Recent Incidents and Lessons Learned at DOE Labs

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SLAC NATIONAL ACCELERATOR LABORATORY

Topics

SLAC

Three Incidents at DOE labs during past 12 months:

1. Entryway to a Laser Controlled Area not interlocked
   - Found during first annual certification for the engineered laser safety system
   - Interface issue between 2 safety systems
2. Exposure to Diffuse Reflection
   - Improper eyewear fit
   - Inadequate design for engineering barrier
3. Door access to Class 3B laser system opened prior to disabling laser hazard
   - Procedural errors
   - Work coordination issue between 2 groups of personnel

Risk Assessment Survey Results from SLAC Laser Personnel

Laser personnel were asked to identify the top 3 risk conditions that could lead to an eye injury incident

SLAC Incident – LCA Entryway not interlocked

Recertification of Laser Safety System discovered that emergency entry into a locked LCA in a “NO ACCESS” state (Rad Safety System state) did not disable the laser hazard

→ No hazardous exposure condition

→ Laser hazards then disabled by removing Master Key until safety logic fixed

SLAC Incident – LCA Entryway not interlocked

Direct Cause: LSS expected to lose RSS-provided NO ACCESS signal in an emergency entry
BUT – RSS logic tripped rad hazards with NO ACCESS signal still asserted

Fix: "rad ready" e-beam stopper permit signal was used instead for LSS, which requires: entry gate closed, area search requirements completed, and the NO ACCESS state set

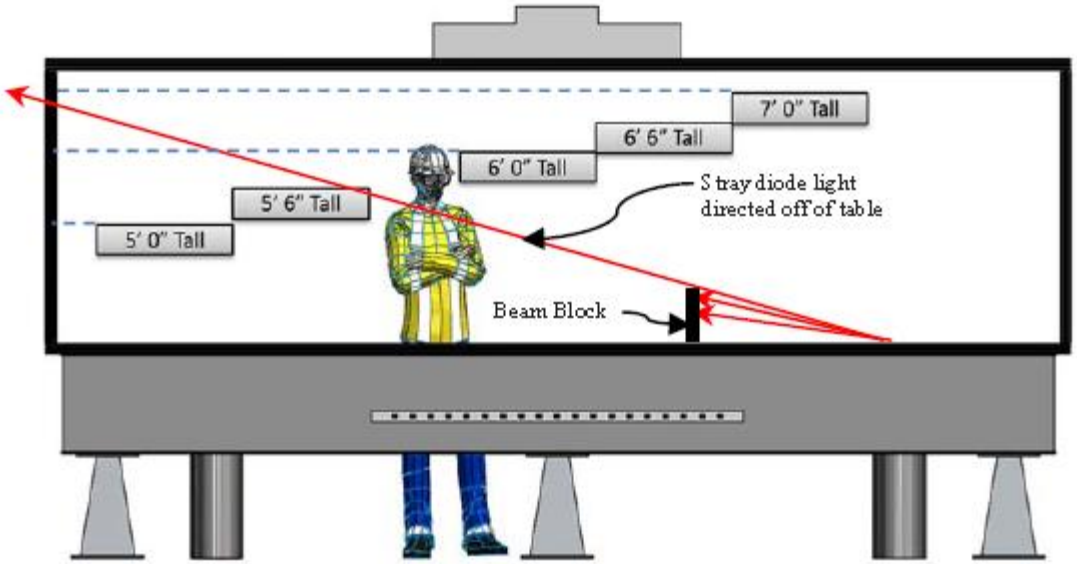
Contributing Causes:

- Interface between 2 safety systems, LSS and RSS
- Inadequate communication between LSS and RSS engineers
- Inadequate design review for the LSS, in particular for LSS-RSS interface
- LSS certification procedure did not have direct test for opening entry gate in NO ACCESS (problem was missed in initial acceptance test and was found indirectly in 1st annual recert)

Extent of Condition: 10 laser labs at SLAC have a RSS-LSS interface with similar configuration. Emergency entry tests were performed and no other failures were found. However, only 2 of the labs had a direct emergency entry certification test.

Additional Corrective Actions were implemented to address the contributing causes

LLNL Incident – Worker exposure to diffuse reflection



Laser eyewear showing path to eye

Worker was exposed to diffuse-scattered 780nm diode pump light due to gap in eyewear between frame nosepiece and bridge of worker's nose. There was line-of-sight to a mirror in the optical beam path for the high power diode pump.

→ Worker had a medical eye exam and there was no injury

→ Measurements and calculations showed diffuse exposure to be below MPE

LLNL Incident – Worker exposure to diffuse reflection

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Causes:

1. Inadequate eyewear fit
   - This eyewear frame style did not have an adequate fit for the particular worker, resulting in a significant gap at the nosepiece. *Note: eyewear fit can be very dependent on shape of worker's face and care of how the eyewear is adjusted*
2. Inadequate barrier design
   - Need to enclose beams as much as practical and implement barriers to prevent line-of-sight to surfaces that can generate significant diffuse reflections. *Note: eyewear is the last line of defense - implement engineering barriers as primary control*!

Additional Lessons Learned:

1. Eyewear selection, use and training
   - Some workers may need to use personal eyewear with particular frame styles
   - Workers need to recognize proper eywear fit + lab supervisors need to check for this
2. Barrier design
   - Need to consider worker height for line-of-sight issues and account for large variations in eye level for different workers

Nevada Test Site Incident – Door opened prior to disabling Class 3B Laser

Incident Description: 3 workers observed diffuse green laser light when opening a chamber door. Door was immediately closed, work stopped and laser source was disabled.

→ Workers had eye exams; no symptoms and no exposure injuries

→ Hazard analysis showed NHZ for diffuse reflection < 3cm

Laser System parameters and operation:

- 300 mW Class 3B laser source
- Prior experiments attenuated beam with ND filters to <5mW prior to transport to chamber.
- New experiment increased power after attenuation to 30 mW. This was split into 2 fibers for transport to chamber.
- 2 groups coordinating work with independent operating procedures:
  - 1 group responsible for source laser operations
  - 1 group responsible for chamber operations

Nevada Test Site Incident – Door opened prior to disabling Class 3B Laser

Causal Factors and Lessons Learned/Corrective Actions:

- Procedural errors were made by both groups. Both sets of procedures required securing laser prior to opening chamber door.
- When more than one group is involved, ***strict coordination is needed***
- ***Need simple procedure checklist*** so critical verification items are not missed (one procedure had requirement to secure laser prior to opening door in a prerequisites section rather than the operations checklist)
- Investigation review determined that hazard from the low power Class 3B laser did not require additional engineering controls such as a door interlock

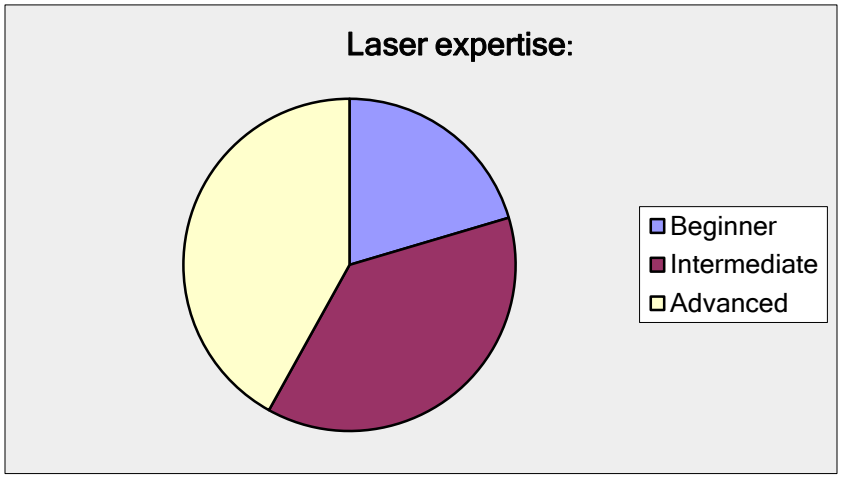
SLAC Risk Assessment Survey

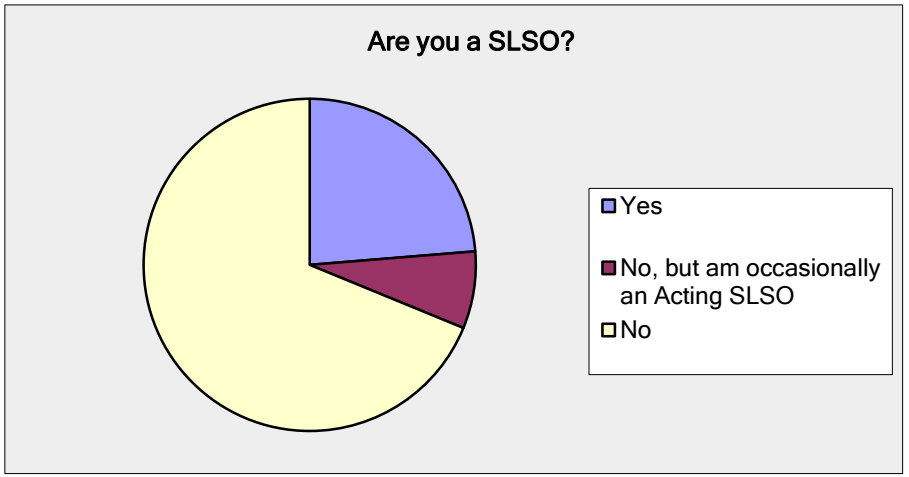
Laser personnel asked to identify top 3 risk conditions that may lead to a potential for hazardous exposure

- a menu of 21 risk choices was given + option to add choice
- 75 laser operators and 11 LCA Workers responded
  (SLAC has ~260 laser operators and 35 LCA Workers)

SLAC Risk Assessment Survey

Demographics of Survey Respondents





SLSOs are “System Laser Safety Officers”
These are the laser safety supervisors for an LCA who are also are the laser operations supervisors

SLAC Risk Assessment Survey

Risk Order	Risk	# Selections - QLOs + LCA Workers	# Selections - LCA Workers	# Selections - SLSOs	# Selections - Advanced	LSO Ranking for highest risk (prior to survey)
1	Admin: Laser operator does not follow core laser safety practices for controlling laser beams, leading to an uncontrolled hazardous stray beam or an unprotected person in hazard zone with accessible beam present.	46	5	12	17	Rank 1
2	PPE: Wrong laser eyewear protection selected for task (or none used when required)	42	5	10	20	Rank 3
3	Admin: Inadequate supervision or OJT, leading to a significant mistake by a laser worker that results in an uncontrolled beam or unprotected personnel present in hazard zone	20	2	6	12	
4	PPE: Eyewear protection does not fit properly	17	2	1	4	Rank 5
5	Engineering: safety shutter fails to close and is not immediately detected, leading to unprotected person in hazard zone with accessible beam present.	15	2	4	8	Rank 6

Engineering - All	49	4	11	20
Admin - All	96	11	25	40
PPE - All	65	8	12	26
Electrical	7	1	3	3
Laser Pointer - Alignment lasers	17	3	3	6

SLAC Risk Assessment Survey

Risk Order	Risk	# Selections - QLOs + LCA Workers	# Selections - LCA Workers	# Selections - SLSOs	# Selections - Advanced	LSO Ranking for highest risk (prior to survey)
6	Admin: Class 1 enclosure configuration requirement not met, leading to unprotected person in hazard zone with accessible beam present.	14	2	3	5	Rank 2
7	Engineering: Class 1 enclosure interlock malfunctions and is not immediately detected, leading to unprotected person in hazard zone with accessible beam present.	11	1	4	5	
7	Admin: service subcontractor does not follow correct admin/PPE requirements, leading to unprotected person in hazard zone with accessible beam present.	11	1	3	4	
9	Low power lasers: Exposure to an alignment laser or laser pointer resulting in temporary impaired vision and startle hazard	10	2	2	5	
10	Engineering: LSS has a design or implementation error (other than ones noted below for LSS-PPS interface), leading to unprotected person in hazard zone with accessible beam present.	8	0	2	4	Rank 6
11	Electrical: exposed HV (or potential for exposed HV) during laser work	7	1	3	3	Rank 4
11	High power laser pointer: exposure to a non-compliant laser pointer whose power exceeds 5mW	7	1	1	1	
13	PPE: Incorrect eyewear available	6	1	1	2	
14	Engineering: entry door interlock malfunctions and is not immediately detected, leading to unprotected person in hazard zone with accessible beam present.	5	1	0	1	
14	Engineering: LSS electronic warning display malfunctions, leading to person not wearing required laser eyewear.	5	0	1	2	

SLAC Risk Assessment Survey

Risk Order	Risk	# Selections - QLOs + LCA Workers	# Selections - LCA Workers	# Selections - SLSOs	# Selections - Advanced	LSO Ranking for highest risk (prior to survey)
16	Engineering: LSS gets wrong signal from PPS for a NO ACCESS state, or other mis-communication between LSS and PPS, leading to unprotected person in hazard zone with accessible beam present.	3	0	0	0	Rank 6
17	Engineering: entry or equipment door not properly locked/secured, leading to unauthorized laser lab entry that challenges the door interlocks for disabling hazard.	2	0	0	0	
17	Admin: Inadequate SOP or JSA document describing laser hazards and controls, leading to a significant mistake by a laser worker that results in an uncontrolled beam or unprotected personnel present in hazard zone	2	0	1	2	
17	Admin: Inadequate equipment labels	2	1	0	0	
20	Admin: failure of a guarded entryway (not locked and not interlocked) resulting in unauthorized entry by an unprotected person to hazard zone	1	0	0	0	
21	Admin: Inadequate posting for a Laser Controlled Area	0	0	0	0	
	Other	13	2	7	8	

Summary

3 Reportable Incidents:

- Each incident had multiple failures
- Failures in engineering, administrative and PPE controls observed
- Engineering failures were design failures rather than malfunction
- Two incidents involved lack of coordination between 2 work groups

SLAC Risk Survey :

- Results help prioritize actions needed to minimize risk for eye injury
- Risk ranking results (highest to lowest):
  1. ***Administrative*** Controls failures (96 responses)
  2. ***PPE*** Controls failures (65 responses)
  3. ***Engineering*** Controls failures (49 responses)