Top sector Energy has 7 TKI's:

- Gas
- Bio-energie
- Wind-op-zee
- Smart grids
- Zonne-energie
- Energiebesparing Gebouwde Omgeving
- Energiebesparing in de Industrie

Less TKI's expected in the future

TKI = Topconsortium voor Kennis en Innovatie

CWI theme Energy

Multiscale Dynamics:

Ebert, Hundsdorfer, Camporeale

Scientific Computing:

Crommelin, **Witteveen**, Batenburg, Oosterlee

Stochastics:

Zwart, **Nair**, **Nunez**

Intelligent Systems:

La Poutre, Kaisers, **Pauwels**, Bosman

Life Sciences:

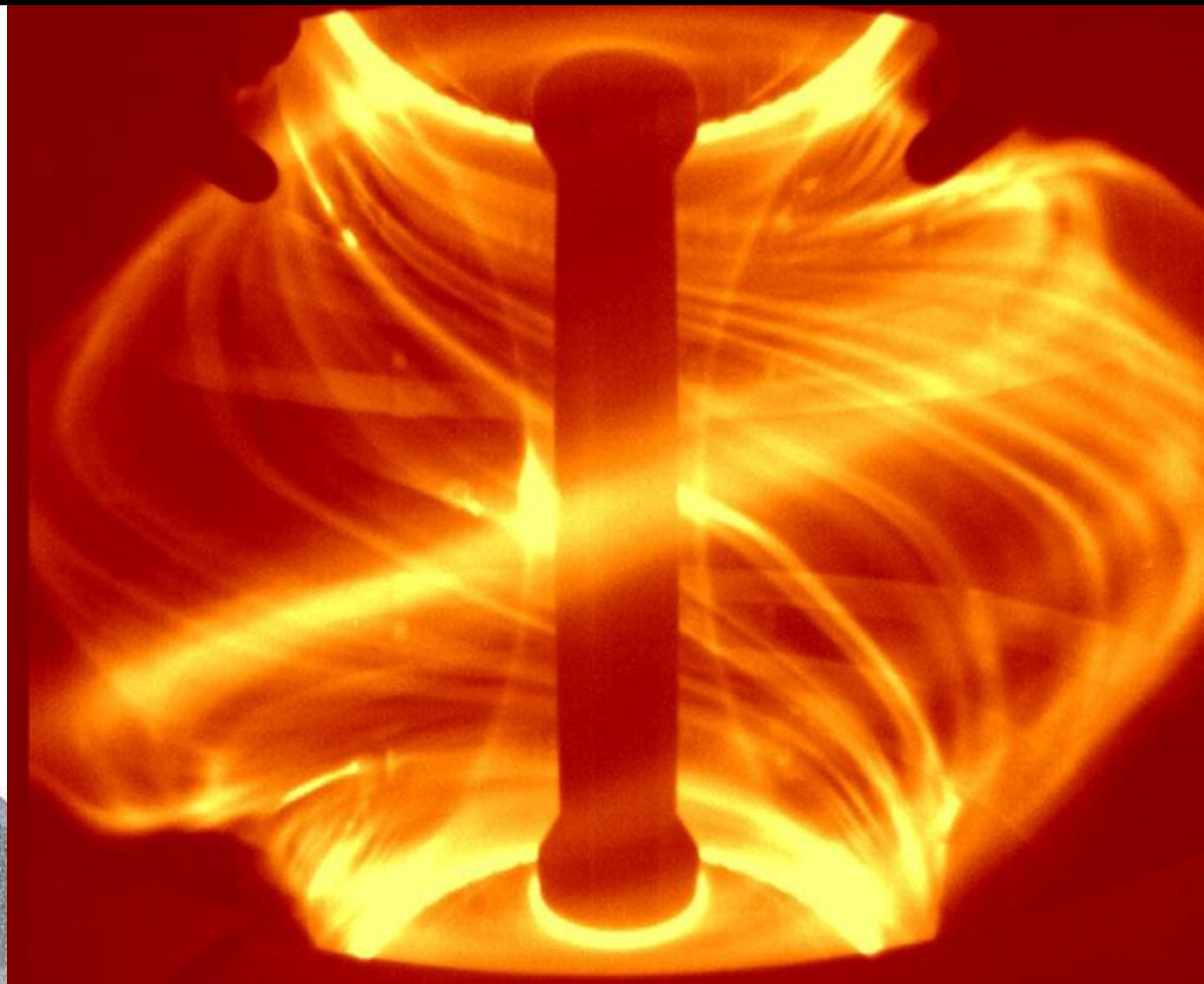
Merks

DIFFER
Dutch Institute for
Fundamental Energy Research

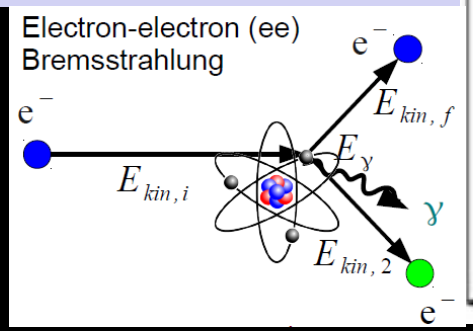
Fusion energy

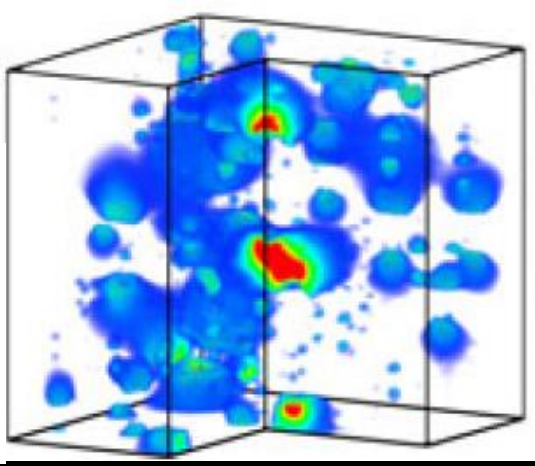
ITER

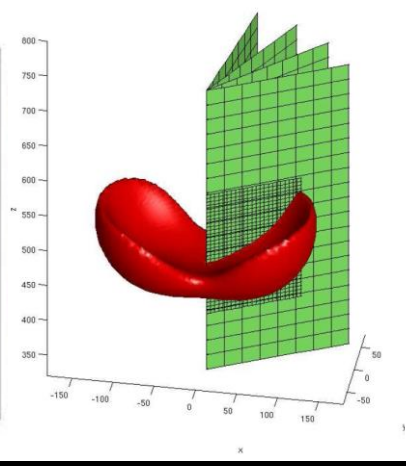
plasma dynamics

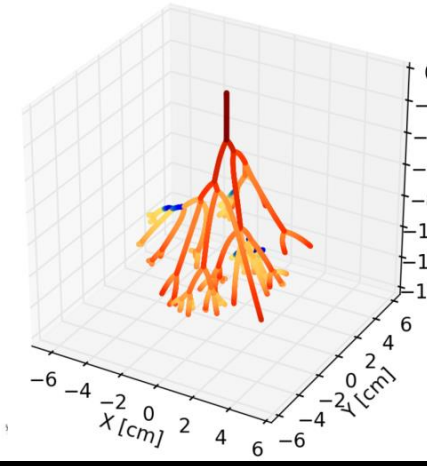


Modeling, analysis, computing:





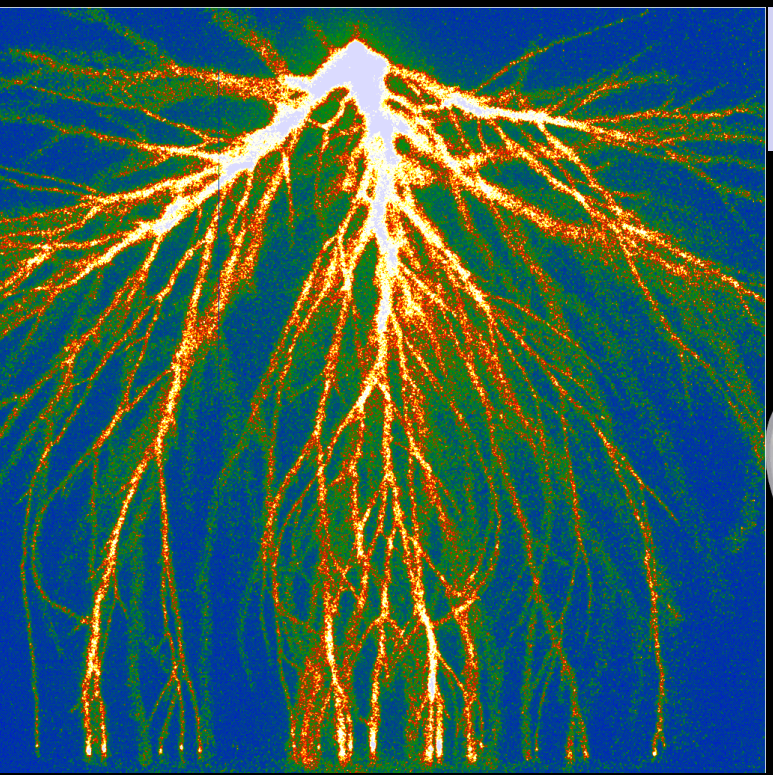




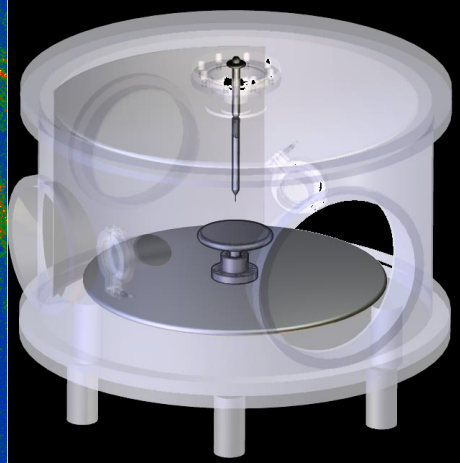
Ute Ebert, Willem Hundsdorfer

CWI Amsterdam

Eindhoven University of Technology, Netherlands

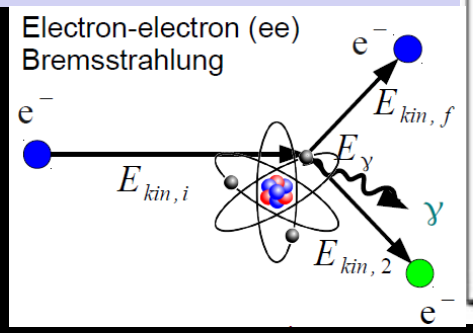


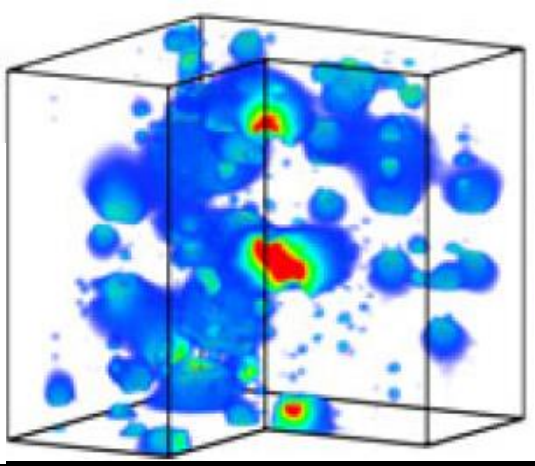
Plasma technology

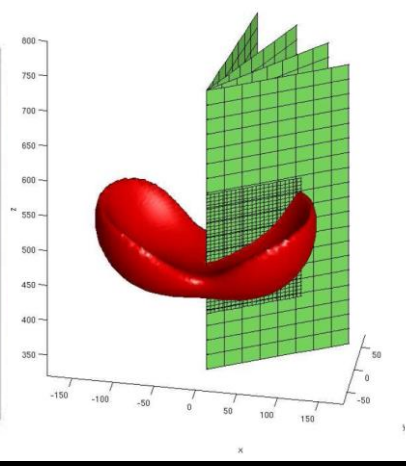


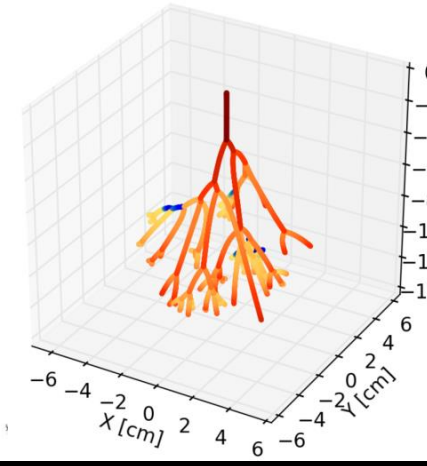
High voltage engineering

Modeling, analysis, computing:









Projects on high voltage engineering for energy transport:

STW-10755: a new medium for electric switching

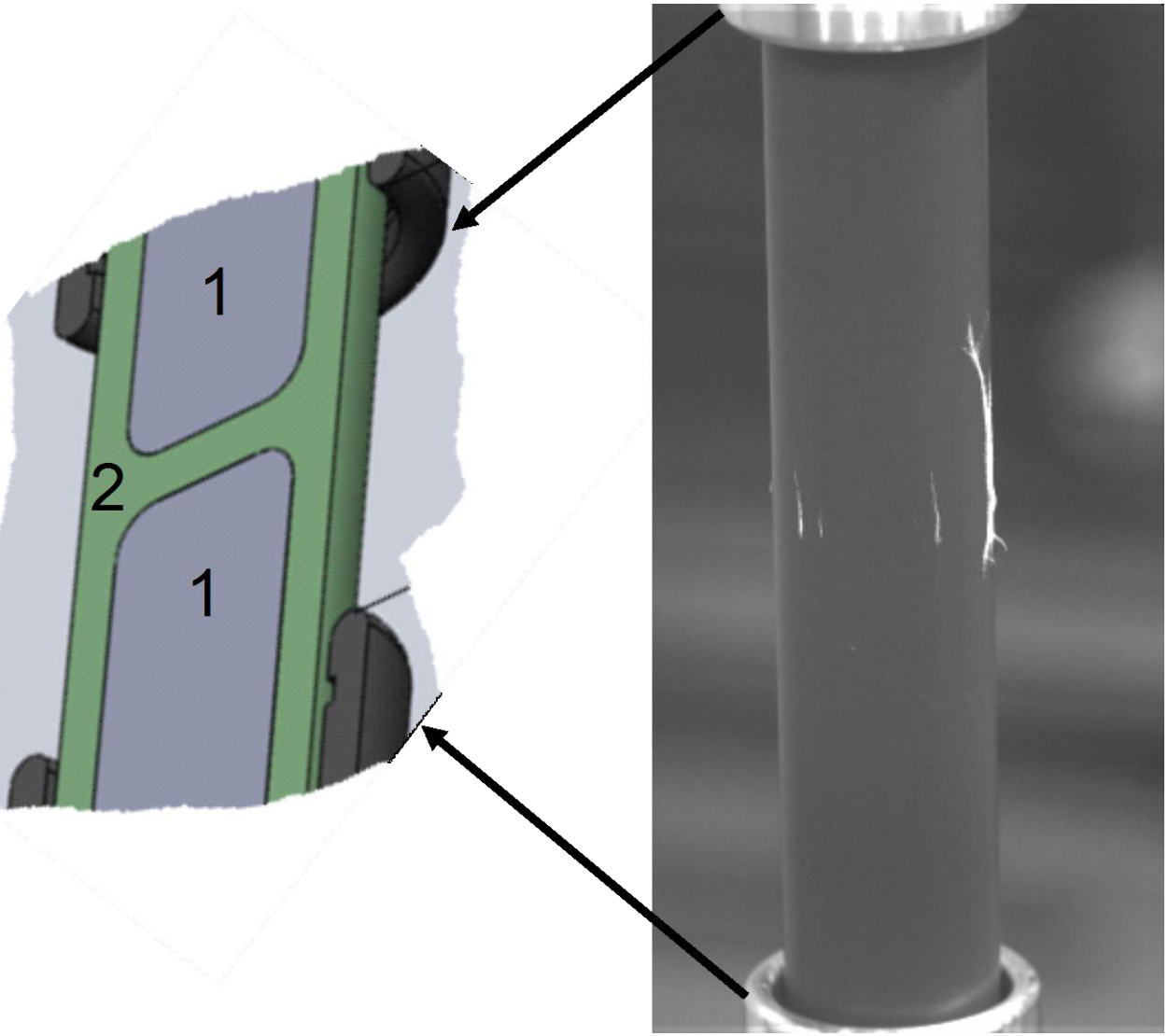
STW-12119: preventing electric flashover

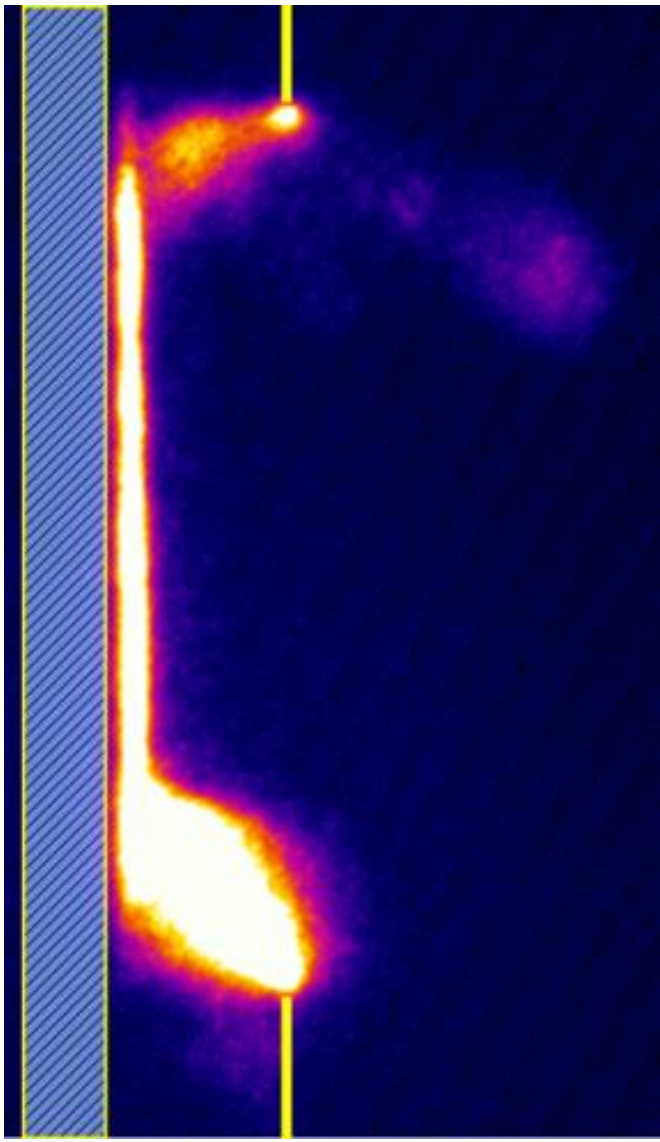
Shell-NWO: electric switching for DC nets

Industrial partners: ABB Corp. Res.,
Siemens, KEMA …

We have 3 more projects on multiscale plasma modeling.

Failure in high voltage technology

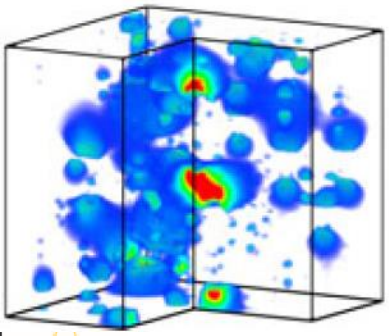




When do discharges start "out of nothing"?

Why and when are they attracted to insulators?

Collision cross-sections for different gases

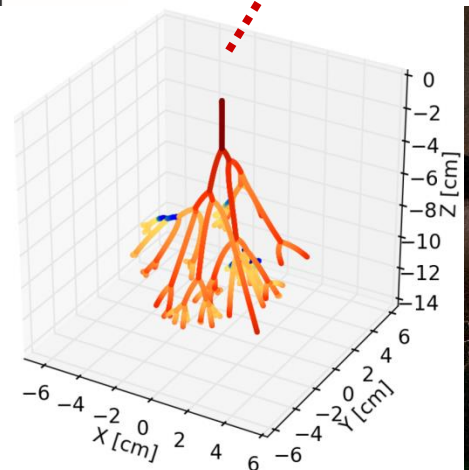


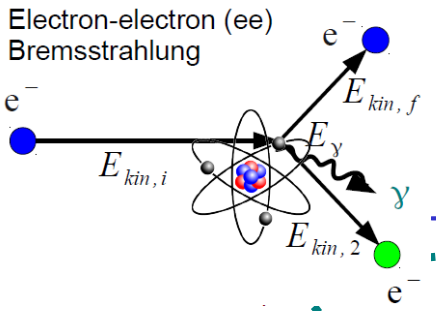
Stochastic electron motion
(Monte Carlo or Boltzmann)

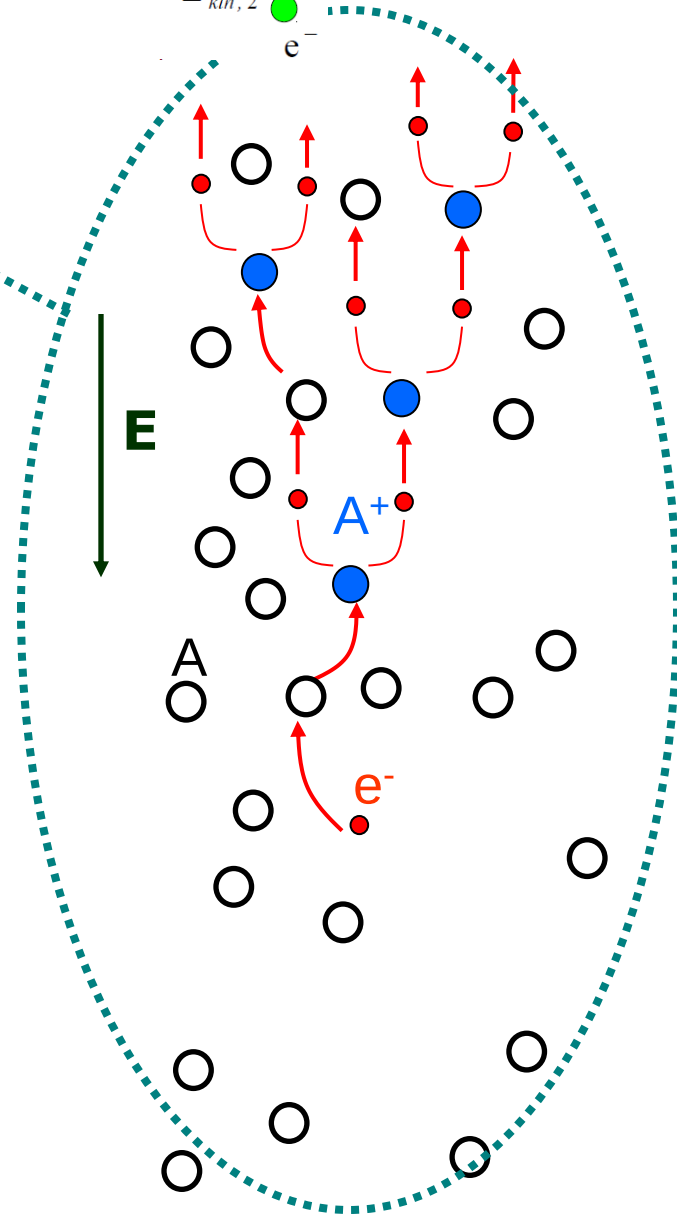
Electron density model
coupled to Poisson equation

Model reduction to tree model

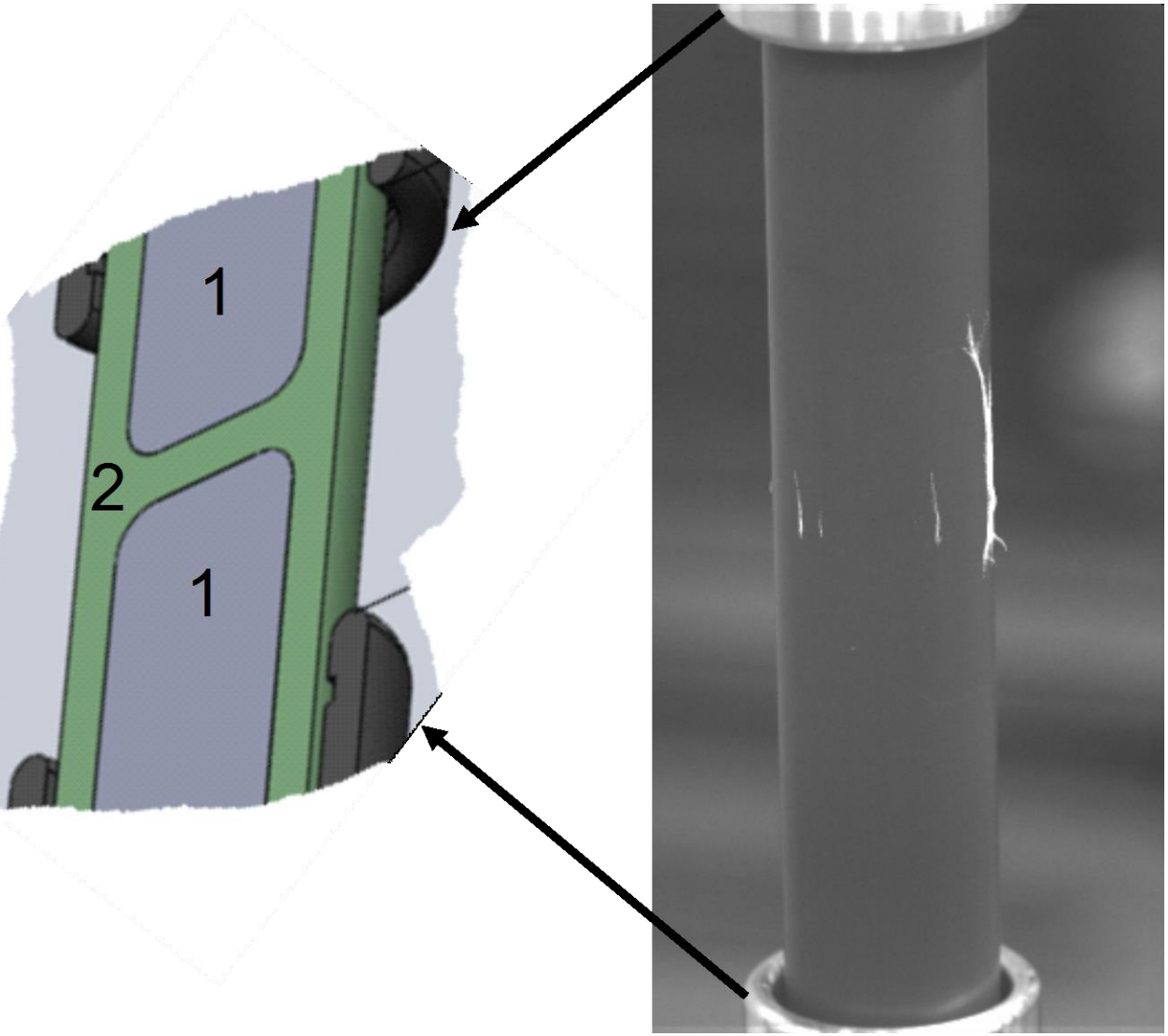
Include ion motion,
heating, chemistry …





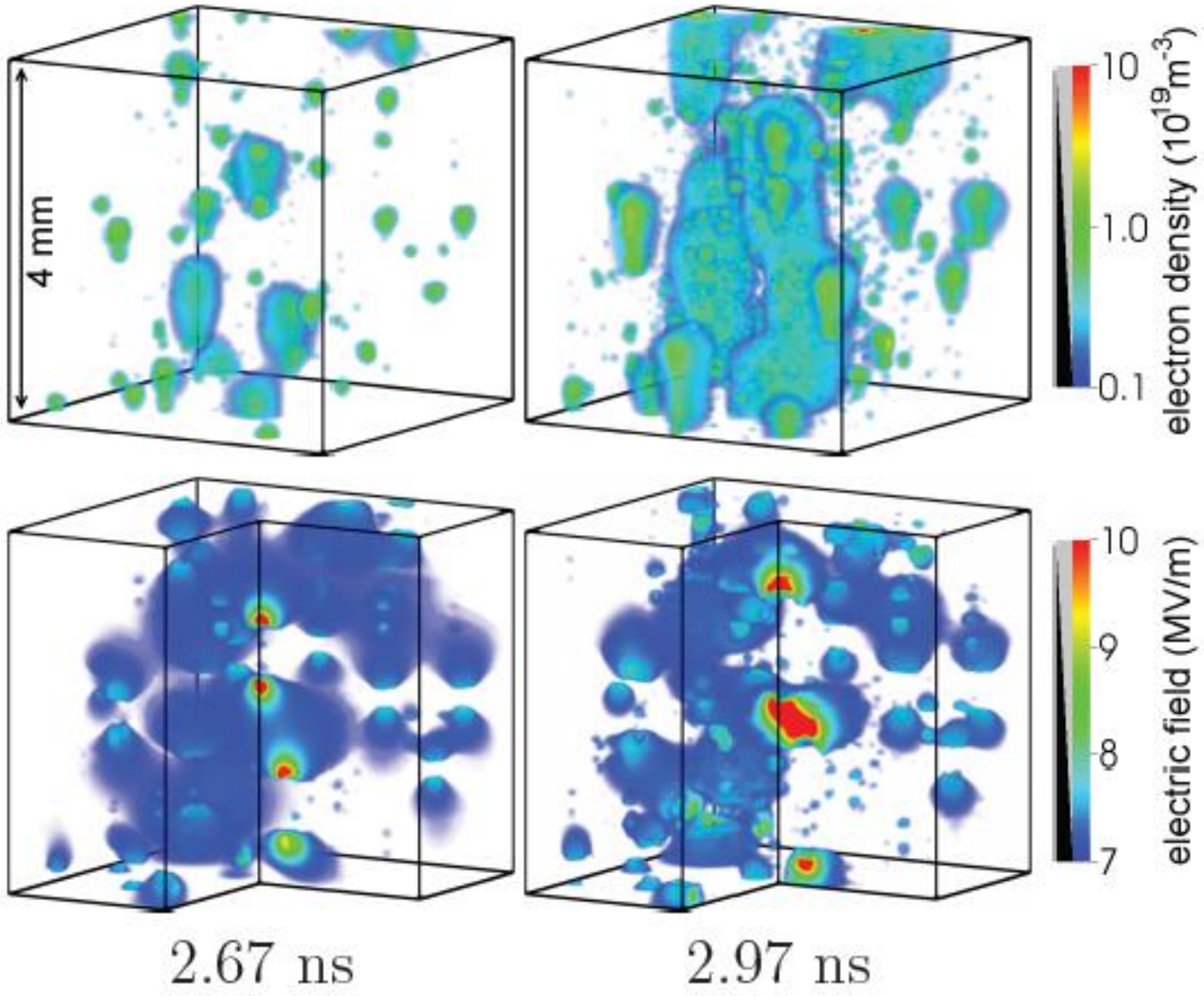


Failure in high voltage technology



When do discharges start “out of nothing”?

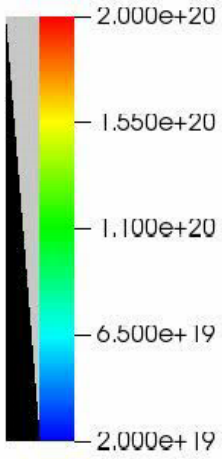
Electric breakdown of overvolted air (7 MV/m) with natural background ion density of 10^3 O_2^-/cm^3



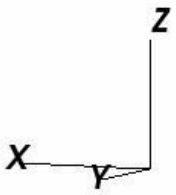
Ionization screening time in overvolted air gaps is similar to streamer formation time.

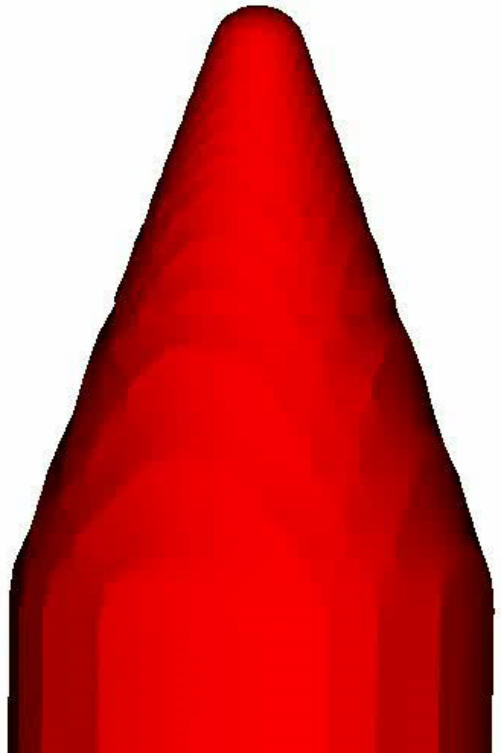
[Sun, Teunissen, Ebert, Geophys. Res. Lett. 2013]

8 kV

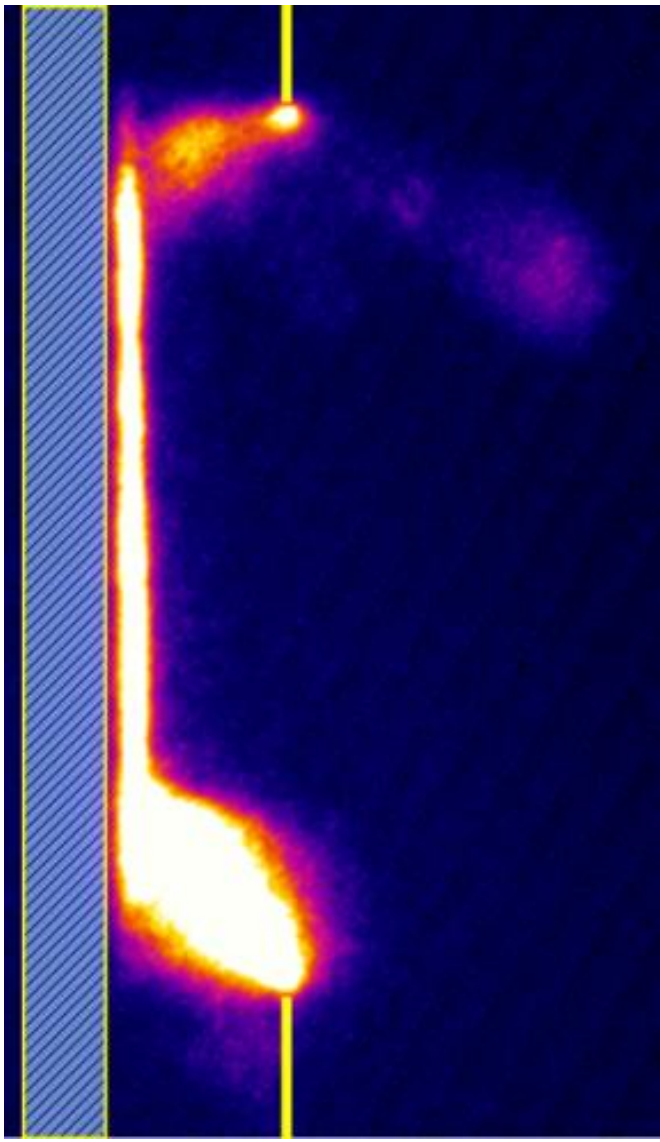


[Teunissen, in prep.]





Failure in high voltage technology

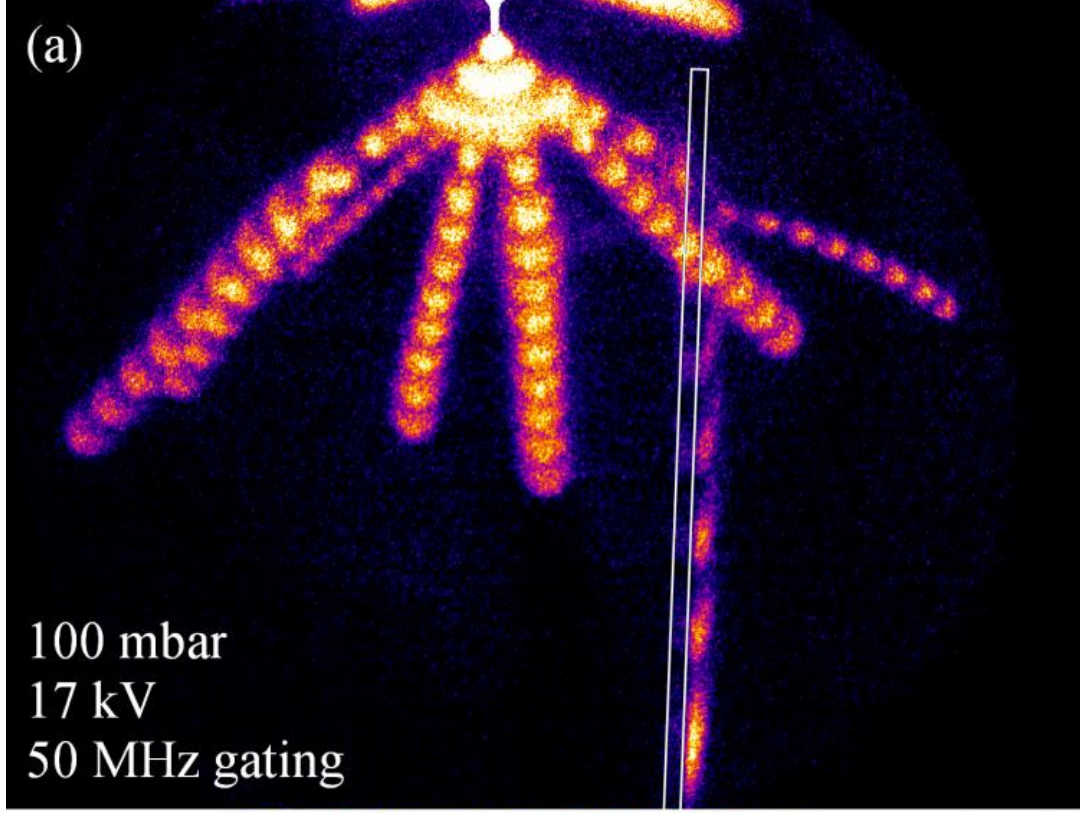


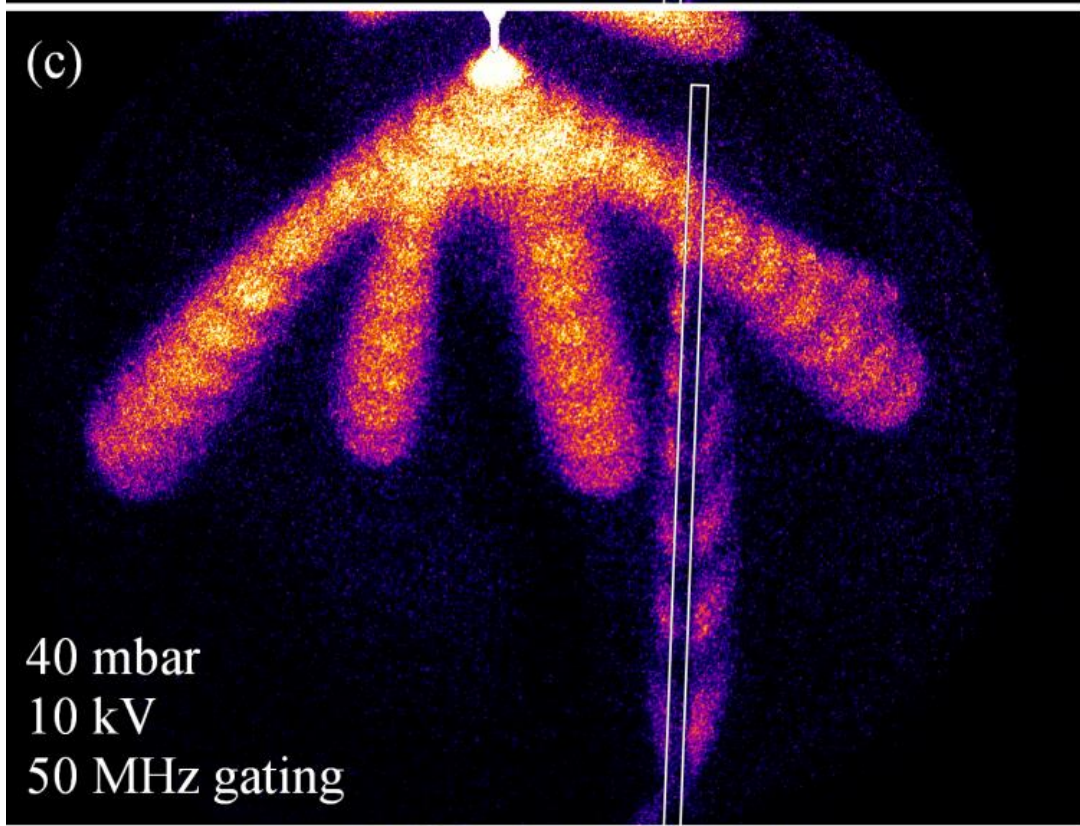
Why and when are they attracted to insulators?

Interaction of discharge with insulating rod

Stroboscopic imaging,

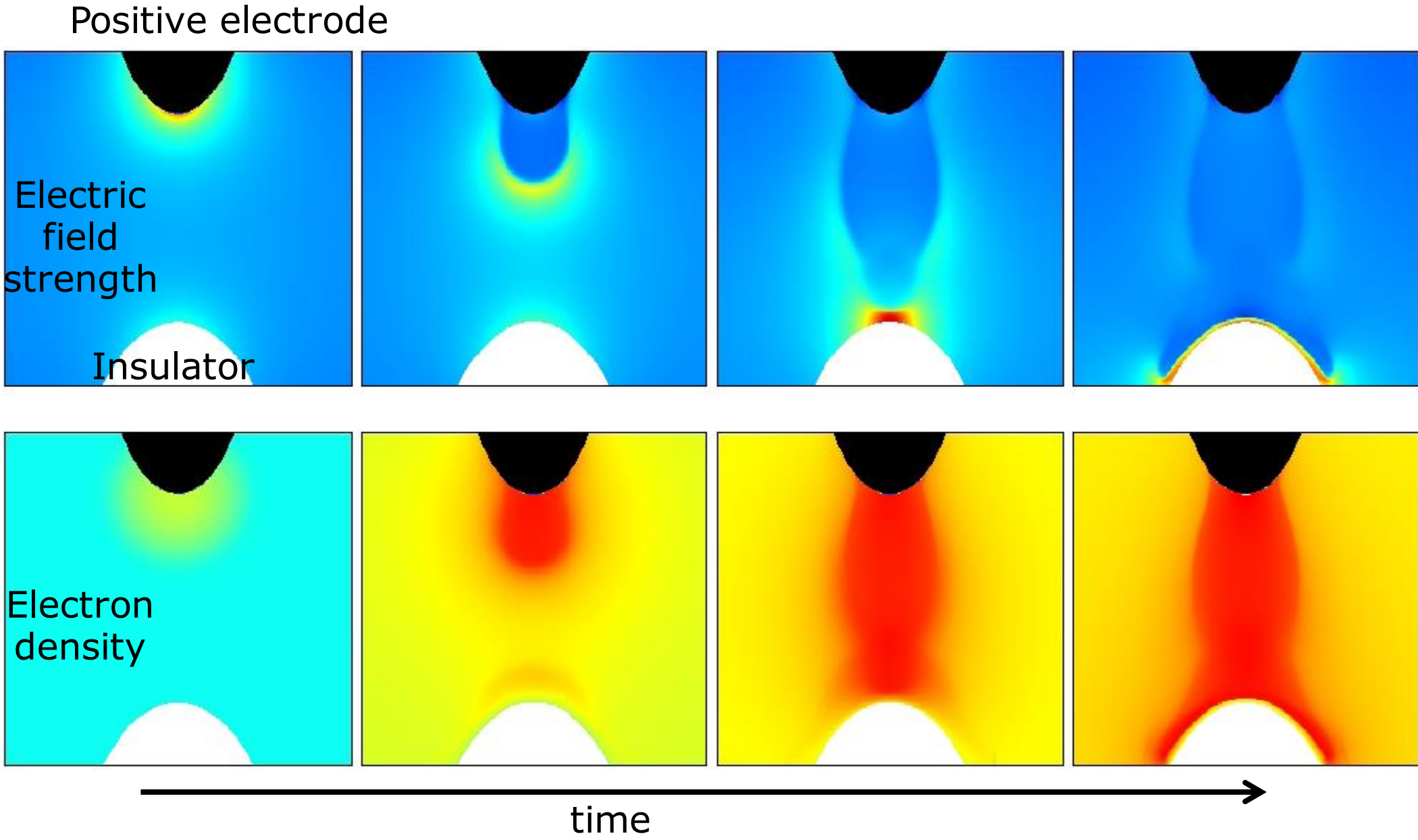
1 max/5 ns



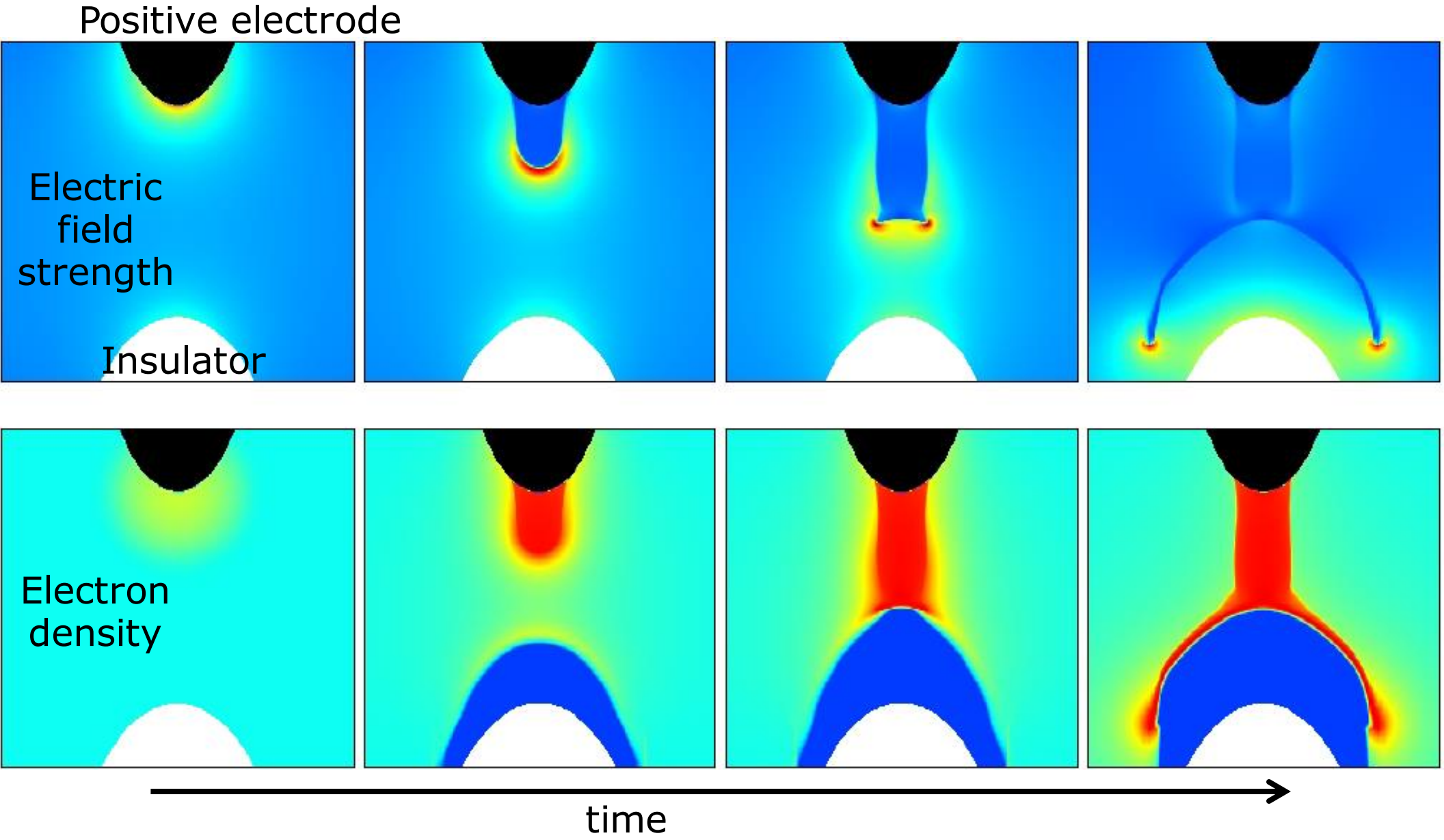


[Trienekens, Nijdam, Ebert, submitted]

Discharge in air

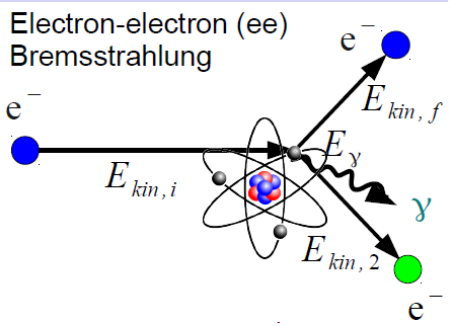


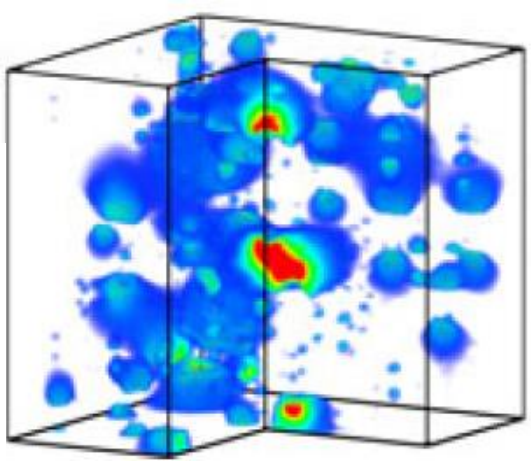
Discharge in pure nitrogen

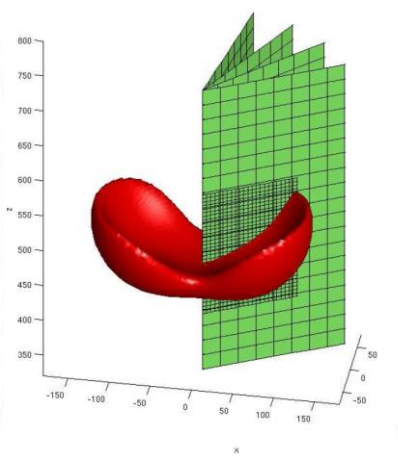


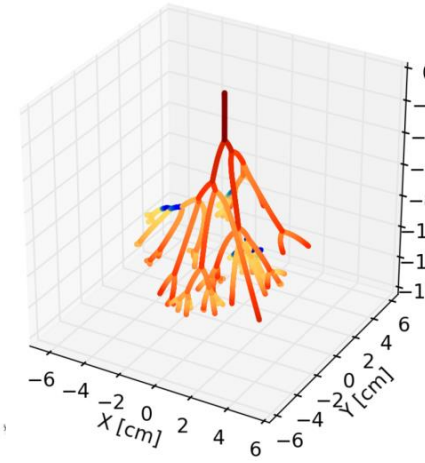
[Dubinova, Teunissen, Ebert, submitted]

Modeling, analysis, computing:









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STW-10755: a new medium for electric switching

STW-12119: preventing electric flashover

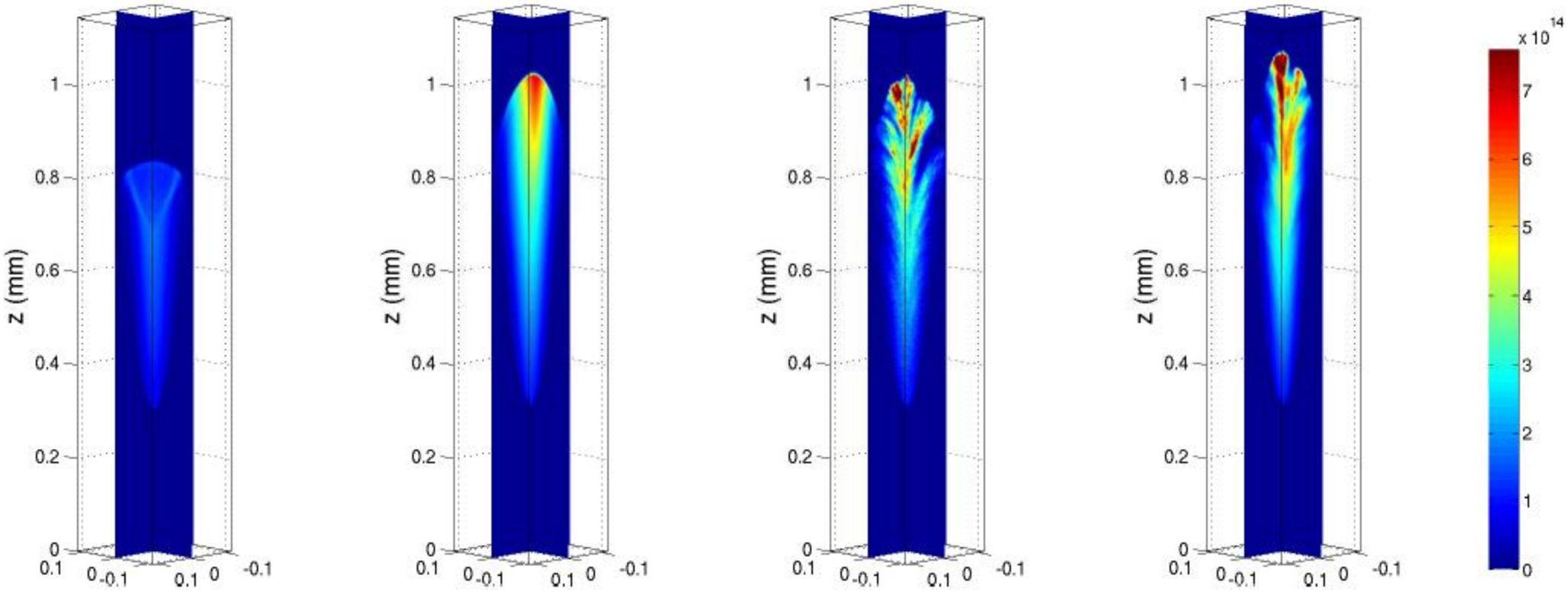
Shell-NWO: electric switching for DC nets

We can contribute based on our expertise and continuous method development.

Streamer in nitrogen at 10 MV/m

Comparison of 3D models

Classical fluid | Extended fluid | Super-particle | Hybrid



[Li, Teunissen, Nool, Hundsdorfer, Ebert, Plasma Sources Sci. Techn. 2012]

High order fluid model derived from Boltzmann equation:
Dujko, Markosyan, White, Ebert, two articles in J Phys D in 2013

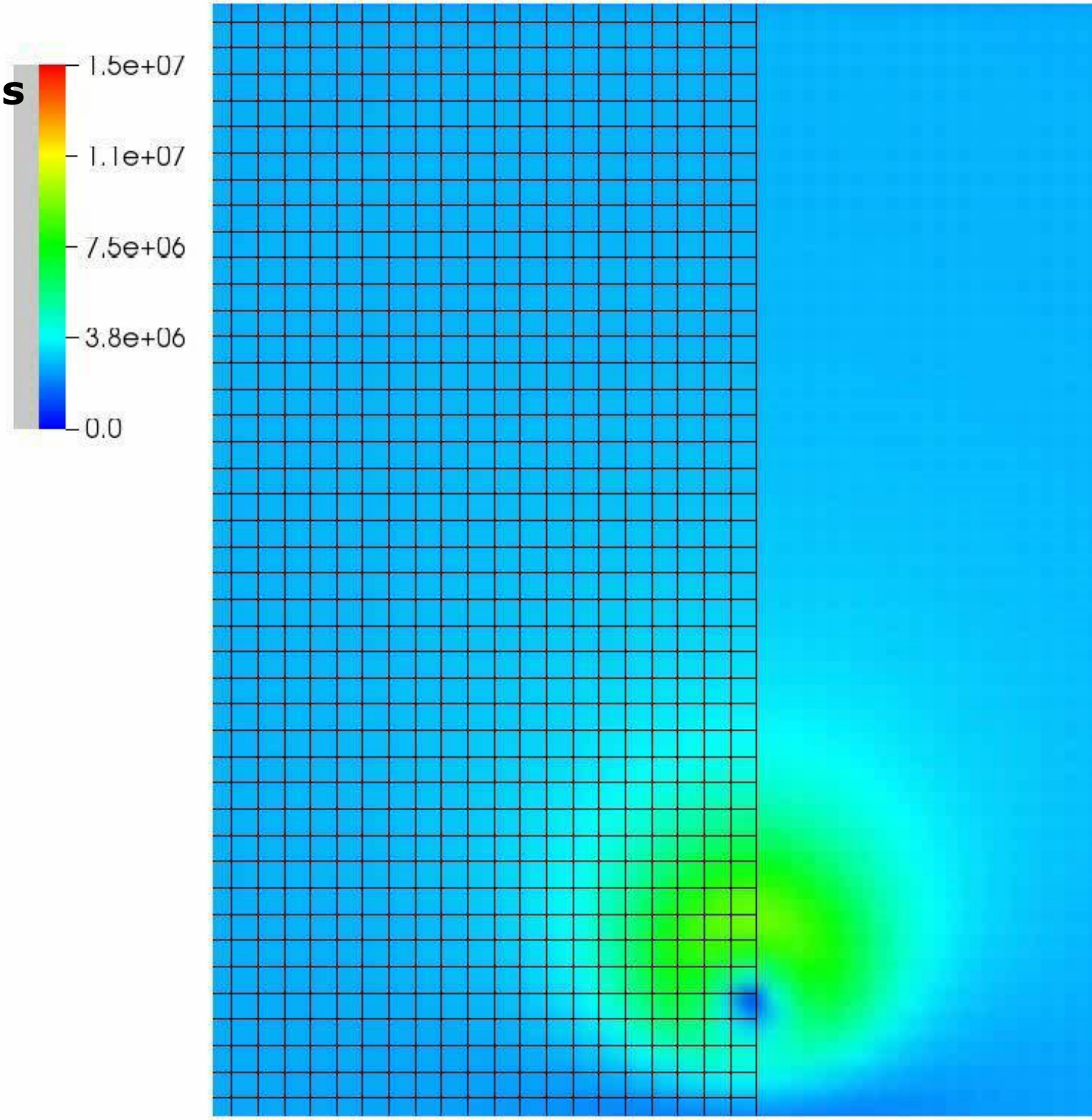
3D particle model with refined meshes

Positive streamer

in 10 mm STP air,

slightly undervolted,

n_e = 50/mm^3



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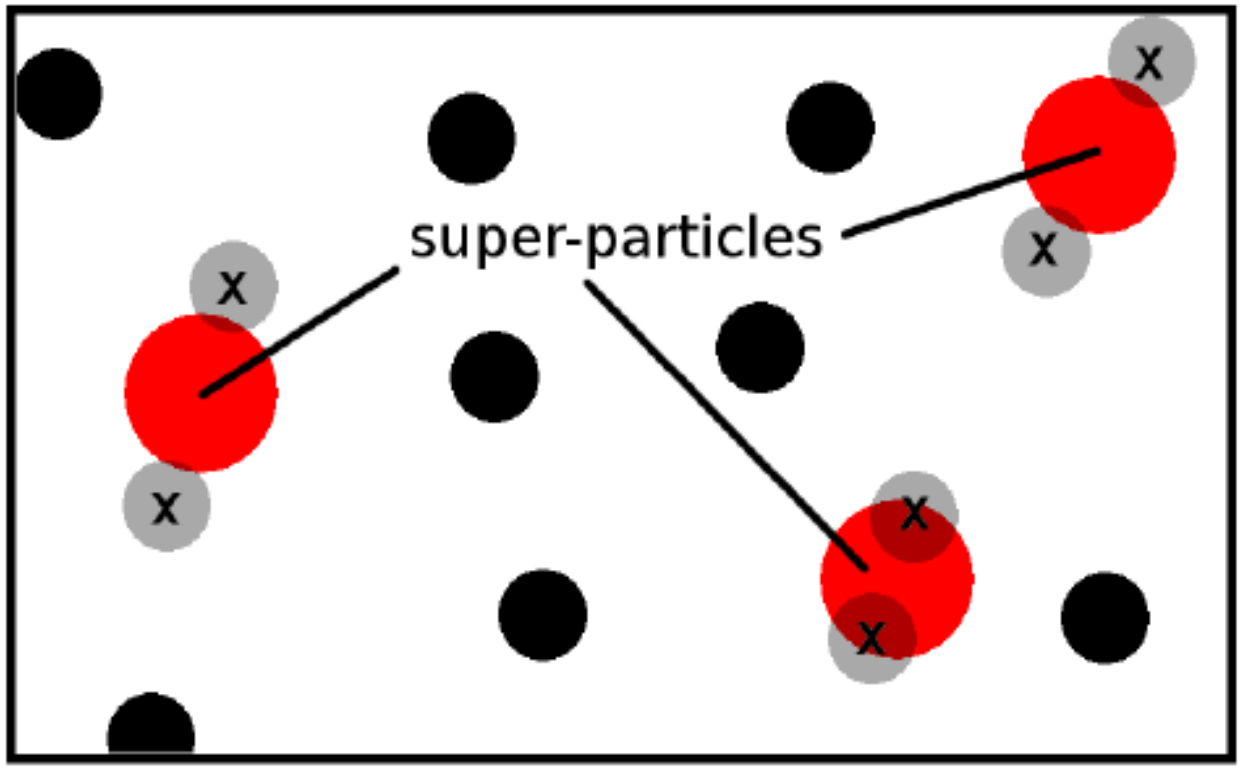

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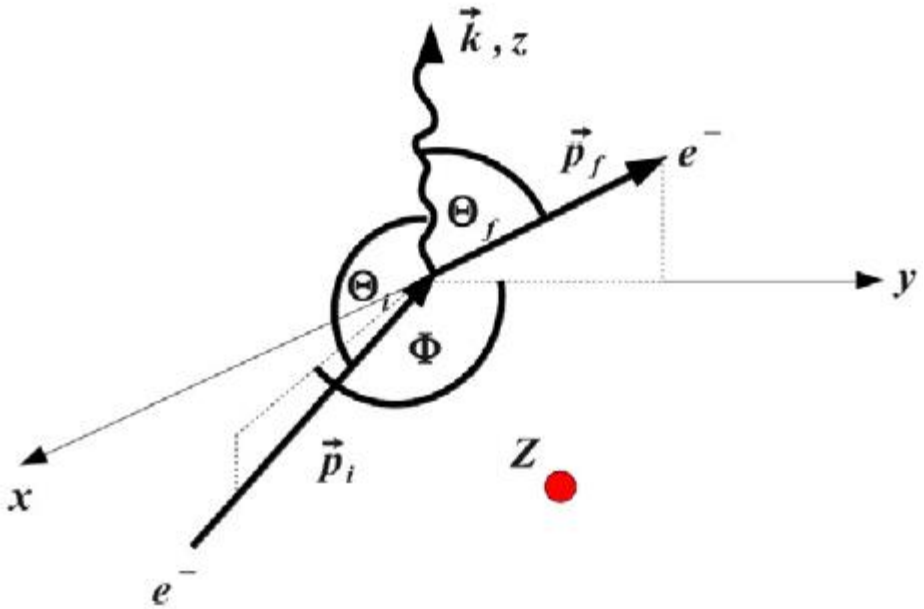

$$\int_0^{\pi} d\Theta_f \frac{2\pi a_4 \alpha}{\sqrt{(\beta^2-\alpha^2)^3}} \sin\Theta_f - \frac{16\pi A p_i^2 p_f^2 \sin^2\Theta_i \left(E_i^2+E_f^2\right)}{E_i - c p_i \cos\Theta_i} \times$$
$$\times \left[-\frac{2\left(\Delta_2 p_f c + \Delta_1 E_f\right)}{\left(-\Delta_2^2+\Delta_1^2-4p_i^2p_f^2\sin^2\Theta_i\right)\left(\left(\Delta_2 E_f+\Delta_1 p_f c\right)^2+4m^2c^4p_i^2p_f^2\sin^2\Theta_i\right)} \right.$$
$$+ \frac{m^2c^4}{\sqrt{\left(\left(\Delta_2 E_f+\Delta_1 p_f c\right)^2+4m^2c^4p_i^2p_f^2\sin^2\Theta_i\right)^3}} \times$$
$$\times \ln\left(\left(\left(E_f - c p_f\right)\left(4p_i^2p_f^2\sin^2\Theta_i\left(-E_f-p_f c\right)+(\Delta_1-\Delta_2)\left(\left(\Delta_2 E_f+\Delta_1 p_f c\right)\right.\right.\right.\right.$$
$$\left.\left.\left.\left. - \sqrt{\square_1^2 E_f^2 + 2\Delta_1\Delta_2 E_f p_f c + \square_2^2 p_f c)}\right)\left(\left(E_f + c p_f\right)\left(4p_i^2p_f^2\sin^2\Theta_i\left(+E_f - p_f c\right)\right.\right.\right.\right.$$
$$\left.\left.\left.\left. + (\Delta_1+\Delta_2)\left(\left(\Delta_2 E_f+\Delta_1 p_f c\right) - \sqrt{\square_1^2 E_f^2 + 2\Delta_1\Delta_2 E_f p_f c + \square_2^2 p_f c)}\right)^{-1}\right)\right].$$

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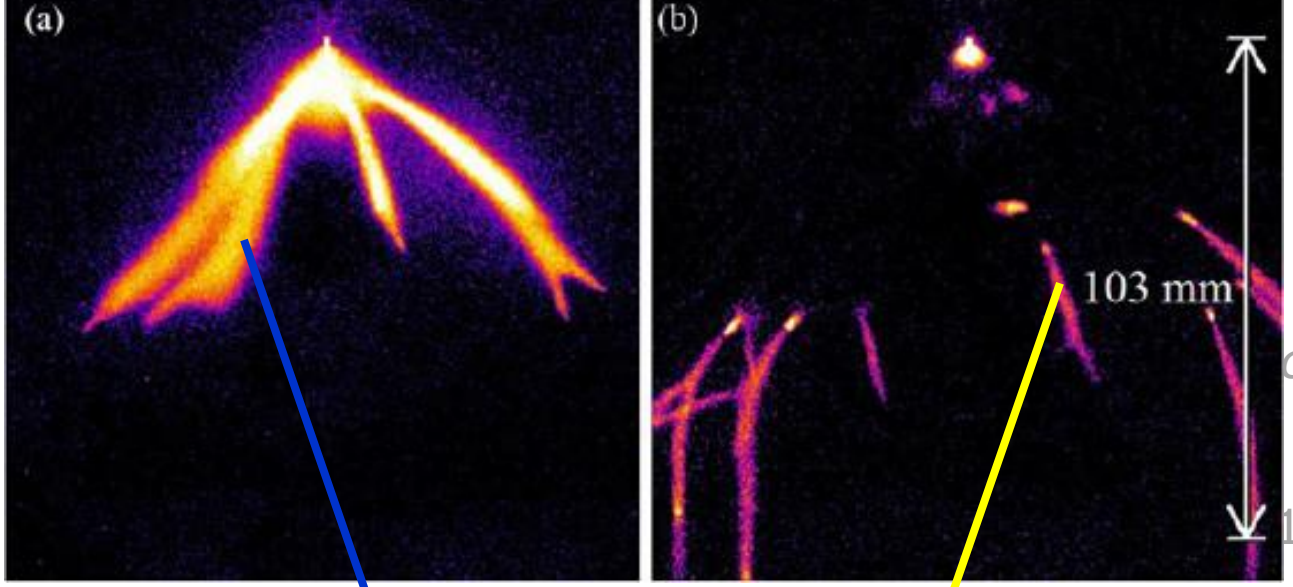

of positrons
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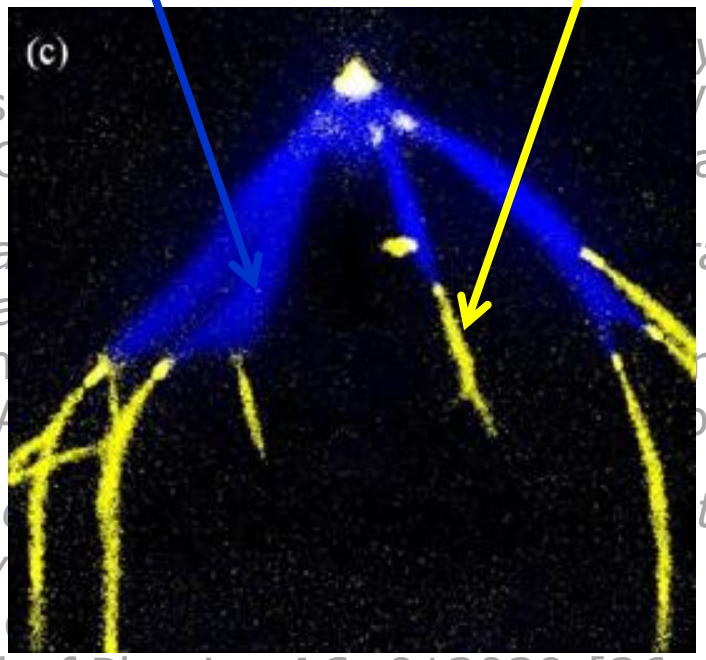
Explained by Aram!



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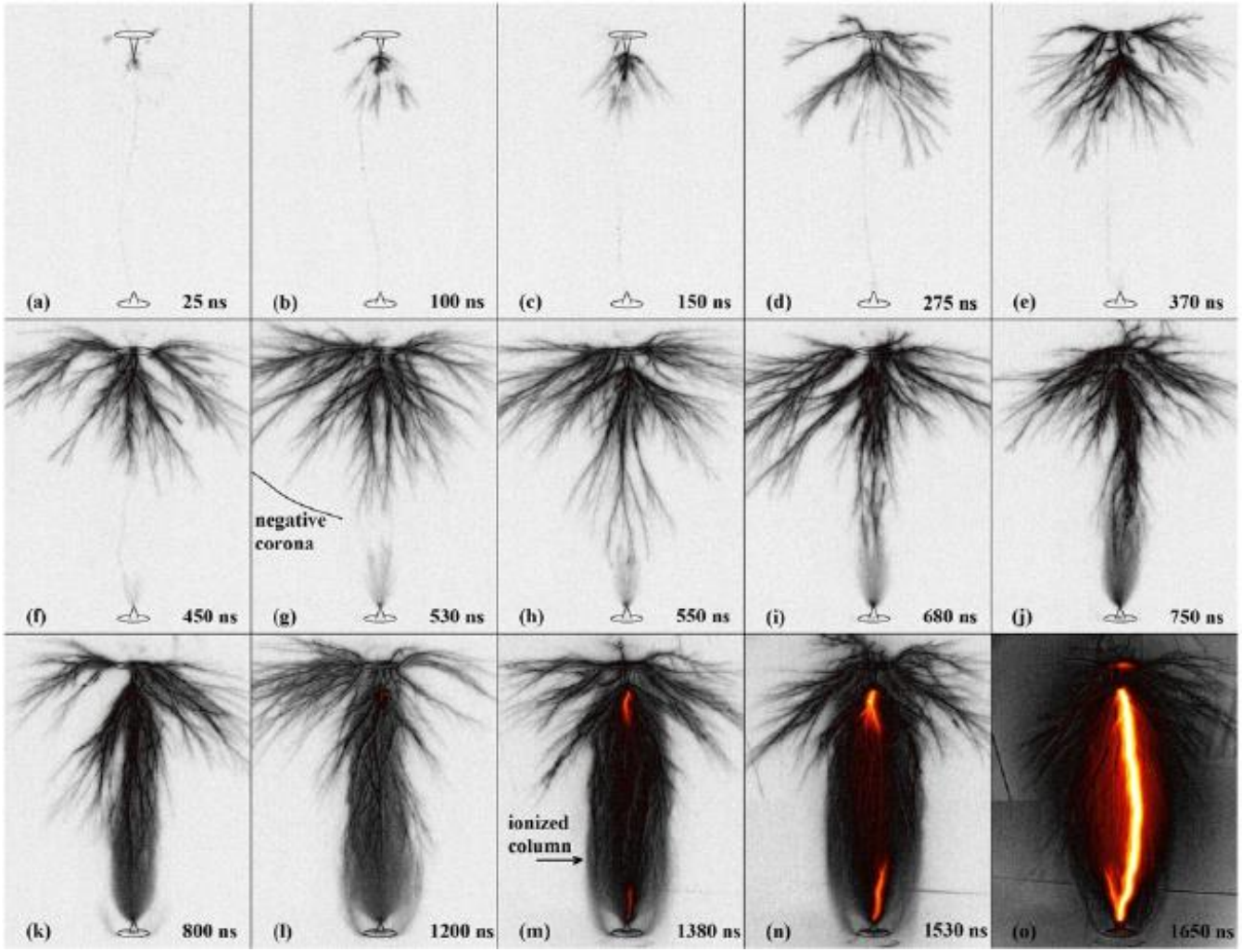

Understand discharge fluid coupling,

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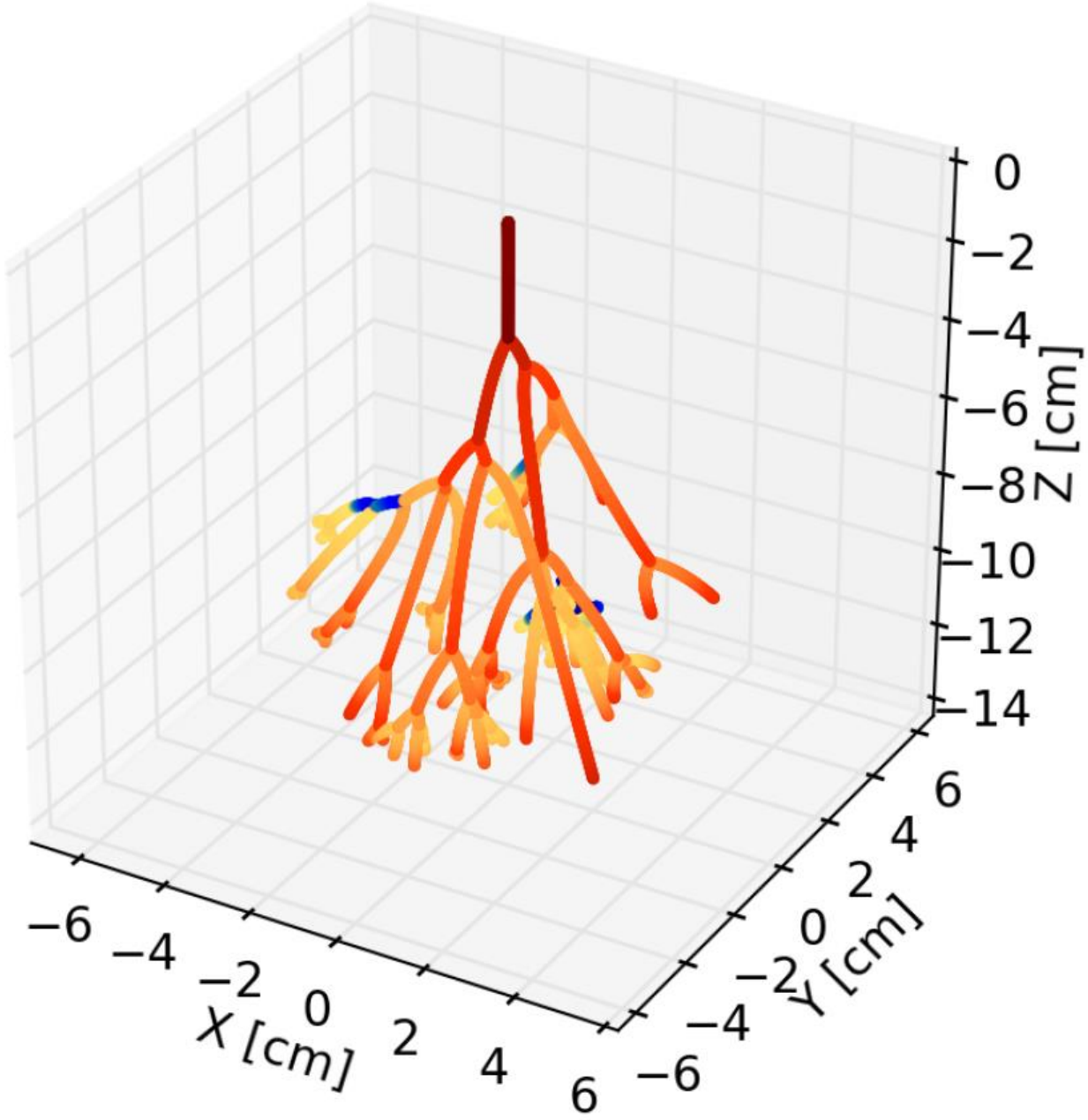

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A. Luque and U. Ebert,
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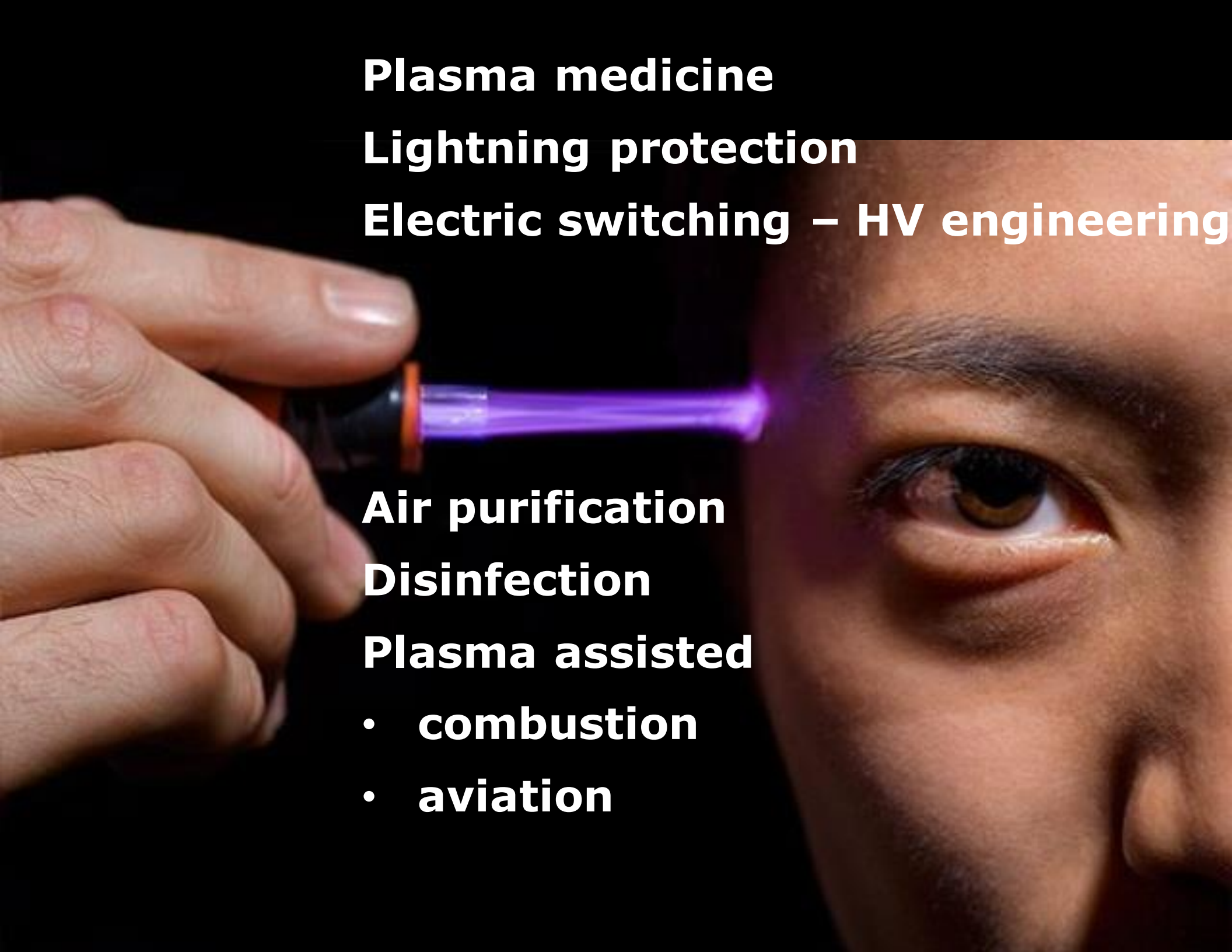
Plasma medicine
Lightning protection
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Air purification
Disinfection
Plasma assisted
• combustion
• aviation