

# **A New Concept for a High Power Diode Laser and Possible Applications**

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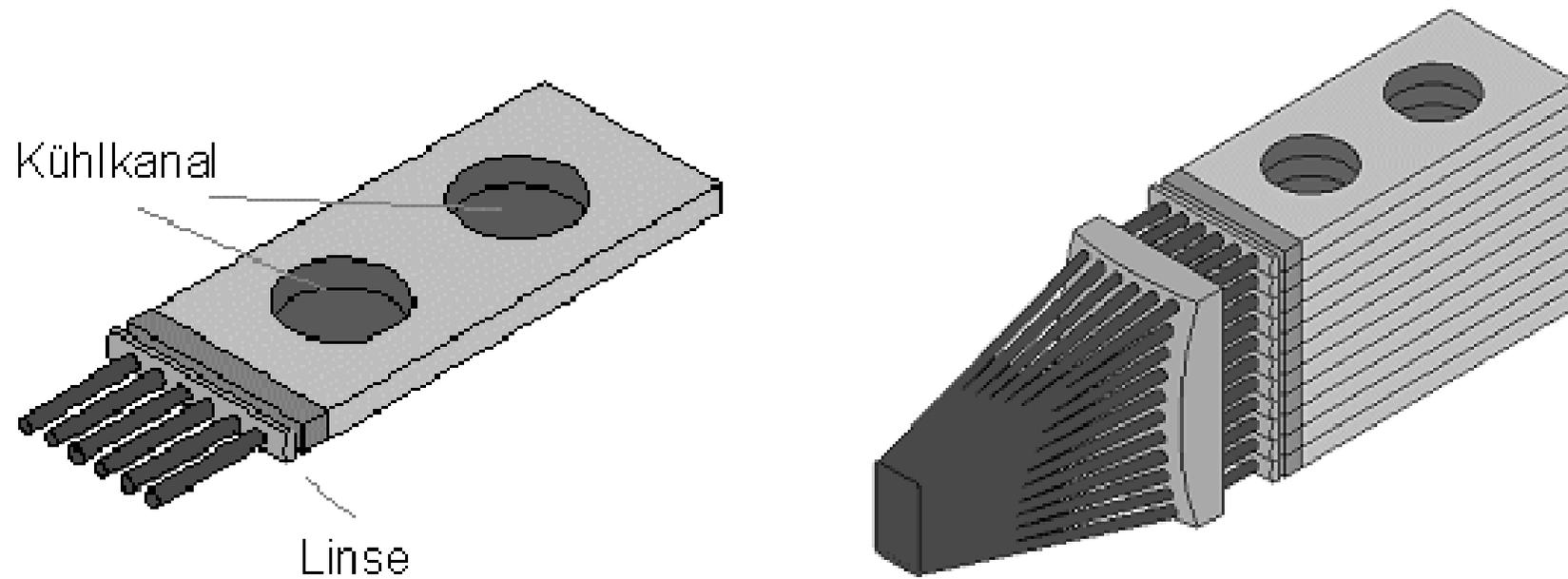
Institute for Nonconventional Forming,  
Processing and Laser Technology

Work supported by FWF

M4PL17 Igls/Innsbruck (A) 21-23.01.2004

# Conventional Diode Lasers:

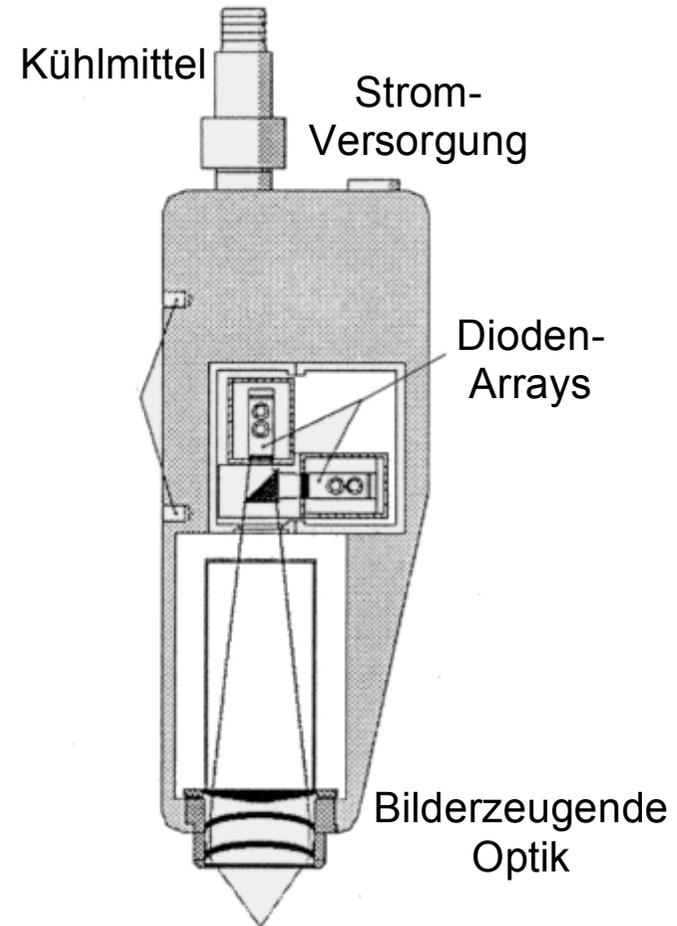
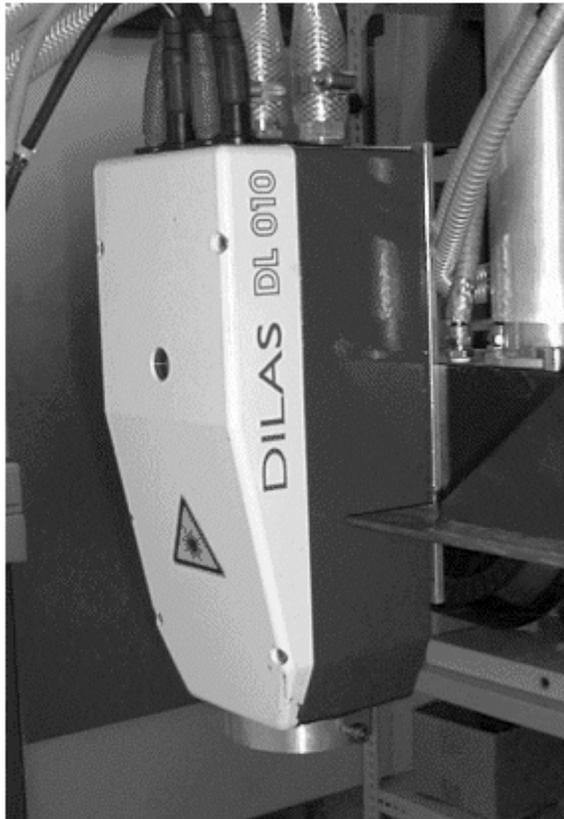
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# Diode Laser

## 1,2 kW Device

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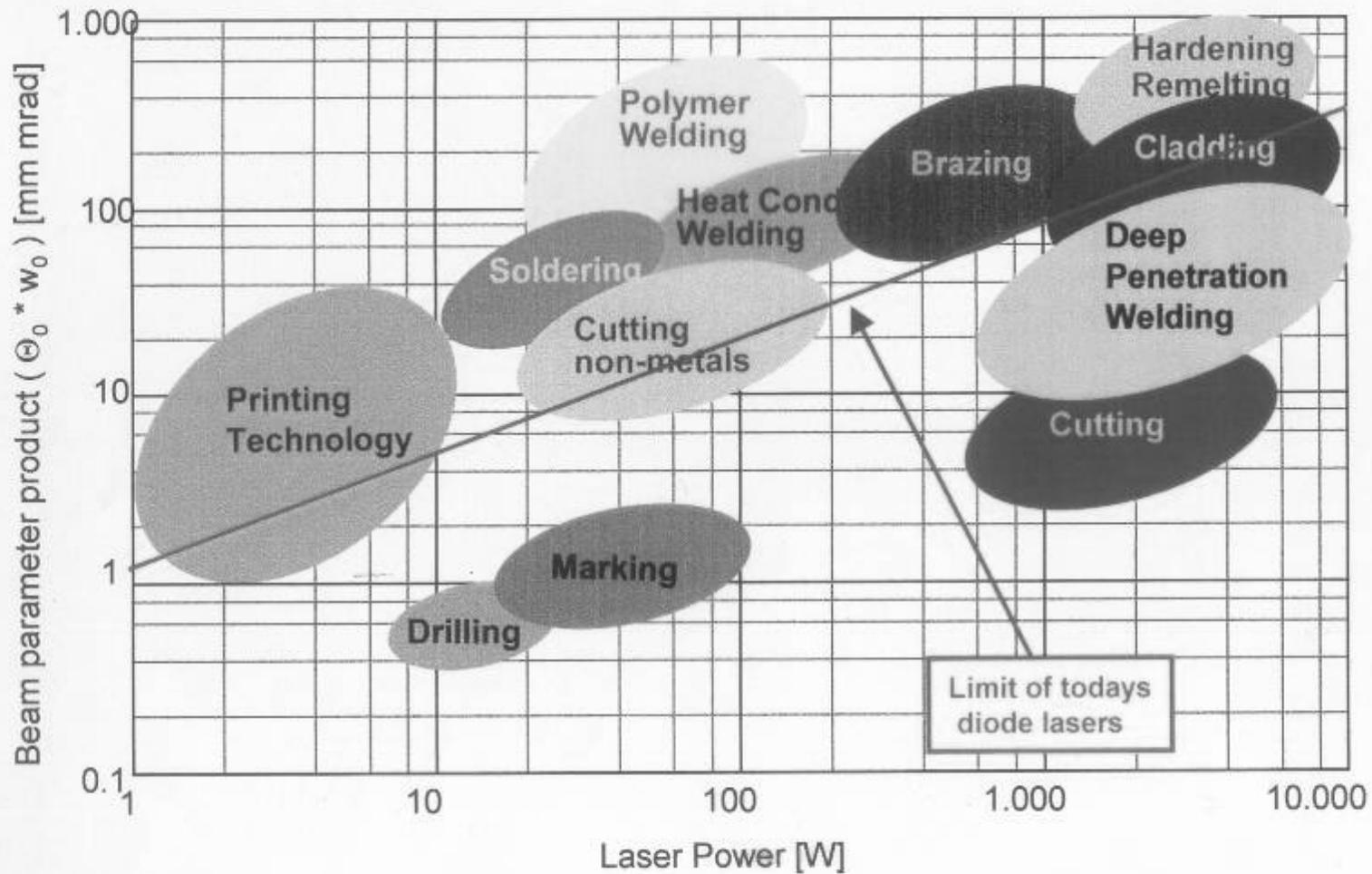


# Properties of High Power Diode Lasers:

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- Very poor beam quality
- Little absorption by plastics
- Coupling into glass fibres
- Optical Powers up to 6kW
- Very compact and easy to handle
- Highest efficiency

# Parameters for laser materials processing (1)



After P. Loosen, Fraunhofer-Institut für Lasertechnik

# The new idea: Time-Multiplexing

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- 1) **Produce with a set of laser diodes a sequence of laser pulses with high peak power**
- 2) **Guide with an optical multiplexer all laser pulses on a common optical path**

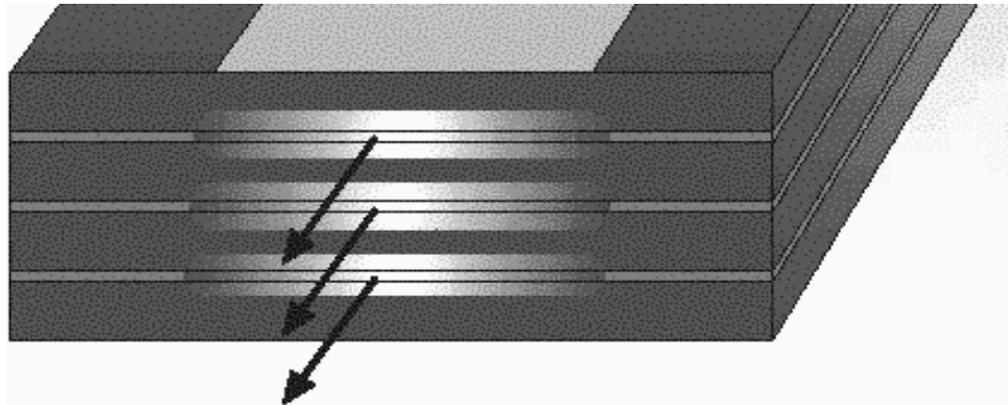
**This yields a laser beam with:**

- 1) **an average optical power in the order of the peak power of one laser diode and**
- 2) **a beam quality like that of one laser diode.**

# Is there any significant peak power achievable with laser diodes ?

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- 1) **Conventional laser diodes can be driven with a peak power ten times the average power if pulse duration is below 100ns (M.Bartram et.al. [2003] 'Pulse widths less than 100ns at 500A Current: Challenge to Explore New Applications with High-Power Laser Diode Arrays', ILT Aachen)**
- 2) **Special designed pulse laser diodes are perfectly suited for high peak powers, e.g. nanostack technology (OSRAM) SPL\_PL90\_3 achieves 75W for 100ns**



# Type of the optical multiplexer

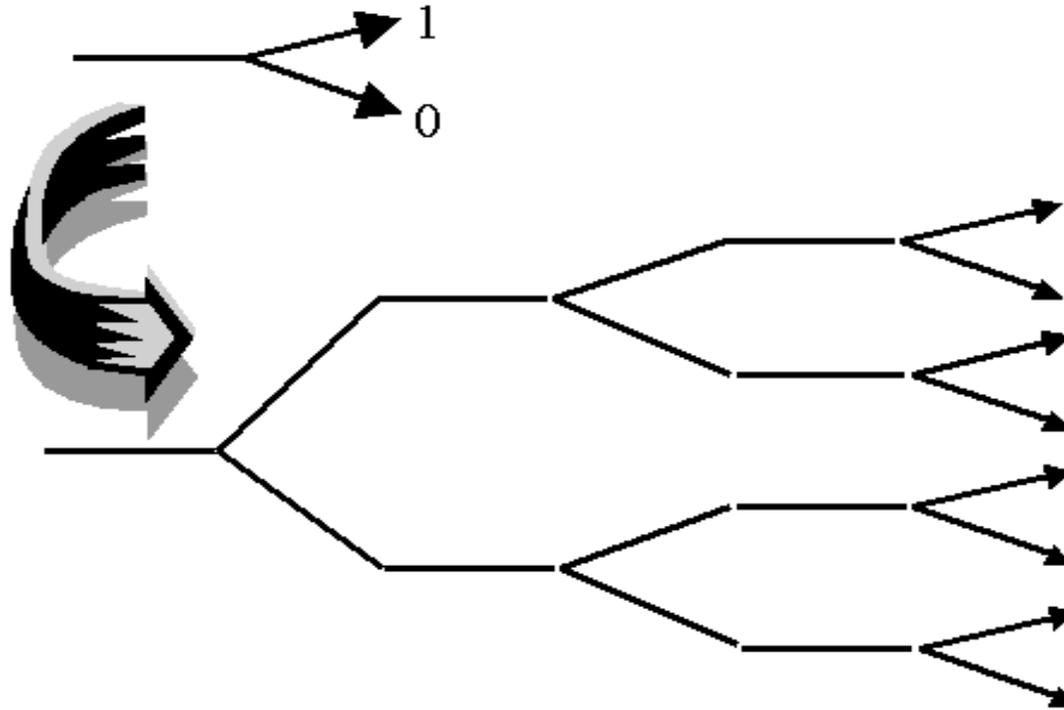
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- ) Any scanner (beam deflector) can be used in the inverse direction to guide laser pulses generated by different sources at different times on a common optical path
- ) But very fast scanners with many addressable optical paths are necessary, since the pulse durations and hence the switching times are in the order of 100ns
- ) Only electro-optical methods are suitable
- ) Digital scanner better than an analogue one

# Digital Multiplexer (1)

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A binary switch can be cascaded to address  $2^n$  paths



## Digital Multiplexer (2)

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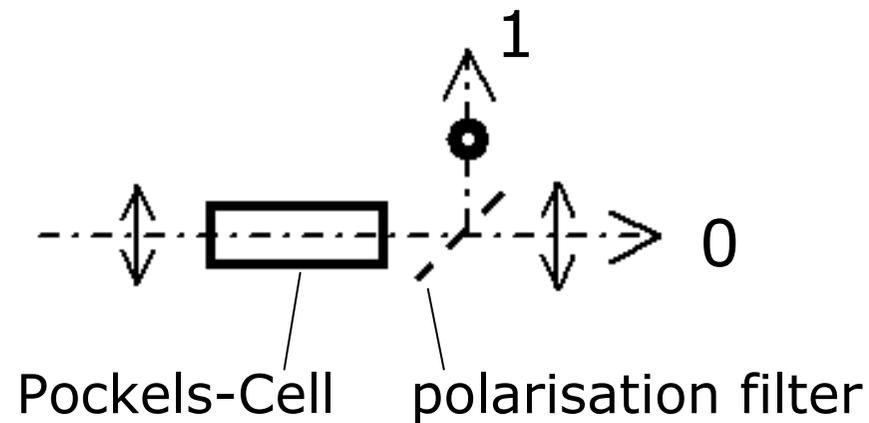
The optical digital switch can be

- ) a polarisation switching device (Pockels-cell) followed by a polarisation sensitive element
- ) a Bragg-modulator, where a sequence of alternating refraction indices is activated by an electro-optic effect

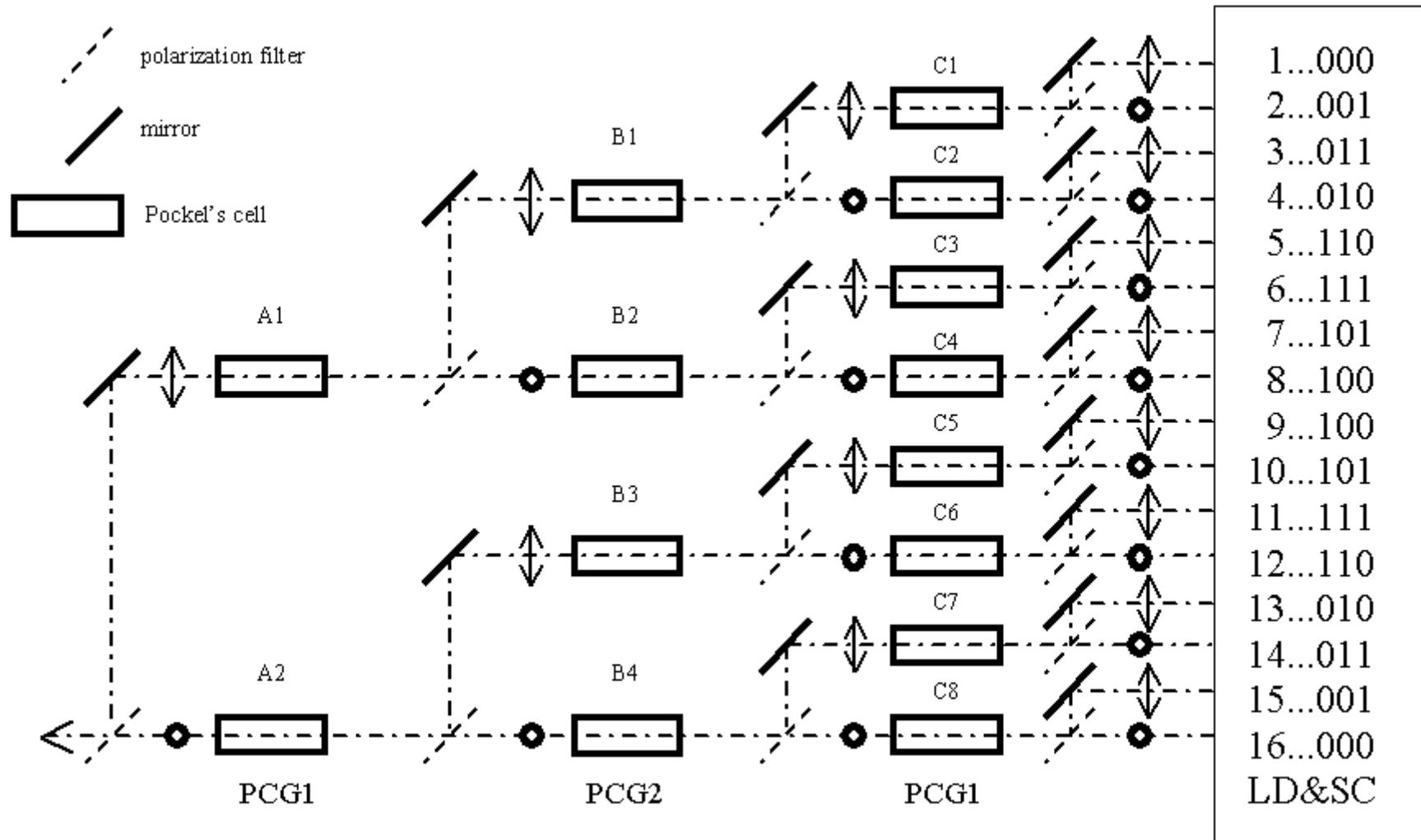
# Polarisation switch

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The polarisation of a linear polarized beam is turned by  $90^\circ$  or it is not turned.

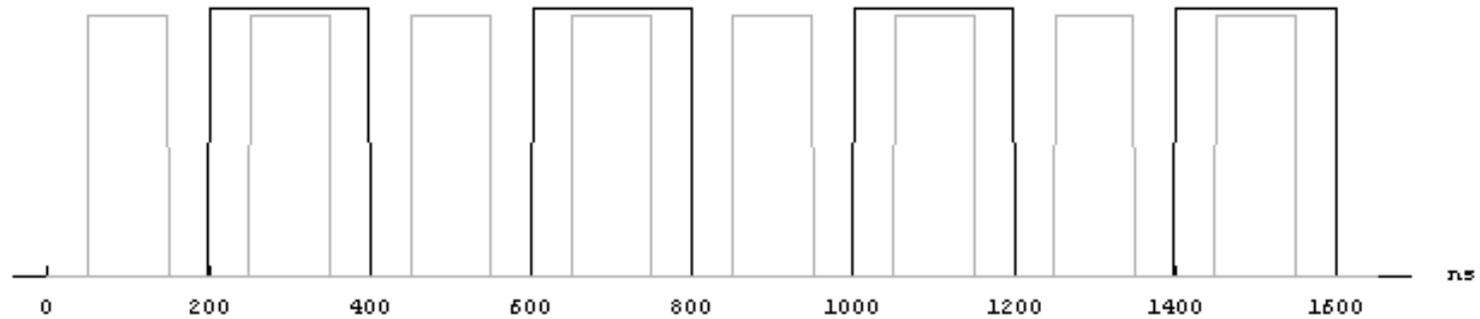


# Cascading of polarization switches:

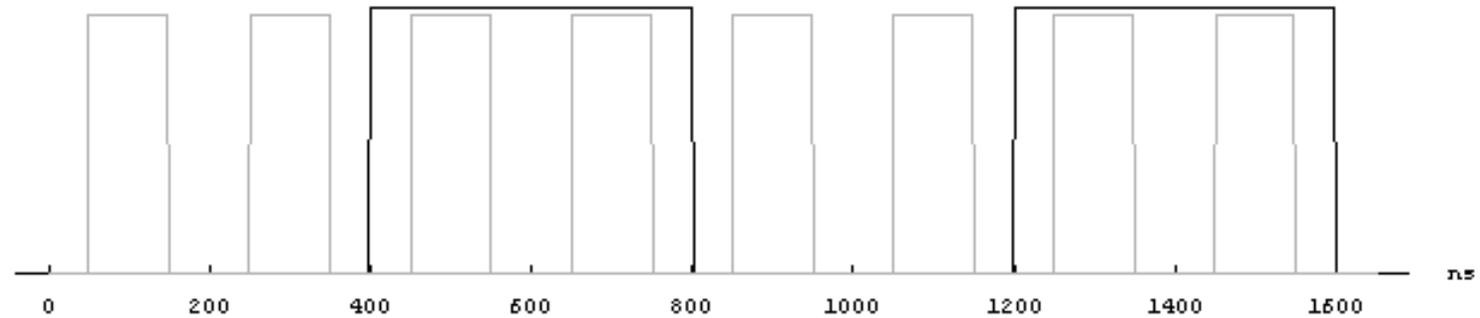


# Switching scheme of the digital multiplexer (1)

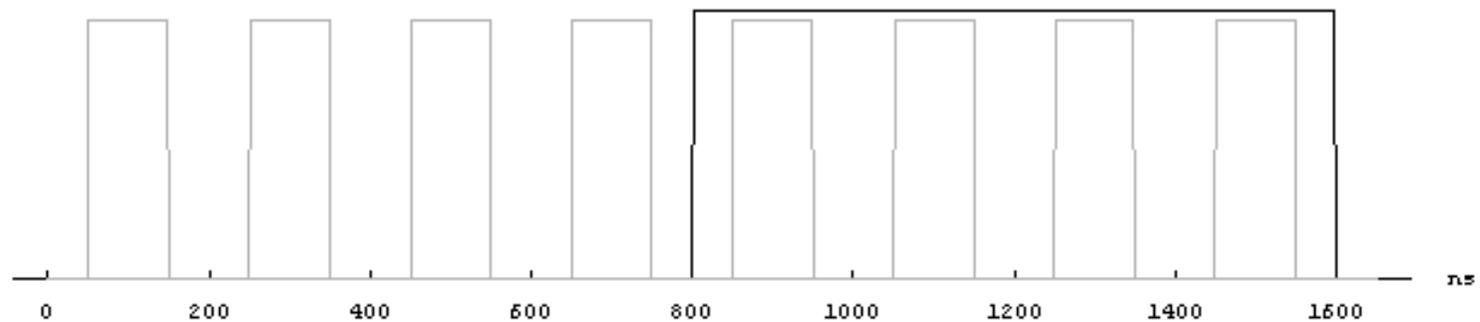
PCG1



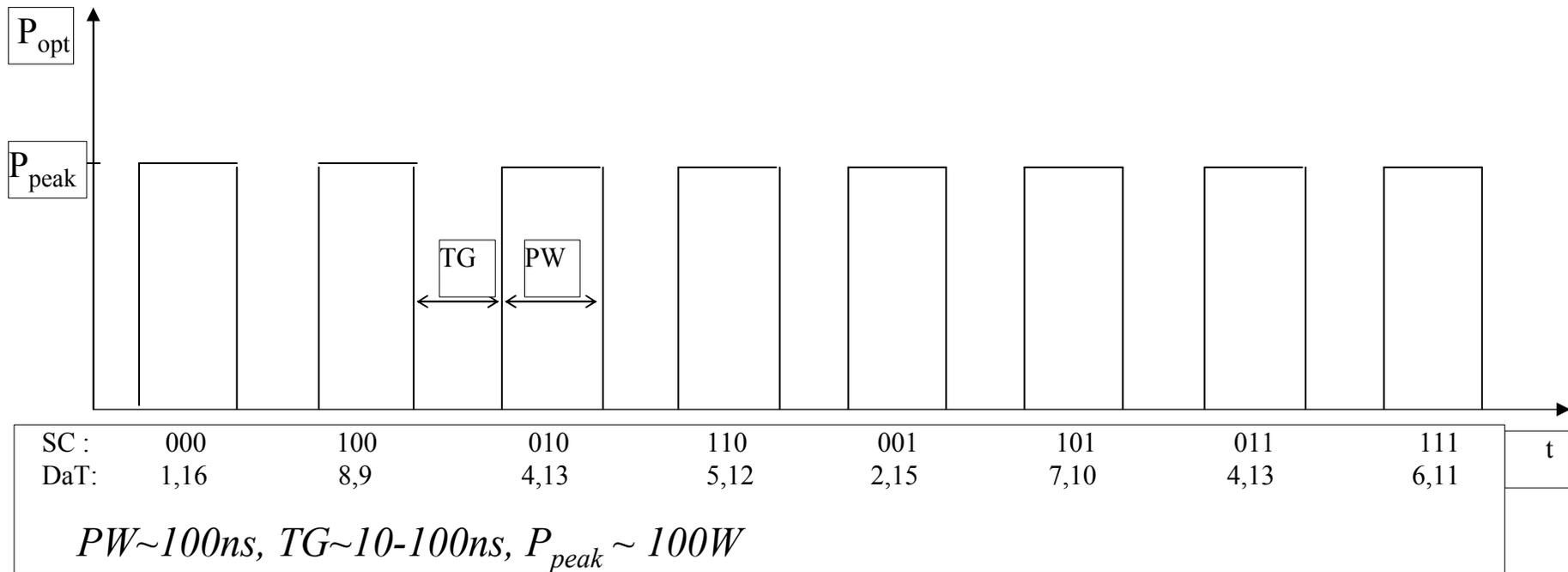
PCG2



PCG3



# Switching scheme of the digital multiplexer (2)



$$P_{av} = \frac{PW}{PW + TG} P_{peak} \sim 50W$$

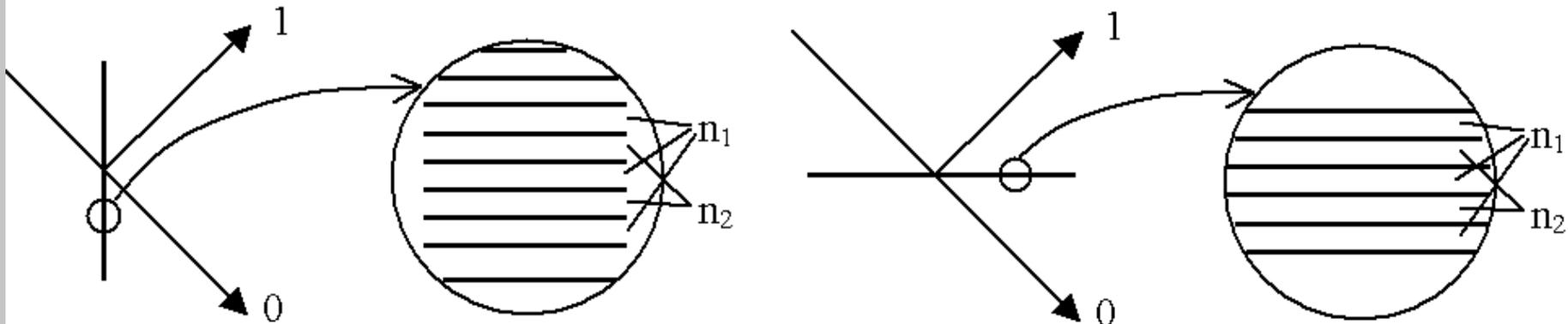
$$P_{av,diode} = P_{av} / 16 \sim 3W$$

$$PRF = \frac{1}{8(PW + TG)} \approx 0.625MHz$$

# Bragg-Modulator (1)

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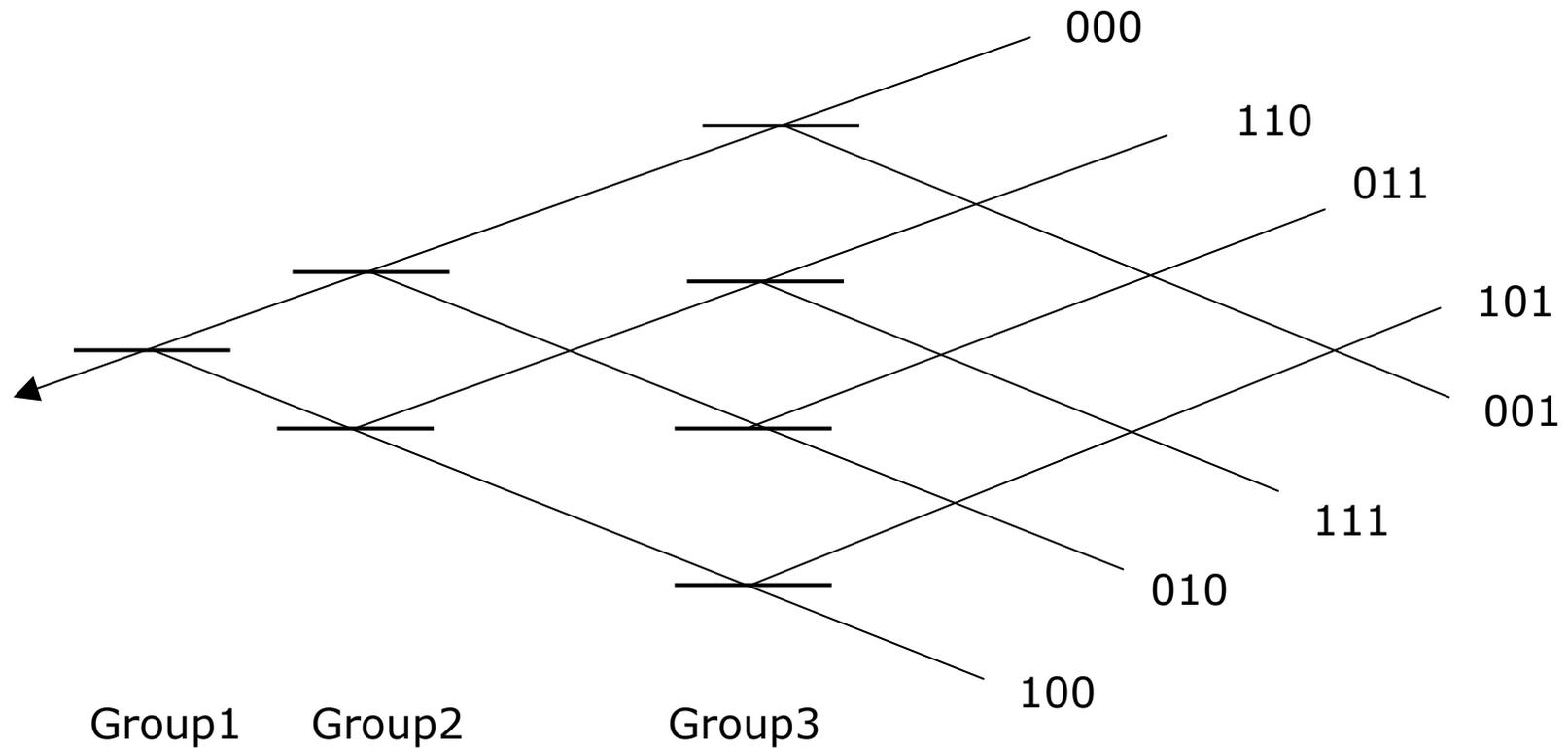
A Bragg-reflector is electro-optically activated



- ) Integrated realization in planar wave guides made of semiconductors or LiNbO<sub>3</sub>
- ) Usage of structured electrodes or of domain inversion to structure the material

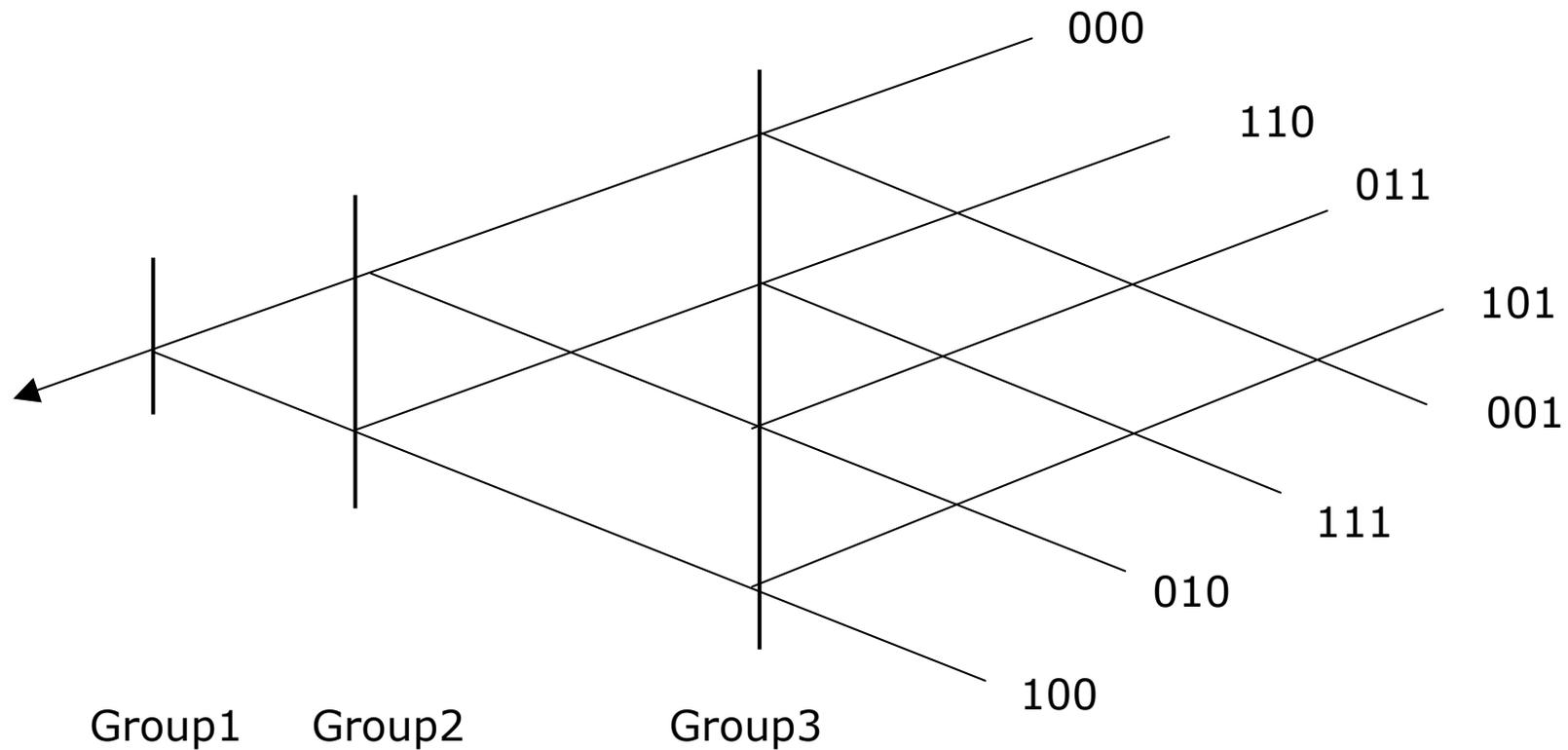
# Bragg-Modulator (2) (using reflection)

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# Bragg-Modulator (3) (using diffraction)

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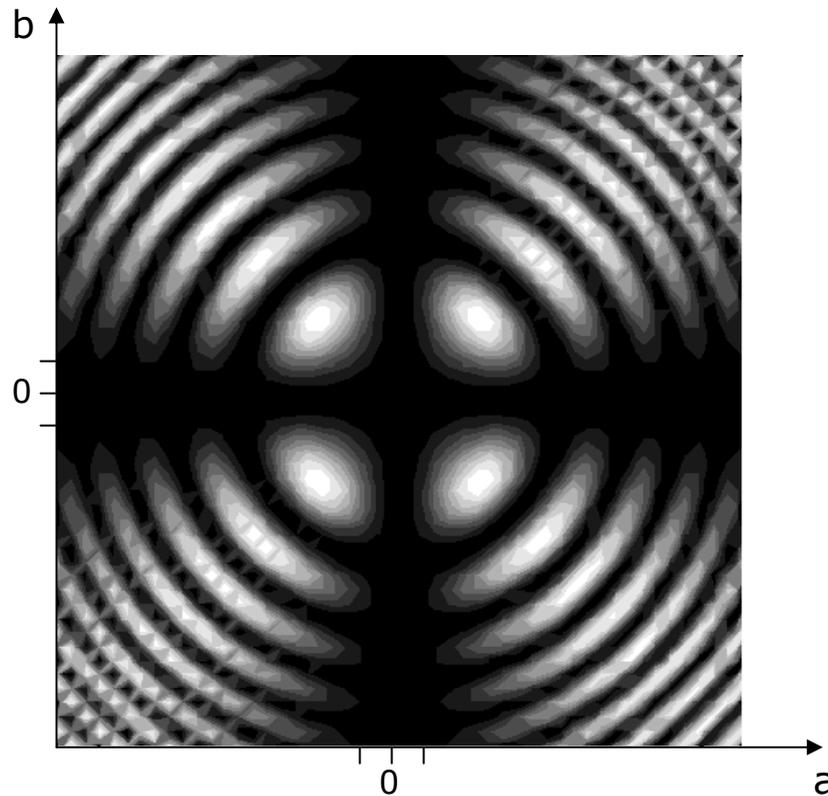
# Problems

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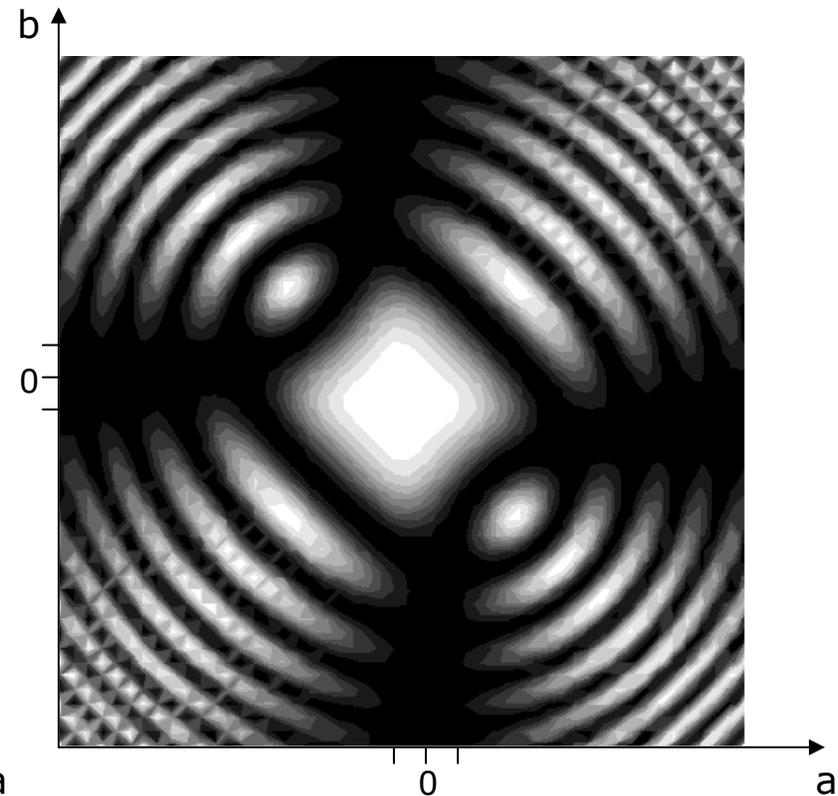
- ❑ Currents up to 50 Ampere have to be switched within ns
- ❑ Voltages up to 500 Volts have to be switched within ns
- ❑ Very fine collimation of the diode laser radiation is necessary

# A comment to beam collimation in case of polarisation switches

Pockels-Cell between crossed polarisers in convergent light:  
without voltage



with half-wave-voltage



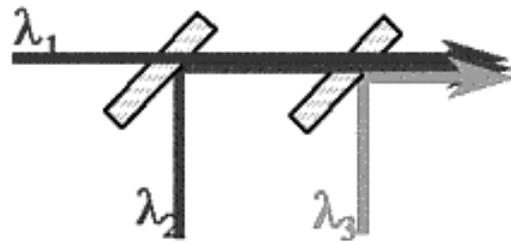
a,b: deviation from the optical axis in mrad

For 30mm LiNbO<sub>3</sub>-crystals beam divergence must be less than 10mrad

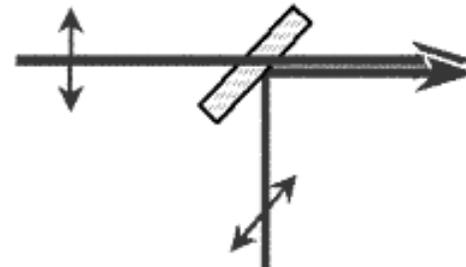
# Additional Usage of Conventional Combination Methods:

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Wavelength-multiplexing

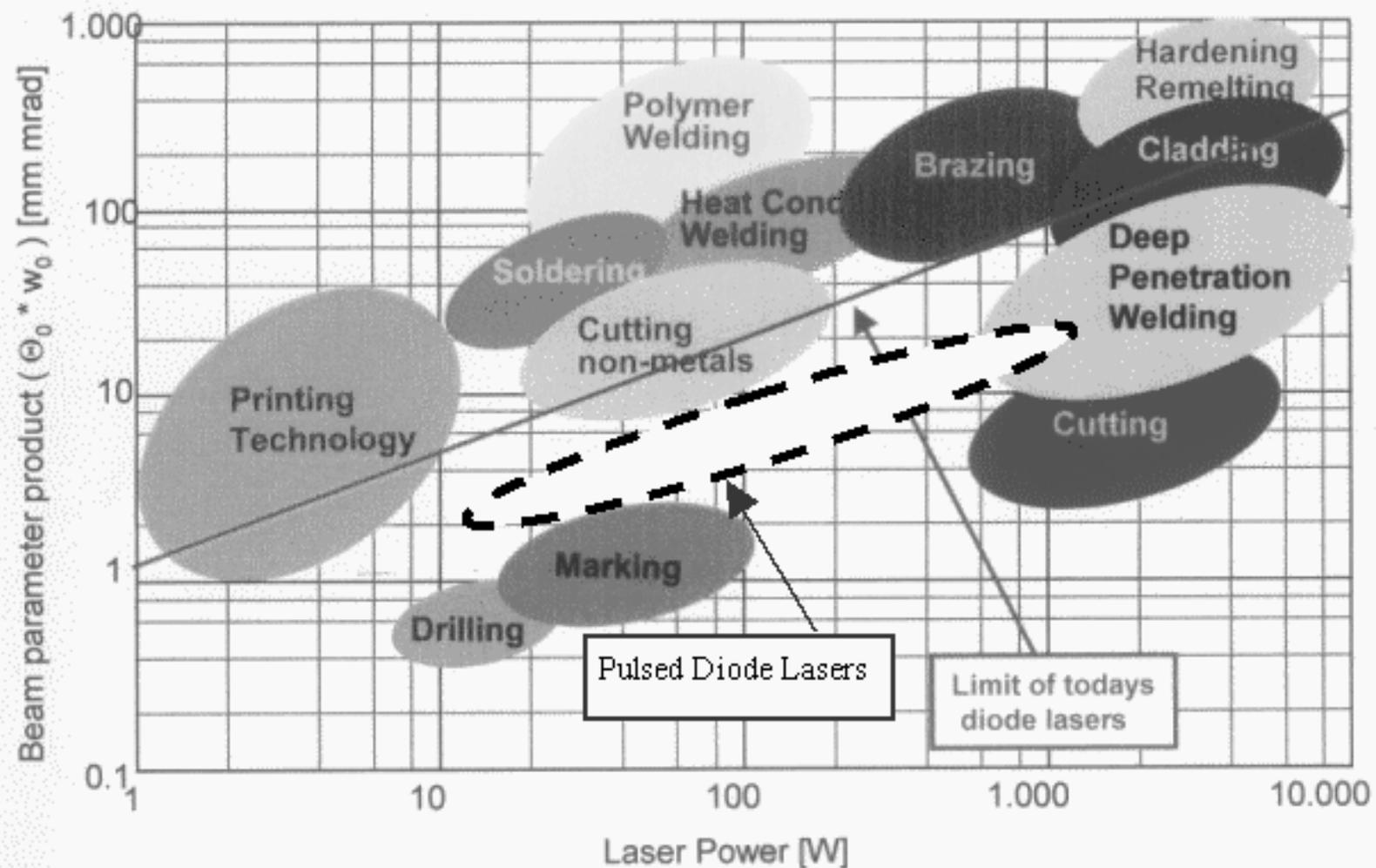


Polarisation-multiplexing



Position- or angle-multiplexing

# Parameters for laser materials processing (1)



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