



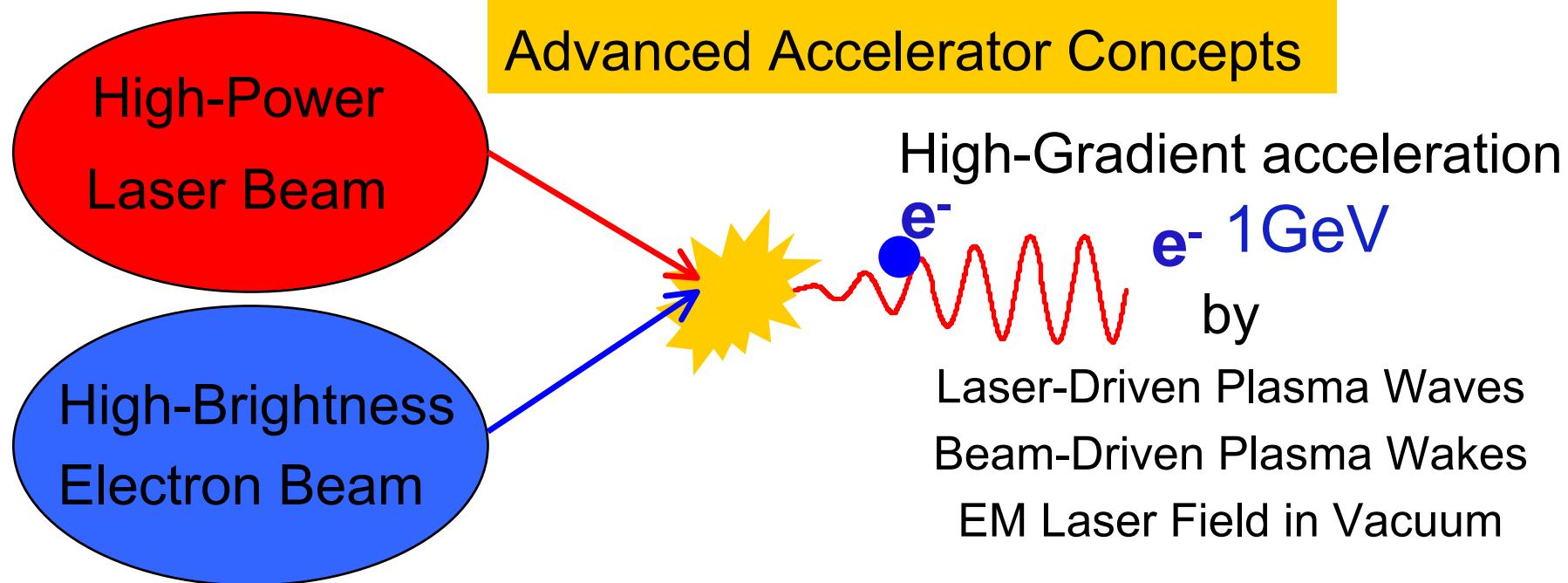
UCLA Neptune Facility for Advanced Accelerator Studies

S. Ya. Tochitsky, C. E. Clayton, K.A. Marsh, J.B.
Rosenzweig, C. Pellegrini and C. Joshi

NEPTUNE Lab, UCLA



NEPTUNE Laboratory: What is it?

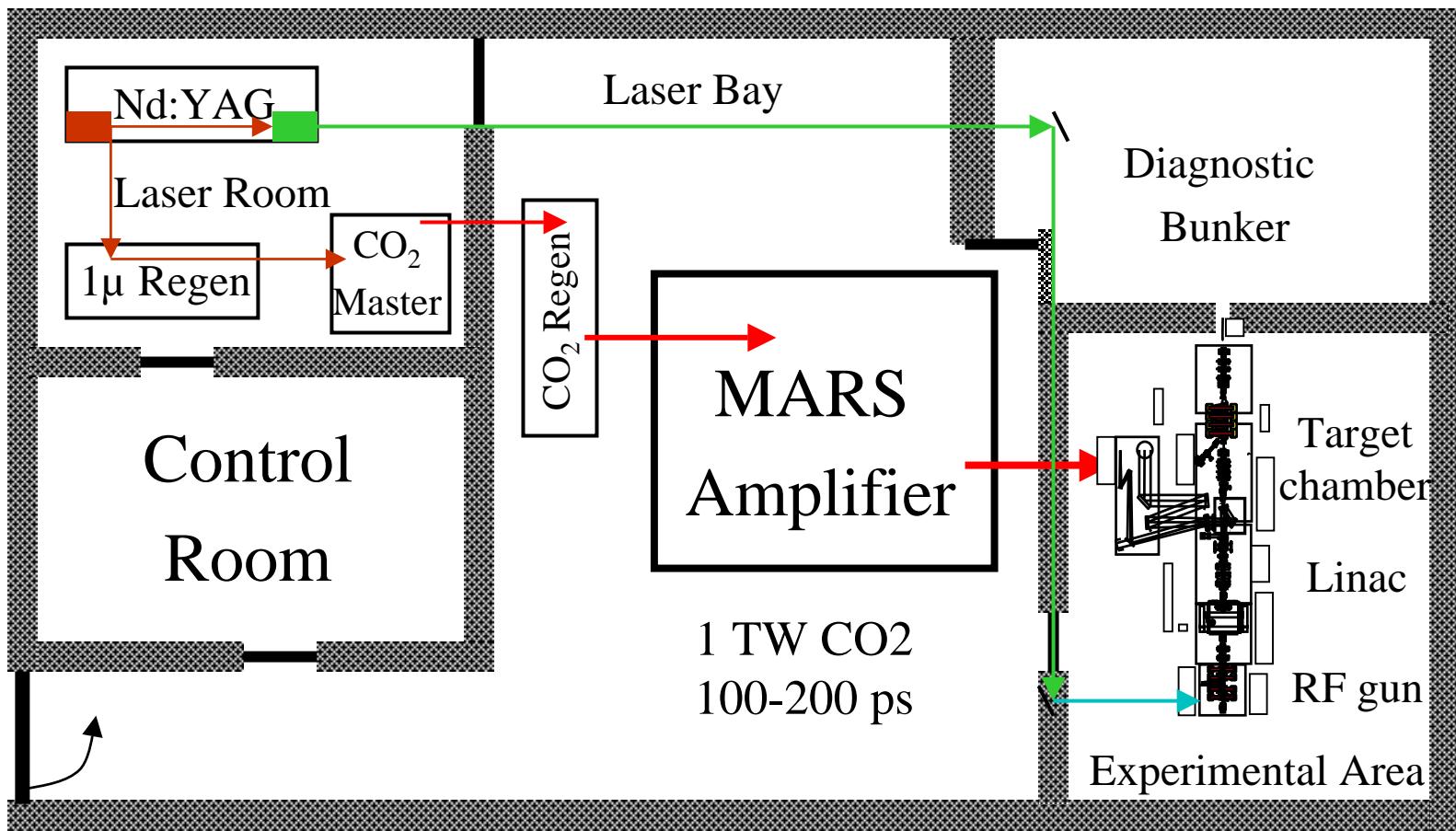


Goals:

- a) Acceleration of injected, high-current beam in PBWA, IFEL.
- b) Electron microbunching: chicane, IFEL, plasma klystron etc. for phase-locking technologies and monoenergetic plasma accelerators.
- c) Beam-physics studies: advanced manipulation of phase-space.
- d) Light-source experiments.



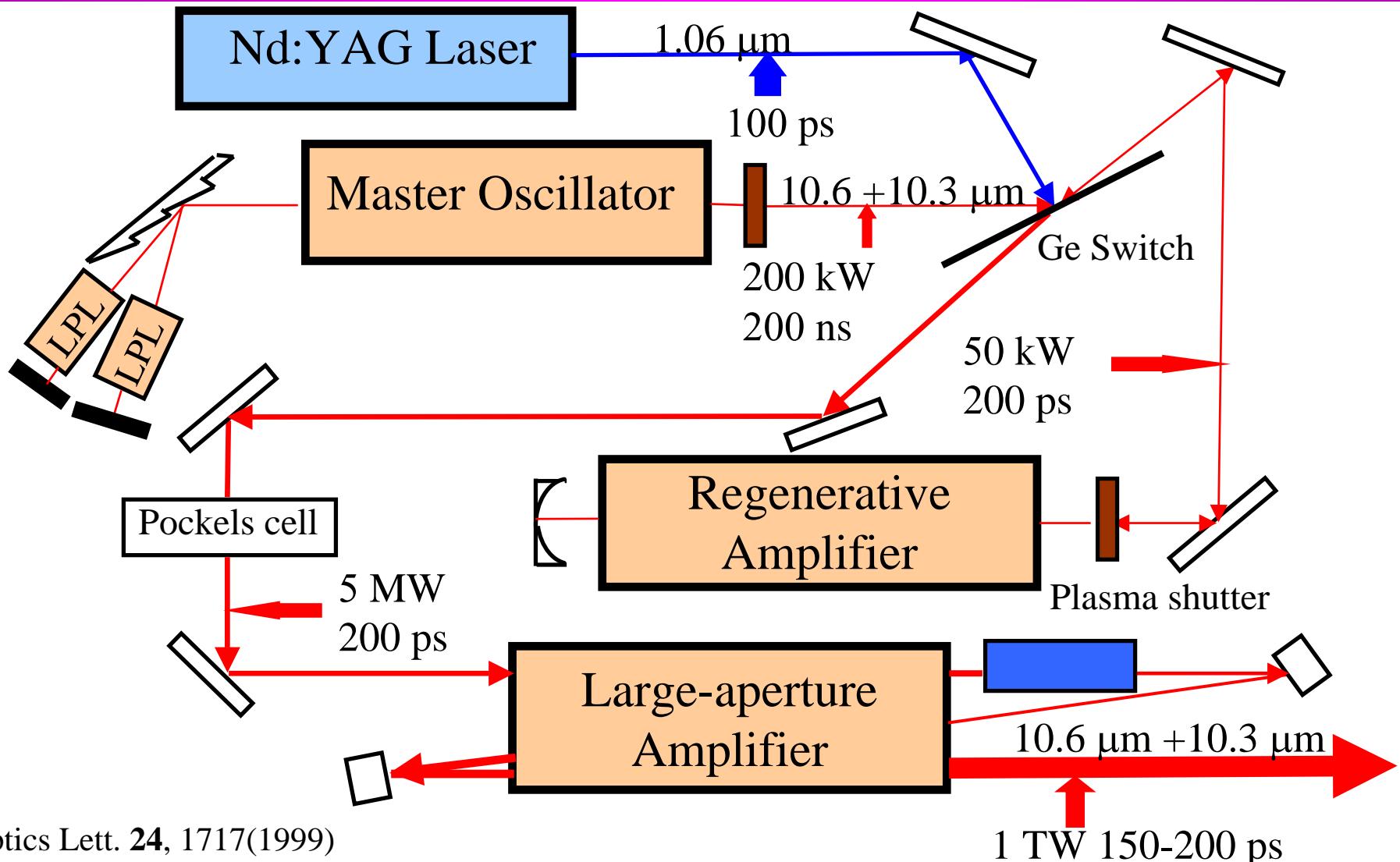
The Neptune Lab for Advanced Accelerator Research





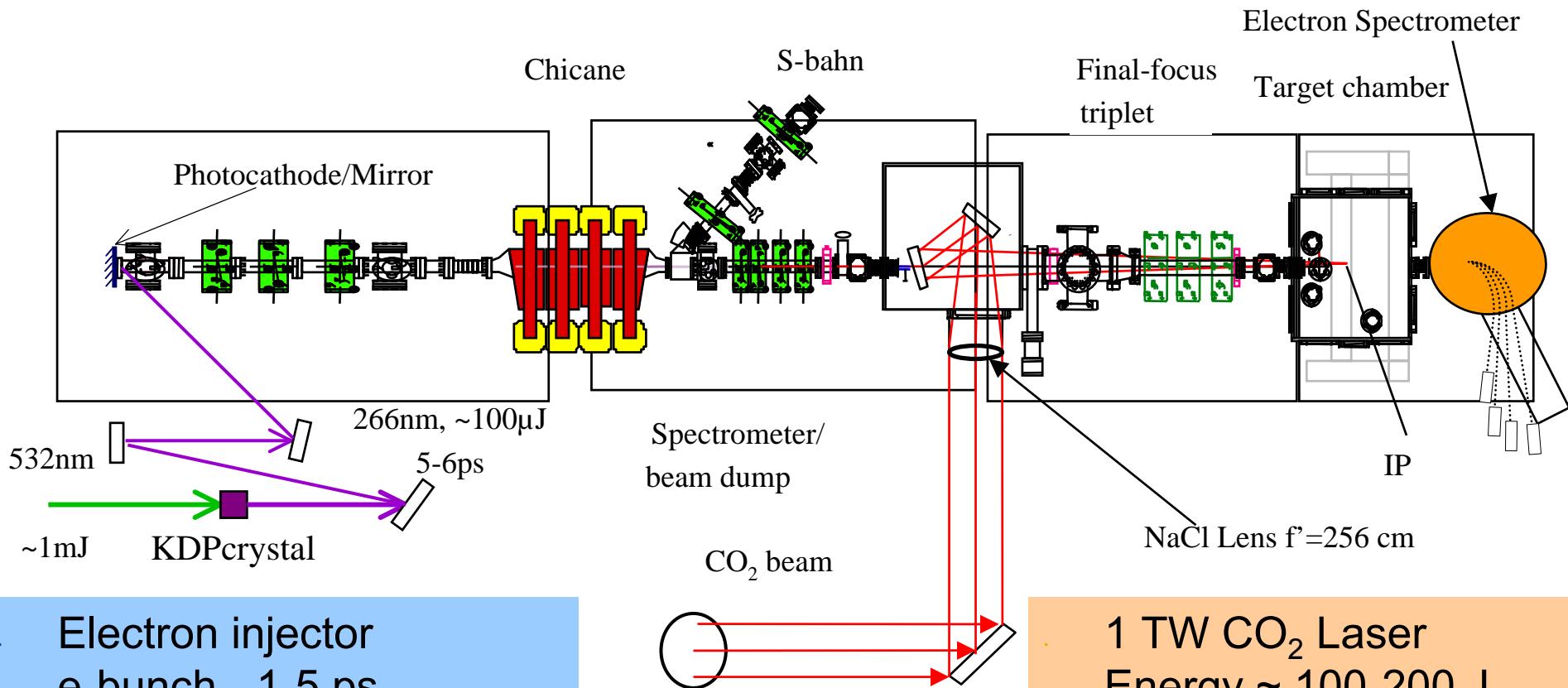
Neptune TW CO₂ Laser System

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Layout of Experimental Area



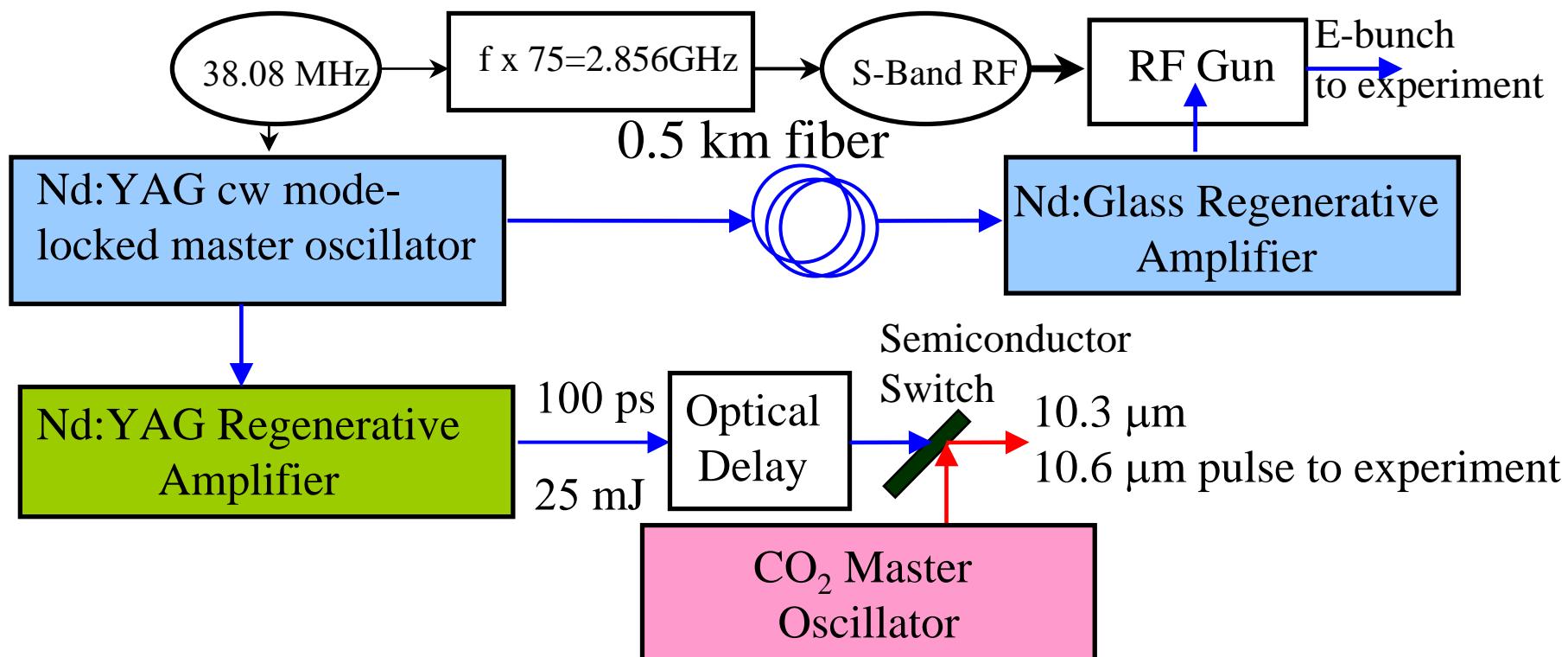
Electron injector
e-bunch - 1-5 ps
Emittance - 5 mm mrad
Energy ~ 12 MeV ± 0.3%
Charge ~ 200 pC

1 TW CO₂ Laser
Energy ~ 100-200 J
Pulse Length ~ 150 ps
 $\lambda_1 = 10.3 \mu\text{m}$ $\lambda_2 = 10.6 \mu\text{m}$
 $I \approx 6 \times 10^{14} \text{ W/cm}^2$



Deterministic psec timing between Linac and CO₂ laser pulse

The same optical pulse (after storage for 300 round trips) is used for e⁻ production and for CO₂ slicing.



Picosecond timing is set via cross-correlation measurements.

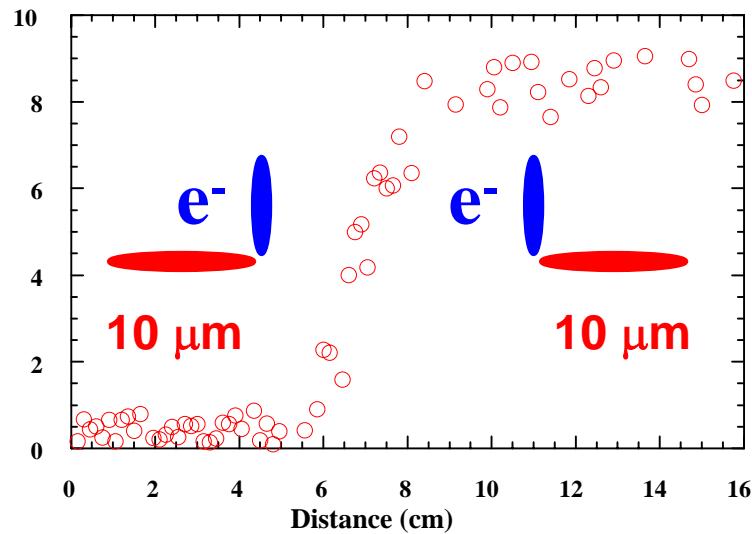
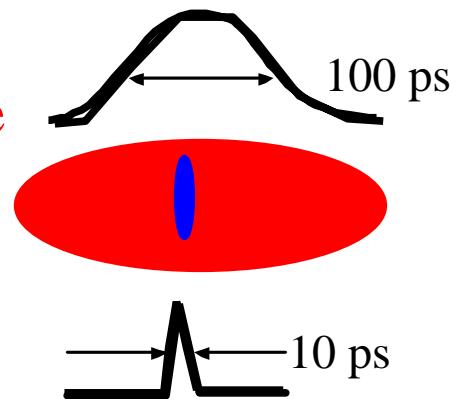


Sub-100 ps synchronization between CO₂ laser and e-bunch

10-μm CO₂ laser pulse

Neptune Lab

e-bunch



Two-Step Procedure:

Step 1 - Cross-correlation between photons and electrons using an unamplified 150 ps CO₂ laser pulse.

Step 2 - Compensation of delay in active medium of the MARS high-power amplifier.



Cross-correlation accuracy - better 10 ps

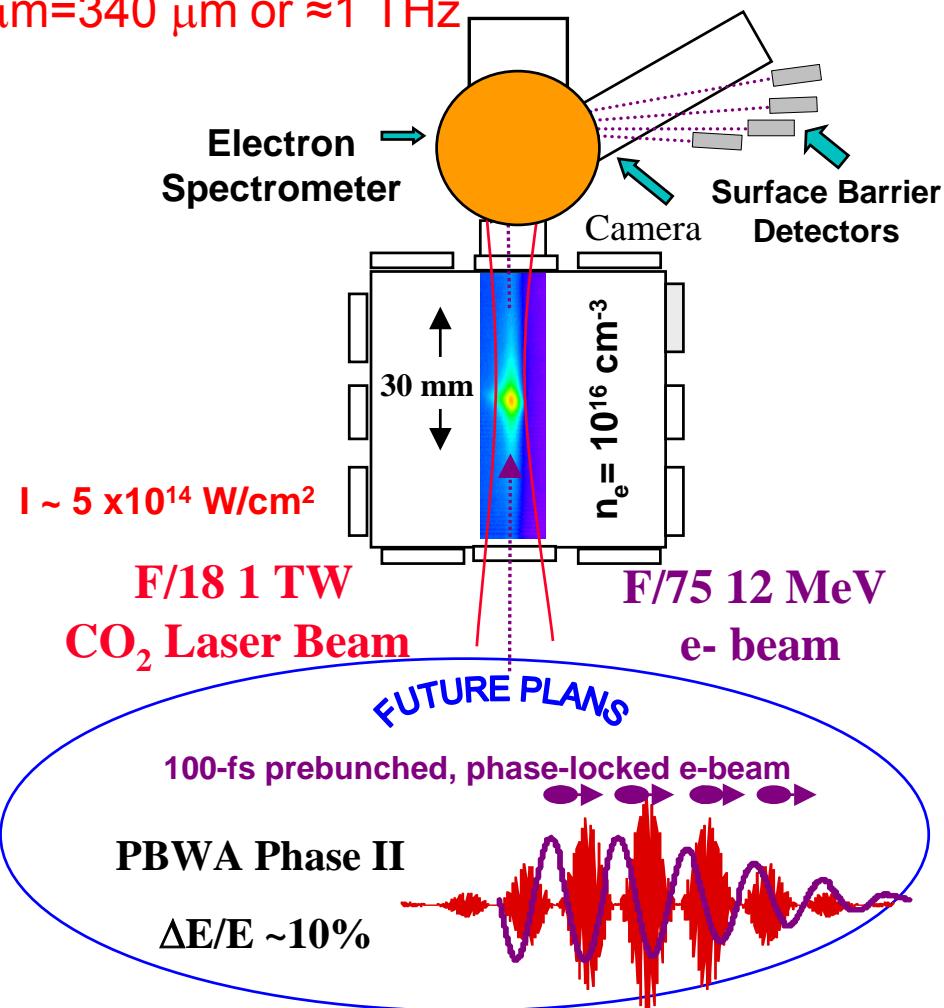
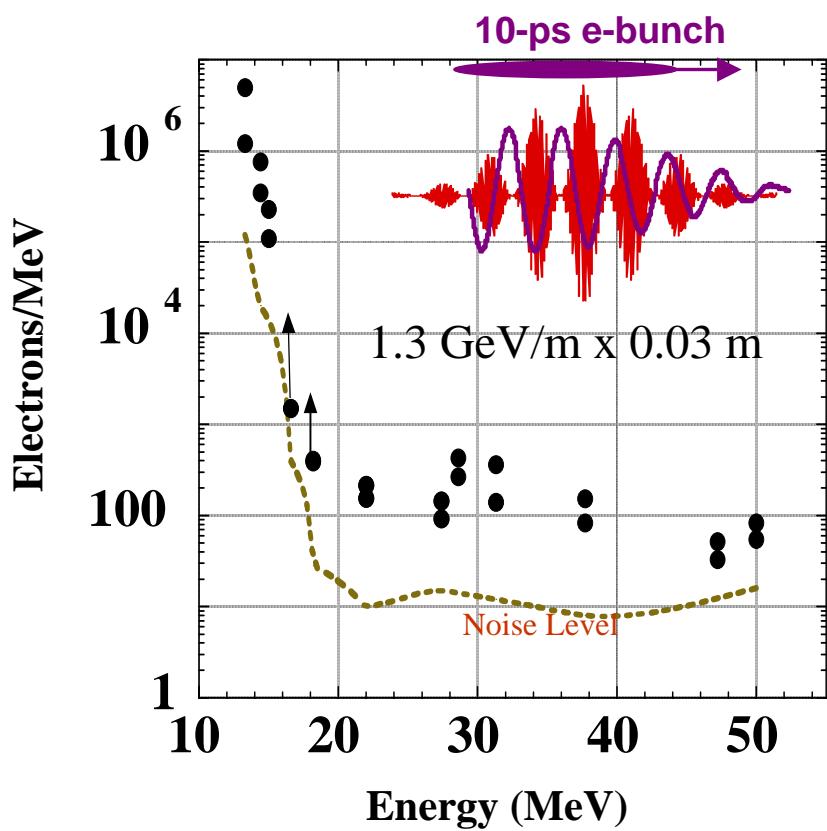
Total uncertainty of synchronization - ± 20 ps



Plasma Beatwave Acceleration Program at Neptune

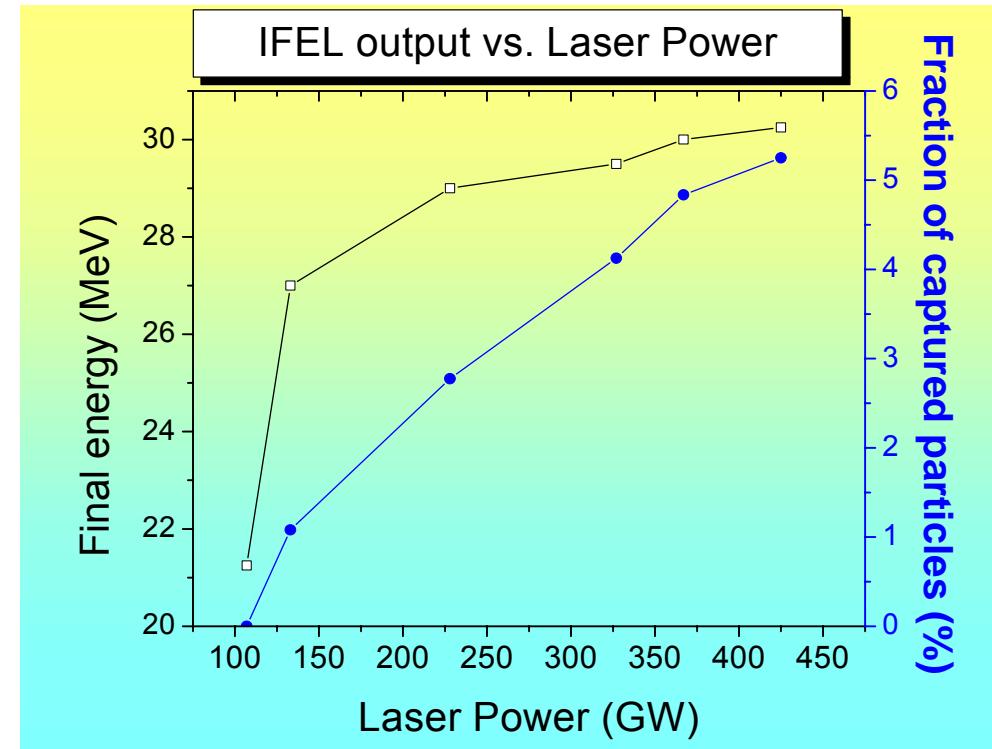
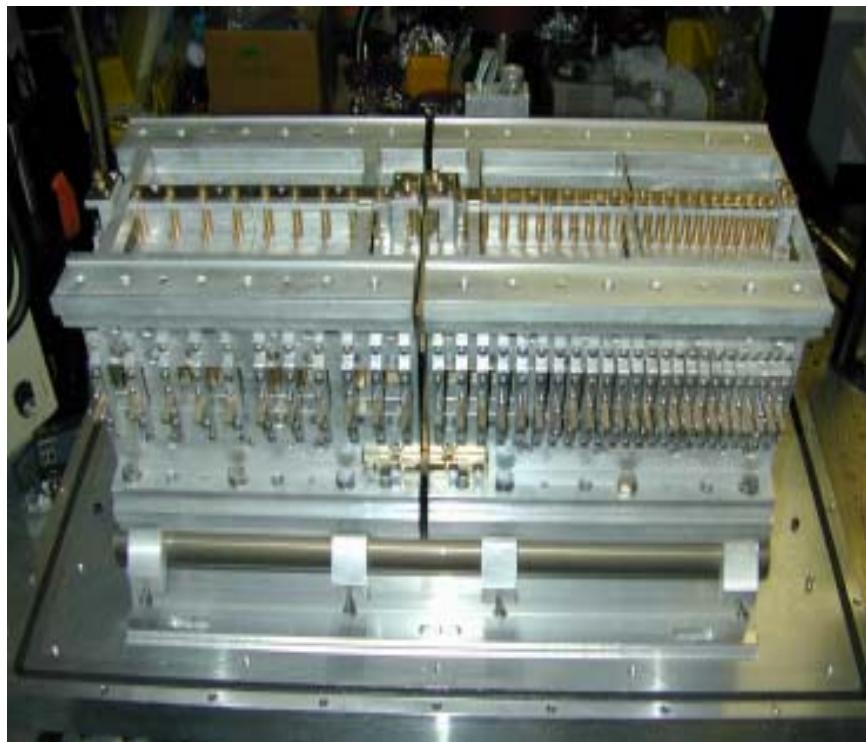
Injection of an electron beam into a relativistic plasma wave driven by laser beatwave

$$\omega_1 - \omega_2 = \omega_{\text{plasma}} \quad 10.3 \mu\text{m} - 10.6 \mu\text{m} = 340 \mu\text{m} \text{ or } \approx 1 \text{ THz}$$





Neptune 10-μm IFEL experiment



5% of electrons trapped and increased kinetic energy from 14.5 to >35 MeV; Energy gain >20 MeV over 25 cm



Future Experiments

- Modulation of the electron beam on the scale 100-500 fs by using: chicane compression, IFEL microbunching, laser beatwave ponderomotive microbunching.
- Injection of a prebunched tightly focused electron beam in a relativistic plasma beatwave for matched acceleration.
- Longitudinal electron beam shaping and compression using the S-bahn.
- Production of polarized X-rays via Compton scattering process.
- Generation of high-power THz radiation.



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Neptune Parameters

Present		Future
<i>Laser Parameters</i>		
Wavelength	9-11 μm	9-11 μm
Laser Power	1 TW	1-3 TW-single shot 100 GW-1-5 Hz
Laser Pulse Length	100-400 ps	3-400 ps
<i>Photoinjector Parameters</i>		
Energy	12-15 MeV	12-15 MeV
Electron Bunch Length (FWHM)	8-10 ps	7-8 ps
With compression	1 ps	0.2-0.5 ps
Emittance	5 mm x mrad	< 2 mm x mrad
Charge	200 pC	1-2 nC