

# **DEVELOPMENT OF TUNABLE/NOVEL SOLID STATE LASERS**

**The Rank Prize Funds  
Mini-Symposium on Solid State Lasers  
3-6 April, 1995**



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## **GENERAL OUTLINE**

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- **Ti:sapphire Lasers**
- **New Tunable Lasers**
- **Infrared Sources**
- **Evolution of CW Diode-Pumped Lasers**

**Occasional history as well**



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## CREDITS FOR THE WORKERS

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- **Glen Rines (Pulsed Ti:sapphire, OPOs)**
- **James Harrison (CW Ti:sapphire, Diode-pumping)**
- **David Welford (Mode-locking) *Imperial College***
- **John Flint (Infrared lasers)**
- **David Rines (Infrared lasers, OPOs)**
- **Andrew Finch (Mode-locking, infrared lasers) *Oxford, St. Andrews***
- **Henry Zenzie (Cr:LiSAF, OPOs)**
- **Bradley Dinerman (Infrared lasers)**
- **Yelena Isyanova (OPOs, Diode-pumping)**
- **Richard Schwarz (Pulsed Ti:sapphire)**



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## WHAT HAPPENED IN THE 60'S

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- n **Transition-metal ions**
  - **Cr, Ni, Co, V**
- n **Rare-earth ions**
  - **Nd, Ho, Tm, Er, Yb**
- n **Sensitized lasers**
- n **Upconversion lasers**
- n **Laser-pumped lasers**
- n **Diode-pumped lasers**

- n **The "ings"**
- n **Monolithic lasers**
  - **ruby!**
- n **Unidirectional rings**
- n **Efficient harmonics**
  - **External, internal**
- n **Parametric oscillators**
- n **"Slab" geometry?**



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## Ti:SAPPHIRE LASERS - OUTLINE

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### **Brief history**

#### **Lamp-pumped devices**

#### **CW-pumped systems**

- **All-solid-state**
- **Repetitively Q-switched**
- **Mode-locked**

#### **Pulse-pumped devices**

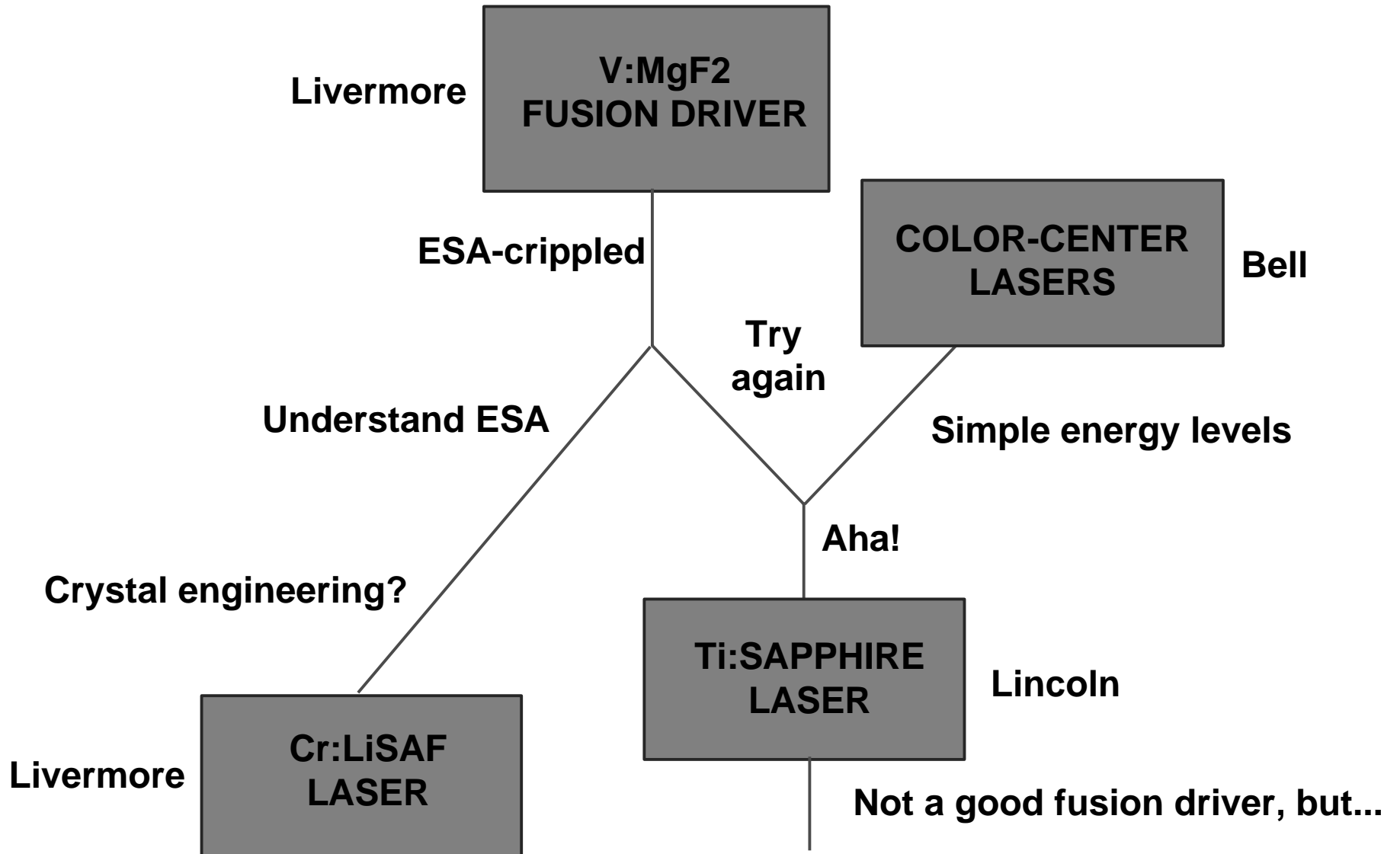
#### **Non-linear conversion for wavelength extension**

#### **Other Ti hosts**



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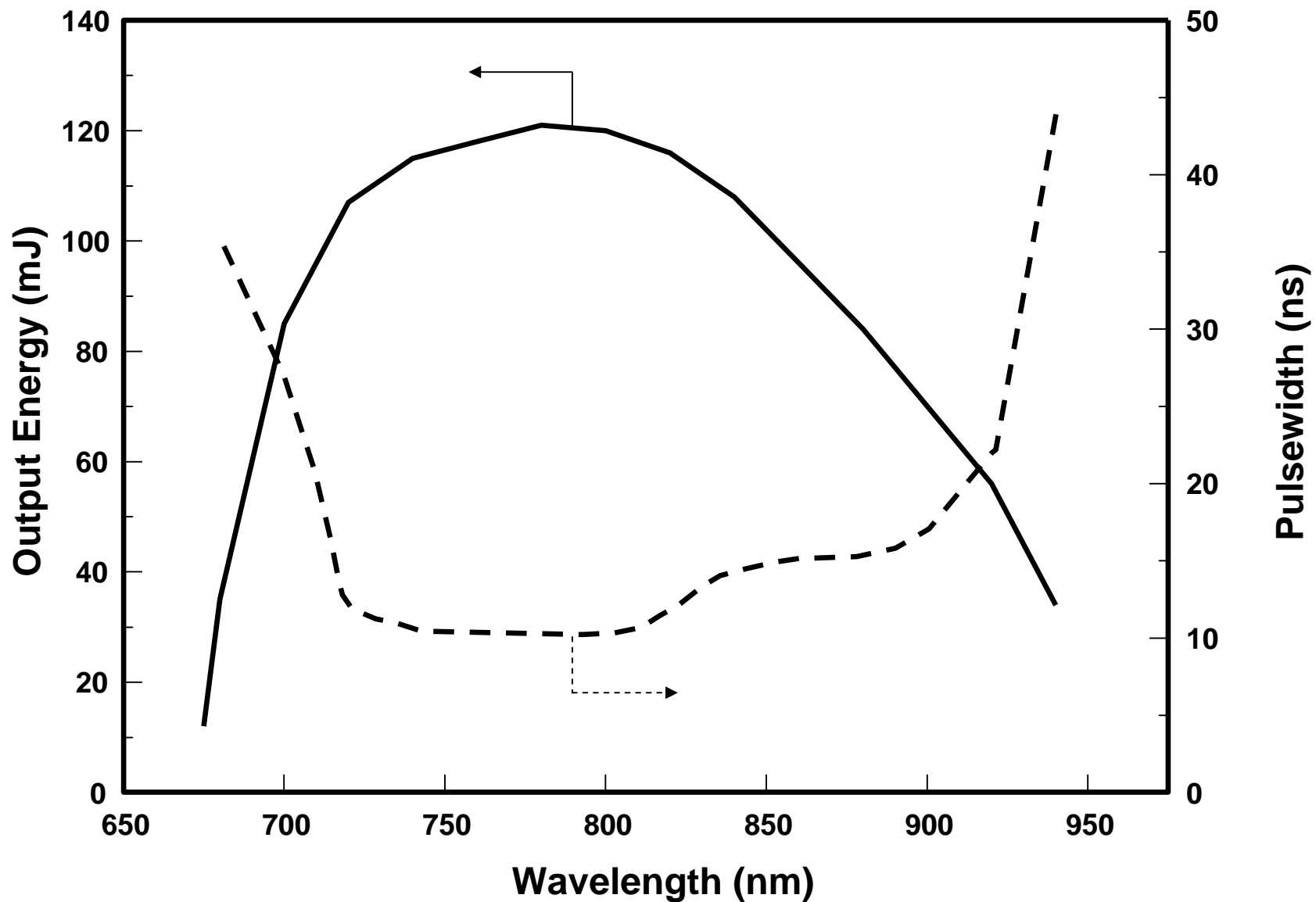
# TECHNOLOGY GENEALOGY





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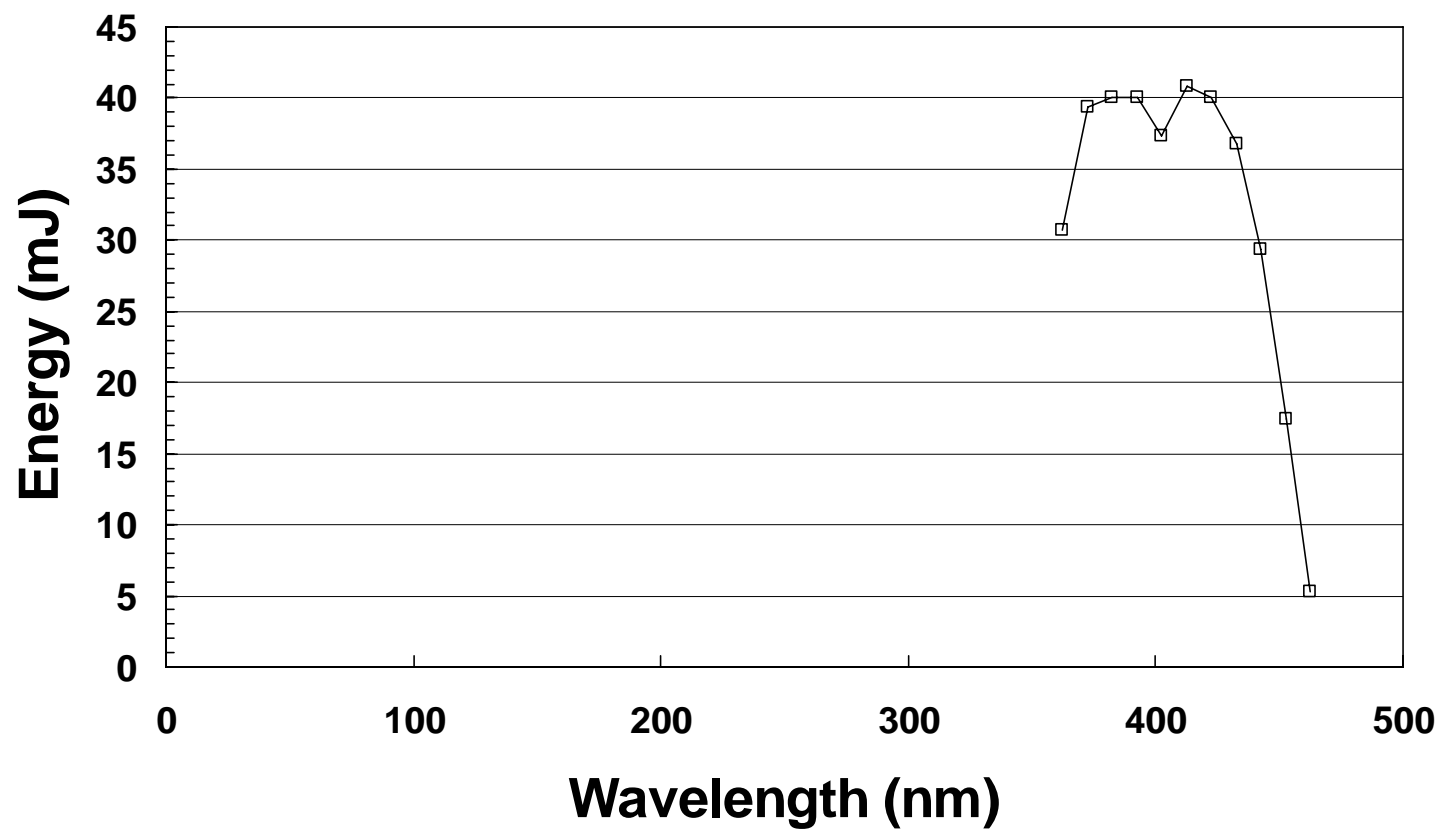
# PULSED Ti:SAPPHIRE LASER - TUNING CURVE





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## TUNING CURVE - SHG Ti:SAPPHIRE

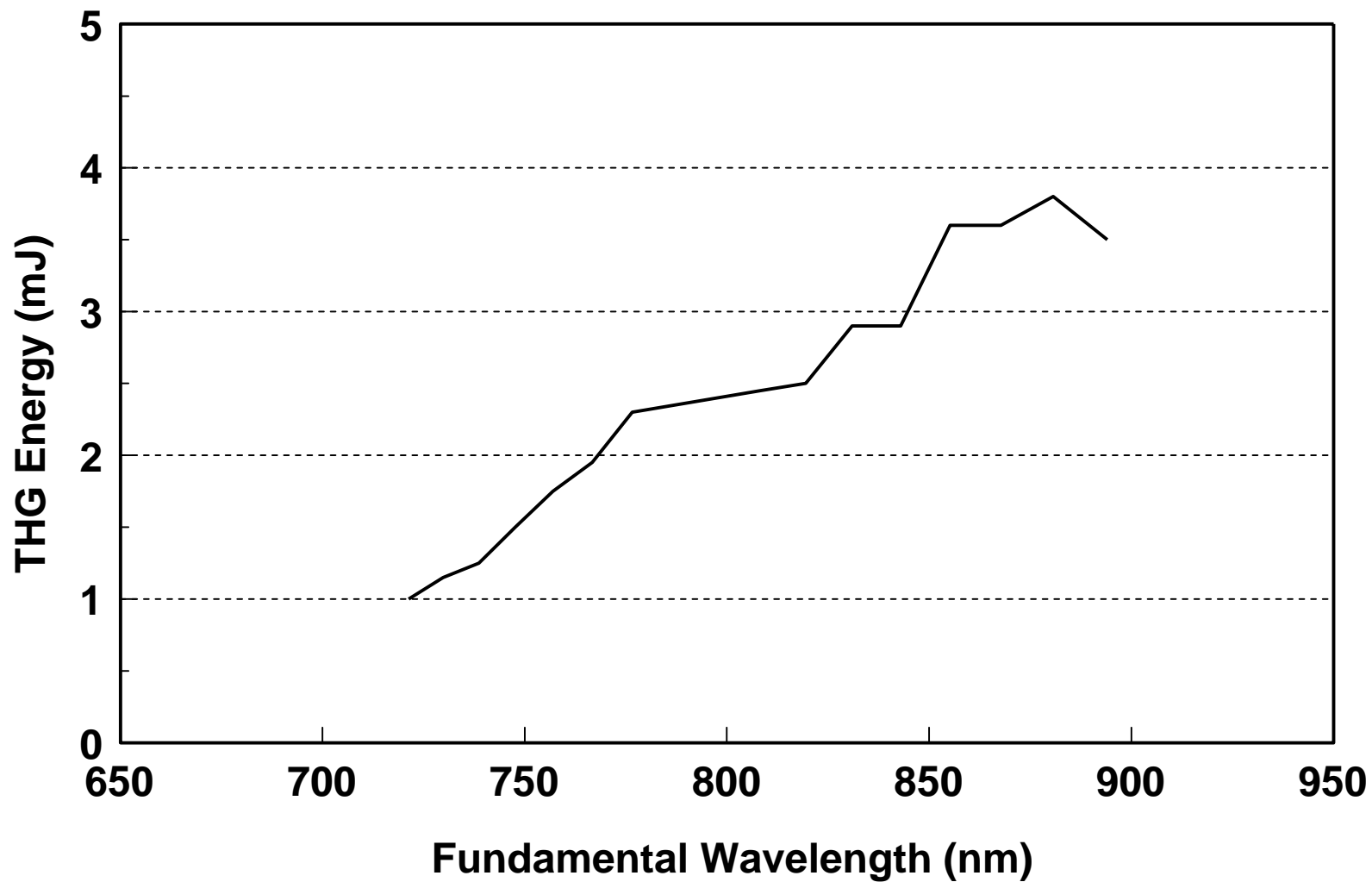






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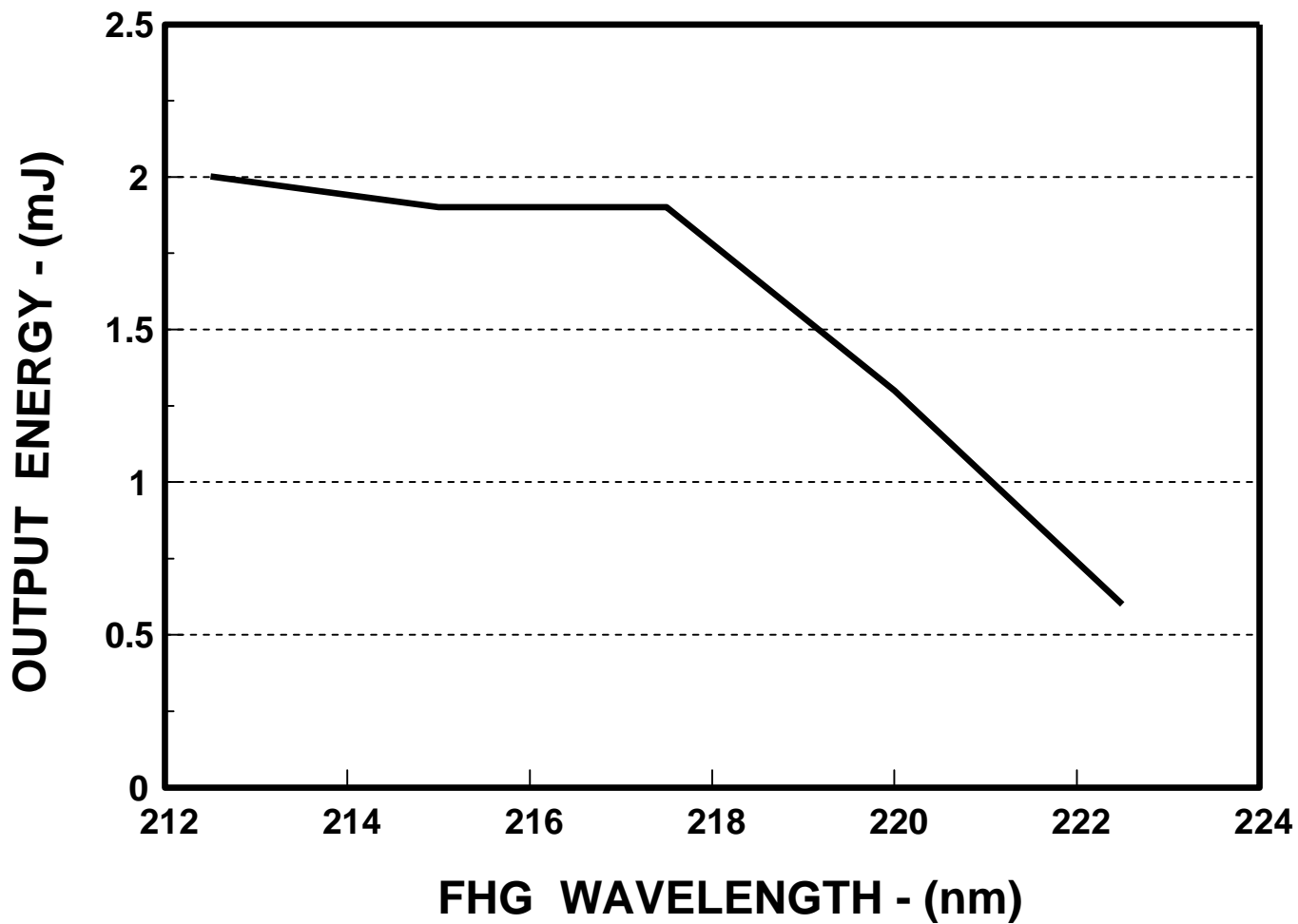
## PULSED Ti:SAPPHIRE - THIRD HARMONIC





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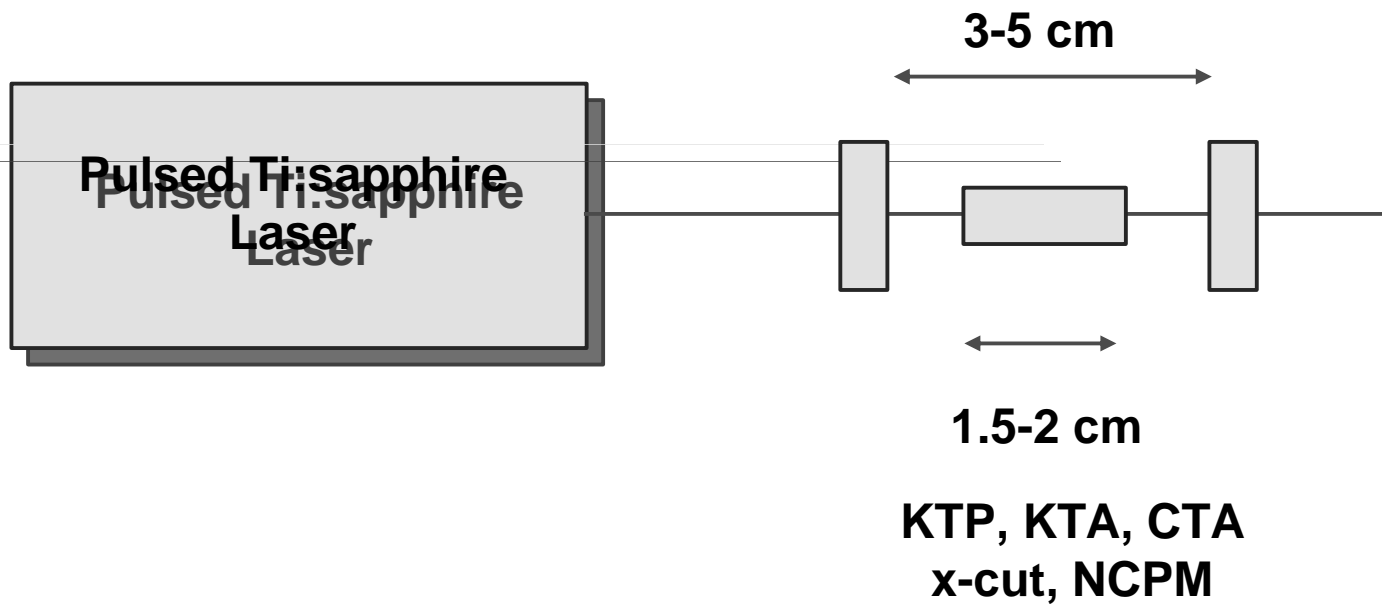
## PULSED Ti:SAPPHIRE - FOURTH HARMONIC

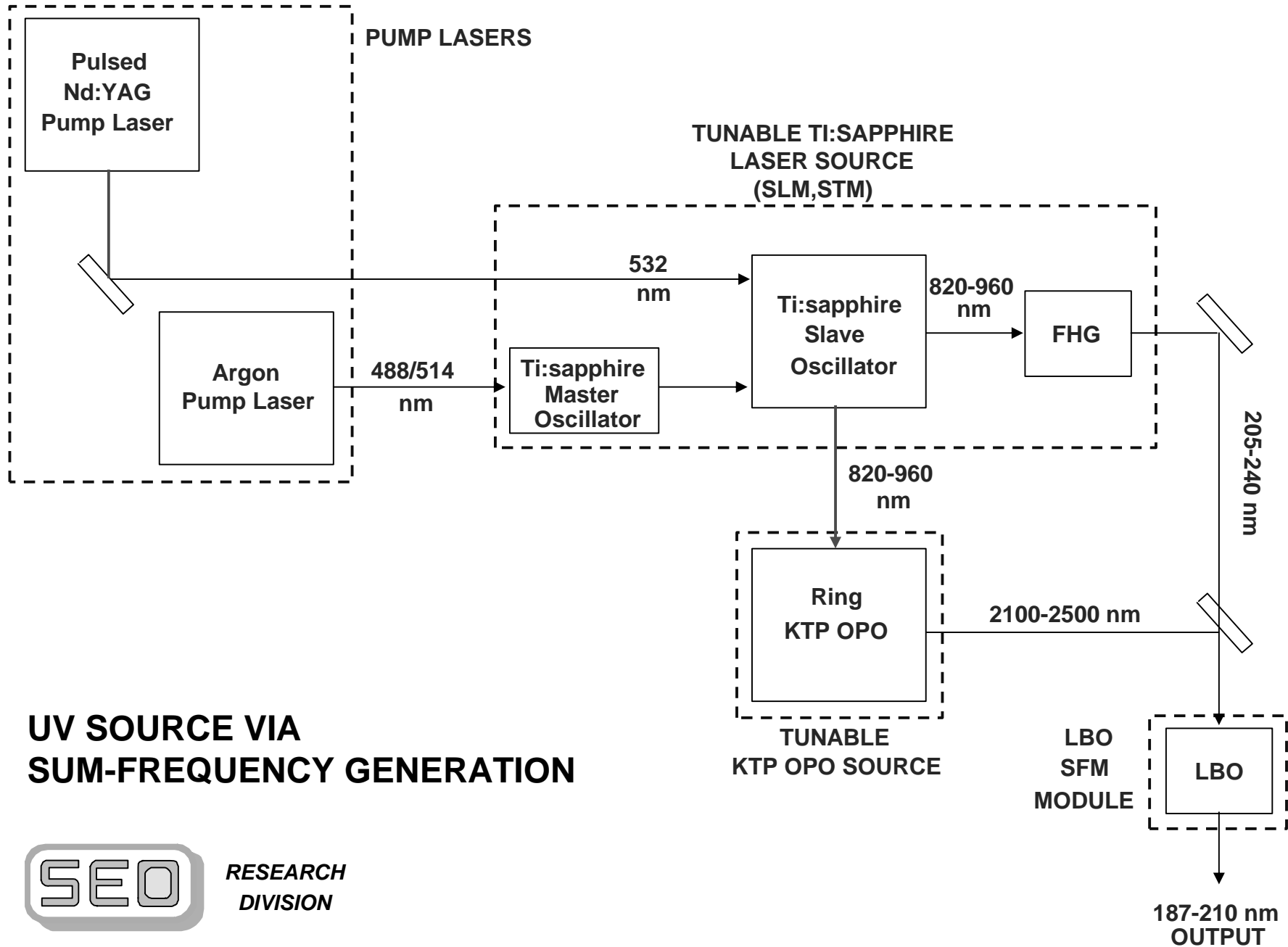




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## GENERIC Ti:SAPPHIRE-PUMPED OPO





## UV SOURCE VIA SUM-FREQUENCY GENERATION

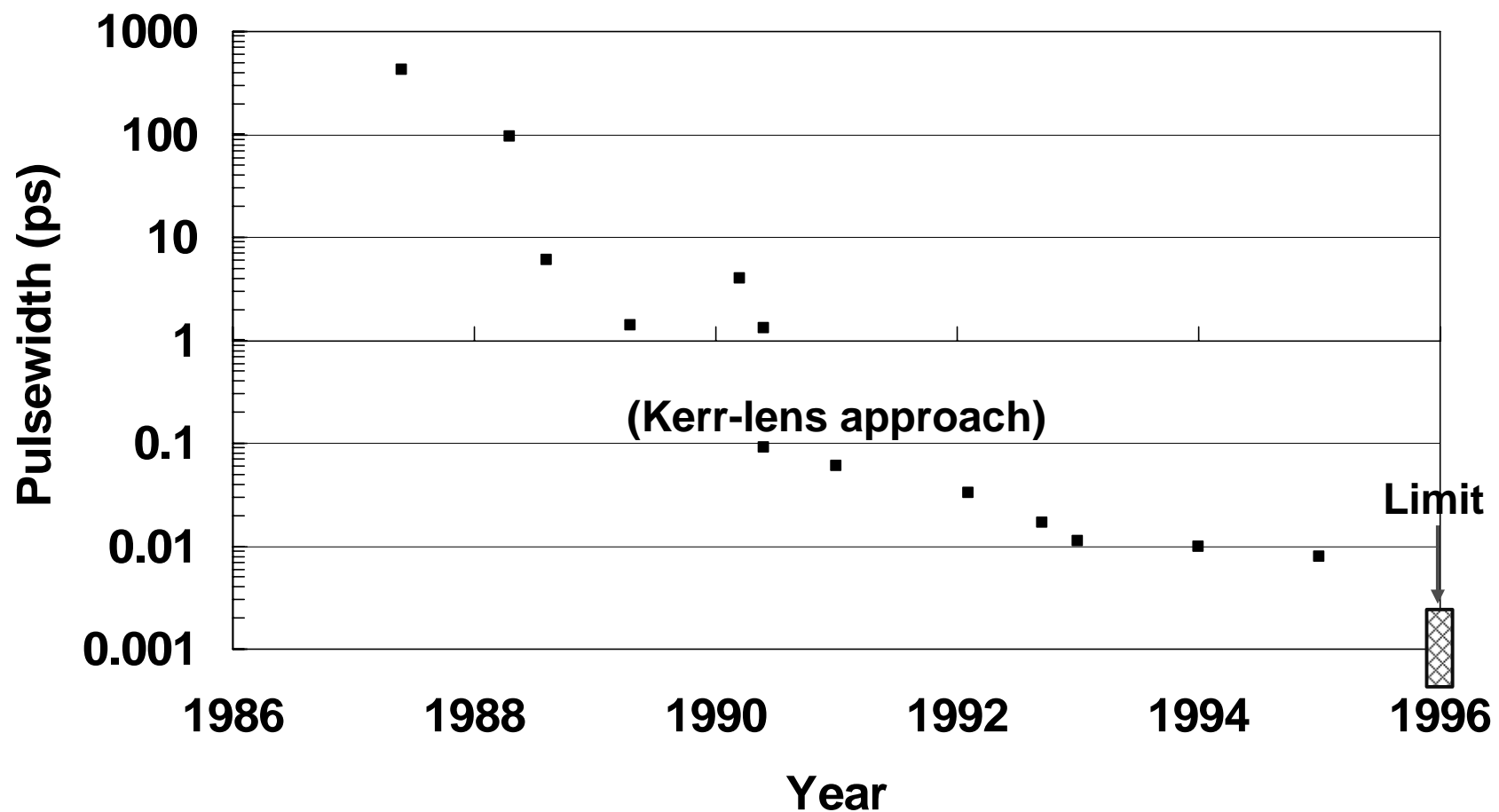


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# TREND IN MODE-LOCKED Ti:SAPPHIRE PULSE DURATION





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## **NEW TUNABLE LASERS - OUTLINE**

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### **Cr:LiSAF**

- **Lamp-pumped, high energy system**
- **Harmonic generation**
- **CW, diode pumped**

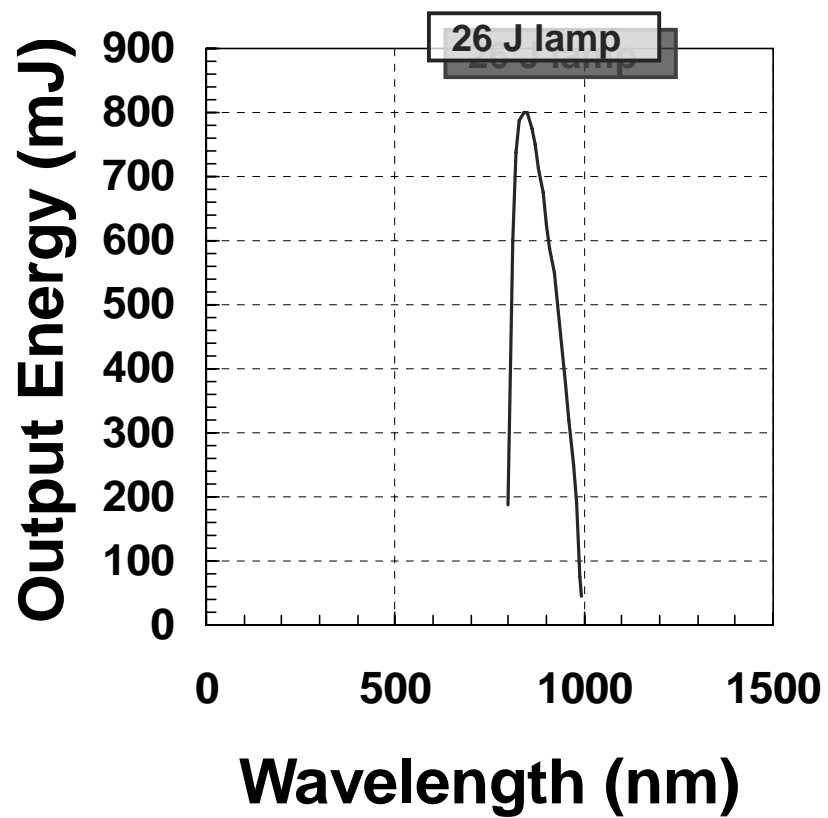
### **Cr:YAG**

- **Pass**

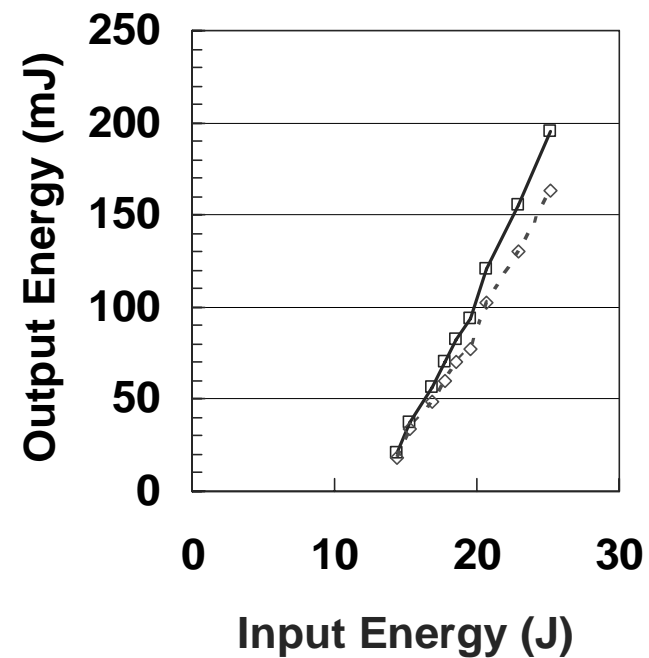


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## DATA ON LAMP-PUMPED Cr:LiSAF



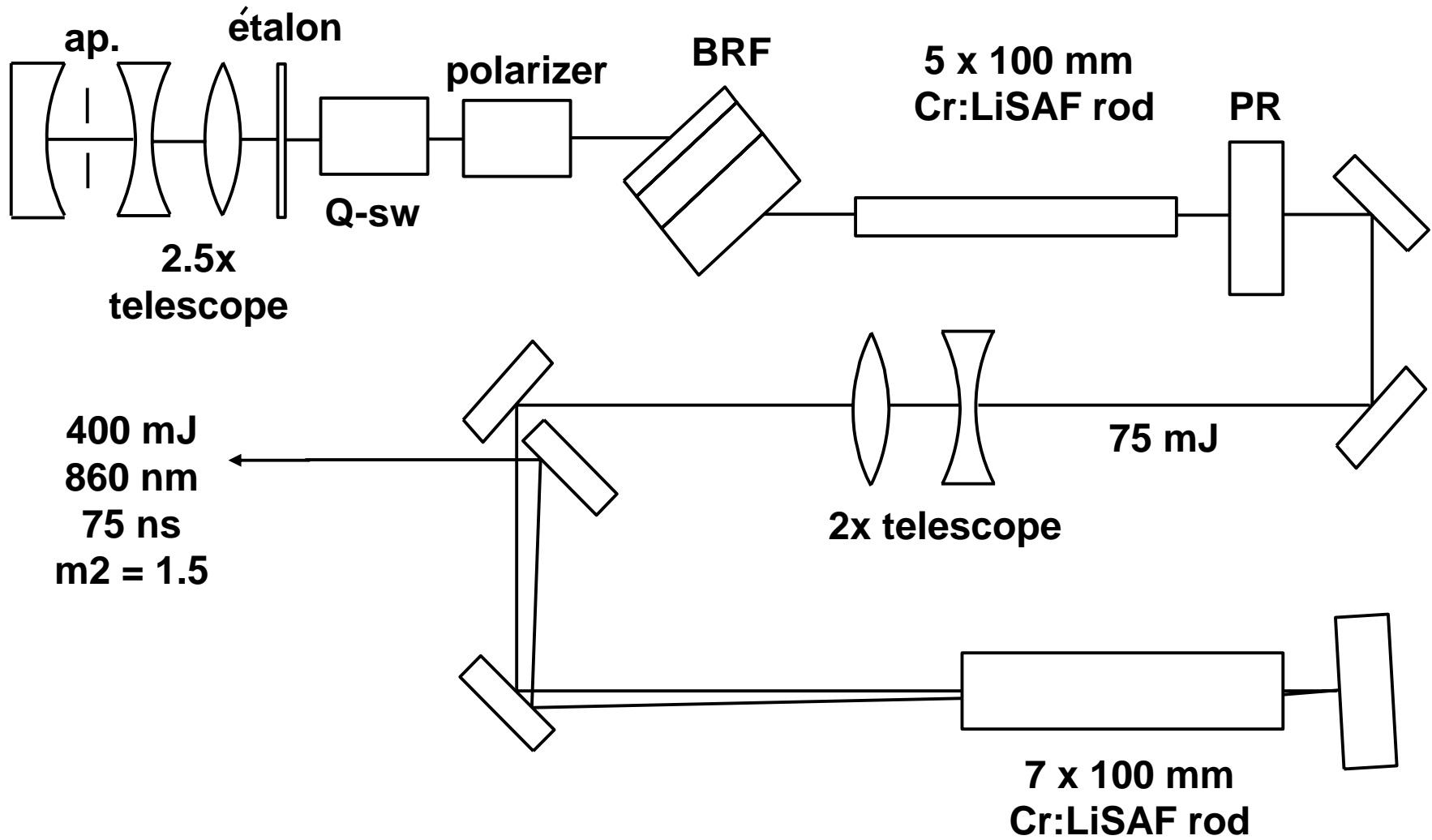
—□— LONG PULSE  
- -◇- - Q - SWITCHED





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## Cr:LiSAF OSC-AMP SYSTEM

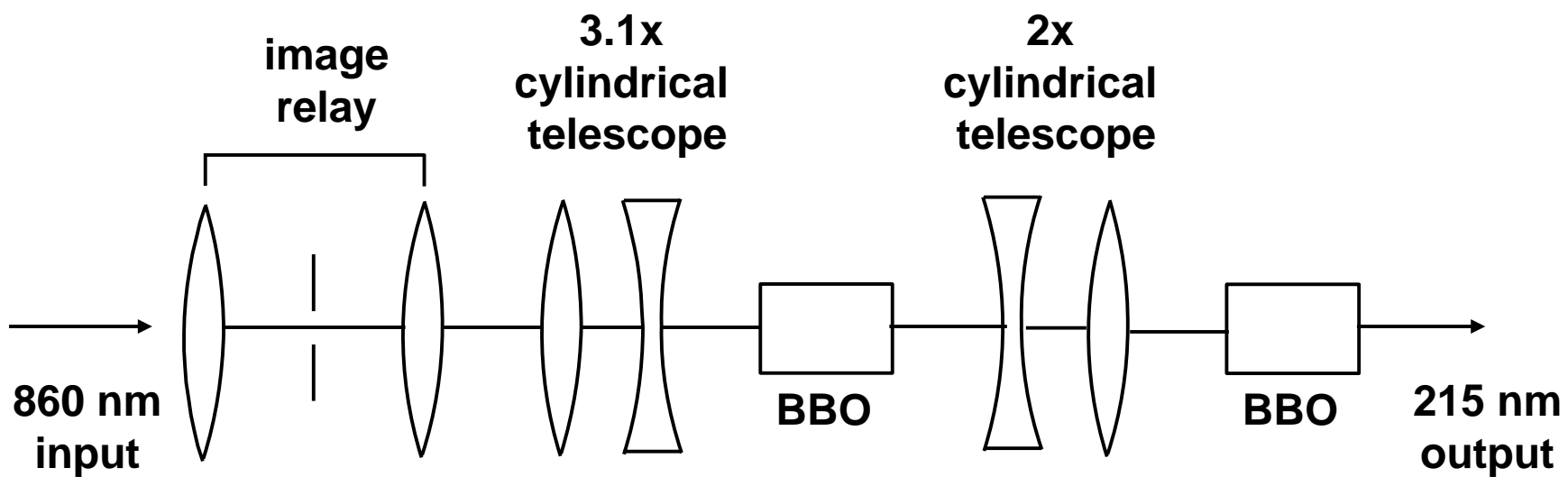






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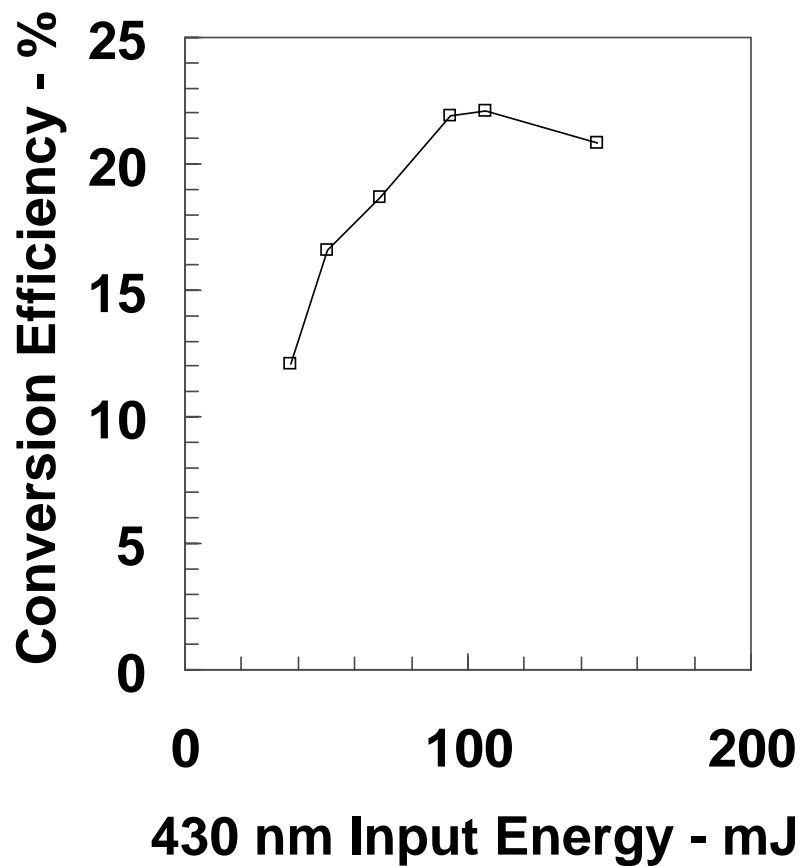
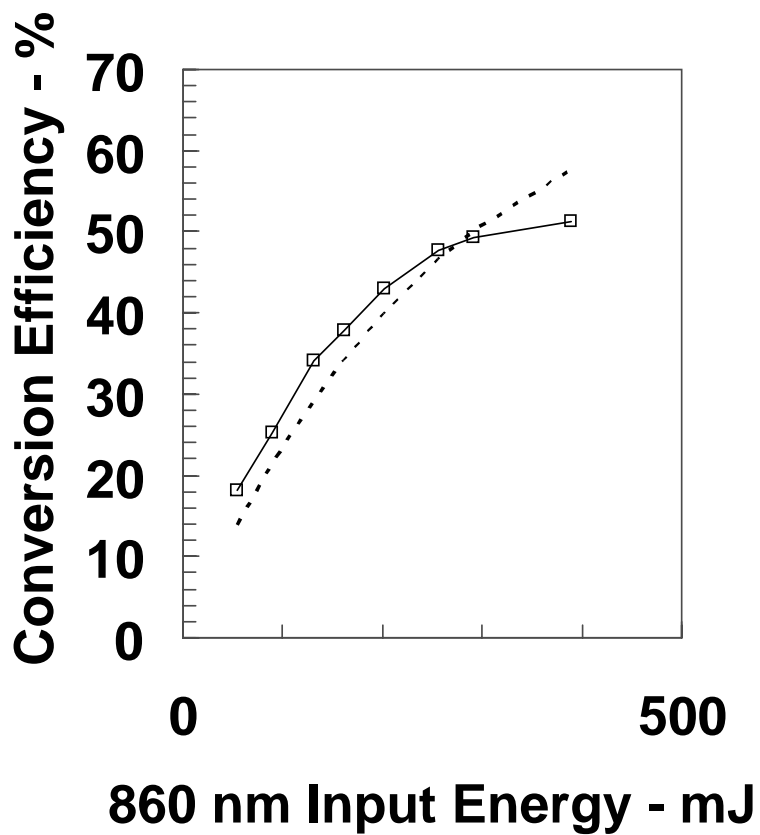
## Cr:LiSAF HARMONIC GENERATION CHAIN





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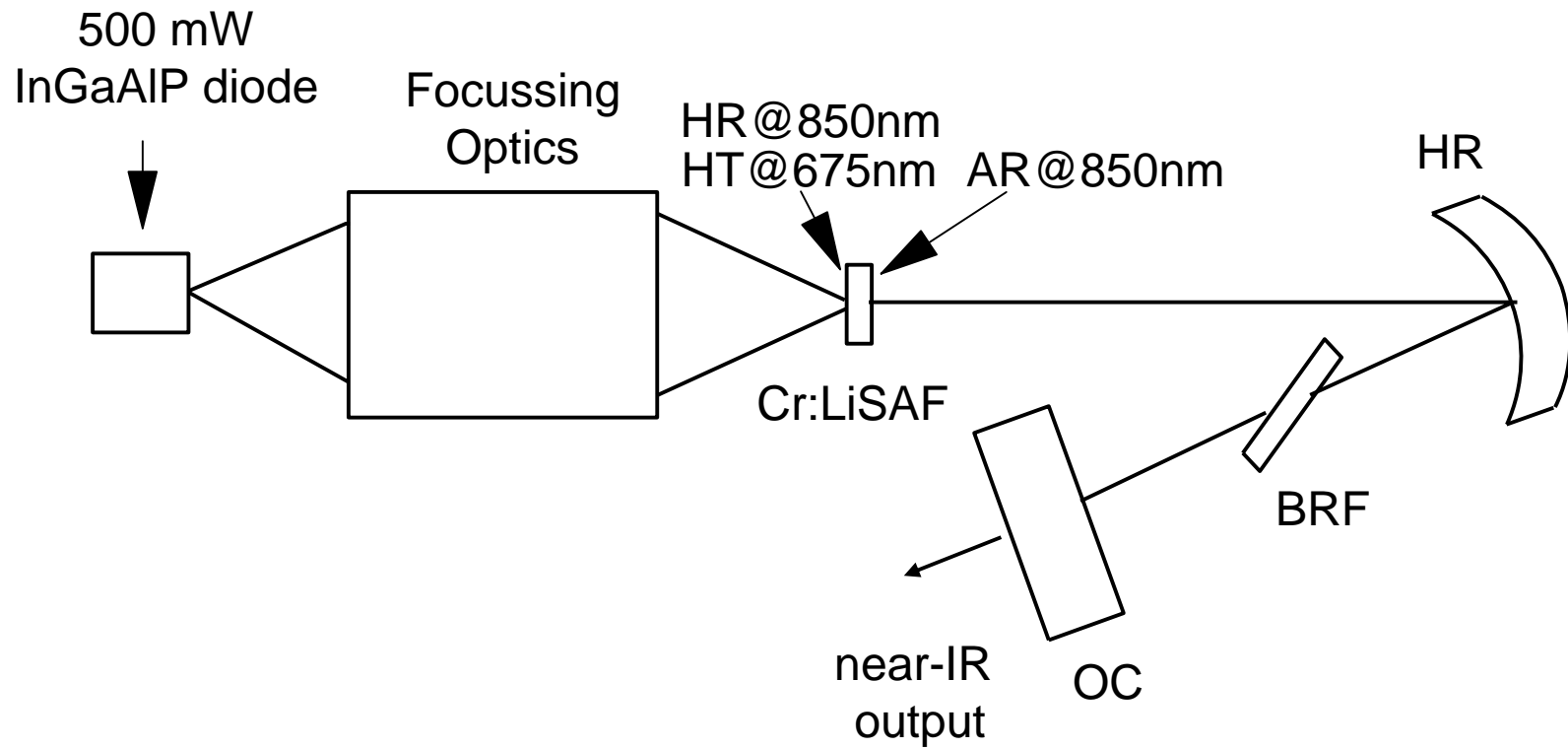
## Cr:LISAF HARMONIC GENERATION - DATA





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## DIODE-PUMPED Cr:LiSAF LASER SCHEMATIC





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## INFRARED SOURCES - OUTLINE

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### **Lasers**

#### **Lamp-pumped, rare-earths**

Holmium

Erbium

#### **Diode-pumped, rare-earths**

Ditto

### **Nonlinear devices**

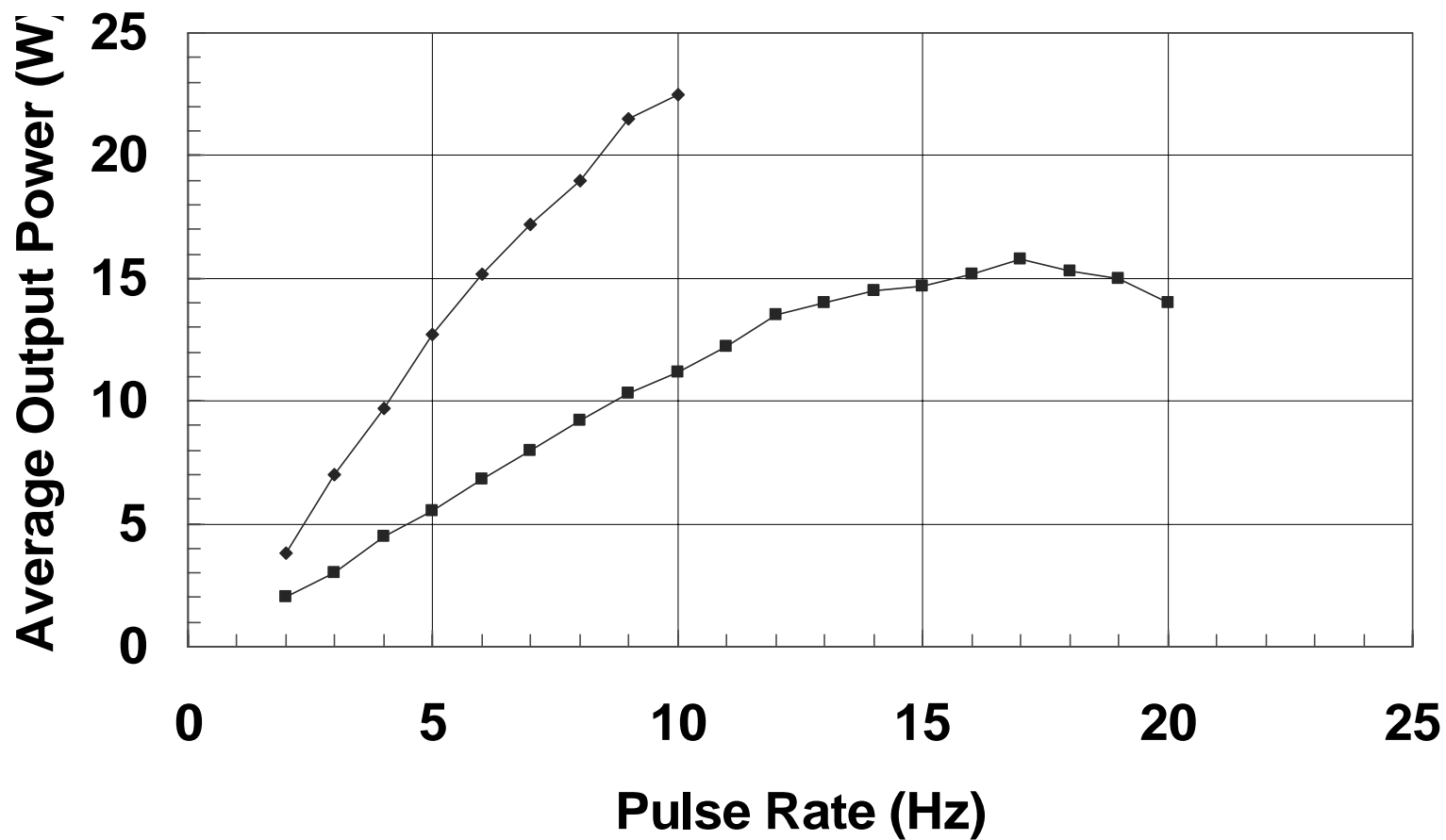
#### **Nd-laser-pumped, KTP OPOs**

#### **Erbium-laser-pumped CdSe OPO**



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## DATA ON HIGH-POWER Er:YAG LASER





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## CW DIODE-PUMPED Nd-DOPED LASERS - OUTLINE

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**"Single aperture," end-pumped, single-frequency sources**

**End pumping with linear array bars**

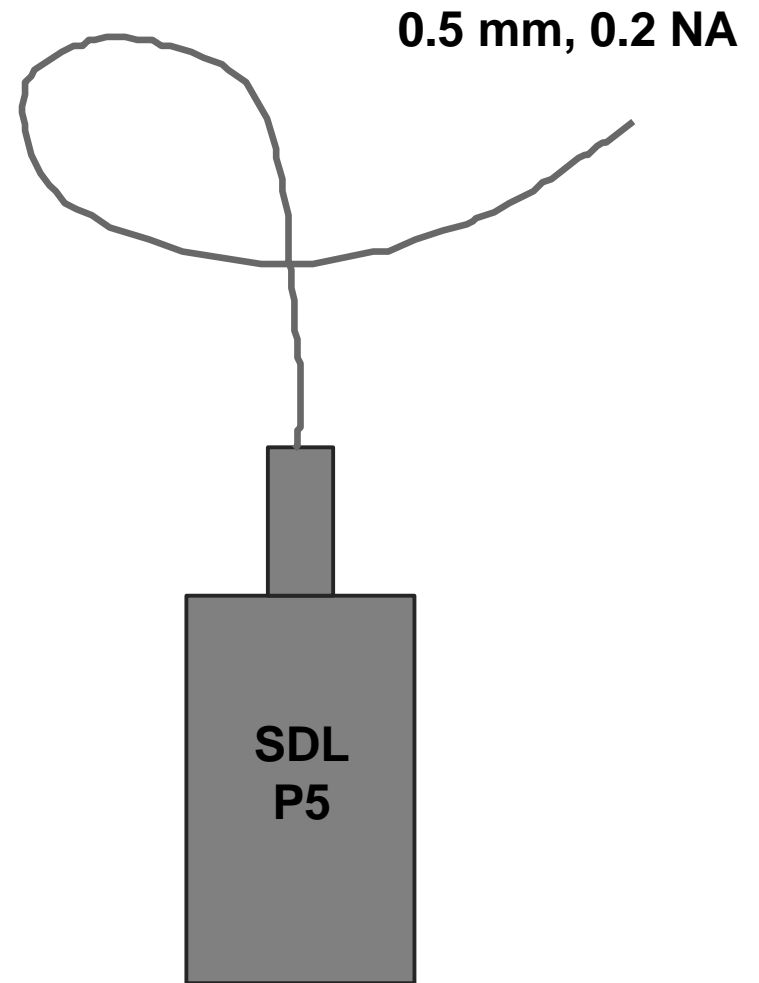
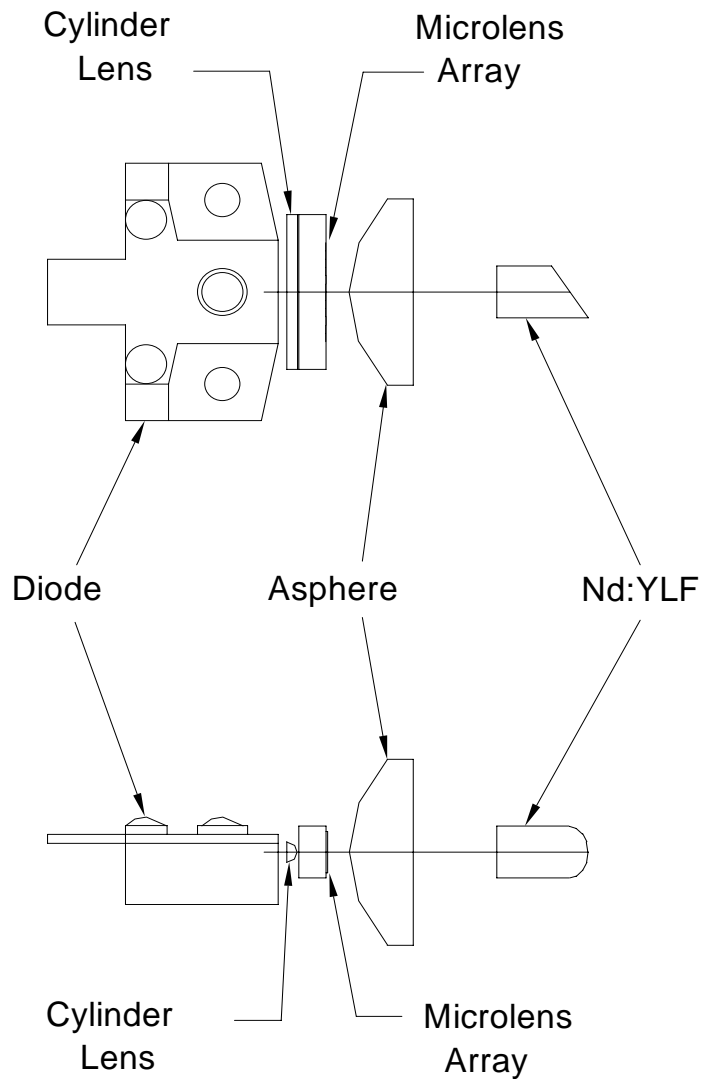
- **Micro-lens optics**
- **Fiber-coupling optics**

**Higher-power systems**



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# DIODE BAR OPTICS FOR END-PUMPING





**Research and development in solid state lasers can be split into two categories:**

- Generic laser/nonlinear concepts**
- Materials**

**There is no lack of concepts available, and many are often re-discovered, especially since work began 35 years ago**

**Materials discoveries/development have a more dramatic effect on advancement and are more random in nature, especially because of the funding mechanisms**

**High power semiconductor lasers are both beneficial and threatening to the field - future development should emphasize areas where overlap is unlikely**