

# Argonne National Laboratory High Energy Physics Division

## Overview of Safety In the HEP Electronics Support Group

Gary Drake  
Sept. 24, 2018



# Talk Outline

- Overview of the Electronics Group
  - Personnel
  - Activities and types of projects
  - Safety hazard identification
- Safety Hazard Mitigation Strategy and Procedures
  - ISM
  - WCDs
  - Training
  - Oversight & reviews

# Electronics Support Group Personnel

Gary Drake	<i>Group Leader, Sr. EE</i>	Todd Hayden	<i>PCB Layout</i>
(Open Position)	<i>Principal Elec. Eng.</i>	Jim Bulka	<i>Instrument Repair/Fabrication</i>
(Open Position)	<i>Elec. Eng.</i>	(Open Position)	<i>Instrument Repair/Fabrication</i>
Marco Trovato	<i>Digital Engineer</i>	Carolyn Adams	<i>Electronics Technician</i>
Tim Cundiff	<i>Engineering Assistant</i>		
Bill Haberichter	<i>Engineering Assistant (p.t.)</i>		

## Total Staff:

2 (→ 4)	Design Engineers
1.5	Technical Assistants
1	CAD Layout Person (EA)
1 (→ 2)	Instrument Repair (EA)
1	Electronics Technician

- ⇒ 7 (→10) People Total
  - ~ Half Support HEP
  - ~ Half Support Other Basic Sciences
- ⇒ Strengthens HEP Program
  - ⇒ Larger Group with More Expertise
  - ⇒ No Standing Army
- ⇒ Provides Crucial Electronics Support for ANL Science & Research
- ⇒ Facilitates Cross-Fertilization Between HEP and other Research (e.g. Physics)

- ⇒ ***We work in a wide range of Electronics Design & Support Activities***
- ⇒ ***Most activities are not hazardous, but some are...***



# Overview of the Electronics Group

## A. High Speed Digital Design

### Types of Projects:

- Data Acquisition
- Trigger Processors
- Computer Interfaces
- High-Speed Communications

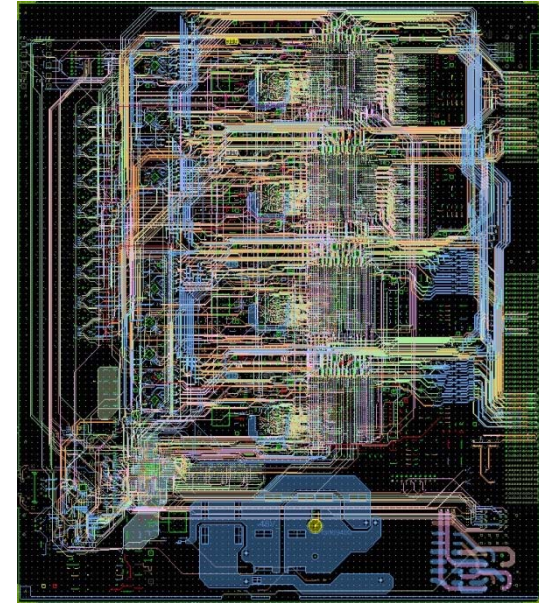
### Tools & Techniques:

- High-Performance Printed Circuit Board Design  
(Schematic Capture, PCB Layout, Auto-routing)
  - Design with Programmable Logic (FPGAs)
    - ⇒ *We use the newest, fastest FPGAs & processors*
  - VHDL Programming Language (Firmware)
  - Timing Simulation
  - Designs Using Surface Mount Technology
  - Designs using Ball Grid Arrays (BGA)
- ⇒ *Prototype through Large-Scale Production*



Kintex-7 for the  
ATLAS TileCal Upgrade

Layout of the FLIC  
18-Layer ATCA Board



### Hazard Summary:

- Activity represents ~50% of the group work load
- All is low voltage
- None is considered hazardous (electrical)



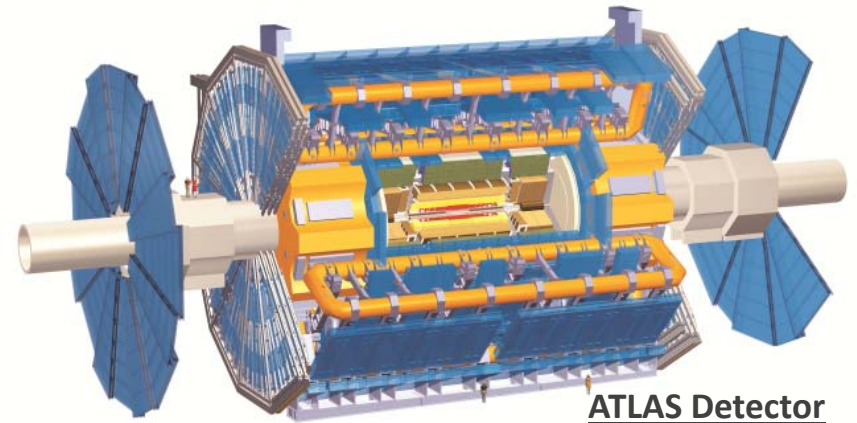
# Overview of the Electronics Group

## A. Digital Design (Cont.)

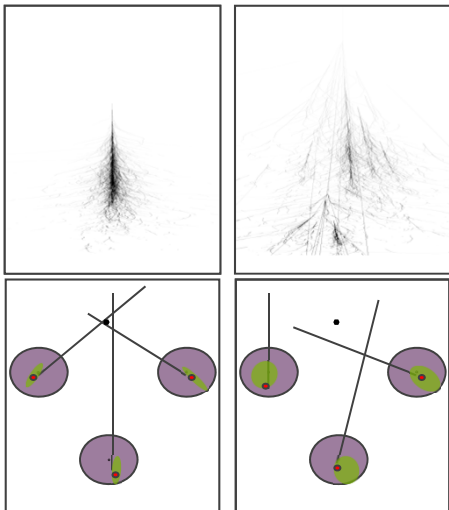
### VERITAS Telescope Array - Arizona



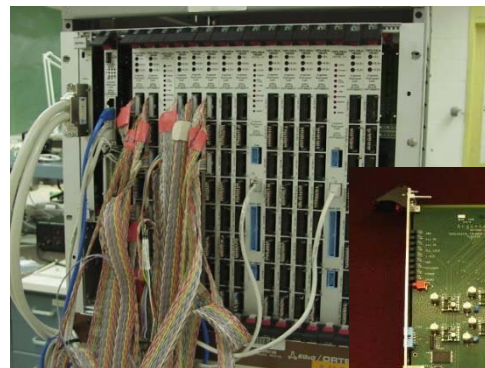
### ATLAS Exp. @ CERN - LHC



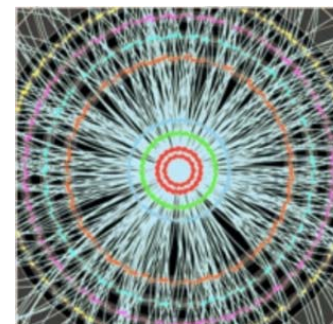
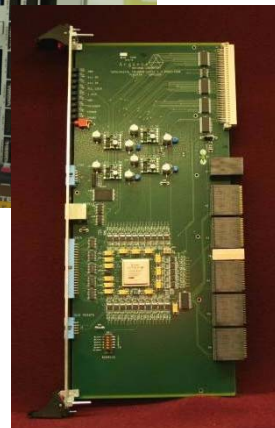
ATLAS Detector



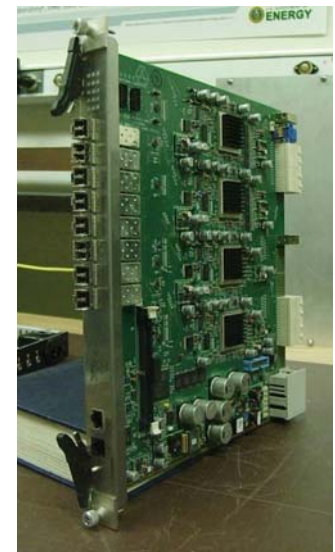
Event Image



Trigger Crate  
&  
Board



Event Image  
Radial View



Trigger Board



# Overview of the Electronics Group

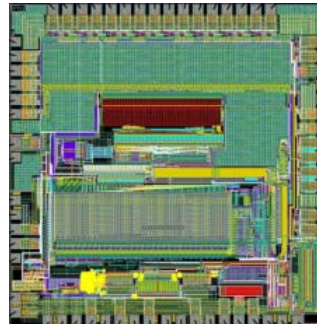
## B. Front End Design

### Types of Projects:

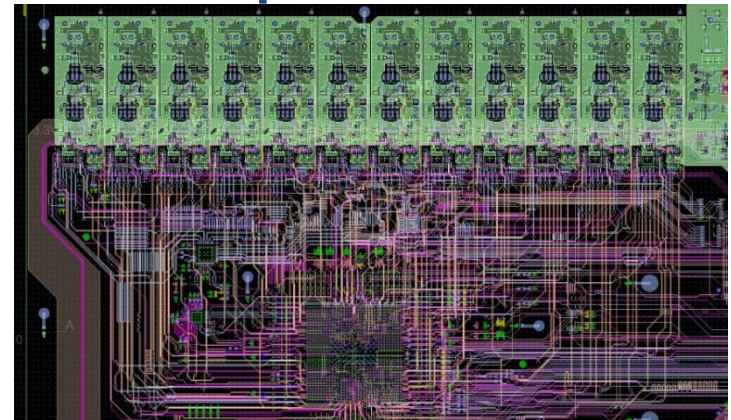
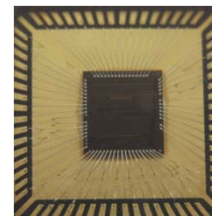
- Charge Amplifiers
- Preamplifiers
- Digitizers
- Discriminators
- *Development & Implementation of Custom Integrated Circuits (ASICs)*
- Low-Noise Design & Analysis
- **HV Power Supply Design**
- **Switching Power Supply Design**

### Implementation Techniques:

- Mixed Signal Printed Circuit Board Design
  - SPICE Simulations
  - Surface Mount Technology
  - *Custom Circuit Design*
- ⇒ **Prototype through Large-Scale Production**
- ⇒ **Often have High-Level of Integration with Detectors**



QIE12 Custom ASIC  
350 nm SiGe



Layout of the SSP  
12-Layer Module, Mixed Signal

### Hazard Summary:

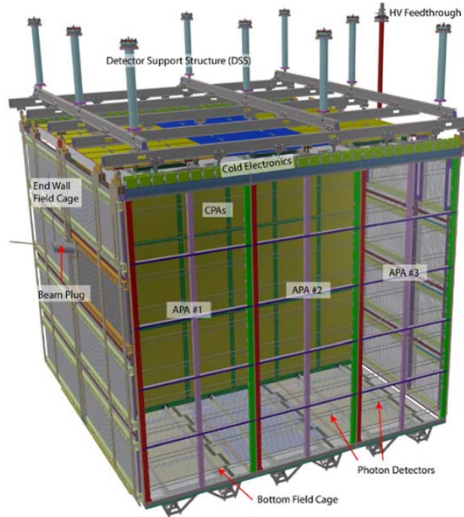
- Activity represents ~30% of the group work load
- Most is low voltage
- ~10% of the work with power supplies is hazardous (electrical)



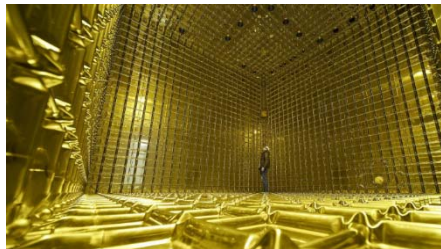
# Overview of the Electronics Group

## B. Front End Design – (Cont.)

### ProtoDUNE Exp. @ CERN (FNAL)



Exterior  
ProtoDune  
Cryostat



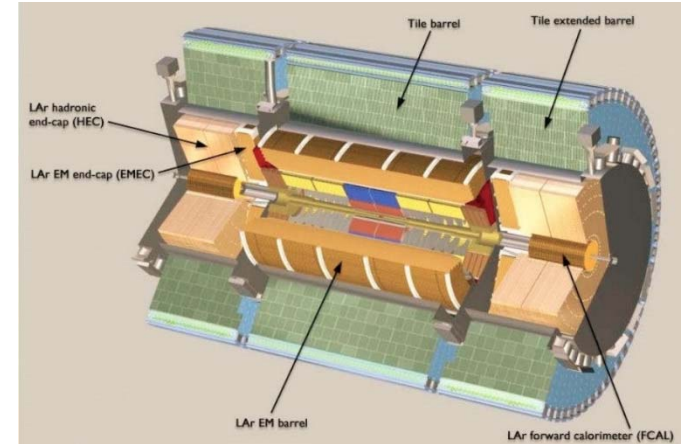
Interior  
ProtoDune  
Cryostat



Readout  
Module



### ATLAS Exp. @ CERN - LHC



ATLAS Detector



Tile Calorimeter Module



Tile Calorimeter Electronics "Drawer"



Photomultiplier Base



Front End Electronics  
Reside inside Base

# Overview of the Electronics Group

## B. FE Design – LV Power

ATLAS Exp. @ CERN - LHC  
**Low Voltage Power Supplies**  
**Tile Calorimeter**

- Full custom DC-DC Converter Brick
- Buck converter, isolated outputs
- Noise performance important
- V7.5 – On detector now
  - 200V DC input
  - Configurable output (8 different configurations)
  - Produced 2400 at ANL
- V8 – In development for Upgrade
  - 200V DC input
  - +10V output
  - Will use POL regulators on front ends with redundancy

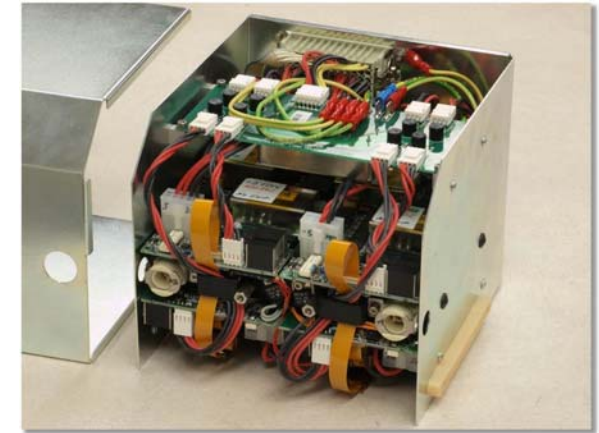
⇒ **Low-Noise DC-DC Converter**

⇒ **Radiation-Tolerant Design**

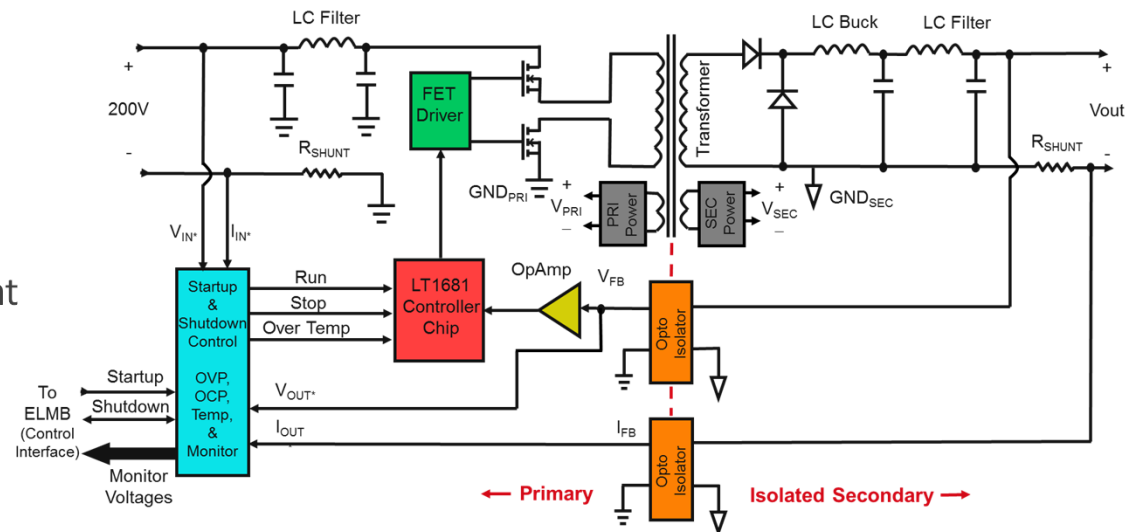
⇒ **Hazard: Input: 200V, 1A DC**



LVPS Brick



LVPS Bow with 8 Bricks



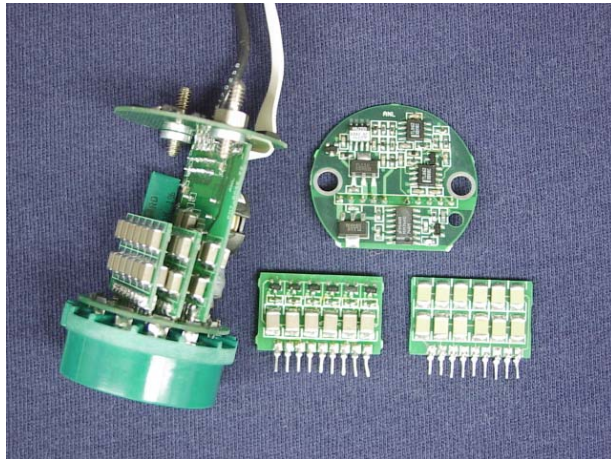
LVPS Block Diagram





# Overview of the Electronics Group

## B. Front End Design – Custom Power Supplies (Cont.)



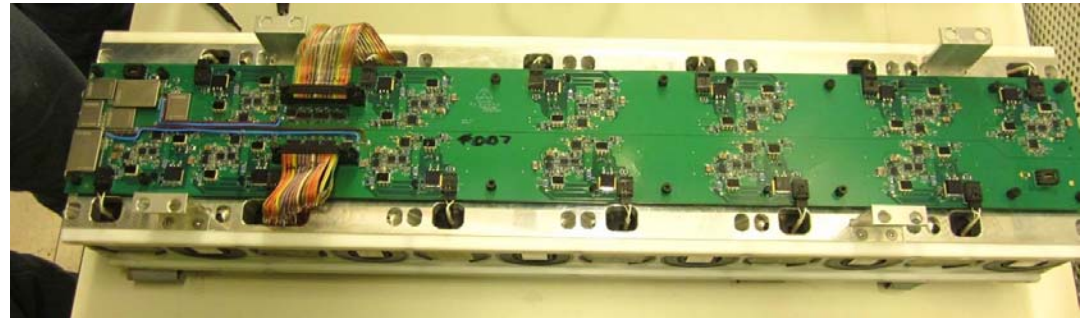
### ZEUS Exp. @ DESY, Germany

- Cockfort-Walton Phototube Base for the Central Calorimeter
- DC-DC Converter: 24V → 2000V
- Includes output monitor & control
- Design produced by PENN State
- Built 1000 bases for production

⇒ **Low-Noise DC-DC Converter**

⇒ **Radiation-Tolerant Design**

⇒ **Hazard: Output: 1000V, 10 mA DC**



### ATLAS Exp. @ CERN - LHC *High Voltage Power Supplies* *Tile Calorimeter*

- In development for the HL Upgrade
- Full custom High Voltage Controller & Monitor
- Optically-isolated outputs
- 1000V, individually-controlled outputs
- 12 channels per board
- 20 modules produced for 2017 Test Beam

⇒ **Low-Noise HV Controller**

⇒ **Radiation-Tolerant Design**

⇒ **Hazard: 1500V, 10 mA DC**

# Overview of the Electronics Group

## **C. Printed Circuit Board Design**

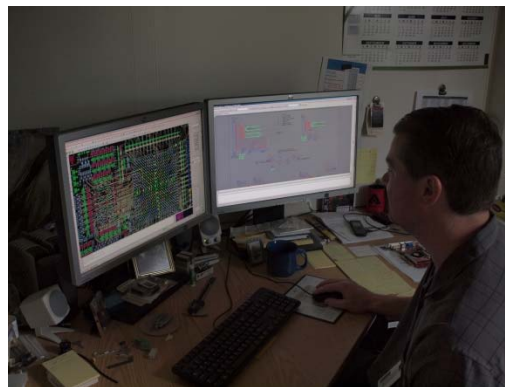
- Skilled in complex PCB layout
- Support internal HEP projects
- Support other divisions (APS, PHY)

## **D. Instrument Repair**

- Highly skilled in instrument repair
- Support internal HEP repair
- Support entire laboratory
- Repair ~250 instruments/yr
- Also do Electrical Safety Inspections

## **E. Fabrication & Assembly**

- Skilled craftspeople
- PCB SMT assembly to chassis
- Support internal HEP projects
- Support other divisions



## **Hazard Summary:**

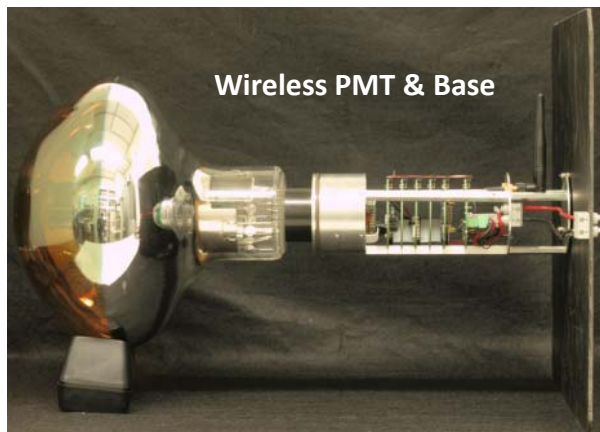
- No Hazards
- ~10% of group work load
- Most is low voltage
- ~30% of the work with hazardous electrical energy
- No Electrical Hazards
- Some power tools
- Soldering



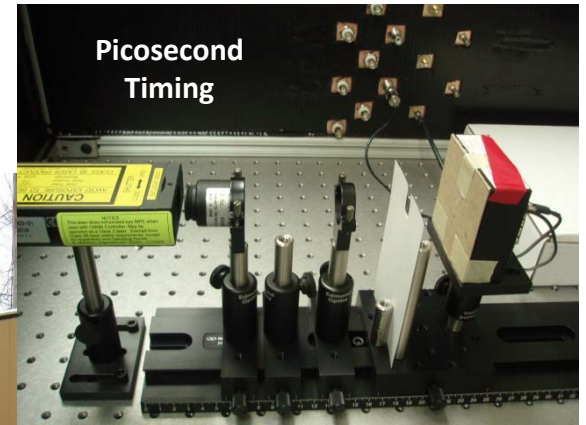
# Overview of the Electronics Group

## F. Detector R&D

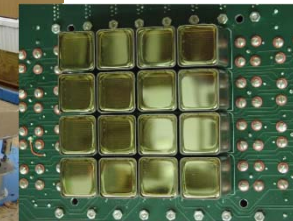
- We have a close working relationship with the HEP Detector Development Group
  - ⇒ **Strategy: High performance systems require high level of elec. integration**
- Have developed several innovative instrumentation systems over the last decade:



Wireless PMT & Base



Picosecond Timing



TRICE Telescope  
- Photomultiplier  
Tube Array



Fine-Grained  
Calorimeter  
- Readout part  
of Detector



Very Low Noise  
Ge Det, FET, & Amp



### Hazard Summary:

- Some detectors use hazardous electrical energy
- Some laser work



# Electronics Group - Hazard Summary

## ■ Hazardous Electrical Energy

- Most of our work (~90%) is low voltage, non-hazardous
- Approximately 5-10% of all work involves hazardous energy
  - Almost all of this work (~99%) is cord-and-plug
  - Most of this work (~90%) is Mode 0 / Mode 1
  - Occasionally we must do energized diagnostics (Mode 2)

Don't forget to multiply to get the total fraction of work!

## ■ Chemicals

- We use solvents to clean printed circuit boards (no accumulation)

## ■ Lead

- We use lead in soldering

## ■ Power Tools & Shop Tools

- We use power tools for fabrication

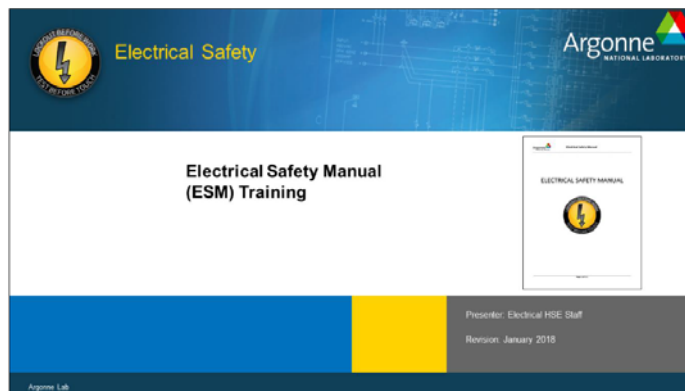
## ■ Lasers

- Used in specific research areas in the division



# Overview of Group Safety Management & Practices

- Integrated Safety Management is the Foundation of our Safe Work Practices
- Work Planning & Control is a key part of ISM
- Electrical Safety Training is the primary training for the electrical work → QEW1



# Implementing Integrated Safety Management

## ■ The ISM Core Functions:

1. Define scope of work

2. Analyze hazards

3. Develop/implement hazard controls

- ⇒ *Defined by our Work Control Documents*
- ⇒ *Generally written by the Electronics Group Leader*
- ⇒ *Input from group members as needed*
- ⇒ *Input on hazard mitigation from SMEs*

2. Perform work within control

- ⇒ *Executed by group members*

2. Feedback and improvement

- ⇒ *Safety and methods are discussed at each weekly group meeting*
- ⇒ *WCDs updated approximately yearly*



# Implementing Integrated Safety Management (Cont.)

- **The ISM Guiding Principles:**

1. Line management responsibility for safety
  - ⇒ *Employees keep safety training up to date*
  - ⇒ *GL monitors training; Frequent observations of work execution*
  - ⇒ *DD & ESH Coord. do safety walk-thrus ~2X per year*
2. Clear roles and responsibilities
  - ⇒ *Employees responsible for their work*
  - ⇒ *Stop work authority emphasized*
  - ⇒ *GL responsible for group safety performance, including monitoring training*
  - ⇒ *DD responsible for division safety performance*
3. Competence commensurate with responsibilities
  - ⇒ *Generally evaluated by GL*
4. Balanced priorities
  - ⇒ *Main issue: Mode 2 work*
  - ⇒ *Current emphasis on minimizing frequency*
  - ⇒ *(Have been in Administrative Stand-down on all Mode 2 work until recently)*



# Implementing Integrated Safety Management (Cont.)

- **The ISM Guiding Principles (Cont.):**

5. Identification of standards and requirements

⇒ **Most electrical safety governed by NFPA70E**

⇒ **Recent edition of Argonne ESM has clarified requirements**

6. Hazard controls tailored to work being performed

⇒ **Main issue is for Mode 2 electrical work**

- PPE & tools
- Shock boundaries & safety watch
- Barriers & isolation where practical

7. Operations authorization

⇒ **First line: WCD → DD, ESH, SMEs**

⇒ **Second line: GL through WAD**

⇒ **Overall: DD**





# Work Control Documents

- Our Current Work Control Documents
    - 22193.4 Electronics R&D, Fabrication, Checkout, & Measurements
      - Task-based hazard analysis
      - Governs general engineering work in the group
      - Blanket WCD that covers many development projects
        - Details differ from project to project
        - But basic activities & hazards are the same
    - 20613.4 HEP Instrument Repair and Calibration
      - Task-based hazard analysis
      - Generally requires QEW1 certification
      - Governs general repair, calibration, & DEEI work in the group
      - Blanket WCD that covers all associated activities
        - Details differ from project to project
        - Specific tasks pertain to
          - » Mode of operation
          - » Cord & Plug or not
          - » Voltage, current, & stored energy levels
- ⇒ ***We provide DEEI services to the division (and the lab)***



# Work Control Documents (Cont.)

- Our Current Work Control Documents (Cont.)
  - 22194.4 ATLAS Low Voltage Power Supply Development
    - Task-based hazard analysis
    - Focused development project with special electrical hazards (200 VDC)
    - History:
      - Began as R&D project to develop prototypes
      - Proceeded through production of 2400 bricks (with no injuries!!!)
      - Currently support only (fix broken bricks, but failure rate has been ~0)
  - 22192.2 HEP Laser Lab
    - Task-based hazard analysis
    - Focused development project with special electrical hazards (1000 VDC)
    - Project is Detector R&D → Develop new photodetectors
    - Hazard:
      - Photodetectors use 1000V for bias
      - Sometimes packaging not complete, and have exposed contacts
      - However, never operated with voltage on outside of dark box



# Work Control Documents (Cont.)

- Example WCD:
  - 22193.4 Electronics R&D, Fabrication, Checkout, & Measurements
    - Tasks classified according to electrical hazard
    - Workers associated with tasks according to training and competency
    - Hazard mitigation specific to tasks

Tasks					
	Task No. ^	Task Title	Scope	Start Date	End Date
	1	<a href="#">Design and Development of Electronic Instrumentation - Non-Hazardous Electrical Energy</a>	This task covers activities associated with the design and development of electronic instrumentation where there is no hazardous energy p...		
	2	<a href="#">Design and Development of Electronic Instrumentation - Hazardous Electrical Energy</a>	This task covers activities associated with the design and development of electronic instrumentation where hazardous energy may be presen...		
	3	<a href="#">Electrical / Electronic Fabrication Activities</a>	The scope of this task includes the assembly and fabrication of electrical and electronic instrumentation for use in scientific research....		

Task Proposed Independent Worker Summary					
Worker ^	Comments	Missing Courses	Task(s)	Edit	Delete
Adams, Carolyn E. (#40642)	Carolyn's work is limited to printed circuit board assembly and electronics fabrication, and does not include work on live circuits.		Task # 3		
Cundiff, Timothy T. (#49671)			Task # 1, 2, 3		
Drake, Gary R. (#50241)			Task # 1, 2, 3		
Haberichter, William N. (#12928)			Task # 1, 3		
Hayden, Todd Alan (#41838)			Task # 1, 2, 3		
Trovato, Marco (#298920)		<a href="#">View List</a>	Task # 1		

Task Proposed Limited Worker Summary					
Worker ^	Comments	Missing Courses	Task(s)	Edit	Delete
Adams, Carolyn E. (#40642)			Task # 1		



# Work Control Documents (Cont.)

- Example WCD:
  - 20613.4 HEP Instrument Repair and Calibration
    - Tasks classified according to electrical hazard → Mode
    - Workers associated with tasks according to training and competency
    - Hazard mitigation specific to tasks

Tasks					
Task No. ▲	Task Title	Scope	Start Date	End Date	
1	<a href="#">Mode 0 Repair of Electrical Equipment</a>	This task concerns the repair of electrical and electronic equipment that have no hazards associated with electrical energy. Typical equ...			
2	<a href="#">Mode 1 Repair of Electrical Equipment</a>	This task concerns the repair of electrical and electronic equipment that may have certain hazards associated with electrical energy. Ge...			
3	<a href="#">Mode 2 Repair of Electrical Equipment</a>	This task concerns the repair of electrical and electronic equipment that have certain hazards associated with electrical energy. Genera...			
4	<a href="#">Calibration of Electronic Equipment</a>	This task concerns the calibration of electrical and electronic equipment. It covers the broad category of electronic calibrations, whic...			
5	<a href="#">DEEI Safety Inspections of Electrical Equipment</a>	This task concerns the safety inspections of electrical and electronic equipment, as part of the designated Electrical Equipment Inspecto...			

Task Proposed Independent Worker Summary					
Worker ▲	Comments	Missing Courses	Task(s)	Edit	Delete
Cundiff, Timothy T. (#49671)			Task # 1, 2, 3, 4, 5		
Drake, Gary R. (#50241)			Task # 1, 2, 3, 4, 5		
Haberichter, William N. (#12928)			Task # 1		
Hayden, Todd Alan (#41838)			Task # 1, 2, 3, 4, 5		

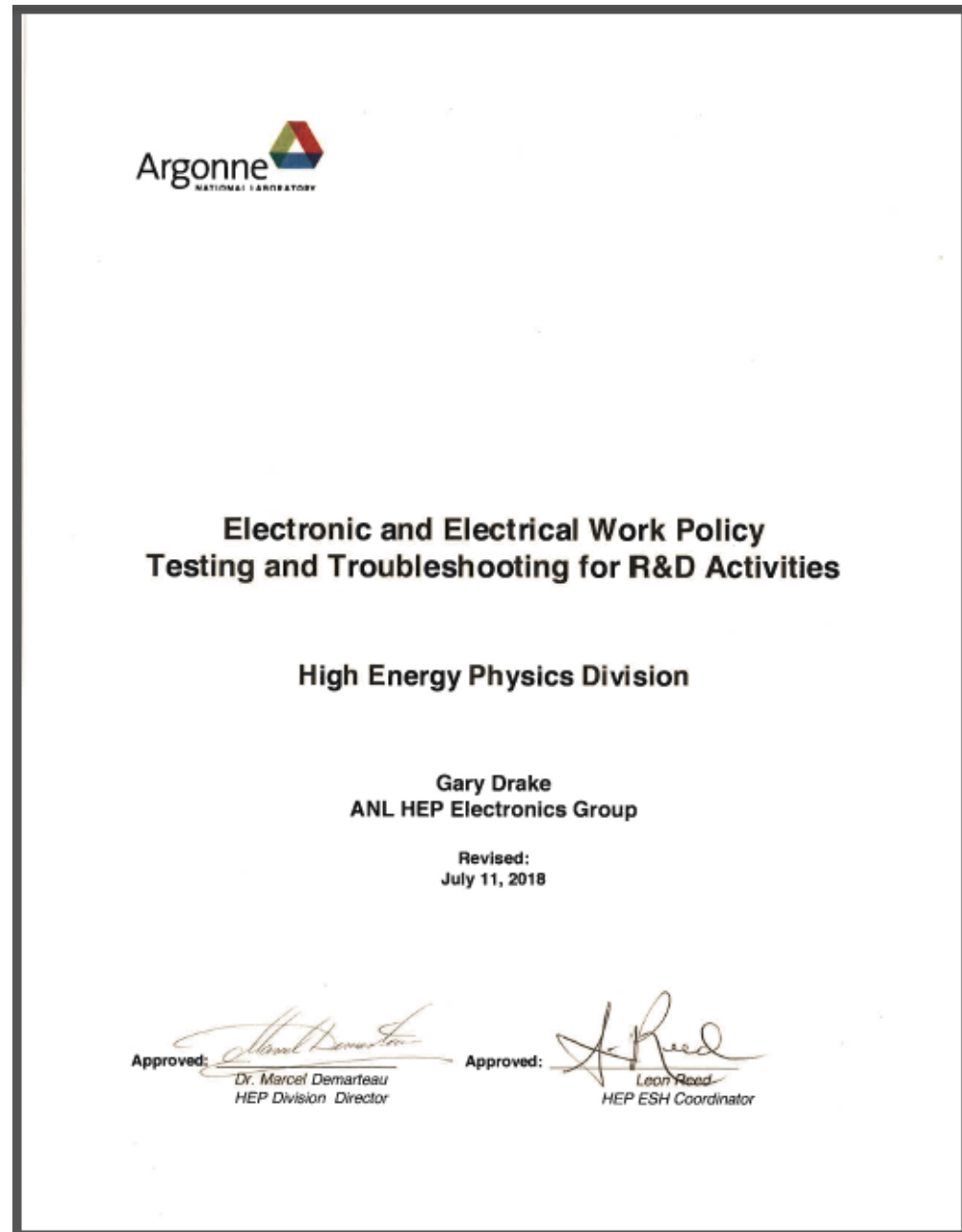
  

Task Proposed Limited Worker Summary					
Worker ▲	Comments	Missing Courses	Task(s)	Edit	Delete
Adams, Carolyn E. (#40642)			Task # 1		



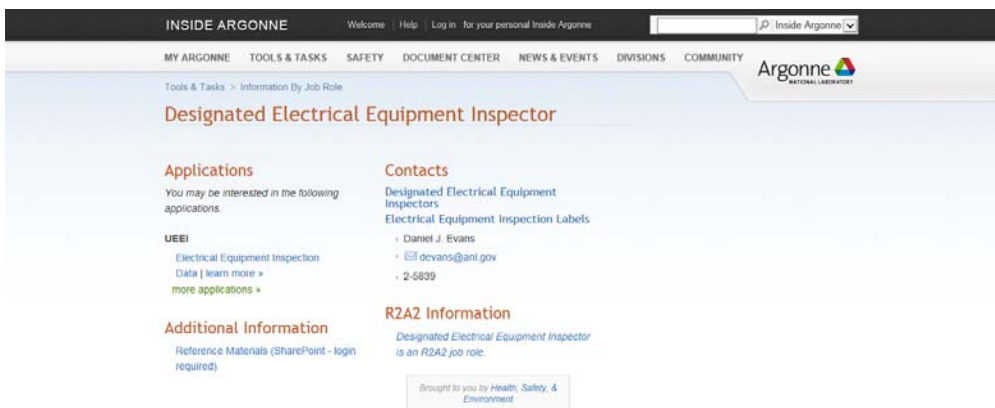
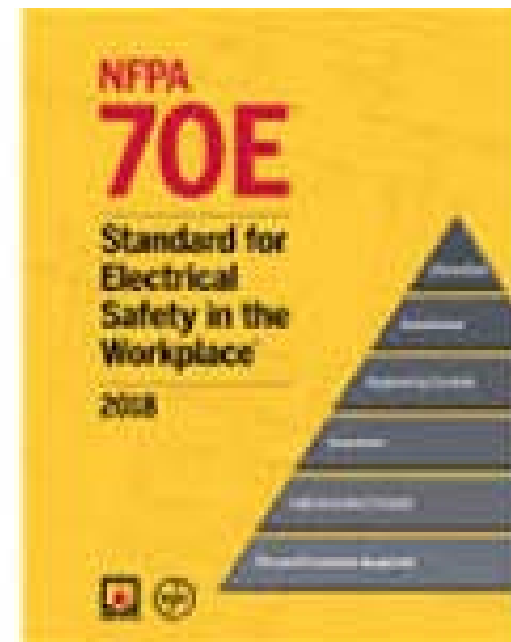
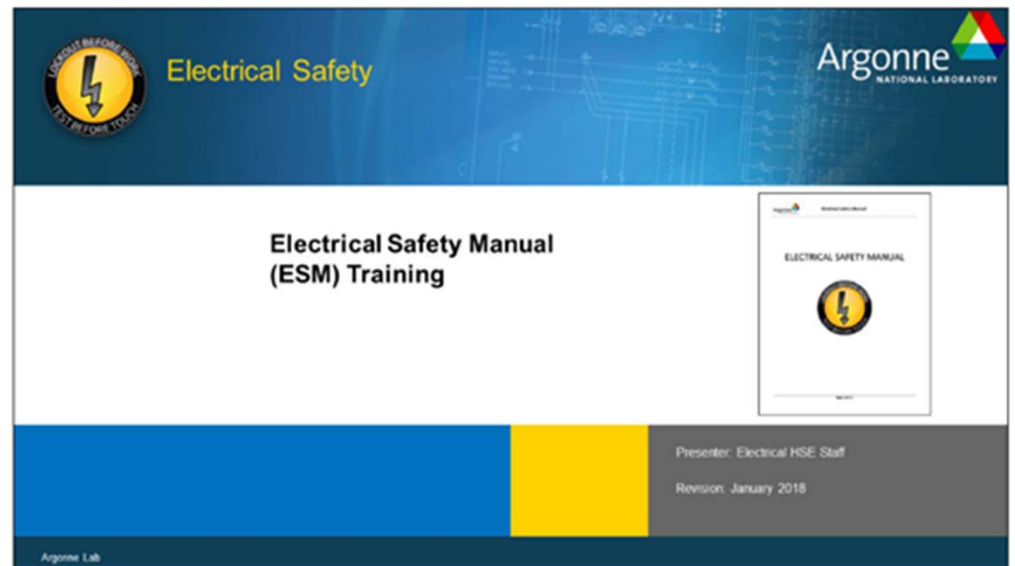
# Other Policies

- The group has it's own Electrical Work Policy
  - 17 page document that defines some of the specifics associated with our electrical work
  - Part of WCDs



# Other Policies (Cont.)

- We make extensive use of the new Electrical Safety Manual
- We use NFPA70E (and DEEI documentation) as references



# Training

- JHQs
  - Reviewed by employee & GL at least once per year
  - Monthly nags → We do pretty well in keeping current

Reason	Course	Course Name	Status	Restrictions	Last Completed	Due Date	History	Take Course	Enroll/Unenroll	Certificate
<b>Required (3 Courses)</b>										
	ESH114	Lockout/Tagout Training	Open		10/05/2015	10/05/2018				
	SCD100	Foreign National Unclassified Visit & Assignment Host Training	Open		10/06/2017	10/06/2018				
	JHQ100	Job and Hazard Questionnaire (JHQ) Review	Open		10/09/2017	10/09/2018				
<b>Required Completed (48 Courses)</b>										
	ESH120	Laser Safety	Completed		12/02/2016	12/02/2018				
	EM116	Emergency Management and Continuity General Awareness	Completed		03/01/2018	03/01/2019				
	ESH115	Laboratory Safety Training	Completed		03/25/2016	03/25/2019				
	ESH562	Machine Guarding	Completed		03/25/2016	03/25/2019				
	HR498	Ethics Training	Completed		04/05/2018	04/05/2019				
	HR720	Statement of Conduct-Employee Certification Form	Completed		04/05/2018	04/05/2019				
	SEC101	Counterintelligence, Classification, Export Control and Security Refresher	Completed		04/05/2018	04/05/2019				
	ESH574RF	Refresher - Chemical Waste Generator	Completed		04/26/2017	04/26/2019				
	EQO209	Control and Calibration of Measuring and Test Equipment Awareness Training	Completed		04/27/2018	04/27/2019				
	ESH1000	General Employee Training	Completed		04/27/2018	04/27/2019				
	ESH108362	Building/Facilities Safety Orientation - Building 362	Completed		05/08/2018	05/08/2019				
	ESH223	Cyber Security Education and Awareness	Completed		05/08/2018	05/08/2019				
	OCF106	Internal Controls	Completed		05/08/2018	05/08/2019				

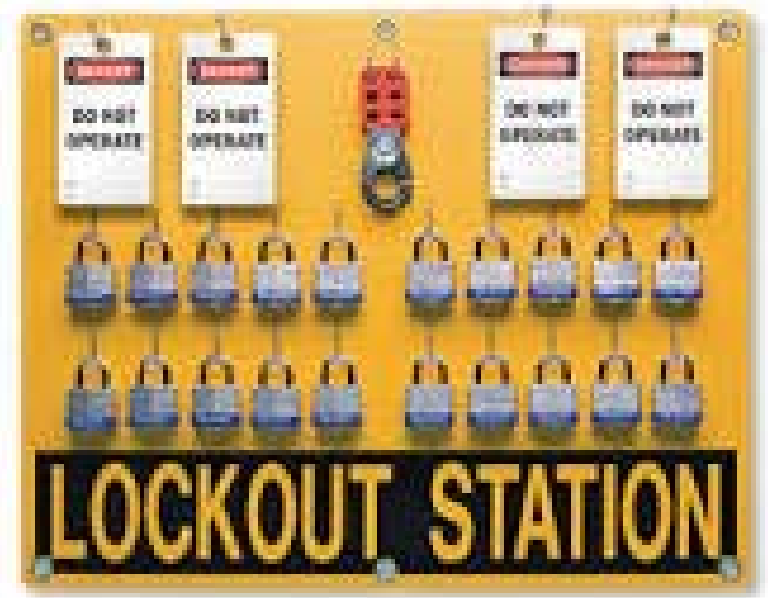
⇒ **My personal training profile has 91 completed courses – many taken multiple times!!!**



## Training (Cont.)

- QEW
  - We have completed QEW training, & are certified:
    - 50241 G. Drake QEW1
    - 49671 T. Cundiff QEW1
    - 41838 T. Hayden QEW1
  
- LOTO
  - We have a LOTO Station in the group (Bldg. 362, C116)
  - Everyone in the group has had LOTO training
  - G. Drake is the LOTO trainer for the division

- ⇒ **Work up to 300 VAC**
- ⇒ **Needed for Repair work, DEEI work, & power supply R&D**



- ⇒ **Again, 99% of LOTO work in the group is cord & plug**







# Periodic Walk-Thrus & Inspections

- Walk-Thrus by Division Management
  - Every lab space is has a walk-thru by division management at least twice per year
  - Seldom find more than housekeeping issues
  - Occasionally find equipment needing DEEI inspection



# Summary



- **The ANL HEP Electronics Support Group takes safety very seriously**
  - We embrace ISM, and use it in the execution of our work
  - We maintain and follow our WCDs
  - We keep our JHQs and training up to date
  - We have periodic walk-thrus, reviews, & oversight
- **We are committed to maintaining a safe work environment**
- **We have a very good safety record over the last 20 years...  
and intend to keep it that way!!!**

