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12.1. Strategy for Implementing Novel Societal Applications of Accelerators

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iFAST

I.FAST Open Steering Committee ; Thursday 14 December 2023

Radiation Chemistry and Technology for Environment Pollution Control

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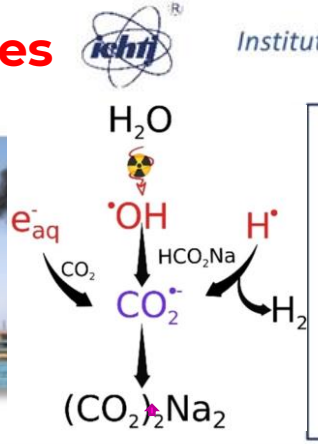
Greenhouse Gases Removal

N O W



Electron beam irradiation

Radiolysis of air

The *G*-values (molecules/100 eV) of main primary species are simplified as follows:

$4.43N_2 \rightarrow 0.29N_2^* + 0.885N(^2D) + 0.295N(^2P) + 1.87N + 2.27N_2^+ + 0.69N^+ + 2.96e$

$5.377O_2 \rightarrow 0.077O_2^* + 2.25O(^1D) + 2.8O + 0.18(O^*) + 2.07O_2^+ + 1.23O^+ + 3.3e$

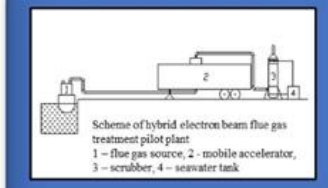
Radiolysis of water

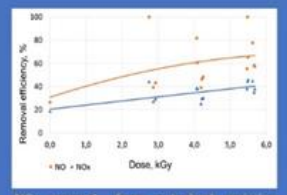
$H_2O \rightarrow 0.51H_2 + 0.46O(^3P) + 4.15H + 4.25OH + 1.99(H_2O^+) + 0.01(H_2^+) + 0.57(OH^+) + 0.67(H^+) + 0.06(O^+) + 3.3e$ (water vapor)

$H_2O \rightarrow 0.45H_2 + 0.7\,H_2O_2 + 0.6\,^{\bullet}H + 2.7\,^{\bullet}OH + 2.7\,(H_3O^+) + 0.1(OH^-) + 2.7e^-_{aq}$ (water)

SOx & NOx done

Electron Beam Flue Gas Treatment



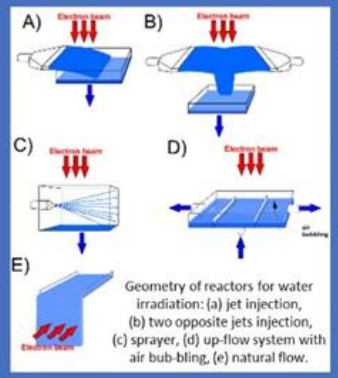


NO_x removal from a tugbart emission using electron beam hybrid wet scrubber system (flue gas: 4500–4900 Nm^3/h; NOx: 230-700ppm; $NaClO_2$:3.3 g/dm^3)

Reduce 40% NOx and 90% VOCs emission at 5.5 kGy dose

A.Pawelec, A. G. Chmielewski, Y.Sun et al., *Nukleonika*, **2021**, *66(4)*, 227 – 231

Safety of ships ballast water



Geometry of reactors for water irradiation: (a) jet injection, (b) two opposite jets injection, (c) sprayer, (d) up-flow system with air bub-bling, (e) natural flow.

- Elimination of biological harmful organisms using doses < 5 kGy
- Low x-ray emission to reduce thickness of shielding

U.Gryczka, Z. Zimek, M. Walo, D. Chmielewska-Śmietanko, S. Bułka, **2021**. *Applied Sciences*. 11(23):11194

Sewage sludge hygienization

- Completely elimination of biological harmful organisms at the dose < 4 kGy
- a good fertilizer after hygienization process

Type of sludge	Preliminary sludge 4% TS	Secondary sludge 2,5% TS	Preliminary sludge 4% TS	Secondary sludge 2,5% TS
Dose [kGy]	Total bacteria count [CFU]		Number of living eggs (ATI)	
0	$6{,}3 \cdot 10^4$	$5 \cdot 10^4$	33	23
2	$1 \cdot 10^4$	$9{,}9 \cdot 10^3$	21	12
3	$2 \cdot 10^2$	$0{,}5 \cdot 10^2$	4	3
4	0	0	0	0
5	0	0	0	0

An installation for flow irradiation of sewage sludges under ILU-6 accelerator

A.G.Chmielewski, M. Sudlitz, B. Han, S. Pillai, *Nukleonika*, **2021**, *66(4)*, 213 – 219

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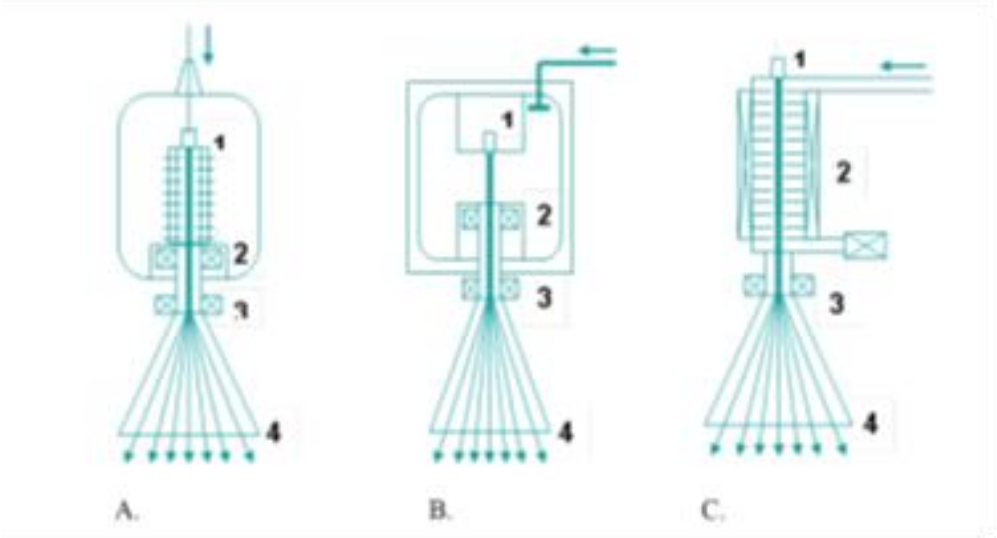
Electron accelerators

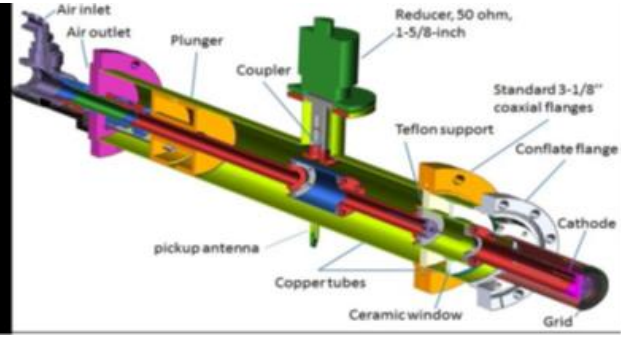
- **Present**



(A) direct high voltage accelerators; (B) single cavity radiofrequency accelerators; (C) linear microwave accelerators. 1 – electron gun, 2 – focusing coil, 3 – scanning electromagnet, 4 - foil window.

- **Needed**

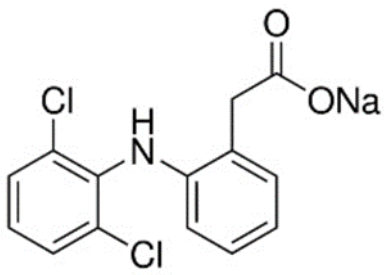
Parameters	Unit	Value
Frequency	MHz	650
Cathode diameter	inch	0.5
Beam current	mA	100
Current density	A/cm^2	2.35
DC bias voltage	kV	2.6
Output Energy	keV	3.5
Bunch rms size	Deg	<15
Energy rms size	%	<25

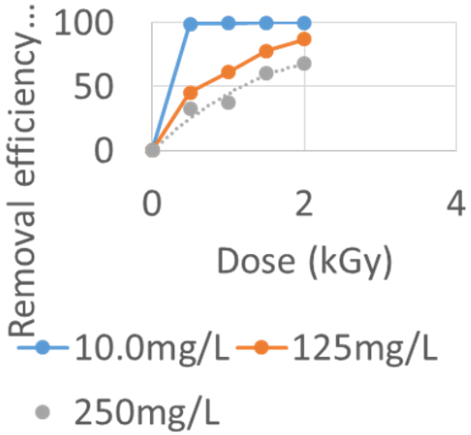


Superconducting RF cavities made of Nb3Sn, with cryogenic operation near the temperature of 4 K, exhibit minimal RF wall dissipation (about six orders of magnitude smaller than copper cavities of similar shape and size), allowing their operation at 100% RF duty cycle (continuous wave or CW operation).

HOPE

- I.FAST (DCF) diclofenac removal in aqueous solution under EB irradiation with & without nano bubble pretreatment
- Sludge basic engineer-ing done T12.2.





- TAPEB Advanced treatment for typical antibiotic pharmaceutical waste-water by electron-beam radiation
- INCT (PL)& Tsinghua Univ.

- 30[illegible]

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Thank you for your attantion !

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