

# ICAP2022

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## **Development of a Deep-ultraviolet Chirped Pulse Laser for Doppler Cooling of Positronium**

*Monday, 18 July 2022 17:00 (1h 30m)*

Positronium (Ps), a bound state of an electron and a positron, is a purely leptonic and anti-particle system. Preparing a cold gas of Ps leads to precision spectroscopy and a realization of Bose-Einstein condensation of exotic atoms. Owing to the nature of the particle-antiparticle pair, Ps has a finite lifetime of 142 ns. Therefore, developing a rapid cooling method is the key to cool Ps effectively.

Laser cooling using the 1S-2P transition is one of the most promising methods for Ps cooling. With laser cooling, Ps atoms at room temperature could ideally be cooled to the photon recoil limit of 0.6 K within one microsecond. The temperature is well below 150 K, achieved by a conventional cooling method via momentum exchange processes with a cold Ps converter[1].

It is well known that laser cooling using continuous-wave lasers can reduce the temperature of a gas of atoms to submillikelvin temperatures[2]. However, because of the finite lifetime and the small mass of Ps, a cooling laser for Ps should be a unique pulsed laser that has a broadband spectrum, a frequency chirp, and a long pulse duration of several hundred nanoseconds[3]. We designed and developed a prototypical cooling laser (Figure 1) that satisfies these requirements. We also numerically simulated its oscillation dynamics and successfully reproduced the measured temporal and spectral structures of the laser[4].

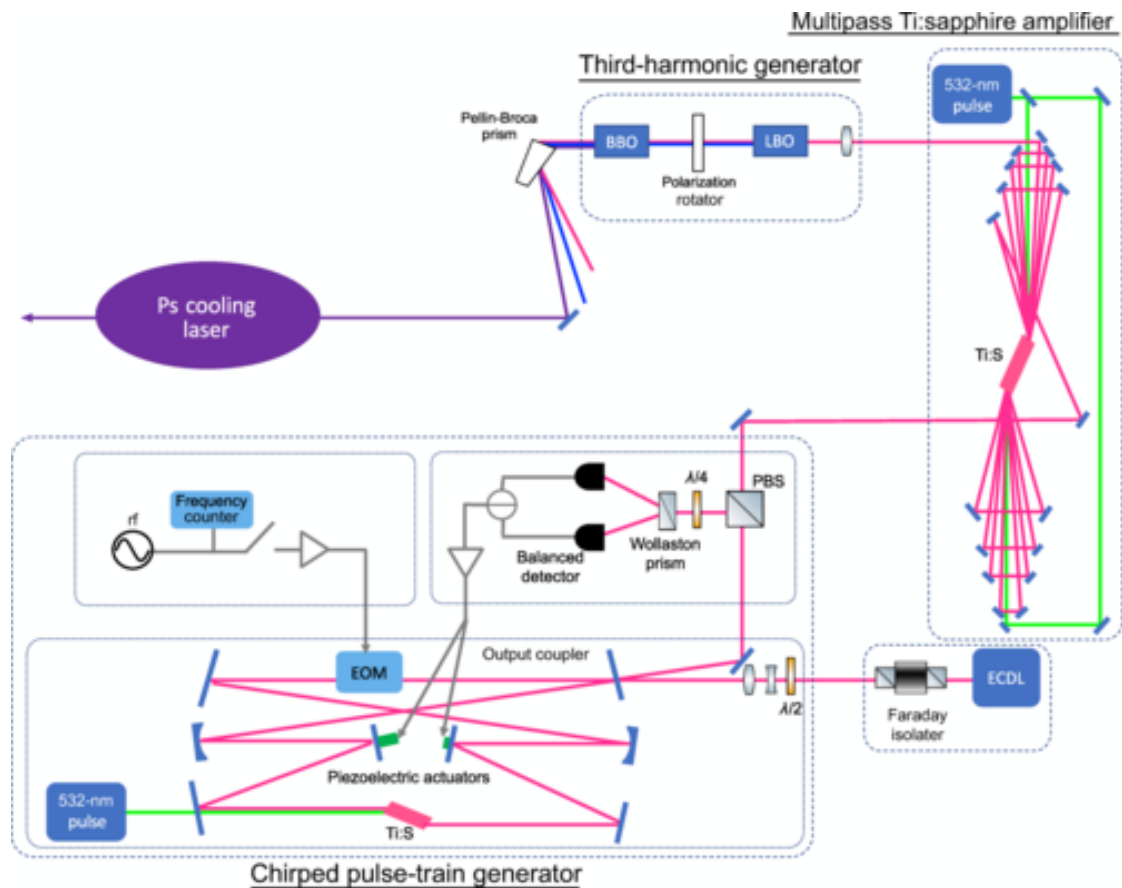


Figure 1: Schematic of the prototypical cooling laser system.

- [1] S. Mariazzi, P. Bettotti, and R. S. Brusa, *Physical Review Letters* 104, 243401 (2010).
- [2] W. D. Phillips, *Reviews of Modern Physics* 70, 721 (1998).
- [3] K. Shu, X. Fan, T. Yamazaki, T. Namba, S. Asai, K. Yoshioka, and M. Kuwata-Gonokami, *Journal of Physics B: Atomic, Molecular and Optical Physics* 49, 104001 (2016).
- [4] K. Yamada, Y. Tajima, T. Murayoshi, X. Fan, A. Ishida, T. Namba, S. Asai, M. Kuwata-Gonokami, E. Chae, K. Shu, and K. Yoshioka, *Physical Review Applied* 16, 014009 (2021).

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## How will you attend ICAP-27?

I am planning on in-person attendance

## online poster URL

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