## Catch the Pulse: A Journey into FROG's Hidden Challenges Ultrafast Photonics Lab

## Team : B480 Advisor : Shang-Da Yang Members : Yu-Ting Wang, Yin-Hsi Kao

## Abstract

This study investigates key factors influencing FROG measurement accuracy, focusing on BBO crystal thickness and beam overlap angles. By analyzing dispersion effects, pulse width accuracy, and delay resolution, we aim to enhance precision and broaden FROG's capabilities in ultrashort pulse diagnostics.

# Experimental Design

### 1.SHG-FROG[1][2]

Electric field of two beams shares the same frequency:

 $E_{total}(t,\tau) = E(t) + E(t-\tau)$ 

By second-order nonlinear optics, the detected intensity of the light can be expressed by the following formula. We can estimate the length of the pulse by observing the autocorrelation.

 $I \propto \left[ E(t) + E(t-\tau) \right]^2 \qquad \Rightarrow I \propto E(t)^2 + 2E(t)E(t-\tau) + E(t-\tau)^2 \qquad S(\tau) = \int E(t)^2 + 2E(t)E(t-\tau) + E(t-\tau)^2$ 2. Effect of BBO Thickness

• Dispersion effect: Leads to the wider pulse

## **Result & Discussion**



The thicker the BBO crystal, the more obvious the impact is.



**3.Effect of incident beam spacing** 

Lens

Fig. 3 Geometric time

smearing[3]

Focus

In a BBO crystal, the signal received at the focal point of the lens corresponds to a single cross-section parallel to the lens. To reduce the delay error caused by the angle, shorter light that overlaps along the longitudinal axis should be utilized.

*Fig.* 7 **BBO thickness and** pulse width trend chart



0.5

## Setup

Beam directiòn

Pulse

7	7.5	8	8.5	9	9.5	10
	Incident Beam Spacing(mm)					

1.5

BBO Thickness(mm)

2

2.5



# **Conclusion & Future Work**

#### **Different BBO Thicknesses:**

No significant variation trends were observed during measurements. Theoretical estimates suggest that a thickness of several kilometers would be required to detect noticeable trend changes.

### **Different Incident Beam Spacing:**

Experimental data indicates a positive correlation between beam spacing and pulse width.

#### **Future Work:**

We aim to enhance measurement tools by expanding beam overlap and minimizing errors through improved alignment and precision adjustments, advancing ultrashort pulse measurement accuracy.

#### **Reference**:

- [1] 超短脈衝雷射的脈衝寬度調控與量測- 賴建智
- [2] Ultrafast Optics Andrew M. Weiner
- [3] Measuring Ultrashort Laser Pulses III: FROG tricks Rick Trebino

### Principal Investigator: 楊尚達 (Shang Da Yang)

Office : Delta(台達館) R810, Phone Ext. 42583 Lab: EECS(資電館) R309, Phone Ext. 34924 Personal website (left), Lab website (right)

