Irradiation as a Phytosanitary Treatment: a Global Solution

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- A bit of history
- International standards
- Characteristics of phytosanitary irradiation
- Global use of phytosanitary irradiation
- The contribution of the Joint FAO-IAEA Division
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Earliest suggestion of irradiation as a phytosanitary treatment ?

Kiyoshi Koidsumi

Quantitative studies on the lethal action of X-rays upon certain insects

J. Soc. Trop. Agriculture 1930 2: 342-363

In the Island of Formosa, a large number of fruits and vegetables such as Citrus, Mango, Bamboo-shoot, Cucumber, Melon, Luffa etc. are damanged in a considerable degree by many species of fruit fly, *Dacus*. These larvae hatching from eggs laid on these plants damage them very considerably. The killing of any stages of these insects which are parasitic to these plants, as they are contained in plants themselves or in a package to be exported, has a very important significance in the exportation of the plants.

It was the purpose of the author to destroy them within fruits or vegetables or packages which contained insects by means of X-ray radiation, and it was developed that a certain intensity of rays killed such naked insects as were not covered with any objects during any stages of development. I first determined the purely scientific relation of the rays to the death of the naked insects. This article will deal with the obtained results, of interest from a scientific point of view.

Milestones

1980:
Joint WHO-FAO-IAEA Expert Committee on the Safety of Irradiated Food:

Irradiated food pose no toxicological, microbiological or nutritional hazard

1986:
US FDA approves irradiation up to 1 kGy for preservation and disinfestation of fresh fruits and vegetables

1990s:
First regular commercial shipments of irradiated fruit from Hawaii

2002:
USDA APHIS establishes regulations providing for use of irradiation as a phytosanitary treatment for imported fruit and vegetables

Development of international standards

International Plant Protection Convention (IPPC)

Multilateral treaty under the Food and Agriculture Organization (FAO)

• ISPM 18 (2003): Guidelines for the use of irradiation as a phytosanitary measure

Technical guidance on procedures for the application of ionizing radiation as a phytosanitary treatment for regulated pests or articles

• ISPM 28 (2007): Phytosanitary Treatments for Regulated Pests

Requirements for submission and evaluation of the efficacy data for a proposed phytosanitary treatment

Annexes: treatments adopted by the Commission on Phytosanitary Measures (CPM).

Development of international standards

Annexes
ISPM 28

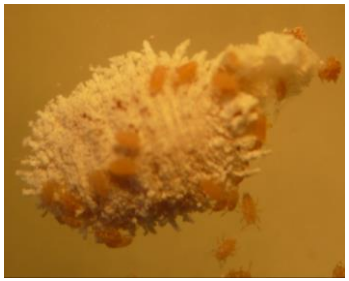
01 (2009)	Irradiation treatment for Anastrepha ludens
02 (2009)	Irradiation treatment for Anastrepha obliqua
03 (2009)	Irradiation treatment for Anastrepha serpentin
04 (2009)	Irradiation treatment for Bactrocera jarvisi
05 (2009)	Irradiation treatment for Bactrocera tryoni
06 (2009)	Irradiation treatment for Cydia pomonella
07 (2009)	Irradiation treatment for fruit flies of the family Tephritidae (generic)
08 (2009)	Irradiation treatment for Rhagoletis pomonella
09 (2010)	Irradiation treatment for Conotrachelus nenuphar
10 (2010)	Irradiation treatment for Grapholita molesta
11 (2010)	Irradiation treatment for Grapholita molesta under hypoxia
12 (2011)	Irradiation treatment for Cylas formicarius elegantulus
13 (2011)	Irradiation treatment for Euscepes postfasciatus
14 (2011)	Irradiation treatment for Ceratitis capitata

Development of international standards

Most recent approval of irradiation treatment by the TPPM (week March 16, 2015)

3 mealy bugs : *Dysmicoccus neobrevipes, Planococcus lilacinus and Planococcus minor (Pseudococcidae)*

Minimum dose: 231 Gy



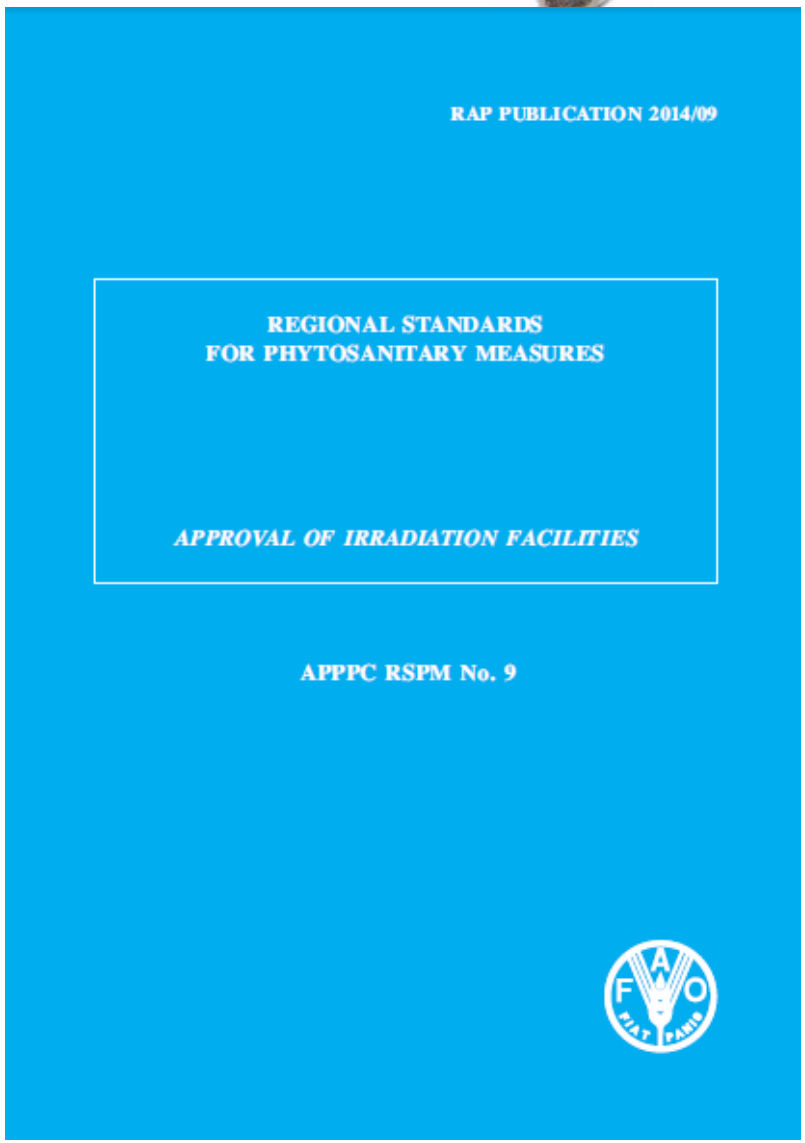
Possible implication subject to APHIS approval:

Dragon fruit from Vietnam could be irradiated at 231 Gy minimum instead of the current 400 Gy because the only pests on the Pest Risk Analysis were these three mealybugs and three fruit flies that require only the 150 Gy generic dose for Tephritidae.

Development of international standards

Approval of Irradiation Facilities

- Endorsed in 2013 by the Asia and Pacific Plant Protection Commission (APPPC)
- Submitted to the IPPC



http://www.fao.org/docrep/019/i3707e/i3707e.pdf

Specifics of irradiation vs. other phytosanitary treatments

- Irradiation does not necessarily result in immediate mortality of target pests.

- Possible effects of irradiation for phytosanitary purpose:

  1. Sterility: target pest alive and may develop to maturity but unable to fly

  2. Inability to emerge or fly: successful development is disrupted. Target pest alive but unable to develop to full maturity (emergence, flight)

  3. Inactivity or devitalization (seeds may germinate but seedlings do not grow)

  4. Mortality: target pest is killed, immediately or after a delay

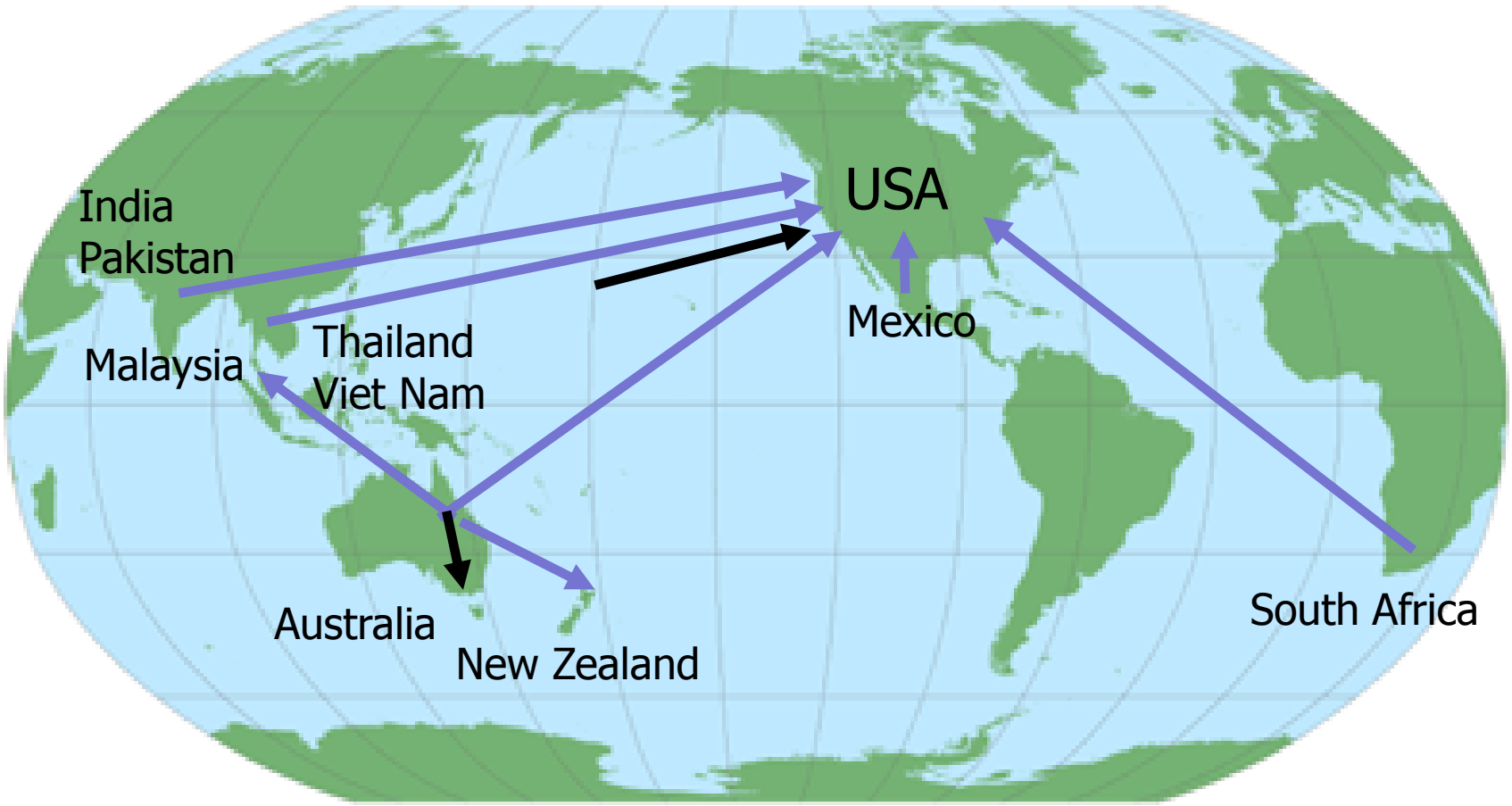
- Products that have been properly irradiated and satisfy quarantine requirements may still contain live pests.

- Ensuring that the treatment has been properly applied is essential.

Advantages of phytosanitary irradiation

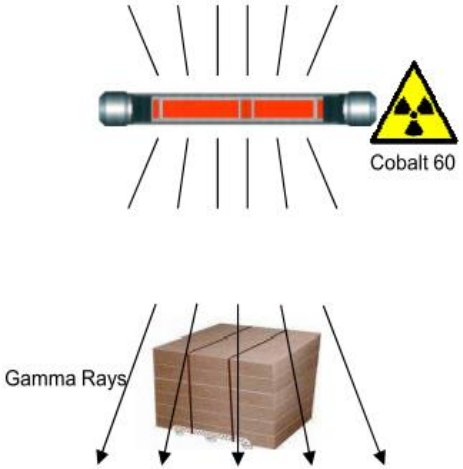
- A non-chemical process, effective and quick
- Applicable to a broad range of products with no or marginal loss of
  - sensory qualities
  - nutritional qualities
- Possibility to use *one fits all* minimum doses (generic doses)
- Tolerance (maximum dose applicable) depends on
  - Species
  - Variety
  - Maturity at time of irradiation
  - Combination with other treatments
- Extends shelf-life in some cases
- Simultaneous inactivation of parasites ?

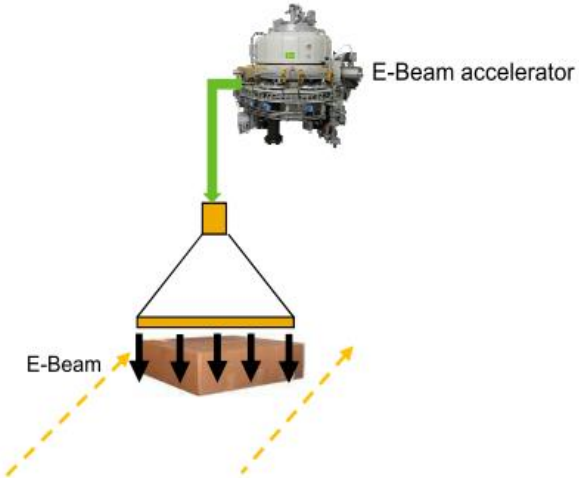
Trade of produce irradiated for phytosanitary purpose

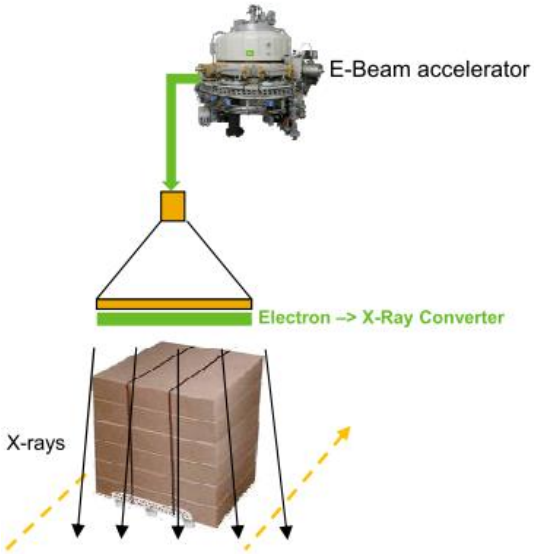


Global volume 2013 ~ 20,000 tons

Technologies used for phytosanitary irradiation







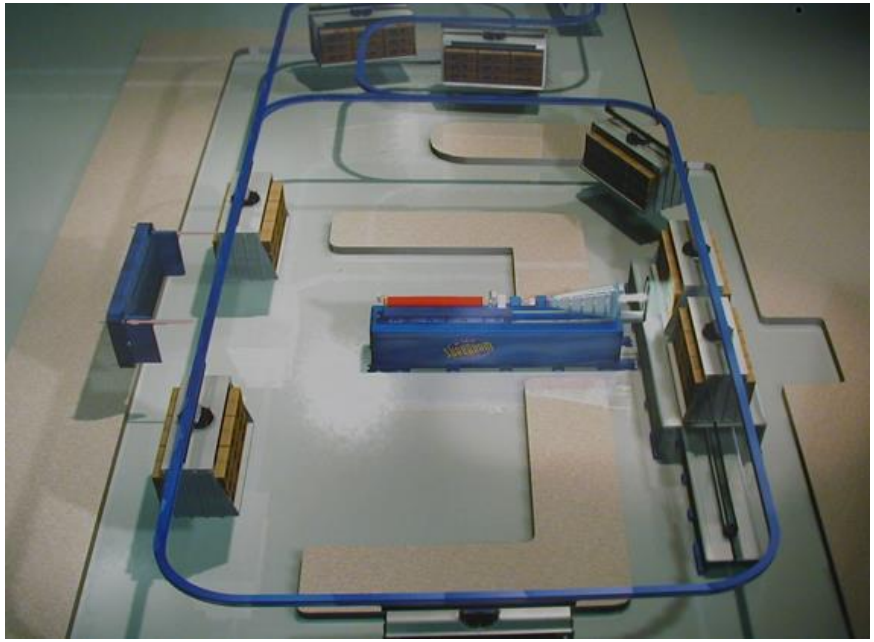
Gamma irradiation **Electron accelerators** **X-Ray machines**

Credit: IBA

X Ray irradiation facility used for phytosanitary treatments

- USA
  - Hawaii Pride – since 2000

    Surebeam system – Linac 5 MeV



Electron beam irradiation facilities used for phytosanitary treatments

- Asia-Pacific
  - Vietnam
    - SonSon Corporation

Credit: NCEBR

- Americas
  - USA
    - National Center for EB Research, College Station, Texas
    - Sadex Sioux City, Iowa

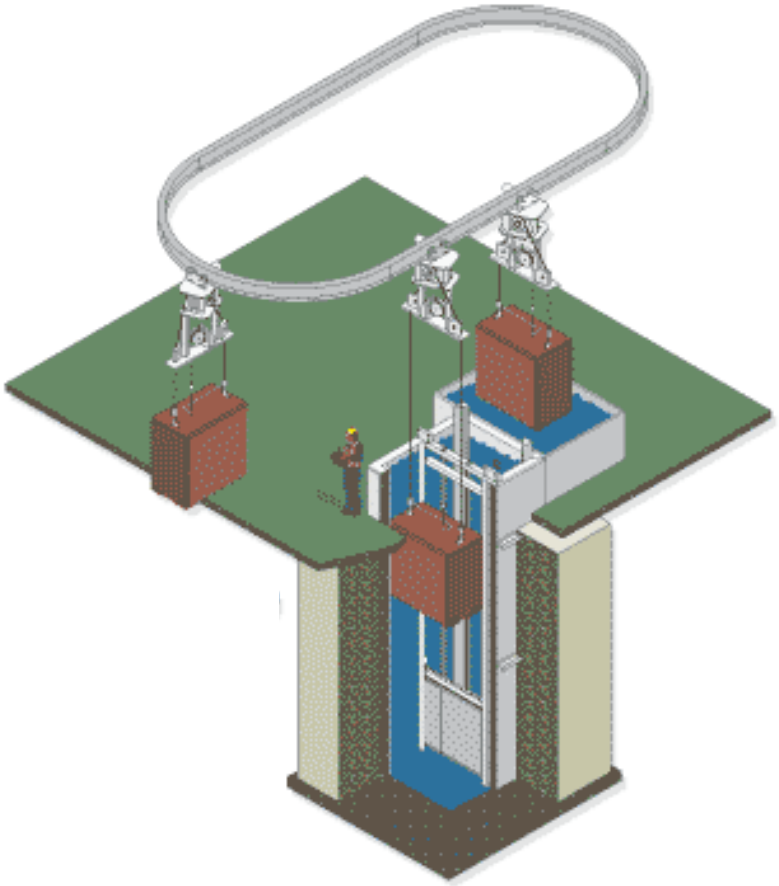
Gamma irradiation facilities used for phytosanitary treatment (1/2)

Credit: Steritech

- Asia-Pacific
  - Australia Steritech, Queensland – Multipurpose
  - India Krushak, Lasalgaon, Maharastra – Food only
  - Thailand Thai Irradiation Centre, Bangkok - Multipurpose
    Synergy Health, Chonburi - Multipurpose
  - Vietnam Anphu, Ho Chi Minh City - Multipurpose

Gamma irradiation facilities used for phytosanitary treatment (2/2)

- Africa
  - South Africa
    - HEPRO, Cape Town – Multipurpose
- Americas
  - USA
    - Gateway, Gulfport, Mississipi
    - Pa' ina, Hawaii – since 2013
  - Mexico
    - Benebion, Guadalajara
    - Sterigenics, Mexico City - Multipurpose



Credit: Graystar

Project of phytosanitary irradiation facility in China

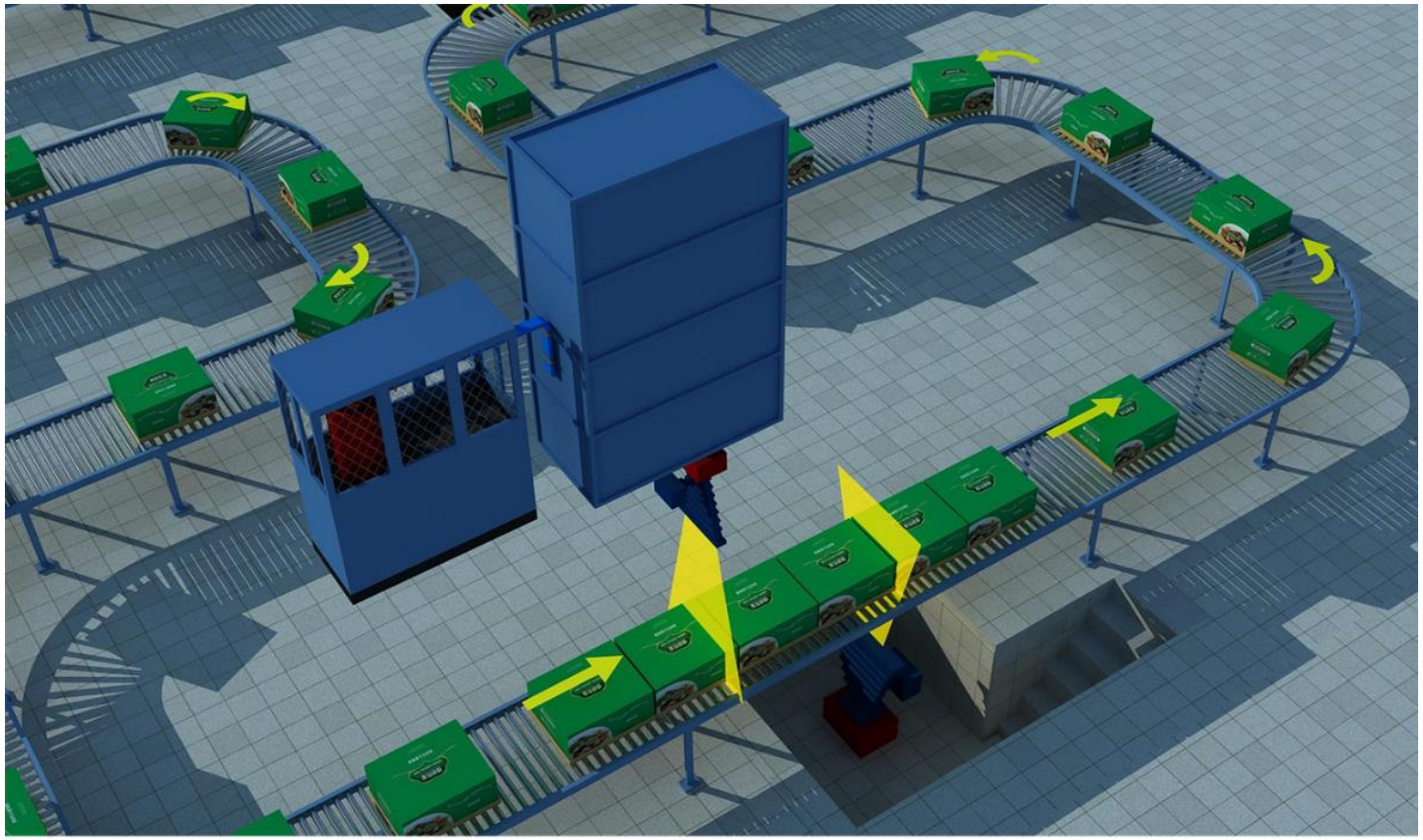
Phytosanitary irradiation has been tested since 2008

In 2015 an EB facility in Pingxiang, Guanxi will treat fruit imported from Vietnam

Project of phytosanitary irradiation facility in China

2 accelerators 7.5 kW – 10 MeV

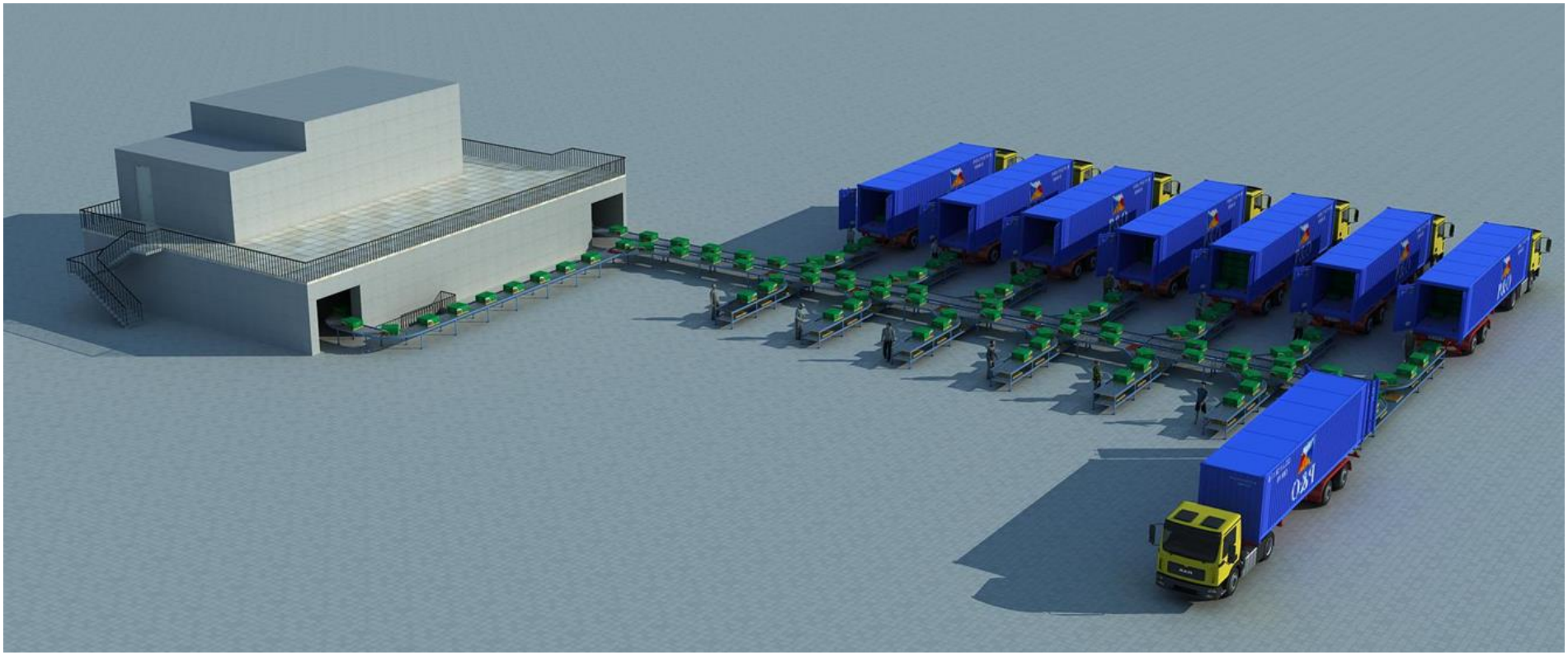
Irradiation from top + bottom



Project of phytosanitary irradiation facility in China

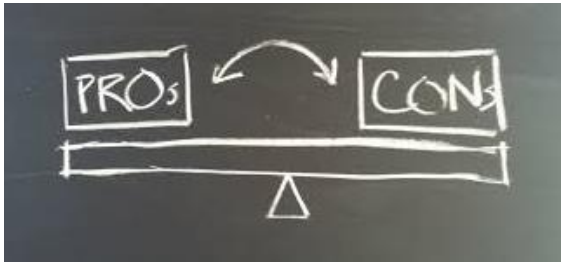
Planned irradiation capacity: 100,000 tons / year

2 x 7 feeding lines



Point of irradiation

Country of origin vs. Country of destination



Minimum phytosanitary risk

Technical factors
- Availability of an approved irradiation facility
- Dimensions of packages that can be irradiated
- Time available between harvest and irradiation

Cost factors
- Logistics cost
- Inspection cost
- Irradiation cost

Contribution of the Joint FAO-IAEA Division

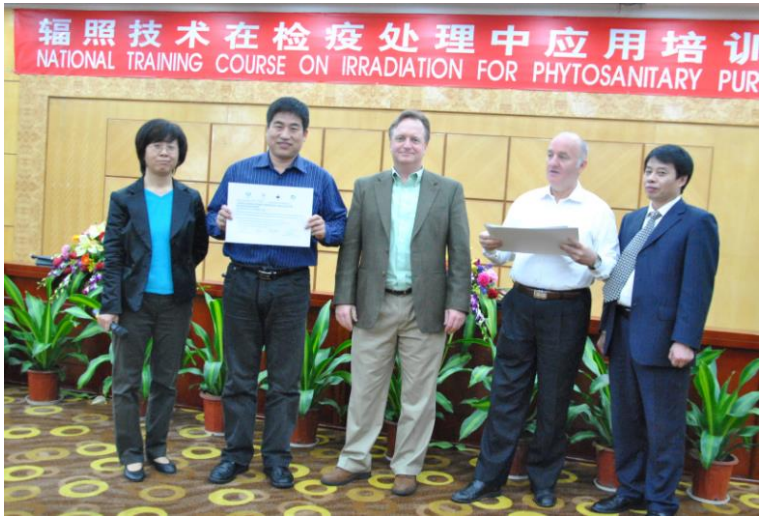
- **Dissemination of information on phytosanitary applications**

  - Technical report to be published in 2015 ***Good Practice in Food Irradiation***

  - E-learning course to go live in April 2015.

Both will be available in Spanish

- Training and workshops



Next one: 5-7 October 2015, Mexico City for Caribean and Latin America

Contribution of the Joint FAO-IAEA Division

- Participation to the development of international standards
- Several Coordinated Research Projects on Phytosanitary Irradiation.

Latest (2009-2014):

The Development of Generic Irradiation Doses for Quarantine Treatments

- 15 participating countries
- 38 species studied of which 13 fully completed using very large numbers of insects in confirmatory tests required to validate treatment efficacy.
- Will lead to propose some generic doses including one of 250 Gy for all mealybugs on all hosts (second most important pest group according to Pest Risk Analyses)
- Results to be published in a special issue of *the Florida Entomologist*

http://www-naweb.iaea.org/nafa/fep/crp/4thRCM-FINAL-22Aug2014.pdf

- Initiatives to facilitate the use of EB and X-ray machines.

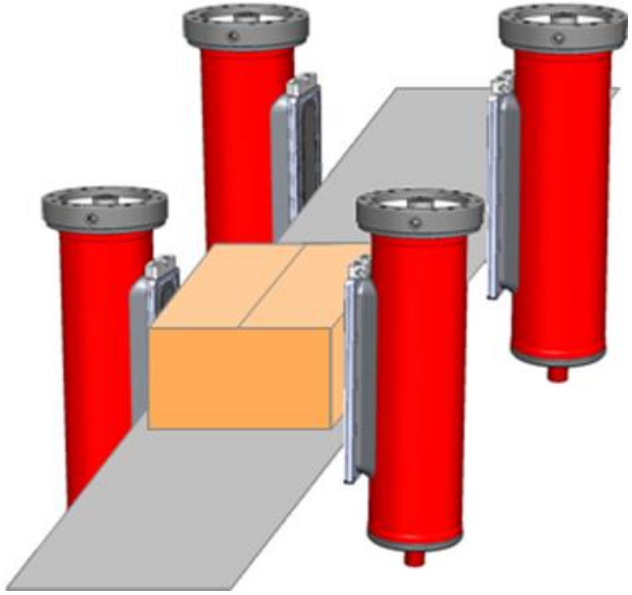
Experimental facilities

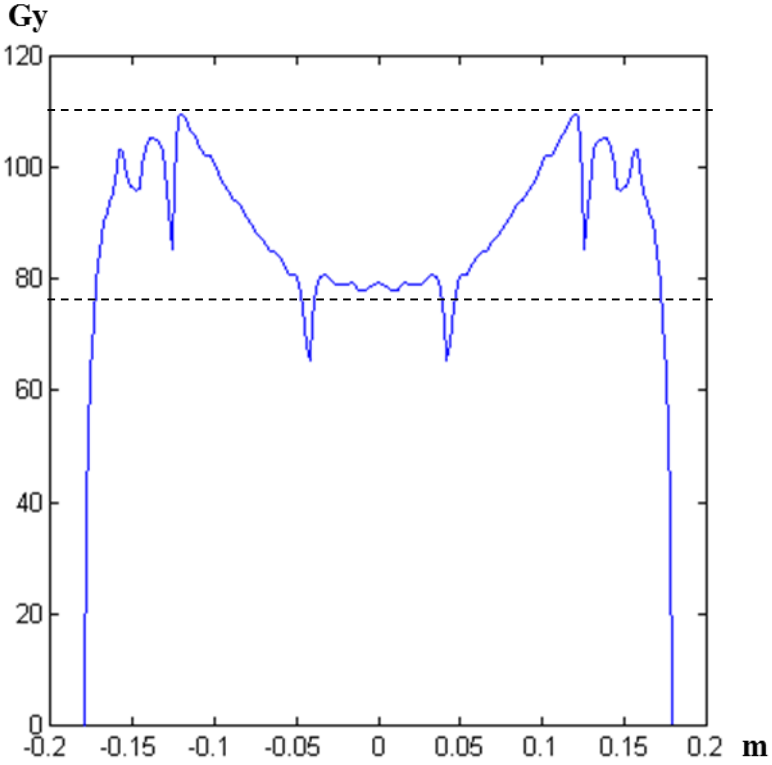
GammaCell using cobalt-60

X Ray irradiator

New technologies being studied for phytosanitary irradiation

Low energy X ray





Dose distribution in a carton of papaya

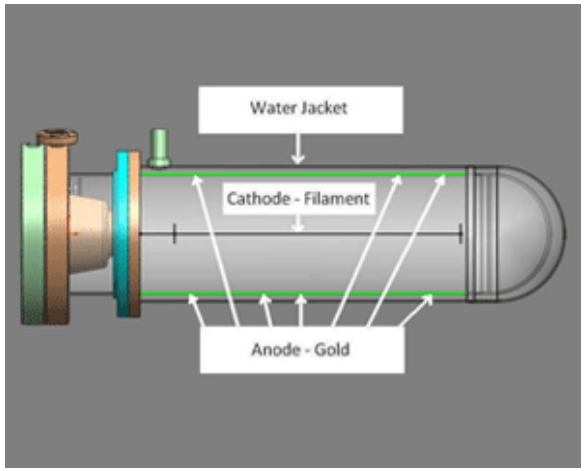
180 keV - 4.5kW – 10 cm/min conveyor speed

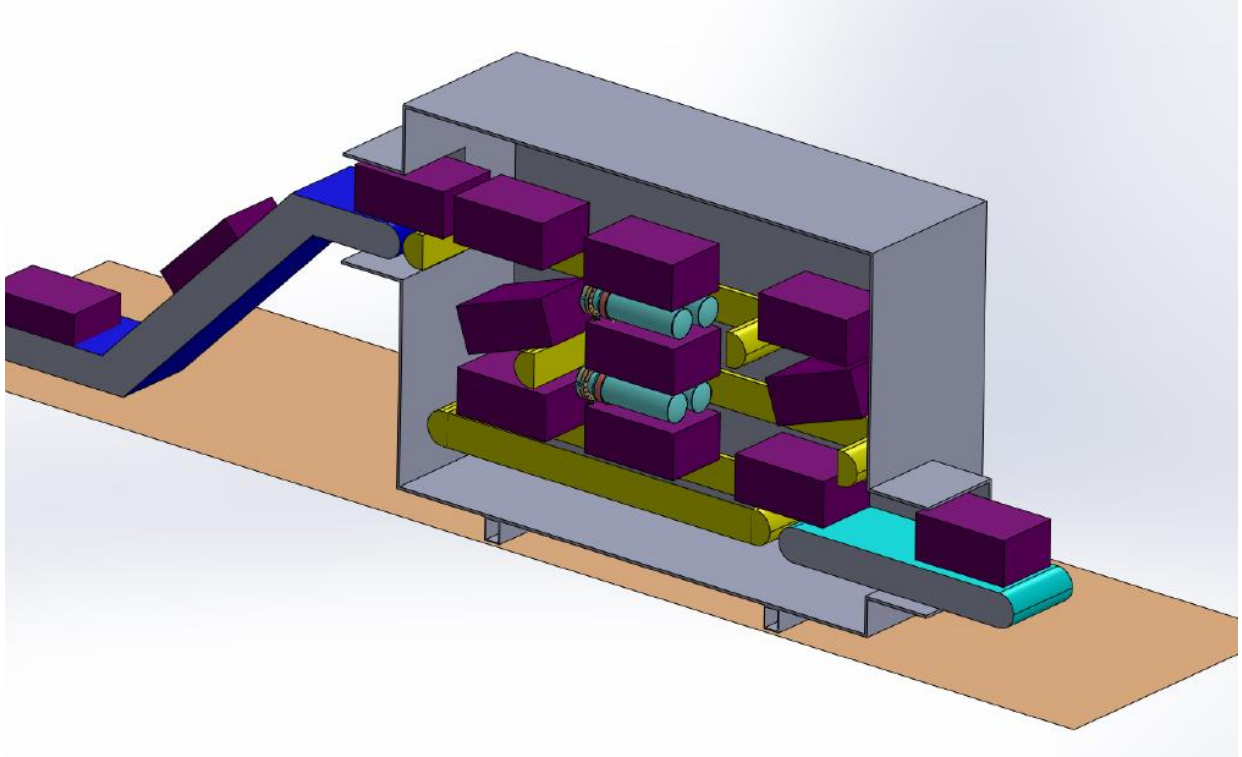
DUR: 1.4

Credit: USDA-ARS Hawaii and Comet

New technologies being studied for phytosanitary irradiation

Low energy EB





Credit: Applied Energy Devices

Marketing irradiated food products

Irradiated products do sell

USA

France

New Zealand

China

Peru

Thailand

Consumers' acceptance less of an issue than retailers' acceptance