THE LASER TARGET DESIGN FOR A THERMONUCLEAR NEUTRON SOURCE OF FUSION-FISSION REACTOR.

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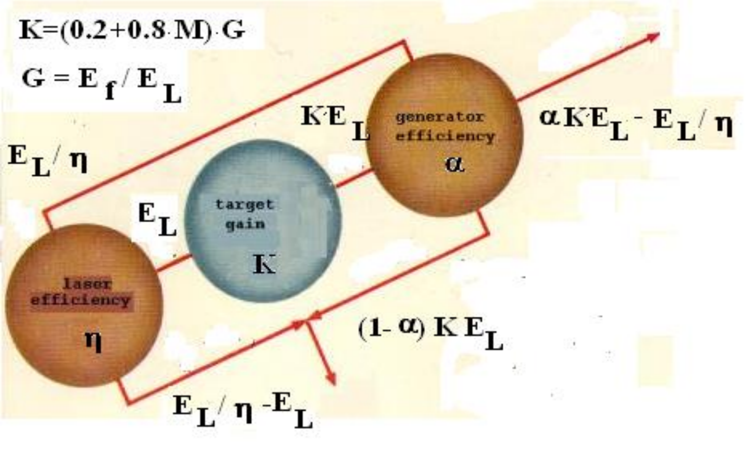
1. Driver-target concept for hybrid reactor
2. Neutron yield of bilateral conical targets
3. Experimental verification of this concept.

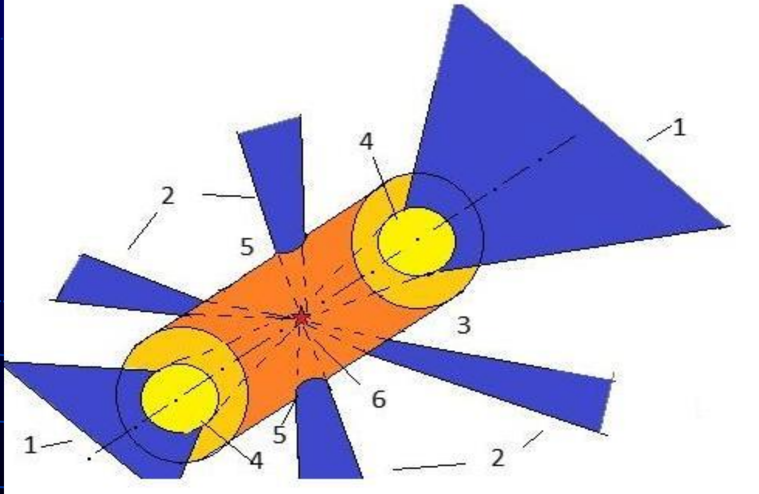
Driver-target concept for hybrid reactor.

If η=5%, M=50, α=50%,
then G~1. Power plant has to operate in pulse repetition regime.

1. ***N.G. Basov, V. I. Subotin, L.P. Feoktistov.* // Vestnik RAN, 63, 878, (1993) – in Russian**
2. ***V.D. Zvorykin, I.G. Lebo// Laser and Particle Beams, v.17, N1, 69, (1999) – long+short pulses regime***
3. ***I.G. Lebo. // Quantum Electronics, 30(5), 409, (2000)***
4. ***V. Kuzenov, A. Lebo, I. Lebo, S.Rizhkov. Fiziko-Matematicheskie modeli …// Monograph, Bauman MSTU, Moscow, 2015 – in Russian***



1. Long pulse; 2. Short pulse; 3. Gold or uranium chamber;
4. Conical chanel ; 5. Thermonuclear microexplosin



“Atlant-Sp” code (r, θ, t-cord.)

See: ***I.G. Lebo, V.F. Tishkin. Issledovanye hydrodynamicheskoy neustoychivosti …/Monograph, FIZMATLIT, Moscow, 2006 – in Russian***

$$\frac{d\rho}{dt} = -\rho\nabla\vec{v}$$

$$\rho\frac{d\vec{v}}{dt} = -\nabla(Z_i \cdot P_E + P_i)$$

$$Z_i\rho\frac{dE_E}{dt} = -Z_i \cdot P_E\nabla\vec{v} + \nabla(\kappa_E\nabla T_E) - Q_{EI} - R_{RAD}(\rho,T_E) + \nabla\vec{q}$$

$$\rho\frac{dE_I}{dt} = -P_I\nabla\vec{v} + \nabla(\kappa_I\nabla T_I) + Q_{EI}$$

$$\left(\frac{\vec{q}}{|\vec{q}|},\nabla\right)\vec{q} = k(\rho,T_E)\cdot\vec{q}$$

$$\frac{dZ_i}{dt} = Z_i \cdot \left(\varphi_1(\rho, T_E, Z_i) - \varphi_2(\rho, T_E, Z_i) - \varphi_3(\rho, T_E, Z_i)\right)$$

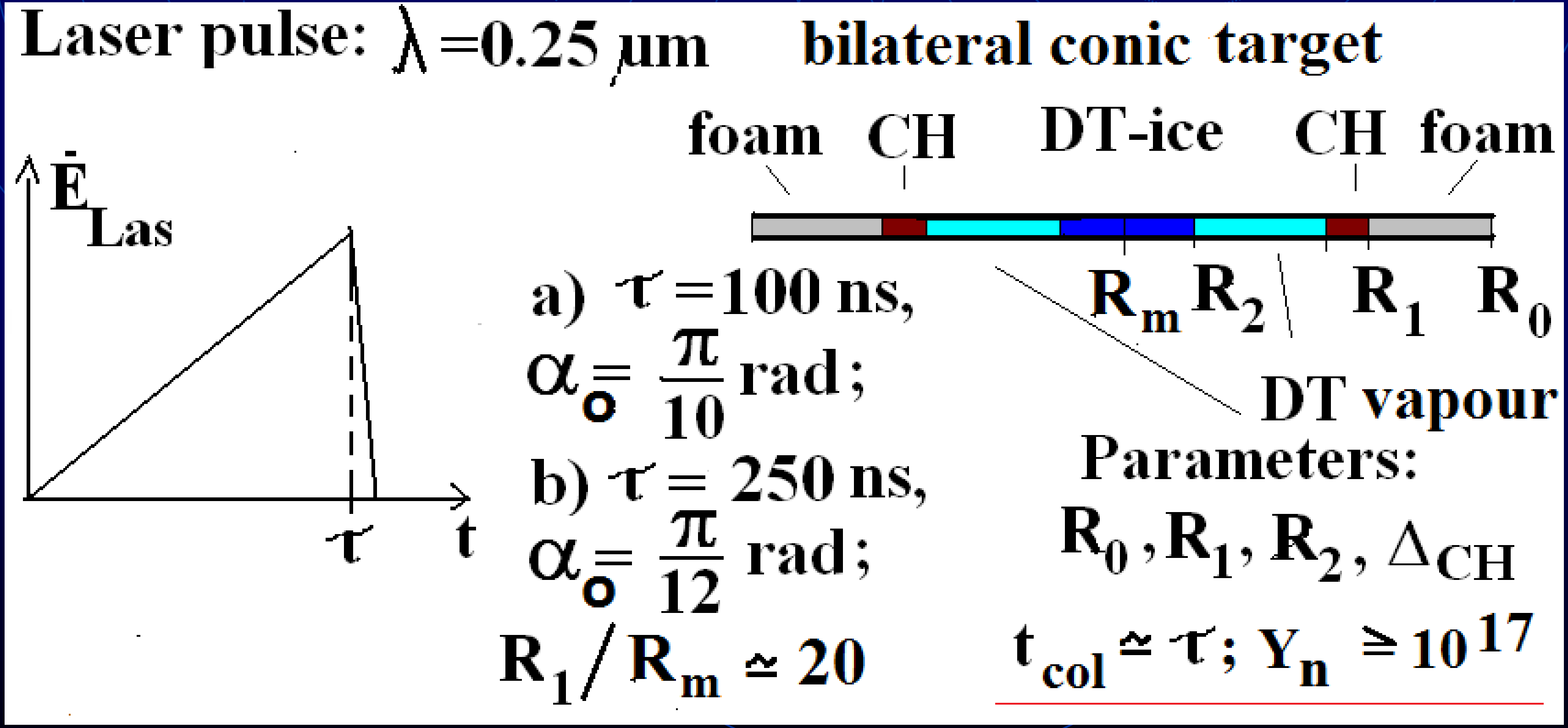
$$P_E = P_E(\rho,T_E); P_I = P_I(\rho,T_I); \qquad Q_{EI} = Q_0(\rho,T_E)\frac{T_E - T_I}{T_E^{3/2}}\rho^2$$

$$E_E = E_E(\rho,T_E); E_I = E_I(\rho,T_I);.$$

Statements of calculations.

Task 1. KrF-laser, E_L=1 MJ, τ= 100 ns, (a)

Task 2. KrF-laser (or heavy ion beams), E_L=1 MJ, τ= 250 ns (b)



Laser pulse: λ=0.25 μm **bilateral conic target**

a) $\tau = 100$ ns, $\alpha_o = \frac{\pi}{10}$ rad;

b) $\tau = 250$ ns, $\alpha_o = \frac{\pi}{12}$ rad;

$R_1 / R_m \simeq 20$

Parameters:

$R_0, R_1, R_2, \Delta_{CH}$

$t_{col} \simeq \tau;\ Y_n \geq 10^{17}$

Physical-mathematical model of energy transport in laser plasma of porous targets.

See I.G. Lebo, A.I. Lebo: *1. Math. Models and Comp. Simul., v .1(6),724, (2009) . 2. Physica Scripta T142, (2010) 014024*

1) $$\frac{\partial q_{Las}}{\partial z} = -\chi_{Las} \cdot q_{Las}; \quad \chi_{Las} = \frac{(\nu_p/c)\cdot(\rho/\rho_{cr})}{\sqrt{1-\rho/\rho_{cr}}}; \quad \nu_e \longrightarrow \nu_p$$

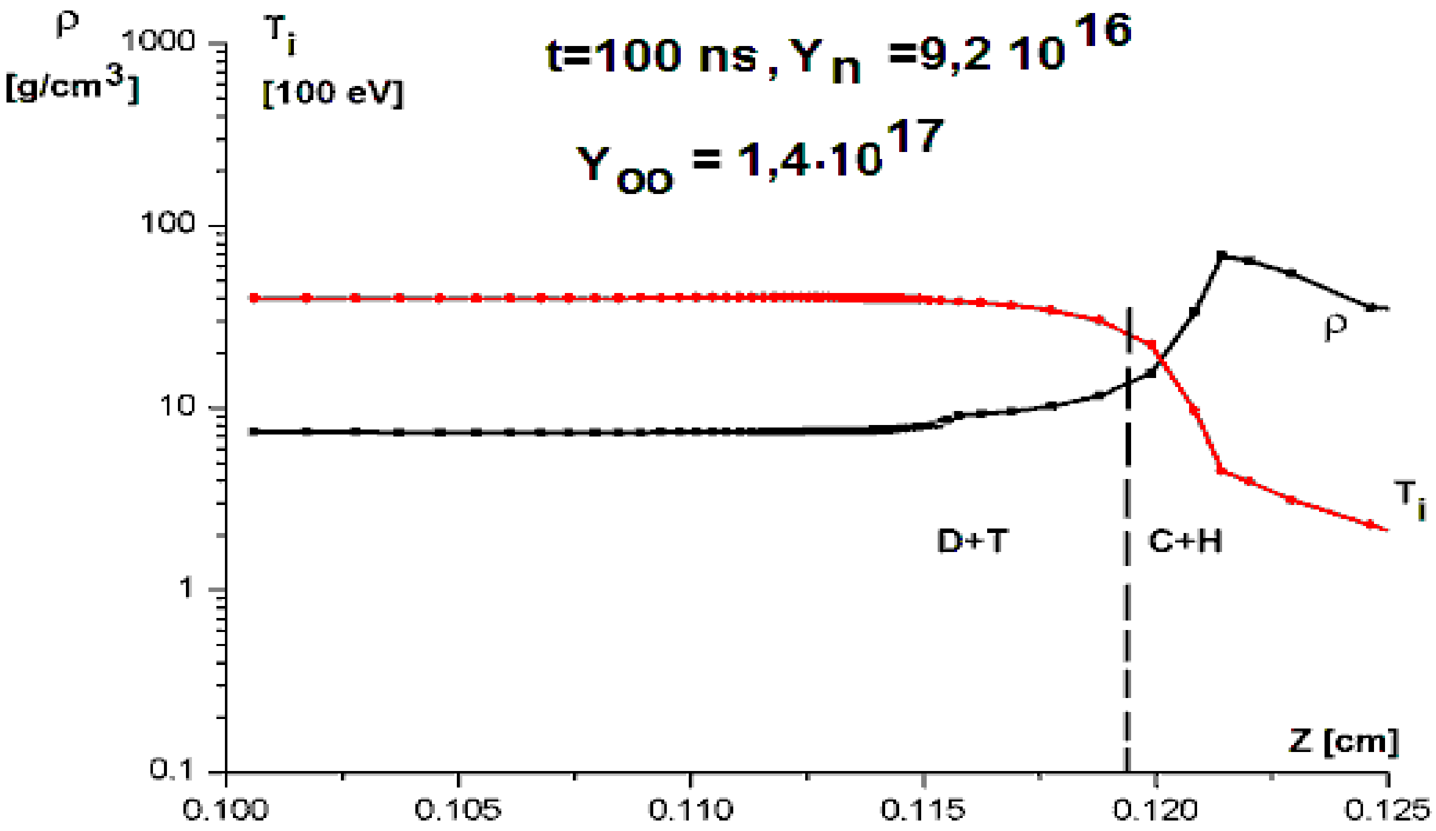
2) $$q_e = -\kappa_e \cdot \mathrm{grad}\, T_e; \quad \kappa_e = n_e \cdot V_e \cdot \bar{l}_e; \quad \bar{l}_e = \frac{l_p \cdot l_e}{l_p + l_e}$$

3) $$Q_{ei} = C_{Ve} \cdot \nu_{ei} \cdot (T_e - T_i); \quad \nu_{ei} = \frac{m_e}{m_i} \max\{\nu_p, \nu_e\};$$

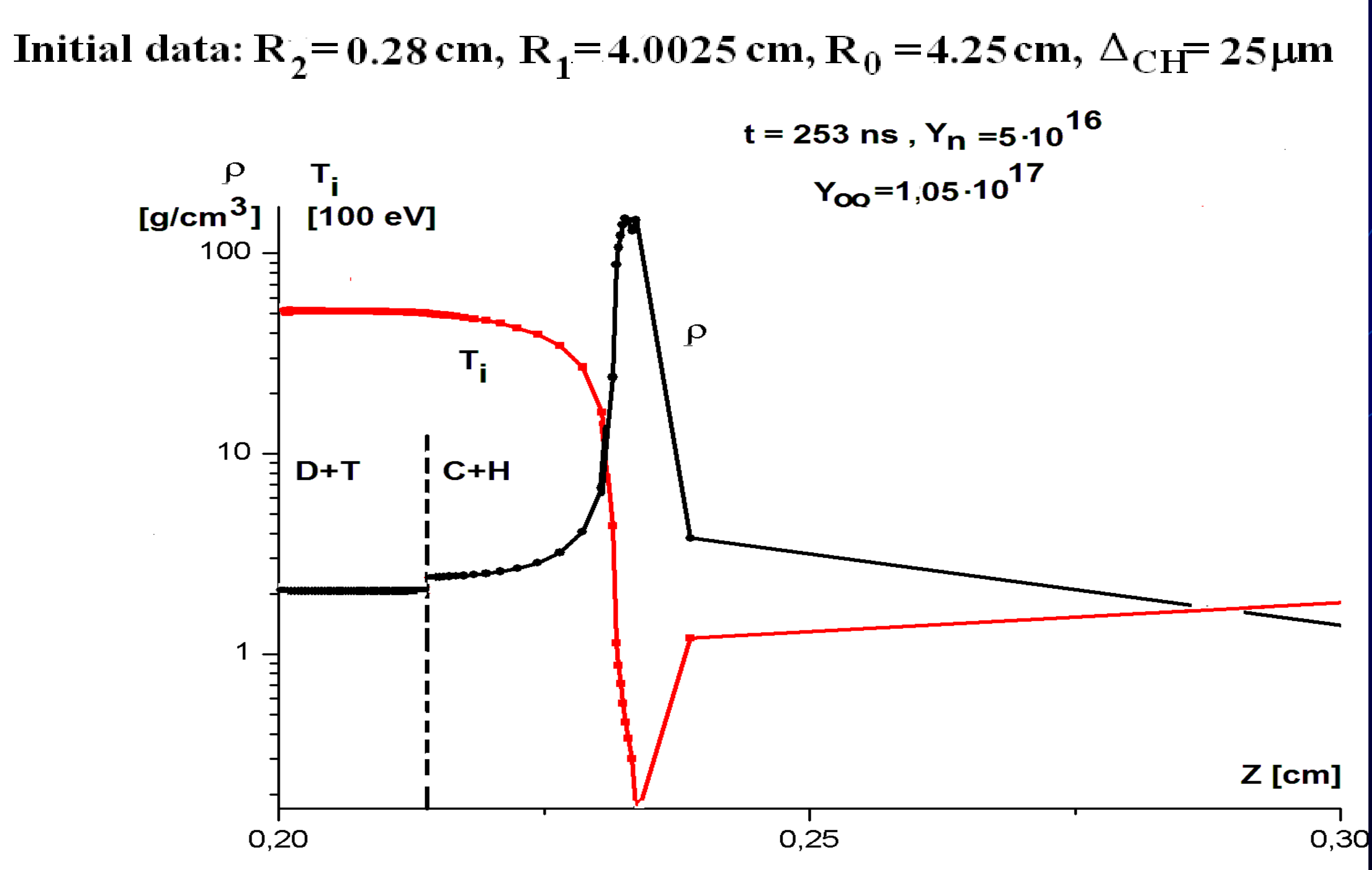
$\nu_p = c / l_p$, l_p - a priori, $l_p = 0.5\ \mu m$

Neutron yield from bilateral cone target (task 1, τ=100 ns)

Initial data: R_2=0.25 cm, R_1=2.0055 cm, R_0 = 2.1 cm, Δ_{CH}=55 μm



Neutron yield from bilateral cone target (task 2, τ=250 ns).



Initial data: $R_2 = 0.28$ cm, $R_1 = 4.0025$ cm, $R_0 = 4.25$ cm, $\Delta_{CH} = 25\mu m$

t = 253 ns , $Y_n = 5\cdot10^{16}$

$Y_\infty = 1{,}05\cdot10^{17}$

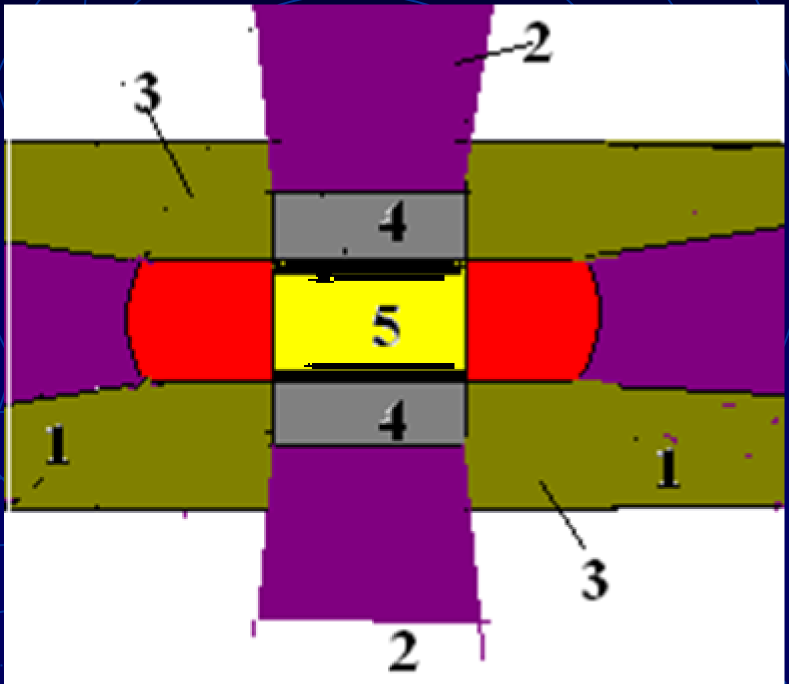
Effects of short pulse.

1. The confinement of compressed fuel at the top of cone.
2. The additional heating of DT plasma.
3. See: a) **I. G. Lebo et. al. //** ***Laser and Particle Beams, 12(3), 361, (1994)***

b) I.G. Lebo et al. // ***QE, 25(12), 1226, (1995)***

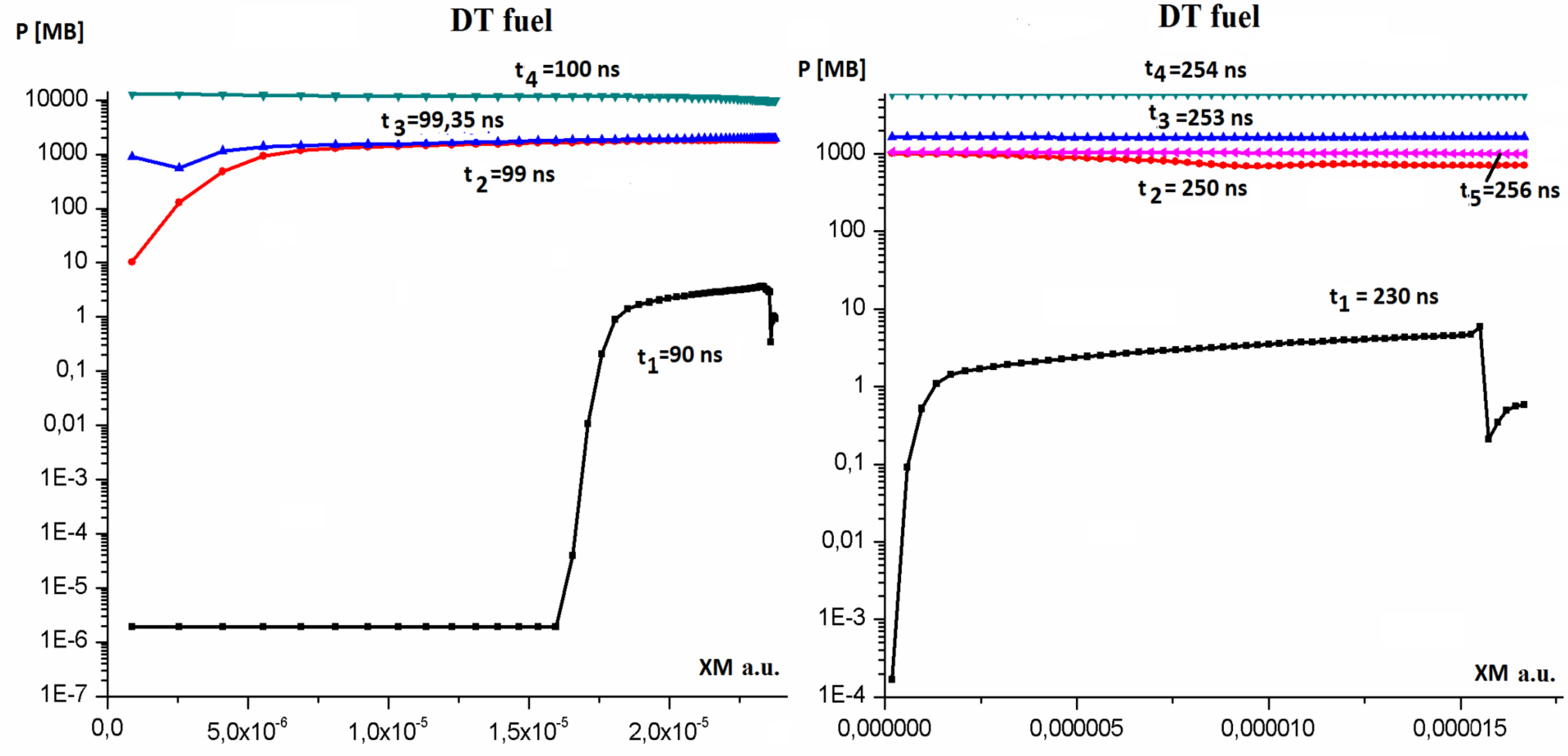
V.D. Zvorykin, I.G. Lebo

// Laser and Particle Beams, v.17, N1, 69, (1999)



1. Long pulse; 2. Short pulse;
3. Gold chamber;
4. Foam; 5. Compressed fuel;
6. U^{238} foil with "relief"

DT pressure profiles at deceleration stage. Task 1 (left) and 2 (right).



Short pulse: E_{las2}~50-60 KJ, $\Delta\tau_2$ ~ 1 ns, P_{max}≥1 GB

The opportunity of experimental verification of new concept (GARPUN installation).

GAPPUN: KrF-laser, E_{las}=50 J, I~10^{12} W/cm^2, τ ~100 ns : long pulse (1 beam).

V_{layer} **~5-10 km/c (*1-st space velocity!*)**

1) V.D. Zvorykin, I.G. Lebo et. al. //J. of Russ. Laser Research, 18, pp.147-152, (1997)

2) I.A. Krasnyuk, I.G. Lebo. //J. Phys. D: Appl. Phys.,39,1462-1464, (2006)

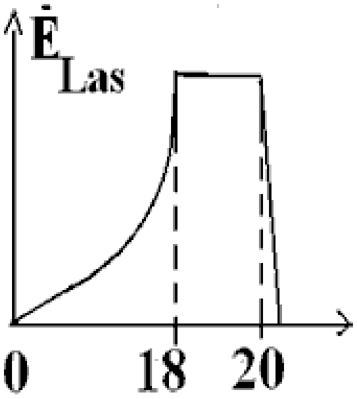
- ***GARPUN-TW: Short pulse: E_{las}=1 J, I~10^{17} W/cm^2, τ ~10 ps // LPB, 25(3), 435, (2007)***
- **1) laser pulse introduce into cavity; 2) energy transport in porous matter**

The opportunity of experimental verification of new concept (NIF installation).

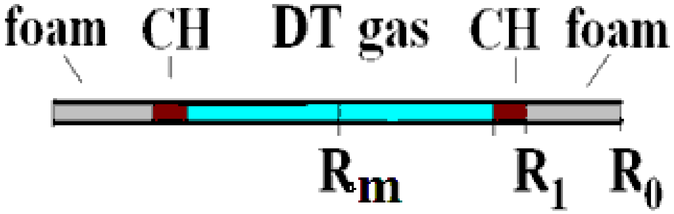
Laser pulse:

$E_{Las} = 1$ MJ,

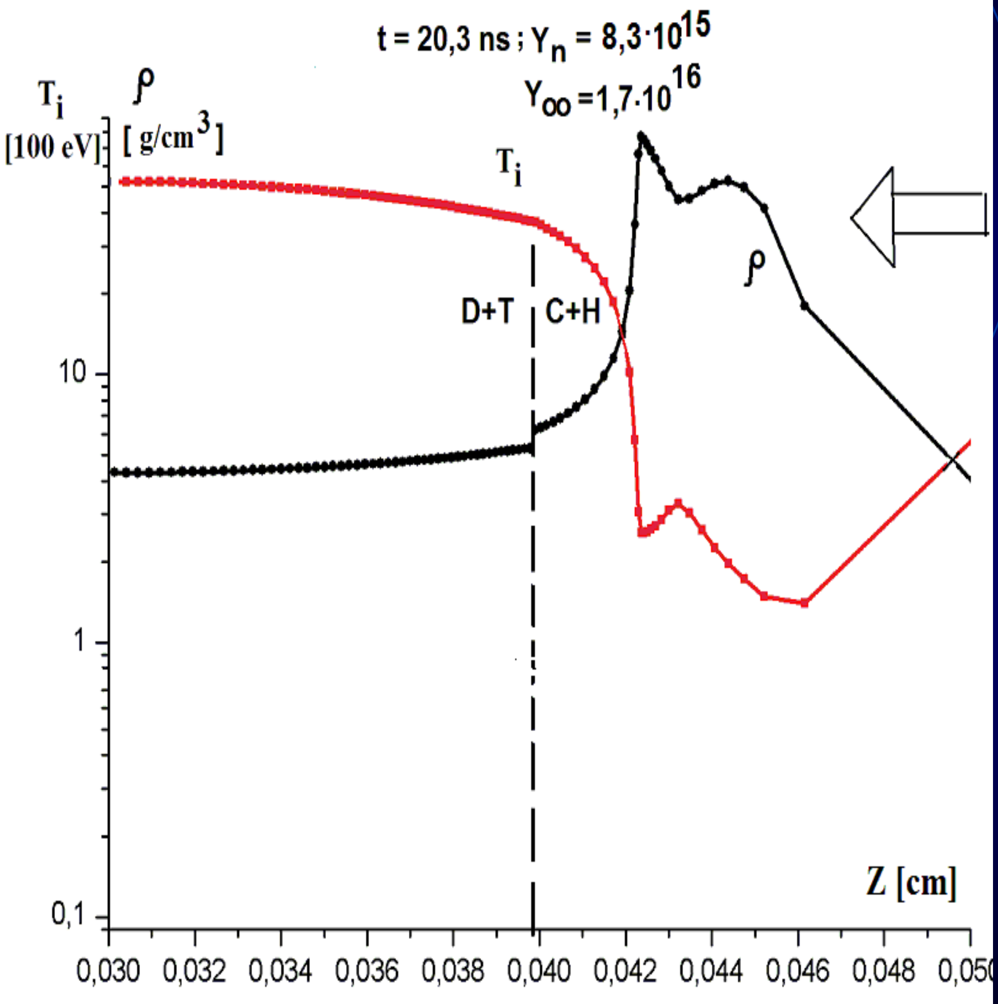
$\lambda = 0{,}351\ \mu m$



bilateral conic target. $\alpha_0 = \frac{\pi}{3}$



$R_m = 0{,}03,\ R_1 = 0{,}309,\ R_0 = 0{,}45$ cm



Next steps of researches.

- Influence of non ideal EOS
- Stability of accelerated layer into channel.
- Wall - moving layer interaction.
- Effect of SMF generation.
- Input short pulse into cavity through the hole and interaction with porous matter.
- Confinement of DT fuel with help of short pulses.