University of California
San Francisco

# Cesium Irradiator Replacement Project

## Implementation at UCSF

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“We have radiators in all our vehicles, and they don’t pose much of a problem. What’s the issue?”

**~new UCPD officer at irradiator training**

# What is a cesium irradiator?

- Cesium irradiators contain Cs-137, a byproduct from nuclear reactors, within small sealed sources surrounded by lead shielding.



- At UCSF, they are used to irradiate...
  - blood products to prevent transfusion associated graft vs host disease.
  - mice to ablate bone marrow and generate bone marrow chimeras.
  - cells to induce senescence, study radiation therapy effects or DNA-repair mechanisms.
  - bone, teeth or vaccines for sterilization.

# Cesium irradiators carry significant risk

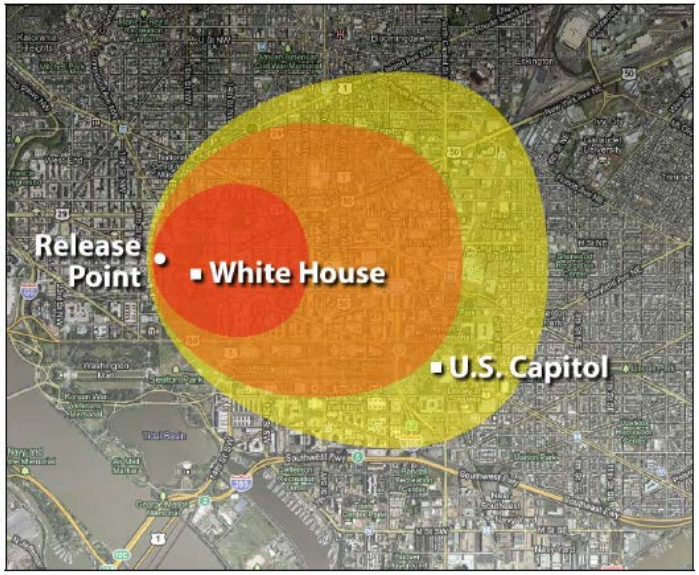
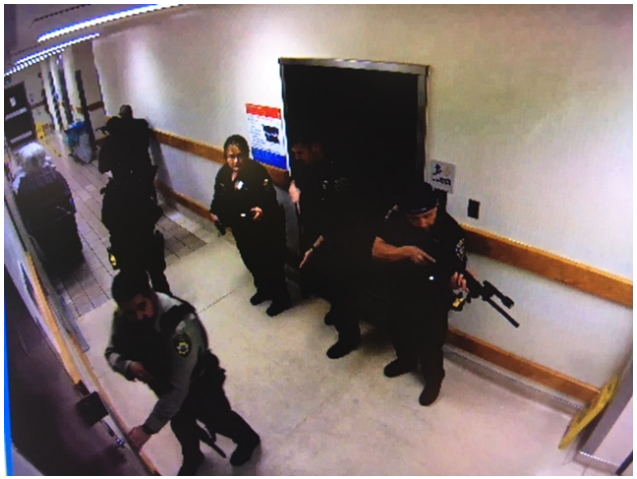


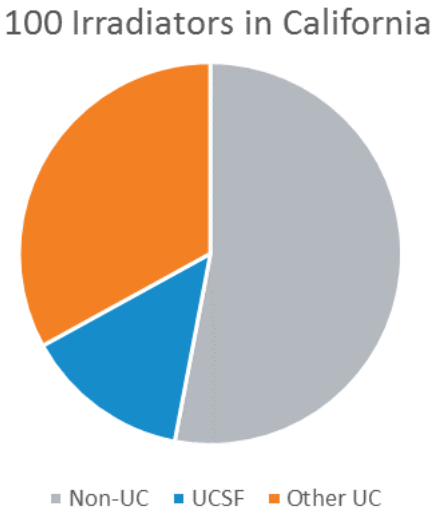

Image: Sandia National Lab, 1000 Curies Cs-137

- As a dispersible powder, Cs-137 is a terrorist target for a dirty bomb.
- The radioactivity in one cesium irradiator could significantly disrupt an entire city. For San Francisco, this is estimated to be ~$4 billion in economic damage.

- Extensive security measures are in place with UCPD and Radiation Safety to mitigate this risk.
- False alarms are triggered almost weekly, yet we remain at constant readiness.

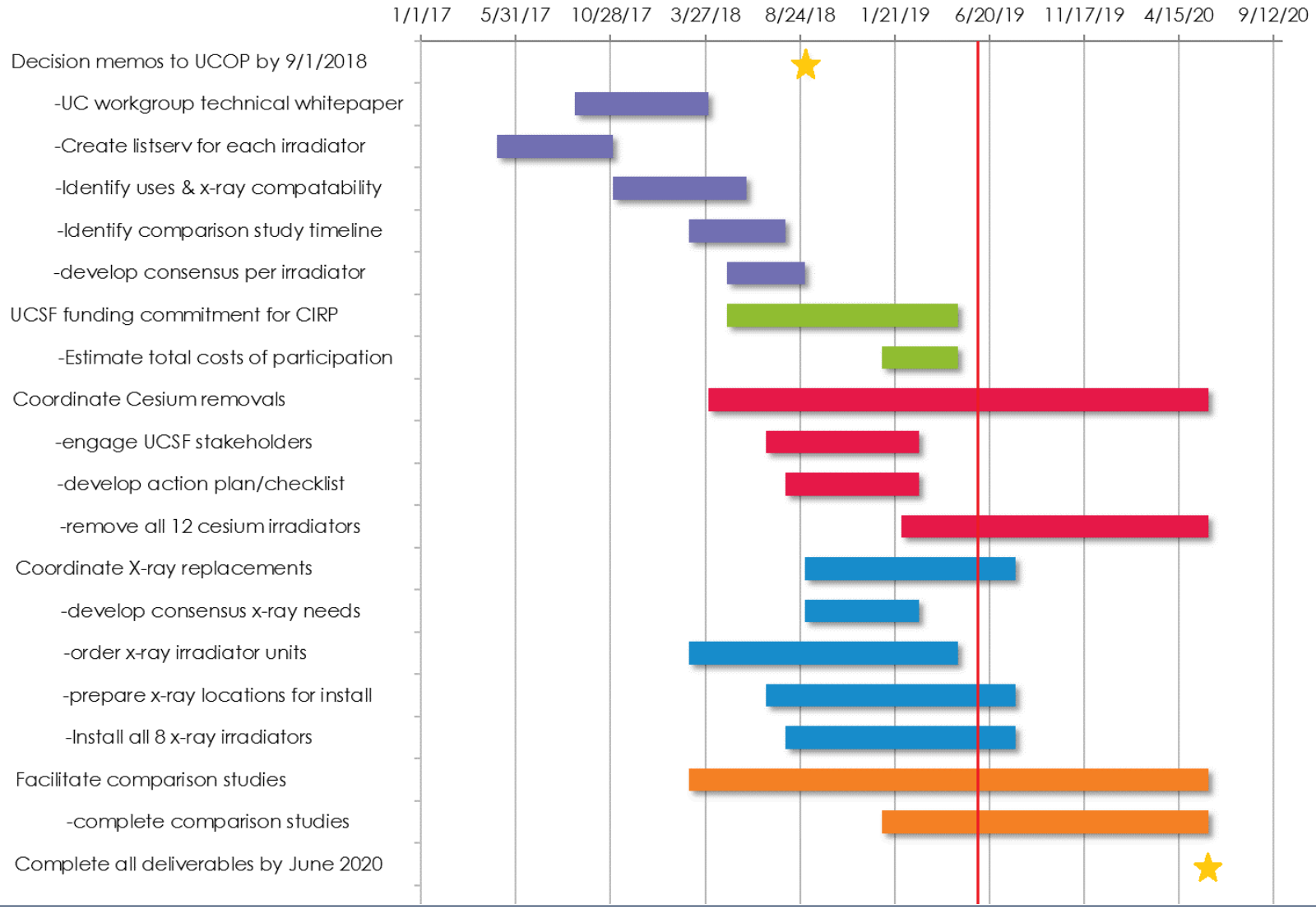


# Cesium Irradiator Replacement Project (CIRP)




- In 2017, the US Department of Energy, Office of Radiologic Security introduced a generous incentive program (CIRP) to pay the entire cost of cesium removal and disposal (~$250k value) and up to $135k toward an x-ray replacement.
- Janet Napolitano voiced her support for CIRP in letters to the UC Chancellors and Hospital CEOs in February 2018. She asked each UC to indicate interest by September 2018 and complete removals/replacements by June 2020.
- **UCSF's goal**: Remove all 12 cesium irradiators at UCSF, and maximize CIRP program benefits for x-ray irradiator replacements, by June 2020.

# UCSF CIRP Implementation Timeline



# Follow up and sharing lessons learned

Image: KIRO7 News (hyperlink)

- A stuck source in the blood bank irradiator forced us to cancel the removal and return a month later with a new strategy.
- On May 2nd, a similar stuck source at the University of Washington resulted in a breached source, contaminating 13 individuals and closing a 7-story animal research tower at UW Harborview Medical Center for months to years.
- Cesium removals are on hold pending investigation at UW and implementing lessons learned.

# Advantages of Transitioning to X-Ray Irradiators

- Elimination of the security risk with large radioactive sources that are easily dispersible and that may become used in terrorist attacks
- Elimination of the institution's liability in the event of a catastrophic release of radioactive materials in a dirty bomb
- Consistent irradiation not affected by the gradual decay in the activity of a radioactive source
- No Further need to recalculate exposure rates
- Easier access for foreign students
- Current difficulties in purchasing cesium irradiators

## Decrease or elimination of the Increased Control Program as the secure access and the regulatory requirements of 10 CFR Part 37 would not be necessary with an X-Ray Irradiator

- Security Access with the NRC/FBI fingerprinting and 7 years of reference checks
- Security Cameras and Video
- RMS-Remote Monitoring Systems
- Source Cables
- Motion Detection
- Biometric Security (Iris Scanners/Fingerprints/Facial Recognition)
- Security Response from Police Department and Radiation Safety
- Quarterly on-site alarm check and wipe tests
- Eventual Disposal Costs
- Constant problem solving for researchers
- Maintaining Records
- Annual Training for users
- Re-fingerprinting every 10 Years

# Disadvantages of X-Ray Irradiators

- Grants may be written and specific for the use of Cesium Irradiators
- Warm up time of an X-Ray tubes
- If unused for a week, warm up time may be as long as 60 minutes
- Researchers will need to calculate exposure comparisons between X-Ray and Cesium Irradiators
- Simultaneous irradiation of multiple mice is not always possible. Some irradiate only one to three animals at a time. All major X-ray irradiator companies have options to accommodate 11 mice in a rotating standard research pie plate.

# Comparison of Research Results X-Ray vs Cesium Irradiators

## Positives

- Performs adequately for Myeloablation in advance of bone marrow transplant procedures (NYU School of Medicine)
- Radiosensitive cells appear to respond without a threshold radiation dose
- Both X-ray and Cesium irradiation provide similar results with regard to long-term peripheral blood reconstitution after bone marrow ablation
- Modest and high doses of both Cs-137 and 320 kV can destroy large numbers of both bone marrow cells and splenocytes
- Throughput has increased compared to using the older cesium irradiators (NYU School of Medicine)

# Comparison of Research Results X-Ray vs Cesium Irradiators

## Negatives

- The 662 kev photon from the Cesium irradiator is difficult to replicate for response, homogeneity and penetration compared to the 160 to 350 kV from the X-ray irradiator
- Mice models are sensitive to very small changes related to penetration and homogeneity
- X-Ray Irradiation radiobiological effects of the mouse model will be difficult to translate and compare from the decades of Cesium irradiation results
- Many mouse models have used the Cesium irradiators for decades and the process is finely honed. This is particularly important in the leukemia models
- Cesium Irradiators are thought to be more effective in causing reconstitution deficits in both bone marrow and spleen
- Penetration depths as well as dose rates will be different between Cesium and X-Ray Irradiator
- Lower energy (soft) x-rays increase the superficial dose to tissues
- Irradiation with Cesium irradiator associated with lower overall morbidity in mice

# Animal and Cell X-Ray irradiator Companies

## Xstrahl

- **Cabinet X-Ray Irradiators**
  - X-Ray research irradiation chamber
  - Beam hardening filters to tailor maximum depth
  - Small footprint and easy access
  - MODELS
    - RS225
    - RS320
    - CIXD
      - Two X-ray tubes upper and lower with focal spots one meter apart
      - Three shelf specimen tray rack at beam center
      - Laser placement option

# Animal and Cell X-Ray irradiator Companies

## Precision X-Ray

### Cabinet X-Ray Irradiators

- X-Ray research irradiation chamber
- Beam hardening filters to decrease low energy x-rays to tailor maximum depth
- Small footprint and easy access
- MODELS
  - X-RAD Series ranging from 160 kV to 450 kV
  - X-RAD Series Custom Systems
  - X-RAD 320 is most popular

o 18-20 machines in California, 8 at UC Campuses

# Animal and Cell X-Ray Irradiator Companies

## Faxitron *US Based (Arizona)*

- Animal X-ray Irradiator
  - MultiRad $110-165K
    - Fully-Shielded
    - Turntable with programmable dosimete
    - Motorized specimen shelf
    - Multiple kV (160, 225,or 350)

- Cell Cabinet X-ray Irradiator
  - Cell Rad $65 K
    - Compact and can be placed on bench top
    - Self-Shielded

# Animal and Cell X-Ray irradiator Companies


## X-RAD

Specimen X-ray
Irradiation Systems

The X-RAD systems are self-contained X-ray irradiation systems for high and low dose radiation studies conducted in research laboratories.

High X-ray Peak Energies (160-450kV)

Proven & Reliable Technology

Gamma Source Alternative

Full line of options & accessories

PXi PRECISION X-RAY

# Animal and Cell X-Ray irradiator Companies


X-RAD320

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