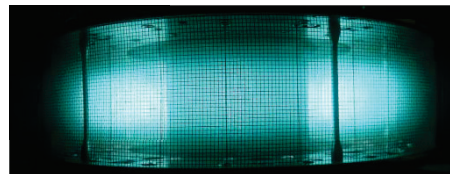
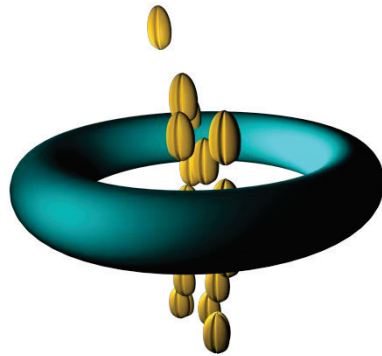

DEVELOPMENT OF A TOROIDAL EB SOURCE FOR NON-THERMAL ELECTRON TREATMENT OF BULK GOODS AND DRESSING OF SEED

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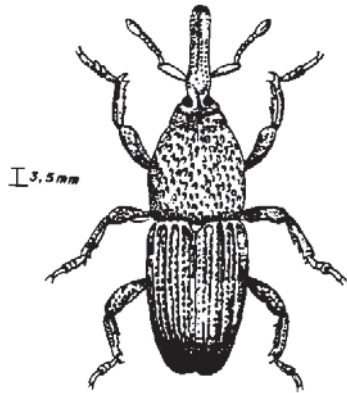
Outline

1. Motivation
2. Technological background
 1. Biochemical effect
 2. Electron treatment of seed
3. State of the art
 1. Electron treatment of seed
 2. Thermionic emitter
4. Toroidal source
 1. Conception
 2. Physical background
 3. Cold cathode conceptual design
 4. Ion source
 5. Electron Beam
5. Conclusions

Motivation

Why seed dressing?

- 5-10% world production is lost due to insects during storage

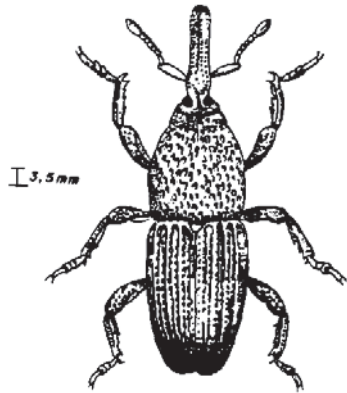


Strophilus granarius

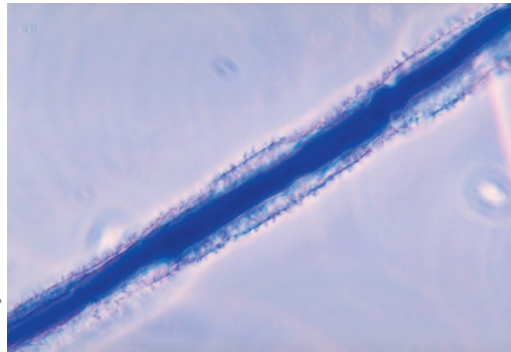
Motivation

Why seed dressing?

- 5-10% world production is lost due to insects during storage
- Bacteria, Fungi and pathogen reduce the seed quality



Strophilus granarius

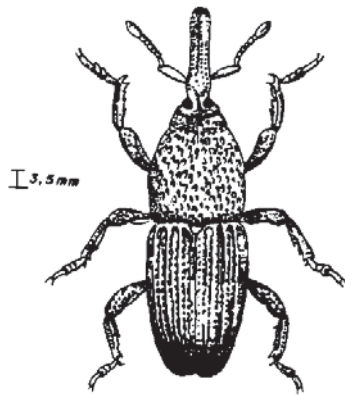


Aspergillus Flavus

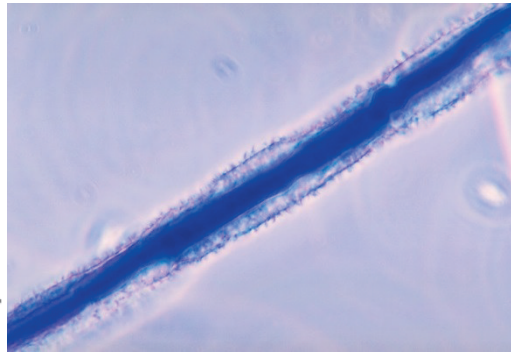
Motivation

Seed dressing by chemical agents

- 5-10% world production is lost due to insects during storage
- Bacteria, Fungi and pathogen reduce the seed quality



Stophilus granarius



Aspergillus Flavus



- Toxic to human being and animals
- Water pollution
- Pest resistance development

Motivation

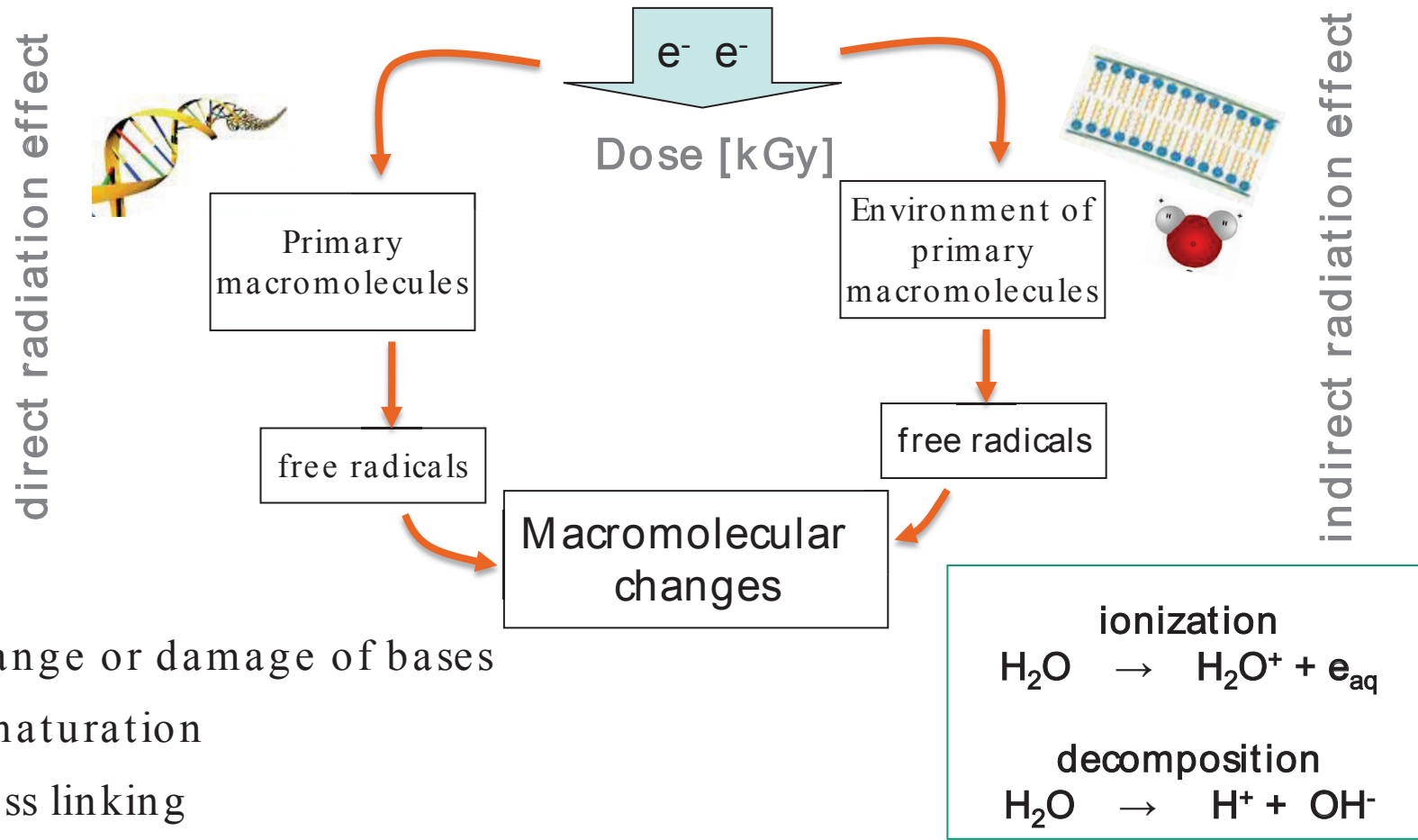
Electron Beam as an alternative to chemicals



- Can inactivate insect eggs on seed's surface
- Can annihilate pathogens
- Physical treatment, therefore **no resistance development**
- No risk for human being
- Friendly with nature

Technological Background

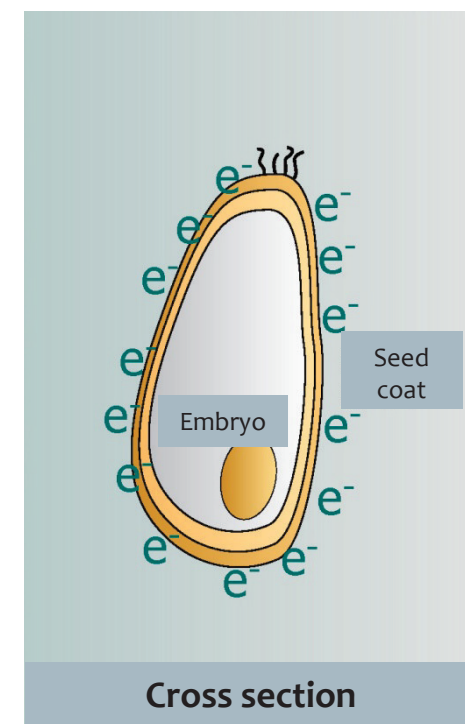
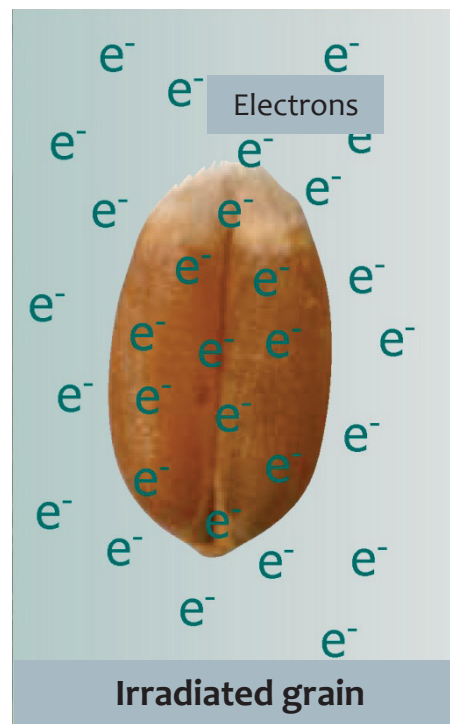
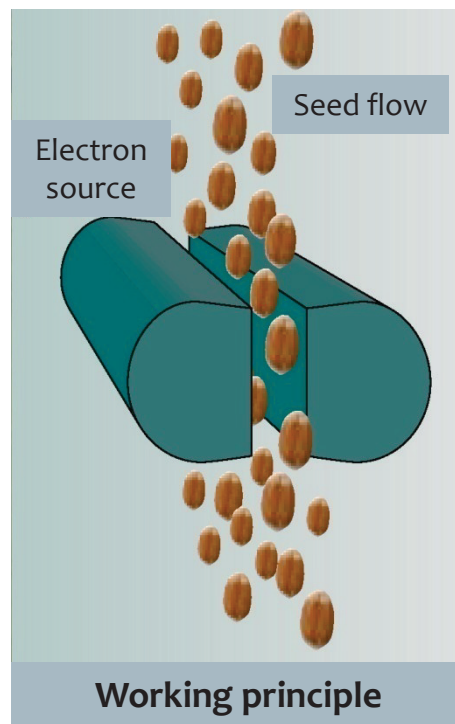
Biochemical effect



- Change or damage of bases
- Denaturation
- Cross linking

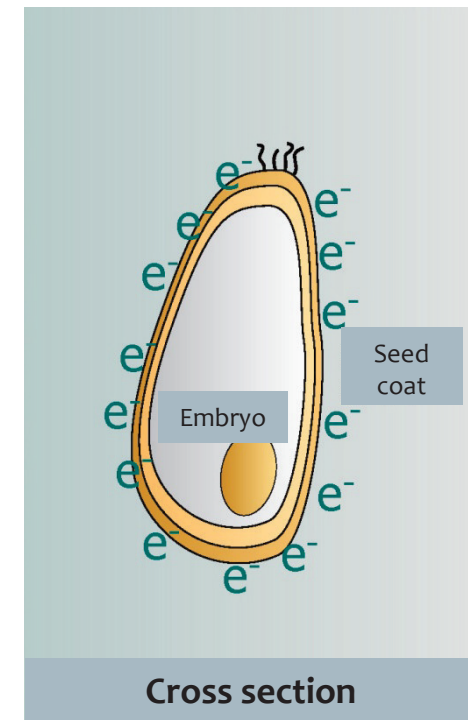
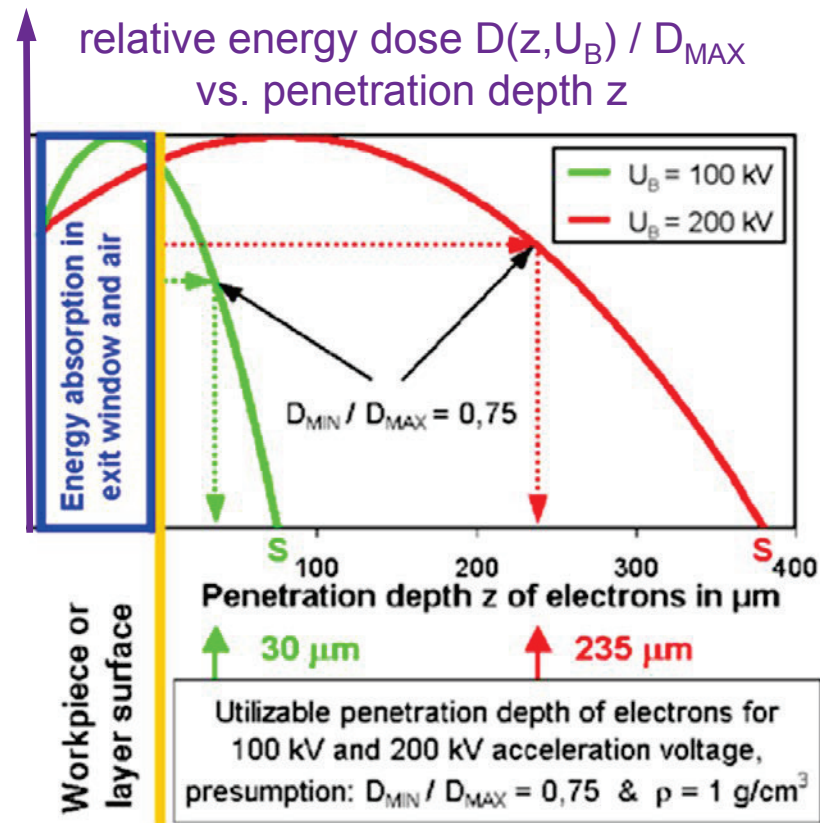
Technological Background

Electron treatment of seed



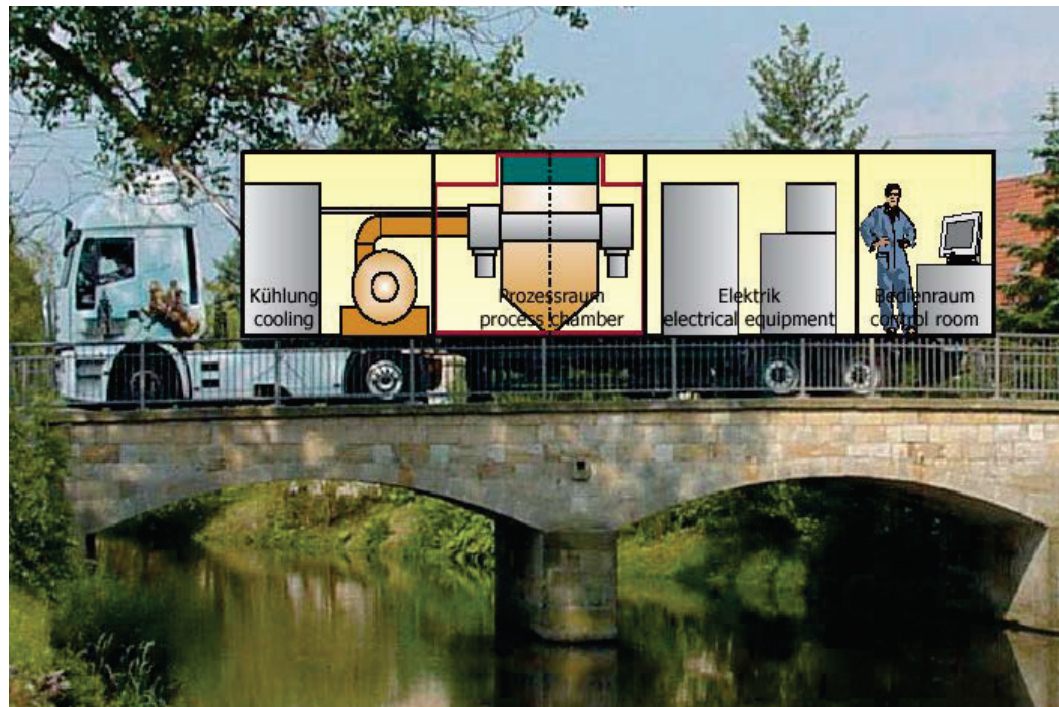
Technological Background

Electron treatment of seed



State of the art

Electron treatment of seed

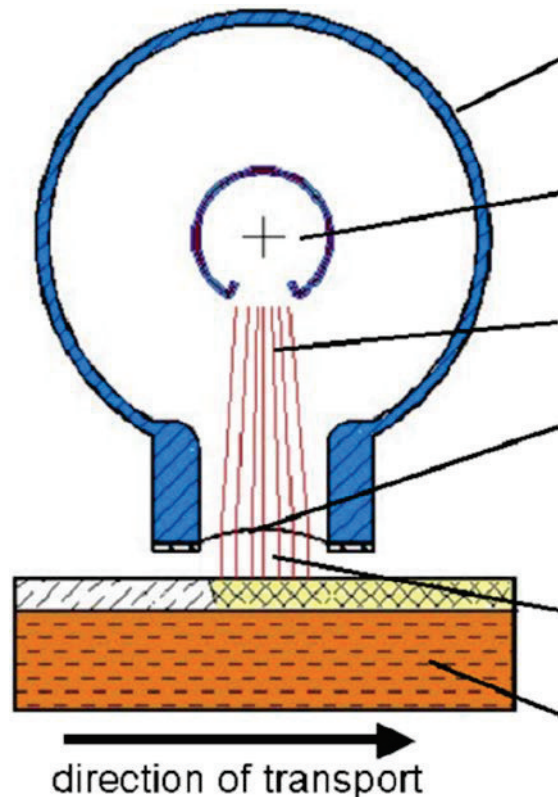


■ Mobile treatment plant WESENITZ 2 (FEP)

- 2 line emitting sources, 145 kV and 30 kW
- Continuous treatment on **air**
- Throughput: 30 t/h

State of the art

Linear EB, thermionic emitter



Linear type EB gun,
high-vacuum inside

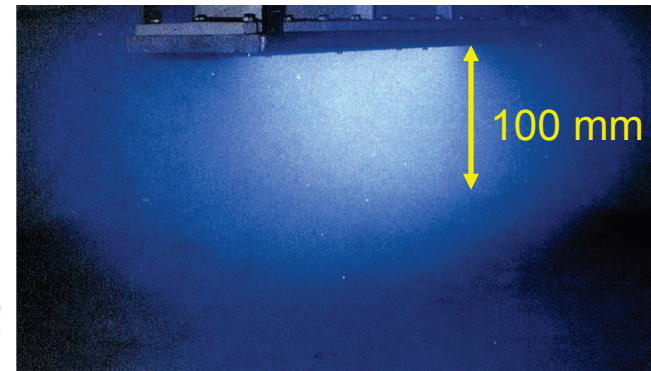
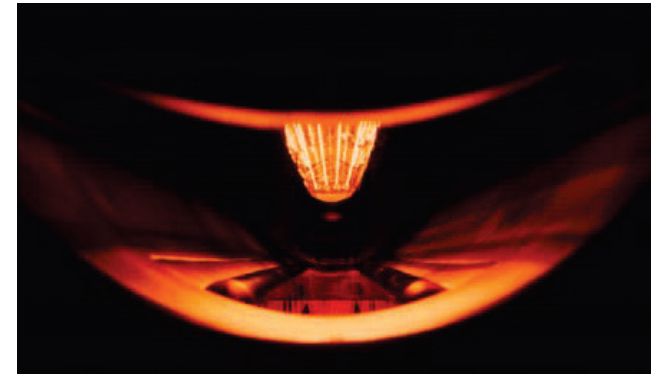
Cathode system

Electrons with energy
 $E_{\text{kin}} = e \cdot U_B$

Electron exit window:
A metal membrane
between atmosphere
and high vacuum

Electron curtain
directed onto product

Product with treated layer
and untreated coating



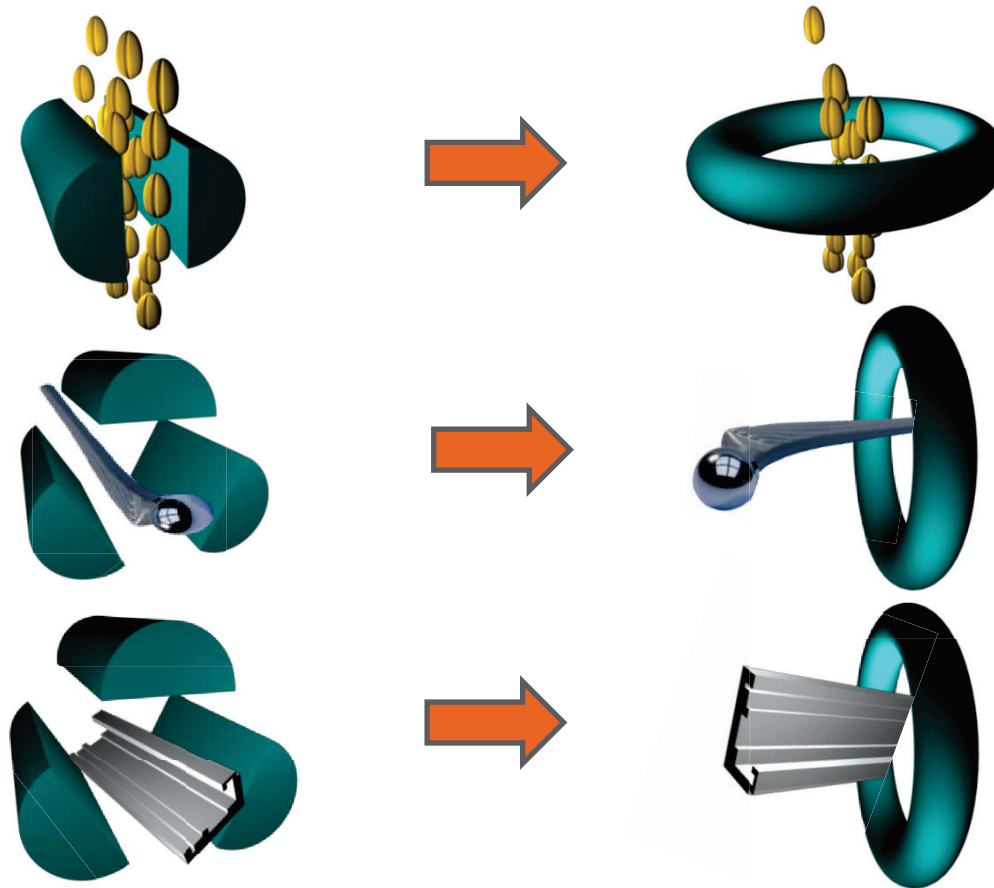
State of the art

Challenges and new demands

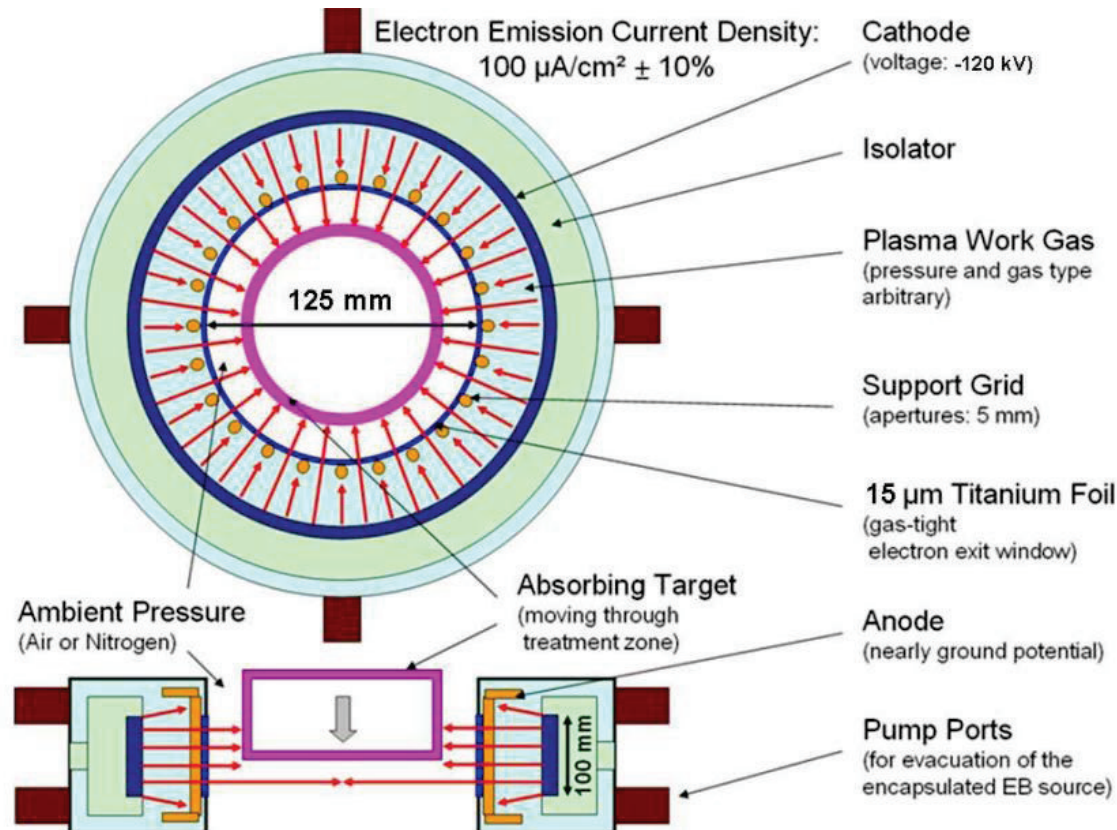


Applications and existing solutions for
EB treatment of bulk goods and parts

Toroidal Electron Source Motivation



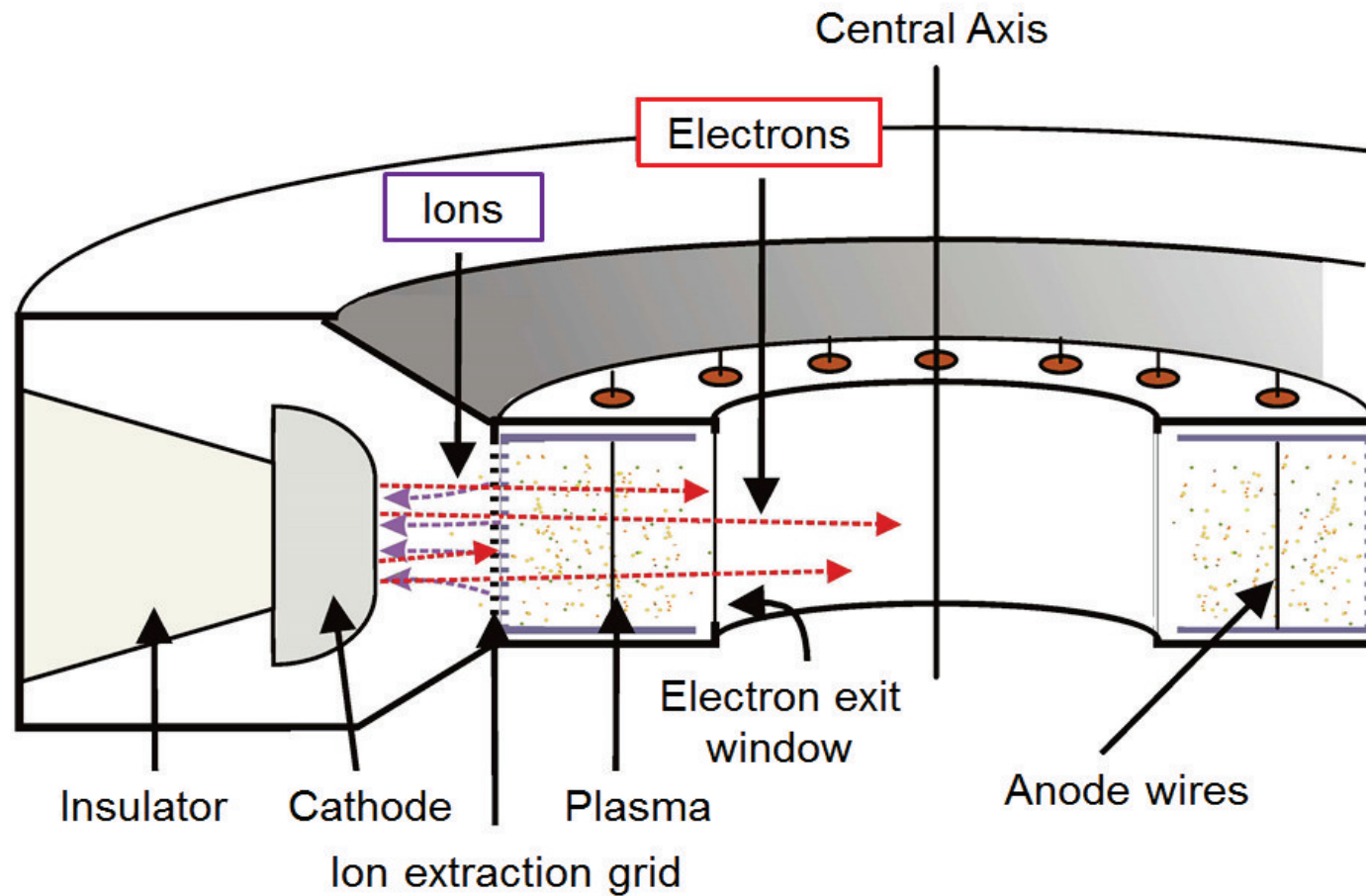
Toroidal Electron Source Conception



- Acceleration voltage 100-150 kV
- Maximum Electron emission current density $200 \mu\text{A}/\text{cm}^2$ (that can be cooled down on a Cu grid)
- Working gas Helium
- Working pressure 0.5 - 3 Pa
- Cathode material Al
- 15 μm Titanium foil

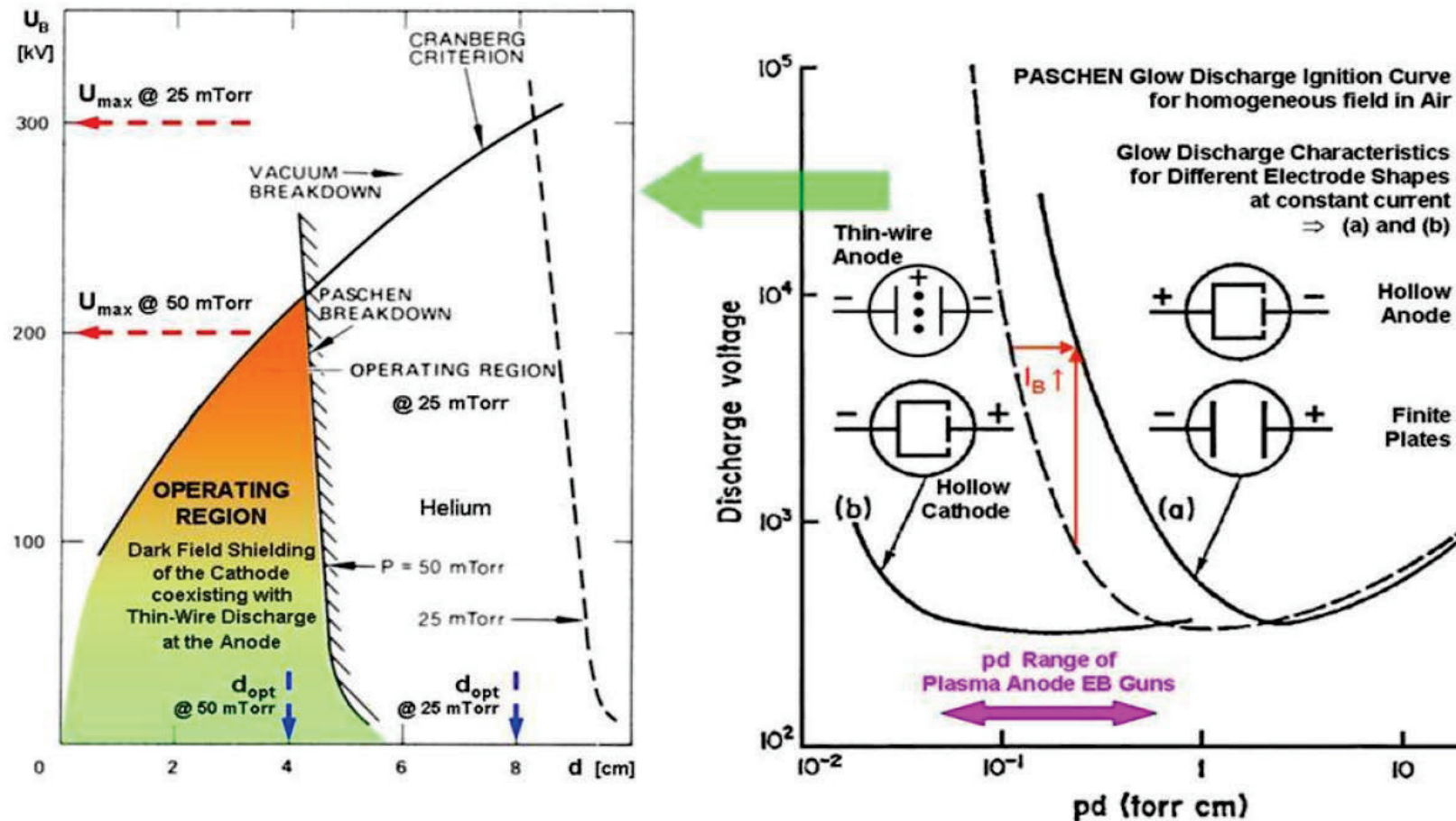
Toroidal Electron Source

Cold cathode conceptual design

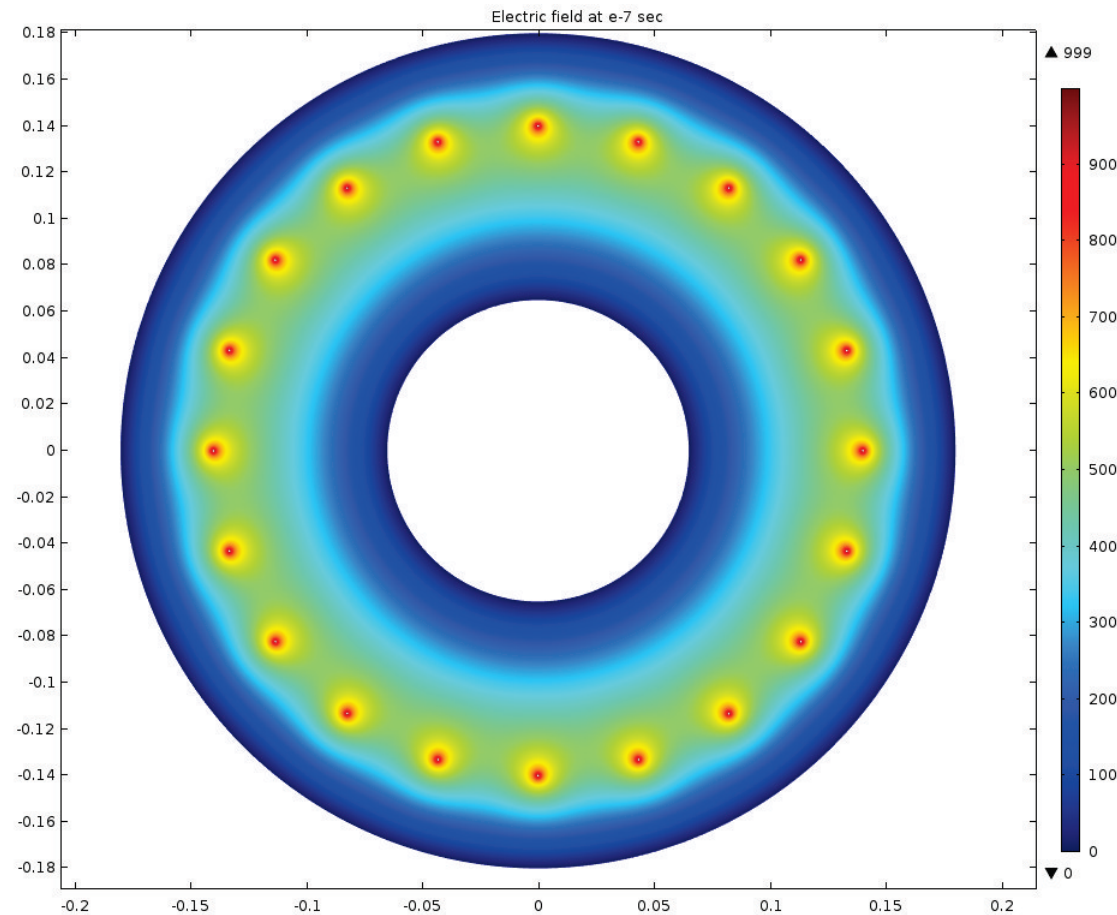


Toroidal Electron Source

Physical background

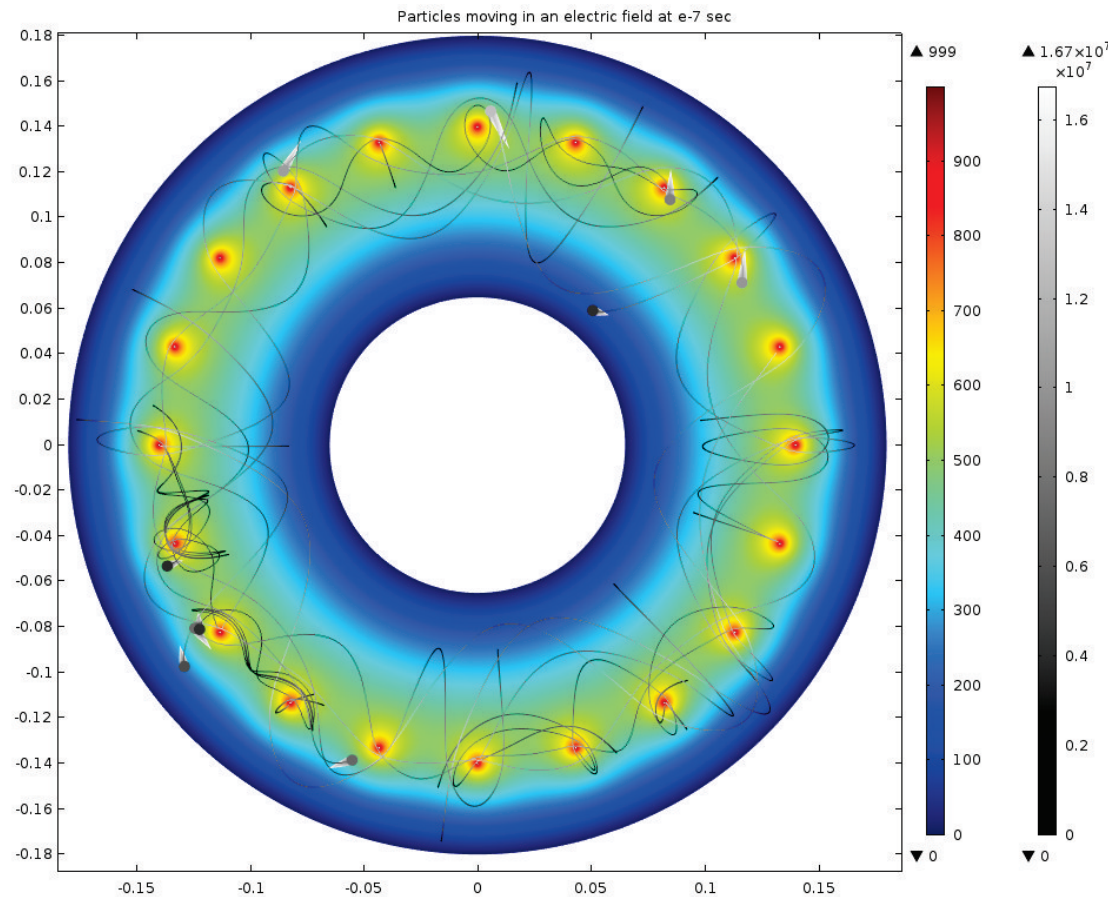


Toroidal Electron Source Ion source



■ 20 equidistant wires as
anode potential

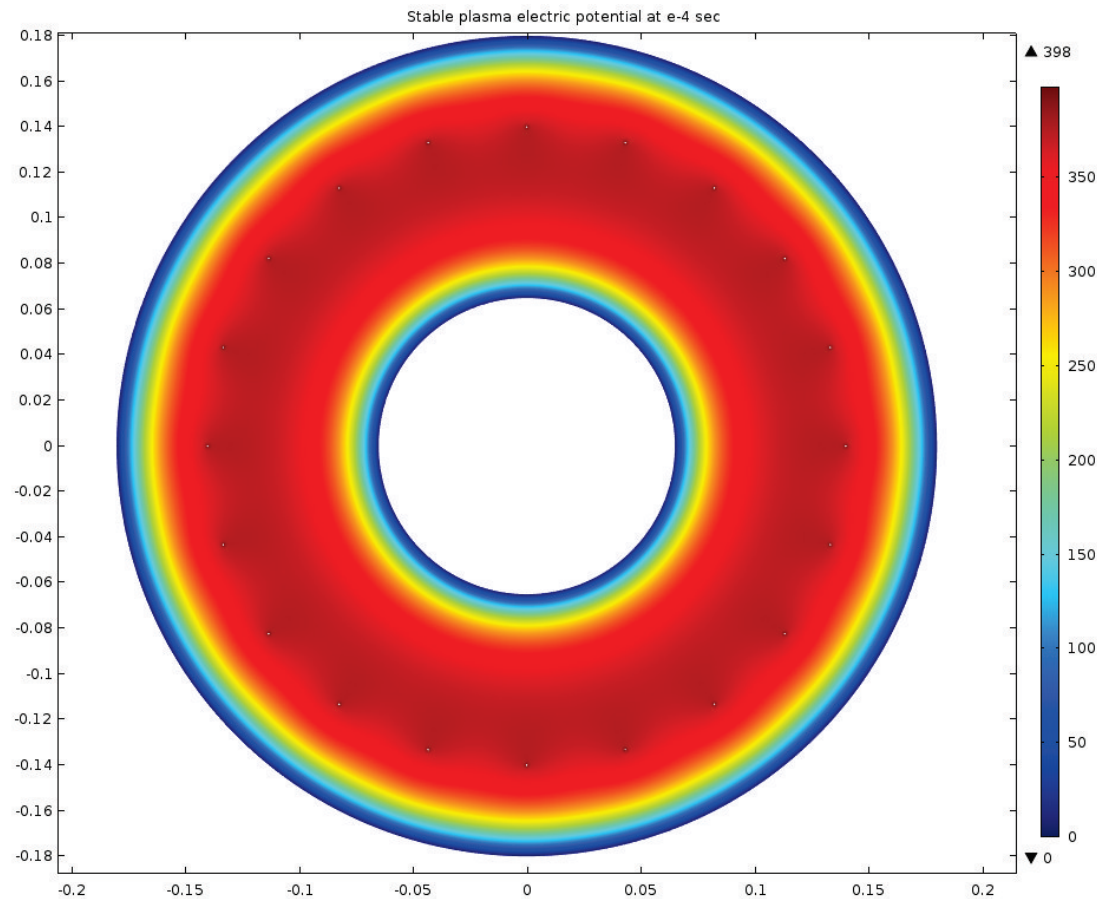
Toroidal Electron Source Ion source



- 20 equidistant wires as anode potential
- Electrons are trapped in the electric potential
- Electron lifetime enhanced as well as ion production

Toroidal Electron Source

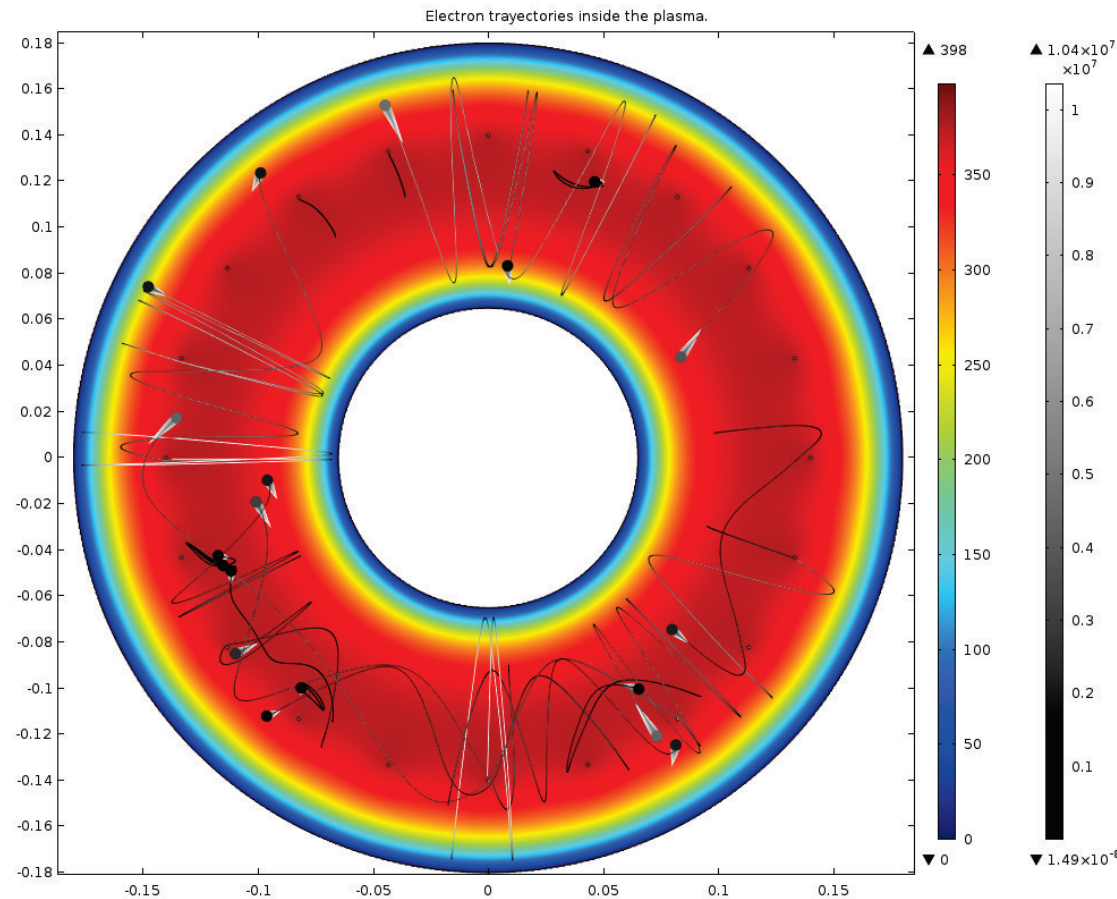
Ion source



- 20 equidistant wires as anode potential
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- Stable plasma can be sustained down to 0.5 Pa

Toroidal Electron Source

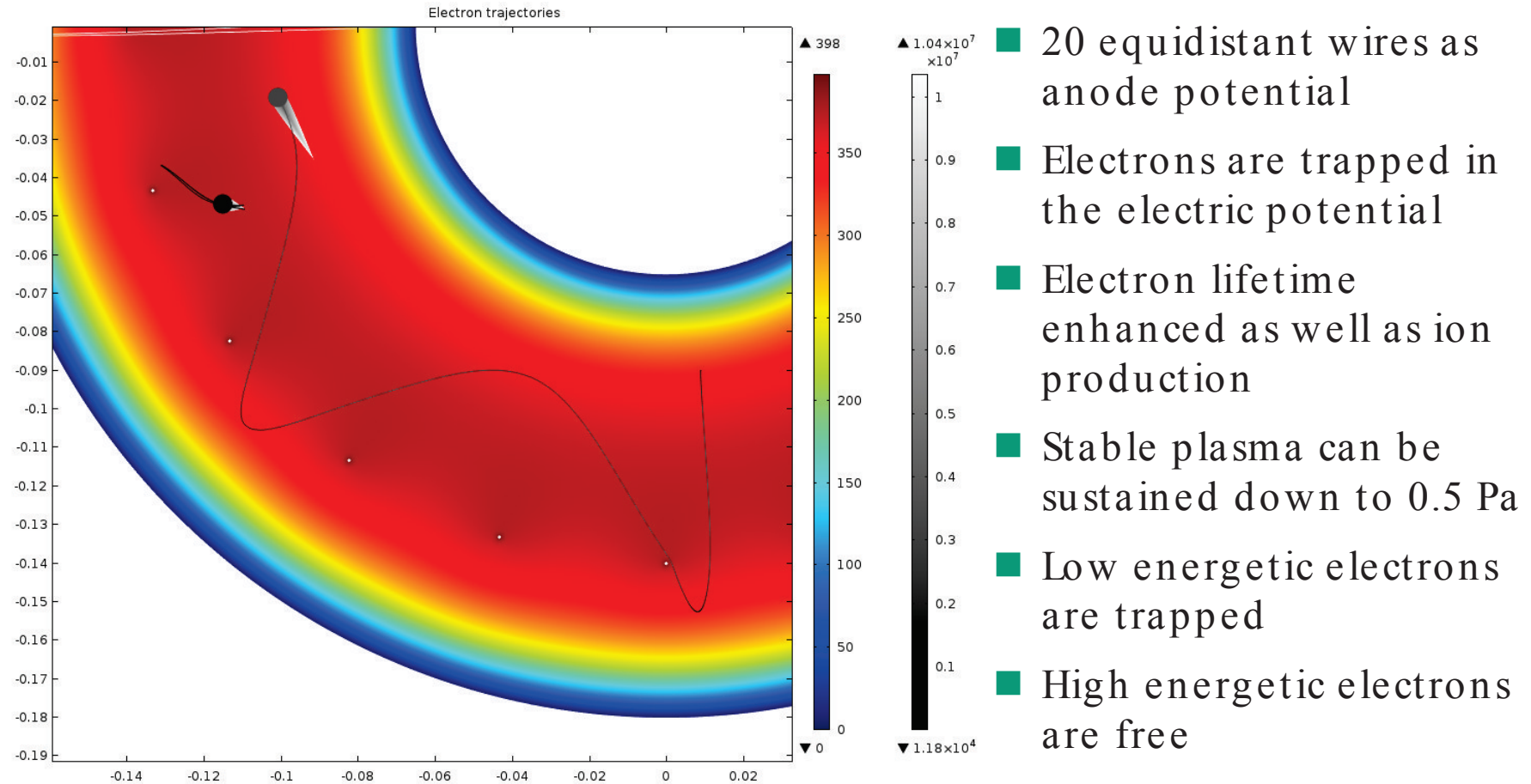
Ion source



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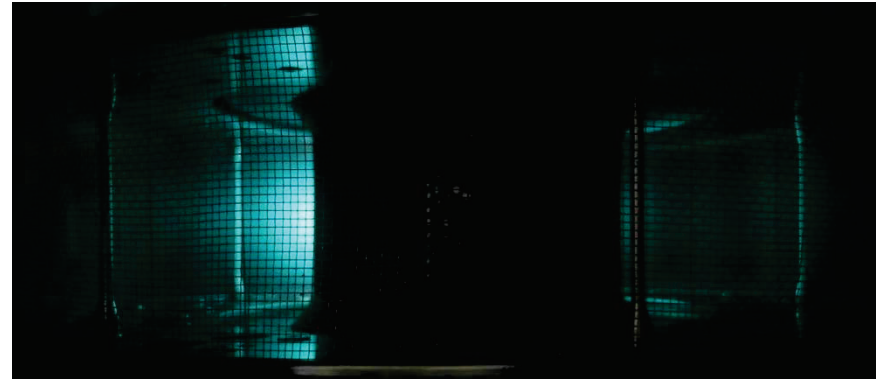
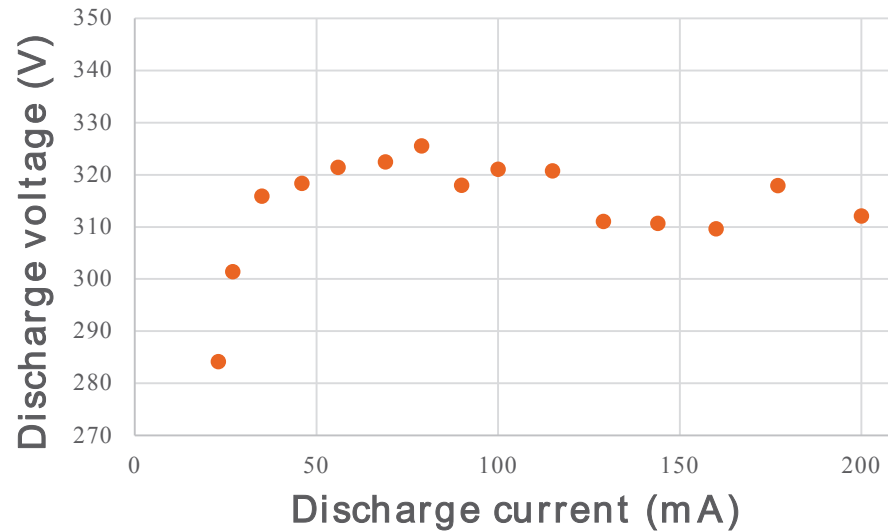
Toroidal Electron Source

Ion source



Toroidal Electron Source

Ion source: Characteristic curves

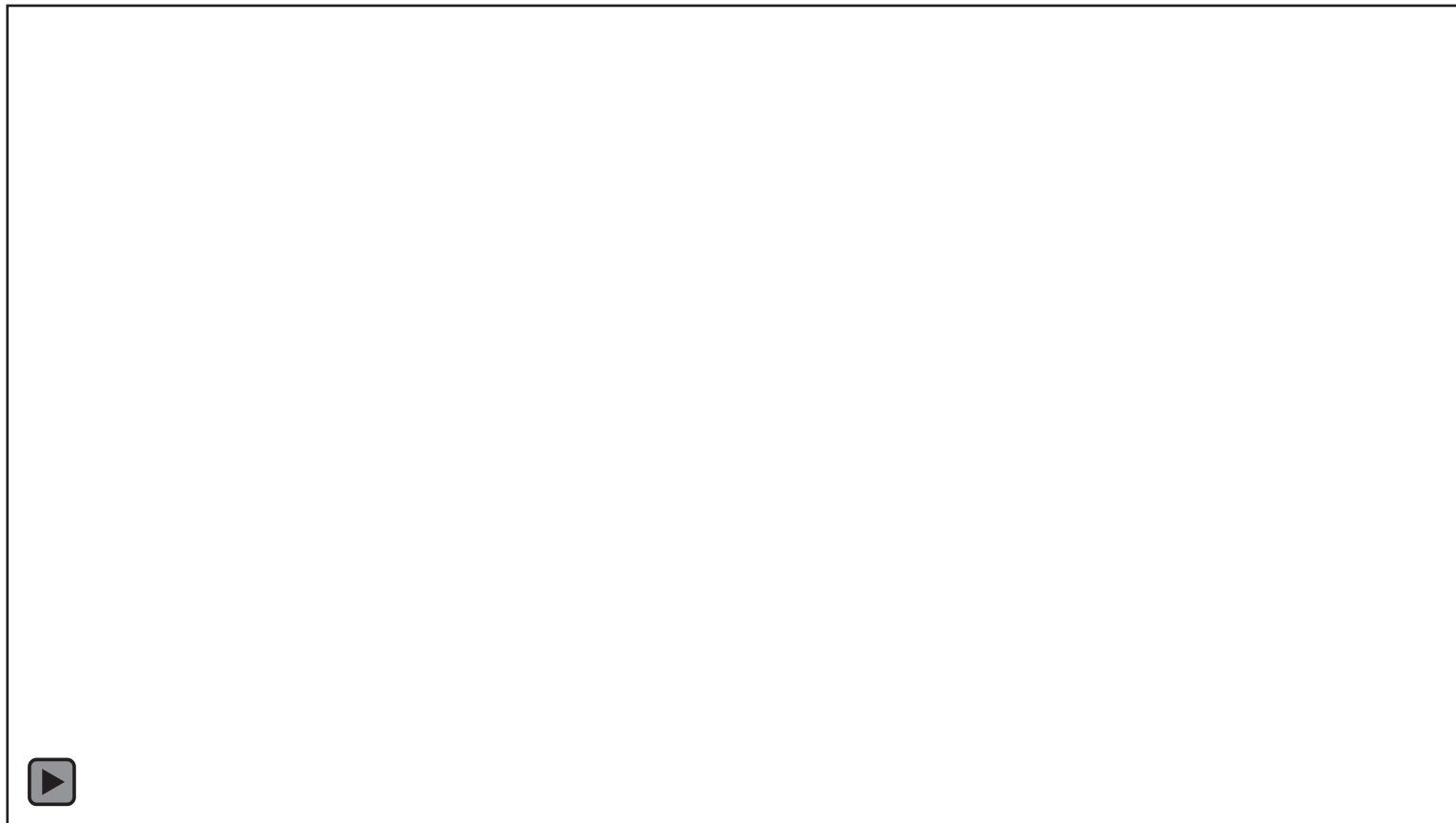


■ Local plasma below 35 mA

Helium discharge at 2.5 Pa

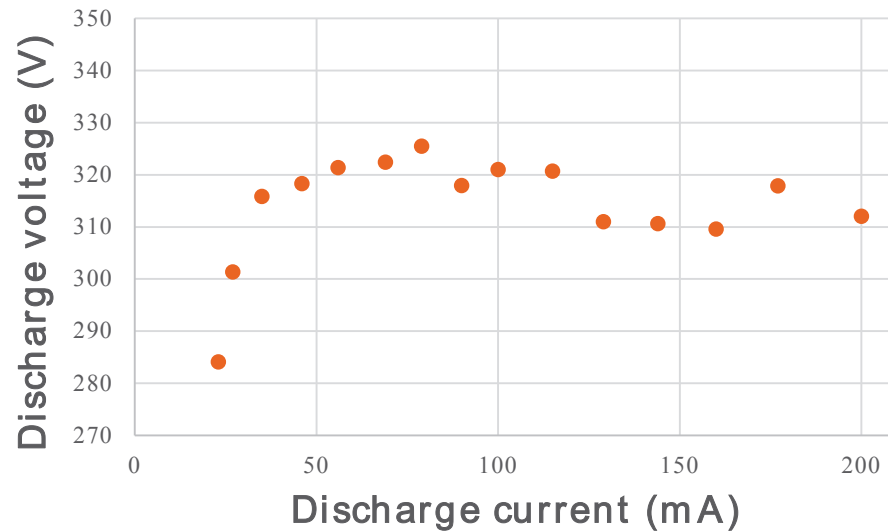
Toroidal Electron Source

Ion source: Local Ar discharge

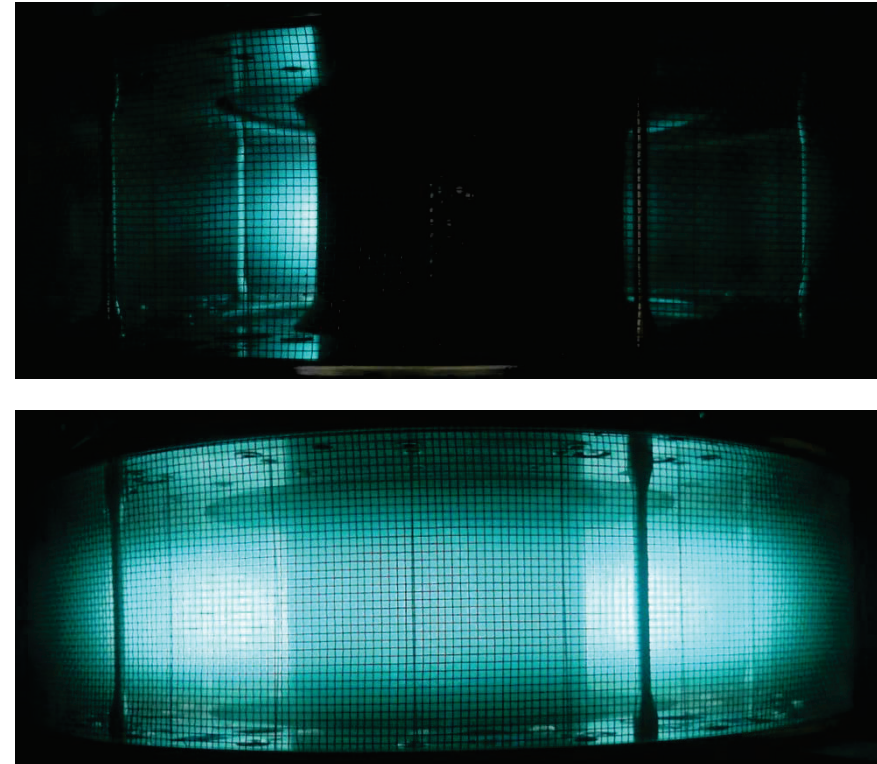


Toroidal Electron Source

Ion source: Characteristic curves



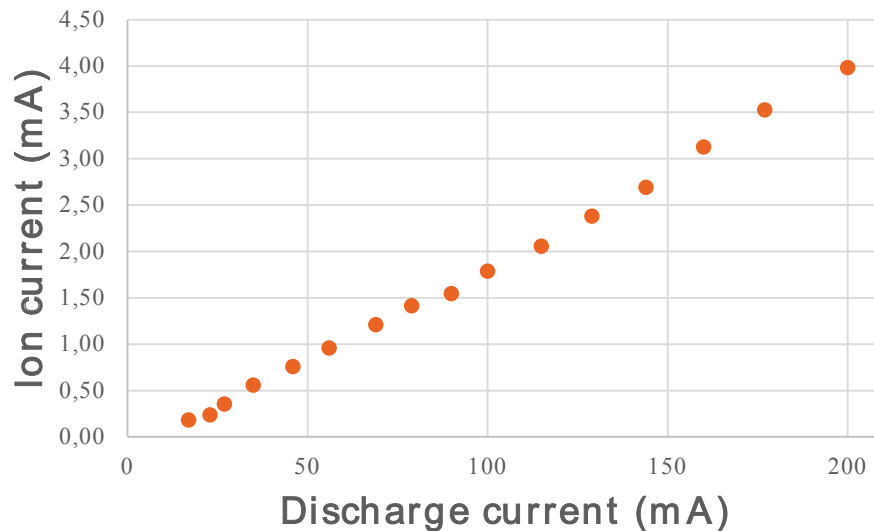
- Local plasma below 35 mA
- Global plasma above 35 mA



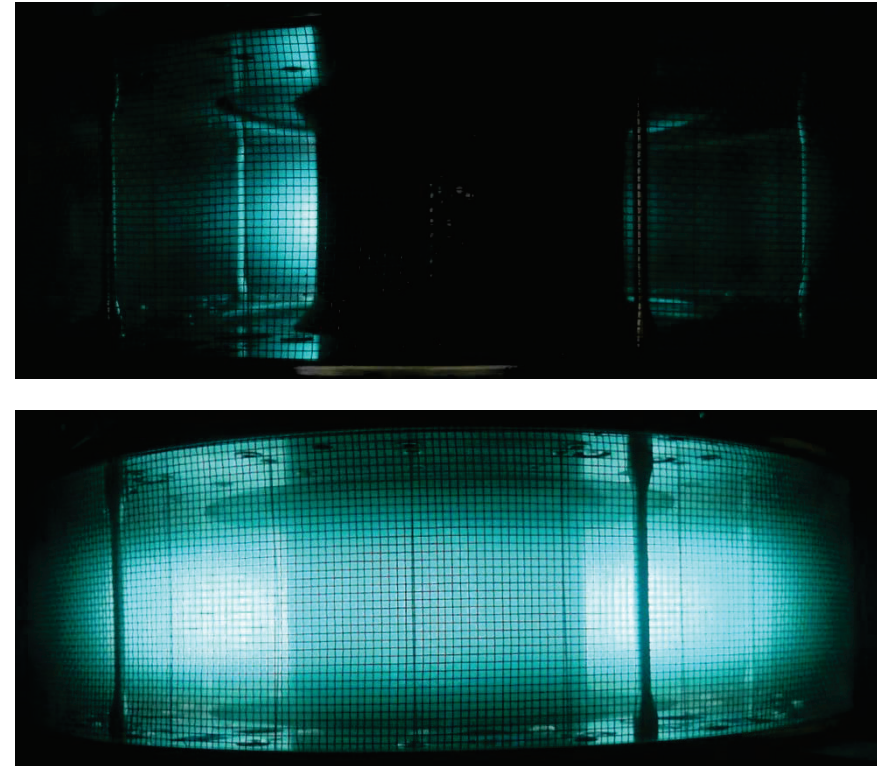
Helium discharge at 2.5 Pa

Toroidal Electron Source

Ion source: Characteristic curves



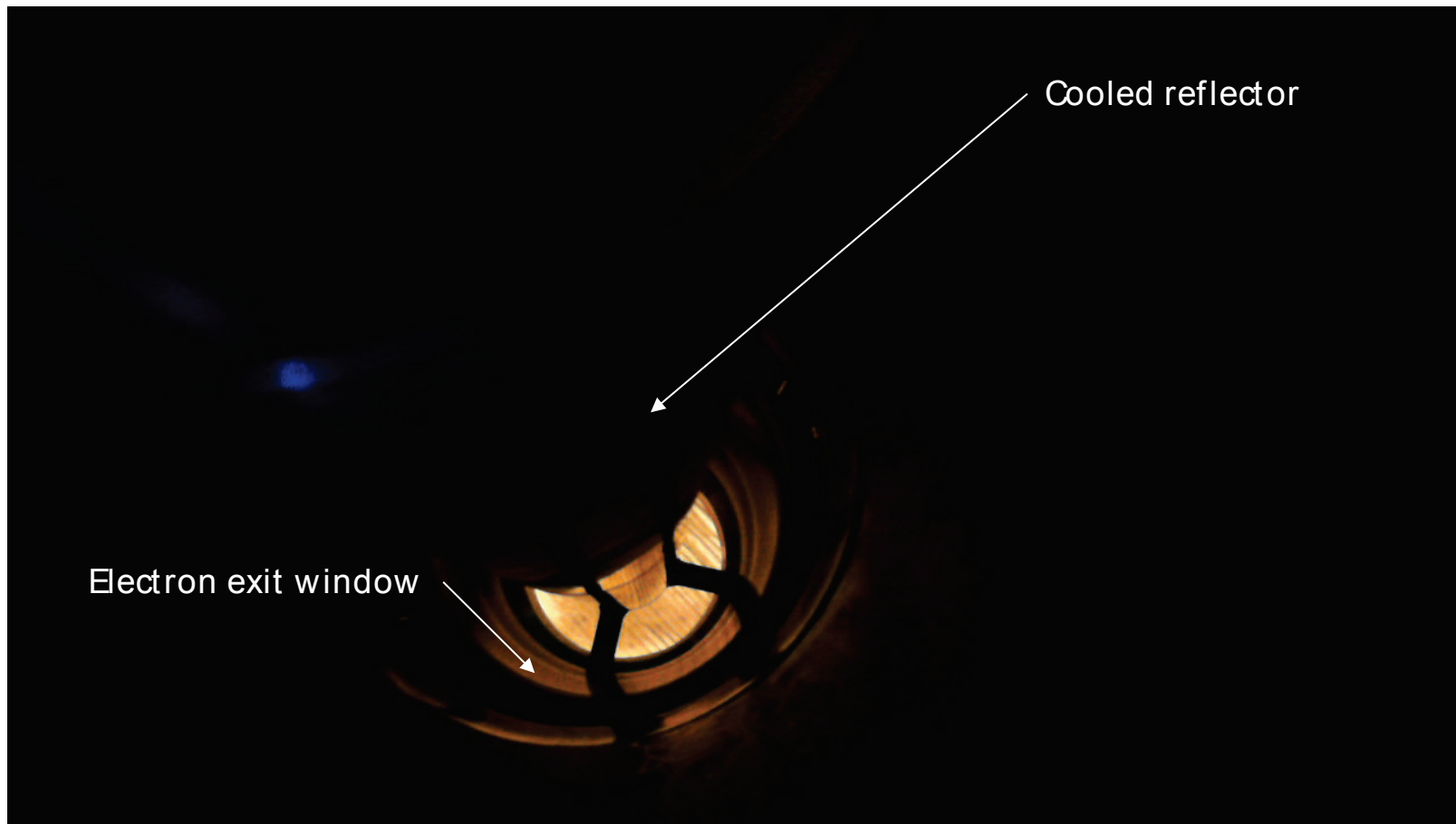
- Local plasma below 35 mA
- Global plasma above 35 mA
- Linear dependency between discharge current and extracted ion current



Helium discharge at 2.5 Pa

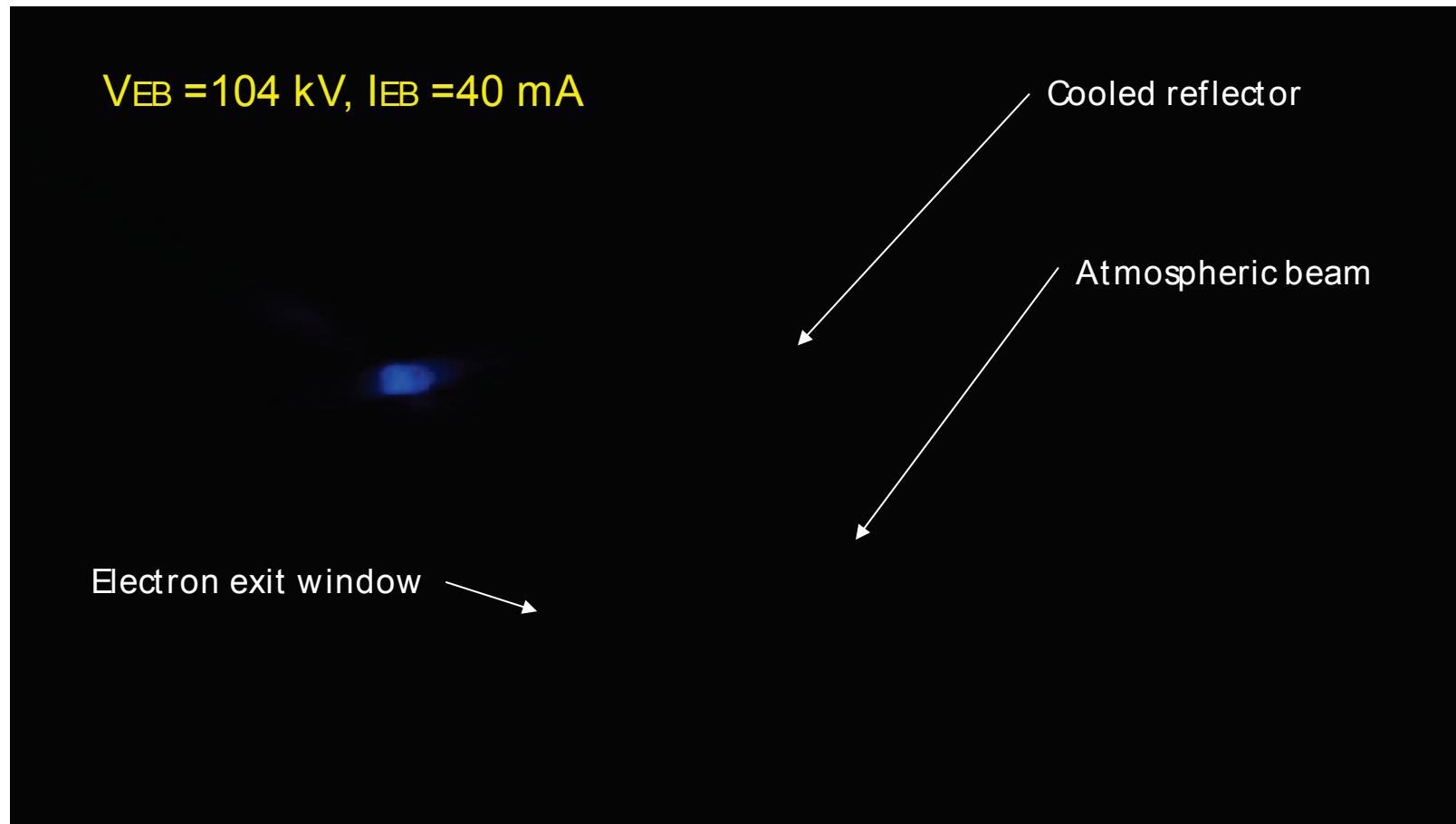
Toroidal Electron Source

Electron Beam at Atmosphere



Toroidal Electron Source

Electron Beam at Atmosphere



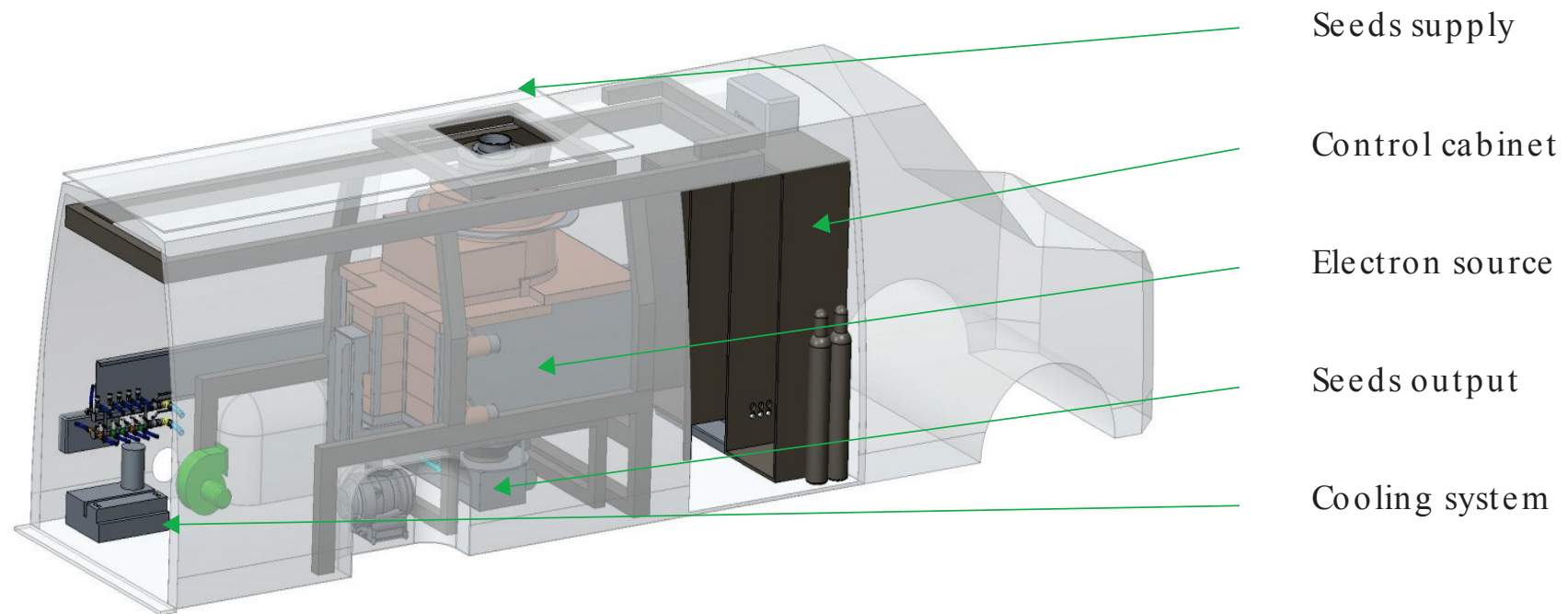
Toroidal Electron Source

Stationary system with seeds feed



Toroidal Electron Source

Mobile system concept



Conclusions

- Electron beam treatment is an environmentally-friendly technology in the field of seeds disinfection
- Planar sources need a complex geometry in order to ensure a homogeneous irradiation of bulk goods and 3D surfaces
- Toroidal electron sources controlled by a wire anode discharge improve the economical viability of EB technology and offer new possibilities for homogeneous or structured treatment of parts, curved surfaces and endless products like tube packaged medical products, lacquered profiles, tubes, etc..
- Further work to optimize electron yield, homogeneity, long-term stability, lifetime of Titanium foil window, ...
- Development of new system conceptions for diversified applications, e.g., for easy gas flow sterilization or flue gas treatment

Thank you for your attention!

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