Stopping of α Particles from the Core in Corona Plasmas

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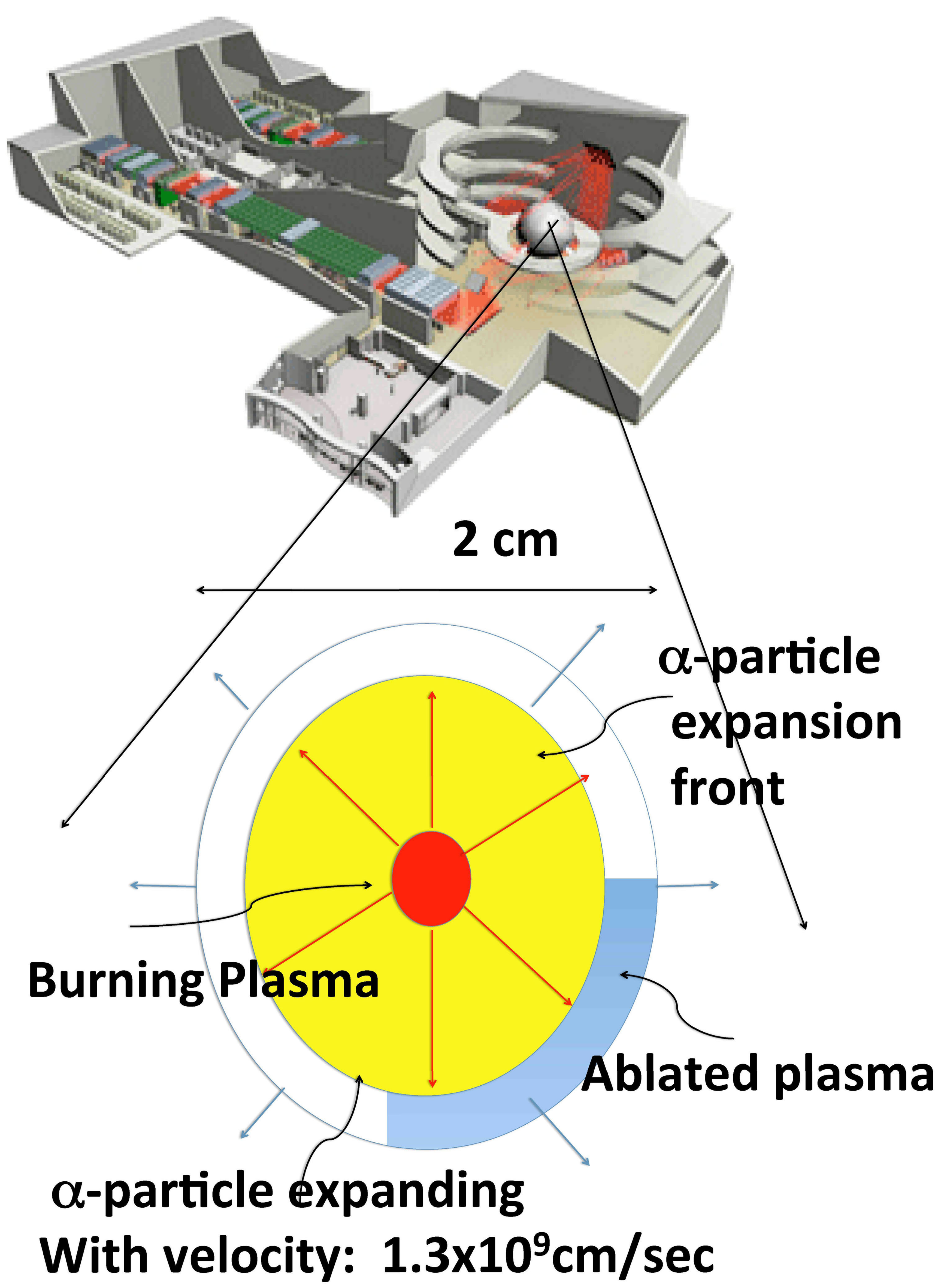
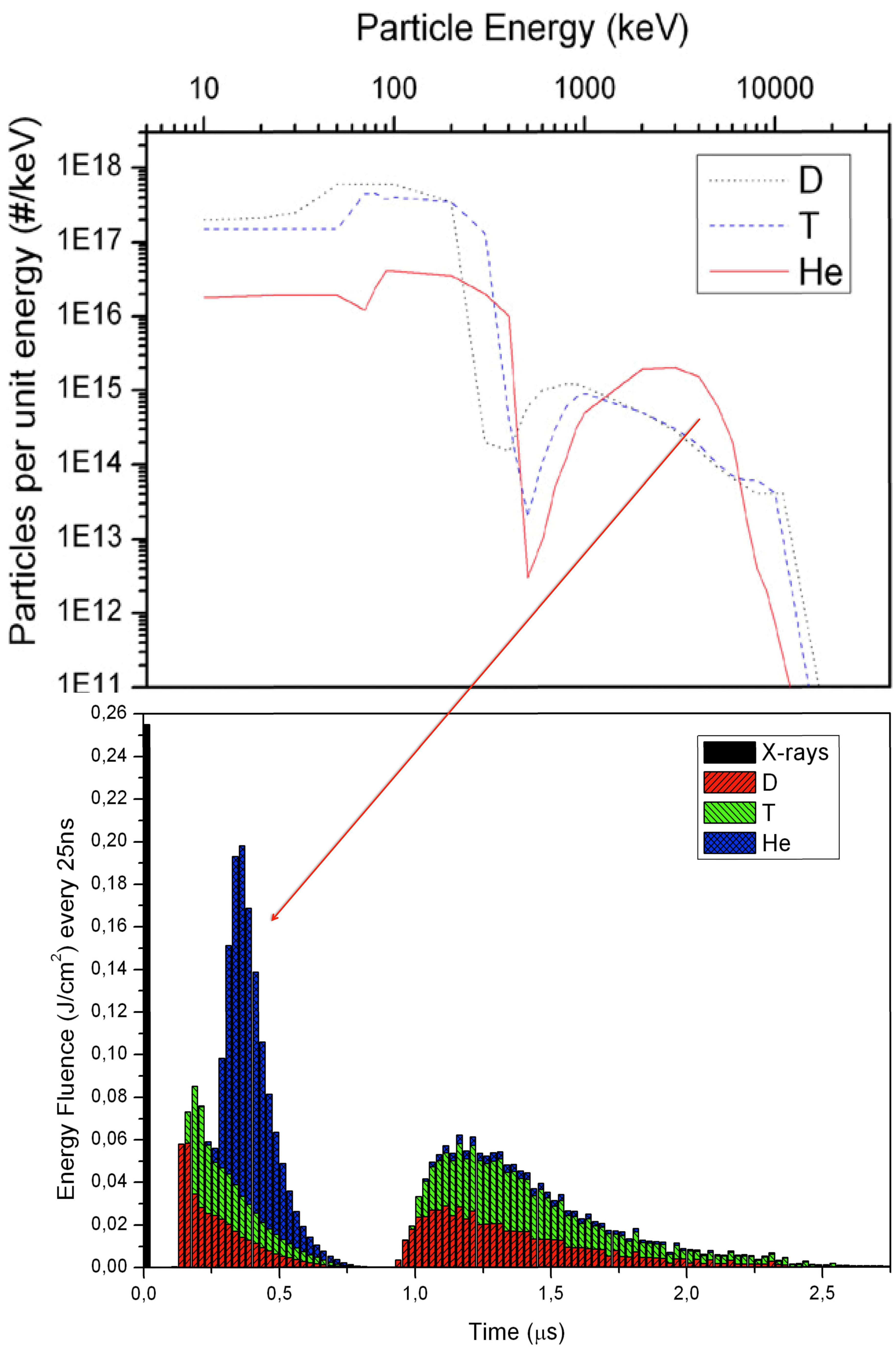
Abstract

In the laser fusion reactor design, the protection of first wall and the final optics from high energy ions is the key issue. So, it is necessary to predict the precise energy spectra of ions. In the previous reactor designs, the ion energy spectra were provided by the classical ion transport codes. However, this poster shows that the α-particle spectrum is significantly modified by the anomalous process in ablated plasmas.





MeV α-particle heating Is critical for determining the chamber wall life.

Ref. Jesus Alvarez, etal., Nuclear Fusion, Vol.51, (2011) 053019

$$1 \quad + \varepsilon_e \quad + \varepsilon_i \quad + \varepsilon_b \quad = 0,$$

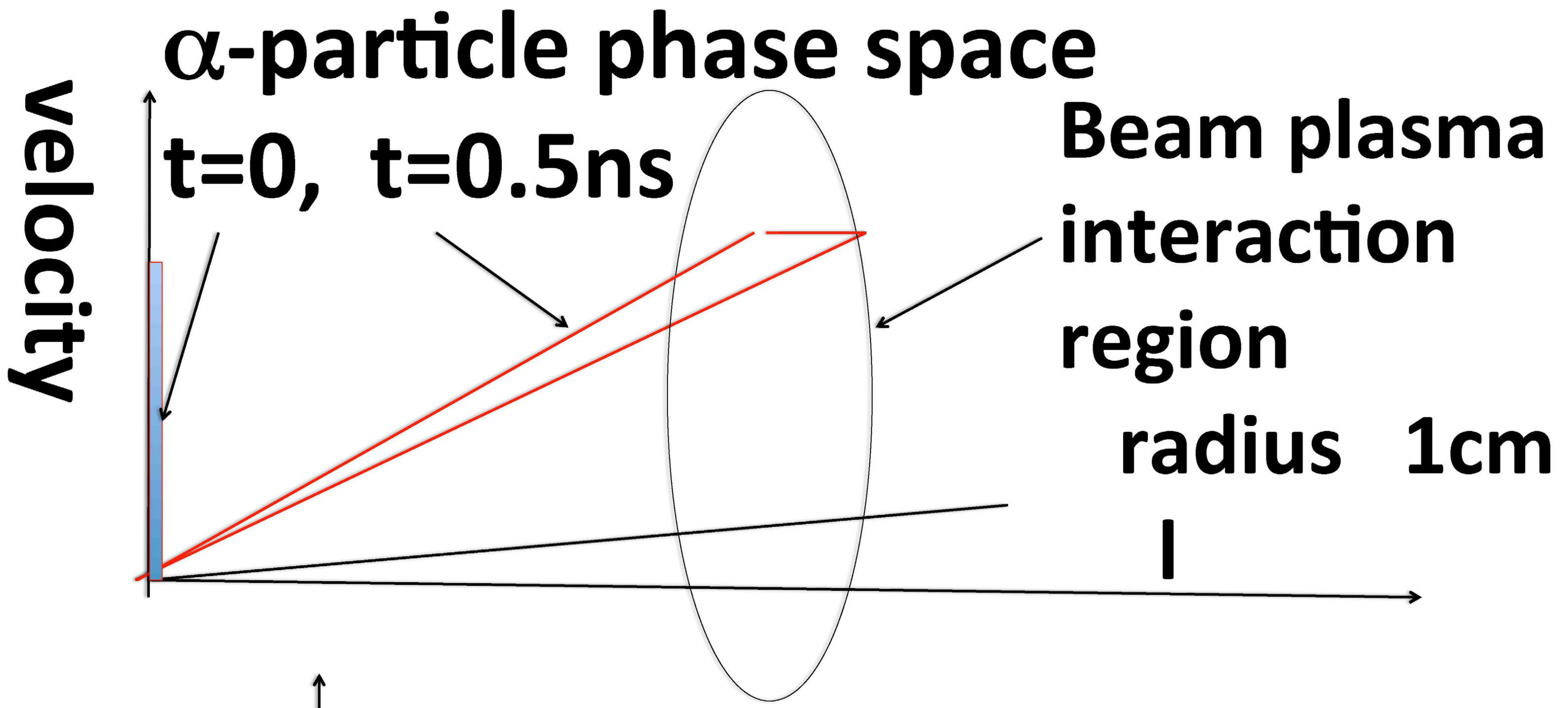
Electron susceptibility, Ion susc., Beam susc.

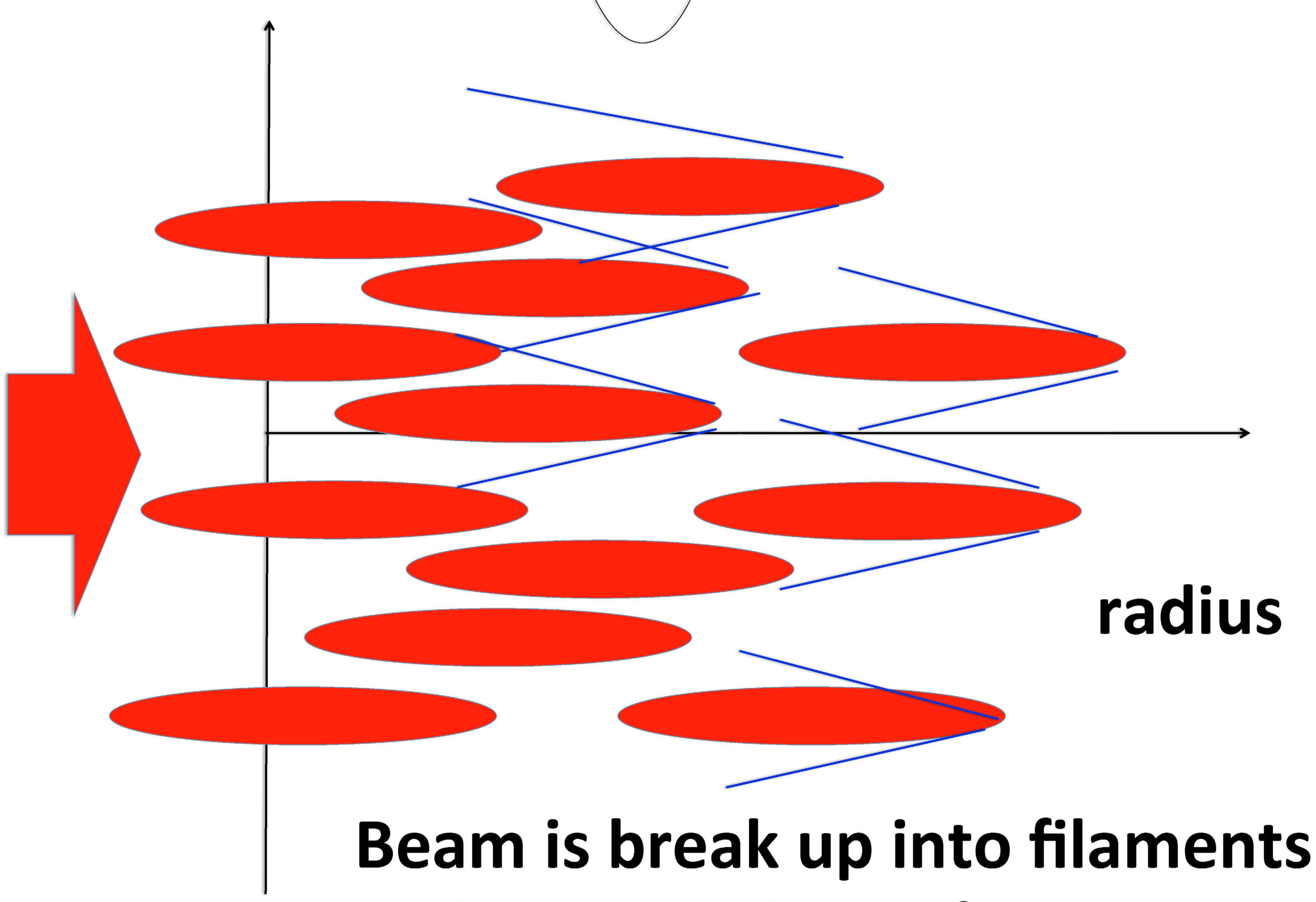
$$1 \quad + k_D^2/k^2 \quad - \omega_{pi}^2/\omega^2 \quad - \omega_b^2/((\omega - k_{ll} v_b)^2 = 0$$

When ω_{pi}^2 (ion plasma freq. $)^2 >> \omega_b^2$ (Beam plasma freq.$)^2$, the solutions are $\omega - k_{ll} v_b \sim 0$ and $\omega = \pm \omega_k$ where $\omega_k = \omega_{pi} / (1 + k_D^2/k^2)^{1/2}$.

When ω_b/ω_{pi} is finite, then the modes satisfying $\omega_k \sim k_{ll} v_b$ have imaginary part of frequency as the solution of the dispersion relation and the modes become unstable. It is the two stream beam instability. The growth rate for $k_{ll} = c_s/v_b k$, and $k = k_D$: $3^{1/2}/2(n_b/8n_i)^{1/3}\omega_{pi}$

T.N. Kato and H.Takabe, Phys. Plasmas 17,032114 (2010)





Beam is break up into filaments of λ_D wide x $\lambda_D x v_b/c_s$ long

Estimated Stopping Power

The α-particle stopping power in ~10^{20} /cm^3 ablated plasma is 20 MeV/cm. So, the α-particles are thermalized in the corona.

Concluding Remarks

The thermalization of α particles causes the delay of the deposition of energy on the wall which allows the material to dissipate the heat more efficiently.

On the other hand, the stopping length of the Particles on the wall is shorter. So, the energy density will be higher. Those opposite effects should be evaluated in a case-to-case .

From an atomistic point of view, the lower energy α particles causes less number of sputtered particles and displacements. However, the α-particle deposition density is higher and accelerate the production of bubbles and swelling.

As for the protection of final optics, since no ions should reach them, a deceleration of α particles will facilitate the implementation of E-M field to deflect the particles.