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Prospect of Nuclear Applications for Sustainable Development and Welfare

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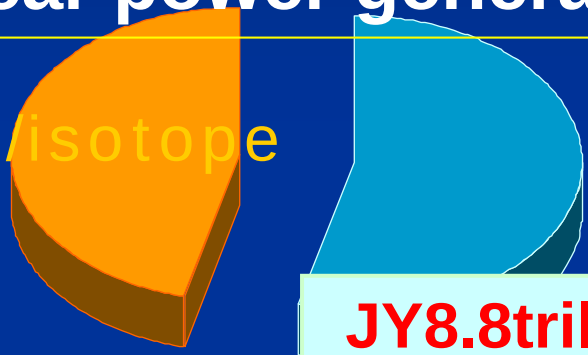
Talking Points

1. Industrial application of radiation processing
2. Nuclear techniques for sustainable agriculture
3. Radiation application for environmental protection
4. Nuclear techniques for better healthcare
5. Roles of IAEA for nuclear applications

Economic Scale of Nuclear Technology of Japan in 2005

Radiation/isotope is competitive with nuclear power generation



JY8.8trillion (US$84b)

Power generation

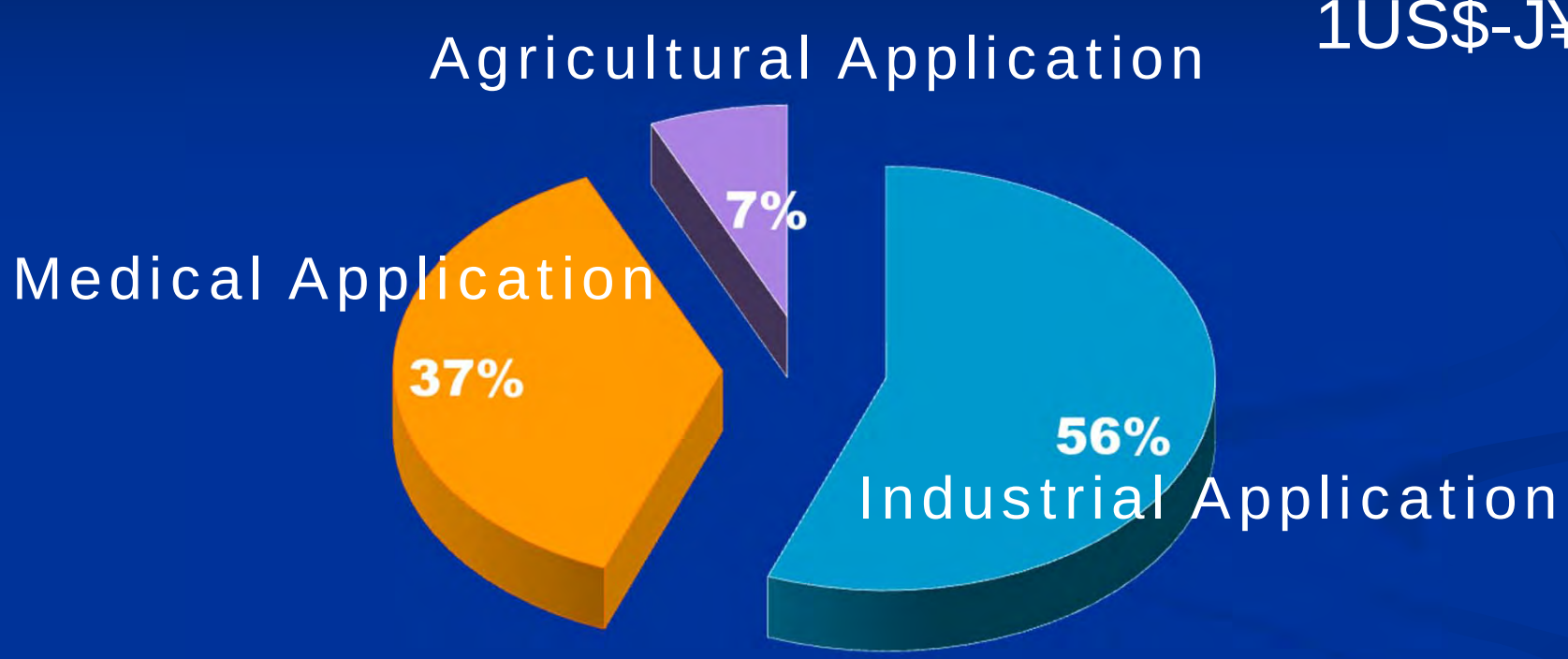
1US$-J¥95.4

Industrial Application US$ 21.9 Billion
Medical Application US$ 14.7 Billion
Agricultural Application US$ 2.7 Billion

Published by CAO

Total economic scale of radiation and isotope application of Japan in 2005: JY4.11trillion (US$39.3Billion)

1US$-J¥95.4



Industrial Application J¥ 2.295 Trillion: US$ 21.9 Billion
Medical Application J¥ 1.537 Trillion: US$ 14.7 Billion
Agricultural Application J¥ 0.279 Trillion: US$ 2.7 Billion

The 1st IAEA Conference on “Large Radiation Source” was held in Poland in 1959

IAEA was established in 1957 being based on President Eisenhower's “Atoms for Peace” Speech

Industrial Applications of Nuclear Technology

- Radiation processing for value added products and environmental protection
- Nucleonic control system for efficient process
- Non-Destructive Testing

Radiation Processing Applications in Industry

- 1. Polymer modification
- 2. Sterilization of medical supplies and food packaging
- 3. Food irradiation
- 4. Ion implantation for semi-conductor production
- 5. Environmental protection

Radiation Processing of Polymers

- Cross-linking
  Graft-polymerization
  Polymerization
  Degradation

- Advantages:
  - Room temperature processing
  - No catalyst → pure products
  - Processing in solid state molded product
  - High speed processing (EB)

Polymer Modification by Radiation

Crosslinking of rubber to control flow properties

Memory Effect by cross-linking

Automobile tires

Heat shrinkable tubes and sheets

Commercially produced cross-linked or grafted polymers by radiation processing – 1

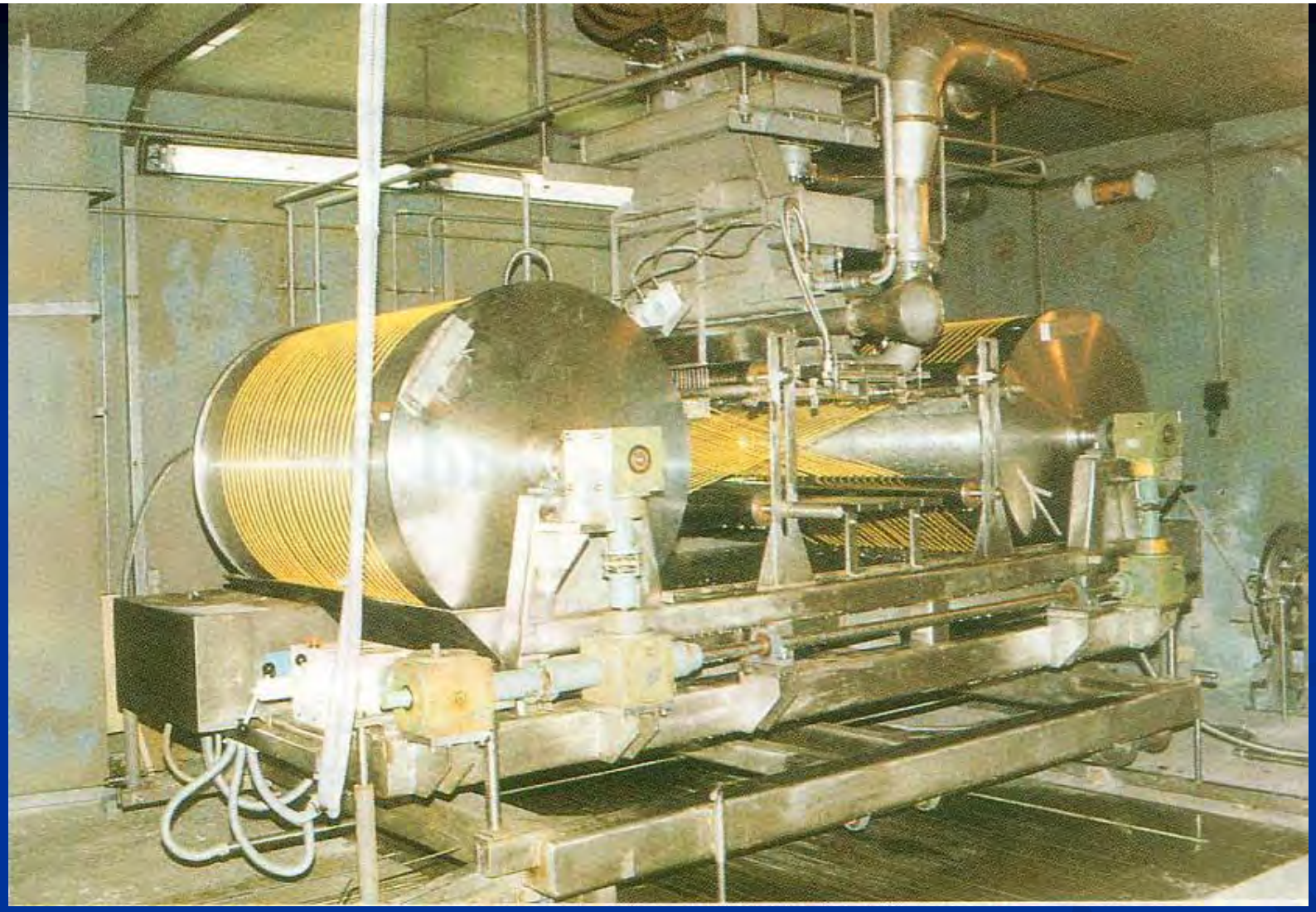
Products	Applications
Cross-linked polyethylene and PVC	Wire insulation resistant to heat and chemicals, pipes for hot water of heating systems
Cross-linked foamed polyethylene	Insulation, packing, floating materials
Heat shrinkable tubes and sheets	Food packaging, wire insulation, protection of welding for corrosion
Cross-linked rubber sheets	Automobile tires (high quality)
AA grafted PE film	Battery separator

Commercially produced cross-linked or grafted polymers by radiation processing – 2

Products	Applications
Cross-linked nylon	Automobile parts resistant to heat and chemicals
Super heat resistant SiC fiber	Metal and ceramic composites,
Vulcanized natural rubber latex	Fingerstall （Malaysia）
Cross-linked hydrogel	**Wound dressing**
Curing of paints/inks	**Surface coating/printing**
Grafted PE fiber	**Deodorant**

Electron Accelerator for Radiation

- Advantages:
  - High processing speed and capacity
  - No source replenishment required
  - Short penetration range
- Number of electron accelerator:
  - Worldwide:1400 for industry,1000 for research(IAEA)
  - **In Japan:248 for industry, 147 for research (2007)**
- Major applications:
  - Polymer processing
  - Sterilization of medical supplies



Electron accelerator for cross-linking of wire Insulation (Nuclear Malaysia with JICA support)

Number of EB Processors in Japan (2007)

Application	Low Energy EB <300keV	Medium Energy EB <300keV～3MeV	High Energy EB <3MeV～10MeV	Total
Wire/Cable	1	53	1	55
Foamed plastics	3	12	0	15
Shrinkable materials	13	18	1	32
Tire	9	20	0	29
Curing/Grafting	69	2	0	71
Flue Gas	0	7	0	7
Sterilization	5	2	9	16
Toll Service, Others	4	10	9	23
R & D	144	2	1	147
Total	248	126	21	395

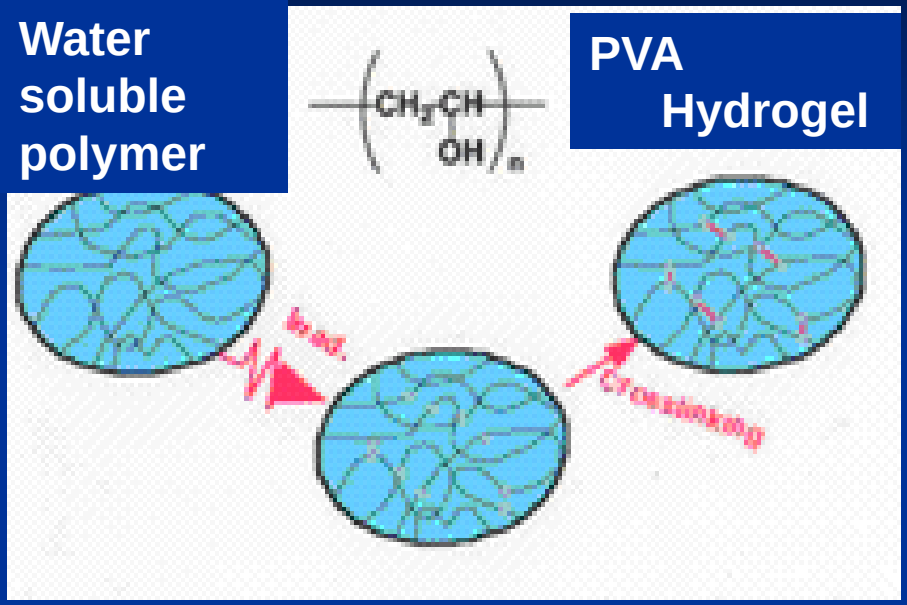
Production Line of Heat-shrinkable Sheets (USA)

Figure 67. Ten Self-shielded EB Units in One Factory

<A. Berejka, IAEA Document on EB Application (2008)>

Hydro-gel Wound Dressing

Water soluble polymer



PVA Hydrogel

ADVANTAGES

1. Healing is faster
2. Changing the dressing without pain
3. Transparency

Treatment for 13 days

EB Curing Over-coat of Decorative Paper for Furniture and Flooring in Japan

- EB processing has following advantages over UV or thermal curing :
  - Higher hardness and scratch resistance
  - Higher chemical resistance
  - Less energy consumption
  - Non-solvent process

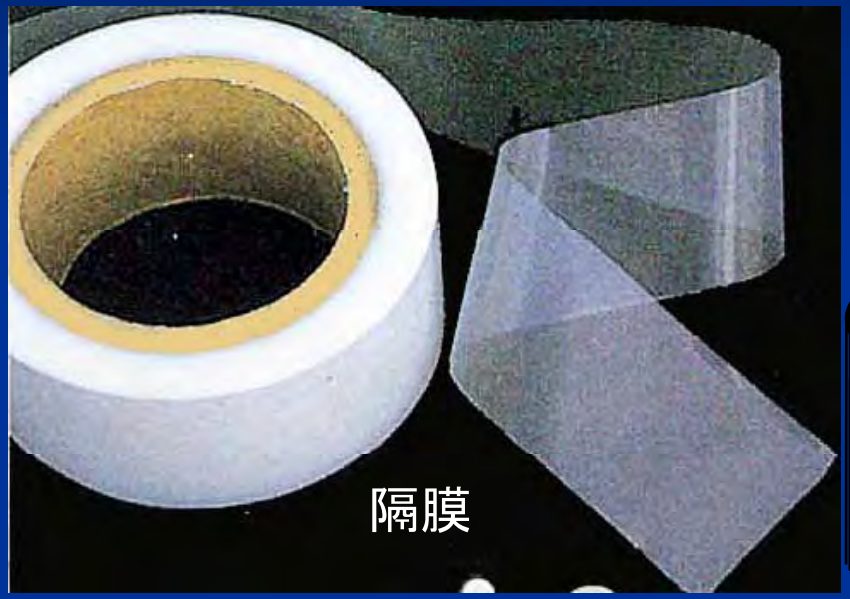
Curing of Coating by Electron Beams for Saving Energy/Environmental Protection

- Comparison of EB curing with thermal curing

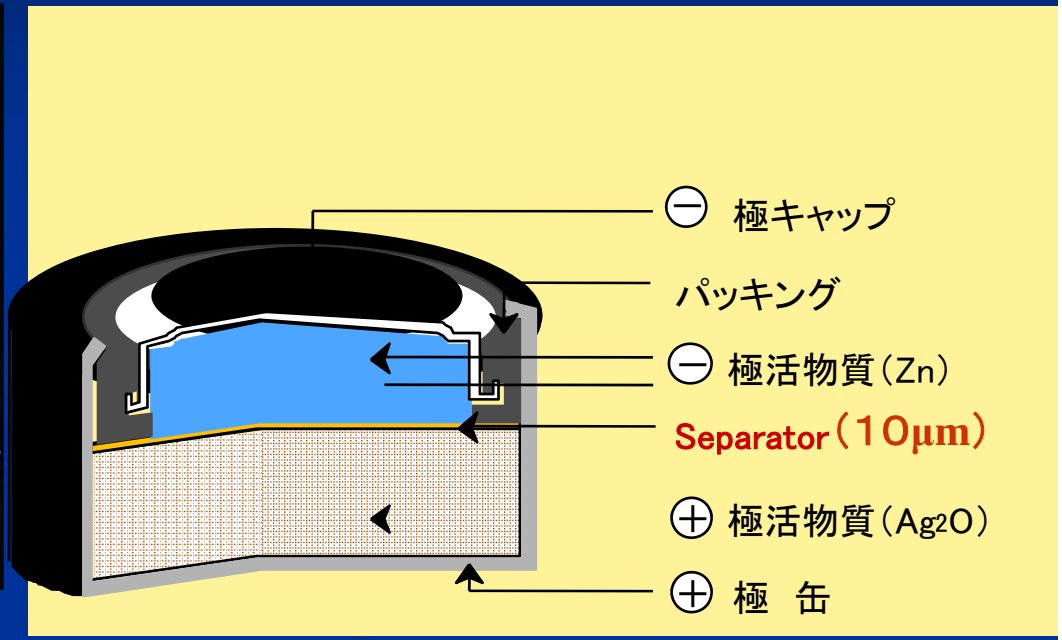
Total energy demand :	EB	Thermal
(kJ/ hour)	9,600	3,700,000
(27.3kJ/g to dry)		
Volatile organic compounds	0	12
(grams/m_2)		
Coating solids concentration	100	60
（%）		

Ref. A. Berejka, The RadTech Report, (Sept./Oct.2003)

Battery Separator Membrans by Radiation Grafting



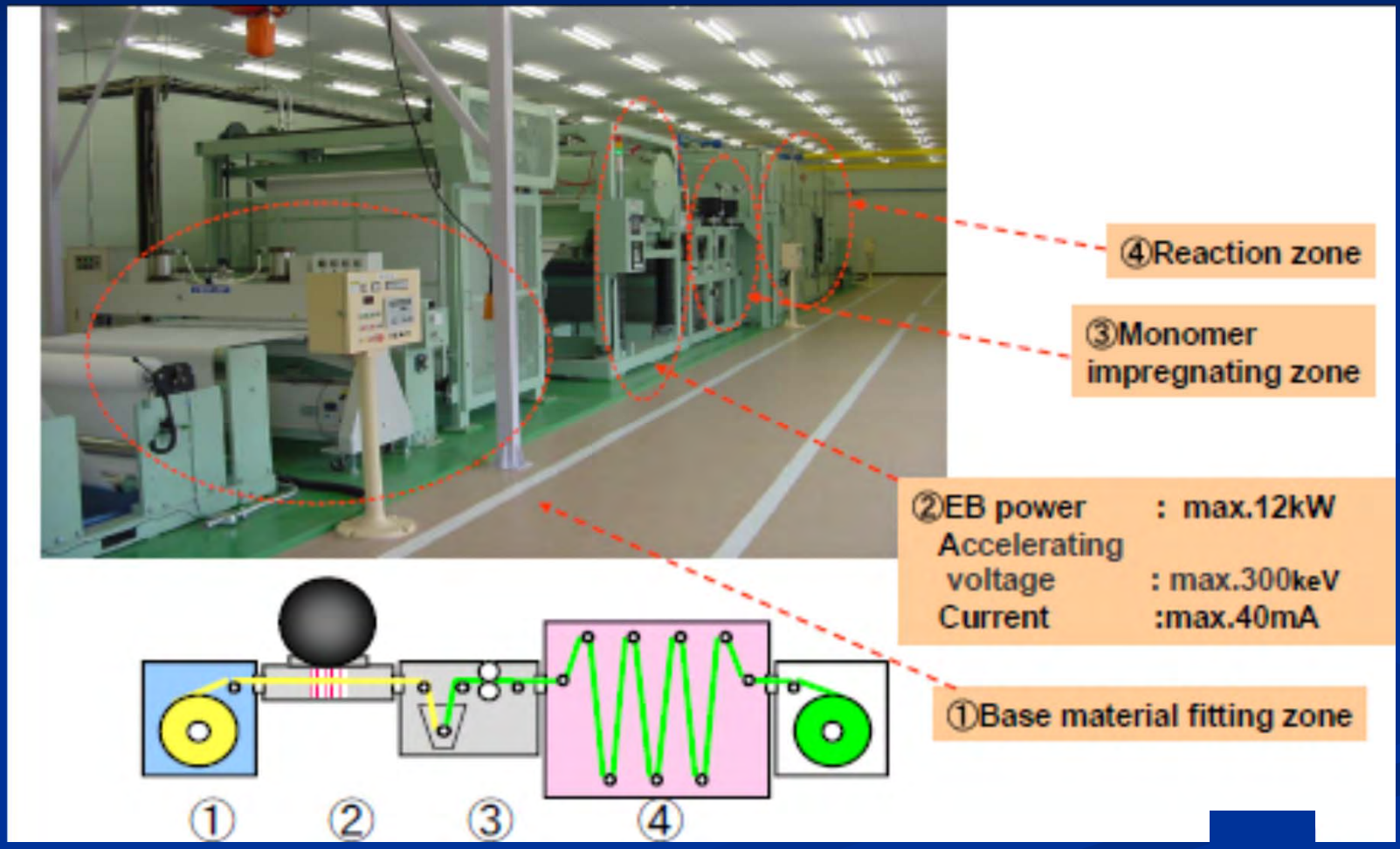
AAc grafted PE film



Button Battery of Silver Oxide Type
Production: 1 Billion/year in Japan

Polyethylene thin film (10μm) by radiation graft-polymerization of acrylic acid

Industrial Grafting Plant Using Electron Accelerator (Japan)



Non-woven cloth: grafting speed; 1.5m width, 0.8 ~ 20m/min

Efficient Sterilization by Radiation

- Sterilization of:
  - Medical supplies to avoid infectious disease
  - Plastic (PET) bottles of drinks and food packages at high speed (new application in Japan)

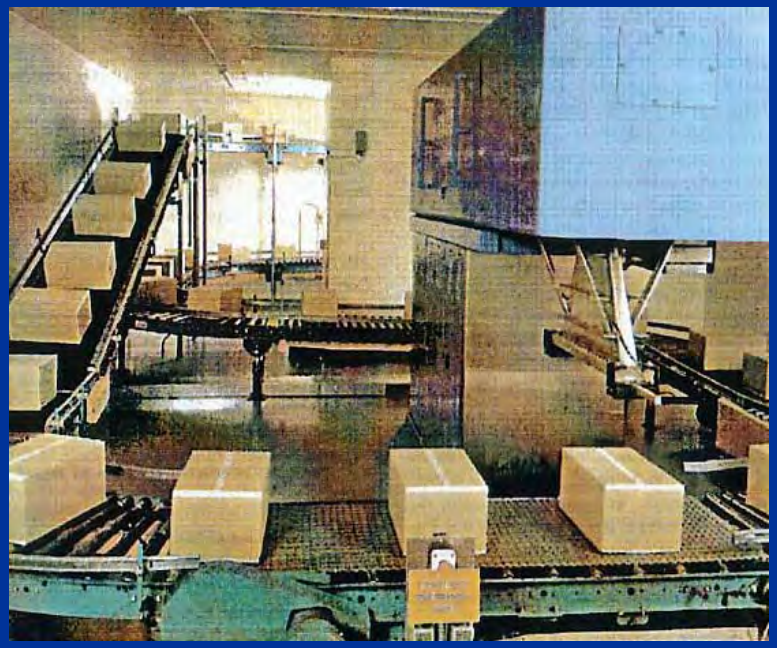
By both Co-60 and electron accelerator

Sterilization of Medical Products
Efficient Processing by Electron Accelerator

Energy: 5-10 MeV
Capacity: 10-100kW

- High speed processing
- Larger capacity

No replenishment of radiation source



New Technology for Sterilization of Plastic (PET) Bottles of Drinks by Electron Accelerator (Japan)

Advantages

- **In line sterilization for filling process**
- **No residual chemicals**
- **Running cost reduction by 10-25 %**
- **Compact system-less space**

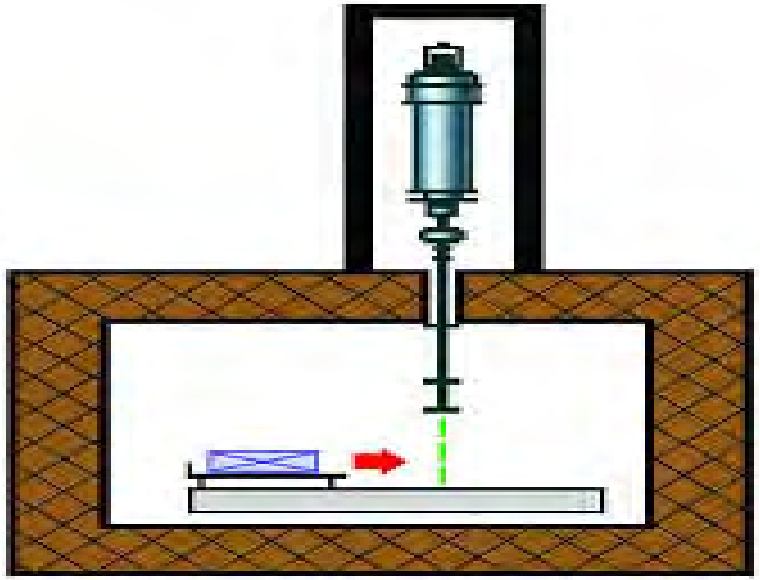
Accelerator 300 keV

Capacity: 600 bottles of 500 ml per minute

Other Unique Radiation Applications

Color Change of Gem Stones : Thailand

Disinfect Anthrax in Mail : USA

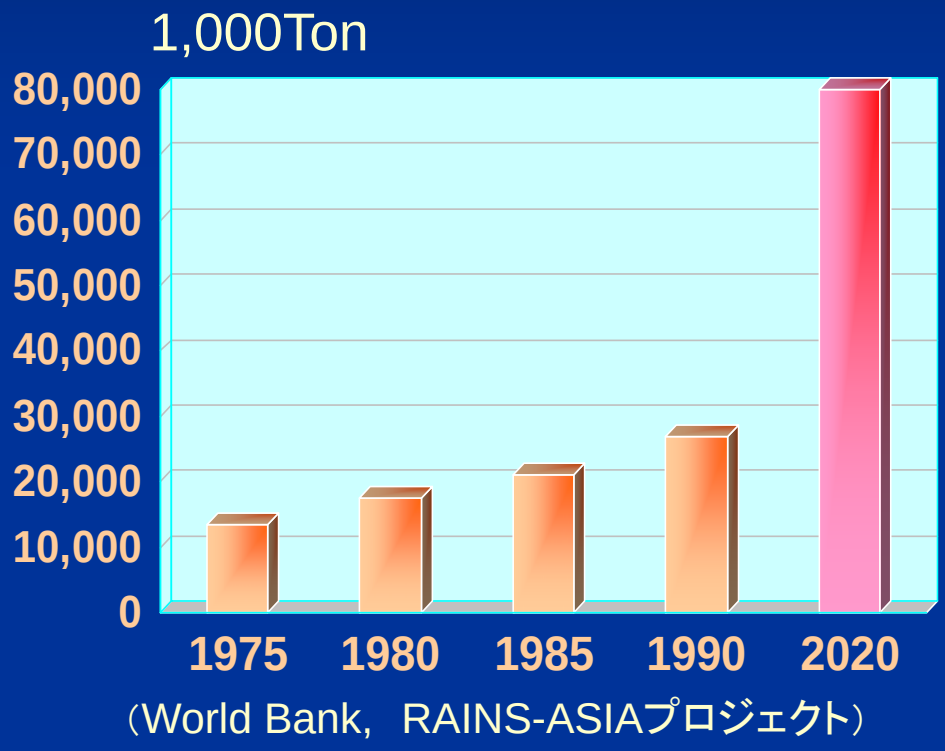


Environmental Protection by Using Radiation Technology

- Cleaning flue gases;
  - Removing SO2 and NOx from power plant
  - Removing dioxin from municipal waste incineration plant (R&D)
  - Removing stinking gas of drying sewage sludge (Japan)
  - Removing VOC (toluene, xylene) (R&D)
- Cleaning waste water from dying factory (Korea)

Environment Is Degraded by Acid Rain

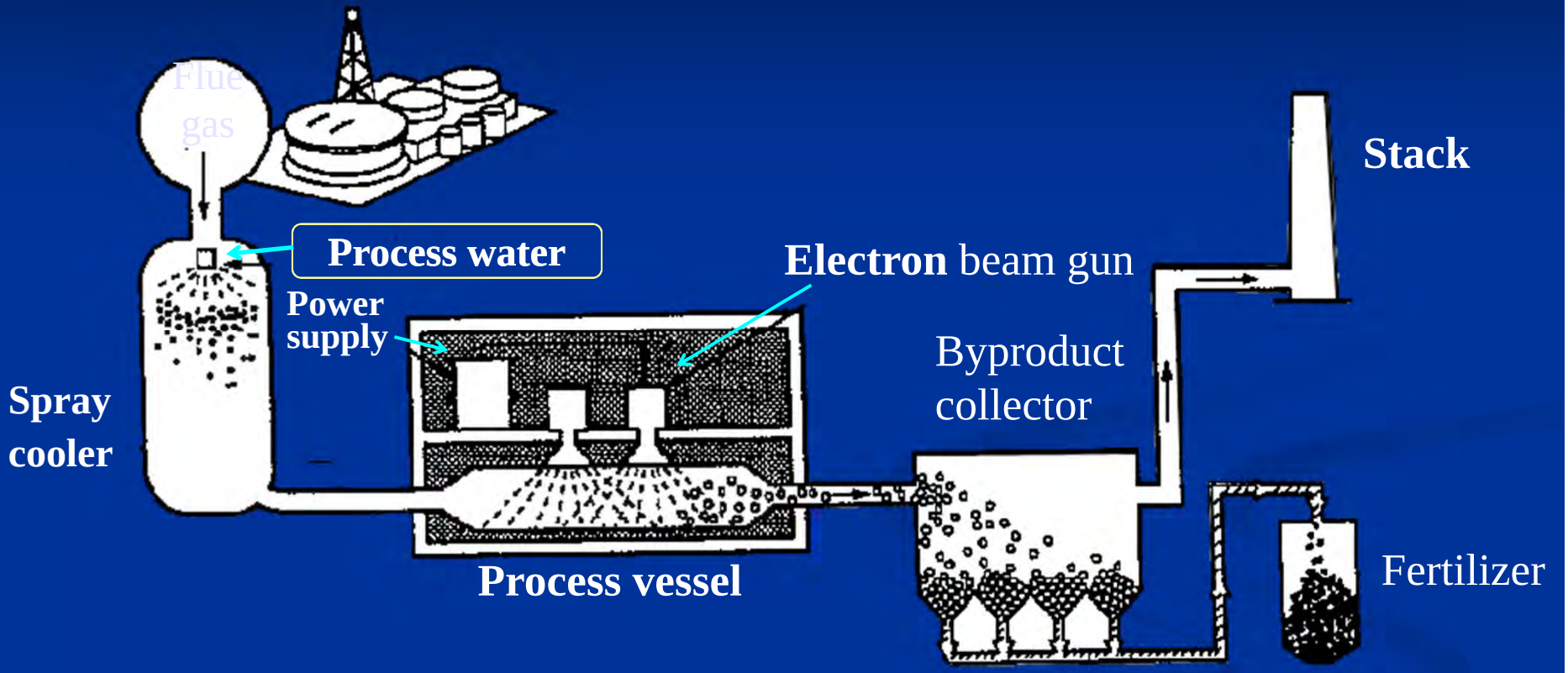
Increasing Emission of SO_2



（World Bank, RAINS-ASIAプロジェクト）

Damaged Forests by Acid Rain in East Europe

Innovative Technology for Cleaning Flue Gases by Electron Beams



Removal efficiency: SO_2 90% **Absorbed dose: 10~15hGy**

Temp: 65~70℃

EBFGT (Electron Beam Flue Gas Treatment) Industrial Plant in Poland

- Pomorzany thermal power station burning coal in Szczecin (north Poland)

- Treatment Capacity: 270,000 m3/h

Industrial Electron Beam Flue Gas Treatment (EBFGT) Plant in Poland

EB Accelerator:
700 keVx375 mA 4 unit

Treatment Capacity:
270,000 m3/h from coal power plant of 100 MW

Control Room of EBFGT for Industrial Plant in Poland

- Ebara Co. installed industrial plant of flue gas treatment in Chengdu, China in 1997

  90 MWe, 300,000 m3/h flue gas

  SO_2 removal 80%

  NOx removal 20%

Industrial Plant of Waste Water Treatment by Electron Beams (Korea) (2006)

Cleaning waste water from fabric dyeing factory in Tegu city

Capacity:
10,000m3/day

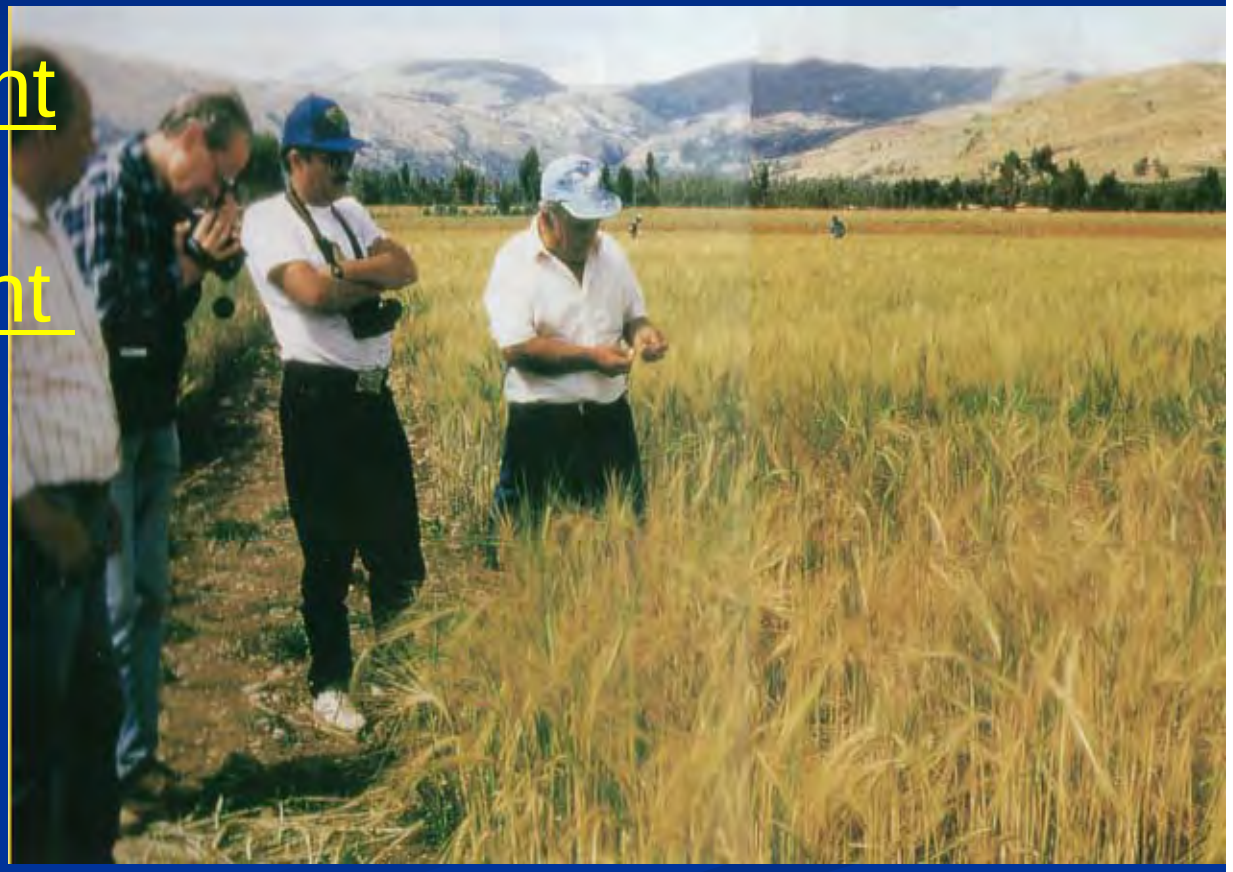
Electron accelerator:
1Mev, 500kW

Radiation for Sustainable Agriculture

- Mutation breeding for better crop varieties
- Sterile insect technique for protection of plants and animals
- Food irradiation for reduction of post-harvest loss
- Bio-fertilizer increasing crop yields
- Plant growth promoter from natural polymers for yield increase

3000 Better Varieties Developed by Radiation-Induced Mutation Breeding

- Higher yield
- Disease resistant
- Early maturity
- Drought resistant
- Dwarf
- Salt resistant



Barley of Early Maturity in High Land of Peru (IAEA)

Recent Success in Japan

Parent

New variety

Disease (brack spot) resistant mutant variety of pear to avoid excess use of pesticides for better economics and environment

FNCA Project on Mutation Breeding

Contributing to develop sustainable agriculture

Completed with success:

Disease (Banchy

- Top virus) resistant banana
Philippines

- Insect resistant orchid;
Malaysia

Focusing on:

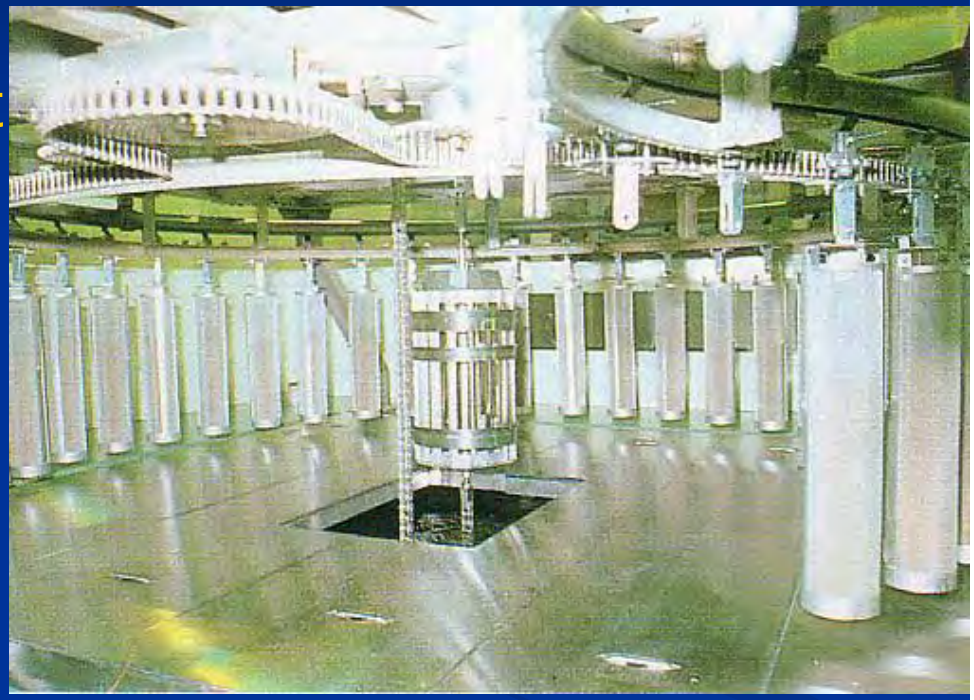
Rice: Environmentally friendly Varieties: High yield with low chemical input; tolerant with high temperature climate:

Rice seeds were irradiated with ion beams by JAEA

New disease resistant rice variety (right): 15% yield increase: Vietnam;

Sterile Insect Technique (SIT) for Eradicate or Control Insect Pests

Puppet

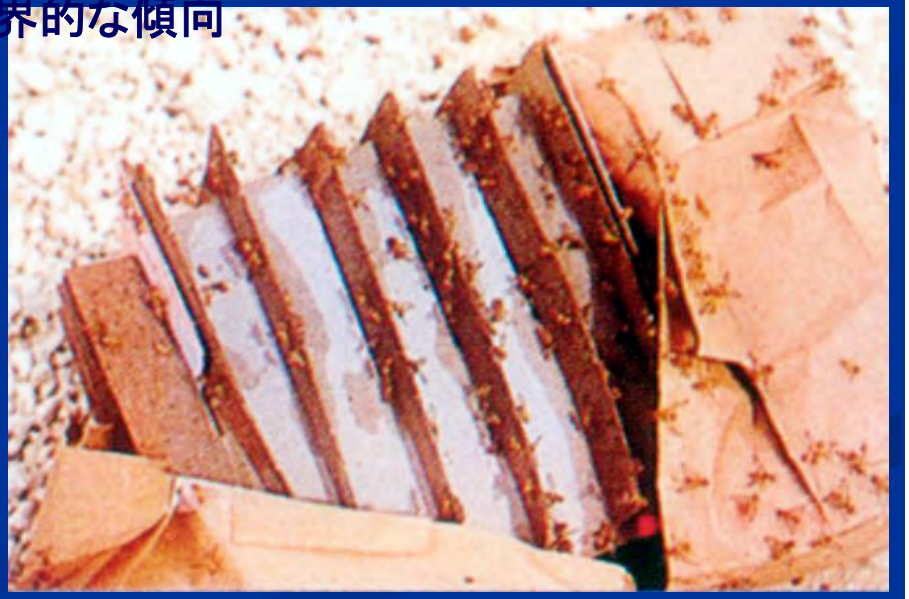


Stocking puppet

Irradiation facility of puppet by Co-60

Release of sterilized flies by air

がん発生率の世界的な傾向



On the ground

IAEA Success Story of Eradication of Tsetse Flies

Tsetse flies transmit Nangana disease of live stock: Damaging livestock industry in Sub-Sahara region

IAEA/FAO achieved to protect livestock industry in Zanzibar Island by eradication of tsetse flies (1996)

勢多農林高　2009年6月9日
町

Production of Bio-fertilizer Inoculants by Radiation

Soybeans with Rhizobium

- **Increasing plant yields (20-50%) by micro-organism, Rhizobium and Mycorrhiza**
- **Less expensive/environmentally friendly than chemical fertilizer**

Carrier of bio-fertilizer is sterilized by radiation to bring better QA/QC and longer shelf-life of inoculants : Commercial application in Indonesia, Malaysia, Philippines, Japan

Challenge: Expansion of commercial application

Achievement and Challenges of the Project

I. Extension of Radiation Sterilization for Commercial Production

The most fruitful result of our project in this year is " The Philippines started to supply Bio-N biofertilizers made by irradiated carrier".

So far, the soil + charcoal is mixed as carrier and steam sterilized for three days at 1 hour each.

From 2012, a total of 2 tons of Bio N carrier was transported to PNRI for gamma irradiation for one load.

Samples of Bio N carrier submitted to PNRI for gamma irradiation

Bio N boxes already subjected to gamma irradiation

Commercial Application of Bio-fertilizer **Produced by Radiation Sterilization** in Malaysia (Mycorrhiza/Rhizobium) and Philippines (Rhizobium)

Mycorrhiza: phosphate solubilizing microorganism

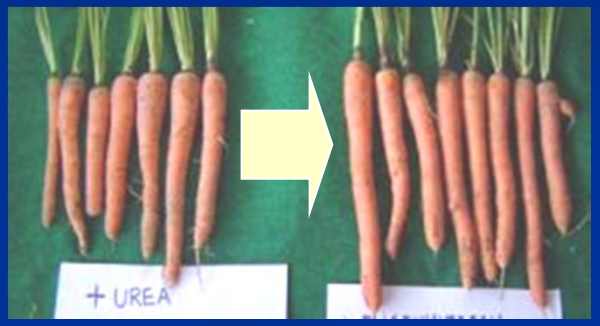
Oligochitosan Plant Growth Promoter Produced by Radiation Degradation of Chitosan

Rice seedling

Chili

60%

Carrot 55%



Potato 34%

Rice

Sheath blight by *Rhizoctonia*

Cyclamen

Damage by *Fusarium*

Reduction of diseases by foliar spray of PGP (Elicitor)

Environment-friendly

Super Water Absorbent (SWA) for Soil Conditioner in Semiarid /Arid Region

- Hydrogel SWA is effectively produced from natural polymers, such as cassava starch by **radiation cross-linking or radiation grafting**
- 1 gram of the SWA absorbs 400 – 500 gram of water
- Soil mixed with small amount of SWA can retain longer the scarce rain or irrigated water

Field tests in Vietnam showed crop yield increase by10-30% by the use of SWA

1 g of SWA absorbs 400-500 g water

Yield Increase of Crops by SWA Soil Conditioner (Vietnam)

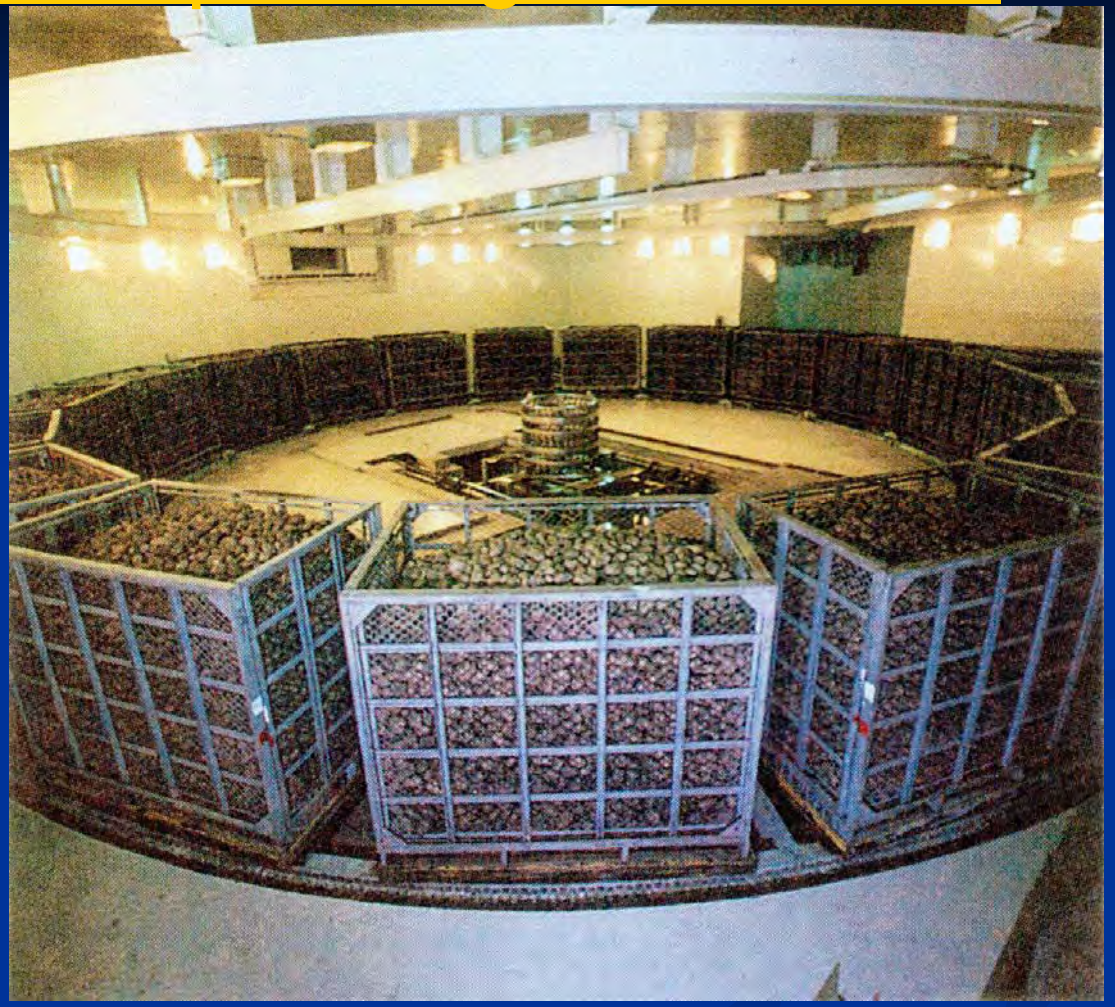
Crops	SWA kg/ha	Yield increase
Corn	40	28.8 %
Cabbage	40	15.4
Peanuts	30	16.3
Peanuts	40	21.1
Cotton	30	31.1
Grape	50	29.8
Sugar cane	60	19.8
Cassava	60	22.8

Field Test of SWA for Lily Plant : Vietnam

With SWA 12 weeks Without SWA

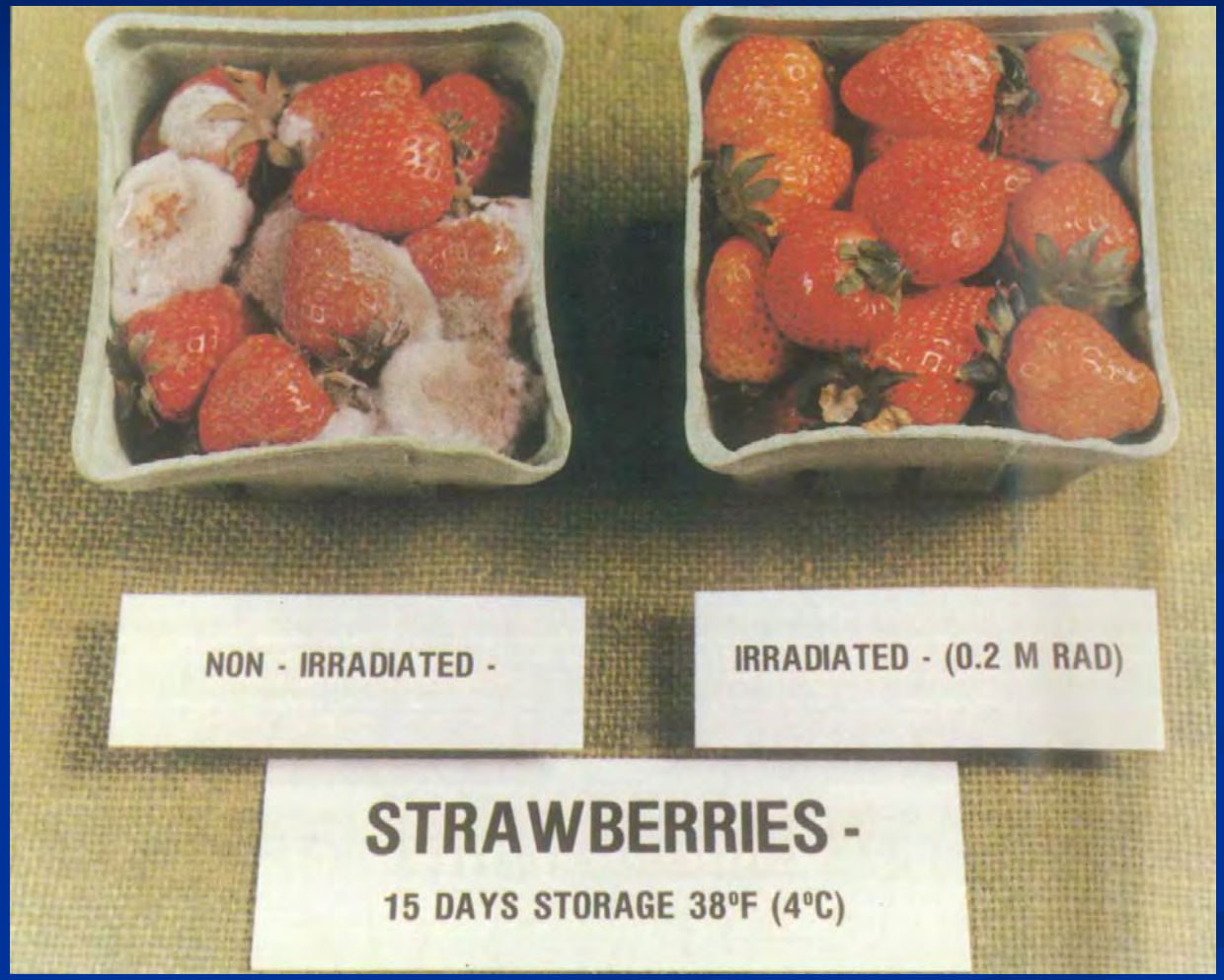
Food Irradiation Expanding Worldwide

-Sprout inhibition:
Garlic, Potatoes,
Onions
-Disinfection:
Spices, Shrimps
Sausage, Beef,
-Disinfestation:
Citrus, Mangos,
Papaya, Cucumber
500,000 tons/year



Irradiation of potatoes for sprout inhibition in Japan by Co-60 (8,000 ton/year): The world first food irradiator

Irradiated Strawberries for Better Preservation: Commercialized in USA



Irradiated Food Increasing

Permitted in 57 countries

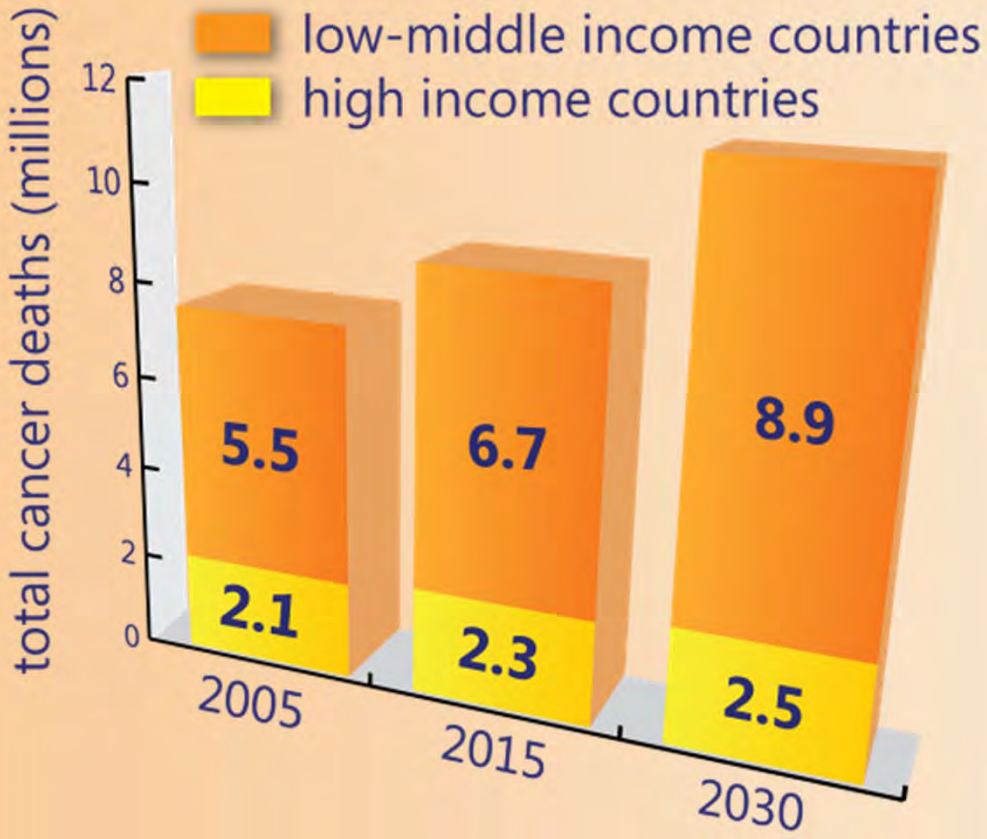
180 gamma irradiators & a dozen EB accelerators

World total of irradiated foods	**ca. 500,000 ton**
China : Garlic, Dried vegetables, etc.	**146,000 ton**
Vietnam : Frozen shrimps, etc.	**14,000 ton**
Japan : Potatoes	**8,000 ton**
USA : Spices, Ground meats, Fruits	**92,000 ton**
Ukraine: Wheat grain	**70,000 ton**
Brazil: Spices, Fruits	**23,000 ton**
South Africa : Spices	**18,000 ton**
Belgium : Spices, Frozen chicken	**7,000 ton**
Others:	**ca.120,000 ton**

Cancer Affects Us All

IAEA | Programme of Action for Cancer Therapy PACT

- **Cancer killed 7.9 million people in 2007**
- **72% of these deaths occurred in developing countries**



* Chart courtesy of WHO

Linear Accelerator (LINAC)

External Beam Radiotherapy Machine

これは患者さんのセットアップの写真です。
治療中は、患者さんのみ治療室内に残り、技師さん達は治療室にいません。

Advanced Technology for Cancer Therapy by Heavy Ion Beam Facility in Japan (NIRS)

Carbon-12 Ion Beam Treatment of Cancer

- World first facility of carbon ion treatment:

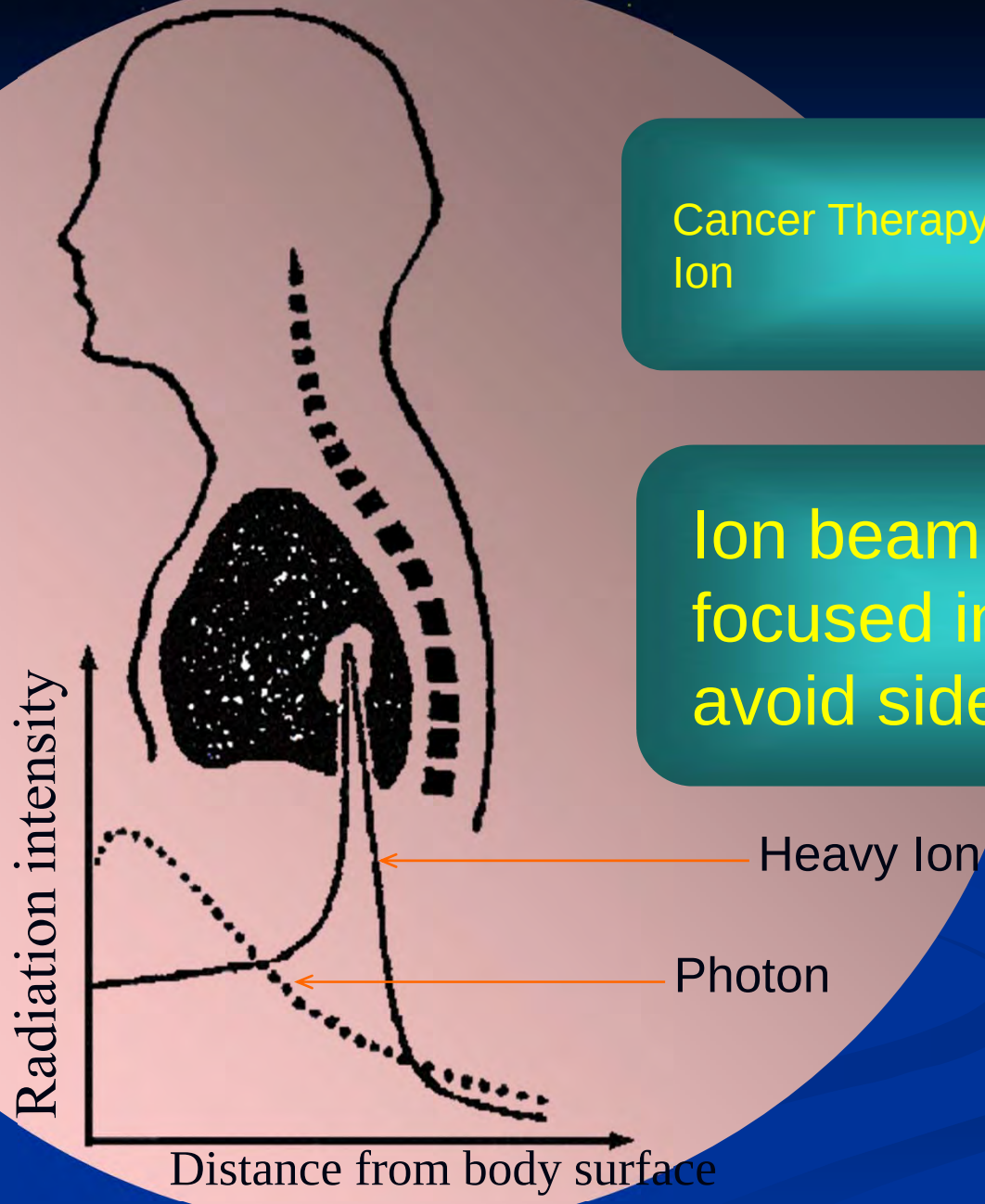
National Institute of Radiological Science, Japan

- Effective damage of cancer tumor (high LET)
- Selective irradiation on targeted tumor
- Much reduced side effect on healthy tissue

- Effective cancer: Lung, Prostate, Liver, Pancreas, Bone, Head-neck, Gullet
- Number of treated patients by NIRS: 7000 patients
- Challenge: reduction of cost
- 2nd facility; Nishiharima, 3rd ; Gunma Univ. 600 p

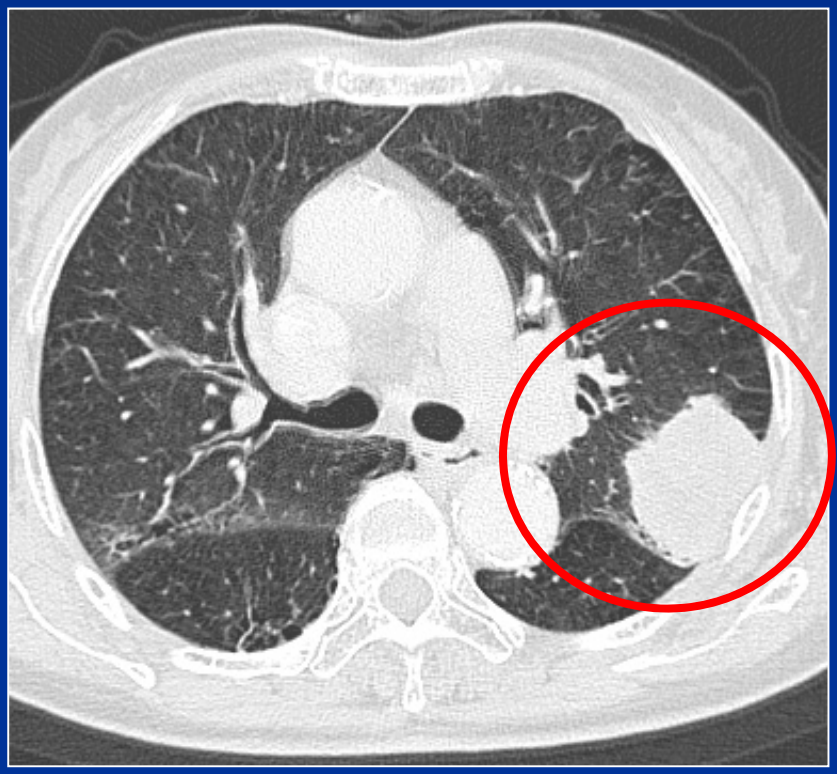
Cancer Therapy by Heavy Ion

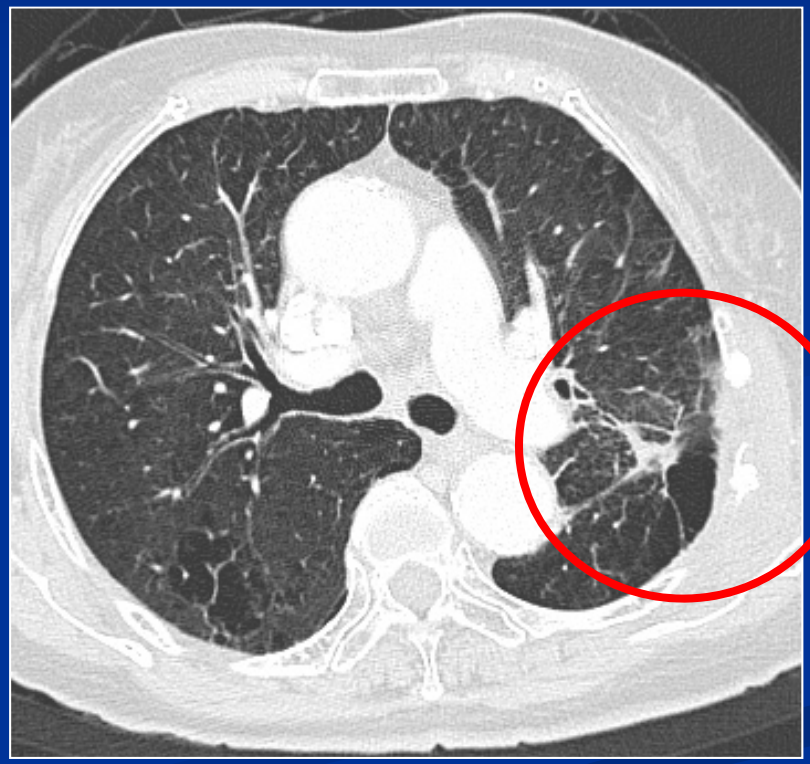
Ion beam can be focused in tumor to avoid side-effects



Lung Cancer: One time irradiation of Carbon-12 ion

71years old Female(扁平上皮がん） by NIRS

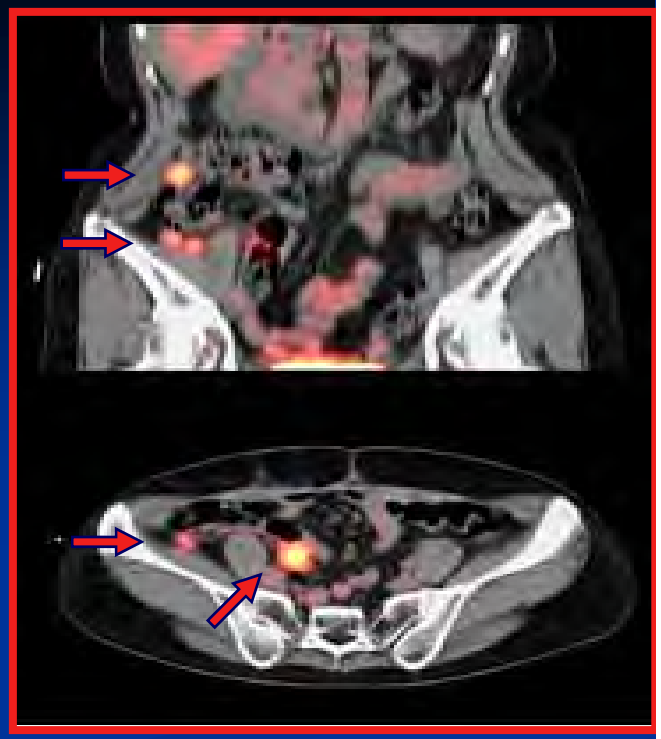




Before treatment

After treatment

Early Diagnosis of Cancer by PET/CT



FNCA

Interpretation of PET images

Compiling PET images with interpretation

-

Guide lines of operation and maintenance for cyclotron and chemical box;

Publication of PET image ATLAS with 200 images, and the guide lines for operation and maintenance

Conclusion

- Radiation application in industry, agriculture and environmental protection will further develop to contribute for sustainable development in both developing and developed countries
- Radiation medicine effectively improve health care through nuclear medicine diagnosis and radiation treatment of cancer
- IAEA plays important roles for supporting MSs to develop nuclear applications
- FNCA is implementing 5 projects to develop nuclear applications in member countries

Thank you for your kind attention!

Annular Solar Eclipse:07:32 May 21, 2012 Tokyo

From National Observatory Home Page