn Permit.
  
- **MITIGATING FACTORS (OPERATIONAL)**
- Gas stored in DOT cylinders in quantities limited to the minimum required for efficient operation.
- Strict adherence to OSHA Construction regulations.
- Integrated Safety Management contractually flowed down to subs.
- Contractor required Health and Safety Plan flowed down to subs.
- Pre qualification of contractors based on past safety performance.
- Dedicated on-site construction safety professionals.
- Contractor safety incentive program.
- NFPA 51B and Fermilab's Fire Protection Program
- Frequent communication with contractor and subs on ES&H (plan of day, tool box)
- Hazard Analysis for unique or first-of-a-kind activities.

# Example

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Risk after passive (Design) and operational mitigation. Active measures will further reduce risk.



## RISK ASSESSMENT FOLLOWING MITIGATION

<b>CONSEQUENCE</b>	<input checked="" type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Minimal
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<b>PROBABILITY</b>	<input type="checkbox"/> Likely	<input type="checkbox"/> Occasional
	<input type="checkbox"/> Probable	<input checked="" type="checkbox"/> Remote

<b>RISK</b>	<input type="checkbox"/> Critical	<input type="checkbox"/> High	<input checked="" type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Minimal
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# Shielding

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- Dedicated AD presentation by Tony Leveling
  - Shielding and monitoring plan
    - Plan is to steer the beam to minimize loss
    - Shielding is fortified at known loss points
    - TLMs will be used to detect/limit losses
      - Will exceed the capability of the available shielding everywhere
    - TLMs have preliminary ES&H approval to be used as a credited safety system.
      - Final approval is expected October 2015.

# Fire and Life Safety

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- More detailed information in Jim Niehoff's presentation
- Aon Fire Protection Corp. reviewed Site design fire protection and life safety
  - Rick Glenn (AON) completed the assessments in June 2013
  - DocDB 1314
- Aon reviewed conceptual design drawings and project description
- The assessments include recommendations based on:
  - 2009 IBC (International Building Code)
  - 2009 IFC (International Fire Code)
  - NFPA 101 – 2009 Edition, the Life Safety Code (LSC)

# Fire and Life Safety

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- Life Safety Assessment
  - Facility Description
    - Transport Line Enclosures
    - Absorber and Support Rooms
    - Detector Hall
    - Detector Building
  - Applicable Codes & Standards



# Fire and Life Safety

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- Areas of Recommendation
  - Compartmentation
  - Construction
  - Smoke Control
  - Means of Egress
  - Automatic Fire Sprinkler Systems
  - Fire Detection & Alarm Systems
  - Emergency Power and Standby Power
  - Emergency Preparedness

# NEPA

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- The Muon Campus Program Plan, which includes Mu2e, has no significant impact to the human environment.
- Mu2e received a categorical exclusion on 6/18/12 and does not need to complete an Environmental Assessment or an Environmental Impact Statement (DocDb 2274).

# Security Vulnerability Assessment

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- A Security Vulnerability Assessment has been developed for Mu2e.
- Security requirements identified and discussed in TDR, along with plans to mitigate them
  - Locations include FNAL and collaborating institutions
  - Different security measures at each of the four phases of project
- Potential threats are conventional theft, vandalism and unauthorized access to computer systems.
- No additional site security should be required
- DocDB 676

# Conclusion

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- ES&H is an integral part of the Mu2e project
  - Project Office includes an ES&H coordinator
  - Roles and Responsibilities described in Project Management Plan
  - Current design incorporates passive mitigation strategies to reduce ES&H related risk
- Fermilab provides a broad blanket of ES&H support
  - Dedicated ES&H personnel within each division
  - Point of Contact - Mu2e ES&H coordinator
  - Assist in identifying potential hazards and their mitigation
  - Assist in identifying relevant regulations

# Conclusion

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- Mu2e has an Integrated Safety Management Plan
- HAR has been completed
- Fire and Life Safety Assessment has been completed
- NEPA status – Categorical Exclusion
- Preliminary Radiation Shielding Assessments have been completed
- Security Vulnerability Assessment Report has been completed