# Chirped Electric Field

## Optical intensity: $I \propto |E|^2$

### Heavily chirped pulse approximation

- $E(t) \propto e^{-\frac{4(\ln 2)t^2}{2[\Delta t^2 + i4(\ln 2)\varphi_2]}} \xrightarrow[\varphi_2 \gg \Delta t^2]{} e^{-i\frac{1}{2\varphi_2}t^2}$, [1]
  - where Δt is FWHM pulse duration and $\varphi_2$ is GDD.
- $E(t) = e^{-4\ln 2\frac{t^2}{\Delta t_{out}{}^2}} e^{-i\omega_0 t} e^{-i\frac{t^2}{2\varphi_2}}$
- Let $x = \frac{4\ln 2}{\Delta t_{out}{}^2}$, $\alpha = \frac{1}{2\varphi^2}$, $\omega_0 = 0$:

$$E(t) = e^{-xt^2} e^{-i\alpha t^2}$$

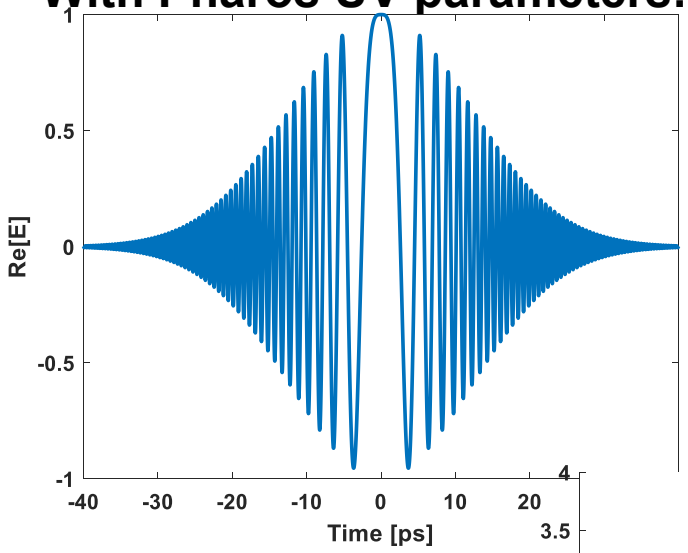
- For Michelson interferometer with delay τ:

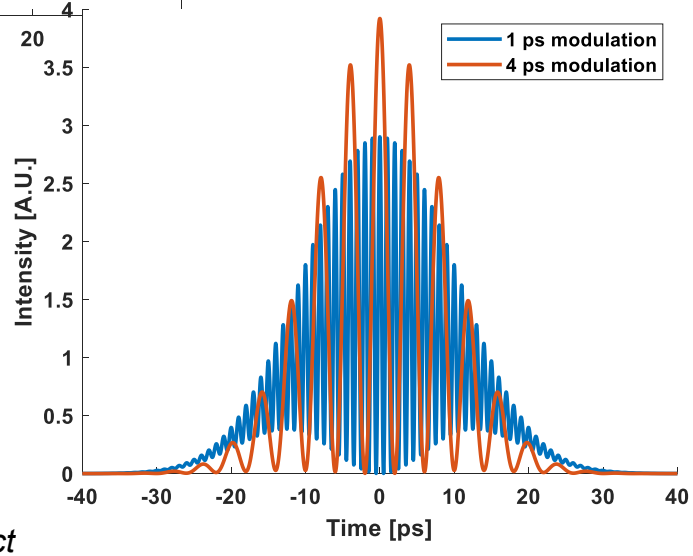
$$I \propto E\left(t - \frac{\tau}{2}\right) E^*\left(t + \frac{\tau}{2}\right)$$

$$I = e^{-x\left(t+\frac{\tau}{2}\right)^2} + e^{-x\left(t-\frac{\tau}{2}\right)^2} + \cos\left(\frac{t\tau}{2\varphi_2}\right)$$

- **Tuneable beat frequency**

### With Pharos UV parameters:




*[1] Newport Technical Note, "The Effect of Dispersion on Ultrashort Pulses"*

# Practical Implementation

## Subheading, optional

**Chirp requirements & methods:**

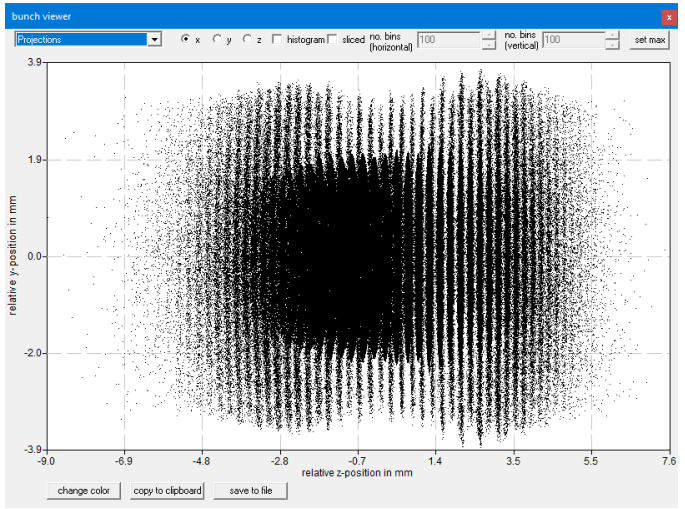
- 300 fs → 10-20 ps = GDD 1-2 $ps^2$
- Double-pass grating stretcher: 1.5-3 m
- FS fiber (GVD=213 $fs^2$/mm): 5-10 m

**Energy budget & losses:**

- Fiber: 300dB/km: ~70%T in 5 m, ~50%T in 10 m.
- Michelson interferometer: <50%T
- ➔20-30% transmission
- Nominal pulse energy: 1 uJ for 1 nC
  ➔2.5 uJ input for 0.5 nC

**Quick PITZ ASTRA sim:**

- Nominal gun & boo. parameters, 500 pC, 20 ps w/ 1 ps modulations, trunc. Gauss w/ BSA 2.5 mm (1.5σ)



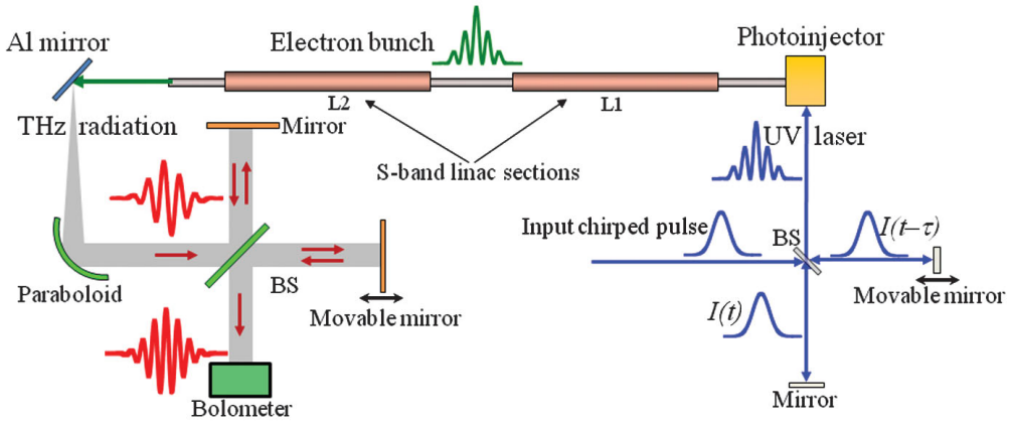

**Already tried and tested:**

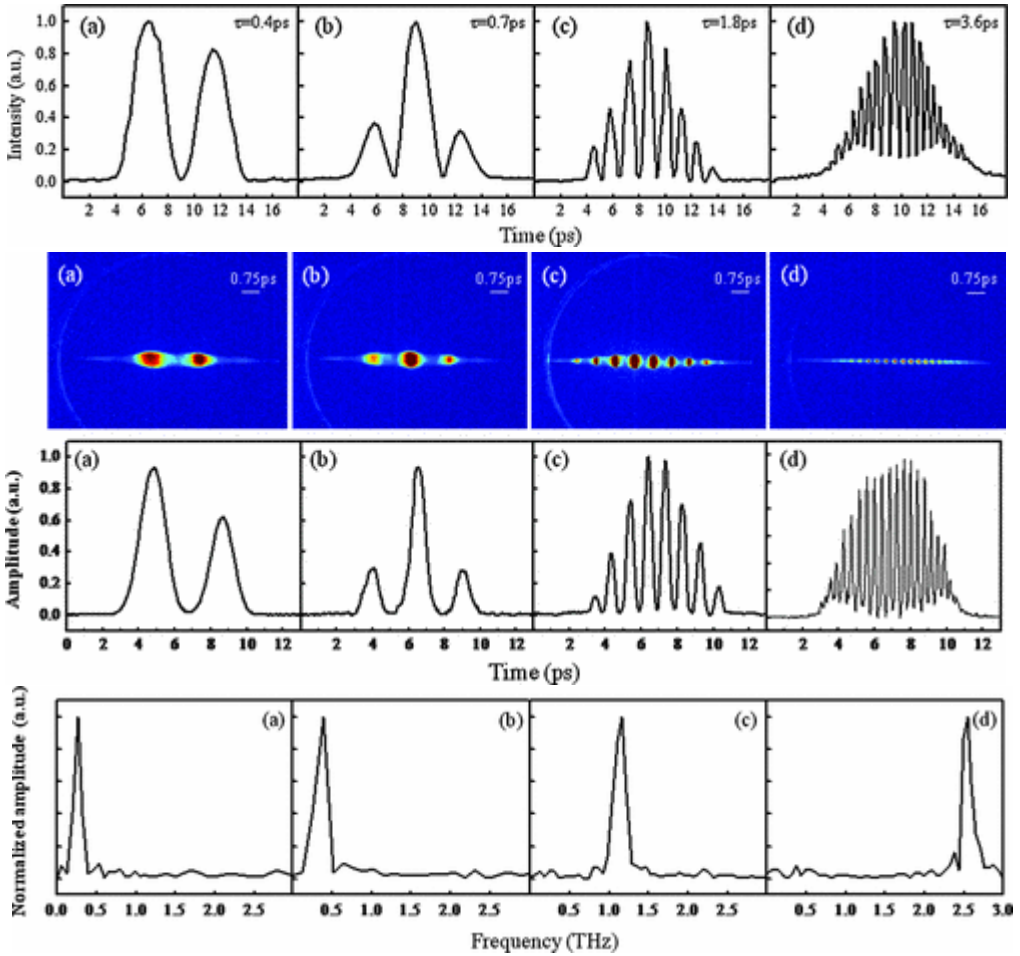
- TU Dortmund, „*Continuously tunable narrowband pulses in the THz gap from laser-modulated electron bunches in a storage ring.*“
- Brookhaven, *“Tunable Few-Cycle and Multicycle Coherent Terahertz Radiation from Relativistic Electrons”*

# *“Tunable Few-Cycle and Multicycle Coherent Terahertz Radiation from Relativistic Electrons”*

## Brookhaven

### Already tried and tested:




- 100 fs, 262 nm grating-chirped laser pulse
- 100 pC beam @ 6 MeV → 120 MeV

# *Oppositely chirped pulses*

## Playing around