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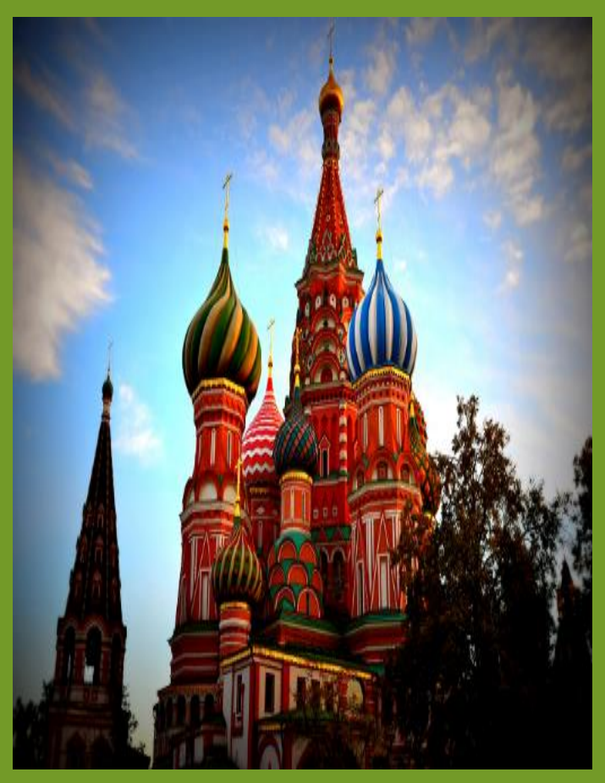
Investigation of parametric Instabilities in shock ignition relevant regime: Back reflected Stimulated Raman scattering and Hot electrons



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1 Introduction

Shock ignition (SI) [1] is a novel approach to Inertial Confinement Fusion (ICF) [2], based on the separation of the compression and ignition phases. The first phase implies compression of a thermonuclear DT pellet by ns laser beams with intensities I < 10^{15}W/cm2. The second relies on a laser pulse with intensities I ≈10^{15}-10^{16}W/cm^2, driving a very strong shock (P ≈ several 100 Mbar), by which generates the hot spot required for ignition. At laser intensities up to 10^{16} W/cm^2, envisaged in the SI scheme, laser interaction with the long scale plasma may lead to the generation of hot electrons (HE).

Here we report and discuss the results of a series of dedicated experiments performed at the Prague Asterix Laser Facility (PALS), aimed at investigating the generation of HE and their role in the generation of the shock wave [3]. In this experiment, we used two beams: a pre-pulse (1ω) of iodine laser (60J, 1×10^{14}W/cm^2) simulating long-scale pre-plasma and (3ω) (Wavelength λ= 1315/438 nm, pulse duration 0.3/0.25 ns, energy 440/170 J focused to intensities I =9×10^{15}/2×10^{16}W/cm^2 for 1ω/3ω, respectively) at various delays with respect to the first beam up to 1.2 ns for shock launch purposes.

We studied the generation and propagation of HE by using multilayer targets with different thickness. The main diagnostic was Cu K-α fluorescence imaging by spherically bent quartz (422) crystal.

2 Experimental Setup

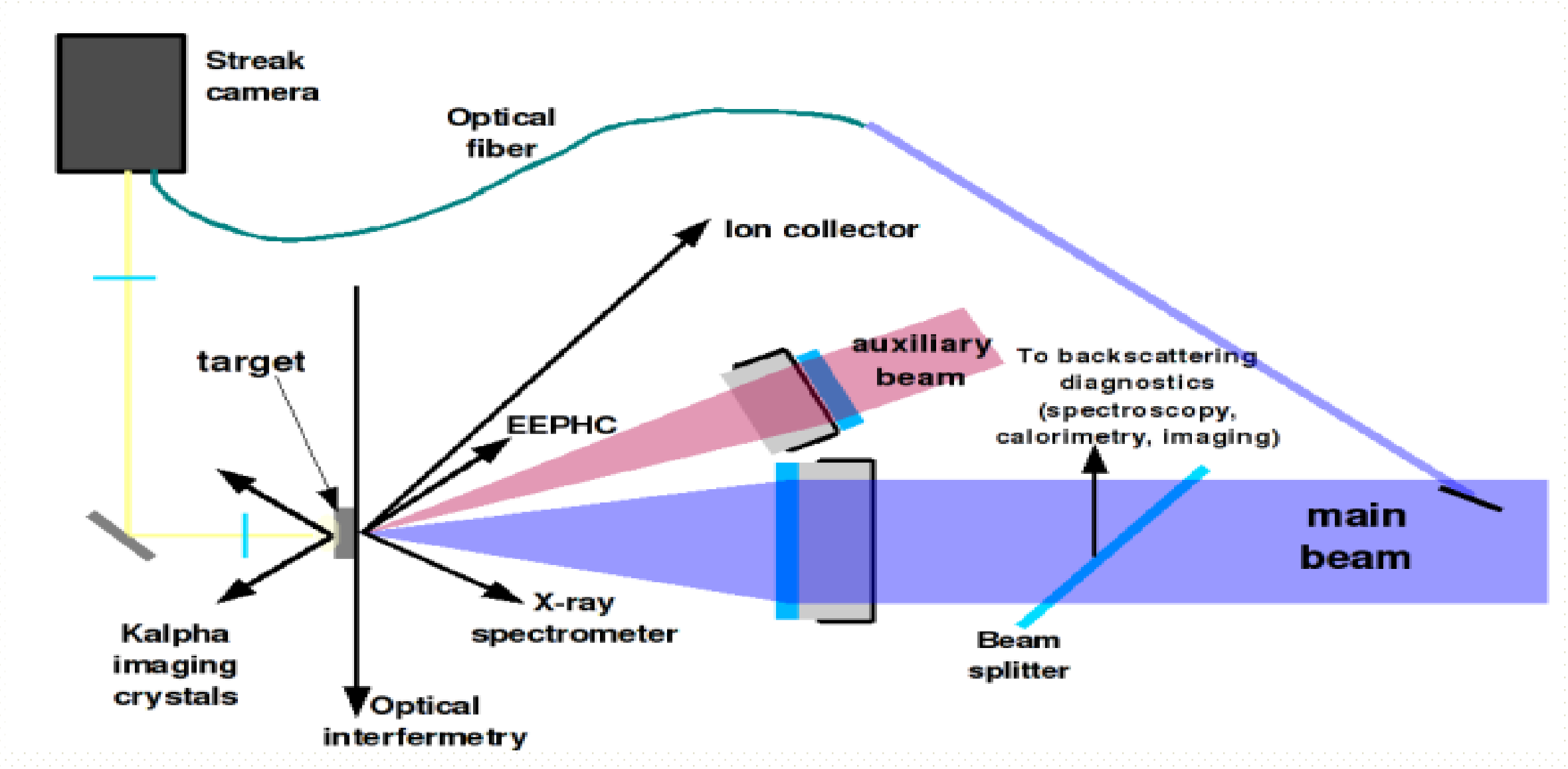

Fig.1 Experiment setup at PALS lab

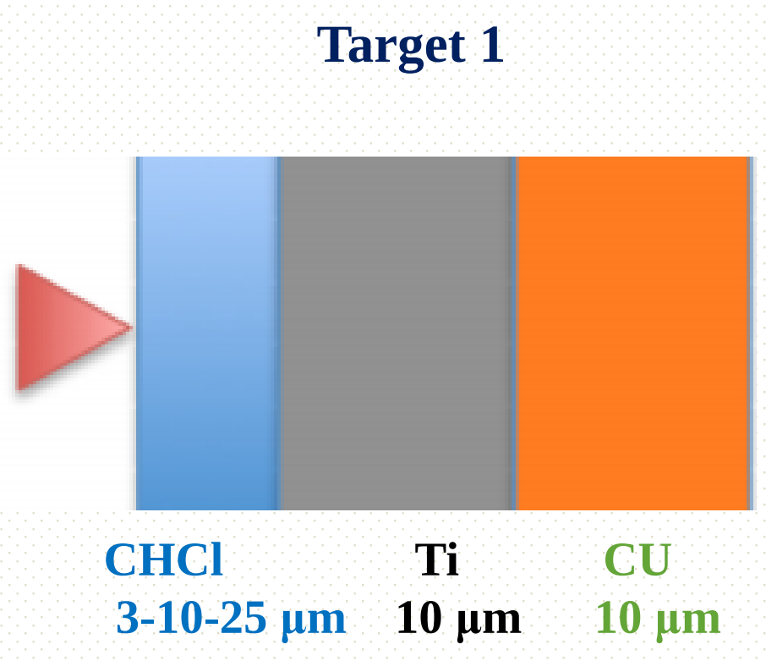

Fig.2 : schematic of main target

3 Experimental Results

1.Measurements of Kα Spot size vs. Laser Energy

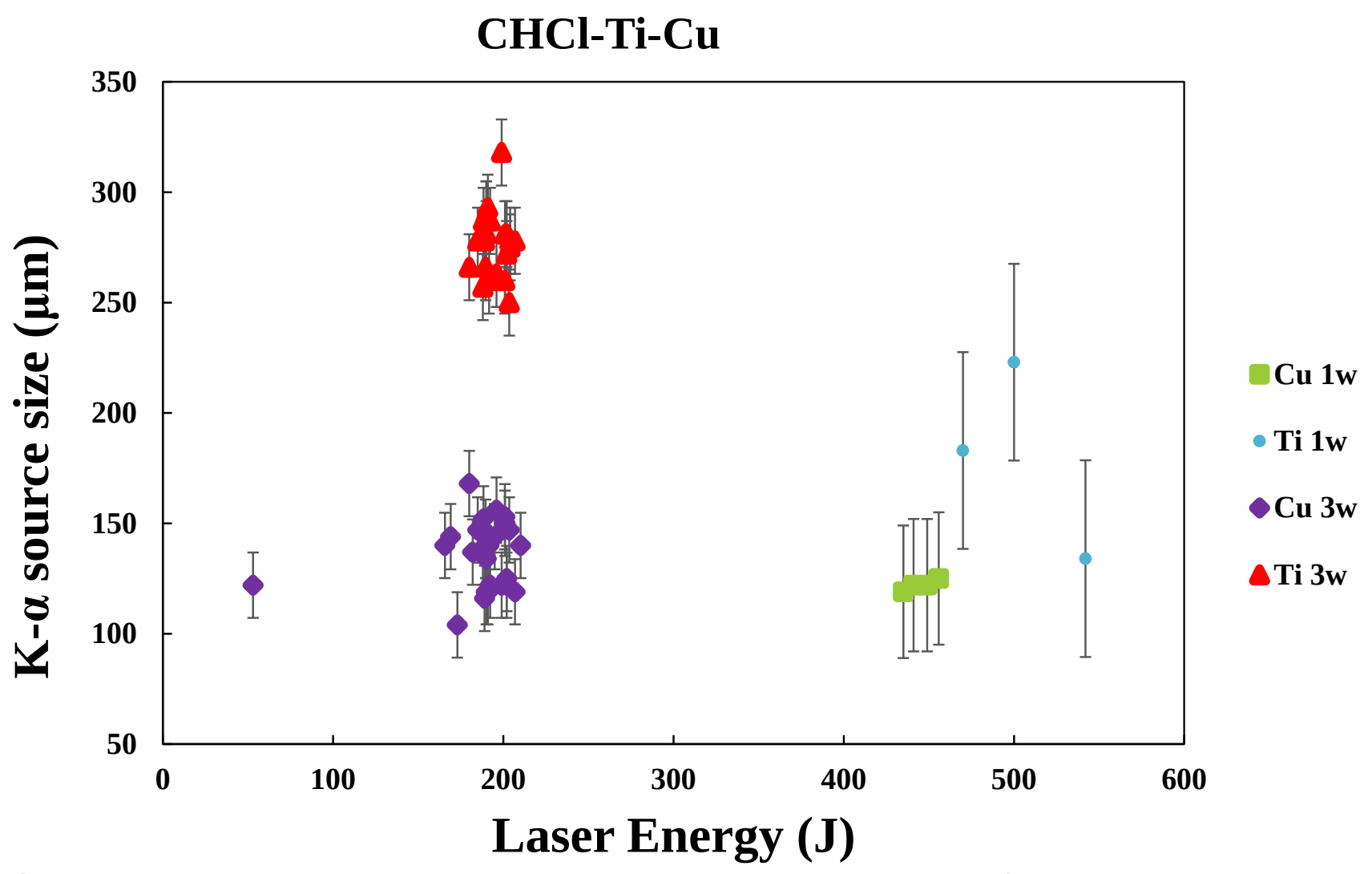

Fig.3: Variation of Kα spot size versus main laser energy for CHCl-Ti-Cu.

2. Measurement of Kα intensity vs. Laser Energy

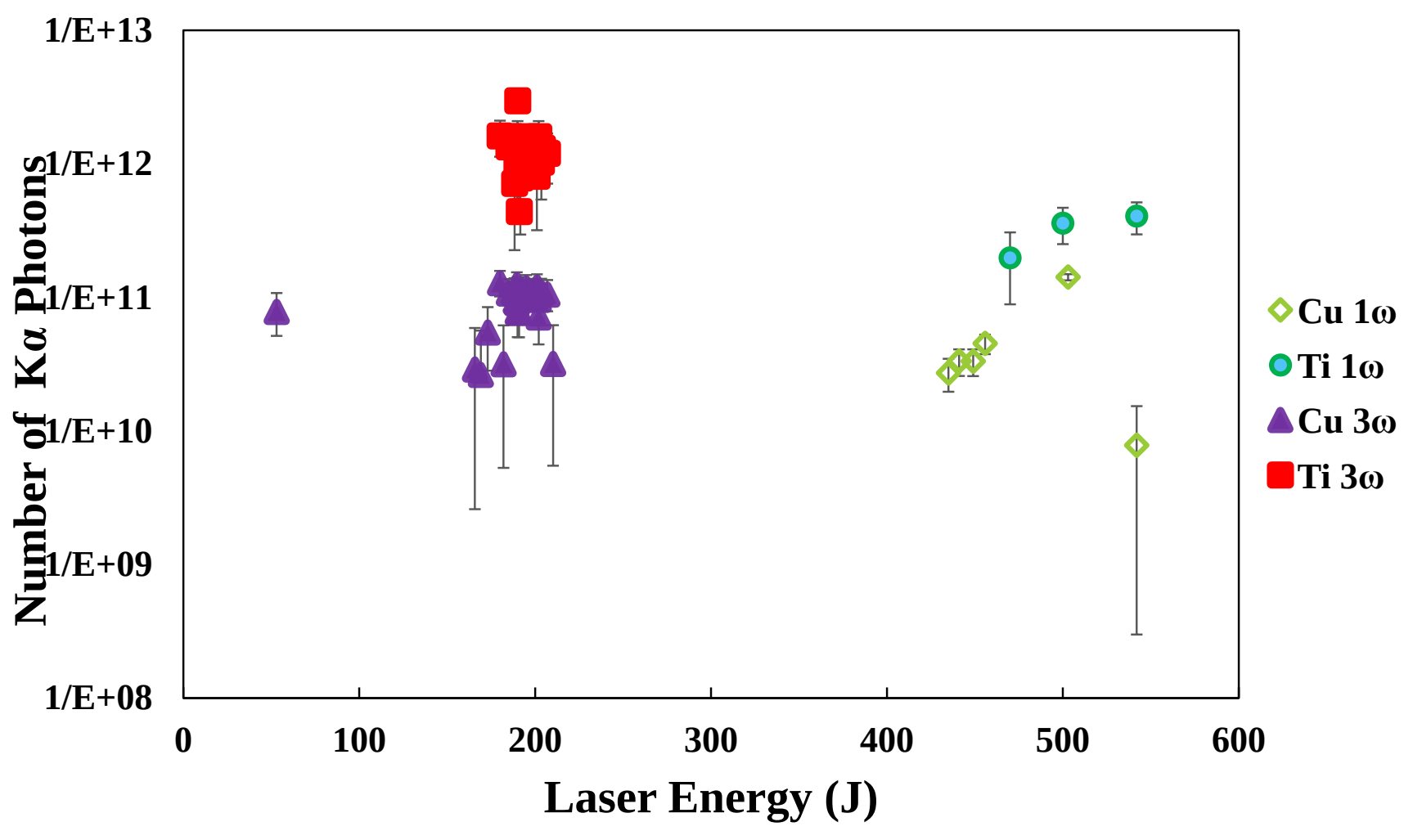

Fig.4: Number of Kα photons versus main laser energy for CHCl-Ti-Cu.

4 Results

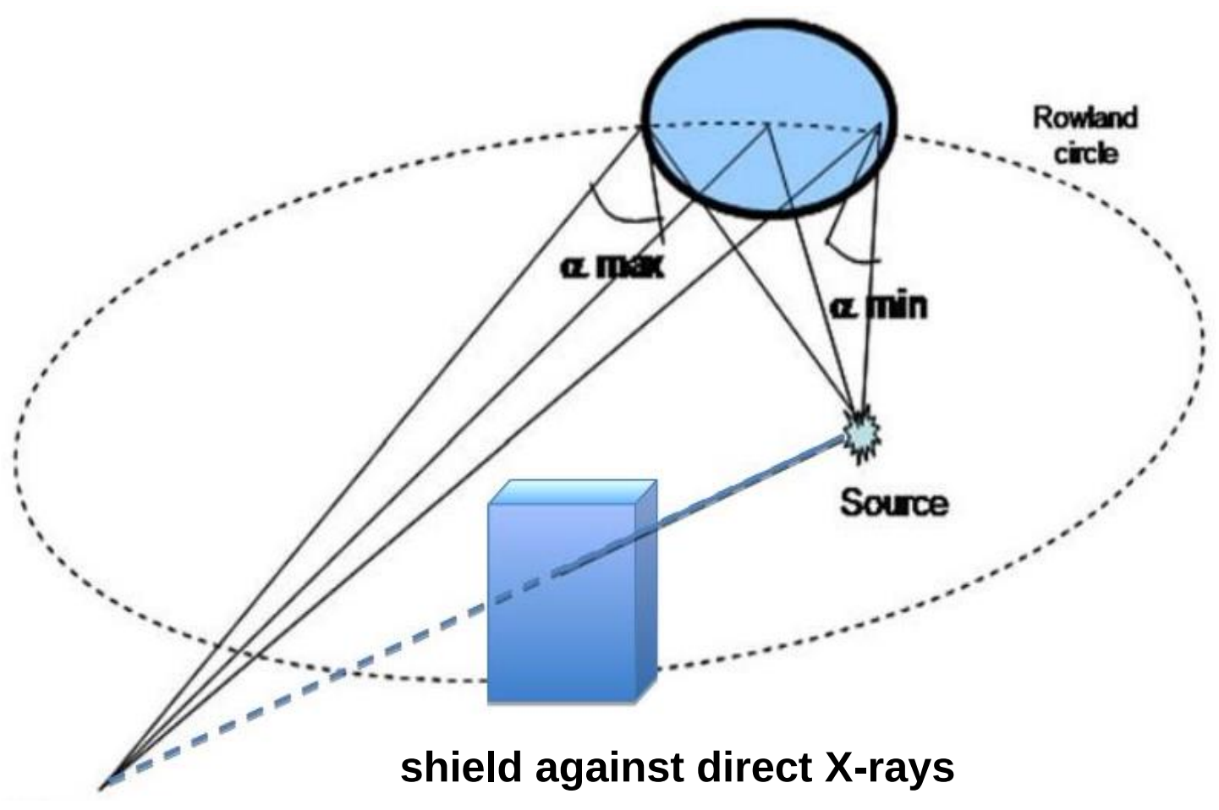

Fig.5: Schematic of the spherically bent Chrystal in imaging configuration.

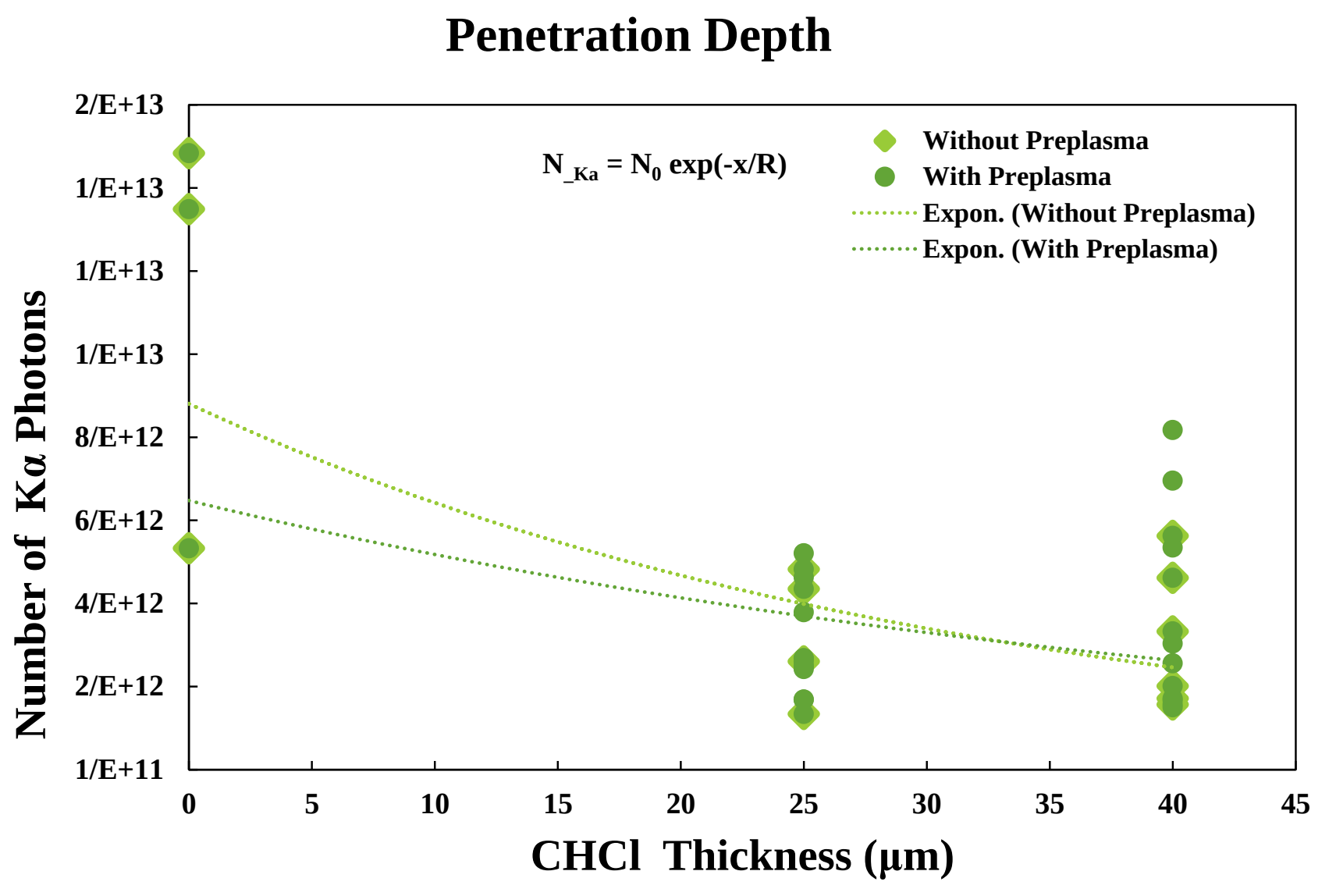

Fig.6: Number of K photons vs. CHCl thicknesses, CHCl-Massive Cu targets at 3ω frequency. Data with and without preplasma are overlapped.

The penetration range R=34μm in plastic corresponds to an electron kinetic energy E=45-55 KeV.

As shown in Fig.7, SRS spectra are only weakly dependent on delay, at least up to 600 ps. Shock breakout was also basically insensitive to the delay. Although a little surprising, this is probably due to the fact that the preformed plasma is too tenuous and cold to strongly affect energy deposition in the overdense plasma region.

SRS spectra are characterized by a Landau cut-off at short wavelengths (λ≈ 670 nm), and at long wavelengths extend to λ ≈ 750 nm. No sign of SRS originating at ≈ n_c/4 was found.”

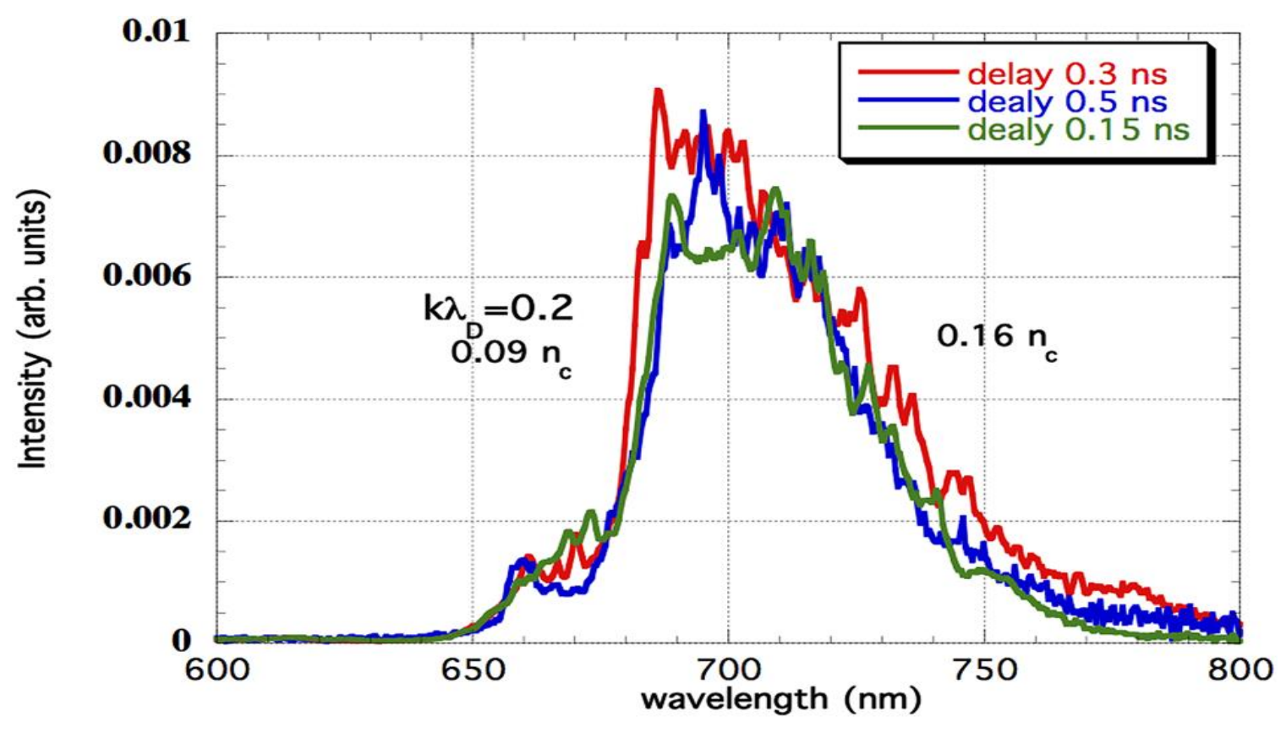

Fig.7. Backreflected Raman spectra at three delays.
The values 0.09 and 0.16 n_c correspond to the FWHM of the spectra.

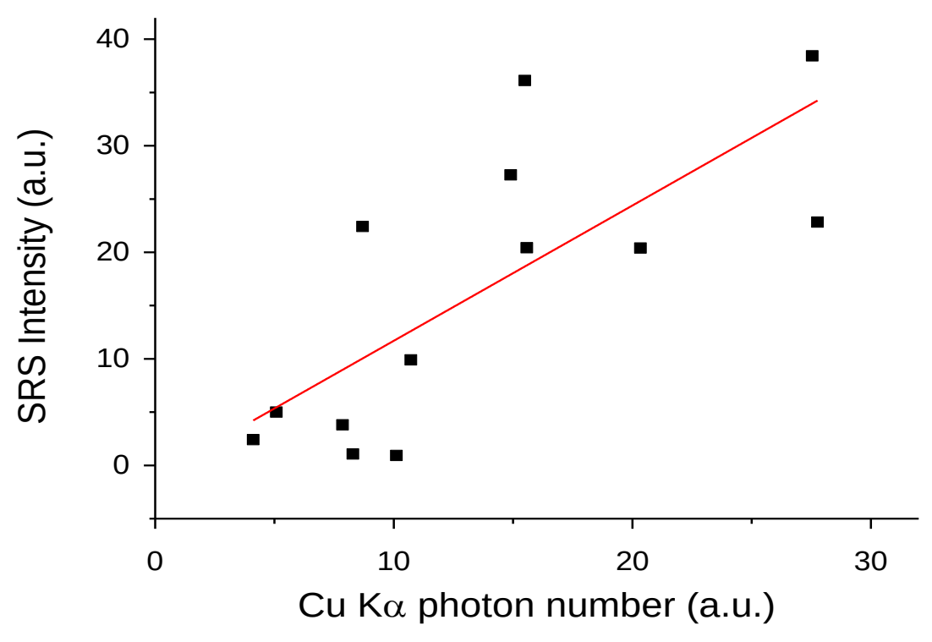

Fig.8: Correlation between hot electron and (backward) SRS signal.

The correlation seems to show that the origin of the hot electron is Stimulated Raman Scattering. The energy expected from SRS in our experimental conditions matches the experimental value quite well. Also in our experiment we measured a very weak TDP signal.

3- Conversion efficiency

By knowing the energy of laser E_{laser}, we can infer the laser-to-electrons conversion efficiency (η) by estimating, with GEANT4, the electron total energy E_e needed to reproduce the measured absolute K-α signal

5 Discussion & Conclusions

BRS (bachward SRS) is of the order of %1. The avarange values of hot electron temperature and conversion efficiency are 45-55 kev and 0.45-1.1% respectively.

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References

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