TARGET EXPLOSION AND REACTOR CHAMBER RESPONSE FOR FAST IGNITION HEAVY ION FUSION

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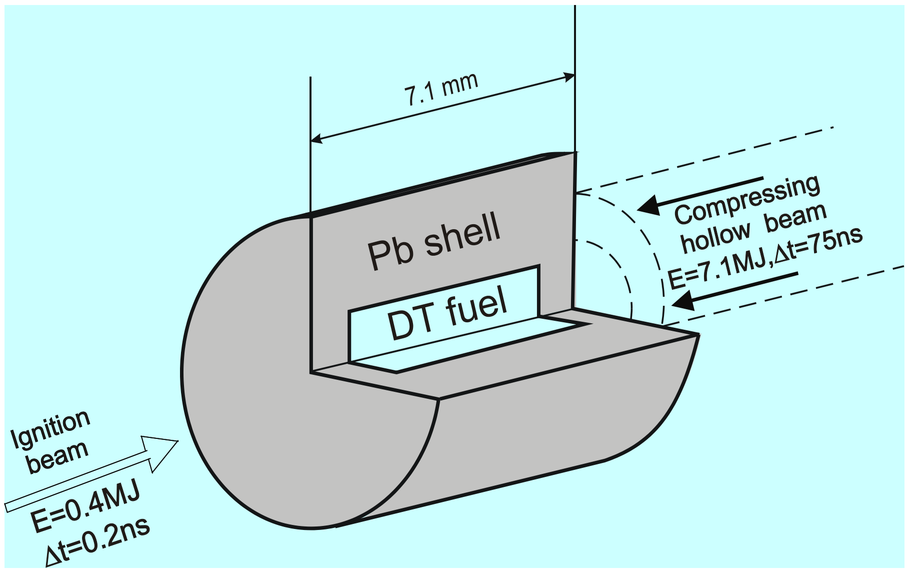
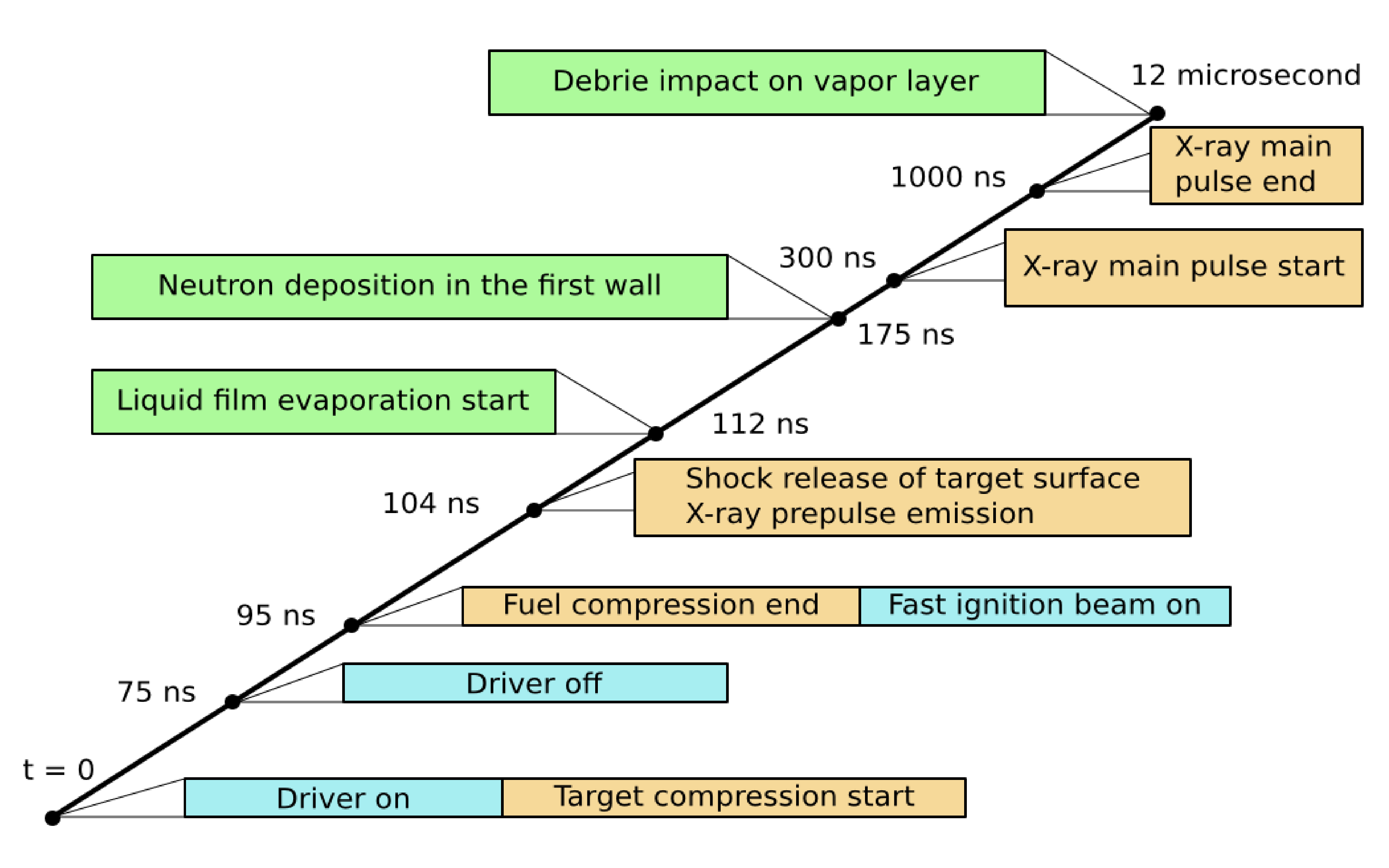
Heavy Ion Fusion
Cylindrical Target



- **TARGET**
- **Target length…………….6.4mm**
- **Target radius…………….4.0mm**
- **DT radius………………..1.12mm**
- **Target mass……………….3.35g**
- **DT mass…………………..5.7mg**
- **ION BEAM**
- **Ion beam energy………..6.4 MJ**
- **Max. beam power………525TW**
- **Beam rotation**
- **frequency…………………1GHz**
- **TARGET OUTPUT**
- **- X-rays…………………..16 MJ**
- **- ion debris……………..149 MJ**
- **- neutrons……………….576MJ**

TARGET MICROEXPLOSION AND FIREBALL EXPANSION SCENARIO



Computation of DT capsule implosion and burn

Physics of the DEIRA radiation-hydrodynamics code

* 1D-3T Lagrangian MHD (spherical, cylindrical, planar)

* Electron and ion thermal conduction and temperature relaxation, ion viscosity

* Electron and ion heating rates by all thermonuclear products

* Radiation diffusion and relaxation between electron and radiation temperatures

* Diffusion and relaxation of energy of fast charged fusion products

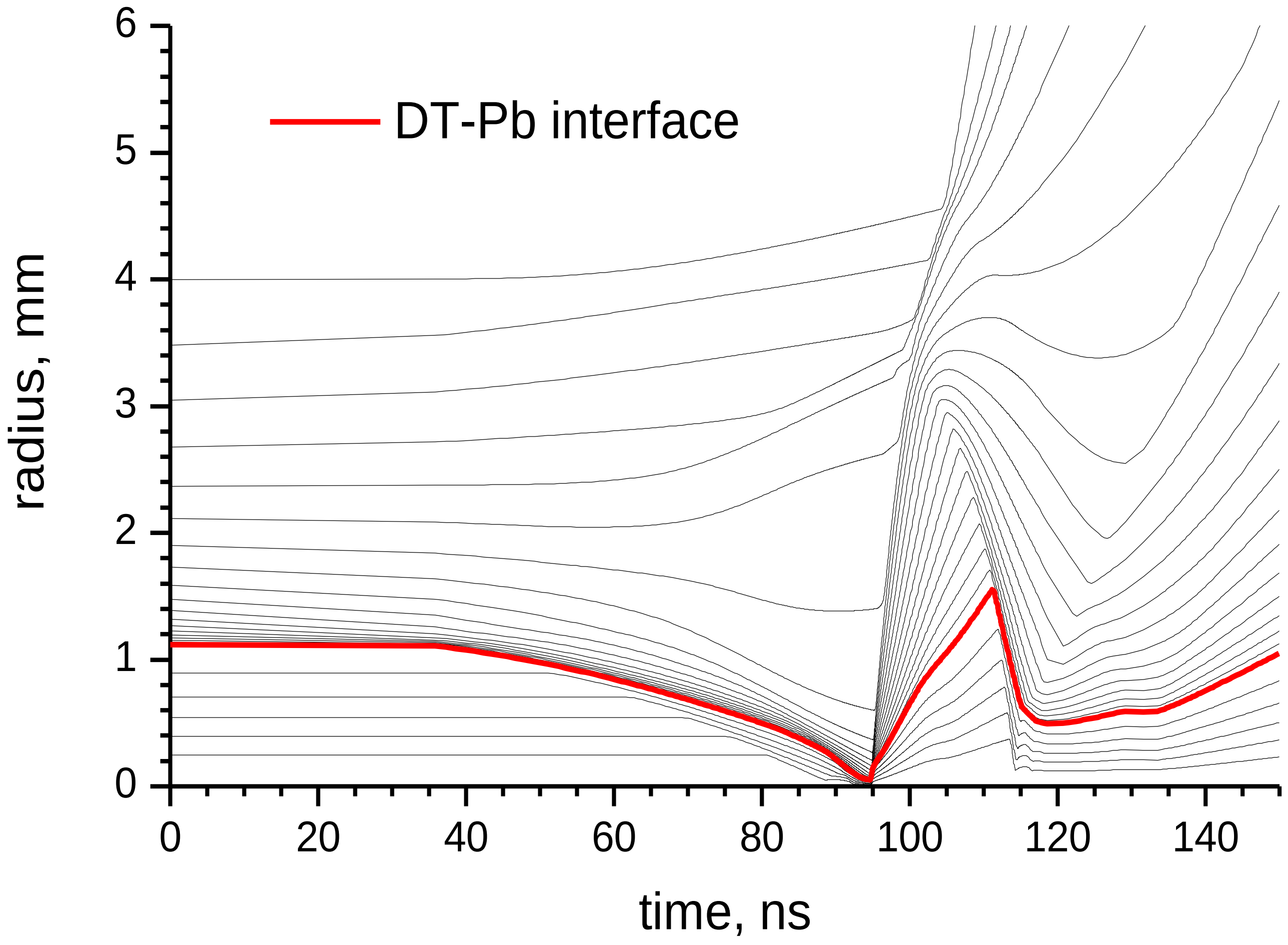
* Mean Rosseland and Planckian opacities

* Two-temperature equation of state

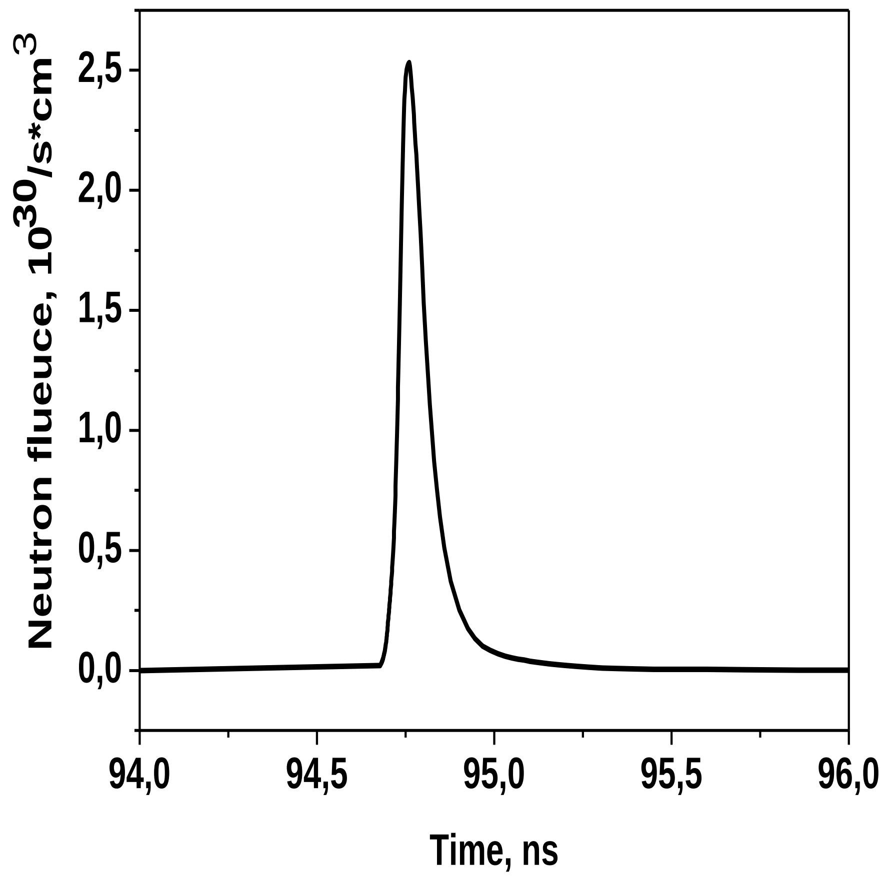
* Thermonuclear burn (DT, DD, DHe^3) without in-flight reactions

* Applied energy sources: ion beams, external quasi-thermal radiation

R-t diagram for cylindrical target computed by DEIRA-4 Code

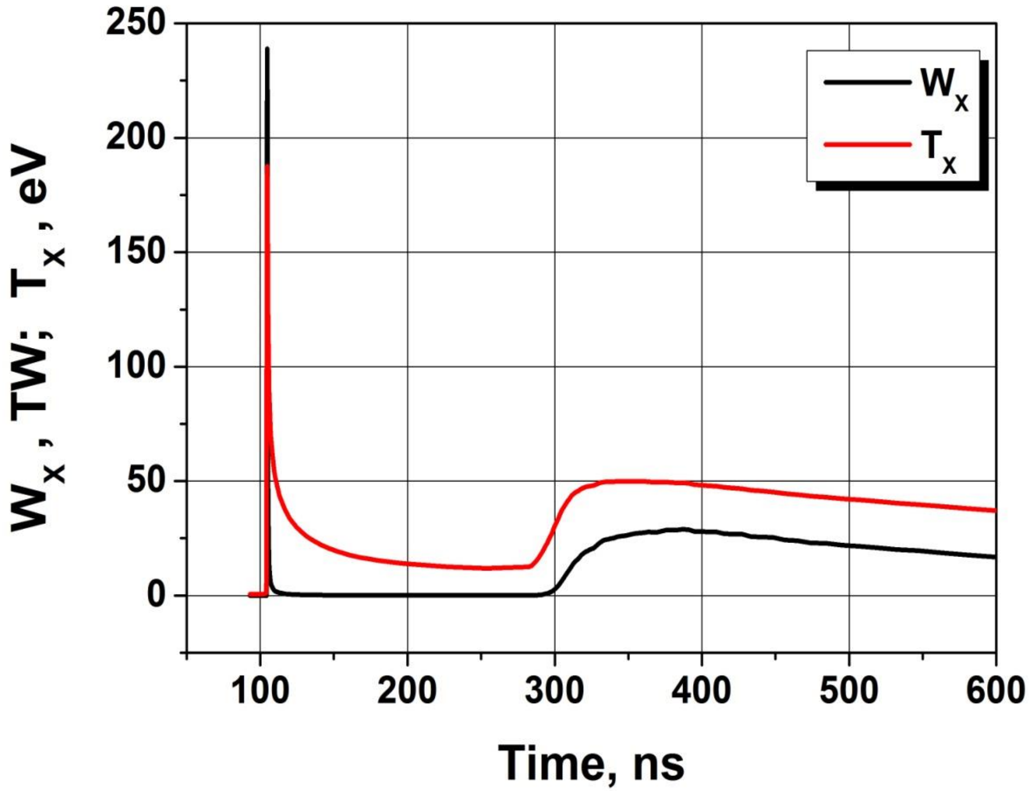


Neutron pulse of HIF target



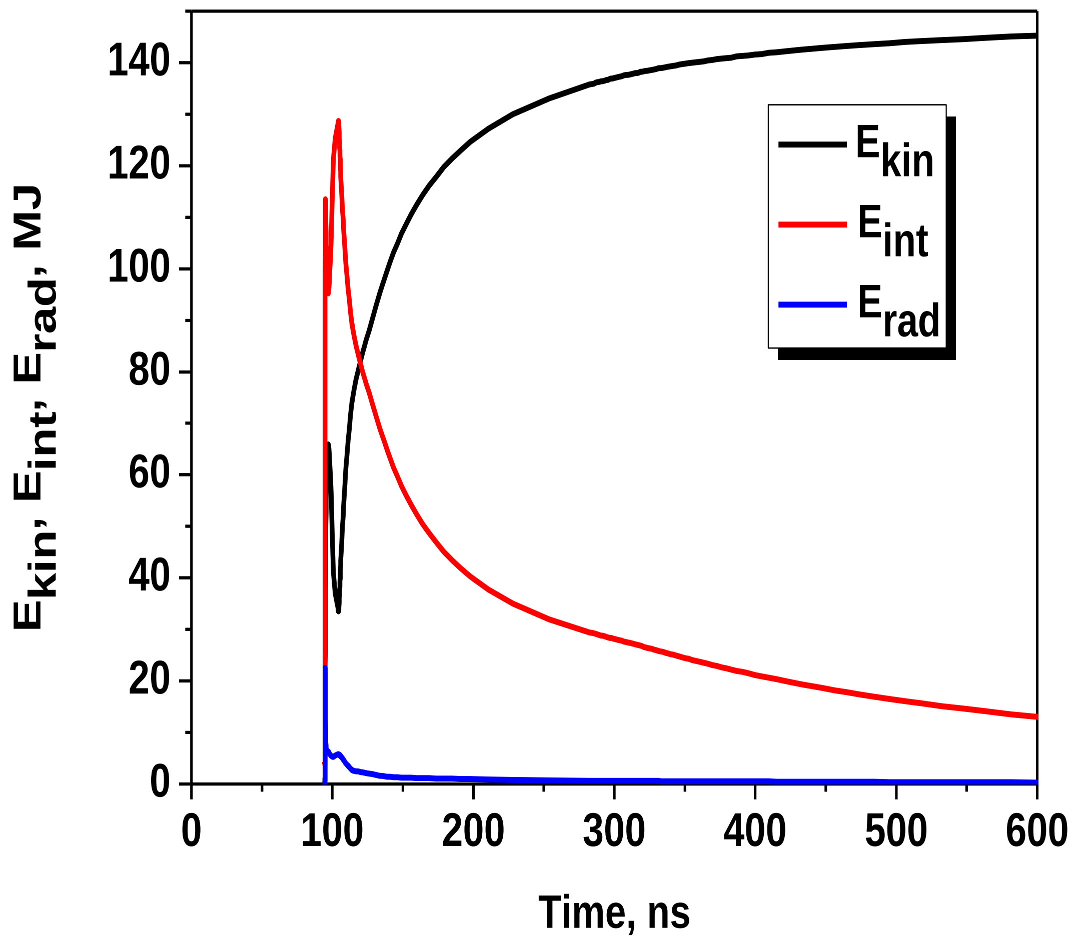
- Neutron pulse is generated in 95ns after the ion beam irradiation starts.
- The FWHM of neutron pulse equals 0.1ns.

X-ray emission from the HIF cylindrical target



- X-ray prepulse is generated by shock arriving at the target surface at t=104ns.
- Prepulse FWHM equals 0.5ns.
- X-ray main pulse starts at t=300ns. Its FWHM equals 360ns.

Target energy histories after fuel microexplosion



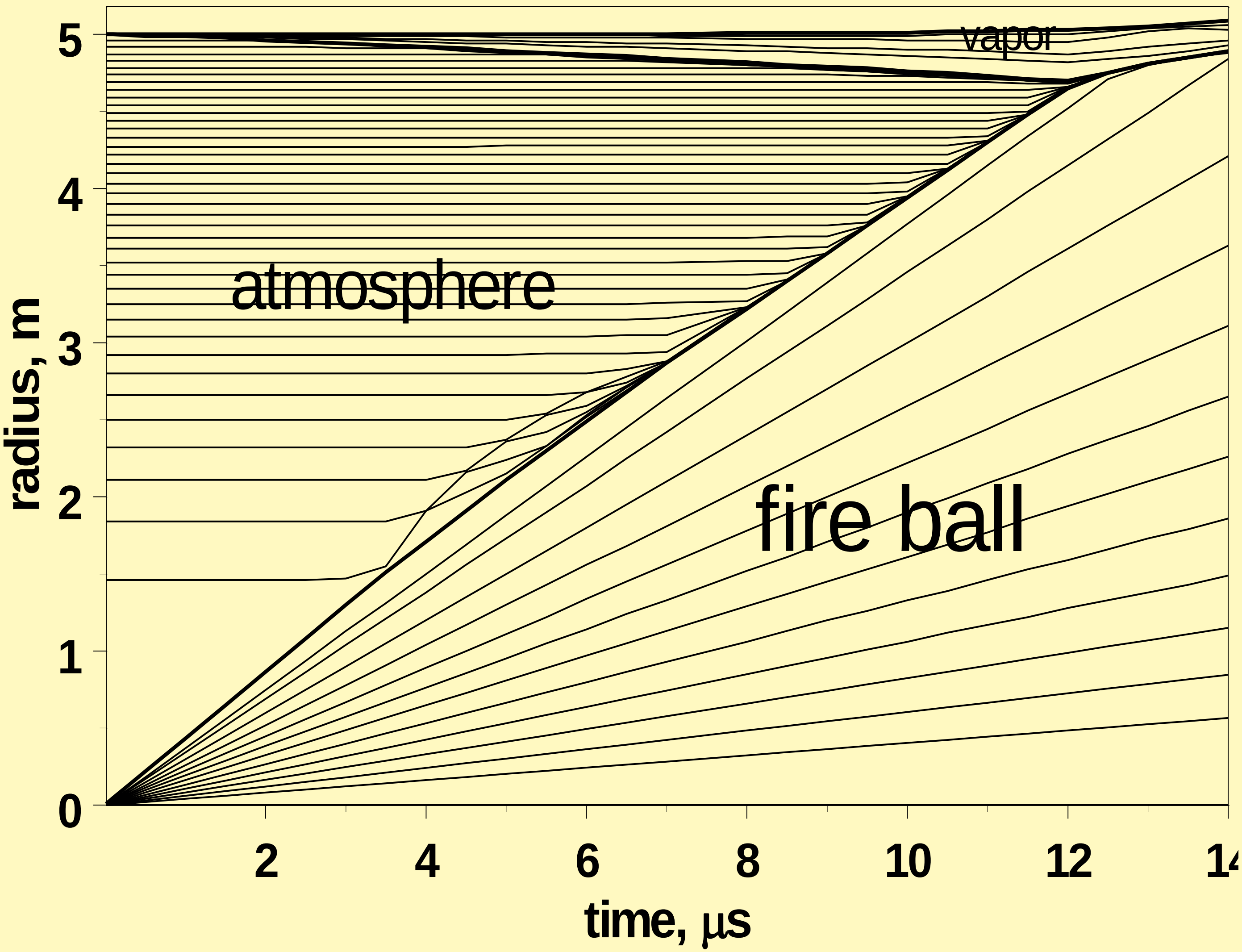
- The first maximum of E_{int} corresponds to the fusion flare at t=95 ns
- The second maximum of E_{int} corresponds to the shock arrival at the target surface at t=104 ns
- The E_{int} pulsation is caused by the shock refraction in non-uniform shell.

Computation of the fireball expansion and the liquid film evaporation

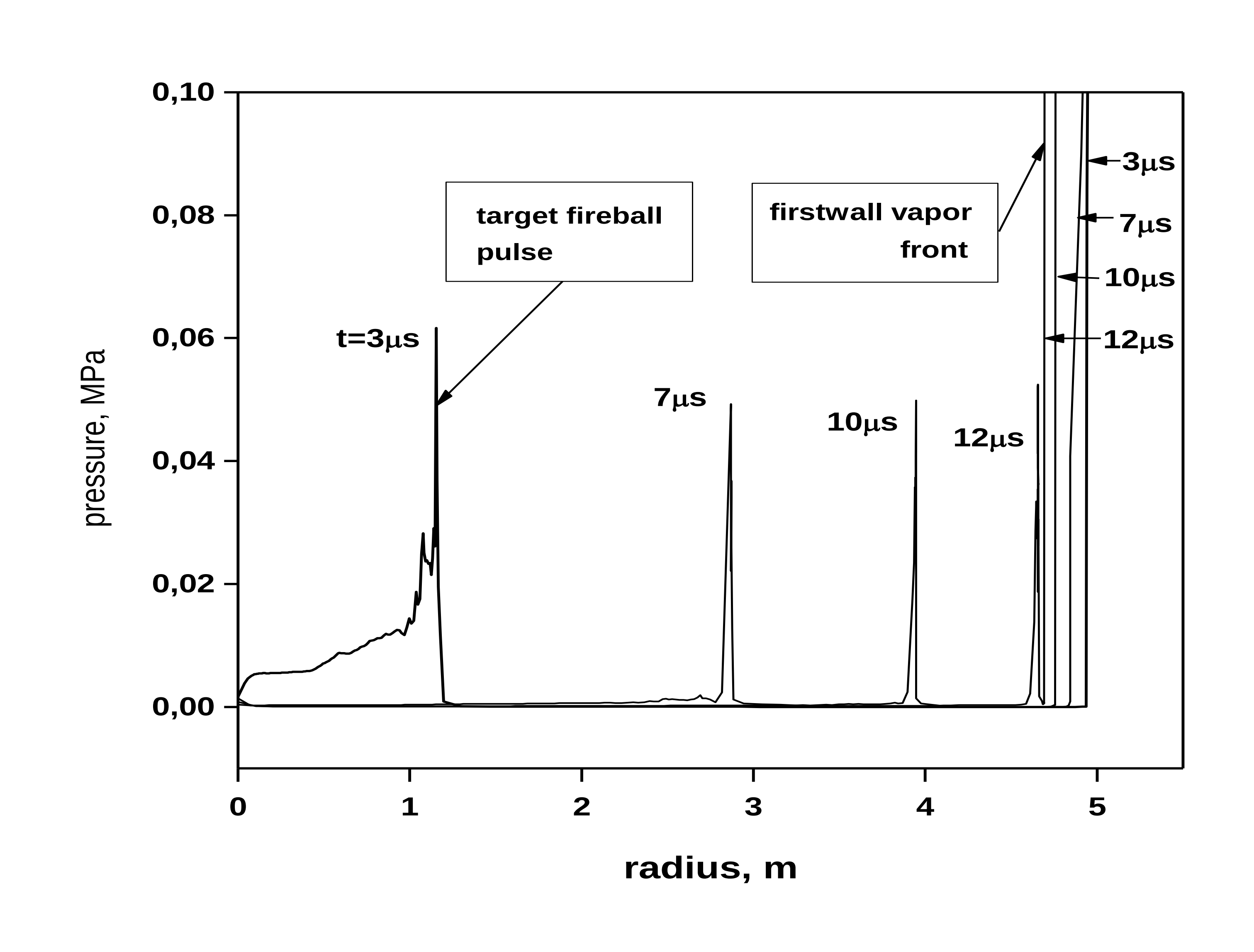
Physics of the RAMPHY radiation-hydrodynamics code

* 1D-2T Lagrangian (spherical, cylindrical, planar)
* Plasma thermal conduction and viscosity
* Radiation diffusion and relaxation between plasma and radiation temperatures
* Mean Rosseland and Planckian opacities
* Neutron diffusion and heating (MCNP)
* Condensed matter strength and spallation
* Wide-range equation of state, phase transitions and ionization
* Applied energy sources: X-ray and fast ions volumetric energy deposition

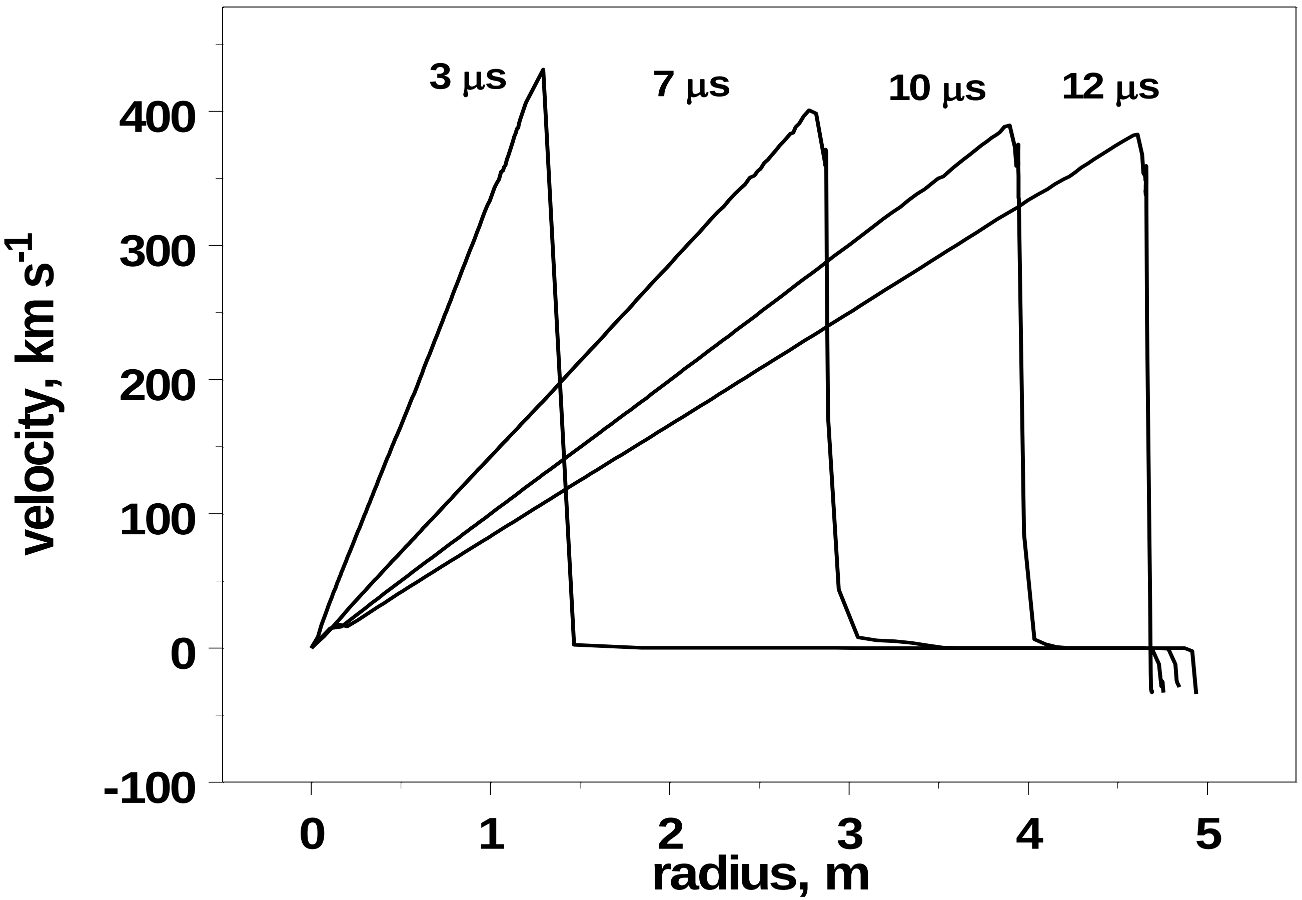
R-t diagram for reactor chamber flow computed by RAMPHY code



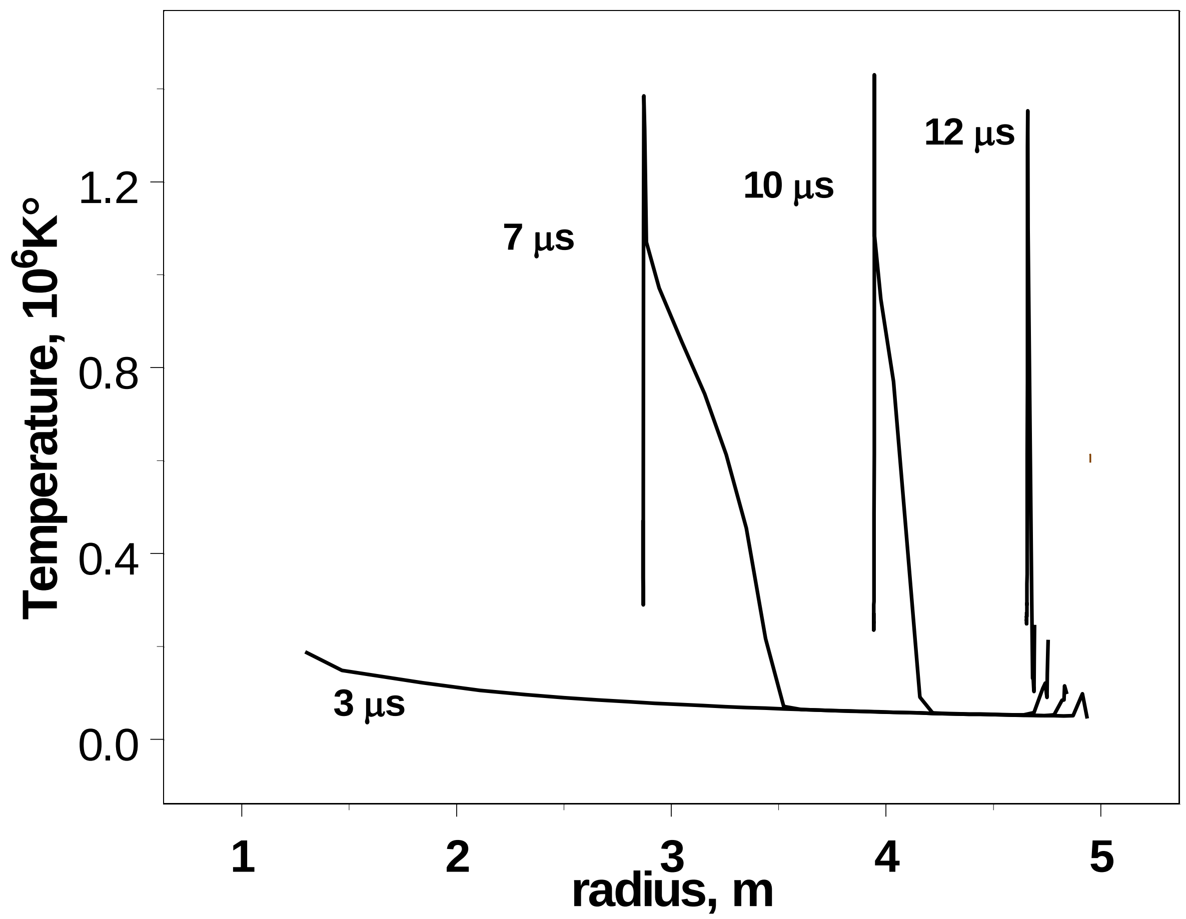
Pressure profiles for the fireball and the coolant vapor



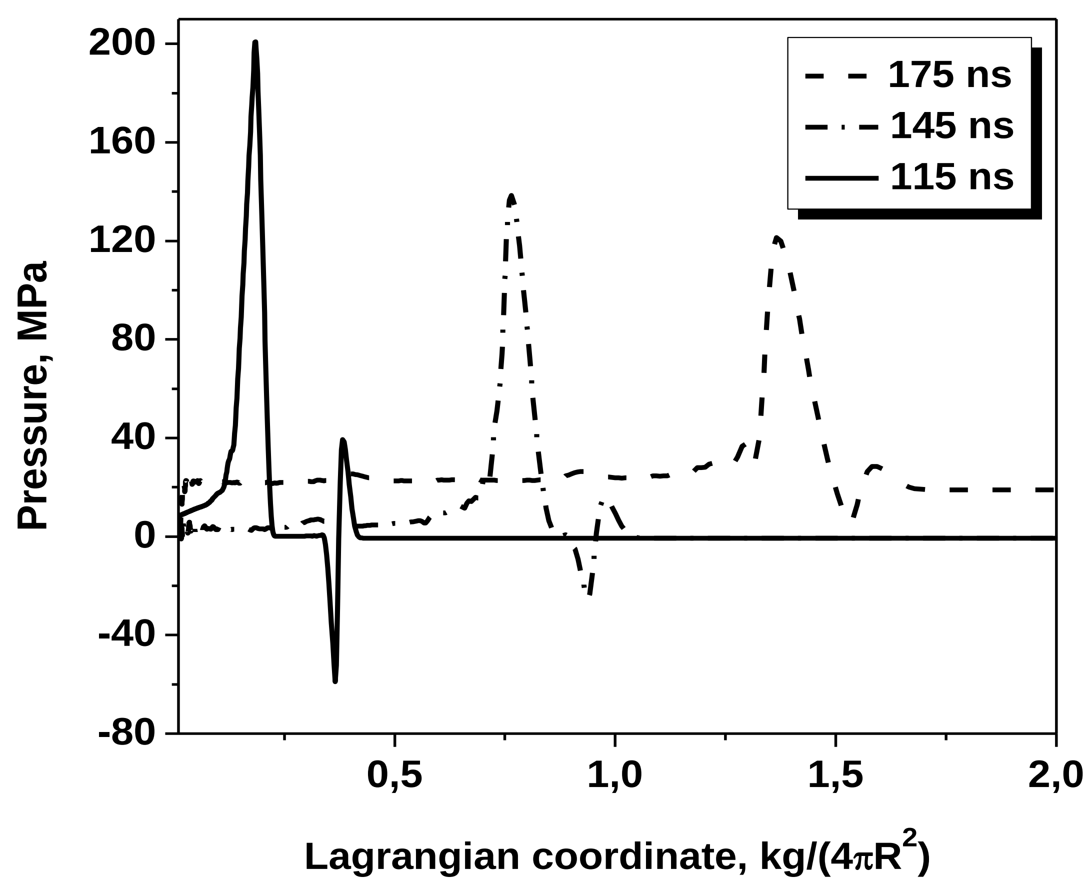
Velocity distribution in the fireball and coolant vapor



Temperature profiles in the reactor chamber



X-ray impact on the liquid film at the first wall



Pressure profiles in the liquid film at various times for the X-rays prepulse impact. R=5m

CONCLUSIONS

- Heavy ion beams are well adjusted to a massive cylindrical target.
- The output of such a target is featured by X-ray emission profile with short intensive prepulse and low-amplitude extended main pulse.
- The vapor layer generated by the prepulse shields the liquid film from the main X-ray pulse.
- The target ion debris is absorbed by the vapor layer as well, and vapor reradiation leads to revaporization of the liquid film.