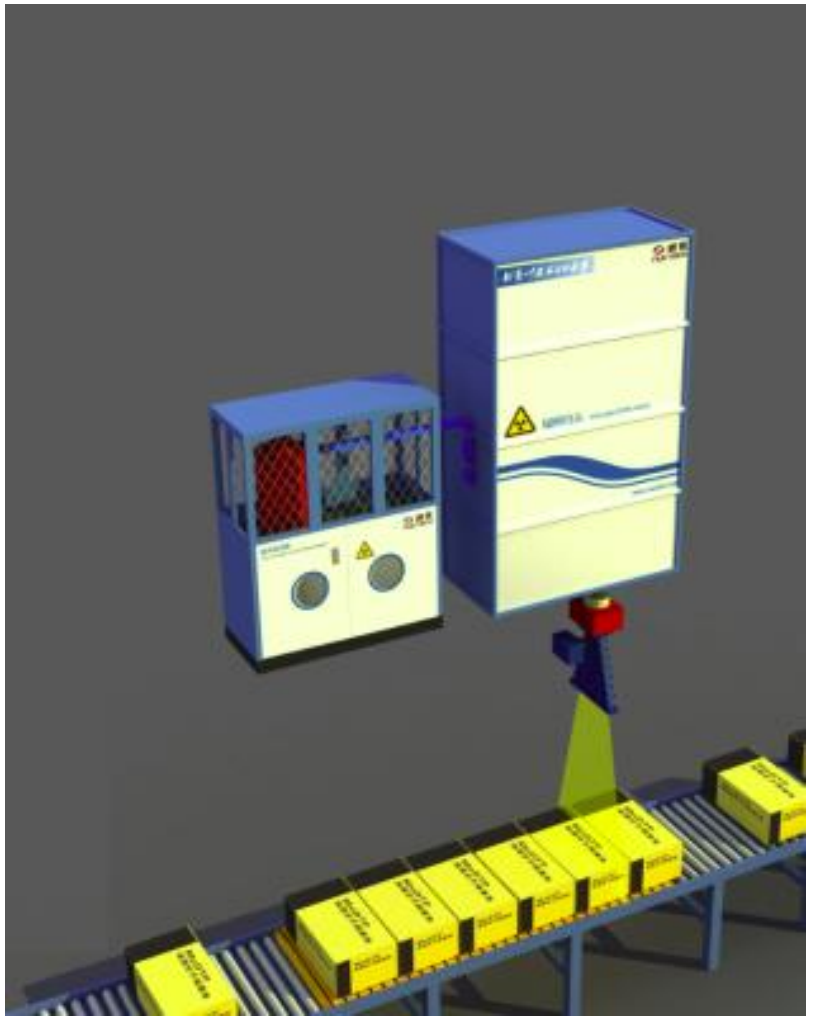
PART 03
E-beam irradiation Technology

1. Technical Solution of EB Irradiation System
2. NUCTECH EB Irradiation Series
3. Customized Technical Proposal Discussion

EB irradiation technology

- Electron Beam irradiation has been booming：
  - with high processing speed & high efficiency;
  - no radionuclide resource, ionizing radiation can be switch off, safer；
  - Multiple adaptability, customized design for targeted applications

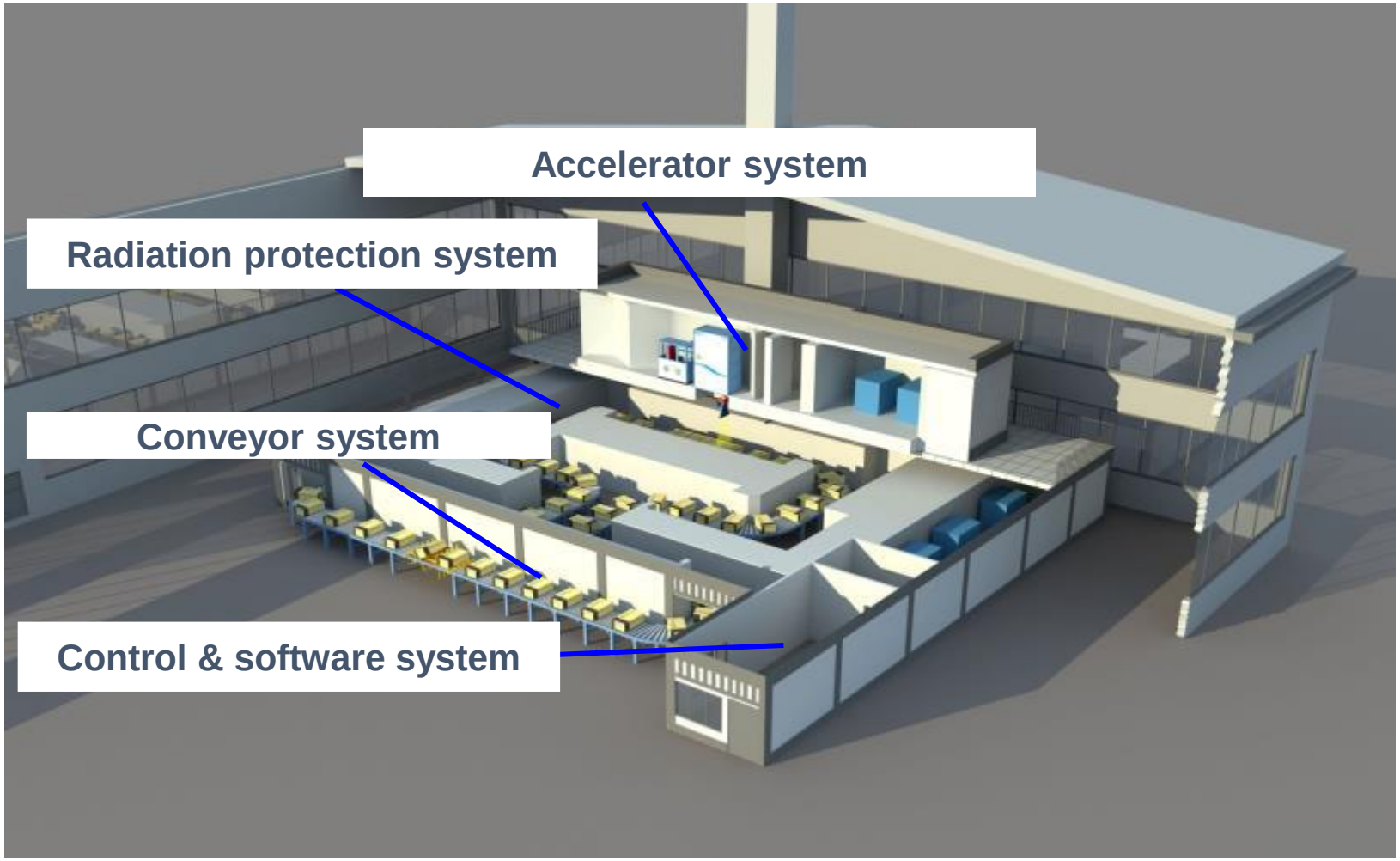


Main Specification

- **Energy**
  - ➢Determines the penetration depth and the thickness of the goods. Higher energy, higher penetration depth .
  - ➢10MeV is up-limit to food irradiation
- **Power**
  - ➢Determines the process output. Higher power, higher output.
- **Penetration ability**
  - ➢Relate to the energy and the density of the goods；To a certain energy, higher density, lower penetration depth.
  - ➢The thickness×density of 10MeV EB (double-side irradiation) is 10g/cm^2, for water, 10cm= 10/1 ； if ρ=0.5，20cm=10/0.5

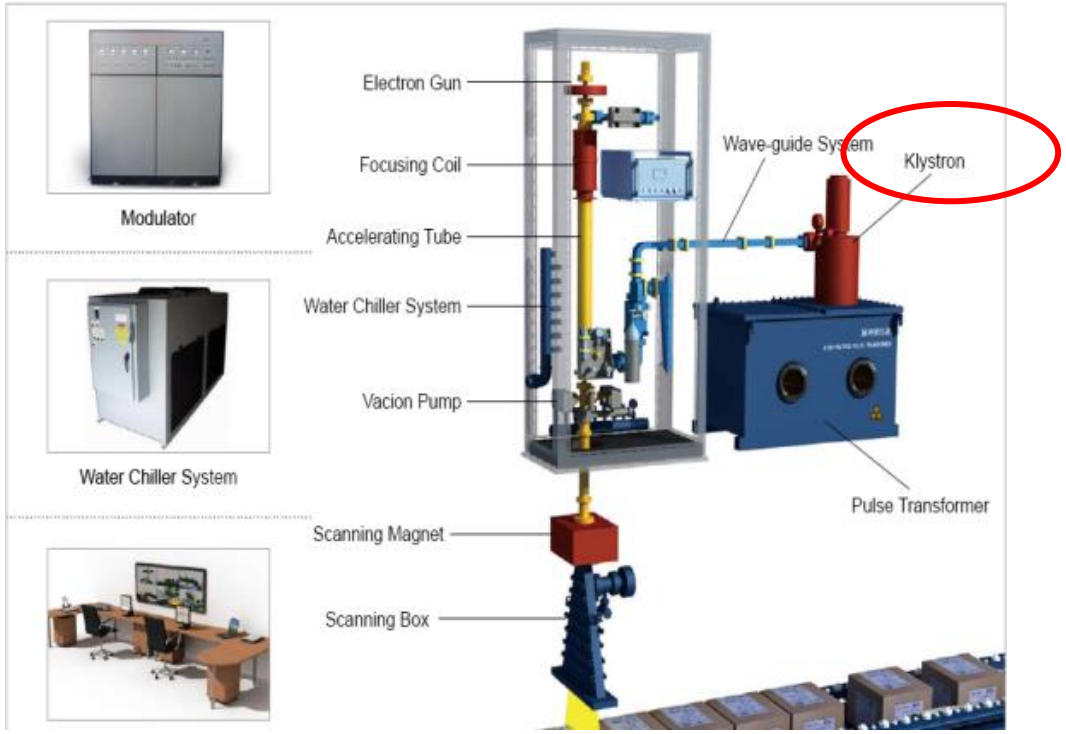
For a certain item, its specifications（size, internal structure…） determine the accelerator energy;
Dose and output determine the power of the accelerator.

EB irradiation system

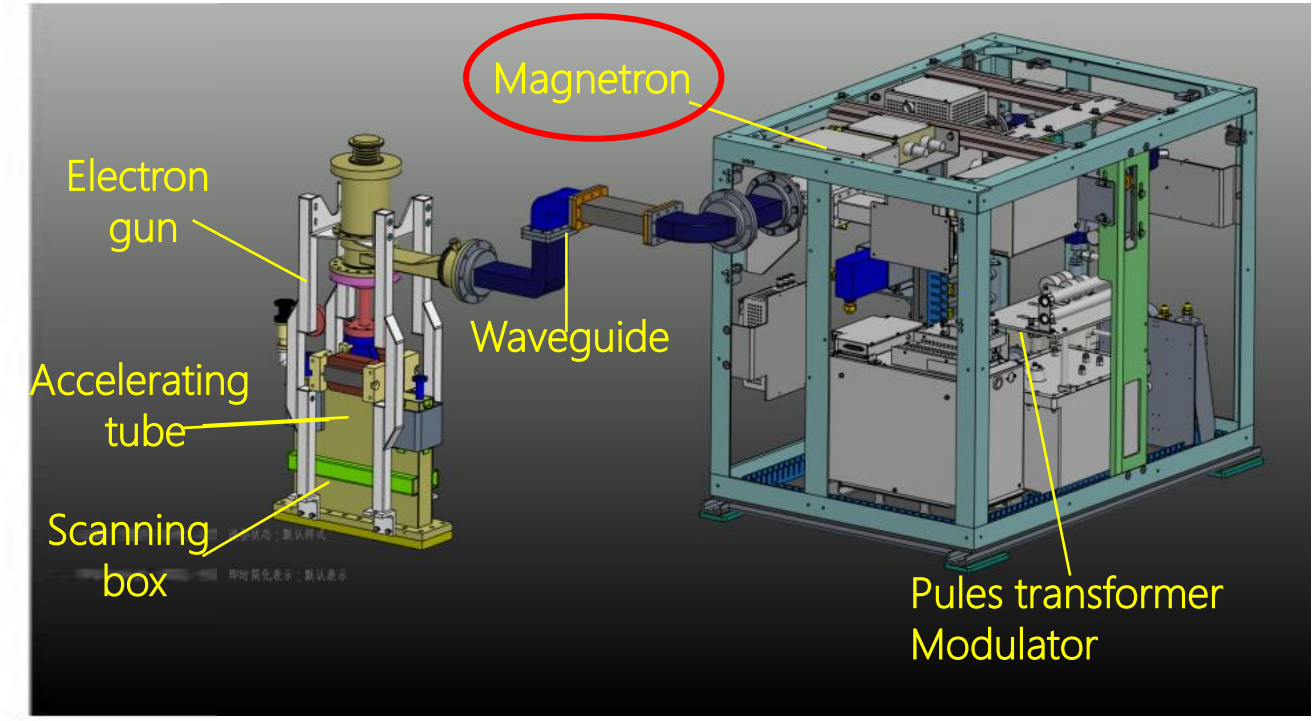


Typical EB irradiation system composition diagram

Irradiation Accelerator (Lanic)



- Energy: **10MeV**
- Power: **10~24kW**
- Scanning width : **500~800 mm**
- Scanning uniformity: **<5%**



- Energy: **2~3 MeV**
- Power: **1~2kW**
- Scanning width : **300mm**
- Scanning uniformity: **<5%**

EB irradiation technology

Klystron

characterized by high power, long service life, large volume, high cost and complex matching system. It is usually used as the power source of the fixed radar base for continuous operation, or as the irradiation equipment with high power and long-time operation.

Magnetron

aims at miniaturization, convenience, low power and short service life. It is usually used for small radars on missiles or fighter planes, or for the discontinuous vehicle inspection , NUCTECH security system.

EB irradiation series

Integrated EB irradiation system

(10MeV/24kW)

Mail Sterilization System

(5MeV/2kW)

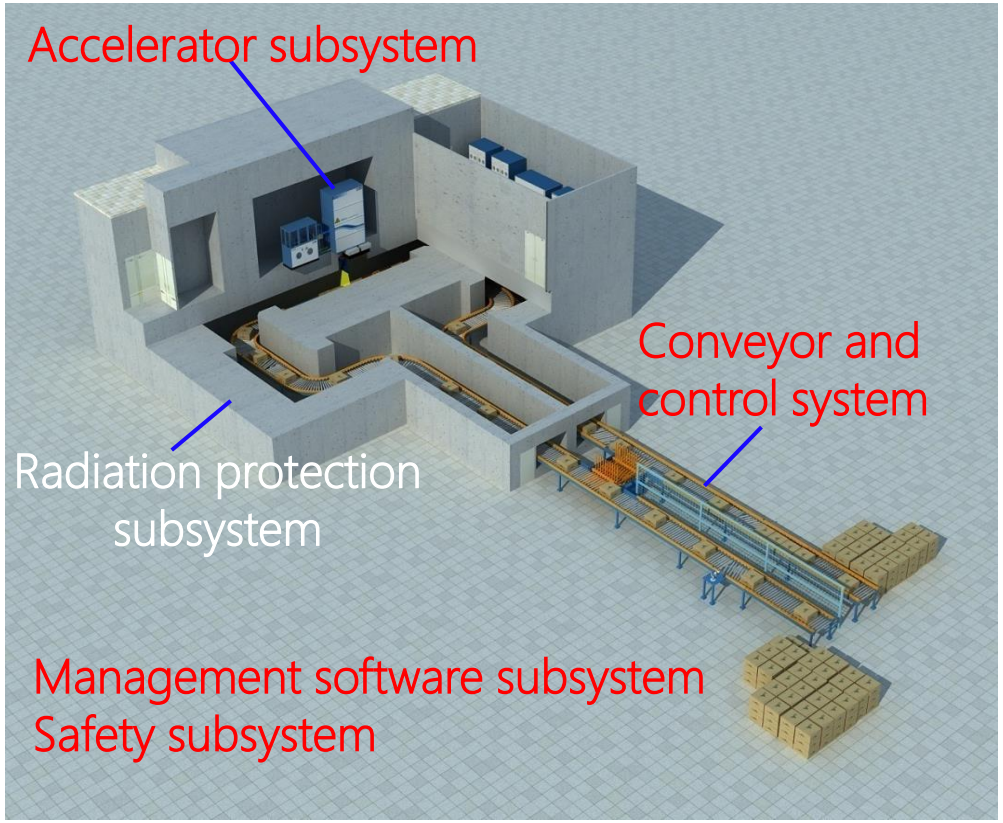
Shelter irradiation system

(3MeV/2kW)

Research irradiation system

(2.5MeV/1kW)

Integrated EB irradiation system-IS1024



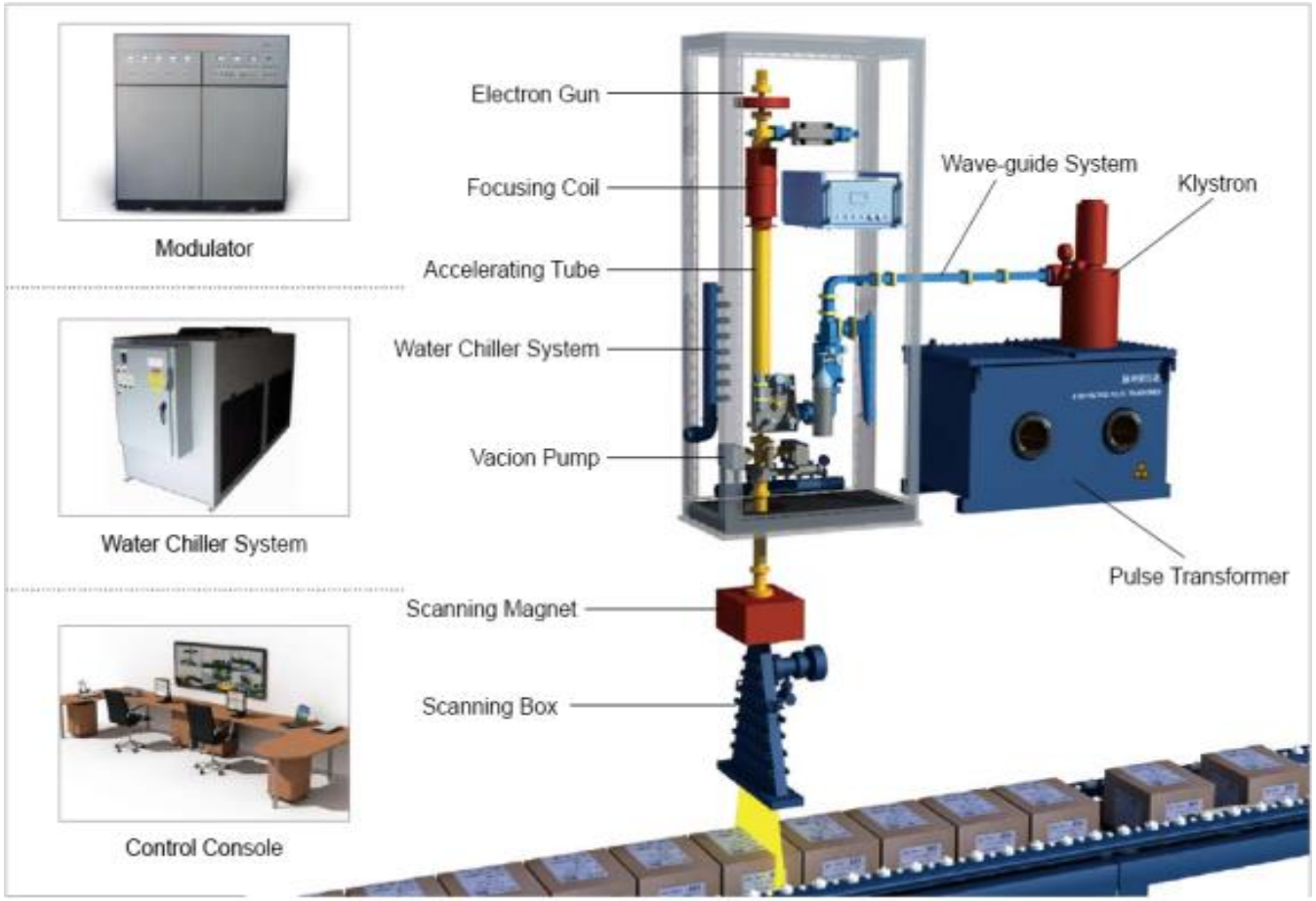
For radiation protection subsystem we will provide civil engineering interface drawings and technical support.

Irradiation processing of food, medical devices, health products, materials modification and etc.

System characteristics and requirements for plant

- 10MeV/20-24kW
- Covers an area of 300m^2
- With the height of 8.5m
- 2000~4000 square meters for storehouse

Accelerator subsystem



- Beam energy：
  10MeV±5%
- Beam current：
  2.4mA±5%
- Beam power：
  ~24kW
- Scanning width ：
  500~800 mm （grades）
- Scanning uniformity：
  <5%

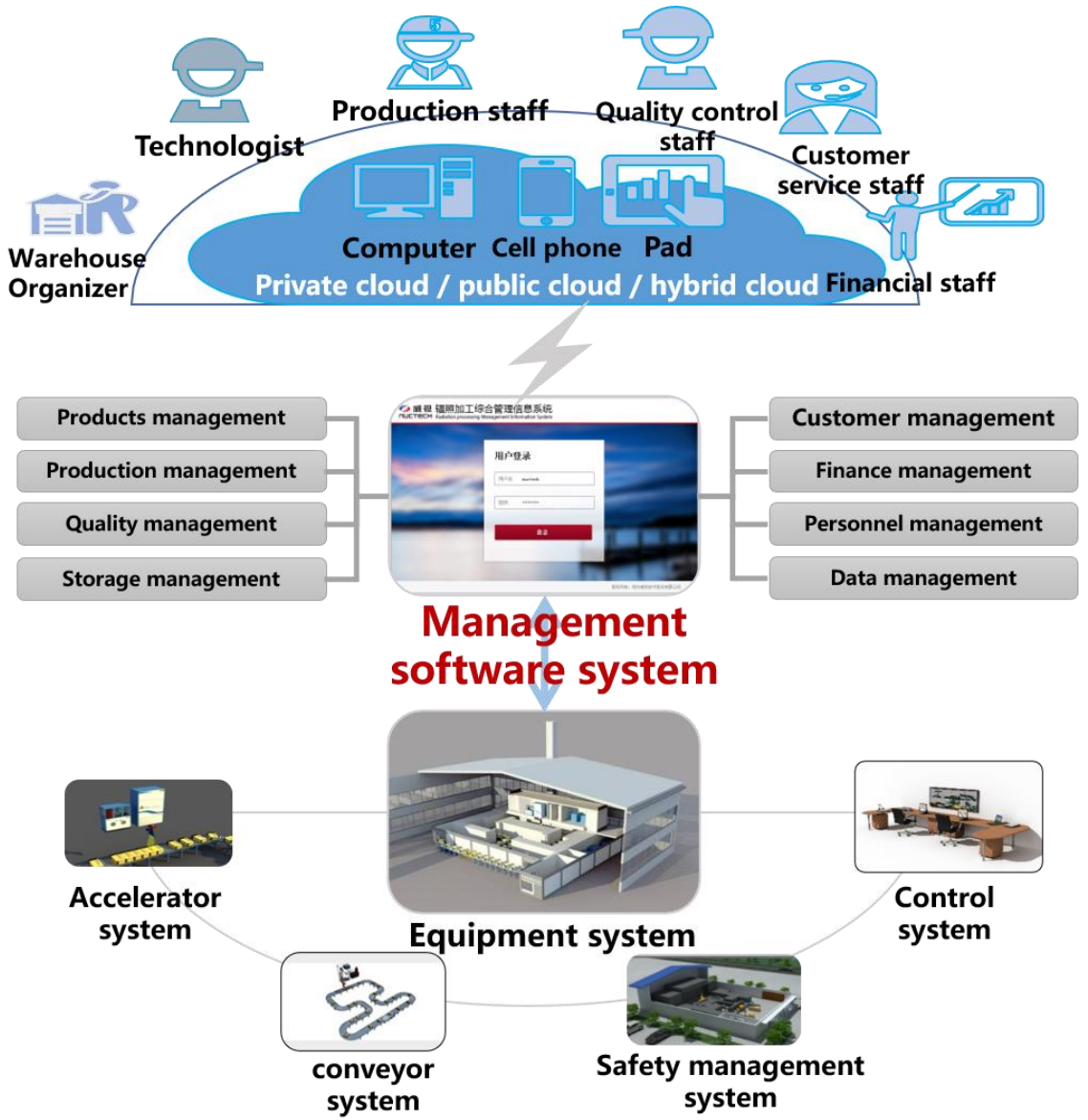
- **Backward-traveling wave linac**
- **Combines the advantages of traveling and standing wave linac**

Conveyor and control subsystem

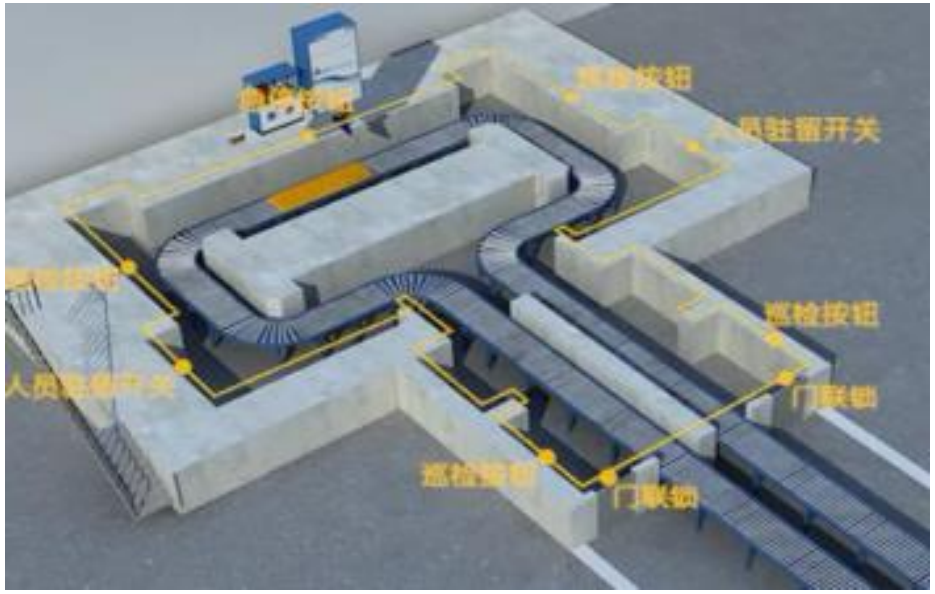
- Suitable for many kinds of goods with large-range packing sizes.
- Efficient: one by one under scanning box.
- Automatic: with barcode and information tracking.
- A friendly human machine interface for the staff easy to operation and supervision.
- Achieve the best matching degree with the accelerator and Maximizing production efficiency.

Management software subsystem

- The management software can interact with the equipment system.
- Full business coverage: products, production, quality, storage, customers, finance, personnel management.
- Management of multi-line, comptable to manage Cobalt source line.
- Data accumulation: Process database(Dose verification, process parameters, production program).



Safety subsystem



- Multi-layer security management mechanism
- Responsive and fast without delay.
- Real time monitoring, displaying and control of border dose.
- Safety inspeciton control process.
- Quick location of safety issue.

Stable running brings long-term value

Yangzhou-2020

Time	Hour/month	Cumulative
2019.11	586	586
2019.12	584	1170
2020.01	561	1731
2020.02	538	2269
2020.03	592	2861
2020.04	671	3532
2020.05	679	4211
2020.06	683	4894
2020.07	695	5589
2020.08	719	6308
2020.09	705	7013
2020.10	637	**7650**

Shanghai-2020

Time	Hour/month	Cumulative
2019.11	575	575
2019.12	535	1110
2020.01	551	1661
2020.02	429	2090
2020.03	560	2650
2020.04	661	3311
2020.05	669	3980
2020.06	670	4650
2020.07	681	5331
2020.08	702	6033
2020.09	698	6731
2020.10	597	**7328**

Chinese New Year Peak production season

Mail Sterilization System

Sterilization of mails and letters for Anti-terrorism (Anthrax….)

- **5MeV/2kW （Magnetron）**
- **100kg/h(20kGy)**
- **System occupy <100m²**
- **4 cases in Beijing**

Cases — Mail Sterilization

- 5MeV/2kW
- Semi underground shielding structure
- Ground occupation ~ 60m^2

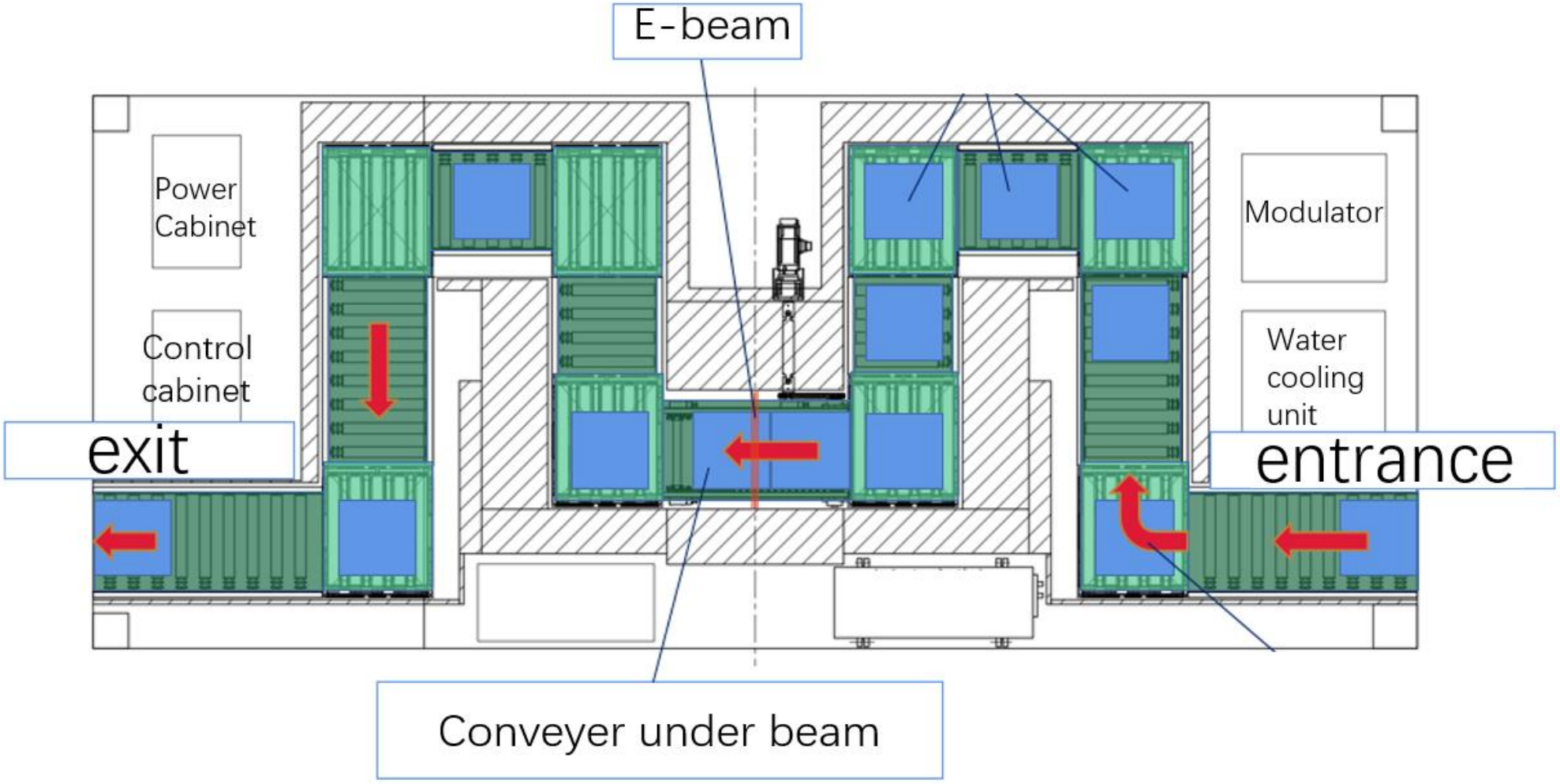
- 5MeV/2kW
- Semi underground shielding structure
- Ground occupation < 50m^2

Shelter irradiation system

China's national scientific research projects during the COVID-19 epidemic, for flexible sterilization in special areas (Epidemic area, infectious disease hospital…)

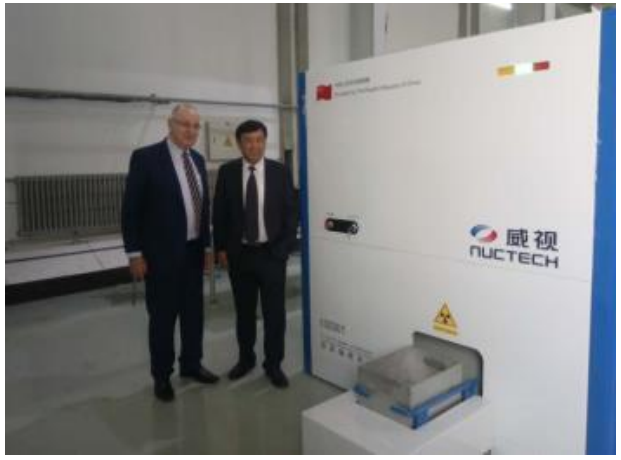
- **3MeV/2kW （Magnetron）**
- **Scanning uniformity：<5%**
- **Self-shielding；standard container 5.9m(L)×2.4m(W)×2.4m(H)**
- **Weight ~35 ton**
- **Boundary dose rate： < 2.5 μSv/h （Max 1.6 μSv/h ）**

Shelter irradiation system

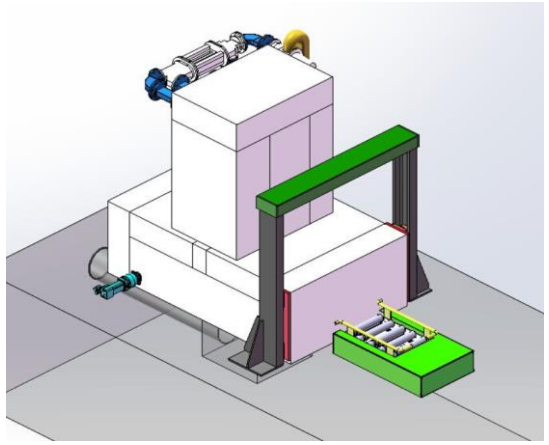


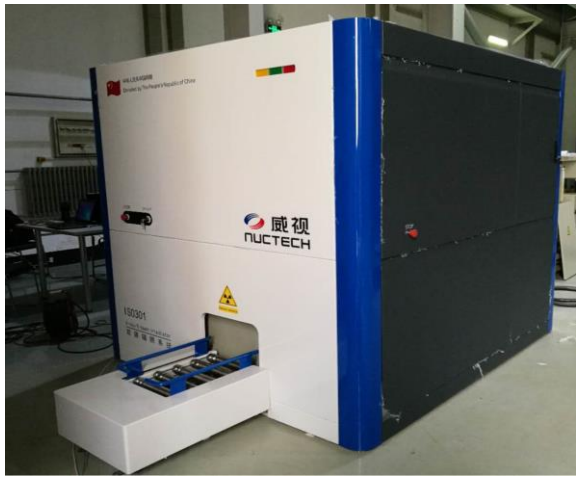
Research irradiation system

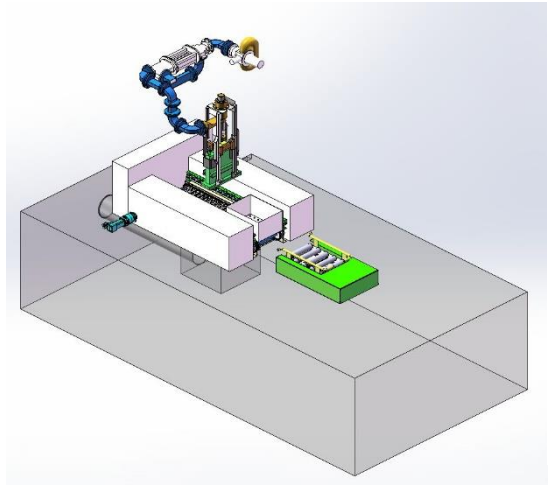
- Scientific research
- Customer developed for nuclear agricultural research(Insect sterility, Mutation breeding), for FAO/IAEA Agriculture and Biotechnology Laboratories
- Self-shielding, a miniaturized instrument

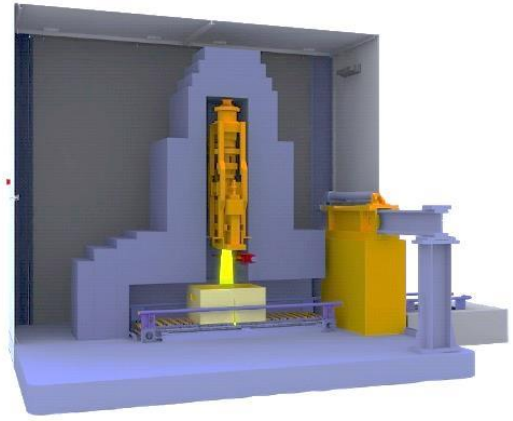


Research irradiation system









- **2.5MeV/1kW** （Magnetron）
- **EB/X-ray, dual source**
  - **X-ray :**
    - **a dose rate of 10 to 250 Gy/min**
    - **minimum throughput 3,000 l.Gy/hr**
  - **E-beam**
    - **1~20kGy once**
- **Scanning width： 30cm**
- **Scanning uniformity： 5~7%**
- **Size： 2.5 x 2.5 x 2 m (w x d x h)**

Technical Proposal Discussion

For in-house —— individual packing

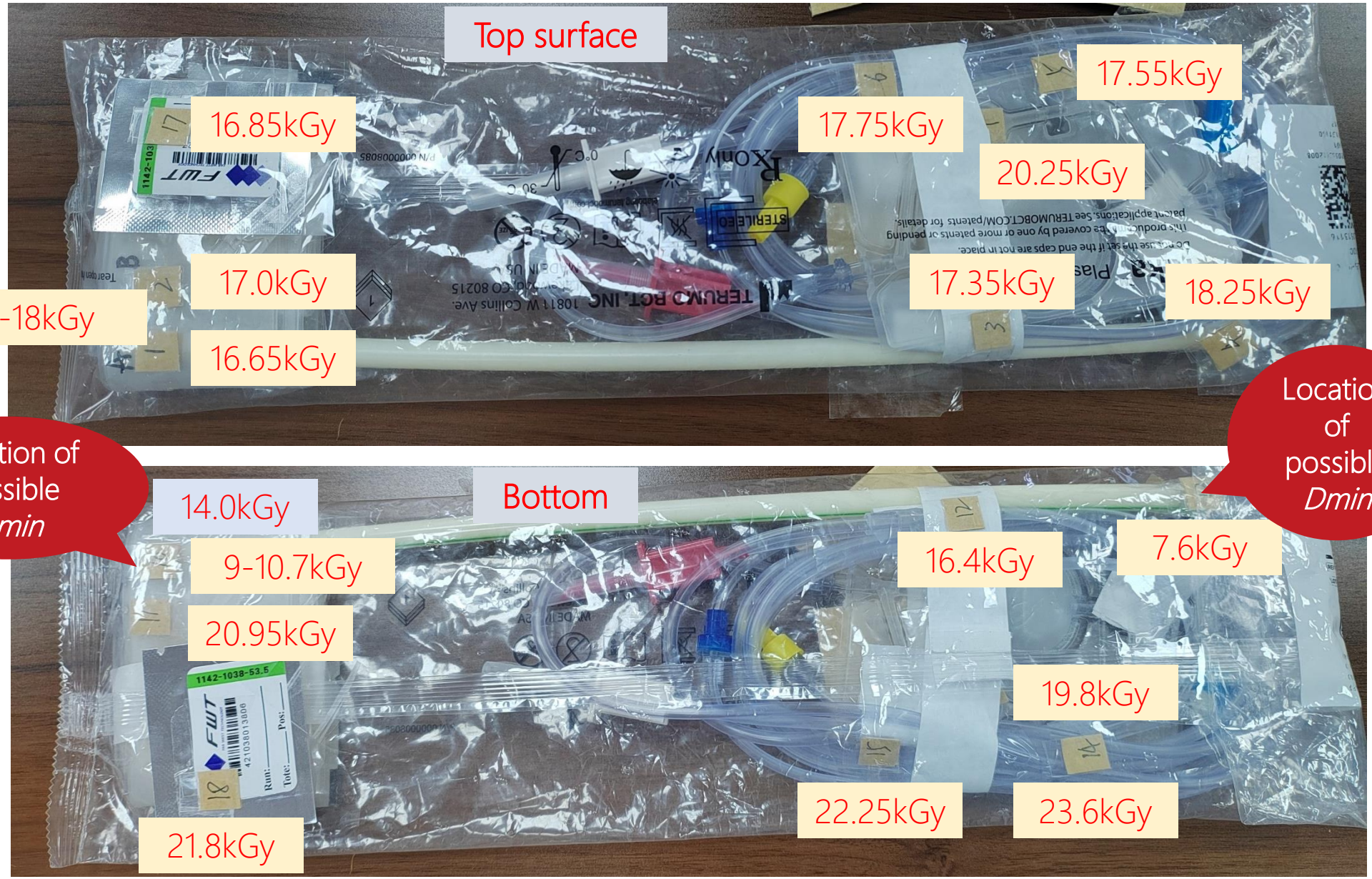
(Full box product maybe beyond 10MeV EB penetration)

Two options

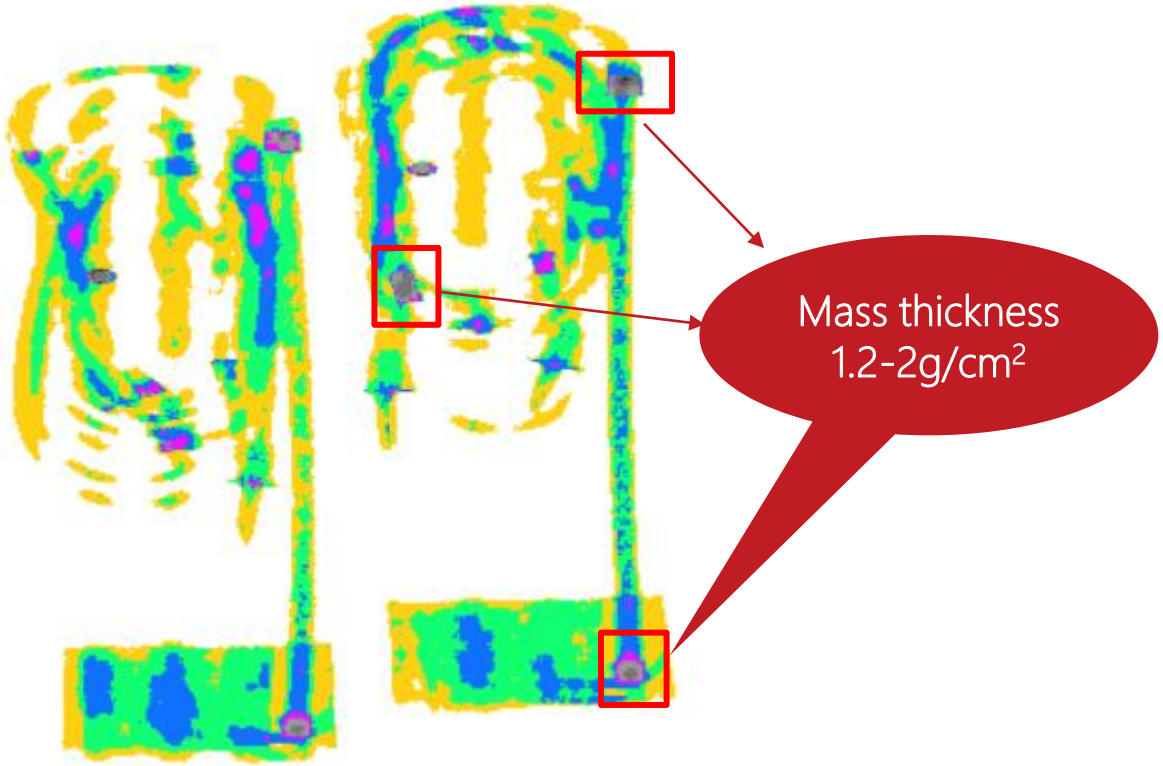
- 4.5~5MeV/10kW (one-sides irradiation)
- 2~3MeV/5kW*2 (double-sides irradiation)

Results of irradiation

Irradiated by 3MeV EB.
Single-side irradiation.



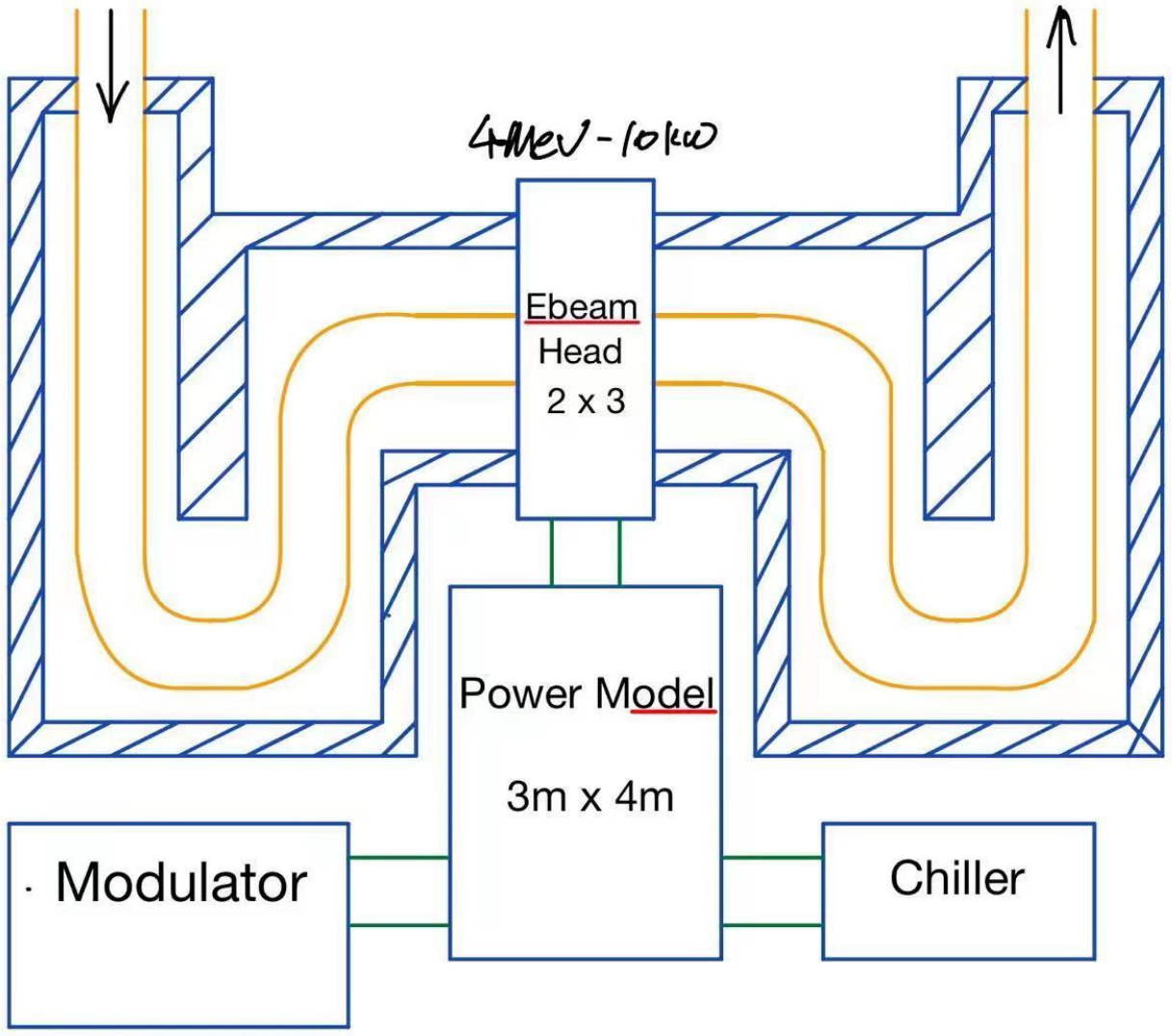
Results of detection



Principle: Utilizing the technology of X-ray detection can achieve and estimate the distribution of the mass thickness of the irradiated items. Then establishing a model of predictive dosimetry through Monte Carlo simulation to predict the dose distribution by using data of X-ray mass thickness detection.

Conclusion: The location of maximum mass thickness is shown in the picture. And the mass thickness of the maximum region is about 1.2 to 2 g/cm^2, and it's also the location of possible *Dmin*, as shown in the dose measurement results.

Technical Proposal Discussion



4.5~5MeV/10kW

One-sides irradiation

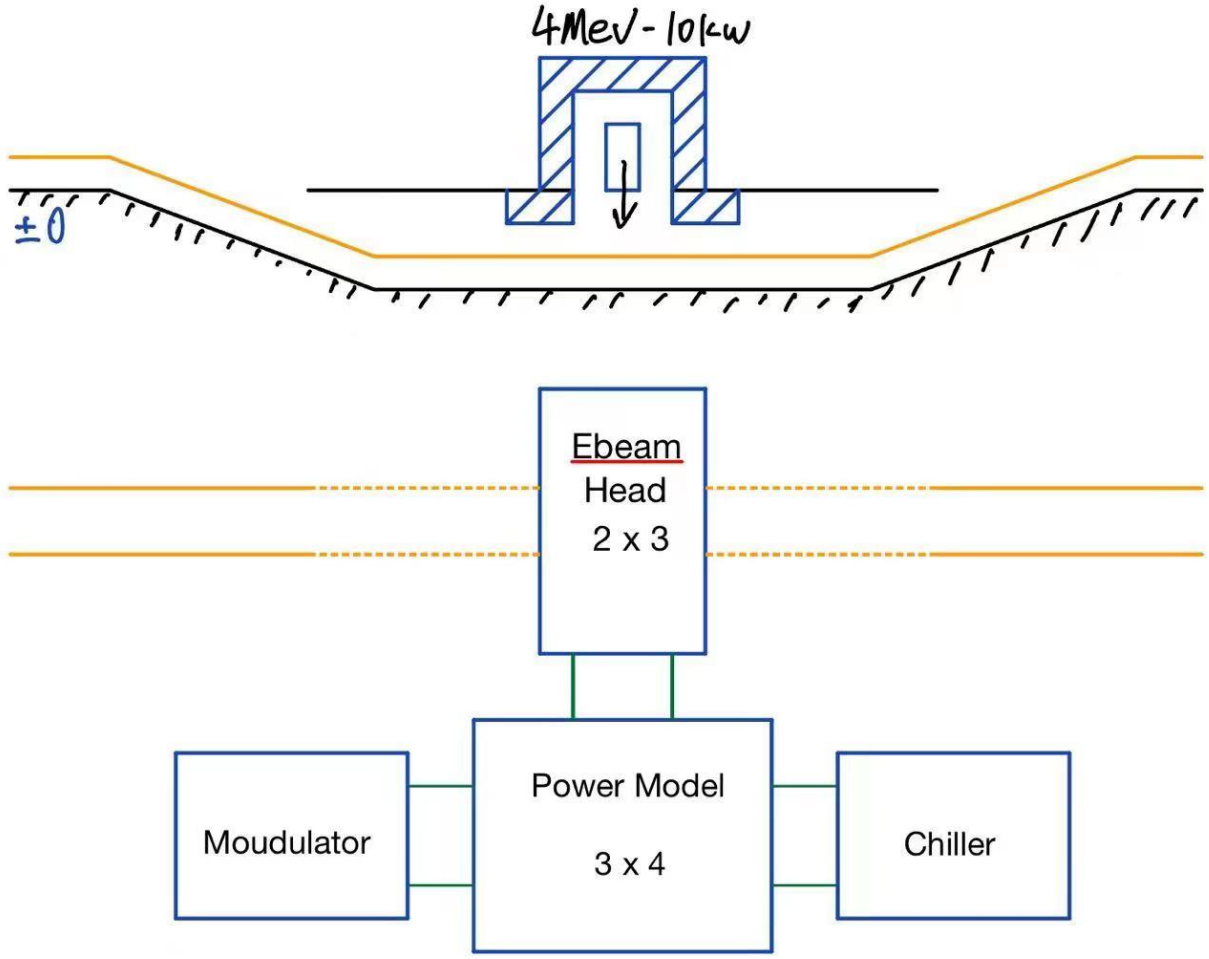
Power souse： Klystron

Self shielding system

Ground occupation： 80~100m²

Reference

Technical Proposal Discussion



4MeV/10kW

One-sides irradiation

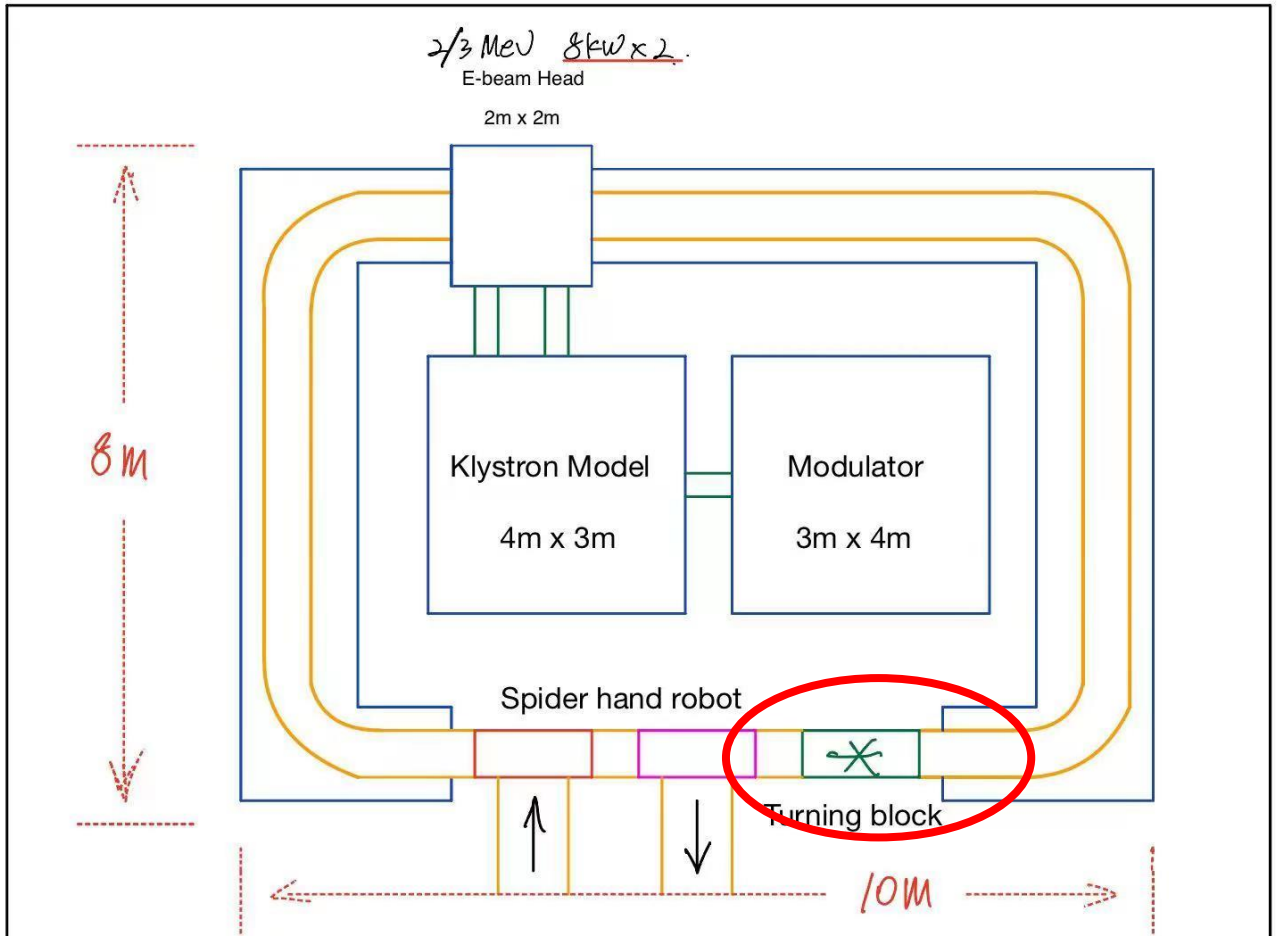
Power souse： Klystron

Self shielding system

Semi-underground

Ground occupation < 80m²

Technical Proposal Discussion



2~3MeV/5~8kW*2

（both irradiated from top）

double-sides irradiation

automatic overturn

Power souse： Klystron

Self shielding system

Ground occupation ~ 80m²

Technical Proposal Discussion

To be confirmed：

1. The energy meet the dose distribution requirements or not
2. The power meets the output requirements or not

Shelter irradiator test results

3MeV 2kW 30cm(scanning width)

@20mm/s—— 15kGy

@12mm/s—— 25kGy

3MeV 10kW 10cm(scanning width)

@300mm/s—— 15kGy

@180mm/s—— 25kGy

NUCTECH

THANKS