Hopewell Designs, Inc.

Irradiators for Research, Therapy, and Blood Irradiation

By Robert Rushton & Dave Schettler

Introduction

- Focus on Cs-137 and Co-60
- Research irradiators – medical, materials, insect control
- Therapy irradiators – domestic & international
- Blood irradiators
- Issues on the shipment of radioactive sources
- Concerns about disposal after irradiators retired

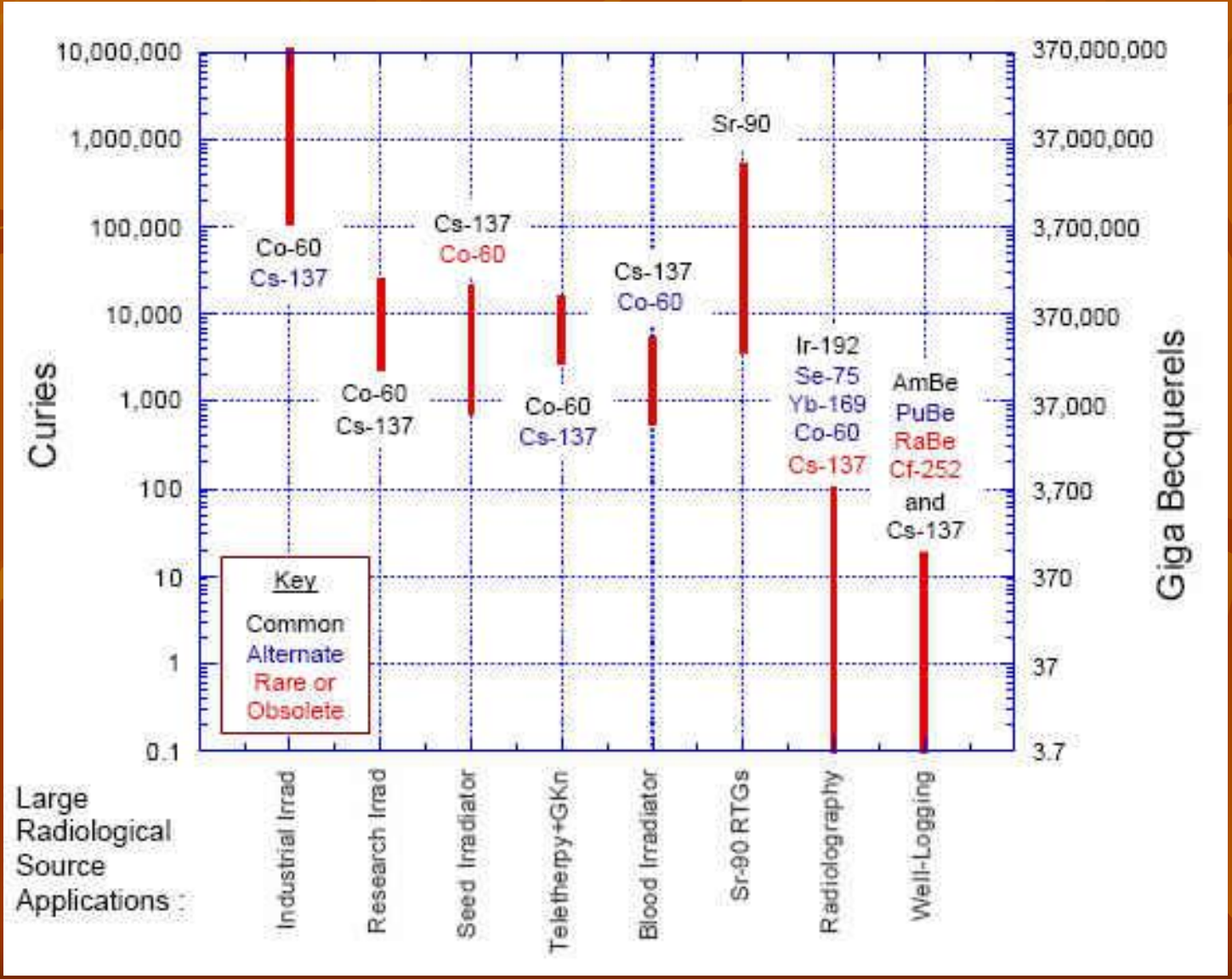
Background

- Hopewell Designs has recently introduced a line of research irradiators.
- Investigated needs and requirements with medical, industrial, and R&D customers
- Reviewed impact from potential elimination of Cesium Chloride

Overview of Irradiators

- Types of Irradiators
  - Calibration: exposure rates mR/hr - 1,000s R/hr
  - Blood: 150,000 R/hr
  - Teletherapy: 10,000 – 100,000 R/hr
  - Research: 10's R/hr to 100,000s R/hr
  - Sterilization: > 5,000,000 R/hr

Range of Sources in Irradiators



Quantity of Irradiators in USA

- Calibration: < 400 units, 1% of source acitivity
- Teletherapy: 200 units, 1% source activity
- Blood: > 600 units, 3% source acitivity
- Research: > 1000 units, 5% source acitivity
- Sterilization: 65 units, 90% source activity

- Cs-137 Volume: >100,000 TBq, 2.8 million Ci
- Co-60: >7 million TBq, 200 million Ci

Research Irradiators

- Self contained
- Old teletherapy units
- Open air
- Mobile
- Pool irradiators
- Open field

Types of Research Conducted

- Medical
- Materials
- Agricultural

Medical Applications

- Immunology,
- Stem cell research,
- Cancer research,
- In vivo immunology,
- Systemic drug research,
- Chromosome aberrations,
- DNA damage/repair,
- Human genome,
- Genetic factors, and
- Radiation metrology

Medical Research

- 100s of Hospitals & Universities
- Govt: NIST, FDA, CDC,
- Pharmaceutical Co
- Private industry

X-Ray Imaging and Irradiation

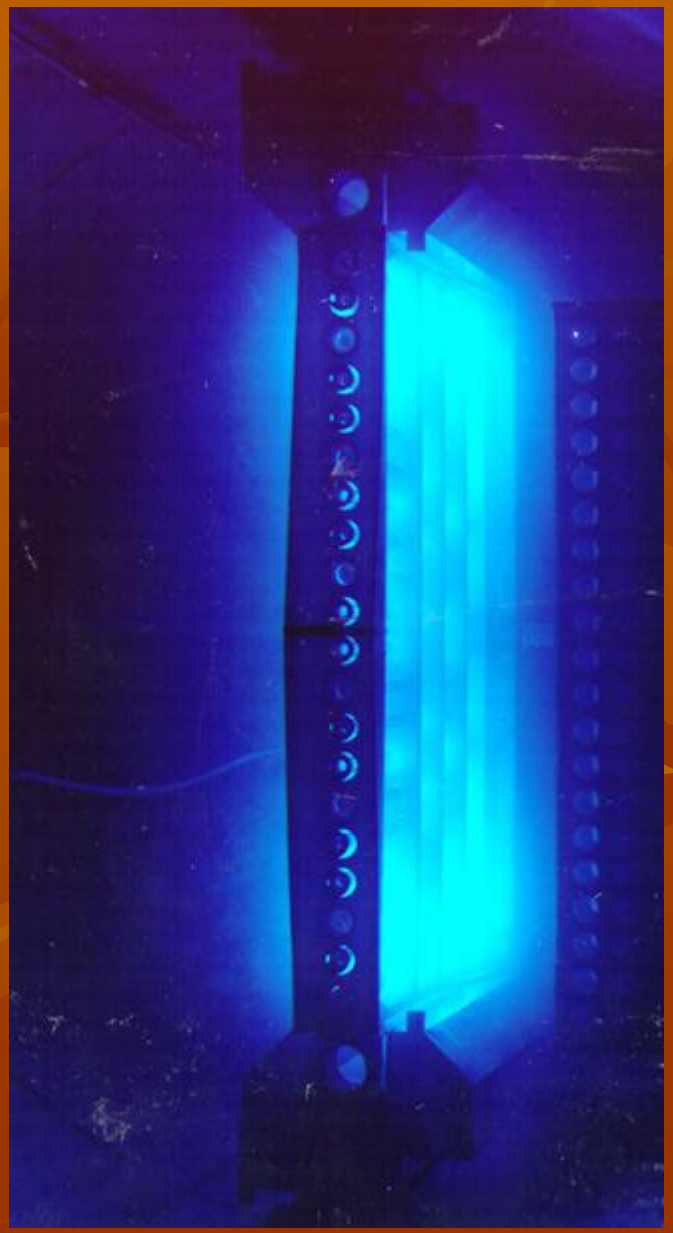
- Gulmay Medical SARRP
- Isocenter accuracy to 0.25mm
- On board cone beam CT and image reconstruction
- Minimum field size of 0.5mm diameter
- Gantry and robotic specimen stage enable non coplanar field arrangements

Materials

- Radiation resistance
- Circuit board design
- Polymer cross-linking
- Cellulose degradation – ethanol production
- Curing of epoxy resin
- Gemstone enhancement
- Soil remediation

Savannah River National Lab Irradiation Facility

- Multiple high level self-contained Co-60 irradiators
- > 1 megarad/hr rates
- Materials degradation
- Electronic circuit boards
- Space research
- Neutron activation analysis



Co-60 Irradiator, ANSTO Australia

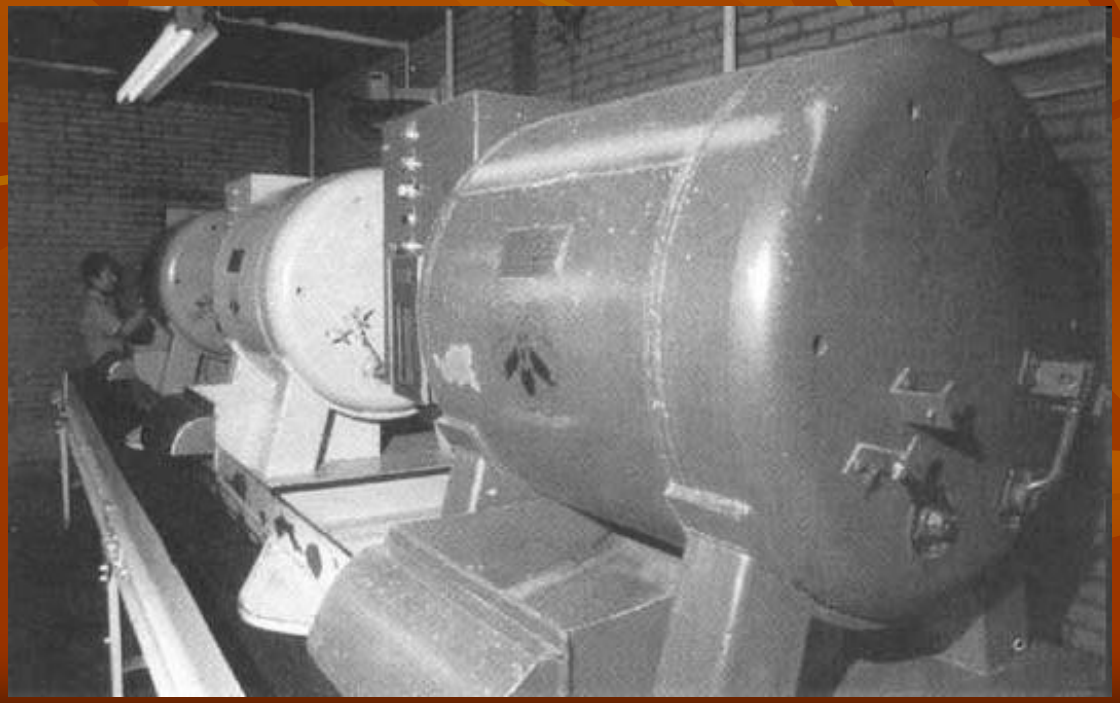
- Precision irradiations
- Validation / dose audit
- Seed mutation studies 10Gy
- Sterile insect technique 70 Gy
- Temperature controlled
- Blood irradiator calibration checks
- Long irradiations for polymer & degradation studies

Agricultural

- Insect sterilization for population control
- Seed irradiation to develop new cultivars
- Extended shelf-life for herbs, vegetables, meats

Insect Sterilization

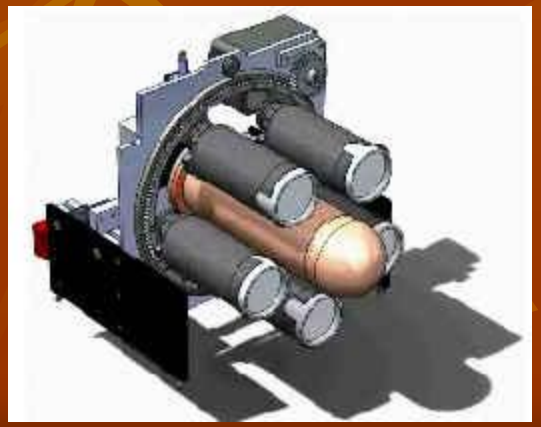
- Research began in 30s
- Implementation on screwworms in 50s
- Programs
  - Screwworm
  - Med. fruit fly
  - Melon fly
  - Pink bollworm
  - Gypsy moth
  - Tsetse flies
- Countries with programs
  - United States
  - Mexico Canada
  - Nigeria Zanzibar
  - Australia China



Screwworm Sterilization

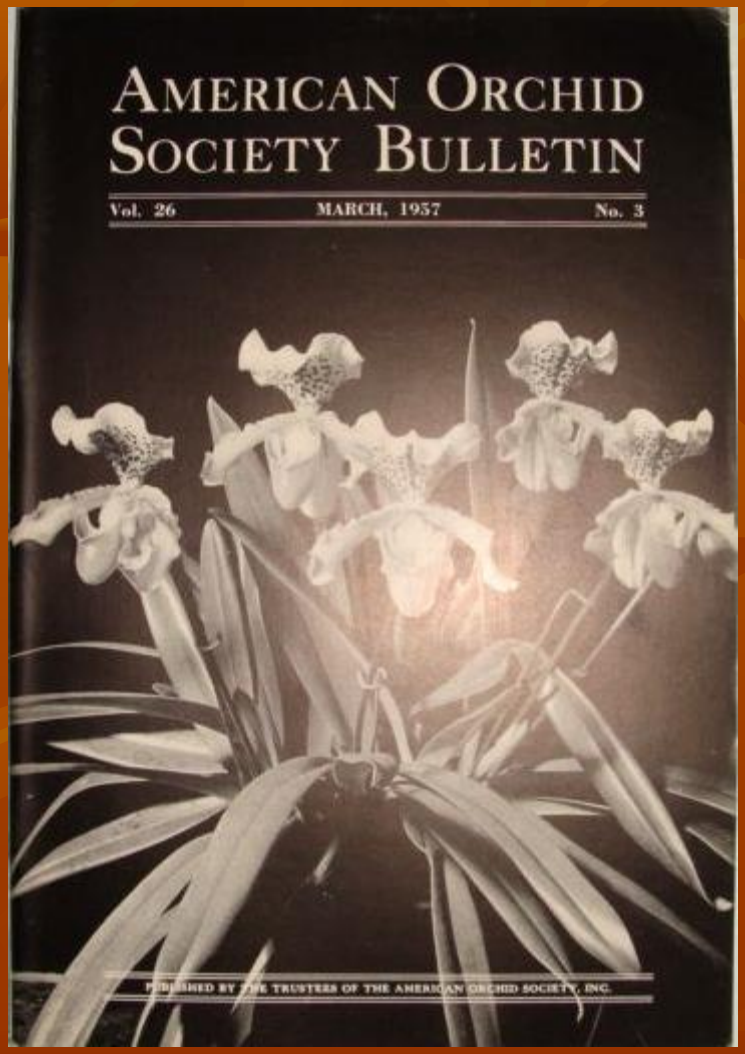
- Process > 15 million/week
- X-ray system in Mexico
- Cs-137 units in US, Mexico, Panama
- USDA Program
- Eradication in US, ongoing effort in Central America, Caribbean

X-Ray Insect Sterilization



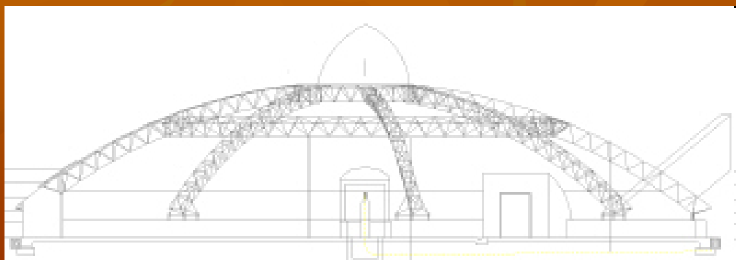
- New tube design gives 4 Pi geometry
- High dose rates of 0.4 megarad/hr
- Suitable for insect sterilization, materials research, other applications

Irradiation of Orchid Seeds



- Started as early as 1957 in US
- Ongoing activities in several Asian countries

Greenhouse Irradiators



- Malaysian Institute of Nuclear Technology
- Gamma Radiation and Nuclear Technology Center - Thailand
- New cultivars of orchids, chrysanthemums, other flowers

Japan's Institute of Radiation Plant Breeding

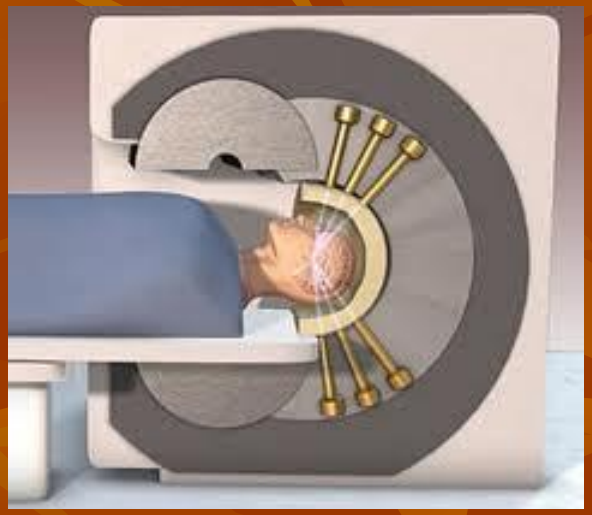
- Gamma Field
  - 200m dia field with 8m shielding wall
  - 2500 Ci Co-60 source
  - Long term exposures
- Gamma Room
  - 1200 Ci Co-60 source
  - Acute irradiation of seed, bulbs, tubers and scions.

Teletherapy Irradiators

- 1 –20k Co-60
- Gamma Knife in US
- In US, teletherapy replaced by linear accelerators
- Worldwide, 3,000 in use

Gamma Knife

- Precise delivery of dose via 200 Co-60 sources of nominal 30 Ci each
- Primarily for intracranial treatments



Co-60 Teletherapy Irradiators

- Co-60 most common type for international arena
- Pros: Simple to use, few parts to break
- Cons: Source shipments, disposal of old units

Blood Irradiators

- To prevent graft-vs.-host disease
- Approx. 15% of blood components irradiated
- Most are Cs-137, few X-ray units
- 700 irradiators in US
- 2000 – 7000 Ci Cs-137

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Characteristics

- Self-contained
- Majority are Cs-137, > 1,000 Ci
- Small footprint
- Deliver 25 Gy dose in nominal 5 min.

X-Ray Blood Irradiators

- No radiation sources and related security issues
- Comparable exposure times
- Still relative few compared to Cs-137

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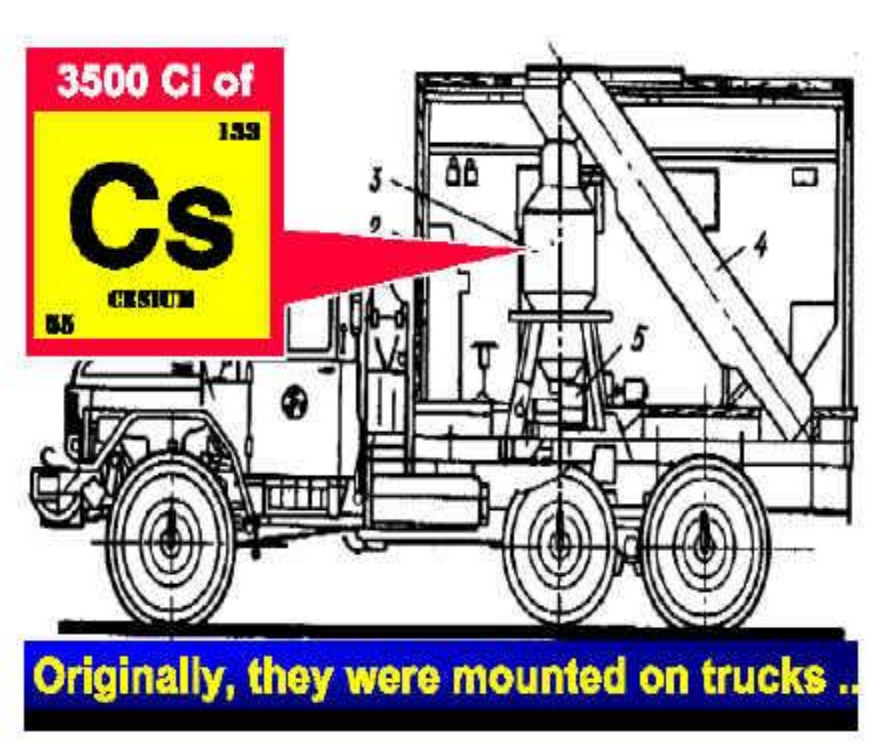
Shipment of Sources

- Rules, regulations, and concerns have changed significantly in last decade
- Many older casks are no longer licensed
- Few Type B casks available
- This issue will only worsen in next several years

In the Past - Mobile Irradiators

- 250,000 Ci Cs-137 or Co-60
- Mfg. in Argentina and China
- Primarily agricultural use
- Seed and crop irradiation

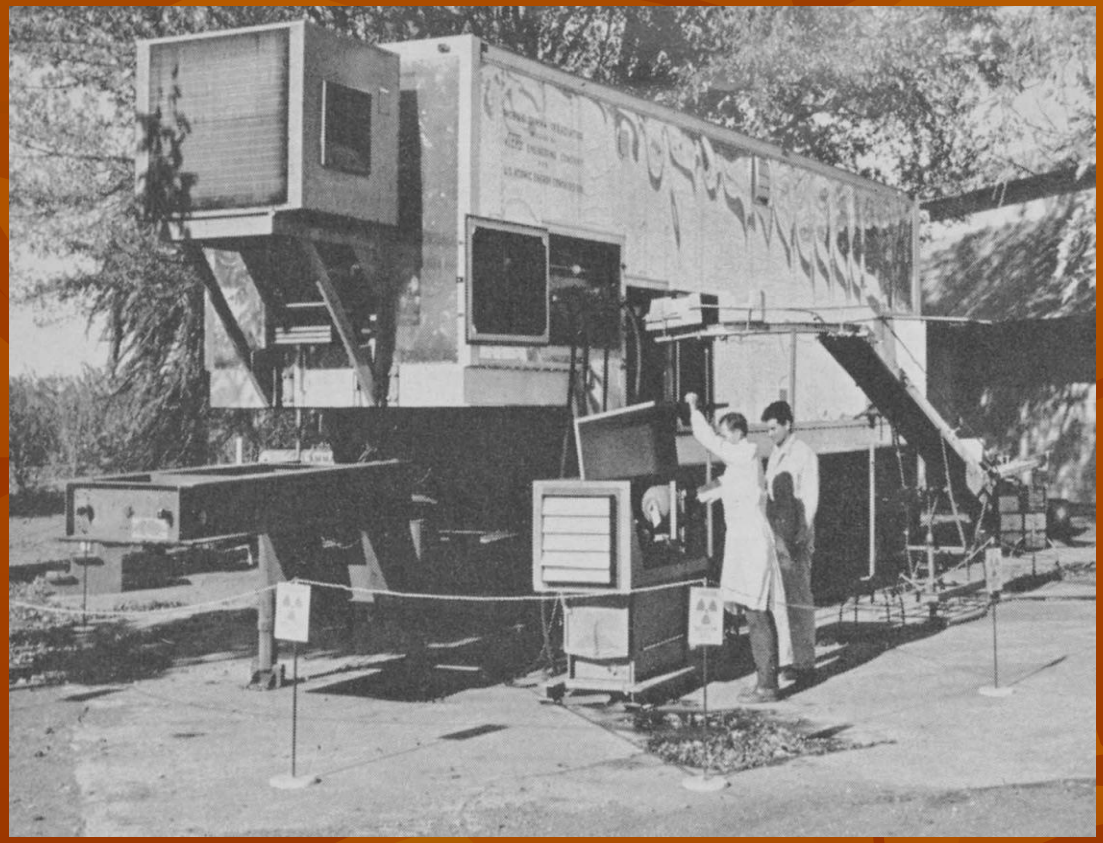
Seed Truck Irradiators



- Project Gamma Kolos
- In 1970s used through out USSR
- Seed irradiation of grains
- In spring to stimulate new varieties
- In fall to delay germination

Mobile Gamma Irradiator, USA

- Univ of Davis, California
- Built 1968
- 88,000 Ci Co-60
- Irradiated fruits, vegetables
- 700 lbs/hr to 200 kRad

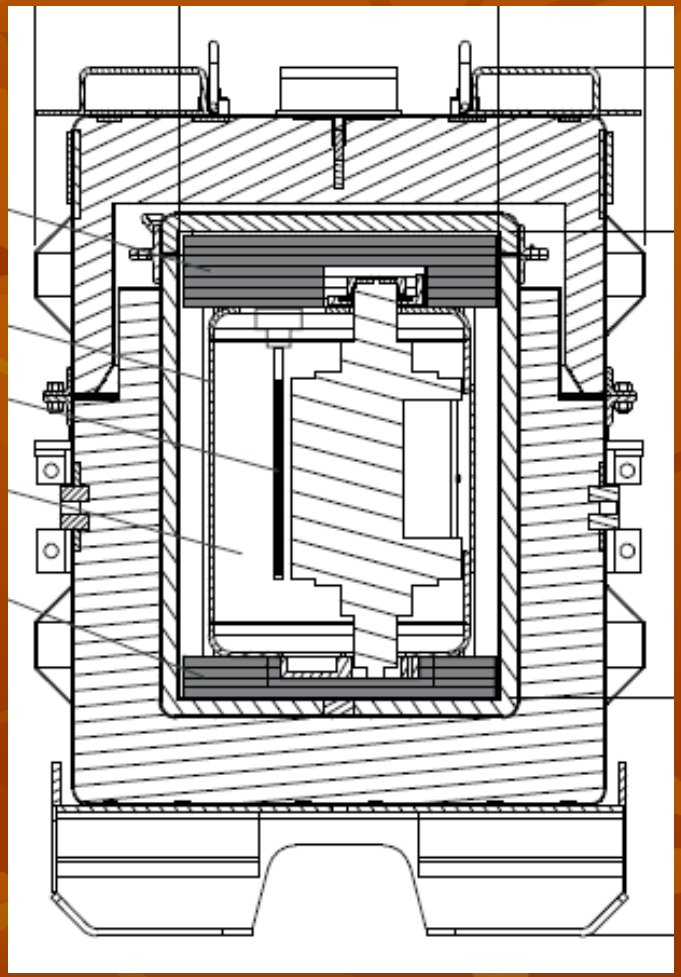


Shipment of Cs-137 & Co-60

- Older casks have lost their license, including overpacks
- Only a handful of casks and overpacks are available.
- Costs for shipment and cask rental can exceed cost of source.
- Disposal of old irradiators limited by availability of casks & overpacks

Licensing & Timetable

- For blood irradiators, Best Theratronics has overpack
- New casks and overpacks are in process, but no certain date for approval
- Cost for Type B cask licensing is prohibitive for small volume shipments



Irradiators in Retirement

- What happens when an irradiator is no longer used?
  - Recycled
  - Stored
  - Stored and forgotten
  - Orphan sources
  - Disposed properly

Recycled and Resold

- Teletherapy units often used as research irradiators
- Box calibrators resold
- Issues
  - Shipping of Type B is now much more difficult & expensive
  - New users require new radioactive materials licenses
  - Large international market for used irradiators

Stored, Sometimes Forgotten

- USSR Truck Irradiators, 100s made, < 50 accounted for
- Goiânia accident was a stored teletherapy head
- No easy disposal path, so storage is sometimes only option

LANL
Off-Site Source Recovery Project

- Mission: to remove excess, unwanted, abandoned, or orphan radioactive sealed sources that pose a potential risk to health, safety, and national security
- Website: osrp.lanl.gov

OSRP Overview

- Recovered 22,800 sources from more than 800 sites
- United States and international work
- Focus is on large activity (>200 Ci) sources
- Register with OSRP to dispose of sources
- OSRP can offer guidance on commercial disposal paths as well

Conclusion

- Cs-137 & Co-60 are essential in research, therapy, and blood irradiation
- Issues involving security, shipping, and disposal have potential negative impact on usefulness of these irradiator systems
- However, radioactive isotopes continue to provide many benefits to diverse applications

Thanks
and
Questions?