Recent developments of eb/X systems and applications based on IMRP 2016 reports

ANDRZEJ G. CHMIELEWSKI

Low energy electron beams for industrial and environmental applications

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WUT Centre for Innovation and Technology Transfer Management
Warsaw.Poland

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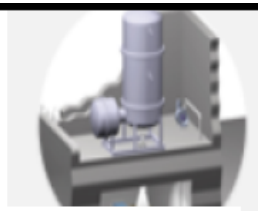
Superconducting RF Linacs for Industry

Dr. Robert Kephart, Director
Illinois Accelerator Research Center (IARC)
Fermilab, Batavia, IL (Nov 7, 2016)

Fermilab | U.S. DEPARTMENT OF ENERGY

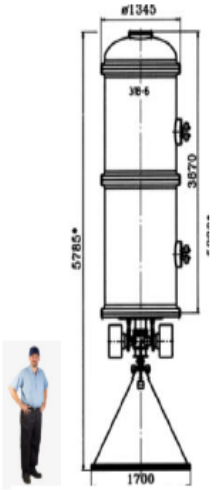
Limitations of Current Technology

- Existing high power (100's of kW) industrial electron accelerators are physically large ➔"fixed" installations
- Bulk materials processing applications may require penetration ➔ higher energy (multi-MeV e or γ)
- > few MeV accelerators are typically RF driven
- Inherent RF losses limit efficiency (heat vs beam)
- Heat removal from the copper limits the duty factor, accelerating gradient (ie size) and average power
- Impractical for high power mobile applications



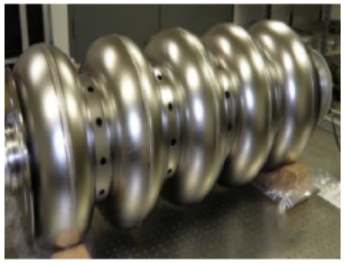
IBA Dynamitron

IBA Rhodatron



Budker ELV-12

New Technology (developed for science)



- Superconducting Radio Frequency (SRF)
  - Enables compact high-average power CW accelerators
  - Why? Accelerating cavities (resonators) can achieve high gradients (> 30 MV/m) and very high

    Q_0 = (stored energy)/(energy loss per RF cycle)

  - → very large fraction of the input RF power end up as beam power (Wall plug efficiency > 75%)
- The downside: Losses occur at low temperature

(e.g. 2-4 K) where there the Carnot efficiency is poor.

Recent SRF Technology Breakthroughs:

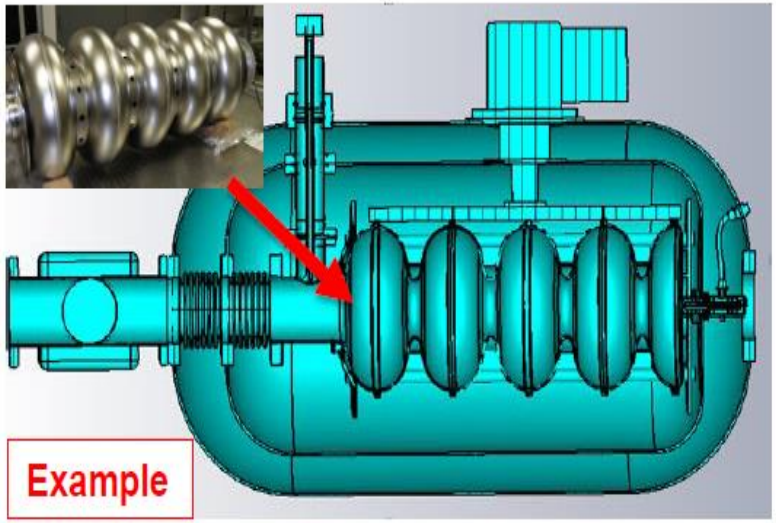
- High temperature superconductors (Nb_3Sn coatings)

➔ high Q_0 at >4K ➔ dramatically lower cryogenic losses

- Conduction Cooling: no Liquid He, simple cryostats
- Cryocoolers: use dramatically simplifies cryogenics
- New RF Power technology: low cost injection locked magnetrons allow phase/amplitude control
- Integrated Electron Gun: reduces size and complexity
- Low Loss RF Power Couplers: reduces cryogenic load

Enable simpler SRF accelerators with lower costs

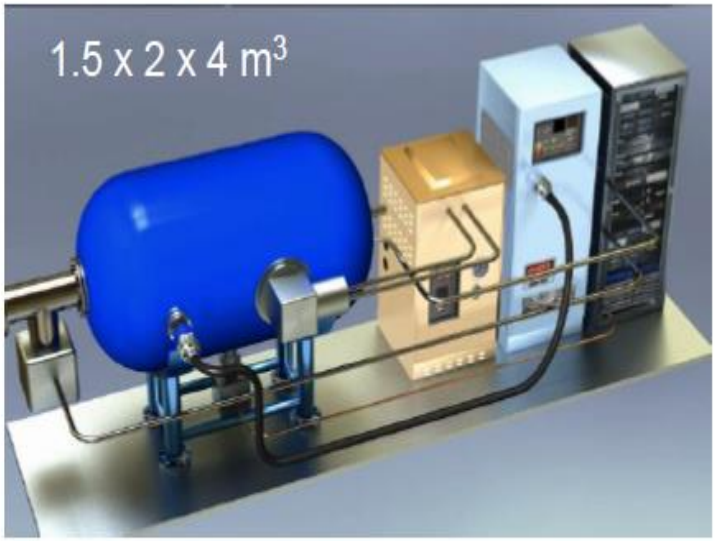
Ideas integrated into a simple SRF accelerator*



- Energy: ~ 10 MeV
- Power: 250 KW
- Compact
- Simple, reliable
- Affordable

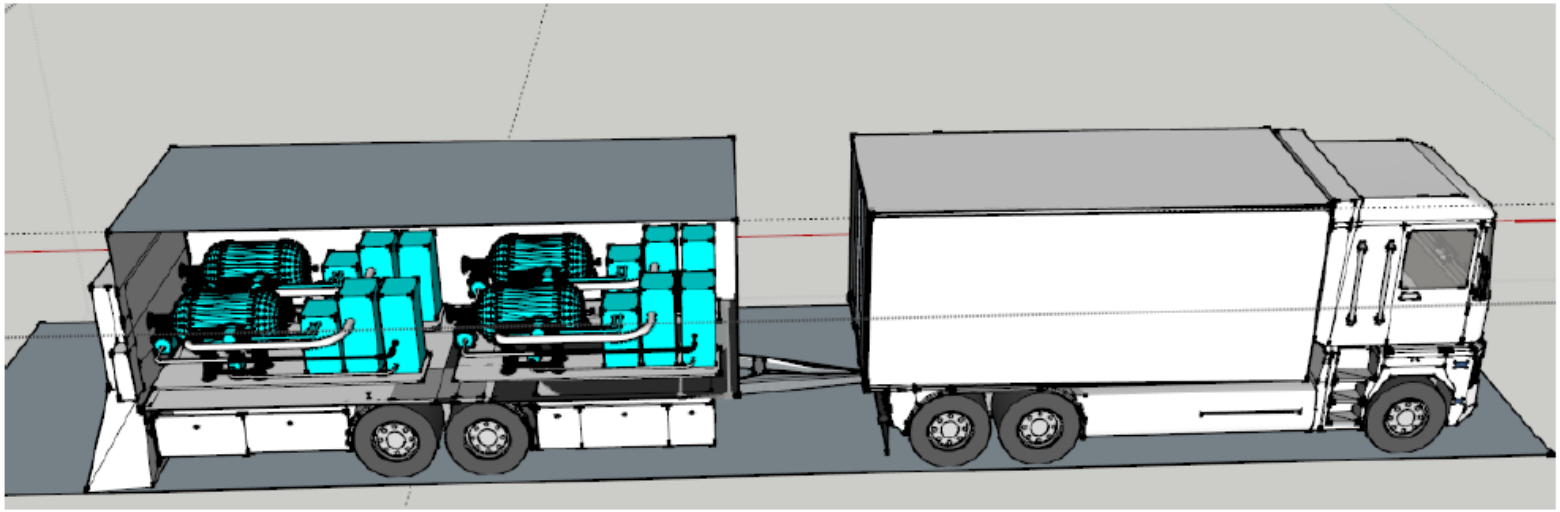
- Modify existing 650 MHz cavity design
- Magnetron RF source & commercial cryo-cooler
- Modular design scales to MW class industrial applications
- Total weight ~3000 lbs ➔ viable for mobile applications

Developing a 250 KW skid mount Version



- Mobile high power accelerators enable new applications
- In-situ cross link and/or environmental applications
- DOE funds for conceptual design & key technologies
- Goal: Create a new class of industrial SRF accelerators!

In-Situ Cross-Link of Pavement*



- Create a tough, strong binder with improved temperature performance vs bitumen to extend pavement lifetime
- U.S. spends $ 50 B/yr to grind off and replace asphalt!

Conclusions

- Exploiting recent lab breakthroughs one can create simple, high average power, SRF-based accelerators
- The Illinois Accelerator Research Center at Fermilab is partnered with government agencies to create the first article of an entirely new class of industrial accelerators
- Compact, mobile, high energy, high power accelerators can enable a variety of entirely new industrial applications
- Several applications have enormous market potential

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Easy-e-Beam® V3 Self-Shielded Dynamitron® Electron Beam Accelerator

Presented by:

Scott Goldfarb, Dynamitron Product Manager
IBA Industrial, Inc. – Edgewood, New York

iba

Introduction

The Dynamitron® is the most popular and widely utilized electron beam accelerator (standard models from 550 Kev @ 160mA to 5 MeV @ 30 mA beam energy) for industrial applications such as crosslinking and vulcanization.

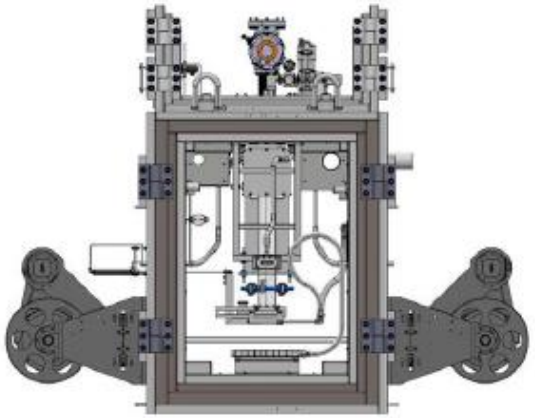
IBA has further improved the Easy-e-Beam® self-shielded version of the Dynamitron® for customer applications with limited manufacturing floor space and to reduce overall facility overhead costs.

Easy-e-Beam® V3 Dynamitron® System

Easy-e-Beam® V3 Dynamitron ® System
Shown Configured for Crosslinking of Wire/Cable

Improved Ergonomic Design

- Convenient access to Under Beam Handling system
  - Easier/faster string-up
    Easier/faster maintenance
  - Simpler change of guides
- Easier and faster beam window change/maintenance
- Mezzanine provides easier, faster and safer accelerator maintenance

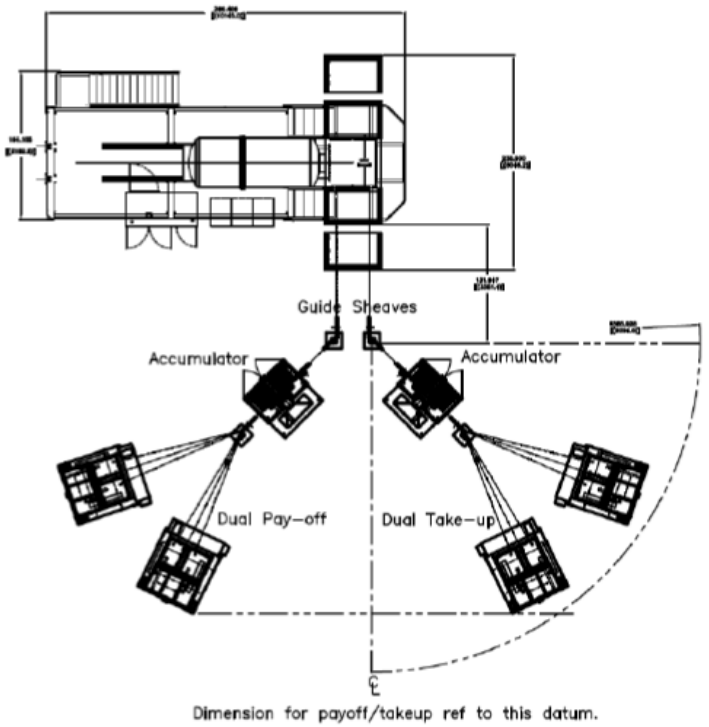


Easy-e-Beam® V3 Beam Room side view for Crosslinking of Wire/Cable

Dual Line Handling

(for wire/cable crosslinking applications)

Depending upon the customers application requirements, version 3 of the Easy-e-Beam® system allows the capability to perform dual line handling and processing to increase efficiency and cost effectiveness.



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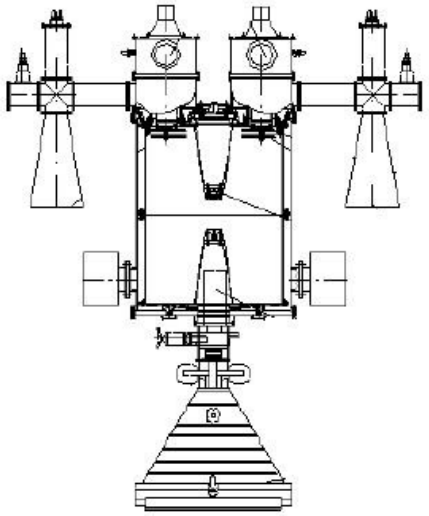
New multi cavity industrial electron accelerator ILU

Aleksandr Bryazgin
Budker Institute Nuclear Physics
Novosibirsk, Russia

- Ordinary ILU accelerators.
  - ILU-8 (1 MeV, 20 kW)
    - Design and Main features.
    - Examples in real industry
  - ILU-10 (5 MeV, 50 kW)
    - Design and main features.
    - Examples in real industry
- New multi-cavity ILU accelerators.
  - Reasons for developing
  - Design
  - ILU-14 (10 MeV, 100 kW)
  - ILU-12 (7.5 MeV, 40 kW)

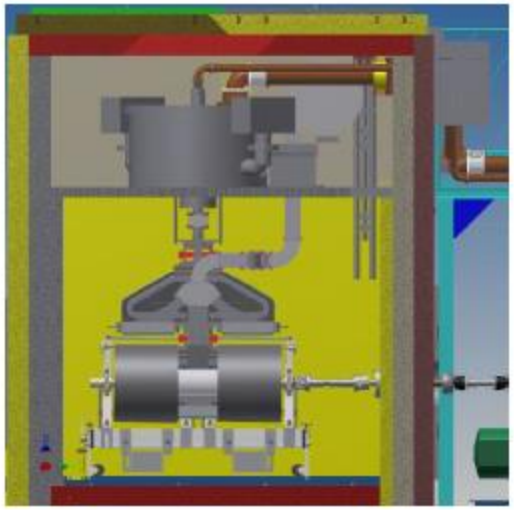
ILU-10 5 MeV 50 kW



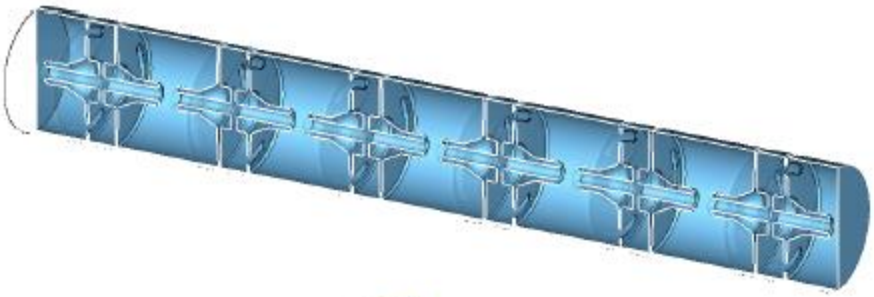
- Pulse duration 500 mks
- Pulse repetition 1-50 Hz
- RF frequency 115 MHz
- Dim. D1280x1480 mm

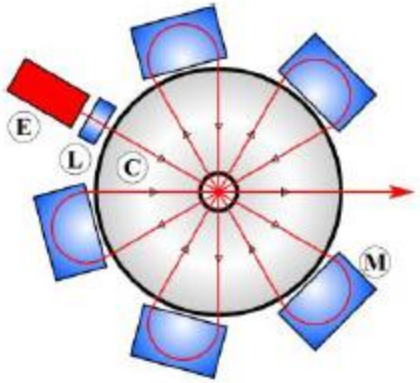
New multi-cavity ILU accelerator.

One cavity



Multi-cavity or multi-pass

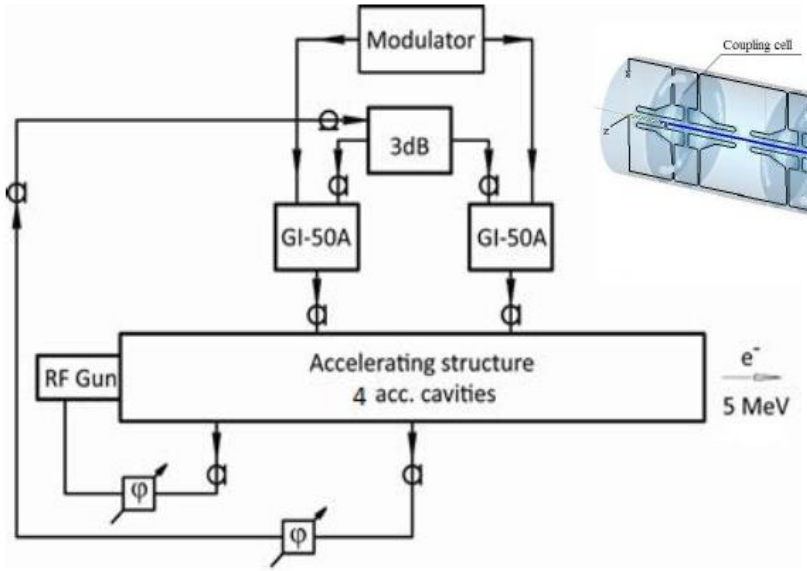


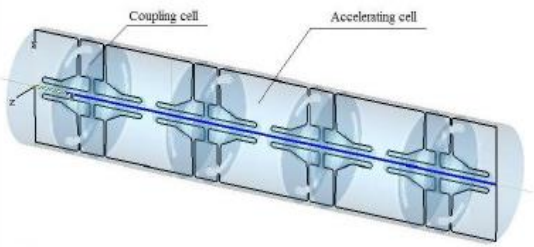


New multi-cavity ILU accelerator.

In operation from 2014 in Moscow

Shorter version – ILU-12





- 5 MeV 60 kW
- 7.5 MeV 40 kW
- 4 cavities
- Possible upgrade to ILU-14

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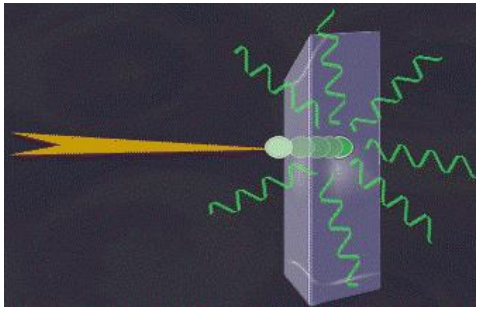
A Novel Process Control Method for a DUO E-Beam/X-Ray System

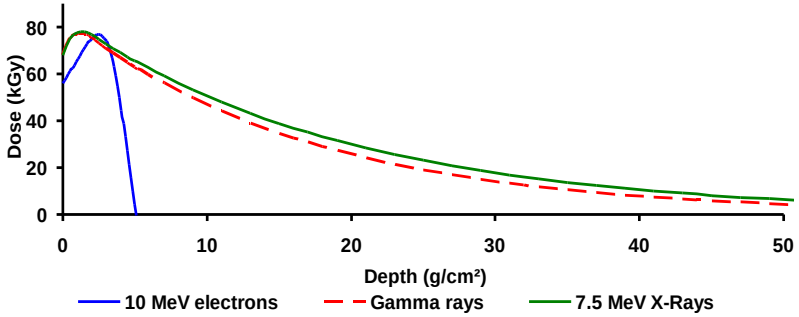
Josef Mittendorfer, Consultant, Mediscan

MEDISCAN

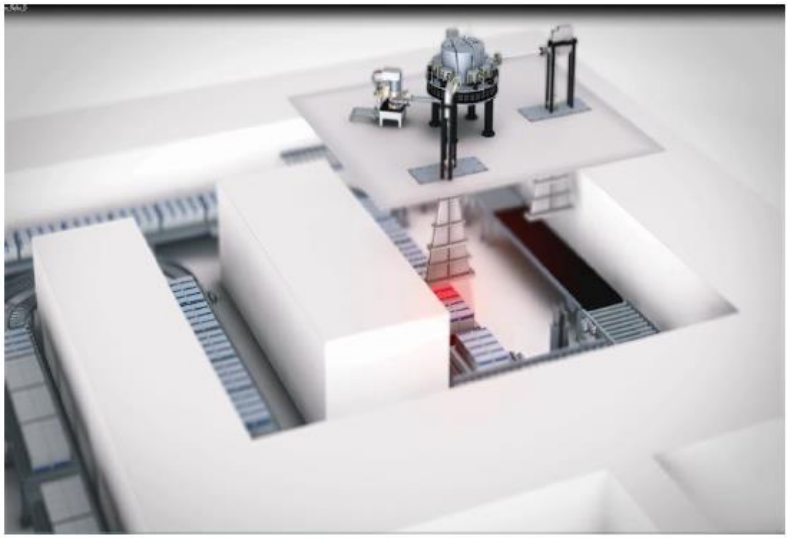
Design Goals for a new E-Beam/X-Ray Irradiator:

- High Dose Accuracy
- Excellent Dose Uniformity
- Allows Narrow Dose Windows
- High Throughput
- Quick Turn Around – Just-in-Time Processing Redefined
- Immediate Change between E-Beam/X-Ray Mode
- Competitive Cost





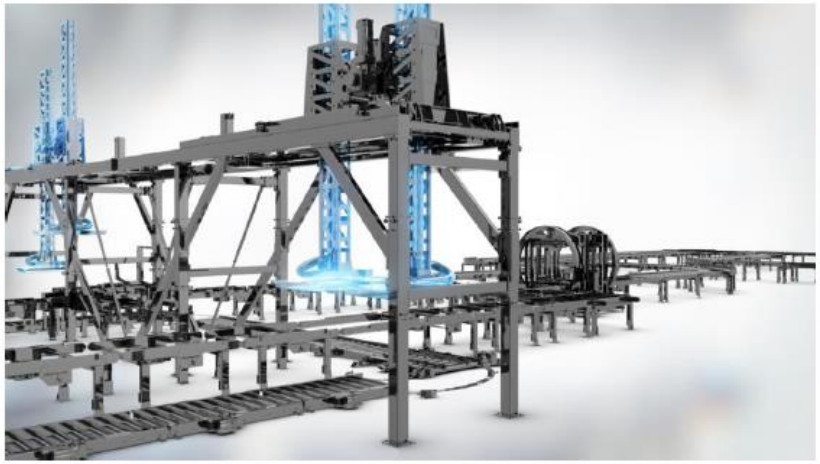
TT-300 "Duo" E-Beam "Workhorse"
X-Ray "Special Products"



190 kW Power E-Beam: 10 MeV 19 mA

X-Ray: 7 MeV 27 mA

Fully Automated Depalleting and Palleting



Depalletizer/Palettizer

Product Turning

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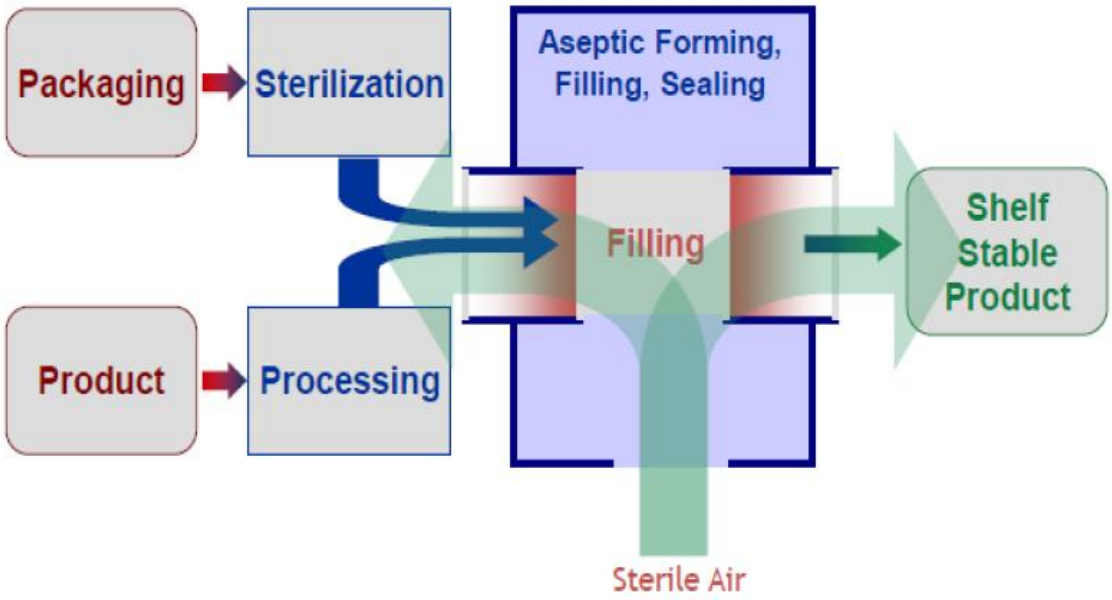
In-Line Sterilization of PET Bottles by EB

Vincent Luo, Lu Jieping, Kenneth Hsiao
CGN Dasheng Electron Accelerator Technology Co.,Ltd

中广核 CGN

Aseptic Packaging Technology

- Sterilization of food materials
- Aseptic of packaging environment
- Aseptic of Medium
- Sterilization of packaging materials



Comparison

Hot Fill

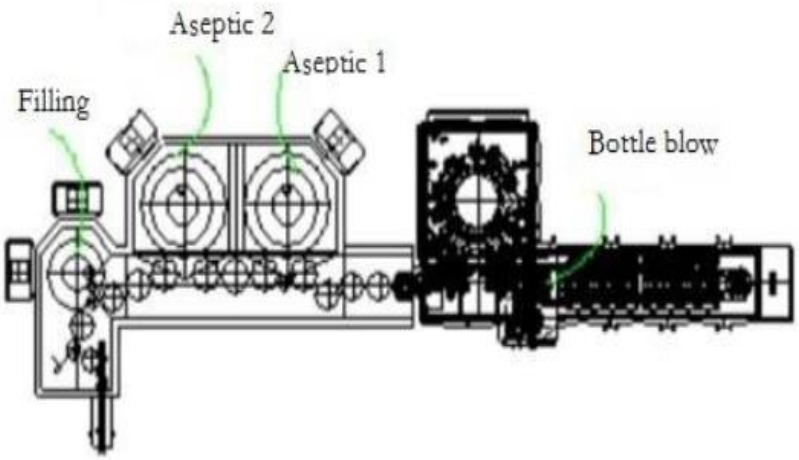
- High resin weight packaging required for stability
- Limits products quality
- Energy intensive

Chemical Aseptic

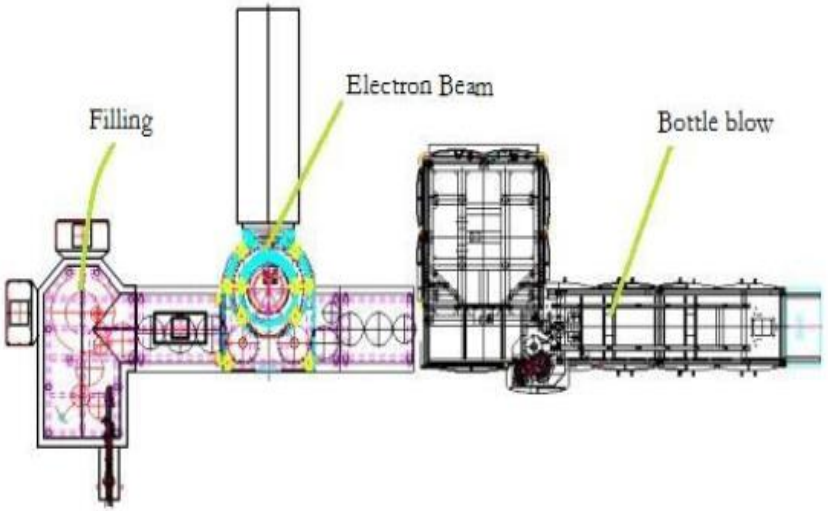
- High operating costs
- Water intensive
- Residual risk
- Preheating and drying
- High complexity

Electron Beam Aseptic

- Room temperature processing
- No water consumed
- No residual risk
- simplicity



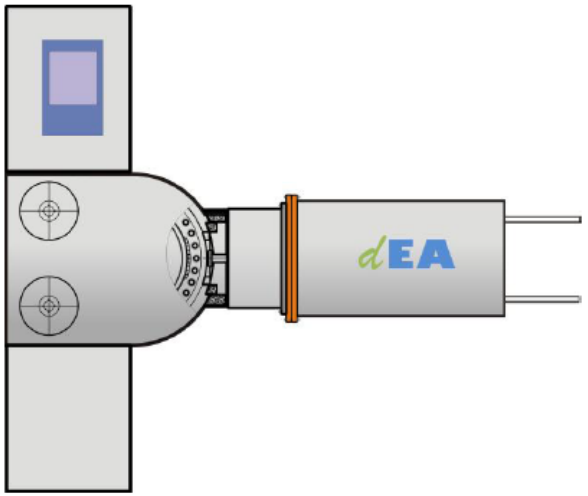
Traditional aseptic filling system



New concept of aseptic filling system

Horizontal Self-Shielding EB Accelerator

- Benefits
  - Simple construction
  - Reliability and Maintainability
  - little area occupied,
  - compaction of equipment
  - higher utilization efficient
  - lower costs



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Industrial application of electron beam (EB) irradiation for wastewater treatment in China

Dr. Shijun He

中广核 CGN
Natural Energy Powering Nature

Industrial-scale EB for textile wastewater treatment

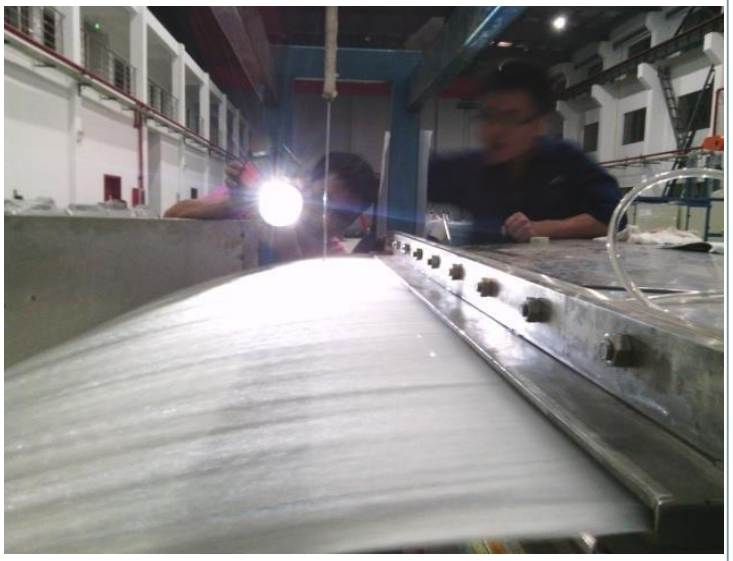
EB Accelerator

Dynamitron type
1.5 MeV, 60 mA

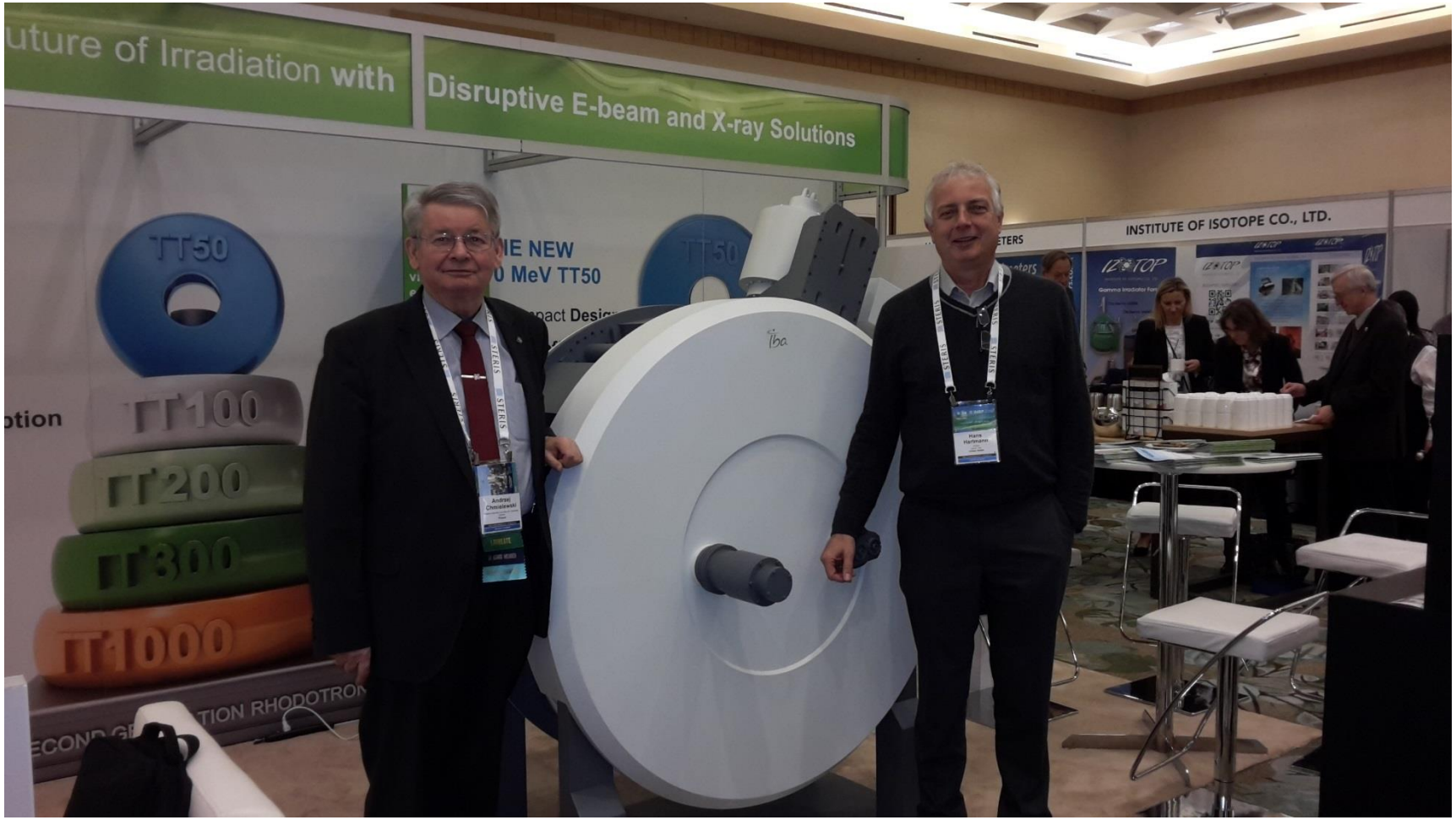
Industrial-scale EB for textile wastewater treatment

Wastewater reactor

Injector:
1500mm X 4 mm

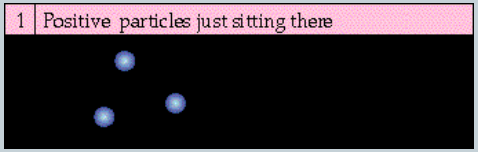


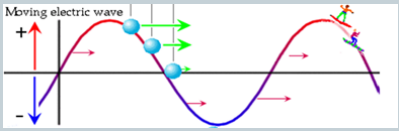
Exhibition – forecast new Rodothron 10 MeV, 15 kW



Conclusions

- New, more compact accelerators are being developed
- Superconducting technology may improve electrical efficiency
- The new in line systems using low energy accelerators are more often applied at the market
- There is a need for high power accelerators for eb/X systems (5 – 10 MeV) and environmental applications (< 1 MeV)





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