Update On Evolution of Pressure In Positron Target Material for Future Linear Collider

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5th Annual Helmholtz Alliance Workshop on "Physics at the Terascale"
December 2011

Outline:

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3. Simulation Results for:
   - Tungsten Target
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4. Conclusion

Positron Production

The target material is one of the main challenges for positron source of any $e^+ - e^-$ linear collider

- The energy deposition in target materials leads to a rise of pressure in the region where such a deposition takes place [G.I. Silvestrov and T. A. Vsevolozhskaya].
- The induced stress by the beam could substantially reduce the lifetime of the target or other materials impinged by the incident intense photon or electron beam.
  - Although there are different opinions on the amount of stress (that is, in terms of percentage of material tensile strength) that can damage material.

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Hydrodynamical Systems

In this ongoing study, we extend [T. A. Vsevolozhskaya, 1984 and Mikhailichenko, CBN06-01, 2006] and analyze the features of thermal pressure waves induced by high power beams by considering the material behaviour from a hydrodynamical point of view and assumed:

- Gaussian distribution for energy deposited on the target;
- immobile target which implies no eddy currents; and
- a single bunch of the photon beam

Hydrodynamical Model For Target Material

The model comprises of:

- Continuity Equation:
- Equation of Motion or Momentum Equation:
- Modified Equation of State (EOS) for the target Material

To obtain the pressure acoustic wave equation, we linearized the three equations mentioned above and applying the equilibrium conditions. This leads to the linear pressure acoustic equation:

$$\boxed{\ddot{P} - \nabla \cdot (c_s^2 \nabla P) = \frac{\Gamma}{V_0} \ddot{Q}} \tag{1}$$

Energy deposited on the target can be described Gaussian distribution (see[Mikhailichenko, CBN06-1, 2006])

$$\dot{Q} = \frac{2cQ_{bunch}}{\sqrt{\pi}\sigma_z} \cdot \frac{z}{l_T} \exp\left(-\frac{(z-ct)^2}{{\sigma_z}^2}\right) \exp\left(-\frac{r^2}{{\sigma_r}^2}\right), \tag{2}$$

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New Results

We have use the model to simulate:

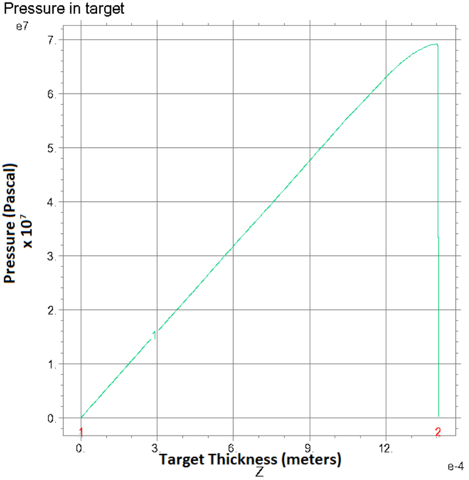
1. Tungsten target with ILC photon beam parameter
2. SLC Tungsten Alloy target with the electron beam parameter
3. ILC Titanium Alloy target with the photon beam parameter

Numerical Analysis of Pressure Wave Equation

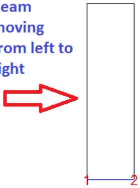
Eq. 1 was numerically solved by using **FlexPDE**.

- The problem was described in 2-D cylinderical co-ordinates (z,r).
- The simulation was carried out using Tungsten (W) target material.

Result: Target Response immediately after the photon beam has left



Beam moving from left to right



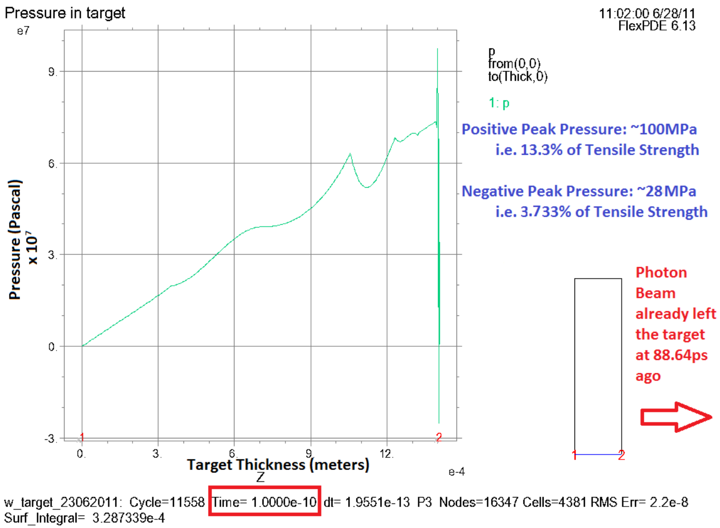
Result and Discussion on ILC Parameters for Tungsten Target

Previous slide show pressure evolution in the target just immediately after photon beam has left the target.

- ➪ Only positive pressure which represents the compression of the target by the photon beam can be observed.

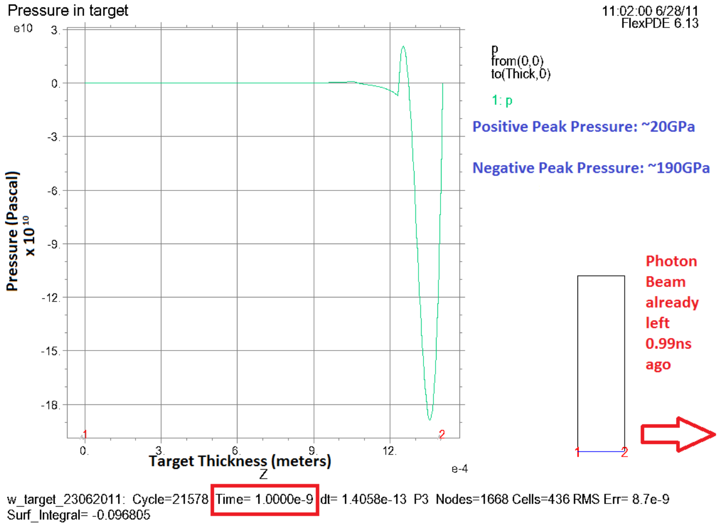
- ➪ The peak pressure is approximately $70MPa$, which is just 9.3% of the material tensile strength.

Result: Target Response at 0.1ns



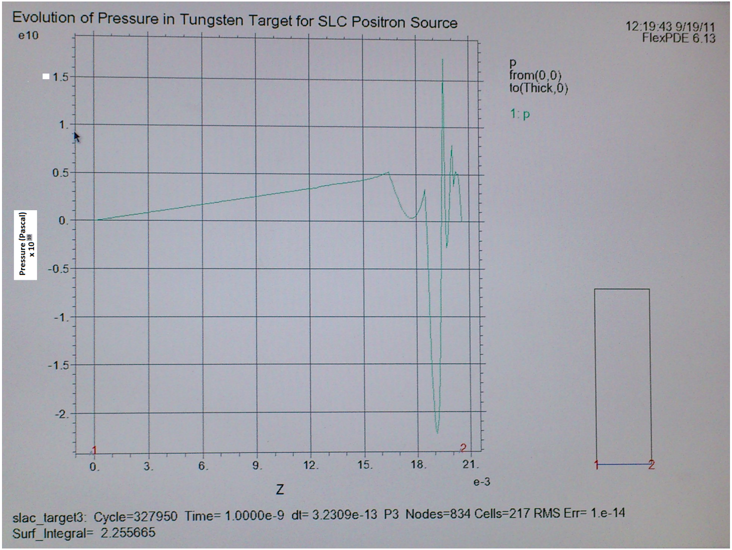
Figure

Result: Target Response at 1ns



Figure

Result on SLC Target

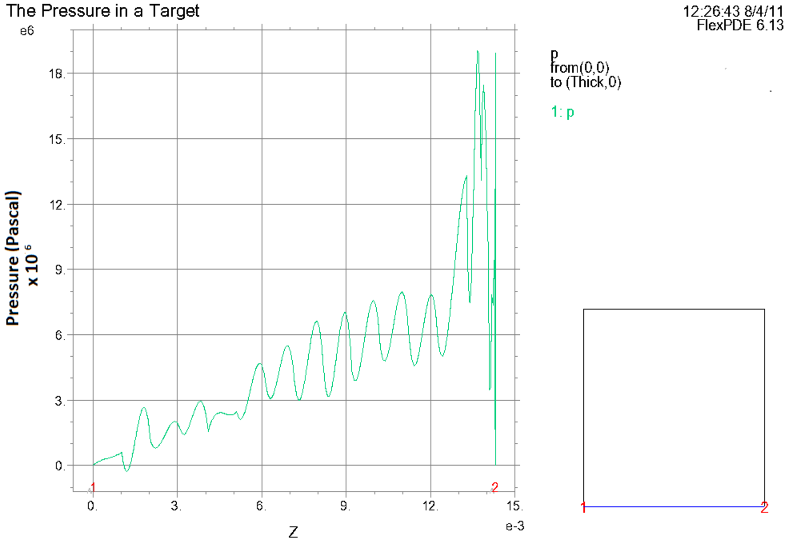


Figure

Decommissioned SLC Target

Figure: Beam Exit Face of the target

Result on ILC Titanium Target



Ti_04082011: Cycle=24294 Time= 1.0000e-9 dt= 3.3697e-13 P3 Nodes=7089 Cells=1867 RMS Err= 7.8e-9
Surf_Integral= 4.107896e-3

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Conclusion

- From this preliminary report we observed that simulation results is very sensitive to the time, because pressure magnitude is continuously growing with time!!!
  - the reason why the pressure keep on going with time (not in totality but to a reasonable extend);
- we know there is some artifact that needed to be fixed
- we will also implement the multi-bunch effect in our code

Thank You!