



Mobile electron beam plant for environmental application

December 08, 2016

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**Low energy electron beams for industrial and environmental applications
EuCARD-2 Workshop with Industry - 8-9 December 2016, Warsaw, Poland**

Accelerator Technology for Pollution Control



Flue gas Purification

Wastewater Treatment

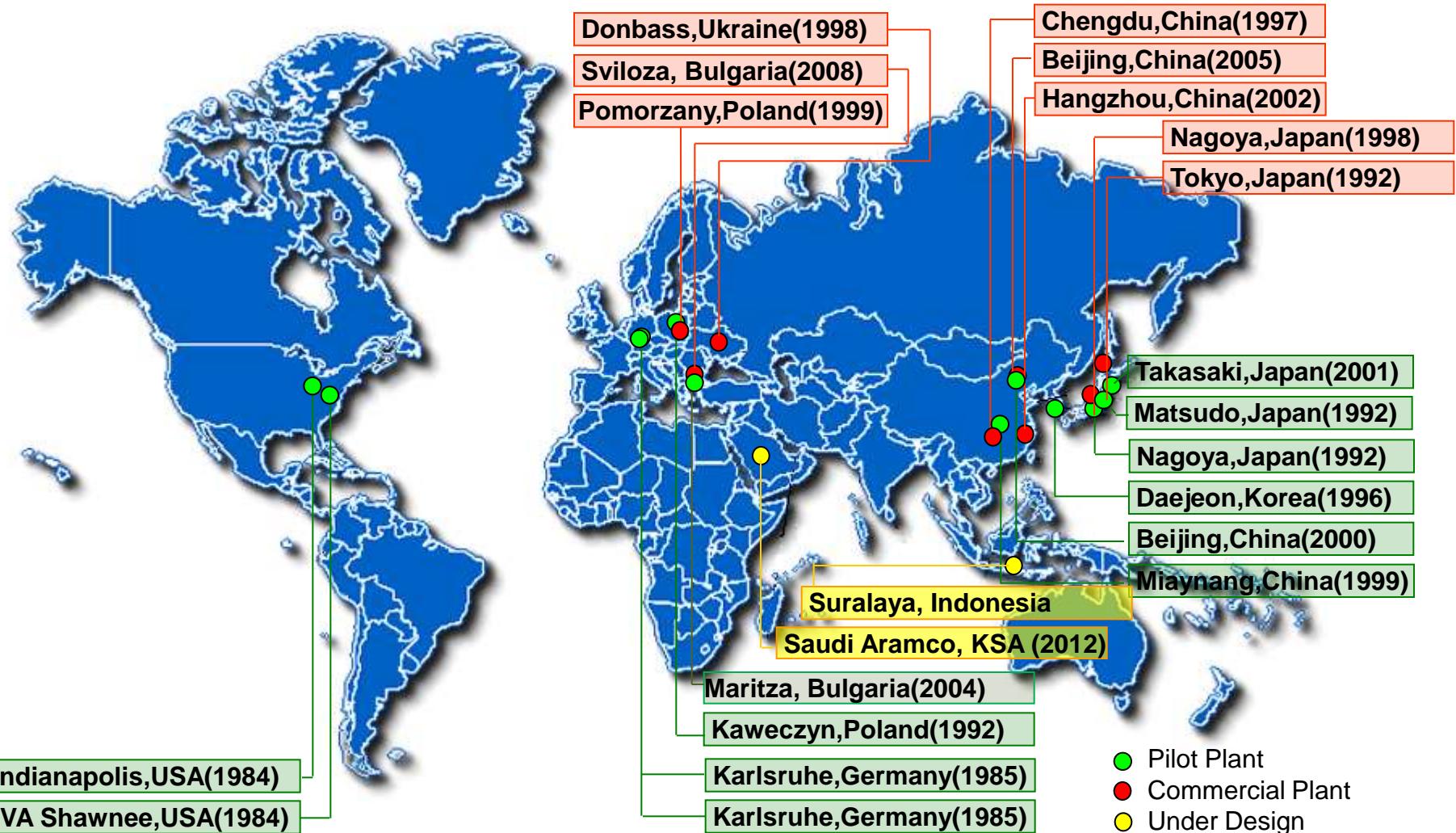
Sludge Hygienization



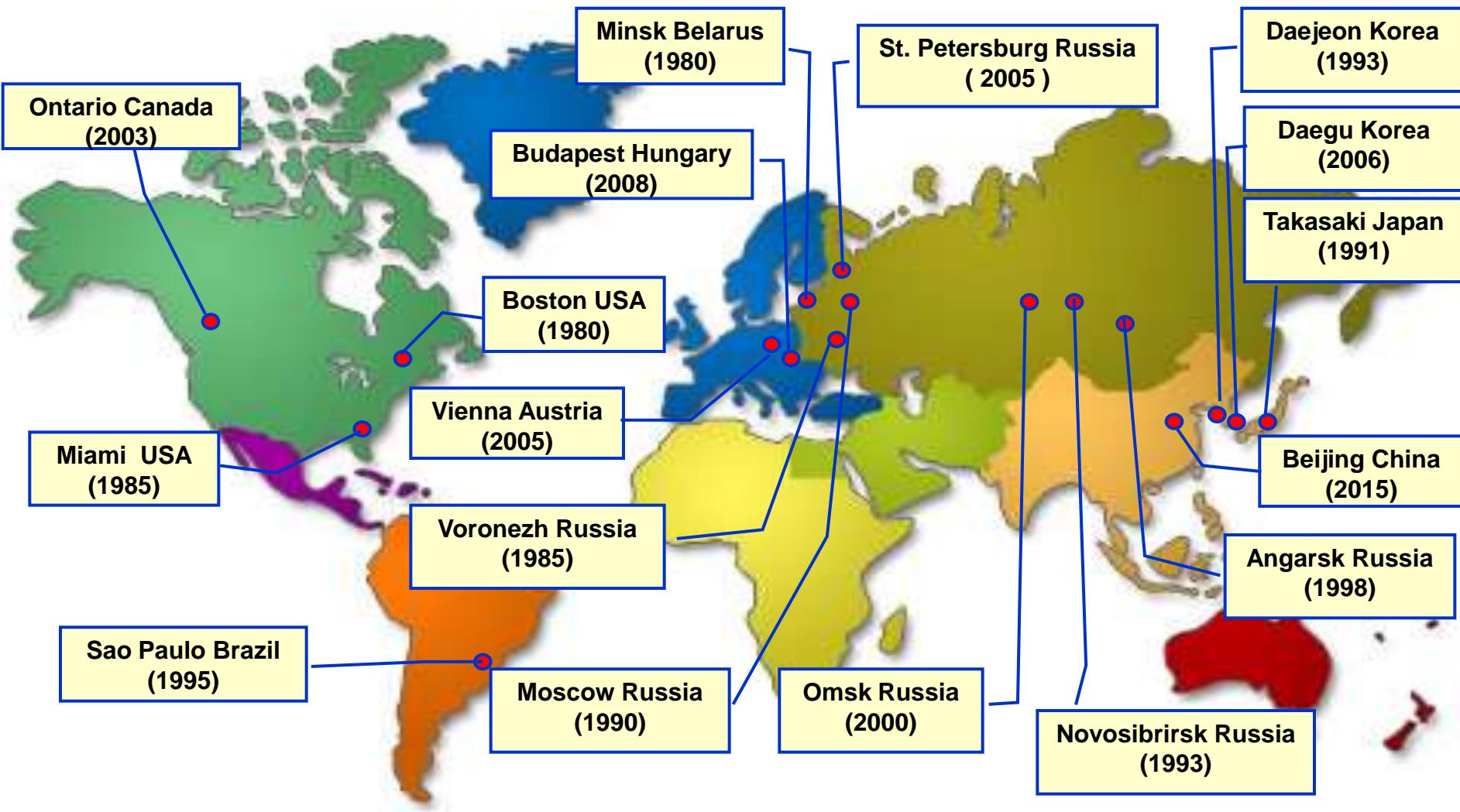
Technical Advantages of Radiation Processing

- *. **Electron Beam Technology is Eco-friendly technology**
 - **No secondary waste generation**
 - **No catalysts, no heating and easy for automation.**
- *. **Experienced in pilot plant and several industrial plants**
- *. **Economical Advantages in capital cost and O & M cost**
- *. **For flue gas treatment and sludge treatment,
by-products are useful for fertilizer.**

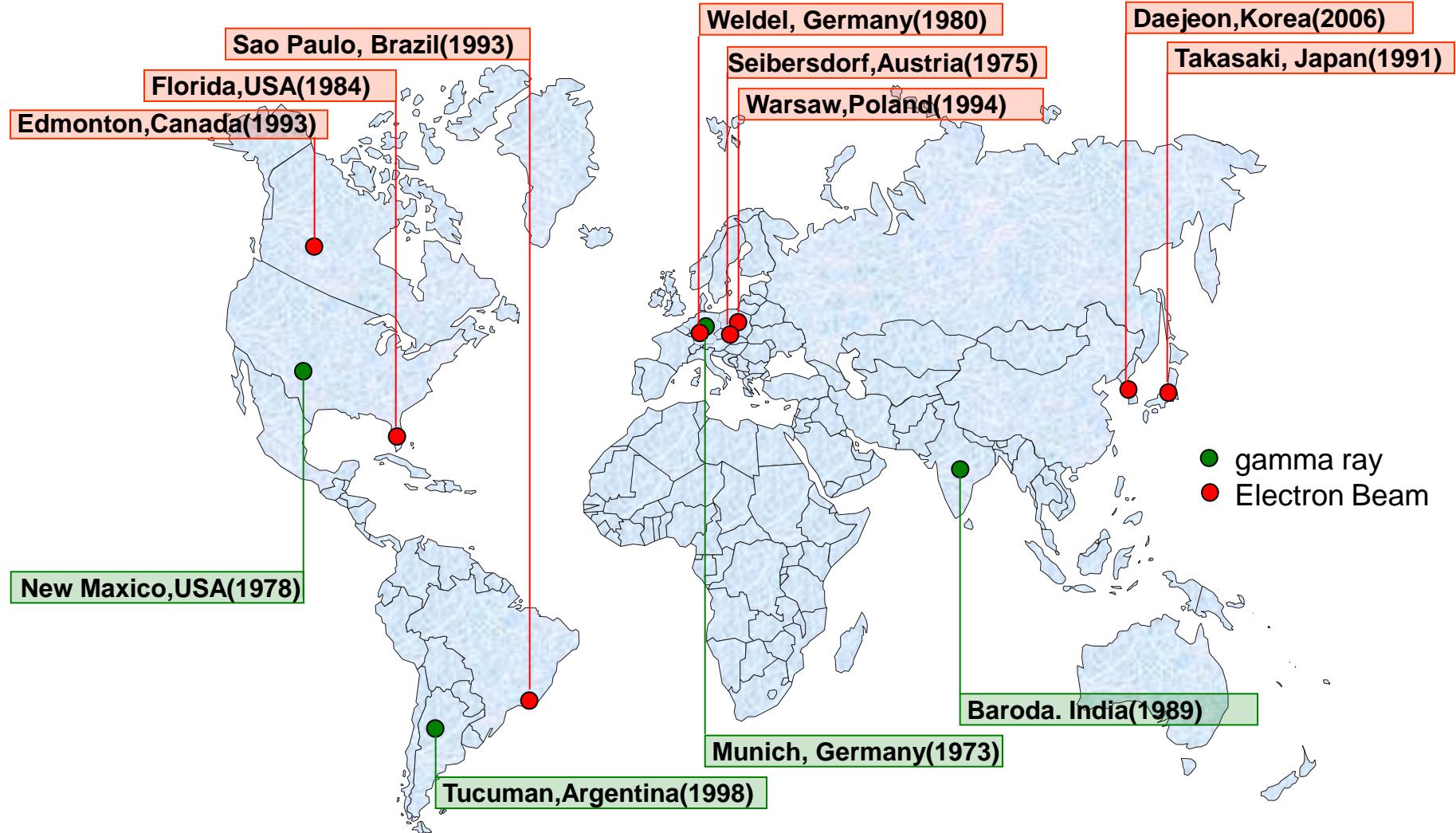
Pilot and Industrial EBFGT Plant



Pilot and Industrial Wastewater Treatment Plant



Pilot and Industrial Sludge Treatment Plant



Years	Flue Gas	Wastewater	Sludge
1970			Commercial Plant Munich, Germany (1973~1984) Pilot Plant
1980	Pilot Plant Indianapolis, USA(1984) Badenwerk, Germany(1985) Novosibirsk, Russia (1989)	Pilot Plant Boston, U.S.A. (1980) Ontario, Canada Miami, U.S.A. (1985) Voronezh, Russia (1985)	New Maxico, USA(1978) Weldel, Germany (1980) Virginia Key Florida, USA(1984)
1990	Kawęczyn, Poland (1992) Nagoya, Japan (1992) Daejeon, Korea (1995) Chengdu, China (1997) Pomorzany, Poland (1999) Nisi-Nagoya, Japan(1999) Hangzhou, China (2002) Beijing, China (2005) Svishtov, Bulgaria (2008)	Seibersdorf, Austria (1990) Daejeon, Korea (1993) Sao Paulo, Brazil (1995) Budapest, Hungary (1998) Angarsk, Russia (1998)	Vadodara, India (1989) Takasaki, Japan (1991) Sao paulo, Brazil (1993) Warsaw, Poland (1994) Tucuman, Argentina (1998)
2000		Commercial Plant Daegu, Korea (2005)	Daejeon, Korea (2005) Tel Aviv, Israel (2007) Texas, U.S.A. (2010)
2010	Commercial Plant Jeddah, Saudi Arabia (2012)	Beijing, China (2015)	
Project on going	Saudi Arabia, Indonesia, Bulgaria, Turkey	Korea, China, Hungary, Saudi Arabia, U.S.A. EU	Israel , India, Egypt, U.S.A.

Why e-beam processes are not widely used ?

Barriers for Industrial Application

- Public Acceptances **Uneasy for the Radiation Safety
New Species by Radiation**
- Technical problems **Reliability for year-round operation
Analysis of by-product, Toxicity**
- Regulation from Authorities
- Competition with Other processes (Economics)
 - Difficult to beat the conventional processes
High investment cost and long returns
No Alternatives or by-passes for shut-down
Not universal for all environmental plant
Difficult to find BP**

**Radiation process
(e-beam, γ-ray etc.)**

**can survive
only when it has
Technical & Economical
advantages
over existing processes.**

**Radiation processing
should be**

**Better & Cheaper
to other processes.**

- 1. Find the proper radiation source for products**
 - **Gamma-ray, X-ray, or e-beam**
- 2. Reduce doses**
 - **with combined methods (Bio-, Physical/chemical etc.)**
- 3. Apply cost-effective accelerator**
- 4. Engineering Approaches**
 - **Analysis of existing process → Calculate the present cost**
 - **Economics of radiation → Max. allowable radiation doses**
 - **Find useful additives or combination for lowering doses**
 - **Laboratory test → Confirmation of process**
 - **Pilot plant → Industrial scale design → Commercial plants**
- 5. Show and Prove the feasibility by pilot operation**
 - **Laboratory experiments → Pilot scale test with Mobile machine**

**Lab. Scale
Experiments
(1~50m³/day)**



**Lab. Scale
Experiments
(1~10,000Nm³/h)**

**Pilot scale
Experiments
(500~1,000m³/day)**

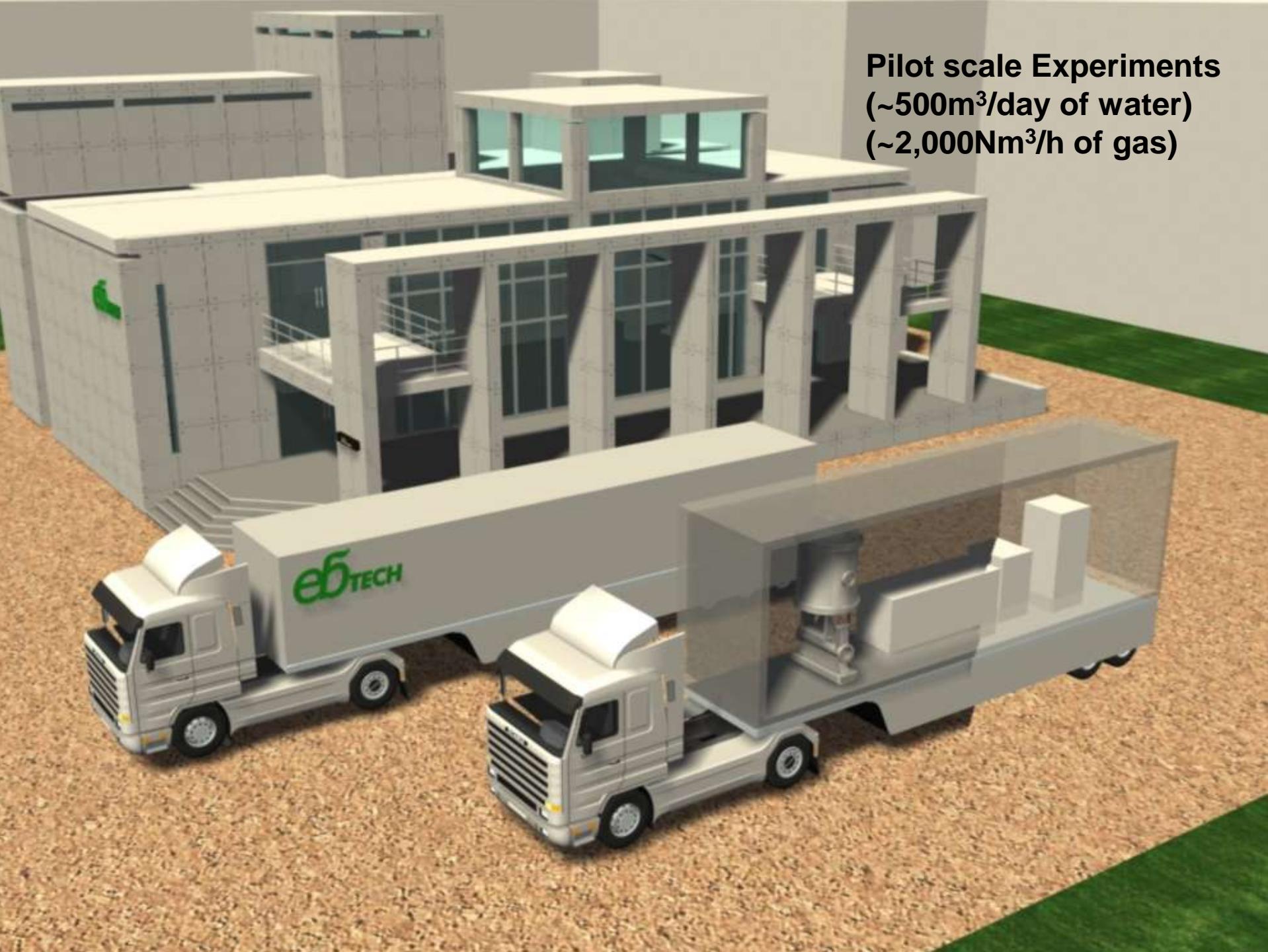


**Industrial scale
Wastewater Plant
(10,000m³/day)**



**Industrial scale
EBFGT Plant
(~600,000Nm³/h)**

Pilot scale Experiments
(~500m³/day of water)
(~2,000Nm³/h of gas)



Application of Mobile Accelerator

1. Pilot scale Demonstration for Environmental Application

- Flue gases from power plant (2,000Nm³/hr at 15kGy max.)
- Water/Wastewater (500m³/day at 2kGy max.)
- Liquid sludge (200m³/day at 5kGy max.)

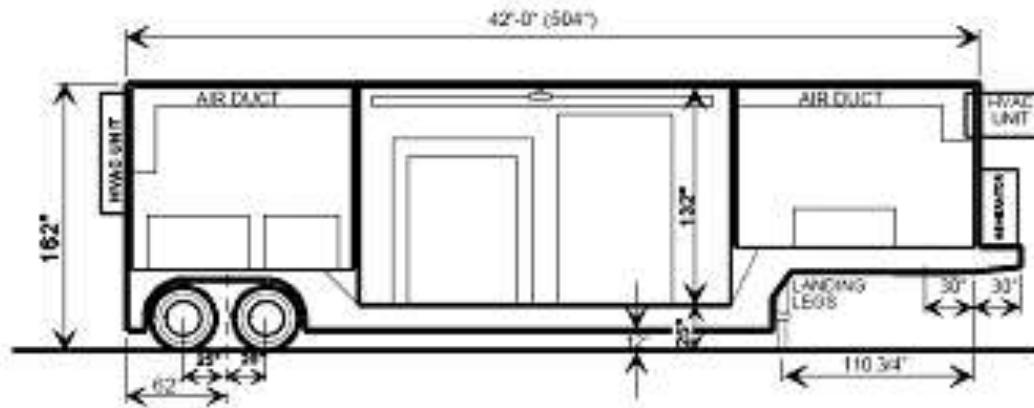
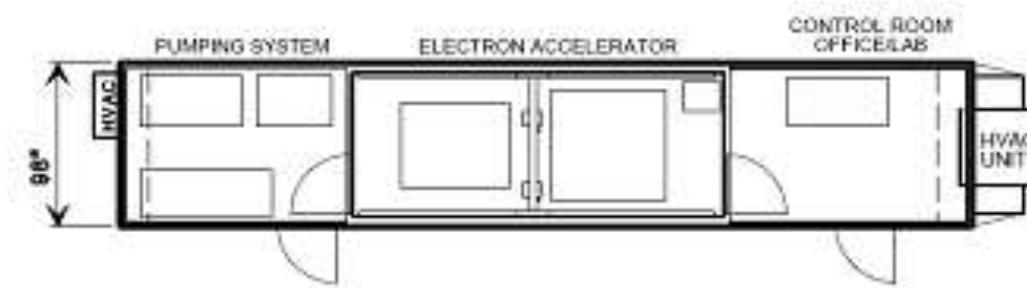
2. Removal of Hazardous Wastes on the Spot

- PCBs, Pesticides, POPs in limited storage
- Remediation of contaminated environment from disasters

3. Polymer Modification (if modified)

- Wire/Cable for automobile etc.
- Films/sheet for industrial uses.

Previous Mobile Accelerator (HVEA, U.S.A. 1990)



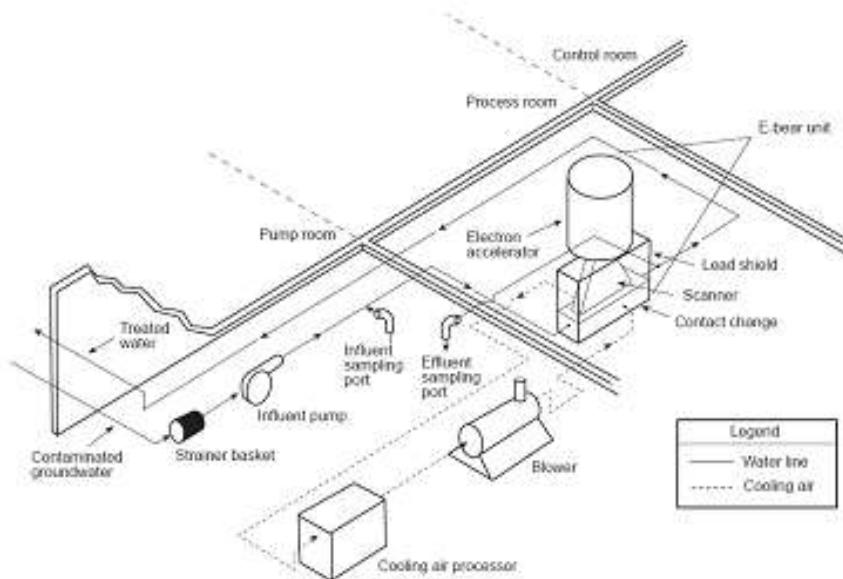
ICT accelerator

500 keV

0~40 mA

Max. 20kGy

for wastewater

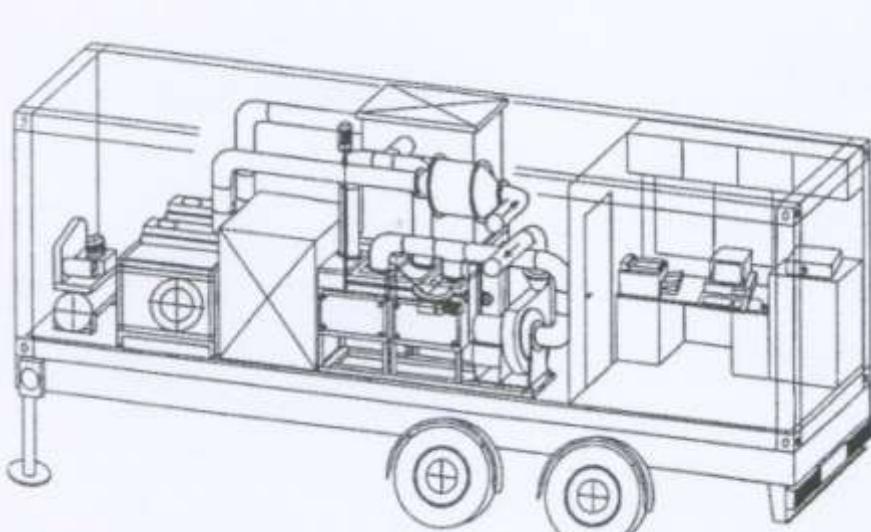


Ref.) Environmental Applications of Ionizing Radiation, Edited by william J. Cooper, Randy D. curry, and Kevin E. Oshea, "Field Application of a mobile 20-kW electron beam treatment system on contaminated groundwater and industrial wastes", p.451-466, ISBN 0-471-17086-0, 1998 John Wiley & Sons, Inc.

Previous Mobile Accelerator (FZK, Germany 1984)

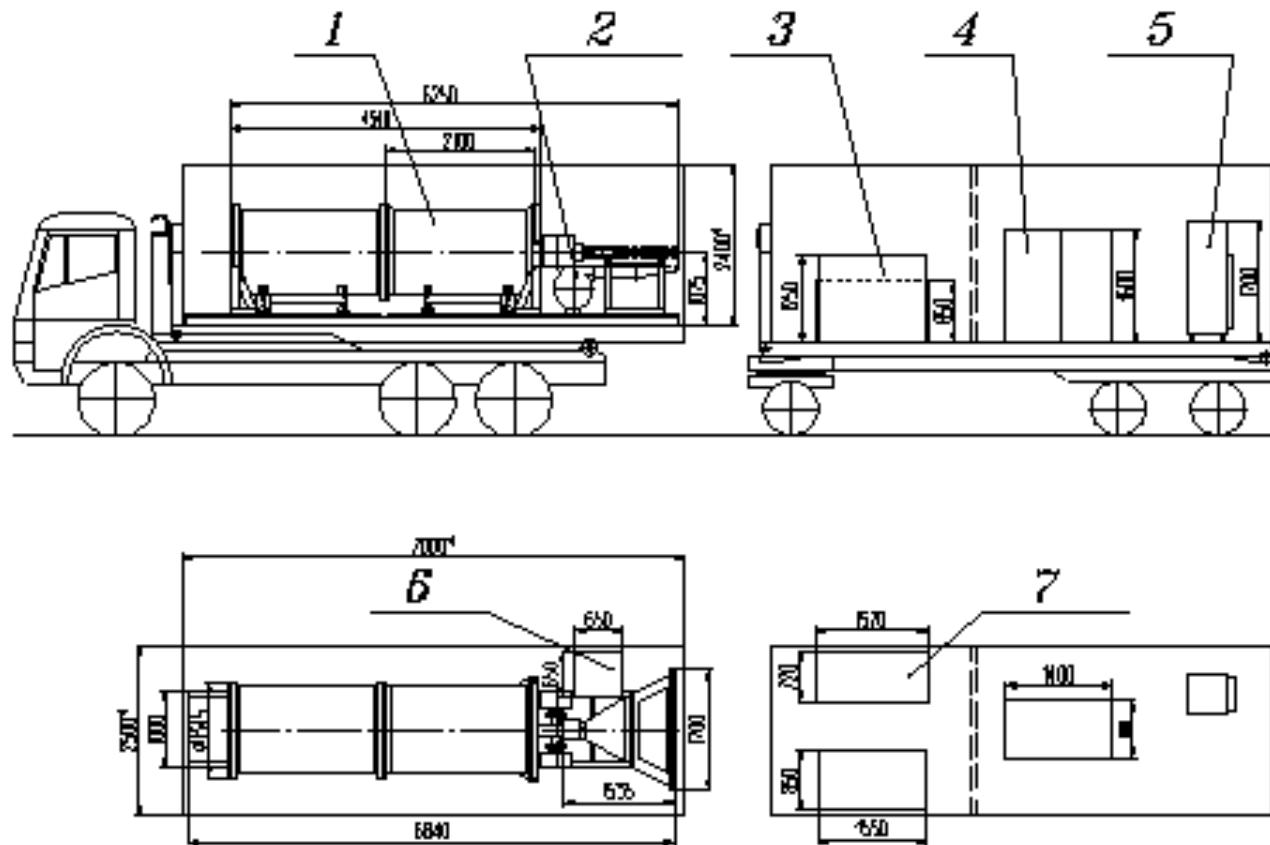
ESI Electrocurtain 200 keV, 0~150 mA

Flow rate : 1,000Nm³/h for gas treatment



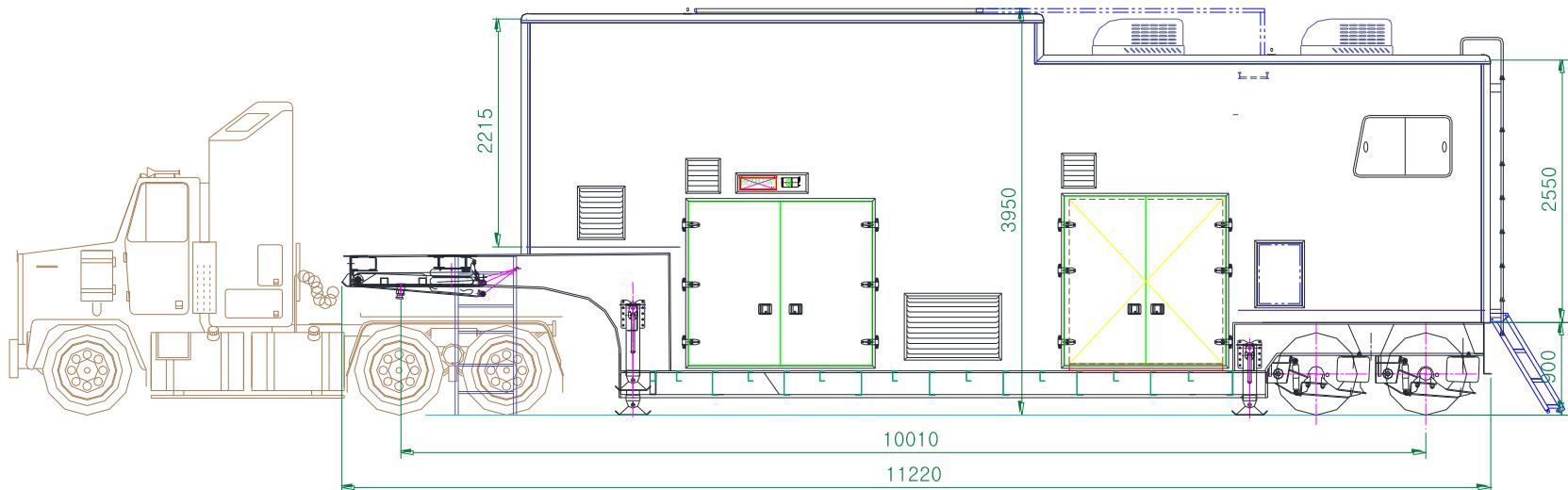
Ref.) FUCH, P.; ROTH B.; SCHWING, U.; ANGELE, H.; GOTTSSTEIN, J. Removal of NOx and SO₂ by the electron beam Process. Radiation Physics and Chemistry, 31, No. 1-3,(1988) 45-56

Previous Mobile Accelerator (BINP, Russia design)



Ref.) VESTNIK "RADTECH-EUROASIA", Edited by S.I.Suminov "Accelerators of ELV type : Status, Development, Applications" pp6~15 Novosibirsk, 1999

Mobile Accelerator of Today



Beam Energy : 0.4~0.7MeV, Beam Power : 20kW

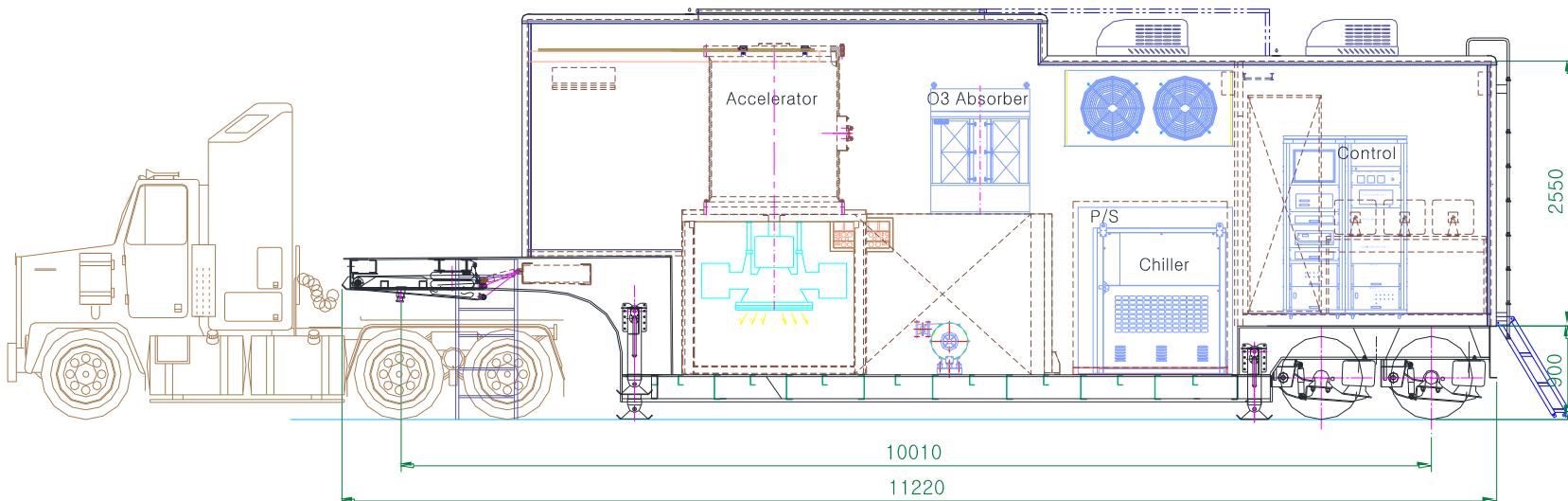
Self-sustaining system : Self-shielded accelerator

Built-in control and monitoring room

Diesel electricity generator (option)

Trailer and Shelter : Fit to U.S. and world standard

Total weight : 40 tons (trailer only 30ton)



Built-in Computerized Experimental & Monitoring System

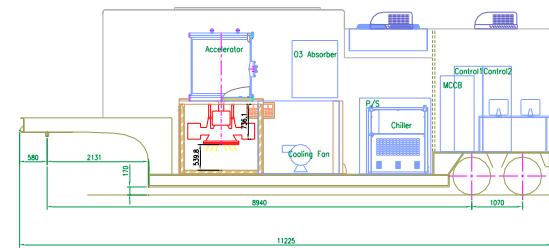
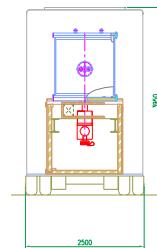
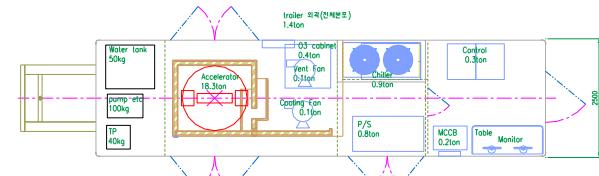
Continuous Treatment of Wastewater/Flue gas on site

Treatment Capacity : Liquid waste : 500m³/day (at max. 2kGy)

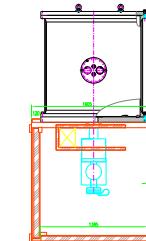
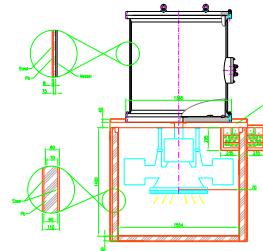
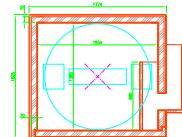
Gaseous waste : 2,000Nm³/h (at max. 15kGy)

Requirement & consideration

- + Purpose
- + Specification
- + Road condition and limit (size & weight)
- + Radiation shielding
- + Trailer
- + Electricity
- + License & permission
- + Air & water cooling
- + Ozone ventilation
- + Pressure vessel
- + Measurement parameter
- + Monitoring system
- + Radiation monitoring
- + High voltage isolation gas
-
-
- etc

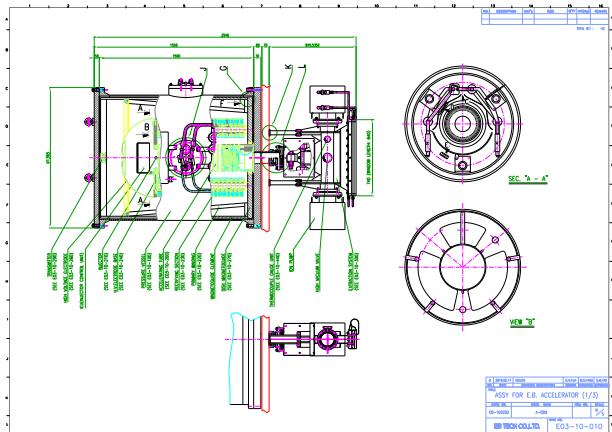


Layout

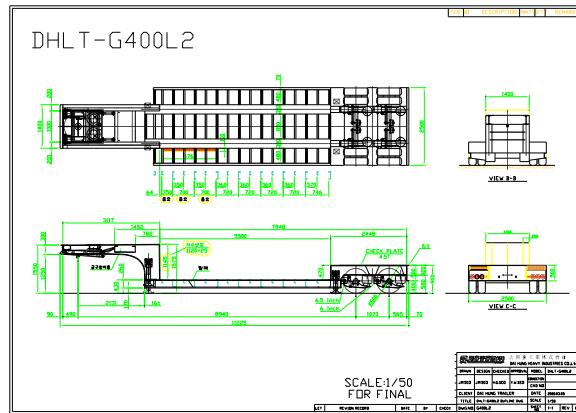


Radiation Shield

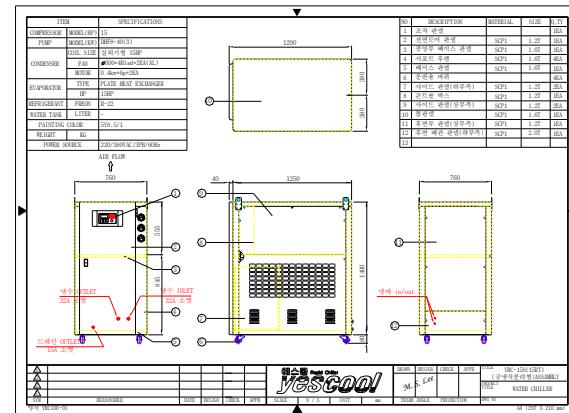
-Detail Designs of each components of Mobile Accelerator



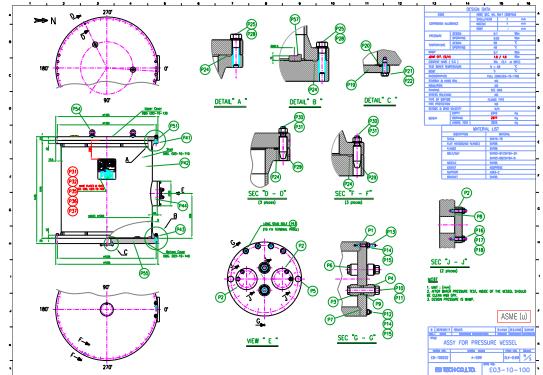
Accelerator



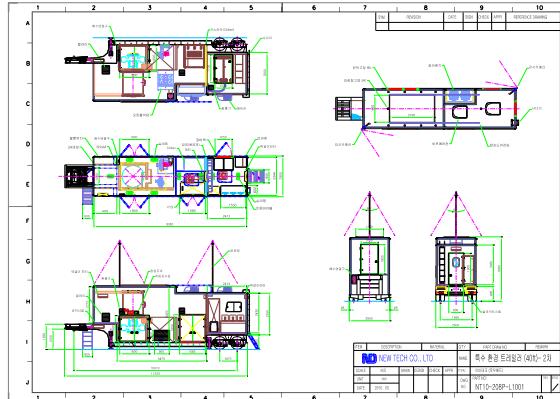
Trailer



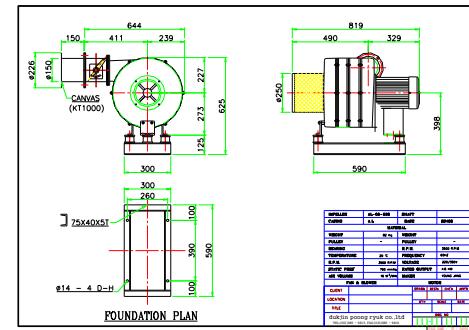
chiller



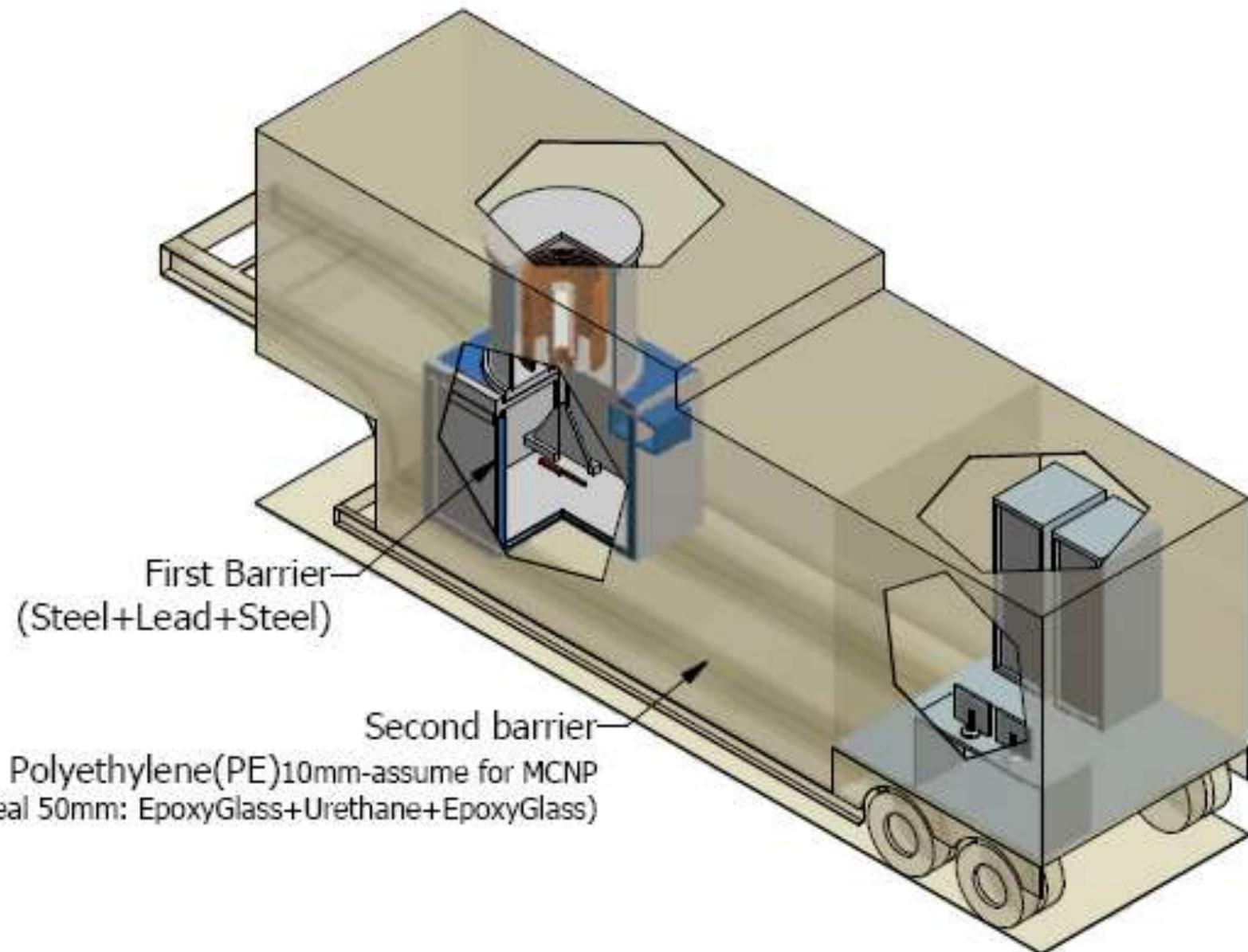
Vessel

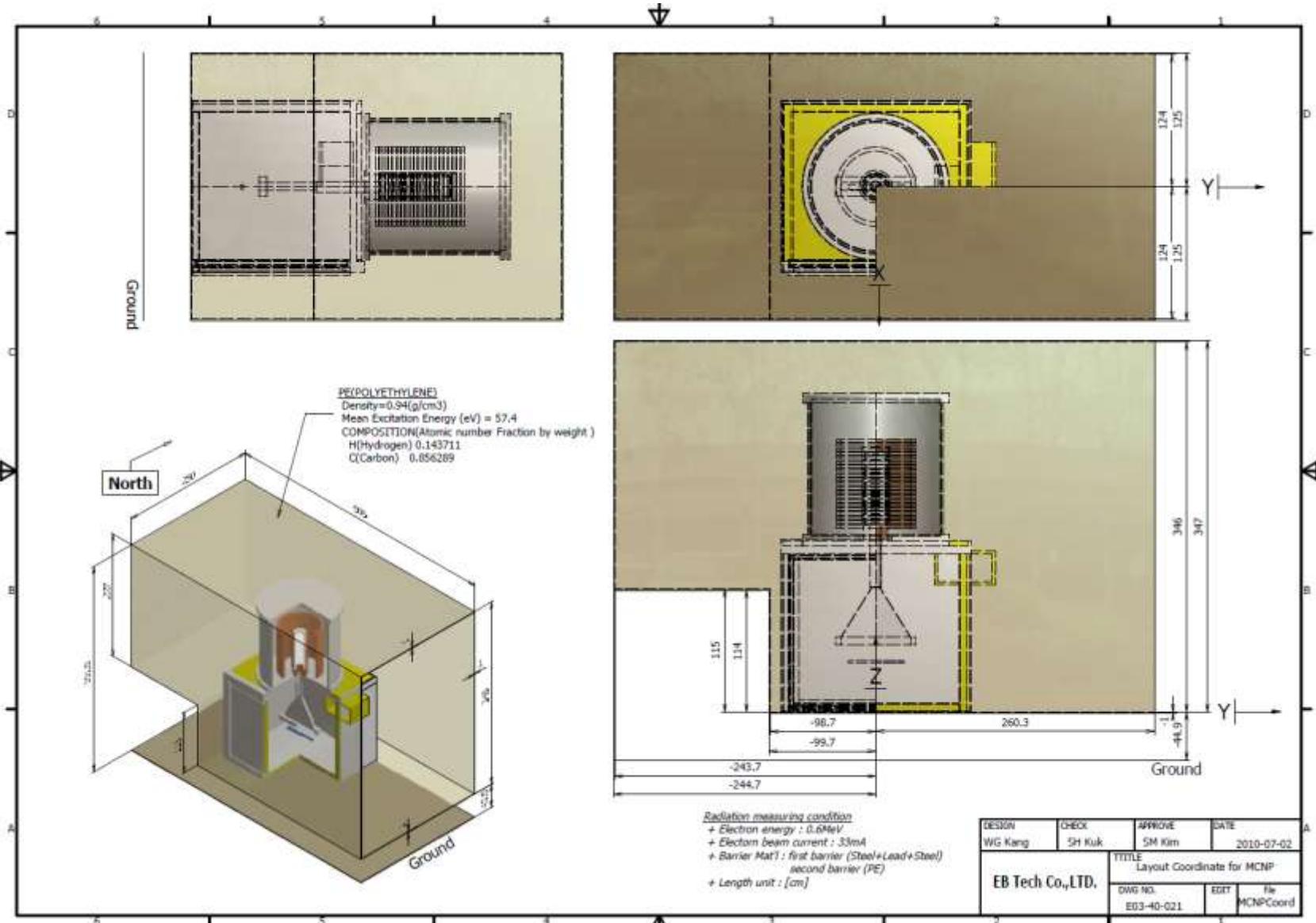


Shelter



Fan & ETC







Trailer



Vessel

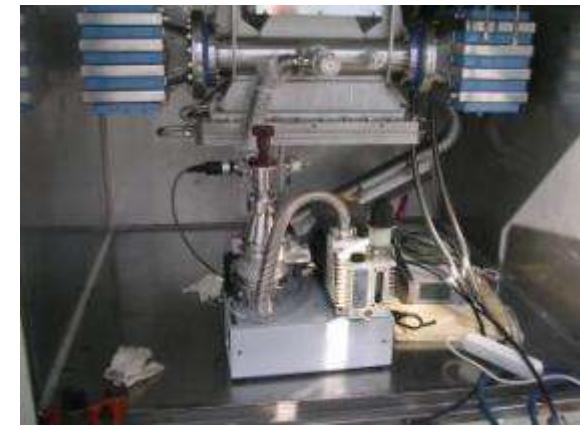


Shield

Shelter

170-9 Techno 2-ro Yuseong-gu, Daejeon 305-500, Korea

Assembling of Mobile Accelerator



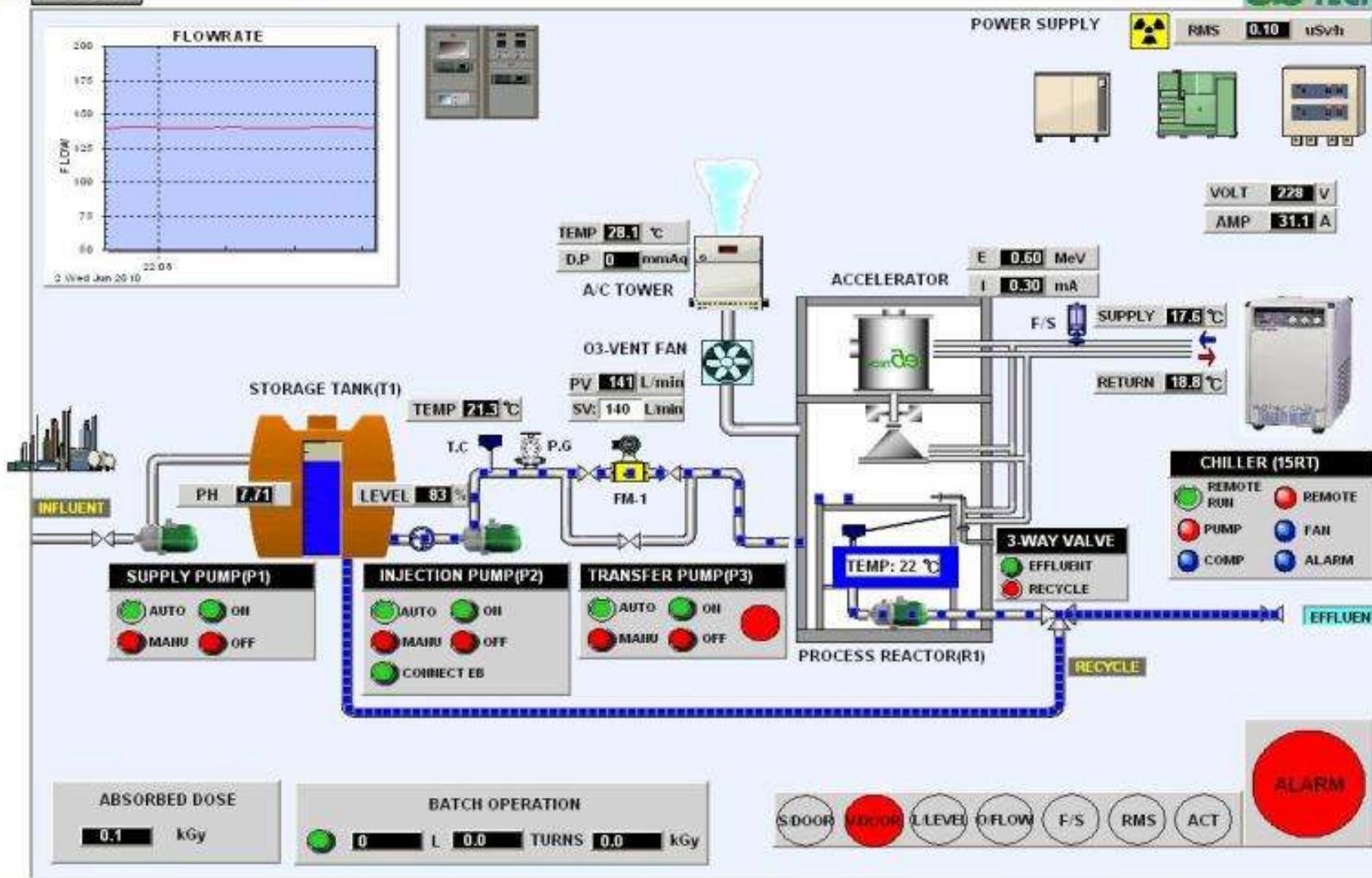






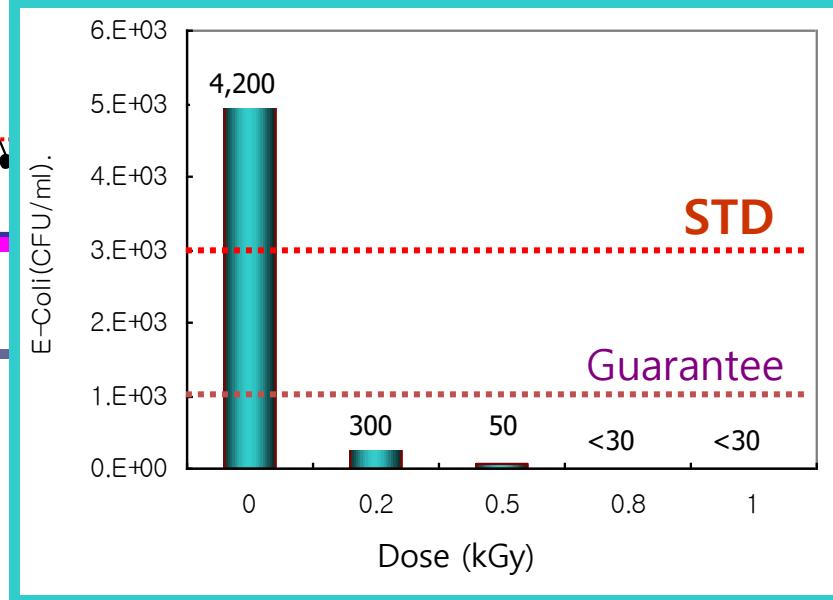
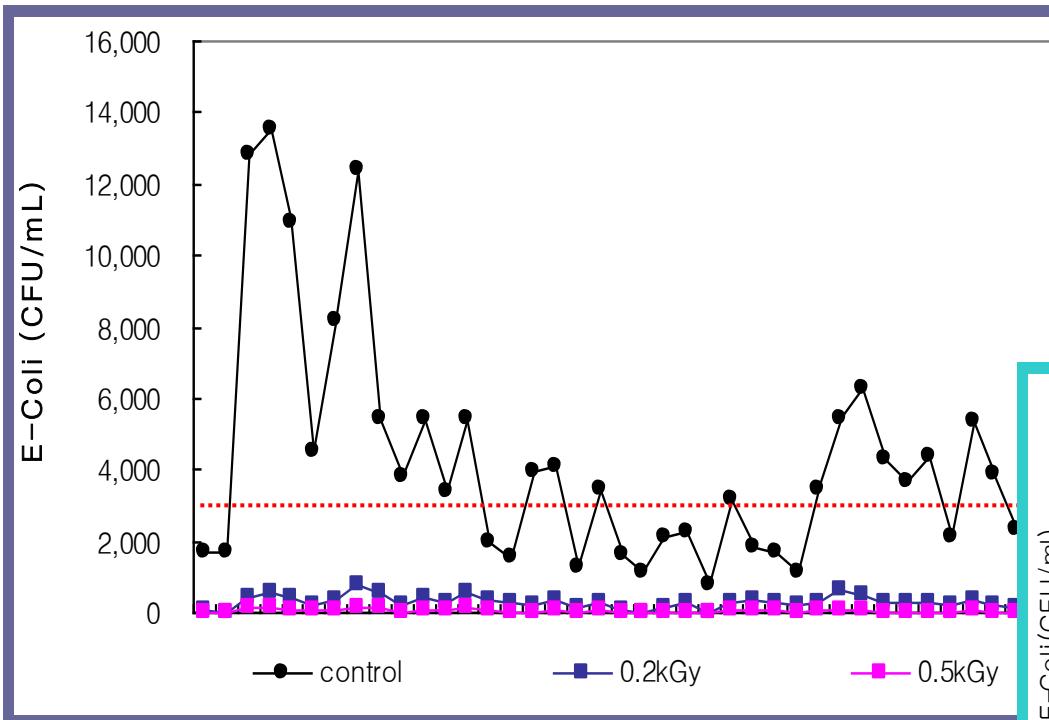
A MOBILE ACCELERATOR SYSTEM

e5TECH





E-Coli





Mobile e-beam in Flue gas Purification from oil-refinery in Saudi Arabia



Mobile e-beam in Flue gas Purification from oil-refinery in Saudi Arabi



1- stack of F 1001 boiler

2- boiler F1001

3-flue gas duct

4-control room

5-humidification unit

6-pilot plant stack

7-bag filter

8-insulated duct part

9-cyclone

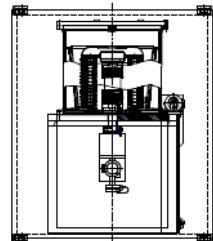
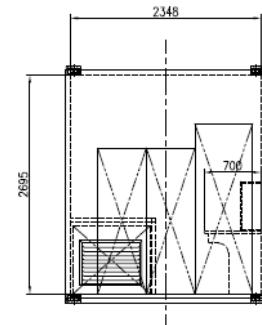
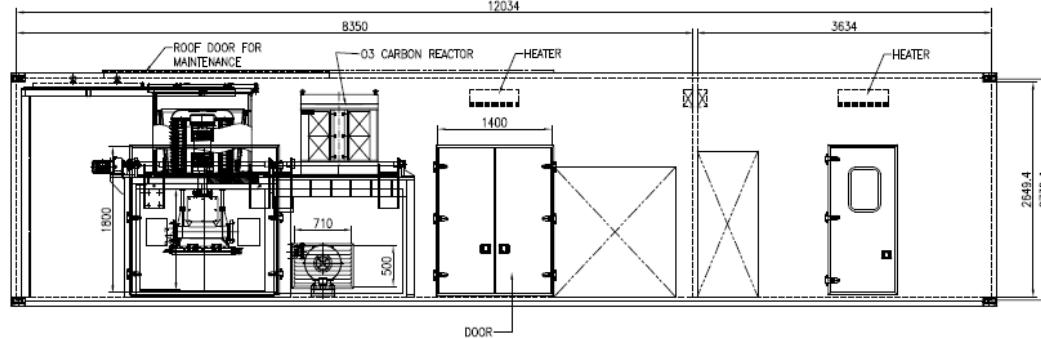
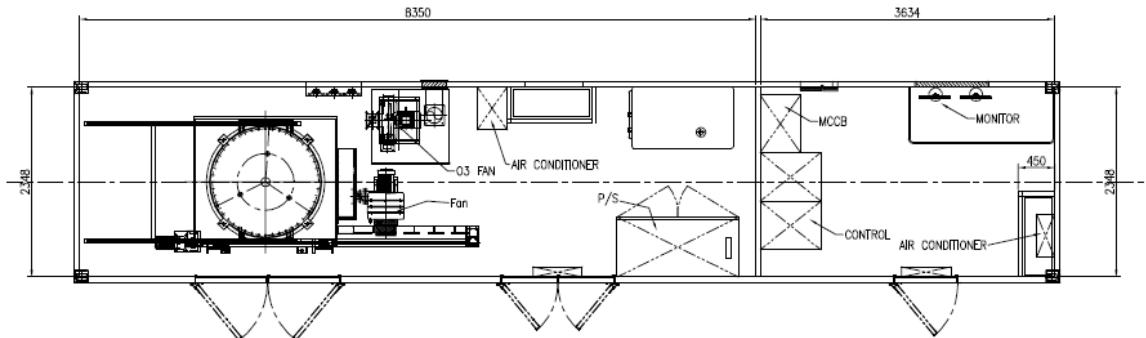
10-ammonia storage and injection unit

11-EB mobile unit

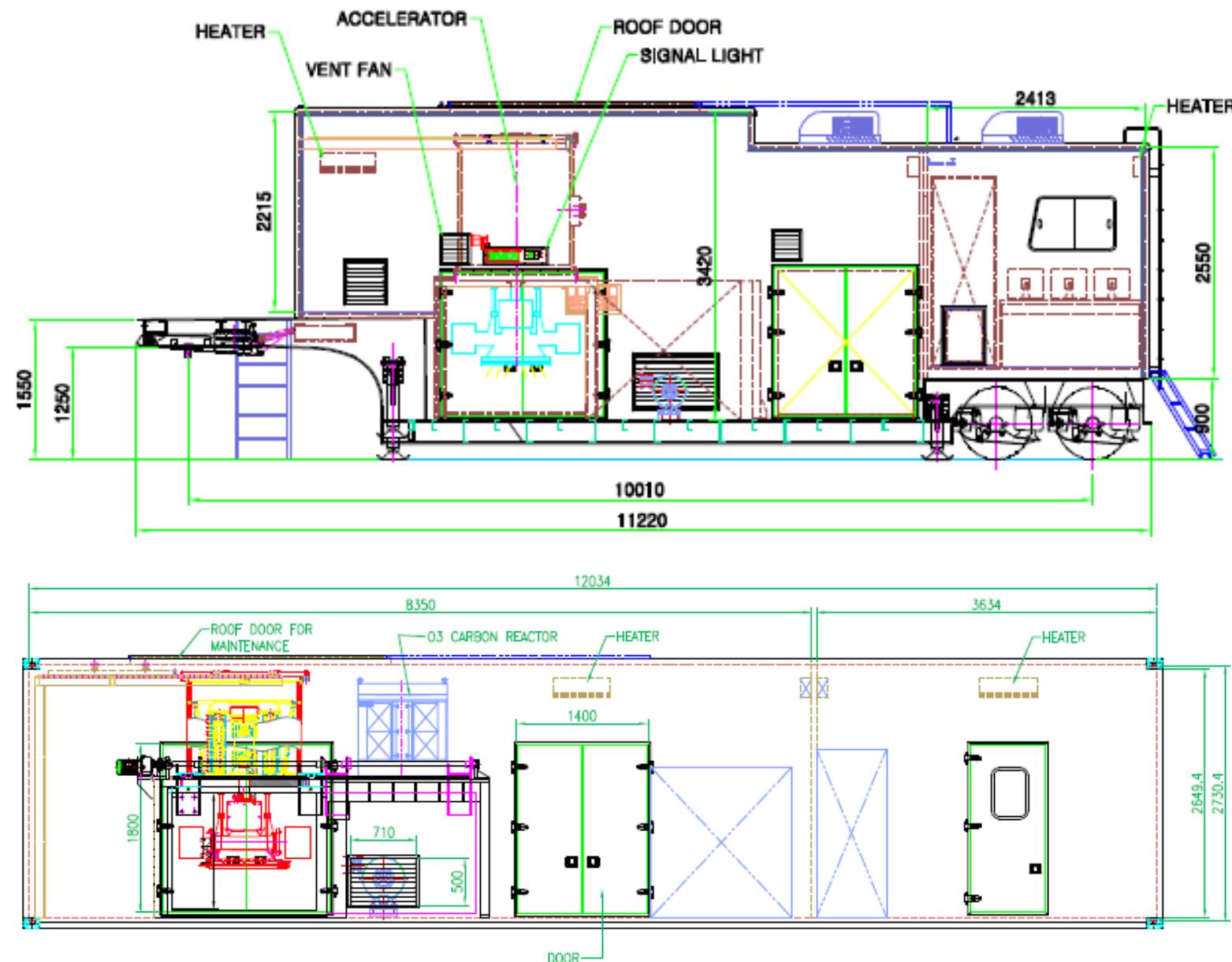
Mobile e-beam in Flue gas Purification from oil-refinery in Saudi Arabia

New Design of Mobile Accelerator

1. New design fit to the standard container (40")
 - Length (40"), Height (10"), width (8")
 - Self-shield structure
 - Needs to modify container – doors, roof door etc.



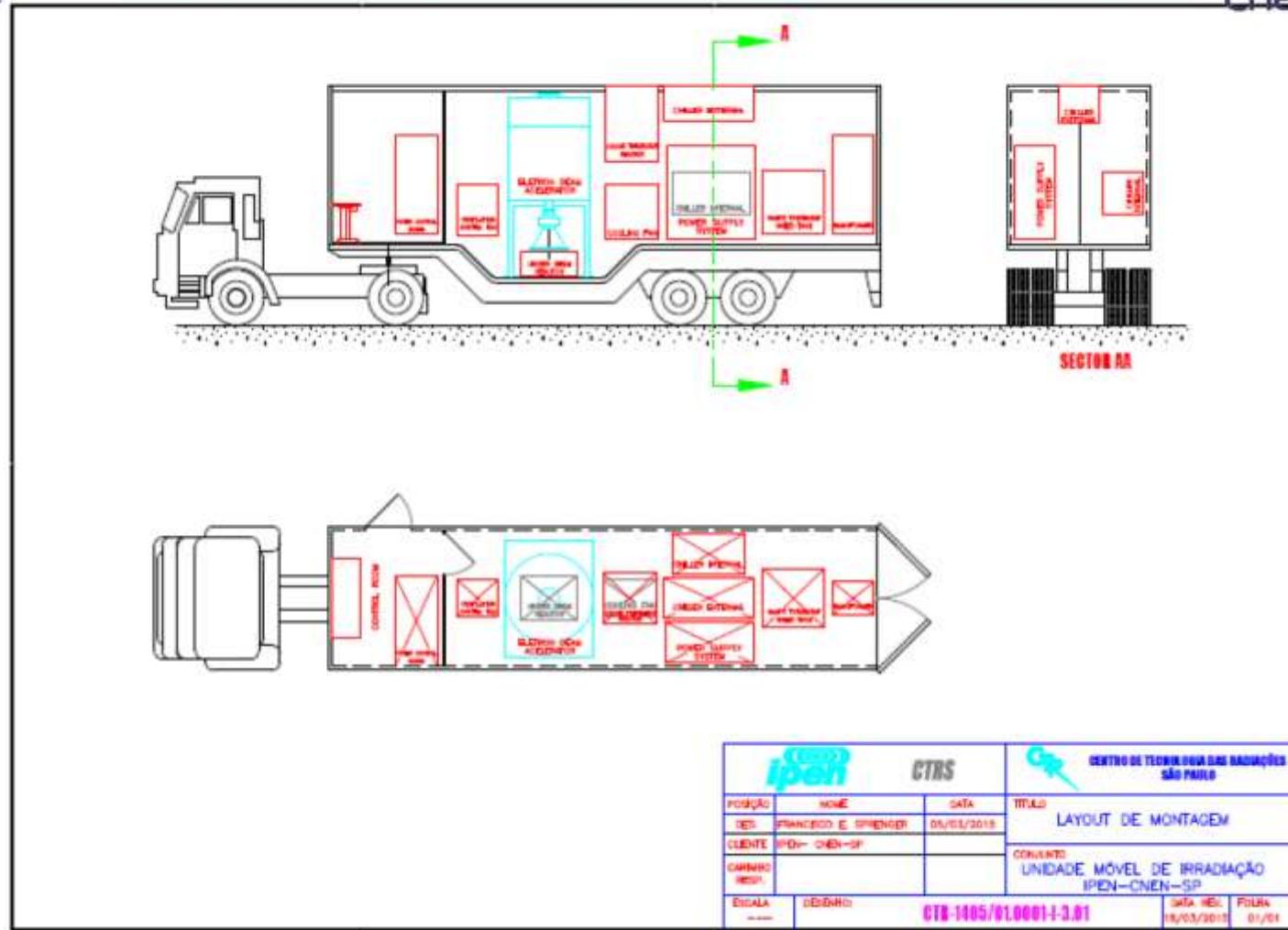
2. Comparison with Existing Mobile Accelerator



3. Mobile Accelerator project in Brazil



IPEN, TRUCKVAN and SENAI's Mobile Electron Beam Accelerator



4. Mobile Accelerator project in Slovakia

Transportable electron beam irradiator for treatment of environment contaminated by PCBs

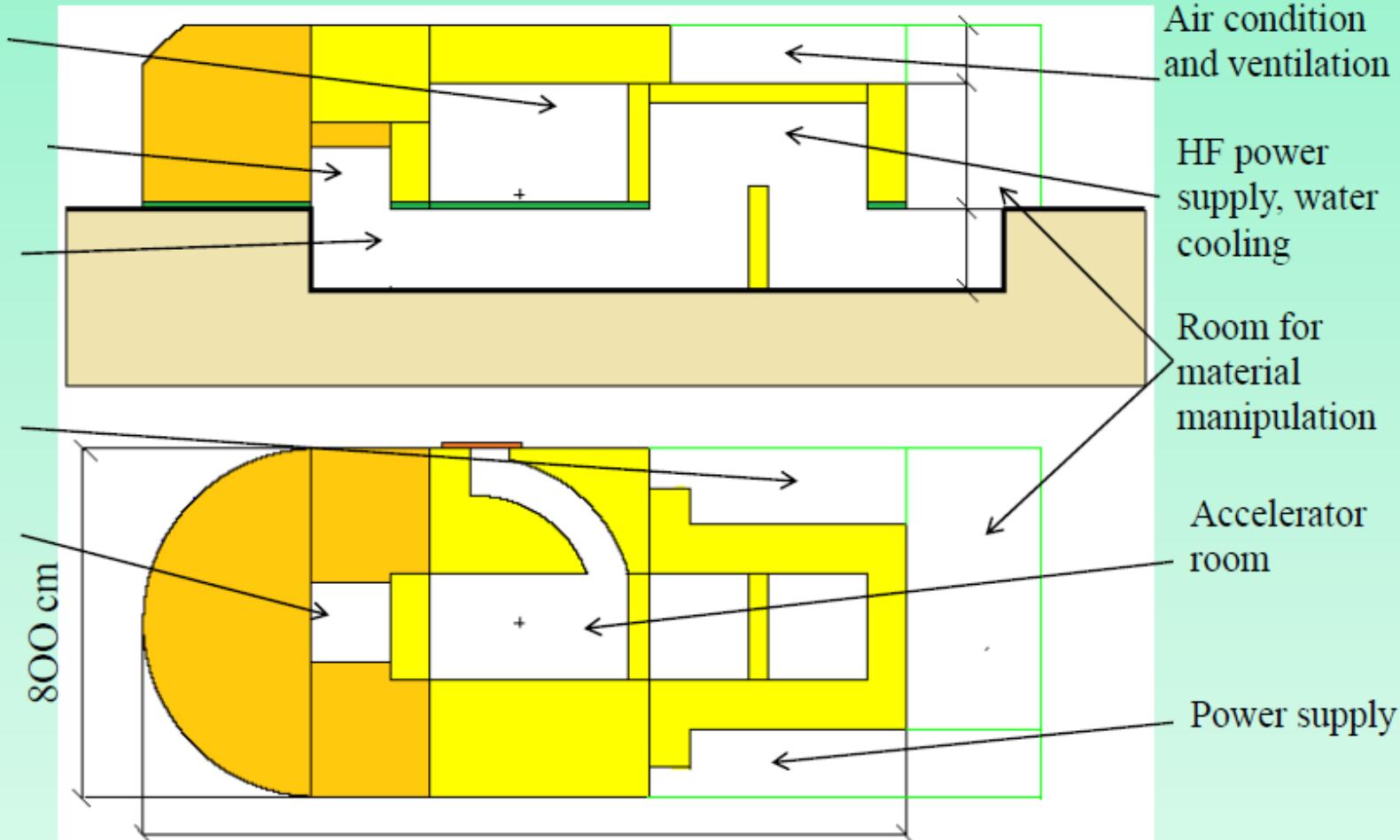
Accelerator room

Material irradiation

Material transport channel

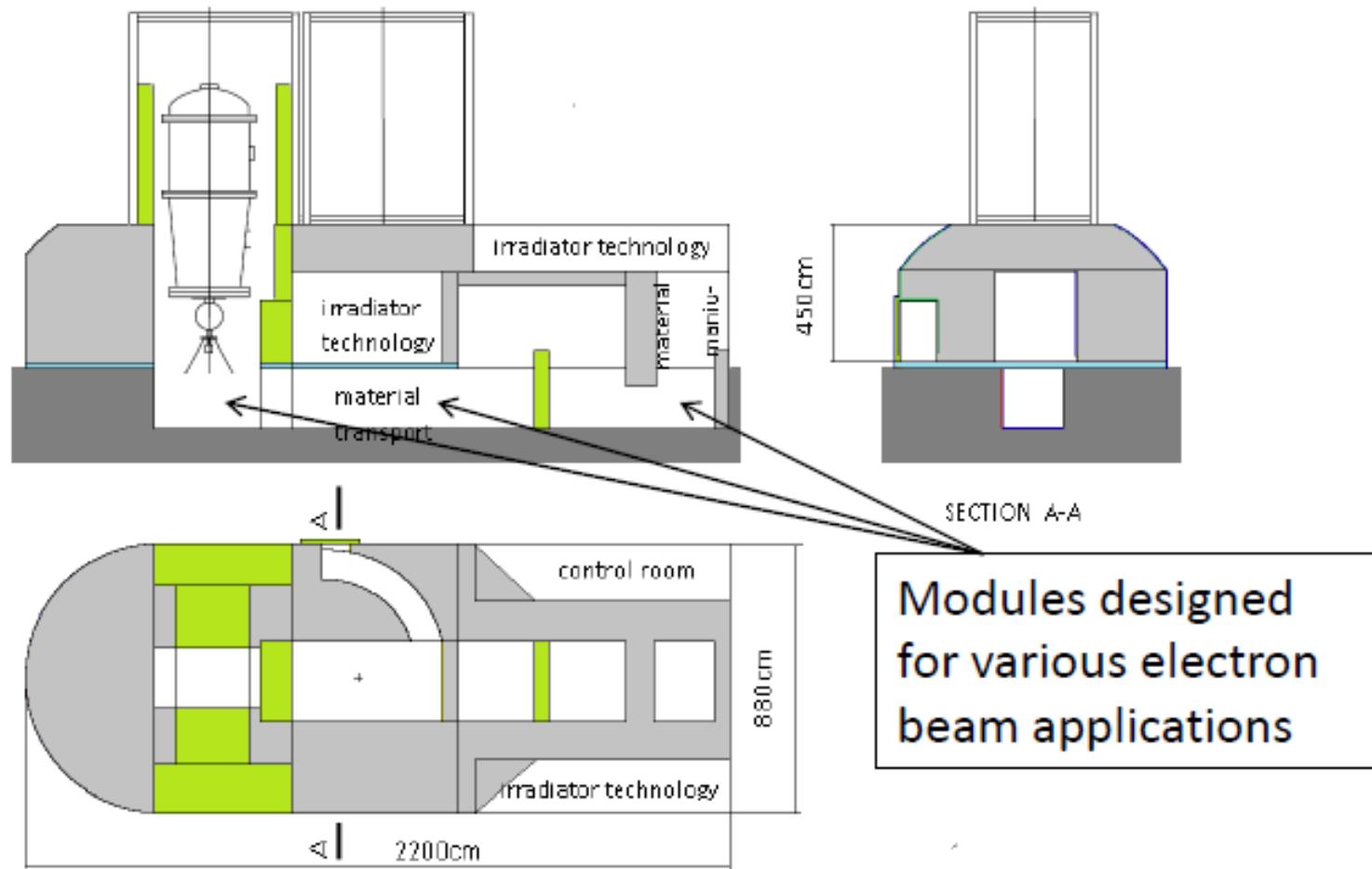
Control room

Material irradiation



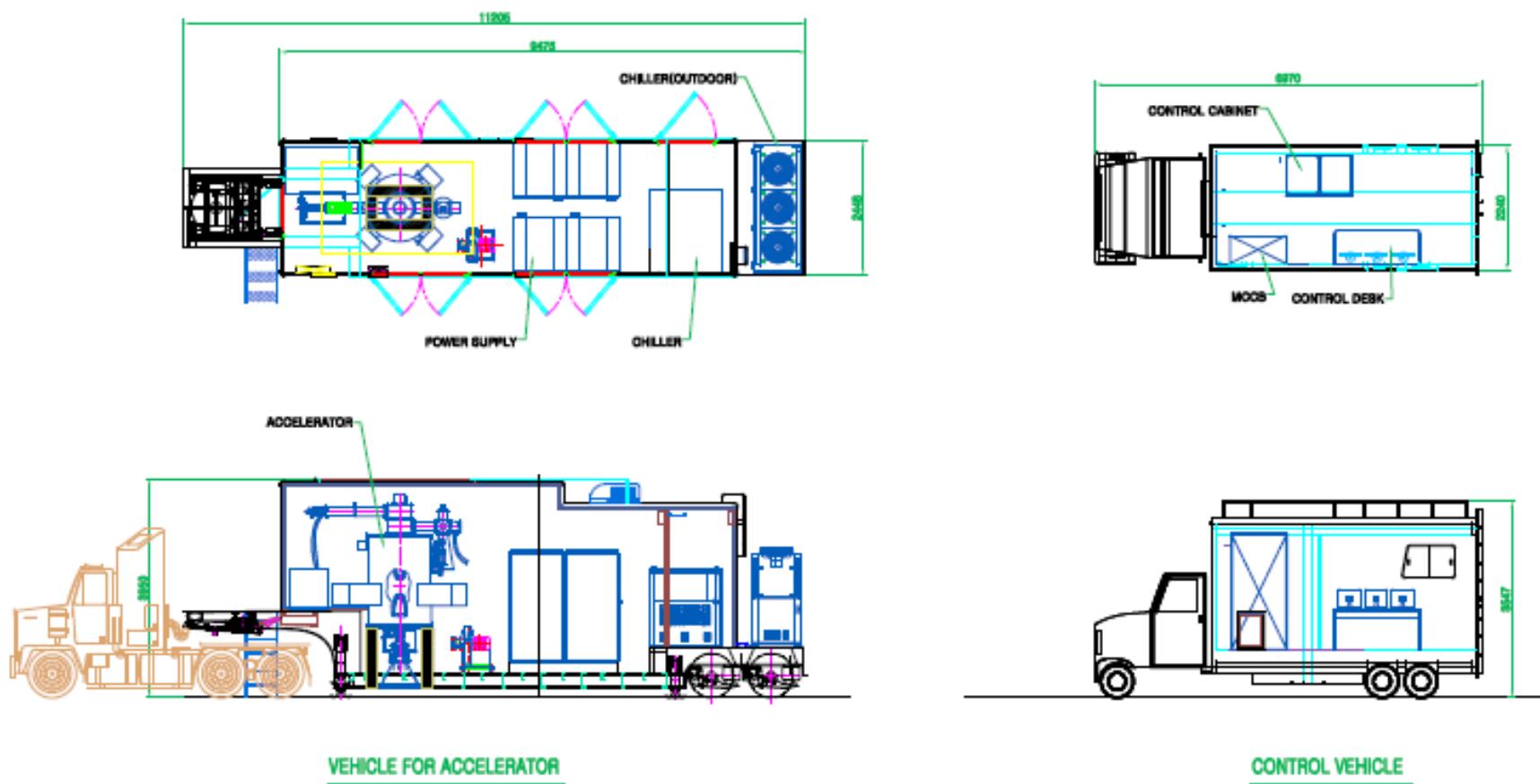
From the Presentation of M. Fulop

Transportable multipurpose electron irradiator with accelerator ELV 8 2,5MeV/100kW



From the Presentation of M. Fulop

4. Re-locatable e-beam project for Viet Nam

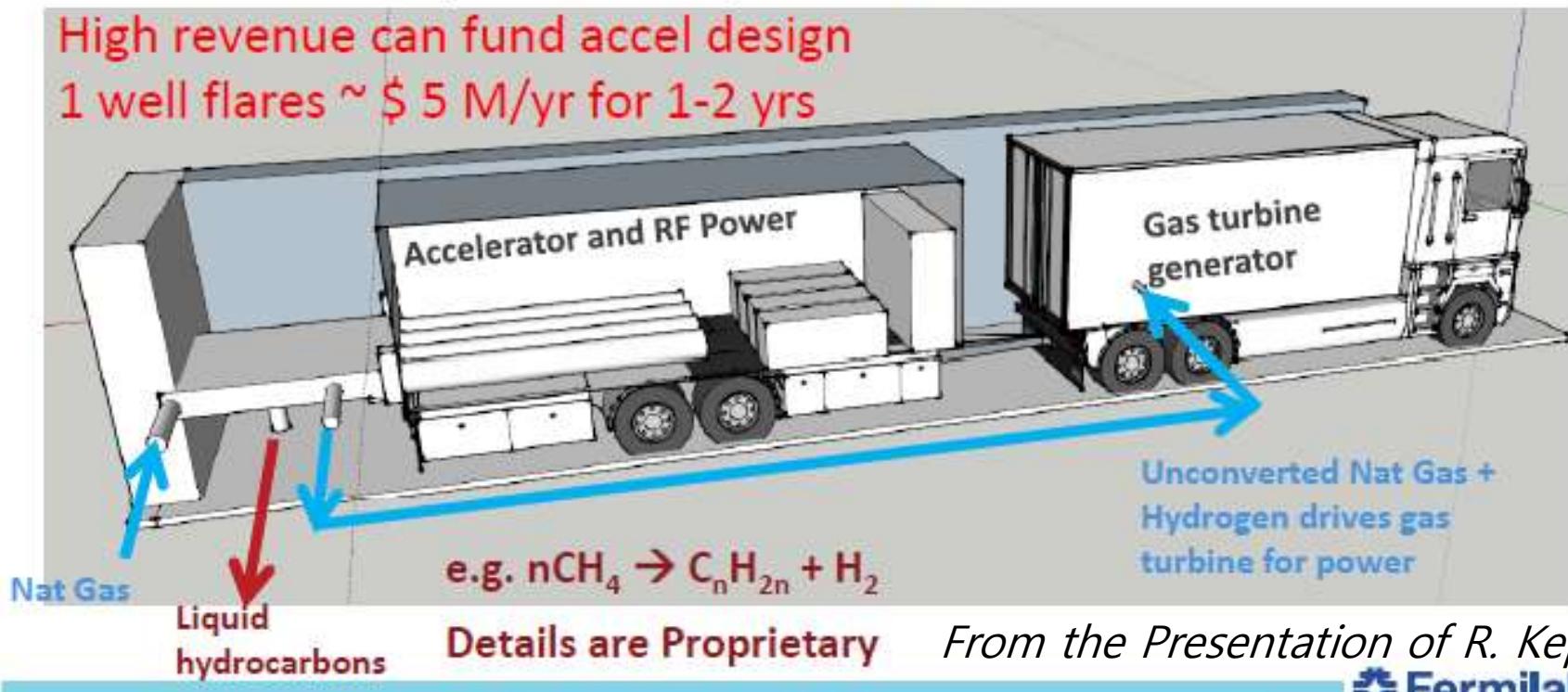


Accelerators for the Environment: Flare Gas

- Trailer mounted high power electron accelerators
- Natural gas turbines provide the local electrical power
- Liquid hydrocarbons created can be mixed and collected with crude oil produced by the well

High revenue can fund accel design

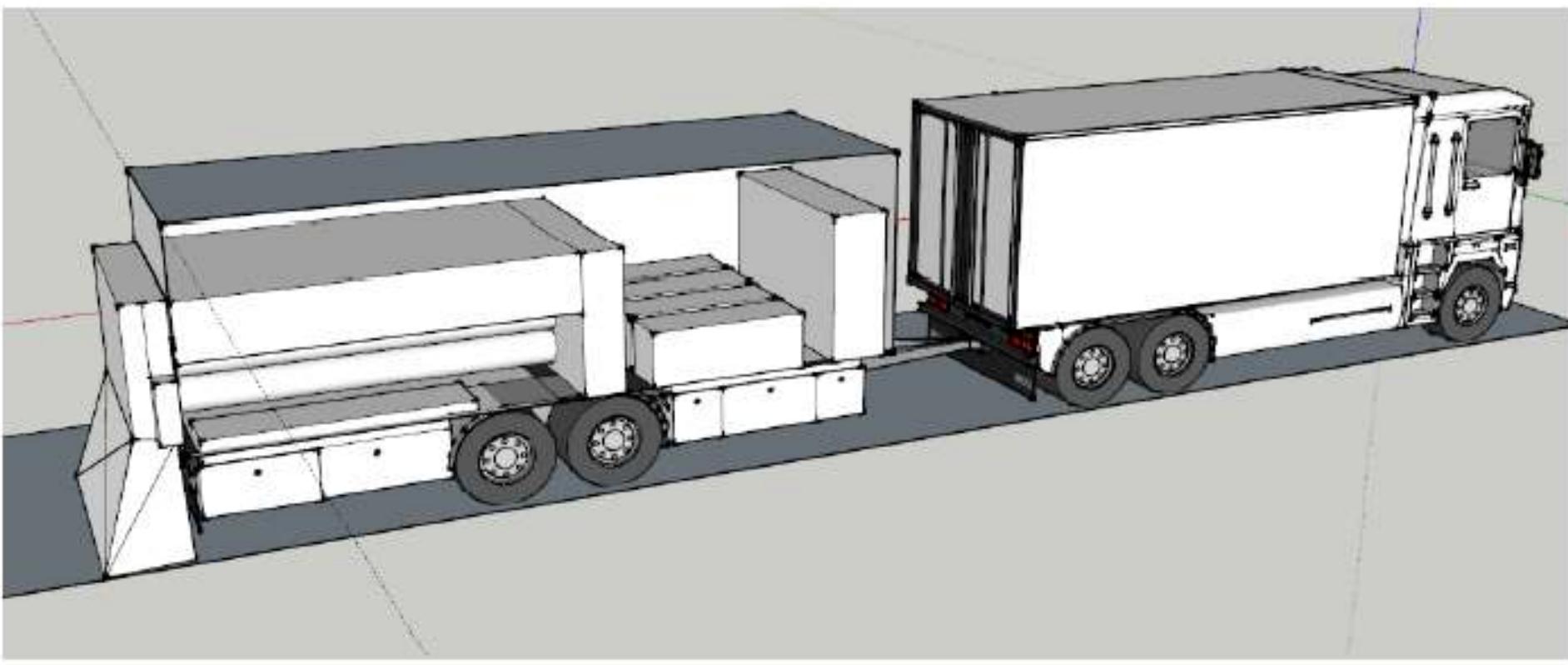
1 well flares ~ \$ 5 M/yr for 1-2 yrs



From the Presentation of R. Kephart



Mobile EB to extend lifetime of highways



- 1400 KW → 2 lane-miles per 8 hr shift
- Cost of 1 lane-mile interstate highway = \$ 2.4 - 6.9 M
- Huge value added ~ \$ 500 K- \$1.4 M per shift (1 yr extension)
- \$ 5-8 M capital cost → very short payback period!

Summary

It is becoming increasingly clear that humankind's environmental problems are no longer merely local or regional, but have become continental in scope. Economically and technically feasible technologies for controlling pollution from gaseous emissions and liquid effluent streams are being sought by technologists working in a variety of areas, including radiation technologies.

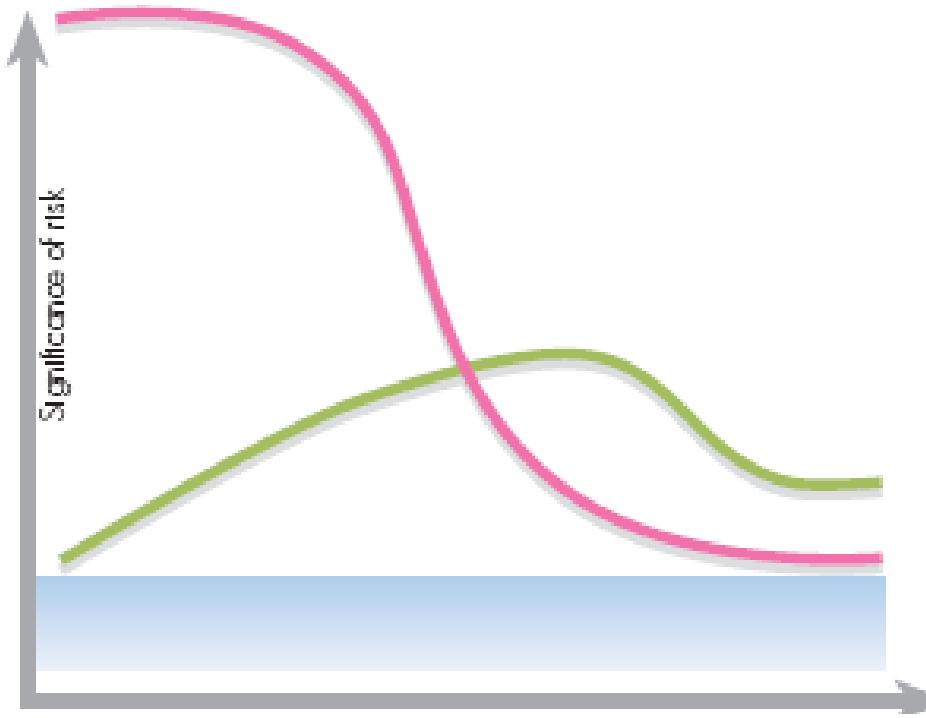
Radiation technology is quite effective for remediation of contaminated environment. When irradiated with high energy radiation, practically all the energy absorbed initiate the ionization and excitation to result in formation of free radical and molecular species to destroy or to convert the harmful chemicals.

Over the last few decades, extensive work has been carried out on utilizing radiation technology for environmental remediation. This work includes the application of radiation technology for simultaneous removal of SO_x and NO_x from the flue gases, purification of drinking water, wastewater treatment and hygienization of sewage for use in agriculture.

Thank you for your attention



Environmental Health Risk Transitions



Low income
Populations
in poverty

Middle income
Populations
in transition

High income
Industrialized
society

Basic risks : Lack of safe water, sanitization and hygiene, indoor air pollution, vector-borne diseases, hazards that cause accidents and injuries

Modern risks : unsafe use of chemicals, environmental degradation

Engineering risks : climate changes, persistent organic pollutants, endocrine disrupters

Source : Global Environment Outlook (GEO-4) Chapter 7, United Nations