Electrical Safety and High Energy Physics

Dr. Perry L Anthony
SLAC Electrical Safety Officer

Electrical Hazards in High Energy Physics

- High Voltage detector components
  - Generally low current, mostly represent a “startle hazard”
- High current power supplies
  - Possible burns from shorting items across terminals
- Stored energy
  - Possible burns from shorting, internal damage

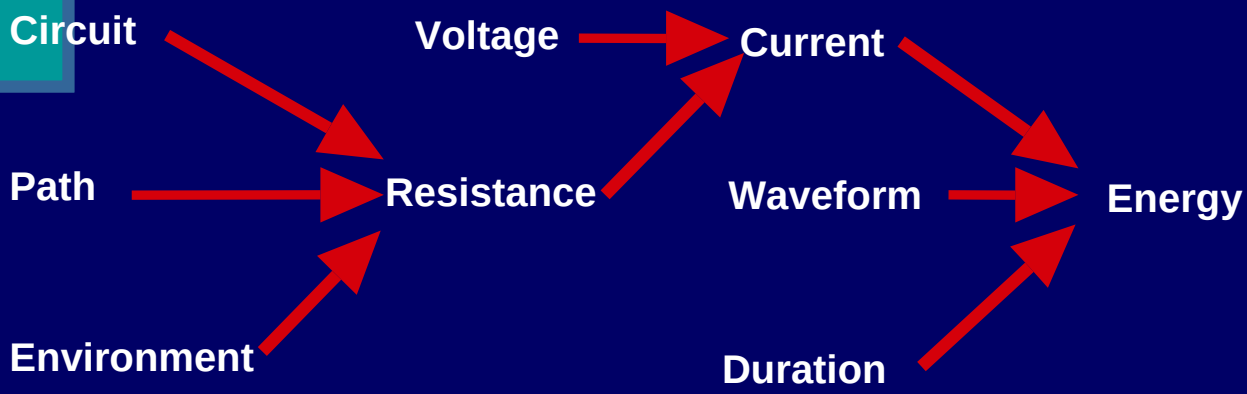
What determines the hazard?

- Voltage
- Current
- Duration
- Energy

What determines the Damage?

$$I = \frac{V}{R}$$

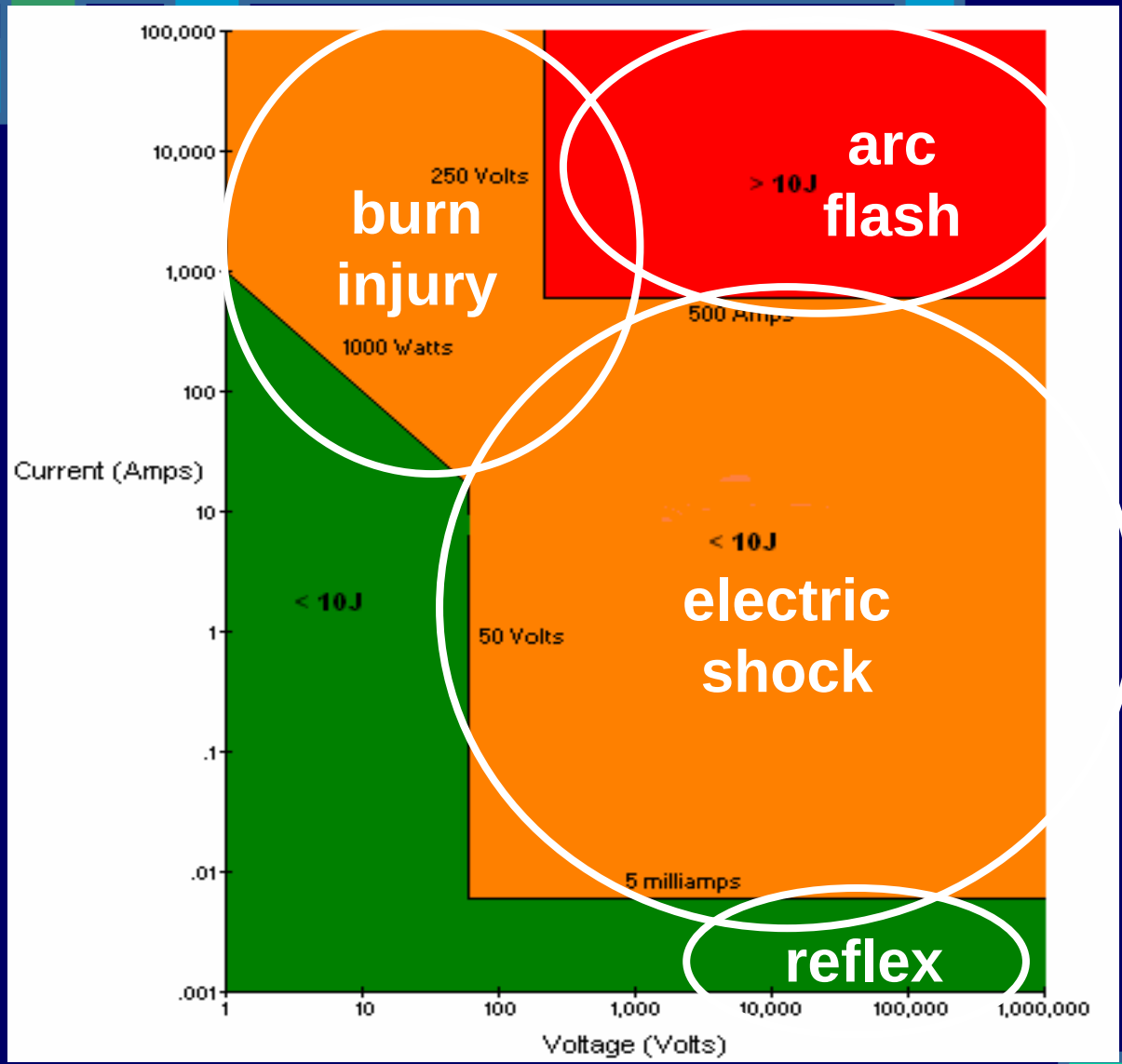
P = I x V
E = P x t



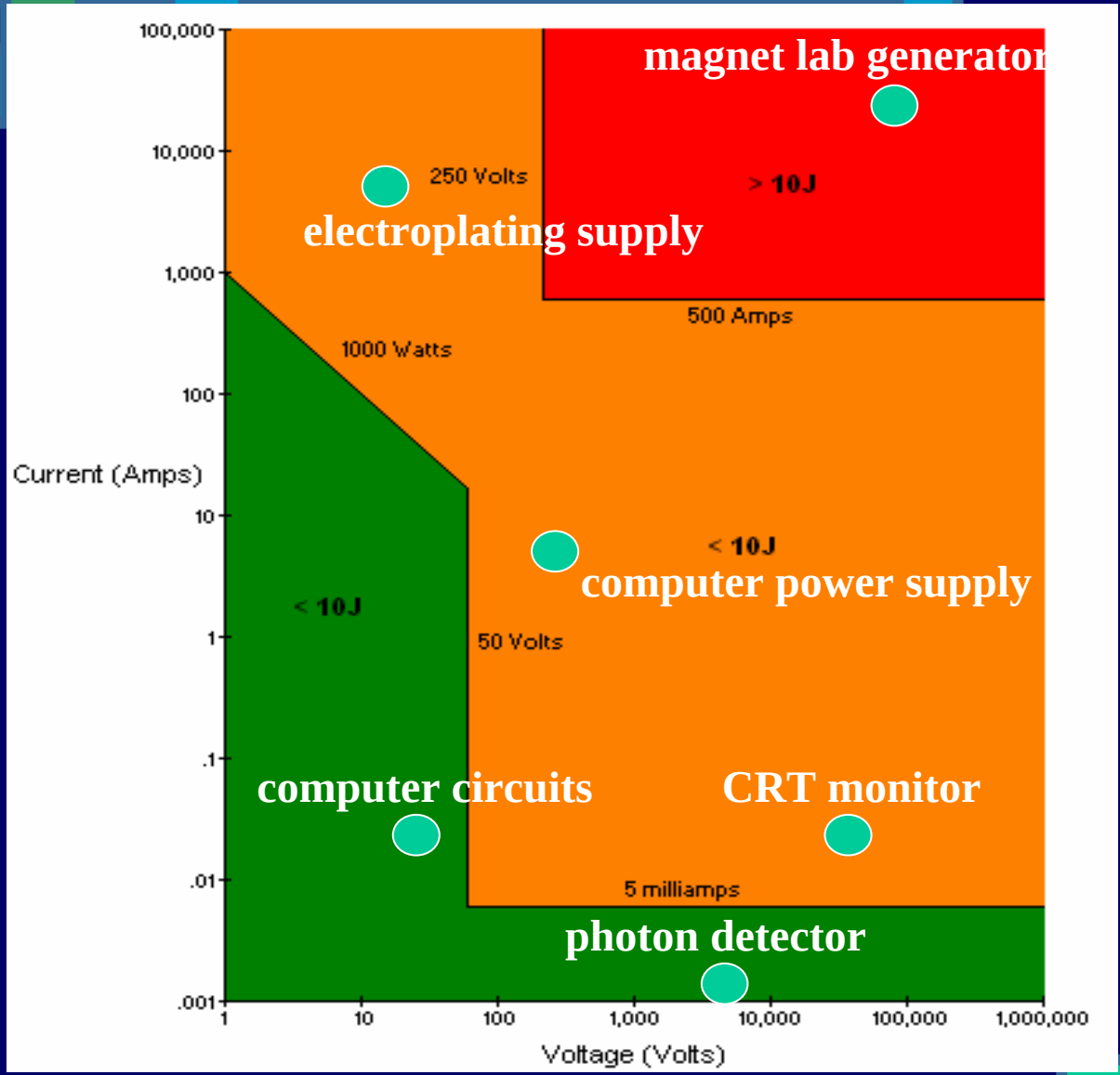
Determines Immediate Impact

Damage Done

Injury from R&D Equipment



Typical Examples



Results of Electric Injury

- Burn from tool across terminals for a low voltage, high current device

Results of Electric Injury (cont.)

- High Voltage breakdown of skin with entrance/exit wounds

Results of Electrical Injury (cont).

- Arc Flash Burns:

Protecting from hazards

- Engineering controls
  - Keep the hazard isolated
  - Interlocks
- Administrative Controls
  - Personnel Protective Equipment (PPE)
  - Procedures (application of Lock Out Tag Out)

When/What protection is necessary?

- Codes and Standards specify when/where protection is required:
  - In the US:
    - OSHA
    - NEC
    - NFPA-70E
    - DOE Electrical Safety Handbook
  - Also Facility standards and procedures

US: NFPA-70E Standard for Electrical Safety in the Workplace

- Must protect against both electric shock and possible arc flash
- Preferred method is to de-energize the equipment
- Special procedures for testing, troubleshooting, voltage measuring, and similar activities on energized parts
- Permit with special procedures for other activities on energized parts

NFPA-70E: Shock Protection

- Triggered when working “on or near” exposed energized parts:
  - Over 50V
  - On = tool or body part touching
  - Near = any activity within the “limited approach boundary” (voltage dependent)
- Requires all body parts within the “Prohibited Approach Boundary” to be insulated against the voltage

Limited and Prohibited Approach Boundaries for Electrical Shock

- Voltage dependent:
  - Prohibited = point where the voltage could jump the air gap
  - Limited = larger region, activity in this region could result in accidental contact
  - Example:
    - 120V: Limited = 42 inches; Prohibited = contact
    - 480V: Limited = 42 inches; Prohibited = 1 inch

Arc Flash Protection Boundary

- Boundary set at point where energy of arc may just cause a 2nd degree burn (blistering)
- Depends on many factors (e.g. current, duration)
- May be larger than Limited Approach Boundary for Shock

What does that give us?

- New labels on equipment:
  - Arc Flash hazard labels

More arc flash labels

Equipment Inspection Labels

- All electrical equipment must be listed for use by a Nationally Recognized Testing Laboratory (NRTL) or other agency certified by the local Authority Having Jurisdiction (AHJ)

Is this enough for the HEP community? NO!

- Good for shock hazard.
- Not enough for burn hazards:
  - NFPA-70E and IEEE-1584 give formulas for 60 Hz AC systems only!
  - Nothing about capacitor Banks
  - Nothing about high current low voltage power supplies
  - Nothing about RF systems

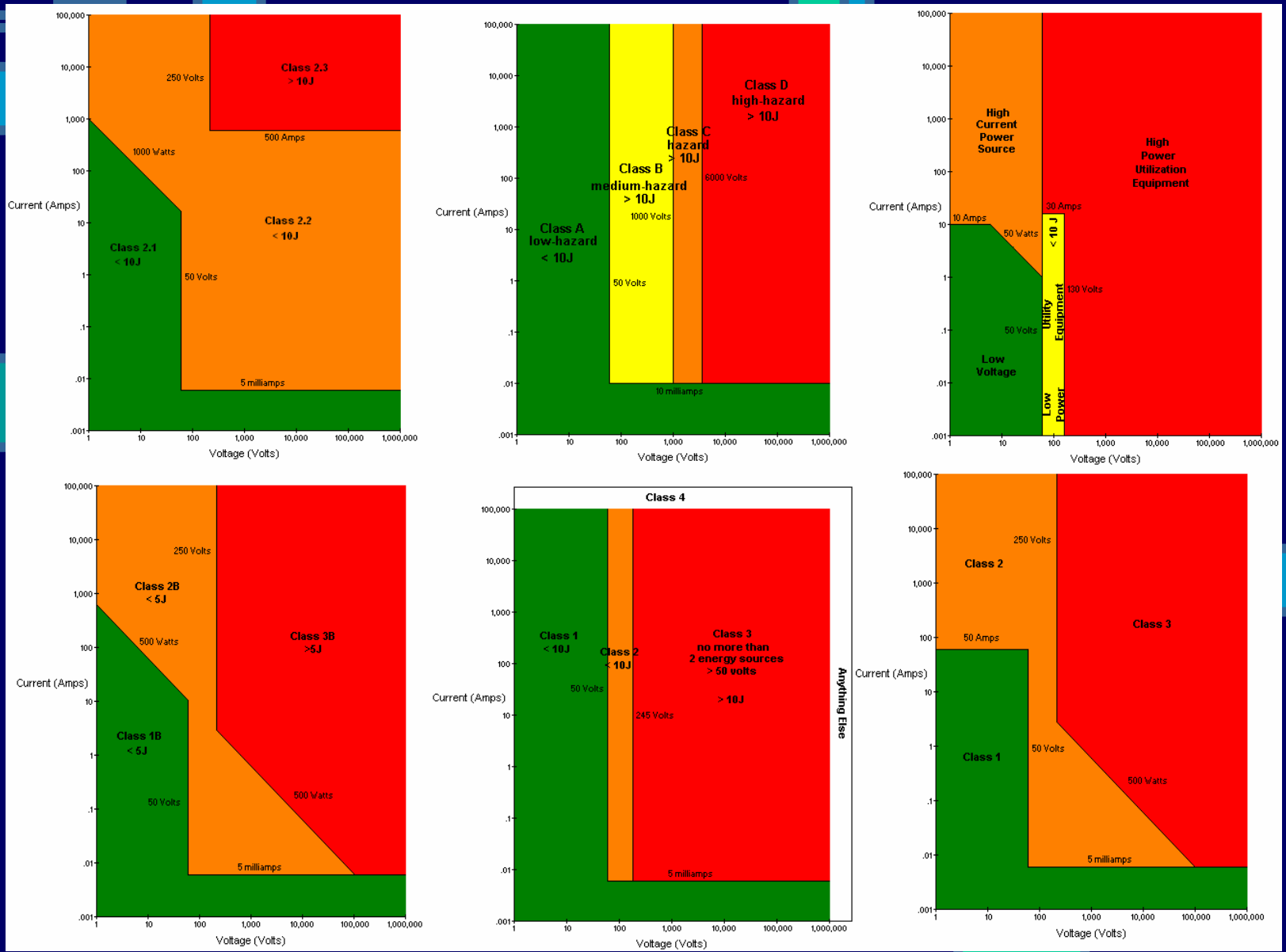
DOE Electrical Safety Handbook

- Only 2 out of 11 chapters applicable to HEP:
  - Chapter 9: Enclosed Electrical/Electronic Equipment
  - Chapter 10: Research and Development
- Gives guidelines for construction
- Limited guidance for protection

Where does that leave the HEP Community?

- Each facility has needed to develop guidance to ensure worker safety
- Hazards may not be recognized
- Standards not uniform

Six US Facilities



Where do we go from here?

- Capitalize on the expertise in the HEP community to develop standards for situations and equipment not covered by existing codes (e.g. RF, capacitor banks)
- Use forums like this one to work towards uniform standards

Initial steps

- The DOE Electrical Safety Handbook is a step in this direction.
- Efforts are underway to establish an international committee under ISA to develop standards for High Energy R&D Electrical Systems.

High-Power Research and Development Electrical Systems Standards Committee

- Scope
  - To develop standards, recommended practices, technical reports and related information documenting design, fabrication, installation, operation, and maintenance of high power electrical systems, and their associated control, monitoring, safety, and protection systems for national and international research programs in accelerators, pulsed power applications, and high power lasers.

- From the 2005 R&D Electrical Safety Meeting and Workshop held at SLAC March 28-31