Safety Using Fluorine Eximer Lasers

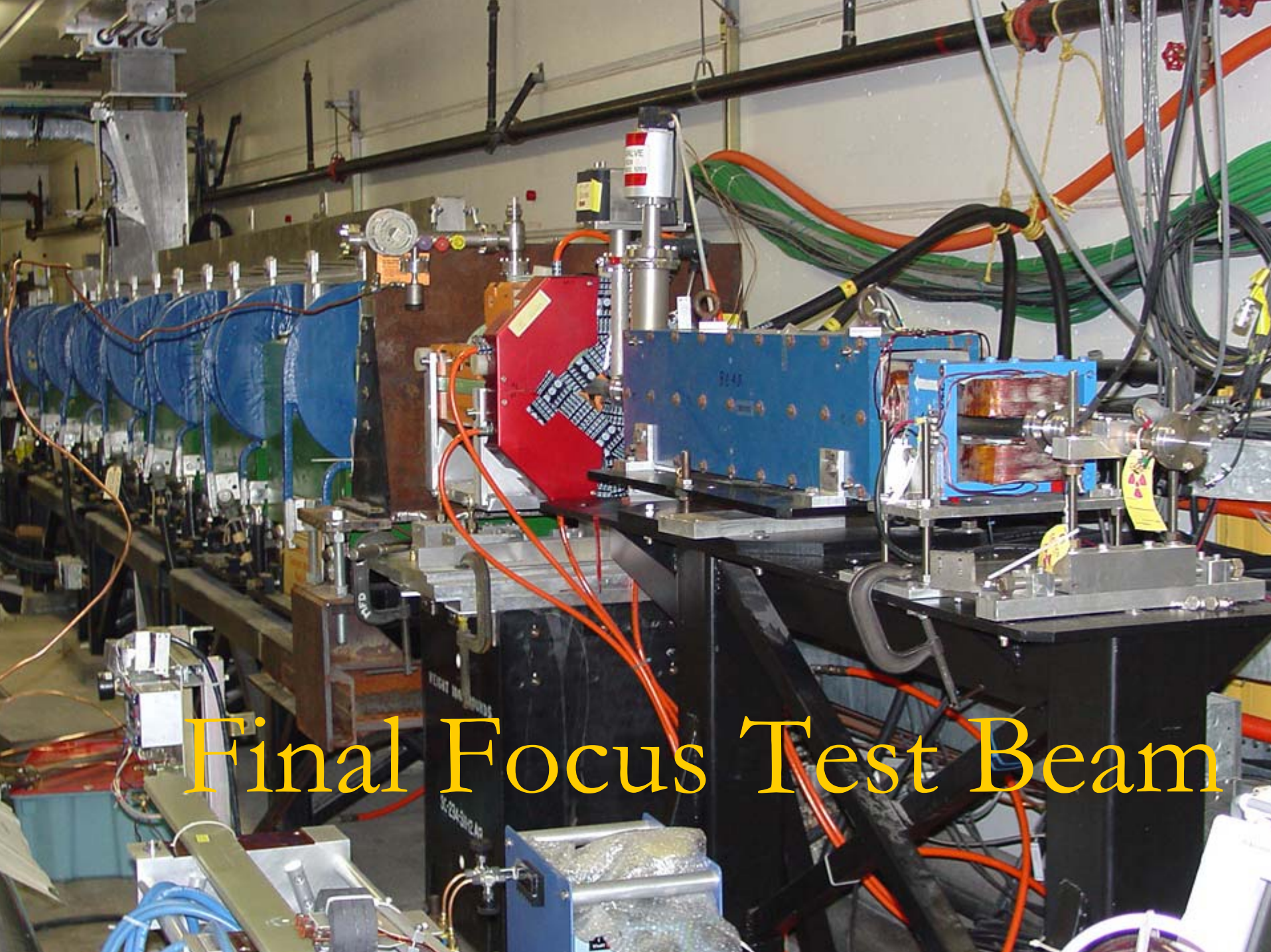
Jack J. Hahn SLAC

Purpose of Today's Talk

- Background on fluorine gas (F2) in Eximer Lasers at SLAC
- Review hazards of F2 gas
- Worst case accident scenarios
- SLAC ES&H Guideline "Safety Using Fluorine Eximer Lasers"
- Equipment design approaches to minimize the hazards of F2 in Eximer Lasers
- Not covering laser beam/electrical other hazards

Background on use of Fluorine in Eximer Lasers at SLAC

- Final Focus Test Beam (FFTB)- GAM, Historical Usage
  - Fringe patterns to measure beam location
- Klystron Test Laboratory- Lambda Physik
  - Laser beams to make plasma deposited oxide cathodes


Final Focus Test Beam

Klystron Test Lab Laser →

What is a Fluorine Eximer Laser?

- Uses "**Ex**cited D**imer**" lasing medium
  - Excited diatomic molecule- Inert gas/halogen
  - Halogen is Fluorine

Some Hazards of Pure Fluorine Gas

- Reacts violently and decomposes to hydrofluoric acid (HF) with moisture
- Fire fighting- Fires with fluorine as oxidizer only extinguished by shutting off source of fluorine. Water, CO2 add fuel to fire
- Immediately dangerous to life and health (IDLH) = 25ppm

Forms of Fluorine Used

- FFTB GAM
  - 1700 ppm premix of F2
  - 5% F2 Passivating Gas
- Lambda Physik
  - Pure F2 generated where needed

Worst Case Accident Scenarios

- Whole-bottle 5% F2 passivating gas release in FFTB
  - 300 yard FFTB area- 3 times FFTB area is affected > IDLH. Unacceptable, required mitigation. (credit to Joe Kenny/Ih Lin for these calculations)

SLAC ES&H Guideline "Safety Using Fluorine Eximer Lasers"

- Networking from International HEP Safety Forum
- Charles (Bill) Nuttall (CERN retired); Joe Kenny, Dr Maria Gherman, John Shepardson
- Hazardous Experimental Equipment Committee (HEEC) all of SLAC

SLAC ES&H Guideline (cont.)

- Other influences
  - Santa Clara County Toxic Gas Ordinance
    - http://www.ehinfo.org/content/0,4745,sid%253D11383%2526chid%253D15213%2526ccid%253D336101,00.html#TGO
  - Not required to follow the Toxic Gas Ordinance (TGO)
    - Not in county's jurisdiction
    - Designed for large quantity Silicon Valley high-tech manufacturing
      - Below the triggers for the TGO

SLAC ES&H Guideline (cont.)

- Devices reviewed by HEEC, guidelines provide resource for reviewers
- Proposals use guideline or be able to justify deviations

SLAC ES&H Guideline (cont.)

- Engineering Controls
  - Flow-restricting orifices to limit material released
  - Keep gas cylinders in a gas cabinets or well ventilated exterior location
    - Small door for adjusting the regulator
    - Large door for changing tanks
  - Ventilate the outside of the area surrounding the gas cylinder and laser cabinet that contains laser chamber.
  - Monitor ventilation with alarm

SLAC ES&H Guideline (cont.)

- Engineering Controls
  - Establish location and design to protect gas systems from physical damage
    - Out of path of heavy equipment
    - Design system to survive earthquake

SLAC ES&H Guideline (cont.)

- Engineering Controls (cont.)
  - Accessible gas system fittings- physical barrier to impede inadvertent loosening of fittings
  - Eliminate fittings entirely if possible
  - Due to reactivity of F2, take extreme care in manipulation and choice of materials

SLAC ES&H Guideline (cont.)

- Administrative Procedures and Signs
  - Post "Danger" signs
  - Alert Fire Department
    - Provide FD Tour
  - Turn off bottles when not in use
  - In event of gas system failure evacuate immediately
    - Turn off cylinders and regulators only if safe to do so without protective equipment

SLAC ES&H Guideline (cont.)

- Administrative Procedures and Signs (cont.)
  - Two people minimum working on toxic gas systems
  - Special precautions may be needed when using passivating gases
    - Evacuating excess staff from an effected area
    - Provide Safety or Security personnel to control area entry

SLAC ES&H Guideline (cont.)

- Personal Protective Equipment (PPE) for Fluorine Use
  - Gas proof goggles (unventilated)
  - Neoprene gloves

SLAC ES&H Guideline (cont.)

- First Aid
  - Eyewash located nearby but outside of potential exposure area
  - Calcium gluconate gel for use on skin- near the eyewash
    - Used to minimize additional damage from the HF

Equipment Design to Minimize the Hazards of F2 Use with Eximer Lasers

- Most problematic issue- Fluorine gas cylinders
  - Passivating gas – Higher concentration
  - Premix operating gas
  - Solution- Eliminate F2 gas cylinders through in situ (in-place) generation of F2

Equipment Design Approaches (cont.)

- Generate F2 gas in-place
  - Heat fluorine containing salt to generate F2 gas
  - Klystron Lab Lambda Physik- In-place


Krypton Gas (inert)
Lambda Physik
HaloSafe™ Unit
F2 Generator

Equipment Design Approaches (cont.)

- Some Lambda Physik Additional Safety Features
  - F2 sources generate only the amount of gas needed for the laser filling cycle
  - F2 is kept under negative pressure
  - F2 filter eliminates the F2 when not in use

Equipment Design Approaches (cont.)

- Advice
  - Buy the right equipment- In-place F2 generation
  - Reports suggest that there are older generation systems available for “free”
    - May want to consider total costs and safety aspects of these systems

More Information

- Safety Using Fluorine Eximer Lasers
  - http://www-group.slac.stanford.edu/esh/guidelines/fluorinelaser.pdf
- Santa Clara County Toxic Gas Ordinance
  - http://www.ehinfo.org/content/0,4745,sid%253D11383%2526chid%253D15213%2526ccid%253D336101,00.html#TGO
- Toxic Gas Ordinance at Stanford
  - http://www.stanford.edu/dept/EHS/prod/researchlab/lab/tgo/
- Lambda Physik- Information on Halosafe systems
  - http://www.lambdaphysik.com/script/content.asp?area=products&sitepages_id=47