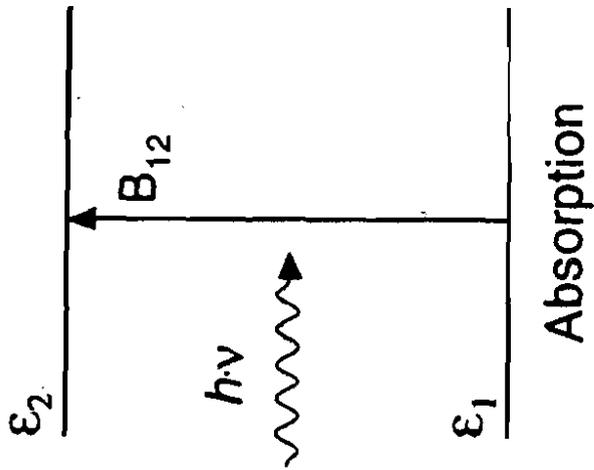


Prof. Dr. C. von Borczyskowski

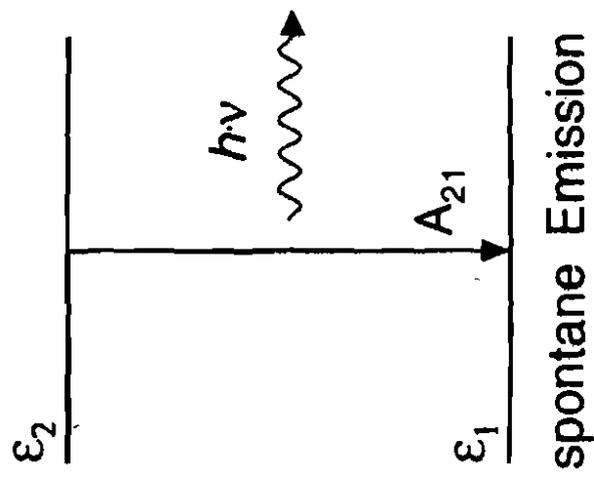
Aspekte der modernen Optik

Vorlesung vom 10.06.2010

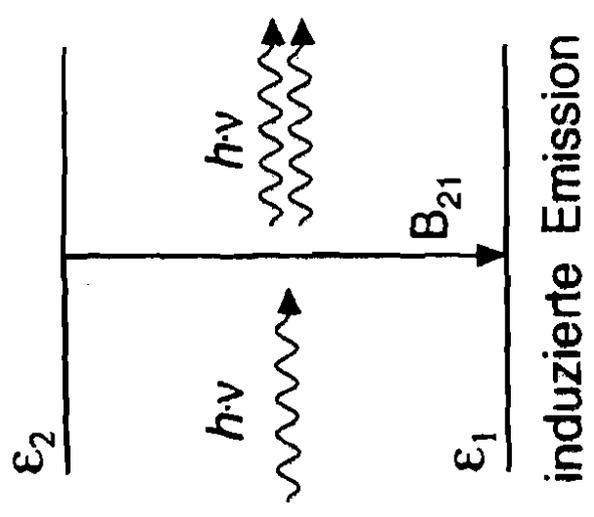
...



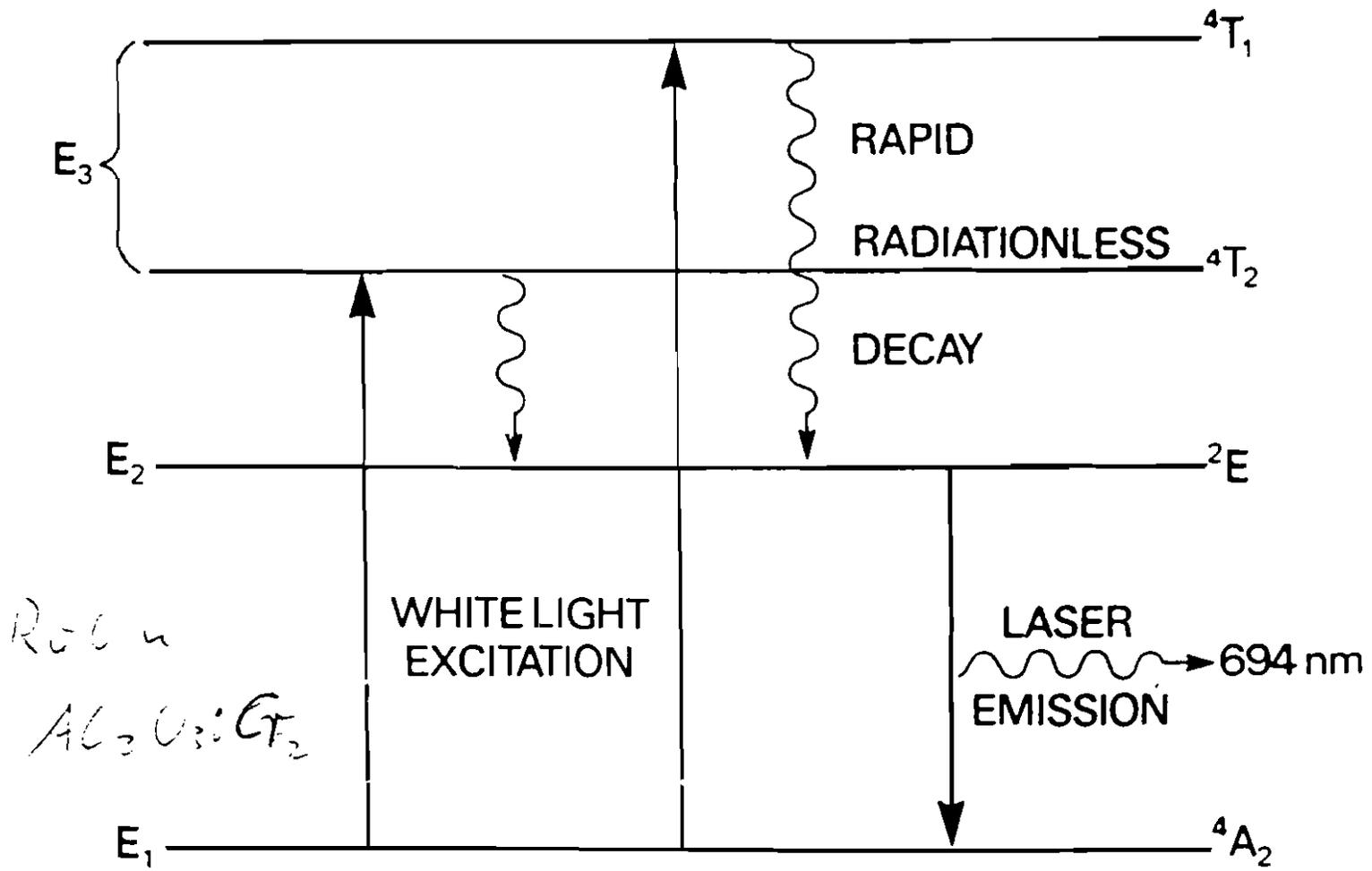
Absorption



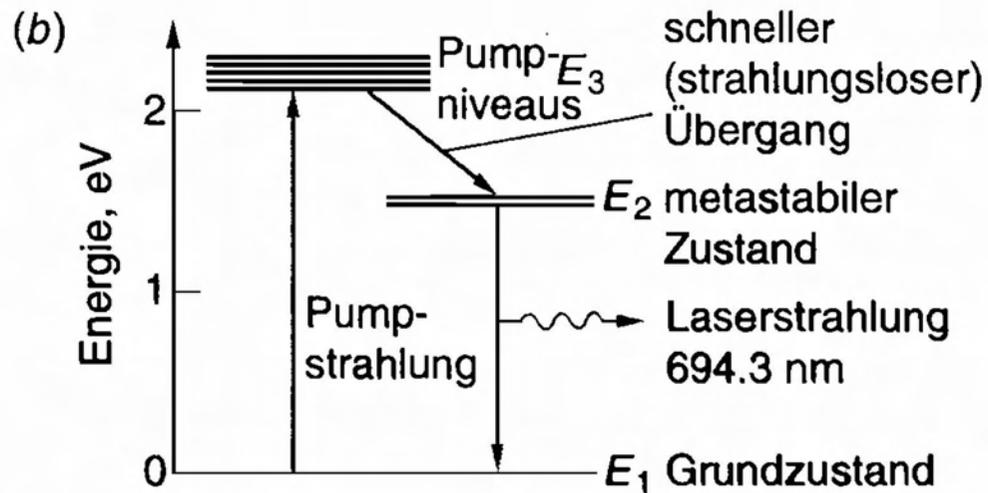
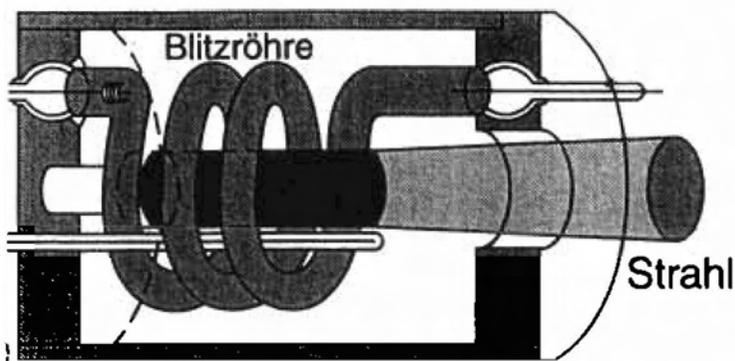
spontane Emission



induzierte Emission



Roll n
 $Al_3O_3:Cr^{2+}$



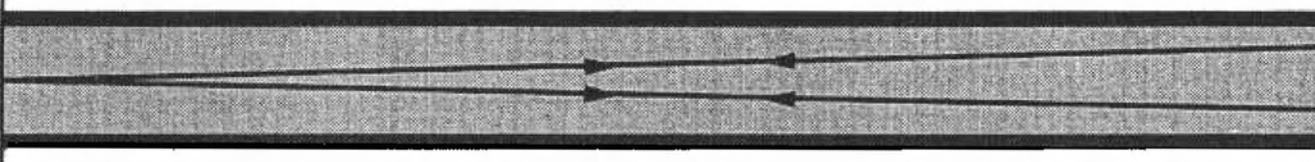
(a) Konstruktionsschema des ersten Rubinlasers. (b) Energien der im Rubin (Al_2O_3) enthaltenen

Rückseite

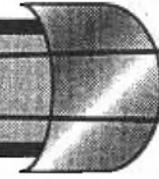


ebener Spiegel
reflektiert 99.9%

Laserröhre

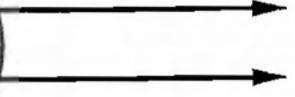


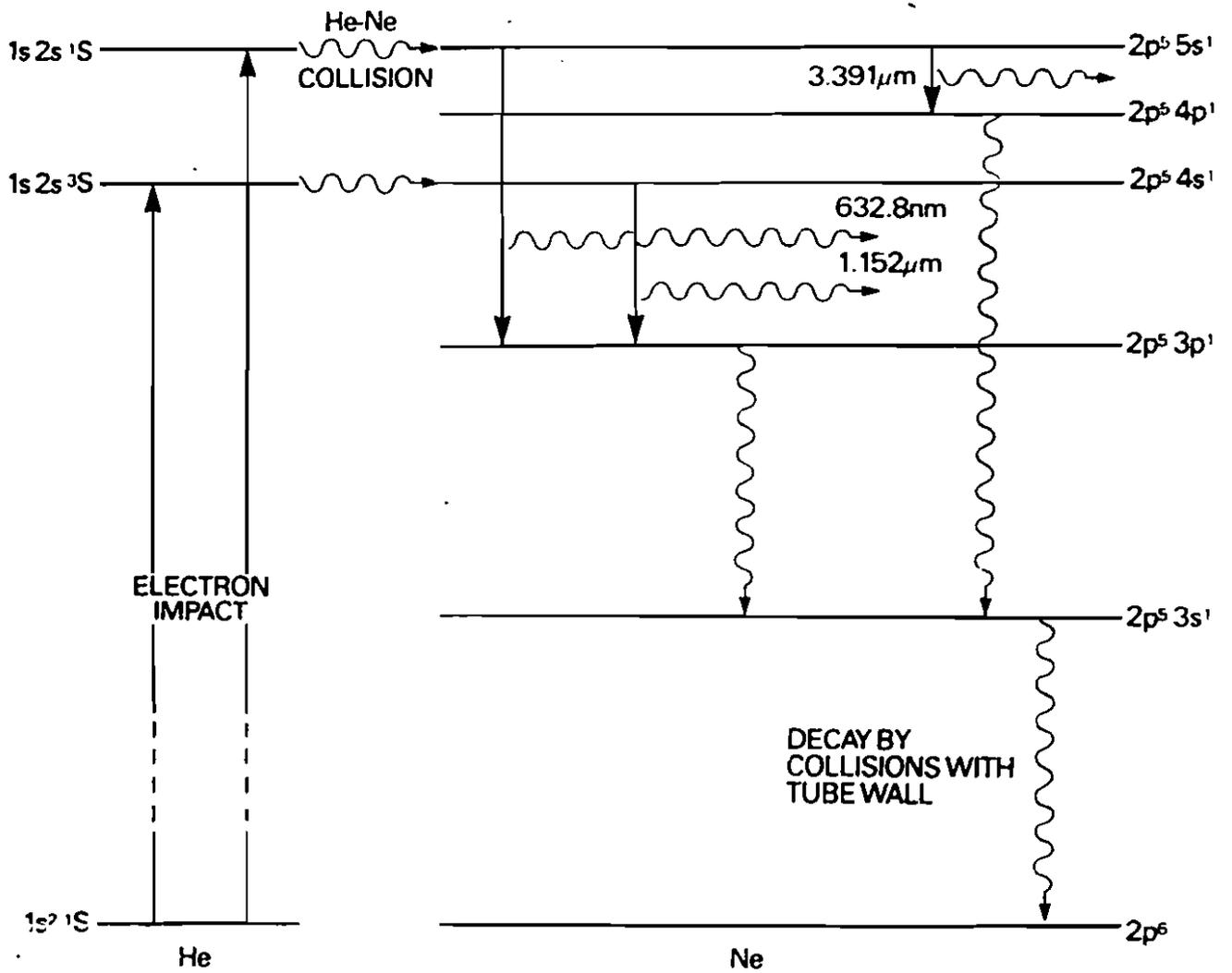
Vorderseite



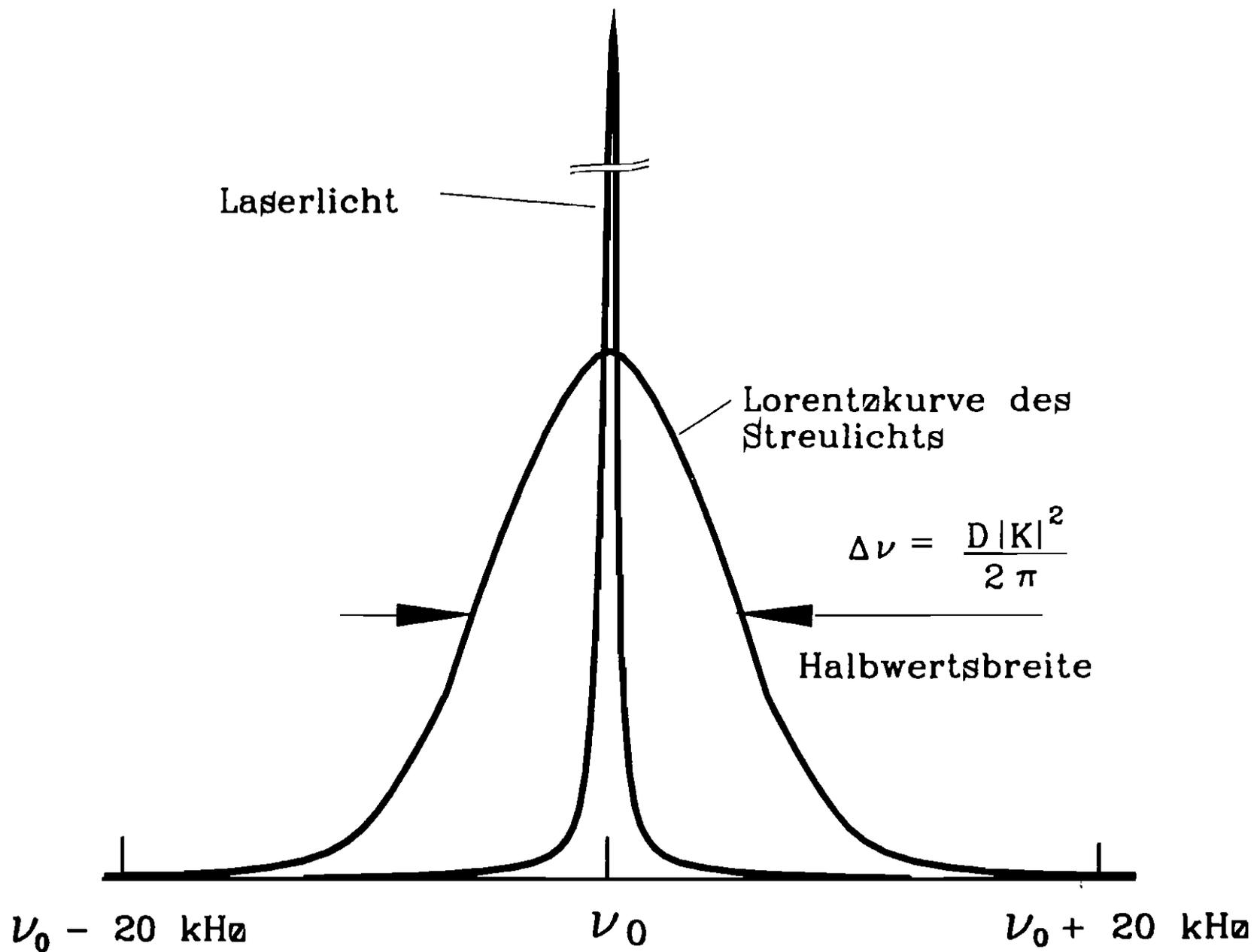
konkaver Spiegel
reflektiert 99%,
läßt 1% durch

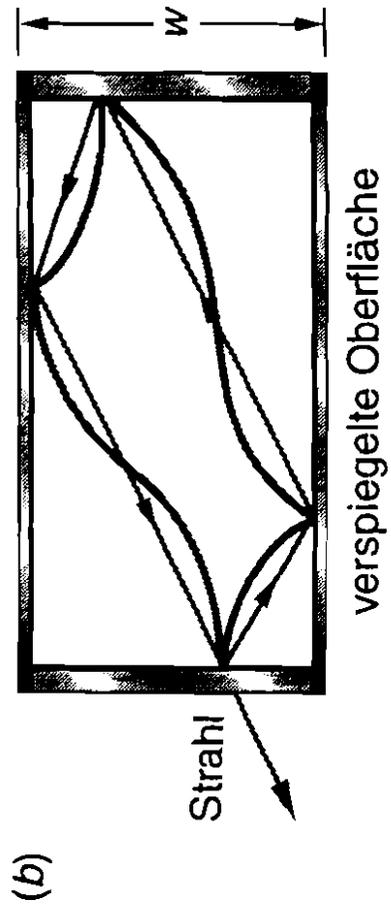
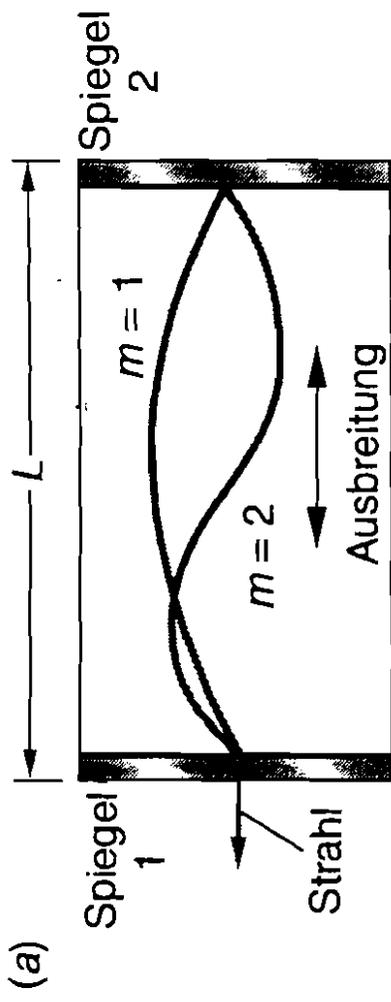
paralleler
Laserstrahl

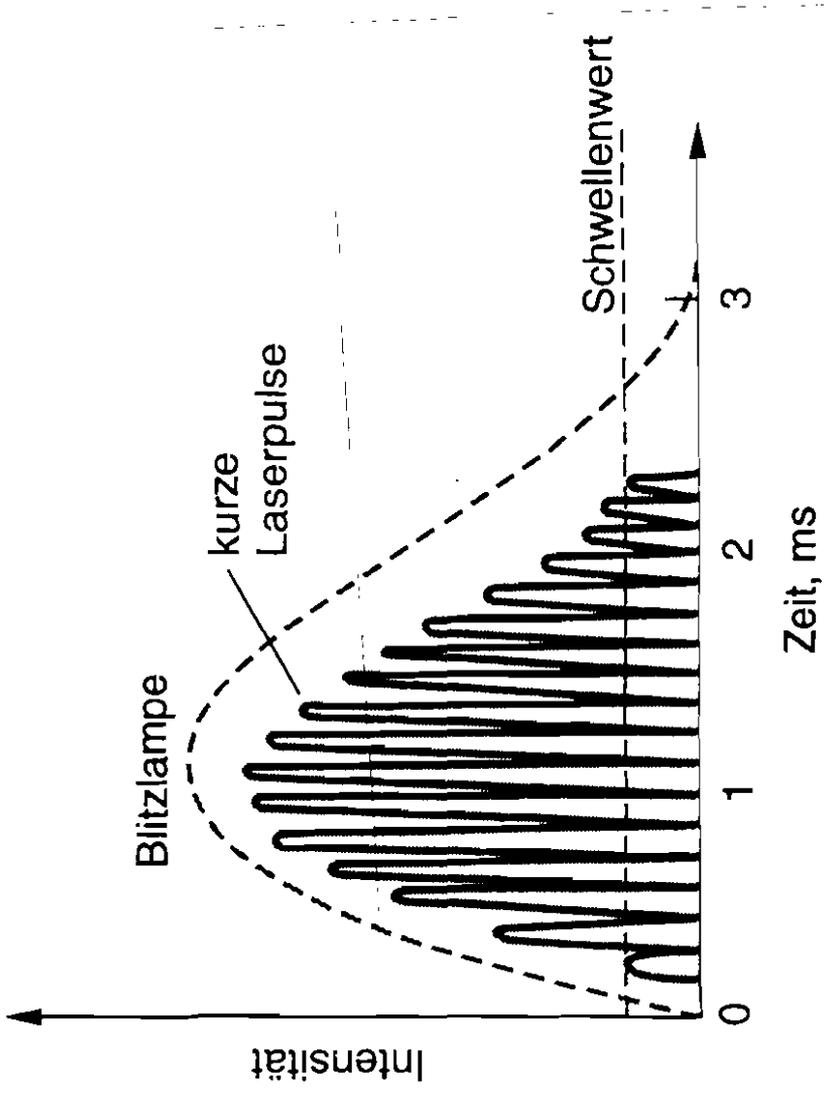


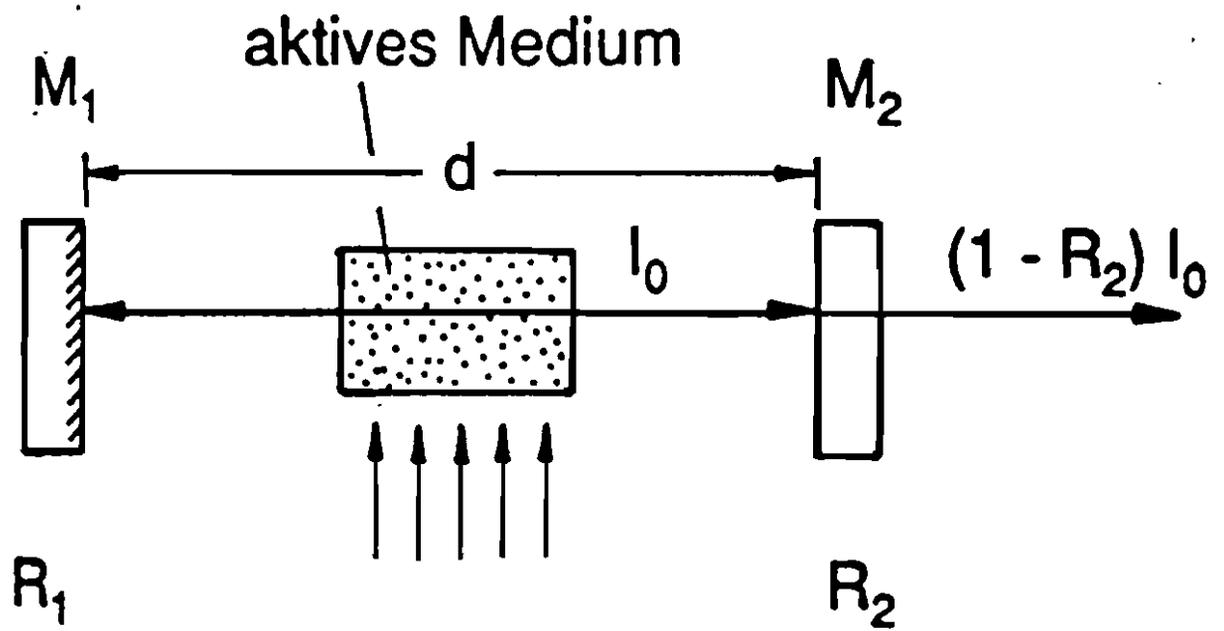


helium-neon laser

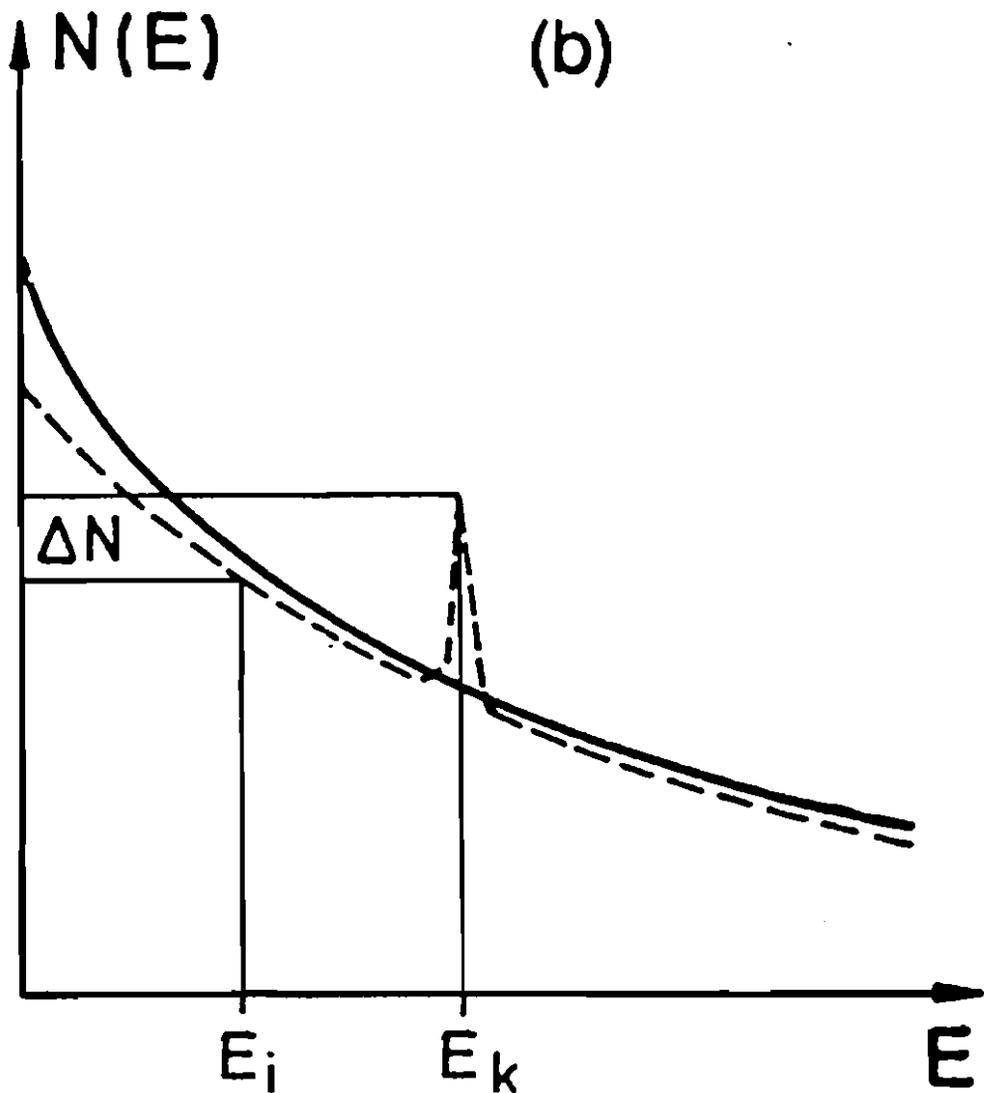








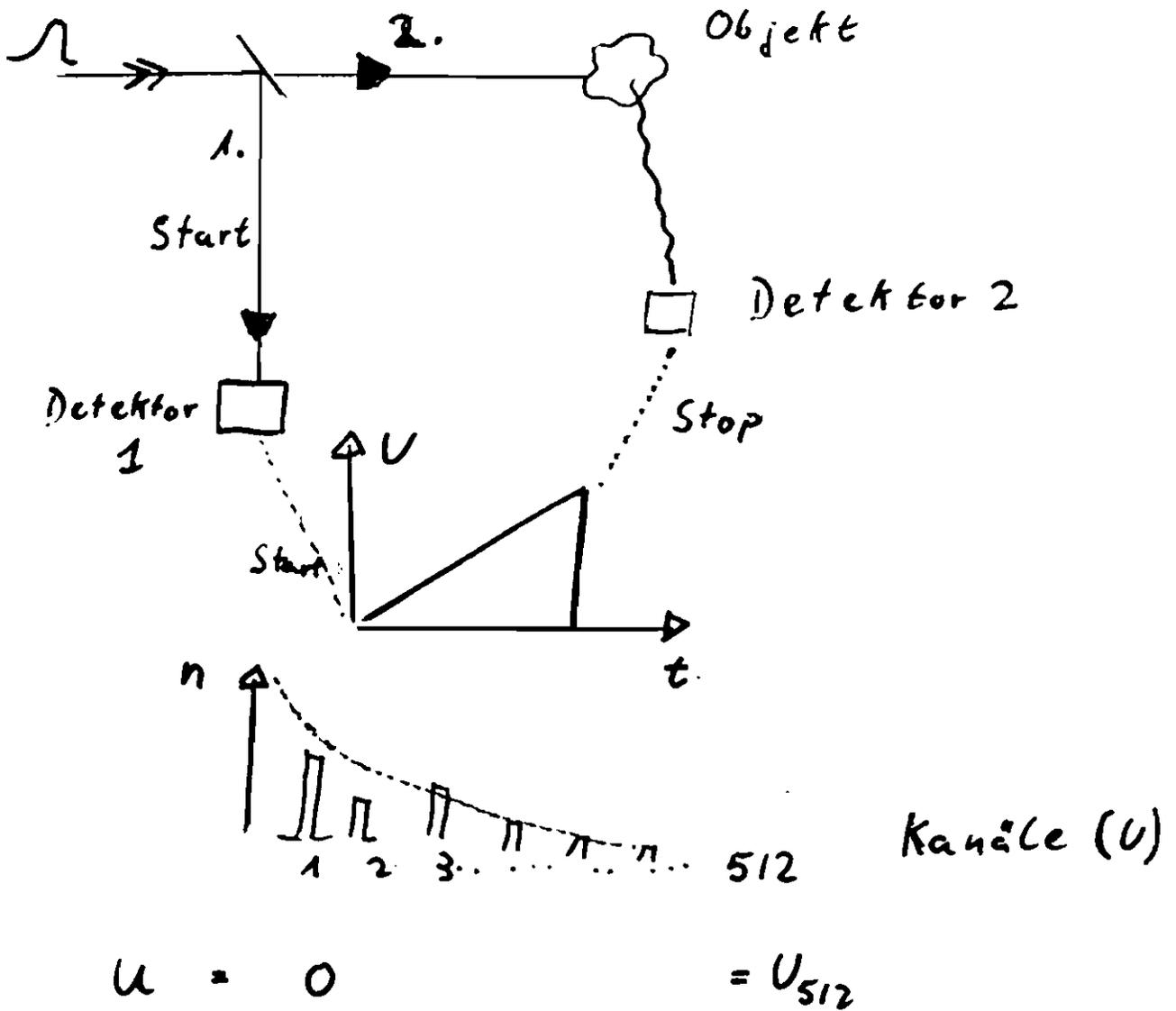
Selektive Energie-
pumpe



Zeitkorrekturtes - Einzelphotonen zählen

$$\Delta t > 20 \text{ ps}$$

$$1 \text{ ps} = 10^{-12} \text{ s}$$



OPERATING PRINCIPLE, FUNCTIONS AND PERFORMANCE

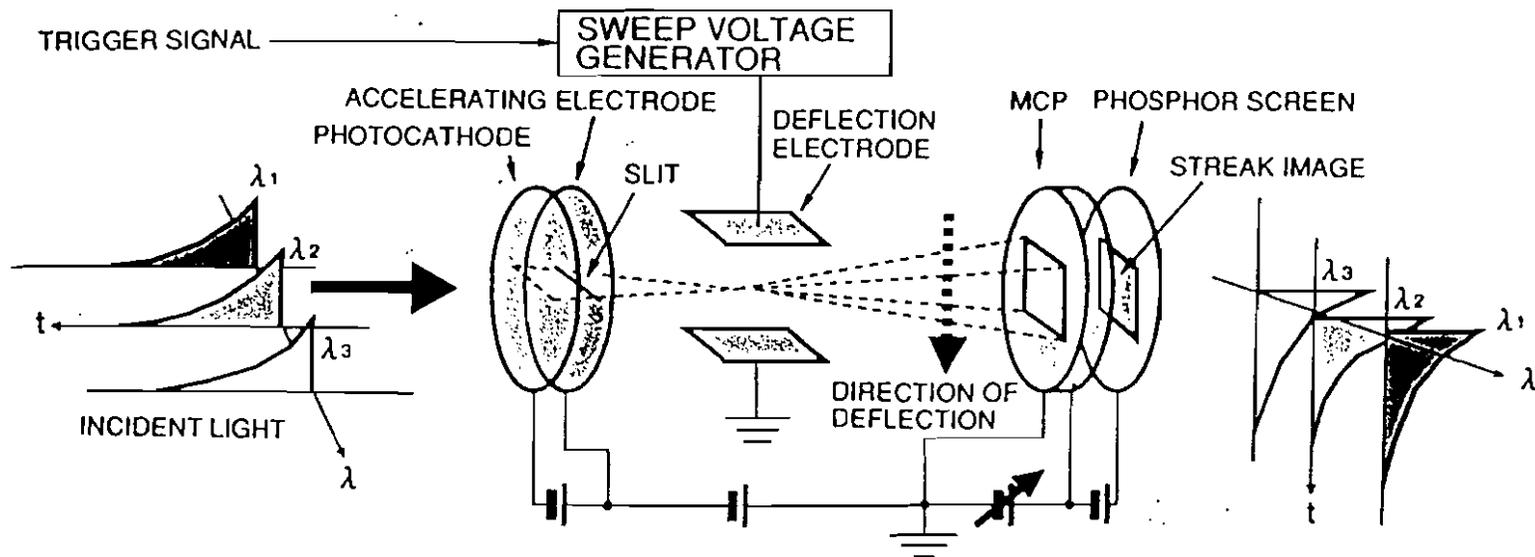
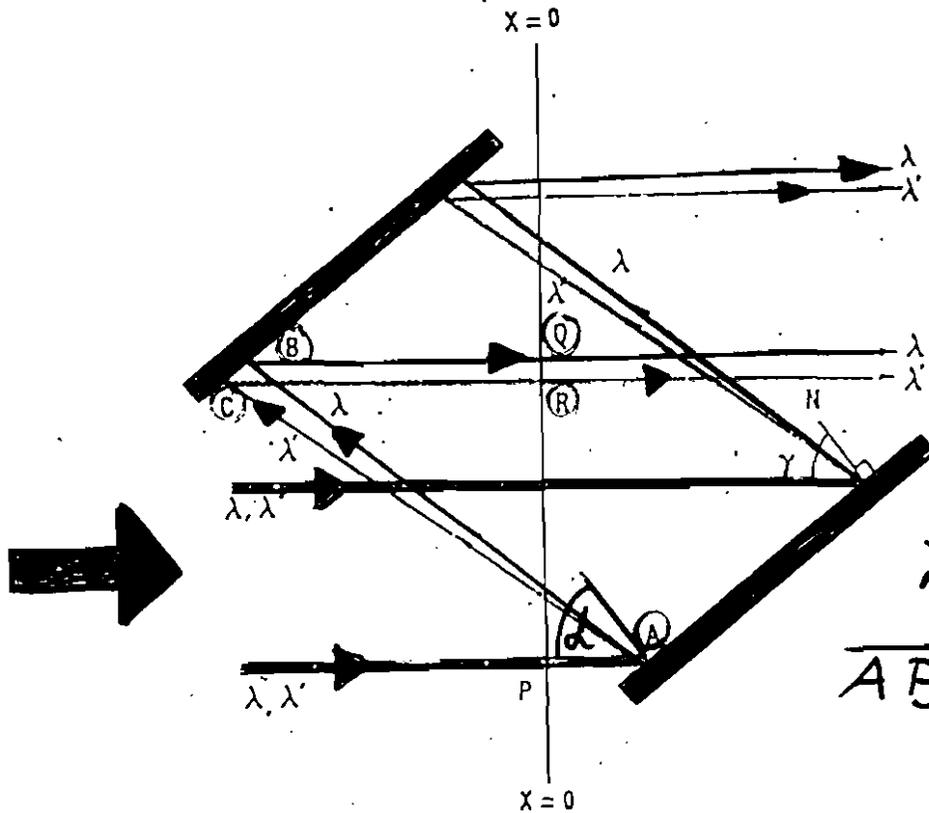


Figure 1: Operating Principle of Streak Tube

Pulskompression durch Beugungsgitter

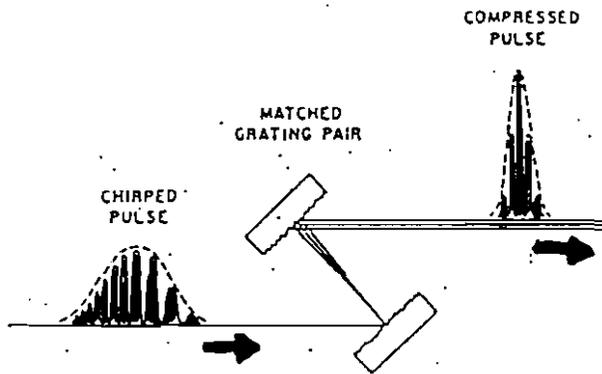
E. B. Treacy 1969



$$\lambda < \lambda' \rightarrow$$

$$\overline{ABQ} < \overline{ACR}$$

$$\sin \beta = \lambda / a$$



Leistung
↓

Faserlänge
↓

Gitterabstand
↓

τ_0 (ein)	P	z_{opt}	b	τ (out)
60 fsec	10 kW 100 kW	~3.1 cm 4.8 mm	1.9 mm 0.30 mm	24 fsec 12 fsec

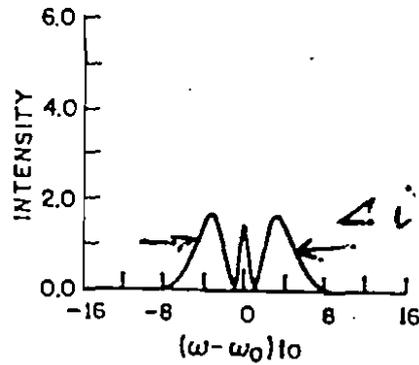
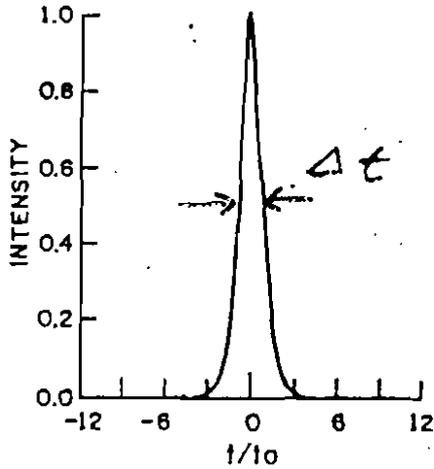
$$\lambda = 600 \text{ nm}$$

$$a = 3.6 \mu\text{m}$$

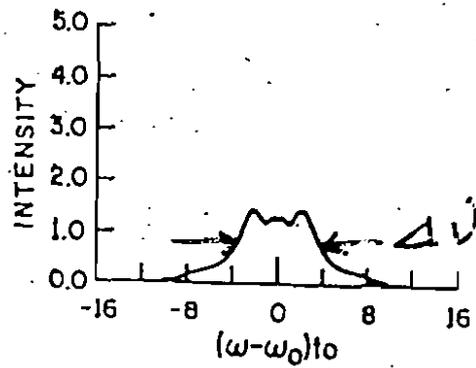
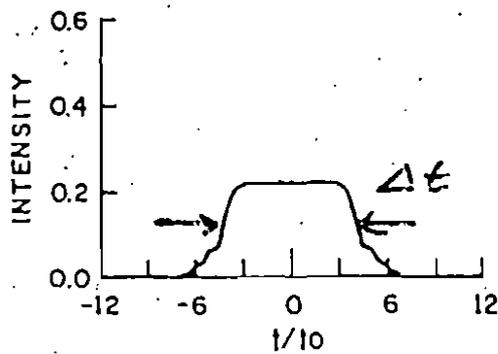
$$d = 1800 / \text{mm}$$

Puls-Chirp

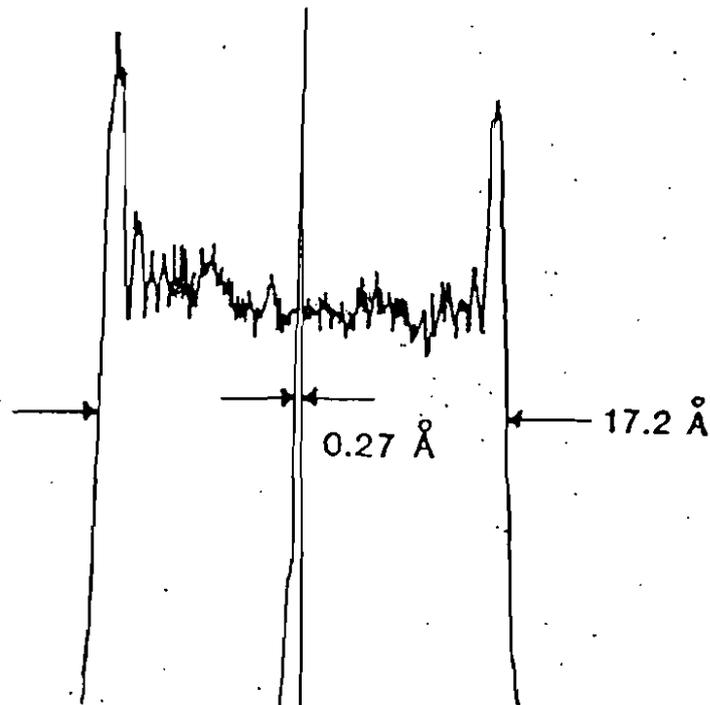
ohne Dispersion



mit (normaler) Dispersion



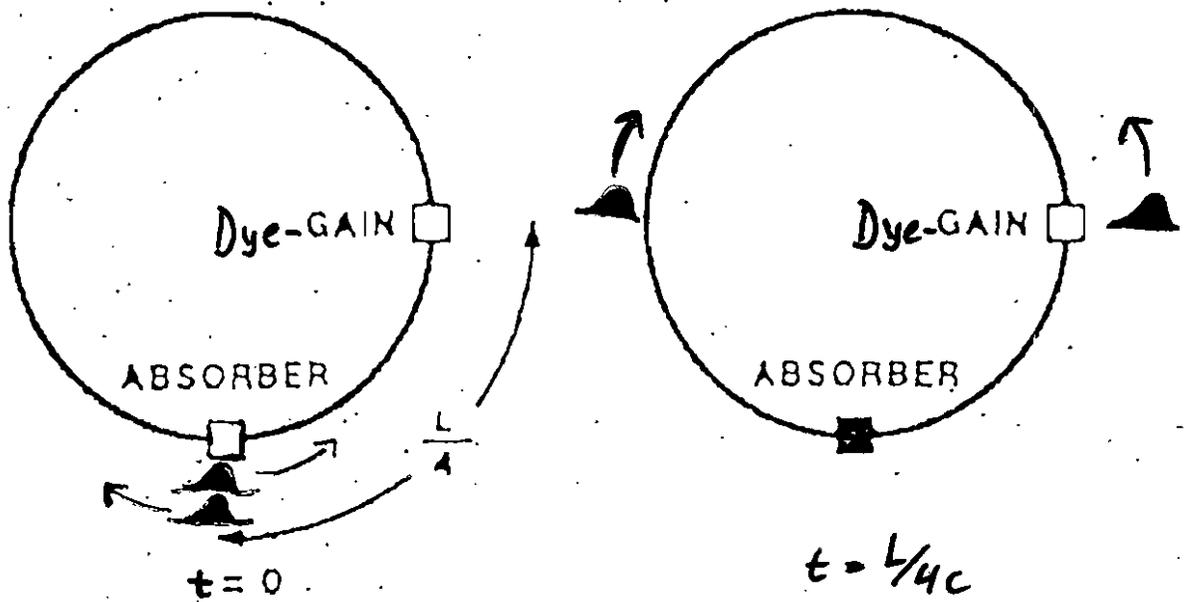
Experiment 512 nm



Colliding-Puls Modenlocken

Shank et al 1981

Ringlaser

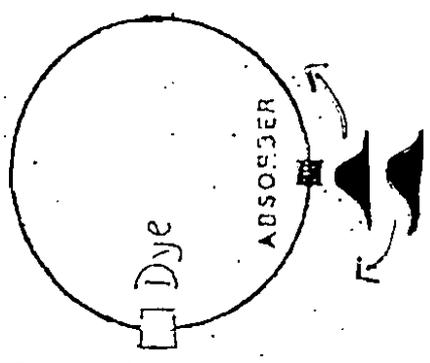


27 fs Fork et al 1985

Pump Laser

Argon 514nm
YAG 532nm

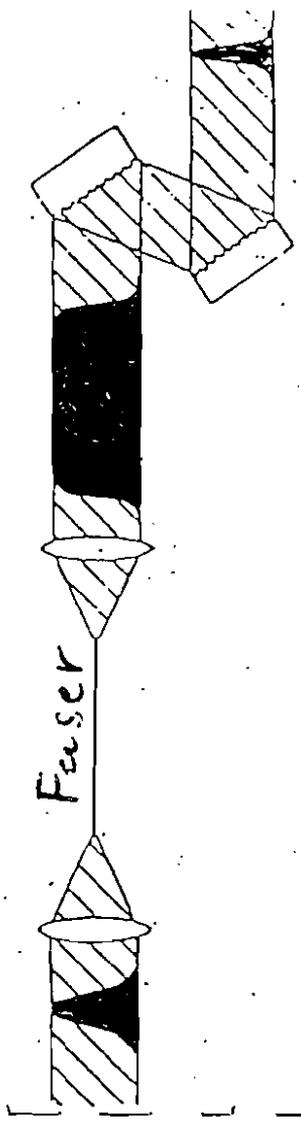
Colliding-Puls
Ring Laser



27 fs

Forst et al. 1998

Pulskompression



30 fs Shank et al. 1992

16 fs T. Papp et al. 1994

12 fs Harcourt et al. 1998

8 fs Shank et al. 1994

6 fs Shank et al. 1994

Shank et al.

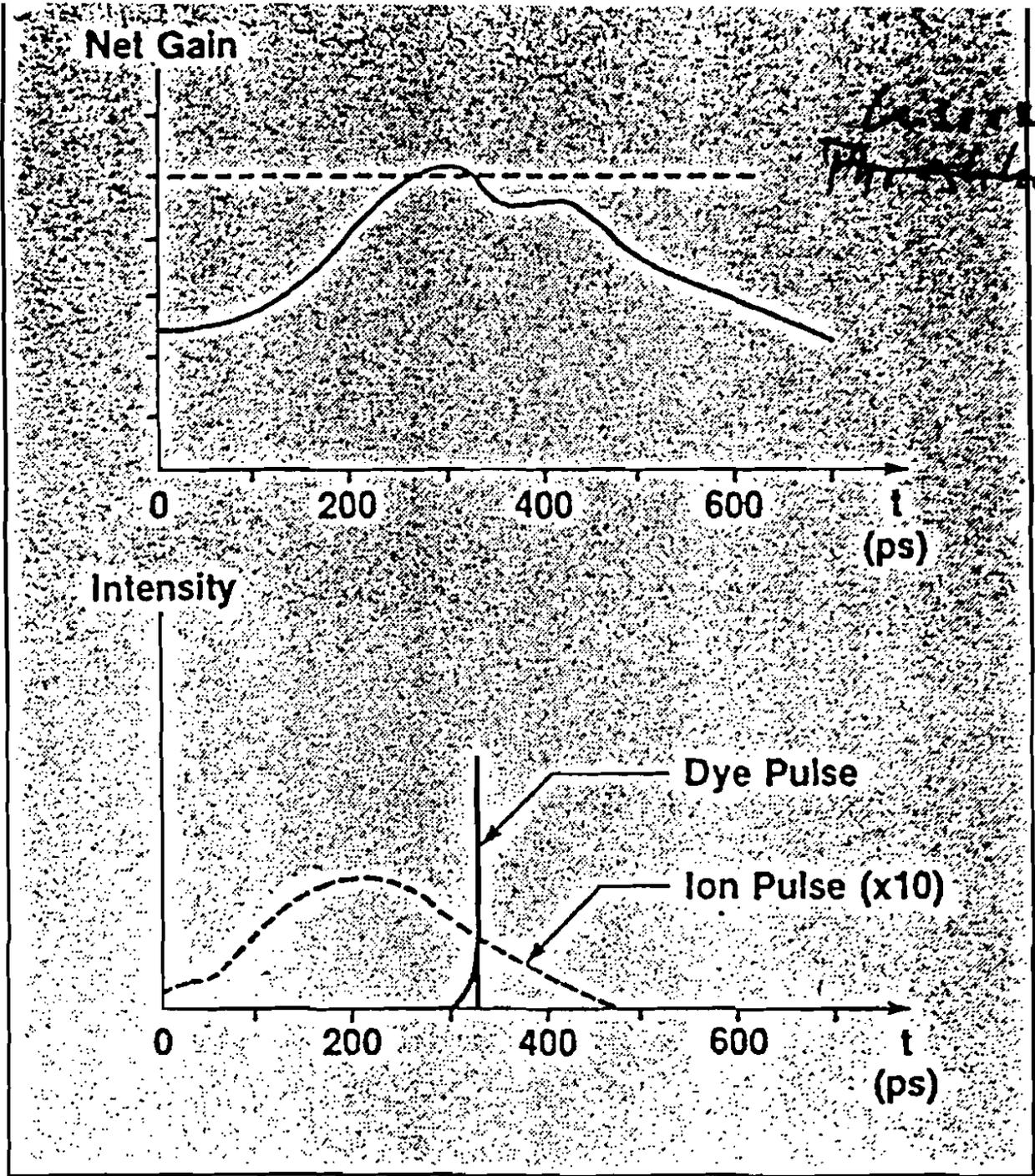
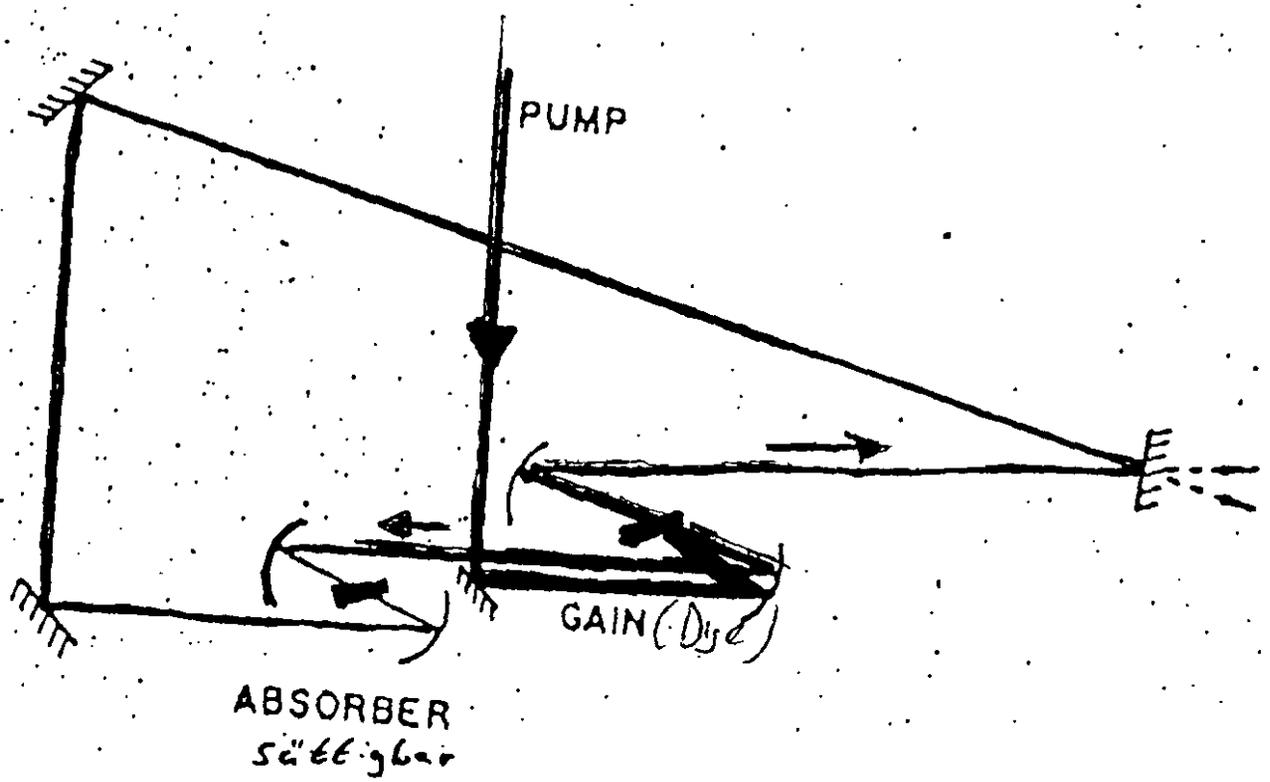
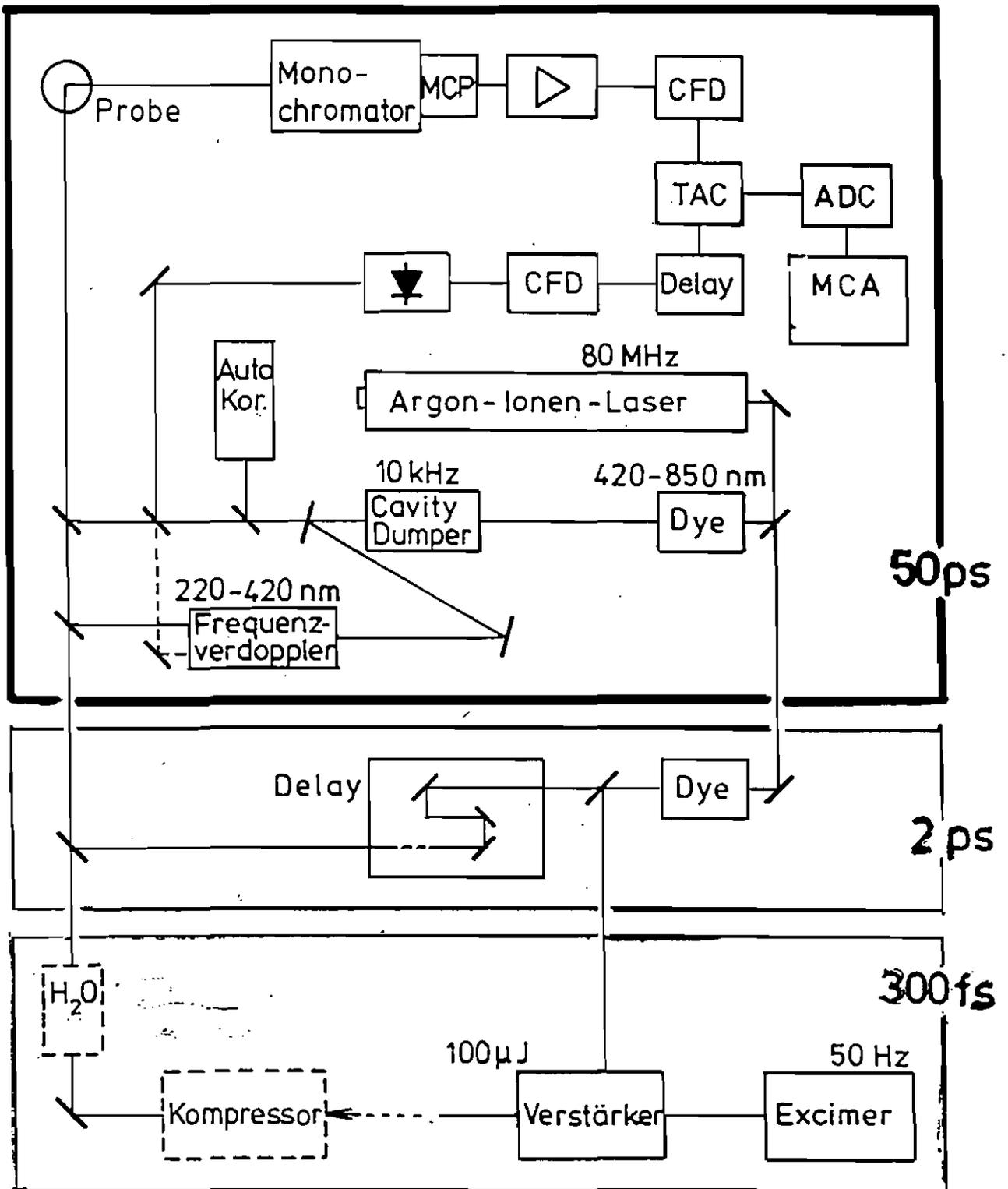
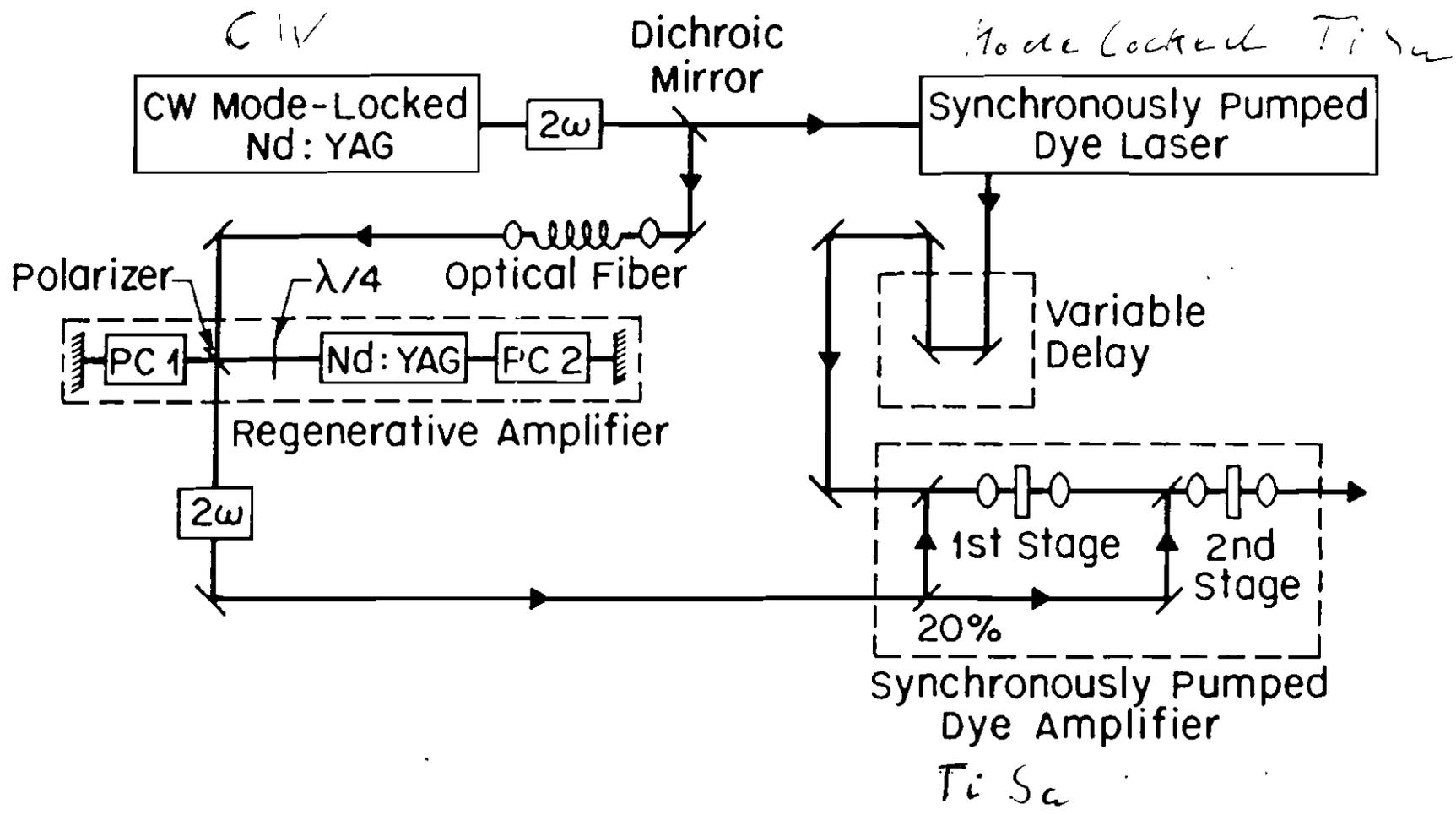


Figure 7. Pulse shortening in the synchronous pumping process.

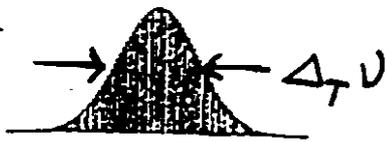




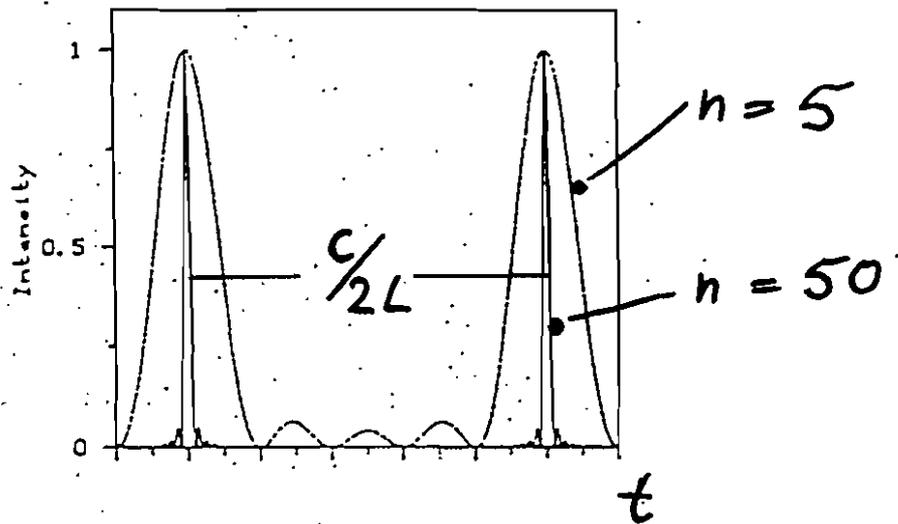
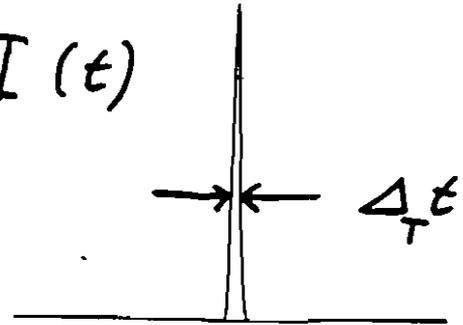


Transformationslimitierte Pulsbreiten

$I(\nu)$



$I(t)$



$$\Delta t \Delta \nu \geq \Delta_T t \Delta_T \nu \geq \frac{1}{2\pi}$$

Gauss: 0.441

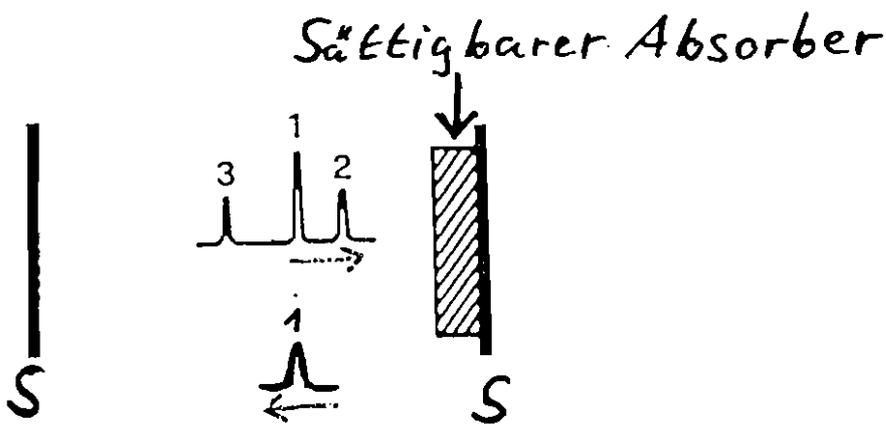
$$\delta T = \frac{2L}{mc}$$

$$\Delta \nu (\text{max}) \approx 20 \text{ nm}^{-1} \hat{=} 540 \text{ cm}^{-1} \hat{=} 16 \text{ THz}$$

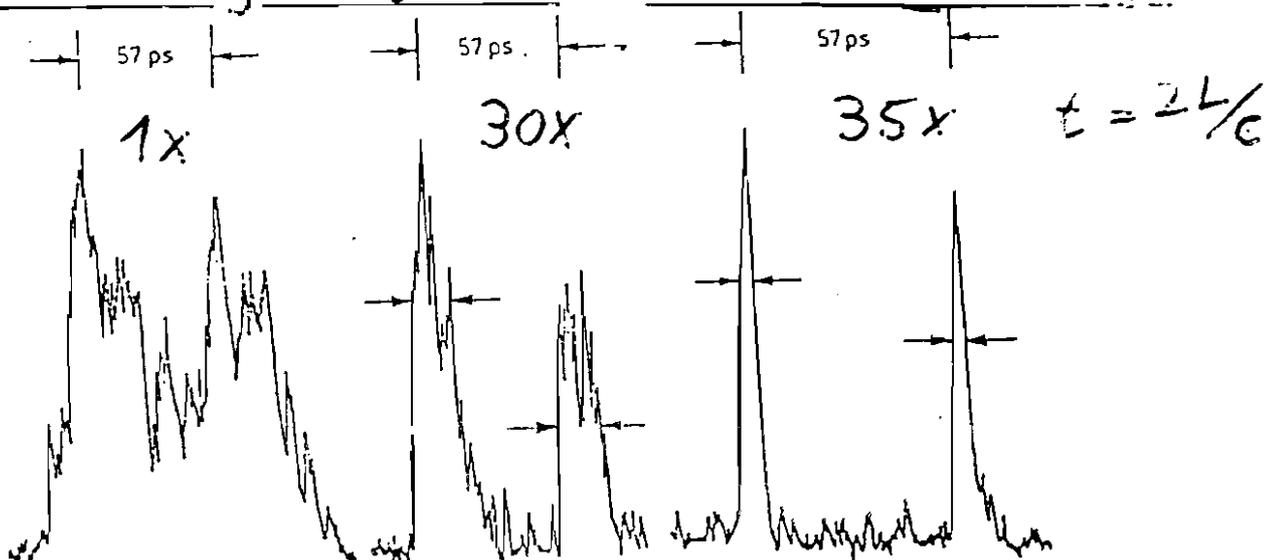
$$\Delta t (\text{min}) \approx 27 \text{ fs}$$

Modenlocken durch Güteschaltung

- aktives Modenlocken (100ps)
- synchrones Pumpen von Farbstofflasern (500 fs)
- passives Modenlocken



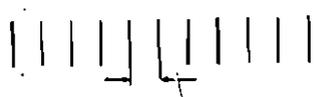
"Selbstorganisierte" Güteschaltung



Kontinuierlicher Laser

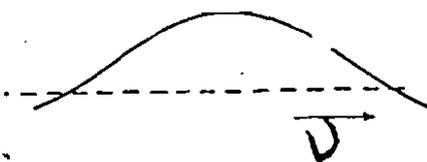
festgelegt
Fabry Perot Resonator: $\lambda / L \approx 10^{-7}$

Modenverteilung

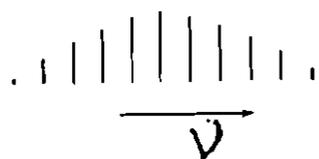


$$\Delta \nu = \nu_{n+1} - \nu_n = \frac{c}{2L}$$

Laserverstärkung

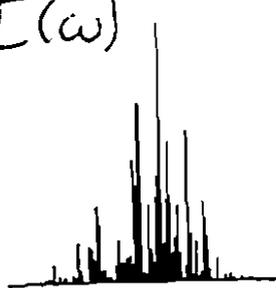


angeregte Moden



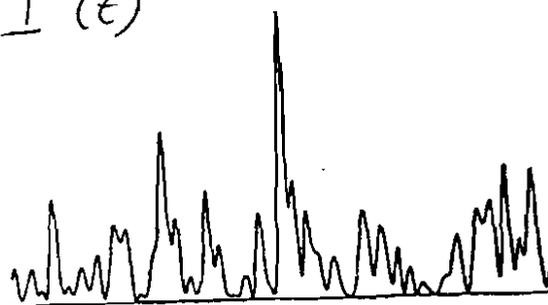
Spektrale Verteilung

$I(\omega)$



zeitliche Verteilung

$I(t)$



$$\rightarrow E(t) = \sum_{-n}^n \bar{E}_0 \exp\{i(\omega_0 + n \Delta \omega)t + n \Phi\}$$

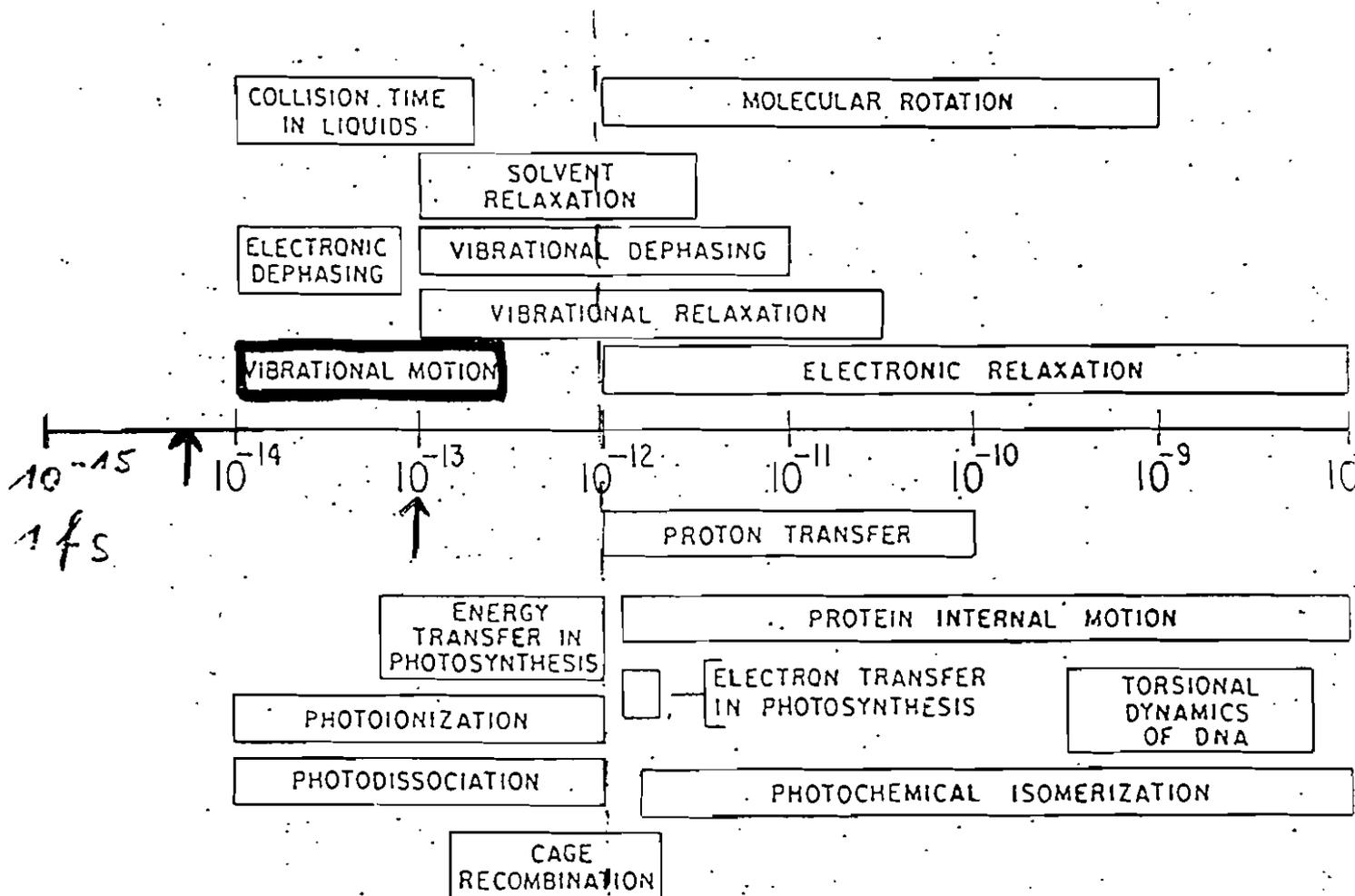
$$\bar{\Phi} = \bar{\Phi}_{n+1} - \Phi_n = \text{const.}$$

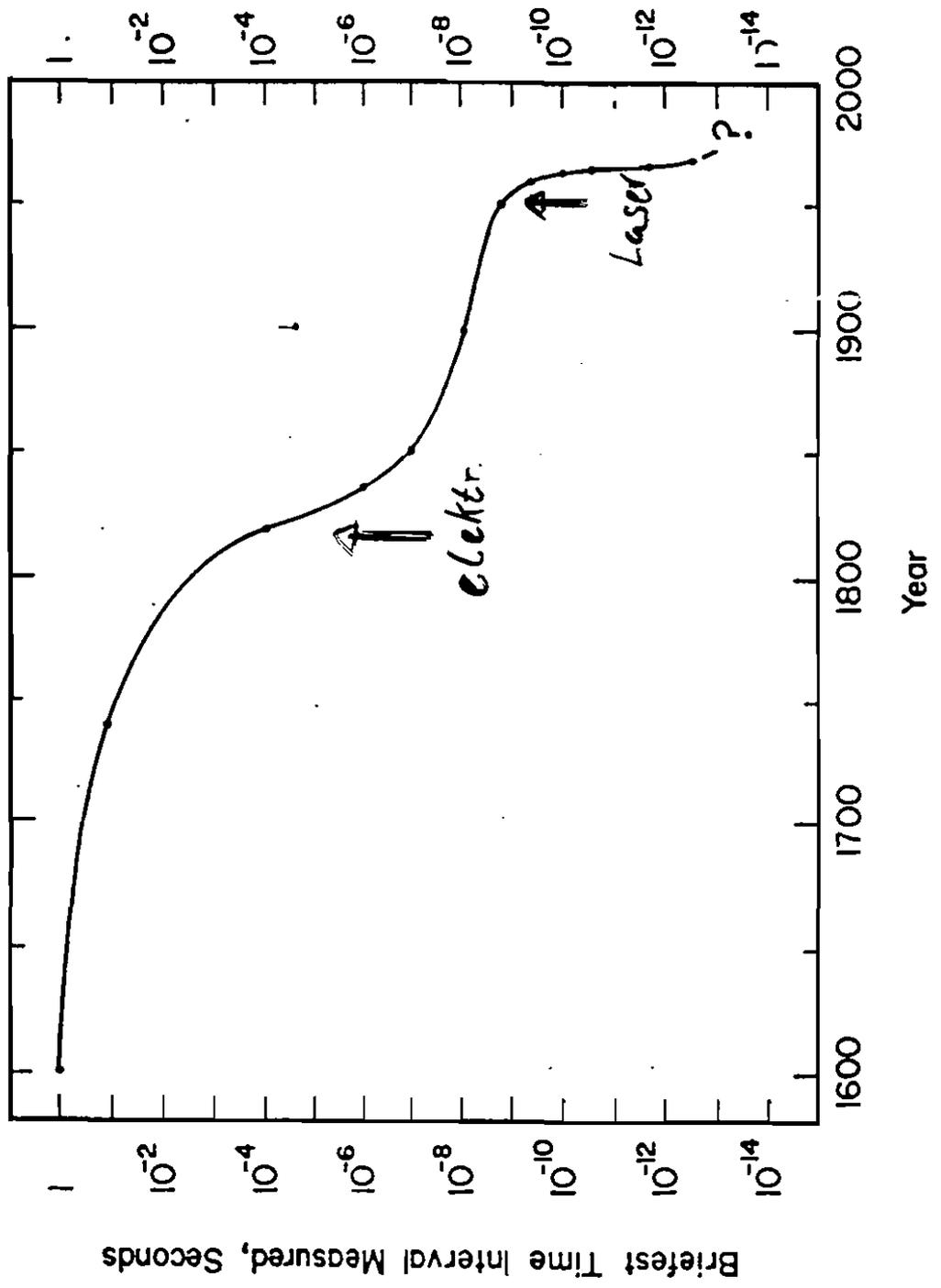
Femtosekunden-Spektroskopie

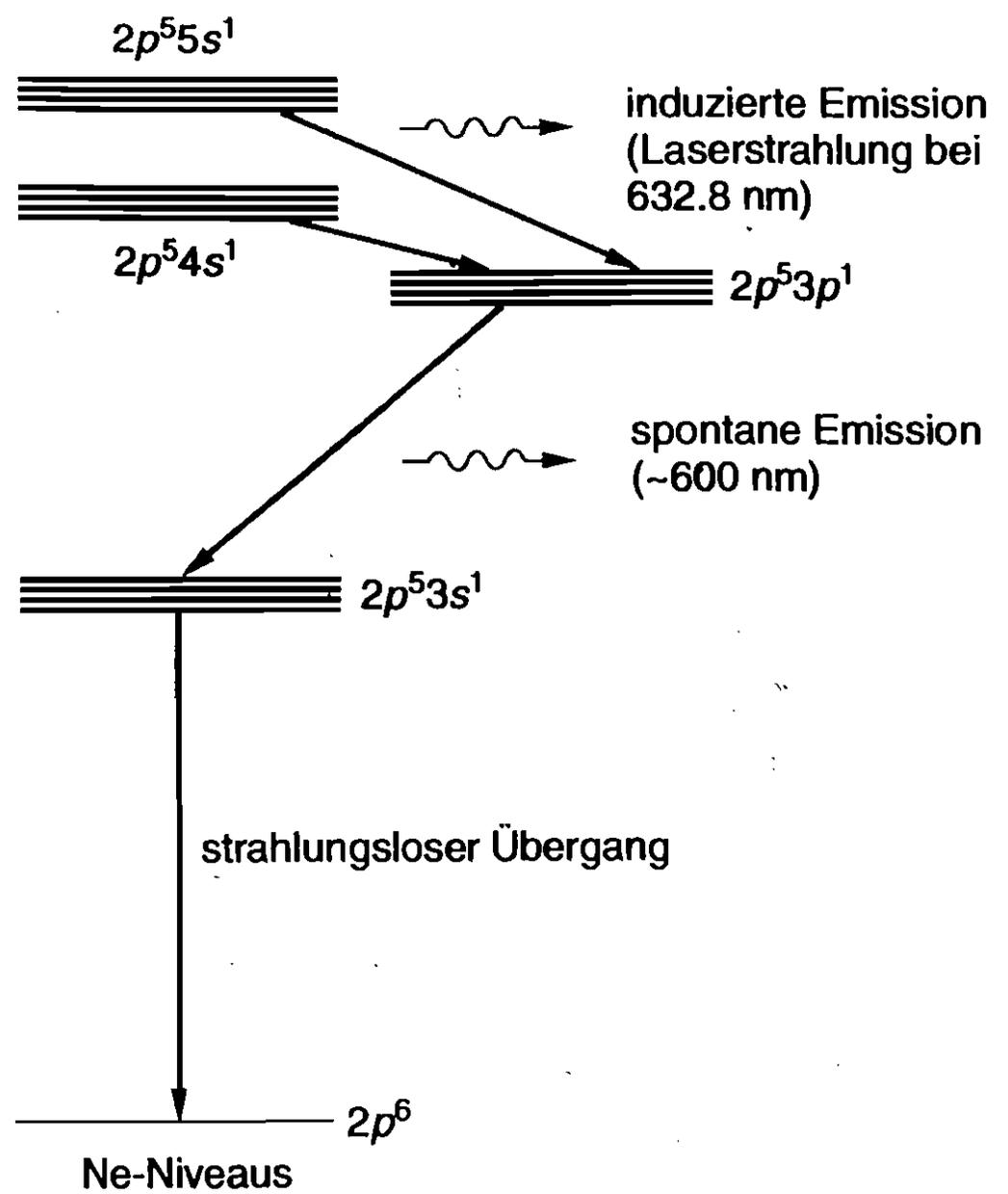
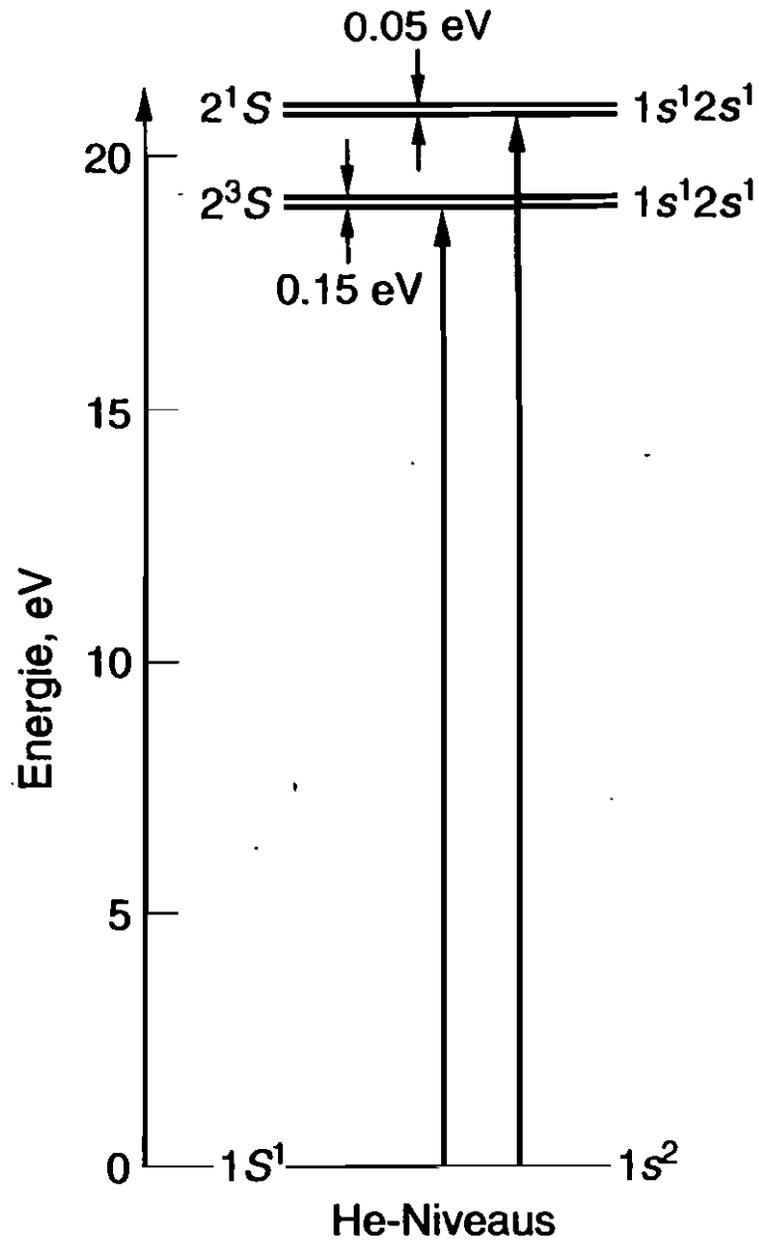
1. Femtosekunde $\hat{=} 10^{-15} \text{ s}$
 $\hat{=} 0.30 \mu\text{m}$

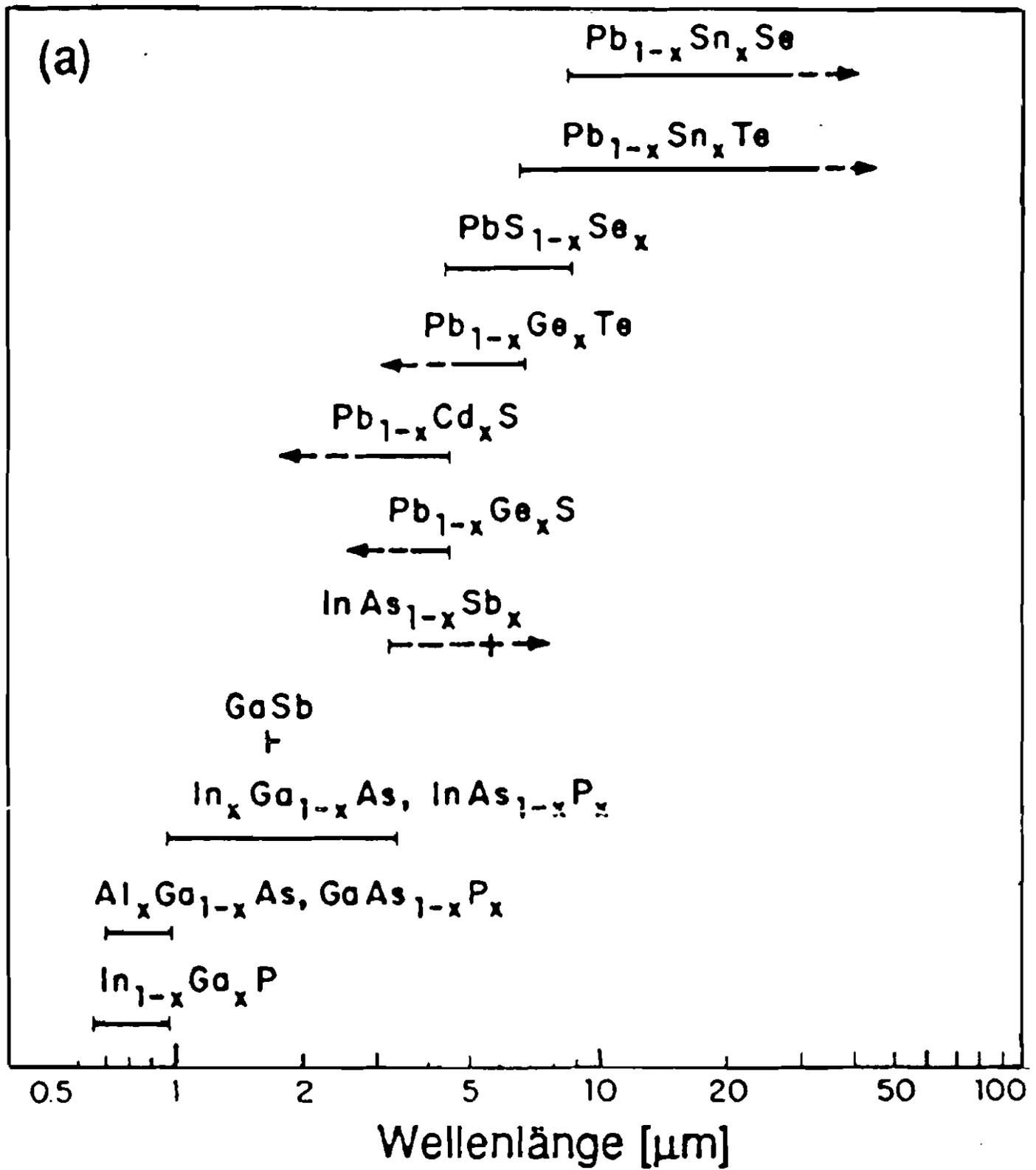
Schwingungsperiode rotes Licht: $2 \cdot 10^{-15} \text{ s}$
Julianerzeit: 1 fs

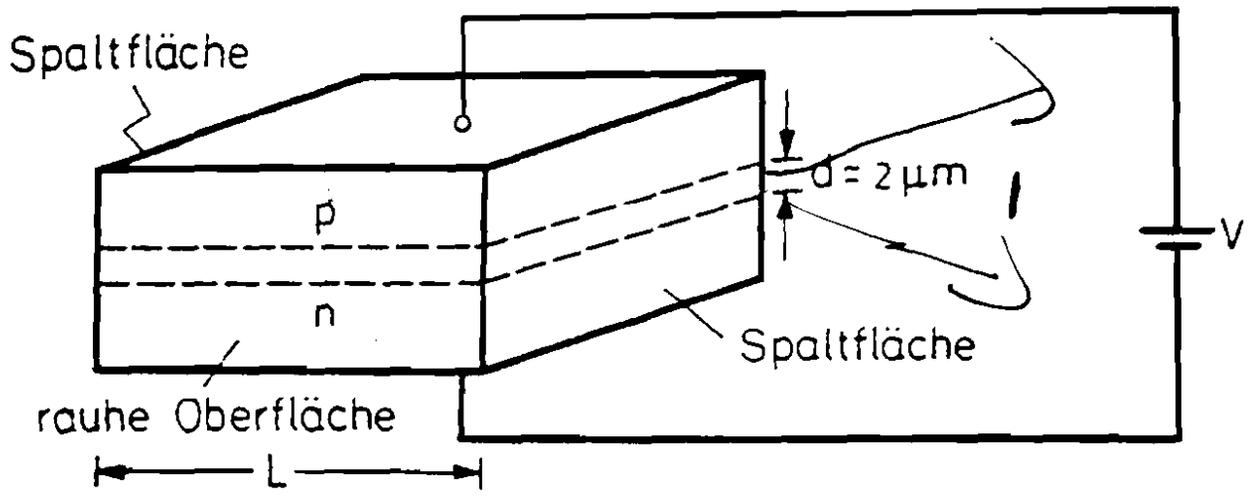
Bahnumlaufzeit eines Elektrons: $2 \cdot 10^{-16} \text{ s}$
 $(\tau = 2 \text{ \AA})$









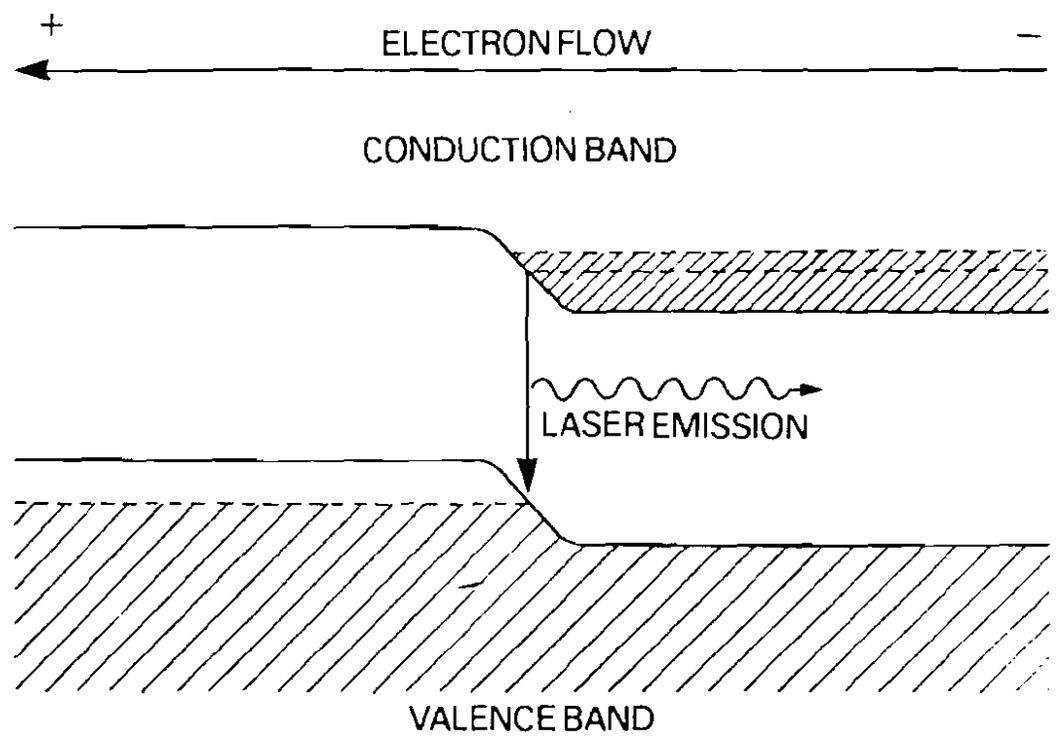


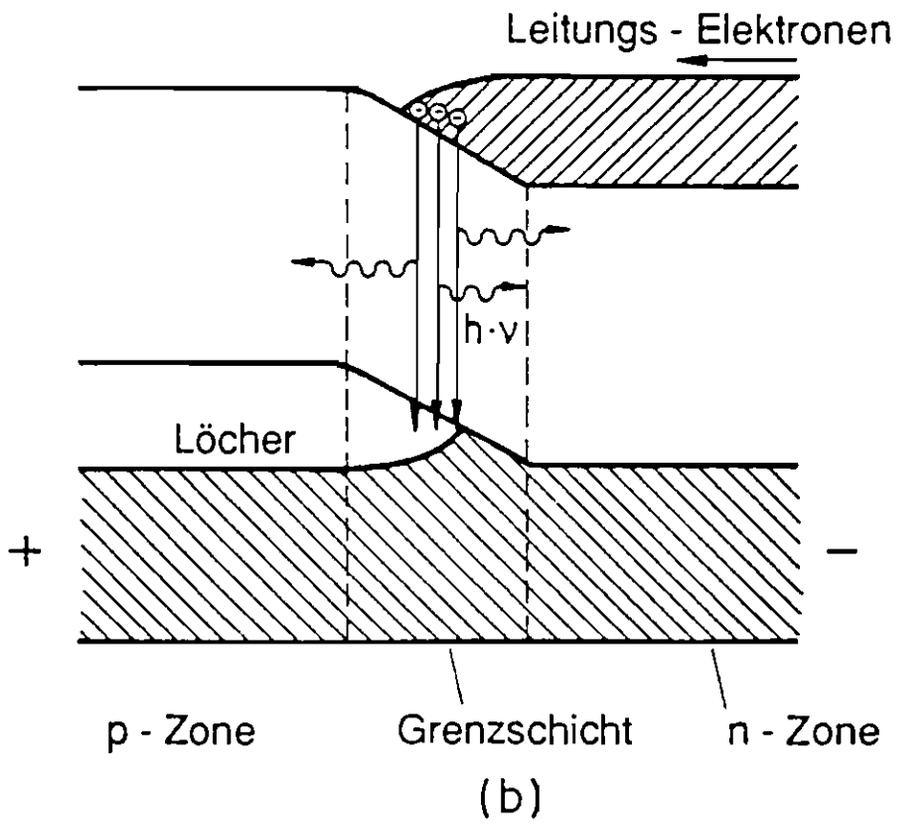
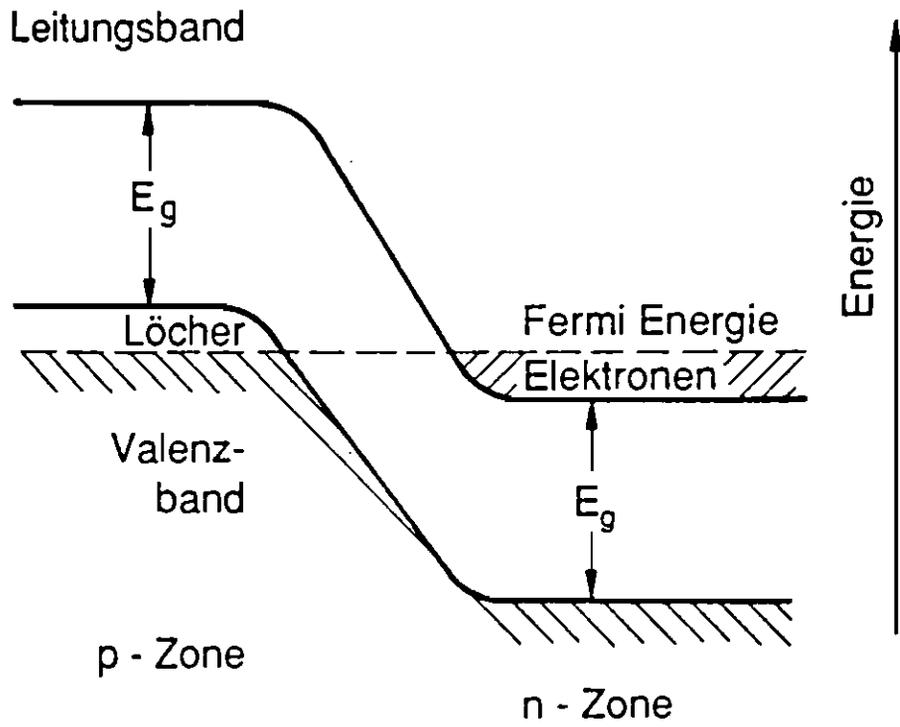
p-n-Übergangslaser Struktur

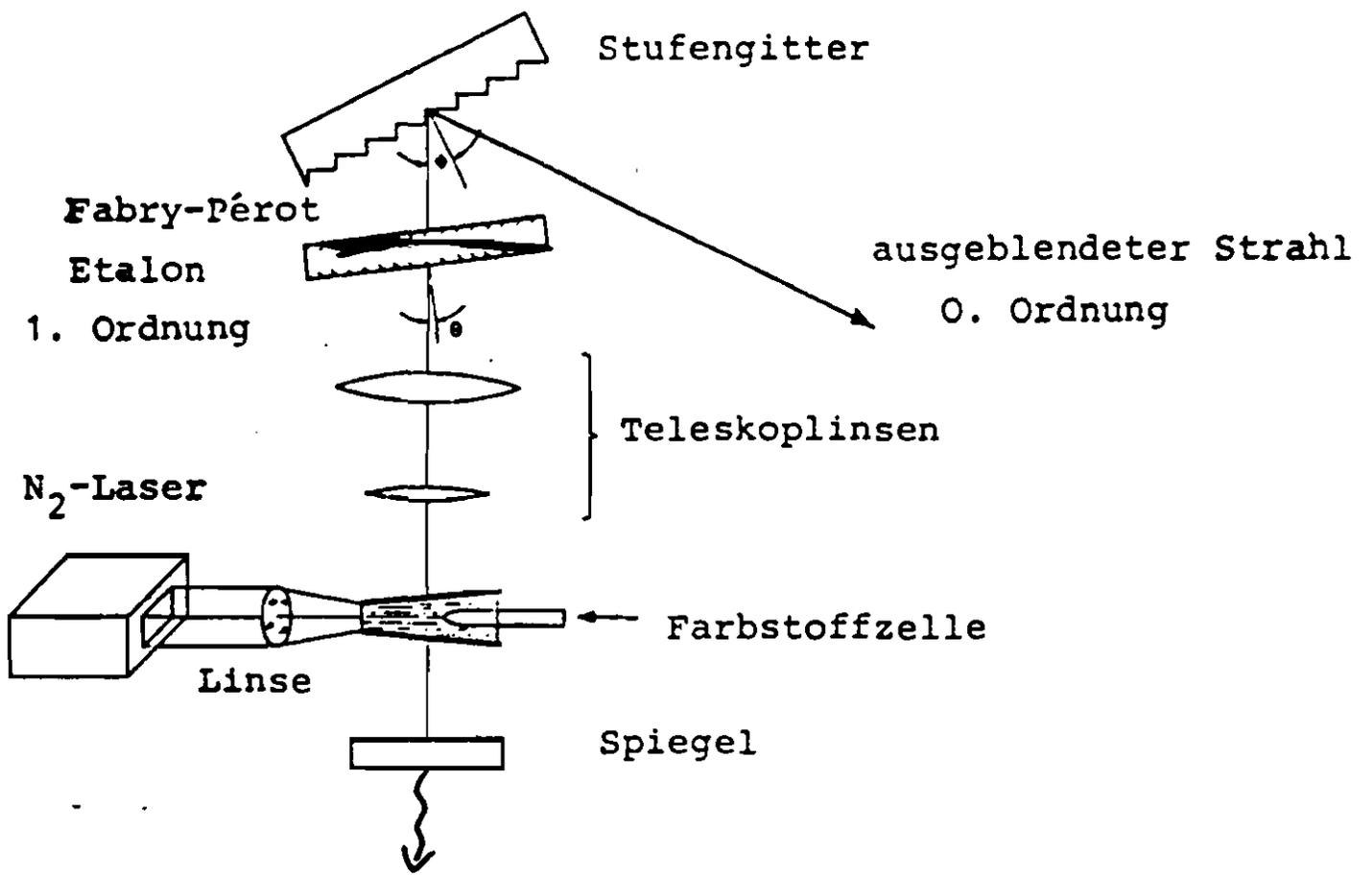
GaAs

0.904 μm

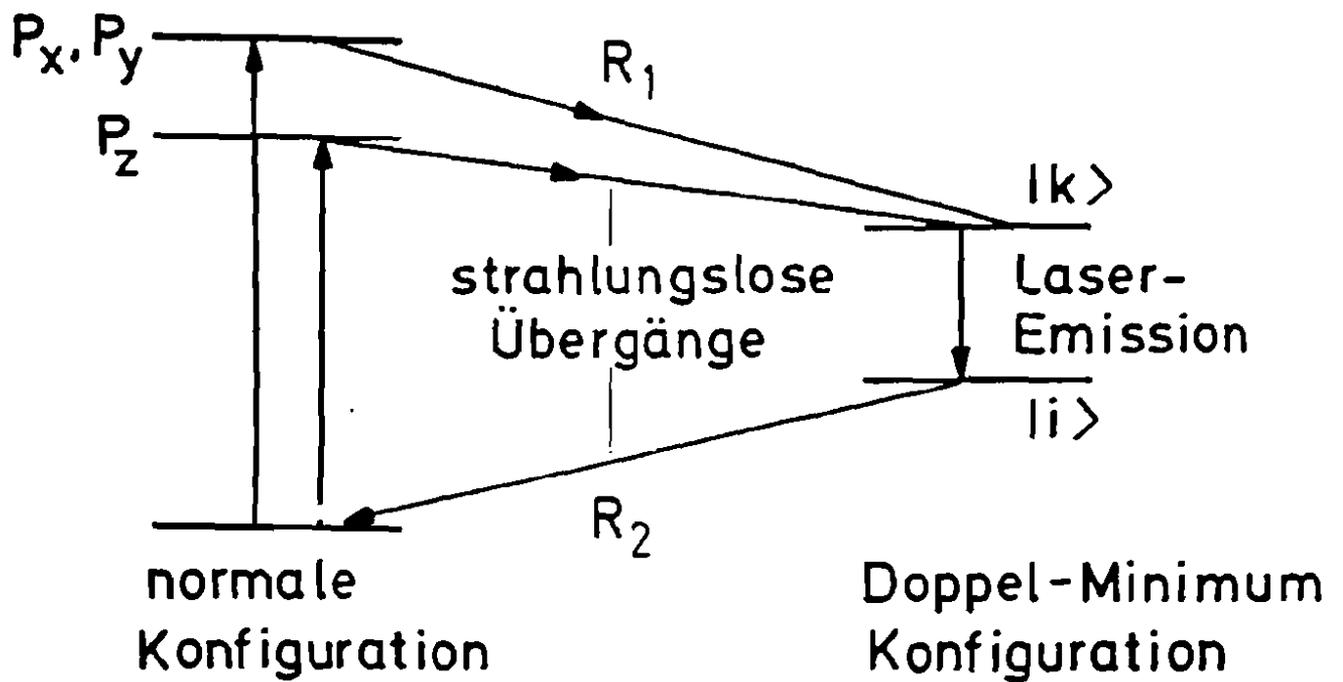
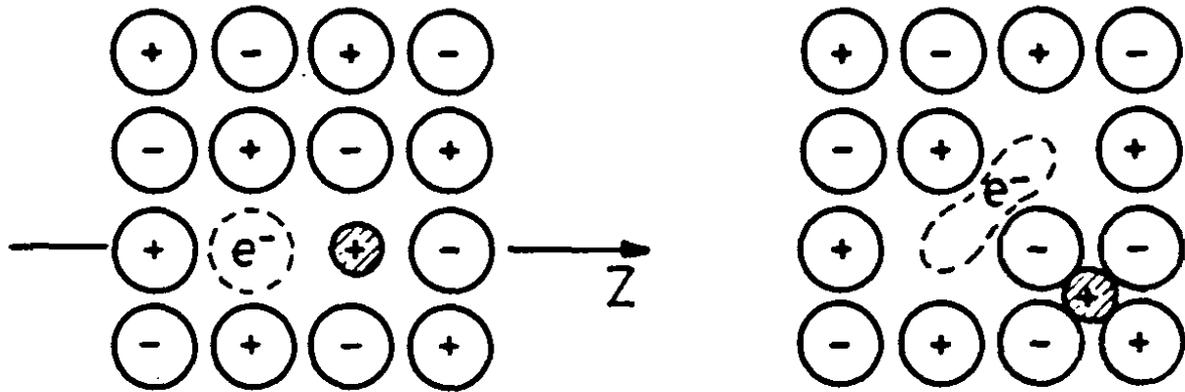
Semiconductor Laser





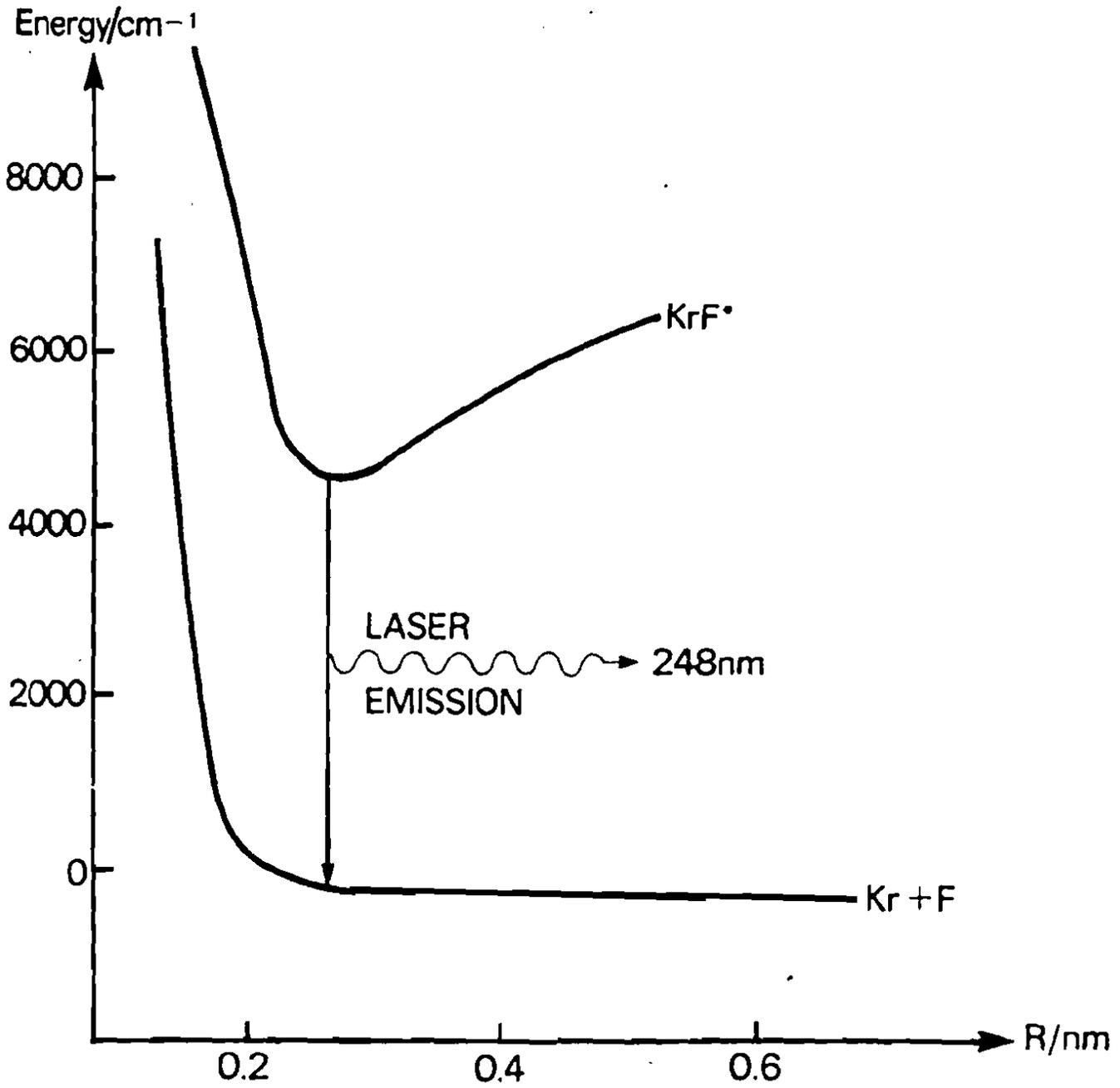


$F_A(II)$ -Zentrums



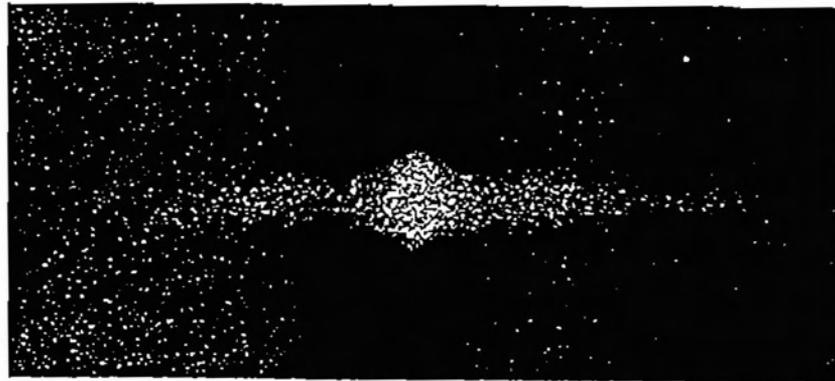
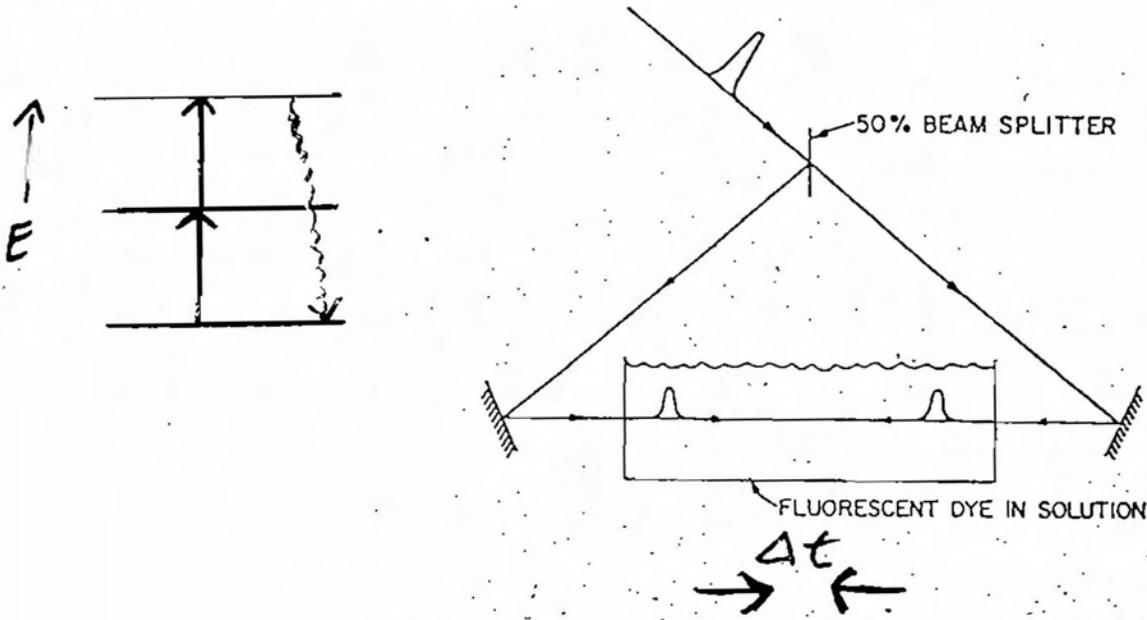
Molecular Gas Lasers

Excimer

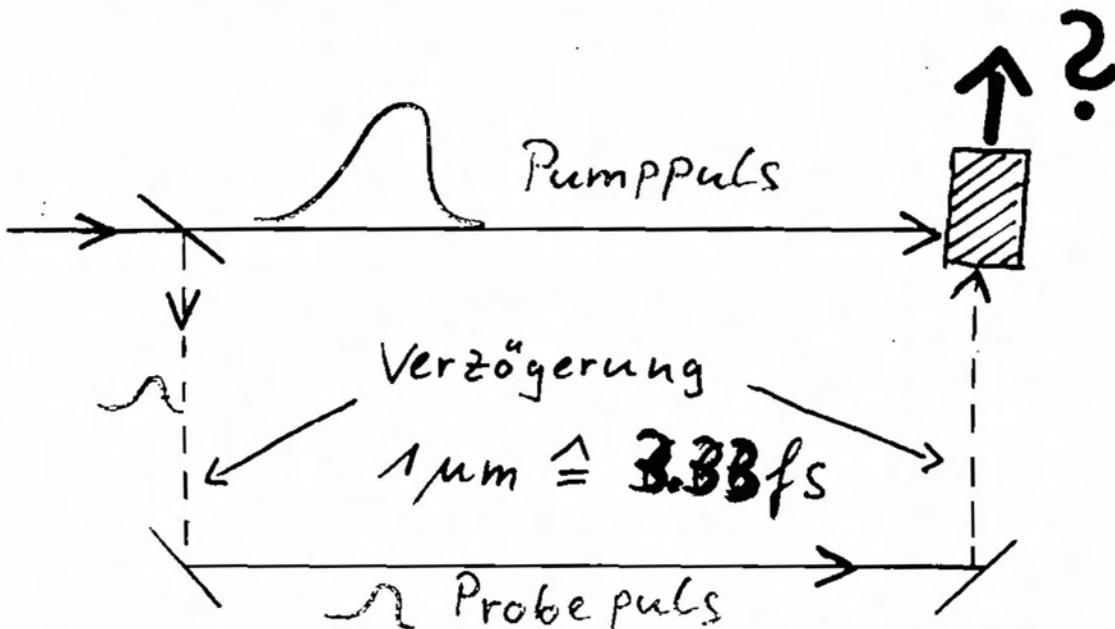


Spektroskopische Techniken

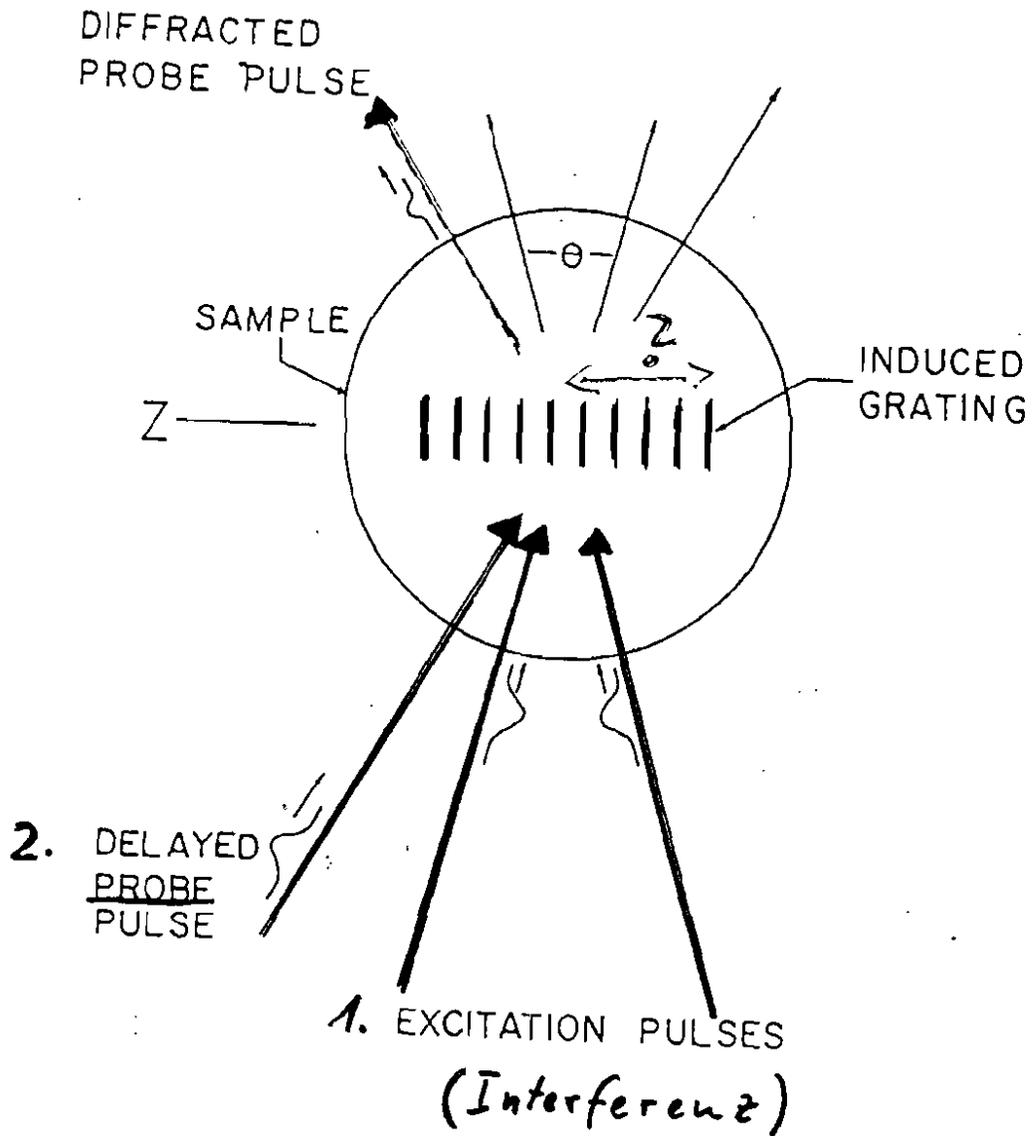
z.B. 2-Photonen fluoreszenz

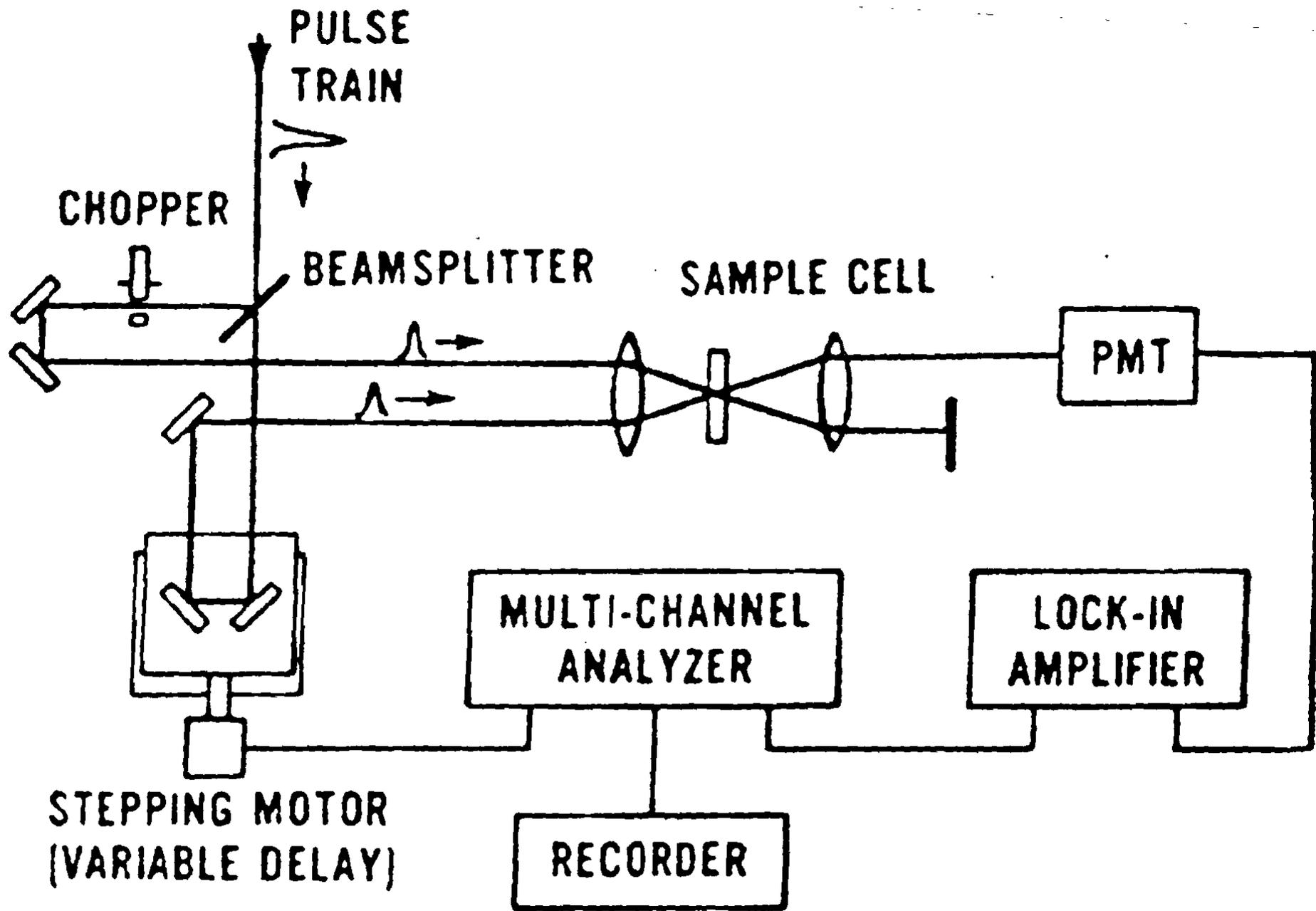


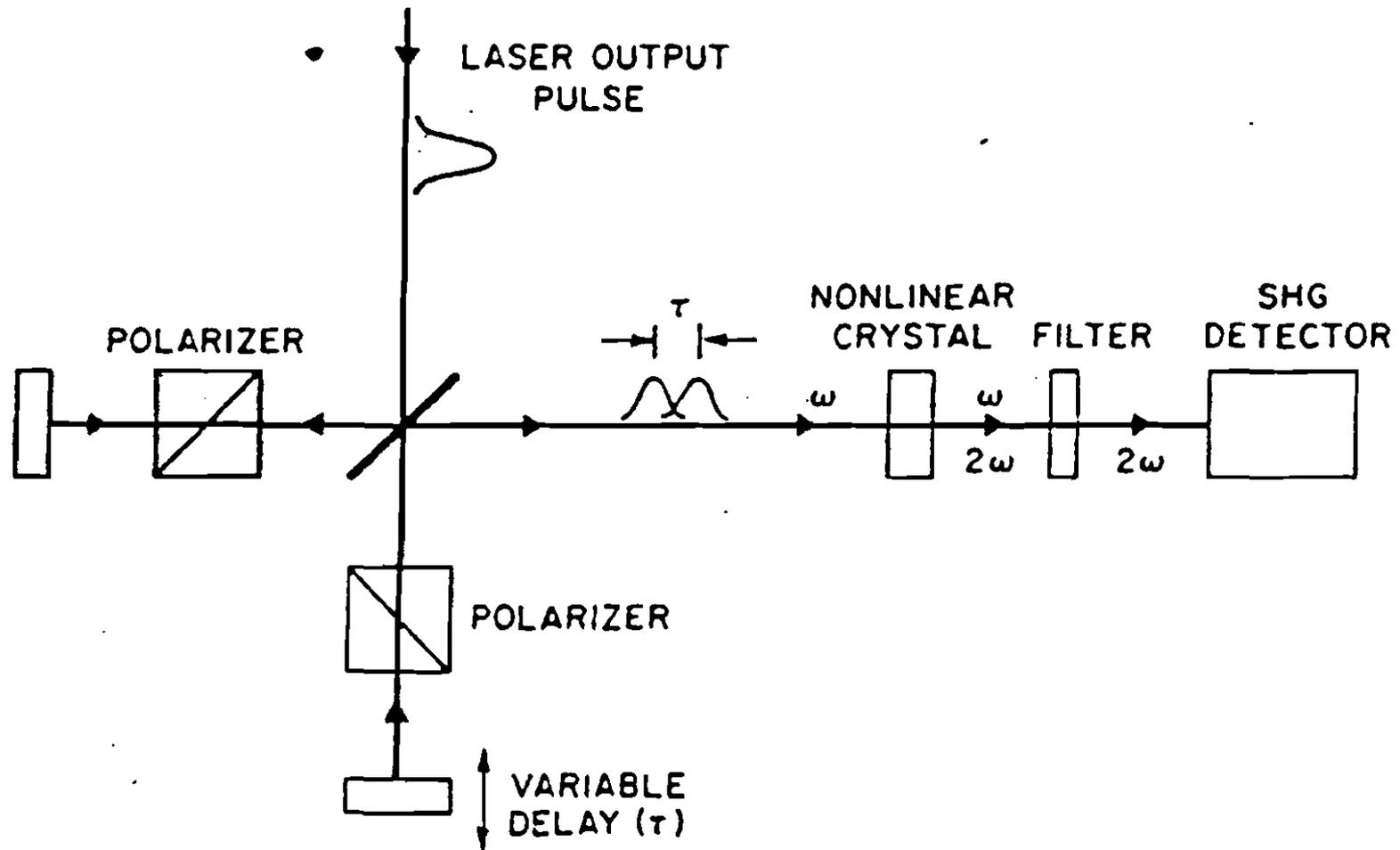
Probenpulstechnik



(Transiente) Gitter

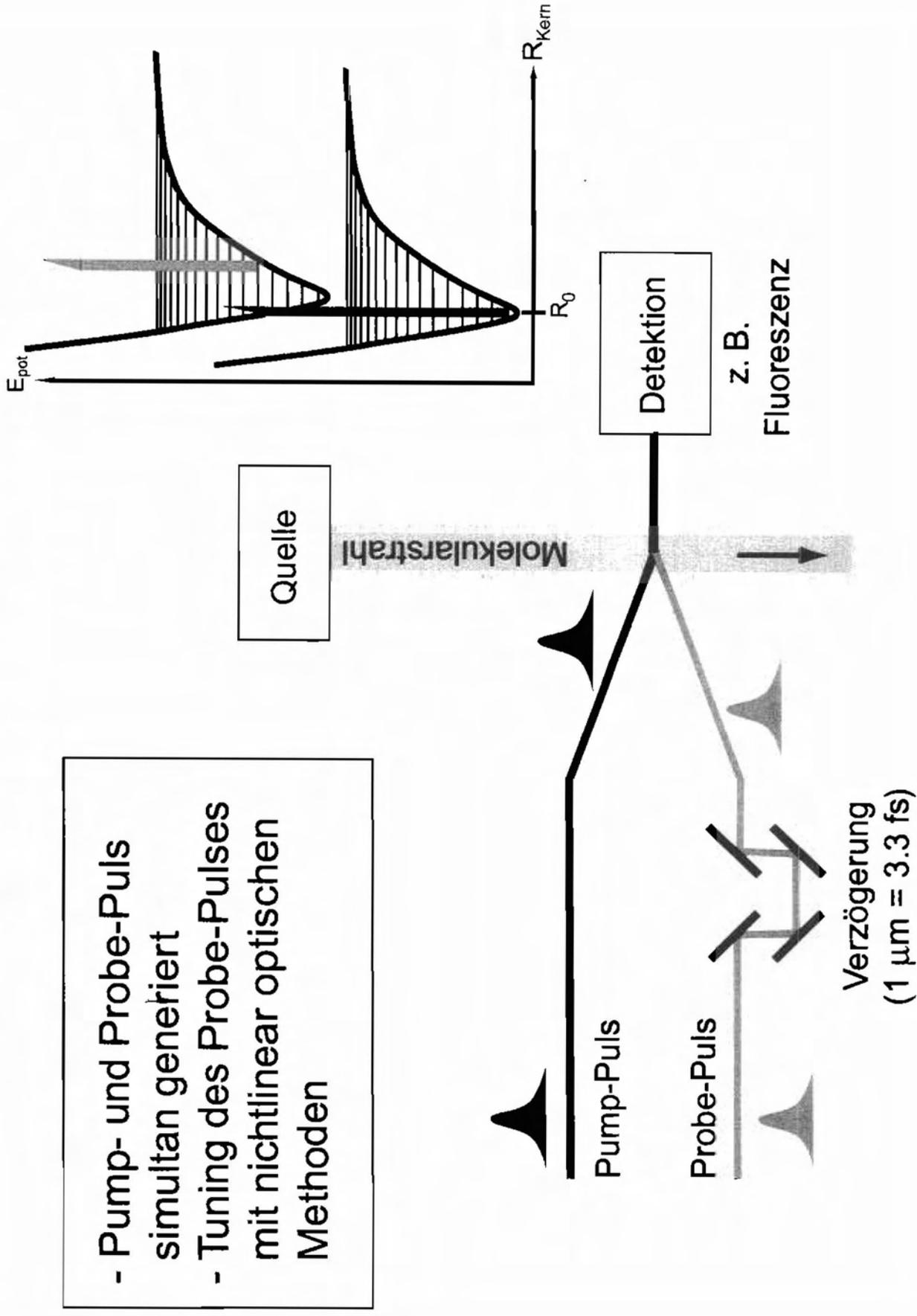


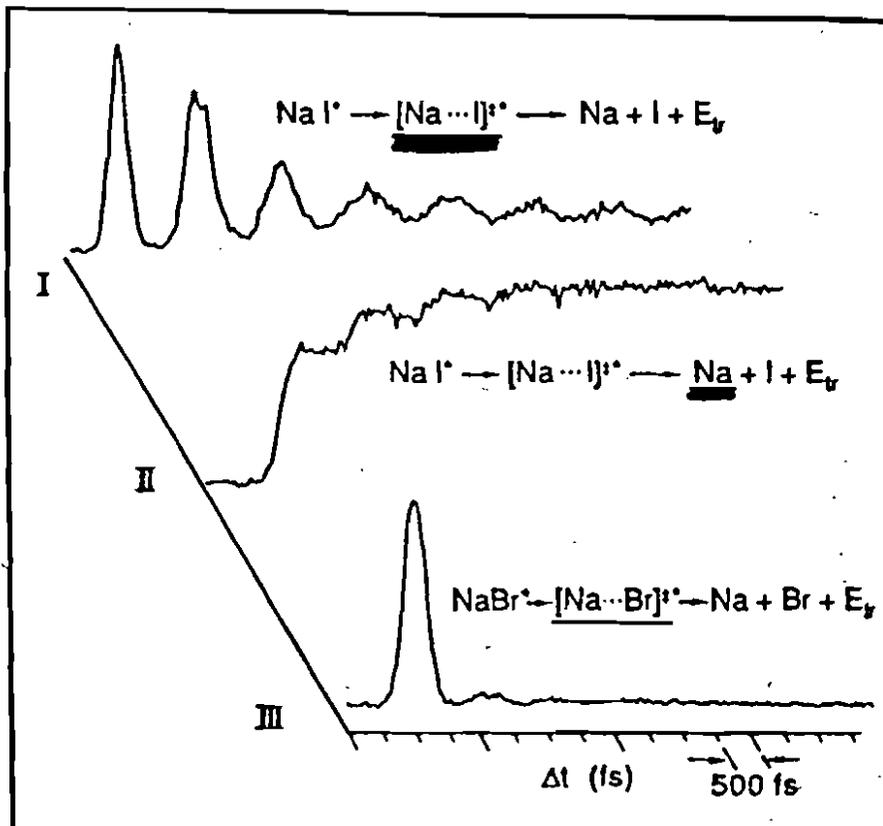
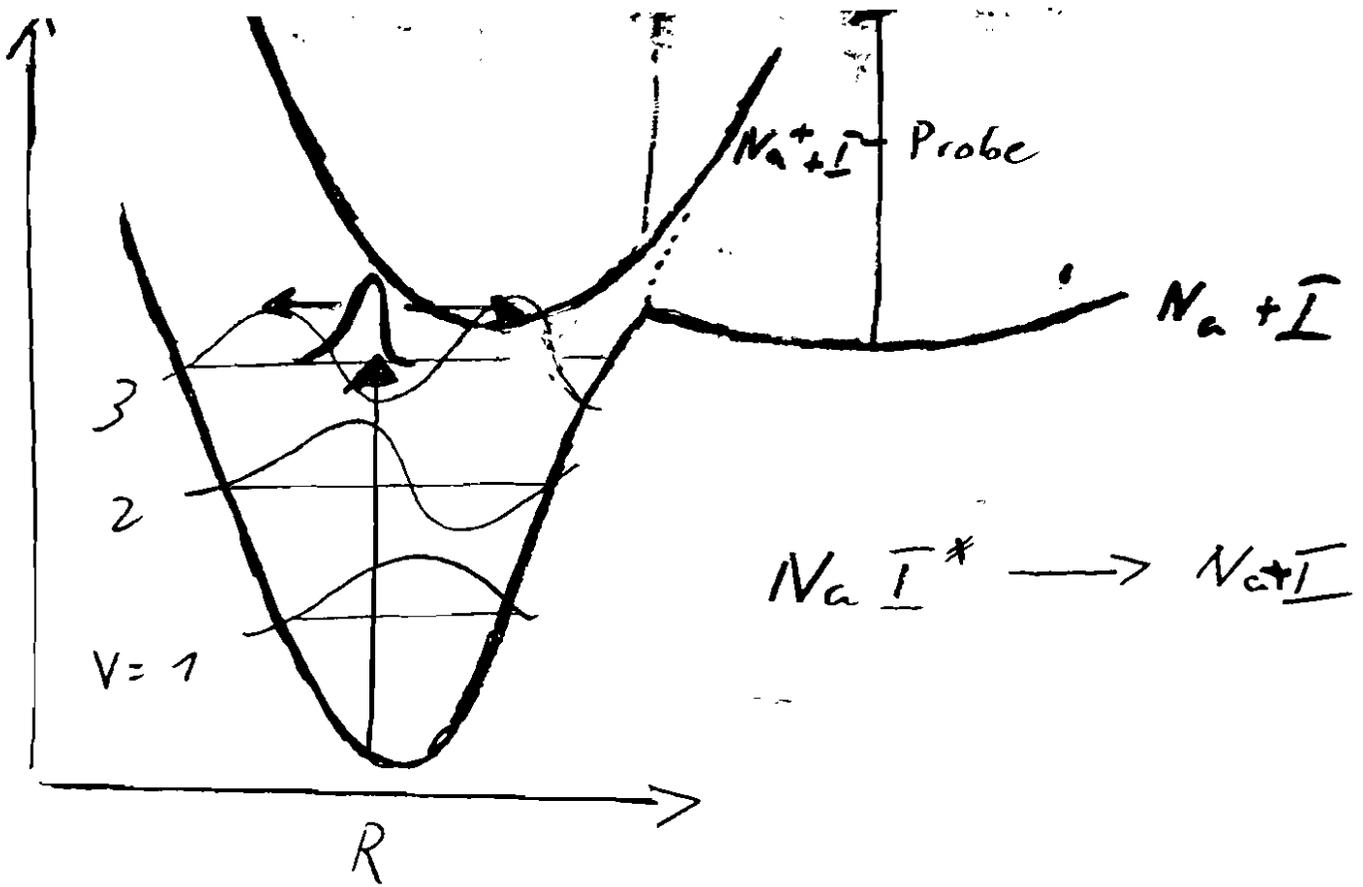


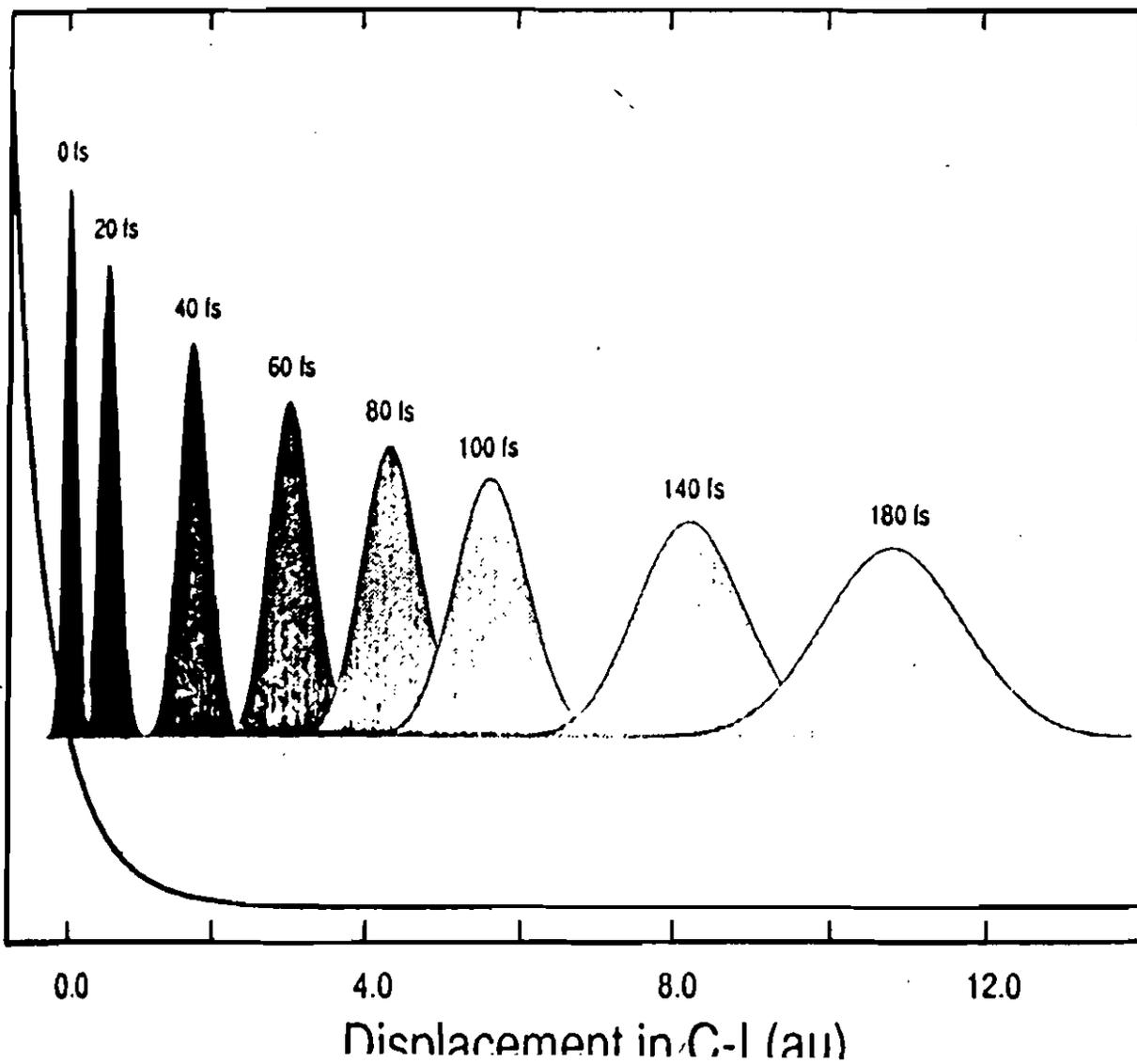
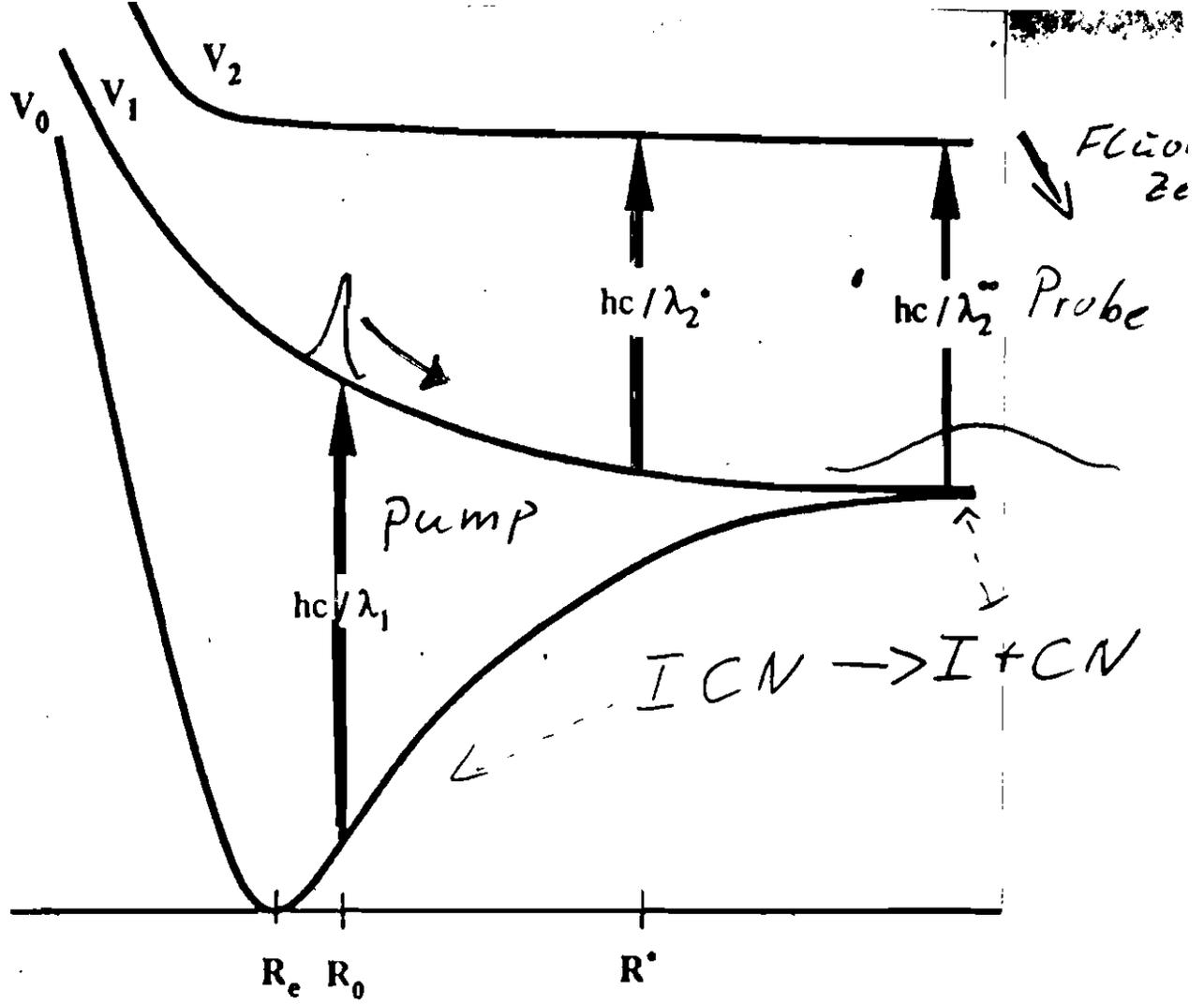


Pump-Probe-Experimente

- Pump- und Probe-Puls simultan generiert
- Tuning des Probe-Pulses mit nichtlinear optischen Methoden

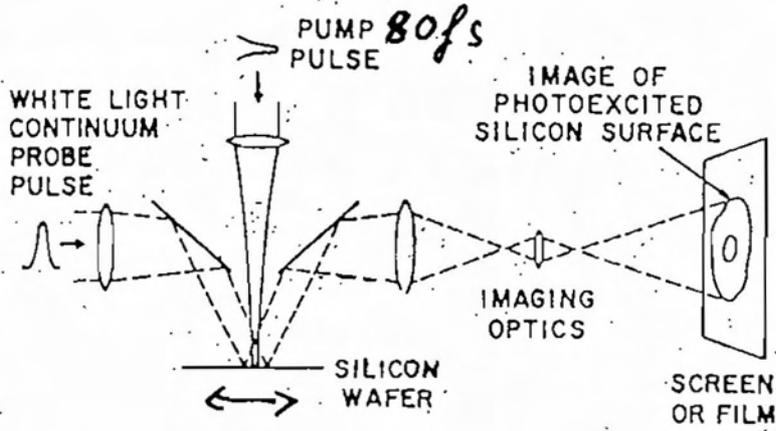






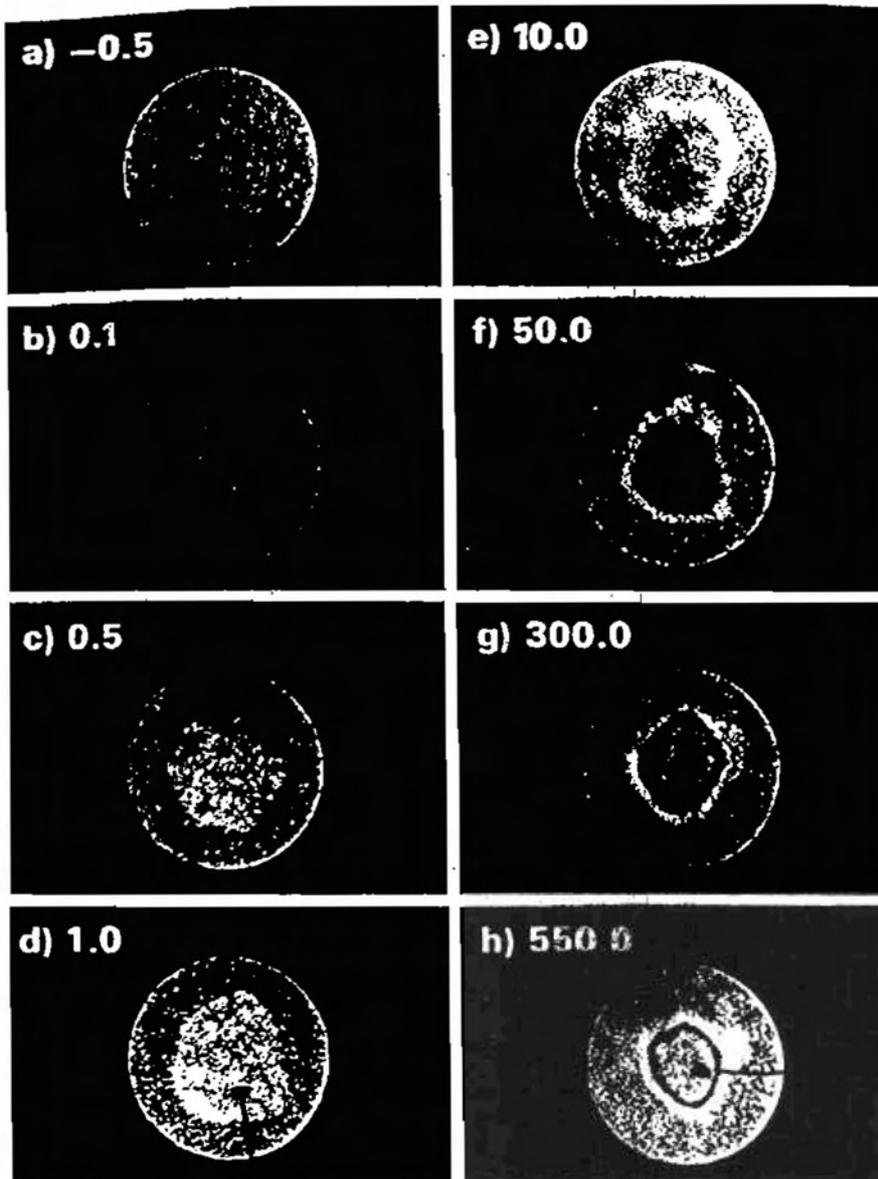
Verdampfen einer Siliziumoberfläche

Shank et al. 1984



620 nm
 150 μ
 10 Hz
 0.2 mJ/pul

Reflexion des Taststrahls (zeit in ps)



Verdampfen von Tröpfchen

"Atomisierung" von Tröpfchen

Schmelzen

