

LABORATORY SAFETY

IESL-FORTH

Petros Samartzis
11/07/2019



GDPR summary

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- Your **signature** confirms your presence in this seminar on this particular date
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- You have the right to be informed of, to access, correct, update or delete the personal information requested & to file a complaint with the Data Protection Authority.
- For more: https://www.forth.gr/gfx/pdf/PrivacyPolicy_EN.pdf
- FORTH Data Protection Officer email: dpo@admin.forth.gr



LABORATORY SAFETY

- GENERAL LAB SAFETY
- FIRE SAFETY
- ELECTRICAL SAFETY
- CHEMICALS & WASTE HANDLING
- PRESSURE SAFETY (HIGH & VACUUM)
- LASER & X-RAYS SAFETY
- CRYOGENICS SAFETY

<http://safety.iesl.forth.gr>



LABORATORY SAFETY

GENERAL LAB SAFETY



RULE NUMBER ONE:

SAFETY
IS OUR FIRST
PRIORITY



GENERAL RULES

- **YOU** are responsible for your safety
- **Safety training mandatory before working in the lab**
 - Lab-specific training by PI/Group Safety Officer
- **Use of appropriate safety equipment is mandatory in the laboratories: get familiar with them**
- **Consider SAFETY when designing an experiment**
 - Safeguard continuously working equipment
 - Avoid working alone in the lab
- **Keep labs clean and tidy**
- **No access of un-authorized personnel in the laboratory (especially kids)**
- **No food & drinks in the lab**
- **Use common sense**
- **If in doubt, ASK!**



SAFETY CONTACTS

- **Group/Activity Safety Officer**
 - **Principal Investigator**
- **Division Safety Officer**
 - **Lasers: Petros Samartzis (x1467)**
 - **Materials: Benoit Loppinet (x1465)**
 - **Microelectronics: Ilias Aperathitis (x4123)**
 - **Comp. Center: Vassilis Kirkinis (x1815)**
- **IESL Safety Officer: Petros Samartzis**
 - **Office: Γ260 – Phone: x1467**
 - **Lab: B217 – Phone: x1333**
 - **Email: sama@iesl.forth.gr**



In Case of an Incident

- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel
- File an incident report

- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



LABORATORY CARDS

ΤΗΛΕΦΩΝΑ ΑΜΕΣΗΣ ΑΝΑΓΚΗΣ – EMERGENCY PHONES

<u>Πύλη ΙΤΕ (Φύλακας)</u>	-1111	<u>FORTH gate / Security</u>
Υποδοχή	-1168	Reception
Πυροσβεστική	199*	Fire Department
Αστυνομία	100*, 2810-282316*	Police
ΕΚΑΒ	166*	Emergency (Ambulance)
ΠΕΠΑΓΝΗ	2810-392111*	University Hospital
<u>Βενιζέλειο</u>	2813-408000*	<u>Venizelio Hospital</u>
Τεχνική Υπηρεσία	-1094, -1095, -1455 -1574, -1570	Technical Service Department

Γραμμή άμεσης ανάγκης: 112 (κινητό ή σταθερό*) - Emergency number: 112 (mobile or fixed* phones)

*Για εξωτερική γραμμή πρώτα το 9 (Dial 9 to get an outside line)

Monday to Friday 08.00-15.30

Available 24/7



LABORATORY CARDS

ΕΡΓΑΣΤΗΡΙΟ (LABORATORY) : B-123 (tel: -1234)

ΥΠΕΥΘΥΝΟΙ ΕΡΓΑΣΤΗΡΙΟΥ : α) Δρ. Α. Υπεύθυνος **a) Dr. A. Ypeythinos**
LAB SAFETY OFFICERS β) Καθ. Β. Υπεύθυνος **b) Prof. B. Ypeythinos**
Τηλέφωνο (Tel.) : α) -1234 γρ. (office), 6944123456 κινητό (mobile)
β) -1234 γρ. (office), 6944123456 κινητό (mobile)

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ ΤΟΜΕΑ (ΟΝΟΜΑ_ΤΟΜΕΑ): Δρ. Ο. Επίθετο
DIVISION SAFETY OFFICER (DIVISION_NAME) **Dr. N. Lastname**
Τηλέφωνο (Tel.) : -1234 γρ. (office), 6944123456 κινητό (mobile)

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ ΙΝΣΤΙΤΟΥΤΟΥ (ΙΗΔΛ): Δρ. Π. Σαμαρτζής
INSTITUTE SAFETY OFFICER (IESL) **Dr. P. Samartzis**
Τηλέφωνο (Tel.) : -1467 γρ. (office), 6946280983 κινητό (mobile)

ΕΠΙΚΙΝΔΥΝΟΤΗΤΑ – HAZARDS:

Λείζερ (LASERS)*: P-UV EXCIMER: 248 nm; 193 nm, CW-VIS HeNe: 632 nm, P-UV Nd-YAG: 355 nm
*P=pulsed, CW=continuous, all lasers CLASS IV

ΧΗΜΙΚΑ: org. διαλύτες (μεθανόλη, αιθανόλη), χρωστικές λείζερ, ορυκτέλαια αντλιών

CHEMICALS: org. solvents (methanol, ethanol), laser dyes, pump oil

ΑΕΡΙΑ (GASES): He, Xe, N₂, F₂ (4 φιάλες (4 cylinders))

ΑΝΤΛΙΑ ΔΙΑΧΥΣΕΩΣ (DIFFUSION PUMP)



A message from Technical Service

Don't abuse building facilities



LABORATORY SAFETY

FIRE SAFETY



Before the Fire

- Check **fire escape routes**
 - Memorize how to leave the lab in case of emergency
- Locate closest **fire alarm** and **fire extinguisher**
- Check that your fire extinguisher works for the materials you use
- Keep flammable materials as away from heat, fire and electricity as possible
- Don't block corridors inside and outside the labs
- **No smoking!**

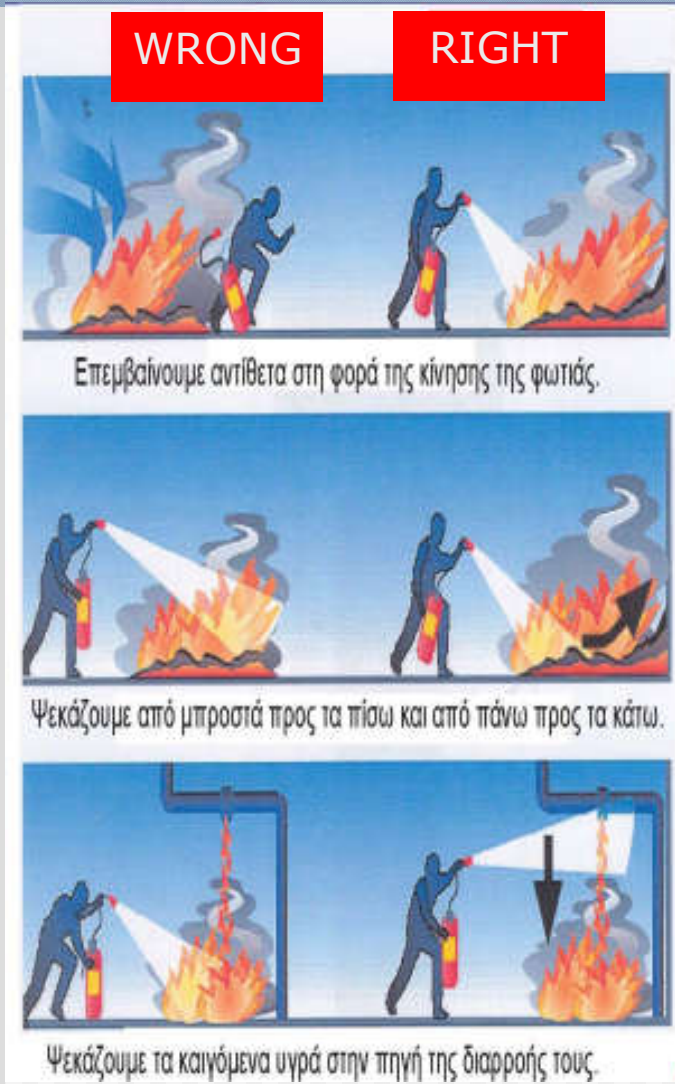


In Case of a Fire

- Keep calm & assess situation
- **Activate fire alarm – Call for help**
- Check for injured people
- Leave immediately
 - Intervene only if you know what you are doing
 - Use the correct fire extinguisher
- Do not open windows/doors
- Attempt rescue ONLY if not in danger
- NO WATER ON ELECTRICAL FIRES



How to fight a fire



<http://www.forth.gr/ty/>



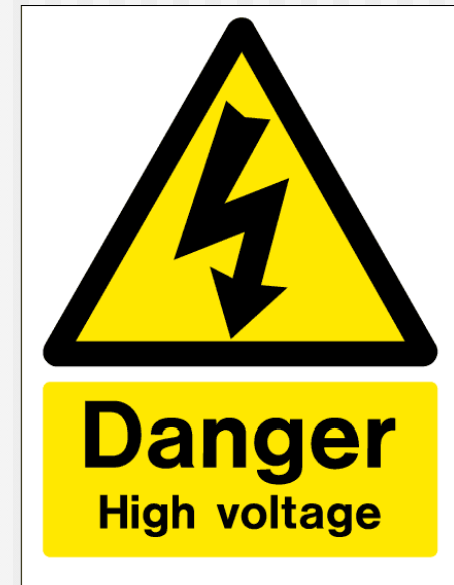
LABORATORY SAFETY

ELECTRICAL SAFETY



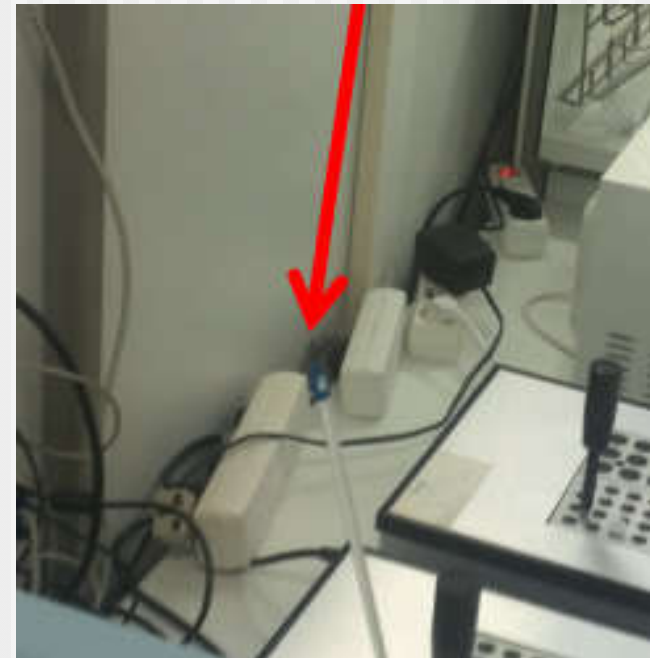
ELECTRICAL HAZARDS

- Sources
 - Regular electrical lines and outlets
 - UPS electrical lines and outlets (red OR labeled "UPS")
 - Equipment (e.g lasers, vacuum pumps, computers)
 - High voltage power supplies
- Hazards
 - Electrocutation
 - Electrical Fires



ELECTRICAL SAFETY PRACTICE

- Keep cables OFF the floor
- Do NOT use back to back power strips
- Keep water away from electrical equipment
 - Water low – electricity high
- Turn OFF power supply before touching “hot” parts
- Ground appropriately
- **DON'T** try to repair equipment
- Beware of BARE cables
- Follow specifications
- **If in doubt, ASK!**



In Case of an Electrical Incident

- **Remain calm!**
- **Assess the situation**
- Cut off power supply
- **No water** on electrical fires
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



LABORATORY SAFETY

CHEMICAL SAFETY & WASTE HANDLING



LAB CHEMICALS

- **Flammable:** e.g. organic solvents, H_2
- **Explosive:** e.g. acetylene, azides
- **Pyrophoric:** e.g. phosphor
- **Toxic:** e.g. chlorine, methyl iodide
- **Corrosive:** e.g. strong acids & bases
- **Carcinogenic:** e.g. benzene



Material Safety Data Sheets (MSDS)

SIGMA-ALDRICH
A Part of MilliporeSigma

200,000+ PRODUCTS ▾ | 500+ SERVICES ▾ | Featured INDUSTRIES ▾ | Hello, Sign in. ACCOUNT ▾ | 24/7 SUPPORT ▾ | 0 Items ORDER ▾

USA Home > 289566 - Iodomethane

289566 SIGMA-ALDRICH
Iodomethane
contains copper as stabilizer, *ReagentPlus*[®], 99.5%
Synonym: Methyl iodide

SDS | SIMILAR PRODUCTS

CAS Number **74-88-4** | Empirical Formula (Hill Notation) CH_3I | Molecular Weight 141.94
Beilstein Registry Number 969135 | EC Number **200-819-5** | MDL number **MFCD00001073**
PubChem Substance ID **24857202**

POPULAR DOCUMENTS: SPECIFICATION SHEET (PDF)

Purchase | Safety & Documentation | Peer-Reviewed Papers **81** | Related Products **1**


Properties | **Price and Availability**

grade | *ReagentPlus*[®] | Price

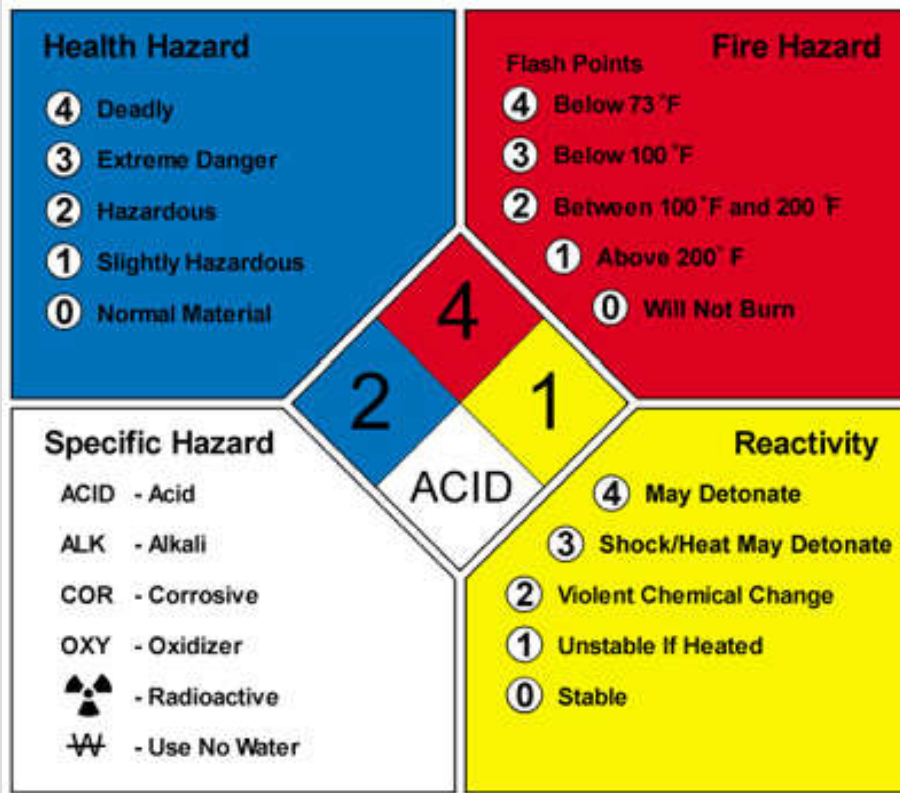
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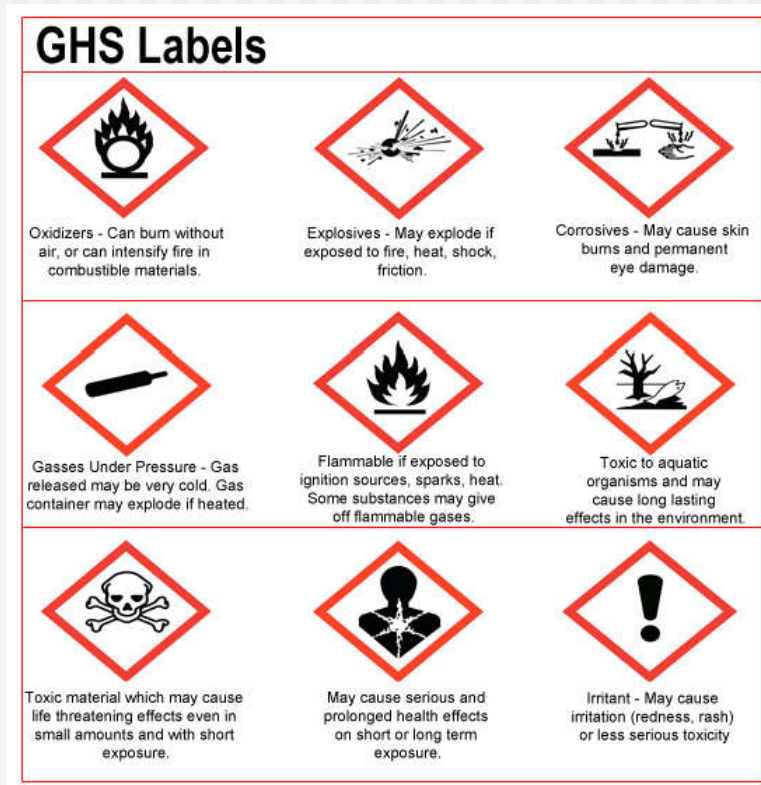
All manufacturers are required to provide MSDS



Different labeling systems



www.nfpa.org



<https://www.osha.gov/dsg/hazcom/pictograms/index.html>



CHEMICAL SAFETY RULES

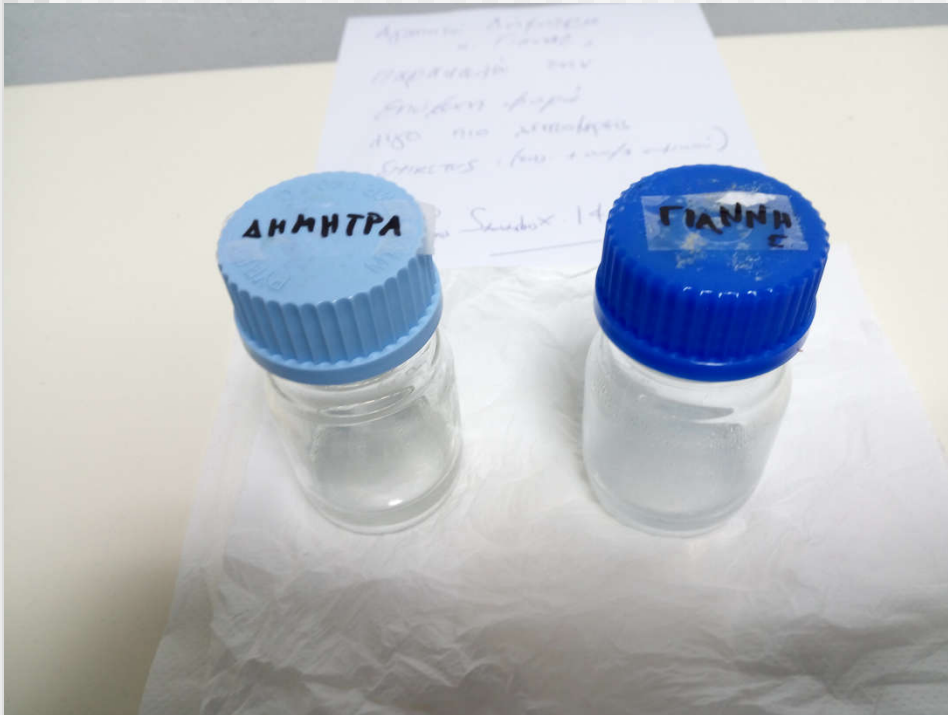
- Design your experiment carefully
- **Study Material Safety Data Sheets**
- Use smallest quantities allowed
- Use **APPROPRIATE** protective equipment
 - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,...
- **Store appropriately (MSDS)** if not in use
- Use appropriate **transport protection equipment & practices**
 - Rubber buckets, cardboard boxes, containers
 - Do not hold containers from lids



CHEMICALS TRANSPORT



LABEL APPROPRIATELY



- Chemical name or formula
- Owner/lab
- Phone
- Date

If not properly labeled, your containers will be treated as waste



BASIC WASTE HANDLING

- Follow **MSDS** instructions for disposal
- Follow/establish **lab rules** related to waste
- Label your waste containers
- Some salts, acids & bases can be disposed in the sink if NEUTRALIZED and DILUTED with plenty of water
- Organic chemicals WITHOUT F, Cl, Br, I go to "**Non-halogenated Organic Waste**"
- Organic chemicals WITH F, Cl, Br, I go to "**Halogenated Organic Waste**"
- Pump oil to "**Mechanical pump oil**"
- Sharps/solid waste go to "**Solid Waste**"
- **If in doubt, ASK!!!**



CHEMICALS



CHEMICALS



In Case of a Chemical Incident

- **Accident examples**
 - Spill, glassware breaking, explosion, fire,...
- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel

- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



LABORATORY SAFETY

HIGH PRESSURE & VACUUM SAFETY



HIGH/LOW PRESSURE HAZARDS

Spark from pressure gauge caused University of Hawaii explosion, fire department says

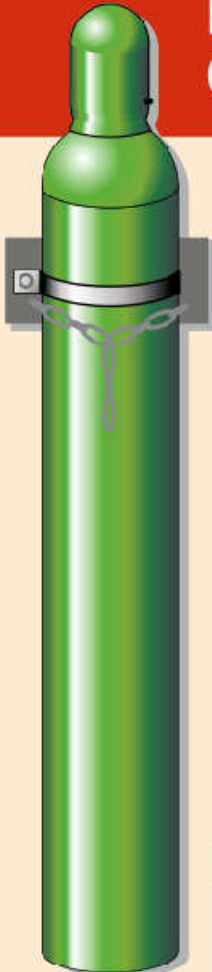
Latest News
Web Date: April 19, 2016

Postdoc Thea Ekins-Coward, who lost an arm in the incident, was using a gauge not specified for work with flammable gases



PRESSURE SAFETY PRACTICE

- **Secure gas cylinders on wall/heavy tables correctly**
- **Always** use appropriate regulator
- Move gas cylinders safely
 - Do **NOT** hold it by the valve or regulator
 - Leak-check gas/vacuum lines/chambers safely
- Beware of pressurized cooling water network
 - Water low – electricity high
- Report any problems you see
- **If in doubt, ASK!**



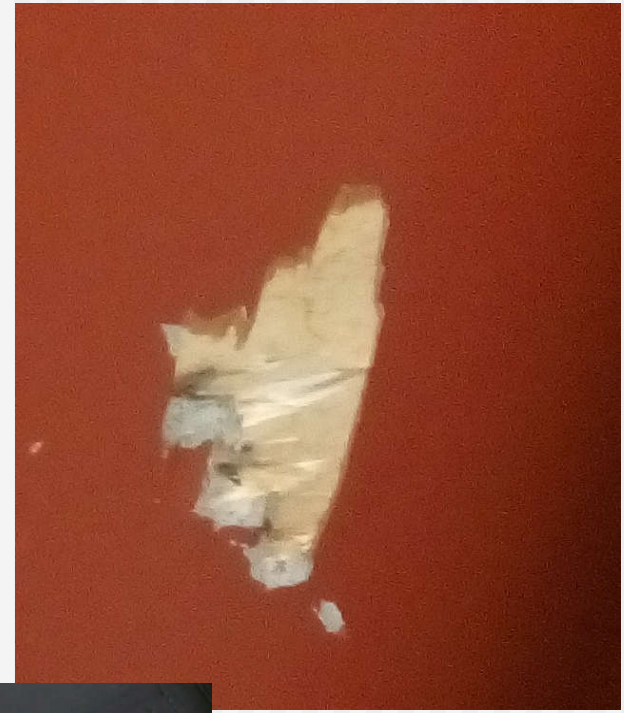
Handling & Storing Cylinders Safely

- 1 SECURE cylinders properly at all times.
- 2 STORE cylinders in cool, well-ventilated, fire-resistant areas in compliance with local, state and federal regulations.
- 3 PLACE cylinders where they will not be damaged by forklifts, knocked over or hit by falling objects.
- 4 CLOSE valves and TIGHTEN caps when not in use.
- 5 INSPECT cylinders for leaks and CHECK support brackets regularly for strength and integrity.
- 6 MOVE cylinders using hand trucks designed for the purpose.
- 7 REPORT leaks or any damage to your supervisor immediately.

EMERGENCY EQUIPMENT LOCATED AT:

SmartSign.com • 800-952-1457 • 3-2014

IESL cylinder 2019



In Case of a Pressure Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



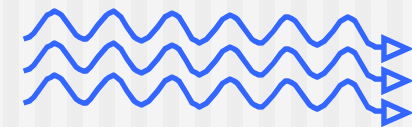
LABORATORY SAFETY

LASER SAFETY



IESL LASER SOURCES

- Solid state (Nd:YAG: 1064/532/355/266 nm, TiSapph: 800 nm)
- Gas lasers (HeNe: 632.8 nm)
- Excimer (KrF:248 nm, ArF:193 nm, XeCl:308 nm)
- Dye lasers (220-800 nm)
- Diode lasers (e.g. femto lasers pump units)



Coherence,
Monochromaticity,
Directionality



LASER PARAMETERS I

- Emission wavelength (UV, Visible, IR)
- Output power/energy (mW-W, nJ-kJ)
- Pulse duration (cw, ns, ps, fs)

Band		Wavelength
Ultraviolet (UV)	UV-C	200 – 280 nm
	UV-B	280 – 315 nm
	UV-A	315 – 400 nm
Visible (VIS)		400 – 700 nm
Infrared (IR)	IR-A	700 – 1400 nm
	IR-B	1400 – 3000 nm
	IR-C	3000 – 1 mm

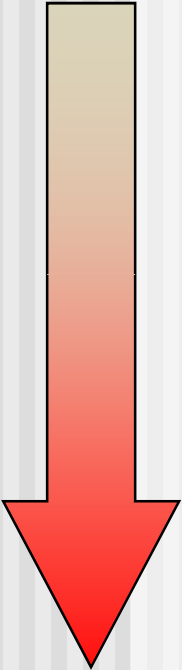


LASER PARAMETERS II

- Radiant Power: P (W)
- Laser pulse energy : $E = \int P(t)dt$ (J)
- Laser pulse peak power : $P = E/\Delta\tau$ (W)
 $\Delta\tau$: temporal pulse width (FWHM)
- Irradiance, Power density: $I = P/A$ (W/m²)
- Energy density (flux) : $F = E/A$ (J/m²)
 A : irradiated area
- Brightness : $\beta_\nu = P(\nu) / A \Delta\Omega \Delta\nu$ (W/cm²srHz)
Sun (580 nm; 5800 K) $\approx 1,5 \times 10^{-12}$ W/cm²srHz
He-Ne laser (1 mW, 632,8 nm) ≈ 25 W/cm² sr Hz
- Intensity : $I(\nu) = P(\nu) / A \Delta\nu$ (W/cm²Hz)



LASER CLASSES

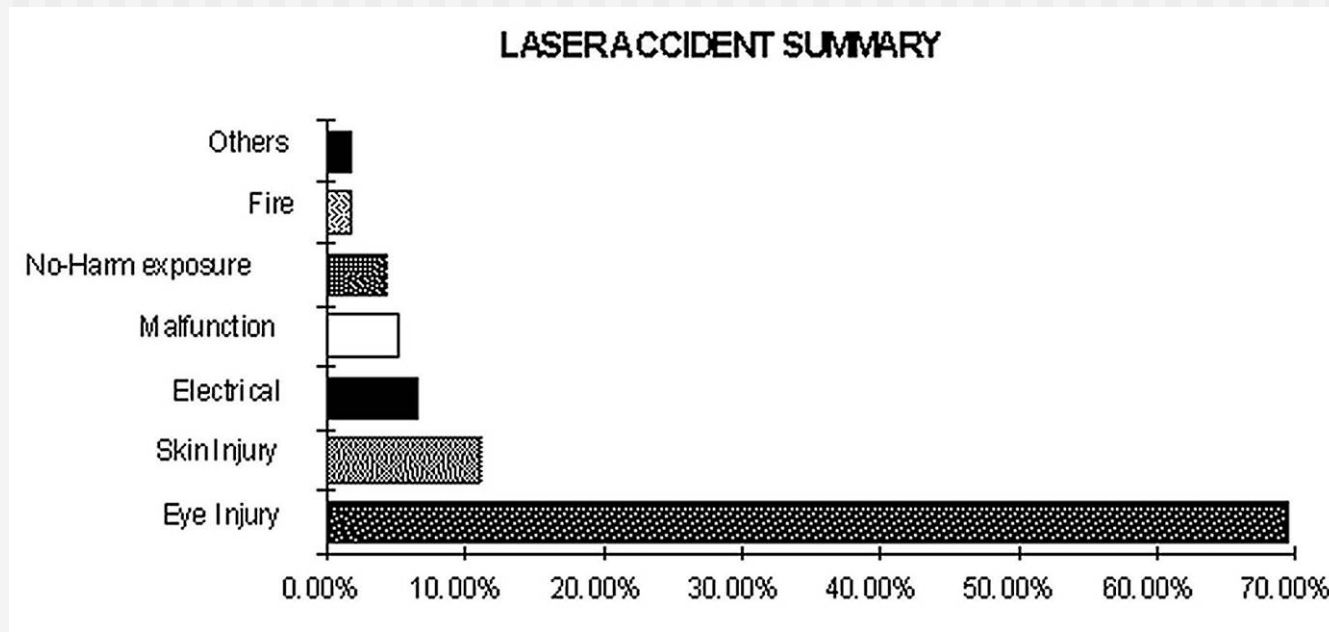
- 
- **CLASS 1** harmless
 - **CLASS 2** visible radiation
momentary exposure (0.25s)
 - **CLASS 3** 3a (1 – 5 mW)
3b (5- 500 mW)
no direct exposure
 - **CLASS 4** Pulse or cw (>500 mW)
Extremely hazardous

ALL lasers in IESL labs are CLASS 4



LASER ACCIDENTS

Laser accidents (USA, 1964-1992)



Most accidents involve **eye injuries**

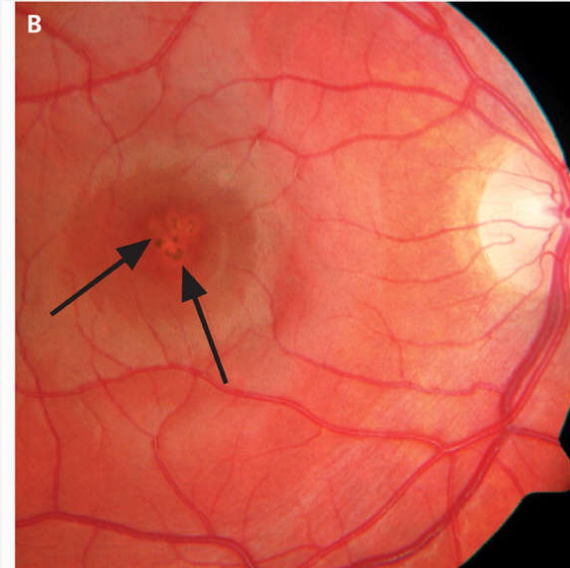
<http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html>



LASER RADIATION DAMAGE

■ EYES

150 mW
green laser pointer
(532 nm)



<http://www.nejm.org/doi/full/10.1056/NEJMc1005818#t=article>

■ SKIN

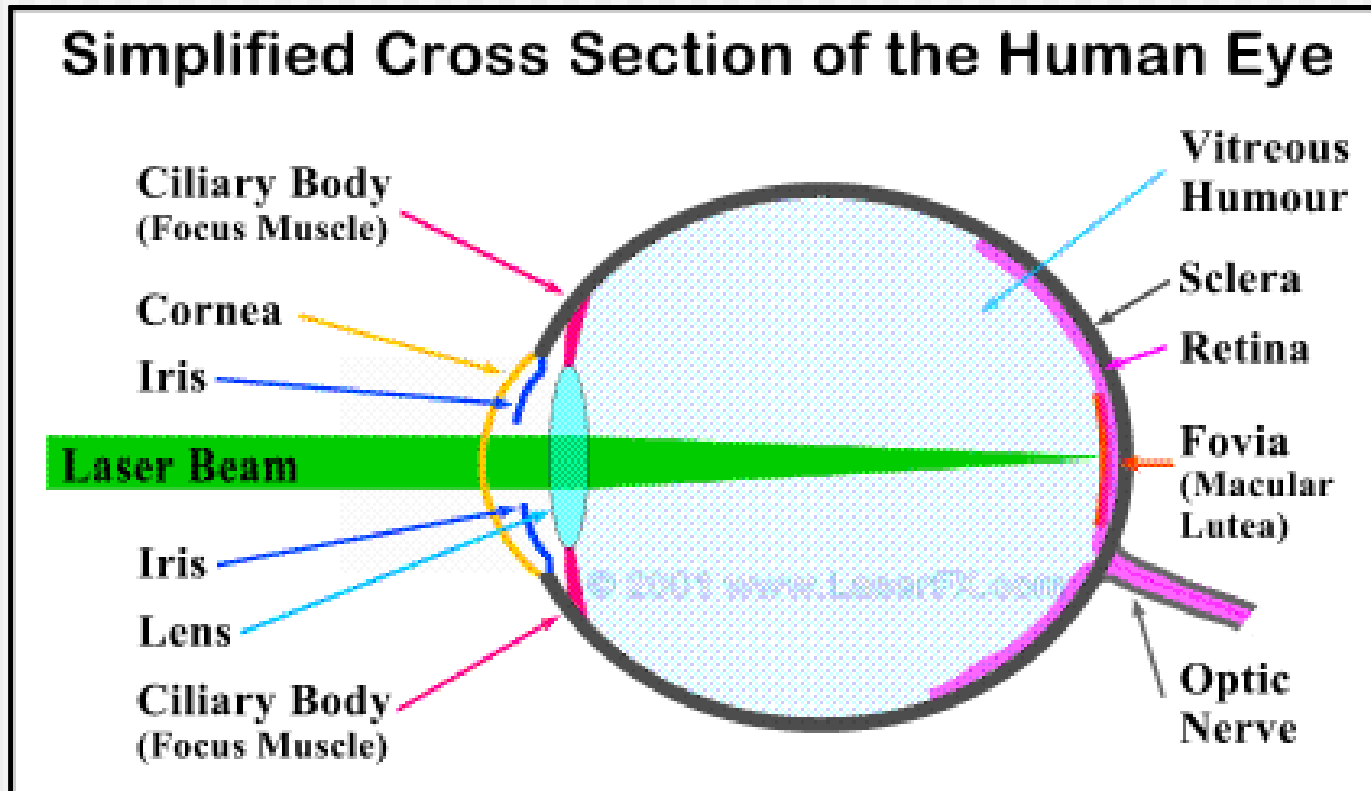
5W/cm² for 1 sec
CO₂ laser
(10,6 μm)



<http://www2.lbl.gov/ehs/safety/lasers/bioeffects.shtml>



LASER vs HUMAN EYE



Cornea (κερατοειδής) : 1400 nm – 1mm & 180 nm – 315 nm

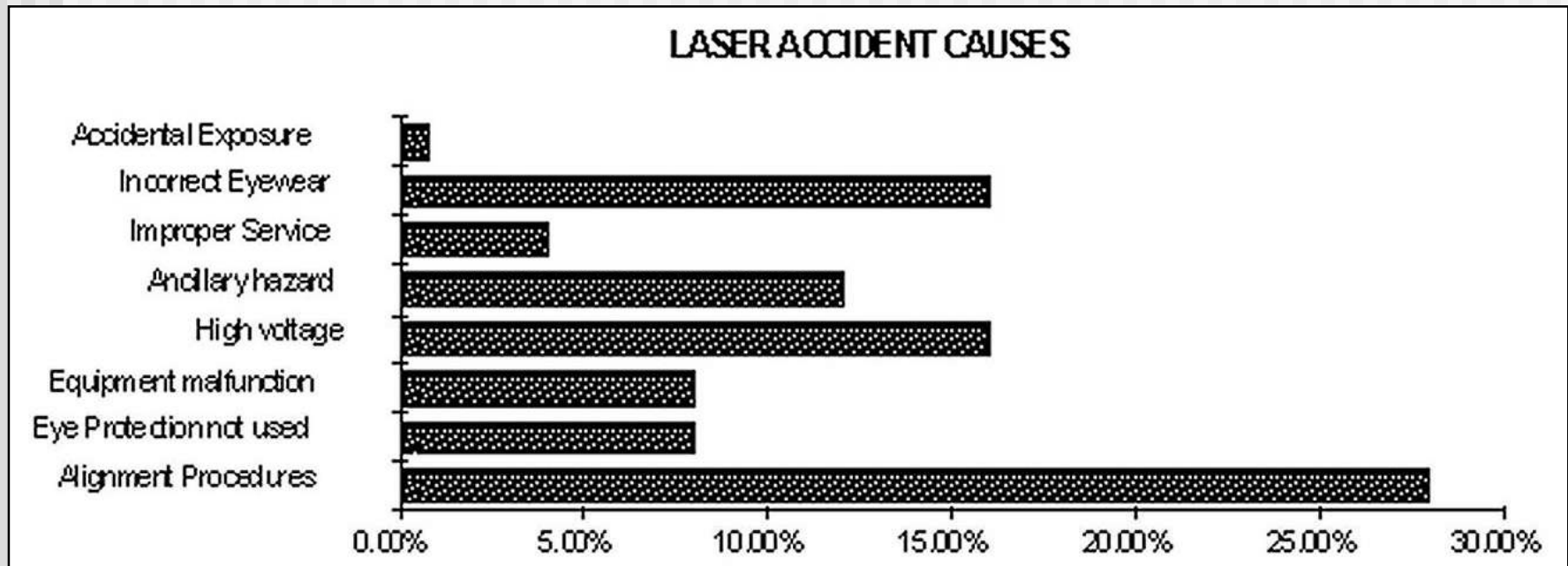
Lens (Φακός): 315 nm – 390 nm & 700 nm – 3000 nm (sel.)

Retina (αμφιβληστροειδής): 400 nm – 1400 nm



LASER ACCIDENT CAUSES

Cause of Laser accidents (НПА, 1964-1992)



Most accidents take place during **beam alignment**
or/and because **no proper eyewear was used**

<http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html>



Student sustains laser eye injury

On July 14, 2004, an undergraduate student employed by another government agency was injured while performing work with a Class IV neodymium (Nd):YAG laser at Los Alamos National Laboratory. The student came to the Laboratory to work with a LANL scientist investigating the potential use of lasers in studying the composition of comets.

The scientist and student had set up a laser experiment designed to suspend and then analyze particles inside a vacuum target chamber using an unusual configuration that was neither described nor analyzed in work control documents.

The experiment used a Particle Generating (PG) laser to suspend the particles and the (Nd:YAG) Laser Induced Breakdown Spectroscopy (LIBS) laser to vaporize the suspended particles. The PG laser was aligned vertically to allow the beam to enter through the top of the target chamber; the LIBS laser was aligned horizontally to allow the beam to enter through a side window. The scientist energized both laser power supplies and was operating the LIBS laser with the Q switch trigger cable disconnected (a mode the scientist believed did not allow the LIBS laser to produce a laser beam). With the Q switch disabled and the LIBS laser's flash lamps operating, the scientist believed that only white light exited the laser's optical tube and traveled down the laser beam path. The scientist wanted to demonstrate that the PG laser could suspend particles from the sample and intended to use the light from the LIBS laser to illuminate the suspended particles and make them visible inside the target chamber.

The scientist fired and secured the PG laser and then observed the suspended particles illuminated by the LIBS laser inside the target chamber. He told the student he could see suspended particles and invited the student to take a look. As the student bent down to look into the chamber, she saw a flash and subsequently noted a reddish brown substance floating in her left eye. Neither the scientist nor the student were wearing laser eye protection. The student was taken to LANL's occupational health facility (HSR-2) and was referred to several eye specialists. Laser eye damage was confirmed. The student continues to experience loss of central vision in her left eye.

Laser operations were suspended and the LANL Director assembled a team to investigate the accident, determine the causal factors, and make recommendations.



Experimental setup showing the target chamber and the LIBS laser



Re-creation of target viewing position

Initial Analysis

The investigation is nearing completion and formal findings will be made available in a few weeks after corrective actions are developed and incorporated. Lines of inquiry have included the use of personal protective equipment, the mentoring and supervision of students, management oversight and control of work/workers, and the reporting and notification process for abnormal

FOR DETAILS:

- Occurrence Report: ALO-LA-LANL-CHEMLASER-2004-0001
- PS-7 Occurrence Investigators: Matt Hardy, 667-6335; Rita Henins, 665-6981

An additional alert about this event will follow if the investigation reveals details that indicate an unknown hazard exists for other employees involved in this type of activity. For more information about "1st Take," please call LANL PS-7 at 665-0033.

August 18, 2004
LANL CHEMLASER 2004-0010

events. Laboratory measurements were made to characterize the conditions and configuration believed to have existed when the accident occurred. Measurements indicated that the student could not have received a laser eye injury under these conditions because the LIBS laser did not emit a beam in this configuration. Consequently, the team is evaluating if other configurations could have resulted in the accident.

Initial Recommendations

Management Level: Managers should:

- Ensure that required safety practices are implemented in the workplace;
- Ensure training requirements are completed before authorizing work;
- Ensure that personal protective equipment is used;
- Ensure laser personnel complete a baseline eye examination;
- Ensure changes to work and associated changes in work configuration are authorized, and that these changes are addressed in work control documents; and
- Provide LANL employees with this "1st Take," either through Nested Safety meetings or required reading programs.

Worker Level: Workers should:

- Know the hazards of their experiment;
 - Wear specified laser eye protection as required;
 - Challenge unsafe or questionable behavior, and if you're not sure, ask;
 - Use interlocks as designed; and
 - Prevent eye exposure to direct or scattered radiation from a Class IV laser.
- More information will be provided to employees in the "Final Take" alert message from Performance Surety.



Experimental setup showing the target chamber and the LIBS laser



Re-creation of target viewing position

GUIDANCE: Resources at hand

For more information related to laser safety you can refer to:

- Lasers LIR 402-400-01.3
- Laser Safety: Class 3b or 4 Self Study Course No. 17817
- American National Standards Institute Z136.1 (Safe Use of Lasers)
- Lessons Learned: Operational Experience Summaries, 2nd Quarter - 2004 (<http://www.oh.doe.gov/paa>)
- Occurrence Report: ALO-LA-LANL-CHEMLASER-2004-001
- Occurrence Report: OAK-LBL-MSD-2003-0001
- Occurrence Report: ALO-LA-LANL-FIRNGHELAB-1999-0002
- Occurrence Report: ALO-LA-LANL-FIRNGHELAB-1998-0002



REFLECT ON THIS

Small fraction (4%) of pulsed laser beam, diameter 2 mm, with energy of 2.5 mJ/pulse, reflected from a piece of optic has energy density of :

$$(0.04 \times 2.5 \text{ mJ}) / (\pi \times (0.1)^2 \text{ cm}^2) = 3.2 \times 10^{-3} \text{ J /cm}^2$$

This exceeds the damage threshold of the cornea ($\sim 10^{-7} \text{ J/cm}^2$) by a factor of 3.2×10^4 .

Protection for this level of exposure requires the use of appropriate laser eye-ware with optical density at the laser wavelength :

$$(\text{OD}) = \log(3.2 \times 10^4) = 4.5$$



LASER SAFETY PRACTICE

- **USE APPROPRIATE LASER PROTECTION EQUIPMENT**
 - **GOGGLES**
 - **LAB COATS**
- **NEVER look directly at the laser beam**
- **Beware of & minimize/block REFLECTIONS**
- **Always know where your beam (and reflection) is**
- **Keep experiment WAY BELOW eye level**
- **Protect others around you**
 - **Laser light ON**
 - **Use protective panels**
- **If in doubt, ASK!**



In Case of a Laser Incident

- Remain calm!
- Assess the situation
- Call for help
 - Turn laser source off to protect others
- Seek medical attention
- Contact safety personnel
- File an accident report

- **USE COMMON SENSE**



X-rays: XRD special rules

- Main X-ray source: XRD
- Use XRD safely : Papoutsakis Labros
- Use of dosimeter is **OBLIGATORY**
 - **No dosimeter – No XRD**
- ALL dosimeters are kept at a place near the XRD – not at the office or in the pocket
- Wear it on the way in, leave it on the way out
- New dosimeter each month
- If dosimeter not needed notify IESL secretariat (Lia or Mania)



LABORATORY SAFETY

CRYOGENICS SAFETY



CRYO HAZARDS

- Explosion
- Frostbites
- Asphyxiation
- Burns
- Fire (liquid O₂)



<http://ehs.ucsf.edu/cryogenic-liquids>



CRYO SAFETY PRACTICE

- Use appropriate handling equipment
 - Gloves, apron, mask
- DO NOT TOUCH cold containers with bare hands
- Vent containers appropriately
- Do not play with cryo-liquids
- L. O₂: no flame/heat/fuel
- Learn how to use cryo-equipment (valves, dewars, hoses) safely
- If in doubt, ASK!



In Case of a Cryogenics Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



Location of First Aid Kits

- **FORTH Main Building B**
 - Basement: **Machine shop**
 - Ground Floor: **Kiriakidis Lab**
 - 1st floor: **Meeting room**
- **FORTH Building C:**
 - **Main Secretariat**
 - Magda's Office
 - Comp. Center
- **STEP C: Electronics shop**
- **Microelectronics: Kitchen**

Each lab may have its own kit on own expenses



LABORATORY SAFETY

ANY QUESTIONS?

<http://safety.iesl.forth.gr>

